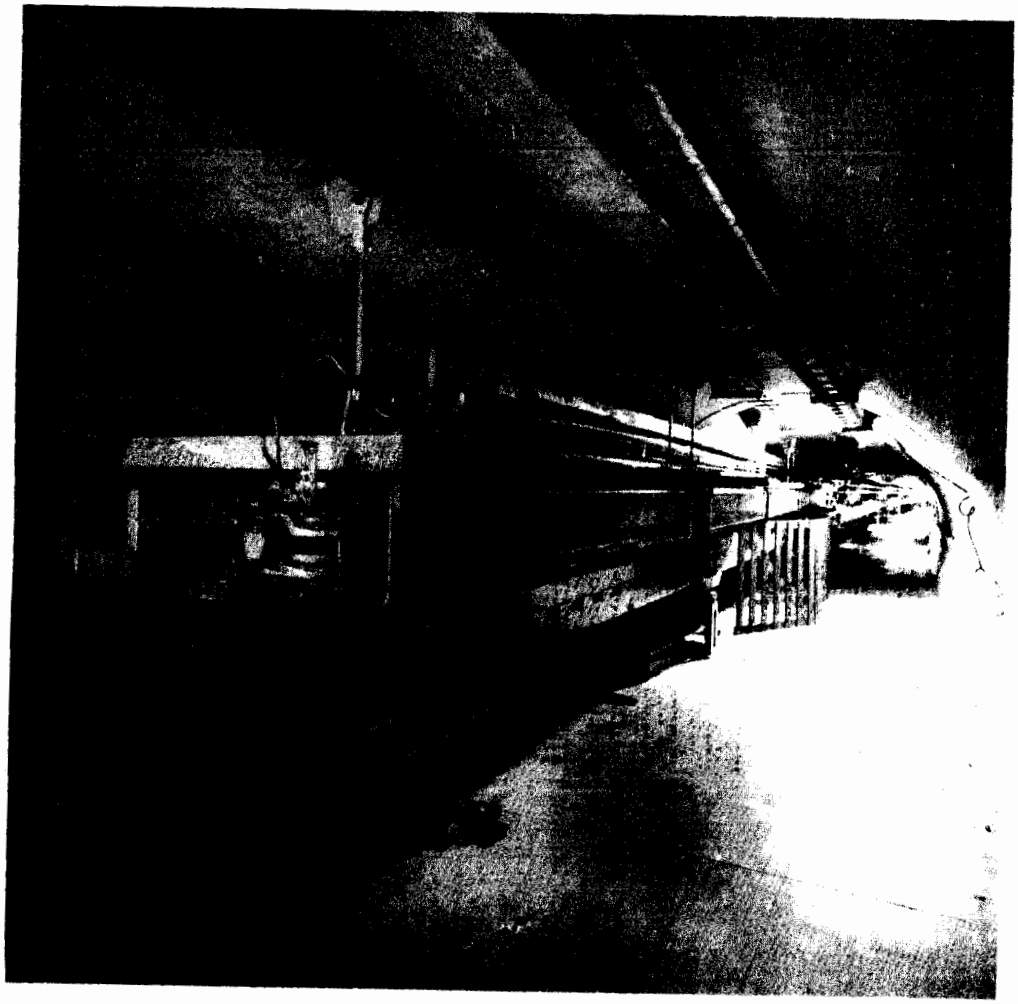
fermilab report

Fermi National Accelerator Laboratory Monthly Report December 1980



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THE COVER: Recently installed 80-GeV extraction line at F17 in the Main Ring. This line will provide protons for the antiproton-production target station for the $\bar{p}p$ collider.
(Photograph by Fermilab Photo Unit)

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Seasons Greetings!

Having failed in our hopes of acquiring for our Users a prosperous Fiscal New Year, the Director seizes on the opportunity to wish you all a fruitful calendar year. May 1981 bring you all peace, serenity, and a few great ideas.

Leon Lederman

COOLING SCENARIO STUDY WEEK

D. E. Young

A year has passed since completion of the Tevatron Phase I Design Report. There have been a number of advances in cooling since then, both here and at CERN. It is an appropriate time for a final review of our plans before detailed design work is undertaken. A study week was therefore held November 10 through 14 to investigate and possibly to improve the antiproton cooling scenario to be used in the Tevatron Phase I colliding-beams project. Our collaborators from Wisconsin, Argonne, and Berkeley participated, as well as visitors from CERN, DESY, and Brookhaven.

One of the concerns in the original Tevatron I plan is the heating of the antiproton target during the beam pulse, which could reduce the antiproton production. Several targeting scenarios were proposed to reduce this heating. Some schemes target segments of the Main-Ring proton beam sequentially, stacking the antiprotons from separate segments together after production and some cooling. A scheme invented at an earlier targeting workshop moves the proton beam laterally across the target faster than the shock wave generated by the beam (total motion is of the order of 1 mm). It may also be possible to target the entire Main Ring beam on a multiple target, a sequence of current-carrying targets interspersed with lithium lenses. Combinations of these targeting schemes are also interesting. These possibilities raised in connection with the study week are being explored further.

During the study week, cooling scenarios involving only stochastic cooling were proposed. These schemes are not completely different from the CERN Antiproton Accumulator system, but one of the targeting-injecting systems discussed above is needed, because in our case the initial proton beam comes in units of Main-Ring length and must be segmented to fit in a smaller ring. In addition, any all-stochastic scenario needs another storage ring in which to accumulate particles or a shutter system and large aperture like that at CERN.

Electron cooling was also advanced during the study week. Cooling at higher energy was explored. It was shown that cooling at 380 MeV, the limit of the present ring, is more efficient than at 200 MeV. The interesting possibility of cooling at 1 or 2 GeV was also raised. In this method, a high-voltage power-supply system, such as a Van der Graaf or Cockcroft-Walton, would be used.

One result of the week was that many schemes for targeting and cooling involve precooler rings of similar radius and aperture. We are exploring further the possibility of designing a ring that could accommodate any of these schemes with only small modifications.

The study week showed that there are a number of scenarios that can meet the Tevatron Phase I goal of $10^{30}/cm^2$-sec luminosity, with room for improvement. We are now working on detailed calculations of these scenarios.

REPORT ON HOLOGRAPHIC TRACK CHAMBER WORKSHOP

L. Voyvodic

An informal workshop was held at Fermilab on November 11 and 12, 1980, on holographic track chambers, with emphasis on high-resolution bubble and streamer chamber vertex detectors for fixed-target Tevatron experiments. About 85 experimenters participated, with approximately equal numbers interested in applications to hadron-photon interactions and to neutrino-beam dump studies.

The possibilities for holography offering advantages over conventional photography of bubble chambers, by providing direct three-dimensional recording as well as high spatial resolution over much larger depths of field, were explored in the late 1960's. Optics scientists in Britain, the United States, and Japan participated in these investigations. Holographic recording of spark and streamer chamber track residues was demonstrated in the early 1970's in the Soviet Union. It is chiefly in the last two years, however, that extensive practical interest has developed in holographic track recording, principally for studies of short-lived charm hadrons and heavy leptons. At the workshop it appeared that the goal for many experimenters is to achieve with practical chambers an order of magnitude improvement in spatial resolution from holograms as compared with conventional photographs. It was emphasized by Leon Lederman in his welcoming address that the realization of higher spatial-resolution detectors is important for increased physics capabilities in Tevatron experiments and would in many cases also allow the use of smaller and more economical apparatus and spectrometer arrangements.

In the first session of the workshop, T. Jeong (Lake Forest) provided background and demonstrations of a variety of general holographic techniques. C. Fisher (Rutherford Laboratory) reviewed limitations of conventional high-resolution track chambers and spectrometers, leading to recent European developments of several varieties of small holographic bubble chambers. P. Lecoq (CERN) showed reconstructed images from the first high-resolution bubble chamber holograms, taken earlier this year at the CERN SPS with the Berne freon mini-chamber (BIBC). Videotape test results with 8-micron bubble-diameter tracks were particularly dramatic. Image resolution of this quality appears to be needed for efficient observation of decay vertices for particles with lifetimes down to 10^{-13} seconds.

The second session provided additional technical perspectives on the limits for holographic techniques by F. Eisler (CUNY), and on the characteristics of the required lasers for practical holographic track chambers by R. Milburn (Tufts). Aspects of high-resolution photography and holography of streamer-chamber tracks were reviewed by J. Sandweiss (Yale), and

of big bubble chambers by H. Bingham (UC, Berkeley). Designs of two novel holographic freon bubble-chamber proposals were described by I. Pless (MIT). One design featured a very small ultrasonic chamber for hadronic interactions, aiming at approximately 5 microns bubble size, the other a 48-inch chamber for Tevatron beam-dump experiments, aiming at approximately 30 micron bubble resolution. Both designs featured classical in-line holographic optics with the addition of auxiliary lenses, providing image magnification for the small chamber and demagnification for the large chamber for similar 70-mm film formats.

Two parallel sessions were held, one on possible holographic mini-detectors for hadron-photon interactions and the other on big holographic bubble chambers for neutrino-beam dump experiments. These sessions developed several lively resonances in audience participation and interchanges of new ideas.

C. Fisher (RHEL), assisted by the "big chambers" chairman V. Peterson (Hawaii), and by on-going group interjections, ended up with an idealized big-cylinder holographic chamber geometry with internal spherical mirrors at the ends, resembling the optics in some forms of astronomical telescopes. It was later learned that T. Kitagaki and others in Japan had recently come to similar conclusions for possible design of the proposed MIT-Tohoku beam-dump holographic chamber. For the 15-ft chamber, discussions were aired on laser speckle problems, liquid turbulence and magnetic-field optical-polarization effects, which may be serious for holographic methods using bright-field Scotchlite and off-axis reference-beam illumination. Possible alternative solutions were also suggested, including possible introduction of a suitable laser beam inside the chamber independently of the camera lens assembly. This might also allow for dark-field Scotchlite illumination and more nearly in-line image holograms.

In the mini-detector session, chaired by J. Sandweiss, it was generally agreed that the holographic optics appeared to pose only minor problems for small transparent chambers. The main discussions centered on chamber types, duty factors, beam rates, laser and triggering-logic requirements, as well as a brief look at the associated problems of scanning and data reduction if millions of holograms are to be taken. C. Roos (Vanderbilt) pointed out the axial optics and high-field solenoid features of the HYBUC bubble chamber as an attractive rapid-cycling holographic target chamber for development and use with Tevatron spectrometers. R. Plano (Rutgers) described an idea for a continuously operating small holographic bubble chamber, using the Bernoulli principle for establishing an appropriate pressure drop for sensitivity together with velocity flow for removing old bubbles. (It was also learned after the workshop that A. Herve at CERN was independently already at work on a continuously sensitive Bernoulli bubble chamber, making use of leftover Gargamelle liquid-pumping facilities.) On the streamer chamber side, L. Voyvodic (Fermilab) discussed recent preprints from a joint Dubna-Leningrad team who reported holographic recording of

tracks in a pressurized hydrogen avalanche chamber. He speculated on idealized holographic streamer-cloud chambers resulting if these holographic techniques were combined with an avalanche-nucleated diffusion cloud chamber method reported several years ago by a group in Tbilisi.

The workshop ended with overviews and comments on directions for future efforts for prospective Tevatron holographic track chambers by V. Peterson and J. Sandweiss, with additional comments by J. Bjorken (Fermilab). After describing his estimates for the copious abundance of Tevatron-produced charm and bottom quarks, Bjorken stressed that their effective study with suitable detector systems may well bring about a richness of physics comparable to the discoveries that have been provided by intensive and detailed studies of strange particles in the past.

The nearly complete detector consisting of the calorimeter plus drift chamber - toroid magnet muon spectrometer for E-613, the first neutrino experiment to be done in the Meson Laboratory. Don Reeder (left) and Mark Duffy, both from the University of Wisconsin, discuss future plans.
(Photograph by Fermilab Photo Unit)

COLLIDING-DETECTOR FACILITY WORKSHOP

John Yoh

About 20 theorists (10 from collaborating institutions) and 40 Colliding Detector Facility (CDF) collaborators participated in the November 5-8 workshop on CDF physics at Fermilab. Preliminary conclusions and plans for further studies were presented on the morning of November 8 in a series of progress reports. Results from these further studies will be collected in mid-December and distributed.

The following is a brief summary of the progress reports, including a list of the processes studied, some preliminary conclusions, and a list of studies being carried out. Complete copies of the progress reports can be obtained by writing or calling me at Fermilab Ext. 4602 or Mail Station #223. Further discussion on data from cosmic rays and the implication for physics at the CDF will take place in early December with the visit of Thomas Gasser.

Group A -- W, Z Physics (M. Mishina, Organizer)

Processes studied included pp into W, Z, WW, ZZ, WZ, $W\gamma$, + gluons.

For W or Z production, the non-scaling cross section is considerably larger than the scaling cross section, although there is probably some (perhaps a factor 2) uncertainty depending on the low-x part of the quark distribution function. Signatures and background will be investigated using the present Monte Carlo program.

Precise measurement of masses and widths of single W and Z was stressed. WW production, although the rate is low (of order 8 pb), could be used to establish the renormalizability of gauge theory. $W\gamma$ production is important, but almost impossible.

Group B -- Heavy Quark (t) (W. Carithers, Organizer)

The QCD process gg into $t\bar{t}$ was studied in detail; the expected cross section was 60 nb × $(M/25\ \mathrm{GeV})^{-4.35}$ giving (for 10^{36} luminosity) 60,000 events if M_t is 25 GeV, but only 300 events for M_t = 75 GeV.

The cleanest signature for this process is for those t produced at high P_t, so that almost all the decayed particles (whether three jets with 40% probability, one jet with an isolated lepton with 30% probability, or three jets with a lepton inside one of the jets with 30% probability) are within 1 to 2 steradians; only about 3% of the produced tt will have P_t greater than

50 GeV/c and decay into an angle θ between 45° and 135° (for M_t = 25 GeV); thus we end up with about 200 top decays for three jets + three jets and about 200 decays with three jets + one jet and one lepton. For the three jet mode, the signal is expected to be above the background from jets with gluon bremsstrahlung (signal/background will be of order 1:1). The three jets + one jet and one lepton mode should be much cleaner and will be studied in detail; leptons inside the jet will also be investigated.

Another possible process for t production was suggested by ISR diffractive dissociation production of charm at large x. Brodsky suggested that this could be due to "intrinsic" heavy quarks inside the proton; he expects that the mass dependence should be $1/M^2$. If this is correct, then we expect 3 μb for M_t = 25 GeV and 0.3 μb for M_t = 75 GeV, completely swamping the QCD $t\bar{t}$ cross section at low P_t and at large x.

Dileptons from toponia should occur at the 10 pb level for $M_{t\bar{t}}$ = 50 GeV and could be seen above the Drell-Yan background. Further studies on t signatures and background at low P_t and for the diffractive dissociation scenario will be done.

Group C/D -- Hard Jets and QCD Tests (G. Bellettini, Organizer)

The rate for QCD jets (as calculated by Horgan) was studied; for 10^{36} cm^{-2} integrated luminosity, one expects 1000 events/GeV at P_t = 80 GeV/c; single-hadron production will be down by about 500 (1000/GeV at P_t = 30 GeV) at 10^{30} cm^{-2} sec^{-1} luminosity, the rate for 10-GeV P_t jets would be 100/sec; various triggering schemes were considered.

Jet flavor study was investigated; in particular, silicon detectors inside the beam pipe were suggested to study secondary vertices (charm decay). Another suggestion was to replace some of the calorimeter modules by Cherenkov modules backed by calorimeters further away from the beam. The silicon detectors could also be used for quark searches.

Other processes studied include Drell-Yan and single photons. Rates for Drell-Yan are low and will only reach masses of 20-30 GeV. Single photons appeared to be very interesting, may have γ/π^0 exceeding 0.1. It could be separated from $\pi^0 \rightarrow 2\gamma$ up to P_t = 20 GeV at the expense of refining the chamber position determination in the shower counters. This separation could be extended if some calorimeter module is moved further back from the beam.

Further studies will be done on understanding whether one can separate bremsstrahlung gluons, more detailed photon studies, and tagging of heavy flavors.

Group E -- New Particles (R. Diebold, Organizer)

This group discussed various possibilities for heavy new particles that might appear at $(s)^{1/2} = 2000$ GeV. In general, heavy particles will be produced at low rapidity and will appear at relatively large angles. "Standard" new particles such as quarks and monopoles were considered briefly, as were Higgs and supersymmetric particles, which according to present ideas will likely be hard to see (of course, Nature may be more imaginative and give us a good signature if we are alert).

Considerable thought was given to the possibility of observing technicolor particles, such as the η_T with mass approximately 250 GeV. If these particles exist, the minimal production cross section is expected to be of order 80 pb, and they would prefer to decay into heavy objects such at $t\bar{t}$ (Kane et al.). This theory would also suggest that the dominant t decay would be $t \to bh^+$ where h^+ would be a charged Higgs of mass 8 GeV. The h^+ decay would often include neutrinos in the final state, and Monte Carlo studies will be made to see if the η_T mass can be reconstructed when the constraints of $t(\bar{t})$ mass and P_t balance are included.

"Stable" ($T \gtrsim 10^{-11}$ sec) particles were also considered; such objects are suggested by delayed particles seen in cosmic ray showers. Further, they are not unexpected in various theoretical scenarios. The identification of such particles would benefit from dE/dx and time-of-flight capabilities not included in the present "standard" detector. Further study will be given to the cost and benefits of adding these capabilities.

Another possibility is that of observing the effects of quark and lepton substructure in hard collisions (for example, DeRujula's glints). These might show up as events with large multiplicities (including several leptons), large $p_\perp$, and acoplanarity. As for many types of heavy particles, a large-$p_\perp$ trigger and the jet capability already built into the detector should work well in this case.

Group F -- 0° Physics (D. Cline, P. McIntyre, and G. Brandenburg, Organizers)

There appear to be good arguments for having at least nonmagnetic tracking, electromagnetic, and hadron calorimeters in the forward region ($\theta < 15°$). The measurement of energy flow would be useful for determining missing P_t; effects such as Centauros could be studied, etc.

Forward magnetic toroids could also be useful for muon identification and triggering; however, trigger and background rates should be investigated much more thoroughly. Some room should be left for the toroids even if they do not exist at first.

At present, there does not appear to be any strong justification for particle identification or momentum analysis (aside from muons) in the forward direction. P. McIntyre and collaborators will investigate further the usefulness and feasibility of these and other options. Compatibility of these options with the forward calorimeter and toroids should be considered.

Items for further studies include diffractive top production, beam jets as background for high-P_t physics, ln s physics, and further work on all the detector elements and options at forward angles.

PROPOSALS RECEIVED FROM MAY 17, 1980
THROUGH DECEMBER 12, 1980

No.	Title	Spokesperson
659	Electron Target Facility at Fermilab and a Lepton-Quark Structure Experiment	R. R. Wilson W. Lee
660	Proposal to Study the Effect of Bent Crystals on Channeling Near the Critical Radius of Bending	W. Gibson
661	Energy and Momentum Dissipation in Nuclei in High Energy Hadron Nucleus Interactions	H. H. Gutbrod
662	Correlations Among Nuclear Fragments in Relativistic Proton-Induced Breakup of Heavy Nuclei	E. P. Steinberg
663	Comparison of Polarizations of Inclusively Produced Lambdas and Antilambdas by Protons, Antiprotons, Kaons, and Pions on Hydrogen	H. Kobrak
664	An Experiment to Search for Neutrino Oscillations Using a ν_e Enriched Beam	R. Loveless
665	Muon Scattering with Hadron Detection at the Tevatron	T. B. W. Kirk
666	Emulsion Exposure to Σ^- Beam at Fermilab	R. J. Wilkes
667	Study of Pion-Nucleus Interactions in Pure Emulsion Stacks and Emulsion Chambers at Energy Above 500 GeV	W. Wolter
668	Study of Proton-Nucleus Interactions in Pure Emulsion Stacks and Emulsion Chambers at Energy Above 800 GeV	W. Wolter

An impromptu discussion held last month between sessions of the Colliding Detector Facility workshop. Participating in this discussion are (left to right) Roy Schwitters from Fermilab and Harvard University, Chris Quigg, head of Fermilab's Theoretical Physics Department, Art Garfinkel, Purdue University, and Willy Chinowski, University of California at Berkeley.
(Photograph by Fermilab Photo Unit)

MANUSCRIPTS AND NOTES PREPARED FROM
NOVEMBER 15, 1980 TO DECEMBER 12, 1980

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

T. Kondo et al. Experiment #531	A Search for ν_τ in the 350 GeV Wide Band Neutrino Beam and an Upper Limit For ν_μ Oscillation Into ν_τ (FERMILAB-Conf-80/92-EXP; talk presented at the Neutrino Mini-Conference, Telemark, Wisconsin, October 2-4, 1980)
B. C. Brown et al. Experiment #557	An Evaluation of Some New Phototubes with High Gain First Dynodes (Presented at the IEEE Nuclear Science Symposium, Orlando, Florida, November 5-7, 1980)
Y. Sakai et al. Experiment #605	Longitudinal Shower Development in a Lead-Scintillator Calorimeter as a Tool to Separate Pions and Electrons at 10-50 GeV Energies (Presented at the IEEE Nuclear Science Symposium, Orlando, Florida, November 5-7, 1980)
J. Hanson et al. Experiment #605.	A Study of Some Properties Which Determine The Resolution of A Lead-Scintillator Sandwich Electromagnetic Shower Detector (Presented at the IEEE Nuclear Science Symposium, Orlando, Florida, November 5-7, 1980)

Theoretical Physics

P. Q. Hung	Dynamical Generation of Fermion Masses (FERMILAB-Pub-80/78-THY; submitted to Phys Lett. D)
A. J. Buras	Seven Topics in Perturbative QCD (FERMILAB-Conf-80/79-THY; presented at the Symposium on "Topical Questions in QCD," Copenhagen, July 1980; to be published in Physica Scripta)

S. K. Mtingwa et al.	Can Color Be Seen in Deep-Inelastic Scattering? (FERMILAB-Pub-80/80-THY; submitted to Nucl. Phys.)
C. Nelson	Avoidance of Counter-Example to Non-Abelian Bloch-Nordsieck Conjecture by Using Coherent State Approach (FERMILAB-Pub-80/82-THY; submitted to Nucl. Phys.)
J. Oliensis	How to Calculate the Heavy Quark Fragmentation Function--An Application of Cut Vertices (FERMILAB-Pub-80/88-THY; Ph.D. Thesis, University of Chicago)
W. A. Bardeen	The Photon Structure Function (FERMILAB-Conf-80/93-THY; presented at the International Summer Institute on Theoretical Physics, Ban Honnef, Germany, September 1-12, 1980)

General

W. Fowler et al.	Summary Data From Large Scale Quality Control Tests on Superconducting Wire (Presented at the Applied Superconductivity Conf., Santa Fe, New Mexico, September 29-October 2, 1980)
C. Schmidt	Operation of the Fermilab H^- Magnetron Source (Submitted to the Symposium on the Production and Neutralization of Negative Hydrogen Ions and Beams, BNL, October 6-10, 1980)

Physics Notes

R. Goodwin et al.	An MC68000 Multibus-Compatible Computer Board (FN-330)
A. Tollestrup	Properties of Superconducting Magnets (FN-331; presented at the March BNL Workshop on Superconducting Magnets)

Colloquia, Lectures, and Seminars

F. Markley et al.	"Magnet Creep" (Fermilab, November 25, 1980)
Y. Kazama	"Decoupling, Effective Lagrangian and Gauge Hierarchy in Spontaneously Broken Non-Abelian Gauge Theories" (Fermilab, November 18, 1980)
F. T. Cole	"Report on Workshop on Cooling Scenarios" (Fermilab, November 18, 1980)
D. Gross	"Quadrupole Magnetic Field Measurements" (Fermilab, December 2, 1980)
T. Nicol	"Overview of Spool Pieces" (Fermilab, December 9, 1980)
D. Neuffer	"Muon Storage Rings for Neutrino Oscillation Experiments" (Fermilab, December 9, 1980)

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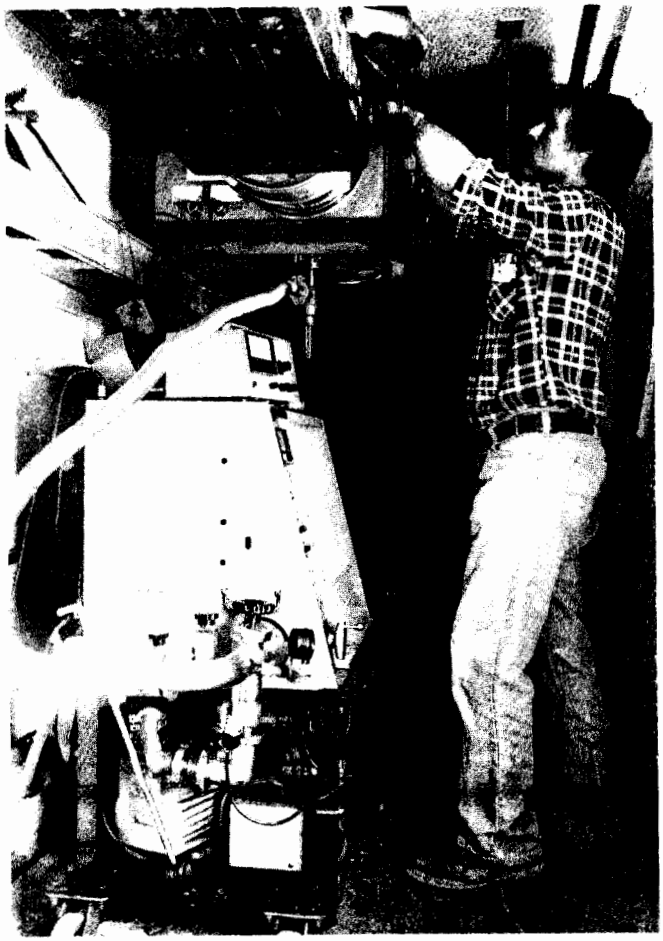

Mike Ziomek of the Accelerator Division's Mechanical Support group connects a superconducting magnet in the Left Bend.
(Photograph by Fermilab Photo Unit)

DATES TO REMEMBER

January 14, 1981	"Neutrinos and the Big Bang," Prof. David Schramm
February 1, 1981	Deadline for proposals for Tevatron experiments with hadron and photon beams in the Meson and Proton Areas to be considered at the June 1981 PAC meeting.
February 12, 1981	"Elementary Particles and Superdense Matter," Prof. Malvin Ruderman
March 11, 1981	"How Can We Learn About Particles from Neutron Stars?" Prof. Gordon Baym
mid April, 1981	"The Very Early Universe," Prof. Steven Weinberg