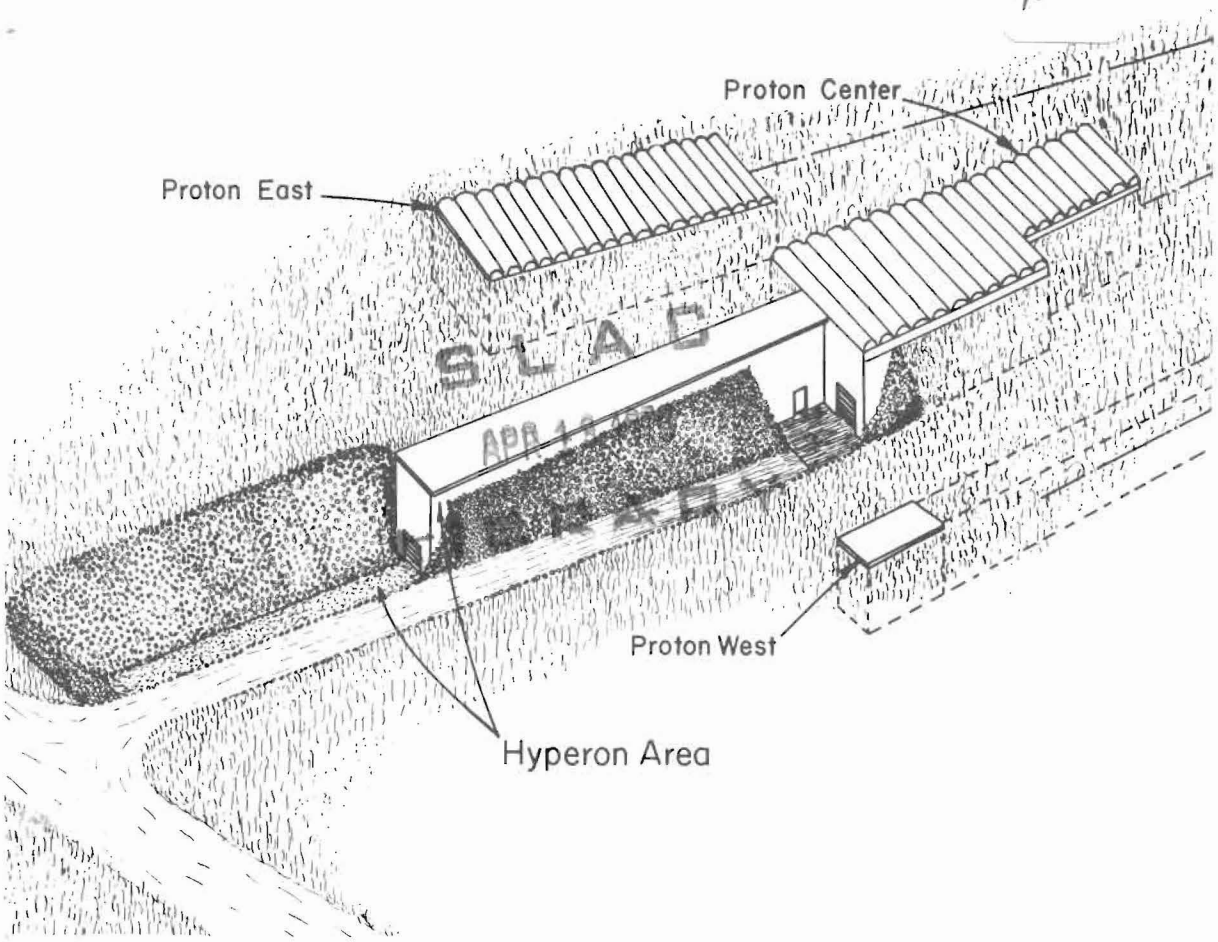
NALREP



Monthly Report of the Fermi National Accelerator Laboratory

March 1976

Fermi National Accelerator Laboratory

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THE COVER: An artist's conception of the hyperon area planned just downstream of the center pit of the Proton Department. The new ramp would provide access to both the new area and the present Proton Center region.

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SO WHAT ABOUT HYPERONS?

A workshop was held at Fermilab on December 18 and 19, 1975, to consider the kinds of physics which could be done with a new short-lived beam facility planned by the Proton Department. The meeting was attended by about 50 physicists from the United States and 3 Europeans who came specifically for the meeting. Physicists from Poland and Czechoslovakia also expressed an interest in the program.

What Are Hyperons?

Hyperons are baryons which carry one or more units of strangeness. In terms of the best model we have of the elementary particles, the hyperons are composed of three quarks, of which at least one is a strange quark. The quark model puts them on the same footing as the more familiar baryons, the neutron and proton. Recall that in the quark model, the familiar baryons are part of a grouping called the baryon octet shown diagramatically on page 3. Plotted vertically in this diagram is hypercharge and horizontally the third component of isotopic spin. We see that there is charge singlet, the Λ; two doublets, the Ξ's; the familiar nucleons, the proton and the neutron; and a triplet of Σ's. Each is composed of three quarks: the Λ and Σ's contain one strange quark, the Ξ's contain two, and the neutron and proton none. Even though the neutron and proton make up most of our surroundings, there is no reason to believe that they are more fundamental than the other members of the octet. The quark model puts them all on the same footing. Because the neutron and proton are long lived, we know much more about them than the other members of the octet. Hyperon beams will allow us to study family relationships of these particles and the limitations of the quark model.

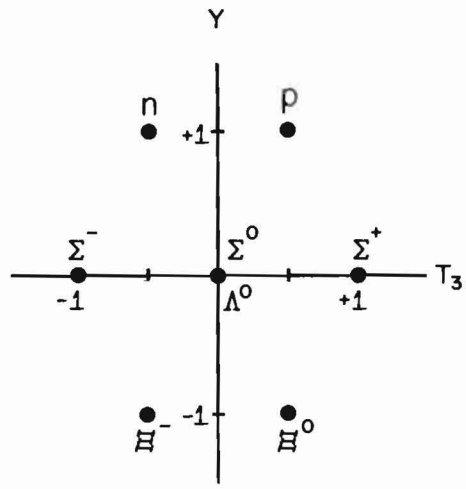
The proton is the only member of the octet which is stable to decays by the strong, weak, and electromagnetic interactions. The Σ^0's very short lifetime, $\sim 10^{-19}$ sec, stems from its allowed electromagnetic decay to the Λ^0. The rest (except for the almost stable neutron) have lifetimes of about 10^{-10} sec.

Other hyperons are part of another group called the baryon decouplet, also shown on the next page. All of these except the Ω^- decay very rapidly through the strong interactions so that even if they are produced with the highest energies available at Fermilab, they only travel distances comparable to nuclear sizes before they decay. The Ω^-, however, does not decay through the strong interactions, hence has a lifetime (1.3×10^{-10} sec) comparable to most of the other hyperons. Being composed entirely of strange quarks, it is the ultimate strange particle. One of the triumphs of the quark model was the prediction of this particle and its subsequent discovery at Brookhaven National Laboratory (BNL) in 1964. To date, however, only about 40 of the particles have been observed.

What About Hyperon Experiments?

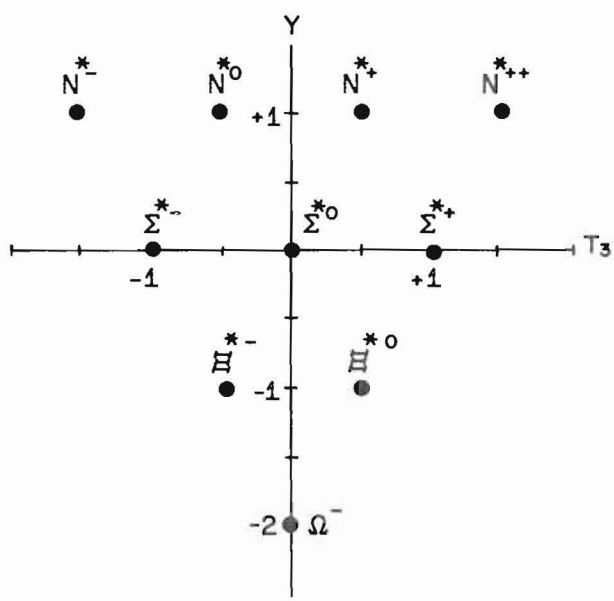
All of the hyperons of the octet and decouplet as well as their anti-particles have now been discovered. All of these discoveries have utilized visual detectors, cloud chambers in the early days, bubble chambers later. Until recently just about all of our knowledge concerning hyperons came from bubble chamber experiments. With lifetimes of $\sim 10^{-10}$ sec and produced with a few GeV of energy, hyperons traveled centimeter-like distances before they decayed. This made them suited for study in hydrogen-filled bubble chambers of meter-like dimensions. This was far from an ideal tool. It is equivalent to demanding that one's apparatus not only

BARYON OCTET



The Baryon Octet and Decouplet. These are the two lowest mass families of particles composed of three quarks.

BARYON DECOUPLET



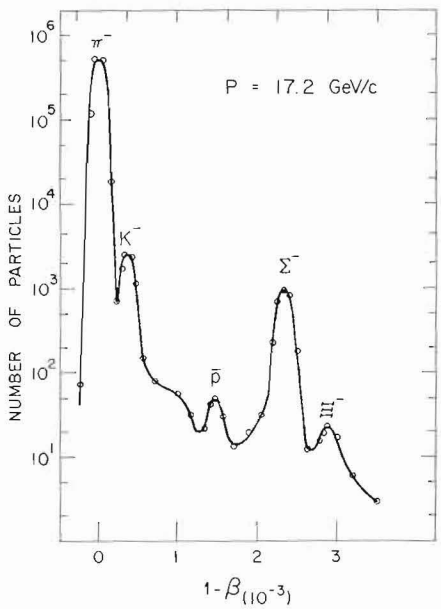
contain the production target, but also that the entire apparatus be only a few meters long.

About 10 years ago groups at Yale University and CERN proposed experiments using another technique. They noted that using the external proton beams from the highest energy accelerators then available at CERN and BNL, one could produce beams which contained substantial hyperon fluxes. Their technique capitalized on two facts. First, hyperons produced with large energies lived longer because of the relativistic time dialation. Second, in certain kinematical regions hyperons were produced in surprisingly large quantities, even more copiously than pions. The first evidence that one could indeed produce hyperon beams well defined in space and momentum came from the CERN group. A pressure curve taken with their Cerenkov counter clearly showing that the hyperons existed in substantial quantities in their beam and could be electronically tagged is shown on the following page.

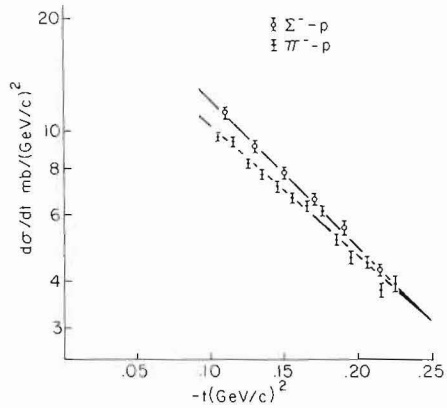
These two experiments gave us a wide variety of new hyperon physics. Measurements were made of total cross sections and elastic differential cross sections. The $\Sigma^- p$ elastic distribution as measured at Brookhaven by the Yale-Fermilab-BNL group is also shown on the next page. In addition, important measurements were made of hyperon decay properties. Among these was a high statistics measurement of Σ^- leptonic decays which resulted in a very accurate measurement of the Cabibbo angle.

Early Fermilab Hyperon Commitments

The higher the incident proton energy, the more energetic are the produced hyperons and the longer their lifetime. Fermilab, with its much



Cerenkov counter pressure curve from the CERN hyperon experiment showing substantial flux of hyperons.



Measurement of the Σ^-p elastic scattering distribution as a function of four momentum transfer, t, done by the Yale-Fermilab-BNL group at 23 GeV/c. Note the simultaneous measurement of π^-p elastic scattering done as a comparison. A similar experiment has been performed by the CERN group.

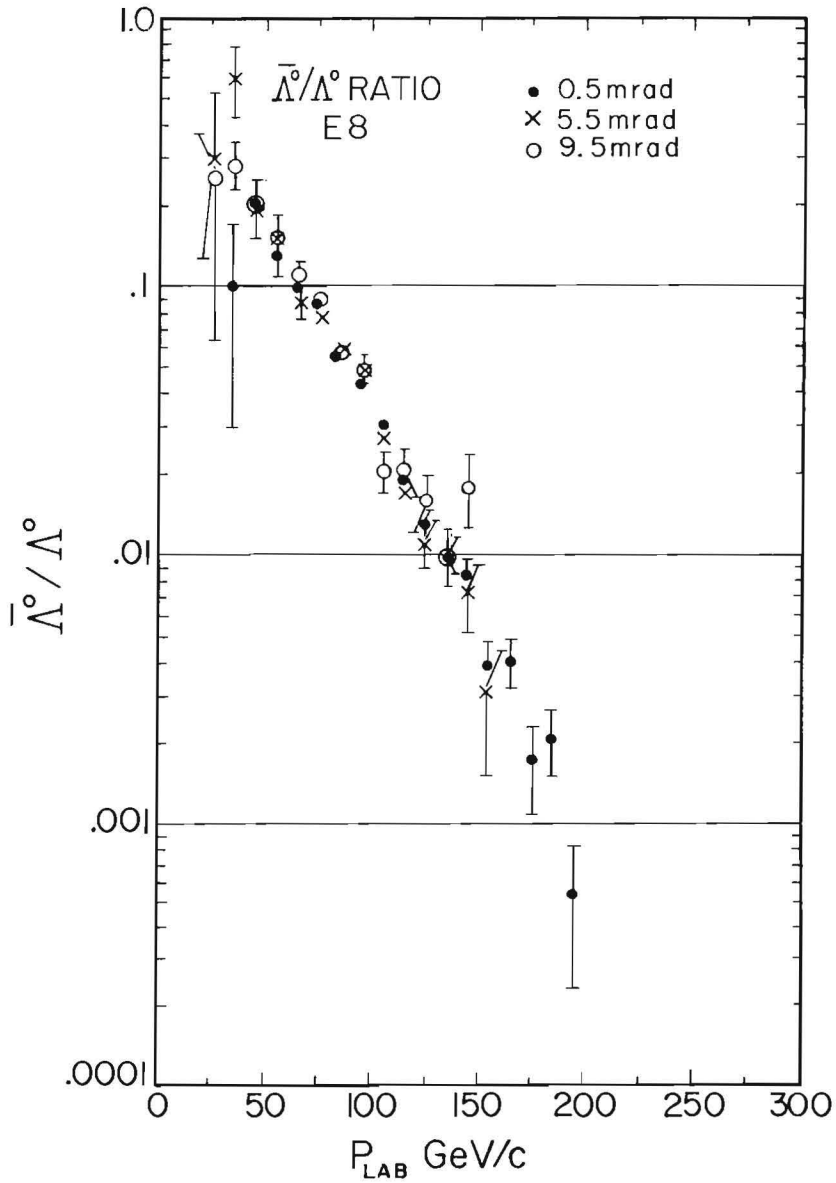
higher energy proton beams, afforded a very exciting opportunity to bring to fruition the hyperon beam technique. In recognition of this potential, the very first round of approved experiments in 1970 included ones to build a neutral hyperon beam (Neutral Hyperon #8) by the Wisconsin, Michigan, Rutgers group, and a charged hyperon beam (Charged Hyperon #97) by the Fermilab-Yale group. It was intended that these experiments be set up sequentially in the diffracted proton beam line (M2) in the Meson Area.

Both of these approved hyperon experiments required a large magnet downstream of the hyperon production target. For the neutral hyperon beam, this magnet has a small straight hole (4 mm in diameter) and a large field

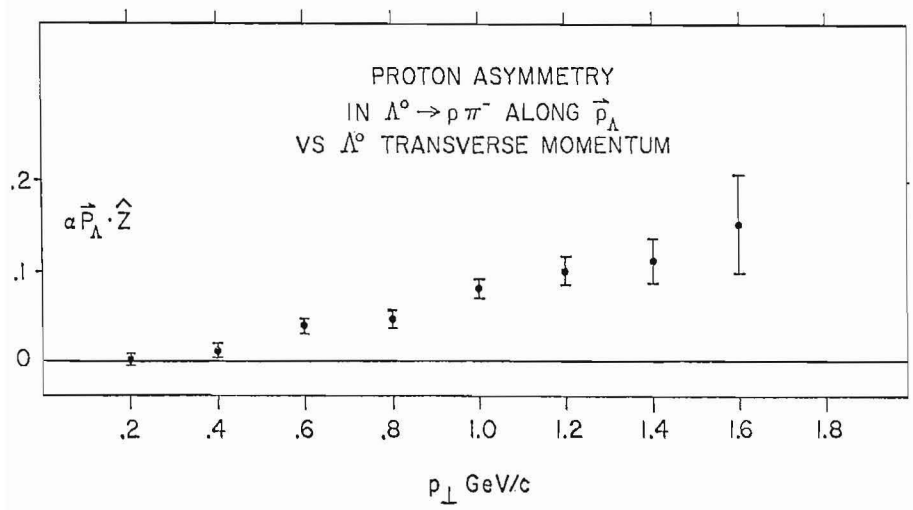
integral (22 kG over 5.4 m) to sweep out the charged particles. In the charged hyperon experiment the straight channel is replaced by a curved one about 1 cm in diameter to provide momentum analysis for the secondary particles and shielding for the downstream detectors. Such a magnet was constructed and the neutral hyperon program began in 1974.

The Neutral Hyperon #8 Program

As part of this workshop, L. Pondrom (University of Wisconsin) gave a progress report on their experiment. One of the first, very comforting observations that they made was that they could get substantial fluxes of Λ^o, $\overline{\Lambda^o}$, and Ξ^o hyperons with very tolerable backgrounds. The experiment is still taking data and although only the earliest results are available, it is clear that exciting physics is emerging. One of the most interesting results is the yield of $\overline{\Lambda^o}$ to Λ^o which is plotted as a function of their momentum and is shown on the next page. The approach to unity of this ratio at low momenta indicates that the production of baryon-antibaryon pairs at Fermilab energies may be an important mechanism for the production of hyperons (and anti-hyperons). The group has also measured hyperon total cross sections as a function of incident hyperon energy. Since the spin orientation of the Λ^o can be determined through the angular distribution of its decay products, it is possible to measure the polarization of the produced Λ^o particles. The measured polarization as a function of $p_\perp$ is shown at the top of page 8. Rotational invariance requires that the polarization be zero in the exact forward direction (for an unpolarized target and projectile) but the existence of substantial polarization just off of the forward direction came as a surprise.



The ratio of $\bar{\Lambda}^o$ to Λ^o yield at 300 GeV incident momentum as a function of hyperon momentum. Note that the ratio increases sharply at low momenta.



Measurement of E8 showing the increasing Λ^0 polarization as a function of their transverse momenta.

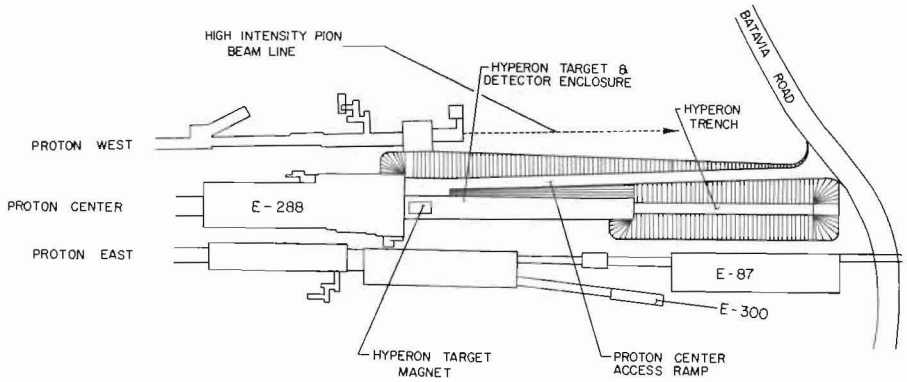
This experiment utilized a beryllium production target but will be repeated using one of liquid hydrogen to see whether the polarization may be due to some complicated nuclear effect. The Neutral Hyperon #8 group will use this polarization to measure the Λ^0 magnet moment to better than 1%.

During the course of the neutral hyperon program a number of facts emerged which led some of us to question the practicality of running the charged hyperon program in the M2 beam line. The Neutral Hyperon #8 group has only scratched the surface of a rich program which should be fully exploited. Already the same group has had two additional experiments approved (Particle Production #415 and Lambda Magnetic Moment #440) and these will further delay the charged hyperon program if it is made to follow the neutral hyperon program in the same beam line. But the problem is

even more serious. The M2 beam was planned to have a spot size of 1 mm and an intensity of 10^{10} protons per pulse. The present beam has a spot size of about 6 mm and an intensity of a few 10^{8} per pulse. This performance is quite acceptable for the present neutral hyperon program but totally inadequate for a charged hyperon beam that really requires a 1 mm beam size (and would profit from an even smaller one) and intensities of 10^{11} to 10^{12} protons per pulse. The M2 beam could probably be made to have this kind of performance, but the price would be high. Additional quadrupoles could probably reduce the spot size to a tolerable value, but massive amounts of shielding would be required to safely achieve the needed intensity. This additional shielding would make it very difficult to have other experiments further upstream in the beam line as there are now. It is these kinds of conflicts which motivated our design of a new hyperon area in the Proton Area for the charged beam and second generation neutral hyperon experiments.

The New Hyperon Area

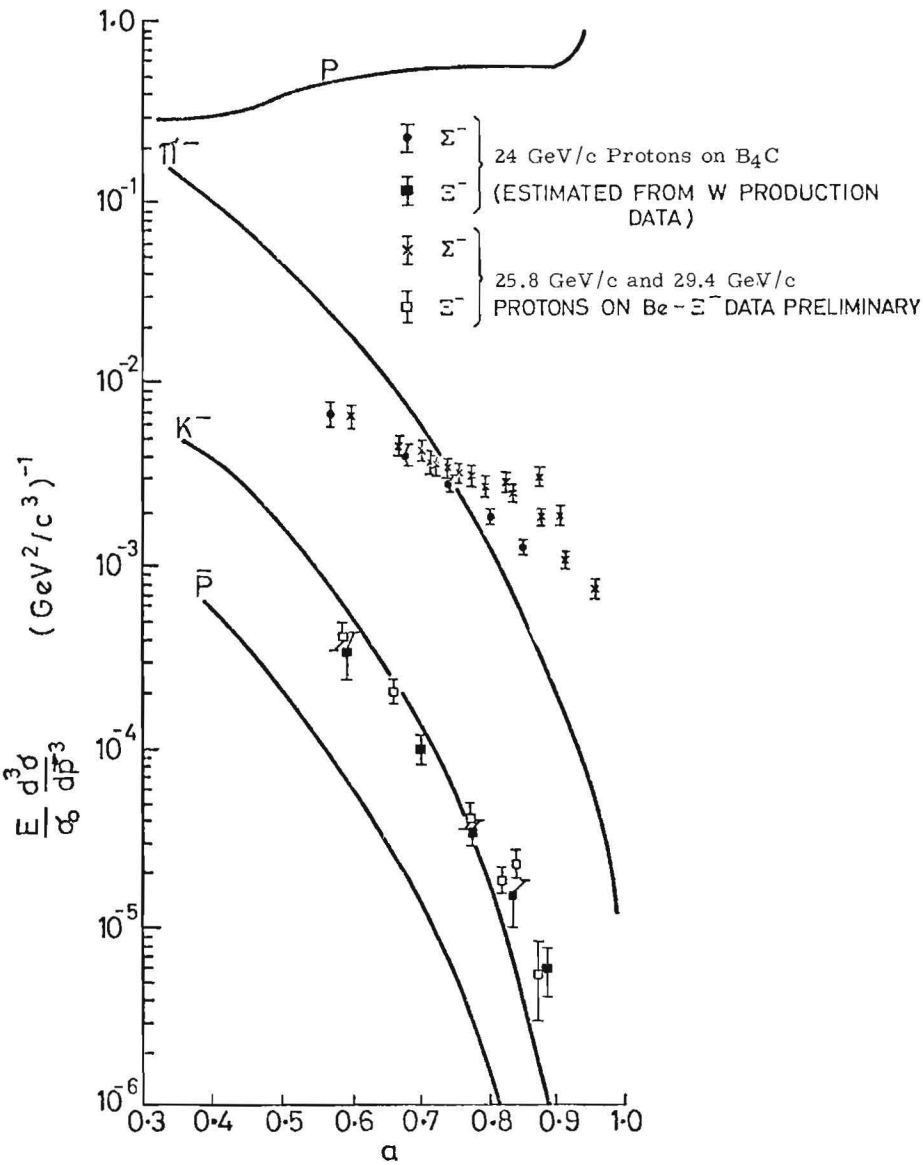
D. Eartly of Fermilab presented a preliminary idea of what the new area might look like. It is shown schematically on the next page and would be located directly downstream of the present Proton-Center pit. The proton beam would be brought through the existing pit and targeted directly in front of a new targeting magnet indicated in the diagram. This magnet would have a removable central section so that channels appropriate for either a charged or a neutral hyperon beam could be installed. The optical design of the charged beam is more complicated than the neutral beam, and a preliminary design has been produced by A. Roberts and S. C. Snowdon.



The new hyperon area and its relation to existing facilities in the Proton Department.

The targeting magnet, as well as the other beam components, would be located in an enclosure about 20 feet wide and 200 feet long. This enclosure would also contain the necessary experimental magnets and most of the detectors although some would extend into a downstream open trench.

Charged hyperon intensity estimates rely on extrapolations from lower energy data summarized on page 11. Here we plot the invariant production cross section in the forward direction as a function of α, the ratio of secondary to primary momentum, for the various particles. When one looks at this plot, one is always impressed by how large the hyperon production cross sections really are. For some kinematic region the Σ^- cross section is considerably larger than the π^- and the Ξ^- is almost identical to the K^-. Data on the Ω^- are very scarce, but what little exist are consistent with the cross section being down from the Ξ^- by the same ratio that the Ξ^- is down from the Σ^-.



The invariant inclusive cross section plotted as a function of the longitudinal laboratory momentum normalized to its kinematic limit for various particles produced in p-Be collisions.

With these cross sections scaled up to Fermilab energies, we can predict the expected fluxes for a given channel design. The design of the charged channel is complicated because its emittance must be matched to a Cerenkov counter detector necessary for the hyperon identification.

In the Roberts and Snowdon design, a pair of quadrupole magnets and a dispersion canceling second dipole are used to achieve a good match. As was done in this study, it is important to consider the channel optics and the Cerenkov counter as a whole to maximize the acceptance of the entire system. The Cerenkov counter cries out for new design ideas and R. Majka (Yale University) spoke on the possibility of utilizing new types of photon detectors which would allow simultaneous detection of Σ^-, Ξ^-, and Ω^-.

Although it is too early to settle on a specific channel design, it is clear that designs exist which would produce very substantial fluxes of hyperons. If we adjust the number of interacting protons to limit the number of hadrons delivered to the experiment to an easily manageable $\sim 10^6$ per pulse, they would include 10^4 to 10^5 Σ^-, 10^2 to 10^3 Ξ^-, and a few Ω^- per pulse. These numbers assume 400-GeV protons incident and secondary momenta in the approximate range of 200 to 300 GeV/c. These are extraordinary hyperon fluxes; the fractional content of Σ^- is comparable to that of K^- in Meson Area beam lines; the Ω^- fluxes would allow one to equal the world sample of Ω^- in one or two minutes!

The data on Σ^+ production are confined to a small amount of bubble chamber information which indicates that the Σ^+ production cross sections are about a factor of two larger than those for Σ^-. If the hyperon channel

polarity is set to accept positive particles, the flux of protons will dominate but one will still be able to achieve Σ^+ fluxes of 10^2 to 10^3 particles per pulse along with 10^6 protons. This is a higher Σ^+ flux than was achieved for Σ^- in the CERN and BNL hyperon beams. The fluxes quoted are those which would be delivered to an experiment and include decay losses.

The major part of the workshop was devoted to discussions of the physics potential of such an area. A major part of the physics is obvious once one has a well defined beam of hyperons. Measurements which were fruitful and exciting with particles such as protons and pions can now be directly transferred to the hyperons. However, the physics possibilities are much richer than this statement implies.

Talks by J. Rosner (University of Minnesota) and C. Ankenbrandt (Fermilab) emphasized the strong interaction aspects, although Ankenbrandt also discussed the intriguing possibility of measuring the Σ^- form factor from scattering from electrons. Certainly it would be feasible to measure the total and differential cross sections for scattering of Σ^-, Ξ^-, and Σ^+ hyperons, also Ω^- but with weaker statistics. To look at a particular feature, such as the total cross section on hydrogen, with projectiles which span the range of strangeness from zero (proton) to -3 (Ω^-) must give more clues as to the role of the strange quark in the baryons. Others equally interesting would include elastic slope parameters and positions of dips or breaks in the elastic slopes.

There is an interesting set of hyperon-induced reactions leading to two-body final states now available to us. Some involve isotopic spin

changes such as $\Lambda p \rightarrow \Sigma^+ n$ or hypercharge exchange such as $\Xi p \rightarrow \Lambda^o \Lambda^o$. Many excited nucleon states have been catalogued but the number of Λ^* and Σ^* states is less complete, much more meager for Ξ^*'s and, of course, non-existent for the Ω^{-*}'s. In the quark model these states must exist, their properties are predicted. It is an important test of the model to see that they do fit the predicted pattern.

B. Lee (Fermilab) and J. Marx (Yale) devoted their talks primarily to the weak interaction potential of the facility. The wide variety of decay modes available to the hyperons provide sensitive probes of the structure of the weak current. Among the most interesting are the semi-leptonic decays; only in a few cases have more than a hundred decays of a particular mode been seen. The decay $\Sigma^- \rightarrow ne^-\nu$ has been studied with moderate statistics ($\sim 10^3$ events) to determine the magnitude of the ratio of the axial to vector form factors. Although the magnitude is in good agreement with the currently accepted Cabibbo theory, some recent analysis indicates the sign may be in disagreement. Looking at other semi-leptonic decays one would be able to provide the consistency tests so necessary to either confirm or modify the theory. Studies of Σ^+ and Σ^- decays to Λ^o will provide sensitive tests for the existence of second class currents. Time reversal violations have never been probed with meaningful sensitivity in the hyperon semi-leptonic decays. The Ω^- will be of great interest since the decay $\Omega^- \rightarrow \Xi^o e^- \nu$ is expected to occur with a very large branching ratio (~1%). We have never seen the weak decay of a member of the decouplet (see page 3).

The two-body radiative decays such as $\Sigma^+ \rightarrow p\gamma$ would provide a sample of events which would allow study of the weak baryon-to-baryon interaction vertex. Present data are based upon a very meager sample (~100) of these events. Lee emphasized that the present theory of the two-body hadronic decays is inadequate and must receive guidance from experiments. One should not overlook the possibility of measuring such a classic quantity as the intrinsic parity. In the article following this one, the possibility of measuring the Ξ intrinsic parity is discussed. It is an exceedingly rich field which would be opened up by this facility and probably the most important discoveries will be those we cannot now foresee. The events of recent years have emphasized the shallowness of our basic understanding, and we should approach this emerging field with openness and imagination.

The progress of CERN charged hyperon beam for their 400-GeV accelerator was described by H. Siebert (Heidelberg University). Their schedule calls for their apparatus to be ready when beam is expected later this year. Their experiments will be set up in the West Area and be limited to accepting only 200-GeV protons. They will begin by looking at the hyperon decay properties.

Reported by J. Lach

[Editor's Note: Fermilab has now made a tentative allocation of funds to construct the new hyperon area. It is hoped that funding will be available to start construction late this year. Being in the Proton Area, it would be able to utilize the highest energy beam available from the accelerator (including beam eventually available from the Energy Doubler/Saver) at intensities limited only by backgrounds in the experimental apparatus. Once started, it will take about 18 months to construct the hyperon area.]

POSSIBILITY OF MEASURING Ξ PARITY

Now that the Σ^0 lifetime has been measured at CERN [the preliminary value for the lifetime is $(0.63 \pm 0.30) \times 10^{-19}$ sec, as compared to the SU(3) prediction 0.8×10^{-19} sec], the only important omissions in the Particle Data Table seem to be the parity of the Ξ's, the magnetic moment of Ξ^0, and various properties of Ω^-, as far as stable baryons are concerned.

There is no doubt in most theorists' minds that the Ξ's are members of the $(1/2)^+$ baryon octet. Nevertheless, experimental verification of this supposition is not only desirable, but imperative. With an intense hyperon beam, the Ξ parity determination may not be too difficult. Let us assume that Ξ (1820) is produced with an appreciable rate and its decays are observed.

The SU(3) systematics assign Ξ (1820) to the $(3/2)^-$ baryon octet which includes N (1520). The spin-parity of Ξ (1820) plays no role in the following discussion, but the known fact that it decays into $\Xi\pi$ and ΛK (also ΣK) is crucial. As usual, we adopt the convention that π and K have the same parity. Irrespective of the relative $\Xi\Lambda$ parity, the decay angular distribution is the same for $\Xi\pi$ as for ΛK. This is related to the Minami ambiguity in πN scattering: if the Ξ and Λ parities are opposite Ξ (1820) decays into ΛK in the $D_{3/2}$ state, but into $\Xi\pi$ in $P_{3/2}$, both of which have the same angular distribution.

What is different, if Ξ and Λ have opposite parity, is that their transverse polarizations are opposite. It is possible to write down a formula (see for example J. D. Jackson's article in High Energy Physics, ed. C. DeWitt and M. Jacob, Gordon and Breach, 1965, p. 341) for the transverse

polarization of the decay baryon in terms of the polarization density matrix of the parent. It is not particularly illuminating, except that it affirms the assertion that the transverse polarization reverses sign under parity change of the decay baryon.

Thus the experiment I envision is a simple one; are the transverse polarizations of Ξ and Λ the same or opposite in the same kinematical configuration in the decaus of Ξ (1820)? The transverse polarization of Ξ or Λ can be measured trivially from the angular distribution of daughters in non-leptonic decays: for the Ξ decay the distribution in angle of the decay Λ is

$$W(\theta) d \cos\theta = \frac{1}{2} (1 - \alpha_{\Xi} \hat{p} \cdot \vec{s}) \, d \cos\theta,$$

where $\vec{s}$ is the polarization of the parent, and $\hat{p}$ is the direction of the decay baryon. Both α_{Ξ} and α_{Λ} are known to be not small.

Reported by B. W. Lee

NOTES AND ANNOUNCEMENTS

SUMMER STUDY ON THE USE OF THE ENERGY DOUBLER/SAVER . . .

Physicists interested in participating in the Summer Study on the uses of the Energy Doubler/Saver should write Joe Lach at Fermilab before April 20, 1976. The study will concentrate on the new physics that will be opened up by the Doubler/Saver, the modifications needed in the present experimental areas and what a new area (the Quark Area) might look like. The number of participants will be limited and each will be expected to participate in the full two-week program (June 28 - July 9, 1976).

WORKSHOPS CANCELLED . . .

It has been decided not to hold the workshop on Elastic Scattering at Large P_t and the workshop on Multiparticle Final State Experiments. The former had been tentatively scheduled for April 15-16 and the latter for May 6-7. Presentations of the proposals that had been associated with these workshops (Elastic Scattering # 301, Elastic Scattering # 347, and Hadron Dissociation # 312) are now tentatively scheduled for the Proposal Presentation Meeting on May 20-21.

It is still the intention of the Laboratory to hold a workshop on second generation experiments for the Multiparticle Spectrometer Facility when the time is ripe. It is now our belief, however, that it would be premature to hold this meeting in May 1976.

WORKSHOP ON EXTERNAL PARTICLE IDENTIFIERS ANNOUNCED . . .

It is tentatively planned to hold a two-day workshop on External Particle Identifiers (EPI) for the 30-in. Bubble Chamber Hybrid Spectrometer Facility

at Fermilab on Friday and Saturday, May 7-8, 1976. The decision to hold this workshop reflects the widespread interest in EPI systems that currently exists in the 30-in. bubble chamber user community. Of the improvements proposed for the 30-in. bubble chamber spectrometer, the Laboratory considers the addition of an EPI system to have the highest priority (as reported in the December 1975 issue of NALREP).

The organization of the workshop program is still quite tentative. One proposal that has been suggested is to organize the discussion around three possible types of systems:

1. Cerenkov counter systems
2. Relativistic rise systems
3. Transition radiation systems

and then to consider each type of system with regard to the following aspects:

1. Operating parameters
2. Acceptance
3. Background sensitivity
4. Gas handling and purity
5. Readout electronics (data handling - on-line computation)
6. Off-line computing
7. Compatibility (gamma ray detection, momentum measurement, etc.)
8. Associated drift chambers (or PWC)
9. Building (size and equipment)
10. Maintenance requirements (number of people, difficulty)
11. Safety
12. Construction and initial test schedule

The workshop will be open to all interested physicists. For further information or to convey suggestions regarding the content of the meeting, contact T. Groves in the Director's Office, Ext. 3211.

NALREP EDITORIAL STAFF CHANGES . . .

There have recently been a number of changes in the editorial staff for NALREP. Nancy Stiening has resigned as Assistant Editor to accompany her husband to CERN and her skilled talents will be missed. Rene Donaldson who has helped in the preparation of NALREP from its beginning has assumed the duties of Assistant Editor and will be available to help authors with their manuscripts. She can be found in the Publications Office, and reached on telephone extension 3278.

Jim Sanford who serves as Editor of NALREP as well as Associate Director for Program Planning will be leaving Fermilab in the near future. Frank Cole has been appointed as Editor and will assume his duties with the April issue. Sanford will become an Associate Director of Brookhaven National Laboratory and head of the ISABELLE storage ring project.

APPOINTMENTS . . .

Tom Nash has been appointed Head of the Internal Target Group, effective April 1, 1976, replacing J. Walker who will now concentrate on research interests.

FOR THE COMING YEAR. . .

Members of the Board of Trustees of Universities Research Association for the coming year include:

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FACILITY UTILIZATION SUMMARY--FEBRUARY 1976

A new milestone in accelerator operation was achieved when beam was very successfully and smoothly slow spilled over a 2-sec flattop at 300 GeV, during a 2-week running period in the latter part of February. A 1 sec front porch at 200 GeV was added to this 300-GeV cycle for an additional 1-week run, beginning the last weekend in the month, which provided beam for nearly 3 sec during each main-ring cycle. In this operating mode, 200-GeV beam was extracted to the Proton Area only, while all external experimental areas received the long 300-GeV beam spill. The runs at lower energy, originally planned for later in the current running period, were rescheduled on February 12 after an electrical flashover seriously damaged an overhead 13.9 kV secondary busduct coming from the main ring pulsed power transformer at the Master Substation. Accelerator operation was continued by using the backup transformer and redistributing main site and experimental area electrical loads. The intensity requirements for the high energy physics research program at 200 and 300 GeV were mostly below the 10^{13} protons/pulse level, contributing greatly to the stability and uniformity of the long beam spill throughout this period. The only major interruptions resulted from the failure in series of 2 main-ring magnets shortly after the initial 300-GeV startup and another rash of failures during the 200/300 GeV front porch startup at the end of February.

At the beginning of the month, 400 GeV slow spill was being delivered to all experimental areas. In addition, fast spill and "pinged" beam was available for the Neutrino Area horn target and bypass beamline respectively

during the period that the 15-ft bubble chamber was operational. The overall operating efficiency of the accelerator for the high energy physics research program was at the highest level for any month since last June, namely 77%. This is particularly significant since it represents the combined results of three distinctly different accelerator operating modes, and including necessary setup time, to meet the requirements of the program.

Running for Di-Lepton 288 in the Proton Area continued to receive the highest priority during almost three weeks of electron-positron pair production data collection at high masses. The P-Central Area was then turned off for one week to modify the experiment for collection of high mass di-muon data; tuneup of the apparatus had begun by month's end. Throughout February Particle Search 300/325 collected data in Proton-East using 400, 300, and later 200-GeV beam, as available, on liquid hydrogen and a series of solid targets. Simultaneously, in Proton-West, Elastic Scattering 177A completed tuneup activities by mid-month and began collecting elastic scattering data in the high-momentum transfer region off hydrogen, using 300 GeV incident protons.

The Neutrino Area program was arranged to continue the emphasis, as of the end of January, on both antineutrino and hadron physics using the 15-ft bubble chamber. Unfortunately, circumstances developed that prevented substantial progress on this aspect of the research effort. Two days after startup, following beamline magnet repairs, the 15-ft chamber became inoperative because of a plugged cooling loop and malfunction of the piston seals. The repair required a major disassembly of the chamber and removal

of the piston. When investigation revealed no basic cause for the trouble, it was decided to reassemble the chamber, using the steel piston, in preparation for running with a heavy neon mixture. This work was still in progress at the end of February. As a result, less than 60 hours of 15-ft bubble chamber operation were achieved this month when beam was available. During this time, 15-ft $\bar{\nu}/H_2$ 31A accumulated some 19.6K pictures, while 15-ft π^--p @ 360 GeV # 384 also obtained another 11.1K. Tachyon Monopole 202 took cosmic-ray data during this period, making use of the chamber magnetic field. Lead glass counter tests were also performed during parasitic running by 30-in. Hybrid # 299, using the bypass beam in Lab E after the 15-ft chamber failure. As planned, Di-Muon 331 accumulated data in the N1 (muon/hadron) beam using slow spill on the horn target to produce hadrons. For the first week, the N1 beam was tuned for +220-GeV/c particles, followed by running with negative beam for an additional ten days, at which time the Neutrino Area was shut down for the remainder of February. The lack of 400-GeV protons coupled with the 15-ft bubble chamber difficulties combined to make continued operation "highly" marginal.

In the Meson Area, Inclusive Scattering 324 collected data in the M1W beam for nearly two weeks after which π Dissociation 86A began beam and equipment tuning and trigger studies in M1E, followed by data taking. In M2, Photon Inclusive completed their data taking work by mid-month and Neutral Hyperon 8 then used the beam for the accumulation of Λ-p scattering data. Particle Search 397 collected data in the M3 line for most of February; Particle Search 366 took control of the beam and began their tuneup activity

during the last several days of this period. Throughout the month, K^0 Regeneration 425 continued their steady run in M4, using the liquid hydrogen target, while Elastic Scattering 69A collected data smoothly in the M6W beam. Nuclear Chemistry 81A parasitically exposed seven (7) targets in the primary beam in Meshall this month. Beam intensity on the Meson target continued to be limited during February to 1.5×10^{12} protons/pulse by the continuing C2 collimator cooling problem. It is expected that the target train will be repaired at the next major shutdown in March and April.

The research program activity in the Internal Target Area was carried out centered primarily on the data collection work by Proton-Proton Inelastic 321, using their warm 3 mil hydrogen gas jet. They single pulsed the jet at various accelerated beam energies and by the end of February had successfully taken some data using a double-pulsed operating mode. Proton-Nucleon Scattering 198A and Polarized Scattering 313 used some beam time with the rotating target to continue testing counters and multiwire proportional chambers for their experimental setup. Considerable effort was also invested in preparing their new warm gas jet for installation in the tunnel at the end of March and readying the superconducting dipole and quadrupole magnets for full operation on the spectrometer arm.

Reported by H. Allen

I. Summary of Accelerator Operations

		Hours	
A.	Accelerator use for physics research		
	Accelerator physics research	55.3	
	High energy physics research	449.7	
	Research during other use	(38.6)	
	Subtotal		505.0
B.	Other activities		
	Accelerator setup and tuning to experimental areas	6.0	
	Scheduled interruption	45.6	
	Unscheduled interruption	139.4	
	Subtotal		191.0
C.	Unmanned time		
	Total		696.0

II. Summaries of High Energy Physics Research Use

		# of Expts.	Hours	Results
A.	Counter experiments	16	3322.4	
B.	Bubble chamber experiments	2	102.9	30,761 pictures
C.	Emulsion experiments	-		
D.	Special target experiments	1	-	7 targets
E.	Test experiments	1	45.9	Pb Glass Counter
F.	Engineering studies and tests	-		
G.	Other beam use	-	14.0	
		20	3485.2	1 expt. completed

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

A.	Beam accelerated in Main Ring		@400 GeV	0.728	
			@300 GeV	0.982	
					1.710
B.	Beam delivered to experimental areas				
	Meson Area		@400 GeV	0.088	
			@300 GeV	0.166	
				0.254	
	Neutrino Area				
		Slow	@400 GeV	0.234	
			@300 GeV	0.336	
		Fast	@400 GeV	0.223	
				0.793	
	Proton Area				
			@200 GeV	0.031	
			@300 GeV	0.223	
			@400 GeV	0.056	
				0.310	
		Total			1.357

IV. Beam Utilization by Experiment

	Hours	
A. Meson Area		
Neutral Hyperon # 8	240.7	Data
Elastic Scattering # 69A	326.8	Data
Nuclear Chemistry # 81A	-	7 Targets bombarded
π Dissociation # 86A	202.7	Trigger studies and data
Inclusive Photon # 268	168.3	Data, completed
Inclusive Scattering # 324	128.3	Data
Particle Search # 366	126.2	Setup and preliminary data
Particle Search # 397	191.6	
K^0 Regeneration # 425	353.1	Data
B. Neutrino Area		
15' Antineutrino/H_2 # 31A	59.6	19.6K pictures
Tachyon Monopole # 202	-	Cosmic-ray data
30" Hybrid # 299	45.9	Lead glass tests
Di-Muon # 331	205.2	Data
15' π^--p @360 GeV # 384	43.3	11.1K pictures
C. Proton Area		
p-p Elastic # 177A	284.6	Data
Di-Lepton # 288	349.9	Data
Particle Search # 300/325	360.7	Data
D. Internal Target Area		
p-N Scattering # 198A	81.4	Tests
p-p Polarization # 313	81.4	Tests
p-p Inelastic # 321	221.5	Preliminary data
Total	3471.2	

MANUSCRIPTS AND NOTES PREPARED DURING JANUARY AND FEBRUARY 1976

Copies of preprints with Fermilab publication numbers can be obtained from the Publications Office or Theoretical Physics Department, 3rd floor east, Central Laboratory. Copies of some articles listed are on the reference shelf in the Fermilab Library.

Experimental Physics

A. R. Erwin et al. Experiment #2B	Search for a Difference Between the Strange and Nonstrange Quark of the K^+ Meson
M. Derrick et al. Experiment #31A	A Study of High Energy Antineutrino-Proton Interactions
Ø. Scheidmann and N. T. Porile Experiment #81	Production of Sc and Ga Nuclides in the Interaction of ^{238}U with 1-300 GeV Protons (Submitted to Phys. Rev. C)
M. I. Adamovich et al. Experiment #183	Distributions of Rapidity Intervals and Their Significance in Understanding Clusters
M. I. Tretyakova et al. Experiment #183	Clusters and the Rapidity Interval Method
M. I. Tretyakova Experiment #183	Experimental Data on Inelastic Proton-Nucleon Interactions at 200 GeV
M. Teranaka and T. Ogata Experiment # 251	Hypothesis of Shrinking Interaction Volume in High-Energy Proton-Nucleus Inelastic Collision [Prog. Theor. Phys. 54, 1727 (1975)]
J. Alspector et al. Experiment #254	Experimental Comparison of Neutrino and Muon Velocities at Fermilab
D. C. Hom et al. Experiment #288	Observation of High Mass Dilepton Pairs in Hadron Collisions at 400 GeV (FERMILAB-Pub-76/19-EXP; submitted to Phys. Rev. Lett.)

Theoretical Physics

S. D. Joglekar and B. W. Lee	General Theory of Renormalization of Gauge Invariant Operators (FERMILAB-Pub-75/50-THY; submitted to Phys. Rev. D)

R. E. Schrock and B. W. Lee	Estimates of Charm Production in Exclusive Neutrino Reactions (FERMILAB-Pub-75/80-THY; submitted to Phys. Rev. D)
C. Quigg and E. Rabinovici	SU(3) Content of the Pomeranchuk Singularity (FERMILAB-Pub-75/81-THY; submitted to Phys. Rev. D)
U. Maor	Diffractive b-Space Peripherality and Nuclear Coherent Production (FERMILAB-Pub-75/82-THY; submitted to Phys. Lett.)
C. H. Albright	Evidence Against 1.8 GeV/c^2 Heavy Charged Muons (FERMILAB-Pub-75/91-THY; submitted to Phys. Rev. Lett.)
B. W. Lee	Possibility of Measuring Ξ Parity (FERMILAB-76/14-THY/EXP)
T. Appelquist et al.	Infrared Finiteness in Yang-Mills Theories (FERMILAB-Pub-76/16-THY; submitted to Phys. Rev. Lett.)

General

J. Lach	Small Angle Elastic Scattering (FERMILAB-Conf-76/15-EXP; invited talk at the Triangle Conference on High Energy Particle Interactions, Bratislava, Czechoslovakia, November, 1975)

Physics Notes

C. Pellegrini and A. G. Ruggiero FN-285	A 60x60 GeV^2 Electron-Positron Storage and Colliding Device. An Alternative to the Several Hundred GeV Proton-Proton Projects
M. Atac et al. FN-286	A Two-Dimensional Readout Drift Chamber with Printed Circuit Delay Lines
D. E. Johnson FN-287	MESSYMESH - A Computer Program to Calculate Linear Accelerator Cavity Fields
A. F. Greene and J. R. Sanford FN-288	The Status of Experiments at Fermi National Accelerator Laboratory (Submitted to Nucl. Instr. and Methods)

DATES TO REMEMBER

April 3, 1976	Fermilab Auditorium Arts Series: Chicago Brass Ensemble. Admission $3.00; tickets available in Guest Office.
April 30, 1976	Fermilab Auditorium Arts Series: "The Adventures of Huckleberry Finn--Part I" performed by the Organic Theater. Admission $3.00; tickets available in Guest Office.
May 7, 1976	Deadline for receipt of new proposals and other written materials to be considered at the Extended Summer Meeting of the Program Advisory Committee.
May 7-8, 1976	Workshop on External Particle Identifiers.
May 14-15, 1976	Annual Meeting of the Fermilab Users Organization.
May 20-21, 1976	Proposal Presentation Meeting.
May 21, 1976	Fermilab Bicentennial Lecture Series: "The Carbon Isotopes and the Rise of American Biochemistry." Dr. Martin Kamen, University of Southern California. No charge; tickets are required and may be obtained in the Guest Office.
June 19-25, 1976	Extended Summer Meeting of the Fermilab Program Advisory Committee (Aspen, Colorado).
June 28 - July 9, 1976	Summer Study on the Use of the Energy Doubler/Saver.