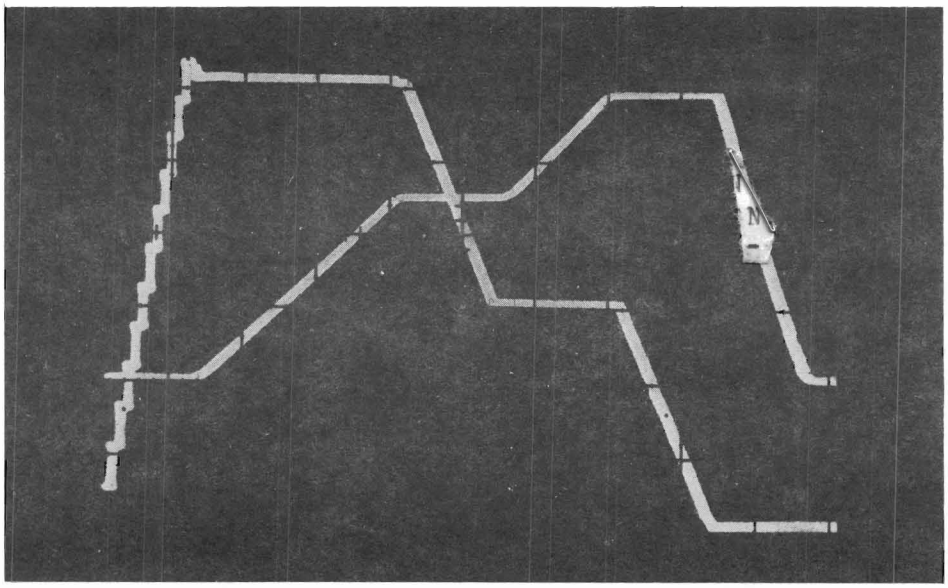
NALREP



Monthly Report of the National Accelerator Laboratory April 1974

National Accelerator Laboratory

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NAL-74/5 0090.01

THE COVER: Photograph of an oscilloscope screen showing the intensity and energy of the proton beam during one accelerator cycle. The notches on the left indicate the twelve booster pulses injected into the Main Ring, and form the trace representing the intensity of the circulating beam. The other trace represents the energy of the beam; it shows one-second constant energy periods at both 200 GeV and 300 GeV. For more details, see page 1.

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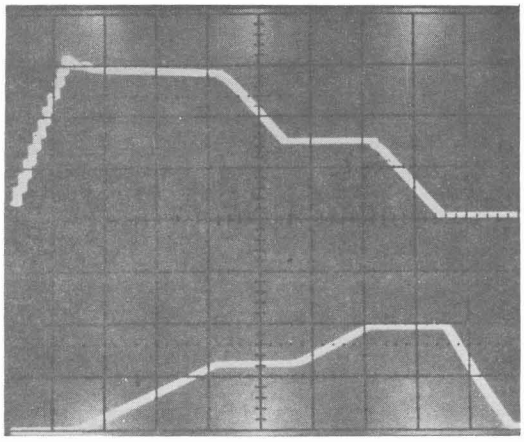
ACCELERATOR OPERATION IN THE DICHROMATIC MODE

From March 25 to 27, the accelerator was operated in a mode in which beams of two energies were extracted from the Main Ring during each accelerator cycle; the dichromatic mode of pulsing. Tests of this new mode were undertaken to determine whether the circulating proton beam could be accelerated, kept at constant energy for a time, and then accelerated again. Such tests will determine the practicality of someday operating one experimental area at an energy lower than that of the other external experimental areas.

This mode of operation is illustrated in the oscilloscope traces on the next page. The intensity of the beam during one accelerator cycle is shown in Trace A. Initially, twelve booster pulses are injected into the Main Ring--indicated by the "staircase" effect on the left. After the last pulse has been injected, the magnetic field, shown in Trace B, is increased (ramped), and the circulating beam accelerated to 200 GeV, where it is held constant for one second. During this period, known colloquially as the front porch, the beam is extracted from the accelerator at a continuous rate, reducing the intensity of the beam remaining in the ring. This is indicated by the decrease in the height of Trace A. The magnetic field is then raised, and the remainder of the beam accelerated to 300 GeV. Again, a constant field (flat-top) is maintained for one second while the beam is extracted for use in the external experimental areas.

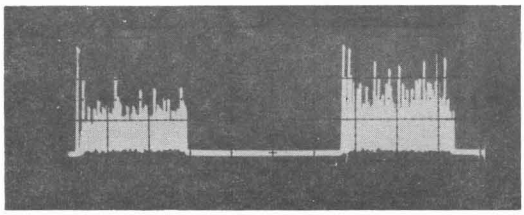
During this test the 200-GeV beam was sent to the Meson Area, and the 300-GeV beam was shared by the Proton and Neutrino Areas. This required

Oscilloscope traces taken during the testing of NAL's dichromatic operating mode. Traces A and B indicate beam intensity and magnetic field (or energy) during one accelerator cycle. Trace C shows the beam intensity bursts during each of the two extraction periods (one at 200 GeV, one at 300 GeV). Trace C was not taken with the same time base as Traces A and B.



Trace A

Trace B



Trace C

that many transport elements in the Switchyard operate at different magnetic field values for each of the energies during the same pulse, in order to maintain efficient transmission of these beams.

An oscilloscope trace of a beam monitor indicating the intensity of the bursts of beam during each of the two extraction periods (spill "structure") as a function of time is shown in Trace C. As can be seen, there are some variations in the uniformity of the intensity. The spill structure was steadily improved during the test, and by the conclusion of the exercise it was nearly as good as beams regularly extracted during single-spill operation.

Reported by P. Livdahl

THE ACCELERATOR RELIABILITY PROGRAM

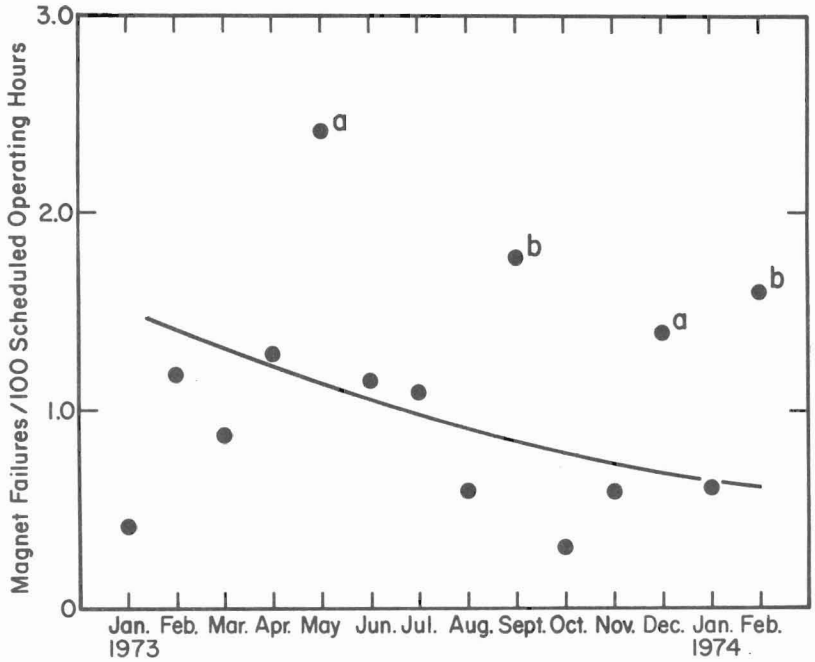
The reliability of accelerator systems has been the primary concern of most Accelerator Division personnel during the past year or two. A special Reliability Committee has been established to study and recommend changes in various systems to make them operate more reliably. Some of the systems improved as a result of these efforts are described in this article.

A reliable system is one which operates when needed, with few unscheduled interruptions. One measure of unreliability is the number of such interruptions or instances of equipment failure occurring during operating hours. During the last six months of 1973, the accelerator systems operated, on the average, about 60% of the time they were scheduled to operate.

Main Ring Magnets

Main ring magnet failures have been a primary cause of accelerator downtime since the first attempt to circulate a proton beam in the summer of 1971. More than half of the magnets originally installed in the ring have been rebuilt and replaced. In the past 18 months, the failure rate has diminished to an average of about one and one-half magnets per week. Although this is fairly constant, the failure rate per one-hundred hours of scheduled operating time per month appears to be decreasing, as the chart on page 4 indicates.

The magnets installed in the Main Ring today are made of the same elements as those originally installed. However, the electrical insulation

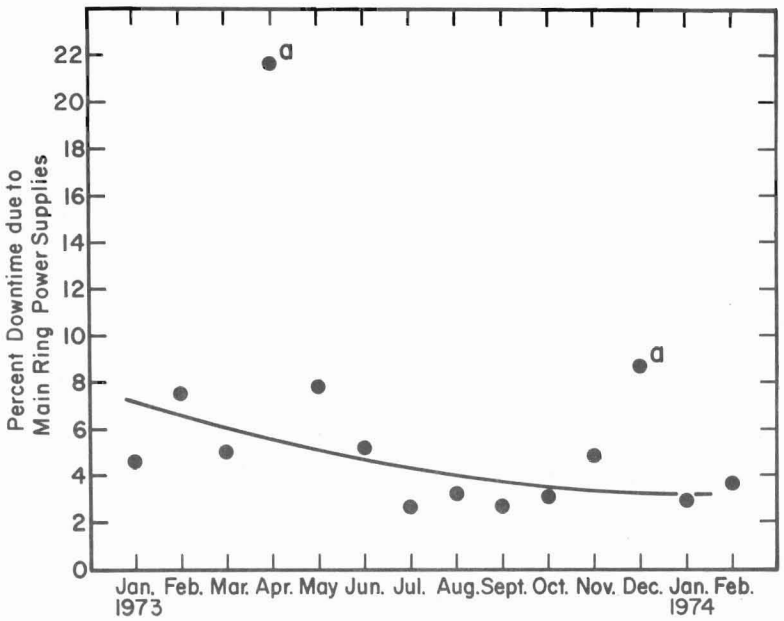


Analysis of the number of magnet failures per one-hundred hours of scheduled operating time. Failures increased sharply during 400-GeV operation in April and December 1973, as indicated by the points labeled a. During September 1973 and February 1974 extended shutdown periods were scheduled for accelerator maintenance and development work, and a number of weak magnets were replaced during those periods labeled b.

has been modified many times. The earliest magnets have the highest rate of failure; it is believed that their demise was caused by the presence of moisture in cracks which occurred in the radiation-resistant epoxy resin used in their manufacture. This moisture could have resulted from either water leaks in the brazed joints of the copper coils or from condensation. To prevent condensation, a special circulating-air dehumidification system has been installed.

The failure rate for magnets made with the newer types of insulation is much lower. Generally, the difference between these magnets and the earlier versions is that the magnet coils are bonded to each other and to the magnet steel with a filled epoxy resin which reduces cracking. This is accomplished by evacuating the coil mold and filling it with the epoxy, in a vacuum impregnation process. Most failures of magnets with this type of insulation system occur at the butt-brazed joints in the inner coil, and at least half of them are the result of water leaks. In the newest magnet design, a specially tested sleeve joint has been incorporated in both the inner and outer coils. Thus far only one of these magnets has failed, although only a few have been installed in the Main Ring.

In addition to attempting to improve the quality of the electrical insulation and the mechanical integrity of the magnets, the designers have reviewed other causes of main ring magnet failures. As a result, major improvements have been made in the protective circuitry, so that unusually high voltages are not applied to the coils. A review of over 100 magnets which have failed in the past 18 months showed that about 40% of them (nearly all with the earlier types of electrical insulation) failed when higher than normal voltage was applied, indicating malfunctions of various kinds in the power supply. Another 20% failed because of external water leaks; 20% apparently failed because of internal water leaks or other problems associated with the butt joint in the inner coil; and 20% failed for undetermined reasons. The Accelerator Division staff expects to reduce the failure rate by a factor of two by improving the protective circuitry of the power supplies and eliminating the water leaks.



Percentage of downtime due to problems associated with the main ring power supplies, per month. The 400-GeV operation during April and December 1974 (a) taxed the present capability of the power supplies.

Main Ring Power Supplies

The percentage of scheduled operating time that the accelerator has been off each month due to problems with the power supply is shown in the diagram above. The average downtime due to power supplies for the first six months of 1973 was nearly 8%, while it was half that for the last six months of 1973.

More reliable performance of the power supplies has been achieved by consistent improvements in the quality of the available thyristors, changes in the firing circuits, mechanical improvements in the bus work, and alterations in the water circuits to insure adequate cooling of the silicon-controlled rectifiers used in the modules. These improvements involved many man-months

of work. There are 360 modules which make up the sixty power supplies, and each one must be removed from the power supply circuit before modifications can be made.

The experience gained in making these modifications has lead to a new design for the modules, which greatly simplifies their construction and eliminates many of the offending components. Fifteen of these new modules are being assembled for testing in the Main Ring; if they prove successful, all the other modules will be rebuilt accordingly.

Main Ring Water Systems

Unfortunately, no substitute has been found for the water which is used to cool most of the accelerator components. Thus far, it has been the cause of more accelerator downtime than any other one factor. Problems occur primarily because of leakage, but condensation from warm, moist air on cold surfaces has also caused much of the downtime experienced. A large percentage of the early magnet failures are believed to have been caused by condensed water resulting from the high humidity in the tunnels. Most of the early problems with power amplifiers, cavities, and tuners in both the Main Ring and Booster rf systems were caused by combinations of condensation and leakage. These difficulties have been eliminated for the most part, by developing new components and techniques which eliminate the sources of water.

The ceramic insulators that connect the cooling water to the magnets is a frequent source of trouble. A number of insulator failures was due to poor brazing of insulators to magnets. The failure of these poorly brazed joints may have been accelerated by corrosion due to the interaction of the

low conductivity water with the brazing material or soldering flux. Improved insulators have been incorporated into all rebuilt magnets. Many of the old-style insulators have been changed as well, greatly decreasing the rate of failure from this cause.

Cracking of welds in the water pipes where vibrations and mechanical strains are concentrated was yet another source of water leaks. Clamps which physically brace the pipes at these sensitive points have been installed, and they appear to have alleviated the problem.

Air coolers are being added to the cooling systems at each service building, so that the ambient magnet temperature can be better regulated. During the summer of 1973, operation was carried on at whatever temperature could be maintained by the cooling ponds. At times during very hot weather the temperature of the magnets and power supply components substantially exceeded the 95° F design temperature. By adding additional cooling, it should be possible to keep the magnets at a uniform temperature. This should increase the reliable performance of the entire accelerator system during the summer months.

Based upon material provided by
P. Livdahl and P. J. Reardon

A SEARCH FOR MAGNETIC MONOPOLES AT NAL

Searches for magnetic monopoles have been underway at the Laboratory for more than a year. One exposure has been completed, and the results published (R. A. Carrigan, Jr., F. A. Nezrick, and B. Strauss, Phys. Rev. D. 8, 1973, p. 3717). Other exposures are being carried out in both the Neutrino and Proton Areas, and, in addition, apparatus for a bound-monopole search is being tested in the Meson Area. To date, no evidence of monopoles has been found in the data that have been analyzed. Although this means that magnetic monopoles are not produced at present NAL energies in abundance, it neither definitively rules out their existence nor places less urgency on carrying the other searches to their logical conclusions.

The modern conjecture of the magnetic monopole owes its origins to P. A. M. Dirac. In 1931, he suggested that the presence of one magnetic monopole somewhere in the universe could explain the quantitization of charge observed so universally. Only very recently, with the advent of schemes such as the Georgi-Glashow model, have alternate hypotheses been brought forward to explain charge quantization. For many years Dirac's conjecture was the major and, indeed, one of the only significant works concerning magnetic monopoles.

One major criticism raised against the conjecture is that a system consisting of both a magnetic charge and an electric charge violates time-reversal invariance. Robert Adair has illustrated this violation graphically by considering the path of an electric charge through a normal electromagnet and its path through a permanent magnet. In the former, the electric current

reverses so that the magnetic field flips; in the latter the magnetic poles do not change under the time reversal operation. It is immediately clear that the time-reversed trajectory must differ in the two cases. Prior to 1964 this was felt to be a strong criticism of the monopole conjecture. Since the observation of parity and charge conjugation violation in K^0_L decays, this problem has become something of an interesting artifact.

Few dynamical theories in the spirit of the quark model have been constructed using magnetic monopoles. Schwinger has suggested one model which is quite interesting in qualitative terms. He postulates a particle, the dyon, which has both magnetic and electric charge. Schwinger proposes two magnitudes of magnetic charge, one twice the size of the other, to neutralize the magnetic charge on the baryons. In some details, this model is quite similar to the normal quark model--baryons consist of three dyons, one with two units of north magnetic charge and the other two with one unit each of south magnetic charge; mesons consist of one north and one south charge. Barut has developed dyon models along a somewhat different line. Neither of these theories has been carried to the point where it is capable of predicting production cross sections for monopoles or dyons. One problem is that the strength of the magnetic monopoles is so great that normal computational techniques involving perturbation calculations are inadequate to the task.

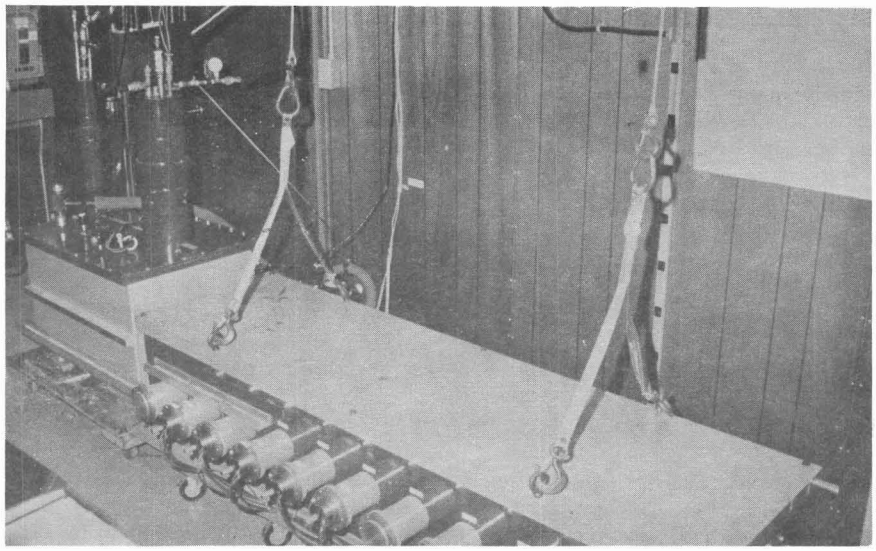
We have carried out the first search for magnetic monopoles at the Laboratory with the object of establishing an upper limit on the production cross section. A second objective has been to cover a wide range of pole properties, such as magnetic charge and mass, and at the same time minimize the dependence on energy loss and binding properties.

At all times, our intention has been to conduct the experiment in a rather low-key manner. However, in pressing to complete our work, we have found ourselves pioneering in doing many other things at NAL as well. For example, we were the first to build and use a superconducting magnet for an experiment (with a magnetic field of over 80 kG, the highest achieved at NAL), one of the first groups to monitor beam properties by measuring radioactivity, and the first to use remote manipulators for handling targets. Perhaps most significant, we were one of the first experimental groups to purchase and paint a Portakamp at the Laboratory.

When the experiment (Monopole #76) was first proposed, cosmic ray experiments had already indicated that the cross section for monopole production at NAL energies would be small. Therefore, we felt that the greatest number of protons possible should be used in a search experiment. Theoretically, magnetic monopoles lose energy very fast, so that a Dirac monopole has a specific ionization equivalent to a fission fragment. Once produced, a monopole will normally travel only a short distance. This is particularly true when it pertains to the separation of a monopole pair in a beam dump. These considerations led us to favor the use of a monopole collector consisting of either a target or a beam dump in which the accelerated proton beam is able to make the maximum number of interactions in some metal object. This is in contrast to experiments in which magnetic fields near the production point of the monopole are used to deflect them in some way from the charged and neutral particles moving in the vicinity of the target. If a dump or target is used as a collector, it will become highly radioactive.

It is desirable to use some magnetic binding, in the form of either a paramagnetic material (aluminum, for example) or a ferromagnetic material (cobalt or iron), to keep the monopole from migrating out of the target due to the effects of stray magnetic fields or of thermal diffusion. A typical target consists of many rectangular iron slugs, to facilitate insertion into the detection apparatus and to diminish the problems of handling radioactive materials.

After the target has been exposed to the proton beam, it is removed from the target box and taken to the monopole extraction solenoid, a 20-in. long 80-kG superconducting magnet with a 2-in. warm bore. A slug from the target is introduced into the solenoid along the solenoid axis. There are ten very thin scintillation counters at the other end of the solenoid, interspersed with iron energy-degraders. The pulse heights from these counters are displayed on a dual-beam oscilloscope. A trigger consists of a coincidence from the first three counters. The counters are calibrated with remotely manipulated alpha sources and light pulsers. The thickness of each (10 mils) is such that the pulse from a 5-MeV alpha is essentially equivalent to the pulse height from a magnetic monopole with one-sixth the Dirac charge passing through the counter. Light pulsers are used to check the electronics over the range of magnetic charges from one-sixth to 24. This range requires a wide dynamic response--more than 10^4--from the counters. Monopole signals would be identified by the pulse height in the counters, as well as the number of counters which have fired. In the searches up to this point, no trigger has occurred which in any way resembles a magnetic monopole signal.



Experimental apparatus for Monopole #76, the first search for magnetic monopoles to be carried out at NAL energies. Detector apparatus is in the foreground; the 80-kG solenoid is on the left.

A cross section limit can be established once the number of protons incident on the target, determined by measuring Mn^{56} activity in the iron sample, is known. The radioactivity measurements are cross-calibrated against known proton exposures in aluminum. For the initial search, 3.4×10^{16} protons were incident on the dump. This establishes a total cross section limit of 6×10^{-42} for magnetic monopole production at 300 GeV, with a 95% confidence level. We are continuing our search with an exposure at 400 GeV. If we don't find monopoles then, we will look again at 500 GeV, and then at 1000 GeV!

Reported by R. A. Carrigan and F. A. Nezrick

SPECIAL BEAMS TO THE 15-FT BUBBLE CHAMBER

On February 15, 1974, the Laboratory was host to a workshop concerning special beams for the 15-ft bubble chamber. The suggestion for this workshop originated during last summer's meeting of the Program Advisory Committee when the Committee first reviewed some of the proposals made for hadron physics in the 15-ft chamber. At that time, they recommended that a group of specialists discuss the beam and device capability for the 15-ft bubble chamber prior to consideration by the Program Committee of any specific proposals. This is quite logical, since the research capability of the chamber is largely determined by the beam facilities provided to it. It was the hope of the Program Committee that such a workshop would bring out the best ideas concerning possible beams prior to their critical review by the Program Advisory Committee.

A panel chaired by H. Foelsche from Brookhaven, and consisting of A. Erwin, J. Lannutti, L. Voyvodic, and R. Yamamoto, met at NAL on February 15 and 16. The first day was devoted to a general discussion about the physics and research capabilities of the 15-ft chamber and a detailed presentation of the different specialized beams which have been suggested. Spokesmen for each of the existing proposals had the opportunity to say a few words concerning their viewpoint about the beam needs for the chamber. On the following day the panel members formulated their conclusions, which have recently been submitted to the Program Advisory Committee. Some of the more important conclusions are described herein, to provide guidance in writing proposals for the use of the 15-ft chamber. It is expected that a

subcommittee meeting will be held in the fall to consider specific proposals and to take action upon them. Details about these arrangements will be announced in NALREP following the June meeting of the Program Advisory Committee.

1. The large chamber provides nearly unique features for an exciting range of physics. For example, if equipped with a track-sensitive target, it would be possible to study hadron interactions when the chamber working volume is filled with a large percentage of neon. Plans for a track-sensitive target suitable for hadron interactions should be supported by the Laboratory.

2. The simple beam that exists to the chamber should be equipped for beam-tagging; two Cerenkov counters and several sets of proportional wire-chambers should be installed.

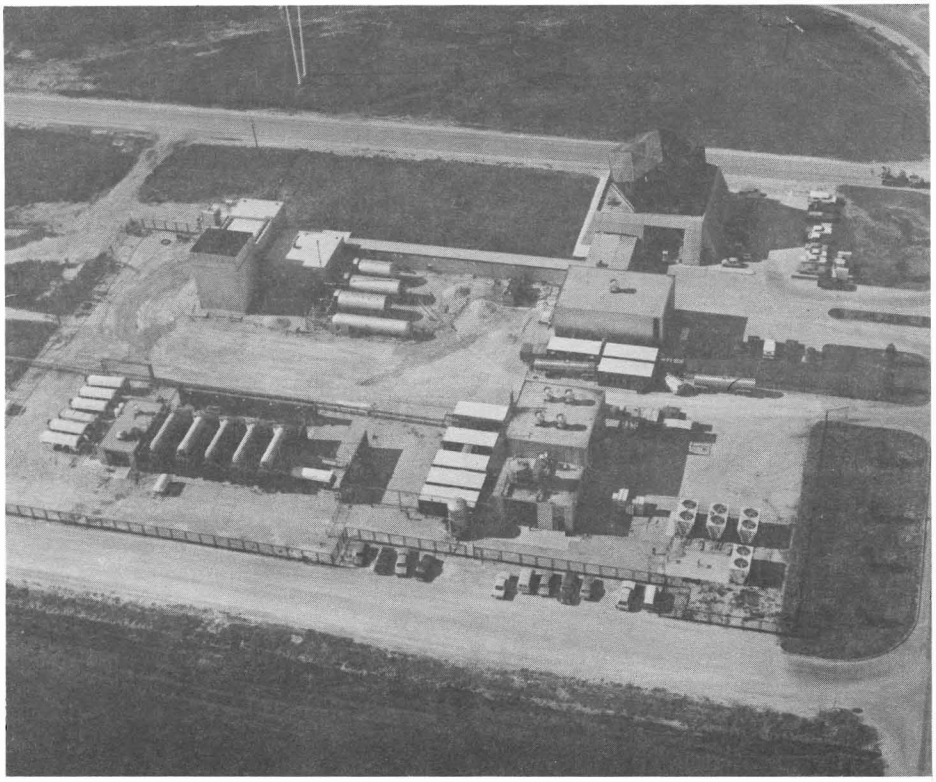
3. Because of the demands on the accelerator intensity when multiple pulsing is feasible, it is hoped that the secondary beam will be modified to provide larger acceptance by adding larger aperture quadrupole magnets along the beam channel.

4. Little enthusiasm was expressed for constructing a superconducting rf-separated beam in the near future, because of the cost. However, it was suggested that another look might be taken into the possible use of conventional separators at high frequency.

5. A number of ideas for new enrichment schemes are being explored to modify the particle ratios in the beam to the 30-in. bubble chamber. Some of these look quite promising for producing antiprotons and improved fluxes of π^+'s, for example. The committee thought these ideas were too new to consider quantitatively, but suggested that more be done in this direction, and that descriptive material be provided for the high energy physics community at large, so that the implications of these studies can be considered.

These are the highlights of the panel discussion. The most far reaching ideas of significant particle enhancement in these beams without extensive new separation will be reported in a future issue of NALREP.

Reported by J. R. Sanford



Aerial view of the 15-ft bubble chamber building. The hadron beam line enters from the left. Storage tanks for cryogenic liquids are located to the right of the building. The roof of the 30-in. bubble chamber building is in the lower right foreground.

NOTES AND ANNOUNCEMENTS

ANNUAL USERS MEETING PLANNED . . .

The annual NAL Users Meeting will be held Friday, May 17. There will be an informal social hour on May 16, in the Atrium of the Central Laboratory, beginning at 7:30 p.m. The format of the meeting will be similar to previous meetings except that the meeting has been compressed to one day. The reports to be presented will focus on the accelerator and its research facilities. As in the past, there will be a report from the Director of the Laboratory and the President of URA. There will be discussions of the accelerator, the experimental areas, and other facilities. In addition, we will have a status report on the energy doubler and a description of plans for the POPAE project. We hope to be finished by 5:00 in the afternoon. As before, there will be an opportunity for nominations for election to the Users Executive Committee. Members of the Users Organization will receive a mailing with information about reservations and the detailed program for the meeting.

Prepared by W. Walker, Duke University
Chairman, NAL Users Organization

WORKSHOP ON SECOND GENERATION NEUTRINO EXPERIMENTS SCHEDULED . . .

Now that promising preliminary results have been obtained from the first neutrino experiments at NAL, it appears an opportune time to begin considering future neutrino work at the Laboratory. A workshop will be held at the Laboratory on Saturday May 18 (one day after the annual Users Meeting), to explore ideas about how plans for second generation neutrino experiments might be implemented.

The primary purposes of the workshop are to air all views of the physics objectives and to explore various possible technical approaches to these objectives. One result of the workshop might be that groups with common interests would work together to formulate or support an experimental proposal. Another possible result is that plans for one or more summer mini-studies might be formulated.

The workshop will be conducted by the Neutrino Department and be chaired by F. R. Huson. He is being assisted by J. K. Walker who is responsible for the program. Interested experimenters are invited to attend, and potential speakers should contact the Neutrino Department.

WORKSHOP ON DRIFT CHAMBERS PLANNED . . .

A workshop on drift chambers and their associated electronics will be held at the Laboratory on Friday afternoon and Saturday morning, June 7 and 8. Sponsored by the Research Services Department, it is intended to bring people together to discuss their experiences in working with drift chambers and readout electronics and to provide an opportunity to exchange ideas about this relatively new type of detector. It may also help resolve some of the questions frequently asked about the use of drift chambers by high energy physics experimenters.

The workshop will begin with a brief description of drift chambers. This will be followed by a talk on "Present and Future Detector Needs at Ultra-High Energies," by L. Lederman of Columbia University. Among the subjects to be covered are:

- High resolution drift chambers
- Large area--moderate resolution drift chambers
- Cylindrical drift chambers
- Drift chamber operation in magnetic fields
- Drift chamber characteristics
- Electronics for measuring drift times

A detailed program will be available soon. More information about the workshop may be obtained from M. Atac, Ext. 3255.

PAC MEETING . . .

The Program Advisory Committee will hold its one-week review of the NAL experimental program in Aspen, Colorado, the week of June 17, 1974.

POPAE TO BE STUDIED THIS SUMMER . . .

As reported in the January 1974 issue of NALREP, long-range planning for the Laboratory will center about a system of storage rings which has been given the acronym POPAE (Protons On Protons and Electrons). A panel is being formed to advise NAL on this project.

Preliminary design work on POPAE will be in progress this summer. Input from users is particularly valuable, even essential, at this early stage in the planning. Anyone who would be interested in participating in the design effort this summer is urged to contact D. Edwards, the Project Leader.

APPOINTMENT . . .

Thomas Groves has joined the NAL staff as an Assistant Director of the Laboratory. His responsibilities will be somewhat similar to those he has had at Argonne National Laboratory in the past. Among other assignments, he will serve as Secretary to the NAL Program Advisory Committee. Hereafter, all proposals for experiments to be carried out at the Laboratory should be directed to his attention.

FOR THE COMING YEAR . . .

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MISCELLANY . . .

Announcements of general interest to the Laboratory community, as well as times and places for all official meetings, symposia, and seminars taking place at NAL each week are listed in NALCAL, under a bright blue masthead. This weekly calendar of events is distributed each Friday morning by the Director's Office. Information to be included in it should be sent to J. Gifford, Ext. 3211, no later than Tuesday afternoon of the preceding week. Separate announcements of meetings are being reduced in response to the paper shortage.

The Laboratory has contracted with Pilots Leasing Company of Itasca, Illinois, for the leasing of new cars for periods of six months or longer by visiting experimenters. Those wishing to have vehicles for shorter periods of time will have to pay the higher rental fees, although all charges are lower than those available elsewhere in the area. Arrangements to lease or rent cars may be made through the NAL Travel Office, on the Atrium Floor of the Central Laboratory (E. Jarzab, Ext. 3397). Vehicles may be picked up and returned only on site.

A coffee lounge--widely anticipated as one answer to the problem of "ambiance"--is now operating on the second floor crossover in the Central Laboratory. It can be reached from the steps in the cafeteria. Coffee and tea cost 10¢ a cup, and at present are available from 9:30 a.m. to 4 p.m. on weekdays. More comfortable chairs are on order, and other amenities will be added as time goes on.

EXPERIMENTAL PROGRAM SITUATION REPORT

The experimental program situation at NAL is summarized below. The experiments are listed separated by experimental area under categories that best describe their circumstance as of April 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 asterisk (*).

Total Number of Approved Experiments - 136

EXPERIMENTS THAT HAVE COMPLETED DATA TAKING (43):

Internal Target Area (4)

*Proton-Proton Scattering #36A	700 hours
*Proton-Proton Missing Mass #67A	600 hours
*Photon Search #120	1,200 hours
*Proton-Nucleon Inclusive #188	1,050 hours

Meson Area (14)

Neutron Cross Section #4	1,450 hours
*Quark #72	500 hours
*Quark #75	1,050 hours
Super-Heavy Elements #147	3 exposures
*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 (23)

*Proton-Proton Inelastic #14A	140 hours
*30-Inch $p_{\pm}$-p @300 #37A	51K pix
*30-Inch π^--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 Hybrid #154	105K pix
*Massive Particle Search #199	2 targets
Beam Dump #211	2 hours
Long-Lived Particles #239	300 hours
*30-Inch p-p @100 #252	33K pix
Neutrino #262	400 hours
Emulsion exposures to muons @150 GeV for experiments 205A, 255	3 stacks
Emulsion exposures to protons @300 GeV for experiments 181, 195, 232, 233, 237, 242, 244, 250, 275	34 stacks

EXPERIMENTS THAT ARE IN PROGRESS (23):

Internal Target Area (4)

*Photon Search #63A	2,400 hours
Particle Search #184	500 hours
Proton-Deuteron Scattering #186	250 hours
Proton-Proton Inelastic #221	300 hours

Meson Area (8)

Elastic Scattering #7	150 hours
Neutron Dissociation #27A	550 hours
*Nuclear Chemistry #81A	53 exposures
K^o Regeneration #82	550 hours
Elastic Scattering #96	350 hours
Total Cross Section #104	800 hours
*Pion Charge Exchange #111	1,050 hours
Multiplicities #178	350 hours

Neutrino Area (9)

*Neutrino #1A	950 hours
*30-Inch Hybrid #2B	406K pix
*Neutrino #21A	800 hours
*Muon #26	600 hours
*Monopole #76	3 targets
Muon #98	200 hours
*30-Inch p-p @400 #138	21K pix
Super-Heavy Elements #142	1 target
Muon #257	100 hours

Proton Area (2)

Monopole #3	4 targets
Lepton #70	1,300 hours

EXPERIMENTS THAT ARE IN TEST STAGE (3):

Meson Area (3)

Monopole #22	50 hours
Missing Mass #51A	100 hours
Elastic Scattering #69A	200 hours

EXPERIMENTS BEING INSTALLED (6):

Meson Area (2)
- Neutron Backward Scattering #12
- Multigamma #230

Neutrino Area (2)
- 15-Foot EMI Test #155
- 15-Foot Engineering Run #234

Proton Area (2)
- Photoproduction #87A
- Photon Search #95A

EXPERIMENTS TO BE SET UP WITHIN A YEAR (37):

Meson Area (10)
- Neutral Hyperon #8
- Beam Dump #108
- Multiparticle #110A
- Form Factor #216
- Detector Development #229
- Hadron Jets #236A
- Neutron Elastic Scattering #248
- Hadron Jets #260
- Detector Development #261
- Photon Inclusive #268

Proton Area (3)
- Photon Total Cross Section #25A
- Muon Search #48
- Proton-Proton Elastic #177A

Neutrino Area (24)
- 15-Foot Anti-Neutrino/H_2 #31A
- Detector Development #34

Neutrino Area (Cont'd)
- 15-Foot Neutrino/H_2 #45A
- 30-Inch π^--p @280 #143A
- 30-Inch p^-p & Ne @300 #161
- 30-Inch π^--p & Ne @100 or 200 #163A
- 30-Inch p-d @100 #194
- 30-Inch p-d @400 #196
- 30-Inch p^-d @300 #209
- 30-Inch π^+-p @200 #217
- 30-Inch π^--d @200 & 400 #218A
- 30-Inch p-$\bar{p}$ @60 #228
- Emulsion/π^- @200 -300 #264
- Emulsion/Protons @200 #271
- 30-Inch p^-d @200 #280
- 30-Inch π^+-d @200 #295
- Emulsion exposures to protons @400 GeV for experiments 238, 243, 245, 249, 251, 265, 279, 292

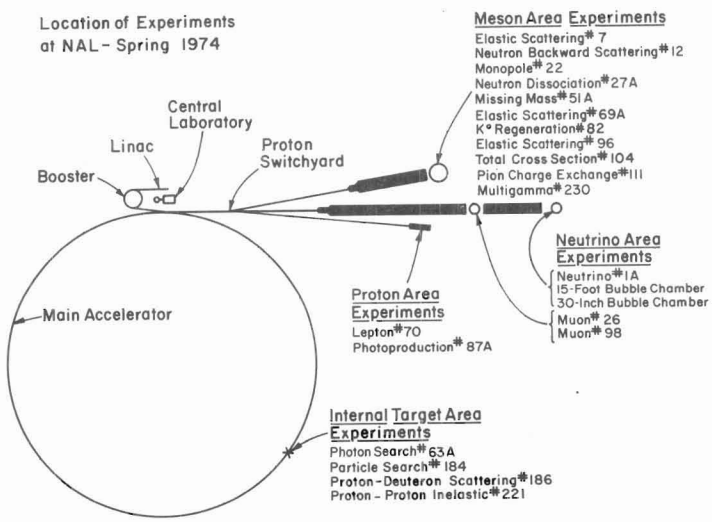
OTHER APPROVED EXPERIMENTS (24):

Internal Target Area (2)
- Proton-Nucleon Scattering #198A
- Proton-Helium Scattering #289

Meson Area (3)
- Polarized Scattering #61
- Diffractive Dissociation #86A
- Charged Hyperon #97

Proton Area (8)
- Monopole #74
- Long-Lived Particles #115
- Photoproduction #152B
- Multigamma #192
- Hadron Jets #246
- Phi Photoproduction #263
- Particle Production #284
- Di-Lepton #288

Neutrino Area (11)
- 15-Foot Neutrino/H_2 & Ne #28A
- Detector Development #32
- 15-Foot Neutrino/H_2 or Ne #53A
- 15-Foot Anti-Neutrino/H_2 & Ne #172
- 15-Foot Anti-Neutrino/H_2 & Ne #180
- Tachyon Monopole #202
- Detector Development #206
- 30-Inch p^--p @500 #207
- 30-Inch π^--p @HiE #215
- 30-Inch π^+-p @300 #277
- Super-Heavy Elements #285



FACILITY UTILIZATION SUMMARY--MARCH 1974

During March the accelerator provided over 380 hours of beam for high energy physics research, at intensities generally above 0.5×10^{13} protons per pulse. This allowed continuation of the work begun at the end of February, following the two-week shutdown period for maintenance and development. Research activities were carried on by 25 experimental groups in all four experimental areas. Several other groups in the initial stages of setting up made intermittent use of the beam as well. This was the first month during which a single period for accelerator research, maintenance, and development was scheduled each week. This format seems to optimize the use of available beam time for accelerator and high energy physics research.

A period of about 50 hours was set aside to test operation of the accelerator in a dichromatic mode--with a 200-GeV front porch superimposed on the normal 300-GeV main ring magnet ramp (see page 1). The test was very successful in proving the ability of the accelerator to deliver beams of two different energies to experimental areas during the same accelerator cycle. This type of operation will be important when the accelerator is operated at 400 GeV, so that a lower energy beam can be delivered to the Meson Area at the same time.

Internal Target Area experimental groups which took data during March included Proton-Deuteron Scattering #186 and Photon Search #63A, who used the deuterium jet target; and Proton-Proton Inelastic #221, Particle Search #184, and Photon Search #63A, who used rotating targets with carbon and polystyrene filaments to produce secondary particles.

In the Proton Area, experimenters from Particle Search #100A, Lepton #70, and Monopole #3 used the beam. The Particle Search #100A group continued data taking on production of hadrons with transverse momenta up to 9.2 GeV/c, a search for heavy leptons, and measurements of the production of other infrequently produced particles. In Proton Center, the Lepton #70 group completed their positron and electron data taking at 83 mrad, and rebuilt their apparatus to begin a search for directly produced muons.

In the Meson Area, ten experimental groups used the available beam. Neutron #4 completed data-taking on total cross sections. Total Cross Section #104, Pion Charge Exchange #111, and Neutron Dissociation #27A, in the M1-West, M2, and M3, beams, respectively, collected data. K^0 Regeneration #82, in the M4 beam line, and Elastic Scattering #96, in the M6-East line, got their apparatus sufficiently well tuned to begin collecting preliminary data. Three other groups, Elastic Scattering #7 in the M1-East beam line, Missing Mass #51A in the M2 beam line, and Elastic Scattering #69A in the M6-West beam line, were scheduled for short periods of priority operation for tuning and equipment checking.

A major effort in the Neutrino Area was directed toward completing Neutrino #262 and the search for neutral currents. A total of 4.8×10^{17} protons was delivered on the narrow-band trainload for this experimental group, in a run which began during the last week in January. Neutrino #1A also collected data during March. Muon #257 began preliminary data taking, and Muon #98 and Muon #26 accomplished some tuning of their apparatus parasitically during the last days of the month.

In the 30-in. bubble chamber two experimental runs were made for Hybrid #2B, one of π^--p interactions at 200 GeV and the other of p-p interactions at 300 GeV. The former was completed with a total of 108,306 pictures, and the latter was ended with 47,609 pictures. In addition, 105,491 pictures were taken for Hybrid #154 of π^--p interactions at 150 GeV to complete the current Laboratory commitment to that group. Some time was also spent on retargeting studies and particle production measurements for the 30-in. hadron beam line. The Neutrino Area was shut down on March 20 to remove the narrow-band train and install the new triplet trainload. Testing of the new load with beam began on March 26, and led to data taking by the Muon #26 group and testing by the Muon #98 group.

The summary of accelerator beam usage for March is as follows:

I. Summary of Accelerator Operations

		Hours
A. Accelerator use for physics research		
Accelerator physics research		84
High energy physics research		383
Research during other use		(119)
	Subtotal	467
B. Other activities		
Accelerator setup and tuning to experimental areas		14
Scheduled interruption		49
Unscheduled interruption		214
	Subtotal	277
C. Unmanned time		0
	Total	744

II. Summaries of High Energy Physics Research Use

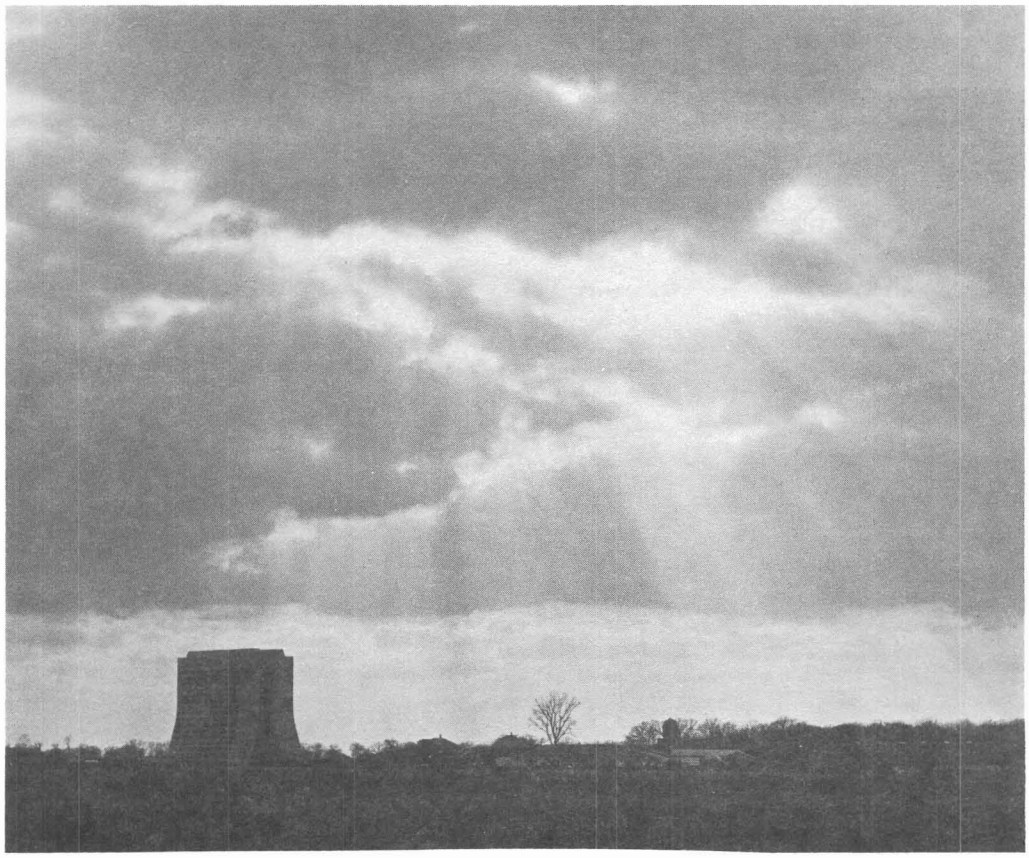
	# of Expts.	Hours	Results
A. Counter experiments	21	3373	3373 hours
B. Bubble chamber experiments	2	193	261,000 pictures
C. Emulsion stacks exposed	1	7	5 stacks
D. Specific target bombardments	1	314	1 target
E. Test experiments	-	-	-
F. Engineering studies and tests	-	41	41 hours
G. Other beam use	-	471	471 hours
	25	4399	

III. Number of Protons Accelerated and Delivered

		Protons
A. Beam accelerated in Main Ring	Total	11.0×10^{17}
B. Beam delivered to experimental areas		
Meson Area		1.64×10^{17}
Neutrino Area		
Main Beam		4.40×10^{17}
Bubble-Chamber Beam (est.)		0.30×10^{17}
Proton Area		2.79×10^{17}
	Total	9.13×10^{17}

PROPOSALS RECEIVED DURING MARCH 1974

No.	Title	Submitted By
282	Proposal to Study Central Collisions in the Reaction $\bar{p} + p \rightarrow$ Mesons at 40 GeV/c in the 15-Foot NAL Hydrogen Bubble Chamber	L. J. Gutay
283	A Proposal to Study Elastic Proton-Proton Scattering in the Range $0.1 < \lvert t \rvert < 3\ (\mathrm{GeV/c})^2$ From 50 to 500 GeV at NAL	J. K. Walker
284	Survey of Particle Production in Proton Collisions at NAL	J. K. Walker
285	A Search for a New State of Matter in the Analysis of a NAL Beam Dump	L. M. Lederman
286	Proposal to Study the Interactions of 100 GeV π^+ Mesons with Deuterons in the 30-Inch Deuterium Filled Bubble Chamber	A. F. Garfinkel
287	Streamer Chamber Study of Large P_T Interactions	H. J. Lubatti
288	A Study of Di-Lepton Production in Proton Collisions at NAL	L. M. Lederman
289	Small Angle Proton-Helium Elastic and Inelastic Scattering from 8 to 500 GeV	E. Malamud
290	Backward Pion-Proton Elastic Scattering	W. F. Baker
291	Proposal to Study Multiparticle Production Using a Highly-Enriched Neon Exposure in the 30-Inch Bubble Chamber	L. Voyvodic
292	Multiparticle Production in Nuclei by Protons of Several Hundred GeV (400 GeV)	K. Gottfried
293	30-Inch Bubble Chamber Proposal $\pi^- d$ Interactions at 200 or 300 GeV/c	S. Hagopian



(Photo by P. Zimmerman)