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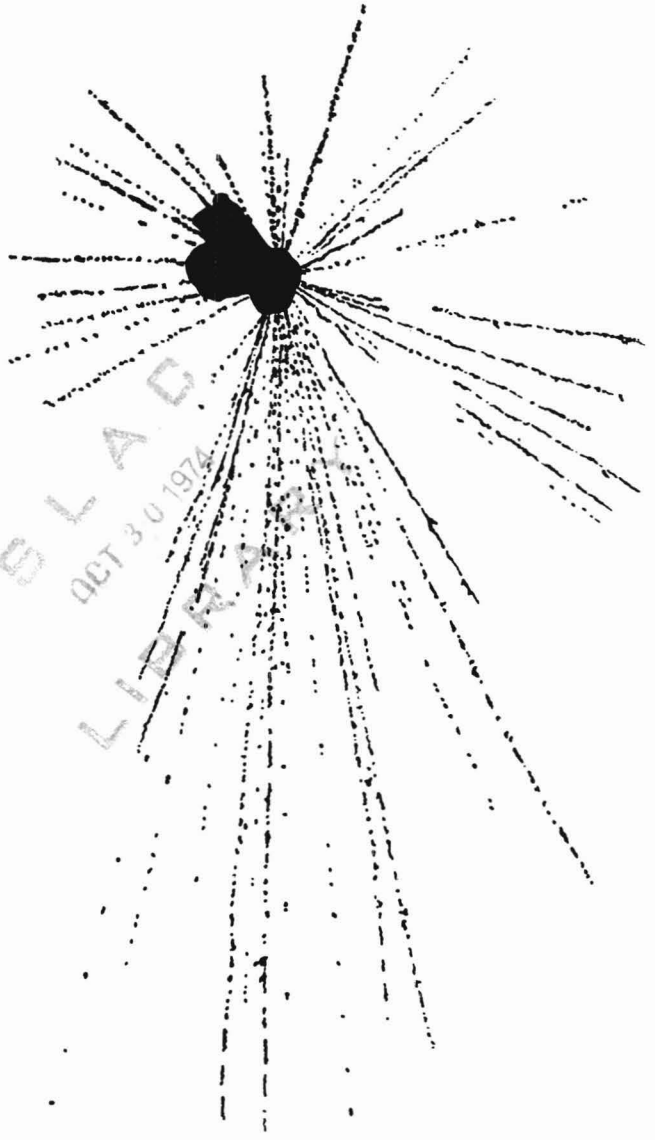

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Monthly Report of the Fermi National Accelerator Laboratory

October 1974

Fermi National Accelerator Laboratory

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THE COVER: Tracing of a microscope projection showing the collision of a 200-GeV proton with a nucleus in a tungsten granule embedded in nuclear emulsion. The proton enters from the top. A total of 66 tracks radiate from the center, 18 of which are due to shower particles.

(Photo courtesy of J. J. Lord, University of Washington)

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NUCLEAR EMULSION EXPOSURES AT FERMILAB

The nuclear emulsion technique played a prominent role in discoveries of new particles and high energy phenomena in cosmic ray and accelerator experiments, especially in the decade between 1947 and 1957. Now this simple and versatile method is experiencing renewed activity with exposures at Fermilab.

The basic component of a nuclear emulsion is a thick photographic layer, composed of specially sensitized silver bromide crystals embedded in gelatin. A charged particle moving through such a layer leaves a path of "exposed" silver bromide crystals which, when developed, show up as a fine track of silver grains which are less than 1 micron in diameter. Particle directions and scattering angles are determined microscopically with position "measurement errors" as small as 0.1 micron, over track lengths of several centimeters. From total track length, density of developed grains, and from scattering angles, direct determinations of the mass, charge, and velocity of individual particles are frequently possible. Very short lifetimes can be observed, down to 10^{-15} sec. Major early discoveries made using these techniques included the charged pions and kaons ($\pi^{\pm}$, $K^{\pm}$), sigma (Σ^{+}), and anti-lambda ($\bar{\Lambda}^{o}$).

The first Fermilab emulsion exposures and searches for new phenomena made use of the 200-GeV proton beam newly transported into the Meson Area Target Hall in September 1972. Ten exposures were carried out, with a total of 45 individual stacks, providing material for over twenty laboratories around the world.

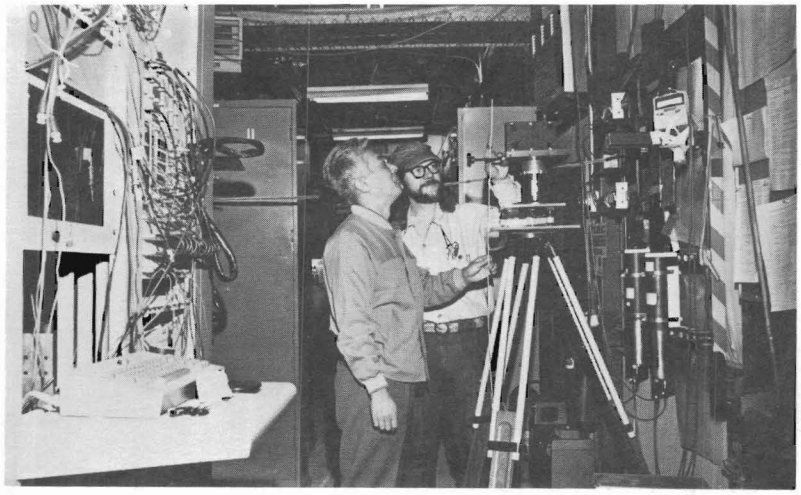
In October 1973, the Neutrino Area provided 300-GeV proton exposures for the nine experiments listed on the table below. These were done in the beam to the 30-inch bubble chamber at the walkway in front of the

Nuclear Emulsion Exposures to 300-GeV Protons; October 1973

Experiment No.	Spokesman	No. of Stacks Exposed	Flux Protons/cm^2
181	A. S. Cary	3	10^4
195	P. S. Young	3	5×10^4 to 5×10^5
232	D. T. King	2	3×10^4
233	J. D. Hebert	8	2×10^4 to 9×10^5
237	J. J. Lord	5	1.5×10^5
242	K. Niu	2	10^4
244	P. L. Jain	1	10^4
250	O. Kusumoto	1	2×10^4
275	W. Enge (Special plastics)	4	4×10^3 to 4×10^5

chamber building. In addition to a leveled and oriented platform for the stacks, this location provides displays and controls for the hadron beam transport elements, scintillation counters, and proportional wire chambers so that emulsion stacks can be exposed under controlled conditions. Facilities for developing and microscope viewing of thin layers of test emulsions have also been made available in the 30-inch chamber area.

Two exposures to 150-GeV muons (Experiments #205A and #255) were also carried out in 1973, just downstream of the Cornell-Michigan State muon spectrometer during the running of Muon #26.

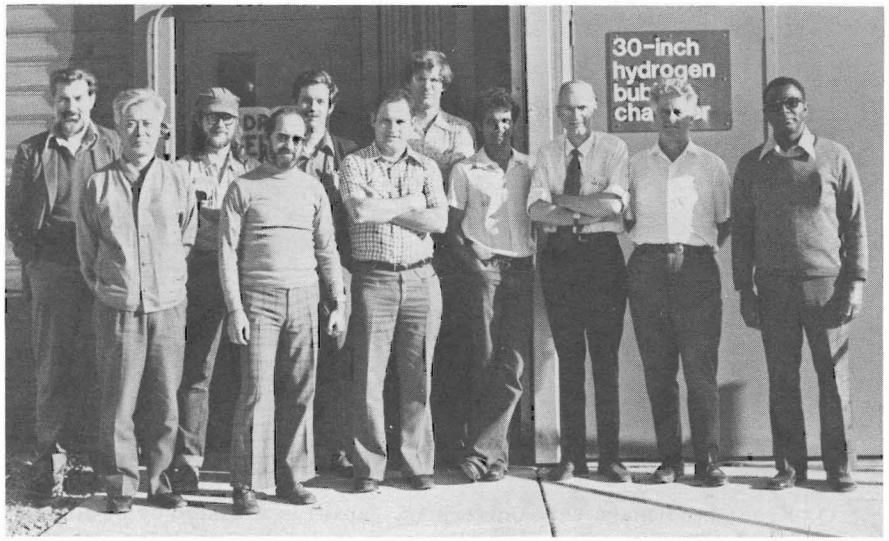


O. Kusumoto (Osaka City University, Japan) is assisted by J. Hoover (30-inch Bubble Chamber Group) in aligning an emulsion stack for 300-GeV proton exposure.

The laboratories represented by all of these emulsion exposures include, in addition to those in the United States, others in Canada, France, West Germany, India, Italy, Japan, Malaya, Poland, Rumania, Spain, Sweden, the USSR, and Yugoslavia.

Future exposures are expected with 400-GeV protons (planned for early 1975) and with high energy pions. There are also plans for a hybrid emulsion-spark chamber experiment (#247) for locating neutrino interaction vertices in an emulsion stack in order to search for short-lived heavy leptons and charmed particles. Proposals have also been made for exposures to electron beams in the Proton Area.

Physics results reported from the Fermilab emulsion exposures thus far bear largely on multiparticle production mechanisms in collisions with



Participants in the exposure of nuclear emulsions to 300-GeV protons on October 18, 1973. Front row, right to left: A. S. Cary (Claremont College), D. T. King (University of Tennessee), J. J. Lord (University of Washington), H. Areti (Universite d'Ottawa, Canada), R. Kaiser (Centre de Recherches Nucleaires, Strasbourg, France), M. A. Vincent (Universite d'Ottawa, Canada), O. Kusumoto (Osaka City University, Japan). Back row: J. Florian and L. Kirkpatrick (University of Washington), as well as Fermilab participants J. Hoover and L. Voyvodic. P. S. Young (Mississippi State University) was absent when photo was taken.

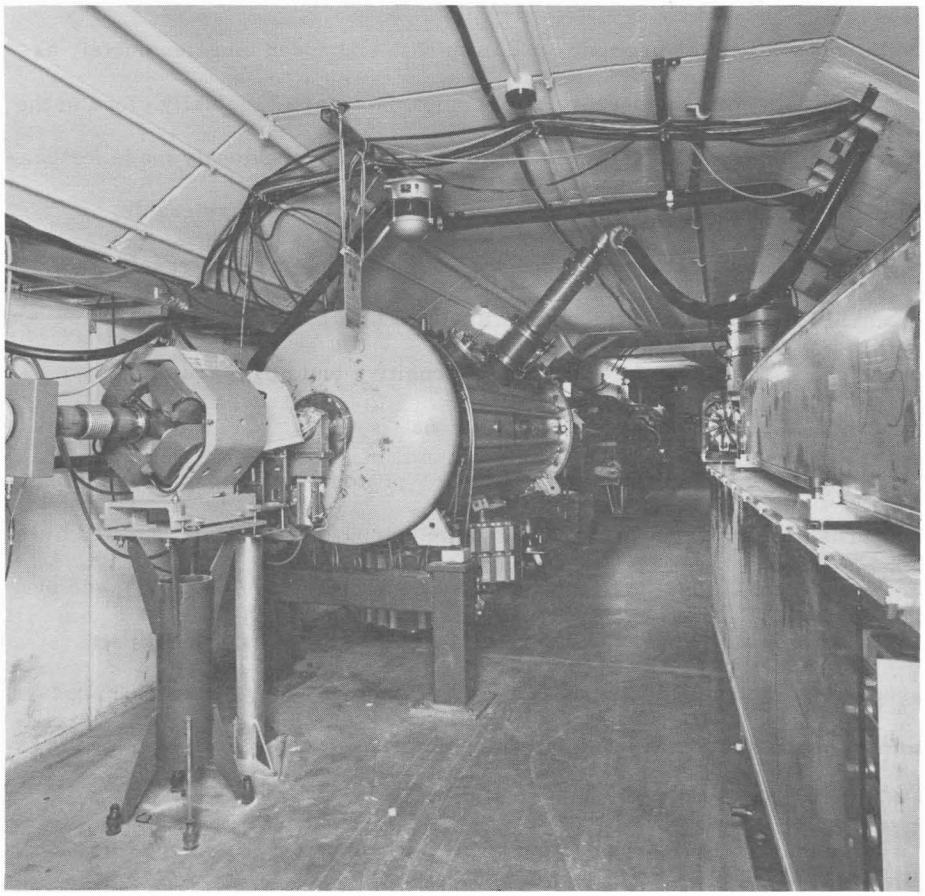
high energy protons. Early data on multiplicities and angular distributions were reported at the Vanderbilt Conference in May 1973 by J. P. Hebert, P. L. Jain, D. T. King, and J. J. Lord, for Experiments #116, #114, #103, and #171, respectively. (The reports have been published in American Institute of Physics Conference Proceedings, Number 12, R. S. Panvini, editor.) Similar results were reported by the Cracow group (Experiment #90), by J. Babecki et al. [Physics Letters 47B, 268 (1973)]. Additional details were reported by various groups at the XVII International Conference on High

Energy Physics this past summer. The most surprising feature has been the striking similarity between the multiplicities and angular distributions observed in 200-GeV proton-proton collisions in the 30-inch bubble chamber (Experiment #141), and those observed in emulsions from 200-GeV proton collisions with silver bromine, and even with embedded tungsten nuclei, as shown in the cover photograph. The comparisons are especially close in the forward hemisphere, and are unlike the predictions previously made for cascading hadronic collision processes within a nucleus. Considerable theoretical interest has since been focused on these emulsion results, for example, by K. Gottfried [Physical Review Letters 32, 957 (1974)] who described such nuclear interactions as sensitive tests of space-time structure in basic hadron-hadron collisions.

Another recent result of the 200-GeV proton interactions in emulsions concerns possible inadequacy of quantum electrodynamics. As reported by J. E. Butt and D. T. King [Physical Review Letters 31, 904 (1973)] and by P. L. Jain et al. [Physical Review Letters 32, 797 (1974)], the direct production of electron pairs by 200-GeV protons in nuclear emulsion appears to have much smaller cross section, with different energy and angular distributions, than predicted theoretically.

In addition to the systematic studies still in progress on 300-GeV protons and the 150-GeV muon exposures, the search for new particles and new phenomena is providing an element of zest and enthusiasm to many laboratories participating by the nuclear emulsion technique, in Fermilab's exploration of new frontiers.

Reported by L. Voyvodic



The debuncher cavity installed in the booster tunnel. Beam travels from back to front of photograph.

THE DEBUNCHER--AN ACCELERATOR IMPROVEMENT PROJECT

In order to achieve high intensity and efficient operation of the injector system, beam must be transferred with low loss from the linac to the booster. To assist in the transfer, a device called a debuncher has been installed in the injection line within the booster tunnel. This debuncher, which was started in January 1974 and installed in May, is shown opposite. It is composed of three cells similar to those in a 200-MeV linac, consisting of two complete drift tubes and two half-drift tubes at the ends of the cavity. The major difference between these and the linac cavities is that the bore hole diameter in the debuncher drift tubes is 8 cm rather than 4 cm. The larger bore is necessary to accommodate manipulations in the beam required to match the linac beam to the acceptance of the booster. The drift tubes are installed in a vacuum tank formed from a test cavity built by the MURA Linac Group in 1964. The system requires 200 kW of electrical power during the linac pulse, and provides a maximum energy gain or loss of 2 MeV to a 200-MeV proton. The debuncher is powered by a driver amplifier and a 5-MW amplifier tube identical to the ones that power the individual linac tanks. At present, the debuncher is powered from the tenth linac rf system, usually used for testing and development work. In December, a new power system will be installed, so that the operation of the debuncher will not interfere with the linac rf system testing program.

The Linac Beam

The 200-MeV beam emerging from the Linac is bunched at the 200-MHz operating frequency of the linac power systems. Actually, the beam consists of a sequence of golfball-sized bunches, each approximately 2-cm diameter containing about 3×10^9 protons, separated by about 84 cm from the next bunch. Such a bunch has a surface electric field of 30-kV per meter, distorted somewhat by the presence of the vacuum chamber walls. This electric field, which increases linearly in size from the center of the bunch, acts to increase the size of the bunch. This, in turn, results in a larger variation of the transverse and longitudinal momenta of the protons.

Quadrupole magnets in the 200-MeV transport line refocus the beam so that the transverse effects are minimized. However, the longitudinal space charge forces continue to act until the bunches have overlapped, and the electric fields become negligible. This occurs after the beam has gone through the transfer line and once around the booster--a distance of about 500 meters. During this time, the momentum spread of the beam increases from ±0.1% to ±0.15% or more. The precise value depends upon the initial configuration of the beam and its actual shape and size during the 500-meter transit.

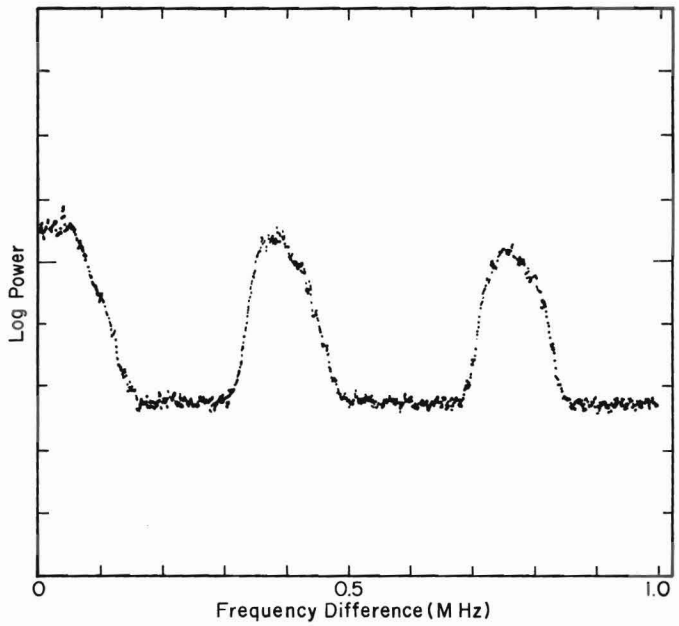
The principle effect of the increase in momentum spread is an increase in the requirement for rf accelerating voltage from the booster rf cavities. This can be seen in analogy with the movement of a pendulum, whose motion resembles that of the longitudinal motion of a particle in an rf field. Depending on its initial condition, the pendulum will oscillate about the

vertical axis, rotate about the axis, or perform some combination of the two motions. The former motion is called trapped; the latter, untrapped. If we could increase the gravitational field, motions which formerly were untrapped would then be trapped. Similarly, increased rf voltage reduces the particle oscillations and the transverse momentum of the beam. Unfortunately, the booster rf system is not yet capable of providing this increased voltage to accelerate the ±0.1% beam emerging from the linac. This is primarily due to an unanticipated high loss of rf energy in the booster cavity tuners. Major steps are being taken to increase the rf voltage, but the final solution will not be available for some time.

Momentum Spread Measurements in the Booster

In the winter of 1973-74, measurements of the momentum spread of the circulating beam in the booster were made. The booster magnetic field was held constant, while the beam was injected from the linac and allowed to coast around the booster vacuum chamber. The momentum spread was measured by the "Schottky scan" method used extensively at the CERN ISR. Each revolution of a proton induces signals in a current detector at the revolution frequency and all of its harmonics. The power spectrum of the signals from the detector is the sum of the spectra of all the protons. In this way, the spectrum of the detector signal is the frequency distribution of the protons replicated at all harmonics. Measurements are made at a frequency high enough that injection correlations have died out, but low enough that the harmonics do not overlap. For the booster, this range is from about 30 to 100 MHz. The signal level is in the picowatt range, so it is necessary to

average the signal from 50 to 100 pulses to overcome noise. A typical Schottky scan at 79 MHz is shown below, where three harmonics are visible. The data in this figure are composed of the logarithm of the power spectrum plus an added noise level. After subtracting the baseline, the data represent three harmonic replications of the proton frequency distribution, hence the proton momentum distribution. By this method, we verified the fact that the momentum spread in the booster, ±0.15%, was greater than it was at the end of the linac. The method requires extreme stability of the linac, booster magnet, and beam, so it was possible to reproduce the momentum spread



A typical Schottky scan at 79 MHz. Power spectrum of beam signal.

measurements to within about 25% in different testing periods. Nevertheless, the growth of the momentum spread was sufficiently convincing to begin to take steps to control it, as well as to increase the booster rf voltage.

The development of the diagnostics, digitization, and applications programming necessary for these measurements was carried out by M. Shea and R. Peters. The experiments were performed by a team including these two, as well as the authors, E. Hubbard, and E. Gray.

The Debuncher

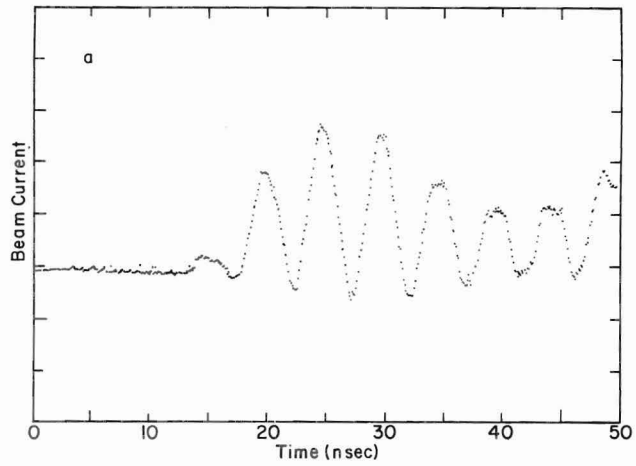
As already indicated, what is needed to control the longitudinal momentum spread is a focusing element such as a specially controlled rf cavity. As the beam comes down the injection line, the higher-momentum particles will increase their longitudinal coordinate (phase) and arrive at the cavity early, and be decelerated, and the lower-momentum particles will arrive late and be accelerated. The space charge forces will increase the phase spread slightly as well as the momentum spread, and change the distribution in the longitudinal phase space. The principle effect will be the need to increase the voltage required. As long as the particles have not drifted in phase until they reach a very non-linear part of the rf waveform before entering the cavity, the debuncher will reduce the momentum spread of the beam. On the other hand, the beam should drift far enough to allow a sizable spread, say 30 to 40 degrees. The present debuncher is located 40 meters from the end of the linac, prior to injection into the booster, and satisfies the above conditions.

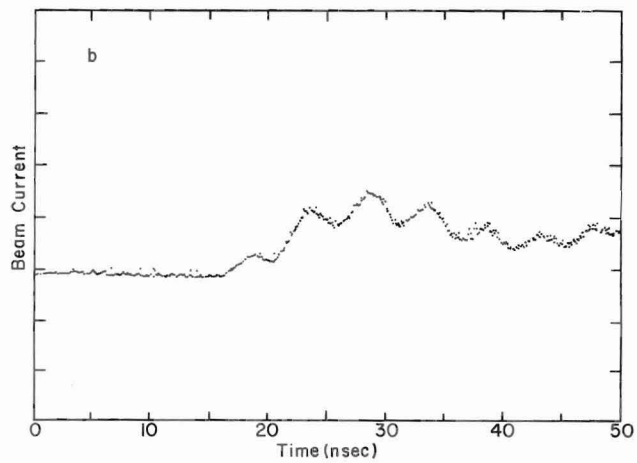
The debuncher has several other attributes which make it desirable. If the linac beam wanders in mean momentum due to an error in phase or gradient in one of the nine linac tanks, the debuncher will restore the mean momentum in the same way it affects any off-momentum particle. Thus, the debuncher acts as a powerful stabilizing element for the linac. Further, the horizontal translation into the booster is not achromatic. The debuncher reduces the chromatic effects of the final part of the 200-MeV line, thereby reducing the effective thickness of the injection septum. This allows for more efficient multiturn injection into the booster.

Results of the Use of the Debuncher

Several definite improvements in booster performance have been achieved as a result of the operation of the debuncher. The injected beam momentum spread has been reduced, allowing more charge to be captured and accelerated by the booster rf system. An interesting demonstration of this is illustrated on page 13, where the waveform of the injected beam after 5/6 revolution in the booster is shown, with the debuncher on (a) and off (b). Clearly, the 200-MHz structure is stronger with the debuncher on. This should be the case, since the smaller momentum spread requires a longer time for the bunch structure to disappear. Other tests show that the rf-captured beam occupies a smaller phase space area, and the transmission of the booster, measured from rf-capture to extraction at 8-GeV, has improved.

The injection momentum has been stabilized. This has allowed the use of higher intensities of protons from the linac without momentum variation during the pulse. Also, the multiturn injection efficiency has improved due to the reduction of chromatic effects at injection.





a. Leading edge of beam entering the booster accelerator at period 20, almost 5/6 of one revolution around the ring. The distance between peaks is 5 nsec. In addition to the 200-MHz structure, one can see the effects of "ringing" (oscillation) in the beam chopper. The debuncher was turned on.

b. Same conditions, but debuncher was turned off.

This improvement in booster performance can be expressed in terms of efficiency in delivering protons to the main ring during HEP running. In operation with single-turn injection, the overall transmission has improved from about 38% to 48%. More striking improvements are noted when the booster is straining for the maximum output. For example, when 10^{13} protons per pulse were first accelerated in the main ring, the booster transmission was 16%. Presently, operation at 10^{13} protons per pulse is achieved with a booster transmission of about 45%.

The debuncher was built by an Accelerator Division task force composed of C. Owen, S. Ohnuma, E. Gray, G. Lee, and R. Winje. The drift tube shapes were calculated by D. Johnson, with advice from S. Snowdon, using a modification of the Lala field computational program developed at Los Alamos.

The speedy construction and operation of the debuncher could not have been achieved without the cooperation of the Machine Shop, the Controls Group, and many other groups in the Accelerator Division.

Reported by F. Mills and C. Owen

REPORT ON THE DRIFT CHAMBER WORKSHOP

A workshop was held at Fermilab in June to discuss drift chambers and the associated electronics. Over 120 scientists attended the meeting, organized by the Research Services Department. Many invited speakers described their recent research results.

B. Sadoulet, from Lawrence Berkeley Laboratory, talked about their cylindrical drift chamber development effort to look at e^+e^- interactions at SPEAR. A spatial accuracy of 100 microns is required for obtaining transverse momentum resolution of $\Delta p/p = 10\%$ from drift chambers operating in 4-kG magnetic fields.

F. Sauli presented CERN data on 50- by 50-cm drift chambers with 5-cm wire spacing. Spatial accuracies of 100 to 200 microns were obtained from these chambers operating under high electric fields (1.3 kV/cm) in the drift region with saturated drift velocities using gas mixtures of 67.2% argon-30.3% isobutane-2.5% methylal. Tests were made in magnetic fields up to 15 kG. Distortions of primary electron trajectories were compensated by proper shaping of electric fields.

W. W. M. Allison, from Oxford University, presented some data on identifying secondary particles by ionization sampling. Their proposed ISIS device is a large drift chamber, 5-meter long and 1-meter high, with 2-meter drift space. It is expected to distinguish between pions, kaons, and protons from 5 to 100 GeV/c. A spatial accuracy of 5 mm is obtained with a drift distance of 85 cm, using a 1-meter long drift chamber. ISIS could be used downstream of a rapid-cycling bubble chamber to cover large solid angles.

M. Atac, Fermilab, talked about developments in parallel-foil drift chambers, which provide excellent field uniformity in the drift region of the primary electrons, and presented some data from such a chamber. For very large chambers, the parallel foils may be replaced by several wires. The spatial resolution from these chambers is better than 100 microns.

W. Kozanecki talked about Harvard University's 4- by 4-m^2 area drift chambers. With 5-cm spacing, these chambers have produced track position accuracies of less than 0.5 mm.

D. Hartill, from Cornell University, reported that he has observed about 1% difference in the height of induced pulses from a pair of cathode wires on the left and right side of the signal wire. This difference is too small to resolve the left-right ambiguity of tracks. Hartill has built an inexpensive readout system ($22.00 per wire) with a timing accuracy of 2 nsec.

In a second session, the topic was drift chamber readout systems. Five of the six speakers discussed fast digital circuits. Although there are very few readout systems in use, it is clear that the subject is rapidly developing. F. Kirsten talked about the West Coast effort to design a general-purpose system for drift chambers. A dialogue was started on this subject at a meeting at Berkeley last May.

After the invited talks, the following topics were considered in open discussion:

--Improvements to the timing of drift chamber pulses in order to achieve better spatial resolution

--Count rate capabilities (10^3 to 10^5 per wire per second) of drift chambers

--Multitrack resolution improvements (adding more wires)

--Stability of drift chambers and electronics

More information about the workshop is contained in an internal Fermilab technical memorandum, TM-504, prepared by M. Atac. A copy is on file in the Fermilab Library.

FERMILAB ARTS AND LECTURE SERIES UNDERWAY

To accommodate a large fraction of the laboratory staff, the user community, and the visiting scientific community, an 800-seat auditorium was incorporated into the design of the Central Laboratory. It seems natural that the auditorium be used for artistic functions to which residents of the local communities would be invited, as well as for Fermilab meetings.

In August 1973, a committee was appointed by the Director to consider the preparation and programming for the auditorium. This committee, consisting of A. Roberts (Chairman), D. Getz, M. Einhorn, H. Hann, M. Paul, J. Roberts, J. Satti, and I. Walker, spent many hours discussing what types of programs could best be presented in the auditorium and exactly what stage equipment would be needed. To facilitate the presentation of a wide range of programs, slide and 16-mm sound film projection equipment, audio equipment, stage lights, and a 7-foot Steinway grand piano have been acquired.

A. E. Brenner assumed the Chairmanship of the committee last January, when both the Roberts took leave of absence for a year.

All of this planning culminated in the inaugural performance in the completed auditorium--a dance program by the Richard Arve Trio and associates, presented in conjunction with the Laboratory Dedication festivities last May. The very first performance was held in September 1972, when the auditorium was still under construction. At that time, the Fine Arts Quartet and Jeffrey Siegel, pianist, played as part of the evening program of the XVI International Conference on High Energy Physics.

The committee is making plans for the coming year, and welcomes all suggestions. Twelve events are planned, about evenly mixed between lectures and the performing arts. On September 20, a program of mime was presented by T. Daniel, a student of Marcel Marceau. The next two events will be lectures: On October 18, comedian and social commentator Dick Gregory will be on hand, and on November 15, Washington Post news reporter Bob Woodward, who helped expose the details of the Watergate break-in, will speak.

Tickets for all performances are $3.00. They can be obtained from M. Paul, Ext. 3027, or from the Visitors Center, Ext. 3440.

NOTES AND ANNOUNCEMENTS

TOPICAL CONFERENCE PLANNED . . .

"Nuclei as Targets: Are They Worth the Trouble?" is the subject of a Fermilab Topical Conference being planned by the Theoretical Physics Department. It will be held at the Central Laboratory on Friday afternoon and Saturday morning, November 15 and 16, 1974. On Friday, L. Voyvodic of Fermilab will summarize the experimental situation. On Saturday, K. Gottfried of Cornell University will review theoretical ideas and describe the pending issues. Both talks will be followed by panel discussions intended to stimulate extensive audience participation.

Attendance is limited to 75 persons, on a first-come, first-serve basis, and all participants are expected to arrange for their own transportation and lodging. A moderately priced dinner on Friday and lunch on Saturday will be available in the Cafeteria.

Anyone interested in attending should contact H. D. I. Abarbanel or C. Quigg at the Laboratory (telephone 840-3404).

WORKSHOP ON FUTURE MUON EXPERIMENTS PLANNED . . .

A one-day workshop is tentatively planned for January 17, 1975, to discuss experimental proposals for future muon experiments at Fermilab. Representatives of groups having muon proposals and any other interested persons are invited to participate in the workshop. The deadline for the submission of written materials to be considered at this meeting is December 17, 1974.

The purposes of the workshop are to review the physics objectives of the current and proposed muon experiments and to determine how best to exploit present and possible future Fermilab capabilities for muon physics. The meeting will probably include a discussion of the current theoretical and experimental situation. Representatives of groups having muon proposals will be invited to present their ideas (approximately one-half hour each). A panel composed of some PAC members, and possibly augmented by additional persons knowledgeable in this area of physics, will formulate recommendations for presentation to the Program Advisory Committee at their spring meeting on March 20 and 21.

Muon proposals already received and awaiting PAC action include:

Proposal	Participating Institutions	Spokesman
Muon #307	University of California, Berkeley Fermilab Lawrence Berkeley Laboratory Princeton University	L. T. Kerth
Muon #319	Michigan State University	K. W. Chen
Muon #203	Lawrence Berkeley Laboratory Princeton University	M. Strovink
Muon #225	Michigan State University	K. W. Chen

Further details relating to the workshop will be announced in future issues of NALREP.

SPRING PAC MEETING SCHEDULED . . .

The spring meeting of the Fermilab Program Advisory Committee has been scheduled for Thursday through Saturday, March 20 to 22, 1975. Possible

topics for discussion at this meeting include future muon experiments, the neutrino program for the 15-foot bubble chamber, and the future program for the multiparticle spectrometer in the Meson Area.

The deadline for receipt of written material for consideration at this meeting is Thursday, February 20, 1975.

WORKSHOP ON RADIATION SHIELDING HELD . . .

An international workshop on radiation shielding design was held at the Laboratory on August 5 and 6. It was attended by 20 physicists from high-energy physics laboratories in the United States and Europe.

Computer programs CASIM and MUSHLD were described in great detail by their authors. CASIM, written by A. Van Ginneken, is intended for calculations of particle fluxes, dose, and heading due to hydronic cascades in thick configurations such as shielding around experiments, around beam-lines, and in targets themselves. K. Lee's program, MUSHLD, gives similar information for muons created by the decay of pions created in realistic interaction geometries by high-energy hadrons. Detailed descriptions of both of these programs are being prepared now, and will be available from the Fermilab Publications Office later this year.

Some of the participants brought magnetic tapes to copy and take programs back to their home institutions. Some of them also prepared for calculating the geometries in which they were interested with the advice of the program authors.

This was the second in a series of workshops planned by the Research Services Department.

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 October 1, 1974. For experiments which have been completed or have received beam there is indication of the amount of running time or exposure. Publications have been prepared or talks given about the experiments marked with an (*).

Total Number of Approved Experiments - 153

EXPERIMENTS THAT HAVE COMPLETED DATA TAKING (61):

Internal Target Area (7)

*Proton-Proton Scattering #36A	700 hours
*Photon Search #63A	2,550 hours
*Proton-Proton Missing Mass #67A	600 hours
*Photon Search #120	1,200 hours
*Particle Search #184	800 hours
*Proton-Nucleon Inclusive #188	1,050 hours
*Proton-Proton Inelastic #221	950 hours

Meson Area (19)

*Neutron Cross Section #4	1,450 hours
Multigamma #22	350 hours
*Neutron Dissociation #27A	850 hours
*Quark #72	500 hours
*Quark #75	1,050 hours
*Pion Charge Exchange #111	1,800 hours
Super-Heavy Elements #147	3 exposures
*Multiplicities #178	550 hours
Multigamma #230	50 hours
*Emulsion exposures to protons @200 GeV for experiments 90, 103, 105, 114, 116, 117A, 156, 171, 183, 189	45 stacks

Proton Area (2)

*Particle Search #100A	1,150 hours
*Particle Search #187	200 hours

Neutrino Area (33)

*30-Inch Hybrid #2B	479K pix
*Proton-Proton Inelastic #14A	140 hours
*Muon #26	900 hours
Detector Development #34	50 hours
*30-Inch p-p @300 #37A	51K pix
*30-Inch $\pi^{\pm}$-p @100 #121A	104K pix
*30-Inch π^{-}-p @100 #125	53K pix
*30-Inch π^{-}-p @200 #137	48K pix
*30-Inch p-p @200 #141A	67K pix
30-Inch π^{-}-p @300 #143A	51K pix
*30-Inch Hybrid #154	105K pix
30-Inch p-p&Ne @300 #161	51K pix
30-Inch π^{-}-p&Ne @200 #163A	52K pix
*Massive Particle Search #199	2 targets
Emulsion/Muons @150 #205A	2 stacks
Beam Dump #211	2 hours
30-Inch $\pi^{\pm}$-p @200 #217	85K pix
30-Inch π^{-}-d @200 #218A	72K pix
30-Inch π^{+}/p-p @60 #228	37K pix
Long-Lived Particles #239	350 hours
*30-Inch p-p @100 #252	33K pix
Emulsion/Muons @150 #255	1 stack
*Neutrino #262	400 hours
Quark #297	50 hours
Emulsion exposures to protons @300 GeV for experiments 181, 195, 232, 233, 237, 242, 244, 250, 275	34 stacks

EXPERIMENTS THAT ARE IN PROGRESS (29):

Internal Target Area (1)

*Proton-Deuteron Scattering #186	450 hours

Neutrino Area (14)

*Neutrino #1A	1,450 hours
Monopole #3	4 targets
*Neutrino #21A	1,050 hours
15-Foot Neutrino/H_2 #45A	14K pix
*Monopole #76	3 targets
Muon #98	750 hours
*30-Inch p-p @400 #138	21K pix
Super-Heavy Elements #142	1 target
30-Inch p-d @100 #194	28K pix
30-Inch p-d @300 #209	55K pix
15-Foot Engineering Run #234	2K pix
30-Inch p-d @200 #280	64K pix
30-Inch π^+-d @200 #295	54K pix
Neutrino #320	500 hours

Meson Area (12)

*Elastic Scattering #7	1,250 hours
Neutron Backward Scattering #12	650 hours
Missing Mass #51A	550 hours
Elastic Scattering #69A	650 hours
*Nuclear Chemistry #81A	66 bombardments
K Zero Regeneration #82	2,050 hours
Elastic Scattering #96	1,300 hours
*Total Cross Section #104	1,250 hours
Beam Dump #108	6 targets
Detector Development #229	300 hours
Detector Development #261	350 hours
Neutron Dissociation #305	600 hours

Proton Area (2)

*Lepton #70	2,400 hours
Photoproduction #87A	750 hours

EXPERIMENTS THAT ARE IN TEST STAGE (5):

Meson Area (4)

Neutral Hyperon #8	100 hours
Diffractive Dissociation #86A	100 hours
Neutron Elastic Scattering #248	
Photon Inclusive #268	400 hours

Neutrino Area (1)

15-Foot EMI Test #155

EXPERIMENTS BEING INSTALLED (6):

Meson Area (3)

Multiparticle #110A	50 hours
Form Factor #216	
Muon Search #335	

Neutrino Area (1)

Tachyon Monopole #202

Proton Area (2)

Photon Search #95A
Particle Production #284

EXPERIMENTS TO BE SET UP WITHIN A YEAR (35):

Internal Target Area (2)

Proton-Nucleon Inelastic #317
Proton-Proton Inelastic #321

Meson Area (4)

Hadron Jets #236A
Hadron Jets #246
Hadron Jets #260
Inclusive Scattering #324

Proton Area (5)

Photon Total Cross Section #25A
Muon Search #48
Di-Lepton #288
Particle Search #300

Neutrino Area (24)

15-Foot Neutrino/H_2&Ne #28A
15-Foot Anti-Neutrino/H_2 #31A
15-Foot Anti-Neutrino/H_2&Ne #180
30-Inch $\bar{p}$-d @400 #196
30-Inch π^--p @Hi E #215
Emulsion/Protons @200 #271
Quark #276
Super-Heavy Elements #285
30-Inch $\bar{p}$-p @100 #311
Detector Development #327
30-Inch π^--d @400 #338
Emulsion exposures to protons @400 GeV for experiments 238, 243, 245, 249, 251, 265, 279, 292, 329, 336
Emulsion exposures to π^- @200 GeV for experiments 264, 328, 339

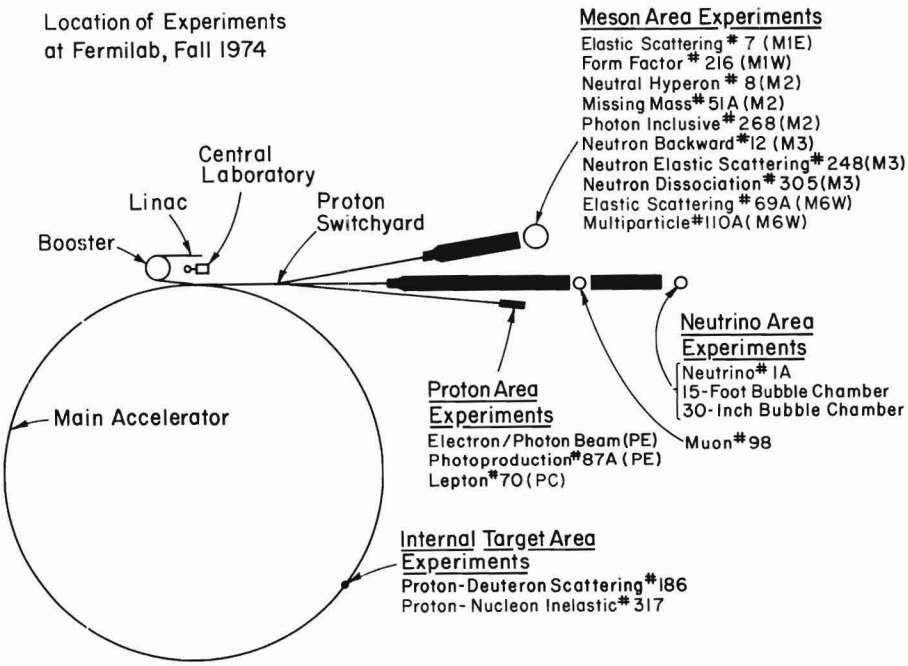
OTHER APPROVED EXPERIMENTS (17):

Internal Target Area (3)
- Proton-Nucleon Scattering #198A
- Proton-Helium Scattering #289
- Proton-Proton Polarization #313

Proton Area (5)
- Photoproduction #152B
- Multigamma #192
- Pion Inclusive #258
- Phi Photoproduction #263
- C-Test #302

Meson Area (2)
- Polarized Scattering #61
- Charged Hyperon #97

Neutrino Area (7)
- Detector Development #32
- 15-Foot Neutrino/H_2 or Ne #53A
- Long-Lived Particles #115
- 15-Foot Anti-Neutrino/H_2&Ne #172
- Detector Development #206
- 30-Inch p-p @500 #207
- 30-Inch π^+-p @300 #277



FACILITY UTILIZATION SUMMARY--SEPTEMBER 1974

The high energy physics research program continued through September with no major interruptions. Operating at 300 GeV, the accelerator ran steadily at intensities above 10^{13} protons per pulse. Over 2.3×10^{18} protons were accelerated, nearly twice the integrated intensity for any previous month. The operating efficiency during scheduled time for high energy physics research was 72%. Both slow- and fast-spilled beam were available, and in addition, three fast "pinged" pulses per cycle were provided for use at the liquid deuterium-filled 30-inch bubble chamber. A considerable effort by the Accelerator Division External Beam Systems Group produced a fast spill of 1- to 2-msec duration with less than 1-msec time jitter, to meet the requirements of the Neutrino # 320 experiment. At one time it had been felt that such spill parameters would not be attainable as a matter of routine operation.

In the Meson Area, eight experimental groups were involved in data-taking activities during the month; namely, Neutron Backward # 12, Missing Mass # 51A, K^0 Regeneration # 82, Elastic Scattering # 96, Total Cross Section # 104, Charge Exchange # 111, Photon Inclusive # 268, and Neutron Dissociation # 305. The Charge Exchange # 111 group completed data taking in mid-September. Meanwhile, two other experiments, Neutral Hyperon # 8 and Multiparticle # 110A, used beam for setup work; in addition, Streamer Chamber # 86A and a test for Proposal # 331 performed beam tuning and equipment testing work. Further studies were conducted on the often-observed reduction in secondary beam fluxes from the Meson Area target,

particularly in the M2 and M4 beam lines, which occurs when the intensity of the primary beam is increased. Although the phenomenon is still not understood, some progress was made.

In the Neutrino Area, the major effort centered on providing high intensity fast spill on the narrow-band target train to enable the Neutrino # 320 group to measure neutral current cross sections. Operating conditions were established to meet fairly rigorous requirements on the fast-spill parameters, and data were taken on both neutrino and antineutrino events. Over 1.3×10^{18} protons at 300 GeV were delivered on the target in September, to complete data taking for the experiment. At the same time, when operating conditions permitted, the Neutrino # 1A group collected data parasitically. Five other experimental groups used the 30-inch bubble chamber for one-week runs to collect approximately 255,000 photographs of interactions in deuterium. These include Experiments # 209, # 280, # 218, # 295, and # 194; the first and last of these runs began in August and ended in October, respectively. In addition, Experiment # 45A tested their Cerenkov counter in the N-3 beam for a short period early in September, and a collaboration from the University of Illinois and Fermilab tested the N-1 muon channel for use as a hadron beam.

The Proton Area received beam for high energy physics research only until September 11, and this period was interrupted by a two-day shutdown. The remainder of the month was used for construction and installation of utilities and components for a segment of the electron and tagged photon beam, and for the moving of the Proton Area Control Center from the P-2 Portakamp

to the basement of the Pagoda. During the nine-day running period, the Lepton # 70 group completed data taking on muon production at the 100-mrad laboratory angle, and Photoproduction # 87A collected data on both photon and neutron production from a series of solid targets.

Activity in the Internal Target Area was minimal during September. Proton-Proton Inelastic #221 completed a series of tests using the hydrogen gas jet during the first week, in preparation for a proposed future experiment. Photon # 63A ran a few hours of calibrations in mid-month, using a rotating target.

The summary of accelerator and beam utilization for the month of September is as follows:

I. Summary of Accelerator Operations

		Hours	
A. Accelerator use for physics research			
Accelerator physics research		42	
High energy physics research		434	
Research during other use		(45)	
	Subtotal		476
B. Other activities			
Accelerator setup and tuning to experimental areas		5	
Scheduled interruption		49	
Unscheduled interruption		190	
	Subtotal		244
C. Unmanned time		0.0	0.0
	Total		720

II. Summaries of High Energy Physics Research Use

	# of Expts.	Hours	Results
A. Counter experiments	17	2846	
B. Bubble chamber experiments	5	340	254,432 pictures
C. Emulsion experiments	-	-	-
D. Special target experiments	2	-	10 targets
E. Test experiments	2	115	-
F. Engineering studies and tests	3	28	-
G. Other beam use	-	30	-
	29	3359	

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

		Protons @ 300 GeV
A. Beam accelerated in main ring	Total	2.30
B. Beam delivered to experimental areas		
Meson Area		0.72
Neutrino Area		
Main beam		1.32
Bubble chamber beam (estimated)		0.01
Proton Area		0.03
	Total	2.08

IV. Beam Utilization by Experiment

	Hours
A. Meson Area	
Neutral Hyperon # 8	77.8
Neutron Backward # 12	163.5
Missing Mass # 51A	69.0
K^0 Regeneration # 82	410.2
Elastic Scattering # 96	338.2
Total Cross Section # 104	297.4
Multiparticle # 110A	44.9
Charge Exchange # 111	193.5
Photon Inclusive # 268	77.8
Neutron Dissociation # 305	214.3
Streamer Chamber # 86A	95.8

B. Neutrino Area

Neutrino # 320	375.2	$\int p = 13.2 \times 10^{17}$ protons
Neutrino # 1A	238.3	
p-d @ 100 GeV # 194	35.2	28,246 pictures
30-inch p-d @ 300 GeV # 209	66.8	36,613 pictures
π^+-p @ 200 GeV # 218	66.7	71,765 pictures
p-d @ 200 GeV # 280	105.5	63,954 pictures
π^+-p @ 200 GeV # 295	66.2	53,854 pictures

C. Proton Area

Lepton # 70	94.6
Photoproduction # 87A	120.8

D. Internal Target Area

Photon # 63A	2.0
Proton-Proton # 221	32.2

PROPOSALS RECEIVED DURING AUGUST AND SEPTEMBER 1974

No.	Title	Submitted By
328	The Interactions of π^--Mesons in Nuclear Emulsion at 200 GeV/c (or 300 GeV/c)	M. Tretjakova
329	The Interactions of Protons in Nuclear Emulsion at 400 (or 500) GeV/c	M. Tretjakova
330	Search for Massive Neutral Particles	H. Gustafson
331	A Proposal for a Detailed Study of Di-Muon Production	J. Pilcher
332	A Proposal to Explore Di-Lepton Production in the Large-P_t Domain: Di-Lepton Structure, Associated Hadron Structure and Beam Particle Dependence	P. Mockett
333	Proposal to Study High-Energy π^+, K^+ and K^- Interactions in the NAL 15-foot Hydrogen Bubble Chamber	J. Rushbrooke
334	Proposal to Study High-Energy π^+, K^+ and K^- Interactions in the NAL 15-foot Hydrogen Bubble Chamber	J. Rushbrooke
335	A Search for Direct Muon Production in the Forward Direction	O. Fackler
336	Multiparticle Production in Nucleon-Nucleus Collisions at 400 GeV	T. Ogata
337	Measure of Di-Muon Events in the Meson Area	D. Eartley
338	Pion-Deuteron Interactions at 400 GeV/c	P. M. Yager
339	Cracow Emulsion Exposures to 200-GeV Pions	J. Gierula

DATES TO REMEMBER

November 4-5, 1974	PAC Bubble Chamber Subcommittee meeting.
November 7-9, 1974	POPAE Workshop II (see p. 18, September issue of NALREP, or call Ext. 4203 for details).
November 9, 1974	Users Executive Committee meeting.
November 14-16, 1974	Fall meeting of the Fermilab Program Advisory Committee.
November 15-16, 1974	Fermilab Topical Conference: "Nuclei as Targets: Are they Worth the Trouble?"
November 16, 1974	Fermilab Lecture Series: Bob Woodward, Washington Post reporter.
December 17, 1974	Deadline for receipt of materials to be considered at the Muon Workshop.
January 17, 1975	Muon Workshop.
February 20, 1975	Deadline for receipt of material to be considered at the spring meeting of the Fermilab Program Advisory Committee.
March 20-22, 1975	Spring meeting of the Fermilab Program Advisory Committee.