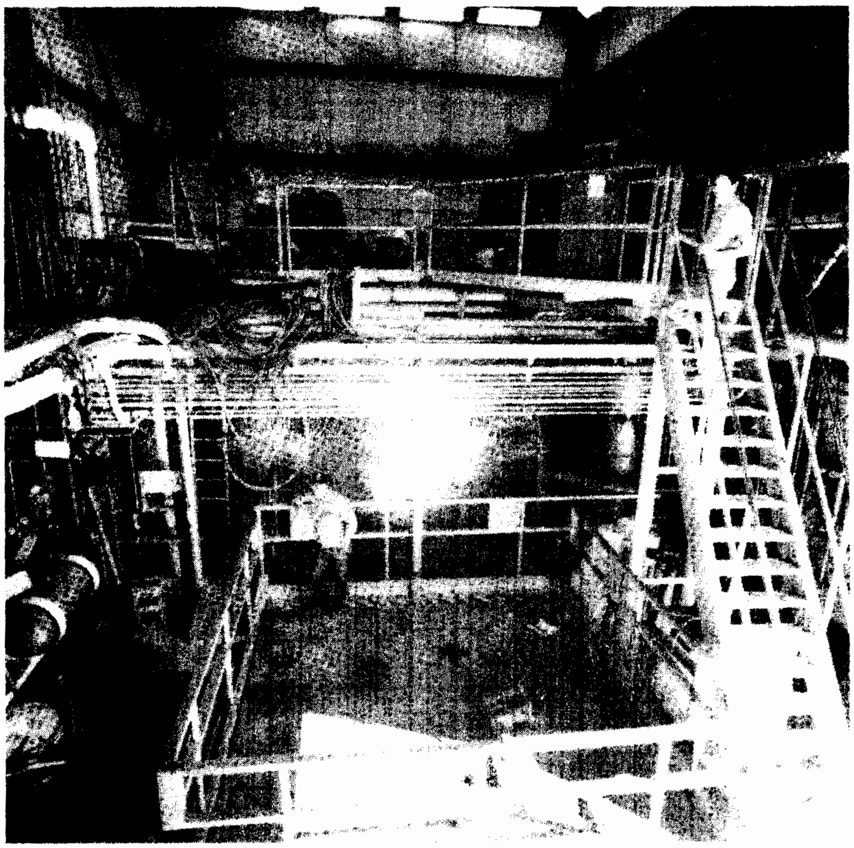
fermilab report

Fermi National Accelerator Laboratory Monthly Report

January/
February
1988



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On the cover: *Fermilab's 15-ft Bubble Chamber has made its final high-energy physics run for E-632. A story on the recently completed fixed-target run begins on page 1. A look at the 15-ft. Bubble Chamber's illustrious history will appear in the next* Fermilab Report. *(Fermilab photograph 86-781-3)*

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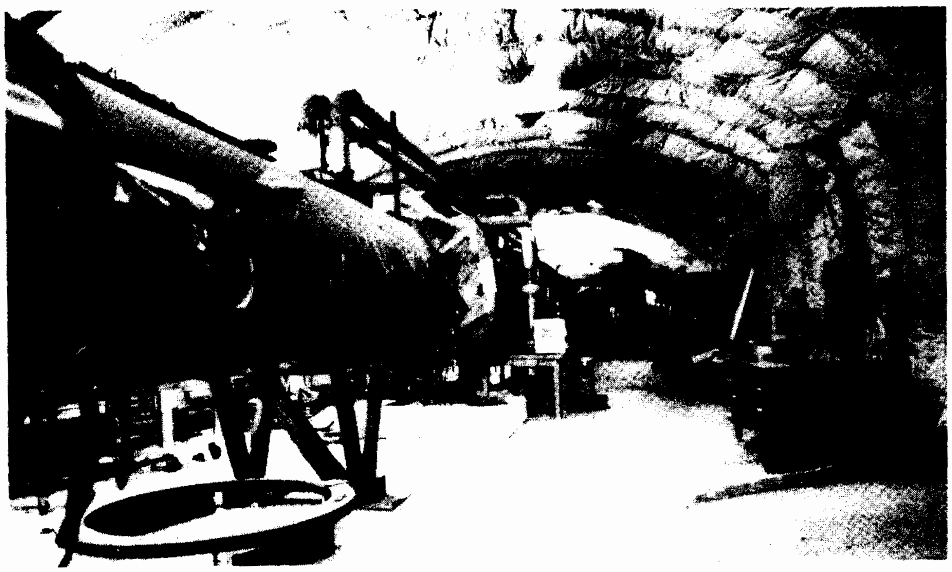
Manuscripts and Notes
prepared or presented from January 1, 1988, to March 31, 1988:

Fermilab's Fixed-Target Run a Success

Mark Bodnarczuk

Eight months, 3000 high-energy physics (HEP) hours, and 35,000 data tapes later, Fermilab's most successful fixed-target physics run came to an end in mid-February 1988 with the highest superconducting accelerator intensity recorded at 1.8 x 10^{13} protons per pulse and the total number of protons accelerated recorded as 2.192 x 10^{18}. This was the first 800-GeV fixed-target physics run in which the entire complement of experiments and beams that were built as part of the TeV II Upgrade project were operated. In total, 10 experiments were completed, with a total of 15 beamlines serving 16 experiments and a variety of test- and calibration-beam users. This report focuses on the highlights of the run. Reports on each individual experiment will appear in future issues of *Fermilab Report* as the data analysis proceeds.

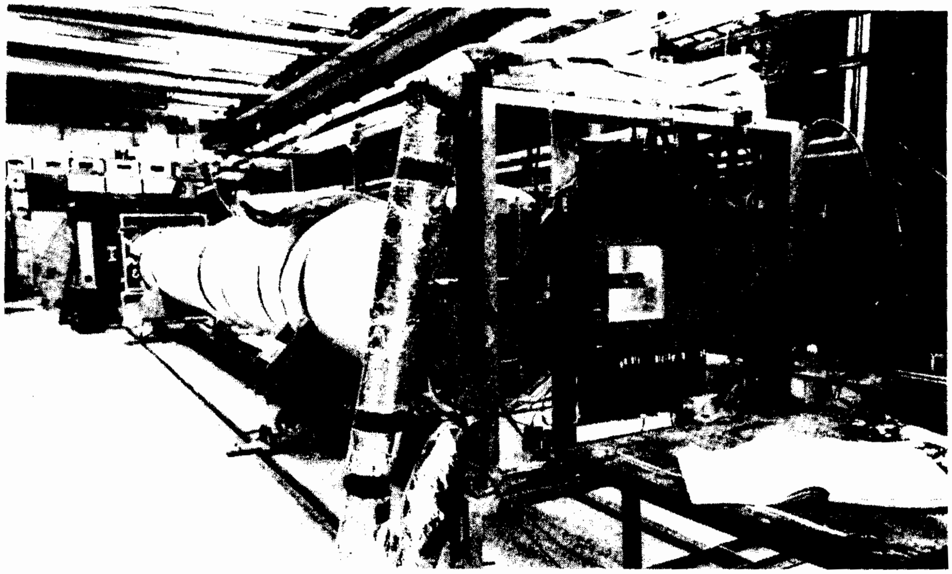
Particle Decays and CP Violation



(Fermilab photograph 88-773-7)

The decay region of Experiment 731's apparatus.

Under the category of particle decays and CP violation, Experiment 731 completed taking data with the goal of measuring the ratio of the CP non-conservation parameters ϵ'/ϵ in the neutral kaon system to a precision of ±0.001. They collected 250,000 $K_L \to \pi^0 \pi^0$ events, 370,000 $K_L \to \pi^+ \pi^-$ events, with a factor of three more events of the $K_S \to \pi^0 \pi^0$ and $K_S \to \pi^+ \pi^-$ variety recorded. The experiment is a collaboration of the University of Chicago; Elmhurst College; Fermilab; Princeton University; and CEN-Saclay (France).



(*Fermilab photograph 87-288-11*)

The apparatus of E-756 located in the P-Center beamline.

Also in this category was Experiment 756, whose goal is to study the polarization and magnetic moment of the Ω^- hyperon. The experiment accumulated about 82,000 Ω^- events during this run. A polarization signal was observed after a dramatic mid-course change in targeting arrangement. The experiment is a collaboration of Fermilab; the University of Michigan; the University of Minnesota; Rutgers University; and the University of Washington.

Electroweak Interactions

In the electroweak interactions category, Experiment 770 did high-statistics measurements of nucleon structure functions at higher neutrino energies than previously possible, and high-statistics measurements of charm production and the strange quark sea in opposite-sign dimuons. The experiment took 5.3×10^{17} protons onto the primary production target, accumulating about 120 same-sign dimuons, 1.6 million neutrino events, and 0.35 million antineutrino events. The experiment is a collaboration of the University of Chicago; Columbia University; Fermilab; and the University of Rochester.

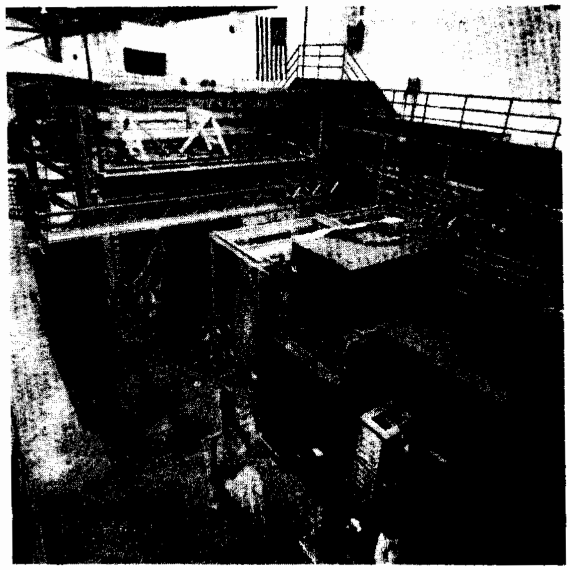
Another experiment in the electroweak interaction category was E-632, which exposed the 15-ft Bubble Chamber to the wideband neutrino beam. This was the final run of the 15-ft Bubble Chamber. The chamber was filled with a neon-hydrogen mixture and was designed to search for new particles and also study like-sign dileptons in both $\mu\mu$ and μe^+ modes. The experiment took 48,000 neutrino events in fiducial volume and 46,000 neutrino events with holograms. E-632 is a collaboration of the University of California, Berkeley; the University of Birmingham (Great Britain); the 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.

Experiment 733, also in the neutrino beam, completed a study of weak neutral currents and comparing neutral current models with measurements of the Weinberg Angle. They also looked at the production of same-sign dimuon events, primarily the missing transverse energy and possible correlations of that energy with the muon and hadron showers. E-733 also performed a time-of-flight search for weakly interacting massive particles (WIMP). They accumulated 90,000 neutrino events in a 100-metric-ton fiducial volume. Experiment 733 is a collaboration of Fermilab; the University of Florida; Massachusetts Institute of Technology; and Michigan State University.

Also in this category was Experiment 665, in the muon beam, which began a run that will be completed during the next fixed-target running period. Using positive muons, the experiment used three types of target with both 500- and 100-GeV beams and accumulated between 0.5 and 2.5 x 10^{11} muons per target. E-665 is a collaboration of Argonne National Laboratory; the University of California, San Diego; Fermilab; the University of Freiberg (West Germany); Harvard University; the University of Illinois at Chicago; the Institute of Nuclear Physics (Poland); the University of Maryland; Massachusetts Institute of Technology; Max-Planck Institute (Germany); the University of Washington; the University of Wuppertal (Germany); and Yale University.

Experiment E-745, based upon the Tohoku Bubble Chamber, completed a run in which they studied neutrino interactions, charm and heavy quark flavors, and looked for new phenomena such as same-sign dileptons. They accumulated 13,000 neutrino events, with 3000 holograms. E-745 is a collaboration of Brown University; Fermilab; IHEP, Beijing (PRC); Indiana University; Massachusetts Institute of Technology; Nagoya University (Japan); Oak Ridge National Laboratory; Technion-Israel Institute of Technology, Haifa (Israel); the University of Tel Aviv (Israel); the University of Tennessee; Tohoku Gakuin University (Japan); and Tohoku University (Japan).

Production of Heavy Quarks



(Fermilab photograph 86-782-8)

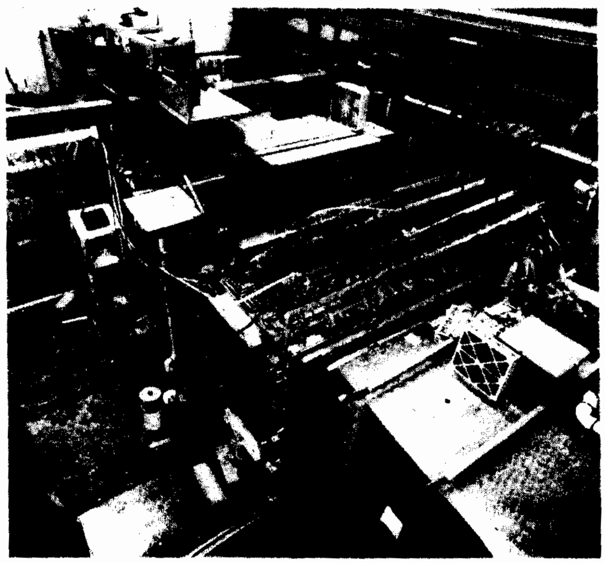
A view of E-687's apparatus.

In the "Production of Heavy Quarks" category, Experiment 687 explored the photoproduction of charm and beauty, especially photo-excited states containing charmed quarks, charmed D mesons and Λ_c baryons, J/ψ and ψ' production, and heavier states containing bottom quarks. The experiment was heavily damaged by a fire which destroyed an electromagnetic calorimeter and other components, but was revitalized with a tremendous effort on the part of the Laboratory and experimenters, and thereby managed to accumulate about 70 million triggers, with 80% of the triggers requiring hadronic energy in the calorimeter. E-687 is a collaboration of the University of Colorado; Fermilab; the University of Illinois; INFN Frascati (Italy); INFN and the Universities of Milano, Bologna, and Pavia (Italy); Northwestern University; and the University of Notre Dame.

E-653 completed a run studying charm and beauty using hadronic production in a hybrid emulsion spectrometer. The goal of the experiment was to search for new charm and beauty ground and excited states (especially baryons), and rare charm decays using 600-GeV pions in emulsion. They accumulated 9.6

million events. 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 Yokahama National University (Japan).

Another heavy quark experiment was E-769, in the Tagged Photon Lab, which looked at the properties of hadronic charm production, measuring the Feynman x, pt and A dependences of this process with 250-GeV pion, kaon, and proton beams at the same time and in a single apparatus. The experiment accumulated over 500 million triggers with their hadronic transverse energy trigger. 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.



(Fermilab photograph 86-772-5)

The detector for E-769 located in the Tagged Photon Facility.

Experiment 705 completed a study of charmonium and direct photon production with 300-GeV antiproton, proton, and $\pi^{\pm}$ beams. The goals of this experiment include the separation of closely spaced charmonium states with the high-resolution measurements of photons given off in the decay $X \to \gamma \psi_{\mu^+\mu^-}$ along with a comparison of the production of direct photons and charmonium states using different beam types, allowing the separation of qq and $\bar{q}$q components of the production process. The experiment accumulated about 100,000 J/ψ events and about the same number of π^{+-} events. 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).

Hard Collisions and QCD Tests

Although E-706 and E-672 are housed in the same experimental hall and ran simultaneously, they are pursuing somewhat different physics goals. Experiment 706 began a comprehensive study of direct photon production in hadron induced collisions, focusing on the study of the gluon structure functions of hadrons and gluon fragmentation. E-706 analyzed the production of direct photons and their accompanying hadrons in collisions of pions, kaons, and protons with a variety of targets. The experiment accumulated 1.8 million triggers with the positive beam and 2.0 million triggers with the negative beam. The experiment is not complete and will run again during the next fixed-target run. 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 (India); and the University of Rochester. E-672 is making a study of hadronic final states in association with high P_t jets and high-mass dimuons, namely the production of particles produced in association with the ψ and high-mass dimuons. They accumulated about 6000 J/ψ events with the full E-706 spectrometer and about 2000 J/ψ events with the muon toroid spectrometer only. The experiment is not complete and will run during the next running period. E-672 is a collaboration of the University of Arizona; the California Institute of Technology; Fermilab; Florida State University; George Mason University; the University of Illinois at Chicago; Indiana University; the Institute of High-Energy Physics, Serpukhov (U.S.S.R.); the University of Maryland; the University of Michigan; and Rutgers University.

Experiment 704's initial goals, using polarized protons and antiprotons, are to study the spin dependence of the interactions $\bar{p}$p and pp in a global way. This is a straightforward experiment which will measure the difference in the total cross section $\bar{p}$p and pp between the states with helicities of target and beam parallel and antiparallel. The experiment took preliminary test 200-GeV proton beam polarization data with Coulomb nuclear interference and Primakoff polarimeters. They also tested antiproton beam and performed electromagnetic calibrations of their detector. They will run during the next fixed-target physics run. E-704 is a collaboration of Argonne National Laboratory; CEN-Saclay (France); Fermilab; the Institute of High Energy Physics, Serpukov (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 Treste (Italy).

Experiment 711 completed a run studying the angular and energy dependence of constituent scattering through measurements of the reaction $p+N \rightarrow h_1+h_2+X$ 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 di-hadron system, the experiment will try to extract the angular and energy dependence of the underlying hard constituent scattering. Using 800-GeV protons, a luminosity of 0.5 - 1.0 x 10^{37}, and a variety of targets, they studied the $h^+ h^-$ mass to 13 GeV and the angular distribution to a mass of 12 GeV. The experiment is a collaboration of the University of California, Davis; Fermilab; Florida State University; and the University of Michigan.

Experiment 772 completed a precise measurement of the A dependence of the Drell-Yan process for 800-GeV protons on targets of deuterium and calcium. Emphasis was 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. In the mass range of 5-14 GeV, they accumulated 500,000 dimuons with a variety of targets. 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.

The conclusion of this run begins a year-long period in which the Collider Detector at Fermilab comes back online for a 10-month physics run with a full complement of standard reconstruction packages ready to analyze the data that will be accumulated. But the fixed-target areas will by no means be idle during this time frame because a number of beamline and fixed-target detector upgrade projects necessary in preparation for the June 1989 fixed-target run are planned and have already begun. Most importantly, the analysis of the 35,000 data tapes accumulated during the run will proceed. This will put a tremendous load on

Fermilab's computing facilities. But given the fact that Fermilab's new large-scale scientific computer will begin to arrive and be installed in early summer, this computing load will be alleviated. According to Jack Pfister, Associate Head of the Computing Department responsible for central computing, there have been major upgrades to the VAX Cluster recently, but the new Amdahl 5890 computer is the largest major increment of general-purpose computing capacity in the last four years. The added capacity is on the order of twice the entire Cyber complex. Another help will be the use of Advanced Computer Program parallel processor systems as part of the offline data reconstruction packages. This combination promises the kind of computing power necessary to meet the data crunching demands of fixed-target users.

(Fermilab photograph 86-773-5

The apparatus for E-772 located in the M-East beamline.

CDF Progress Report

John W. Cooper
and
the CDF Collaboration

The first data run for CDF (the Collider Detector at Fermilab) took place during January-May 1987. The run served as an engineering run for the TEVATRON Collider and for the complete CDF detector. This progress report reviews the TEVATRON performance, the CDF detector performance, and some preliminary physics at 1.8 TeV.

Figure 1 shows the gain in peak luminosity during the run to a final value of about 1.5×10^{29} cm^{-2} sec^{-1}. An integrated luminosity total of about 74 nb^{-1} was delivered and 34 nb^{-1} was written to tape (see Fig. 2). These luminosity values have an uncertainty of ±20%. More than 900 hours of pbar-p collisions took place (see Fig. 3), and we had access to the detector only eight times during this

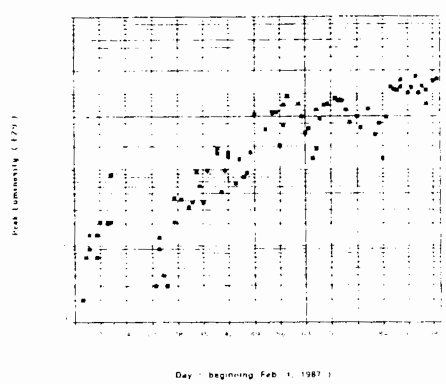


Figure 1. TEVATRON peak luminosity (10^{29} $cm^{-2}sec^{-1}$) for February 1 - May 11, 1987. Each point represents a separate pbar-p store.

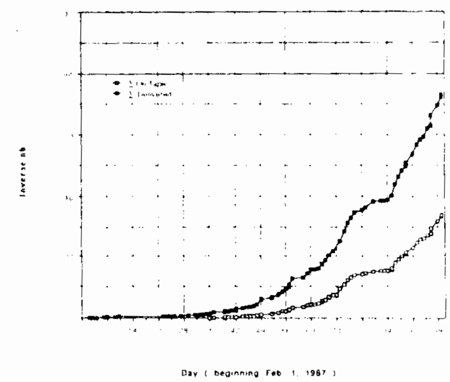


Figure 2. The integrated luminosity (nb^{-1}) versus time for the 1987 run. The solid squares are delivered luminosity, and the open squares are the luminosity written to tape.

The CDF Collaboration

F.Abe[p], D.Amidei[c], G.Apollinari[k], G.Ascoli[g], M.Atac[d], P.Auchincloss[n], A.R.Baden[f], A. Barbaro-Galtieri[i], V.E.Barnes[l], E.Barsotti[d], F.Bedeschi[k], S.Belforte[k], G.Bellettini[k], J.Bellinger[q], J.Bensinger[b], A.Beretvas[n], P.Berge[d], S.Bertolucci[e], S.Bhadra[g], M.Binkley[d], R.Blair[a], C.Blocker[b], J.Bofill[d], A.W.Booth[d], G.Brandenburg[f], A.Brenner[d], D.Brown[f], A.Byon[l], K.L.Byrum[q], M.Campbell[c], R.Carey[f], W.Carithers[i], D.Carlsmith[q], J.T.Carroll[d], R.Cashmore[1], F.Cervelli[k], K.Chadwick[l,d], T.Chapin[m], G.Chiarelli[k], W.Chinowsky[i], S.Cihangir[o], D.Cline[q], D.Connor[j], M. Contreras[b], J.Cooper[d], M.Cordelli[e], M.Curatolo[e], C.Day[d], R.DelFabbro[k], M.Dell'Orso[k], L.DeMortier[b], T.Devlin[n], D.DiBitonto[o], R.Diebold[a], F.Dittus[d], A.DiVirgilio[k], R.Downing[g], G. Drake[d], T.Droege[d], M.Eaton[f], J.E.Elias[d], R.Ely[i], S.Errede[g], B.Esposito[e], A.Feldman[f], B.Flaugher[n], E.Focardi[k], G.W.Foster[d], M.Franklin[f,g], J.Freeman[d], H.Frisch[c], Y.Fukui[h], S.Galeotti[k], I.Gaines[d], A.F.Garfinkel[l], P.Giannetti [k], N.Giokaris[m], P.Giromini[e], L.Gladney[j], M.Gold[i], K.Goulianos[m], J.Grimson[d], C.Grosso-Pilcher[c], C.Haber[i], S.R.Hahn[j], R.Handler[q], D.Hanssen[d], R.M.Harris[i], J.Hauser[c], Y.Hayashide[p], T.Hessing[o], R.Hollebeek[j], L.Holloway[g], P.Hu[n], B.Hubbard[i], P.Hurst[g], J.Huth[d], M.Ito[p], J.Jaske[q], H.Jensen[d], R.P.Johnson[d], U.Joshi[n], R.W.Kadel[d], T.Kamon[o], S.Kanda[p], I.Karliner[g], H.Kautzky[d], K.Kazlauskis[n], E.Kearns[f], R.Kephart[d], P.Kesten[b], H.Keutelian[g], Y.Kikuchi[p], S.Kim[p], L.Kirsch[b], S.Kobayashi[2], K.Kondo[p], U.Kruse[g], S.E.Kuhlmann[l], A.T.Laasanen[l], W.Li[a], T.Liss[c], N.Lockyer[j], F.Marchetto[o], R.Markeloff[q], L.A. Markosky[q], M.Masuzawa[p], P.McIntyre[o], A.Menzione[k], T.Meyer[o], S.Mikamo[h], M.Miller[j], T.Mimashi[p], S.Miscetti[e], M.Mishina[h], S.Miyashita[p], H.Miyata[p], N.Mondal[q], S.Mori[p], Y.Morita[p], A.Mukherjee[d], A.Murakami[3], Y.Muraki[3], C.Nelson[d], C.Newman-Holmes[d], L.Nodulman[a], J.O'Meara[d], G.Ott[q], T.Ozaki[p], S.Palanque[4], R.Paoletti[k], A.Para[d], D.Passuello[k], J.Patrick[d], R.Perchonok[d], T.J.Phillips[f], H.Piekarz[b], R.Plunkett[m], L.Pondrom[q], J.Proudfoot[a], G.Punzi[k], D.Quarrie[d], K.Ragan[j], G.Redlinger[c], R.Rezmer[a], J.Rhoades[q], L.Ristori[k], T.Rohaly[j], A.Roodman[c], H.Sanders[c], A.Sansoni[e], R.Sard[g], V.Scarpine[g], P.Schlabach[g], E.E.Schmidt[d], P.Schoessow[a], M.H.Schub[l], R.Schwitters[f], A.Scribano[k], S.Segler[d], M.Sekiguchi[p], P.Sestini[k], M.Shapiro[f], M.Sheaff[q], M.Shibata[p], M.Shochet[c], J.Siegrist[i], V.Simaitis[g], J.K.Simmons[l], P.Sinervo[j], M.Sivertz[5], J.Skarha[q], D.A.Smith[g], R.Snider[c], L.Spencer[b], R.St.Denis[f], A.Stefanini[k], Y.Takaiwa[p], K.Takikawa[p], S.Tarem[b], D.Theriot[d], J.Ting[c], A.Tollestrup[d], G.Tonelli[k], W.Trischuk[f], Y.Tsay[c], K.Turner[d], F.Ukegawa[p], D.Underwood[a], C.vanIngen[d], R.VanBerg[j], R.Vidal[d], R.G.Wagner[a], R.L.Wagner[d], J.Walsh[j], T.Watts[n], R.Webb[o], T.Westhusing[g], S.White[m], V.White[d], A.Wicklund[a], H.H.Williams[j], T.Winch[q], R.Yamada[d], T.Yamanouchi[d], A.Yamashita[p], K.Yasuoka[p], G.P.Yeh[d], J.Yoh[d], F.Zetti[k]

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[m] Rockefeller University- [n] Rutgers University- [o] Texas A&M University
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[5] Haverford College, Haverford, PA.

period. By the end of the run the typical "day" consisted of a 4- to 8-hour set-up time for antiproton transfer, followed by a 12- to 20-hour Collider store with a luminosity lifetime of around 8 hours.

Figures 4, 5, and 6 show several views of the CDF detector. A 1.5 tesla superconducting solenoid surrounds two charged-particle tracking systems, a vertex TPC and a central drift chamber. Outside the coil, electromagnetic and hadronic sampling calorimeters point in tower geometry towards the nominal interaction point. In the central and endwall calorimeters the active medium is scintillator; the endplug and forward calorimeters use proportional tube chambers with cathode pad readout. The electromagnetic calorimeters use lead plates as the absorber and the hadronic calorimeters use steel. Muon drift chambers surround the central region calorimeters and solenoid, and a system of magnetized steel toroids and drift chambers detects forward muons.

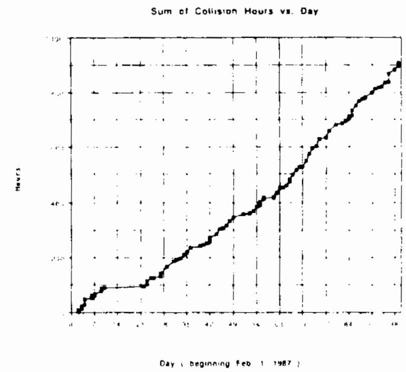

Figure 3. Hours of Collider running during 1987.

The detector was essentially complete for this run with the exception of: (1) half of the sampling planes in the forward hadron calorimeter, (2) a Level-2 trigger system for cluster triggers and track matching, and (3) a Level-3 trigger system of microprocessors and the associated full-rate data acquisition system. The data acquisition system and online software performed satisfactorily, reading out nearly 70,000 channels via FASTBUS. The front end electronics reliability was such that less than 1% of the channels were dead at any time. Routine procedures were established for monitoring, pedestals, and calibration. This included Cs^{137} sources, a laser flasher, a Xenon flasher, and an LED flasher for the scintillator calorimeters, and a gas gain monitoring system of proportional tubes with Fe^{55} sources for the gas calorimeters. The gas gain system ran continuously and the gain constants were downloaded every two hours (if necessary) into the trigger and readout electronics.

A standard trigger mix was established with a ~1 Hz rate @ 90% livetime. This "Level-1" trigger consisted of the following:

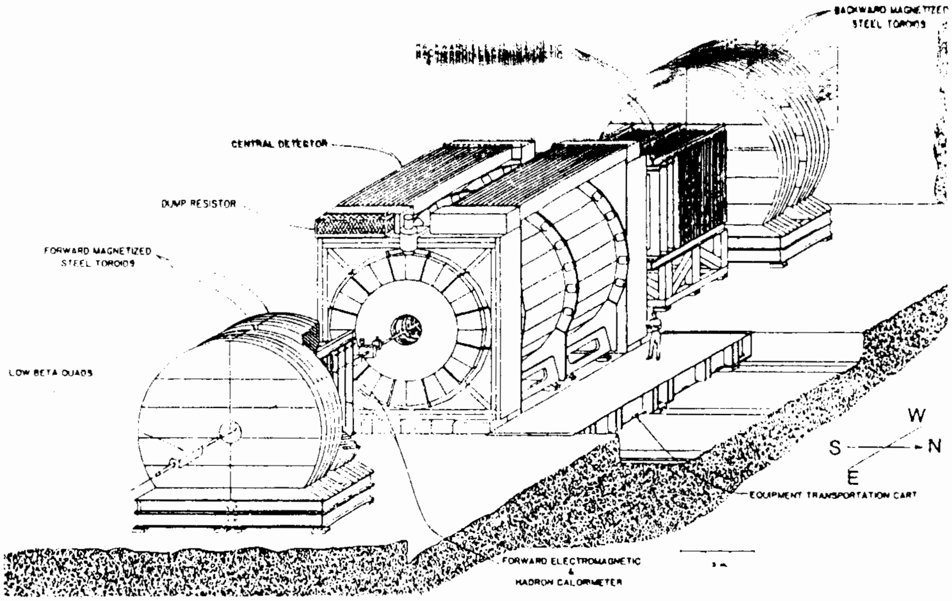

Figure 4. Isometric drawing of CDF.

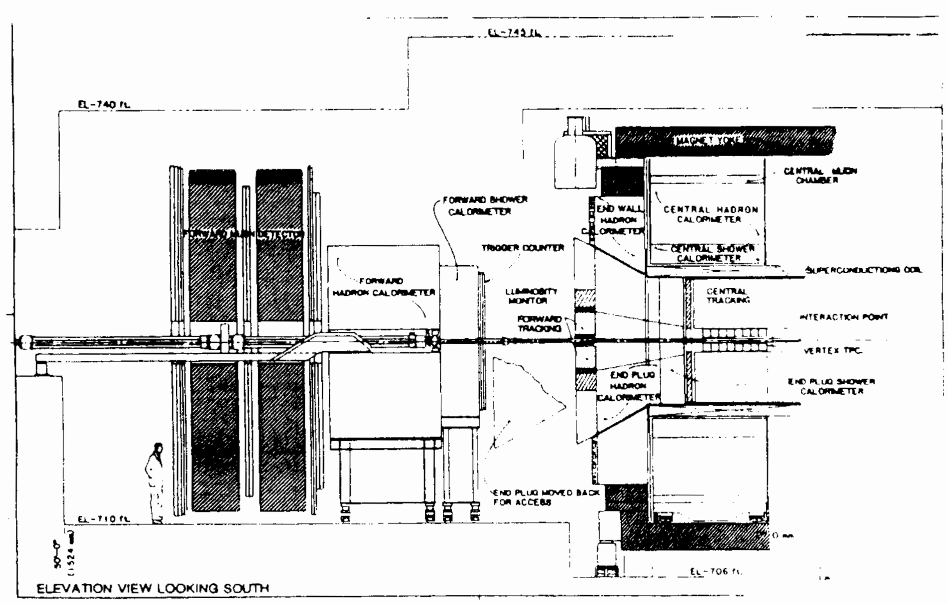

Figure 5. A cut through one-half of CDF.

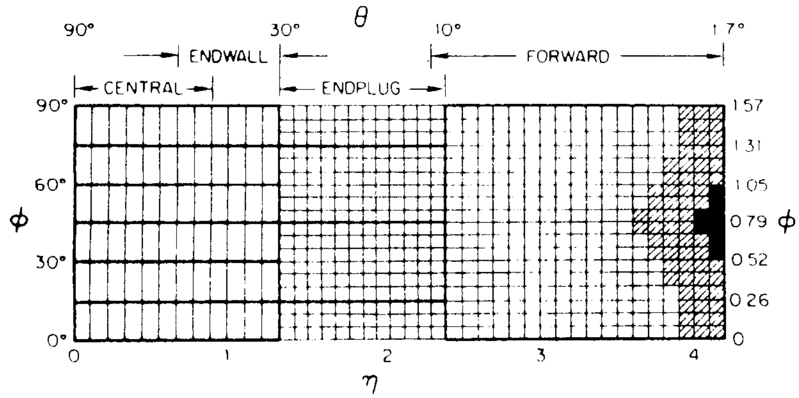

Figure 6. One quadrant of hadron calorimeter towers. The heavy lines indicate module or chamber boundaries. The cross-hatched area has only partial hadron depth coverage due to space required for the low beta quadrupoles. The shaded area has no coverage. The electromagnetic calorimeters have complete ∅ coverage out to a pseudo-rapidity of 4.2.

a) A total transverse energy (E_t) trigger made from the sum of the E_t deposited in the calorimetry. The threshold was varied from 20 to 45 GeV depending on the luminosity.

b) An electron trigger formed using the sum of E_t deposited in the electromagnetic calorimetry with an E_t threshold of 15 GeV.

c) A high transverse momentum (P_t) muon trigger made from the coincidence of a central muon chamber track with a high P_t track (>3 GeV) in the central drift chamber. The high P_t track was found with a fast track processor.

d) A high P_t muon trigger from the forward muon system. This trigger was rate limited in this run.

e) A rate limited "minimum bias" trigger made from a coincidence from the beam-beam counters (see Fig. 5) at the proper crossing time. This beam-beam coincidence was also required for triggers a) - d).

The performance of the detector can be illustrated by several *preliminary* physics distributions.

The minimum bias data sample for the single particle P_t spectrum has ~12,000 tracks at $\sqrt{s}$=0.63 TeV and ~138,000 tracks at $\sqrt{s}$=1.8 TeV. Some data was taken at the higher energy triggering only on beam crossings, in order to study the effects of trigger bias. Intensive scanning of events in the VTPC and central drift chamber, and detailed detector simulation are being used to evaluate a number of sources of systematic errors and to improve the accuracy of the pattern recognition in the tracking programs. The present error of the momentum measurement is $\Delta p/p \approx 0.004$ p, which is about twice the design value and is still being improved. The cell structure of the chamber is tipped to compensate for the E x B effect so that electron drift is along lines of constant radius. As a consequence, positive and negative tracks are not treated symmetrically by the track reconstruction programs. Figure 7 shows superimposed spectra for positive and negative tracks in the 1.8-TeV data sample. They demonstrate that the chamber construction does not lead to any appreciable sign-dependent bias. The preliminary data (sum of both signs) at 1.8 TeV is shown in Fig. 8 and a comparison between 0.63 TeV and 1.8 TeV will be forthcoming.

A typical two-jet event in the detector is shown in Fig. 9. The same two-jet event is shown in Fig. 10 in the tracking chamber view. The jets have raw cluster transverse energies of 83 GeV and 75 GeV. Cluster algorithms are still under study, and this one uses a nearest neighbor algorithm with an E_t tower threshold of 0.1 GeV with cluster seed towers required to have more than 1.0 GeV. Clusters were merged if separated by less than the maximum merging distance R=0.7, where R is the square root of the sum of the squares of the phi and pseudo-rapidity deviations. The preliminary uncorrected energy scale is based

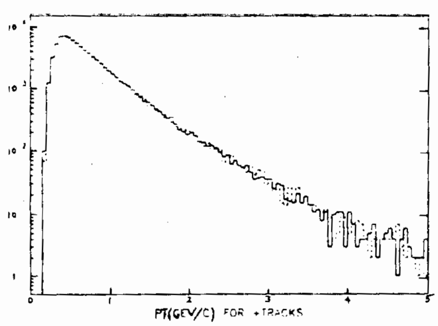

Figure 7. Single particle P_t spectrum for positive (solid line) and negative (dashed line) tracks as obtained from the central tracking chamber.

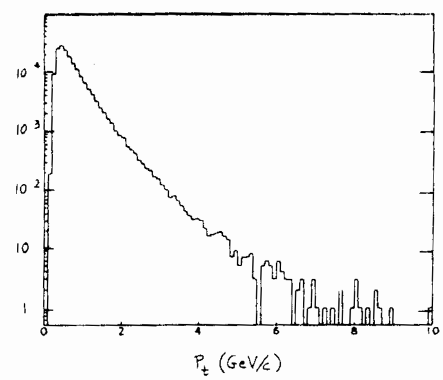

Figure 8. Unnormalized single particle P_t spectrum at $\sqrt{s}$ = 1.8 TeV.

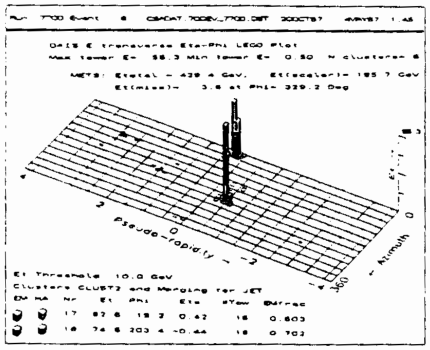

Figure 9. Calorimeter "LEGO" plot of a typical two-jet event.

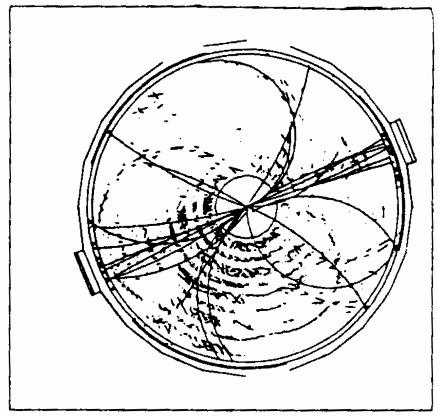

Figure 10. Central tracking chamber view of the same two-jet event shown in Fig. 9. The TEVATRON beam pipe is perpendicular to the plane of the paper in this view.

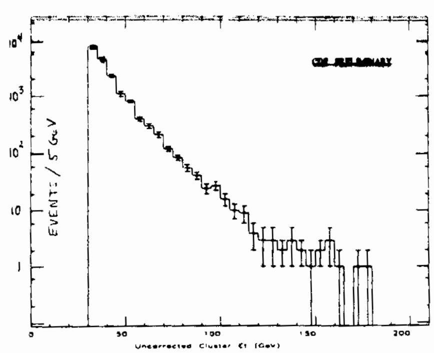

Figure 11. Transverse energy distribution of clusters with pseudo-rapidity in the range -1.0 to +1.0. This sample is obtained by combining samples with various E_t thresholds (all >30 GeV) weighted by the inverse of their relative integrated luminosities.

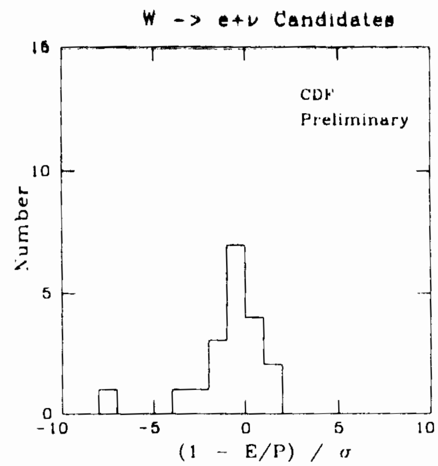

Figure 12. The agreement between the central drift chamber measured transverse momentum (P) and the calorimeter measured transverse energy (E) for electrons in the CDF sample of W → (e+ neutrino) candidates.

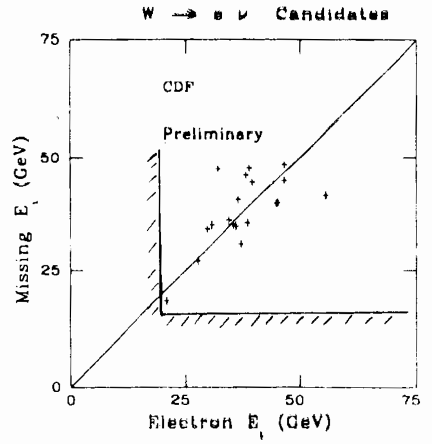

Figure 13. Event missing transverse energy versus Electron transverse energy for the CDF sample of W→ (e+ neutrino) candidates. The shaded lines indicate cuts used in the analysis.

on a simple sum of electromagnetic and hadronic energies in the clustered towers. The transverse energy distribution of jet clusters from the central calorimetry is shown in Fig. 11. Figure 11 is based on only about 1/3 of our total sample and it contains several events above 150 GeV. We are therefore already able to study the complete E_t range accessible at the CERN SPS collider.

A complete analysis of the data for W and Z production is not yet available. We show here a selection W → e+ neutrino candidates which were produced with the following cuts on the electron cluster:

1. -1.0 < pseudo=rapidity < 1.0,
2. E_t ≥20 GeV,
3. Missing E_t ≥20 GeV,
4. (Hadronic energy ÷ Electromagnetic energy) < 0.1,
5. Only one track within a ΔØ x Δ (pseudo-rapidity) cone of 15° x 0.3,
6. 0.2 < E ÷ p < 1.8.

Figures 12 and 13 show distributions of events passing these cuts. These candidates are consistent with W → e+ neutrino production. We have about 20 such candidates. We also have six candidates compatible with Z → e+e-.

The TEVATRON Collider experimental program is under way and CDF's goals for the 1987 run have been met. The detector checkout was satisfactory, and we have ~34 nb^{-1} integrated luminosity on tape. The expected physics signals at 1.8 TeV are seen and they look reasonable.

This paper was presented (by J. W. Cooper) at, and is to be published in the proceedings of, the Summer Institute on Particle Physics, Stanford Linear Accelerator Center, Berkeley, California, August 10-21, 1987.

A Fast Calorimeter Simulation for Hadron Collider Detector Design

Catherine Newman-Holmes and James Freeman

Introduction

Computer simulations of detectors are now one of the most widely used tools for detector design. As detectors have become more complex, the computer simulations have also grown and become much more complicated. We have written a computer simulation which is both fast and flexible. The speed is obtained by using parametrizations for showers and a fairly simple geometry. The flexibility is provided by allowing many characteristics of the simulated detector including thickness, segmentation, resolution, and electron/hadron response to be easily set by the user. We see this program not as a replacement for the more elaborate computer simulations of detectors but rather as a complementary tool. A simple program may be used to determine which detector issues are worthy of study with the more time-consuming and detailed programs.

Description of the Simulation Program

The simulated detector is shown in Fig. 1. It consists of three regions: a decay volume, an electromagnetic calorimeter and a hadronic calorimeter. Both calorimeters are spherical shells with conical holes for the beam pipe. The

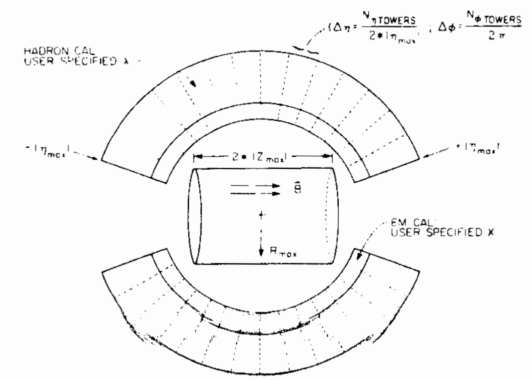

Figure 1. Diagram of the simulated detector.

rapidity cutoff is specified by the user. The decay volume contains a cylindrical region where a solenoidal magnet field may be present. The radius of the spherical decay volume is chosen to just enclose the cylinder. The cylinder's size and the magnetic field strength are specified by the user. The radiation length, absorption length and thickness of each calorimeter are also settable. We mention here two limitations of the detector geometry. The first is that all of the calorimetry is outside of the magnetic field. Most detector designs under consideration for the next generation of hadron colliders place at least some of the calorimetry inside the magnet. Secondly, in this program, the segmentation of the electromagnetic and hadronic calorimeters is required to be the same whereas detector designs generally make the electromagnetic calorimeter more finely segmented. These restrictions may be relaxed in a subsequent version of the program.

The program is currently interfaced to the event generation program of the Collider Detector at Fermilab (CDF) which allows one to use a variety of generators as input. The program goes through a list of particles made by the generation program. For each particle, a distance to decay point, distance to electromagnetic conversion and distance to hadronic interaction are calculated using probability distributions appropriate for the particle type. Particles are then tracked through the detector one by one. In the decay volume, a particle will decay if the distance to its decay point is less than the distance it travels through this volume. If a nonzero magnetic field has been specified, charged particles follow helical trajectories.

When a particle reaches its predetermined shower or conversion point, parameters for its shower are generated. The shower parametrization has been described elsewhere; longitudinal and transverse shower profiles as well as fluctuations are modeled. This parametrized shower is then integrated over the distance between the shower point and the calorimeter edge. If a shower starts in the electromagnetic calorimeter, the same shower is continued into the hadronic calorimeter. The electromagnetic/hadronic energy response is settable for each calorimeter. Note that in this model, a particle may not decay once its shower has begun. The total (electromagnetic + hadronic) energy deposited in the calorimeters is available for each particle both before and after smearing with a resolution function. The resolution is assumed to be of the form σ_E/E = const/ $\sqrt{E}$+1% where the constant is supplied by the user for each calorimeter (electromagnetic and hadronic) and the additional 1\% is a systematic error associated with calibration. In addition, the energy is deposited in an η - ϕ array with specifiable segmentation. Energy is shared between the central tower (i.e., the one to which the particle track pointed) and its four nearest neighbors in η - ϕ space. The fraction of energy deposited in the central tower depends on the ratio of the shower size to tower size. The remaining energy is shared equally among the four nearest neighbor towers. Electromagnetic and hadronic calorimeter energies are saved separately in the η - ϕ array; only their sum is saved in the particle-oriented arrays. A simple clustering algorithm is used to find energy clusters in the η - ϕ array.

At a luminosity of 10^{33} cm^{-2}/sec, one expects an average of about 10 interactions in a 100 ns integration time. Our simulation includes an option to overlap minimum bias events with the generated events of interest. The average number of events to overlap may be varied. Then the actual number of overlapped interactions is determined for each event by sampling from a Poisson distribution with the specified mean.

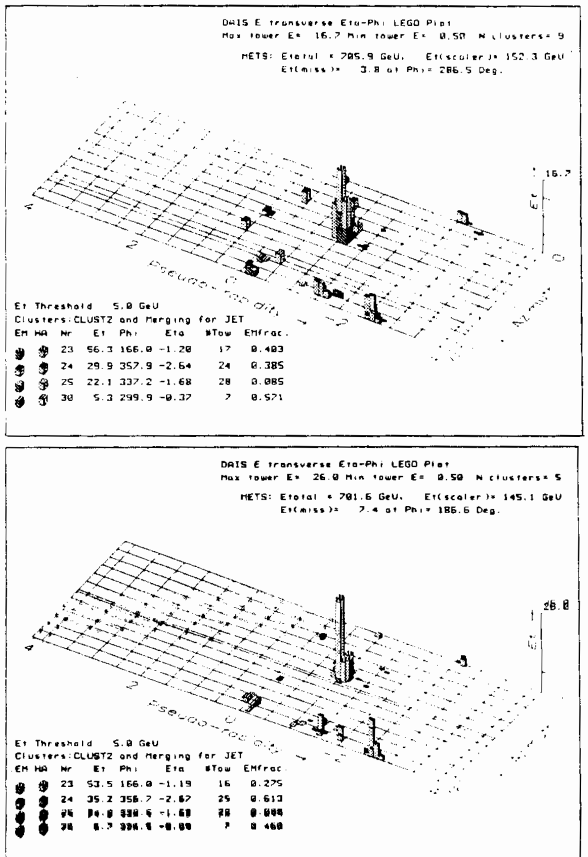

Figure 2. Transverse energy in η - ϕ towers for this program (a) and the full CDF simulation (b).

Figure 2 shows the energy in the η - ϕ array for an event simulated by this program (Fig. 2a) compared to the same event simulated by the full CDF simulation program (Fig. 2b). The distributions, as well as the list of clusters in the lower left corner of each plot, are in good agreement. Our program is widely used in the CDF collaboration for applications where the detail of the full CDF simulation program is not required. On a VAX 8650, the program requires 100 msec for initialization. The time taken per event depends on the topology of the events being studied. For W pair events at $\sqrt{s}$=40 TeV, with the W's decaying to quarks, the average number of produced particles is about 900 and the time required is about 2.5 sec/event. For comparison, the full CDF detector simulation (which also uses parametrized showers but much more complicated geometry) takes about 100 times longer.

An Example of the Program's Use

We present here some results obtained with the simulation program as examples of its utility. We choose for illustration to study the invariant mass distribution for 500-GeV P_t W's decaying into quarks which then hadronize into jets. This example is discussed in more detail in Reference 2. The parameters used by the simulation program for this example are given in Table I. The first five parameters in Table I were chosen to match the CDF detector.

Table I.

EM calorimeter radiation length	1.94 cm
EM calorimeter absorption length	48.36 cm
Hadron calorimeter radiation length	2.94 cm
Hadron calorimeter absorption length	33.25 cm
EM calorimeter thickness in rad lengths	17.82
Hadron calorimeter thickness in abs lengths	10.0
EM calorimeter energy resolution	$15\%/\sqrt{E}$
Hadron calorimeter energy resolution	$50\%/\sqrt{E}$
EM calorimeter e/h response ratio	1.0
Hadron calorimeter e/h response ratio	1.0
Tracking volume radius	140.0 cm
Tracking volume half-length	140.0 cm
Magnetic field	0.0 tesla
Maximum absolute value of η	2.5
Number of η bins	160
Number of ϕ bins	210

The events were generated using the ISAJET program (version 5.2). The W's were produced by the WPAIR option, with θ between 80° and 90°, and the P_t range 450 - 550 GeV. After the events were created, the simulation was used to generate calorimetry energy depositions. Clusters were then found in the calorimetry using a simple algorithm. To reconstruct the W invariant mass, each tower within R < 0.7 of the cluster center was treated as a massless particle with all energy assumed to be deposited in the tower center, and the resultant invariant mass of this set of ''particles" was calculated. Here R is defined as:

$$R = \sqrt{(\phi - \phi_i)^2 + (\eta - \eta_i)^2}$$

where (η,ϕ) is the cluster direction and i is the tower index. We note that these calculations are very insensitive to the clustering algorithm used, since only the cluster direction is required. Some additional cuts were applied to suppress problems in pattern recognition. The jets produced by the decay of 500-Gev W's are coalesced in our choice of calorimeter geometry. To ease pattern recognition, we chose events where no more than 25 GeV E_t of cluster energy was outside of the two leading clusters, and where the ratio of E_t's of the leading to the next to leading cluster was less than 1.25 . These cuts were typically 40% efficient. The remaining events can in principle be used, but the pattern recognition is more difficult.

The curves shown in Figures 3-6 are from a sample of approximately 175 W's per case for the W analysis. Figure 3 shows the effect of calorimeter thickness on the W mass resolution. Clearly thickness is not very important for this process. This is partially caused by the cuts that define the event sample. The requirement of cluster E_t balance suppresses events where there is substantial leakage or punchthrough. In addition, the jets from the W decay are fairly soft, again reducing the effect of leakage.

The results are sensitive to the segmentation chosen as shown in Fig. 4. In our invariant mass algorithm, the tower size is very important. All energy deposited in a tower is assumed to come from the tower center, so the larger the tower, the larger the possible error in determining the direction of the energy flow into the tower. Figure 4 shows the W invariant mass distributions for three cases of tower size: δR=0.01, 0.03, and 0.1 . The resolution suffers substantially if the tower size is as large as 0.1.

Figure 5 indicates that calorimeter resolutions mentioned in typical future hadron collider detector designs are reasonable for observing the process under consideration. We note, though, that low-energy particles in the lab frame can

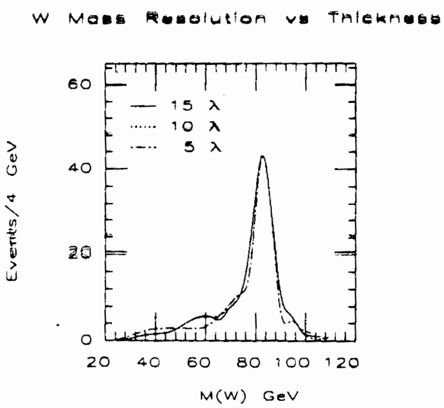

Figure 3. Effect of calorimeter thickness on W mass resolution.

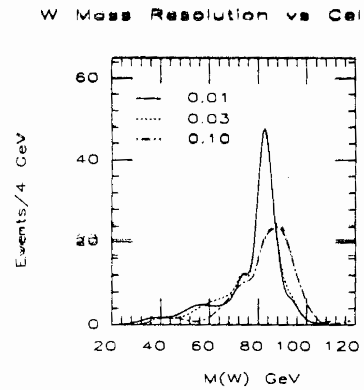

Figure 4. Effect of segmentation on W mass resolution. The three curves are for three different tower sizes where a tower is a rectangle in η - φ space.

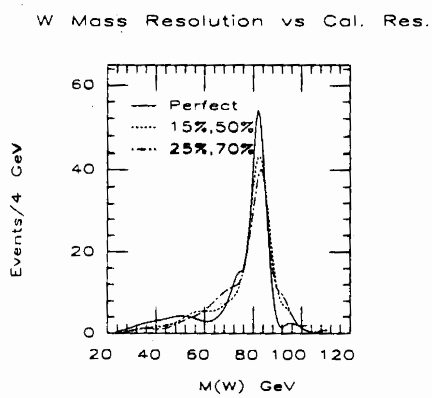

Figure 5. Effect of calorimeter resolution on W mass resolution. The first number of the pair labeling the curve is the electromagnetic calorimeter resolution, and the second number is the hadron calorimeter resolution.

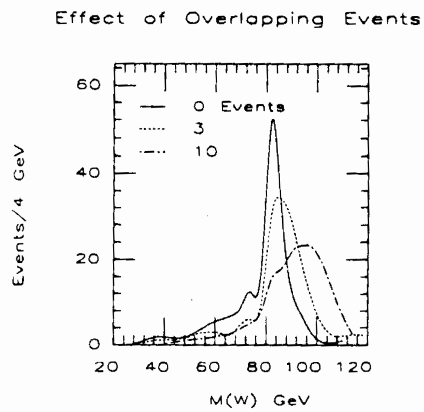

Figure 6. Effect of overlapping minimum bias events on W mass resolution. The curve labels are the mean number of events added to each W event.

make large contributions to the invariant mass calculation. It is important to measure these particles accurately.

Figure 6 indicates that the problem of overlapping events at high luminosities may significantly worsen a detector's ability to reconstruct W's from two jets. For this study, we considered the effect of additional background events which fall within the detector resolving time of the signal events. For the background events, we used ISAJET TWOJET events with jet P_t's between 3 and 15 GeV. This corresponds to about 150 millibarns of cross section at 40 TeV, so it should be a reasonable model for the background. The W mass resolution has a striking sensitivity to the number of superimposed background events.

Conclusion

We have written a simple Monte Carlo simulation program which may be used as a design tool for detectors for future hadron colliders. Different processes may be studied with the program and gross detector features easily changed. This allows one to see which detector characteristics are most important for processes of interest. Detailed design studies with more elaborate simulation programs then become more efficient and manageable.

This paper was presented by C. Newman-Holmes at the Workshop on Detector Simulation for the SSC, Argonne, Illinois, August 24-28, 1987.

In October 1981, the Two Rivers Council of the Boy Scouts of America contacted Fermilab Director Leon Lederman about organizing an Explorer Scout post at Fermilab. Lederman accepted the invitation and asked Lauta Joyner of the Fermilab Equal Employment Opportunity Office to be scouting coordinator and chairman of the advisory committee. Students in local high schools who had checked science, engineering, or computer science on a career interest survey conducted by the Boy Scouts were invited to an organizational meeting at Fermilab in December 1981. At that meeting, two Explorer Scout computer posts (1203 and 1204) were set up under the guidance of George Wyatt, of The Lab's Research Division Electronics/Electrical Department, who had many years of scouting leadership experience. These posts are still running today.

An Explorer Scout engineering post was also set up, but declining interest within the year caused the remaining students, who were working in the laboratory of Finley Markley, to be merged into George's post for administrative efficiency. One of the students who continued their engineering projects was James McAdams. For the next four years, Jim came to Fermilab every Tuesday, spending the time from 4:00 p.m. to 6:00 p.m. on his engineering project, grabbing a quick bite at Wilson Hall, then spending from 7:00 p.m. to 9:00 p.m. with the computer post. For the first two years his parents drove him back and forth to Fermilab from their home in Maple Park.

Jim's first engineering project was to make a transparent structural material of fiberglass-reinforced epoxy plastic. To do this he had to find additives for the epoxy to adjust its index or refraction to match the fiberglass. During this work he observed that when the fiberglass cloth was immersed in a matching index fluid, most of the fibers disappeared, except for any hollow fibers whose internal bores became visible. Since it is not widely known that these hollow fibers exist and can cause leaks when fiberglass reinforced plastics are used to construct vacuum or pressure vessels, Jim changed the emphasis of his work to investigate and report on these hollow fibers. Jim has published this work as a Fermilab TM, has submitted it to the Review of Scientific Instruments, *and it appears beginning on the next page.*

During the summer of 1987, Jim became a Fermilab summer employee and worked on the new "warm" superconductors with Markley. He is now continuing that work in the laboratory of Dr. Mason at Northwestern University where he is a full time student in his freshman year.

- Finley Markley

Fermi National Accelerator Laboratory

TM-1511

Investigation of Leaks in Fiberglass-Reinforced Pressure Vessels by Direct Observation of Hollow Fibers in Glass Cloth*

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Investigation of Leaks in Fiberglass-Reinforced Pressure Vessels by Direct Observation of Hollow Fibers in Glass Cloth

J. McAdams

Abstract

A simple method of visual observation of hollow fibers within fiberglass cloth has been developed. This visualization can aid in determining the contribution these fibers make toward leaks observed in fiberglass-reinforced epoxy resin pressure or vacuum vessels. Photographs and frequency data of these hollow fibers are provided.

Fiberglass-reinforced epoxy resin (typified by the commercial material designated N.E.M.A. grade G-10) has found widespread use as a mechanical support and electrical insulator. The electromagnetic coils found in fusion reactors and high-energy physics accelerators are typical examples. It is common for the material to act as a pressure or vacuum vessel in these applications. However, the integrity of such barriers may be compromised by the presence of hollow fibers within the fiberglass cloth.

The existence of hollow fibers in fiberglass cloth was originally proven by R.J.B. Hadden and A. Kirk[1]. In their paper, they provided photographs of a single, hollow fiber. Here, I provide further evidence of the existence of hollow bores within the glass fibers and offer a simple method for estimating the frequency of these bores.

A small area of fiberglass cloth is saturated with a fluid with a refractive index similar to that of the fiberglass. The fluid must be kept in a confined area by capillary action, such as is produced by sandwiching the fiberglass cloth between a slide and a cover slip. This procedure effectively removes the fibers from view, and the air-filled bores become plainly visible. To illustrate this effect, Fig. 1 shows an intersection of two bundles of fibers while Fig. 2 shows the same area after the introduction of the fluid.

A second method involves the use of a fluid with a slightly different index of refraction than that of the fiberglass cloth. (I used a fluid with an index approximately .002 less than the index of refraction of the fiberglass.) The air in the bores is still plainly visible, and the glass of the fibers can also be faintly seen. This produces an image of the glass fibers and the hollow bores simultaneously. Figure 3 is a photograph of this effect on a different section of fiberglass cloth.

Both of these methods provide a means to optically measure the diameter of the bores within the fibers. My observations indicated that the diameters range from 1 to 2.5 microns. Another benefit of immersing an entire bundle of glass fibers is that a frequency count of the hollow bores can be taken. In the fiberglass cloth used here, each strand contains 816 fibers of which 1.5 to 2.6 % were found to be hollow in any cross section. Although I have observed ends of the hollow bores, neither of these methods can be readily used to determine the maximum length of a hollow bore which has been measured at over 86 cm[1]. The observed ends of the hollow bores suggest that they are formed by air bubbles trapped in the molten glass. They also indicate that only when both ends of a hollow bore have been cut open during machining will leakage occur. A bore with only one end open may produce a virtual leak to a vacuum. To produce a continuous leak, a bore must span the pressure wall and be cut on both ends. Epoxy paints have been successfully used to seal machined surfaces of pressure vessel walls.

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1. R.J.B. Hadden and A. Kirk, "Leakage Within Glass-Fibre Reinforced Epoxy Resin Laminates," (Harwell, Berkshire, 1960).

Acknowledgements: This work was performed while the author was a member of Explorer Scouts Post Number 1204, sponsored by the Fermilab Equal Employment Opportunity Office, and was carried out with the guidance of Mr. Finley Markley in his lab at Fermi National Accelerator Laboratory.

Figure 1. Intersection of two bundles of fibers. (65x magnification)
Figure 2. Same intersection immersed in refractive index fluid. (65x magnification)
Figure 3. Intersection of two fiber bundles in fluid. (100x magnification)
(The thin black lines are the hollow bores.)

Figure 1.

Figure 2.

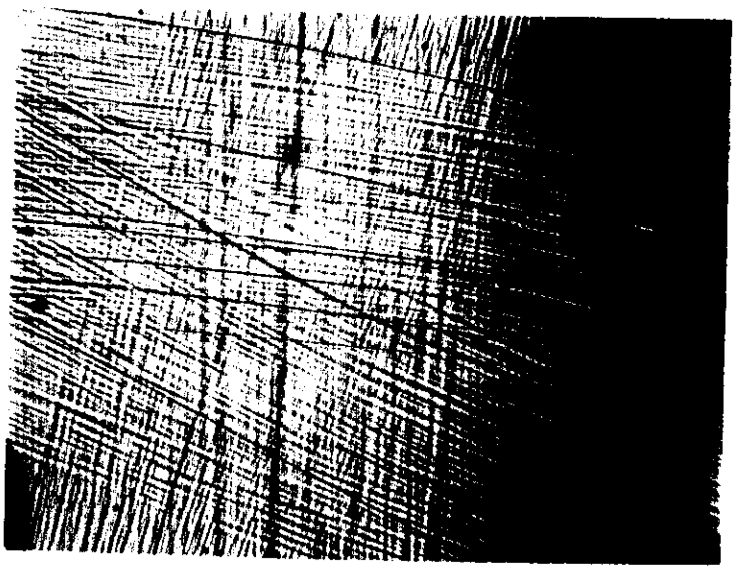


Figure 3.

A Luminosity Upgrade for Fermilab

Mark Bodnarczuk

This is the first in a series of reports describing Fermilab's plan to upgrade the TEVATRON, with the goal being to reach a luminosity of 5 x 10^{31} cm^{-2} sec^{-1}. (The luminosity is the product of the number of particles per second circulating in one beam and the average number of intercepted particles per unit transverse area in the other beam. When multiplied by the cross section for a given reaction, it gives the average number of events per second for that reaction.) The TEVATRON I Project (TeV I), which converted the superconducting TEVATRON into a collider, had a luminosity design goal of about 1 x 10^{30}. The machine was first commissioned for fixed-target operation in 1983, and the first 1.6-TeV center-of-mass colliding-beams events were observed in October of 1985 with a luminosity of about 10^{24}. Fermilab's Director, Leon Lederman, has remarked, "I believe it was the world's lowest recorded luminosity. . . It even beat the ISR because, when they first measured it in 1971, it was at least 10^{27}." Since that time, the luminosity has climbed by five orders of magnitude to 10^{29}. The proposed luminosity upgrade would give Fermilab a factor of 50 above the TeV I design goal.

There are a few issues that must be addressed in order to achieve this goal. The first is significantly reducing the beam emittance. The second is going from the present three-bunch operation to "multibunch" operation, storing about 100 bunches. Finally, the number of antiprotons must be significantly increased over the amount currently being produced. There are a few initial steps that Fermilab is proposing in order to reach the goal.

Initial steps toward multibunch operation are already under way. Studies of helically separated counter-rotating beams are currently in progress, with the intent of installing electrostatic separators in time for the 1989 run. The CERN experience with separated beams in the SPS provides valuable guidance in this work. The "6 on 6" bunch operation in the 1988 Collider run will be carried out without the benefit of beam separation.

A second significant step is the proposed upgrade of the existing Linac. The upgrade will elevate the energy of the Linac from its current level of 200 MeV to 400 MeV. This will involve replacing roughly half of the Linac with higher gradient structures, tripling the gradient in the later stages to 7.5 MeV per meter. This new configuration would enable the H^- ions to reach an energy of 400 MeV before being injected into the 8-GeV Booster. The higher injection energy produces a greatly reduced dilution of the beam emittance in the Booster. This dilution is believed to be due to space charge effects.

A third proposed step could be the addition of two new 20-GeV rings. The first 20-GeV synchrotron, called the Proton Super Booster (PSB), will be interposed between the 8-GeV Booster and the Main Ring. It will accept 8-GeV protons from the Booster, accelerate and inject them into the Main Ring at 20 GeV, with a significantly smaller beam emittance. Studies predict that this will produce a much improved Main Ring performance resulting from the combination of a smaller beam and better magnetic field quality. The second 20-GeV ring is called the Antiproton Super Booster (ASB). To reach the luminosity goal of 5×10^{31} it is necessary to increase the number of pbars in hand by about a factor of 10. In this new scenario, the Accumulator would continue in its present role, cooling and stacking pbars, then transferring them to the new ASB holding ring where they will be cooled and stored while the Accumulator stacks fresh batches. When a suitable number of pbars have been accumulated, they will be accelerated to 20 GeV and transferred to the Main Ring and ultimately to the TEVATRON. The ASB will also enhance pbar economy, offering the option of taking "old" pbars whose emittance was diluted by interbeam scattering out of the TEVATRON, decelerating them in the TEVATRON and Main Ring, and putting them back into the ASB to be used again.

Alternatives to the 20-GeV rings approach are also being considered. In particular, the Accelerator Division has begun to study a possible pp approach to higher luminosity.

In order to keep a vital colliding-beams physics program going, Fermilab must make significant improvements in the TEVATRON's luminosity. Initial steps of this program are already under way, with conceptual design reports being prepared. Portions of the project could conceivably be funded as early as 1990. This is an interim program that fills the gap between the TEVATRON and the SSC, and is a necessary evolutionary step to provide new physics opportunities in the intervening period.

Experimental Notes

New Tagged Hadron Beam and ACP Used with E-769

Fermilab Experiment 769 is a new fixed-target experiment currently measuring the properties of hadronic production of charmed particles at the Tagged Photon Spectrometer facility. The experiment measures the flavor, Feynman x, transverse momentum, and A dependences of charm and charm-strange state production at the same time and in a single apparatus. E-769 is a collaboration of Centro Brasiliero de Pesquisas Fisicas; Fermilab; Northeastern University; the University of Toronto; Tufts University; the University of Wisconsin; and Yale University. During the previous fixed-target run, the Tagged Photon Spectrometer was host to Experiment 691, "The Photoproduction of Charmed Particles," which accumulated the world's largest sample of reconstructed charm decays.

Since that time, there have been some major additions for E-769. The first is the reconfiguration of the beamline leading to the experimental hall. Previously, the beamline was an electron/tagged photon beam, but it has been redesigned for E-769 to transport 250-GeV/c pions, kaons, and protons to the spectrometer. A newly developed beamline transition radiation detector (TRD) and a differential isochronous self-focusing Cerenkov counter (DISC) were a major part of this effort. The Cerenkov counter is being operated at the upper limit of its useful momentum range to provide a positive tag for charged kaons. Its high-quality optics allow the separation of kaons from pions and protons by discriminating among the angles at which these particles produce Cerenkov light, a difference of only 0.069 milliradians for pions and kaons at 250 GeV. The TRD was specially designed for E-769 and is composed of 24 identical chamber-radiator assemblies. A stack of 200 polypropylene sheets equally spaced over 50 mm makes up each radiator. Transition radiation photons produced by beam particles as they pass through this stack are detected in two thin multiwire chambers filled with xenon. As the probability for production and detection of these TR photons is higher when the beam particle is a pion than when it is a proton or kaon, a large number of detector planes firing provides a positive pion tag.

The second major addition for E-769 is a new data acquisition system partially composed of Fermilab-developed Advanced Computer Program (ACP) modules. An ACP system is a series of single-board, microprocessor-based computers with large memories. The ACP modules were originally developed for offline event analysis, but now have also been used by E-769 in a data acquisition mode as well. This development was motivated by the high statistics needed for E-769 (over 300 events per second with a total data sample of over 300 million events). The old data acquisition system consisted of CAMAC electronics, which were read out serially by two CAMAC branch highways and a PDP11. This took about 2 microseconds per word. The experiment replaced the CAMAC branch highways with seven parallel highways that go to bins of read-out buffers and ACP modules. The seven parallel highways are read out simultaneously at between 1 and 0.6 microseconds per word. By reading the modules at 0.6 microseconds, E-769 gains a factor of three on read-out speed alone and, combined with the seven parallel branches, a factor of 20 in read-out time!

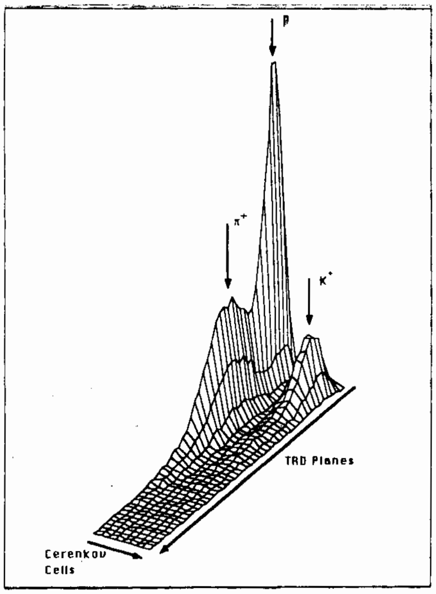


Figure 1. Offline analysis of data from E-769.

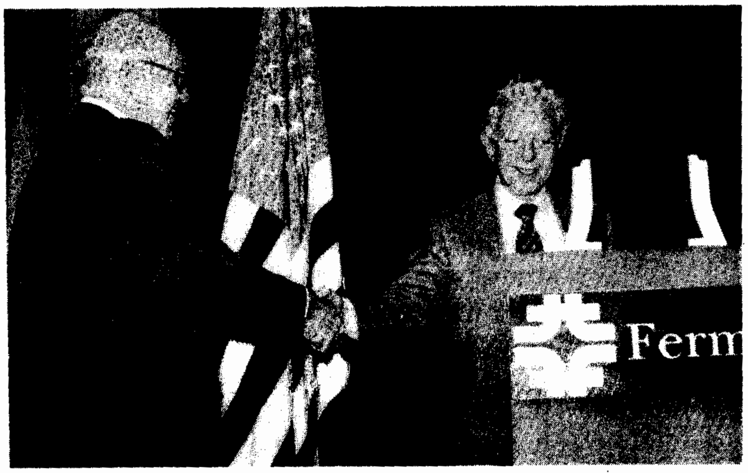
E-769 also replaced the PDP11 with the new system. Because each ACP module has 2 Mbytes of memory, and because the TEVATRON spill is 20 seconds long, E-769 can store the events in the ACP buffers and comfortably write them all to tape. The system also has the advantage of writing data to magnetic tape from the ACP memories directly, without other intervening computers. The experiment is using a 6250-bpi tape drive which has a rate of 100 inches/second, writing about 600 Kbytes of data per second.

Another major upgrade is in the experiment's target region. To track the beam particles, eight planes of 1-mm PWC's, and two planes of silicon microstrip detectors with 25-micron pitch have been installed. This beam tracking, in conjunction with a target consisting of 26 foils, 250 microns thick, will allow precision location of the primary interaction vertex in three dimensions.

E-769 will reach its goal of accumulating 300 million events on tape before the fixed-target run ends at the close of January 1988. The collaboration has begun offline analysis of this data as shown in the graph (Fig. 1). In addition, an enlarged collaboration has submitted a Letter of Intent to Fermilab for an experiment to extend the charm studies currently under way and begin new studies of the hadroproduction of beauty. - *M. Bodnarczuk*

Wallenmeyer Fest Held at Fermilab...

A symposium in honor of William Wallenmeyer, "Homage to Bill," was held at Fermilab on January 8, 1988. After more than 20 years of working in the United States Department of Energy, most recently as the Director for High Energy Physics, Office of High Energy and Nuclear Physics, Wallenmeyer will be assuming the presidency of the Southern University Research Association.



(Fermilab photograph 88-16-5)

Fermilab Director Leon Lederman welcomes William Wallenmeyer to the platform at "Homage to Bill."

The symposium began with opening statements from Leon Lederman and Wolfgang Panofsky. Lederman recalled the initial phases of the High Energy Physics Advisory Panel (HEPAP), which was chartered by the Division of Research of the U.S. Atomic Energy Commission in 1967, and with which Wallenmeyer was directly involved. The first Chairman of HEPAP was Victor Weisskopf, and since that time the chair has been held by Sidney Drell, Jack Sandweiss, and currently by Francis Low. The symposium agenda was organized around the chronology of HEPAP. Beginning with Weisskopf and proceeding through Low, each chairman gave his own impressions about the historical development of high-energy physics from 1966-1987, and related what they perceived Wallenmeyer's role to have been in this development.

The overall consensus was that Wallenmeyer's assiduousness and commitment to high-energy physics had contributed greatly to the success of the field during his time of service. During the part of the program where comments were encouraged from the floor, this sentiment was echoed by many others, including Sam Ting and L. Edward Temple.

The last portion of the symposium centered on the future of high-energy physics, with perceptions from what Lederman called the "younger generation." After Lederman placed baby bottles filled with milk in front of each speaker seated at the table, Bruce Winstein, Michael Witherell, Edward Patterson, and Derek Lowenstein each gave his own impression of what future accelerator complexes would need to look like in order to explore the physics goals currently envisioned in and beyond the Standard Model.

One of the most amusing portions of the program was when HEPAP Chairman Low passed out song sheets and then stepped to the piano to lead those present in singing an original song entitled, "He'll Always Be Our Bill":

He's still our Bill,
An extraordinary guy,
You'll meet him on the street
And always notice him;
His manly grace
His handsome face
Is just the kind that you
Would find on a statue.
But how to explain?
It isn't just his brain
That makes us thrill;
We love him
Because he'll always be,
He'll always be our Bill

At the end of nearly four hours of praising and pranking, Wallenmeyer was allowed 5-10 minutes to respond to those who had gone before him.

M. Bodnarczuk

Peter Cooper New Associate Head of Fermilab Computing Department...

Peter Cooper has been named Associate Head of Fermilab's Computing Department. Cooper's primary responsibility is data acquisition, both hardware and software. Before coming to Fermilab, Cooper was Associate Professor of Physics at Yale University. Jack Pfister will continue as Associate Head with responsibility for central computing, and Jeff Appel will remain Head of the Department.

("Lab Notes" continued)

Computer Conference on Beauty Physics at Fermilab. . .

In the aftermath of the Beauty Workshop that was recently held at Fermilab, a computer conference has been organized to discuss the possible design of a Collider experiment to explore Beauty physics at the TEVATRON. All those who are interested in either following the discussion or contributing to the computer conference may do so via VAX Notes, which is available on various computing machines on the HEP DECnet. The conference is at:
FNAL::USR$ROOT:[BEAUTY.CONFERENCE]B_COLLIDER.NOTE.

The conference moderator is Ray Stefanski (FNAL::STEFANSK). If you would like to examine the conference contents, log into an account on the VXCRNA VAX. At the $ prompt, type the following:

```
$NOTES
Notes>ADD ENTRY FNAL::USR$ROOT:[BEAUTY.CONFERENCE]B_COLLIDER
Notes>OPEN_B
Notes>do VAX Notes commander
```

- for starters, just type digits 1,2,3,4,5,5.1,6,7,8 to see initial notes.

- David Ritchie

Nominations Sought for 1988 Prize for Achievement in Accelerator Physics and Technology. . .

The US Particle Accelerator School invites nominations for prizes awarded on a competitive basis for outstanding accomplishment in accelerator physics and technology. Nominations should include the name and institution of the candidate, a description of the candidate's accomplishment, supporting documentation, and the names of those submitting the nomination.

Members of the Prize Selection Committee for 1988 are R. Billinge, J. E. Leiss, C. Pellegrini, and J. Rees.

Nominations must be submitted no later than May 15, 1988, to the US Particle Accelerator School Office, c/o Marilyn Paul, P.O. Box 500, MS 125, Batavia, Illinois, 60510.

Prizes will be presented at the APS Division of Particles and Fields Summer Study, Snowmass, Colorado, July 1988.

Normally, two prizes of $1,000 are awarded. They are made possible by donations from the Continuous Electron Beam Accelerator Facility, the Houston Area Research Center, Universities Research Association, Inc., Varian Associates, and Westinghouse Electric Corporation.

Manuscripts and Notes

prepared or presented from January 1, 1988 to March 31, 1988. Copies of technical publications with Fermilab publication numbers can be obtained from the Fermilab Publications Office, Theoretical Physics Department, or Theoretical Astrophysics Group, 3rd floor, Wilson Hall. Copies of some articles listed are on the reference shelf in the Fermilab Library, 3rd-floor crossover, Wilson Hall.

Experimental Physics Results

Experiment #400

J. Enagonio, "Measurements of Neutron Production of Lambdas and Antilambdas," (Ph.D. Thesis, University of Colorado, 1987)

C. Shipbaugh et al., "Production of the $D_s^{\pm}$ by High Energy Neutrons," (FERMILAB-Pub-87/220-E; submitted to Phys. Rev. Lett.)

Experiment #619

C. C. James, "A Measurement of the Branching Ratio of the Weak Radiative Hyperon Decay $\Xi^0 \rightarrow \Lambda\gamma$, (Ph.D. Thesis, University of Minnesota, October 1987)

Experiment #632

H. Akbari, "High Resolution Imaging of Particle Interactions in a Large Bubble Chamber Using Holographic Techniques," (Ph.D. Thesis, Tufts University, June 1987)

Experiment #691

J. C. Anjos et al., "Measurement of the Λ_c^+ Lifetime," (FERMILAB-Pub-87/218-E; submitted to Phys. Rev. Lett.)

J. C. Anjos et al., "A Study of D^0 - $\overline{D}^0$ Mixing," (FERMILAB-Pub-87/219-E; submitted to Phys. Rev. Lett.)

Experiment # 740

R. Raja, "On Micro Vax Farms and Shower Libraries - Monte Carlo Techniques Developed for the D0 Detector," (FERMILAB-Pub-88/16-E; invited talk given at the Workshop on Detector Simulation for the SSC, Argonne, Illinois, August 24-28, 1987)

Experiment # 741/CDF

D. Amidei et al., "A Two Level FASTBUS Based Trigger System for CDF," (FERMILAB-Pub-87/187-E; submitted to Nucl. Instrum. Methods A)

G. Ascoli et al., "Central Muon Level-1 Trigger Electronics," (FERMILAB-Pub-87/188-E; submitted to Nucl. Instrum. Methods A)

M. Atac et al., "Radial Wire Drift Chambers for CDF Forward Tracking," (FERMILAB-Pub-87/186-E; submitted to Nucl. Instrum. Methods A)

E. Barsotti et al., "FASTBUS Data Acquisition for CDF," (FERMILAB-Pub-87/190-E; submitted to Nucl. Instrum. Methods A)

S. Bhadra et. al., "A Computer-Controlled Wire Tension Measurement System Used in the Fabrication of the CDF Central Drift Tube Array," (FERMILAB-PUB-87/185-E; submitted to Nucl. Instrum. Methods A)

G. Drake et al., "CDF Front End Electronics: The Rabbit System," (FERMILAB-Pub-87/189-E; submitted to Nucl. Instrum. Methods A)

G. W. Foster et al., "A Fast Hardware Track-Finder for the CDF Central Tracking Chamber," (FERMILAB-Pub-87/191-E; submitted to Nucl. Instrum. Methods A)

General Particle Physics

T. Altomari et al., "CP-Violating Lepton Asymmetry Due to B-$\overline{B}$ Mixing," (FERMILAB-Pub-88/14)

J. A. Appel, "QCD: Photo/Hadroproduction of Heavy Flavors; Fermilab E691, E769 & Beyond," (FERMILAB-Conf-88/22; invited talk given at the Advanced Research Workshop on QCD Hard Hadronic Processes, St. Croix, U.S. Virgin Islands, October 8-13, 1987)

A. Chao et al., "A Progress Report on Fermilab Experiment E778 - An Experimental Study of the SSC Magnet Aperture Criterion," (FN-471 [SSC-156])

The CDF Collaboration, "CDF Progress Report," (presented by J. W. Cooper) (to be published in the Proceedings of the Summer Institute on Particle Physics, SLAC, Berkeley, California, August 10-21, 1987)

J. Freeman, "CDF Detector Simulation," (FERMILAB-Conf-87/230; presented at the Workshop on Detector Simulation for the SSC, Argonne, Illinois, August 24-28, 1987)

C. Newman-Holmes and J. Freeman, "A Fast Calorimeter Simulation for SSC Detector Design," (FERMILAB-Conf-87/231; presented at the Workshop on Detector Simulation for the SSC, Argonne, Illinois, August 24-28, 1987)

H. B. Prosper, "On Estimating Mean Lifetimes in the Presence of Background," (FERMILAB-PUB-88/26; submitted to Phys. Rev. D)

M. V. Purohit, "Bottom Acceptance, Trigger Efficiency and Resolution at Fermilab Fixed-Target Experiments," (FERMILAB-Conf-88/15; talk contributed to the Workshop on High Sensitivity Beauty Physics, Fermilab, Batavia, Illinois, November 11-14, 1987))

Accelerator Physics

S. A. Bogacz, "Emittance Growth through a Betatron Instability Decoherence," (FN-478)

K.-Y. Ng, "Linear Beam-Beam Effects for Round Beams," (FN-472 [SSC-161])

K.-Y. Ng, "Resonant Impedance in a Toroidal Beam Pipe," (FN-477 [SSC-163])

J. A. Satti, "Injection Septum Magnets for the Loma Linda Medical Accelerator," (TM-1496; presented at the 10th International Conference on Magnet Technology [MT-10], Boston, Massachusetts, September 21-25, 1987)

Theoretical Physics

E. Eichten, "Heavy Quarks on the Lattice," (FERMILAB-Conf-87/158-T; talk delivered at the International Symposium on Field Theory on the Lattice, Seillac, France, September 28-October 2, 1987)

R. K. Ellis and Z. Kunszt, "Photoproduction and Electroproduction of Heavy Flavours with Gluon Bremsstrahlung," (FERMILAB-Pub-87/226-T; submitted to Nucl. Phys. B)

P. Q. Hung and M. Lindner, "Are Physical Cutoffs Required in Spontaneous Gauge Symmetry Breaking?" (FERMILAB-Pub-88/21-T; submitted to Phys. Lett. B)

P. Q. Hung and S. Mohan, "Left-Right Symmetry and Neutrino Masses in a Non-Perturbative Unification Framework," (FERMILAB-Pub-87/212-T; submitted to Phys. Rev. Lett.)

A. L. Kagan and C. H. Albright, "Quark and Lepton Masses in Superstring-type Models with Mirror Families," (FERMILAB-Pub-87/67-T; submitted to Phys. Rev.)

M. Mangano, "The Color Structure of Gluon Emission," (FERMILAB-Pub-88/35-T; submitted to Nucl. Phys. B)

P. Nason et al., "The Total Cross Section for the Production of Heavy Quarks in Hadronic Collisions," (FERMILAB-Pub-87/222-T; submitted to Nucl. Phys. B)

F. I. Olness and W.-K. Tung, "When is a Heavy Quark Not a Parton? Charged Higgs Production and Heavy Quark Mass Effects in the QCD-Based Parton Model," (FERMILAB-Pub-87/221-T; submitted to Nucl. Phys. B)

R. D. Pisarski, "Computing Finite Temperature Loops with Ease," (FERMILAB-Pub-87/140-T; submitted to Nucl. Phys. D)

Theoretical Astrophysics

A. Albrecht, "Cosmology for High Energy Physicists," (FERMILAB-Conf-87/206-A; lectures presented at the 1987 Theoretical Advanced Studies Institute, Santa Fe, New Mexico, July, 1987)

D. P. Bennett and F. R. Bouchet, "Evidence for a Scaling Solution in Cosmic String Evolution," (FERMILAB-Pub-87/205-A; submitted to Phys. Rev. Lett.)

L. Brown and D. N. Schramm, "The Lithium Isotope Ratio in Population II Halo Dwarfs: A Proposed Test of the Late Decaying Massive Particle Nucleosynthesis Scenario," (FERMILAB-Pub-88/20-A; submitted to Astrophys. J. Lett.)

S. A. Colgate et al., "Son of Supernova 1987a: Thunder and Lightning?" (FERMILAB-Pub-87/213-A; submitted to *Nature*)

O. J. P. [illegible], "Composite Leptoquarks in Hadronic Colliders," (FERMILAB-Pub-87/232-A; submitted to Phys. Rev. D)

J. A. Frieman et al., "Solitogenesis: Primordial Origin of Non-Topological Solitons," (FERMILAB-Pub-88/13-A; submitted to Phys. Rev. Lett.)

F. Grassi, "Quark Core Stars, Quark Stars, and Strange Stars," (FERMILAB-Pub-88/19-A; submitted to Phys. Rev. D)

K. Griest, "Effect of the Sun's Gravity on the Distribution and Detection of Dark Matter Near the Earth," (FERMILAB-Pub-87/224-A; submitted to Phys. Rev. D)

M. Kawasaki and K. Maeda, "Baryon Number Generation from Cosmic String Loops," (FERMILAB-Pub-87/208-A; submitted to Phys. Lett. B)

E. W. Kolb and M. S. Turner, "Limits to the Radiative Decays of Neutrinos and Axions from γ-Ray Observations of SN 1987A," (FERMILAB-Pub-87/223-A-Rev.; submitted to Phys. Rev. Lett.)

K. Maeda and N. Turok, "Erratum to FERMILAB-Pub-87/209-A, Finite Width Corrections to the Nambu Action for the Nielsen-Olesen String," (submitted to Phys. Lett. B)

S. Marques, "Einstein Metrics and Brans-Dicke Superfields," (FERMILAB-Pub-88/18-A; submitted to J. Math. Phys.)

G. J. Mathews and D. N. Schramm, "Thorium/Neodymium Cosmochronology and Galactic Chemical Evolution," (FERMILAB-Pub-87/195-A; submitted to Astrophys. J.)

R. Mayle et al., "Constraints on Axions from SN 1987A," (FERMILAB-Pub-87/225-A; submitted to Phys. Rev. Lett.)

A. Stebbins, "Cosmic Strings and the Microwave Sky I: Anisotropy from Moving Strings," (FERMILAB-Pub-87/227-A; submitted to Astrophys. J.)

M. S. Turner, "Particle Cosmology Comes of Age," (FERMILAB-Conf-87/228-A; to appear in the Proceedings of the 1987 International Symposium on Lepton and Photon Interactions at High Energies, Hamburg, Germany, July 27-August 3, 1987)

M. S. Turner and L. M. Widrow, "Gravitational Production of Scalar Particles in Inflationary Universe Models," (FERMILAB-Pub-87/194-A; submitted to Phys. Rev. D)

N. Turok, "String Driven Inflation," (FERMILAB-Pub-87/215-A; submitted to Phys. Rev. Lett.)

J. Yokoyama and K. Maeda, "On the Dynamics of the Power Law Inflation Due to an Exponential Potential," (FERMILAB-Pub-87/207-A; submitted to Phys. Lett. B)

Computing

G. Chartrand, "DECnet DLM Circuit Plans," (FN-474; presented at the January 7th HEPnet Technical Coordinating Committee Meeting, CALTECH, Anaheim, California, January 7-8, 1988)

G. Chartrand, "Inter-Network Traffic Management Proposal," (FN-475; presented at the January 7th HEPnet Technical Coordinating Committee Meeting, CALTECH, Anaheim, California, January 7-8, 1988)

Other

D. F. Anderson, "Measurement of TMAE and TEA Vapor Pressures," (FN-473)

J. McAdams, "Investigation of Leaks in Fiberglass-Reinforced Pressure Vessels by Direct Observation of Hollow Fibers in Glass Cloth," (TM-1511; submitted to Rev. Sci. Instrum.)

Publications from Fermilab Experiments - November, 1987, eds. D. Jovanovic and G. Giacomelli, lists Fermilab experimental publications from 1979 to 1987. The volume is available from the Fermilab Publications Office. See the inside front cover of *Fermilab Report* for our address.

Colloquia, Lectures, and Seminars

by Fermilab staff, at Fermilab, January-February 1988, unless otherwise noted.

January 6

R. Carrigan, R. Lundy: "Patents and Royalties"

January 12

B. Brown: "Magnets and Measurements for European Accelerators - DESY, CERN, GSI"

January 14

R. Webber: "Intensity Measurements Upgrade"

D. Beechy: "A Programmable Finite State Machine"

January 19

H. Itoyama: "The Vertex as a Bogoliubov Transformed Vacuum State in String Field Theory"

A. Tollestrup and D. Finley: "Intrabeam Scattering and the Upgraded TEV-ATRON Collider"

January 21

B. Hanna: "Examining the Bowels of TEVATRON Magnets"

G. Jackson: "Fermilab Quad Vibrations and Beam Dynamics"

January 26

G. Chartrand: "Wide Area Networking in High-Energy Physics"

January 28

J. Carson: "Coil Size Monitoring for SSC Magnet Coil Curing - the Overall Problem"

J. Gannon: "Coil Size Monitoring for SSC Magnet Coil Curing - Data Acquisition System"

M. Kuchnir: "Technical Support, Magnet Development and Testing, Status of High T_c Superconductors"

R. Yamada: "Muon Chamber Production/Tests"

February 2

M. Syphers, S. Holmes: "Recent Results of Main Ring 8-GeV/20-GeV Studies"

February 4

M. Harrison: "Coherent Instability in the TEVATRON: Observations"

A. Bogacz: "Coherent Instability in the TEVATRON: Interpretation"

February 11

S. Hsueh: "Progress on 4/8 GHz Stochastic Cooling System: Pick-up"

R. Pasquinelli: "Progress on 4/8 GHz Stochastic Cooling System: Low Noise Preamps"

February 25

R. Walker: "CHL: Status and Plans"

J. Maillet: "On Some Algebraic Structures Related to Integrable Field Theories"

February 26

M. Frey: "Hardware Monitoring Database"

Dates to Remember

May 11, 1988

Deadline for receipt of material to be considered at June 1988 Physics Advisory Committee Meeting

May 13-14, 1988

Users Annual Meeting

May 26-27, 1988

Eighth Annual Fermilab Industrial Affiliates Meeting

June 13-14, 1988

Future Polarization Physics at Fermilab Symposium. For information contact: Phyllis Hale, Fermilab Users Office, (312) 840-3111 or BITNET POLSYMP @ FNAL

June 18-24, 1988

Physics Advisory Committee Meeting

June 20-24, 1988

7th Topical Workshop on Proton-Antiproton Collider Physics. For information contact: Phyllis Hale, Fermilab Users Office, (312) 840-3111 or BITNET PBARP7 @ FNAL

August 1-12

1988 US Particle Accelerator School, Cornell University, Ithaca, New York. Send applications to US Particle Accelerator School, P.O. Box 500, MS 125, Batavia, Illinois, 60510

September 21-24, 1988

Lattice Gauge Theory Workshop. For information contact: Phyllis Hale, Fermilab Users Office, (312) 840-3111 or BITNET LAT88 @ FNAL