## RESEARCH ACTIVITIES DURING JUNE 1977

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The accelerator operating crews who struggled with an unusual variety of accelerator problems in the month of June probably will be surprised to learn that all the ups and downs averaged to a record month for protons delivered at 400 GeV. June also ties the prior record set at 300 GeV two years ago in the last full month of 300-GeV operation. This fact must be viewed in the context that fiscal constraints impose a reduced repetition rate at 400 GeV. As shown in the table on page 22, the average cycle time in June 1975 was 7 seconds, compared to 11 seconds last month. The tabular comparison between June 1977, two prior record months, and a "typical" month for the last year suggests quite a bit about how operation has changed, but the numbers require some interpretation. For instance, although it is true that the Main-Ring intensity is the big reason for matching the 300-GeV monthly proton totals, there is also an effect from increased rate of acceleration, increased Main-Ring feeder capacity, and increased number of hours scheduled for high-energy physics. It would also be wrong to interpret the figures on "HEP efficiency" (actual hours/scheduled hours) to mean that there has been no improvement in reliability. The greater number of hours scheduled for high-energy physics has been possible because accelerator maintenance periods have been cut from every week in 1975 to every third week in 1977.

Accelerator problems during the month included two interruptions caused by effects of thunderstorms on accelerator controls, two occasions of booster magnet power-supply problems, serial failures of gas barriers in the linac, a Main-Ring quad replacement with slow pumpdown, and a preaccelerator

Typical and Record Months for Accelerator Operation

| | 6/77 | "Typical Month" (1976-1977) | 6/75 | 11/76 |
|---|---|---|---|---|
| Protons ($\times 10^{18}$) | 2.77 | 1.80 | 2.77 | 2.63 |
| HEP (h) | 478 | 385 | 451 | 487 |
| Scheduled HEP (h) | 640 | 550 | 556 | 638 |
| HEP efficiency (%) | 75 | 70 | 81 | 76 |
| Unscheduled Interruption (h) | 183 | 180 | 122 | 169 |
| Energy (GeV) | 400 | 400 | 300 | 400 |
| Flattop (sec) | 1.25 | 1.0 | 1.0 | 1.5 |
| Average Cycle (sec) | 11 | 11 | 7 | 12 |
| Average Intensity ($10^{13}$p/p) | 1.8 | 1.4 | 1.1 | 1.8 |

ion-source filament failure. Generally, the down time was characterized by the unusually large fraction attributable to the injector; as the above table indicates, the total amount of unscheduled interruption was not particularly out of line with recent experience. Instability of the accelerator's master clock and occasional periods of increased extraction loss reduced the usefulness of some of the beam hours, but by no means prevented an unusually good month of operation.

The top priority in the experimental program was the Neutrino Area for almost the entire month. Neutrino #310 took antineutrino data using a 2-msec spill on the sign-selected bare target up to June 27, when they switched the polarity for neutrino data; they received about $2 \times 10^{18}$ protons. The 15-ft bubble chamber ran for 15-ft $\bar{\nu}/H_2$ & Ne #180 until a failure of the 9-in. hydraulic valve in the expansion system required a warmup. Two leaks from hydrogen cooling loops into the main vacuum tank were also repaired during the warmup. The chamber provided 87K antineutrino pictures during the month. For two days starting the morning of June 20, the N5 line was tuned to bring 20-GeV negatives into the 15-ft chamber for a test of the

practicality of doing calorimetry on electromagnetic showers. The chamber was double-pulsed and about 4500 pictures were taken on the hadron cameras during the antineutrino running. Particle Search #379 ran in Lab E with diffracted protons from the N5 line until June 5 and then switched to negatives at various momenta to get a good pion beam to understand secondaries in the calorimeter. The experiment was completed on June 7. Particle Search #361 started up June 9 in the N1 line, using the production target in the N7 bypass line.

Three experiments ran throughout the month in the Proton Area. Photoproduction #401 began taking data using the broadband photon beam in Proton East after completing system tests and trigger studies during the first week. They lost just over a week of running because of a failure of the 70-ft deuterium cryostat on June 18. Di-Lepton #288 continued to take data on high mass (> 6 GeV) dimuon states in Proton Central. Photon Search #95A, which was just completing electron beam calibration of lead-glass detectors in Proton West at the beginning of the month, spent most of the month in data taking on high mass diphoton states. Both E288 and E95A had similar difficulties with the spill structure at various times, but both also had some extended periods of solid data taking.

In the Meson Area, Hadron Jets #236A (M1E) and $\Lambda$ Polarization #441 (M2) were just starting up at the beginning of the month. Both experiments had their beam-line problems, E236A with magnet power supplies and E441 with a modified radiation-safety system. Both experiments were taking data by the third week, but E236A accepted a momentum of 340 GeV/c in place of

the 400 GeV/c they had planned to use. Inclusive Neutron #404 ran parasitically behind E441 in M2 making use of the copious neutrons in the neutral-hyperon beam. Multiparticle #110A concluded a five-week run in the first half of the month in M6W, accompanied by some low-profile activity of Hadron Dissociation #396 upstream. For the last half of the month, M6 was run in the east branch for Inclusive Scattering #118A using the single-arm spectrometer. This experiment also had some serious beam-line startup problems, including several failures of 3Q120 beam-line quadrupoles and power-supply and control problems associated with the newly installed 4Q120 quads in the single-arm spectrometer. Inclusive $K_S^o$ #383 worked on their equipment on an approximately half-time schedule while awaiting the installation of additional vacuum pipe, which was delayed primarily by the work required to get M6E going.

The internal target continued with p-He Scattering #289 using a cold helium jet and Nuclear Fragments #442 looking at the distribution of recoil fragments of heavy noble gases with semiconductor counter telescopes mounted on the movable arm of the superconducting spectrometer. For the first half of the month, these experiments operated under a complicated agreement for interleaving of pulses so that each could cover its desired energy range. After June 17, E289 was unable to run because a newly installed collimator in the jet did not work. After this was removed, the pulsing valve failed leading to an overdose of helium in C0 and neighboring parts of the main accelerator. While E289 was off, E442 was able to run their jet with a single pulse covering nearly the entire energy range.

# FACILITY UTILIZATION SUMMARY -- JUNE 1977

## I. Summary of Accelerator Operations

| | | | Hours | |
|---|---|---|---|---|
| A. | Accelerator use for physics research | | | |
| | Accelerator physics research | | 37.6 | |
| | High energy physica research | | 478.5 | |
| | Research during other use | | (16.1) | |
| | | Subtotal | | 516.1 |
| B. | Other activities | | | |
| | Accelerator setup and tuning to experimental areas | | 2.0 | |
| | Program interruption | Scheduled 16.5, Ad hoc 2.6 | 19.1 | |
| | Unscheduled interruption | | 182.8 | |
| | | Subtotal | | 203.9 |
| C. | Unmanned time | | — | |
| | | Total | | 720.0 |

## II. Summaries of High Energy Physics Research Use

| | | # of Expts. | Hours | Results |
|---|---|---|---|---|
| A. | Counter experiments | 16 | 4069.6 | 1 expt. completed |
| B. | Bubble-chamber experiments | 1 | 279.9 | 87,406 15-ft pictures |
| C. | Emulsion experiments | 1 | — | 1 stack in progress |
| D. | Special target experiments | — | — | — |
| E. | Test experiments | — | — | — |
| F. | Engineering studies and tests | (1) | 35.3 | 4,500 15-ft pictures |
| G. | Other beam use | (1) | 5.4 | Test of N1 beam line |
| | | 18 | 4390.2 | |

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

| | | | | |
|---|---|---|---|---|
| A. | Beam accelerated in Main Ring | | | 2.77 |
| B. | Beam delivered to experimental areas | | | |
| | Meson Area | | 0.32 | |
| | Neutrino Area | | | |
| | Slow Spill | 0.09 | | |
| | Fast Spill | 2.06 | 2.15 | |
| | Proton Area | | 0.06 | |
| | | | | 2.53 |

BEAM UTILIZATION BY

| | Beam | Run Dates | Hours |
|---|---|---|---|
| MESON AREA | | | |
| Multiparticle #110A | M6W | 6/1-6/15 | 216.3 |
| Inclusive Scattering #118A | M6E | 6/18-6/30 | 174.5 |
| Hadron Jets #236A | M1E | 6/1-6/30 | 270.5 |
| Inclusive $K_s^o$ #383 | M4 | 6/1-6/30 | 140.9 |
| Hadron Jets #395 | M2 | 6/1-6/2 | 35.0 |
| Hadron Dissociation #396 | M6W | 6/1-6/15 | 136.8 |
| Inclusive Neutron #404 | M2 | 6/18-6/30 | 270.6 |
| $\Lambda$ Polarization #441 | M2 | 6/1-6/30 | 344.6 |
| NEUTRINO AREA | | | |
| 15' $\bar{\nu}/H_2$ & Ne #180 | N0 | 6/1-6/22 | 279.9 |
| Neutrino #310 | N0 | 6/1-6/30 | 440.9 |
| Particle Search #369 | N1 | 6/9-6/30 | 256.1 |
| Particle Search #379 | N5 | 6/1-6/7 | 107.7 |
| Emulsion/$\nu$ #536 | N0 | 6/1-6/30 | - |
| PROTON AREA | | | |
| Photon Search #95A | PW | 6/1-6/30 | 399.0 |
| Di-Lepton #288 | PC | 6/1-6/30 | 376.2 |
| Photoproduction #401 | P1 | 6/1-6/30 | 255.4 |
| INTERNAL TARGET AREA | | | |
| Proton-Helium Scattering #289 | C0 | 6/1-6/15 | 203.6 |
| Nuclear Fragments #442 | C0 | 6/1-6/30 | 441.5 |
| HOURS FOR EXPERIMENTS | | | 4349.5 |
| HOURS FOR TESTS AND BEAM TUNING | | | 40.7 |
| TOTAL HOURS FOR HIGH ENERGY PHYSICS | | | 4390.2 |

EXPERIMENT -- JUNE 1977

Activities

data: 2 and 3 $\pi$ exclusive data at -100 GeV/c

tuneup & data: inclusive data for 100 GeV $\pi^-$, $K^-$, $\bar{p}$ on $H_2$ and $D_2$

tuneup & data: +340 GeV/c and -280 GeV/c on $LH_2$ and solid targets with segmented recoil calorimeter and MWPC magnetic spectrometer

tests: chamber and counter tests

data: 200 GeV and 400 GeV on $LH_2$ target with segmented calorimeters

tests: drift chamber tests

setup & data: inclusive neutron production by 400-GeV protons on hydrogen

setup & data: polarization of $\Lambda$ produced at various angles by 400-GeV protons on hydrogen

data: 87K $\bar{\nu}$ pictures in the 15-ft bubble chamber filled with 62% Ne-$H_2$ mix

data: primarily $\bar{\nu}$ data, some $\nu$ data taken with iron scintillator target calorimeter

setup & data: $\mu$ and $2\mu$ triggers from $\pi$'s on hydrogen target using the cyclotron spectrometer

data: complete; 400-GeV protons on variable density target calorimeter

data: $\bar{\nu}$ and $\nu$ on an emulsion stack in the neutrino beam from the sign-selected bare target

setup & data: lead glass calibration and high mass diphoton data

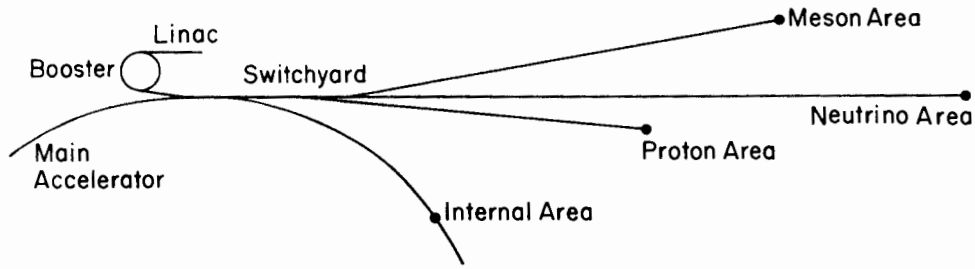
data: high mass (> 6 GeV) dimuon data from protons on heavy targets with a beryllium hadron filter

tests & data: trigger studies and high mass hadron and muon systems produced by a broadband photon beam

data: proton-helium elastic and inelastic scattering using the internal proton beam on a gas jet target

data: angular and energy distributions of low mass fragments recoiling from a high Z noble gas jet target

# Fermi National Accelerator Laboratory




## Experiments in the Research Areas

JULY - SEPTEMBER 1977

### Internal Area

SHUTDOWN UNTIL OCTOBER

### Proton Area

PROTON EAST:
PHOTOPRODUCTION #401
PHOTOPRODUCTION #152B

PROTON CENTER:
DI-LEPTON #288

PROTON WEST:
PHOTON SEARCH #95A

### Neutrino Area

NEUTRINO BEAM:
15-FT BUBBLE CHAMBER

MUON/HADRON BEAM:
PARTICLE SEARCH #369

### Meson Area

M1 BEAM:
HADRON JETS #236A
INCLUSIVE SCATTERING #324

M2 BEAM:
HADRON JETS #395
PARTICLE SEARCH #468

M4 BEAM:
INCLUSIVE $K_S^0$ #383

M6 BEAM:
INCLUSIVE SCATTERING #118A
ASSOCIATED PRODUCTION #99