Appendices

APPENDIX I. EXISTING MESON AREA BEAMS

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The present beams will continue to evolve, and the descriptions which follow describe them as it is assumed they will be just prior to Tevatron II (1982).

M1

The M1 beam line is currently an extension of the M East primary proton beam. It's maximum energy is matched to the maximum energy of the Energy Doubler/Saver using ED/S dipoles in two bend strings of approximately 45 mrad each and conventional quadrupoles in a "weak" focusing doublet structure. The beam line has been designed to control possible loss points. These points have then been shielded to safely handle single pulse losses of over 10^{13} protons.

M2/M3

M2 and M3 are the principle beam lines using the M-Center target. M2 is normally run as a diffracted proton beam in the intensity range from 10^8 to 10^{10} protons per pulse although recently it was run as a primary proton beam at over 10^{12} protons per pulse. M3 is a neutral hadron beam with an acceptance of ≈ 0.6 μsr. This beam produces large fluxes of gammas, neutrons, and K_L^0. For the first 64 meters, these two beams lines share the same line. At this point 9 meters of magnet bend M2 (and all charged hadrons) away from M3. M3 then proceeds through additional sweepers and variable collimators to the experimental area 425 meters from the production target. M2 is a conventional two-stage beam with simple doublet focusing and a total of 50 mrad of bend.

M6

M6 is the principle beam using the M-West target. It is the last fully tagged hadron beam at Fermilab. Hadrons at an experiment can be tagged as to position, angle, momentum, and species. Currently this beam has two branches M6 East and M6 West both of which have a maximum energy of 400 GeV. M6 West transports beam to the Multiparticle Spectrometer (MPS), a large intensively instrumented detector facility. This beam is a three-stage beam providing a momentum-dispersed focus for momentum selection and tagging and a parallel section for particle species tagging with a DISC type differential Cherenkov counter. Additional threshold Cherenkov counters are provided to further enhance particle identification. At the higher energies it is also possible to employ transition radiator detectors to the same end.

Test Beams, M4 and M5

M4 and M5 are the wide-angle beams using the M-Center and M-West targets respectively. M4 is a charged beam which was converted from a neutral beam several years ago. It therefore has an extremely broad momentum acceptance. It is also the only Meson Area beam which is underground, being under the M3 small-angle neutral beam. It has been used extensively as a source of moderate flux kaon beams. Because of its underground location, access is limited which limits its usefulness in this role. Long-range plans call for improving its accessibility as funds become available.

M5

M5 is the heavily used 50-GeV test beam. It supplies moderate flux hadron and electron beams to a test area under the Detector Building crane. With the facilities maintained in this area, including computers and beam-line counters, this area is the only area at Fermilab designed specifically to test apparatus in a convenient, quick manner. It is also, probably, the most heavily used beam at Fermilab.

Plans for Meson Area Beams

M1

M1, until 1984, will be a primary proton beam fed by a second split of the M-Center beam. This version of the beam already exists except for the split itself. As equipment funds allow and the physics program demands, the beam will be rebuilt into a high-intensity pion beam. The pion beam has been described in an earlier report. The expected beam flux using energy-doubler elements is shown in Fig. 1. As part of the construction of this beam line, a target/dump system will be built in the existing M1 target gallery 460 feet downstream of the other targets.

A second west branch of this high flux pion beam can be built by having the second stage of this two-stage beam a mirror image bending west. This would produce a recombined focus about fifteen feet west of the east branch focus. Both beams would be covered by the M1 extension building. The west wall of the last 300 feet of the M1 enclosure preceeding the target building must be removed, at some expense. This project is not included in Tevatron II; the availability of funds to build it is limited. Whether it will be built or not depends upon the interest shown by possible users.

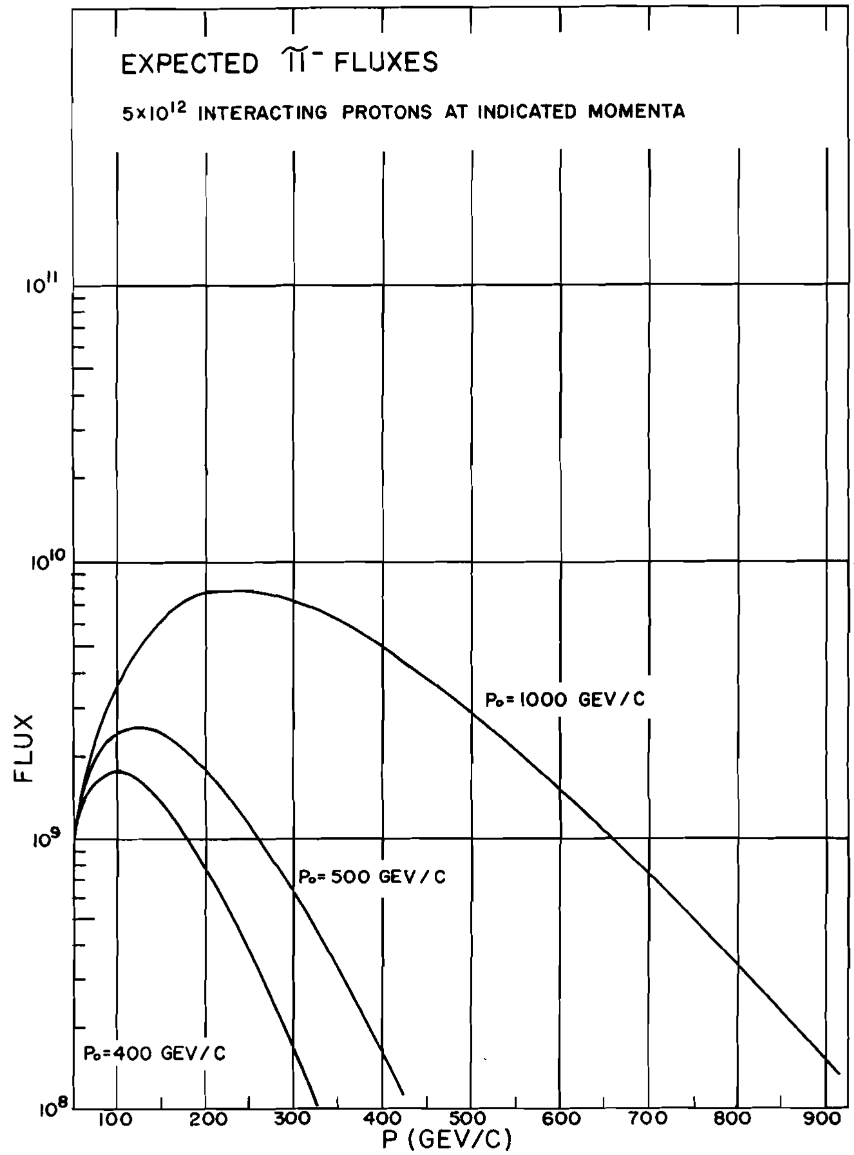

Fig. 1(a). M1 high-intensity pion beam; energy-saver apertures 20 μsr%.

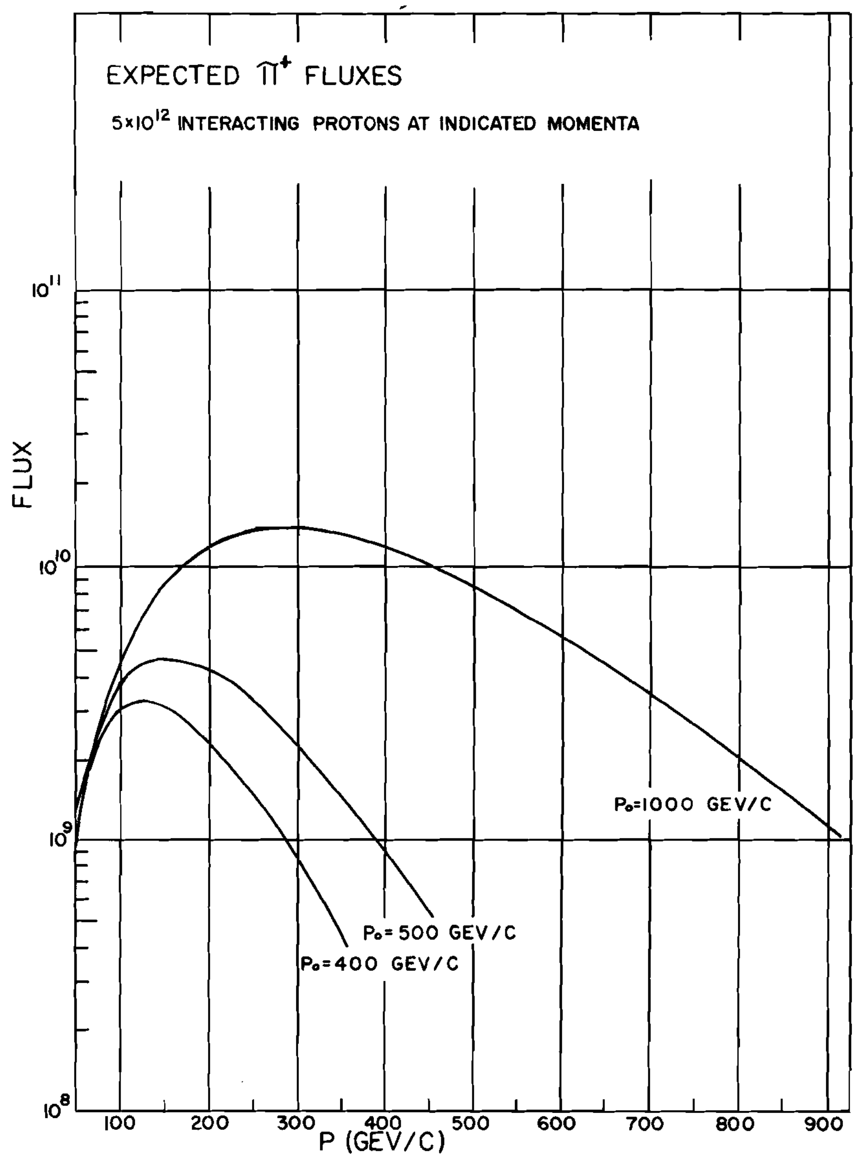

Fig. 1(b). M1 high-intensity pion beam; energy-saver apertures 20 μsr%.

M2

M2 will be an upgraded version of the present beam. It can be used as either a primary or a diffracted proton beam at intensities ranging from 10^8 to 3×10^{12} protons per pulse. One of its functions will be to transport primary protons to the production target for the polarized proton beam. This beam line is discussed in a later section. By moving the first section of the polarized beam, it will still be possible to use the M2 line in its traditional role, for example, for a beam for a beam-dump experiment.

As with M1 it would be possible to build a west branch to M2 if enough interest is shown. A section of pipe would need to be installed in the berm preceeding the target building and west of the present M2.

M3

M3 is a K_L^0 and neutron beam, so its upgrade, except for the change in targeting and the primary beam dump is straightforward. The new dump magnet opens the aperture of this beam, and folding forward of the secondary angles results in the expected Tevatron fluxes shown.

It is proposed to add an additional enclosure at some future time downstream of the detector building to house experiments as described here.

Beam Line M6

In Tevatron II, the high resolution beam line M6 will continue to have much the same character it has had previously. East and west branches will be available with a bending magnet located at 1240 feet providing switching between. The beam will be focused on this bending magnet so that it does not affect recombination. There are two intermediate foci upstream of this bending magnet. A total of twelve superconducting bending magnets and fourteen superconducting quadrupoles is required up to this point. In addition, a conventional B-2 bending magnet is placed on the target train.

It is advantageous for the beam line to be placed in the M5 tunnel up until it crosses the M6 tunnel. The number of beam components will then be reduced, and the beam optics will prove most tractable. The beam starts at an angle of 18 mrad and is bent immediately 5 mrad by a conventional B-2 on the target train. A set of five superconducting bends in the Front End Hall bends the beam to an angle of 73 mrad with respect to the Meson Laboratory center line. There are no bends in the second stage, and an additional five superconducting bend magnets in the third stage provides recombination.

A set of four quadrupoles in each stage provides focusing. In the first and third stages, the quadrupoles are interspersed with the bending magnets to provide both maximum focusing strength and minimum length of strings of superconducting elements. In each stage, the polarities of the quadrupoles are DFFD, giving maximum acceptance and beam stability. Field lenses are provided at the first and second focus to provide recombination in angle and to maximize the momentum bend pass.

The quadrupole/bend string in the third stage falls outside the present tunnels and will require construction of a new enclosure approximately 150 feet long. The acceptance of the beam will be 1.6 μsr%, using presently existing superconducting components. Both first and second foci will have a magnification of approximately unity in both planes and will also both provide a horizontal dispersion of 3 cm/%.

The recombined third focus can be used to locate a transition radiation detector for particle identification. Additional quadrupoles beyond this focus can be used to transport the beam to experiments, either the MPS or any east branch experiments. A set of four quadrupoles may be used to provide a parallel section before the final focus. This parallel section may contain a DISC-type differential Cherenkov counter for particle identification.

M6 Enclosure

The M6 beam will be the only beam line in which incident particles can be tagged in position, direction, momentum, and mass. This feature will be utilized in the multiparticle spectrometer in M6 West and a possible new detector facility to replace the Single Arm Spectrometer in M6 East. An enclosure would be built to house both of these facilities and would consist of a high bay area with crane and two counting rooms. This structure will release some Wonder Buildings which would be relocated in the M6 beam area to make it a viable installation.

The MPS detectors would not be moved for the installation. The enclosure would be built over it so that it would occupy one-half of the high bay area, Fig. 1.

The east half of the high bay area would contain the new detector facility. Access to it from the counting room would be via the overhead catwalks when the MPS is running. Beam intensities in this area will be low enough to permit such access. A single 20-ton crane would span the area, and a roll-up door at the east end would provide a delivery area. The counting rooms would have raised flooring to provide space for cable runs and to provide ducting for cooling air. Moveable partitions can separate electronic and computer areas from workshop and office space.

Wonder building "worms" will house the components leading the two beams to the area. An additional "worm" downstream from the building in the M6E line would hold the forward arm spectrometer of the new detector facility.

The housing of the two spectrometer facilities in one building has obvious operational advantages. A single liquid helium supply would service both installations as they run in an alternating mode. Operating personnel would be shared between the two facilities.

The Wonder buildings shown in Fig. 2 all presently exist in M6 but most will require relocation. The building, 40 feet by 80 feet, presently covering the MPS would be moved to cover both M6W and M6E just downstream of the detector building in order to relieve the severe congestion in that region. This move will liberate 160 feet of beam-line enclosure. An additional 110 feet will become available from the new high bay area. This total of 270 feet would be added downstream to house the forward arm of the new detector. It would also provide partial coverage for a hadron total cross-section experiment and for possible scattering experiments. The M6E beam enclosure from the detector building to the new area would be straightened out to house a Cherenkov counter. The M6W beam enclosure would not be changed.

A bypass from the M5 to the M6 tunnel will enable the M5 tunnel to be used to bring a beam to the detector facilities along the present final beam line.

Polarized Beam

The beam line proposed here would provide polarized protons in a 10% momentum band from 70 to 350 GeV/c utilizing either 400-GeV or 1000-GeV primary protons. Polarized antiprotons would also be provided.

When the primary (unpolarized) proton beam from the accelerator strikes a target, lambda hyperons, along with many other types of particles, are produced. It was discovered in experiments at Fermilab that the lambdas are polarized. When the polarized lambdas decay the resultant protons are themselves polarized, and the direction of polarization is determined by the geometry of the particular decay. This phenomenon is used to produce a high-energy polarized proton beam which is then guided by a series of magnets, which conserves the polarization, to a polarized target. The spin dependence of exclusive and inclusive processess can then be measured to study spin effects in quark-quark scattering.

The production target will be located in the M2 beam line at the 1420 foot mark which is in the Meson Detector Building. Figure 1 shows the layout following this target. The charged secondaries and remaining primary protons are dumped after a

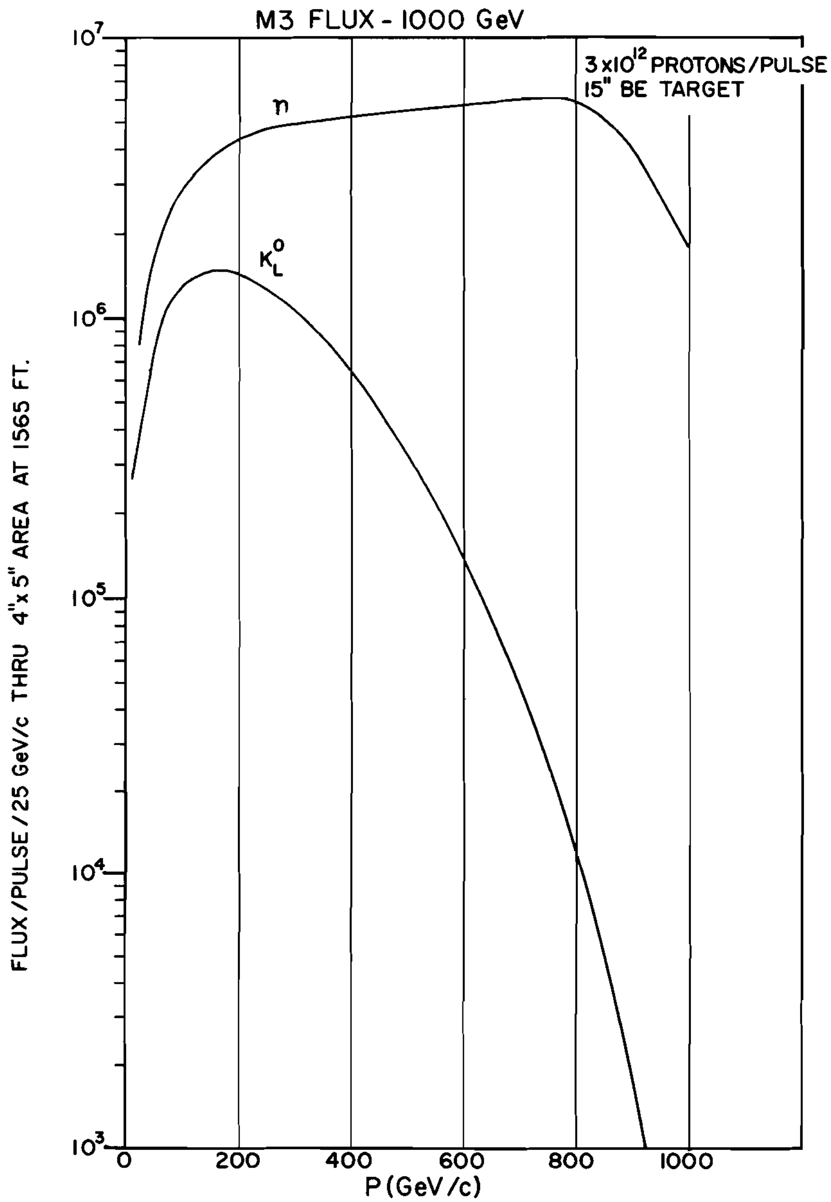
M3 FLUX - 1000 GeV
3x10^12 PROTONS/PULSE
15" BE TARGET
n
K_L^0
FLUX/PULSE/25 GeV/c THRU 4"x5" AREA AT 1565 FT.
10^7
10^6
10^5
10^4
10^3
0
200
400
600
800
1000
P(GeV/c)

Fig. 2.

sweeping magnet. The lambdas then decay to give the polarized protons. The remaining neutral particles are interacted out at the neutral dump. The beam has a focus at the collimators, and there the protons with the desired polarization are selected. The beam is again refocused at the polarized target, some 1000 feet from the production target.

Beam-transport elements include sixteen large-aperture dipole magnets and sixteen large-aperture high-field quadrupole magnets. The former will be BM-105 magnets provided by Argonne and the latter will be superconducting quadrupoles developed and provided by Argonne. The plane of polarization can be rotated from transverse to vertical or longitudinal using a magnetic "snake" preceeding the polarized target. The "snake" consists of eight superconducting dipole magnets. The elements will be powered from a 2.5 megawatt substation.

The clusters of magnets will be housed in Wonder Buildings, and these will be connected by sections of 6-inch beam pipe. A 100-foot long Wonder Building extending downstream from the polarized target will provide housing for the experiments and will house the final beam stop. It will contain, for example, the polarimeter used to measure the beam polarization and used in some experiments.

In a typical experiment, 3×10^{12} protons per spill will be targeted on the production target which will be surrounded with steel and concrete. The intensities of polarized protons and antiprotons expected under these conditions from 400- and 1000-GeV primary protons are given in W. R. Ditzler's section "Jet Physics in the Fermilab Polarized Proton Beam."

When not used to provide polarized protons, the beam can feed primary (unpolarized) protons, pions, and other secondary particles to the polarized target or to an experiment at the central focus.