A REPORT ON THE MESON AREA

C. N. Brown

It is now a tradition that the status of the Meson Area and its experimental program be reported each 18 months in this publication. In January, 1974, Dick Landy reported on the newly created Meson Detector Building and the preparation of the first experiments in the area. In August, 1975, Peter Koecher reported that all beam lines were operating and many experiments were being completed. At this time, January, 1977, all the original experimental proposals have been disposed of, as well as a large number of interesting new ideas that have been proposed in the last few years. It appears that there is a good possibility of completing all the currently approved experiments in the near future. Thus the Meson Laboratory is at a crossroad and much thought is being given by various physicists as to the appropriate future directions for experiments in the Meson Area.

In the last 18 months, the accelerator has provided beam during 65 of the 79 weeks. For 60 weeks, the incident energy was 400 GeV/c; four weeks were run at energies of 200 or 300 GeV/c. The operating record of the Meson Area during this time was extremely good, except for the first months of 1976, when the meson production target train developed problems. On December 26, 1975, the water-cooled C2 collimator on the target train developed a leak. After the excess water was drained from the target tube, the Meson Area returned to high-energy physics with only reduced intensity permitted. An improved spare collimator was hastily fabricated in Lab 6. During the March, 1976 facility and development shutdown, the target train
was pulled and the new collimator installed. This shutdown had to be extended one week in the Meson Area to complete the target repair.

While the collimator was being replaced, it was noticed that the movable target mechanism was completely rusted and inoperable. Because of the unserviceability of the present target mount, it was decided to run with the current target and fabricate an improved, more serviceable spare. Many other items on the train are also in need of repair or upgrading and funds were allocated to construct a second-generation Meson target train. Currently, it is planned to do some of this work during the forthcoming spring shutdown.

The present C2 water-cooled collimator has been in place nine months and has absorbed more integrated beam energy than its predecessor. Its main component is an aluminum core 10 ft long which contains the defining holes of the secondary-beam lines, plus water-cooling holes drilled longitudinally through its entire length. The 0.060-in. square by 3-in. long beryllium production target, which is frozen in place on the inoperable target shuttle, has been receiving beam now for three years. This little Be knitting needle has done yeoman duty and should be entered in the Guiness Book of World Records for having been bombarded by high-energy protons so long in the service of physics.

The secondary particles produced so copiously by the Be target have been used to complete a large number of experiments. Five particle-search experiments have led to the conclusion that charmed-particle production in hadron collisions is not large and is buried under the general multi-meson backgrounds. In a continuing sequence of strong-interaction measurements,
various experiments have measured total cross sections, elastic-scattering
cross sections, and charge-exchange cross sections. Lately, more detailed
second-generation studies of hadron interactions have included inclusive
particle spectra measurements, multiplicities, and polarization measure-
ments. Surprises include the unexpected large polarization of lambda's
produced at high transverse momentum, the observation of jet-like behavior
of high transverse-momentum events on the multiparticle spectrometer and
the copious production of high transverse-momentum \( \pi^0 \)'s by incident
charged pions.

Clearly, the general features of strong interactions at Fermilab
energies are now basically mapped out by these completed first-generation
experiments. It is thus the task of current experiments to check detailed
predictions of various theoretical models, including Regge models and
scaling predictions. Alternatively, they can exploit the higher energies and
intensities now available in the various meson beams to search for new
particles at higher sensitivities or to study hadron jets and high \( p_T \) phenom-
ena in more detail. The locations of the experiments currently occupying
real estate in the Meson Detector Building are indicated in the figure at the
top of page 4.

In order to utilize the higher-energy secondaries produced by 400-
GeV/c incident protons, the meson beams have been upgraded in various
ways. Recent work in the M1 pion beam has increased its maximum
momentum to 400 GeV/c, adding diffracted-proton capabilities in that beam.
It is instrumented to identify mesons up to 300 GeV/c.
Schematic of the Meson Area, showing locations of experiments as of January, 1977.

E61 - Polarized Scattering
E104 - Total Cross Section
E110 - Multiparticle Spectrometer
E118 - Inclusive Scattering
E226 - K$^0$-Electron Regeneration
E236 - Hadron Jets
E290 - Backward Elastic Scattering
E324 - Inclusive Scattering
E350 - Inclusive Neutral Pion Production
E395 - Hadron Jet Calorimeter
E396 - Diffraction Dissociation
E438 - Inelastic Neutron Cross Sections
E439 - Multi-Muon Production
E440 - Lambda Magnetic Moment
E456 - Kaon Form Factor

The M2 beam line has run much of the time transporting 400-GeV diffracted protons. Experiments have been run at intensities of the order of $2 \times 10^8$ protons/pulse and provisions are now being implemented to allow intensities at least an order of magnitude larger than this. It is also equipped with two Cerenkov counters and can transmit and identify more than $10^6$ pions per pulse at 250 GeV/c.

The M3 neutron beam has seen a great deal of improvement in the collimating and sweeping stations. It was used to define a very precise
intense neutron beam for particle-search experiments E366 and E397. The broad neutron spectrum of this beam peaks at 300 GeV.

The collimators in the M4 neutral kaon beam were reconfigured last fall to provide a split double-kaon beam. This enabled E226/486, \( K^0 \)-electron scattering, to do a precise measurement of the regeneration of kaons by electrons by alternating thin regenerators and thick regenerators in the two adjacent sharply defined neutral beams. It is currently planned to convert the M4 beam to a broad-band charged-particle beam in the spring of this year. This beam with its large (\( 7\text{ mrad} \)) production angle should have a favorable percentage of \( K^- \) and antiprotons.

The M5 test beam became fully operational last winter and has been an unqualified success. The beam can be tuned from 5 to 50 GeV/c, but is typically set for 35 GeV negative particles. This results in a beam of about \( 10^5 \) particles per pulse comprised mainly of pions and electrons, ideal for calibrating counters and calorimeters of all types. The beam is exceptionally easy to use and has hosted many experimenters from all three external areas at Fermilab, as well as cosmic-ray researchers from the University of Chicago.

The precision M6 pion beam has a maximum momentum of 200 GeV/c. The east branch houses the single-arm spectrometer, E118, inclusive scattering, makes full use of the seven Cerenkov counters in the beam line and spectrometer to measure all particle types simultaneously. The west branch houses the Multiparticle Spectrometer on which E260, hadron jets, was recently completed. E110, peripheral multiparticle production is now
setting up in the MPS and E290, backward elastic scattering, is setting up upstream in the west branch.

The experimental program in the Meson Area often requires the operation of all the beam lines at or near their upgraded maximum momenta and many large experimental analyzing magnets. This is accomplished within the constraints of the original power distribution and cooling-water systems by careful ramping of all major beam-line magnets and the use of four large superconducting-coil analyzing magnets. The Meson Operations Group is currently working on a project to make the optimum ramping of the magnets much easier for the experimenter to control.

A helium recovery system is now fully operational in the Meson Detector Building. This system collects the helium gas boiled off the large superconducting analyzing magnets and recompresses it into tube trailers. The gas is trucked to Lab 6 where it is purified and liquefied by a dual CTI-1400 refrigerator system recently completed in Lab 6. This system is operated by the Cryogenic Group in the Research Services Department. Liquid helium is then returned in 1000-liter dewars to the Detector Building to cool the superconducting magnets.

The Lab 6 Helium Facility also includes provisions for open- and closed-loop testing of developmental superconducting beam-line magnets. A program is currently being manned by a Proton Department group to develop low-current, superconducting beam-line magnets. The future availability of 1000-GeV protons will require extensive use of 40-kG magnets to make efficient use of the physical plant already in existence in the three external areas.
The time is now ripe for considering possible future uses of the Meson Area. Some immediate planning for possible new experiments will take place in workshops this spring. The Multiparticle Spectrometer Workshop to discuss the future use of this large facility in the M6 West beam line will be held on March 4-5 at Fermilab. Ernest Malamud should be contacted for details. A workshop to discuss hadron-jet experiments is currently planned for March 31-April 1, 1977. Three hadron-jet experiments have been approved for running in the Meson Area, and one of them, E260, will be presenting results at these two workshops.

One clear thread of most new proposals in the Meson Area is the need for higher intensities and higher-energy secondaries. Table I lists the approximate yields in the various beam lines as of the present. It is clear that a provision for changing the apparent production angle of the M1 and M6 beam lines might help considerably at all secondary energies. Designs for the new target train are being considered that include some magnets on the train. The design goal is to create variable and yet still independent production angles for M1 and M6. Only the M6 line is currently thought to be limited in its maximum momentum. Thus the possibility of using the first series of doubler dipoles to raise its capability to 400 GeV is being studied.

Many people have speculated on the longer-range future of the Meson Area. The 1976 Summer Study Report on a 1000 GeV Meson Area concept outlines some of the possibilities. It is hoped, of course, that a continuing
series of sound experiments and unexpected surprises will provide the life-blood for the Meson Area. It is certainly true that opportunities exist in all the Meson beam lines for good proposals to enjoy reasonably swift execution. The main constraint will be the competing demands for funds for other laboratory projects that might command a higher physics priority.

Table I. Current Properties of the Meson Beam Lines.\(^a\)

<table>
<thead>
<tr>
<th>Beam Line</th>
<th>Description</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>pion or diffracted proton beam line</td>
<td>(\theta = 3) mrad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(\theta = 3) mrad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2 \times 10^7 \pi^-) at 100 GeV/c</td>
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<tr>
<td></td>
<td></td>
<td>(\pi^- = 10^6) at 250 GeV</td>
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<tr>
<td></td>
<td></td>
<td>(p = 10^7) at 400 GeV (^b)</td>
</tr>
<tr>
<td>M2</td>
<td>pion or diffracted proton beam line</td>
<td>(\theta = 1) mrad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(\theta = 1) mrad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>approximately the same as M1 except</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(10^9) (p) at 400 GeV</td>
</tr>
<tr>
<td>M3</td>
<td>neutron beam</td>
<td>(\theta = 1) mrad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(\theta = 1) mrad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>neutron spectrum broad peaks at 300 GeV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(10^7) neutrons in 2 in. beam</td>
</tr>
<tr>
<td>M4</td>
<td>neutral or charged kaon beam</td>
<td>(\theta = 7.5) mrad</td>
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<tr>
<td></td>
<td></td>
<td>(\theta = 7.5) mrad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(10^6) (K^0) below 200 GeV in 2 in. beam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(10^6) (K^-) at 100 GeV (^b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3 \times 10^5) (p^-) at 100 GeV</td>
</tr>
<tr>
<td>M5</td>
<td>test beam</td>
<td>(\theta = 20) mrad</td>
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<tr>
<td></td>
<td></td>
<td>(\theta = 20) mrad</td>
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<tr>
<td></td>
<td></td>
<td>5-40 GeV/c</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5 \times 10^5) particles at 30 GeV</td>
</tr>
<tr>
<td>M6</td>
<td>high precision pion beam</td>
<td>(\theta = 2.5) mrad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(\theta = 2.5) mrad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200 GeV maximum momentum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(10^6) (\pi^-) at 200 GeV</td>
</tr>
</tbody>
</table>

\(^a\) Particle yields quoted for \(2 \times 10^{12}\) protons incident on meson target
\(^b\) Estimated, capability being installed.
Experiment 357/472 (Purdue, Michigan, Fermilab), a particle search experiment, set up a double magnetic spectrometer in the M2 diffracted-proton beam. The spectrometer contained five drift chambers and three Cerenkov counters on each arm.
Members of the E216/456 collaboration (UCLA, Notre Dame, Pittsburgh, Dubna): back row (left to right) A. Vodepyanov, E. Tsyganov, D. Stork, N. Tsyganova, T. Nigmanov, C. Rey, P. Shepard, and John Zumbro; front row (left to right) Z. Guzik, C. May, and P. Rapp. Their experiment, measuring K-e elastic scattering to determine the kaon electromagnetic form factor, is currently set up in the M1 meson beam.
NOTES AND ANNOUNCEMENTS

RETIREMENT.

Captain Bradley F. Bennett, Executive Vice President of Universities Research Association, is retiring on February 24. Brad Bennett was "present at the creation" of Fermilab and has been active ever since in the development of the Laboratory.

TRANSITIONS.

Eric Jarzab, Food Service Manager, is leaving Fermilab on February 28 for a position as food-service manager at Argonne National Laboratory West in Idaho Falls, Idaho. John Barry has been named interim manager.

Cheryl Stadtfeldt of Public Information is leaving the Laboratory on February 18. She has been an important link between Fermilab and the public in managing tours of the Laboratory by many thousands of visitors.

HADRON-JET EXPERIMENTS WORKSHOP.

This is the second in a series of three workshops to be held at Fermilab during the spring in preparation for the 1977 summer meeting of the Program Advisory Committee. The workshop is scheduled for March 31-April 1, 1977; it will be preceded by the Multiparticle Spectrometer Workshop early in March and followed by the Future Neutrino Experiments Workshop later in April.

Currently, the program for the Hadron-Jet Experiments Workshop includes reports on the present-generation hadron-jet experiments (E260, E236, and E395) to be followed by presentations of proposals for second-generation experiments. A panel composed primarily of PAC members will
be in attendance. Following the presentations and discussion, the panel will formulate recommendations on the proposals for second-generation experiments. These recommendations will be transmitted to the full PAC for their consideration at the summer meeting.

The Hadron-Jet Experiments Workshop will be an open meeting and all interested physicists are invited to attend and to participate in the discussion to the extent time permits. Experimenters interested in submitting proposals for future hadron-jet experiments at Fermilab should observe the March 4 deadline for submission of proposals to be considered at this workshop.

FUTURE NEUTRINO EXPERIMENTS WORKSHOP.

This workshop (also an open meeting) is scheduled to be held at Fermilab April 21-22, 1977. Our purpose in holding this meeting is to consider proposals for new neutrino experiments and related facilities. There will be representatives from the PAC at this meeting, probably again in the form of a panel, and the outcome of the discussions will form a major topic for consideration at the summer PAC meeting. Groups interested in submitting proposals for future neutrino experiments to be presented at this workshop should observe the March 25 deadline.

Questions pertaining to either the Hadron-Jet Experiments Workshop or the Future Neutrino Experiments Workshop should be addressed to T. Groves in the Director's Office.
FUTURE COLLIDING-BEAM EXPERIMENTS ACTIVITIES.

There are two announcements on future activities of the Colliding Beam Experiments Department. These are a March Workshop on Colliding Beams and the announcement of the Fermilab 1977 Summer Study on Colliding Beams.

The Workshop on Colliding Beams is one in a series of regular open workshops and will be held at Fermilab on March 25. Several reports will be given on the various activities of the Department. The directions of future work will be discussed and User involvement in various ways is encouraged.

A Summer Study on aspects of colliding beams at Fermilab will be held at Aspen, Colorado, for a three-week session from June 27 to July 15, 1977. The study will cover both proton-proton and antiproton-proton interactions. The utilization of the Energy Doubler/Saver beam in collision with the Main-Ring beam for proton-proton collisions will be explored. Use of the Main Ring or ultimately the Energy Doubler/Saver will provide the focus for antiproton-proton collision studies.

The purpose of the Study will be to examine the designs of the intersection regions, experimental areas, techniques to obtain high luminosity for both pp and $\bar{p}p$ collisions, possible detectors, and physics objectives. Working groups will be established to study these and other topics.

Participants will be expected to be supported by their home institutions. Because of the limited facilities available, the number of invitees will have to be quite restricted. Those desiring to participate should indicate their specific fields of interest by March 25 to J. K. Walker, Ext. 4272.
SUMMER HOUSING.

The Housing Office is now making plans and taking reservations for accommodations for the summer. Since there is always an influx of experimenters during the summer months, the office established March 31 as a deadline for receipt of reservations for on-site housing.

In order to assure an equitable distribution, Fermilab housing assignments will be determined again this year by the same priority and lottery system established by the Laboratory last year. The housing assignments will be made early in April based on the expected running schedule for the summer, and responses will be mailed out by April 15.

The priority system allocates four houses or apartments to the theoretical program and the remaining houses, apartments, and dormitory rooms to experimenters on running experiments, experiments in the test stage, and experiments setting up for the summer and fall. After housing has been allocated to foreign experimenters at Fermilab under official exchange agreements, the priority is one house or apartment and one dormitory room per running experiment. If there is still housing available after each experimental group with an experiment running during the summer has received one house or apartment and one dormitory room, there will be a second-round assignment by lot. Five of the eighty-nine dormitory rooms will be set aside for the use of people on running experiments who were not selected in the assignment and will be staying longer than three weeks. These rooms must be reserved at least one month prior to expected date of occupancy. There will not be double occupancy in dorm rooms unless it is requested.
The starting dates for summer occupancy will be staggered over the week of May 29 through June 4. If for any reason assigned housing is not to be used for some portion of the summer, the Housing Office should be notified so that it can be utilized by another group.

In the event that on-site housing facilities are filled, the Housing Office will assist in finding off-site accommodations.