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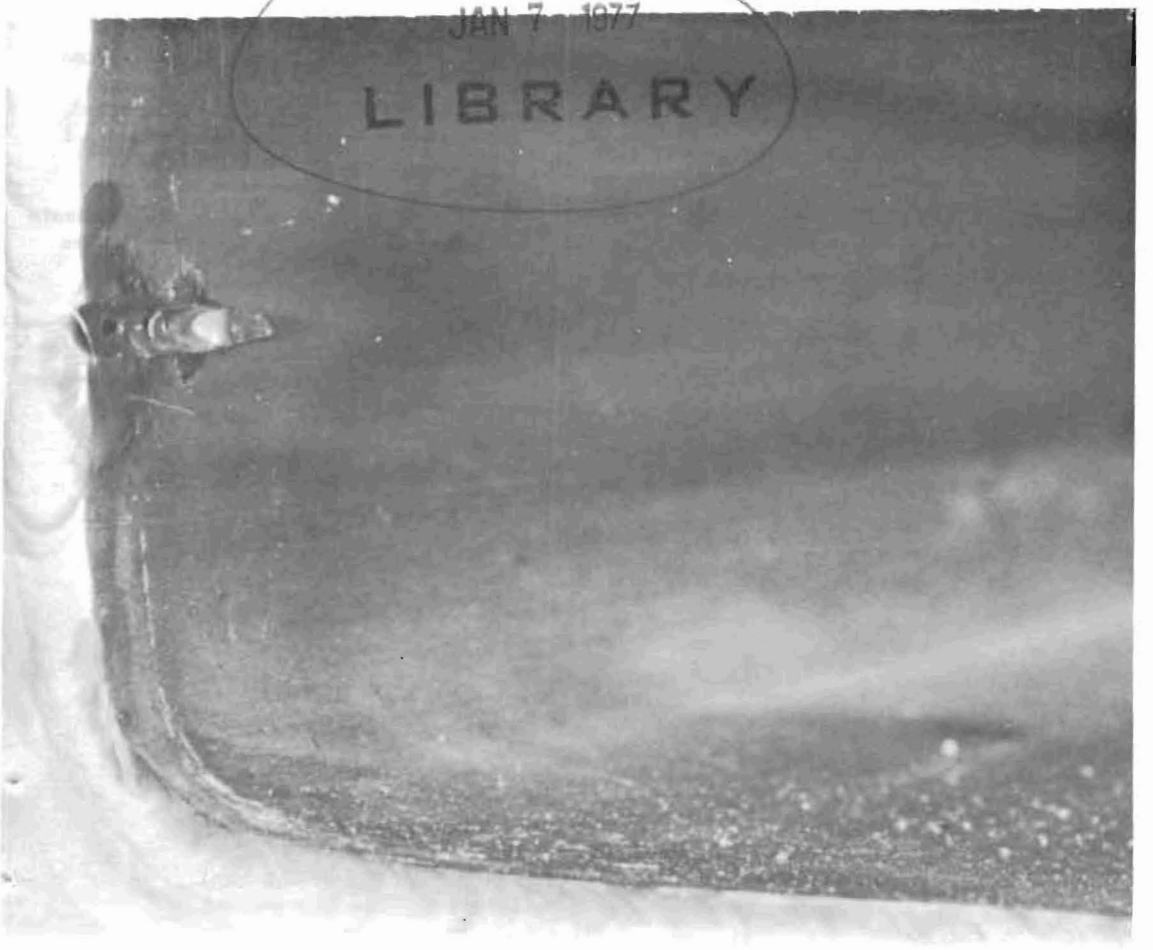

Monthly Report of the Fermi National Accelerator Laboratory December 1976

Fermi National Accelerator Laboratory

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F. T. Cole, Editor

R. Donaldson, Assistant Editor

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FERMILAB-76/12 0090.01

THE COVER: The vacuum chamber of main-ring bending magnet C16-3, melted by the errant proton beam on November 28. The depression is 2 mm in diameter and 16 mm long. The chamber is stainless steel of thickness 50 mil (1.2 mm). There are three separate holes through the chamber walls.

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Dates to Remember

OBSERVATION OF A CHARMED PARTICLE

The group of Experiment 247 has announced they have directly observed a likely example of the production and decay of a charmed particle. The experiment was performed in the wide-band neutrino beam utilizing a technique in which spark chambers are placed downstream of nuclear-emulsion stacks. A neutrino interaction occurring in the emulsion may be located by tracing back from the secondary-particle tracks in the spark chambers to their point of origin in the emulsion. Nuclear emulsion is the only detector that makes it possible to observe directly particles of lifetimes 10^{-14} to 10^{-12} seconds. The search for interactions in the emulsion is only partially complete, but an event has already been found in which one of the secondary particles produced by an incident neutrino is a likely candidate for a charmed particle. The particle decays after 0.2 millimeters, corresponding to a lifetime of approximately 6×10^{-13} seconds. Detailed measurements of the decay particles from this particle make it most probable that the event represents a massive new short-lived particle with characteristics compatible with those expected for a charmed particle. The possibility that the event is an inelastic diffractive scattering event cannot be completely ruled out by the evidence, but it is highly probable that a charmed particle has been directly observed for the first time.

HIGHER ACCELERATOR INTENSITY

An accelerated-beam intensity of 2.4×10^{13} protons per pulse was reached during the Thanksgiving weekend, making a total increase of more than 20% in peak intensity during 1976.

The new intensity record is the result of work in many different parts of the accelerator. One of the major efforts has been to change linac operation from the 75-mA peak-current and four-turn booster-injection pulse-length parameters of the original design to 300-mA peak-current and single-turn booster-injection pulse length. This change gives smaller beams, more acceptable to both Booster and Main Ring. It has required major upgrading of the linac rf systems. There has also been extensive development of accelerating columns, resulting in a new column of larger total current and brightness, and modification and retuning of the 750-keV transport line.

There have also been a number of booster improvements. The booster working point was changed from (6.62, 6.80) to (6.75, 6.90), which gave reduced losses early in the cycle and smaller beam size at 8 GeV. Quadrupole and sextupole correction elements are now also ramped on a program.

The booster rf system has had improvement in the turn-on system and a change in the total method of operation to damp coherent longitudinal instabilities near the end of the cycle. One station is driven at the 83rd rather than the usual 84th harmonic of the revolution frequency, which determines coherent effects in the beam. This is an adaptation of an idea proposed and used by K. W. Robinson at the Cambridge Electron Accelerator.

These efforts have produced a much better beam for main-ring injection and extraction. The Main Ring itself has had improvements in beam-position control at transition, magnet realignment, development of higher-mode dampers in the rf system and injection-correction retuning.

It has been possible to extract the higher-intensity beams with acceptable losses because of developments in the extraction system, including new extraction septa and a septum-shadowing device in the Proton split. Simultaneously with the greater intensity, there have been improvements in reliability, spill structure, and splitting and fast/slow flexibility, all of which help to make the extracted beams more useful for high-energy physics research.

ELECTRON COOLING AT FERMILAB

Introduction

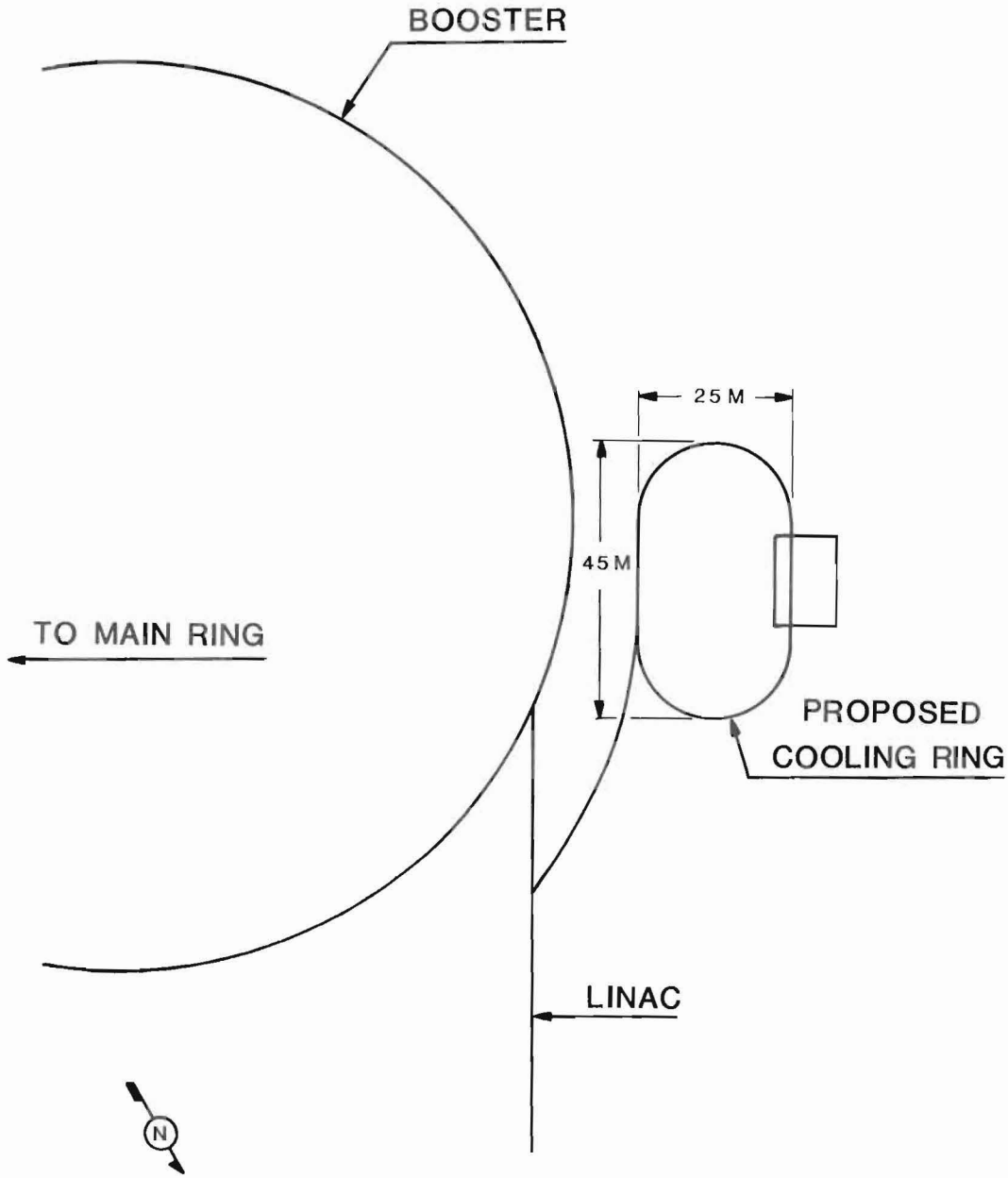
Electron cooling, the damping of the oscillations of a proton beam by interaction with an electron beam, has been demonstrated experimentally by G. I. Budker and his colleagues at the Institute of Nuclear Physics, Novosibirsk, USSR. This success has led a group here to consider the use of electron cooling at Fermilab and the Laboratory has submitted a proposal to the National Science Foundation to study electron cooling in a small ring that would be constructed just west of the Booster. If these tests are successful, it will be possible to utilize electron cooling in several ways at Fermilab. For example, it will be possible to build at modest cost a proton-antiproton colliding-beam facility that can be used to explore an entirely new energy region and to search for the intermediate vector boson that is believed to moderate the weak interaction. It will also be possible to improve the intensity of the Fermilab beam by reducing its size and thereby reducing losses during injection and acceleration.

Electron cooling of baryon beams was first proposed by Budker as a means to make intense antiproton beams. An electron beam is made to travel parallel to the baryon beam at the same speed in a long straight section of a storage ring. Collisions with electrons reduce the oscillation amplitudes and momentum spread of the baryons and, consequently, reduce the volume of phase space occupied by the baryon beam. The beam is then denser and has higher luminosity. This higher density and luminosity make electron cooling attractive for proton-antiproton colliding beams.

All the experimental work to this time has been carried out on the NAP-M storage ring constructed for this purpose at Novosibirsk. In their experiments, a beam of 65-MeV protons has been cooled by a 35-keV electron beam. They find that the relative difference in speed $\Delta v/v$ between the proton and electron beams must be less than 2×10^{-3} for cooling to take place. When there is cooling, the lifetime of a coasting proton beam in NAP-M is increased from 900 to 5000 seconds. The proton beam damps from an amplitude of 2 cm to a final amplitude of 0.8 mm, a figure in reasonable agreement with the predictions of the theory. The damping time depends linearly on the electron beam current, as predicted. The quantitative agreement of predicted and measured damping times is not yet clear.

Proposed Cooling Tests at Fermilab

It is important to verify the Novosibirsk results and to study in more detail the cooling time and its dependence on various parameters of interest. For these studies, it is proposed to construct a storage ring in an above-ground temporary building just west of the Booster. The location and size of the ring are shown in the figure. A beam of protons from the linac will be used to fill the ring. One of the two long straight sections will be used for this injection, while the other will be used for cooling apparatus. Linac beam is available, of course, while main-ring acceleration is in progress, and an extracted 200-MeV beam is already in existence for the proton-radiography studies now going on. The linac energy of 200 MeV is advantageous for these tests, because the cooling time increases rapidly with energy (as γ^5) and cooling experiments would therefore become much more difficult at higher



Proposed cooling ring location.

energy. The electron-beam energy is fixed at 110 keV by the requirement that the proton and electron speeds match. It is planned that the electron gun in the Fermilab cooling ring will have higher current density than has been available at Novosibirsk, making use of the technology of an electron gun developed for the SPEAR rf system.

The table below is a listing of the important parameters of the proposed storage ring.

Storage-Ring Parameters

Proton Energy	200 MeV
Electron Energy	110 keV
Electron Current Density	1.3 A/cm^2
Magnetic Radius	4.7 m
Maximum Dipole Strength	4.6 kG
Long Straight Sections	
Number	2
Length	22 m
Limiting Apertures	
Horizontal	15 cm
Vertical	6 cm
Tunes $\nu_h = \nu_z$	3.7

The storage-ring parameters are determined by the experiments planned. It is not a difficult ring to build. The field strengths required are small and the aperture only slightly larger than that of the Main Ring. A modest rf system is planned for use in beam manipulation and stacking.

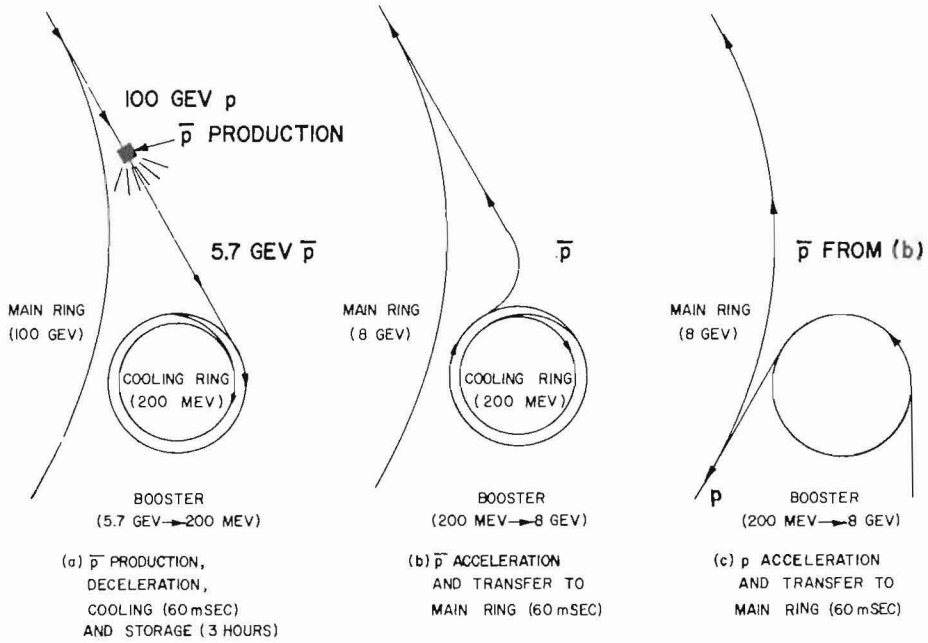
Applications of Cooling at Fermilab

If the tests of electron cooling are successful, there are a number of possible applications of the method here at Fermilab. One simple, straightforward application would be to reduce the size of the beam injected into the Booster. This would make it possible to reach higher beam intensity at full

energy, since a significant amount of beam is now scraped off during Booster injection. One could also consider using electron cooling to reduce beam size at other times in the acceleration cycle. These beams of higher luminosity could also be advantageous for the proton-proton colliding-beams systems being discussed.

An application that holds great promise for physics experiments has been proposed by Cline, McIntyre, Mills, and Rubbia. In this plan, antiprotons of 5 to 6 GeV energy are produced by 100-GeV main-ring protons on a target in F sector. The antiprotons are transported to the Booster, injected and decelerated to 200 MeV. They are then transferred to a 200-MeV cooling ring installed in the Booster tunnel. This ring is presently envisaged as an expanded version of the experimental cooling ring discussed above. The cooling time is calculated to be 60 milliseconds. Cooled antiprotons are collected in the cooling ring for several hours to achieve a total stack containing of the order of 10^{11} antiprotons. This stack is then injected into the Booster, accelerated to 8 GeV and injected into the Main Ring, going in the opposite direction to that of protons. Then one Booster batch of protons is accelerated to 8 GeV and injected into the Main Ring. Both protons and antiprotons are then accelerated together in the Main Ring to full energy, and brought together to collide at a long straight section. This scheme is shown schematically in the figure on the following page.

When the Energy Doubler/Saver is completed, it can also be used, both for acceleration and for storage of $\bar{p}p$ colliding beams. It will then be possible to have a center-of-mass energy of 2 TeV without construction of a major new ring.



Schematic plan of $\bar{p}$-p colliding beams.

It should be understood that the antiproton-proton facility being discussed will not initially give luminosities comparable to those that can be achieved in proton-proton colliding beams, but they would provide a unique glimpse of elementary-particle physics in an entirely new energy range. In this new range, it will be possible to search for the intermediate vector boson, now predicted to have a mass of 64 GeV/c^2 for the charged state and 79 GeV/c^2 for the neutral state. Center-of-mass energies of several hundred GeV are needed to produce these bosons in proton-proton or proton-antiproton systems. Even in an electron-positron system, a center-of-mass energy of 80 GeV (40 GeV in each beam) is needed. No existing or approved accelerator

can reach these energies, whereas the ring discussed here could survey the region thoroughly at a cost far smaller than that of constructing a totally new facility.

There are many other interactions to be explored in this totally new energy range. At much lower luminosities, cosmic rays have produced many unexplained super-high energy events. The antiproton-proton facility will permit these processes to be explored. In addition, one might hope to produce heavy leptons, Higgs bosons, or even free quarks.

All these applications make the study of electron cooling of great interest for Fermilab, with a possible large impact on future directions of the Laboratory. Cooling studies are now being pursued as a Laboratory effort, collaborating with interested users, to learn more about this important accelerator-physics development.

DEPARTMENT OF COLLIDING BEAM EXPERIMENTS

A meeting was held at Fermilab on November 17 to discuss various possibilities for the organization of work on colliding beam experiments. In accordance with some of the ideas which were discussed at that meeting a Colliding Beam Experiments Department has now been set up. Professor James Cronin of the University of Chicago has agreed to head this new department.

The department is to be a center for a number of activities directed toward planning for the exploitation of pp and $\bar{p}p$ colliding beams in the present Main-Ring tunnel. Financial restrictions prevent adding very many people to Fermilab, so most of the contribution to the work will be made by people in other departments and divisions of the Laboratory. However, some people will be transferred to the Department as it seems desirable to do so. It is expected that a strong contribution will be made in this department by both Fermilab and non-Fermilab physicists who expect eventually to submit proposals for use of the colliding-beam facilities.

Among the responsibilities of this Department will be:

1. The new department will be responsible for establishing the number of experimental enclosures in the Main Ring, the scope of each, and then their design specifications.

2. It will be responsible for the construction of actual experimental facilities if their size and scope are as complex as, for example, a large bubble chamber.

3. It will also be responsible for maintaining free and easy access to some of the facilities for less global research.

4. Development work necessary to establish the feasibility of experimental equipment will also be organized by this department.

5. Consideration of and possible planning for a by-pass of the Main Ring, to be used with the Energy Doubler, will also be a responsibility of this department.

The actual attainment of cooled protons and of producing and storing antiprotons and protons in the Doubler or in the Main Ring will remain the responsibility of the Accelerator Division. Responsibility for eventual construction of the enclosures and their management is also envisaged as remaining in the Accelerator Division.

NOTES AND ANNOUNCEMENTS

GENERAL COMMENTS ON MEETINGS TO COME. . .

A general schedule for PAC-related meetings to be held at Fermilab during the period January-June 1977 will be found at the end of this issue under "Dates to Remember." This schedule was prepared following the November meeting of the Program Advisory Committee and was shaped by the discussion and recommendations at that meeting. (A report on the November PAC meeting appeared in last month's issue of NALREP.) Workshops and Proposal Presentations are open meetings. All interested persons are welcome to attend and to participate in the discussion to the extent time permits. General questions about these meetings should be addressed to T. Groves in the Director's Office. Further information pertaining to specific workshops follows.

MULTIPARTICLE SPECTROMETER WORKSHOP. . .

The Multiparticle Spectrometer Workshop, originally scheduled for December 9-10, 1976 is now planned for Friday and Saturday, March 4-5, 1977. A committee chaired by E. Malamud is responsible for organizing the program and a separate mailing containing preliminary program information is planned for early January.

HADRON JET EXPERIMENTS WORKSHOP. . .

This workshop will be convened to consider a new generation of experiments designed to explore in some detail the production dynamics

and the structure of hadron jets. There are three current generation hadron jet experiments at Fermilab. Data taking has been concluded for E260, the first of the three and our expectation is that by the time of the workshop the analysis of the results from this experiment will be reasonably well in hand. A major portion of the data taking will have been completed for E236 and preliminary results may be available. E395, the last of the three, will be in a relatively early state with the bulk of the data taking expected to come after the workshop. Tentatively, we expect that reports will be given on these three experiments as a prelude to evaluating proposals for future experiments of this type. Experimenters interested in submitting proposals for future hadron jet experiments at Fermilab should note the March 4, 1977 deadline for submission of proposals to be considered at the workshop.

FUTURE NEUTRINO EXPERIMENTS WORKSHOP. . .

During a discussion of E310 at the November PAC meeting, the proponents of that experiment re-emphasized their agreement with the Laboratory's policy that the equipment they have put together for that experiment is available as a Laboratory facility. We are aware that there is some interest on the part of several new groups in undertaking studies of neutrino interactions. Some of these studies would require large detectors, and a number of ideas have been proposed for detectors which would be entirely different from those which exist today. Our purpose in holding this workshop in the spring is to consider proposals addressed to new neutrino experiments and related facilities. Groups interested in pursuing future

neutrino experiments at Fermilab should note the March 25, 1977 deadline data for the receipt of written materials to be considered at this workshop. The outcome of the discussions at this workshop will form a major topic to be dealt with at the 1977 Summer PAC meeting.

RESEARCH ACTIVITIES DURING NOVEMBER 1976

James MacLachlan

The accelerator had a premier month in November despite two major power interruptions. The accelerated proton total of 2.6×10^{18} is second only to the June, 1975 figure of 2.8×10^{18} obtained in the last month of straight 300 GeV running. The flattop was maintained at 1.5 sec for the entire month. A two-day interruption began on Tuesday morning, November 9, when a main-ring feeder failed because of secondary splice failures. A site-wide outage was caused by the shorting of a secondary bus duct on the spare transformer T-82 at the Master Substation on the following Saturday, November 13. Although power was restored to the experimental areas in an hour and to the accelerator in two hours, the damage done to control systems, etc., cost a day of operation. The accelerator maintenance period arranged during the feeder failure was the only one in November; thus, an unusually high 638 hours of high energy physics research was scheduled. The accelerator operating efficiency of 76% was also above average, so that a record 487 hours of beam time were available. Main-ring intensity records were set and broken several times; the intensity was generally over 2×10^{13} ppp throughout the month. The current record set on the Thanksgiving weekend is 2.41×10^{13} ppp. The major downtime on the Thanksgiving weekend, Sunday, the 28th, was clearly associated with a failure to control the high intensity beam. A vacuum leak in the Main Ring was caused by a wayward beam pulse puncturing the main-ring vacuum chamber in a bending magnet (see the cover photograph).

The Proton Area program ran unchanged through the month. Photon Total Cross Section #25A completed a two-month run on November 30 with a few days of lead glass calibration. They had run nearly all of November at high intensity with the electron beam at 200 GeV, but, following a leak in the target box over the Thanksgiving weekend, they dropped to low intensity for the calibrations of lead-glass counters. Di-Hadron #494 ran steadily in P-Central, obtaining some extended periods of stable running. p-p Scattering #177A changed their geometry to cover the "intermediate" t-range -8 to -13 $(GeV/c)^2$ around November 10. With some efforts to improve shielding they eventually were able to use about 4×10^{11} protons/pulse.

The Neutrino Area program was also rather stable. The major high-intensity user was Muon #398, which collected data on inelastic muon-proton scattering. They received about 1.4×10^{18} protons in slow spill and achieved an average μ/p of about 10^{-7}. The experiment 30-in. $\bar{p}$-p @ 50 GeV #344 was completed at the 30-in. bubble chamber on the morning of November 1. After a somewhat slow start that included repeated troubles with the tagging computer, 30-in. Hybrid #299 ran until Monday, November 22, taking 273K pictures using a beam with nearly 10% K^+ at 150 GeV. Both experiments were run with eight expansions per machine cycle. Experiment #299, setting restrictions on particle count but not on species, achieved extended periods with pictures on nearly every expansion in its later running. A total of 538K pictures were taken in the 30-in. chamber in the operating period that began in August. Neutrino #310 ran much of the early part of the month with about 10^{12} ppp of 1-2 msec spill to establish trigger rates, check

backgrounds, and test the optical spark chambers they were installing. For the last week and a half, they did not run while working intensively to get ready for high-priority running in December. A 12-hour test at 10^{13} ppp on November 5 helped to establish the feasibility of the December run. Neutrino #482 was active in parasitic testing and setup using muons from the slow spill for much of their work. Three tests of the antineutrino plug for use with the horn train, each approximately two hours long, were conducted during the month (11/3, 11/12, and 11/30). The final test of a segmented plug at 1.5×10^{13} of 20-μsec spill was a success.

The Meson Area had the same experiments in all beamlines for the month. Particle Search #472 completed its run in M2 line on Monday, November 29. Inclusive Scattering #118A took data at -100 GeV in the M6-E line. Form Factor #456 moved from testing and calibration to data taking in the M1W line which they ran to yield about 10^6 particles at -250 GeV. Neutron Elastic Scattering #248 continued to take data routinely. They finished the month with a couple of days of p-p elastic scattering for calibration by taking advantage of time with the M2 line off to run the M3 line as a diffracted proton (95% purity) beam. K^o Regeneration #226/#486 completed the E486 part of their work (A-dependence of particle-antiparticle cross section difference). They ended the month with tests to establish the optimum Z and thickness of the regenerator for the electron regeneration part of the experiment. The installation for tests of Multi-Muon #439 started the last two days of the month in the M2 line.

The Internal Target Area had a rather meager month with a total of 204 hours spread among four experiments. p-N Scattering #198A received half that time during a little over a week starting November 5 when the helium liquifier was working reasonably well. Adding to the difficulties of two liquifier down periods were cold leak troubles with the jet for p-N Scattering #381. Nuclear Fragments #442 had a productive test run in which they established the feasibility of their running with the most forward angles of the spectrometer arm. p-N Scattering #381 got well underway with a deuterium jet the last two days of the month.

FACILITY UTILIZATION SUMMARY -- NOVEMBER 1976

I. Summary of Accelerator Operations

		Hours	
A. Accelerator use for physics research			
Accelerator physics research		53.6	
High energy physics research		487.4	
Research during other use		(35.7)	
	Subtotal		541.0
B. Other activities			
Accelerator setup and tuning to experimental areas		5.8	
Program interruption		4.6	
Unscheduled interruption		168.6	
	Subtotal		179.0
C. Unmanned time			
	Total		720.0

II. Summaries of High Energy Physics Research Use

	# of Expts.	Hours	Results
A. Counter experiments	16	3807.0	1 exp. completed
B. Bubble chamber experiments	2	274.3	281K 30-in. pictures; 2 exp. comp.
C. Emulsion experiments	1	-	2 stacks exposed
D. Special target experiments	-	-	
E. Test experiments	-	-	
F. Engineering studies and tests	2	11.0	$\bar{\nu}$ plug tests; N3 had beam test
G. Other beam use	-	51.7	N3 beam tuning
	21	4144.0	

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

A. Beam accelerated in Main Ring			2.63
B. Beam delivered to experimental areas			
Meson Area		.286	
Neutrino Area			
	Slow Spill	1.36	
	Fast Spill	.183	
Proton Area		.315	
	Total		2.14

IV. Beam Utilization by Experiment

	Hours	Results
A. Meson Area		
Inclusive Scattering #118A	400.5	Data
K^0 Regeneration #226/#486	276.4	Data on E486 complete; tests for E226
n Elastic Scattering #248	374.5	Data
Form Factor #456	409.0	Setup tests and data
Particle Search #472	376.8	Data; experiment complete
B. Neutrino Area		
30" Hybrid #299	265.6	273K pictures and Pb glass calibration; complete
Neutrino #310	142.8	Setup and test data
30" $\bar{p}$-p @ 50 GeV #344	8.7	8K pictures; complete
Emulsion/Muons @ 50-100 GeV #373		2 emulsion stacks; complete
Muon #398	434.1	Data
Neutrino #482	76.4	Setup and checkout
C. Proton Area		
Photon Total Cross Section #25A	375.6	Data
p-p Elastic #177A	350.0	Data
Di-Hadron #494	387.3	Data
D. Internal Target Area		
p-N Scattering #198A	103.0	Data
p-p Polarization #313	22.8	Data
p-N Scattering #381	0.0	Data
Nuclear Fragments #442	40.5	Test data
Total	4081.3	

MANUSCRIPTS AND NOTES PREPARED DURING NOVEMBER AND DECEMBER 1976

Copies of preprints with Fermilab publication numbers can be obtained from the Publications Office or Theoretical Physics Department, 3rd floor east, Central Laboratory. Copies of some articles listed are on the reference shelf in the Fermilab Library.

Experimental Physics

D. Weingarten et al. Experiment #2B	Evidence for Local Compensation of Transverse Momentum in pp Collisions at 200 and 300 GeV/c (Submitted to Phys. Rev. Lett.)
B. Y. Oh et al. Experiment #2B	Semi-Inclusive π^- Cross Sections in pp Interactions Up to 300 GeV/c (Submitted to Nucl. Phys. B)
M. Pratap et al. Experiment #2B	Three and Higher Order Rapidity Distributions in pp Collisions at 200 GeV/c (Submitted to Nucl. Phys. B)
H. R. Barton, Jr. et al. Experiment #12	Some Features of N-P Charge Exchange Scattering Between 60 and 300 GeV/c
D. L. Cheshire et al. Experiment #34	Measurements of Cascades Initiated by 5-300 GeV Hadrons in a Tungsten Ionization Spectrometer
J. P. Berge et al. Experiment #45	Search for μe Events in Antineutrino-Nucleon Interactions (FERMILAB-Pub-76/81-EXP; submitted to Phys. Rev.)
T. Kitagaki et al. Experiment #83	Structure of Dissociative Clusters
T. Kitagaki et al. Experiment #83	On the Resolution of the 100 GeV/c π^-p Data from the FNAL 15' Bubble Chamber
A. E. Brenner et al. (Fermilab Single Arm Spectrometer Group) Experiment #96)	Inclusive Hadron Scattering from 50 to 175 GeV/c (FERMILAB-Pub-76/84-EXP; submitted to Phys. Rev. Lett.)
D. Ljung et al. Experiment #137	π^-p at 205 GeV/c: Multiplicities of Charged and Neutral Particles; Production of Neutral Particles (FERMILAB-Pub-76/92-EXP; submitted to Phys. Rev.)

C. Bromberg et al. Experiment #'s 138 and 252	Rapidity Correlations in pp Collisions at 102 and 400 GeV/c (Submitted to Phys. Rev.)
F. A. Nezrick Experiment #180	Search for New Particles Produced in $\bar{\nu}_\mu$ Nucleon Interactions in the 15-Ft Bubble Chamber (FERMILAB-Conf-76/90-EXP; invited talk at the SLAC Summer Institute on Particle Physics, Oct. 2-13, 1976)
J. E. A. Lys et al. Experiment #194	Rescattering in 100 GeV/c Proton-Deuteron and Positive Pion-Deuteron Interactions (FERMILAB-Pub-76/89-EXP; submitted to Phys. Rev.)
E. H. S. Burhop et al. Experiment #247	Observation of a Likely Example of the Decay of a Charmed Particle Produced in a High Energy Neutrino Interaction (FERMILAB-Pub-76/91-EXP; submitted to Phys. Lett.)
E. W. Anderson et al. Experiment #281	Direct e^+e^- Pair Production by 360 GeV/c π^- in Hydrogen (Submitted to Phys. Rev. Lett.)
A. Firestone et al. Experiment #281	π^-p Interactions at 360 GeV/c: Measurement of the Total and Elastic Cross Sections and the Charged-Particle Multiplicity Distribution (Submitted to Phys. Rev. D)
J. Biel et al. Experiment #305	Structure in Momentum-Transfer for $(p\pi^-)$ Systems Produced in Diffractive Dissociation of Neutrons on Protons (Submitted to Phys. Lett.)
M. J. Lauterbach et al. Experiment #435	The Polarization of Prompt Muons Produced at P_t = 2.15 GeV/c by 400 GeV Proton Interactions

Theoretical Physics

G. Marchesini and E. Rabinovici	Diffractive Production Amplitudes for $\alpha_P > 1$ (FERMILAB-Pub-76/74-THY; submitted to Nucl. Phys. B)
H. B. Thacker	Many-Body Scattering Processes in a One-Dimensional Boson System (FERMILAB-Pub-76/77-THY; submitted to Phys. Rev.)
R. Savit	New Approximation Schemes for Lattice Theories (FERMILAB-Pub-76/78-THY; submitted to Phys. Rev.)

K. Igi	Factorization of Regge Slopes for Ordinary and New Hadrons (FERMILAB-Pub-76/82-THY; submitted to Phys. Lett.)
A. Halprin and P. Sorba	Gluon Exchange Corrections to the Nucleon Magnetic Moment in the MIT Bag Model (FERMILAB-Pub-76/83-THY; submitted to Phys. Lett.)
K. M. Bitar and P. Sorba	Classification of Pseudo Particle Solutions in Gauge Theories (FERMILAB-Pub-76/85-THY; submitted to Phys. Rev.)

General Review

I. Otterlund	Inclusive Production in Emulsion with Accelerator Beams (General review of emulsion experiments)
P. Stix and T. Ferbel	Charged-Particle Multiplicities in High Energy Collisions (Submitted to Phys. Rev.)

General

R. Yamada et al.	Operational Test and Field Measurement of Prototype Bending Magnets for Energy Saver/Doubler Project (Submitted to the 1976 Applied Superconductivity Conference, Stanford University, August 17-20, 1976)
P. A. Sanger et al.	Damage to Stabilizing Materials by 400 GeV Protons (Submitted to the 1976 Applied Superconductivity Conference, Stanford University, August 17-20, 1976)

Other

K. L. Brown et al.	The Effect of Beam Line Magnet Misalignments (FERMILAB-76/88; submitted to Nucl. Instrum. Methods)

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Energy Doubler/Saver		
Summer Study announced	Mar	19
Summer Study reported	Aug	7
Progress Report	Nov	5
Hadron Physics, Particle Identifiers for	Jul	13
Higher Accelerator Intensity	Dec	3
Highlights of Fermilab Experiments in 1975	Feb	1
Highlights of the Summer PAC Meeting	Jul	1
Hyperons		
So What About Hyperons?	Mar	1
Main Ring, Beam Stability in the	Jan	1
Modest Colliding Beams Meeting	Apr	1
Notes and Announcements		
Books available	Jul	37
General comment on meetings to come	Dec	14
History of Science room	Oct	9
Holiday schedule	Jan	13
Photographs solicited	Apr	18
NALREP editorial staff changes	Mar	21
New assignments	Jan	13
	Feb	16
	Mar	21
	Apr	18
	May	13
	Jul	37
	Nov	13

Notes and Announcements		
Special announcement (500 GeV)	Jun	1
Summer housing	Apr	17
Summer Study on use of Energy Doubler/Saver	Mar	19
URA trustees and officers	Mar	22
Summaries of Fermilab proposals now available	Aug	12
Observation of a Charmed Particle	Dec	1
Parity		
Possibility of measuring Ξ parity	Mar	17
Particle Identifiers for Hadron Physics	Jul	13
POPAE Design Collaboration	Jun	3
Prairie Restoration Project	Jul	31
Procedures for Experimenters 1976 Available	Jan	12
Program Advisory Committee		
Plans for spring PAC meeting	Jan	11
Summer meeting highlights	Jul	1
A review of forthcoming PAC-related meetings	Aug	11
A reminder of forthcoming PAC-related meetings	Sep	12
Report on the autumn meeting	Nov	1
Progress Report on the Energy Doubler	Nov	5
Proton Area		
The Proton Area, September 1974 to March 1976	May	1
So What About Hyperons ?	Mar	1
Special Announcement (500 GeV)	Jun	1
Storage at Fermilab	Oct	10
Summer Program for Minority Students	Oct	1
Summer Study on Utilization of Energy Doubler/Saver	Aug	7
Users Organization		
Annual meeting scheduled	Feb	15
Users Executive Committee Report	Jan	9
	Sep	19
Who Answers the Phone at Extension 3333 ?	Sep	13
Workshops		
Elastic scattering at large P_t	Jan	11
	Feb	15
Elastic scattering at large P_t cancelled	Mar	19
External particle identifiers - announcement	Mar	19
External particle identifiers - report	Jul	13
Future neutrino experiments workshop announced	Dec	15
Hadron jet experiments workshop announced	Dec	14
Multiparticle spectrometer workshop deferred	Mar	19
Multiparticle spectrometer workshop deadline	Oct	9
Multiparticle spectrometer workshop postponed	Nov	13
Multiparticle spectrometer workshop rescheduled	Dec	14
W-Search Experiment	Apr	11

DATES TO REMEMBER

January 28, 1977	Deadline for receipt of all new proposals and other written materials to be considered at the March meeting of the Program Advisory Committee.
February 10-11, 1977	Proposal Presentation Meeting.
March 4, 1977	Deadline for receipt of written materials to be considered at the Hadron Jet Experiments Workshop.
March 4-5, 1977	Multiparticle Spectrometer Workshop.
March 10-11, 1977	Spring meeting of the Fermilab Program Advisory Committee.
March 25, 1977	Deadline for receipt of written materials to be considered at the Future Neutrino Experiments Workshop.
March 31 - April 1, 1977	Hadron Jet Experiments Workshop.
April 21-22, 1977	Future Neutrino Experiments Workshop.
May 6, 1977	Deadline for receipt of all new proposals and other written materials to be considered at the Summer meeting of the Program Advisory Committee.
May 19-20, 1977	Proposal Presentation Meeting.
June 18-24, 1977	Summer meeting of the Fermilab Program Advisory Committee.