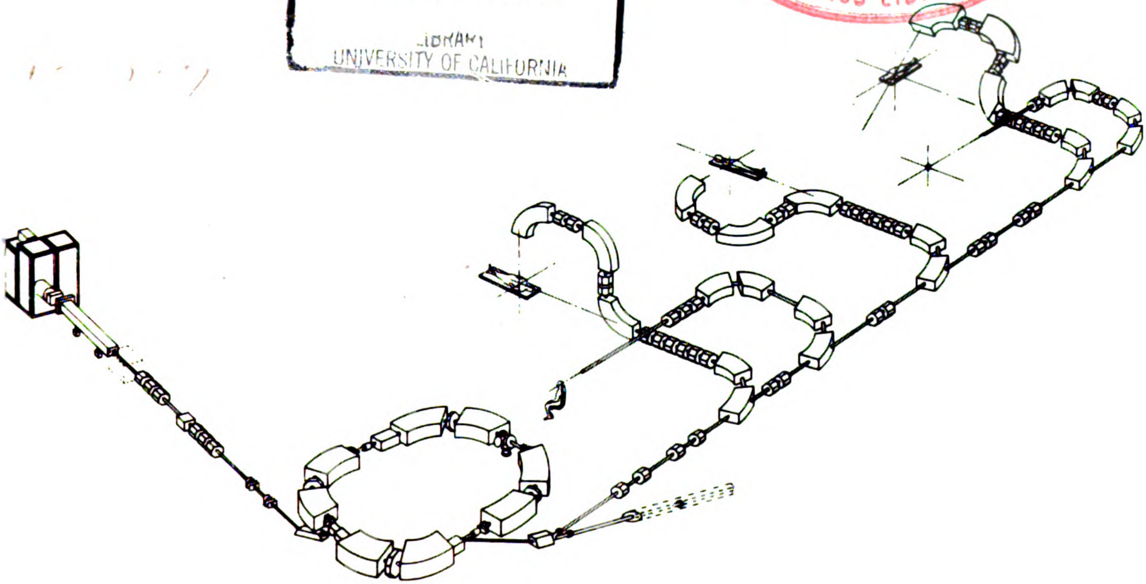
# fermilab report

Fermi National Accelerator Laboratory Monthly Report

July/August
1987





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**87/7** **Fermi National Accelerator Laboratory** **0090.01**

***On the cover:*** An isometric drawing of the Loma Linda Medical Accelerator. Last reported on in the July 1986 *Fermilab Report*, this "work for other" project undertaken by Fermilab for the Loma Linda Medical Center in Loma Linda, California, is nearing the prototype stage. An update on this new medical-accelerator technology appears on page 11. The isometric drawing, by Michael Notarus of the Fermilab Construction Engineering Services Section, shows the accelerator layout "in space," with all elements 1-to-1. Notarus is currently assigned to the Medical Accelerator Project as interface project coordinator.

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July/August 1987

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prepared or presented from July 1, 1987, to September 18, 1987:

**Manuscripts and Notes**

# Fermilab and Physics Education in Latin America

## Introduction

For the past half-dozen years, Fermilab has had a program of cooperation with Latin American physics institutions; this has the goal of assisting the growth of Latin American physics, and particularly (in keeping with Fermilab's mission), of stimulating the study of high-energy physics in the region. A summary of these activities has been given recently in an article in *Fermilab Report* (March/April 1987). Not covered there in any detail were activities in the field of physics teaching, mainly carried out by the Friends of Fermilab Association; this is the subject of the present article. - *Roy Rubinstein*

I.

# Fermilab Sponsors a Mini-Course in Mexico City on the Teaching of Modern Physics

*Stanka Jovanovic*

> We at Fermilab are much concerned about science education and about science in Latin American nations. We both share the common realization that science creates technology and that beneficial technology is the key to survival in the twenty-first century. . . It is tragic that so few of our young people are caught up in the excitement or the importance of science. . . We must do vastly better in reaching the young people: For their own future as workers in an ever escalating technological world, for their crucial role as citizens, and for those few - rare and blessed young people who, by the miracle of genius, will change the way we humans think. . .
>
> Leon M. Lederman
> Director, Fermilab

In the spirit of this message by Leon Lederman, the Mini-Course on the Teaching of Modern Physics was held in Mexico City on July 17 and 18, 1987. Sponsored by Fermilab, Friends of Fermilab Association (FFLA), Universidad Autonoma Metropolitana (UAM), and Instituto Nacional de Investigaciones Nucleares (ININ), and in conjunction with the Inter-American Conference - Networks in Physics Education (see the accompanying article, "High School Teachers at the Inter-American Conference"), the Mini-Course on Particle Physics, Relativity and Cosmology was conducted for 185 Mexican physics teachers. Participants came from over 20 institutions, high schools, universities, and research institutes in Mexico City and beyond. They listened to the lectures and related classroom demonstrations, and left with many materials to share with their students and other teachers.

The Mini-Course was modeled on the experience of the Summer Institute for Science Teachers (SIST) now in its fifth year at Fermilab. The two-hour lectures were designed for high-school and introductory college physics courses. Demonstrations designed by master high-school physics teachers and presented in two-hour sessions were closely related to the lecture material and could be easily reproduced in the classroom.

The Conference on the Teaching of Modern Physics (CTMP) held at Fermilab in April 1986 (see *Fermilab Report* April/May 1986), marked the beginning of Fermilab's effort to share physics education programs with our Latin American neighbors. Since that conference, the ten Latin American physics educators (see Appendix) translated and distributed conference materials and initiated programs in their respective countries.

The successful conduct of the Mini-Course is due in large part to the efforts of one of these colleagues, Jaime Klapp Escribano of UAM. At the request of Jorge Barojas Weber, Chairman of the Inter-American Conference Organizing Committee, and with the full support of ININ Director Ruben Bello, Jaime Klapp Escribano organized the Mini-Course. Over 400 brochures and posters were mailed to education institutions in Mexico. Two hundred and fifty applications were received and 185 of those responding were invited to participate. To assist the participants who were not fluent in English, the viewgraphs used by the lecturers were handed out before the presentations. In addition, two lectures from the CTMP proceedings, "Elementary Particle Physics: Discoveries, Insights, and Tools" by Chris Quigg and "Symmetry and Physics" by Christopher T. Hill, were translated into Spanish. The Spanish versions of Fermilab's big-bang poster and the particle chart have also been distributed. (These materials are available on request at no cost from FFLA).

ININ, located in the mountains 25 miles outside Mexico City, provided a beautiful setting for the first day of the program. For most of the participants this was their first visit to ININ, definitely an added bonus to the Mini-Course. Director Bello and his staff hosted a cookout at picnic grounds in the woods. Mexican food was at its best.

The second day of the program was held at the Museum of Technology in Mexico City. The museum's auditorium is equipped for simultaneous translation, and museum exhibits were open to the participants. Especially impressive was a room full of computers with continuous free classes for school children.

The purpose of the Mini-Course was two-fold. In addition to the three topics in modern physics, Fermilab's experiences with physics education programs were shared with the participants. Marjorie G. Bardeen, FFLA Program Director, described the successful Saturday Morning Physics program for high-school students, the Summer Institute for Science Teachers, and Physics West, a network of physics teachers that provides a continuous forum for teachers to share their classroom experiences.

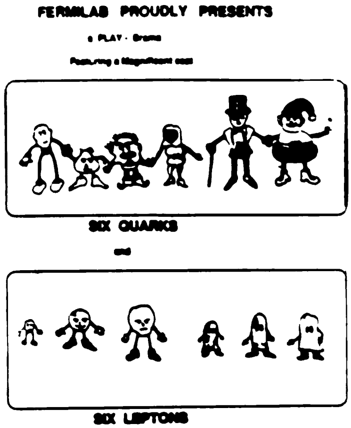


*Fig. 1. Quarks and leptons for high-school students as demonstrated by Drasko Jovanovic in his lecture to physics teachers at the Mexico City Mini-Course.*

The particle physics lecture by Drasko Jovanovic (Fermilab), which brought the Standard Model to the level of the high-school physics course, was delightfully illustrated (Fig. 1). The classroom demonstrations by Walter P. Schearer, a physics teacher from Glenbard North High School in Carol Stream, Illinois, showed the participants several ways to involve students in particle physics projects in the classroom as shown in Fig. 2.

In the table below supply the names of the mesons formed from each quark/antiquark combination.

MESON COMPOSITION

| | $\bar{u}$ | $\bar{d}$ | $\bar{c}$ | $\bar{s}$ | $\bar{t}$ | $\bar{b}$ |
|---|---|---|---|---|---|---|
| u | $\pi^0 \rho^0 \eta^0$ | | | | | |
| d | | $\pi^0 \rho^0 \eta^0$ | | | | |
| c | | | | | | |
| s | | | | | | |
| t | | | | | | |
| b | | | | | | |

MESON PROPERTIES

| Meson Name | Charge | Mass (MeV) | Strangeness | Charm | Beauty | Truth | Composition Quark Anti-quark |
|---|---|---|---|---|---|---|---|
| $\pi^0$ | 0 | 135 | 0 | 0 | 0 | 0 | |
| $\pi^-$ | -1 | 140 | 0 | 0 | 0 | 0 | |
| $\pi^+$ | 1 | 140 | 0 | 0 | 0 | 0 | |
| $\rho^0$ | 0 | 776 | 0 | 0 | 0 | 0 | |
| $\eta^0$ | 0 | 549 | 0 | 0 | 0 | 0 | |
| $K^0$ | 0 | 498 | 1 | 0 | 0 | 0 | |
| $\bar{K}^0$ | 0 | 498 | -1 | 0 | 0 | 0 | |
| $K^+$ | 1 | 494 | 1 | 0 | 0 | 0 | |
| $K^-$ | -1 | 494 | -1 | 0 | 0 | 0 | |
| $D^0$ | 0 | 1865 | 0 | 1 | 0 | 0 | |
| $\bar{D}^0$ | 0 | 1865 | 0 | -1 | 0 | 0 | |
| $D^+$ | 1 | 1869 | 0 | 1 | 0 | 0 | |
| $D^-$ | -1 | 1869 | 0 | -1 | 0 | 0 | |
| $F^+$ | 1 | 1971 | 1 | 1 | 0 | 0 | |
| $F^-$ | -1 | 1971 | -1 | -1 | 0 | 0 | |
| $J/\psi$ | 0 | 3097 | 0 | 0 | 0 | 0 | |
| $B^0$ | 0 | 5274 | 0 | 0 | 1 | 0 | |
| $\bar{B}^0$ | 0 | 5274 | 0 | 0 | -1 | 0 | |
| $B^+$ | 1 | 5271 | 0 | 0 | 1 | 0 | |
| $B^-$ | -1 | 5271 | 0 | 0 | -1 | 0 | |
| $\phi$ | 0 | 1020 | 0 | 0 | 0 | 0 | |
| $\Upsilon$ | 0 | 9460 | 0 | 0 | 0 | 0 | |

*Fig. 2. Meson composition and meson property chart.*

David N. Schramm (Fermilab and the University of Chicago), lectured on cosmology and how it relates to particle physics. The lecture followed the cosmology "fact list" (Fig. 3). As a special treat to all, in the second half of his lecture Schramm talked about the 1987a Supernova and the latest results from continuous world-wide observations.

**The Cosmology Fact List**

**THE UNIVERSE... HAS THREE DIMENSIONS AND TIME**
**IS BIG!**
**IS EXPANDING**
**WAS HOT AND DENSE**
**IS OLD**
**HAS MATTER IN IT**
**IS SMOOTH**
**IS BUMPY**

*Fig. 3.*

James A. Ruebush, a physics teacher from St. Charles High School in St. Charles, Illinois, demonstrated how to get students involved in cosmology experiments in the classroom. The basic concepts of very small to very large (Fig. 4) are developed through a sequence of experimental measurements the students can perform with available classroom materials. Hubble's law was demonstrated for the participants through the use of rubber tubing with several "galaxies" attached. The distances between galaxies were measured with a tape measure after each expansion of the Universe and the data was tabulated and plotted.

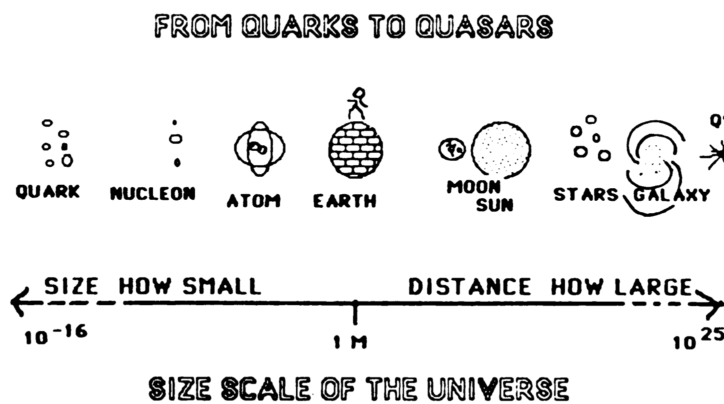


*Fig. 4. Very large and very small.*

The two lectures on general relativity were given in Spanish by Octavio Pimentel and Bogdand Mielnik of UAM. The animated lectures and the audience's obvious enjoyment indicated that the lectures were very well received.

The Mini-Course ended with a panel discussion on problems in physics education. The panelists (A. Sarmiento [UNAM], S. Galindo [ININ], and A. Garcia [CINVESTAV], Mexico; B. Hoeneisen, Equador, C. Ladera, Venezuela, and D. Jovanovic and W. Schearer, U.S.A.) recognized the universal problems and needs for science education. The Mini-Course was applauded as an effort in the right direction. The recommendation to publish the proceedings of the Mini-Course is now under consideration.

The Mini-Course was evaluated by the participants at the end of the program. The summary of the survey questionnaire is given in Fig. 5. The participants were asked to rate the survey questions on a scale of 1 to 10. The interest in the topics and the need to include them into existing curricula of high-school and introductory college physics courses received the highest rating.

Stanka Jovanovic of FFLA and Jamie Klapp Escribano were instrumental in planning and organizing the Mini-Course. The program was funded by Universities Research Association, Inc., and ININ.

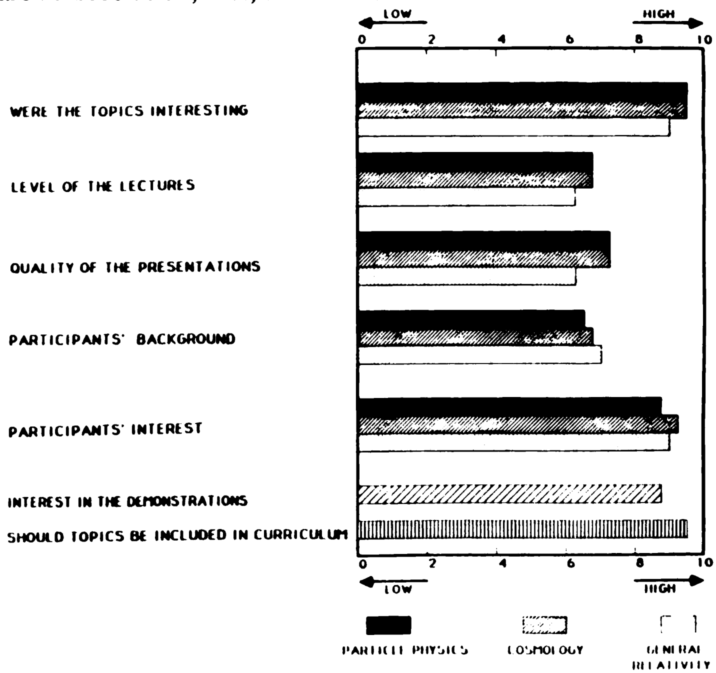


*Fig. 5. Evaluation of the Mini-Course.*

# II.

# A Participant's View of the Mini-Course in Mexico City

*Gerardo Moreno*

I was on vacation in Mexico City last July when I was told that Fermilab and two institutions from Mexico, Instituto Nacional de Investigaciones Nucleares and Universidad Autonoma Metropolitana, were organizing a Mini-Course on the Teaching of Modern Physics in the areas of general relativity, particle physics, and cosmology.

I decided to attend the Mini-Course because I thought it had something to do with the teaching of physics at a university or graduate-school level. I was surprised to find out later that the aim of the course was to encourage high-school teachers to teach "The New Physics" to young students! Unfortunately, there were just a few high-school teachers, but at least it made us aware of the lack of modern physics (the physics of the last 30 years) in most of the programs offered by Mexican universities.

*Drasko Jovanovic lectures on the Standard Model to Mexican teachers at the Mini-Course in Mexico City.* *(Photograph by Stanka Jovanovic)*

College students, graduate students, high-school teachers, college professors, and researchers were among the 185 participants, representing 20 institutions from five states. Most of them have a strong background in physics and have taught courses at different levels.

We were given lectures on how to explain the main ideas of physics at an elementary level. Drasko Jovanovic gave us a fantastic lecture on the Standard

Model. Walter Schearer presented a model of the scientific method applied to particle physics. Octavio Pimentel computed some effects of general relativity without using Einstein's equations and compared the results with experimental data. Bogdand Mielink talked about general relativity in science fiction and made up a story of his own. James Ruebush and Walter Schearer showed us how to measure large distances and presented a model of an expanding Universe that obeys Hubble's law (photograph, page 9). David Schramm discussed the up-to-now known facts about our Universe. We also had a lecture on the different programs for science teaching developed by Friends of Fermilab.

During the Mini-Course some of my friends and I discussed the idea of organizing something like the Summer Institute for Science Teachers that is held at Fermilab each year. One of the possibilities would be to bring three or five Mexican teachers to Fermilab next summer and have them take courses. After that they could organize in Mexico something similar to the course offered here, with Mexican teachers and staff. Doesn't it sound good?

---

*Gerardo Moreno is a graduate student at CINVESTAV, Mexico City. He is working toward his Ph.D. on Fermilab experiment 605.*

## III.

## High-School Teachers at the Inter-American Conference

*James A. Ruebush and Walter P. Schearer*

The Inter-American Conference on Physics Education - Networks in Physics Education convened in Oaxtepec, Mexico, during July 19-25, 1987. It brought together 200 people from 36 nations around the world. These people represented high schools, universities, research facilities, professional organizations, and government agencies in an attempt to establish networks for the improvement of physics education. On behalf of Fermilab and Friends of Fermilab, physics teachers Jim Ruebush of St. Charles High School, St. Charles, Illinois and Walt Schearer of Glenbard North High School, Carol Stream, Illinois, participated in the conference. They have both been involved with Fermilab educational programs since the inception of Friends of Fermilab in 1983. These programs have included the Summer Institute for Science Teachers, Physics West, the Conference on Teaching Modern Physics, held at Fermilab in April 1986, and the U.S. Department of Energy High School Honors Program.

*The expanding Universe as demonstrated by Walter Schearer (left) and James Ruebush.* *(Photograph by Saul Tellez Minor)*

At Oaxtepec, Jim Ruebush was a member of the working group on teaching modern physics. The group recommended that self-contained modules be developed for modern physics with each one containing information on background, an annotated bibliography, worksheets, suggested demonstration, audio-visual aids, lab kits, microcomputer simulations, questions, and problems. Also suggested was the creation of in-service training facilities and self-help sharing programs for high-school teachers. The group also felt that further conferences, workshops, and mini-courses similar to the Mini-Course described in section I. of this article would prove of value. Finally, the working group stressed the importance of developing effective networks of communication and the sharing of ideas.

Walt Schearer was a commentator for the working group on physics education at the secondary level. He presented a talk on the status and continuing education needs of high-school teachers. Included in the talk were examples of Fermilab programs which are helping to meet these continuing education needs. Among the recommendations of this working group was the creation of a Western Hemisphere clearing house to facilitate the exchange of journal articles, curriculum materials, etc. Also recommended was the involvement of high-school teachers in all aspects of network development as well as in the planning and delivery of continuing education.

During the conference, Ruebush and Schearer were part of a five-person team from the U.S.A. which presented a series of 14 physics demonstrations to a plenary session. These demonstrations emphasized that good physics could be enjoyed when presented with common, everyday items. All the demonstration materials had been gathered after arrival at Oaxtepec.

During the conference poster session, a presentation was made on three of the Friends of Fermilab programs that aid physics education: Saturday Morning Physics for high-school students, Summer Institute for Science Teachers, and Physics West for high-school and university teachers. Many individuals inquired about the Friends of Fermilab programs and expressed interest in the possibility of a similar association of education and research in their country. They were impressed by the dynamic programs in place through Fermilab and Friends of Fermilab. After sharing the value of the programs and having their questions answered, some wondered if they could be instrumental in starting programs themselves. These people were offered the assistance of Friends of Fermilab in their endeavors.

The conference provided the opportunity for various segments of the physics community to interact. Extensive interaction did occur, and participants did learn of Fermilab and Friends of Fermilab programs. Hopefully, similarly beneficial programs can be replicated in other areas of the Western Hemisphere.

## Appendix

*CTMP Latin American Participants*

Luis Humberto Canderle (Argentina), Luis L. Cantu (Mexico), Francisco Claro (Chile), Jeanette L. DeBascones (Venezuela), Jaime Klapp Escribano (Mexico), Julio Gratton (Argentina), Celso Luis Ladera (Venezuela), Eugenio Ley-Koo (Mexico), Saul Tellez Minor (Mexico), Piotr Trzesniak (Brazil).

# Progress on the Medical Accelerator

*F.T. Cole and P.V. Livdahl*

A little more than a year ago, we gave a first report on the Loma Linda Medical Accelerator in these hallowed pages. Since that time, the project has moved ahead in many ways. This report will cover these happenings and bring the reader up to date on the status of the medical accelerator.

Design work began officially in April 1986 (although there had been a little thinking about the project ahead of that time). In the 17 months since then, we have produced two design reports, a conceptual report in May 1986, and an engineering report in June of this year. The synchrotron ring (Fig. 1) has the unusual feature in modern terms of zero-gradient focusing. The eight dipole mag-

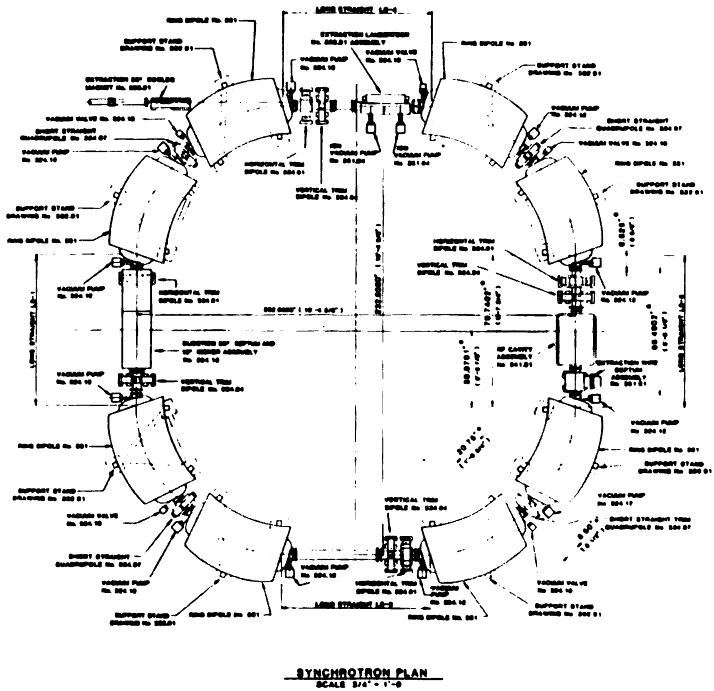


*Fig. 1. Current design of the synchrotron ring.*

nets of the ring have end packs of laminations machined to a triangular shape (looked at from above). Particle orbits enter and leave the field at an angle with respect to the perpendicular, so a particle on a slightly different orbit goes through a different length of field and is bent through a different angle.

The intensity goal of $1.5 \times 10^{11}$ seemed modest compared with the Fermilab Main Ring intensity of more than $10^{13}$ at first sight, but this is a small ring and the intensity goal is difficult to achieve, because of a combination of many-particle effects and the limited momentum acceptance of such a small ring. High dispersion is needed to suppress microwave instabilities and, as a consequence, the momentum acceptance of the ring is somewhat small. The rearrangement of injection now being worked out provides much better matching, both in transverse phase space and in dispersion, than the original design.

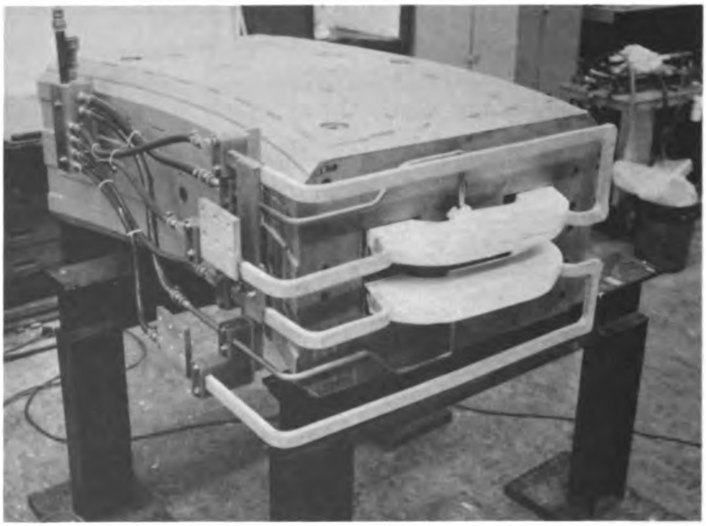

*Fig. 2. Prototype accelerator dipole magnet.* *(Fermilab photograph 87-3190-3)*

As part of the design effort, we have built and measured a prototype dipole magnet of the ring (Fig. 2). After a slight adjustment of the edge angle of the end packs, the magnet achieved the desired field within $\pm 2 \times 10^{-4}$. With the magnet performing satisfactorily and the design firmed up reasonably well, the Board of Trustees of Loma Linda University Medical Center approved the project in May of this year. We have now begun to build the production magnets for the ring. The cores and coils are built in the Conventional-Magnet Facility in Industrial Building II, while the end packs are being machined in the Village Machine Shop. We have also designed and ordered most of the other components of the accelerator. A number of Fermilab people have worked on the design of the special magnets for injection and extraction. An area in Industrial

Building I has been cleared. At present, power and water lines are being brought to the spot where the accelerator will be assembled, beginning in October. We plan to have the ring ready to accelerate beam by April of 1988.

The pacing item for the schedule has been the injector. At the beginning of the design effort, we considered an electrostatic generator to produce a beam of a few MeV for injection. But finally we decided on a 2-MeV radiofrequency quadrupole (RFQ) linear accelerator. The ACCSYS company of Pleasanton, California, is now building the RFQ and is scheduled to deliver it to Fermilab in February 1988. The radiofrequency amplifier system for the RFQ is being bid as a separate purchase. We are looking forward with great eagerness to seeing the accelerator whole and trying it out.

Loma Linda has contracted with Fermilab to design and build this first accelerator of a new technology, a synchrotron for medical use. We hope that there will be many more accelerators of this technology following on to treat patients, but once the technology is established, it would be inappropriate for Fermilab to build them in competition with private industry. Fermilab's role will end when the first synchrotron is operating and treating patients at Loma Linda. To carry on with the new technology, Loma Linda has chosen Science Applications International Corporation (SAIC) as an industrial participant to build and market later accelerators. They are now on board and working with us, as will be discussed below. It is interesting that the SAIC people involved in this work are in large part Fermilab recidivists.

The work in which SAIC is especially active is the design of the beam-delivery system. Loma Linda has chosen to build a major clinical facility, including provisions for bringing the beam to the patient from any direction, making it possible for the beam to miss healthy vital organs on the way to the disease site. To do this, the beam must be swung away from its axis by magnets, then brought back perpendicular to that axis, along which the patient is placed. The last 10 feet of travel before the beam gets to the patient must be left free for special medical equipment to shape and monitor the beam for each patient. When the space for the bending magnets to swing the beam is added, the entire assembly is more than 30 feet in diameter. What is more, it must be a rotating structure, a *gantry*. Three treatment rooms with gantries, plus a room with two fixed beams, are included in the design.

The rotating gantry structure, with its magnets and other equipment, weighs about 50 tons. In order to take full advantage of the localizability of dose possible with proton beams, a gantry must bring the beam to the patient within a position accuracy of one or two millimeters. The gantries are to be in rooms surrounded by several feet of dense shielding, so that they must be assembled to

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There are also special problems that come with the building site. The facility must work in harmony with the existing parts of the Loma Linda Medical Center Hospital, so the building design, which is being carried out by NBBJ, a Seattle-based architectural firm, is quite different from what it might be if the facility were being built in a pasture. Furthermore, the hospital is in California and there are tight strictures on design arising from the seismic code of the State. Our group is producing reams of drawings and calculations demonstrating the stability of the magnet and equipment support stands under severe stresses. All these must be approved by the State of California before building construction can begin.

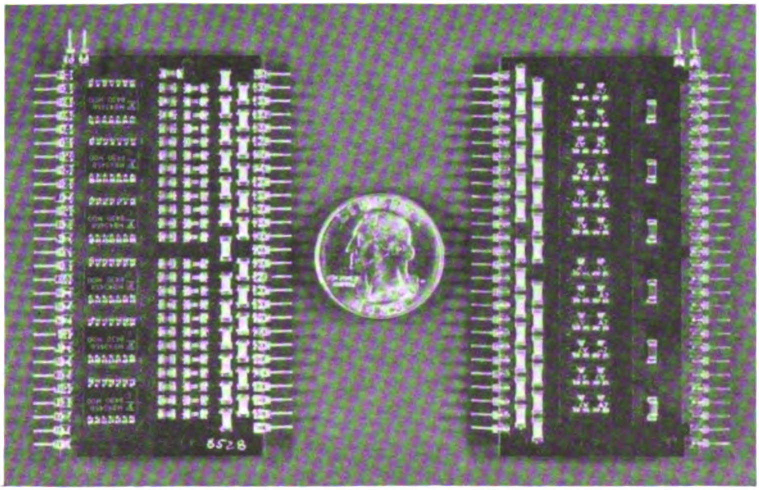
Thus, our status is that we are deep into the project, working hard on a number of different facets. In fact, the number and diversity of new considerations and issues is surprising to a group of people who have heretofore led a sheltered life in a large science laboratory. We are grinding our way through these issues and now can see our first goal, accelerated beam, in sight. The accelerator will then be busy with commissioning and experiments to study shielding, dosimetry, and radiobiology until the time in 1989 when the building is ready to receive it and it is taken to Loma Linda.

# Surface-Mount Technology Finds a Foothold at Fermilab

*Raymond J. Yarema*

Traditionally, printed circuits with leaded components and hybrid circuits have been the backbone of electronic circuit construction for high-energy physics (HEP). More recently, semicustom and custom integrated circuit (IC) design have become popular. SMT (surface-mount technology), however, now offers the electronics-design engineer another option for the fabrication of demanding circuits.

Many industries are implementing SMT designs to improve their products. To understand the advantages and problems associated with SMT, engineers and scientists at Fermilab have been exploring SMT by using it in their electronics designs for HEP.

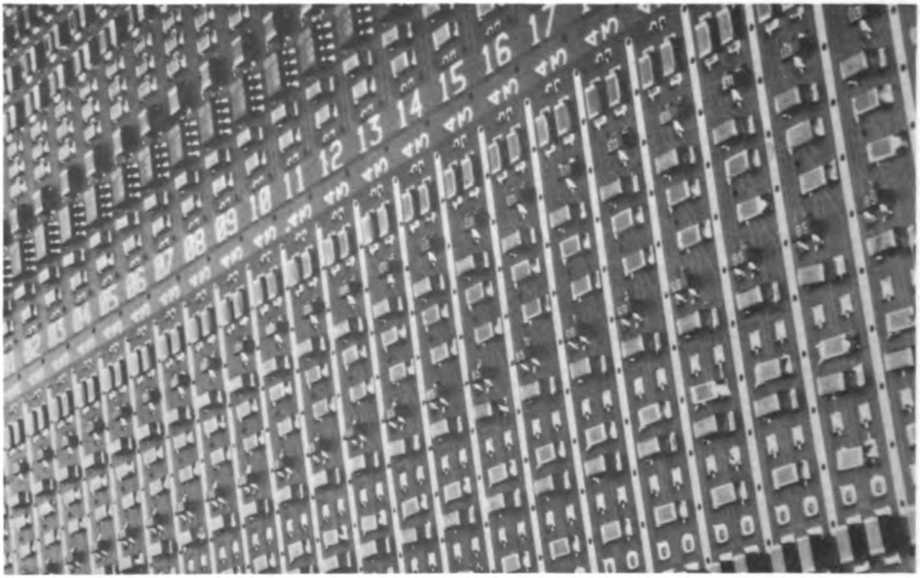


*Top and bottom views of a 24-channel pre-amplifier card.*

*(Fermilab photograph TN85-723-9)*

A surface-mount circuit is different from a conventional leaded component board because components are attached to the substrate without the aid of holes or feed-through mechanical hardware. Generally, the components are miniaturized and commonly attached to both sides of the substrate, as shown in the photograph above. A hybrid circuit is a type of surface-mount circuit. The difference is that a hybrid is usually assembled on an alumina substrate and has screened and fired resistors. A surface-mount circuit is usually assembled on FR-4 substrate and uses chip resistors.

Both analog and digital surface-mount circuit boards, ranging in size from a tiny 0.8 sq in. to a large 210 sq in., have been designed and installed at Fermilab. The board types include: 1) several different detector preamplifier boards, 2) a FADC differential line receiver, 3) a front-end input latch and readout shift register board, and 4) multichannel ASD (amplifier-shaper-discriminator) boards for four different detectors in the Collider Detector Facility at Fermilab. The photograph below shows a typical ASD board.



*A portion of a typical ASD circuit board with 2200 surface-mount components.*

*(Fermilab photograph 87-546CN)*

At the time the ASD's were manufactured, they were the largest known surface-mount board. Assembly of the ASD's was a challenge because of their size and density. Automated placement equipment was used to place all of the surface-mount components in about 20 minutes.

Surface-mount circuits have found a niche in the electronics industry because of several advantages over other fabrication technologies. Compared to leaded printed wire boards, surface-mount circuits are generally 40% to 60% smaller, have improved performance due to lower inductance and capacitance, and can be less expensive depending on choice of components. Surface-mount designs at Fermilab have been driven mainly by a need for the smaller electronics packages associated with large experiments.

Hybrids and surface-mount circuits have about the same circuit density. However, surface-mount circuits have a couple of advantages over hybrids. First, considerably larger circuits can be fabricated in surface mount because the substrate material is not as fragile as with hybrids. Second, circuits can be prototyped considerably faster as a surface-mount circuit than as a hybrid since, at Fermilab, hybrids are fabricated by outside vendors, and outside vendors usually take 8-10 weeks to build a circuit on an alumina substrate. If nothing else, a circuit can be prototyped in-house as a surface mount on FR-4 and then later fabricated on alumina substrate.

In most cases, SMT does not compete with custom or semicustom IC designs because extreme size reduction is often required with the custom designs. The advantage of surface mount over custom or semicustom integrated circuits, however, is primarily the lower cost for lower quantity production runs and shorter turn-around time for construction of prototype and production quantities.

A common misconception regarding surface mount is that getting started is expensive. Most universities and HEP laboratories can easily afford the space and cost of a surface-mount lab/assembly area. For under $5000 and in 100 sq ft, an individual can assemble prototype surface-mount circuits as well as repair surface-mount and hybrid circuits. The basic equipment required is minimal. Solder paste and a pneumatic solder dispenser such as the EFD model 1000DV are essential for application of solder to a substrate material. Several different types of equipment and techniques, including vapor phase, infra-red, special soldering irons, and hot air, are available to reflow the solder paste. The most versatile instrument is a HART200A hot-air repair tool. The temperature-controlled low-velocity air from the tool can be used to assemble surface-mount boards of almost any size and remove components from SM boards requiring repair. The HART was used to assemble a board 12 in. x 17 in. with 2200 SM parts. A small, hot-air pen, Weller model AG700, is useful for some types of repair but is not necessary. Board cleaning can be done in a vapor phase chamber such as the Multicore Solders Vaporette, but in most cases a spray cleaner such as Chemtronics Flux-Off is easier to use. A good stereo zoom microscope with 7 to 30X magnification is essential for inspection of solder joints. The only other necessary equipment is a set of non-magnetic tweezers for component placement.

The most common assembly problem with surface-mount circuits at Fermilab is open solder joints. Choice of a reliable assembly house can minimize the problem. For circuits assembled in-house, most faulty solder joints can be found by visual inspection under a microscope.

Once the circuits have been tested and installed, their reliability appears quite good. Component failures do not appear to be any more frequent than for devices which have leads.

The main difficulties experienced at Fermilab have been component availability of selected devices and a limited selection of qualified assembly houses. With proper attention, however, these problems become merely a nuisance.

As HEP experiments and accelerators grow in complexity and size, the need for smaller, improved circuits will continue to drive future electronic designs. While it is certainly true that custom IC's and hybrid circuits will play important roles, surface mount has taken a foothold at Fermilab and can be expected to take on added significance in the accelerators and experiments of the future.

# Fermilab Observes National Quality Month

*Mark Bodnarczuk*

> **QUALITY (kwŏl'e-tē) n.**
> *A systematic approach to the search for excellence. (Synonyms: productivity, cost reduction, schedule performance, sales, customer satisfaction, teamwork, the bottom line.)*

October is National Quality Month, and this year's theme is "Quality - The Competitive Advantage." In 1984, the American Society for Quality Control (ASQC) initiated the first national campaign designed to capture and direct the attention of business and industry to the strategic imperative of quality improvement. The intent of the campaign was to stimulate, support, and strenghten America's commitment to Quality. The campaign was launched with a Joint Resolution from Congress and a Proclamation by President Reagan naming October National Quality Month. In the proclamation, President Reagan stated that "...foreign competitors have gained ground by adopting a strategy first conceived and carried out in America - the relentless drive to offer high quality at affordable prices. National Quality Month offers a good occasion to rededicate ourselves to this winning strategy." Through focused activities implemented over the last four years, the campaign has sought to stimulate awareness of the importance of quality improvement as the best way to increase productivity and sustain long-term profitability.

Although Fermilab's goal of isolating the fundamental constituents of matter and the forces that interact between them is out of the mainstream concerns of the business world, the Director's Office is committed to assuring the quality of all that is done at the Laboratory. There are a number of ways to define "Quality Assurance" (QA) as is evident by the number of QA theoreticians and consultants in the marketplace today. One of the more notable of them, J. M. Juran, claims that quality means "fitness for use." He claims that all institutions (industrial companies, schools, hospitals, governments, and laboratories) are engaged in providing services to other human beings. The goods and services produced by these institutions must meet the needs of the individuals and corporate bodies that buy them. To the degree that a product or service fully meets the needs of the buyer, it is designated as "fit for use." To the degree that it is "fit for use," Juran claims it is a"quality" item or service. Another notable quality theoretician named Phil Crosby claims that a product is a quality product when it "conforms to specifications." In other words, if you send a job to the machine shop and specify that the tolerances must be plus or minus an eighth of an inch and it comes back with a measurement of plus or minus one inch, the product does not conform to the specifications of the purchase order, and this nonconformance is defined as a lack of quality.

Although Fermilab has always been committed to producing the highest quality physics data with the best possible physics tools and support systems, within the last year a more formalized QA program has been instituted on a Lab-wide scale. The Director's Office has developed and issued a QA program to all Division and Section Heads which defines the position of the Laboratory on matters of QA and establishes the structure and standards by which work done at Fermilab should proceed. Each Division and Section then is responsible to establish a QA program that conforms to the specifications from the Director's Office and is specially tailored to the needs of that particular Division or Section. Dick Lundy has nominated a QA Officer for each Division and Section to serve on the Fermilab Quality Assurance Committee (QAC). The QAC oversees the QA program for the entire Laboratory. The QA officers are Sam Baker (Safety Section), Don Beatty (Business Services), Mark Bodnarczuk, who is Chairman of the QAC and also represents the Research Division and Physics Section, John Crawford (Accelerator Division), Roger Dixon (Director's Office), Richard Fenner (Laboratory Services Section), Greg Kobliska (Technical Support), and Vic Kuchler (Construction Engineering).

A few of the initial goals of the QA program at Fermilab are to increase the awareness of all employees at the Laboratory about quality-related issues by encouraging them to reflect on how they do their jobs and ways to improve the quality of the work performed. Also, it is important to decrease the frequency of errors that cause a job to be done two or more times along with increased documentation about proper procedures for jobs. Quality and integrity in one's work along with doing the job right the first time are the responsibilty of each individual at the Laboratory.

According to one of the foremost quality theoreticians in Japan today, Genichi Taguchi, the cost of poor quality is not just the monetary loss incurred by the factory producing a defective product (say toasters), but the total loss is defined as "the losses a product imparts to *the society* from the time a product is shipped." In other words, a single defective toaster imparts a loss to the entire society in which it is produced. Initially, this may sound ridiculous, but imagine how many man-hours in salaries, etc., are lost in designing, building, packaging, shipping, displaying, buying, then returning a toaster that doesn't work properly. The cumulative effect of this type of "value loss" is staggering when multiplied by the total number of defective products produced annually in a given country. In a similar way at Fermilab, when an employee receives defective parts from a vendor or has to do a job two or more times in order to get it right, each of these things, when multiplied by over 2000 employees, has a significant cumulative effect on the entire Laboratory.

# Lab Notes

## New UEC Members and Officers. . .

Six new members joined the Fermilab Users Executive Committee (UEC) at its August 8th meeting. The Committee, a group of 12 physicists, manages the day-to-day business of the Fermilab Users Organization whose international membership numbers about 1400. The Organization was formed in 1967 to represent Fermilab's user community and to address matters of interest between users and management. The six newly elected UEC members are Marjorie Corcoran (Rice University), Eugene Engels, Jr., (University of Pittsburgh), Stephen Errede (University of Illinois), Arthur Garfinkel (Purdue University), Stephen Holmes (Fermilab), and James Siegrist (Lawrence Berkeley University). They join Rosanna Cester (Instituto di Fisica, Torino), Thomas Ferbel (University of Rochester), Hugh Montgomery (Fermilab), Anna Jean Slaughter (Yale University), and Bruce Winstein (University of Chicago).

*Phyllis Hale of the Fermilab Users Office (back row, center), with this year's members of the UEC. Seated (left to right) are M. Franklin, T. Ferbel, S. Holmes (Secretary), A. J. Slaughter (Chair), H. Montgomery, and M. Corcoran. Standing (left to right) are E. Engels, Jr., R. Cester, J. Siegrist, A. Garfinkel, S. Errede, and B. Winstein.* ***(Fermilab photograph 87-510-1)***

Other business of the August meeting of the Committee addressed the election of a new chairman and secretary. Selected by an overwhelming majority were Anna Jean Slaughter as Chair and Stephen Holmes as Secretary to replace Thomas Ferbel and Hugh Montgomery, respectively.

The UEC meets bimonthly; correspondence to the Committee should be addressed to the Users Office, MS 103. *- Phyllis Hale*

## Information Management System for Research Division Operators. . .

Fermilab is currently exploiting both upgraded and new fixed-target beamlines and detectors designed for 1-TeV operation. This includes the world's highest energy photon, muon, pion, and polarized proton beams. In total, the present fixed-target physics run involves 14 high-energy particle beamlines and 16 experiments. But this proliferation of beams, experiments, and experimental users has presented a formidable problem in operating and servicing the beamlines and attending to the needs of the users. This is the responsibility of the Research Division Operations Group at Fermilab. The Operations Group monitors cooling systems, enclosure interlocks, safety systems - both radiation and conventional - power supplies, instrumentation, and control systems, as well as tuning the primary (and sometimes secondary) beams to all experimental areas. Needless to say, tremendous amounts of data are transmitted and received through the Central Operations Center each second.

In the past, the Operations Group used a handwritten logbook to record all problems and pertinent information. As the transport system expanded and became more complicated, this method proved to be cumbersome and inefficient. Information was easily lost and it was time consuming to research problems that were more than a few hours old. It became apparent that a computerized Information Management System was needed.

The idea was to develop a system tailored to Operations needs encompassing the crew chief's logbook and other beamline documentation. Three operators, Jack Schmidt, Roger Zimmermann, and Mike Vraniak, were assigned to the project. Their first objective was to set about listing the requirements for such a system. The list included the ability to make daily log entries, display current memos, update phone numbers and lists, capability of searching through past log entries for problem tracking, easily definable keys to accommodate growth, accessibility from the central computer cluster, and automatic hardcopy generation of logged entries at end of shift. After researching various methods of implementing this system, such as commercially available database software, Fermilab-developed software, etc., it was determined that customized software was required.

After exploring the different programming languages and hardware available, the operators decided to write the "electronic" logbook in TPU - a programmable editor provided by DEC - and to run the logbook on a Microvax II. Special features of the system include: examination of current shift entries by experimenters and supervisors, quick access to pertinent memos and lists, multiple windowing to allow the operator to examine memos while making log entries, and the ability to examine previous shift records.

Although the idea of a logbook written in an editor met with some initial skepticism, the electronic logbook has proven to be very reliable. The software was implemented during the 1987 fixed-target physics run with great success, and additional software will be available for use by experimenters during the 1988 fixed-target physics run. - *Jack Schmidt*

## The Joint University-Fermilab Doctoral Program in Accelerator Physics. . .

Michael J. Syphers of the Fermilab Accelerator Division has become the first recipient of a doctorate in accelerator physics under the auspices of the Joint University-Fermilab Doctoral Program in Accelerator Physics. Syphers, a Fermilab employee and the first person to apply and be accepted for the program, earned his Ph.D. from the University of Illinois at Chicago while serving as project manager for the new 8-GeV Booster Line; the title of his thesis was "An Improved 8 GeV Beam Transport System for the Fermi National Acclerator Laboratory" (also published as Fermilab TM-1456).

With Don Edwards of the Accelerator Division Headquarters staff as his thesis advisor, Syphers, in the space of two years, oversaw the design, construction, commissioning, and analysis of the 8-GeV line while doing both course and thesis work.

Initiated in 1985 by Director Leon Lederman, the motivation for the Joint University-Fermilab Doctoral Program in Accelerator Physics is the current shortage of accelerator physicists. Colleagues in nuclear physics and materials science need, as high-priority facilities, large high-energy accelerators; examples are the 4-GeV CEBAF electron accelerator and a 6-GeV synchrotron light source. There are also plans for medical accelerators, kaon factories, other synchrotron light sources, all in addition to the demands of the HEP field for new accelerators and for upgrades of existing facilities. The output of accelerator physicists from the few university Ph.D. programs that do exist is deemed insufficient to meet the anticipated needs.

In order to help alleviate the problem, the joint program was set up. Students from a university who wish to join the program are expected to have passed all their graduate physics qualifying exams and be ready to choose a thesis topic. They arrange for a sponsor in their Physics Department (usually a member of the high-energy physics group) who is Fermilab's contact with the university while the student is carrying out thesis research at Fermilab. The program is administered by Roy Rubinstein of the Director's Office. A committee of senior Fermilab staff consisting of James Bjorken, Don Edwards, Leon Lederman, Fred Mills, Lee Teng, and Alvin Tollestrup, interviews candidates, approves thesis topics, and assures the university of the student's progress. A Fermilab staff member (approved by both the committee and the university) is the student's supervisor during the thesis research here. Thesis problems can be in either theoretical or experimental accelerator work. At the conclusion of the research, the student will be awarded a Ph.D. by the university following its normal practice of thesis defense, etc. Students receive free housing at Fermilab and the same stipend as they would receive at their university.

Fermilab currently has seven students in the program. They are Enrique Henestroza (MIT), Lia Merminga (Michigan), John Palkovic (Wisconsin), Steve Stahl (Northwestern), Xia-Qing Wang (IIT), and Peilei Zhang (Houston).

## The Sixth Annual US Particle Accelerator School. . .

The 1987 US Particle Accelerator School was held at Fermilab from July 20 to August 14, 1987. After six years of operation with two-week summer schools, this year's school was expanded to four weeks. There were two sessions, each of two-week duration, with Session I devoted entirely to three courses given university-style in order to allow courses to be presented in greater depth, to promote student-teacher interaction and feedback, and to encourage the attendance of young people. These courses, each including 25 hours of lectures, problem-solving, recitation periods, and a final examination, were offered by the University of Chicago; 65 of the 101 students registered for Session I will each each receive a university course credit, equivalent to a 3-1/2 semester-hour course.

Session II had about 180 participants and consisted of a series of short courses. There were a total of 28 lectures, including courses on a wide range of subjects in the physics and technology of particle accelerators, reflecting the rapid growth in accelerator-based scientific research, such as high-energy physics, nuclear physics, materials science, and the ever-widening range of applications in industry, medicine, defense, and energy science. In addition, there was a general-interest symposium session on "Big Science" and the presentation ceremony for the 1987 Prizes for Achievement in Accelerator Physics and Technology, an annual award of the US Particle Accelerator School initiated in 1985. This year, prizes were awarded to Klaus Halbach, a research scientist at the Lawrence Berkeley Laboratory of the University of California, and Lars Thorndahl, a research engineer at CERN.

Klaus Halbach was honored "for making high-field permanent magnets practical tools for accelerator technology." He has pioneered the use of modern permanent magnets in particle accelerators and has had a dramatic impact on research with synchrotron radiation and on free-electron laser projects around the world.

Lars Thorndahl was cited "for essential theoretical and experimental contributions to the stochastic cooling of particle beams." His inventiveness, physical insight, and technological expertise have made possible the development of stochastic cooling systems. This work has had a revolutionary impact on elementary particle physics by opening the door to the accumulation of antiproton beams and the proton-antiproton colliding-beam experiments at CERN in the early 1980s and more recently at Fermilab.

Winners of the Accelerator School prizes are chosen on a competitive basis. The 1987 Prize Committee consisted of Helen Edwards, Edward Knapp, Claudio Pellegrini, and Gustav-Adolf Voss. This year's awards were supported by Universities Research Association, Inc., the Continuous Electron Beam Accelerator Facility, the Houston Area Research Center, Varian, Inc., and Westinghouse Electric Co.

Mel Month, Director of the US Particle Accelerator School, said recently, "The school attracts scientists and students in physics, engineering, and related disciplines from all over the world. Basic and advanced courses on the theory and operation of particle accelerators are offered to those who attend. Accelerator science has become a specialty in the discipline of physics as advances in electronics, cryogenics, and other technologies require more and higher education from those who conceive, design, and operate particle accelerators. One of the most important uses of accelerators is to produce beams of subatomic particles which are used as probes to study the most basic properties of matter."

The US Particle Accelerator School is held annually and is sponsored by the U.S. Department of Energy, the National Science Foundation, and major high-energy physics laboratories.

*- S. Winchester*

## *Manuscripts, Notes, Colloquia, Lectures, and Seminars*

prepared or presented from July 1, 1987, to September 18, 1987. 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.

# Manuscripts and Notes

### Experimental Physics Results

J.E. Filaseta
Experiment #400

Hadroproduction of $\Lambda_c \rightarrow pK\pi$ (Ph.D Thesis, University of Illinois, Champaign-Urbana, Illinois, 1987)

M. Bertani et al.
Experiment #710

Small t Physics at the TEVATRON Collider (FERMILAB-Conf-87/109-E; invited talk presented at "Workshop: From Colliders to Super Colliders," University of Wisconsin, Madison, Wisconsin, May 11-22, 1987)

R. Raja
Experiment #740

Physics at $\sqrt{(s)}$ = 2 TeV; An Experimentalist's Perspective (FERMILAB-Pub-87/125-E; based on lectures delivered at the 2nd School of Particle Physics, Cuernevaca, Mexico, December 4-12, 1986)

### Accelerator Physics

D.F. Anderson

Some New Ideas in Liquid Detectors (FERMILAB-Pub-87/127; presented at the London Conference on Position-Sensitive Detectors, University College London, London, England, September 7-11, 1987. To be submitted to Nucl. Instrum. Methods A)

C. Ankenbrandt and
S.D. Holmes

Limits on the Transverse Phase Space Density in the Fermilab Booster (TM-

1471; submitted to the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)

N.H. Engler et al. — SSC Dipole Magnet Model Construction Experience (to appear in the Proceedings of the 1987 Cryogenic Engineering Conference/International Cryogenic Materials Conference, St. Charles, Illinois, June 14-18, 1987)

M. Kuchnir and F. Markley — Simple Instrumentation for Testing of Ceramic Superconductors (TM-1464; presented post-deadline at the 1987 Cryogenic Engineering Conference/International Cryogenic Materials Conference, St. Charles, Illinois, June 14-18, 1987)

E.T. Larson et al. — Improved Design for a SSC Coil Assembly Suspension Connection (to appear in the Proceedings of the 1987 Cryogenic Engineering Conference/International Cryogenic Materials Conference, St. Charles, Illinois, June 14-18, 1987)

W. Merz et al. — Transition Jump System for the Fermilab Booster (TM-1473; presented at the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)

K.Y. Ng — Distortion Functions (FN-455; lecture given at KEK Oho '87 High Energy Accelerator Seminars, Tsukuba, Japan, August 17-21, 1987)

T.H. Nicol et al. — SSC Magnet Cryostat Suspension System Design (to appear in the Proceedings of the 1987 Cryogenic Engineering Conference/International Cryogenic Materials Conference, St. Charles, Illinois, June 14-18, 1987)

S. Stahl and C. Ankenbrandt — Simulation of the Capture Process in the Fermilab Booster (TM-1472; presented at the 12th Particle Accelerator Conference, Washington, D.C., March 16-19, 1987)