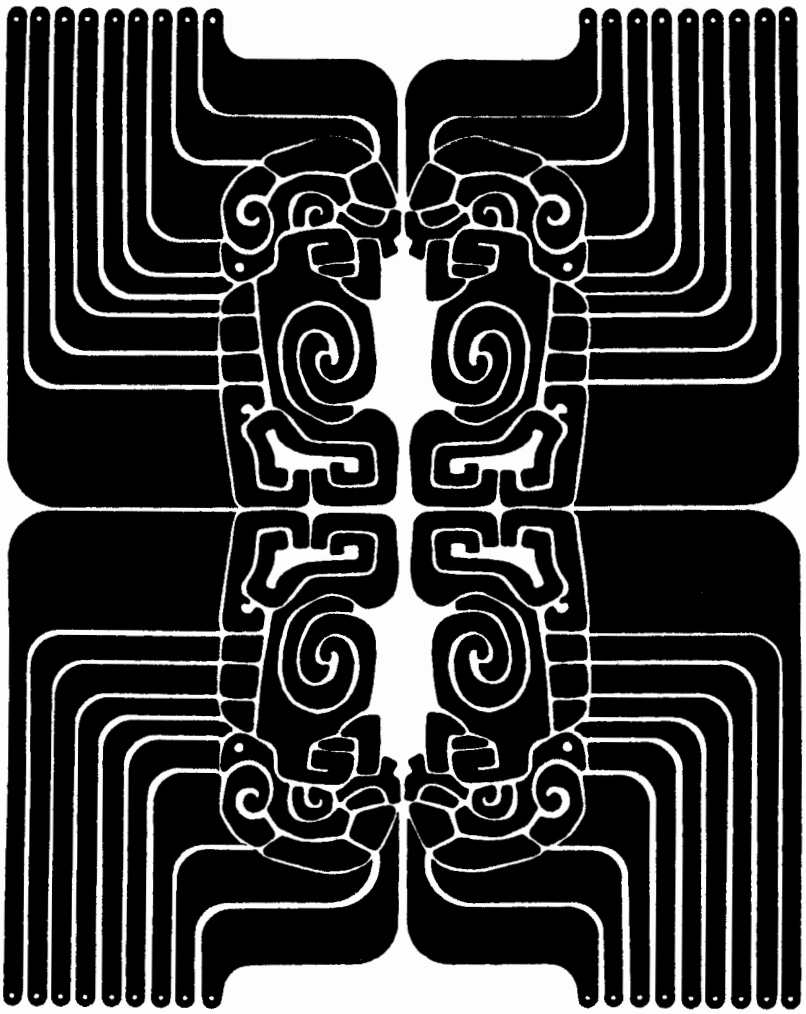
fermilab report

Fermi National Accelerator Laboratory Monthly Report

March/April
1987



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On the cover: The cover design for the *Proceedings of the Symposium on Recent Developments in Computing, Processor and Software Research for High-Energy Physics* [eds. R. Donaldson and M.N. Kreisler] held at Guanajuato, Mexico, on May 8-11, 1984. The Symposium, co-sponsored by CoNaCyt (Mexico), Fermilab, the National Science Foundation, Secretaría de Educación Publica, Universidad de Guanajuato, Universidad de México University of Massachusetts at Amherst, and the U.S. Department of Energy, is one example of the inter-American physics activities discussed in the article "U.S.-Latin American Cooperation in Physics: The Fermilab Experience" which begins on page 5. (Original cover design by Angela Gonzales)

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CP Violation in K_S^0 Decay - Experiment 621

Gordon B. Thomson
Rutgers, The State University of New Jersey

The E-621 Collaboration
P. Border, P.-M. Ho, M. Longo, O. Overseth
University of Michigan
J. Duryea, K. Heller, N. Grossman,
C. James, M. Shupe, K. Thorne
University of Minnesota
A. Beretvas, A. Caracappa, T. Diehl, T. Devlin
U. Joshi, K. Krueger, P. Petersen, S. Teige
Rutgers, The State University of New Jersey

Experiment 621 was the first experiment in the Proton Center beamline to run using 800-GeV/c protons. In preparation for the higher energies, a new focusing enclosure was built just south of the Proton Lab Pagoda (called the PC2 Enclosure), and extensive modifications were made to the whole Proton Center beam. We have now completed our approved experimental program. We wish to thank the Laboratory very much for all the enthusiastic help we received in the design, setup, and running of the experiment.

CP symmetry nonconservation in the weak interaction has been found only in four K_L^0 decays, to $\pi^+\pi^-$, $\pi^0\pi^0$, $\pi e\nu$, and $\pi\mu\nu$. Our experiment is looking for CP violation in the next easiest place to find it: in the decay $K_S^0 \to \pi^+\pi^-\pi^0$. We are measuring η_{+-0}, defined to be,

$$\eta_{+-0} = \frac{\mathrm{Amp}(K_S^0 \to \pi^+\pi^-\pi^0)}{\mathrm{Amp}(K_L^0 \to \pi^+\pi^-\pi^0)}$$

It is easy to make a beam of K_L mesons to study their CP violating decays, just go far from the production target so that the K_S are all gone. For our case, that trick doesn't work, and we therefore look for CP violation close to the target, in K_L-K_S interference. To see CP violation we must see a deviation from pure exponential behavior in the time evolution of $\pi^+\pi^-\pi^0$ decays.

If we study the time dependence of $\pi^+\pi^-\pi^0$ decays by collecting data and dividing by the acceptance of the detector, as calculated by a Monte Carlo

simulation, we would be limited to an accuracy in $|\eta_{+-0}|$ of about .005. We instead decided to measure our acceptance by using two targets to produce the kaons. One target was located at the entrance to the P-Center Hyperon Magnet, which is 7.2 m long, with a field of 35 kG. A collimator with a straight hole in the magnet made a beam of neutral particles: gamma rays, neutrons, Λ^0 and Ξ^0 hyperons, and kaons. The second target was located 25 m upstream of the magnet, and produced a beam aimed at a second hole in the Hyperon Magnet collimator. From the downstream target we measure the K_L-K_S interference; from the upstream target, we detect almost pure K_L decays because of the falling time exponential factor in the interference term, and measure our acceptance. To minimize systematic errors due to rate differences, we split the P-Center beam into two proton beams (using an electrostatic septum and two Lambertson magnets) and struck both targets simultaneously. The beam design is described in Fermilab Technical Memo TM-1144 (unpublished).

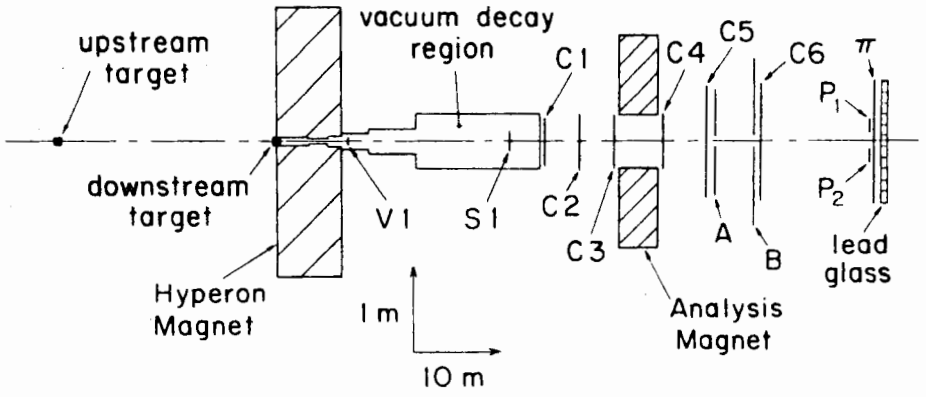

Figure 1. Targets, Hyperon Magnet, and detector for E-621.

Figure 1 shows the targets, Hyperon Magnet, and our vee spectrometer. It consisted of a vacuum decay region defined by scintillation counters (run in the vacuum) at both ends; six multi-wire proportional chambers (MWPC); a spectrometer magnet; three hodoscopes of scintillation counters; and an array of 86 lead-glass blocks. We triggered on a neutral particle decaying in the decay pipe; required two hits in each of the A and B hodoscopes, one on the left and one on the right; and demanded that each of three trigger processors gave a "yes" vote on the event.

The first trigger processor used commercial CAMAC memory look-up units, into which were fed signals from the A and B hodoscopes. Here we picked out decays where the π^+ and π^- positions were symmetric about the beam. $\pi^+\pi^-\pi^0$ decays are symmetric in this way, while one of our background decays, $\Lambda^0 \rightarrow p\pi^-$, is asymmetric. The second trigger processor also aimed at the same criterion, but used fast outputs of our MWPC's. We built a circuit, using ECL computer chips, that chose MWPC hits using a priority scheme, calculated the slopes of tracks behind the analysis magnet, and chose symmetric patterns. The third trigger processor used advanced TTL logic IC's, and counted clusters of hits in our lead-glass array. The pi-hodoscope just in front of the lead glass consisted of scintillation counters the size of rows of the lead-glass counters. By comparing hits in the pi-hodoscope with hits in the lead-glass array, it chose events with two or more neutral particles showering in the lead glass.

In April 1984, when the TEVATRON first delivered 800-GeV/c protons, our experiment was the first to take them. We tuned up our spectrometer and collected data for the rest of the run, amassing 200,000 $\pi^+\pi^-\pi^0$ events. From what we learned from this running, we made improvements to our beamline, spectrometer shielding, and trigger, and took data in the whole 1985 run, collecting 3,200,000 $\pi^+\pi^-\pi^0$ events. The 1985 run did not go as smoothly for us as we would have liked: part of the cable run from the experiment to our electronics trailer, going over the Proton-West berm, was struck by lightning, frying some of our electronics; and a terrorist woodchuck who lived in the Proton-West berm attacked some of these same cables. He was trapped and released in the middle of the ring.

As this article is being written, analysis of the two data sets is going on in parallel. To use a musical analogy, the analysis of the 1984 data is entering its coda, while the 1985 data is still in the first movement. For the 1984 data, our expectations of negligible background, and ability to measure the acceptance of the spectrometer are being borne out very well. Up to this point we have put 101,000 events into the proper time histogram, and have not found the bumps and wiggles that would signal CP violation. We can put an upper limit on $|\eta_{+-0}|$ of about 0.03. We feel that our final results will be a factor of 2 more accurate. The world's previous data consists of two experiments with about 400 events each, plus several experiments of considerably smaller statistics. The Particle Data Group summarized their results as $|\eta_{+-0}| < 0.35$.

The trigger used in the data collection in 1985 was biased more toward high-momentum events, which are more sensitive to CP violation. This and the factor of 32 more events leads us to expect an order of magnitude greater sensitivity when this analysis is complete.

Theoretical predictions of $|\eta_{+-0}|$ vary from .002 to .004, and if we have an uncertainty of .003 we might be close, but will have won no cigar. Our thought is that in this case we will go for more statistics. In E-621 we targeted the proton beams at a few tenths of a milliradian, and if we rotate the Hyperon Magnet to hit the targets at 3 mrad, the main backgrounds of gamma rays and neutrons will be reduced greatly. We would also build a new, larger spectrometer to maximize our acceptance. So it is quite possible that we will propose a "son of E-621" soon.

U.S.-Latin American Cooperation in Physics: The Fermilab Experience*

Roy Rubinstein

Introduction

This article reviews the current status of Fermilab's cooperation program with Latin American physics institutions. It is a program started about six years ago; we know that Fermilab has benefited from it (for example, by having skilled Latin American physicists and engineers work at the Laboratory), and we hope that it has assisted the growth and progress of Latin American physics. Except for our commitment to this goal, the program is not unique - other U.S. institutions can - or have - undertaken some of the same activities. A major aim here is to stimulate discussion of what has been accomplished, and to solicit ideas for future activities.

Background

The program was initiated by Fermilab Director Leon M. Lederman with the goal of assisting the growth of Latin American physics, and particularly (in keeping with Fermilab's mission) of stimulating the study of high-energy physics (HEP) in the region. Inspired by the success of Abdus Salam's Theory Institute for developing-country scientists in Trieste, the hope was that Fermilab (in coordination with other national labs) could provide the same service for experimental science, concentrating on Latin America for the obvious advantages of cultural and geographic proximity. Latin America already has many centers of excellence and many talented physicists, so that these goals seem realistic.

The reasons why less-developed countries should become active in physics have been the subject of many reports and conferences, and we will not repeat the discussions here; among the reasons cited are that in any country, physics is the basis for much technology, with the corollary that a strong physics community is necessary for technological strength and self-sufficiency. The rationale for HEP activities in such countries may be less obvious. One reason frequently cited is the significant technological "spin-off" from the field. In addition, training in HEP, which to a significant extent is training in problem solving, is much valued by other fields. In the U.S., for example, many new HEP Ph.D.'s

*Based on a talk given at Escuela Latinoamericana de Fisica, UNAM, Mexico, 30 July, 1986.

are hired away either by industry or by other branches of physics. Fields such as communications, synchrotron radiation, computers, etc., all have significant numbers of HEP Ph.D.'s.

Some concern has been expressed about the effectiveness of an institution, new to HEP, joining in one of the large collaborations now common in the field. The number of physicists from a single institution taking part in an HEP experiment does not have to be large, and this allows a new group to become established. Although this seems a paradox in view of the 200-person teams now active, each team carrying out an experiment is composed of subgroups of physicists (typically from 1-20 physicists per subgroup) from different institutions. Each subgroup is generally responsible for a particular piece of the experiment, but all take part in the analysis and physics interpretation.

Fermilab and International Activities

Fermilab, with its 900-GeV (eventually 1000-GeV) proton synchrotron used for fixed-target experiments and as a $\bar{p}p$ collider, opens its facilities to all users, with the criteria for acceptance of a research proposal to use these facilities being the scientific merit and technical competence of the proposal. Involved in the currently approved experimental program are 890 physicists and students from 79 U.S. institutions, together with 350 physicists and students from 62 non-U.S. institutions; these latter institutions are located in 17 different countries. In order to serve these foreign scientists (and their frequently accompanying families), Fermilab provides English language classes, has a foreign-visitor desk for scientists, and also a visitor's office to assist their families; in addition, a limited amount of housing for the visiting scientists and their families is available on the Fermilab site.

There are, of course, limitations on Fermilab's ability to help physics in other countries. The Laboratory is funded by the U.S. government through its Department of Energy in order to provide facilities for HEP research; the funds can only be used for this mission, although with some flexibility in interpretation. Fermilab is not a funding agency (like NSF, OAS, UNESCO, etc.), nor is it a university with undergraduate training and degree programs.

There are many areas (in addition to HEP) where Fermilab has expertise and can collaborate with Latin American institutions; among them are superconductivity, cryogenics, advanced computer processors, microprocessor control systems, radiation and environmental safety, neutron and proton therapy, rf engineering, HEP theory, astrophysics, etc., etc.

Brief History of Fermilab's Latin American Activities

In 1981, Lederman visited UNAM, Mexico; amongst the topics discussed was HEP activity at UNAM and in other Mexican institutions. These discussions led to the January 1982 Pan-American Symposium on High Energy Physics and Technology, held at Cocoyoc, Mexico; Fermilab was one of the organizers and sponsors of this symposium. There were about 50 attendees from Latin America, the U.S., and Europe, including such as J. Flores, M. Moshinsky, S. Glashow, J. Bjorken, and G. Charpak. In addition to the invited talks, there were extensive group discussions on HEP and its sociology, and also on the prospects for this activity in Latin America; the meeting gave specific encouragement to the formation of the UNAM HEP group led by C. Avilez.

A September 1982 visit by Lederman to Brazil was followed by the Second Pan American Symposium, held in Rio de Janiero in July 1983; again, Fermilab was one of the organizers and sponsors. The meeting topic was broader than at Cocoyoc, involving branches of physics other than HEP, and also encompassing collaboration between physics and industry. The meeting was one factor leading to the formation of a Brazilian HEP group (A. Santoro from CBPF and C. Escobar from Sao Paulo). Another important outcome was the request to the U.S. NSF for a grant to aid physics in Latin America; this is discussed further below.

A third symposium in this series will be held in Rio de Janiero, Brazil, in 1987.

Fermilab Latin American Activities

We give here short descriptions of the activities carried out up to the present time.

Sponsorship of Meetings in Latin America

We have already mentioned Fermilab's co-sponsorship of the Cocoyoc and Rio de Janiero meetings; there was also co-sponsorship of a 1984 meeting in Guanajuato (Mexico) on advanced computers in HEP. For all of these meetings, Fermilab provided some financial support, help in the organization of the meeting, assistance in obtaining financial support from U.S. funding agencies, and assistance in obtaining U.S. speakers (including those from Fermilab). For the Guanajuato meeting, Fermilab helped, in addition, to produce the conference proceedings.

Simposio Panamericano de
Panamerican Symposium on
Física de Partículas Elementales y de Tecnología
Particle Physics and Technology

Enero 5, 6 y 7 de 1982 Cocoyoc, Morelos, México
January 5, 6 and 7, 1982 Cocoyoc, Morelos, Mexico

Entre los Participantes Estaran
Partial List of Participants

J. D. Bjorken • G. Cocho • J. Cronin • R. P. Feynman • C. García Canal • S. Glashow • L. Lederman
J. Leite Lopes • R. Marshak • M. Moravcsik • W. Panofsky • B. Richter • R. Salmeron • R. R. Wilson

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Apdo. Postal 20-364, México 20, D.F.

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Fermi National Accelerator Laboratory, Batavia, Illinois

Fermilab Staff to Latin America

Many Fermilab physicsts have given seminars and lecture courses at Latin American institutions. A partial list follows:

J. Bjorken	CINVESTAV, Mexico - Course on particle physics
I. Gaines	Rio de Janiero, Brazil - Seminars on the Advanced Computer Program
R. Huson	Tegucigalpa, Honduras - Course on particle physics; advice on cosmic ray experiment
	UNAM, Mexico - Sabbatical
H. Johnstadt	Sao Paulo, Brazil - Seminars on HEP software development
H. Jöstlein	Bogota, Colombia - Course on vacuum techniques
E. Kolb	Rio de Janeiro, Brazil - Course on astrophysics
R. Rubinstein	Tegucigalpa, Honduras - Course on particle physics techniques; suggestions for physics thesis topics
M. Sokoloff	Rio de Janeiro, Brazil - Three months helping with analysis of collaboration experiment
L. Voyvodic	La Paz, Bolivia; Rio de Janeiro, Brazil - Talks on the interface of cosmic ray and particle physics
A. Wehmann	UNAM, Mexico - Sabbatical

Lectures at recent physics schools in Mexico have been given by R. Dixon, C. Hojvat, E. Kolb, R. Raja, and R. Rubinstein.

So far, all the topics of these visits have been physics related; recently, interest has been expressed in also having Fermilab speakers on engineering topics visit Latin American institutions.

Payment of the costs for these trips has been negotiated in each case between Fermilab and the receiving institution.

Theoretical Physics and Theoretical Astrophysics Visitors

Fermilab has had a program for many years for a limited number of visits by theorists from other institutions to its Theoretical Physics Department and Theoretical Astrophysics Group; these visits are usually, although not exclusively, during the summer months. Theorists from many foreign countries have taken part, including Mexico, Honduras, Brazil, and Argentina.

Ph.D. Students in HEP

CINVESTAV (Mexico) currently has three graduate students (H. Mendez, A. Morelos, and G. Moreno) working towards their Ph.D.'s on experiments at Fermilab; all had previously completed their Ph.D. course requirements at CINVESTAV. They now work under the supervision of Fermilab physicists,

who provide periodic progress reports to CINVESTAV. Assuming that the students' research is satisfactory, they will eventually receive CINVESTAV Ph.D.'s. Some of them had previously spent a summer working at Fermilab, before deciding that they wanted to do experimental HEP research. Fermilab has provided accommodations and some salary for the students.

HEP Groups

UNAM - Mexico: This group is led by C. Avilez, who had previously worked in theoretical particle physics. They have taken part in a just-completed Brookhaven National Laboratory experiment on $n+p \rightarrow \Omega^-$, etc., and are on an approved Fermilab experiment (E-690) studying charm hadroproduction. Avilez and an engineer have spent one-year sabbaticals at Fermilab. In addition to their HEP experiments, the group is also undertaking an ion-source development project, and assistance and information on this topic has been made available by Fermilab. (The history and experiences of the UNAM group was the subject of an invited talk by Avilez at the 1986 APS Washington Meeting.)

Brazil: This group of physicists from CBPF, Rio de Janeiro (J. Anjos, A. Santoro, M. Souza) and Sao Paulo (C. Escobar) is also composed of former theoretical physicists. Those mentioned spent two years at Fermilab working on a charm photoproduction experiment (E-691), and learning the techniques of experimental HEP. In their early days, this group, like their Mexican counterpart, had some difficulties in obtaining adequate financial support from their funding agencies, but now this appears to be more assured. They have borrowed equipment from Fermilab, and are in the process of setting up a lab at CBPF to construct and test equipment for future experiments. Currently they are analyzing data at CBPF from the photoproduction experiment, and are exploring the possibility of a computer link to Fermilab. An engineer from their group spent several months at Fermilab working on the Advanced Computer Program.

The CBPF group is now involved in an upcoming Fermilab experiment on hadro-production of charm (E-769); two graduate students are currently here preparing for the experiment, and the senior members will spend periods of several months at Fermilab during the coming year. Discussions are under way on the group joining the D0 detector collaboration, which is building the large second-generation detector to study $\bar{p}p$ collisions.

C. Escobar, of Sao Paulo, has joined an experiment (E-761) to study $\Xi^- \rightarrow \Sigma^-\gamma$; already one graduate student has been at Fermilab, and others are scheduled to come later.

Colombia: One particle physicist (Negret) from ACIF (Bogota) is working at Fermilab for a year on a small $\bar{p}p$ collider experiment (E-710). Other physicists who have received U.S. Ph.D.'s and returned to Colombia are exploring ways to stay in the field.

In each of the above cases of collaboration with Latin American HEP groups, Fermilab and the Latin American institution negotiate agreements on payment of salaries, transportation, and housing costs while the physicists are at Fermilab, and a variety of different arrangements have evolved.

Engineers to Fermilab

Several Latin American engineers have come to Fermilab, where they have been able to acquire experience with state-of-the-art equipment, while Fermilab has benefited from the services of some very skilled people.

(i) S. Zimmerman (Porto Allegre, Brazil) worked for two years on FASTBUS data-acquisition electronics. During that time he also attended a nearby university in evenings, and obtained an M.S. degree in electrical engineering.

(ii) O. Calvo (La Plata, Argentina) is currently in his second year here; his two projects have been a computer study of magnet current regulation for the Superconducting Super Collider and writing software for data-acquisition readout.

(iii) R. Vignoni (La Plata, Argentina) is in his first year, and presently working on a data-acquisition system for speeding up CAMAC readout.

(iv) C. Da Barros (CBPF, Brazil) worked for six months in Fermilab's Advanced Computer Program.

As in the case of visiting HEP physicists discussed earlier, arrangements for salaries, etc., are negotiated between Fermilab and the engineer's home institution.

Used Books and Journals

For several years, Fermilab has collected used books and journals from its staff for distribution to Latin American institutions; as would be expected, the

books and journals collected are mainly, although not exclusively, related to HEP (such as *Physical Review Letters* and *Physical Review D*). About once a year, a list of the material is sent to around 25 Latin American universities, and based on their requests, about 60 boxes of material are shipped each time.

NSF/APS Grant for Latin American Physics

During the 1983 Rio de Janeiro meeting mentioned earlier, there was considerable discussion of the financial crisis in Latin America, with the consequent shortage of foreign exchange in the countries there. It was realized that a relatively small amount of money could make a substantial impact in overcoming the effects of this crisis on the growing scientific infrastructure of the most developed countries in the region. An estimate was made that the sum of about $300,000 per year would have a significant effect. This led to a grant request to the NSF by Lederman and Leo Falicov, which subsequently led to a (one-time) grant of $300,000 to the American Physical Society (APS) for this purpose. The APS designated their International Physics Group (chaired then by Falicov and now by Rubinstein) to oversee the grant. By arrangement with DOE, it was administered by Fermilab, including purchasing, accounting, secretarial, etc., assistance, at no cost.

The five countries which received grant assistance were Argentina, Brazil, Chile, Mexico, and Venezuela; funds were used for per diem during visits to the U.S. (20%), page charges for publications in U.S. journals (15%), subscriptions to U.S. journals (20%), and small equipment items (45%). Representatives in each country solicited and selected requests from physicists and institutions in their countries, which were then transmitted to the U.S. administrators.

At the present time, the grant funds have all been expended; the response to this initiative from the recipient countries has been very positive, and the possibility of applying for a second grant is being explored. A more complete description of the grant and its administration is available (*Fermilab Report*, September 1985, page 11.)

Miscellaneous

A mathematician and computer specialist from UNAH, Honduras, visited Fermilab to study uses of an IBM 4341 computer.

A UNAH graduate student spent a summer here learning to use HEP equipment for a cosmic ray experiment.

Leon Lederman is honorary co-chairman (with Abdus Salam) of the Board of ACIF (Bogota).

In April 1986, a conference on the teaching of modern physics was held at Fermilab; among the attendees were about a dozen from Latin America, who held meetings with Fermilab staff on possible assistance from the Laboratory. Many suggestions were made, amongst them that copies of videotapes of the Fermilab lectures for high school students be made available, and that Fermilab should provide information to help in organizing similar meetings elsewhere.

Summary

Fermilab, which is already, by the nature of the research it undertakes, an international laboratory, has established relations with a number of Latin American physics institutions. The cooperative activities have included HEP, and also related fields such as engineering. Although use of Fermilab's funds is restricted to activities related to its HEP mission, that does not have to be too narrowly interpreted, and consequently many activities have been carried out which, hopefully, have helped advance physics in Latin America. We realize that what has been done so far can be improved and expanded, and are open to comments, criticisms, and suggestions.

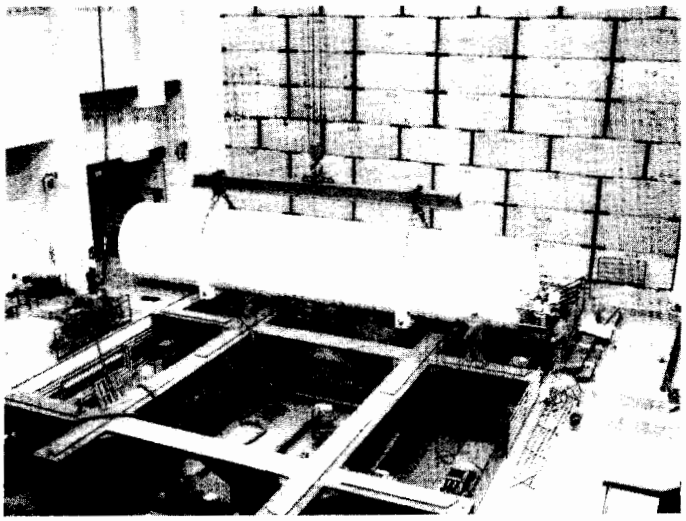
Lab Notes

CDF Puts Increased TEVATRON Luminosity to Good Use

The engineering run of the Collider Detector at Fermilab (CDF) is taking advantage of TEVATRON luminosity which has climbed to a peak of just under 10^{29} and is still rising. The detector is now regularly recording jets, and the experimenters have seen a triple jet as well as some jets above 150 GeV. On March 26, a first candidate "new world" *W* event was observed. The event consists of a clean 36-GeV electron with a rapidity of approximately zero (that is, the electron is nearly perpendicular to the colliding beams). The event appeared at approximately the integrated luminosity expected for *W* production.

Based on recent developments, the need for a thorough engineering shakedown of the detector, and the possibility of achieving some new physics with a run of 50 inverse nanobarns, CDF has been approved for an extension of three weeks in the colliding-beams run.

Progress on the D0 Experiment



Riggers perform the delicate feat of setting in place the 20,000-gallon Liquid Argon Dewar at the D0 Detector Hall. The detector platform is in the foreground and the 12-ft-thick shield wall rises behind the dewar. (Fermilab photograph 87-168-4)

("Lab Notes" cont'd.)

Fermilab's Third Buffalo Auction

The curfew tolls the knell of parting day,
The lowing herd wind slowly o'er the lea...
(Thomas Gray, "Elegy Written in
a Country Church-yard" [1751])

In the case of Fermilab's renowned herd of *Bison bison* (known in the vernacular as buffalo), the lowing won't be quite as loud, and the journey o'er the lea won't take quite as long, now that the bell has tolled for a total of 52 of the Laboratory's ~150-member herd at Fermilab's first buffalo auction since 1984.

Going. . .going. . .gone.
(Fermilab photograph 87-193-2)

Three hundred buffalo buyers, buffalo aficionados, and the just-plain-curious assembled at the Fermilab buffalo pens on March 27, 1987, as 20 bulls, 12 bull calves, 8 cows, 6 heifers, and 6 heifer calves were sold for end-uses ranging from breeding stock to pets and dinner. Rudy Dorner, Fermilab's Emergency Services Coordinator/Business Services Section, noted that, "Currently, the herd grazes on 90 acres of land, and considering the 'carrying capacity' of that acreage, we try to keep the herd at around 100 animals."

Herdsman Don Hanson, (Business Services Section/Roads and Grounds), and Bob Hall, Manager of Roads and Grounds, maintain the herd as a continuation of a tradition begun by the Lab's first Director, Robert R. Wilson, and enthusiastically supported by Director Leon Lederman, as an aknowledgement of Illinois' prairie heritage and a glimpse of true Americana for Fermilab's visitors.

*("**Lab Notes**" cont'd.)*

The *Bison bison* was, of course, a primary source of the basic staples of life (food, bowstrings, rope, spoons, drinking vessels, belts, clothing, fuel, and ceremonial ornaments) for the Plains Indian. Apparently, the buffalo's usefulness and man's inventiveness are timeless and intertwined, e.g., the letter below.

Princeton University
Plasma Physics Laboratory **Office of the Director**
James Forrestal Campus
P.O. Box 451, Princeton, N.J. 08544
609-683-3555

September 16, 1986

Dr. Erich Bloch, Director
National Science Foundation
Room #520
1800 G Street, N.W.
Washington, D.C. 20550

Dear Erich,

Major advances in science tend to occur when seemingly unreasonable propositions turn out to be true after all. I enclose two pages from Giuliano Bugialli's Foods of Italy (New York, 1984) containing a brief discussion of Mozzarella cheese-making and a picture of an Italian buffalo herd.

As in most scientific controversies, the situation is more complex than anyone had expected: While first-class US restaurants serve real Mozzarella cheese, pizza parlors apparently use Fior di latte, made from cow's milk, and call it "Mozzarella." Also in the US, bison are called "buffalo."

How can American science make the most of these circumstances? Fermilab has a splendid herd of bison as well as an enterprising research staff. At our dinner last week, I brought up the subject of Mozzarella in hopes of persuading Leon Lederman to launch a new line of investigation.

American cheese-making has lagged far behind the frontiers of that rewarding science. Research on bison-based Mozzarella may be one of those cases where NSF support for special resources at DOE laboratories would be appropriate.

Sincerely,

Hank

prepared or presented from February 13, 1987, to April 26, 1987. Copies of technical publications with Fermilab publication numbers can be obtained from the Fermilab Technical Publications Office, Theoretical Physics Department, or Theoretical Astrophysics Group, 3rd floor, Wilson Hall. Copies of some articles listed are on the reference shelf in the Fermilab Library, 3rd floor crossover, Wilson Hall.

Manuscripts and Notes

Experimental Physics Results

J. Bofil et al. Experiment # 594	Limits on $\nu_\mu \rightarrow \nu_\tau$ and $\nu_\mu \rightarrow \nu_e$ Oscillations (FERMILAB-Pub-87/33-E; submitted to Phys. Rev.)
J.C. Anjos et al. Experiment # 691	Measurement of the D_s^+ Lifetime (FERMILAB-Pub-87/29-E; [CBPF-NF-030/87]; submitted to Phys. Rev. Lett.)
J.C. Anjos et al. Experiment # 691	Charm Photoproduction Results from the Fermilab Tagged Photon Spectrometer (FERMILAB-Conf-87/37-E; [CBPF-NF-031/87]; invited talk presented at "DPF '87": 13th Annual Meeting of the Division of Particles and Fields of the APS January 14-17, 1987, Salt Lake City, Utah)
R. Belusevic and D. Rein Experiment # 733/649	Is There a Way to Measure the Deep-Inelastic Cross-Section Using Wide-Band Neutrino Beams? (FERMILAB-Pub-87/19-E; submitted to Zeit. Phys. C)

General Particle Physics

The CDF Collaboration	Central and Forward Tracking Chambers of CDF (Invited talk presented by R.L. Wagner at the International Conference on Advances in Experimental Methods for Colliding Beam Physics,

	Stanford Linear Accelerator Center, Stanford, California, March 9-13, 1987)
R.L. Dixon	Fermilab Fixed-Target Program (Lectures given at the Second Mexican School on Particles and Fields, Cuernavaca, Mexico, December 4-12, 1986)
D.C. Lamb	A Purely Mathematical Look at the Energy-Angle Distribution of Axion-Production by Electrons (FN-448)
J.G. Morfín	A Space-Time Analysis of Muo-Produced Hadronic Showers (FN-450; presented at the Workshop on Electronuclear Physics with Internal Targets, Stanford Linear Accelerator Center, Stanford, California, January 5-8, 1987)
D. Theriot et al.	4 π Detectors (To be published in the Proceedings of the 1986 Summer Study on the Physics of the Superconducting Super Collider, Snowmass, Colorado, June 23-July 11, 1986)

Accelerator Physics

L. Bartleson et al.	Kicker for the SLC Electron Damping Ring (Submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)
S.A. Bogacz and K.-Y. Ng	Nonlinear Behavior of the Longitudinal Modes of the Coasting Beam in a Storage Ring (Submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)
S.A. Bogacz and K.-Y. Ng	Nonlinear Saturation of the Longitudinal Modes of the Coasting Beam in a Storage Ring (FERMILAB-Pub-87/55; submitted to Phys. Rev. D)
O. Calvo and G. Tool	Analysis of Transmission Line I in the SSC Magnet System (Sub

to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)

O. Calvo et al. — Magnet Current Regulation in the SSC (Submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)

R.J. Ducar et al. — FNAL Booster Intensity, Extraction, and Synchronization Control for Collider Operation (TM-1446; submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)

D.A. Finley et al. — Time Dependent Chromaticity Changes in the TEVATRON (FN-451; presented at the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)

R. Gerig et al. — Simulations of the Fermilab Main Ring (Submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)

C. Kerns et al. — New Low-Level rf System for the Fermilab Booster Synchrotron (TM-1447; submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)

J.R. Lackey et al. — Installation and Operation of a New Extraction Area in the FNAL Booster (Submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)

P. Lucas and Q. Kerns — Simulation of a Programmed Frequency Shift Near Extraction from the Fermilab Booster (TM-1445; submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)

P. Lucas and J. MacLachlan	Simulation of Space Charge Effects and Transition Crossing in the Fermilab Booster (TM-1444; submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)
J.A. MacLachlan	Longitudinal Phase Space Tracking with Space Charge and Wall Coupling Impedance (FN-446)
P.S. Martin	Operational Experience with Superconducting Synchrotron Magnets (TM-1439; submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)
D. Martin and P. Cliff	A Pulse Amplifier for Nuclear Instrumentation (Submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)
P. Martin et al.	Antiproton Acceleration in the Fermilab Main Ring and TEVATRON (TM-1440; submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)
L. Michelotti	Combining Multipole Data (FERMILAB-Conf-87/49; presented at the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)
L. Michelotti	Resonance Topology (FERMILAB-Conf-87/50; presented at the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)
C.D. Moore and T.A. Topolski	Polar Coordinate Alignment of the Magnet Stands in the B0 Overpass Region of the Fermilab Main Ring (Presented at the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)
K.-Y. Ng	Impedances of Bellows Corrugations (FN-449)

R.H. Siemann	Advanced Accelerator Concepts and Electron-Positron Linear Colliders (FERMILAB-Pub-87/26; submitted to Ann. Rev. Nucl. Part. Sci.)
M.J. Syphers	The New FNAL Booster-to-Main Ring Beam Transport System (TM-1443; submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)
A. Van Ginneken et al.	Shielding Calculations for Multi-TeV Hadron Colliders (FN-447)
R. Webber et al.	A Beam Position Monitoring System for the Fermilab Booster (Submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)
D. Wildman et al.	Bunch Coalescing in the Fermilab Main Ring (TM-1441; presented at the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)
J.R. Zagel et al.	Tuning Loop Control System for the Fermilab Debuncher DRF1 Cavities (Submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)

Theoretical Physics

P. Arnold and M.P. Mattis	Operator Products in 2-Dimensional Critical Theories (FERMILAB-Pub-87/27-T; submitted to Nucl. Phys. B)
U. Baur et al.	Testing the Standard Model Versus a Composite Structure of Weak Interactions in High Precision Experiments at LEP and SLC (FERMILAB-Pub-86/163-T [MPI-PAE/PTh 74/86]; submitted to Nucl. Phys. B)

U. Baur et al.	Excited Weak Vector Bosons Facing theHigh Energy and High Precision Frontiers (FERMILAB-Pub-87/43-T [MPI-PAE/PTh 21/87]; submitted to Nucl. Phys. B)
N.-P. Chang et al.	Kähler Manifolds with Vanishing Chiral Potential (FERMILAB-Pub-87/20-T; submitted to Phys. Rev. Lett.)
W. Kwong et al.	Heavy Quark Systems (FERMILAB-Pub-87/15-T; submitted to Ann. Rev. Nucl. Part. Sci.)
L. McLerran	Report on the Parallel Session on High Energy Nuclear Interactions (FERMILAB-Conf-86/164-T; submitted to the XXIII International High Energy Physics Conference, Berkeley, California, July 23, 1986)
S.K. Mtingwa	Transient Effects in the Plasma Wakefield Acceleration Scheme (FN-452)
R.D. Pisarski	Heavy and Smooth Strings in QCD (FERMILAB-Conf-86/171-T; presented at the Paris-Meudon Colloquium on "String Theory, Quantum Cosmology, and Quantum Gravity," Meudon, France, September 22-26, 1986)
R.D. Pisarski	Perturbative Stability of Smooth Strings (FERMILAB-Pub-87/13-T; submitted to Phys. Rev. Lett.)

Theoretical Astrophysics

F.S. Accetta	Instabilities of Higher Dimensional Compactifications (FERMILAB-Conf-87/40-A; presented at the XIII Texas Symposium on Relativistic Astrophysics, Chicago, Illinois, December 14-19, 1986)

D.B. Cline et al.	Neutrino Families: The Early Universe Meets Elementary Particle/Accelerator Physics (FERMILAB-Pub-87/28-A; submitted to Comments on Nucl. Part. Phys.)
M. Gleiser	Cosmological Stability of Quantum Compactification (FERMILAB-Conf-87/32-A [RU-87/B_1/189]; Presented at the XIII Texas Symposium on Relativistic Astrophysics, Chicago, Illinois, December 14-19, 1986)
M. Gleiser et al.	Vacuum Energy of $M^4 \times S^M \times S^N$ in Even Dimensions (FERMILAB-Pub-87/25-A; submitted to Phys. Rev.)
E.W. Kolb and M.S. Turner	Electroweak Anomaly and Lepton Asymmetry (FERMILAB-Pub-87/17-A; submitted to Mod. Phys. Lett. A)
M.S. Turner	Toward the Inflationary Paradigm: Lectures on Inflationary Cosmology (FERMILAB Conf-87/35-A; summary of lectures given at [1] Gauge Theories and the Early Universe, Erice, Italy, May 20-30, 1986; [2] GIFT Seminar, Peniscola, Spain, June 1-7, 1986, [3] XXVI Kracow School on Theoretical Physics, Zakopane, Poland, June 1-15, 1986, and [4] NATO ASI: The Early Universe, Victoria, British Columbia, August 17-30, 1986. To be published in the Proceedings of the GIFT Seminar.)
J.J. van der Bij and M. Gleiser	Stars of Bosons with Non-Minimal Energy-Momentum (FERMILAB-Pub-87/41-A; submitted to Phys. Lett.)
A. van Dalen and D.N. Schramm	Cosmic String Induced Peculiar Velocities (FERMILAB-Pub-87/30-A; submitted to Astrophys. J.)

Computing

J. Biel et al.	Software for the ACP Multiprocessor System (FERMILAB-Conf-87/22; presented at the Conference on Computing in High Energy Physics, Asilomar, California, February 2-6, 1987)
A.W. Booth and J.T. Carroll	An Expert System for FASTBUS Diagnosis (Presented at the Conference on Computing in High Energy Physics, Asilomar, California, February 2-6, 1987)
J.T. Carroll et al.	Level 3 System at CDF (Presented at the 3rd Pisa Meeting on Advanced Detectors, Castiglione della Pescaia, Italy, June 1986)
I. Gaines and T. Nash	Use of New Computer Technologies in Elementary Particle Physics (FERMILAB-Pub-87/38; submitted to Ann. Rev. Nucl. Part. Sci.)
H. Johnstad and J. Nicholls	Producing and Supporting Sharable Software (TM-1438; to be published in the Proceedings of the Conference on Computing in High Energy Physics, Asilomar, California, February 2-6, 1987)
H.E. Montgomery	Status of (U.S.) High Energy Physics Networking (FERMILAB-Conf-87/39; presented at the Conference on Computing in High Energy Physics, Asilomar, California, February 2-6, 1987)
T. Nash	Asilomar Conference on Managing Complexity in High Energy Physics: A Summary and Renaming of the Conference (FERMILAB-Conf-87/48; invited summary talk at the Conference on Computing in High Energy Physics, Asilomar, California, February 2-6, 1987)

Other

M. Kobayashi et al.	Electrical and Mechanical Properties of Lead/Tin Solders and Splices at 4.2K (Submitted to Cryogenics)

Colloquia, Lectures, and Seminars

(All at Fermilab in 1987 unless otherwise noted)

S. Holmes and R. Noble	"The 400 MeV Linac Upgrade: Design and Expected Impact" (February 24)
J. Tverdik	"Data Bases in the Technical Environment" (February 24)
G. Tool et al.	"The Use of CAD System in Electronics Design in the Accelerator Division" (February 26)
G. Mulholland	"D0 Cryogenics" (February 27)
F. Grassi	"Phenomenological Quark Matter Equations of State" (March 2)
T. Nash	"*Summary Talk, Conference on Computing in HEP*" (March 4)
D. Finley et al.	"Collider Status Report" (March 10)
S. Hansen and M. Bernett	"Smart Crate Controller" (March 10)
J. Pfister	"Personal Computer: Acquisitions, Care, and Feeding" (March 10)
S. Hansen and M. Bernett	"Smart Crate Controller" (March 17)
D. Sachs	"Scientific Word Processing with Microsoft Word on the Macintosh" (March 17)
A. Albrecht	"Cosmic Strings: Possible Seeds for the Galaxies" (March 23, 25)
R. Thatcher	"Using the VAX Language Sensitive Editor" (March 24)

M. Gleiser	"Boson Stars (?)" (March 30)
M. Johnson	"The Use of Digital Frequency Synthesizers in Lower Level rf Systems" (April 2)
H. Edwards et al.	"Division News and Accelerator Status" (April 7)
D. Edwards	"Current Understanding of Emittance Growths in the TEVATRON" (April 9)
R. Siemann	"The Performance of the TEVATRON Schottky Detector" (April 9)
J. Elias	"Experience Designing and Operating the CDF Flammable Gas System" (April 7)
M. Sokoloff	"Beauty Production and Evidence for B^0-$\bar{B}^0$ Mixing at UA1" (April 10)
G. Chatrand	"Basic Tutorial on Electronic Mail" (April 14)
E. Kolb	"Overview of Type I and Type II Supernova" (April 20)
A. Stebbins	"Limits on Particle Properties" (April 20)
A. Stebbins	"The Remnant" (April 20)
M. Turner	"Supernova Shelton, Gravity Waves" (April 20)
L. Widrow	"Cosmic Rays from Supernova Shelton" (April 20)
J. Marriner	"Review of Physics, Technology, and Practice of Stochastic Beam Cooling" (April 21)
L. Roberts	"Evaluation of the FPS 164 Computer for High Energy Physics Pattern Recognition Problems" (April 21)

Dates to Remember

May 8 - 9, 1987	Annual Users Meeting, Ramsey Auditorium, Fermilab
May 21 - 22, 1987	Seventh Annual Meeting of the Fermilab Industrial Affiliates, Fermilab
June 13 - 19, 1987	Physics Advisory Committee meeting, Fermilab
June 14 - 18, 1987	1987 Cryogenic Engineering Conference & International Cryogenics Material Conference, Fermilab; for more information contact Jean Plese, P.O. Box 105, Batavia, IL 60510, (312)-840-3211