CERN COURIER

International Journal of High Energy Physics

VOLUME 26 6 JULY/AUGUST 1986

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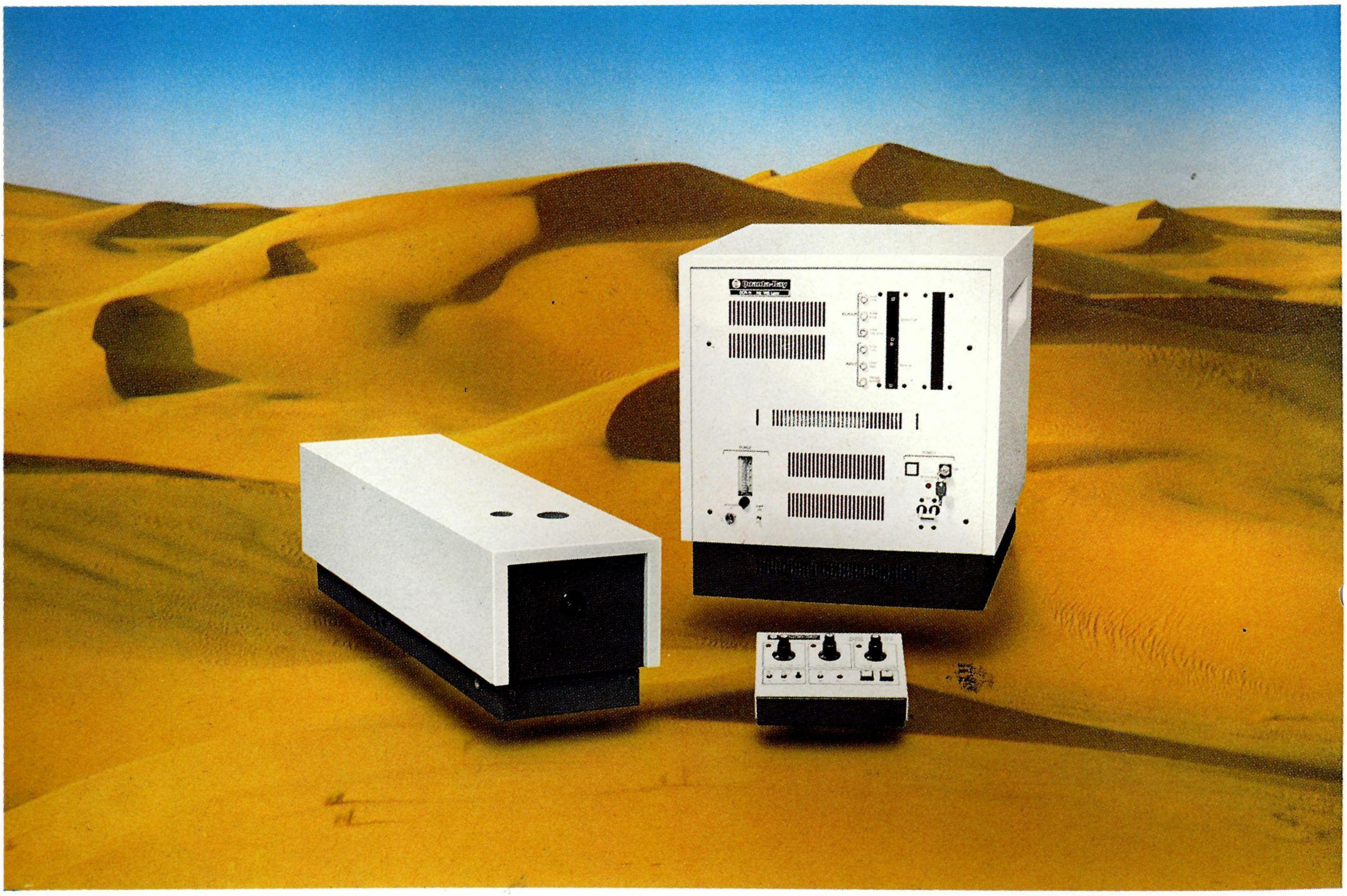

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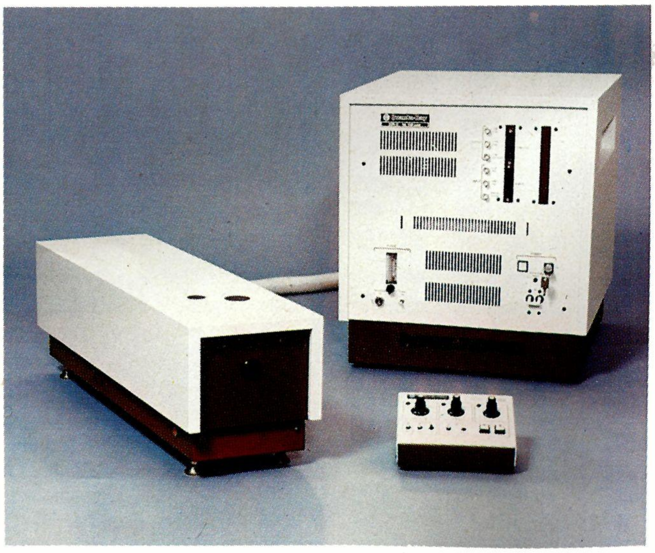

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Cover photograph: Light at the end of the tunnel for CERN's LEP electron-positron Collider. With excavation of the 27 kilometre tunnel, shafts and vast underground areas nearing completion, finishing work is well under-way (Photo CERN X821.4.86 by Gilbert Cachin).

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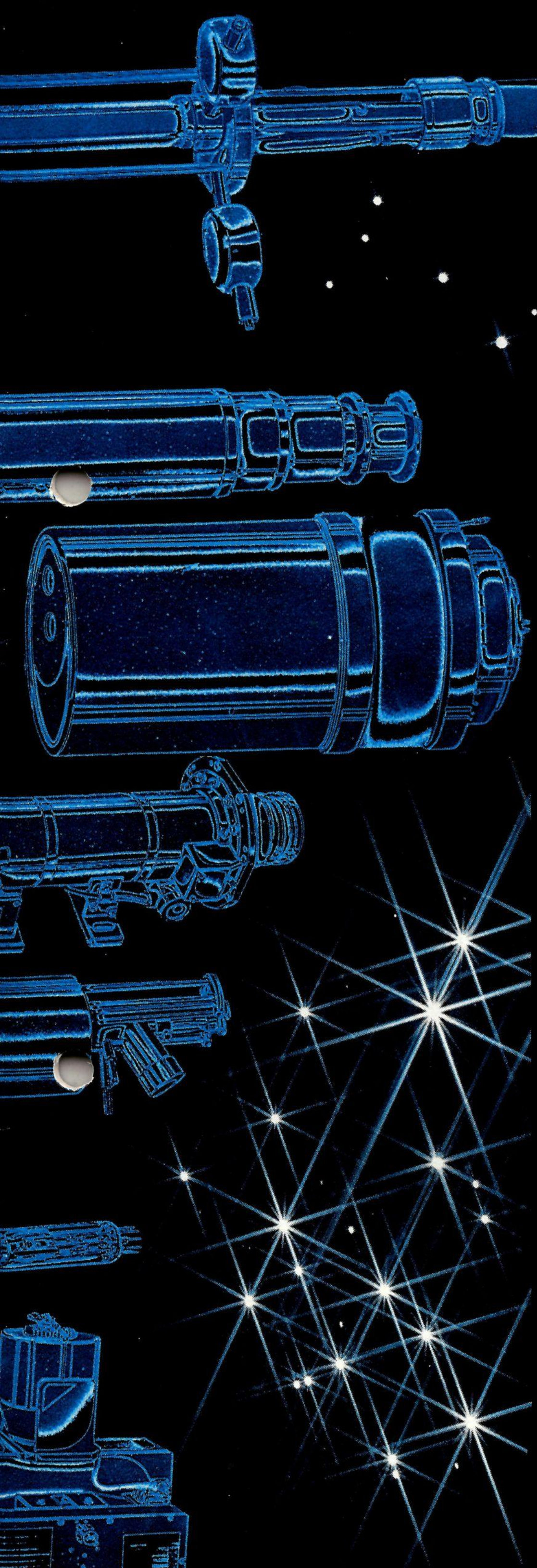

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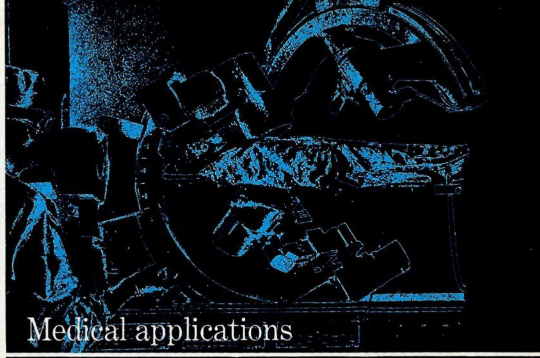

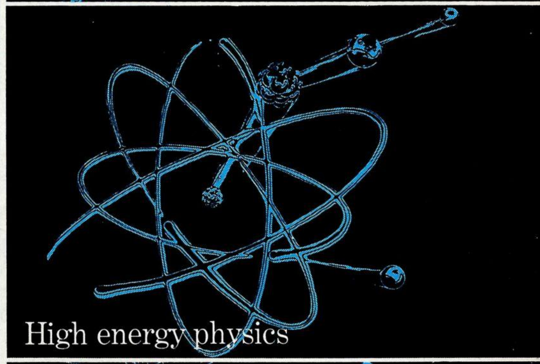

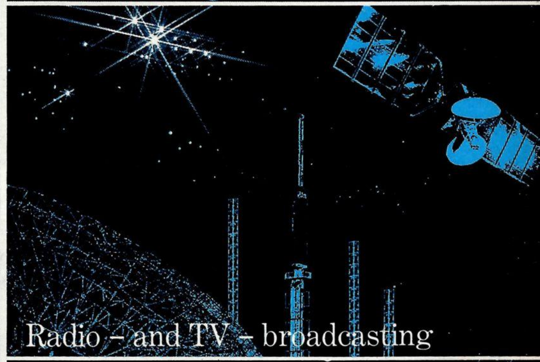

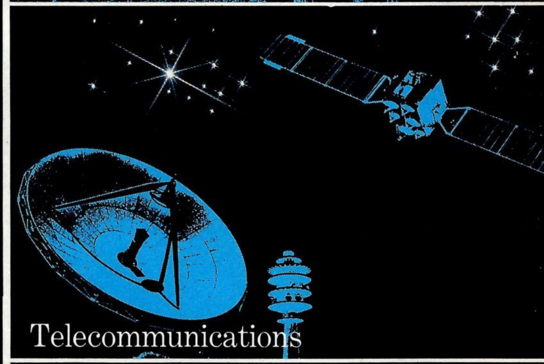

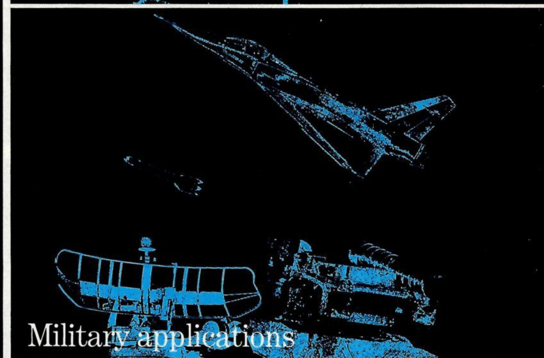

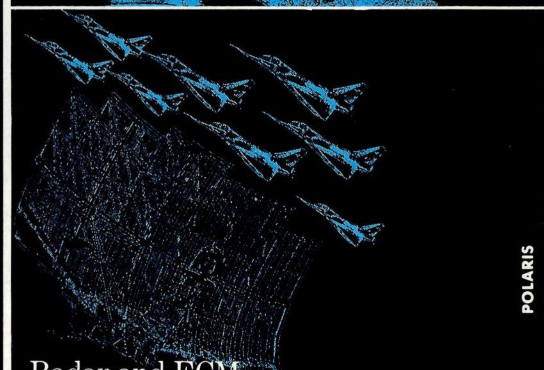

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The last of the rings?

A personal view of the history of colliding beam machines for high energy physics by John Rees, project director of the Stanford Linear Collider now under construction — the first large-scale colliding beam machine to dispense with the idea of a ring.

John Rees — touting linear colliders as the wave of the future.

The largest of all the colliding beam storage rings, LEP, is being built at CERN. The proposed US Superconducting Super Collider — SSC, see page 12 — would require a ring three times larger than LEP. At the same time linear colliders such as the machine now being built at Stanford are being touted for the future. If linear colliders take over then the whole history of designing and building colliding beam storage rings will have spanned just over three decades.

Following the invention of the alternating gradient technique for synchrotrons in the early fifties, e early cyclic AG synchrotrons were limited in their beam intensity because particles could be injected for only a brief time at the bottom of the cycle. This limitation could be overcome in fixed field (dc) machines of a type developed primarily at the Mid-western Universities Research Association (MURA), initially under the direction of Donald Kerst. Since the main advantage pursued was higher intensity, the MURA scientists had to learn more about stacking particles in machines than had ever been known before.

In the course of their studies Kerst and his MURA co-workers realized that, with stacking, they could hope for beam densities sufficient to do colliding-beam physics, and at the International Accelerator Conference at CERN in 1956, Kerst made the first proposal for a collider consisting of a pair of clashing-beam accelerators.

Although MURA was the most active centre, it was not the only place where colliding beam systems were being devised. At the same CERN conference Gerry O'Neill of Princeton also gave a paper about storage rings in which he suggested that one need not approach colliding beams via clashing accelerators but rather via storage rings separate from the accelerators that would feed them. In other words any kind of an accelerator could feed particles into two static storage rings in which the particles could be stacked and could collide.

However, the high energy proton machine proposed by MURA was never built, and thinking soon turned to colliders using electrons instead, which had the advantage of being easier to stack. What was needed was a source of electrons.

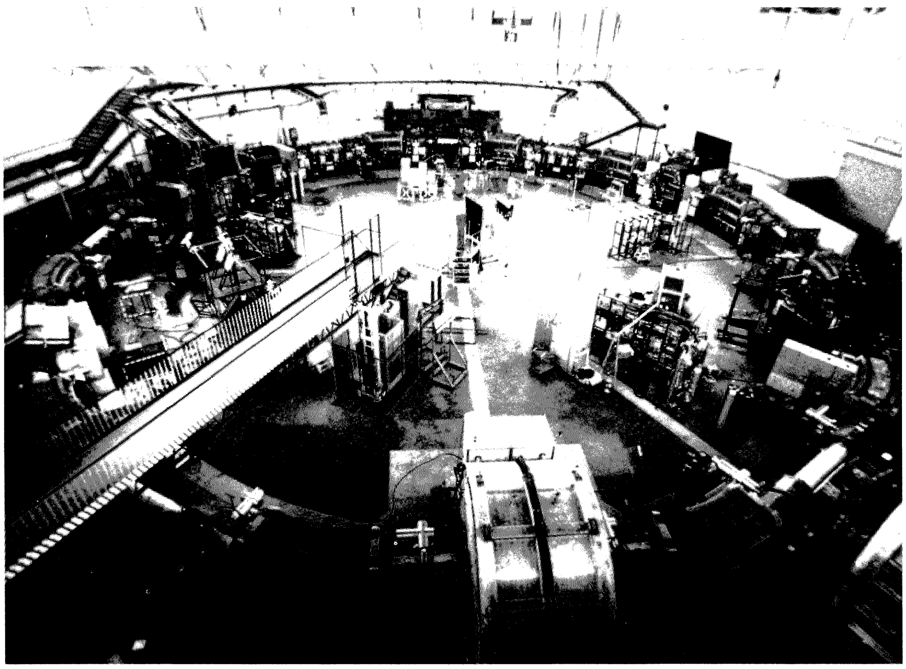
This is where Stanford entered the picture. Stanford's High Energy Physics Laboratory had an ideal source in the Mark III linear accelerator, so O'Neill came to Stanford with Bernie Gittelman, his student, and discussed these ideas with Pief Panofsky, Burt Richter, and Carl Barber. The Princeton-Stanford colliding beam experiment was proposed in 1958, and work began in that same year. The beam energy was planned to be 500 MeV; the radii of the rings were about 1.4 metres and they were weak focusing.

At the same time, Gersh Budker's Institute for Nuclear Physics in Novosibirsk started work on a pair of rings called VEP-1 to collide electrons of 140 MeV.

The scientists at Frascati, Italy, were thinking along a slightly different line. Bruno Touschek's idea was to put electrons and positrons in a single storage ring for both beams, which offered economic and physics advantages. They became extremely enthusiastic about the idea, and in 1960, just two years after the Princeton-Stanford proposal, they proposed the construction of a small initial proof-of-principle machine called ADA with a much larger one to follow.

ADA was a 250 MeV machine, with a radius of only 60 centimetres, and using weak focusing. But at the outset they called for their larger machine which they even then named — ADONE, for 'big ADA' — with an energy of 1.5 GeV, if possible. Thus in the four years from 1956 to 1960 the first generation of colliding beam storage rings was well and truly launched, and protons had disappeared temporarily from the scene.

The builders of the first generation faced what all pioneers have to face: the banes of the first generation, the unanticipated problems that plague new machines, to which their builders have to find



The ADONE electron-positron collider at Frascati, Italy — an example of the second generation of storage rings, and which turned in some sterling performance.

solutions — solutions which became part of their heritage to the next generation.

After overcoming a series of technical obstacles, the Princeton-Stanford physicists came up against what may fairly be characterized as the Fundamental Limit, the beam-beam limit of the colliding beam storage ring. This phenomenon has proved to be insurmountable and continues to limit performance.

ADA never reached the beam-beam limit, although it did uncover a basic limitation on low energy storage capacity, and was at first curbed by its injection scheme. Subsequently a more sophisticated system was installed, but the power of the Frascati synchrotron was inadequate, so ADA was eventually moved to Orsay, France, and put at the end of the Orsay linac. Then it was able to accumulate enough current to find a new limitation on storage ring behaviour, the Touschek effect.

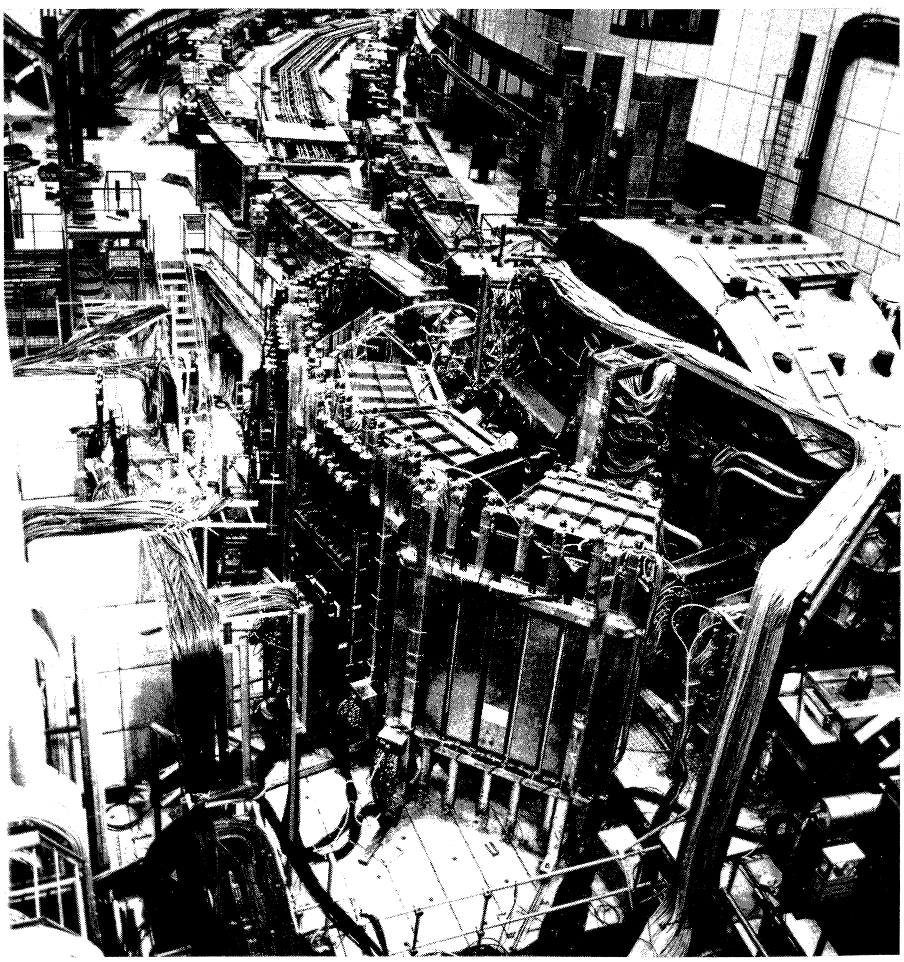
In 1962, construction began on the second generation of machines, ACO at Orsay, ADONE at Frascati and VEPP-2 at Novosibirsk.

ACO was designed to operate at beam energies up to 500 MeV; it had a radius of 3.5 metres and was strong focusing. ADONE was a larger strong focusing machine with a radius of 16.5 metres, operating at energies up to 1.5 GeV. ADONE was designed to take advantage of just about everything that had been learned in the first generation, and turned in some remarkable performances (luminosity 6×10^{29} cm^{-2} s^{-1}).

Meanwhile the physicists at the Cambridge Electron Accelerator (CEA) had a synchrotron and wanted to get into the colliding beam business, but were prevented from building a new storage ring to fill from their synchrotron.

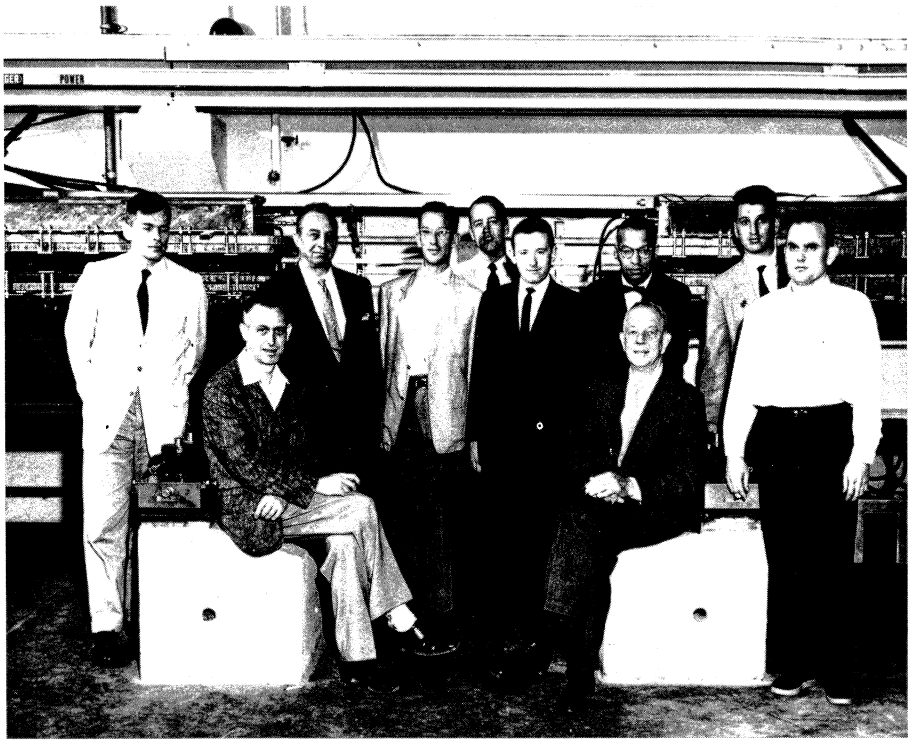
Then two of them — Ken Robinson and Gus Voss — had a brainwave. They saw that performance could be improved by modifying the beams (low beta) in just a few places, even if the machine was limited to small currents.

Using this idea, the CEA synchrotron itself was converted into a special 'bypass' storage ring. The result was — and I can't think of a better way of saying this — a machine of staggering complexity. It was made to do colliding beam physics in 1973 at a maxi-



An experiment at CERN's Intersecting Storage Rings — the only proton-proton collider constructed so far.

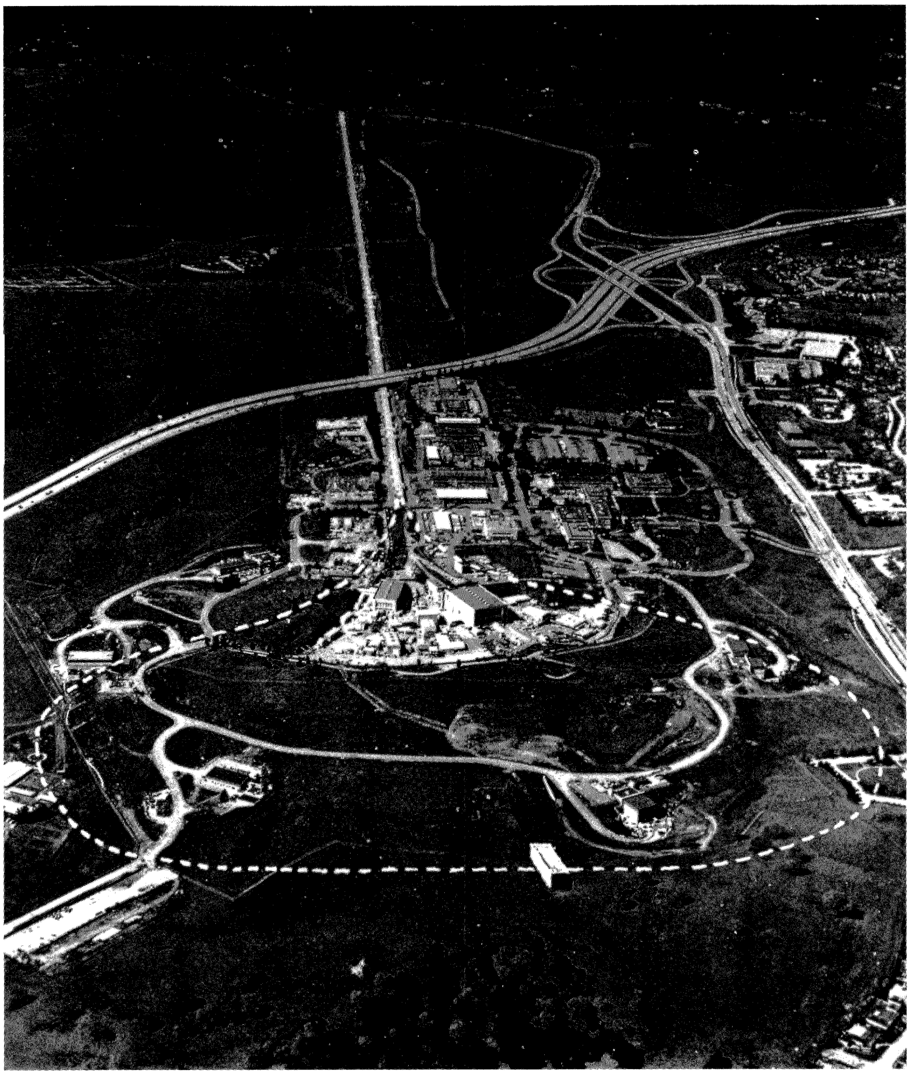
(Photo CERN 326.11.77)



Cambridge, Massachusetts, 1959 — The group that led the Cambridge Electron Accelerator (CEA). The machine was later converted for colliding beam experiments, testing the technique of 'low-beta' that proved so important in storage rings. Seated from left: Thomas Collins and David Jacobus. Standing from left: Fred Barrington, CEA Director Stanley Livingston, Robert Cummings, Lee Young, John Rees, William Jones, Janez Dekleva, and the late Kenneth Robinson.

mum energy of 2.5 GeV per beam, and the low beta invention was a great success.

Then there arrived the first — and to date the only — proton-proton colliding beam system, the Intersecting Storage Rings of CERN. Construction took place between 1966 and 1971. The ISR was a great success in accelerator physics terms. It exceeded its design goals in terms of energy and luminosity, the two most important parameters. Designed for a maximum energy of 28 GeV, it reached 31.4 GeV; and designed to produce a luminosity of 4×10^{30} cm^{-2} s^{-1}, it attained 10^{32} cm^{-2} s^{-1}, the highest luminosity yet reached by any colliding beam system.



The new Stanford Linear Collider — after acceleration in the two-mile linac, the electron and positron beams are brought together to collide (once only) in the experimental hall in the foreground.

The third generation of electron storage rings were SPEAR at Stanford, DORIS at DESY and VEPP-2M at Novosibirsk. This generation took full advantage of what had been learned at such great expense of effort in the first two generations; good vacuum technique; low beta, etc. These advances paid off — especially in SPEAR where a luminosity of 10^{31} cm^{-2} s^{-1} was achieved at 3.7 GeV, the highest luminosity achieved up to that time in any machine (the ISR had not yet bettered that figure).

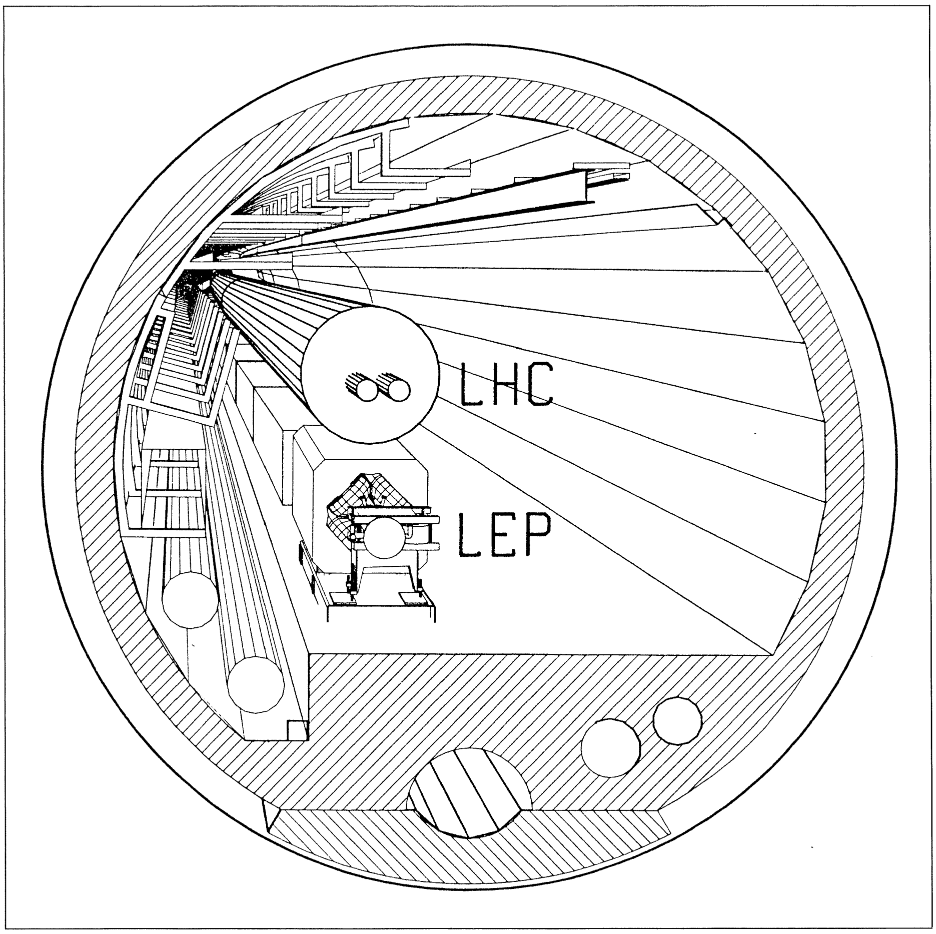
The fourth generation machines — CESR at Cornell, PEP at Stanford and PETRA at DESY — showed the maturity of the technology. Using already successful techniques, energy was scaled up by an order of magnitude, and luminosities slightly improved (3×10^{31} cm^{-2} s^{-1} at PEP).

Back in 1971, the idea had been put forward to build a system of rings to collide electrons with protons. Initially this idea failed to get very far, but is now coming to fruition with the HERA project at DESY.

And so to LEP — several thousand times larger than the first electron collider.

After LEP?

The designers of the LEP electron-positron Collider now being built at CERN were far-sighted enough to leave enough room for a possible second machine.



Work for the LEP electron-positron Collider at CERN continues to drive ahead with the aim of achieving first colliding beams in the 27 kilometre tunnel towards the end of 1988.

However LEP is far from being the last word in CERN's long term plans. A clue was already in the LEP Design Study '... by the adoption of a beam height of only 80 cm, there is enough room left (in the tunnel) for the installation of a second machine at a later stage...'.

A workshop, organized by the European Committee for Future Accelerators (ECFA) and CERN in March 1984, examined the feasibility of a hadron collider in the LEP tunnel (see June 1984 issue, page 185).

There the idea emerged for a ring of superconducting magnets, installed above the LEP ring, to collide protons together (or protons with antiprotons) at as high an energy as possible.

Since this meeting, considerably more work has been done to firm up the ideas for the new Collider:

- determining the best configuration for the proton-proton option and establishing its advantages over a realistic proton-antiproton option;
- assessing collisions between the electron beam of LEP and one proton beam;
- designing a complete section of the machine;
- making tentative designs of superconducting magnets providing between 8 and 10 tesla, and working out a European magnet development programme towards this goal;
- outlining where and how the various types of collisions could be exploited in the LEP tunnel.

Proton-proton collisions

Using 10 tesla dipole bending magnets, collision energies of 17 TeV (17 000 GeV, 8500 GeV per beam) could be achieved with a respectable collision rate (luminosity 10^{33} cm^{-2} s^{-1}). A 'two-in-one' aperture solution for the superconducting magnets is recommended for economy and compactness.

It is the relative ease of colliding proton beams (as compared to the difficulties of first making and then handling antiprotons) which promise high collision rates and make the proton-proton option the preferred solution. Despite the need to provide a large number of bunches (a figure of 3564 has been quoted), the two proton rings in the LEP tunnel could be filled using CERN's existing 450 GeV SPS machine and its proton supply in only a few minutes and the injection procedure could be activated a short notice. Of course new injection lines would have to be built.

Proton-antiproton collisions

Contra-rotating beams of protons and antiprotons can be handled in the same magnet aperture, as is done in the SPS Collider. This facilitates magnet construction but provides lower collision rates than the proton-proton option.

For 10 T dipoles giving 16.6 TeV total collision energy the estimated luminosity using CERN's improved antiproton source is 2.7×10^{30} cm^{-2} s^{-1}. The introduction of electrostatic beam separators to eliminate unwanted proton-antiproton collisions (as is now done in the SPS) would boost the luminosity to 13.5×10^{30} but bites into the cost savings of the single aperture approach.

Pending further studies, the proton-antiproton option is disfavoured. Proton-antiproton collisions (useful for comparison with proton-proton) could be achieved in one of the apertures of the proton-proton configuration.

Electron-proton collisions

With protons in the upper ring and electrons in the lower, electron-proton collisions are a natural bonus. The radiofrequency power which will be installed to boost the energy of the LEP beams could either be used to maintain the electron beam at its highest energy, or to boost the electron current at lower energy to increase the luminosity.

The total collision energy would thus be between 1.4 and 1.8 TeV (compared with 314 GeV in the HERA Collider now being built at the German DESY Laboratory in Hamburg), and the luminosity between 10^{31} and 10^{32}.

Experiments

Initially, the four LEP experiments would continue to look at electron-positron collisions but would have to get out of the way of the proton beams, when these are in use. For protons, new experiments could be mounted in other areas of the tunnel (the LEP tunnel has eight large vertical shafts). In time, some or all of the LEP experiments could be transformed.

However the production of suitable superconducting magnets for the collider would require a vigorous development programme.

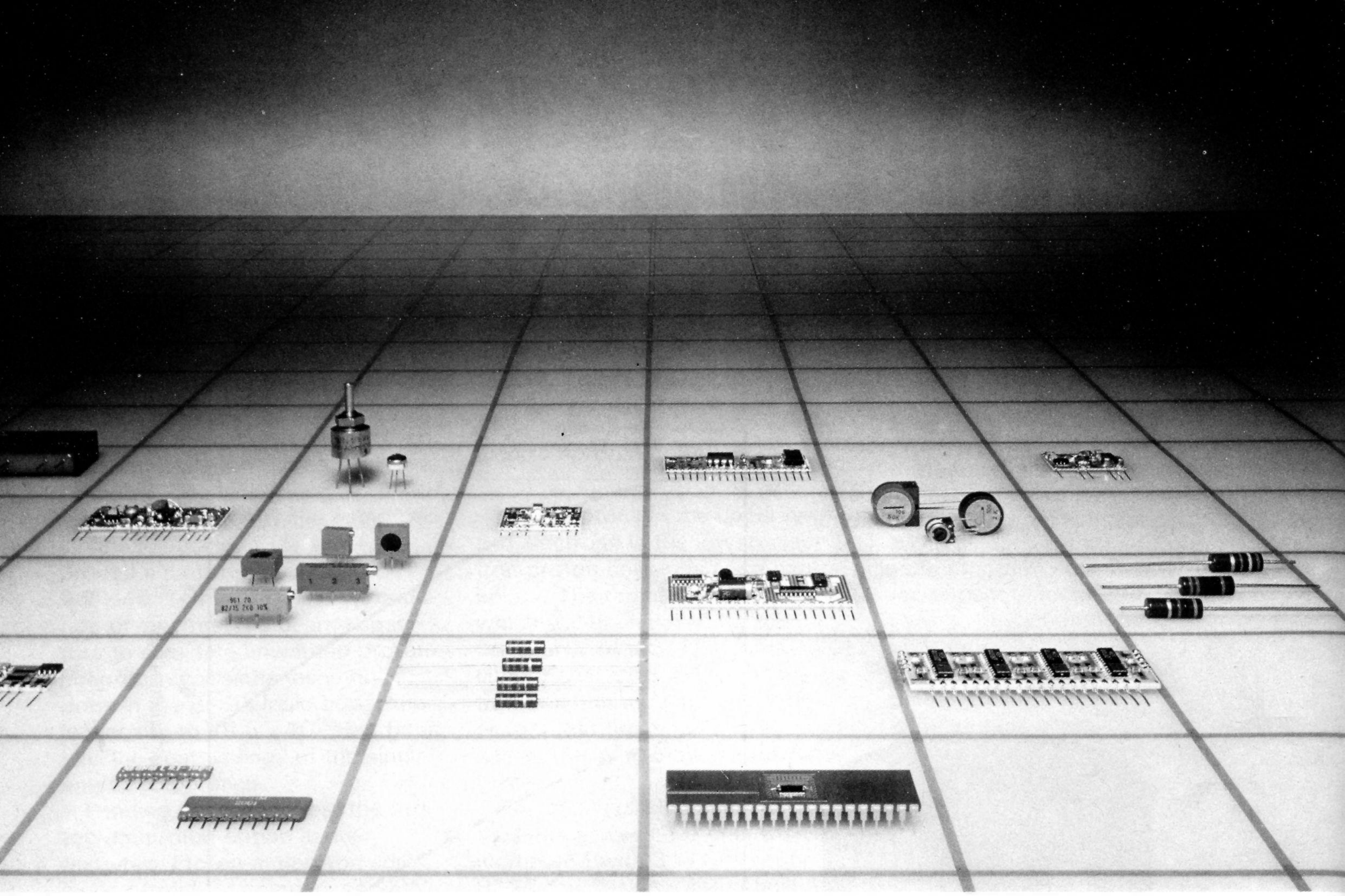
The future seen from Erice

A few specialists have been finding time to think beyond the LEP electron-positron Collider now being built at CERN and the SSC Superconducting Super Collider proposed for the US to the physics needs and accelerator possibilities of the future. Despite the modest effort, a lot of progress has been made in sorting the wheat from the chaff amongst proposed accelerator schemes and in defining crucial features of future machines.

Some of this thinking came together at a seminar on 'New Techniques for Future Accelerators' held in Erice, Sicily, from 12-17 May. It concentrated on linear electron-positron colliders with beam energies of at least 1 TeV and luminosities of at least 10^{33} per cm^2 per second. Earlier approaches concentrated on reaching accelerating gradients as high as possible (with reduced machine length and cost in mind). This, though still obviously very desirable, now carries less emphasis and other features are more prominent.

Two of these features were confronted by Bob Palmer in one of his usual stimulating talks. They concerned the input to the linacs, where reaching the desired luminosities will need very low emittance beams, and the output from the linacs, where luminosity again dictates concentration of the particle bunches in miniscule cross-sections when they collide.

Emittance should ideally be as low as 10^{-8} but, if this could be slackened off to 10^{-7}, it is not so frighteningly far from what should be achieved soon in the damping rings for the big linear collider nearing completion at Stanford. It could however require bunches spending a long time in damping rings which, to have a reasonable repetition rate, could involve tens or hundreds of such rings. Ugo Amaldi called attention to this problem



because these rings could be as complicated and costly as the linacs themselves.

Palmer proposed, instead of the comparatively slow damping of conventional rings, to incorporate the idea of Klaus Stefan and use high field wigglers as the bending magnet structure to speed up the damping. Such a lattice could damage other beam properties too much but it is an approach to the important task of achieving low emittances in short times.

At the other end of the machine, the necessary colliding bunch cross-sections are likely to be of the order of a tenth of a micron; there the problem of the 'final focus' speaks for itself. Palmer discussed an idea which is misleadingly called 'super-disruption' since it uses the 'disruptive' focusing effect of the fields in a bunch acting on the particles in another bunch passing through. The idea is that each bunch intended for high luminosity collision is immediately preceded by a larger diameter bunch which serves as a focusing lens as the collision bunch passes through. An enhancement of about thirty could be feasible by this trick.

Having raised the problems of the beginning and the end, there comes the middle — the linacs themselves. The aim is to find the most cost-effective way of converting power drawn from the mains into power in the colliding beams. The presently considered possibilities were neatly reviewed by Kjell Johnsen who has become involved in this work as Chairman of the CERN Linear Collider (CLIC) Panel set up to advise the CERN Long Range Planning Committee led by Carlo Rubbia.

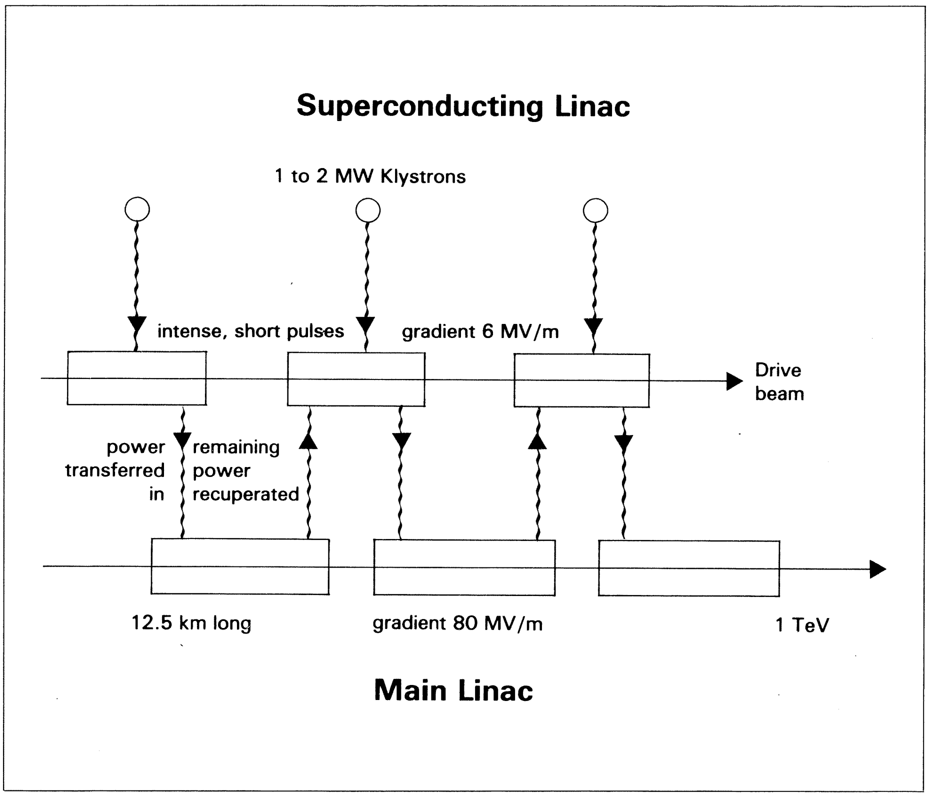
The GeV per metre accelerating gradients which can be generated in plasmas by beating two laser beams have made the beat-wave scheme the most alluring of all and it must obviously be thoroughly investigated. Recent work was described by Vittorio Vaccaro. Experiments at Los Angeles and Quebec confirm the basic principle and further tests are being prepared at Rutherford Appleton. However grown men, particularly those involved in controlled thermonuclear fusion, have been known to weep at the thought of taming a plasma and the payoff of the technique is likely to take a very long time.

Though not discussed at Erice, a much simpler idea for using the high gradients in plasmas was put forward by Chen, Huff and Dawson in 1984 which involves using the fields left in the wake of intense bunches fired through a plasma. Theoretical work is going on at Stanford (Ron Ruth, Chao, Phil Morton and Perry Wilson) and at CERN (Simon van der Meer), where Ted Wilson has proposed experimental tests using the new LEP electron linac.

Tom Weiland described progress at DESY in investigating the wakefield technique to achieve high gradients. A hollow beam, 10 cm diameter, travels down the rim of a cylindical structure to generate high gradients along the axis where the beam to be accelerated will pass. In April they achieved the necessary hollow beam accelerated to 7 MeV. They hope to be ready for experiments at the end of this year.

Some of the interest in this wakefield route to high gradients has waned since experiments at Stanford showed that over 150 MV per metre can be obtained in conventional structures provided

An idea for a future linear collider using a high current drive beam travelling down a superconducting linac alongside the main linac.



Erice's Centre for Scientific Culture

Erice is a small pre-medieval city huddled on a hill with splendid views over the countryside and the sea near Trapani in Sicily. Its age and evident history give a deep sense of participating in continuing human culture; its isolation turns off the everyday world making it an ideal environment for thinking.

It is here that Antonino Zichichi set up the Centre for Scientific Culture named after the Italian theoretical physicist Ettore Majorana. Two monasteries (San Domenico and San Rocco) and a former palace of the Viceroys of Sicily (which became a Convent named San Francesco) have been restored and provide the lecture halls, the accommodation and the offices for the Centre.

By now over seventy Schools, covering almost all branches of science, hold regular Conferences at the Centre and many of them have high international reputation in their respective fields. For example the International School of Subnuclear Physics draws the leaders of our own research every year and there are Schools on Nuclear Physics, Experimental High Energy Physics, Cosmic Ray Astrophysics, Accelerator Physics, and Instrumentation.

Zichichi is particularly proud to have initiated a series of Seminars on Nuclear War where scientific implications are debated with participants from all the major powers. From these Seminars in 1982 emerged the 'Erice Statement' on Science, Technology and Peace which has since been signed by over ten thousand scientists worldwide.

It is a brilliant achievement to have created and sustained such a wide ranging and evidently successful forum for science. These days, it seems to be particularly in Italy that people have the vision, the courage and the political will to give practical expression to belief in the cultural value of science.

the power pulse is not long. This led to the proposal from Bill Willis to switch short pulses of power, for example using photocathodes, rather than using conventional r.f. power. Bob Palmer has recently extended this in a 'micro-lasertron' and tests are planned at Brookhaven to see just what it is possible to get out of photocathodes where currents like1 kA per cm^2 might be called for.

Another way of getting power in an appropriate form into a high gradient structure is a two-beam scheme promoted by Andy Sessler. It involves a high current, low energy beam (topped up in energy en route by induction accelerator modules) travelling alongside the main linac and generating microwave power to feed the linac by passing through free electron laser sections. Don Hopkins reported the Berkeley/Livermore work which has given encouraging results on the ELF free electron laser and has produced very elegant high precision engineering in the production of pencil-thin accelerator structures.

A major problem with this scheme could be retaining the correct timing between the drive beam and the main linac beam. This is circumvented in a new scheme developed by Wolfgang Schnell in the context of the CLIC thinking. This received a lot of interest at Erice because the concepts are not so remote from presently mastered technology.

It is another two beam system with a high current drive beam travelling through a superconducting linac (which keeps average power down) alongside the main linac. A parameter list has a drive linac of 15 GeV powered at 350 GHz using high efficiency (70 per cent) klystrons of 1 MW giving accelerating gradients of 6 MV/m along an active length of 2.5 km. These figures are all achievable today and ought to be considerably exceeded by the time such linacs are built, with the exception that the superconducting linac would be required to handle very intense bunches (around 4×10^{11}).

The drive linac would be coupled to the main linac by using very short drive bunches which would interact directly with travelling wave transfer structures at the main linac frequency. (There are similar ideas developed by Ugo Amaldi and Claudio Pellegrini using free electron laser sections to create coherent radiation at the main linac frequency.)

In principle high values of transfer efficiency can be obtained, and the ratio of the accelerating gradients is proportional to the ratio of the linac frequencies. Thus setting the main linac at 30 GHz would correspond to an accelerating gradient of 80 MV/m even with the low estimate of 6 MV/m in the superconducting linac. For 1 TeV main linac energy the active length would be 12.5 km.

The outstanding advantages of the scheme are the fact that it is possible to recuperate into the superconducting linac the energy remaining in the main linac structure after the main linac bunches have passed, and the fact that the drive beam is highly relativistic so that the timing relative to the main beam would remain in phase all along the machine. The main problem is the need to have very intense (some 4×10^{11} electrons) drive bunches which are very short (a millimetre or less).

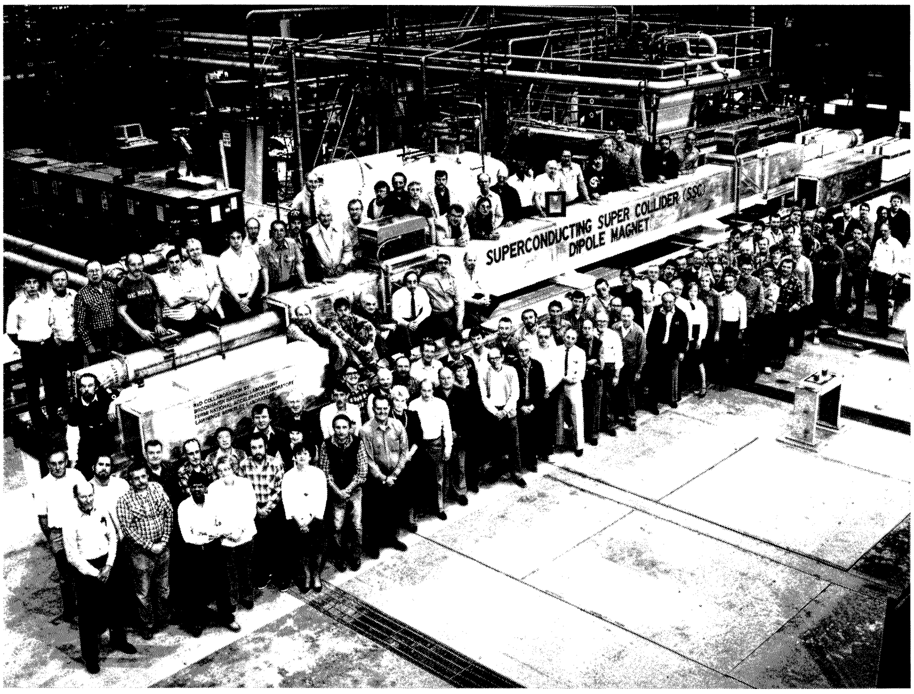
Nevertherless this looks the sort of system that could be put on the table for construction in some ten years or so if a Laboratory has sufficient courage to launch a serious research and development programme. This was an encouraging thought to carry away from Erice.

By Brian Southworth

Supercollider design submitted

Full-length turnout for the first full-length (17 metre) dipole of the preferred design for the proposed US Superconducting Supercollider (SSC) at Brookhaven, ready for its transfer to Fermilab for cryogenic testing.

(Photo Mort Rosen, Brookhaven)



The research and development programme for the proposed US Superconducting Super Collider (SSC) passed a major milestone on schedule with the submission of a conceptual design report to the US Department of Energy (DOE) on 31 March. Since then, the design has been favourably reviewed by DOE officials.

The main volume of the SSC Central Design Group Report (SSC-SR-2020: 'Conceptual Design of the Superconducting Super Collider') consists of 712 pages. It covers the particle physics justification for the SSC, its technical foundations in previous big machines and the vigorous R&D programme of the past three years, the accelerator physics issues that delimit the design requirements, the engineering conceptual design to meet those requirements, and the necessary conventional construction, as well as the estimated cost and schedule. The main volume is accompanied by four attachments giving details of accelerator parameters, magnet design, conventional facilities, and the cost estimate.

The bottom line on costs is 3.01 thousand million dollars (1986 prices), including a 530 million contingency, with a tight 6.5 year construction schedule.

The cost estimate is based on a detailed analysis of every nut, bolt and piece of wire. In accordance with standard US practice, the cost estimate includes all labour costs, not only for fabrication and civil construction, but also for engineering, design and inspection, technical supervision, laboratory management and support, etc.

The submission of the Conceptual Design Report was the first step in a DOE review and evaluation process. From 28 April to 3 May, 56 DOE reviewers came to Berkeley to evaluate the technical feasibility, estimated cost, and proposed construction schedule for the SSC, as documented. The first three days had the appearance of a sizeable conference, with many parallel sessions (accelerator physics, injector, magnets, cryogenics, other accelerator systems, tunnelling, surface facilities).

The review committee, chaired by L. E. Temple of the DOE Office of Energy Research, concluded 'the design is technically feasible and properly scoped to meet the requirements of the US high energy physics programme from the mid-1990s to well into the next century'. It also stated 'the SSC cost estimate is credible and consistent with the scope of the project' and 'the proposed 6.5 year construction schedule appears feasible for the assumed funding profile and for the reasonable assumptions made concerning the characteristics of the site'.

The review is one part of the current consideration of the SSC within the DOE. Earlier this year, in the President's 1987 Budget request and in Congressional testimony, the Department of Energy is on record as stating that a major review of the status and future prospects of the SSC would occur this summer.

With the detailed conceptual design in hand, the 1986 Snowmass Summer Study (23 June-11 July) gets its teeth into issues of interaction halls and detector design, in addition to further exploration of the expected (and unexpected) physics that the machine would open up.

Meanwhile, the SSC R&D programme continues, with the first full-scale (16.6 m) prototype superconducting dipole magnets being assembled in a string at Fermilab for a half-cell test. The inner assemblies of beam tube, superconducting coils, collars, and flux-return yoke are being fabricated at Brookhaven and shipped to Fermilab for installation into their cryostats. The half-cell test is scheduled to commence in early 1987. Late in 1987, more full-scale magnets will be produced and an accelerated lifetime test will begin at Brookhaven.

Based on a joint Berkeley / Brookhaven / Fermilab design, the magnet embodies a cold iron dipole wound with high homogeneity niobium / titanium cable in a two-layer coil of 40 mm inner diameter. The coil is prestressed by a laminated stainless steel collar and mounted in an iron yoke of outer diameter 267 mm. The entire assembly is supported in a split and welded stainless steel tube which also serves as the helium containment vessel. It benefits from experience with two successful series (18 magnets) of shorter (1 m and 4.5 m) model dipoles made at Brookhaven and Berkeley.

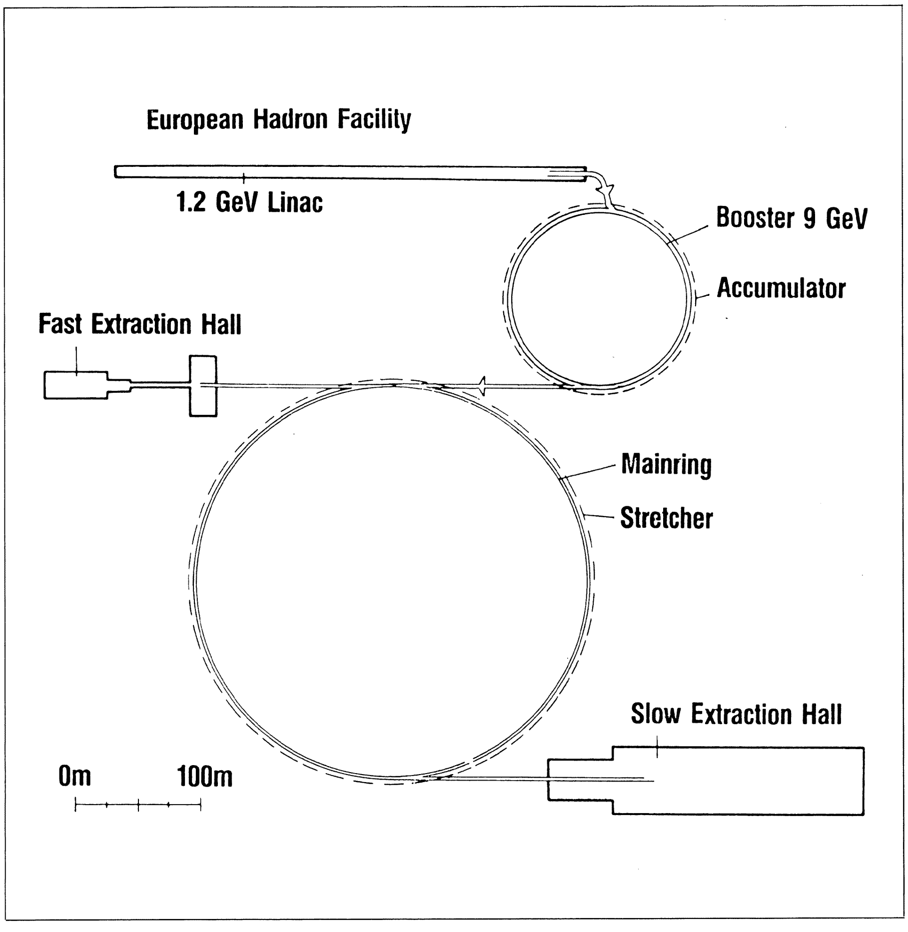
In the meantime, the choice of this design for the proposed SSC has been underlined in the face of strong lobbying by the Texas Accelerator Center for its 'superferric design (see May issue, page 23).

European hadrons

The European Hadron Facility (EHF) is a project for particle and nuclear physics in the 1990s which would consist of a fast cycling high intensity proton synchrotron of about 30 GeV primary energy and providing a varied spectrum of intense high quality secondary beams (polarized protons, pions, muons, kaons, antiprotons, neutrinos).

The physics case of this project has been studied over the last two years by a European group of particle and nuclear physicists (EHF Study Group), whilst the conceptual design for the accelerator complex was worked out (and is still being worked on) by an international group of machine experts (EHF Design Study Group). Both aspects have been discussed in recent years in a series of working parties, topical seminars, and workshops held in Freiburg, Trieste, Heidelberg, Karlsruhe, Les Rasses and Villigen. This long series of meetings culminated in the International Conference on a European Hadron Facility held in Mainz from 10–14 March.

The conference was organized by members of the Faculty of Physics of Mainz' Johannes Gutenberg University. It took place under the



Schematic layout of the proposed European Hadron Facility (EHF) in its 'green pasture' version. The Booster and the Accumulator would fit into the same 480 metre tunnel, with the Main Ring and Stretcher in a longer (960 metre) tunnel. The Linac and Booster would be operated at a repetition rate of 25 Hz, the Main Ring at half this figure. EHF would thus produce a primary proton beam of 100 microamps (6 x 10^{14} protons/s).

patronage of the University's president, and was sponsored by the Federal German Ministry of Science and Technology. The aims of the conference were: (1) to review the physics programme in both low energy particle physics and in modern nuclear physics with non-nucleonic probes, with special emphasis on interactions in the quark confinement regime of quantum chromodynamics (QCD); (2) to announce the results of the EHF Design Study Group on the accelerator design, and to prepare the way for the project.

The scientific programme was divided into sixteen review lectures on various topics in particle and nuclear physics, in close relation to the experimental possibilities opened up by a hadron project such as EHF, LAMPF II (Los Alamos), or Canada's KAON, and into five parallel sessions on nonperturbative methods in QCD (convener D. Amati), meson and baryon spectroscopy (E. Klempt), antiproton physics (P. Dal Piaz), mesons in nuclei (M. G. Huber), and precision experiments (E. Zavattini). The results of these parallel working sessions were reported by the conveners in a plenary session towards the end of the conference week.

The conference was opened by N. Cabibbo (Rome) talking on trends in particle physics. He pointed out the threefold division of present experiments into large scale active experiments at colliders, the class of passive experiments (such as proton decay searches and astrophysical observations), and the experiments at the precision frontier which will be possible at new hadron machines.

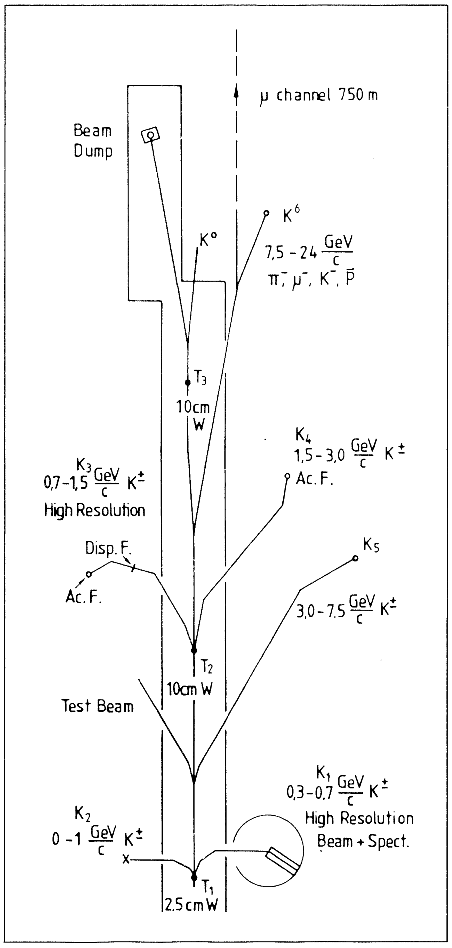
The closing lecture by A. Faessler (Tübingen) was devoted to perspectives in nuclear physics in the light of EHF. This illustrated the role such a facility could play in European physics, providing a bridge between nuclear and elementary particle physics. In both theory and experiment the two disciplines recently have drawn much closer.

Illustrating this, hadronic interactions in the quark confinement regime were covered from the point of view of particle physics by J. Gasser (Bern) who talked on chiral perturbation theory, by E. de Rafael (Marseille) who discussed weak interactions of hadrons, by G. Karl (Guelph) who covered meson and baryon spectroscopy in the light of QCD, and by G. Preparata (Bari) who spoke on spin physics at intermediate energies and who defended unconventional, non-perturbative approaches to QCD.

On the nuclear physics side, the same general domain was taken up by F. Lenz (SIN) and K. Yazaki (Tokyo) who described possibilities for uncovering gluonic degrees of freedom in meson and baryon states by exposing them to nuclear matter, and on unconventional nuclear properties which arise from quark interactions. These contributions illustrated vividly that even though tools and methods may sometimes be different the physics aims are the same: a better understanding and more rigorous testing of quark interaction theory.

Hyperon-nucleon and hypernuclear physics, as well as the dependence of nucleon quark content on its nuclear environment (the EMC effect) are closely related to this general theme of QCD at low energies. These topics were dealt with by, respectively, V. Hepp (Heidelberg), R. Bertini (Orsay), and K. Rith (Heidelberg). G. Garvey (Los Alamos) described possible ways

For the secondary EHF beams which would be operated in parallel, the MAXIM (Multiple Achromatic EXtraction of Independent Momentum Beams) scheme of C. Tschalar is a likely contender. These beams would be in the Slow Extraction Hall marked on the overall schema (page 13).



of obtaining new and complementary information on the physics behind the EMC effect.

Finally, the classical topic of rare and ultrarare decays for whose study EHF and its sister projects are ideal, was covered by L.S. Littenberg (Brookhaven) and H.K. Walter (SIN).

F. Bradamante (Trieste), chairman of the EHF Design Group, presented the results of the three previous machine workshops in the form of a detailed proposal. This foresees a set of five major components: A 1.2 GeV linac; a booster taking the beam to 9 GeV; an accumulator in the same tunnel as the booster; the main synchrotron taking the beam to the final energy; followed by a stretcher that fits into the same tunnel as the main ring of circumference 960 m (any resemblance to existing presently empty tunnels is not unintentional). Bradamante pointed out that earlier criticisms are no longer valid. The price seems under control, the total investment for a 'green pasture' version amounting to about 870 million Deutschmarks. A version using existing facilities would be somewhat cheaper because some expenditure on buildings and general infrastructure would be saved.

In his concluding remarks, F. Scheck of Mainz, chairman of the EHF Study Group, pointed out that the physics case for EHF was well demonstrated, that there was a strong and competent European physics community pushing for it, and that there were good reasons for building it in Europe. He also described three site options: a 'green pasture' version in Italy; at CERN using the now defunct ISR tunnel (this would require complementary funding beyond the normal CERN budget); and at the Swiss SIN Laboratory. Finally he pointed out that it was really one large community of future users, not three, who were pushing for a 'kaon factory'. Whoever would be first to obtain approval, the others would beat a path to his door.

National decisions on the project will be taken this year.

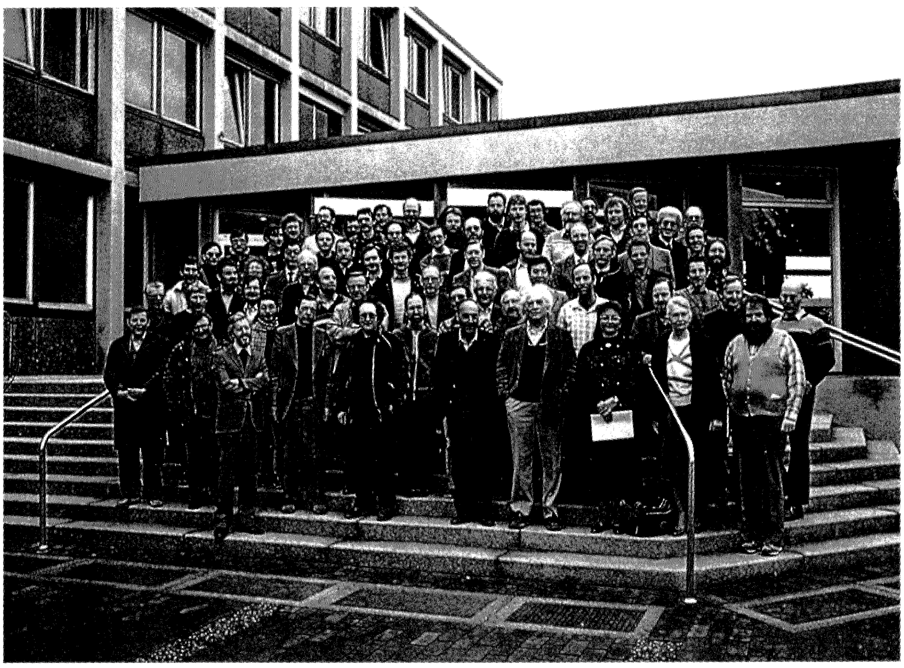
By Florian Scheck

ZEUS and HERA

The HERA electron-proton collider now being built at the German DESY Laboratory in Hamburg will be a unique physics tool. Colliding 820 GeV protons with 30 GeV electrons in a 6.3 km tunnel will probe the structure of matter down to distances of 10^{-18} — a hundred times finer than CERN's proton-antiproton Collider.

Electron probes have a tradition of opening up new physics frontiers — the Franck and Hertz investigations which revealed details of atomic structure; Hofstadter's studies at Stanford which saw the structure of the nucleus; and the experiments at the Stanford linac in the late sixties which showed that the nucleon too had a structure. Will HERA be able to find a deeper layer in the structure of matter?

In addition, the machine will be able to explore particle interactions under new conditions, and will supply physics insights complementary to those from CERN's LEP electron-positron Collider.



A ZEUS group meeting, with spokesman Günter Wolf one step in front of the pack.

(Photo DESY)

Construction of detectors for HERA is a new challenge. As well as having to measure particles and jets of particles with precision at up to very high energies, the large momentum imbalance between the colliding protons and electrons means that most of the emerging

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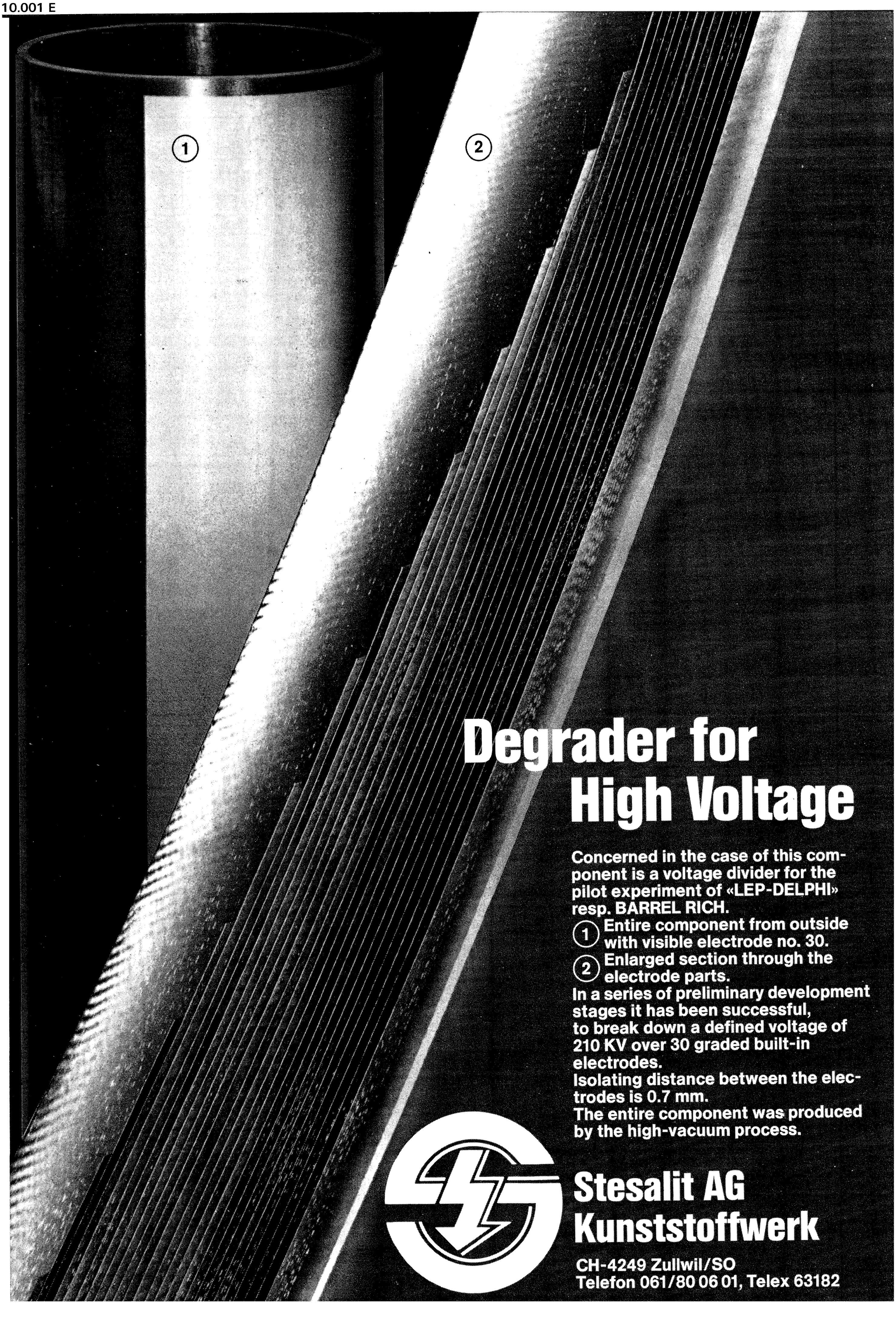

1
2
Degrader for
High Voltage
Concerned in the case of this component is a voltage divider for the pilot experiment of «LEP-DELPHI» resp. BARREL RICH.
(1) Entire component from outside with visible electrode no. 30.
(2) Enlarged section through the electrode parts.
In a series of preliminary development stages it has been successful, to break down a defined voltage of 210 KV over 30 graded built-in electrodes.
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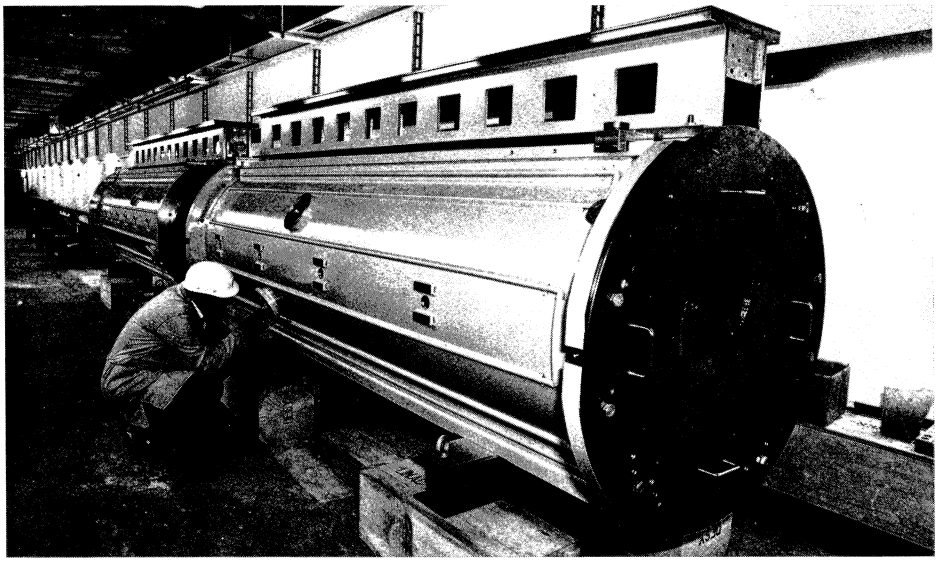
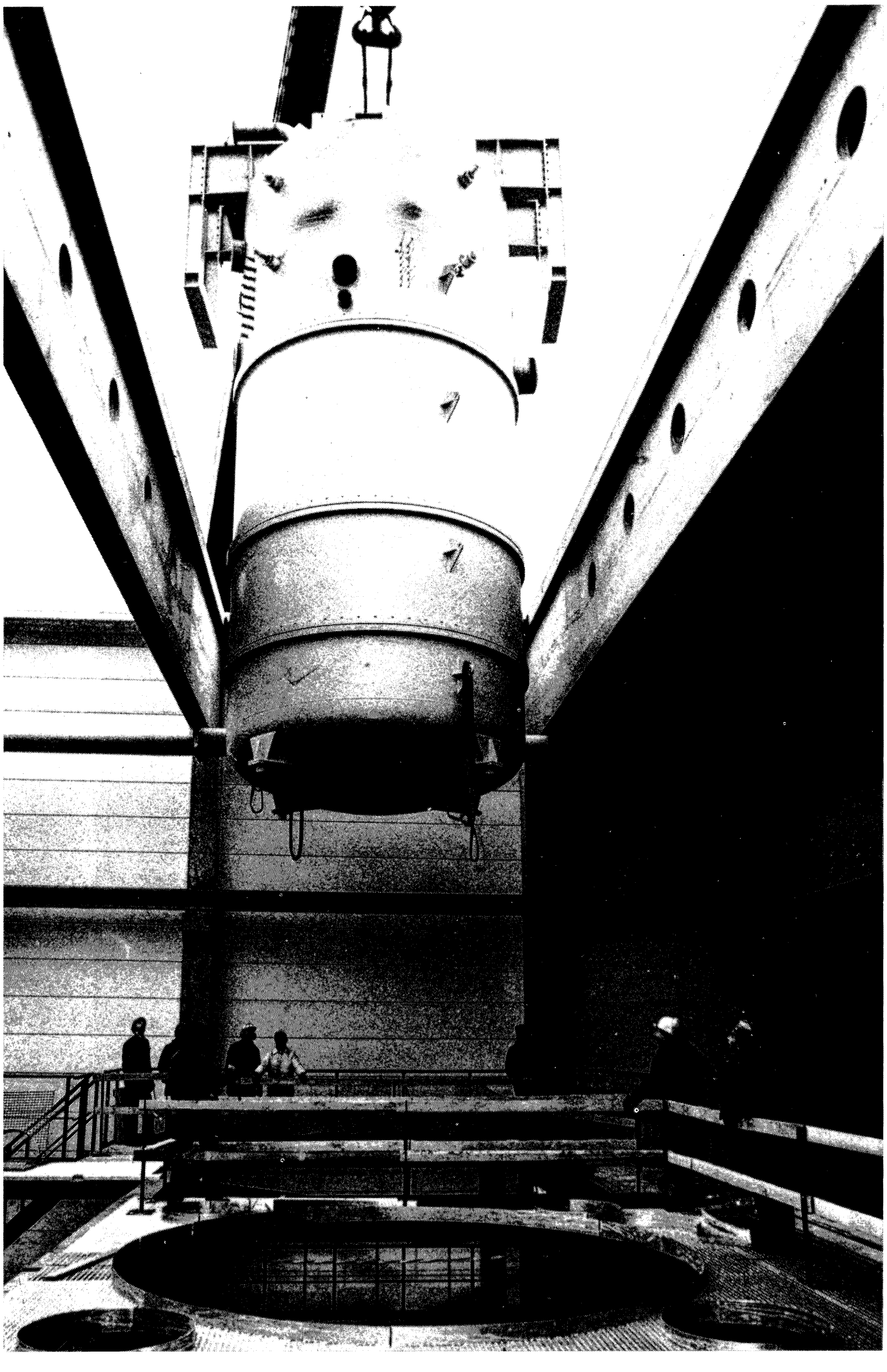




Construction work for the HERA electron-proton Collider at the German DESY Laboratory in Hamburg continues to progress according to schedule. For example installation work has started on the linac which will supply DESY's first protons (so far DESY has been using electrons). Here are seen the first linac tanks to arrive.

HERA progress

Work is also well underway for the huge refrigeration plant for the 6.3 km ring of superconducting magnets to handle the high energy protons.

(Photos DESY)

particles will sweep out in a narrow cone around the protons.

Two detectors have been proposed — H1 and ZEUS. The remainder of this article describes the proposed ZEUS setup: H1 will be covered in a forthcoming issue.

ZEUS is a collaboration of some 300 physicists from 41 research institutes in 9 countries. The most important design consideration has been the accurate identification and measurement of produced leptons (electroweakly interacting particles) and 'jets' of hadrons (strongly interacting particles) in a 'hermetic' calorimeter which intercepts all the released energy.

Two superconducting solenoids are foreseen. A thin solenoid of inner radius 86 cm and length 280 cm mounted between the central tracking detector and the outer calorimeter will provide a field of 1.8 T. In addition, a second compensating solenoid will be inserted in the rear endcap of the central iron yoke to provide the necessary corrections for the colliding beams.

After experience with the TASSO detector at DESY's PETRA electron-positron collider, the ZEUS

team places great emphasis on a central vertex detector (VXD in the figure) immediately surrounding the beam pipe to pick up the fragments emerging directly from the collisions. This will detect the highly unstable particles which decay before encountering the rest of the detector. However the final design of this vertex detector has yet to be decided.

Outside the vertex detector will be the central cylindrical tracking detector (CDT, radius 85 cm, length 245 cm) consisting of a jet-type drift chamber. Track position and energy loss information will be measured in nine 'superlayers' each containing eight layers of sense wires. Four superlayers will be fitted with stereo view wires. A resolution of 100 microns is expected. Close to the beam, tracking will be aided by planar drift chambers.

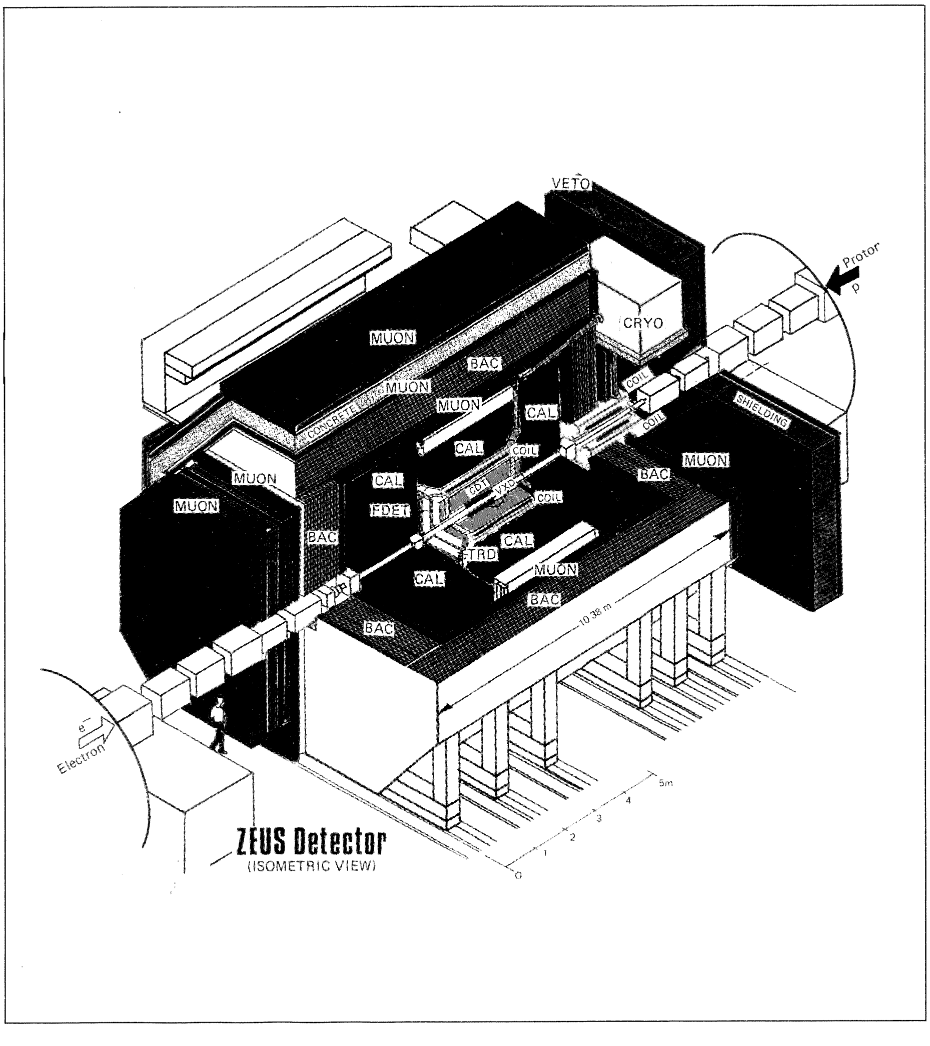
Electron identification will use energy loss information from the tracking detector together with the signals from the electromagnetic calorimeter. In the forward (proton) direction, transition radiation detectors (TRD) will 'reject' the hadron signal.

Electromagnetic and hadronic energy deposition will be measured in a calorimeter (CAL) surrounding the central coil, using uranium plates as absorber and scintillator as the active material to achieve the best possible energy resolution for hadrons and jets. The calorimeter will be divided into forward, central barrel and rear portions. A further 'backing' calorimeter (BAC) consisting of an iron box and streamer chambers will surround the detector to catch late-developing showers. Muon detectors will make up ZEUS' outer envelope.

The detector will be structurally divided into the inner components, supported by the bottom of the magnet yoke, and two sideways-retracting 'clam-shells' carrying most of the backing calorimeter and the muon detectors.

The timetable for ZEUS construction and assembly is governed by the delivery date of the solenoid, probably in 1988. ZEUS should be complete by the summer of 1990.

In Greek mythology, Zeus' union with Hera was divine. It remains to be seen whether this will be repeated in the ring being built underneath Hamburg.

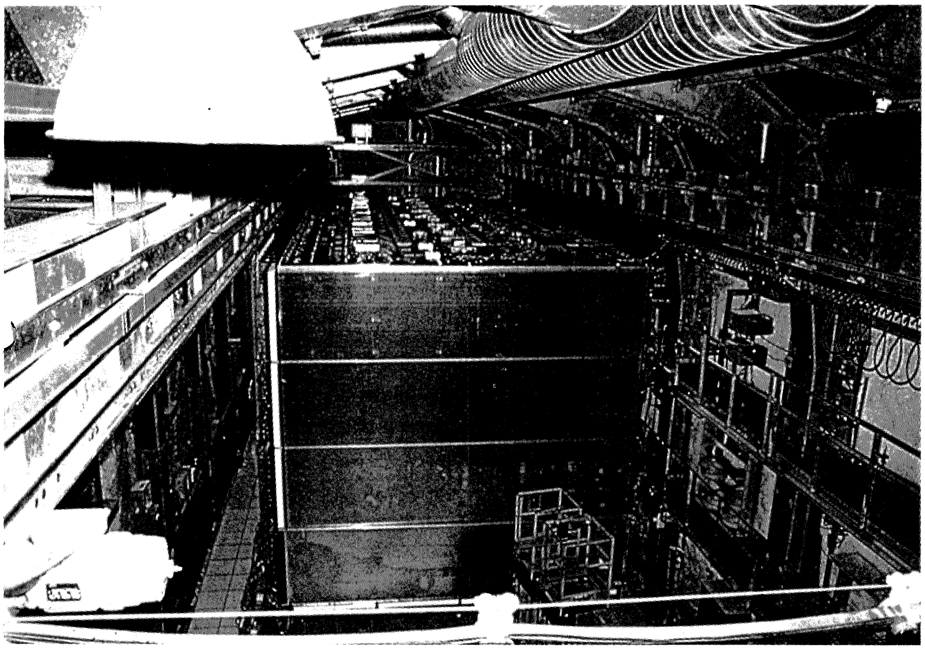


Proposed layout of the ZEUS detector for the HERA electron-proton collider at the German DESY Laboratory in Hamburg. With 820 GeV protons coming in from the right hitting 30 GeV electrons travelling in the opposite direction, most of the emerging particles will be caught in a cone aroud the proton direction. The configuration is described in the text.

Around the Laboratories

The 900-ton fine grain tracking calorimeter used by a French/German collaboration in the Fréjus road tunnel under the Alps which has spotted a candidate for proton decay.

(Photo F. Siohan)



Underground protons

Deep underground in the Fréjus road tunnel linking France and Italy under the Alps is a 900-ton fine grain tracking calorimeter used by a French/German physics collaboration to look for signs of proton decay and to search for directional sources of highly penetrating extra-terrestrial particles.

Ambitious theories predict that the proton, classically considered to be stable, should occasionally decay. However these decays would be very rare, requiring a big detector (lots of protons) operational for years and well shielded from cosmic rays which would obscure any signal. Initial studies showed that the proton was more reluctant to decay than was first thought. It became clear that the search for proton decay would be long and hard.

The Fréjus detector went live with 240 tons of active volume in March 1984, and the complete version came into action in May of last year, accumulating so far some 600 ton-years of information. This provides a sample of 65 'contained' events with no visible incoming track. However all these events, except one, look likely to be due to invisible incoming neutrinos. The one event which remains could be a proton within the detector decaying into a number of particles (electron, pion and photon).

However, a lone event is not conclusive, and the big underground detectors continue their painstaking search.

In contrast with earlier studies which saw signs of mysterious ultra high energy muons coming from the direction of the binary star Cygnus X-3 (see September 1985 issue, page 264), the Fréjus study sees no such directional source, a result being underlined by data coming in from other underground laboratories throughout the world.

BERKELEY
Bevalac upgrade?

Relativistic (high energy) heavy ion physics is emerging as an exciting and potentially highly productive new branch of nuclear science. Projects are afoot at CERN and Brookhaven (see June issue, page 3). In the meantime the high energy spearhead of heavy ion physics has been the Bevalac machine at Berkeley which supplies beams of nuclei across the Periodic Table at energies from 20 MeV to 2 GeV per nucleon.

In March, Berkeley submitted a preproposal to the US Department of Energy proposing a major Bevalac upgrade. It involves replacing the venerable Bevatron (which commenced operations in 1954) by a modern strong focusing synchrotron, installing new vacuum, beam handling and controls systems, and placing an emittance matcher in the transfer line from the SuperHILAC heavy ion injector. The present buildings, shielding, injectors and experimental areas would continue to be used. Estimated cost is 32.5 million dollars (including a 40 per cent contingency), and the project could be completed in three years.

The new synchrotron would deliver beams over the same energy range as the Bevalac, but with a hundred times the current intensity and improved duty factor (from 20 to at least 50 per cent). Single turn injection and extraction would allow the new synchrotron to be used in conjunction with a future storage ring.

The dominant theme of relativistic heavy ion physics is the creation and study of nuclear matter under extreme conditions. A few years ago, hot dense nuclear matter was created for the first time under laboratory conditions (see June 1984 issue, page 196). This opened the door to the systematic investigation of a wide range of exotica, which will be boosted by the availability of high intensity, high quality, high duty factor beams. New experimental techniques will be possible for investigating the equation of state of nuclear matter; studies of nuclear structure and nuclear astrophysics using radioactive beams will be extended; new experiments in biology, atomic physics and technology will become feasible.

The numerous scientific rewards could be augmented by subsequent addition of a storage ring with beam cooling. However this is not included in the present proposal as a substantial research and development effort is first needed to optimize the design.

The Superstring Syndrome

Particle theorists all over the world have fallen victim to it. Should measures be taken before panic sets in? Noboru Nakanishi of Kyoto's Research Institute for Mathematical Sciences commented in the Japanese journal Soryushiron Kenkyu (Researches of Elementary Particle Theory).

A recent epidemic among the Elementaly (sic) Particle Theorists is the Superstring Syndrome, which causes the Kaluza-Klein symptoms. The pathogen is said to be much smaller than any virus known and is ring- or string-shaped. Young and cheerful people are observed to be more susceptible to this disease. The infection is usually oral, but since it occurs occasionnally through the eye, special precautions are necessary.

The disease was also epidemic more than ten years ago, but then the damage was minor, since it was not associated with the Kaluza-Klein symptoms. Eventually Yang-Mills was found to be an excellent remedy, and most of the cases were said to be completely cured. However the current wave is much more severe, for which Yang-Mills can cause undesirable side-effects rather than cure.

Adding further to the worries is the fact that the brain may be affected. Victims believe that 'anomalies' are at the root of everything. In contrast to healthy people, who regard normality as such and observe anomalies as deviations from the norm, superstring syndrome cases prefer anomalies and observe normality as an aberration. Researchers into abnormal psychology are therefore quite interested in the syndrome.

Cases also believe in a miracle. Not a comparatively minor one like the parting of the Red Sea in the story of the Exodus, but a Great Miracle in which a ten-dimensional space-time is divided into four-dimensional space-time and a six-dimensional space. The magic 'Calabi-Yau' spell apparently enables cases to see clearly the varied structures of the six-dimensional space.

Another trouble is that patients do not recognize their own abnormality, regarding the Kaluza-Klein symptoms are normal and disregarding the fourfold dimensionality of the real world. We are worried about a possible disaster if an antidote is not found soon.

RUTHERFORD APPLETON
ISIS nice

The ISIS pulsed spallation neutron source continues to make good progress. In March the machine reached its highest intensity when 5 x 10^{12} protons per pulse at 550 MeV and 50 pulses per second were delivered to the neutron production target. This 40 microamperes of mean proton current is 20% of the design performance and confirms once again the potential of ISIS as a powerful accelerator-based pulsed neutron source.

Much hard work had gone into achieving this important milestone. It was the first time that there had been a sustained run at 50 Hz and confirmed that all systems are capable of performing at the design repetition rate. Just prior to this highest intensity run, with 4 x 10^{12} ppp hitting the neutron target, 80 per cent of the particles from the injector were transported to the target station. Efficiency of injection into the synchrotron was typically 96 per cent, trapping and acceleration efficiency was 86 per cent and extraction efficiency 99 per cent.

However a few systems had been giving problems and a three month shutdown was called to attack these and other items. Also during the shutdown, major installation work will begin for the first stage of the muon spin rotation and resonance beam which is funded by the European Economic Community, France, Germany, Italy and others. This beam is designed as the most powerful muon beam for the study of condensed matter.

On the target station further improvements will be made and the front ends of three new neutron lines will be installed. The remaining two radiofrequency cavities will be installed on the synchrotron to permit trials of operation towards the design energy of 800 MeV. However priority will be given to injector work so as to achieve a period of reliable running for the neutron scattering research programme during the second half of this year.

A superconducting future

Big machines being considered for construction in the next decade in both the high energy physics (HEP) and fusion energy sectors worldwide are critically dependent on reliable sources of high field high erformance superconductors. There is also a growing commercial demand for such conductors in nuclear magnetic resonance systems operating at about 12 tesla, to be followed by an increase in field to 16-17 tesla in the next decade.

Furthermore it is forecast that applications such as magnetic separation and motors and generators will require windings operating at 9 tesla. It is anticipated that expanding world sales of superconductor for these known fields of commercial application will have reached a value of several million pounds sterling per annum by 1990. This however will be far xceeded by new HEP and fusion requirements if they come to fruition at that time.

Significant improvements from the present state of the art in conductor performance and reliability of production will be necessary to meet most of the application requirements. The development will be expensive compared to the initial returns expected from the commercial market but as the timescales are short for the big new machines, it must be vigorous and actively encouraged by the HEP and fusion users.

This situation has its parallels in the 1960s development of niobium-titanium conductors which was almost exclusively led by HEP Laboratories. In this sense the present world market of around £250 million per annum in sales of such conductors for use in magnetic resonance imaging systems, themselves valued at ten times this figure, is a spinoff from past investment in HEP. Such an expansion could not have been foreseen in the early days but in view of this precedent it should be expected that high field conductors will trigger the development of other high technology devices.

The potential future for high field superconductors is clearly very exciting. There is however a growing consensus that collaboration and pooling of resources will be necessary to meet the high development costs. Against this background and in order to assist the process of collaboration, particularly in Europe, an informal meeting was held recently at Rutherford Appleton Laboratory on the future for high field superconducting materials, including requirements and forecasts for their fulfilment.

The meeting, jointly sponsored by the UK Institute of Physics, the Institute of Metals and RAL, was attended by 82 participants drawn mainly from Europe with a small contingent from the US and was addressed by 14 invited experts. The aim of the meeting was to explore technical guidelines for conductor development programmes in which the conductor specification covered the widest possible range of applications. The proceedings should be published in a future edition of 'Cryogenics' journal.

by Colin Walters

At the recent meeting on the future for high field superconducting materials held at the Rutherford Appleton Laboratory, a point by CERN Director Giorgio Brianti (right) provokes thoughtful responses from Tony Appleton of International Research and Development (centre), and Peter Komarek of Karlsruhe's Kernforschungszentrum.

(Photo RAL)

Coordinating controls

While physics Laboratories are having to absorb cuts in resources, the machines they rely on are becoming more and more complex, requiring increasingly sophisticated systems. Rather than being a resourceful engineer or physicist able to timber together solutions in his 'backyard', the modern controls specialist has become a professional in his own right.

Because of possible conflicts between increasing sophistication on one hand and scarcer resources on the other, there was felt a need for more contacts among controls specialists to exchange experiences, coordinate development and discuss 'family problems', away from meetings where the main interest is on experimental physics.

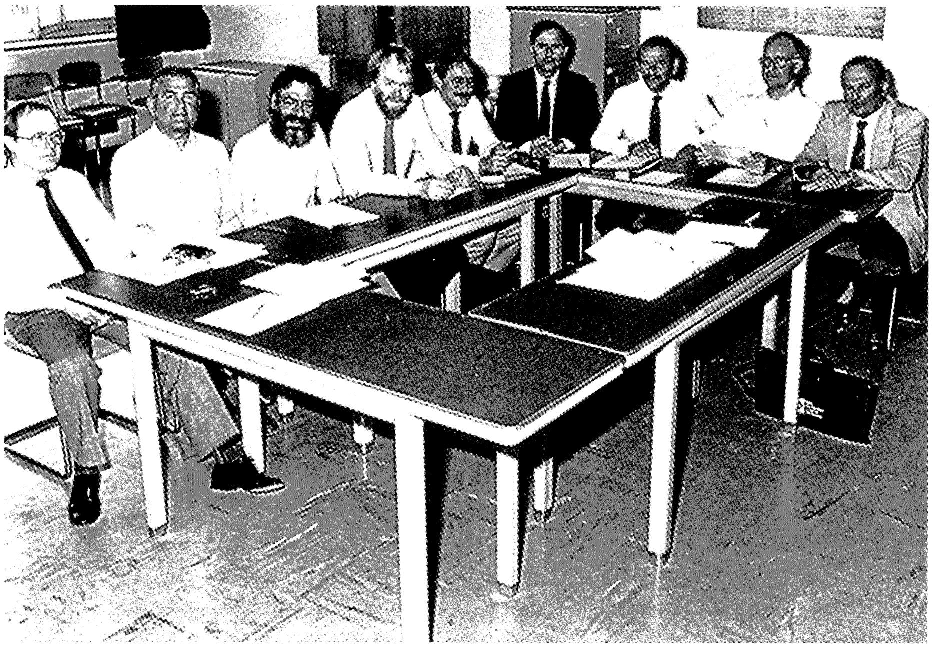
Two such controls workshops were held last year at Brookhaven in January and Los Alamos in October, and in subsequent discussions European specialists felt the time had come for them to set up a professional group, and the European Physical Society (EPS) seemed to provide the best way of doing so.

At its Council meeting in London in March, the EPS approved the setting up of an Interdivisional Group on Experimental Physics Control Systems. Its objectives are: to promote controls technology in a range of fields (accelerators, fusion, lasers, etc.); to establish contacts between specialists in Europe and elsewhere; to stimulate international cooperation and information exchange; to make best use of available resources; and to foster the adoption of high standards. This will be achieved through meetings, project investigations, encouraging postgraduate training, consultancy, and collaboration.

The business of the new group is handled by a Board with members mostly drawn from controls groups in major European research centres. Its chairman is Axel Daneels from CERN's Proton Synchrotron Division, main instigator of the idea for such a group.

Board members of the European Physical Society's Interdivisional Group on Experimental Physics Control Systems at their first meeting at CERN: (left to right) Winfried Busse (Hahn-Meitner Inst., Berlin), Michel Promé (GANIL, Caen), Thomas Blumer (SIN, Villigen), Peter Clout (Los Alamos), Ivo Jirousek (SIN, observer only), Axel Daneels (CERN, Chairman), Henri Van der Beken (JET, Vice-Chairman), Berend Kuiper (CERN), Klaus Müller (KFA, Jülich, Treasurer). Board member Ted Owen from Daresbury does not appear on the photograph.

(Photo CERN 635.5.86)



On 28 February the High Resolution Spectrometer completed five years of operation at Stanford's PEP electron-positron collider. During this time an impressive volume (300 inverse picobarns) of data was collected, containing over 100 000 examples of electron-positron annihilation into quarks at 29 GeV, as well as a large sample of final states with weakly interacting particles.

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Published from CERN, Switzerland, it also has correspondents in the Laboratories of Argonne, Berkeley, Brookhaven, Cornell, Fermi, Los Alamos and Stanford in the USA, Darmstadt, DESY and Karlsruhe in Germany, Orsay and Saclay in France, Frascati in Italy, Daresbury and Rutherford in the U.K., SIN in Switzerland, Dubna and Novosibirsk in the USSR, KEK in Japan, TRIUMF in Canada and Peking in China.

The annual expenditure on high energy physics in Europe is about 1000 million Swiss francs. The expenditure in the USA is about $ 400 million. There is similar expenditure in the Soviet Union

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1/4	90 x 130	580	550	530	510

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All enquiries to:
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CH-1211 Geneva 23 Switzerland
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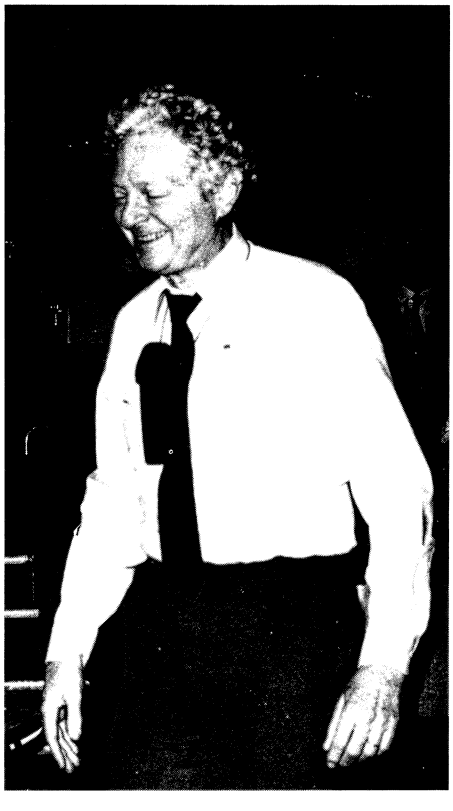
Top: Jack Steinberger — a memorable 65th birthday.

Below: Leon Lederman — Great Successes, Great Failures - high comedy underpinned by real physics.

(Photos Gérard Bertin, CERN)



CERN Jackfest

Over four decades, from his initial investigations which helped open up meson physics at the end of the 1940s to leadership of one of the big experiments being prepared for CERN's LEP electron-positron Collider, the career of Jack Steinberger has paced the development of particle physics.

To mark his 65th birthday, friends, colleagues and admirers at CERN paid a special tribute on 16 May. T. D. Lee, who was a graduate student in Chicago with him in 1946, sketched the evolution of the weak interaction and in particular Steinberger's own landmark contributions. He recalled a discussion with Steinberger on angular distributions in hyperon decays which led Lee (with C. N. Yang) to realize that parity (left/right symmetry) is broken when the weak force is in action.

Emilio Picasso took over to describe the current and future status of the LEP Collider, scene of the ALEPH experiment, Steinberger's latest physics venture, now being prepared for final assembly deep under the Jura mountains.

'After T. D. Lee who praised him, and Emilio Picasso who buried him, it's my turn', said Fermilab Director and contemporary Leon Lederman. Entitled 'Great successes, great failures — incidents in experimental physics', Lederman's habitual high comedy was underpinned by real physics.

In conclusion, Konrad Kleinknecht presented the Festschrift he had edited in collaboration with T. D. Lee, with contributions from Baltay to Yang.

Happy and surrounded by friends, Jack thanked all those in front and behind the scenes for a memorable afternoon.

Passing through CERN in May was Italian Foreign Minister Giulio Andreotti (second from right), the second time he has visited the Laboratory in less than a year. He is seen flanked by (left to right) Nobel prizewinners Sam Ting and Abdus Salam, Italian physicist Antonino Zichichi, prime mover in obtaining Italian support for new projects, LEP Project Director Emilio Picasso, and Remo Paolini, Italian Ambassador to the International Organizations in Geneva.

(Photo CERN 258.5.86)

People and things

Left to right, Sergei Denisov, Yuri Prokoshkin and Mirian Mestvirishvili of Serpukhov, USSR, who received 1986 Lenin Awards for science and technology, together with Nguyen Van Heu of Vietnam.

On people

Georges Charpak of CERN has been elected foreign associate of the US National Academy of Sciences. These elections are in recognition of distinguished and ontinuing achievements in original research.

American Physical Society Awards

This year's American Physical Society (APS) awards were distributed at the Spring meeting in Washington in April. The Tom W. Bonner Prize in Nuclear Physics went to Lowell M. Bollinger of Argonne National Laboratory; the Davisson-Germer Prize to Daniel Kleppner of the Massachusetts Institute of Technology; the Dannie Heineman Prize to A. M. Polyakov of the Landau Institute for Theoretical Physics in Moscow; the J. J. Sakurai Prize to David Gross, of Princeton University, H. David Politzer, of the California Institute of Technology and Frank Wilczek, of the Institute for Theoretical Physics, Santa Barbara, California; and the Maria Goeppert-Mayer Award to Judith Young of the University of Massachusetts.

The 1986 APS meeting was a distinctly international affair, with participants from 50 Societies, and featured an International Conference on Research and Communications in Physics.

Presented at the American Physical Society's Forum on Physics and Society was the Leo Szilard Award for Physics in the Public Interest, which went for 1986 to Arthur H. Rosenfeld of Berkeley for his work in the application of physics to energy conservation. Rosenfeld originally worked at Berkeley with Luis Alvarez in particle physics, and created the famous 'Rosenfeld Tables'—the periodic Review of Particle Properties, now compiled by what has become known as the Particle Data Group. In 1974 he turned his interests to energy conservation, and is now Director of the Center for Building Science at Berkeley.

Lenin Prizes

Recipients of the 1986 Lenin Prize awards for Soviet science and technology include Sergei Petrovich Denisov, and Yuri Dmitrievich Prokoshkin, Corresponding Member of the USSR Academy of Sciences, both of them Departmental Heads at the USSR's Institute of High Energy Physics, Serpukhov.

Prokoshkin is also spokesman of the joint CERN/USSR experiment studying pion-proton interactions. Awards go also to Mirian Alekseevich Mestvirishvili, Laboratory Head at Serpukhov, and to Nguyen Van Heu, President of Vietnam's National Centre for Scientific Research, and currently a member of the International Committee for Future Accelerators (ICFA). The awards are in recognition of their important work on production processes in strong interactions.

THE INSTITUTE OF PARTICLE PHYSICS OF CANADA

The Institute of particle Physics of Canada (IPP) invites applications for positions in experimental particle physics. Depending on experience and qualifications the applicant will be considered for appointment as Research Associate or Research Scientist. The Research Scientist appointment will be associated with an academic position at a Canadian university and includes the right to hold research grants and supervise graduate students. This appointment may lead to permanence after three years. The successful candidate will participate in the experimental particle physics program of the Institute which is listed below:

(I) e^+e^- collisions in the T region (ARGUS Group at DESY);

(II) photoproduction of charmed particles in a tagged photon beam (E691, FNAL);

(III) hadronic production of p-wave charmonium states and direct photons (E705, FNAL);

(IV) direct lepton production at the CERN SPS (NA34);

(V) hadronic collisions with the UA-1 Detector at the CERN SPS Collider;

(VI) e^+e^- collisions at LEP (OPAL Group at CERN);

(VII) e-p collisions at HERA (ZEUS Group at DESY), including participation in the accelerator construction;

(VIII) e^+e^- collisions at the SLC (SLD Group);

(IX) Quark Structure of the Hyperons (E811, BNL).

Interested persons are invited to apply, including Curriculum Vitae and the names of three references to:

D.G. Stairs, Chairman
The Institute of Particle Physics
Rutherford Physics Building
McGill University
3600 University Street
Montreal, Quebec H3A 2T8
Canada

Applications should be received before August 31, 1986. In accordance with immigration regulations, preference will be given to citizens or permanent residents of Canada.

UNIVERSITÉ DE GENÈVE

Le Département de physique théorique de la Faculté des sciences ouvre une inscription pour un poste de

maître d'enseignement et de recherche

Fonction à plein temps exigeant un doctorat ou titre équivalent. Enseignement (minim. 2 heures) et recherche en théorie des champs et des particules. Tâches d'organisation.

Entrée en fonctions:
1er octobre 1987 ou à convenir.

Pour information et inscription, prière de s'adresser avant le 15 juillet 1986 au

Prof. C. P. Enz,
directeur du Département
de Physique théorique,
24, quai E.-Ansermet,
CH-1211 Genève 4

NIKHEF

The Nuclear Physics section (K) of NIKHEF, the Netherlands' National Institute for Nuclear Physics and High-Energy Physics, has two openings for a position resident at Geneva (CERN) for an

Experimental Postdoctoral Physicist (m/f)

to participate in the New Muon collaboration (NMC) which has an approved research programme on the EMC-effect and related QCD-aspects of nuclei at the 300 GeV muon beam at CERN. They will act as local contact person and supervisor of PhD students of the recently initiated Dutch participation in this programme. Experience in High-Energy and/or Nuclear Physics Instrumentation is required.

The appointment will be for two years with the Foundation for Fundamental Research on Matter (FOM). Information can be obtained from Dr. R. van Dantzig, tel. (20) 592012 0 or 430315.

Candidates are invited to apply within a month after appearance of this advertisement, while enclosing a curriculum vitae and names of referees, to

Prof. Dr. G. van Middelkoop,
Scientific Director
of NIKHEF section K,
P.O. Box 4395,
1009 AJ Amsterdam,
the Netherlands.

THE PENNSYLVANIA STATE UNIVERSITY

Experimental High Energy Physics

The Department of Physics is seeking candidates for a tenure-track position of Assistant or Associate Professor in Experimental High Energy Physics starting in the 1986-87 or 1987-88 academic year.

Candidates should have a Ph.D. in Physics, an established record of research accomplishments and expect to work initially in conjunction with other faculty and staff in the research effort at Penn State.

Research projects which are presently in their early stages include Fermilab experiment E-706, a study of direct photon production utilizing a spectrometer with liquid argon calorimetry located in the Meson Laboratory, and Fermilab experiment E-760, a study of charmonium states utilizing a hydrogen gas jet target inside the antiproton accumulator storage ring.

A desire and aptitude for teaching of undergraduate and graduate students is essential.

Send applications, including a curriculum vitae and names of at least four references, to

Professor Gerald A. Smith
Head
Department of Physics
Box B.
The Pennsylvania State University,
University Park, PA 16802,

by September 15, 1986, or until a suitable pool of applicants is identified.

An affirmative action/equal opportunity employer.

André Berthelot

André Berthelot

André Berthelot, former director of Saclay's Department of Elementary Particle Physics, died on 30 March at the age of 74.

He was the initiator of fundamental physics research in the French Atomic Energy Commission and in 1947 set up its nuclear physics branch, becoming its head. In 1958 he established what was to become the Department of Elementary Particle Physics, of which he remained head until 1975. Under his leadership, Saclay became one of Europe's leading centres for particle physics.

Professor Berthelot was a scientific pioneer who left his mark on the development of French and European physics.

Beam frontiers

Together the CERN Accelerator School and the US Particle Accelerator School organize a series of courses on advanced topics. This year's course, Frontiers of Particle Beams, will be the second in this series and will be held on South Padre Island, Texas, from 23-29 October. It should be useful for graduate students, post-doctoral researchers and scientists interested in entering accelerator physics as well as experienced workers. Material from previous general accelerator schools would provide suitable preparation. The number of participants (including lecturers) is limited to 150.

Further information from US Particle Accelerator School, c/o Marilyn Paul, Fermilab MS 125, P.O. Box 500, Batavia, Illinois 60510, USA, or CERN Accelerator School, c/o Suzanne von Wartburg, CERN, 1211 Geneva 23, Switzerland.

Proceedings

The Proceedings of the Joint US-CERN School on Particle Accelerators, held in Santa Margherita di Pula, Sardinia, in 1985 are available as Lecture Notes in Physics, No. 247, Nonlinear Dynamics Aspects of Particle Accelerators, published by Springer-Verlag, Berlin. The proceedings were edited by J. M. Jowett and S. Turner (CERN) and M. Month (Brookhaven).

Fermilab and industry

The Fermilab Industrial Affiliates organization was established to improve university-industry research communications and to foster technology transfer from Fermilab. The Affiliates' meeting this year concentrated on particle physics in the nineties, with talks on the design of the proposed US Superconducting Supercollider, discussion of future instrumentation and electronics needs, and a review of supercomputer developments.

There was also a report on the new proton accelerator for medical therapy project at Fermilab. This is developing a small proton accelerator for Loma Linda hospital in California that may serve as a prototype for a series of accelerators for hospital use. The State of Illinois has awarded the Laboratory a grant to promote commercialization of medical accelerator technology.

Fermilab Industrial Affiliates now includes forty institutions.

Meeting on Symmetry in Nuclear Physics

The Joliot-Curie School of Nuclear Physics organized by the French Institut National de Physique Nucléaire et de Physique des Particules, together with the Institut de Recherche Fondamentale du Commissariat à l'Energie Atomique will be held from 15-19 September at Maubuisson, France. The school is aimed at all nuclear physicists, experimental and theoretical, with a special effort to cater for non-specialists. The theme this year is 'Symmetries in Nuclear Physics'. Further details from Mme. E. Perret, Ecole Joliot-Curie, IN2P3, 20 rue Berbier du Mets, 75013, Paris, France. There are no registration fees.

W for Watkins

Recently published by Cambridge University Press in the UK is the 'Story of the W and Z', a first-hand account of the discovery at CERN in 1983 of the carriers of the weak force written by Peter Watkins, of the University of Birmingham and member of the UA1 collaboration at CERN. As well as explaining the discoveries, Watkins' book provides an interesting insight into the daily life of modern physicists with its ups and downs.

Another book covering the W/Z saga is 'The Particle Connection' (published by Hutchinson in the UK and Simon and Schuster in the US), written by Christine Sutton, an ex-particle physicist who has subsequently carved out a name for herself as a writer on the subject.

ICFA actions

Though the vision of a 'world' accelerator stays beyond the horizon, the International Committee for Future Accelerators does continue to provide a forum for interregional cooperation on front line research and technology in particle physics.

Recent activities included a Workshop on Superconducting Magnets and Cryogenics held at Brookhaven (we will carry a report on the meeting in a forthcoming issue). The ICFA Instrumentation Panel is planning a School on 'Concepts and Trends' in ICTP Trieste for June 1987. This Panel also publishes its' Instrumentation Bulletin' to convey recent developments to the community.

CERN Director General Herwig Schopper (left) welcomes Swiss President Alphons Egli to the Laboratory in May.

(Photo CERN 29.5.86)