FERMILAB UPGRADE: MAIN INJECTOR
CONCEPTUAL DESIGN REPORT

January 12, 1989

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APPENDICES

1. INTRODUCTION AND SUMMARY

This report contains a description of the design and cost estimate of a new 150 GeV accelerator, designated the Main Injector, which will be required to support the upgrade of the Fermilab Collider. The construction of this accelerator will simultaneously result in significant enhancements to the Fermilab fixed target program. The Main Injector (MI) is to be located south of the Antiproton Source and tangent to the Tevatron ring at the FO straight section as shown in Figure 1-1. The MI will perform all duties currently required of the existing Main Ring. Thus, operation of the Main Ring will cease following commissioning of the MI, with a concurrent reduction in background rates as seen in the colliding beam detectors. The performance of the MI, as measured in terms of protons per second delivered to the antiproton production target or total protons delivered to the Tevatron, is expected to exceed that of the Main Ring by a factor of two to three. In addition the MI will provide high duty factor 120 GeV beam to the experimental areas during collider operation, a capability which does not presently exist in the Main Ring.

The location, operating energy, and mode of construction of the Main Injector is chosen to minimize operational impact on Fermilab's ongoing High Energy Physics (HEP) program. The area in which the MI is to be situated is devoid of any underground utilities which might be disturbed during construction, while the separation between the MI and Tevatron is sufficient to allow construction during Tevatron operations. The energy capability of the MI is chosen to match the antiproton production and Tevatron injection energies presently used in the Fermilab complex. The Main Injector will be built from newly constructed dipole magnets allowing a large portion of the installation process to proceed independent of Tevatron operations. The use of newly designed dipoles is also desirable from the standpoint of enhanced performance and reliability, and results in a reduction of the operating costs by a factor of two relative to what would be obtained by recycling existing Main Ring magnets.

The Total Project Cost (TPC) of the Main Injector is estimated to be $144,300,000 including a Total Estimated Cost (TEC) of $132,300,000 and $12,000,000 in associated R&D, pre-operating, and capital equipment costs. Included within the scope of the project are all technical and conventional construction components associated with the ring itself, with beamlines needed to tie the ring into the existing accelerator complex, and with modifications to the Tevatron and switchyard required to accomodate the relocated injections. The project involves the construction of 17,200 ft of tunnel enclosures and ten service buildings encompassing at total of 39,300 ft^2. The Main Injector ring and all beamline interconnections to existing facilities are shown schematically in Figure 1-2. It is proposed to complete construction over a four-and-one-half year period starting on October 1, 1990. Design of conventional construction will be overseen by the Fermilab Construction Engineering Services Group. Design of technical components will be done by Accelerator Division personnel, and fabrication by the Technical Support Section and Accelerator Division. It is anticipated that construction and operation of the new Main Injector will not require any expansion of the Fermilab permanent staff.

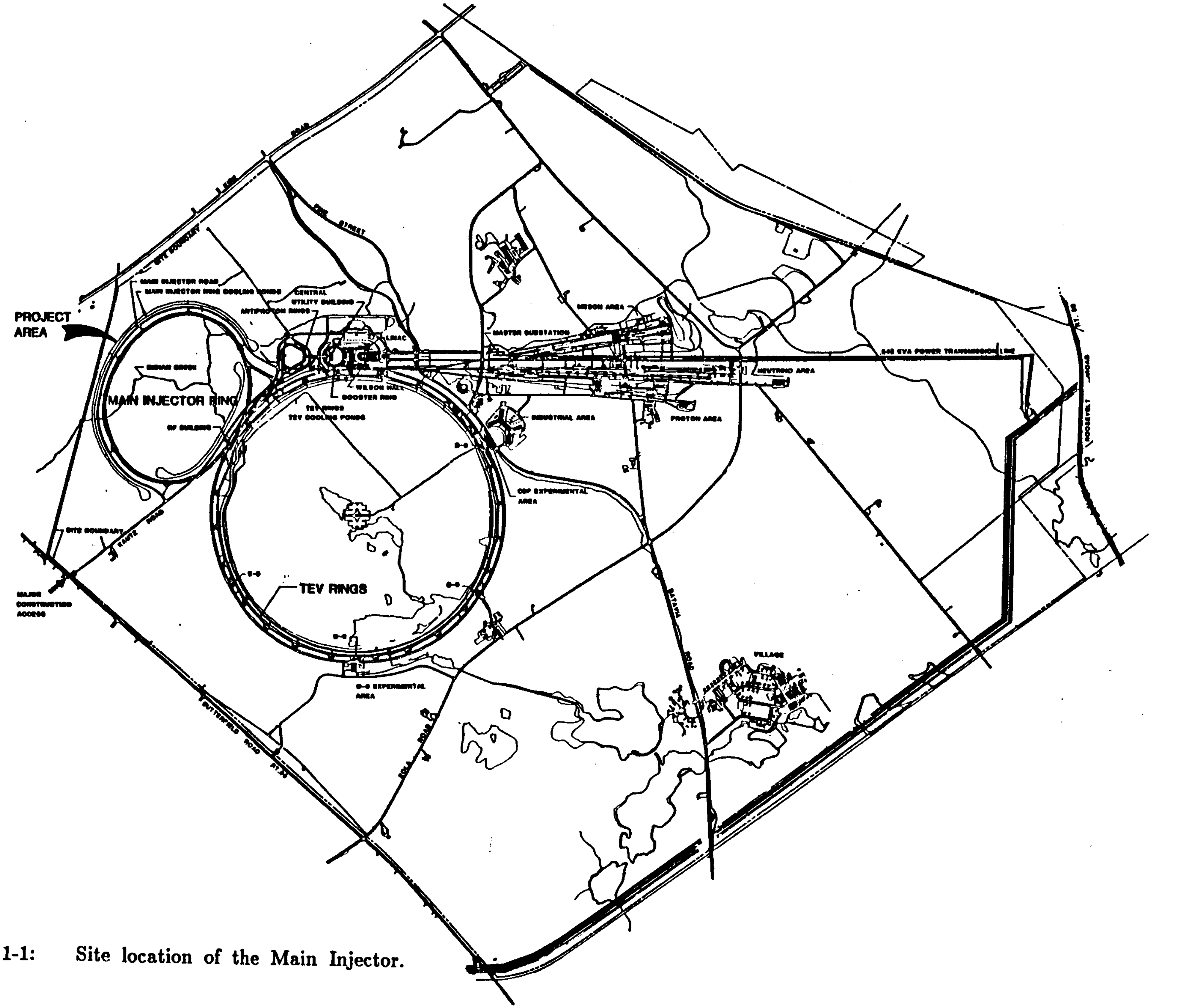


Figure 1-1: Site location of the Main Injector.

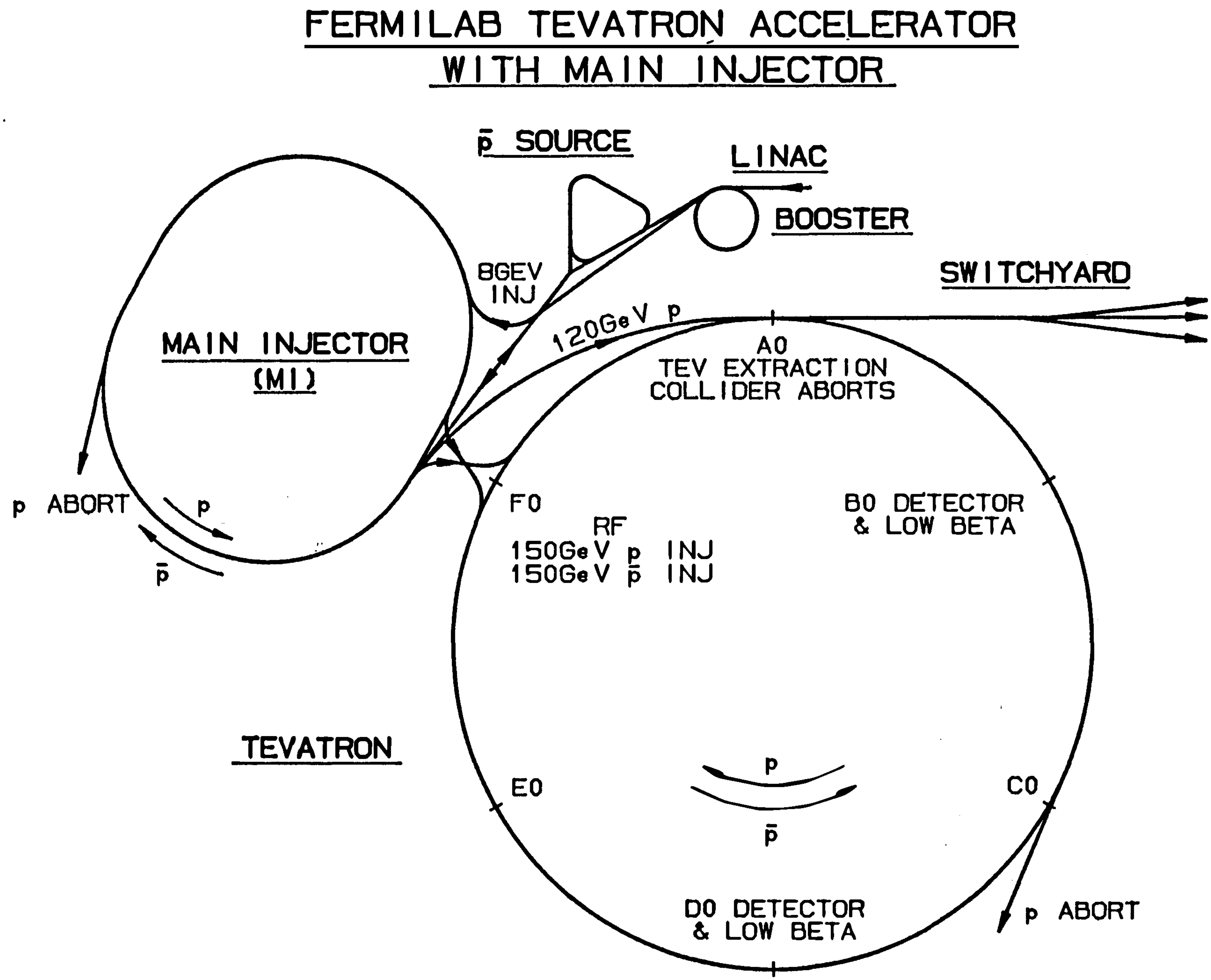


Figure 1-2: Schematic view of Main Injector connections to Booster, Antiproton Source, Tevatron, and Switchyard.

1.1 Role in the Upgrade Program

The primary purpose of the upgrade is to maintain the growth in physics output of the Fermilab HEP program during the pre-SSC era. The Fermilab Antiproton-Proton Collider is routinely operating at 1.8 TeV (center-of-mass) with initial luminosities in excess of 1.5×10^{30} $cm^{-2}sec^{-1}$, 50% above the design value. During fixed target operations the Tevatron delivers up to 1.8×10^{13} protons at 800 GeV every two minutes. The goal of the upgrade is to increase the energy to or above 3.0 TeV and the luminosity by more than an order of magnitude.

The upgrade will take place in stages. Projects already underway include upgrades to the Antiproton Source to improve the yield by a factor of three, development of new low-β systems which will allow the implementation of a second high luminosity interaction region, development of separators to allow multibunch operation, and the installation of cold compressors to raise the Tevatron energy. In a separate proposal plans have been put forward to increase the Linac energy from 200 MeV to 400 MeV for the purpose of increasing the antiproton production rate by 75% and reducing proton beam emittances by 40%. As a result of these enhancements it is expected that the luminosity of the collider will gradually increase to $1\times10^{31}cm^{-2}sec^{-1}$ by 1993. It is also anticipated that these developments will increase the number of protons delivered from the Tevatron up to 3×10^{13}.

Further improvements to performance will require the construction of a new accelerator. The present bottleneck in the production of antiprotons and in the delivery of intense beams to the Tevatron is the Main Ring. The Main Ring is not capable of accelerating the quantity of beam which can be provided at injection by the 8 GeV Booster. This is for the simple reason that the aperture of the Main Ring (12π mm-mr as measured in normalized units) is about half the size of of the Booster aperture (20π mm-mr). As a result the Booster is run at about two thirds of its capability during normal operations. The restricted aperture in the Main Ring is due to perturbations to the ring which have been required for the integration of overpasses and new injection and extraction systems related to operations with antiprotons. With the 400 MeV Linac upgrade the Booster aperture will be increased to 30π mm-mr due to increased adiabatic damping within the new linac. The mismatch between Booster and Main Ring capabilities will become even more acute. **Only with the construction of the Main Injector will this mismatch be removed and the full benefit of the Linac upgrade to the collider and fixed target programs realized.**

The construction of the Main Injector will also provide beams of up to 3×10^{13} protons at 120 GeV to the experimental areas during collider runs. Such beams are envisioned as being used both for the debugging and shakedown of fixed target experiments prior to commencement of 1 TeV fixed target runs, and for supporting certain specialized rare K decay and neutrino experiments which can benefit from the high average intensity deliverable from the MI. The Main Ring as presently configured does not support a slow spill, nor is it felt that implementation of a high intensity slow spill in the existing ring would be feasible in light of the small machine aperture and the need to minimize backgrounds in the collider experiments.

Specifically, benefits expected from the construction of the Main Injector include:

1. An increase in the number of protons targeted for $\bar{p}$ production from $4.5x10^{15}$/hour (following the Linac upgrade) to $1.2x10^{16}$/hour.

2. An increase in the total number of protons which can be delivered to the Tevatron to $6x10^{13}$.

3. The reduction of backgrounds and deadtime at the CDF and DO detectors through removal of the Main Ring from the Tevatron enclosure.

4. Provision for slow extracted test beams at 120 GeV during collider operations and potential development of very high intensity, high duty factor ($\geq 1x10^{13}$ protons/sec at 120 GeV with 34% duty factor) beams for use in high statistics K decay and neutrino experiments.

5. Freeing up the E0 Tevatron straight section for possible use as a third interaction region by moving beam tranfers to F0.

6. The creation of space in the Tevatron enclosure for eventual installation of a second superconducting accelerator.

It is expected that with the construction of the Main Injector and the completion of planned improvements to the Antiproton Source the antiproton production rate will exceed $1x10^{11}$ $\bar{p}$/hour, and that a luminosity of $2x10^{31}$ $cm^{-2}sec^{-1}$ will be supportable in the existing collider.

1.2 Performance

The Main Injector parameter list is given in Table 1-1. It is anticipated that the Main Injector will perform at a significantly higher level than the existing Main Ring as measured either in terms of protons delivered per cycle, protons delivered per second, or transmission efficiency. For the most part expected improvements in performance are directly related to optics of the ring. The MI ring lies in a plane with stronger focussing per unit length than the Main Ring. This means that the maximum betas are half as big and the maximum (horizontal) dispersion a third as big as in the Main Ring, while vertical dispersion is nonexistent. As a result physical beam sizes associated with given transverse and longitudinal emittances are significantly reduced compared to the Main Ring. The elimination of dispersion in the RF regions, raising the level of the injection field, elimination of sagitta, and improved field quality in the dipoles will all have a beneficial impact on beam dynamics. The construction of new, mechanically simpler magnets is expected to yield a highly reliable machine.

The Main Injector is seven times the circumference of the Booster and slightly more than half the circumference of the existing Main Ring and Tevatron. Six Booster cycles will be required to fill the MI and two MI cycles to fill the Tevatron. The MI is designed to have a transverse aperture of 40π mm-mr (both planes, normalized at 8.9 GeV/c). This is 30% larger than the expected Booster aperture following the 400 MeV Linac upgrade, and a factor of

Table 1-1: Main Injector Parameter List

Circumference	3319.419 meters
Injection Momentum	8.9 GeV/c
Peak Momentum	150 GeV/c
Minimum Cycle Time (@120 GeV)	1.5 sec
Number of Protons	$3x10^{13}$
Harmonic Number (@53 MHz)	588
Horizontal Tune	22.42
Vertical Tune	22.43
Transition Gamma	20.4
Natural Chromaticity (H)	-27.5
Natural Chromaticity (V)	-28.5
Number of Bunches	498
Protons/bunch	$6x10^{10}$
Transverse Emittance (Normalized)	20π mm-mr
Longitudinal Emittance	0.25 eV-sec
Transverse Acceptance (at 8.9 GeV)	40π mm-mr
Momentum Acceptance	2.0 %
β_{max} (Arcs)	57 meters
β_{max} (Straight Sections)	80 meters
Maximum Dispersion	2.2 meters
Number of Straight Sections	8
Length of Standard Cell	34.3 meters
Phase Advance per Cell	90 degrees
RF Frequency (Injection)	52.8 MHz
RF Frequency (Extraction)	53.1 MHz
RF Voltage	4 MV
Number of Dipoles	300
Dipole Length	6.1 meters
Dipole Field (@150 GeV)	17.2 kGauss
Dipole Field (@8.9 GeV)	1.0 kGauss
Number of Quadrupoles	202
Quadrupole Gradient	196 kG/m
Number of Quadrupole Types	3
Number of Quadrupole Busses	2

three larger than that of the existing Main Ring. It is expected that the Linac upgrade will yield a beam intensity out of the Booster of 5-7x10^{12} protons per batch with a 20-30π mm-mr transverse and a 0.25 eV-sec longitudinal emittance. (All emittances in this report are quoted as 95% normalized values.) A single Booster batch needs to be accelerated for antiproton production while six such batches are required to fill the MI. The MI should be capable of accepting and accelerating these protons without significant beam loss or degradation of beam quality. Yields out of the MI for a full ring are expected to lie in the range 3-4x10^{13} protons (6-8x10^{13} delivered to the Tevatron.) By way of contrast the existing Main Ring is capable of accelerating 1.8x10^{13} protons in twelve batches for delivery to the Tevatron.

The power supply and magnet system is designed to allow a significant increase in the number of 120 GeV acceleration cycles which can be run each hour for antiproton production, as well as to allow a 120 GeV slow spill with a 35% duty factor. The cycle time at 120 GeV can be as low as 1.5 seconds. This is believed to represent the maximum rate at which the Antiproton Source might ultimately stack antiprotons and is to be compared to the current Main Ring capability of 2.6 seconds. The dipole magnets to be used are designed with twice the total cross section of copper and half as many turns as existing Main Ring dipoles. This is done to keep the total power dissipated in the dipoles during antiproton production at roughly the same level as in present operations while keeping the number of power supplies and service buildings low.

1.3 Operational Modes

At least four distinct roles for the MI have been identified along with four corresponding acceleration cycles. These are identified in Table 1-2 along with the average power over the cycle for each case. For reference the current 120 GeV antiproton production cycle runs at 2.6 seconds and 4.3 MW. More detailed description of the acceleration cycles and power supply requirements are given in Section 2 of this report.

Table 1-2. Main Injector Operational Modes

Operational Mode	Energy	Cycle	Flattop	Power
Antiproton Production	120 GeV	1.5 sec	.05 sec	7.1 MW
Fixed Target Injection	150	3.0	.05	6.2
Collider Injection	150	9.0	3.0	10.9
High Intensity Slow Spill	120	2.9	1.0	11.9

In the antiproton production mode a single Booster batch containing 5x10^{12} protons is injected into the Main Injector at 8.9 GeV/c. These protons are accelerated to 120 GeV and extracted in a single turn for delivery to the antiproton production target. As mentioned earlier it is anticipated that with this flux of protons onto the target and expected improvements in the Antiproton Source the antiproton production rate will exceed 1x10^{11}/hour.

For fixed target injection the MI is filled with 6 Booster batches each containing 5x10^{12} protons at 8.9 GeV/c. Since the Booster cycles at 15 Hz, 0.4 seconds are required to fill the MI. The beam is accelerated to 150 GeV and extracted in a single turn for delivery to the Tevatron. The MI is capable of cycling to 150 GeV every 3 seconds. Two MI cycles are required to fill the Tevatron at 150 GeV.

The MI operates on a 9 second, 150 GeV cycle for delivery of beam to the Tevatron for collider operations. The acceleration cycle and beam manipulations are the same for both protons and antiprotons. A 3 second flattop is required for bunch coalescing and cogging of the beams prior to injection into the Tevatron. Under the currently envisioned filling scenario twenty two cycles of the MI are required to load the Tevatron with protons and antiprotons. This results in a 3 minute collider fill time.

A much higher intensity, high duty factor (34%) beam can be delivered at 120 GeV with a 2.9 second cycle time. The average proton current delivered is about 2 μA (3×10^{13} protons/2.9 seconds). Running in this mode does not put any peak power demands on the power supply system beyond those imposed by the antiproton production cycle, but it does expend 67% more power. This cycle can also be used to provide test beams to the experimental areas during collider running. In this mode it is likely that a much lower cycle rate, accompanied by a much lower average power, would satisfy experimenters' needs.

Combinations of the above operational modes are also possible. One such example is simultaneous operation for antiproton production and high intensity slow spill. One might load the MI with six Booster batches containing 3×10^{13} protons, accelerate to 120 GeV, fast extract one batch to the antiproton production target, and slow extract the remainder of the beam over a second. This would produce slightly more than half the antiproton flux into the source and 83% of the average intensity of the dedicated scenarios listed in Table 1-2.

2. THE MAIN INJECTOR

The Main Injector (MI) is a 150 GeV accelerator with a circumference 28/53 times that of the existing Main Ring. The primary design goals are to increase the aperture to 40π and lower the cycle time to 1.5 sec. The MI will be situated tangent to the Tevatron at the F0 straight section on the southwest side of the Fermilab site. Other possible sitings have been considered, including locations inside the existing Tevatron ring, but these were deemed less desirable than the site shown in this report. The MI, as described here, is constructed using newly designed (conventional) dipole magnets. The choice of building new magnets is based on considerations of field quality, aperture, and reliability. With the major exception of the dipoles, existing components from the Main Ring are for the most part recycled. Such components specifically include quadrupoles and the radio frequency (RF) systems. The use of all 18 existing rf cavities in a ring roughly half the size of the Main Ring will support an acceleration rate of 240 GeV/sec as compared to 120 GeV/sec in the present Main Ring. The power supply systems described are designed to support this rate.

2.1 Lattice

The design of the MI is driven by a number of considerations. Once the siting is determined (as described below) a maximum physical size of the ring is established. This in turn leads to a minimum needed field strength in the magnets. The number and location of the straight sections is determined by the roles the ring is asked to play. In all phases of design the motivation has been to produce a lattice in which the transverse beam sizes are smaller than the Main Ring in the energy range 8.9 to 150 GeV/c. The two lattice parameters which effect beam size are the beta function, β, and the dispersion, η. In this β is kept small by using 90° cells with a short distance between quadrupoles. This is a cost effective approach because the quadrupoles will be taken from the existing Main Ring. The η is kept smaller in the MI than in the Main Ring in part due to the 90° cells, but more importantly due to careful dispersion matching around all straight section insertions. Dispersion matching insures that the maximum dispersion in the ring is no larger than the maximum dispersion in the standard cell. Of course the MI will not have overpasses, in contrast to the present Main Ring, and therefore the vertical dispersion will be zero.

Siting Considerations

The MI must serve a number of purposes. It must function as a bi-directional injector into the Tevatron. This means it must be near and approximately tangent to the Tevatron. Secondly, it must receive 8 GeV protons from the Booster. It must also provide 120 GeV protons to the antiproton target, and receive 8 GeV antiprotons from the Antiproton Source. This constraint requires a portion of the MI to lie south of and nearly tangent to the present beamline which provides these functions. Finally, the MI must provide a 120 GeV test beam to the present Fermilab switchyard. In light of these constraints two sites were considered: the one chosen, and a site inside the Main Ring tunnel running concentric with it from F0 to A0. It was found that the transfer lines were equally long in both site options. Furthermore, the considerable interferences with the existing accelerator utilities on the inside of the ring, and the fact that the inside siting led to a longer circumference for the MI led to the selection of the outside siting.

Lattice Design

The present Main Ring lattice is made of FODO cells with four dipoles between the quadrupoles. Two of these dipoles (B1) have a 1.5 inch vertical by 5.0 inch horizontal aperture and are placed nearest the horizontally focusing quadrupoles. The other two dipoles (B2) have a 2.0 inch vertical by 4.0 inch horizontal aperture, and are placed near the vertically focusing quadrupoles. The MI will use new dipoles with a 2.0 inch by 4.0 inch aperture.

Figure 2-1 shows the MI geometric layout. The standard cell of the MI is, like the Main Ring, a FODO design but with two dipoles between the quadrupoles as shown in Figure 2-2. The interelement spacing is the same as in the present Main Ring so that the length of the half cell is shorter by the length of two dipoles and the short drift spaces which follow them. Because of the shorter circumference, there are fewer than half the number of dipoles as in the Main Ring. This leads to higher fields in the dipoles, and a larger bending angle in each. The resulting sagitta is 0.62 inch. The new dipoles will be built with a curvature which eliminates loss of aperture due to sagitta. A 90° phase advance per cell was chosen, resulting in a maximum β in the cells of 58 meters and a maximum η in the cells of 2.0 meters. Thus the beam size due to transverse emittance will be only 70% of what it is presently, and the maximum beam size due to momentum spread will be down by a factor of three from the Main Ring. Figure 2-3 shows the MI lattice functions.

The MI contains eight straight sections, six of the "long straight" type and two "RF" type. Their locations are shown in Figure 2-1 and details of their layout are shown in Figures 2-4 and 2-5. Their numbering and their functions are as follows:

10 - 8 GeV injection
20 - (unused)
30 - (unused)
40 - proton abort
50 - (unused)
60 - 150/120 GeV proton extraction;
8 GeV antiproton injection
70 - MI RF section
80 - 150 GeV antiproton extraction

The six long straights (10, 20, 40, 50, 60, 80), illustrated with MI-20 in Figure 2-4, are needed for 150 GeV extraction and are designed using matching quadrupoles. This design requires two new quadrupole types, similar to existing Main Ring quadrupoles, but of different lengths. All quadrupoles in the ring can thus be on the main quadrupoles busses. The long straight section insertion is dispersion matched to the cells. Space is provided 90° from the long straight for kickers and septa, a situation not provided for in the present Main Ring lattice.

The second type of straight section (30, 70), illustrated with MI-70 in Figure 2-5, is provided by omitting dipoles while retaining the standard quadrupole spacing. This straight section is designed for RF systems. Only one is needed at present.

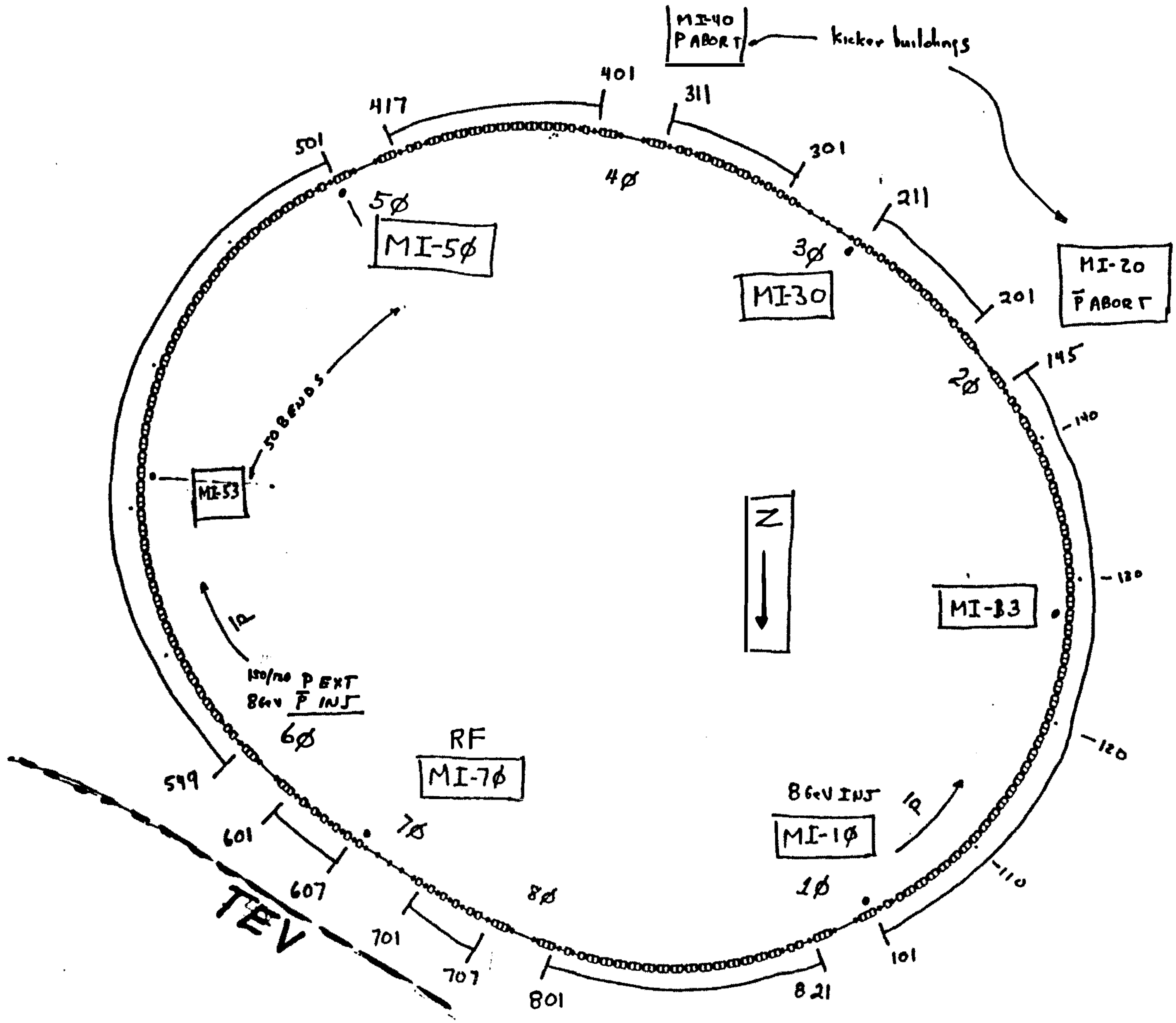


Figure 2-1: Main Injector geometric layout. Locations of the eight straight sections and eight service buildings are indicated.

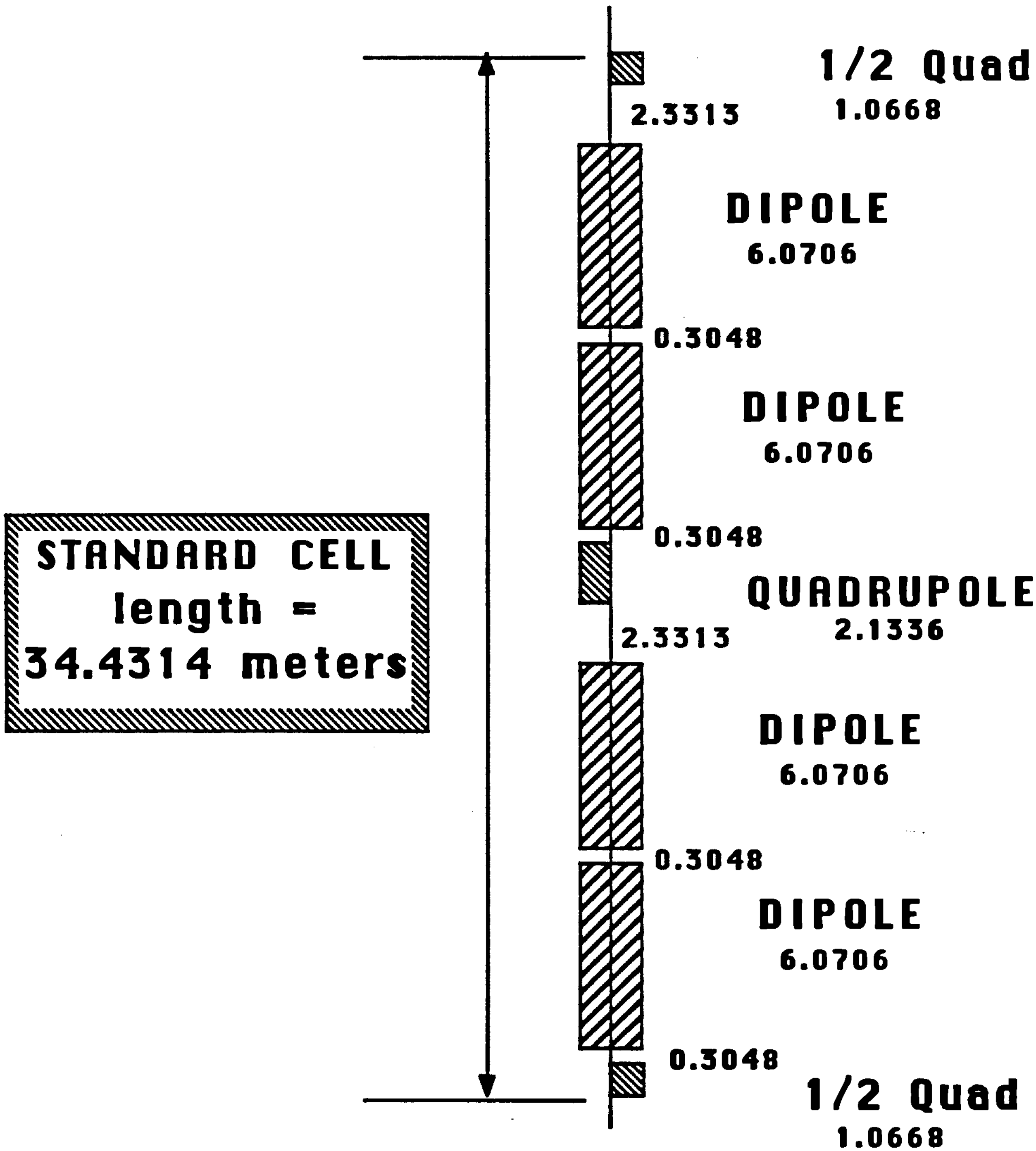


Figure 2-2: Main Injector standard cell.

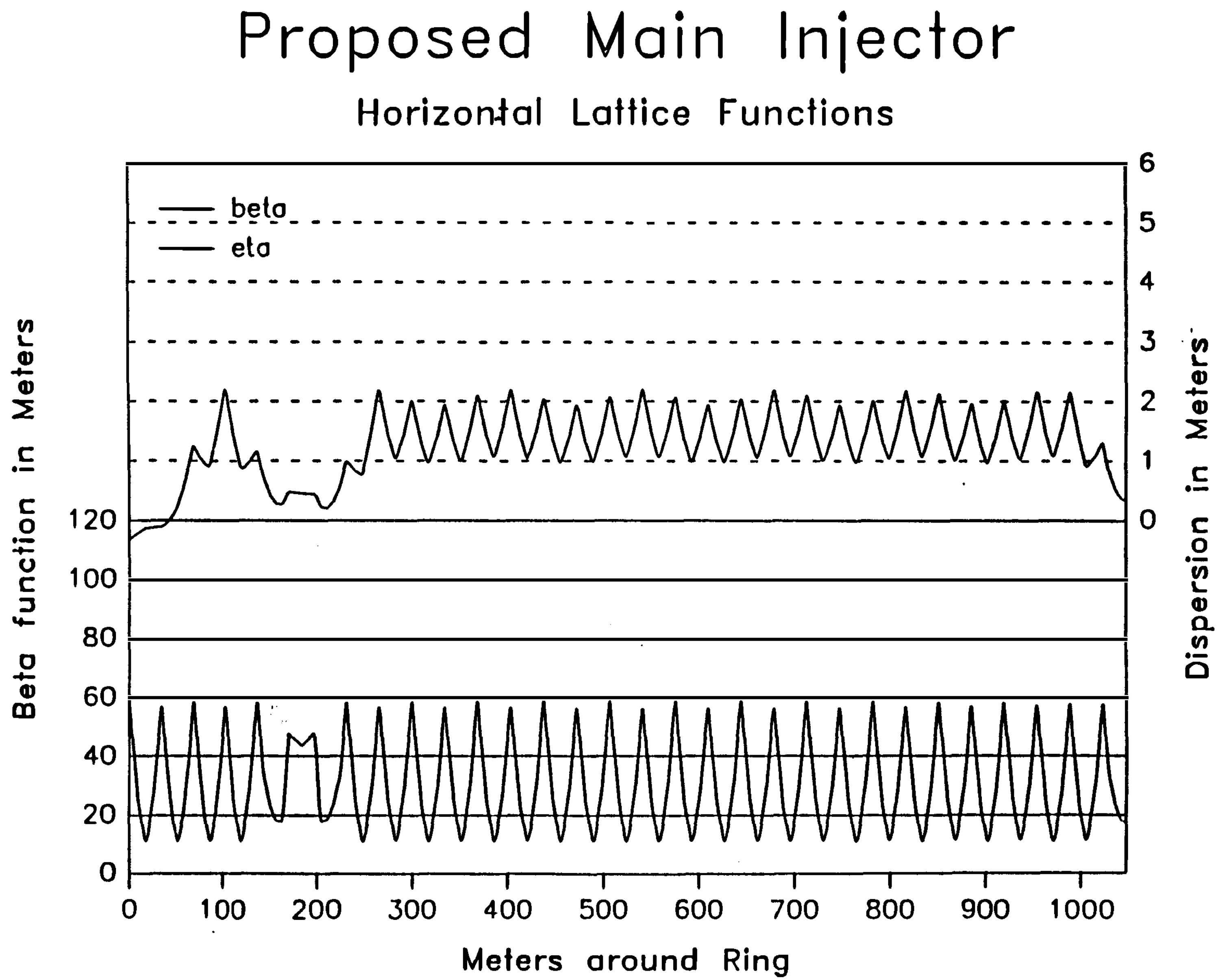


Figure 2-3: Main Injector lattice functions. Approximately one third of the ring is shown starting at the RF straight section.

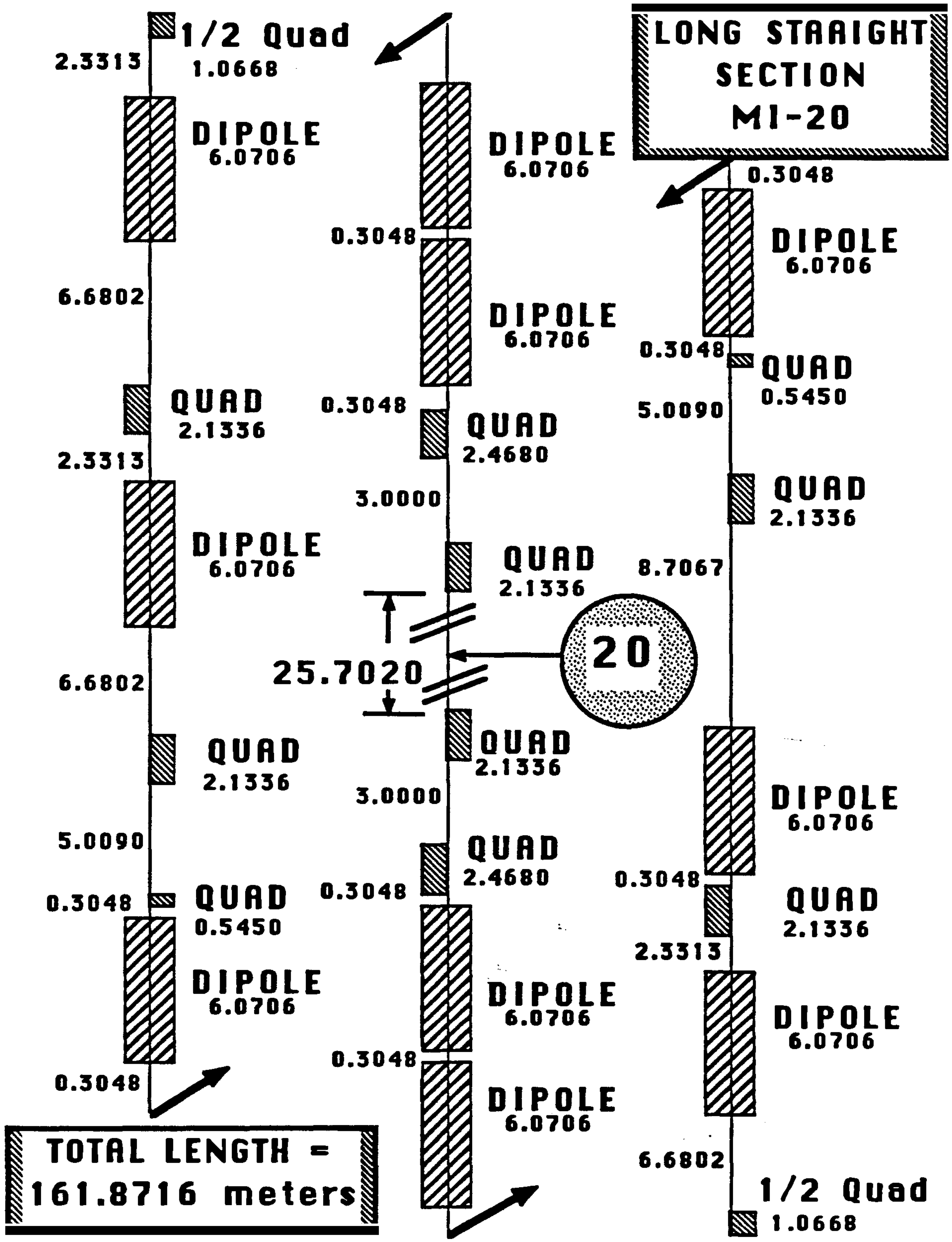


Figure 2-4: Optical layout of the long straight section, MI-20.

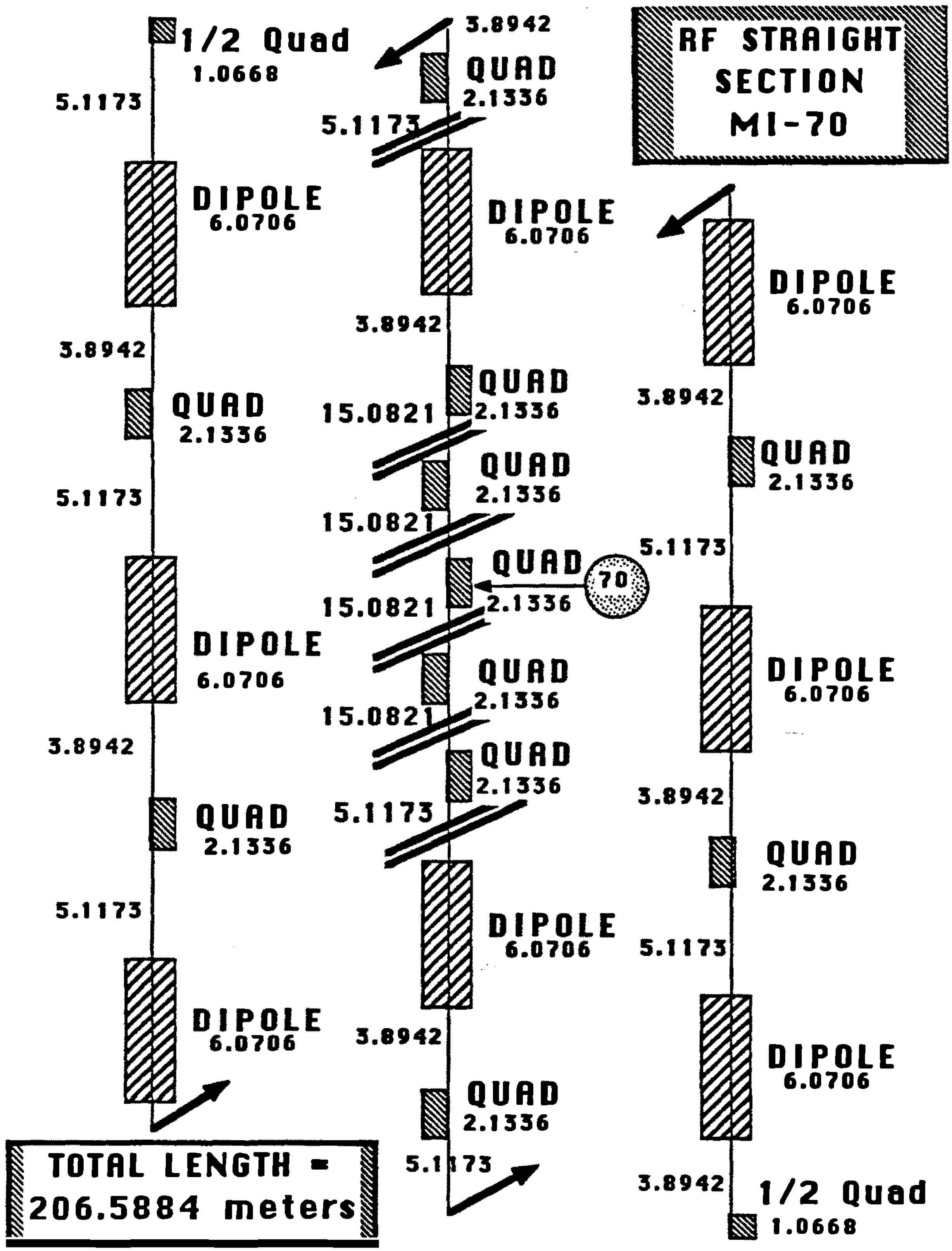


Figure 2-5: Optical layout of the RF straight section, MI-70.

The six long straight sections are capable of beam extraction at the highest MI energy. Due to the fact the ring lies 10 meters from the Tevatron, two of these (60, 80) are required to provide injection into the Tevatron, one each for protons and antiprotons. On the opposite side of the ring are two additional straight sections (20, 40) which can be used for beam abort. They are not symmetric with long straight sections MI-60 and MI-80 in order to avoid tangents which intersect the nearby site boundaries. Finally, straight section MI-10 is necessary for injection of protons from the Booster. Straight section MI-50 was added on the opposite side, but in a nonsymmetrical position in order to avoid a tangent which interferes with the site boundary.

2.2 Acceleration Cycles

There are four acceleration cycles, shown in Figure 2-6, serving each of the four operational modes of the MI:

(a) The antiproton production cycle: 1.5 second cycle, peak energy of 120 GeV.
(b) The Tevatron fixed target injection cycle: 3.0 second cycle for Tevatron injection at 150 GeV.
(c) The Tevatron collider injection cycle: 9.0 second cycle with a 3 second flattop at 150 GeV for coalescing and cogging.
(d) The 120 GeV slow spill cycle: 2.9 second cycle with a one second slow spill at 120 GeV to the fixed target area.

The operational limits for the RF cavities and power supply systems are discussed in Sections 2.4 and 2.6 respectively. The 18 existing Main Ring cavities in their current running mode are adequate for all of the above cycles.

2.3 Magnets

The MI uses conventional iron core magnets. A total of 300 dipole, 202 quadrupole, 160 sextupole, and 202 correction dipole magnets are required. The magnet apertures need to be sufficient to provide a transverse acceptance of 40π mm-mr and a momentum aperture of $\pm 1.0\%$. The dipole and sextupole are newly designed and manufactured magnets. The quadrupoles and the correction dipoles are to be recycled from the Main Ring. Dipole and quadrupole parameters are listed in Table 2-1. The sextupole and correction dipole magnets are described in Section 2.5.

The decision was made to construct the MI using newly designed dipole magnets for several reasons. First, the existing Main Ring magnets are straight. Recycling these magnets into the MI would result in a loss of about 16 mm of aperture due to sagitta. This aperture is recovered by constructing curved magnets. Second, the existing magnets suffer from reliability problems. Most of the failures in the existing magnets occur at conductor joints within the coil. The number of such joints per magnet will be reduced in the new magnet and at the same time the reliability of the joints improved to the level achieved in the best existing Main Ring magnets. Third, it is believed that higher field quality can be achieved in a newly constructed magnet so that the dynamic aperture is only limited by the magnet physical aperture - a situation not achieved in the existing Main Ring.

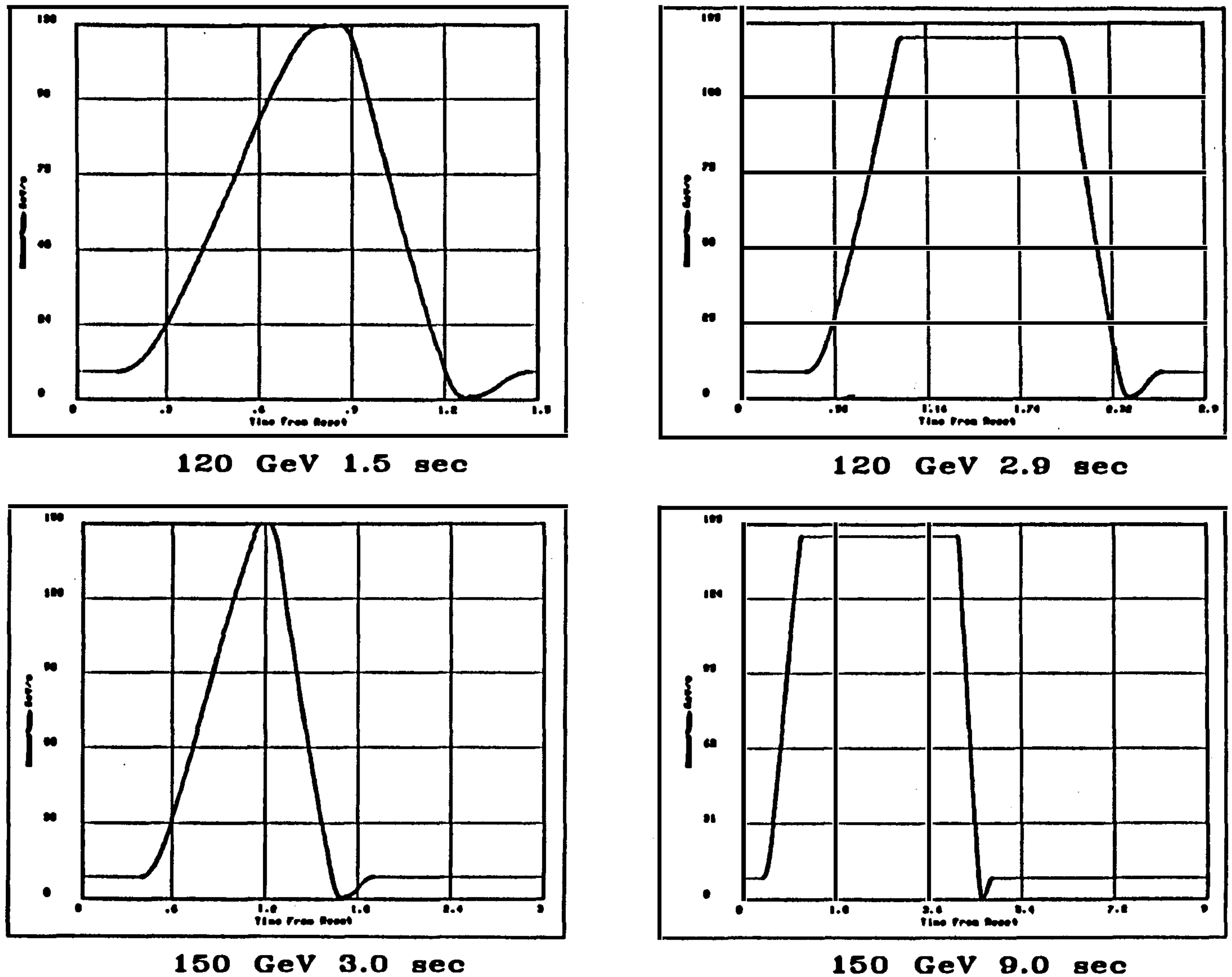


Figure 2-6: Beam momentum versus time for the four operational modes described in the text.

Table 2-1. Main Injector Magnet Parameters

	Dipole	Quadrupole
Strength (@150 GeV)	17.3 kG	196.0 kG/m
Length	6.1 m	2.1 m
Full Aperture	15x5 cm^2	7.6 cm
Turns/pole	4	4
Maximum Current	8926 A	3630 A
Coil Resistance	0.7 mΩ	4.5 mΩ
Coil Inductance	1.9 mH	1.3 mH
Peak Power	57 kW	59 kW
Number Required	300	202
Newly Constructed	Yes	No

Once it was decided to build new dipole magnets, a cost optimization was performed which minimized the sum of construction plus operating costs over five years. The result is a magnet with twice as much conductor and half as many turns as the existing Main Ring B2 magnet. The dipole magnet cross section is shown in Figure 2-7. The magnet is 6.07 meters long, the same length as the existing magnets. The core is constructed from 0.060" thick laminations which are split on the magnet midplane. The coil consists of four turns per pole of a 1" X 4" conductor. Since no conductor is contained in the median plane of the magnet, the coil can be wound as two "pancakes" with no bends along the long dimension of the conductor. This conductor is available in 40 foot long pieces so each coil can be made with eight joints. The joints will be of a type with demonstrated reliability in which conductors are brazed together with a ferrule inserted between the conductor water holes. The water hole is 0.375 in. in diameter. A single water circut in each pancake (two circuts per magnet) provides sufficient cooling.

A four terminal construction has been chosen for the dipole magnet. In a magnet of this design the role of return bus is filled by one of the conductor turns within the magnet. This has the advantage of removing the need for approximately 12,000 ft of 4 in^2 copper bus (@ $40/ft) in the MI enclosure. The price paid for this benefit is the requirement that the insulation be sufficient to hold off 1000 volts between conductors within the coil.

2.4 Power Supplies

The MI power supply system has been designed to ramp the magnet system from an injection level of 8.9 to 150 GeV/c excitation at a repetition rate adequate to meet requirements for Antiproton Source stacking, Tevatron injection, and test beam operation. The power system will consist of 12 new rectifier power supplies for the bend bus, reuse of existing equipment on the quadrupole bus including six main bus supplies, a new power feeder system for all the supplies, reuse of the pulsed power substation transformer, a new harmonic correction system, and the reuse of many smaller items from the present Main Ring. A summary of the MI power supply requirements is given in Table 2-2.

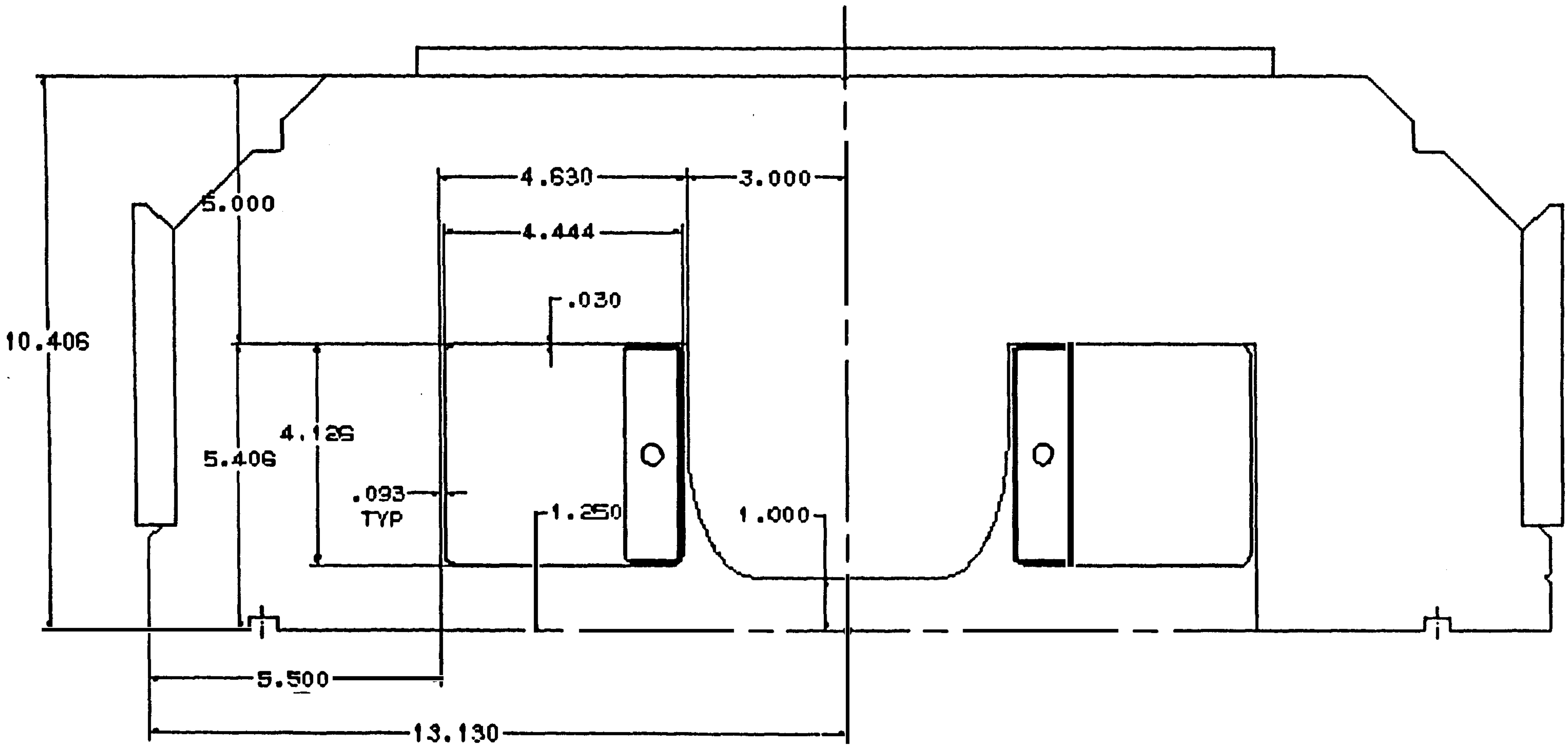


Figure 2-7: Dipole magnet lamination. One of the four conductor turns in the coil window is shown.

Table 2-2. Power Supply Summary for the MI System

	Power Supplies	Voltage	Current
Bend	12 new	1000	5000 rms
Quad F	3	850	2800 rms
Quad D	3	850	2800 rms
	Other Equipment Needed:		
Quad regulator	2 new	300 volts	500 amps
Regulation			
Transductors	2 new		10,000 amps
Transductors	2 new		5,000 amps
Computer link	1 new		
Harmonic filter	1 new		

Power supply spacing for minimum voltage to ground requires an equal number of magnets between power supplies on the dipole bus. The proposed system will have six service buildings with two dipole supplies per building, one on each of two busses and one quadrupole supply. The buildings are spaced so that there are 25 dipole magnets between each supply, with the magnets on a folded bus loop. The third supply in each of the six buildings is configured such that three are in series with the focussing quadrupole magnet bus; three are similarly used with the defocussing quadrupole bus.

Criteria for Ramps and Constraints on Power Supply Layout

The overriding design criterion was to design a combined magnet and power supply system that would be cost effective during operation. A system was chosen to have low power consumption and a safe power supply voltage without being unduly expensive to construct and unwieldy in physical size. The existing 66 MVA power distribution transformer, which is designed to run at 300 MVA peak, will be reused in the new installation with an operational limit set at 120 MVA peak and an rms value less than 12 MW. There will be a new 13.8 kV six cable feeder system installed from the transformer to the new ring with an rms current rating of 1,800 amps, 1,600 amps for the dipole and quadrupole magnets and 200 amps for the beamlines. This sets the maximum rms power to the injector at 24 MW of pulse power.

The maximum rate of rise will be set by the use of the existing main ring RF system which has at present an operational limit of about 240 GeV/sec. The maximum ramp repetition rate is set by the 1,800 amp feeder current limit and a chosen rms dipole bus current of 4700 amps. The use of three supplies on the quadrupole bus further limits the rate of rise at high currents; the three supplies give a total bus voltage of 2500 volts and a peak current of 4200 amps, which yields the limits described below.

The dipole configuration will be two busses internal to the new magnets with a fold at MI-70 allowing for six upper bus supplies and six lower bus supplies. The impedance of the magnet load in the new injector dipole bus is 0.6 Henries and, with the use of 4 in^2 cross section copper for the magnets and power supply bus, will have a dc resistance of 0.3 ohms. The required peak power supply voltage will be 12,000 volts for the bend bus.

The quadrupole configuration will be two separate busses in continuous loops around the injector with current flowing in opposite directions, one focusing and one defocussing, each having three supplies for ramping and a transistor regulator supply for injection current regulation. Each quadrupole magnet loop impedance will be 0.132 Henries, and with the use of 2 in^2 power distribution bus, will have a dc resistance of 0.46 ohms. Thus the required peak power supply voltage will be 2,500 volts for each quadrupole bus. With only three power supplies on the quadrupole bus, the ramp rate will need to decrease above 120 GeV from 240 GeV/sec to 178 GeV/sec. This is required due to the lack of power supply voltage to maintain high inductive voltage and high resistive voltage at the same time. The lower rate of rise will slightly increase the rms current in the magnets and feeders. The feeder current limit sets the maximum repetition rate at 3.0 seconds for a 150 GeV ramp with a 50 msec flat top and the slower acceleration rate described above.

Ramp Details

For antiproton stacking the voltage and number of power supplies were chosen to provide a repetition rate of 1.5 seconds and a maximum rate of rise of 240 GeV/sec. This requirement has also set the upper limits on the operation of test beams and 150 GeV injection rates. Figure 2-8 and Table 2-3 give details on this mode of operation.

Table 2-3. Parameters for antiproton stacking.

Peak dipole bus current: 7168 amps
Peak quadrupole bus current: 3360 amps

	Ramp power	Feeder current	Peak MVA	Bus current
Bend	4.1 MW	1206 amps	69.8	3691 amps
Quad (each)	1.5 MW	165 amps	9.5	1698 amps
Totals	7.1 MW	1536 amps	88.8	

Table 2-4 and Figure 2-9 give details on operation during injection into the Tevatron. Maximum energy is 150 GeV with a 50 millisec flattop and a 3 sec repetition rate.

Table 2-4. Parameters for Tevatron injection.

Peak dipole bus current: 8960 amps
Peak quadrupole bus current:4200 amps

	Ramp power	Feeder current	Peak MVA	Bus current
Bend	3.8 MW	1211 amps	89.3	3560 amps
Quad (each)	1.2 MW	167 amps	15.6	1679 amps
Totals	6.2 MW	1545 amps	120.5	

Power supply parameters for the Tevatron collider injection cycle are shown in Table 2-5 and Figure 2-10. The maximum energy is 150 GeV with a 3 second flattop for cogging and coalescing. The cycle can be repeated every 9 seconds.

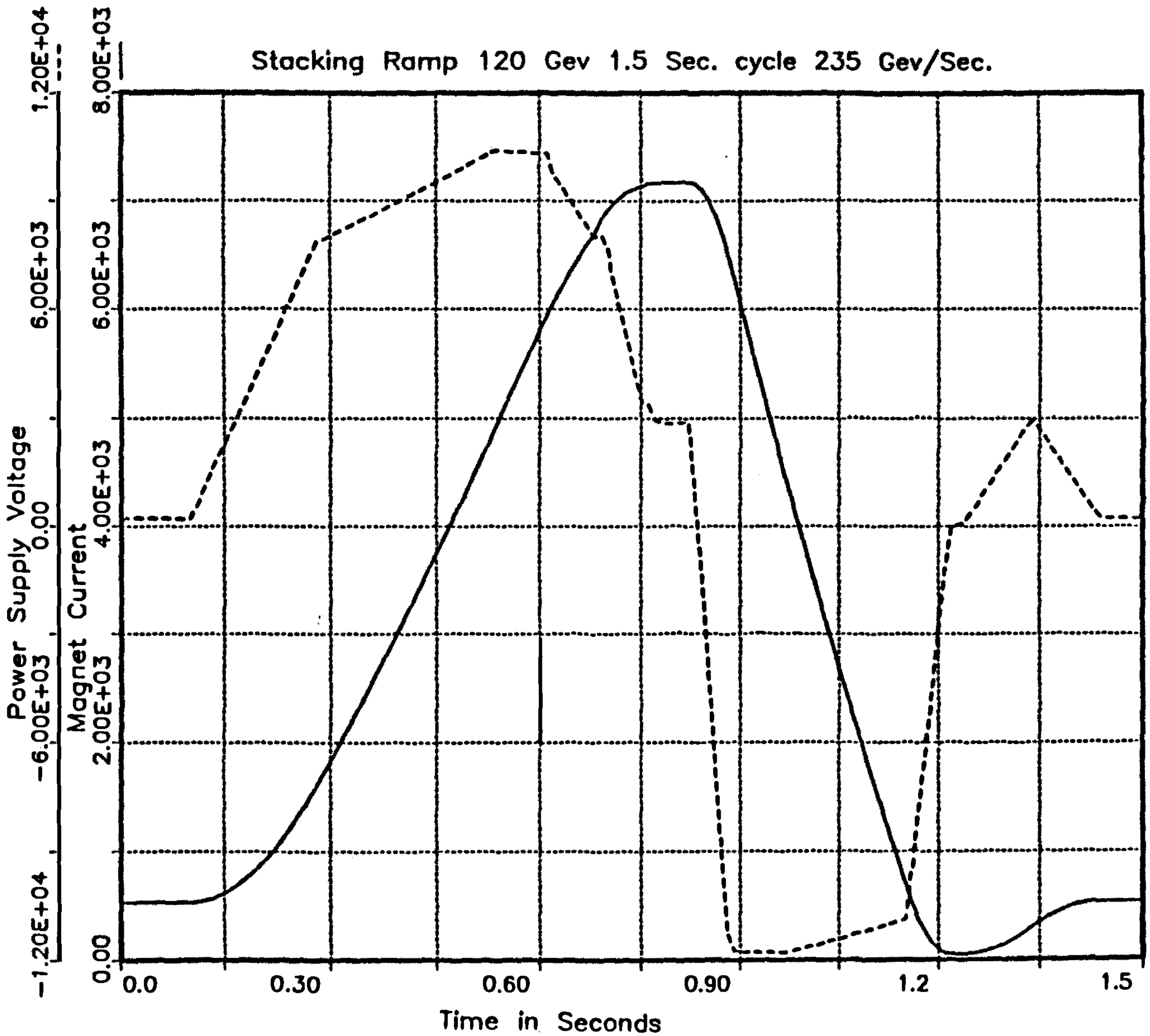


Figure 2-8: Ramp parameters for the antiproton stacking cycle.

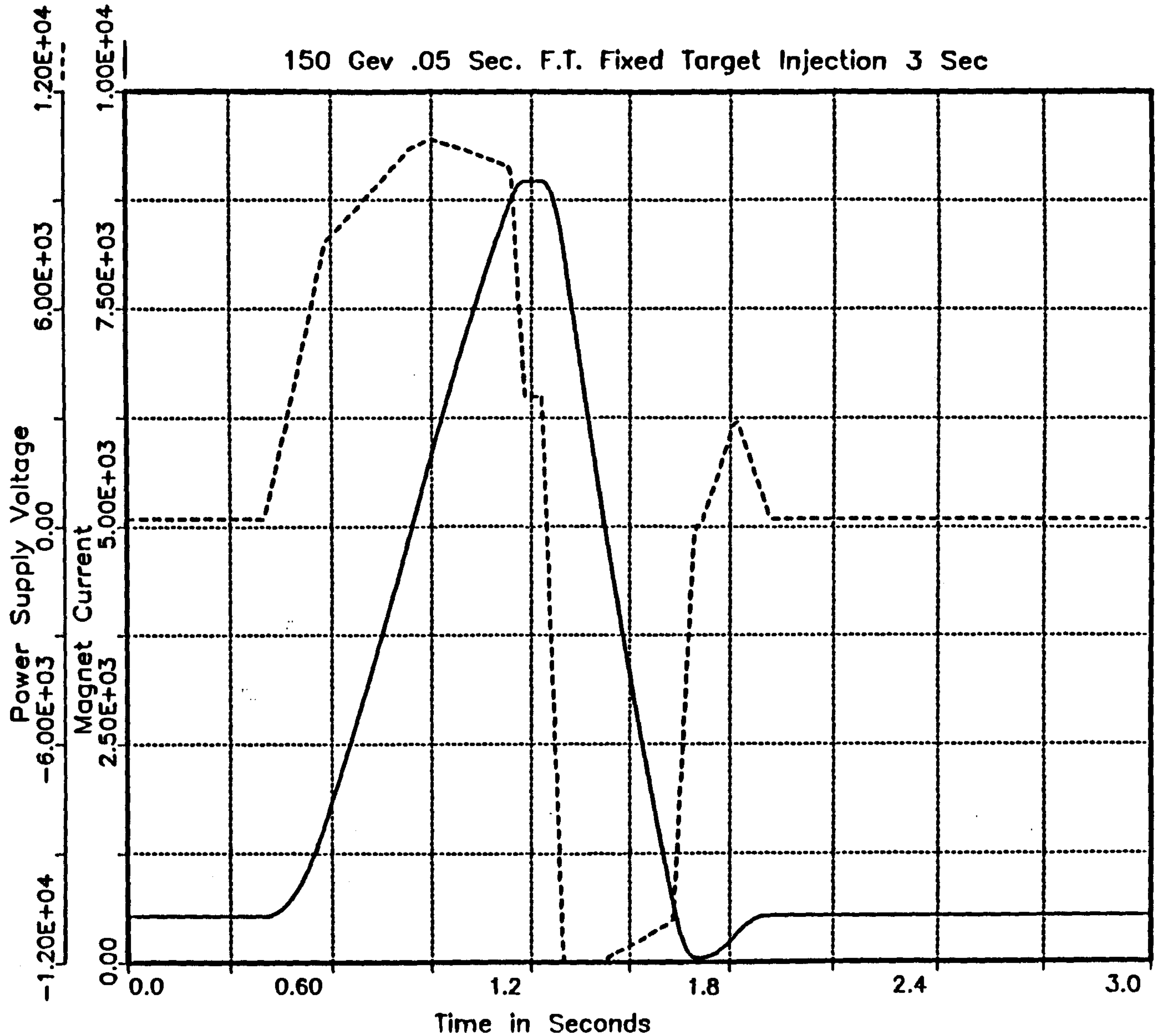


Figure 2-9: Ramp parameters for Tevatron fixed target injection cycle.

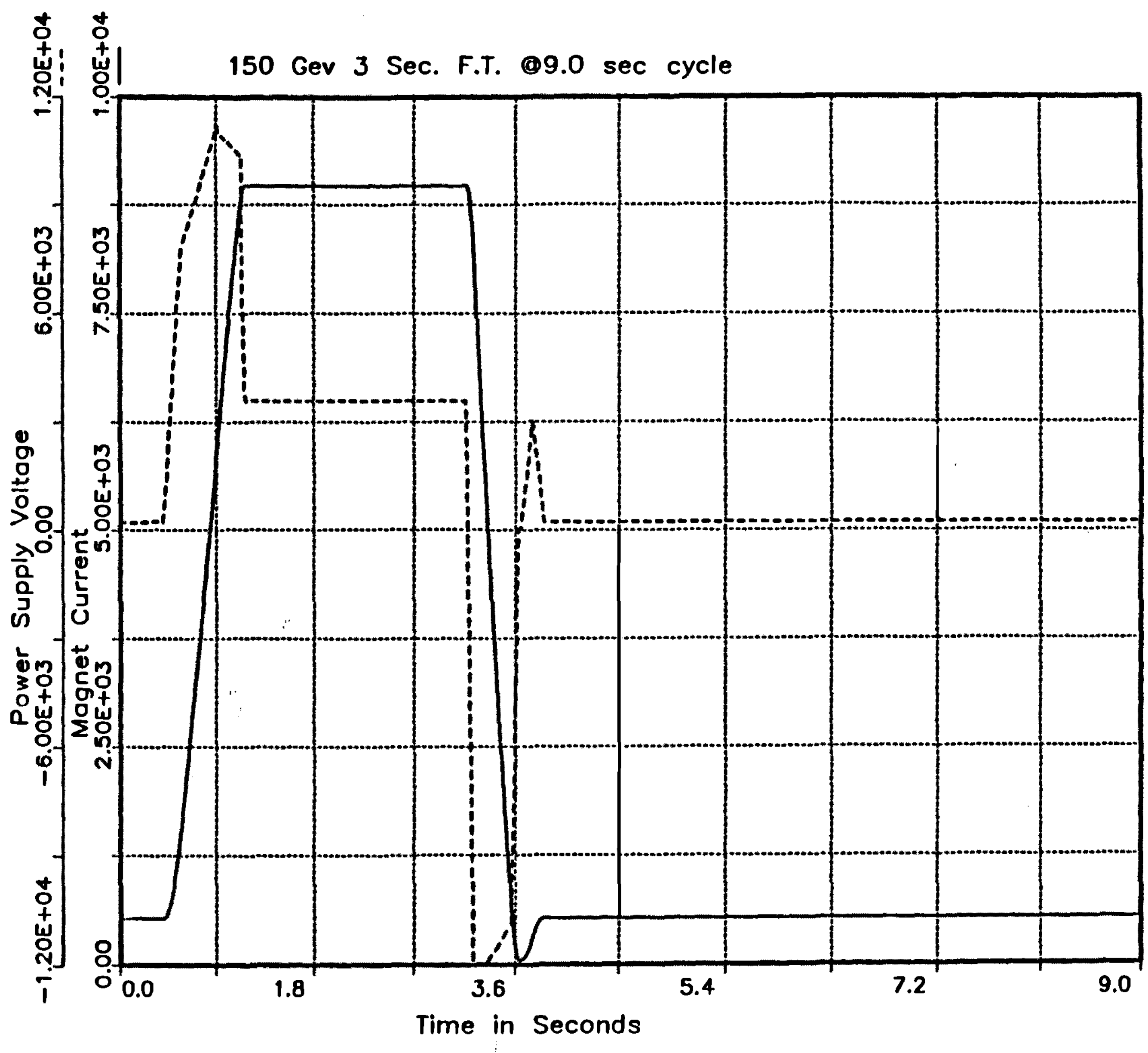


Figure 2-10: Ramp parameters for Tevatron collider injection cycle.

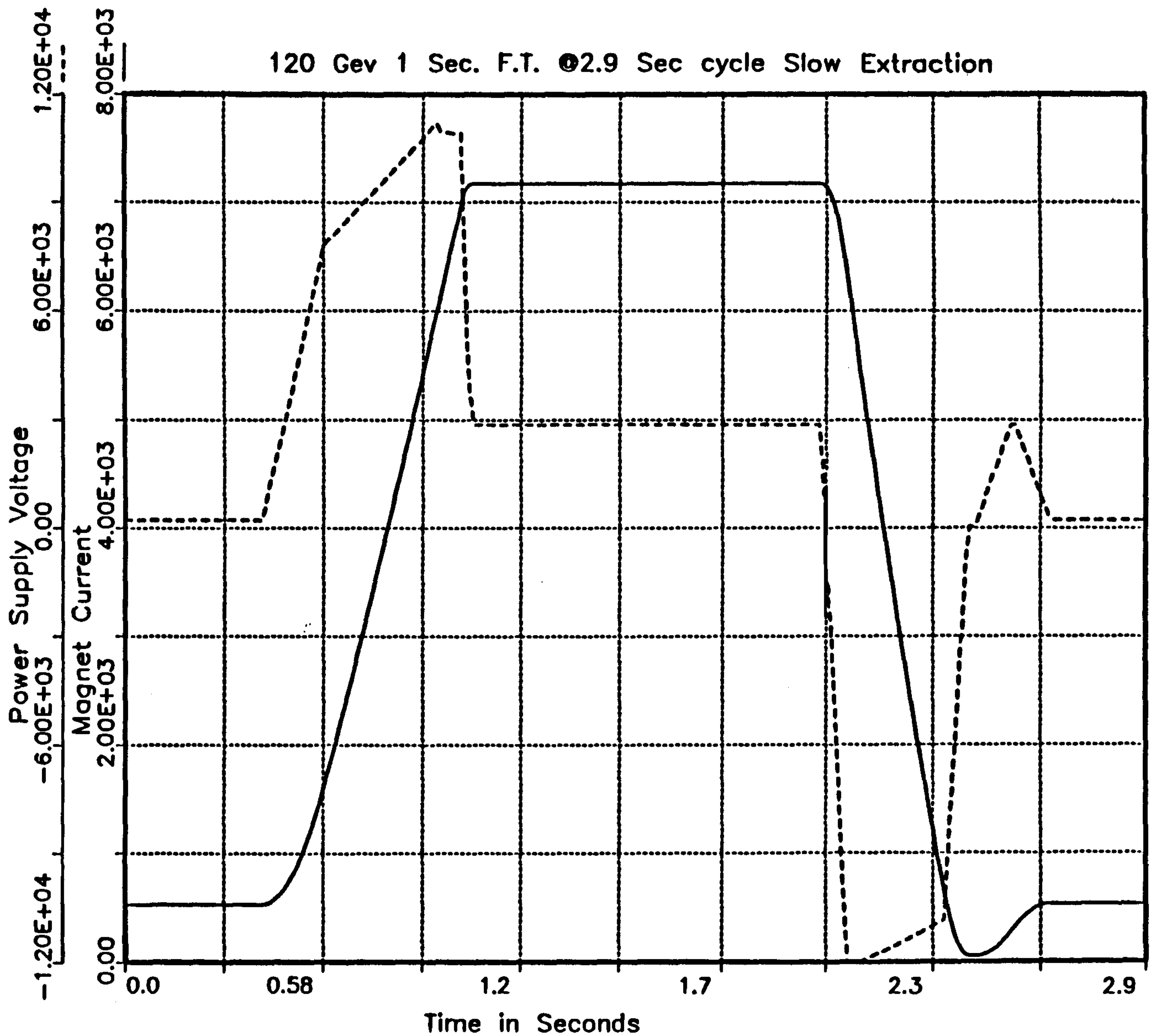


Figure 2-11: Ramp parameters for 120 GeV slow spill cycle.

Table 2-5. Parameters for collider injection.

Peak dipole bus current: 8960 amps
Peak quadrupole bus current:4200 amps

	Ramp power	Feeder current	Peak MVA	Bus current
Bend	6.5 MW	830 amps	89.3	4650 amps
Quad (each)	2.2 MW	252 amps	15.6	2180 amps
Totals	10.9 MW	1334 amps	120.5	

Finally, operation with the MI can provide 120 GeV beam to the fixed target areas for beamline and experiment setup. The ramp will have a 0.4 sec injection time and a 1 sec slow extraction flattop for a total cycle time of 2.9 sec. Power supply parameters for this mode are shown in Table 2-6 and Figure 2-11.

Table 2-6. Parameters for 120 GeV slow spill.

Peak dipole bus current: 7168 amps
Peak quadrupole bus current: 3360 amps

	Ramp power	Feeder current	Peak MVA	Bus current
Bend	7.1 MW	971 amps	69.8	4862 amps
Quad (each)	2.4 MW	186 amps	9.5	2274 amps
Totals	11.9 MW	1343 amps	88.8	

Power Feeder Loading

The main 13.8 kV power feeders have an operating limit of 300 amps rms each. With six feeder cables for the new injector the total feeder current supplied to the ring will be 1,800 amps. The power supplies around the ring will be supplied in a two feeder loop to ensure proper current sharing. More details are given in Section 2-14.

The use of rectifier power supplies on this system draws current pulses from the feeders which then drive harmonic resonances, causing higher voltages at the resonant frequencies to be imposed on the power equipment. The present Main Ring has an harmonic filter to limit the peak voltages of higher frequencies superimposed on the 60 Hz line voltage. The MI will run with 12 power supplies at two times the current of the Main Ring, requiring the filter to damp four times more harmonic power. Therefore, in the MI a new filter needs to be designed to correct for the higher harmonic driving force of the system. This new filter can be installed at the switch in the feeder system where the feeders change from direct feed to loop feed.

2.5 Correction Elements

The correction elements for the MI have been designed into the lattice. The elements needed are steering dipoles, trim quadrupoles, sextupoles, and skew quadrupoles. Wherever possible exisiting components will be reused. The steering dipoles, trim quadrupoles, and skew quadrupoles will be Main Ring components. The sextupoles will be a modified version of the Antiproton Source sextupole. Correction elements will be placed next to each quadrupole. A horizontal (vertical) steering dipole will be placed at each focussing (defocussing) quadrupole. Sextupoles will be placed next to quadrupoles in the arcs where the dispersion is large. The trim quadrupoles and skew quadrupoles will be placed around the ring as needed. In addition, a small number of sextupoles to cancel harmonics due to the chromaticity sextupoles will be located in the straight sections.

Steering Dipoles

The steering dipoles correct the closed orbit. The primary sources of orbit distortion are quadrupole placement errors, dipole tilt, dipole rotation, and power supply errors. These errors cause orbit distortions proportional to β, and, if uncorrected, would yield an rms error of 1.5 mm. If the gap in the existing Main Ring steering dipoles is increased to 2" they will produce a field strength of 0.13 kG-m at their full excitation. Use of these magnets will allow insertion of bumps of up to 22 mm at 8.9 GeV/c, which will easily correct closed orbit errors, permit aperture scans and allow other bumps to be installed as needed.

Trim Quadrupoles

The main quadrupoles of the MI will run on their own busses and will be used for all necessary tune adjustments. Trim quadrupoles are needed for harmonic generation or cancellation. A sufficient number of Main Ring trim quadrupoles will be installed around the ring to cancel half-integer stopbands, if they are significant. In addition, slow extraction will require a small number of trim quadrupoles for excitation of the half-integer resonance.

Sextupoles

Sextupoles will be used primarily for correction of the MI chromaticity. However, sextupoles will also be included for cancellation of harmonic terms. The natural chromaticities of the MI are -27.5 horizontally and -28.5 vertically. The lattice has been designed to have low β and η (58 m and 2.2 m are the maximum values in the arcs). Thus, very strong sextupoles will be needed to cancel the natural chromaticity. The configuration chosen places an F(D) sextupole at each F(D) main quadrupole in the arcs where η is large. Sixty-four of each sextupole type will be needed. The strengths at 150 GeV are 675 kG/m^2-m vertically and 325 kG/m^2-m horizontally. To provide a margin of safety, sextupoles will be designed to have a maximum field strength of 800 kG/m^2-m .

It is not known what sextupole component will be in the bending magnets. However, in conventional magnets (e.g. Main Ring magnets) it is largest at low field and negligible at high field. If the sextupole component is assumed equal to that of the Main Ring dipoles, it will add -10 units to the horizontal and 8 units to the vertical chromaticity at 8.9 GeV/c. At this energy the currents needed for the natural chromaticity correction are small. With sextupoles a concern is that harmonic driving terms will become significant. Due to the low β, the driving terms are small. They can be cancelled with two sextupoles for each resonance (i.e. $3\nu_x$, $2\nu_x+\nu_y$, etc.) in the straight sections where η is small and the contribution to the chromaticity will be small. The "S9" sextupoles used in the Antiproton Source have strengths of 330 kG/m^2-m, but with a much larger aperture. The MI sextupoles will be a redesign of these magnets, shrinking the aperture and increasing the length as necessry to obtain the proper strength.

Skew Quadrupoles

At present the magnitude of the coupling in the MI is unknown. However, skew quadrupoles will be installed to cancel coupling. They will be identical to the trim quadrupoles but rotated by 45°.

2.6 Radio Frequency System (RF)

The 18 existing (53.1 MHz, harmonic number 588) Main Ring RF cavities will be installed in straight section MI-70. The RF ramps are defined by the need to maintain a bucket area of at least 0.4 eV-sec while accelerating the beam. Figures 2-12 (a) through (d) show the bunch momentum spread and the RF bucket area throughout the acceleration phase, assuming a longitudinal emittance of 0.25 eV-sec. The momentum spread, $\delta p/p$ (95% half-width), remains under 1×10^{-3} before transition (γ_t=20.4) and 6×10^{-3} after transition.

The Main Ring cavities are currently running with operating limits determined by tuner and gap spark conditions. Figures 2-13 (a) through (d) show the total RF voltage needed for the four acceleration cycles defined in Section 2.2. The sloped line represents the Main Ring cavities operation ceiling at a duty factor of 45%. It can be seen from these figures that the cavities never have to operate above this ceiling for the proposed cycles. This limit is further relaxed for cycles with duty factors much lower than 45%.

Besides the main cavities, the existing Main Ring coalescing cavities will also be employed in the MI. Six of the coalescing cavities will run at h=28 (2.5 MHz) with peak voltage of 26 kV and one coalescing cavity will run at h=56 (5.0 MHz) with peak voltage of 4 kV.

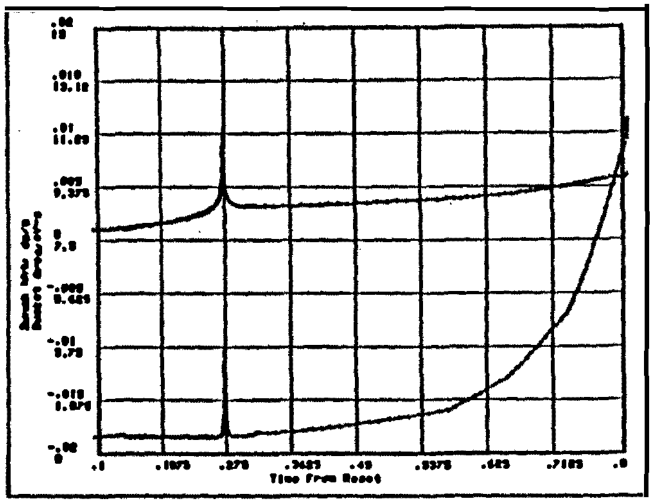
2.7 Vacuum System

The vacuum system for the MI will be similar to the Main Ring system. Each dipole magnet chamber will have a port for a 30 liter/sec ion pump and straight sections will have a port approximately every six meters for the same type of pump. Ion pumps and their power supplies from the Main Ring will be reused. The stainless steel vacuum chambers will be chemically polished. Since two inch aperture magnets are used throughout the MI, the conductance will be higher, and an average pressure lower than the Main Ring should be achievable. The design goal is an average pressure of $<5\times10^{-8}$ Torr. With this pressure storage times of minutes at 8.9 GeV/c will be available for studies.

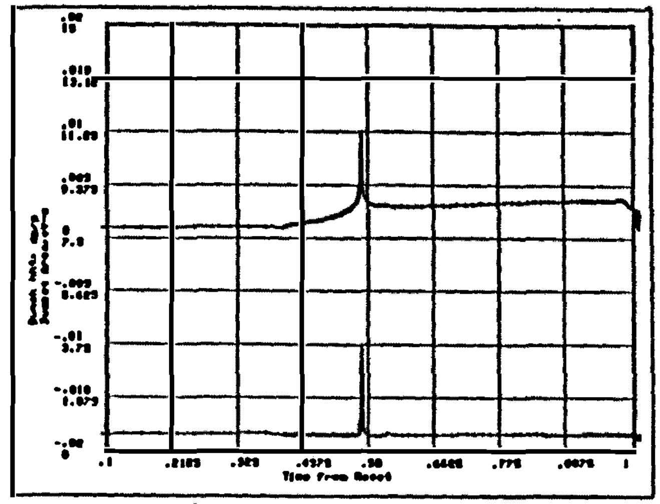
Gate valves will be used to divide the MI into sections. There will be a gate valve at the end of each straight section with appropriate interlocks. There will be 32 gate valves in the system.

The beamlines will use 30 liter/sec ion pumps of the same type as the MI, spaced approximately every 12 meters.

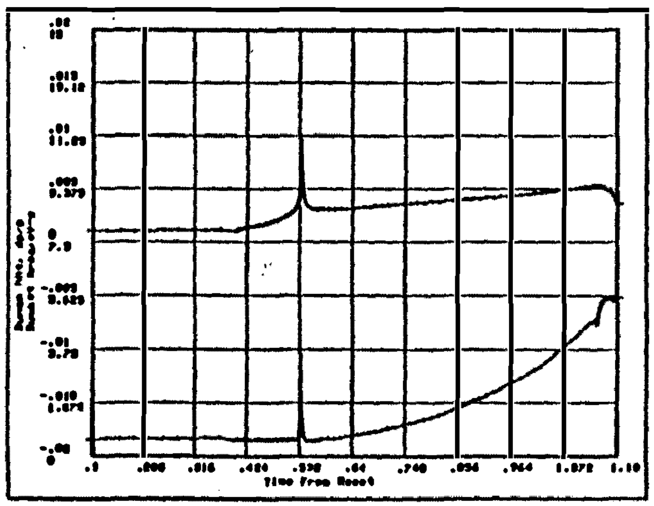
Vacuum pressure during pump down will be monitored by a combination of thermocouple and cold cathode gauges; high vacuum will be monitored by the



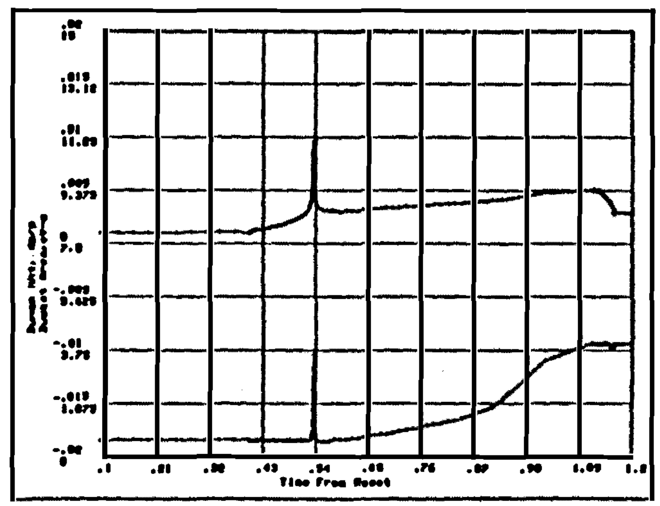
120 GeV 1.5 sec



120 GeV 2.9 sec

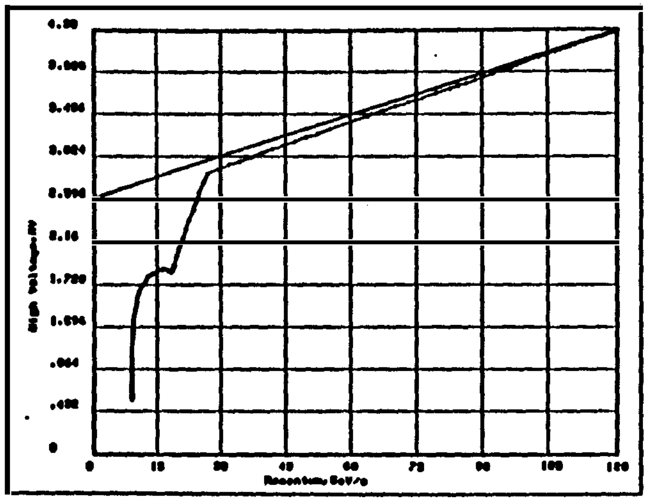


150 GeV 3.0 sec

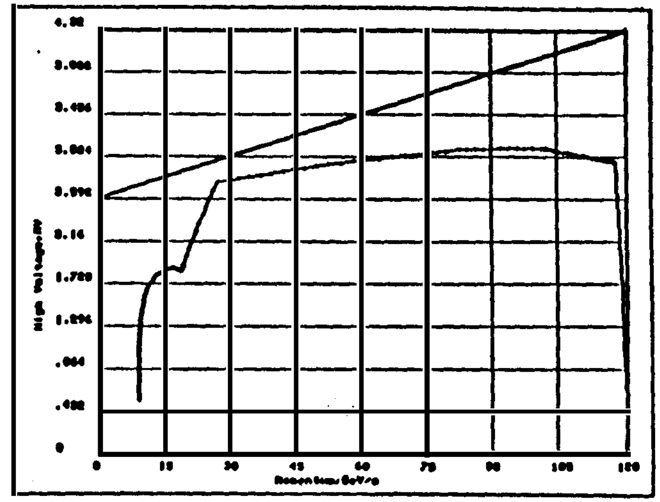


150 GeV 9.0 sec

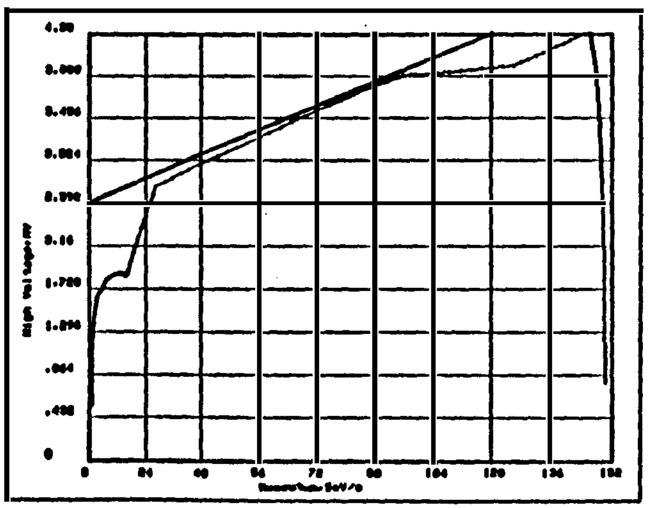
Figure 2-12: Momentum spread and bucket area verus time for the four operational modes. The longitudinal emittance is 0.25 eV-sec. Only that portion of the cycle during which beam is accelerated is shown.



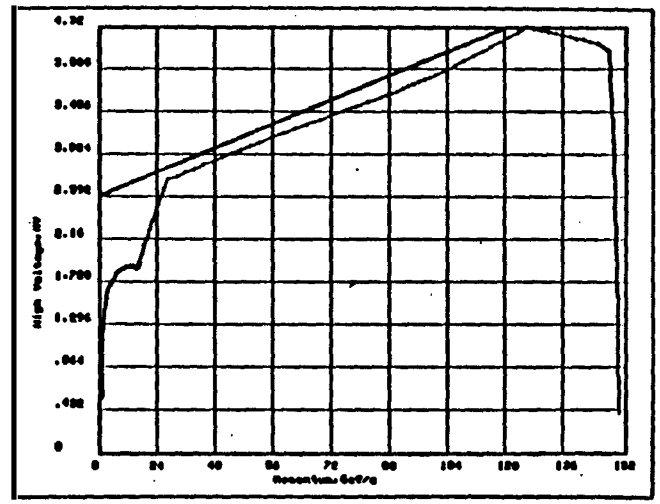
120 GeV 1.5 sec



120 GeV 2.9 sec



150 GeV 3.0 sec



150 GeV 9.0 sec

Figure 2-13: Total RF voltage versus momentum for the four operational modes.

current readout of each ion pump. Vacuum pump down will be done using portable turbomolecular units that can be wheeled to any area being worked on. Ten units are provided.

2.8 Instrumentation

Beam Position Detector (BPM)

The beam position system for the MI is patterned after the existing Main Ring system At each F(D) main quadrupole there will be a horizontal (vertical) pickup. BPM's will also be located at the ends of the straight sections. New horizontal beam position detectors will be built for the MI. For the vertical plane the pickups presently in the Main Ring will be reused. The processing electronics are the Fermilab standard amplitude-to-phase conversion style with a center frequency of 53 MHz. The system will be capable of producing first turn orbits, turn-by-turn readouts, and closed orbits.

Beam Loss Monitors (BLM)

The loss monitor system will utilize (newly constructed) ion chambers at each quadrupole in the ring and be of the same type as the present Tevatron system.

Other Special MI Diagnostics

The MI will employ a second harmonic dc current transducer. This will enable accurate acceleration efficiency measurements and will also be used for dc storage studies.

In order to analyze longitudinal and transverse instabilities, the MI will be equipped with a broad band longitudinal pickup and two broad band transverse pickups, one for each plane. These detectors should be very useful in studies of coupled bunch and head tail instabilities common to such high intensity rings.

The MI will also be equipped with three flying wires to allow dynamic emittance and momentum spread measurements during acceleration.

Dampers and Scrapers

The MI damper systems will be patterned after the Tevatron bunch-by-bunch system. The system will allow damping of injection oscillations and coherent instabilities, as well as providing the capability of knocking out selected bunches or heating the beam transversely in either plane.

The MI will have beam scrapers for measuring the acceptance of the machine in both planes and a momentum scraper to aid in beam transfer function measurements.

2.9 Controls

The entire accelerator complex, from the ion source to the Tevatron and antiproton rings, is controlled by a uniform system known as ACNET. Each accelerator subsystem has a front end computer which drives a link attached to all appropriate hardware for that subsystem; all links constructed recently are CAMAC while some older systems utilize different technologies. Application programs and file storage, as well as a central database detailing all electronic components, are under control of VAX computers networked to the front ends. Also connected to this network are a number of operator consoles, attached in such a manner that any console can monitor and control any accelerator.

ACNET is currently being upgraded in a number of important aspects, with more modern hardware and software being added. However, the basic structure described is not being changed. A major upgrade is the reworking of Main Ring controls in CAMAC. Much of the MI hardware will be these CAMAC modules and associated equipment, moved to the new location. Also ongoing as part of the Main Ring upgrade is the installation of 24 channels of fiber optic cable as the conduit for various controls and timing links. Similar cable will be used for the MI, with a path from the Cross Gallery roughly along the 120 GeV beamline. This path is chosen so that beamline controls can be handled by these same links.

The MI fits naturally into the existing system. To the current complement of ten front ends will be added one for the MI; there exists sufficient network bandwidth and VAX computer cycles that this addition can be made with minimal impact. A new front end is needed because the one installed for the Main Ring system cannot be easily moved since it has been convenient to attach some Tevatron devices to it. The new computer will drive a CAMAC link running to and around the MI; this link will connect to a number of crates and relay racks, and will have a number of cable terminations, scaled according to experience with the Main Ring. Twelve thousand feet of fiber and 84 repeaters are appropriate to provide this link, as well as to distribute timing signals and real-time accelerator data, and to extend the laboratory wide Token Ring network.

Since most of the new hardware connected to the control system will be copies of existing modules, the software effort necessary for support is expected to be manageable. Applications and front end code should be straightforward migrations of what is currently being created for the Main Ring. However, there are other computers associated with the current Main Ring beyond those normally associated with data collection. The ramp is generated by a pair of PDP-11's (DEC-B and DEC-C); with the variety of MI operational modes some software effort will be needed in transferring these machines to the MI.

Based on the Antiproton Source commissioning experience, entry of database information concerning new or transferred modules will involve a significant effort, often required on an urgent basis.

The Main Ring high level RF is controlled by one of the few remaining Lockheed "MAC" computers in the Laboratory, along with its associated MIU (module interface unit). A new computer and hardware system, and associated software effort, will be required for this function.

2.10 Abort Systems

The proposed proton abort system for the new MI relies heavily on the technology and design utilized in the existing Main Ring abort system commissioned in 1983, This system has successfully provided clean single-turn abort capability for all subsequent Main Ring proton beam operation. The abort system for the new MI reuses much of the hardware of the present Main Ring system, with the exception of the beam dump.

The system will track the energy of the MI ring, and be capable of aborting the beam at any point in the 8.9 - 150 GeV/c range, within 50 μsec (5 turns) of the abort command. A 1.5 μsec abort kicker risetime matched to a corresponding minimum gap in the circulating beam allows abort efficiency approaching 100%.

Two 2.2 m long kicker magnets are located about 39 m upstream of the 25.7 m long straight section MI-40. The peak kicker field required is 1.9 kG with the 90° phase advance between the kicker location and two 4.9 m long Lambertson magnets at the upstream end of the long straight section. A horizontal displacement of the aborted beam of about 44 mm at the first Lambertson magnet positions the beam appropriately for the abort channel.

The two Lambertsons, with peak fields of 6.3 kG, then deflect the aborted beam vertically downward at an angle of 11.7 mr so as to clear the quadrupole at the downstream end of straight section MI-40 and exit the MI tunnel toward the abort beam dump.

The beam dump will be constructed with a graphite core of length 4.4 m, similar to the existing Main Ring beam dump. A small kicker building, MI-40, located on the berm directly above the kicker location enables the use of relatively short cables (<25 m) between pulsing units and kicker magnets. This is crucial for maintaining the kicker pulse shape.

Because of the low intensities transported, there is no $\bar{p}$ abort.

2.11 Slow Extraction

The slow extraction system has been designed to provide 120 GeV/c resonant extracted beam with a uniform spill over times of one second with losses of less than 3%. Slow spill of the entire beam is easily achieved with half-integer extraction. Extraction is implemented by using special quadrupoles and octopoles to bring the beam onto the half-integer resonance in such a manner that the amplitude of betatron oscillations will grow in a controlled fashion until the particles are deflected by an electrostatic septum. The kick supplied by the electrostatic septum provides enough space between the circulating beam and the extracted beam to allow magnetic septa to be used to extract the beam.

Septa

The choice of the location of the magnetic septa (Lambertson magnets) is dictated by the location of the extraction channel to the A0 area of the Tevatron. The Lambertsons will be placed in the upstream region of the MI-60 straight section in order to maximize the transverse separation when the extracted beam reaches the location of the downstream quadrupoles. The expected separation of 31 cm generated over 19 m by two standard 5 m Lambertsons running with a field of 9 kG will be adequate to miss the first quadrupole.

The placement of the electrostatic septum is made easy by the fact that a location 90° in phase is available in the cell immediately upstream of the long straight. The slot length is adequate for a septum of 3.6 m. It is desirable to have a separation of 6 mm at the magnetic septa between the circulating beam and the extracted beam. A 120 mr kick from the electrostatic septum will achieve this, and with the length available, the applied voltage gradient of 40 kV/cm will not be excessive.

Harmonic Elements

The appropriate harmonics for quadrupoles (45th) and octopole (0th) will be provided by special magnets designed for this purpose. Quadrupoles will be located at points equidistant in phase around the ring, while the special octopoles will be located in phase with the quadrupoles. Air core quadrupoles are sufficient to provide the necessary stop band width to ensure total extraction of the beam. Required strengths for the quadrupoles are 60 kG-in @ 1 inch, and for the octopoles 116 kG-in @1 inch.

Phase Space

Extraction starts by raising the normal horizontal tune from 22.42 towards 22.5, while turning on a 0th harmonic octopole. The octopole is used to produce an amplitude dependent tune; thus a larger amplitude has a larger tune and is closer to the half-integer. Then a 45th harmonic quadrupole is used to increase the width of the half-integer stop band. Small ampltude (smaller tune) particles are stable while larger amplitude particles stream out along the separatrix until they encounter the electrostatic septum. Phase space distributions produced by these elements at the electrostatic septum and at the magnetic septa are shown in Figure 2-14. The rough angle of 45° exhibited by the beam is a compromise between high extraction efficiency (where the angle would be zero) and aperture considerations at the location of the magnetic septa (i.e. if the angle were zero at the electrostatic septum the magnetic septa would be in the center of the aperture). For the extracted phase space shown the emittance is 6π, with an extraction inefficiency of 3%.

Quadrupole Extraction Regulator System (QXR)

The goal of the slow extraction system is to provide a constant rate of extraction during the slow spill. This is accomplished by moving the stop band smoothly through the beam using the quadrupole extraction regulator system, QXR. There are two parts to this system, distinguished by strength and bandwidth. The stronger, lower bandwidth components are tied to a normal beam intensity monitor which is insensitive to fast fluctuations. After the signal is sampled during the spill and compared to an ideal signal, the resultant smoothed error signal is used to modify the power supply output. This system is the base from which the weaker, faster responding system works. Monitoring is based on a fast reacting detector in the extracted beamline itself. The type of error signal that this component can handle is power supply ripple up to about 360 Hz.

2.12 Environmental and Shielding Considerations

The proposed construction of the MI lies in approximately 400 acres southwest of the existing Main Ring tunnel, between the F0 building and the site boundary. Access to the construction project will be via the existing Kautz Road. No adverse environmental impact is foreseen as a result of this project. Efforts will be made throughout the construction period to protect and enhance the local conditions. Details are discussed in Appendix C.

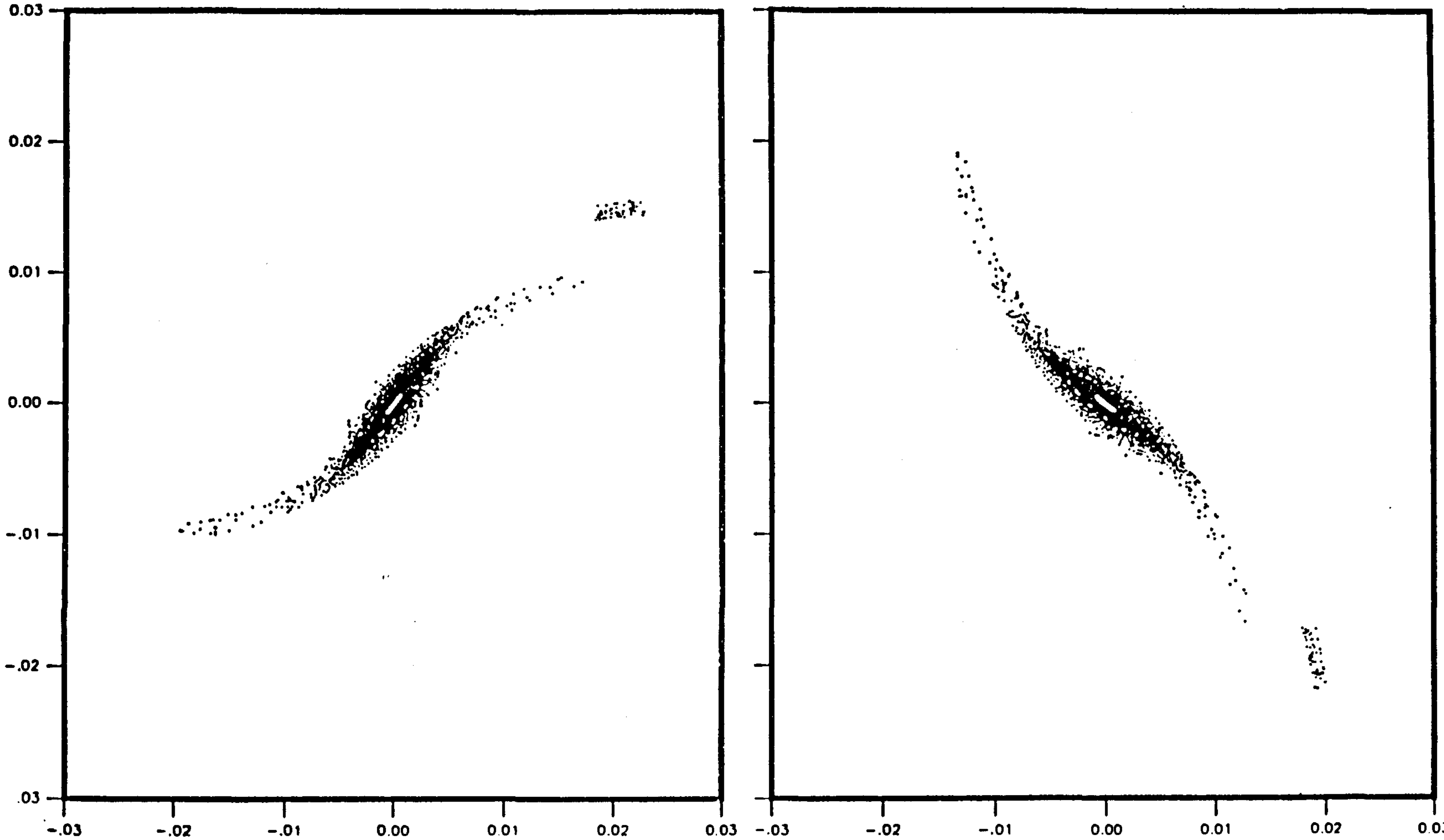


Figure 2-14: **Phase space distributions at the electrostatic septum (left) and at the extraction Lambertson (right) during slow extraction.**

Calculations have been made of radiation dose near the tunnel when beam is lost on the magnets or dumped intentionally. The dose is esimated both on the surface of the earth berm covering the tunnel and at the site boundary at the point of closest approach (approximately 75 m) to the MI. A berm thickness of 17 ft, corresponding to that of the present Main Ring, is assumed, although near the site boundary an additional 3 feet will be added. The dose rate in the vicinity of the abort dump (Section 2.10) is also investigated and found to be lower than required.

The highest muon dose is only 0.3 mR and occurs about 70 m downstream of the loss point, where the berm meets grade level (assumed to be 10 ft above the center of the tunnel). The average exposure rate due to muons during routine operation at the surface of the berm is also small and amounts to approximately 12 mR/year. The dose at the site boundary is estimated at 0.3 mR for the worst case scenario and at 10 mR/year for routine operation. See Appendix C for details.

The most important component of radiation for shielding considerations is hadrons. Appendix C contains details of the assumptions made in calculating hadron dose and required shielding. For accidental loss the prediction is 3 mR at the surface of the berm, thus requiring this area to be defined as minimal occupancy. Further from the berm the dose falls off rapidly so that 60 feet from the berm the dose is below the minimal occupancy limit of 1 mR. A small amount of beam is lost continuously. This results in integrated levels of less than the 500 mR/year limit for permanent occupancy. By adding an extra 3 feet to the berm at the closest approach to the site boundary, the off-site dose is a factor of 5 below the required limit of 10 mR/year.

2.13 Component Alignment

The final goal of the alignment procedure is to minimize the closed orbit distortions. In practice this means precise transverse alignment of the quadrupoles and attention paid to dipole roll. After tunnel construction is complete there are two main steps towards the final alignment of the components: installation of properly generated monuments, and prealignement of the magnet stands.

<u>Monuments</u>

There will be two sets of monuments for placement of the components in space. One set will be used for vertical alignment and the other set will be used for both longitudinal (along the beam direction) and horizontal alignment. The MI elements will be placed in a Cartesian plane whose normal will be parallel to gravity in the center of the ring. In order to accomplish this there will be a set of vertical monuments of known elevation. The monuments will be located on the floor near the quadrupoles and their relative accuracy using direct leveling methods will be 0.003 inches. Component elevations will be calculated so that the components lie in a plane.[1] During prealigment of the stands and alignment of the elements the nearby monument will be used as a basis for elevation determination.

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1. C. D. Moore, "The Vertical Alignment of the DO Overpass in the Fermilab Main Ring," (to be published).

Setting the horizontal control points is not as straightforward as in the vertical case. Above ground the relative geometry between each octant will be determined using a combination of triangulation and trilateration incorporating the ME5000 Mekometer and the E2 theodolite. The relative position of these control points can be determined to ±0.080 inches. A check of this scheme will be made on several of the points by using the satellite ranging scheme.

These control points will be extrapolated into the tunnel and distributed to a series of monuments (brass plugs in the floor) using a trilateration scheme (linear measurements only) within the tunnel. These measurements will consist of a mixture of length measurements and offset measurements similar to the configuration incorporated in the LEP tunnel geometry.[2] The length will be measured with the Mekometer to an rms accuracy of ±0.010 inches. The offset measurements will be made using optical tooling procedures with an rms accuracy of ±0.005 inches. The original layout of the horizontal monuments will have an rms accuracy of ±0.008 inches, with an associated longitudinal rms accuracy of ±0.015 inch.

Pre-alignment of Stands

With the monuments installed it will be relatively easy to pre-align quickly the stands to an accuracy of ±0.080 inches using fixturing and methodology already developed. This accuracy has been achieved in the installation of the overpasses[3] and there should be no reason not to achieve a similar accuracy in an easier geometry.

Final Accuracy

It is expected that the total vertical error in reading a quadrupole position will be on the order of 0.006 inch, a combination of original error in the monument placement, rereading the monument position, and reading the scales on the quadrupole. It is apparent that the reproducibility of the fiducials on the magnet is crucial in determining the final accuracy. For the discussion in the next section an rms accuracy of ±0.010 inch in setting the quadrupole will be asssumed. This includes a reasonable tolerance for the surveyors to use in the actual setting.

Proper planning will allow setting the horizontal tunnel monuments near the theoretical bend centers along the orbit so that lines connecting these monuments will be parallel to the quadrupoles. Alignment of the fiducial point of the quadrupoles to this line can be done to an accuracy of ±0.005 inch. Hence an rms accuracy of 0.012 for the horizontal quadrupole positions should be attainable (again allowing a reasonable tolerance of 0.005 for the surveyors in setting the quadrupole).

Closed Orbit Considerations

From these estimates of the rms of the random quadrupole displacements the maximum closed orbit deviation can be estimated. There is approximately a factor of two in the maximum deviation between 50% and 98% probability.

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2. M. Mayoud, "Applied Metrology for LEP," CERN 87-01, p. 233.

3. C. D. Moore and T. A. Topolski, "Polar Coordinate Alignment of the Magnet Stands in the BO Overpass Region of the Fermilab Main Ring," Proc. 1987 Particle Accelerator Conf., Washington, DC, March 1987.

Results below are for the 98% case using a convenient parametrization:[4]

$$X = Y = 12.5 * f(v) * v^{1/2} * (\Delta Q)rms$$

where v=22.4 and $f(v) * v^{1/2} = 6.44$. Therefore

$$X = Y = 80.5 * (\Delta Q)rms.$$

This implies Y = 0.8" from the quadrupole deviations, i.e. there is a 98% probability that the maximum vertical deviation resulting from a 0.01" rms in the quadrupole error distribution, will be 0.8". (This also implies that there is a 50% probability that the maximum deviation will be 0.4") Hence the contribution to the closed orbit from the dipole roll should be less than this. A similar calculation for the maximum deviation for a given rms in the roll distribution gives:

$$Y = 950 \text{ inches} * \Delta\Phi$$

Hence, if $\Delta\Phi$ 1 mrad the two effects will be of the same magnitude, but in fact it will be easy to do better by a factor of four. There will be a 0.078 mrad systematic roll to account for the earth's curvature.

For the horizontal the maximum deviation is X = 1". In conclusion, there is a finite probability of having some circulating beam with no correction dipoles activated.

2.14 Utilities

Main Injector Low Conductivity Water System and Magnet Bus Connections

The proposed system for connecting the power and water to the MI is similar to the Main Ring. This system requires minimum maintenance. Stainless steel headers supply low conductivity water (LCW) to copper pipes which conduct both power and cooling water to the magnets. Ceramic feedthroughs, with flexible metal braid hoses, electrically insulate the piping to the copper bus system. All connections are either brazed or welded.

The MI components and associated utilities are grouped together at the outside wall of the tunnel leaving most of the enclosure space for servicing, as shown in Figure 2-15. All connections to the magnets are designed so they are accessible from the inner space of the tunnel. There will be six utility buildings uniformly spaced along the perimeter of the Main Injector. These are labelled MI-10, 13, 30, 50, 53, and 70. Each utility building will supply power and cooling water to about 1815 feet of circumference in the MI.

Four service building will have three pumps each, and the remaining two buildings will have four pumps all connected in parallel. Each pump has a 50 HP motor, and delivers 300 gpm of LCW with a pressure head of 162 psi (375 TDH). The heat from the magnets is transferred to the LCW and dissipated in a tube and shell heat exchanger placed above the pumps in each service building. Pond water is circulated in the tube side of the heat exchanger to remove the heat by evaporation.

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4. C. D. Moore et al., "SSC Closed Orbit Correction," Report of the 1983 Ann Arbor Workshop on Accelerator Physics Issues for the Superconducting Super Collider, p. 78.

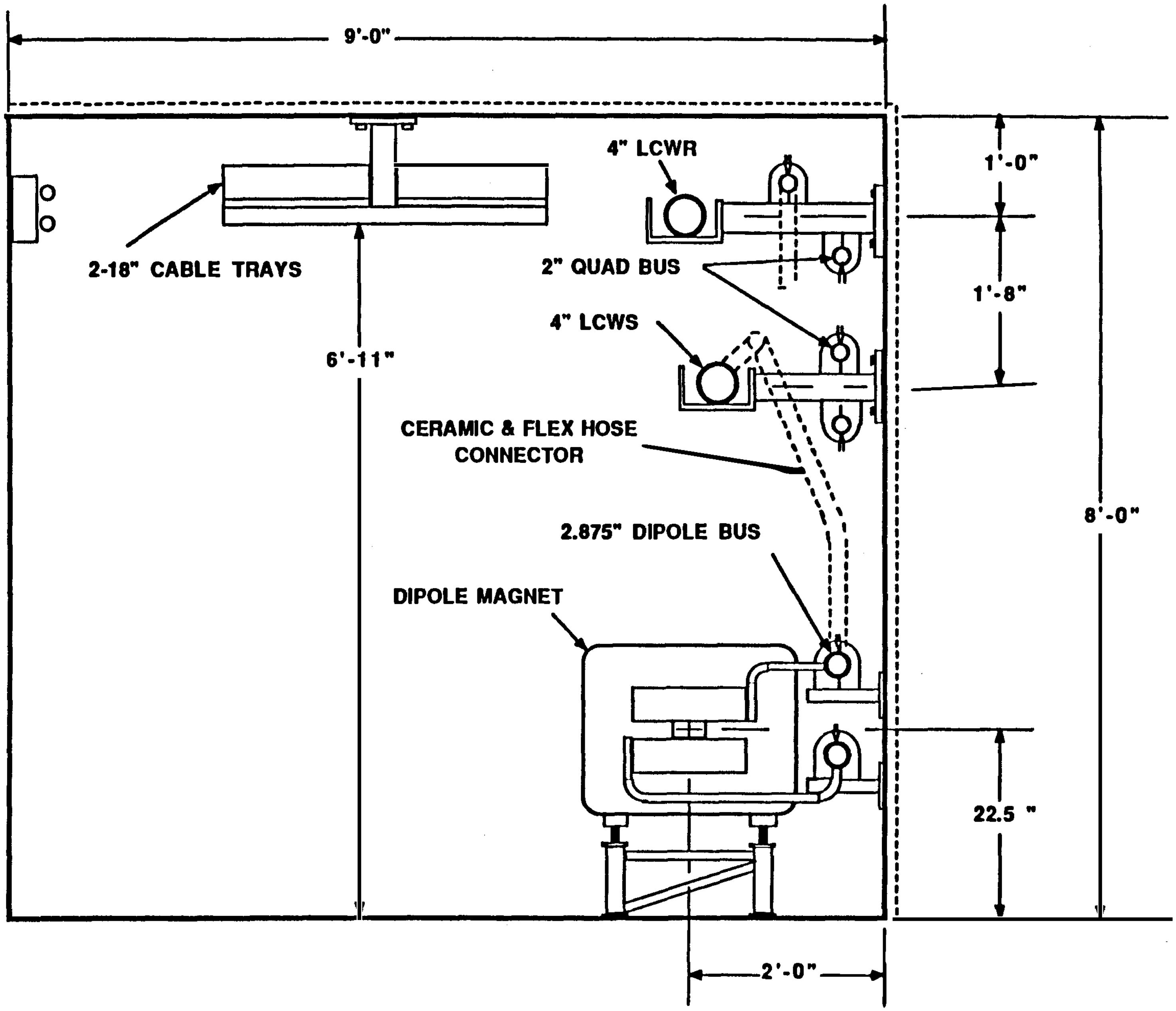

Figure 2-15: **Typical cross section of Main Injector Enclosure**

From the existing LCW system in the Main Ring, 12 pumps with starters and controllers, and six heat exchangers will be reused for the MI. Seven existing spare pumps will also be used, and one new pump will be required. The remaining water cooling equipment in the Main Ring will remain as part of the Tevatron. New extra strong copper bus (2.875" o.d. by 1.771" i.d. for the dipoles, and 2.00" o.d. by 1.2" i.d. for the quadrupoles) will be used for the MI. The old copper bus from the Main Ring (1.625" o.d. by 0.187" wall) with the porcelain clamps will be reused for the beamlines.

Two 4 in. stainless steel pipe headers will be installed over the magnets along the 10,891 ft circumference of the MI. A total of 20 pumps (300 gpm each) will be connected in parallel across the supply and return pipes. All magnet and bus systems will also be connected in parallel across the LCW headers. Flow control devices, used in the Main Ring, will be altered and can be reused in the new injector to limit the water flowing to 8 gpm through the dipole magnets. For 120 GeV operation (4342 amps rms), the water temperature rise across the magnets is calculated to reach about 7°C. An average of 950 GPM of LCW from each of the six service buildings will be required to cool magnets, bus, power supplies, chokes, and electronics equipment. The heat load removing capacity per building is about 2 MW limited by the cooling pond.

At each utility entrance, the enclosure will have an enlarged cross section. The walls will extend one foot from the regular tunnel. The purpose of this extra space is to make room for expansion joints for the 4 in stainless steel pipes, copper bus, and trays. At this position the enlarged enclosure allows the utilities to cross over without obstructing the regular tunnel clearance for the magnet moving vehicle.

A net counterclockwise flow in the ring will be accomplished with restricting valves at each of the entrances. In one of the larger service buildings, a LCW processing system will be installed. A continuous polishing flow action is required to keep low conductivity in the water. Two mixed bed de-ionizers will be used with about 80 gpm flow going through one of the beds. An average of 9 MΩ-cm resistivity of the LCW will be maintained in the ring. An expansion tank and a 3,000 gallons storage tank are also to be used. The MI will required an estimated 29,000 gallons of low conductivity water to fill the pipes, tanks, bus, and magnets.

Power Distribution for the MI

There are three separate power systems associated with the MI: 1)the power system for pulsed power supplies; 2)the conventional power system; and 3)the beamline power systems. Figures 2-16 and 2-17 show the power distribution system and feeder configuration for the MI complex.

Power System for Pulsed Power Supplies

This system consists of the existing 82B transformer at the Master Substation and a new 15 kV distribution system to the MI. Six 15 kV feeders will be used in a ductbank from the Master Substation to the MI. A 15 kV switchgear area at the north side of the MI will allow sectionalizing of the system. From this switchgear, two direct buried loop feeders will be used to bring pulsed power to the ring.

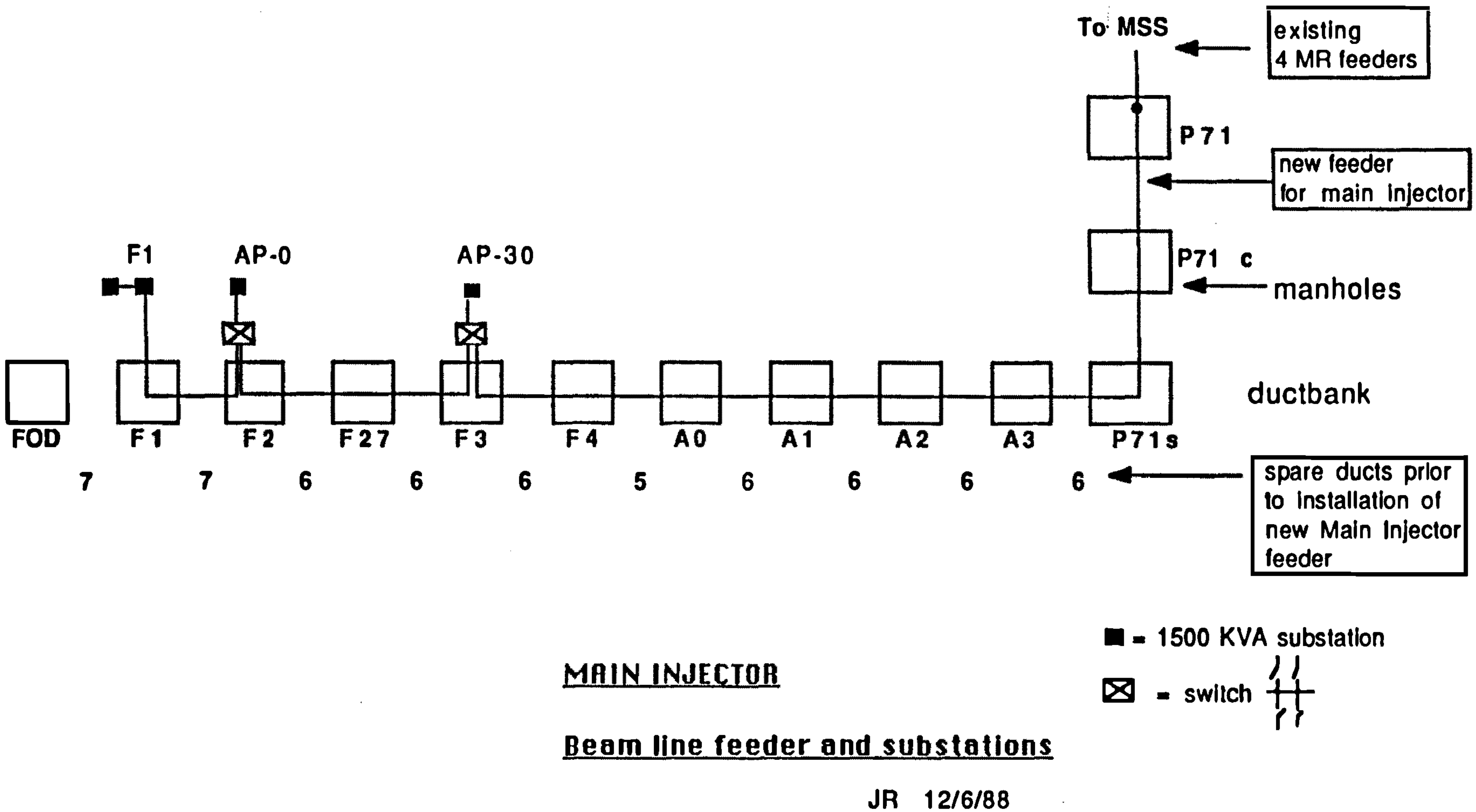

Figure 2-16: Power routing through the MI complex.

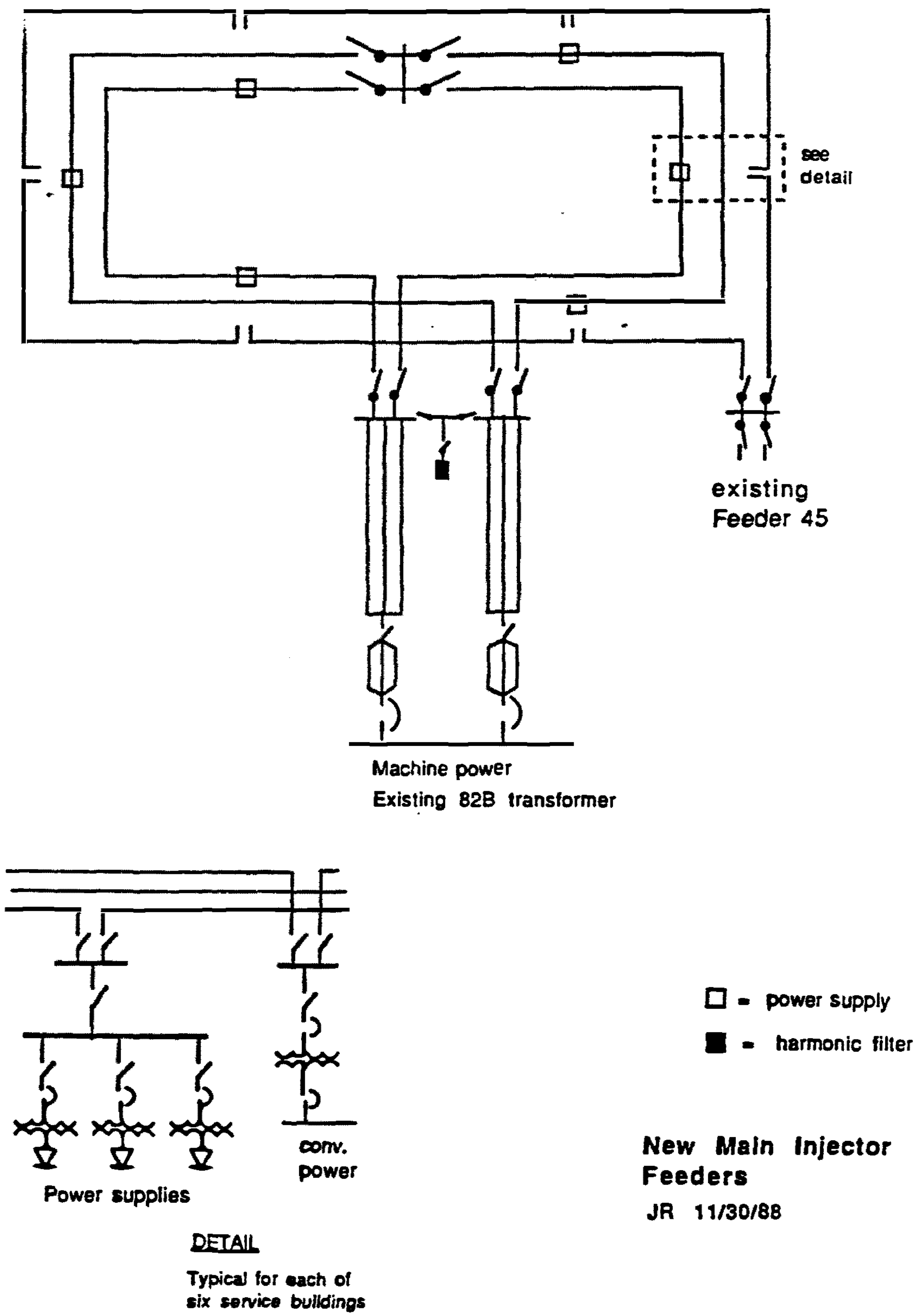

Figure 2-17: MI feeder configuration.

At each service building, there is a disconnect switch to supply power to the power supplies. From this switch to the power supply transformers, the feeders are routed in a ductbank. A paralleling switch at the south side of the ring enables uneven loading of each segment without overloading the feeders. This switch can also be used for feeder isolation during maintenance.

Each feeder consists of three 750 MCM aluminum 15 kV power cables, each 2000 feet long so that no splices are needed between service buildings. Feeder construction type will be cross-linked polyethelene, concentric neutral with overall jacket.

An harmonic filter will be installed at the switchgear area from feeders to ground, to prevent possible component damage due to excessive harmonic distortion caused by the non-linear power supplies. The filter will be similar to the existing filter in the Main Ring pulsed power system.

Conventional Power System for the MI

This system will consist of one 15 kV feeder around the MI ring, with a 500 kVA transformer at each of the eight service buildings. The conventional power will be used for building power, lights, pumps, etc. The existing Main Ring conventional power feeder (feeder 45) will be intercepted at F2 and will be extended to the MI switchgear area through an underground duct bank. From this switchgear, the feeder will continue as a direct buried feeder to the six service buildings. At each service building there will be a disconnect switch with a ductbank connection to the 500 kVA conventional power transformer.

Power for Beamlines

Total rms power required for the beamlines is 5 MW. This requires one feeder and a total of four 1500 kVA substations. Power for the beamlines will be routed through the existing Main Ring ductbank. One of the existing Main Ring feeders will be intercepted at the P71 manhole and spliced to a new feeder. The new feeder will be routed in the existing Main Ring ductbank. Switches at F3 and F2 will allow selective maintenance of each substation with the rest of the system operational. Conventional power can also be supplied via these switches.

3. BEAMLINES AND BEAM TRANSFERS

Five new beamlines with a combined length of 3035 meters are required to integrate the MI into the existing Fermilab accelerator complex:

1. A 730-meter beamline for transport of 8.9 GeV/c protons from the Booster to the MI.

2. A 210-meter Tevatron injection beamline for clockwise injection of 150 GeV protons from the MI into the Tevatron.

3. A 210-meter beamline for counterclockwise injection of 150 GeV antiprotons from the MI into the Tevatron.

4. A 575-meter beamline to transport 120 GeV protons to the antiproton production target and transport 8.9 GeV/c antiprotons back into the MI.

5. A 1310-meter beamline to transport 120 GeV slow spill to the existing upstream end of Switchyard.

The first 230 meters of beamline 4 and 5 are in common. The site coordinates of all beamline elements are shown in the beamline layout, Figure 3-1. Longitudinal beamline sections showing the disposition of the elements within the beam transfer lines are shown in Figure CDR 17-19 (Appendix E).

3.1 The 8 GeV Line

The 8 GeV line is composed of three major sections; a matching section from Booster into the beamline, a section of three major achromatic bends incorporated in a periodic FODO lattice, and a final matching section into the MI. The main geometrical constraints in the design of the 8 GeV transfer line were minimizing both the total beamline length and the impact on existing roads and structures.

Protons are extracted from the Booster at straight section L3 and follow the existing AP-4 line for a short distance at an elevation of 728.1 ft. The vertical bending magnet (BB4), used to deflect the protons into the AP-4 line beam pipe, is deenergized to allow the protons to enter the new 8 GeV line destined for the MI. A horizontal bend is used to deflect the protons approximately 24° to the east (toward the Tevatron) starting the trajectory around the existing Antiproton Source complex. The protons are transported approximately 450 meters, through two achromatic bends of 35.3° and 52°, seperated by a 150 meter periodic focussing section (FODO lattice without bends), before crossing the existing AP-2/AP-3 beamline enclosure at an elevation of 728.1 ft After crossing this enclosure, the beamline elevation is reduced to 726.9 ft, the required elevation prior to injection in the MI. The protons are then transported through 160 meters of a second major periodic focussing region before entering the last major achromatic bend center of 37°. A final 12 mr horizontal bend and 33 mr vertical bend will place the protons on the proper trajectory for injection.

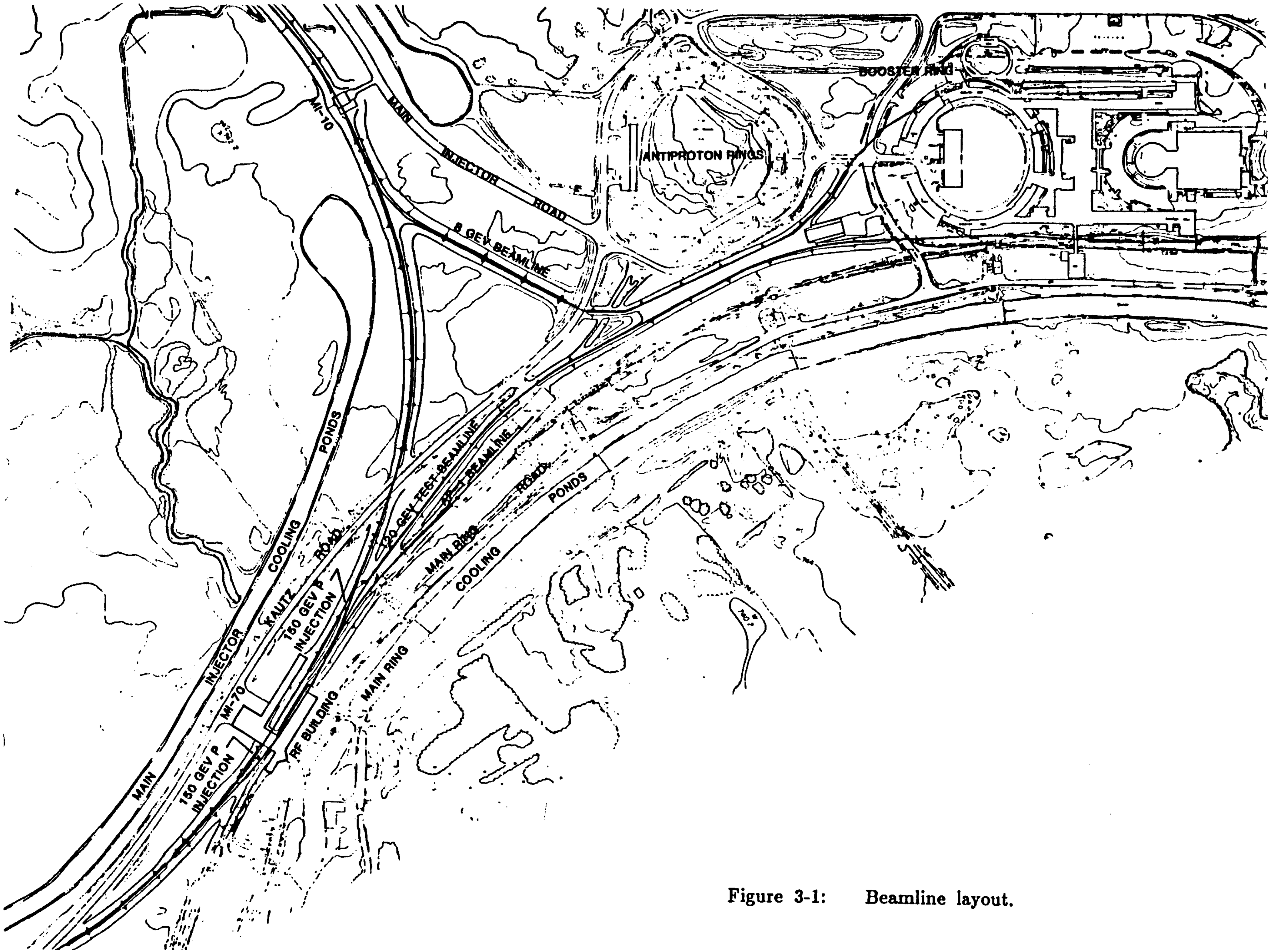

Figure 3-1: Beamline layout.

MI Injection

The injection process for 8.9 GeV/c protons is accomplished in the MI straight section, MI-10. A plan and elevation view of the injection straight section are shown in Figure 3-2. The straight section is approximately 25 meters long and has to accomodate only the vertical injection Lambertson. This Lambertson is centered in the straight section to allow clearance between the injected beam line and the upstream MI magnets. The beam trajectory at the entrance of the Lambertson is 37.7 mm above center with a downward 33 mr vertical angle and 60 mm outside and parallel to the the MI centerline. The Lambertson removes the 33 mr vertical angle to bring the beam onto the vertical closed orbit of the MI.

Four horizontal kicker magnet modules located 90° downstream of the Lambertson removes the 60 mm horizontal offset present at the Lambertson. The kicker provides a 1.37 mr bend to place the injected protons onto the horizontal closed orbit of the MI.

No other magnetic elements are required for the injection of 8.9 GeV/c protons. The injection of 8.9 GeV/c antiprotons from the Accumulator will take place in straight section MI-60 which is also used for extraction, discussed in Section 3.3. The injection process will use the same vertical Lambertson and horizontal kicker as is used for extraction.

Proton Injection Magnets and Power Supplies

The Lambertson and its power supply that is currently being used for 8.9 GeV/c proton injection into the Main Ring will be used without any major modifications. The injection kicker magnets will be constructed following the existing Booster extraction kicker technology. The magnets will have a 2.5 in x 2.5 in aperture to allow room for a 2.25" i.d. ceramic beam tube. The four kicker magnets are each capable of a 1.5 mr kick. The existing injection kicker power supply will be used with minor modifications.

3.2 The 150 GeV Lines

Two beamlines connect the MI to the Tevatron. One of these simply provides transport of the 150 GeV antiprotons to the Tevatron. The other, in addition to providing 150 GeV protons to the Tevatron, must share an extraction system in the MI with another beamline that provides antiproton targeting, test beams and allows injection of 8.9 GeV/c antiprotons. These additional functions are described in other sections; this section describes only the two optically identical beamlines which transport particles to the Tevatron.

The vertical separation of the MI and the Tevatron is 30 cm. Beam will be bent vertically out of the MI (see Section 3.6), but before there is sufficient space to insert a vertical dipole to level the beam off, it will already be below the level of the Tevatron. Thus, two vertical bends are required in the beamline; the first to bend the beam up, and a second to level it off at the Tevatron elevation. The transfer between the MI and Tevatron requires two rather complicated beamlines 210 meters in length. The total magnet count in each, not including correctors is eight horizontal dipoles of the same type that are in the ring, two vertical dipoles, and 12 quadrupoles.

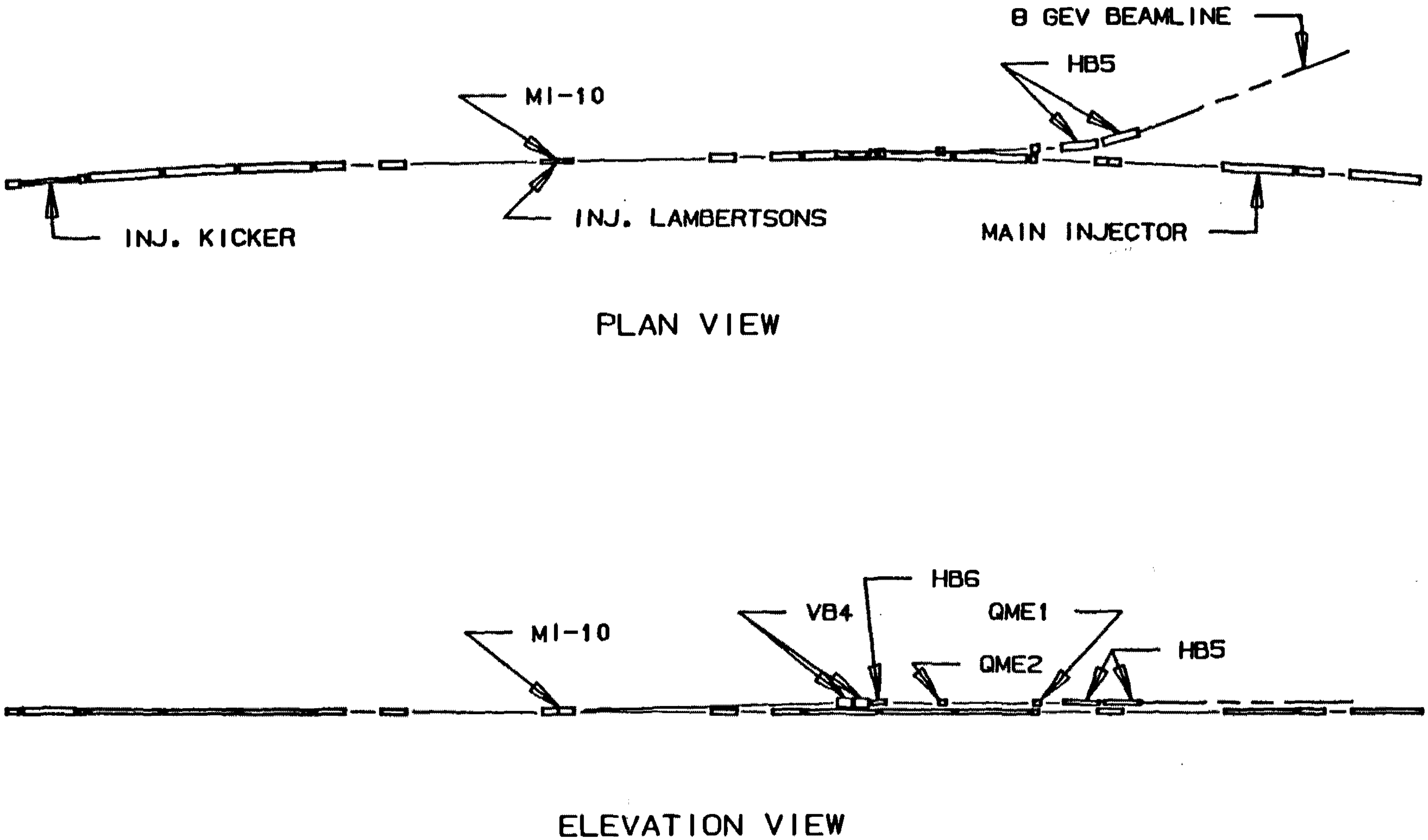

Figure 3-2: Plan and elevation view of the 8 GeV injection area.

3.3 MI Extraction

Extraction will take place at the two long straight sections near Tevatron straight section F0: MI-60 (proton extraction) and MI-80 (antiproton extraction). Figure 3-3 shows a plan and elevation view of long straight MI-60 and the first part of the extraction lines.

Transfer into the Tevatron will be initiated by a kicker located 90° upstream from a bipolar Lambertson septum magnet at the upstream end of the long straight. The kicker will produce a horizontal displacement at the Lambertson, placing the beam into a field region of the Lambertson. The Lambertson will bend the beam down for the 150 GeV Tevatron injection lines and produce an upwards bend for the 120 GeV extraction lines (for antiproton production and test beams to Switchyard). The Lambertson produces a 13.3 mr bend, just clearing the bottom (top) of the quadrupole at the end of the long straight section.

3.4 The 120 GeV (Antiproton) Target Beamline

The existing AP-1 beamline, which is used to target 120 GeV protons for antiproton production and transport 8.9 GeV/c antiprotons back into the Main Ring, will be extended from 174 meters to 574 meters to connect straight section MI-60. The first 230 meters of this beamline will transport 120 GeV protons to the antiproton target, transport 8.9 GeV/c antiprotons into the MI, and will also be used in the transport of 120 GeV slow extracted beams. The test beam will be further discussed in Section 3.5.

Geometry Considerations

The 10 meter separation between the MI and the Tevatron places a geometric constraint on the beamline location. The beamline has to bend at least as hard as the 150 GeV Tevatron injection beamlines so as to not interfere with the existing Tevatron in the E48-E49 region. Not enough bend was available to keep the 120 GeV beam in the MI tunnel. The 10 meter separation does not allow space for a separate tunnel for this beamline between the two rings. These constraints, along with rigging and tunnel space dictated that the beamline must follow the 150 GeV proton injection line into the Tevatron rf region, and in addition, follow the 150 GeV antiproton back out of the Tevatron rf region toward the MI.

The 120 GeV beam line reaches an elevation of 728.2 feet within the first 100 meters after the extraction Lambertson remains clear of both Tevatron injection lines and the Tevatron itself. The beamline remains at this elevation for another 130 meters until it departs from the 150 GeV antiproton injection line. At this point, the 120 GeV beamline splits to transport beam to either the antiproton target or switchyard. A single bending magnet is used to select the target line (de-energized) or the test beam line (energized). A plan view of this region is shown in Figure 3-4. This first 230 meters represent a reverse bending to clear new or existing beamlines and tunnels and not steer the beam onto the target trajectory. This section of the line has a total bend of 14.21°.

Connection with the Existing AP-1 Beamline

If the selection dipole is de-energized, the protons enter a 250 meter section of the beamline which will provide about 17° of bend to steer the beam

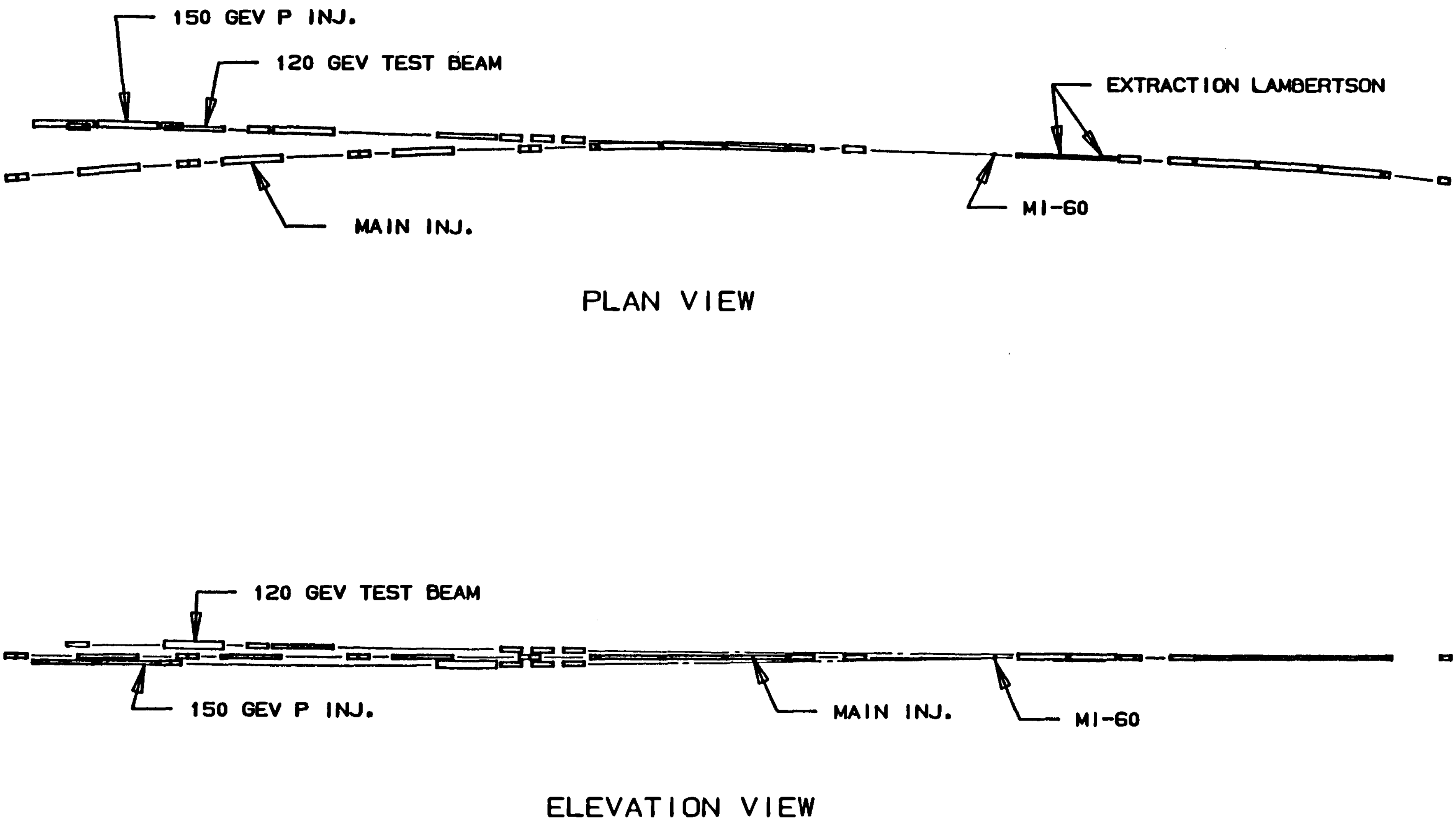

Figure 3-3: Plan and elevation view of MI-60 showing upstream ends of the 120 GeV and proton extraction lines.

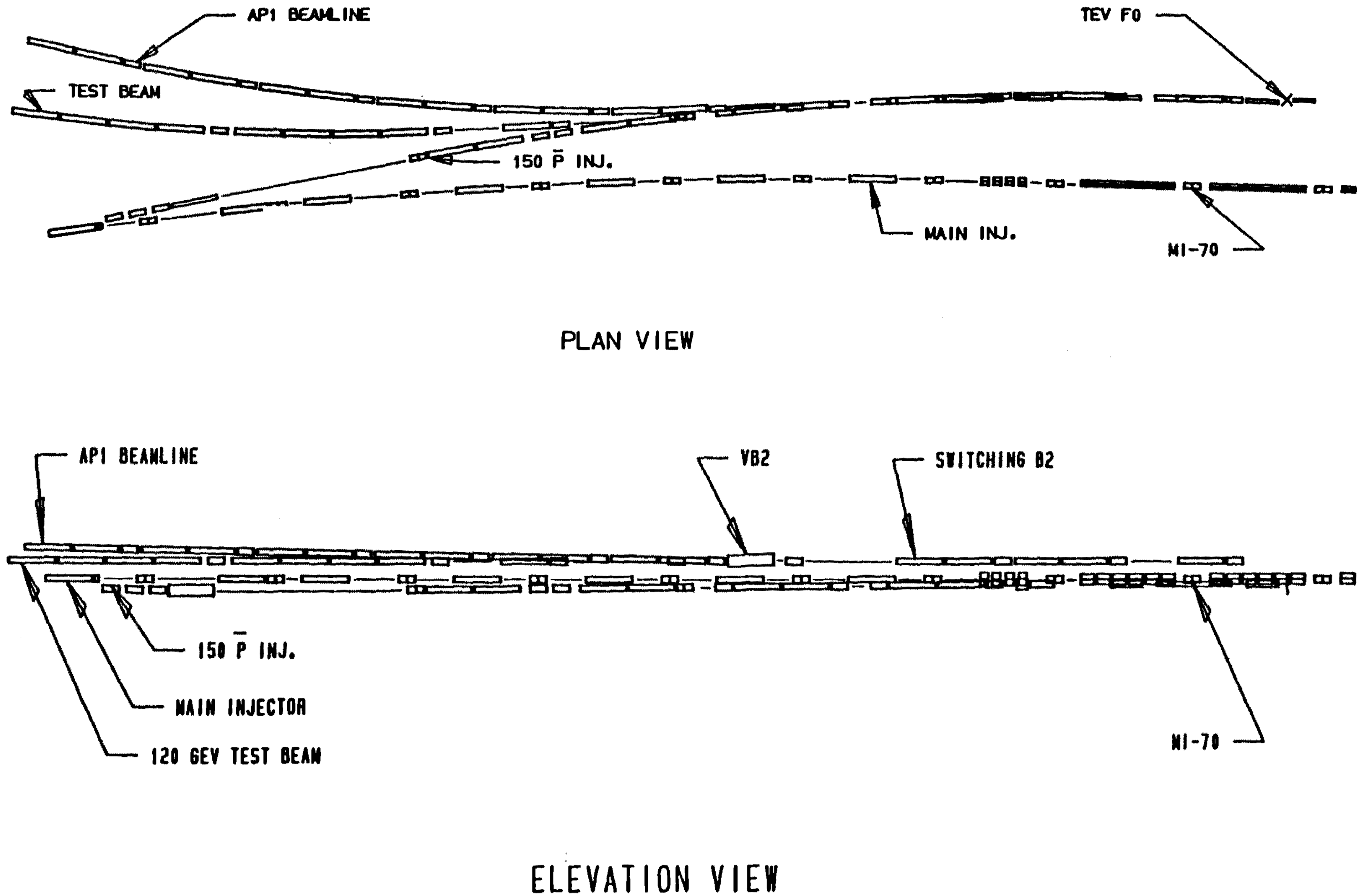

Figure 3-4: Plan and elevation views of the region in which the 120 GeV Testbeam/AP1 split is achieved. The 150 GeV $\bar{p}$ transfer line is also shown.

toward the AP-1 enclosure. The elevation of the beamline is also raised from 728.2 ft to the final 732.5 ft required for targeting. This section of beamline has an additional 2.13° of bend in order to minimize any inteference with the existing Tevatron tunnel or helium transfer lines and to allow minimum impact on the entry into the existing AP-1 enclosure. This 2.13° is then removed at the end of this major bending region to place the beam on the correct horizontal and vertical trajectory for enterance into the AP-1 enclosure and targeting. The last 95 meters of the beamline are used to place the beam on the proper horizontal and vertical trajectory and form the final focus for the antiproton production target, making a total length of approximately 575 meters.

3.5 The 120 GeV Text Beam

The 120 GeV test beam will be used to transport slow and fast extracted beam from the MI to the experimental areas for a variety of purposes during Collider runs. This beamline transports the beam approximately 1300 meters to join with the existing upstream end of the Switchyard without intefering with fixed target operation from the Tevatron.

The first 230 meters of the beamline was described above as a common line between test beam and the 120 GeV antiproton target line. When the selection magnet is energized, the beam is deflected into a 270 meter section designed to maximize the separation between the 150 GeV Tevatron antiproton injection beamline and the 120 GeV targeting beamline and create the initial horizontal trajectory to bypass the AP-0 service building. The last 100 meters of this section reduces the elevation from 728.2 ft to 727.0 ft.

The remaining 950 meters of the beamline can be broken down into three major sections each containing a basic FODO lattice. The first section contains two 25° bends. The bend centers are separated approximately 150 meters. In between are sections of periodic focusing to transport the beam past the AP-0 service building, across the existing AP-2/AP-3 beamline enclosure, past the Antiproton Source to the East Gallery of the Booster. This section is approximately 535 meters long and contains about 80% of the bending magnets and about 50% of the quadrupoles of the entire beamline and is contained in a single beam enclosure.

This enclosure stops short of the Booster enclosure and a 50 meter beam pipe is used to connect the two enclosures at Booster long straight section 13 at an elevation of 727.0 ft. Booster long straight section 13 is currently used for the 8.9 GeV/c transport line between Booster and Main Ring. The 8 GeV line will be removed upon construction of the MI and the enclosure will be used to transport 120 GeV test beam into the Tevatron A0 Transfer Hall where connection will be made with the existing Switchyard.

Geometry Considerations

The geometry of the test beamline and how to transport the beam past the AP-0 target station and service building with minimum disruption to existing enclosures played a major role in the current design. Three options considered were to

1) use the existing AP-1 enclosure and bypass the AP-0 target building to the East between the building and the existing Main Ring/Tevatron enclosure,

2) use the existing 8.9 GeV/c antiproton target bypass line and the existing AP-1 enclosure, and

3) bypass the AP-0 target building 10 to 15 meters to the West (missing the existing roads).

The first and second option required transporting both the 120 GeV target beam and 120 GeV test beam through the 7 ft wide AP-1 enclosure. Both beamlines could fit into the enclosure, but rigging and safety considerations would have dictated the removal of the entire enclosure and replacement with a much wider enclosure. This would have had a negative impact on the Main Ring tunnel and construction would have required a dedicated shutdown. An additional civil construction problem with the first option was the close proximity between the target building and the Main Ring tunnel. For these reasons the first option was abandoned.

The second option of using the existing 8.9 GeV/c target bypass for transporting the 120 GeV test beam looked promising, but the target bypass and much of the AP-0 target building is shielded only for low intensity 8.9 GeV/c beams. To satisfy the shielding requirements would have required major building modifications and the addition of several feet of steel and concrete inside the building.

The third option presented the best solution and has the additional operational advantage of separating beam enclosures according to function.

Connections to the Switchyard

Linking of the test beamline to the existing Tevatron Switchyard is established in a straightforward manner with only minimal changes required at the Switchyard interface. Space for the final test beamline element, a 20 ft vertical bend, is established in the Switchyard channel by shifting the proton area electrostatic septa splitting station PSEP downstream by 12.6 ft, the length of one septum module. The vertical dipole is then energized to link the Switchyard system with the new MI test beam line, and is turned off to maintain the existing Tevatron extraction line.

As the test beam link to Switchyard is established upstream of the first Switchyard beam split, test beam capability to all Research Division fixed target experiments should be possible. A loss in splitting effectiveness of the PSEP septa of 7%, resulting from the downstream displacement of the septa string, should be inconsequential. This is one of the more conservatively designed splitting stations, readily permitting a compensating high voltage increase of this magnitude. Beam optics in the test beamline is being designed to match that of the existing Tevatron Switchyard.

3.6 Tevatron Injection

Injection into the Tevatron is moved from the E0 long straight section to the F0 long straight section. By combining the injection process and the rf accelerating system into a single region, the E0 straight section is left free for a possible third interaction region.

By placing the accelerating cavities to one side of the straight section, the proton and antiproton injection lines can converge toward a common set of injection septum magnets located on the other side of the straight section. This reduces the number of such elements needed in the Tevatron. In the present Tevatron, the accelerating cavities are arranged in a manner such as to ensure proper phasing between the proton and antiproton systems and to minimize the effects of cavity trips. Thus, a new layout of the cavities is necessary and its consequences must be investigated.

The most appropriate injection scheme into the Tevatron machine is one in which the incoming beam approaches the accelerator horizontally, the last horizontal bend being produced by a magnetic septum magnet, and closure onto the vertical orbit being produced by a kicker magnet downstream of the injection point. The nearest points on either side of the long straight section where kickers may be placed are the F17 medium straight section (for clockwise proton injection) and the E48 short straight section (for counterclockwise antiproton injection). Both of these locations have larger horizontal β functions, favoring horizontal kickers, but presently available kicker strengths are sufficient for vertical kicks.

Since the short straight section E48 is very close to the F0 region, the logical location of the injection point is at the opposite end of the straight section. This generates the largest amount of betatron phase advance between the injection magnetic septa and the kickers for the counterclockwise injected beam. The phase advance between this injection point and the F17 medium straight for the proton beam is also favorable.

<u>RF System Layout</u>

To maximize the amount of free space available for injection, the rf cavities are concentrated in the upstream (proton beam direction) end of the long straight section. To allow for independent high voltage control for the proton and antiproton beams, pairs of cavities need to be separated by an odd number of quarter rf wavelengths. Each cavity is one half wavelength long, so that the entire system of eight cavities requires 4.25 wavelengths, as depicted in Figure 3-5. In this figure, the pairs of cavities P1-P3 and P2-P4 are used for proton acceleration, while A1-A3 and A2-A4 are used for antiproton acceleration. The center of cavity A4 is one half wavelength from the proton-antiproton collision point.

The cavity phasing is shown in Figure 3-6. Here, the circled arrows indicate the direction of the cavity field when the synchronous particle is present. The upper portion of the figure illustrates a synchronous proton moving left to right, while the lower portion of the figure illustrates a synchronous antiproton moving right to left.

The effect of a tripped station can be seen by studying this figure. If one of cavities P1, A1, P2, or A2 trip off, both proton and antiproton beams will see a reduction of rf voltage by 25%. When one of cavities P3, A3, P4, or A4 trip off, one beam will see a decrease of 25% while the other beam will see an increase of 25%. Changes of this magnitude in the rf voltage alter the rf bucket area by roughly 10%. In each of the above cases, no rf phase offsets are induced by a tripped station.

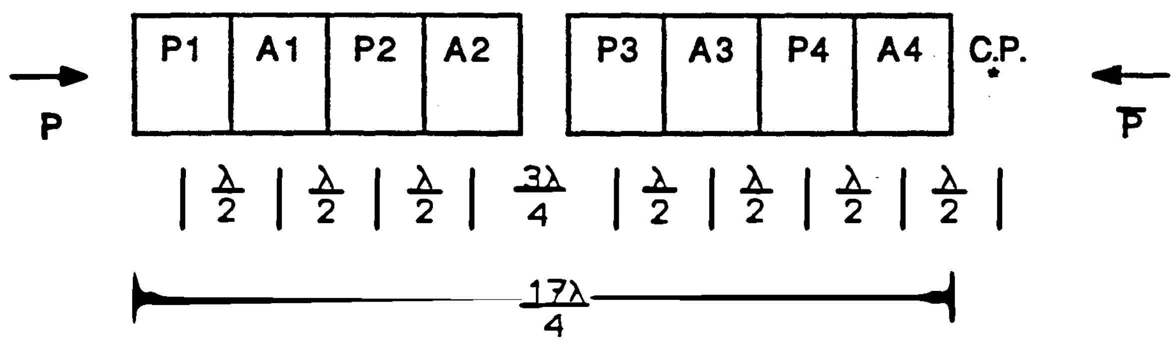

Figure 3-5: RF cavity arrangement in the Tevatron.

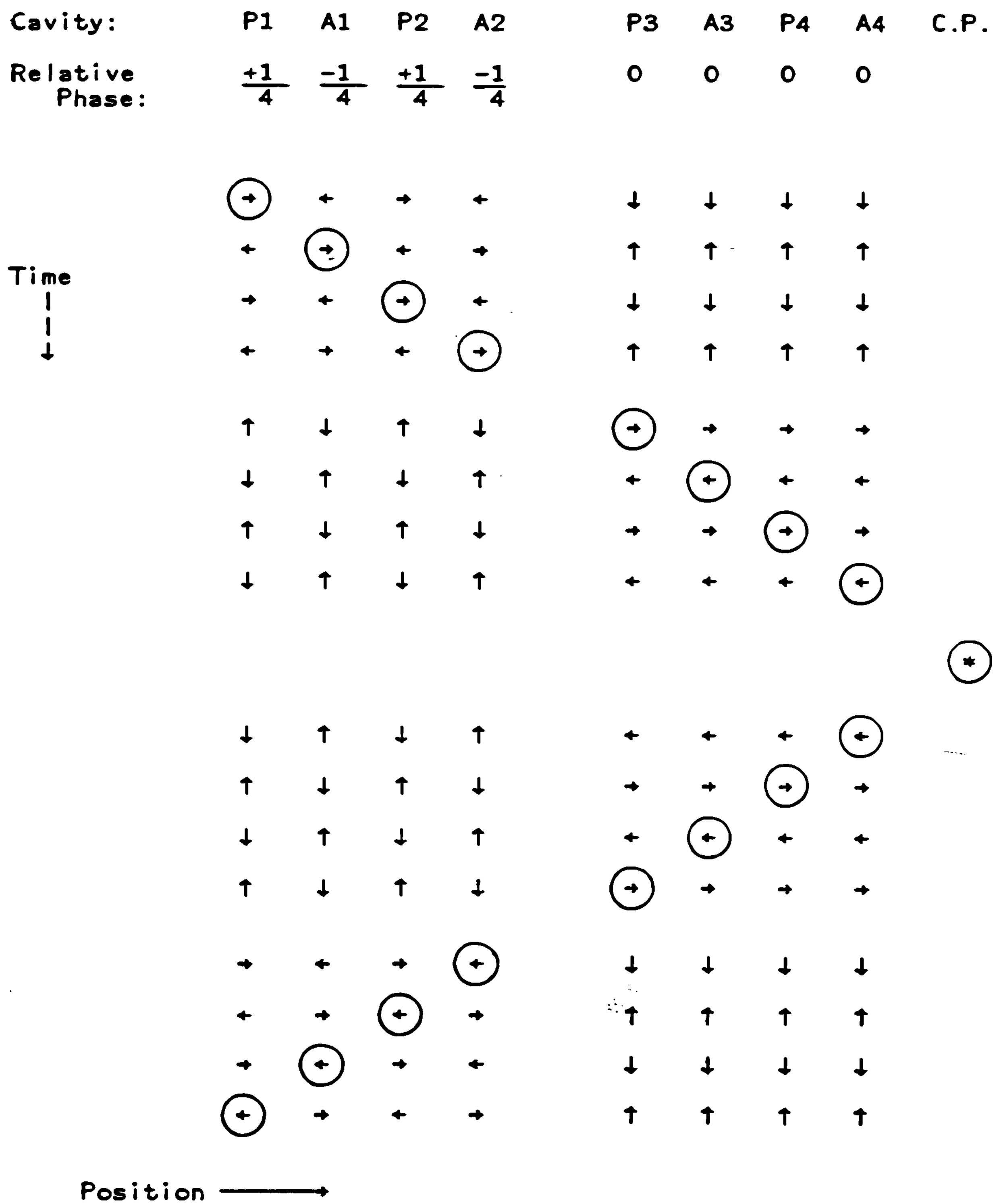

Figure 3-6: RF cavity phasing for independent proton and antiproton control in the Tevatron.

Injection System Layout

The rf system described above occupies roughly 26 m of the 52 m straight section. In the remaining 26 m, two Lambertson magnetic septa are placed symmetrically about the point 13 m upstream (proton direction) of the end of the straight section. These Lambertsons are two of four used in the present Tevatron injection system at E0. Both the proton and antiproton beams pass through the field region of these magnets upon injection. To provide more clearance at the ends of the free space, each of the injection lines incorporates one ''C'' style magnet just in front of the Lambertsons. As stated earlier, the vertical injection kicker magnets will be located at the E48 and F17 straight sections. A plan view of the F0 region is shown in Figure 3-7.

3.7 Beamline Magnets and Power Supplies

Magnet Requirements

Magnet requirements for all beamlines are summarized in Table 3-1. Decomissioning the Main Ring and the 8 GeV line will provide a major source of magnets for the beamlines.

The 8 GeV line requires construction of new antiproton debuncher-style bending magnets, SDA and SDB. The SDA is a 15 ft magnet with a sagitta of 5.7" and bend angle of 0.2618 radians; the SDB is a 10 ft dipole with a sagitta of 2.5" and bend angle of 0.175 radians. About half of the quadrupoles used in the 8 GeV line exist in the current 8 GeV line and can be reused. The remainder of the quadrupoles are of the antiproton SQB type and will be constructed in various lengths for use in the achromatic bending sections of the beam.

The portion of the 120 GeV extraction line common to both "target" and "test" 120 GeV lines will recover all necessary bending magnets from decomissioning of the Main Ring. The 120 GeV test beam will also recover all bending magnets from the Main Ring. Since the MI is using the existing Main Ring quadrupoles and the beamlines require 87 of the same type quadrupoles, new quadrupoles will be constructed for the beamlines. These will use the existing Main Ring 7 ft quadrupole design. The 120 GeV target beamline will recover all bending magnets from decomissioning of the Main Ring. The 15 quadrupoles required for the transport to the AP-1 final focus will be constructed. The existing quadrupoles used to focus the beam on target will be reused for the same purpose.

The two 150 GeV Tevatron injection lines will recover all bending magnets from the Main Ring except for two small 3 ft vertical dipoles. These will be constructed using existing laminations from the Main Ring B3 dipoles. Twelve new 8-ft quadruppoles will be constructed using the same laminations as the current Main Ring quadrupoles. In addition, two standard EPB quadrupoles are to be constructed.

The required trims for both the 120 GeV and 150 GeV beamlines will be constructed utilizing a current Fermilab design. These will be made using 40" of standard EPB dipole laminations.

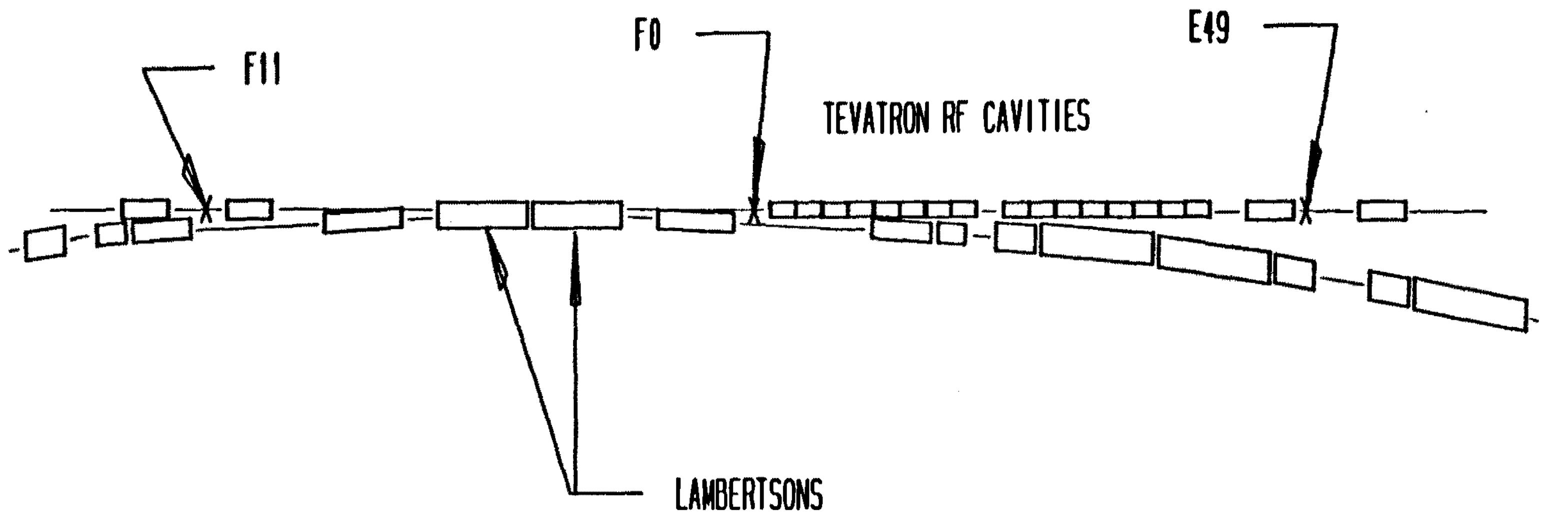

Figure 3-7: **Plan view of the F0 region in the Tevatron with the 150 GeV proton and antiproton injection lines shown.**

Power Supply Requirements

The power supply requirements for all beamlines are summerized in Table 3-2. The power supplies will be located in the new MI North Service Building (MI-10), the existing AP-0 Service Building, the new MI FO Service Building (MI-70), the new MI-50 Service Building, and in the existing Booster Transfer Hall Gallery. All major dipole and quadrupole supplies for the 120 GeV and 150 GeV beamlines will be ramped to minimize the average power consumed. The 8 GeV line will be run dc.

Table 3-1. Beamline Magnet Requirements

	Number Required	Magnet Style	Status
120 GeV Extract			
Lambertson	1	F17	exist
Dipoles (H)	13	B2	exist
Dipoles (V)	1	B3	exist
Quadrupoles	14	3Q84	new
Trims (H)	1	4-2-40" EPB	new
Trims (V)	1	4-3-40" EPB	new
120 GeV Target			
Dipoles (H)	16	B2	exist
Dipoles (V)	2	B3	exist
Quadrupoles	15	3Q84	new
	13	3Q120	exist AP-1
Trims (H)	4	4-2-40" EPB	2 exist AP-1
Trims (V)	2	4-3-40" EPB	1 exist AP-1
120 GeV Test Beam			
Dipoles (H)	58	B2	exist
Dipoles (V)	4	B3	exist
Quadrupoles	38	3Q84	new
Trims (H)	7	4-2-40" EPB	new
Trims (V)	4	4-3-40" EPB	new
150 GeV			
Dipoles (H)	16	B2	exist
Dipoles (V)	2	B3	exist
	2	3' B3	new
Quadrupoles	12	3Q96	new
	8	3Q84	exist
	2	3Q120	new
Trims (H)	8	4-2-40" EPB	new
Trims (V)	8	4-3-40" EPB	new
8 GeV			
Dipoles (H)	6	SDA	new
	8	SDB	new
	1	Vernier	exist
	1	4' dipole	exist
Dipoles (V)	1	AP-4 bend	exist
	5	CRD	exist
Quadrupoles	2	AP-4 quads	exist
	13	SQA	exist
	18	SQB	new
Trims (H)	5	Vernier	exist
Trims (V)	2	Vernier	exist
Lambertson	1	AO	exist
Kicker	4	Booster style	new

Table 3-2 Beamline Power Supply Requirements*

	Number	Current(KA)	Peak Power (MVA)
120 GeV Extract			
Dipole	1	3.3	2.8
	1	2.2	0.24
Quad	1	2.2	0.3
	1	2.2	0.25
	1	0.9	0.03
120 GeV Target			
Dipole	1	3.5	3.85
	1	3.0	0.5
	1	1.5	0.15
Quad	1	2.2	0.75
120 GeV Test			
Dipole	1	3.3	2.8
	2	3.6	6.8
	1	3.3	1.4
	1	3.2	0.5
Quad	1	2.2	1.8
	2	2.2	0.08
	2	0.9	0.01
150 GeV			
Dipole	1	4.2	3.6
Quad	6	5.0	0.2
	4	1.0	0.02
8 GeV			
Dipole	1	1.2	0.11
	1	1.0	0.09
	1	1.2	0.20
	1	1.1	0.11
Quad	9	1.2	0.01

*This table includes only the power supply requirements for the major bends and quadrupole strings. It does not include existing AP-1 magnet power supplies currently in use or trim magnet power supplies.

4. CIVIL CONSTRUCTION

4.1 Overview

The Civil Construction for the Main Injector includes all below-grade beamline enclosures, shielding, above-grade buildings, roads, parking, ponds, utilities, and services to accommodate the equipment for, and operation of, the Main Injector. This includes transport lines to conduct 8-GeV protons from the Booster to the Main Injector, and transport of 150 GeV protons and antiprotons from the Main Injector to the Tevatron. Also, the production and injection of antiprotons require new connections to the Antiproton Source to be constructed to provide a beamline for 120 GeV protons for antiproton production and an 8 GeV beamline for injection of antiprotons into the Main Injector. Also, an extraction system and beam transport is required and included to provide 120 GeV protons in the fixed target area directly from the Main Injector. The Civil Construction also includes remodeling work in the existing Tevatron Ring enclosure to accommodate the new configuration of the Main Injector.

New construction is similar to presently used and proven construction methods at Fermilab. The architectural style of the new buildings reflects, and is harmonious with, existing adjacent buildings. Existing topography, vegetation, natural habitat and site boundaries have been carefully observed in the layout of the new construction.

Safety provisions for radiation, fire protection and conventional safety are included in this conceptual design. Energy efficient construction techniques will be incorporated into all new structures. Quality assurance provisions will be part of all project phases, conceptual, preliminary, and final design, construction, and construction management.

4.2 Beam Geometrics and General Layout.

Beam Geometrics of the new Main Injector, the associated beam transport lines and the present Fermilab Tevatron are illustrated on Drawing No. CDR-9. (All civil construction drawings are included in Appendix E.) These geometrics are the definition about which the beam enclosures, radiation shielding, service buildings, roads and utility extensions are designed relative to the Fermilab site. Drawing No. CDR-1 shows the Main Injector on the Fermilab site relative to the present Tevatron, Experimental Areas, Industrial Area and Fermilab Village. Drawing No. CDR-3 illustrates the Main Injector on the Fermilab site as an aerial perspective. The design and general layout is compatible with the Fermilab Site Development and Utilization Plan.

4.3 Radiation Shielding and Life Safety Criteria

All new construction will provide adequate personnel shielding. Consideration has been given to various operational conditions as well as fault conditions in determining shielding designs.

Areas of specific shielding design include beam enclosures, service buildings, labyrinth accesses, stairways, drop hatches, and cable/pipe penetrations. Another area of design is access to adjacent rings or transport lines while other lines are operational.

Shielding will be done with compacted earth, regular density concrete and steel plate. Various combinations and thicknesses of these materials will be proportioned according to the limitations of economic design and space.

Life safety access control into the various beam enclosures, labyrinths, stairs, and buildings is maintained by a series of locked and interlocked barriers. Solid partitions with doors will separate the Tevatron Oxygen Deficient Hazardous (ODH) areas in the F-0 Enclosure and near A-0 from the Main Injector and transport lines in the F-0 and A-0 locations.

4.4 Main Injector Ring Enclosure

The Main Injector Ring Enclosure is a race track shaped, below-grade enclosure, approximately 10,900 ft. long, 9600 ft. of which has 9'0" wide and 8'0" high cross sections, 1200 ft. of which is 9'0" wide and 10'0" high, and the remainder is 15'0" wide and 10'0" high. The enclosure plan and sections are shown on Drawing Nos. CDR-5, CDR-6, CDR-26, and CDR-27. The floor of the enclosure is at Elevation 722'-6" or 11' to 23' below existing grade. The main injector ring equipment is centered on Elevation 724'-4.5" or 1'10.5" above the floor and is positioned 2'-0" from the outer curved wall. Earth shielding berms over the Main Injector Enclosure provide the required 17' earth equivalent shielding.

The Main Injector Ring Enclosure is constructed on a reinforced concrete cast-in-place (CIP) base slab over compacted granular fill bearing on undisturbed glacial till. Both CIP and precast reinforced concrete wall and roof construction are used. More than 9600' of the ring will be built with precast concrete inverted "U" wall/roof sections which are welded to a CIP base slab. Nearly 26,000' of this type precast have been economically constructed at Fermilab during the past two decades. The enclosures and alcoves beneath Service Buildings will be CIP base slab, walls, and roof. Footing drains, moistureproofing, and granular backfills are used to insure a dry enclosure.

Cable trays, power bus, piping, lighting, and other utilities are ceiling or wall-mounted on both inner and outer walls. Numerous penetrations connect to the service buildings constructed above the Main Injector Enclosure.

Personnel access stairs to the Main Injector are provided at six service buildings including the MI-70 RF Service Building. No stairs occur at the Abort/Kicker Service Buildings. Ventilation equipment is near these stairs and is described in Section 4.10 below.

A common earth berm above the Main Injector Enclosure defines the location of the below-grade ring enclosure. Top of the berm is approximately 1'-0" above the Service Building floor.

4.5 Beam Transport Enclosures

The Beam Transport Enclosures serve to house six functionally distinct transport purposes: 1) the transport of 8 GeV protons from the Booster to the Main Injector, 2) the transport of 150 GeV protons from the Main Injector to the Tevatron, 3) the transport of 120 GeV extracted protons to the fixed target switchyard for ''test beam'' purposes, 4) the transport of 120 GeV protons from the Main Injector to the Antiproton target at AP-0 for the production of 8 GeV antiprotons, 5) the transport of 8 GeV antiprotons from the accumulator to the Main Injector, and 6) the transport of 150 GeV antiprotons from the Main Injector to the Tevatron. Although there are six functionally different lines, the design of the beam transport system variously utilizes either shared beam line elements or shared beam line enclosures to reduce the total linear length of civil construction of beam line enclosure. Therefore, only four distinct civil construction entities are specified. These are: 1) An 8 GeV Beam Transport Enclosure 2,250 feet long connecting the Booster to the Main Injector, 2) A Proton Injector enclosure 160 feet long connecting the Main Injector to the Tevatron, 3) An AP-1 Target Beamline 600 feet long connecting the Main Injector to the Antiproton Target which enclosure contains both a line of shared elements for 120 GeV antiproton production and 8 GeV antiproton injection, and the 150 GeV Antiproton line elements for transport from the Main Injector to the Tevatron, and 4) The Test Extracted Beam Enclosure 3,200 feet long to transport 120 GeV extracted protons from the Main Injector to the start of the fixed target switchyard at A-0.

With the exception of the 160 foot 150 Gev Proton transport Enclosure from the Main Injector to the Tevatron, whose cross section is 9'-0" wide by 10'-0" high, the cross section of the 6,050' of beam transport enclosure in the remaining three enclosures is 9'-0" wide by 8'-0" high.

The floor elevation of the 8 GeV Proton Injection Enclosure is ____'-__" and the beam line elevation is ____'-__" or ____'-__" above the floor. The floor elevation of the Proton Injection Enclosure is ____'-__" and the beam line elevation is ____'-__" or ____'-__" above the floor. The floor elevation of the AP-1 Target beamline Enclosure is ____'-__" and the beamline elevation is ____'-__" or ____'-__" above the floor. The floor elevation of the Test Extracted Beam Enclosure is ____'-__" and the beamline elevation is ____'-__" or ____'-__" above the floor.

Drawing Nos. CDR-9, and CDR-11, through CDR-16 show the various beam and equipment configurations in plan. Drawing Nos. CDR-17, CDR118, and CDR-19 illustrate a longitudinal cut through these beam lines.

The Proton Injection Enclosure connects on the upstream end to the Booster Enclosure and passes under Well Pond Road. Existing buried steel shielding above the beam pipe to the Antiproton Rings Enclosure will be removed and later replaced after new enclosure construction.

Construction details of the Beam Transport Enclosures are very similar to the Main Injector Ring Enclosure. Equipment Access is from new hatches in the MI-70 service building, new hatches in the North Hatch Building, or from existing hatches in the Target Hall, or the Booster Enclosure. Additional personnel stairs are provided on very long enclosure lengths.

4.6 Main Injector Service Buildings

Ten service buildings in five size configurations contain equipment, services, and utilities for the Main Injector and various Beam Transport

Lines. Other equipment for the Beam Transport Lines will be contained in the existing Transfer Gallery. Locations of the ten service buildings are shown on Drawing CDR-5.

Four of the ten service buildings are identical to each other and are illustrated on Drawing Nos. CDR-20 and CDR-21. These buildings are located atop the shield berm approximately 1800' apart. Since the buildings house the magnet power supplies, the locations occur following every 50 dipole magnets in the beam enclosure below. The buildings also contain control racks, pumps, and heat exchangers, and provide personnel stairs and equipment access to the beam enclosure. Conduits to a utility alcove off the beam enclosure below provide for dc buss, power cable, control cable, and LCW piping.

The four buildings are 34'-0" wide and 50'-0" long in plan with 10'-0" clear interior heights. Construction is insulated metal siding on a steel frame with built-up roof and concrete floor. During Title I design, precast wall panel buildings will be investigated together with precast subgrade beams to reduce construction times and possible settlements. The electrical and mechanical systems for these buildings are described in detail in Sections 4.9 and 4.10 below.

The fifth building, the service building at location MI-10, is similar to the above four buildings except larger, enclosing 2,250 square feet versus the 1,700 square feet in the previous four. The extra size is necessary to house power supplies, etc. for nearby beam transport lines. The plan dimensions of the MI-10 building are ____'-__" by ____'-__".

Three of the ten service buildings are small single-purpose buildings containing the pulsed power supplies for the Main Injector Beam Abort and Beam Transfer Kickers. These buildings are 20'-0" square with 10'-0" clear interior height. There is no stair access to the beam enclosure below. Construction will be similar to the other service buildings.

The ninth and tenth buildings are larger, and the detailed description more involved. The ninth building is the final Main Injector Ring Service building called MI-70. When completed it will be physically connected to the modified and partially rebuilt service building F-0. The construction scenario for these connected structures is discussed below in section 4.7. The MI-70 portion will consist of 3,750 sq.ft. of high bay area and 13,125 sq.ft. of low bay area. The plan view of this structure is show in Drawing No. CDR-22. Roughly, the high bay area is enclosed in an area of 50'-0" by 75'-0". There is crane coverage, utilizing a 20 Ton bridge crane with coverage over this area of 50'-0" by 75'-0". Included in this area is a drop hatch with an opening of 9'-0" by 30'-0" and an 8'-0" by 9'-0" freight elevator with a 5 ton capacity. This location is one of two locations that will be constructed for the staging of magnets and equipment into the Main Injector and associated Beam Transport lines. The low bay area houses the RF power supplies for the Main Injector, in addition to a full complement of control racks, magnet power supplies, and cooling system equipment for the 1/6th of the Main Injector surrounding location MI-70. The equipment access hatch is above a curved labyrinth leading to the inner aisle of the Main Injector; this labyrinth serves as a major vehicle access into the Main Injector. Personnel stairs to the Main Injector are provided. The high bay area has a 24'-0" clear height; the low bay areas have 10'-0" clear interior height. A central off-loading area is provided in the high bay area, with a 16'-0" wide 14'-0" high equipment door. The construction otherwise is similar to the other service buildings.

The tenth and last new service building is designated the North Hatch Building, the location of which is in a "Y" formed by the approach of the 8-GeV Proton Injection Line to the 120 GeV extracted test beam line. This building encloses 6,250 sq ft and is designed to house control racks, magnet power supplies, and cooling system equipment, as well as to provide independent access to both of these lines. There is high bay area of 6,250 sq ft with 24'-0" clear height. There is a 20 Ton bridge crane covering an area of 125'-0" by 50'-0". Included in this area are two hatches providing independent access to labyrinths into each line; the hatches provide openings of 7'-2" by 30'-0". The drop hatches will be covered by removable shielding blocks. There is a central off-loading area served by a 16'-0" wide by 14'-0" high equipment door. Stairs are provided for personnel access into the labyrinth areas. The construction is similar to the Industrial Center Building using vertical precast concrete walls.

4.7 F-0 Beam Enclosure and F-0 Service building Addition.

The F-0 Beam Enclosure contains components from the accelerator(s) to be located in the existing Main Ring, as well as from several Beam Transport Lines. Functionally these are elements of the 150 GeV Proton Injection Line, the 150 GeV Antiproton Injection Line, the 120 GeV Antiproton production line, the 8 GeV Antiproton Accumulator to Main Injector line, and the 120 GeV Extracted Test Beam Line. As mentioned above, some of these lines share common elements at certain locations, or share common enclosures at other locations. In the immediate F-0 location, a back-to-back double "Y" must be constructed as seen in Drawing No. CDR-10.

The existing F-0 Enclosure has insufficient space for the new Transport beams to be included in addition to provisions for the accelerator(s) to be located in the Main Ring. Hence it must be completely demolished and rebuilt. In order to do this construction work, a portion of the existing F-0 Service Building directly above the F-0 enclosure must also be demolished and then rebuilt. Refer to Section 4.8 for a description of the earth retention system planned to accomplish this work, which is a three stage process: 1) the new Main Injector Enclosure is built, and most of the MI-70 Service building constructed, 2) The existing F-0 Enclosure and Buildings on top are demolished, and a new F-0 Enclosure constructed which connects to stubs left incomplete when the Main Injector was constructed, and 3) The F-0 Service Building is rebuilt and a connecting link to the MI-70 Service building constructed. All these steps may be seen in Drawing Nos. CDR-17, CDR-22, and CDR-23.

The demolished section of the existing F-0 enclosure will be approximately 400' long, and it will be replaced with the aforementioned double "Y" shaped structure as seen in plan view in Drawing CDR-10. The width of the common structure varies from ____'-__" to ____'-__" and is 8'-0" in height. Of the four ends in the double "Y", two will reconnect to the existing Main Ring tunnel, and two to the stubs left from the earlier construction of the Main Injector and the Beam Transport Lines. The floor of the enclosure under the Main Ring Accelerator(s) will be at Elevation ____'-

__" and the floor of the Enclosure under the Beam Transport elements will be at Elevation ____'-__" which implies a step across the width of the enclosure as seen in cross section in Drawing CDR-23.

The F-0 Enclosure is constructed of CIP reinforced concrete. Since no portion of the existing base slab can be reused due to the increase span loads, a completely new base slab will be poured. The glacial till and the existing granular sub-base is adequate. Underdrains from the existing Tevatron/Main Ring enclosure and the new Beam Transport Enclosures will be routed to new sump pits. Moistureproofing and granular backfills will be used similar to the Main Injector.

An existing freight elevator, stairs, and curved labyrinth from the reused portion of the F-0 Service Building will be reconnected to the new beam enclosure on the Tevatron side. Access on the opposite side will be through the Beam Transport Lines and stairs and freight elevators in the MI-70 building. In addition, a stair leading directly to the west side of the rebuilt F-0 enclosure will be provided for emergency personnel exit, since personnel are otherwise trapped in an 'island' defined by beamlines and the major accelerators. Numerous penetrations connect the building and the enclosure below and are shown in the drawing sections.

The F-0 Service Building Addition, and the connection to the MI-70 Service Building, can be built only after the F-0 Beam Enclosure below is completed and backfilled. A ___'-__" wide, ____'-__" long, 10'-0"(?) clear height addition is built on top and parallel to the F-0 enclosure for RF power and controls for the accelerator(s) in the Tevatron/Main Ring Enclosure. A ___'-__" wide, ___'-__" long ___'-__" addition at Elevation ___'-__" crosses the space between the two accelerator enclosures as projected to the surface, connecting the F-0 Service building to the MI-70 Service building. This structure is seen in Drawing Nos. CDR-22 and CDR-23. The final connected structure encompassing MI-70 and F-0 buildings is at three different elevations; Elevation ____'-__" for the preserved 'front or southeast' portion of F-0, Elevation ____'-__" for the reconstructed Tevatron RF and connection section, and Elevation ____'-__" for the MI-70 Main Injector RF and service section.

The construction of the F-0 addition is similar to the existing structure, with insulated metal siding over a steel frame, built-up roof and concrete floor. Equipment access doors are provided to all large equipment areas.

The co-joined F-0/MI-70 building contains the RF cavity power supplies for the Main Injector and the Tevatron accelerator(s), magnet power supplies, an existing helium compressor room, LCW cooling systems, control racks, test areas and small technical work areas. The space allocation is shown on the drawings.

4.8 Structural Foundation Systems and Earth Retention

All base slabs and piers under Main Injector enclosures will be founded on glacial till with high bearing capacity. Soil boring logs near the Main Injector perimeter indicate the unsuitability of shallow foundations if founded on high water bearing strata above the glacial till. Soil boring locations, elevations of glacial till, and unconfined compressive strengths are shown on Drawing No. CDR-4. During Title I, additional borings will be made to better define the sub-surface conditions.

Although the till varies in depth of 4 to 21 feet below grade, the requirements for various beam enclosure structures place the base slab excavation well into the till except at a very few isolated areas. In these areas, a compacted granular backfill or lean concrete will replace the several additional feet required to reach glacial till.

The Main Injector enclosures may also serve as the foundations for the nine Service Buildings around the ring. Piers will extend above the enclosure roof and precast grade beams will support the CIP service building floors. Similar techniques have been successfully used for the Antiproton Source Service Building construction in quite similar sub-grade conditions. For portions of the ring Service Buildings which extent beyond the enclosure piers, and for the North Hatch Service Building, spread footings on virgin soil will also be employed.

In the immediate F-0/MI-70 location, earth retention systems will be employed during construction. At all other locations where new construction approaches or joins existing structures, it will be possible to schedule construction so that questions of retaining adequate shielding, or retaining existing structures in service, will not be a consideration. In particular, the joining of Beam Transport lines to the Booster Enclosure for the 8 GeV Proton injection line, for the 120 GeV Test Beamline, and joining to the Antiproton pretarget enclosure will be done during scheduled accelerator downtime periods. The intention in the case of the entire Main Injector ring enclosure, however, is to build it and as much of the Beam Transport enclosures as possible, during a period of normal accelerator operations. In the immediate vicinity of the closest approach of the Main Injector tunnel enclosure to the Tevatron enclosure at F-0 it will not be possible to excavate the Main Injector enclosure without the installation of approximately 600 feet of sheet piling to maintain the minimum necessary shielding radius. This sheet piling will be driven parallel to the Tevatron enclosure on the outer radius, just beyond the edge of the new Main Injector enclosure; the sheet piling may be used as an outside form for the Main Injector CIP walls at that point. Later, during the demolition and reconstruction of the Tevatron enclosure at F-0, a second row of sheet piling will be driven to retain the soil under the parts of the existing F-0 Service Building which may be thereby preserved. The entire area between the two parallel rows of sheet piling will be excavated to permit the destruction and reconstruction of the 'double "Y"' enclosure at F-0. Thus, only the southwest longitudinal half of the existing F-0 Service Building need be demolished in order to excavate down and reconstruct the F-0 Beam Enclosure below. Refer to Drawing No. CDR-23.

4.9 Primary Power, Secondary Power, and Distribution

As discussed in Section 2.14 above, there are three separate power systems associated with the Main Injector System: 1) Power System for pulsed power supplies, 2) Power system for the Beamlines, and 3) Conventional Power system.

The power system for the pulsed power supplies consists of the existing 82B transformer at the Master Substation and a new 15KV distribution system to the Main Injector. Six 15 KV feeders are used in a new ductbank to be buried from the Master Substation to the Main Injector as shown in Drawing No. CDR-32. A 15 KV switchgear area at the north end of the MI-70 building area allows the sectionalizing of the system. From this switchgear, two direct buried loop feeders are used for the pulsed power of the ring. At each service building, there is a disconnect switch to supply power to the power supplies. From this switch to the power supply transformers, the feeders are routed in a ductbank. This is shown in Drawing No. CDR-31.

A paralleling switch on the opposite side of the Main Injector will enable uneven loading of each segment without overloading the feeders. This switch can also be used for feeder isolation for maintenance purposes.

The total rms power required for the Beamlines is 5 MW. This will require one feeder and four 1500 KVA substations. The locations will be seen on Drawing No. CDR-31. Power for the beamlines will be routed through the existing Main Ring ductbank as shown in Drawing No. CDR-32. One of the existing main ring feeders is intercepted at the P71 manhole and spliced to the new feeder. The new feeder is routed in the existing Main Ring Duct bank. Switches at F3 and at F2 allow selective maintenance of each substation with the rest of the system operational; conventional power can also be supplied via these switches.

The conventional power system will consist of one 15 KV feeder around the Main Injector ring, with a 500 KVA transformer at each of the principal service buildings. The conventional power will be used for building power, lights, pumps, etc. The existing Main Ring conventional power feeder (feeder 45) will be intercepted at F2 and will be extended to the Main Injector switchgear area located at MI-70 through an underground duct bank, as shown in Drawing No. CDR-32. From this switchgear, the feeder will continue as a direct buried feeder to the six service buildings. At each service building there will be a disconnect switch with a ductbank connection to the 500 KVA conventional power transformer.

Conventional power will be connected to power distribution panelboards in each service building. 480 volt, 3 phase branch circuits will power the water pumps, heating and ventilating equipment, control racks and service outlets. Stepdown transformers and panelboards provide 208/120 volt power for lighting and outlets. Refer to Drawing Nos. CDR-31 and CDR-32.

4.10 Primary Cooling, Distribution and Mechanical Systems.

The primary heat rejection medium for the 12 MW generated by the Main Injector is cooling pond water (PW). Drawing No. CDR-5 shows the two new interconnected cooling ponds that roughly encircle the Main Injector Road and provide 16.0 acres of cooling surface. The ponds total 11,650' in length, are 60' wide, and the average to maximum depth is 4'-6" to 7'-0". Transverse concrete dams near each service building provide intake and discharge piping separation and elevation control. Pond water level varies from Elev. 739'(?) matching the Tevatron ponds at F-0 down to Elev. 735'(?). Cross connect piping between the Main Injector ponds and the Tevatron Ponds allow load shedding and water level control.

As described in section 2.14 the Low Conductivity Water (LCW) system is a closed piping loop exchanging heat from the Main Injector and Beam Lines magnets and power supplies to the pond water. Much of the equipment now in the present Tevatron Service Buildings will be reinstalled in the new Main Injector service buildings and perform in a similar capacity. New LCW piping will be installed in the Main Injector Beam Enclosure. A system-wide deionizer is located MI-10, one of the larger Main Injector service buildings, for slip stream polishing.

Existing chilled water (CW) in the F-0 Service Building which comes from the Central Utility Building will be retained and reused, and extended into the connecting MI-70 building. The new combined loads on the chilled water system are comparable to the present loads.

The underdrain system for all new beam enclosures is similar to the design used for the Antiproton Rings. Perforated drain piping surrounded by granular material and covered with geotextile fabric is installed on both sides of the enclosure base slabs. Duplexed pump sump pits connect to the underdrain piping and discharge into surface ditches.

The fire detection/suppression systems used for the Main Injector are similar to those systems used for the Tevatron enclosures and buildings. Industrial Cold Water (ICW) will serve fire hydrants and hose cabinets in the F-0, MI-70, MI-10(?), and North Hatch(?) Service Buildings. These buildings will also be equipped with smoke detectors which report to the site-wide FIRUS system, as will be the other service buildings. The Main Injector tunnel enclosure, and the Beam Line Enclosures will be equipped, as is the present Main Ring, with 'derivative thermal detectors' and link to the FIRUS system.

Moderate ventilation rates with dehumidification will be used in the Main Injector Beam Enclosure. Refer to Drawing No. CDR-___. Ventilation fans will be placed in alternate(?) service Buildings to supply/exhaust air through the stairway and alcove openings. Two air changes per hour will be used when needed during non-operating periods. Periodically placed dehumidifiers about the beam enclosure will control humidity. At the F-0 enclosure, a duct will allow the Main Injector air circulating through the Proton Injection and Antiproton production stubs to pass through the ODH partitioned area of the Tevatron enclosure. Also, air will be circulated through the longer beam lines by a push-pull ventilation system.

The Main Injector and North Hatch Service Buildings are equipped with a variety of HVAC equipment to accommodate the required occupancies. Local, self-contained air conditioners will be used to cool Control Rack areas. Unit heaters will heat the power supply and water systems areas when operations are off. Roof fans and wall louvers will provide ventilation to these areas when the temperature requires.

4.11 Underground Utilities and Services

Power ducts, communication ducts, industrial cold water (ICW) piping and pond water (PW) piping will be extended from existing utility corridors along South Booster Road, Kautz Road, and Main Ring Road. A new power duct from the Master Substation to the Main Injector Switchyard is also required.

Utility routings and connection points are shown on Drawing Nos. CDR-5, CDR-7 and CDR-32.

A new 13.8 kV power cable corridor along the inside toe of the Main Injector Berm is reserved for both direct buried pulsed and conventional feeders. At each of the six Main Injector Service Buildings the new direct buried feeders will connect through concrete power manholes to the substation foundations supporting three Main Injector power substations and one conventional power substation. The substation foundations will provide transformer oil containment reservoirs.

A new communication duct bank loop encircling the Main Injector will be installed along the inside shoulder of the Main Injector Road. The communication duct bank will be branched through concrete manholes into each of the six Main Injector Service Buildings. The new duct bank will also be extended via a stub into the North Hatch Service Building. The communication duct will be connected back to the Cross Gallery through a combination of new duct installation and utilization of existing routings in the South Booster and Antiproton Source areas. In some areas, where existing duct banks are near capacity, additional ductbanks will be paralleled along the same routing.The precise routing will be determined during Title I design as well as the usage of the existing fiber optic links already installed into the Antiproton source.

Industrial cold water (ICW) piping will be extended along Kautz Road as far as Service Building MI-10 to serve fire hydrants and hose cabinets in MI-10 and the North Hatch Building. Short extensions to domestic water (DOM) piping connects to the rebuilt RF/70 Service Building and to the North Hatch Building.

No additional toilet facilities are planned for the Main Injector project since facilities are available in nearby buildings. No extensions to sanitary sewers (SAN) are required. Existing septic systems at the existing Antiproton Target Hall and F-0 Service building will be retained and any portions of the field damaged during construction will be replaced.

4.12 Survey and Alignment Control

A coordinated system of monuments, benchmarks and working points is planned for complete geometric control of the Main Injector during all phases of construction. Deep concrete piers will be set at construction start to define ring centers and major baselines. This control will be extended onto enclosure base slabs as construction progresses and will be tied into control of the existing survey systems of the Tevatron, Booster and Antiproton accelerators. Provision will be made for survey sighting tubes in addition to available equipment hatches to facilitate survey checks to accelerator equipment after all construction is completed.

4.13 Roads, Drainage and Landscaping

Road access to the Main Injector site is from existing Kautz Road. A new loop road around the site, Main Injector Road, will connect to Kautz Road at two places. Early construction of this new road will maintain access to the existing Antiproton Target Hall and will provide direct construction access via Kautz Road from Illinois Highway 56, Butterfield Road. Refer to Drawing No. CDR-1 and CDR-5.

A portion of existing Kautz Road, between the Main Injector Road intersections, will be rebuilt to the alignment required by the Main Injector cooling ponds and new service buildings. Refer to Drawing No. CDR-5. Service drives with small parking areas are provided at each service building with access to either Kautz Road or the new Main Injector Road.

The construction site is mainly open cropland with approximately one third in current leased cultivation. The overall drainage pattern is to the southwest into Indian Creek. There are isolated areas of trees and fence rows, shallow ditches meander the site and abandoned agricultural tiles are in evidence. A small area of dead timber has provided an unusually fine nesting habitat for great blue herons.

The Main Injector impacts the site with three salient features, the shielding berm, the new road and the cooling ponds. The site drainage will be designed to minimize this impact according to the following design goals:

1. Maintain the existing watershed characteristics within the project area and the surrounding topography.

2. Control surface runoff into Indian Creek so as to create no adverse impact on downstream off-site residential areas.

3. Provide for collection of excess surface runoff when required for pond level maintenance.

Drainage structures will be placed through and under the shield berms, road beds and ponds to maintain the normal surface water flow through the interior ring area of the Main Injector. Pump stations, control dams and weirs will be provided for seasonal adjustment of the drainage patterns needed to maintain the heron nesting habitat. Operations of these controls will be coordinated with the existing Swan Lake and Booster Pond cooling systems which also connect to Indian Creek.

Special precautions will be made to protect large trees that are adjacent to the construction site. Within the construction site, topsoil will be segregated and later replaced. Crown vetch will be used on berm slopes and crests. The ring interior area will be returned to natural field grasses. Grass seed will be planted adjacent to roads and building areas.

The southwestern boundary of Fermilab abuts to an abandoned railroad right-of-way, now converted into the Illinois Prairie Path. The existing railroad berm and ditch, together with the new ponds and adjacent pond berms, create a significant barrier to any errant cyclist/hiker along the Prairie Path. In addition, appropriate shrubbery and thicket-type vegetation will be planted along the site boundary as a further visual screen and natural fence row.

4.14 Construction Packages and Schedules

The Main Injector civil construction work has been grouped into the following four general categories for the preparation of cost estimates and construction schedules.

Site Preparations: (WBS 1.2.1) Site development including mobilization, fencing around habitat areas, site protection, survey control, temporary utilities, rough roads, major excavation and backfills, most underground utilities, site drainage, ponds and dams.

Beam Enclosures and Service Buildings: (WBS 1.2.2) Construction of all underground enclosures, surface buildings, utilities and services that can be done simultaneously with Fermilab colliding beam or fixed target operations. Included is 100% of the 10,900' Main Injector Enclosure, 80% of the 6,200' Beam Transport Enclosures, 9 of the 10 various sized Service Buildings, substation foundations, the remaining underground utilities and some of the earth retention systems.

RF/F-0 Service Building & Beam Enclosure and Modifications to Existing Beam Enclosures: (WBS 1.2.3) Construction that requires Tevatron operations be off. Included is earth retention systems, demolition and rebuilding of the RF/F-0 Beam Enclosure and Service Building, completion of the remaining Beam Transport Enclosures, and extension of the Booster Beam Enclosure.

Landscaping and Paving: (WBS 1.2.4) Site clean-up, road regrading, paving and landscaping work to complete the project.

During development of Title I and Title II these four categories will be divided into the actual constructon packages tailored to the detailed design, operational conditions and early occupancy requirements.

5. COST ESTIMATE

The Total Estimated Cost for construction of the Main Injector, associated beamlines, and required modifications to existing facilities is $132,300,000 in then-year dollars. The cost estimate is summarized in Table 5-1. An additional $12,000,000 will be required in direct R&D, pre-operating, and capital equipment costs to support the project. The cost estimate methodology is adapted from that used to estimate the Superconducting Super Collider (SSC). Our recent experience with the TeV I (Antiproton Source) and Main Ring overpass construction projects forms the basis for a large fraction of the cost estimate of this project.

5.1 Methodology

A Work Breakdown Structure (WBS) is set up in order to identify all required components of the Main Injector project and to insure that each component is adequately specified and incorporated into the estimate. The WBS through fourth level is shown implicitly in Table 5-1. The actual WBS used for the cost estimate extended through the seventh level.

All components are estimated at the lowest applicable level in 1989 dollars and then summed upwards. At the lowest level materials costs and labor (fabrication) hours are entered separately along with the basis for the estimate. Labor estimates are also associated with a craft code specifying the type of labor to be used. When materials costs are based on previous purchases of identical components they are escalated to 1989 prices using standard DOE inflation factors. The translation of craft codes into hourly costs is based on local labor rates and is given in Table 5-2. Through this approach a categorized estimate of the total manpower required for completion of the project is created at the same time as the cost estimate. The manpower estimate is given in Table 5-3.

The cost estimate is produced in 1989 dollars. Escalation to then year dollars is accomplished through a convolution of the spending profile with DOE construction project escalation rates. (See Appendix I - Schedule 44.)

5.2 Technical Components

The technical components of the rings and beamlines include magnets, vacuum, RF, diagnostics, controls, and safety systems. Included in the estimate are materials, fabrication, and installation costs. The total cost estimate for these components is $48,770,000 (1989). All components are similar to components already built and installed at other locations within the Fermilab complex. The only extraordinary items are the new dipole magnets. A modest R&D effort will be associated with this item.

5.3 Conventional Construction

The conventional construction cost estimate includes the Main Injector ring enclosure, beamline enclosures, service buildings, modifications to the Main Ring enclosure and service building at F0, and all associated utilities including primary power and water distribution. Also included are the requisite sitework and road development. Specifically provided for are new cooling ponds and a new ductbank originating at the Master Substation.

The total conventional construction is estimated at $31,000,000 (1989). The cost estimate includes contractor overhead and profit at 20%.

5.4 Engineering Design Inspection & Administration (EDIA)

EDIA and G&A are estimated at 16% of total costs. The basis of this percentage is the Fermilab TeV I project.

5.5 Other Project Costs (R&D, Pre-operating, Capital Equipment)

Specific R&D required to support the Main Injector is limited to the areas of the dipole magnet, the 8000 Amp/1000 Volt power supply, and the special short quadrupole magents required at the MI straight sections. Dipole magnets required for one sixth of ring (50 magnets), dipole tooling, two special quadrupole magnets and tooling, and two 8 MVA power supply will be constructed using R&D funds. Total estimated cost of this effort is $9100K including $5800K for the prototype dipole string, $200K for special quadrupole prototypes, $1700K for magnet tooling, and $1400K for the prototype power supply. It is estimated that approximately 20 man-years of effort are required for ED&I associated with the R&D program. These costs are included here as is a 37% G&A surcharge.

Pre-operating costs ($2000K) include the operation of the MI ring and beamlines during a six month commissioning period. Capital equipment required in support of R&D is estimated at 10% of R&D costs ($910K).

Table 5-1. Main Injector Cost Estimate
(Dollar amounts in thousands)

WBS	Description				Total
1.	MAIN INJECTOR CONSTRUCTION (TEC)				132300
1.1	Technical Components			48770	
.1	Main Injector Ring		33712		
.1	Magnets	18163			
.2	Vacuum	366			
.3	Power Supplies	3992			
.4	RF Systems	186			
.5	Aborts	71			
.6	Slow Extraction	17			
.7	Instrumentation	1040			
.8	Controls	365			
.9	Safety	329			
.10	Utilities & Install	9183			
.2	Beamlines		15055		
.1	Magnets	5318			
.2	Vacuum	294			
.3	Power Supplies	2458			
.4	Injection Systems	717			
.5	Extraction Systems	237			
.6	Instrumentation	743			
.7	Controls	446			
.8	Safety	269			
.9	Utilities & Install	4572			
1.2	Conventional Construction			31000	
.1	Site Preparation		4000		
.2	Ring Enclosure		10500		
.3	Beam Line Enclosures		4000		
.4	Generic Service Buildings		4000		
.5	RF/70 Service Building		1500		
.6	North Hatch Building		1500		
.7	Utilities & Services		1600		
.8	RF/F0 Enclosure		1400		
.9	RF/F0 Service Building		300		
.10	Booster, $\bar{p}$, and A0 Mods		600		
.11	AP0 Target Hall Mods		300		
.12	F15 Kicker Building		100		
.13	Landscaping & Paving		1200		
1.3	EDIA(15%)			11960	
1.4	Contingency(20%)			18350	
1.5	G&A (0.7%)			770	
1.6	Escalation			21450	
2.	OTHER PROJECT COSTS				12010
.1	R&D			9100	
.2	Pre-operating			2000	
.3	Capital Equipment			910	
	TOTAL PROJECT COST				144300

Table 5-2. Cost Estimate Labor Codes & Rates ($/hour)

Fabrication		
Technician, Conventional Magnets	T1	30.00*
Technician, Accelerator Division	T2	17.20
Shops, average capability	S1	33.00*
Shops, specialized/precision	S2	37.15
Installation		
Plumber, steam fitter, sheet metal	IP	32.00
Electrician	IE	36.00
Rigger, crane operator	IG	37.00
Laborer	IL	26.00
Technician	IT	17.20
EDIA		
Physicist	PH	31.30
Engineer	EN	30.10
Engineer, Construction Services	CE	38.00*
Designer/drafter	DC	30.00*
Drafter, Accelerator Division	DR	17.40
Programmer	PR	25.85

*Fermilab Service Center chargeback rates

Table 5-3. Total Labor Effort (Man-years)

Fabrication		
Technician, Conventional Magnets	T1	222
Technician, Accelerator Division	T2	7
Shops, average capability	S1	1
Shops, specialized/precision	S2	3
Installation		
Plumber, steam fitter, sheet metal	IP	3
Electrician	IE	47
Rigger, crane operator	IG	5
Laborer	IL	0
Technician	IT	33
EDIA		
Physicist	PH	33
Engineer	EN	42
Engineer, CES	CE	64
Designer/drafter	DC	33
Drafter, Accelerator Division	DR	61
Programmer	PR	1
Total		555

6. SCHEDULE

It is proposed that the Main Injector project be completed over the period October 1, 1989 through April 31, 1995. The schedule is shown in Figure 6-1. The period October 1, 1989 through September 30, 1990 will be devoted to R&D with preparatory engineering in support of construction beginning on October 1, 1990. The schedule shown reflects the spending profile given in the Schedule 44 (Appendix I) and the total manpower estimate shown in Table 5-3. The schedule results in a one year disruption to operation of the Tevatron. This disruption will occupy the entire calendar year of 1994. The schedule as shown is funding and manpower limited, and is based on the assumption that Fermilab will be engaged in the construction of a new superconducting 1.5 TeV accelerator during the same time period. In the event that the laboratory were not undertaking the simultaneous development of such an accelerator it is believed that the Main Injector could be completed approximately one year earlier.

A set of project milestones is given in Table 6-1. As can be seen the Main Injector ring and 8 GeV beamline can be largely installed without disturbing Tevatron operations. The length of the HEP shutdown is tied to the conventional construction in the area of FO. Overall downtime has been minimized by situating the Main Injector 10 meters away from FO so that commissioning can actually begin prior to completion of construction in this area. As currently envisioned priority would be given to installing and commissioning the 150 GeV proton and 120 GeV testbeam lines so that operations in a fixed target mode would be initiated following the shutdown. The 120 GeV $\bar{p}$ production line and 150 GeV $\bar{p}$ transfer line would then be commissioned during the fixed target run.

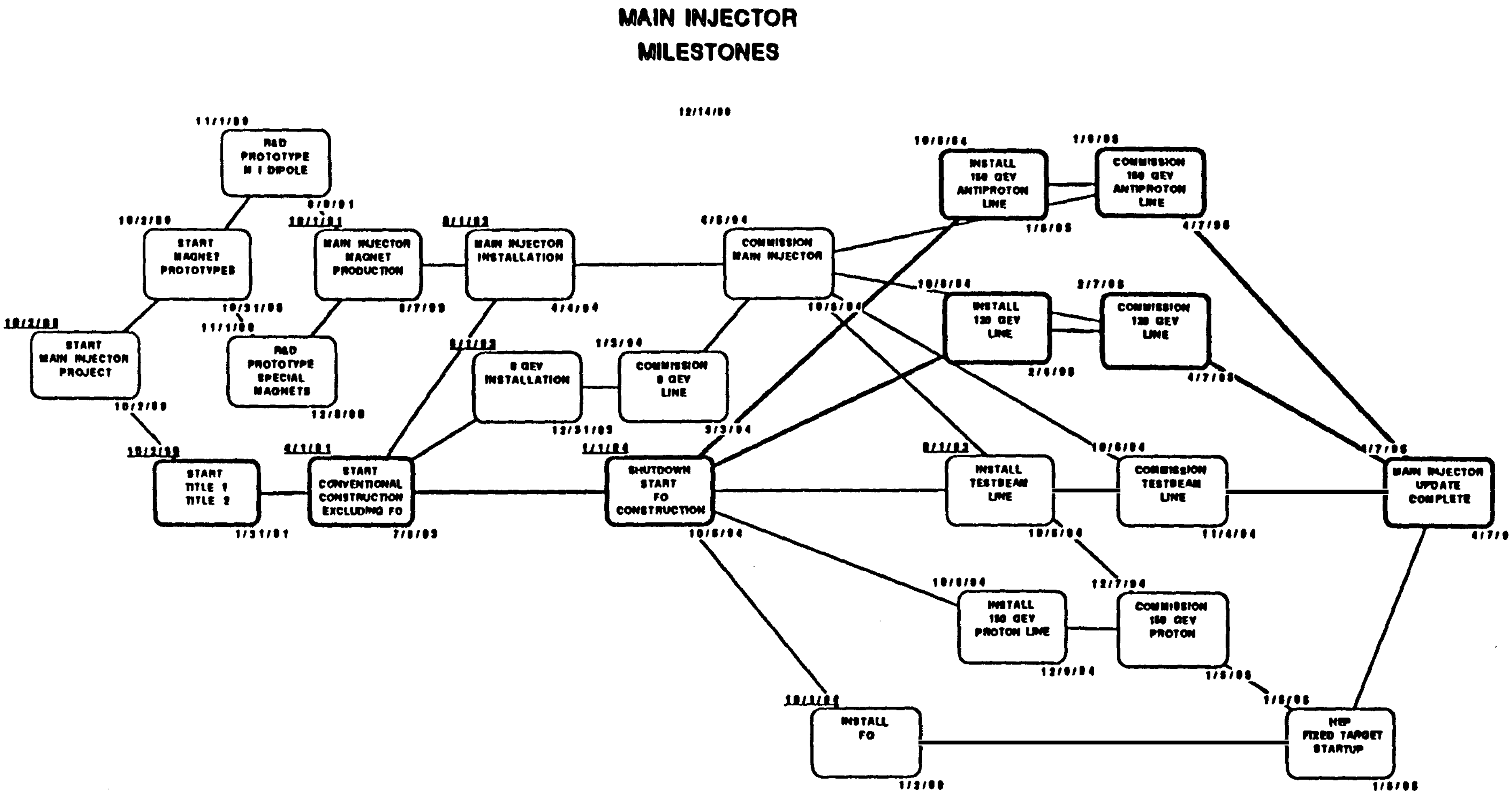

Figure 6-1: MI construction schedule.

Table 6-1. Major Project Milestones

	Milestone	Date	Description
1989			
	1	October 1	Start Magnet R&D
1990			
	2	October 1	Start Project
1991			
	3	April 1	Start Conventional Construction
	4	August 1	Complete Magnet Prototypes
	5	October 1	Start Magnet Production
1992			
1993			
	6	June 1	Beneficial Occupancy of 8 GeV Service Building and Enclosure. Start 8 GeV Installation.
	7	August 1	Beneficial Occupancy of all MI Service Buildings and Enclosure, and Testbeam Enclosures. Start MI, Testbeam Installation.
1994			
	8	January 1	Begin Tevatron Shutdown. Initiate FO Conventional Construction.
	9	April 1	Begin Commissioning MI Ring.
	10	October 1	Complete FO Construction. Begin Testbeam Commissioning. Start installation of 150 GeV and 120 GeV lines.
	11	December 1	Commission 150 GeV proton line.
1995			
	12	January 1	MI, 150 GeV proton and Testbeam lines operational. Fixed Target HEP Startup. Begin commissioning 150 GeV antiproton line.
	13	February 1	Begin commissioning 120 GeV line.
	14	May 1	Commissioning complete. Project Complete.

APPENDIX A

Schedule 44

DEPARTMENT OF ENERGY
GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
FY 1991 BUDGET REQUEST
(TABULAR DOLLARS IN THOUSANDS. NARRATIVE MATERIAL IN WHOLE DOLLARS.)
CONSTRUCTION PROJECT DATA SHEETS

CHICAGO OPERATIONS
Field Office

HIGH ENERGY PHYSICS
FERMI NATIONAL ACCELERATOR

1. Title and location of Project:
Fermilab Upgrade: Main Injector
Fermi National Accelerator Laboratory, Batavia, Illinois

2. Project No. 91-CH-400

3. Date A-E work initiated: 1st Quarter FY 1991

3a. Date physical construction starts: 2nd Quarter FY 1991

4. Date construction ends: 3rd Quarter FY 1995

5. Previous cost estimate: None

6. Current cost estimate: $132,300

Date: January 12, 1989

7. Financial Schedule:

Fiscal Year	Authorization	Appropriation	Obligation	Costs
1991	$132,300	$30,000	$30,000	$25,000
1992		34,000	34,000	30,000
1993		34,000	34,000	35,000
1994		32,000	32,000	38,000
1995		2,300	2,300	4,300
Total	$132,300	$132,300	$132,300	$132,300

8. Brief Physical Description of Project

This project provides for the construction of a new accelerator, designated the Main Injector, in support of the Fermilab Collider Upgrade. The accelerator is about 3.3 km meters in circumference and is capable of accelerating protons to 150 GeV. It is constructed entirely using conventional iron core magnets. Also provided are five new beamlines required to tie the Main Injector onto the existing accelerator complex and to provide slow extracted beam to the AØ Transfer Hall, from where it can be directed toward the fixed target areas. The accelerator will recycle many technical components from the existing Main Ring including quadrupole magnets, some power supplies and correction magnets, RF systems, some controls components, and diagnostic devices. Following commissioning of the Main Injector operation of the Main Ring will cease.

9. <u>Purpose, Justification of Need for, and Scope of Project</u>

The immediate purpose of this project is to increase the the luminosity available at the Fermilab Proton-Antiproton Collider, to improve data collection efficiency in the CDF and DO detectors through removal of the Main Ring, to increase the number of protons which can be delivered to the Tevatron for acceleration and delivery to the (fixed target) experimental areas, and to provide 120 GeV protons to the experimental areas.

The Fermilab Proton-Antiproton Collider is presently running with a luminosity 50% higher than the design value. The primary programatic goal at Fermilab is to increase the luminosity delivered to the experimental detectors by at least a factor of ten over the next six years. Increasing the luminosity is intimately related to increasing the number of antiprotons available. Measures are currently being taken to increase the antiproton production rate by a factor of ~3. However, following implementation of these improvements the Main Ring will remain the primary bottleneck restricting further production rate improvements. The Main Injector is designed to remove this bottleneck.

Substantially improved performance, relative to the Main Ring, is expected to result from the improved aperture of the Main Injector and the decreased cycle time. Protons are presently delivered to the Main Ring, and will be delivered to the Main Injector, from the 8 GeV Booster. This machine currently has an aperture which is significantly larger than that of the Main Ring, hence the bottleneck. The aperture of the Main Injector is designed to be 30% larger than the aperture of the 8 GeV Booster while the Main Ring aperture is currently 65% that of the Booster. The improvement arises from tighter focussing, improved field quality, and the elimination of overpasses. It is anticipated that the Main Injector will be capable of accelerating as much as $3x10^{13}$ protons when filled with six Booster batches. For antiproton production, the ring is designed to cycle to 120 GeV at 1.5 seconds as compared to 2.6 seconds in the existing Main Ring. As a result we expect the total number of protons per cycle deliverable from the Main Injector to be up to a factor of three higher, and the number of protons per second deliverable to the antiproton production target could be as great as a factor of 5 higher than is achieved from the present Main Ring operation.

Specifically provided for in the scope of the project are:

a. Construction of the enclosure (~11,000 linear feet), service buildings (~33,000 square feet), utilities, and new technical components required to implement the Main Injector accelerator. New technical components required include dipole magnets, power supplies, and vacuum systems.

b. Construction of beamline enclosures (~3,200 linear feet), service buildings (~6,300 square feet), utilites, and technical components required to implement the 8 GeV Booster-to-Main Injector beamline, the 150 GeV proton and antiproton Main Injector-to-Tevatron transfer lines, and the 120 GeV Main Injector-to-antiproton production target beamline.

c. Construction of beamline enclosures (~3,000 linear feet), utilities, and technical components required to implement the delivery of 120 GeV beam from the Main Injector to the AØ Transfer Hall.

d. Construction modifications to the FO area of the Tevatron required for installation of the 150 GeV proton and antiproton transfers.

10. Details of Cost Estimate

	Item Cost	Total Cost
a. EDI&A at 16% of construction costs		$15,100
b. Main Injector construction costs		95,200
1. Conventional construction	$37,000	
2. Special facilities	58,200	
c. Contingency at 20% of above cost		22,000
Total		$132,300

11. Method of Performance

Design of facilities will be by the operating contractor and subcontractors as appropriate. To the extent feasible construction and procurement will be accomplished by fixed-price contracts awarded on the basis of competitive bids.

12. Schedule of Project Funding and Other Related Funding Requirements

	FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	TOTAL
a. Total project cost							
1. Total facility costs							
(a) Construction line item	$0	$25,000	$30,000	$35,000	$38,000	$ 4,300	$132,300
Total facility cost	$0	$25,000	$30,000	$35,000	$38,000	$ 4,300	$132,300
2. Other project costs							
(a) Direct R&D costs necessary to complete construction	$1,000	$3,000	$3,000	$2,100	$0	$0	$9,100
(b) Pre-operating costs	$0	$0	$0	$0	$1300	$700	$2,000
(c) Capital equipment	$100	$300	$300	$200	$0	$0	$900
Total other project costs	$1,100	$3,300	$3,300	$2,300	$1,300	$700	$12,000*
Total project costs	$1,100	$28,300	$33,300	$37,300	$39,300	$5,000	$144,300

*G&A included where appropriate

b. Total related incremental annual funding requirements (estimated life of project: 20 years)

1. Facility operating costs for Main Injector Power	$1,700
2. Facility operating costs for 120-GeV beamline operation	$1,000
Total incremental annual funding	$2,700

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements

a. Total project costs
   1. Total facility cost
      (a) Construction line item - explained in items 8, 9, 10.
   2. Other project costs
      (a) Direct R&D operating costs - This will provide for the design and development of critical new components and for the fabrication and testing of prototypes. R&D on all elements of the project to optimize performance and minimize costs will continue through early stages of the project. Specifically included are development of the high current dipole magnet/power supply system and special length quadrupoles required in the Main Injector and beamlines. A subsection of the ring technical components will be developed and installed on R&D in order to assure complete system development prior to cessation of Main Ring operations.
      (b) Pre-operating costs - Includes personnel and power costs for a six month commissioning period.
      (c) Capital equipment - Includes test instruments, electronics, and other general equipment to support 12.1.1.(a) and (b).

b. Total incremental funding requirements - It is assumed that the Fermilab complex will continue to operate both the fixed target and collider programs, with each running about 40% of the time. It is further assumed that during collider runs the Main Injector is supplying 120 GeV test beams to the experimental areas for shakedown of fixed target detectors. The Main Injector replaces the existing Main Ring in all its functional roles. The Main Injector and associated beamlines are designed to require almost the same amount of power to operate as the existing Main Ring for Tevatron fixed target and collider operation. Hence we expect only small incremental cost for power during standard collider operation and no increase during normal fixed target operation. For 120 GeV operation of the Main Injector for external beams there will be an increase for power of ~$1.7M annually, assuming 40% operation. The beamlines will require supplemental funding for M&S and personnel for the 120 GeV operation. This is estimated to be an additional $1M increment annually. We also assume that the Main Injector will require AIP funding at the same level as the existing Main Ring. The increase in operating costs in 12.b reflects soley the demands of delivering 120 GeV protons to the experimental areas during collider runs.

14. Incorporation of Fallout Shelters in Future Federal Buildings

Not applicable.

15. Incorporation of Measure for the Prevention, Control, and Abatement of Air and Water Pollution at Federal Facilities.

The total estimated cost of this project includes the cost of those measures necessary to assure the facility will comply with Executive Order 12088.

16. Evaluation of Flood Hazard

This project will be located in the area of Indian Creek. Construction will be in accordance with the requirements of Executive Order 11988.

17. Environmental Impact

This project is in compliance with the National Environmental Policy Act.

18. Accessibility to the Handicapped

Not applicable.

APPENDIX B

Project Basic Data and Validation Checklist

PROJECT BASIC DATA
for
FY91 VALIDATIONS

Program:	High Energy Physics/ Fermi National Accelerator	Status of Design:
		Conceptual - 100%
Project:	Fermilab Collider Upgrade: Main Injector	Title I - 0%
		Title II - 0%
Project No:	______ 91-CH-400	
(Program Office Assigned number only, if available)		

TEC:

The TEC is $132M
ED&I is 13.6% of Construction Cost
(Excluding construction management and project management at 2.2% and 2.2%)
Contingency: 20% of Design and Construction Cost.

Project Description and Background:

This project provides for the construction and installation of a new Main Injector Accelerator to replace the 150 GeV Fermilab Main Ring conventional accelerator. The purpose of the project is to increase collider luminosity, to increase fixed target intensity, improve collider detector performance by the removal of a major source of background, and to provide a fixed target test beam at approximately 120 GeV during collider operation. An additional possible benefit is a future high duty factor Kaon production capability. A new tunnel for the 150 GeV Main Injector, with associated beamlines, extraction systems and an abort system will be constructed adjacent to the existing Tevatron Tunnel.

About 17,200 ft of tunnel and 39,300 (net 30,600) sq ft of service building will be constructed. Technical components for the Main Injector and the beamlines and beam transfers include conventional magnets and accelerator components. Some reuse of technical components from the existing Main Ring is included in the design of the Main Injector and extracted beam lines. The project includes building and tunnel construction, standard and accelerator utilities, and new conventional magnets, expecially the main bending dipoles for the Main Injector.

FY91 Budget Authority (B/A):

The request is for $30M for FY91.
This request is to cover initial procurement for long term magnet and accelerator systems components for the conventional Main Injector accelerator.

This request also covers authority to release the bid package for the Main Injector, site prep, beam enclosures, and service buildings, and to start site prep construction.

The FY90 request was $0M; prior year funding was $0M.

Technical/R&D:

There is no particularly unusual construction in the beamlines and Main Injector. The Main Injector dipoles are a new, conventional, design however, and

R&D will be carried out to obtain tooling and to prototype the new magnets and accelerator components. The Main Injector and the beamlines make extensive use of existing accelerator magnets and technical components.

Additional R&D costs are associated with power supplies for the new high current main dipoles and special length quadrupoles.

The risk of this project is low for a project of this type. The Fermilab staff is experienced in all aspects of this project; it is similar to the recently completed TeV I project in technical scope and detail.

Schedule:

Title I design start scheduled 1QFY91.
Title I and II design duration: 36 months (?) total.
Procurement and construction start scheduled:
1QFY91, 3QFY91.
Procurement and construction complete: 3QFY95 (?)

Status of Documentation: (For major projects and major systems acquisitions only)

Justification for New Start:	Approved __/__/__	(mm/dd/yy)
Project charter:	Approved __/__/__	(mm/dd/yy)
Project Plan:	Approved __/__/__	(mm/dd/yy)

Additional Information:

Environmental Assessment may be required.

(State programmatic and budgetary constraints.)

Contingency factor used is 20%. This is an overall factor and has not yet been split for varying degrees of certainty in the different components of the work breakdown structure. This overall contingency is appropriate for the present level of the conceptual design. As the design continues, it will probably become appropriate to allocate varying contingency factors as certainties become better determined.

FY91 FERMILAB COLLIDER UPGRADE: MAIN INJECTOR

PROJECT VALIDATION CHECKLIST

I. OBJECTIVES

Fermilab Collider Upgrade: Main Injector project objectives and performance parameters have been developed to support the programmatic needs and goals of the laboratory. These have been defined in the light of much experience and a number of studies which have been made to understand the current limitations of the accelerator and how to improve the performance of the accelerator in order to support the High Energy Physics program in future years. Additional information has been supplied to the Validation Review Committee.

II. SCOPE

A. REQUIREMENTS

1. Facility Performance Requirements

Fermilab has kept both the High Energy Physics Program Office and the Batavia Area Office fully informed of the goals for the Fermilab Collider Upgrade: Main Injector and the improvements expected. There is a mutual understanding of the programmatic needs for the Fermilab Collider Upgrade: Main Injector project.

2. Facility Requirements

The general requirements for the facility both in terms of real property, buildings and hardware have been defined at the conceptual level of design. Materials documenting these requirements have been distributed to the Validation Review Committee.

3. Evaluation of Seismic and Tornado Hazards

The total estimated cost of the project includes the cost of those measures necessary to assure the facility will comply with DOE 6430.1. The project is located in an area of low seismic and tornado activity. The site is equipped with a tornado warning system. The underground enclosures will provide an adequate tornado shelter area.

4. Safeguards and Security Requirements

Advice and guidance from cognizant safeguards and security personnel will be utilized during the project planning and design stages. Any radiation hazards that are know to exist will be treated in the same manner as the hazards are now treated in the present operating complex under Accelerator

.Division control. The facility does not involve items of a classified nature. Physical security will be provided in the same manner as that currently existing in the accelerator facility.

5. Location

Location is determined, to a large extent, by the existing beam lines and accelerator enclosures and technical requirements. Basically, three alternative locations were considered. The area selected best fits both the technical requirements and provides the best site from a civil engineering perspective. The project is in compliance with the overall Site Development and Facilities Utilization Plan. Land acquisition is not required.

6. Function Definitions

Functions of all major structures, systems and components are defined to the extent appropriate for a conceptual design.

7. Matching of Exiting Facilities to Demands

To the largest extent possible, available utilities, roads and accesses and other support facilities will be used. In particular, extensive use will be made in the Main Injector of utilities relocated from the present Main Ring, such as transformers, and heat exchangers, as well as some of the technical components.

8. Initial Complement of Equipment

The requirements for the initial complement of equipment have been defined. Cost estimates have been made based on similar equipment installed at Fermilab.

9. Quality Levels and Program Requirements

The quality levels and program requirements have been defined by many years of operation of the present facility. The levels and requirements have been incorporated into the conceptual design and cost estimate.

10. Emissions and Wastes

Emissions and wastes will be no different than those occurring in the presently operating accelerator. Total compliance with Federal and State emission and waste regulations will not be a problem.

11. Codes and Standards

The facility will operate within applicable local, state and national codes and standards.

12. Office space

Office space is not required for this project.

13. Space Requirements

Space for tunnel and equipment enclosures is in addition to current space. Where possible current equipment and tunnel enclosures will be utilized.

At the F0 (RF) straight section part of the rf building must be demolished in order to construct the modified tunnel enclosure at the injection point for 150 GeV protons and antiprotons to be delivered from the Main Injector to the Tevatron. Also, beamlines carrying 120 Gev protons to the antiproton target at AP-0 and to the Test Beam Line, and 8 GeV antiprotons from the Accumulator to the Main Injector traverse this region. When completed, two connected buildings, the rebuilt F0 rf building and a Main Injector Service Building MI-70 will house the rf systems for accelerators in both enclosures, and also beam transfer and extraction equipment for equipment to be located in the F0 and MI-70 locations in the respective tunnels.

B. Design (Conceptual)

1. Design Status

All designs, at this point, are at the conceptual level. Studies have been made based upon current experience, and general civil engineering practices. All major items have been scoped. The scope has been well defined from the programmatic requirements of the Laboratory. The Fermilab Collider Upgrade: Main Injector project has been included in the current Fermilab Site Development and Facility Utilization Plans. The schedule has been developed using time estimates based on similar work performed at Fermilab on projects of comparable nature. The Main Injector involves the construction of some new components and the relocation of some existing Main Ring components, and is similar in nature to numerous modifications made to the Main Ring in recent years. The Main Injector dipoles will be designed and prototyped starting in FY90. This work is similar to the production of conventional magnets for the Antiproton Source. Cost and schedule projections are based heavily on similar recent experience.

2. Site Conditions

Soil borings are available for areas in close proximity to the site considered. Recent nearby construction experience (TeV I) has been used to prepare cost estimates.

3. Safety hazards and Risks

Hazards and risks are characteristic of those already encountered in the accelerator complex and its construction. No new unique hazards are expected.

4. Solar Energy Applications

Solar energy applications were considered but no application was found to be appropriate.

5. Design Cost Effectiveness

The design is cost effective at a conceptual design level. Further studies to minimize cost and lifecycle costs will be carried out in parallel with the Title I design. In particular, specific attention will be paid to the design of the area where the proton and antiproton injection lines into the Tevatron from the Main Injector connect to the Tevatron at F0. Optimization of beam transport line design will also continue.

6. Environmental Assessment

The environment surrounding the proposed construction site has been characterized to the extent that the entire Laboratory site is characterized. Topology and hydrology are documented. The impact of the proposed facility on the environment will be no different from the existing facility; no unique hazards are expected. To be noted is the flow of Indian Creek through the proposed site of the Main Injector, and the heron rookery located inside the Main Injector Ring. Care will be taken to provide proper creek drainage and to avoid disturbing the herons during the breeding season.

7. Prerequisite R&D

The necessary R&D required to design and specify the basic system has been done. Additional R&D is in progress to refine the design. R&D will be required to work out detailed designs and to support prototype fabrication of the Main Injector main dipoles and of special components. These activities will continue to help refine the requirements that are necessary for specifying and accomplishing the construction of special facilities.

Some R&D may be necessary to support fabrication of the Main Injector main dipoles in quantity after prototyping is complete. A schedule for all the required R&D costs so far identified has been provided in the project data sheets. R&D funding will be required for detailed design, tooling, prototype fabrication, and production development for the Main Injector main dipoles and other necessary special components.

8. Participants

The conceptual designs presented to the Validation Review Committee have been prepared by Fermilab staff members. In particular, members of the Accelerator Division, Technical Support Section, and Construction Engineering Services have participated.

9. Uncertainties.

The Main Injector main dipole magnets are conventional, not superconducting, magnets. Their fabrication should be similar to recently constructed TeV I magnets. The civil construction techniques are similar to previous work on the Fermilab site. Thus, there are no unique aspects to this proposal. The 8,000 Ampere power supplies necessary for the Main Injector dipole bend bus might be classified as unusual, but are not regarded as technically unique.

10. Energy Conservation Report

An Energy Conservation Report will be prepared during Title I/II.

III. Schedule

All of the following factors have been considered at a depth appropriate at this conceptual design level in developing the schedule.

- budget cycle timing
- contractor selection duration
- Headquarters review and approvals
- prerequisite R&D schedule constraints
- dependency upon timing and amount of operating funds
- historical experience on design, procurement, and construction durations
- procurement lead times for equipment (particularly reflecting vendor quotes)
- logical sequence of design, procurement, and construction
- reasonable manpower levels, buildup and rampdown
- reasonable obligation and costing rates
- shift work or overtime work requirements
- work space constraints
- exposure constraints

The construction schedule falls into two distinct phases. In the first phase, the large majority, if not all, of the Main Injector main dipoles will be fabricated, and the entire Main Injector ring tunnel enclosure constructed, as well as most of the beam transport lines. This conventional construction will include all of the

Main Injector above ground facilities as well, with the exception of the work on the Tevatron side at FO. As occupancy becomes possible, the main dipoles may be set in place in the Main Injector. During this phase the fabrication of the new main dipoles will be the critical path.

During the above first phase, the existing accelerator complex will be maintained fully operational.

During the second phase the accelerator complex will be shut down. Civil construction of the FO tunnel enclosure, following demolition and removal of the existing enclosure, will be the critical path item. Main dipole fabrication will conclude, and installation of the main dipoles will be completed. Civil construction of those portions of the beam transport lines left unfinished in the first phase will be undertaken and completed. Installation of technical components to be removed from the existing Main Ring conventional accelerator can proceed in parallel in the Main Injector tunnel enclosure and Service Buildings. Reinstallation of components in the Tevatron FO area, and the completion of installation of components in the connecting and adjacent beam transport lines must await completion of the conventional construction. Since the Main Injector itself can be operated entirely within the new Main Injector tunnel enclosure, commissioning of the Main Injector can begin upon completion of installation of Main Injector components but prior to completion of the Tevatron FO reinstallation.

IV. Estimate

A. General

1. Estimate Preparation

The estimates presented were prepared in December 1988. The cost estimate is done in FY89 base year dollars with the escalation shown in "year of expenditure" dollars.

2. Estimate Basis

Estimates are based upon conceptual design layouts, preliminary engineering calculations, and experience with similar projects done at Fermilab. Our recent experience with the TeV I construction project forms the basis for a large fraction of the cost estimate for this project. For construction, estimates are based on quantity takeoffs where available and square foot estimates. Cost comparisons have been made with specific portions of recent similar Fermilab construction such as Transfer Hall Addition, Booster Laboratories, Industrial Center Building, and several of the Tevatron I and II buildings. The cost estimate methodology is adapted from that used to estimate the Superconducting Super Collider (SSC) Injection System as incorporated into the SSC conceptual Design Report. Manpower estimates where appropriate have been derived from the TeV I project, and recent experience (1988) on modification and reinstallation of Main Ring components has also been considered.

3. Support of Estimates

Vendor quotes are not appropriate at the conceptual level for this design. Catalogue prices have been used for components where appropriate. Manpower rates are based on present Fermilab Accelerator tech experience, Fermi chargeback rates, or T&M trade rates. Commercially published construction data bases such as R. S. Means, have been used very successfully at Fermilab for cost estimation.

4. Contingency

The contingency reflects the degree of confidence in the scope of work, development features, pricing methodology, and complexity of the project. The contingency analysis provides for but does not presently utilize varying degree of uncertainty in the different components of the Work Breakdown Structure.

5. Escalation Rates

Escalation rates provided by DOE were used. The most recent information obtainable was dated August 1988.

6. Project Reviews

This is the first cost estimate submitted to DOE for this project and is a bottoms up estimate. It has been reviewed by knowledgeable Fermilab staff and management.

7. Uniqueness

The technical components and civil construction are similar to work that has already been done at Fermilab and are therefore not unique. The 8000 Ampere power supplies for the Main Injector dipole bus are unusual, however.

8. Estimating Guides

Conventional construction items and standard equipment estimates were made using standard estimating guides. Square foot estimating data available from commercial publishers (Means & Richardson) have been used where applicable.

9. Indirect Costs

All known indirect costs have been included in the estimate.

10. Title I/Title II Estimates

Not applicable.

11. Experimental Components

Experimental detector improvement costs are not included in the estimate. Detector upgrades are usually incorporated in the ongoing laboratory capital equipment expenditure profile.

12. Procurement Strategy

To the extent feasible, construction and procurement will be accomplished by fixed-price contracts awarded on the basis of competitive bids. As presently planned, final magnet assembly will take place at Fermilab, as in the case of the TeV I project.

B. Construction

1. Bulk Materials

Both engineering drawings and past experience were used to estimate the bulk material quantities.

2. Quantity Growth

Normal estimating methods for conceptual estimates allow for quantity growth.

3. Bulk Material Pricing

The bulk material costs are current and reflect local conditions.

4. Labor Costs

Labor estimates are based on (Davis-Bacon) local rates where applicable and at actual average rate for component fabrication and include applicable fringe and other hidden costs. Costs have been derived from the Tevatron I Project. The local labor market has critical skill construction labor available.

5. Equipment Pricing

Equipment Pricing is based upon actual experience in the Tevatron I Project, other Fermilab construction, and on commercially published cost data.

6. Special Process Spares

Not applicable.

7. Indirect Costs

Indirect construction costs have been included.

8. Labor Productivity

·Labor productivity is based on much local experience.

9. Labor Availability

All necessary craft labor is available in the Chicago area.

10. Pricing variants

To the extent required for the conceptual design, the cost estimate reflects code, QA, scheduling, climatic, geographic, and other unique specification requirements.

11. Unitized Pricing

Not applicable.

C. Engineering and Management

1. Contractor Project Management

Contractor project management and engineering costs are included in the EDIA.

2. EDIA Estimate

EDIA costs are estimated at the same percentage of construction costs as those for the recently completed Tevatron I Project at Fermilab.

3. Inspection

Inspection, QA, and QC costs have been included. Magnetic measurements and magnet assembly inspection are provided in the laboratory through G&A.

4. Management

FNAL has considerable experience with Program Management Control systems as used in TeV I and II. We consider the management system responsible for this activity to be mature and reasonable. Adequate personnel will be made available.

V. Funding and Costs Status

1. Basis for the Planned Authorization, Appropriation, and Cost Schedule.

The programmatic goal of the Fermilab Collider Upgrade: Main Injector project is to achieve an improvement in Collider luminosity, an improvement in Fixed Target intensity, and to provide for the operation of test beams in approximately one half of the fixed target areas during Collider operation. This goal has been set by the demands of the physics experimental program. Increased luminosity in the mid 1990's time scale is crucial to productive utilization of the Tevatron. This increased potential is necessary for a viable national high energy physics program in the pre-SSC era. The test beam capability is vital to the development of detector technology for the SSC era. The authorization of the proposal at the earliest possible time is urged. The appropriation and obligation schedule is predicated on issuing the long-lead contracts at the earliest possible time. The costing is based on an estimate of the effort done as a function of time. The schedule calls for a shutdown of the order of one year for moving those Main Ring components to be reused into the Main Injector, and to accomplish the civil construction in the FO area. In order for this shutdown to be utilized effectively all the civil construction for the Main Injector Ring and almost all of the beam transport line civil construction, and almost all of the Main Injector main dipoles must be complete prior to the shutdown. Thus, the significant fraction of funding is required prior to shutdown. Any delay in authorization or appropriation will result in extending the time to operation.

2. Other Associated Project Costs

Other associated project costs include $ 12M R&D, preoperation, and capital equipment costs. When the project is complete there is expected to be a related annual funding increase for operating and improvement costs. These include cryogenic (in the test beams) and power costs, personnel and M&S costs totaling $ 2.7M, of which $ 1.0M is directly related to the operation of the test beam in the fixed target area. It is estimated that no additional people will be required to maintain and operate the facility.

3. Funding Consistency

The annual funding proposed is consistent with the project schedule. The schedule has been developed on the basis of a preliminary Critical Path Network (CPN). The CPN will be revised, updated, and expanded as the R&D, design, and project advances.

4. Continuing Resolution Alternatives

In the event of a continuing resolution, the project will be delayed proportionally.

5. Contributing Funding

External contributory funding is not considered for this project.

6. Incrementally Funded Construction Contracts

None.

7. Funding by Client or Consultant Agencies

Not applicable.

APPENDIX C

Environmental and Shielding Considerations

C. ENVIRONMENTAL AND SHIELDING CONSIDERATIONS

C.1 Environment

The proposed construction of the MI lies in approximately 400 acres southwest of the existing Main Ring tunnel, between the FO building and the site boundary. Access to the construction project will be via the existing Kautz Road. No adverse environmental impact is foreseen as a result of this project. Efforts will be made throughout the construction period to protect and enhance the local conditions. In the future, the need for an environmental assessment or impact statement as outlined in the NEPA requirements will be reviewed.

The area is a floodplain fed by Indian Creek, which originates on the Fermilab site and gives rise to a wetland region encircled by the proposed ring. There is a heron colony which is located in a wetland region completely encircled by trees. The great blue heron is not an endangered or protected species. The construction will come no closer than 100 m to the heron rookery. The herons are in residence April through August; efforts will be made to schedule construction to avoid this time interval. The tree cover directly in the path of the tunnel, roads, and cooling ponds represents a small percentage of the total tree cover in the region. The affected wooded areas are previously disturbed regions of young immature trees and do not need to be avoided. The higher quality forested regions will be undisturbed and protected from construction traffic and debris.

The tunnel with its underdrain system will affect the water levels inside the ring. The wetland character of the site is maintained by Indian Creek and the floodplain nature of the sheet drainage in this area. In order to maintain the features of the water flow an active drainage system to allow active control of the water level will be installed. Changes of water levels over a long time period affect the area; the dead trees in the rookery are the result of such changes. The ability to control the water level will ensure that existing flow patterns will be maintained inside and outside the ring. The project will add approximately 16 acres of surface water through the cooling pond system.

The construction goes through prairie plot #12. At the present time this plot does not contain any threatened or endangered plant species. Fifty acres of corn leases lie inside the proposed ring. These leases will be retired and the area could be used to enhance the prairie project acreage.

The construction area contains no known archaeological sites; however, some of the land adjacent to Indian Creek has not been surveyed. A study of this region will be completed by the end of 1988. There is sufficient time available in the schedule to allow any new sites uncovered by this survey to be examined, if desired. The Lorentz site does lie within the new ring but will be unaffected by the construction. Any topsoil disturbed by the construction will be replaced, graded, and reseeded as part of the project. The visual impact of the project will be minimal. The highest item will be the tunnel berm, which is not expected to exceed 20 ft. Existing vegetation next to the bicycle path will be augmented to reduce the visual impact and restrict access.

C.2 Shielding

Calculations of radiation dose near the tunnel are mode for two conditions: when beam is lost on the magnets, and when it is dumped intentionally. The dose is estimated both on the surface of the earth berm covering the tunnel and at the site boundary at the point of closest approach (approximately 75 m) to the MI. These represent the expected maximum exposure conditions respectively for Fermilab personnel (in areas of unrestricted access) and the general public. A constant berm thickness of 17 ft, corresponding to that of the present Main Ring, is assumed. For each location estimates are made assuming two beam loss scenarios: an integrated dose when the full beam is lost accidentally at one point, and a dose rate (rem/year) under normal operating conditions. The dose rate in the vicinity of the abort dump (sec. 2.10) is also investigated. It is convenient to treat hadron dose separately from muon dose. The dose per proton lost is calculated using the Monte Carlo code CASIM.[1] The result is then converted, assuming certain loss mechanisms and loss rates, to a give a final estimate of dose.

CASIM results compare well with dose measurements for a variety of hadron and muon shielding arrangements under known beam loss conditions. The tunnel geometry in CASIM consists of a close approximation to a continuous dipole centered in a 1.5 m radius tunnel of circular cross section. The arc radius of the tunnel is 400 m and the continuous dipole field is chosen at 1.25 Tesla so as to accommodate 150 GeV protons in the aperture. The field outside the dipole gap is supplied numerically. The tunnel is completely and uniformly surrounded by soil with a (Fermilab standard) density of 2.24 g/cm^3.

The operating scenario assumes either a 150 GeV ramp at a 3 sec cycle with an operating intensity of 3×10^{13} protons per pulse, or a 120 GeV ramp at a 1.5 sec cycle with 4×10^{12} protons per pulse. These cycle times represent the fastest possible rates. The MI is assumed to run 60% of the time, divided equally between 150 GeV and 120 GeV operation. Under these conditions, about 1.2×10^{20} protons are accelerated per year. For the worst case accidental loss scenario the full 150 GeV beam is assumed lost at one point in the ring for 10 successive machine cycles (i.e., 3×10^{14} protons). To establish dose rates under normal operation it is assumed that each cycle loses 20% of the protons at low energy (8-20 GeV) and 1% at high energy (120 or 150 GeV), spread uniformly around the ring. The low energy losses are anticipated to occur but no measurable beam loss is expected at high energy. The 1% figure is strictly for the purpose of establishing safety criteria and should be regarded as an upper limit.

Hadron Dose

A loss point is assumed to occur in the middle of the beampipe. Since the hadron dose in the soil is mainly due to neutrons, it is quite insensitive to the lateral position of the loss point within the beampipe. For the same reason it is acceptable to average the dose over the tunnel azimuth. Figures

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1. A. Van Ginneken, Fermilab publication FN-272 (1985).

C-1 and C-2 show isodose contours due to hadrons in the soil outside the tunnel for injection and high energy, respectively. The abscissa is the distance along the tunnel arc from the loss point. The curves are normalized to a single proton lost.

For the accidental loss scenario Figures C-1 and C-2 predict an exposure of about 3 mR at the surface of the berm. Fermilab radiation criteria require this area to be defined as minimal occupancy, i.e., unrestricted but no continual occupancy (equipment but not offices). Clearly, there is no intention of constructing any permanently occupied buildings directly on top of the berm. Further from the berm, the dose diminishes at least as fast as the inverse of the distance from the loss point, so that at about 60 ft from the berm the dose falls below the level where minimal occupancy regulations apply (1 mR). At the site boundary (about 75 m), the dose from such accidental losses is reduced further by at least a factor of four. Under the scenario for routine operation the annual exposure rate at the surface of the berm is 50 mR/year from 150 GeV beam and 250 mR/year from lower energies. The combined value is below the 500 mR/year limit for permanent occupancy. Since the distance of closest approach to the site boundary is reasonably small compared to the dimensions of the MI it is acceptable to use 1/r scaling which extrapolates to an off-site dose rate of 20 mR/year due to routine operation. Because of the relatively short distance, the surrounding air can be ignored in calculating the maximum off-site dose rate.

<u>Muon Dose</u>

For a circular ring the muon dose is maximum close to a line tangent to the loss point. Averaging over azimuth is no longer justified since the worst muon penetration is expected in the median plane, though up-down symmetry still holds. Beam loss on the inside of the beampipe produces a larger muon flux by providing a relatively long pion decay length along the tangent inside the beampipe.

Figures C-3 and C-4 show isodose contours in the median plane for beam loss on the radial inside and radial outside of the beampipe, respectively. Because the ring elevation is between 10 ft and 20 ft below grade, the isodose contours of Figures C-5 and C-6, which represent averages over top and bottom quadrants, are more relevant in calculating muon dose rates at the surface. Since 8 GeV muons range out in less than 20 m, only the high energy component warrants consideration. Under the worst case loss condition the highest muon dose is only 0.3 mR and occurs about 70 m downstream of the loss point, where the berm meets grade level (assumed to be 10 ft above the center of the tunnel). The average exposure rate during routine operation at the surface of the berm is also small and amounts to approximately 12 mR/year. The dose at the site boundary is estimated at 0.3 mR for the worst case scenario and at 10 mR per year for routine operation. Clearly muons do not pose a problem.

<u>Abort Dump</u>

The abort dump described in Section 2-10 is patterned after the dump currently in use in the Tevatron/Main Ring complex. The trajectory of the beam line to the dump slants downward by 10 mrad, which results in 6 m of soil coverage at the dump location from the existing grade level. The maximum number of protons accelerated per year in the MI is expected to be about 2.5 times the number typical for the Main Ring. This means that approximately

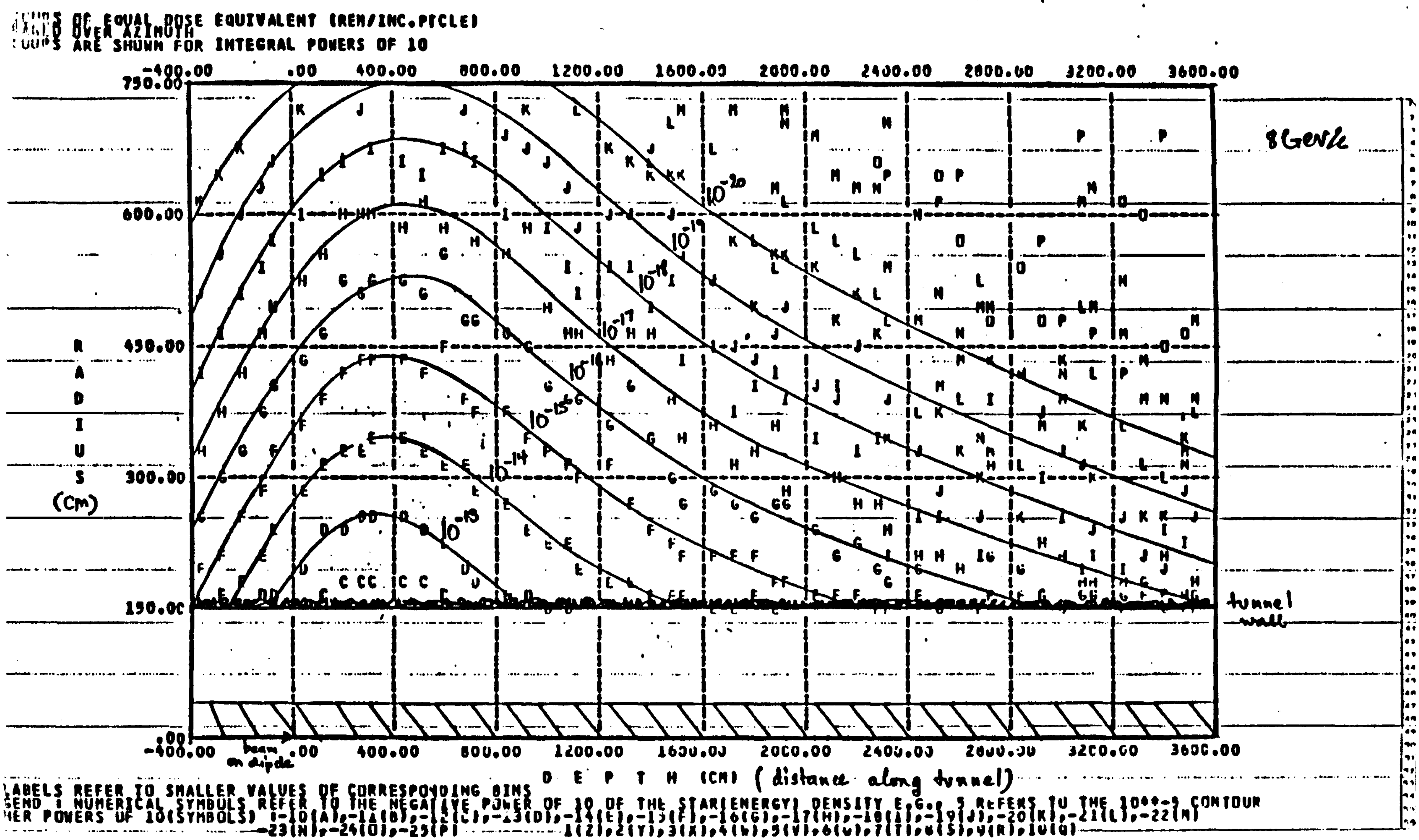


Figure C-1: Isodose contours due to hadrons in the MI berm per 8.9 GeV/c proton lost. All distances are in centimeters.

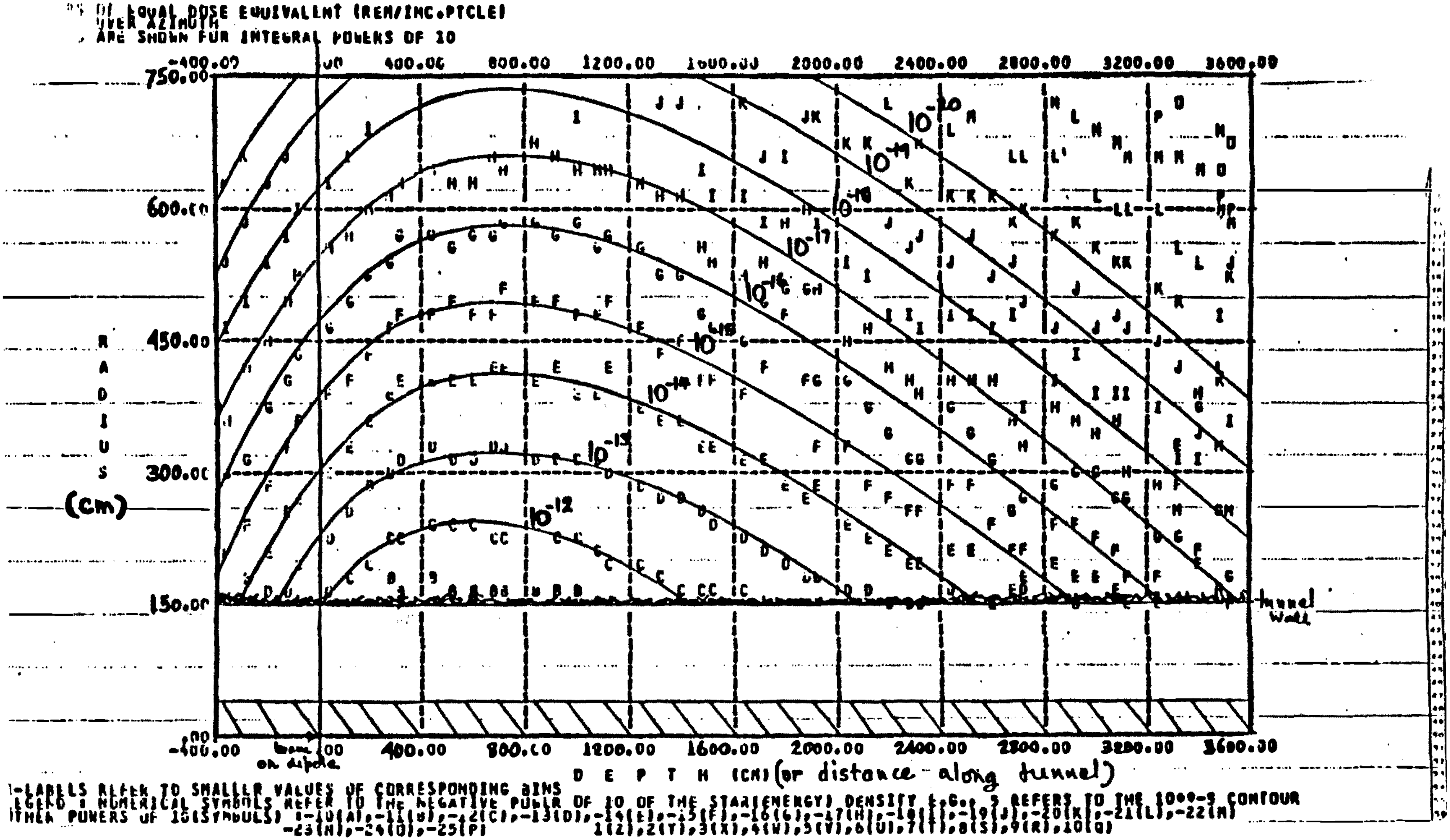


Figure C-2: Isodose contours due to hadrons in the MI berm per 150 GeV/c proton lost.

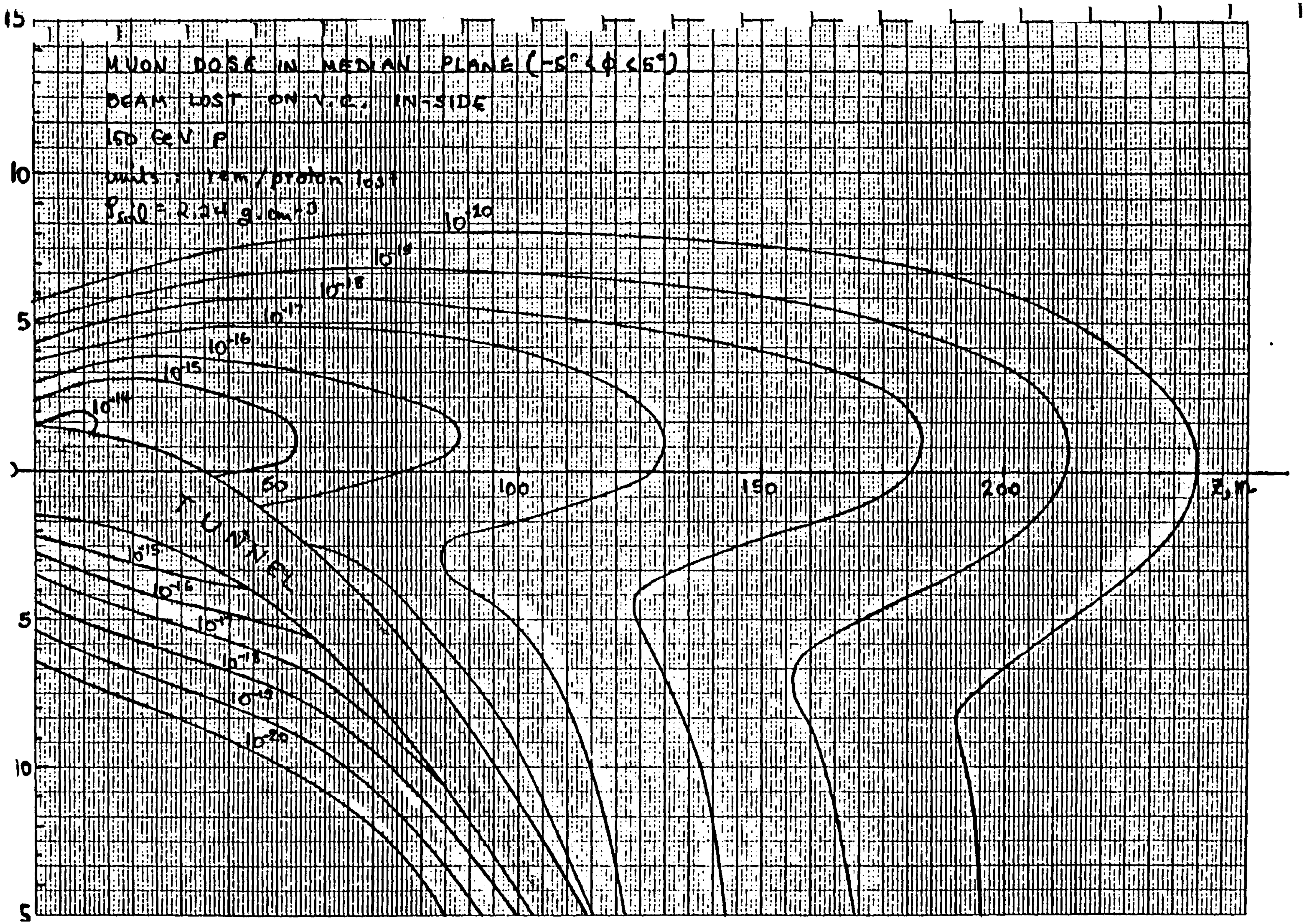


Figure C-3: Isodose contours due to muons in the median plane for a 150 GeV proton lost on the radial inside of the MI beampipe.

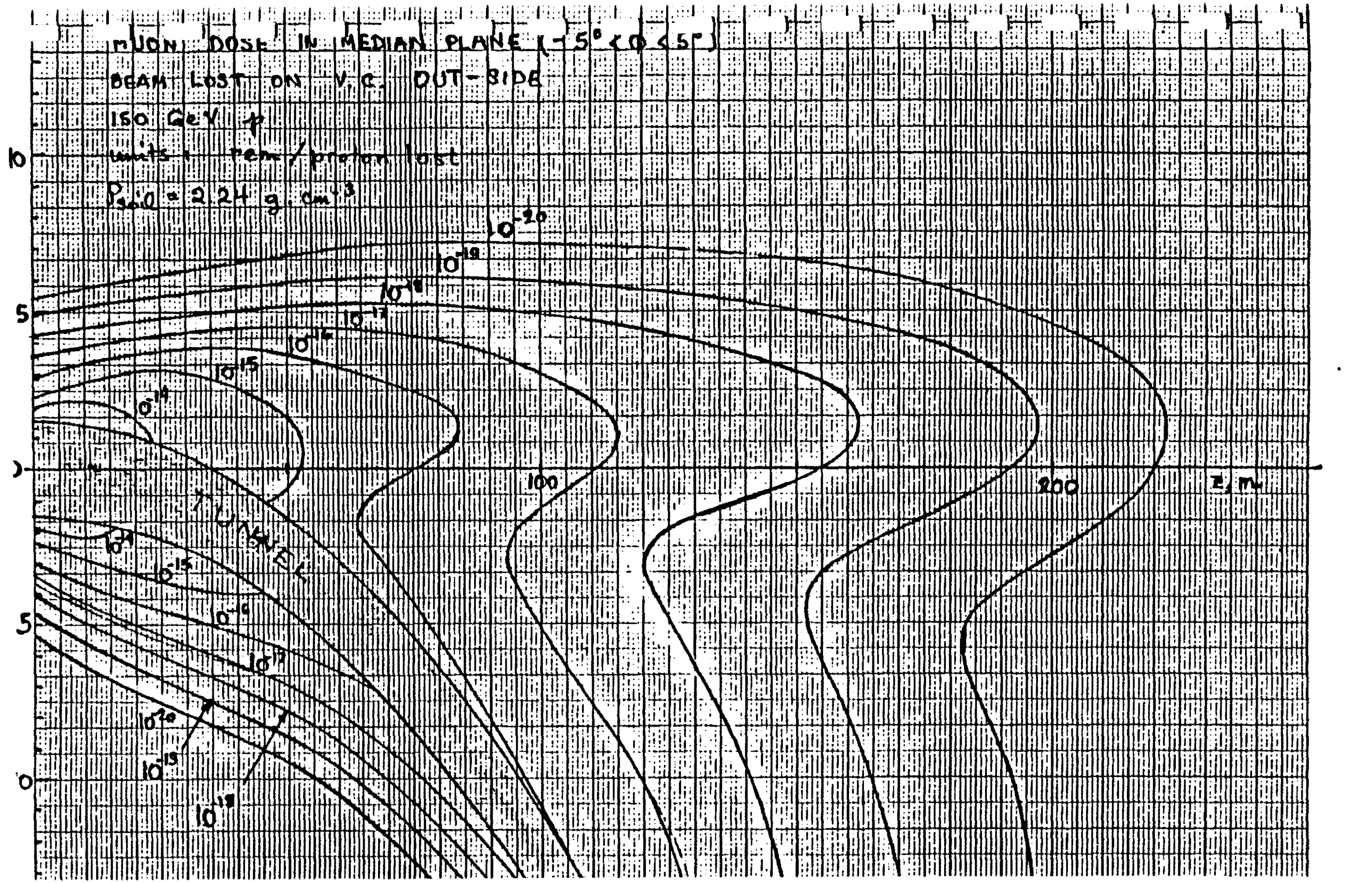


Figure C-4: Isodose contours due to muons in the median plane for a 150 GeV proton lost on the radial outside of the MI beampipe.

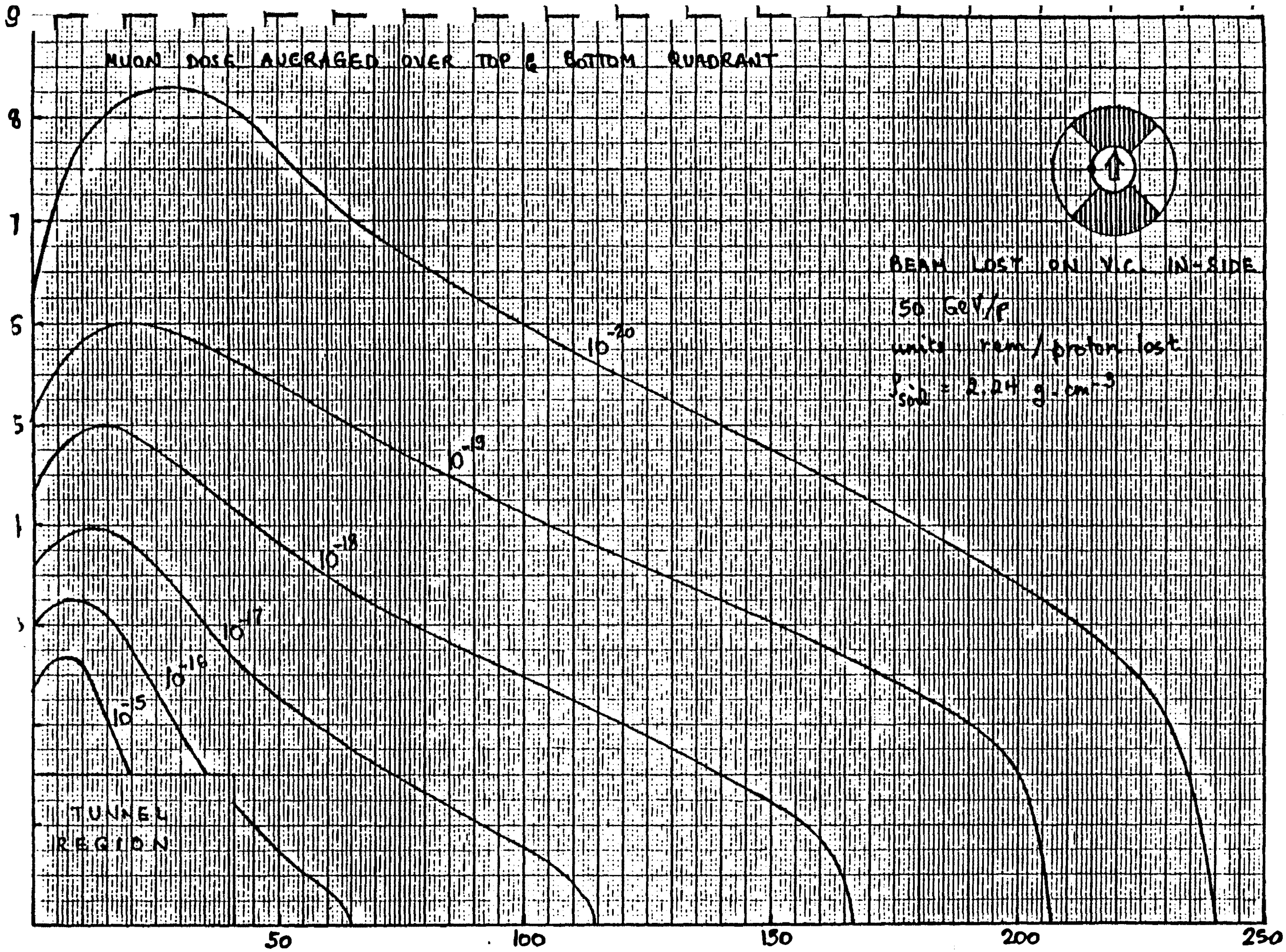


Figure C-5: Isodose contours averaged over top and bottom azimuths for muons produced under the same conditions as C-3.

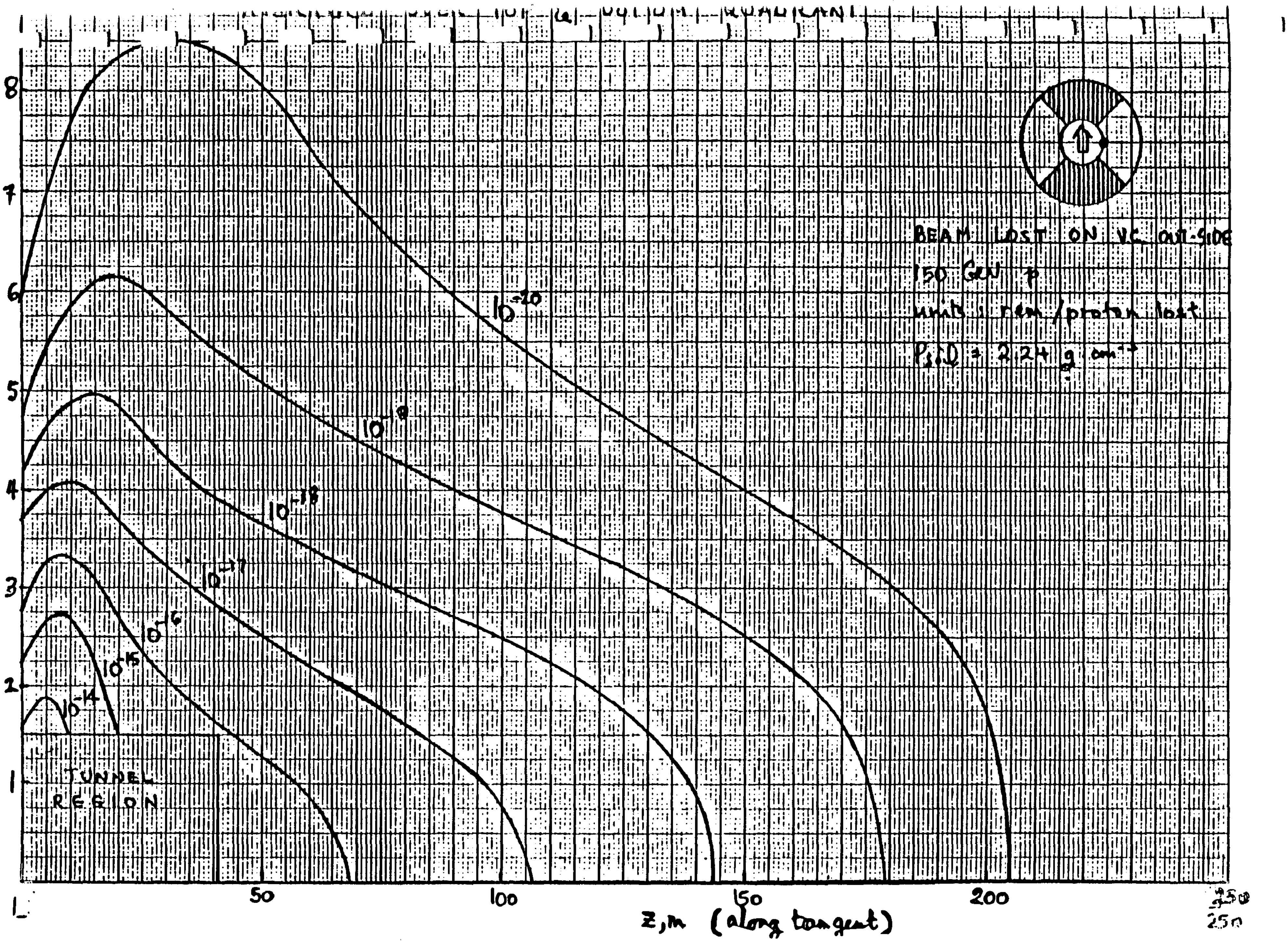


Figure C-6: Isodose contours averaged over top and bottom azimuths for muons produced under the same conditions as C-4.

2.5×10^{18} protons/year will strike the MI abort dump. The high density construction of the beam dump ensures that the hadron dose in the immediate vicinity of the dump is negligible. The major radiation problem associated with hadrons is ground water activation. The current Tevatron dump, which has been in continuous operation for the last six years, was desgined to deal with this problem, along with questions of radiation heating and material integrity of its components.[2] The ground water is frequently monitored and results show that water immediately adjacent to the Tevatron dump meets EPA release limits for unrestricted use.

Estimated muon isodose contours for the abort dump are shown in Figure C-7. From these results the maximum dose rate on the surface is 250 mR per year at 5 m downstream of the dump location, which is below permanent occupancy limits. Continuous maximum intensity running to the dump produces an exposure rate of 4 mR/hour in the same place. The trajectory of the abort line intercepts the site boundary 425 m downstream of the dump. At this point the beam is 10 m beneath the surface and the distance is sufficient to range out all the muons.

Discussion

The largest uncertainties in the above estimates result from assumptions made regarding beam losses, i.e., in converting the CASIM results to dose for a single accident and to an annual dose rate for routine operation. The above calculations and assumptions regarding beam loss establish that no gross radiation problems are expected to accompany operation of the MI. This conclusion could also have been anticipated from similarities with the present Main Ring, and the absence of any such problems with it The only difference is the proximity of the MI to the site boundary.

The maximum off-site dose for a single accident is expected to be quite small (<0.25 mR), but the dose rate from routine operation is estimated to be twice the Fermilab limit unless the berm is gradually enlarged near the point of closest approach. An extra 3 ft reduces the off-site dose by about an order of magnitude (see Figs. C-1 and C-2). Conformance to the off-site limit can easily be ensured by monitoring the radiation either at the site boundary or at selected on-site locations from which one can confidently extrapolate to the boundary.

2. J. Kidd et al., IEEE Transactions on Nuclear Science, NS-28, 2774 (1981).

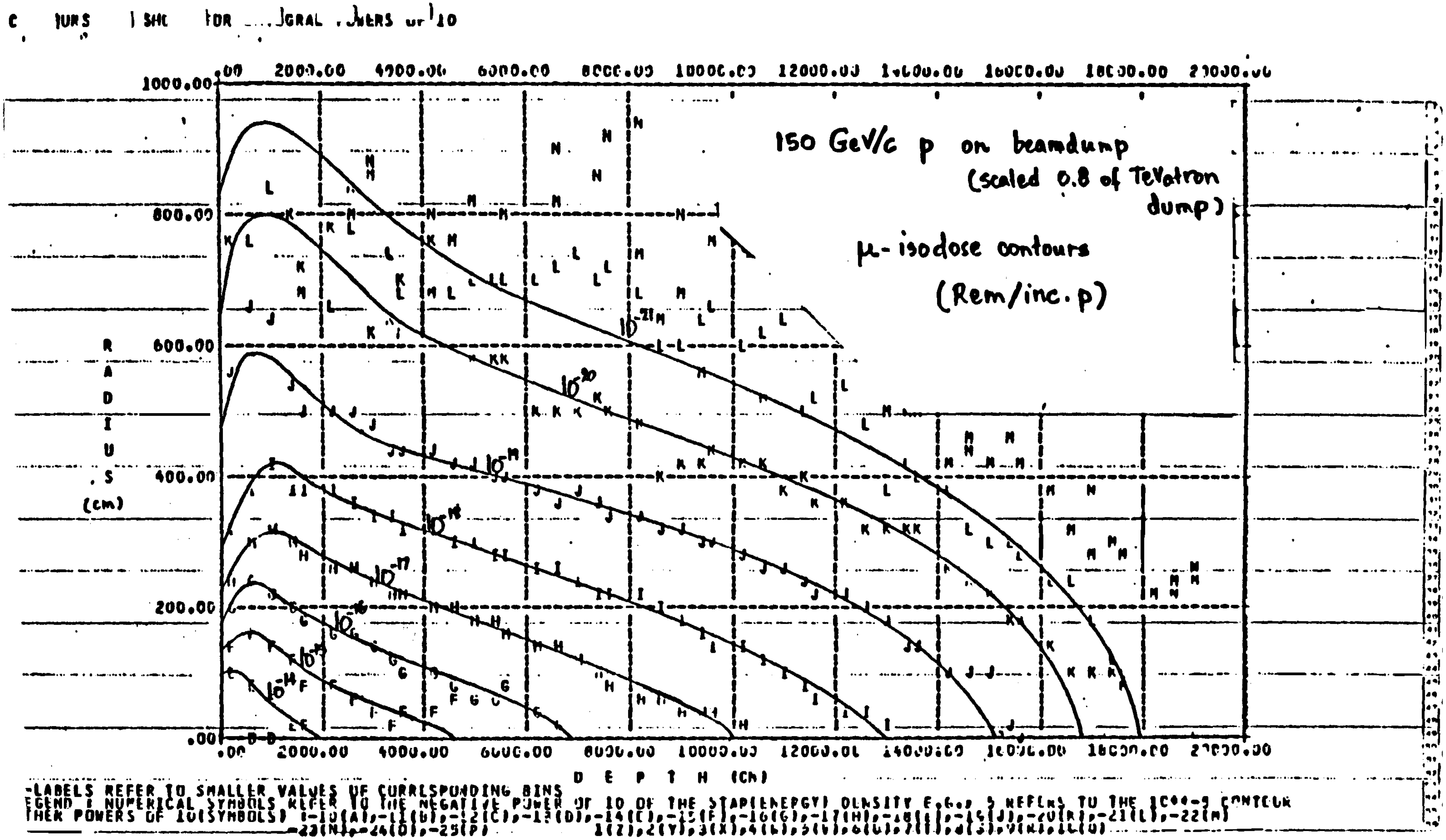


Figure C-7: Estimated muon isodose contours for the MI abort dump.

APPENDIX D

Main Injector Lattice Functions

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
0	0.0000	0.00000	0.00000	58.26201	10.91639	-0.32438	0.00000	0.0000	-0.00103	0.00106	-0.00149	0.00000
1 QF2	1.0668	0.00296	0.01528	55.73079	11.51254	-0.31878	0.00000	0.0000	2.33847	-0.56814	0.01196	0.00000
2 BPM	1.4423	0.00405	0.02038	53.99096	11.95541	-0.31428	0.00000	0.0000	2.29489	-0.61128	0.01196	0.00000
3 CED	2.2899	0.00664	0.03117	50.18405	13.07420	-0.30414	0.00000	0.0000	2.19651	-0.70867	0.01196	0.00000
4 000	3.3981	0.01033	0.04387	45.45825	14.78600	-0.29089	0.00000	0.0000	2.06789	-0.83600	0.01196	0.00000
5 SB	9.4687	0.03937	0.09108	24.62890	29.17030	-0.21826	0.00000	0.0000	1.36330	-1.53350	0.01196	0.00000
6 O	9.7735	0.04137	0.09272	23.80862	30.11580	-0.21462	0.00000	0.0000	1.32792	-1.56853	0.01196	0.00000
7 SB	15.8441	0.09993	0.11691	11.96336	53.39385	-0.14200	0.00000	0.0000	0.62333	-2.26603	0.01196	0.00000
8 O	16.1489	0.10405	0.11781	11.59416	54.78590	-0.13835	0.00000	0.0000	0.58795	-2.30105	0.01196	0.00000
9 QD2	17.2157	0.11925	0.12081	10.96203	57.26688	-0.12860	0.00000	0.0000	0.01340	0.01018	0.00639	0.00000
10 QD2	18.2825	0.13448	0.12382	11.53526	54.74375	-0.12461	0.00000	0.0000	-0.55872	2.31961	0.00111	0.00000
11 BPM	18.6580	0.13957	0.12493	11.97090	53.01815	-0.12420	0.00000	0.0000	-0.60144	2.27585	0.00111	0.00000
12 CED	19.5056	0.15036	0.12757	13.07218	49.24387	-0.12326	0.00000	0.0000	-0.69785	2.17706	0.00111	0.00000
13 000	20.6138	0.16307	0.13134	14.75860	44.56178	-0.12203	0.00000	0.0000	-0.82391	2.04789	0.00111	0.00000
14 SB	26.6844	0.21051	0.16106	28.95393	23.99319	-0.11531	0.00000	0.0000	-1.51446	1.34034	0.00111	0.00000
15 O	26.9892	0.21216	0.16312	29.88772	23.18695	-0.11497	0.00000	0.0000	-1.54913	1.30481	0.00111	0.00000
16 SB	33.0598	0.23656	0.22335	52.88809	11.64024	-0.10825	0.00000	0.0000	-2.23968	0.59726	0.00111	0.00000
17 O	33.3646	0.23746	0.22759	54.26397	11.28698	-0.10792	0.00000	0.0000	-2.27435	0.56173	0.00111	0.00000
18 QF2	34.4314	0.24050	0.24318	56.72407	10.69663	-0.10435	0.00000	0.0000	0.00258	-0.00017	0.00555	0.00000
19 QF2	35.4982	0.24354	0.25877	54.25330	11.28772	-0.09617	0.00000	0.0000	2.27906	-0.56210	0.00974	0.00000
20 BPM	35.8737	0.24466	0.26397	52.55782	11.72630	-0.09251	0.00000	0.0000	2.23618	-0.60588	0.00974	0.00000
21 CED	36.7213	0.24732	0.27497	48.84907	12.83715	-0.08425	0.00000	0.0000	2.13941	-0.70470	0.00974	0.00000
22 OOL	40.6155	0.26257	0.31395	33.91782	20.09358	-0.04631	0.00000	0.0000	1.69481	-1.15870	0.00974	0.00000
23 B2	46.6861	0.30259	0.34899	17.54904	38.44601	0.07639	0.00000	0.0001	1.00178	-1.86381	0.03069	0.00000
24 OOL	50.5803	0.34682	0.36252	11.47811	54.72673	0.19589	0.00000	0.0001	0.55718	-2.31695	0.03069	0.00000
25 QD2	51.6471	0.36214	0.36553	10.90614	57.24488	0.23327	0.00000	0.0001	-0.01307	-0.00825	0.03964	0.00000
26 QD2	52.7139	0.37741	0.36854	11.53555	54.76088	0.28111	0.00000	0.0001	-0.58569	2.30191	0.05038	0.00000
27 BPM	53.0894	0.38249	0.36965	11.99182	53.04837	0.30003	0.00000	0.0001	-0.62941	2.25872	0.05038	0.00000
28 CED	53.9370	0.39325	0.37229	13.14243	49.30202	0.34273	0.00000	0.0001	-0.72809	2.16123	0.05038	0.00000
29 OOL	57.8312	0.43129	0.38740	20.57868	34.21384	0.53891	0.00000	0.0001	-1.18148	1.71330	0.05038	0.00000
30 B2	63.9018	0.46557	0.42714	39.21209	17.64074	0.90829	0.00000	0.0150	-1.88820	1.01616	0.07132	0.00000
31 OOL	67.7960	0.47885	0.47127	55.68371	11.47378	1.18604	0.00000	0.0150	-2.34158	0.56747	0.07132	0.00000
32 QF2	68.8628	0.48181	0.48660	58.22384	10.87772	1.23529	0.00000	0.0150	-0.00409	-0.00047	0.02067	0.00000
33 QF2	69.9296	0.48477	0.50193	55.70065	11.47586	1.22982	0.00000	0.0150	2.33412	-0.56850	-0.03090	0.00000
34 BPM	70.3051	0.48586	0.50704	53.96405	11.91907	1.21821	0.00000	0.0150	2.29065	-0.61180	-0.03090	0.00000
35 CED	71.1527	0.48845	0.51787	50.16411	13.03902	1.19203	0.00000	0.0150	2.19253	-0.70953	-0.03090	0.00000
36 OOL	75.0469	0.50330	0.55633	34.84334	20.31362	1.07171	0.00000	0.0150	1.74172	-1.15854	-0.03090	0.00000
37 B2	81.1175	0.54230	0.59110	17.96382	38.61677	0.94774	0.00000	0.0360	1.03902	-1.85585	-0.00995	0.00000
38 OOL	85.0117	0.58572	0.60459	11.62706	54.81611	0.90898	0.00000	0.0360	0.58821	-2.30401	-0.00995	0.00000
39 QD2	86.0785	0.60087	0.60760	10.99550	57.30210	0.91868	0.00000	0.0360	0.01259	0.00851	0.02819	0.00000
40 QD2	87.1453	0.61606	0.61060	11.57170	54.78086	0.96958	0.00000	0.0360	-0.56074	2.31954	0.06760	0.00000
41 BPM	87.5208	0.62113	0.61171	12.00883	53.05530	0.99497	0.00000	0.0360	-0.60339	2.27581	0.06760	0.00000
42 CED	88.3684	0.63189	0.61435	13.11330	49.28103	1.05227	0.00000	0.0360	-0.69967	2.17709	0.06760	0.00000
43 OOL	92.2626	0.67026	0.62949	20.28517	34.09123	1.31552	0.00000	0.0360	-1.14201	1.72353	0.06760	0.00000
44 B2	98.3332	0.70518	0.66953	38.33494	17.44723	1.78944	0.00000	0.0682	-1.83152	1.01760	0.08855	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
45 OOL	102.2274	0.71878	0.71428	54.32209	11.29096	2.13426	0.00000	0.0682	-2.27386	0.56328	0.08855	0.00000
46 QF2	103.2942	0.72182	0.72986	56.77844	10.69752	2.18075	0.00000	0.0682	0.00555	0.00122	-0.00172	0.00000
47 QF2	104.3610	0.72485	0.74546	54.29911	11.28560	2.13062	0.00000	0.0682	2.28398	-0.56062	-0.09191	0.00000
48 BPM	104.7365	0.72597	0.75065	52.59998	11.72304	2.09611	0.00000	0.0682	2.24099	-0.60435	-0.09191	0.00000
49 CED	105.5841	0.72863	0.76166	48.88330	12.83120	2.01820	0.00000	0.0682	2.14395	-0.70306	-0.09191	0.00000
50 OOO	106.6923	0.73242	0.77459	44.27204	14.53248	1.91635	0.00000	0.0682	2.01708	-0.83212	-0.09191	0.00000
51 B2	112.7629	0.76223	0.82244	24.00259	28.91851	1.42201	0.00000	0.1030	1.32212	-1.53715	-0.07096	0.00000
52 O	113.0677	0.76429	0.82409	23.20726	29.86636	1.40038	0.00000	0.1030	1.28722	-1.57259	-0.07096	0.00000
53 SB	119.1383	0.82408	0.84841	11.79793	53.24494	0.96958	0.00000	0.1030	0.59222	-2.27852	-0.07096	0.00000
54 O	119.4431	0.82825	0.84931	11.44756	54.64473	0.94795	0.00000	0.1030	0.55732	-2.31397	-0.07096	0.00000
55 QD2	120.5099	0.84361	0.85233	10.87427	57.16022	0.89295	0.00000	0.1030	-0.01195	-0.00878	-0.03254	0.00000
56 QD2	121.5767	0.85892	0.85534	11.50009	54.68107	0.87800	0.00000	0.1030	-0.58339	2.29796	0.00442	0.00000
57 BPM	121.9522	0.86402	0.85645	11.95465	52.97150	0.87966	0.00000	0.1030	-0.62716	2.25483	0.00442	0.00000
58 CED	122.7998	0.87481	0.85909	13.10154	49.23163	0.88340	0.00000	0.1030	-0.72594	2.15748	0.00442	0.00000
59 OOO	123.9080	0.88747	0.86286	14.85366	44.59086	0.88829	0.00000	0.1030	-0.85511	2.03019	0.00442	0.00000
60 B2	129.9786	0.93427	0.89246	29.52943	24.16059	0.97867	0.00000	0.1223	-1.56259	1.33452	0.02536	0.00000
61 O	130.2834	0.93588	0.89451	30.49282	23.35776	0.98640	0.00000	0.1223	-1.59811	1.29944	0.02536	0.00000
62 SB	136.3540	0.95974	0.95402	54.19097	11.82283	1.14035	0.00000	0.1223	-2.30565	0.60070	0.02536	0.00000
63 O	136.6588	0.96062	0.95819	55.60732	11.46734	1.14808	0.00000	0.1223	-2.34117	0.56561	0.02536	0.00000
64 QF2	137.7256	0.96359	0.97353	58.15008	10.87493	1.14951	0.00000	0.1223	-0.00693	-0.00209	-0.02270	0.00000
65 Q1	138.7924	0.96655	0.98887	55.63604	11.47652	1.10000	0.00000	0.1223	2.32852	-0.57017	-0.06976	0.00000
66 XO	143.8014	0.98460	1.04238	35.20505	20.08538	0.75057	0.00000	0.1223	1.75034	-1.14851	-0.06976	0.00000
67 QOO	144.3464	0.98713	1.04658	33.72900	21.12832	0.71686	0.00000	0.1223	0.96854	-0.75769	-0.05407	0.00000
68 O	144.6512	0.98858	1.04885	33.14391	21.59713	0.70038	0.00000	0.1223	0.95103	-0.78040	-0.05407	0.00000
69 B2	150.7218	1.02331	1.08492	23.71538	33.80615	0.43573	0.00000	0.1340	0.60223	-1.23033	-0.03313	0.00000
70 O	151.0266	1.02537	1.08633	23.35359	34.56307	0.42563	0.00000	0.1340	0.58472	-1.25299	-0.03313	0.00000
71 B2	157.0972	1.07271	1.10909	18.37212	52.49760	0.28812	0.00000	0.1412	0.23593	-1.70069	-0.01218	0.00000
72 O	157.4020	1.07536	1.11001	18.23363	53.54123	0.28440	0.00000	0.1412	0.21842	-1.72329	-0.01218	0.00000
73 B2	163.4726	1.13022	1.12506	17.69922	77.16824	0.27402	0.00000	0.1469	-0.13038	-2.16790	0.00876	0.00000
74 O	163.7774	1.13295	1.12569	17.78403	78.49665	0.27670	0.00000	0.1469	-0.14789	-2.19041	0.00876	0.00000
75 QO	166.2454	1.15294	1.13075	23.61930	70.75308	0.33295	0.00000	0.1469	-2.40207	5.07374	0.03773	0.00000
76 XI	169.2454	1.16838	1.13934	40.61136	43.71243	0.44615	0.00000	0.1469	-3.26195	3.93982	0.03773	0.00000
77 QI	171.3790	1.17590	1.14830	47.36190	34.90703	0.48520	0.00000	0.1469	0.28788	0.42904	-0.00167	0.00000
78 LS	184.2300	1.22146	1.21389	43.73865	29.48189	0.46368	0.00000	0.1469	-0.00594	-0.00688	-0.00167	0.00000
79 LS	197.0810	1.26686	1.27914	47.66726	35.26065	0.44216	0.00000	0.1469	-0.29976	-0.44279	-0.00167	0.00000
80 QI	199.2146	1.27433	1.28801	40.91045	44.19868	0.39994	0.00000	0.1469	3.27660	-3.99187	-0.03731	0.00000
81 XI	202.2146	1.28965	1.29650	23.83272	71.59829	0.28803	0.00000	0.1469	2.41598	-5.14134	-0.03731	0.00000
82 QO	204.6826	1.30944	1.30150	17.97419	79.46737	0.22738	0.00000	0.1469	0.14415	2.21128	-0.01281	0.00000
83 O	204.9874	1.31215	1.30212	17.89159	78.12626	0.22348	0.00000	0.1469	0.12684	2.18869	-0.01281	0.00000
84 B2	211.0580	1.36637	1.31698	18.44431	54.25583	0.20927	0.00000	0.1512	-0.21789	1.74259	0.00813	0.00000
85 O	211.3628	1.36899	1.31788	18.58242	53.20046	0.21174	0.00000	0.1512	-0.23520	1.71991	0.00813	0.00000
86 B2	217.4334	1.41587	1.34033	23.53045	35.04173	0.32467	0.00000	0.1566	-0.57994	1.27069	0.02908	0.00000
87 O	217.7382	1.41791	1.34173	23.88926	34.27405	0.33353	0.00000	0.1566	-0.59725	1.24795	0.02908	0.00000
88 B2	223.8088	1.45247	1.37733	33.23260	21.86047	0.57359	0.00000	0.1659	-0.94198	0.79647	0.05002	0.00000
89 O	224.1136	1.45392	1.37957	33.81210	21.38189	0.58884	0.00000	0.1659	-0.95929	0.77368	0.05002	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
90 QOO	224.6586	1.45644	1.38372	35.27877	20.31879	0.61959	0.00000	0.1659	-1.74229	1.16937	0.06294	0.00000
91 XO	229.6676	1.47447	1.43679	55.60316	11.52738	0.93486	0.00000	0.1659	-2.31528	0.58575	0.06294	0.00000
92 Q1	230.7344	1.47744	1.45208	58.09006	10.89505	0.98080	0.00000	0.1659	0.01876	0.01574	0.02287	0.00000
93 QF2	231.8012	1.48041	1.46741	55.52547	11.45821	0.98329	0.00000	0.1659	2.34951	-0.55143	-0.01822	0.00000
94 BPM	232.1767	1.48150	1.47253	53.77755	11.88838	0.97644	0.00000	0.1659	2.30541	-0.59417	-0.01822	0.00000
95 CED	233.0243	1.48410	1.48340	49.95378	12.97738	0.96100	0.00000	0.1659	2.20588	-0.69063	-0.01822	0.00000
96 OOO	234.1325	1.48782	1.49621	45.20888	14.64787	0.94081	0.00000	0.1659	2.07575	-0.81676	-0.01822	0.00000
97 SB	240.2031	1.51711	1.54400	24.33424	28.75854	0.83020	0.00000	0.1659	1.36290	-1.50767	-0.01822	0.00000
98 O	240.5079	1.51914	1.54566	23.51433	29.68818	0.82465	0.00000	0.1659	1.32711	-1.54236	-0.01822	0.00000
99 B2	246.5785	1.57869	1.57021	11.72964	52.59130	0.77761	0.00000	0.1824	0.61431	-2.22961	0.00272	0.00000
100 O	246.8833	1.58289	1.57112	11.36607	53.96102	0.77844	0.00000	0.1824	0.57852	-2.26422	0.00272	0.00000
101 QD2	247.9501	1.59839	1.57417	10.74590	56.40053	0.79883	0.00000	0.1824	0.01146	0.01164	0.03564	0.00000
102 QD2	249.0169	1.61393	1.57723	11.31572	53.91283	0.85506	0.00000	0.1824	-0.55353	2.28544	0.07016	0.00000
103 BPM	249.3924	1.61911	1.57835	11.74770	52.21274	0.88140	0.00000	0.1824	-0.59688	2.24210	0.07016	0.00000
104 CED	250.2400	1.63011	1.58103	12.84247	48.49487	0.94087	0.00000	0.1824	-0.69473	2.14426	0.07016	0.00000
105 OOO	251.3482	1.64303	1.58486	14.52406	43.88410	1.01862	0.00000	0.1824	-0.82267	2.01634	0.07016	0.00000
106 B2	257.4188	1.69102	1.61503	28.76551	23.64338	1.50808	0.00000	0.2086	-1.52347	1.31715	0.09110	0.00000
107 O	257.7236	1.69268	1.61712	29.70494	22.85119	1.53585	0.00000	0.2086	-1.55866	1.28190	0.09110	0.00000
108 SB	263.7942	1.71716	1.67807	52.88348	11.55023	2.08891	0.00000	0.2086	-2.25950	0.57969	0.09110	0.00000
109 O	264.0990	1.71806	1.68233	54.27160	11.20760	2.11668	0.00000	0.2086	-2.29469	0.54444	0.09110	0.00000
110 QF2	265.1658	1.72110	1.69801	56.77539	10.65065	2.16626	0.00000	0.2086	-0.01743	-0.01465	0.00151	0.00000
111 QF2	266.2326	1.72413	1.71365	54.34379	11.27199	2.11987	0.00000	0.2086	2.26289	-0.57639	-0.08815	0.00000
112 BPM	266.6081	1.72525	1.71885	52.66024	11.72152	2.08677	0.00000	0.2086	2.22060	-0.62077	-0.08815	0.00000
113 CED	267.4557	1.72791	1.72985	48.97679	12.85875	2.01205	0.00000	0.2086	2.12513	-0.72094	-0.08815	0.00000
114 OOO	268.5639	1.73169	1.74273	44.40497	14.60179	1.91436	0.00000	0.2086	2.00032	-0.85192	-0.08815	0.00000
115 B2	274.6345	1.76129	1.79015	24.27049	29.29194	1.44284	0.00000	0.2436	1.31664	-1.56743	-0.06721	0.00000
116 O	274.9393	1.76332	1.79178	23.47832	30.25841	1.42235	0.00000	0.2436	1.28232	-1.60340	-0.06721	0.00000
117 B2	281.0099	1.82205	1.81576	12.06062	54.05718	1.07796	0.00000	0.2695	0.59864	-2.31607	-0.04626	0.00000
118 O	281.3147	1.82614	1.81664	11.70615	55.48000	1.06386	0.00000	0.2695	0.56431	-2.35195	-0.04626	0.00000
119 QD2	282.3815	1.84115	1.81961	11.12708	58.03898	1.03800	0.00000	0.2695	-0.01344	-0.01095	-0.00240	0.00000
120 QD2	283.4483	1.85612	1.82258	11.76523	55.52535	1.05871	0.00000	0.2695	-0.59363	2.33198	0.04136	0.00000
121 BPM	283.8238	1.86110	1.82368	12.22726	53.79038	1.07424	0.00000	0.2695	-0.63680	2.28844	0.04136	0.00000
122 CED	284.6714	1.87165	1.82628	13.38934	49.99432	1.10930	0.00000	0.2695	-0.73423	2.19016	0.04136	0.00000
123 OOO	285.7796	1.88405	1.82999	15.15785	45.28244	1.15514	0.00000	0.2695	-0.86161	2.06167	0.04136	0.00000
124 B2	291.8502	1.93010	1.85915	29.85360	24.50995	1.46979	0.00000	0.2968	-1.55937	1.35940	0.06231	0.00000
125 O	292.1550	1.93170	1.86116	30.81487	23.69205	1.48878	0.00000	0.2968	-1.59441	1.32398	0.06231	0.00000
126 B2	298.2256	1.95538	1.92006	54.40698	11.89252	1.93057	0.00000	0.3324	-2.29217	0.61931	0.08325	0.00000
127 O	298.5304	1.95626	1.92420	55.81496	11.52580	1.95594	0.00000	0.3324	-2.32720	0.58385	0.08325	0.00000
128 QF2	299.5972	1.95922	1.93949	58.31790	10.89739	2.00077	0.00000	0.3324	0.01587	0.01393	0.00048	0.00000
129 QF2	300.6640	1.96217	1.95481	55.74923	11.46460	1.95696	0.00000	0.3324	2.35616	-0.55348	-0.08231	0.00000
130 BPM	301.0395	1.96326	1.95993	53.99632	11.89633	1.92605	0.00000	0.3324	2.31203	-0.59627	-0.08231	0.00000
131 CED	301.8871	1.96586	1.97079	50.16138	12.98899	1.85629	0.00000	0.3324	2.21243	-0.69285	-0.08231	0.00000
132 OOO	302.9953	1.96955	1.98358	45.40208	14.66456	1.76507	0.00000	0.3324	2.08219	-0.81912	-0.08231	0.00000
133 B2	309.0659	1.99871	2.03131	24.45373	28.80025	1.32900	0.00000	0.3646	1.36885	-1.50891	-0.06137	0.00000
134 O	309.3707	2.00073	2.03297	23.63020	29.73065	1.31030	0.00000	0.3646	1.33303	-1.54359	-0.06137	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
135 B2	315.4413	2.06000	2.05749	11.77699	52.64753	1.00137	0.00000	0.3886	0.61968	-2.23064	-0.04042	0.00000
136 O	315.7461	2.06419	2.05840	11.41015	54.01787	0.98905	0.00000	0.3886	0.58386	-2.26523	-0.04042	0.00000
137 QD2	316.8129	2.07963	2.06145	10.78034	56.45694	0.96779	0.00000	0.3886	0.01528	0.01306	0.00042	0.00000
138 QD2	317.8797	2.09513	2.06450	11.34298	53.96380	0.98995	0.00000	0.3886	-0.55052	2.28905	0.04128	0.00000
139 BPM	318.2552	2.10030	2.06563	11.77262	52.26103	1.00545	0.00000	0.3886	-0.59366	2.24563	0.04128	0.00000
140 CED	319.1028	2.11127	2.06830	12.86153	48.53730	1.04044	0.00000	0.3886	-0.69103	2.14762	0.04128	0.00000
141 OOO	320.2110	2.12418	2.07212	14.53422	43.91932	1.08618	0.00000	0.3886	-0.81834	2.01948	0.04128	0.00000
142 B2	326.2816	2.17221	2.10228	28.70211	23.64763	1.40031	0.00000	0.4144	-1.51568	1.31911	0.06222	0.00000
143 O	326.5864	2.17387	2.10437	29.63674	22.85427	1.41928	0.00000	0.4144	-1.55070	1.28379	0.06222	0.00000
144 B2	332.6570	2.19842	2.16537	52.69560	11.53097	1.86055	0.00000	0.4485	-2.24803	0.58107	0.08317	0.00000
145 O	332.9618	2.19933	2.16964	54.07668	11.18753	1.88590	0.00000	0.4485	-2.28305	0.54571	0.08317	0.00000
146 QF2	334.0286	2.20237	2.18535	56.56426	10.62726	1.93219	0.00000	0.4485	-0.01410	-0.01276	0.00330	0.00000
147 QF2	335.0954	2.20542	2.20103	54.13508	11.24362	1.89288	0.00000	0.4485	2.25732	-0.57354	-0.07672	0.00000
148 BPM	335.4709	2.20654	2.20624	52.45571	11.69102	1.86407	0.00000	0.4485	2.21504	-0.61793	-0.07672	0.00000
149 CED	336.3185	2.20921	2.21727	48.78167	12.82345	1.79904	0.00000	0.4485	2.11960	-0.71811	-0.07672	0.00000
150 OOO	337.4267	2.21301	2.23019	44.22206	14.56022	1.71402	0.00000	0.4485	1.99482	-0.84910	-0.07672	0.00000
151 B2	343.4973	2.24274	2.27774	24.15320	29.21640	1.31188	0.00000	0.4800	1.31133	-1.56466	-0.05578	0.00000
152 O	343.8021	2.24478	2.27937	23.36427	30.18119	1.29488	0.00000	0.4800	1.27701	-1.60064	-0.05578	0.00000
153 B2	349.8727	2.30380	2.30341	12.00979	53.94669	1.01988	0.00000	0.5040	0.59353	-2.31336	-0.03483	0.00000
154 O	350.1775	2.30790	2.30429	11.65843	55.36785	1.00927	0.00000	0.5040	0.55921	-2.34924	-0.03483	0.00000
155 QD2	351.2443	2.32296	2.30727	11.08838	57.92617	0.99447	0.00000	0.5040	-0.01692	-0.01305	0.00699	0.00000
156 QD2	352.3111	2.33798	2.31024	11.73278	55.42189	1.02429	0.00000	0.5040	-0.59611	2.32544	0.04912	0.00000
157 BPM	352.6866	2.34298	2.31134	12.19675	53.69179	1.04273	0.00000	0.5040	-0.63948	2.28203	0.04912	0.00000
158 CED	353.5342	2.35355	2.31395	13.36379	49.90635	1.08437	0.00000	0.5040	-0.73740	2.18403	0.04912	0.00000
159 OOO	354.6424	2.36597	2.31766	15.14003	45.20765	1.13880	0.00000	0.5040	-0.86541	2.05591	0.04912	0.00000
160 B2	360.7130	2.41201	2.34686	29.90288	24.49284	1.50054	0.00000	0.5314	-1.56662	1.35566	0.07007	0.00000
161 O	361.0178	2.41361	2.34887	30.86863	23.67720	1.52190	0.00000	0.5314	-1.60183	1.32035	0.07007	0.00000
162 B2	367.0884	2.43723	2.40774	54.57185	11.90955	2.01077	0.00000	0.5682	-2.30304	0.61769	0.09101	0.00000
163 O	367.3932	2.43811	2.41188	55.98652	11.54378	2.03851	0.00000	0.5682	-2.33825	0.58234	0.09101	0.00000
164 QF2	368.4600	2.44106	2.42714	58.50547	10.91911	2.08973	0.00000	0.5682	0.01214	0.01187	0.00465	0.00000
165 QF2	369.5268	2.44400	2.44243	55.93624	11.49160	2.04836	0.00000	0.5682	2.36040	-0.55645	-0.08191	0.00000
166 BPM	369.9023	2.44509	2.44754	54.18015	11.92557	2.01760	0.00000	0.5682	2.31629	-0.59924	-0.08191	0.00000
167 CED	370.7499	2.44767	2.45837	50.33797	13.02327	1.94817	0.00000	0.5682	2.21671	-0.69584	-0.08191	0.00000
168 OOO	371.8581	2.45135	2.47113	45.56913	14.70549	1.85739	0.00000	0.5682	2.08652	-0.82213	-0.08191	0.00000
169 B2	377.9287	2.48039	2.51872	24.56698	28.87835	1.42373	0.00000	0.6023	1.37338	-1.51203	-0.06097	0.00000
170 O	378.2335	2.48240	2.52037	23.74068	29.81066	1.40515	0.00000	0.6023	1.33758	-1.54671	-0.06097	0.00000
171 B2	384.3041	2.54138	2.54483	11.83095	52.76604	1.09862	0.00000	0.6283	0.62444	-2.23386	-0.04002	0.00000
172 O	384.6089	2.54555	2.54574	11.46120	54.13835	1.08642	0.00000	0.6283	0.58863	-2.26846	-0.04002	0.00000
173 QD2	385.6757	2.56093	2.54878	10.82318	56.57882	1.06777	0.00000	0.6283	0.01832	0.01499	0.00493	0.00000
174 QD2	386.7425	2.57637	2.55183	11.38067	54.07626	1.09703	0.00000	0.6283	-0.54866	2.29581	0.05011	0.00000
175 BPM	387.1180	2.58152	2.55295	11.80883	52.36846	1.11585	0.00000	0.6283	-0.59159	2.25227	0.05011	0.00000
176 CED	387.9656	2.59247	2.55563	12.89382	48.63373	1.15832	0.00000	0.6283	-0.68849	2.15398	0.05011	0.00000
177 OOO	389.0738	2.60535	2.55944	14.56018	44.00206	1.21386	0.00000	0.6283	-0.81517	2.02547	0.05011	0.00000
178 B2	395.1444	2.65336	2.58956	28.66896	23.66995	1.58163	0.00000	0.6574	-1.50911	1.32307	0.07106	0.00000
179 O	395.4492	2.65503	2.59164	29.59953	22.87420	1.60329	0.00000	0.6574	-1.54396	1.28765	0.07106	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
180 B2	401.5198	2.67962	2.65265	52.55594	11.51628	2.09820	0.00000	0.6959	-2.23789	0.58291	0.09200	0.00000
181 O	401.8246	2.68053	2.65693	53.93078	11.17175	2.12625	0.00000	0.6959	-2.27274	0.54745	0.09200	0.00000
182 QF2	402.8914	2.68359	2.67267	56.40277	10.60733	2.17657	0.00000	0.6959	-0.01001	-0.01056	0.00199	0.00000
183 QF2	403.9582	2.68664	2.68837	53.97226	11.21815	2.13047	0.00000	0.6959	2.25446	-0.57047	-0.08811	0.00000
184 BPM	404.3337	2.68777	2.69360	52.29505	11.66324	2.09738	0.00000	0.6959	2.21214	-0.61484	-0.08811	0.00000
185 CED	405.1813	2.69044	2.70465	48.62599	12.79040	2.02271	0.00000	0.6959	2.11662	-0.71499	-0.08811	0.00000
186 OOO	406.2895	2.69425	2.71761	44.07312	14.52020	1.92507	0.00000	0.6959	1.99173	-0.84592	-0.08811	0.00000
187 B2	412.3601	2.72410	2.76529	24.04551	29.13621	1.45382	0.00000	0.7311	1.30763	-1.56122	-0.06716	0.00000
188 O	412.6649	2.72616	2.76693	23.25885	30.09889	1.43335	0.00000	0.7311	1.27328	-1.59718	-0.06716	0.00000
189 B2	418.7355	2.78546	2.79103	11.95343	53.82088	1.08923	0.00000	0.7573	0.58918	-2.30964	-0.04622	0.00000
190 O	419.0403	2.78958	2.79192	11.60473	55.23977	1.07515	0.00000	0.7573	0.55483	-2.34552	-0.04622	0.00000
191 QD2	420.1071	2.80471	2.79490	11.04198	57.79597	1.04959	0.00000	0.7573	-0.01948	-0.01481	-0.00187	0.00000
192 QD2	421.1739	2.81979	2.79788	11.69037	55.30112	1.07112	0.00000	0.7573	-0.59733	2.31850	0.04239	0.00000
193 BPM	421.5494	2.82480	2.79898	12.15533	53.57618	1.08704	0.00000	0.7573	-0.64091	2.27521	0.04239	0.00000
194 CED	422.3970	2.83541	2.80159	13.32519	49.80207	1.12296	0.00000	0.7573	-0.73929	2.17749	0.04239	0.00000
195 OOO	423.5052	2.84786	2.80531	15.10628	45.11746	1.16994	0.00000	0.7573	-0.86791	2.04973	0.04239	0.00000
196 B2	429.5758	2.89394	2.83456	29.91945	24.46544	1.49081	0.00000	0.7849	-1.57242	1.35149	0.06333	0.00000
197 O	429.8806	2.89554	2.83657	30.88878	23.65230	1.51011	0.00000	0.7849	-1.60780	1.31628	0.06333	0.00000
198 B2	435.9512	2.91913	2.89544	54.68443	11.92182	1.95812	0.00000	0.8210	-2.31231	0.61564	0.08428	0.00000
199 O	436.2560	2.92000	2.89958	56.10480	11.55727	1.98380	0.00000	0.8210	-2.34769	0.58038	0.08428	0.00000
200 QF2	437.3228	2.92294	2.91481	58.63870	10.93711	2.02910	0.00000	0.8210	0.00776	0.00953	0.00033	0.00000
201 QF2	438.3896	2.92588	2.93008	56.07267	11.51539	1.98450	0.00000	0.8210	2.36184	-0.55960	-0.08363	0.00000
202 BPM	438.7651	2.92696	2.93517	54.31547	11.95173	1.95310	0.00000	0.8210	2.31779	-0.60242	-0.08363	0.00000
203 CED	439.6127	2.92954	2.94598	50.47064	13.05488	1.88222	0.00000	0.8210	2.21835	-0.69908	-0.08363	0.00000
204 OOO	440.7209	2.93321	2.95871	45.69797	14.74437	1.78954	0.00000	0.8210	2.08834	-0.82545	-0.08363	0.00000
205 B2	446.7915	2.96215	3.00616	24.66767	28.96014	1.34546	0.00000	0.8536	1.37620	-1.51577	-0.06269	0.00000
206 O	447.0963	2.96415	3.00781	23.83963	29.89473	1.32635	0.00000	0.8536	1.34045	-1.55048	-0.06269	0.00000
207 B2	453.1669	3.02286	3.03220	11.88895	52.89837	1.00941	0.00000	0.8779	0.62831	-2.23804	-0.04174	0.00000
208 O	453.4717	3.02700	3.03311	11.51683	54.27323	0.99668	0.00000	0.8779	0.59255	-2.27266	-0.04174	0.00000
209 QD2	454.5385	3.04231	3.03615	10.87252	56.71654	0.97418	0.00000	0.8779	0.02038	0.01657	-0.00061	0.00000
210 QD2	455.6053	3.05768	3.03919	11.42724	54.20460	0.99538	0.00000	0.8779	-0.54809	2.30289	0.04050	0.00000
211 BPM	455.9808	3.06282	3.04031	11.85491	52.49152	1.01058	0.00000	0.8779	-0.59082	2.25923	0.04050	0.00000
212 CED	456.8284	3.07372	3.04297	12.93823	48.74522	1.04491	0.00000	0.8779	-0.68728	2.16066	0.04050	0.00000
213 OOO	457.9366	3.08656	3.04678	14.60127	44.09915	1.08979	0.00000	0.8779	-0.81339	2.03179	0.04050	0.00000
214 B2	464.0072	3.13450	3.07684	28.66920	23.70228	1.39918	0.00000	0.9037	-1.50417	1.32742	0.06144	0.00000
215 O	464.3120	3.13617	3.07892	29.59671	22.90391	1.41791	0.00000	0.9037	-1.53885	1.29190	0.06144	0.00000
216 B2	470.3826	3.16078	3.13992	52.47197	11.50652	1.85444	0.00000	0.9378	-2.22963	0.58516	0.08239	0.00000
217 O	470.6874	3.16170	3.14420	53.84172	11.16064	1.87956	0.00000	0.9378	-2.26431	0.54961	0.08239	0.00000
218 QF2	471.7542	3.16476	3.15996	56.29958	10.59137	1.92516	0.00000	0.9378	-0.00539	-0.00809	0.00280	0.00000
219 QF2	472.8210	3.16782	3.17569	53.86406	11.19621	1.88548	0.00000	0.9378	2.25447	-0.56725	-0.07692	0.00000
220 BPM	473.1965	3.16894	3.18093	52.18687	11.63886	1.85659	0.00000	0.9378	2.21207	-0.61158	-0.07692	0.00000
221 CED	474.0441	3.17163	3.19201	48.51811	12.76042	1.79140	0.00000	0.9378	2.11635	-0.71164	-0.07692	0.00000
222 OOO	475.1523	3.17545	3.20500	43.96611	14.48270	1.70615	0.00000	0.9378	1.99121	-0.84247	-0.07692	0.00000
223 B2	481.2229	3.20539	3.25281	23.95319	29.05334	1.30281	0.00000	0.9690	1.30573	-1.55720	-0.05597	0.00000
224 O	481.5277	3.20745	3.25446	23.16770	30.01356	1.28575	0.00000	0.9690	1.27131	-1.59313	-0.05597	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
225 B2	487.5983	3.26703	3.27862	11.89455	53.68286	1.00954	0.00000	0.9929	0.58583	-2.30502	-0.03503	0.00000
226 O	487.9031	3.27117	3.27951	11.54792	55.09893	0.99887	0.00000	0.9929	0.55141	-2.34087	-0.03503	0.00000
227 QD2	488.9699	3.28638	3.28250	10.99036	57.65159	0.98362	0.00000	0.9929	-0.02101	-0.01620	0.00635	0.00000
228 QD2	490.0367	3.30152	3.28549	11.64026	55.16601	1.01251	0.00000	0.9929	-0.59724	2.31132	0.04801	0.00000
229 BPM	490.4122	3.30656	3.28659	12.10522	53.44642	1.03053	0.00000	0.9929	-0.64101	2.26815	0.04801	0.00000
230 CED	491.2598	3.31721	3.28921	13.27559	49.68405	1.07122	0.00000	0.9929	-0.73980	2.17071	0.04801	0.00000
231 OOO	492.3680	3.32969	3.29294	15.05841	45.01408	1.12442	0.00000	0.9929	-0.86896	2.04330	0.04801	0.00000
232 B2	498.4386	3.37587	3.32224	29.90241	24.42840	1.47939	0.00000	1.0199	-1.57645	1.34700	0.06895	0.00000
233 O	498.7434	3.37746	3.32426	30.87424	23.61797	1.50041	0.00000	1.0199	-1.61197	1.31189	0.06895	0.00000
234 B2	504.8140	3.40105	3.38315	54.73867	11.92901	1.98251	0.00000	1.0562	-2.31946	0.61320	0.08989	0.00000
235 O	505.1188	3.40193	3.38729	56.16345	11.56592	2.00991	0.00000	1.0562	-2.35499	0.57804	0.08989	0.00000
236 QF2	506.1856	3.40486	3.40251	58.71046	10.95094	2.06058	0.00000	1.0562	0.00296	0.00695	0.00474	0.00000
237 QF2	507.2524	3.40780	3.41775	56.15119	11.53536	2.01996	0.00000	1.0562	2.36039	-0.56287	-0.08062	0.00000
238 BPM	507.6279	3.40888	3.42283	54.39504	11.97418	1.98969	0.00000	1.0562	2.31644	-0.60574	-0.08062	0.00000
239 CED	508.4755	3.41145	3.43362	50.55229	13.08304	1.92136	0.00000	1.0562	2.21725	-0.70250	-0.08062	0.00000
240 OOO	509.5837	3.41512	3.44632	45.78171	14.78025	1.83202	0.00000	1.0562	2.08755	-0.82901	-0.08062	0.00000
241 B2	515.6543	3.44397	3.49364	24.75039	29.04358	1.40623	0.00000	1.0899	1.37716	-1.52005	-0.05967	0.00000
242 O	515.9591	3.44597	3.49529	23.92174	29.98080	1.38804	0.00000	1.0899	1.34149	-1.55480	-0.05967	0.00000
243 B2	522.0297	3.50442	3.51961	11.94790	53.04123	1.08938	0.00000	1.1156	0.63109	-2.24308	-0.03873	0.00000
244 O	522.3345	3.50854	3.52051	11.57406	54.41918	1.07758	0.00000	1.1156	0.59542	-2.27774	-0.03873	0.00000
245 QD2	523.4013	3.52378	3.52354	10.92573	56.86670	1.06013	0.00000	1.1156	0.02135	0.01776	0.00589	0.00000
246 QD2	524.4681	3.53908	3.52658	11.48022	54.34564	1.09023	0.00000	1.1156	-0.54884	2.31012	0.05077	0.00000
247 BPM	524.8436	3.54419	3.52769	11.90838	52.62718	1.10930	0.00000	1.1156	-0.59140	2.26634	0.05077	0.00000
248 CED	525.6912	3.55504	3.53035	12.99236	48.86905	1.15233	0.00000	1.1156	-0.68748	2.16751	0.05077	0.00000
249 OOO	526.7994	3.56784	3.53415	14.65528	44.20817	1.20859	0.00000	1.1156	-0.81309	2.03830	0.05077	0.00000
250 B2	532.8700	3.61566	3.56415	28.70281	23.74379	1.58031	0.00000	1.1446	-1.50111	1.33203	0.07171	0.00000
251 O	533.1748	3.61732	3.56623	29.62841	22.94264	1.60217	0.00000	1.1446	-1.53566	1.29641	0.07171	0.00000
252 B2	539.2454	3.64193	3.62718	52.44818	11.50194	2.10103	0.00000	1.1831	-2.22368	0.58778	0.09266	0.00000
253 O	539.5502	3.64284	3.63146	53.81427	11.15449	2.12927	0.00000	1.1831	-2.25823	0.55213	0.09266	0.00000
254 QF2	540.6170	3.64590	3.64724	56.26022	10.57976	2.18022	0.00000	1.1831	-0.00048	-0.00542	0.00250	0.00000
255 QF2	541.6838	3.64897	3.66299	53.81627	11.17833	2.13458	0.00000	1.1831	2.25735	-0.56395	-0.08776	0.00000
256 BPM	542.0593	3.65009	3.66823	52.13697	11.61848	2.10163	0.00000	1.1831	2.21481	-0.60823	-0.08776	0.00000
257 CED	542.9069	3.65278	3.67933	48.46379	12.73426	2.02724	0.00000	1.1831	2.11881	-0.70817	-0.08776	0.00000
258 OOO	544.0151	3.65660	3.69235	43.90677	14.44865	1.92999	0.00000	1.1831	1.99329	-0.83884	-0.08776	0.00000
259 B2	550.0857	3.68661	3.74030	23.88118	28.96983	1.46086	0.00000	1.2184	1.30574	-1.55269	-0.06681	0.00000
260 O	550.3905	3.68868	3.74195	23.09572	29.92729	1.44050	0.00000	1.2184	1.27121	-1.58857	-0.06681	0.00000
261 B2	556.4611	3.74851	3.76618	11.83632	53.53603	1.09850	0.00000	1.2448	0.58367	-2.29960	-0.04587	0.00000
262 O	556.7659	3.75267	3.76707	11.49104	54.94878	1.08452	0.00000	1.2448	0.54914	-2.33540	-0.04587	0.00000
263 QD2	557.8327	3.76795	3.77007	10.93629	57.49658	1.05955	0.00000	1.2448	-0.02141	-0.01717	-0.00112	0.00000
264 QD2	558.8995	3.78317	3.77307	11.58513	55.01990	1.08212	0.00000	1.2448	-0.59584	2.30408	0.04358	0.00000
265 BPM	559.2750	3.78823	3.77417	12.04910	53.30570	1.09848	0.00000	1.2448	-0.63976	2.26102	0.04358	0.00000
266 CED	560.1226	3.79893	3.77679	13.21764	49.55519	1.13542	0.00000	1.2448	-0.73890	2.16384	0.04358	0.00000
267 OOO	561.2308	3.81147	3.78053	14.99897	44.90009	1.18371	0.00000	1.2448	-0.86851	2.03676	0.04358	0.00000
268 B2	567.3014	3.85778	3.80990	29.85268	24.38266	1.51180	0.00000	1.2728	-1.57849	1.34230	0.06452	0.00000
269 O	567.6062	3.85937	3.81192	30.82580	23.57507	1.53147	0.00000	1.2728	-1.61414	1.30727	0.06452	0.00000

BETATRON FUNCTIONS THRU .RNG

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
270	B2	573.6768	3.88298	3.87087	54.73168	11.93096	1.98670	0.00000	1.3094	-2.32412	0.61042	0.08547	0.00000
271	O	573.9816	3.88386	3.87500	56.15933	11.56953	2.01275	0.00000	1.3094	-2.35977	0.57536	0.08547	0.00000
272	QF2	575.0484	3.88679	3.89021	58.71689	10.96026	2.05867	0.00000	1.3094	-0.00200	0.00421	0.00030	0.00000
273	QF2	576.1152	3.88973	3.90544	56.16761	11.55104	2.01338	0.00000	1.3094	2.35613	-0.56618	-0.08489	0.00000
274	BPM	576.4907	3.89081	3.91052	54.41460	11.99236	1.98150	0.00000	1.3094	2.31233	-0.60911	-0.08489	0.00000
275	CED	577.3383	3.89338	3.92128	50.57854	13.10705	1.90955	0.00000	1.3094	2.21347	-0.70601	-0.08489	0.00000
276	OOO	578.4465	3.89704	3.93396	45.81586	14.81225	1.81548	0.00000	1.3094	2.08421	-0.83270	-0.08489	0.00000
277	B2	584.5171	3.92585	3.98116	24.81071	29.12663	1.36378	0.00000	1.3425	1.37619	-1.52476	-0.06394	0.00000
278	O	584.8219	3.92784	3.98280	23.98263	30.06674	1.34429	0.00000	1.3425	1.34064	-1.55956	-0.06394	0.00000
279	B2	590.8925	3.98607	4.00705	12.00464	53.19112	1.01972	0.00000	1.3670	0.63262	-2.24885	-0.04300	0.00000
280	O	591.1973	3.99018	4.00795	11.62983	54.57259	1.00661	0.00000	1.3670	0.59707	-2.28356	-0.04300	0.00000
281	QD2	592.2641	4.00534	4.01097	10.97994	57.02560	0.98298	0.00000	1.3670	0.02117	0.01852	-0.00147	0.00000
282	QD2	593.3309	4.02056	4.01400	11.53675	54.49592	1.00345	0.00000	1.3670	-0.55088	2.31733	0.03998	0.00000
283	BPM	593.7064	4.02565	4.01511	11.96639	52.77209	1.01846	0.00000	1.3670	-0.59330	2.27343	0.03998	0.00000
284	CED	594.5540	4.03645	4.01777	13.05333	49.00214	1.05235	0.00000	1.3670	-0.68907	2.17436	0.03998	0.00000
285	OOO	595.6622	4.04919	4.02155	14.71933	44.32644	1.09666	0.00000	1.3670	-0.81428	2.04482	0.03998	0.00000
286	B2	601.7328	4.09684	4.05148	28.76799	23.79349	1.40294	0.00000	1.3930	-1.50010	1.33680	0.06093	0.00000
287	O	602.0376	4.09850	4.05355	29.69295	22.98946	1.42151	0.00000	1.3930	-1.53454	1.30109	0.06093	0.00000
288	B2	608.1082	4.12307	4.11444	52.48586	11.50264	1.85493	0.00000	1.4271	-2.22037	0.59070	0.08187	0.00000
289	O	608.4130	4.12398	4.11872	53.84989	11.15344	1.87988	0.00000	1.4271	-2.25481	0.55495	0.08187	0.00000
290	QF2	609.4798	4.12705	4.13450	56.28680	10.57280	1.92494	0.00000	1.4271	0.00445	-0.00262	0.00228	0.00000
291	QF2	610.5466	4.13011	4.15027	53.83145	11.16495	1.88471	0.00000	1.4271	2.26293	-0.56066	-0.07741	0.00000
292	BPM	610.9221	4.13124	4.15552	52.14802	11.60261	1.85564	0.00000	1.4271	2.22024	-0.60487	-0.07741	0.00000
293	CED	611.7697	4.13392	4.16664	48.46596	12.71256	1.79003	0.00000	1.4271	2.12386	-0.70465	-0.07741	0.00000
294	OOO	612.8779	4.13774	4.17968	43.89828	14.41890	1.70424	0.00000	1.4271	1.99785	-0.83510	-0.07741	0.00000
295	B2	618.9485	4.16779	4.22776	23.83334	28.88775	1.29789	0.00000	1.4583	1.30765	-1.54780	-0.05647	0.00000
296	O	619.2533	4.16986	4.22940	23.04676	29.84221	1.28068	0.00000	1.4583	1.27299	-1.58363	-0.05647	0.00000
297	B2	625.3239	4.22990	4.25370	11.78185	53.38402	1.00147	0.00000	1.4820	0.58279	-2.29352	-0.03552	0.00000
298	O	625.6287	4.23408	4.25460	11.43714	54.79304	0.99064	0.00000	1.4820	0.54813	-2.32926	-0.03552	0.00000
299	QD2	626.6955	4.24944	4.25760	10.88266	57.33477	0.97468	0.00000	1.4820	-0.02066	-0.01771	0.00549	0.00000
300	QD2	627.7623	4.26473	4.26061	11.52795	54.86638	1.00245	0.00000	1.4820	-0.59320	2.29696	0.04676	0.00000
301	BPM	628.1378	4.26982	4.26171	11.98997	53.15750	1.02000	0.00000	1.4820	-0.63724	2.25401	0.04676	0.00000
302	CED	628.9854	4.28057	4.26435	13.15447	49.41868	1.05963	0.00000	1.4820	-0.73663	2.15705	0.04676	0.00000
303	OOO	630.0936	4.29317	4.26810	14.93117	44.77827	1.11145	0.00000	1.4820	-0.86659	2.03029	0.04676	0.00000
304	B2	636.1642	4.33964	4.29754	29.77293	24.32932	1.45883	0.00000	1.5086	-1.57844	1.33749	0.06770	0.00000
305	O	636.4690	4.34125	4.29956	30.74604	23.52464	1.47947	0.00000	1.5086	-1.61419	1.30255	0.06770	0.00000
306	B2	642.5396	4.36490	4.35859	54.66383	11.92761	1.95399	0.00000	1.5444	-2.32604	0.60739	0.08865	0.00000
307	O	642.8444	4.36578	4.36272	56.09267	11.56801	1.98101	0.00000	1.5444	-2.36178	0.57240	0.08865	0.00000
308	QF2	643.9112	4.36871	4.37793	58.65766	10.96483	2.03099	0.00000	1.5444	-0.00685	0.00136	0.00472	0.00000
309	QF2	644.9780	4.37165	4.39314	56.12103	11.56203	1.99100	0.00000	1.5444	2.34929	-0.56944	-0.07942	0.00000
310	BPM	645.3535	4.37273	4.39821	54.37310	12.00582	1.96118	0.00000	1.5444	2.30567	-0.61244	-0.07942	0.00000
311	CED	646.2011	4.37531	4.40897	50.54798	13.12632	1.89386	0.00000	1.5444	2.20721	-0.70952	-0.07942	0.00000
312	OOO	647.3093	4.37897	4.42162	45.79858	14.83958	1.80585	0.00000	1.5444	2.07848	-0.83645	-0.07942	0.00000
313	B2	653.3799	4.40777	4.46871	24.84542	29.20724	1.38733	0.00000	1.5776	1.37335	-1.52979	-0.05847	0.00000
314	O	653.6847	4.40976	4.47035	24.01901	30.15043	1.36951	0.00000	1.5776	1.33795	-1.56465	-0.05847	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
315 B2	659.7553	4.46781	4.49453	12.05612	53.34432	1.07814	0.00000	1.6030	0.63282	-2.25521	-0.03753	0.00000
316 O	660.0601	4.47189	4.49543	11.68114	54.72969	1.06670	0.00000	1.6030	0.59742	-2.28998	-0.03753	0.00000
317 QD2	661.1269	4.48699	4.49844	11.03226	57.18931	1.05029	0.00000	1.6030	0.01987	0.01883	0.00665	0.00000
318 QD2	662.1937	4.50213	4.50146	11.59382	54.65172	1.08100	0.00000	1.6030	-0.55408	2.32432	0.05113	0.00000
319 BPM	662.5692	4.50720	4.50257	12.02583	52.92267	1.10020	0.00000	1.6030	-0.59641	2.28033	0.05113	0.00000
320 CED	663.4168	4.51794	4.50521	13.11787	49.14122	1.14354	0.00000	1.6030	-0.69197	2.18103	0.05113	0.00000
321 OOO	664.5250	4.53062	4.50899	14.78999	44.45105	1.20021	0.00000	1.6030	-0.81690	2.05121	0.05113	0.00000
322 B2	670.5956	4.57808	4.53883	28.86125	23.85013	1.57417	0.00000	1.6318	-1.50121	1.34160	0.07208	0.00000
323 O	670.9004	4.57973	4.54090	29.78685	23.04319	1.59614	0.00000	1.6318	-1.53557	1.30582	0.07208	0.00000
324 B2	676.9710	4.60424	4.60170	52.58298	11.50861	2.09724	0.00000	1.6703	-2.21988	0.59383	0.09302	0.00000
325 O	677.2758	4.60515	4.60598	53.94669	11.15753	2.12559	0.00000	1.6703	-2.25424	0.55801	0.09302	0.00000
326 QF2	678.3426	4.60821	4.62176	56.37789	10.57065	2.17701	0.00000	1.6703	0.00915	0.00025	0.00302	0.00000
327 QF2	679.4094	4.61127	4.63754	53.90879	11.15642	2.13198	0.00000	1.6703	2.27093	-0.55746	-0.08712	0.00000
328 BPM	679.7849	4.61239	4.64279	52.21942	11.59163	2.09927	0.00000	1.6703	2.22805	-0.60158	-0.08712	0.00000
329 CED	680.6325	4.61507	4.65392	48.52450	12.69583	2.02542	0.00000	1.6703	2.13124	-0.70116	-0.08712	0.00000
330 OOO	681.7407	4.61889	4.66698	43.94109	14.39417	1.92887	0.00000	1.6703	2.00467	-0.83136	-0.08712	0.00000
331 B2	687.8113	4.64894	4.71516	23.81224	28.80911	1.46359	0.00000	1.7056	1.31137	-1.54267	-0.06618	0.00000
332 O	688.1161	4.65101	4.71682	23.02344	29.76042	1.44342	0.00000	1.7056	1.27656	-1.57843	-0.06618	0.00000
333 B2	694.1867	4.71121	4.74119	11.73405	53.23057	1.10528	0.00000	1.7321	0.58326	-2.28692	-0.04523	0.00000
334 O	694.4915	4.71541	4.74209	11.38911	54.63555	1.09149	0.00000	1.7321	0.54845	-2.32260	-0.04523	0.00000
335 QD2	695.5583	4.73083	4.74510	10.83236	57.17016	1.06736	0.00000	1.7321	-0.01880	-0.01780	-0.00018	0.00000
336 QD2	696.6251	4.74620	4.74812	11.47176	54.70926	1.09111	0.00000	1.7321	-0.58947	2.29013	0.04487	0.00000
337 BPM	697.0006	4.75131	4.74922	11.93102	53.00546	1.10796	0.00000	1.7321	-0.63358	2.24727	0.04487	0.00000
338 CED	697.8482	4.76211	4.75186	13.08944	49.27789	1.14599	0.00000	1.7321	-0.73313	2.15053	0.04487	0.00000
339 OOO	698.9564	4.77477	4.75562	14.85861	44.65164	1.19571	0.00000	1.7321	-0.86330	2.02403	0.04487	0.00000
340 B2	705.0270	4.82146	4.78514	29.66742	24.26972	1.53165	0.00000	1.7604	-1.57630	1.33271	0.06582	0.00000
341 O	705.3318	4.82306	4.78718	30.63924	23.46793	1.55171	0.00000	1.7604	-1.61211	1.29785	0.06582	0.00000
342 B2	711.4024	4.84679	4.84630	54.53874	11.91905	2.01479	0.00000	1.7975	-2.32511	0.60416	0.08676	0.00000
343 O	711.7072	4.84766	4.85043	55.96704	11.56139	2.04123	0.00000	1.7975	-2.36091	0.56926	0.08676	0.00000
344 QF2	712.7740	4.85061	4.86564	58.53594	10.96455	2.08789	0.00000	1.7975	-0.01133	-0.00152	0.00038	0.00000
345 QF2	713.8408	4.85355	4.88085	56.01397	11.56806	2.04204	0.00000	1.7975	2.34023	-0.57257	-0.08601	0.00000
346 BPM	714.2163	4.85464	4.88592	54.27275	12.01424	2.00975	0.00000	1.7975	2.29682	-0.61567	-0.08601	0.00000
347 CED	715.0639	4.85721	4.89667	50.46226	13.14038	1.93684	0.00000	1.7975	2.19881	-0.71296	-0.08601	0.00000
348 OOO	716.1721	4.86089	4.90930	45.73081	14.86155	1.84152	0.00000	1.7975	2.07067	-0.84016	-0.08601	0.00000
349 B2	722.2427	4.88970	4.95630	24.85264	29.28342	1.38299	0.00000	1.8311	1.36880	-1.53501	-0.06507	0.00000
350 O	722.5475	4.89168	4.95793	24.02896	30.22981	1.36315	0.00000	1.8311	1.33356	-1.56994	-0.06507	0.00000
351 B2	728.6181	4.94961	4.98204	12.09958	53.49707	1.03175	0.00000	1.8559	0.63169	-2.26200	-0.04412	0.00000
352 O	728.9229	4.95369	4.98294	11.72524	54.88661	1.01830	0.00000	1.8559	0.59645	-2.29685	-0.04412	0.00000
353 QD2	729.9897	4.96872	4.98594	11.07988	57.35381	0.99372	0.00000	1.8559	0.01749	0.01869	-0.00213	0.00000
354 QD2	731.0565	4.98380	4.98895	11.64836	54.80920	1.01372	0.00000	1.8559	-0.55829	2.33094	0.03977	0.00000
355 BPM	731.4320	4.98883	4.99006	12.08352	53.07522	1.02866	0.00000	1.8559	-0.60057	2.28686	0.03977	0.00000
356 CED	732.2796	4.99953	4.99270	13.18251	49.28286	1.06236	0.00000	1.8559	-0.69602	2.18737	0.03977	0.00000
357 OOO	733.3878	5.01214	4.99646	14.86346	44.57891	1.10643	0.00000	1.8559	-0.82081	2.05730	0.03977	0.00000
358 B2	739.4584	5.05939	5.02622	28.97759	23.91232	1.41138	0.00000	1.8821	-1.50435	1.34633	0.06071	0.00000
359 O	739.7632	5.06103	5.02829	29.90511	23.10252	1.42989	0.00000	1.8821	-1.53868	1.31048	0.06071	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
360 B2	745.8338	5.08546	5.08897	52.73434	11.51971	1.86198	0.00000	1.9163	-2.22222	0.59712	0.08166	0.00000
361 O	746.1386	5.08637	5.09325	54.09947	11.16664	1.88687	0.00000	1.9163	-2.25654	0.56123	0.08166	0.00000
362 QF2	747.2054	5.08941	5.10902	56.52861	10.57336	1.93153	0.00000	1.9163	0.01336	0.00312	0.00178	0.00000
363 QF2	748.2722	5.09246	5.12479	54.04415	11.15293	1.89063	0.00000	1.9163	2.28092	-0.55442	-0.07818	0.00000
364 BPM	748.6477	5.09359	5.13005	52.34736	11.58583	1.86127	0.00000	1.9163	2.23782	-0.59844	-0.07818	0.00000
365 CED	749.4953	5.09626	5.14119	48.63626	12.6B452	1.79501	0.00000	1.9163	2.14054	-0.69780	-0.07818	0.00000
366 OOO	750.6035	5.10007	5.15427	44.03291	14.37509	1.70837	0.00000	1.9163	2.01336	-0.82771	-0.07818	0.00000
367 B2	756.6741	5.13008	5.20254	23.81899	28.73587	1.29739	0.00000	1.9476	1.31669	-1.53740	-0.05723	0.00000
368 O	756.9789	5.13215	5.20420	23.02700	29.68394	1.27994	0.00000	1.9476	1.28171	-1.57308	-0.05723	0.00000
369 B2	763.0495	5.19245	5.22864	11.69550	53.07946	0.99609	0.00000	1.9712	0.58505	-2.27998	-0.03629	0.00000
370 O	763.3543	5.19666	5.22954	11.34952	54.48019	0.98503	0.00000	1.9712	0.55006	-2.31557	-0.03629	0.00000
371 QD2	764.4211	5.21215	5.23256	10.78806	57.00680	0.96812	0.00000	1.9712	-0.01594	-0.01744	0.00447	0.00000
372 QD2	765.4879	5.22758	5.23559	11.41960	54.55239	0.99465	0.00000	1.9712	-0.58484	2.28377	0.04544	0.00000
373 BPM	765.8634	5.23272	5.23670	11.87538	52.85335	1.01171	0.00000	1.9712	-0.62897	2.24099	0.04544	0.00000
374 CED	766.7110	5.24357	5.23935	13.02605	49.13628	1.05022	0.00000	1.9712	-0.72858	2.14441	0.04544	0.00000
375 OOO	767.8192	5.25629	5.24312	14.78520	44.52333	1.10058	0.00000	1.9712	-0.85882	2.01815	0.04544	0.00000
376 B2	773.8898	5.30320	5.27272	29.54180	24.20533	1.43996	0.00000	1.9976	-1.57219	1.32807	0.06638	0.00000
377 O	774.1946	5.30481	5.27476	30.51113	23.40634	1.46019	0.00000	1.9976	-1.60801	1.29327	0.06638	0.00000
378 B2	780.2652	5.32862	5.33399	54.36313	11.90549	1.92671	0.00000	2.0328	-2.32138	0.60083	0.08733	0.00000
379 O	780.5700	5.32950	5.33813	55.78916	11.54984	1.95333	0.00000	2.0328	-2.35720	0.56599	0.08733	0.00000
380 QF2	781.6368	5.33246	5.35336	58.35824	10.95941	2.00253	0.00000	2.0328	-0.01521	-0.00436	0.00457	0.00000
381 QF2	782.7036	5.33541	5.36857	55.85214	11.56898	1.96302	0.00000	2.0328	2.32945	-0.57549	-0.07838	0.00000
382 BPM	783.0791	5.33650	5.37364	54.11895	12.01740	1.93359	0.00000	2.0328	2.28625	-0.61870	-0.07838	0.00000
383 CED	783.9267	5.33908	5.38438	50.32596	13.14888	1.86715	0.00000	2.0328	2.18872	-0.71623	-0.07838	0.00000
384 OOO	785.0349	5.34276	5.39700	45.61618	14.87763	1.78029	0.00000	2.0328	2.06121	-0.84374	-0.07838	0.00000
385 B2	791.1055	5.37162	5.44391	24.83199	29.35328	1.36807	0.00000	2.0656	1.36278	-1.54029	-0.05744	0.00000
386 O	791.4103	5.37361	5.44554	24.01193	30.30292	1.35056	0.00000	2.0656	1.32771	-1.57531	-0.05744	0.00000
387 B2	797.4809	5.43148	5.46959	12.13270	53.64559	1.06548	0.00000	2.0907	0.62928	-2.26905	-0.03649	0.00000
388 O	797.7857	5.43554	5.47049	11.75979	55.03946	1.05436	0.00000	2.0907	0.59421	-2.30399	-0.03649	0.00000
389 QD2	798.8525	5.45052	5.47348	11.12026	57.51503	1.03879	0.00000	2.0907	0.01418	0.01810	0.00719	0.00000
390 QD2	799.9193	5.46554	5.47648	11.69746	54.96448	1.06982	0.00000	2.0907	-0.56327	2.33701	0.05120	0.00000
391 BPM	800.2948	5.47056	5.47758	12.13635	53.22596	1.08904	0.00000	2.0907	-0.60556	2.29286	0.05120	0.00000
392 CED	801.1424	5.48121	5.48021	13.24380	49.42356	1.13244	0.00000	2.0907	-0.70101	2.19322	0.05120	0.00000
393 OOO	802.2506	5.49376	5.48397	14.93582	44.70688	1.18918	0.00000	2.0907	-0.82581	2.06294	0.05120	0.00000
394 B2	808.3212	5.54077	5.51365	29.11078	23.97857	1.56354	0.00000	2.1193	-1.50938	1.35086	0.07214	0.00000
395 O	808.6260	5.54241	5.51571	30.04136	23.16599	1.58553	0.00000	2.1193	-1.54371	1.31495	0.07214	0.00000
396 B2	814.6966	5.56673	5.57626	52.93184	11.53565	2.08703	0.00000	2.1575	-2.22728	0.60047	0.09309	0.00000
397 O	815.0014	5.56764	5.58053	54.30005	11.18056	2.11540	0.00000	2.1575	-2.26160	0.56452	0.09309	0.00000
398 QF2	816.0682	5.57068	5.59628	56.73090	10.58088	2.16712	0.00000	2.1575	0.01685	0.00591	0.00350	0.00000
399 QF2	817.1350	5.57371	5.61205	54.23027	11.15457	2.12282	0.00000	2.1575	2.29235	-0.55163	-0.08624	0.00000
400 BPM	817.5105	5.57483	5.61731	52.52497	11.58533	2.09044	0.00000	2.1575	2.24904	-0.59554	-0.08624	0.00000
401 CED	818.35B1	5.57750	5.62845	48.79526	12.67889	2.01734	0.00000	2.1575	2.15128	-0.69465	-0.08624	0.00000
402 OOO	819.4663	5.58130	5.64154	44.16882	14.36211	1.92178	0.00000	2.1575	2.02346	-0.82423	-0.08624	0.00000
403 B2	825.5369	5.61124	5.68989	23.85326	28.66982	1.46186	0.00000	2.1927	1.32333	-1.53214	-0.06529	0.00000
404 O	825.8417	5.61331	5.69155	23.05727	29.61466	1.44196	0.00000	2.1927	1.28818	-1.56773	-0.06529	0.00000

BETATRON FUNCTIONS THRU .RNG

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
405	B2	831.9123	5.67364	5.71605	11.66825	52.93444	1.10919	0.00000	2.2192	0.58805	-2.27286	-0.04435	0.00000
406	O	832.2171	5.67786	5.71696	11.32049	54.33079	1.09567	0.00000	2.2192	0.55290	-2.30836	-0.04435	0.00000
407	QD2	833.2839	5.69339	5.71999	10.75215	56.84872	1.07258	0.00000	2.2192	-0.01223	-0.01663	0.00090	0.00000
408	QD2	834.3507	5.70888	5.72302	11.37423	54.39966	1.09761	0.00000	2.2192	-0.57957	2.27803	0.04620	0.00000
409	BPM	834.7262	5.71404	5.72414	11.82605	52.70490	1.11496	0.00000	2.2192	-0.62367	2.23531	0.04620	0.00000
410	CED	835.5738	5.72494	5.72679	12.96768	48.99735	1.15411	0.00000	2.2192	-0.72322	2.13887	0.04620	0.00000
411	OOO	836.6820	5.73772	5.73057	14.71487	44.39649	1.20531	0.00000	2.2192	-0.85338	2.01278	0.04620	0.00000
412	B2	842.7526	5.78485	5.76026	29.40282	24.13772	1.54929	0.00000	2.2478	-1.56632	1.32368	0.06714	0.00000
413	O	843.0574	5.78648	5.76230	30.36856	23.34139	1.56975	0.00000	2.2478	-1.60212	1.28893	0.06714	0.00000
414	B2	849.1280	5.81039	5.82167	54.14640	11.88726	2.04088	0.00000	2.2854	-2.31506	0.59748	0.08809	0.00000
415	O	849.4328	5.81128	5.82582	55.56857	11.53364	2.06773	0.00000	2.2854	-2.35085	0.56268	0.08809	0.00000
416	QF2	850.4996	5.81424	5.84106	58.13409	10.94956	2.11520	0.00000	2.2854	-0.01827	-0.00709	0.00058	0.00000
417	QF2	851.5664	5.81720	5.85628	55.64423	11.56478	2.06896	0.00000	2.2854	2.31752	-0.57813	-0.08695	0.00000
418	BPM	851.9419	5.81830	5.86136	53.91991	12.01523	2.03631	0.00000	2.2854	2.27453	-0.62146	-0.08695	0.00000
419	CED	852.7895	5.82089	5.87210	50.14638	13.15161	1.96262	0.00000	2.2854	2.17748	-0.71925	-0.08695	0.00000
420	OOO	853.8977	5.82458	5.88471	45.46082	14.88743	1.86626	0.00000	2.2854	2.05060	-0.84710	-0.08695	0.00000
421	B2	859.9683	5.85352	5.93156	24.78458	29.41512	1.40205	0.00000	2.3194	1.35561	-1.54550	-0.06600	0.00000
422	O	860.2731	5.85552	5.93318	23.96884	30.36795	1.38193	0.00000	2.3194	1.32071	-1.58061	-0.06600	0.00000
423	B2	866.3437	5.91339	5.95718	12.15371	53.78623	1.04486	0.00000	2.3446	0.62572	-2.27620	-0.04506	0.00000
424	O	866.6485	5.91744	5.95807	11.78291	55.18448	1.03113	0.00000	2.3446	0.59082	-2.31123	-0.04506	0.00000
425	QD2	867.7153	5.93238	5.96105	11.15122	57.66899	1.00583	0.00000	2.3446	0.01011	0.01708	-0.00254	0.00000
426	QD2	868.7821	5.94736	5.96404	11.73847	55.11373	1.02566	0.00000	2.3446	-0.56877	2.34239	0.03985	0.00000
427	BPM	869.1576	5.95236	5.96515	12.18152	53.37119	1.04062	0.00000	2.3446	-0.61110	2.29819	0.03985	0.00000
428	CED	870.0052	5.96296	5.96777	13.29846	49.55986	1.07440	0.00000	2.3446	-0.70667	2.19843	0.03985	0.00000
429	OOO	871.1134	5.97546	5.97151	15.00319	44.83180	1.11857	0.00000	2.3446	-0.83162	2.06800	0.03985	0.00000
430	B2	877.1840	6.02225	6.00111	29.25369	24.04712	1.42406	0.00000	2.3710	-1.51602	1.35508	0.06080	0.00000
431	O	877.4888	6.02388	6.00316	30.18833	23.23202	1.44259	0.00000	2.3710	-1.55038	1.31913	0.06080	0.00000
432	B2	883.5594	6.04809	6.06357	53.16489	11.55605	1.87521	0.00000	2.4056	-2.23478	0.60381	0.08174	0.00000
433	O	883.8642	6.04899	6.06783	54.53769	11.19894	1.90013	0.00000	2.4056	-2.26915	0.56782	0.08174	0.00000
434	QF2	884.9310	6.05201	6.08356	56.97390	10.59301	1.94459	0.00000	2.4056	0.01944	0.00856	0.00131	0.00000
435	QF2	885.9978	6.05504	6.09932	54.45718	11.16131	1.90291	0.00000	2.4056	2.30462	-0.54915	-0.07917	0.00000
436	BPM	886.3733	6.05615	6.10457	52.74275	11.59016	1.87318	0.00000	2.4056	2.26110	-0.59294	-0.07917	0.00000
437	CED	887.2209	6.05881	6.11571	48.99299	12.67908	1.80608	0.00000	2.4056	2.16287	-0.69178	-0.07917	0.00000
438	OOO	888.3291	6.06259	6.12880	44.34154	14.35555	1.71834	0.00000	2.4056	2.03444	-0.82101	-0.07917	0.00000
439	B2	894.3997	6.09243	6.17721	23.91318	28.61259	1.30132	0.00000	2.4370	1.33094	-1.52701	-0.05823	0.00000
440	O	894.7045	6.09450	6.17888	23.11261	29.55427	1.28358	0.00000	2.4370	1.29562	-1.56251	-0.05823	0.00000
441	B2	900.7751	6.15480	6.20344	11.65377	52.79906	0.99370	0.00000	2.4606	0.59212	-2.26573	-0.03728	0.00000
442	O	901.0799	6.15902	6.20434	11.30358	54.19104	0.98234	0.00000	2.4606	0.55679	-2.30114	-0.03728	0.00000
443	QD2	902.1467	6.17458	6.20738	10.72654	56.69982	0.96430	0.00000	2.4606	-0.00786	-0.01540	0.00335	0.00000
444	QD2	903.2135	6.19012	6.21042	11.33811	54.25482	0.98953	0.00000	2.4606	-0.57393	2.27305	0.04412	0.00000
445	BPM	903.5890	6.19529	6.21154	11.78567	52.56379	1.00610	0.00000	2.4606	-0.61796	2.23037	0.04412	0.00000
446	CED	904.4366	6.20623	6.21420	12.91747	48.86453	1.04349	0.00000	2.4606	-0.71734	2.13403	0.04412	0.00000
447	OOO	905.5448	6.21906	6.21800	14.65138	44.27426	1.09239	0.00000	2.4606	-0.84728	2.00807	0.04412	0.00000
448	B2	911.6154	6.26642	6.24777	29.25790	24.06857	1.42379	0.00000	2.4867	-1.55901	1.31965	0.06507	0.00000
449	O	911.9202	6.26805	6.24982	30.21917	23.27469	1.44362	0.00000	2.4867	-1.59474	1.28494	0.06507	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
450 B2	917.9908	6.29208	6.30933	53.90016	11.86481	1.90216	0.00000	2.5215	-2.30647	0.59418	0.08601	0.00000
451 O	918.2956	6.29297	6.31348	55.31708	11.51320	1.92838	0.00000	2.5215	-2.34221	0.55942	0.08601	0.00000
452 QF2	919.3624	6.29595	6.32875	57.87549	10.93523	1.97674	0.00000	2.5215	-0.02035	-0.00964	0.00432	0.00000
453 QF2	920.4292	6.29893	6.34399	55.40136	11.55555	1.93753	0.00000	2.5215	2.30508	-0.58044	-0.07756	0.00000
454 BPM	920.8047	6.30002	6.34907	53.68632	12.00778	1.90840	0.00000	2.5215	2.26229	-0.62388	-0.07756	0.00000
455 CED	921.6523	6.30263	6.35981	49.93316	13.14850	1.84266	0.00000	2.5215	2.16570	-0.72194	-0.07756	0.00000
456 OOO	922.7605	6.30634	6.37243	45.27306	14.89070	1.75671	0.00000	2.5215	2.03941	-0.85016	-0.07756	0.00000
457 B2	928.8311	6.33538	6.41922	24.71294	29.46739	1.34946	0.00000	2.5538	1.34767	-1.55051	-0.05662	0.00000
458 O	929.1359	6.33738	6.42084	23.90199	30.42331	1.33220	0.00000	2.5538	1.31294	-1.58572	-0.05662	0.00000
459 B2	935.2065	6.39531	6.44479	12.16148	53.91551	1.05209	0.00000	2.5786	0.62120	-2.28326	-0.03567	0.00000
460 O	935.5113	6.39936	6.44568	11.79338	55.31809	1.04122	0.00000	2.5786	0.58647	-2.31838	-0.03567	0.00000
461 QD2	936.5781	6.41429	6.44866	11.17112	57.81190	1.02623	0.00000	2.5786	0.00550	0.01566	0.00748	0.00000
462 QD2	937.6449	6.42923	6.45164	11.76922	55.25326	1.05729	0.00000	2.5786	-0.57447	2.34694	0.05096	0.00000
463 BPM	938.0204	6.43421	6.45274	12.21658	53.50731	1.07642	0.00000	2.5786	-0.61691	2.30271	0.05096	0.00000
464 CED	938.8680	6.44479	6.45536	13.34355	49.68838	1.11962	0.00000	2.5786	-0.71269	2.20287	0.05096	0.00000
465 OOO	939.9762	6.45724	6.45909	15.06195	44.95059	1.17609	0.00000	2.5786	-0.83793	2.07234	0.05096	0.00000
466 B2	946.0468	6.50381	6.48860	29.39866	24.11640	1.54899	0.00000	2.6069	-1.52391	1.35889	0.07190	0.00000
467 O	946.3516	6.50544	6.49065	30.33814	23.29899	1.57091	0.00000	2.6069	-1.55835	1.32291	0.07190	0.00000
468 B2	952.4222	6.52953	6.55090	53.42101	11.58040	2.07095	0.00000	2.6448	-2.24433	0.60705	0.09285	0.00000
469 O	952.7270	6.53042	6.55515	54.79965	11.22132	2.09925	0.00000	2.6448	-2.27877	0.57103	0.09285	0.00000
470 QF2	953.7938	6.53343	6.57085	57.24461	10.60945	2.15107	0.00000	2.6448	0.02099	0.01100	0.00394	0.00000
471 QF2	954.8606	6.53644	6.58659	54.71273	11.17297	2.10759	0.00000	2.6448	2.31707	-0.54704	-0.08515	0.00000
472 BPM	955.2361	6.53755	6.59184	52.98903	11.60019	2.07561	0.00000	2.6448	2.27336	-0.59070	-0.08515	0.00000
473 CED	956.0837	6.54020	6.60297	49.21885	12.68509	2.00344	0.00000	2.6448	2.17470	-0.68927	-0.08515	0.00000
474 OOO	957.1919	6.54396	6.61606	44.54182	14.35559	1.90908	0.00000	2.6448	2.04570	-0.81813	-0.08515	0.00000
475 B2	963.2625	6.57369	6.66451	23.99557	28.56559	1.45577	0.00000	2.6798	1.33910	-1.52214	-0.06421	0.00000
476 O	963.5673	6.57574	6.66618	23.19006	29.50428	1.43620	0.00000	2.6798	1.30362	-1.55754	-0.06421	0.00000
477 B2	969.6379	6.63594	6.69079	11.65282	52.67668	1.11002	0.00000	2.7063	0.59703	-2.25878	-0.04326	0.00000
478 O	969.9427	6.64017	6.69170	11.29969	54.06439	1.09684	0.00000	2.7063	0.56155	-2.29409	-0.04326	0.00000
479 QD2	971.0095	6.65574	6.69474	10.71262	56.56377	1.07494	0.00000	2.7063	-0.00306	-0.01378	0.00206	0.00000
480 QD2	972.0763	6.67130	6.69779	11.31316	54.12146	1.10128	0.00000	2.7063	-0.56823	2.26895	0.04748	0.00000
481 BPM	972.4518	6.67648	6.69891	11.75639	52.43349	1.11911	0.00000	2.7063	-0.61214	2.22630	0.04748	0.00000
482 CED	973.2994	6.68746	6.70158	12.87810	48.74109	1.15935	0.00000	2.7063	-0.71125	2.13001	0.04748	0.00000
483 OOO	974.4076	6.70033	6.70538	14.59813	44.15965	1.21197	0.00000	2.7063	-0.84084	2.00412	0.04748	0.00000
484 B2	980.4782	6.74790	6.73524	29.11482	23.99958	1.56377	0.00000	2.7351	-1.55065	1.31609	0.06843	0.00000
485 O	980.7830	6.74954	6.73729	30.07096	23.20787	1.58463	0.00000	2.7351	-1.58629	1.28139	0.06843	0.00000
486 B2	986.8536	6.77369	6.79697	53.63760	11.83871	2.06357	0.00000	2.7731	-2.29609	0.59102	0.08937	0.00000
487 O	987.1584	6.77458	6.80113	55.04816	11.48901	2.09081	0.00000	2.7731	-2.33173	0.55628	0.08937	0.00000
488 QF2	988.2252	6.77757	6.81643	57.59631	10.91677	2.13913	0.00000	2.7731	-0.02134	-0.01195	0.00089	0.00000
489 QF2	989.2920	6.78056	6.83169	55.13656	11.54153	2.09269	0.00000	2.7731	2.29279	-0.58234	-0.08764	0.00000
490 BPM	989.6675	6.78166	6.83677	53.43067	11.99523	2.05978	0.00000	2.7731	2.25018	-0.62591	-0.08764	0.00000
491 CED	990.5151	6.78428	6.84752	49.69770	13.13962	1.98549	0.00000	2.7731	2.15399	-0.72425	-0.08764	0.00000
492 OOO	991.6233	6.78801	6.86014	45.06295	14.88735	1.88837	0.00000	2.7731	2.02823	-0.85283	-0.08764	0.00000
493 B2	997.6939	6.81718	6.90691	24.62092	29.50881	1.41995	0.00000	2.8075	1.33939	-1.55521	-0.06669	0.00000
494 O	997.9987	6.81918	6.90853	23.81497	30.46763	1.39963	0.00000	2.8075	1.30481	-1.59052	-0.06669	0.00000

BETATRON FUNCTIONS THRU .RNG

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
495	SB	1004.0693	6.87725	6.93243	12.15504	54.04784	0.99475	0.00000	2.8075	0.61592	-2.29381	-0.06669	0.00000
496	O	1004.3741	6.88130	6.93331	11.79012	55.45691	0.97442	0.00000	2.8075	0.58133	-2.32912	-0.06669	0.00000
497	QD2	1005.4409	6.89622	6.93629	11.17845	57.96753	0.92460	0.00000	2.8075	0.00056	0.01087	-0.02706	0.00000
498	QD2	1006.5077	6.91114	6.93926	11.78767	55.41188	0.91625	0.00000	2.8075	-0.58011	2.34896	0.01136	0.00000
499	BPM	1006.8832	6.91612	6.94036	12.23932	53.66440	0.92052	0.00000	2.8075	-0.62268	2.30479	0.01136	0.00000
500	CED	1007.7308	6.92667	6.94296	13.37635	49.84182	0.93014	0.00000	2.8075	-0.71879	2.20509	0.01136	0.00000
501	OOO	1008.8390	6.93909	6.94668	15.10872	45.09890	0.94273	0.00000	2.8075	-0.84444	2.07475	0.01136	0.00000
502	B2	1014.9096	6.98548	6.97608	29.53831	24.22933	1.07524	0.00000	2.8284	-1.53270	1.36231	0.03230	0.00000
503	O	1015.2144	6.98709	6.97812	30.48317	23.40981	1.08509	0.00000	2.8284	-1.56726	1.32638	0.03230	0.00000
504	SB	1021.2850	7.01107	7.03803	53.68996	11.64965	1.28118	0.00000	2.8284	-2.25556	0.61085	0.03230	0.00000
505	O	1021.5898	7.01196	7.04226	55.07548	11.28823	1.29103	0.00000	2.8284	-2.29012	0.57492	0.03230	0.00000
506	QF2	1022.6566	7.01495	7.05787	57.53227	10.67047	1.29664	0.00000	2.8284	0.02141	0.01271	-0.02183	0.00000
507	Q1	1023.7234	7.01795	7.07352	54.98682	11.23237	1.24480	0.00000	2.8284	2.32918	-0.54721	-0.07499	0.00000
508	XO	1028.7324	7.03627	7.12830	34.58480	19.61689	0.86916	0.00000	2.8284	1.74389	-1.12668	-0.07499	0.00000
509	QOO	1029.2774	7.03884	7.13260	33.10899	20.64173	0.83328	0.00000	2.8284	0.97454	-0.74644	-0.05679	0.00000
510	O	1029.5822	7.04032	7.13492	32.52038	21.10377	0.81597	0.00000	2.8284	0.95659	-0.76944	-0.05679	0.00000
511	B2	1035.6528	7.07588	7.17175	23.07687	33.21442	0.53480	0.00000	2.8424	0.59913	-1.22509	-0.03585	0.00000
512	O	1035.9576	7.07800	7.17319	22.71711	33.96823	0.52387	0.00000	2.8424	0.58118	-1.24804	-0.03585	0.00000
513	B2	1042.0282	7.12676	7.19629	17.83121	51.87749	0.36984	0.00000	2.8515	0.22372	-1.70147	-0.01490	0.00000
514	O	1042.3330	7.12949	7.19721	17.70030	52.92169	0.36530	0.00000	2.8515	0.20577	-1.72436	-0.01490	0.00000
515	B2	1048.4036	7.18575	7.21241	17.37201	76.59657	0.33841	0.00000	2.8587	-0.15169	-2.17471	0.00604	0.00000
516	O	1048.7084	7.18853	7.21304	17.46995	77.92922	0.34025	0.00000	2.8587	-0.16964	-2.19751	0.00604	0.00000
517	QO	1051.1764	7.20881	7.21814	23.35862	70.34587	0.39728	0.00000	2.8587	-2.40366	5.02117	0.04109	0.00000
518	XI	1054.1764	7.22438	7.22676	40.39196	43.57240	0.52054	0.00000	2.8587	-3.27412	3.90332	0.04109	0.00000
519	QI	1056.3100	7.23193	7.23574	47.24036	34.88960	0.56002	0.00000	2.8587	0.25693	0.40470	-0.00463	0.00000
520	LS	1069.1610	7.27722	7.30075	44.36334	29.99663	0.50049	0.00000	2.8587	-0.03306	-0.02396	-0.00463	0.00000
521	LS	1082.0120	7.32169	7.36459	48.93971	36.12110	0.44097	0.00000	2.8587	-0.32305	-0.45262	-0.00463	0.00000
522	QI	1084.1456	7.32896	7.37324	42.05639	45.26582	0.39273	0.00000	2.8587	3.35562	-4.08459	-0.03991	0.00000
523	XI	1087.1456	7.34384	7.38153	24.54635	73.28937	0.27301	0.00000	2.8587	2.48107	-5.25659	-0.03991	0.00000
524	QO	1089.6136	7.36305	7.38642	18.52818	81.30981	0.20385	0.00000	2.8587	0.14882	2.27018	-0.01725	0.00000
525	O	1089.9184	7.36567	7.38702	18.44259	79.93294	0.19860	0.00000	2.8587	0.13200	2.24711	-0.01725	0.00000
526	B2	1095.9890	7.41842	7.40156	18.87277	55.41032	0.15747	0.00000	2.8622	-0.20287	1.79158	0.00370	0.00000
527	O	1096.2938	7.42098	7.40245	19.00156	54.32524	0.15860	0.00000	2.8622	-0.21969	1.76842	0.00370	0.00000
528	B2	1102.3644	7.46715	7.42448	23.70134	35.63519	0.24461	0.00000	2.8662	-0.55456	1.30969	0.02464	0.00000
529	O	1102.6692	7.46918	7.42585	24.04453	34.84389	0.25212	0.00000	2.8662	-0.57137	1.28646	0.02464	0.00000
530	B2	1108.7398	7.50374	7.46102	33.01391	22.02086	0.46527	0.00000	2.8735	-0.90625	0.82539	0.04559	0.00000
531	O	1109.0446	7.50520	7.46325	33.57148	21.52479	0.47916	0.00000	2.8735	-0.92306	0.80212	0.04559	0.00000
532	QOO	1109.5896	7.50773	7.46737	34.99505	20.42974	0.50685	0.00000	2.8735	-1.69914	1.19933	0.05613	0.00000
533	XO	1114.5986	7.52598	7.52058	54.80386	11.40949	0.78800	0.00000	2.8735	-2.25551	0.60148	0.05613	0.00000
534	Q1	1115.6654	7.52899	7.53605	57.19828	10.74057	0.82998	0.00000	2.8735	0.04439	0.03483	0.02228	0.00000
535	QF2	1116.7322	7.53200	7.55163	54.62001	11.25643	0.83519	0.00000	2.8735	2.33650	-0.52554	-0.01255	0.00000
536	BPM	1117.1077	7.53311	7.55685	52.88197	11.66710	0.83047	0.00000	2.8735	2.29210	-0.56811	-0.01255	0.00000
537	CED	1117.9553	7.53576	7.56793	49.08137	12.71161	0.81984	0.00000	2.8735	2.19186	-0.66421	-0.01255	0.00000
538	OOO	1119.0635	7.53954	7.58102	44.36856	14.32299	0.80593	0.00000	2.8735	2.06081	-0.78985	-0.01255	0.00000
539	SB	1125.1341	7.56951	7.62996	23.70593	28.09078	0.72973	0.00000	2.8735	1.34291	-1.47810	-0.01255	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
540 0	1125.4389	7.57159	7.63166	22.89828	29.00236	0.72590	0.00000	2.8735	1.30687	-1.51265	-0.01255	0.00000
541 B2	1131.5095	7.63292	7.65675	11.38993	51.52915	0.71328	0.00000	2.8883	0.58902	-2.19733	0.00839	0.00000
542 0	1131.8143	7.63724	7.65768	11.04185	52.87915	0.71584	0.00000	2.8883	0.55298	-2.23181	0.00839	0.00000
543 QD2	1132.8811	7.65319	7.66080	10.46405	55.29870	0.74091	0.00000	2.8883	-0.00332	-0.00235	0.03880	0.00000
544 QD2	1133.9479	7.66911	7.66391	11.05644	52.88886	0.79923	0.00000	2.8883	-0.56022	2.22753	0.07094	0.00000
545 BPM	1134.3234	7.67442	7.66506	11.49392	51.23189	0.82587	0.00000	2.8883	-0.60484	2.18520	0.07094	0.00000
546 CED	1135.1710	7.68563	7.66779	12.60462	47.60852	0.88599	0.00000	2.8883	-0.70556	2.08965	0.07094	0.00000
547 000	1136.2792	7.69878	7.67169	14.31437	43.11545	0.96461	0.00000	2.8883	-0.83725	1.96473	0.07094	0.00000
548 B2	1142.3498	7.74705	7.70229	28.85742	23.40171	1.45879	0.00000	2.9135	-1.55857	1.28197	0.09188	0.00000
549 0	1142.6546	7.74870	7.70440	29.81856	22.63071	1.48680	0.00000	2.9135	-1.59479	1.24754	0.09188	0.00000
550 SB	1148.7252	7.77297	7.76539	53.56047	11.64691	2.04459	0.00000	2.9135	-2.31617	0.56181	0.09188	0.00000
551 0	1149.0300	7.77387	7.76962	54.98344	11.31493	2.07259	0.00000	2.9135	-2.35239	0.52738	0.09188	0.00000
552 QF2	1150.0968	7.77686	7.78512	57.57933	10.79718	2.12398	0.00000	2.9135	-0.04477	-0.03488	0.00410	0.00000
553 QF2	1151.1636	7.77985	7.80051	55.16888	11.46821	2.08127	0.00000	2.9135	2.27069	-0.60343	-0.08387	0.00000
554 BPM	1151.5391	7.78095	7.80562	53.47932	11.93816	2.04977	0.00000	2.9135	2.22879	-0.64809	-0.08387	0.00000
555 CED	1152.3867	7.78357	7.81641	49.78124	13.12226	1.97868	0.00000	2.9135	2.13421	-0.74892	-0.08387	0.00000
556 000	1153.4949	7.78729	7.82902	45.18801	14.92824	1.88573	0.00000	2.9135	2.01055	-0.88073	-0.08387	0.00000
557 B2	1159.5655	7.81625	7.87533	24.89083	29.99602	1.44017	0.00000	2.9481	1.33321	-1.60081	-0.06293	0.00000
558 0	1159.8703	7.81823	7.87692	24.08847	30.98291	1.42099	0.00000	2.9481	1.29920	-1.63701	-0.06293	0.00000
559 B2	1165.9409	7.87529	7.90037	12.42733	55.21719	1.10256	0.00000	2.9743	0.62186	-2.35418	-0.04199	0.00000
560 0	1166.2457	7.87925	7.90123	12.05861	56.66330	1.08977	0.00000	2.9743	0.58785	-2.39030	-0.04199	0.00000
561 QD2	1167.3125	7.89383	7.90414	11.44260	59.25042	1.06909	0.00000	2.9743	-0.00183	0.00142	0.00307	0.00000
562 QD2	1168.3793	7.90841	7.90705	12.06667	56.65743	1.09637	0.00000	2.9743	-0.59185	2.39288	0.04827	0.00000
563 BPM	1168.7548	7.91327	7.90812	12.52692	54.87711	1.11449	0.00000	2.9743	-0.63387	2.34831	0.04827	0.00000
564 CED	1169.6024	7.92358	7.91067	13.68185	50.98155	1.15540	0.00000	2.9743	-0.72872	2.24769	0.04827	0.00000
565 000	1170.7106	7.93573	7.91431	15.43440	46.14557	1.20889	0.00000	2.9743	-0.85273	2.11613	0.04827	0.00000
566 B2	1176.7812	7.98132	7.94302	29.90999	24.81338	1.56543	0.00000	3.0031	-1.53199	1.39712	0.06921	0.00000
567 0	1177.0860	7.98291	7.94501	30.85429	23.97275	1.58653	0.00000	3.0031	-1.56610	1.36086	0.06921	0.00000
568 B2	1183.1566	8.00667	8.00371	53.99041	11.82758	2.07021	0.00000	3.0412	-2.24536	0.63936	0.09015	0.00000
569 0	1183.4614	8.00756	8.00788	55.36958	11.44889	2.09769	0.00000	3.0412	-2.27947	0.60306	0.09015	0.00000
570 QF2	1184.5282	8.01054	8.02330	57.78976	10.77800	2.14669	0.00000	3.0412	0.04456	0.03512	0.00137	0.00000
571 QF2	1185.5950	8.01352	8.03883	55.18502	11.29453	2.10058	0.00000	3.0412	2.36078	-0.52647	-0.08748	0.00000
572 BPM	1185.9705	8.01462	8.04403	53.42888	11.70585	2.06773	0.00000	3.0412	2.31605	-0.56893	-0.08748	0.00000
573 CED	1186.8181	8.01724	8.05508	49.58829	12.75154	1.99358	0.00000	3.0412	2.21509	-0.66478	-0.08748	0.00000
574 000	1187.9263	8.02099	8.06812	44.82505	14.36382	1.89663	0.00000	3.0412	2.08309	-0.79009	-0.08748	0.00000
575 B2	1193.9969	8.05066	8.11696	23.92466	28.11525	1.42917	0.00000	3.0758	1.36005	-1.47466	-0.06654	0.00000
576 0	1194.3017	8.05272	8.11866	23.10663	29.02469	1.40889	0.00000	3.0758	1.32375	-1.50908	-0.06654	0.00000
577 B2	1200.3723	8.11366	8.14376	11.42488	51.49114	1.06856	0.00000	3.1015	0.60071	-2.19097	-0.04559	0.00000
578 0	1200.6771	8.11797	8.14469	11.06975	52.83722	1.05466	0.00000	3.1015	0.56441	-2.22531	-0.04559	0.00000
579 QD2	1201.7439	8.13389	8.14781	10.46910	55.24464	1.02931	0.00000	3.1015	0.00700	0.00235	-0.00210	0.00000
580 QD2	1202.8107	8.14983	8.15093	11.03899	52.82748	1.05014	0.00000	3.1015	-0.54914	2.22960	0.04130	0.00000
581 BPM	1203.1862	8.15514	8.15208	11.46802	51.16899	1.06565	0.00000	3.1015	-0.59341	2.18715	0.04130	0.00000
582 CED	1204.0338	8.16639	8.15481	12.55867	47.54253	1.10066	0.00000	3.1015	-0.69335	2.09135	0.04130	0.00000
583 000	1205.1420	8.17960	8.15871	14.24021	43.04607	1.14642	0.00000	3.1015	-0.82401	1.96609	0.04130	0.00000
584 B2	1211.2126	8.22823	8.18939	28.58835	23.32716	1.46068	0.00000	3.1286	-1.53971	1.28146	0.06224	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
585 O	1211.5174	8.22990	8.19150	29.53791	22.55650	1.47966	0.00000	3.1286	-1.57565	1.24694	0.06224	0.00000
586 B2	1217.5880	8.25441	8.25278	53.01119	11.58463	1.92105	0.00000	3.1640	-2.29135	0.56004	0.08319	0.00000
587 O	1217.8928	8.25531	8.25702	54.41896	11.25377	1.94641	0.00000	3.1640	-2.32729	0.52548	0.08319	0.00000
588 QF2	1218.9596	8.25834	8.27261	56.98655	10.73794	1.99138	0.00000	3.1640	-0.04375	-0.03480	0.00081	0.00000
589 QF2	1220.0264	8.26136	8.28809	54.60015	11.40672	1.94813	0.00000	3.1640	2.24746	-0.60136	-0.08160	0.00000
590 BPM	1220.4019	8.26247	8.29323	52.92794	11.87518	1.91749	0.00000	3.1640	2.20584	-0.64619	-0.08160	0.00000
591 CED	1221.2495	8.26512	8.30407	49.26821	13.05636	1.84833	0.00000	3.1640	2.11191	-0.74737	-0.08160	0.00000
592 OOO	1222.3577	8.26887	8.31674	44.72348	14.85942	1.75790	0.00000	3.1640	1.98909	-0.87966	-0.08160	0.00000
593 B2	1228.4283	8.29813	8.36322	24.65884	29.92975	1.32616	0.00000	3.1961	1.31637	-1.60231	-0.06065	0.00000
594 O	1228.7331	8.30013	8.36481	23.86667	30.91760	1.30767	0.00000	3.1961	1.28259	-1.63864	-0.06065	0.00000
595 B2	1234.8037	8.35757	8.38828	12.37923	55.18722	1.00307	0.00000	3.2200	0.60986	-2.35838	-0.03971	0.00000
596 O	1235.1085	8.36155	8.38915	12.01775	56.63594	0.99097	0.00000	3.2200	0.57608	-2.39462	-0.03971	0.00000
597 QD2	1236.1753	8.37617	8.39206	11.42487	59.23369	0.97052	0.00000	3.2200	-0.01207	-0.00408	0.00123	0.00000
598 QD2	1237.2421	8.39076	8.39497	12.07081	56.65282	0.99361	0.00000	3.2200	-0.60241	2.38719	0.04222	0.00000
599 BPM	1237.6176	8.39561	8.39604	12.53914	54.87672	1.00946	0.00000	3.2200	-0.64481	2.34279	0.04222	0.00000
600 CED	1238.4652	8.40591	8.39859	13.71333	50.99017	1.04525	0.00000	3.2200	-0.74051	2.24257	0.04222	0.00000
601 OOO	1239.5734	8.41802	8.40223	15.49326	46.16496	1.09204	0.00000	3.2200	-0.86564	2.11153	0.04222	0.00000
602 B2	1245.6440	8.46332	8.43090	30.16268	24.87123	1.41189	0.00000	3.2460	-1.55101	1.39538	0.06317	0.00000
603 O	1245.9488	8.46490	8.43288	31.11866	24.03161	1.43115	0.00000	3.2460	-1.58542	1.35926	0.06317	0.00000
604 B2	1252.0194	8.48844	8.49135	54.52653	11.88835	1.87814	0.00000	3.2805	-2.27080	0.64064	0.08411	0.00000
605 O	1252.3242	8.48932	8.49550	55.92129	11.50884	1.90378	0.00000	3.2805	-2.30521	0.60448	0.08411	0.00000
606 QF2	1253.3910	8.49227	8.51084	58.37175	10.83699	1.95067	0.00000	3.2805	0.04235	0.03462	0.00348	0.00000
607 QF2	1254.4578	8.49523	8.52628	55.74589	11.35671	1.91115	0.00000	3.2805	2.38249	-0.52900	-0.07731	0.00000
608 BPM	1254.8333	8.49632	8.53145	53.97353	11.76988	1.88212	0.00000	3.2805	2.33752	-0.57131	-0.07731	0.00000
609 CED	1255.6809	8.49891	8.54244	50.09701	12.81933	1.81659	0.00000	3.2805	2.23601	-0.66683	-0.07731	0.00000
610 OOO	1256.7891	8.50261	8.55542	45.28821	14.43570	1.73092	0.00000	3.2805	2.10329	-0.79172	-0.07731	0.00000
611 B2	1262.8597	8.53198	8.60407	24.16651	28.19272	1.32522	0.00000	3.3122	1.37631	-1.47395	-0.05636	0.00000
612 O	1263.1645	8.53402	8.60576	23.33864	29.10170	1.30804	0.00000	3.3122	1.33981	-1.50825	-0.05636	0.00000
613 B2	1269.2351	8.59447	8.63081	11.48580	51.54393	1.02949	0.00000	3.3365	0.61283	-2.18781	-0.03542	0.00000
614 O	1269.5399	8.59877	8.63174	11.12335	52.88805	1.01869	0.00000	3.3365	0.57633	-2.22202	-0.03542	0.00000
615 QD2	1270.6067	8.61462	8.63485	10.49967	55.28600	1.00347	0.00000	3.3365	0.01698	0.00781	0.00679	0.00000
616 QD2	1271.6735	8.63053	8.63797	11.04872	52.85571	1.03328	0.00000	3.3365	-0.53929	2.23627	0.04929	0.00000
617 BPM	1272.0490	8.63584	8.63912	11.47020	51.19228	1.05179	0.00000	3.3365	-0.58316	2.19363	0.04929	0.00000
618 CED	1272.8966	8.64709	8.64186	12.54270	47.55520	1.09357	0.00000	3.3365	-0.68219	2.09740	0.04929	0.00000
619 OOO	1274.0048	8.66033	8.64575	14.19818	43.04594	1.14820	0.00000	3.3365	-0.81166	1.97159	0.04929	0.00000
620 B2	1280.0754	8.70924	8.67647	28.35682	23.27884	1.51099	0.00000	3.3641	-1.52084	1.28390	0.07024	0.00000
621 O	1280.3802	8.71092	8.67859	29.29478	22.50675	1.53239	0.00000	3.3641	-1.55645	1.24922	0.07024	0.00000
622 B2	1286.4508	8.73566	8.74009	52.49544	11.52574	2.02232	0.00000	3.4011	-2.26563	0.55926	0.09118	0.00000
623 O	1286.7556	8.73657	8.74436	53.88743	11.19539	2.05012	0.00000	3.4011	-2.30125	0.52455	0.09118	0.00000
624 QF2	1287.8224	8.73963	8.76003	56.42317	10.67956	2.10126	0.00000	3.4011	-0.04038	-0.03387	0.00434	0.00000
625 QF2	1288.8892	8.74268	8.77560	54.05468	11.34423	2.05931	0.00000	3.4011	2.22756	-0.59839	-0.08269	0.00000
626 BPM	1289.2647	8.74380	8.78076	52.39733	11.81050	2.02826	0.00000	3.4011	2.18614	-0.64334	-0.08269	0.00000
627 CED	1290.1123	8.74647	8.79166	48.77062	12.98710	1.95816	0.00000	3.4011	2.09266	-0.74481	-0.08269	0.00000
628 OOO	1291.2205	8.75027	8.80440	44.26791	14.78493	1.86652	0.00000	3.4011	1.97043	-0.87748	-0.08269	0.00000
629 B2	1297.2911	8.77983	8.85107	24.41036	29.84155	1.42812	0.00000	3.4354	1.30091	-1.60223	-0.06175	0.00000

BETATRON FUNCTIONS THRU .RNG

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
630	O	1297.5959	8.78185	8.85267	23.62758	30.82937	1.40930	0.00000	3.4354	1.26729	-1.63866	-0.06175	0.00000
631	B2	1303.6665	8.83977	8.87619	12.30630	55.11194	1.09803	0.00000	3.4615	0.59778	-2.36049	-0.04081	0.00000
632	O	1303.9713	8.84377	8.87706	11.95214	56.56197	1.08560	0.00000	3.4615	0.56416	-2.39684	-0.04081	0.00000
633	QD2	1305.0381	8.85846	8.87997	11.38187	59.16794	1.06609	0.00000	3.4615	-0.02166	-0.00946	0.00410	0.00000
634	QD2	1306.1049	8.87309	8.88289	12.04735	56.60114	1.09441	0.00000	3.4615	-0.61141	2.37958	0.04919	0.00000
635	BPM	1306.4804	8.87795	8.88396	12.52259	54.83067	1.11288	0.00000	3.4615	-0.65423	2.33538	0.04919	0.00000
636	CED	1307.3280	8.88826	8.88651	13.71357	50.95629	1.15458	0.00000	3.4615	-0.75089	2.23561	0.04919	0.00000
637	OOO	1308.4362	8.90036	8.89015	15.51789	46.14583	1.20909	0.00000	3.4615	-0.87726	2.10517	0.04919	0.00000
638	B2	1314.5068	8.94546	8.91880	30.36994	24.90971	1.57126	0.00000	3.4903	-1.56947	1.39225	0.07014	0.00000
639	O	1314.8116	8.94703	8.92078	31.33729	24.07195	1.59264	0.00000	3.4903	-1.60423	1.35630	0.07014	0.00000
640	B2	1320.8822	8.97038	8.97905	55.01498	11.94501	2.08195	0.00000	3.5286	-2.29644	0.64091	0.09108	0.00000
641	O	1321.1870	8.97126	8.98318	56.42549	11.56528	2.10971	0.00000	3.5286	-2.33120	0.60491	0.09108	0.00000
642	QF2	1322.2538	8.97418	8.99844	58.90894	10.89440	2.15943	0.00000	3.5286	0.03787	0.03326	0.00177	0.00000
643	QF2	1323.3206	8.97711	9.01380	56.26864	11.41913	2.11347	0.00000	3.5286	2.40030	-0.53240	-0.08761	0.00000
644	BPM	1323.6961	8.97819	9.01894	54.48296	11.83481	2.08057	0.00000	3.5286	2.35518	-0.57460	-0.08761	0.00000
645	CED	1324.5437	8.98076	9.02987	50.57678	12.88962	2.00631	0.00000	3.5286	2.25333	-0.66987	-0.08761	0.00000
646	OOO	1325.6519	8.98442	9.04278	45.73007	14.51235	1.90922	0.00000	3.5286	2.12017	-0.79442	-0.08761	0.00000
647	B2	1331.7225	9.01350	9.09121	24.41826	28.29111	1.44099	0.00000	3.5635	1.39075	-1.47483	-0.06667	0.00000
648	O	1332.0273	9.01552	9.09290	23.58162	29.20059	1.42067	0.00000	3.5635	1.35413	-1.50904	-0.06667	0.00000
649	SB	1338.0979	9.07542	9.11788	11.56920	51.65808	1.01597	0.00000	3.5635	0.62466	-2.19035	-0.06667	0.00000
650	O	1338.4027	9.07968	9.11880	11.19957	53.00374	0.99565	0.00000	3.5635	0.58803	-2.22455	-0.06667	0.00000
651	QD2	1339.4695	9.09544	9.12191	10.55410	55.40181	0.94633	0.00000	3.5635	0.02601	0.01024	-0.02614	0.00000
652	QD2	1340.5363	9.11128	9.12502	11.08523	52.96133	0.93947	0.00000	3.5635	-0.53128	2.24323	0.01322	0.00000
653	BPM	1340.9118	9.11657	9.12617	11.50053	51.29273	0.94443	0.00000	3.5635	-0.57472	2.20046	0.01322	0.00000
654	CED	1341.7594	9.12781	9.12890	12.55790	47.64433	0.95564	0.00000	3.5635	-0.67276	2.10392	0.01322	0.00000
655	OOO	1342.8676	9.14103	9.13279	14.19108	43.12107	0.97029	0.00000	3.5635	-0.80095	1.97771	0.01322	0.00000
656	B2	1348.9382	9.19012	9.16347	28.17709	23.29302	1.11412	0.00000	3.5851	-1.50311	1.28782	0.03417	0.00000
657	O	1349.2430	9.19181	9.16558	29.10413	22.51857	1.12453	0.00000	3.5851	-1.53836	1.25303	0.03417	0.00000
658	SB	1355.3136	9.21674	9.22711	52.04453	11.51127	1.33194	0.00000	3.5851	-2.24057	0.56018	0.03417	0.00000
659	O	1355.6184	9.21766	9.23139	53.42113	11.18039	1.34236	0.00000	3.5851	-2.27583	0.52540	0.03417	0.00000
660	QF2	1356.6852	9.22075	9.24708	55.92337	10.66228	1.34880	0.00000	3.5851	-0.03486	-0.03255	-0.02213	0.00000
661	Q1	1357.7520	9.22382	9.26268	53.56550	11.32345	1.29549	0.00000	3.5851	2.21222	-0.59637	-0.07745	0.00000
662	XO	1362.7610	9.24250	9.31626	34.16417	20.30175	0.90756	0.00000	3.5851	1.66107	-1.19606	-0.07745	0.00000
663	QOO	1363.3060	9.24510	9.32042	32.77237	21.39486	0.87057	0.00000	3.5851	0.90260	-0.80185	-0.05844	0.00000
664	O	1363.6108	9.24659	9.32266	32.22729	21.89080	0.85276	0.00000	3.5851	0.88572	-0.82525	-0.05844	0.00000
665	B2	1369.6814	9.28198	9.35799	23.51463	34.72850	0.56161	0.00000	3.5997	0.54960	-1.28902	-0.03749	0.00000
666	O	1369.9862	9.28406	9.35937	23.18473	35.52140	0.55019	0.00000	3.5997	0.53273	-1.31238	-0.03749	0.00000
667	B2	1376.0568	9.33106	9.38145	18.75757	54.26049	0.38618	0.00000	3.6093	0.19661	-1.77380	-0.01655	0.00000
668	O	1376.3616	9.33366	9.38233	18.64286	55.34890	0.38114	0.00000	3.6093	0.17973	-1.79710	-0.01655	0.00000
669	B2	1382.4322	9.38665	9.39688	18.50120	79.95486	0.34427	0.00000	3.6166	-0.15639	-2.25531	0.00440	0.00000
670	O	1382.7370	9.38927	9.39748	18.60168	81.33677	0.34561	0.00000	3.6166	-0.17327	-2.27852	0.00440	0.00000
671	QO	1385.2050	9.40834	9.40236	24.78110	73.34776	0.39907	0.00000	3.6166	-2.52708	5.25323	0.03979	0.00000
672	XI	1388.2050	9.42306	9.41065	42.62611	45.33726	0.51843	0.00000	3.6166	-3.42125	4.08361	0.03979	0.00000
673	QI	1390.3386	9.43022	9.41928	49.69002	36.20691	0.55539	0.00000	3.6166	0.30912	0.44647	-0.00565	0.00000
674	LS	1403.1896	9.47383	9.48281	45.38619	30.20212	0.48278	0.00000	3.6166	0.02578	0.02079	-0.00565	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
675 LS	1416.0406	9.51805	9.54734	48.36466	35.13826	0.41017	0.00000	3.6166	-0.25755	-0.40489	-0.00565	0.00000
676 QI	1418.1742	9.52543	9.55626	41.32797	43.86777	0.36253	0.00000	3.6166	3.35769	-3.92630	-0.03834	0.00000
677 XI	1421.1742	9.54066	9.56483	23.85476	70.79349	0.24750	0.00000	3.6166	2.46671	-5.04894	-0.03834	0.00000
678 QO	1423.6422	9.56055	9.56989	17.77633	78.40321	0.17924	0.00000	3.6166	0.18951	2.21546	-0.01807	0.00000
679 O	1423.9470	9.56329	9.57052	17.66622	77.05967	0.17373	0.00000	3.6166	0.17175	2.19249	-0.01807	0.00000
680 B2	1430.0176	9.61901	9.58563	17.72842	53.18935	0.12763	0.00000	3.6196	-0.18199	1.73877	0.00288	0.00000
681 O	1430.3224	9.62174	9.58655	17.84478	52.13642	0.12851	0.00000	3.6196	-0.19975	1.71571	0.00288	0.00000
682 B2	1436.3930	9.67082	9.60956	22.41710	34.07487	0.20955	0.00000	3.6229	-0.55349	1.25889	0.02382	0.00000
683 O	1436.6978	9.67297	9.61100	22.75993	33.31450	0.21681	0.00000	3.6229	-0.57125	1.23576	0.02382	0.00000
684 B2	1442.7684	9.70916	9.64777	31.84237	21.09498	0.42499	0.00000	3.6294	-0.92499	0.77670	0.04477	0.00000
685 O	1443.0732	9.71067	9.65009	32.41166	20.62857	0.43863	0.00000	3.6294	-0.94275	0.75353	0.04477	0.00000
686 QOO	1443.6182	9.71330	9.65440	33.84420	19.59638	0.46564	0.00000	3.6294	-1.69598	1.13302	0.05444	0.00000
687 XO	1448.6272	9.73204	9.70937	53.70820	11.16975	0.73830	0.00000	3.6294	-2.26968	0.54928	0.05444	0.00000
688 Q1	1449.6940	9.73511	9.72511	56.18386	10.60146	0.77959	0.00000	3.6294	-0.01646	-0.00870	0.02268	0.00000
689 QF2	1450.7608	9.73817	9.74083	53.77636	11.20798	0.78634	0.00000	3.6294	2.23965	-0.56825	-0.01008	0.00000
690 BPM	1451.1363	9.73930	9.74606	52.11016	11.65138	0.78256	0.00000	3.6294	2.19764	-0.61257	-0.01008	0.00000
691 CED	1451.9839	9.74199	9.75713	48.46508	12.77460	0.77402	0.00000	3.6294	2.10282	-0.71261	-0.01008	0.00000
692 OOO	1453.0921	9.74581	9.77010	43.94177	14.49900	0.76285	0.00000	3.6294	1.97885	-0.84342	-0.01008	0.00000
693 SB	1459.1627	9.77571	9.81786	24.03892	29.08885	0.70169	0.00000	3.6294	1.29972	-1.55995	-0.01008	0.00000
694 O	1459.4675	9.77776	9.81950	23.25700	30.05076	0.69862	0.00000	3.6294	1.26562	-1.59592	-0.01008	0.00000
695 B2	1465.53B1	9.83691	9.84363	12.01408	53.75948	0.70102	0.00000	3.6438	0.58654	-2.30872	0.01087	0.00000
696 O	1465.8429	9.84101	9.84452	11.66691	55.17782	0.70434	0.00000	3.6438	0.55244	-2.34461	0.01087	0.00000
697 QD2	1466.9097	9.85606	9.84751	11.11127	57.73493	0.73182	0.00000	3.6438	-0.02386	-0.01656	0.04084	0.00000
698 QD2	1467.9765	9.87103	9.85049	11.77179	55.24641	0.79213	0.00000	3.6438	-0.60449	2.31440	0.07265	0.00000
699 BPM	1468.3520	9.87601	9.85159	12.24212	53.52452	0.81941	0.00000	3.6438	-0.64805	2.27120	0.07265	0.00000
700 CED	1469.1996	9.88654	9.85421	13.42402	49.75704	0.88098	0.00000	3.6438	-0.74636	2.17368	0.07265	0.00000
701 OOO	1470.3078	9.89890	9.85793	15.22071	45.08061	0.96149	0.00000	3.6438	-0.87490	2.04617	0.07265	0.00000
702 B2	1476.3784	9.94465	9.88719	30.11616	24.46339	1.46605	0.00000	3.6690	-1.57898	1.34932	0.09359	0.00000
703 O	1476.6832	9.94623	9.88921	31.08949	23.65156	1.49457	0.00000	3.6690	-1.61434	1.31418	0.09359	0.00000
704 SB	1482.7538	9.96969	9.94802	54.96395	11.94496	2.06274	0.00000	3.6690	-2.31847	0.61423	0.09359	0.00000
705 O	1483.0586	9.97056	9.95214	56.38806	11.58124	2.09126	0.00000	3.6690	-2.35382	0.57908	0.09359	0.00000
706 QF2	1484.1254	9.97349	9.96734	58.92218	10.96460	2.14404	0.00000	3.6690	0.01369	0.00749	0.00499	0.00000
707 QF2	1485.1922	9.97641	9.98257	56.33134	11.54832	2.10184	0.00000	3.6690	2.37881	-0.56275	-0.08383	0.00000
708 BPM	1485.5677	9.97749	9.98765	54.56153	11.98703	2.07036	0.00000	3.6690	2.33442	-0.60556	-0.08383	0.00000
709 CED	1486.4153	9.98005	9.99842	50.68914	13.09549	1.99931	0.00000	3.6690	2.23423	-0.70220	-0.08383	0.00000
710 OOO	1487.5235	9.98371	10.01111	45.88236	14.79188	1.90641	0.00000	3.6690	2.10323	-0.82856	-0.08393	0.00000
711 B2	1493.5941	10.01256	10.05842	24.70398	29.04458	1.46115	0.00000	3.7041	1.38570	-1.51875	-0.06288	0.00000
712 O	1493.8989	10.01456	10.06006	23.87024	29.98099	1.44198	0.00000	3.7041	1.34967	-1.55345	-0.06288	0.00000
713 B2	1499.9695	10.07336	10.08439	11.84033	53.01996	1.12385	0.00000	3.7307	0.63214	-2.24089	-0.04194	0.00000
714 O	1500.2743	10.07752	10.08529	11.46595	54.39656	1.11106	0.00000	3.7307	0.59611	-2.27550	-0.04194	0.00000
715 QD2	1501.3411	10.09291	10.08832	10.81255	56.84029	1.09091	0.00000	3.7307	0.02548	0.01902	0.00402	0.00000
716 QD2	1502.4079	10.10837	10.09136	11.35396	54.31780	1.11970	0.00000	3.7307	-0.54053	2.31019	0.05016	0.00000
717 BPM	1502.7834	10.11354	10.09247	11.77594	52.59929	1.13854	0.00000	3.7307	-0.58326	2.26639	0.05016	0.00000
718 CED	1503.6310	10.12452	10.09514	12.84645	48.84113	1.18105	0.00000	3.7307	-0.67973	2.16750	0.05016	0.00000
719 OOO	1504.7392	10.13746	10.09893	14.49276	44.18036	1.23663	0.00000	3.7307	-0.80585	2.03821	0.05016	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
720 B2	1510.8098	10.18576	10.12896	28.46946	23.71944	1.60466	0.00000	3.7602	-1.49668	1.33154	0.07110	0.00000
721 O	1511.1146	10.18743	10.13104	29.39241	22.91859	1.62633	0.00000	3.7602	-1.53137	1.29591	0.07110	0.00000
722 B2	1517.1852	10.21220	10.19207	52.17716	11.48643	2.12149	0.00000	3.7993	-2.22220	0.58688	0.09205	0.00000
723 O	1517.4900	10.21312	10.19636	53.54238	11.13955	2.14955	0.00000	3.7993	-2.25689	0.55120	0.09205	0.00000
724 QF2	1518.5568	10.21620	10.21215	55.99800	10.56625	2.19940	0.00000	3.7993	-0.01074	-0.00586	0.00107	0.00000
725 QF2	1519.6236	10.21927	10.22792	53.58687	11.16530	2.15181	0.00000	3.7993	2.23729	-0.56398	-0.08995	0.00000
726 BPM	1519.9991	10.22041	10.23318	51.92246	11.60550	2.11803	0.00000	3.7993	2.19521	-0.60831	-0.08995	0.00000
727 CED	1520.8467	10.22310	10.24429	48.28166	12.72152	2.04179	0.00000	3.7993	2.10022	-0.70837	-0.08995	0.00000
728 OOO	1521.9549	10.22694	10.25732	43.76437	14.43653	1.94210	0.00000	3.7993	1.97602	-0.83920	-0.08995	0.00000
729 B2	1528.0255	10.25699	10.30528	23.90426	28.96724	1.45964	0.00000	3.8347	1.29574	-1.55390	-0.06901	0.00000
730 O	1528.3303	10.25905	10.30693	23.12478	29.92545	1.43860	0.00000	3.8347	1.26158	-1.58983	-0.06901	0.00000
731 B2	1534.4009	10.31857	10.33116	11.93819	53.55459	1.08328	0.00000	3.8609	0.58130	-2.30171	-0.04806	0.00000
732 O	1534.7057	10.32270	10.33205	11.59425	54.96864	1.06863	0.00000	3.8609	0.54714	-2.33755	-0.04806	0.00000
733 QD2	1535.7725	10.33783	10.33505	11.04719	57.52017	1.04094	0.00000	3.8609	-0.02673	-0.01847	-0.00404	0.00000
734 QD2	1536.8393	10.35289	10.33805	11.71172	55.04512	1.05995	0.00000	3.8609	-0.60544	2.30386	0.03981	0.00000
735 BPM	1537.2148	10.35790	10.33915	12.18286	53.33108	1.07490	0.00000	3.8609	-0.64926	2.26083	0.03981	0.00000
736 CED	1538.0624	10.36848	10.34177	13.36730	49.58084	1.10864	0.00000	3.8609	-0.74816	2.16370	0.03981	0.00000
737 OOO	1539.1706	10.38088	10.34551	15.16882	44.92594	1.15276	0.00000	3.8609	-0.87747	2.03671	0.03981	0.00000
738 B2	1545.2412	10.42670	10.37485	30.12093	24.40653	1.45798	0.00000	3.8880	-1.58575	1.34268	0.06075	0.00000
739 O	1545.5460	10.42829	10.37688	31.09845	23.59870	1.47649	0.00000	3.8880	-1.62132	1.30767	0.06075	0.00000
740 B2	1551.6166	10.45172	10.43575	55.08113	11.94711	1.90885	0.00000	3.9232	-2.32960	0.61125	0.08170	0.00000
741 O	1551.9214	10.45258	10.43987	56.51210	11.58517	1.93375	0.00000	3.9232	-2.36517	0.57621	0.08170	0.00000
742 QF2	1552.9882	10.45550	10.45507	59.06506	10.97465	1.97743	0.00000	3.9232	0.00764	0.00454	-0.00012	0.00000
743 QF2	1554.0550	10.45842	10.47027	56.48045	11.56521	1.93350	0.00000	3.9232	2.37911	-0.56630	-0.08193	0.00000
744 BPM	1554.4305	10.45950	10.47534	54.71036	12.00660	1.90273	0.00000	3.9232	2.33483	-0.60918	-0.08193	0.00000
745 CED	1555.2781	10.46205	10.48610	50.83707	13.12132	1.83329	0.00000	3.9232	2.23488	-0.70597	-0.08193	0.00000
746 OOL	1559.1723	10.47672	10.52440	35.21913	20.35148	1.51423	0.00000	3.9232	1.77568	-1.15067	-0.08193	0.00000
747 B2	1565.2429	10.51547	10.55918	18.00680	38.51842	1.08045	0.00000	3.9502	1.05989	-1.84128	-0.06099	0.00000
748 OOL	1569.1371	10.55900	10.57271	11.54020	54.58751	0.84295	0.00000	3.9502	0.60068	-2.28514	-0.06099	0.00000
749 QD2	1570.2039	10.57429	10.57573	10.87979	57.04324	0.79632	0.00000	3.9502	0.02758	0.01758	-0.02678	0.00000
750 QD2	1571.2707	10.58966	10.57876	11.41899	54.51472	0.78540	0.00000	3.9502	-0.54052	2.31719	0.00624	0.00000
751 BPM	1571.6462	10.59480	10.57987	11.84088	52.79099	0.78774	0.00000	3.9502	-0.58302	2.27332	0.00624	0.00000
752 CED	1572.4938	10.60572	10.58252	12.91051	49.02119	0.79303	0.00000	3.9502	-0.67893	2.17429	0.00624	0.00000
753 OOL	1576.3880	10.64476	10.59776	19.91433	33.85878	0.81731	0.00000	3.9502	-1.11960	1.71930	0.00624	0.00000
754 B2	1582.4586	10.68033	10.63813	37.67614	17.27989	0.91873	0.00000	3.9681	-1.80649	1.01112	0.02718	0.00000
755 OOL	1586.3528	10.69416	10.68333	53.46186	11.17973	1.02458	0.00000	3.9681	-2.24716	0.55536	0.02718	0.00000
756 QF2	1587.4196	10.69724	10.69907	55.90012	10.59911	1.03066	0.00000	3.9681	-0.00445	-0.00305	-0.01581	0.00000
757 QF2	1588.4864	10.70032	10.71480	53.48029	11.19312	0.99109	0.00000	3.9681	2.23904	-0.56200	-0.05811	0.00000
758 BPM	1588.8619	10.70146	10.72004	51.81462	11.63175	0.96927	0.00000	3.9681	2.19682	-0.60614	-0.05811	0.00000
759 CED	1589.7095	10.70416	10.73113	48.17135	12.74374	0.92002	0.00000	3.9681	2.10152	-0.70578	-0.05811	0.00000
760 OOL	1593.6037	10.71961	10.77032	33.50903	20.02342	0.69374	0.00000	3.9681	1.66365	-1.16358	-0.05811	0.00000
761 B2	1599.6743	10.75999	10.80541	17.45480	38.47108	0.40459	0.00000	3.9794	0.98113	-1.87461	-0.03716	0.00000
762 OOL	1603.5685	10.80427	10.81892	11.51851	54.85068	0.25988	0.00000	3.9794	0.54326	-2.33155	-0.03716	0.00000
763 QD2	1604.6353	10.81950	10.82193	10.97697	57.39468	0.22577	0.00000	3.9794	-0.02809	-0.01752	-0.02703	0.00000
764 QD2	1605.7021	10.83466	10.82493	11.64199	54.92324	0.20178	0.00000	3.9794	-0.60455	2.29959	-0.01810	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
765 BPM	1606.0776	10.83969	10.82603	12.11254	53.21240	0.19499	0.00000	3.9794	-0.64859	2.25660	-0.01810	0.00000
766 CED	1606.9252	10.85033	10.82866	13.29629	49.46927	0.17964	0.00000	3.9794	-0.74800	2.15955	-0.01810	0.00000
767 OOL	1610.8194	10.88785	10.84371	20.90070	34.38599	0.10914	0.00000	3.9794	-1.20475	1.71371	-0.01810	0.00000
768 B2	1616.8900	10.92158	10.88318	39.84847	17.78811	0.06282	0.00000	3.9810	-1.91671	1.01983	0.00284	0.00000
769 OOL	1620.7842	10.93465	10.92690	56.55526	11.58446	0.07389	0.00000	3.9810	-2.37346	0.57322	0.00284	0.00000
770 QF2	1621.8510	10.93756	10.94209	59.12419	10.98014	0.07526	0.00000	3.9810	0.00119	0.00163	-0.00028	0.00000
771 QF2	1622.9178	10.94048	10.95729	56.55031	11.57729	0.07330	0.00000	3.9810	2.37564	-0.56966	-0.00339	0.00000
772 BPM	1623.2933	10.94155	10.96235	54.78277	12.02123	0.07203	0.00000	3.9810	2.33153	-0.61262	-0.00339	0.00000
773 CED	1624.1409	10.94411	10.97309	50.91478	13.14193	0.06916	0.00000	3.9810	2.23195	-0.70959	-0.00339	0.00000
774 000	1625.2491	10.94775	10.98573	46.11217	14.85517	0.06541	0.00000	3.9810	2.10175	-0.83637	-0.00339	0.00000
775 SB	1631.3197	10.97640	11.03278	24.92385	29.22584	0.04485	0.00000	3.9810	1.38856	-1.53089	-0.00339	0.00000
776 0	1631.6245	10.97838	11.03442	24.08829	30.16970	0.04382	0.00000	3.9810	1.35276	-1.56576	-0.00339	0.00000
777 SB	1637.6951	11.03651	11.05858	11.99369	53.39597	0.02326	0.00000	3.9810	0.63957	-2.26027	-0.00339	0.00000
778 0	1637.9999	11.04062	11.05948	11.61472	54.78446	0.02223	0.00000	3.9810	0.60376	-2.29514	-0.00339	0.00000
779 INS1	1639.9933	11.07073	11.06482	9.67451	64.38918	0.01548	0.00000	3.9810	0.36957	-2.52319	-0.00339	0.00000
780 QDI	1641.0601	11.08867	11.06739	9.43687	66.90671	0.01219	0.00000	3.9810	-0.14351	0.19857	-0.00281	0.00000
781 QDI	1642.1269	11.10605	11.06997	10.30529	63.56687	0.00944	0.00000	3.9810	-0.68262	2.88536	-0.00236	0.00000
782 BPM	1642.5024	11.11170	11.07093	10.83800	61.42065	0.00855	0.00000	3.9810	-0.73604	2.83027	-0.00236	0.00000
783 CED	1643.3500	11.12345	11.07321	12.18793	56.72817	0.00656	0.00000	3.9810	-0.85662	2.70593	-0.00236	0.00000
784 000	1644.4582	11.13684	11.07650	14.26124	50.91091	0.00394	0.00000	3.9810	-1.01426	2.54335	-0.00236	0.00000
785 SB	1650.5288	11.18284	11.10347	31.81799	25.43777	-0.01037	0.00000	3.9810	-1.87783	1.65279	-0.00236	0.00000
786 0	1650.8336	11.18434	11.10542	32.97593	24.44385	-0.01109	0.00000	3.9810	-1.92119	1.60808	-0.00236	0.00000
787 SB	1656.9042	11.20585	11.16782	61.54391	10.32606	-0.02540	0.00000	3.9810	-2.78476	0.71752	-0.00236	0.00000
788 0	1657.2090	11.20663	11.17262	63.25471	9.90228	-0.02612	0.00000	3.9810	-2.82812	0.67281	-0.00236	0.00000
789 INS2	1658.6281	11.20998	11.19765	71.56815	8.28813	-0.02946	0.00000	3.9810	-3.03000	0.46462	-0.00236	0.00000
790 QF2	1659.6949	11.21229	11.21897	74.86696	7.81066	-0.03131	0.00000	3.9810	-0.01627	-0.01043	-0.00109	0.00000
791 QF2	1660.7617	11.21459	11.24024	71.63555	8.33397	-0.03176	0.00000	3.9810	3.00031	-0.48737	0.00023	0.00000
792 BPM	1661.1372	11.21543	11.24725	69.40200	8.72092	-0.03168	0.00000	3.9810	2.94788	-0.54312	0.00023	0.00000
793 CED	1661.9848	11.21745	11.26190	64.50507	9.74830	-0.03148	0.00000	3.9810	2.82954	-0.66899	0.00023	0.00000
794 000	1663.0930	11.22032	11.27865	58.40515	11.41341	-0.03122	0.00000	3.9810	2.67481	-0.83354	0.00023	0.00000
795 SB	1669.1636	11.24308	11.33485	31.07511	27.00587	-0.02981	0.00000	3.9810	1.82722	-1.73498	0.00023	0.00000
796 0	1669.4684	11.24467	11.33661	29.97421	28.07731	-0.02974	0.00000	3.9810	1.78467	-1.78024	0.00023	0.00000
797 SB	1675.5390	11.29355	11.36126	13.45155	55.16377	-0.02832	0.00000	3.9810	0.93708	-2.68167	0.00023	0.00000
798 0	1675.8438	11.29723	11.36212	12.89328	56.81231	-0.02825	0.00000	3.9810	0.89453	-2.72693	0.00023	0.00000
799 INS2	1677.2629	11.31657	11.36584	10.63557	64.85110	-0.02792	0.00000	3.9810	0.69638	-2.93766	0.00023	0.00000
800 QDI	1678.3297	11.33340	11.36838	9.74885	68.24470	-0.02829	0.00000	3.9810	0.14715	-0.19590	-0.00094	0.00000
801 QDI	1679.3965	11.35077	11.37089	9.98875	65.66238	-0.02994	0.00000	3.9810	-0.37537	2.58036	-0.00216	0.00000
802 BPM	1679.7720	11.35667	11.37182	10.28676	63.74098	-0.03075	0.00000	3.9810	-0.41826	2.53656	-0.00216	0.00000
803 CED	1680.6196	11.36932	11.37401	11.07786	59.52479	-0.03258	0.00000	3.9810	-0.51507	2.43771	-0.00216	0.00000
804 000	1681.7278	11.38441	11.37711	12.35974	54.26510	-0.03496	0.00000	3.9810	-0.64165	2.30846	-0.00216	0.00000
805 SB	1687.7984	11.44130	11.40094	24.35937	30.53577	-0.04805	0.00000	3.9810	-1.33503	1.60044	-0.00216	0.00000
806 0	1688.1032	11.44326	11.40255	25.18381	29.57098	-0.04871	0.00000	3.9810	-1.36984	1.56489	-0.00216	0.00000
807 SB	1694.1738	11.47179	11.44930	46.02456	14.86943	-0.06179	0.00000	3.9810	-2.06322	0.85687	-0.00216	0.00000
808 0	1694.4786	11.47283	11.45262	47.29291	14.35792	-0.06245	0.00000	3.9810	-2.09803	0.82132	-0.00216	0.00000
809 INS1	1696.4720	11.47899	11.47735	56.11108	11.54695	-0.06675	0.00000	3.9810	-2.32571	0.58884	-0.00216	0.00000

BETATRON FUNCTIONS THRU .RNG

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
810	QF2	1697.5388	11.48193	11.49262	58.59714	10.90887	-0.06755	0.00000	3.9810	0.02996	0.01813	0.00065	0.00000
811	QF2	1698.6056	11.48487	11.50793	55.98697	11.46726	-0.06536	0.00000	3.9810	2.38039	-0.54930	0.00343	0.00000
812	BPM	1698.9811	11.48595	11.51305	54.21608	11.89579	-0.06407	0.00000	3.9810	2.33568	-0.59192	0.00343	0.00000
813	CED	1699.8287	11.48854	11.52392	50.34218	12.98076	-0.06116	0.00000	3.9810	2.23476	-0.68814	0.00343	0.00000
814	OOL	1703.7229	11.50338	11.56271	34.74262	20.06171	-0.04779	0.00000	3.9810	1.77108	-1.13019	0.00343	0.00000
815	B2	1709.7935	11.54282	11.59801	17.62838	37.95515	0.03663	0.00000	3.9806	1.04832	-1.81672	0.02438	0.00000
816	OOL	1713.6877	11.58737	11.61174	11.26928	53.82269	0.13156	0.00000	3.9806	0.58465	-2.25794	0.02438	0.00000
817	QD2	1714.7545	11.60302	11.61480	10.63314	56.25503	0.16072	0.00000	3.9806	0.02052	0.01198	0.03048	0.00000
818	QD2	1715.8213	11.61874	11.61786	11.17910	53.77309	0.19708	0.00000	3.9806	-0.53989	2.27979	0.03795	0.00000
819	BPM	1716.1968	11.62398	11.61899	11.60085	52.07722	0.21133	0.00000	3.9806	-0.58327	2.23651	0.03795	0.00000
820	CED	1717.0444	11.63512	11.62168	12.67261	48.36868	0.24349	0.00000	3.9806	-0.68119	2.13882	0.03795	0.00000
821	OOL	1720.9386	11.67472	11.63711	19.72994	33.45842	0.39126	0.00000	3.9806	-1.13108	1.69001	0.03795	0.00000
822	B2	1727.0092	11.71044	11.67786	37.71835	17.17675	0.68517	0.00000	3.9917	-1.83234	0.99145	0.05889	0.00000
823	OOL	1730.9034	11.72422	11.72314	53.74129	11.20563	0.91451	0.00000	3.9917	-2.28222	0.54188	0.05889	0.00000
824	QF2	1731.9702	11.72729	11.73882	56.24258	10.65394	0.95661	0.00000	3.9917	-0.02759	-0.01710	0.01975	0.00000
825	QF2	1733.0370	11.73035	11.75445	53.85555	11.28078	0.95633	0.00000	3.9917	2.23188	-0.57917	-0.02027	0.00000
826	BPM	1733.4125	11.73148	11.75964	52.19507	11.73243	0.94872	0.00000	3.9917	2.19018	-0.62362	-0.02027	0.00000
827	CED	1734.2601	11.73415	11.77063	48.56207	12.87465	0.93154	0.00000	3.9917	2.09604	-0.72396	-0.02027	0.00000
828	OOL	1738.1543	11.74945	11.80934	33.92148	20.30841	0.85261	0.00000	3.9917	1.66355	-1.18497	-0.02027	0.00000
829	B2	1744.2249	11.78916	11.84392	17.81779	39.04589	0.79315	0.00000	4.0087	0.98938	-1.90095	0.00068	0.00000
830	OOL	1748.1191	11.83244	11.85723	11.79631	55.64312	0.79579	0.00000	4.0087	0.55689	-2.36109	0.00068	0.00000
831	QD2	1749.1859	11.84732	11.86019	11.23585	58.21431	0.81437	0.00000	4.0087	-0.02371	-0.01309	0.03428	0.00000
832	QD2	1750.2527	11.86213	11.86315	11.90054	55.69733	0.86948	0.00000	4.0087	-0.60861	2.33721	0.06942	0.00000
833	BPM	1750.6282	11.86706	11.86424	12.37384	53.95844	0.89555	0.00000	4.0087	-0.65185	2.29364	0.06942	0.00000
834	CED	1751.4758	11.87748	11.86684	13.56159	50.15362	0.95439	0.00000	4.0087	-0.74946	2.19529	0.06942	0.00000
835	OOL	1755.3700	11.91441	11.88169	21.14496	34.81537	1.22474	0.00000	4.0087	-1.19789	1.74345	0.06942	0.00000
836	B2	1761.4406	11.94790	11.92077	39.93085	17.91311	1.70973	0.00000	4.0392	-1.89690	1.04022	0.09037	0.00000
837	OOL	1765.3348	11.96097	11.96436	56.45098	11.57408	2.06164	0.00000	4.0392	-2.34534	0.58759	0.09037	0.00000
838	QF2	1766.4016	11.96389	11.97958	58.96385	10.93948	2.11166	0.00000	4.0392	0.02484	0.01605	0.00307	0.00000
839	QF2	1767.4684	11.96682	11.99485	56.34809	11.50352	2.06814	0.00000	4.0392	2.39067	-0.55259	-0.08437	0.00000
840	BPM	1767.8439	11.96789	11.99995	54.56950	11.93451	2.03645	0.00000	4.0392	2.34592	-0.59520	-0.08437	0.00000
841	CED	1768.6915	11.97046	12.01078	50.67832	13.02502	1.96494	0.00000	4.0392	2.24491	-0.69138	-0.08437	0.00000
842	OOO	1769.7997	11.97412	12.02354	45.84907	14.69674	1.87144	0.00000	4.0392	2.11284	-0.81713	-0.08437	0.00000
843	B2	1775.8703	12.00305	12.07122	24.58981	28.79083	1.42287	0.00000	4.0735	1.38942	-1.50406	-0.06343	0.00000
844	O	1776.1751	12.00506	12.07288	23.75388	29.71823	1.40354	0.00000	4.0735	1.35310	-1.53859	-0.06343	0.00000
845	B2	1782.2457	12.06432	12.09743	11.71807	52.55704	1.08210	0.00000	4.0993	0.62969	-2.22278	-0.04248	0.00000
846	O	1782.5505	12.06853	12.09834	11.34529	53.92255	1.06915	0.00000	4.0993	0.59336	-2.25724	-0.04248	0.00000
847	QD2	1783.6173	12.08409	12.10139	10.69357	56.34873	1.04748	0.00000	4.0993	0.02662	0.01696	0.00169	0.00000
848	QD2	1784.6841	12.09972	12.10445	11.22826	53.85231	1.07279	0.00000	4.0993	-0.53528	2.28817	0.04594	0.00000
849	BPM	1785.0596	12.10495	12.10558	11.64642	52.15022	1.09005	0.00000	4.0993	-0.57831	2.24469	0.04594	0.00000
850	CED	1785.9072	12.11605	12.10827	12.70908	48.42820	1.12899	0.00000	4.0993	-0.67543	2.14655	0.04594	0.00000
851	OOO	1787.0154	12.12912	12.11210	14.34681	43.81281	1.17991	0.00000	4.0993	-0.80240	2.01822	0.04594	0.00000
852	B2	1793.0860	12.17782	12.14235	28.31012	23.56254	1.52237	0.00000	4.1274	-1.49792	1.31684	0.06689	0.00000
853	O	1793.3908	12.17950	12.14444	29.23389	22.77058	1.54276	0.00000	4.1274	-1.53284	1.28147	0.06689	0.00000
854	B2	1799.4614	12.20437	12.20570	52.06496	11.48153	2.01235	0.00000	4.1644	-2.22836	0.57775	0.08783	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
855 O	1799.7662	12.20529	12.20999	53.43401	11.14013	2.03913	0.00000	4.1644	-2.26328	0.54234	0.08783	0.00000
856 QF2	1800.8330	12.20837	12.22576	55.90848	10.58532	2.08697	0.00000	4.1644	-0.02176	-0.01459	0.00152	0.00000
857 QF2	1801.8998	12.21145	12.24150	53.52412	11.20423	2.04235	0.00000	4.1644	2.22358	-0.57415	-0.08486	0.00000
858 BPM	1802.2753	12.21259	12.24673	51.86987	11.65215	2.01048	0.00000	4.1644	2.18188	-0.61871	-0.08486	0.00000
859 CED	1803.1229	12.21528	12.25779	48.25094	12.78624	1.93855	0.00000	4.1644	2.08775	-0.71929	-0.08486	0.00000
860 OOO	1804.2311	12.21912	12.27074	43.76005	14.52622	1.84451	0.00000	4.1644	1.96467	-0.85081	-0.08486	0.00000
861 B2	1810.3017	12.24911	12.31835	24.00048	29.22079	1.39296	0.00000	4.1981	1.29053	-1.56927	-0.06392	0.00000
862 O	1810.6065	12.25116	12.31998	23.22410	30.18843	1.37348	0.00000	4.1981	1.25668	-1.60539	-0.06392	0.00000
863 B2	1816.6771	12.31024	12.34399	12.05980	54.02921	1.04906	0.00000	4.2232	0.58253	-2.32100	-0.04297	0.00000
864 O	1816.9819	12.31432	12.34488	11.71501	55.45507	1.03596	0.00000	4.2232	0.54868	-2.35703	-0.04297	0.00000
865 QD2	1818.0487	12.32930	12.34785	11.16888	58.02621	1.01302	0.00000	4.2232	-0.02915	-0.01710	-0.00021	0.00000
866 QD2	1819.1155	12.34419	12.35082	11.84311	55.52588	1.03552	0.00000	4.2232	-0.61226	2.32585	0.04255	0.00000
867 BPM	1819.4910	12.34914	12.35191	12.31929	53.79544	1.05149	0.00000	4.2232	-0.65585	2.28250	0.04255	0.00000
868 CED	1820.3386	12.35960	12.35451	13.51450	50.00907	1.08755	0.00000	4.2232	-0.75425	2.18466	0.04255	0.00000
869 OOO	1821.4468	12.37187	12.35822	15.32879	45.30876	1.13470	0.00000	4.2232	-0.88290	2.05674	0.04255	0.00000
870 B2	1827.5174	12.41729	12.38734	30.32504	24.57710	1.45653	0.00000	4.2501	-1.58759	1.35761	0.06349	0.00000
871 O	1827.8222	12.41886	12.38934	31.30362	23.76025	1.47588	0.00000	4.2501	-1.62297	1.32235	0.06349	0.00000
872 B2	1833.8928	12.44217	12.44797	55.28452	11.96156	1.92484	0.00000	4.2855	-2.32765	0.62081	0.08443	0.00000
873 O	1834.1976	12.44304	12.45209	56.71424	11.59387	1.95058	0.00000	4.2855	-2.36304	0.58550	0.08443	0.00000
874 QF2	1835.2644	12.44594	12.46728	59.25327	10.96429	1.99678	0.00000	4.2855	0.01838	0.01338	0.00186	0.00000
875 QF2	1836.3312	12.44885	12.48252	56.63813	11.53509	1.95451	0.00000	4.2855	2.39657	-0.55634	-0.08080	0.00000
876 BPM	1836.7067	12.44993	12.48760	54.85509	11.96890	1.92417	0.00000	4.2855	2.35186	-0.59896	-0.08080	0.00000
877 CED	1837.5543	12.45248	12.49840	50.95375	13.06582	1.85569	0.00000	4.2855	2.25094	-0.69519	-0.08080	0.00000
878 OOO	1838.6625	12.45612	12.51112	46.11098	14.74606	1.76615	0.00000	4.2855	2.11900	-0.82100	-0.08080	0.00000
879 B2	1844.7331	12.48486	12.55863	24.77280	28.88888	1.33926	0.00000	4.3178	1.39626	-1.50822	-0.05985	0.00000
880 O	1845.0379	12.48685	12.56029	23.93270	29.81882	1.32102	0.00000	4.3178	1.35997	-1.54277	-0.05985	0.00000
881 SB	1851.1085	12.54565	12.58475	11.80879	52.72729	0.95768	0.00000	4.3178	0.63718	-2.23091	-0.05985	0.00000
882 O	1851.4133	12.54983	12.58566	11.43142	54.09778	0.93943	0.00000	4.3178	0.60089	-2.26546	-0.05985	0.00000
883 QD2	1852.4801	12.56527	12.58870	10.76694	56.53363	0.89618	0.00000	4.3178	0.03124	0.01626	-0.02154	0.00000
884 QD2	1853.5469	12.58080	12.59175	11.29411	54.03046	0.89313	0.00000	4.3178	-0.53274	2.29511	0.01580	0.00000
885 BPM	1853.9224	12.58600	12.59288	11.71022	52.32319	0.89906	0.00000	4.3178	-0.57542	2.25155	0.01580	0.00000
886 CED	1854.7700	12.59704	12.59555	12.76734	48.58970	0.91245	0.00000	4.3178	-0.67177	2.15323	0.01580	0.00000
887 OOO	1855.8782	12.61007	12.59937	14.39586	43.95974	0.92996	0.00000	4.3178	-0.79774	2.02468	0.01580	0.00000
888 B2	1861.9488	12.65871	12.62952	28.26909	23.63868	1.08944	0.00000	4.3387	-1.48774	1.32204	0.03675	0.00000
889 O	1862.2536	12.66040	12.63161	29.18658	22.84357	1.10064	0.00000	4.3387	-1.52239	1.28661	0.03675	0.00000
890 SB	1868.3242	12.68534	12.69269	51.85922	11.50630	1.32371	0.00000	4.3387	-2.21244	0.58096	0.03675	0.00000
891 O	1868.6290	12.68626	12.69697	53.21849	11.16295	1.33491	0.00000	4.3387	-2.24709	0.54553	0.03675	0.00000
892 QF2	1869.6958	12.68936	12.71272	55.66784	10.60225	1.34425	0.00000	4.3387	-0.01476	-0.01217	-0.01930	0.00000
893 Q1	1870.7626	12.69245	12.72843	53.27962	11.21644	1.29403	0.00000	4.3387	2.22015	-0.57207	-0.07449	0.00000
894 XO	1875.7716	12.71127	12.78282	33.83020	19.91637	0.92091	0.00000	4.3387	1.66274	-1.16479	-0.07449	0.00000
895 QOO	1876.3166	12.71390	12.78706	32.43303	20.97973	0.88561	0.00000	4.3387	0.91083	-0.77874	-0.05518	0.00000
896 O	1876.6214	12.71541	12.78934	31.88303	21.46157	0.86879	0.00000	4.3387	0.89363	-0.80208	-0.05518	0.00000
897 B2	1882.6920	12.75130	12.82541	23.11265	34.00997	0.59743	0.00000	4.3539	0.55120	-1.26455	-0.03423	0.00000
898 O	1882.9968	12.75341	12.82682	22.78187	34.78794	0.58700	0.00000	4.3539	0.53401	-1.28784	-0.03423	0.00000
899 B2	1889.0674	12.80135	12.84935	18.37742	53.22150	0.44277	0.00000	4.3644	0.19158	-1.74802	-0.01329	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
900 O	1889.3722	12.80400	12.85026	18.26587	54.29417	0.43872	0.00000	4.3644	0.17439	-1.77125	-0.01329	0.00000
901 B2	1895.4428	12.85797	12.86507	18.22735	78.57892	0.42164	0.00000	4.3732	-0.16804	-2.22826	0.00766	0.00000
902 O	1895.7476	12.86063	12.86568	18.33503	79.94432	0.42397	0.00000	4.3732	-0.18524	-2.25140	0.00766	0.00000
903 QO	1898.2156	12.87995	12.87065	24.52122	72.14799	0.49536	0.00000	4.3732	-2.51807	5.15437	0.05134	0.00000
904 XI	1901.2156	12.89479	12.87907	42.32391	44.66066	0.64940	0.00000	4.3732	-3.41616	4.00808	0.05134	0.00000
905 QI	1903.3492	12.90200	12.88783	49.42481	35.72699	0.69882	0.00000	4.3732	0.28773	0.42441	-0.00570	0.00000
906 LS	1916.2002	12.94560	12.95172	45.64758	30.27383	0.62555	0.00000	4.3732	0.00619	-0.00008	-0.00570	0.00000
907 LS	1929.0512	12.98935	13.01561	49.10642	35.73096	0.55227	0.00000	4.3732	-0.27534	-0.42457	-0.00570	0.00000
908 QI	1931.1848	12.99661	13.02437	42.01206	44.66612	0.49207	0.00000	4.3732	3.40089	-4.00866	-0.04989	0.00000
909 XI	1934.1848	13.01157	13.03278	24.29869	72.15748	0.34240	0.00000	4.3732	2.50357	-5.15513	-0.04989	0.00000
910 QO	1936.6528	13.03109	13.03775	18.13676	79.95521	0.25608	0.00000	4.3732	0.18914	2.25163	-0.02145	0.00000
911 O	1936.9576	13.03377	13.03836	18.02677	78.58967	0.24954	0.00000	4.3732	0.17173	2.22849	-0.02145	0.00000
912 B2	1943.0282	13.08840	13.05317	18.04619	54.30219	0.18290	0.00000	4.3775	-0.17493	1.77146	-0.00051	0.00000
913 O	1943.3330	13.09108	13.05407	18.15814	53.22939	0.18274	0.00000	4.3775	-0.19234	1.74824	-0.00051	0.00000
914 B2	1949.4036	13.13952	13.07660	22.59746	34.79331	0.24324	0.00000	4.3818	-0.53900	1.28804	0.02044	0.00000
915 O	1949.7084	13.14165	13.07801	22.93134	34.01522	0.24947	0.00000	4.3818	-0.55641	1.26475	0.02044	0.00000
916 B2	1955.7790	13.17774	13.11407	31.79056	21.46452	0.43710	0.00000	4.3887	-0.90307	0.80226	0.04138	0.00000
917 O	1956.0838	13.17925	13.11636	32.34637	20.98258	0.44972	0.00000	4.3887	-0.92047	0.77892	0.04138	0.00000
918 QOO	1956.6288	13.18188	13.12060	33.75333	19.91899	0.47494	0.00000	4.3887	-1.67113	1.16503	0.05127	0.00000
919 XO	1961.6378	13.20072	13.17498	53.31390	11.21701	0.73175	0.00000	4.3887	-2.23396	0.57224	0.05127	0.00000
920 Q1	1962.7046	13.20381	13.19069	55.73042	10.60248	0.76983	0.00000	4.3887	0.00243	0.01233	0.01986	0.00000
921 QF2	1963.7714	13.20690	13.20644	53.30383	11.16284	0.77380	0.00000	4.3887	2.23840	-0.54537	-0.01243	0.00000
922 BPM	1964.1469	13.20804	13.21169	51.63869	11.58880	0.76913	0.00000	4.3887	2.19606	-0.58901	-0.01243	0.00000
923 CED	1964.9945	13.21075	13.22284	47.99695	12.67079	0.75859	0.00000	4.3887	2.10048	-0.68752	-0.01243	0.00000
924 OOO	1966.1027	13.21461	13.23594	43.47992	14.33736	0.74481	0.00000	4.3887	1.97552	-0.81633	-0.01243	0.00000
925 SB	1972.1733	13.24493	13.28445	23.65005	28.53178	0.66933	0.00000	4.3887	1.29102	-1.52190	-0.01243	0.00000
926 O	1972.4781	13.24701	13.28613	22.87352	29.47032	0.66554	0.00000	4.3887	1.25665	-1.55732	-0.01243	0.00000
927 B2	1978.5487	13.30732	13.31076	11.77218	52.64423	0.65364	0.00000	4.4023	0.57219	-2.25924	0.00851	0.00000
928 O	1978.8535	13.31150	13.31166	11.43385	54.03223	0.65623	0.00000	4.4023	0.53782	-2.29458	0.00851	0.00000
929 QD2	1979.9203	13.32685	13.31471	10.90079	56.53418	0.68010	0.00000	4.4023	-0.03072	-0.01566	0.03640	0.00000
930 QD2	1980.9871	13.34210	13.31776	11.56889	54.09706	0.73448	0.00000	4.4023	-0.60485	2.26603	0.06592	0.00000
931 BPM	1981.3626	13.34717	13.31888	12.03978	52.41127	0.75923	0.00000	4.4023	-0.64918	2.22344	0.06592	0.00000
932 CED	1982.2102	13.35786	13.32155	13.22508	48.72356	0.81511	0.00000	4.4023	-0.74925	2.12732	0.06592	0.00000
933 OOO	1983.3184	13.37039	13.32536	15.03070	44.14783	0.88816	0.00000	4.4023	-0.88008	2.00165	0.06592	0.00000
934 B2	1989.3890	13.41647	13.35521	30.06534	24.01063	1.35190	0.00000	4.4256	-1.59673	1.31479	0.08687	0.00000
935 O	1989.6938	13.41806	13.35726	31.04968	23.21969	1.37838	0.00000	4.4256	-1.63272	1.28016	0.08687	0.00000
936 SB	1995.7644	13.44148	13.41685	55.22364	11.86513	1.90572	0.00000	4.4256	-2.34942	0.59026	0.08687	0.00000
937 O	1996.0692	13.44235	13.42100	56.66681	11.51586	1.93220	0.00000	4.4256	-2.38540	0.55562	0.08687	0.00000
938 QF2	1997.1360	13.44526	13.43626	59.25645	10.94591	1.98138	0.00000	4.4256	-0.00599	-0.01346	0.00500	0.00000
939 QF2	1998.2028	13.44816	13.45148	56.69162	11.57502	1.94279	0.00000	4.4256	2.37447	-0.58497	-0.07709	0.00000
940 BPM	1998.5783	13.44923	13.45655	54.92490	12.03069	1.91384	0.00000	4.4256	2.33051	-0.62852	-0.07709	0.00000
941 CED	1999.4259	13.45178	13.46727	51.05835	13.17945	1.84850	0.00000	4.4256	2.23126	-0.72680	-0.07709	0.00000
942 OOO	2000.5341	13.45541	13.47985	46.25679	14.93274	1.76307	0.00000	4.4256	2.10150	-0.85530	-0.07709	0.00000
943 B2	2006.6047	13.48394	13.52649	25.05841	29.58157	1.35869	0.00000	4.4580	1.39073	-1.55724	-0.05615	0.00000
944 O	2006.9095	13.48591	13.52810	24.22150	30.54162	1.34157	0.00000	4.4580	1.35504	-1.59253	-0.05615	0.00000

BETATRON FUNCTIONS THRU .RNG

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
945	B2	2012.9801	13.54363	13.55195	12.08532	54.12608	1.06433	0.00000	4.4830	0.64428	-2.29164	-0.03520	0.00000
946	O	2013.2849	13.54771	13.55284	11.70344	55.53379	1.05360	0.00000	4.4830	0.60859	-2.32685	-0.03520	0.00000
947	QD2	2014.3517	13.56279	13.55581	11.03210	58.03592	1.03940	0.00000	4.4830	0.03006	0.01644	0.00848	0.00000
948	QD2	2015.4185	13.57795	13.55878	11.57130	55.46572	1.07183	0.00000	4.4830	-0.54301	2.35683	0.05254	0.00000
949	BPM	2015.7940	13.58302	13.55987	11.99488	53.71240	1.09156	0.00000	4.4830	-0.58502	2.31245	0.05254	0.00000
950	CED	2016.6416	13.59381	13.56248	13.06701	49.87723	1.13609	0.00000	4.4830	-0.67987	2.21229	0.05254	0.00000
951	OOO	2017.7498	13.60654	13.56620	14.71130	45.11904	1.19432	0.00000	4.4830	-0.80388	2.08133	0.05254	0.00000
952	B2	2023.8204	13.65436	13.59561	28.59394	24.18996	1.57684	0.00000	4.5118	-1.48315	1.36553	0.07349	0.00000
953	O	2024.1252	13.65603	13.59765	29.50846	23.36854	1.59924	0.00000	4.5118	-1.51726	1.32943	0.07349	0.00000
954	B2	2030.1958	13.68078	13.65779	52.05166	11.58510	2.10889	0.00000	4.5504	-2.19652	0.61121	0.09443	0.00000
955	O	2030.5006	13.68170	13.66205	53.40105	11.22352	2.13767	0.00000	4.5504	-2.23063	0.57507	0.09443	0.00000
956	QF2	2031.5674	13.68479	13.67775	55.80634	10.60332	2.19032	0.00000	4.5504	0.00948	0.01489	0.00390	0.00000
957	QF2	2032.6342	13.68788	13.69350	53.36181	11.15809	2.14592	0.00000	4.5504	2.24792	-0.54261	-0.08682	0.00000
958	BPM	2033.0097	13.68902	13.69876	51.68962	11.58195	2.11332	0.00000	4.5504	2.20532	-0.58617	-0.08682	0.00000
959	CED	2033.8573	13.69172	13.70991	48.03265	12.65897	2.03974	0.00000	4.5504	2.10917	-0.68450	-0.08682	0.00000
960	OOO	2034.9655	13.69558	13.72302	43.49719	14.31857	1.94353	0.00000	4.5504	1.98346	-0.81306	-0.08682	0.00000
961	B2	2041.0361	13.72592	13.77164	23.59705	28.45677	1.48012	0.00000	4.5861	1.29489	-1.51539	-0.06587	0.00000
962	O	2041.3409	13.72801	13.77332	22.81822	29.39132	1.46004	0.00000	4.5861	1.26032	-1.55070	-0.06587	0.00000
963	B2	2047.4115	13.78860	13.79802	11.69731	52.47061	1.12377	0.00000	4.6129	0.57175	-2.25028	-0.04493	0.00000
964	O	2047.7163	13.79281	13.79893	11.35932	53.85312	1.11007	0.00000	4.6129	0.53717	-2.28550	-0.04493	0.00000
965	QD2	2048.7831	13.80826	13.80199	10.82510	56.34372	1.08669	0.00000	4.6129	-0.02896	-0.01426	0.00092	0.00000
966	QD2	2049.8499	13.82362	13.80505	11.48663	53.91216	1.11205	0.00000	4.6129	-0.60036	2.25950	0.04681	0.00000
967	BPM	2050.2254	13.82872	13.80618	11.95420	52.23125	1.12963	0.00000	4.6129	-0.64483	2.21697	0.04681	0.00000
968	CED	2051.0730	13.83950	13.80886	13.13240	48.55439	1.16931	0.00000	4.6129	-0.74521	2.12099	0.04681	0.00000
969	OOO	2052.1812	13.85211	13.81267	14.92954	43.99252	1.22118	0.00000	4.6129	-0.87646	1.99549	0.04681	0.00000
970	B2	2058.2518	13.89846	13.84263	29.93407	23.92428	1.56890	0.00000	4.6419	-1.59539	1.30960	0.06776	0.00000
971	O	2058.5566	13.90005	13.84469	30.91762	23.13650	1.58955	0.00000	4.6419	-1.63149	1.27501	0.06776	0.00000
972	B2	2064.6272	13.92355	13.90448	55.08835	11.83181	2.06441	0.00000	4.6799	-2.35041	0.58679	0.08870	0.00000
973	O	2064.9320	13.92442	13.90865	56.53216	11.48466	2.09144	0.00000	4.6799	-2.38651	0.55216	0.08870	0.00000
974	QF2	2065.9988	13.92733	13.92394	59.13040	10.92088	2.13904	0.00000	4.6799	-0.01283	-0.01587	0.00020	0.00000
975	QF2	2067.0656	13.93025	13.93919	56.58531	11.55441	2.09187	0.00000	4.6799	2.36309	-0.58677	-0.08830	0.00000
976	BPM	2067.4411	13.93132	13.94427	54.82703	12.01148	2.05871	0.00000	4.6799	2.31940	-0.63045	-0.08830	0.00000
977	CED	2068.2887	13.93387	13.95500	50.97878	13.16381	1.98386	0.00000	4.6799	2.22077	-0.72907	-0.08830	0.00000
978	OOO	2069.3969	13.93751	13.96760	46.19956	14.92260	1.88600	0.00000	4.6799	2.09182	-0.85800	-0.08830	0.00000
979	B2	2075.4675	13.96603	14.01422	25.09161	29.61849	1.41355	0.00000	4.7143	1.38551	-1.56230	-0.06736	0.00000
980	O	2075.7723	13.96800	14.01583	24.25782	30.58166	1.39302	0.00000	4.7143	1.35004	-1.59771	-0.06736	0.00000
981	B2	2081.8429	14.02550	14.03964	12.15534	54.24318	1.04770	0.00000	4.7396	0.64373	-2.29916	-0.04642	0.00000
982	O	2082.1477	14.02956	14.04053	11.77374	55.65552	1.03356	0.00000	4.7396	0.60826	-2.33448	-0.04642	0.00000
983	QD2	2083.2145	14.04454	14.04349	11.10546	58.16854	1.00685	0.00000	4.7396	0.02748	0.01402	-0.00383	0.00000
984	QD2	2084.2813	14.05960	14.04645	11.65296	55.59745	1.02532	0.00000	4.7396	-0.54832	2.36006	0.03858	0.00000
985	BPM	2084.6568	14.06464	14.04754	12.08049	53.84171	1.03981	0.00000	4.7396	-0.59023	2.31569	0.03858	0.00000
986	CED	2085.5044	14.07534	14.05014	13.16123	50.00105	1.07251	0.00000	4.7396	-0.68484	2.21553	0.03858	0.00000
987	OOO	2086.6126	14.08799	14.05385	14.81618	45.23568	1.11527	0.00000	4.7396	-0.80853	2.08457	0.03858	0.00000
988	B2	2092.6832	14.13550	14.08318	28.74464	24.26695	1.41303	0.00000	4.7659	-1.48605	1.36881	0.05953	0.00000
989	O	2092.9880	14.13717	14.08521	29.66091	23.44352	1.43118	0.00000	4.7659	-1.52007	1.33272	0.05953	0.00000

BETATRON FUNCTIONS THRU .RNG

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
990	B2	2099.0586	14.16181	14.14516	52.22776	11.61994	1.85608	0.00000	4.8001	-2.19760	0.61453	0.08047	0.00000
991	O	2099.3634	14.16273	14.14940	53.57778	11.25634	1.88061	0.00000	4.8001	-2.23162	0.57839	0.08047	0.00000
992	QF2	2100.4302	14.16580	14.16506	55.97705	10.63030	1.92416	0.00000	4.8001	0.01602	0.01711	0.00088	0.00000
993	QF2	2101.4970	14.16888	14.18078	53.51144	11.18115	1.88247	0.00000	4.8001	2.26085	-0.54109	-0.07875	0.00000
994	BPM	2101.8725	14.17002	14.18603	51.82965	11.60381	1.85290	0.00000	4.8001	2.21796	-0.58451	-0.07875	0.00000
995	CED	2102.7201	14.17272	14.19716	48.15181	12.67773	1.78615	0.00000	4.8001	2.12116	-0.68251	-0.07875	0.00000
996	OOO	2103.8283	14.17657	14.21026	43.59073	14.33244	1.69887	0.00000	4.8001	1.99459	-0.81064	-0.07875	0.00000
997	B2	2109.8989	14.20688	14.25887	23.58393	28.42702	1.28440	0.00000	4.8311	1.30133	-1.51063	-0.05781	0.00000
998	O	2110.2037	14.20898	14.26055	22.80124	29.35862	1.26678	0.00000	4.8311	1.26652	-1.54582	-0.05781	0.00000
999	B2	2116.2743	14.26976	14.28529	11.63345	52.36445	0.97945	0.00000	4.8544	0.57326	-2.24306	-0.03686	0.00000
1000	O	2116.5791	14.27399	14.28621	11.29459	53.74252	0.96821	0.00000	4.8544	0.53845	-2.27817	-0.03686	0.00000
1001	QD2	2117.6459	14.28954	14.28928	10.75551	56.22237	0.95031	0.00000	4.8544	-0.02562	-0.01167	0.00318	0.00000
1002	QD2	2118.7127	14.30500	14.29234	11.40721	53.79084	0.97504	0.00000	4.8544	-0.59434	2.25689	0.04336	0.00000
1003	BPM	2119.0882	14.31014	14.29347	11.87029	52.11189	0.99133	0.00000	4.8544	-0.63889	2.21435	0.04336	0.00000
1004	CED	2119.9358	14.32099	14.29615	13.03856	48.43950	1.02808	0.00000	4.8544	-0.73944	2.11833	0.04336	0.00000
1005	OOO	2121.0440	14.33369	14.29998	14.82315	43.88356	1.07613	0.00000	4.8544	-0.87091	1.99279	0.04336	0.00000
1006	B2	2127.1146	14.38035	14.33002	29.76738	23.84941	1.40290	0.00000	4.8801	-1.59101	1.30668	0.06431	0.00000
1007	O	2127.4194	14.38195	14.33209	30.74828	23.06341	1.42250	0.00000	4.8801	-1.62717	1.27207	0.06431	0.00000
1008	B2	2133.4900	14.40556	14.39208	54.87381	11.79566	1.87642	0.00000	4.9144	-2.34728	0.58364	0.08525	0.00000
1009	O	2133.7948	14.40643	14.39625	56.31573	11.45043	1.90240	0.00000	4.9144	-2.38344	0.54900	0.08525	0.00000
1010	QF2	2134.8616	14.40936	14.41159	58.91731	10.89210	1.95053	0.00000	4.9144	-0.01899	-0.01789	0.00465	0.00000
1011	QF2	2135.9284	14.41228	14.42688	56.39438	11.52905	1.91225	0.00000	4.9144	2.34879	-0.58800	-0.07616	0.00000
1012	BPM	2136.3039	14.41336	14.43197	54.64673	11.98710	1.88365	0.00000	4.9144	2.30540	-0.63183	-0.07616	0.00000
1013	CED	2137.1515	14.41592	14.44272	50.82164	13.14205	1.81910	0.00000	4.9144	2.20745	-0.73077	-0.07616	0.00000
1014	OOO	2138.2597	14.41956	14.45534	46.07097	14.90509	1.73471	0.00000	4.9144	2.07939	-0.86013	-0.07616	0.00000
1015	B2	2144.3303	14.44814	14.50197	25.08447	29.64089	1.33600	0.00000	4.9464	1.37794	-1.56674	-0.05521	0.00000
1016	O	2144.6351	14.45010	14.50358	24.25522	30.60680	1.31917	0.00000	4.9464	1.34271	-1.60227	-0.05521	0.00000
1017	B2	2150.7057	14.50747	14.52736	12.21220	54.33774	1.04760	0.00000	4.9709	0.64126	-2.30603	-0.03427	0.00000
1018	O	2151.0105	14.51151	14.52824	11.83202	55.75430	1.03715	0.00000	4.9709	0.60604	-2.34147	-0.03427	0.00000
1019	QD2	2152.0773	14.52641	14.53120	11.17034	58.27787	1.02359	0.00000	4.9709	0.02342	0.01127	0.00874	0.00000
1020	QD2	2153.1441	14.54137	14.53415	11.72908	55.70762	1.05595	0.00000	4.9709	-0.55495	2.36203	0.05214	0.00000
1021	BPM	2153.5196	14.54638	14.53524	12.16157	53.95039	1.07553	0.00000	4.9709	-0.59682	2.31768	0.05214	0.00000
1022	CED	2154.3672	14.55701	14.53784	13.25342	50.10629	1.11972	0.00000	4.9709	-0.69134	2.21758	0.05214	0.00000
1023	OOO	2155.4754	14.56957	14.54154	14.92267	45.33629	1.17751	0.00000	4.9709	-0.81492	2.08670	0.05214	0.00000
1024	B2	2161.5460	14.61676	14.57079	28.92507	24.33924	1.55760	0.00000	4.9994	-1.49184	1.37135	0.07309	0.00000
1025	O	2161.8508	14.61841	14.57282	29.84486	23.51426	1.57987	0.00000	4.9994	-1.52583	1.33528	0.07309	0.00000
1026	B2	2167.9214	14.64291	14.63257	52.47785	11.65718	2.08710	0.00000	5.0375	-2.20274	0.61749	0.09403	0.00000
1027	O	2168.2262	14.64383	14.63680	53.83100	11.29176	2.11576	0.00000	5.0375	-2.23673	0.58138	0.09403	0.00000
1028	QF2	2169.2930	14.64689	14.65241	56.22965	10.66070	2.16846	0.00000	5.0375	0.02170	0.01891	0.00441	0.00000
1029	QF2	2170.3598	14.64996	14.66808	53.74111	11.20866	2.12510	0.00000	5.0375	2.27633	-0.54014	-0.08541	0.00000
1030	BPM	2170.7353	14.65109	14.67332	52.04781	11.63055	2.09303	0.00000	5.0375	2.23314	-0.58342	-0.08541	0.00000
1031	CED	2171.5829	14.65378	14.68443	48.34483	12.70236	2.02064	0.00000	5.0375	2.13564	-0.68110	-0.08541	0.00000
1032	OOO	2172.6911	14.65761	14.69750	43.75265	14.35349	1.92599	0.00000	5.0375	2.00817	-0.80882	-0.08541	0.00000
1033	B2	2178.7617	14.68785	14.74610	23.61123	28.41212	1.47113	0.00000	5.0729	1.30994	-1.50653	-0.06446	0.00000
1034	O	2179.0665	14.68994	14.74778	22.82338	29.34119	1.45148	0.00000	5.0729	1.27488	-1.54161	-0.06446	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1035 B2	2185.1371	14.75083	14.77255	11.58437	52.28208	1.12375	0.00000	5.0996	0.57664	-2.23658	-0.04352	0.00000
1036 O	2185.4419	14.75508	14.77346	11.24353	53.65616	1.11049	0.00000	5.0996	0.54158	-2.27157	-0.04352	0.00000
1037 QD2	2186.5087	14.77070	14.77653	10.69620	56.12574	1.08863	0.00000	5.0996	-0.02090	-0.00878	0.00238	0.00000
1038 QD2	2187.5755	14.78626	14.77960	11.33541	53.69251	1.11560	0.00000	5.0996	-0.58718	2.25556	0.04838	0.00000
1039 BPM	2187.9510	14.79143	14.78073	11.79312	52.01456	1.13377	0.00000	5.0996	-0.63173	2.21299	0.04838	0.00000
1040 CED	2188.7986	14.80236	14.78342	12.94926	48.34455	1.17478	0.00000	5.0996	-0.73229	2.11689	0.04838	0.00000
1041 000	2189.9068	14.81515	14.78726	14.71799	43.79192	1.22840	0.00000	5.0996	-0.86376	1.99125	0.04838	0.00000
1042 B2	2195.9774	14.86213	14.81738	29.57563	23.78014	1.58566	0.00000	5.1289	-1.58390	1.30454	0.06933	0.00000
1043 O	2196.2822	14.86375	14.81945	30.55220	22.99545	1.60679	0.00000	5.1289	-1.62006	1.26991	0.06933	0.00000
1044 B2	2202.3528	14.88749	14.87963	54.59152	11.75757	2.09118	0.00000	5.1674	-2.34019	0.58089	0.09027	0.00000
1045 O	2202.6576	14.88837	14.88382	56.02912	11.41403	2.11870	0.00000	5.1674	-2.37635	0.54621	0.09027	0.00000
1046 QF2	2203.7244	14.89131	14.89921	58.62860	10.86027	2.16736	0.00000	5.1674	-0.02413	-0.01946	0.00061	0.00000
1047 QF2	2204.7912	14.89425	14.91454	56.12905	11.49957	2.11999	0.00000	5.1674	2.33233	-0.58866	-0.08908	0.00000
1048 BPM	2205.1667	14.89533	14.91964	54.39365	11.95816	2.08655	0.00000	5.1674	2.28925	-0.63262	-0.08908	0.00000
1049 CED	2206.0143	14.89790	14.93042	50.59534	13.11470	2.01105	0.00000	5.1674	2.19200	-0.73187	-0.08908	0.00000
1050 000	2207.1225	14.90156	14.94306	45.87789	14.88063	1.91233	0.00000	5.1674	2.06486	-0.86163	-0.08908	0.00000
1051 B2	2213.1931	14.93022	14.98972	25.03737	29.64820	1.43520	0.00000	5.2022	1.36842	-1.57047	-0.06813	0.00000
1052 O	2213.4979	14.93219	14.99133	24.21384	30.61642	1.41443	0.00000	5.2022	1.33345	-1.60611	-0.06813	0.00000
1053 B2	2219.5685	14.98951	15.01509	12.25284	54.40742	1.06443	0.00000	5.2280	0.63701	-2.31209	-0.04719	0.00000
1054 O	2219.8733	14.99353	15.01597	11.87518	55.82770	1.05005	0.00000	5.2280	0.60204	-2.34764	-0.04719	0.00000
1055 QD2	2220.9401	15.00837	15.01892	11.22328	58.36121	1.02289	0.00000	5.2280	0.01811	0.00826	-0.00392	0.00000
1056 QD2	2222.0069	15.02326	15.02188	11.79559	55.79351	1.04162	0.00000	5.2280	-0.56254	2.36270	0.03916	0.00000
1057 BPM	2222.3824	15.02823	15.02296	12.23379	54.03575	1.05632	0.00000	5.2280	-0.60445	2.31840	0.03916	0.00000
1058 CED	2223.2300	15.03880	15.02556	13.33864	50.19036	1.08952	0.00000	5.2280	-0.69905	2.21840	0.03916	0.00000
1059 000	2224.3382	15.05127	15.02925	15.02507	45.41839	1.13292	0.00000	5.2280	-0.82273	2.08766	0.03916	0.00000
1060 B2	2230.4088	15.09813	15.05843	29.12556	24.40505	1.43422	0.00000	5.2546	-1.50019	1.37307	0.06011	0.00000
1061 O	2230.7136	15.09977	15.06046	30.05045	23.57901	1.45254	0.00000	5.2546	-1.53421	1.33704	0.06011	0.00000
1062 B2	2236.7842	15.12412	15.12002	52.78854	11.69589	1.88098	0.00000	5.2893	-2.21167	0.62002	0.08105	0.00000
1063 O	2237.0890	15.12503	15.12423	54.14715	11.32892	1.90568	0.00000	5.2893	-2.24569	0.58394	0.08105	0.00000
1064 QF2	2238.1558	15.12807	15.13980	56.55060	10.69376	1.94930	0.00000	5.2893	0.02622	0.02025	0.00041	0.00000
1065 QF2	2239.2226	15.13112	15.15542	54.03853	11.23994	1.90655	0.00000	5.2893	2.29354	-0.53979	-0.08025	0.00000
1066 BPM	2239.5981	15.13225	15.16064	52.33241	11.66152	1.87642	0.00000	5.2893	2.25004	-0.58293	-0.08025	0.00000
1067 CED	2240.4457	15.13492	15.17172	48.60137	12.73225	1.80840	0.00000	5.2893	2.15185	-0.68032	-0.08025	0.00000
1068 000	2241.5539	15.13874	15.18477	43.97429	14.38120	1.71946	0.00000	5.2893	2.02346	-0.80764	-0.08025	0.00000
1069 B2	2247.6245	15.16886	15.23332	23.67749	28.41244	1.29590	0.00000	5.3207	1.32024	-1.50320	-0.05931	0.00000
1070 O	2247.9293	15.17094	15.23500	22.88344	29.33945	1.27782	0.00000	5.3207	1.28493	-1.53817	-0.05931	0.00000
1071 B2	2253.9999	15.23183	15.25978	11.55271	52.22552	0.98140	0.00000	5.3441	0.58170	-2.23099	-0.03836	0.00000
1072 O	2254.3047	15.23610	15.26070	11.20886	53.59617	0.96971	0.00000	5.3441	0.54639	-2.26588	-0.03836	0.00000
1073 QD2	2255.3715	15.25178	15.26377	10.65034	56.05620	0.95023	0.00000	5.3441	-0.01507	-0.00566	0.00171	0.00000
1074 QD2	2256.4383	15.26741	15.26685	11.27509	53.61959	0.97338	0.00000	5.3441	-0.57926	2.25556	0.04186	0.00000
1075 BPM	2256.8138	15.27261	15.26798	11.72682	51.94168	0.98910	0.00000	5.3441	-0.62374	2.21293	0.04186	0.00000
1076 CED	2257.6614	15.28360	15.27067	12.86927	48.27188	1.02458	0.00000	5.3441	-0.72414	2.11670	0.04186	0.00000
1077 000	2258.7696	15.29647	15.27451	14.61972	43.71986	1.07096	0.00000	5.3441	-0.85540	1.99088	0.04186	0.00000
1078 B2	2264.8402	15.34379	15.30470	29.36910	23.71819	1.38860	0.00000	5.3697	-1.57442	1.30324	0.06280	0.00000
1079 O	2265.1450	15.34542	15.30678	30.33987	22.93430	1.40774	0.00000	5.3697	-1.61052	1.26856	0.06280	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1080 B2	2271.2156	15.36932	15.36715	54.25660	11.71847	1.85252	0.00000	5.4036	-2.32953	0.57860	0.08375	0.00000
1081 0	2271.5204	15.37020	15.37135	55.68769	11.37634	1.87805	0.00000	5.4036	-2.36564	0.54388	0.08375	0.00000
1082 QF2	2272.5872	15.37316	15.38679	58.27973	10.82618	1.92512	0.00000	5.4036	-0.02797	-0.02056	0.00419	0.00000
1083 QF2	2273.6540	15.37611	15.40216	55.80354	11.46668	1.88691	0.00000	5.4036	2.31460	-0.58871	-0.07556	0.00000
1084 BPM	2274.0295	15.37720	15.40728	54.08134	11.92536	1.85854	0.00000	5.4036	2.27182	-0.63280	-0.07556	0.00000
1085 CED	2274.8771	15.37979	15.41808	50.31200	13.08245	1.79450	0.00000	5.4036	2.17526	-0.73234	-0.07556	0.00000
1086 000	2275.9853	15.38347	15.43075	45.63068	14.84983	1.71076	0.00000	5.4036	2.04901	-0.86248	-0.07556	0.00000
1087 B2	2282.0559	15.41226	15.47747	24.95284	29.64024	1.31569	0.00000	5.4350	1.35747	-1.57339	-0.05461	0.00000
1088 0	2282.3607	15.41423	15.47908	24.13591	30.61027	1.29904	0.00000	5.4350	1.32275	-1.60913	-0.05461	0.00000
1089 B2	2288.4313	15.47159	15.50284	12.27509	54.45050	1.03110	0.00000	5.4592	0.63121	-2.31717	-0.03367	0.00000
1090 0	2288.7361	15.47561	15.50372	11.90089	55.87391	1.02084	0.00000	5.4592	0.59649	-2.35283	-0.03367	0.00000
1091 QD2	2289.8029	15.49040	15.50667	11.26144	58.41651	1.00755	0.00000	5.4592	0.01182	0.00505	0.00866	0.00000
1092 QD2	2290.8697	15.50523	15.50962	11.84891	55.85299	1.03946	0.00000	5.4592	-0.57069	2.36204	0.05139	0.00000
1093 BPM	2291.2452	15.51019	15.51070	12.29328	54.09571	1.05876	0.00000	5.4592	-0.61270	2.31781	0.05139	0.00000
1094 CED	2292.0928	15.52070	15.51329	13.41231	50.25119	1.10231	0.00000	5.4592	-0.70754	2.21796	0.05139	0.00000
1095 000	2293.2010	15.53310	15.51698	15.11790	45.47996	1.15926	0.00000	5.4592	-0.83152	2.08742	0.05139	0.00000
1096 B2	2299.2716	15.57963	15.54611	29.33537	24.46277	1.53475	0.00000	5.4872	-1.51067	1.37394	0.07233	0.00000
1097 0	2299.5764	15.58126	15.54813	30.26667	23.63618	1.55680	0.00000	5.4872	-1.54477	1.33796	0.07233	0.00000
1098 B2	2305.6470	15.60544	15.60751	53.14319	11.73512	2.05943	0.00000	5.5249	-2.22392	0.62205	0.09328	0.00000
1099 0	2305.9518	15.60635	15.61171	54.50928	11.36690	2.08786	0.00000	5.5249	-2.25802	0.58602	0.09328	0.00000
1100 QF2	2307.0186	15.60937	15.62722	56.92271	10.72867	2.14038	0.00000	5.5249	0.02934	0.02109	0.00483	0.00000
1101 QF2	2308.0854	15.61240	15.64280	54.38775	11.27423	2.09808	0.00000	5.5249	2.31156	-0.54004	-0.08384	0.00000
1102 BPM	2308.4609	15.61352	15.64800	52.66822	11.69595	2.06660	0.00000	5.5249	2.26776	-0.58306	-0.08384	0.00000
1103 CED	2309.3085	15.61618	15.65905	48.90769	12.76667	1.99554	0.00000	5.5249	2.16891	-0.68017	-0.08384	0.00000
1104 000	2310.4167	15.61997	15.67207	44.24376	14.41489	1.90263	0.00000	5.5249	2.03966	-0.80713	-0.08384	0.00000
1105 B2	2316.4873	15.64993	15.72054	23.77917	28.42798	1.45727	0.00000	5.5598	1.33169	-1.50072	-0.06290	0.00000
1106 0	2316.7921	15.65200	15.72222	22.97821	29.35345	1.43810	0.00000	5.5598	1.29614	-1.53558	-0.06290	0.00000
1107 B2	2322.8627	15.71280	15.74700	11.54016	52.19619	1.11989	0.00000	5.5864	0.58817	-2.22644	-0.04195	0.00000
1108 0	2323.1675	15.71707	15.74792	11.19245	53.56403	1.10710	0.00000	5.5864	0.55262	-2.26122	-0.04195	0.00000
1109 QD2	2324.2343	15.73278	15.75100	10.62040	56.01548	1.08685	0.00000	5.5864	-0.00842	-0.00238	0.00384	0.00000
1110 QD2	2325.3011	15.74847	15.75408	11.22947	53.57390	1.11535	0.00000	5.5864	-0.57099	2.25688	0.04980	0.00000
1111 BPM	2325.6766	15.75369	15.75521	11.67494	51.89503	1.13405	0.00000	5.5864	-0.61534	2.21417	0.04980	0.00000
1112 CED	2326.5242	15.76473	15.75791	12.80289	48.22328	1.17626	0.00000	5.5864	-0.71542	2.11776	0.04980	0.00000
1113 000	2327.6324	15.77768	15.76175	14.53358	43.66916	1.23145	0.00000	5.5864	-0.84629	1.99171	0.04980	0.00000
1114 B2	2333.7030	15.82532	15.79199	29.15883	23.66507	1.59731	0.00000	5.6158	-1.56308	1.30280	0.07074	0.00000
1115 0	2334.0078	15.82695	15.79407	30.12266	22.88147	1.61887	0.00000	5.6158	-1.59908	1.26806	0.07074	0.00000
1116 B2	2340.0784	15.85102	15.85462	53.88699	11.67934	2.11187	0.00000	5.6546	-2.31587	0.57684	0.09169	0.00000
1117 0	2340.3832	15.85191	15.85884	55.30972	11.33830	2.13982	0.00000	5.6546	-2.35186	0.54206	0.09169	0.00000
1118 QF2	2341.4500	15.85489	15.87433	57.88938	10.79068	2.18951	0.00000	5.6546	-0.03032	-0.02114	0.00112	0.00000
1119 QF2	2342.5168	15.85787	15.88975	55.43529	11.43120	2.14220	0.00000	5.6546	2.29654	-0.58815	-0.08949	0.00000
1120 BPM	2342.8923	15.85896	15.89488	53.72655	11.88951	2.10859	0.00000	5.6546	2.25404	-0.63237	-0.08949	0.00000
1121 CED	2343.7399	15.86157	15.90572	49.98681	13.04608	2.03274	0.00000	5.6546	2.15811	-0.73216	-0.08949	0.00000
1122 000	2344.8481	15.86527	15.91842	45.34257	14.81345	1.93356	0.00000	5.6546	2.03269	-0.86264	-0.08949	0.00000
1123 B2	2350.9187	15.89422	15.96522	24.83539	29.61722	1.45390	0.00000	5.6899	1.34567	-1.57542	-0.06855	0.00000
1124 0	2351.2235	15.89620	15.96683	24.02558	30.58852	1.43301	0.00000	5.6899	1.31118	-1.61125	-0.06855	0.00000

BETATRON FUNCTIONS THRU .RNG

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1125	B2	2357.2941	15.95370	15.99059	12.27776	54.46591	1.08049	0.00000	5.7160	0.62416	-2.32117	-0.04760	0.00000
1126	O	2357.5989	15.95771	15.99147	11.90778	55.89179	1.06598	0.00000	5.7160	0.58967	-2.35691	-0.04760	0.00000
1127	QD2	2358.6657	15.97249	15.99442	11.28277	58.44241	1.03873	0.00000	5.7160	0.00491	0.00173	-0.00368	0.00000
1128	QD2	2359.7325	15.98728	15.99736	11.88621	55.88461	1.05807	0.00000	5.7160	-0.57896	2.36008	0.04008	0.00000
1129	BPM	2360.1080	15.99222	15.99845	12.33684	54.12877	1.07313	0.00000	5.7160	-0.62114	2.31593	0.04008	0.00000
1130	CED	2360.9556	16.00269	16.00104	13.47050	50.28726	1.10710	0.00000	5.7160	-0.71635	2.21628	0.04008	0.00000
1131	OOO	2362.0638	16.01503	16.00472	15.19618	45.51947	1.15152	0.00000	5.7160	-0.84084	2.08600	0.04008	0.00000
1132	B2	2368.1344	16.06127	16.03381	29.54326	24.51096	1.45841	0.00000	5.7431	-1.52271	1.37394	0.06103	0.00000
1133	O	2368.4392	16.06289	16.03582	30.48194	23.68435	1.47701	0.00000	5.7431	-1.55695	1.33803	0.06103	0.00000
1134	B2	2374.5098	16.08690	16.09504	53.52279	11.77391	1.91104	0.00000	5.7784	-2.23881	0.62353	0.08197	0.00000
1135	O	2374.8146	16.08779	16.09923	54.89801	11.40476	1.93603	0.00000	5.7784	-2.27305	0.58758	0.08197	0.00000
1136	QF2	2375.8814	16.09080	16.11469	57.32604	10.76456	1.97994	0.00000	5.7784	0.03089	0.02141	0.00006	0.00000
1137	QF2	2376.9482	16.09380	16.13021	54.77008	11.31067	1.93614	0.00000	5.7784	2.32941	-0.54089	-0.08187	0.00000
1138	BPM	2377.3237	16.09491	16.13540	53.03723	11.73300	1.90540	0.00000	5.7784	2.28536	-0.58380	-0.08187	0.00000
1139	CED	2378.1713	16.09755	16.14642	49.24739	12.80476	1.83601	0.00000	5.7784	2.18591	-0.68067	-0.08187	0.00000
1140	OOO	2379.2795	16.10132	16.15940	44.54663	14.45373	1.74529	0.00000	5.7784	2.05588	-0.80731	-0.08187	0.00000
1141	B2	2385.3501	16.13109	16.20778	23.91080	28.45835	1.31192	0.00000	5.8102	1.34367	-1.49914	-0.06092	0.00000
1142	O	2385.6549	16.13316	16.20945	23.10260	29.38283	1.29335	0.00000	5.8102	1.30791	-1.53392	-0.06092	0.00000
1143	B2	2391.7255	16.19376	16.23422	11.54740	52.19479	0.98713	0.00000	5.8338	0.59570	-2.22303	-0.03998	0.00000
1144	O	2392.0303	16.19803	16.23514	11.19517	53.56053	0.97494	0.00000	5.8338	0.55994	-2.25773	-0.03998	0.00000
1145	QD2	2393.0971	16.21375	16.23822	10.60797	56.00457	0.95384	0.00000	5.8338	-0.00133	0.00096	0.00028	0.00000
1146	QD2	2394.1639	16.22947	16.24130	11.20101	53.55656	0.97554	0.00000	5.8338	-0.56283	2.25948	0.04055	0.00000
1147	BPM	2394.5394	16.23470	16.24243	11.64027	51.87576	0.99076	0.00000	5.8338	-0.60698	2.21667	0.04055	0.00000
1148	CED	2395.3870	16.24578	16.24513	12.75368	48.19995	1.02513	0.00000	5.8338	-0.70662	2.12005	0.04055	0.00000
1149	OOO	2396.4952	16.25878	16.24897	14.46420	43.64108	1.07006	0.00000	5.8338	-0.83690	1.99372	0.04055	0.00000
1150	B2	2402.5658	16.30671	16.27925	28.95611	23.62211	1.37975	0.00000	5.8593	-1.55050	1.30325	0.06149	0.00000
1151	O	2402.8706	16.30836	16.28134	29.91222	22.83826	1.39849	0.00000	5.8593	-1.58633	1.26843	0.06149	0.00000
1152	B2	2408.9412	16.33260	16.34205	53.50250	11.64114	1.83532	0.00000	5.8929	-2.29994	0.57565	0.08244	0.00000
1153	O	2409.2460	16.33350	16.34628	54.91546	11.30085	1.86045	0.00000	5.8929	-2.33577	0.54079	0.08244	0.00000
1154	QF2	2410.3128	16.33650	16.36182	57.47848	10.75462	1.90653	0.00000	5.8929	-0.03104	-0.02120	0.00363	0.00000
1155	QF2	2411.3796	16.33949	16.37730	55.04403	11.39401	1.86814	0.00000	5.8929	2.27913	-0.58701	-0.07533	0.00000
1156	BPM	2411.7551	16.34060	16.38244	53.34827	11.85150	1.83986	0.00000	5.8929	2.23687	-0.63132	-0.07533	0.00000
1157	CED	2412.6027	16.34322	16.39332	49.63718	13.00650	1.77601	0.00000	5.8929	2.14148	-0.73135	-0.07533	0.00000
1158	OOO	2413.7109	16.34695	16.40605	45.02900	14.77239	1.69253	0.00000	5.8929	2.01677	-0.86212	-0.07533	0.00000
1159	B2	2419.7815	16.37609	16.45295	24.69133	29.57969	1.29884	0.00000	5.9240	1.33366	-1.57652	-0.05438	0.00000
1160	O	2420.0863	16.37808	16.45456	23.88878	30.55169	1.28226	0.00000	5.9240	1.29936	-1.61244	-0.05438	0.00000
1161	B2	2426.1569	16.43579	16.47834	12.26070	54.45328	1.01571	0.00000	5.9478	0.61625	-2.32397	-0.03344	0.00000
1162	O	2426.4617	16.43981	16.47922	11.89549	55.88089	1.00552	0.00000	5.9478	0.58195	-2.35980	-0.03344	0.00000
1163	QD2	2427.5285	16.45459	16.48217	11.28614	58.43826	0.99213	0.00000	5.9478	-0.00227	-0.00161	0.00825	0.00000
1164	QD2	2428.5953	16.46937	16.48512	11.90547	55.88758	1.02325	0.00000	5.9478	-0.58690	2.35685	0.05031	0.00000
1165	BPM	2428.9708	16.47430	16.48620	12.36216	54.13412	1.04215	0.00000	5.9478	-0.62931	2.31281	0.05031	0.00000
1166	CED	2429.8184	16.48474	16.48879	13.51009	50.29770	1.08479	0.00000	5.9478	-0.72503	2.21340	0.05031	0.00000
1167	OOO	2430.9266	16.49704	16.49248	15.25572	45.53596	1.14055	0.00000	5.9478	-0.85017	2.08343	0.05031	0.00000
1168	B2	2436.9972	16.54303	16.52153	29.73810	24.54843	1.50953	0.00000	5.9754	-1.53566	1.37306	0.07126	0.00000
1169	O	2437.3020	16.54464	16.52354	30.68473	23.72233	1.53125	0.00000	5.9754	-1.57008	1.33723	0.07126	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1170 B2	2443.3726	16.56848	16.58261	53.90701	11.81129	2.02737	0.00000	6.0124	-2.25557	0.62442	0.09220	0.00000
1171 O	2443.6774	16.56937	16.58678	55.29250	11.44157	2.05548	0.00000	6.0124	-2.28999	0.58856	0.09220	0.00000
1172 QF2	2444.7442	16.57235	16.60220	57.73900	10.80055	2.10758	0.00000	6.0124	0.03078	0.02121	0.00512	0.00000
1173 QF2	2445.8110	16.57534	16.61767	55.16502	11.34838	2.06631	0.00000	6.0124	2.34615	-0.54232	-0.08220	0.00000
1174 BPM	2446.1865	16.57644	16.62284	53.41969	11.77174	2.03545	0.00000	6.0124	2.30188	-0.58514	-0.08220	0.00000
1175 CED	2447.0341	16.57906	16.63382	49.60225	12.84559	1.96578	0.00000	6.0124	2.20194	-0.68179	-0.08220	0.00000
1176 OOO	2448.1423	16.58280	16.64676	44.86668	14.49676	1.87468	0.00000	6.0124	2.07127	-0.80817	-0.08220	0.00000
1177 B2	2454.2129	16.61237	16.69503	24.06536	28.50280	1.43930	0.00000	6.0469	1.35555	-1.49852	-0.06125	0.00000
1178 O	2454.5177	16.61442	16.69670	23.24997	29.42688	1.42063	0.00000	6.0469	1.31961	-1.53323	-0.06125	0.00000
1179 B2	2460.5883	16.67475	16.72145	11.57405	52.22137	1.11238	0.00000	6.0732	0.60389	-2.22085	-0.04031	0.00000
1180 O	2460.8931	16.67901	16.72236	11.21687	53.58576	1.10009	0.00000	6.0732	0.56795	-2.25547	-0.04031	0.00000
1181 QD2	2461.9599	16.69471	16.72544	10.61372	56.02375	1.08145	0.00000	6.0732	0.00584	0.00429	0.00522	0.00000
1182 QD2	2463.0267	16.71043	16.72852	11.19121	53.56798	1.11132	0.00000	6.0732	-0.55521	2.26330	0.05099	0.00000
1183 BPM	2463.4022	16.71567	16.72965	11.62466	51.88436	1.13046	0.00000	6.0732	-0.59911	2.22039	0.05099	0.00000
1184 CED	2464.2498	16.72677	16.73235	12.72425	48.20247	1.17368	0.00000	6.0732	-0.69819	2.12351	0.05099	0.00000
1185 OOO	2465.3580	16.73981	16.73619	14.41530	43.63629	1.23018	0.00000	6.0732	-0.82774	1.99685	0.05099	0.00000
1186 B2	2471.4286	16.78798	16.76649	28.77178	23.59035	1.60324	0.00000	6.1027	-1.53735	1.30456	0.07193	0.00000
1187 O	2471.7334	16.78964	16.76858	29.71981	22.80573	1.62516	0.00000	6.1027	-1.57298	1.26965	0.07193	0.00000
1188 B2	2477.8040	16.81405	16.82944	53.12371	11.60481	2.12536	0.00000	6.1417	-2.28259	0.57505	0.09287	0.00000
1189 O	2478.1088	16.81495	16.83369	54.52604	11.26491	2.15366	0.00000	6.1417	-2.31822	0.54010	0.09287	0.00000
1190 QF2	2479.1756	16.81797	16.84928	57.06903	10.71892	2.20430	0.00000	6.1417	-0.03010	-0.02073	0.00171	0.00000
1191 QF2	2480.2424	16.82099	16.86481	54.65071	11.35603	2.15729	0.00000	6.1417	2.26329	-0.58531	-0.08953	0.00000
1192 BPM	2480.6179	16.82210	16.86997	52.96677	11.81227	2.12367	0.00000	6.1417	2.22122	-0.62970	-0.08953	0.00000
1193 CED	2481.4655	16.82474	16.88088	49.28184	12.96468	2.04778	0.00000	6.1417	2.12627	-0.72991	-0.08953	0.00000
1194 OOO	2482.5737	16.82850	16.89365	44.70677	14.72766	1.94856	0.00000	6.1417	2.00212	-0.86093	-0.08953	0.00000
1195 B2	2488.6443	16.85784	16.94067	24.52837	29.52859	1.46867	0.00000	6.1773	1.32208	-1.57667	-0.06859	0.00000
1196 O	2488.9491	16.85985	16.94228	23.73284	30.50069	1.44776	0.00000	6.1773	1.28793	-1.61265	-0.06859	0.00000
1197 B2	2495.0197	16.91784	16.96609	12.22484	54.41291	1.09501	0.00000	6.2037	0.60790	-2.32551	-0.04764	0.00000
1198 O	2495.3245	16.92187	16.96697	11.86467	55.84149	1.08048	0.00000	6.2037	0.57375	-2.36141	-0.04764	0.00000
1199 QD2	2496.3913	16.93668	16.96992	11.27135	58.40417	1.05352	0.00000	6.2037	-0.00933	-0.00491	-0.00310	0.00000
1200 QD2	2497.4581	16.95147	16.97287	11.90567	55.86182	1.07381	0.00000	6.2037	-0.59410	2.35245	0.04129	0.00000
1201 BPM	2497.8336	16.95640	16.97396	12.36786	54.11163	1.08932	0.00000	6.2037	-0.63677	2.30853	0.04129	0.00000
1202 CED	2498.6812	16.96683	16.97654	13.52895	50.28224	1.12432	0.00000	6.2037	-0.73309	2.20939	0.04129	0.00000
1203 OOO	2499.7894	16.97911	16.98023	15.29334	45.52901	1.17008	0.00000	6.2037	-0.85903	2.07976	0.04129	0.00000
1204 B2	2505.8600	17.02491	17.00927	29.90944	24.57427	1.48432	0.00000	6.2313	-1.54884	1.37132	0.06224	0.00000
1205 O	2506.1648	17.02651	17.01128	30.86417	23.74920	1.50329	0.00000	6.2313	-1.58347	1.33559	0.06224	0.00000
1206 B2	2512.2354	17.05020	17.07022	54.27528	11.84634	1.94466	0.00000	6.2671	-2.27328	0.62472	0.08318	0.00000
1207 O	2512.5402	17.05108	17.07438	55.67163	11.47642	1.97002	0.00000	6.2671	-2.30792	0.58894	0.08318	0.00000
1208 QF2	2513.6070	17.05404	17.08974	58.13944	10.83575	2.01446	0.00000	6.2671	0.02902	0.02048	-0.00017	0.00000
1209 QF2	2514.6738	17.05701	17.10517	55.55143	11.38641	1.96966	0.00000	6.2671	2.36087	-0.54429	-0.08351	0.00000
1210 BPM	2515.0493	17.05810	17.11032	53.79510	11.81122	1.93830	0.00000	6.2671	2.31644	-0.58703	-0.08351	0.00000
1211 CED	2515.8969	17.06070	17.12126	49.95329	12.88815	1.86752	0.00000	6.2671	2.21614	-0.68353	-0.08351	0.00000
1212 OOO	2517.0051	17.06442	17.13416	45.18677	14.54292	1.77497	0.00000	6.2671	2.08500	-0.80968	-0.08351	0.00000
1213 B2	2523.0757	17.09378	17.18230	24.23454	28.56024	1.33161	0.00000	6.2995	1.36668	-1.49886	-0.06257	0.00000
1214 O	2523.3805	17.09581	17.18397	23.41240	29.48451	1.31254	0.00000	6.2995	1.33061	-1.53351	-0.06257	0.00000

BETATRON FUNCTIONS THRU .RNG

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1215	B2	2529.4511	17.15580	17.20868	11.61866	52.27527	0.99632	0.00000	6.3234	0.61229	-2.21995	-0.04162	0.00000
1216	O	2529.7559	17.16004	17.20960	11.25640	53.63909	0.98363	0.00000	6.3234	0.57623	-2.25452	-0.04162	0.00000
1217	QD2	2530.8227	17.17570	17.21267	10.63734	56.07254	0.96096	0.00000	6.3234	0.01269	0.00753	-0.00104	0.00000
1218	QD2	2531.8895	17.19140	17.21574	11.20061	53.60790	0.98140	0.00000	6.3234	-0.54854	2.26826	0.03950	0.00000
1219	BPM	2532.2650	17.19663	17.21688	11.62894	51.92060	0.99623	0.00000	6.3234	-0.59215	2.22521	0.03950	0.00000
1220	CED	2533.1126	17.20774	17.21957	12.71620	48.23077	1.02971	0.00000	6.3234	-0.69060	2.12805	0.03950	0.00000
1221	OOO	2534.2208	17.22079	17.22342	14.38948	43.65493	1.07349	0.00000	6.3234	-0.81931	2.00102	0.03950	0.00000
1222	B2	2540.2914	17.26914	17.25372	28.61573	23.57059	1.37683	0.00000	6.3489	-1.52433	1.30671	0.06044	0.00000
1223	O	2540.5962	17.27081	17.25581	29.55575	22.78469	1.39525	0.00000	6.3489	-1.55973	1.27170	0.06044	0.00000
1224	B2	2546.6668	17.29537	17.31680	52.77092	11.57125	1.82573	0.00000	6.3824	-2.26475	0.57507	0.08139	0.00000
1225	O	2546.9716	17.29627	17.32105	54.16230	11.23137	1.85054	0.00000	6.3824	-2.30015	0.54002	0.08139	0.00000
1226	QF2	2548.0384	17.29932	17.33669	56.68296	10.68444	1.89573	0.00000	6.3824	-0.02755	-0.01975	0.00302	0.00000
1227	QF2	2549.1052	17.30235	17.35227	54.27641	11.31818	1.85694	0.00000	6.3824	2.24988	-0.58309	-0.07548	0.00000
1228	BPM	2549.4807	17.30347	17.35745	52.60249	11.77278	1.82859	0.00000	6.3824	2.20794	-0.62755	-0.07548	0.00000
1229	CED	2550.3283	17.30613	17.36840	48.93983	12.92165	1.76462	0.00000	6.3824	2.11327	-0.72790	-0.07548	0.00000
1230	OOO	2551.4365	17.30992	17.38122	44.39313	14.68036	1.68097	0.00000	6.3824	1.98950	-0.85910	-0.07548	0.00000
1231	B2	2557.5071	17.33947	17.42836	24.35524	29.46517	1.28635	0.00000	6.4132	1.31155	-1.57584	-0.05454	0.00000
1232	O	2557.8119	17.34149	17.42998	23.56609	30.43679	1.26973	0.00000	6.4132	1.27751	-1.61188	-0.05454	0.00000
1233	B2	2563.8825	17.39983	17.45382	12.17208	54.34582	1.00225	0.00000	6.4368	0.59955	-2.32575	-0.03359	0.00000
1234	O	2564.1873	17.40388	17.45470	11.81697	55.77455	0.99201	0.00000	6.4368	0.56551	-2.36170	-0.03359	0.00000
1235	QD2	2565.2541	17.41874	17.45766	11.23921	58.34098	0.97816	0.00000	6.4368	-0.01588	-0.00807	0.00753	0.00000
1236	QD2	2566.3209	17.43356	17.46061	11.88679	55.80799	1.00819	0.00000	6.4368	-0.60016	2.34698	0.04898	0.00000
1237	BPM	2566.6964	17.43849	17.46170	12.35364	54.06185	1.02659	0.00000	6.4368	-0.64313	2.30319	0.04898	0.00000
1238	CED	2567.5440	17.44894	17.46429	13.52608	50.24127	1.06810	0.00000	6.4368	-0.74012	2.20434	0.04898	0.00000
1239	OOO	2568.6522	17.46121	17.46798	15.30701	45.49880	1.12239	0.00000	6.4368	-0.86693	2.07510	0.04898	0.00000
1240	B2	2574.7228	17.50688	17.49702	30.04811	24.58783	1.48329	0.00000	6.4639	-1.56153	1.36877	0.06993	0.00000
1241	O	2575.0276	17.50847	17.49903	31.01065	23.76428	1.50460	0.00000	6.4639	-1.59641	1.33315	0.06993	0.00000
1242	B2	2581.0982	17.53203	17.55787	54.60785	11.87821	1.99264	0.00000	6.5003	-2.29101	0.62439	0.09087	0.00000
1243	O	2581.4030	17.53291	17.56202	56.01508	11.50845	2.02034	0.00000	6.5003	-2.32588	0.58873	0.09087	0.00000
1244	QF2	2582.4698	17.53585	17.57733	58.50594	10.86930	2.07181	0.00000	6.5003	0.02571	0.01925	0.00527	0.00000
1245	QF2	2583.5366	17.53880	17.59271	55.90860	11.42383	2.03150	0.00000	6.5003	2.37279	-0.54675	-0.08057	0.00000
1246	BPM	2583.9121	17.53988	17.59785	54.14335	11.85047	2.00124	0.00000	6.5003	2.32826	-0.58944	-0.08057	0.00000
1247	CED	2584.7597	17.54247	17.60875	50.28168	12.93138	1.93295	0.00000	6.5003	2.22775	-0.68582	-0.08057	0.00000
1248	OOO	2585.8679	17.54616	17.62161	45.48974	14.59107	1.84366	0.00000	6.5003	2.09633	-0.81182	-0.08057	0.00000
1249	B2	2591.9385	17.57531	17.66960	24.40929	28.62925	1.41816	0.00000	6.5342	1.37647	-1.50016	-0.05962	0.00000
1250	O	2592.2433	17.57734	17.67127	23.58121	29.55429	1.39999	0.00000	6.5342	1.34033	-1.53476	-0.05962	0.00000
1251	B2	2598.3139	17.63693	17.69593	11.67885	52.35516	1.10163	0.00000	6.5602	0.62047	-2.22036	-0.03868	0.00000
1252	O	2598.6187	17.64116	17.69684	11.31163	53.71921	1.08984	0.00000	6.5602	0.58433	-2.25489	-0.03868	0.00000
1253	QD2	2599.6855	17.65674	17.69991	10.67757	56.14974	1.07271	0.00000	6.5602	0.01886	0.01060	0.00645	0.00000
1254	QD2	2600.7523	17.67239	17.70298	11.22871	53.67533	1.10371	0.00000	6.5602	-0.54317	2.27422	0.05188	0.00000
1255	BPM	2601.1278	17.67762	17.70411	11.65290	51.98361	1.12319	0.00000	6.5602	-0.58648	2.23104	0.05188	0.00000
1256	CED	2601.9754	17.68870	17.70681	12.72996	48.28416	1.16716	0.00000	6.5602	-0.68424	2.13357	0.05188	0.00000
1257	OOO	2603.0836	17.70175	17.71065	14.38814	43.69653	1.22465	0.00000	6.5602	-0.81205	2.00614	0.05188	0.00000
1258	B2	2609.1542	17.75021	17.74094	28.49630	23.56331	1.60312	0.00000	6.5896	-1.51214	1.30964	0.07282	0.00000
1259	O	2609.4590	17.75188	17.74303	29.42882	22.77566	1.62531	0.00000	6.5896	-1.54729	1.27452	0.07282	0.00000

BETATRON FUNCTIONS THRU .RNG

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1260	B2	2615.5296	17.77657	17.80411	52.46303	11.54128	2.13092	0.00000	6.6287	-2.24738	0.57570	0.09377	0.00000
1261	O	2615.8344	17.77748	17.80838	53.84375	11.20105	2.15950	0.00000	6.6287	-2.28253	0.54053	0.09377	0.00000
1262	QF2	2616.9012	17.78054	17.82407	56.34097	10.65203	2.21095	0.00000	6.6287	-0.02352	-0.01829	0.00234	0.00000
1263	QF2	2617.9680	17.78360	17.83969	53.94117	11.28141	2.16445	0.00000	6.6287	2.23961	-0.58040	-0.08919	0.00000
1264	BPM	2618.3435	17.78472	17.84489	52.27494	11.73400	2.13096	0.00000	6.6287	2.19773	-0.62490	-0.08919	0.00000
1265	CED	2619.1911	17.78740	17.85587	48.62947	12.87847	2.05537	0.00000	6.6287	2.10320	-0.72534	-0.08919	0.00000
1266	OOO	2620.2993	17.79121	17.86874	44.10490	14.63166	1.95653	0.00000	6.6287	1.97961	-0.85667	-0.08919	0.00000
1267	B2	2626.3699	17.82096	17.91602	24.18121	29.39100	1.47870	0.00000	6.6644	1.30263	-1.57408	-0.06824	0.00000
1268	O	2626.6747	17.82300	17.91764	23.39749	30.36155	1.45790	0.00000	6.6644	1.26863	-1.61015	-0.06824	0.00000
1269	B2	2632.7453	17.88173	17.94154	12.10525	54.25364	1.10721	0.00000	6.6911	0.59165	-2.32469	-0.04730	0.00000
1270	O	2633.0501	17.88580	17.94242	11.75494	55.68174	1.09280	0.00000	6.6911	0.55766	-2.36067	-0.04730	0.00000
1271	QD2	2634.1169	17.90073	17.94538	11.19144	58.25024	1.06647	0.00000	6.6911	-0.02159	-0.01102	-0.00224	0.00000
1272	QD2	2635.1837	17.91561	17.94834	11.84985	55.72739	1.08799	0.00000	6.6911	-0.60476	2.34057	0.04273	0.00000
1273	BPM	2635.5592	17.92056	17.94943	12.32027	53.98601	1.10404	0.00000	6.6911	-0.64804	2.29692	0.04273	0.00000
1274	CED	2636.4068	17.93102	17.95202	13.50163	50.17580	1.14025	0.00000	6.6911	-0.74573	2.19838	0.04273	0.00000
1275	OOO	2637.5150	17.94331	17.95571	15.29600	45.44607	1.18761	0.00000	6.6911	-0.87345	2.06956	0.04273	0.00000
1276	B2	2643.5856	17.98892	17.98478	30.14668	24.58878	1.51055	0.00000	6.7191	-1.57306	1.36548	0.06367	0.00000
1277	O	2643.8904	17.99050	17.98678	31.11632	23.76721	1.52996	0.00000	6.7191	-1.60819	1.32997	0.06367	0.00000
1278	B2	2649.9610	18.01396	18.04554	54.88692	11.90610	1.98004	0.00000	6.7556	-2.30779	0.62347	0.08462	0.00000
1279	O	2650.2658	18.01484	18.04968	56.30446	11.53687	2.00583	0.00000	6.7556	-2.34292	0.58791	0.08462	0.00000
1280	QF2	2651.3326	18.01777	18.06496	58.81884	10.90036	2.05100	0.00000	6.7556	0.02102	0.01755	-0.00025	0.00000
1281	QF2	2652.3994	18.02070	18.08029	56.21740	11.45973	2.00531	0.00000	6.7556	2.38127	-0.54964	-0.08510	0.00000
1282	BPM	2652.7749	18.02178	18.08541	54.44580	11.88853	1.97335	0.00000	6.7556	2.33672	-0.59231	-0.08510	0.00000
1283	CED	2653.6225	18.02435	18.09628	50.56984	12.97423	1.90122	0.00000	6.7556	2.23615	-0.68861	-0.08510	0.00000
1284	OOO	2654.7307	18.02802	18.10909	45.75936	14.64002	1.80691	0.00000	6.7556	2.10465	-0.81453	-0.08510	0.00000
1285	B2	2660.8013	18.05698	18.15694	24.58026	28.70812	1.35391	0.00000	6.7885	1.38440	-1.50238	-0.06416	0.00000
1286	O	2661.1061	18.05899	18.15860	23.74735	29.63451	1.33435	0.00000	6.7885	1.34823	-1.53696	-0.06416	0.00000
1287	SB	2667.1767	18.11818	18.18320	11.75085	52.47615	0.94489	0.00000	6.7885	0.62793	-2.22571	-0.06416	0.00000
1288	O	2667.4815	18.12238	18.18411	11.37909	53.84349	0.92533	0.00000	6.7885	0.59176	-2.26029	-0.06416	0.00000
1289	QD2	2668.5483	18.13788	18.18717	10.73181	56.27994	0.87714	0.00000	6.7885	0.02399	0.01052	-0.02654	0.00000
1290	QD2	2669.6151	18.15346	18.19023	11.27363	53.79990	0.86829	0.00000	6.7885	-0.53942	2.27949	0.00989	0.00000
1291	BPM	2669.9906	18.15866	18.19136	11.69488	52.10425	0.87200	0.00000	6.7885	-0.58242	2.23624	0.00989	0.00000
1292	CED	2670.8382	18.16971	18.19405	12.76447	48.39611	0.88039	0.00000	6.7885	-0.67948	2.13862	0.00989	0.00000
1293	OOO	2671.9464	18.18273	18.19788	14.41112	43.79751	0.89135	0.00000	6.7885	-0.80639	2.01099	0.00989	0.00000
1294	B2	2678.0170	18.23122	18.22811	28.42035	23.61199	1.01495	0.00000	6.8083	-1.50150	1.31340	0.03083	0.00000
1295	O	2678.3218	18.23289	18.23020	29.34630	22.82206	1.02435	0.00000	6.8083	-1.53640	1.27823	0.03083	0.00000
1296	SB	2684.3924	18.25768	18.29117	52.22014	11.55591	1.21153	0.00000	6.8083	-2.23157	0.57763	0.03083	0.00000
1297	O	2684.6972	18.25859	18.29543	53.59114	11.21451	1.22093	0.00000	6.8083	-2.26647	0.54245	0.03083	0.00000
1298	QF2	2685.7640	18.26167	18.31110	56.06525	10.66194	1.22654	0.00000	6.8083	-0.01824	-0.01682	-0.02036	0.00000
1299	Q1	2686.8308	18.26474	18.32672	53.66668	11.28845	1.17781	0.00000	6.8083	2.23319	-0.57914	-0.07066	0.00000
1300	XO	2691.8398	18.28342	18.38073	34.09369	20.05833	0.82387	0.00000	6.8083	1.67438	-1.17169	-0.07066	0.00000
1301	QOO	2692.3848	18.28602	18.38493	32.68691	21.12749	0.79009	0.00000	6.8083	0.91690	-0.78244	-0.05341	0.00000
1302	O	2692.6896	18.28752	18.38720	32.13320	21.61155	0.77381	0.00000	6.8083	0.89973	-0.80570	-0.05341	0.00000
1303	B2	2698.7602	18.32314	18.42305	23.28510	34.19423	0.51320	0.00000	6.8215	0.55790	-1.26657	-0.03246	0.00000
1304	O	2699.0650	18.32523	18.42445	22.95024	34.97341	0.50331	0.00000	6.8215	0.54074	-1.28978	-0.03246	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1305 B2	2705.1356	18.37288	18.44688	18.46044	53.42077	0.36984	0.00000	6.8304	0.19891	-1.74835	-0.01152	0.00000
1306 O	2705.4404	18.37551	18.44778	18.34441	54.49363	0.36633	0.00000	6.8304	0.18175	-1.77150	-0.01152	0.00000
1307 B2	2711.5110	18.42939	18.46254	18.21291	78.77169	0.36000	0.00000	6.8378	-0.16008	-2.22691	0.00943	0.00000
1308 O	2711.8158	18.43205	18.46315	18.31573	80.13624	0.36287	0.00000	6.8378	-0.17725	-2.24997	0.00943	0.00000
1309 QO	2714.2838	18.45141	18.46811	24.45025	72.29008	0.43135	0.00000	6.8378	-2.50348	5.17149	0.04717	0.00000
1310 XI	2717.2838	18.46630	18.47651	42.14623	44.71526	0.57286	0.00000	6.8378	-3.39518	4.02012	0.04717	0.00000
1311 QI	2719.4174	18.47354	18.48527	49.18850	35.74239	0.62035	0.00000	6.8378	0.29258	0.43183	-0.00332	0.00000
1312 LS	2732.2684	18.51742	18.54931	45.31345	30.12573	0.57772	0.00000	6.8378	0.00896	0.00523	-0.00332	0.00000
1313 LSI	2732.2961	18.51752	18.54946	45.31297	30.12547	0.57762	0.00000	6.8378	0.00834	0.00432	-0.00332	0.00000
1314 LS	2745.1471	18.56160	18.61374	48.74337	35.49667	0.53499	0.00000	6.8378	-0.27528	-0.42228	-0.00332	0.00000
1315 QI	2747.2807	18.56891	18.62255	41.71031	44.37742	0.48124	0.00000	6.8378	3.37382	-3.98396	-0.04632	0.00000
1316 XI	2750.2807	18.58398	18.63102	24.13925	71.70291	0.34229	0.00000	6.8378	2.48320	-5.12454	-0.04632	0.00000
1317 QO	2752.7487	18.60361	18.63602	18.03869	79.46192	0.26514	0.00000	6.8378	0.18269	2.23546	-0.01745	0.00000
1318 O	2753.0535	18.60631	18.63664	17.93264	78.10620	0.25982	0.00000	6.8378	0.16523	2.21246	-0.01745	0.00000
1319 B2	2759.1241	18.66110	18.65153	18.03755	53.99729	0.21745	0.00000	6.8426	-0.18251	1.75809	0.00349	0.00000
1320 O	2759.4289	18.66378	18.65244	18.15413	52.93260	0.21851	0.00000	6.8426	-0.19997	1.73500	0.00349	0.00000
1321 B2	2765.4995	18.71212	18.67508	22.69267	34.64100	0.30328	0.00000	6.8478	-0.54771	1.27749	0.02444	0.00000
1322 O	2765.8043	18.71424	18.67650	23.03188	33.86930	0.31073	0.00000	6.8478	-0.56517	1.25433	0.02444	0.00000
1323 B2	2771.8749	18.75013	18.71267	32.00406	21.42871	0.52264	0.00000	6.8563	-0.91291	0.79454	0.04538	0.00000
1324 O	2772.1797	18.75163	18.71496	32.56589	20.95143	0.53647	0.00000	6.8563	-0.93037	0.77134	0.04538	0.00000
1325 QOO	2772.7247	18.75425	18.71920	33.98634	19.89627	0.56439	0.00000	6.8563	-1.68609	1.15720	0.05715	0.00000
1326 XO	2777.7337	18.77295	18.77353	53.71456	11.25314	0.85066	0.00000	6.8563	-2.25247	0.56832	0.05715	0.00000
1327 Q1	2778.8005	18.77602	18.78918	56.15264	10.64797	0.89234	0.00000	6.8563	0.00102	0.00735	0.02069	0.00000
1328 QF2	2779.8673	18.77908	18.80485	53.71032	11.22085	0.89448	0.00000	6.8563	2.25433	-0.55229	-0.01669	0.00000
1329 BPM	2780.2428	18.78021	18.81008	52.03328	11.65202	0.88821	0.00000	6.8563	2.21181	-0.59597	-0.01669	0.00000
1330 CED	2781.0904	18.78290	18.82116	48.36517	12.74585	0.87407	0.00000	6.8563	2.11583	-0.69454	-0.01669	0.00000
1331 OOO	2782.1986	18.78674	18.83418	43.81470	14.42808	0.85557	0.00000	6.8563	1.99034	-0.82343	-0.01669	0.00000
1332 SB	2788.2692	18.81682	18.88238	23.82260	28.71159	0.75426	0.00000	6.8563	1.30292	-1.52947	-0.01669	0.00000
1333 O	2788.5740	18.81889	18.88405	23.03885	29.65475	0.74918	0.00000	6.8563	1.26841	-1.56492	-0.01669	0.00000
1334 B2	2794.6446	18.87886	18.90853	11.81241	52.92359	0.71144	0.00000	6.8714	0.58104	-2.26728	0.00426	0.00000
1335 O	2794.9494	18.88303	18.90944	11.46873	54.31651	0.71274	0.00000	6.8714	0.54653	-2.30265	0.00426	0.00000
1336 QD2	2796.0162	18.89834	18.91247	10.91868	56.82272	0.73330	0.00000	6.8714	-0.02326	-0.01153	0.03444	0.00000
1337 QD2	2797.0830	18.91358	18.91550	11.57099	54.36425	0.78676	0.00000	6.8714	-0.59728	2.28162	0.06616	0.00000
1338 BPM	2797.4585	18.91865	18.91662	12.03608	52.66685	0.81161	0.00000	6.8714	-0.64130	2.23875	0.06616	0.00000
1339 CED	2798.3061	18.92935	18.91928	13.20745	48.95372	0.86768	0.00000	6.8714	-0.74069	2.14200	0.06616	0.00000
1340 OOO	2799.4143	18.94190	18.92306	14.99312	44.34639	0.94100	0.00000	6.8714	-0.87063	2.01550	0.06616	0.00000
1341 B2	2805.4849	18.98819	18.95281	29.88324	24.06851	1.40617	0.00000	6.8958	-1.58238	1.32411	0.08711	0.00000
1342 O	2805.7897	18.98979	18.95486	30.85875	23.27196	1.43272	0.00000	6.8958	-1.61812	1.28925	0.08711	0.00000
1343 SB	2811.8603	19.01337	19.01446	54.82566	11.83461	1.96150	0.00000	6.8958	-2.32991	0.59481	0.08711	0.00000
1344 O	2812.1651	19.01424	19.01862	56.25687	11.48264	1.98805	0.00000	6.8958	-2.36565	0.55994	0.08711	0.00000
1345 QF2	2813.2319	19.01717	19.03393	58.82266	10.90255	2.03625	0.00000	6.8958	-0.00372	-0.00815	0.00292	0.00000
1346 QF2	2814.2987	19.02010	19.04922	56.27227	11.51844	1.99424	0.00000	6.8958	2.35887	-0.57771	-0.08139	0.00000
1347 BPM	2814.6742	19.02118	19.05431	54.51721	11.96863	1.96367	0.00000	6.8958	2.31507	-0.62119	-0.08139	0.00000
1348 CED	2815.5218	19.02374	19.06509	50.67652	13.10486	1.89468	0.00000	6.8958	2.21619	-0.71933	-0.08139	0.00000
1349 OOO	2816.6300	19.02740	19.07775	45.90781	14.84140	1.80448	0.00000	6.8958	2.08692	-0.84766	-0.08139	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1350 B2	2822.7006	19.05615	19.12469	24.87022	29.39139	1.37398	0.00000	6.9288	1.37882	-1.54861	-0.06045	0.00000
1351 D	2823.0054	19.05813	19.12631	24.04053	30.34616	1.35555	0.00000	6.9288	1.34327	-1.58386	-0.06045	0.00000
1352 B2	2829.0760	19.11622	19.15031	12.03108	53.81936	1.05219	0.00000	6.9538	0.63517	-2.28200	-0.03950	0.00000
1353 D	2829.3808	19.12032	19.15120	11.65471	55.22118	1.04015	0.00000	6.9538	0.59962	-2.31715	-0.03950	0.00000
1354 QD2	2830.4476	19.13545	19.15418	11.00036	57.71682	1.02102	0.00000	6.9538	0.02287	0.01274	0.00351	0.00000
1355 QD2	2831.5144	19.15064	19.15717	11.55420	55.16844	1.04770	0.00000	6.9538	-0.54973	2.34038	0.04669	0.00000
1356 BPM	2831.8899	19.15572	19.15827	11.98294	53.42737	1.06523	0.00000	6.9538	-0.59205	2.29629	0.04669	0.00000
1357 CED	2832.7375	19.16651	19.16089	13.06756	49.61904	1.10480	0.00000	6.9538	-0.68758	2.19678	0.04669	0.00000
1358 DOD	2833.8457	19.17924	19.16463	14.72993	44.89430	1.15654	0.00000	6.9538	-0.81248	2.06666	0.04669	0.00000
1359 B2	2839.9163	19.22690	19.19416	28.74649	24.11522	1.50351	0.00000	6.9815	-1.49661	1.35549	0.06763	0.00000
1360 D	2840.2211	19.22856	19.19621	29.66930	23.29985	1.52413	0.00000	6.9815	-1.53097	1.31963	0.06763	0.00000
1361 B2	2846.2917	19.25315	19.25638	52.40849	11.60722	1.99824	0.00000	7.0181	-2.21510	0.60605	0.08858	0.00000
1362 D	2846.5965	19.25407	19.26063	53.76929	11.24872	2.02523	0.00000	7.0181	-2.24945	0.57015	0.08858	0.00000
1363 QF2	2847.6633	19.25713	19.27629	56.19832	10.63958	2.07417	0.00000	7.0181	0.00637	0.00928	0.00282	0.00000
1364 QF2	2848.7301	19.26020	19.29198	53.74291	11.20792	2.03121	0.00000	7.0181	2.26107	-0.54991	-0.08306	0.00000
1365 BPM	2849.1056	19.26133	19.29721	52.06088	11.63729	2.00002	0.00000	7.0181	2.21837	-0.59354	-0.08306	0.00000
1366 CED	2849.9532	19.26402	19.30830	48.38202	12.72695	1.92962	0.00000	7.0181	2.12196	-0.69204	-0.08306	0.00000
1367 DOD	2851.0614	19.26785	19.32135	43.81857	14.40349	1.83757	0.00000	7.0181	1.99592	-0.82081	-0.08306	0.00000
1368 B2	2857.1320	19.29796	19.36965	23.77822	28.64301	1.39696	0.00000	7.0518	1.30553	-1.52432	-0.06211	0.00000
1369 D	2857.4368	19.30003	19.37132	22.99294	29.58302	1.37803	0.00000	7.0518	1.27087	-1.55969	-0.06211	0.00000
1370 B2	2863.5074	19.36022	19.39587	11.75499	52.77852	1.06455	0.00000	7.0771	0.58048	-2.26043	-0.04117	0.00000
1371 D	2863.8122	19.36441	19.39677	11.41170	54.16724	1.05200	0.00000	7.0771	0.54581	-2.29571	-0.04117	0.00000
1372 QD2	2864.8790	19.37980	19.39982	10.86121	56.66536	1.03135	0.00000	7.0771	-0.02213	-0.01100	0.00231	0.00000
1373 QD2	2865.9458	19.39512	19.40286	11.50897	54.21277	1.05697	0.00000	7.0771	-0.59409	2.27566	0.04590	0.00000
1374 BPM	2866.3213	19.40021	19.40398	11.97170	52.51982	1.07420	0.00000	7.0771	-0.63823	2.23286	0.04590	0.00000
1375 CED	2867.1689	19.41098	19.40664	13.13808	48.81656	1.11311	0.00000	7.0771	-0.73787	2.13626	0.04590	0.00000
1376 DOD	2868.2771	19.42359	19.41044	14.91785	44.22172	1.16397	0.00000	7.0771	-0.86814	2.00996	0.04590	0.00000
1377 B2	2874.3477	19.47008	19.44027	29.78889	24.00440	1.50613	0.00000	7.1049	-1.58172	1.31968	0.06684	0.00000
1378 D	2874.6525	19.47168	19.44232	30.76402	23.21053	1.52650	0.00000	7.1049	-1.61755	1.28487	0.06684	0.00000
1379 B2	2880.7231	19.49531	19.50206	54.73310	11.81285	1.99580	0.00000	7.1416	-2.33113	0.59224	0.08778	0.00000
1380 D	2881.0279	19.49619	19.50623	56.16508	11.46244	2.02255	0.00000	7.1416	-2.36696	0.55739	0.08778	0.00000
1381 QF2	2882.0947	19.49912	19.52157	58.73793	10.88700	2.07071	0.00000	7.1416	-0.00893	-0.01001	0.00216	0.00000
1382 QF2	2883.1615	19.50205	19.53687	56.20208	11.50644	2.02712	0.00000	7.1416	2.35065	-0.57922	-0.08357	0.00000
1383 BPM	2883.5370	19.50313	19.54197	54.45311	11.95780	1.99574	0.00000	7.1416	2.30706	-0.62280	-0.08357	0.00000
1384 CED	2884.3846	19.50570	19.55276	50.62561	13.09697	1.92491	0.00000	7.1416	2.20864	-0.72118	-0.08357	0.00000
1385 DOD	2885.4928	19.50936	19.56542	45.87297	14.83793	1.83230	0.00000	7.1416	2.07997	-0.84980	-0.08357	0.00000
1386 B2	2891.5634	19.53810	19.61234	24.89975	29.42406	1.38862	0.00000	7.1751	1.37517	-1.55242	-0.06262	0.00000
1387 D	2891.8682	19.54009	19.61396	24.07223	30.38118	1.36953	0.00000	7.1751	1.33978	-1.58774	-0.06262	0.00000
1388 B2	2897.9388	19.59800	19.63793	12.08515	53.91156	1.05298	0.00000	7.2002	0.63498	-2.28753	-0.04168	0.00000
1389 D	2898.2436	19.60208	19.63881	11.70886	55.31678	1.04028	0.00000	7.2002	0.59959	-2.32277	-0.04168	0.00000
1390 QD2	2899.3104	19.61713	19.64179	11.05641	57.82015	1.01882	0.00000	7.2002	0.02109	0.01122	0.00130	0.00000
1391 QD2	2900.3772	19.63225	19.64478	11.61614	55.27032	1.04307	0.00000	7.2002	-0.55357	2.34323	0.04433	0.00000
1392 BPM	2900.7527	19.63730	19.64587	12.04773	53.52711	1.05972	0.00000	7.2002	-0.59580	2.29914	0.04433	0.00000
1393 CED	2901.6003	19.64803	19.64849	13.13854	49.71398	1.09729	0.00000	7.2002	-0.69113	2.19960	0.04433	0.00000
1394 DOD	2902.7085	19.66069	19.65222	14.80849	44.98302	1.14642	0.00000	7.2002	-0.81577	2.06945	0.04433	0.00000

BETATRON FUNCTIONS THRU .RNG

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1395	B2	2908.7791	19.70812	19.68169	28.85627	24.17093	1.47908	0.00000	7.2275	-1.49847	1.35814	0.06528	0.00000
1396	O	2909.0839	19.70978	19.68373	29.78018	23.35395	1.49898	0.00000	7.2275	-1.53275	1.32227	0.06528	0.00000
1397	B2	2915.1545	19.73430	19.74377	52.53229	11.63025	1.95878	0.00000	7.2635	-2.21544	0.60854	0.08622	0.00000
1398	O	2915.4593	19.73521	19.74801	53.89328	11.27023	1.98506	0.00000	7.2635	-2.24973	0.57262	0.08622	0.00000
1399	QF2	2916.5261	19.73827	19.76364	56.31718	10.65666	2.03239	0.00000	7.2635	0.01138	0.01103	0.00218	0.00000
1400	QF2	2917.5929	19.74133	19.77931	53.84614	11.22176	1.98967	0.00000	7.2635	2.27049	-0.54858	-0.08196	0.00000
1401	BPM	2917.9684	19.74246	19.78453	52.15712	11.65009	1.95890	0.00000	7.2635	2.22757	-0.59211	-0.08196	0.00000
1402	CED	2918.8160	19.74514	19.79562	48.46307	12.73712	1.88943	0.00000	7.2635	2.13068	-0.69037	-0.08196	0.00000
1403	OOO	2919.9242	19.74897	19.80865	43.88102	14.40964	1.79860	0.00000	7.2635	2.00400	-0.81884	-0.08196	0.00000
1404	B2	2925.9948	19.77907	19.85697	23.76377	28.61516	1.36467	0.00000	7.2964	1.31012	-1.52070	-0.06101	0.00000
1405	O	2926.2996	19.78114	19.85864	22.97574	29.55293	1.34607	0.00000	7.2964	1.27528	-1.55598	-0.06101	0.00000
1406	B2	2932.3702	19.84149	19.88322	11.70535	52.69332	1.03927	0.00000	7.3211	0.58141	-2.25506	-0.04007	0.00000
1407	O	2932.6750	19.84569	19.88413	11.36154	54.07873	1.02706	0.00000	7.3211	0.54656	-2.29026	-0.04007	0.00000
1408	QD2	2933.7418	19.86116	19.88717	10.80779	56.56917	1.00703	0.00000	7.3211	-0.01977	-0.00934	0.00238	0.00000
1409	QD2	2934.8086	19.87656	19.89022	11.44846	54.11742	1.03218	0.00000	7.3211	-0.58970	2.27322	0.04494	0.00000
1410	BPM	2935.1841	19.88168	19.89134	11.90793	52.42630	1.04906	0.00000	7.3211	-0.63391	2.23043	0.04494	0.00000
1411	CED	2936.0317	19.89250	19.89401	13.06710	48.72716	1.08715	0.00000	7.3211	-0.73369	2.13383	0.04494	0.00000
1412	OOO	2937.1399	19.90518	19.89781	14.83782	44.13770	1.13696	0.00000	7.3211	-0.86415	2.00753	0.04494	0.00000
1413	B2	2943.2105	19.95189	19.92771	29.66658	23.94971	1.47333	0.00000	7.3482	-1.57875	1.31727	0.06589	0.00000
1414	O	2943.5153	19.95350	19.92977	30.63992	23.15732	1.49342	0.00000	7.3482	-1.61463	1.28246	0.06589	0.00000
1415	B2	2949.5859	19.97721	19.98964	54.57973	11.78870	1.95693	0.00000	7.3842	-2.32923	0.58986	0.08683	0.00000
1416	O	2949.8907	19.97809	19.99382	56.01056	11.43974	1.98340	0.00000	7.3842	-2.36511	0.55501	0.08683	0.00000
1417	QF2	2950.9575	19.98103	20.00919	58.58654	10.86850	2.03141	0.00000	7.3842	-0.01367	-0.01163	0.00285	0.00000
1418	QF2	2952.0243	19.98398	20.02452	56.06719	11.49084	1.98942	0.00000	7.3842	2.34016	-0.58036	-0.08127	0.00000
1419	BPM	2952.3998	19.98506	20.02962	54.32602	11.94310	1.95891	0.00000	7.3842	2.29679	-0.62405	-0.08127	0.00000
1420	CED	2953.2474	19.98763	20.04042	50.51549	13.08457	1.89003	0.00000	7.3842	2.19888	-0.72266	-0.08127	0.00000
1421	OOO	2954.3556	19.99130	20.05309	45.78376	14.82914	1.79997	0.00000	7.3842	2.07087	-0.85158	-0.08127	0.00000
1422	B2	2960.4262	20.02007	20.10000	24.89894	29.44691	1.37024	0.00000	7.4171	1.36970	-1.55585	-0.06032	0.00000
1423	O	2960.7310	20.02205	20.10163	24.07470	30.40615	1.35185	0.00000	7.4171	1.33450	-1.59126	-0.06032	0.00000
1424	B2	2966.8016	20.07985	20.12556	12.12969	53.98925	1.04926	0.00000	7.4421	0.63333	-2.29270	-0.03938	0.00000
1425	O	2967.1064	20.08391	20.12645	11.75434	55.39764	1.03725	0.00000	7.4421	0.59812	-2.32802	-0.03938	0.00000
1426	QD2	2968.1732	20.09891	20.12942	11.10649	57.90862	1.01820	0.00000	7.4421	0.01819	0.00944	0.00352	0.00000
1427	QD2	2969.2400	20.11395	20.13240	11.67439	55.35855	1.04482	0.00000	7.4421	-0.55844	2.34524	0.04658	0.00000
1428	BPM	2969.6155	20.11898	20.13350	12.10963	53.61383	1.06231	0.00000	7.4421	-0.60064	2.30114	0.04658	0.00000
1429	CED	2970.4631	20.12965	20.13611	13.20856	49.79729	1.10179	0.00000	7.4421	-0.69588	2.20162	0.04658	0.00000
1430	OOO	2971.5713	20.14224	20.13983	14.88891	45.06182	1.15341	0.00000	7.4421	-0.82041	2.07150	0.04658	0.00000
1431	B2	2977.6419	20.18943	20.16924	28.98946	24.22425	1.49971	0.00000	7.4696	-1.50252	1.36029	0.06752	0.00000
1432	O	2977.9467	20.19108	20.17128	29.91583	23.40594	1.52029	0.00000	7.4696	-1.53677	1.32442	0.06752	0.00000
1433	B2	2984.0173	20.21550	20.23118	52.71317	11.65538	1.99373	0.00000	7.5062	-2.21888	0.61080	0.08847	0.00000
1434	O	2984.3221	20.21641	20.23541	54.07624	11.29398	2.02070	0.00000	7.5062	-2.25313	0.57490	0.08847	0.00000
1435	QF2	2985.3889	20.21946	20.25101	56.49906	10.67647	2.06961	0.00000	7.5062	0.01578	0.01250	0.00290	0.00000
1436	QF2	2986.4557	20.22251	20.26665	54.01088	11.23903	2.02684	0.00000	7.5062	2.28192	-0.54763	-0.08279	0.00000
1437	BPM	2986.8312	20.22364	20.27187	52.31336	11.66661	1.99575	0.00000	7.5062	2.23877	-0.59106	-0.08279	0.00000
1438	CED	2987.6788	20.22631	20.28294	48.60077	12.75167	1.92558	0.00000	7.5062	2.14136	-0.68909	-0.08279	0.00000
1439	OOO	2988.7870	20.23013	20.29596	43.99580	14.42102	1.83383	0.00000	7.5062	2.01400	-0.81727	-0.08279	0.00000

BETATRON FUNCTIONS THRU .RNG

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1440	B2	2994.8576	20.26017	20.34428	23.77983	28.59745	1.39483	0.00000	7.5398	1.31639	-1.51748	-0.06185	0.00000
1441	0	2995.1624	20.26225	20.34595	22.98804	29.53323	1.37598	0.00000	7.5398	1.28136	-1.55268	-0.06185	0.00000
1442	B2	3001.2330	20.32268	20.37055	11.66651	52.62364	1.06412	0.00000	7.5651	0.58375	-2.25013	-0.04090	0.00000
1443	0	3001.5378	20.32690	20.37146	11.32134	54.00602	1.05165	0.00000	7.5651	0.54872	-2.28525	-0.04090	0.00000
1444	QD2	3002.6046	20.34242	20.37451	10.76172	56.48897	1.03128	0.00000	7.5651	-0.01636	-0.00745	0.00257	0.00000
1445	QD2	3003.6714	20.35790	20.37756	11.39325	54.03686	1.05717	0.00000	7.5651	-0.58441	2.27166	0.04616	0.00000
1446	BPM	3004.0469	20.36304	20.37869	11.84874	52.34692	1.07451	0.00000	7.5651	-0.62863	2.22886	0.04616	0.00000
1447	CED	3004.8945	20.37392	20.38136	12.99899	48.65046	1.11363	0.00000	7.5651	-0.72843	2.13223	0.04616	0.00000
1448	000	3006.0027	20.38667	20.38517	14.75809	44.06461	1.16478	0.00000	7.5651	-0.85892	2.00589	0.04616	0.00000
1449	B2	3012.0733	20.43363	20.41512	29.52429	23.89810	1.50852	0.00000	7.5929	-1.57367	1.31538	0.06710	0.00000
1450	0	3012.3781	20.43525	20.41718	30.49454	23.10685	1.52897	0.00000	7.5929	-1.60956	1.28056	0.06710	0.00000
1451	B2	3018.4487	20.45906	20.47720	54.37377	11.76275	1.99985	0.00000	7.6296	-2.32431	0.58772	0.08804	0.00000
1452	0	3018.7535	20.45994	20.48139	55.80161	11.41510	2.02668	0.00000	7.6296	-2.36020	0.55286	0.08804	0.00000
1453	QF2	3019.8203	20.46289	20.49678	58.37661	10.84751	2.07502	0.00000	7.6296	-0.01768	-0.01295	0.00224	0.00000
1454	QF2	3020.8871	20.46584	20.51214	55.87482	11.47202	2.03143	0.00000	7.6296	2.32795	-0.58111	-0.08366	0.00000
1455	BPM	3021.2626	20.46693	20.51725	54.14273	11.92488	2.00001	0.00000	7.6296	2.28481	-0.62489	-0.08366	0.00000
1456	CED	3022.1102	20.46951	20.52806	50.35207	13.06797	1.92910	0.00000	7.6296	2.18743	-0.72373	-0.08366	0.00000
1457	000	3023.2184	20.47319	20.54075	45.64495	14.81523	1.83639	0.00000	7.6296	2.06011	-0.85295	-0.08366	0.00000
1458	B2	3029.2890	20.50203	20.58768	24.86784	29.45938	1.39211	0.00000	7.6632	1.36272	-1.55883	-0.06272	0.00000
1459	0	3029.5938	20.50401	20.58930	24.04780	30.42046	1.37300	0.00000	7.6632	1.32770	-1.59432	-0.06272	0.00000
1460	B2	3035.6644	20.56176	20.61321	12.16230	54.05050	1.05586	0.00000	7.6884	0.63032	-2.29737	-0.04177	0.00000
1461	0	3035.9692	20.56581	20.61410	11.78873	55.46176	1.04313	0.00000	7.6884	0.59530	-2.33277	-0.04177	0.00000
1462	QD2	3037.0360	20.58075	20.61707	11.14792	57.98005	1.02163	0.00000	7.6884	0.01431	0.00744	0.00132	0.00000
1463	QD2	3038.1028	20.59574	20.62005	11.72583	55.43095	1.04597	0.00000	7.6884	-0.56408	2.34634	0.04447	0.00000
1464	BPM	3038.4783	20.60074	20.62114	12.16530	53.68540	1.06267	0.00000	7.6884	-0.60629	2.30227	0.04447	0.00000
1465	CED	3039.3259	20.61137	20.62375	13.27386	49.86690	1.10036	0.00000	7.6884	-0.70158	2.20280	0.04447	0.00000
1466	000	3040.4341	20.62389	20.62747	14.96689	45.12875	1.14964	0.00000	7.6884	-0.82616	2.07274	0.04447	0.00000
1467	B2	3046.5047	20.67083	20.65682	29.13893	24.27385	1.48316	0.00000	7.7158	-1.50855	1.36190	0.06542	0.00000
1468	0	3046.8095	20.67247	20.65886	30.06899	23.45456	1.50310	0.00000	7.7158	-1.54281	1.32605	0.06542	0.00000
1469	B2	3052.8801	20.69678	20.71862	52.94145	11.68199	1.96375	0.00000	7.7519	-2.22520	0.61280	0.08636	0.00000
1470	0	3053.1849	20.69768	20.72284	54.30838	11.31937	1.99008	0.00000	7.7519	-2.25947	0.57691	0.08636	0.00000
1471	QF2	3054.2517	20.70072	20.73841	56.73422	10.69852	2.03744	0.00000	7.7519	0.01934	0.01367	0.00211	0.00000
1472	QF2	3055.3185	20.70376	20.75402	54.22830	11.25928	1.99454	0.00000	7.7519	2.29475	-0.54709	-0.08224	0.00000
1473	BPM	3055.6940	20.70488	20.75923	52.52123	11.68642	1.96366	0.00000	7.7519	2.25137	-0.59043	-0.08224	0.00000
1474	CED	3056.5416	20.70754	20.77028	48.78773	12.77022	1.89396	0.00000	7.7519	2.15343	-0.68824	-0.08224	0.00000
1475	000	3057.6498	20.71134	20.78328	44.15677	14.43736	1.80283	0.00000	7.7519	2.02538	-0.81612	-0.08224	0.00000
1476	B2	3063.7204	20.74130	20.83158	23.82555	28.59030	1.36720	0.00000	7.7848	1.32399	-1.51475	-0.06129	0.00000
1477	0	3064.0252	20.74338	20.83325	23.02918	29.52440	1.34852	0.00000	7.7848	1.28878	-1.54988	-0.06129	0.00000
1478	SB	3070.0958	20.80383	20.85786	11.64004	52.58828	0.97644	0.00000	7.7848	0.58734	-2.24940	-0.06129	0.00000
1479	0	3070.4006	20.80806	20.85878	11.29274	53.97022	0.95776	0.00000	7.7848	0.55212	-2.28452	-0.06129	0.00000
1480	QD2	3071.4674	20.82363	20.86183	10.72508	56.45325	0.91337	0.00000	7.7848	-0.01210	-0.00825	-0.02224	0.00000
1481	QD2	3072.5342	20.83916	20.86488	11.34594	54.00440	0.90996	0.00000	7.7848	-0.57853	2.26946	0.01581	0.00000
1482	BPM	3072.9097	20.84433	20.86601	11.79700	52.31609	0.91589	0.00000	7.7848	-0.62270	2.22670	0.01581	0.00000
1483	CED	3073.7573	20.85526	20.86868	12.93711	48.62321	0.92930	0.00000	7.7848	-0.72241	2.13017	0.01581	0.00000
1484	000	3074.8655	20.86807	20.87249	14.68272	44.04178	0.94682	0.00000	7.7848	-0.85277	2.00396	0.01581	0.00000

BETATRON FUNCTIONS THRU .RNG

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1485 B2	3080.9361	20.91528	20.90245	29.37014	23.89439	1.10638	0.00000	7.8061	-1.56684	1.31416	0.03676	0.00000
1486 O	3081.2409	20.91690	20.90452	30.33621	23.10388	1.11758	0.00000	7.8061	-1.60270	1.27938	0.03676	0.00000
1487 SB	3087.3115	20.94084	20.96450	54.13000	11.77660	1.34072	0.00000	7.8061	-2.31682	0.58655	0.03676	0.00000
1488 O	3087.6163	20.94172	20.96868	55.55326	11.42964	1.35193	0.00000	7.8061	-2.35267	0.55176	0.03676	0.00000
1489 QF2	3088.6831	20.94469	20.98405	58.12342	10.86483	1.36090	0.00000	7.8061	-0.02074	-0.01450	-0.01999	0.00000
1490 Q1	3089.7499	20.94765	20.99939	55.63915	11.49336	1.30959	0.00000	7.8061	2.31483	-0.58338	-0.07586	0.00000
1491 XO	3094.7589	20.96567	21.05261	35.31647	20.26360	0.92962	0.00000	7.8061	1.74240	-1.16752	-0.07586	0.00000
1492 QOO	3095.3039	20.96819	21.05677	33.85010	21.32537	0.89363	0.00000	7.8061	0.95865	-0.77310	-0.05636	0.00000
1493 O	3095.6087	20.96963	21.05902	33.27097	21.80361	0.87645	0.00000	7.8061	0.94137	-0.79593	-0.05636	0.00000
1494 B2	3101.6793	21.00414	21.09470	23.93136	34.21645	0.59788	0.00000	7.8213	0.59724	-1.24837	-0.03542	0.00000
1495 O	3101.9841	21.00618	21.09610	23.57254	34.98440	0.58709	0.00000	7.8213	0.57996	-1.27116	-0.03542	0.00000
1496 B2	3108.0547	21.05297	21.11858	18.62049	53.15452	0.43566	0.00000	7.8318	0.23584	-1.72132	-0.01447	0.00000
1497 O	3108.3595	21.05558	21.11948	18.48199	54.21077	0.43125	0.00000	7.8318	0.21856	-1.74405	-0.01447	0.00000
1498 B2	3114.4301	21.10971	21.13435	17.91751	78.10468	0.40696	0.00000	7.8404	-0.12557	-2.19110	0.00647	0.00000
1499 O	3114.7349	21.11241	21.13497	17.99932	79.44727	0.40893	0.00000	7.8404	-0.14285	-2.21373	0.00647	0.00000
1500 QO	3117.2029	21.13218	21.13997	23.85619	71.59378	0.47544	0.00000	7.8404	-2.41656	5.13799	0.04850	0.00000
1501 XI	3120.2029	21.14748	21.14846	40.93589	44.21015	0.62093	0.00000	7.8404	-3.27668	3.98989	0.04850	0.00000
1502 QI	3122.3365	21.15495	21.15732	47.68804	35.28155	0.66695	0.00000	7.8404	0.30190	0.44009	-0.00600	0.00000
1503 LS	3135.1875	21.20036	21.22246	43.70731	29.55781	0.58988	0.00000	7.8404	0.00786	0.00530	-0.00600	0.00000
1504 LS	3148.0385	21.24597	21.28787	47.28406	35.00897	0.51281	0.00000	7.8404	-0.28618	-0.42948	-0.00600	0.00000
1505 QI	3150.1721	21.25350	21.29680	40.54021	43.83533	0.45546	0.00000	7.8404	3.25730	-3.94977	-0.04697	0.00000
1506 XI	3153.1721	21.26897	21.30537	23.57384	70.94227	0.31456	0.00000	7.8404	2.39815	-5.08588	-0.04697	0.00000
1507 QO	3155.6401	21.28900	21.31042	17.74775	78.69902	0.23235	0.00000	7.8404	0.14779	2.19765	-0.02098	0.00000
1508 O	3155.9449	21.29174	21.31104	17.66300	77.36621	0.22595	0.00000	7.8404	0.13025	2.17507	-0.02098	0.00000
1509 B2	3162.0155	21.34671	21.32606	18.20327	53.65993	0.16218	0.00000	7.8442	-0.21925	1.72917	-0.00003	0.00000
1510 O	3162.3203	21.34936	21.32697	18.34227	52.61274	0.16217	0.00000	7.8442	-0.23680	1.70650	-0.00003	0.00000
1511 B2	3168.3909	21.39675	21.34968	23.33857	34.61544	0.22554	0.00000	7.8481	-0.58629	1.25751	0.02091	0.00000
1512 O	3168.6957	21.39881	21.35110	23.70132	33.85579	0.23191	0.00000	7.8481	-0.60384	1.23478	0.02091	0.00000
1513 B2	3174.7663	21.43355	21.38714	33.15365	21.60062	0.42241	0.00000	7.8547	-0.95334	0.78355	0.04186	0.00000
1514 O	3175.0711	21.43500	21.38941	33.74015	21.12991	0.43517	0.00000	7.8547	-0.97089	0.76077	0.04186	0.00000
1515 QOO	3175.6161	21.43753	21.39361	35.21895	20.08369	0.46057	0.00000	7.8547	-1.75304	1.15144	0.05143	0.00000
1516 XO	3180.6251	21.45557	21.44718	55.68265	11.45416	0.71819	0.00000	7.8547	-2.33234	0.57137	0.05143	0.00000
1517 Q1	3181.6919	21.45853	21.46255	58.20282	10.84932	0.75675	0.00000	7.8547	0.00510	0.00398	0.02058	0.00000
1518 QF2	3182.7587	21.46149	21.47792	55.66153	11.43668	0.76177	0.00000	7.8547	2.34165	-0.56269	-0.01119	0.00000
1519 BPM	3183.1342	21.46258	21.48305	53.91938	11.87549	0.75757	0.00000	7.8547	2.29791	-0.60592	-0.01119	0.00000
1520 CED	3183.9818	21.46517	21.49393	50.10765	12.98536	0.74809	0.00000	7.8547	2.19918	-0.70350	-0.01119	0.00000
1521 OOO	3185.0900	21.46887	21.50671	45.37643	14.68598	0.73569	0.00000	7.8547	2.07010	-0.83108	-0.01119	0.00000
1522 SB	3191.1606	21.49799	21.55421	24.53535	29.01882	0.66778	0.00000	7.8547	1.36302	-1.52995	-0.01119	0.00000
1523 O	3191.4654	21.50000	21.55586	23.71527	29.96217	0.66436	0.00000	7.8547	1.32751	-1.56503	-0.01119	0.00000
1524 B2	3197.5360	21.55887	21.58016	11.89067	53.18879	0.66002	0.00000	7.8683	0.62048	-2.26021	0.00976	0.00000
1525 O	3197.8408	21.56301	21.58106	11.52324	54.57728	0.66300	0.00000	7.8683	0.58498	-2.29521	0.00976	0.00000
1526 QD2	3198.9076	21.57830	21.58408	10.89491	57.05530	0.68835	0.00000	7.8683	0.01276	0.00707	0.03796	0.00000
1527 QD2	3199.9744	21.59363	21.58710	11.46715	54.54799	0.74459	0.00000	7.8683	-0.55714	2.30811	0.06787	0.00000
1528 BPM	3200.3499	21.59875	21.58821	11.90167	52.83096	0.77008	0.00000	7.8683	-0.60005	2.26456	0.06787	0.00000
1529 CED	3201.1975	21.60960	21.59086	13.00097	49.07541	0.82760	0.00000	7.8683	-0.69691	2.16624	0.06787	0.00000

BETATRON FUNCTIONS THRU .RNG

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1530	OOO	3202.3057	21.62238	21.59464	14.68594	44.41662	0.90281	0.00000	7.8683	-0.82355	2.03769	0.06787	0.00000
1531	B2	3208.3763	21.66998	21.62444	28.89468	23.93728	1.37834	0.00000	7.8920	-1.51721	1.33510	0.08881	0.00000
1532	O	3208.6811	21.67163	21.62650	29.83019	23.13421	1.40541	0.00000	7.8920	-1.55204	1.29967	0.08881	0.00000
1533	SB	3214.7517	21.69606	21.68682	52.88507	11.63842	1.94454	0.00000	7.8920	-2.24575	0.59402	0.08881	0.00000
1534	O	3215.0565	21.69696	21.69105	54.26470	11.28710	1.97161	0.00000	7.8920	-2.28058	0.55859	0.08881	0.00000
1535	QF2	3216.1233	21.70000	21.70664	56.73826	10.70331	2.02198	0.00000	7.8920	-0.00362	-0.00326	0.00527	0.00000
1536	QF2	3217.1901	21.70304	21.72222	54.27969	11.30144	1.98277	0.00000	7.8920	2.27398	-0.56570	-0.07851	0.00000
1537	BPM	3217.5656	21.70415	21.72741	52.58796	11.74275	1.95329	0.00000	7.8920	2.23129	-0.60956	-0.07851	0.00000
1538	CED	3218.4132	21.70681	21.73839	48.88715	12.85998	1.88675	0.00000	7.8920	2.13493	-0.70856	-0.07851	0.00000
1539	OOL	3222.3074	21.72204	21.77728	33.98354	20.14978	1.58103	0.00000	7.8920	1.69220	-1.16340	-0.07851	0.00000
1540	B2	3228.3780	21.76193	21.81222	17.62876	38.56731	1.16805	0.00000	7.9206	1.00209	-1.86982	-0.05756	0.00000
1541	OOL	3232.2722	21.80593	21.82570	11.54812	54.89817	0.94389	0.00000	7.9206	0.55937	-2.32381	-0.05756	0.00000
1542	QD2	3233.3390	21.82115	21.82870	10.97398	57.42322	0.90319	0.00000	7.9206	-0.01318	-0.00776	-0.01901	0.00000
1543	QD2	3234.4058	21.83632	21.83171	11.60605	54.93029	0.90302	0.00000	7.9206	-0.58812	2.30967	0.01868	0.00000
1544	BPM	3234.7813	21.84138	21.83281	12.06408	53.21199	0.91003	0.00000	7.9206	-0.63166	2.26636	0.01868	0.00000
1545	CED	3235.6289	21.85207	21.83544	13.21819	49.45290	0.92587	0.00000	7.9206	-0.72995	2.16862	0.01868	0.00000
1546	OOL	3239.5231	21.88993	21.85051	20.66194	34.31164	0.99863	0.00000	7.9206	-1.18154	1.71954	0.01868	0.00000
1547	B2	3245.5937	21.92410	21.89015	39.27912	17.67369	1.17561	0.00000	7.9431	-1.88546	1.02060	0.03963	0.00000
1548	OOL	3249.4879	21.93736	21.93423	55.72241	11.47664	1.32992	0.00000	7.9431	-2.33705	0.57075	0.03963	0.00000
1549	QF2	3250.5547	21.94032	21.94957	58.25093	10.87383	1.34243	0.00000	7.9431	0.00209	0.00266	-0.01628	0.00000
1550	QF2	3251.6215	21.94328	21.96491	55.71374	11.46495	1.29546	0.00000	7.9431	2.34087	-0.56495	-0.07146	0.00000
1551	BPM	3251.9970	21.94437	21.97003	53.97215	11.90546	1.26862	0.00000	7.9431	2.29719	-0.60816	-0.07146	0.00000
1552	CED	3252.8446	21.94696	21.98087	50.16150	13.01907	1.20806	0.00000	7.9431	2.19862	-0.70569	-0.07146	0.00000
1553	OOL	3256.7388	21.96182	22.01941	34.80150	20.26012	0.92979	0.00000	7.9431	1.74571	-1.15376	-0.07146	0.00000
1554	B2	3262.8094	22.00092	22.05428	17.89341	38.49644	0.55960	0.00000	7.9585	1.03974	-1.84962	-0.05051	0.00000
1555	OOL	3266.7036	22.04456	22.06781	11.55924	54.64361	0.36289	0.00000	7.9585	0.58683	-2.29685	-0.05051	0.00000
1556	QD2	3267.7704	22.05981	22.07083	10.92826	57.12209	0.31675	0.00000	7.9585	0.01342	0.00828	-0.03633	0.00000
1557	QD2	3268.8372	22.07509	22.07384	11.50024	54.60932	0.28481	0.00000	7.9585	-0.55755	2.31195	-0.02377	0.00000
1558	BPM	3269.2127	22.08019	22.07496	11.93503	52.88942	0.27588	0.00000	7.9585	-0.60035	2.26832	-0.02377	0.00000
1559	CED	3270.0603	22.09101	22.07760	13.03463	49.12763	0.25573	0.00000	7.9585	-0.69696	2.16984	-0.02377	0.00000
1560	OOL	3273.9545	22.12960	22.09279	20.19144	33.99007	0.16315	0.00000	7.9585	-1.14085	1.71737	-0.02377	0.00000
1561	B2	3280.0251	22.16465	22.13293	38.24168	17.41073	0.08241	0.00000	7.9608	-1.83276	1.01312	-0.00283	0.00000
1562	OOL	3283.9193	22.17827	22.17774	54.24449	11.28516	0.07139	0.00000	7.9608	-2.27664	0.55988	-0.00283	0.00000
1563	QF2	3284.9861	22.18131	22.19333	56.71044	10.69861	0.06682	0.00000	7.9608	-0.00054	-0.00193	-0.00572	0.00000
1564	QF2	3286.0529	22.18435	22.20892	54.24672	11.29365	0.05928	0.00000	7.9608	2.27566	-0.56409	-0.00836	0.00000
1565	BPM	3286.4284	22.18547	22.21411	52.55376	11.73374	0.05614	0.00000	7.9608	2.23289	-0.60792	-0.00836	0.00000
1566	CED	3287.2760	22.18813	22.22510	48.85039	12.84814	0.04906	0.00000	7.9608	2.13635	-0.70685	-0.00836	0.00000
1567	OOO	3288.3842	22.19192	22.23801	44.25527	14.55815	0.03980	0.00000	7.9608	2.01013	-0.83620	-0.00836	0.00000
1568	SB	3294.4548	22.22171	22.28574	24.04733	29.01204	-0.01094	0.00000	7.9608	1.31869	-1.54476	-0.00836	0.00000
1569	O	3294.7596	22.22376	22.28738	23.25404	29.96458	-0.01349	0.00000	7.9608	1.28398	-1.58034	-0.00836	0.00000
1570	SB	3300.8302	22.28332	22.31162	11.86241	53.45322	-0.06423	0.00000	7.9608	0.59255	-2.28890	-0.00836	0.00000
1571	O	3301.1350	22.28747	22.31252	11.51178	54.85938	-0.06677	0.00000	7.9608	0.55783	-2.32448	-0.00836	0.00000
1572	QD2	3302.2018	22.30273	22.31552	10.93961	57.38767	-0.07726	0.00000	7.9608	-0.01352	-0.01009	-0.01136	0.00000
1573	QD2	3303.2686	22.31796	22.31852	11.57120	54.90115	-0.09120	0.00000	7.9608	-0.58732	2.30608	-0.01488	0.00000
1574	BPM	3303.6441	22.32303	22.31963	12.02867	53.18550	-0.09679	0.00000	7.9608	-0.63097	2.26287	-0.01488	0.00000

BETATRON FUNCTIONS THRU .RNG

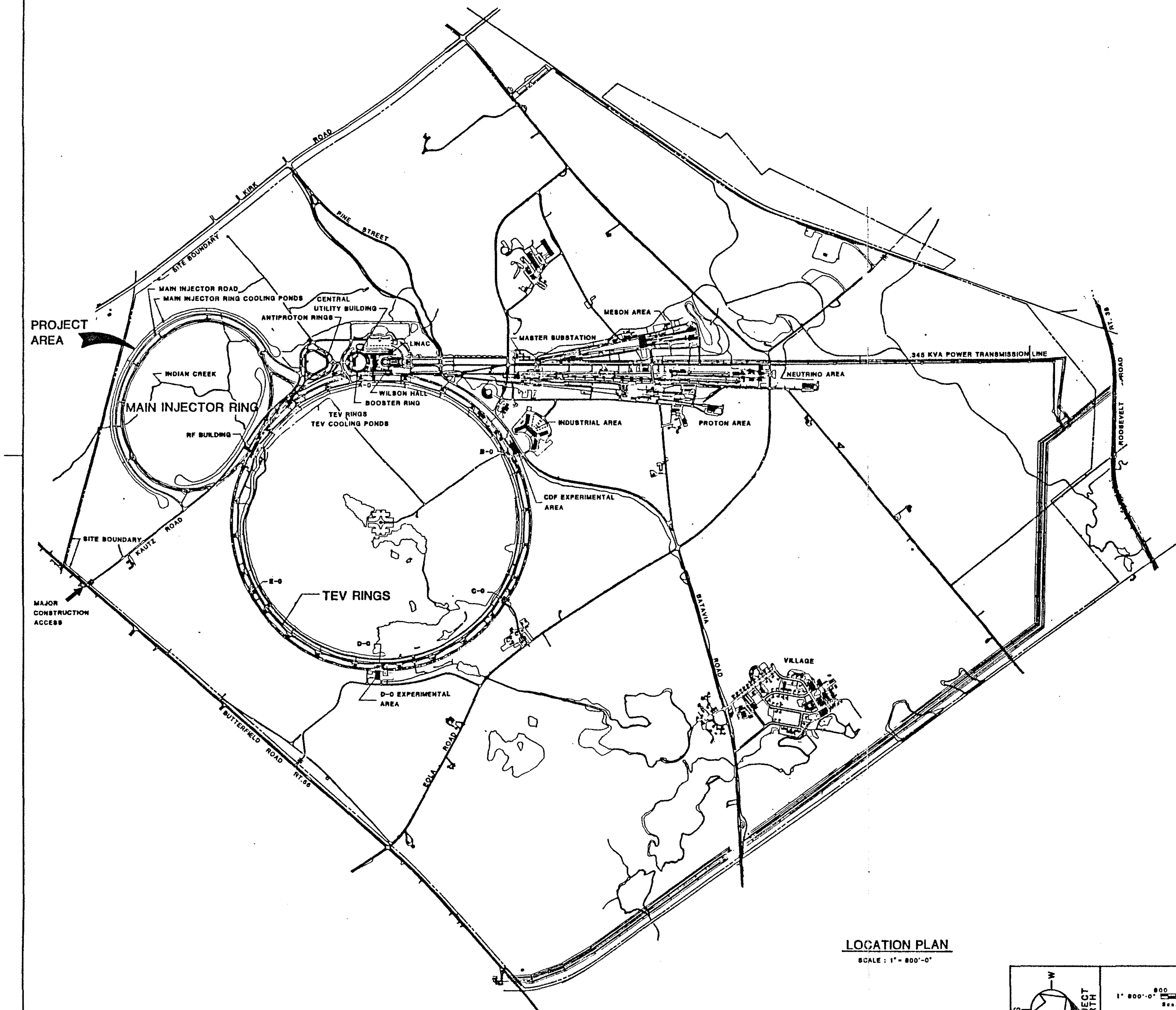
POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1575 CED	3304.4917	22.33375	22.32226	13.18179	49.43216	-0.10940	0.00000	7.9608	-0.72948	2.16533	-0.01488	0.00000
1576 OOO	3305.5999	22.34633	22.32601	14.94136	44.77425	-0.12589	0.00000	7.9608	-0.85829	2.03780	-0.01488	0.00000
1577 SB	3311.6705	22.39290	22.35548	29.64547	24.27389	-0.21622	0.00000	7.9608	-1.56389	1.33919	-0.01488	0.00000
1578 O	3311.9753	22.39451	22.35752	30.60961	23.46820	-0.22075	0.00000	7.9608	-1.59932	1.30412	-0.01488	0.00000
1579 SB	3318.0459	22.41829	22.41675	54.31067	11.87561	-0.31108	0.00000	7.9608	-2.30492	0.60551	-0.01488	0.00000
1580 O	3318.3507	22.41917	22.42090	55.72654	11.51718	-0.31562	0.00000	7.9608	-2.34034	0.57044	-0.01488	0.00000
1581 QF2	3319.4175	22.42213	22.43617	58.26201	10.91639	-0.32438	0.00000	7.9608	-0.00103	0.00106	-0.00149	0.00000

```
CIRCUMFERENCE =    3319.4175 M       THETX =   6.28318530 RAD     NUX =    22.42213      DNUX/(DP/P) =  -27.47646
       RADIUS =    528.3017 M        THETY =   0.00000000 RAD     NUY =    22.43617      DNUY/(DP/P) =  -28.54360
 (DS/S)/(DP/P)=  0.0023983             TGAM=(  20.41979,    0.00000)

MAXIMA    --- BETX(  790) =    74.86696    BETY(  670) =     81.33677     XEQ( 1262) =      2.21095     YEQ( 1581) =        0.00000
MINIMA    --- BETX(  780) =     9.43687    BETY(  790) =      7.81066     XEQ(    1) =     -0.32438     YEQ( 1581) =        0.00000
-------------------------------------------------------------------------------------------------------------------------------


***         FIN             // CORE USE SUMMARY                        MAXIMUM          USED     UNUSED
                                INFF    (ELEMENT DEFINITIONS)       2000(INFMAX)        99       1901
                                FLIB  (F.P. DATA AND STORAGE)       5000(IFLMAX)       104       4896
                                ILIB  (INTEGER DATA)                1000  (IMAX)         5        995
                                CHLIB(CHARACTER DATA)               5000(ICHMAX)       566       4434
                                SFLIB(F.P.CHARACTER DATA)           5000(ISFMAX)       104       4896
                                LQFIL(CALCULATED DATA)             20000 (IQMAX)      1361      18639
   ARRAY DIMENSIONS ARE SET IN COMMON FILES BINFF.CCC, BSTORE.CCC, CSTORE.CCC

===============================================================================================================================
END OF SYNCH RUN MI_9
```

APPENDIX E

Conventional Construction Drawings

COLLIDER UPGRADE: MAIN INJECTOR



LOCATION PLAN

SCALE : 1" = 800'-0"

LIST OF DRAWINGS

CDR-1	LOCATION PLAN AND LIST OF DRAWINGS
CDR-2	
CDR-3	
CDR-4	EXISTING SITE CONDITIONS
CDR-5	SITE PLAN
CDR-6	
CDR-7	
CDR-8	
CDR-9	BEAMLINE PLAN
CDR-10	F-0 ENCLOSURE
CDR-11	120 GEV TEST/AP-1 BEAMLINES
CDR-12	120 GEV TEST/8 GEV BEAMLINES SHT. 1
CDR-13	120 GEV TEST/8 GEV BEAMLINES SHT. 2
CDR-14	120 GEV TEST/8 GEV BEAMLINES SHT. 3
CDR-15	120 GEV TEST BEAMLINE AT A-0
CDR-16	ENLARGED 120 GEV TEST BEAMLINE AT BOOSTER/A-0
CDR-17	
CDR-18	
CDR-19	
CDR-20	TYPICAL SERVICE BUILDING PLAN
CDR-21	TYPICAL SERVICE BUILDING SECTIONS
CDR-22	RF SERVICE BUILDINGS PLAN
CDR-23	RF SERVICE BUILDINGS SECTIONS
CDR-24	
CDR-25	
CDR-26	ENCLOSURE SECTIONS SHEET 1
CDR-27	
CDR-28	
CDR-29	
CDR-30	
CDR-31	SINGLE LINE POWER DIAGRAM
CDR-32	
CDR-33	

PROJECT NORTH

1" = 800'-0" — 800 0 800 1600 Scale Feet

REV.	DATE	DESCRIPTIONS
		REVISIONS
DESIGNED		
DRAWN		
CHECKED		
APPROVED		
SUBMITTED		

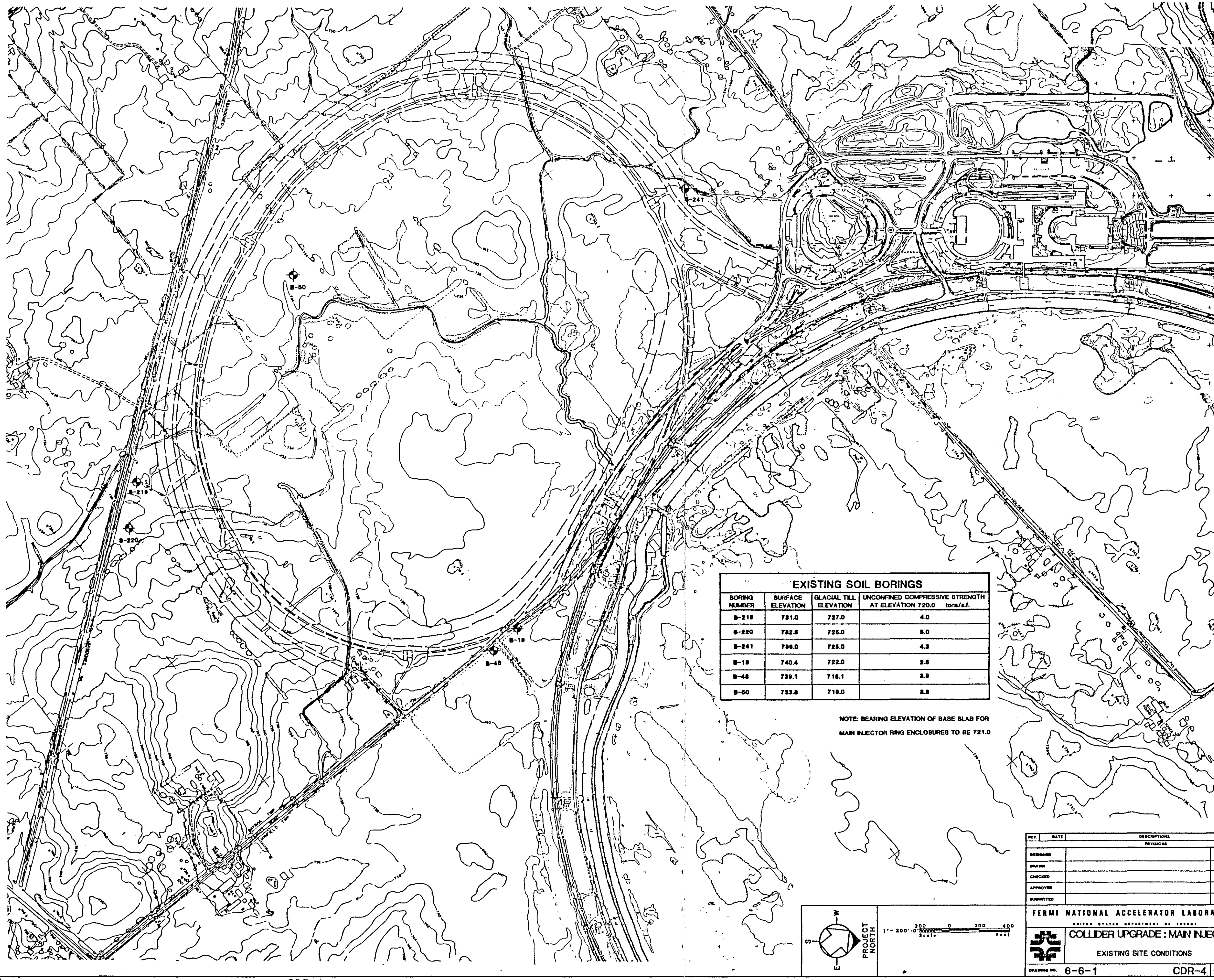
FERMI NATIONAL ACCELERATOR LABORATORY

UNITED STATES DEPARTMENT OF ENERGY

COLLIDER UPGRADE: MAIN INJECTOR

LOCATION PLAN AND LIST OF DRAWINGS

DRAWING NO. 6-6-1 CDR-1 REV.



EXISTING SOIL BORINGS

BORING NUMBER	SURFACE ELEVATION	GLACIAL TILL ELEVATION	UNCONFINED COMPRESSIVE STRENGTH AT ELEVATION 720.0 tons/s.f.
B-219	731.0	727.0	4.0
B-220	732.5	725.0	5.0
B-241	739.0	725.0	4.3
B-19	740.4	722.0	2.5
B-45	739.1	718.1	3.9
B-50	733.8	719.0	3.8

NOTE: BEARING ELEVATION OF BASE SLAB FOR MAIN INJECTOR RING ENCLOSURES TO BE 721.0

REV.	DATE	DESCRIPTIONS
		REVISIONS

DESIGNED		
DRAWN		
CHECKED		
APPROVED		
SUBMITTED		

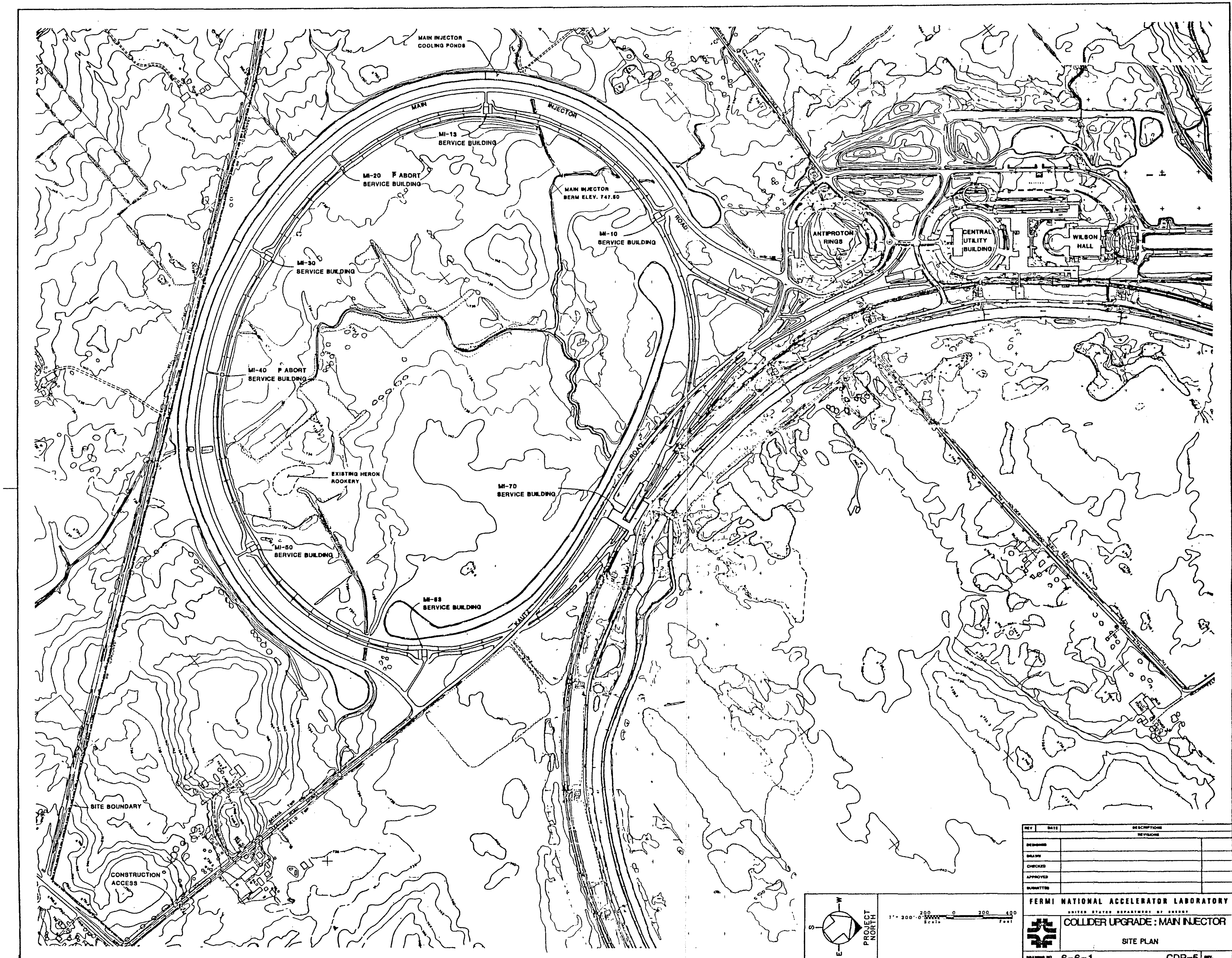
FERMI NATIONAL ACCELERATOR LABORATORY

UNITED STATES DEPARTMENT OF ENERGY

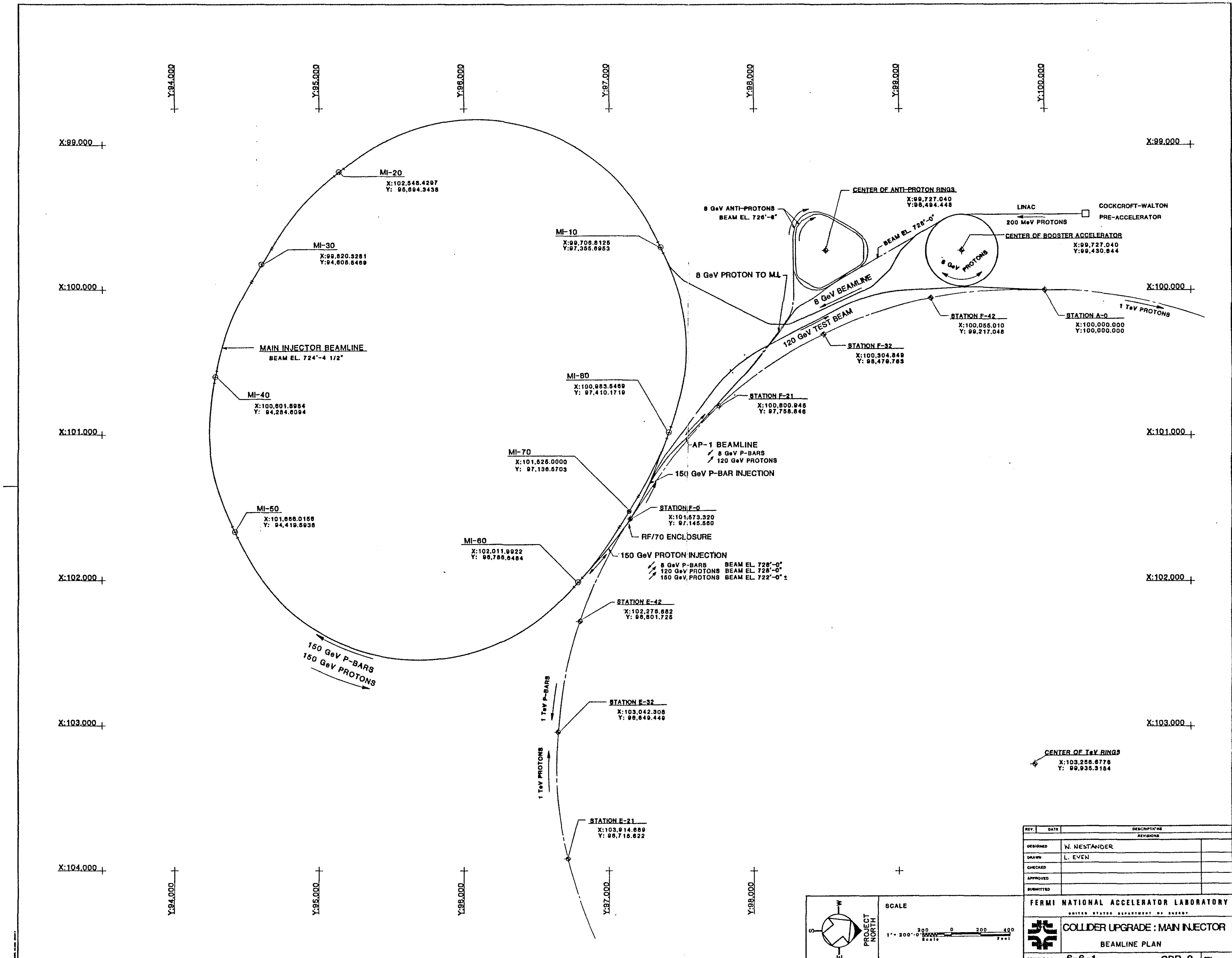
COLLIDER UPGRADE : MAIN INJECTOR

EXISTING SITE CONDITIONS

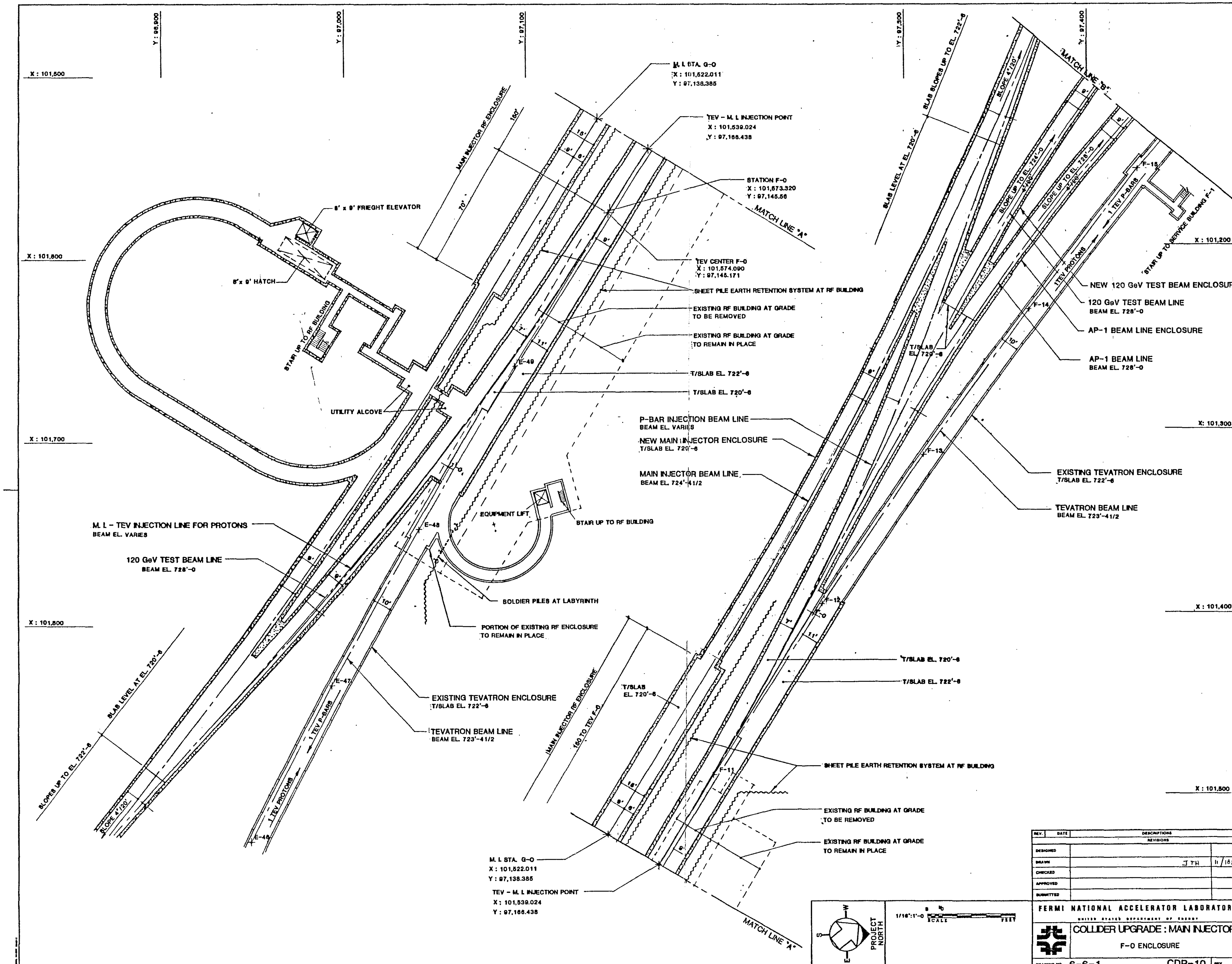
DRAWING NO. 6-6-1 CDR-4 REV.

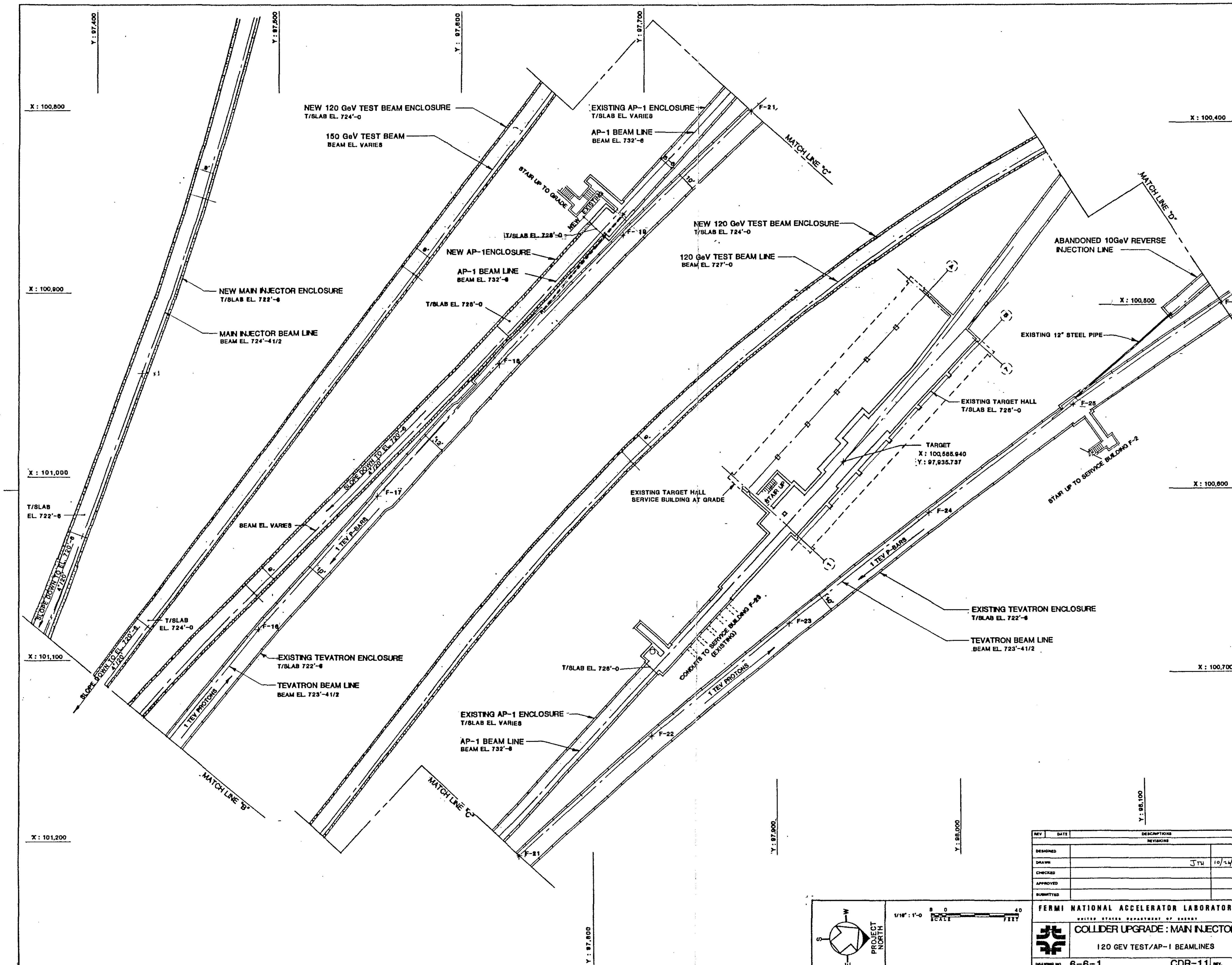


MAIN INJECTOR COOLING PONDS
MAIN
INJECTOR
MI-13 SERVICE BUILDING
MI-20 P̄ ABORT SERVICE BUILDING
MAIN INJECTOR BERM ELEV. 747.50
ROAD
MI-10 SERVICE BUILDING
ANTIPROTON RINGS
CENTRAL UTILITY BUILDING
WILSON HALL
MI-30 SERVICE BUILDING
MI-40 P̄ ABORT SERVICE BUILDING
EXISTING HERON ROOKERY
MI-70 SERVICE BUILDING
ROAD
MI-50 SERVICE BUILDING
MI-62 SERVICE BUILDING
KAUTZ
SITE BOUNDARY
CONSTRUCTION ACCESS
W
S
E
PROJECT NORTH
1" = 200'-0"
200 0 200 400
Scale
Feet
REV
DATE
DESCRIPTIONS
REVISIONS
DESIGNED
DRAWN
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
COLLIDER UPGRADE : MAIN INJECTOR
SITE PLAN
DRAWING NO. 6-6-1
CDR-5
REV.

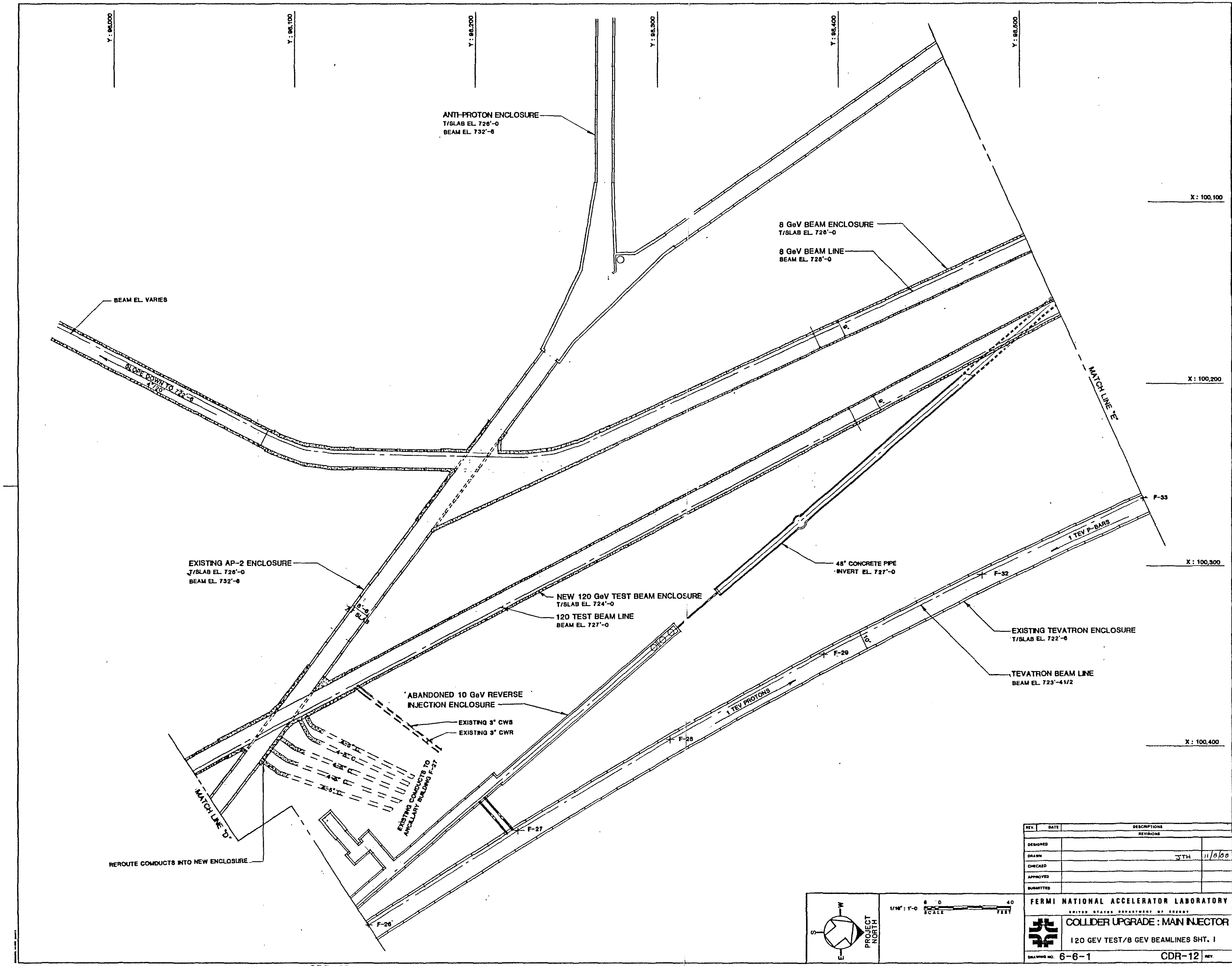


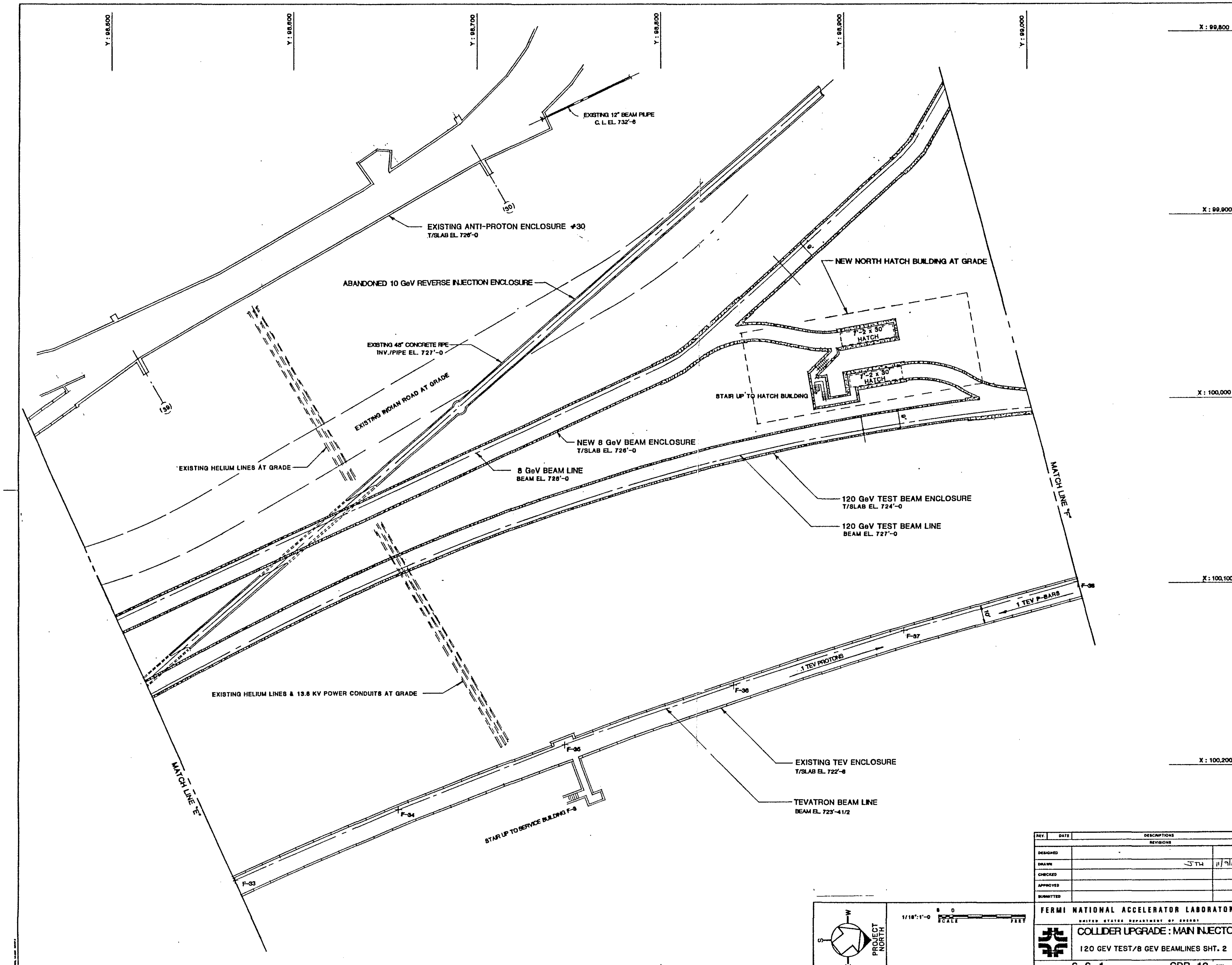
MI-20
X:102,546.4297
Y: 95,694.3436
MI-30
X:99,820.3261
Y:94,605.5469
MI-10
X:99,706.8125
Y:97,355.6953
MAIN INJECTOR BEAMLINE
BEAM EL. 724'-4 1/2"
MI-40
X:100,601.8984
Y: 94,284.6094
MI-80
X:100,983.5469
Y: 97,410.1719
MI-70
X:101,525.0000
Y: 97,136.5703
MI-50
X:101,668.0156
Y: 94,419.5938
MI-60
X:102,011.9922
Y: 96,786.5484
150 GeV P-BARS
150 GeV PROTONS
CENTER OF ANTI-PROTON RINGS
X:99,727.040
Y:96,494.446
8 GeV ANTI-PROTONS
BEAM EL. 726'-8"
LINAC
200 MeV PROTONS
COCKCROFT-WALTON
PRE-ACCELERATOR
BEAM EL. 726'-0"
CENTER OF BOOSTER ACCELERATOR
X:99,727.040
Y:99,430.644
8 GeV PROTONS
8 GeV PROTON TO M.I.
8 GeV BEAMLINE
120 GeV TEST BEAM
STATION F-42
X:100,055.010
Y: 99,217.046
STATION A-0
X:100,000.000
Y:100,000.000
1 TeV PROTONS
STATION F-32
X:100,304.849
Y: 98,479.763
STATION F-21
X:100,800.946
Y: 97,758.846
AP-1 BEAMLINE
8 GeV P-BARS
120 GeV PROTONS
150 GeV P-BAR INJECTION
STATION F-0
X:101,673.320
Y: 97,145.550
RF/70 ENCLOSURE
150 GeV PROTON INJECTION
8 GeV P-BARS BEAM EL. 726'-0"
120 GeV PROTONS BEAM EL. 726'-0"
150 GeV PROTONS BEAM EL. 722'-0" ±
STATION E-42
X:102,278.882
Y: 96,801.725
1 TeV P-BARS
STATION E-32
X:103,042.308
Y: 96,649.449
1 TeV PROTONS
STATION E-21
X:103,914.689
Y: 96,718.622
CENTER OF TeV RINGS
X:103,256.6776
Y: 99,935.3184
X:99,000
X:100,000
X:101,000
X:102,000
X:103,000
X:104,000
Y:94,000
Y:95,000
Y:96,000
Y:97,000
Y:98,000
Y:99,000
Y:100,000
PROJECT NORTH
SCALE
1" = 200'-0"
200 0 200 400
Scale Feet
REV. DATE DESCRIPTIONS
REVISIONS
DESIGNED W. NESTANDER
DRAWN L. EVEN
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
COLLIDER UPGRADE : MAIN INJECTOR
BEAMLINE PLAN
DRAWING NO. 6-6-1 CDR-9 REV.


Y : 96,900
Y : 97,000
Y : 97,100
Y : 97,300
Y : 97,400
X : 101,500
X : 101,600
X : 101,700
X : 101,800
X : 101,200
X : 101,300
X : 101,400
X : 101,500
M. I. STA. G-0
X : 101,522.011
Y : 97,138.385
TEV - M. I. INJECTION POINT
X : 101,539.024
Y : 97,166.438
STATION F-0
X : 101,573.320
Y : 97,145.56
TEV CENTER F-0
X : 101,574.090
Y : 97,145.171
MATCH LINE "A"
MATCH LINE "B"
MAIN INJECTOR RF ENCLOSURE
8' x 9' FRIEGHT ELEVATOR
8' x 9' HATCH
STAIR UP TO RF BUILDING
UTILITY ALCOVE
SHEET PILE EARTH RETENTION SYSTEM AT RF BUILDING
EXISTING RF BUILDING AT GRADE TO BE REMOVED
EXISTING RF BUILDING AT GRADE TO REMAIN IN PLACE
T/SLAB EL. 722'-6
T/SLAB EL. 720'-6
EQUIPMENT LIFT
STAIR UP TO RF BUILDING
SOLDIER PILES AT LABYRINTH
PORTION OF EXISTING RF ENCLOSURE TO REMAIN IN PLACE
M. I. - TEV INJECTION LINE FOR PROTONS
BEAM EL. VARIES
120 GeV TEST BEAM LINE
BEAM EL. 728'-0
EXISTING TEVATRON ENCLOSURE
T/SLAB EL. 722'-6
TEVATRON BEAM LINE
BEAM EL. 723'-41/2
SLAB LEVEL AT EL. 720'-6
SLOPES UP TO EL. 722'-6
SLOPE 4"/20'
1 TEV P-BARS
1 TEV PROTONS
P-BAR INJECTION BEAM LINE
BEAM EL. VARIES
NEW MAIN INJECTOR ENCLOSURE
T/SLAB EL. 720'-6
MAIN INJECTOR BEAM LINE
BEAM EL. 724'-41/2
SLAB SLOPES UP TO EL. 722'-6
SLOPE UP TO EL. 724'-0
SLOPE UP TO EL. 726'-0
STAIR UP TO SERVICE BUILDING F-1
NEW 120 GeV TEST BEAM ENCLOSURE
120 GeV TEST BEAM LINE
BEAM EL. 728'-0
AP-1 BEAM LINE ENCLOSURE
AP-1 BEAM LINE
BEAM EL. 728'-0
EXISTING TEVATRON ENCLOSURE
T/SLAB EL. 722'-6
TEVATRON BEAM LINE
BEAM EL. 723'-41/2
MAIN INJECTOR RF ENCLOSURE
150' TO TEV F-0
T/SLAB EL. 720'-6
E-49
E-48
E-47
E-46
F-15
F-14
F-13
F-12
F-11
PROJECT NORTH
1/16":1'-0
SCALE
FEET
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
COLLIDER UPGRADE : MAIN INJECTOR
F-0 ENCLOSURE
DRAWING NO. 6-6-1
CDR-10
REV.
DATE
DESCRIPTIONS
REVISIONS
DESIGNED
DRAWN
CHECKED
APPROVED
SUBMITTED
JTH
11/18/88



Y : 97,400
Y : 97,500
Y : 97,600
Y : 97,700
X : 100,800
X : 100,900
X : 101,000
X : 101,100
X : 101,200
X : 100,400
X : 100,500
X : 100,600
X : 100,700
Y : 97,800
Y : 97,900
Y : 98,000
Y : 98,100
NEW 120 GeV TEST BEAM ENCLOSURE
T/SLAB EL. 724'-0
150 GeV TEST BEAM
BEAM EL. VARIES
EXISTING AP-1 ENCLOSURE
T/SLAB EL. VARIES
AP-1 BEAM LINE
BEAM EL. 732'-6
F-21
MATCH LINE "C"
STAIR UP TO GRADE
NEW
EXISTING
T/SLAB EL. 728'-0
F-19
NEW AP-1ENCLOSURE
AP-1 BEAM LINE
BEAM EL. 732'-6
T/SLAB EL. 728'-0
F-18
NEW MAIN INJECTOR ENCLOSURE
T/SLAB EL. 722'-6
MAIN INJECTOR BEAM LINE
BEAM EL. 724'-41/2
NEW 120 GeV TEST BEAM ENCLOSURE
T/SLAB EL. 724'-0
120 GeV TEST BEAM LINE
BEAM EL. 727'-0
MATCH LINE "D"
ABANDONED 10GeV REVERSE
INJECTION LINE
F-26
EXISTING 12" STEEL PIPE
EXISTING TARGET HALL
T/SLAB EL. 728'-0
F-25
TARGET
X : 100,585.940
Y : 97,935.737
STAIR UP TO SERVICE BUILDING F-2
EXISTING TARGET HALL
SERVICE BUILDING AT GRADE
STAIR UP
F-24
1 TEV P-BARS
SLOPE DOWN TO EL. 720'-6
F-17
T/SLAB
EL. 722'-6
BEAM EL. VARIES
1 TEV P-BARS
SLOPE DOWN TO EL. 720'-6
T/SLAB
EL. 724'-0
F-16
EXISTING TEVATRON ENCLOSURE
T/SLAB 722'-6
TEVATRON BEAM LINE
BEAM EL. 723'-41/2
1 TEV PROTONS
EXISTING TEVATRON ENCLOSURE
T/SLAB EL. 722'-6
TEVATRON BEAM LINE
BEAM EL. 723'-41/2
F-23
CONDUITS TO SERVICE BUILDING F-23
(EXISTING)
T/SLAB EL. 728'-0
1 TEV PROTONS
EXISTING AP-1 ENCLOSURE
T/SLAB EL. VARIES
AP-1 BEAM LINE
BEAM EL. 732'-6
F-22
MATCH LINE "B"
MATCH LINE "C"
F-21
PROJECT NORTH
1/16" : 1'-0
SCALE
FEET
REV
DATE
DESCRIPTIONS
REVISIONS
DESIGNED
DRAWN
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
COLLIDER UPGRADE : MAIN INJECTOR
120 GEV TEST/AP-1 BEAMLINES
DRAWING NO. 6-6-1
CDR-11


Y: 98,000
Y: 98,100
Y: 98,200
Y: 98,300
Y: 98,400
Y: 98,500
X: 100,100
X: 100,200
X: 100,300
X: 100,400
ANTI-PROTON ENCLOSURE
T/SLAB EL. 726'-0
BEAM EL. 732'-6
8 GeV BEAM ENCLOSURE
T/SLAB EL. 726'-0
8 GeV BEAM LINE
BEAM EL. 728'-0
BEAM EL. VARIES
SLOPE DOWN TO 732'-6
MATCH LINE "E"
F-33
1 TEV P-BARS
48" CONCRETE PIPE
INVERT EL. 727'-0
EXISTING AP-2 ENCLOSURE
T/SLAB EL. 726'-0
BEAM EL. 732'-6
NEW 120 GeV TEST BEAM ENCLOSURE
T/SLAB EL. 724'-0
120 TEST BEAM LINE
BEAM EL. 727'-0
F-32
EXISTING TEVATRON ENCLOSURE
T/SLAB EL. 722'-6
F-29
TEVATRON BEAM LINE
BEAM EL. 723'-41/2
ABANDONED 10 GeV REVERSE
INJECTION ENCLOSURE
EXISTING 3" CWS
EXISTING 3" CWR
1 TEV PROTONS
F-28
EXISTING CONDUCTS TO ANCILLARY BUILDING F-27
MATCH LINE "D"
F-27
REROUTE CONDUCTS INTO NEW ENCLOSURE
F-26
PROJECT NORTH
1/16" : 1'-0
SCALE
FEET
REV.
DATE
DESCRIPTIONS
REVISIONS
DESIGNED
DRAWN
JTH
11/8/88
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
COLLIDER UPGRADE : MAIN INJECTOR
120 GEV TEST/8 GEV BEAMLINES SHT. 1
DRAWING NO. 6-6-1
CDR-12
REV.



REV.	DATE	DESCRIPTIONS
		REVISIONS

DESIGNED		
DRAWN	JTH	11/9/88
CHECKED		
APPROVED		
SUBMITTED		

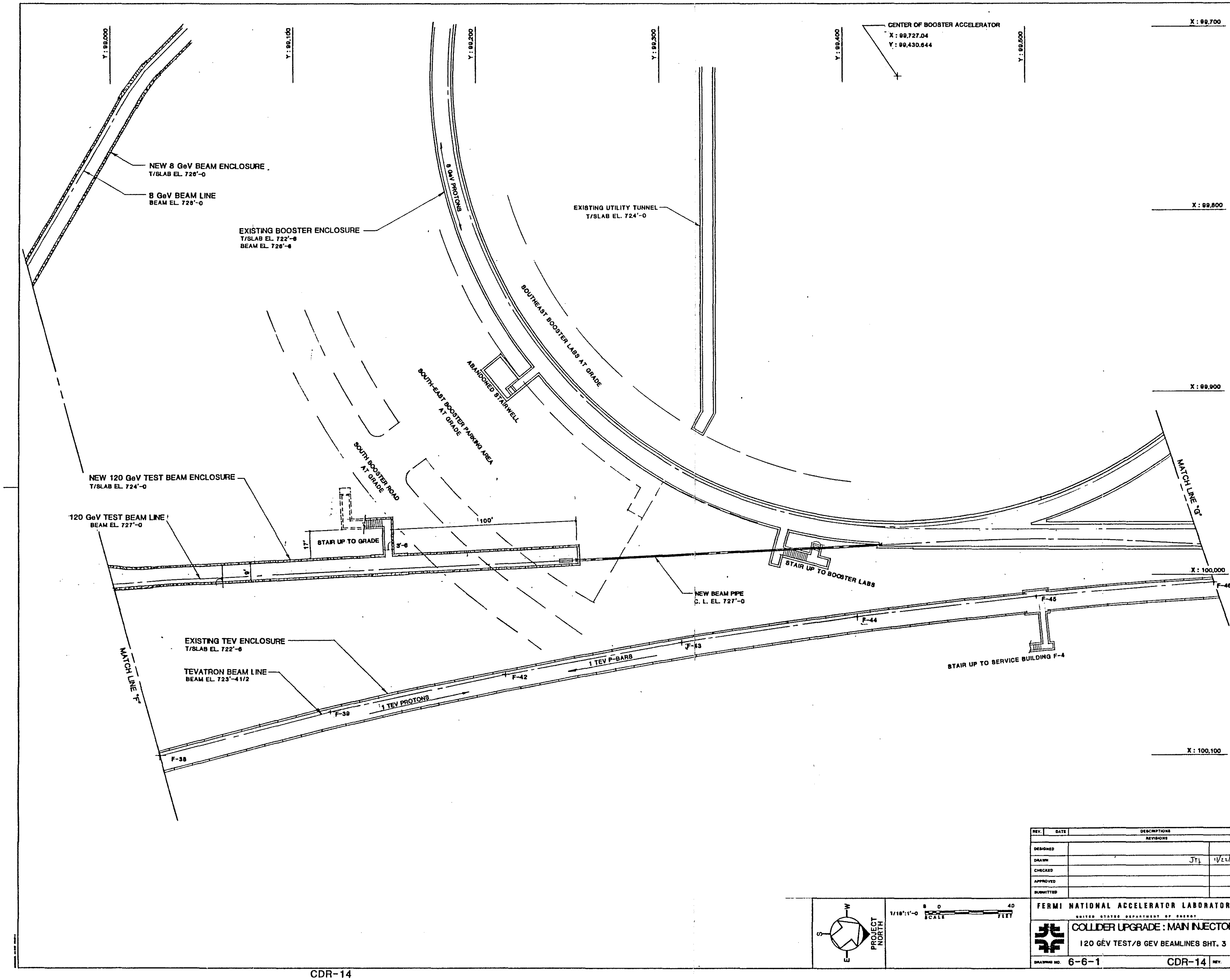
FERMI NATIONAL ACCELERATOR LABORATORY

UNITED STATES DEPARTMENT OF ENERGY

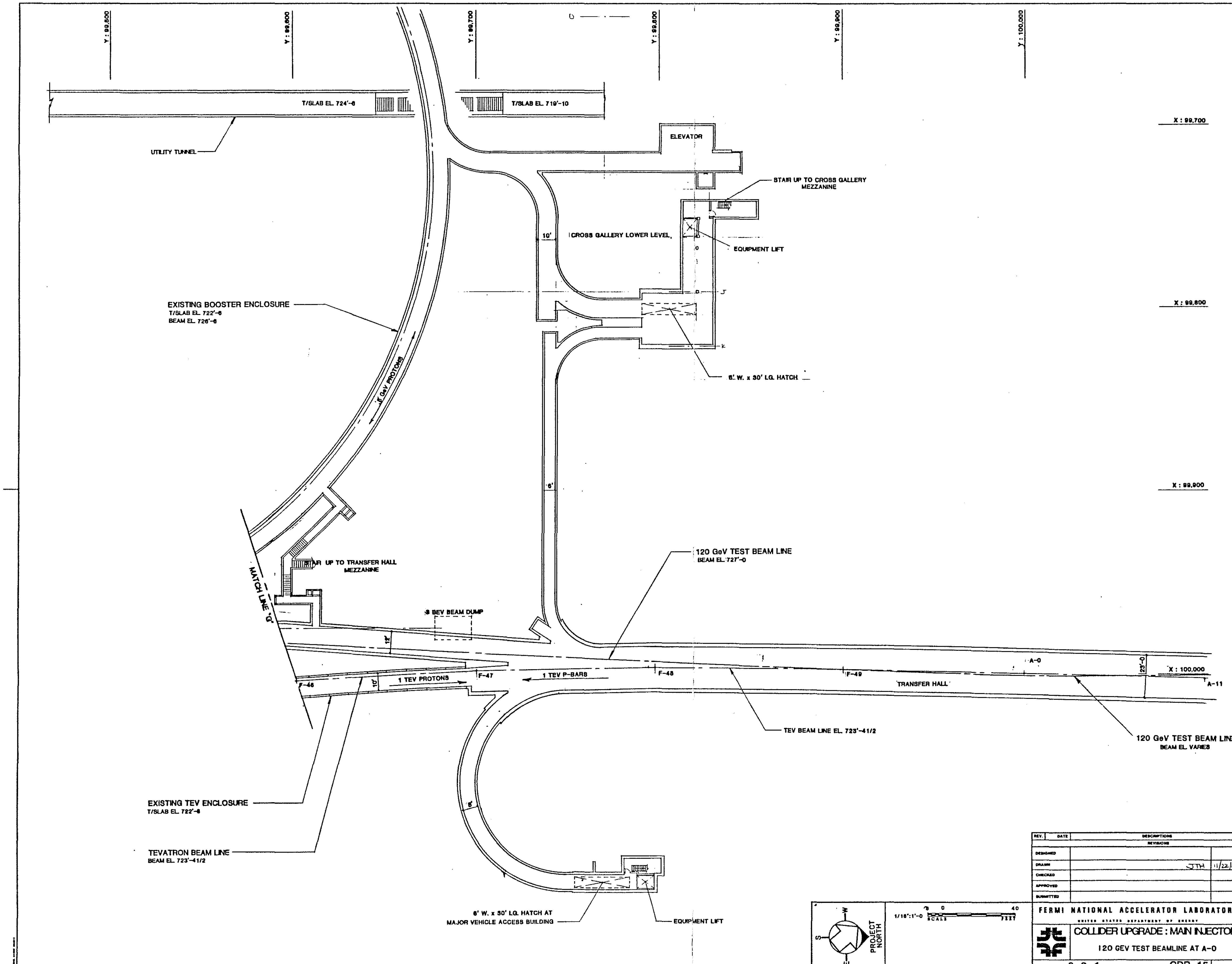
COLLIDER UPGRADE : MAIN INJECTOR

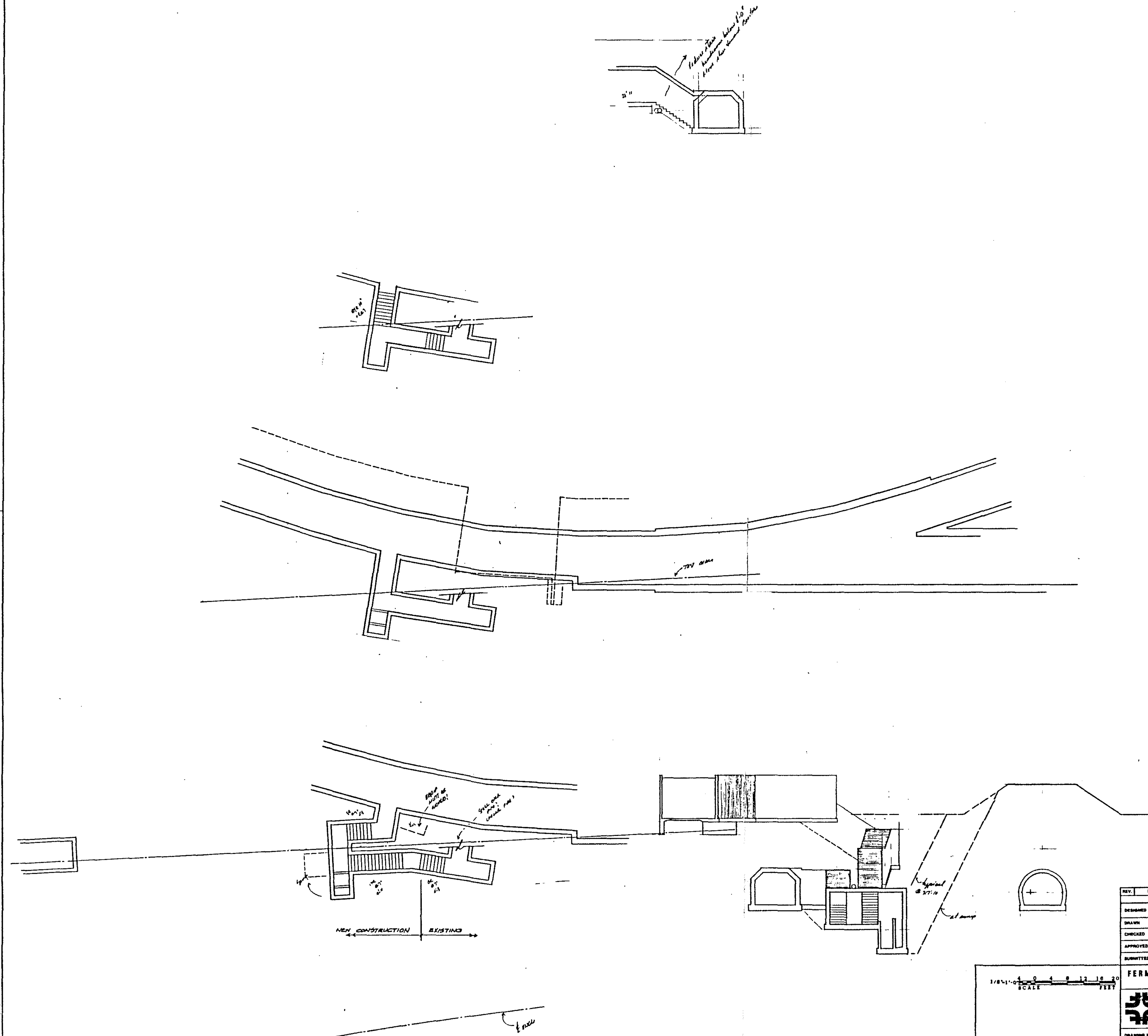
120 GEV TEST/8 GEV BEAMLINES SHT. 2

DRAWING NO. 6-6-1 CDR-13 REV.



Y: 99,000
Y: 99,100
Y: 99,200
Y: 99,300
Y: 99,400
Y: 99,500
CENTER OF BOOSTER ACCELERATOR
X: 99,727.04
Y: 99,430.644
X: 99,700
X: 99,800
X: 99,900
X: 100,000
X: 100,100
NEW 8 GeV BEAM ENCLOSURE
T/SLAB EL. 726'-0
8 GeV BEAM LINE
BEAM EL. 728'-0
8 GeV PROTONS
EXISTING BOOSTER ENCLOSURE
T/SLAB EL. 722'-6
BEAM EL. 726'-6
EXISTING UTILITY TUNNEL
T/SLAB EL. 724'-0
SOUTHEAST BOOSTER LABS AT GRADE
ABANDONED STAIRWELL
SOUTH-EAST BOOSTER PARKING AREA AT GRADE
SOUTH BOOSTER ROAD AT GRADE
MATCH LINE "G"
NEW 120 GeV TEST BEAM ENCLOSURE
T/SLAB EL. 724'-0
120 GeV TEST BEAM LINE
BEAM EL. 727'-0
100'
17'
STAIR UP TO GRADE
5'-6
STAIR UP TO BOOSTER LABS
NEW BEAM PIPE
C. L. EL. 727'-0
F-45
F-46
F-44
F-43
F-42
F-39
F-38
1 TEV P-BARS
1 TEV PROTONS
STAIR UP TO SERVICE BUILDING F-4
EXISTING TEV ENCLOSURE
T/SLAB EL. 722'-6
TEVATRON BEAM LINE
BEAM EL. 723'-4 1/2
MATCH LINE "F"
W
S
E
PROJECT NORTH
1/16":1'-0
SCALE
FEET
REV. DATE DESCRIPTIONS
REVISIONS
DESIGNED
DRAWN
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
COLLIDER UPGRADE : MAIN INJECTOR
120 GEV TEST/8 GEV BEAMLINES SHT. 3
DRAWING NO. 6-6-1
CDR-14
REV.


Y : 99,500
Y : 99,600
Y : 99,700
Y : 99,800
Y : 99,900
Y : 100,000
X : 99,700
X : 99,800
X : 99,900
X : 100,000
T/SLAB EL. 724'-6
T/SLAB EL. 719'-10
UTILITY TUNNEL
ELEVATOR
STAIR UP TO CROSS GALLERY MEZZANINE
CROSS GALLERY LOWER LEVEL
EQUIPMENT LIFT
6' W. x 30' LG. HATCH
EXISTING BOOSTER ENCLOSURE
T/SLAB EL. 722'-6
BEAM EL. 726'-6
8 GeV PROTONS
STAIR UP TO TRANSFER HALL MEZZANINE
MATCH LINE "G"
8 BEV BEAM DUMP
120 GeV TEST BEAM LINE
BEAM EL. 727'-0
1 TEV PROTONS
1 TEV P-BARS
F-46
F-47
F-48
F-49
A-0
A-11
TRANSFER HALL
TEV BEAM LINE EL. 723'-41/2
120 GeV TEST BEAM LINE
BEAM EL. VARIES
EXISTING TEV ENCLOSURE
T/SLAB EL. 722'-6
TEVATRON BEAM LINE
BEAM EL. 723'-41/2
6' W. x 30' LG. HATCH AT MAJOR VEHICLE ACCESS BUILDING
EQUIPMENT LIFT
PROJECT NORTH
1/16":1'-0
SCALE
FEET
REV.
DATE
DESCRIPTIONS
REVISIONS
DESIGNED
DRAWN
JTH
11/22/88
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
COLLIDER UPGRADE : MAIN INJECTOR
120 GEV TEST BEAMLINE AT A-0
DRAWING NO. 6-6-1
CDR-15
REV.



REV.	DATE	DESCRIPTIONS
		REVISIONS

DESIGNED		
DRAWN		
CHECKED		
APPROVED		
SUBMITTED		

1/8"=1'-0" SCALE 4 0 4 8 12 16 20 FEET

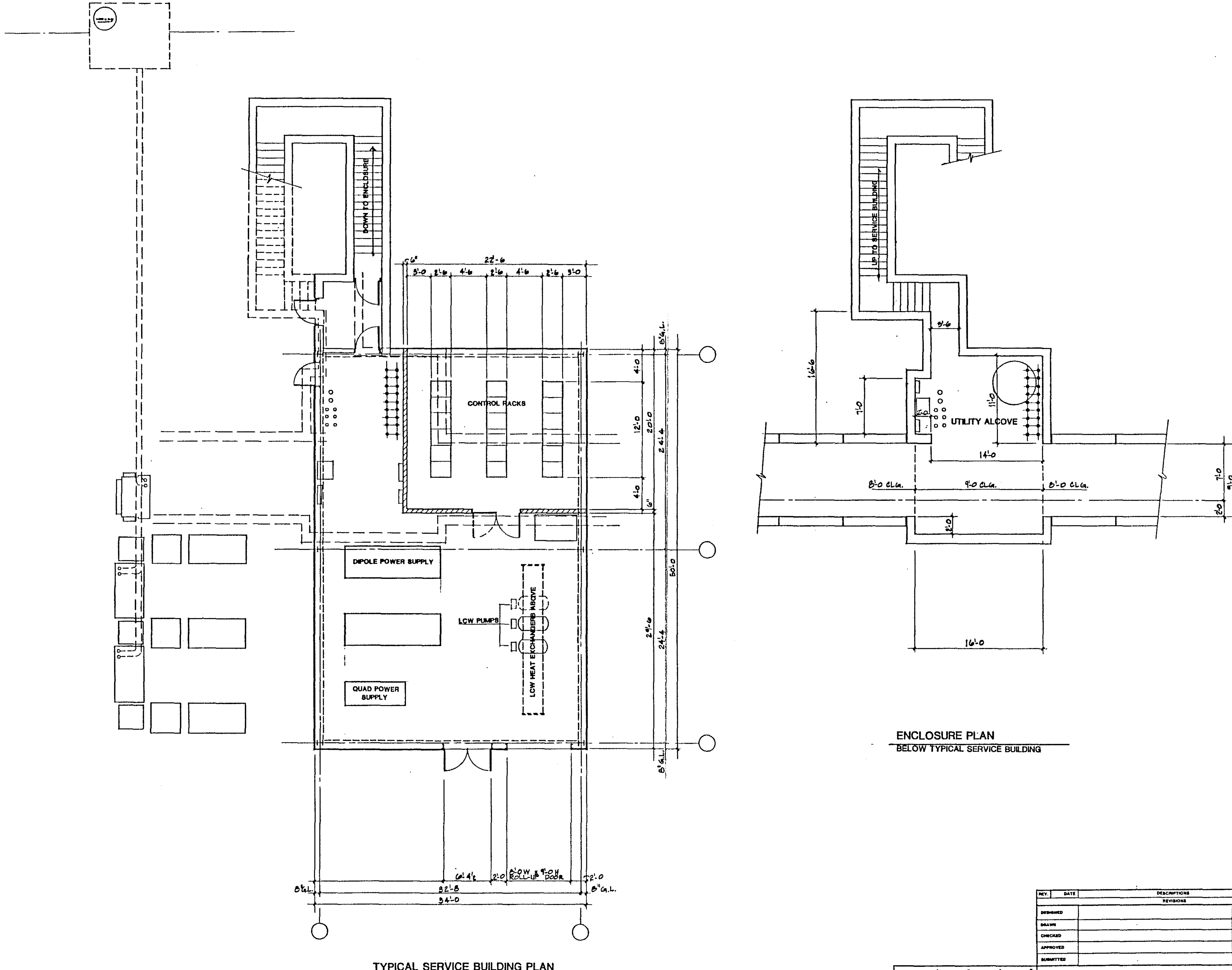
FERMI NATIONAL ACCELERATOR LABORATORY

UNITED STATES DEPARTMENT OF ENERGY

COLLIDER UPGRADE : MAIN INJECTOR

ENLARGED 120 GeV TEST BEAMLINE
AT BOOSTER/A-0

DRAWING NO. 6-6-1 CDR-16 REV.



REV.	DATE	DESCRIPTIONS
		REVISIONS

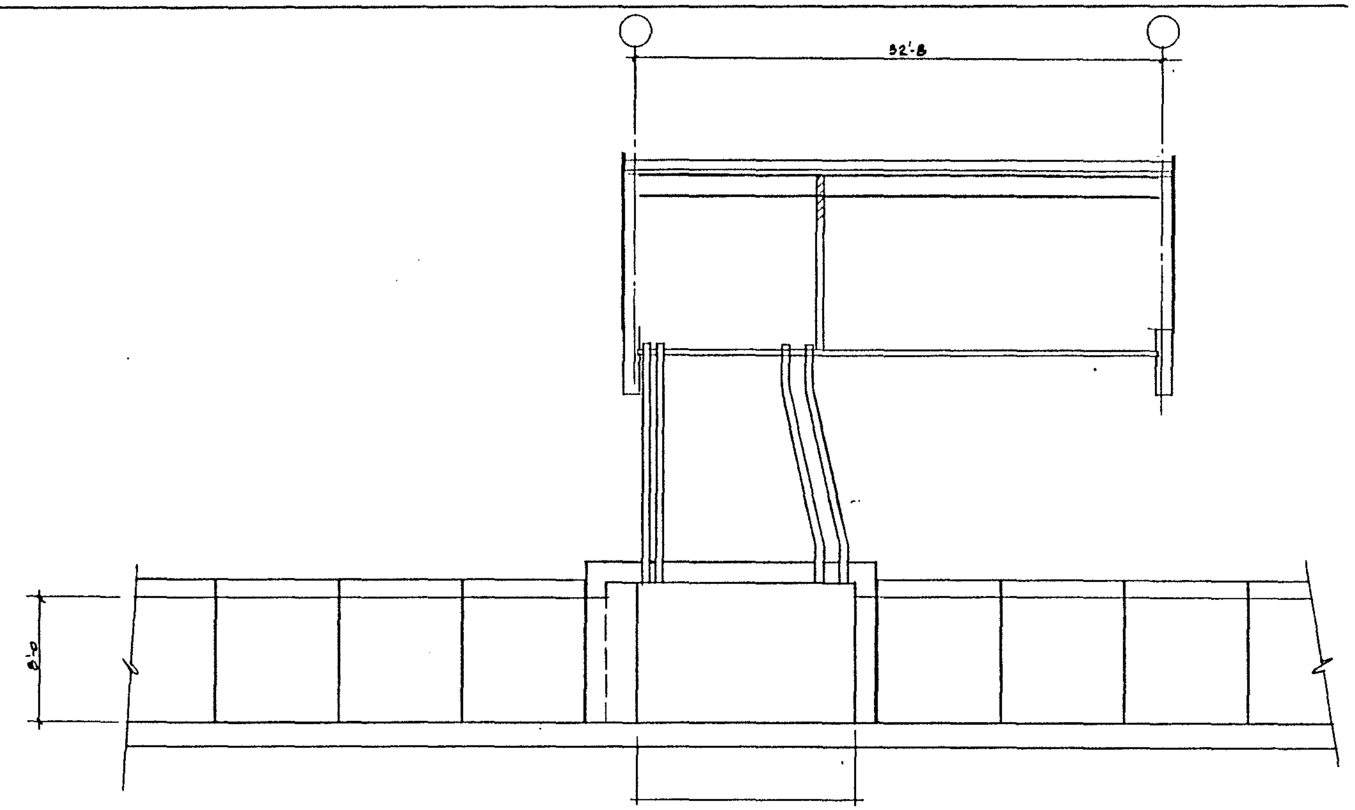
DESIGNED
DRAWN
CHECKED
APPROVED
SUBMITTED

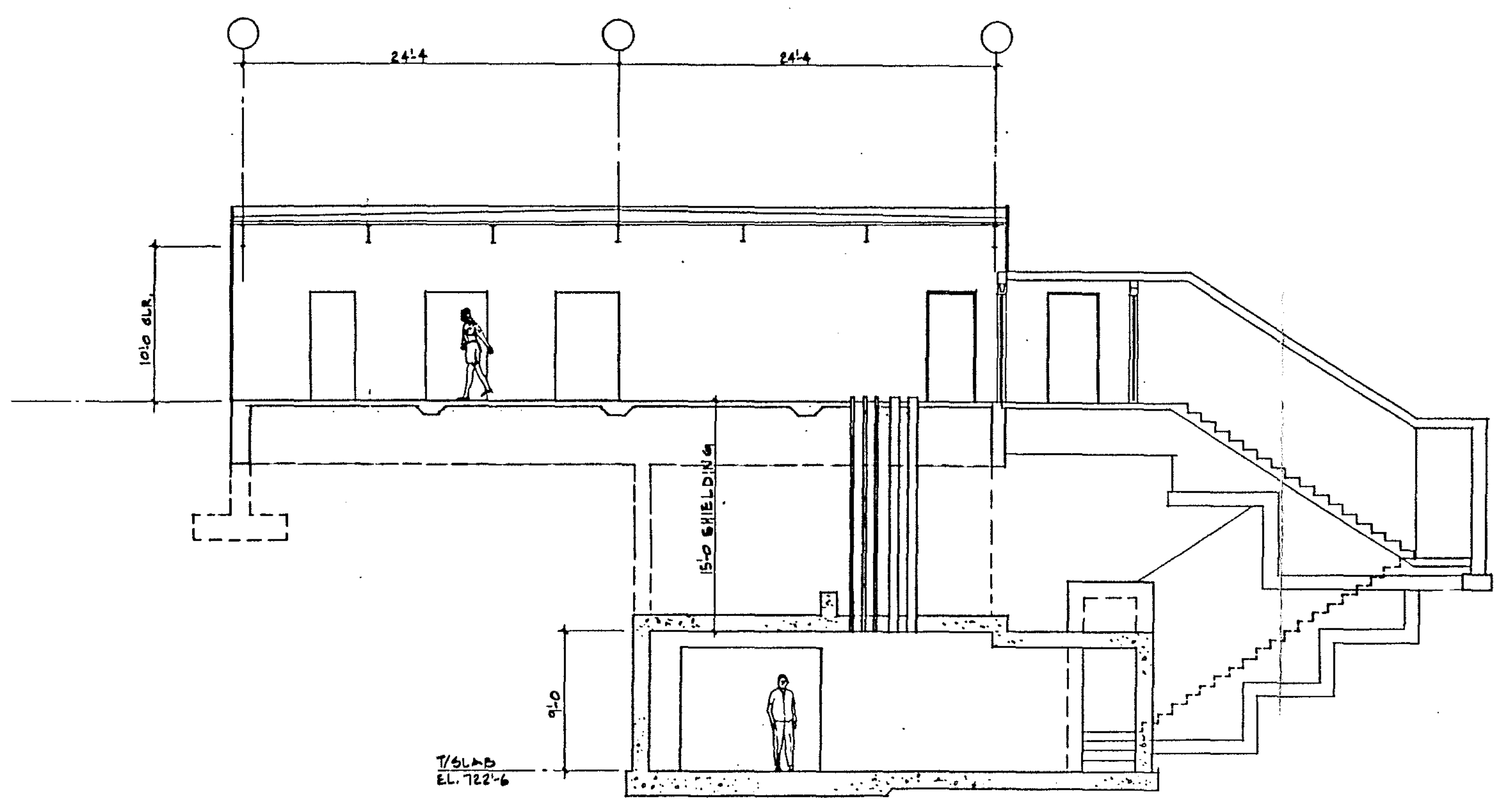
1/4"=1'-0" SCALE FEET

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

COLLIDER UPGRADE : MAIN INJECTOR
TYPICAL SERVICE BUILDING PLAN

DRAWING NO. 6-6-1 CDR-20 REV.





REV.	DATE	DESCRIPTIONS
		REVISIONS

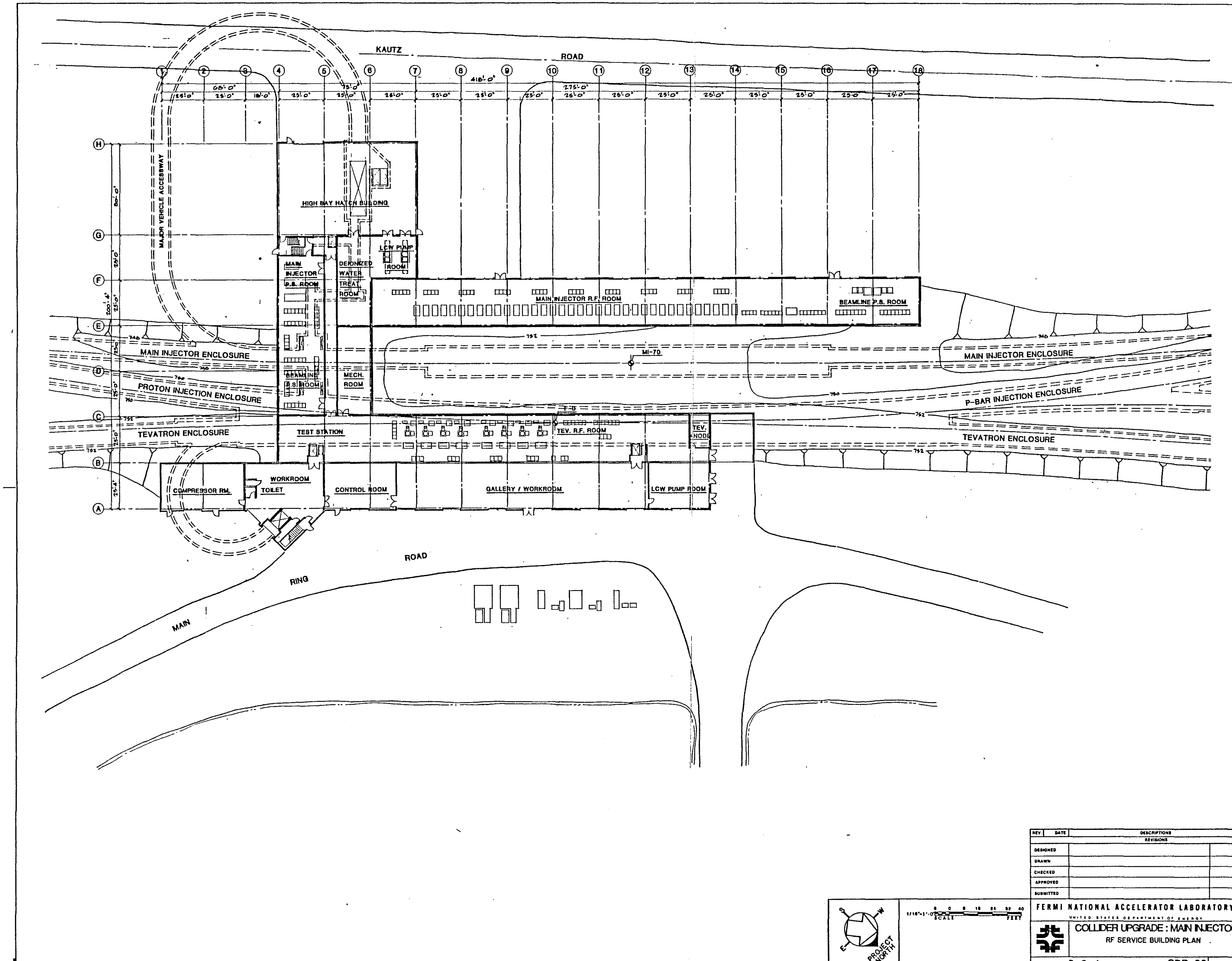
DESIGNED
DRAWN
CHECKED
APPROVED
SUBMITTED

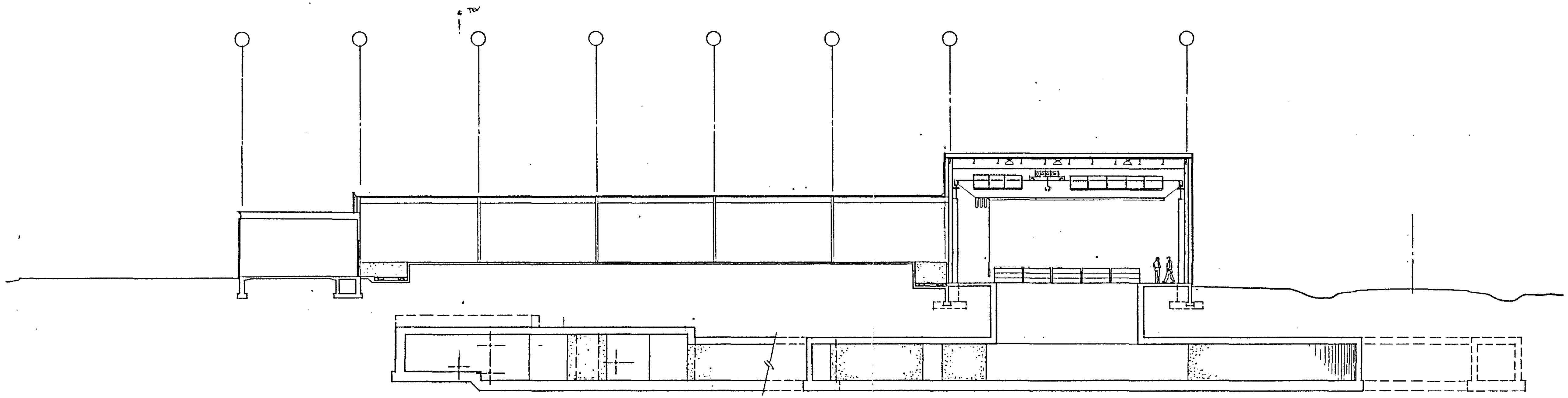
1/4"=1'-0" SCALE FEET

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

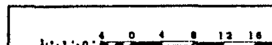
COLLIDER UPGRADE : MAIN INJECTOR
TYPICAL SERVICE BUILDING SECTIONS

DRAWING NO. 6-6-1 CDR-21 REV.


KAUTZ
ROAD
HIGH BAY HATCH BUILDING
MAJOR VEHICLE ACCESSWAY
MAIN INJECTOR P.S. ROOM
DEIONIZED WATER TREAT ROOM
LCW PUMP ROOM
MAIN INJECTOR R.F. ROOM
BEAMLINE P.S. ROOM
MAIN INJECTOR ENCLOSURE
MI-70
PROTON INJECTION ENCLOSURE
P-BAR INJECTION ENCLOSURE
BEAMLINE P.S. ROOM
MECH. ROOM
TEST STATION
TEV. R.F. ROOM
TEVATRON ENCLOSURE
COMPRESSOR RM.
WORKROOM
TOILET
CONTROL ROOM
GALLERY / WORKROOM
LCW PUMP ROOM
MAIN
RING
ROAD
PROJECT NORTH
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
COLLIDER UPGRADE : MAIN INJECTOR
RF SERVICE BUILDING PLAN
DRAWING NO. 6-6-1
CDR-22



SECTION AA



REV.	DATE	DESCRIPTIONS
		REVISIONS
DESIGNED		
DRAWN		
CHECKED		
APPROVED		
SUBMITTED		

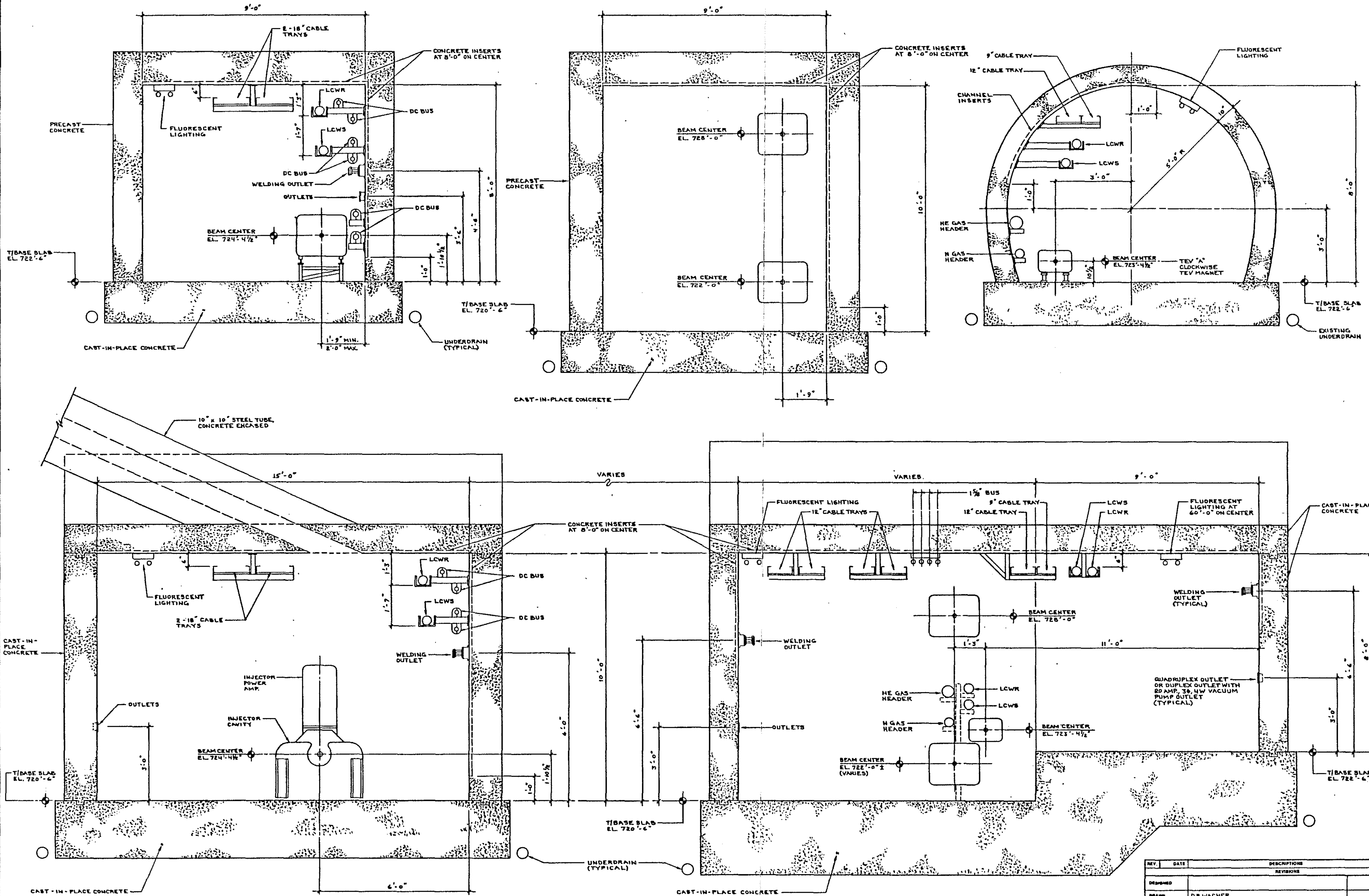
FERMI NATIONAL ACCELERATOR LABORATORY

UNITED STATES DEPARTMENT OF ENERGY

COLLIDER UPGRADE : MAIN INJECTOR

RF SERVICE BUILDING SECTIONS

DRAWING NO. 6-6-1 CDR-23 REV.



REV.	DATE	DESCRIPTIONS
		REVISIONS

DESIGNED	
DRAWN	D R WAGNER
CHECKED	
APPROVED	
SUBMITTED	

FERMI NATIONAL ACCELERATOR LABORATORY

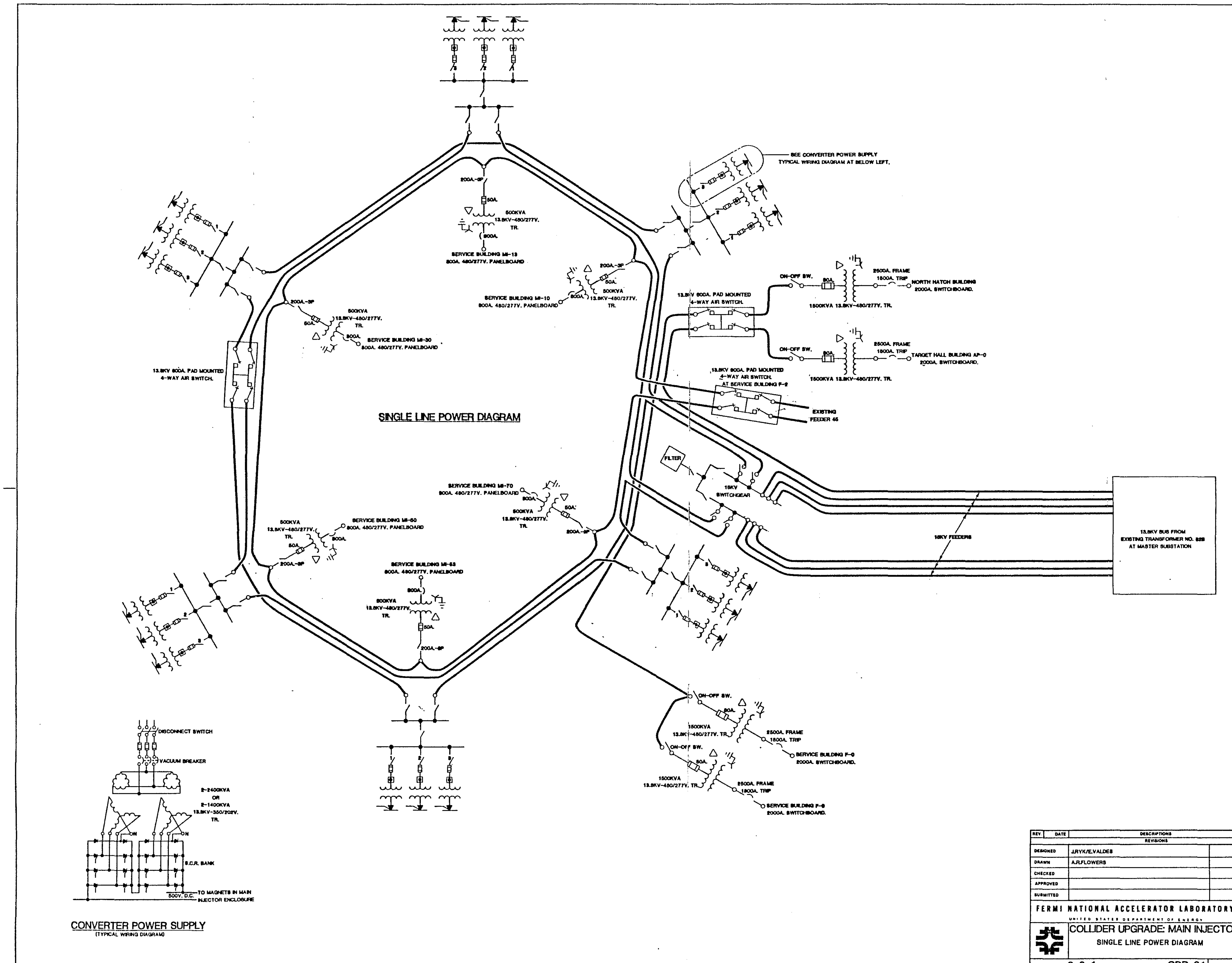
UNITED STATES DEPARTMENT OF ENERGY

COLLIDER UPGRADE : MAIN INJECTOR

ENCLOSURE SECTIONS

SHEET-1

DRAWING NO. 6-6-1 CDR-26 REV.


SINGLE LINE POWER DIAGRAM
SEE CONVERTER POWER SUPPLY TYPICAL WIRING DIAGRAM AT BELOW LEFT.
200A.-3P
50A.
500KVA 13.8KV-480/277V. TR.
800A.
SERVICE BUILDING MI-12 800A. 480/277V. PANELBOARD
SERVICE BUILDING MI-10 800A. 480/277V. PANELBOARD
SERVICE BUILDING MI-30 800A. 480/277V. PANELBOARD
SERVICE BUILDING MI-70 800A. 480/277V. PANELBOARD
SERVICE BUILDING MI-50 800A. 480/277V. PANELBOARD
SERVICE BUILDING MI-53 800A. 480/277V. PANELBOARD
13.8KV 600A. PAD MOUNTED 4-WAY AIR SWITCH.
13.8KV 600A. PAD MOUNTED 4-WAY AIR SWITCH. AT SERVICE BUILDING F-2
ON-OFF SW.
2500A. FRAME 1600A. TRIP
NORTH HATCH BUILDING 2000A. SWITCHBOARD.
TARGET HALL BUILDING AP-0 2000A. SWITCHBOARD.
1500KVA 13.8KV-480/277V. TR.
EXISTING FEEDER 45
FILTER
15KV SWITCHGEAR
15KV FEEDERS
13.8KV BUS FROM EXISTING TRANSFORMER NO. 828 AT MASTER SUBSTATION
SERVICE BUILDING F-0 2000A. SWITCHBOARD.
SERVICE BUILDING F-9 2000A. SWITCHBOARD.
DISCONNECT SWITCH
VACUUM BREAKER
2-2400KVA OR 2-1400KVA 13.8KV-350/202V. TR.
ON
S.C.R. BANK
500V. D.C.
TO MAGNETS IN MAIN INJECTOR ENCLOSURE
CONVERTER POWER SUPPLY
(TYPICAL WIRING DIAGRAM)
REV. DATE DESCRIPTIONS
REVISIONS
DESIGNED J.RYK/E.VALDES
DRAWN A.R.FLOWERS
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
COLLIDER UPGRADE: MAIN INJECTOR
SINGLE LINE POWER DIAGRAM
DRAWING NO. 6-6-1
CDR-31
REV.

APPENDIX F

Supplementary Project Data for Strategic Facilities

TITLE AND LOCATION OF PROJECT:

FERMILAB COLLIDER UPGRADE:
MAIN INJECTOR
FERMI NATIONAL ACCELERATOR LABORATORY

Project No: xxxxxxx
91-CH-400
Line Item

Supplementary Project Data for Strategic Facilities

Site Wide Requirements/Assets for CATEGORY: 70, Research and Development

Other Projects Affecting this Category: BAKALIC 91-CH-400; FOOTPRINT GALLERY UPGRADE

Unit of Measure: Square Foot

	CURRENT	THIS PROJECT	RESULT
A. Total Existing Assets (in this category)	222,400	30,600	253,000
	-	-	-
B. less: Substandard assets (in this category)	0	0	0
	=	=	=
C. Amount Adequate: (in this category)	222,400	30,600	253,000
	-		-
D. less: Amount Required: (in this category)	285,900	XXXXXX	285,900
	=	+	=
E. Excess/(Deficiency) of Adequate Assets	(63,500)	30,600	(32,900)
			=
F. Excess/(Deficiency) of Total Assets (A-D)	(63,500)	30,600	(32,900)