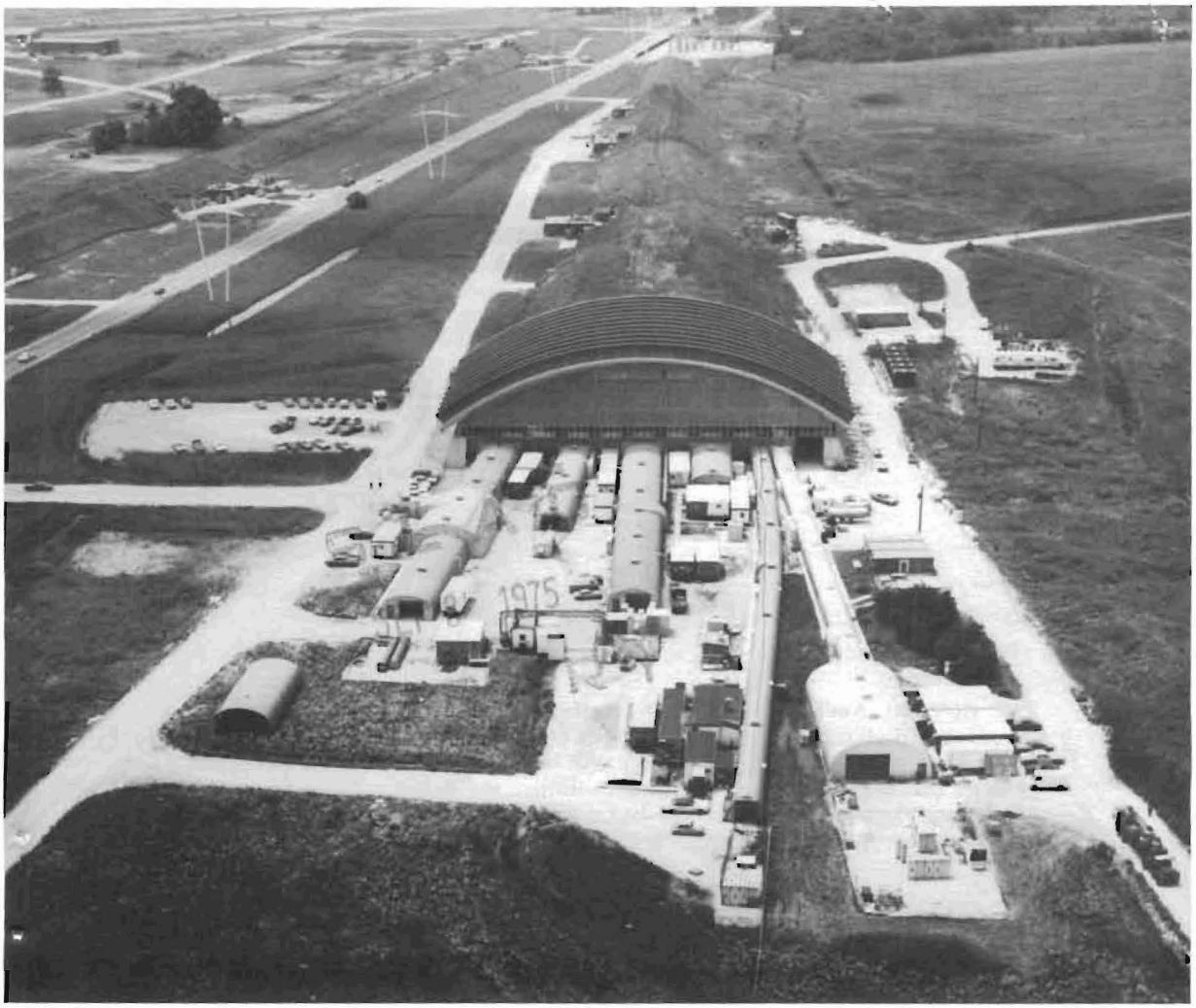
NALREP



Monthly Report of the Fermi National Accelerator Laboratory

August 1975

Fermi National Accelerator Laboratory

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THE COVER: Aerial view of the Fermilab Meson Area, looking south toward the Central Laboratory. The secondary beam lines originate in the common production target located under the earth berm at the center top of the photograph. Downstream of the Detector Building, the Wonder Building extensions house experimental apparatus for beam lines M1, M2, M3, M5, M6 East, and M6 West (left to right). The neutral M4 beam line lies beneath the M3 line.

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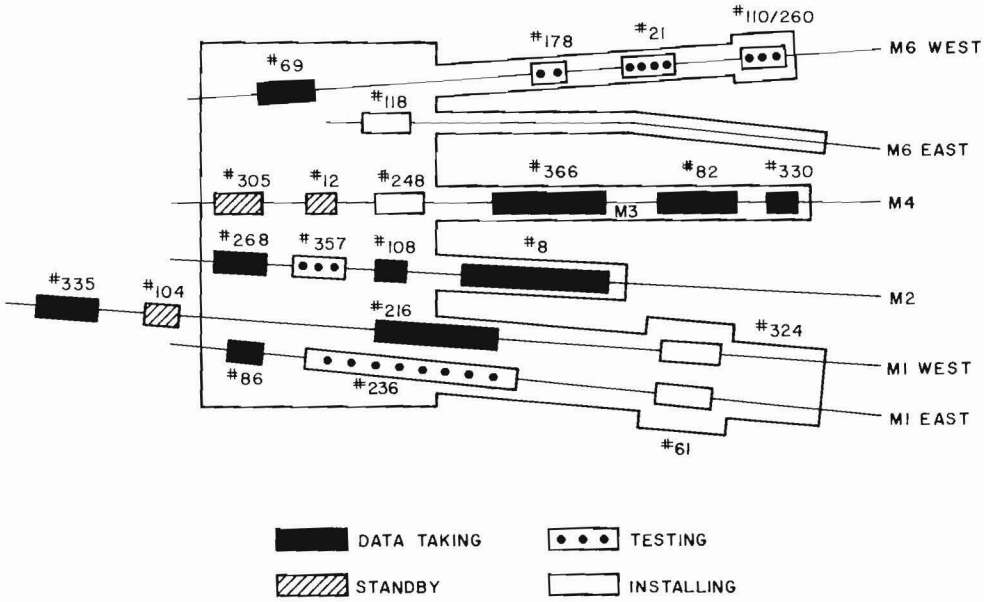
THE STATE OF THE MESON AREA

The facilities comprising the Meson Area were described by R. Lundy in a NALREP article in January 1974; they have not changed substantially since then. During the past 18 months, these facilities have been utilized to the fullest extent in order to reduce the original backlog of approved experiments.

Since the earlier report, the main accelerator has provided beam for 68 weeks, 60 of them at an energy of 300 GeV which could be transported to the Meson Area production target. The Meson Area actually received beam for a total of 55 weeks. A possible perfect operating record was spoiled primarily by the downtime in early 1974 which was required to clean up the interior of the Meson Detector Building in the aftermath of the fire in the M6 West beam extension.

Whenever a stable beam of primary protons is directed at the Meson Area production target, all five of the presently installed secondary beam lines (M1 East or West, M2, M3, M4, and M6 East or West) are normally turned on. The experimental areas for each beam line have been arranged so as to accommodate many experimental setups simultaneously. The utilization of Meson Area floor space by experimental groups in May 1975 is shown on page 2. In most instances, a newly installed experiment can be provided with valuable parasitic beam time for testing apparatus and equipment. Alternatively, in the early stages, an experiment can be assigned several short stretches of prime beam time (up to a week) for testing before being scheduled for a long data-taking run. While this flexibility has many



# 8 - Neutral Hyperon	# 216 - Form Factor
# 12 - Neutron Backward Scattering	# 236 - Hadron Jets
# 21 - Neutrino (Counter Test)	# 248 - Neutron Elastic Scattering
# 61 - Polarized Scattering	# 260 - Hadron Jets
# 69 - Elastic Scattering	# 268 - Inclusive Photon
# 82 - K^o Regeneration	# 305 - Neutron Dissociation
# 86 - Pion Dissociation	# 324 - Inclusive Scattering
# 104 - Total Cross Section	# 330 - Test Particle Search
# 108 - Beam Dump	# 335 - Muon Search
# 110 - Multiparticle	# 357 - Particle Search
# 118 - Inclusive Scattering	# 366 - Particle Search
# 178 - Multiplicities	

Diagram of the Fermilab Meson Area, showing the locations of experiments in the beam lines as of May 1975.

advantages, it also has its disadvantages. In particular, one must keep in mind the fact that each experiment installed on the floor, whether it uses beam or not, ties up costly and often scarce Fermilab resources; e.g., PREP electronics, beam-line controls, cryogenic target equipment, analyzing magnets, a BISON computer, a Portakamp, and the like. Also, the greater the number of potential prime users in a beam line, the more time it will require to finish each experiment. Generally, it seems unwise to have more than three experiments fully ready for data-taking in any one beam line at one time.

Aided in no small measure by the steady increase in the reliability of the accelerator performance, the many weeks of operating the Meson Area for experiments have left their mark on the high energy physics research program. This can be seen by comparing the statistics in the table below. Nearly all of the large first-round experiments have now been completed: Neutron Total Cross Section # 4, Elastic Scattering # 7, Neutron Backward

Meson Area Experiments

Status	January 1, 1974		July 1, 1975	
Completed experiments	2	(1400 hours)	19	(16,805 hours)
Experiments in progress	5	(3500 hours)	10	(12,050 hours)
Experiments in test stage	3	(370 hours)	4	(670 hours)
Experiments being installed	2	(170 hours)	4	
Experiments to be installed within one year	6		6	
Other approved experiments	7		7	
Total	25	(5440 hours)	50	(29,525 hours)

Note: In addition, about 13 experiments involving emulsion exposures or special target irradiations are not listed here because they require only a negligible fraction of Meson Area manpower and beam time.

Scattering # 12, Neutron Dissociation # 27A, Elastic Scattering # 96, and Pion Charge Exchange # 111. Total Cross Section # 104 has completed all of their measurements within the limitations of a 300-GeV primary proton beam feeding a 280-GeV/c secondary beam; the experimental apparatus has been mothballed until a major upgrading of the M1 beam line will allow an extension of the data to higher momenta. K^0 Regeneration # 82 has completed measurements with a carbon regenerator.

The results from these and other experiments in the Meson Area have made valuable contributions to our knowledge of high-energy phenomena:

--All hadronic total cross sections level off and start to rise in the Fermilab energy range.

--Slopes for hadronic differential elastic cross sections are increasing, indicating further shrinkage of the forward peak.

--A simple Regge pole model seems to work well, particularly with respect to pion-proton charge exchange data.

Just as these first-round experiments were being replaced by second-round ones, the Laboratory was engulfed by a veritable flood of requests for particle searches stimulated by the discovery of the ψ(J) at SLAC and Brookhaven. Nine such searches were initially approved for the Meson Area, requiring anything from minor additions to installed apparatus (3 experiments) to major modifications of existing apparatus (4 experiments) to completely new setups (2 experiments). The accessibility of the Meson Area for rigging operations greatly facilitated these changeovers. At this writing, five of these searches have been concluded, but in none of them was evidence found for the existence of charmed particles. However, this first scan of a

new horizon did turn up a few hints which are presently being worked into new proposals. It now seems that the intensities of the secondary beams in the Meson Area are a limitation in reaching the level of sensitivity needed for these searches. Frequently the total intensity requirements of all three Fermilab external experimental areas exceed the available accelerator yield. Usually the priority for high intensity goes to the Neutrino Area, and the Meson Area is operated at an intensity considerably below that requested. The anticipated availability of higher intensity accelerated beam should satisfy all of these needs in the future.

While the emphasis has been placed on operating the Meson Area for high energy physics research, additions to and improvements of the existing facilities have not been neglected. After suffering a serious setback in the form of a fire in the M6 West beam line extension, the Multiparticle Spectrometer Facility is now nearly complete. The large superconducting analyzing magnet (48 inches wide, 24 inches high, and 48 inches long) is operational, and detectors are being installed around it. The first experimental group to use this facility (for Hadron Jets # 260 and Multiparticle # 110A) will begin taking data this fall or winter.

The polyurethane insulation in all the beam-line extensions has been replaced with a nonflammable material. Two other construction projects have recently been completed. The Wonder Building extension of the M1 beam line has been widened and lengthened to accommodate the polarized proton target apparatus for Polarized Scattering # 61 in the East branch and Inclusive Scattering # 324 in the West branch. The MS3 Service Building has

been enlarged to alleviate the high concentration of beam line power supplies elsewhere. This also permits the elimination of some of the excessively long magnet power bus runs inside the tunnels, which waste energy. Other steps are being taken to reduce electrical energy consumption in the Meson Area. The power supplies for many of the beam-line bending magnets are now operated in a ramped mode, and many more superconducting analyzing magnets are being utilized. A recovery system for helium gas has also been installed so that the full economic advantage of using superconductivity can be realized.

With the commissioning of the aluminum insert on the C2 collimator, the Meson Area targeting system became capable of accepting an intensity of 10^{13} protons per pulse. Because the insert absorbs most of the energy of the primary proton beam, water cooling is required. A special closed-loop cooling system has been installed to prevent radioactive contamination of the regular cooling water systems. This targeting system has operated successfully since July 1974 at intensities up to the design value. The only problem encountered so far is a distortion in the iron portion of the C2 collimator caused by overheating when the target box is operated under vacuum. For now, the difficulty is solved by filling the target box with helium. A new collimator is being built; it has a water-cooled insert with a larger radius.

Considerable effort has been devoted to improving the regulation of power supplies and the accuracy of the readouts of these supplies. Many proportional wire chamber systems have been installed in the beam lines to facilitate beam tuning. In these projects Meson Department personnel were assisted by members of the Research Services Department.

Since January 1, 1974, the Meson Area research program has been suspended for 8 of 68 weeks because of the 300-GeV limit of the beam transport system to the Meson production target. Even though a 300-GeV bimodal ramp (the "front porch") is available, it is expensive to operate with long flat-tops at both 300 and 400 GeV on the same accelerator cycle. The reliability of the accelerator at 400 GeV is improving, and the point is approaching at which this will become the standard operating energy. For these reasons, it was decided to upgrade the Meson Area beam transport system to 400 GeV. The necessary magnets (conventional EPB dipoles and quadrupoles) were installed in May 1975, in a joint effort with the Accelerator Division External Beam Systems Group. The magnets completely fill the available space; so that any higher energy operation of the transport system will require magnets capable of higher fields.

As a consequence of increasing the energy of the primary proton beam, the possibilities of upgrading the charged secondary beams have been examined. In order to retain the ability to bring a diffracted proton beam into the Meson Detector Building, the M2 beam line has been upgraded to 400 GeV/c. A reasonable scheme, also relying on conventional magnets, has been developed which would raise the maximum momentum of the M1 beam line from 280 to 370 GeV/c. If the necessary magnets can be procured in time, and if funds are available, this improvement could be completed early next year.

While these two beam lines can be operated at higher energies without prohibitive increases in electrical power consumption, such is not the case with the M6 beam line. Therefore, it seems advisable to begin developing

appropriate superconducting magnets, drawing on the experience which has been gained elsewhere at Fermilab.

A brief mention of plans for two of the other beam lines should be made. The M5 test beam is to be installed; it will have a momentum capability of 50 GeV/c, and might be operational late this fall. Since this installation will deplete the supply of spare magnets, collimators, and the like, all of the components of this test beam will be regarded as "installed spares" for the other beam lines. An interesting scheme has also been proposed by which the presently neutral M4 beam line could be converted to a charged particle beam with the properties listed in the table below. This conversion would not be irreversible.

Estimated Particle Yields of the Proposed M4 Charged Beam.

Momentum	Particle Intensities Per Pulse* $\pi^{\pm}$	K^{+}	$\bar{p}$
50 GeV/c	10^7	2×10^6	2×10^5
100 GeV/c	2×10^6	5×10^5	10^5
150 GeV/c	5×10^5	10^5	-

*Based on the following assumptions:

Primary proton beam energy	300 GeV
Primary proton beam intensity	10^{13}/pulse
Production target	8" long beryllium
$\Delta p/p$ acceptance	±5%

Fermilab Technical Memo TM-588, 2254 (1975).

Thus, as the Meson Area enters into its third year of operation, it has several new options available which should help in keeping it the active and responsive experimental area which it has shown itself to be so far. With a bit of luck it might even have to be renamed the "Charmed Meson Area."

Reported by P. F. M. Koehler

400-GeV PROTONS NOW IN MESON AREA

On July 23 a beam of 400-GeV protons was first transported to the Meson Area; the area has operated with a 400-GeV primary beam since that date. Early measurements indicate that the targeting efficiency on a 0.060 by 0.060(inch)^2 production target is about 70%. This efficiency is as good as that which had been attained with the 300-GeV beam transport system. Thus, the second major upgrading of the primary proton beam to this external experimental area has been completed successfully. The Accelerator Division External Beam Systems Group, under H. Edwards, was primarily responsible for the organization and execution of this work. The Meson Department rebuilt many of the transport magnets and provided substantial help with the installation work.

Working within the narrow confines of the Switchyard Tunnel, technicians install the additional bending magnets which were required to enable the Meson Area production target to accept a 400-GeV beam.

NOTES AND ANNOUNCEMENTS

MORE DETAILS ABOUT THE BUBBLE CHAMBER SYMPOSIUM . . .

Plans are in progress for the Symposium on Bubble Chamber Hadron Physics at Fermilab, to be held on September 18 and 19, 1975. The meeting is scheduled to begin at 9:00 a. m. in the Fermilab Auditorium.

Because of the nature of this symposium, considerable effort has been made to obtain suggestions from many bubble chamber physicists concerning the presentations to be made and the corresponding choices for speakers. At the Laboratory's request, I. A. Pless, of Massachusetts Institute of Technology, has served informally as a program consultant and has provided much help in this regard. In the preliminary version of the program which follows, many of the suggestions which have been received are incorporated.

Thursday, September 18

High energy p-p interactions

Leading particle, low-multiplicity and 4-C fit results from the 30-inch bubble chamber spectrometers

Multibody final state results from the 30-inch bubble chamber spectrometers

First presentation on the theory of hadron interactions

Performance of the 15-foot bubble chamber

Special hadron beams to the Fermilab bubble chambers

Track-sensitive target development for the 15-foot chamber

Experience with Ne-H_2 mixtures

Improvement program for the 30-inch bubble chamber spectrometer

Second presentation on the theory of hadron interactions

Friday morning, September 19

Report on bubble chamber plans at the CERN-SPS

Review of multiparticle counter experiments at Fermilab

Possible future hadron program for the 15-foot bubble chamber

Possible future physics program for the 30-inch bubble chamber spectrometer

Third presentation on the theory of hadron interactions

A panel will participate in the symposium and afterwards formulate recommendations on the future bubble chamber hadron physics program at Fermilab. The panel will consist of the following:

M. L. Good, Chairman	SUNY, Stony Brook
D. Cline	University of Wisconsin
R. L. Lander	University of California, Davis
D. H. Miller	Northwestern University
T. M. O'Halloran	University of Illinois
J. L. Rosner	University of Minnesota
J. Sandweiss	Yale University
G. H. Trilling	Lawrence Berkeley Laboratory

The symposium is an open meeting, and all interested physicists are welcome to attend and to participate in the discussion to the extent time permits. Further questions should be addressed to T. Groves in the Fermilab Directors' Office.

USERS EXECUTIVE COMMITTEE . . .

At its first meeting on July 10, 1975, the Users Executive Committee elected L. N. Hand, Cornell University, as its Chairman. J. Pine of California Institute of Technology was chosen as Secretary. The Committee will meet again in September, at which time subcommittees on areas of specific concern to users will be established. Correspondence to the Committee should continue to be directed to the Users Office at Fermilab.

FACILITY UTILIZATION SUMMARY -- JULY 1975

The high energy physics research program during the first week of July was essentially a continuation of the work in progress at the end of June, with beam being utilized in all experimental areas except Neutrino, where a target train change was in progress. The accelerator operated steadily at 300 GeV during this time, and delivered over 106 hours of useful beam for the research program at 90% efficiency. The machine was turned off early on July 7 for a two-week period of maintenance and development work, primarily to connect the transformer-capacitor bank system and to complete the installation of additional main-ring feeder lines in preparation for upgrading routine accelerator operation to 400 GeV. The transformer was energized on July 11, and although commissioning did not occur until one week later, a 300-GeV magnet ramp was obtained soon after startup. Accelerator tune-up continued through that weekend and into the following week, first at 300 GeV and then at 400 GeV. This effort was suspended for about 12 hours on Sunday, July 20, to prepare for and conduct a Fermilab Open House, a highly successful event which over 30,000 persons attended. By the following Wednesday, 400-GeV beam had been tuned and transported to all three external experimental areas, and beam tuning for the high energy physics research program was underway.

There were continuing problems with some control and protective circuitry in the capacitor bank system through the remainder of the month. This resulted in several short intervals of operation with the bank connected in the circuit interspersed with longer running periods without it, while

modifications, repairs, and tests were carried out. Without the capacitor bank, operation was limited to a 13-second cycle, with a 1/2-second flat-top; most of the 76 hours of 400-GeV beam delivered for the research program through the end of July were under these conditions, at an average intensity of 0.5×10^{13} protons per pulse. With the capacitor bank operating, a 13-second cycle with a 1-second flat-top was established which used only slightly more average power. When the system becomes fully operational, the accelerator should be able to operate at 400-GeV with a 10-second cycle period and a 1-second flat-top.

In the Meson Area, Particle Search # 366, Particle Search # 330, K^0 Regeneration # 82, and Particle Search # 416 completed data-taking for their experiments in early July, while Neutral Hyperon # 8 ended a second period of such activity. Hadron Jets #236A, Hadron Jets #260, Particle Search # 357, and Multiplicities # 178 began checking equipment and tuning beam prior to the shutdown period, and then continued this work for the remainder of the month following the resumption of accelerator operation. In addition, Neutron Elastic Scattering #248 used beam for setup and checking equipment while Nuclear Chemistry # 81A exposed three targets in Meshall.

The Neutrino Area was turned off for the first three weeks of July, so that the horn could be exchanged for the narrow-band trainload. Neutrino #21A and Neutrino #254 used the available 400-GeV beam for initial train and equipment tuning, while Quark #276 installed a target on the trainload for a long-term exposure.

Experimental activities were carried on in all three target halls of the Proton Area during July, both before and after the shutdown. Photon Total Cross Section # 25A completed tuning work and began preliminary data-taking in Proton East. Muon Search # 48 completed tuning and equipment testing in Proton Central, and began collecting data, while Photon Search # 95 first continued tuning the upgraded Proton West beam line and then began to bring some apparatus for their experiment into operation.

In the Internal Target Area, available beam time was shared by Proton-Nucleon Inelastic # 317 and Particle Production # 418, with each group receiving both 300- and 400-GeV beam. The # 317 group collected data using the hydrogen gas jet target, while the # 418 group used a rotating target with carbon and tungsten fibers.

The summary of accelerator and experimental area beam utilization for the month of July is as follows:

I. Summary of Accelerator Operations

		Hours	
A.	Accelerator use for physics research		
	Accelerator physics research	51.7	
	High energy physics research	182.7	
	Research during other use	(19.5)	
	Subtotal		234.4
B.	Other activities		
	Accelerator setup and tuning to experimental areas	75.6	
	Scheduled interruption	341.5	
	Unscheduled interruption	92.5	
	Subtotal		509.6
C.	Unmanned time		
	Total		744.0

II. Summaries of High Energy Physics Research Use

	# of Expts.	Hours	Results
A. Counter experiments	19	1231.3	
B. Bubble chamber experiments	0	-	
C. Emulsion experiments	0	-	
D. Special target experiments	2	74.3	4 Targets
E. Test experiments	0	-	
F. Engineering studies and tests	2	95.7	
G. Other beam use	-	1.5	
	23	1402.8	

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

	@300 GeV	@400 GeV	Total
A. Beam accelerated in main ring	0.441	0.118	0.559
B. Beam delivered to experimental areas			
Meson Area	0.273	0.039	0.312
Neutrino Area			
Main beam (N-0)	0.000	0.0003	0.0003
Bypass beam (N-7)	0.000	0.0004	0.0004
Proton Area	0.097	0.013	0.110
Total	0.370	0.0537	0.4237

IV. Beam Utilization by Experiment

	Hours	
A. Meson Area		
Neutral Hyperon # 8	92.7	
Nuclear Chemistry # 81A	-	3 Targets
K^0 Regeneration # 82	42.5	
Multiplicities # 178	41.0	
Hadron Jets #236A	112.8	
Neutron Elastic Scattering # 248	17.0	
Hadron Jets # 260	95.0	
Photon Inclusive # 268	19.0	
Particle Search # 330	31.5	
Particle Search # 357	26.6	
Particle Search # 366	93.5	
Particle Search # 416	10.0	

	Hours	
B. Neutrino Area		
Neutrino #21A	61.5	
Neutrino #254	48.0	
Quark #276	74.3	1 Target
C. Proton Area		
Photon Total Cross Section #25A	140.6	
Muon Search #48	145.9	
Photon Search #95A	61.7	
D. Internal Target Area		
Proton-Nucleon Inelastic #317	89.2	
Particle Production #418	102.8	
Total	1305.6	

PROPOSALS RECEIVED DURING JUNE AND JULY 1975

Number	Title	Submitted by
416	Streamer chamber search for new states which decay semi-leptonically	H. Lubatti
417	A measurement of the polarization of lambdas at large transverse momenta in the reaction p, π^-, $K_L^0 + N \rightarrow \Lambda + X$	U. Nauenberg
418	Nuclear size dependence for particle production at intermediate transverse momentum	F. Sannes
419	Search for short-lived particles produced by 300-GeV protons in emulsions	G. Giacomelli
420	Fermilab proposal for high-precision studies of deep-scattering phenomena from protons, pions, electrons, and gamma-rays on hydrogen and deuterium	Z. Guiragossian
421	Exposure of an emulsion chamber to a 300-GeV/c proton beam	V. Dzhelepov
422	Proposal to study $\bar{p}$-induced reactions by means of the 15-foot bubble chamber	A. Fridman
423	Search for new particles in emulsion chamber	H. Sugimoto
424	Multiple pion production by 200-GeV/c muons	T. Wada
425	Proposal to investigate regeneration of neutral K-mesons at very high energies	S. Aronson
426	Proposal on the study of fragmentation particles created in a plastic detector by 300-GeV protons	K. Fukui
427	A proposal for testing a transition radiation detector and a high energy shower detector for cosmic-ray experiments	L. C. L. Yuan

DATES TO REMEMBER

September 18-19, 1975	Symposium on Bubble Chamber Hadron Physics.
September 26, 1975	Deadline for receipt of new proposals to be considered for oral presentation at the Proposal Presentation Meeting.
October 9-10, 1975	Proposal Presentation Meeting.
October 11, 1975	Fermilab Auditorium Arts Series: Fine Arts Quartet. Tickets available in Guest Office after October 1.
October 17, 1975	Deadline for receipt of all written materials to be considered at the fall meeting of the Program Advisory Committee.
November 14, 1975	Deadline for receipt of materials to be considered at the Workshop on the Short-Lived Particle Beam Facility.
November 20-21, 1975	Fall meeting of the Fermilab Program Advisory Committee.
December 18-19, 1975	Workshop on the Short-Lived Particle Beam Facility.