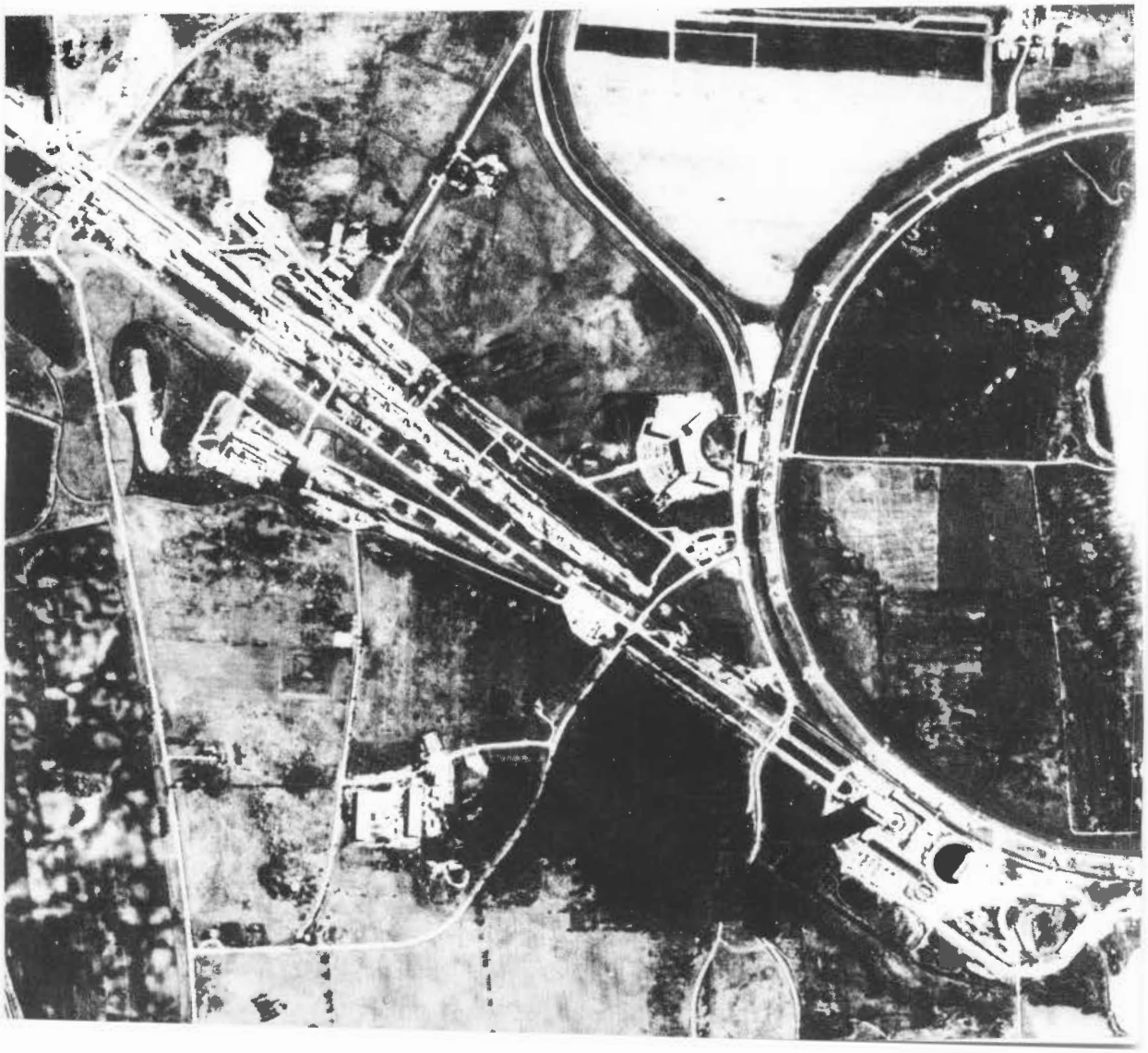
fermilab report

Fermi National Accelerator Laboratory Monthly Report

February 1985



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

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FERMILAB-85/2 Fermi National Accelerator Laboratory 0090.01

THE COVER: Current aerial photograph of the site showing the Main Ring, Debuncher Ring, Footprint Area, Industrial Complex, Site 38 Warehouse, and Experimental Areas from Switchyard to the new Muon Lab. (Fermilab photograph 85-96CN-B)

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THE TEVATRON II PROJECT: A STATUS UPDATE

Tom Kirk

A year has flown swiftly by since the last artricle in these pages devoted to the status of the Tevatron II Construction Project. The highlight of last year's article was the extraction, splitting, and transport of 400-GeV slow-spill beam from the newly commissioned superconducting accelerator to the Meson, Neutrino, and Proton Areas. The next step ahead at that time was the long awaited step "from it's present 400 GeV to 700 GeV or greater." The machine, as we all know, actually accelerated beam to 800 GeV where it ran very successfully and productively until mid-July 1984. Here we trace the highlights of the past year as they occured in the TeV II Project.

Extraction and Switchyard

The final piece of the TeV II-provided primary beam extraction system was the 1.5 ms fast spill for neutrino physics. A successful test of this very tricky maneuver was completed in March 1984. It appears that fast primary proton beam bursts up to 2.5×10^{12} protons per pulse can be successfully extracted during and after the slow beam spill and transmitted, without appreciable losses, to the neutrino production target.

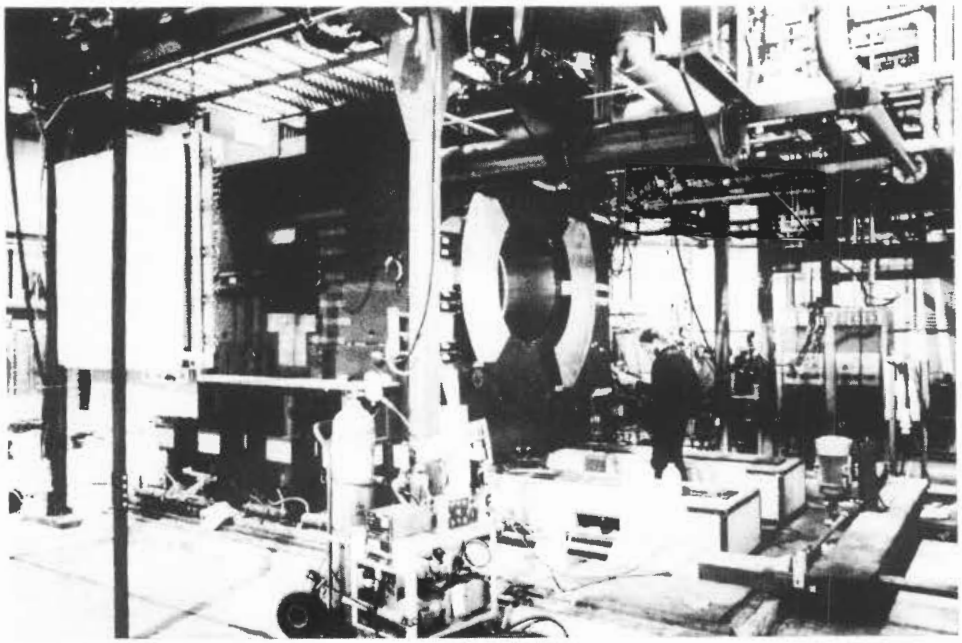
It is presently planned to deliver three such pulses per machine cycle to neutrino users in the present 800-GeV physics run. This rate could be increased if the total accelerated beam per cycle (proton economics) permits. The fast extraction, long worried about because of a greatly increased danger of quenching the machine, is a success and will permit a fruitful neutrino run for the four experiments presently sitting in the beam. These experiments consist of E-632 in the 15-Ft Bubble Chamber, E-745 in the new Tohoku Bubble Chamber, E-733 in Lab C, and E-744 in Lab E. All these detectors have been significantly improved for the first Tevatron neutrino beam run.

Worthy of note is the way the slow beam spill for the rest of the physics program repeated its beautiful 400 GeV duty factor and trouble-free performance at 800 GeV during the spring and summer. Successful runs were accomplished for experiments in the Meson and Proton expereimental areas (E-605, E-615, E-557/672A, and E-400). Test beams were also provided in the M Bottom, N West and N Test beam lines for groups ranging from CDF and D0 of the colliding beam program, to E-665, E-731, and E-691 in the final target program. Demand for test beam use last year was even more spirited, and beam time certainly more hotly debated, than among the regularly scheduled experiments.

The fact that the Tevatron Switchyard operated so smoothly, and delivered the apportioned beam fractions on demand to the many slow-spill targets, redounds to the credit of the Switchyard Group in the Accelerator Division. Their careful planning and sound conceptual designs made possible the reliable operation. The run at 800 GeV, getting underway this month, has had some rocky problems, but the Tev II switchyard does not seem to be a significant contributor. It just goes on working, adding the multi-pulse fast spill for the neutrino target to the prior eight slow spill beams, and pumping out the beam!

Civil Construction

A very large part of the TeV II Project activity this past year has been in civil construction. In this period alone, one major new laboratory building was completed (Lab F), two were constructed and beneficially occupied (Muon and Wide Band), and a third begun (M West Experimental Hall). The members of E-745 were anxiously awaiting the completion of Lab F last March so that they could install and commission the new Japanese-built Tohoku Bubble Chamber, shown below, with its high-resolution holographic optics. Tests of the operation of the bubble chamber and its brand-new, superconducting magnet coils will begin in the

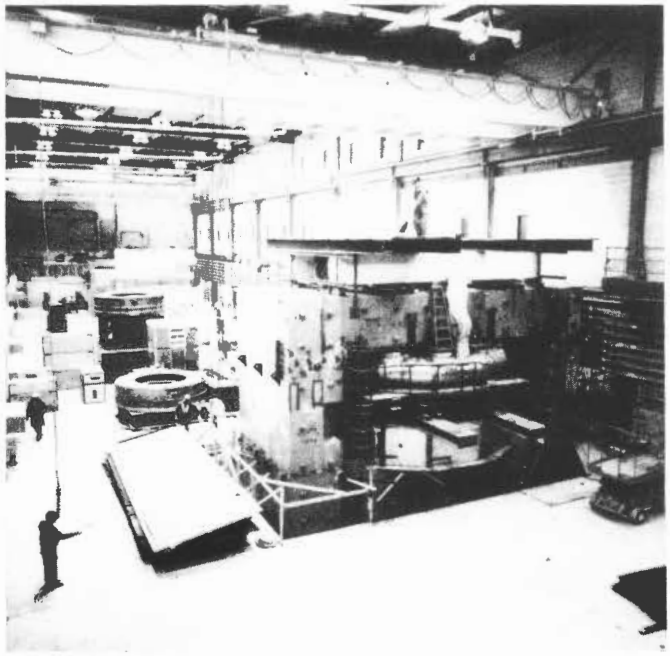


The Tohoku Holographic Bubble Chamber in Lab F coming into operation. (Fermilab photograph 85-42-8)

immediate future after safety reviews are complete. The Lab F Building, a TeV II Project item that houses the bubble chamber and its associated electronic detectors and support equipment, was custom designed for this detector system and seems to be serving its mission successfully.

The largest laboratory building in the TeV II Project, and by acclamation the most beautiful, is the new Muon Lab, north of Wilson Road. This striking concrete structure will provide a new architectural landmark for Fermilab. We owe its inspiring design to our polymath Director Emeritus Robert R. Wilson, whose artistic talents were lent to the building at its birth on the drafting boards of the Fermilab Tevatron Construction Group. Its strong horizontal lines and crisp angles reprise the architecture in the Wilson Hall footprint area, and bring to mind echoes of the prairie style practised by Frank Lloyd Wright.

Just as beautiful to the experimenters of E-665 are the carefully planned technical amenities. The heart of the experiment is a pair of large superconducting magnets, the CERN-built Vertex Streamer Chamber Magnet and the University of Chicago Cyclotron, both shown below. Even as this article goes to press,



The Chicago Cyclotron Magnet is shown with the unassembled pieces of the Vertex Streamer Chamber Magnet in the background. (Fermilab photograph 85-22-3)

the CVM has been assembled and stands ready to receive a streamer chamber provided by the Max Planck Institute at Munich. The pace of installation of E-665 in the Muon Lab is increasing rapidly as the last few workmen from the construction crews finish their painting and wiring. We look forward to a successful test run for E-665 this summer.

Not far away, in the Proton Area, the new Wide Band Experimental Hall and Service Building is reaching completion as this is written. As with the other new laboratories, the Wide Band Hall has been custom designed for the needs of the two Tevatron photon experiments that will be installed there (E-683 and E-687). These groups, hardened veterans of the traditional porta-kamp life at Fermilab, may not yet be accustomed to such amenities as computer floors, engineered air-conditioning and bathrooms, but they are very eager to learn. Repeating the Muon Lab pattern, the anxious experimenters and supporting Fermilab staff members will flood into the building this month as the contractor's people complete their jobs. They are racing to complete parts of the E-687 so that a test run to check out the apparatus (and maybe do some physics) can take place starting in late spring. The Laboratory as a whole, and TeV II in particular, are pushing hard to realize this goal.

Much less apparent to experimenters, but of vital interest, are the beamline-tunnel civil construction projects and magnetic beam transports that bring primary and secondary beams to the experiments. In TeV II the past year, a great deal of work of this nature has taken place in the Muon Beam, and in the Wide Band Beam as well. A total of more than $5 million has been spent by TeV II on building the thirty-odd beam enclosures for these two beams alone. Even in sub-zero winter temperatures, the intrepid contractor personnel have persisted in the digging and placement of the enclosures. Such determination matches the "can-do" spirit that has, all along, characterized the Fermilab attitude toward providing new TeV II facilities.

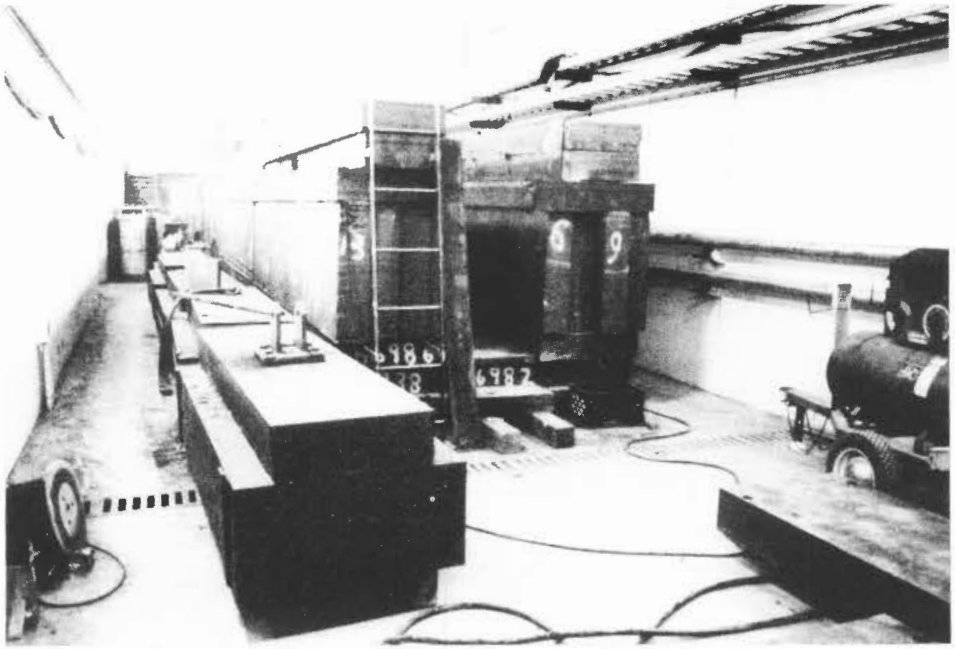
Finally, the last civil construction phase of the TeV II Project is now starting to roll. This is the construction of the M West Experimental Hall (E-706 and E-672) and the M Polarized Experimental Hall (E-704). The earthmoving was begun in January for M West, and will begin in March for M Polarized. Later in the spring, the beam enclosures for these experiments will be started. All these projects will be completed by this time next year, and will be ready for beam in summer 1986.

Technical Systems

During the past year, a less visible but equally important part of TeV II has gone on in the primary beam transport and target areas. This is the installation of target stations and beam dumps for the M West and Wide Band beams. Because targeting and dumping intense machine energy proton beams generates significant

amounts of radiation, and produces high residual radioactivity, the primary beam targets and magnetic dumps are shrouded in massive steel and concrete vaults.

The most recently completed of these, the Wide Band Target Pile, is shown below. In service, dump magnets are placed along



The thick steel target pile and beam dump ready to receive the Wide Band Beam target-sweeping dipole magnets. (Fermilab photograph 85-63-5)

the central channel and the whole pile closed with steel plugs, shown laying on the side. A long, water-cooled aluminum core intercepts the central proton beam and carries away the kinetic energy of the beam. The steel contains and absorbs the slow and fast neutrons genertated by the primaries. Outside the pile, residual radiation levels are safe for people a few minutes after the beam goes off.

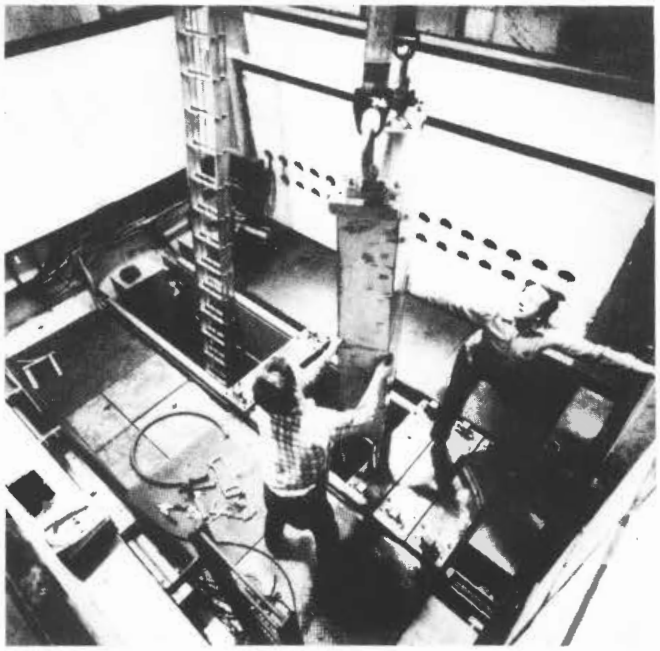
Work is just begining on the Muon target and dump system. Due to the unusual characteristics of this type of beam, three seperate dump piles will be needed. Also, to limit multiple scattering of the desired beam muons, a large beryllium-metal absorber is used for hadron removal in the third of the three dumps. Next summer, the Polarized Proton beam dumps will be fabricated for later installation. The polarized beam dump will

represent the last technical area to be completed for the TeV II Project.

Physics

The purpose, of course, for digging all this dirt, pouring all the concrete, welding all the steel, and stringing all the wires is to prepare new facilities for HEP experiments and, ultimately, to foster the physics of the Tevatron fixed-target physics program. In this regard, it was very exciting to attend the Division of Particles and Fields Meeting last November in Santa Fe, New Mexico, and hear, from members of the first Tevatron generation, their first physics results! At this meeting, the first really convincing evidence for hadron jets in a fixed target hadron experiment (E-609), and a beautiful new experiment (E-715), which laid to rest the serious challenge to the "standard model" presented by prior data on the sigma hyperon beta decay asymmetry, were among the many highlights. In the new experiment, a total of 80,000 beta decays were recorded, several hundred times the total from all previous experiments.

Well, theorists can maybe breathe easier for a little while, but the standard model will be in for many more challenges, and the data storehouse of physics subject to a new motherlode of data, as the TeV II experimental program moves into high gear over the next two years. These should be rewarding times to be a high-energy physicist at Fermilab!



John Spencer and George Biallas intserting the fifth of 14 filler modules in the antiproton target hall vault. (Fermilab photograph 85-60-9)

PHYSICS DEPARTMENT SUMMER PROGRAM FOR UNDERGRADUATE STUDENTS

Drasko Jovanovich

Every summer, the Fermilab Physics Department assumes a "rejuvenated look." The main cause of that rejuvenation is the presence of some 25 undergraduates, freshman to senior, from colleges and universities throughout the United States, as well as an occassional foreign student.

Some time in March, a large stack of applications for summer jobs at Fermilab are examined. There are usually more than 500 applicants. Many local kids know of Fermilab, and apply for a variety of summer jobs, outdoor and indoor. Of these 500 or so applications, about 150-200 are from physics, computer science, math, and engineering majors who are seeking a summer expereience closely related to their field of study. The vast majority of these applicants are excellent, and it is a painful process indeed to narrow the list down to the 25 students who are allowed into the Physics Department Summer Program by the department's budget constraints and the realities of available supervisory personnel.

Every incoming undergraduate is assigned to either a technician or one of our Fermilab research assistants (post-docs) on a one-to-one basis. The Summer Program student then becomes the "right-hand-person"to his or her mentor, and experiences all the work which a young Ph.D. must do to make an experiment a success. Sometimes this involves downright repetitive mechanical work, like manufacturing hundreds of plastic scintillators and light pipes for calorimeters. Sometimes it is wire-chamber manufacturing, sometimes programming. The student's assignment is based on individual interviews, and the goal is to match aptitudes and expectations.

The work these Summer Program students do is important. A great deal of work is accomplished during their brief, 10-week stay. But even more important is their interaction with Fermilab. Students are encouraged to go to all lectures and colloquia given on site. There are also special tutorials every Friday at 9 a.m. These sessions give the Summer Program students a chance to interact with physicists in an informal but learning-intensive situation.

It is a pleasure to watch a double metamorphisis take place each summer: the cautious, somewhat timid youngsters who begin each Summer Physics Program soon become "pro junior" particle physicists. Questions are asked and answers demanded; reasons are expected. "What is gauge field?" "What is Higgs?" The tutors sweat and toil to explain.

The other transformation occurs among the technicians and R.A.'s who have taken on the responsibility for these students. At the begining of each summer, it is the heavy investment of the

professional's time which brings the student up to a state of usefullness. By the time summer draws to a close, it is the students who have often become irreplacable. "Who will finish this Monte Carlo?" "Who will check that trigger electronics?" Many times, after students have gone back to their colleges and universities, requisitions appear seeking replacements for the Summer Program students, without which the experiment will surely "fail" for lack of help!

Upon departure, every student is asked to write a one-page summary of his or her experience in the Summer Physics Program in order to aid the Physics Department in planning future programs. With much gratitude to all our students for their thoughtful comments, we present two such letters:

Dear Drasko,

I am writing this letter to tell you about my experience at Fermilab, as you requested. I want you to know first of all that my job turned out much better than I had expected, and in fact was better than I had hoped. Credit should go to Mike Sokoloff. He showed great concern; he was available at all times; he was very knowledgeable; and he gave me projects that were at the right level for a summer job. In sum, I can say that I feel very lucky that you assigned me to work for him.

I learned a great deal this summer. I had never been to a physics institution outside of Harvard, so it was interesting to see the different ideas and emphases of the physicists at Fermilab. I also learned a fair amount of particle physics. The things that I do not understand yet are serving as motivation--I really feel re-energized to go back to the classroom and learn more physics. I also am now much more certain about my career future--I definitely want to be a high-energy theorist.

As fas as what I did on my job this summer, the most important physics result is summarized in my memo, "A Test of the OZI Rule." The idea was similar to that in a paper that you had co-authored about the photoproduction of ϕ particles. (I believe it was Ackerloff, et al. sometime around 1978.) Basically, I had a large sample of ϕ particles, and the OZI rule predicts that each ϕ particle produced by quark pairs bubbling out of the vacuum will be accompanied by two extra strange particles. I looked for this extra strangeness by searching for kaons, but I only found about $.45 \pm .25$ kaons per ϕ event. Mike will have a copy of this memo if you are interested. I also produced a couple of other memos describing my analysis of data tapes from E-516. Finally, I successfully fused Milind Purohit's event-generation Monte Carlo program from E-691 with the old tracking and reconstruction Monte

Carlo from E-516. Other people will want to do this in the future, so my notes should be useful.

I think that your summer student program is very worthwhile, and I urge you to continue it. I am sorry that I have no criticisms to help you improve the program, but I really cannot think of any.

Yours truly,
Jonathan Yedidia

P.S. After I gave you that problem about the statistical mechanics of hydrogen atoms in free space, I found it in a book called **Surprises in Theoretical Physics** by Peierels. He gives essentially the explanation that I gave you, and the exposition is very clear. It is in the chapter on statistical mechanics, under "ionization." You were right that the effect is important for astrophysics.

Dear Drasko,

As a summer intern in ten weeks time, I came to grow fond and familiar with my experimental group composed of ten or so senior members, grave and dependable; a number of young and industrious postdocs; a bunch of graduate students, working and worrisome; and a handful of fleeting summer students, professing ignorance and being obliging.

I found myself involved in an experiment which seemed of seriousness and important consequence; an inquest in need of long-term planning, testing, changing; an overriding presence in the mind presiding over the vicissitude of night and day.

Specifically, E-705 aims at detecting excited chi states and direct photons from the interaction between a $\pi^{\pm}$, p, $\bar{p}$ beam, and a beryllium target. My first task was to generate a list of wire connections to be made on the electronics portion of the cluster finder. The signal from each block of the 425 lead-glass block array is compared to the signal from its neighbor blocks. When the signal is larger than its neighbors, a hit is said to have occurred, and the energies from that cluster is summed to determine the energy of the particle which hit the glass.

My second project was to read through a Monte Carlo program which generated the background noise of the experiment. Subsequently, I was to use the information gathered from the Monte Carlo and say how often two or more photons from a π^0 background decay hit the same block of the lead-glass array, and to make up a relevant histogram and scatter plot. When two photons hit the same block, the detector will not distinguish the two photons separate from one another and a misleading energy will be read.

My recommendation to a student at Fermilab in your program is that he or she become involved and feel himself or herself to be a component of the large social network here, to be in a family which does not hold in common nationality, culture, geographic area, school alliance, age, and experience, but who come together with one goal--to do, understand, and discover physics.

I did not like very much to leave and would have liked to be a more lasting or serious member of the experiment. It is to your doing that I was given this introduction to an aspect of certain physicist's lives. My gratefulness.

Sincerely,

Mary Dung

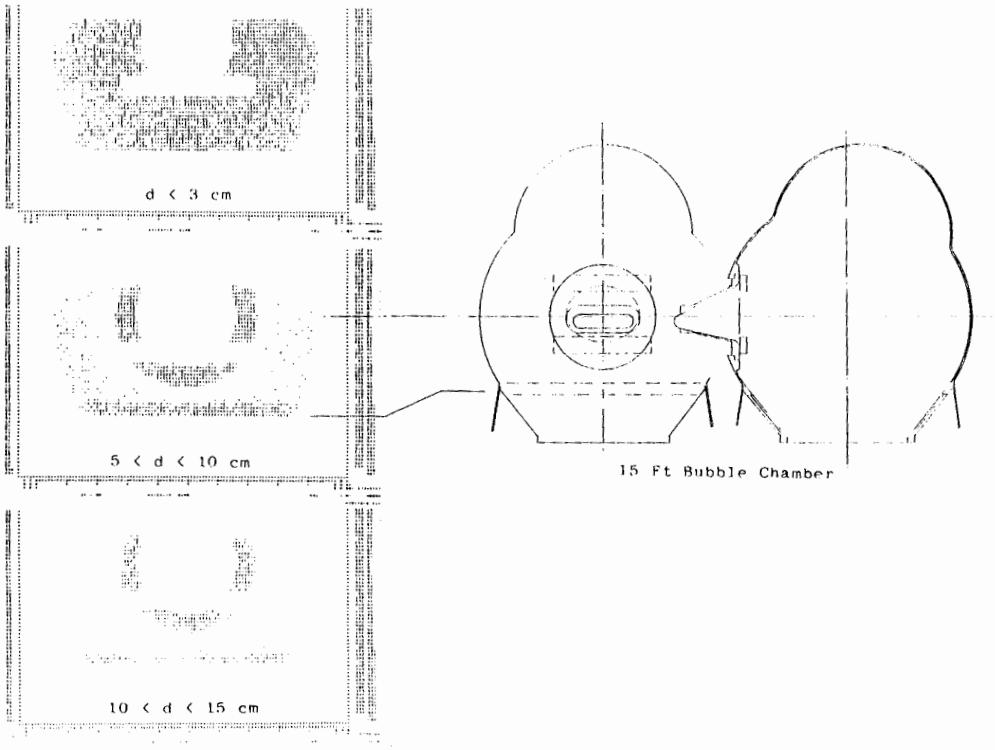
NEUTRINO TOMOGRAPHY

T. Kitagaki
Tohoku University

Fermilab E-545 is a neutrino experiment in the deuterium-filled 15-ft bubble chamber, carried out by groups from IIT, Maryland, Stony Brook, Tohoku, and Tufts. More than ten papers have been published on the neutrino deuterium reactions. Recently, we analyzed neutrino interactions that originated inside the iron wall of the bubble chamber. These so-called "wall-on" events are normally rejected from the measurements. The vertices of these events are not seen but their positions can be established from the observed parts of the secondary tracks. The spatial resolution of the vertex of this analysis is the order of several millimeters. In essence, it is possible to carry out neutrino tomography of the upstream structure of the bubble chamber in much the same way as x-ray tomography is done in medical applications.

The figure shows the spatial distribution of neutrino events near the iron structure of the 15-ft bubble chamber in three regions of depth (d) measured from the chamber wall surface along the beam direction. The top panel is for events near the inner surface of the wall, the middle panel is in a thick region of the nose-cone flange, and the lower panel is 10 to 15 cm upstream, at the thickest part of the flange. The panels are taken looking upstream. The central blank area in the event distributions corresponds to the nose cone and emulsion stack regions which were not used in these measurements.

These are beautiful pictures of tomography using neutrino beams, raising speculations for additional applications.



Neutrino Tomography

NOTES AND ANNOUNCEMENTS

FERMILAB REPORT EDITORS CHANGE. . .

F. T. Cole and Rene Donaldson, two of the editors of **Fermilab Report**, have both gone on leave of absence. Cole has gone to Argonne National Laboratory and Donaldson has gone to the SSC Central Design Group at Lawrence Berkeley Laboratory. Richard Fenner will join Lou Voyvodic as a new editor.

SUMMER HOUSING. . .

The Fermilab Housing Office is now making plans and taking reservations for summer accommodations. Since there is always an influx of experimenters during the summer months, the Office has established March 22 as the deadline for receipt of reservations for on-site housing.

An attempt will be made again this year to satisfy the annual summer housing crisis by a procedure of decision making based upon individual needs and optimization of the Laboratory program.

All requests should be in by March 22, and responses will be mailed out by April 12. Requests can be for any period in summer and need not commence May 27. People currently in Fermilab housing may request extensions into the summer but are reminded that current occupancy does not guarantee placement.

All persons using housing for summer will be asked to state that they will make steady use of housing for the period they request. If the space will not be used for some portion of the visit, Housing should be notified. In accord with the recommendations from the Users Executive Committee, a fee equal to two weeks rent will be charged to an individual or group if two weeks notice of cancellation or postponement is not given prior to the scheduled arrival.

Postponements are allowed on a one-time basis only, for a maximum period of two weeks. After that it may be necessary to reassign the accommodation.

Double occupancy will not be employed for dormitory rooms unless requested. The charge for the second person will be $4 per night.

Allocation Priority

1. Theorists - six houses or apartments and five dorm rooms.

2. Long-term commitments (foreign experimenters at Fermilab under official exchange agreement).

3. Running experiments

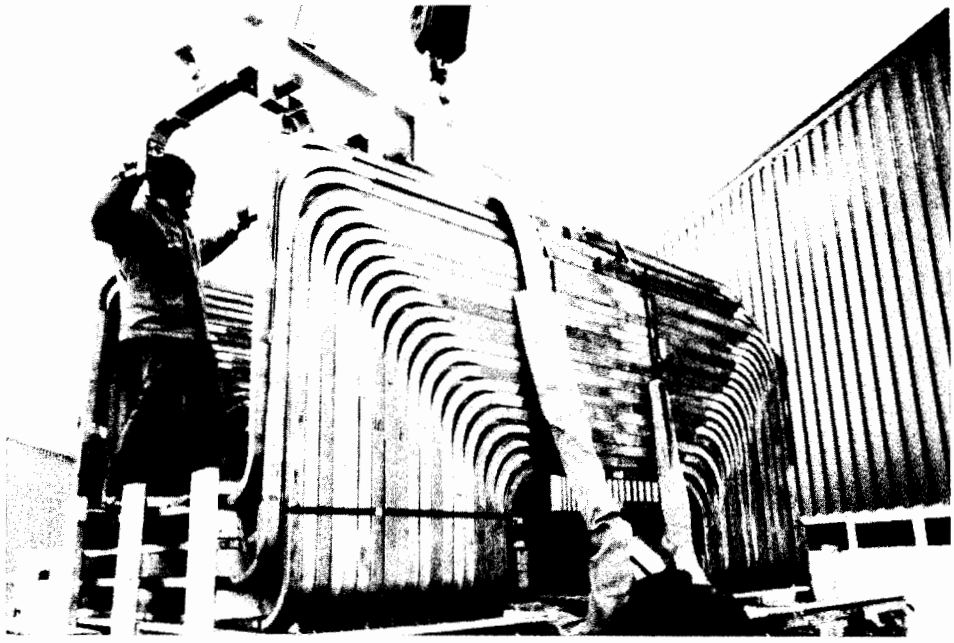
   (a) Families - at least one house or apartment per experiment in this category.

   (b) Individuals - at least one dormitory room per experiment in this category.

   (c) Remaining dormitory rooms, houses, and apartments will be assigned until as many requests as possible from persons in this category can be met.

The starting dates for summer occupancy will be staggered during the week of May 27. In the event that the on-site housing facilities are filled, the Housing Office will assist in finding off-site accommodations. For further information, contact the Housing Office, (312) 840-3777.

Welding on a single-phase assembly SSC prototype being constructed to study SSC magnet design concepts. (Fermilab photograph 84-1251-13)



Coils for two analyzing magnets to be used in the broad-band photo-beam experiment, E-687, are delivered to Industrial Building 2, where the magnets will be assembled this spring for a test run in May. (Fermilab photograph 85-2-13)

MANUSCRIPTS, NOTES, LECTURES, AND COLLOQUIA PREPARED
OR PRESENTED FROM FROM JANUARY 25, 1985 TO FEBRUARY 17, 1985

Copies of preprints with Fermilab publication numbers can be obtained from the Publications Office or Theoretical Physics Department, 3rd floor east, Wilson Hall. Copies of some articles listed are on the reference shelf in the Fermilab library.

Experimental Physics

D. A. Bauer et al. Experiment #673	Differences Between Proton π^- Induced Production of the Charmonium X States (Submitted to Phys. Rev. Lett.)
S. Y. Hsueh et al. Experiment #715	Measurement of the Electron Asymmetry in the Beta Decay of Polarized Σ^- Hyperons (FERMILAB-Pub-85/21-E; submitted to Phys. Rev. Lett.)

Theoretical Physics

S. Dawson et al.	Search for Supersymmetric Particles in Hadron-Hadron Collisions (FERMILAB-Pub-83/82-T-Revised; submitted to Phys. Rev. D)
K. Freese et al.	Covariant Functional Schroedinger Formalism and Application to the Hawking Effect (FERMILAB-Pub-84/100-T; submitted to Nucl. Phys. B)
D. Hochberg and H. B. Thacker	Finite Volume Effects on Spectrum Calculations: Monte Carlo Study of an Exactly Solvable Lattice Field Theory (FERMILAB-Pub-84/123-T; submitted to Nucl. Phys.)
W. A. Bardeen	The Photon Structure Function-Theory (FERMILAB-Conf-84/133-T; presented at the VIth International Workshop on Photon-Photon Collisions, Lake Tahoe, California, September 10-13, 1984)

Astrophysics

A. S. Szalay	Formation of Galaxies (FERMILAB-Conf-84/135-A; submitted to the Proceedings of the International Symposium on Phase Transitions in the Very Early Universe, University of Bielefeld, Bielefeld, West Germany, June 4-8, 1984)

Physics Notes

J. D. Cossairt et al.	Absorbed Dose Measurements at an 800 GeV Proton Accelerator; Comparison with Monte-Carlo Calculations (FN-414; submitted to Nucl. Instrum. Methods)
A. W. Kolb	A Chronology: VBA (ICFA) → SSC (US-DOE) (FN-415)

General

S. C. Loken and J. G. Morfín	A Fixed Target Facility at the SSC (FERMILAB-Conf-85/14; submitted to the 1984 Summer Study on the Design and Utilization of the Superconducting Super Collider, Snowmass, Colorado, June 23-July 13, 1984)
J. G. Morfín and J. F. Owens	Measuring Structure Functions at SSC Energies (FERMILAB-Conf-85/15; submitted to the 1984 Summer Study on the Design and Utilization of the Superconducting Super Collider, Snowmass, Colorado, June 23-July 13, 1984)

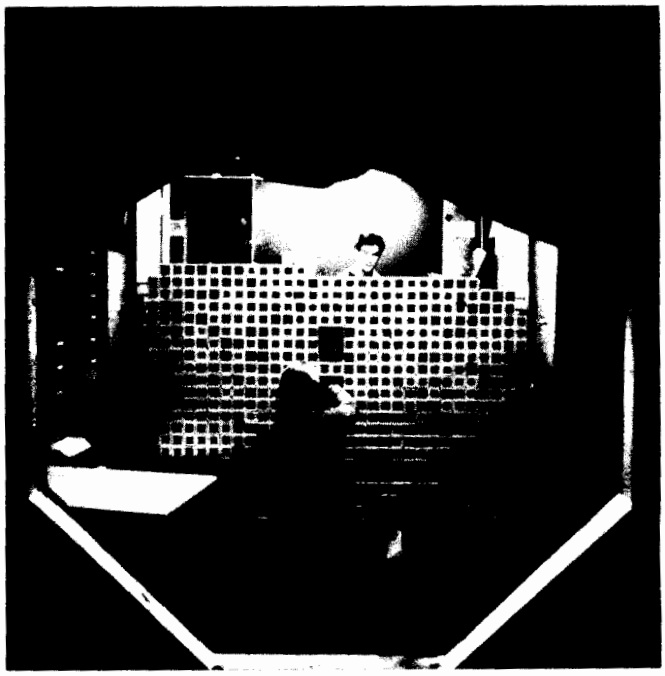
Colloquia, Lectures, and Seminars

D. Green	"Particle Physics Detectors" (Fermilab, January 21 and 23, 1985)
T. Toohig	"SSC Site Criteria and Site Selection Status" (Fermilab, January 22, 1985)
J. Lach	"Hyperon Physics (E-715)" (Fermilab, January 28, 1985)

L. Teng	"Report on Second Workshop on Laser Accelerlators" (Fermilab, January 29, 1985)
T. Kirk	"Charmonium Production (E-610/E-673)" (Fermilab, January 30, 1985)
C. Brown	"Dimuons & Upsilons (E-70/E-605)" (Fermilab, February 4, 1985)
R. Gerig and G. Dugan	"Recent Results from Machine Studies: I) Main Ring Operation; II) $\bar{p}$ Targetting" (Fermilab, February 5, 1985)
E. Fisk	"Neutrino Scattering (E-21/E-652)" (Fermilab, February 6, 1985)
J. Cumalat, Spokesperson	"Directors Review of E-687 - High Energy Photoproduction of States Containing Heavy Quarks and Other Rare Phenomena" (Fermilab, February 8, 1985)
M. Atac	"What's New in Chambers in Europe" (Fermilab, February 14, 1985)

DATES TO REMEMBER

March 15, 1985	Deadline (5 p.m.) for submission of material to be considered at the April PAC Meeting
March 28-30, 1985	Symposium on Anomalies, Geometry and Topology, Argonne National Laboratory and the University of Chicago. For further information contact Alan White, HEP 362, Argonne National Laboratory, Argonne, IL 60439, (312) 972-7381.
April 19-20, 1985	PAC Proposal Presentation Meeting
May 1-4, 1985	International Symposium on Particle Physics in the 1950s: Pions to Quarks, Fermi National Accelerator Laboratory. For more information, write L. Hoddeson, Fermilab, P. O. Box 500, Batavia, IL 60510.
June 15-21, 1985	Summer PAC Committee



Bruce Winstein (facing) of the University of Chicago aligns the lead-glass array for E-731 with his graduate student. The construction is currently underway in the Meson Center beam line. The experiment is scheduled to take data during the spring run. (Fermilab photograph 84-1275-3)