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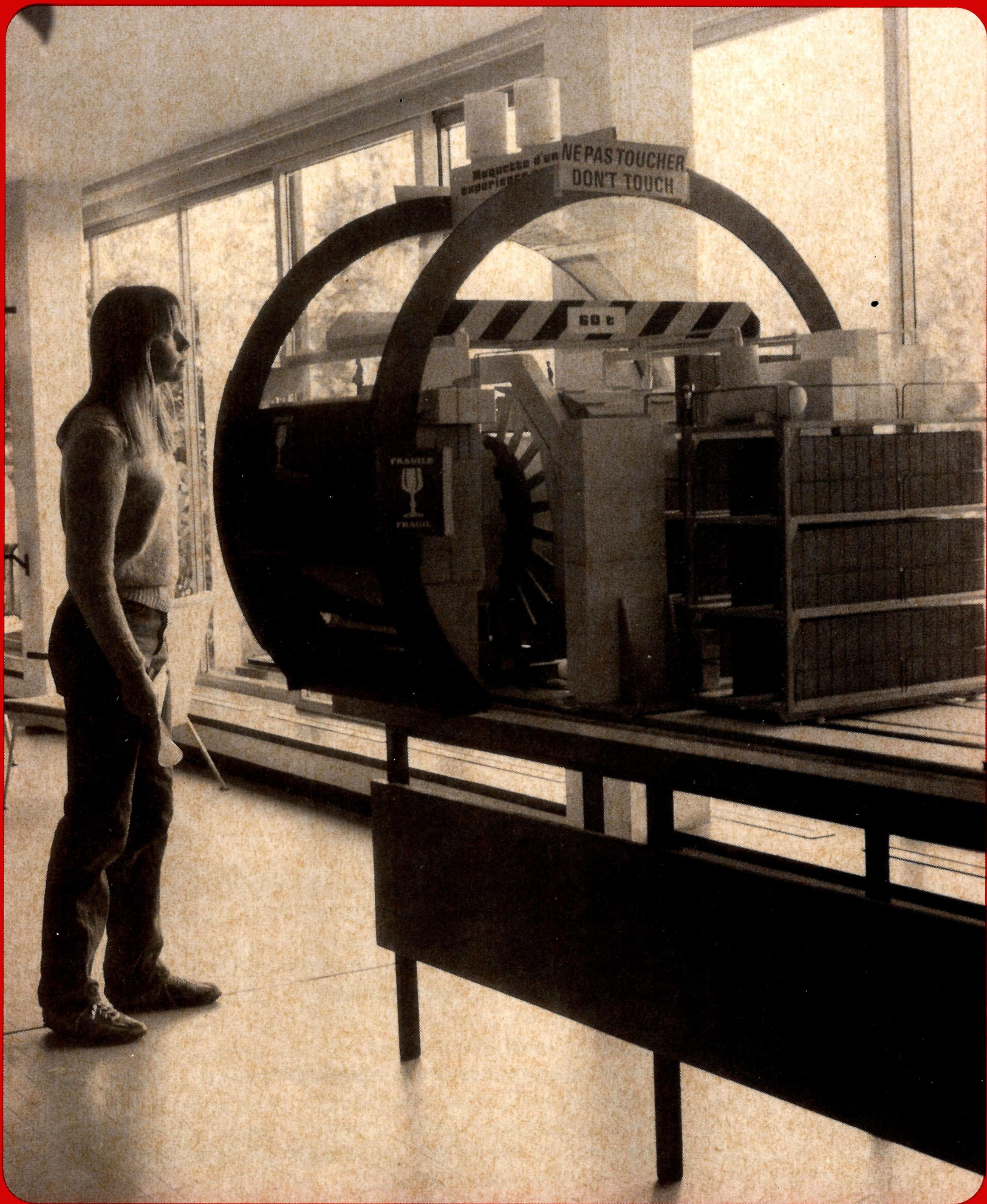

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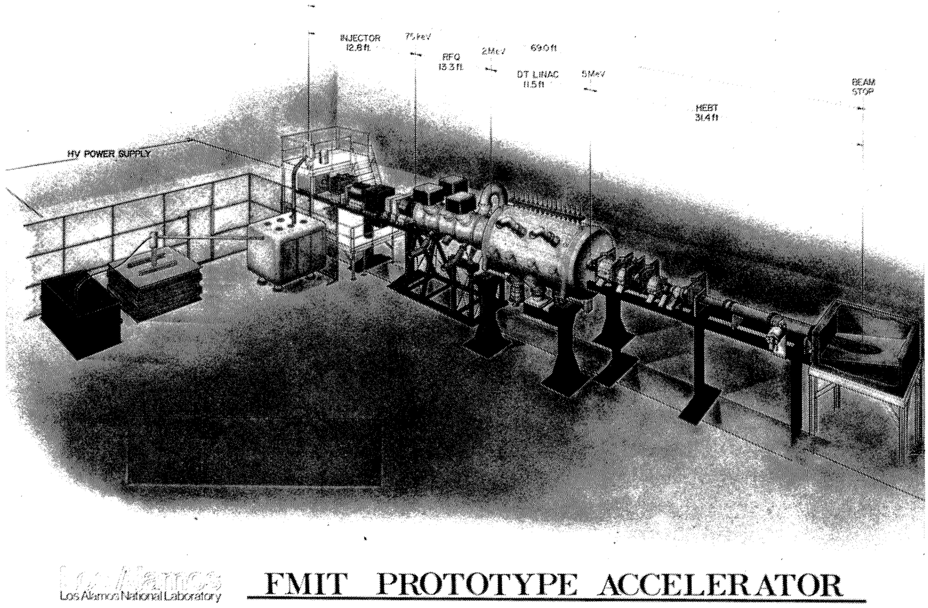
VOLUME 22 Nº 9 NOVEMBER 1982

Around the Laboratories

Cover photograph: Youth contemplates an idea for a physics experiment. A study from the recent highly successful 'Portes ouvertes' (Open Day) at CERN, which attracted many visitors to the site and the installations (Photo CERN 377.9.82).

Around the Laboratories

LOS ALAMOS Present projects in accelerator technology



Sketch of the Fusion Materials Irradiation Test (FMIT) project at Los Alamos. The idea is to accelerate an intense deuteron beam, subsequently stripped to obtain the same energy neutrons that emerge from fusion reactions.

The financial constraints of recent years have driven all the high energy physics Laboratories to cut back the resources they assign for accelerator technology to those directly related to the needs of their immediate projects. The financial flexibility of some years ago which allowed a modest amount of 'pure' accelerator research at most Laboratories has gone. This situation may seem necessary at the moment but, long term, could jeopardize the health of high energy research. The danger has been recognized, for example by the USA Committee led by Maury Tigner (see August 1980 issue, page 203) and ECFA also expressed its concern via the September Conference in Oxford on novel acceleration techniques.

One Laboratory which has managed to retain variety and search for novelty in its accelerator programme is the Los Alamos National Laboratory where a Division (until recently led by Ed Knapp who has now taken up a senior position in the National Science Foundation) was set up four years ago with the title 'Accelerator Technology'. The Division is contributing to several projects outside high energy or nuclear physics and has consistently looked for novel ways of achieving required machine performance.

Probably their most famous contribution emerged from the programme known as PIGMI (Pion Generator for Medical Irradiations) searching for a cheap source of pions for cancer therapy in hospitals. The programme itself is now in abeyance but among its technological developments was the demonstration of the abilities of radio-frequency quadrupoles, RFQs (see May 1980 issue, page 108). Based on a concept initially proposed by I.M. Kapchinskii and V.A. Teplyakov, RFQs give bunched, linac-quality, beams with high efficiencies and from low energies. This development is being taken up at many Laboratories — Brookhaven, CERN, Darmstadt, Fermilab, etc.... We now turn to some of the present projects of the Accelerator Technology Division to indicate the technological challenges now under investigation.

Fusion Materials Irradiation Test

One project, which has endured more than the usual share of oscillations in the USA funding cycles (the slope now being positive after passing through zero) is the Fusion Materials Irradiation Test, FMIT. Emerging from work at Brookhaven, the aim is to accelerate an intense beam of deuterons and strip them to neutrons which will have the energy of the neutrons which emerge from fusion reactions. The neutron beam can then be used to investigate the behaviour, under intense flux, of materials which might be used in a fusion reactor. Construction of the machine has been assigned to the Hanford Engineering Development Laboratory who have needed to lean on Los Alamos for accelerator expertise. The machine specifications are to accelerate 100 mA c.w. of deuterons to 35 MeV and to strip in a target of flowing lithium to yield intense fluxes of neutrons.

The Los Alamos work is at present concentrated on a 5 MeV prototype to handle 100 mA. It consists of a RFQ section taking the beam up to 2 MeV; this is under construction and should be in operation next Spring. If further funding becomes available a drift tube linac section will be added to extend the energy to 5 MeV by the fall of 1984. Hanford are building a prototype lithium target. The present project schedule hopes for beam from the completed FMIT in 1987.

Accelerator Inertial Fusion

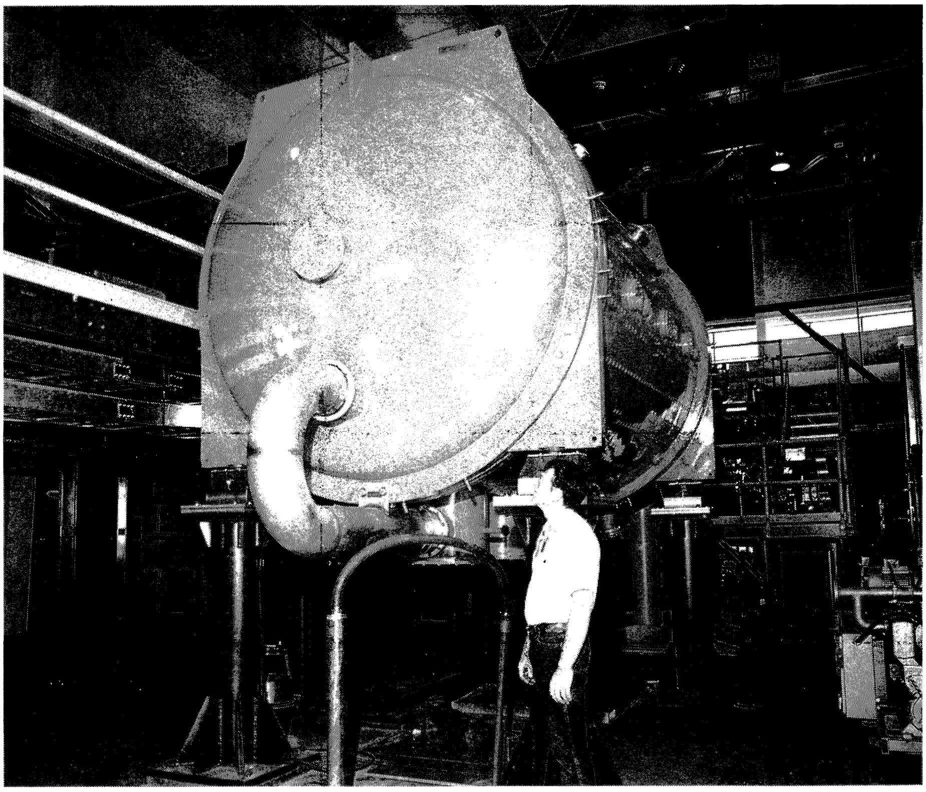
Another possible application of accelerators in the field of fusion is to achieve inertial fusion by bombarding pellets with intense beams of heavy ions. If inertial fusion is to be a successful route, it now seems more and more certain that ion beams will be used for pellet compression rather than lasers. However, even to test the feasibility of a heavy ion fusion reactor would require high investment in a prototype. Different approaches have been proposed at Berkeley (using induction linacs) and Argonne (using r.f. linacs). Los Alamos has been designated 'lead Laboratory' to investigate the field and to advise the funding agency on the optimum project. Here again there have been severe financial restraints and the name of the game has been changed to Accelerator Inertial Fusion, AIF, rather than Heavy Ion Fusion, HIF, perhaps for psychological reasons. Responsibility for the work will pass from the Defense to the Energy Department in 1983.

While Berkeley continues to pursue the use of induction linacs, Argonne has had to drop its programme and the Accelerator Technology Division at Los Alamos is therefore picking up the further investigation of r.f. linacs. The aim is to have a 'high temperature experiment' before the end of the decade with ion beams onto a target to heat matter to 50-100 eV. The design of the ion accelerator should ideally be in place before the end of 1986.

The Los Alamos initial contribution is to study the use of RFQs in high current designs, perhaps using other forms rather than the four-vane resonators, the necessary funnelling techniques whereby many linac beams will be brought together, the beam dynamics (with an attempt at three dimensional simulation of the intense space charge effects), the use of higher multipoles (rather than the usual quadrupoles) in beam focusing, and some ideas on heavy ion storage rings.

The linac tank for the Los Alamos Fusion Materials Irradiation Test (FMIT) project.

(Photo Los Alamos)



Free Electron Laser

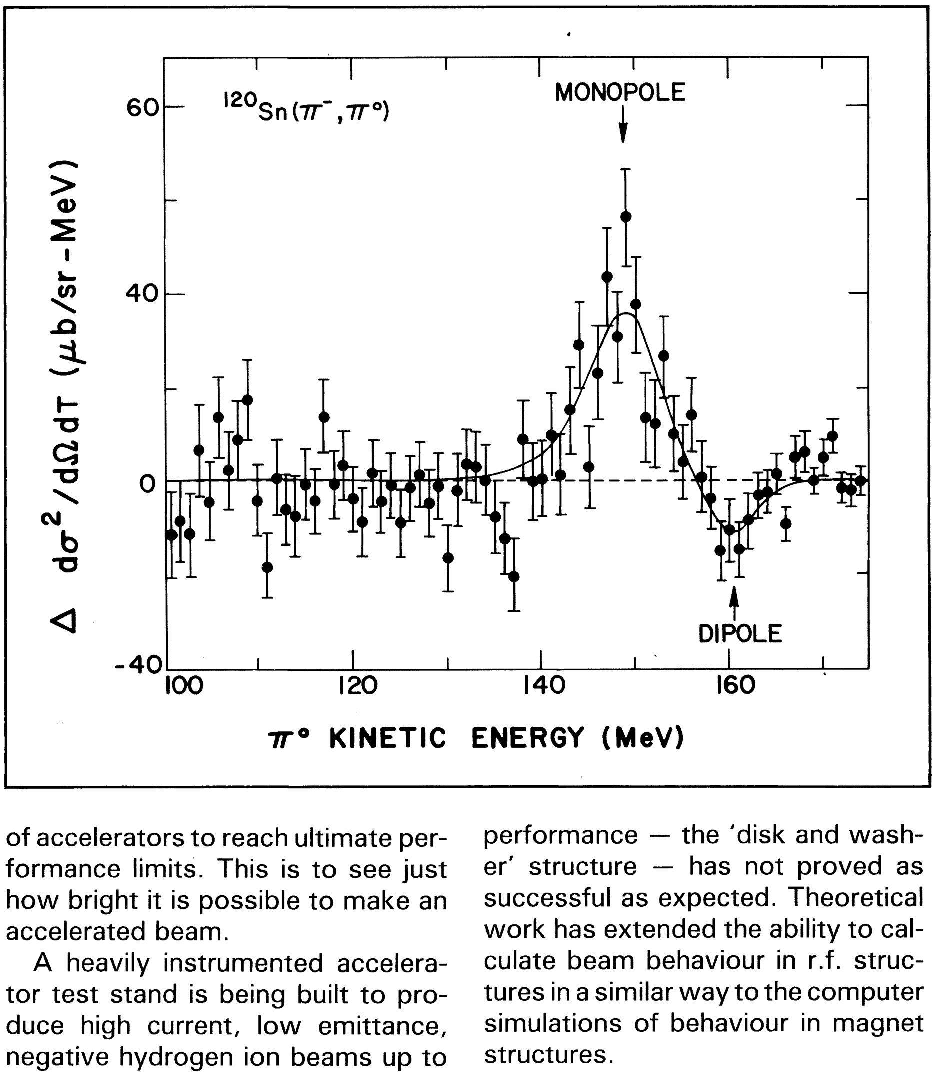
Work on a Free Electron Laser, FEL, began two years ago and very encouraging results have been obtained using a 20 MeV electron linac, a permanent magnet wiggler array and a pulsed carbon dioxide laser. The transfer of 4% of the electron energy to amplify the laser beam was clearly demonstrated. Inverse operation, accelerating the electrons by transfer of energy from the laser light, was also seen. The next stage will be to install mirrors to achieve operation as an oscillator. Later, recirculation of the used electron beam to give energy back to the r.f. system will be tried with the aim of reaching overall efficiencies in the region of 30%.

The potential abilities of free electron lasers in efficiency and in beam quality would represent a tremendous breakthrough in laser technology.

Other projects

The accelerator technology division has major responsibilities in the construction of the proton storage ring at LAMPF and in the preparatory thinking for the extension of the research abilities LAMPF II project (see October issue, page 324). There is also work on pushing the perfection

Difference between energy spectra at two different scattering angles for the charge exchange reaction of 165 MeV negative pions on tin 120 at Los Alamos, showing the well known giant dipole resonance and the newly discovered isovector monopole state.



of accelerators to reach ultimate performance limits. This is to see just how bright it is possible to make an accelerated beam.

A heavily instrumented accelerator test stand is being built to produce high current, low emittance, negative hydrogen ion beams up to 5 MeV. An RFQ structure is used and permanent magnet focusing elements are proving amenable to rather straight forward modifications to perfect their properties.

Other small-scale work includes a 185 MeV racetrack microtron project in collaboration with the National Bureau of Standards. This prototype will be used to judge the appropriateness of this type of machine for a 1 to 2 GeV nuclear physics facility.

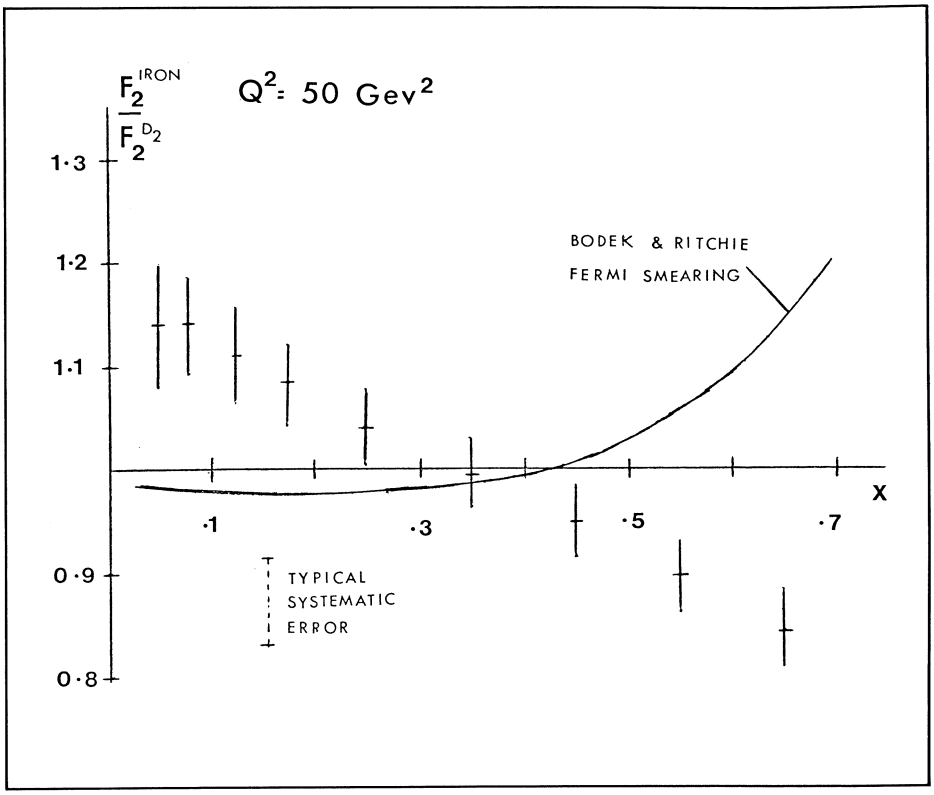
R.f. amplifier systems (klystrons and gyrocons) are under study with the aim of improving efficiencies. Different r.f. structures have been tried; a strong favourite for improved performance — the 'disk and washer' structure — has not proved as successful as expected. Theoretical work has extended the ability to calculate beam behaviour in r.f. structures in a similar way to the computer simulations of behaviour in magnet structures.

Nuclear monopole

In 1948 Goldhaber and Teller deduced from the resonance behaviour of photoabsorption cross-sections that the nucleus undergoes collective dipole excitations. The magnitude of the observed cross-sections showed that almost all of the possible electric dipole transition strength was concentrated in a single resonance. This fundamental mode of nuclear excitation, since called the giant dipole resonance, occurs in all nuclei having more than a few nucleons.

Extensive work using hadronic and electromagnetic probes has shown that the nucleus exhibits additional giant resonances. These excitations are characterized by isospin and angular momentum quantum numbers. For isovector resonances, such as the giant dipole, the neutrons and protons move out of phase, and for isoscalar resonances they move in phase. Giant resonances with angular momentum greater than zero are primarily surface excitations in contrast to monopole (zero angular momentum), modes which involve density oscillations of the nuclear interior. Thus the excitation energy of the isovector monopole is sensitive to the isovector compressibility of nuclear matter.

Before an experiment was carried out at LAMPF by a Los Alamos / Tel Aviv / TRIUMF collaboration, there was no direct evidence for the existence of the isovector monopole excitation. The absence of this state presented problems for theories of collective nuclear excitation. In order to produce an isovector excitation with a favorable signal-to-background ratio, it is necessary to have a probe that selectively excites either protons or neutrons. In first order the negative to neutral pion charge exchange reaction couples only to protons and produces only isovector excitations. The interior of the nucleus is black for resonant pions, so elementary scattering theory predicts that the maximum of the monopole angular distribution occurs in the forward direction. Therefore the experiment should detect forward scattered pions. The kinematics of the neutral pion to two gamma decay are attractive experimentally because decay photons can be detected outside the incident beam. The intense monochromatic negative pion beams available at the Low Energy Pion Channel (LEP) coupled to



Results from the European Muon Collaboration experiment at CERN, which uses high energy muon beams to probe the structure of nuclear targets. The F_2 structure function, which is a measure of the nucleon quark and antiquark content, has been measured using iron and deuterium targets, and the results show how the ratio of measured structure functions depends on x, the momentum fraction. This effect remains to be explained, even if it only turns out to be some systematic effect in the apparatus.

the neutral pion spectrometer (see June 1979 issue, page 156) are well suited to detect the isovector monopole resonance.

An experiment to search for the isovector monopole resonance was done at LAMPF last summer. Fluxes of greater than ten million negative pions per s in a one-MeV energy interval are delivered at the Low Energy Pion Channel. The beam energy was set at the delta resonance to maximize absorption. The spherical heavy nuclei tin 120 and zirconium 90 were selected because these are well studied by other reactions. It is expected that the excitation energy and the width of the resonance should decrease as the atomic number of the nucleus increases.

Data were taken over a range of scattering angle with two settings of the spectrometer. These data were sorted into angular bins to give six differential cross-section spectra as a function of detected pion energy. A feature of the data is that there is a peak in the forward-angle spectra which vanishes at larger angles. The signature for the resonance is seen by subtracting an observed energy spectrum from the forward spectrum. At most measured kinetic energies, the difference of the two measured spectra is consistent with zero, which suggests that the nonresonant background is isotropic. However two peaks are seen. One (negative) peak occurs at the energy of the well-known giant dipole resonance, while a positive peak occurs at the expected energy of the isovector monopole. From an analysis of the other spectra, the angular distribution of the positive peak has a maximum in the forward direction as expected for a monopole. The size of the cross-section is close to the value predicted by the isovector monopole sum rule, indicating the collective nature of the state. The excitation energy for the monopole peak in zirconium 90 is slightly higher than that for tin 120, as predicted by the hydrodynamic model estimate of the excitation energy.

Further studies are planned for later this year to determine the systematic behaviour of the monopole resonance, as well as other isovector resonances. The discovery of the monopole resonance is a triumph for nuclear physicists working at medium energy accelerators since the special properties of the pion are used to elucidate previously unknown features of nuclei.

CERN
Hints from high energy muons

The two experiments using the high energy muon beam from the SPS 400 GeV proton synchrotron have some indications of interesting new effects which could have significant implications for our understanding of particle interactions.

Upstream in the beam is the European Muon Collaboration spectrometer. As well as the muons scattered from the target (hydrogen, deuterium or iron) the hadrons produced are also measured in the spectrometer which has recently been modified by incorporating a large aperture vertex magnet and detector (see January/February issue, page 4).

From measurements made with this apparatus, physicists have obtained the quark distributions (structure functions) of the different targets. Recent results seem to indicate that there is a systematic difference between the structure functions measured in iron and in deuterium. The quarks in iron do not behave like those in deuterium. Initial efforts to explain this in terms of the normal internal motion of the nucleons (Fermi motion) do not work, in fact going in the opposite direction, and the effect remains to be explained. Final checks prior to publication of the result are now in progress.

While the target of the European Muon Collaboration is only a few metres long, the downstream experiment of the NA4 group (Bologna / CERN / Dubna / Munich/ Saclay) has a carbon target 40 m long, surrounded by a toroidal spectrometer which traps the scattered muons.

With this long target, the chances of encountering rare types of collisions between muons and nucleons are considerably increased. The muon cannot interact through the strong nuclear force, and the observed behaviour is due mainly to the electromagnetic force. (There is an additional contribution from the weak force, see January/February issue, page 5.)

The HOBC holographic bubble chamber used at CERN. The visible volume, filled with freon, is a third of a litre. This is the first time that holographic techniques have been used to collect physics data.

The conventional interpretation of collisions between muons and nuclei is in terms of the interactions of muons with individual moving nucleons. These nucleons are trapped in nuclei and their position is restricted. The Uncertainty Principle says they therefore must possess a certain amount of momentum. Preliminary indications from the NA4 experiment show a higher rate of larger nucleon momenta than would be expected on the basis of the simplest theories. However quantitative conclusions await further data analysis to separate any effect from potential sources of background.

Whatever the final explanations of these two effects, the results obtained so far only heighten the current interest in experiments which probe the nature of nuclear matter. Interesting results have been obtained over a wide range of energies and experimental conditions.

40 000 holograms

Holographic techniques are among the new tools being exploited in the continuing study of short-lived particles. In September, the first holographic bubble chamber experiment took physics data. The NA25 study (a Bari / Brussels / CERN / Mons / Paris / Strasbourg / University College London / Vienna collaboration) had a successful run at the SPS 400 GeV proton synchrotron. A total of 40 000 holograms of high energy particle interactions were taken. These will be used to study the production of charmed particles in hadronic interactions.

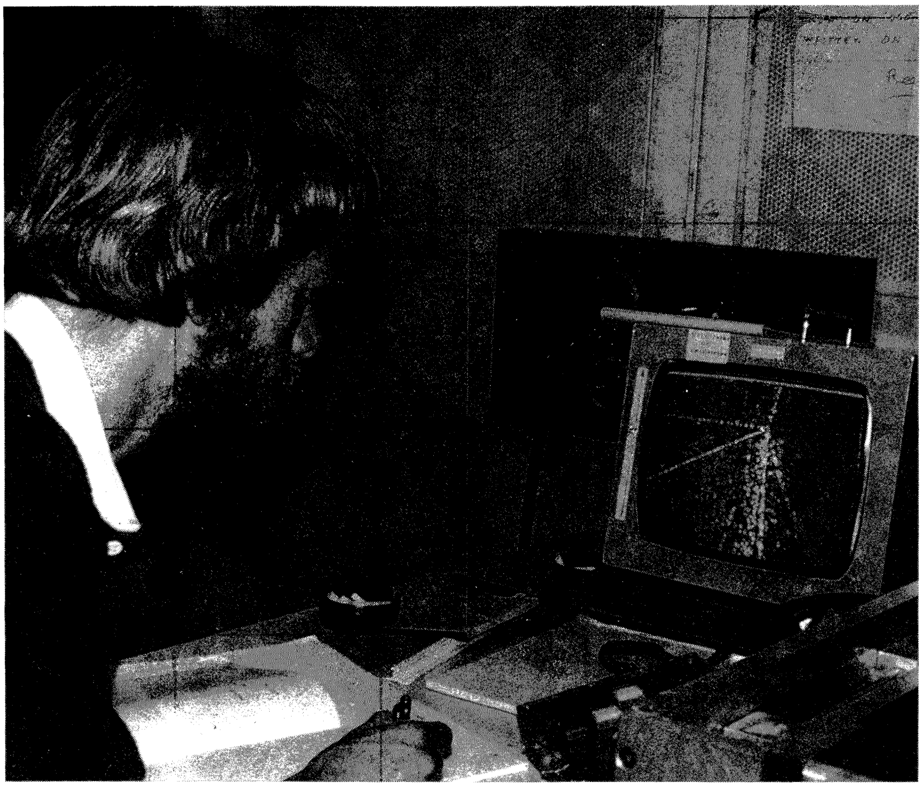
Data were taken at 360 and 200 GeV incident momenta. The aim of the experiment is to determine the total charm cross-section at each energy, and consequently its energy dependence.

The great advantage with holographic recording is the very large depth of field. For a spatial resolution of about 10 microns, the depth of field with classical optics is a fraction of a millimetre, while for holography, events in the whole bubble chamber are correctly recorded. With classical optics the incident particles all have to lie inside a very narrow band, while for holography they can be spread in the whole chamber. This makes it possible to fill the chamber with many more particles.

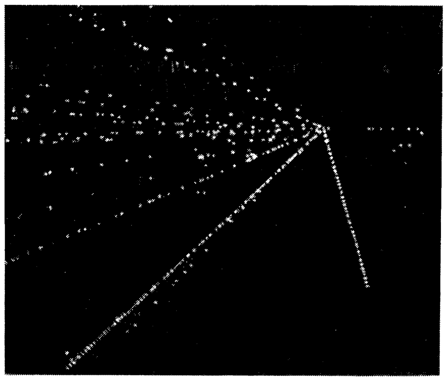
During the last two years tests with holography have been made in several small bubble chambers. The first holographic recording of bubble chamber tracks was in 1980 at the SPS, using the BIBC chamber. A year later the NA25 experiment had a holographic test run with the HOBC chamber, during which some 12 000 holograms were accumulated. Of these only a small fraction employed a muon trigger and could be used for the study of charmed particle production. Tests of a variety of different optical arrangements have been made both in HOBC and in the hydrogen bubble chamber HOLEBC (Experiment NA26).

HOBC (a small two-litre chamber) was specially built for in-line holography in the NA25 experiment. It is a see-through chamber with two high quality optics windows. It was filled with the heavy liquid freon and was heated to a temperature of 53°C. The chamber was expanded at a frequency of 10 Hz (limited by the time necessary to dissipate the heat due to the recompression of the bubbles from the preceding expansion) thus producing 26 expansions per SPS cycle. During the run the chamber was expanded 2 million times.

The small dimensions of the chamber (the visible volume is 5 x 6 x 11 cm^3) and the compact thermal shielding resulted in a very neat chamber which simplified the instal-



Scanning on holograms in situ. The event seen on the TV screen covers 1.4 mm in space.



A blowup of an event contained in a 2 mm length. Bubble size is 10 microns and there are more than one hundred bubbles per centimetre.

lation of the optical elements needed for an optimal recording of the holograms. Illumination was provided by a two-stage laser. The holographic arrangement used was of the in-line (or Gabor) type using one laser beam through the chamber. Bubbles in the chamber caused some of the light to scatter, while the majority went straight through the chamber to provide the reference beam. The scattered light interfered with this to produce the hologram.

The quality of the hologram depends very much on the distance from the bubble chamber to the hologram, especially when there is turbulence in the liquid. In order to artificially reduce this distance some lenses were used to produce an image of the bubbles at a distance of around 5 cm from the hologram. This image rather than the tracks themselves was then holographed.

A muon trigger was used to enrich the number of events with charm particles. Immediately downstream of the chamber a 1.8 m iron dump with a core of tungsten was situated. Further downstream was the muon detector, composed of layers of iron, scintillators and proportional wire chambers of the old NA19 experiment.

The beam intensity was typically 80 particles per bubble chamber expansion. Particles arriving before and after the useful part of the bubble chamber sensitive time were removed from the beam with a kicker magnet in order not to clutter up the picture unnecessarily. For special test runs the number of beam particles per expansion was as high as 200, but to obtain very good pictures, the time between expansions had to be increased. The holograms taken were usually of very high quality. The bubble size was typically 10 microns and the bubble density was about 100 cm^{-1} for the beam particles.

Film test strips were rapidly developed and scanned at the experiment in order to get fast feedback for the picture quality. During the setting-up

Holography

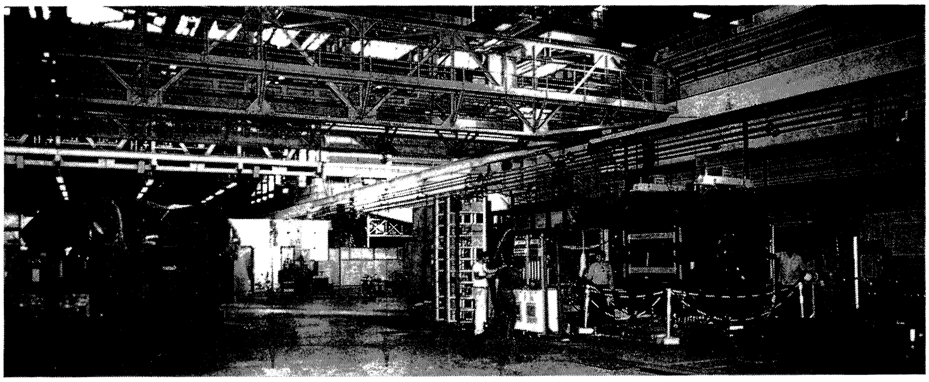
A hologram contains the interference pattern of two light waves — a plane wave that serves as reference and which does not contain any information, and a spherical wave (or a superposition of several spherical waves) caused by light scattered by an object. The information about the object is stored in the hologram as interference fringes.

When a hologram is illuminated by a laser beam (a plane reference wave) then the object wave is reconstructed, giving a real and a virtual image of the original object. The two images can be seen in three dimensions by an observer. Usually the real image is first magnified and then either recorded photographically or projected on a screen or a TV camera. The image is scanned in depth by moving the recording plane.

* *The LEAR ring had its first antiprotons on 11 October.*

A view of the experimental area for the new LEAR Low Energy Antiproton Ring at CERN. The available space will soon be filled by the 16 experiments in preparation.

(Photo CERN 127.7.82)



phase this was one of the most important activities, but once the production was started the main aim was to verify that the stable running conditions were maintained. For this fast scanning of holograms, the Bari scanning table was used. This compact device is the only portable holographic scanning table in the collaboration (and probably in the world!). Also the CERN scanning and measuring machine HOLMES was used to determine the optimal working conditions.

Holographic recording of the bubble chamber picture can easily permit 80 to 100 incident particles per bubble chamber expansion. This dramatically improves the possibility of studying event configurations with very small production cross-sections if the bubble chamber is combined with a suitable enriching trigger. At the same time a spatial resolution of around 10 microns is obtained — ideal for charm and maybe good enough for beauty.

LEAR workshop *

With the commissioning of the LEAR low energy antiproton ring imminent (see September issue, page 272), attention turns naturally to the range of new physics which is opened up by this unique machine.

Earlier this year, a workshop on LEAR physics was held at the Ettore Majorana Centre in Erice. With 100 participants from 45 institutes in 11 European countries plus Canada, the USA and the USSR, it reflected the interest in this new sphere of study.

Presentations on the machine itself set the scene. The remainder of the programme covered the physics, including the theoretical motivation and progress reports on the 16 LEAR experiments in varying degrees of preparation (see April 1981 issue, page 113).

In its initial form, LEAR will provide low energy antiproton beams to fixed target experiments. However future developments were also aired — co-rotating antiproton and negative hydrogen ions to produce protonium atoms for precision spectroscopy; an internal gas jet target for precision scattering; contra-rotating proton and antiproton beams for charmonium spectroscopy; an additional smaller ring to attain energies down to 200 keV, and lots, lots more.

The image of the LEAR physics programme emerging from the workshop was a lively one. The range of studies too is impressive — searches for glueball states; meson and baryon spectroscopy; searches for new quark states and for structures in the nucleon-antinucleon system; study of annihilation dynamics; precision measurements on protonium; elastic scattering; specific annihilation channels with a polarized target; the possibility of using a polarized antiproton beam; production of antibaryons; antiproton reactions with nuclei.

As well as opening up a new field of study, the compact LEAR ring seems to offer excellent research value for money in these cost-conscious times.

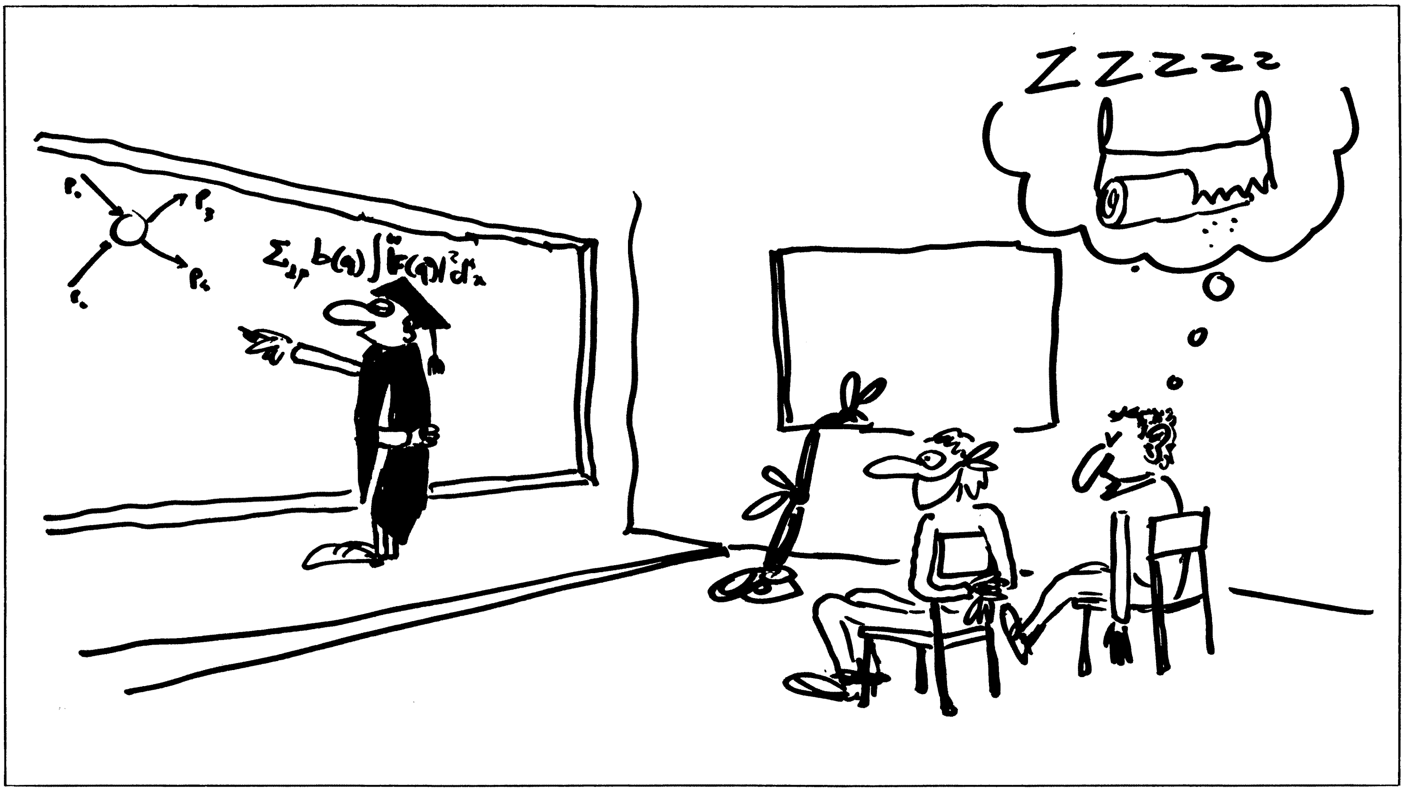
(We thank Ugo Gastaldi for providing us with this information.)

School of Physics...

The venerable University of Cambridge (UK) provided an interesting and unusual setting for the 1982 CERN School of Physics, held from 5-18 September, with financial support from the Rutherford Appleton Laboratory. The lectures took place in the Department of Applied Mathematics and Theoretical Physics while all participants were accommodated in Pembroke College, one of the oldest Colleges (founded 1347).

The main lecture courses were 'Introduction to gauge theories' by B. de Wit (NIKHEF-H, Amsterdam); 'Fundamentals of QCD' by J. C. Taylor, (Cambridge); 'Applications of QCD' by P. V. Landshoff, (Cambridge); 'Unification and grand unification' by R. Peccei (MPI, Munich) and 'Experimental tests of gauge theories' by G. Barbiellini (INFN, Frascati and CERN). In addition, C. Michael (Liverpool) spoke on 'Lattice gauge theories', H. G. Fischer (CERN) spoke on 'Physics of Detectors' and J. D. Dowell (Birmingham) on 'Proton-antiproton physics'.

In the afternoons, the presence of ten discussion leaders made it possible to divide the 70 students into several different groups to clarify points arising out of the lectures. This feature of the CERN Schools seems to play an increasingly important role. An evening poster ses-



A student's view of the recent CERN School of Physics, held in Cambridge, UK, by Dario Menasce.

sion was a great success.

The less formal part of the programme included a lecture by a former 'Brain of Britain', Henry Button, who spoke on 'Cambridge, Past and Present', stressing its fundamental differences with its traditional rival, Oxford; together with talks on 'The History of the Appearance of Particles' by Sir Rudolf Peierls and on 'Astrophysics and particle physics' by Martin Rees.

Visits were made to the New Cavendish Laboratory, and to the Radio-Astronomy Laboratory at Lords Bridge, as well as to Kings College Chapel, Ely Cathedral and the mediaeval village of Lavenham.

Many students found living in an old college to be a rewarding experience although a few found the conditions a little spartan. The food was plentiful and served at the evening formal dinner with a startling rapidity! For the record the 70 enthusiastic students of 18 different nationalities are working presently in nine CERN Member States and three non-Member States. The Director of the School was Peter Landshoff of Cambridge, assisted as Deputy Director by John Ellis of CERN, while Tom White of the Cavendish Laboratory very efficiently organized the visits and took care of many matters behind the scenes to ensure the smooth running of the School.

... and School of Computing

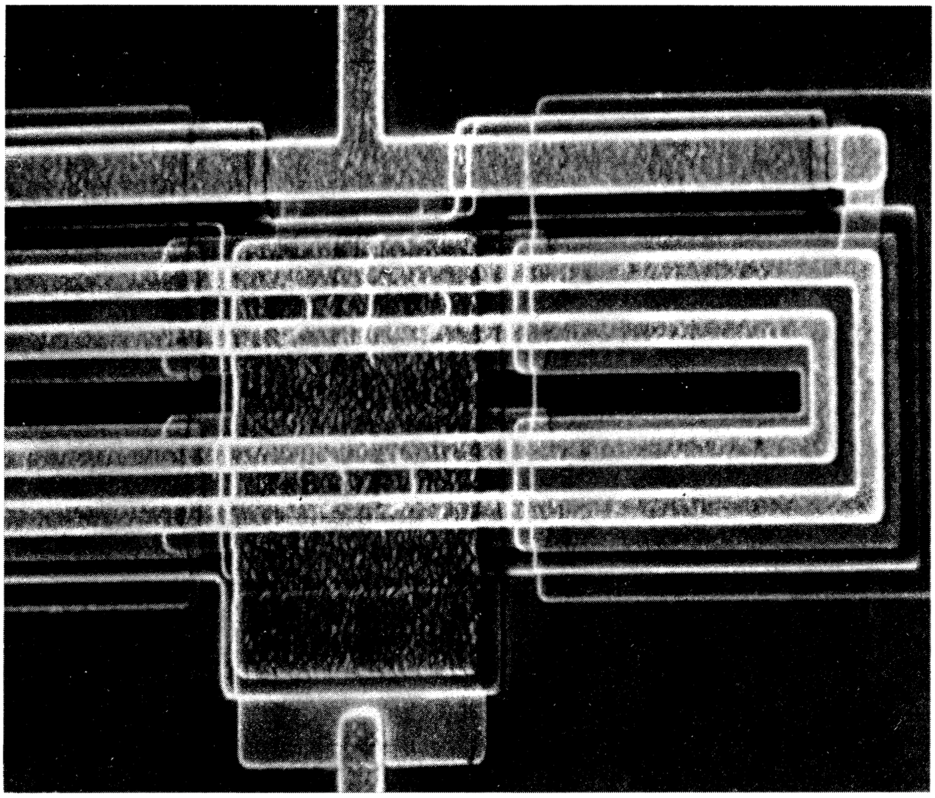
These days, computing is an intrinsic part of nearly every aspect of high energy physics. With this in mind, the aim of the recent CERN School of Computing, held in Zinal, Switzerland, was to make young physicists more aware of computing, and to inform computer specialists about recent advances in techniques.

This School was the seventh in a biennial series, and was the first time it had been held in Switzerland. On this occasion, some very welcome financial support was received from the Swiss authorities. The school was attended by about 50 students, mostly from CERN Member States, and staffed by internationally-known lecturers.

To fulfil its objectives, the School programme included both survey courses on topics of widespread use in the community, and subjects of more recent development. An important aspect of the choice of subjects was that there should be an appropriate balance between physics and computing. Thus there were courses on triggering and filtering for collider experiments, on programmable digital micro-circuits, and on bus systems for distributed computing. All these are of interest not only to those involved in the present gen-

A scanning electron micrograph of a superconducting binary logic circuit based on the Josephson effect, one of the exciting new developments discussed at the recent CERN School of Computing.

(Photo IBM)



eration of collider experiments, at CERN and elsewhere, but also to all those now thinking about experiments at LEP. In addition, there were courses on computer graphics, on numerical and computational aspects of linear equations and matrices, and on algorithms and data structures. Programming and command languages is a topic of great importance at the moment in high energy physics, and this was also included in the curriculum. The question of the future of FORTRAN and of ADA aroused particular interest.

A number of subjects were discussed which were not familiar to most participants in the School, but which could be of importance in the future. Among these was the question of parallelism and array processing, and program validation. Another of the topics was that of robotics in an industrial environment.

The School lasted for two weeks and the programme was a very full one, both from the standpoint of formal lectures and of the discussions which took place. Judged by any standards, the School was highly successful, well attended, topical and useful. Among students and lecturers it was unanimously felt that in view of the rapid pace of developments in both physics and in computing, never was the need greater for a School of this type, and they hoped that this would not be the last.

CORNELL
Studying upsilon decays

The wide fourth upsilon state discovered at the CESR electron-positron ring at Cornell decays into beauty mesons, composed of beauty quarks combined with lighter quarks. Beauty mesons in turn decay through the weak decay of the beauty (b) quark. In the standard, six-quark model of the weak decays of quarks, the b quark decays into the more common 'charm' (c) and/or 'up' (u) quarks. This model does not specify the relative proportions of $b \rightarrow c$ and $b \rightarrow u$ decays; this ratio has to be determined by experiment.

The lepton spectrum in semileptonic B meson decay is an excellent source of information on the $(b \rightarrow u)$ / $(b \rightarrow c)$ ratio. The momentum distribution of the produced lepton will depend on the mass of the accompanying hadrons. When b decays to c, these hadrons will contain a c quark, so the hadronic mass will be at least as large as the D (charmed) meson mass. On the other hand, when b decays to u, the hadronic mass can in principle be as small as the pion mass. Since the total energy of the B meson is about 5.3 GeV, the 1.9 GeV mass of the D meson greatly limits the maximum possible energy available for leptons associated with $b \rightarrow c$ decay. The observation of leptons with higher energy would be evidence for the decay $b \rightarrow u$.

The CUSB (Columbia / Stony Brook / Louisiana State / MPI-Munich) collaboration has measured the electron energy spectrum for B meson decays using the good electromagnetic calorimetry of their sodium iodide/lead glass detector. The CLEO (Cornell / Harvard / Ithaca College / MIT / Ohio State / Rochester / Rutgers / Syracuse / Vanderbilt) group has measured both the electron and muon spectra in their drift chamber. In the CLEO experiment, electrons were identified in ionization chambers and electromagnetic shower counters, and muons were identified in drift chambers placed outside of iron absorbers.

The CUSB energy spectrum of electrons from B meson decay falls very much on top of the prediction for b → c, and an upper limit of 9 per cent is obtained for the ratio b → u/b → c. By studying how the results depend on the mass of the u quark hadrons, the CLEO group finds that the results are insensitive to masses below about 1 GeV. Upper limits for the ratio of branching ratios of 9 per cent are obtained by the CLEO group from both their muon and their electron spectra.

These three measurements establish that the b quark decays predominately into c quarks, rather than u quarks. This results in a significant improvement of our knowledge of the parameters of the six-quark model. With the larger data samples that will become available, is should be possible to measure the b → u fraction from the lepton spectrum.

STANFORD
Anniversary time

Five physicists whose work spans fifty years of experimental and theoretical study in particle physics spoke at the recent multiple anniversary celebration of the Stanford Linear Accelerator Center.

This multiple anniversary marked 35 years of electron linacs, 25 years since the launching of the proposal for the SLAC linac, 20 years since the beginning of the linac construction, 15 years since the linac achieved its design energy, 10 years of SPEAR operation, and 5 years since the beginning of PEP construction.

Edward Ginzton traced the beginnings of the linear accelerator work at Stanford from ideas of young students with $100 to spend on materials, to the famous klystron tubes which have found great use in radar and other microwave work, to a section of accelerator which could be carried on a man's shoulder, to the Mark 3 Linac at Stanford used by Robert Hofstadter in his Nobel prize winning study of the structure of the proton, and finally to the beginnings of the Two Mile Linac with the announcement of support for the project by President Eisenhower in 1957.


George A. Keyworth, Science Adviser to President Reagan and Director of the President's Office of Science and Technology Policy, speaking at the SLAC anniversary — 'a deep personal pleasure to pay tribute to the powerful impact this excellent laboratory has had on the world's science'.

SLAC Director Pief Panofsky continued the story through the years of construction of the enormous project which was 30 times larger than existing machines of the kind. Many problems broke new ground in areas requiring the cooperation of the university staff with industry. New ways of managing the powerful beams of up to one megawatt were needed.

James Bjorken, now at Fermilab, reviewed the theoretical and experimental work which has resulted from these intense electron beams. A series of theories were used to understand the ways in which electron and photon beams actually probe the structure of matter. Much of this culminated in the understanding of the unexpected results obtained with SLAC's giant spectrometers in electron scattering on hydrogen. This led to the parton picture of pointlike constituents in the proton and neutron.

Burt Richter discussed the invention of storage rings with its beginnings as the Princeton-Stanford electron rings on the campus. The technique of colliding beams has proven enormously useful to particle physics and has spawned nearly 20 machines of increasing size. The most prolific has been SPEAR, a ring built at SLAC in 1972. Richter shared the Nobel prize of 1976 for his work in the discovery of the charmed quark and the development of this new technique. A new kind of machine using the colliding beam idea is now being planned at SLAC so this study can continue past the present practical limits.

Sidney Drell presided over this symposium on electron physics. Theoretical work by Drell has been very important both in the exploitation of secondary particle beams as well as in understanding many of the experimental results. As Deputy Director of SLAC he heads the theoretical section, which has students and researchers from around the world.

Accelerator Summer School

Approximately 150 physicists and engineers from the United States, Canada, Europe and Asia spent two weeks at SLAC in the Second Summer School on High Energy Particle Accelerators. The school was sponsored jointly by the US Department of Energy (DOE), the US National Science Foundation, and SLAC. M. Month of DOE was Chairman of the Organizing Committee and G. Loew

Physicists who spoke at the recent multiple anniversary ceremony at SLAC, left to right, Edward Gintzon, Sidney Drell, James Bjorken, Burt Richter, 'Pief' Panofsky.

(Photos Stanford News and Publications Service)

of SLAC was the school's director.

The school was divided into 12 morning lectures and 7 afternoon seminars with time out in the early afternoon for study and informal discussion. The lectures covered the principles of linacs and synchrotrons, lattice and magnet design, beam instrumentation, new methods of acceleration and new accelerator technology, the beam-beam interaction and coherent beam phenomena, and computer techniques in accelerator design. The afternoon talks covered the application of these tools and principles to current and planned machines including colliders, hadron and lepton, linear and circular.

M. Veltman surveyed the theoretical landscape for points of reference to machine builders. He concluded that we are facing an energy curtain which has been raised beyond the first two families of quarks and leptons and almost past the third. The top quark and the W, Z boson family is still behind. Detailed study of the Z should be possible in 5 to 7 years in the US and Europe. At that point experiment has caught up with theory. The next questions probe the domain of ignorance: how many families of quarks and leptons are there, and which of the several mechanisms of Higgs particles, technipartictes and so on, if any, are responsible for curing the unacceptable high energy behaviour of the postulated vector bosons? There is much talk of the 'desert' in which there is little happening beyond the Z and W until extraordinarily high energies. Veltman noted that this is another name for lack of knowledge and imagination and said we must explore the particle spectrum above 100 GeV up to 1 TeV. This requires electron-positron collisions of 1 TeV and proton-antiproton at 10 TeV.

Pief Panofsky presented his perspectives on accelerators at the opening of the conference. He concluded that the candidates for the coming generation of very large circular proton-antiproton colliders, and very large r.f. supplied linear colliders for several particle combinations look both practical and extremely promising. The generation after next looks very difficult, and the talents of the accelerator physicists are needed more than ever to enrich the technology, to keep the enterprise going, and to make the great inventions.

Bob Wilson described thinking towards a 20 TeV synchrotron. The conceptual study foresees 'superferric' magnets using superconducting coils within an iron yoke. This was described at the recent American Physical Society's meeting at Aspen (see October issue, page 332). The radius of such a machine would be

25 miles (!) and magnets would have to be extruded like toothpaste. In characteristic indomitable mood, Bob Wilson said 'when we're ready for a 20 TeV accelerator, yes we can build it'. He also voiced the opinion that the students at the school would build a 100 TeV machine and get results, but not using any of the techniques being described at the SLAC school.

One of the afternoon study periods was enlivened by a film showing the computer simulation of wake field patterns with electric field lines snapping along discontinuities in several beam structures. The film was created by Tom Weiland about two years ago while at Los Alamos. It was called back for several encores.

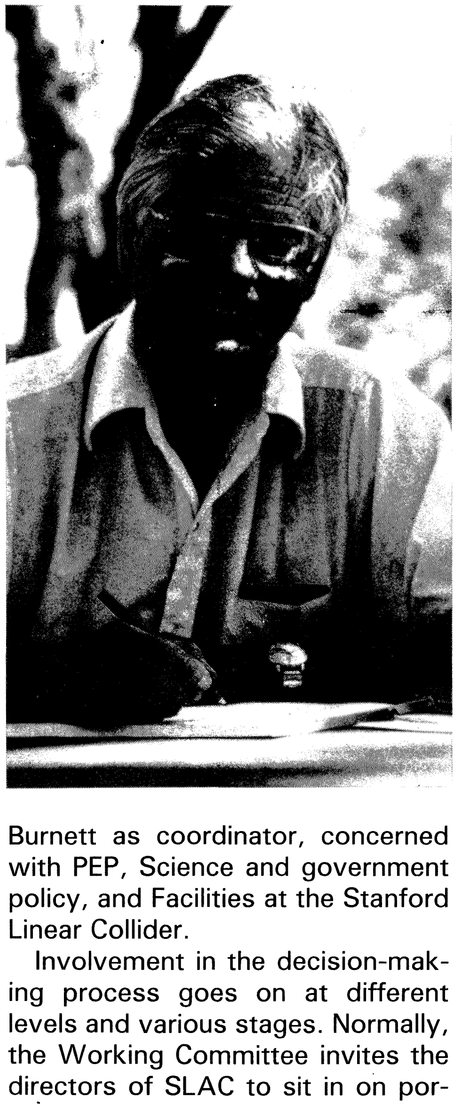
SLUO anniversary

In addition to the many other Stanford based anniversaries this year, the SLAC-LBL Users Organization (which suffers the abbreviation SLUO) is also celebrating ten years existence since it was initiated by R. Lauder in 1972. It now groups thirty-five universities and institutes (including Stanford and Berkeley) with about 500 physicists. SLUO is a channel of user communication to the managements of the two Laboratories, eases the involvement of university scientists in projects at the Laboratories and helps the flow of information from the Labs to the users.

SLUO is not a 'creature' of the Laboratories as many user groups are, but is funded by the participating Universities and Institutes. A Working Committee with representatives from all the participating institutes meets about five times a year. The Chairman, at the time of writing is David Pellett and Bruce Barnett is the Secretary and Treasurer. At present there are subcommittees, with Toby Burnett as coordinator, concerned with PEP, Science and government policy, and Facilities at the Stanford Linear Collider.

Bob Wilson at the recent SLAC Accelerator Summer School — 'when we're ready for a 20 TeV accelerator, yes we can build it'.

(Photo SLAC)



Involvement in the decision-making process goes on at different levels and various stages. Normally, the Working Committee invites the directors of SLAC to sit in on portions of meetings where information and opinions can be freely exchanged. Often, the issues and concerns to the user community which are brought up and discussed on these occasions are resolved during these discussions. Other items of concern are communicated directly to the appropriate people in the Laboratory. In addition, the chairman of SLUO often presents user points of view to the various advisory committees of SLAC including the Scientific Policy Committee. SLUO has been actively involved in many of the policy decisions at Stanford.

BROOKHAVEN
Preparing for polarized protons

The project to accelerate polarized protons in the Brookhaven Alternating Gradient synchrotron is well advanced and a call for proposals to use this unique facility has been issued. (Interested experimenters should make contact with Derek Lowenstein at Brookhaven.)

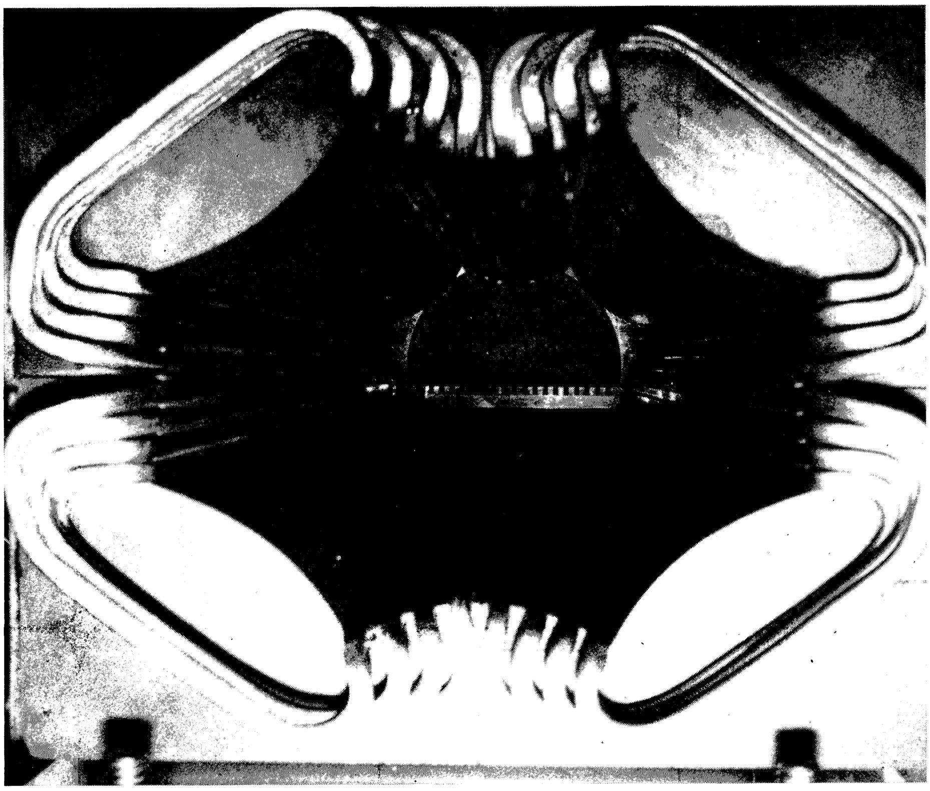
The major items of the scheme are the polarized source, a radio-frequency quadrupole (RFQ) pre-injector, polarimeters and quadrupoles to jump depolarizing resonances. These are being prepared in collaborations involving Argonne / Brookhaven / Michigan / Los Alamos / Rice / Yale.

The polarized source is being developed to provide negative hydrogen ions at 20 keV via the interaction of caesium ions with polarized neutral hydrogen atoms. The AGS has been converted for negative ion injection and the proton source has been taken out. This will give a brighter beam and possibly higher intensity for normal proton beam operation. With the polarized beam it is hoped to reach around 10 μA from the source in 500 ns pulses which is the maximum pulse that the linac can take. The use of an RFQ preinjector, rather than the conventional Cockcroft-Walton, avoids the complex source being up at high voltage. The aim is to have the RFQ ready for May 1983. By then a polarimeter will be installed at the end of the 200 MeV linac to allow continuous monitoring of the polarized beam.

In the AGS the beam has to be manoeuvred through eight intrinsic resonances and many imperfection resonances (due to magnet misalignments etc.). The latter can be dealt with by existing dipoles (though the process may initially be rather te-

The Michigan pulsed quadrupole for the Brookhaven AGS polarized beam. The hyperbolic ferrite poles and coils form a very symmetric pattern. The AGS polarized protons will pass through 12 of these quads in order to 'jump' the depolarized resonances.

(Photo Brookhaven)



dious) but the intrinsic resonances need twelve additional special quadrupoles installed in the AGS ring to provide Q jumps. The quadrupoles themselves have been built. They require rather unconventional power supplies allowing them to be turned on in less than 2 μs and their currents then to be sustained for some 3 ms. This involves a combination of thyratrons for fast turn on and large ignitrons to take over the long current pulse. Production of these supplies will start in January of next year for installation in the autumn. The quadrupoles themselves, plus aluminized ceramic vacuum chambers are being installed now.

An internal polarimeter will be installed in the AGS at the end of this year and an external polarimeter with two large spectrometer arms will provide an absolute measurement which will also serve for calibration of the other two polarimeters. The research programme with polarized protons is scheduled to start in 1984.

GOESGEN
Looking for neutrino oscillations

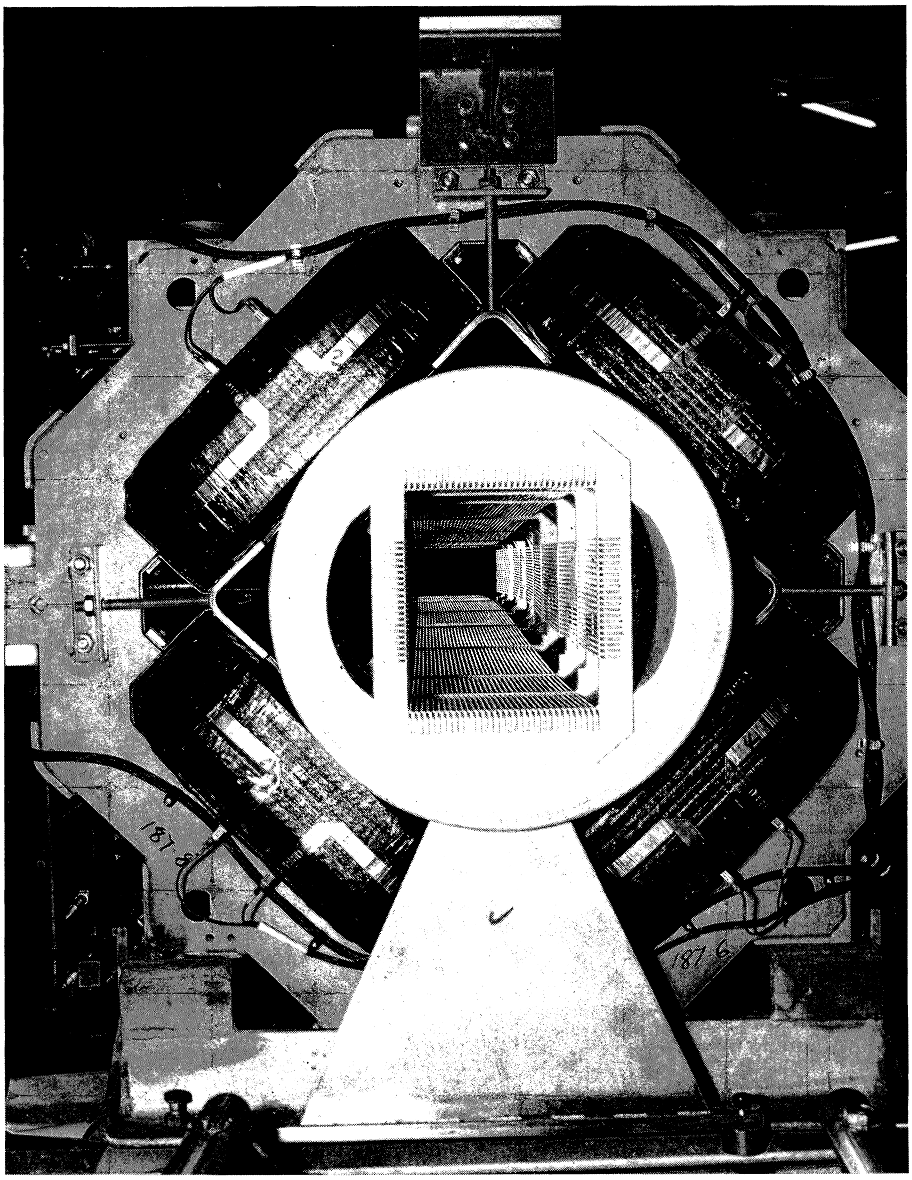
A team from Caltech, SIN and Munich Technical University has recently produced new results on the much discussed subject of neutrino oscillations. (There are several types of neutrinos, once thought to be immutable. However there is a possibility that these different types of neutrinos could interchange roles, albeit at a very low rate.) Indications of such oscillations came from earlier work at the Savannah River reactor and from the continuing measurements of the solar neutrino flux in the Homestake Mine experiment.

The measurement was of the rate at which the electron antineutrino interacts with a proton to give a positron and a neutron. It was essentially an extension, with an improved detector and with better statistics, of a previous experiment carried out at the Institut Laue-Langevin, Grenoble. The neutrinos came from beta decays of fission products from the Swiss Goesgen light water reactor. The protons were contained in 377 litres of liquid scintillator, which also detected the positrons and moderated the neutrons.

Neutrino production in the reactor is well understood and the absolute energy spectrum of the emerging neutrinos is known to an accuracy of a few percent. The cross-section for the reaction can be found from weak interaction theory and hence the dependence of the rate of the reaction on the distance from the reactor core can be predicted. If the neutrinos oscillate or disappear in any way at all, the observed and predicted rates will differ.

During a six month period, the experimenters were able to record some 11 000 neutrino events with the apparatus set up at a distance of 37.9 m from the reactor core. The ratio of the observed to the predicted event rate was 1.05 ± 0.02 (statistical) ± 0.05 (systematic). Hence the result is consistent with there being no neutrino oscillations, and sets new limits on the relevant oscillation parameters. The measurement is being continued at a distance of 46 m to improve the sensitivity.

The results of these searches have wide implications, extending from particle physics to theories of solar evolution and beyond to questions on the possible gravitational closure of the entire universe. This is an impressive contribution from a modest experiment at a power station in a small country on a minor planet of a typical star in an average galaxy!



The first quadrupole shield for the Rutherford Appleton Laboratory's Spallation Neutron Source fitted into its ceramic vacuum chamber. This is a tricky job, and having mastered the technique for straight sections, the next task is to deal with the more difficult curved dipoles.

(Photo Rutherford)

RUTHERFORD Neutron source components

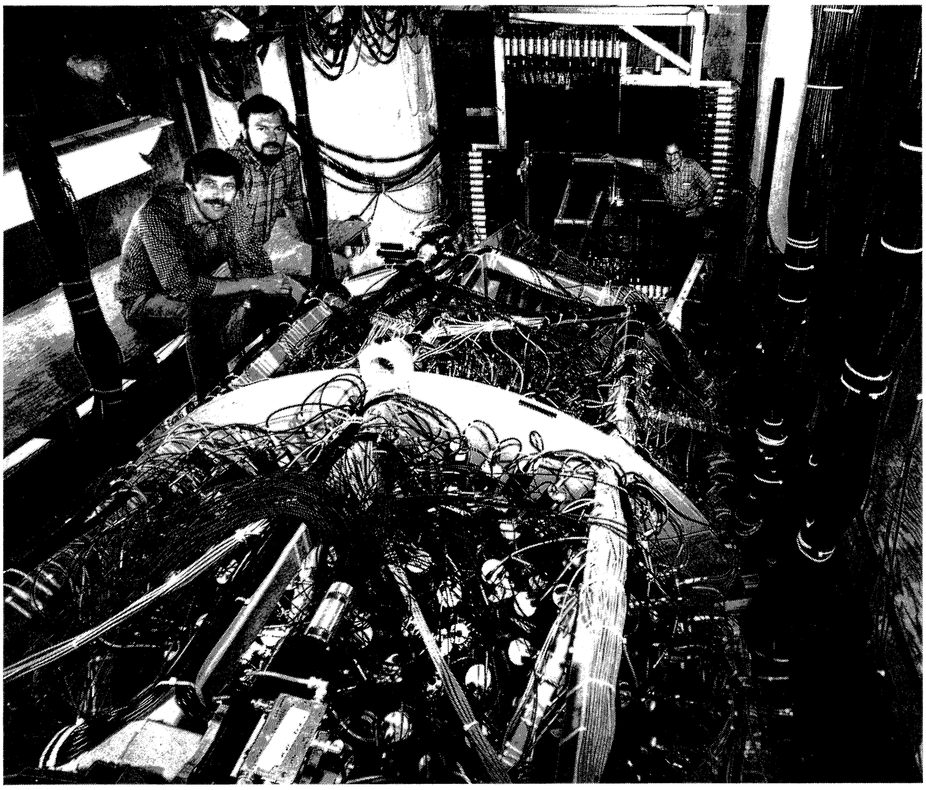
The Spallation Neutron Source (SNS) now being constructed aims to provide 800 MeV protons in pulses of 2.5×10^{13} particles at a repetition rate of 53 Hz. Fired into a heavy metal target, these particles will produce neutrons for a wide range of research applications (see July/August issue, page 232).

In the SNS the maximum intensity achievable will probably be determined by coherent beam instabilities. Longitudinal and transverse motions of the proton beam circulating within the synchrotron vacuum chamber induce image currents in the structures surrounding the beam. These currents produce electric and magnetic fields and forces which act back on the circulating beam. If the interaction enhances an original perturbation (for example caused by a slight construction error or other discontinuity), then unstable collective longitudinal and transverse oscillations of the beam can occur, with subsequent beam loss. For the SNS, the frequencies of such unstable oscillations range from 100 kHz upwards. The forces and their effect on the beam depend on the beam energy, beam distributions and beam intensity and also on the strength of the coupling between the beam and the surrounding structure. To maximize the intensity in the synchrotron it is necessary to minimize the beam coupling impedances.

The fast cycling (50 Hz) magnets of the SNS synchrotron are laminated in a direction transverse to the direction of motion of the circulating beam and the induced image currents. These laminated structures surrounding the beam therefore have very high resistive and reactive impedance components and it is necessary to interpose radio-frequency shields between the beam and the magnets to screen the beam from the laminated magnet structures and reduce the beam coupling impedances to acceptable values. To be fully effective the shields have to be positioned accurately in the ceramic vacuum vessels and have to follow, as closely as possible, the circulating beam profile.

The design and construction of the shields have presented many problems — solid metal plates can only be used in a few places because of eddy currents, supports have to be made of ceramics to withstand radiation, the shield has to be accurately aligned and supported from the inside of the ceramic vacuum vessel. The structure, handling and construction techniques have to conform to ultra-high vacuum requirements.

The Plastic Ball/Plastic Wall detector at the Berkeley Bevalac — an example of the growing interest in nuclear reactions using beams of heavy ions.



BERKELEY VENUS rising

From 15—18 September a Workshop was held at the Lawrence Berkeley Laboratory to discuss the proposal which it is intended to present by the end of this year concerning the accelerator complex, known as VENUS, for physics with heavy ion beams. The project, as then conceived, was described in the December 1979 issue, page 406. The ultimate aim is to have multi-GeV per nucleon colliding beams but the financial resources to reach this aim are not within reach at the moment. Much could be done, however, to extend the research programme by building just the injection stages of the full VENUS project.

The interest in nuclear physics with heavy ion beams has grown in the past decade with the use of the Bevalac (the ex-Bevatron constant gradient synchrotron fed by the SuperHILAC heavy ion linear accelerator). It now supports a community of some 200 physics users and in addition has a thriving biomedical research programme (which we return to as a separate item at the end of this article). This year the abilities of the accelerator have been increased via a new ion source (ABLE) on the linac, to make good beams of ions up to uranium available, and via the installation of a new vacuum liner in the synchrotron to achieve a low enough pressure for the heavier ion beams to be transmitted during their acceleration. These improvements have worked very well and usable beams of uranium ions at 1 GeV per nucleon can now be provided to the experimenters.

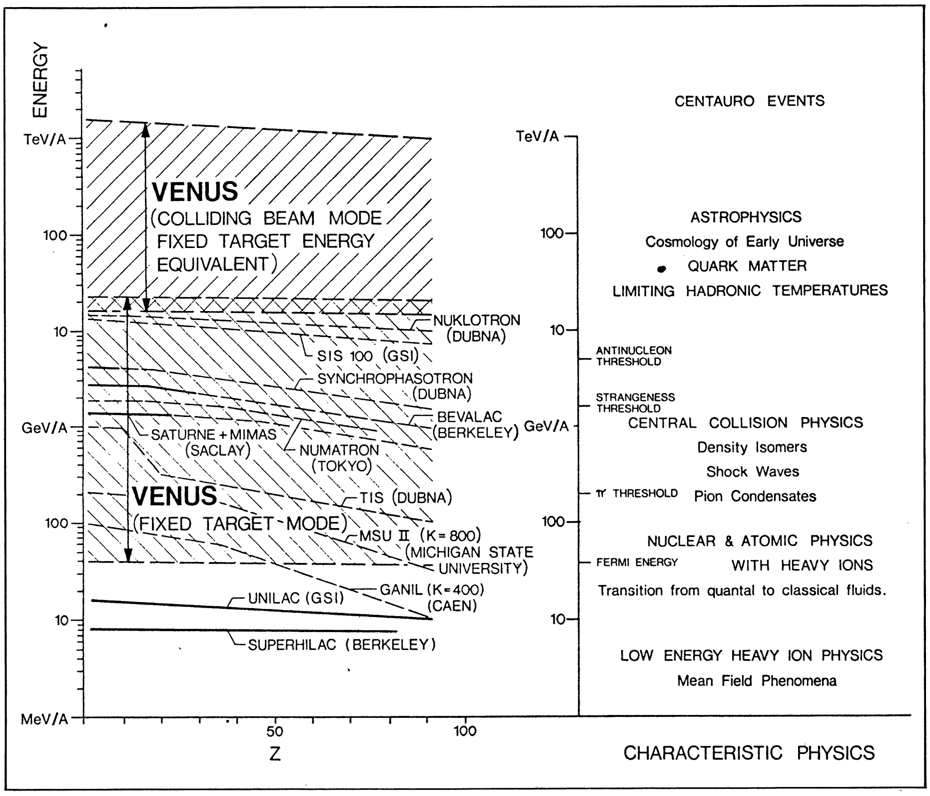
Just as important, in terms of pulling out significant results, is the coming into action of more sophisticated detectors. There has been difficulty in extracting the physics from the complex heavy ion collisions (as was commented upon by the DOE nuclear science review committee, chaired by Erich Vogt, which reported on existing research facilities in June of this year). The new detectors are a heavy ion superconducting spectrometer, HISS, and the 'Plastic Ball' described in our November 1981 issue, page 393. There are projects to add the lampshade magnet and, longer term, a heavy ion Time Projection Chamber. The improved detection abilities should help to clarify the information which has come from the first survey of collisions between high energy nuclei.

The VENUS project in its present form requires rebuilding the prestripper on the SuperHILAC to increase injected ion beam intensities by a factor of ten. Two rings would then receive the beams. A superconducting booster ring of 30 m radius would accelerate uranium ions to 7 GeV per nucleon. The second d.c. superconducting stretcher ring, probably stacked on top of the first ring (both of them being installed in the Bevatron hall), will store ions and allow 100% duty factor with the beams ejected to external targets. A variety of modes of operation with interplay between the two rings would be possible. In particular beams from this second ring could be reinjected into the first ring after stripping so as to be accelerated to higher energies (10 GeV per nucleon which is ten times the energy available from the present Bevalac). Stochastic cooling in the storage ring may also be used to produce beams with much lower energy spread, 10^{-5}, than is possible now. At a later date, two large superconducting rings each to give colliding beam energies of 20 GeV per nucleon could be built to take VENUS parameters to the very high centre of mass energies initially projected.

High fields from the superconducting magnets are anticipated for all the storage rings — for example 6 T in the dipoles of the booster ring. This is in line with a programme of work on high field superconducting magnets at Berkeley initiated several years ago with the major aim of developing magnets suitable for the next generation of high energy proton synchrotrons (20 TeV and above). The goal of the development programme is to produce magnets capable of 10 T in a 4 cm bore. En route, the team did build an 'alternative ISABELLE magnet' and, with a four-layer coil structure, achieved 7.6 T in helium-2 at 1.8 K with little training.

Two designs are being pursued at Berkeley to achieve high current density in the superconductor with minimum copper stabilizer. One involves a four-layer coil structure like the alternative ISABELLE magnet; the other involves the use of niobium-tin conductor in rectangular cable — the so-called 'block' design — operating at 4.2 K. Niobium-titanium and niobium tin are possibilities for the superconductor. (Another approach, involving Fermilab and KEK, is to use a niobium-titanium-tantalum alloy in a four layer magnet. KEK are also trying niobium-tin and niobium-titanium.) It is hoped to have a first niobium-titanium prototype tested before the end of the year.

Graph of the energies and ion species which could be covered by the VENUS project at Berkeley. Other existing and planned machines are also indicated. On the right is a list of the fields of physics which could be studied by the machine in its various operating modes.



Plans for a 'medical accelerator'

The success of the biomedical programme on the Bevalac has led to the National Institute of Health funding a study at Berkeley to design a heavy ion accelerator appropriate for use in a hospital environment. For the treatment of cancer by bombardment with particle beams, heavy ions seem to be emerging as the strong candidate. The use of neutrons is also continuing but pion beams are now not in favour. The pion facility at LAMPF has been closed down and the PIGMI project at Los Alamos to develop a pion accelerator for hospitals is no longer active (though it did yield some superb accelerator technology). The production of secondary beams of pions is harder than using primary beams and biologically their effect is not as useful as heavy ions.

The present design for a 'medical accelerator' aims to achieve beams of silicon ions (which are preferred in order to limit spallation from the irradiated volume) at an energy of 800 MeV per nucleon using a synchrotron. Lower mass ions could also be accelerated and perhaps argon ions.

Great emphasis is put on operational simplicity and reliability since the accelerator will have to run in an environment where little accelerator expertise will be available. The design will incorporate a radio-frequency quadrupole to avoid a high voltage Cockcroft-Walton. The Berkeley team fed in the idea of rings in the RFQ structure to help in balancing the structure. In addition to the synchrotron design there is also work on the system to deliver beam to the patient so as to irradiate the required volume in the most effective way.

With this medical accelerator it is hoped that an extensive programme of heavy ion therapy can be carried out to ensure a very thorough evaluation of effectiveness and appropriateness for different types of cancer.

Ten years on the IUPAP Commission on Particles and Fields

by Edwin Goldwasser

My participation with the IUPAP Commission on Particles and Fields started in 1970 when Bob Wilson and I (then Fermilab Director and Deputy Director respectively) proposed to host the XVIth International Conference on High Energy Physics at Fermilab in 1972. The Conference was eventually held in the Fermilab auditorium, then still under construction (Parke Rohrer, Manager of the Laboratory's architect-engineering firm, spent the night before the Conference caulking the auditorium roof to stop the leaks). During the following year I was elected to serve a three year term as one of the two US representatives on the Commission. Frank Yang (USA) was then Chairman and when he was succeeded by Bernard Gregory (France). I was elected Secretary. On the tragic and unexpected death of Bernard Gregory, I was asked to act in his place as Chairman.

Six years is the normal limit in terms of service on the Commission, but in 1978 a number of important problems were unresolved and the other members requested the General Assembly of IUPAP that I be elected for one more term. The request was accepted and my third term was completed last year.

One of the notable features of the decade was a transition from an age of plenty to an age of scarcity for research in general, and for high energy physics in particular. The impact of the change in the world economy was felt more acutely in the arena of international scientific cooperation than in other scientific activities.

In 1972 there was an insistent call for a proliferation of international conferences on high energy physics. New developments seemed to be too rapid for the journals to respond. The principal means of communication was becoming preprints or short 'letters'. Such communications alone were not completely satisfactory and physicists were finding that a valuable medium was presentation at a conference where active physicists could compare notes, criticize interpretations, develop new ideas, and even arrange new collaborations.

With the increasing size and complexity of facilities, experimental groups had increased in size. Furthermore, with the increasing cost of such facilities, there was pressure to avoid duplication. Large facilities first involved the joint effort of a number of scientists at a single institution. Then came inter-institutional cooperation. Finally, international teams have become common. That last step requires a suitable forum where people can meet to discuss their interests and ideas.

It has always been my belief that such conferences also serve an almost independent purpose in the sphere of international relations. If we are to develop a better understanding among nations, nothing is more important than improving communication. IUPAP sponsorship has been important in the development of fuller participation in international conferences. Such sponsorship is recognized in many nations as an indication of the value and appropriateness of a conference.

With the tightening of research budgets during the past decade, the atmosphere surrounding the previous proliferation of conferences gradually changed. The choice whether to invest funds in foreign travel or in research equipment and operations became more difficult. Sponsoring agencies in a number of countries established tighter controls over foreign travel. Valuable as international conferences may be, it is understandable to look at them as peripheral to the 'real' conduct of research. I believe this jeopardizes the effectiveness of research in our era. It also poses a real threat to one of the fragile threads of international cooperation.

Edwin L. Goldwasser, now Vice-Chancellor for Academic Affairs of the University of Illinois at Urbana-Champaign.

As funding decreased, those authorities and agencies who screen or sponsor foreign travel leaned more heavily on the symbol of IUPAP's sponsorship as an indicator of the importance of conferences in high energy physics. This responsibility has become increasingly evident and the Commission is more selective in its sponsorship, tending to limit it to those conferences which are vital to the vigour of the scientific enterprise and to the health of international cooperation. The Commission has felt that the symbol of IUPAP sponsorship must be protected in order to maintain its value as an 'imprimatur', accepted by many national authorities as an indicator that visas should be issued and travel supported.

Today, the Commission reserves its sponsorship, in the main, for three series. One is the biennial International Conference in High Energy Physics (the 'Rochester Conference'). Another is the biennial International Symposium on Leptons and Photons at High Energies, held in alternate years to the Rochester Conference. Finally there is the International Conference on High Energy Accelerators whose frequency has decreased to once every three years since accelerator developments have slowed.

Each of these series falls within the spirit of the general IUPAP guidelines, and gives good coverage to the field with a time frequency matched to the rate of developments. They do not give as much in-depth coverage as can be realized through small topical conferences, but these are still held on an ad hoc basis, usually without IUPAP sponsorship.

Attendance at IUPAP conferences has always been a sensitive issue. Their importance is widely recognized and leading scientists usually attend. Because of the working nature of the conferences and because of the unique forum they present, active physicists feel they 'must' be there. Unfortunately, because their effectiveness seems to many to hinge upon a limitation on the number of participants, attendance has traditionally been by invitation. This has made it possible to maintain appropriate international representation.

It has been traditional to give the organizer the broadest possible autonomy in arranging the conference. However during the past decade it became clear, in particular with the Rochester series, that the interests of international participation would be furthered if the Commission took responsibility for the national quotas. On several occasions, an organizing committee arbitrarily reduced the traditional representation of some other nation. On one occasion during Bernard Gregory's chairmanship, one organizing committee arbitrarily halved the Commission-established quota for another nation. After other appeals had been ineffective, Gregory and I had to indicate that IUPAP sponsorship would be withdrawn unless the problem was rectified and the quota was restored. The Commission has therefore established detailed quotas which are transmitted to the conference host.

There has been an increasing sentiment in the USA against the exclusivity implied by the practice of participation by invitation only. IUPAP representatives from elsewhere still tended to believe that practical considerations limit attendance. The 1980 Rochester Conference was scheduled to be held in the United States, and there were two proposals. The first came from the University of Wisconsin on condition that they could experiment with an 'open conference' format. A California group submitted a second proposal to host the conference on an invitational basis. The Commission finally decided for Madison, under the condition that provision would nevertheless have to be made for the established international quotas. The Wisconsin group, in consultation with the Commission, devised procedures which made it possible both to maintain national quotas and to make the conference effectively open to all. The Commission was pleased with the result and now encourages such open conferences.

Another major development in the activities of the Commission has been the decision to sponsor a new committee which concerns itself with the long range future. This International Committee on Future Accelerators (ICFA) has its roots in a series of meetings of laboratory directors, physicists, and officials, culminating in a meeting in New Orleans in 1975. The subject was 'Perspectives in High Energy Physics'. During that meeting it was noted that the progress of high energy physics, in the next decade, would almost certainly require an accelerator and experimental facilities so large that they could not be built by an individual nation or region. It was recognized also that the technical, organizational, economic and political problems connected with the formation of a 'world' laboratory would be formidable. It was suggested that a study be started to consider the next large high energy physics development, then seen about a decade in the future. The facility was named the Very Big Accelerator (VBA).

After some preliminary meetings, the informal study group established at the New Orleans meeting approached the Commission requesting sponsorship for the formation of ICFA. In 1976 the Commission agreed and it was decided that ICFA should have three members from CERN Member States, three from the Soviet Union, three from the USA, one from Japan, and one from Dubna Member States (other than the Soviet Union). The Chairman of the IUPAP-Commission was designated to be a twelfth member, ex officio. The Commission defined ICFA responsibilities 'to organize workshops for the study of problems related to an international super high energy accelerator complex (VBA) and to elaborate the framework of its construction and use; to organize meetings for the exchange of information on future plans of regional facilities and for the formulation of advice on joint studies and uses.' ICFA elects its own chairman. Before he died, Bernard Gregory had been chosen to

The University of Wisconsin-Madison, scene of the 1980 'Rochester' Conference, which dispensed with the traditional rule of participation by invitation only.

(Photo University News Service)

be the first. John Adams was elected to replace him.

In its first five years ICFA has organized more than a half a dozen meetings and workshops to consider the physics motivation for the construction of a VBA, possible designs and limitations, and developments in detectors, magnets, and instrumentation. It has also been agreed that there should be a meeting on some of the political, economic and organizational problems associated with the establishment of an international laboratory. ICFA has been successful in stimulating the kind of discussion which must occur prior to any serious planning for the VBA. On the other hand, the world economy has faltered and the original lead time of one decade from 1975 was clearly too short.

Another development during the past decade is the reestablishment of communications with the People's Republic of China. China indicated an interest in high energy physics and the Commission responded immediately with an invitation to join. Although there has been much friendly conversation, the Chinese have not yet engaged in the activities of the Commission. They are reluctant because IUPAP recognizes Taiwan as an active participant in its affairs. Sporadic discussions are still in progress, and it is hoped that China will enter into the activities of IUPAP and ICFA in the near future.

During my decade on the Commission, the most troublesome problem has been the inability of conference organizers to arrange for the participation of some of the outstanding physicists from the USSR. A ten year survey showed that whereas 95 per cent of speakers invited from other nations had accepted invitations to speak at IUPAP-sponsored conferences, less than 30 per cent of those invited from the USSR had similarly been able to accept and attend the conferences. In response to a series of problems faced by conference organizers and in response to the results of its ten year survey, the Commission, at its 1978 meeting in Tokyo, therefore passed the following resolution:

'At all conferences sponsored by the IUPAP Commission on Particles and Fields every endeavour must be made to ensure that the best qualified scientists from all regions are able to attend. The foundation of the Commission's programme of major meetings has, in the past, been a regular rotation of the venue among those regions actively engaged in high energy physics research. The principle of a parity of rotation is only meaningful if there is a corresponding parity in the participation at the conferences by scientists who are most actively engaged in the research to be discussed. The Commission's established policy must necessarily be placed in jeopardy if any nation or region is judged by the Commission not to be contributing its fair share to the scientific exchange. The Commission will not normally choose such a nation or region as a site for any conferences.'

Since this resolution was passed there have been three major conferences sponsored by the Commission. In each case, the conference organizers were unable to get the same kind of participation from invited Soviet scientists as is traditional from scientists of other nations.

Normal procedure dictated that a site for the 1984 Rochester Conference should be chosen at the 1981 meeting of the Commission in Bonn. In accordance with the usual rotation among the three major regions, the 1984 Conference normally would

People and things

have been scheduled for the USSR. However there was substantial support of the Tokyo resolution by high energy physicists in the United States and in Europe.

At the Bonn meeting, a tentative invitation was submitted by East Germany, proposing that the 1984 Conference be held in Leipzig. The Commission accepted that invitation on a provisional basis, pending a satisfactory response to the usual questions which were answered at the Commission meeting in conjunction with the 1982 Rochester Conference in Paris. Just before retiring as Chairman, I wrote to Anatoly Alexandrov, President of the Academy of Sciences of the USSR, and to Andrei Petrosyants, Chairman of the USSR State Committee for Utilization of Atomic Energy. In that letter I indicated my own thoughts as follows:

'I would not be completely honest if I did not inform you about my own ideas about the future, recognizing, of course, that my official responsibility for these matters is now coming to an end. Of course I join all of my colleagues in hoping that USSR participation in international conferences will soon become indistinguishable from the participation of other IUPAP members... You have my very best wishes for success in your continued efforts to further the goals of science in the USSR. The potential for major contributions in high energy physics from the Soviet Union is great, and the potential for achievement by the gradually developing international community of scientists is greater yet. The potential of each of us can be magnified manyfold if we join hands in a common effort. But such an effort requires the full and free participation of the best scientists, no matter from where they come. Not only does such a cooperative effort enhance the progress of science, but it also contributes significantly to the prestige of those nations whose scientists are able to push the frontiers of knowledge still further ahead. On the other hand, any nation which frustrates the efforts of its scientists and handicaps them in their activities not only sets back the progress of science, in general, but also deals itself a costly blow in world prestige, in its ability to contribute to the advancement of science, and in its ability to exploit the full potential of its own scientific talent.'

On people

Paul Reardon, at present heading construction of the Tokamak Fusion Test Reactor (TFTR) project at the Princeton Plasma Physics Laboratory, is to move to Brookhaven where amongst his responsibilities will be leadership of the ISABELLE project (now, in view of its likely reformulation — see October issue, page 318 — usually referred to as the Colliding Beam Accelerator, CBA). He has extensive previous experience at Princeton, MIT (where he headed the team that built the electron linac) and Fermilab (where he headed Booster construction and was later Technical Director).

Meetings

The 11th International Symposium on Lepton-Photon Interactions at

Dame Margaret Weston, Director of the Science Museum in London, gives the opening address at the inauguration of a CERN exhibition at the Museum, open until the end of November. Left is William Shelton, Under Secretary of State at the UK Department of Education and Science, who formally inaugurated the exhibition, and right is CERN Director General Herwig Schopper.

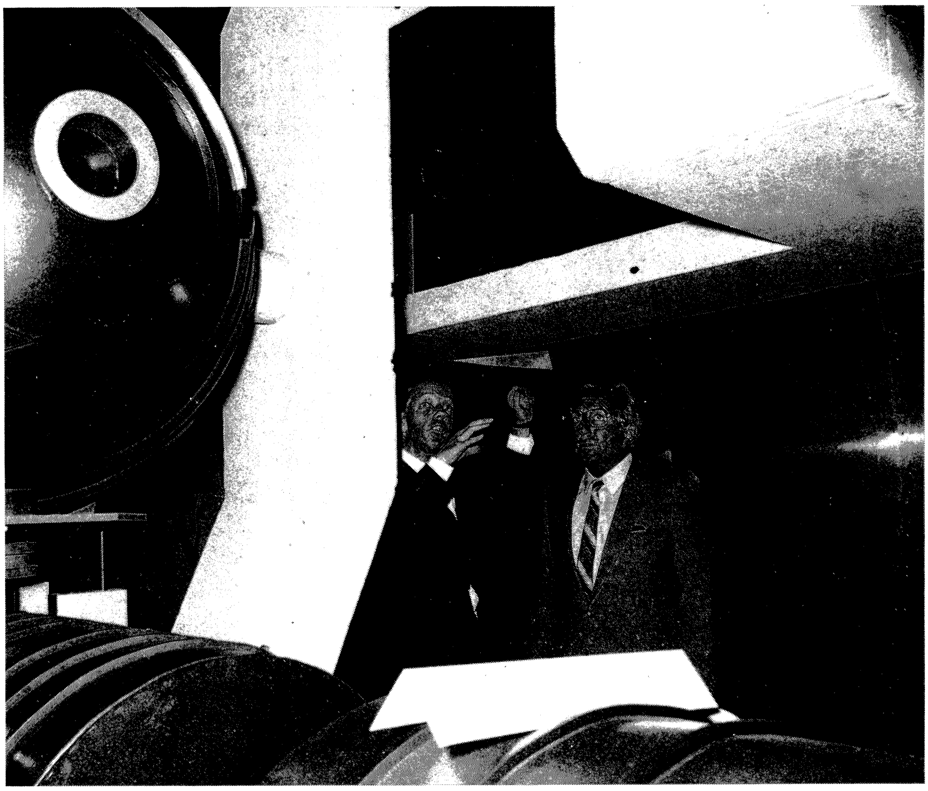
(Photo 531.9.82)

The Nobel Prize for Physics goes this year to Cornell theorist Kenneth Wilson.

Paul Reardon.

Among the visitors to CERN in September was Belgian Secretary of State for Energy Etienne Knoops, seen here (right) receiving animated explanation about the LEP project from CERN's Energy Coordinator Oscar Barbalat.

(Photo CERN 35.9.1982)



High Energies will be held at Cornell University, Ithaca, New York, from 4—9 August 1983. Attendance is by invitation only. Requests for invitations should be addressed to the Conference Secretary, Newman Laboratory, Cornell University, Ithaca, New York 14853, USA. Persons in the USA may correspond directly with Prof. F. J. Sciulli, Nevis Laboratory, PO Box 137, Irvington-on-Hudson, New York 10533, and in Europe with Prof. E. Lohrmann, DESY, Notkestrasse 85, D-2000 Hamburg 52, Federal Republic of Germany.

Glueballs

According to our present understanding of the quark forces acting deep inside strongly interacting particles (hadrons), these forces are communicated by the exchange of gluons. These new force carriers thus appear high up on experimenters' want lists. But as well as carrying the inter-quark force, gluons should also be able to stick together to form new particles, called variously 'gluonia' or 'glueballs'.

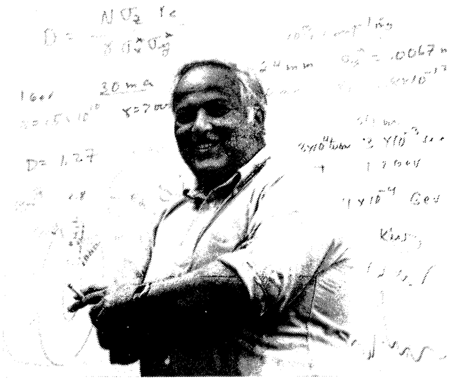
At each major physics conference these days, a number of glueball candidates are proposed, and the list is steadily increasing. Although no definite claim can be made, confidence in glueballs is increasing. One such candidate is the E (1425) meson, recently studied at SLAC in the radiative decays of J/psis.

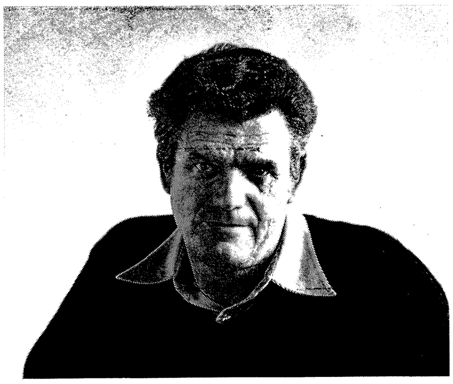
However this particle is no newcomer to the physics scene. Glueballs could have been seen no less than 19 years ago by a CERN/Collège de France team in the analysis of proton-antiproton annihilations at rest, observed in a hydrogen bubble chamber.

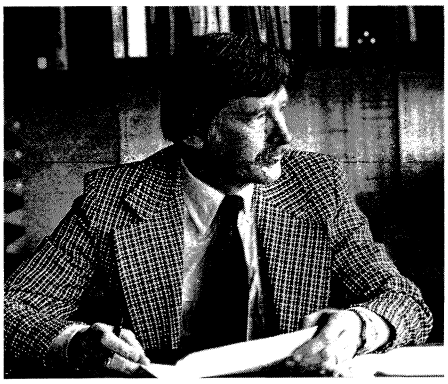
Reorganization at SLAC

With the retirements of Dick Neal and Joe Ballam at SLAC, more details of Laboratory reorganization have been announced (see also September issue, page 285, which reported the appointment of Burt Richter as Laboratory Technical Director, and Associate Director in charge of an expanded Technical Division). While Joe Ballam initially remained in charge of Research Division, this responsibility was assumed on 1 November by Richard Taylor.

In Technical Division, Ewan Patterson becomes Head of the new Operations Department, with responsibility for the existing accelerators. Matt Allen becomes Head of Accelerator Physics Department. Klystron Department and the PEP Vacuum Group are combined into a new Klystron-Vacuum Depart-







Prominent faces from the reorganization at SLAC: top, Burt Richter, who becomes Technical Director and Associate Director in charge of an expanded Technical Division; centre, Richard Taylor, new Associate Director in charge of Research Division; below, John Rees, Project Director of the SLAC Linear Collider (SLC).

ment, headed by Gerry Konrad with Norm Dean deputizing. As already announced, Lew Keller's Experimental Facilities Department is transferred to Research Division.

The SLAC Linear Collider Project (SLC), under Project Director John Rees is now a formal part of the SLAC management structure and specific responsibilities have been assigned. David Leith will oversee the optimization of the SLC for physics experiments and will promote user involvement.

Muon lifetime

The contest to measure the lifetime of the positive muon to high accuracy has a new entry. A group from the College of William and Mary in Virginia, using a muon beam at the TRIUMF cyclotron in Vancouver has recently measured the positive muon lifetime to one part in 36 000. The new value is 2.19695 ± .00006 microsec, which differs slightly from the current world average while increasing its precision. Indeed, the relative precision with which the positive muon lifetime is known is better than that for any other radioactive decay, thanks to the convenient timescale involved. This scale lies comfortably within the reach of digital clocking techniques and is yet brief enough to minimize cosmic ray background.

By following the theoretical methods of A. Sirlin for calculating radiative contributions to the decay rate, the above value can be converted into a weak coupling constant for muon decay. This constant is, for non-strange weak interactions, analogous to the fine structure constant for electromagnetic interactions. In dimensional form, as is necessary until the experimental weak boson mass is known, the muon decay coupling deduced from the new muon lifetime measurement is (1.16637 ± 0.00002) x 10^{-5} GeV^{-2}.

More synchrotron light at Brookhaven

Early in September, first circulating beam was achieved in the X-ray ring of the US National Synchrotron Light Source at Brookhaven, just over a year after the first beams were obtained in the vacuum ultraviolet ring. Full experimental use of the VUV ring has been under way since early August. The X-ray ring should be available to experimenters this year.

This 1951 photograph by C.F. Powell, passed to us by John E. Hooper, illustrates the risks of particle physics research. The launching of a hydrogen-filled balloon to register cosmic rays did not quite go as planned. The unfortunate victims were, left to right, John Mulvey, the late Max Roberts, Owen Lock and John Hooper.

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Nuclear Research Centre
Department of Physics

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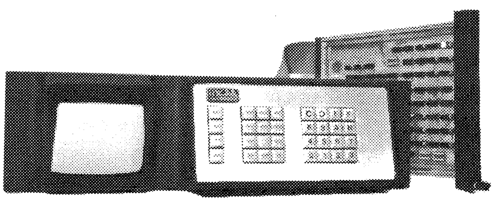

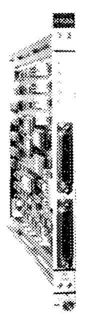

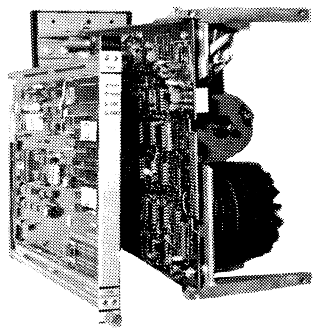

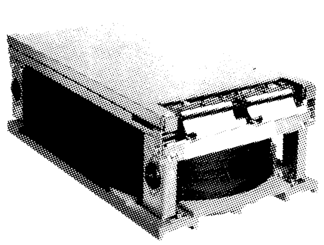

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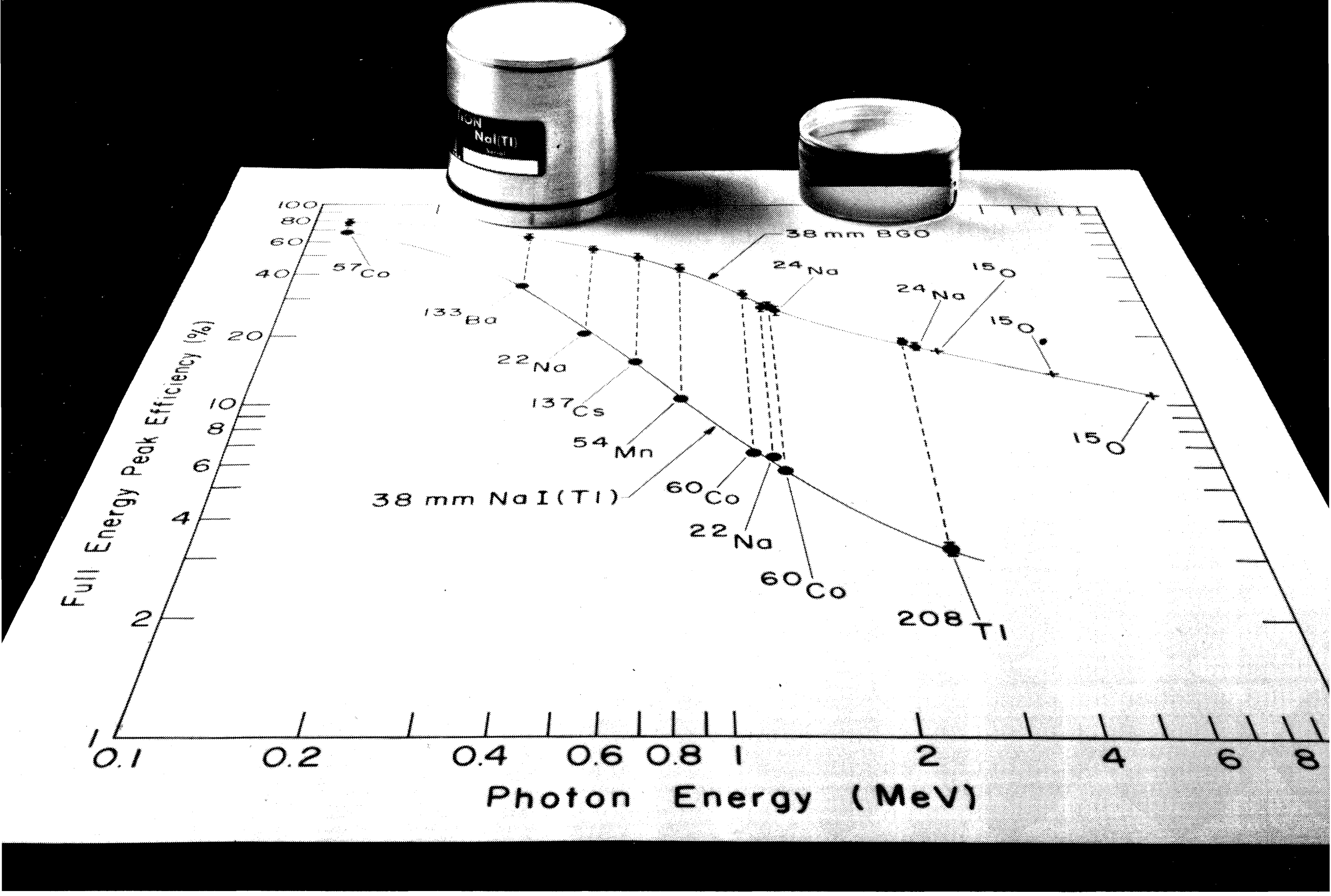

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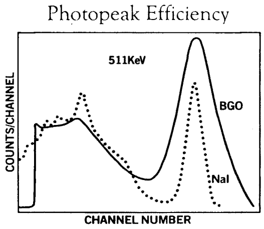

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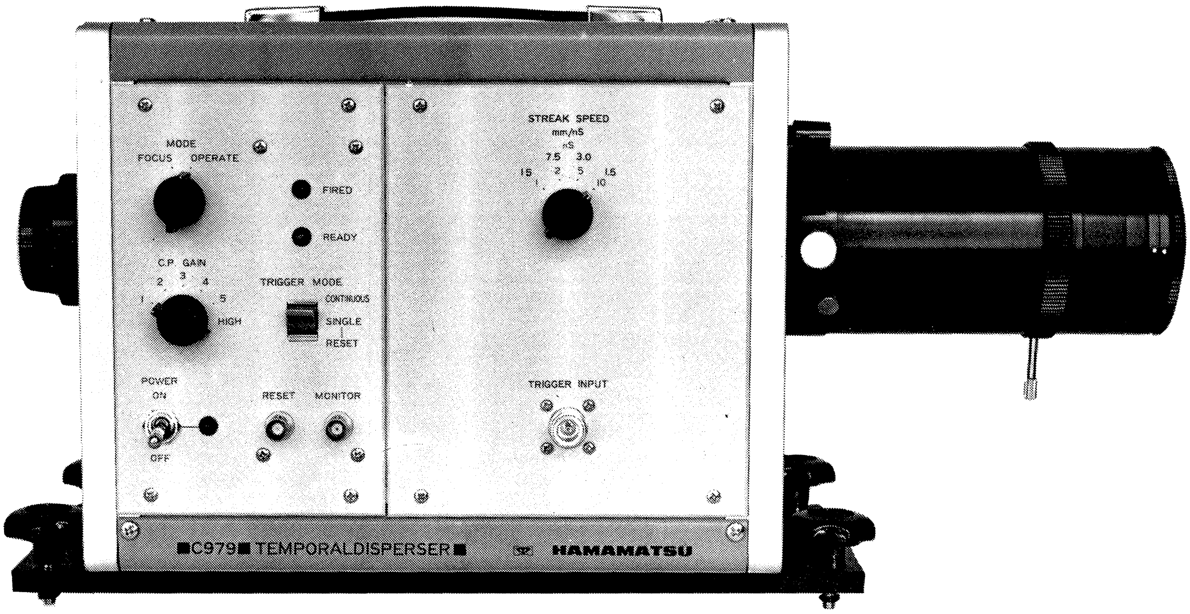

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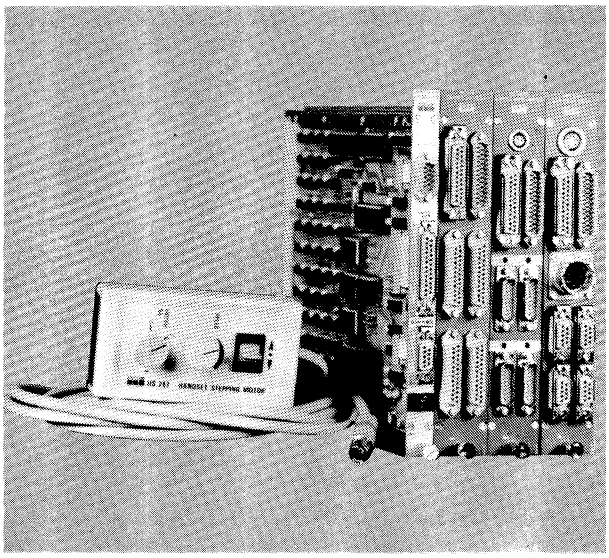

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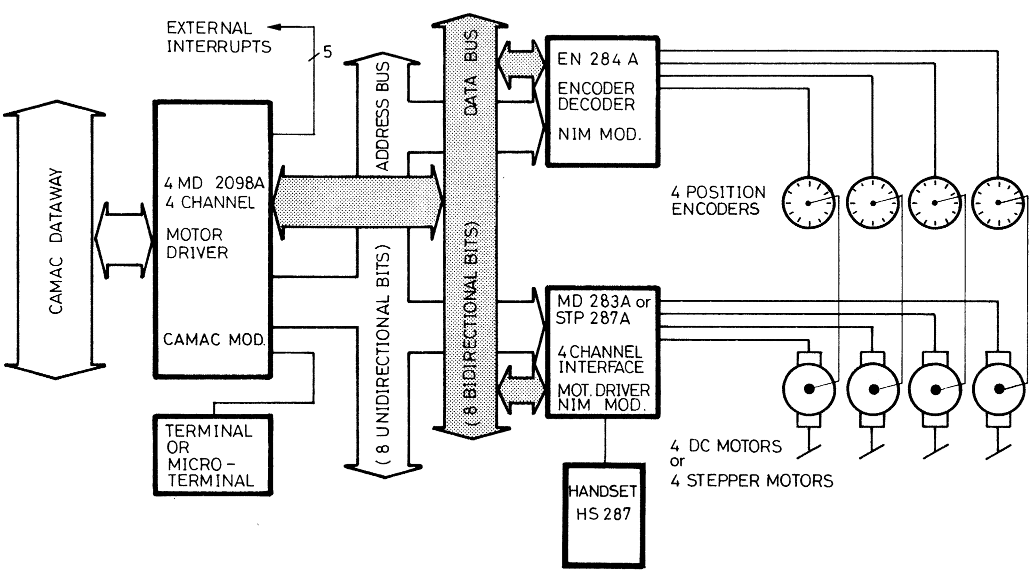

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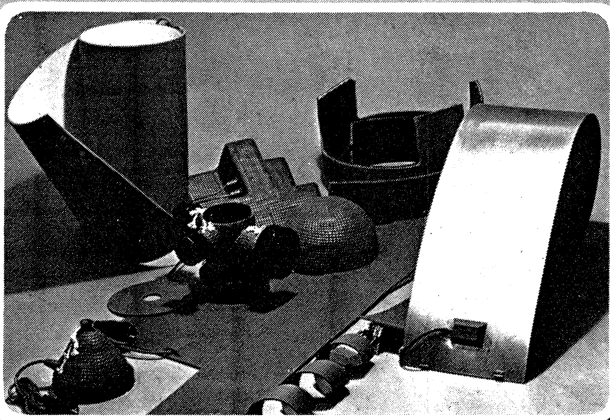

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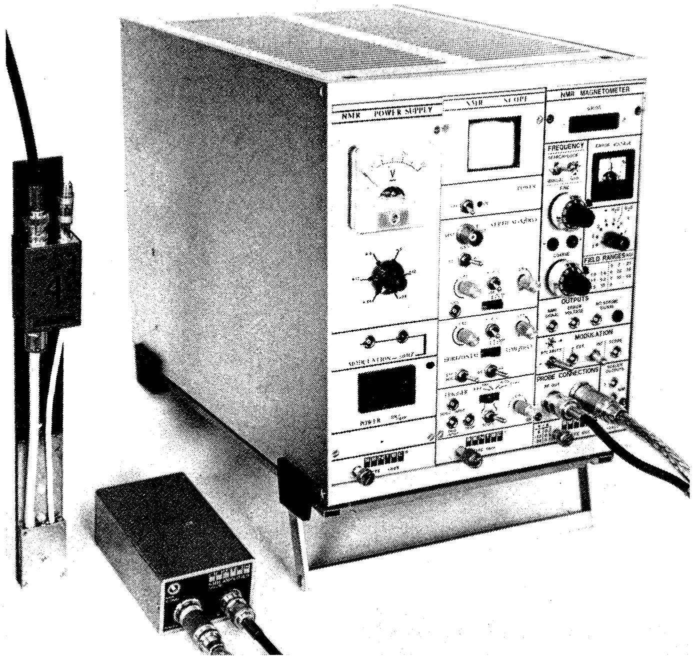

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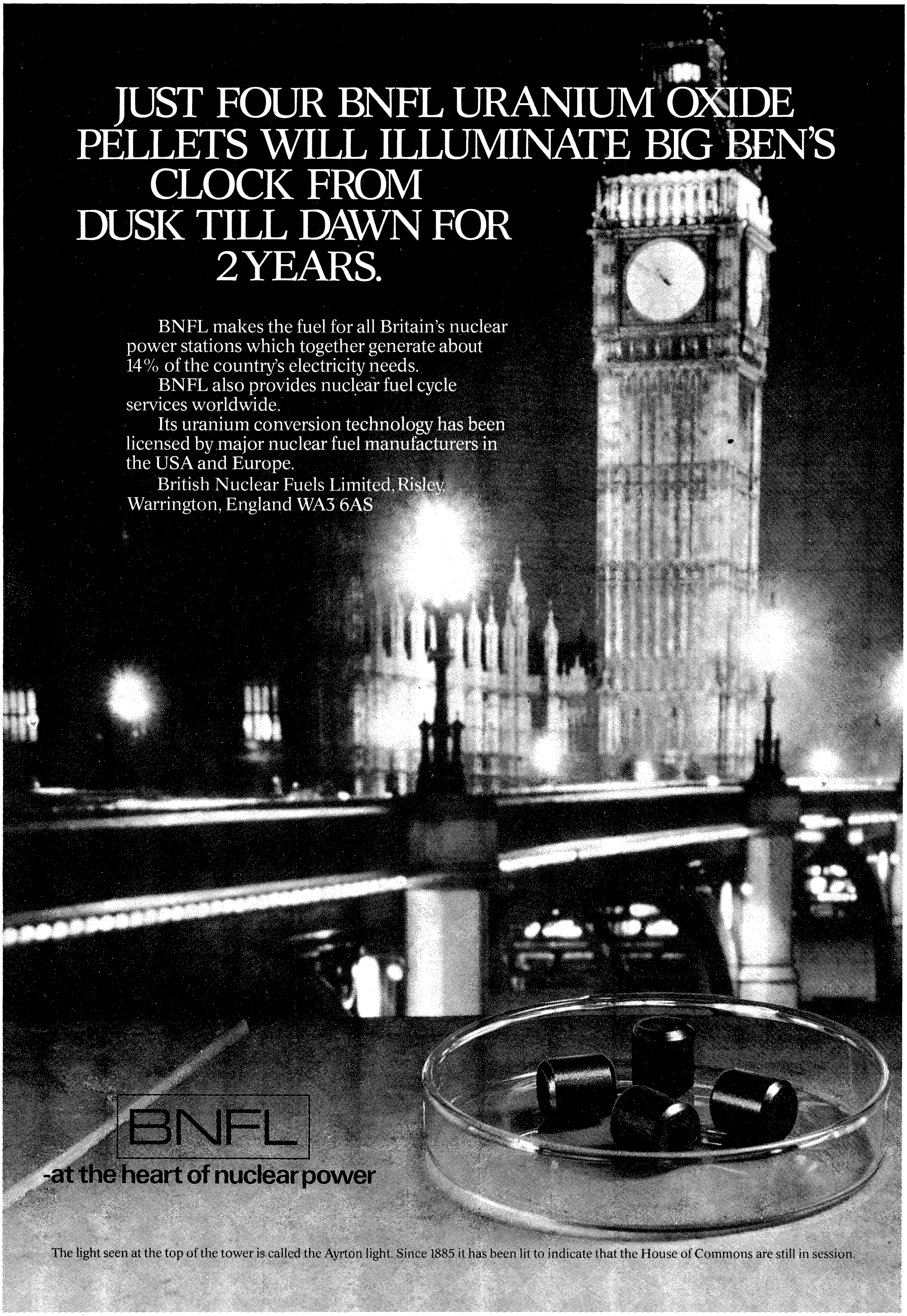
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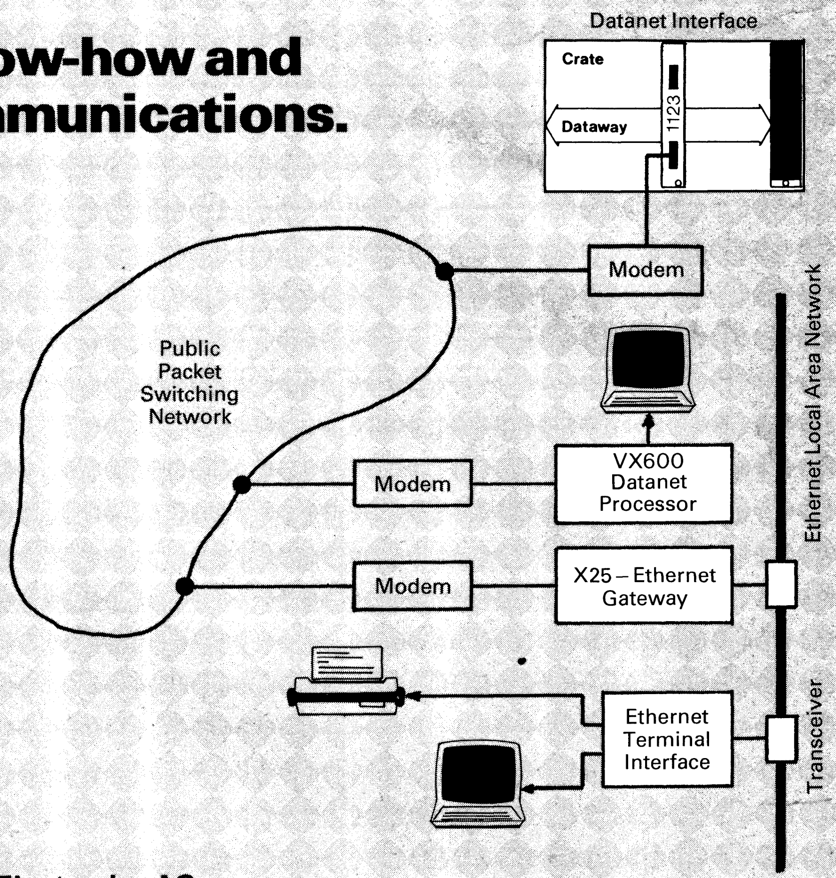

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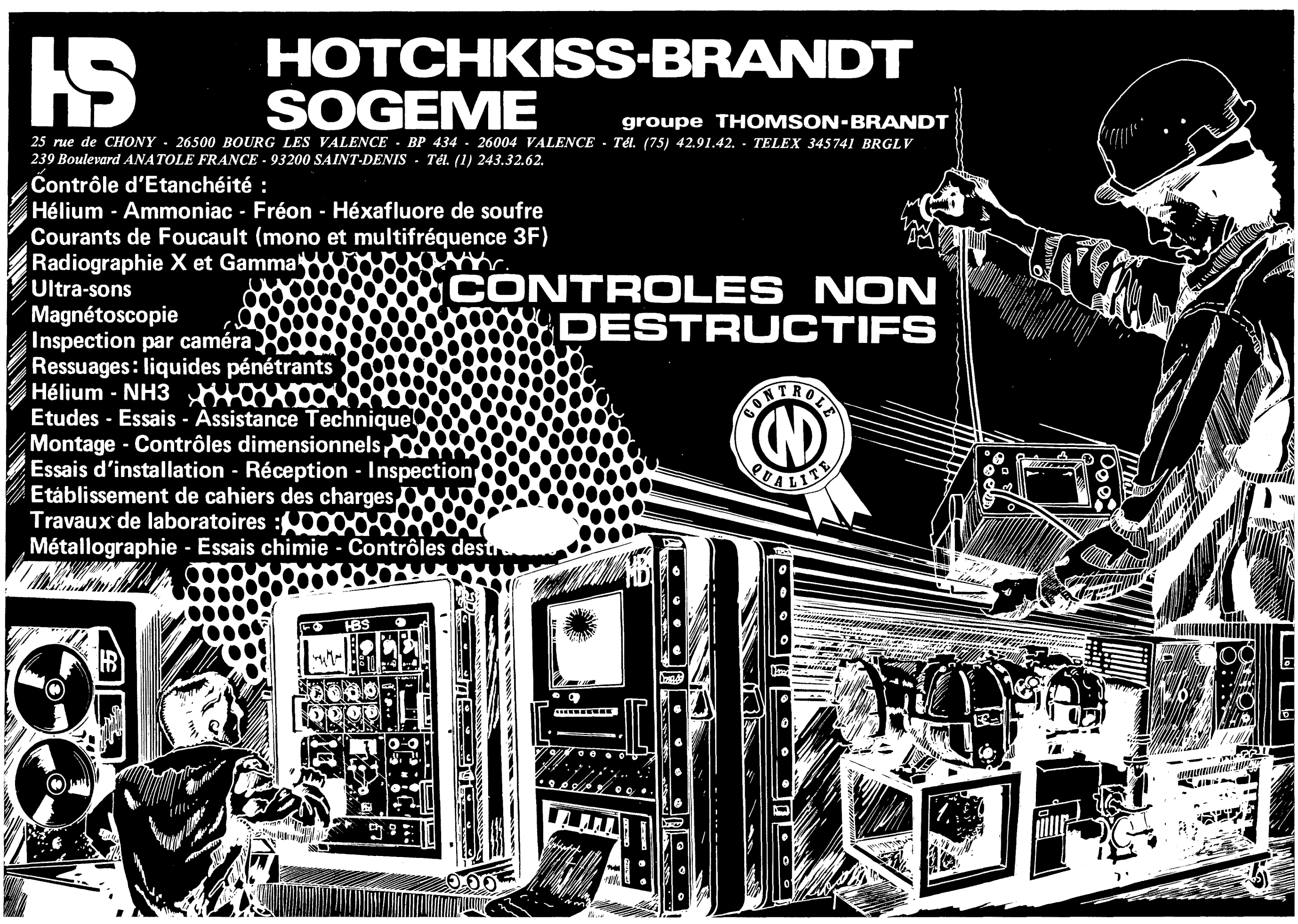

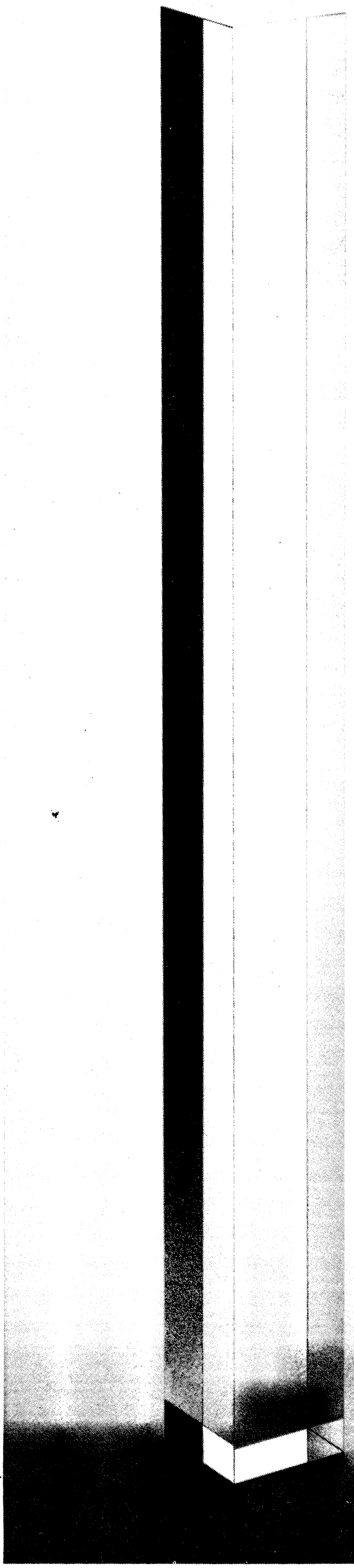

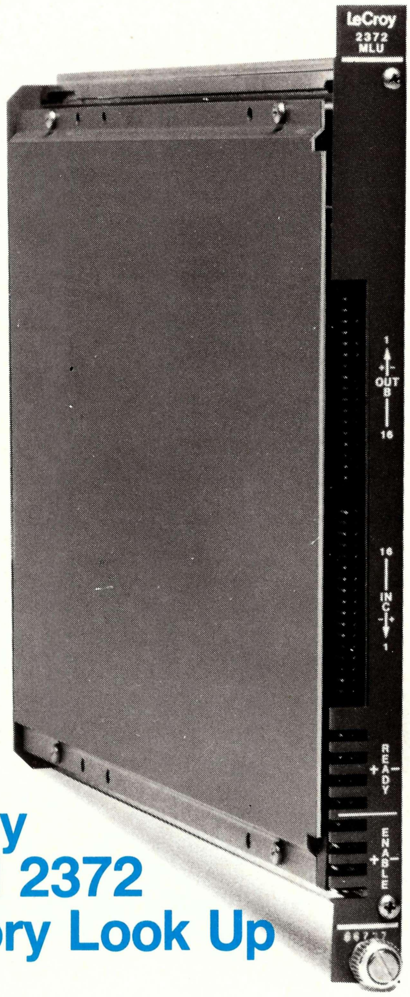

LeCroy Model 2372 Memory Look Up

Modular Trigger Processing

- **Used for Trigger Processors, Complex Fast Triggers, and Synchronous Applications**
- **Programmable Dimensionality— selects input and output word sizes**
- **High Multiplicity—up to 16 inputs**
- **Strobed Input Operation—simplifies signal timing**

The ECLine MLU is more than just another logic module. It is the fundamental building block of a Trigger Processor and is useful to generate complex Fast Triggers in both beam-on-target and synchronous colliding beam "gate-clear-gate" applications.

As a memory-based logic unit, it can be CAMAC loaded to define its logic characteristics. The Model 2372 allows triggers more complex than can be achieved with conventional trigger logic.

The MLU may also be treated like an element of a computer program. By applying data words to its input instead of conventional trigger logic signals, the MLU responds as if it is a subroutine call. The Model 2372 can help put physical parameters like energy, momentum, mass or rapidity into your trigger.

For more information contact your local LeCroy representative.

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AsH_3	C_4H_6	NO
BCl_3	C_4H_8	NO_2
BF_3	C_4H_{10}	N_2
B_2H_6	C_4H_{14}	N_2O
CF_4	C_4H_{16}	N_2O_4
CH_4	C_5H_{12}	Ne
$(CN)_2$	C_6H_{14}	O_2
CO	C_7H_{16}	PF_5
$COCl_2$	ClF_3	PH_3
COS	Cl_2	SF_6
CO_2	D_2	SO_2
C_2H_2	GeH_4	SeH_2
C_2H_4	HBr	SiH_2Cl_2
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