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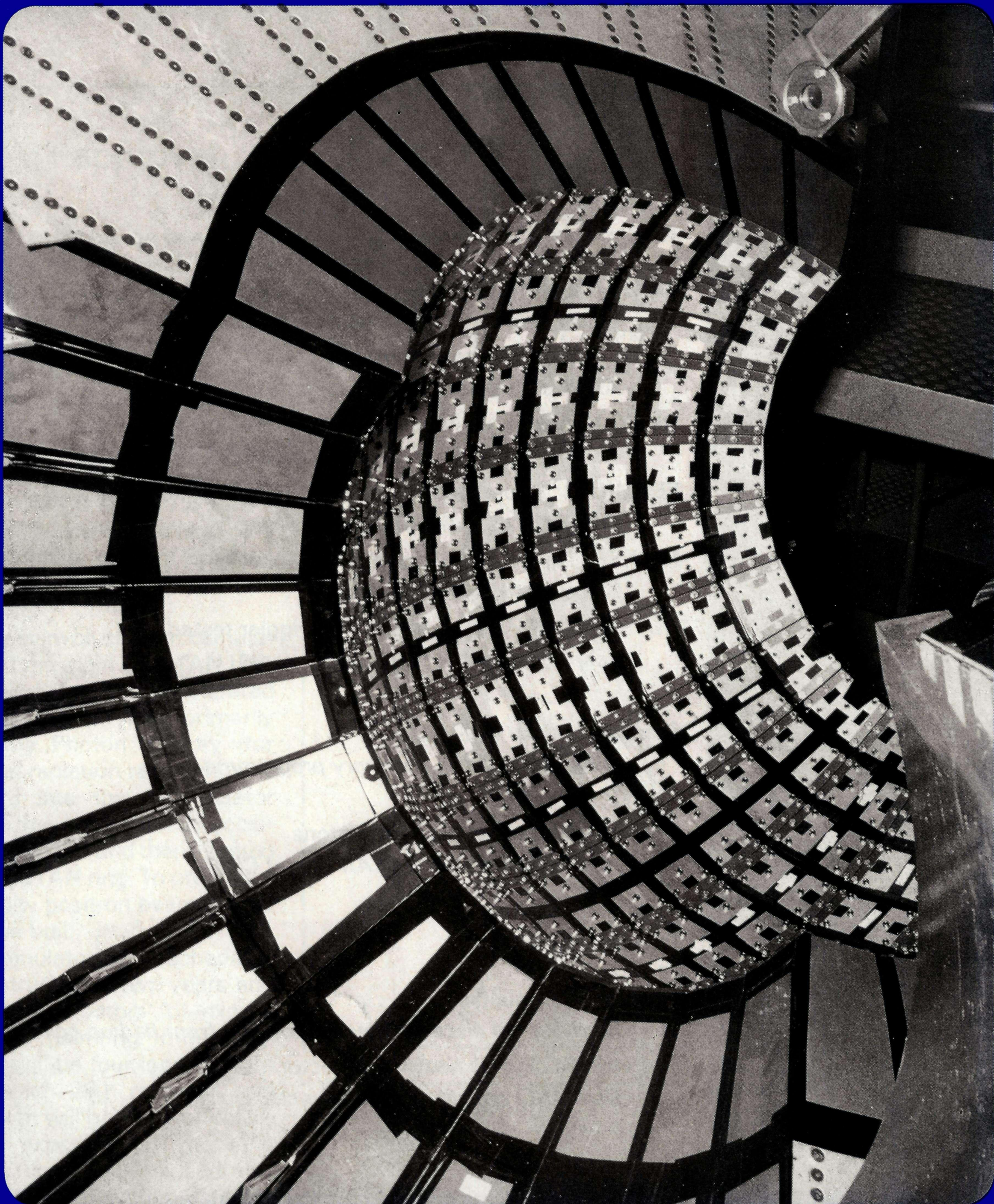

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CERN COURIER

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Cover photograph: not a 'golf-ball' for an electric typewriter but a view of the assembly of the central calorimeter of the UA2 experiment for CERN's proton-antiproton colliding beams. The 'orange slices' which make up the calorimeter contain trapezoidal electromagnetic (lead-scintillator sandwich) detection elements on the inside, and outer hadronic detectors. Although this is not readily apparent in the photo, one is seeing the inside, rather than the outside of the 'golf-ball'. (Photo CERN 391.1.81)

Around the Laboratories

KEK
TRISTAN approval

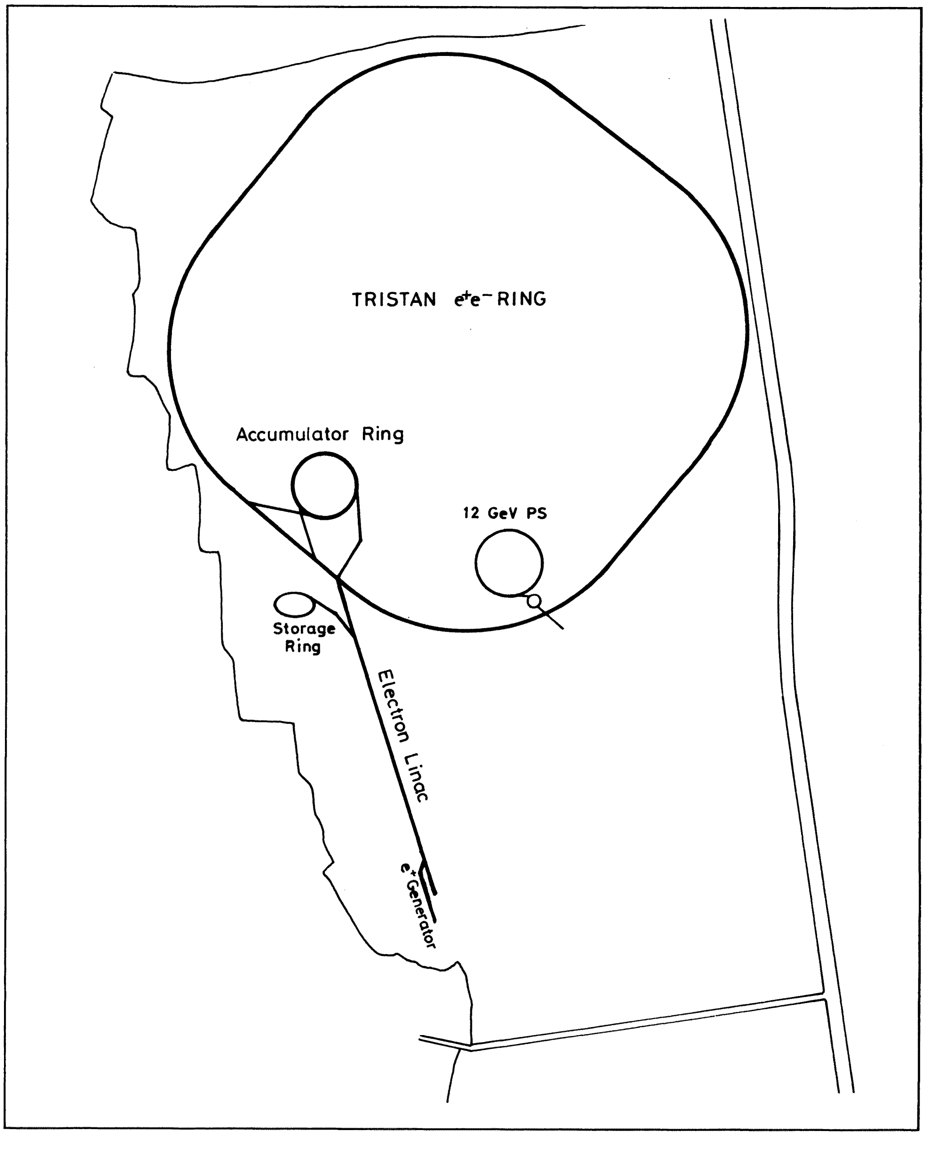
In what will probably be one of the world's major new research centres for particle physics, the electron-positron phase of TRISTAN (Transposable Ring Intersecting STorage Accelerators in Nippon) has been approved by the Japanese government with a five-year construction programme, beginning immediately. The estimated total cost of the construction at KEK is about 7.5 x 10^{10} yen (about 350 million dollars). The total KEK staff at present is about 350, and is expected to rise to about 680 in 1985.

The project involves an accumulator ring and the main TRISTAN ring. Electrons and positrons accelerated to 2.5 GeV by the linac, primarily built for the Photon Factory (for synchrotron radiation research), will be injected into the accumulator ring, where they will be stored, accelerated up to 8 GeV and then injected into the TRISTAN ring. To produce a high intensity positron beam, a new linac will be built.

The accumulator ring is scheduled to be constructed in two years and used to test detectors for experiments at the main ring. In the main ring, there will be four long straight sections (each 231 m long), and three of them will be used for colliding beam experiments. The long straight sections are designed also for r.f. accelerating systems and for future electron-proton colliding beam experiments.

The accumulator ring will be built 4.7 m below ground, and the main ring will be at a depth of 11.4 m. Thus the main ring tunnel will be below the existing 12 GeV proton synchrotron buildings. Special problems will arise at the point where

A plan of the KEK site, showing the position of the new TRISTAN ring, to be built over the next five years.



TRISTAN parameters

	Accumulator Ring	TRISTAN Ring
maximum energy	8 GeV (pulse mode)	30 GeV
circumference	377 m	3016 m
mean radius	60 m	480 m
bending radius	24 m	224 m
r.f. frequency	501 MHz	509 MHz
maximum current	120 mA	(15+15)mA
energy loss/turn	15 MeV at 8 GeV	320 MeV at 30 GeV

Recent aerial picture of the Japanese KEK Laboratory. On the right can be seen the 450 m-long electron linac for the Photon Factory. This will have an important role to play in the TRISTAN project, now approved.

(Photo KEK)

the tunnel will go under the beam transport line between the existing linac and the booster, but fortunately there are no piles in the way. Both of the two new tunnels will be constructed by cut-and-cover digging, faster and cheaper than tunnelling.

With TRISTAN in mind, the reorganization of the Laboratory is being discussed and decisions will soon emerge. However TRISTAN construction will be carried out under the present scheme, with the Accelerator Department and the Physics Department in charge of the accelerator and the experimental facilities respectively.

CERN Antiproton synchrotron

The antiproton project, scheduled to provide the world's first collisions between intense beams of protons and antiprotons, continues to run according to plan. The latest successes were achieved from 11-14 February when the 28 GeV proton synchrotron passed another milestone in its remarkable career, becoming the world's first antiproton synchrotron.

Intense pulses of antiprotons (the design figure is 6 x 10^{11} antiprotons from 24 hours of stacking) are provided by the Antiproton Accumulator (AA), which first came into operation last year (see September 1980 issue, page 235). However it is the PS which takes the antiprotons at 3.5 GeV from the AA and accelerates them to 26 GeV for use either in the ISR or for subsequent acceleration in the SPS.

The TT6 beamline, recently completed and soon scheduled to supply the CERN Intersecting Storage Rings with antiprotons accelerated in the 28 GeV proton synchrotron.

(Photo CERN 27.2.81)

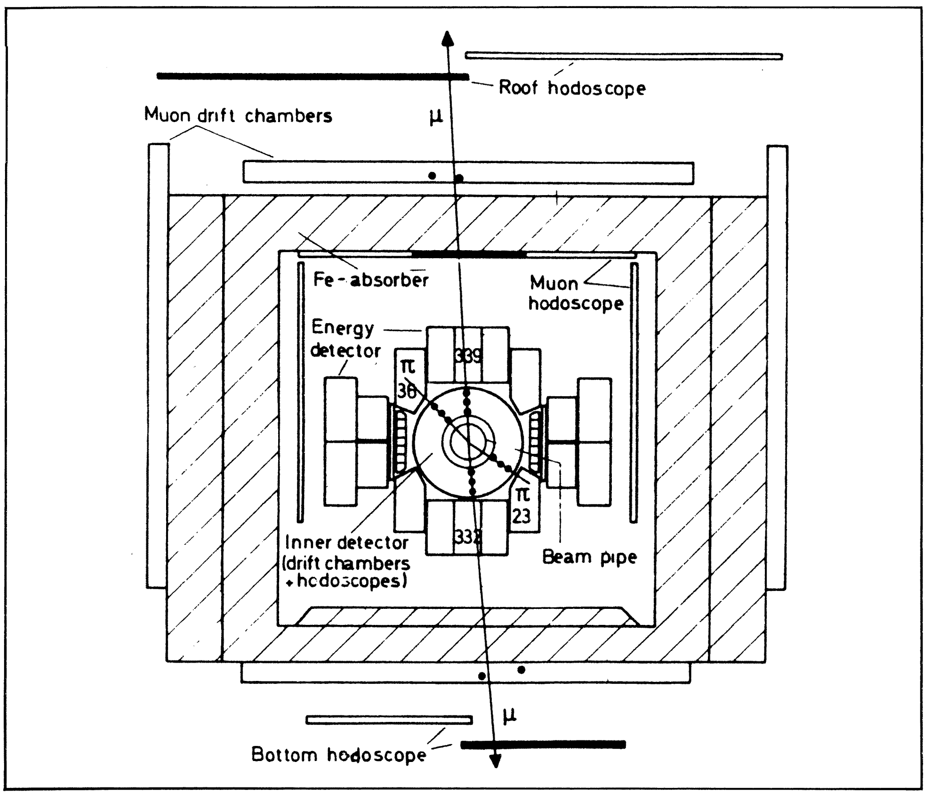
For this, the PS has to become the world's first antiproton synchrotron. Tests with antiprotons from the AA started at the PS before the Christmas break, and on 19 December a 3.5 GeV antiproton beam was seen to circulate in the PS. Further tests, this time using r.f. accelerating cavities, were carried out at the end of anuary, culminating on 28 January when a batch of 10^8 antiprotons was accelerated to 5.4 GeV.

In the third series of tests, in mid-February, further success was not long in coming when a pulse of 5 x 10^8 particles, only the 34th antiproton pulse to be supplied by the AA, was successfully accelerated all the way to 26 GeV. This feat was repeated several times during the course of the next few days.

The ill-omened Friday 13 ran true to form when a record stack of 3 x 10^{10} antiprotons from the AA was lost due to a vacuum leak. However more antiprotons were soon obtained and the cautious team waited until the first hour of Saturday 14 before trying the next step - extracting an antiproton beam and sending it towards the ISR.

A 24 GeV antiproton beam was gently extracted from the PS and led down the recently completed TT6 transfer tunnel, built to allow the ISR to be supplied with antiprotons. The ISR was in fact undergoing a routine shutdown, so beam could only get as far as the vacuum in the transfer line would allow. The first ISR antiprotons are scheduled for the next series of tests.

Thanks to the enthusiasm of all involved, and some dedicated teamwork, these initial antiproton accomplishments have been achieved in a very short time and with a relatively efficient use of the available antiprotons. All this augurs well for the future success of the project.



DESY
Upsilon transitions at DORIS

Data from the DORIS electron-positron ring at DESY has confirmed that the upsilon prime (10.01 GeV) is definitely an excitation of the upsilon (9.46 GeV) particle.

After having been used for measurements in the charm energy region in 1974-1977, DORIS was upgraded in energy in 1978 to be able to produce the upsilon (9.46) and upsilon prime (10.01) resonances (see September 1978 issue, page 298). The leptonic decay widths of the two resonances, as well as the precise value of their mass difference, was measured and it was shown that the upsilon is indeed a bound system of two quarks with charge one-third.

From October 1979 to March 1980, DORIS was used for a second round of upsilon experiments. The objectives were:

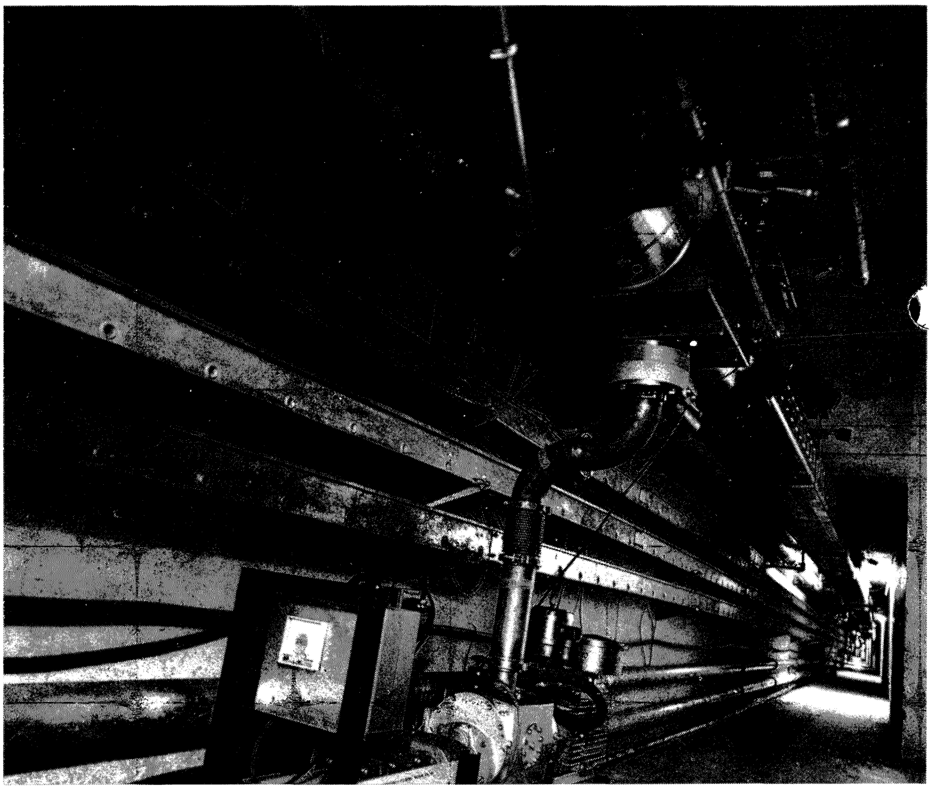
1. To measure the branching ratio of the upsilon's decay into muons, so as to obtain the total decay width.
2. To get improved values for the resonance parameters of the upsilon prime.
3. To obtain first results on the topology of the upsilon prime decays.
4. To observe transitions from the upsilon prime to the upsilon.

The branching ratio of the upsilon into muons is $3.2 \pm 0.8 \pm 0.4$ per cent (the first error is statistical, the second systematic). This value, together with the leptonic width, gives the total decay width as 40 +13

A decay of an upsilon prime as seen by the LENA detector at the DORIS electron-positron storage ring. The decay (seen looking along the beam) produces two muons, which penetrate the iron shielding, and two pions. The invariant mass of this muon pair corresponds to the upsilon.

The superconducting left bend, curving away towards the Fermilab Meson Laboratory.

(Photo Fermilab)



(-8) + 9 (-7) keV. This should be compared with the J/psi total width of 63 ± 9 keV. Assuming that the direct hadronic decays of the upsilon resonance proceed via a three-gluon intermediate state, the strong coupling constant comes out as 0.17 +0.04 (-0.02) ± 0.01, using lowest order quantum chromodynamics calculations (QCD). These values are an average of results obtained by the DASP-II, LENA and PLUTO collaborations.

The LENA collaboration was formed in 1979 as a Cracow / DESY / Erlangen - Nürnberg / Hamburg / Michigan State / Carnegie-Mellon/Saclay/Tel-Aviv collaboration which has now been joined by Nijmegen. Their detector, built by a DESY/Heidelberg collaboration, is well-suited for photon detection and electron identification. The muon detection system was improved in 1979.

The LENA collaboration has now observed the decay of the upsilon prime into an upsilon and two pions, together with the subsequent decay of the upsilon. These events have a clear topology and signature and can be kinematically fitted. With seven such events, the two-pion branching ratio is found to be 19 ± 8 per cent. This gives the partial width of the upsilon prime decay into an upsilon and two gluons (which then fragment into a pion-pair or an eta meson) of 10 ± 5 keV. The ratio of this value to the corresponding two-gluon width of the J/psi (110 ± 22 keV) is 0.09 ± 0.05, which agrees with the QCD prediction of 0.11. On the other hand one would expect a ratio near unity with scalar gluons.

Similar results for upsilon prime decay parameters have also been observed and measured by the CUSB experiment at Cornell. Data is also expected from the CLEO experiment at Cornell.

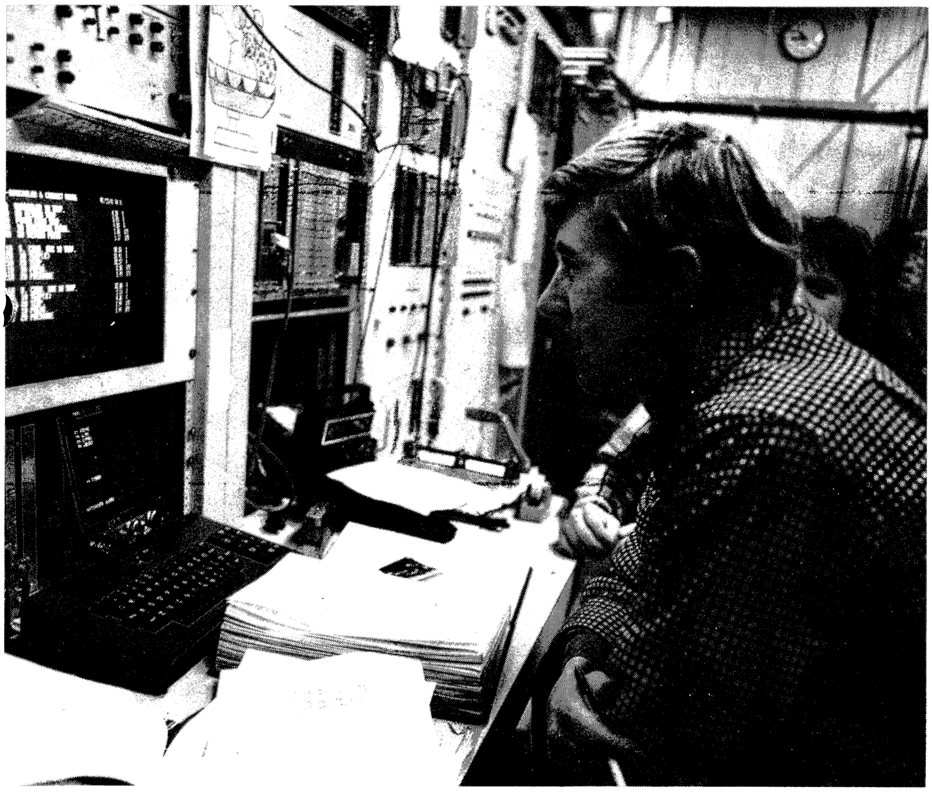
FERMILAB
Superconducting left bend goes into service

As we reported briefly in the March issue (page 62), the superconducting 'left bend' has now gone into service at Fermilab. The left bend extracted beam serves the Meson Laboratory, one of the three major external areas at Fermilab. The twenty-one magnet string — more than four hundred and fifty feet of superconducting magnets — is by far the largest superconducting magnet string yet placed in operation for beam transport. First operation occurred in mid-December. By mid-January system operation was approaching routine and normal beam intensity requests in the neighbourhood of 5×10^{12} protons/pulse for the Meson Laboratory were being handled with ease. The system is currently operating at 400 GeV but the installed magnet bending power could bend the 1 TeV beams of the Tevatron. The system has shown itself capable of easily recovering from quenches.

The need for superconducting external beamlines with the Energy Doubler has been evident from the earliest days of the project. The confined beam transport enclosures do not permit lengthening the bending strings to achieve Doubler energies. In 1977 it was realized that a superconducting left bend would give substantial energy savings even before Tevatron operation began, and would give extremely useful operating experience with superconducting systems. The US Department of Energy agreed to the installation of the left bend as an energy saving project. Russ Huson, head of the

Don Ljung at the computer control console for the left bend.

(Photo Fermilab)



Accelerator Division, spearheaded the efforts to get the project under way. Prototype twenty-two foot Energy Doubler magnets were used since they were no longer needed after the decision was made to employ shorter twenty-one foot magnets for the Doubler.

The decision to go ahead on the left bend had important implications for the Laboratory and particularly the Meson Laboratory users. An operating experiment would find it difficult to face the possibilities of a slow turn-on. Because of the tight constraints of the tunnel it was not possible to maintain the old conventional magnet string in place.

Actual installation began in June 1980 managed by the Accelerator Division beam switchyard group led by Roger Dixon. Jack McCarthy headed the engineering efforts. Contributions to the project came from many other groups in the Laboratory. Installation continued through the long summer shutdown in parallel with a large-scale project to upgrade the neutrino shield and associated installations.

First beam was transported through the superconducting string to the F1 manhole halfway to the Meson targets on 12 December. Later that weekend the beam was transported all the way to the Meson Laboratory. At that stage the refrigeration was still limited, leaving little flexibility to cope with magnet quenches. During the first weeks, this reduced refrigeration capacity gave rise to some system reliability problems. The initial steps were taken cautiously as the switchyard's experts learned to handle the beam in a possibly delicate situation. At one point the full accelerator beam of more than 2×10^{13} protons was accidentally dumped into the superconducting system without damaging effects, demonstrating that the superconducting line can handle the full beam.

By 1 January beam was being delivered to the two Meson Laboratory targets. The system then began operating more or less steadily, except for a few early shutdowns to install additional refrigeration compressors and thereby increase the refrigerator capacity. By late January installation of additional compressor capacity was complete. Early February saw a few problems due to vacuum contamination, but this was quickly cleared up and satisfactory operations resumed.

The cryogenic left bend uses 21 of the 22-foot-long prototype doubler dipoles. With a current of 1500 A these give 15 kilogauss for 400 GeV operation. This is sufficient to produce the necessary ten degree bend out to Meson. The field required at 1 TeV is 37 kilogauss, well within the capabilities of the Doubler magnets. The new magnet string replaced 56 ten-foot beam transfer bending magnets. The original conventional quadrupoles are still in use. In general it is not sensible to convert widely spaced quadrupoles with superconducting elements in a beam transport situation.

The cryogenic system for the superconducting left bend consists of a prototype of the satellite refrigerator for the doubler coupled to a 420 foot transfer line system. The satellite refrigerator, with a wet and a dry engine, originally had a minimum complement of two reciprocating compressors, each rated to handle 35 grams per s of helium at 300 psi. A third screw compressor was added in January, with an additional capacity of 57 grams per s. The screw compressors are used for doubler satellite refrigerators.

The quench recovery properties of the system are good. There is now something like one beam-induced quench per week, usually from missteering the beam. Other quenches occasionally occur because of refrigerator problems or compressor trips. At present the quench recovery time is set by the desire to gather a large amount of retrospective data with the computer when a quench occurs. Typically the data gathering takes fifteen minutes. Under 'normal' quench conditions the recovery time, based on thermodynamic limits, is much shorter.

The entire system operates under automatic computer control. Collection of monitoring data is automatic, and the control system is now aiming for total closed loop control.

Operation of the Meson Area is rapidly becoming independent of any special superconducting questions. It is a fact that the first week of operation with the superconducting left bend was one of the most efficient weeks of accelerator operation at Fermilab ever. The number of tunnel accesses to service the left bend have not been at all unusual. On the other hand, for the first several weeks of operation it was necessary to shut Meson off for short periods to complete installation.

One new feature of operation is the remote possibility of release of large quantities of helium gas. At present, personnel carry oxygen level monitors as well as mini-emergency air packs as a safeguard.

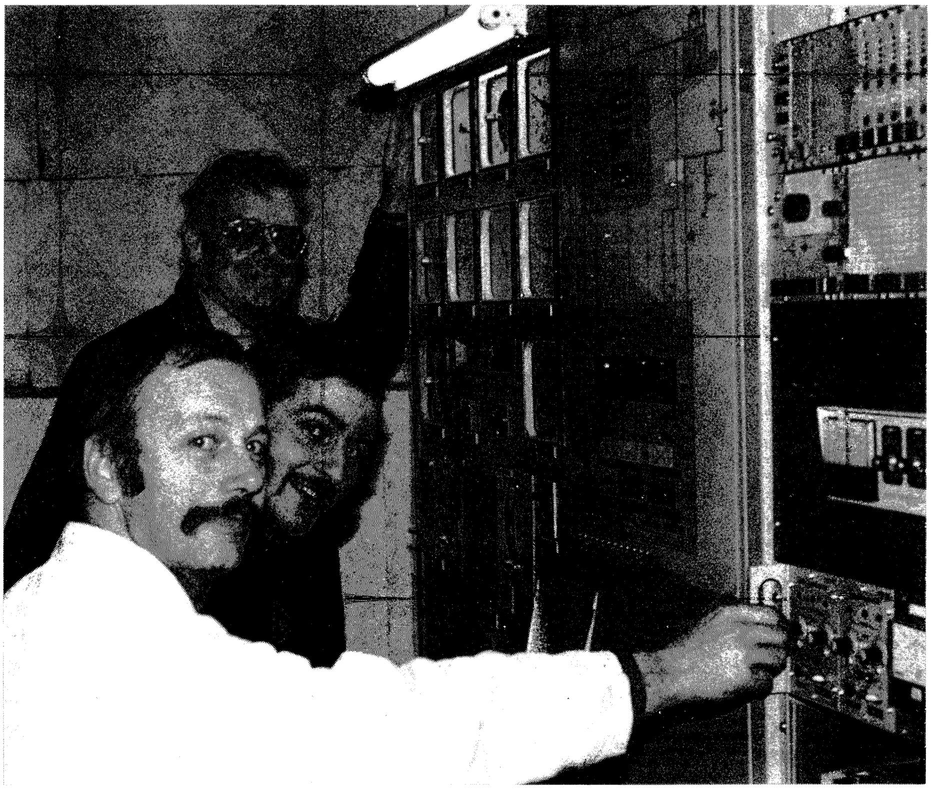
The present left bend system can handle Tevatron operation with only minor modifications. A similar right bend must be built to distribute protons to the three Proton Laboratory target stations. Plans exist for this project in conjunction with the Tevatron II proposal for the construction of the Doubler experimental areas. No similar installation is necessary for the Neutrino line since it is straight.

Critics sometimes question the energy economy of superconducting operation. The conventional magnet left bend operating in a pulsed mode required an average power of one Megawatt at 400 GeV exclusive of power supply and lead losses. The superconducting bend uses something like 200 kilowatts, mostly for compressor operation. This is a net savings of a factor of five. In more down-to-earth terms it is sufficient power to supply the needs of a village of several thousand or to save ten thousand barrels of oil a year. These savings extrapolate by factors of thirty to fifty for the Energy Saver.

NIKHEF Superconducting muon channel

At the end of January, the superconducting solenoid forming the principal element of the muon channel was successfully brought into operation at the 500 MeV electron linac at the Dutch NIKHEF (formerly IKO) Laboratory. Stable operation was achieved at 1000 A (15 per cent over the design current) with a mean coil temperature of 4.7 K. At this current the solenoid provides an axial magnetic field of nearly 6 T over a free evacuated bore of diameter 12 cm.

The 5 m-long solenoid is a copy of the units already in operation at the Swiss SIN Laboratory, and was built by a project group led by Ron Fortune and working in close collabora-

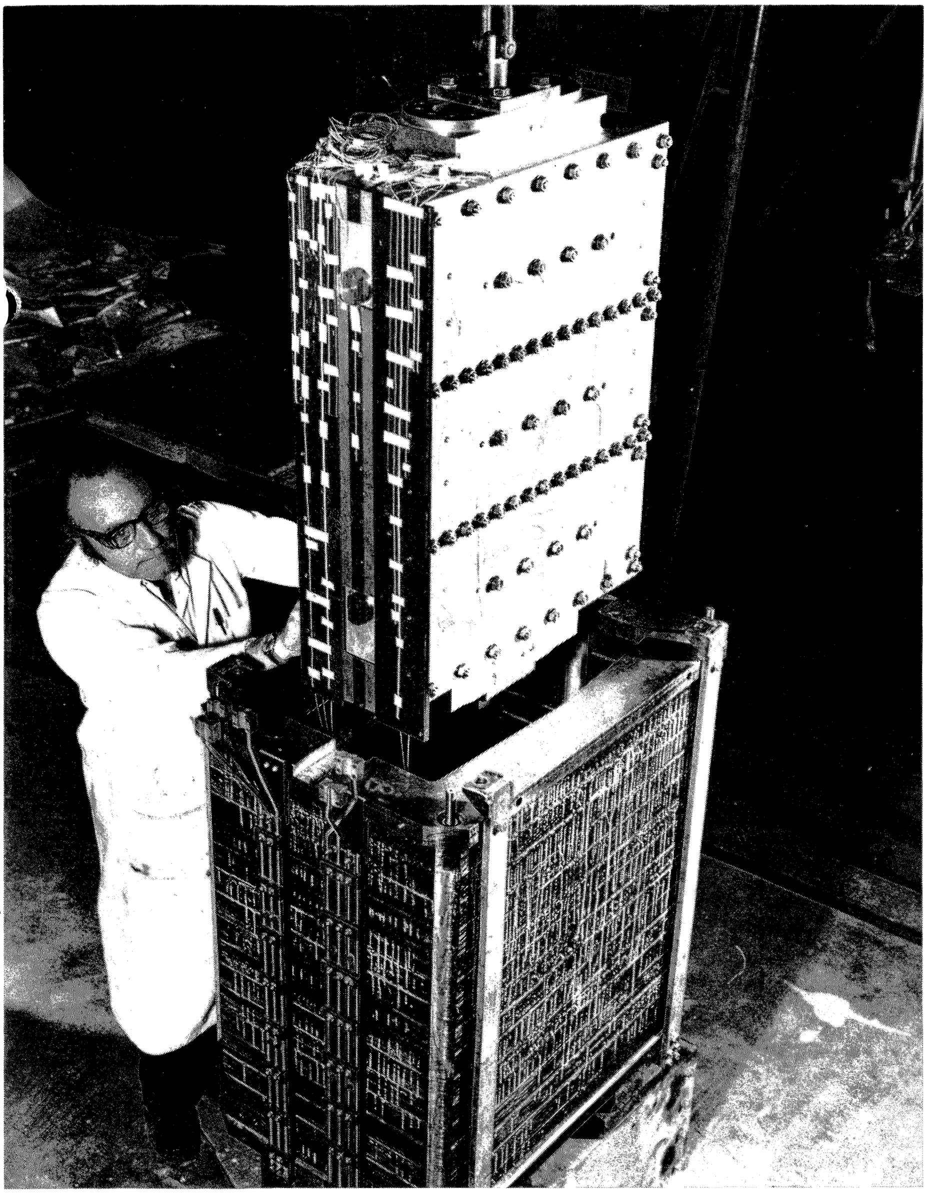


Smiles from Jan Lefevere (front left), Tom Sluijk and Project Leader Ron Fortune (rear) as the new NIKHEF (formerly IKO) superconducting solenoid reaches a current of 1000 A, well above its design value.

(Photo R. Spruit)

Assembly at the Rutherford Laboratory of the superconducting wiggler magnet designed for use at the new Daresbury Synchrotron Radiation Source.

(Photo Rutherford)



tion with the SIN Cryogenics Group. The project was completed within a budget fixed in 1977, and in a remarkably short time, despite manpower shortages.

In the advanced design, supercritical helium at 10 atmospheres and 4.5 K is used to cool the 5 ton assembly of superconducting coils and iron magnet yoke, with a cool-down time of seven days. Particular attention was given to the quality of thermal radiative and conductive insulation, so that heat losses are less than 20 W at the operating temperature.

The solenoid will be used to transport a muon-rich beam from the pion production pit into the muon experimental areas. Injection and extraction beam transport sections, using conventional quadrupole and bending magnets, are under construction and will be installed later this year.

RUTHERFORD
Superconducting wiggler tested

Electron storage rings built for production of synchrotron radiation for use in many areas of research are now in action at Daresbury and Wisconsin and in the offing at several other Laboratories. A clever way of extending their usefulness by expanding the radiation spectrum they can provide has been the introduction of wiggler magnets.

The synchrotron radiation wavelength peaks at a value dependent upon the radius of curvature of the orbiting electrons. The idea of the wiggler magnet is simply to bend the beam harder at a location where radiation is tapped off (and then wiggle the beam back again to its storage ring orbit by an equal and opposite magnetic field). The radiation emerging from the sharper bend will allow experiments at shorter wavelengths.

The first successful operation of a wiggler in a storage ring was at Stanford in SPEAR during 1979 (see May issue 1979, page 105). Now another first is on its way, courtesy of the Rutherford Laboratory. They have built a wiggler to profit from the higher fields available in superconducting magnets. This wiggler was successfully tested in February.

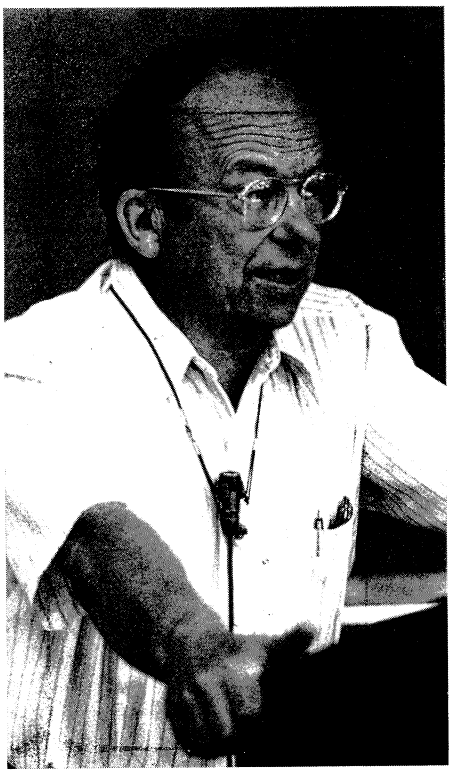
The magnet is designed for peak fields of 5 T (giving a wiggle to the beam which will produce radiation of usable intensity down to 0.1 ångströms). In the test, 5.5 T was achieved after only five quenches. The wiggler is designed for use in the Synchrotron Radiation Source at Daresbury which came into action last year (see January issue, page 8).

The space available in the SRS limited the size of the wiggler's cryostat to 1.2 m. The magnet is built of a series of 16 racetrack superconducting coils inside a laminated yoke. It will be held at a temperature of 4.35 K and its refrigerator is now being commissioned at Daresbury.

After the test, the wiggler is being installed in a horizontal cryostat for shipping to Daresbury.

Panofsky's view of SLAC

Pief Panofsky: 'innovate we must'.



After the ups and downs of funding which have beset US high energy physics during the current fiscal year, SLAC Director Pief Panofsky in his traditional 'State of SLAC' speech had to contend with further uncertainties in the budget for the next fiscal year (which begins in October).

He thought it 'disappointing but not unforeseen' that the outgoing President's budget (still to be reviewed by Congress) contains no explicit support for the proposed SLAC Linear Collider (SLC, see December 1979 issue, page 403). To compensate for this, SLC research and development efforts have been intensified. While in the current fiscal year some seven per cent of SLAC's operating funds were channelled into work for the SLC, this figure is expected to increase to about ten per cent for the next fiscal year. In addition, a 'substantial fraction' of available capital will be injected into the SLC project.

Turning specifically to the SLC, Panofsky said: 'One way to push this (energy) frontier further is to replace storage rings with single-pass colliders. In such machines, electrons and positrons are produced and accelerated, are brought into collision only once, and are then thrown away. If everything else here is equal, then this seemingly wasteful process cannot be competitive with storage-ring devices if the collisions occur only relatively infrequently (say 10 to 100 times per second). If, however, the particle density during collisions is made to be extremely high by focusing such beams into 'needles' of a tiny diameter (a small fraction of the diameter of a human hair), then the reaction rate can become respectable. Thus the plan is to accelerate electrons and positrons in concentrated bunches in the SLAC two-mile linac, then guide the electrons and positrons separately into collisions at a single point near the east boundary of our site. A new interaction region near that boundary will be built to accommodate two detectors which can be placed alternately into the beam.

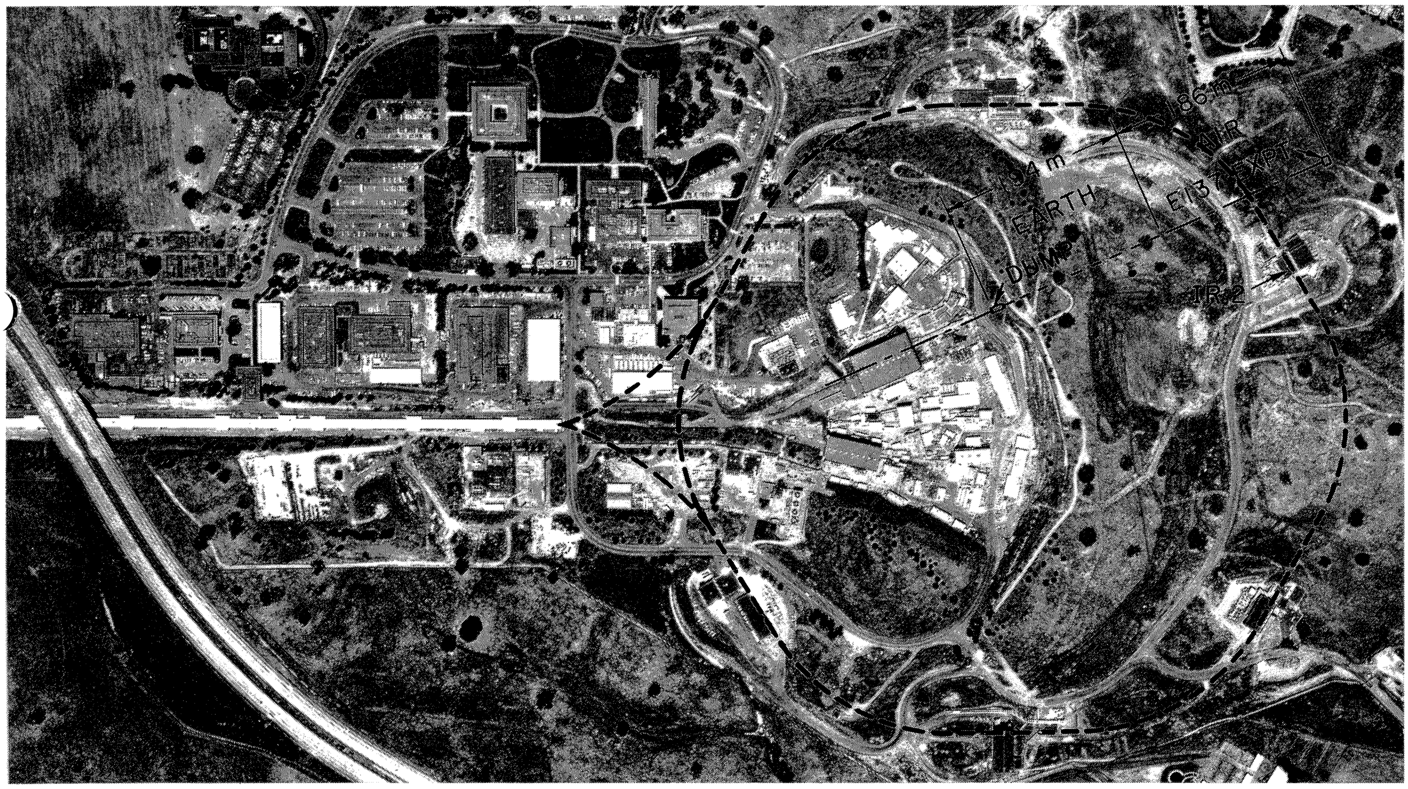
This new project has two objectives. First, it will make possible collisions at energies up to abou 100 GeV — essentially as high an energy as that accessible to LEP, but at very much lower cost. At these energies physics is expected to be extraordinarily rich. If this machine performs according to theoretical predictions, roughly 1 million events from new particles can be logged per year.

The second objective of the SLC project is at least equally important, both to the future of SLAC and the future of high energy physics throughout the world. This is the role of the SLC as a pioneering programme to demonstrate the feasibility of this new class of colliders, and to examine some of the detailed properties of this new class of machines. Thus, should the SLC go forward and be operated successfully, we are looking forward not only to vital experimentation at 100 GeV collision energies, but also to the possibility of single-pass devices which could reach collision energies much higher than are conceptually possible by the now well-established storage-ring technique.

For these reasons, we are now proceeding intensively with development of the SLC technique. We have just completed installation of a new front end in the SLAC linac, including modification of the first 300 feet of the machine, which constitutes the injection end of the SLC. We are also planning to convert the instrumentation of approximately the first one-third of the two-mile linear accelerator to make it meet

Bird's-eye view of SLAC, showing the layout of a new beam-dump experiment to search for neutral unstable penetrating particles. The detector, containing modules from an old Fermilab experiment, will be mounted on a hilltop near the SLAC site boundary, just north-east of PEP Interaction Region 2 (IR2).

(Photo SLAC)



SLC standards. During the next year, an architectural-engineering firm will be hired to produce the final drawings for the new tunnels and housing for the machine, and we are also going to do a large amount of engineering development on the other SLC components. All of this is designed to give us a flying start for eventual authorization, but it is too early yet to tell whether such authorization can be obtained in the prevailing financial climate.'

The SLAC Director also covered the highlights of the physics programme (see also September 1980 issue, page 245).

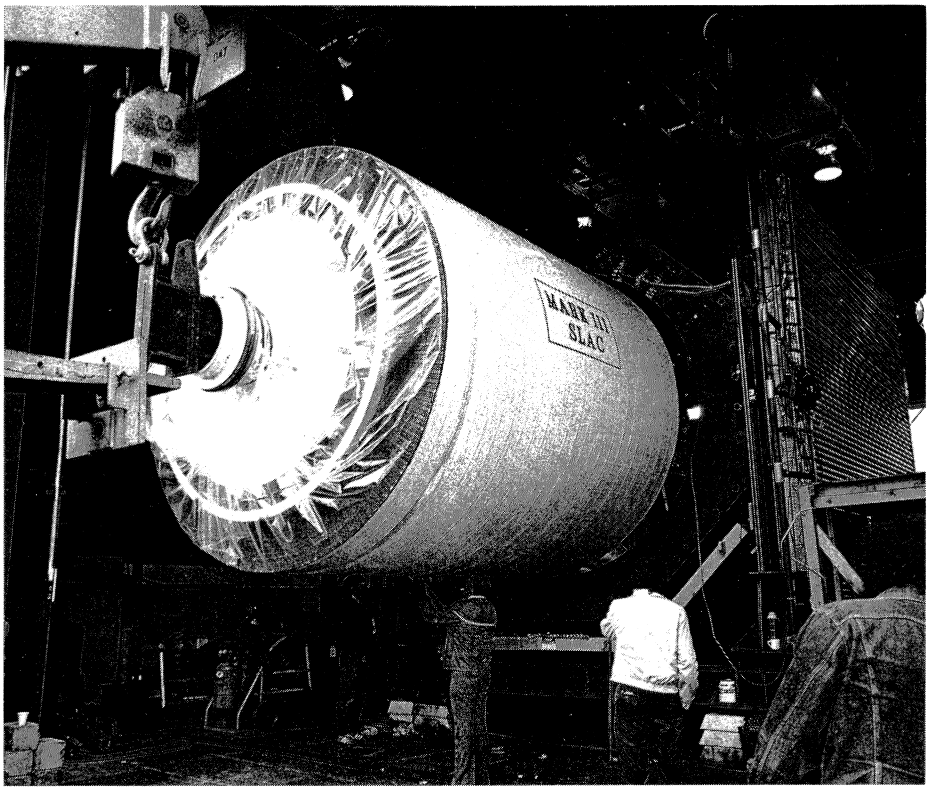
'Currently three of our major detectors at PEP — Mark II, MAC and DELCO — are fully operational and are in full data-taking operation during the operating cycle which will terminate in June, and they will resume physics data-taking operations next fall. In addition, the High Resolution Spectrometer (HRS) will hopefully be in physics production by next fall, and unless there are substantial setbacks, the Time Projection Chamber (TPC) detector, which combines many of the most advanced features, will be installed during the next fiscal year. It is believed that the quark search experiment will have finished its work by this summer, either with or without finding quarks. Thus by the next fiscal year the full arsenal of major PEP detectors will be in place, and we are eagerly looking forward to having their enormous experimental potential bear fruit in important physics results.

We also expect that the Mark III detector, which is now being assembled at SPEAR, will be fully operational this fall. This means that SPEAR will again have two major detectors operating, the Crystal Ball and Mark III. The energy region accessible to SPEAR continues to be incredibly rich in terms of very important physics, and the work with the Crystal Ball during the last year has amply reaffirmed this. It is therefore gratifying that during the next fiscal year both interaction regions at SPEAR will again be occupied by powerful instruments.

We are planning to continue to share the use of SPEAR with the Stanford Synchrotron Radiation Laboratory (SSRL) on the same basis as before: one-half of the running time of SPEAR will be used in single-beam operation fully dedicated to the use of the large multitude of SSRL users. During the other half of the time, SPEAR will run in the colliding-beam mode for high energy physics work, with SSRL taking data parasitically. SSRL has been an extraordinarily productive enterprise, and this shared operation has greatly increased the opportunities avai-

The Mark III shower counter being installed in its magnet in the assembly building adjacent to the SPEAR west pit. The detector is scheduled to be installed in the ring during the summer shutdown.

(Photo Joe Faust)

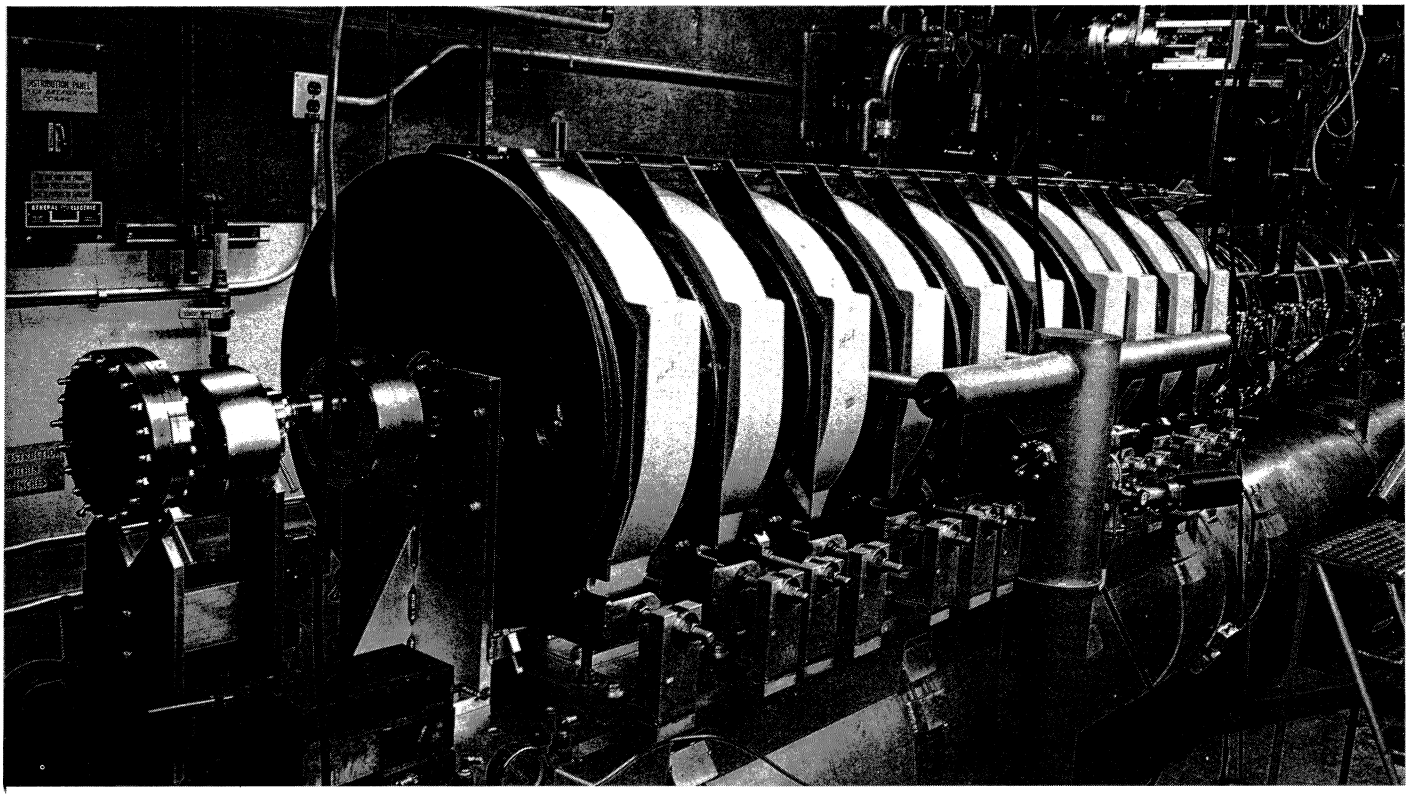


lable to that Laboratory. At the same time, since the cost of supporting SPEAR is shared between SSRL and SLAC, this has liberated funds which have been sorely needed for operating the balance of the Laboratory.

During the current fiscal year, the LASS large-angle spectrometer has resumed data-taking and has logged literally tens of millions of events. The work of LASS will provide definitive data on some of the fundamental interactions of kaons with nuclear matter. During the next fiscal year LASS will not operate for a large amount of time, since most of the time will be required to analyse the enormous amount of data that has

Below, a subharmonic buncher for a new injector being constructed at SLAC for studies of the generation and acceleration of large single electron bunches. This is part of the groundwork for the proposed SLAC Linear Collider (SLC) project.

(Photo Joe Faust)



Linear collider studies

Although the SLAC Linear Collider (SLC) project has yet to receive official funding, initial studies are already under way at SLAC, and a new front end for the two-mile linac is in the final stages of assembly. Using a recently developed high current photoemission electron gun and a new subharmonic buncher together with a standard SLAC injector section, it is hoped that intense bunches of electrons (containing over 10^{10} particles per 30 pseconds) will be available for subsequent acceleration in the main linac.

been accumulated. Also, the SLAC Hybrid Bubble Chamber Facility has been operating in a laser backscattered gamma-ray beam, and these runs have been extremely successful. Some of this work will continue into the next fiscal year.

There is also a beam dump experiment that is currently being installed and tested which will be ready for data-taking next year. When an intense beam of high-energy electrons strikes a target, new particles might be produced. A detector weighing 20 tons is being installed on the embankment near PEP Interaction Region 2 to register such particles. This, like the quark-search experiment, is one of the 'long shot' experiments which SLAC is engaged in. In general, we like to balance our programme between such 'long shots' and 'sure things', where the experiments exploit phenomena which are already known to exist.

At this time we are not quite sure whether experimentation in End Station A will resume next year. Under financial pressures we had suspended End Station A operations last year. The final decision whether to reactivate End Station A will depend upon what new experimental proposals may be accepted, and upon the financial outlook of the Laboratory once the proposed budget has jumped more hurdles.'

In conclusion, Panofsky said that continued innovation was vital despite the unpredictability of the present course of high energy physics. 'The whole progress of this field has been nurtured by a succession of new inventions. As any one invention has run out of steam, a new one has followed, and it is the result of all these inventions that has led high energy physics to the succession of spectacular revelations of the nature of matter.'

Physics with low energy antiprotons

This year, the CERN proton-antiproton project should bear fruit and experimenters should see the world's first collisions of high intensity beams of antimatter. While the 540 GeV collisions in the SPS and the search for the elusive intermediate bosons of weak interactions will be the natural focus of world attention, at the other end of the antiproton energy scale, preparations are under way which could also provide a rich harvest of new physics.

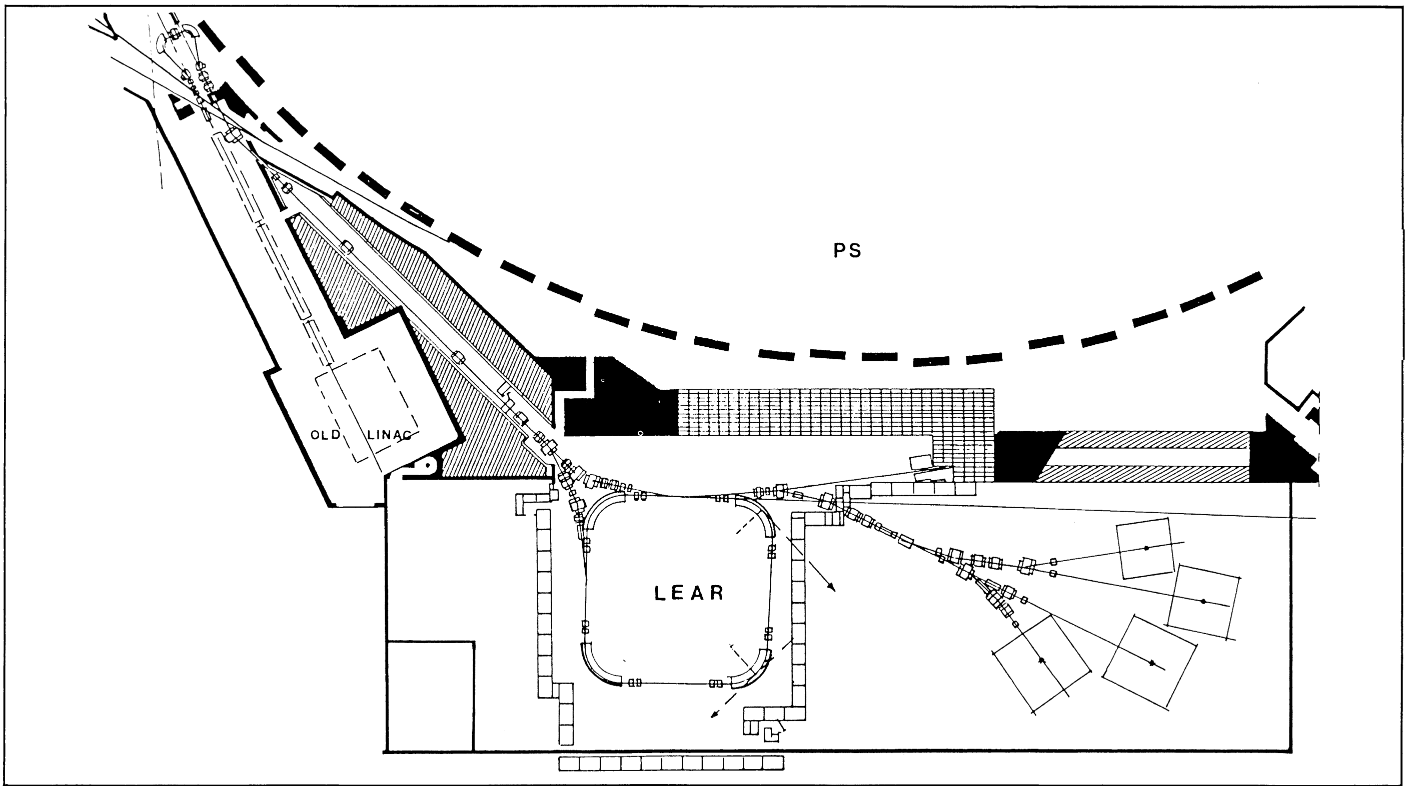
The Low Energy Antiproton Ring (LEAR), to be constructed in the South Experimental Hall at the PS, will provide intense beams of antiprotons in the energy range 0.1 to 2 GeV (see June 1980 issue, page 150). While nucleon-nucleon interactions have been studied in detail over the years, data on low energy nucleon-antinucleon interactions is less complete, although some fine work has been carried out.

As well as proton-antiproton annihilation and antiproton elastic scattering, LEAR physics will cover the spectroscopy of protonium — atoms composed of a proton and an antiproton. LEAR could also provide a definitive answer on baryonium —states expected on certain grounds to be formed from baryons and antibaryons. In addition, there will be other mesonic states to look for in proton-antiproton annihilations, and the properties of the antiproton itself will be accurately measured.

It is hoped that together these experiments will enable nucleon-nucleon and nucleon-antinucleon interactions to be compared, providing a better understanding of hadrons. In addition, LEAR should improve our knowledge of quark behaviour, especially through the investigation of the dynamics of the proton-antiproton annihilation mechanism.

Ten experiments have been approved for LEAR, including four rela-

A plan of the LEAR low energy antiproton ring to be built in the South Hall of the CERN PS, showing the transfer lines and the experimental area.



tively major installations and four studies of exotic atoms. The allocation of available beam time between these experiments has yet to be decided, but the antiproton yield should be so high that some detectors will have only a small requirement for beam time, allowing different experiments to be mounted in parallel, and with a beam splitter allowing simultaneous operation of different experiments.

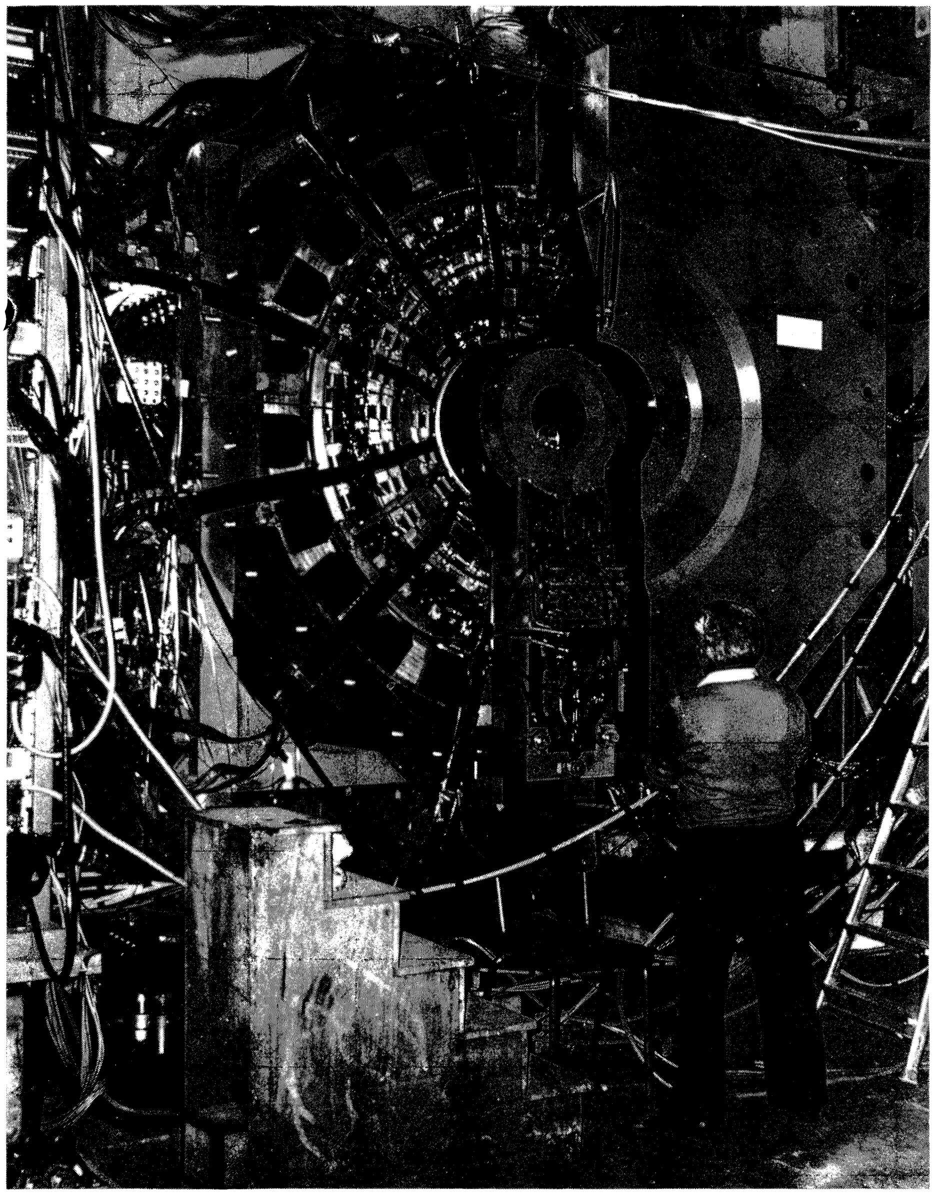
The first LEAR experiment to be approved involves an Annecy / Padova / Saclay / Torino collaboration for 'precision measurements of the proton electromagnetic form factors in the time-like region, and vector meson spectroscopy'. By looking at the annihilation of protons and antiprotons into electron-positron pairs, physicists can compare the behaviour of the electromagnetic form factor of the proton under these conditions (the time-like region) with the precision data obtained from electron-proton scattering (the space-like region). Previous experiments at the CERN PS and at low energy electron-positron rings were able to monitor about one proton-antiproton annihilation into electrons per day, but this experiment hopes to be able to have ten thousand times this event rate. In addition, the electron-positron spectrum could be used to study vector mesons in the mass range below the J/psi.

Another major LEAR experiment will be a study of proton-antiproton interactions in a hydrogen gas target by a CERN / Mainz / Munich / Orsay / TRIUMF / Zurich group, also known as ASTERIX (Antiproton STop Experiment with tRigger on Initial X-rays). The experiment will study protonium spectroscopy and proton-antiproton annihilations in different angular momenta, with each event having data on both the initial atomic state and the final annihilation products. Antiprotons will be stopped in a hydrogen gas target at atmospheric pressure. A large-acceptance low-threshold X-ray detector of novel design (see March issue 1979, page 10) will surround the target and count X-rays emitted in transitions to low-lying atomic levels. Final annihilation products will be measured in the DM1 magnetic detector previously used in electron-positron colliding beam experiments at Orsay and now upgraded with gamma detectors. The experiment will have greatly increased abilities for observing any narrow quasinuclear proton-antiproton bound states, and provide valuable comparisons of annihilations with different angular momenta.

Also representing a considerable experimental effort will be an examination of proton-antiproton total cross-sections and spin effects in

The DM1 magnetic spectrometer being installed in its previous incarnation at the Orsay electron-positron ring. It is now being lengthened to accommodate further multiwire chambers ready for use by the 'ASTERIX' collaboration at LEAR.

(Photo Orsay)



the resultant elastic and charged two-body pion and kaon channels by an Amsterdam / Geneva / London (Bedford and Queen Mary Colleges) / Surrey / Trieste collaboration, using the LEAR beam on a conventional polarized target. This is an attempt to piece together the annihilation mechanism by looking at specific channels. While baryonium is presently out of fashion, it could make a come-back, and this could be one of the experiments to see it. Provided a source of polarized antiprotons can be obtained, another possible objective is to look for spin effects with completely-defined spin states of the incoming particles. Also covering some of this ground will be a Heidelberg group studying the energy variation of proton-antiproton total cross-sections, elastic scattering, and the charge exchange process producing neutrons and antineutrons, down to very low energies.

A precision survey of the X-rays from proton-antiproton (or deuteron-antiproton) exotic atoms is to be carried out by an Amsterdam / Birmingham / Rutherford / William & Mary collaboration. Using a gas target to avoid Stark mixing and achieve good population of low-lying states, the aim is to look harder at the X-rays from simple exotic atoms to search for transitions between low-lying states. While some of these spectral lines have already been seen (see July/August 1978 issue, page 257), the lowest-lying transitions (giving the highest energy photons and corresponding to the Lyman series in ordinary hydrogen) have yet to turn up.

The search for these transitions, which could provide valuable information on proton-antiproton forces, is also the aim of a Karlsruhe group using a novel technique. A superconducting magnet will first make the antiprotons rotate, but subsequent energy losses due to collisions in the very low pressure gas environment will make the antiprotons spiral inwards. In this way low energy antiprotons will accumulate in the central region, equipped with a semiconductor detector. This technique could provide new experimental opportunities.

Another specialist exotic atom group (Basel / Karlsruhe / Stockholm / Strasbourg / Thessaloniki) will look at the characteristics of antiprotonic atoms with heavier nuclei. This will be an extension of the group's previous work on exotic atoms, employing the detector already used in previous experiments at SIN and at CERN.

The relatively high rate of kaon production in proton-antiproton annihilations should provide a source of kaons which compares favourably with normal secondary kaon beams. A CERN / IKO / Uppsala collaboration plans to exploit this, together with the ready absorption of the kaons in the same nuclei which produced them, to search for hypernuclei. Suitable heavy nuclear targets will be used in which the hypernuclear decays produce fission, rather than other effects. The fission products will be detected by a recoil distance method previously used in the study of nuclear isomers, and allowing lifetimes to be measured in the range 10^{-9} to 10^{-11} s.

A Padova group will look at antineutron production, not so much as an experiment in itself, but more to investigate the feasibility of future studies at LEAR using beams of antineutrons.

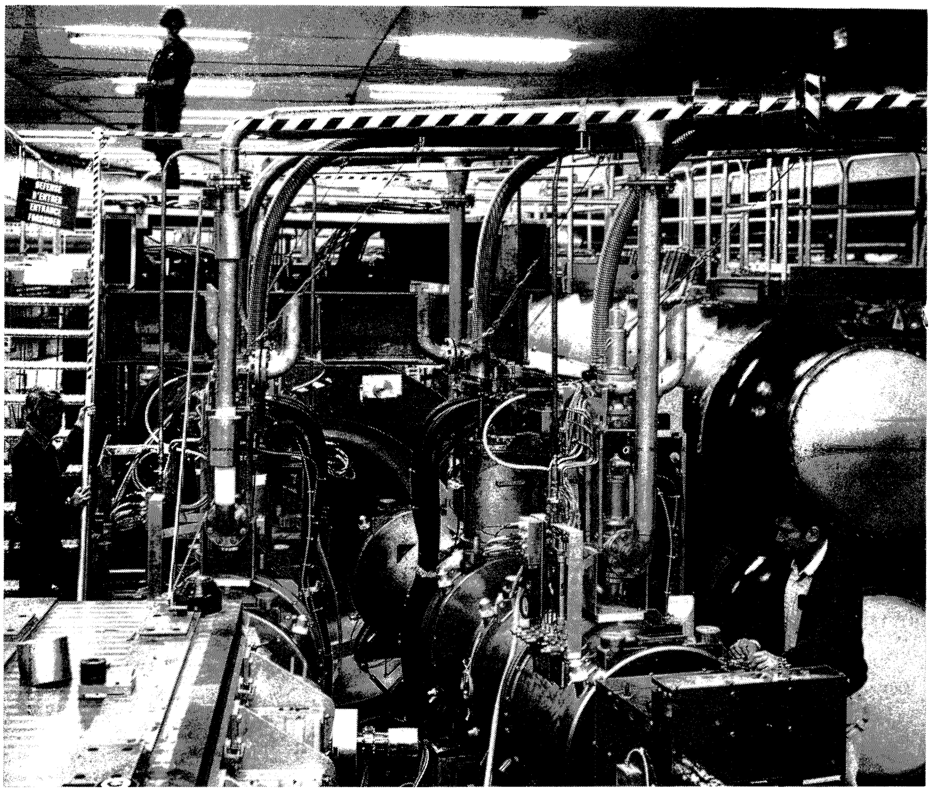
A major LEAR installation, belonging to a Dubna / Frascati / Padova / Pavia / Torino collaboration, will look at the interactions of low energy antiparticles and nuclear targets using a streamer chamber. This is the only experiment using visual techniques to study annihilation, and as such could yield interesting results.

Together, these experiments account for slightly over half the available floor space for initial operations at LEAR. To begin with, LEAR will be used as a stretcher ring with extracted beams. Further studies could be possible with an internal gas target, and low energy proton-antiproton colliding beam physics is another option. By the time the full experimental programme takes shape, the physics potential could be out of all proportion to the modest size of the LEAR ring, with its circumference of only 78 metres, just one-eighth that of the PS.

Physics monitor

Contributing to the results on single photon production at the CERN ISR is Experiment R807, by a Brookhaven/CERN/Copenhagen/ Lund/Rutherford/Tel-Aviv collaboration. This uses arrays of Cherenkov counters, some of which are clearly visible on the right. In the foreground are the superconducting low beta magnets, a recent addition to the instrumentation at intersection 8.

(Photo CERN 397.10.80)



Photons from quarks

Quarks are electrically-charged particles, which like any others, should give off electromagnetic radiation (photons) when excited. But it is only in the last few years that such radiation has been observed. This radiation provides a very direct window on the interactions of the smallest components of matter.

In the usual interactions between hadrons, photon emission (by particles rather than quarks) is common enough, but as it is an electromagnetic process, the photons are produced less readily than strongly interacting mesons. In the violent reactions (characterized by large transverse momentum of the emerging fragments) which occur when the constituent quarks deep inside hadrons clash against each other, electromagnetic effects are still less copious than hadronic ones. However these hadronic processes typically produce 'jets' whose momentum is shared by many particles. The production levels of photons and one type of jet particle, say pions, could be more comparable. This has now been established in several careful experiments.

This quark electromagnetic radiation is characterized by a single photon which can be traced to an individual collision process (presumed to involve quarks and gluons). The extraction of this single photon spectrum from the raw experimental data is not easy. Typically it involves a careful sequence of successive subtractions in order to isolate a signal which derives only from single photon production.

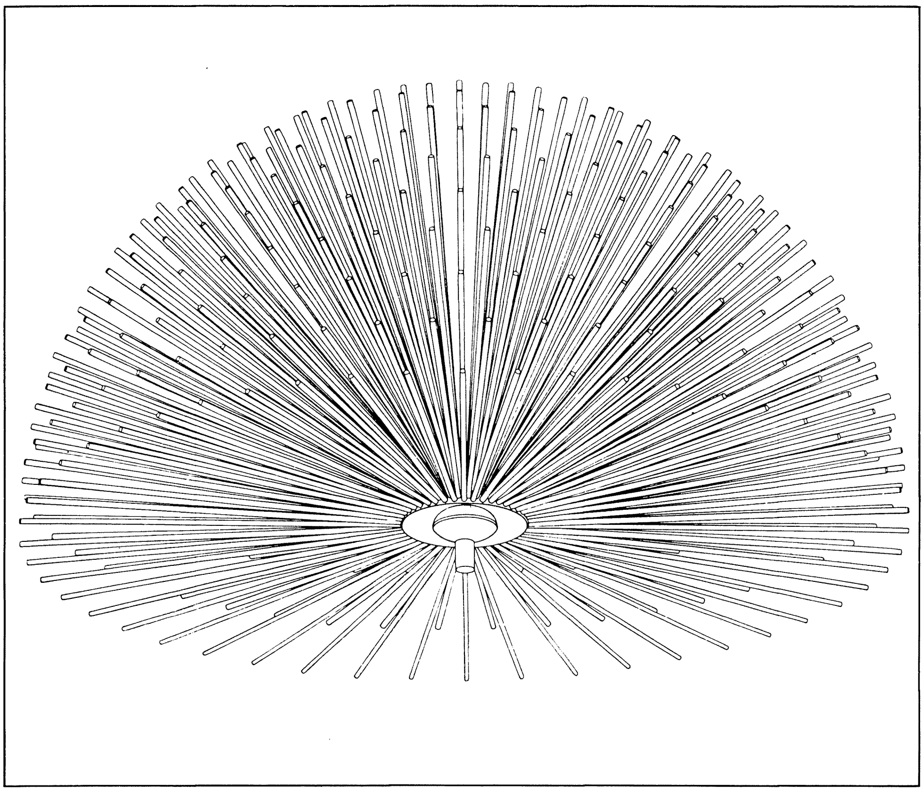
So far evidence has been seen at Fermilab by a Fermilab/Johns Hopkins collaboration and at CERN by three experiments at the Intersecting Storage Rings: Athens/Brookhaven/CERN/Syracuse (see June 1979 issue, page 153), Brookhaven/CERN/Copenhagen/Lund/Rutherford/Tel Aviv, and CERN/Columbia/Oxford/Rockefeller (following an earlier study by Adelphi/Brookhaven/Rome).

Most of the photons seen emerging from high energy scattering come in pairs from the decay of neutral mesons (pions or etas). Even photon pairs can fake single photon signals if one of the photons eludes the detector or if the two are so close together that the detector cannot resolve them. All these effects have to be carefully filtered out of the experimental data.

A bona fide residual signal of single photons is a direct probe of the behaviour of hadron constituents. The basic interaction (quark struck by gluon giving quark plus photon) provides an immediate lever on the distribution of gluons in nuclear matter, which otherwise is accessible only through more difficult measurements of fine structure. One problem is that complications may arise under the usual kinematical conditions. In particular, single photons may be produced by bremsstrahlung radiation from quarks, a process which is of only passing interest.

Additional clues on the underlying quark-gluon interaction mechanism could come by looking at the correlations between the single photons and the associated secondary hadrons. This study is still in its infancy, although analysis of the charge ratio of the produced pions seems to show that it is an 'up' quark, favoured by its charge and by its abundance in protons, which recoils against the produced photon and produces a hadron jet.

Further experiments to compare the single photon production by different particles would make useful contributions. Experiments with meson beams, and in particular with the proton-antiproton collisions soon scheduled for the ISR, will provide new sources of photons and will open up the study of gluon jets produced by quark-antiquark annihilations.



The aptly-named 'sea-urchin' optical sensor proposed for the DUMAND undersea neutrino detector project. A prototype has been built and tested.

The world's biggest neutrino detector

Since their discovery in 1953, most of the information on neutrinos has resulted from neutrinos produced either in the form of beams at accelerator Laboratories, or as a by-product of fission reactors. These neutrinos have produced some of the most important results in particle physics (see for example March 1978 issue, page 59).

In addition to these terrestrial neutrinos, there are also cosmic neutrinos, the study of which is still in its infancy. Our knowledge of astronomy stems from observations using various kinds of telescope to scan the electromagnetic radiation (visible light, radio waves, etc.) reaching the earth from outer space. After being confined for centuries to the visible spectrum, in recent years astronomy was able to make great progress following the development of large telescopes which could monitor the shorter wavelength radiation coming from outer space. Similar, if not greater, advances could be made by building suitable neutrino telescopes.

The trouble with neutrinos is that they are difficult to intercept. Even at high energies where the neutrino's affinity for matter is considerably increased, detectors have to contain tens, hundreds or even thousands of tons of material to provide a target which has a good chance of catching any.

For neutrino astronomy, one serious additional problem is posed by the muons produced by cosmic ray particles striking terrestrial or atmospheric targets. Although much less penetrating than neutrinos, high energy muons can pass through many metres of earth or rock. So far, experiments to detect cosmic neutrinos have usually been set up deep underground in mines to minimize contamination of the neutrino data by such muons.

A very different type of neutrino telescope is being investigated by an enthusiastic group based at Hawaii. Called DUMAND (Deep Underwater Muon and Neutrino Detector), it plans to exploit the most abundant material on the planet — seawater — as a neutrino detector. The interactions of cosmic neutrinos and seawater will be monitored by underwater light sensors which pick up the Cherenkov radiation given off by the collision products. This radiation is blue light, to which the water around Hawaii is unusually transparent. The detector elements have to be at a great depth to ensure adequate muon shielding.

Another possibility for monitoring neutrino interactions is to use acoustic detectors to pick up the tiny shock waves produced by the cascade of particles produced in the neutrino collisions. However it is thought that this technique would only be effective for neutrinos carrying more than about 10^{16} eV, as otherwise the sound of the collision would be lost in the general background noise.

As well as having a larger detector volume and good shielding, DUMAND will also be able to track the progress of the secondary particles, especially muons, produced in the neutrino collisions. In this way the direction of the incident neutrino could be deduced. As well as tracking neutrinos reaching the detector from above, DUMAND will also be able to pick up neutrinos from below which will have passed right through the earth!

At this early stage, no firm configuration for DUMAND has appeared, but the general idea is to mount strings of light sensors, with units some 50 m apart, above the ocean bed at a depth of several kilometres. The data would be fed through cables to an on-shore computer. For this ambitious project, the deep ocean basin, remarkably transparent water and local oceanographic expertise of Hawaii provide significant advantages.

One type of optical detector being considered for DUMAND is nicknamed 'sea-urchin'. It consists of a hemispherical photomultiplier mounted inside a pressure-bearing glass envelope and viewing an array of 'spines', each about two metres long and filled with fluorescing material. A prototype sea-urchin has been built and tested by the DUMAND team.

The first DUMAND trials, which could begin this year, would concentrate on muons rather than neutrinos. As well as testing out the optical sensors under real conditions, the plan is to suspend a string of optical sensors to measure the near-vertical muon intensity. A handy asset for this work is the availability of a drilling ship equipped with a central well, tower and winch to deploy the detector string.

In addition to this test of a muon detector string, imminent plans cover the development of larger phototubes and undersea cables, including optical fibre data-links.

If a big DUMAND assembly gets off the ground (into the sea!), it could mark the beginning of a new era in astronomy, and could lead to new discoveries about the furthest depths of the universe. A modest level of funding is assured for short-term developments, but ongoing work and more ambitious pilot projects would require an increased level of support.

People and things

An irresistible photograph: at a SLAC Christmas party, Laboratory Director Pief Panofsky was presented with a CERN T-shirt, which he promptly put on. With him in the picture are (left to right) Roger Gearhart playing a seasonal master of ceremonies role, J.J. Murray and Ed Seppi.

On people

Elected vice-president of the American Physical Society for this year is Robert E. Marshak of Virginia Polytechnic Institute and State University. He succeeds Maurice Goldhaber, who becomes president-elect. The new APS president is Arthur Schawlow of Stanford.

In the same elections, Columbia theorist Malvin Ruderman was elected to serve for four years as councillor-at-large.

Gisbert zu Pulitz, Scientific Director of the Darmstadt Heavy Ion Linear Accelerator Laboratory and Professor of Physics at the University of Heidelberg, has been elected as the new Chairman of the Association of German Research Centres (Arbeitsgemeinschaft der Grossforschungseinrichtungen in der Bundesrepublik Deutschland), succeeding Herwig Schopper. The Association includes the Jülich and Karlsruhe nuclear research centres, DESY, and the Max Planck Institute for Plasma Physics as well as other centres in the technical and biomedical fields.

Gisbert zu Pulitz

Moves at Brookhaven

Nick Samios, former chairman of Brookhaven's Physics Department, becomes the Laboratory's Deputy Director for High Energy and Nuclear Physics. Taking over from Samios as chairman of physics is Arthur Schwarzschild. Martin Blume becomes Associate Director for Low Energy Physics and Chemistry. His responsibilities will include the National Synchrotron Light Source.

Meanwhile Brookhaven Senior Physicist Ernest Courant has been elected Fellow by the Council of the American Association for the Advancement of Science.

LEP optimization

The detail of the LEP electron-positron storage ring project continues to be studied so as to optimize the machine parameters from the point of view of performance and of cost. This optimization stays within the description of Phase I of LEP which was agreed by the Member States at the CERN Council meeting in June 1980 (see September 1980 issue, page 255).

Some of the latest work has concentrated on the location of the LEP ring in the context of potential tunnelling problems which could be encountered deep under the Jura mountains. A modified lattice and r.f. tune have been suggested which permit a reduction in the machine's circumference from 30 to 27 km, while keeping the performance pa-

rameters of the machine intact. In this way tunnelling risks can be considerably reduced. The optimization was well received at meetings of the CERN Scientific Policy Committee, Finance Committee and Committee of Council at the end of February. More technical details will appear in a coming issue.

New theory centre at Weizmann Institute

The Weizmann Institute of Science in Israel has established the Albert Einstein Centre for Theoretical Physics with an endowment fund from the Federal Republic of Germany. Aimed at strengthening the ties and exchange of ideas between theoretical physicists from Israel and abroad, the Centre plans to host postdoctoral fellows and visiting senior theorists.

Winter institutes may also be set up, at which several people working in some specific area will spend several weeks together at the Institute. Subjects for these winter institutes will include particle physics.

New SLAC computer

After several years of planning, a major upgrade has now been decided for the central computer system at SLAC, presently based on IBM 360/91 and 370/168 machines. These will soon be joined by an IBM 3081 dual processor with 16 Megabytes of main memory. The capacity of the new system means that the 360/91 will probably be redundant this summer, two years ahead of the previous schedule. In addition to a new array of peripheral equipment, IBM 4341 machines have been selected for small computer systems. All the new equipment is scheduled to be installed by May.

Physics attraction at Brookhaven at the end of January was a highly topical workshop on neutrino oscillations, organized by CERN Courier correspondent Neil Baggett (left), and Nick Samios (right). Between the organizers in the photograph are three of the workshop session chairmen, left to right Hugh Williams, Fred Reines and Charles Baltay.

(Photo Brookhaven)

March saw the publication of the 100th volume of the journal Physics Letters B, which for many years has been the traditional channel for publication of many of the physics results obtained at CERN and other Laboratories. Physics Letters began publication in 1962, and in 1967 the decision was taken to split the journal into A and B editions, with Physics Letters A covering general, atomic and solid state physics, and B dealing with nuclear, elementary particle and high energy physics.

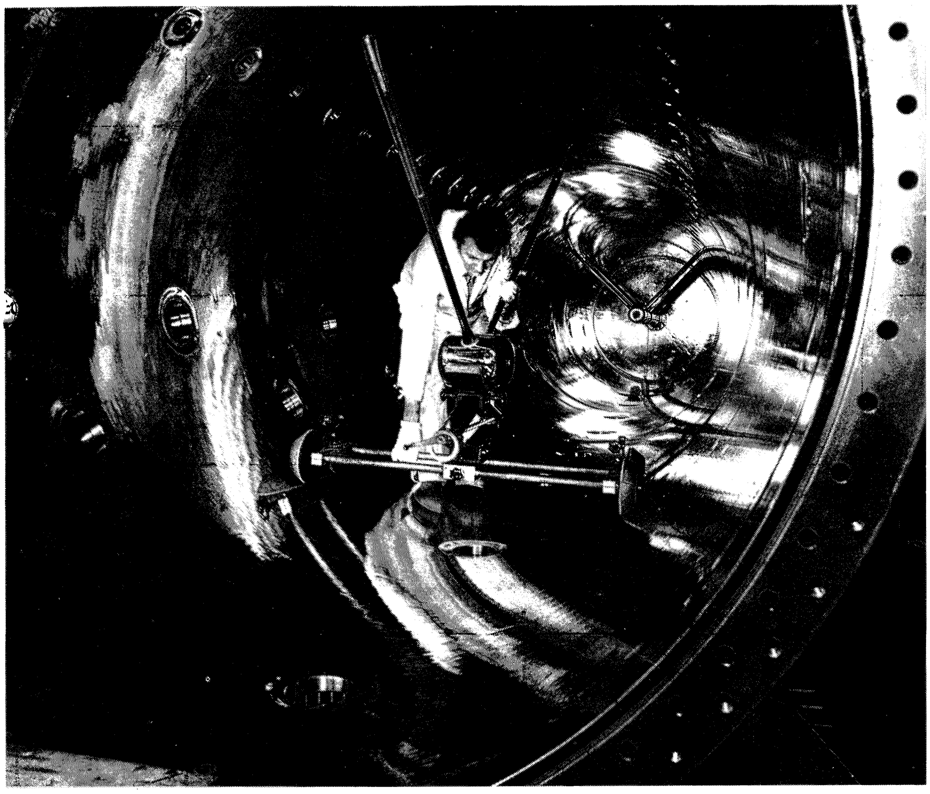
Fermilab Industrial Affiliates

Fermilab has established an Industrial Affiliate Programme designed to foster improved communication between the basic research carried out at Fermilab and in industry. The affiliate programme will acquaint the Industrial Associates with work at Fermilab through special seminars and publications. It is hoped that the Laboratory Scientists and Engineers will also profit through more general contact with industrial technology. Areas where contact should be particularly fruitful include extremely fast electronics, digital and analogue data processing, 'smart' triggers and microprocessing, large cryogenic systems, superconductivity, high voltage r.f., particle optics, and particle detectors.

The industrial affiliates include Bell Laboratories, Caterpillar Tractor Company, Chicago Bridge & Iron Company, Combustion Engineering Inc., Commonwealth Edison, Deere and Company, Digital Pathways Inc., General Electric Company, The Harshaw Chemical Company, International Business Machines Corporation, State of Illinois, International Harvester, Kinetic Systems Corporation, Lester B. Knight and Asso-

Two more Alvarez tanks have arrived at GSI Darmstadt and are presently being equipped with drift tubes and vacuum components. They will be installed into the linac tunnel later this year and will provide an additional 46 MV acceleration voltage, enabling the effective energy of the UNILAC accelerator to be doubled.

(Photo GSI – A. Zschau)



ciates Inc., Litton Industries, Nalco Chemical Company, Nuclear Data Inc., Raychem Corporation, Sargentn-Welsh Scientific Company, Shell Development Company, Standard Oil Company (Indiana), Texaco Inc. and Westinghouse Corporation.

Basic research activities in particle physics can influence industry, as is well demonstrated by the impact of modern applications of superconductivity to magnets. The intensive R&D effort in superconductivity at particle physics Laboratories in the later 60s and the 70s has had a significant effect on the development of the fledgling superconducting alloy industry. The greatest push to the industry came with the Fermilab decision to go ahead with the Energy Doubler/Saver.

Although the requisite alloys were then available, the industrial capability for making wire and cable was marginal. When Fermilab committed itself to the Superconducting Energy Doubler, it gave a new lease of life to the struggling wire and cable industry. The decision in 1976 to propose the construction of 1000 superconducting magnets involved vastly more wire than had ever been produced. Companies like Teledyne Wah Chang, Intermagnetics General Corporation, Magnetic Corporation of America, New England Electric, and AirCo developed improved superconducting alloys, wire, and cable. Fundamental requirements in subnuclear physics led to an industrial capability in superconductivity.

This capability could lead to applications in practical fusion power, superconducting transmission lines for efficient transport of electrical energy over long distances, and superstable, high-speed trains. Such trains, designed to go over 300 mph, have been modelled at MIT. Full-scale trains are planned in Germany and in Japan.

Super-strong magnetic fields have been proposed and tested in such diverse applications as iron ore separators, coal desulphurization, and water purification. They are employed in a wide variety of surgical aides. Compact motors and generators are being made. In short, whenever strong magnetic fields of large currents are required, superconductivity has potential application.

SLC Meeting

A further indication of the commitment of Stanford to the linear collider project (SLC) is the organization of a meeting on 25-27 March to inform the US high energy physics community of the progress of the project, to promote involvement in machine design and to indicate the experimental possibilities it will provide. The meeting is organized by the Laboratory and the SLAC Users Organization. It is hoped that working groups will be set up to tackle specific topics during the rest of this year (parametric design of detectors, review of detector technology, physics specifications for SLAC energies, polarization, logistics of having two detector systems, etc.).

Baryon Conference Proceedings

The Proceedings of the IVth International Conference on Baryon Resonances (Baryon 1980), held in Toronto in July 1980, are now available for sale in a paperbound volume containing almost a thousand pages of invited contributions on the status of baryon physics. The 45 papers cover a wide range of *topics, including the experimental status of non-charmed resonances and their couplings in various channels, observations of charmed baryons and the experimental status of multiquark baryons and other exotics, as well as the most recent theoretical developments in each of these areas. Major topics are summarized in contributions by J.J. DeSwart, M. Ferro-Luzzi, D.P. Gopal, A.J.G. Hey, R. Kelly, D.B. Meadows, and A. Yokosawa; the volume ends with a historical review by G. Zweig and the conference summary by H.J.Lipkin.*

The Proceedings may be ordered by sending a cheque for $40 (Canadian) payable to Baryon 1980 Secretariat, Department of Physics, University of Toronto, Toronto, Canada M5S 1A7.

The origins of the quark model

Although now firmly established as part of particle physics dogma, the quark model has had a somewhat chequered history. Before the discovery of the omega minus baryon in 1964, it had a particularly rough time. In an invited talk at last year's Baryon Conference in Toronto, George Zweig of Caltech reminisced about the early years of the model.*

He used a parable to describe the intellectual history of the model in its early days:
Man asked God for a riddle, and God obliged:
'What is green, hangs from a tree, and sings?'
This, of course, was a very difficult question.
So man asked God for the answer, and God replied:
'A herring!'
'A herring? But why is it green?'
'Because I painted it green.'
'But why does it hang from a tree?'
'Because I put it there.'
'And why does it sing?'
'If it didn't sing you would have guessed it was a herring.'

Describing personal landmarks in his early career, Zweig described as 'fantastic' a seminar given at Caltech by Gell-Mann on the 'Eightfold Way', the famous classification scheme for particles first published in preprint form in 1961. Although the discovery of the omega minus was at that time still three years in the future, Zweig thought that the classification into SU3 patterns was 'obviously correct'. By building on the successes of the particle classification schemes and maintaining a 'basic commitment to reality', his ideas crystallized.

Zweig's 'ace' model was described in an 80-page CERN preprint issued early in 1964, while Murray Gell-Mann's thinking on quarks was first presented as a paper in Physics Letters (an unusual medium for Gell-Mann at the time) at about the same time. It was in this paper that Gell-Mann introduced the now universally-used name borrowed from Irish novelist James Joyce.

Zweig spoke of his disappointment at the negative reaction of the theoretical physics community at the time to his model. One critic apparently described the ace model as the work of a 'charlatan'. The idea of hadrons containing smaller particles with fractional quantum numbers was somewhat unconventional at the time.

While free quarks have yet to be observed in high energy collisions and much still remains to be explained, the quark model is now one of the main pillars of our understanding. The tenacity of its early proponents has been vindicated.

* 'Origins of the Quark Model' by George Zweig, also published as DOE Research and Development Report CALT-68-805.

LEP proceedings

The Proceedings from the International Conference on Experimentation at LEP, held in Uppsala, Sweden, 16-20 June last year, have now been printed. They are being published in two volumes as the April issue of the journal 'Physica Scripta'. Participants at the Conference will receive by mail one copy free of charge. Extra copies can be ordered from Physica Scripta, The Royal Academy of Sciences, Publication Department, S-10405 Stockholm, Sweden, at the price of 550 Swedish Crowns (about 235 Swiss Francs) per copy (volumes 1 and 2).

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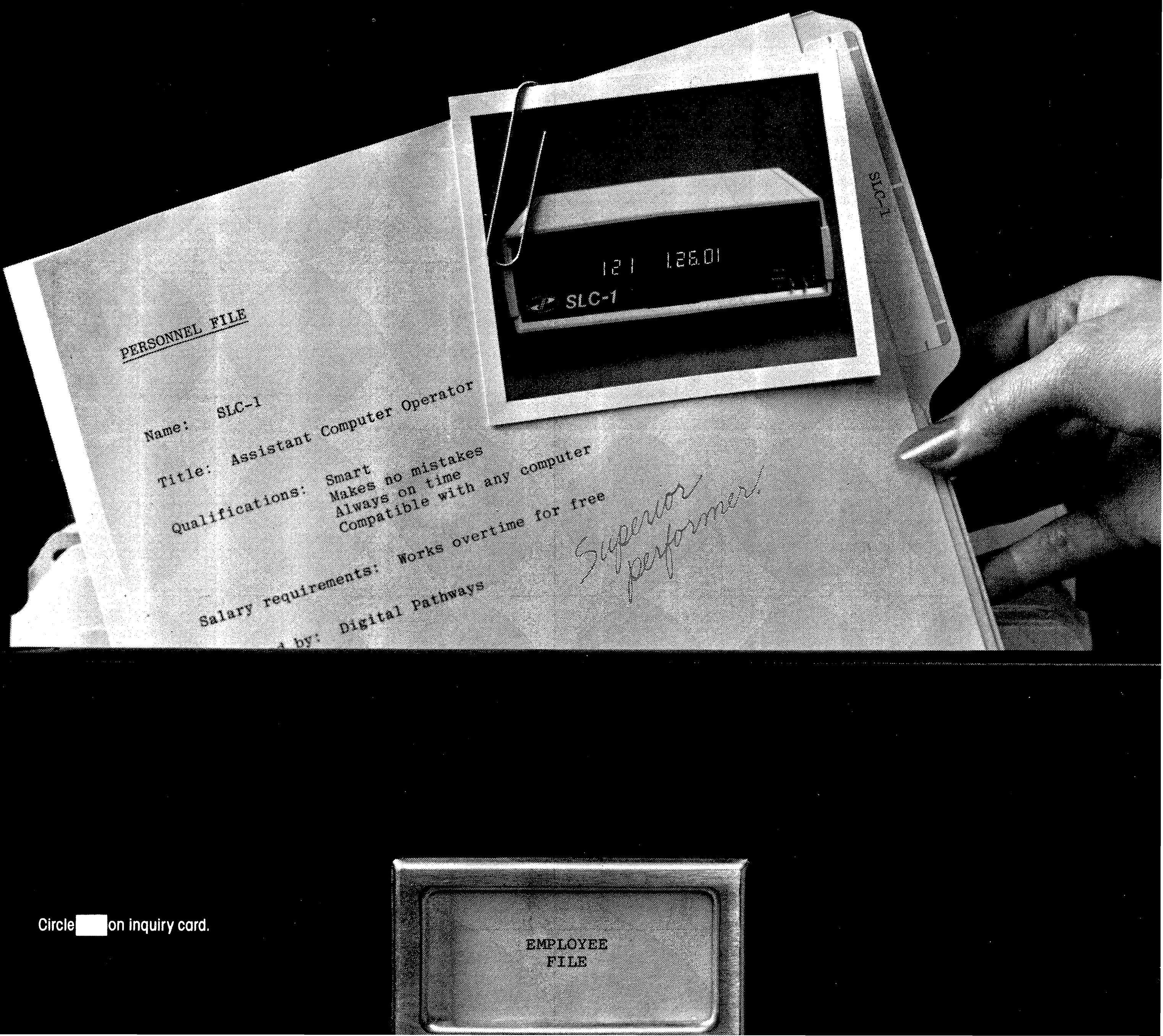

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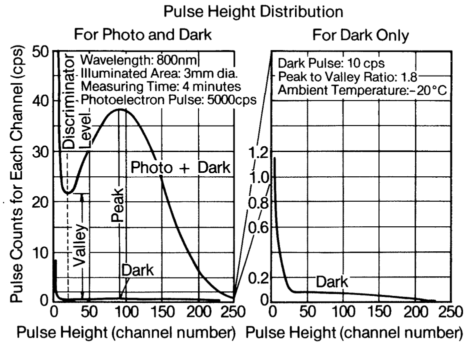

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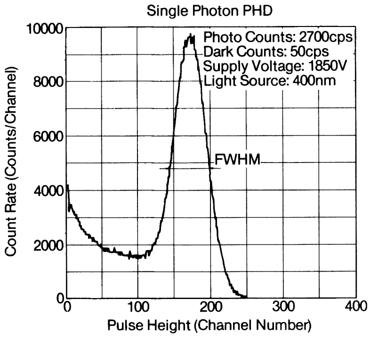
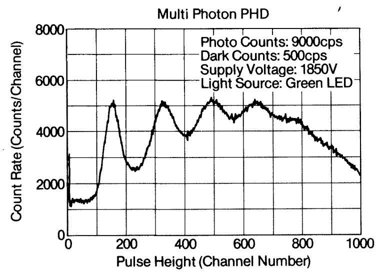
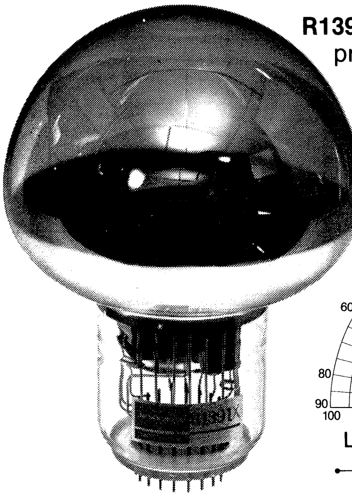


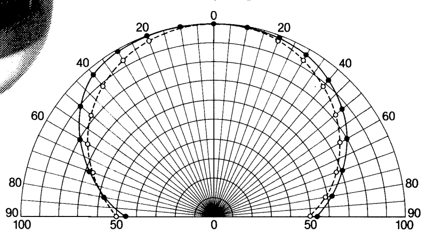


R1262—A GaAsP high gain first dinode PMT capable of excellent single and multi-photon discrimination.



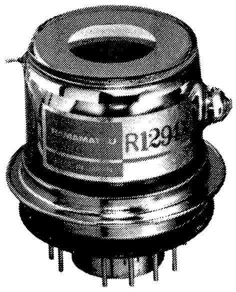
R1391—A 5″ hemispherical PMT providing good quantum efficiency, timing characteristics and light acceptance significantly greater than 2π solid angle.

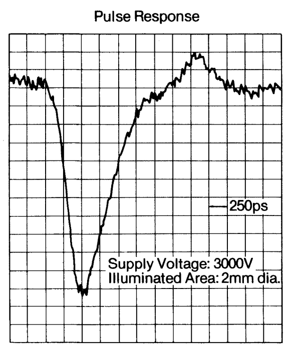
ANGLE (Degrees)



LIGHT ACCEPTABILITY OF R1391X

•—• measured ○----○ calculated





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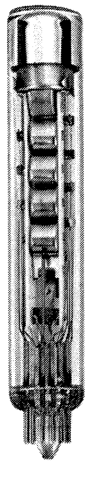

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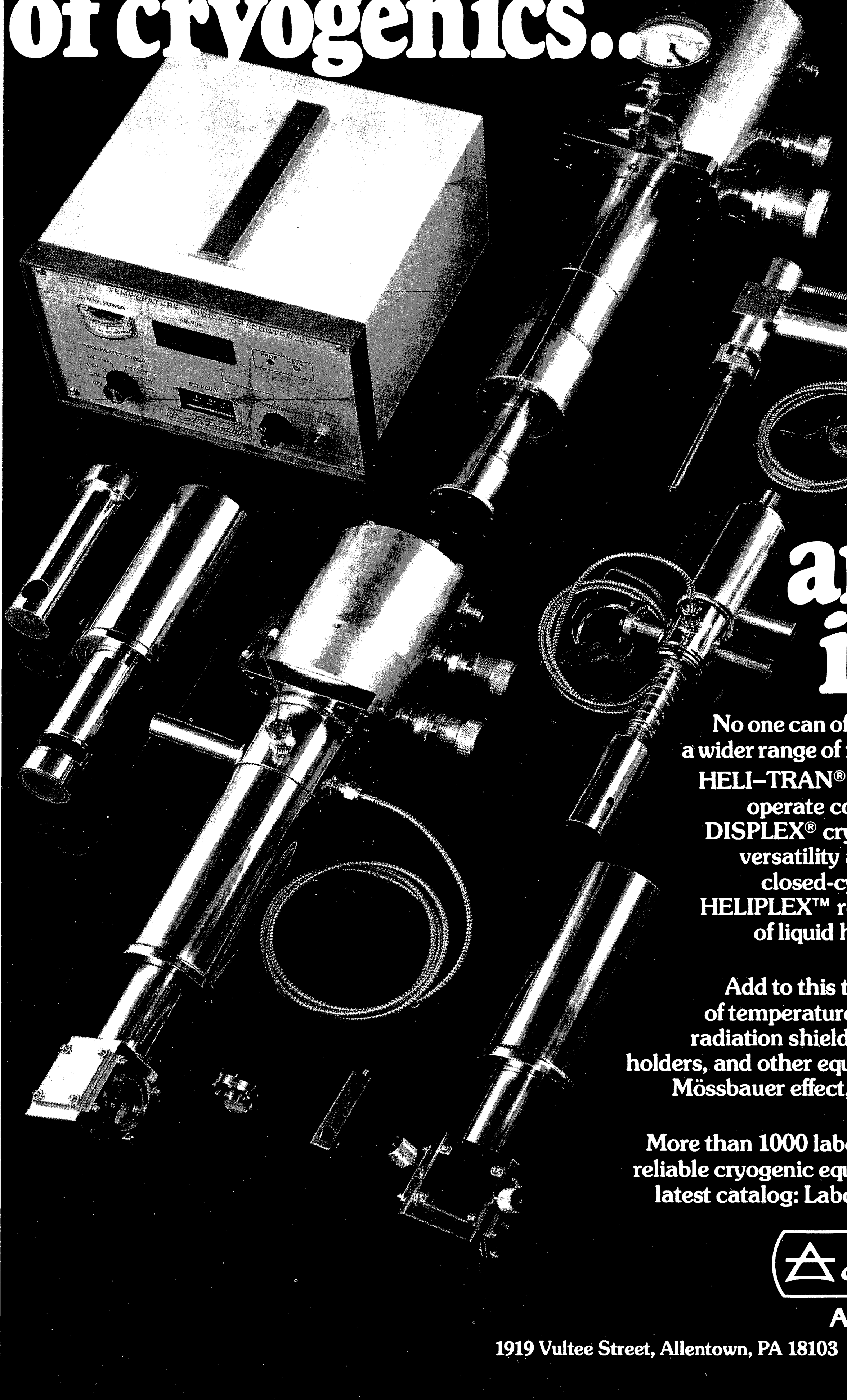

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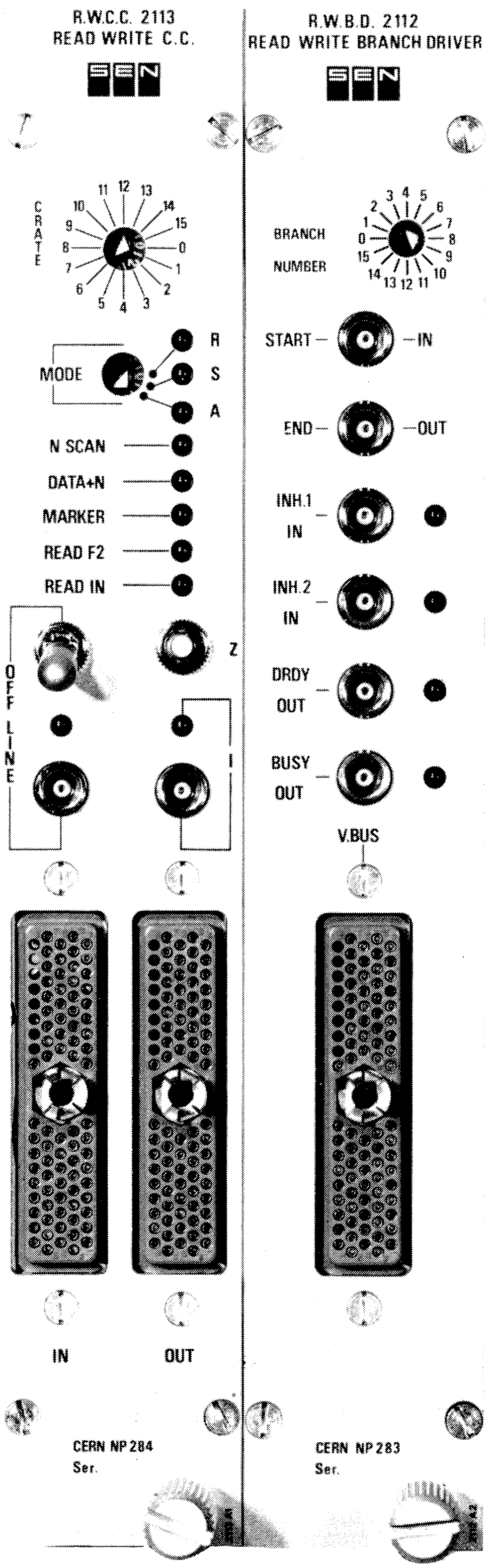

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Description

These modules are intended for use in large systems where large numbers of similar type modules are to be read as a block and where a minimum amount of program control is required.

The controllers and branch drivers form a subsystem located within a normal CAMAC configuration.

The data structure is defined by pointers (word counts) generated by the branch drivers, minimising software overheads.

By using 40 word FiFos in controllers and branch drivers a high data acquisition rate is obtained and data acquisition can occur before and during the opening of the DMA channel. All branches are activated simultaneously, hence slow modules e.g. ADCs with long conversion times can be situated in the farmost branches. Ideally, the process resolves to one of sequentially reading out the FiFos.

Several read modes are available:
Repeat Mode, Stop Mode, Adress Scan Mode and LAM Scan Mode.

Some write facilities have been added to allow pedestal control in ADCs.

The system is organised as a tree with branches and subbranches and can thus process data of very large systems.

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