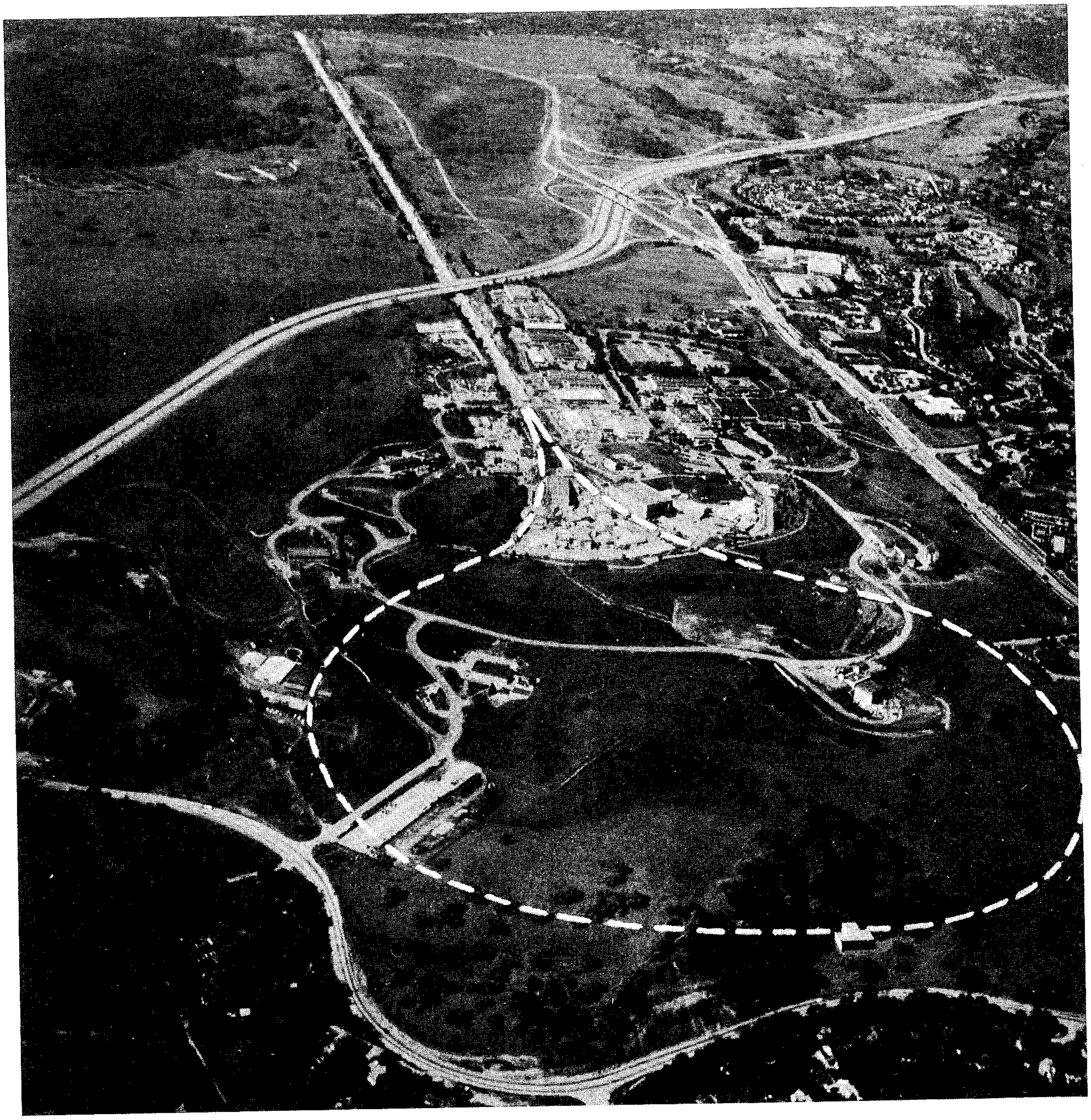
SLAC BEAM LINE

Where there is matter, there is geometry.
—*Johannes Kepler*

Volume 12, Numbers 3 & 4 *March-April 1981*



The cover photo shows how the proposed SLAC Linear Collider (SLC) would fit onto the SLAC site. The SLC project was the subject of a recent Workshop held on the Stanford campus. See pages 3-6 of this issue for a report on the Workshop and its participants.

In This Issue

SSRL REPORT

EXAFS STUDIES OF COAL

Coal is the major natural energy resource in the United States. Approximately 85% of our domestic fossil fuel energy reserves are in the form of coal. The use of coal is increasing now and is expected to continue to do so into the foreseeable future. The ways in which coal will be used will extend beyond simple combustion for steam generation into the areas of transportation fuels, chemical raw materials, and synthetic natural gas. Some of the energy-use forecasts call for coal utilization to almost triple by the year 1995.

The useful part of the coal "rock" is the carbon-hydrogen matrix. Unfortunately, coal also contains heteroatom species such as sulfur, nitrogen and oxygen, and these can both consume hydrogen during a coal-liquefaction process and also give rise to pollutants in a combustion process. Mixed in with the hydrocarbon matrix there is typically about 15% by weight mineral matter. These minerals are generally unwanted. They are a burden to transport, and their removal during conversion processes such as gasification or liquefaction is a continuing technological and engineering problem. In addition to the heteratoms in the organic matrix and the elements found in the major minerals, coal contains at the trace level virtually all of the other elements found in the Periodic Table. Even at trace levels, considerable quantities of these elements must be processed in a modern coal conversion plant. For example, a 60,000 barrel/day liquefaction plant would use about 30,000 tons/day of coal, and so must process economically and in an environmentally acceptable manner about 3 tons/day of a trace element that is present in a concentration of 100 parts per million.

Trace elements can occur in the mineral fraction of coal, either as small amounts of pure minerals or as replacement atoms in major mineral lattices. They could also occur as organmetallic compounds. However, because of the complex nature of coal and the lack of a suitable conventional, analytical probe, there has been considerable uncertainty concerning the chemical and structural environments of trace elements in coal.

A successful determination of the nature of trace elements in coal has recently been made at SSRL by a collaboration of scientists from the General Electric Co. Research & Development Center in Schenectedy, NY and the Boeing Co. in Seattle, Washington. In this investigation, we take advantage of the unique atom-selectivity of the x-ray absorption technique and utilize both the high-resolution near-edge K spectra and the extended x-ray absorption fine structure (EXAFS), using the intense synchrotron radiation from SPEAR as an x-ray source to probe the local atomic structure of vanadium, which is a troublesome trace metal found in coal as well as in liquid fossil fuels. In even minute concentrations (as little as 100 parts per million), vanadium can cause serious hot-corrosion problems with steam boiler pipes, combustion turbine airfoils, and other components contacted by hot gases containing the metal. Over the years, various fuel pre-treatment procedures have been developed to minimize the corrosive effects of vanadium in fuel oils. However, no treatment procedures have been developed for coal-derived liquids. As a result, questions as to where vanadium and the many other impurities are located, and how they are bound chemically in the coal structure, have largely gone unanswered.

Aided by a parallel study of selected vanadium model compounds, it was found that vanadium exists in at least two environments: a trivalent site 6-fold coordinated by oxygens at a distance of about 2.0 angstroms; and a tetravalent 5- or 6-fold coordinated also by oxygens, one of which forms a short V=O bond at about 1.6 angstroms. No evidence of nitrogen (porphyrin) or sulfide environment was found. It was also found that the vanadium environments in the raw coal did not survive unchanged in a liquefaction process.

These findings provide for the first time the much-needed basic knowledge for coal cleaning processes and for understanding trace element release into liquefaction process streams. Moreover, they demonstrate the need for a stable, high-flux <u>dedicated</u> x-ray beam for measurements in dilute systems such as trace vanadium in coal. We are waiting impatiently for our next beam-time allocation to continue the work on this important source of energy.

—Joe Wong
General Electric Co.

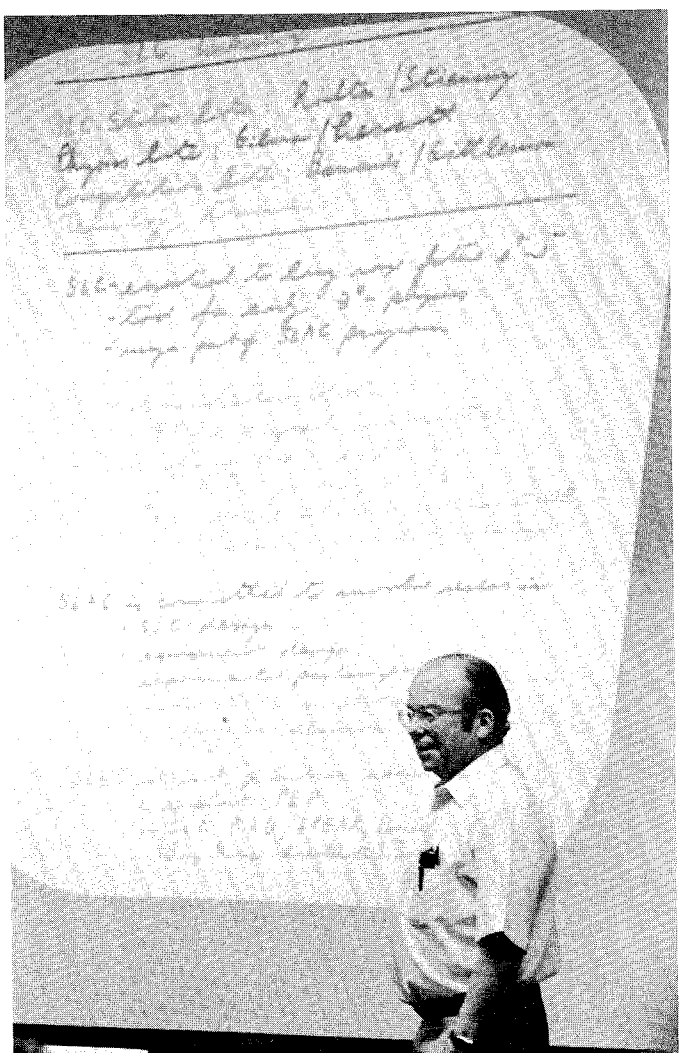
JOGGERS TAKE NOTE

Construction of the Damping Ring Vault, an underground adjunct to the accelerator housing just to the south of Sector 1 of the linac, is now scheduled to begin about May 15. (The Damping Ring is a part of a project now underway to improve linac performance, both in its own right and for the Linear Collider program.) As of that date, this region will be designated a Construction Area, and the road next to the linac on the south side of Sector 1 will be closed both to vehicles and to pedestrian traffic. Joggers should take note that from about May 15 until further notice, they will no longer be able to make a complete circuit around the Klystron Gallery. We'll report again when this construction work is near completion.

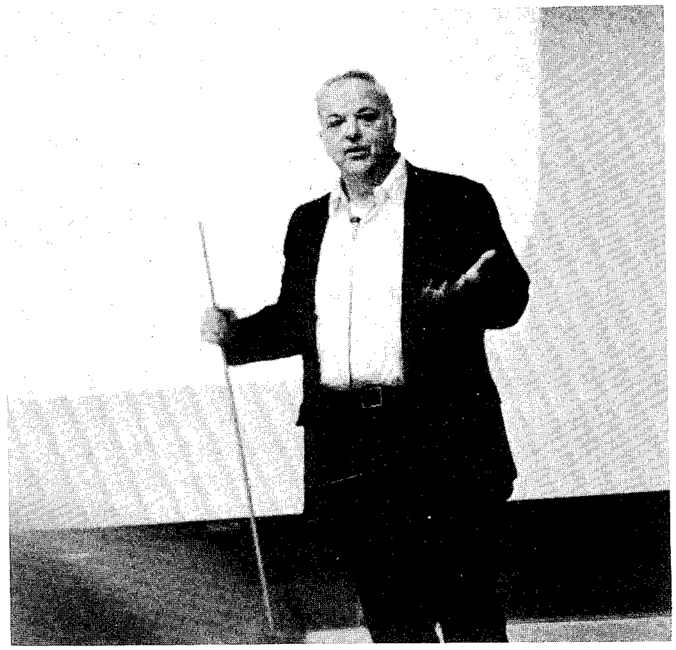
SLAC LINEAR COLLIDER WORKSHOP

On March 25-27, a group of about 250 physicists gathered at Stanford University to participate in a Workshop on the SLAC Linear Collider (SLC), a new kind of high-energy machine that has been proposed for construction at SLAC. The particle-physics community was broadly represented at the Workshop, with about 80 SLAC participants, 150 from other US institutions, and 20 from foreign nations. David Leith of SLAC organized the meeting, which was jointly sponsored by SLAC and by the SLAC-LBL Users Organization.

This SLC Workshop had several purposes. The first was to provide detailed descriptions of the present plans for the Linear Collider itself, of the R&D program that SLAC has undertaken to resolve the remaining issues in machine design, and of the important experimental research opportunities that the SLC will provide. The second purpose was to encourage the formation of a number of specific working groups who will begin immediately to study the challenges and opportunities offered by the Collider's physics environment and its prospective research program.



Pief outlines the SLC Workshop agenda.



Burt Richter discusses SLC luminosity.

Organizing The Work

SLAC Director Wolfgang Panofsky began the meeting by discussing how the SLC is to be built, and how it will be operated for physics research with a large number of potential users. The machine itself will be built within the SLAC laboratory, an arrangement that seems suited to the relatively modest scope of the project. Individual physicists from the general community are encouraged to work on the many important problems of machine design and eventual experimental use, and many are already doing so. The lab expects that experimental physics collaborations will evolve naturally as this work progresses, in a pattern similar to that followed in the Fermilab and CERN proton-antiproton projects. It was suggested that an "anti-deadline" be set, before which no decisions on the experimental program would be made (although proposals can of course be submitted at any time). If the SLC project is authorized for construction beginning in Fiscal Year 1983, as presently requested, then its three-year construction schedule would have it ready for first operation in late 1985.

Rationale For The SLC

Burton Richter of SLAC then reviewed the development of electron-positron storage rings during the past two decades, and the remarkable succession of physics discoveries that such machines have made possible. These machines have grown from less than a meter to about 400 meters in radius, and the LEP storage ring now being planned at the CERN laboratory will be about 10 times larger. It seems likely, however, that the LEP machine will be the largest electron-positron storage ring ever built. This is because the cost of such storage rings scales approximately as the square of the maximum energy. Thus a storage ring designed to collide 350 GeV electrons with 350 GeV positrons, for example, would have to have a circumference of about 300 kilometers and would cost on the order of 7 billion dollars.

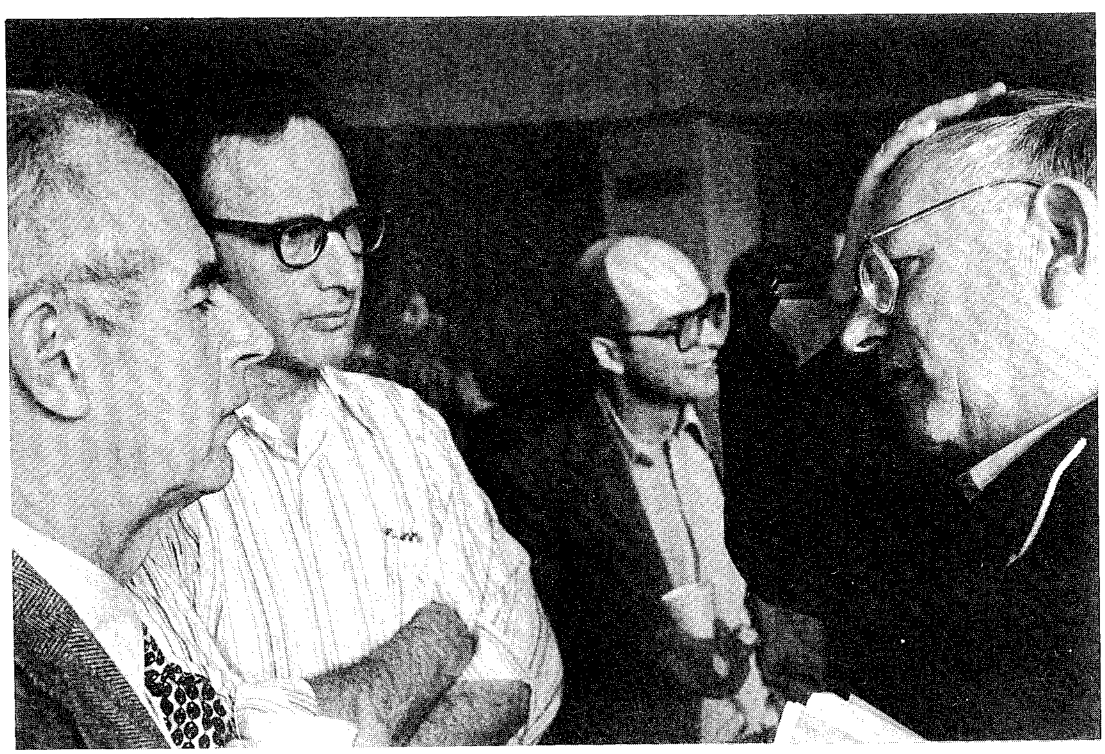
This is to be contrasted with the new class of electron-positron colliding-beam machines called "linear colliders," in which intense bunches of electrons and positrons are made to collide with each other only once, and are then disposed of. Although this would be an expensive was to produce colliding beams at low energies, the cost of such machines increases only linearly with increasing energy. At some point, therefore, the cost curves of the two kinds of machines must cross over, and linear colliders will become the preferred machines for producing very high energy electron-positron collisions.

We are now at the threshold of this crossover point, and the motivation for building the SLAC Linear Collider is thus twofold. First, the SLC will be the pioneer machine for developing the many new accelerator techniques that the new era of linear colliders will require. Second, the SLC will provide an early and relatively inexpensive means for reaching the very important energy region around collision energies of 100 GeV, where fundamentally new physics processes are expected to make their appearance.

Technical Challenges

Successful design and operation of the SLC presents many technical challenges which were described by Rae Stiening of SLAC. An intense, polarized electron beam must be produced; a laser-pumped photoemission electron gun is being developed for this purpose. The required positron beam will be produced from a special target, followed by a booster and transport system. Damping rings and compressors will be used partway down the linac to achieve the desired beam characteristics. The injected beams must be carefully centered on the linac axis, thus requiring new beam-monitoring and feedback devices. Acceleration of the beams to energies of 50 GeV or more requires the "SLED II" mode of SLAC linac operation, which involves RF storage cavities and modified operation of the high-power klystrons. The accelerated electron and positron beams must then be split apart and guided around two gently curving arcs to final focusing sections that bring the two beams into collision with each other.

The very small size of the beams allows the use of small magnets in the arcs and final focus



Left to right:

Guy Von Dardel
Lund, Sweden

Herb Steiner
LBL

Jim Pilcher
Univ. of Chicago

Mervyn Hine
CERN

sections. The dipole magnet laminations are small enough so that Stiening was able to use one of them directly on an overhead projector during his talk. These laminations will be placed on square aluminum conductors, like "beads on a string," to form the actual dipole magnets. The final focus sections will reduce the beam sizes to a radius of about 2 microns at the interaction point (2 microns is about 1/50th the thickness of a human hair).

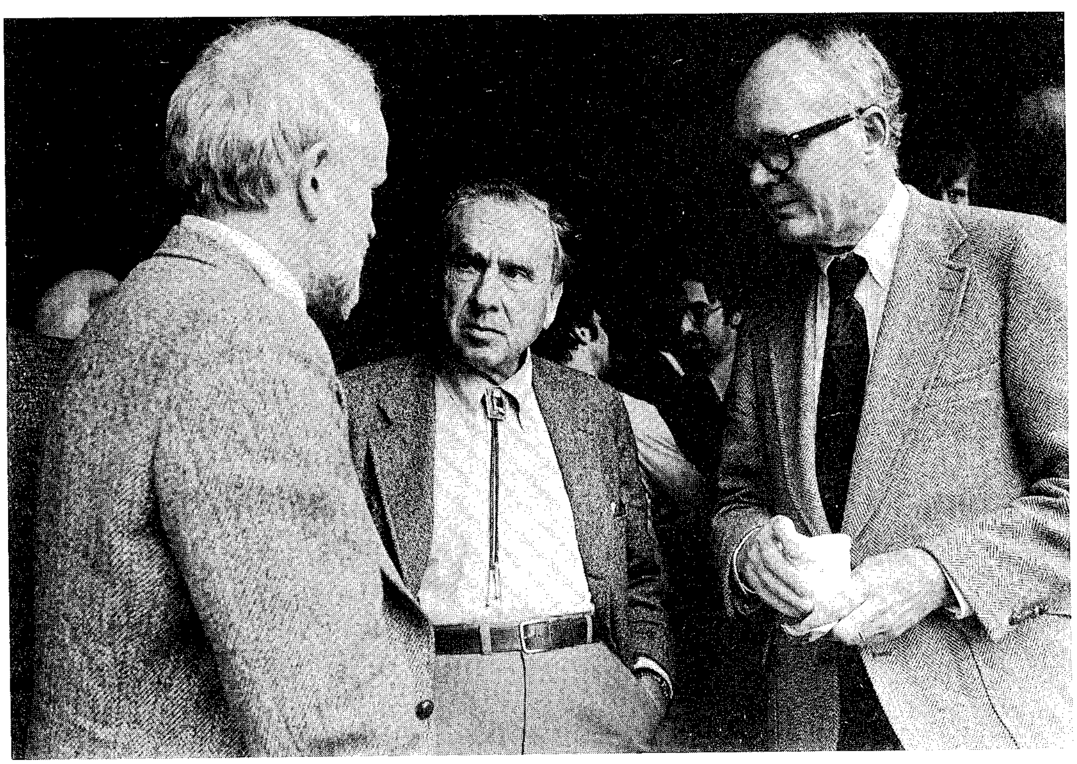
Physics Prospects

Fred Gilman of SLAC described the exciting physics opportunities that will become available at the SLC. If the presently accepted "standard" model of the weak and electromagnetic interactions is correct, then there remain to be discovered several important kinds of new particles. These include the t (or top) quark, the Higgs boson, and especially the neutral "carrier" of the weak force called the Z^o particle. Working at its design luminosity, the SLC will be able to produce more than one million Z^o events per year, thus enabling detailed studies to be made of the production and many decay modes of this important particle. This work will include accurate measurement of the one free parameter in the present theory, the so-called Weinberg angle; determination of the number of neutrino types by measuring the width of the Z^o; searches for new heavy leptons and quarks; and detailed tests of the present candidate theory of the strong interactions called "quantum chromodynamics."

If the present standard model turns out to incorrect, the SLC will still have an important role to play in sorting out the alternatives. In one of these, several different types of Z^o particles are predicted, at least one of which would be accessible at SLC energies. Other schemes, which avoid the Higgs' mechanism for mass generation, might lead to a different class of "low"-mass bosons. There are several other alternative possibilities that the SLC could explore.

Polarized Electrons

Since the SLC is a single-pass machine, its electron beam is not subject to the depolarizing resonances that occur in a storage ring. Moreover, since the SLAC linac can produce highly polarized electron beams, the SLC will have polarized-beam experiments as a unique part of its physics program. Charles Prescott of SLAC described some of the special experiments that can be done with such beams at the SLAC. Because of the left-right asymmetry of the standard model, the electroweak interactions are expected to show a significant spin dependence at high energies, with a preference for left-handedness. A specific example of this effect is the charge asymmetry that is expected to show up in the production of muon pairs. For comparable running times, a measurement made with a polarized beam will reduce the error on measurement of the Weinberg parameter by almost a factor of three. Several other kinds of polarized-beam experiments can provide information on weak-interaction couplings that is available in no other way.



Left to right:

Harry Bingham
LBL

Bob Hofstadter
Stanford

Vincent Peterson
Univ. of Hawaii

LEP and CESR II

Franco Bonaudi of CERN described his laboratory's plans for the very large electron-positron storage ring called LEP, for which final approval is hoped to be obtained this June. Construction is scheduled to begin in 1982, and the first phase, with 50 GeV per beam, is expected to be ready near the end of 1987. The present design calls for a machine circumference of 27 kilometers, part of which would be tunneled under the Jura Mountains near Geneva. Considerable effort is now going into studies of the expected beam-beam interactions and design of the magnet lattice in order to achieve good luminosity. Novel techniques for distributed pumping of the vacuum chamber are under study, and novel prototype magnets using iron laminations separated by concrete spacers have been fabricated and tested.

Bernie Gittelman described Cornell University's plans for a 50 on 50 GeV electron-positron storage ring that would be built near the present CESR ring. A key element in this project is superconducting RF cavities, which would reduce the cost of building the machine by allowing a smaller radius, and also of operating it once it was built. Cornell has successfully operated such cavities in their present machines. This new project would require a lower frequency cavity, and a prototype of such a cavity has already been built. A second model will be tested in CESR this fall.

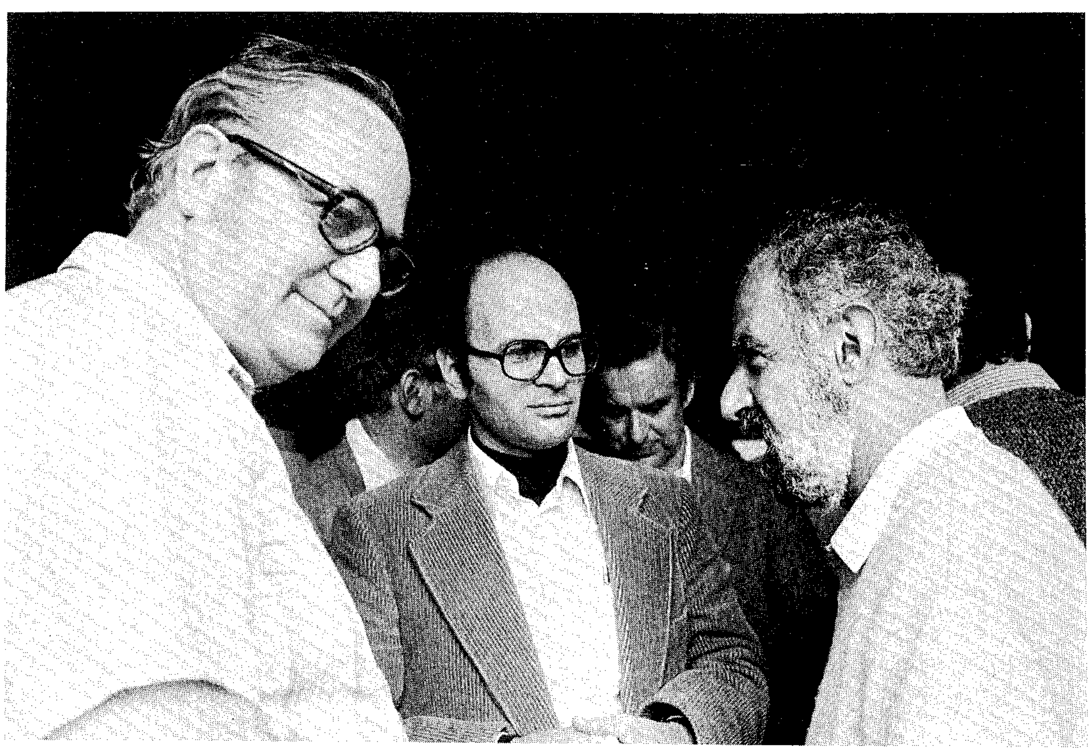
The SLC Working Groups

One of the main purposes of the Workshop was to establish a number of working groups who will address specific technical areas of SLC experimental use during the coming months. Eight such groups were formed during the Workshop, as follows:

- Polarization
- Parametric Study of Detectors
- Technology Review Groups:
  - Tracking
  - Calorimetry
  - Particle Identification
  - Fast Electronics and Computing
- Support For Two-Detector Scenario
- Interaction Region

Each of these topics was described briefly to the full Workshop, with the talks serving also to begin recruiting those in attendance to the individual group meetings that were held on the second day. Each of the working groups is co-chaired by a physicist from SLAC and a physicist from an oustide institution. Each of the groups subsequently established its own schedule for further meetings, typically once a month during the remainder of the spring, with more intensive work planned for the summer. Reports will be prepared for the next meeting of the full Workshop, which is presently scheduled for next fall, probably October. *(Photos by Joe Faust.)*

—Bill Ash



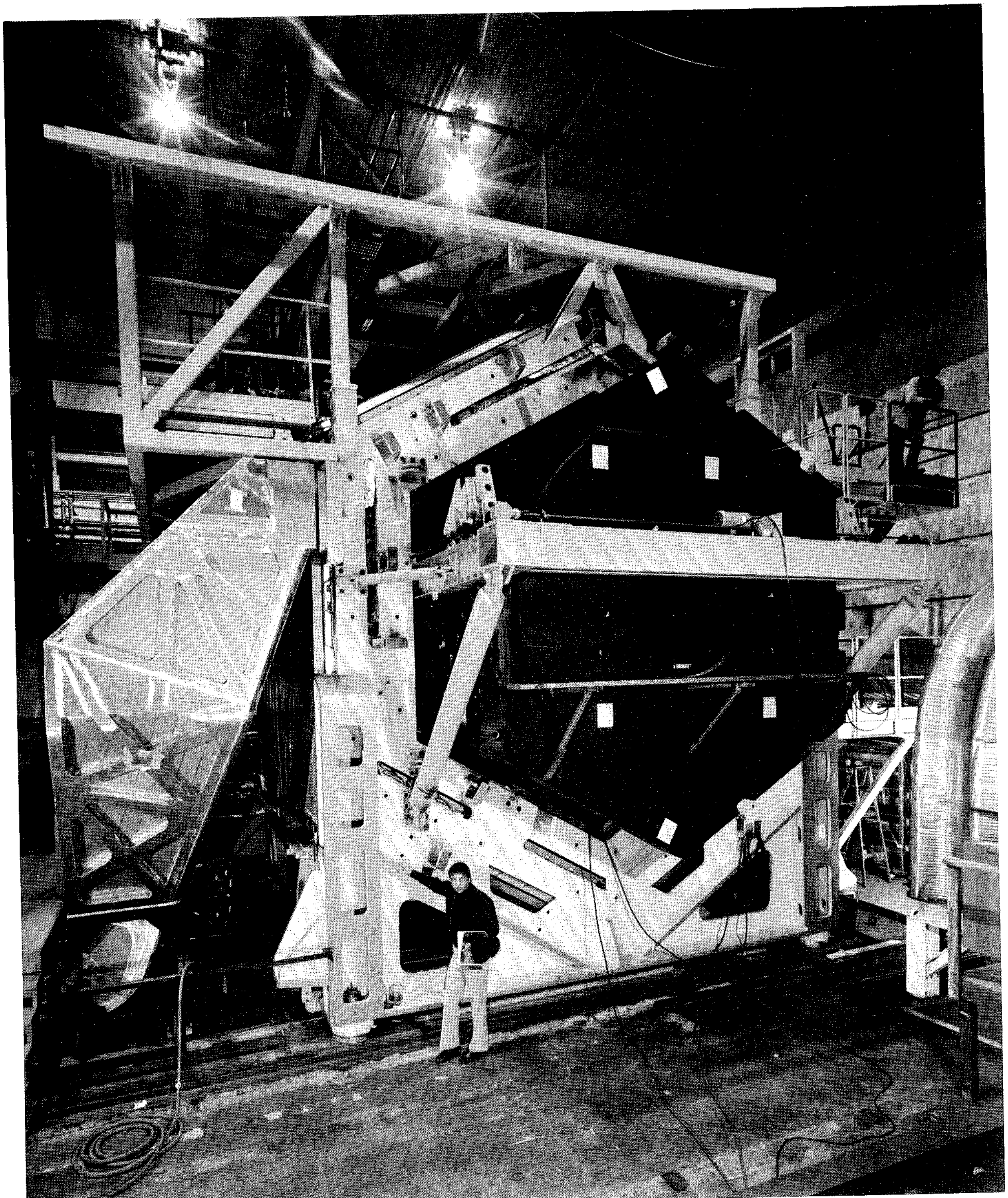
Left to right:

Roy Weinstein
Northeastern Univ.

Giora Tarnopolsky
SLAC

Bernie Gittelman
Cornell University

Al Odian
SLAC



This LBL photo shows Fred Catania, IR-2 coordinator at PEP, standing before the assembled magnet iron for the TPC (Time Projection Chamber) facility. The original superconducting coil for the TPC was damaged during testing and will have to be repaired. In the meantime, a conventional coil is being fabricated at SLAC to serve in the interim. It is scheduled to be installed late this year.

The light-colored structure at the left in the photo is a cableway for the thousands of cables that will run from the detector to the electronics house. The TPC facility is a collaborative effort among groups from LBL, UCLA, UC-Riverside, and Yale, Johns-Hopkins and Tokyo Universities.

EMPLOYEE ASSISTANCE PROGRAM

We are all becoming aware that outside pressures can affect our emotional states. We can usually cope with the stress of daily life, but any additional stress, such as that caused by separation, divorce, or overwhelming problems with children, can cause a variety of emotional states. For example, one might develop a feeling of anxiety or depression. A recent study produced an estimate that 25% of the people in this country suffer from some form of depression. A crisis occurs when a depressive state begins to interfere with work or with family relationships.

We are all creatures of habit, so most of us fall back on old ways of coping with stress. Thus some people will use a SEDAtive to help reduce the internal pressure (S = oversmoking, E = overeating, D = overuse of drugs or medication, A = overuse of alcohol), which in turn can cause problems. A crisis can occur to anyone, and it is sometimes helpful to talk with someone who has no connection with work or family. That's what the Employee Assistance Program is for.

The "Help Center" was established at Stanford by Dr. Dave Kaplan in 1977. It is located at the back of Galvez House on Galvez Street on campus. It is open Monday through Friday from 9 AM to 5 PM, and an appointment can be made by calling 497-4577.

Since March, the Help Center has been providing a counselor (Lawrence J. Starkey, L.C.S.W.) at SLAC on Wednesday mornings. This is a free medical benefit. The day may be changed to make it more convenient for employees and members of their families. Please call 487-4577 to make an appointment.

—Larry Starkey

<u>Note to Librarians</u>: Volume 11, Nos. 7 & 8 (July-August 1980) of the *SLAC Beam Line* was never published. Please note this gap in your collection of *Beam Lines*.

SCHAWLOW OFFERS INSTANT FAME AND (SMALL) FORTUNE

Arthur L. Schawlow, President of the American Physical Society for 1981, is sponsoring a contest for the Society's members. Prizes will be awarded to those who submit the best methods of publicizing their own contributed papers at general or divisional meetings. Methods might include such things as handbills, T shirts or balloons imprinted with experimental data or equations. Any expenditure required should be modest. Entrants are encouraged to try out their schemes at a meeting, but that is not required.

First prize will be $10, and second prize $5. Third prize will be a copy of Schawlow's latest paper, and fourth prize his two latest papers.

Entries must include details with drawings or photographs. They should be sent to Schawlow at the Department of Physics, Stanford University, Stanford, California 94305, not later than 31 December 1981. A distinguished panel of graduate students and secretaries will select the winners, who will receive their prizes at the time of the January meeting.

—*Physics Today*
March 1981

The transmission of power by electricity both for short and long distances is not only practicable but also economical; and the sanitary and other advantages of drawing power from a distance, for small manufacturing and for operating domestic machinery, are so enormous that the new system is sure to work great changes in all branches of industrial affairs. It is no stretch of the imagination to say that our children, if not ourselves, will see the small steam engine everywhere displaced by the electric motor, which will convert into motive power the subtle energy conveyed by wires from central sources of energy . . . .

—*Scientific American*
January 1880

SLAC Beam Line (Bin 80)
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Stanford, California 94305

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