THE RESEARCH DIVISION 1980 - 1984

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Introduction

I served as Head of the Research Division from October 1, 1980, until September 30, 1984. These were years of transition during which the energy of the protons delivered by the accelerator to the external experimental areas increased from 400 to 800 GeV as a result of the completion of the Energy Saver. The advent of the Tevatron strongly influenced the activities in the Research Division throughout this period: the installation of the new accelerator necessitated extended shutdowns, thus reducing the beam time available for carrying out the experimental program; many groups in the Research Division were called on to undertake projects in support of the Tevatron construction; major upgrades of beam lines and facilities were required to prepare the fixed target experimental areas for operation at Tevatron energies; and the design and construction of the CDF detector was given high priority in order to have it completed by the turn-on of the Tevatron collider. In this report I will review these activities, but first I want to express my gratitude to all the dedicated members of the Research Division whose ingenuity and hard work made it possible to achieve a great many successes during these years under often trying conditions and faced with seemingly impossible deadlines.

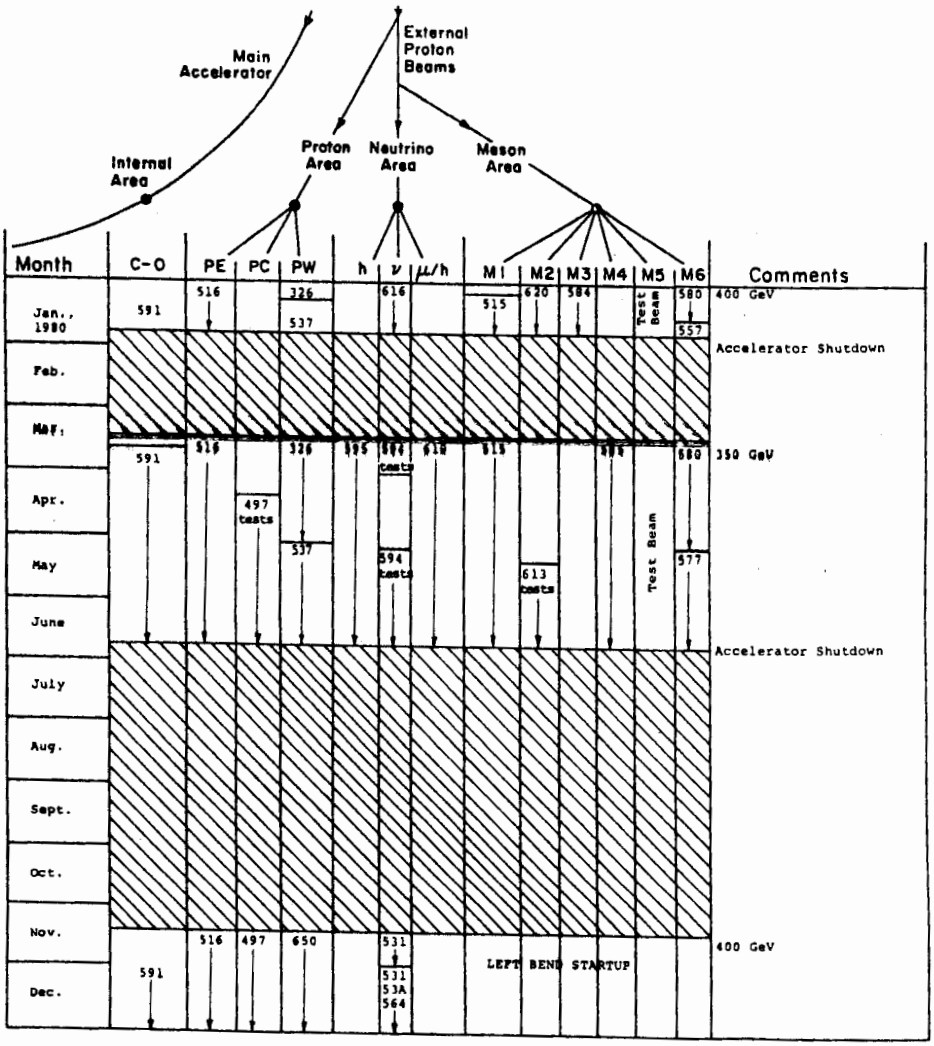
The Experimental Program

The as-run schedules for the fixed-target experiments in the years 1980-1984 are shown in Figs. 1-5. The limited amount of running time is reflected in the statistics for this four-year time period: 11 experiments which began prior to October 1, 1980, were continued; 26 new experiments were started; 34 experiments were completed, leaving 3 experiments to continue their runs in the next running period.

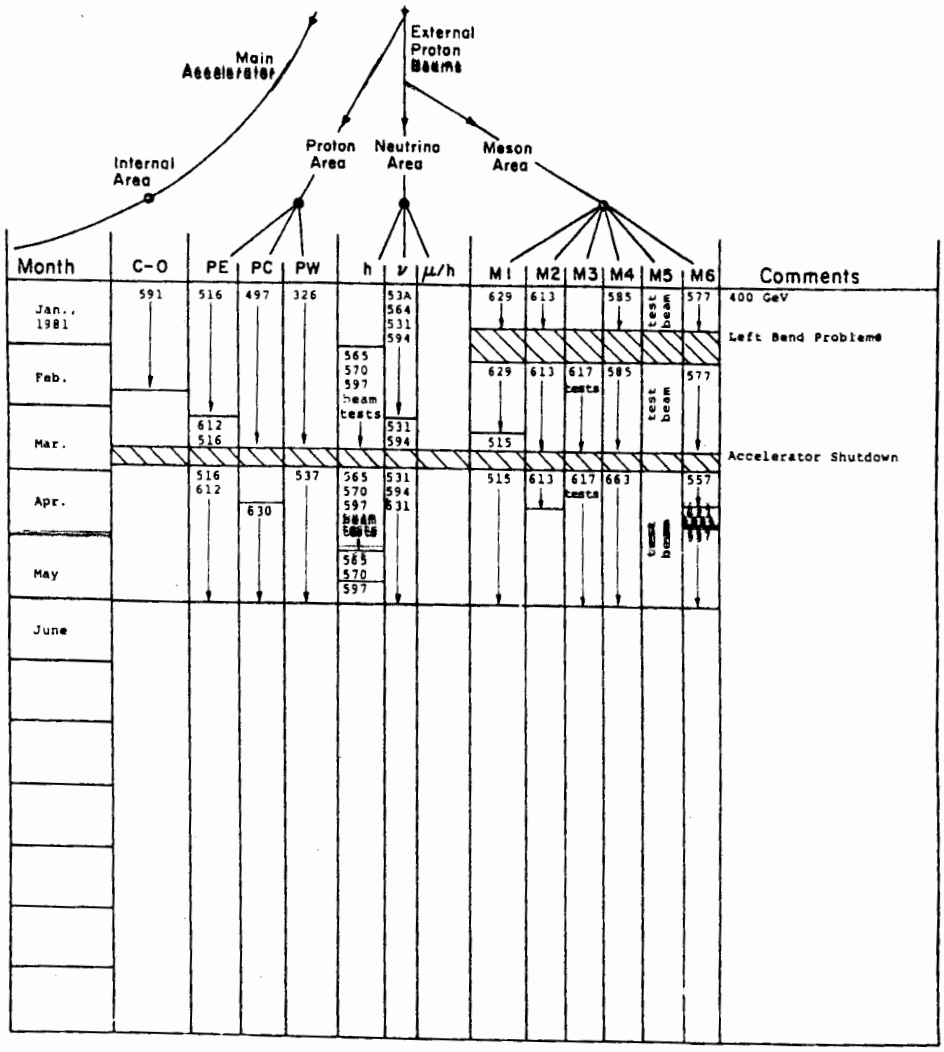
This time period can best be characterized as one during which the 400-GeV experimental program was brought to an end in order to make room for the new slate of Tevatron experiments which are now being set up in the beam lines. At least eight of these should be ready for a first run in early 1985.

This last set of 400-GeV experiments produced no headline-making discoveries but nevertheless a number of noteworthy results. I personally found the following of particular interest because of their goals, techniques, or results.

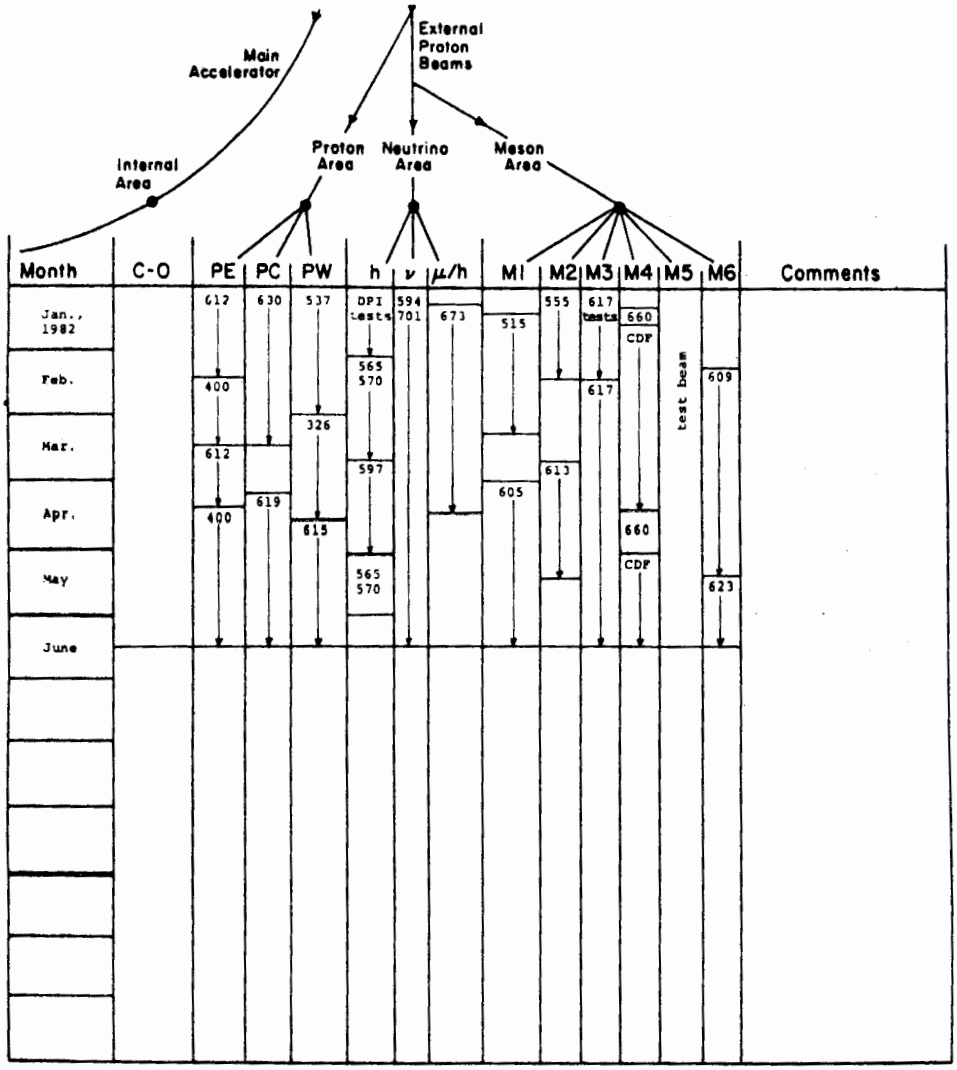
E-531 (Reay). In a novel combination of techniques this experiment used stacks of photographic emulsion together with particle tracking and identification in a magnetic spectrometer



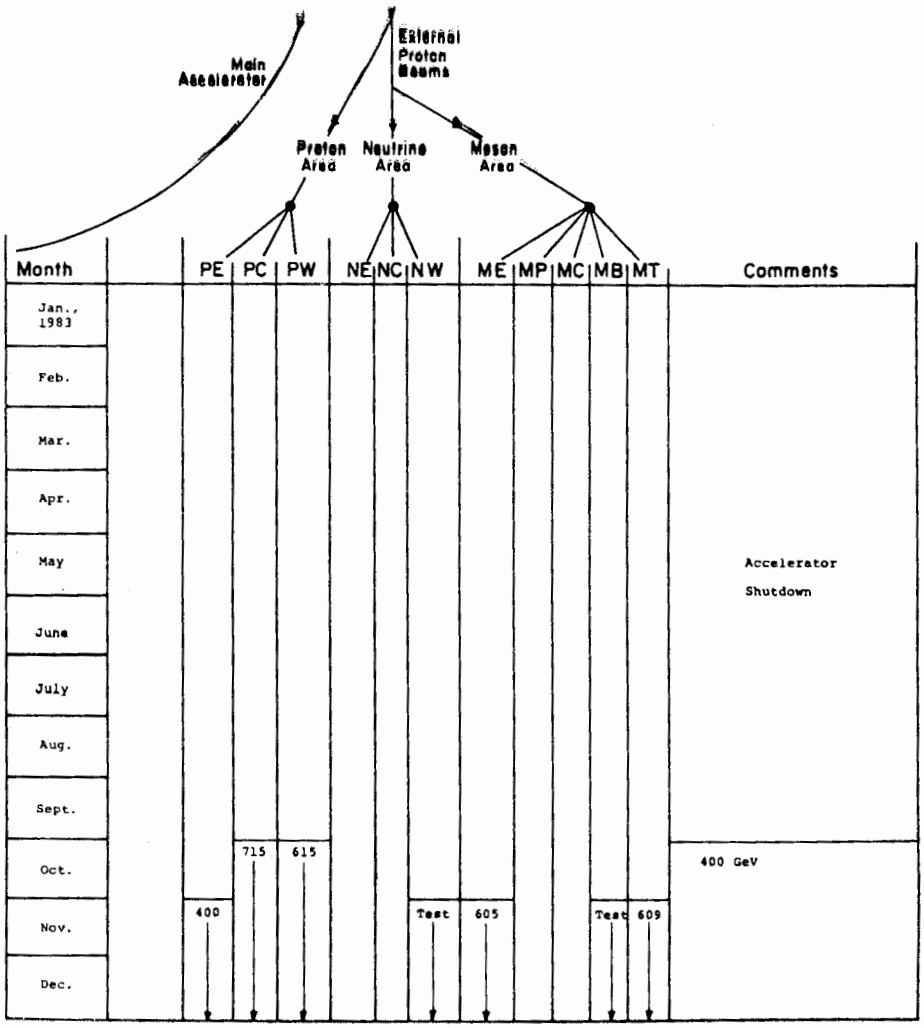
Experiments at Fermilab in 1980.



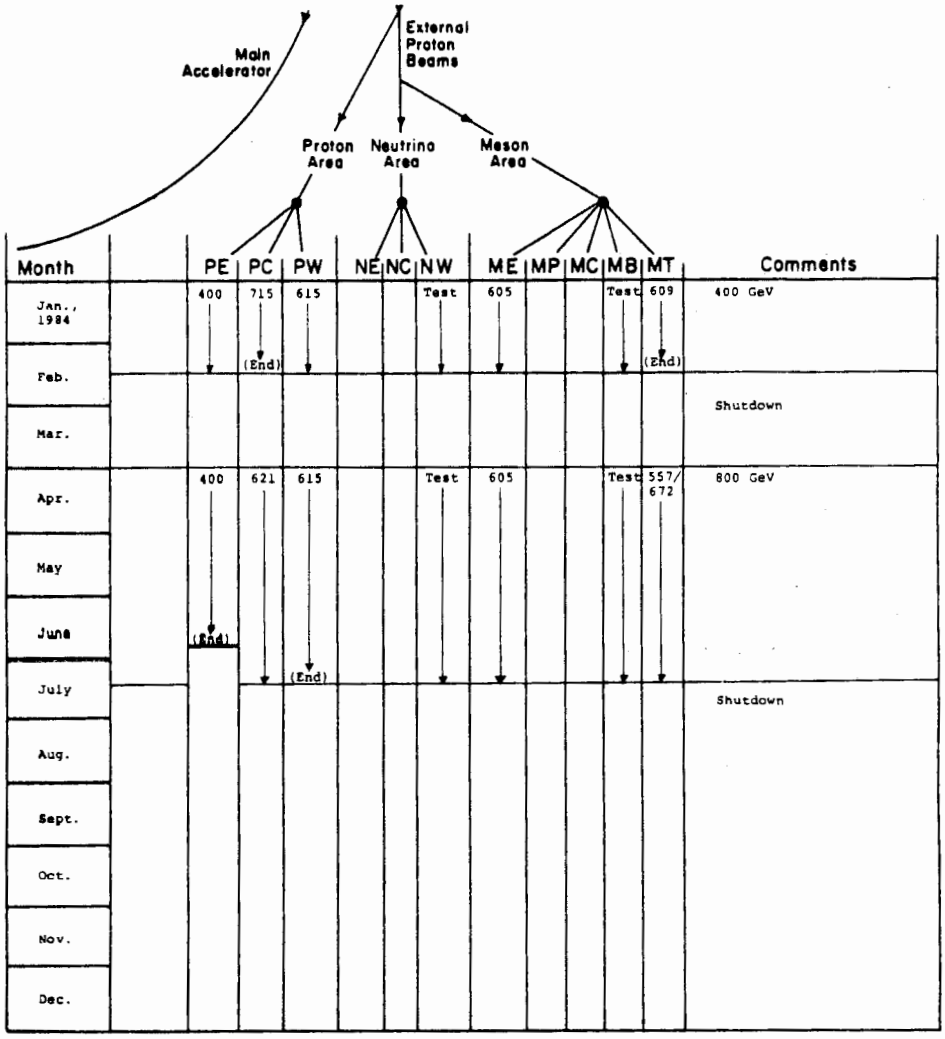
Experiments at Fermilab in 1981.



Experiments at Fermilab in 1982.



Experiments at Fermilab in 1983.



Experiments at Fermilab in 1984.

to study neutrino-production and decay of charmed particles. It resulted in the first direct determination of D-meson lifetimes.

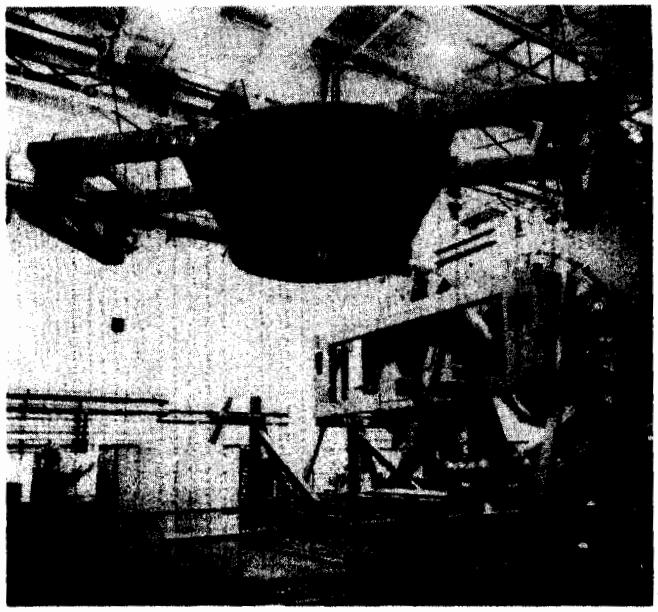
E-617 (Winstein). In order to reduce systematic errors this experiment prepared a double-barreled neutral kaon beam (K_L in one branch, regenerated K_S in the other) to determine the amplitude of the CP violation parameter $|\eta_{00}/\eta_{+-}|$ to a precision at which the experiment becomes sensitive to differences in the predictions for the value of this parameter by theoretical models for the cause of CP violation. (See Bruce Winstein's article in the September 1984 **Fermilab Report.**) A follow-up experiment, E-731, will determine this parameter to even greater precision.

E-619 (Devlin). In a clever utilization of the Primakoff effect this experiment was designed to measure the Σ-Λ transition magnetic moment for the first time; this effort capped a long series of precision measurements of the magnetic moments of hyperons by this same group.

E-701 (Shaevitz). Looking at the flux of ν_μ in two similar neutrino detectors at distances of 715 m and 1115 m, respectively, from the source of the narrow-band neutrino beam this experiment searched for evidence of neutrino oscillations in the region of large mass difference and small mixing angles. In the absence of any such evidence the experiment yielded tighter upper limits.

E-715 (Cooper). This experiment collected a data sample of more than 80,000 beta decays of polarized Σ^-, which was 200 times larger than the sum of four previous experiments and had much less background from hadronic decays as a result of an electron identification system consisting of transition radiation detectors and lead glass. (See Peter S. Cooper, **Fermilab Report**, April 1984.) The result from this experiment confirms that the value of the electron asymmetry parameter for the decay $\Sigma^- \rightarrow ne^-\nu$ agrees with the prediction of the Cabibbo theory.

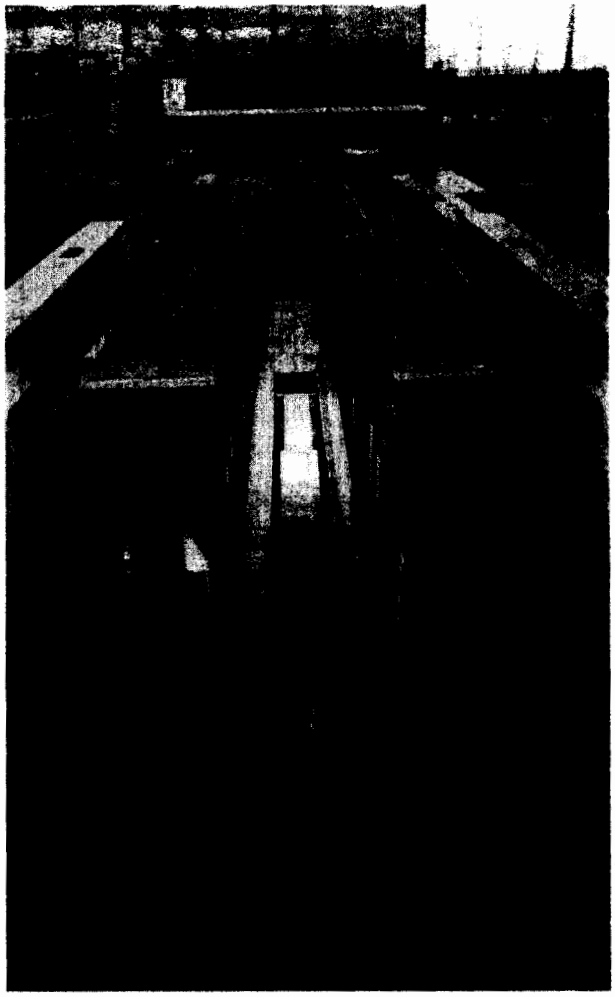
During these past four years the Research Division also became very active in the preparations for colliding-beams experiments. Most of the work was concentrated on the design and construction of the CDF detector, the first large detector being built at Fermilab to study $\bar{p}p$ collisions at 2 TeV. (See Roy F. Schwitters, **Fermilab Report** September 1983.) In order to meet Fermilab's responsibilities for the implementation of this large project, the CDF Department was built up from its 1980 manpower level of 21 to its 1984 size of 114. Additional growth will probably be required in order to assure that this detector will be ready for data taking in the fall of 1986. Trying to reach that deadline while operating under the limitations on manpower and funding during these years made it rather difficult to maintain the proper balance between the fixed-target and the colliding-beams programs.



Installation of the endplug calorimeters in the CDF detectors.
(Photograph by Fermilab Photo Unit)

Facility Upgrades

In addition to the support for the on-going experimental program, much of the effort in the Research Division during the past four years has been devoted to the design and implementation of facility upgrades in preparation for the utilization of the Tevatron for fixed-target experiments. Most of this work was formally carried out as part of the Tevatron II Project which began in FY82 and is right on course for completion at the end of FY85. (See Tom Kirk's account in **Fermilab Report**, February 1984.) This project provides for the energy upgrades of the extraction system, switchyard, and some existing beam lines as well as for the construction of four entirely new beam lines: the M-West pion beam, the M-Polarized proton beam, the N-Muon beam, and the P-Broadband photon beam. Just as important are the Industrial Center Building and the six new experimental halls (M-West, M-Polarized, Lab F, Lab G, N-Muon, P-Broadband) which are included in this project. They are sized and equipped to handle the new generation of Tevatron experiments which tend to be larger than their 400-GeV predecessors.



The target station for the M-West beam line.
(Photograph by Fermilab Photo Unit)

Several construction and improvement projects were carried out during these years which did not fall within the scope of Tevatron II. Among them I should mention the Assembly Buildings in both the Proton and the Meson Areas which at long last provide suitable working space for the support groups in close proximity to their areas of responsibilities; the Experimental Areas Operations Building which provides adequate space for a consolidated operations center for all three fixed-target experimental areas;

The control room in the Experimental Areas Operations Building.
(Photograph by Fermilab Photo Unit)

and the Meson Cryogenics Building which accommodates in one centralized location all of the helium refrigeration installations and their controls which are needed for operation of the cryogenic magnets in the Meson beam lines. This system of coupled loads connected by long transfer lines has taught us the painful lesson that reliable operation demands proper instrumentation and adequate refrigeration capacity in excess of the heat load.

There were several improvements made to experimental facilities which are worth noting: Although the 30-inch bubble chamber was decommissioned in June 1982 after a last series of runs which resulted in more than 1 million pictures, its magnet lives on: it was converted to superconducting coils and now provides the magnetic field for the 32-inch holographic bubble chamber which was built by Tohoku University for E-636/745. At the 15-foot bubble chamber the Internal Picket Fence was extended to cover the upstream half of the chamber's circumference as well; furthermore, the detectors which make up the External Muon Identifier were replaced and the chamber itself was modified to make it possible to take holographic pictures of events. The conversion of the Chicago Cyclotron Magnet to a set of superconducting coils was successfully completed; the magnet operated reliably and helium-economic during E-673 and has now been relocated to the N-Muon hall in preparation for E-665.

When this entire program of improvements has been completed a very good set of facilities will exist for fixed-target experiments to explore the new energy range opened up by the Tevatron. The first running period with the superconducting accelerator gave us a taste of what the experiments can look forward to in terms of flattop, duty cycle, and particle yields. The overall efficiency and reliability of the accelerator and the beam lines will no doubt improve with time.

I also should mention here a major change in the organization of the experimental areas which was implemented in order to optimize the utilization of the existing manpower as we tackled all of these projects. In June 1982 the Meson, Neutrino, and Proton Departments were merged into a single Experimental Areas Department. This reorganization resulted in the formation of task forces in the different specialty areas (e.g., cryogenic, electrical, mechanical, facilities, etc.) which were of sufficient size to provide the necessary support for the facility upgrades and the experiments. This change, which broke with longstanding tradition, was not instituted without considerable trepidation because of the danger that such a large department would be less responsive to the needs of the individual user groups. But I believe that the evidence to date has shown that this reorganization was, in fact, a correct step.

Change was not limited to the experimental areas; during these years a series of steps were taken in the Computing and the Research Services Departments in order to keep up with the growing and changing demands which were made on them by the research program. Both of these departments have been reported on very recently. (See Frank Beck, **Fermilab Report** November 1984, and Al Brenner, **Fermilab Report**, December 1984.) Thus I will mention only a few highlights: the central computing facility was enhanced by the addition of a dual processor Cyber 875 with 750K words of memory; delivery of the new hardware began late in 1983 and should be completed during 1985. A new beam line controls system, based on more modern hardware, was successfully completed by the Software Support Group in the Research Services Department in time for the 1984 running period, but the demands which the experimental areas are placing on the controls program are rapidly growing and require enhancements which are now being implemented.

During the last four years the Research Division also became the home to three new initiatives at the Laboratory: A Particle Detector Group was formed in the Research Services Department in 1983 in order to work on new types of detectors without the pressure of project deadlines. The Advanced Computer Group was transferred from the Physics Department in 1983 in order to be in closer contact with its future customers as it develops special-purpose computers to relieve the growing load on the central computing facility which the Tevatron experiments will produce. And in 1982 a Theoretical Astrophysics Group was started in the Theoretical Physics Department, reflecting the close relationship between these two branches of physics.

Assistance to the Tevatron

Throughout my tour of duty in the Research Division the construction of the Tevatron was given highest Lab-wide priority. Thus it was entirely appropriate that the Research Division helped out whenever assistance was requested. As a result, members of the Research Division made an impressive number of contributions to the accelerator during these years, and I would like to list them here for the record:

(1) The Cryogenics Group of the Proton Department built the four miles of helium transfer line which connect the satellite refrigerators to each other around the ring and to the Central Helium Liquefier.

(2) Individuals from several departments assisted with the set-up and operation of the Magnet Test Facility.

(3) The Neutrino Department's Bubble Chamber Group assisted with the assembly of the spool pieces.

(4) The Research Services Department's Hydrogen Target Group turned a portion of Lab 3 into a "Correction Center" where all of the correction coil sets were wound and assembled into packages for installation in the spool pieces.

(5) The Research Services Department's Electronics Support Group designed and built two major systems: the power supplies for the correction coils and the processors for the beam position monitors. Both systems contributed greatly to the smooth commissioning of the Tevatron.

(6) The Experimental Areas Department's Electrical Support Group built the power supply for the injection kicker which is critical for transferring the proton beam from the Main Ring into the Tevatron during acceleration. This group also built the interface chassis required for the cryogenics controls.

(7) Several teams from the Research Division helped with the installation of the Tevatron components in the tunnel and with operations during start-up.

(8) Members of the Alignment Group of the Research Services Department contributed their skill throughout the installation of the Tevatron magnets.

(9) The Computing Department's Minicomputer Software Group provided assistance to the Accelerator Controls Group.

The members of the Research Division can be proud of their contributions to the success of the Tevatron, particularly in view of the fact that in many instances these projects placed a heavy additional burden on them. Working side by side fostered a spirit of cooperation and healthy competition between members of the two divisions which was reminiscent of the early days of the Laboratory. Each side learned a great deal from the other and this will benefit future projects.

The Research Division has passed through four years during which only a rather limited amount of running time was available

for the execution of experiments because of the installation of the superconducting accelerator. The time was used to complete the program of 400-GeV experiments and to implement a broad range of facility upgrades and enhancements in preparation for doing physics with the Tevatron. This work is now nearing completion, and the emphasis at Fermilab will shift to the utilization of these facilities in which so much has been invested. Given adequate levels of funding in the years ahead we can look forward to exciting physics results from the Tevatron program of fixed-target and colliding-beams experiments.

The record of the Seventh Meeting of the US/USSR Joint Coordinating Committee for Research and the Fundamental Properties of Matter was signed at Fermilab on December 6, 1984. Signing was the Head of the U.S. delegation, James E. Leiss (left), Director of High Energy and Nuclear Physics, U.S. Department of Energy, and the Head of teh USSR delegation, Ivan V. Chuvilo, Director, Institute of Theoretical and Experimental Physics, Moscow.

(Photograph by Fermilab Photo Unit)