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Fermi National Accelerator Laboratory

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F. T. Cole, Editor

R. Donaldson, Assistant Editor

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THE COVER: Purple cone flowers (Echinacea pallida) graced the Prairie Demonstration Plot, located off Road D, in time for the Nation's Bicentennial festivities on July 4. The demonstration plot was planted using the transplant method in 1974 and exists to suggest what the Main-Ring prairie (on the other side of the berm) will eventually look like. More information on the Fermilab Prairie Restoration Project is given in the article on page 31. (Photograph by A. R. Donaldson)

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HIGHLIGHTS OF THE SUMMER PAC MEETING

E. L. Goldwasser

The Fermilab Program Advisory Committee met for its annual week-long meeting from June 18 - June 25. There were about 50 previously unconsidered or deferred proposals before the Committee for consideration at this meeting. Of those proposals, 17 were rejected as a result of discussions we had with our Committee. A total of 21 proposals were newly deferred or remain deferred. Only 6 proposals were approved following the recent meeting.

This record of 6 approvals out of 50 proposals considered is by far the lowest since we first invited the submission of proposals. It reflects to a large extent the severe fiscal constraints under which the Laboratory is operating. Progress through the approved program is somewhere around one half as fast as it might be if we could operate the Laboratory in the most effective manner possible. The total backlog of approvals still corresponds to a waiting period of about two years for an experiment taking its place at the end of the line in any given beam.

One of the general discussion periods was devoted to a consideration of the overall effectiveness of the Laboratory's research program. Are we using our available resources in the most effective way possible? Are studies of hadron-hadron interactions profitable, or are the backgrounds inherent in such interactions so large compared with the signal from events and particles of special interest that we need some new, qualitative improvement in our approach or technique in order to study the effects we are looking for? Is

our present mode of operating the accelerator the best one for achieving our physics goals? Should there be an entirely different emphasis among the kinds of experiments that are being done in order to optimize our physics output? These and a number of similar questions were discussed at some length. The Laboratory now intends to schedule a critical evaluation session, perhaps in connection with the autumn meeting of the PAC.

At our meeting we focused more sharply than usual on questions surrounding relative priorities of experiments which had previously been approved. One example of this is in the Proton East Area, where it seemed that we should take another look at the overall emphasis and the relative emphasis which should be given to the tagged photon program and the broad-band photon program. As a result of our discussions, we have decided that both programs still have great promise. We intend to press vigorously ahead using both of those techniques. In particular, now that the tagged photon experiments are really under way, we expect to focus a major portion of our time and effort on that work.

In connection with the neutrino program, there are some questions concerning the kind of device to be used in forming the neutrino beam for one or another of the approved experiments. The pulsed horns, the dichromatic beam, and a so-called bare-target, sign-selected beam are three available choices. Furthermore, in connection with the 15-ft bubble chamber program, there are the options of a hydrogen fill, a deuterium fill, a light neon/hydrogen mix and a heavy neon/hydrogen mix.

The recent experience with the first heavy hydrogen/neon mix in the chamber was much more successful than many people had expected. The pictures are as good as any that have ever been taken in the 15-ft chamber. There does not seem to be a great deal of confusion due to the short interaction length in the neon, and it seems to be quite possible to use the combination of the bubble chamber pictures and the EMI to make useful identifications of muons.

The data seemed to be so good from the recent run that it is very tempting, from the point of view optimizing the physics output, to undertake more running in that mode. At the same time, the chamber has yet to be run with a deuterium fill. There is much interesting physics to be learned through the bombardment of the relatively free neutron in the deuteron.

As a result of our discussions with the Program Advisory Committee, we have tentatively decided to schedule our next 15-ft bubble chamber run with an initial fill of hydrogen, to be followed by a subsequent fill of a heavy hydrogen/neon mix. That run is currently scheduled for late autumn and is intended to extend for a period of about four months. There would then follow another period of muon running in the Muon Laboratory. After that, in the subsequent 15-ft chamber operating period, we plan to run with a deuterium fill in the chamber.

We spent some time discussing the status of the hadron bubble chamber physics program. That program has received a great deal of attention during the past year, with special workshops, symposia, subcommittee meetings, and so forth. It is our hope that when the 15-ft bubble chamber runs this fall

with a hydrogen fill, it will be possible to obtain a substantial number of new pictures of hadron interactions in that chamber. It is further our hope that the 30-in. chamber will operate regularly, perhaps with an average of four pictures per second, during those periods when we are using the quadrupole triplet train load to provide a muon bombardment in the Muon Laboratory. Thus the 30-in. chamber should be starting a good run now, and it should have another good running period sometime next spring. That should help considerably in diminishing our backlog of approved pictures in our hadron bubble chamber program.

We also discussed the desirability of having an external particle identifier for some of the future runs that have been proposed for the 30-in. bubble chamber and hybrid electronic detector system. It was agreed that much could be gained from the availability of a good EPI. Accordingly, the Laboratory plans to explore ways of acquiring an EPI within the next two years. Discussions will be started toward that end in the very near future.

In discussing dichromatic beam bombardments of the 15-ft bubble chamber, it was pointed out that the dichromatic horn, which has been designed and which is in the early stages of construction, would not be scheduled before the time when the new dichromatic train load would be completed for use with approved experiment E-356. That being the case, it was suggested that the Laboratory might cancel its plans to complete construction of a dichromatic horn. We are now giving serious consideration to that change in our plans. If it seems reasonable, we shall consider running the 15-ft bubble chamber together with E-356, both using the dichromatic train load.

It was recognized that it may be advantageous to run some neutrino experiments that use electronic detectors with a beam which is generated by the quadrupole triplet. The use of the quadrupole triplet suppresses the low energy end of the neutrino spectrum, thus, for some purposes, making it possible to focus a study on events produced by high-energy neutrinos. For the time being, it has been decided to delay any special neutrino running in that mode. However, one of our short-term goals is to achieve an accelerator intensity of 3×10^{13} protons per pulse. At that level, it should be possible to produce a long pulse of muons for the Muon Laboratory, followed by a one millisecond pulse for neutrino experiments. Both those pulses could be fed through the quadrupole triplet train load. Furthermore, with the higher intensity it should become possible to double pulse the 15-ft bubble chamber for ν runs using the focusing horns. That should expedite our progress through those experiments substantially.

We once again reviewed proposals and plans for hyperon experiments at Fermilab. During the year, a hyperon workshop had identified P-Center as a natural location for a facility for charged hyperon studies. At our June PAC meeting, the desirability of proceeding with the construction of a hyperon facility was confirmed. We now are planning to initiate construction within the next few months. During the past year, two options for a hyperon facility were considered. The first, which was presented at the Hyperon Workshop, provided for almost complete independence for experimental set-ups in the hyperon area and others that might be located in the present P-Center pit. That plan required two independent target stations. A second option provided

for a sharing of the present pit so that it would serve both as a location for experiments in the proton beam, as at present, and as the first half of the hyperon beam and facility. Because the difference in construction cost was significant, the Laboratory had made a tentative decision to go ahead with the reduced-scope facility. The PAC concurred in that choice. It is hoped that the first charged hyperon experiment will be started by the summer of 1978.

One rather unusual area of discussion at our recent PAC meeting was the possibility of "modest storage ring experiments" at Fermilab. The Laboratory had received five different proposals for the construction of one or another kind of storage ring or for the performance of experiments exploiting those storage ring ideas.

Of the five proposals, P-478 was the first. It envisioned the construction of a small storage ring directly adjacent to the Main Ring at the E sector straight section. The storage ring would be used to stack protons at an energy of 25-35 GeV and those protons would be brought into collision with accelerating protons in the Main Ring in the course of a normal acceleration cycle. The luminosity in that mode of operation was claimed by the experimenters to be around 10^{31} cm^{-2} sec^{-1}. The proponents proposed to build a detector for the observation of the intermediate boson, W.

The second proposal, P-480, proposed the use of the same small storage ring but with a modified detector oriented principally toward the observation of heavy leptons or new particles other than the intermediate boson.

P-491 was a proposal for producing collisions between protons in the present Main Ring and protons in the soon-to-be-constructed Energy Doubler. Particles in the two rings could be made to circulate in opposite directions and collisions could be realized in the vicinity of one or more of the existing straight sections. Whereas P-478 could achieve a center-of-mass energy of about 250 GeV, P-491 might achieve an energy of 750 GeV in the center of mass. The luminosity, however, was estimated to be only around 1/5 that which is claimed in P-478.

P-492 and P-493 were two closely related proposals, both oriented principally toward the production of antiproton-proton collisions either in the Main Ring or in the Energy Doubler. P-492 focused principally on the production of antiprotons, the cooling of a circulating beam of antiprotons, and the reinjection of such a beam into the present accelerator or into the Energy Doubler. With that accomplished, protons could be injected in the normal direction and the protons and antiprotons could be accelerated in opposite directions and made to collide at an energy as high as 2 TeV in the center of mass. P-493 proposed a detector which might be used to observe the products of these antiproton-proton collisions, or, alternatively, to observe products of proton-proton collisions that might occur as a result of the successful completion of the facilities proposed either in P-478 or P-491.

As a result of a long set of discussions about all five of these proposals, it was finally decided to reject all of them. The reasons for these decisions are manifold. The impact is most severe upon the small storage ring proposal, P-478. In that case, the Laboratory's decision to reject is

tantamount to a decision to pass over that opportunity of getting a look at interactions with high center-of-mass energies on a time scale on the order of two to three years.

One of the principal reasons for giving up that attractive opportunity is the fact that the Laboratory is already deeply committed to the construction of the Energy Doubler. One opportunity, described above, which seems to come hand in hand with the construction of the Doubler is the opportunity to collide a circulating beam in the Doubler with a circulating beam in the Main Ring. That arrangement would give interactions with larger energies in the center of mass and with comparable event rates. It was the advice of our Committee that the Laboratory should focus on the rather difficult job of constructing the Doubler, of doing so on a rapid time scale, and of exploiting all of the opportunities associated with the Doubler, including the production of colliding beams. Within that framework, construction of a small storage ring could be viewed as diversionary and as a potential drain of Laboratory resources otherwise available to construct the Doubler.

Although the specific proposal submitted in connection with the colliding Doubler and Main Ring beams was rejected, it was recognized that the Laboratory was already committed to pursue construction of the Doubler, together with its colliding beam possibilities. The Laboratory was strongly encouraged to continue along that direction. We intend to do so.

Similarly, although it was felt to be premature to be considering a specific proposal for an experiment involving colliding antiproton-proton beams, the techniques of antiproton production, cooling and stacking were

considered important ones which should be studied and mastered. It was recommended that the Laboratory initiate such studies and the associated preliminary development of hardware. We intend to pursue that path also.

The opportunities that might be made available through projects envisioned in these five proposals were very great. On the other hand, we found the advice of our Committee to be sound and persuasive. We did feel that the proposals were sufficiently out of the ordinary that it would be advisable to have a thoughtful statement of the opinions and recommendations of our Program Advisory Committee formulated for general distribution. Accordingly, the Committee prepared the following comments for our use:

Comments on Modest Storage Ring Proposals

The modest storage-ring-related proposals (P-478, P-480, P-491, P-492, P-493) hold out the prospect of doing physics experiments at center-of-mass energies between 200 GeV and 2 TeV and of doing so on a time scale of a few years. Such experiments could lead to important new discoveries and, in any case, would provide a wealth of new information. In bringing the high energy community's attention to these possibilities the proponents of these proposals have made an extremely important contribution. However, it is the Committee's view that the way for Fermilab to pursue the goal of ultra-high energy at an early date is to push as hard as possible on the Energy Doubler/Saver effort and on its colliding beam applications.

To arrive at an optimal set of experimental facilities, detectors, etc., to do actual experiments with colliding beams, the Laboratory might proceed in the following way. Within about a year, a workshop could be held to help define optimal configurations of the Energy Doubler/Saver, the experimental halls, and detectors for various representative experiments. At a somewhat later time, as the development of the colliding facilities becomes more specific, there might be a call for particular physics proposals from interested users.

Until such time as these proposals are invited, the Committee expects to recommend rejection of proposals for specific experiments in the colliding beam facility. This avoids the staking out of priorities for various pieces of physics on the basis of a low proposal number. It is in line with this approach that the Committee has recommended the rejection of P-480, P-491, and P-493.

Comments on $\bar{p}p$ Storage Rings and $\bar{p}$ Cooling

The long range implications of producing intense stored beams of antiprotons are very great. As pointed out in P-492, one might ultimately anticipate, at Fermilab, $\bar{p}p$ collisions at a center-of-mass energy of the order of 2 TeV, considerably higher than that anticipated in P-491. The attainable luminosity will probably be less than for pp rings of similar energy. However, the probability of processes dependent on conjectured quark-antiquark interactions, such as resonant formation of an intermediate boson, W, is expected to be greater by a factor 10-100 for a $\bar{p}p$ collision than for a pp collision of the same energy. This, as well as the possible higher center-of-mass energy, may help to mitigate any disparity in luminosity.

When, in addition to this, one takes into account the implications of antiproton sources for the more distant future, one finds that the physics goals of such systems are considerable and the development work easily justifiable.

The Committee recognizes and appreciates the efforts of the proponents of Proposal 492 toward realizing the goal of obtaining intense cooled antiproton beams. The Committee, however, feels that the development of the cooling and colliding beam techniques and facilities are so intimately tied to the development and operation of the accelerator that such a project should not be treated as a normal experimental proposal. Instead, the development of the techniques and the facilities for colliding beams should be a primary responsibility of Fermilab. The Committee feels that a strong group of physicists should be brought together to study these problems and to carry out this important work. This might be implemented by first organizing a workshop on this topic. The Committee hopes that the proponents of proposal P-492 will participate fully in these activities.

In conclusion, the following tentative dates set for PAC-related meetings during the coming year should be noted:

Proposal Presentations:	October 14-15, 1976
PAC Meeting:	November 11-12, 1976
Multiparticle Spectrometer Workshop:	December 9-10, 1976

Proposal Presentations:	February 10-11, 1977
PAC Meeting:	March 10-11, 1977
Workshop on Modest Colliding Beam Facilities and Experiments:	No definite date set
Proposal Presentations:	May 19-20, 1977
PAC Meeting:	June 18-25, 1977

PARTICLE IDENTIFIERS FOR HADRON PHYSICS

Vera Kistiakowsky, Massachusetts Institute of Technology

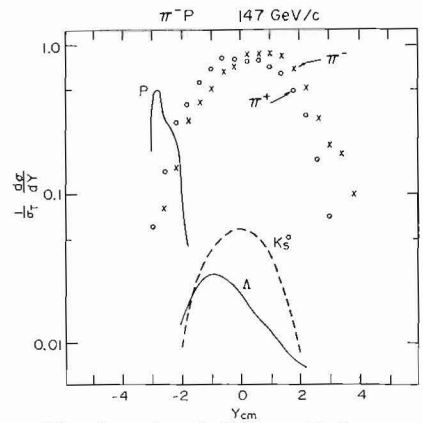
A workshop was held at Fermilab on May 7-8, 1976, to discuss what system of particle identifiers would be optimum for further studies of hadron collisions with the Fermilab hybrid bubble chamber proportional wire chamber system. The meeting was attended by about 40 physicists from various institutions.

What Can Be Learned?

The bare bubble-chamber experiments and the experiments with the two hybrid systems have already yielded many interesting results concerning hadron physics at Fermilab energies. For example, leading-particle studies have demonstrated the factorization of the Pomeron. Inclusive $\pi^{\pm}p$ studies have shown that the leading particles and clusters retain the charge of the given incoming particle to low Feynman x and studies of the distribution of charge as a function of rapidity have indicated the absence of a central neutral plateau. Studies of two-particle correlations have shown a strong dependence of this correlation on the respective charges and on the azimuthal and rapidity separations of the two particles. The new results on $\bar{p}p$ charged multiplicities and a comparison with pp data have yielded hints of some of the interesting properties of high energy $\bar{p}p$ annihilations.

T. Ludlam (Yale) discussed some of the physics questions pertaining to particles produced in the central region of rapidity. The graph on the next page gives the differential cross sections for various particles from π^-p interactions at 147 GeV/c and it can be seen that, except for elastic scattering and beam and

target fragmentation, most of the particle production is between y = -2 and y = +2. Investigations already being carried out on the charge structure of the particles in the central region of rapidity indicate the presence of short-range correlations and of local conservation of charge and raise the question of whether neutral clusters exist. An obvious extension of charge-transfer studies lies in similar investigations of strangeness. With charged-particle identification it should be possible to study strangeness transfer and it would be very interesting to determine whether the Quigg prediction of local strangeness conservation is verified. Turning to two-body resonances, charged-particle identification would permit investigation of K^*, ϕ, and Y^* production and, together with previous results on ρ^0 and Δ^{++} production, this would again permit an enlightening comparison between charge- and strangeness-dependent effects. Since a photon detector will shortly be part of the hybrid system, this will permit π^0 identification and thus studies of $\rho^\pm$ and ω production. Finally, the recent observation at the ISR that in pp interactions there is apparently a sizable cross section (~ 1 mb) for events where both protons come almost to rest in the center-of-mass system raises the question whether the pions associated with such events are produced in jets or distributed isotropically. In conclusion, a rich source of information would be



The fractional differential cross section as a function of c. m. rapidity for p, $\pi^\pm$, n, and K^0_S produced in 147 GeV/c π^-p interactions.

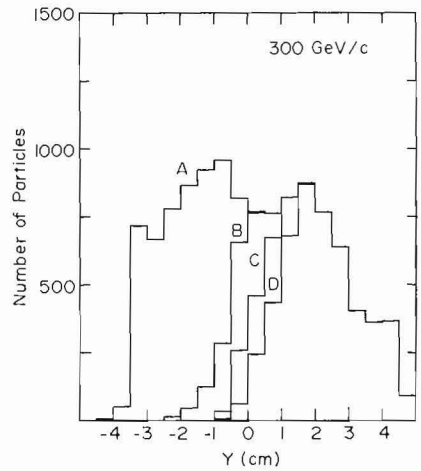
opened up if clean $\pi/K/p$ separation were possible over most of the central region and if programmatic studies with several incident beams and reasonably good statistics were carried out.

J. Whitmore (Michigan State) emphasized the physics question which could be studied in $\bar{p}p$ and pp interactions, but also mentioned the interest in the central-region physics from the $\pi^{\pm}$ interactions which could be obtained in the same exposures. One topic of considerable interest is a measurement of the relative contributions of annihilation and nonannihilation final states in $\bar{p}p$ interactions and the study of baryon annihilations at high energy. The study of the annihilation channels is of particular importance since this process has not been studied at all above approximately 12 GeV/c and has not been studied in any detail above approximately 7 GeV/c. It is estimated that for $\bar{p}p$ at 100 GeV/c (P-394) about 97% of the nonannihilation events could be identified by a suitable combination of particle identifiers, and the consequent identification of annihilation events would permit a comparison of the annihilation cross section with the difference between the $\bar{p}p$ and pp total cross sections, as well as a study of the annihilation multiplicity distributions and related topics. $\pi\pi$ correlations and single particle inclusive studies would also be possible and would contribute to a much better understanding of the annihilation channels at high energies. With respect to the central-region physics, in addition to the topics already mentioned, it would be interesting to determine the cross sections for production of $K\bar{K}$ and $N\bar{N}$ pairs in $\bar{p}p$, pp, and πp interactions and to determine the properties of such events. Studies of this variety would require $\pi/K/p$ separation both for leading particles and in the central region, a neutral-hadron detector, and high-statistics experiments.

W. Walker (Duke) reviewed the results of hadron-nucleus interaction studies, which have shown that the multiplicity, momentum and rapidity distributions are very similar to those for hadron-nucleon collisions. The differences, which are relatively small, indicate that the characteristic time for particle production is considerably longer than the collision time for hadron-nucleus collisions. It is necessary to measure the production spectra for K's, π's and nucleons separately to further illuminate this result.

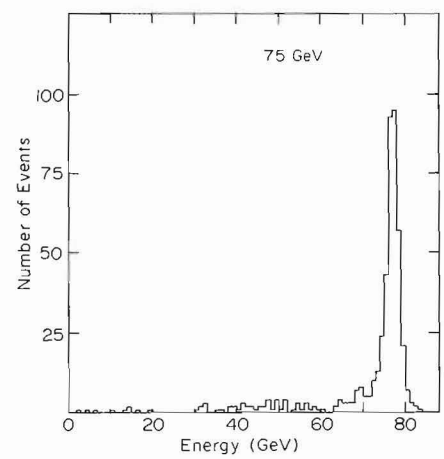
Fermilab Hybrid System

R. Plano (Rutgers) presented some possible configurations of the Fermilab hybrid system with downstream particle identifiers and described acceptance studies for these systems. The next phase of the hybrid system will include drift chambers and a photon detector, as well as proportional wire chambers. A downstream charged-particle identifier would be the next addition desired, and two possibilities have been considered by the Proportional Hybrid System Consortium (PHSC). The first consists of three 1 m × 1 m × 1 m sections of a relativistic rise detector (ISIS) and the second of a 3 m diam × 3 m tall Cerenkov detector (CANUTE). Both detectors can only separate $\pi/K/p$ above 5 GeV/c and this corresponds kinematically to a limitation on the region of rapidity for which particle identification is possible. This limitation is less severe at higher incident-particle momenta and thus acceptance studies have been carried out at 300 GeV/c as well as 150 GeV/c, both based on data from the 147-GeV/c $\pi^- p$ (E-154) exposure. The graph at the top of the next page shows the 300 GeV/c distribution of particles with $p > 5$ GeV/c as a function of rapidity which traverse a 3 m ISIS located 2.25 m from the bubble chamber center.



The number of particles from simulated 300 GeV/c π p interactions as a function of rapidity: A) all particles, B) particles which leave bubble chamber magnet, C) particles with p > 5 GeV/c which leave bubble chamber magnet and D) which pass through ISIS.

R. Yamamoto (MIT) described the photon detector and the results of recent tests of this device in the N-5 beam. This detector consists of two lead-glass photon converter detectors, each containing five counters, and four shower-energy absorber detectors. A scintillation-counter hodoscope permits an accurate location of the shower vertex. The total energy of the shower is obtained by adding the converter and absorber pulse heights, permitting very good energy resolution ($\Delta E \simeq 0.15E^{\frac{1}{2}}$, where E is in GeV). Tests with electrons of various energies have verified

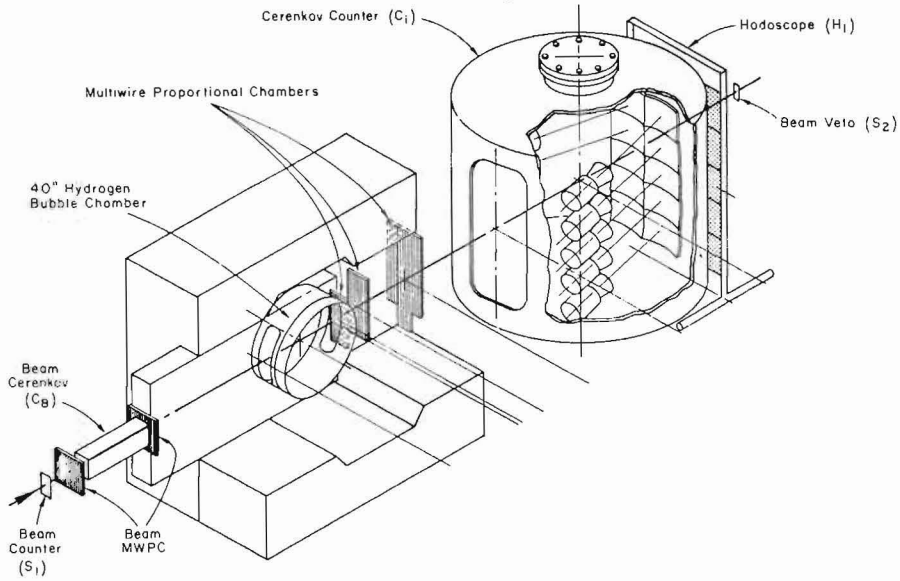


The number of events in the photon detector as a function of energy with 75-GeV electrons incident on the detector.

this prediction. The figure at the bottom of page 17 shows the pulse-height distributions of showers generated by 75-GeV/c particles tagged as electrons by a Cerenkov counter. The events observed at low energies are probably from pions which produce knock on electrons in the Cerenkov counter. This detector is currently being installed and will be used in Experiment 299 as soon as the schedule permits.

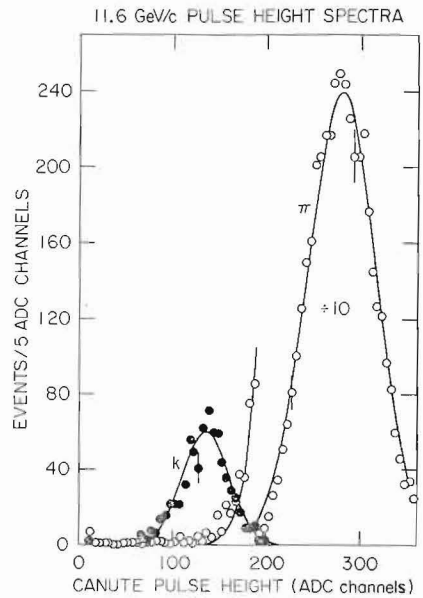
Charged-Particle Identifiers

R. Lewis (SLAC) described the Cerenkov counter operating in the SLAC hybrid facility and showed some experimental results on K/π^- separation obtained in a $\pi^+ p \rightarrow K^+ Y^*$ experiment at about 12 GeV/c. The figure below shows the experimental layout and the 3 m diameter by 3 m high cylindrical Cerenkov counter (CANUTE). This is a segmented device with two rows of



The layout of the SLAC 40-in. bubble chamber hybrid system including the Cerenkov detector (CANUTE).

five 75 cm wide by 50 cm high black lucite mirrors focusing the light on phototubes on either side of the beam line. CANUTE has been designed both mechanically and optically to operate with freon at pressures from slightly above atmospheric up to 4 atmospheres. With a filling of 45 psia of freon 100 photoelectrons are produced by particles with B of order 1 and thus K/π separation by pulse-height analysis is possible. It can be seen from the figure at the right that a good separation of K^+ from π^+ is achieved at 11.6 GeV/c.



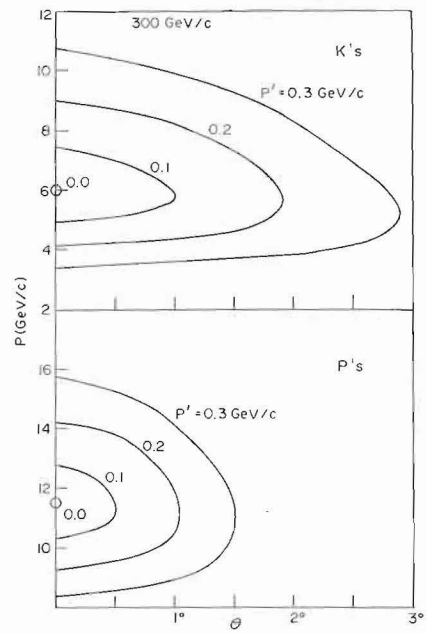
The number of events as a function of pulse height for 11.6 GeV/c π mesons and K mesons in CANUTE.

G. Smith (Michigan State) discussed the particle-identification considerations necessary to a 9 GeV/c $\bar{p}p$ experiment to be carried out at the SLAC 40-in. hybrid facility by a Cambridge-Michigan State collaboration (BC-64) and considered the same questions for the 100 GeV/c $\bar{p}p$ experiment proposed for the Fermilab hybrid spectrometer (P-394). The two essential components of the SLAC experiment are CANUTE and the UCLA neutron detector, suitably modified, used for antineutrons. This device will contain 26 layers of iron alternated with scintillator and three hodoscopes for accurate location of the $\bar{n}$ interaction. This device will have an efficiency of approximately 88% for $\bar{n}$. A possible particle-identification scheme for the Fermilab 100 GeV/c $\bar{p}p$ experiment would involve a CANUTE-type Cerenkov counter to separate $\pi/K/p$ for central-region

physics followed by a multi-cell 2 m × 2 m × 5 m atmospheric pressure Cerenkov counter (C_2) similar to that constructed at Michigan State for E-366, which when filled with approximately 95% helium and 5% nitrogen would permit a $\pi/K/\bar{p}$ separation between 53 GeV/c (K threshold) and 100 GeV/c (p threshold). Acceptance calculations yield a 97% overall detection efficiency for $\bar{p}$ by C_2. An antineutron detector similar to that planned for SLAC would follow the Cerenkov counters and would have about 90% acceptance. This, together with the conversion efficiency, would yield an overall detection efficiency of about 80% for antineutrons. These estimates, together with cross-section information, yield a 73% estimated purity of the annihilation sample. The cost for building C_1 would be approximately $110,000 (based on the construction cost of CANUTE) and for C_2 approximately $30,000 (based on the Michigan State E-366 Cerenkov cost).

V. Kistiakowsky (MIT) discussed the problems associated with using Cerenkov detectors for central-region physics and presented some estimates of the separation expected from a CANUTE-type detector at 150 GeV/c and 300 GeV/c. The graph on the following page gives the laboratory momentum p as a function of laboratory angle θ for K-mesons and protons produced with very low c.m. momenta p' by 300 GeV/c interactions. It is seen that the region where particle separation would be desired stretches from p approximately 3 to 16 GeV/c. For lower incident momenta, these curves are shifted downward in laboratory momentum. Currently attainable K thresholds are $\gtrsim$ 5.3 GeV/c (4 atmospheres freon) due to safety considerations. Using the experimental results for the number of photoelectrons in CANUTE,

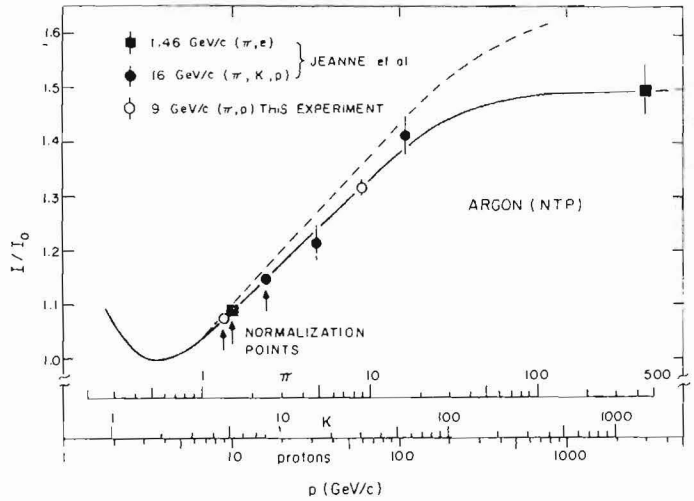
the efficiency for distinguishing $\pi/K/p$ has been estimated. From about 5.5 GeV/c to 11 GeV/c K's can be identified by pulse-height analysis, but there is an overlap between the pulse-height distributions for π, K and p which results in the misidentification of up to 30% of the K-mesons. Another problem which seriously affects the detection efficiency of such a detector is the overlap of Cerenkov light spots from different particles. This cannot be improved by decreasing the CANUTE mirror size, since at 4 atmospheres of freon the size of the spots is comparable to that of the mirrors. At 300 GeV/c, the acceptance of a CANUTE-type detector located 6 m from the bubble chamber would be 46% for particles with momenta 5.5 < p < 11 GeV/c. However, only 43% of the particles accepted would have sufficient separation to permit identification. The advantages of such a device are that it is guaranteed to work and that engineering costs could be minimized by copying CANUTE (estimated cost about $110,000). The disadvantages are the limited region of $\pi/K/p$ separation, the limited particle spatial resolution, and the incompatibility of such a device and the photon detector.



The laboratory momentum p as a function of laboratory angle θ for protons and K mesons produced at various c. m. momenta p' close to zero in 300 GeV/c interactions.

J. Whitmore (Michigan State) described the CERN External Particle Identifier (EPI) and discussed the pros and cons of constructing such a device

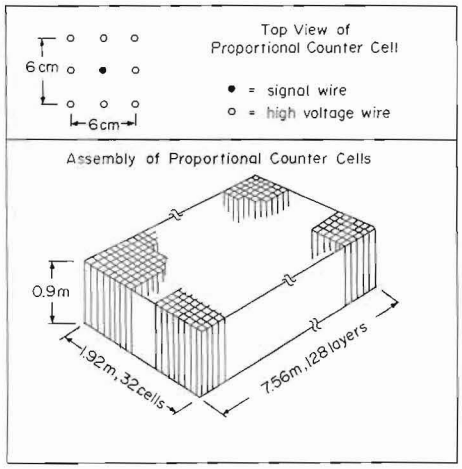
for the Fermilab hybrid system. This device is being built (75% completed) for use at BEBC and extensive tests which have been made with prototypes are very promising. This device measures the ionization of the particles in the region (3 to 100 GeV/c) where dE/dx for π, K, and p is different due to the rise at relativistic velocities (see figure below). Since an individual



The relative ionization as a function of momentum for π mesons, K mesons, and protons. The dashed line is that calculated by Sternheimer, the solid line is hand drawn through the points which are the results of ex experiments carried out by the group developing the BEBC EPI.

ionization measurement can yield a wide range of values for dE/dx with a probability given by the Landau distribution, the ionization of a given particle must be sampled a large number of times and an average of these measurements (or an equivalent quantity) used to typify the particle. With a large enough number of samples, good resolution can be achieved for the distribution of the average values for a given particle type at a given momentum. The CERN EPI will consist of 128 layers of 32 individual proportional

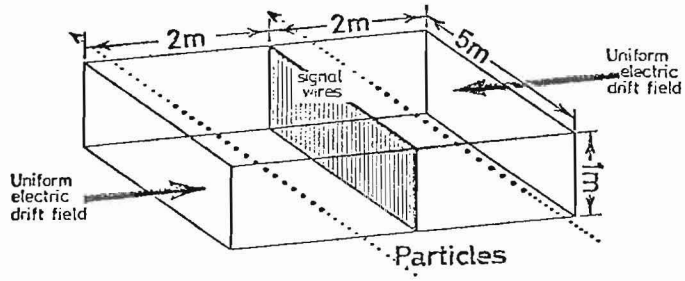
counters, each of which is 6 cm × 6 cm × 90 cm (see figure below). The active volume of each proportional counter is defined by eight high-voltage wires and the device is filled with 95% A-5% CH_4. Based on experimental studies, 5.5% FWHM resolution is anticipated for 128 6 cm ionization samples suitably analyzed. The acceptance of an EPI located 2.5 m from the bubble chamber center has been estimated using data from a 100 GeV/c $\bar{p}p$ experiment (E-311), and 59.1% of all particles and 97.3% of all forward-hemisphere particles would enter the device. A consideration of the track-overlap problem indicates that in 4-prong events, typically, the information from approximately 31% of the cells must be discarded because of particles passing through the same cell, with a corresponding reduction in resolution to 6.6% FWHM (for 128 layers). In 12-prong events, the loss is approximately 4% with essentially no decrease in resolution. A recent estimate made at CERN for the cost of a 64-layer EPI was $188,000 plus salaries.



Schematic representation of the BEBC EPI.

W. Bugg (Tennessee) described another relativistic-rise detector and presented some estimates of its anticipated performance with the Fermilab hybrid system. This device is a smaller version of ISIS, the device being developed at Oxford for use with the CERN rapid-cycling bubble-chamber hybrid system. ISIS consists of a 1 m × 4 m × 5 m drift chamber which

contains 330 signal wires with a 1.5 cm spacing (see the illustration below).



Schematic representation of the Oxford ISIS.

The pulse-height resolution predicted for the mean of the 330 1.5 cm samples is 6.2% FWHM. The time resolution of the signal collection is 250 nsec and thus, with a 2 cm/μsec drift velocity, measurements on tracks within roughly 1 cm of each other cannot be used. A full-scale ISIS has not yet been tested, but extensive studies of both its drift chamber and relativistic-rise aspects have been carried out. There are some stringent constraints on gas purity and field uniformity for operation with a full 2 m drift space, but these disappear if the drift-space dimension is decreased to 50 cm. Such a device could be operated with commercial bottled gas (purity 2 ppm) and an off-the-shelf power supply. Thus it is proposed that three sections of a 1 m × 1 m × 1 m ISIS-type device be constructed, each containing 66 wires at a 1.5 cm spacing, permitting a total of 198 1.5 cm samples of the ionization and a corresponding 7.8% FWHM resolution. The figure at the top of the next page gives the percentage of misidentified K-mesons as a function of particle momentum corresponding to this resolution and this device is seen to give better than 70% K identification from 5 to 30 GeV/c. The figure at the top of page 26 gives the rapidity distribution both for all particles and for those

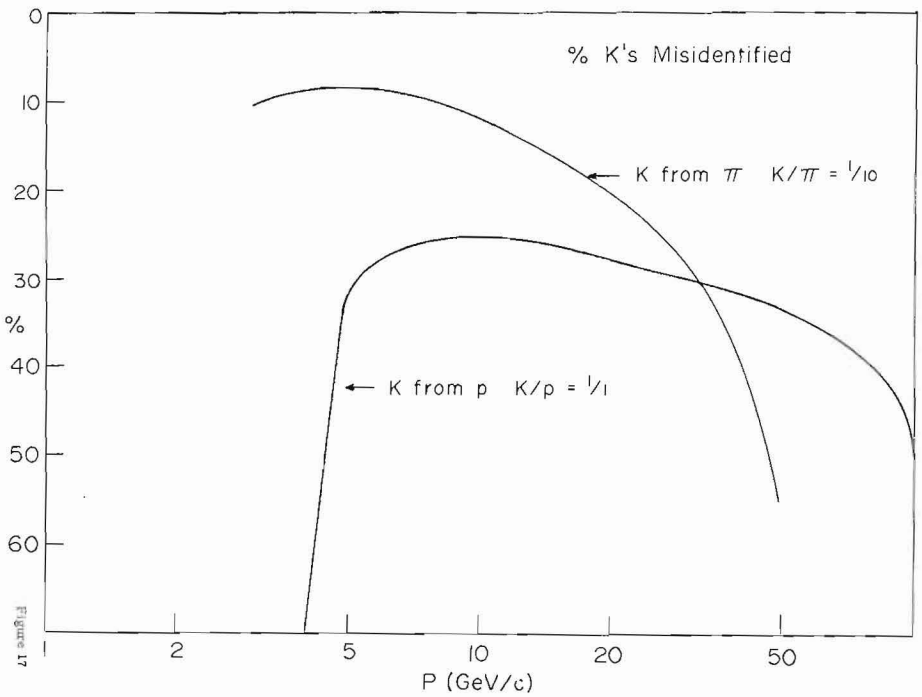
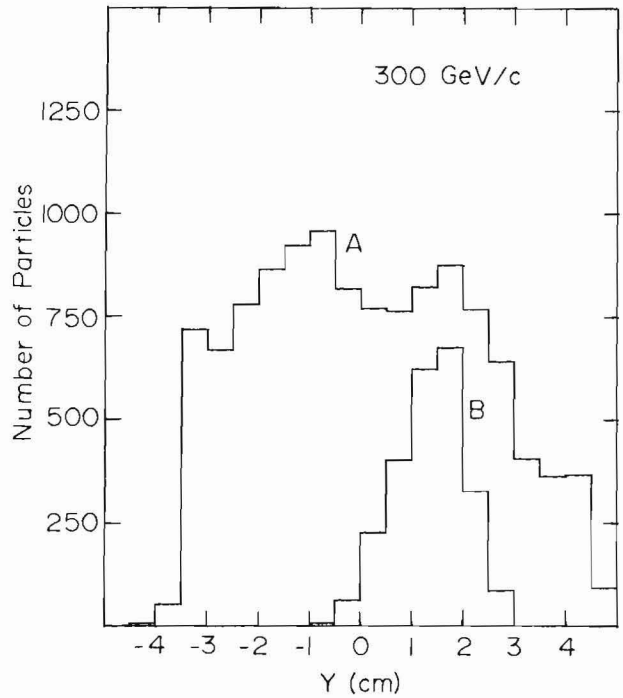


Figure 17

The percentage of K mesons which are misidentified in a relativistic rise detector with 8% FWHM resolution at a function of momentum for $\pi/K/p = 10/1/1$.

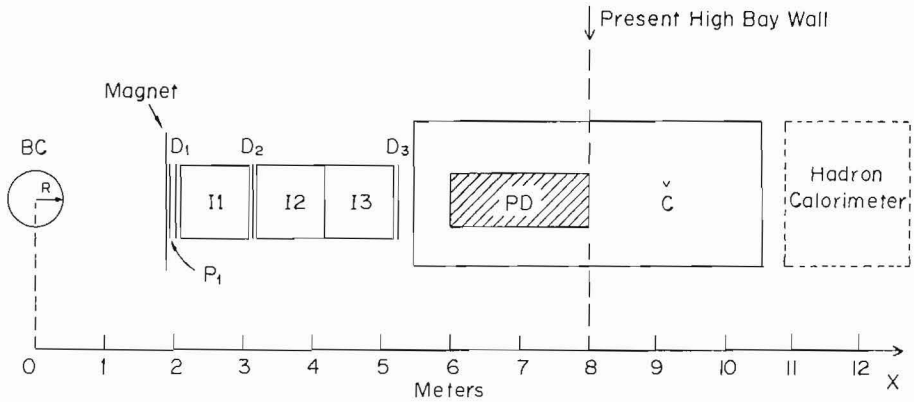
which both pass through ISIS and have momentum, $5 < p < 40$ GeV/c. At 300 GeV/c, 18% of all particles and 30% of those escaping the magnet satisfy these criteria. One topic of importance to all varieties of particle identifiers is the question of charged-particle background, since a background particle passing through the same cell as a particle from the event renders the information from that cell not useable. A background study has been carried out using the proportional wire counter data for several hundred events chosen at random from E-154 ($\pi^- p$ at 147 GeV/c) and E-299 ($\pi^+ p$ at 150 GeV/c). The percentage of cells which must be discarded is estimated to be 25% for



The number of particles as a function of rapidity from simulated 300 GeV/c $\pi^- p$ interactions: A) all particles, B) those particles with $5 < p < 40$ GeV/c which pass through 13 in the figure on page 27.

an ISIS (1 cm cells) and 51% for an EPI (6 cm cells), both located 2 meters from the bubble chamber center, with the current bubble chamber configuration. Improvements in the background could be made by reductions in the amount of matter downstream of the bubble chamber. The cost estimated by the Oxford group for a 1 m × 1 m × 1 m ISIS module is $17,200; thus, including provision for contingencies, a conservative estimate would be $30,000 per module. The first module could be constructed in 6-9 months and the remaining modules could be completed within a year at a total cost of $100,000 plus salaries.

I. Pless (MIT) presented a proposal agreed upon by the workshop for a system which would permit both "central-region" physics (5-50 GeV/c) and "leading-particle" physics (50-100 GeV/c). This system is shown in the figure below and would consist of three elements: an ISIS consisting of three 1 m× 1 m× 1 m sections interspersed with drift chambers (5-50 GeV/c), a 2 m× 2 m× 5 m multi-cell atmospheric pressure N_2-He Cerenkov detector (50-100 GeV/c), and the photon detector. The photon and Cerenkov detectors



The particle identification system proposed in the recommendations of the workshop for the Fermilab 30-in. bubble chamber hybrid system. I1, I2, and I3 are 1 m× 1 m× 1 m ISIS-type modules; C is a 2 m× 2 m× 5 m multi-cell Cerenkov detector; P_1 is a proportional wire counter; and D_1, D_2, D_3 are drift chambers. The location of the photon detector (PD) and possible location of a future hadron calorimeter are also shown.

could not be used simultaneously and would be mounted on rails for easy interchange. This arrangement would necessitate an addition to the present high-bay area which would accommodate either the Cerenkov or the photon detector when not in use. At a future date, this could be expanded to include a neutral-hadron calorimeter for $n/\bar{n}$ detection. The workshop had been asked to consider 12 aspects of particle identifier systems (NALREP, p. 19,

March, 1976). The proposed system has (1) operating parameters of $\pi/K/p$ separation from 5-100 GeV/c and (2) an acceptance that is reasonably well matched to the geometric profile of the particles leaving the bubble chamber. (3) The background sensitivity is acceptable and (4) the problems of gas handling and purity are minimized since commercially available bottled gas (2 ppm impurity) is satisfactory. (5) The readout electronics can use elements already available and this problem and (6) that of off-line computing are already solved in principle. (7) The system is compatible with photon detection and high-resolution momentum measurements and (8) requires no drift chambers or proportional wire counters other than those already in existence or under construction for the hybrid system. (9) A modest extension of the building will be necessary, but not a crane. (10) The maintenance requirements will be about the same as those of the present system, and (11) the system poses no safety problems. (12) The construction and testing of ISIS would be carried out by the PHSC and that of the Cerenkov detector, by Michigan State University. Conservative estimates of the costs are respectively $100,000 and $30,000. The construction, initial test and installation schedule would involve 6 to 9 months for construction, 1 to 2 months for testing and 3 months for installation, for a total of 12 to 15 months. The PHSC would assume overall responsibility for the integration of these detectors with the proportional hybrid system.

A NEW DETECTOR FACILITY AT FERMILAB

Muzaffer Atac

On May 4, 1976, a celebration in the Village marked the opening of a new Detector Facility. This facility is a Research Services Operation and at the present includes a winding machine, a drift-chamber wiring table, and a granite worktable. The winding machine (see photograph on next page) is a modified and improved version of the machine located on the 10th floor of the Central Laboratory, which was originated in 1970.

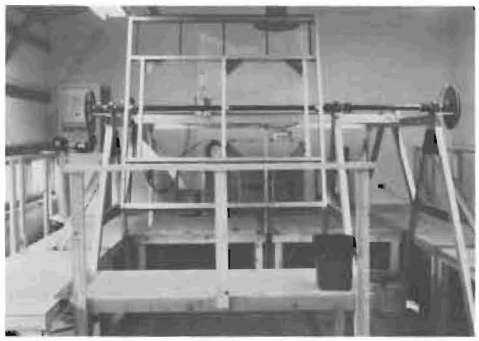
Specifications of Large Winding Machine

Maximum Size	3 m × 4 m
Speed	Variable between 0-4 rpm
Wire Spacing	Digitally set from 100μ to 10 cm
Wire-Spacing Accuracy	Measured to be an average value 5μ for a spacing of 3 mm in entire 2-m winding. Maximum error was measured to be 50μ
Tension on Wire	Adjustable from 10 g to 250 g
Tension Accuracy	Better than 2%

Notes: a) Temperature is continuously recorded.

b) The machine is automatically shut off when winding is complete or something goes wrong. There is provision for being notified by telephone in case of failure or completion of winding.

The winding machine was built by the Detector Development Group, consisting of Muzaffer Atac, John Urish, and Michael Hrycyk, who are a part of Research Services.



Research Services winding machine located in Lab 8 in the Village.

The drift-chamber wiring table is a device that will enable users to construct wire chambers with a high degree of accuracy.

Specifications for Drift-Chamber Wiring Table

Maximum Size	75 cm × 100 cm
Wire Spacing	Set from 100μ to whatever is desired
Wire-Spacing Accuracy	Within 5μ
Tension on Wire	Any tension that is desired

The granite table provides an extremely uniform and level surface for the construction of detector frames. It is a leveled block of granite 3 m × 3 m in surface size.

Better physics will result from better instrumentation of experiments. Detectors are a vital part of such instrumentation. With this facility, we will be able to construct larger and more accurate detectors.

The facility is available to all Fermilab users. The Research Services Department stands ready to provide information and guidance to users in the construction of their detectors. More information can be obtained from the Detector Development Group.

FERMILAB PRAIRIE RESTORATION PROJECT

Rene Donaldson

The Illinois tallgrass prairie is gradually returning to an area where buffalo used to graze in seas of six-foot high Indian grass. The Laboratory's second Main-Ring prairie planting occurred in June when approximately 250 pounds of prairie seeds were planted with a specially designed tractor-driven seed drill in 8.5 acres, making a total of 16.5 acres now planted in native, perennial prairie grasses and flowers.

Volunteers of all ages braved October winds to harvest prairie seeds at the Arboretum's 10-acre prairie restoration, at Gensberg-Markham Prairie on the south side of Chicago, and at locally scattered prairie remnants. The seeds were cleaned and bagged in February prior to being placed in cold, damp storage for three months. This procedure, referred to as "stratification," simulates the prairie winter and helps most of the seeds to "break dormancy" after they are sown in the spring. Other seeds, such as the prairie legumes, were "scarified" or scratched with sandpaper blocks and innoculated with nitrogen-fixing bacteria prior to being planted.

Eventually the Laboratory will be able to harvest seeds with a modified agricultural combine from the first eight acres planted last year. In this way, there will be a continuing supply of seeds with which to sow successive acreage. The Main-Ring prairie restoration will eventually include most of the 650 acres inside the ring. This area also encompasses a remnant bur-oak grove that dates back to the days of the original Illinois prairie. One of the project's goals is to restore the shrubs of this grove that have been

eliminated by overgrazing. One such shrub is the hazelnut, which is now only an isolated minor constitutent of the woods, but was mentioned by early travelers and surveyors as a dominant shrub surrounding the prairie groves.

Another aspect of the Fermilab restoration that makes it unique is that it is the only major restoration attempted on Mundelein silt loam, a deep rich soil (evidence of former prairie occupation). Most of the surviving prairie remnants are on relatively poor soil (rocky, sandy, or shallow) and belong to minor soil types. This fact alone usually accounts for their being any prairie left. The prairie that once grew on the more valuable soils (and they were in the majority) was the first to be destroyed by plowing when the settlers first entered the "Prairie State."

Tony Donaldson, chairman of Fermilab's Prairie Restoration Project, says that this year's planting went more smoothly than last year's and that the plants are already showing a high percentage of germination. The Laboratory is guided by an Advisory Committee headed by prairie authorities Robert F. Betz, a biology professor at Northeastern Illinois University, and Ray Schulenberg, curator of the Morton Arboretum herbarium. The project has the moral support of the Illinois Chapter of the Nature Conservancy, a private non-profit organization interested in preserving native ecosystems. Professor Betz is very enthusiastic about the first planting that took place a year ago, and he says, "There are thousands of prairie plants out there, and our job is to aid them in every way we can." One of the ways the Laboratory recently helped the new prairie plants was to mow above them, enabling the small, year-old plants to receive more light once the taller "weedy" species were cut.

One of the biggest problems the prairie seedlings face is competition from introduced Eurasian "weeds," such as thistles and quack grass. Fire plays an important role in reducing this threat, but it requires two years after planting before an area the size of the Main-Ring plantings can sustain a good burn (see April issue of NALREP). Fire tends to destroy weeds and tree seedlings, while the prairie plants, perennials with well-developed root systems, can withstand recurrent fires.

Another aspect of the Laboratory's prairie restoration project is a prairie nursery located on Eola Road across from Farm Management. Here, prairie seeds have been planted in rows in order to facilitate harvesting. Some of the species planted in the nursery are ones that mature early and thus make harvesting difficult; others were saved from housing-development bulldozers near Calumet City in the spring of 1974, brought back, and transplanted in the nursery plot.

More volunteers became involved in planting 18 different species of seeds, mostly warm-season grasses and flowers, in a 40-ft by 40-ft prairie demonstration plot located off Road D near the Central Laboratory Building. This plot was burned successfully in April and requires only occasional hand weeding. The fall is one of the best times of year to view the demonstration plot in order to see the tall and stately "turkey's foot" or big bluestem grass.

The word "prairie" was derived from the French word for meadow, and it was the dominant vegetation of Illinois prior to the 1840's. Settlement was encouraged in this area after the end of the Blackhawk War in 1832, and with settlement came the demise of the prairie. Prairie plants, nonaggressive

in nature, could not stand continuous grazing and plowing, and by 1900 the only prairie remnants left were in old cemeteries, railroad rights-of-way, and in patches of ground that were too wet or too steep to plow.

Approximating the original prairie ecosystem is a challenging task. The ecosystem is incredibly complex, and it ranges from the tall grasses and flowering plants through the animals and birds, all the way to specialized soil organisms. Eventually with the restoration of a prairie and its associated species, wildlife will be attracted to the tall grasses and seeds produced, providing a habitat for nesting birds as well as a resting place for migrating ones. When one begins to comprehend its living interrelationships, the prairie becomes more than a place of beauty and uninterrupted vistas. It becomes a place to go for peace and solitude, a link with the past, and an unforgettable experience.

Robert F. Betz, Fermilab prairie advisor, examines seeds of Indian grass prior to loading in seed drill. Volunteers ride drill and assist flow of seeds into the drill. (Photograph by A. R. Donaldson)

Volunteers harvest grass seeds at the Morton Arboretum in Lisle.
(Photographs by A. R. Donaldson)

Volunteers help clean and prepare seeds for stratification.
(Photographs by A. R. Donaldson)

NOTES AND ANNOUNCEMENTS

APPOINTMENTS. . .

Russ Huson has succeeded Phil Livdahl as head of the Accelerator Division, and Phil Livdahl has become associate head of the Accelerator Division effective July 14.

Thornton Murphy has been appointed associate head of the Proton Department effective June 1.

Dennis Theriot has been appointed associate head of the Neutrino Department effective July 1.

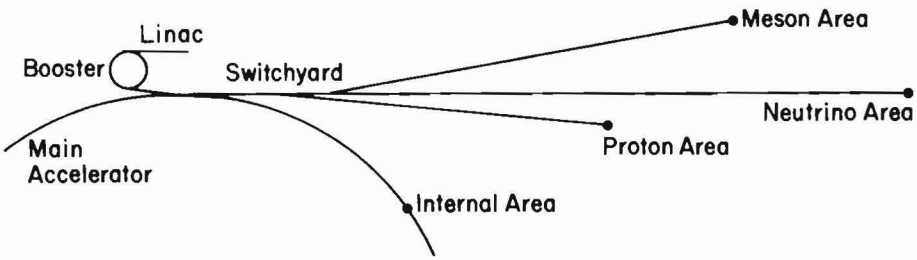
Effective July 1, Research Services has been reorganized into two subdepartments, Cryogenics Services and Electronic Services. Paul Mantsch is in charge of Cryogenics Services, and Robert Shafer is in charge of Electronic Services. The latter position is a new one. The Electronic Services subdepartment includes the BEST Group, PREP and Instrument Repair, Detector Development, and Electronics Development.

BOOKS AVAILABLE. . .

A limited number of copies of the 1976 edition of the Fermilab Research Program Workbook are available from the Director's Office at a price of $5.00 each. The material in this booklet was prepared to assist the Laboratory staff and members of the Program Advisory Committee (PAC) in their review of the research program at the extended summer PAC meeting. While the Workbook is intended primarily for this purpose, the general information it contains about the status of research at Fermilab may be of interest to others.

POPAE--A 1000 GeV on 1000 GeV Proton-Proton Colliding Beam Facility--proposals are available upon request from the Publications Office. The proposal is the result of a collaborative effort, headed by Robert Diebold, between scientists at Argonne National Laboratory and Fermilab (discussed in last month's NALREP).

Fermi National Accelerator Laboratory



Experiments in the Research Areas

JULY - OCTOBER 1976

Internal Area	Proton Area	Neutrino Area	Meson Area
P-N SCATTERING #198A	PROTON EAST:	MUON/HADRON BEAM:	M1 BEAM:
	PHOTON CROSS SECTION #25A	MUON #319	INCLUSIVE SCATTERING #324
		MUON #398	FORM FACTOR #456
P-P POLARIZATION #313	PROTON CENTER:	HADRON BEAM:	M2 BEAM:
	MUON SEARCH #435	PARTICLE SEARCH #379	PARTICLE PRODUCTION #415
	DI-HADRON #494	30-IN. B.C.	PARTICLE SEARCH #472
P-P INELASTIC #321	PROTON WEST:		M3 BEAM:
	PHOTON SEARCH #95A		PARTICLE SEARCH #397
	PARTICLE PRODUCTION #284		NEUTRON ELASTIC #248
P-N SCATTERING #381			M4 BEAM:
			K^0 REGENERATION #226
NUCLEAR FRAGMENTS #442			M6 BEAM:
			HADRON JETS #260
			INCLUSIVE SCATTERING #118A

RESEARCH ACTIVITIES DURING JUNE 1976

James MacLachlan

The 300-GeV run which started in the last week of May ended at noon on June 1. The complimentary remarks from various experimenters on the virtues of the 2-second flattop used during the 300-GeV running helped motivate a stepwise lengthening of the flattop from the 1.25 sec used in early May to 1.5 sec in early June. In further quarter-second increments on June 15 and June 17, the flattop was lengthened to 2 seconds. With this ramp, the cycle period was generally limited to 14.7 sec by main-ring feeder current restrictions. On a few occasions, LCW cooling capacity became the operative limitation, and it was necessary to add a second or so to the cycle for a few hours. Despite the long cycle, experimenters were in surprisingly general agreement that they preferred the long flattop and lost little time in becoming accustomed to it.

The accelerator ran 413 of the 569 hours scheduled for high-energy physics research. The reliability of 73% and availability of 100 beam hours per week both mark June as a good month. The delivered beam of 10^{18} protons reflects a combination of lower demand for part of the month and the long-cycle, all-slow-spill program. The weekdays from June 7 to June 11, which had been at one point part of a tentatively scheduled financial shutdown, were devoted to an extended accelerator research, maintenance, and development period while changeovers were taking place in all the external experimental areas.

The Neutrino Area was still off changing to the triplet target train during the early part of June. When the accelerator completed its study week, the area took beam for tuning of the train and the N1 and N7 beamlines. This work went rather slowly because of a series of water leaks, power-supply troubles, and ac-power distribution problems. The N1 beam was turned over to Muon # 319 on June 22. The experimenters started the high-momentum part of this scaling experiment with 275-GeV μ's and a μ/p ratio of about 4×10^{-8}. The yield continued to improve throughout the month as tuning of N1 beamline and, more importantly, targeting of the proton beam were optimized. Particle Search # 379 received some beam for parasitic testing of their calorimeter in Lab E. Both 400-GeV protons and 100-GeV μ's were employed, but the transmission of beam between Enclosure # 99 and Enclosure # 100 was so poor that the whole operation was marginal.

The Meson Area was busy in all beamlines except M4 all month. Hadron Jets # 236A set up and tuned in M1E before the accelerator study week and began production data taking at ±200 GeV thereafter. Particle Search # 357 was completed in the M2 line and was replaced by Inclusive Neutral Meson # 350 in their low-momentum (100 GeV/c) configuration who reached the data-taking stage before the end of the month. The M3 line started the month under the control of Particle Search # 366 who gave it over to Particle Search # 397 after the study week. Experiment # 366 continued to parasite successfully, however. The switch over from Inclusive Scattering # 118A, who had run at 175 GeV in M6E, to Hadron Jets # 260 in M6W also took place over the study week. Their startup was slowed by trouble with M6 power

supplies and magnets, difficulty in getting liquid helium for their spectrometer magnet, and computer problems, but they succeeded in taking some data at ±200 GeV with ~ 3×10^6 particles in the beam.

Particle Production # 325 turned off in Proton East at the end of 300-GeV running, and that area was down for a major fraction of the month while the tagged-photon beam was being revived. After a somewhat hectic weekend with the P-East interlocks, e/γ beam tests were started Sunday, June 20; the beam tuning was completed. Di-Lepton # 288 ran in P-Central until the study week, taking both hadron and electron pair data. Muon Search # 435 then started up for their final data taking; after several days of severe computer problems, they moved into smooth running for the rest of the month. Photon Search #95A ran for the entire period in Proton West, taking both photon and electron pair data from several solid targets and at several settings of their two-arm spectrometer.

p-p Inelastic # 321 has continued to run in the Internal Target Laboratory using their warm gas jet, and the superconducting spectrometer saw some initial data taking by p-N Scattering # 198A and p-p Polarization # 313, also using primarily a warm jet. The helium-liquifier system was down for several days while contamination was being cleaned out of the system. With only two compressors operative it was not possible to keep up completely with the consumption of the dipole alone. However, substantial progress was made in understanding liquid-helium use, and the prognosis is now favorable for nearly continuous running of both the quadrupoles and the dipole. Nuclear Fragmentation # 442 also conducted some brief tests.

FACILITY UTILIZATION SUMMARY -- JUNE 1976

I. Summary of Accelerator Operations

	Hours	
A. Accelerator use for physics research		
Accelerator physics research	55.8	
High energy physics research	413.0	
Research during other use	(39.8)	
Subtotal		468.8
B. Other activities		
Accelerator setup and tuning to experimental areas	22.0	
Scheduled interruption	66.9	
Unscheduled interruption	162.3	
Subtotal		251.2
C. Unmanned time		
Total		720.0

II. Summaries of High Energy Physics Research Use

	# of Expts.	Hours	Results
A. Counter experiments	19	2678.4	1 expt. completed
B. Bubble chamber experiments	-	-	
C. Emulsion experiments	-	-	
D. Special target experiments	-	-	
E. Test experiments	-	-	
F. Engineering studies and tests		115.3	e/γ Tests
G. Other beam use	-	72.0	N0, N1, N7 beam tuning
	19	2865.7	

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

A. Beam accelerated in Main Ring	@ 400 GeV	1.160	
	@ 300 GeV	0.080	
			1.240
B. Beam delivered to experimental areas			
Meson Area	@ 400 GeV	0.319	
	@ 300 GeV	0.033	
			0.352
Neutrino Area			
Slow Spill	@ 400 GeV		0.546
Proton Area	@ 400 GeV	0.041	
	@ 300 GeV	0.022	
			0.063
Total			0.961

IV. Beam Utilization by Experiment

	Hours	Results
A. Meson Area		
Polarized Scattering # 61	2.0	Data
Inclusive Scattering # 118A	90.5	Data
Hadron Jets # 236A	189.3	Data
Hadron Jets # 260	215.8	Data
Inclusive Neutral Meson	191.9	Startup and data
Particle Search # 357	114.7	Complete
Particle Search # 366	343.4	Data
Hadron Dissociation # 396	31.2	Setup
Particle Search # 397	210.5	Data
B. Neutrino Area		
Muon # 319	166.5	Data
Particle Search # 379 Tests	5.5	Calorimeter tests
C. Proton Area		
Photon Search # 95A	373.2	Data
Di-Lepton # 288	113.9	Data
Particle Search # 325	9.0	Data
Muon Search # 435	234.8	Data
D. Internal Target Area		
p-N Scattering # 198A	138.4	Test data
p-p Polarization # 313	40.0	Test data
p-p Inelastic # 321	191.2	Data
Nuclear Fragmentation # 442	16.6	Tests
Total	2678.4	

PROPOSALS RECEIVED DURING JUNE AND JULY 1976

No.	Title	Submitted By
491	Clashing Gigantic Synchrotrons	R. P. Johnson
492	Proposal to Construct an Antiproton Source for the Fermilab Accelerators	D. Cline
493	Search for New Phenomena Using Very High Energy pp and $\bar{p}p$ Colliding Beam Devices at Fermilab	D. Cline
494	Di-Hadron Mass Search	L. Lederman
495	A Proposal to Study Ξ^0 and Λ^0 Production and Polarization	K. Heller
496	A Neutrino Detector Sensitive to Rare Processes I. A Study of Neutrino Electron Reactions	H. H. Chen
497	Elastic Scattering of Hyperons	J. Lach
498	A Measurement of the Relativistic Rise in the Most Probable Energy Loss in Thin Solid Films	C. R. Gruhn
500	A High Precision Experiment to Measure p-p Elastic Scattering and the Inelastic Inclusive Reaction $p + p \rightarrow p + X$ up to 1 TeV Laboratory Energy at the Energy Doubler/Saver	P. Franzini J. Lee-Franzini

DATES TO REMEMBER

August 7, 1976	Fermilab Arts Series: Preservation Hall Jazz Band. All seats are reserved, and tickets are required. Auditorium, 8:30 p.m.
September 25, 1976	Illinois Prairie Day: "Prairie Panorama." Auditorium, 8 p.m.