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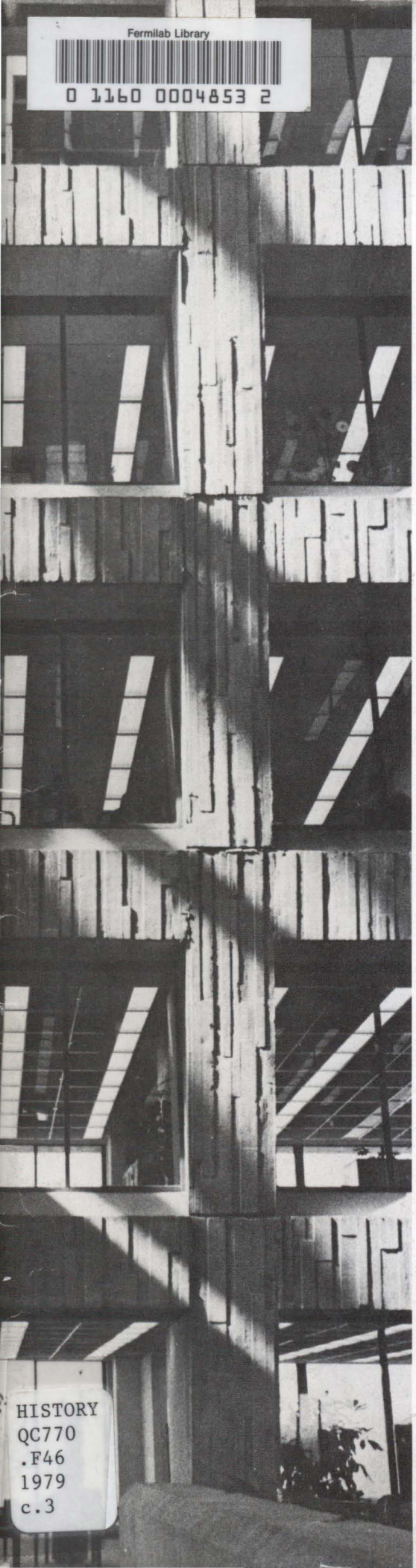

HISTORY
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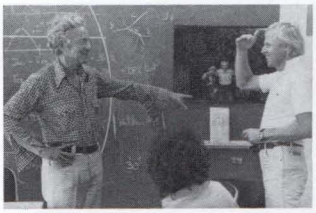
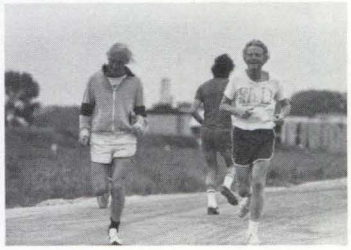
Fermilab

1979 ANNUAL REPORT





THE STATE OF THE LABORATORY . . .

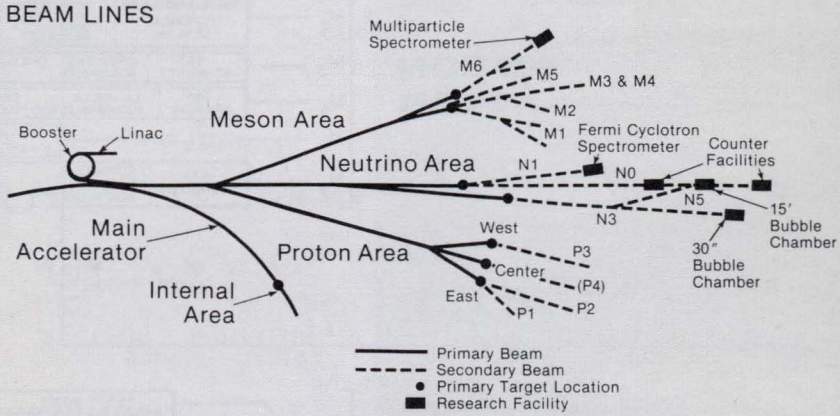
The good news is that the 400-GeV program has never been stronger. Figure 1 shows the deployment of beam lines—the result of an adiabatic development that has been proceeding since the inception of the Laboratory. Figure 2 illustrates the occupants of these beam lines—just finished, ongoing (it's hard to make anyone go home!) and in construction. There are over 100 groups and 500 physicists involved in this current phase of our program. Many of these experiments have Tevatron capability and could profit from the higher energy that will be available after 1981. Many of them are also "third-generation" experiments and have in their design and execution the experience of two previous efforts, together with the new technology of precise drift chambers, sophisticated electronic triggering, etc.

But . . . the Laboratory's traditionally minimal ability to provide adequate support for these users is further restricted by the priority we must give to the Tevatron program. A point I have been trying to make to anyone who will listen is that Fermilab's mission from inception has been to supply facilities for research to the entire high-energy physics community. Table I and Fig. 3 indicate that we are doing this. Keep in mind that the total population of U.S. experimental physicists is 1100. We are trying to service roughly 60% of the community with 40% of the funding that buys research.

Nevertheless, there is more GOOD NEWS. We are into the construction of the Energy SAVER—the world's first superconducting accelerator. This is "high-risk technology" with a vengeance. It is also the boldest, most exciting program in accelerator art and in physics potential since Galileo's (nearly) vertical linear accelerator. We at Fermilab are privileged and humbled (!) by this task. The nobility of the objectives is illustrated by Figs. 4 and 5, which place our projects in the

FIGURE 1

BEAM LINES



Particle beams and research facilities at Fermilab. The individual beams and their general purposes are listed below.

Meson Area (Spring and Summer 1979)

- M1 General-Purpose Charged Hadron Beam
- M2 Charged Hadron Beam (diffracted protons)
- M3 Neutron Beam (neutrons and K_L^0)
- M4 Charged Hadron Beam (with emphasis on K^-)
- M5 Test Beam of Low Energy Charged Particles
- M6 Charged Hadron Beam

Neutrino Area

- N0 Neutrino Beam
- N1 Muon/Hadron Beam
- N5 15-ft. Bubble Chamber Charged Hadron Beam
- N3 30-In. Bubble Chamber Charged Hadron Beam

Proton Area

(Primary protons available in all branches)

- P1 Proton East Neutral Beam (photons or neutrons)
- P2 Proton-East Electron Beam for Tagged Photons
- P3 Proton-West Charged Hadron Beam
- (P4) Proton-Center Charged Hyperon Bean (in preparation)

Internal Area - at C-0

Primary Protons circulating inside the Main Accelerator

TABLE 1

I. Numbers of Persons Associated with Fermilab Experiments Since January 1, 1978

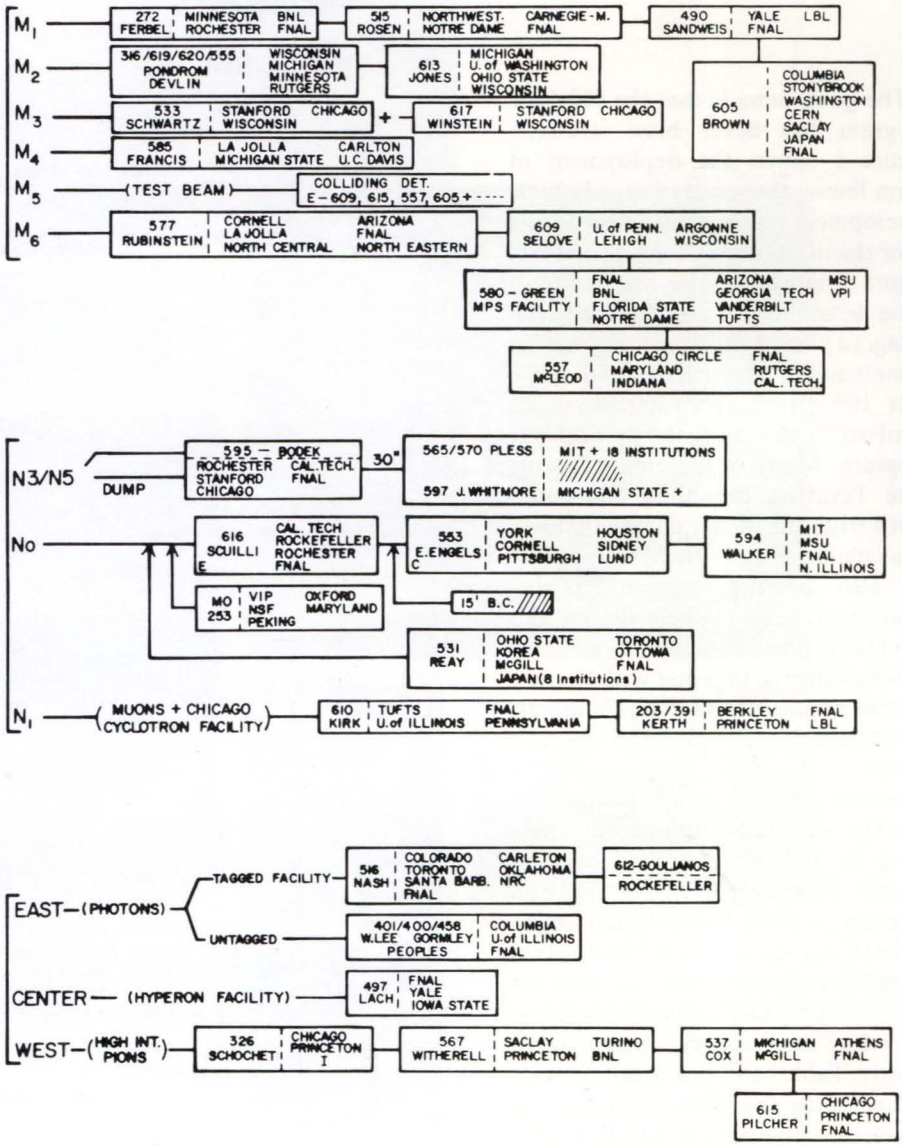
	Non-Fermi	Fermilab	Total
Physicists (PhD's, Masters, etc.)	744	106	850
Graduate Students	251	—	251
Misc. Support (Engineers, Programmers, Undergrads, etc.)	219	4	223
Total	1,214	110	1,324

II. Numbers of Institutions Associated with Fermilab Experiments Since January 1, 1978

American	72
European	33
Other	30
Total	135

FIGURE 2

FNAL 79-80 RESEARCH

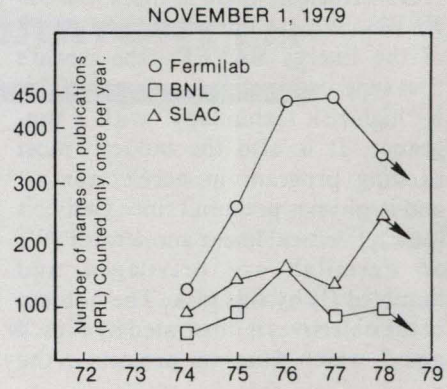


context of the world inventory of accelerators.

And it is difficult. We need to and we are co-opting the best people in the Lab. We are continually torn between our commitments to the users in the 400-GeV program and our obligation to the future, the Tevatron program.

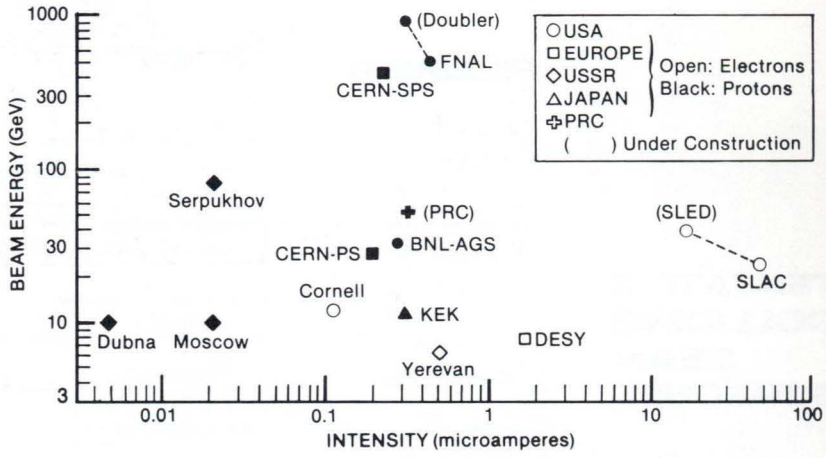
To recapitulate our objectives: The SAVER gives us 500-GeV circulating beam in a new ring of 1000 superconducting magnets. We can store this beam or extract it to continue the "400" GeV program. TEVATRON I upgrades the superconducting accelerator to 1000 GeV for storage and will provide an intense source of antiprotons for colliding beams at 2000 GeV in the center of mass. TEVATRON II will give us the means to accelerate and extract approximately 10^{12} protons per second at 1000 GeV and to provide these protons and secondary beams of neutrinos, muons, photons, and hadrons to a new phase of fixed-target research. The overall estimated construction costs are approximately $115 M and the

FIGURE 3



HIGH ENERGY ACCELERATORS ...(1979)

FIGURE 4



COLLIDING BEAM STORAGE RINGS - 1979...

FIGURE 5

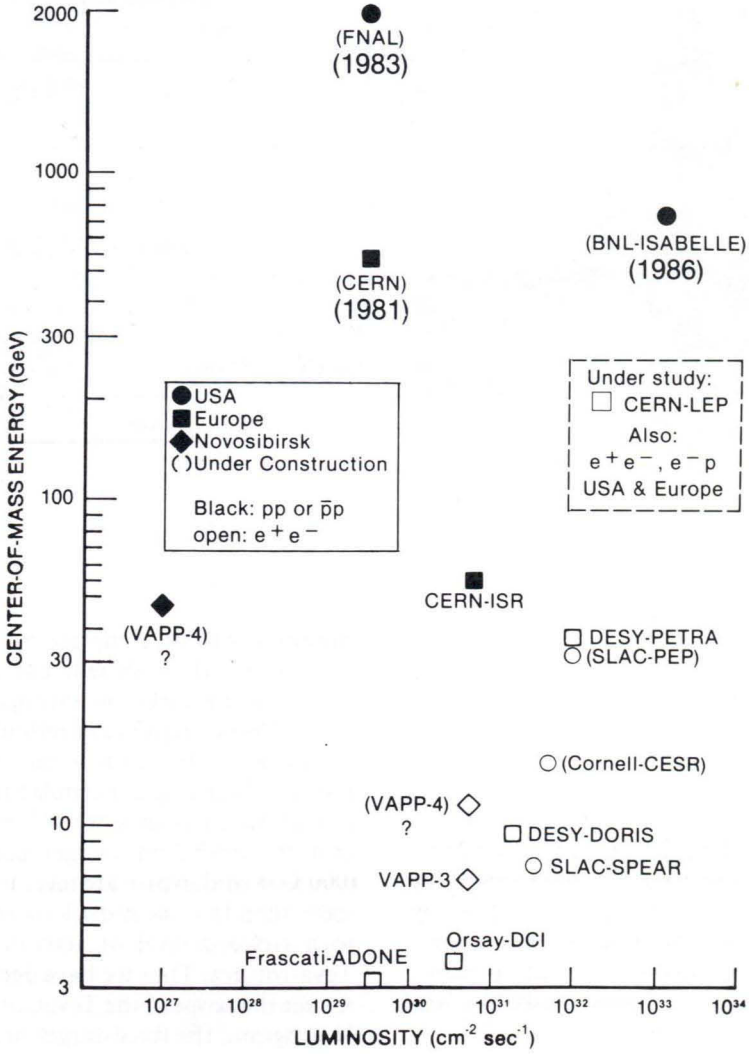
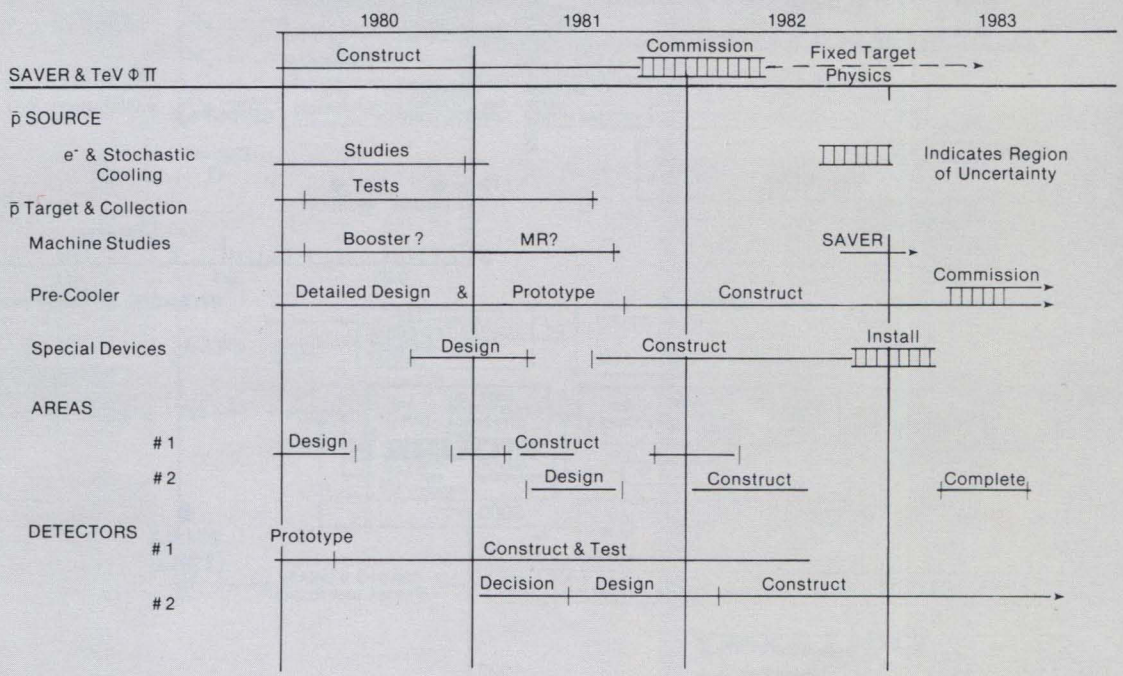


FIGURE 6

TENTATIVE COLLIDING BEAM SCHEDULE



program is to be complete by 1984.

In Table II, I present our budget history and projections through 1983. This reflects a significant rethinking of our program. It is clear to me from the history of funding at Fermilab that it is unrealistic to assume we will ever obtain the operating budget commensurate with the user activity. It would seem then that we must look forward to a reduced level of activity in the Tevatron era. Thus we have decided to reduce the scope of the Tevatron Phase II program, the fixed-target program. Finally, I show in Fig. 6 the present long-range plan for bringing in the Tevatron Phase I and Phase II programs.

Looking even further into the future we see an obligation to capitalize on what we hope will be the experience of a successful 1000-GeV accelerator construction program. This obligation will be toward a 5-TeV "site-filler" accelerator envisaged some time ago by R.R. Wilson. Fermilab will have to offer not only the expertise, but also the unique 500-1000 GeV injector.

Leon Lederman

FERMILAB FUNDING SUMMARY... (in millions)

TABLE 2

	79	80		81*		82*	83*
OPERATING COSTS							
Research	4.1	4.7		5.0	(.4)	6.1	7.0
Accelerator Opns	16.3	20.6	(1.2)	23.2	(0)	25.8	33.0 (g)
Facility Opns	18.9	20.7		22.0	(.2)	25.8	30.0 (g)
Acel. R&D (a)	20.1	17.4	(2.0)	17.5	(1.1)	14.3	12.0
Facility R&D (b)	3.3	3.8		4.3	(.9)	6.0	6.0
Total Op	62.7	67.3	(3.2)	72.0	(2.6)	78.0	88.0
Fixed '80 $	68.9	67.3		65.4		64.4	66.2
CONSTRUCTION							
Line Items							
TEC							
Saver 46.6	12.0	15.0		19.6		0	0
TeV Φ I (c) 33.7				2.0	(5.5)	19.2	12.5(-5.5)
TeV Φ II (d) 47.0 + PE&D						7.0	12.0 (i)
Facility Improvement (e)							4.8
Total Line Item	12.0	15.0		21.6	(5.5)	26.2	29.3
P. E. & D. (f)			(.390)			1.0	(-5.5)
Other Constr. Projects							
AIP/Acc	1.1	1.4		1.94	(.75)	5.0 (h)	4.3
AIP/Research	1.1	1.5		1.56	(1.25)	2.0	3.0
GPP	0.9	1.5		1.4	(.6)	2.0	3.0
Total Constr.	15.1	19.4	(.390)	26.5	(8.1)	36.2	39.6(-5.5)
EQUIPMENT	11.6	13.0	(.4)	17.5	(1.0)	23.0	25.0
Total Fermilab	89.4	99.7	(3.99)	166.0	(11.7)	137.2	152.6(-5.5)
Fixed '80 $	98.3	99.7	(3.99)	105.5	(10.6)	133.2	114.7 (4.1)

G&A is now being revised so as to conform to Saver Management Plan - will not apply to construction-related R&D.

Items in brackets are requests outside of DOE allocations.

*Proposed to D.O.E.

FOOTNOTES...

		FY 79	80		81		82	83
(a)	Accelerator R&D Details							
	Saver	12.3	7.9	(2.0)	4.0		1.0	0
	TeV - Φ I (c)	1.1	2.4		3.0		3.0	2.0
	TeV - Φ II (d)	0	1.6		4.0		2.0	2.0
	General Acc R&D	2.5	1.2		2.5		5.0	5.0
	G&A	4.2	4.3		4.0		3.3	3.0
		20.1	17.4		17.5		14.3	12.0
(b)	Facility R&D							
	TeV Φ II (d)	0			.4		.5	
	General	2.4	2.7		2.9		4.0	4.3
	G&A	0.9	1.1		1.0		1.5	1.7
		3.3	3.8		4.3		6.0	6.0

(c) TeV Φ I FY 81 — Includes the Collider, with Experimental Areas: Refrigeration for1000 GeV coasting beam and RF Schedule 44 Project No. 81-CH-097 11/27/79

(d) TeV Φ II FY 82 — Includes Extraction of 1000 GeV, Switchyard and Area upgrades to acept 1000 GeV beams. Form 45 8/30/79

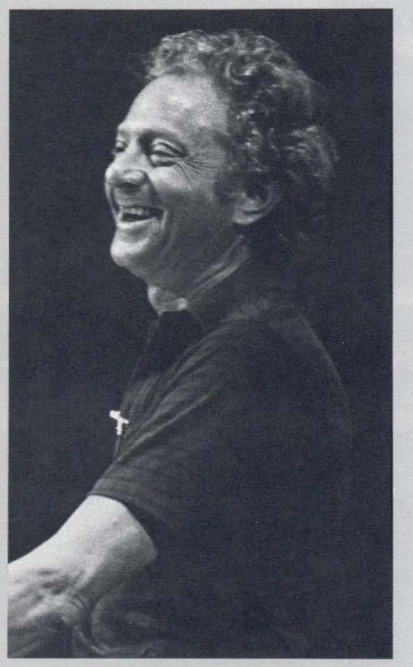
(e) Facility Improvements: Particle Detector Development and Assembly Area $1.2M
Superconducting Technology Engineering Complex $1.8M
Road Construction Improvements $1.8M
Schedule 44 of 9/5/79 FY 82
This item has also been shifted to FY 83 to "flatten" the total construction cost history

(f) PE&D $1M — To plan and engineer super high field magnets for site filling accelerator and to plan improvements in colliding beam facilities
$390K — Tevatron Phase II - Extraction and RF

(g) Increase of Accelerator Operating Budget to $33.0 and Facility Opns to $30.0. Here we plan a 48 week operating schedule in order to supply both fixed target and colliding beam requirements. Reliability requirements become crucial. Maintenance costs of refrigeration and other new equipment additions.

(h) Large AIP increase for expected Improvements in Saver/Doubler performance—correction coils, replacements of magnets with worst excursions, etc.

(i) In view of high priority to Operating and Equipment needs, we have drastically reduced the scale of area upgrades in FY 83 and deferred $13.0M to subsequent year(s).



WHERE WE ARE IN PHYSICS . . .

High-energy physics, the science of the fundamental constituents of matter and their interactions, is in a period of remarkable excitement and promise. Recent research has brought us to the threshold of a new level of understanding of the universe around us.

Experiments throughout the past decade have indicated the existence of two classes of apparently elementary constitutents: *the quarks,* which make up objects such as the proton, and *the leptons,* of which the electron is the most familiar example. At the limit of present resolution, the quarks and leptons have no spatial extent and no internal structure. That is, they appear like geometrical points. All the known forms of matter may be viewed as regular combinations of these building blocks. The leptons are observed directly, but free quarks have not been observed. Nevertheless, the indirect, circumstantial evidence for quarks is so overwhelming that their physical reality seems unavoidable.

For half a century, physicists have distinguished four fundamental forces: gravity, electromagnetism, the weak interaction responsible for radioactivity, and the strong force that binds atomic nuclei. Electromagnetism is itself the union of electricity and magnetism, which until the nineteenth century were regarded as distinct and unrelated phenomena. The unification of electricity and magnetism led to an understanding of many phenomena involving light, a form of electromagnetic radiation, and laid the foundation for our contemporary television and microwave-oven society. It also supplied crucial clues to the theory of relativity, which brought together and gave new meaning to the ancient concepts of space and time.

Unification of fundamental forces is again in the air today. We are now confident that electromagnetism and weak interaction are two aspects of the same underlying interaction. A unified theory of weak and electromagnetic interactions put forward by Steven Weinberg and Abdus Salam makes detailed predictions that are in remarkable agreement with experiment. As the unified theory of electricity and magnetism predicted the existence of electromagnetic waves, the Weinberg-Salam theory predicted a new form of radioactivity, known as the neutral-current interaction. The effects of the neutral-current interaction were first detected in 1973. Since then, many experiments at Fermilab and elsewhere have been devoted to the study of its properties.

Because the Weinberg-Salam theory is a quantum field theory, it requires the weak and electromagnetic forces to be mediated by quanta that are themselves elementary particles. The quantum of light, the photon, has been known for 75 years, since it provided the basis for understanding the photoelectric effect. According to the Weinberg-Salam theory, the weak interactions are mediated by two species of force particles, called W and Z. These *intermediate bosons* are extremely massive, about 100 times the mass of the proton, so their detection is beyond the reach of existing accelerators. The Fermilab proton-antiproton collider project, intended to attain center of mass energies of two thousand times the proton mass, will create an important facility for the study of these objects.

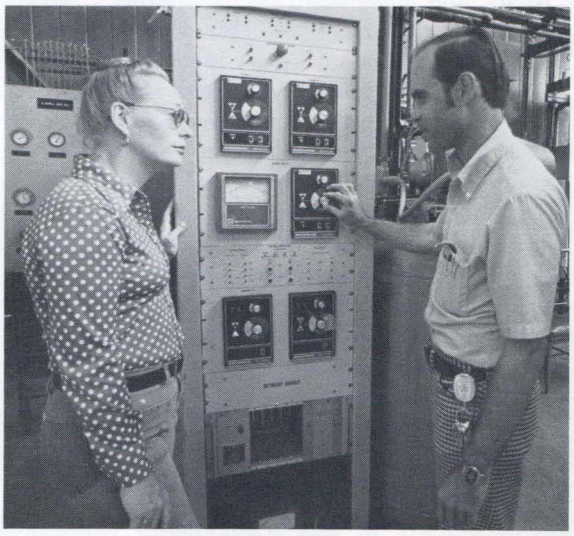
There is another side to the unification story. It now appears highly likely that the strong interactions result from an elementary interaction among the quarks that is mediated by force particles called gluons. A theory known as quantum chromodynamics (QCD) has emerged as a probable description of these strong interactions. QCD still requires extensive experimetal testing. Indeed, because of calculational difficulties, its predictions have not been completely elaborated. The mathematical structure of QCD is very similar to that of the unified theory of weak and electromagnetic interactions. This resemblance leads us (whether by supreme insight or by mere hubris, it is too soon to know) to the audacious proposal of a "grand unification" of the strong, weak, and electromagnetic interactions. Nothing we know compels grand unification, but perhaps more importantly, nothing is preventing it: we are free to take the leap!

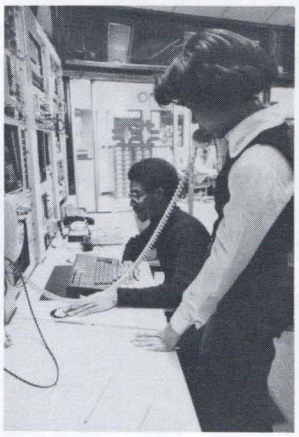
Returning to QCD itself, it remains to devise ways of making quantitative predictions and testing them experimentally. One important precept of the prevailing view of QCD is that free quarks and free gluons cannot exist. A search for free quarks, which can be carried out with the Tevatron more incisively than before, thus takes on added significance.

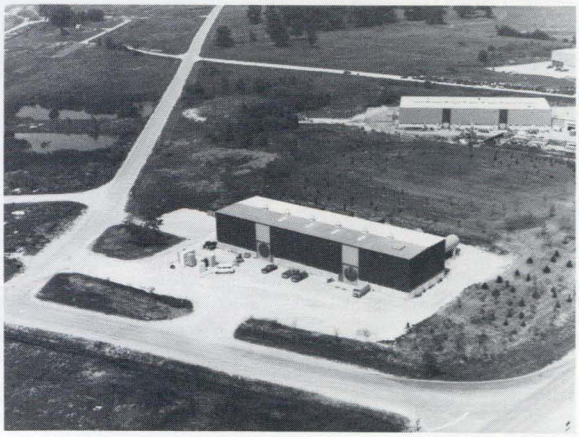
Exuberance over the possibility of grand unification is tempered by the recognition that some fundamental issues have not yet been addressed. Among these is the question of why the mass spectrum of quarks and leptons is as it is. There are two broad views of the spectrum problem. One is that the ultimate unification of all the forces of nature, including gravitation, will result in a definite prescription for the kinds of fundamental particles that may exist. The contrary is that we have already found too many quarks, leptons, and force particles—more than thirty—for them to be truly elementary. If this is so, higher-resolution instruments such as the Tevatron and Collider may begin to reveal an internal structure of the quarks and leptons we now perceive as structureless.

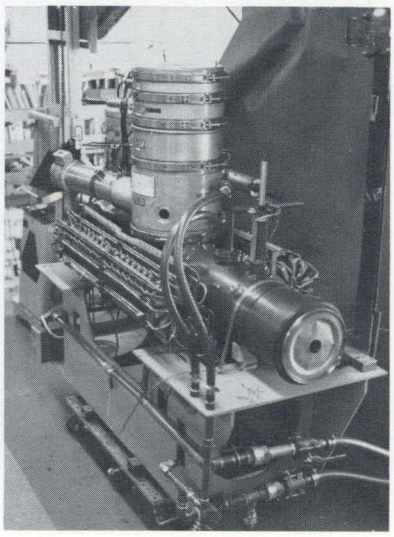
Many questions still must be answered, and countless more have not yet been phrased. What our recent discoveries imply for cosmic concerns about the origin and ultimate fate of the universe is only beginning to be understood. As we improve our instruments and extend the sweep of our theories, let us delight together in the beauty of nature and recall with humility that nature's possibilities are not limited by our imagination.

ACCELERATOR ACTIVITIES . . .









INTRODUCTION

Several different kinds of activities are simultaneously going on involving the Fermilab accelerators. These activities are stretching all of us concerned with the accelerator. It has been a year of hard work and a number of significant accomplishments.

First, we are operating as vigorous a program at 400 GeV as funds will permit, including improvement of the accelerator to run more reliably at higher energy and at higher intensity. In the last years, the pressure of other activities had led to a lessened emphasis on accelerator performance for the high-energy physics program and one of the things we have accomplished this year is to re-emphasize the prime importance of the 400-GeV program and to devote the resources and people to it to make it work well. The 400-GeV program is operating at a better level in reliability and intensity than it has for several years.

We must also work toward the future, because the results of the 400-GeV program strongly urge us on to experiments at higher energy that will give a clearer picture of the basic structure of matter.

The short history of accelerator development (it is only 52 years since the first resonant accelerator) clearly indicates a pattern of each new accelerator yielding ideas and designs that make possible a combination of higher energies and higher intensities for the next accelerator.

Recognizing this rapid development in the evolution of accelerator concepts, the first Fermilab Director, Robert Wilson, made provision in the design of the Main-Ring tunnel for the addition of a separate superconducting ring to exploit the unique features that become available with superconductivity. It is possible with present-day superconducting materials to reach twice the peak field of the Main-Ring magnets and thus to double the energy of the Main Ring to 1000 GeV (1 TeV). Developmental work on superconducting magnets has been going on at Fermilab since 1972, and construction began on the first phase of the superconducting accelerator, the Energy Saver, in July 1979, following the completion of a successful test-magnet run and the writing of a definitive report on all phases of the proposed accelerator.

The Energy Saver will provide a 500-GeV accelerator with an available length flattop that will be superior to any previous accelerator for electronic detector experiments and with a large saving in electrical power, because of the low electrical losses in superconducting magnet coils. This project has been funded by the Department of Energy in the three fiscal years from FY 79 through FY 81, and construction of magnets and refrigeration systems is going on.

The development of superconducting accelerator magnets is one of the two great currents moving in the accelerator field. The other is the invention of "beam-cooling" techniques to increase the density of particles in a beam. These techniques have been demonstrated experimentally at Novosibirsk in the USSR and at CERN. An experiment in beam cooling is being done at Fermilab.

Beam cooling can give another great leap in the energy available from the Fermilab superconducting ring. Antiprotons produced by the Main-Ring proton beam can be "cooled" and collected to make an antiproton beam that will fit in the superconducting ring. Then beams of antiprotons and protons can circulate in opposite directions in the same ring and colliding-beams experiments can be carried out at energies up to 2 TeV in the center of mass, an energy range beyond any other accelerator now being built.

Design work has been carried out by accelerator scientists at Fermilab and a design report completed on a feasible optimized cooling scheme. This second capability for the new accelerator is expected to be supported for initial funding by the Department of Energy in FY 81 for the development of a colliding-beam facility, with experimental areas available at straight sections B and D (Tevatron I).

An additional unique capability will be available soon after approval of another phase of the Tevatron program that will provide facilities necessary for extraction of 1000-GeV particles from the superconducting ring and delivery of these particles to the fixed-target experimental areas, upgraded to 1000 GeV as part of this later phase. Conceptual design work for these activities is in progress and funding is being requested to begin in FY 82 (Tevatron II).

These new projects open up vistas for experimental programs that have heretofore only been available in the imagination of the experimenter. It is exciting to know that experiments in a totally new regime will be available in the same ring and colliding-beams experiments can be carried out at energies up to 2 TeV in the center of mass.

ACCELERATOR OPERATION

Operation of the Accelerator in 1979 was somewhat improved over previous years. Despite the longest shutdown in the history of the accelerator and nagging problems with power-amplifier vacuum tubes, many operational records were set and a respectable number of high-energy protons was delivered to experimental targets. Several significant changes were made during 1979 to improve accelerator characteristics, both for delivering beam to the present 400-GeV program and for its eventual role as the injector to the Tevatron.

The year began with a continuation of a run at 350 GeV into March, followed by an 80-hour test of the accelerator at 450 GeV. During the 350-GeV run, several operational records were set, including a single-pulse Main-Ring intensity of 2.7×10^{13} protons and a level of more than 10^{18} protons/week, which was maintained throughout the month of February. The 450-GeV run was also quite reliable. Several subsequent improvements to the power supply system have been made; we believe these changes have made the Main Ring as good at 450 GeV as at lower energies.

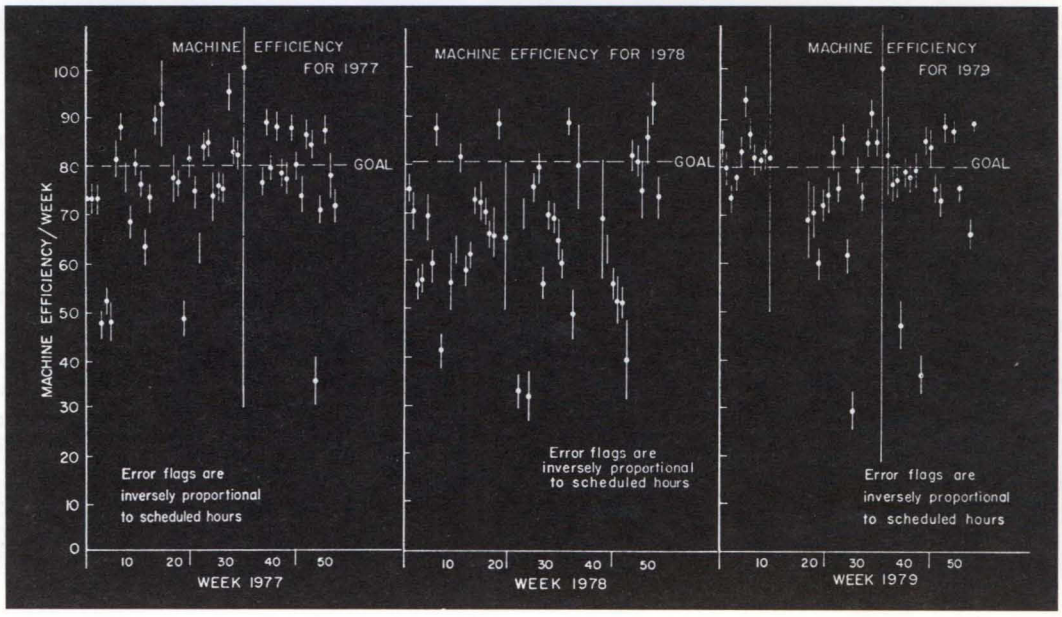
The accelerator was off for much of March, April, and May to reduce power costs while waiting for the Neutrino and Meson areas to become operational. Operation resumed in June, with emphasis on the Neutrino program using the dichromatic train and on the reincarnation of the Meson Lab and the commissioning of its two-target system. Except for three short 200-GeV calibration runs for the major Neutrino experiment, operation of the accelerator continued from May through December.

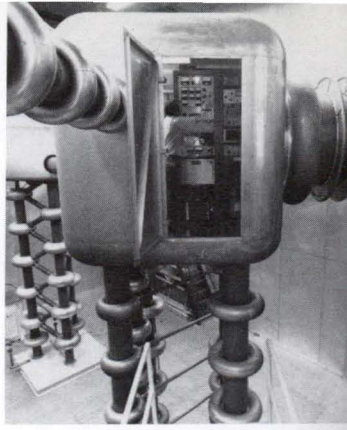
In comparing recent records to earlier years, one can note that in 1979 a weekly cycle of operation, studies, and maintenance was used, with more time devoted to accelerator studies and more downtime to aid the installation of the Tevatron in the Main-Ring tunnel. Day-night cycle variations to take advantage of cheaper power at night and on weekends became quite routine and rarely caused difficulty. Figure 1 shows the weekly accelerator reliability for the last 3 years. The ordinate is the ratio of actual to scheduled hours of operation for high-energy physics or accelerator studies. The error flags are inversely proportional to the number of hours scheduled in the week. One can see that operation has improved in the last year and that 400-GeV operation can be as good as at 350. Figure 2 shows the total accumulated protons accelerated in the last 3 years, together with a comparison with the CERN SPS.

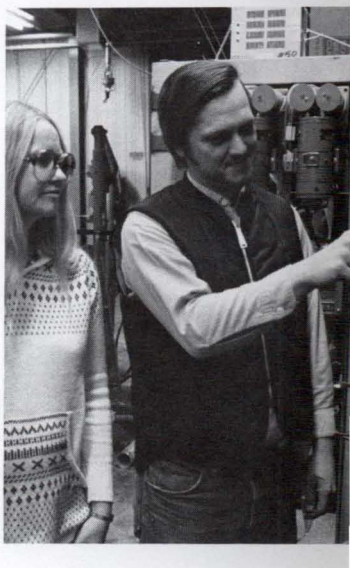
Acceleration of H^- ions is now the exclusive mode of Linac operation and the second Cockcroft-Walton pre-accelerator has been converted to an H^- source. A major sentimental event in 1979 was the decommissioning of the proton source, which had served so well since 1971.

The experimental Booster low-level rf control system was made operational in November. The new system, over 2 years in development, is

FIGURE 1







much more stable and versatile, allowing less operator intervention and more sophisticated studies. The Booster cavities and magnet power-supply system have been upgraded to allow the energy to be increased from 8 to 10 GeV. The failure of a vendor to supply sufficiently good vacuum tubes left the Booster with only a marginally adequate system at 8 GeV for much of the year and so 10 GeV has not yet become operational.

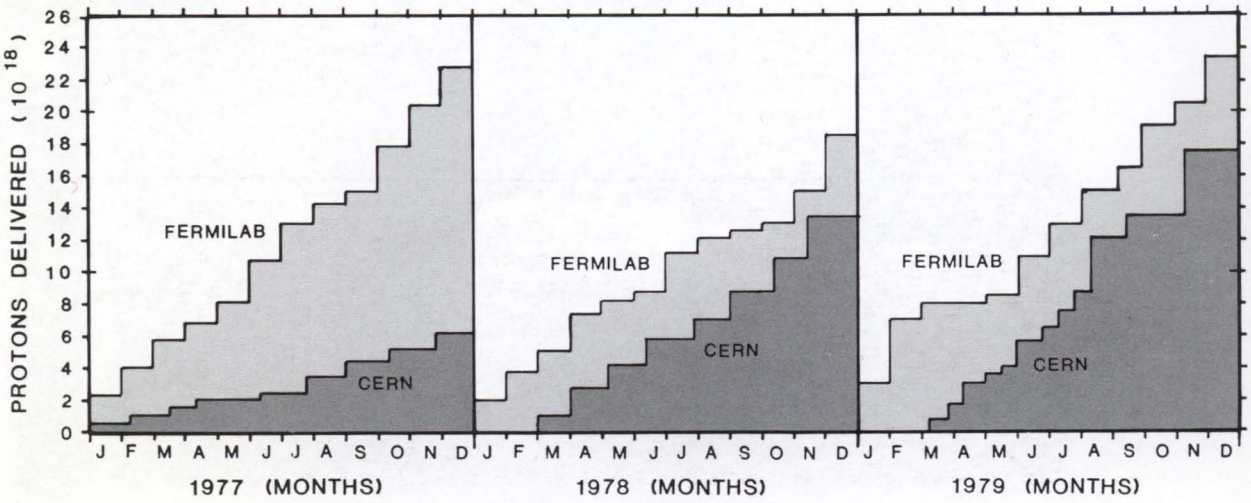
The Main Ring's most notable improvement was increased reliability of the magnets and power-supply systems. New computers for power-supply control and better filter elements have greatly improved regulation. Zinc-oxide varistors installed on the output of the power supplies prior to the 450-GeV run have prevented high-voltage transients from damaging Main-Ring magnets. Only four of the 1000 magnets were lost during operation in 1979. Increased study time led to understanding some aperture restrictions, as well as the damaging effect of stray field from the electrostatic septa.

The most outstanding improvement in the Switchyard was the commissioning of the D0 extraction system. In this mode, the extracted beam is initially deflected by an electrostatic septum in the D0 straight section, rather than in the transfer area at F48. There are several advantages of this scheme, including less residual radioactivity in the Transfer Hall, as well as having a redundant extraction septum. Much of the effort in the Switchyard was in the installation and debugging of the two-way split to the Meson Lab. The Switchyard group has also been heavily involved in preparations for the installation of 21 superconducting magnets to transport the extracted beam to the Meson Lab at energies up to 1000 GeV.

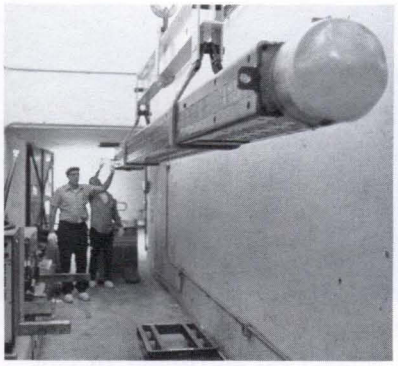
Thus 1979 has seen improvements in reliability and intensity of the accelerator. Major improvements have been made to the operating systems, which should lead to greater understanding and flexibility. There is considerable optimism and enthusiasm that accelerator performance, in its present role and in its future one as the Tevatron injector, can be considerably improved.

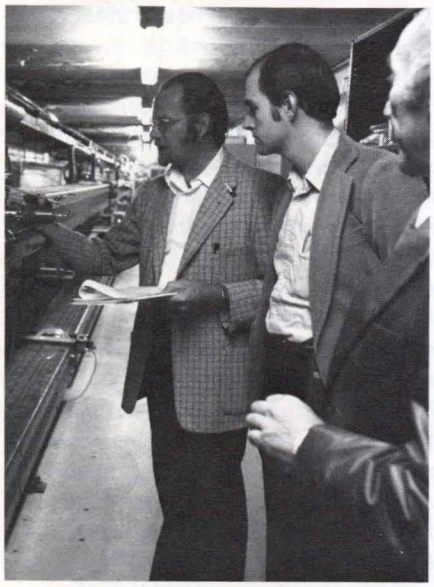
COMPARISON OF PROTONS DELIVERED TO TARGETS

FIGURE 2



THE SUPERCONDUCTING ACCELERATOR . . .



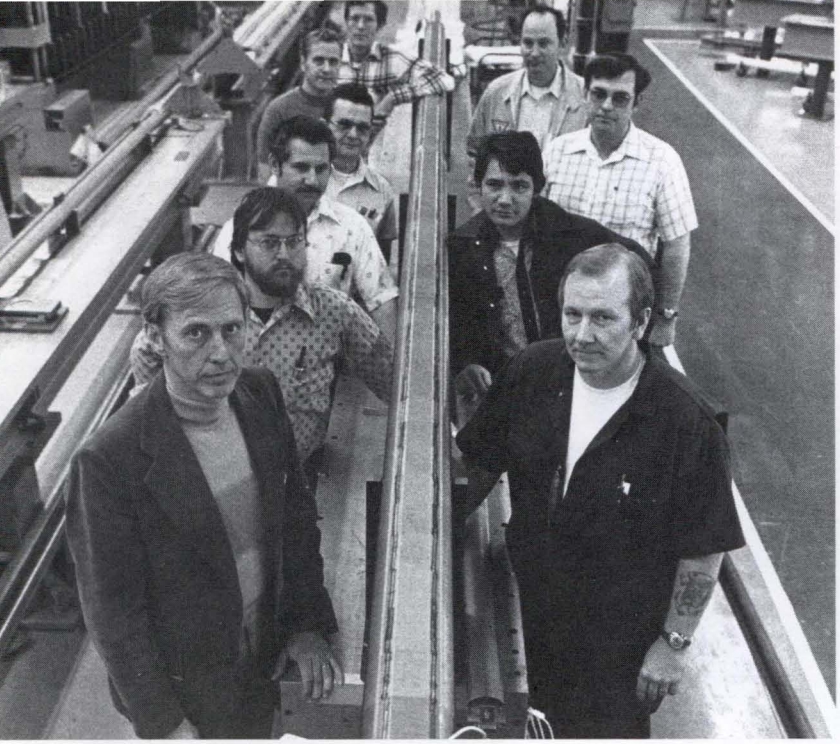


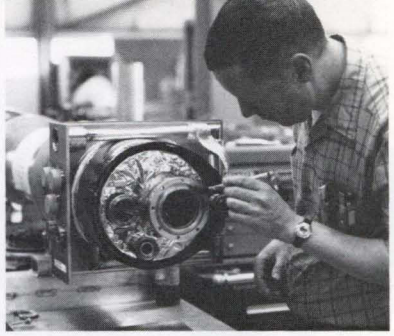
In the first step of the Tevatron program, the Energy Saver, we are constructing the superconducting magnet ring that is the basis of the entire program and installing it in the Main-Ring tunnel. Protons will be injected from the Main Ring at 150 GeV, then accelerated to 400 or 500 GeV. Operation with the Energy Saver rather than with the Main Ring to full energy will reduce the Laboratory's electric-energy bill up to $5 million per year.

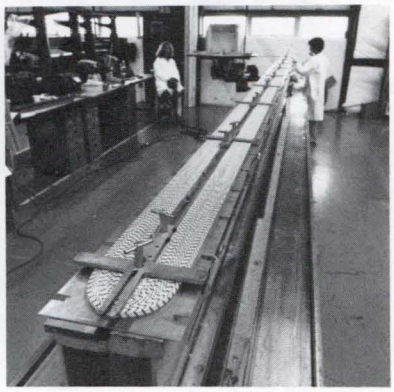
Up until July 1979, all the work on superconducting magnets was a research and development effort. As one part of this effort, the design of the accelerator was refined and a comprehensive design report issued. One result of this work is that the magnets have been shortened from 22 to 21 feet to accommodate correction magnets in the ring circumference. As another part, a whole series of magnets were built and tested. These magnets were then utilized in one of the systems tests. Above ground, a string of eight magnets has been cooled and operated successfully. This work is a test, not only of the magnet system, but even more of the satellite refrigeration system developed here. This string has now been extended to 20 magnets.

Below ground, in the Main-Ring tunnel, another set of 20 magnets has been installed. Many hard lessons were learned in this work. The string was put under vacuum, cooled, and powered. Protons of 90-GeV energy were injected from the Main Ring and transported through the magnet string. The tests were successful in that beam was detected at the end of the string and that beam-induced quenching was much less of a problem than we had feared it might be. Very little diagnostic equipment was available to test beam properties.

These various hurdles were overcome and construction funds for the Energy Saver were released in July. Since that time, development work has continued on magnets, as well as production of them for the ring. In addition, work is proceeding on the refrigeration and nitrogen and helium distribution system, both above ground and in the tunnel. The distribution systems are largely complete through A sector of the ring and refrigerators and compressors are now being installed. Work on injection, vacuum acceleration, beam detection, abort and other systems is proceeding at an appropriate pace.







SUPERCONDUCTING MAGNET SECTION

MAGNETS

Work at Fermilab on superconducting magnets for accelerators began in 1972, as soon as construction of the Main Ring was completed and operation begun. More than 150 research magnets have been built and tested in this program. Superconducting cable has been developed in this program to a point where it is now built for us in private industry. Coil winding and magnet assembly are done at Fermilab. In the last year the work has been concentrated on full-scale magnets, which have undergone exhaustive testing, both individually and as part of systems.

In October, a problem was detected with magnets produced after June 1979. A new design of cryostat with several design simplifications giving easier assembly and reduced costs had been incorporated. When these magnets were tested, unacceptably large variations of vertical magnet axis appeared. We have identified the defect as insufficient torsional clamping between the liquid-nitrogen shield and the outer jacket, modified the design, and incorporated the fix in all subsequent cryostats.

Enough magnets plus spares were in the assembly line to meet our next major objective, the installation and testing of a full cryogenic loop (32 dipoles and 8 quadrupoles) in the Main-Ring tunnel. The vertical-axis variation that exists in these magnets will not interfere with the cryogenic objectives of this test. Later, these magnets will be removed from the tunnel for correction of the cryostat defect.

A major success of the Energy Saver program is the establishment and verification of a steady flow of highly specialized parts for the magnets. Very high quality control is necessary to insure magnets that meet all the requirements for accelerator use. The system has now been operating at a steady rate for a long enough period that we are confident that we have demonstrated that only unusual occurrences can cause delays. As production is stepped up again in April of 1980, even more attention will be required if we are to avoid costly interruptions in the production process.

Efforts to bring on quad and correction-element production have been steadily increased. (About one quad is required for each 4 dipoles.) By the end of the year 18 new quads that match the 21-foot dipoles were produced. Only two of these were installed in their cryostats because of a design change in which the correction elements are now in a separate cryostat. This change was made in recognition of the likelihood that during commissioning of the Energy Saver, sufficient changes and additions in the correction-element packages might require ready access to this portion of the ring.

CENTRAL HELIUM LIQUEFIER

A major event in 1979 was the start of the commissioning of the Central Helium Liquefier. This plant will double the world's capacity for liquefying helium when it is brought into full operation early in 1980. Work began on this facility in 1976 and the first important operating milestone was passed when one of the 4000-horsepower helium compressors passed a 150-hour continuous-operation break-in period. In addition, all other equipment necessary for start-up was completed by the end of 1979.

COLLIDING BEAMS DEPARTMENT

A design has been completed for a scheme to give proton-antiproton colliding-beam luminosity of more than 10^{30} cm^{-2} sec^{-1} at 2000-GeV center of mass energy in the Fermilab Superconducting Magnet Ring. This energy and luminosity permit the study of a wide range of new phenomena far beyond what is possible at any other institution.

In addition to the superconducting magnet ring, this scheme requires the construction of a "bright" source of antiprotons. The scheme proposed will use stochastic cooling of the antiprotons to reduce the energy spread with which they are produced in a target by Main-Ring protons, then electron-beam cooling to reduce further the dimensions of the antiproton beam so that accumulation of an adequate antiproton beam can occur within a period of several hours. This antiproton beam will then be accelerated to 1000 GeV in the superconducting ring and will collide with a counter-circulating proton beam so that physics experiments can be performed in either of two colliding-beam experimental areas to be constructed in Main-Ring straight sections.

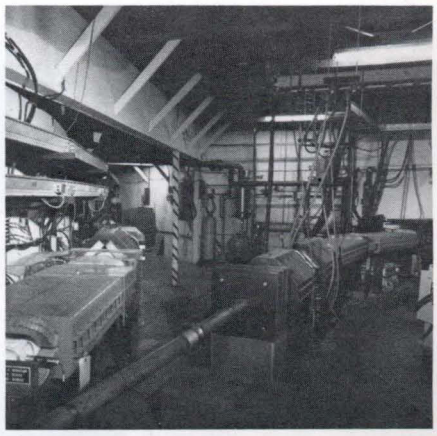
In the proposed scheme, the antiprotons will be produced by extracting a beam of 100-GeV protons from the Main Ring and directing them to a target. The antiprotons are collected at about 4 GeV in a new Booster-size magnet ring, the Precooler, where the "hot" antiprotons are cooled by stochastic cooling. The antiprotons are decelerated to 200 MeV in the Precooler and transferred to a 200-MeV storage ring (already built), where further cooling takes place, utilizing the mechanism of electron cooling. The antiprotons will be continually cooled and accumulated over many cycles in the Electron Cooling Ring to achieve reasonable intensity for colliding beams.

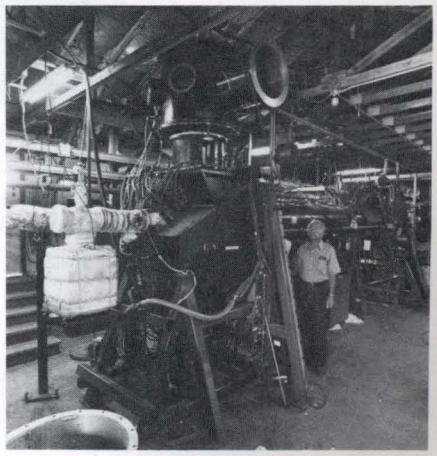
Experiments are in progress to study the processes of electron and stochastic cooling. These studies are being carried out in the 200-MeV ring using protons from the linear accelerator. During 1979 the performance of the storage ring has been improved by the addition of an accelerating system to bunch and stack the proton beam, by developing beam-position and beam-profile monitors, and by improving the magnet power supplies to reduce magnet ripple and thus increase beam lifetime in the ring. A vacuum of 5×10^{-11} Torr was achieved in the ring, which will give beam lifetime in excess of a day. Assembly of the electron cooling system was completed during the year; initial testing of the system was favorable, with the exception that improvements were necessary to allow 110 kV to be maintained on the electron collector at high beam current. These improvements have been made and the system is ready to be used for the first electron-cooling experiments. A stochastic-cooling system has been installed in the ring by a group from Lawrence Berkeley Laboratory and cooling experiments are underway.

In order to achieve the desired antiproton intensity in the Precooler, the proton beam in the Main Ring must be rebunched before extraction and targeting. In addition, it is necessary to rebunch the colliding proton beam in the Main Ring to a few intense bunches for better collision with the antiproton bunches. These bunching requirements for colliding beams will place new demands on the performance of the Main Ring and an effort is underway to study Main-Ring performance and develop the required capability.

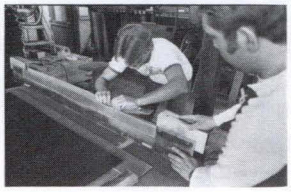
The antiproton target station is under construction. The civil construction is completed and magnet installation is in progress. When the 100-GeV extracted-beam transport line is complete, targeting studies will start. Experiments in the Meson Laboratory on production of antiprotons are planned to start early in the coming year.

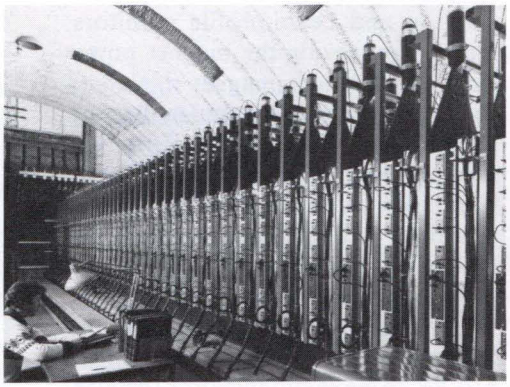
This broad program on colliding beams is carried out as a collaborative effort with several other institutions. The participating institutions are Argonne National Laboratory, the Institute of Nuclear Physics at Novosibirsk, USSR, Lawrence Berkeley Laboratory, and the University of Wisconsin.

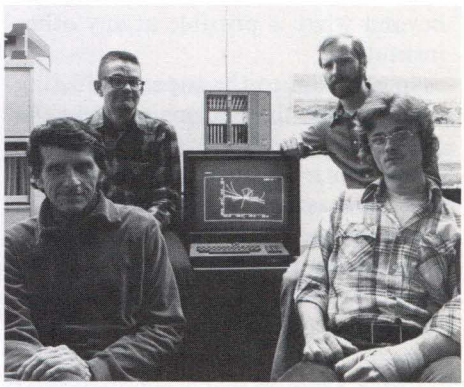


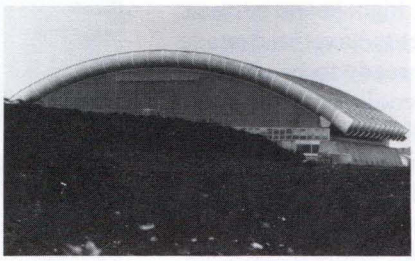


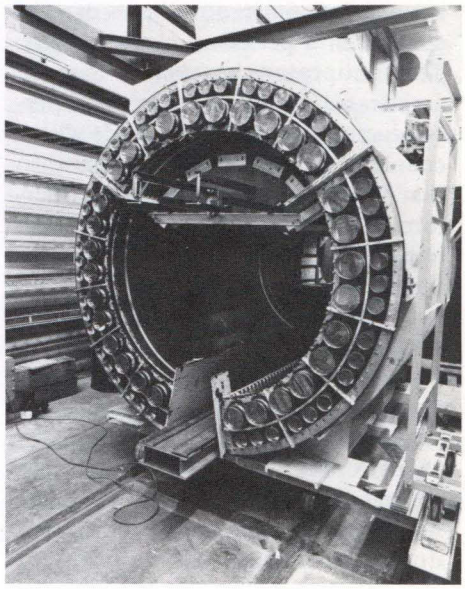
HIGH ENERGY PHYSICS RESEARCH ACTIVITIES . . .

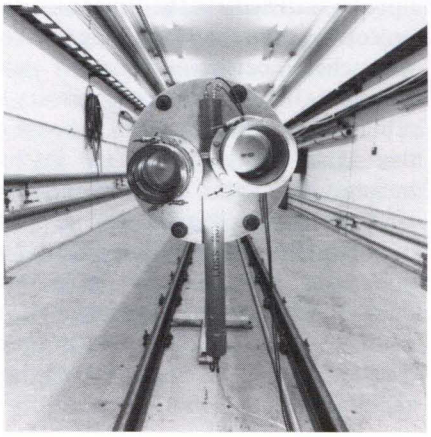












INTRODUCTION

Fermilab is one of the premier research institutions in high-energy physics, providing the accelerated protons, experimental areas, and technical support for a program of great vigor and distinction. The program is limited only by available funds and people.

The 400-GeV high-energy physics program is continuing into an era of increased sophistication of experimental technology and increasing demands for intensity and precision. In spite of long shutdowns for money saving and for Energy Saver installation in 1979, we continued to accelerate more protons for high-energy physics than our competitor. Users came from all over the world. Experiments were increasingly for investigation of higher quark states and quark-gluon or quark-quark interactions.

At the same time, we continued to make incremental improvements in beams and experimental areas. The long Mesopause ended, bringing a new Meson Area with two target stations and some TeV capability. The High-Intensity Area in Proton came into full being in 1979 and the Proton Area department also did significant work in superconducting-magnet development. All three areas carried out studies and conceptual-design work for the Tevatron Phase II project, the 1000-GeV fixed-target program.

The Physics Department was reorganized during the year to give greater strength to its activities in support of Fermilab staff research activities. The user community continued to provide valued input to the direction of the Laboratory.

PHYSICS ADVISORY COMMITTEE

At any given time, there are far more physicists anxious to do experiments at Fermilab than can possibly be accommodated. To help select the experiments that should be performed, the Director appoints a Physics Advisory Committee (PAC) consisting of twelve members appointed for 3-year staggered terms. The current membership is shown below. Physicists who want to perform experiments at Fermilab submit proposals to the Laboratory, which are then referred to the PAC. The Committee meets three times a year to make recommendations.

In 1979 the PAC considered fifteen proposals. The PAC asks the experimenters to present the details of their proposals in an open meeting. The PAC, based on the written proposal and the oral presentation, then poses questions to the experimenter. Based on all the available information, the PAC then makes a recommendation to the Director on whether or not the experiment should be approved. In 1979, the Director approved six experiments, rejected six, and deferred consideration of three other experiments, based on recommendations from the PAC.

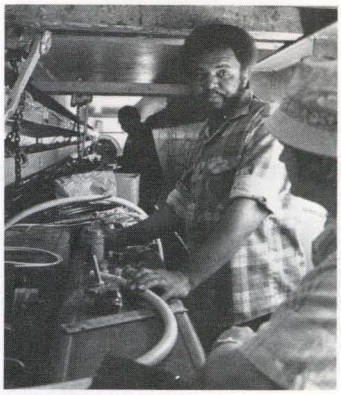
In addition to making recommendations on proposals, the PAC also advises the Director on general Laboratory policy. Of particular importance this year was the firm statement of the PAC regarding proposals from physicists outside the United States. The PAC recommended that "the predominant considerations in accepting or rejecting an experimental proposal should continue to be:

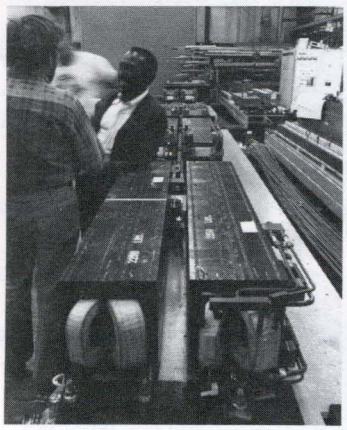
1) The physics merit,
2) The technical feasibility,
3) The capability of the group,
4) The resources required"

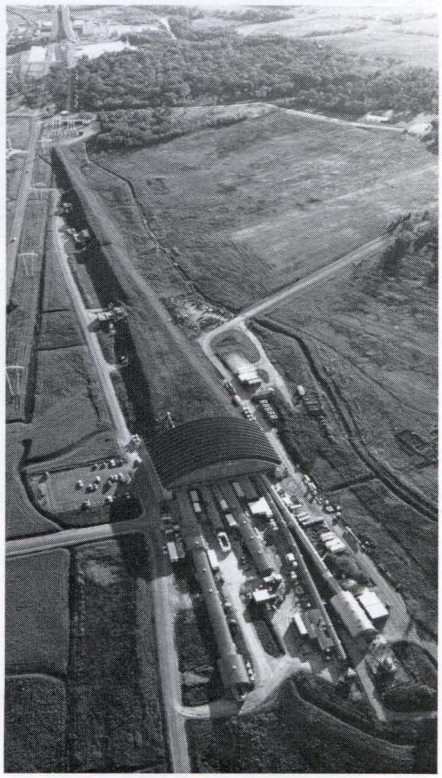
and that "the national or institutional affiliations of the proponents should not *per se* influence the acceptance or rejection of proposals." The PAC continued by stating that "we do not feel that it is in the interests of the Laboratory or of the field of particle physics to establish quotas or restrict the international character of the field. We hope that other major laboratories around the world would have similar policies." The position of the Fermilab PAC has been endorsed by the High Energy Physics Advisory Panel (HEPAP) and the International Committee on Future Accelerators (ICFA) as a model for other laboratories.

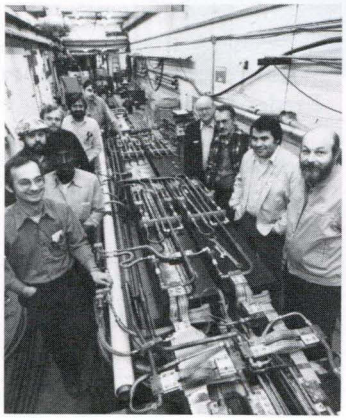
MEMBERS OF PHYSICS ADVISORY COMMITTEE

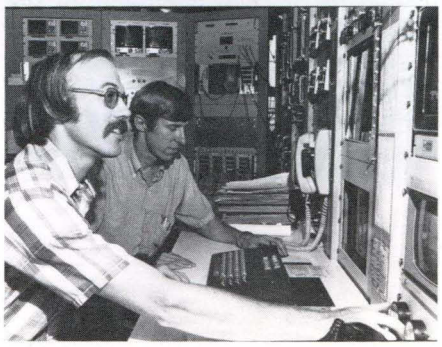
Stephen Adler
Institute for Advanced Study
Malcolm Derrick
Argonne National Laboratory
Roy Schwitters
Harvard University
Charles Baltay, Chairman
Columbia University
William Carithers
Lawrence Berkeley Laboratory
Frederick Gilman
SLAC
James Pilcher
Enrico Fermi Institute
Francis Low
MIT
Karl Berkelman
Cornell University
Myron Good
SUNY, Stony Brook
Martin Perl
SLAC
Lee Pondrom
University of Wisconsin











MESON DEPARTMENT

In late May, the Meson Area came out of a pause of operations that had begun in October of the previous year. During this period, major improvements were carried out in the existing beam-line facilities and construction of several beam-line enclosures was completed. This work increases the capabilities of the Meson Area to a significant extent. In addition, the Meson Area Operations group took advantage of the interruption to make significant improvements in the power-supply, cooling-water, and radiation-safety systems to increase their operational reliability. Meson Area experimentalists spent the months of July and August recommissioning beams and detectors that had been idle since September of 1978. In spite of the fact that there were only

four months of normal operation, five experiments were completed.

Because of the strong interest in studies of hadron constituents, which are thought to govern the behavior of rare high-p_t processes, the experimental program required intensity and energy increases in the beams. The original Meson Laboratory design employed a single production target viewed by the six secondary-beam lines. By steering the primary proton beam, one of the beams could be taken to a very small production angle for high intensity, but only at the expense of lower intensity in the other beams. During the pause, a two-way split of the primary proton beam and a new production-target train were built to improve this situation. By separating the two west beams, M5 and M6, and providing an independent primary proton beam and production target, two or more beams can be simultaneously operated at small production angles.

The two-way split and the target train have worked successfully, giving considerably enhanced meson and proton fluxes in the beam lines. Full use of the two-way split capabilities has already been made by a Fermilab-Cornell-Arizona-California-Northeastern-North Central experiment, E-577, in M6 studying pion-proton elastic scattering at very high t-values and a Rutgers-Michigan-Minnesota-Wisconsin group measuring the form factors describing Λ^0 beta-decay in M2, E-361. Consideration of a future three-way split was included in the project and the groundwork begun.

The energy of the M6 beam line has been doubled from 200 to 400 GeV by changing the optics mode and quadrupole configuration and converting the main bend point from conventional dipoles to high-field superconducting dipoles, utilizing Energy Saver-Doubler magnets. Since it was commissioned, this superconducting bend point has been operating continuously with better than 95% reliability, providing optimism for upgrading the energy of other Meson Area beams and saving considerable electrical power. The energy increase will considerably enhance the physics potential of the multiparticle spectrometer facility in M6, particularly for the study of high-p_t processes (hadron jets) being set up now, in E-557, by a Fermilab-Chicago Circle-Rutgers-Indiana-Maryland group.

In the M1 beam, the enclosures were made continuous to accommodate future installations. A phased development is planned in M1 to raise the energy to Tevatron levels and incorporate a very high intensity pion beam using highly corrected optics to achieve a 2-mm final spot size. The aperture for the M3 neutral beam was increased by replacing 260 feet of buried 14-inch diameter beam pipe with 36-inch pipe. Following this construction, the improved beam was used for a study of the rate at which pion-muon atoms are formed in the decay of neutral kaons to test experimentally our present understanding of the interactions between pi and mu mesons. Following this experiment, the Stanford-Chicago-Wisconsin team of E-584 will search for the existence of long-lived neutral massive particles suggested by some theories of quark spectroscopy.

A Rochester-Minnesota-Fermilab group measured the rate of electromagnetic transitions of a K^+ meson to a spin -1 excited state K^{+*} in E-272. This transition can be thought of as a spin-flip of one of the constituent quarks of the K^+. The technique for measurement is necessarily sophisticated because of the rapid decay of the K^+. Previously, the data taking was completed for an experiment measuring the radiative widths of vector-meson states by this same collaboration. The naive quark model interprets these rates in terms of the magnetic moments of the constituent quarks and the preliminary results indicate good agreement with SU3 symmetry predictions.

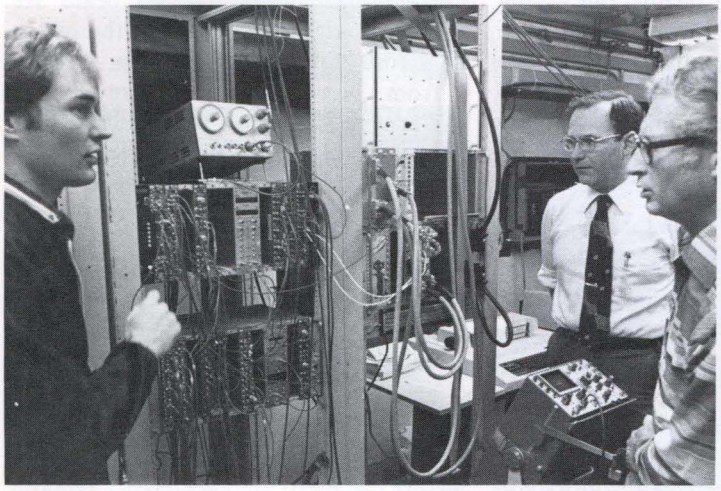
Experiments in the M1 beam are also looking at aspects of the quark picture of hadronic processes. A group from Northwestern, Notre Dame, Carnegie Mellon, and Fermilab is testing a large new spectrometer system designed to study the direct production of charmed states in pion-proton collisions in E-515. A prompt muon from a decay of a charmed state provides the trigger.

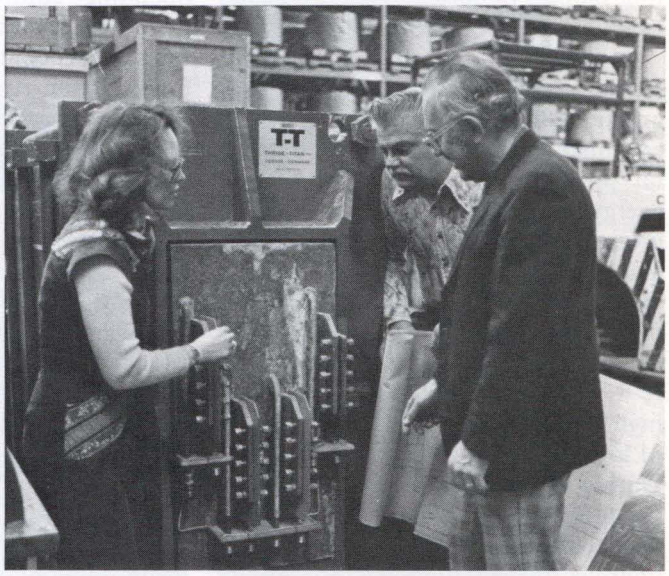
The Rutgers-Minnesota-Michigan-Wisconsin group working in M2, in E-620, has extended their earlier highly successful work on neutral-hyperon magnetic moments, specifically the Λ^0 and Ξ^0, to the charged hyperon moments. After the apparatus was reconfigured to produce a charged beam, the initial running has shown that charged hyperons produced inclusively are polarized and that measurements of the Σ^-, Ξ^-, and Σ^+ magnetic moments are practical. A preliminary result for the Ξ^- magnetic moment shows it to be different from a prediction based on measured values of the neutron, proton, and Λ^0 moments and on a simple valence-quark model.

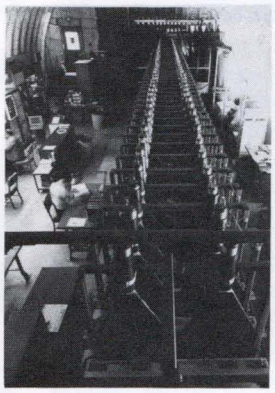
The multiparticle spectrometer in M6 is also being used by a group from Arizona, Brookhaven, Florida State, Notre Dame, Tufts, Vanderbilt, and Virginia Tech for a new-particle search in E-580. The trigger will select final states containing at least two neutral "V's", either Λ^0 or K^0 signatures, to study the mass spectrum of possible parent states.

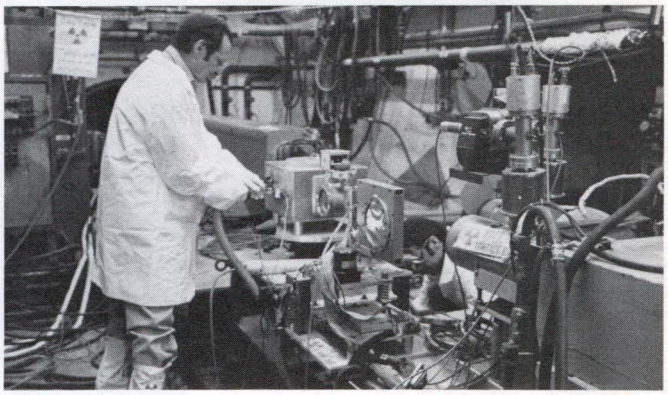
Although the original rationale for the long interruption of research activities in the Meson Area was to conserve operating funds, the unique opportunity for major construction activities has been fully utilized. The Area has returned to research operation with major and significant improvements in the beams and facilities and a vigorous experimental program.

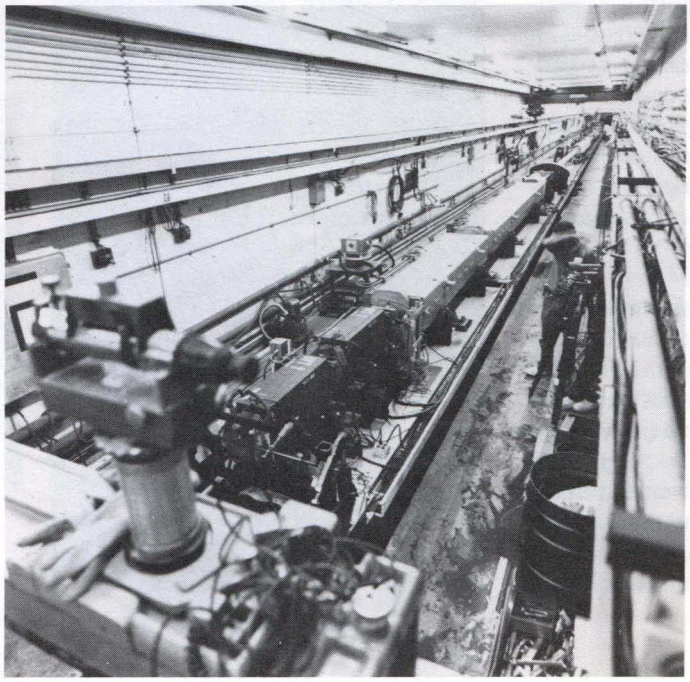
NEUTRINO DEPARTMENT

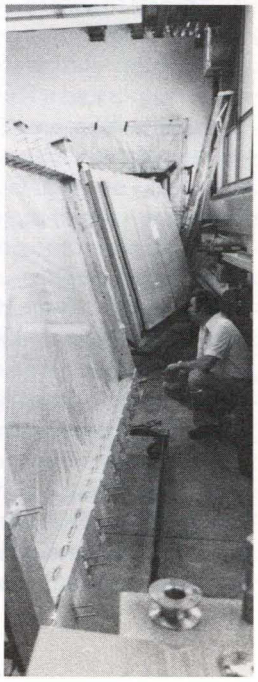


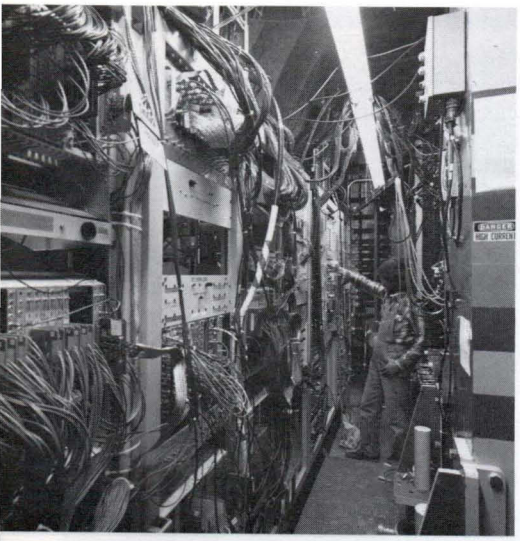












Two large steps were taken in the Neutrino Experimental Area this year toward understanding the mysteries deep in the heart of matter. We have known for several years that protons, neutrons and heavier nucleii can be thought of as being composed of quarks, and that the quarks may themselves be truly elementary. But there is still much to be learned about "how quarks move," that is, the dynamical interactions that cause them to bind together and make nucleons and mesons.

One very important way of learning about quark motion is via the scattering of very high energy neutrinos from quarks in the nuclei of atoms. Scientists from Cal Tech, Rockefeller University, the University of Rochester, and Fermilab did such an experiment, E-616, in the Neutrino Area this year in an electronic apparatus weighing over 1200 tons, but delicate enough that it could detect and measure a neutrino collision and its recoiling muon to within a fraction of a centimeter in space and the energy deposited in the collision to a few percent. Many thousands of such collisions are recorded in the course of the experiment and the pattern of the events compared with theoretical predictions. The end product will be published under a cumbersome technical heading in a scientific journal, but it could as well be titled "How Quarks Move!"

The second big step was taken by an international collaboration of scientists from Canada, Japan, Korea and the United States. The E-531 group, led by Professor N. Reay from Ohio State University, measured for the first time the lifetime of the heavy quarks that give rise to "charmed" mesons. These heavy c quarks behave somewhat like heavy uranium nuclei in that they cannot exist forever in a stable condition. They experience radioactive decay into lighter quarks much like the radioactive decays of uranium nuclei into lighter elements. But where uranium takes thousands or millions of years to decay, the heavy c quark takes only a few millionths of a millionth of a second. The group tackled the problem using nuclear emulsions and a clever new technique for locating the events in the developed emulsion. They have already reported early results at the International Lepton-Photon Symposium held this year at Fermilab and are preparing more extensive and complete results for publication. Measurement of the lifetime of charmed mesons is a unique and helpful tool for understanding the properties of heavy quarks and heavy-quark bound systems.

Beam-line improvements in the Neutrino Area were directed at either reliability improvements or shielding improvements. The N5 beam line, an outdoor above-ground beam line, was covered with concrete shielding over the 1 kilometer of its length that had been exposed. The desire of E-595 to transport 10^5 to 10^6 particles per pulse to Lab E, together with more-stringent requirements on the possible radiation levels in an accident condition, led to the very extensive shielding. The 350-GeV/c dichromatic beam and the associated monitoring equipment, which was commissioned for the first time in June of 1978, was improved during 1979 in order to meet the experimental requirements of E-616, the Caltech-Fermilab-Rockefeller neutrino experiment. The work was carried out successfully, resulting in a very reliable beam that performed without failure during the entire 8-month run. This reliability serves the experimenters well, while also reducing the radiation exposures of the workers who maintain this equipment.

As part of Neutrino Department's program to reduce radiation exposures to workers who work on target trains, a significant amount of maintenance work on the horn train and quadrupole-triplet train was done with remote-handling equipment. This equipment has been an important factor in reducing radiation exposure.

PROTON DEPARTMENT

Major accomplishments this year in the Proton area include completion of two experiments, E-258 and E-567, in the new High Intensity beam line, installation of a large new multiparticle spectrometer in the Tagged Photon Laboratory, the completion of major installation work on several large new detectors (including E-516 and E-326), operation of the P-4 satellite refrigerator, and the successful test of the Proton Laboratory 4-foot low-current superconducting dipole.

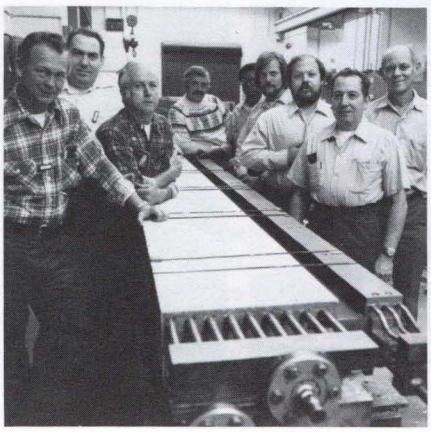
The High Intensity Area (HIA) located in the Proton-West beam line has been improved in two significant ways during the past year. The first upgrade came less than one year after the HIA first operated, when the transported beam momentum was increased by 50% to 300 GeV/c, making it the most intense 300-GeV/c π^- beam anywhere. The second improvement was completed in the fall when a 10-component muon spoiler system totaling 75 feet of magnetized iron was installed. These spoilers reduce the unwanted muon background, making the HIA a "clean" experimental facility attractive for di-muon experiments.

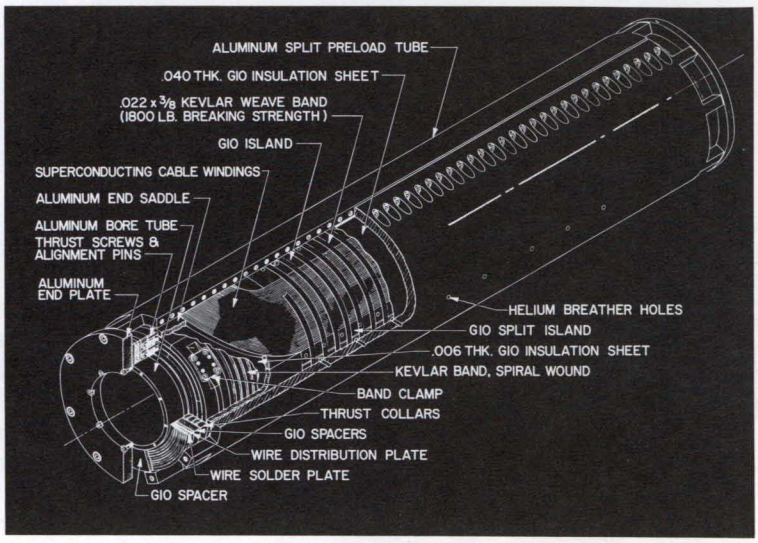
A collaboration from the University of Chicago and Princeton University completed an experiment, E-258, studying high transverse momentum inclusive hadron production by negative pions on protons. The experiment and its results were described in *Fermilab Report* (October, 1979).

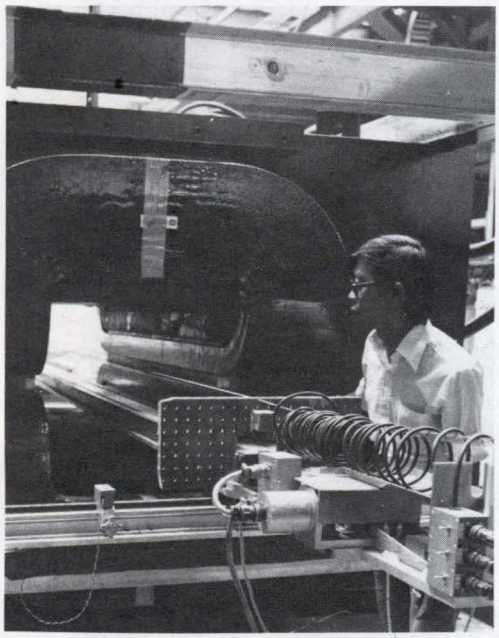
The same collaboration is preparing a new experiment, E-326, which will use a solid-iron toroidal magnet system for the detection and analysis of muon pairs produced in pion-nucleon collisions. Muon pairs will be detected to masses of 15 GeV. This experiment is installed and taking beam for testing purposes and will take data early in 1980.

The Princeton University—Torino University—Saclay and Brookhaven National Laboratory collaboration working on E-567 has recently completed a charm search in the High Intensity Laboratory. A first-pass analysis of the data has been encouraging. Sixty J/ψ events have been reconstructed, and final analysis of the data is now in progress.

The major activities in the Proton-East photon beams included the completion of an E-401 run to study the photoproduction of high-mass two-body final states. This is an experiment in the broad-band photon beam and is an extension of their earlier work, which led to their discovery of a







charmed-baryon state. In the current experiment, the spectrometer has been upgraded to include more magnets, much better particle identification, and improved mass resolution. Their data taking was completed in November and includes measurements of the energy dependence of ψ (3.1) and ψ (3.7) cross sections and the investigation of the mass spectrum of photoproduced e^+e^-, $\mu^+\mu^-$, K^+K^- and other identifiable two-body states in the mass range 3 to 7 GeV.

This year has seen the major part of the installation of a large new multiparticle spectrometer facility in the Tagged-Photon Laboratory. The installation of this very large system has been a major effort of the Proton Department.

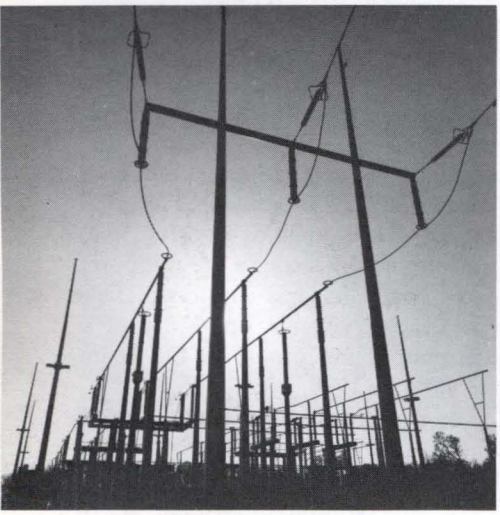
1979 saw the removal of one major experiment, E-288, from Proton Center and the installation of another, E-497. The final phase of the dimuon experiment, which discovered the upsilon particle, was complete last spring and the substantial job of removing their apparatus, making major modifications to the pit to allow for more efficient movement of heavy apparatus, and the installation of the charged-hyperon beam were major activities this spring. The heart of the charged-hyperon beam is a very large dipole magnet 7 m long with a magnetic field of 35 kG. This magnet was complete this fall and was successfully tested at full field in November.

The Proton Lab has continued an extensive research and development effort in the area of superconducting-system applications. Large-aperture, high-field magnets are being developed for use in secondary beam lines. High fields are necessary to upgrade the Proton Lab facilities conveniently to Tevatron energies. The magnet apertures are 4.5 to 6 inches in diameter, large enough to use the primary proton beams economically. These magnets attain the necessary fields using low, 200-400 A currents, thereby minimizing electrical-lead thermal loads and simplifying both cryogenic and electrical distribution systems.

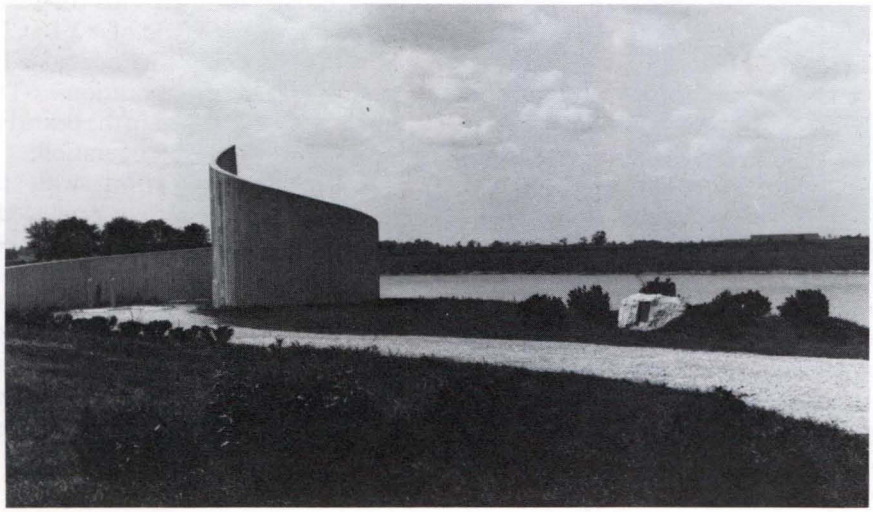
Significant progress toward realization of a superconducting beam line in P-West occurred during 1979. A 500-W liquid-helium refrigerator was installed and tested in place. This installation features a screw compressor, modified Energy Saver satellite heat exchangers, Proton-Lab developed gas and wet-expansion engines, associated gas purification, and instrumentation. This system first produced helium into a test dewar in August 1979. Fabrication and installation of liquid-helium transfer lines from the refrigerator to the midpoint of the beam line has continued. This will allow cryogenic operation of a superconducting dipole in the beam line early in 1980.

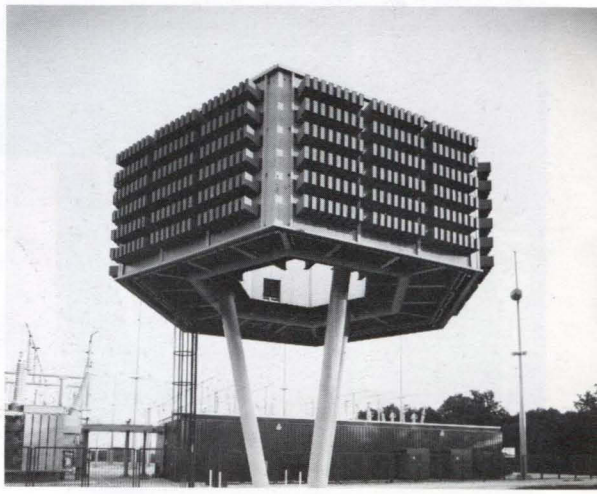
The past year also saw completion of our first superconducting dipole. This magnet consists of 4 shells of NbTi superconductor wound on a stainless-steel bore tube. A shrink-fit aluminum outer pipe provides clamping to minimize conductor motion under the electromagnetic forces. After immersion tests in a vertical dewar, a 4-foot long, 6-inch clear-bore coil was encased in its vacuum-insulated helium vessel and suspended within an ion yoke, thereby forming a useful dipole magnet. This dipole attained a measured field of 4.2 T at 210 A, with field uniformity adequate for beam-transport application. This dipole will be installed in the beam line in time for early 1980 operation.

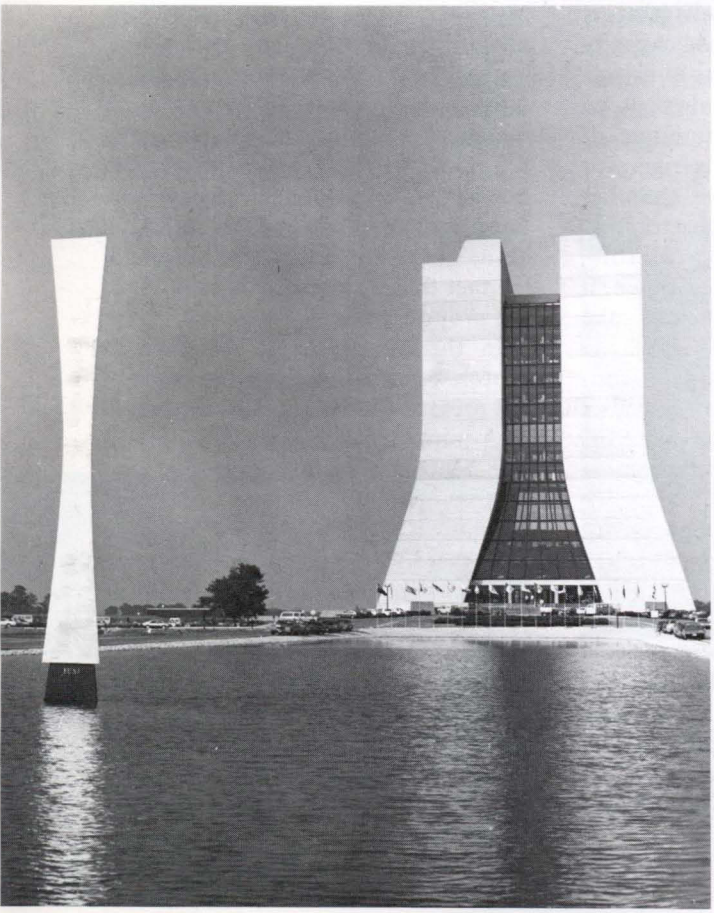
A collaborative effort with the Research Services Group produced a companion quadrupole coil. This coil attained 13 kG/inch gradient at the short-sample limit 340 A after only three training quenches. Finally, the fixtures for 10-foot long, 6-inch bore dipoles have arrived, allowing production of the necessary number of dipole magnets to begin.



Fermilab







MAJOR DETECTOR CONSTRUCTION

The commissioning of six major new electronic detectors began in 1979. The construction of each detector was begun prior to 1978 and each is expected to be completed during the first quarter of 1980. Four of the detectors are large-aperture multiparticle spectrometers. The largest of these spectrometers has been constructed in the Tagged-Photon Laboratory by a collaboration of Colorado-Fermilab-Univ. Calif. at Santa Barbara-Toronto. Its first use will be for measurement of the photoproduction cross section of charmed particles as part of E-516. A Rockefeller University group, E-612, has also been approved to measure diffractive photoproduction of the light vector meson with this facility. A Carnegie-Mellon-Northwestern-Notre Dame collaboration, E-515, has constructed a large-aperture spectrometer in M1 in the Meson Area to measure the cross section for charm production in πp interactions. A Fermilab-Iowa State-Yale collaboration, E-497, has built a forward particle spectrometer in Proton-Center in order to measure the interaction cross section of charged hyperons on hydrogen. Finally, an Athens-Fermilab-McGill collaboration, E-537, has built a spectrometer for dimuon production in $\bar{p}$-nucleon collisions in the P-West high-intensity area.

In addition to these four detectors, a large toroidal spectrometer was constructed by the Chicago-Princeton group of E-258 in P-West to measure dimuon production in π-p collisions and a high-resolution calorimeter has been built in Lab C of the Neutrino Area for the purpose of measuring neutral-current interactions.

Major improvements were carried out for several laboratory detectors that have been in use for many years. The Chicago Cyclotron Spectrometer has been largely rebuilt for E-610, an Illinois-Fermilab-Pennsylvania-Purdue-Tufts collaboration. It now has modern proportional and drift chambers. The most significant improvement, still in progress, is superconducting coils that will replace the conventional coils on the Chicago Cyclotron Magnet. The construction of these coils began in 1978, under the direction of Research Services, and the final pre-installation testing will be complete in February 1980.

During 1979, work was also begun on the design of a set of superconducting coils for the 30-inch bubble chamber. A consortium of universities in the United States and Europe has also been building a downstream particle identifier that separates particles on the basis of their differential energy loss.

A major set of improvements to the 15-foot chamber was underway during 1979. Two new hydrogen refrigerators were installed. The combined capacity of the two new refrigerators is sufficient to cool the chamber down without using up large amounts of liquid hydrogen. The old refrigerator was also a major cause of chamber down time. The new refrigerators are expected to be more reliable. Moreover, once it is cooled down, a single refrigerator can keep the chamber at its operating point.

Since these new detectors are considerably more complex than detectors built a few years ago, the demand for laboratory-supplied pool equipment has increased significantly. For example, the Computing Department, which formerly supplied one-third of the groups at Fermilab with data-acquisition computers, is now providing complete data-acquisition systems to thirteen of the nineteen experimental setups. It is also providing peripheral equipment, such as disks and tape drives, to most of the remaining six. A similar evolution has occurred in the detector electronics provided from the PREP pool by the Laboratory. Five years ago a large experiment had approximately 50 counters; today the largest experiments have nearly 1000 counters.

TEVATRON PHASE II

Tevatron Phase II is a project to carry out the improvements for 1-TeV fixed-target research. The project has provision for 1-TeV slow extraction, for upgrading the Switchyard to 1 TeV and construction of three new beam lines, which will replace existing beam lines. In the Neutrino Area, a 750-GeV/c muon beam is planned for below-ground installation on the east side of the Neutrino Area, between it and Proton Area. The beam will provide 10^7 muons for 10^{12} interacting protons at 500 GeV/c. The below-ground beam was chosen in order to range out all muons before they reach the site boundary. The present muon beam, the N1 beam, will be dismantled because it cannot meet the Laboratory's above-ground radiation limits at the site boundary, in spite of the fact that its intensity is only 1% of the proposed beam.

In the Meson Area, a polarized-proton beam will be built in place of the present M2 beam. This beam will be a joint Argonne-Fermilab project. The beam makes use of the fact that protons from Λ^0 decay are longitudinally polarized. The three-way split that has been designed for the Meson Area will be implemented as part of this project.

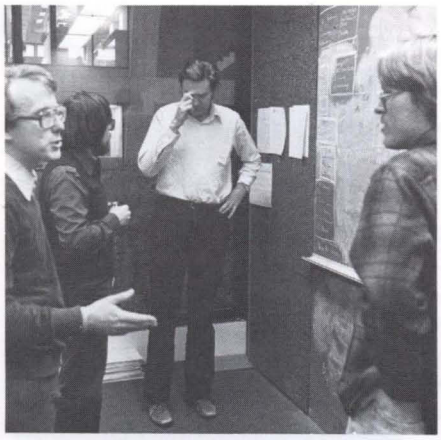
Major modifications are planned to Proton East in order to improve the tagged-photon beam and to replace the existing broad-band photon beam with a new beam. It is proposed that the new enclosure have the capability

of containing a broad-band photon beam, as well as a proton beam. A splitting station will be installed in P-East in order to have simultaneous operation of the new beams and the tagged-photon beam.

The energy of certain secondary beams, such as the N5 beam, M1 beam, M2 beam, and the P-West high-intensity beam, will be increased to 1 TeV by replacing conventional magnets with superconducting magnets. These improvements, while related to Tevatron II, will be carried out using capital-equipment funds.

A series of accelerator improvement projects that are needed for both the present 400-GeV neutrino program and the Tevatron 500-GeV neutrino program has been planned for the Neutrino Area. The first of these projects, the hardening of the N0 muon shield with steel between enclosure 100 and 101, is planned for the summer of 1980. This improvement is being carried out in order to reduce the muon background in the neutrino hybrid emulsion located in the Wonder Building so that the experiment can run at 400 GeV and perhaps 500 GeV. As part of this project, the N7/N5 beam between enclosure 99 and 103 will be relocated so that it does not interfere with the steel shield. It is further expected that a new flavor (beam-dump neutrinos) neutrino beam located at the end of the present muon shield will be of great interest with the Tevatron. These projects when completed in 1982 will also provide a major step towards 1-TeV operation in the Neutrino Area. Tevatron II includes provision to bring the shield to a full 1 TeV, to make it possible to increase the N7/N5 beam to 1 TeV, and to provide an enriched electron-neutrino beam.

During 1979 conceptual designs, prepared in earlier years, were re-examined for potential cost savings. Because the Tevatron II project will not begin until 1982, cost estimates have been revised. In order to keep the total estimated cost within fixed limits, the scope of the project has been reduced. The increase of the secondary beam energy in M1, M2, M4, M6, P-West high-intensity beam, the charged-hyperon beam, the tagged-photon beam, and the N7/N5 beams will not be done as part of Tevatron II. Improvements will be made when experiments are approved to use the higher energies.

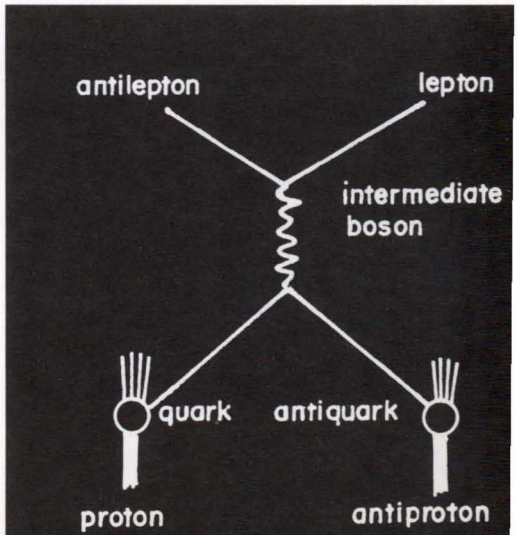


THEORETICAL PHYSICS

The theoretical physics program at Fermilab has two important components: the development of an outstanding resident theoretical group and the operation of a vigorous visitors program.

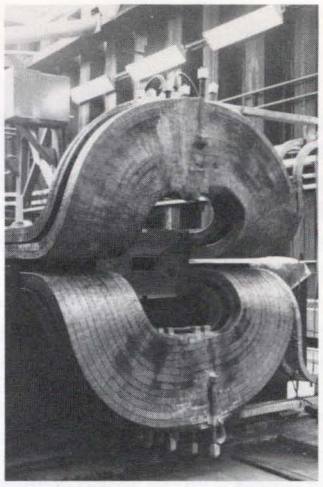
At this time, the Fermilab group consists of three permanent members, two five-year members, six research associates, and six long-term visitors. In addition, several faculty members at nearby universities participate actively in our research program. The group will continue to grow judiciously in the immediate future.

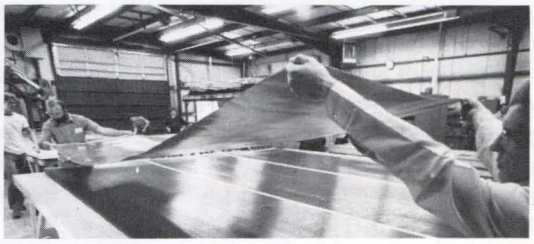
In the recent past, the Fermilab group has provided facilities (and in many cases, support) to 150 to 200 visitors per year. Most visits last for periods of a few days to a month. A number of important benefits are derived from this large flux of visitors. It enriches theoretical activity at Fermilab and exposes the Fermilab experimental program to a wide range of theoretical ideas and opinions. Beyond that, it makes a significant contribution to the national theoretical physics program by providing stimulation, both theoretical and experimental, to university physicists. A special effort has been made to include promising young theorists, as well as established senior theorists in the program.

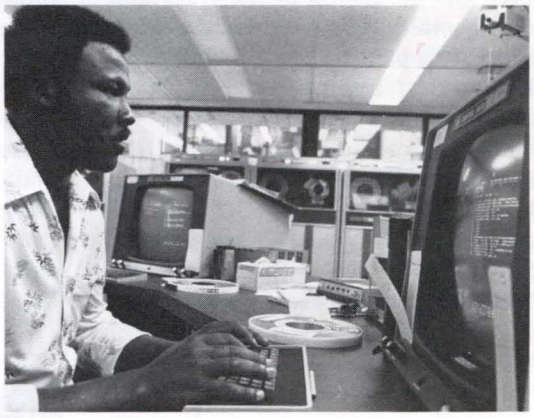


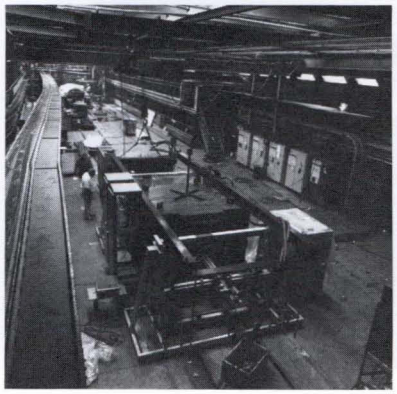
The Theoretical Physics Department makes key contributions to the intellectual life of the laboratory. Members of the department organize weekly theoretical seminars and the weekly joint experimental-theoretical ("wine and cheese") seminar. A series of Academic Lectures on current research topics is intended as cultural enrichment for experimental graduate students and others. Members of the group are frequently called upon to speak at laboratory workshops or informal soirees on specific physics topics. A few members of the group participate regularly in meetings of the laboratory's Physics Advisory Committee. Others have become involved with particular proposals or experiments. Of course, informal interaction with experimentalists takes place constantly.

Recent research activity has covered a wide range of topics in high-energy physics. Several members of the group have contributed extensively to elaborating the predictions of quantum chromodynamics (QCD), the theory of the strong interaction between quarks and gluons, for the deep inelastic scattering of muons or neutrinos from the proton. Their work has helped to refine the experimental tests of QCD and has provided new insights into the structure of the theory. Others in the group have studied the quantum inverse problem of two-dimensional field theories, and have produced a succession of elegant results ranging from the formal underpinnings to exact solutions of several specific field theories. The motivation for studying these two-dimensional theories lies in part in the hope that they will provide needed insight into the problem of solving QCD. On the more phenomenological side, considerable effort has gone into the study of particles composed of heavy quarks—so-called quarkonium systems. Old and new techniques of nonrelativistic quantum mechanics have led to new understanding of the nature of the force between quarks.









PHYSICS DEPARTMENT

There are approximately 160 PhD physicists at Fermilab, by far the largest agglomeration of single-discipline physicists in the country. This number includes some 15 theorists and 20 to 25 research associates. Over 90% of the Fermilab physicists received their degrees in the last two decades from the two dozen

major U.S. universities in the field of high-energy particle physics. It is also a young group, with the median age significantly under 40.

The Physics Department of Fermilab provides for the essential need of this group of professionals, participation in particle research. Although the majority of physicists hold administrative and leadership roles and work in a variety of support jobs, most still maintain active participation in particle research. In most cases, the participation in high-energy physics experiments is through groups of four, five, or more. In these cases, both the intellectual and effective participation in any major Fermilab experiment is large in importance. Moreover, in several instances Fermilab physicists are the spokespersons of such efforts, carrying the burden of organization and intellectual leadership. Finally, there are experiments where Fermilab participation is minimal, one or two Fermilab physicists. Although not supported in a major way, such endeavors provide variety and freedom of choice in the pursuit of experimental research opportunities.

The Physics Department provides a central organizational home for the youngest particle physicists, research associates. Although the young Research Associates work exclusively on a single experiment during their residence at Fermilab, they share a common wing of the 10th floor as their office space, so that their interaction and communication are maximized. The Physics Department actively searches for the best graduating PhD's and maintains contacts with top U.S. and foreign universities and research centers in the recruiting process.

The second most important facet of the Physics Department is that it provides an effective, skilled technical manpower support pool. There are approximately thirty highly skilled technicians in the Physics Department. Rather than dispersing the manpower into many experiments, the pool operates in such a manner that experiments in the construction phase are most helped by the manpower pool of the Physics Department. Thus one or two major experiments can be mounted per year. Major experiments so helped are, for instance, the neutrino experiment E-616, for which the Physics Department designed and built some 40 large 10 × 10 ft wire spark chambers and readouts. Presently in the finishing phases are very large chambers for the two major Proton Area experiments, E-516 and E-537. Massive support is also being provided for two other experiments, E-497 and E-594. Some of the largest and most difficult drift-chamber detectors for E-516 are constructed in the shops of the Physics Department. Precision wire-placing machines and tables were designed and locally constructed. A small but versatile electronics group undertakes projects varying in scope from the design and construction of time-digitization systems for several thousand wires to a few sophisticated photomultiplier bases.

Fermilab physicists most often participate in mounting and executing large experiments in collaboration with their university colleagues. Some notable examples of this in recent history are:

E-288. COLUMBIA, STONY BROOK, FERMILAB COLLABORATION
An experiment which discovered Υ, Υ' *and* Υ'' *mesons, thus opening vistas of new quark flavors and quarkonium states.*

E-87. COLUMBIA, ILLINOIS, FERMILAB COLLABORATION
Using an elaborate particle spectrometer in the broad-band photon beam, this group established that the newly discovered ψ *particle is a hadron. In addition, the first indication of new-flavor baryon states was observed.*

E-326/616. CAL TECH, ROCHESTER, ROCKEFELLER, FERMILAB COLLABORATION
Utilizing a massive 1200-ton detector, a precise value of the neutrino cross section was measured by this group. An extensive measurement of the nucleon structure function utilizing the same apparatus is in progress.

Looming on the horizon is a whole roster of experiments where Fermilab physicists play a major role:

E-516. FERMILAB, UNIV. OF COLORADO, SANTA BARBARA, TORONTO COLLABORATION
A very massive and sophisticated spectrometer in the tagged-photon beam.

E-594. FERMILAB, MICHIGAN STATE, NORTHERN ILLINOIS UNIV. COLLABORATION
A very novel design, massive (200-ton) flash-tube neutrino detector capable of resolving directions of hadronic and electromagnetic showers induced by neutrino interactions.

E-537. FERMILAB, MCGILL, UNIV. OF MICHIGAN, UNIV. OF ATHENS COLLABORATION
A massive wide-acceptance spectrometer to utilize the newly constructed high-intensity beam of antiprotons in P-West.

E-557 FERMILAB, CAL TECH, UNIV. OF ILLINOIS, UNIV. OF INDIANA, MARYLAND COLLABORATION
A superconducting-magnet spectrometer using a calorimeter and Cerenkov counter to study jet production in hadron collisions up to 400 GeV in energy.

E-497. FERMILAB, YALE COLLABORATION
In a recently constructed pit in the Proton Center beam line, this group has created a hyperon beam facility to study properties of hyperons.

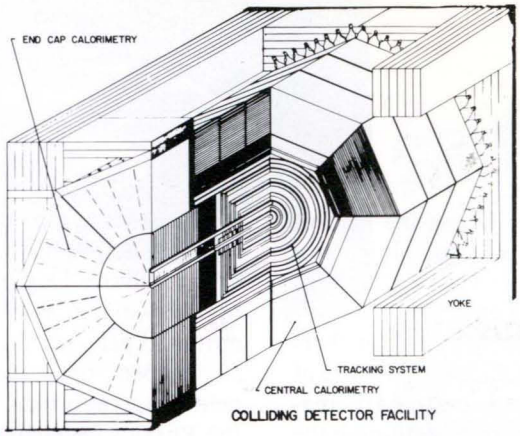
The Physics Department can and does provide support in mounting massive modern experiments of particle research. As such, it compares favorably with shops and technicians of many major physics departments at major universities. The comparison ends, however, when one notes that while major university high-energy groups may number a dozen or so

physicists, the Fermilab Physics Department must support 50 to 60 physicists currently active in particle research. Only by straining efforts to the maximum and, often, short-changing experiments can the Physics Department cater to the three major efforts and eight smaller ones now underway.

A third facet of the Physics Department is its maintenance and support of a large bubble-chamber film-analysis facility (FAF). During the past seven years, the facility has grown and been perfected so that it now represents the best and perhaps largest single facility in the U.S. The six scanning and measuring tables are under central large computer control, allowing instant return on the quality of measurement and kinematic fits. The most complex neutrino-induced events generated by the 15-foot bubble chamber detector are scanned and measured on these machines (MOMM's).

In addition, the engineers and physicists of the Physics Department have constructed a semi-automatic film-measuring machine (SAMM) that can measure events of lesser complexity than neutrino events with a minimum of human assistance. In fact, SAMM was successfully used in the measurement of some 100,000 spark chamber pictures of the Wisconsin-Harvard-Pennsylvania neutrino experiment. A dozen scanners and several physicists and programmers constitute the manpower of FAF.

Besides these three major facets of support that the Fermilab Physics Department provides, a multitude of smaller services is provided. The clerical and typing support for all scientific papers and manuscripts and all graphs and drawings in preparation for publication are provided by the physics department. Other support includes travel to conferences, collaboration meetings, support and organization of travel for colloquium speakers, and support of major conferences organized at Fermilab.



COLLIDING DETECTOR FACILITY

COLLIDING BEAMS DETECTOR

When the Collider Facility at Fermilab is completed in 1983, it will be possible to commence a program investigating $p\bar{p}$ collisions at 2 TeV in the center of mass system. A powerful detector is needed to explore this very high energy region where new phenomena and heavy particles, like the W-bosons, mediators of the weak interaction, can be expected to be discovered.

The Colliding Detector Facility Department has, together with collaborating universities and national laboratories, been concerned with the design of such a detector in 1979. A preliminary design report was issued in May 1979, summarizing the work up to that time. It describes a detector based on a 1.5-T solenoid containing charged-particle tracking and surrounded by photon and hadron calorimetry and muon detection. Since then, the design work has continued with the aim of completion during the first half of 1980.

Since May, extensive work has gone into the design of the calorimeter. We are trying to optimize the design with regard to cell size, resolution, and event identification. To this end, event structures such as W-boson production and decay, $t\bar{t}$ jets, and $q\bar{q}$ scattering are being modeled on a computer and then studied by various hypothetical calorimeter simulations. Progress is being made on this problem, and, as a result, more cells of a smaller size are being considered than originally planned.

In addition to the theoretical work, an extensive experimental program has been undertaken in the M5 beam to measure the response function of two types of electromagnetic calorimeters and two types of hadron calorimeters. Prototype structures proposed for the detector form the basis of these tests.

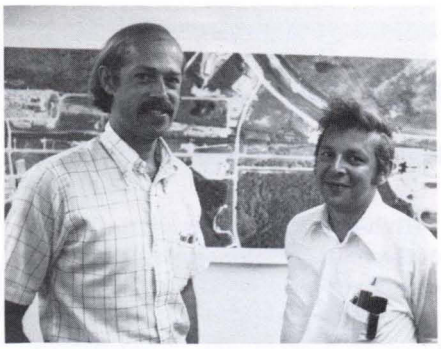
The work is receiving much valuable help from the outside community. At present, the following groups are participating in the design:

1. Fermilab
2. Argonne National Laboratory
3. Japan
   University of Tsukuba
   KEK
   University of Tokyo
4. Cal Tech
5. University of Chicago
6. University of Illinois
7. Purdue University
8. University of Wisconsin

In addition, we expect connections with an Italian group to be established during this next year, as well as other universities in the U.S. At present, these outside groups are providing extrememly valuable support to the theoretical understanding of the detector as well as the construction of actual prototypes. This support is and will remain vital to the success of the detector.

In order to insure adequate debugging time, it is essential to have large parts of the detector assembled and operational as much as a year ahead of the time planned for their use. Design and prototype work is expected to be finished in 1980, and we hope to begin installation in an experimental hall in 1982.

USERS ORGANIZATION . . .



The Fermilab Users Organization consists of graduate students, scientists, and senior engineers who visit or are in residence at Fermilab to engage in high-energy physics research. Between annual meetings of the full membership, held in late April, the affairs of the Organization are handled by the 13 members of the users executive Committee (UEC).

One half the UEC members are elected annually. During 1978-79 the members were R. Deibold (Argonne), A. Erwin (Wisconsin), L. Leipuner (BNL), S. Loken (LBL), M. Longo (Michigan), T. O'Halloran (Illinois), J. Prentice (Toronto), A.L. Read (FNAL), J. Rutherford (Washington), F. Sciulli (Cal Tech), M. Schocher (Chicago), P. Surko (Princeton), and S. Wojcicki (Stanford).

Early in the tenure of this committee, the Laboratory suffered the resignation of R.R. Wilson as director. The committee expressed strong and deep gratitude to him from the user community for his singular accomplishments in the creation of the laboratory. They followed this by appointing a subcommittee that worked directly with a subcommittee of the trustees (URA) to plan and carry through a very successful symposium in Wilson's honor held in April.

The UEC spent a considerable fraction of its meetings during the past year in frank discussion with the new director about users' concerns and the relationship of these concerns to his vision for the lab. Topics discussed with Dr. Lederman and his deputies included the Laboratory priorities and time scales, status of Tevatron magnet construction and installation timescale, concerns about 400-GeV operation, and the very worrisome situation of funding. Besides providing one channel of information to the director, the committee saw an important role as a conduit from the lab to the users. To maximize this, an attempt was made to provide minutes of their meetings to the users in a minimum of time with as much frankness as possible.

Historically, the committee has played an important role and spent considerable time discussing recreational facilities, the Users Center, housing, and so forth. These are concerns that may generally be classified as affecting the quality of users' lives at the Laboratory. The committee's limited time (one meeting approximately every 2-1/2 months) and a membership of dominantly commuting physicists have not optimized its effectiveness in this regard, particularly as it relates to users in residence (post-docs, grad students, etc.). The committee requested that the director appoint his Quality of Life Committee from a list of candidates provided by the UEC. This committee is to be a forum for discussion with relevant FNAL staff on an on-going basis. Its membership is to be revised annually by the director in consultation with the UEC. In its first year, the Quality of Life Committee, chaired by R. Gustafson (Michigan), provided important input in creating recreational, cultural, and social outlets for the laboratory's users.

Other specific examples of UEC business this last year include discussions of the role of small computers at the laboratory, nomination of several Physics Advisory Committee members to the director, and organization of the new Annual Users Meeting. This meeting provided an opportunity for the new director to present to the users his plans for the short and long term. There were also presentations relating to Tevatron plans, the 400-GeV program, and the new CYBER 175 computing system. This last year also saw implementation of a request by a previous UEC for a Laboratory Visiting Committee appointed by the trustees. The UEC and the users generally saw a new laboratory administration off to a strong and exciting start.

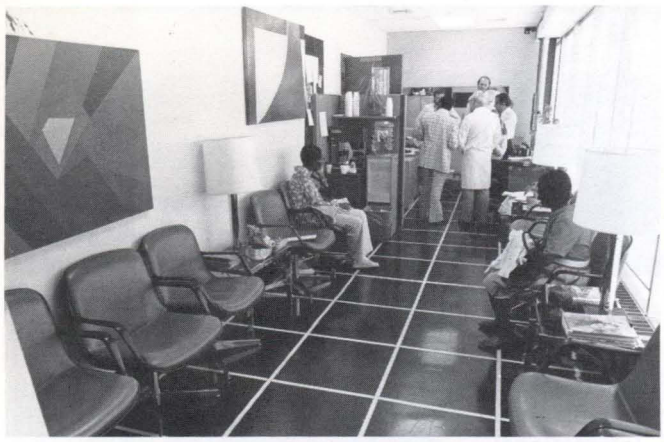
INTERNATIONAL PARTICIPATION . . .

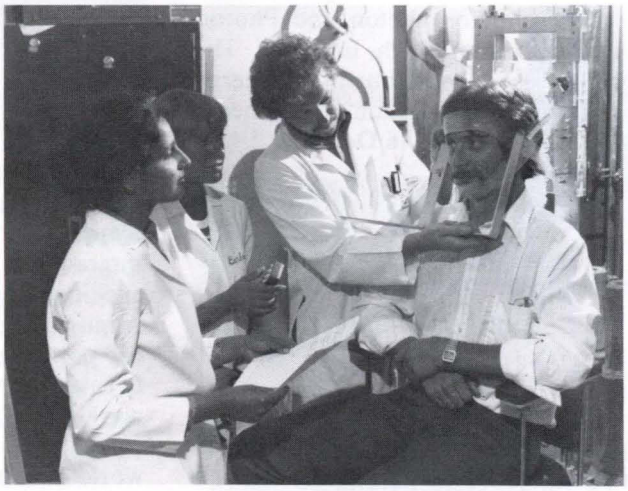
High-energy physics is a field of research in which scientists from all over the world work together in a common endeavor to achieve a better understanding of nature. At present, approximately 130 institutions are associated with experiments or other technical activities in progress at Fermilab. Of these, slightly less than one-half are non-American. The flags of twenty foreign countries that fly in front of the Fermilab Central Laboratory are symbolic of the international collaboration that is characteristic of the field of high-energy physics.

International collaborations at Fermilab range in size from the small, relatively informal participation of one or more physicists from non-U.S. institutions in the conduct of a high-energy physics experiment to large institutionalized collaborations in which the participation of people from non-U.S. institutions is governed by formal agreements that have been worked out in international negotiations between the countries involved. The first example of the latter situation at Fermilab has been the participation of physicists from the Soviet Union in the Fermilab experimental program under the terms of a Protocol negotiated between the United States and the USSR. More recently, a large collaboration has developed between the Peoples Republic of China (PRC) and the U.S. as a result of a decision by the government of the PRC to build a large high-energy physics accelerator facility near Beijing. Many Chinese physicists and engineers are already in the United States or scheduled to visit in the next several years at Fermilab and the other U.S. high-energy physics laboratories to acquire the experience that will be needed to carry out the ambitious Chinese accelerator project. Scientists and engineers from the PRC are currently participating in many Fermilab activities, including the design and fabrication of accelerator components, accelerator operations, and direct participation in some of the high-energy physics experiments. A number of Fermilab physicists have also been invited to visit China for consultation on many of the technical subjects that are relevant to the construction and operation of a large high-energy physics accelerator facility.

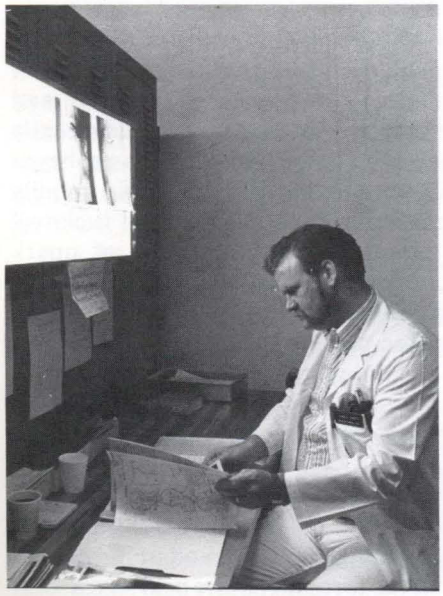
The third major international collaboration involving Fermilab is being carried out under a formal agreement between Japan and the United States. At this time, physicists from Japanese institutions are actively involved in a number of high-energy physics experiments at Fermilab, as well as participating in the planning and design of several very large future Fermilab experiments.

As our plans for the Tevatron progress, we are aware of a great deal of interest on the part of groups now involved in large experiments at CERN to bring their detectors to Fermilab in order to pursue their research at the higher energy. Clearly this interest offers both problems and opportunities in the development of Tevatron fixed-target programs.





CANCER THERAPY FACILITY . . .



PATIENT REFERRALS

228 patients were referred to the Cancer Therapy Facility in 1979 for consideration for treatment. 120 of these patients have been entered in the national neutron studies, 15 were not treated for various reasons, and 93 were treated as either local-protocol patients or pilot patients. Local-protocol or pilot-study patients are those who refuse to participate in the national study, have relatively unusual tumors, or are not eligible for the national studies because of previous treatment.

Although the national trials began in 1975, the Fermilab CTF treated its first patient in September 1976. Despite a late start, the CTF has entered more patients into the national trials than any other neutron facility in the United States.

MEDICAL ACCOMPLISHMENTS

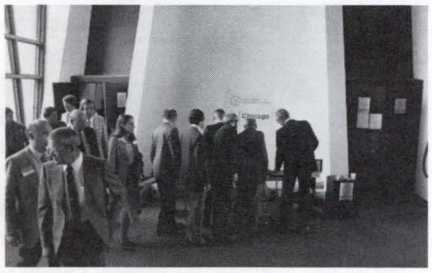
Several studies have matured enough to allow preliminary analysis of results. As a consequence, Drs. Cohen and Hendrickson have begun drafting replacement studies and major modifications of existing studies. Drs. Cohen and Hendrickson are the authors of 5 of the 10 currently active national studies. In addition, they are working on new protocols for glioma (brain), esophagus, pancreas, head and neck, and salivary gland. Preliminary statistical analysis indicates that neutron therapy is superior to conventional therapy for head and neck tumors. The new generation of protocols for these tumors will be designed to optimize treatment. Radiosensitizing drugs are being used in addition to neutron therapy for some glioma patients.

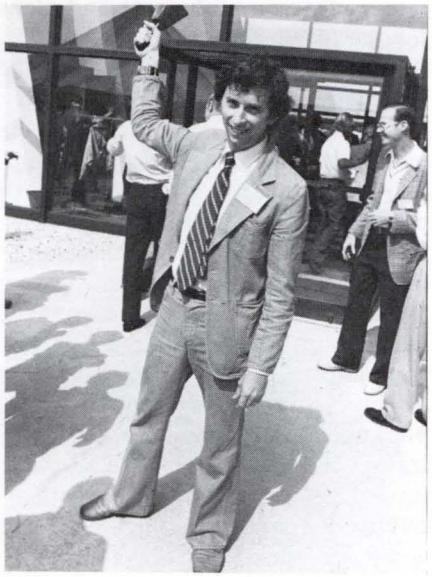
In addition to the clinical developments just described, two other accomplishments deserve mention.

(i) On November 1, 1979, a team from the National Cancer Institute visited the Cancer Therapy Facility, reviewed accomplishments and plans for the future. The report written by the visitors assured funding of the work for five more years.

(ii) In addition, during this year the patient-treatment area was greatly improved without interfering with patient care. The improvements range from panelling of walls, installation of flooring over the elevator, piping music, and other cosmetic work to the installation of a completely new collimator system and commissioning a new treatment-planning software package. Furthermore, proper transducers were installed to allow for future monitoring of most patient-treatment parameters by a microcomputer-based control system.

1979 SYMPOSIA





Three major symposia were held at Fermilab in 1979. The first, in April, honored the retiring Fermilab director, Robert Wilson. The second, in late August, was the Ninth International Symposium for Lepton and Photon Interactions at High Energies. The third was a Department of Energy sponsored symposium on energy management, held in October.

R.R. WILSON SYMPOSIUM

On April 27, an international symposium in honor of Robert Wilson was held at Fermilab. The organization of this symposium was the result of the desire of many groups to honor the contributions of Bob Wilson to science. The event was sponsored by Universities Research Association, the Fermilab Users Organization, and the University of Chicago.

The contributions of Bob Wilson covered many areas, including particle physics, accelerator design and construction, and international cooperation. Furthermore, Wilson has stressed in lectures and articles the aesthetic and civilizing nature of pure science. A correspondingly broad program of lectures was arranged for the symposium. These lectures were: "Fermilab" by Leon M. Lederman, "Early History of Accelerators" by Wolfgang Paul, "Beauty and the Quest for Beauty in Science" by S. Chandrasekar, "Los Alamos and Cornell" by Hans A. Bethe, and "Science and Art" by Victor F. Weisskopf.

The symposium was attended by 450 friends and colleagues of Bob Wilson. The lecture program was followed by a banquet and a concert by the Guarneri String Quartet. The proceedings of the symposium will appear in a volume entitled, "Science and Aesthetics" which will be available in January, 1980.

PHOTON-LEPTON SYMPOSIUM

The largest gathering of the year at Fermilab was the Ninth International Symposium on Lepton and Photon Interactions at High Energies. This exciting topical conference, held August 23 to 29, attracted more than 650 particle physicists from more than twenty-five countries around the world. The participants heard a rich program of exciting new results in the world of subnuclear particles.

Four groups from the PETRA e^+e^- colliding-beam storage ring in Hamburg, Germany reported the first compelling evidence for the elusive carrier of nuclear force, the gluon. They failed to find a sixth expected quark, the so-called top quark, leaving for later machines a clear goal for future work.

Nucleon structure-function measurements, essentially the rules of motion of quarks in protons and neutrons, have been measured recently by both muon and neutrino probes at Fermilab and CERN. This rapidly maturing experimental field is closely related to another probe of quark motion in nucleons, the so-called Drell-Yan process, which occasionally takes place when two protons strike one another violently at high energy. The complementarity and unity of these experiments was reviewed by W.S.C. Williams of Oxford University and by A. Para of CERN.

On the theoretical side, the newly emerging ideas of grand unification of all the forces in nature held a great deal

of interest. These ideas, pursued in vain by Albert Einstein in the later part of his career, and abandoned for many years as hopeless, are now beginning to yield to the powerful mathematical methods now available. Other theoretical talks concentrated on the progress being made in QCD, the quantum theory of the strong interactions. This theory may be the long-sought answer theory of the strong nuclear forces.

Participants in the symposium enjoyed some fine social moments as well. A banquet was held in the Chicago Art Institute following a boat cruise along the scenic Chicago lakefront. Another evening saw an old-fashioned western barbeque featuring square dancing under the stars.

The International Union of Pure and Applied Science, the U.S. Department of Energy, and the National Science Foundation were co-sponsors of the symposium with Fermilab.

DOE ENERGY MANAGEMENT SYMPOSIUM

Fermilab was the host for the Department of Energy Management Symposium from October 16 through October 18, 1979. This was a nationwide gathering of about 250 energy management specialists from the major DOE installations.

The discussions were wide-ranging, covering a large number of energy-saving devices installed or proposed for various DOE facilities. Improved driver training, computer controls for energy-consuming devices, and solar-heating schemes were also discussed. DOE organization, plans, and budgets were also topics of discussion.

Fermilab received an award for meritorious energy conservation practices during the conference.

SAFETY SECTION . . .

The Safety Section was formed in July 1978 by unification of the Safety Office and the Radiation Physics Group. On March 5, 1979, the Environmental Protection Group was formed as part of the Safety Section and a Senior Environmental Protection Officer appointed.

GENERAL SAFETY

In addition to monitoring of construction projects, electrical and mechanical safety, safety of experiments, target reviews, and liaision with all Laboratory departments, several new programs were begun by the General Safety Group during 1979. An Industrial Hygiene Program was developed and an Industrial Hygienist added to the staff. A new Training Program was implemented and a staff member was appointed Safety Training Coordinator. Although this area of the safety program is still understaffed, progress has been made on the development of the new programs, as well as the maintenance of the ongoing programs. Addition of professional staff in the next year will make possible more thorough implementation of the Laboratory Safety Program.

RADIATION SAFETY

The Radiation Physics Group interfaces with operating areas of the Laboratory to monitor the radiation-safety programs. Support is given to the operating areas in the form of shielding and radioactivation calculations, beam-intensity measurements using thermoluminescent and hydrogen-pressure dosimeters, radiation-monitoring instrumentation, design reviews, and training. During the last year a radioactive waste-compaction facility was brought into operation, which will considerably reduce the cost of disposal of radioactive waste.

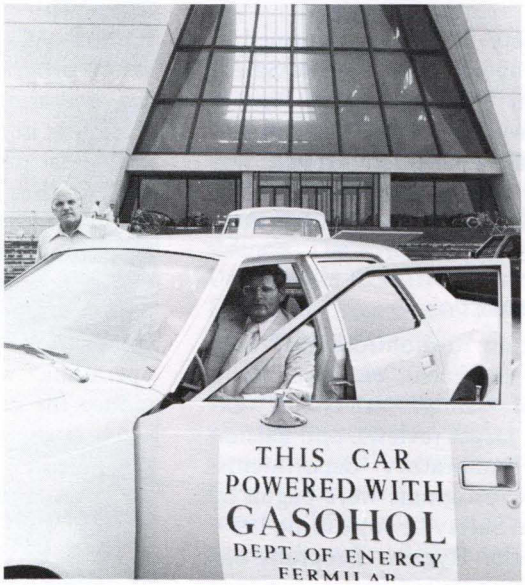
ENVIRONMENTAL PROTECTION

The Environmental Protection Program, covering both radioactive an non-radioactive environmental pollutants, was fully implemented in 1979. Monitoring, sampling, control, and disposal of pollutants are included. The program is under the direction of the Senior Environmental Protection Officer, supported by the staff of the Environmental Protection Group and by Environmental Protection Officers, who have been appointed in all operating groups at the Laboratory.

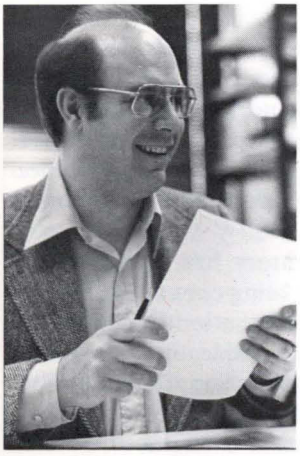
THE UNSUNG HEROES . . .

The operation of the Laboratory depends on the services of a wide variety of support activities. These Fermilab services are supplied through an organization consisting of five sections that provide services for the program divisions, ranging from machine shops to personnel functions, safety consultation to business activities. Other shared services include the design and fabrication of magnets, maintenance of plant equipment, the cafeteria, and housing for visitors and users groups.

The persons who make up these support activities are the unsung heroes of each experiment. Although their names are not included in the reports summarizing the experimental results, the success of the experiment depends heavily on them. The support activities are summarized in the following section.



BUSINESS SERVICES SECTION . . .



Early in the year, in conjunction with a general Laboratory reorganization, the Business Services Section was formed by combining the Business Office and Site Services. Many Laboratory efforts have been gathered into this new section. The Special Process Spares inventory moved from the Accelerator Division. A new system is being developed to monitor progress on the superconducting wire being built for the Superconducting Accelerator in private industry, and to keep track of its costs. Record keeping on approximately $11 million of Fermilab inventory is also a responsibility of the new section.

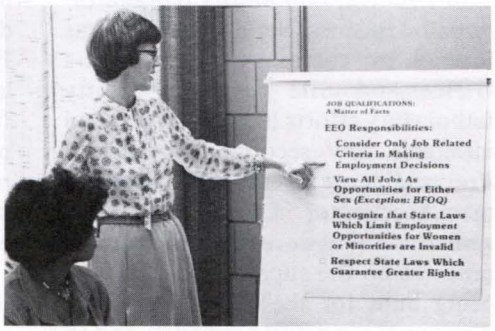
The Contracts Department has had some 2,000 procurement actions, totaling approximately $16.8 million. Over 600 of the actions, worth almost $7 million, have been awarded in the last quarter of the calendar year, including 6 actions individually valued between $600,000 and $1,350,000 during November and December. Approximately $519,000 worth of business has been contracted for with minority firms.

The Purchasing Department's procurement activities have shown significant increases in both actions and dollars committed. This was particularly evident for the last quarter, when increases of 78% in dollars and 16% in actions occurred over a like period a year ago. The Department continues to maintain a dynamic, effective posture toward small and minority-owned businesses. We have awarded over $1 million to minority-owned businesses in each of the last two years, while placing 69% of total commitment dollars with small businesses.

The major new program of the Support Services Department was the introduction of gasohol as the standard fleet fuel in April of this year. Fermilab was the first national laboratory to utilize this alternative fuel on a fleet-wide basis. Approximately 184 vehicles were driven 1 million miles this year with 75% of that using gasohol. Our experience in this endeavor has been very good.

The most significant achievement of the Site Services Department this year was keeping the roads on the site open despite the record snowfall that almost paralyzed Northern Illinois. Other noteworthy activities were: 1) bringing all buildings into compliance with Federal temperature requirements; 2) modernization of the communications center; 3) construction of a new vehicle-maintenance facility; 4) hiring of the first female fire fighter; and 5) working with a volunteer Fermilab group to obtain the seeds for and plant an additional 70 acres in the Prairie Restoration effort.

The Legal Office has assisted other Laboratory groups in a wide-ranging spectrum of activities. The most significant of such activities has been work on agreements with representatives of the Peoples Republic of China. Fermilab, along with other national laboratories, is engaged in a technical exchange aimed at assisting scientists in the PRC to construct a 50 GeV accelerator near Beijing, China. The Legal Office also participated with other groups in the assemblage of materials and information for the submittal of a URA proposal to site the NASA Space Telescope Institute at Fermilab. There were seven separate actions in litigation this year. Three of the seven actions were completed and three were new this year.



LABORATORY SERVICES SECTION . . .

During FY79 the total number of Fermilab employees rose from 1,493 to 1,632. Our largest growth was in the technical and technical support categories, where a total of 68 employees were added to the payroll.

The growth in the number of employees reflects the decision to proceed with the Energy Saver program. This program has caused a ripple effect; other areas of Laboratory Services have had increased activities. The Travel Office, which handles interviewee travel, has noticed the impact, as well as the Medical Office, which gives pre-employment physical exams.

Improvements made in the Laboratory's employee group benefit program during the year included increased medical benefits and the introduction of a dental plan.

The Equal Opportunity Office participated with the technical staff in the ninth Summer Program for Physics Students. Seventeen students from ten universities or colleges majoring in physics or related sciences were employed as Laboratory Assistants or Laboratory Technicians. The Fermilab Summer Program has had significant success in helping minority students toward careers in science. The Program is now being expanded to include a graduate fellowship program.

Fermilab provided the training site for the first Mechanical Technician Training Program sponsored by the Minority Information Referral Center (MIRC) in Des Plaines, Illinois. There were eleven males and two females taking part in the training. Graduates accepted full-time employment with the Laboratory after completing the program. The Laboratory has exceeded the national availability for minority electronic and mechanical technicians, primarily as a result of participation in CETA and TAT Training Programs.

Laboratory Services is conducting a series of equal-opportunity management training seminars for top-level managers, supervisors, and prospective managers. The objective is to help managers and supervisors gain a better understanding of affirmative action and its guidelines and to learn how to apply the guidelines to their operations more effectively.

Fermilab became a member of the National Consortium for Graduate Degrees for Minorities in Engineering. The program provides summer employment and financial assistance in graduate school to engineering students.

The Laboratory has always taken great pride in being open to the public. The Public Information Office played host to 5,700 people on 215 guided tours during 1979. The groups covered a wide spectrum of interests, from senior citizens to science writers. Another 25,000 people visited on self-guided tours. New exhibits were prepared to assist these visitors. There has been a steady flow of information about the Laboratory's scientific activities, as well as general announcements. Thirty press releases were issued. The material in our weekly newspaper, *Ferminews,* mailed to metropolitan media, was also picked up on many occasions.

The work of the Laboratory is abstract and a great deal of effort has been focused upon communicating with the general public. The Laboratory has enjoyed excellent local, metropolitan, and national exposure in the news media during 1979. News about Fermilab has appeared frequently in major news publications. Information about the scientific results announced at the Lepton-Photon conference in August received extensive media attention both locally and nationally. Many individual press visits were arranged during the year.

The Technical Information Group provided library, editorial, publishing,

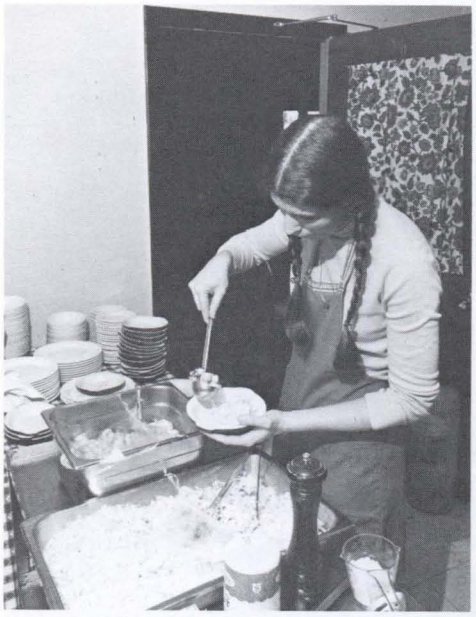
photographic, and duplicating services. Along with the normal activities, an important library service includes a catalog tracing each preprint from time of inception to its journal publication. In addition, information retrieval from appropriate data bases is available using the library terminal.

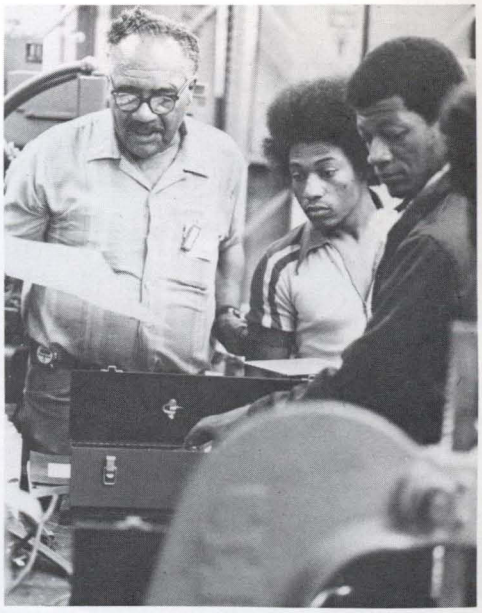
The Publications Office provides editorial assistance, prepares the monthly *Fermilab Report*, as well as many Laboratory books and conference proceeding, such as the 1979 DUMAND Proceedings, the Superconducting Accelerator Design Report, the Antiproton Source Design Report, and the Wilson Symposium Proceedings. A new text-editing system makes assembly easier for documents that must go through many revisions. During the summer, all the Laboratory's reports, both TM's and FN's, were entered into SPIRES, SLAC's computer-retrieval system. These reports are now available to scientists across the country using the SPIRES system.

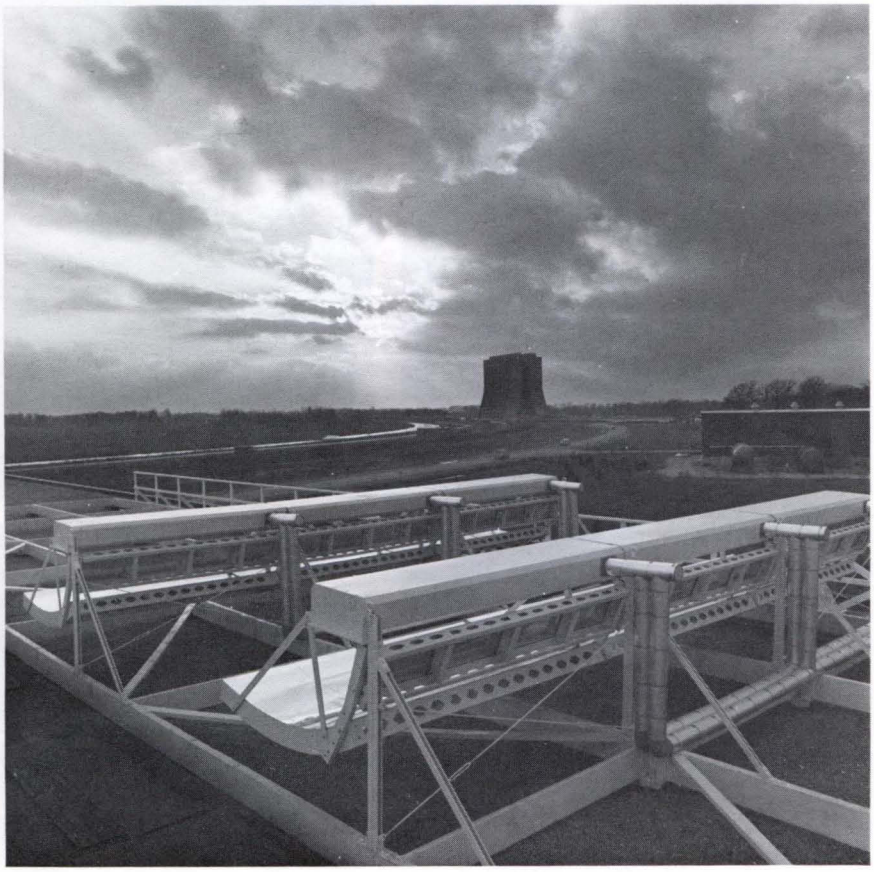
Photography has acquired a color processor and is now providing virtually all Laboratory photographic needs. The department has expertise in producing aerial, artistic, and technical photographs.

In addition to producing such basic items as the Users Handbook, Procedures for Experimenters, and many preprints, Duplicating Services also contributed to the success of the Lepton-Photon Conference by providing hundreds of pages of transparency reproductions ordered by the participants.

On-site housing capacity was increased for the summer of 1979 and for future experimental support. The Chez Leon dining area was opened as a specialty luncheon and evening eating area in the Users Center. Work was begun on the addition of a tennis court in the guest housing area and major improvements were accomplished at the swimming pool.







TECHNICAL SERVICES SECTION . . .

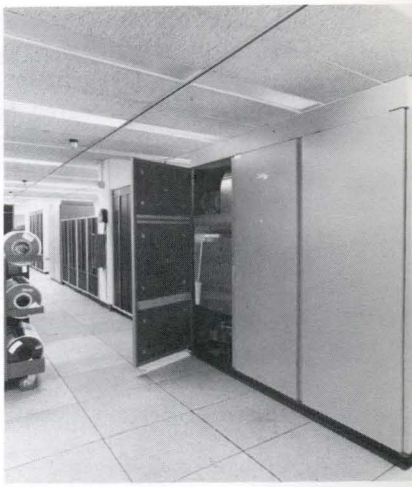
CONVENTIONAL CONSTRUCTION

To accommodate the growing population of the Laboratory and respond to the changing needs for facilities, we are engaged in an active construction program. Highlights of this program include:

1. Up-dating of the Meson target areas and beam lines upstream of the Detector Building.
2. Additional office and technician space in and adjacent to the Cross Gallery.
3. Additions to, and new service buildings in the Main Ring and Experimental areas. These include a large addition to the A0 Major Vehicle Access Building.
4. Additions to industrial buildings. These include Lab 3, Lab 8, and Lab B.
5. The antiproton reverse-injection pipeline.
6. New computer facilities on the 7th and 8th floors of the central Lab.

ELECTRONICS DEVELOPMENT

New firing circuits were developed for the many high-power supplies used in the Laboratory. These circuits provide improved response time and subharmonic ripple reduction and are a significant improvement in the state of the high-power magnet-supply art. About 600 of the Laboratory supplies have been retrofitted to give a significant improvement in operational control. A number of fast-trigger processors are under development in an effort to reduce the amount of experimental data written on tape and thus to reduce the requirement for computer-center time. Two of these projects achieved significant progress during 1979. The M7 processor was placed in the trigger for E-401, giving an improvement in the fraction of good events taken and an increase in acceptable beam intensity. The E-516 processor was completed and testing has started. All these projects are being carried out by the Electronic Services part of Research Services.

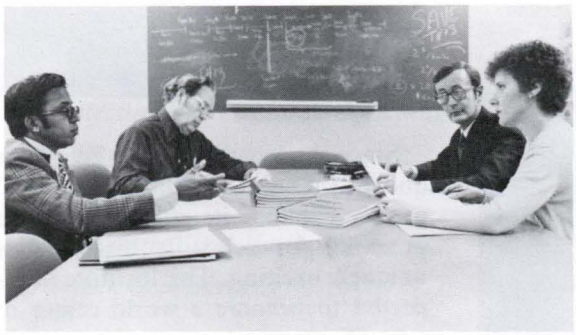


ENERGY CONSERVATION

Much of the work to conserve energy at Fermilab in the last year has involved converting conventional magnets to superconducting magnets. Conversion of the Chicago Cyclotron Magnet is nearing completion. This will save 2 MW. Design of superconducting coils for the 30-in. bubble chamber is nearing completion, with winding scheduled to start in March 1980. These coils will save 7 MW compared with the present coils operating at maximum current. These projects are being done by the Cryogenics Group of Research Services.

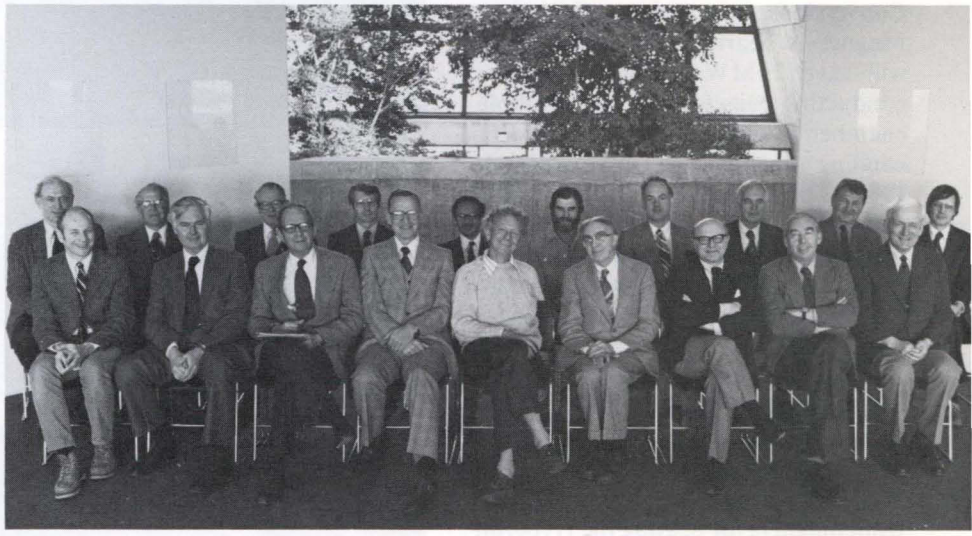
A proposal to use Swan Lake to produce chilled water in winter, rather than operating an electrically driven chiller, has been submitted to DOE for funding. A proposal to use waste heat from magnets for heating the Hyperon Area has also been submitted for funding.

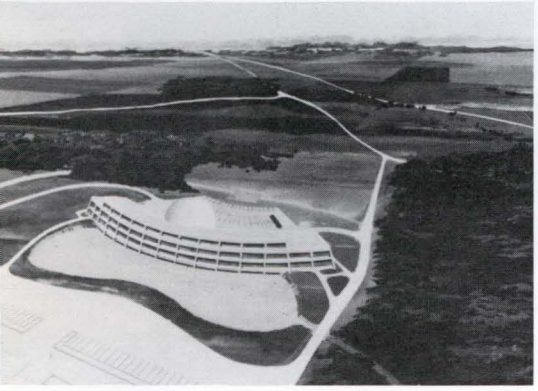
Installation of a bank of solar collectors on the roof of Industrial Building 1 is nearing completion. These are of a novel design that suppresses convective losses by the orientation of the collector. This results in higher temperatures than are achievable by conventional flat-plate solar collectors. In addition to use for space heating and curing the epoxy in magnets, it is planned to install a small alcohol still using this solar heat. The alcohol will be used for our gasohol fleet. Fermilab is in full compliance with Federal building-temperature regulations. We have also reduced lighting levels and turned off other equipment such as fountains wherever possible.



UNIVERSITIES RESEARCH ASSOCIATION INC. . . .

The Fermi National Accelerator Laboratory is managed under a contract with the Department of Energy by Universities Research Association, Inc., a consortium of 53 universities. The principal activities of URA concern Fermilab policies and the performance of work under the DOE contract, as well as under an NIH grant for the operation of the Cancer Therapy Facility. It also manages such subsidiary programs as scholarship assistance for the benefit of the children of Fermilab employees.

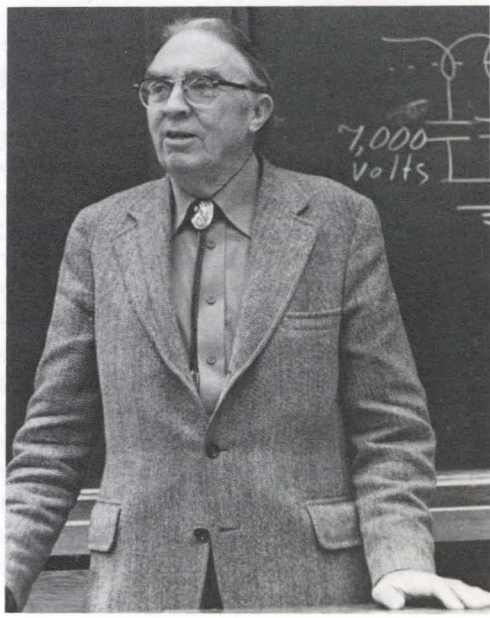




Universities Research Association has begun preparation of a proposal to manage the Space Telescope Science Institute to be established by NASA in late 1980. The Institute will be responsible for the scientific management of a 2.4-m orbiting optical telescope scheduled for launch in 1983. The location proposed by URA is a site at Fermilab. URA is preparing the proposal in cooperation with astronomers from several participating universities, and with the assistance of technical groups from Fermilab and Science Applications, Inc. A URA Astronomy Committee has been organized to provide a senior source of guidance and counsel to the proposal effort.

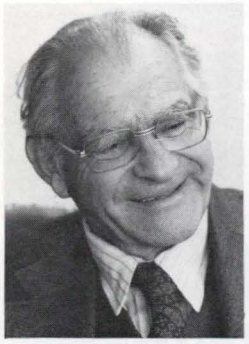
Since the location of the Telescope above the earth's atmosphere will greatly enhance its effectiveness, the potential for scientific discovery is uniquely exciting. The Institute is expected to become a world center of astrophysics and approximately 15 percent of its staff will be drawn from the European astronomical community.

Science and the Laboratory suffered a severe loss in October upon the death of Milton Grandison White, President of Universities Research Association. A faculty member at Princeton University for 41 years, Professor White had been a pioneer in experimental high-energy physics. his research was the first ever performed using a cyclotron. He directed the Princeton Cyclotron, the Cosmotron, and the Princeton-Pennsylvania Accelerator. In recent years, he served as a member of the URA Board of Trustees, as Chairman of the Board, and as President of the Corporation. His judgment and enthusiasm during that period proved to be among Fermilab's most valuable assets.



The URA Board of Trustees in November of 1979 named Harvard Professor Norman F. Ramsey to fill Professor White's term of office as President. Professor Ramsey has previously served as President of URA from 1966 to 1973, and from 1974 to 1979.

WEDNESDAY COLLOQUIA . . .



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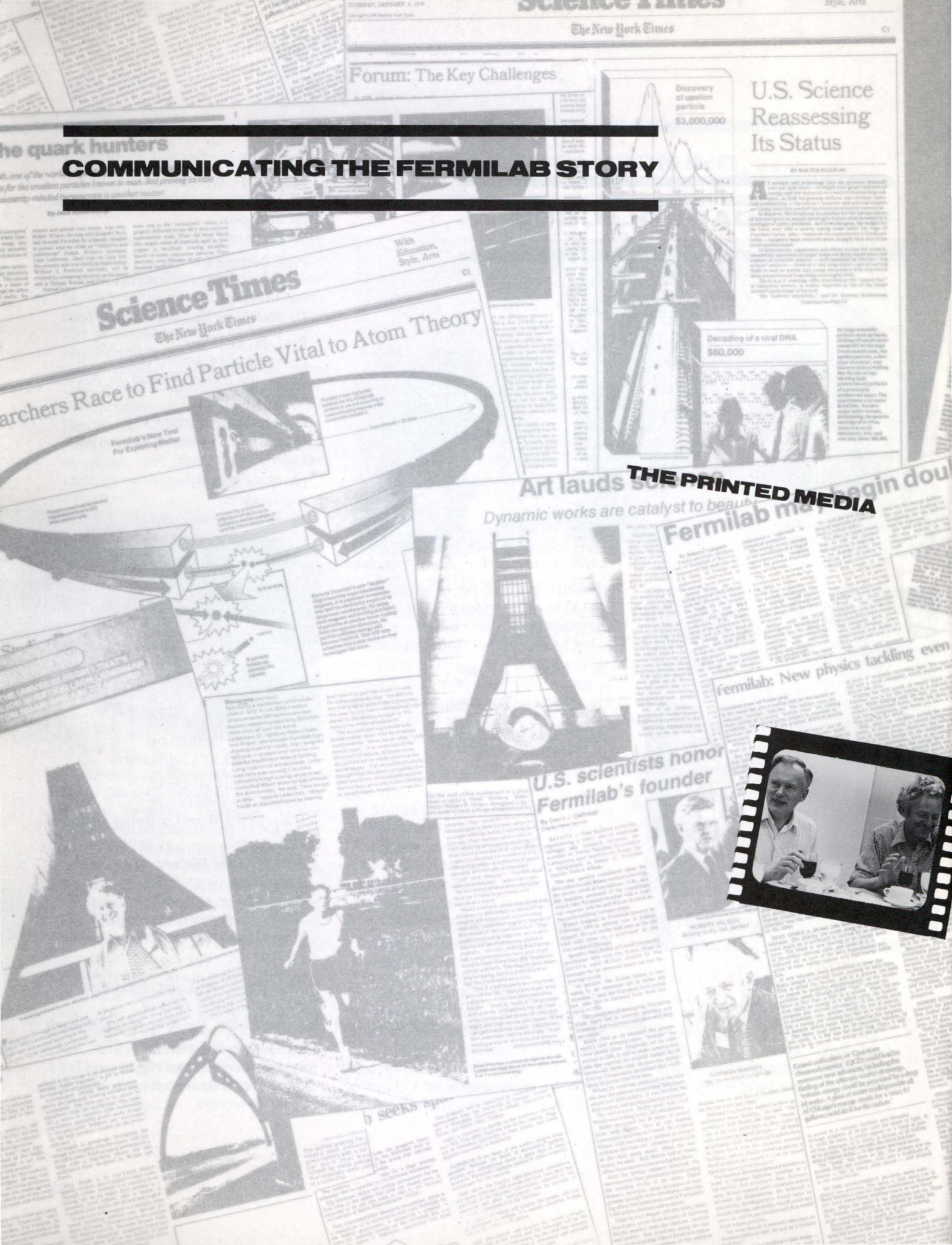

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PHOTON TOTAL CROSS SECTION #25A

MEASUREMENTS OF ELASTIC RHO AND PHI MESON PHOTOPRODUCTION CROSS-SECTIONS ON PROTONS FROM 30-GEV TO 180-GEV.

By R.M. Egloff, P.J. Davis, G. Luste, J.F. Martin, J.D. Prentice (Toronto U.), D.O. Caldwell, J.P. Cumalat, A.M. Eisner, A. Lu, R.J. Morrison, S.J. Yellin (UC, Santa Barbara), T. Nash (Fermilab), Fermilab-Pub-79/34-Exp., May 1979. 13pp.
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By J. Bell, C.T. Coffin, R.N. Diamond, H.T. French, W.C. Louis, B.P. Roe, R.T. Ross, A.A. Seidl, J.C. Vander Velde, E. Wang (Michigan U.), J.P. Berge, D.V. Bogert, F.A. DiBianca, R. Endorf, R. Hanft, C. Kochowski, J.A. Malko, G.I. Moffatt, F.A. Nezrick, W.G. Scott, W. Smart (Fermilab), R.J. Cence, F.A. Harris, M. Jones, M.W. Peters, V.Z. Peterson, V.J. Stenger (Hawaii U.), G.R. Lynch, J.P. Marriner, M.L. Stevenson (LBL, Berkeley), UMBC 78-6, Jun. 1978. 59pp.
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By W.A. Loomis, B.A. Gordon, F.M. Pipkin, S.H. Pordes, W.D. Shambroom, L.J. Verhey, Richard Wilson (Harvard U.), H.L. Anderson, R.M. Fine, R.H. Heisterberg, H.S. Matis, L. Mo, L.C. Myrianthopoulos, S.C. Wright (Chicago U., EFI), W.R. Francis, R.G. Hicks, T.B.W. Kirk (Illinois U., Urbana), V.K. Bharadwaj, N.E. Booth, G.I. Kirkbride, T.W. Quirk, A. Skuja, M.A. Staton, W.S.C. Williams (Oxford U., NPL), Fermilab-Pub-78/94-Exp., Dec. 1978. 82pp.
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By M.L. Stevenson (LBL, Berkeley, LBL-7926, June 1978. 15pp.
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30-INCH P-P @ 400 #138

INCLUSIVE STUDY OF STRANGE PARTICLE PRODUCTION IN P P INTERACTIONS AT 405-GEV/C.

By H. Kichimi, M. Fukawa, S. Kabe, F. Ochiai, R. Sugahara, A. Suzuki, Y. Yoshimura, K. Takahashi (KEK, Tsukuba), T. Okusawa, K. Tanahashi, M. Teranaka, O. Kusumoto (Osaka City U.), T. Konishi (Kinki U., Osaka) H. Okabe, J. Yokota (Osaka Prefecture U., Sci. Educ. Inst.), KEK-Preprint-78-10, Jan. 1979, 50pp.
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By D. Brick, D. Fong, M. Heller, A.M. Shapiro, M. Widgoff (Brown U.), F. Bruyant (CERN), D. Bogert, M. Johnson (Fermilab), R. Burnstein, C. Fu, D. Petersen, M. Robertson, H. Rubin (Illinois Tech), R.D. Sard, A. Snyder, J. Tortora (Illinois U., Urbana), E.D. Alyea (Indiana U.), C.Y. Chein, P. Lucas, A. Pevsner, R. Zdanis (Johns Hopkins U.), F. Barreiro, O. Benary, J.E. Brau,

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By J.P. Berge, D. Bogert, R. Hanft, D. Hamilton, G. Harigel, J.A. Malko, G.I. Moffatt, F.A. Nezrick, J. Wolfson (Fermilab), V.V. Ammosov, A.G. Denisov, P.F. Ermolov, G.S. Gapienko, V.A. Gapienko, V.I. Klukhin, V.I. Koreshev, P.V. Pitukhin, V.I. Sirotenko, E.A. Slobodyuk, V.G. Zaetz (Serpukhov, IFVE), V.I. Efremenko, A.V. Fedotov, P.A. Gorichev, V.S. Kaftanov, G.K. Kliger, V.Z. Kolganov, S.P. Krutchinin, M.A. Kubantsey, I.V. Makhlyueva, V.I. Shekelyan, V.G. Shevchenko (Moscow, ITEP), J. Bell, C.T. Coffin, W. Louis, B.P. Roe, R.T. Ross, A.A. Seidl, D. Sinclair, E. Wang (Michigan U.), Fermilab-Pub.-79/27-Exp. Mar. 1979. 7pp.
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By A.R. Clark, K. J. Johnson, L.T. Kerth, S.C. Loken, T.W. Markiewicz, P.D. Meyers, W.H. Smith, M. Strovink, W.A. Wenzel (UC, Berkeley & LBL, Berkeley), R.P. Johnson, C. Moore, M. Mugge, R.E. Shafer (Fermilab), G.D. Gollin, F.C. Shoemaker, P. Surko (Princeton U.), LBL-9125, May 1979, 9pp.
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HADRON JETS #260

EXPERIMENTAL TESTS OF QUANTUM CHROMODYNAMICS IN HIGH P-TRANSVERSE JET PRODUCTION IN 200-GEV/C HADRON-PROTON COLLISIONS.

By C. Bromberg, G. Fox, R. Gomez, J. Pine, J. Rohlf, S. Stampke, K. Yung (Cal Tech), S. Erhan, E. Lorenz, M. Medinnis, P. Schlein (UCLA), V. Ashford, H. Haggerty, R. Juhala, E. Malamud, S. Mori (Fermilab), R. Abrams, R. Delzenero, H. Goldberg, S. Margulies, D. McLeod, J. Solomon, R. Stanek (Illinois U., Chicago), A. Dzierba, W. Kropac (Indiana U.), CALT-68-724, May 1979. 12pp.
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JETS PRODUCED IN PI-, PI+ AND PROTON INTERACTIONS AT 200-GEV ON HYDROGEN AND ALUMINUM TARGETS.

By C. Bromberg, G. Fox, R. Gomez, J. Pine, J. Rohlf, S. Stampke, K. Yung (Cal Tech), S. Erhan, E. Lorenz, M. Medinnis, P. Schlein (UCLA), V. Ashford, H. Haggerty, R. Juhala, E. Malamud, S. Mori (Fermilab), R. Abrams, R. Delzenero, H. Goldberg, S. Margulies, D. McLeod, J. Solomon, R. Stanek (Illinois U., Chicago), A. Dzierba, W. Kropac (Indiana U.), CALT-68-694, N.D. (Recd. Apr. 1979) 12pp.
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DI-LEPTON #288

EVIDENCE FOR THE UPSILON''AND A SEARCH FOR NEW NARROW RESONANCES.

By K. Ueno, B.C. Brown, C.N. Brown, W.R. Innes, R.D. Kephart, T. Yamanouchi (Fermilab), S.W. Herb, D.C. Hom, L.M. Lederman, H.D. Snyder, J.K. Yoh (Columbia U.), R.J. Fisk, A.S. Ito, H. Jostlein, D.M. Kaplan (SUNY, Stony Brook), Fermilab-Pub.-78/96-Exp. Dec. 1978. 16pp.
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30-INCH PI+ & P-D @ 200 #295

INCLUSIVE PARTICLE SPECTRA IN P (PI+) N INTERACTIONS AT 195-GEV/C.

By Y. Eisenberg, B. Haber, D. Hochman, U. Karshon, L. Lyons, E.E. Ronat, A. Shapira, R. Yaari, G. Yekutieli (Weizmann Inst.), WIS-78/49-Ph, N.D. (Recd. May 1979) 44pp.
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HIERARCHY OF MEAN MULTIPLICITIES IN P N AND PI+ N INTERACTIONS AT 195-GEV/C.

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INCLUSIVE PI+ TO PI- RATIOS IN PI+ N AND P N INTERACTIONS AT 195-GEV/C.

By Y. Eisenberg, B. Haber, D. Hochman, U. Karshon, E. Kogan, E.E. Ronat, A. Shapira, G. Yekutieli (Weizmann Inst.), WIS-78/19-Ph, Jul. 1978. 10pp.
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PARTICLE SEARCH #300

PRODUCTION OF HADRONS AT LARGE TRANSVERSE MOMENTUM IN 200-GEV, 300-GEV AND 400-GEV P P AND P N COLLISIONS.

By D. Antreasyan, J.W. Cronin, H.J. Frisch, M.J. Shochet (Chicago U., EFI), L. Kluberg, P.A. Piroue, R.L. Sumner (Princeton U.), EFI 78/29-Chicago, N.D. (Recd. Jul. 1978) 51pp.
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NEUTRON DISSOCIATION #305

A STUDY OF DIFFRACTIVE DISSOCIATION USING NUCLEAR TARGETS.

By J. Biel, T. Ferbel, W. Ford, L. Golding, W. Mollet, P. Slattery, D. Underwood (Rochester U.), B. Gobbi, L. Kenah, J. Rosen, R. Ruchti (Northwestern U.), E. Bleser (Fermilab), D. Freytag (SLAC), UR-690A, N.D. (Recd. May 1979) 14pp.
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INCLUSIVE CHARGED PARTICLE PRODUCTION IN NEUTRON-NUCLEUS COLLISIONS.

By D. Chaney, T. Ferbel, P. Slattery, D. Underwood (Rochester U.), E. Bleser, D. Johnson (Fermilab), B. Gobbi, R. Lipton, J. Rosen, R. Richti, D. Spelbring (Northwestern U.), UR-689, N.D. (Recd. Mar. 1979) 64pp.
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NEUTRINO #310

MEASUREMENT OF THE STRUCTURE FUNCTIONS IN NEUTRINO AND ANTINEUTRINO INELASTIC INTERACTIONS.

By A. Benvenuti, F. Bobisut, D. Cline, P.S. Cooper, M.G.D. Gilchriese, S.M. Heagy, R. Imlay, M.E. Johnson, T.Y. Ling, R. Lundy, A.K. Mann, P. McIntyre, S. Mori, D.D. Reeder, J.A. Rich, R. Stefanski, T. Trinko, D.R. Winn (Fermilab & Harvard U. & Ohio State U. & Penn U. & Rutgers U. & Wisconsin U., Madison), Print-79-0137 (Wisconsin), N.D. (Recd. Feb. 1979) 11pp.
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RATES AND PROPERTIES OF TRIMUON EVENTS OBSERVED IN HIGH-ENERGY NEUTRINO INTERACTIONS.

By A. Benvenuti, F. Bobisut, D. Cline, P.S. Cooper, M.G.D. Gilchriese, S.M. Heagy, R. Imlay, T.Y. Ling, A.K. Mann, P. McIntyre, S. Mori, D.D. Reeder, J. Rich, R. Stefanski, T. Trinko, D.R. Winn (Fermilab & Harvard U. & Ohio State U. & Penn U. & Rutgers U. & Wisconsin U., Madison), UPR-0064E, Jan. 1979, 11pp.
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MEASUREMENT OF THE ENERGY AND X-DEPENDENCE OF THE Y-DISTRIBUTIONS IN ANTINEUTRINO INTERACTIONS.

By A. Benvenuti, F. Bobisut, D. Cline, P.S. Cooper, M.G.D. Gilchriese, S.M. Heagy, R. Imlay, M.E. Johnson, T.Y. Ling, R. Lundy, A.K. Mann, P. McIntyre, S. Mori, D.D. Reeder, J.A. Rich, R. Stefanski, D.R. Winn (Fermilab & Harvard U. & Ohio State U. & Penn U. & Rutgers U. & Wisconsin U., Madison), Print-78-0974 (PENN), N.D. (Recd. Oct. 1978) 10 pp.
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PROTON-PROTON POLARIZATION #313

PROTON POLARIZATION IN INCLUSIVE PROCESSES AT FERMILAB ENERGIES.

By R.O. Polvado, S.C. Ems, S.W. Gray, R.M. Lefore, H.A. Neal, H.O. Ogren, D.R. Rust, G.A. Walters (Indiana U.), IUHEE-26, Feb. 1979. 11pp.
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MUON #319

MEASUREMENT OF NUCLEON STRUCTURE FUNCTION IN MUON SCATTERING AT HIGH Q**2.

By R.C. Ball, D. Bauer, C. Chang, K.W. Chen, S. Hansen, J. Kiley, I. Kostoulas, A. Kotlewski, L. Litt, P.F. Schewe (Michigan State U.), A. Van Ginneken (Fermilab), MSU-CSL-60, Dec. 1978. 11pp.
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15-FOOT P-P @ 400 #341

CHARGED AND NEUTRAL PARTICLE PRODUCTION FROM 400-GEV/C P P COLLISIONS.

By R. D. Kass, W. Ko, R.L. Lander, W. Michael, D.E. Pellett, P.M. Yager (UC, Davis), R. Ely, G. Gidal (LBL, Berkeley), UCD PPL 7871, Aug. 1978. 52pp.
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15-FOOT P-P @ 300 #343

CORRELATIONS BETWEEN NEUTRAL AND CHARGED PIONS PRODUCED IN 300-GEV/C P P COLLISIONS.

By T. Kafka, F. LoPinto, A. Brody, R. Engelmann, J. Hanlon, S. Sommars (SUNY, Stony Brook), W.A. Mann, F.T. Dao, J. Schneps, A.J. Segar, H. Wald (Tufts U.), R. Ammar, R. Davis, C. Eklund, L. Herder, N. Kwak, R. Riemer, R. Stump, D. Zacref (Kansas U.), K. Jaeger (Argonne), SUNY SB-BCG-7801, N.D. (Recd. Aug. 1978) 13pp.
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PARTICLE SEARCH #357

NUCLEON NUMBER DEPENDENCE OF INCLUSIVE DIHADRON PRODUCTION IN PROTON-NUCLEUS COLLISIONS AT 400-GEV/C.

By D.A. Finley, W.R. Ditzler, O.E. Johnson, F.J. Loeffler, E. Shibata (Purdue U.), C.W. Akerlof, P. Alley, R. Fabrizio, D. Koltick, D.I. Meyer, R. Thun (Michigan U.), D. Bintinger, R.L. Loveless, R.A. Lundy, K.C. Stanfield, D.D. Yovanovitch (Fermilab), Fermilab-Pub.-78/89-Exp., Nov. 1978. 12pp.
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TWO-PARTICLE QUANTUM NUMBER CORRELATIONS IN 400-GEV/C PROTON-NUCLEUS COLLISIONS.

By D.A. Finley, W.R. Ditzler, O.E. Johnson, F.J. Loeffler, E. Shibata (Purdue U.), C.W. Akerlof, P. Alley, R. Fabrizio, D. Koltick, D.I. Meyer, R. Thun (Michigan U.), D. Bintinger, R.L. Loveless, R.A. Lundy, K.C. Stanfield, D.D. Yovanovitch (Fermilab), Fermilab-Pub.-78/90-Exp., Nov. 1978. 10pp.
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PARTICLE SEARCH #369

PI- PRODUCTION OF PSI AND CHI PARTICLES AT 217-GEV/C.

By T.B.W. Kirk, R. Raja (Fermilab), M. Goodman, W.A. Loomis, A.L. Sessoms, C. Tao, R. Wilson (Harvard U.), G.O. Alverson, G. Ascoli, D.E. Bender, J.W. Cooper, L.E. Holloway, L.J. Koester, U.E. Kruse, W.W. MacKay, R.D. Sard, M.A. Shupe, E.B. Smith (Illinois U., Urbana), J. Davies, T.W. Quirk, W.S.C. Williams (Oxford U., NPL), R.K. Thornton, R.H. Milburn (Tufts U.), Fermilab-Pub.-78/76-Exp., Oct. 1978. 11pp.
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PARTICLE SEARCH #379

OBSERVATION OF PROMPT SINGLE MUON PRODUCTION BY 400-GEV PROTONS.

By K.W. Brown, Barry C. Barish, J.F. Bartlett, A. Bodek, M.H. Shaevitz, E.J. Siskind (Cal Tech), A. Diamant-Berger, J.P. Dishaw, M. Faessler, J. Liu, F. Merritt, Stanley G. Wojcicki (SLAC & Stanford U., Phys. Dept.), SLAC-Pub.-2329, May 1979. 13pp.
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LIMITS ON THE PRODUCTION OF NEUTRINO-LIKE PARTICLES IN PROTON-NUCLEUS INTERACTIONS FROM CALORIMETRY MEASUREMENTS.

By J.P. Dishaw, A. Diamant-Berger, M. Faessler, J. Liu, F. Merritt, Stanley G. Wojcicki (SLAC & Stanford U., Phys. Dept.), Barry C. Barish, J.F. Bartlett, A. Bodek, K.W. Brown, M.H. Shaevitz, E.J. Siskind (Cal Tech), SLAC-Pub.-2291, Mar. 1979. 15pp.
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EMULSION/PI- @ 200 #237

INTERACTIONS OF 200-GEV PIONS IN NUCLEI.

By M.Y. Lee, J.J. Lord, R.J. Wilkes (Washington U., Seattle), VTL-Pub.-56, Aug. 1978. 42pp.
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HADRON JETS #395

EFFECT OF CALORIMETER RESOLUTION ON HIGH P-TRANSVERSE PARTICLE DISTRIBUTIONS.

By Manolis A. Dris (Penn U.), UPR-0056E, Oct. 1978. 16pp.
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PI+ STRUCTURE INFORMATION FROM A JET EXPERIMENT.

By. M. Dris, M.D. Corcoran, L. Cormell, A.R. Erwin, P.J. Gollon, E.H. Harvey, A. Kanofsky, W. Kononenko, B. Robinson, W. Selove, M. Thompson, B. Yost (Fermilab & Lehigh U. & Penn U. & Wisconsin U., Madison), UPR-39E-Rev., Aug. 1978. 30pp.
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By M. Dris (Penn U.), UPR-0047E, Jul. 1978. 11pp.
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K ZERO REGENERATION #425

COHERENT K-S REGENERATION ON PROTONS FROM 30-GEV/C TO 130-GEV/C.

By G. J. Bock, S.H. Aronson (Wisconsin U., Madison), K. Freudenreich (SIN, Villigen), A. Gsponer, W. R. Molzon, J. Roehrig, V.L. Telegdi, B. Winstein (Chicago U.), H.G. Kobrak, R.E. Pitt, R.A. Swanson (UC, San Diego), Print-79-0082 (Wisconsin), N.D. (Recd. Jan. 1979) 12pp.
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NUCLEAR FRAGMENTS #442

NUCLEAR FRAGMENT EMISSION IN HIGH-ENERGY P XE AND P KR COLLISIONS AND A DESCRIPTION OF THEIR PRODUCTION MECHANISM.

By J.A. Gaidos, L.J. Gutay, A.S. Hirsch, R. Mitchell, T.V. Ragland, R.P. Scharenberg, F. Turkot, R.B. Willmann, C.L. Wilson (Purdue U. & Fermilab), D79-00948, Apr. 1979.
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DI-MUON #444

PRODUCTION OF MUON PAIRS BY 225-GEV PI+-, K+, P+-BEAMS ON NUCLEAR TARGETS.

By K.J. Anderson, R.N. Coleman, G.E. Hogan, K.P. Karhi, K.T. McDonald, C.B. Newman, J.E. Pilcher, E.I. Rosenberg, G.H. Sanders, A.J.S. Smith, J.J. Thaler (Chicago U., EFI & Illinois U., Urbana & Princeton U.), EFI-79-6-Chicago, Apr. 1979, N.D. (Recd. Feb. 1979) 14pp.
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COMPARISON OF MUON PAIR PRODUCTION TO THE QUARK-ANTIQUARK ANNIHILATION MODEL.

By G.E. Hogan, K.J. Anderson, R.N. Coleman, K.P. Karhi, K.T. McDonald, C.B. Newman, J.E. Pilcher, E.I. Rosenberg, G.H. Sanders, A.J.S. Smith, J.J. Thaler (Chicago U., EFI & Illinois U., Urbana & Princeton U.), EFI-79-7-Chicago, Apr. 1979, N.D. (Recd. Feb. 1979) 14pp.
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A DETREMINATION OF THE PION STRUCTURE FUNCTION FROM MUON PAIR PRODUCTION.

By C.B. Newman, K.J. Anderson, R.N. Coleman, G.E. Hogan, K.P. Karhi, K.T. McDonald, J.E. Pilcher, E.I. Rosenberg, G.H. Sanders, A.J.S. Smith, J.J. Thaler (Chicago U., EFI & Illinois U., Urbana & Princeton U.), EFI-79-8-Chicago, Apr. 1979, N.D. (Recd. Feb. 1979) 13pp.
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EMULSION/PROTONS @ 400 #463

A POSSIBLE EXAMPLE OF THE CHARMED PARTICLE DECAY INTO THE CHANNEL B(C) — E+ E- HADRONS.

By M.M. Chernyavskii, A.A. Komar, G.I. Orlova, M.I. Tretyakova (Lebedev Inst.), Lebedev-78-175, Aug. 1978. 10pp
Presented at 19th Int. Conf. on High Energy Physics, Tokyo, Japan, Aug. 23-30, 1978.
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*(*Komar First Author in Journal*)*
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OBSERVATION OF THE NEW SHORT-LIVED PARTICLES IN NUCLEAR EMULSION EXPOSED TO PROTONS WITH THE MOMENTUM 400-GEV/C.

By M.M. Chernyavskii, A.A. Komar, G.I. Orlova, N.A. Salmanova, M.I. Tretyakova (Lebedev Inst.), Lebedev-78-149, Jul. 1978. 36pp.
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K ZERO CROSS SECTION #486

PRECISE COHERENT K-S REGENERATION AMPLITUDES FOR C, AL, CU, SN AND PB NUCLEI FROM 20-GEV/C TO 140-GEV/C AND THEIR INTERPRETATION.

By A. Gsponer, J. Hoffnagle, W.R. Molzon, J. Roehrig, V.L. Telegdi, B. Winstein (Chicago U., EFI), S.H. Aronson, G.J. Bock, D. Hedin, G.B. Thomson (Wisconsin U., Madison), Print-78-0823 (EFI, Chicago), N.D. (Recd. Aug. 1978) 12pp.
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K-L NUCLEUS TOTAL CROSS-SECTIONS BETWEEN 30-GEV AND 150-GEV: QUANTITATIVE EVIDENCE FOR INELASTIC SCREENING.

By A. Gsponer, J. Hoffnagle, W.R. Molzon, J. Roehrig, V.L. Telegdi, B. Winstein (Chicago U., EFI), S.H. Aronson, G.J. Bock, D. Hedin, G.B. Thompson (Wisconsin U., Madison), Print-78-0823 (EFI, (Chicago), N.D. (Recd. Aug. 1978) 12pp.
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DI-HADRON #494

SCALING PROPERTIES OF HIGH MASS SYMMETRIC HADRON AND PION PAIR PRODUCTION IN PROTON-BERYLLIUM COLLISIONS.

By H. Jostlein, R.J. Engelmann, R.J. Fisk, M.L. Good, A.S. Ito, D.M. Kaplan, R.D. Kephart, R.L. McCarthy, H. Wahl (SUNY, Stony Brook), S.W. Herb, D.C. Hom, L.M. Lederman, J.C. Sens, H.D. Snyder, J.K. Yoh (Columbia U.), J.A. Appel, B.C. Brown, C.N. Brown, W.R. Innes, K. Ueno (Fermilab-Pub.-78/86-Exp., Nov. 1978. 14pp.
Published in Phys. Rev. Lett. 42:146, 1979.
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NUCLEAR SCALING #592

'BACKWARD' PRODUCTION OF PROTONS, DEUTRONS, TRITONS, HE-3, HE-4 AND, PIONS IN THE INTERACTION OF 400-GEV PROTONS WITH NUCLEI.

By Y.D. Bayukov, V.I. Efremenko, S. Frankel, W. Frati, M. Gazzaly, G.A. Leksin, N.A. Nikiforov, C.F. Perdrisat, V.I. Tchistilin, Y.M. Zaitsev (Penn U. & Moscow, ITEP & William and Mary Coll.), UPR-0058E, Nov. 1978. 8pp.
Published in Phys. Lett. 85B:315, 1979.
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PROGRAM PLANNING OFFICE
21 JAN 1980

FERMI NATIONAL ACCELERATOR LABORATORY
EXPERIMENTAL PROGRAM SITUATION REPORT

THE EXPERIMENTAL PROGRAM SITUATION AT FERMILAB IS SUMMARIZED BELOW. THE EXPERIMENTS ARE LISTED SEPARATED BY EXPERIMENTAL AREA UNDER CATEGORIES THAT BEST DESCRIBE THEIR CIRCUMSTANCE AS OF JANUARY 1, 1980. FOR EXPERIMENTS WHICH HAVE BEEN COMPLETED OR HAVE RECEIVED BEAM THERE IS INDICATION OF THE AMOUNT OF RUNNING TIME OR EXPOSURE. THE EXPERIMENTAL AREA NAMES ARE ABBREVIATED AS FOLLOWS: MESON AREA (MA), NEUTRINO AREA (NA), PROTON AREA (PA), INTERNAL TARGET AREA (ITA).

TOTAL NUMBER OF APPROVED EXPERIMENTS - 301

AREA-BEAM		SPOKESPERSON	EXTENT OF RUN TO DATE	DATE COMPLETED
A. EXPERIMENTS THAT HAVE COMPLETED DATA TAKING (256):				
(ONLY EXPERIMENTS COMPLETED SINCE 1 JAN 1979 ARE LISTED BELOW)				
MA-M1	HADRON DISSOCIATION #272	FERBEL	1,950 HOURS	3 DEC 1979
-M2	LAMBDA BETA-DECAY #361	PONDROM	1,250 HOURS	29 OCT 1979
-M3	PI-MU ATOMS #533	THOMSON	2,050 HOURS	28 NOV 1979
NA-NO-DICHROM	NEUTRINO #356	SCIULLI	1,350 HOURS	17 JAN 1979
	15-FOOT NEUTRINO/H2&NE #380	BALTAY	196K PIX	31 OCT 1979
	15-FOOT ANTI-NEUTRINO/H2&NE#388	PETERSON	181K PIX	12 SEP 1979
-NO-WB HORN	NEUTRINO #253	MO	2,050 HOURS	7 MAR 1979
	15-FOOT NEUTRINO/D2&HIZ #545	SNOW	317K PIX	17 JAN 1979
PA-PE	PHOTOPRODUCTION #401	GOBMLEY	2,100 HOURS	26 NOV 1979
-PC	PARTICLE SEARCH #608	BROWN	600 HOURS	7 MAR 1979
-PW	PION INCLUSIVE #258	SHOCHET	1,500 HOURS	9 JUL 1979
	PARTICLE SEARCH #567	WITHERELL	1,650 HOURS	7 NOV 1979

B. EXPERIMENTS THAT ARE IN PROGRESS (14):			EXTENT OF RUN TO DATE	DATE OF RECENT RUN
MA-M1	PARTICLE SEARCH #490	SANDWEISS	850 HOURS	1 OCT 1978
-M2	CHARGED HYPERON MAG MOMENT #620	PONDROM	600 HOURS	1 JAN 1980
	QUARK #622	GUSTAFSON	UNSPECIFIED	1 JUL 1979
-M3	PARTICLE SEARCH #584	WINSTEIN	100 HOURS	1 JAN 1980
-M4	KAON CHARGE EXCHANGE #585	FRANCIS	1,100 HOURS	1 OCT 1978
NA-NO-DICHROM	NEUTRINO #616	SCIULLI	2,600 HOURS	1 JAN 1980
-NO-WB HORN	15-FOOT NEUTRINO/H2&NE #53A	BALTAY	163K PIX	1 JUL 1977
	NEUTRINO #531	REAY	1,150 HOURS	1 JUL 1979
	NEUTRINO #553	FRISKEN	1,500 HOURS	1 APR 1979
	15-FOOT & EMULSION/NEUTRINO#564	VOYVODIC	EMULSION EXPOSURE	1 JUL 1979
	15-FOOT ANTI-NEUTRINO/D2 #390	GARFINKEL	10K PIX	1 APR 1979
	15-FOOT ANTI-NEUTRINO/H2&NE#180	ERMOLOV	273K PIX	1 JUL 1977
-OTHER	MONOPOLE #502	BARTLETT	COSMIC RAY RUNNING	1 APR 1979
	NUCLEAR FRAGMENTS #466	SUGARMAN	33 TARGETS EXPOSED	1 JAN 1980

C. EXPERIMENTS THAT ARE IN TEST STAGE (8):			EXTENT OF RUN TO DATE	DATE OF RECENT RUN
MA-M1	PARTICLE SEARCH #515	ROSEN	300 HOURS	1 JAN 1980
-M6	ELASTIC SCATTERING #577	RUBINSTEIN	300 HOURS	1 JAN 1980
	HADRON JETS #557	MCLEOD	150 HOURS	1 JAN 1980
	PARTICLE SEARCH #580	GREEN	50 HOURS	1 JAN 1980
NA-15-FT	PARTICLE SEARCH #595	BODEK	500 HOURS	1 APR 1979
-OTHER	QUARK #549	LONGO	1 TARGETS EXPOSED	1 OCT 1978
PA-PE	PHOTOPRODUCTION #516	NASH	650 HOURS	1 JAN 1980
-PW	DI-MUON #326	SHOCHET	200 HOURS	1 JAN 1980

D. EXPERIMENTS BEING INSTALLED (7):			EXTENT OF APPROVAL
MA-M2	BEAM DUMP #613	ROE	1,000 HOURS
NA-NO-DICHROM	NEUTRINO #594	WALKER	PARASITIC RUNNING
-MUON/HADRON	PARTICLE SEARCH #610	KIRK	1,000 HOURS
PA-PC	CHARGED HYPERON #497	LACH	400 HOURS
-PW	DI-MUON #537	COX	1,000 HOURS
	C-TEST #302	WITHERELL	400 HOURS
ITA-C-O	PARTICLE SEARCH #591	GUTAY	800 HOURS

E. EXPERIMENTS TO BE SET UP WITHIN A YEAR (1):			EXTENT OF APPROVAL
PA-PE	PHOTON DISSOCIATION #612	GOULIANOS	1,150 HOURS

F. OTHER APPROVED EXPERIMENTS (15):			EXTENT OF APPROVAL
MA-M1	HIGH MASS PAIRS #605	BROWN	1,000 HOURS
-M2	TRANSITION MAGNETIC MOMENT #619	DEVLIN	250 HOURS
	NEUTRAL HYPERON #555	DEVLIN	450 HOURS
	POLARIZED SCATTERING #581	YOKOSAWA	UNSPECIFIED
-M3	CP VIOLATION #617	WINSTEIN	1,000 HOURS
-M6	HADRON JETS #609	SELOVE	UNSPECIFIED
NA-30-IN	30-INCH HYBRID #570	PLESS	1,500 HOURS
	30-INCH HYBRID #565	PLESS	PARASITIC RUNNING
	30-INCH HYBRID #597	WHITMORE	1,000 HOURS
-OTHER	EMULSION/PROTONS @ 500 #508	WOLTER	EMULSION EXPOSURE
	EMULSION/PROTONS @ 500 #524	WILKES	EMULSION EXPOSURE
	EMULSION/PROTONS @ 500 #576	HEBERT	3 STACKS
PA-PE	PARTICLE SEARCH #400	PEOPLES	UNSPECIFIED
	PHOTOPRODUCTION #458	LEE	UNSPECIFIED
-PW	FORWARD SEARCH #615	ANDERSON	1,000 HOURS

PENDING PROPOSALS (9):			EXTENT OF REQUEST
MA-M1	PHOTON SEARCH #614	ROSEN	300 HOURS
-M2	DI-MUON #589	MOCKETT	750 HOURS
	CP VIOLATION #621	THOMSON	1,200 HOURS
-M6	MULTIPARTICLE #523	DZIERBA	800 HOURS
	PARTICLE SEARCH #623	LAI	1,000 HOURS
NA-15-FT	DETECTOR DEVELOPMENT #528	ROBERTS	100 HOURS
-30-IN	DETECTOR DEVELOPMENT #550	ATAC	TEST RUNNING
PA-PE	PHOTOPRODUCTION #627	KNAPP	1,000 HOURS
ITA-C-O	PROTON-PROTON SCATTERING #500D	FRANZINI	1,000 HOURS

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