fermilab report

Fermi National Accelerator Laboratory Monthly Report

April 1981

fermilab report is published monthly by the Fermi National Accelerator Laboratory, P. O. Box 500, Batavia, Illinois 60510

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FERMILAB-81/4 **Fermi National Accelerator Laboratory** 0090.01

THE COVER: Relocation of shielding under access road in Proton West.

(Photograph by Fermilab Photo Unit)

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SUPERCONDUCTING ACCELERATOR UPDATE

Tim Toohig

Signs of progress on the Superconducting Accelerator project are evident even to the casual observer at Fermilab these days. Among the most obvious is the installation of the high-pressure helium line and the two branches of the LHe/LN2 transfer line passing under Road D from the Main Ring shielding berm to the Central Helium Liquefier (CHL) Building. The high-pressure line is already in service to allow use of the 40,000 SCF helium buffer tank at CHL in conjunction with the magnet tests at B12. Also very evident these days are the transfer-line support stands which are now in place for the entire ring except for the straight sections. In F-sector three of the four auxiliary service buildings now have their bright-blue heat exchangers protruding from their downstream walls.

Magnets

Meanwhile back at the Magnet Facility, a total of 149 dipoles of the "smart bolt" design had been produced through the end of March, along with 20 final design quadrupoles and seven spool pieces. There still exists a very large backlog of collared-coil assemblies and the production rate of cryostats to house these has been raised above the projected 10/week to clear the backlog. The A3 upstream cryoloop has been fully installed and all the dipoles of the A3 downstream loop are in place.

B12 Test Facility

The testing program at B12 using older-style magnets was completed and the facility has been rebuilt using accelerator magnets of the final design and the newer versions of the vacuum and quench-protection circuits. The newer systems were developed on the basis of the earlier B12 tests.

The new system incorporates the alternating bus scheme designed to reduce voltages across the loads during quenching. A collecting header similar to these in the tunnel have been installed and connected to the magnet relief valves. The helium relief valves are now nonlinear, solenoid-driven, Kautzky valves.

The revised system will allow studies aimed at further refinement of the quench-protection system. Extensive studies will be made of the thermal and mechanical performance of the new "smartbolt" trimpots of the vacuum system, etc. A major thrust of the revised B12 program will be the development of the control systems for the accelerator.

Controls

Considerable hardware and software development and installation has taken place in the past six months. One of the most obvious signs of progress is the appearance of an Energy Saver control console in the Main Control Room. Link drivers have been installed and debugged and both vacuum and refrigeration subsystems in A-sector and B12 can be controlled from the Main Control Room. The Resident Local Intelligence unit has been installed at B12 and is in use.

Before the old B12 system was dismantled, it was operated for a week on closed-loop control using a standard Doubler ramp to 4000A. This was accomplished without operator intervention. These closed-loop controls are now being down-loaded from the PDP-11 to microprocessors.

Refrigeration

Installation of refrigeration is paced to construction and procurement of components.

Some compressors have been commissioned and some others are being procured and installed, limited by the availability of funding. The valve boxes connecting the satellite refrigerators to the tunnel have been installed in F-sector. The remaining valve boxes are in hand and will be installed when the tunnel becomes accessible at the beginning of the summer shutdown.

The CHL has had a very successful three-week reliability run which also served to train the operating crews. The run was terminated for installation of the valving and connections to permit delivery of LN2 and LHe to the Main Ring.

Enough LHe/LN2 transfer line and 3 in. high-pressure He line has been fabricated for over half the ring. In A-sector, the line is in place and being welded up. The line for E and F-sectors is stored near F0 and A0 respectively ready to be installed on the support stands.

RF

The prototype rf cavity has been completed and successfully tested in the Main Ring beam. Installation work for the 3-cavity Saver system is proceeding. The cooling water circuits in the rf Saver addition have been completed.

Power Supply

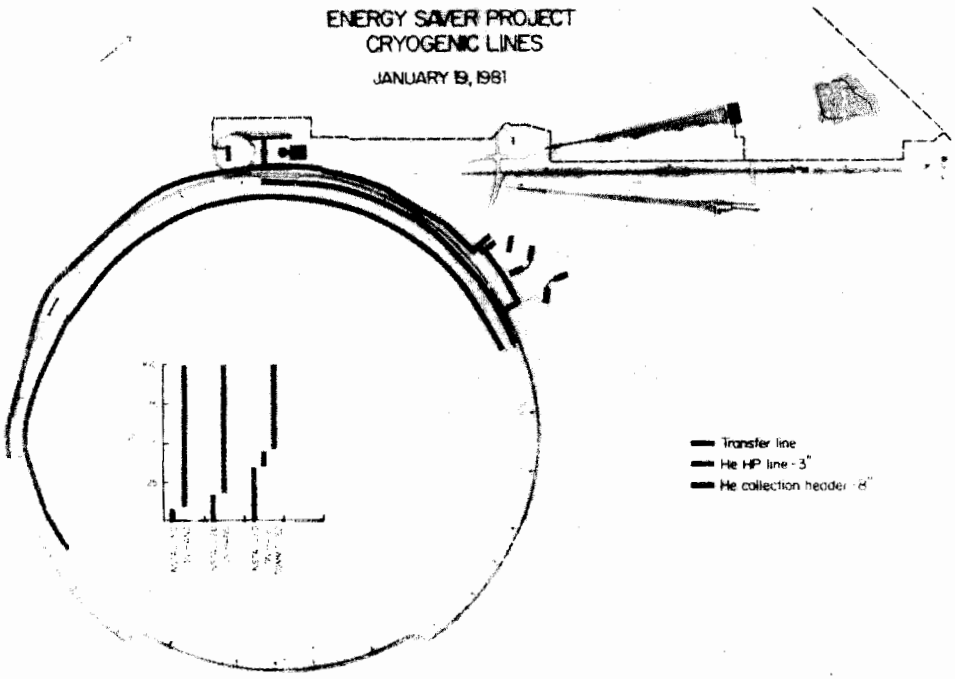
At A2 the Main Ring power supply has been disconnected from the Main Ring system and is being modified for Energy Saver use.

Injection and Extraction

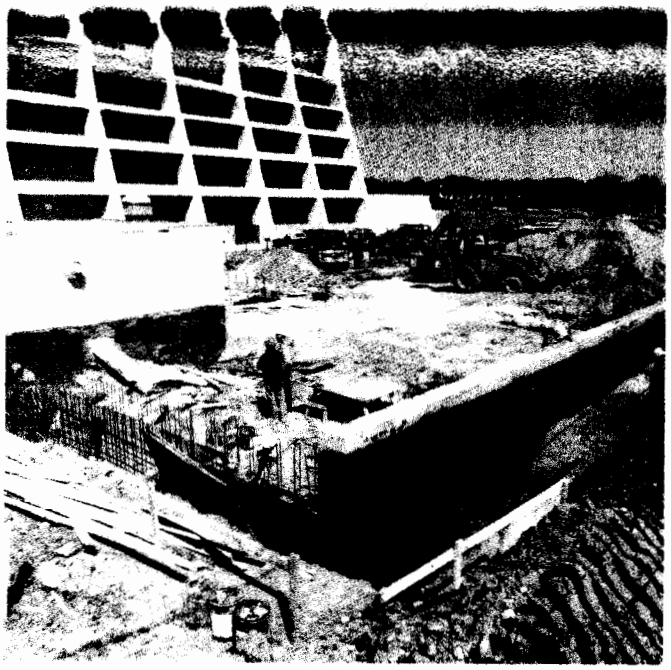
The conventional bump magnets for injection and extraction were completed by the Magnet Facility. Work proceeds apace on the other components of the systems.

Summary

All in all, the past six months have witnessed a decisive turn away from prototype activity to production of components and final installation. The Superconducting Accelerator is moving along at high speed.



Progress on the cryogenic system.



Construction of the North Addition to the Transfer Gallery.
(Photograph by Fermilab Photo Unit)

FERMILAB AT THE PARTICLE ACCELERATOR CONFERENCE

The 1981 Particle Accelerator Conference was held in Washington on March 11-13, sponsored by the Department of Energy, the National Science Foundation, and the American Physical Society. The Fermilab work was represented by more than 50 papers covering a broad spectrum of advances in all our accelerator efforts.

The nearest-term work was represented by a number of papers reporting on detailed work to understand and improve high-intensity operation of the Booster and Main Ring. This work was vital in the success reported last month in **Fermilab Report**, the achievement of 3×10^{13} protons per pulse and in the excellent reliability of 400-GeV operation.

The next nearest term work reported was on the Energy Saver. Progress on that project is reported separately in this month's **Fermilab Report**. The Energy Saver is building magnets successfully and is also bringing many complex accelerator systems to reality.

Progress was also reported on colliding beams. Since the 1979 Accelerator Conference, stochastic and electron cooling have been demonstrated experimentally at Fermilab (in collaboration with Argonne, Lawrence Berkeley Laboratory, INP, and Wisconsin) and Fermilab people presented a number of papers on the experimental results, on the design of a $\bar{p}$-production target, on study of dense proton bunches in the Main Ring, and on the design of the Precooler and Electron Accumulator storage rings to be built for $\bar{p}$ accumulation.

In the farther future were proposals to make use of the Precooler as a muon-storage ring to study neutrino oscillations and to improve the operation of the Tevatron by a 120-GeV super-booster. There was also design work reported on the design of an 85-kilogauss superconducting magnet, the next generation after the Tevatron.

Finally, there were a number of basic theoretical investigations reported on studies of nonlinear forces, beam-beam interactions and particle motion in severe space-charge conditions.

These papers, which will be published in the proceedings, are an indication of our work toward the future physics program of Fermilab. A list of accepted papers is appended to this report.

PAPERS SUBMITTED TO THE IEEE 1981 PARTICLE ACCELERATOR CONFERENCE, WASHINGTON, D. C., MARCH 11-13, 1981

Snapshot Digitizer System for Fermilab Main Accelerator
R. J. Pasquinelli

Preparation and Study of Bunches Containing 10^{11} Protons in the Fermilab Main Ring
J. E. Griffin, J. A. MacLachlan, and J. F. Bridges

Antiproton Collection from a Production Target
F. Krienen and J. A. MacLachlan

Electron Cooling Experiments at Fermilab
R. Forster, T. Hardek, D. E. Johnson, W. Kells, V. Kerner, H. Lai, A. J. Lennox, F. Mills, Y. Miyahara, L. Oleksiuk, R. Peters, T. Rhoades, D. Young, and P. M. McIntyre

Electron Cooling for the Fermilab $\bar{p}$ Source
W. Kells, F. Krienen, F. Mills, L. Oleksiuk, J. Peoples, and P. M. McIntyre

The Fermilab Proton-Antiproton Collider
D. E. Young

Improved FNAL Linac Beam Choppers
K. Bourkland, C. Curtis, G. Lee, and G. Tool

The Tevatron Control System
D. Bogert, L. J. Chapman, R. J. Ducar, and S. L. Segler

A 120-GeV Superbooster for Fermilab
F. R. Huson

An RF Beam Position Measurement Module for the Fermilab Energy Doubler
S. P. Jachim, R. C. Webber, and R. E. Shafer

Fermilab Power Monitor
R. Gerig and H. Pfeffer

Multi-Level Computer Simulation of the Energy Saver Cooling Provisions
H. R. Barton, Jr., G. T. Mulholland, and J. E. Nicholls

Large Dynamic Range Beam Profile Measurement in a High Background Environment
W. Merz, R. Dixon, M. Harrison, and J. McCarthy

Review of the Fermilab Main Ring Accelerator Study Program as Directed to the $\bar{p}p$ Program
J. E. Griffin, J. A. MacLachlan, and J. F. Bridges

A Vacuum Control Subsystem for the Fermilab Tevatron
J. R. Zagel and L. J. Chapman

Tevatron Satellite Refrigeration Control Subsystem
J. R. Zagel, D. Bogert, L. J. Chapman, R. J. Ducar, J. C. Gannon, M. Harrison, G. Johnson, M. Martin, and S. Segler

Magnetostatic Design of 85kG Superconducting Dipoles
S. C. Snowdon

"Arnold Diffusion" and Diffusion Enhancement by the Beam-Beam Interaction
D. Neuffer, A. Riddiford, and A. G. Ruggiero

Mechanical Design of Lambertson Magnets for Injection into the Energy Saver
M. May, H. Edwards, M. Harrison, J. Jagger, and R. Isiminger

Collective Longitudinal Motion in Intense Ion Beams
D. Neuffer

Design of Muon Storage Rings for Neutrino Oscillations Experiments
D. Neuffer

Comments on Stable Motions in Nonlinear Coupled Resonances
S. Ohnuma

Heavy Ion Accelerators for Inertial Fusion
L. C. Teng

Approximate Physical Treatment of the Beam-Beam Effects
L. C. Teng

Status of Efforts to Improve the Transverse Properties of the Fermilab Booster
C. W. Owen, B. C. Brown, J. Crawford, J. Garvey, H. Gerzevske, J. Lackey, K. Meisner, and R. Rice

Fermilab Energy Doubler Beam Position Detector
R. E. Shafer, R. C. Webber, and T. H. Nicol

Energy Doubler Vacuum Devices and Controls
L. Bartelson and H. Jöstlein

A CAMAC Serial Crate Controller for the Tevatron Accelerator
R. J. Ducar

Tevatron Serial Data Repeater System
R. J. Ducar

A 3kG Kicker Magnet System for the Tevtron Beam Abort System
G. Krafczyk, H. Edwards, Q. Kerns, M. May, E. Tilles, and F. Turkot

A High Intensity Beam Dump for the Tevatron Beam Abort System
J. Kidd, N. Mokhov, T. Murphy, M. Palmer, T. Toohig, F. Turkot, and A. VanGinneken

Spool Piece Testing Facility
M. Kuchnir, R. J. Walker, W. B. Fowler, and P. M. Mantsch

Quasi-Optimal Algorithms for the Control Loops of the Fermilab Energy Saver Satellite Refrigerator
M. Martin, J. Gannon, C. Rode, and J. McCarthy

Pulsed High Current Optics for $\bar{p}$ Production at 5.4 GeV/c
J. A. MacLachlan, G. Nicholls, J. Nicholls, G. Silvestrov, and T. Vserolozhskaya

Very Low Intensity Storage-Ring Profile Monitor
T. Hardek, W. Kells, and H. Lai

Active Filter for High Current dc Magnets
F. F. Cilyo, F. E. Mills, and Y. Miyahara

Instrumentation for the Tevatron Abort Dump
E. Harms, B. Hendricks, G. Lee, and T. Williams

Energy Saver Prototype Accelerating Resonator
Q. Kerns, M. May, H. Miller, J. Reid, F. Turkot, R. Webber, and D. Wildman

A Four-Quadrant Magnet Power Supply for Superconducting and Conventional Accelerator Applications
R. Yarema

Fermilab Energy Saver Refrigeration System Tests
C. Rode, R. Ferry, M. Leininger, J. Makara, D. Mizicko, J. Misek, D. Richied, and J. Theilacker

Progress in Superconducting Magnet Technology for Accelerators/ Storage Rings
A. Tollestrup

Advanced Stochastic Cooling Mechanisms
W. Kells

Measurement and Compensation of Coherent Laslett Tune Shifts in the Fermilab Main Ring
R. Gerig, C. Moore, and S. Pruss

Beam Quality Measurements in Fermilab Main Ring
R. Gerig, C. Moore, and S. Pruss

Measurement of Incoherent Laslett Tune Shifts in the Fermilab Main Ring
R. Gerig, C. Moore, and S. Pruss

Correction Magnet Packages for the Energy Saver
D. Ciazynski and P. Mantsch

The Energy Saver/Doubler Quench Protection Monitor System
R. Flora, J. Saarivirta, G. Tool, and D. Voy

Longitudinal Beam Signal Processing for the Fermilab Beam Quality Monitor
E. Higgins and C. Moore

A Microprocessor Based Function Generator for Superconducting Dipole Correction Coils
D. Beechy, D. Bogert, S. Segler, and T. Watts

60 MHz 6 Bit Digital to Analog Converters for the Super Beam Damper of the Fermilab Main Accelerator
R. Pasquinelli

Electron Beam Studies in the Fermilab Electron Cooling Experiment
W. Kells, L. Oleksiuk, and P. McIntyre

Status of Efforts to Improve the Transverse Properties of the Fermilab Booster
C. Owen, B. Brown, J. Crawford, J. Garvey, H. Gerzevske, J. Lackey, K. Meisner, and R. Rice

Water-Cooled Aluminum Coils for a 14.4 m Dipole
R. Fast, E. Bosworth, and J. Jagger

Dependences of the Emittances of the Fermilab Injectors on Intensity
C. Moore, C. Curtis, J. Lackey, C. Owen, C. Ankenbrandt, R. Gerig, and S. Pruss

Improving Regulation in the Fermilab Main Ring Magnet Power Supply System
D. Wolff, H. Pfeffer, C. Briegel, J. Dinkel

Thermodynamic Performance of the Central Liquefier
H. Burton

Multilevel Computer Simulation of the Energy Saver Cooling Provisions
G. Mulholland, J. Nicholls

Fermilab Energy Saver Satellite Refrigeration Control Loops
C. Rode, J. Gannon, M. Hentges, and M. Martin

Multiple Element Vapor Cooled Current Leads for the Fermilab Energy Saver Correction Elements
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Doubler Vacuum Devices and Controls
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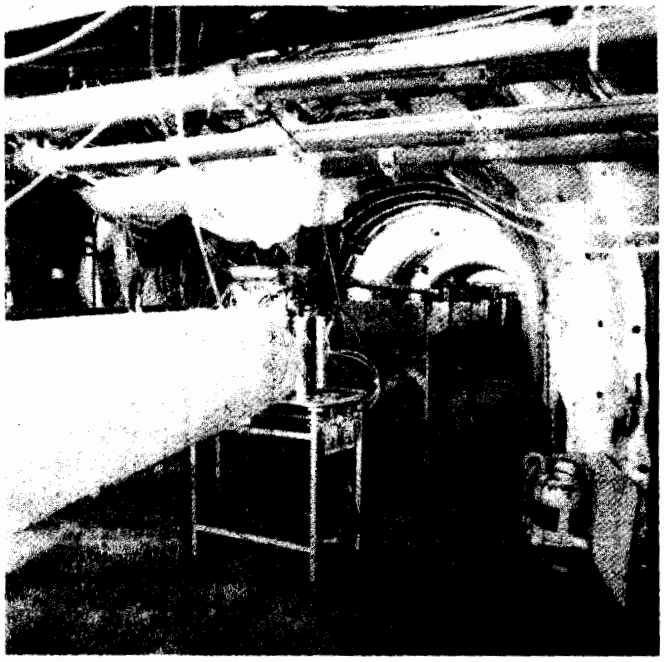


The new M6 beam line.
(Photograph by Fermilab Photo Unit)

SUMMARY OF OPERATIONS - MARCH 1981

Program Planning Office

The 400-GeV high-energy physics program was interrupted for about two weeks during the month of March to allow construction of facilities needed for the Energy Saver. Nevertheless, the experimental and accelerator programs clearly made progress, and six experiments completed their data taking during the month.

Dimuon #326 in the High-Intensity Laboratory and Charged Hyperon #497 in Proton Center relinquished their experimental areas to Dimuon #537 (testing their apparatus) and Charm Production #630 (setting up), respectively. In the Tagged Photon Laboratory, Experiments 516 and 612 (Photoproduction and Photodissociation) have been studying what conditions are necessary in order to take data in both the magnetic spectrometer and time projection chamber simultaneously.

The Meson Area has seen the completion of Kaon Charge Exchange #585 and Elastic Scattering #577, and the startup of E-663 (Lambda Polarization) and E-577 (Hadron Jets). The Beam Dump Experiment in M2 (E-613) began taking special data to study the effects of background particles produced in the Meson targets. Particle Search #515 has been testing equipment in M1.

The 15-ft bubble chamber was warmed up after Experiments 53A and 564 finished their neutrino exposures, and the 30-in bubble chamber program was started up. Tests of this chamber and its beam were conducted this month in preparation for experiments expected to begin in April. Continuing to run in the Neutrino Area was E-531. Experiment 594 progressed with the equipment testing phase of its run.

The accelerator passed a milestone this month (see March 1981 Fermilab Report) when a new world intensity record was set for 400-GeV operation: 3.003×10^{13} protons were accelerated and delivered to experimental areas in one cycle. This accomplishment was preceeded by two weeks of running with intensities averaging about 2.5×10^{13} protons per pulse.

FERMI NATIONAL ACCELERATOR LABORATORY
MONTHLY OPERATIONS HISTORY
MARCH 1981

Date		Accelerator	Internal Target Area	Proton Area	Neutrino Area	Meson Area
Sun.	3/1	~ 2.5×10^{13} ppp @400 GeV 1.0 sec flattop	OFF	516 (PE) 326 (PW) 497 (PC)	53A,564,531(N0) 594,P635,631 565,570,597(N3)	577(M6), 613(M2) 585(M4), 629(M1) 617(M3) Test
Mon.	3/2					
Tue.	3/3					
Wed.	3/4				End 53A,564	
Thu.	3/5	Accelerator M&D				
Fri.	3/6	SY Vacuum	OFF	497 (PC) 326 (PW) 612 (PE) 516 (PE)	531 (N0) 565,570,597(N3) 594 (N0) P635 Tests 631	613(M2), 577(M6) 629(M1),585(M4) 617(M3) Test
Sat.	3/7					
Sun.	3/8					
Mon.	3/9	Nec.Repairs/MR Dipole				613(M2),585(M4) 577(M6),515(M1) 617(M3) Test
Tue.	3/10	Replace MR Quad				
Wed.	3/11	~ 2.2×10^{13} ppp @400 GeV/c 1.0 sec flattop				
Thu.	3/12					
Fri.	3/13					
Sat.	3/14					
Sun.	3/15			End 497,326		End [illegible]
Mon.	3/16					
Tue.	3/17					
Wed.	3/18	Accelerator Shutdown				
Thu.	3/19					
Fri.	3/20					
Sat.	3/21					
Sun.	3/22					
Mon.	3/23					
Tue.	3/24					
Wed.	3/25					
Thu.	3/26					
Fri.	3/27	Startup & Tuneup				
Sat.	3/28	~ 2.0×10^{13} PPP	OFF	537 (PW) 516/612 (PE) OFF (PC)	531 (N0) 565,570,597(N3) 594 (N0)	613(M2),515(M1) 663(M4),557(M6)
Sun.	3/29	[illegible] Blowing Fuses @400 GeV/c 1.0 sec flattop				Meson OFF
Mon.	3/30	13 BKZ Grnd Fault				
Tue.	3/31					

BEAM UTILIZATION BY EXPERIMENTAL ACTIVITY - MARCH 1981

	Beam	Hours	Activities
PROTON AREA			
Dimuon #326	PW	180	data taking completed
Charged Hyperon #497	PC	230	hyperon polarization data; completed
Protoproduction #516	PE	240	data and tests
Dimuon #537	PW	85	startup and testing
Photodissociation #612	PW	215	setup and tuning; detector tests
NEUTRINO AREA			
15-ft ν/H_2 and Ne #53A and 15-ft w/Emulsion #564	NO		additional 27 K pictures; run completed
Neutrino #531	NO	325	data; short-lived charmed particle studies
Neutrino #594	NO	280	data and flash tube calorimeter tests
MESON AREA			
Particle Search #515	M1	75	setup, tuning, timing
Hadron Jets #557	M6	5	setup and calorimeter tests
Elastic Scattering #577	M6	210	data taking completed
Kaon Charge Exchange #585	M4	185	end of data collection
Beam Dump #613	M2	195	data; background studies
Direct Photon Production #629	M1	120	finish data taking
TOTAL HOURS FOR HIGH ENERGY PHYSICS		2345	

FACILITY UTILIZATION SUMMARY - MARCH 1981

I. Summary of Accelerator Operations

	Hours	
A. Accelerator use for physics research		
High energy physics research	317.2	
Accelerator physics research	-	
Subtotal		317.2
B. Other Activities		
Program interruption	324.7	
Accelerator setup and tuning to experimental areas	11.5	
Subtotal		336.2
C. Unscheduled interruption		90.6
D. Unmanned time		-
Total		744.0

II. Summaries of High Energy Physics Research Use

	# of Expts.	Hours	Results
A. Counter experiments	13	2345	
B. Bubble chamber experiments	1		26.7 K pictures
C. Emulsion experiments	-	-	
D. Special target experiments	-	-	
E. Test experiments	-	-	
F. Engineering studies and tests	-	-	
G. Other Beam Use	-	-	
Totals	1	2345	

III. Number of Protons Accelerated and Delivered ($\times 10^{17}$)

A. Beam accelerated in Main Ring	21.5	
B. Beam delivered to experimental areas	20.1	
Proton Area	5.1	
Neutrino Area		
	Slow Spill	0.24
	Fast Spill	11.2
Meson Area	3.6	

Annual User's Meeting Committee. From left Phyllis Hale, Lawrence Jones of Michigan, and Sherry Balika.
(Photograph by Fermilab Photo Unit)

Graduation of the second Saturday Morning Physics class.
(Photograph by Fermilab Photo Unit)

MANUSCRIPTS, NOTES, LECTURES, AND COLLOQUIA PREPARED OR PRESENTED FROM MARCH 13, 1981 TO APRIL 14, 1981

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. N. Brown et al. Experiment #'s 288 and 605	The Status of the Columbia-Fermilab-Stony Brook Collaboration (Presented by C. Brown at 16th Recontre de Moriond, Les Arcs, France, January 25-31, 1981)
D. Brick et al. Experiment #299	Multiple Correlations and High Transverse Momentum Jets in 147 GeV/c π^-p Interactions (Submitted to Phys. Rev. D)
P. Rapp et al. Experiment #557	A Segmented Calorimeter for High-P_t Jet Experiments (FERMILAB-Pub-81/31-EXP; submitted to Nucl. Instrum. Methods)
A. Bodek and J. L. Ritchie Experiment #616	Further Studies of Fermi Motion Effects in Lepton Scattering from Nuclear Targets

Theoretical Physics

U. P. Sukhatme et al.	Diquark Fragmentation (FERMILAB-Pub-81/20-THY; submitted to Phys. Rev. D.)
D. Creamer et al.	Some Exact Results for the Two Point Function of an Integrable Quantum Field Theory (FERMILAB-Pub-81/23-THY; submitted to Phys. Rev. Lett.)
H. J. Lipkin	Magnetic Moments of Composite Fermions (FERMILAB-Conf-81/25-THY; to be included in the Proceedings of Orbis Scientiae 1981, Center for Theoretical Sstudies, University of Miami, January 19-22, 1981)

A. J. Buras	An Upper Bound on the Top Quark Mass from Rare Processes (FERMILAB-Pub-81/27-THY; submitted to Phys. Rev. Lett.)
J. F. Schonfeld	Colliding Beams: What Is an Appropriate Mathematical Approach? (FERMILAB-Conf-81/29-THY; presented to a seminar on the beam-beam interaction at "Workshop on Long-Time Prediction in Nonlinear Conservative Dynamical Systems," Austin, March 16-19, 1981)

Physics Notes

R. Orava	Quark Jets (FN-335)

General*

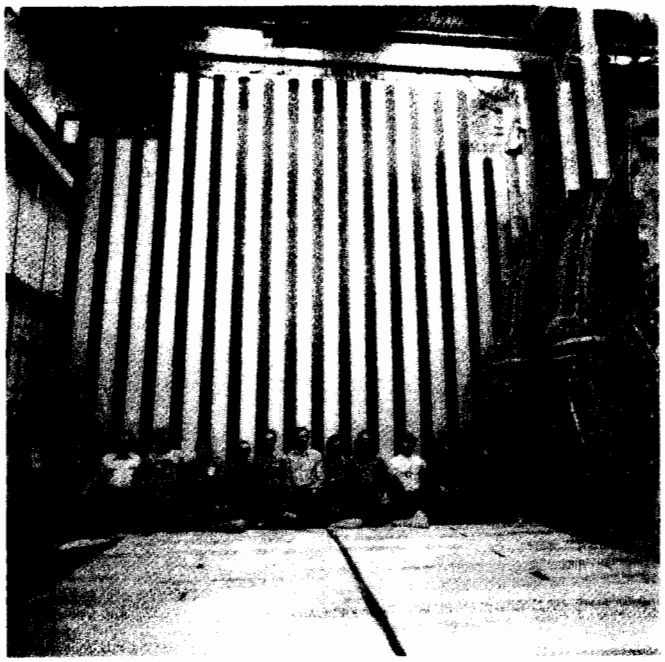
R. W. Fast et al.	14.4 m Large Aperture Analysis Magnet with Aluminum Coils (Presented at the 7th International Magnet Conference, Karlsruhe, Germany, March 30-April 3, 1981)
J. Grimson	Applications of Robotics in Accelerator Research Facilities (Submitted to Workshop to Delineate the Economic, Technical and Policy Issues for Remote Maintenance in Energy Systems, Gainesville, Florida, March 9-10, 1981)

Colloquia, Lectures, and Seminars

D. Harding	"Psi Photoproduction in E401" (Fermilab, March 13, 1981)
D. Ritchie	"RTMULTI Tutorial I - An Overview of the RTMULTI Online Data Acquisition and Analysis System" (Fermilab, March 16, 1981)
D. E. Johnson	"Tevatron Lattice and Proton Tune Shifts" (McGill University, March 18, 1981)

*For a list of papers submitted to the 1981 Particle Accelerator Conference, Washington, D. C., March 11-13, 1981, see page 6.

D. Ritchie	"RTMULTI Tutorial II" (Fermilab, March 18, 1981)
H. J. Lipkin	"The Potential Model of Colored Quarks: Success for Single-Hadron States; Failure for Hadron-Hadron Interactions" (Fermilab, March 24, 1981)
G. Fisk	"Neutral and Charged Current Neutrino Total Cross Sections" (Fermilab, March 27, 1981)
S. Mtingwa	"Introduction to Symmetries and Group Theory" (Fermilab, April 6, 1981)
T. Murphy, H. Jöstlein, L. Sauer et al.	"Report on Progress In and Above the Tunnel" (Fermilab, April 7, 1981)
S. Mtingwa	"Introduction to Symmetries and Group Theory (Fermilab, April 9, 1981)
L. Lederman	"Fermilab Programs" (Fermilab, April 10, 1981)
R. Raja	"The ψ-γ Spectrum in π^-p Interactions/Results from E610" (Fermilab, April 10, 1981)



Fermilab Experiment #594, billed as the world's largest wire chamber.

(Photograph by Fermilab Photo Unit)

DATES TO REMEMBER

May 1, 1981	VIII Annual Day of Scientific Lectures of the National Society of Black Physicists
May 27-28, 1981	Fermilab Industrial Affiliates Symposium on Technology Transfer
June 20-26, 1981	Summer meeting of the Physics Advisory Committee (Aspen)
July 13-24, 1981	1981 Summer School on High Energy Particle Accelerators