Who's Who in the Upcoming Fixed-Target Physics Run?

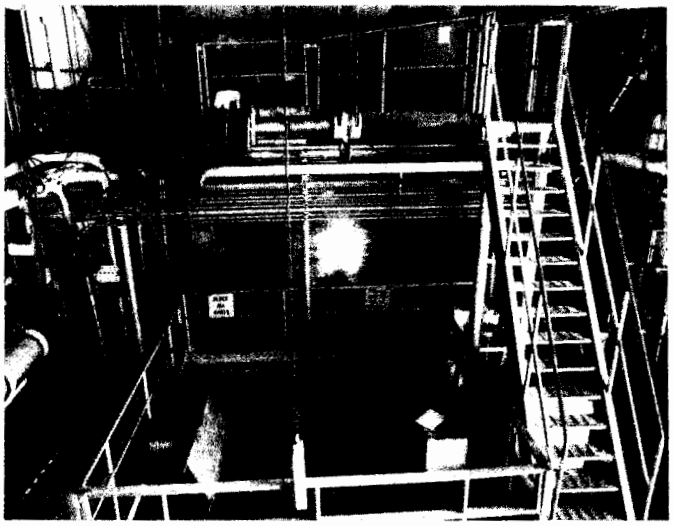
Mark W. Bodnarczuk

Introduction

The purpose of this article is to identify the 16 experiments and major test beam programs that will operate during the upcoming fixed-target run scheduled to begin in the middle of March 1987. In his Overview for the 1986 DOE Lab-Wide Review, Fermilab Director Leon Lederman elegantly described the goals of fixed-target physics at Fermilab as a program with a variety of particle beam probes and sophisticated detectors that would provide a "...solid advance along the broad frontier, addressing all the uncertainties in the Standard Model, making the precision measurements of masses and lifetimes and branching ratios and angles...the structure functions and cross sections, the magnetic moments and coupling parameters." The section that follows shows pictures of each experiment, a brief description of the physics they will be doing during the next running period, the current status of the experimental installation, and the names of the institutions currently working on the experiment as listed by Fermilab's Program Planning Office. The experiments are listed according to the type of physics they will explore, namely electroweak interactions, particle decays and CP violation, production of heavy quark flavors, and finally, hard collisions and QCD tests. In addition to the 16 experiments, two major test beams will be operated for the Collider Detector at Fermilab (CDF) in the M-Test beamline and D0 Detector in the N-West beamline.

Electroweak Interactions

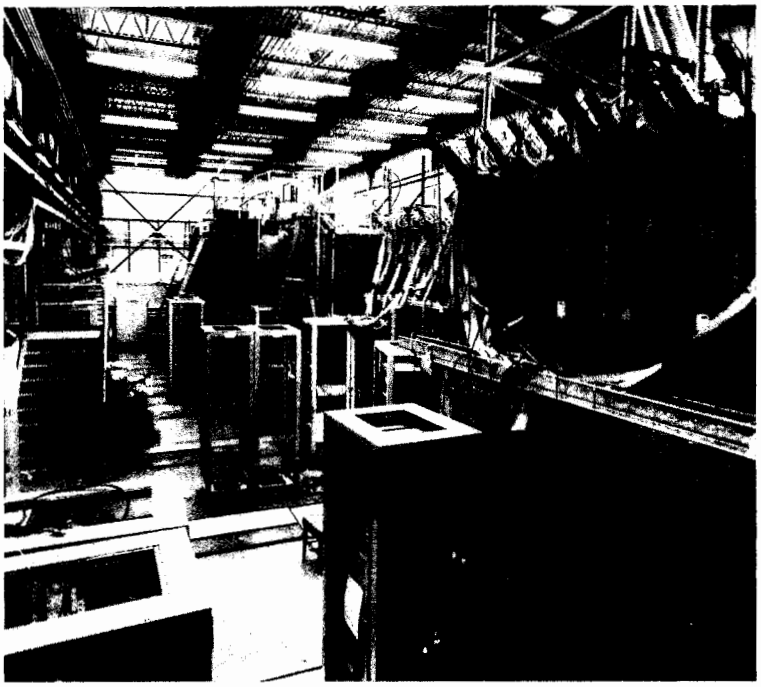
E-632: "An Exposure of the 15-ft Bubble Chamber with a Neon-Hydrogen Mixture to a Wideband Neutrino Beam from the TEVATRON." The main goal of this experiment is exploratory - to search for new particles or new effects in a new energy range. A second goal is to study like-sign dileptons in both the $\mu\mu$ and μe



modes since previous results at lower energies gave an indication of a deviation from the Standard Model. E-632 will continue to run during the next running period with numerous improvements to the detector, especially the laser holographics system. In particular, the installation of baffles within the 15-ft Bubble Chamber will improve holograms by absorbing light introduced into the chamber by the illumination beam at the bottom of the chamber. Also, the dispersing lens used during the last run did not give the proper balance between the reference beam and the illumination beam. The lens has been redesigned and is currently being ground with installation to follow. Pictured above is the 15-ft Bubble Chamber. E-632 is a collaboration of the University of California, Berkeley, the University of Birmingham (Great Britain), Universite Libre de Brussels (Belgium), CERN, Fermilab, the University of Hawaii, Illinois Institute of Technology, Jammu University (India), Max-Planck Institute (Germany), Punjab University (India), Rutgers University, CEN-Saclay (France), Stevens Institute of Technology, and Tufts University. (Spokespersons: D. Morrison, M. Peters)

(Fermilab photograph 86-771-7)

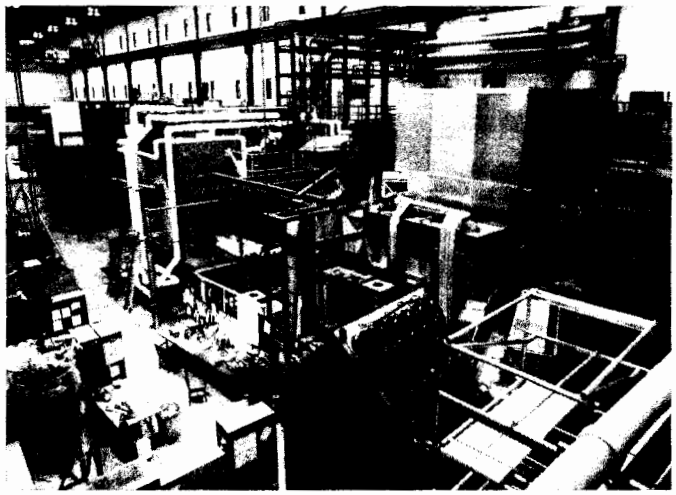
E-770: "Neutrino Physics at the TEVATRON" is a continuation of experiment 744 with an upgrade to the Lab E detector. The experiment will emphasize high statistics measurements of nucleon structure functions at higher energies than previously possible, high statistics measurements of charm production and the strange



quark sea in opposite sign dimuons, and improved statistical power in addressing existing questions concerning anomalous same-sign dimuon events. The upgrade to the Lab E detector includes flash analog to digital converters (ADC) for the new drift chambers. The addition of ADC's allows the experiment to make measurements of particle energy with increased resolution and also determines the direction of the hadrons penetrating the detector. The picture above shows an overview of the detector. E-770 is a collaboration of the University Chicago, Columbia University, Fermilab, and the University of Rochester. (Spokesperson: W. Smith)

(Fermilab photograph 86-771-9)

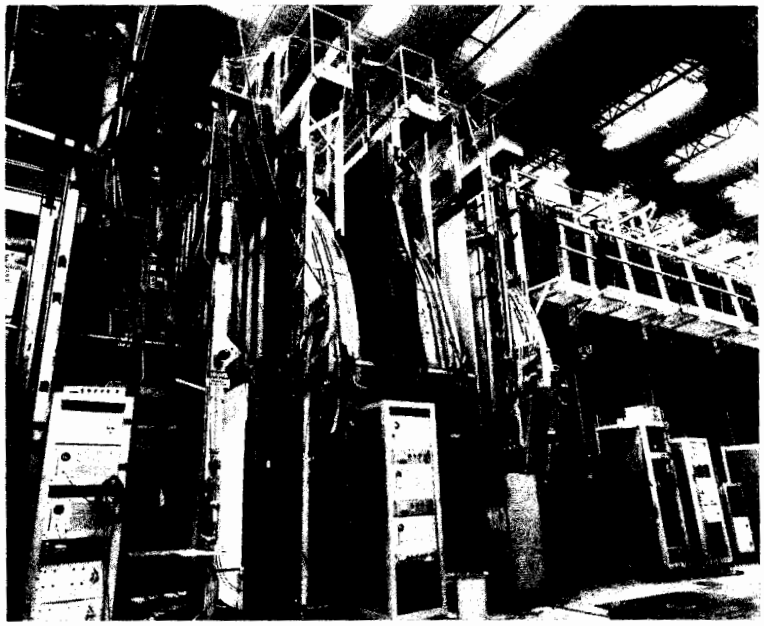
E-665: "Muon Scattering with Hadron Detection." This experiment will study the interactions of muons with beam energies up to 750 GeV in various targets and with the capability of making detailed measurements on the recoil hadrons that emerge from the collision vertex. In particular they will study the properties of hadrons recoiling from deep inelastic muon collisions in hydrogen and heavy nuclei. Complementing the fragmentation studies in hydrogen and heavy nuclear targets, the experiment will study the nucleon structure functions with these same targets. The new Muon beamline leading to this experiment was commissioned at



the end of the last running period when beams of focussed and unfocussed muons were transported to the Muon Experimental Hall. Major projects addressed during the shutdown include the installation of the Ring Imaging Cerenkov Counter, the redesign and installation of a new halo veto wall, the completion of the Muon Hall cryogenic facility which services the superconducting Chicago Cyclotron Magnet (CCM) and the superconducting CERN Vertex Magnet (CVM), the installation of the time-of-flight counters and threshold Cerenkov counters, the installation of the electromagnetic calorimeter and muon hodoscope. Main components pictured above are the CCM and the CVM. E-665 is a collaboration of Argonne National Laboratory, the University of California, San Diego, Fermilab, the University of Freiburg (West Germany), Harvard University, the University of Illinois, Chicago Circle, the Institute of Nuclear Physics (Poland), the University of Maryland, MIT, Max-Planck Institute (Germany), the University of Washington, the University of Wuppertal (Germany), and Yale University. (Spokesperson: T. Kirk)

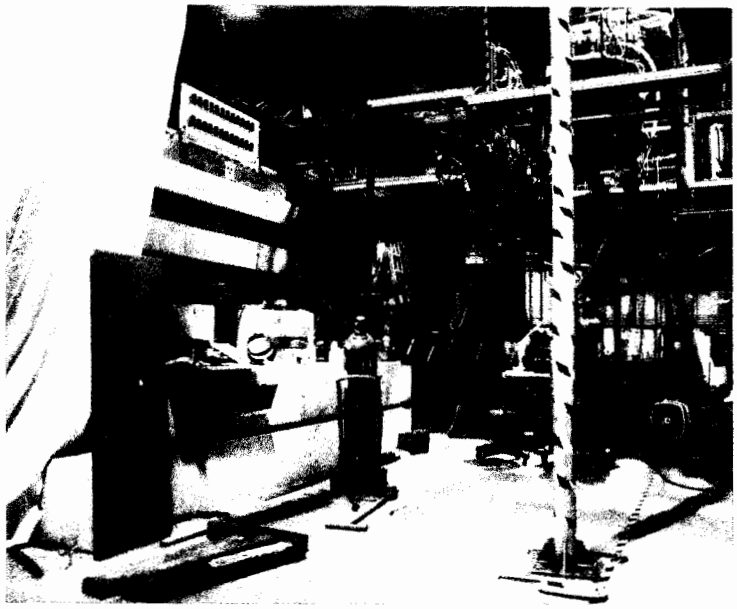
(Fermilab photograph 86-771-3)

E-733: "The Study of High-Energy Neutrino Interactions with the TEVATRON Wide Band Triplet Beam." This experiment is interested in studying weak neutral currents and comparing neutral current models with measurements of the Weinberg Angle. They are also interested in the production of same-sign dimuon



events, primarily the study of the missing transverse energy and possible correlations of that energy with the muons and hadron shower. Improvements to the experiment that will be completed before the upcoming run include an upgrade of the drift chamber and proportional tube read-out system which will allow the recording of multiple events in the same spill, and the construction of a new veto wall at the upstream end of Lab C which will increase the fiducial volume of the detector. The picture above (looking upstream) shows the toroid magnets and the Flash-Chamber Proportional-Tube Calorimeter. E-733 is a collaboration of Fermilab, the University of Florida, MIT, and Michigan State University. (Spokes-person: R. Brock) *(Fermilab photograph 86-771-5)*

E-745: "Neutrino Experiments Using the High Resolution Bubble Chamber." The goals of this experiment are to study neutrino interactions in the high Q^2 region, charm and heavy quark flavors, and finally, to look for new phenomena like same-sign dileptons. Since the last running period, the 1-meter Tohoku Bubble Chamber has been removed and will be replaced with a 1000-liter chamber which will be installed and tested by February 1987. The larger chamber will increase the fiducial volume of the chamber for the experiment. During the next running period, E-745 will study D meson lifetimes with high resolution. During the last run the experiment accumulated about 2000 charged current events and is expecting to record about 16,000 during the next run with about 10^{18} protons



incident on target. In the above picture (looking upstream), the empty Tohoku Bubble Chamber yoke awaits the installation of the new 1000-liter Tohoku Bubble Chamber. E-745 is a collaboration of Brown University, Fermilab, IHEP, Beijing (PRC), Indiana University, MIT, Nagoya University (Japan), Oak Ridge National Laboratory, Technion-Israel Institute of Technology, Haifa (Israel), University of Tel-Aviv (Israel), University of Tennessee, Tohoku Gakuin University (Japan), and Tohoku University (Japan). (Spokesperson: T. Kitagaki)

(Fermilab photograph 86-771-12)

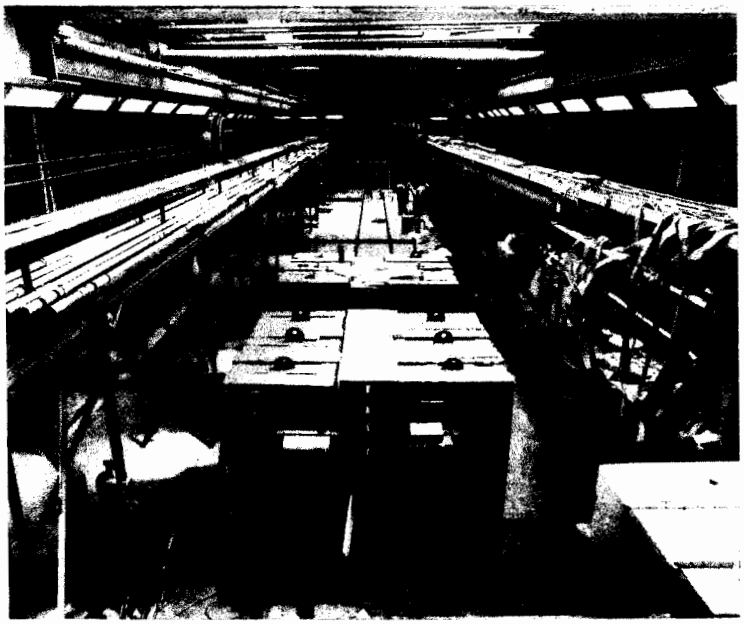
Particle Decays and CP Violation

E-731: "A Precision Measurement of the CP Violation Parameter ε'/ε in the Neutral Kaon System." The goal of this experiment is a measurement of the ratio of the CP nonconservation parameters ε'/ε in the $K^{\circ}\bar{K}^{\circ}$ system to a precision of ± 0.001. During the last running period, E-731 accumulated about 8000 $K_L \rightarrow \pi^{\circ}\pi^{\circ}$ events during a test run. In anticipation of the next run, they are upgrading their

data acquisition system and installing additional shielding which will enable them to run at an increased intensity (3×10^{12} ppp). The additional intensity will increase their trigger rate, allowing the experiment to accumulate data about 6 times faster than the last run. E-731 hopes to accumulate an additional 100,000 $K_L \rightarrow \pi^{\circ}\pi^{\circ}$ events. This data sample will give the experiment a sensitivity to better than 1 part in 10^3 in the ε'/ε ratio. The picture above shows the experiment's large decay pipe. E-731 is a collaboration of the University of Chicago, Elmhurst College, Fermilab, Princeton University, and CEN-Saclay (France). (Spokesperson: B. Winstein)

(Fermilab photograph 86-773-7)

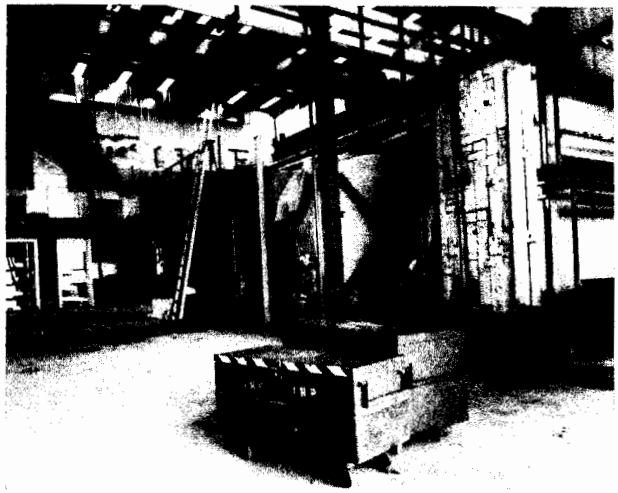
E-756: "Measurement of the Magnetic Moment of the Omega Minus Hyperon." The goals of this experiment are to make a precision measurement of the magnetic moment of the omega minus and also to determine whether the Ω^-'s produced by protons in inclusive reactions are polarized. This measurement will provide important information about the production mechanism of the Ω^- and how hyperons get their polarization in general. They will also make the definitive measurement of the Cascade minus magnetic moment. In addition to Multiwire



Proportional Chambers (MWPC) that will be used from experiment E-620, E-756 is fabricating new 1mm MWPC's that will be installed later this year. The experiment is also fabricating and installing silicon microstrip vertex detectors to trace parent particles coming out of the Hyperon magnet channel. Also being installed is a Ring Imaging Cerenkov Counter. The picture above shows part of the apparatus; two large analysis magnets are seen in the foreground. E-756 is a collaboration of Fermilab, the University of Michigan, the University of Minnesota, Rutgers University, and the University of Washington. (Spokesperson: B. Luk) *(Fermilab photograph 86-772-6)*

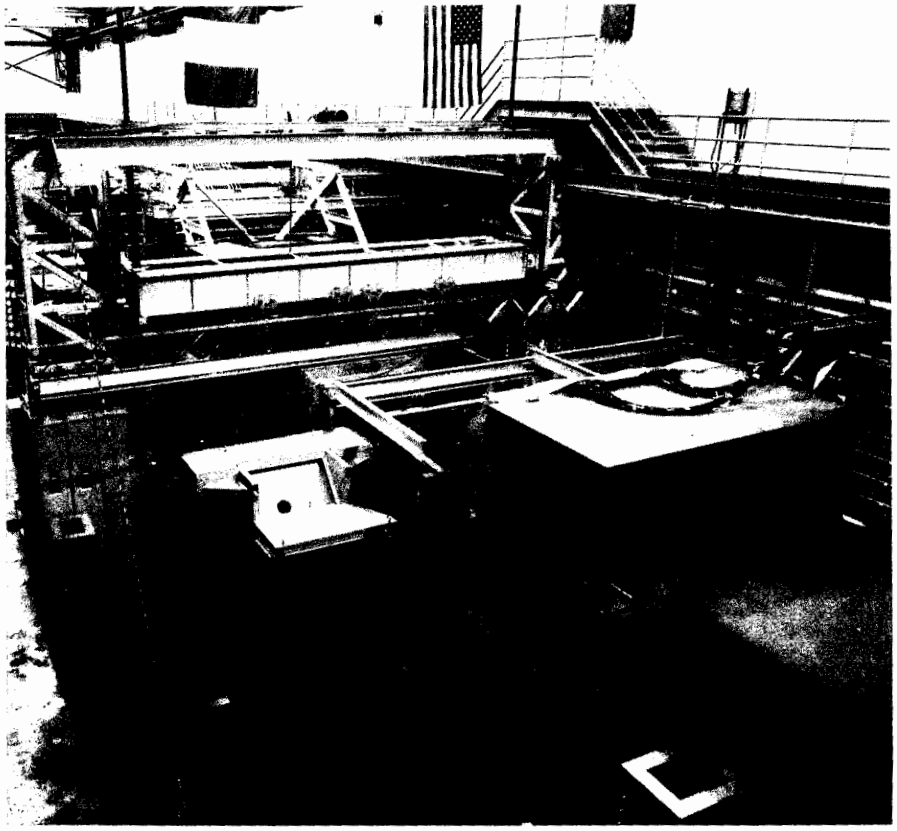
Production of Heavy Quark Flavors

E-653: "Study of Charm and Beauty Using Hadronic Production in a Hybrid Emulsion Spectrometer." The goal of this experiment is to search for new charm and beauty ground and excited states (especially baryons) and rare charm decays. During the last running period, E-653 ran with an 800-GeV proton beam with an intensity of about 3×10^5 protons per pulse. The experiment received about 5.4 million triggers and exposed about 32 liters of emulsion, searching for events containing charmed mesons (D° and F°) and baryons (Λ_c). During this shutdown, the N-East beamline which feeds the experiment was converted to a pion beam.



The π^- beam should give a better yield of b mesons. The picture above shows a portion of the apparatus located in Lab D looking upstream. E-653 is a collaboration of Aichi University of Education, Kariya (Japan), the University of California, Davis, Carnegie-Mellon University, Chonan National University, Kwangju (Korea), Fermilab, the University of Gifu (Japan), Gyeongsang National University, Chinju (Korea), Jeonbug National University, Jeonju (Korea), Kobe University (Japan), Korea University, Seoul (Korea), Nagoya Institute of Technology (Japan), Nagoya University (Japan), Ohio State University, Okayama University (Japan), the University of Oklahoma, Osaka City University (Japan), Osaka Prefecture, Science Education Institute (Japan), Sookmyong Woman's University, Seoul (Korea), Toho University (Japan), Utsunomiya University (Japan), Won Kwang University, Iri (Korea), and Yokohama National University (Japan). (Spokesperson: N. Reay) *(Fermilab photograph 86-771-2)*

E-687: "Photoproduction of Charm and Beauty." The goal of this experiment is to study various aspects of the photo-excited states containing charmed quarks; charmed mesons $D^{\circ}\bar{D}^{\circ}$ $D^{+}D^{-}$; charmed baryons $\Lambda_c \bar{\Lambda}_c$; and J/ψ and ψ' production as well as heavier states containing bottom quarks. At the end of the last running



period, the new Wide Band Beam leading to E-687 was commissioned when 600-GeV electrons were produced and transported to the experimental hall. The installation of E-687's apparatus is nearing completion. Major highlights which have been completed include the installation of the silicon microstrip vertex detectors and 20 proportional wire chambers (PWC), the installation of two muon hodoscopes (proportional tubes), and two electromagnetic calorimeters. When the experiment begins receiving beam, they hope to accumulate large samples of the charm particles listed above along with a moderate sample of mesons containing

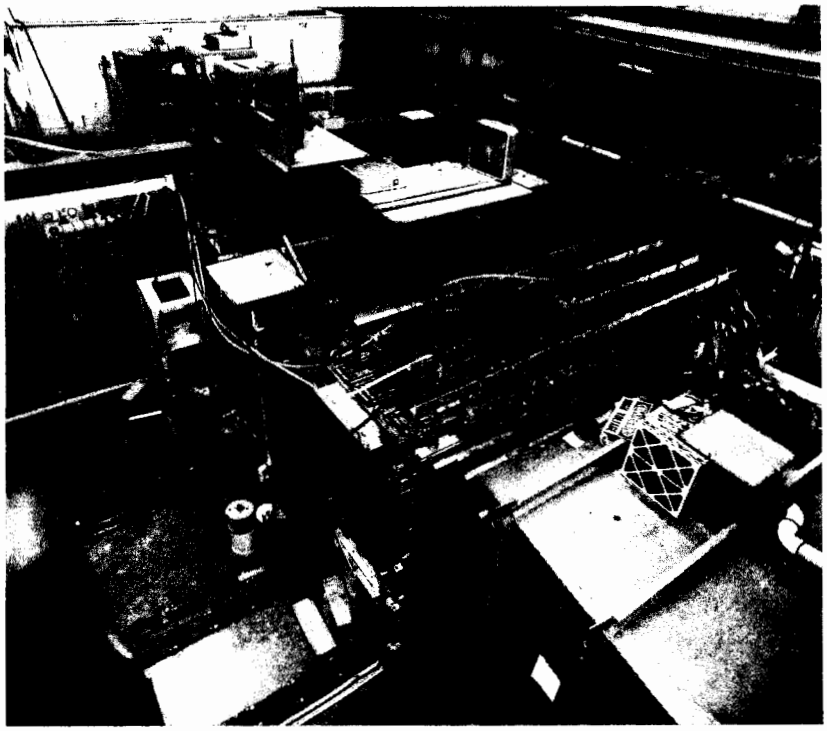
bottom quarks. The picture on the preceding page is of E-687's apparatus in the Wide Band Hall looking downstream. E-687 is a collaboration of the University of Colorado, Fermilab, the University of Illinois, INFN, Frascati (Italy), INFN, Milano (Italy), the University of Milano (Italy), Northwestern University, and the University of Notre Dame. (Spokespersons: J. Butler, J. Cumalat, I. Gaines)

(Fermilab photograph 86-772-2)

E-705: "A Study of Charmonium and Direct Photon Production by 300 GeV/c Antiproton, Proton and $\pi\pm$ Beams." The goals of this experiment include the separation of closely spaced charmonium states with the high resolution measurement of photons given off in the decay $\chi \rightarrow \gamma \psi \rightarrow \mu^+\mu^-$ along with the comparison of the production of direct photons and charmonium states using different beam types, allowing the separation of gg and $q\bar{q}$ components of the

production process. Before the fixed-target run begins, E-705 will install a gas tube hodoscope and active converter to detect electromagnetic showers produced by photons produced in the chi decay. Also, steel shielding will be installed to protect E-705's lead-glass electromagnetic calorimeter from fringe magnetic field of their analysis magnet (Rosie). The picture above shows an overall view of the beamline leading to the detector. E-705 is a collaboration of the University of Arizona, the University of Athens (Greece), Duke University, Fermilab, McGill University, Montreal (Canada), Northwestern University, and Shandong University (PRC). (Spokesperson: B. Cox) *(Fermilab photograph 86-772-8)*

E-769: "Pion and Kaon Production of Charm and Charm-Strange States." The goal of this experiment is to measure the flavor, x, P_t , and A dependences of hadronically produced charm particles at the same time and in a single apparatus. In addition, high statistics lifetime measurements of several charm states are expected. The Tagged Photon Lab apparatus was used during the last running

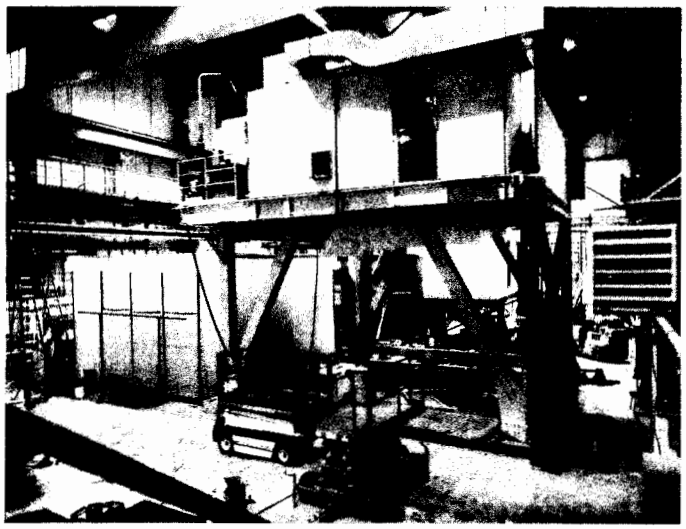


period by experiment E-691 to obtain the world's largest sample of charmed meson decays. E-769 will use the same apparatus with modifications to the beamline and detector. The beam leading to E-769's detector will contain pions and kaons rather than E-691's tagged photons. Additions and modifications to the detector include the addition of the CERN Disc Cerenkov Counter to tag kaons and transition radiation detectors to tag pions. Also, PWC's used previously in the Multiparticle Spectrometer (MPS) will be used for improved tracking along with additional silicon microstrip detectors for increased vertex resolution. On the electronics side, a new data acquisition system using Advanced Computer Program (ACP) processors will be used. Features of the new system include buffering of a full spill's worth of data and the capability of recording up to 600 events per spill

second. In addition, ACP processors may be used to do some on-line analysis, filtering the amount of data written to tape. The picture of the detector looks upstream. E-769 is a collaboration of Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro (Brazil). Fermilab, Northeastern University, the University of Toronto (Canada), Tufts University, the University of Wisconsin-Madison, and Yale University. (Spokesperson: J. Appel) *(Fermilab photograph 86-772-5)*

Hard Collisions and QCD Tests

E-706/672: Although these two experiments are housed in the same experimental hall and will run simultaneously, they will pursue diverse physics goals. E-706, "A Comprehensive Study of Direct Photon Production in Hadron Induced Collisions," will study the gluon structure functions of hadrons and gluon

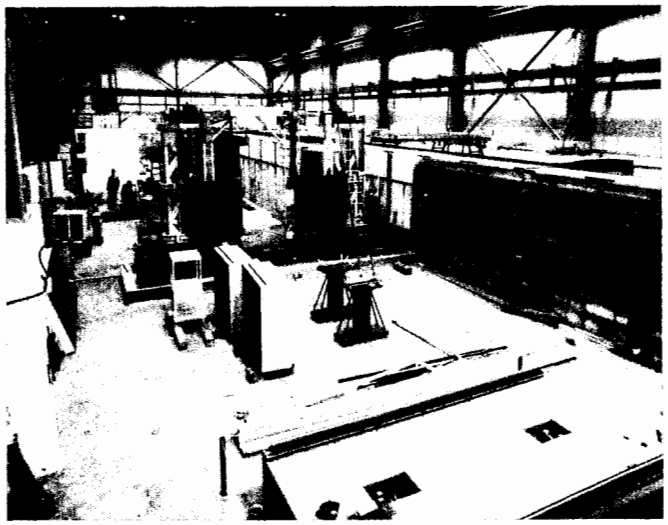


fragmentation by analyzing the production of direct photons and their accompanying hadrons in collisions of pions, kaons, and protons with a variety of nuclear targets. The experiment is being assembled on schedule and will be serviced by the new M-West beamline. The very large Liquid Argon Calorimeter is nearing completion, the photon calorimeter is complete and being assembled, the 52 absorber plates of the hadron calorimeter have been installed, and the detector cookies are also being installed. As can be seen in the picture above (left background), the analysis magnet is complete and has been zip-tracked. E-672, "A

Study of Hadronic Final States in Association with High P_t Jets and High Mass Dimuons," will study the production of particles produced in association with ψ and high mass dimuon pairs. E-706 is a collaboration of Delhi University (India), Fermilab, Michigan State University, the University of Minnesota, Northeastern University, Pennsylvania State University, the University of Pittsburgh, Rajasthan University, Jaipur (India), and the University of Rochester. E-672 is a collaboration of the University of Arizona, California Instititue of Technology, Fermilab, Florida State University, George Mason University, the University of Illinois at Chicago, Indiana University, Institute of High-Energy Physics, Serpukhov (U.S.S.R.), University of Maryland, University of Michigan, and Rutgers University. (Spokespersons: P. Slattery [E-706], A. Zieminski [E-672])

(Fermilab photograph 86-772-4)

E-704: "Experiments with the Polarized Beam Facility." The initial goal of this experiment is to explore the spin dependence of the interactions $\bar{p}$ p and pp in a global way using a straightforward experiment which will measure the difference in total cross section $\bar{p}$ p and pp between the states with helicities of target and beam parallel and antiparallel. This will be done as a test run of the new M-polarized beamline that feeds this experiment. Experience shows that accuracy



of ±100 microbarns can easily be achieved. Currently, the experiment is installing the Central Electromagnetic Calorimeter from Serpukhov which consists of about 1000 lead-glass cells. Also underway is the installation of hodoscopes, drift chambers, and the polarized target. During the upcoming fixed-target run, E-704

will study the polarization of the beam as well as timing and calibration studies of the detectors and electronics. The picture (page 14) is an overall view of the new M-Polarized Experimental Hall where E-704's apparatus is being assembled. E-704 is a collaboration of Argonne National Laboratory, CEN-Saclay (France), Fermilab, Institute of High-Energy Physics, Serpukhov (U.S.S.R.), KEK-National Lab for High-Energy Physics (Japan), Kyoto University (Japan), Lab. A Physique des Particules, Annecy-le-Vieux (France), Los Alamos National Laboratory, Lawrence Berkeley Laboratory, Northwestern University, Rice University, the University of Texas at Austin, and Universitat Degli Studi di Trieste (Italy). (Spokesperson: A. Yokosawa) *(Fermilab photograph 86-773-2)*

E-711: "A Study of the Angular and Energy Dependence of Constituent Scattering through Measurements of the Reaction $p+N \rightarrow h_1+h_2+X$." The goal of the experiment will be to measure the reaction p+N to h_1+h_2+X where h_1 and h_2 are both high transverse momentum hadrons, roughly back-to-back in the pN center-of-mass system. By determining the angular distribution and mass dependence of the cross section of the dihadron system, the experiment will extract the

angular and energy dependence of the underlying hard constituent scattering. The experiment will come up in the upcoming run with several modifications to the detector. A fifth PWC was added to complement the existing four, as pictured above. This will enable the experiment to take higher rates and increase pattern recognition. Also, pre-amplifiers were installed on the chambers to increase the

rate capabilities, allowing the chambers to run at lower voltages. E-711 is a collaboration of the University of California, Davis, Fermilab, Florida State University, and the University of Michigan. (Spokesperson: D. Levinthal)

(Fermilab photograph 86-772-11)

E-772: "A Study of the Nuclear Antiquark Sea Via p+N→Dimuons." The goal of this experiment will be a precise measurement of the A dependence of the Drell-Yan process for 900-GeV protons on targets of deuterium and calcium using the existing E-605 spectrometer which is pictured below. Emphasis will be placed

on the kinematic region $M \geq 4$ GeV and $x_f \geq 0.2$, where one is most sensitive to beam-valence-quark, target-antiquark annihilation. E-772 is a collaboration of Fermilab, the University of Illinois at Chicago, Los Alamos National Laboratory, Rutgers University, the University of Texas at Austin, SUNY/Stony Brook, and the University of Washington. (Spokesperson: J. Moss)

(Fermilab photograph 86-773-5)