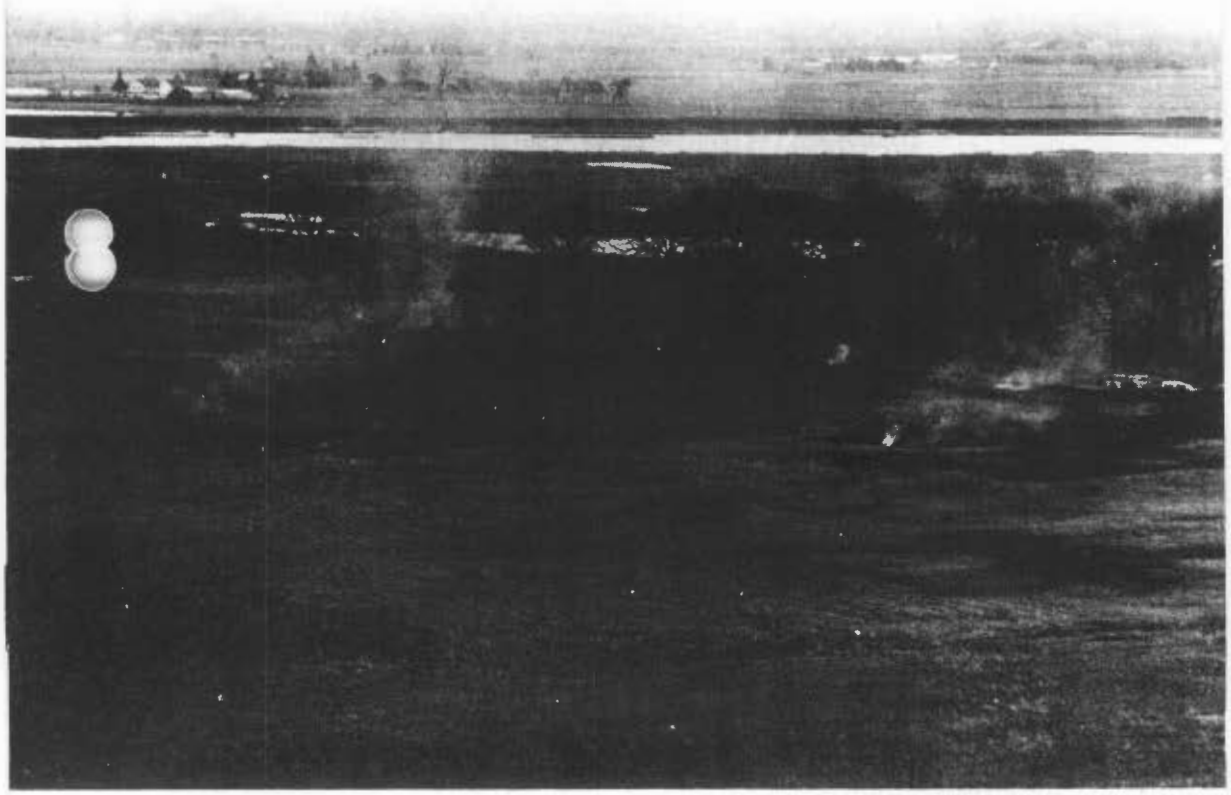
fermilab report

Fermi National Accelerator Laboratory Monthly Report

May 1978



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THE COVER: The annual burning of the Fermilab prairie inside the Main Ring. Beyond the oak trees, one can see C0 on the left, the farm beyond it and, in the far distance, the Village. At the far right, one can see the major access at D0 and, in the distance, the Big Woods Church just beyond the site boundary. The Assistant Editor of Fermilab Report is standing just to the left of the burning area.
(Photograph by Fermilab Photo Unit)

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MESON II WORKSHOP

T. Toohig

Introduction

The second and concluding Workshop - Meson II - on the upgrade of the Meson Area took place at Fermilab on April 14. Approximately seventy-five Users attended the all-day session.

Since the first Workshop in February, a number of working groups have met regularly to consider various aspects and possibilities for making the Meson Area facilities competitive with the CERN North Area.

In his introductory remarks, John Peoples set an optimistic tone for the Workshop in announcing that Dr. Wilson has allocated approximately $600,000 for construction in the Meson Area in FY 78. This will cover construction of a splitting station and new target train to allow an independent proton beam and target for M6, an annex to the Meson Target Hall for assembling and monitoring the more-sophisticated target systems envisaged after Mesopause, completion of the M1 tunnels to accommodate a very high intensity pion beam, and minor modifications to M6 to accommodate a 400-GeV upgrade.

Timothy Toohig reviewed the historical development of the Meson Area as background for the Workshop development. He pointed out that the Meson Area had been designed and built to operate with the accelerator as originally conceived at 200 GeV. Over the years, the Switchyard capability was increased, first to 300 GeV in 1973 and then to 400 GeV in 1975. The production angles of the secondary beams were, however, still those chosen

for 200 GeV. In the summer of 1977, the target train was modified to permit variation of the targeting angle to favor one beam line, while reducing the available flux in the other beam lines. In the same period, the secondary beam lines were gradually increased in energy to match the primary energy, except for the M6 line. The M6 line was limited to 200 GeV because of constraints in the enclosures. In M2, the controls and shielding were improved at the same time to allow targeting of approximately 10^{12} protons per pulse at the target station in the Detector Building. At this juncture, all that could be done adiabatically had been done.

The rationale for these construction projects is spelled out in "The Fermilab Meson Area: Proposal for 400-1000 GeV Upgrade," March, 1972.

Targeting: M1, M6 Independent Target

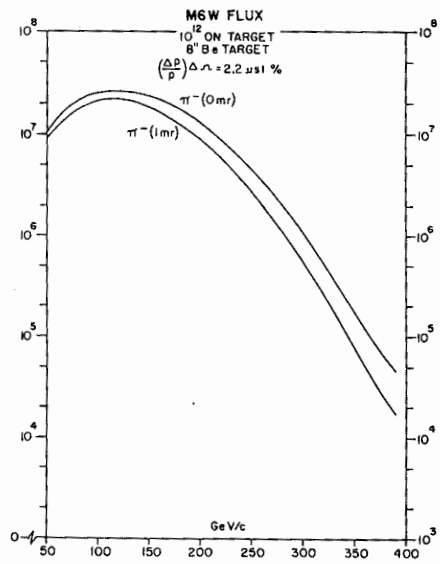
Alan Jonckheere reported on the design of an independent targeting system for the major beam lines. He pointed out that a factor of 4 to 5 in flux had been achieved in practice in the M1 or M6 beam lines by reducing the targeting angle to less than 1 mrad using the new targeting-angle magnets. It is desirable to have the capability of simultaneously having high flux in M1 and M6 by providing independent targets. The geometry of the Switchyard channel to the Meson Area is such that splitting the proton beam is trivial. Three manholes, F1, F2, F3, are separated from one another by 500 ft; from F3 to Meshall is 500 ft. With all this drift space, a single 3-m electrostatic system running at modest voltage in F1 and two Lambertsons in F3 suffice to provide an independent production target for M6. Some modest construction is required between F3 and Meshall to accommodate the split

beam. The Accelerator Division has agreed to installation of this split during Mesopause. At a later date, an electrostatic septum in F1 with Lambertsons in Meshall will provide an independent target for M1 and a direct proton beam to M2.

Details of the split are laid out in a report distributed at the Workshop, A. Jonckheere, "Meson Primary Proton Beam Targeting Upgrade," March, 1978.

M6: 400-GeV Upgrade

Ernest Malamud reported on plans for the M6 beam line. It is planned to increase the peak energy of the M6 line to 400 GeV by the use of superconducting Energy Doubler/Saver magnets. The beam will retain its character as a high-resolution beam with mass tagging. The figure below indicates the fluxes to be expected from M6 after the Mesopause. A more detailed report is available as "M6 Upgrade," E. Malamud et al., April, 1978.

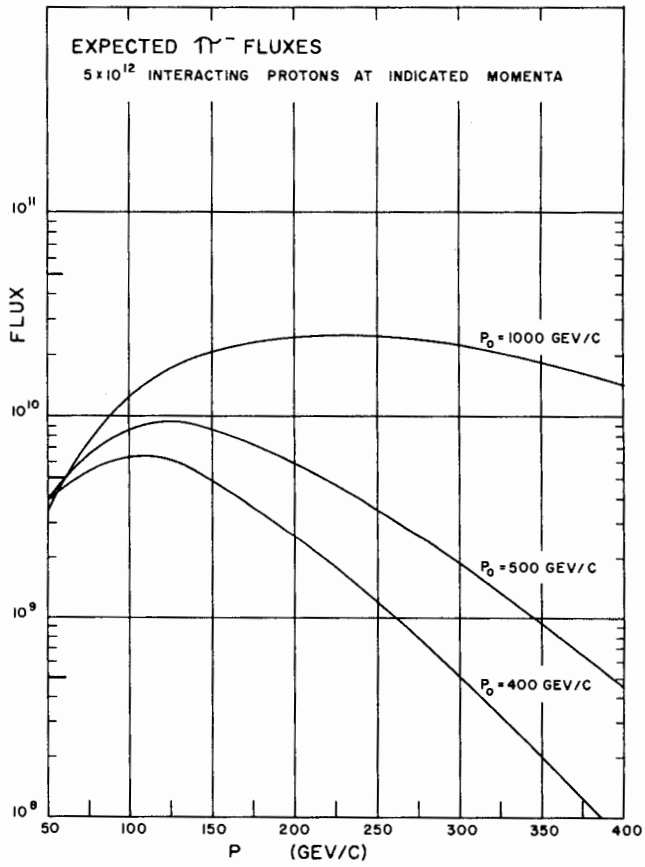


Estimated pion fluxes at several angles in the M6 beam line.

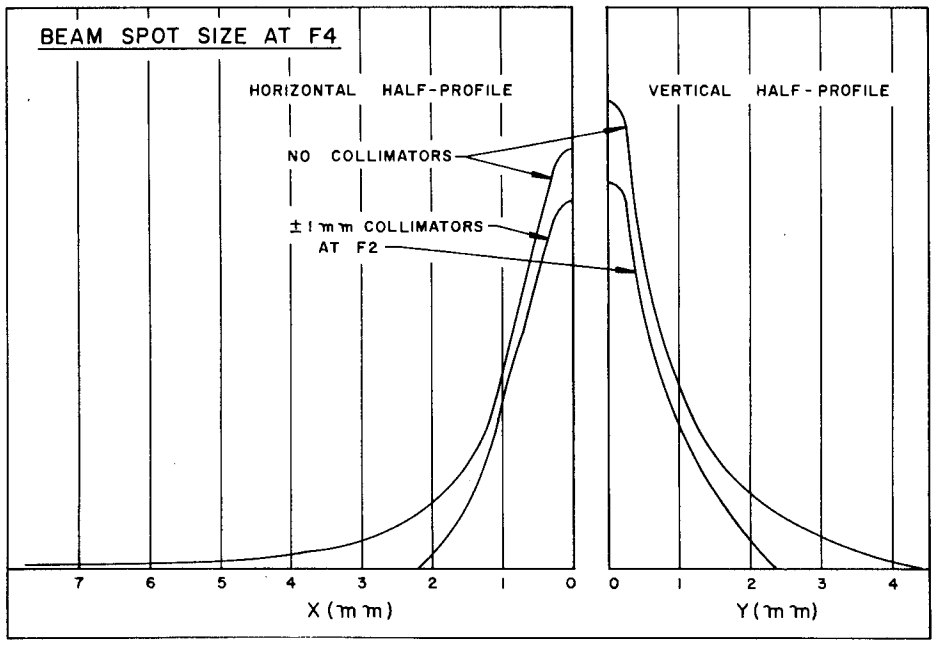
M1: High Intensity Pion Beam

Winslow Baker, David Carey, and Robert McCarthy described plans for the M1 beam line. A working group under Baker's direction has evolved a very high intensity pion beam design based on a new principle developed by Karl Brown of SLAC and applied by Carey to this case.

By the use of a periodic lattice incorporating sextupoles as major elements, a momentum acceptance $\Delta p/p = 24\%$ is achieved. A beam energy of 400 GeV is possible in the existing tunnels. Because of the unique character of the beam, fluxes of greater than 10^{10} π^-/pulse are attainable with very small spot sizes. The graph below illustrates the π^- flux as a function of beam energy, while the figure on the next page illustrates the spot size at the high-energy target station at 1000 feet.



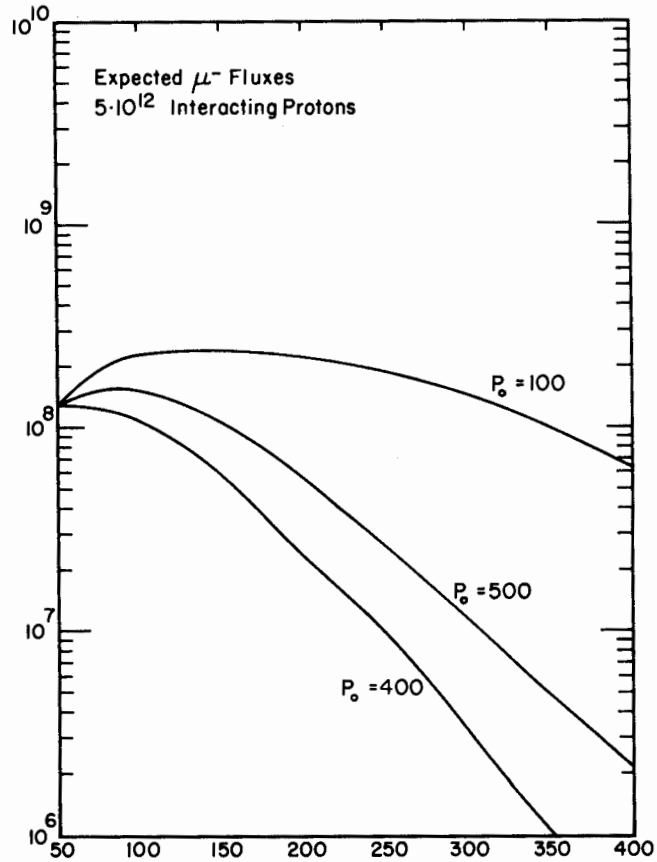
Estimated π^- flux as a function of beam energy.



Beam spot size at F4.

Preliminary studies, illustrated in the graph on the next page, indicate the possible utility of the beam as an alternative muon channel.

Present plans call for completion of the M1 civil construction during the Mesopause, with provision for an independent M1 target incorporated into the new target train. The beam would be only slightly modified from its present configuration coming out of the Mesopause in order to complete the presently installed experimental program. Procurement of the necessary elements would take place during the running of this program, with installation of the full high-intensity design envisaged for approximately 18 months after the Mesopause. Funds for the implementation are requested for FY 80.



Estimated μ^- flux as a function of beam energy.

A detailed design report is available as "A High Flux M1 Beam," W. Baker et al., February, 1978.

M2: 10^{12} ppp and Hyperon Move

On the day of the Workshop a new record intensity of 7×10^4 ppp was targeted successfully in M2. Plans for M2 include provisions for targeting up to 5×10^{12} protons per pulse in the Detector Building target station

contingent on a review of residual activation and shielding design. The neutral hyperon facility will be moved approximately 50 ft downstream of the Detector Building to accommodate more extensive experiments in the upstream target location.

M3: Polarized Protons and $\bar{p}$

Akihiko Yokosawa reported on the activities of an enthusiastic working group who considered a polarized proton beam and a $\bar{p}$ option in the M3 line. Construction of such a facility is tentatively envisaged for FY 80 budget submission. A detailed report is available as "A Polarized Beam for the M3 Line," A. Yokosawa et al., January 31, 1978.

Left Bend: Superconducting Installation

Russ Huson and Roger Dixon reported on plans to install Energy Doubler/Saver dipoles in the Left Bend during Mesopause. An access into the Switchyard to accommodate the 22-ft magnets will be constructed during the May-June maintenance and development period. Two ED/S dipoles will be installed in a zero-deflection arrangement to be operated prior to Mesopause. Based on the success of these tests, the upstream conventional magnet bend string will be removed during the August and September shutdown and ten ED/S dipoles installed in their places. With shielding in the tunnel, the installation of the twelve downstream dipoles can go on during Neutrino-Proton operation. Target dat for operation is before the February 15 scheduled end of the Mesopause.

Conclusion

The projects discussed at the Workshop are the beginning of the Mesopause work. The design work has proceeded rapidly with the aid of enthusiastic help from many Meson Area users. The construction work that is now beginning will result in a revitalized area capable of extending to the 1000-GeV regime the wide range of experiments that has always been characteristic of the Meson Area.

RECENT DOINGS IN THE INTERNAL-TARGET AREA

Peter McIntyre

Two experiments, E-522 and E-552, have recently completed data-taking in the Internal Target Area (C0). These are the latest in a series of experiments by a number of groups to study collisions of Main-Ring protons on a gas jet intersecting the beam.

Experiment #522, an experiment by a group from Indiana University, studied inclusive polarization of protons in pp scattering. Similar measurements on inclusive Λ polarization in the Fermilab hyperon beam (E-8 and E-441) indicate an inclusive polarization of 28%, much larger than had been expected. A systematic study of proton polarization in the same kinematic region is important to understand the polarization mechanism.

E-552, a Rutgers-Rochester-Imperial College collaboration measured differential cross sections for pp and pd elastic scattering and isobar production in the region of large momentum transfer ($1 < -t < 5$ GeV^2). The results may connect the observed energy independence of ISR cross sections for $|t| > 2.5$ GeV^2 with the factor of 2 decrease in $d\sigma/dt$ between E = 200 and 400 GeV for $5 < -t < 10$ GeV^2, seen in E-177 at Fermilab.

Another long series of experiments ended last November, when the Soviet-American collaboration completed their experiment E-289, a study of small-angle p-He scattering. This collaboration, working at C0 since 1972, first developed at Fermilab the cold He jet technique which allowed them to use very high jet density while maintaining acceptable Main-Ring vacuum. Many Russian physicists and their families have visited Fermilab for

extended periods during these experiments, making this a very successful Soviet-American collaboration from both humanistic and scientific points of view.

For the first time since the beginning of Fermilab beam operation, the Internal Target Area is entering an extended pause in its experimental program. No experimental operation is planned until early 1979. The experiments described above mark the completion of a rather full study of those properties of high-energy proton scattering that are accessible in the kinematic region of gas-jet experiments. That whole program will begin anew in the 1000-GeV energy range available with the Energy Doubler/Saver. C0 will be the first place where fixed-target experiments using 1000-GeV protons can be performed, since circulating beam will certainly be achieved in advance of extraction to the other experimental areas.

Meanwhile, searches for more exotic processes will become the focus of further experiments at C0 using the Main-Ring beam. E-591, a Purdue-Fermilab collaboration, has been approved for an experiment to search for anomalous (Z, A) fragments in proton collisions on a heavy nucleus gas (e.g., Xe). Running is expected to begin in early 1979.

The technical support group at C0 has for the past year been building the electron beam for the proton/antiproton Cooling Ring, in addition to support of the experimental program. In the coming months they will play a strong role in completing the Cooling Ring and in implementing the program to improve the Main-Ring vacuum.

An historic photograph - a complete set of the heads of C0: (left to right) Drasko Jovanovic, Peter McIntyre, Tom Nash, Ernie Malamud, and Jim Walker.

(Photograph by Don Mizicko)

SUMMARY OF OPERATIONS - APRIL 1978

Program Planning Office

During April the accelerator operated steadily, producing a high-intensity slow spill with the largest fraction used by two muon experiments collecting data in the Neutrino Area. This period represented the highest intensity operation ever with all slow spill; Main-Ring intensities at times exceeded 2×10^{13} protons per pulse. Furthermore this beam was obtained from rather reliable operation of the new H^- ion source and Booster injection system which were commissioned a month ago.

The completion of an experiment (E-552) in the Internal Target Area represented the end of experimental activities there until next year (see article on page 9). A single remaining experiment is tentatively scheduled to operate during January and February 1979.

Damping the enthusiasm over the steady high intensity operation of the Fermilab facilities has been the recent concern over increasing costs for electrical energy. With the coal strike this winter came the increased use of liquid petroleum for generation of electrical energy, and unfortunately with this there are substantially higher costs due to a steeply climbing fuel adjustment factor used in the power billing. As a consequence of this the cycle time of the accelerator at night and on weekends has been restricted to greater than 10 seconds, rather than about 8.6 seconds previously maintained. Rather than to increase the cycle time further, there is a plan to increase the amount of calendar time scheduled for shutdowns in the future.

FERMI NATIONAL ACCELERATOR LABORATORY
MONTHLY OPERATIONS HISTORY
APRIL 1978

Date		Accelerator	Int. Target Area	Proton Area	Neutrino Area	Meson Area
Sat.	4/1	Reprs: Booster	p-N Scattering 552	Photoprod.87A (PE)	Muon 203A/391 &	Multipart.110A (M6W)
Sun.	4/2	1.8×10^{13} ppp @400 GeV (1.25 sec flattop)		Di-Lepton 288 (PC)	Muon 448 (N1)	Multi-μ 439 (M2)
Mon.	4/3			P 519 Tests (PW)	Neutrino 310 Calib. (N5)	Part.Search 490 (M1W)
Tue.	4/4	Reprs:2 magnets & Linac				Incl.K^0_s 383 (M4)
Wed.	4/5					
Thu.	4/6	Reprs:Linac & Main Ring				
Fri.	4/7	Reprs:200 MeV Line				Multi-μ 439 (M2)
Sat.	4/8					Part.Search 490 (M1W)
Sun.	4/9		OFF			Part.Search 469 (M6E)
Mon.	4/10	Tour & Repairs				Incl.K^0_s 383 (M4)
Tue.	4/11	Accelerator Studies				
Wed.	4/12		OFF	Photoprod.87A (PE) P 519 Tests (PW) OFF (PC)	Muon 203A/391 & Muon 448 (N1)	Multi-μ 439 (M2) Part.Search 469 (M6E)
Thu.	4/13	Reprs:MR magnet				Incl.K^0_s 383 (M4)
Fri.	4/14	1.9×10^{13} ppp @400 GeV		Photoprod.87A (PE) Di-Lepton 288 (PC) P 519 Tests (PW)	Yield Meas. (N3)	Had.Dissoc.272 (M1E)
Sat.	4/15					
Sun.	4/16					as above but Repairs (M2)
Mon.	4/17	Accelerator Studies				
Tue.	4/18	Accelerator and Experimental Area Maintenance & Development				
Wed.	4/19					
Thu.	4/20					
Fri.	4/21	Reprs.& Startup 1.7×10^{13} ppp @400 GeV (1.25 sec flattop)	OFF	Photoprod. 87A (PE)	Muon 203A/391 &	Multi-μ 439 (M2) Part.Search 469 (M6E)
Sat.	4/22			Di-Lepton 288 (PC)	Muon 448 (N1)	Incl.K^0_s 383 (M4)
Sun.	4/23			OFF (PW)	Yield Meas. (N3)	Had.Dissoc.272 (M1E)
Mon.	4/24					
Tue.	4/25	Reprs: Gnd.Fault				
Wed.	4/26	~~Power Factor Meas.~~				
Thu.	4/27	Reprs:Ion source				
Fri.	4/28					
Sat.	4/29				as above but	
Sun.	4/30				ν356 Calib. (N5)	

BEAM UTILIZATION BY

	Beam	Hours
MESON AREA		
Particle Search #490	M1W	95
Multi-Muon #439	M2	240
Inclusive K_s^o #383	M4	350
Multiparticle #110A	M6W	60
Particle Search #469	M6E	275
Hadron Dissociation #272	M1E	155
Nuclear Chemistry #81	M0	-
NEUTRINO AREA		
Muon #203A/391	N1	405
Muon #448	N1	380
Neutrino #310 Calibration	N5	140
Neutrino #356 Calibration	N5	4
Yield Measurements	N3	220
Nuclear Fragments #466	N0	-
PROTON AREA		
Photoproduction #87A	PE	360
Di-Lepton #288	PC	315
P #519 Tests	PW	205
INTERNAL TARGET AREA		
p-N Scattering #552	C0	90
TOTAL HOURS FOR HIGH ENERGY PHYSICS		3294

EXPERIMENTAL ACTIVITY -- APRIL 1978

Activities

tuneup: including tests of a new high pressure streamer chamber

data: for study of high mass dimuon and multimuon spectra produced by 400-GeV proton interactions

data: for study of the reaction $K^- p \rightarrow K_S^0 X$ at 200 and at 75 GeV

completed: study of the reaction $\pi^- p \rightarrow \pi^+ \pi^- n$ at 175 GeV

tuneup & data: including a search for heavy long-lived particles using Cherenkov and time-of-flight techniques

tuneup: for eventual study of coherent dissociation of π, K, p into strange particles

data: 5 targets exposed

data: including a search for heavy neutral leptons produced in muon interactions at 225 GeV

data: for study of muon interactions with nuclear targets at 225 GeV

calibration: of liquid and iron calorimeters using a hadron beam

tests: of new experimental apparatus using a hadron beam

tuneup & data: for measurements of π's and K's produced at various energies and angles by 400-GeV proton interactions with a BeO target

data: 3 targets exposed

data: including a search for charmed states produced in photon interactions

data: primarily for a high-resolution study of the dimuon spectra produced by 400-GeV protons

tests: of ability to collect data using a high-intensity proton beam

completed: pp and pd scattering studies using an internal proton beam

FACILITY UTILIZATION SUMMARY--APRIL 1978

I. Summary of Accelerator Operations

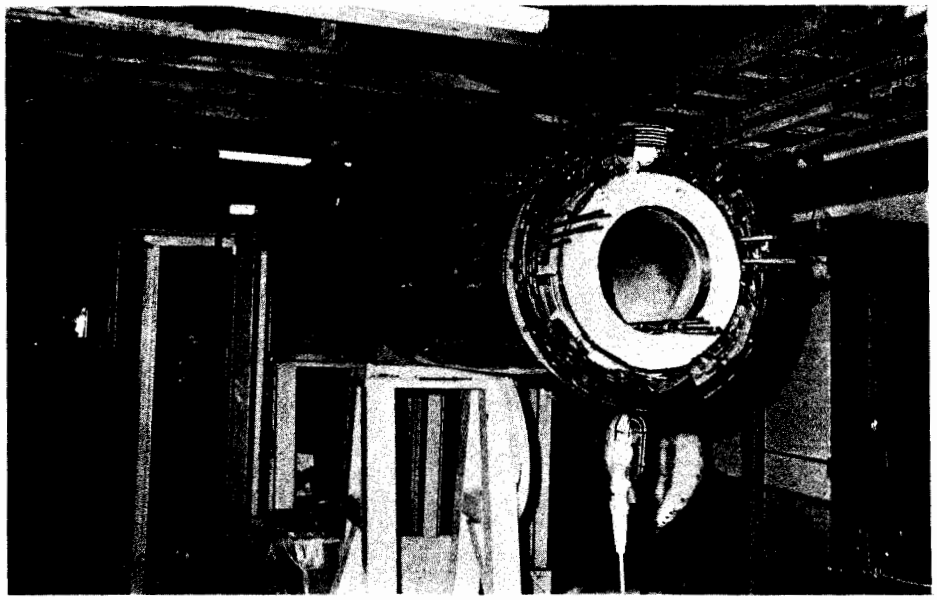
		Hours	
A. Accelerator use for physics research			
Accelerator physics research		29.2	
High energy physics research		418.8	
	Subtotal		448.0
B. Other activities			
Accelerator setup and tuning to experimental areas		0.5	
Program interruption		50.0	
Unscheduled interruption		220.5	
	Subtotal		271.0
C. Unmanned time			
	Total		719.0

II. Summaries of High Energy Physics Research Use

	# of Expts.	Hours	Results
A. Counter experiments	13	2869	2 expts. complete
B. Bubble chamber experiments	-	-	-
C. Emulsion experiments	-	-	-
D. Special target experiments	2	-	8 targets exposed
E. Test experiments	1	205	P519 tests; completed
F. Engineering studies and tests	(1)	220	Yield measurements (N3)
G. Other beam use	-	-	-
Totals	16	3294	

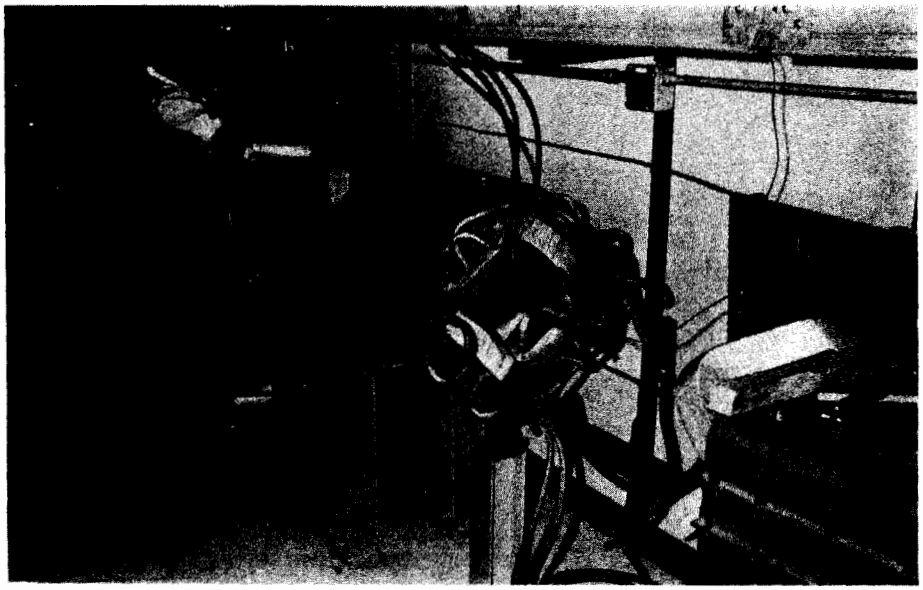
III. Number of Protons Accelerated and Delivered @ 400 GeV ($\times 10^{18}$)

A. Beam accelerated in Main Ring		2.45
B. Beam delivered to experimental areas		2.33
Meson Area		0.30
Neutrino Area		
	Slow Spill	1.90
	Fast Spill	0.00
Proton Area		0.13



Ed Faught is sitting astride the electron-beam solenoid as it is being installed in the Cooling Ring.

(Photograph by Fermilab Photo Unit)



Shree Agrawal with his belly to the bench working on a Cooling Ring dipole. One of the early quadrupoles is installed in the foreground.
(Photograph by Fermilab Photo Unit)

PROPOSALS RECEIVED FROM FEBRUARY 1978 THROUGH MAY 9, 1978

No.	Title	Spokesperson
596	On Searching for Heavy Stable Particles	L. Lederman
597	Proposal for a High Statistics Study of $\bar{p}p$ Annihilations and a Comparison of $\bar{p}$, p, π^-, π^+, and K^+ Interactions on Hydrogen, Magnesium, and Gold at 100 GeV/c Utilizing the Fermilab 30-In. Hydrogen Bubble Chamber and Downstream Particle Identifier	J. Whitmore/ W. Shephard/ W. Walker
598	Proposal for a High-Statistics Study of $\bar{p}p$ and π^-p Interactions at 50 GeV with the Fermilab 30-In. Hydrogen Bubble Chamber Hybrid Spectrometer with Downstream Particle Identifiers	V. Barnes
599	A Prompt Neutrino Experiment at Fermilab	L. Mo
600	Proposal to Study Neutrino-Electron and Antineutrino-Electron Scattering	J. Cronin
601D	ARGONAUT - A Novel Detector for Very High Energy Neutrino Interactions	P. McIntyre
602D	A Proposal to Study the Interactions of Neutrinos and Antineutrinos at the Energy Doubler/Saver	A. Sessoms
603	A Search for the Production of Prompt Neutrinos in High Energy Proton Nucleus Collisions	D. Reeder
604	A Sensitive Search for Massive Neutral Long-Lived Particles	L. Jones
605	A Study of 15-20 GeV Massive Muon Pairs	C. Brown

DATES TO REMEMBER

June 2, 1978	Special Presentation Meeting for Hadron Jet Proposals.
June 17-23, 1978	Summer meeting of the Fermilab Physics Advisory Committee.
August 1-4, 1978	Photon Workshop at Fermilab (details next month).