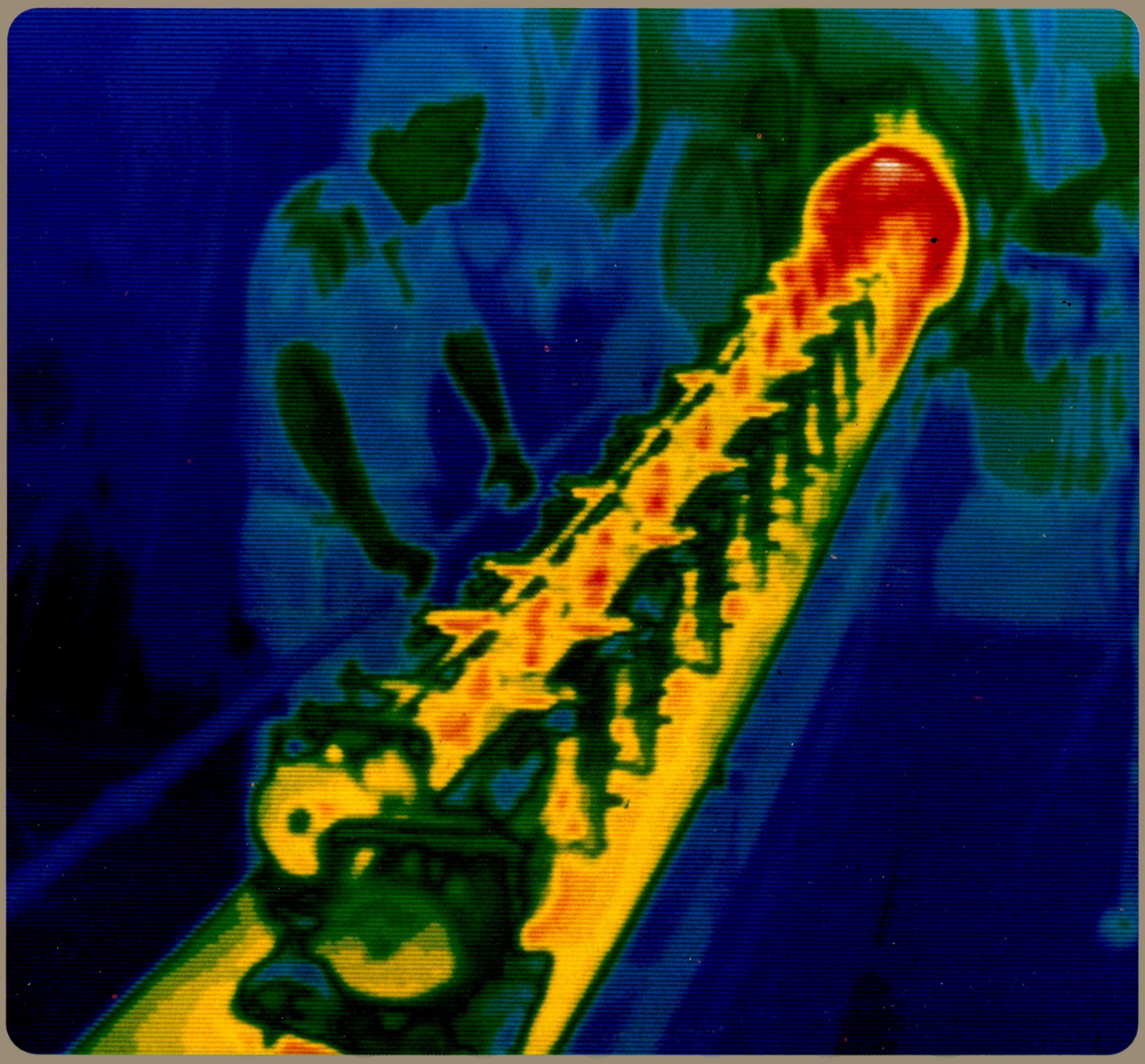
CERN COURIER

International Journal of High Energy Physics



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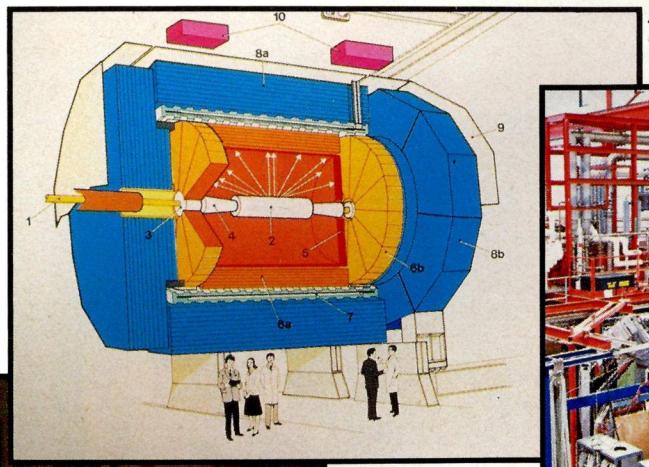

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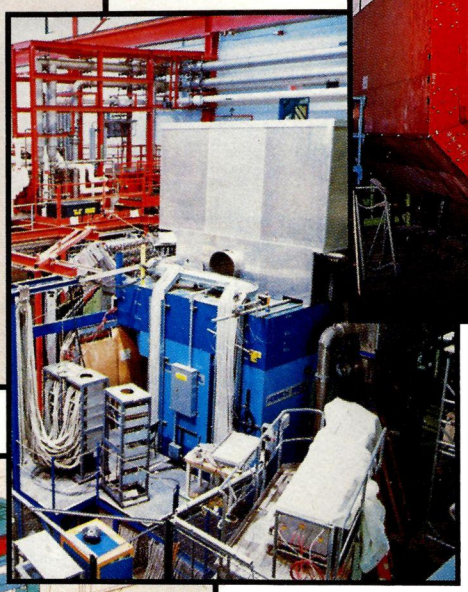

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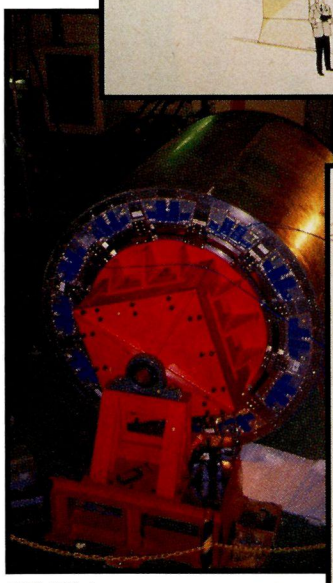

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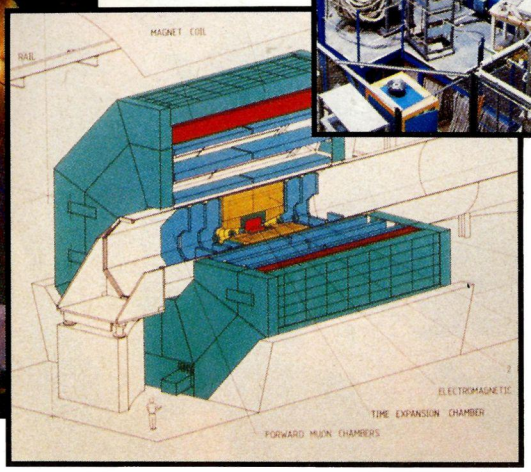

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Covering current developments in high energy physics and related fields worldwide

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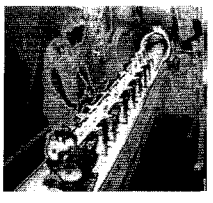
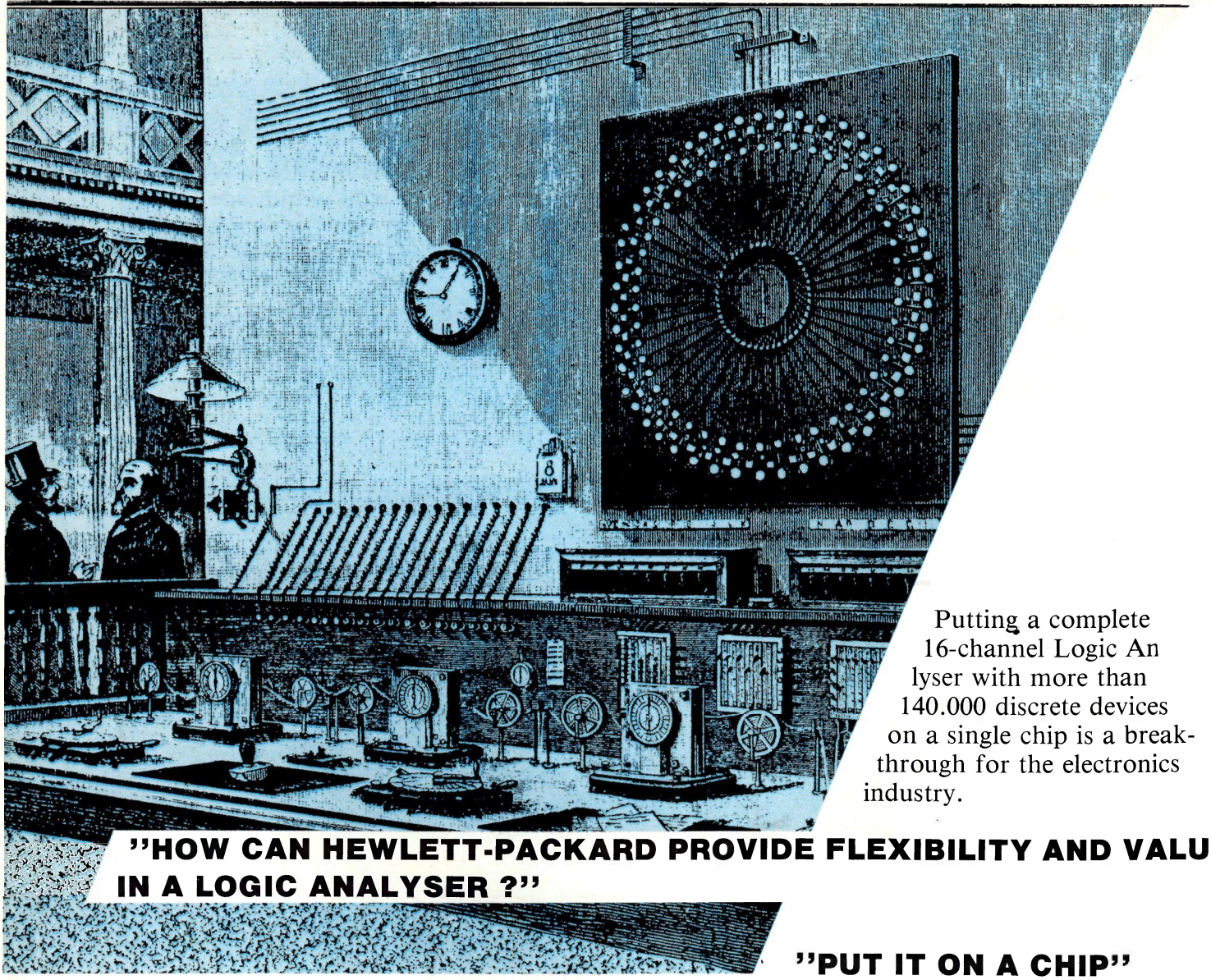


Cover photograph:
Infra-red camera view of one of the last 14-metre copper vacuum pipes for the electron ring of the HERA electron-proton collider under test at the DESY Laboratory in Hamburg. The HERA design prefers copper to the more conventional aluminium vacuum pipe.



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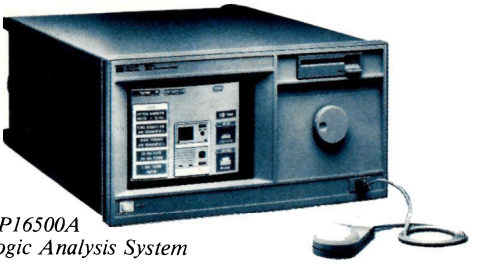

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Energy not the only frontier

Erich Vogt: $ 11 million for the KAON project

In the major world areas active in high energy physics, proposals have been prepared for new machines to manufacture intense beams of strongly interacting particles (hadrons) to complement the physics coming in from the high energy frontier. An information session (chaired by George Igo of UCLA) on these plans for intense hadron facilities was included in the Third International Conference on the Intersections between Particle and Nuclear Physics, held in Rockport, Maine, in May.

Erich Vogt, director of the Canadian TRIUMF Laboratory in Vancouver, explained the main features of the 100 microamp 30 GeV KAON Factory (April 1986 issue, page 20) and summarized its current status. Recent developments suggest that the project may be approved soon. As well as a $90 million commitment from the provincial government of British Columbia, the federal government has joined in exploring foreign participation, and there appears to be substantial potential for such support.

According to Vogt, the next step is for the government of Canada to give approval in principle, possibly contingent on subsequently negotiating a portion of the construction funds from abroad. With $11 million for prototyping studies approved, coupled with authority to formally negotiate foreign contributions, the KAON project looks in good shape.

Gerry Garvey, the director of LAMPF, focused on Los Alamos plans for a 25 microamp 60 GeV Advanced Hadron Facility (AHF), pointing out the advantages of the higher 60 GeV energy. With no slack in the present level of US nuclear physics funding, this project has to wait in the queue, with design efforts being vigorously pushed. Garvey stressed the cooperative nature of this work, with many areas being jointly researched and prototyped by a LAMPF/TRIUMF collaboration. He also said that the technical problems of constructing an intense hadron facility are sufficiently challenging that design studies and prototyping could take up much of the time before funding could be considered. He looked forward to the benefits of increased research and development funding for both the AHF and the KAON projects.

Bob Adair covered Brookhaven's impressive physics achievements with a 30 GeV proton beam. The 1.5 GeV booster ring now under construction and scheduled for completion by mid-1991 would increase beam intensity to 4 microamps (8 microamps pulsed). An additional stretcher ring could further increase both intensity and duty factor. Operationally, kaon physics at Brookhaven still feasible if the proposed RHIC heavy ion collider goes ahead, since RHIC filling would only take a few hours per day, leaving lots of time for kaon physics with the existing facility. A more ambitious proposal foresees additional rings to push beam intensities still higher.

Ewart Blackmore from TRIUMF described the proposed experimental facilities for the different projects, and emphasized the potential impact of a users' group on the final outcome. He also summarized many of the problems to be solved, such as handling the beam power in the production target region. (To join the Intense Hadron Facility Users' Group, write to Michael LaBrooy at TRIUMF, 4004 Wesbrook Mall, Vancouver, B.C., V6T2A3 Canada).

A number of groups outside North America have also developed proposals for intense hadron facilities, all aiming to provide 100 microamp proton beams at 30 GeV. It is hoped their supporters will also join the IHF Users' Group. A European Hadron Facility proposal has been under development for the past few years by a large international group with major support from Italy and West Germany (July/August 1986 issue, page 13).

In the USSR the Institute of Nuclear Research team just completing the Moscow Meson Factory (a 600 MeV proton linac) propose to use it as the injector for a kaon factory. This project is approved and construction should begin around 1993.

In Japan the Institute for Nuclear Study of the University of Tokyo and the KEK Laboratory are designing a multi-stage Japanese Hadron Facility, to be located at KEK

Intersecting particles and nuclei

Given the job of summarizing the recent Conference on the Intersections between Particle and Nuclear Physics, held in mid-May at Rockport, Maine, Robert Jaffe of MIT likened the meeting to a Maine shore dinner – 'a vast quantity of food, mostly crustacean, which is guaranteed to be more than you could possibly digest'. After an array of physics hors d'oeuvres and appetizers, Jaffe's main course selection was a discussion of the quark model in the light of known data such as magnetic moments, and the new data on the spin structure of the proton (June issue, page 9). Dessert was astrophysics.

These 'Intersection' conferences have been held every two years, first at Steamboat Springs, Colorado (1984), then at Lake Louise in the Canadian Rockies (1986). Their purpose has been to provide a new forum for interactions between particle physicists and nuclear physicists and to focus on new physics in the 1 GeV to 100 GeV regime. Initially aimed at a North American audience, the meetings have also become more international, reflecting the worldwide research effort.

The astrophysics 'dessert' included a good slice of supernova, with Hans Bethe adding a special contribution on stellar collapse. One long-standing astrophysics enigma has been the 'solar neutrino puzzle' – the measured level of neutrinos from the sun is only a fraction of the expected signal. However William Marciano hinted that the abundance of neutrinos in Davis' Brookhaven experiments had leaped up, during the latest run, to roughly the predicted value (see below).

At the Rockport (Maine) particle-nuclear physics 'Intersections' meetings, Hans Bethe spoke on stellar collapse at a special evening session.

(July/August 1987 issue, page 5).

Another recent initiative has been the formation by the International Union of Pure and Applied Physics (IUPAP) of an International Committee on High Intensity Accelerators, under the chairmanship of Herman Feshbach (MIT). This committee, which had its first meeting at MIT this spring, will attempt to coordinate national efforts in this field, a major topic at the moment of course being the considerable worldwide interest in intense hadron facilities.

Munich

An apparently increased solar neutrino level was one of the highlights of the 24th International Conference on High Energy Physics, held in Munich from 4-10 August.

Other Munich talking points concentrated on new negative results. After a relatively high decay rate for 'charmless' decays of beauty mesons from the ARGUS team at the DORIS electron-positron collider at the German DESY Laboratory in Hamburg (September 1987 issue, page 4), the CLEO team at Cornell's CESR collider cannot corroborate. However some charmless B decay is needed to support conventional physics ideas ('the Standard Model').

A dearth of muon-like atmospheric neutrinos reported from the Japanese Kamioka underground experiment (May issue, page 25) is now not confirmed by the Frejus detector in France, while all experiments looking for 'oscillations' of synthetic neutrinos from accelerators or nuclear reactors now draw a blank. At Munich, neutrino physics was suddenly well behaved.

A full report on the Munich meeting will feature in the October issue.

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Collision physics going west

'The centroid of proton-antiproton physics is moving west across the Atlantic,' concluded Luigi Di Lella of CERN in his summary talk at the Topical Workshop on Proton-Antiproton Collider Physics, held at Fermilab in June.

Previous meetings in this series had been dominated by results from CERN's big proton-antiproton collider, dating back to 1981. However last year saw the first physics run at Fermilab's collider, and although the number of collisions in the big CDF detector was only about one thirtieth of the score so far at CERN, the increased collision energy at Fermilab of 1.8 TeV (1800 GeV, compared to the routine 630 GeV at CERN) is already paying dividends.

With its revamped Antiproton Accumulator Complex poised to boost the antiproton supply for the forthcoming and subsequent collider runs, and with major upgrade programmes for the big detectors (largely complete for UA2 and still in the pipeline for UA1), CERN still has major contributions to add to its spectacular pioneer achievements in this field, but Fermilab and the CDF team now hold the higher energy trump card.

At the Fermilab workshop, Kiyoshi Yasuoka (Tsukuba) and James Proudfoot (Argonne) described CDF results on the W and Z particles, the weak nuclear force's charged and neutral carriers respectively, discovered at CERN in 1983. The mass of the W is measured at around 80 GeV, in line with the values measured by UA1 and UA2 at CERN, and the W production rate increases at the higher Fermilab energy, again broadly in line with expectations. However refined measurements of the increased production rate could be used to help probe the detailed quark/gluon structure of the proton (and antiproton).

While the CDF fix on the W mass will be improved and a similar measurement made for the Z, the figures from UA1 and UA2, when compared to results from experiments using neutrino beams, have now reached a level where they can probe the detailed (radiative) corrections to the underlying 'electroweak' model. Anthony Weidberg of CERN showed how the results gave an upper limit for the mass of the unseen but expected sixth ('top') quark at about 250 GeV, or even down to 180 GeV with some 'optimistic' assumptions.

For the future, increased sensitivity will come from precision Z mass measurements from the big new electron-positron colliders now gearing up – SLC at Stanford and LEP at CERN.

Other important indicators of future physics power came from Arthur Garfinkel (Purdue) and James Patrick (Fermilab), who showed initial CDF results on the production of tight clusters of particles ('jets'), probing the interactions of quark/gluon constituents deep inside the colliding protons and antiprotons. The Fermilab jets are produced more readily than at CERN, as expected, and transverse momenta extend out to about 250 GeV, reflecting the increased violence of the collisions. The angular distributions of the jets are also in accordance with theory.

Bradley Hubbard of Berkeley sketched the potential usefulness of the CDF jet data in measuring 'fragmentation' - the physics term for the way released quarks and gluons materialize as hadrons.

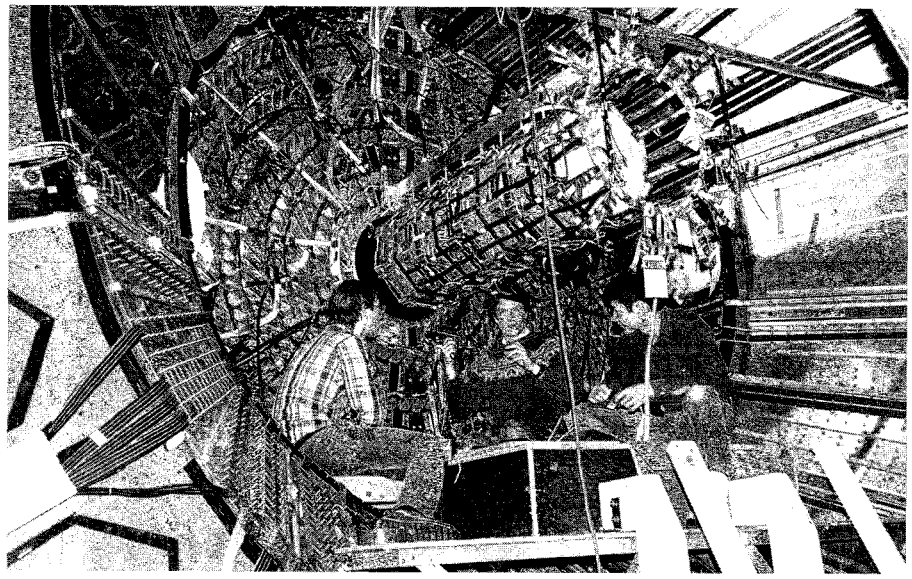
At CERN, the refigured UA2 detector took its first data sample last year. Luciano Mandelli (Milan)

Luigi Di Lella – proton-antiproton physics moving west.

covered the results and although the statistics are yet meagre (only five percent of the total collisions collected since 1981), good electron and missing energy signatures are promised for subsequent runs.

Another useful UA2 result was presented by Vanina Ruhlmann of Saclay, who showed how the coupling strength of quark-gluon forces can be extracted from proton-antiproton collisions producing a W particle and a jet of hadrons. This is a cleaner method, sidestepping many of the problems inherent in the previous technique of comparing the production of two and three hadron jets.

John Dowell outlined the now comprehensive information compiled by UA1 over the years on the global features of proton-antiproton collisions at these high energies, with a high production rate of hadron jets, lots of secondary particles, and increasing transverse momentum. The behaviour seen at higher collision energies by CDF (reported by Adam Para of Fermi-



The Fermilab CDF detector, now beginning to make its mark on proton-antiproton physics.

lab) appears to follow the same trends, although results are still very preliminary.

The E735 experiment was set up at the Fermilab collider to look for signs of the long-awaited quark-gluon plasma at these higher collision energies. Frank Turkot of Fermilab could not report any plasma news, but the measurements of hadron production complement nicely those of UA1 and of CDF.

Jean-Pierre Mendiburu (Collège de France) compared the production rates measured at UA1 of the carriers of all inter-particle forces – photons (electromagnetism), gluons (inter-quark force), and W and Z particles (weak nuclear force) – an impressive picture of physics. More photon production information came from UA2 (Flavio Costantini, Pisa), while Robert Blair (Argonne) showed the first CDF signals of photon production.

Peter Schlein from the UA8 experiment at CERN showed how high transverse energy hadron jets can accompany forward protons. This 'diffractive' scattering gives an insight into the mechanism of elastic scattering, where particles 'bounce' off each other, showing that 'soft' (low energy) gluons appear to play a role.

The combined information gathered by the UA1 and UA2 experiments at CERN can probe the possible number of different types of neutrinos. Thomas Müller of CERN showed how there is not much room for more than the three types now known, although precise results await a mass fix on the sixth ('top') quark.

Keith Ellis (Fermilab) reported on new calculations for the production of heavy quarks. Because of gluon uncertainties, the input for the fifth ('beauty' or 'bottom' 'b') quark is less certain than that for the top quark. 'In physics, as in life, things are better at the top than at the bottom,' he remarked. Using these calculations, Nick Ellis (Birmingham) reported that the UA1 b signal is in accord with expectations.

One surprise result to come out of the CERN collider has been the unusual behaviour of proton-antiproton elastic scattering measured by the UA4 experiment (January/February issue, page 32). This has serious implications for the way protons and antiprotons bounce off each other at the higher Fermilab energies. Robert Cahn of Berkeley suspected that there might be more surprises here than in the production levels of Z particles.

For the moment, the Fermilab experiments are only just beginning to get to grips with elastic scattering. Jay Orear (Cornell) presented results from the special E710 study, showing that the exponential falloff in transverse momentum is sharper – 'the proton is still getting bigger with energy.' Initial elastic results from the CDF detector (Guido Tonelli, Pisa) gave a similar behaviour.

In a summary talk 'Prospects for Future Discoveries at Hadron Colliders', Haim Harari (Weizmann Institute) drew heavily from an authoritative article in the Chicago Tribune. In addition to Di Lella's summary of the Workshop, Carlo Rubbia painted an impressive picture of CERN's plans for the future, making maximum use of the tunnel built for the LEP electron-positron collider.

by Gordon Fraser

Protons for antiprotons?

For the forthcoming collider runs at CERN and at Fermilab, the push is for more proton-antiproton collisions to boost their accumulated stocks of data by several factors of ten. (So far the big CERN experiments have about 900 'inverse nanobarns' under their belts while the initial Fermilab run netted about 30. However the higher Fermilab collision energy provides increased production rates.)

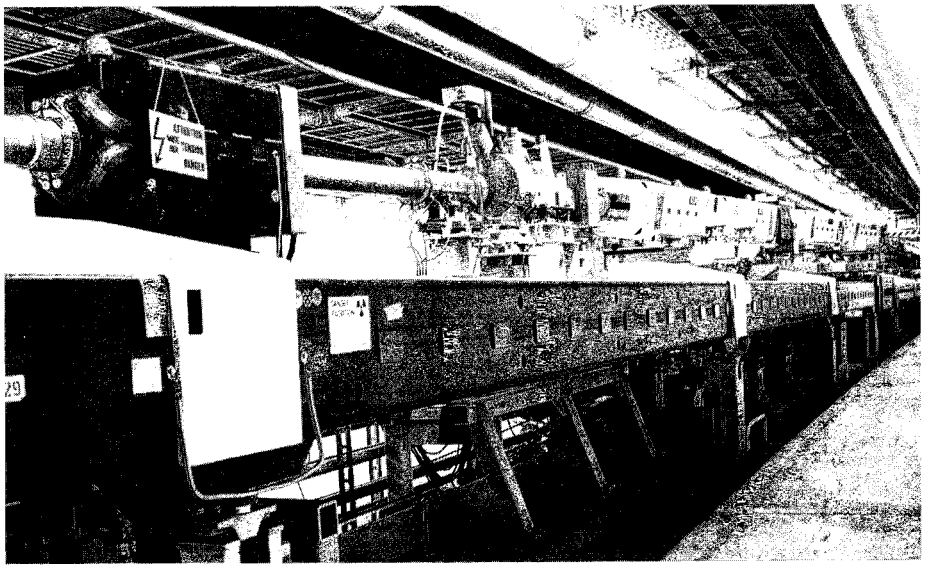
The big hope is the expected but so-far unseen sixth ('top') quark, whose mass is now ruled out below about 41 GeV, but which should be lighter than about 180 GeV. Wagers and counter-wagers have been made about CDF's chances of reaching the top soon.

To further push the collision rate, Fermilab has launched an upgrade boat (March issue, page 4), and initial work will soon get underway (see page 16). Still higher proton-antiproton collision rates become increasingly difficult, and long term plans now include provision for more powerful magnets to contain a still higher energy beam in the existing tunnel, and a proton-proton collider option.

First beams in LEP

On 12 July, an 18 GeV beam of positrons was injected into and successfully steered round 2.5 kilometres of the first complete octant of CERN's new LEP electron-positron collider. The beam glided through with the main LEP bending and focusing magnets at their nominal settings, without the help of the available orbit correctors. In addition, the positrons, supplied by the LPI LEP Pre-Injector at 500 MeV, were subsequently boosted in energy by the PS and SPS synchrotrons, interleaved with their normal supply of protons, with no interruption to SPS fixed target running. Meanwhile the remainder of the 26.7 kilometre ring is being fitted out and the four big experiments installed in line with the schedule for first colliding beams next summer.

The extraction line for LEP positrons running above the ring of CERN's SPS synchrotron.



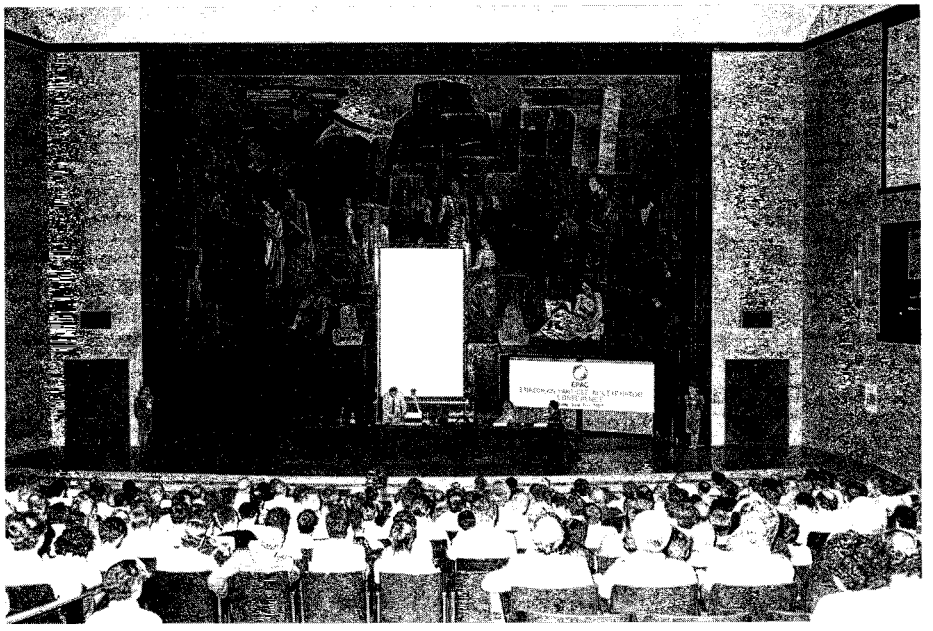
Modern accelerators in ancient Rome

For the first time, the achievements and hopes of the broad European accelerator community were brought together in a European Particle Accelerator Conference, held in Rome in June. Ranging from the vast machines at CERN to the small medical accelerators operating in thousands of hospitals, the programme underlined how modern civilization has benefited from the ability to handle charged particle beams.

Although accelerators used in practical applications must outnumber those used in particle physics by a hundred to one, the particle physics machines remain the front line. Another striking feature emerging from the Conference was the impact of recent accelerator technologies, developed for high energy physics, on machines used in other fields.

It is only a few years since techniques such as beam cooling

The scene in the Aula Magna of the Universita la Sapienza where the opening and closing sessions of the Rome Accelerator Conference were held.



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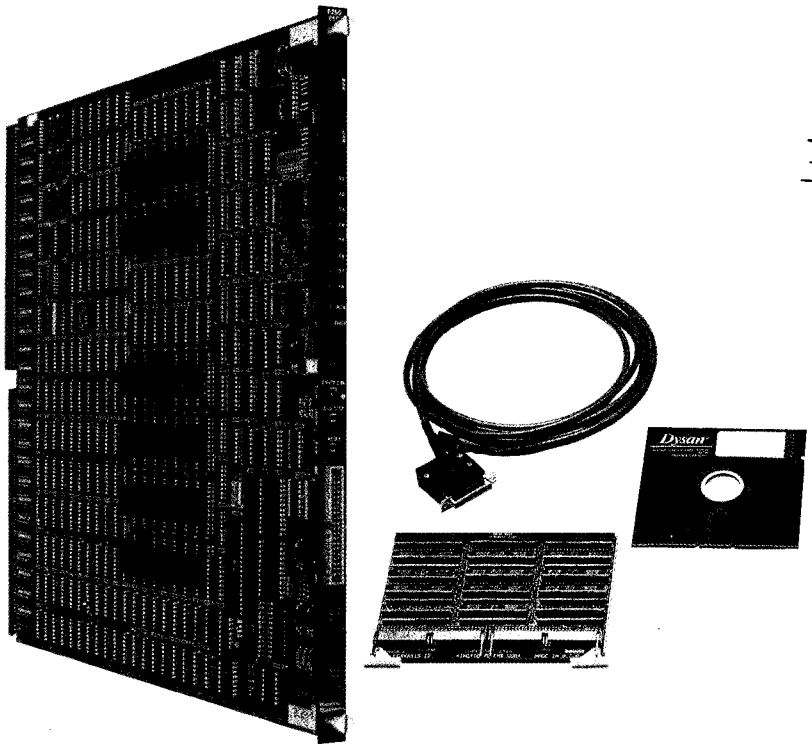

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```
10 REM      Routine to write data to a module in slot 7
20 REM
30 REM      Assert address on the segment with 'AS'
40          AD = 7 EG = 1 AS = 1
50 REM      Continue if the module responds with 'AK'
60          IF AK = 1 THEN NEXT ELSE WAIT
70 REM      Assert data on the segment with 'DS'
80          AD = 5A5A5A5AH DS = 1
90 REM      Continue if the module responds with 'DK'
100         IF DK = 1 THEN NEXT ELSE WAIT
110 REM     Clean up the bus
120         AD = 0 EG = 0 AS = 0 DS = 0
130 REM     Loop to line 10 when module negates 'AK'
140         IF AK = 0 THEN 10 ELSE WAIT
```

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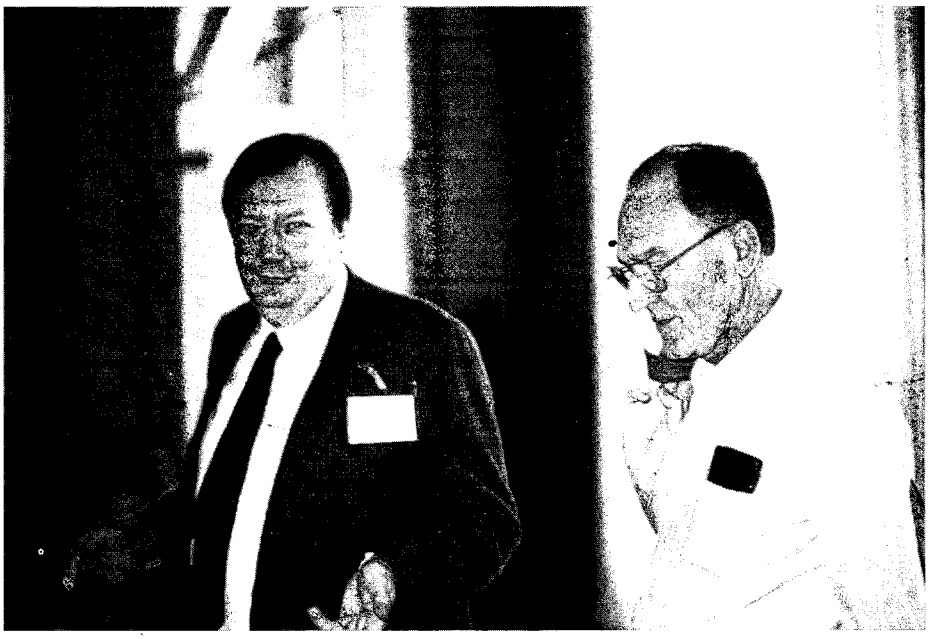
Carlo Rubbia (left) and Giorgio Brianti – pushing for construction of the Large Hadron Collider in the LEP tunnel at CERN. Rubbia chaired the Committee which recommended this project to the CERN Council. Brianti leads the technical work on the project at CERN and gave the LHC talk at the Rome Conference.



(based on ideas from CERN and Novosibirsk), radiofrequency quadrupoles (a Soviet idea but where most of the practical work was done at Los Alamos), pulsed superconducting magnets (Fermilab pioneering with the Tevatron), and superconducting radiofrequency cavities (developed at CERN, DESY (Germany), KEK (Japan) and Cornell) were regarded as exotica. With amazing rapidity, these techniques have been absorbed in projects of all sizes as if they were standard, well-established tools for handling beams.

Rome underlined the present strength of the European accelerator community, with its reputation for thoroughness in the analysis of the accelerator physics and in the subsequent accelerator engineering. This meticulousness has sometimes met criticism as being initially costly. However experience over the years has shown how this careful approach pays off, making for easier operation and facilitating subsequent upgrades.

The front line

Regular readers of the CERN Courier have been able to follow the detailed progress of the LEP electron-positron collider at CERN and the HERA electron-proton collider at DESY in Hamburg. At Rome, Emilio Picasso (LEP) and Gus Voss (HERA) gave status reports. Burt Richter described the arduous commissioning of the SLC Stanford Linear Collider.

Developments at Tristan at KEK in Japan were covered by Y. Kimura; the machine is currently operating at 28 GeV per beam and 16 superconducting cavities (prototypes have given 10 MV/m) are being added, with a further batch of sixteen to follow. K. Myznikov conveyed the new impetus at UNK in the Soviet Union; industry is now producing good superconducting cable and a hundred superconducting magnets should be constructed by the end of next year.

Factories – kaon, hadron and beauty

The proposed 'kaon factories' of yesteryear – proton machines of over 30 GeV and very high intensity to yield healthy fluxes of secondary particles – are now generally called hadron factories to emphasize their broad physics base with a range of particle beams. There are projects under discussion in North America, Japan, the USSR and Europe. Front-runner at the moment seems to be the TRIUMF Laboratory in Canada (see page 1).

The Paul Scherrer Laboratory (SIN) in Switzerland had been involved in the hadron factory work in Europe but attention has turned to an electron-positron collider as a prolific source of beauty particles. A double ring scheme is envisaged (July/August 1987 issue, page 21), and there are also ideas at Cornell (adding a ring to CESR). DESY, SLAC and KEK have also looked at what they could do with additions to their existing machines.

An approach with a vision of the longer term future has come from Italy with the ARES proposal. Z mass energies would be reached by electron and positron superconducting recirculating linacs (the CEBAF concept but with higher energy). In preparing for the project, a number of the issues confronting an electron-positron collider of energies beyond LEP would be studied. Eventually the ARES machines could serve as injectors for such a collider. R and D money is expected in the next five-year plan in Italy.

Ions and neutrons

A plethora of ion accelerators of low, medium and high energy is in

▲ *Italian Minister for the Coordination of Scientific and Technological Research Antonio Ruberti – proud of CERN.*

Italian Minister for the Coordination of Scientific and Technological Research Antonio Ruberti opened the Rome Accelerator Conference with some stirring words for the scientific and political future of Europe:
'We have witnessed an extraordinary time of scientific unification of Europe. The role of CERN in this process, important not only scientifically but also politically, has been decisive, placing it amongst the most significant initiatives in European cooperation... The record of CERN provides an appropriate response to those (fortunately not very many) who indulge in criticism of the Organization. It is suprising that they do not take account of the very high quality of CERN's performance, the great scientific value of its work, and its important political significance for Europe... Italy is proud of these achievements and of Italy's cooperation.

The spirit of Geneva has been an example for the whole of Europe. New initiatives have developed in DESY, Grenoble, Rutherford, Trieste, and Gran Sasso... In the field of physics, cooperation between scientists from different European nations has become the norm and an essential condition for success... Europe's vitality in this sector is driving physics towards horizons that go beyond Europe...The Italian government will steer political initiatives which favour science and the growth of the European scientific and social community.'

or coming into action. The low energy machines' scale and complexity can be tackled in individual universities; the newcomers are storage rings (like ASTRID at Aarhus or TSR in Heidelberg, see page 17) and all have electron cooling to improve beam quality. The smooth operation of electron cooling in CERN's LEAR Low Energy Antiproton Ring last year was a great stimulus to these projects.

In the medium energy range, we reported on the Indiana machine (July issue, page 13) and the next year should see other machines coming on-line in Uppsala and Tokyo. Major upgrades are underway or contemplated at GSI Darmstadt with the addition of a synchrotron and storage ring to the linac, at Saturne where the MIMAS accumulator ring is in action, and at Berkeley where the replacement of the Bevatron as part of the Bevalac project is proposed.

At high energy, while awaiting the advent of RHIC at Brookhaven, CERN has unique ion beam abilities. Following the oxygen and sulphur runs of the past two years, there is a proposal to accelerate lead ions. This would be a three year project requiring replacement of a linac and improvements to the Booster vacuum. For the long-term future, the possibility of ion acceleration in a Large Hadron Collider in the LEP tunnel is really moving to Big Bang energies.

Accelerators have taken over from reactors as the most intense sources of neutrons. Argonne did much of the pioneering work in this area, followed particularly by Los Alamos, KEK and the Rutherford Appleton Laboratory in the UK which presently has the ISIS advanced neutron facility. Designed to accelerate proton beams to 800 MeV at 50 Hz with a beam intensity of 2.5 10^{13}, ISIS already provides 100 times the neutron fluxes of reactors at the high energy end of the spectrum. Future possible developments include an 800 MeV linac to push for higher intensities, conversion of the synchrotron to a storage ring, and the addition of another target zone for neutron production.

The electron and positron storage rings used as the world's most powerful sources of electromagnetic radiation were not as heavily represented at the Conference as one

Wolfgang Schnell speaking about linear collider studies in Europe at the closing session of the Conference. He has proposed one of the most promising schemes for achieving electron-positron collisions beyond LEP energies.

might have anticipated. This may be because the community is developing its own independent channels of communication. J.L. Laclare's review emphasized the European Synchrotron Radiation Facility to come into operation in Grenoble in 1993.

The newest machines are built around insertion devices (undulators and wigglers) of which there are some 35 now working in the world and another 11 under construction. For example, the ESRF will have 32 straight sections, 29 of them destined for insertion devices.

There is great interest in Europe, the US and Japan in commercial synchrotrons, or compact synchrotrons (codename COSY) for mass production of circuits with line dimensions of less than 0.4 microns using X-ray lithography. In ten years this market could require over 150 such machines each with an annual revenue of over $500 million. A COSY is scheduled to be in operation in Japan within the next six months.

Industrial and medical applications

K. Bethge listed some of the other industrial applications of accelerators, where the optical, chemical and semiconductor industries predominate. Machines with energies up to 400 keV for ion implantation are now available commercially and higher energy machines are under development. As with all accelerators destined for an industrial or medical environment, they have to be simple to operate, reliable and cheap.

There is great demand from industry for backscattering analysis (for example, using 2 MeV alpha particles from a Van de Graaff) to determine element distribution. Related work is nuclear reaction analysis and charged particle activation analysis to look for carbon content and location in semiconductors.

The chemical, petrochemical, coatings and adhesives, plastics and rubber industries are using electron beam irradiation in food preservation, strengthening of rubbers and plastics, water disinfection, etc.

(Mirroring these applications, a first European Conference on Accelerators in Applied Research and Technology is to be held in Frankfurt in September of next year.)

The interest in using accelerators for therapy dates back to the 1930s and present developments were reviewed by Y. Jongen. There are now thousands of radiofrequency linacs in hospitals for cancer radiotherapy and several centres have been exploiting the particular advantages of neutrons, pions, ions and protons. Ions and protons hold the most promise as their energy deposition can destroy a tumour with minimum damage to surrounding healthy tissue.

Their application has been boosted by recent advances in precision tumour location (for example by nuclear magnetic resonance). The machines for ions and protons are, however, comparatively expensive and R and D is needed to bring costs down before the machines become widespread.

One important project is the cyclotron EULIMA (EUropean Light Ion Medical Accelerator), where the European Communities have just made funds available for a detailed two-year study. Twelve European countries are involved and a Workshop will be held in Nice in November. Another important project is the small proton synchrotron being built at Loma Linda University Medical Center in the USA with help from Fermilab.

Preparing for the future

For the front line of particle physics at the start of the next century, Giorgio Brianti described the Large Hadron Collider project for CERN, a proton-proton collider of 8 TeV per beam using 10 T two-in-one magnets in the tunnel built for the LEP electron-positron collider. As well as using much existing infrastructure, it would allow a variety of particle collision possibilities, and shoots for very high luminosity (10^{33} and above). The machine design is being well honed and the recent success of an industrially-produced superconducting magnet (above 9 T, June issue page 13)

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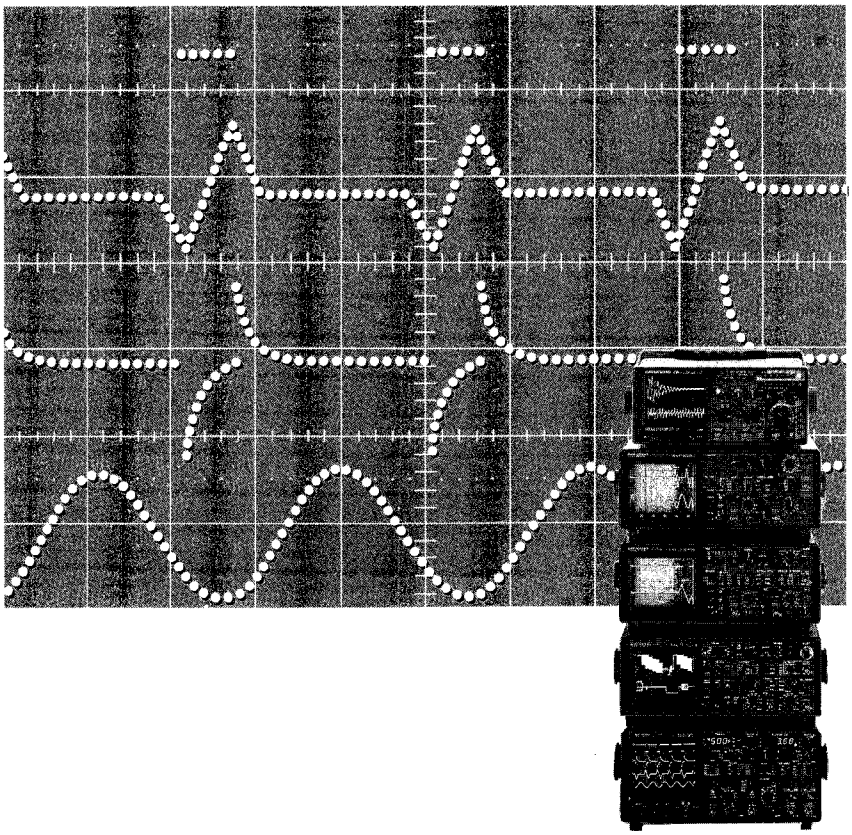

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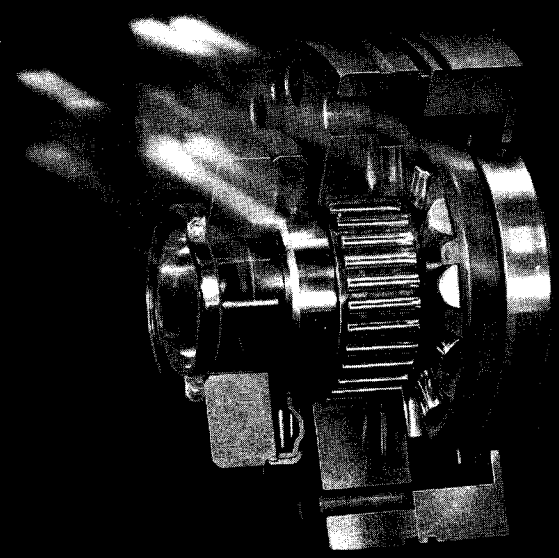

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has been encouraging. The impact on LEP operation of building LHC in the same tunnel has been studied, showing that LHC could be installed in lengthy shutdowns during two years while still allowing physics at LEP.

For a subsequent generation, Antonino Zichichi spoke on a 2 x 100 TeV collider, Eloisatron. This enabled John Peoples to introduce the US Superconducting Super Collider project (SSC) as 'a modest proposal'. This two-ring 20 TeV per beam scheme is awaiting final site selection early next year and the authorization of construction funds. $100 million is currently available and will be used particularly to solve the problems of constructing good quality long superconducting magnets.

For electron linear colliders to take energies beyond LEP, Wolfgang Schnell was also able to report 'progress towards reality', though the challenges of input beam quality, power sources and final focus still need work; Burt Richter pitched it as at least four years before a design could be put on the table. The problems are being attacked at Stanford and CERN as well as in Japan and the Soviet Union.

Since about half the cost of such machines is likely to be absorbed by the power sources there was special interest in the talk of Matt Allen on radiofrequency power sources, based on the pioneering development of klystrons at Stanford. In a collaboration with Livermore and Berkeley, 80 MW of peak power has been obtained from an X-band cavity in 30 ns pulses. Peak power is related to pulse length and hundreds of MW could be available from a single klystron at the frequencies required for linear colliders.

There were various reports on superconducting r.f. cavities, also an important part of some of the collider schemes like CLIC at CERN. The technology of solid niobium cavities seems thoroughly mastered. D. Proch maintained that 7 MV per m could now be guaranteed from such cavities (5 MV is required for LEP). Niobium coated copper cavities could do the trick less expensively, and during the Conference C. Benvenuti announced that at CERN a coated cavity had reached LEP parameters. However the reliability of such cavities remains to be proven.

A shining hope is that the newly discovered high temperature superconductors could be used to coat copper cavities. O. Fischer warned that it is very early for such speculations since the basic parameters of the materials are still being sorted out, but recognized the very great potential.

Carlo Rubbia ('Future physics at accelerators') underlined why these big machines are being put forward and what they could go on to discover.

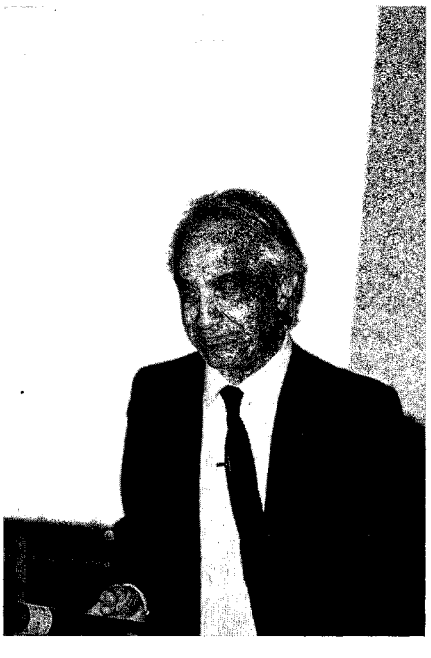
Nice to be in Nice

The European series of accelerator conferences was launched to provide a forum for the large and powerful community of accelerator physicists and engineers in the 'old continent'. A similar meeting has been held in North America for many years where understandably the emphasis is on progress in the US. The International series moves between continents and includes Europe only once a decade; this series attracts high-level participation and does not provide a platform for the hundreds of younger European specialists.

This was rectified in Rome. There were about 700 participants, predominantly from Europe but with stimulating contingents from the US and USSR, presenting some 850 papers. The second European Accelerator Conference will be held in Nice in 1990.

by Brian Southworth

Antonino Zichichi has done wonders for the cause of particle physics in Italy and heads the LAA project at CERN to develop detectors for the next generation of accelerators. He spoke at the Conference about the Eloisatron project for physics even beyond LHC energies.



ICFA at Rome

The International Committee for Future Accelerators (ICFA) held its 17th meeting in Rome in June in conjunction with the European Particle Accelerator Conference, and heard reports from the Chairmen of its four specialist panels. Following the success of earlier workshops and of the 1987 Instrumentation School (proceedings now published by World Scientific, Singapore, see page 39), ICFA approved plans for future workshops and schools. Further information from the appropriate Panel Chairmen (see box).

Both the Instrumentation Bulletin and the Beam Dynamics Newsletter are now firmly established, thanks to support from DESY and the University of Siegen, and Instrumentation Bulletin advertising income now covers its printing costs. Preparations are well advanced for a Review of Detector Properties (analogous to the Review of Particle Properties), edited by H. Leutz (CERN) and R. Kenney (Berkeley). It will be published in Nuclear Instruments and Methods with financial support from CERN and Berkeley, and also as a small booklet.

The Committee agreed that the name of the Panel on Superconducting Magnets and Cryogenics could be changed to Superconductivity and Cryogenics so that it could also cover work on superconducting r.f. cavities. This panel is also working on an 'ICFA Standard for Superconducting Wire and Cable for Accelerator Magnets' with the aim of reaching agreement by the time of the International High Energy Accelerator Conference to be held in Japan in August 1989. A draft version of the standard is available from the Panel Chairman, H. Hirabayashi, KEK, Japan, tel. 298-64.11.71, telex 365 2534 KEK HO J, telefax 0081-298-64.40.51.

Following the earlier seminars held at KEK in 1984 and Brookhaven in 1987, ICFA unanimously decided to accept an invitation from the USSR State Committee for Atomic Energy to hold the next 'Seminar on Future Perspectives in High Energy Physics' at Serpukhov in Spring or Autumn 1990. The next ICFA meeting will be held in Beijing in August 1989 at the invitation of the Institute of High Energy Physics and of the Academia Sinica.

ICFA – International Committee for Future Accelerators at its previous meeting in Brookhaven in October 1987.

(Photo Brookhaven)

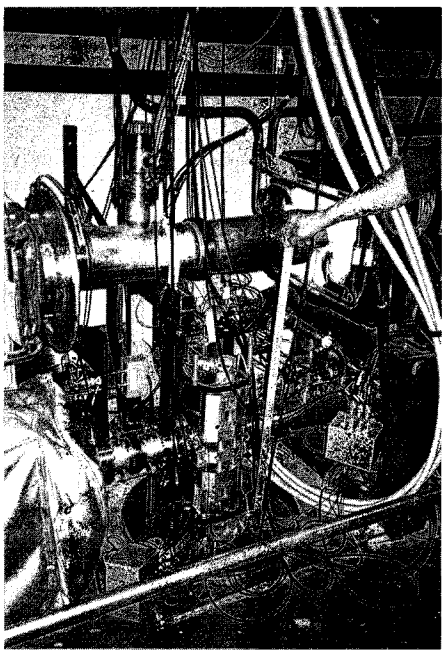
Forthcoming ICFA Schools and Workshops

Instrumentation Panel (Chairman T. Ekelof, EP Division CERN Telex 419000 CER CH, tel. (022) 83 59 46 or (022) 83 59 22 Fax 022 83 37 68 bitnet EKE.VT at GEN)
SECOND ICFA SCHOOL ON INSTRUMENTATION, 12 – 23 June 1989, ICTP Trieste.
Beam Dynamics Panel (Chairman E. Keil, LEP Division CERN Telex 419000 CER CH, Tel. (022) 83 34 26 Fax 022 83 02 21, Bitnet Keil at CERNVM)
FIRST ICFA SCHOOL ON BEAM DYNAMICS, Beam Dynamics and Engineering of Synchrotron, Radiation Sources, 1990 ICTP Trieste.

THIRD BEAM DYNAMICS WORKSHOP, Beam-Beam Effects in Circular Colliders, 29 May – 3 June 1989, Institute of Nuclear Physics, Novosibirsk.
FOURTH BEAM DYNAMICS WORKSHOP, Short Bunch Collective Effects (topic to be confirmed), 1990 KEK Japan.
New Accelerator Schemes Panel (Chairman R. Palmer, Brookhaven and SLAC. At BNL: Tel. 516-282-2842, Telex 6852516, Fax 516-282-3000, At SLAC Tel. 415-926-2190, Telex 910 373 1162 Bitnet Palmer at SLACVM)
ICFA WORKSHOP, 10 TeV e^+e^- Collider Design, May 1990 (place to be decided).

Around the Laboratories

Experiment 710 at the Fermilab Tevatron proton-antiproton collider finds that the proton is still getting bigger at these higher collision energies (1800 GeV, see page 4). E710's 'Roman pots' (below) are embedded in the Tevatron ring, and the Fermilab Main Ring (conventional magnets) passes above.



FERMILAB Linac Upgrade

The Fermilab linear accelerator (Linac) was conceived 20 years ago, produced its first 200 MeV beam of protons on November 30, 1970, and has run without major interruption since.

However its responsibilities have steadily increased as greater demands have been placed on it by the added complexity of the downstream chain of accelerators and by the increased load of the Neutron Therapy Facility.

The major improvements during the last 17 years have been the conversion from proton to negative hydrogen ion acceleration, a new control system, and replacement of the radiofrequency control and monitoring system. Despite its achieving 98.7% reliability in 1987, the technological advances of the last 17 years could improve the linac's performance to the benefit of all downstream systems.

It is now planned to replace the last four Linac 'tanks' with seven new accelerating modules operating at a higher frequency and higher accelerating fields so as to boost output from 200 to 400 MeV. The r.f. power to drive the new modules will be supplied by high power 805 MHz klystrons.

The higher energy will reduce the tune spread due to beam space-charge forces at injection in the downstream Booster accelerator thereby improving the ratio of the total number of particles in the accelerator to the normalized transverse emittance. At 400 MeV this ratio should be increased by 75% compared to the ratio at 200 MeV.

Today's linacs use radiofrequency quadrupoles (RFQs) to capture, bunch, focus, and accelerate the beam from the ion source. This is the region where beam space-charge forces are most severe, especially for negative hydrogen ions. Substituting a 2 MeV RFQ for Fermilab's 750 keV traditional Cockcroft-Walton preaccelerator will reduce emittance growth, while replacing the present first tank with a new structure to go from 2 to 10 MeV would have further benefits. This improved low energy behaviour would be transmitted through the Linac to 400 MeV and benefit the Booster.

R&D work for both the low-energy and the high-energy Linac improvements were started in 1987. The full programme aims to bring a brighter Linac beam at twice the energy, promising another 20 years of exceptional operation. This is the first step in the Fermilab Accelerator Upgrade (March issue, page 4) to provide more proton-antiproton collisions and more intense beams for fixed-target operations.

Quarks and astrophysics

The two frontiers of physics – the very big and the very small – are increasingly working in harmony. The increased understanding of the behaviour of the quark constituents of protons and neutrons has led to new insights into stellar evolution and behaviour, while astronomy provides quark physicists with valuable new scenarios to test their ideas. Mirroring this trend, the Fermilab Astrophysics Group sponsored a workshop on the role of quark field theory (quantum chromodynamics – QCD) in astrophysics from 29 April to 1 May.

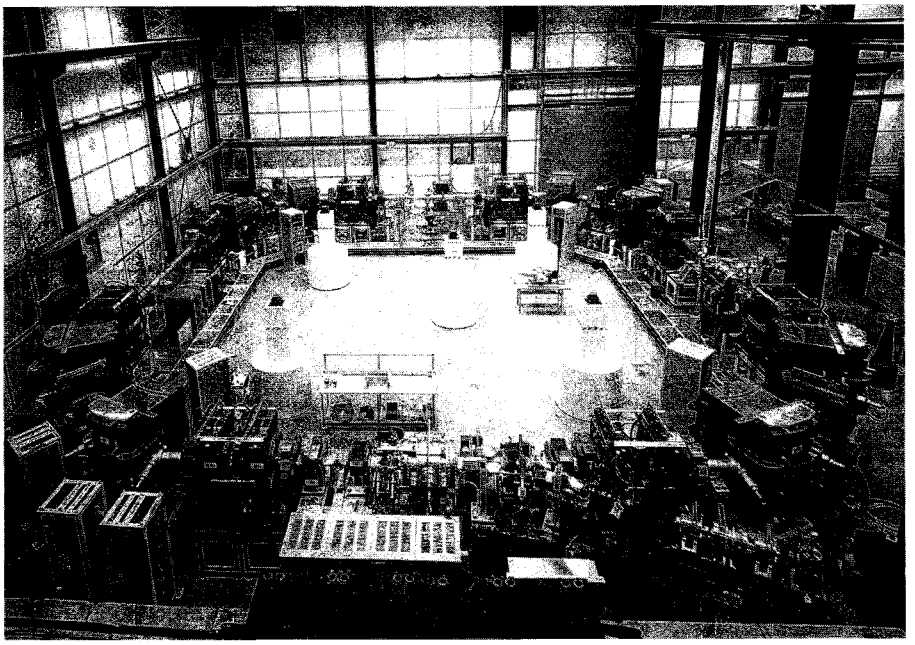
The small, informal meeting brought together particle physicists, astronomers, experimentalists, and astrophysicists interested in sharing recent theoretical advances in QCD itself, in the lattice gauge technique for making quark calculations, in models of transitions between quarks and particles, and in the manufacture of light nuclei in the aftermath of the Big Bang (primordial nucleosynthesis).

The transition between quarks and particles (hadrons) can be studied in dense matter (neutron stars and supernovae) and at high temperatures. From a lattice gauge theory perspective, there are many things that can be calculated and astrophysicists can help the particle physicists understand what types of calculations are needed to gain insights into these transitions.

A lot of attention was given to primordial nucleosynthesis, a valuable window into the early Universe. Several groups have been trying to calculate how composite particles (hadrons) crystallized out as the initial smooth quark/gluon soup cooled. Other sessions focussed

*** On 20 August, a bunch of 3×10^9 7 GeV electrons was stored in the electron ring of DESY's HERA electron-proton collider in Hamburg.**

TSR, the new 55m Test Storage Ring for Heavy Ions at Heidelberg's Tandem-Postaccelerator Combination.



on neutron stars and conjectured on the observational signatures of quark stars, the equations needed to make calculations, the expected masses, etc.

There was also discussion on more exotic phenomena from cosmic rays, such as the signals from Cygnus X-3 and Hercules X-1. Ultra high energy cosmic rays could provide hints on quark-hadron transitions.

HEIDELBERG
Cooler storage ring in operation

The first of the heavy ion cooler storage rings, the Heidelberg TSR (Test Storage Ring) entered its commissioning phase after construction lasting only just over two and a half years. Built in cooperation with GSI Darmstadt and groups from Heidelberg, Giessen and Marburg, the low energy 55 m TSR ring at the MP-Tandem Postaccelerator combination of Heidelberg's Max Planck Institute is able to store ions up to about 30 MeV/nucleon for a charge to mass ratio of 0.5, and is specially designed to investigate many still open questions of electron cooling for ions as heavy as iodine.

The simultaneous availability of fully or partially stripped heavy ions together with a cold intense electron bath (1 A typically) of adjustable relative energy will provide unique possibilities for atomic and plasma physics as well as for high resolution experiments in nuclear physics. In addition TSR allows a completely new class of studies of the interaction of electrons and laser photons with heavy ions in all possible charge states.

Laser and electron cooling are expected to compress beam behaviour to such an extent that new collective phenomena could be seen, possibly even leading to the crystallization of ion beams.

One of the first internal target experiments will be the 'proof of principle' test of the polarization of a stored proton beam by spin dependent interaction with a polarized hydrogen target, crucial for plans to polarize antiprotons at CERN's LEAR low energy antiproton ring.

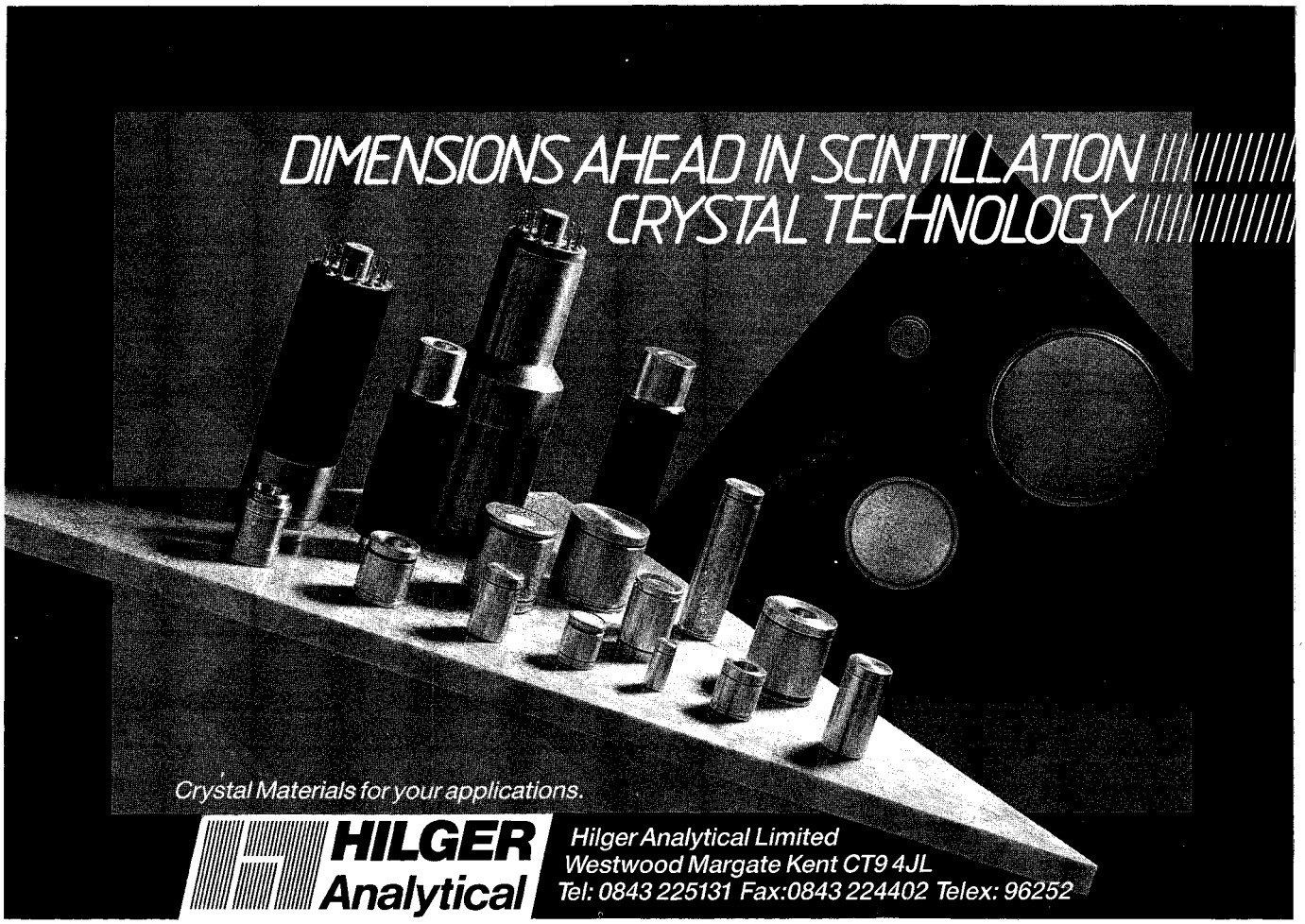
TSR's twenty quadrupole lenses in five families give a very flexible selection of tunes and dispersion settings. Small dispersion and large apertures permit 'multi-chargestate operation', changing the charge-state of accumulated ions in either the electron bath or internal targets.

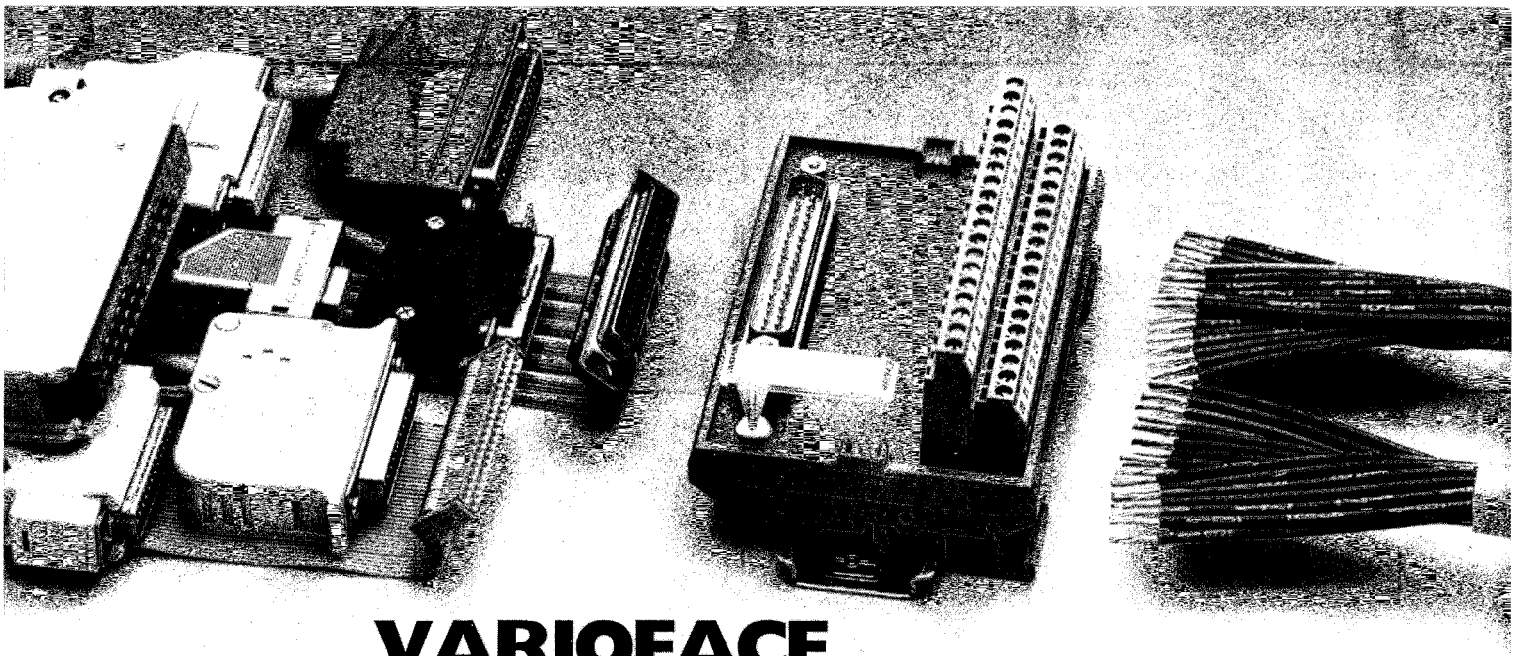
The ring was completely assembled by mid-May, and the first test run stored a beam of 73 MeV carbon 12 (6+) ions with a lifetime of 4.5 s. Subsequent finetuning and improvements in the (as yet unbaked) vacuum chamber to reach 10^{-9} mbar improved the lifetime to 1 minute, promising beam lifetimes of some thousand seconds when the chamber is baked and pressures below 10^{-11} mbar are reached as planned. The TSR will be available for experiments late this year after installation of the electron cooler.

DESY
HERA progress*

Work is well underway for the two big experiments, ZEUS and H1, for the HERA electron-proton collider being constructed at the German DESY Laboratory in Hamburg. With first data-taking scheduled for mid-1990, construction of the huge detectors began in 1986.

At the beginning of July, installation of the 2200 ton external iron structure for ZEUS, from the Bremer Vulkan shipyard, was completed





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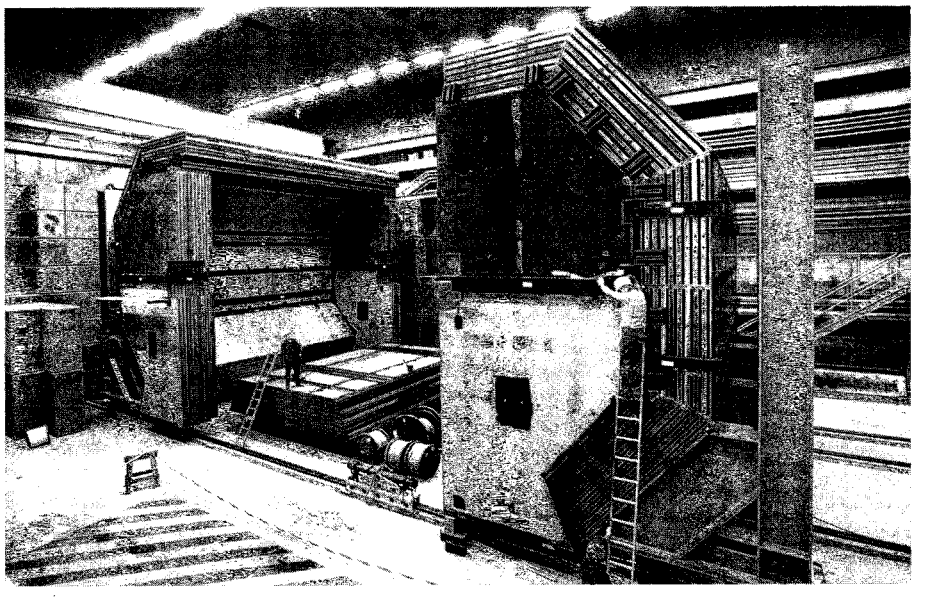
The 2200 ton external iron structure of the ZEUS experiment takes shape at the HERA electron-proton collider being built at the German DESY Laboratory in Hamburg.



in HERA's South Hall. This iron will serve as a muon filter as well as a 'tail catcher' for jets intercepted in the main ZEUS calorimeter. Instrumented with aluminium streamer tubes, the iron will shield the 1.7 tesla field of the inner superconducting solenoid, but is fitted with additional coils to bend muon tracks and supply valuable additional information.

For the HERA machine itself, series production of the 246 superconducting quadrupoles for the proton ring has begun, supplied by Alsthom (France) and Noell (West Germany). In the meantime finishing touches are being put to the electron ring.

In the drive to develop superconducting radiofrequency cavities for the electron ring, explosion-bonded 2.5 mm plates of copper and niobium were used for a new design, easier to handle and safer to run. The prototype unit reached an accelerating gradient of 7 MV/m in its first cooldown after helium processing to 9 MV/m. Cooling is through a few helium pipes electron-beam welded around the cavity body, rather than through a liquid helium bath. One advantage is that helium pressure changes do not affect the resonator. The development work is in collaboration with Interatom.

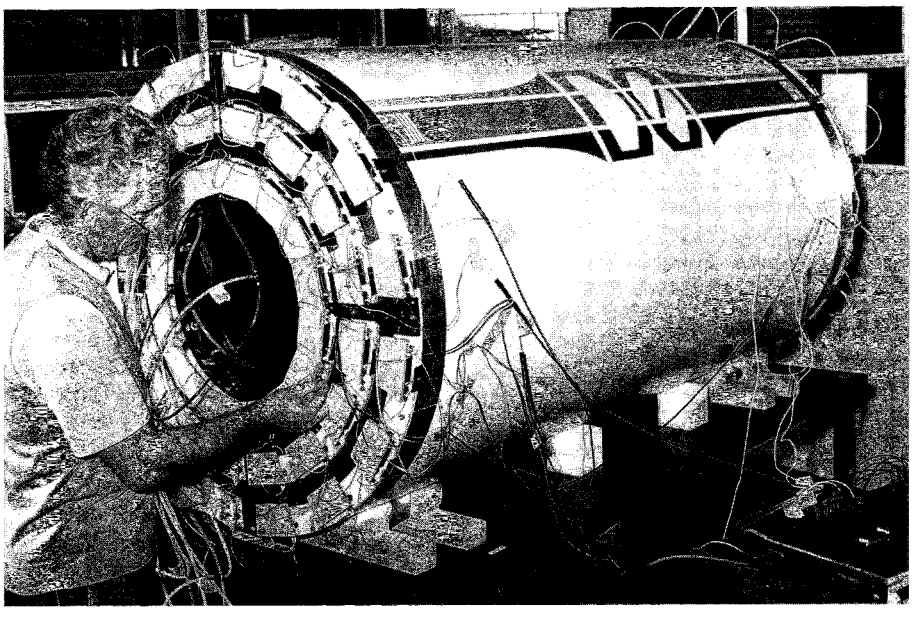
SACLAY
Transition radiation detector for Fermilab

A Transition Radiation Detector (TRD) has been built by the High Energy Physics Department of the French Saclay Laboratory for the D0 experiment being put together at Fermilab for the Tevatron proton-antiproton collider

Transition radiation, in the form of X-rays, is produced when a particle travelling close to the speed of light passes through two materials with different electrical characteristics (dielectric constants). To obtain enough X-rays, several hundred foils are needed, each separated by a light gas, and the produced X-ray photons are picked up in proportional counters filled with a heavy gas (usually xenon).

Such detectors can distinguish electrons from pions below 150 GeV and in a restricted volume, and are well suited to electron identification at colliding beam experiments.

Final assembly at Saclay of the Transition Radiation Detector built for the D0 experiment at Fermilab's Tevatron proton-antiproton collider.



Physics monitor

Prototype construction at Saclay and tests in a 5 GeV beam at the CERN PS proton synchrotron allowed both an optimal choice of parameters for the final version, and the refinement of the electron/pion discrimination.

The DO TRD consists of concentric cylinders. First is a radiator of 390 18-micron polypropylene sheets with 150 micron separation in nitrogen. Then comes a two-stage xenon/methane (9:1) filled drift chamber detector – in the first stage electrons drift 1.5 cm radially, while the second, separated by a 2 mm grid of 70-micron wires, acts as amplifier, using 256 drift cells each 8 mm square and 185 cm long. A 20 micron aluminized mylar double window separates the radiator from the chamber and acts as cathode.

Using measurements of the total energy deposited by a particle in the xenon chambers together with the energy spread along the particle trajectory, the prototype tests achieved a rejection factor of 70 for 5 GeV pions with 90 per cent efficient electron detection.

In June, the complete assembly was set up in the PS test beam and initial results confirm the behaviour seen with the prototype. Next year the TRD unit will be shipped to Fermilab for installation in the central tracker of the DO experiment.

Superconducted tour

Superconductivity – the dramatic drop in electrical resistance in certain materials at very low temperatures – has grown rapidly in importance over the past two or three decades to become a key technology for high energy particle accelerators.

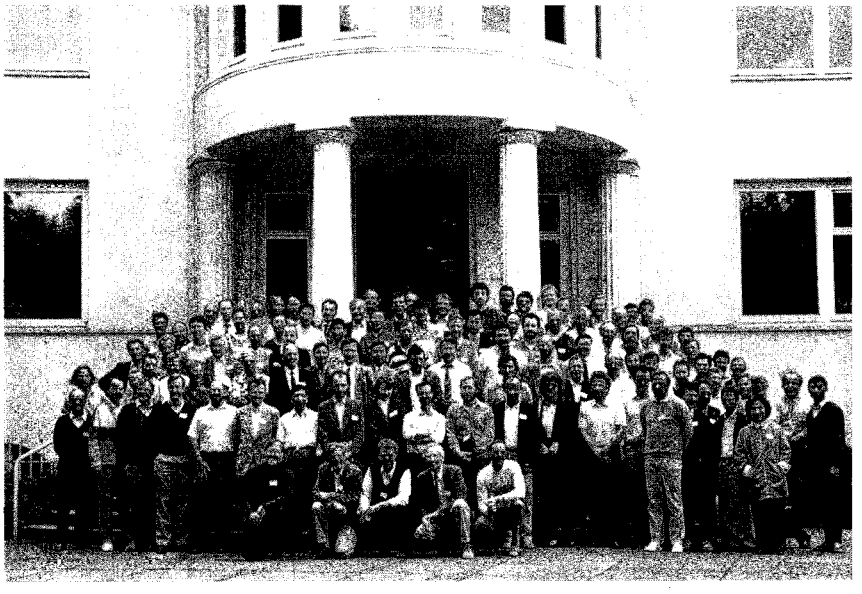
Physics detectors have long relied on superconductivity and for many years it has been recognized that multi-TeV (thousands of GeV) proton colliders need superconducting magnets. More recently, superconductivity has come of age for the radiofrequency accelerating cavities for electron machines. In step with these applications, the size and sophistication of liquid helium refrigeration plants has also increased, as has the need for trained personnel.

It was in this setting that a hundred students and 15 lecturers met in Hamburg in June for a week's course on superconductivity in particle accelerators, organized by the CERN Accelerator School and the nearby DESY Laboratory.

'Conventional' superconductivity is now a mature field and Peter Schmuser (DESY) used the recent results from CERN's prototype dipole for the proposed LHC proton collider in the LEP tunnel (June issue, page 13) to illustrate the state of the art and how well theory and numerical calculations can guide the designer working close to the performance limits of materials.

The beautiful temperature maps of the internal surfaces of r.f. cavities shown by Helmut Piel (Wuppertal) demonstrated the level of refinement being reached for diagnostics. Herbert Lengeler of CERN described the equally sophisticated design of cavities and couplers.

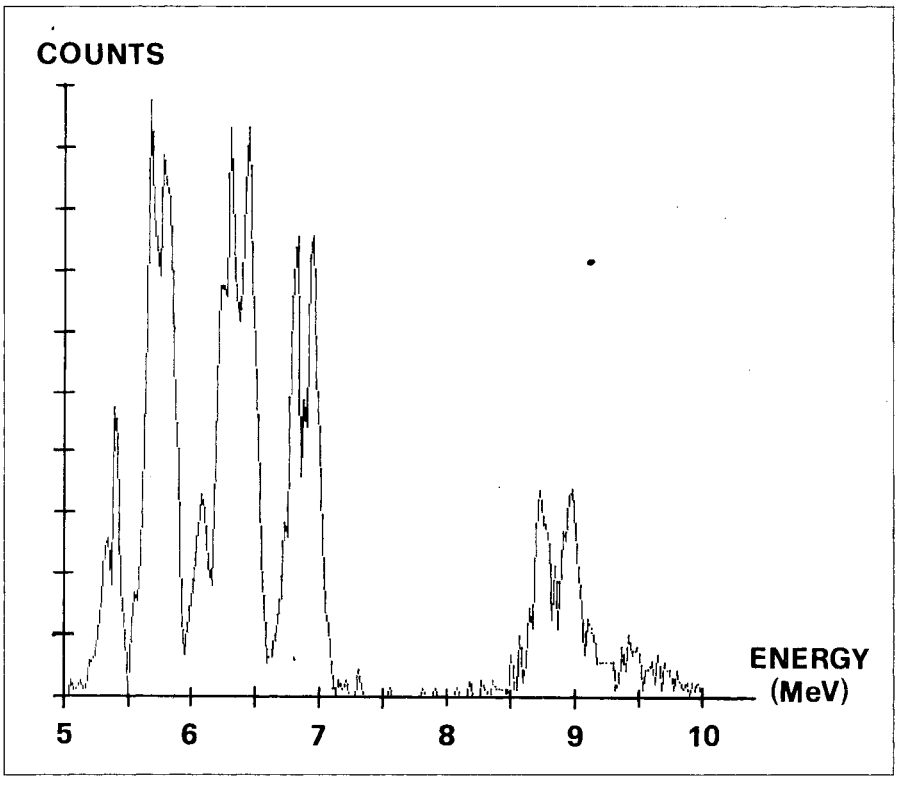
Mid-way through the course, a visit to the DESY Laboratory, scene of construction and installation work for the HERA electron-proton collider, provided a chance to view practical examples and admire large scale cryogenic engineering.

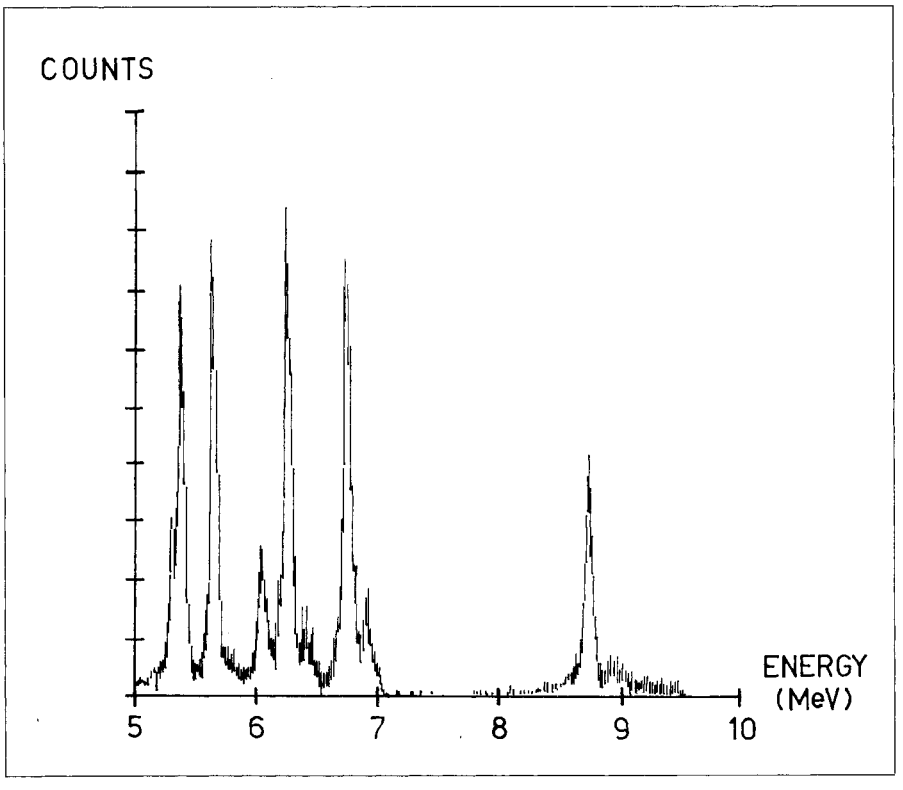


Students and lecturers at the superconductivity in particle accelerators course in Hamburg in June, organized by the CERN Accelerator School and the DESY Laboratory.

(Photo S. Turner)

Low temperature detectors at work. Energy spectra of alpha particles from an implanted source of radium-228 in radioactive equilibrium with its daughters, obtained by the Milan group with a germanium bolometer at 44 millikelvin. The first alpha decay implants the radium daughter nucleus in the crystal. Above, the initial satellite peaks are broadened by nuclear recoil energy. Two weeks later, most of the implanted nuclei have decayed and the 1% energy resolution of the bolometer is seen.





The final day of the course was given over to the ever-warmer new superconductors. While the steady rise in the temperatures at which these materials go superconducting elicited the remark that soon all helium liquifiers could be discarded in favour of air-conditioners, summarizer Peter Komarek (KfK Karlsruhe) preferred to be prudent. Even with optimistic assumptions about the development of the new materials, the potential gains for electrical engineering were not large, he claimed, although the easier availability of liquid nitrogen compared to liquid helium would favour applications in more remote areas.

Low temperatures – hot topic

Neutrino mass measurements, next-generation double beta experiments, solar neutrino detection, searches for magnetic monopoles and the challenge of discovering what most of the Universe is made of (dark matter), not to mention axions (cosmic and solar), supersymmetric neutral particles and cosmic neutrinos. All this physics could use cryogenic techniques.

Thus the second European Workshop on Low Temperature Devices for the Detection of Low Energy Neutrinos and Dark Matter, held at LAPP (Annecy) in May, covered an active and promising field.

P. de Bernardis, G. Fritz and K.H. Gundlach, described how astronomers have been using cryogenic devices for years to detect very low energy photons, such as the microwave background radiation. Small bolometers and superconducting tunneling junctions (STJ)

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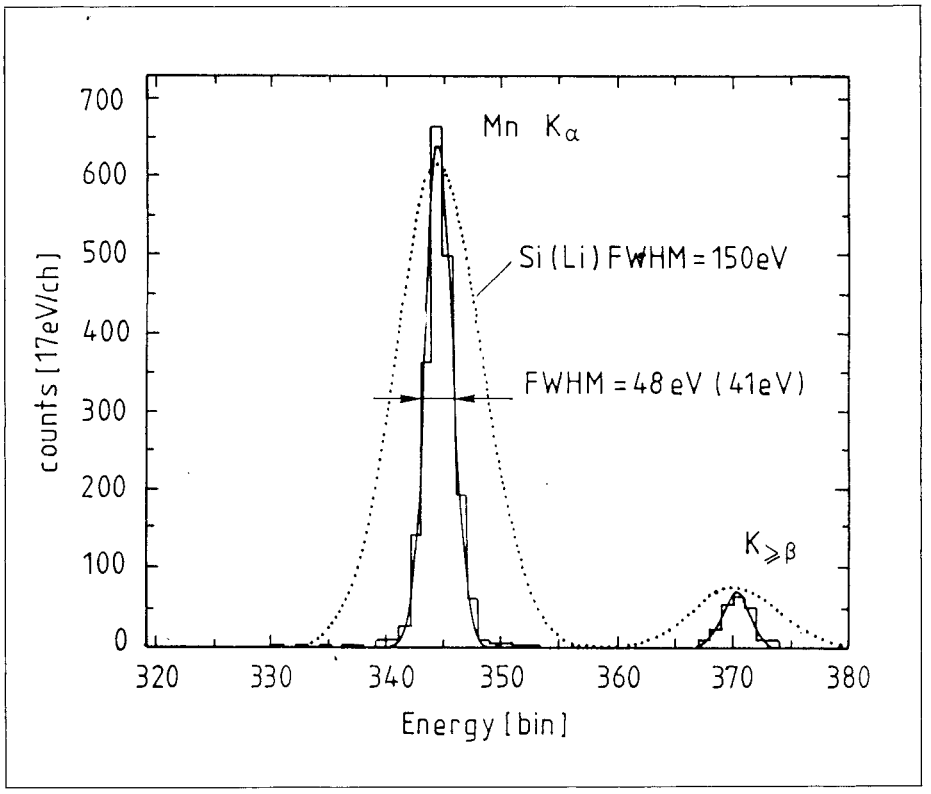
Energy spectra from X-rays measured at the Swiss Paul Scherrer Institute (formerly SIN) with a Sn/SnO/Sn tunneling junction irradiated at 400 mK. The dotted line corresponds to the best resolution obtained with silicon detectors cooled in liquid nitrogen.



have already proved useful, but the problem for 'astro-particle' experiments is to produce larger detectors with similar sensitivity. Other techniques have been proposed – superheated superconducting granules (SSG), superfluid helium, superconducting wires, films, strips, ceramics, powders,...

Another low temperature ancestor is the germanium double beta detector technique (D.O. Caldwell), giving high sensitivity and energy resolution for rare low energy events. Such devices have provided interesting limits on dark matter candidates (Dirac neutrinos, cosmions, solar axions) and may still probe further, although new detectors are required for a full study of the dark matter problem.

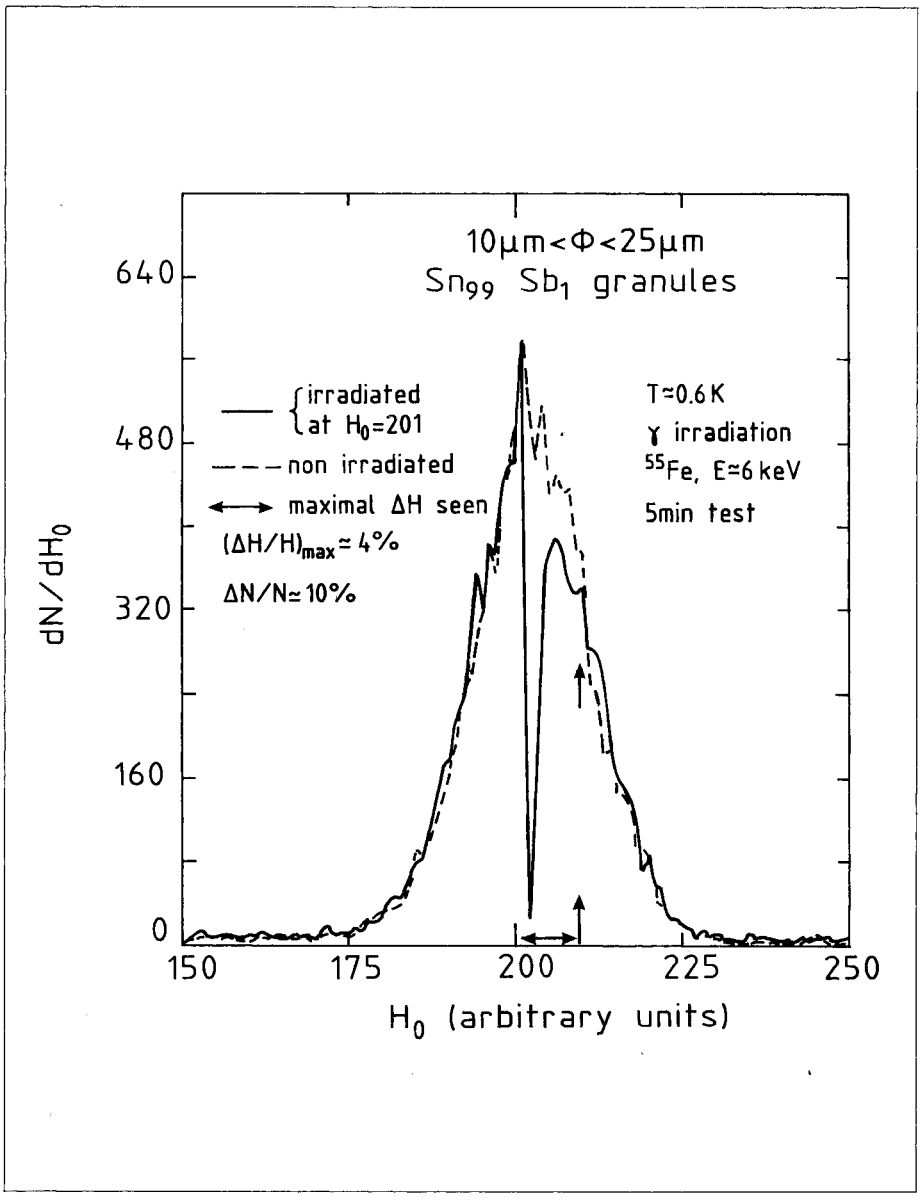
Two kinds of low temperature detectors have produced useful results: induction loops for monopole detection (discussed by J. Incandela) and low temperature electromagnetic cavities for cosmic axion searches (presented by P. Sikivie and S. de Panfilis). Both techniques can potentially provide larger detectors in the near future and give results of cosmological relevance, although background problems may become rather severe for any monopole search based on the detection of a few flux quanta. Calorimetric techniques (bolometers, STJ, SSG,...) are more diversified and require further development. In general, cryogenic particle physics detectors are still at the level of feasibility studies, but interesting results have emerged as the number of groups involved and the development effort increase.

'Bolometers' are cold crystal calorimeters with a small resistive thermometer ('thermistor') to detect the temperature increase due to heat released by ionization, photoelectric effect, nuclear recoil, etc. The energy resolution is such that a large increase in mass can be compensated by a small decrease in temperature.

Traditional bolometers used to be very small (a few 10^{-3} mm^3). However at Annecy the Milan group described how a 0.2 cm^3 germanium bolometer operating at 44 millikelvin was irradiated with alpha particles of a few MeV, giving energy resolution in the 50 keV range (about 1%). This may be the first step towards a new generation of double beta decay detectors, where background rejection would be improved through a better energy resolution.

Focusing mainly on dark matter detection (smaller energy deposition), B. Sadoulet presented recent results from strong effort on bolometers and ballistic phonon detectors at Berkeley and Stanford, while S. Read acted as spokesman for the UK Dark Matter Collaboration. Ballistic phonon detectors developed by the Garching group have given encouraging results using thin phosphor-doped silicon wafers using STJ readout. M. Lindroos reported new developments by the Aarhus/CERN/Goteborg/New York/Verrieres collaboration on micromechanics for bolometer fabrication, and S. Vitale and A. Rijllart presented results from Genova (ruthenium oxide thermistor) and CERN (study of bolometric signals).

STJ depends on quasiparticle (or hole) tunneling across the potential barrier of an insulating layer between two superconductors. As discussed by D. Twerenbold, for suitably prepared junctions the response does not depend on the site of the interaction (superconductor or insulator). The key advantage of STJ over semiconductor devices is



Irradiation curve at 600 mK obtained at LAPP (Annecy) for collection of 10 to 25 micron superconducting granules made with a tin-antimony alloy . The dashed line shows the number of granules changing state with increasing magnetic field in the absence of irradiation. The full line is obtained when the applied field is set for 5 minutes to a fixed value (about 250 Gauss) before being further increased. In this interval, many granules flip due to the 6 keV gamma ray source implanted in the detector. The 'missing' granule transition signals were detected individually in real time with conventional electronics during the irradiation period. Smaller granules are expected to show a much higher sensitivity.

the lower excitation energy of charge carriers. The superconducting energy gap lies in the range 10^{-3} to 10^{-6} eV , and effective excitation energies of a few millielectronvolts have already been achieved. Thus STJ may be well suited for electron neutrino mass measurements, where energy resolution below 1 eV is required (F. Cardone). STJ have also been suggested for ballistic phonon device readout. Larger junctions may lead to unwanted phenomena, but new solutions are being studied.

S. King summarized work at the US Naval Research Laboratory (Washington DC). Besides the study of the basic properties of STJ, granular CERMET films made of 3 to 12 nm NbN (nitride) particles in an insulating matrix are being considered. They are poor bolometers, but may be good vortex flow detectors. The comparatively high operating temperature (6 to 6.5 K for NbN), obviates the need for sophisticated cryogenics.

SSG are tiny spheres of type I superconducting material (pure metals) embedded in a dielectric (paraffin, epoxy or varnish). In a magnetic field they become superheated and can undergo a fast phase transition under a thermal deposit of energy. This may be the best technique for large cryogenic detectors, but several problems must be overcome. Recent irradiation tests (Garching/Paris/Munich/Vancouver/Annecy) have confirmed the principle, but the expected sensitivity and energy resolution is insufficient for full size detectors (except possibly for monopole searches).

A new version of SSG, based on 'amplification by thermal microavalanche', with latent heat amplifying response and improving linearity, is being investigated. Progress in fast electronics for SSG readout was reported for both conventional amplifiers (R. Bruere-Dawson) and superconducting SQUID devices (M. Le Gros). Large scale production of micron granules is vital and a programme using high frequency ultrasonic devices is underway with French manufacturers (EXTRAMET).

Devices working below 1 mK were considered for the first time as particle detectors. T. Niinikoski presented limits on galactic dark matter from coherent phonon scattering and proposed new methods based on unresolved fluctuations in solids. G.R. Pickett discussed the possible use of superfluid helium-3, where the quasiparticle energy gap is around 10^{-7} eV. However high temperature superconductors (C.Chaillout) already provide operating devices. D. Robbes presented the achievements of the Caen group in the preparation of dc SQUIDs using YBaCuO ceramics. More conventional techniques were also discussed.

In his summary talk, Klaus Pretzl asked if a kilogram neutrino detector could be built in the near future. Although the immediate answer is no, the field of low temperature detectors is developing so fast that unexpected breakthroughs should not be discounted.

The next Workshop will be organized by the Milan group (contact E. Fiorini or D. Camin) in Como or Gran Sasso, and is scheduled for June 1989.

From Luis Gonzalez-Mestres and Denis Perret-Gallix

Accelerator technology for fusion

After 12 years of research on the possibilities of heavy ion beams for thermonuclear fusion, the recent 4th International Symposium on Heavy Ion Fusion held at GSI, Darmstadt, reflected the undiminished enthusiasm behind the push to use accelerator techniques in the search for new energy sources.

After an early phase of mainly theoretical work, previous meetings had focussed on ideas such as HIBALL (Heavy Ion Beams and Lithium Lead). The latest meeting, attended by about 140 participants from 12 countries, hinted that proof of the principle, both in the field of accelerators and in beam-plasma interaction, is closer.

Highlights in 'conventional' techniques were the completion of the first stage of a heavy ion induction linac at Berkeley, with demonstration of pulse compression during acceleration (D. Keefe, T. Fessenden), and a progress report on the new GSI synchrotron/storage ring complex scheduled to become operational next year (D. Böhne, I. Hoffmann). This high current machine (consisting of the rapid cycling SIS synchrotron coupled to the ESR storage ring) will probe the dynamics of both space-charge dominated ion beams and of beam-plasma interaction, providing input for many key parameters of a possible fusion driver accelerator.

Good news from S. Kahalas (US Department of Energy) was a previously classified result from studies of thermonuclear fuel pellet implosions indirectly driven by X-rays from an underground nuclear explosion, confirming the idea that 5 megajoule HIBALL-like pulses should be sufficient for ignition (there had been worries that much more energy might be needed). Another milestone was the report from a French-German collaboration (D. Hoffmann) that the stopping power of heavy ions in a plasma is about twice as high as in cold matter, promising increased concentrations of energy for pellet heating.

A significant effort is also underway at Moscow's Institute for Theoretical and Experimental Physics.

Finally the fertile imagination of Carlo Rubbia suggested how advances in accelerator technology could pay off in this important sphere. Powerful (non-Liouvillian) techniques, analogous to the beam cooling used so successfully for physics, could follow from stripping charges from ions injected from a linac into a compact HIBALL-type accelerator. The required flux of 16 eV photons could be supplied by a free electron laser, giving a simpler accelerator system with no unwieldy stacking rings.

Another Rubbia brainwave foresaw direct conversion of a high power electron beam into soft X-rays by an undulator, supplying a photon beam of hundreds of eV for focusing on a target.

From Rudolf Bock

At the recent International Symposium on Heavy Ion Fusion, Carlo Rubbia (left) with G. Linhart and symposium organizer Rudolf Bock.

BROOKHAVEN Looking towards heavy ion physics

July 11-22 were busy days at Brookhaven with a two-week Summer Institute on Relativistic Heavy Ion Physics. After an intensive first week designed to introduce young physicists to high energy heavy ion research, The second week was a workshop on detector technology for Brookhaven's proposed Relativistic Heavy Ion Collider (RHIC), attended by some 150 physicists.

David Hendrie, Director of Nuclear Physics for the US Department of Energy, was on hand to announce that R&D funding will be available during the coming year to support generic detector development work for heavy ion collider physics. Summer Institute Chairman Thomas Ludlam invited participants to 'provide an assessment of RHIC detector development needs

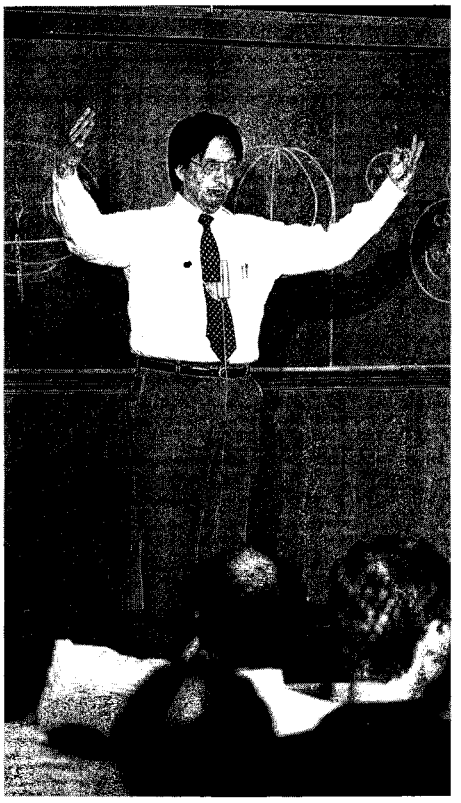
and priorities which will both motivate and support proposals for R&D funding from the user community.'

During the Workshop, detector concepts emerging from previous RHIC studies were matched against the unique problems of the RHIC environment. Topics addressed by specific working groups were –
- tracking and particle identification of many secondary particles (S. Nagamiya, Columbia);
- electronics for fast, high-density readout (W. Cleland, Pittsburgh);
- calorimeter response in the many-particle, collider environment (S. Aronson, Brookhaven);
- simulation of high energy nuclear interactions and detector response (B. Shivakumar, Yale);
- data acquisition (M. Levine, Brookhaven.

In addition a group headed by N. Lockyer (Pennsylvania) studied the possibility of a B meson experiment with high luminosity proton beams at RHIC.

Some conceptual designs for experiments at RHIC are described in the proceedings of last year's Workshop on Experiments and Detectors for RHIC held at Berkeley (copies from RHIC Office, Bldg 1005, Brookhaven National Laboratory, Upton, NY 11973). Proceedings of this year's workshop will be available soon. Proposals for detector R&D can be sent to Dr. David Hendrie, US Department of Energy, ER-23 G-309 GTN, Washington, 20545.

Brookhaven Director Nick Samios – large scope for heavy ion collisions.



Aspiring heavy ion physicists at Brookhaven.

People and things

A tribute to Heinz Pagels, physicist, author and Executive director of the New York Academy of Sciences, who died in a climbing accident on 24 July, will appear in the next issue.

Edoardo Amaldi – President of the Accademia dei Lincei.

On people

Edoardo Amaldi, 80, doyen of Italian physics and one of the prime movers behind the establishment of CERN as an international Laboratory in the early 1950s, has been elected President of the prestigious Italian 'Accademia dei Lincei'. He was previously its Vice-President.

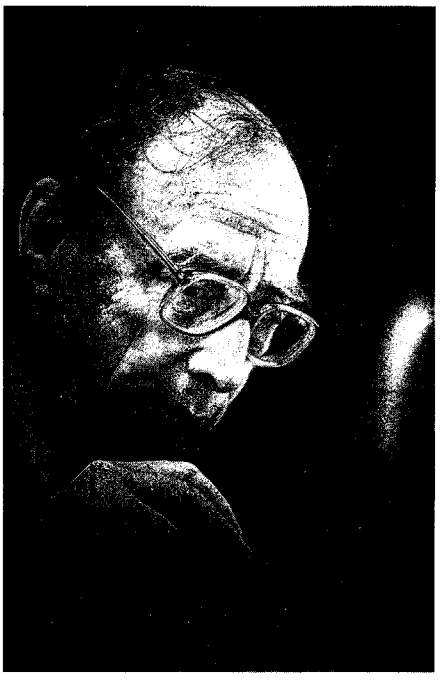
The Fujiwara Prize, one of the most highly regarded national awards for pure and applied science in Japan, has been awarded to Tetsuji Nishikawa, Director General of the KEK Laboratory, for his distinguished achievements in the development of high energy particle accelerators. As well as his researches on high intensity linear accelerators and his promotion of accelerator research in Japan, he has played a major role in bringing Japan to the forefront of world high energy physics through the construction of the KEK 12 GeV proton synchrotron and the big TRISTAN electron-positron collider, and has furthered the use of machines such as the KEK Booster and Photon Factory in other fields of science.

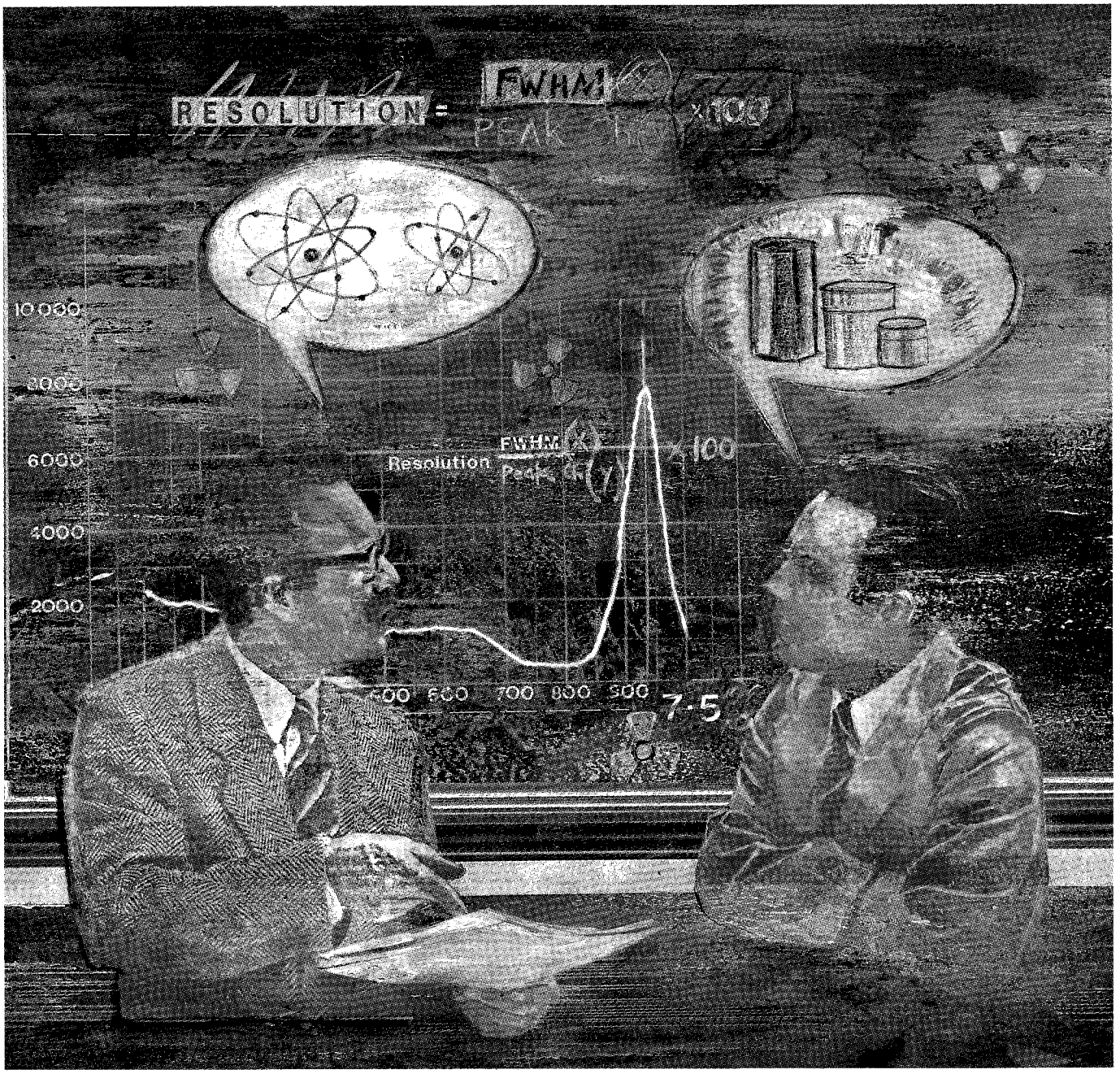
The Japanese Government's Purple Ribbon Medal for scientific and artistic achievement has been awarded to Yoshio Yamaguchi, Chairman of the International Committee for Future Accelerators (ICFA) and Vice President of the International Union for Pure and Applied Physics (IUPAP), for his contributions to particle, nuclear and cosmic ray physics theory.

Among this year's recipients of the US National Medal of Science, the country's highest scientific honour bestowed by the President, were – D. Allan Bromley (Yale, particle/nuclear physics, tandem accelerators), Paul Chu (Houston, high temperature superconductors), Norman F. Ramsey (Harvard, basic physics

KEK Director General Tetsuji Nishikawa – Fujiwara Prize.

Distinguished Soviet theoreticians Dimitry V. Shirkov (top) and Victor I. Ogievetsky (below) of the Joint Institute for Nuclear Research, Dubna, near Moscow, recently celebrated their 60th birthdays.





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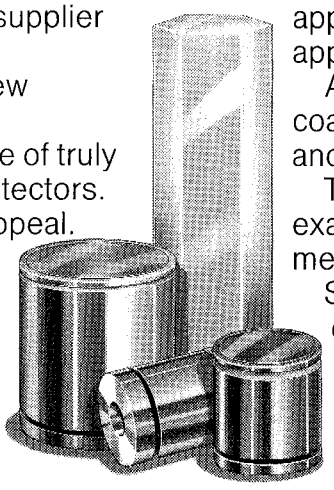

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US Particle Accelerator School 1988 Prizes for Achievement in Accelerator Physics and Technology – (left to right) Andrew M. Sessler, Ilya M. Kapchinskii and Vladimir A. Teplyakov.

and service to the US scientific community), and Jack Steinberger (CERN, strange particles, neutral kaons and high energy neutrinos).

The US Particle Accelerator School 1988 Prizes for Achievement in Accelerator Physics and Technology went to Andrew M. Sessler (Berkeley) for his contributions to the understanding of particle beam instabilities, and jointly to Ilya M. Kapchinskii (Institute for Theoretical and Experimental Physics, Moscow) and Vladimir A. Teplyakov (Institute for High Energy Physics, Serpukhov) for their invention of the radio-frequency quadrupole.

Among the six scientists selected for the 1988 E.O. Lawrence Memorial Awards for outstanding US contributions in fields of science and technology related to atomic energy is theorist Mary K. Gaillard of Berkeley.

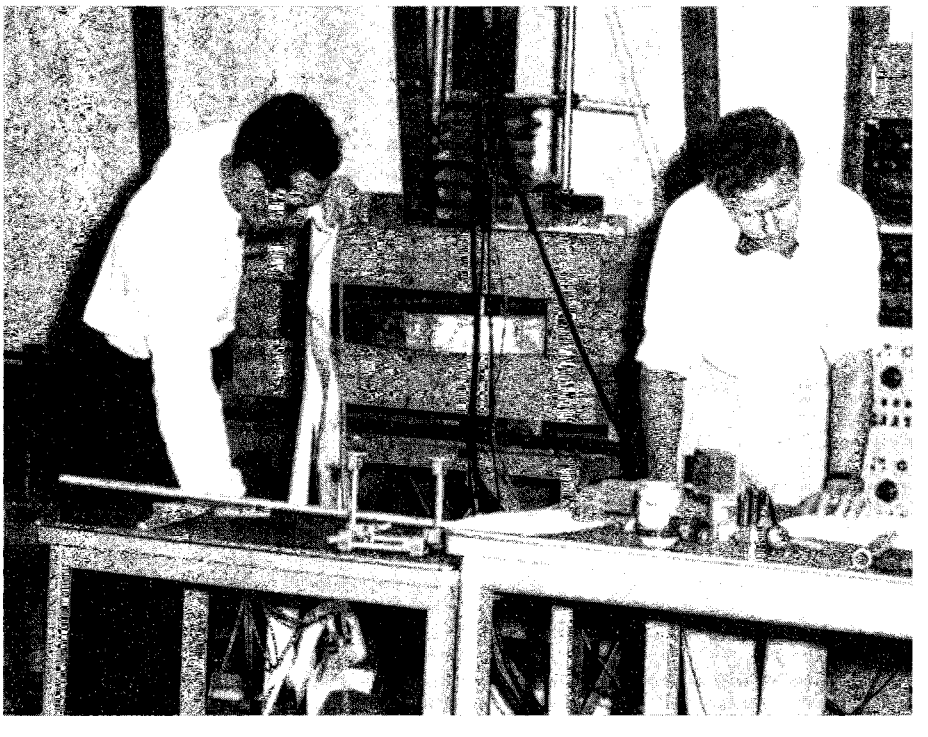
Saclay theorist Claude Itzykson has been awarded the Prix Robin of the Societe Francaise de Physique.

CERN career milestone

Another CERN pioneer, Kes Zilverschoon, is formally retiring after a distinguished career in accelerators and in administration. Responsible for installation during the building of the PS proton synchrotron, he went on to take the key role as deputy to Kjell Johnsen in the legendary smooth construction of the Intersecting Storage Rings. Since then he has held senior management posts, including a spell as Directorate member, and from 1981-87 was Chairman of CERN's Pensions Board.

Pierre Germain 1922-1988

Pierre Germain died on 16 August. Born in Brussels in 1922, he joined CERN in 1955 working on the construction of the radiofrequency system for the Proton Synchrotron. He became Leader of the PS Division in 1961 and was appointed Directorate Member for Technical Management in 1963.



Gifted Norwegian experimenter Arne Lundby passed a formal retirement milestone at CERN this summer. Arriving at the infant CERN in 1956 from Chicago, he contributed over the years to a whole series of ingenious experiments. Here (right) he prepares with Jean-Pierre Stroot a pioneer study using the scale model (rear) of CERN's first machine, the synchro-cyclotron.

Physicists and Engineers

The Superconducting Super Collider (SSC) is a proposed basic research laboratory designed to advance understanding of the structure of matter. In the collider's underground tunnel, 53 miles in circumference, two beams of protons will be steered in opposite directions by two rings of superconducting magnets and accelerated to an energy of twenty trillion electron volts. When the beams collide head-on, enormous energy will be concentrated in a volume of subnuclear size, revealing the fundamental particles and forces in detail far beyond the reach of today's accelerators. The SSC will require 10,000 superconducting electromagnets of various geometries. Now under intensive development are the 8,000 dipoles, each a 22,000-pound complex structure two feet in diameter, 55 feet long, cooled by liquid helium. The magnet development program will require a combination of analytic and numerical calculations, laboratory experiments, and tests of full-scale magnets. Congress has appropriated $100 million for FY 1989 for research and development toward the SSC. A site is to be named early in 1989. The SSC R&D program is managed for the U.S. Department of Energy by Universities Research Association, Inc., a consortium of 66 leading research universities.

The SSC Central Design Group (CDG) invites applications from physicists and engineers interested in participating in the SSC R&D program. Appointments at various levels are available in the following areas:

Accelerator Design

We seek candidates with experience and interest in applications of analysis to practical accelerator design for several positions, including computer simulation of beam dynamics, calculation of beam tube impedances and collective effects, particle tracking simulation, lattice design, injector design, systems design and integration, and the modeling of magnetic and mechanical properties of superconducting magnets.

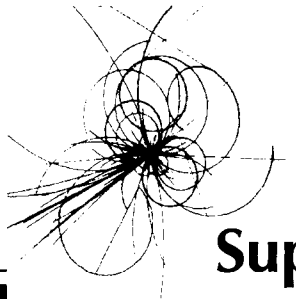
These positions require either a Ph.D. in physics or an engineering degree with equivalent experience; knowledge of modern computational methods; and the demonstrated ability to pursue a vigorous, well-organized research program. Strong verbal, writing, analytical, and interpersonal skills are desirable.

Superconducting Magnet Development

We seek candidates who will make significant contributions to the development of superconducting accelerator magnets. The primary responsibility to is to test model and full-size prototypes and to analyze mechanical, electrical, and magnetic measurement data. Some of these positions require the candidate to work at the Magnet Test Facility at Fermi National Accelerator Laboratory, with periodic trips to the CDG at Lawrence Berkeley Laboratory and to Brookhaven National Laboratory.

These positions require a Ph.D. in experimental physics, applicable hardware experience, and experience with data analysis software. Candidates should have demonstrated the ability to initiate, plan, and carry out experiments. Familiarity with computer data acquisition systems is desirable. Strong verbal, writing, analytical, and interpersonal skills are desirable.

Initial assignment for these positions will be at the SSC Central Design Group headquarters in Berkeley, California. URA employees enjoy competitive salaries and a comprehensive benefits program, including relocation assistance. *Universities Research Association is an equal opportunity, affirmative action employer.* To learn more about these outstanding opportunities write:



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For further information and application forms, please apply to: Fellowship Service - Personnel Office, Istituto Nazionale di Fisica Nucleare (I.N.F.N.) - Casella Postale 56 - 00044 Frascati (Roma) Italy.

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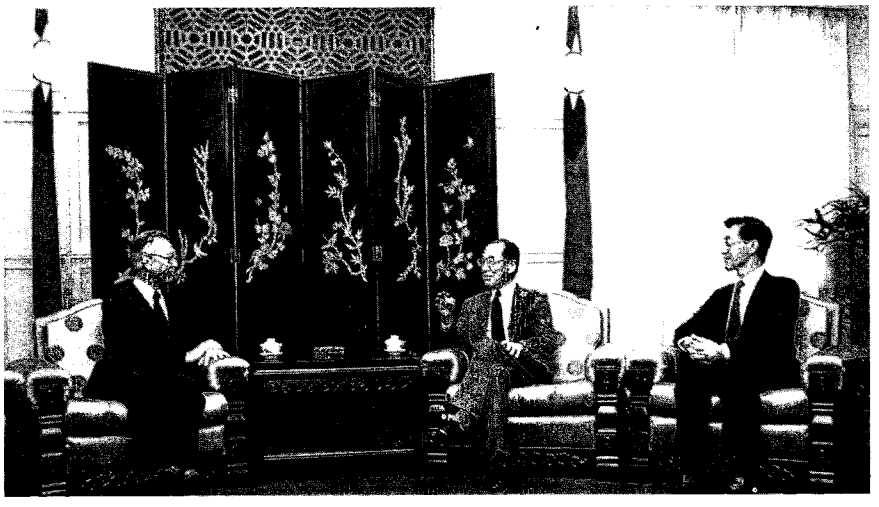
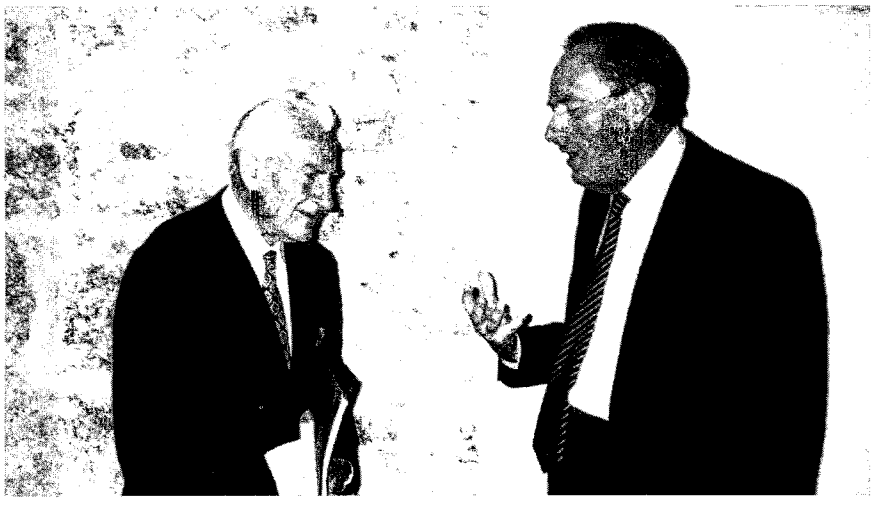
Universität Karlsruhe,
Postfach 6980,
7500 Karlsruhe 1.

Physics without frontiers. CERN Director General Herwig Schopper (left) discusses with Lee Teng-hui, (centre) President of Taiwan, ways of improving scientific cooperation between Taiwan and Europe. Right is President of the Taiwan Commission for Sciences Chen Li-an. Below, Schopper, with Sam Ting (right) and Zhou Guangzhao, President of the Academy of Sciences of the People's Republic of China, on the occasion of the signing of an extension to the agreement covering Chinese participation in experiments at CERN's new LEP electron-positron collider.





Meetings

An International Workshop on High Transverse Momentum and Higher Twist Physics is being held at the College de France, Paris, from 21-23 September. Further information from Maurice Benayoun or Jean-Louis Narjoux, Laboratoire de Physique Corpusculaire, College de France, 11 place Marcelin Berthelot, 75231 Paris, Cedex 05, France; telefax (1) 43 54 69 89; telex INPNPP 204929F; telephone (1) 43 29 12 11, ext 2014, 2013, 2004; bitnet narjoux at frcpn11, benayoun at frcpn11; decnet CDFVAX::LERUSTE

An international conference entitled 'Inside the Sun' will be held in Versailles, France, from 22-26 May 1989, organized by the Department de Physique des Particules Elementaires and Service d'Astrophysique, Saclay; Nice Observatory; Meudon Observatory; and LPSP, Verrieres le Buisson. Scheduled topics include standard solar models, probing stellar interiors, probing the solar interior, and 'beyond the standard model'. Further information from Jacqueline Boratav, CEN-Saclay, DPhPE/SEPH, 91191 Gif-sur-Yvette, Cedex, France.

A Switched Power Acceleration Workshop is being held from 17-21 October in Shelter Island, New York. Further information from R. Palmer at Brookhaven or SLAC *(see page 14).*

At a meeting in Pisa in June to mark the 20th Anniversary of the European Physical Society (EPS) and the 90th Anniversary of the Italian Physical Society – (left) G. Bernardini, first EPS President and CERN Research Director in the early 1960s, with Sir Alec Merrison, President of CERN Council 1982-84, both of whom played important roles in CERN's early research programme.

(Photo M. Jacob)

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University of British Columbia
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The starting date for these positions is January 1, 1989.

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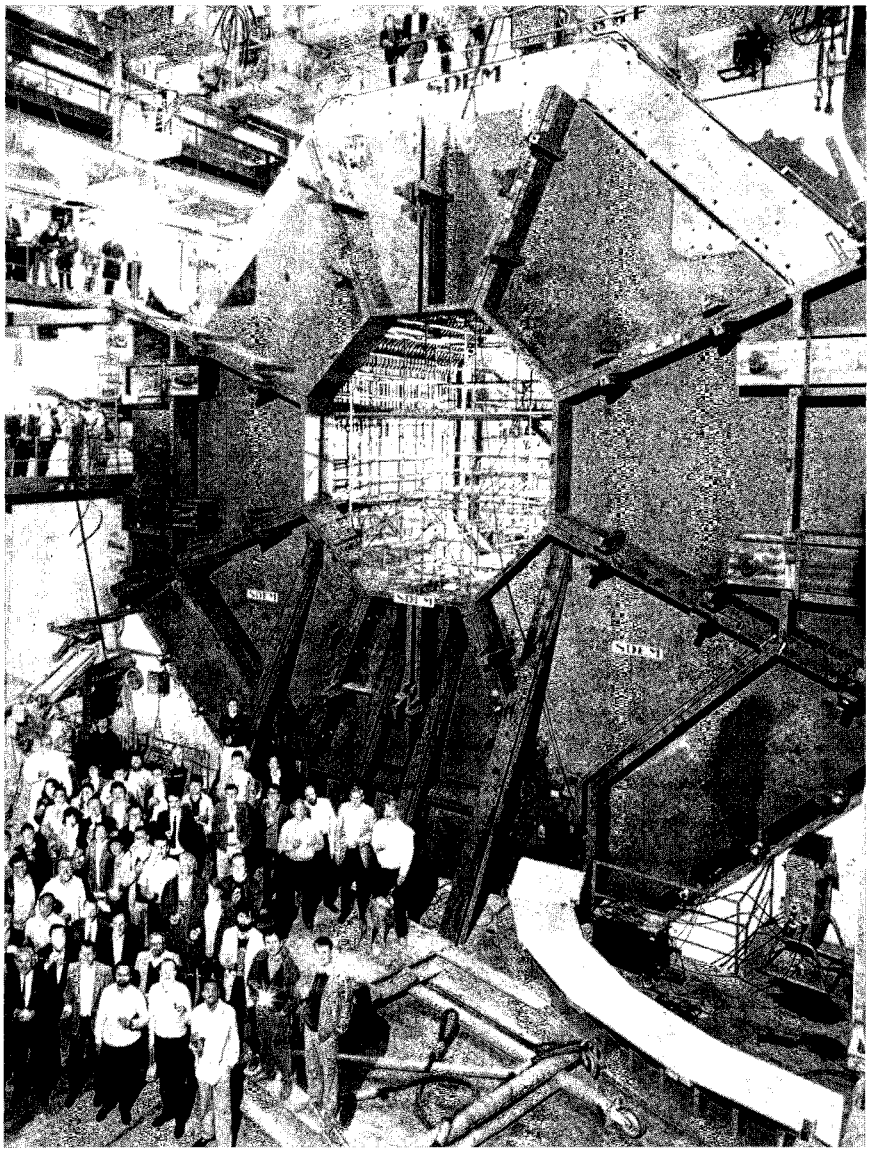

A visitor to CERN in July was Italian Education Minister Giovanni Galloni (centre) who saw among other things the progress in the Italian-funded LAA project for new detector technologies, headed by Antonino Zichichi (left), and progress (photo below) at CERN's LEP electron-positron collider for the L3 experiment headed by Sam Ting (right).

(Photo CERN 0666.7.88)

The XII International Conference on the Few Body Problem in Physics will be held in Vancouver from 2-8 July 1989. Further information from the Conference Organizer, Harold W. Fearing, TRIUMF, 4004 Wesbrook Mall, Vancouver, BC, Canada V6T 2A3.

•

A 'Workshop on Thermal Field Theories and their Applications' to be held in Cleveland, Ohio, from 3-5 October will also include a special session on the statistical mechanics of strings. Further information from the Organizing Committee Chairman, K.L. Kowalski, Physics Dept., Case Western Reserve University, Cleveland, Ohio 44106, BITNET: KOWALSKI at CWRU.

Books

As the proceedings of the first ICFA School on Instrumentation held at Trieste in June 1987, 'Instrumentation in Elementary Particle Physics', edited by C.W. Fabjan (CERN) and J.E. Pilcher (Chicago) and published by World Scientific, Singapore, is a useful introduction to modern detector techniques, an important area of physics where textbooks are thin on the ground.

(Following the success of the 1987 school, the second school is scheduled for Trieste's International Centre for Theoretical Physics from 12-23 June, 1989. Further information from C. Fabjan at CERN or J. Pilcher at the Enrico Fermi Institute, Chicago.)

In parallel with installation of LEP machine components in the 27 km tunnel, the four LEP experiments are taking shape in their underground caverns. At L3, a contingent poses in front of the vast 'door' of the experiment's magnet.

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IMPORTANT TITLES

PERSPECTIVES IN STRING THEORY

Proceedings of the Niels Bohr Institute/Nordita Meeting
Copenhagen, Denmark 12–16 Oct 1987

edited by **P Di Vecchia** (*Nordita*) & **J L Petersen** (*Niels Bohr Institute*)

This volume of proceedings contains papers on the most recent advances in different aspects of String Theories, contributed by those who are at present actively engaged in this field of research.
Readership: High energy physicists, astrophysicists and cosmologists.

524 pp **Jun. 1988** 50-526-6(US$76)H/C 50-534-7 (**US$48)S/C

INSTRUMENTATION IN ELEMENTARY PARTICLE PHYSICS

Proceedings of the ICFA School on Instrumentation
ICTP, Trieste, Italy June 1987

edited by **C W Fabjan** (*CERN, Geneva*) & **J E Pilcher** (*Univ. of Chicago*)

This didactic introduction of Modern Concepts in Particle Detection provides an excellent opportunity for established researchers in particle physics to refresh their knowledge, or for students to become acquainted with current techniques. There are no equivalent text books existing.
Readership: Researchers in particle physics and electrical engineers.

540 pp **Jun 1988** 50-585-1(US$74)H/C 50-637-8(**US$35)S/C

World Scientific Lecture Notes in Physics – Vol. 25

THE PHYSICS OF MASSIVE NEUTRINOS

by **B Kayser** (*Nat'l Sci. Foundation*) with **F Gibrat-Debu** (*CEN-Saclay*) & **F Perrier** (*Stanford Linear Accelerator Center*)

This book explains the physics and phenomenology of massive neutrinos. This volume requires of the reader only a knowledge of quantum mechanics and of very elementary quantum field theory.
Readership: Particle physicists and nuclear physicists.

180 pp **Sep. 88** 50-661-0(US$42)H/C 50-662-9(US$22)S/C

EXPERIMENTS, DETECTORS, AND EXPERIMENTAL AREAS FOR THE SUPERCOLLIDER

Proceedings of the Workshop
Berkeley, California,USA 7–17 July 1987

edited by **R Donaldson & M G D Gilchriese** (*LBL*)

This volume presents the findings of the workshop in four broad groups: physics and experiments at large P_T, physics and experiments at intermediate P_T, physics and experiments at low P_T, and physics and experiments related to "exotic" particle searches or interactions.
Readership: High energy physicists and nuclear physicists.

936 pp **Apr. 1988** 50-473-1(US$89)H/C

Advanced Series in Mathematical Physics – Vol. 8

INTRODUCTION TO STRING FIELD THEORY

by **W Siegel** (SUNY, Stony Brook)

This volume covers the latest findings on string field theory.
Readership: High energy physicists, mathematical physicists and mathematicians.

256 pp **Oct. 1988** 50-731-5(US$24)H/C 50-732-3(US$16)S/C

VARIATIONAL CALCULATIONS IN QUANTUM FIELD THEORY

Proceedings of the Workshop on Variational Calculations in Quantum Field Theory
Wangerooge, West Germany 1–4 September 1987

edited by **L Polley** (*Oldenburg*) & **D E L Pottinger** (*IBM, UK*)

This workshop brought together for the first time the leading researchers in this field in order to review its current state-of-art as well as to identify profitable directions for future research in the possibility of obtaining accurate qualitative and quantitative information on the structure of quantum field theories using non-perturbative continuum and lattice variational techniques.
Readership: High energy and nuclear physicists, condensed matter physicists, mathematical physicsists.

316 pp **Jul. 1988** 50-500-2(US$55)H/C 50-501-0(**US$35)S/C

FIRST EUROPEAN PARTICLE ACCELERATOR CONFERENCE (EPAC 88) – In 2 Volumes

Rome, Italy 7–11 June 1988

edited by **S Tazzari** (*INFN, LNF-Frascati, Rome*) & **K Huebner** (*CERN*)

This conference provide a comprehensive overview of Research, technology and applications in the field of accelerators. The proceedings will include papers from the whole field of accelerators, including low-and high-energy machines, medical and industrial accelerators.

Readership: High energy physicists and accelerator physicists.

1600 pp (approx.) **Dec 1988** 50-642-4(US$78 Vol. 1)(US$82 Vol. 2) H/C
50-643-2(**US$47 Vol. 1) (**US$49 Vol. 2) S/C

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604 pp **Jun. 1988** 50-419-7(US$78)H/C 50-420-0(**US$37)S/C

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John R. Schrieffer (right, UC Santa Barbara – 'High-temperature superconductors') and Maurice Jacob (CERN – 'How to find evidence for the quark-gluon plasma') were keynote speakers at the annual meeting of the Norwegian Physical Society in Oslo in June.

(Photo Geir Holm, Oslo)

'Frontiers of Particle Beams', edited by M. Month and S. Turner and published by Springer-Verlag, is the proceedings of the course organized by the Joint US-CERN School on Particle Accelerators held at South Padre Island, Texas, in October 1986. A central theme of the internal physics of beams is supplemented by material on recent projects and ideas.

'Experiments, Detectors and Experimental Areas for the Supercollider' is the title of the Proceedings of the Workshop held at Berkeley from 7 – 17 July 1987. Edited by Rene Donaldson and M.G.D. Gilchriese and Published by World Scientific Publishing Company, Singapore, this detailed volume presents the potential experimental programme at the proposed US SSC Superconducting Supercollider. The workshop findings are categorized into two broad groups: the evaluation of physics signatures and the resultant requirements for detectors parameters; and the presentation of conceptual designs of first generation experiments to allow comparison among the competing designs.

'A Passion for Science', published by Oxford University Press and edited by Lewis Wolpert and Alison Richards is a series of fascinating interviews with famous scientists (including Abdus Salam, Martin Rees, Francis Crick, Dorothy Hodgkin) exploring the frequently ignored human and personal side of their work.

The summer/fall 1984 edition of 'Los Alamos Science' published by Los Alamos National Laboratory was an imaginative attempt to put across the current state of particle physics and has been on the CERN Courier's office bookshelf ever since. Equally impressed was Cambridge University Press, which has now published the updated volume as 'Particle Physics – A Los Alamos Primer', edited by Necia Grant Cooper and Geoffrey B. West. Four years down the line, it is still a good read.

VMEbus

VMEbus in Research is the title of an international conference and exhibition to be held at ETH Zurich on the 11, 12 and 13 October, sponsored by CERN, the Paul Scherrer Institute (formerly SIN) Switzerland, IFIP – International Federation for Information Processing, ECA – European CAMAC Association, VITA – VMEbus International Trade Association, and SAP – Swiss Automation Pool. Covering hardware, software and systems aspects as well as developments in the applicable standards, it is open to all interested in the design and use of equipment based on the VMEbus specifications in all types of research. Two days will be of a strong technical and scientific interest, with one day for VMEbus manufacturers to present their latest design concepts. Information on registration may be obtained from VITA Europe (address below) or from any member of the organizing committee – A. Bolsinger (PSI-SIN), C. Eck (CERN), M. Hugelshofer (SAP), Z. Hunor (VITA), D. Jones (ECA), C. Parkman (CERN), W. Schoeps (SIN) In parallel with the conference, and at the same location, VITA will hold a two day exhibition on 12 and 13 October. Companies wishing to participate should contact VITA Europe, PO Box 192, 5300 AD Zaltbommel, Netherlands.

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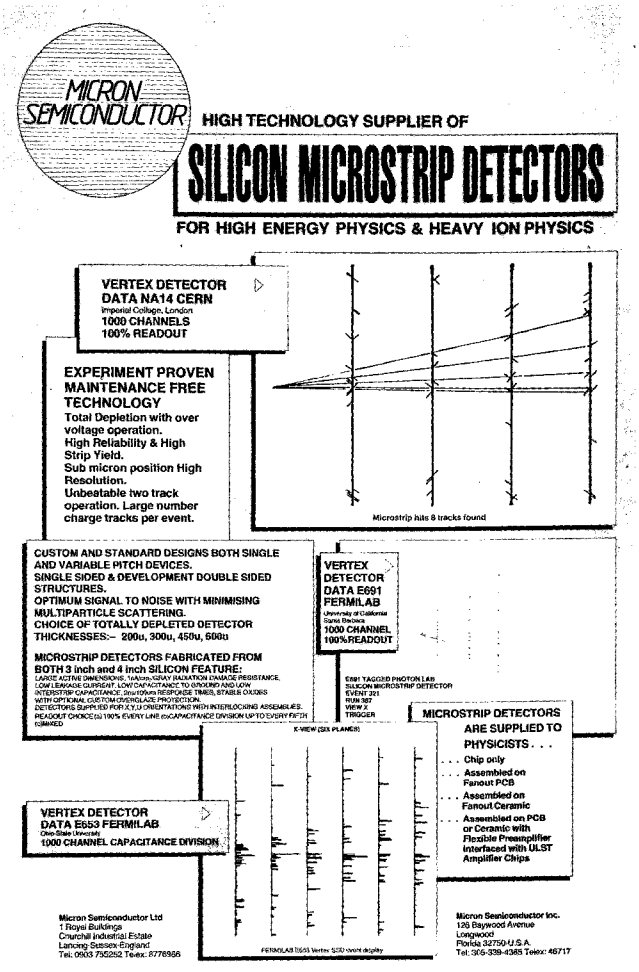

UNIVERSITÄT KARLSRUHE

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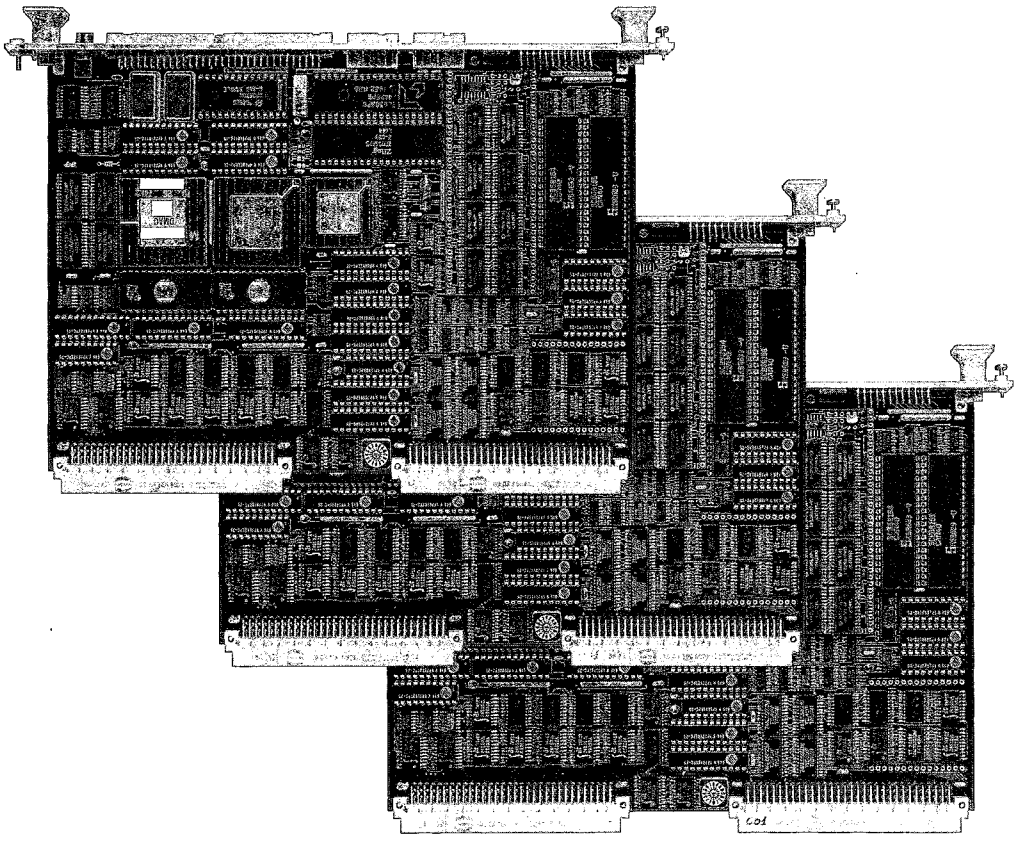

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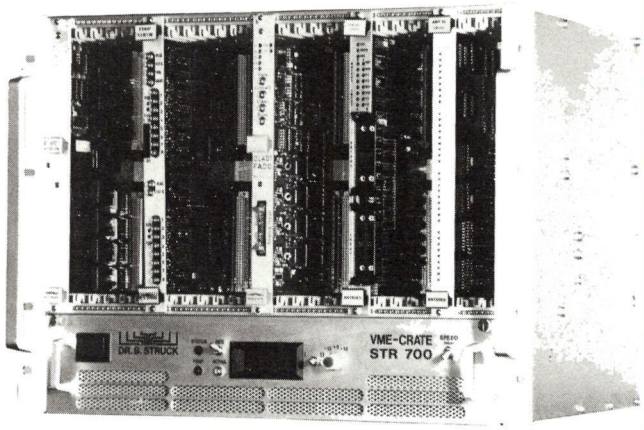

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