fermilab report

Fermi National Accelerator Laboratory Monthly Report

June 1982

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F. T. Cole, R. Donaldson, and L. Voyvodic, Editors

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FERMILAB-82/4 Fermi National Accelerator Laboratory 0090.01

THE COVER: Paul Mantsch (third from right) and Drasko Jovanovic (rear) sho members of the Fermilab Industrial Affiliates the superconductin coil winding equipment during their recent meeting (see story o page 11).

(Photograph by Fermilab Photo Unit

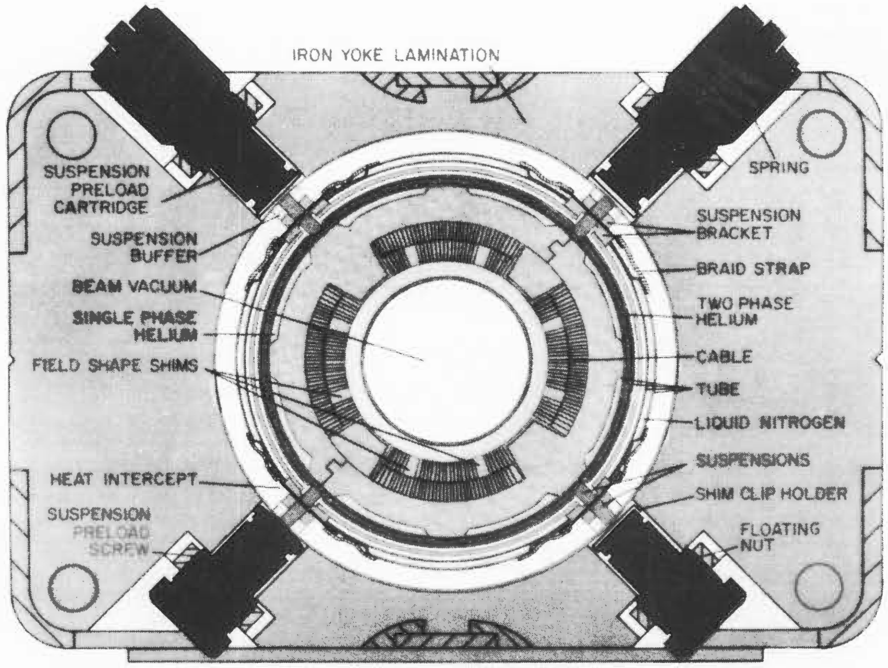
Operated by Universities Research Association Inc. under contract with the United States Department of Energy

INTENSITY RECORD

A new international intensity record of 3.25×10^{13} protons per pulse at 400 GeV was set at Fermilab on May 30.

ELECTRON COOLING

Experiments on electron cooling are continuing. Cooling has now been performed at the design energy of 110 keV and at currents up to 5 amperes of electrons. The system has been used to accumulate proton bunches, injecting, and rf accelerating new bunches, and cooling them to a "stack" of previously cooled bunches. Several hundred pulses have been accumulated this way. Lifetimes in excess of one hour have been observed. The work is continuing.



A new cross-section drawing of the Energy Saver quadrupole.

TEVATRON I PROGRESS

John Peoples and Don Young

After many parlous adventures, the Tevatron I project staff has revised the basic design of the Antiproton Source by adopting an all-stochastic cooling scheme. The revised design was scrutinized by several outside review committees, all of which have enthusiastically endorsed the changes. While this was taking place, the Tevatron Construction Group completed the engineering design of the Experimental Hall at B0 that will house the Collider Detector Facility. From the bids that were received on June 8, the Laboratory selected the low bidder to build the massive Experimental Hall. Construction is expected to begin during July and will continue into the fall of 1984. By the spring of 1983, the construction should be sufficiently advanced to permit commissioning of the Energy Saver with beam.

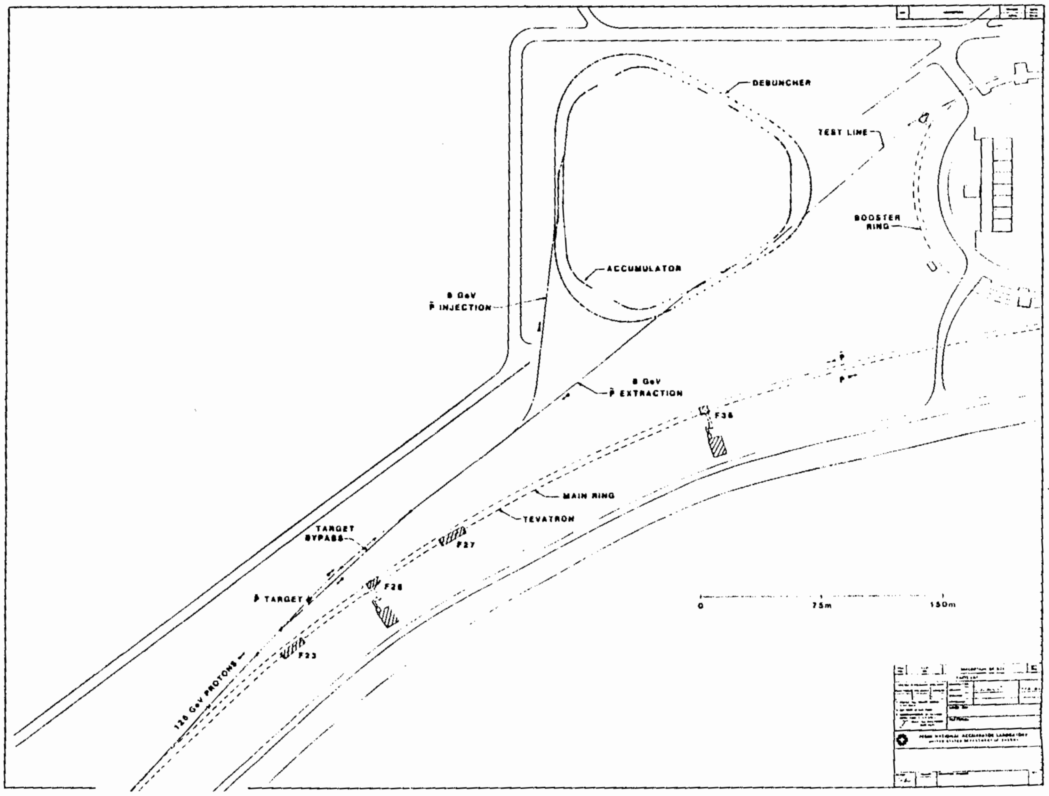
The Tevatron I project will enable experimenters to observe proton-antiproton collisions in the Energy Saver at the B0 and D0 experimental areas. The center-of-mass energy of 2 Tev will be the highest available in the world until at least the early 1990s.

The revised Antiproton Source design will use stochastic cooling, a technique which was invented by Simon van der Meer of CERN. The method is based on sensing deviations of a sample of particles in the circulating beam from the ideal orbit in one location and then partially correcting the deviations in another location. In the case of betatron cooling, a circulating beam induces in a pickup electrode a voltage proportional to the average position of the particles passing through the pickup at that moment. This voltage is amplified and then applied to a kicker in order to reduce deviations of the average positions of the particles. After many turns, the beam width is gradually reduced. Stochastic cooling was first used to cool proton beams in the ISR at CERN more than a decade ago. The method is the basis for the very successful Antiproton Accumulator now being used to supply antiprotons to the CERN Collider program. Stochastic cooling has also been demonstrated experimentally at Fermilab on our small cooling ring (see **Fermilab Report**, April 1980 and June 1980).

The Fermilab Antiproton Source is designed to accumulate 10^{11} antiprotons per hour, which is sufficient to provide the necessary antiprotons for luminosity of $10^{30}\mathrm{cm}^{-2}\mathrm{sec}^{-1}$ in a little more than 1-1/2 hours. Since the luminosity lifetime of the antiproton is in excess of 24 hours, we expect to exceed the design luminosity once the full potential of the Antiproton Source is reached.

The sequence of operations that must be performed is as follows: Protons are accelerated to 125 GeV in the Main Ring in

2 seconds, extracted at F17, and focused on a target as shown in the layout below. The 8-GeV antiprotons produced are focused by a lithium lens developed at the Institute for Nuclear Physics



General plan of the Antiproton Source

at Novosibirsk and transported to the debuncher, a storage ring approximately the size the Booster. In the debuncher, the antiprotons are rotated in longitudinal phase space to reduce their momentum spread and given their first cooling in transverse phase space. They are then transferred to the accumulator, a second storage ring where they are stacked and cooled. The accumulator is designed around stochastic cooling systems to cool newly injected antiprotons (the "tail") into the stack (the "core") and also to cool them in transverse phase space. After a large enough beam has been accumulated, its dense core is extracted, taken to the Main Ring and accelerated there and in the Tevatron. Detectors are planned for the B0 and D0 straight sections.

We plan to complete the engineering design of the Accumulator and Debuncher ring enclosures, the target station, and the beam-transport enclosures in the fall of 1982. The construction of the enclosures will begin early in 1983. The design of the magnets for the rings has advanced to the point where prototype magnets will be started in the fall.

The work described here was carried out by a collaboration of the University of Wisconsin, Argonne National Laboratory, Lawrence Berkeley Laboratory, Novosibirsk, and Fermilab. Our collaborators have been particularly active in the increased understanding and design work of stochastic cooling systems. We are all working to bring protons and antiprotons into collision by 1986 or earlier.

People at Fermilab will see more and more of Tevatron I in the coming year. Tevatron I will move particle physics into a new energy range and we all expect important new results. We believe Tevatron I will be the jewel of particle physics in the United States.

THE KAUTZKY VALVE

The development of a very large cryogenic system at Fermilab has given rise to the need for many new components, not only because of new technical requirements, but also because cost is a much more important issue when many copies are needed. A good example of a component developed here to meet a specific need is the Kautzky relief valve.

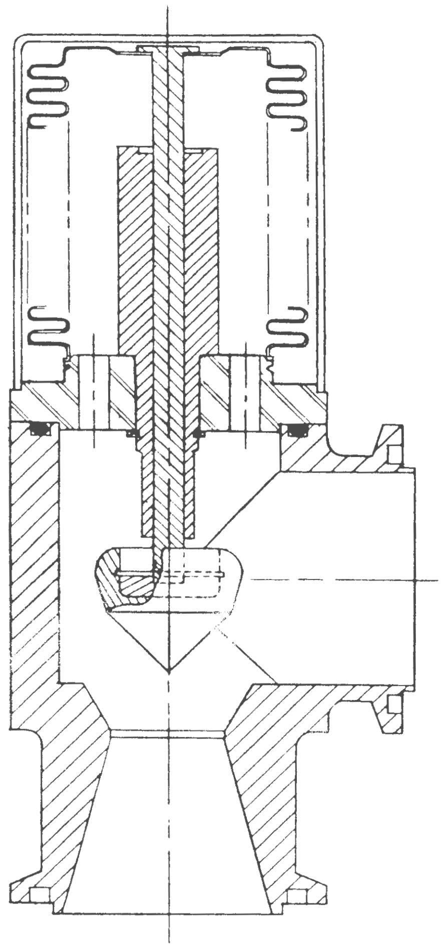
Every Energy Saver magnet must have a pressure relief valve to permit cold helium to be vented into a helium return line if the internal pressure rises too high, as it does if the magnet "quenches" (ceases to be superconducting, or goes normal) and dissipates its stored energy inside the magnet. Such relief valves existed before the Energy Saver (and were in fact used in the early development work), but had the difficulties of being very costly and not reseating positively, but instead chattering between partly open and closed.

This problem had been of interest to Hans Kautzky, a member of the Fermilab Colliding Detector Facility Department, when he designed expansion valves for the Princeton 15-inch rapid-cycling bubble chamber at an earlier time. He had also conceived of an automotive-crankcase pollution-control valve that stayed positively closed during idling. Kautzky built four prototypes of a valve for the Energy Saver and tested them, using a small Physics Department shop on the 9th floor of Wilson Hall. Maynard Lindo did the shop work. The results were sufficiently encouraging to warrant building 25 copies commercially, at a cost of about $300 each, for the purpose of testing them at B12, the Energy Saver's system-testing facility. It replicates 400 feet of the Energy Saver with the latest versions of dipoles, quadrupoles, spool pieces, and all cryogenic and controls support.

There was considerable discussion and concern about the valve size, because it is important not to restrict the flow through it during a quench. The B12 test proved that the valve size and flow characteristics were adequate to handle the flow during a full-current Energy Saver quench. Quantitative tests performed by Karl Koepke and Phil Martin showed that the open valve presented a much smaller impedance to the flow than did the magnet cryostat that the valve was emptying. But the B12 tests also showed that the prototype valve had a high probability of leaking at an unacceptable rate after reseating following a quench.

Kautzky was then joined by Thornton Murphy from the Energy Saver Accelerator Systems Department. Murphy's quantitative analysis of the seating forces involved and Kautzky's new ideas led to a joint effort in design, building, and testing, which led in turn to the second version of the valve. This version was briefly tested at both B12 and the Magnet Test Facility, passed the reseat test, and seemed reliable enough to make 240 copies for use in the A-Sector test. Further engineering improvements and control of mass-production were turned over by Kautzky to Tom Peterson, a member of the Energy Saver Satellite Refrigeration Group. He made some engineering modifications to increase reliability and reduce costs and, along with Murphy, supervised the testing, manufacture, and assembly (by the Meson Department) of valves for all the Energy Saver magnets.

The unusual and crucial feature of the Kautzky valve is that the poppet moves counter to the flow when opening. The "spring" that provides the seating force is the remote pressurization of a bellows-driven actuator, as can be seen in the diagram below.



Cross section of a Kautzky valve.

During a quench, the seating force is reduced by the high cryostat pressure acting on the inner surface of the actuator, thus opposing the "gas spring." When the force holding the poppet on its seat is reduced to zero, the poppet begins to open. As soon as flow past the poppet is sufficient to equalize the pressure on the two sides of the poppet, this additional force on the poppet pushes it rapidly to its fully open position until the cryostat pressure is reduced to a few psi less than the pressure at which the valve first cracked open. Thus the valve is chatter free.

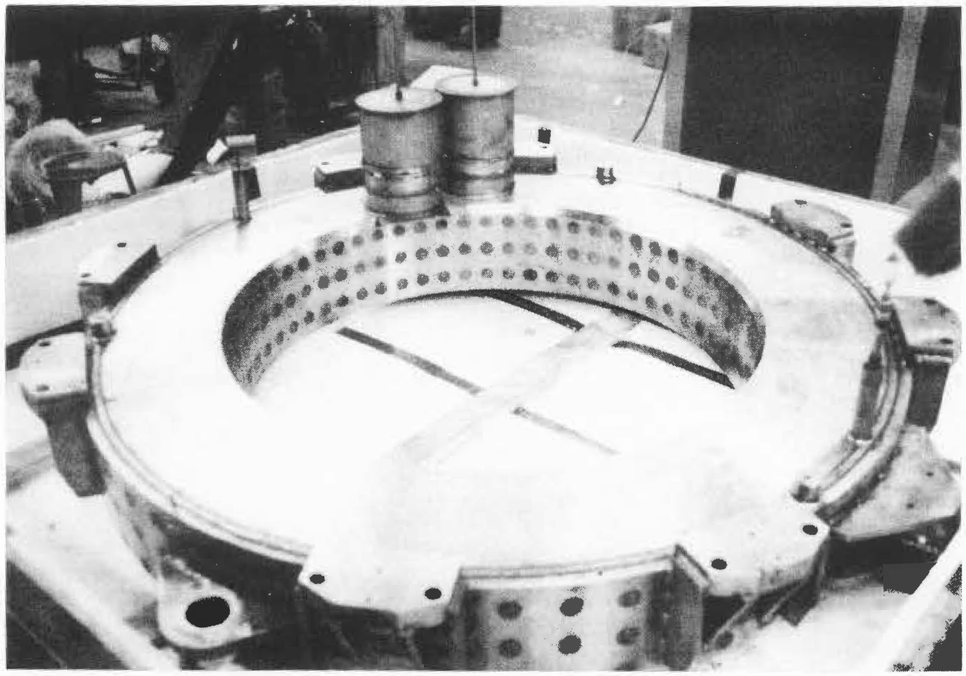
Using a gas spring instead of conventional steel springs has several advantages. The gas is supplied and regulated at bottles outside of the cryogenic area and all valves can therefore be simultaneously and remotely adjusted to whatever relief pressure is deemed most suitable. All valves on a given manifold can be opened remotely (by removing the actuator pressure) for vacuum pumping or to open briefly a valve that is leaking because of debris trapped between the poppet and the seat. The flow of helium from the cryostat past the poppet then sweeps the debris out into the recollection header--sometimes. Various screws and spacer material have been ingested into the valves. Fortunately, they cause failure in the more-desired open mode.

One of the early valve designs had a Teflon poppet and a welded actuator bellows. In testing, it was found that the Teflon poppet cracked after a few tens of cold shocks. An ultra-high molecular weight polyethylene was found that did not crack during cold shocking, was sufficiently soft to seat well, and was one-hundred times more radiation resistant than Teflon. A "hydroformed" actuator bellows has been substituted for the welded bellows at one-third the cost and works well. The bellows lifetime appears to be 1000 to 1500 quenches, adequate for the Energy Saver application.

There were also alignment problems that could inhibit proper valve seating. These problems have been solved by careful attention to tolerances. The weld of the actuator stem to the top plate of the bellows turned out to be critical because in the version used for the A-Sector test it could (and did) fail in a closed mode. A redesign of the attachment of the stem to the bellows plate has produced a valve that "fails safe" (open) even if the weld does crack, and that has a much sturdier weld. There are, of course, possible failure modes of the system that are not "fail-safe." Experimentation has also made it possible to choose the correct size O-ring to maintain a seal between the actuator and valve body even after cooldown to cryogenic temperature. All of these developments have matured the initial concept into an inexpensive ($100) and more reliable device.

The first 480 of the 1500 valves of the final design needed are presently being assembled by the Experimental Areas Department and are undergoing tests both at MTF and at the Materials Development Laboratory in the Village. The success of the

Kautzky valve in our Energy Saver applications leads us to believe that there must be a broad range of cryogenic uses for the valve. It is, we believe, a step forward into the superconducting era.



One of the superconducting coils for the 30-in. bubble chamber about to be cold shocked and leaked checked.
(Photograph by Fermilab Photo Unit)

SECOND ANNUAL MEETING OF THE FERMILAB INDUSTRIAL AFFILIATES

Richard Carrigan

The Fermilab Industrial Associates annual meeting was held at Fermilab on May 20 and 21. The meeting was attended by more than sixty people from forty-five different organizations. Nineteen of the thirty-two organizations in the Affiliates sent representatives. In addition, there was also substantial participation from Fermilab, URA, and DOE. There was a stimulating panel on technology transfer, technical presentations, and tours of the work at the Laboratory, as well as opportunities for the Affiliates to interact directly with the Laboratory staff.

A highlight of the meeting was the roundtable on technology transfer and the university-industry interface. The panel subject was introduced by Robert Frosch, vice president of General Motors and former administrator of NASA. The panel included four other distinguished industrial research leaders as well as Tom Martin, president of Illinois Institute of Technology, and Robert Jones, editor of **Industrial Research.** Frosch pointed out that technology transfer is not a neat process, but rather a non-linear one with lots of feedback. Even within an industrial organization, the transfer process is not smooth. "Brokering" of technologies is important along with actual movement of people. The panelists cited many areas of the university-industrial interface: recruiting, consulting, contractual agreements and joint ventures, donations including equipment, employee education, and participation in governing boards. There are difficulties--licensing, proprietary information, understanding university organizations, and a sensitivity of universities to faculty raiding. Robert Spinrad, vice president-research, Xerox, stressed that the proprietary concerns were largely misplaced; the value of new ideas far outweighed the diffusion of company secrets. Robert Jones of **Industrial Research** emphasized the importance of venture capital in exploitation of technology. He also noted that small businesses often felt that R&D technology needed much more development to bring it into the market place.

Questions from the audience brought out concerns about motivating the developers of technology to be active in the transfer process. There was also recognition that ordinary competitive bidding sometimes acted to suppress technology transfer to companies that could exploit the technology. Generally, the participants were pleased with the meeting. At the close-out, the importance of continuing communications was stressed--the possibility of getting more Laboratory reports, monthly reports, and of actually exchanging people.

REORGANIZATION IN RESEARCH DIVISION

The Meson, Neutrino, and Proton Departments are being combined into a single department to be called the Experimental Areas Department. This reorganization becomes effective at the end of the current 400-GeV running period. The new department, consisting of about 200 people, will be headed by Ken Stanfield, and it will remain part of the Research Division under Peter Koehler. The primary motivation for this reorganization is the fact that the departments are faced with a number of jobs which are too large for any one group to achieve alone, and which can best be handled by pooling resources, talents, and skills of all three departments.

The work of the combined department will be carried out by eight support groups listed below, each of which is responsible for work in all three experimental areas. Names of the persons who have accepted leadership responsibilities are given for each group.

Construction Planning and Coordination: Ray Stefanski, Tony Glowacki

Cryogenics: Peter Garbinicius, Stan Stoy, Jim Kilmer, Peter Mazur, Wes Smart

Electrical Support: Joel Butler, Bob Trendler, Age Visser, Paul Czarapata

Experimental Areas Support: Alan Jonckheere, Al Guthke, Delmar Miller, Dick Worland

Facilities Support: Dan Green, Stephen Pordes

Mechanical Support: Dave Eartly, Ron Currier, Jack Lindberg

Operations: Marshall Mugge, Jon Hawkins, Romesh Sood, Skip McGuire

Radiation Safety: Don Cossairt

GENERAL RECOMMENDATIONS OF THE PHYSICS ADVISORY COMMITTEE

Traditionally the Fermilab Physics Advisory Committee, in its annual June meeting, makes general recommendations relevant to Laboratory policy. In the June, 1982, meeting the following General Recommendations were made to the Director:

I. 400-GeV Program

The Committee congratulates the Laboratory on the successful completion of the 1982 400-GeV running period. We endorse the plan to complete the remaining 400-GeV experiments in an early run with the Saver ring operating at that energy. We also endorse the decision to operate the conventional accelerator at 400 GeV only if the Saver operation is substantially delayed.

II. Saver Commissioning

The Committee is very pleased with the progress made in Saver construction and the success of the A-sector tests during the 1982 400-GeV running period. The A-sector tests did not interfere with the experimental program and demonstrated the capability of the Saver magnet design. The completion of the Saver ring on schedule in the spring of 1983 can be predicted with confidence.

III. Tevatron II Program

The Committee wishes to review the Tevatron II running program, which is scheduled to start in mid-1984, at its meeting in the fall of 1982 and requests that the relevant materials be made available prior to the meeting date. Special emphasis will be placed on the readiness of the approved Tevatron II experiments, the turn-on of the beam lines, the proton economics, and the total projected running time required to complete the presently approved program.

IV. Tevatron I Program

The Committee enthusiastically endorses the present plans for Tevatron I. The completion of this project will make possible experiments with $\bar{p}p$ collisions at 2 TeV total center-of-mass energy and high luminosity, and thus will be a unique facility in the world for research in this energy domain. As such, its construction should have high priority in the national program.

The CDF project will also be reviewed at the fall 1982 meeting. In this regard, the Committee recommends that a set of proposed milestones and bench marks be made available prior to that meeting so that progress may be monitored more effectively on physics goals, hardware, software, and management. It is also recommended that better contact be established with the CERN SPS collider experimental groups. This might be accomplished more effectively if a senior person from the CDF collaboration were to work with the UA1 group at CERN during the coming year.

The Committee recommends that the Laboratory call for new proposals for $\bar{p}p$ experiments in the D0 and E0 straight sections, to be due in February 1983. It recommends that the D0 area be expanded to encourage proposals with a wider scope than in the original call. The E0 straight section may be suitable for certain low luminosity experiments.

V. Future Options

The Committee endorses the general plan of the Laboratory to pursue development of 10T superconducting magnets and novel designs of superconducting rings aimed toward the next generation of proton rings in the early 1990's. The emphasis should be on the highest practical energy. The construction of a dedicated proton ring with $\bar{p}p$ and ep options may be an attractive project for the late 1980's.

Laboratory Comment

Construction bid experience for the B0 interaction area indicates that more resources are available for a larger D0 area. We concur with the PAC recommendation and ask that new D0 proposals be submitted before February 1, 1983, in order to be considered by the June 1983 PAC meeting. For guidance, one can think about an interaction region volume about 50% larger than the 500 m^3 previously suggested, e.g., 8m×8m×12m. E0 proposals will have to fit in the available tunnel and be non-interfering with the beam transfer functions in that area.

PHYSICS ADVISORY COMMITTEE MEMBERSHIP

Name	Institution	Term Expires
Lee Pondrom, Chr.	University of Wisconsin	Oct. 82
Edmond Berger	Argonne National Laboratory	Apr. 83
Wit Busza	Massachusetts Inst. of Tech.	Apr. 83
Edward Witten	Princeton University	Apr. 83
Stanley Brodsky	SLAC	Apr. 84
Vera Luth	SLAC	Apr. 84
John Peoples	Fermilab	Apr. 84
Frank Sciulli	Columbia University	Apr. 84
Bruce Winstein	Enrico Fermi Institute	Apr. 84
John Cumalat	University of Colorado	Apr. 85
Thomas Devlin	Rutgers University	Apr. 85
Gary Feldman	SLAC	Apr. 85
Hugh (Brig) Williams	University of Pennsylvania	Apr. 85

Note: As of the November meeting, the new Chairperson will be Dr. Vera Luth.

HEPAP

S. Drell, SLAC
P. Carruthers, LANL
T. Collins, Fermilab
M. Derrick, ANL
K. Gottfried,* Cornell
W. Metz
M. Perl, SLAC
L. Pondrom, Wisconsin
J. Sandweiss, Chr., Yale
N. Samios, BNL
R. Thun, Michigan
H. Williams, Pennsylvania

P. K. Williams, DOE/HEPAP, Secretary

* ex officio

NOTES AND ANNOUNCEMENTS

FUTURE WORKSHOPS AND CONFERENCES. . .

A Workshop on Drell-Yan Processes will be held at Fermilab October 7-8, 1982. The most recent developments in theory and experiments on massive lepton pair production will be emphasized. It is intended that the workshop will lead to new analyses of present data and guide the choices of future experiments. Topics to be discussed include: effect of initial and final-state interactions via soft gluons, A-dependence, angular distributions, higher-order QCD contributions (K factor), higher-twist terms, p_T distributions, associated hardon production, and structure functions. Phenomenological uncertainties in the data analyses will be stressed in the experimental part of the workshop. The relationship of symmetric hadron pair production at large p_T to the Drell-Yan process will also be explored. Those interested in participating may contact Risto Orava, Fermilab, (312) 840-4093.

The 12th International Conference on High-Energy Accelerators will be held at Fermilab on August 11-16, 1983. The program will include sessions on colliding-beam straight sections and detectors. Individuals interested in participating should contact Russ Huson, conference chairman.

MANUSCRIPTS, NOTES, LECTURES, AND COLLOQUIA PREPARED OR PRESENTED FROM MAY 15, 1982 TO JUNE 19, 1982

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

C. Nelson et al. Experiment #272/629	Operational Performance of a Large Liquid Argon Photon Calorimeter (FERMILAB-Pub-82/41-EXP; submitted to Nucl. Instrum. Methods)
D. H. Kaplan et al. Experiment #577	Antiproton-Proton and Proton-Proton Elastic Scattering at 100 and 200 GeV/c (FERMILAB-Pub-82/40-EXP)
P. E. Karchin Experiment #577	Measurement of Pion Proton Deep Elastic Scattering at 13.7 and 19.4 GeV Center-of-Mass Energies (Ph.D. Thesis, Cornell University, May 1982)

General

W. B. Fowler	Large Cryogenic Systems of the Energy Doubler (International Conference on Cryogenic Engineering, Tokyo, May 1982)
K. Ishibashi and A. D. McInturff	Stress Analysis of Superconducting 10T Magnets for Synchrotron (Submitted to the International Conference on Cryogenic Engineering, Tokyo, May 1982)

Physics Notes

S. Conetti and A. G. Ruggiero	Production of Electrons and Positrons by Impinging 100 GeV Protons on a Target for Purpose of Filling an Electron Storage Ring (FN-364)
K. Takayama	A New Method for Potential of a 3-Dimensional Non-Uniform Charge Distribution (FN-365)

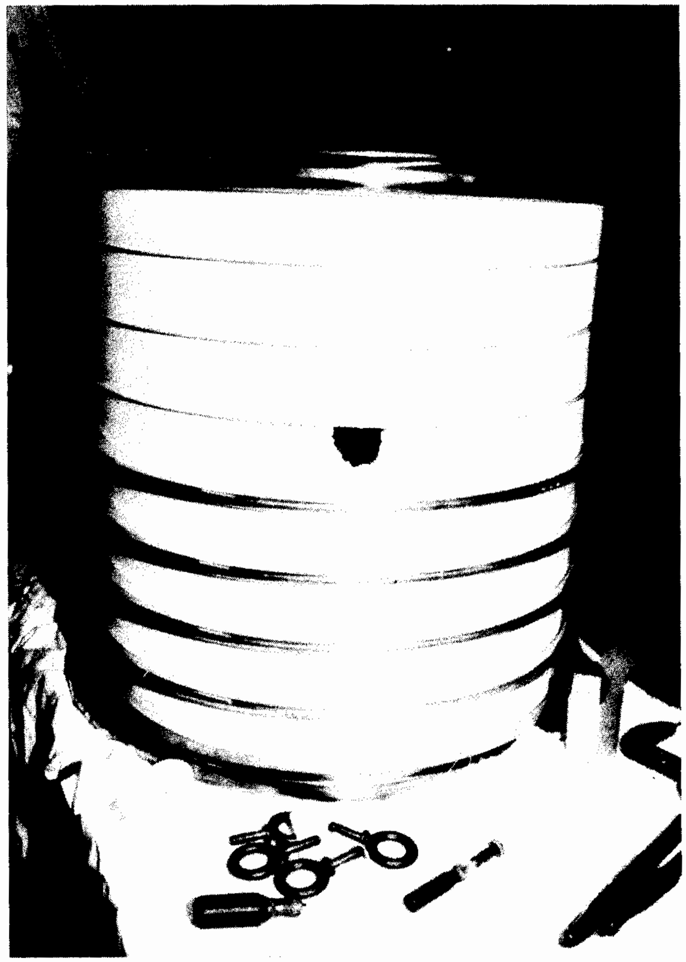
L. C. Teng	Superconducting Magnets (FN-367)

Colloquia, Lectures, and Seminars

Z. Bang-Rong	"Constraints from Unification of Interactions in a Class of Composite Models" (Fermilab, May 18, 1982)
T. Peterson and T. Murphy	"Further Development of the Doubler Relief Valve" (Fermilab, May 18, 1982)
W. Nestander	"Tevatron I Construction Work for 1982" (Fermilab, May 25, 1982)
C. Moore	"Beam Quality Measurements at Fermilab" (Los Alamos National Laboratory, May 26, 1982)
C. Nelson	"Direct Photon Production at 200 GeV/c" (Fermilab, May 28, 1982)
T. Collins	"The Accumulator" (Fermilab, June 1, 1982)
B. Wagner	"Antiproton Production of Dimuons E-537)" (Fermilab, June 4, 1982)
L. Lederman	"Exploring Particle Physics" (Fermilab, June 7, 1982)
K. Bitar	"Phase Structure and Renormalization Trajectories of Lattice SU(2) Gauge Theory" (Fermilab, June 8, 1982)
W. Fowler	"Report of the 9th International Cryogenic Engineering Conference" (Fermilab, June 8, 1982)
J. Ingebretsen	"Introduction to the Fermilab Central Computing Facility" (Fermilab, June 9, 1982)
P. Martin	"Doubler A-Sector Test" (Fermilab, June 15, 1982)
F. Cole	"Particle Accelerators" (Fermilab, June 16, 1982)
P. O. Mazur	"Cryogenics and Superconductivity" (Fermilab, June 17, 1982)

R. Huson "Transporting the Beam to your Experiment" (Fermilab, June 18, 1982)

One of the 20 buffalo calves born in the last few months.
(Photograph by Fermilab Photo Unit)



Damage from sparking to the accelerating column of the old preaccelerator. Repairs have been completed and the system is back in operation.

(Photograph by Fermilab Photo Unit)

DATES TO REMEMBER

July 1-12, 1982	Advanced Study Institute on Techniques and Concepts of High Energy Physics, Lake George, New York (see November 1981 issue for details).
July 23, 1982	Deadline for requests for fall on-site housing. Responses will be mailed out by August 13, 1982. Starting dates for fall occupancy will begin the first week of September. For information, please call the Housing Office, Ext. 3777.
November 11-13, 1982	Physics Advisory Committee Meeting.
February 1, 1983	Deadline for new D0 proposals and other submissions for consideration of the Physics Advisory Committee.