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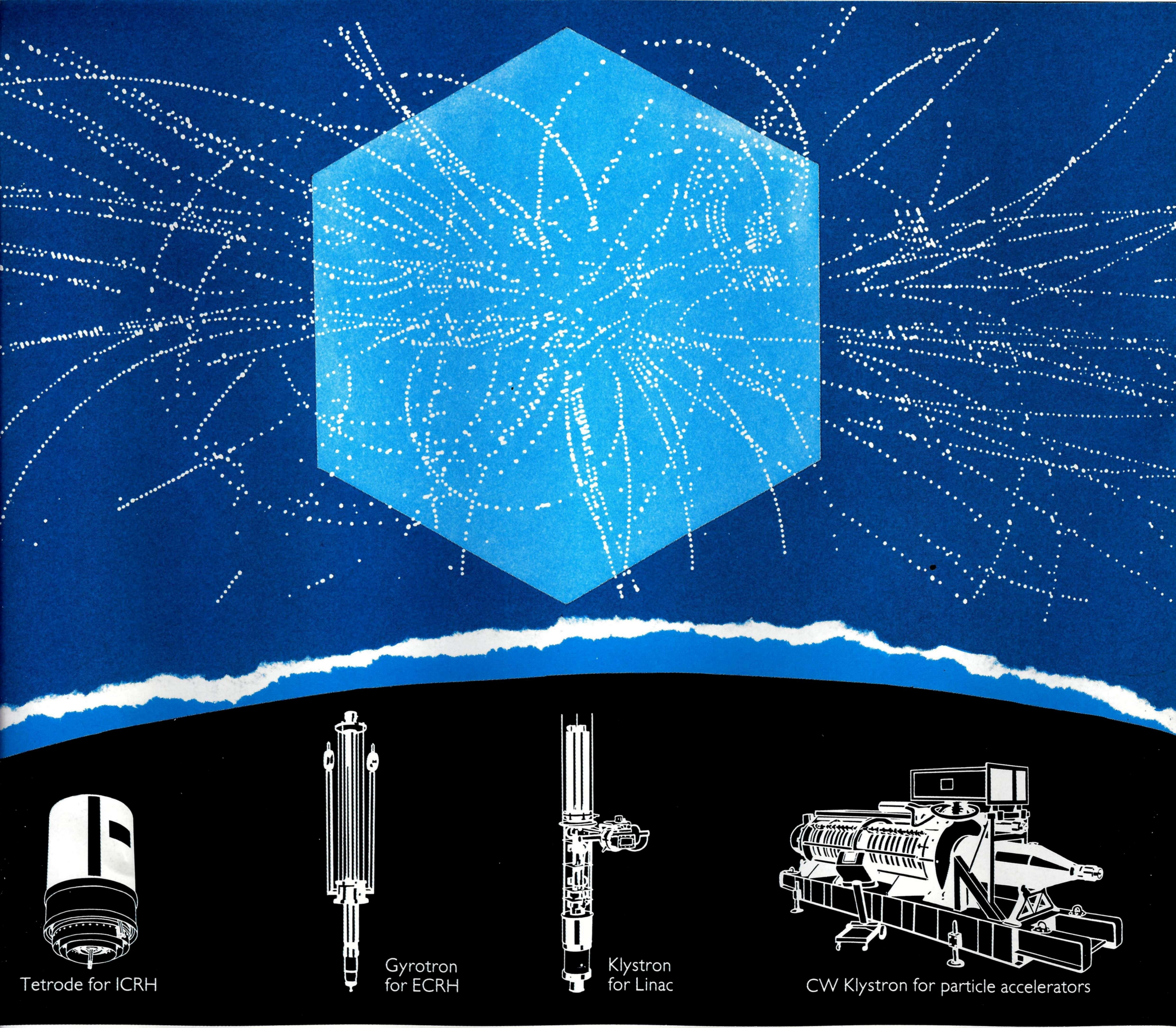

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1 More light on dark matter
LEP and the Universe

5 Buses at the crossroads
New backplane electronics standards

Around the Laboratories

9 DARMSTADT: SIS/ESR inauguration
New German heavy ion facility in operation

10 CERN: B factory ideas/RFQ2/Beam current monitor
Back in the ISR/High proton currents/Working with industry

16 BAKSAN: Solar neutrino study underway
Underground Laboratory

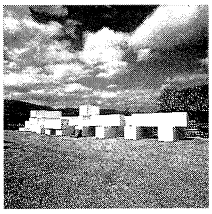
17 DESY: East German contribution
Z-chamber from Zeuthen

17 DUBNA/SERPUKHOV: Rare decays
One in a billion

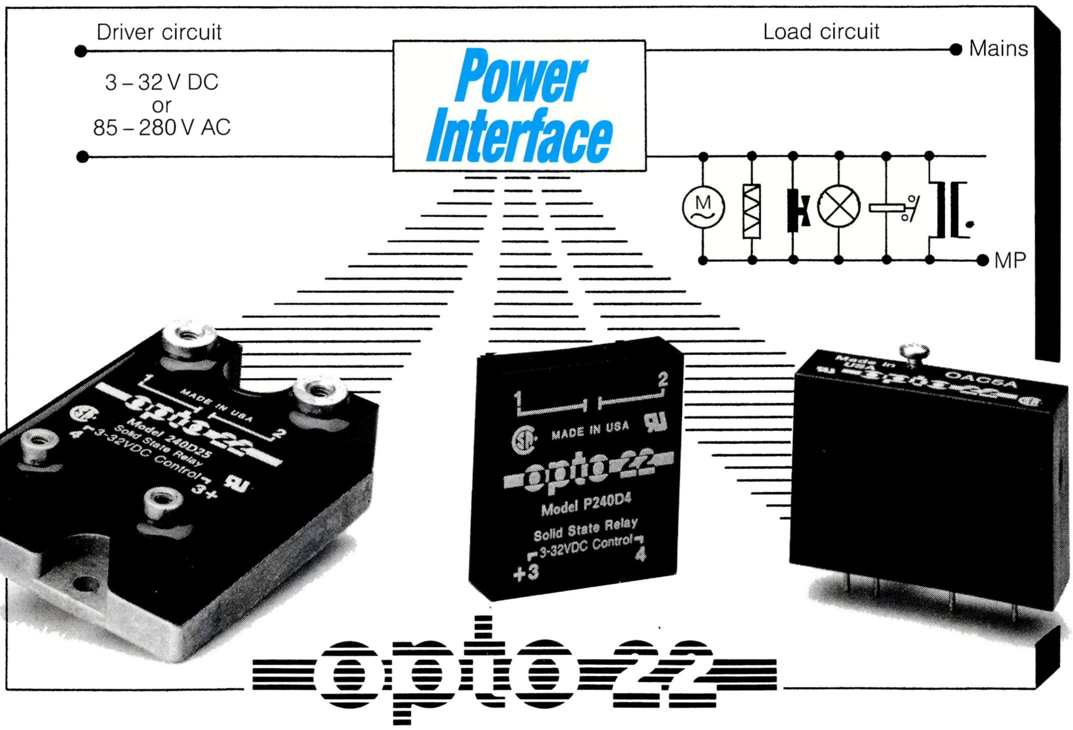
19 ACCELERATORS: Power converters
Technology in high energy machines

21 COMPUTING: Lattice work
Handling tough calculations

23 **People and things**



Cover photograph:
A still-life of concrete shielding blocks. If an experiment at CERN's LEP electron-positron collider were to be pulled back out of the ring into the "garage" position, these blocks, each weighing up to 21 tonnes, could protect it so that modifications or repair work could proceed while LEP continued to run (Photo CERN 24.4.90).



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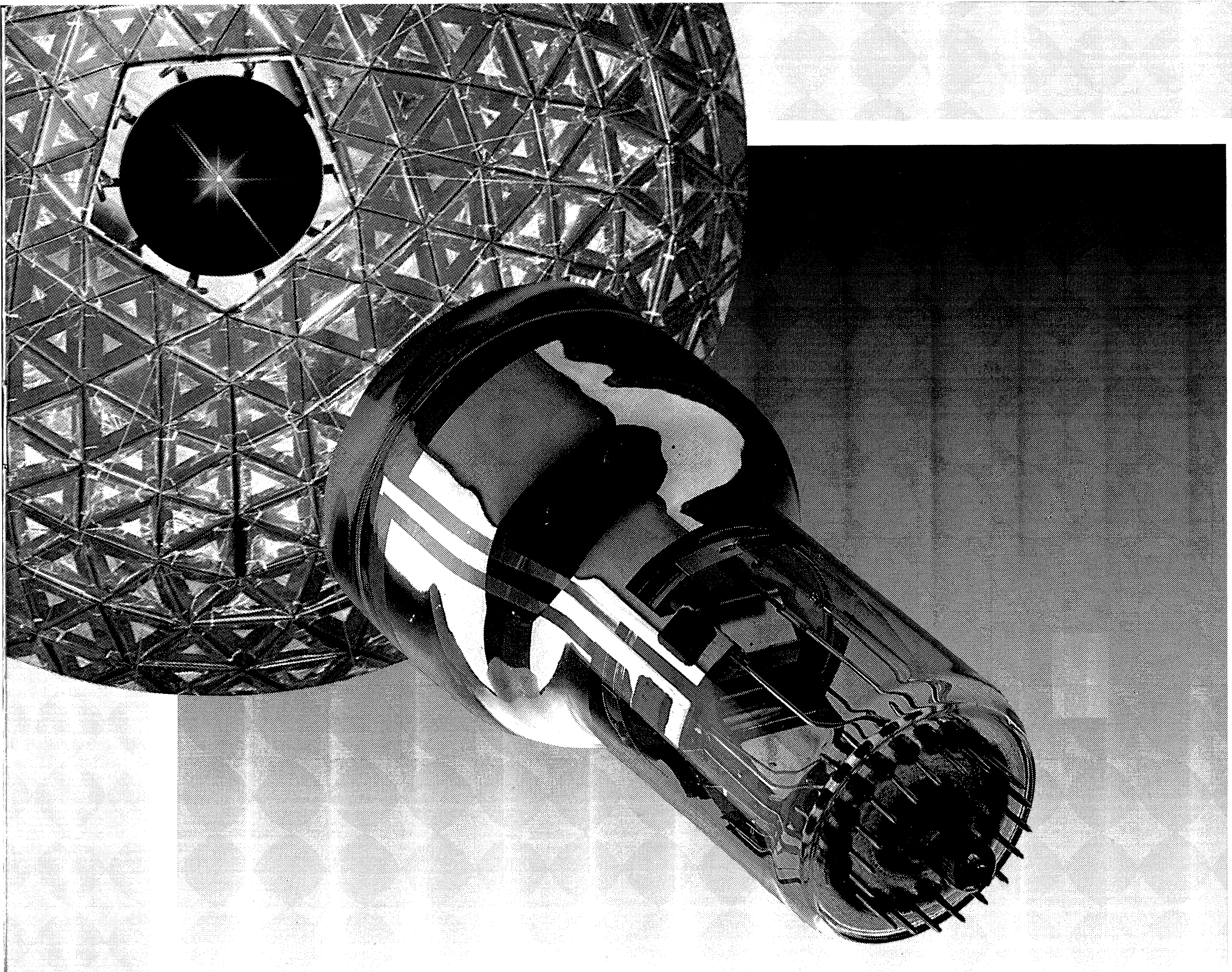

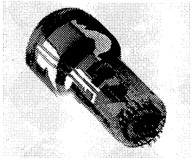

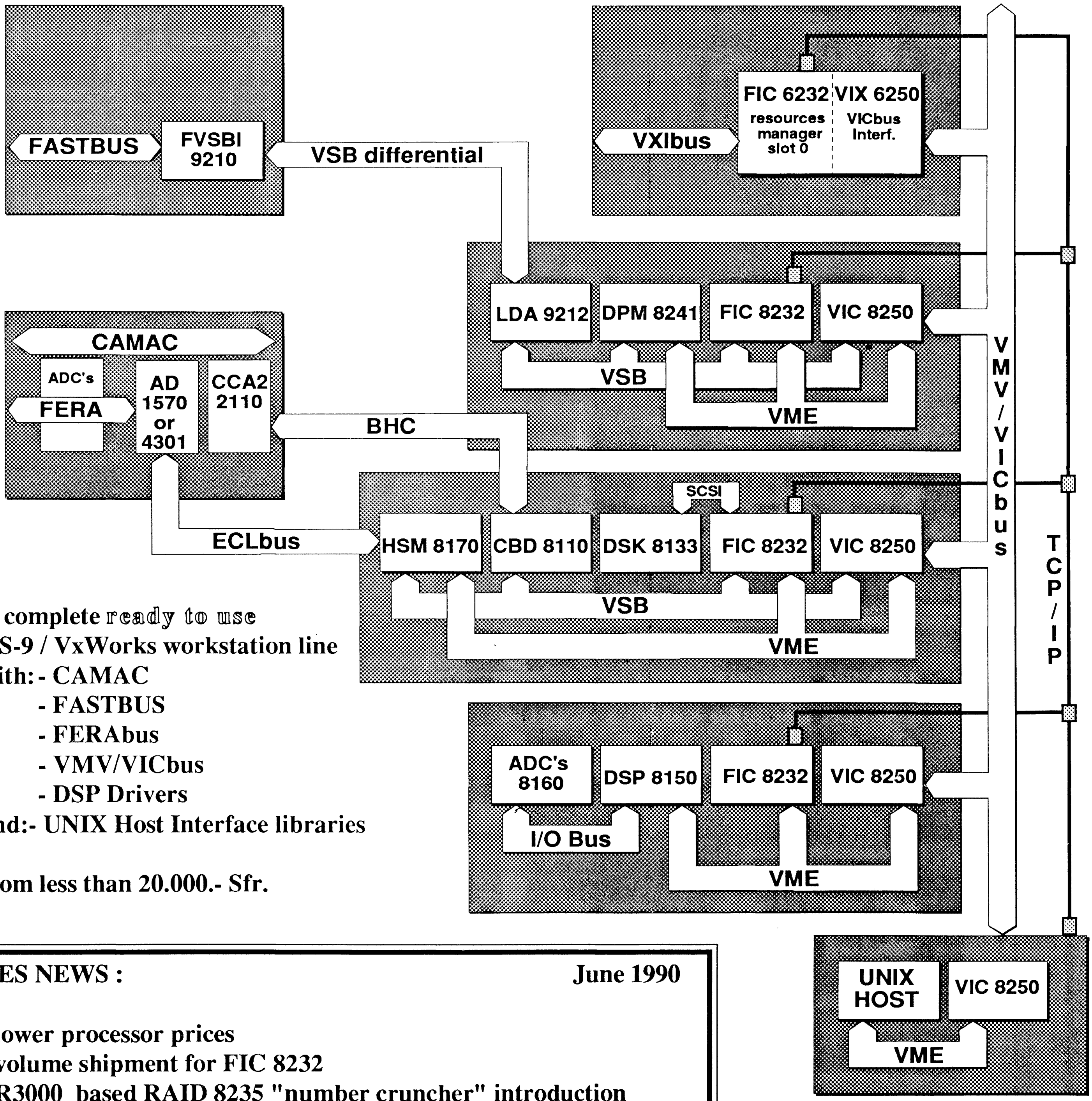

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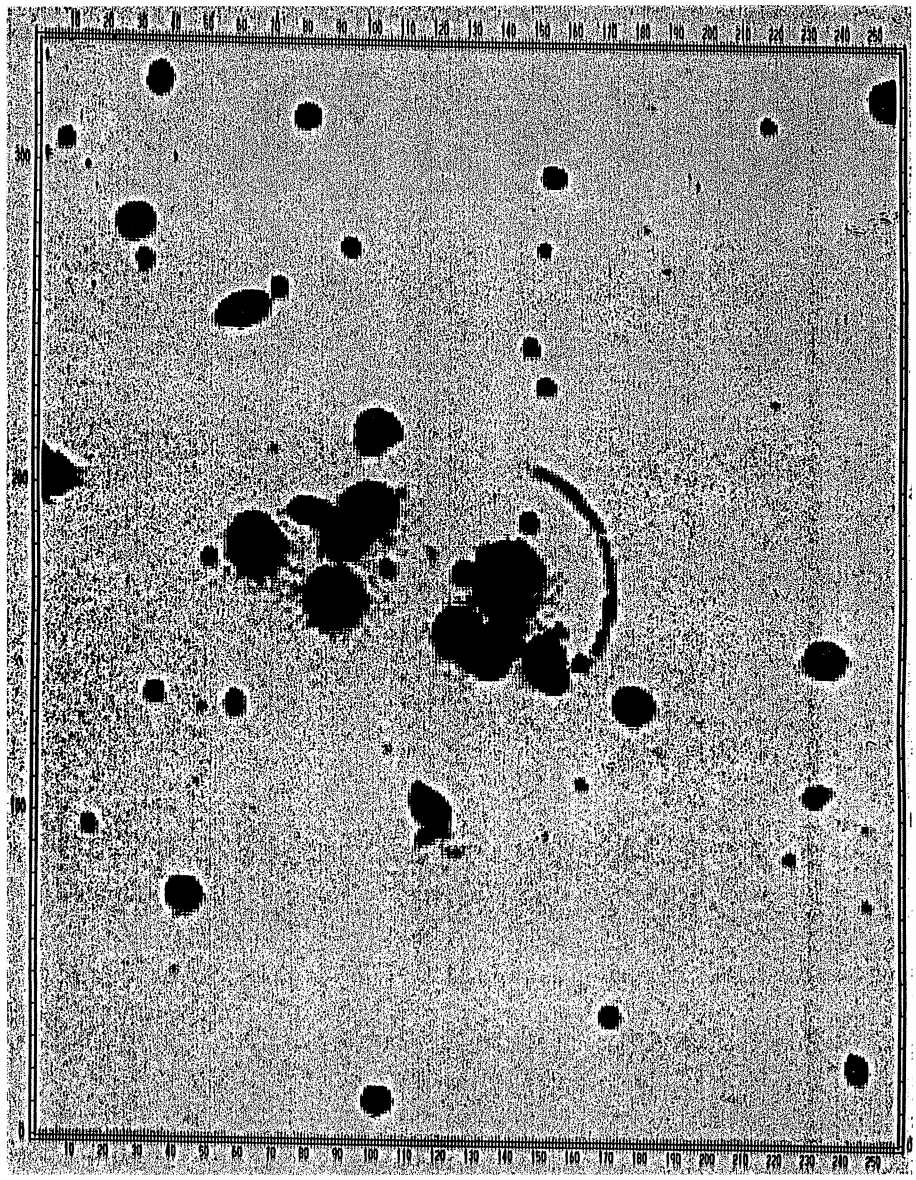
More light on dark matter



The curved image is due to the 'gravitational lensing' of light from distant galaxies by the intervening matter. The effect is stronger than can be accounted for by visible matter alone, indicating that invisible 'dark matter' also plays a role.

For half a century, astrophysicists have suspected that there is more to the Universe than meets the eye. With the gravitational pull between bodies depending on their masses, the relative motion of different parts of the Universe is a pointer to the masses involved.

In the 1930s, Fritz Zwicky made the first speculations about so-called 'dark matter', and Jan Oort discovered that there was not enough visible material surrounding the sun to explain the motion of stars around our own galaxy.

Over a wide range of astronomical structures, from individual galaxies (the 'elementary particles' of cosmology) through to clusters, close analysis of relative motion now shows that the masses implied by gravitational forces are much bigger than the amount of visible matter.

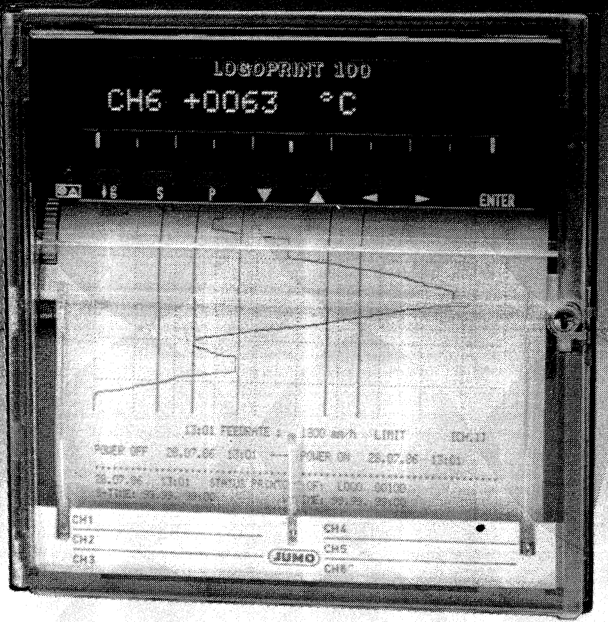
Since then, dark matter evidence has continued to accumulate, and despite our proud new understanding resulting from the 'Big Bang' idea, it is becoming increasingly clear that we know more about less.

This suspicion has been confirmed by recent astronomical observations, and, for the first time, powerful constraints from particle physics experiments are providing valuable new input.

Last year, the experiments at the big new electron-positron colliders at CERN (LEP) and Stanford (SLC) showed that there are only three kinds of light neutrinos in Nature, and that our list of known building blocks of matter is now complete (December 1989, page 18). There are six types of quark, grouped pairwise into three families – 'up' with 'down', 'strange' with 'charm', and 'beauty' with 'top' – each family being associated with weakly interacting particles (leptons) – respectively the electron, the muon and the tau, each partnered by its own brand of neutrino.

Some fifteen years ago such parsimony was not apparent, as new particles were being found each time new accelerators pushed back the energy frontier. A fourth type of quark, charm, was discovered in 1974, and soon after the tau particle appeared on the scene, showing that there was an energy ladder for leptons too. With the discovery in 1977 of the upsilon particle carrying a fifth type of quark, beauty, there was no compelling reason to believe why a list of quarks and leptons should be any shorter, say, than the Periodic Table of elements.

Meanwhile in astrophysics, the Big Bang idea was enjoying unparalleled success. The discovery of the 3K cosmic background radiation and the relative abundances of light elements pointed to the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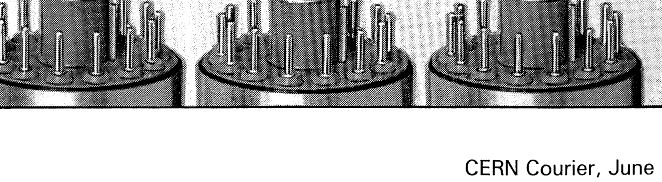

Together at the recent workshop 'LEP and the Universe' organized jointly by CERN and the European Southern Observatory (ESO) were CERN Theory Division Leader John Ellis (left) and Bernard Pagel, now at Nordita, Copenhagen. At the workshop, Ellis spoke on the implications coming from LEP for the invisible 'dark matter' of the Universe. Pagel, one of this year's recipients of the UK Royal Astronomical Society's gold medals, summarized the status of knowledge on the light element content of the Universe.

(Photo CERN 29.4.90)

Universe being born in a single fiery cataclysm.

Drawing on these ideas, David Schramm of Chicago and James Gunn of Princeton, and Gary Steigman of Yale, looking at calculations of the amount of helium formed a few minutes after the Big Bang, suggested there has to be a definite limit to the number of particle species, and hence the number of different types of light neutrinos.

Courageously, they predicted that Nature had room for at the most five kinds of light neutrinos. (Initially Schramm and Gunn were working independently, but at a chance encounter with Steigman at an astrophysics meeting they realized that they were planning to write essentially the same paper and decided to join forces.)

As the astronomical measurements of helium content improved, they were able to bring the neutrino limit down in 1980 to a maximum of four, and no more than 3.5 by 1988.

Initially, this prediction did not fall on fertile ground, and fellow Chicagoan Bruce Winstein wagered Schramm a case of wine that there was more neutrino room to maneuver. In the wake of the LEP results last year, Schramm was one case of wine better off.

Awaiting these neutrino limits, confidence in the Big Bang had wavered slightly as alternative cosmological ideas on the synthesis of light elements were put forward. But the robust predictions of the standard Big Bang picture for the levels of rare light elements such as lithium-7 – only one part in ten billion relative to hydrogen – has helped keep Big Bang morale high. Steven Weinberg has claimed 'Big Bang nucleosynthesis is a part of particle cosmology which has now been experimentally proved'.

Speaking at a workshop 'LEP and the Universe' organized jointly by CERN and the European Southern Observatory (ESO) to underline the importance of the initial LEP results, Schramm showed how the light neutrino limit of three powerfully constrains the light element abundances. 'These are the first particle physics tests of a cosmological model', he declared.

The amount of strongly nuclear interacting matter (baryons) in the Universe can now be put at between two and ten per cent that of the critical mass needed to supply enough gravitational attraction to brake the Big Bang expansion and 'close' the Universe. With the amount of visible matter less than one per cent of this critical mass, the need for dark baryonic matter becomes evident.

The gravitational lensing of distant bodies provides an independent handle on the amount of intervening matter, showing again that the attraction is several times more powerful than anything luminous stars can muster.

This baryonic dark matter could be Jupiter lookalikes scattered throughout the Universe, or 'brown dwarves' – small invisible stars.

Among astronomers there is widespread conviction that the Universe has exactly the critical density where there is enough material around to slow, and ultimately stop, the expansion caused by the Big Bang. If this is so, then as well as baryonic dark matter, the Universe contains other kinds of dark matter.

Neutrinos with mass could fit the bill, although the masses would have to fall in slots around 25 eV or a few GeV. Other possibilities

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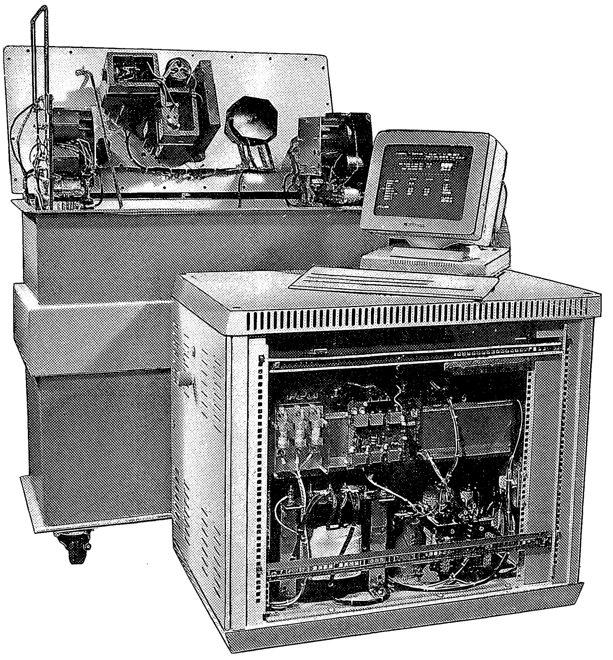

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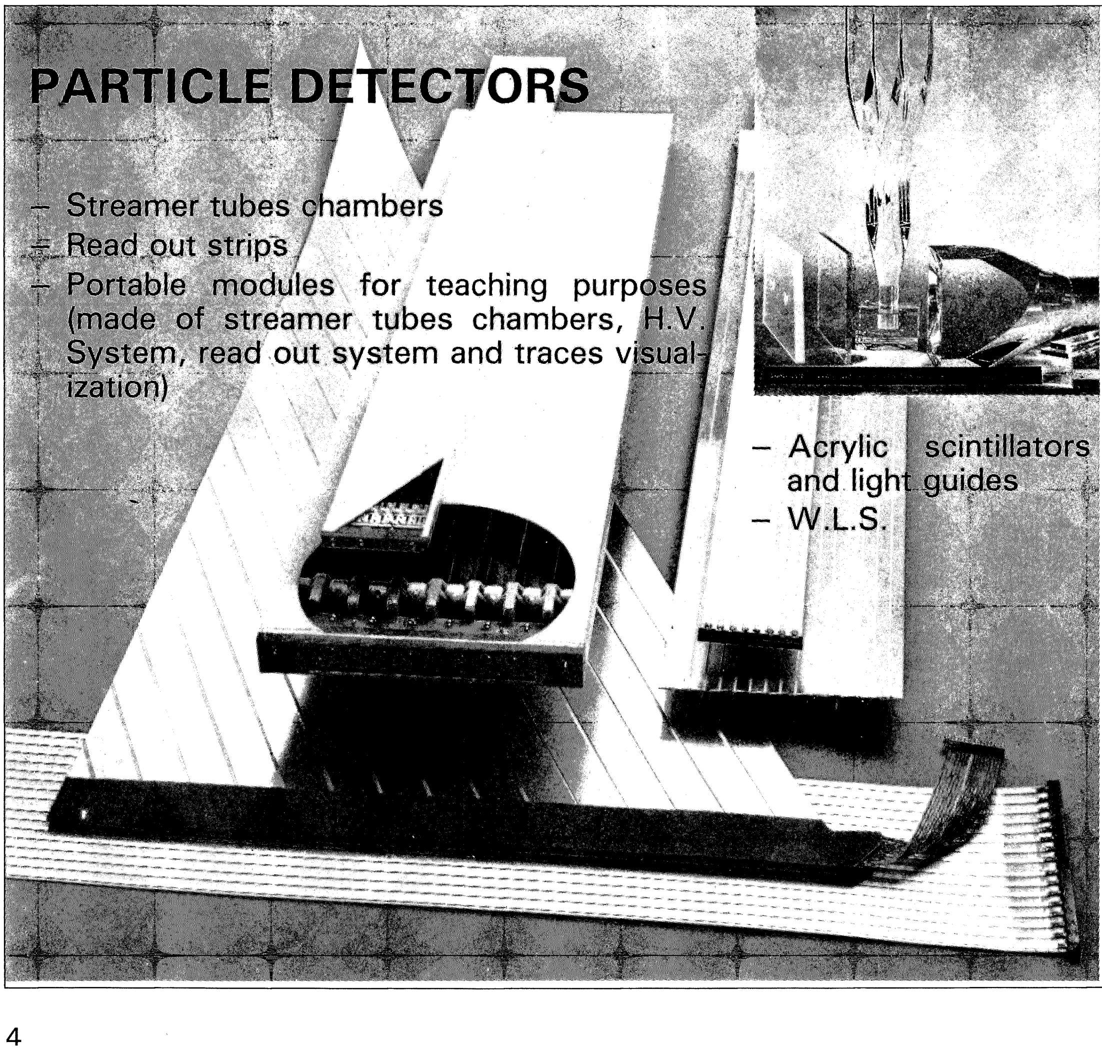

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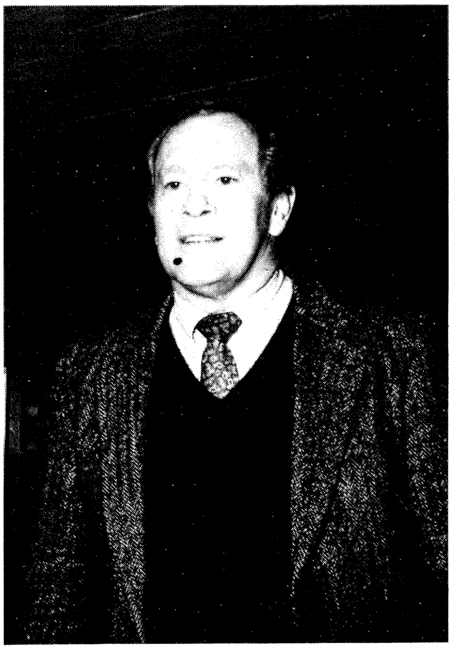
are 'supersymmetric' partners of existing particles, or other feeble interactors, such as axions.

With the first wave of LEP results not seeing any unknown particles, the limits are pushed up awaiting the next harvest of data. Speaking at the CERN/ESO workshop, CERN Theory Division Leader John Ellis said 'LEP has made it more difficult to find what dark matter is'. With evidence for invisible material building up, laboratory physics might only be skating across the thin ice covering a very deep lake. 'Are we made of the same stuff as the rest of the Universe?' wondered Ellis.

Emboldened by these Big Bang successes, some cosmologists have embarked on ambitious new dark matter candidate schemes with limits unheard of in this branch of science, where even the most basic parameters are notoriously difficult to fix. At the CERN/ESO workshop, Denis Sciama enthused over some of these ideas.

But we might not be in the dark about dark matter for much longer. With the Hubble telescope in orbit, astronomers are set for an unprecedentedly clear view of the Universe.



David Schramm – particle physics tests for cosmology.

Buses at the crossroads

With demanding new physics data handling requirements on the horizon, the VMEbus Working Group of ESONE (the European Standards On Nuclear Electronics committee of European laboratories) organized a fruitful meeting entitled 'New Backplane Bus Architectures' at CERN in March.

Backplane buses provide the physical and logical framework for building large parts of custom-built data handling systems for both the 'front-end', and the parts requiring processing and data communication. The meeting reviewed the past and present applications, and the lessons learnt from the development of bus standards, but concentrated on the latest developments: Futurebus+, Scalable Coherent Interface (not even a backplane bus!), and extensions to VMEbus, including VXIbus.

Traditionally, much of the data acquisition electronics for particle physics experiments has been constructed in the CAMAC and Fastbus standards, both of which were developed in the physics world before being adopted by industry. In the case of VMEbus and the recently announced Futurebus+, the roles have been reversed, nevertheless, ESONE keeps a watching brief on these standards, and actively contributes to their development.

Both the existing and the newer backplane buses provide features useful to the construction of a coherent practical system. Shlomo Pri-Tal of Motorola's Computer Group, and an influential figure in many electronics standards organizations made the point that 'every system needs more than one bus'.

Opening the meeting, Henk Verweij, Leader of CERN's Electronics Development Group and Secretary of ESONE, underlined that readout electronics depends on the use of international standards, emphasizing the role played by the continuing highly successful minicomputer-orientated CAMAC standard, and by VMEbus, which emerged in the early 80s as a platform for 16/32 bit microprocessors.

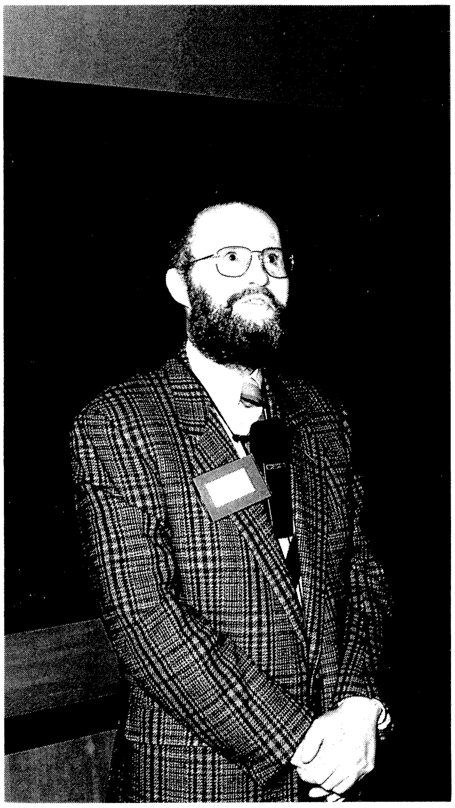
In his talk Chris Eck, Leader of CERN's 'PRIAM' project for microprocessor support, put backplane buses into perspective, describing the approaches being taken to provide 'new solutions to old problems'.

Phil Ponting of CERN's Electronics Group reviewed the lessons learnt from Fastbus (IEEE960), the highly successful heir and complement to CAMAC, recalling how lack of insight and experience caused a few blunders on the way, but maintaining that 'after-sales' support is the key to long-term success.

The requirements of future physics applications were covered by John Hansen of Copenhagen's Niels Bohr Institute, describing event and data rates foreseen for the next generation of high luminosity hadron colliders, where a whole new set of problems will have to be solved in the front-end electronics and data acquisition systems.

Pri-Tal and Anatol Kaganovich of Philips gave the meeting's keynote presentation: a detailed 'tutorial' on Futurebus+ (IEEE 896.n), outlining its origins and aims as a well accepted, industry-wide, 'open' standard. In describing its basic functions, as well as the fundamental limitations of backplane bus systems, which are being reached with this new generation backplane bus, they showed its aim of a tenfold increase in bandwidth over VMEbus to be no idle boast.

Chris Eck – looking for new solutions to old problems.



Although almost ten years old, VMEbus still has a lot to offer, and represents much accumulated investment, both in material and in expertise. Pri-Tal presented what he called a 'mid-life kicker' to VMEbus, enhancing its addressing and data bandwidth, as well as the use of the present reserved line to implement a retry function. The meeting's main organizer, Chris Parkman of CERN, took the opportunity to present VICbus, a standard VMEbus crate interconnection being developed by a working group of the International Organization for Standardization and the International Electrotechnical Commission, but based on work originated by ESONE. Suitable extended, VMEbus will have a lot to offer on its own count or as a complement to Futurebus+.

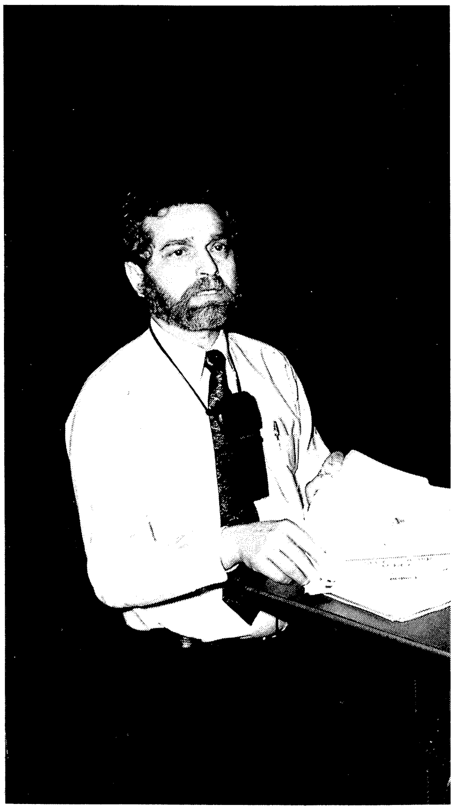
The VMEbus Extensions for Instrumentation (VXIbus) was the subject of a talk by Christoph Ender (University of Heidelberg), who demonstrated its potential in trigger processing and in delicate, high-precision, front-end applications.

Moving away from backplane buses, Ernst Kristiansen of Dolphin Server Technology, Oslo, presented the Scalable Coherent Interface (SCI). The subject of work within a committee of the IEEE (P1596), the SCI describes point-to-point links with a 1 Gbyte/s bandwidth, scalable to 64000 nodes, and a system-wide mechanism of cache coherence.

The software aspects were covered by Andre Bogaerts of CERN, who reviewed the techniques being applied to microprocessor-based systems in real-time applications.

All the speakers took part in a panel discussion, chaired by Chris Eck, which provided further insight into the role of backplane buses in physics applications, and finally Hans Muller of CERN summarized the whole meeting in just half an hour, giving his personal views on the subject.

Shlomo Pri-Tal – every system needs more than one bus.



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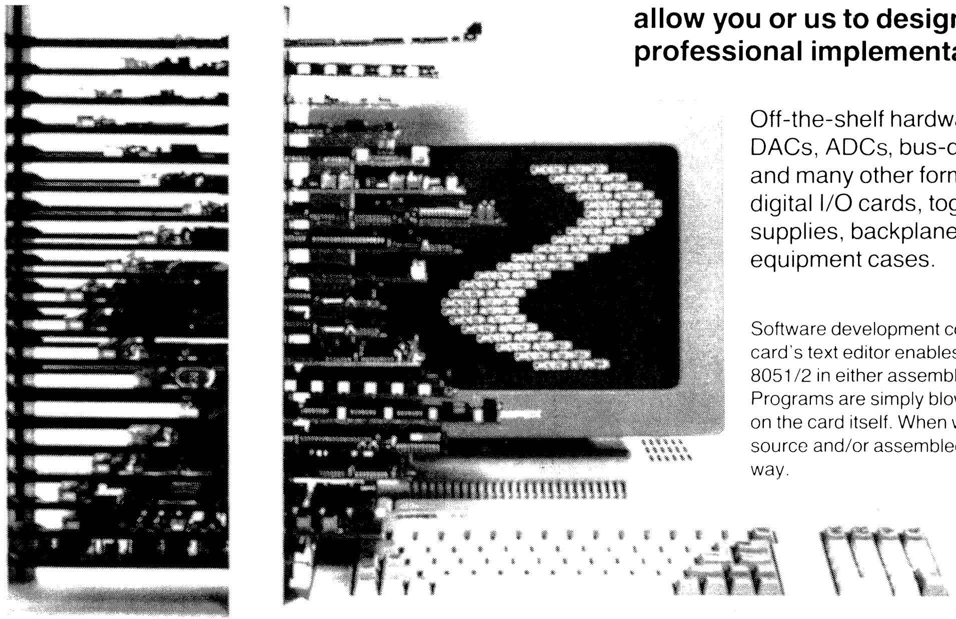

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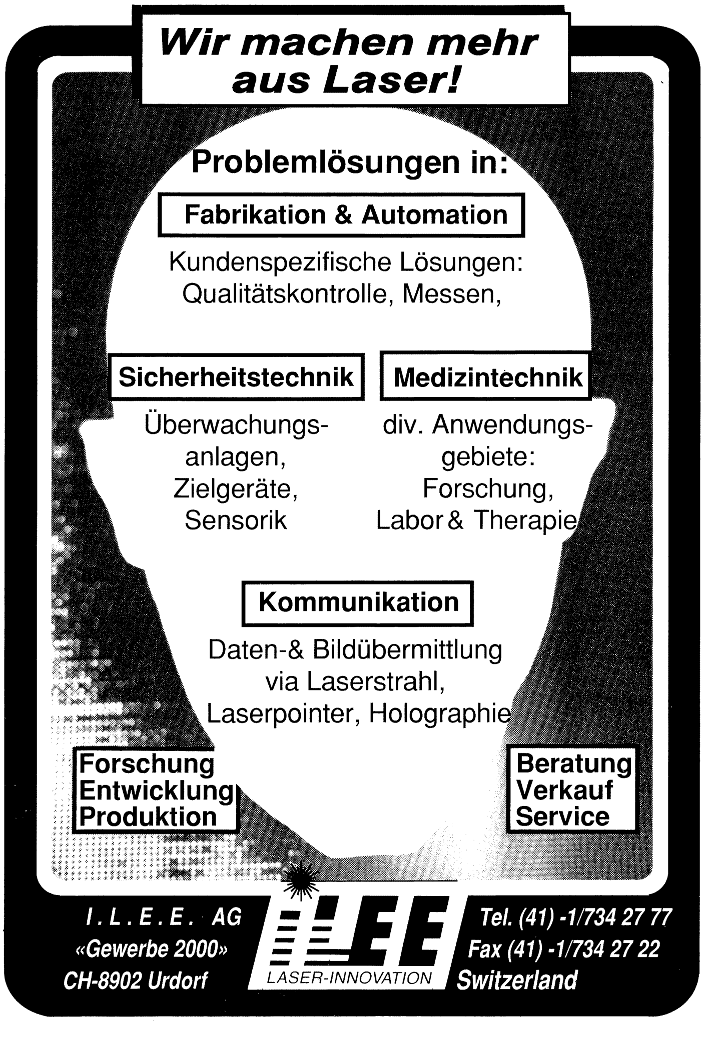

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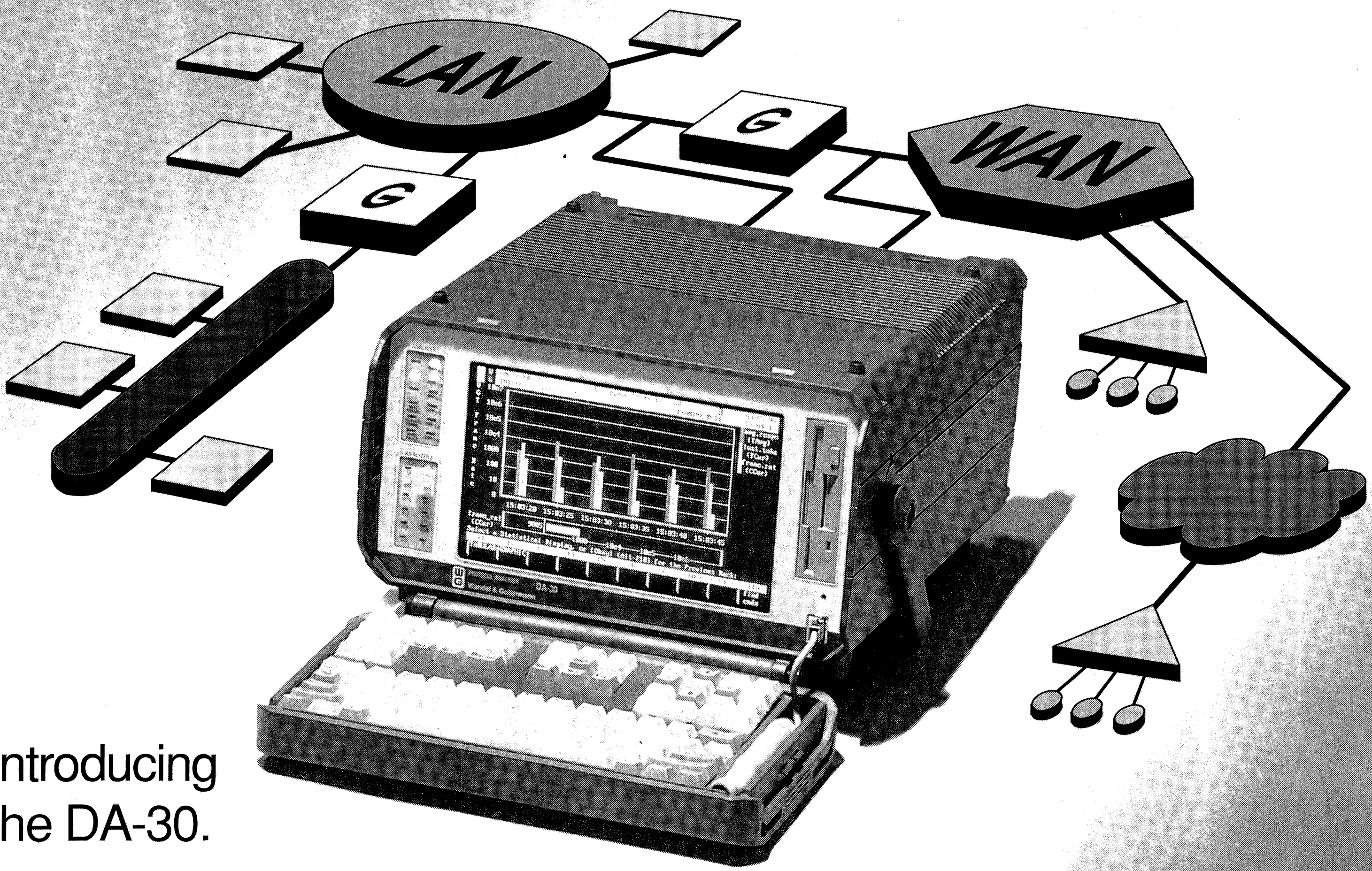
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DARMSTADT SIS/ESR inauguration

On 23 April Federal German Research Minister Heinz Riesenhuber pressed the button to start the experimental programme at the new SIS heavy ion synchrotron and ESR storage ring complex at the GSI heavy ion research Laboratory, Darmstadt.

Recalling his long involvement with the GSI project, Minister Riesenhuber pointed to the leading international position established by GSI with its Unilac machine, commissioned in 1975, with forefront scientific results, such as the synthesis of new heavy elements. With SIS/ESR, continued Riesenhuber, the Laboratory is well set to explore promising new areas of physics, notably the behaviour of nuclear matter under extreme conditions, with its deep implications for astrophysics, and fusion research, where the search continues to find routes for controlled energy production.

A champion of his cause, the Minister underlined the wide range of spinoff benefits stemming from fundamental research, profiting areas as diverse as philosophy and high technology. 'There are those who have criticized big scientific projects,' he remarked, but was confident that the track record of achievements, certainly in his own country, should mute such dissenting voices. 'Science is the bridge to technical progress', he declared.

Turning to the increasing international participation which is the hallmark of modern Big Science, Riesenhuber highlighted the interplay of collaboration and competition which provides so much driving force. Thanks to imaginative insight and courageous decisions, 'science points the way to go', he claimed. 'What happens in science can also happen in other areas.'

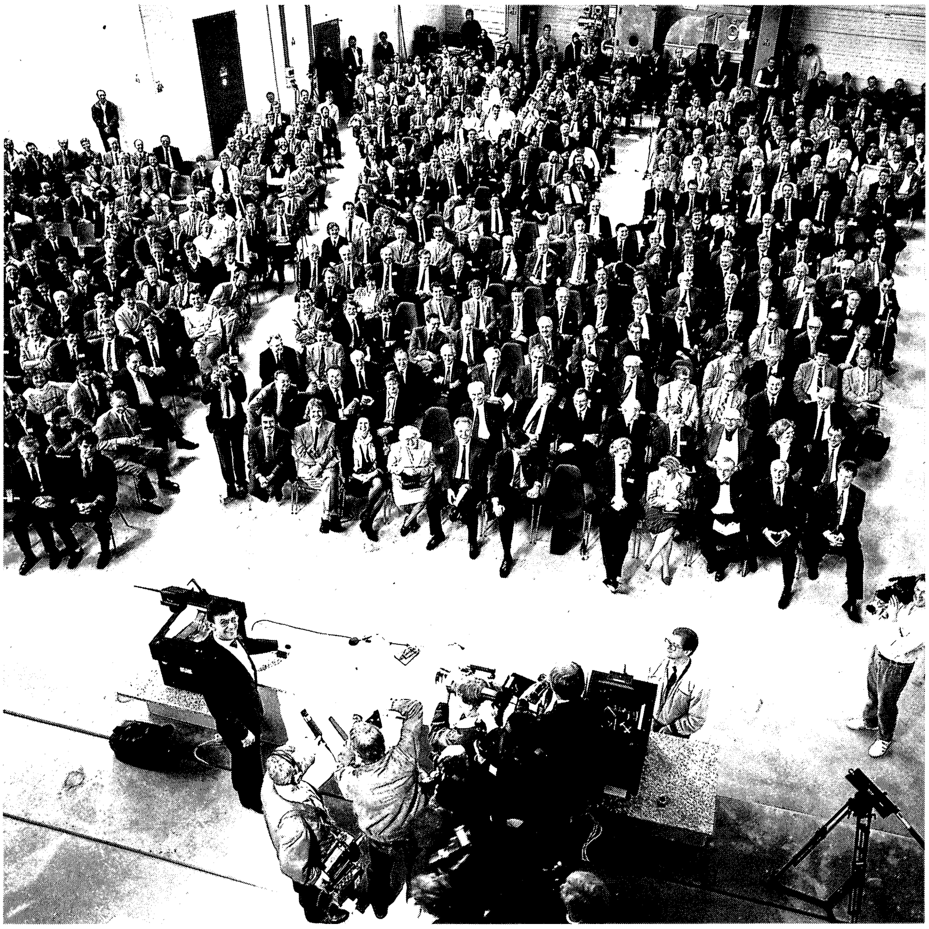
Introducing the proceedings, GSI Director Paul Kienle sketched over the history of the SIS/ESR project, which took its first major step forward in November 1988 when first injection into the SIS coincided happily with the 80th birthday of GSI pioneer Christoph Schmelzer. Towards the end of last year SIS took uranium ions to 1 GeV per nucleon, and argon ions to 1.7 GeV per nucleon.

Downstream from the 216 metre circumference SIS ring is ESR, exactly half the circumference, but with a much wider beampipe, and equipped with cooling equipment to shrink the momentum spread of its stored beams. In preparation for the official launch, ESR had had its first taste of heavy ions – argon-18 at 200 MeV/nucleon – earlier in the month.

Besides the machine physics and experimental objectives, Director Kienle also mentioned the heavy ion possibilities for radiation therapy, and looked forward to new horizons with colliding beams of cooled heavy ions. Searching for a timely opportunity, the GSI Director invoked Mikhail Gorbachov's remark – 'he who arrives late ruins life'.

Following Kienle, GSI Supervisory Board Chairman Josef Rembser (also President of CERN Council) and Scientific Committee Chairman

Federal German Research Minister Heinz Riesenhuber presses the button to begin the experimental programme using the new SIS/ESR complex at the Darmstadt heavy ion Laboratory.



Dirk Schwalm wished the Laboratory continued success with SIS/ESR marking the start of a second phase of GSI operations.

With the Laboratory well integrated into the local scene, Darmstadt Mayor Günther Metzger and Hesse Science and Culture Minister Wolfgang Gerhardt added their best wishes and assurances of continued support.

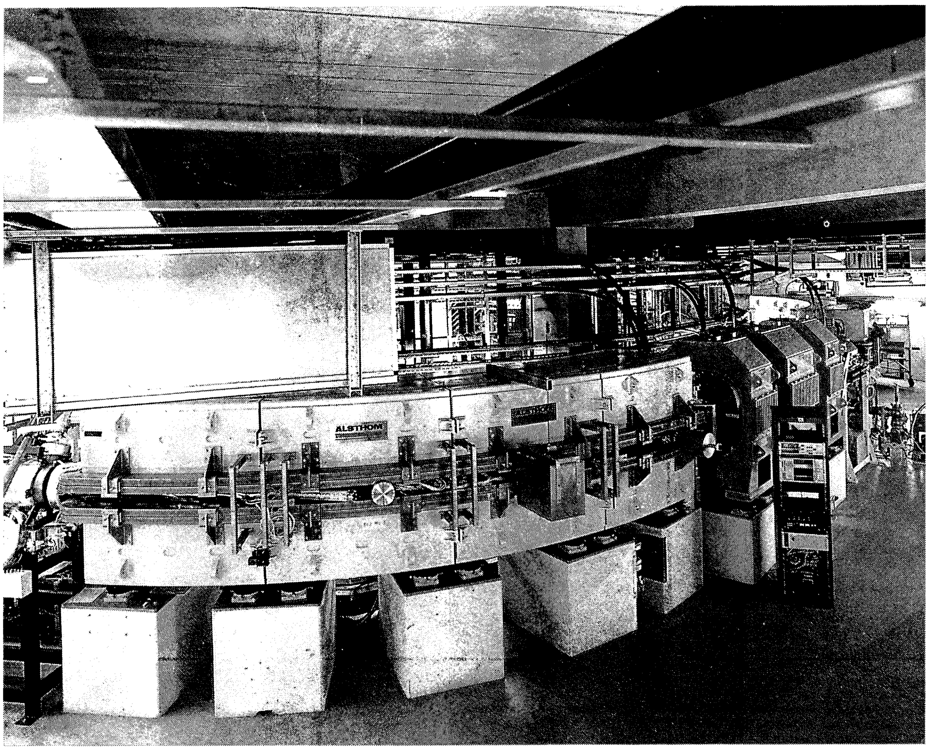
For the heavy ion research community, Claude Detraz of the French GANIL Laboratory, Caen, and chairman of the Nuclear Physics European Collaboration Committee, traced the evolution of heavy ion research, with the increasing demand for heavier projectiles and more energy. The close international collaboration of modern physics is well illustrated by the TAPS photon detector for studies at GANIL and GSI (May, page 10).

Behind the scenes, the extended GSI experimental programme now gets under way in earnest, attacking a range of physics and applications objectives.

A special area is the careful investigation of ultra-cold beams, where the minimal momentum spread could open up many new research avenues, both for beam applications and beam physics ('crystalline' beams). Next year a transfer line from the new ESR back to the SIS ring will open up a new range of possibilities, and in the meantime pioneer beam studies are also continuing at the Heidelberg TSR ring, completed in 1988 with GSI assistance.

The wide aperture ESR storage ring at Darmstadt's GSI heavy ion Laboratory is now in operation.

(Photos Achim Zschau, GSI)



CERN B factory ideas

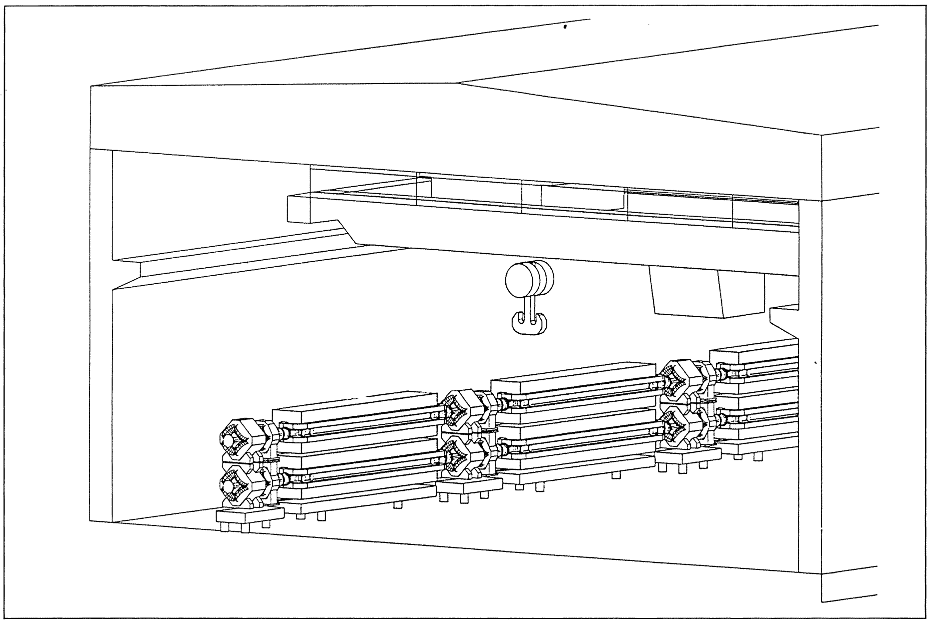
A lot of new physics could come from the study of B mesons (carrying the heavy b quark), which, like their cousins the neutral kaons, can show delicate effects which probe the very foundations of physics.

The tiny violation (typically a few events per thousand) of the combined left/right particle/antiparticle (CP) symmetry has been studied using neutral kaons for more than 25 years, but is still not completely understood. An explanation could open up a much deeper understanding of the underlying structure of matter. The late Andrei Sakharov was one of the first to realize that this obscure but intriguing signal could be a pointer to why a Big Bang presumably producing matter and antimatter in equal amounts resulted in a Universe where natural antimatter is virtually unknown.

B mesons would provide a new theatre for CP violation, but a copious supply of particles would be needed to be sure of uncovering these phenomena, hence the current worldwide interest in plans for 'B factories'.

(CP violation would not be the only course on the menu: other choices include B mixing, analogous to that seen with neutral kaons; rare B decays and the spectroscopy of all particles containing b quarks; while other heavy quark particles and heavy leptons would also profit from a deeper investigation at a high rate machine. These high precision studies would also complement the mainline physics attack at high energy proton colliders.)

European conviction in such a machine has been strong for sev-



Sketch of the two rings from a study for a 'B factory' using the tunnel from CERN's Intersecting Storage Rings, phased out in 1984.

eral years and was endorsed by the European Committee for Future Accelerators (ECFA) in 1987.

The B particles would be produced by colliding intense electron and positron beams tuned to the energy of one of the upsilon levels (b quark-antiquark bound states) near 10 GeV. The idea now being investigated at CERN is to build a new machine in the 300-metre circumference tunnel from the old proton Intersecting Storage Rings (ISR), phased out for physics in 1984, using electrons and positrons from the LEP injection system. With intense beams a major requirement, the design foresees an initial collision luminosity of 10^{33} per sq cm per s, rising eventually to 10^{34}.

B meson factory designs usually incorporate provision for 'asymmetric' collisions between beams of unequal energies, to relativistically boost the B mesons and give a better chance of intercepting them in the millionth of a millionth of a second before they decay. (Neutral kaons live at least a hundred times longer.)

The ISR tunnel study, with two equal rings and two beam intersections, foresees colliding 3.5 and 8 GeV beams, optimal for CP studies, but as the use of asymmetric beams is almost unexplored and unexpected problems of beam-beam interaction could make life difficult, a symmetric equal-energy option is included.

Positrons from the LEP injector would be taken to 3.5 GeV in the PS synchrotron, however the electron beams would need to be passed to the larger SPS synchrotron to be ramped up to 8 GeV, before being injected into the new ring (via the PS). No new civil engineering would be required as all the necessary tunnels are already in place, an inheritance from the ISR. Because of the unique flexibility of CERN's accelerator chain, the new machine would not interfere in any way with LEP operations, however the LEP injector would have to be upgraded to provide the required level of positrons.

The machine design takes over many of the features proposed in an earlier study at the Swiss Paul Scherrer Institute (July/August 1989, page 27), with the racetrack layout modified for the circular ISR tunnel. The high photon absorption of a copper vacuum chamber will cope with the abundant synchrotron radiation produced by the hefty beam currents.

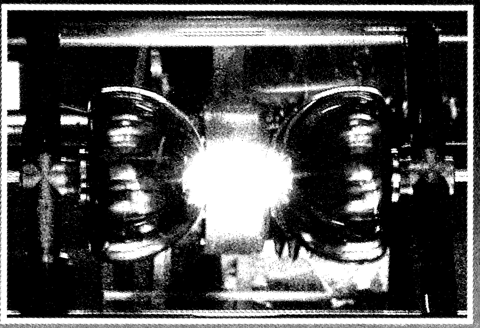
Although geared to the lower luminosity goal, the initial design already incorporates many of the features needed to attain higher collision rates. Conventional copper radiofrequency accelerating cavities would suffice for initial operation, however the ultimate design with very short bunches would need superconducting radiofrequency.

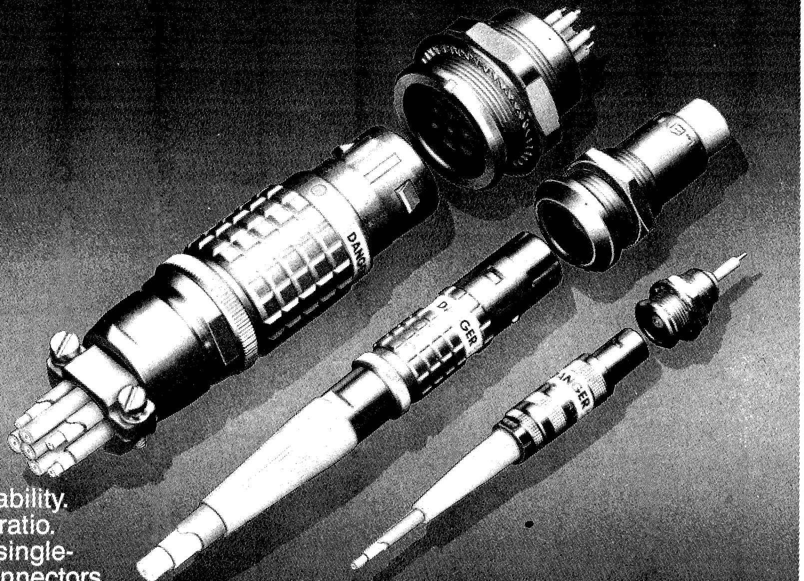
The 10^{34} luminosity goal is a challenge to machine specialists and many options are purposely left open. Although CERN's major machine objective for this decade remains the LHC proton collider in the LEP tunnel, a B factory could be built in the vacant ISR tunnel for a relatively modest outlay.

RFQ2

The second radiofrequency quadrupole (RFQ) constructed at CERN – RFQ2 – is being prepared to inject protons into CERN's Linac 2. Auguring well for its future career, after only an hour of beam tests it delivered its nominal proton beam of 200 mA at 750 keV, attesting to the care put into its design, construction, field adjustment and tuning.

RFQ2 provides by far the highest current of any such unit designed as an injector to other accelerators. So far it has accelerated up to 240 mA, and its limits have still to be probed in beam tests prior to final installation in Linac 2.





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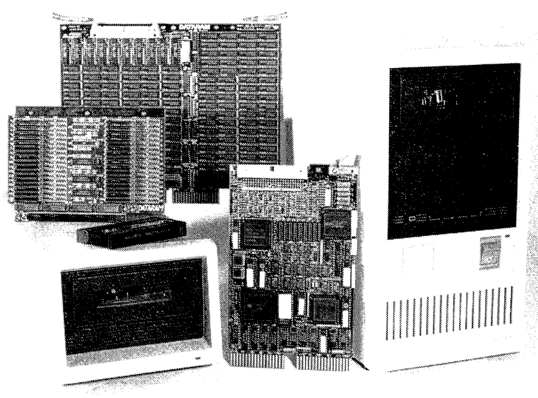

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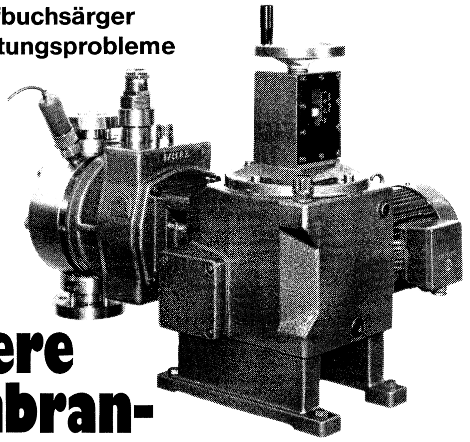

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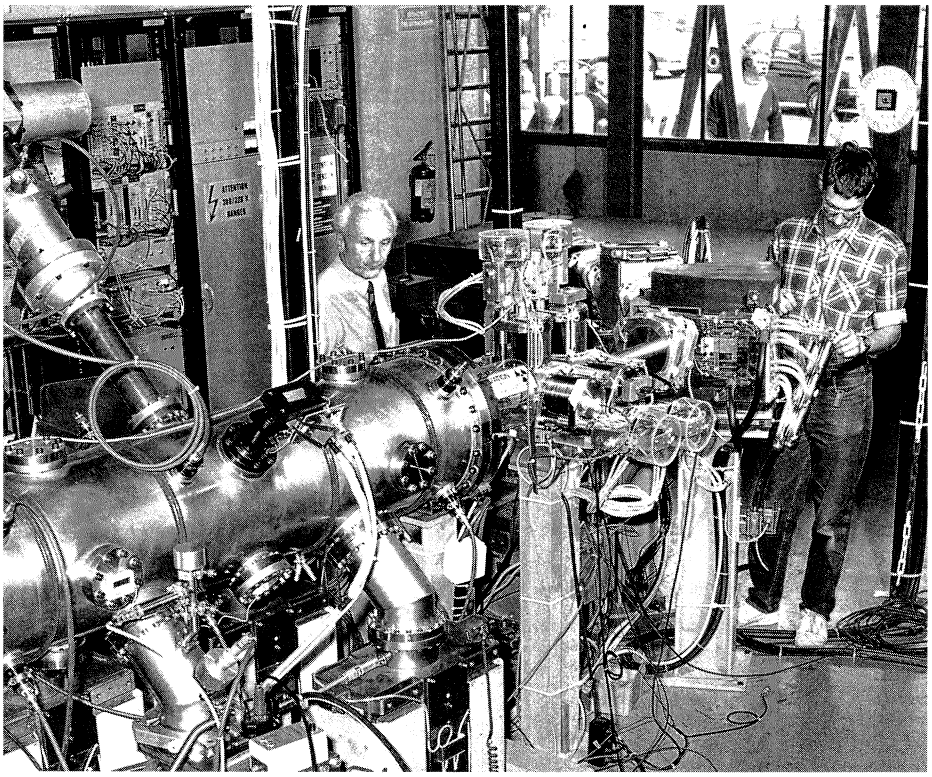
Mario Weiss (centre) with CERN's RFQ2 radiofrequency quadrupole in its test area. So far currents of up to 240 mA have been attained.

(Photo CERN 109.4.90)

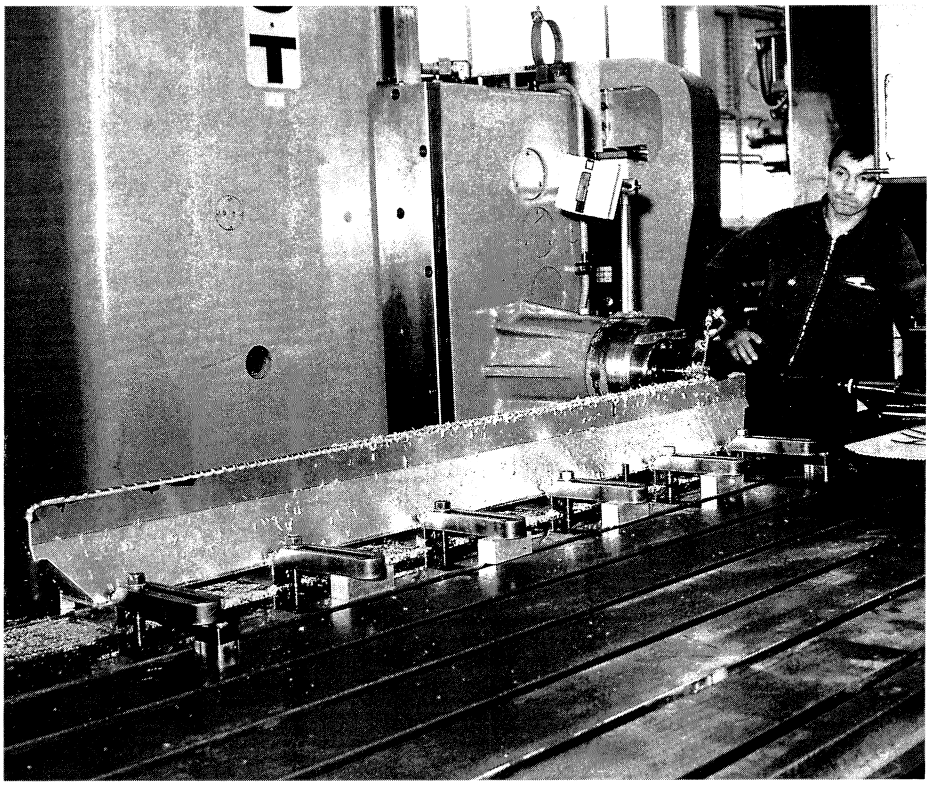


Over the past decade, RFQs have replaced the traditional electrostatic Cockcroft-Walton high voltage generator for handling charged particles in the 1 MeV range. The initial idea, from I.M. Kapchinsky and V.A. Teplyakov of ITEP Moscow, was subsequently developed at Los Alamos in the US, and has gone on to become part of the scenery at proton Laboratories throughout the world.

The idea is to use radiofrequency fields to provide all the beam operations – focusing, bunching and acceleration. Four long vane-like electrodes around the axis of a cylindrical tank provide the quadrupole focusing, while the characteristic wavy vane surface (vane modulation) gives bunching and acceleration.

CERN's RFQ programme was launched in 1981. The first phase, completed at the beginning of 1984, was the 520 keV, 80 mA RFQ1 for Linac 1. For low intensities, another RFQ was built at Berkeley to handle heavy ions for a new range of CERN experiments. A further RFQ is being built at Frankfurt for use in a CERN/Orsay experiment at CERN's LEAR low energy antiproton ring to compare the masses of the proton and the antiproton.

While design of the high intensity RFQ2 began in 1983 and parameters fixed by the following year, the multiple commitments at CERN's PS synchrotron meant that production could not start in earnest until 1988. All the precision mechanical design and production was done in-house, with a numerically-controlled milling machine

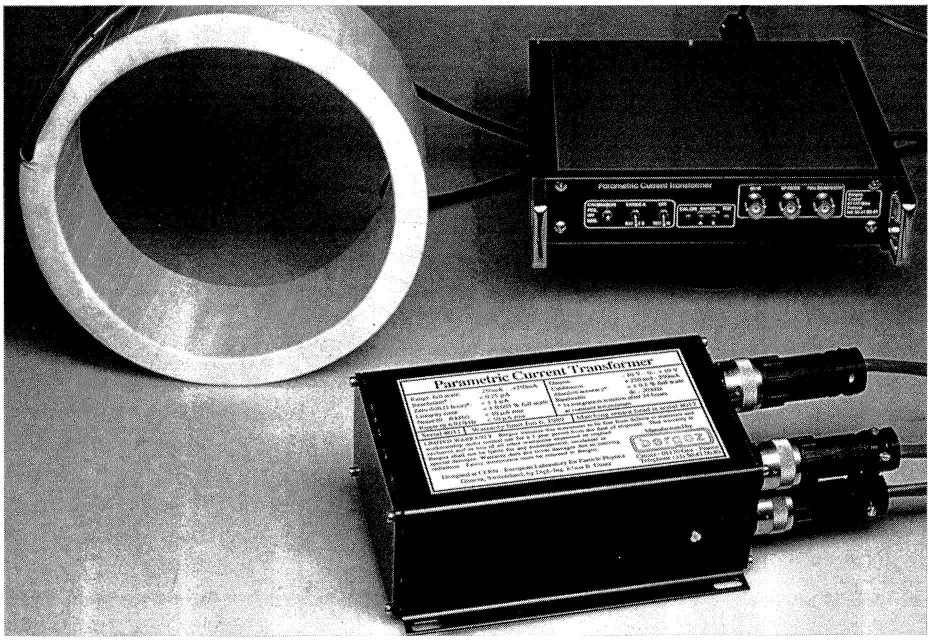


CERN's RFQ2 radiofrequency quadrupole was produced entirely in-house. This numerically-controlled milling machine was used to precision grind the vanes.

(Photo CERN 61.4 89)

providing the delicate modulations of the vane tips. Finishing was carefully controlled by precision metrology, with consequent feedback ensuring the required accuracy. When complete, the vanes could be positioned to within a few hundredths of a millimetre over their entire 1.7 metre length.

The mild steel tank was copper-plated and techniques such as beam and arc welding as well as brazing were used to fix the vanes securely to the tank. Currents as high as 7000 A from vane to vane via the tank were achieved, and fields up to 35 MV/m, about 2.5 times the Kilpatrick limit.



The Parametric Current Transformer from Bergoz, developed in collaboration with CERN. Technological advances have resulted in a compact, simple-to-use device which has been widely adopted for precision beam current measurement.

Beam current monitor

With specialist areas increasingly seeking CERN's expertise, a wide range of 'technology transfer' agreements have been set up between CERN and industry to exploit these skills and develop new techniques and products.

A good example is the Parametric Current Transformer (PCT), developed jointly by Klaus Unser of CERN and electronics firm Bergoz in nearby France in the framework of a special collaboration.

Now marketed by Bergoz, the PCT has become a standard beam current measurement tool for a wide range of circulating beam machines. Units have now been supplied by Bergoz for research and applications physics machines in the US, UK, Switzerland, Germany, Italy, Canada, China, the Netherlands and Denmark.

The new device was developed with CERN's LEP electron-positron collider in mind, where the particles in each of the two colliding beams are concentrated in four regularly spaced bunches. Although peak current may be high (more than 1 kA), mean currents are measured in microamps.

The technique uses four thin toroidal cores of an amorphous magnetic alloy as sensor. To meet the stringent performance requirements, the magnetic material (supplied by Vacuumschmelze of Hanau, West Germany) was specially selected and subsequent treatments developed.

Beam current transformers are among the oldest instruments for beam diagnostics, consisting of a toroid of magnetic material through which a particle beam passes, essentially forming the single turn primary winding of a transformer.

The low frequency limit of such a device is of the order of a few hundred Hz, good enough for showing the high frequency structure of a beam or the envelope of a short pulse, but insufficient for monitoring a storage ring with a long cycle time and where beam may be held for hours, days, or even weeks at a time.

The next step, adopted some 30 years ago, was to put a beam current transformer into the feedback loop of an amplifier, extending the frequency range to below 0.1 Hz. For the ISR, which had to contend with wide ranges of beam current, the technique was extended by an auxiliary magnetic modulator circuit to correlate primary and feedback currents. For LEP, the idea was taken further by boosting the magnetic sensor signal before applying it to the amplifier, thereby improving signal to noise ratio, and increasing the modulation frequency.

In this way the total number of particles circulating can be measured directly without additional timing information and without special calibration over a wide frequency range, including d.c.

The new circuitry drastically reduces the amount of magnetic material required, so that the sensors can be made from thin ribbons of alloy. In addition, the availability of new magnetic materials and the special treatments make for improved performance.

What have all these accelerators in common ?

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CESR, Cornell University, Ithaca, NY, U.S.A.
LEP, CERN, Geneva, Switzerland
TSR, Max Planck Institute, Heidelberg, F.R.Germany
ADONE, LNF, Frascati, Roma, Italy
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HERA , DESY, Hamburg, F.R.Germany
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CEBAF, Newport News, VA, U.S.A.
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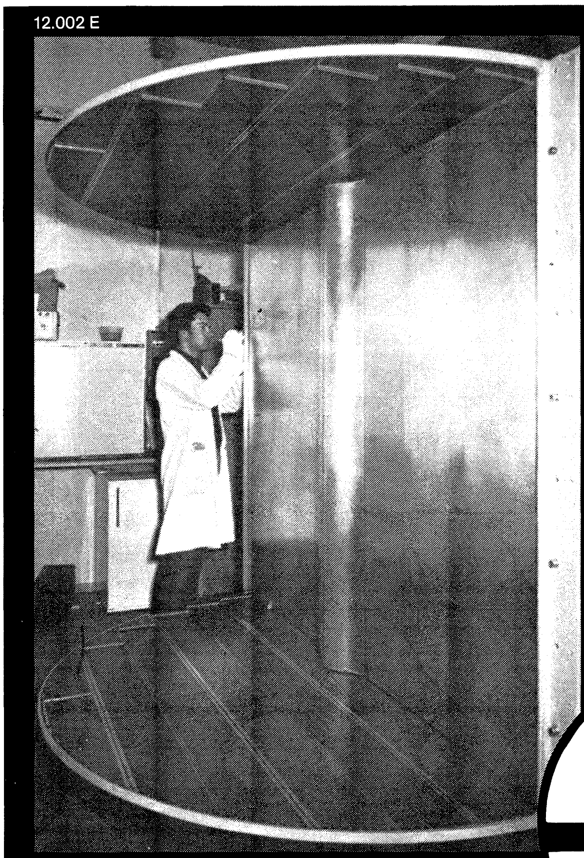

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BAKSAN
Solar neutrino study underway

The radiochemical gallium experiment at the Baksan (North Caucasus) Neutrino Observatory of the USSR Academy of Sciences Institute for Nuclear Research aims to measure the flux of low energy neutrinos from the sun.

Measurements have begun with 30 tons of metallic gallium, and by the beginning of next year the amount of detector will be doubled.

For more than twenty years the only experiment capable of picking up solar neutrinos was the radiochemical chlorine study led by Ray Davis in the Homestake Mine, South Dakota. Sensitive to relatively high energy neutrinos, this showed that boron-8 processes did not provide the predicted neutrino level. One of the mysteries of modern physics, this 'solar neutrino puzzle' has been confirmed by the Japanese Kamiokande detector which picks up the Cherenkov light produced by particles travelling through water.

Explanations for the puzzle include changing the basic astrophysics ideas, neutrino oscillations (conventional or matter enhanced), neutrino spin flip in the solar magnetic field, neutrino decay, and strange processes in the sun's interior.

To choose between these alternatives, or to find whether the puzzle is artificial because of the restricted energy range so far studied, more information is needed. Measuring the flux of low energy neutrinos from solar proton-proton fusion is particularly important – if nothing happens to these particles between the solar core and the Earth, their flux is a direct probe of the sun's luminosity.

The transition threshold for gallium-germanium conversion is 233 keV, well inside the spectrum of neutrinos from proton-proton fusion.

The Baksan neutrino telescope is in a specially-built underground laboratory, 3.5 kilometres inside Mount Andyrchi, with 2000 metres of overhead rock. Inside the 60 x 10 x 12 metre cavern, a 60 cm-thick low radioactivity concrete lining and a 6 mm steel shell reduce background activity. Construction was finished in 1988.

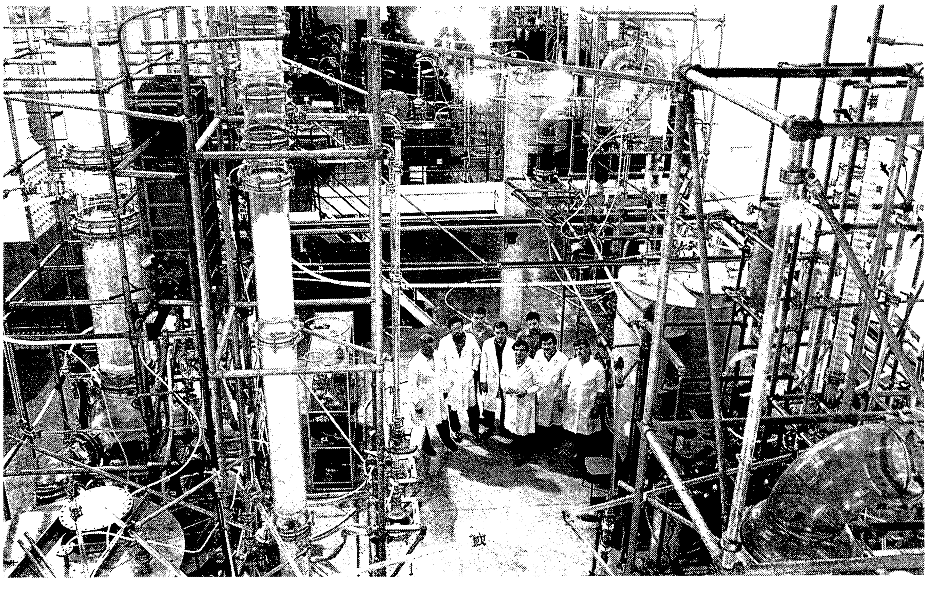
The experiment involves a Soviet-American Gallium Experiment (SAGE) collaboration including groups from Los Alamos, Pennsylvania and elsewhere. The 30 tons of metallic gallium are exposed for about 30 days at a time (the halflife of germanium-71 is 11 days), followed by a complicated radiochemical extraction procedure in which the germanium-71 is converted into gaseous hydride.

The original metallic gallium was full of germanium isotopes produced by cosmic rays, and it took more than twenty extractions to reduce this activity to an acceptable level for physics to begin, and since then background has decreased further. First Baksan physics data should soon emerge.

The 60-ton target, after initial purification of the additional gallium and modification of the extraction system, should boost statistics fourfold.

A gallium solar neutrino experiment ('Gallex') is also being prepared at the Italian Gran Sasso underground laboratory (May 1987, page 26).

Dwarfed by the impressive installations are some members of the experimental group for the underground radiochemical gallium experiment to detect solar neutrinos at the Soviet Baksan laboratory. Left to right: A.V. Kalikhov, O.L. Anosov, O.E. Pikhulya, A.V. Ostrinsky, V.N. Gavrin (experiment spokesman), N.E. Revzin, A.M. Pshukov, N. Yu. Lukashov.



DESY
East German contribution

The Institute for High Energy Physics of the East German Academy of Sciences with laboratories at Zeuthen, near Berlin, has a long tradition of collaboration both with Eastern and Western research centres. Current activities include experiments at CERN (the L3 group at the LEP electron-positron collider) and at the German DESY Laboratory in Hamburg (the H1 group preparing for the HERA electron-proton collider).

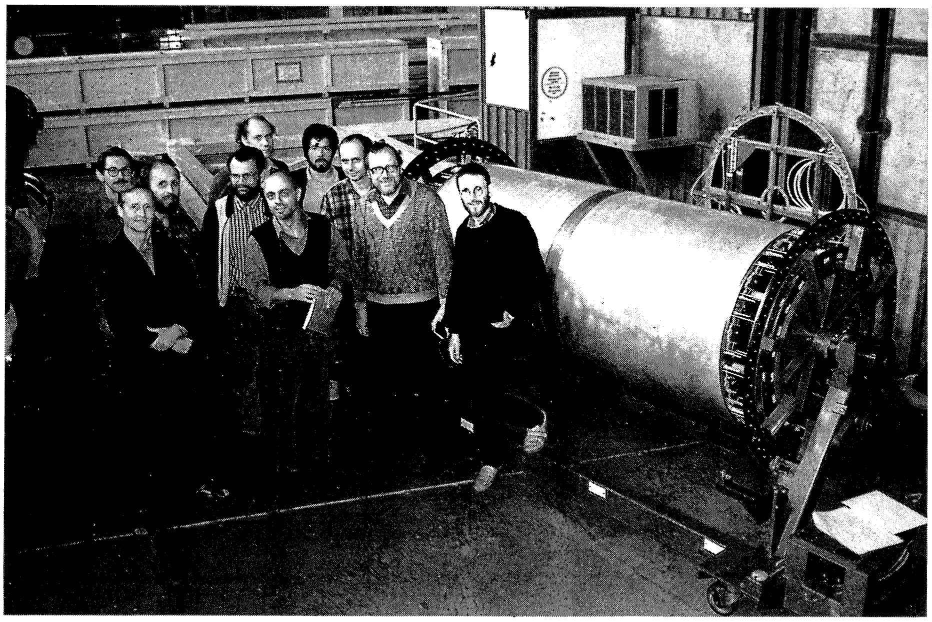
Zeuthen's 50 scientists can profit from extensive technical and industrial facilities at ZWG, the East German centre for scientific instrumentation.

ZWG is building a flat three-layer proportional chamber for the 'backward' (electron direction) region of H1 under a contract with the Zeuthen group. Cables for the drift chambers and structure for the backward electromagnetic calorimeter were also assembled for Zeuthen at ZWG.

In April a major consignment of equipment to arrive at DESY from Zeuthen was the precision z-chamber for the central H1 tracking system. This cylindrical drift chamber, 2.2 m long and 1 m in diameter, should fix tracks to within 0.2 mm and is now being tested in a DESY electron beam.

The Zeuthen z-chamber and a cylindrical proportional chamber from the Brussels/Antwerp group will be placed between the two 'central' tracking drift chambers being completed at Hamburg. A second z-chamber, from Zurich, will be placed inside the central tracker. The forward (proton direction) region will be instrumented with drift chambers, proportional chambers and transition radiation detectors. The liquid argon calorimeter surrounding the tracking is being mounted in its cryostat, while construction of the hadron calorimeter forges ahead.

Zeus, the other experiment being prepared for HERA, is also progressing well, with its big central drift chamber arriving from Oxford on 25 April.



East German collaborators with their z-chamber for the H1 experiment at the HERA electron-proton collider nearing completion at the German DESY Laboratory.

(Photo P. Waloschek)

DUBNA/SERPUKHOV
Rare decays

When physicists talk about 'rare decays', they frequently mean decays which are forbidden by conventional selection rules. However a sighting of any such forbidden decay would immediately be indicative of new physics, and the search continues (April 1989, page 16).

However there are examples of allowed processes which are genuinely rare, for example when pairs of produced particles unite into atom-like states, as in the decay of a neutral pion into a photon and a positronium atom (electron-positron bound state) observed at the Serpukhov proton synchrotron in a collaboration between the Joint Institute for Nuclear Research (JINR, Dubna) and the Institute for High Energy Physics (Serpukhov, March 1989, page 15).

The branching ratio for this decay relative to the main decay channel into two photons is measured as (1.8 ± 0.3) · 10^{-9}. While searches for forbidden decays have probed lower, the researchers claim this as the rarest ever detected particle decay.

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ACCELERATORS
Power converters

Particle accelerators touch many disciplines and technologies and the curriculum of the CERN Accelerator School (CAS) reflects this. The most recent CAS course, held in Montreux, Switzerland, from 26-30 March, focused on d.c. and slow pulsed power converters for particle accelerators. With lecturers coming from accelerator laboratories, universities and industry, it was very apparent that these three communities put a lot of emphasis on communications and technology transfer.

Accelerators and power converters have always been closely associated. The first accelerator capable of nuclear physics research, built by Cockcroft and Walton, was mainly an exercise in building a high-voltage power converter. They were so successful that their solution was the preferred pre-injector for large accelerators for many decades.

Today, power converters have diversified and proliferated into all the sub-systems of large accelerators, until in a machine like LEP there are literally hundreds of independent converters powering the guide field alone. The consequent demands on reliability and performance have been a major driving force.

The Montreux course opened with lectures on the classification and topologies of converters and on the general guidelines for achieving high performance, going on to cover the more detailed aspects of feedback theory, simulation, measurements, components, remote control, fault diagnosis and protection. To obtain the very highest performance levels, the power converter must be considered as an integral part of its environment and lectures were included on systems and grid-related problems.

The programme also covered contract specification and management, and looked at likely future developments in semiconductor components. Although the course was principally directed towards d.c. and slow pulsed supplies, lectures were added on fast converters and resonant excitation, and the programme was rounded off by seminars on Tokamak converters, battery power storage for electric cars and the control of shaft generators for ships.

From 3-10 April 1991, CAS and the UK Rutherford Appleton Laboratory will jointly organize a course at Exeter College, Oxford, on 'RF Engineering for Particle Accelerators' and at about the same time the following year one on 'Magnet Measurement and Alignment'. Meanwhile, arrangements are well advanced for the usual biennial course on General Accelerator Physics, to be held from 17-28 September this year at KFA Jülich. Further information from Ms. S. von Wartburg, CERN Accelerator School, CERN, SL Division, 1211 Geneva 23, Switzerland.

The modern face of power conversion. Four 37.5 kW switch-mode power converters in one cubicle for CERN's LEP electron-positron collider.

(Photo CERN 64.2.88)

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EXPERIMENTAL PHYSICS (n. 14)

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Applications are invited for 1-year fellowships, starting on May-November 1991.
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The successful applicants may carry on their research at any of the following laboratories and sections of INFN : National Laboratories of Frascati (Rome), National Laboratories of Legnaro (Padova), National Southern Laboratories (Catania) and National Gran Sasso Laboratory (L'Aquila).
INFN Sections in the universities of : Turin, Milan, Padua, Genoa, Bologna, Pisa, Rome, 'La Sapienza', Rome II, Naples, Catania, Trieste, Florence, Bari, Pavia, Perugia, Ferrara, Cagliari, Lecce and National Institute for Health (Rome).
Enquiries, requests for application forms, and applications should be addressed to :

Fellowship Service – Personnel Office,
Istituto Nazionale di Fisica Nucleare (INFN),
Caselle Postale 56,
I – 00044 Frascati (Roma),
Italy

Our institute, formerly the Swiss Institute for Nuclear Research (SIN), represents the largest national research centre and is situated in Northern Switzerland, not far from Zurich. The department for Nuclear and Particle Physics (F1) operates a 600 MeV isochronous cyclotron which is used to produce a number of pion-, muon-, and nucleon beams. The facility is presently being upgraded to deliver a 1.5 mA proton beam to feed a neutron spallation source and, in combination with new secondary beam lines, to provide the world's most intense low energy pion and muon beams. The F1 research group also participates in experiments at CERN and other laboratories. On a contractual basis, we are looking for the

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For further information or nomination of candidates, please contact: PD Dr. H.K. Walter (Tel. +41 56 99 36 44 or 99 32 54).

Formal applications for this position should be accompanied by a curriculum vitae, a list of publications, a statement of research interests and the names and addresses of referees and should be sent as soon as possible, but not later than 15 July 1990 to

PAUL SCHERRER INSTITUTE,
Personnel Division, ref.code 1100,
CH – 5232 Villigen PSI,
Switzerland

COMPUTING
Lattice work

One of the major recent developments in particle theory has been the use of very high performance computers to obtain approximate numerical solutions of quantum field theories by formulating them on a finite space-time lattice. The great virtue of this new technique is that it avoids the straitjacket of perturbation theory and can thus attack new, but very fundamental, problems, such as the calculation of hadron masses in quark-gluon field theory (quantum chromodynamics – QCD).

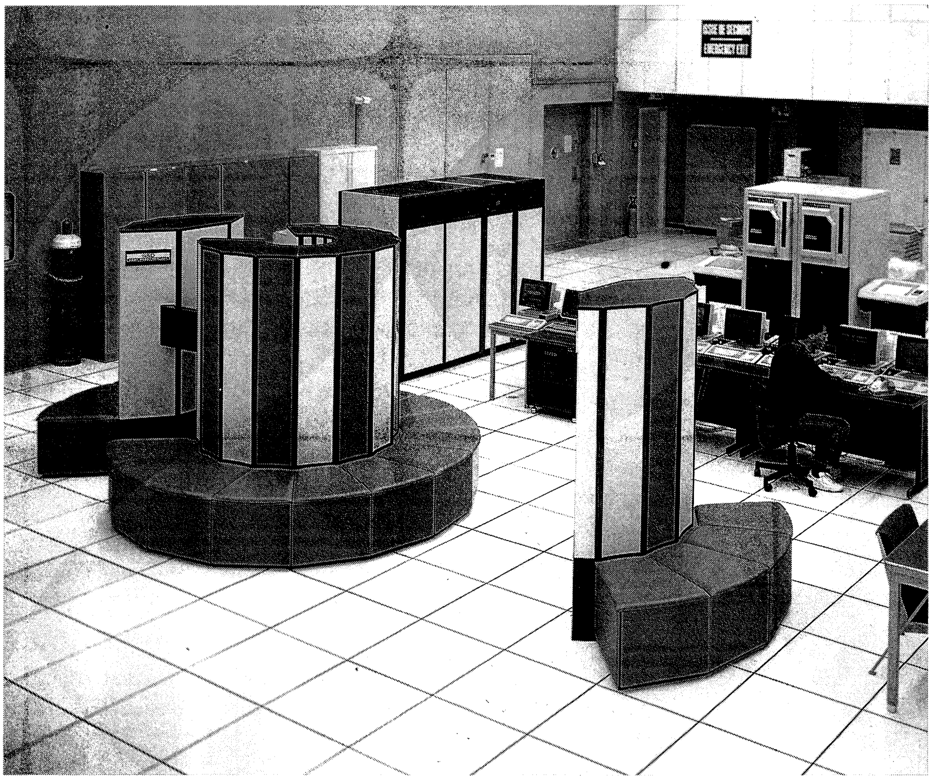
On 7 February, members of the High Energy Particle Physics Group of the UK Institute of Physics took part in a half-day meeting 'Phenomenology from the Lattice' organized by Chris Sachrajda at Southampton University.

The lattice formulation of QCD looks like a problem in statistical mechanics, but in four dimensions instead of the usual three. Quark and gluon fields are associated with the sites and links of the lattice respectively, and a sequence of configurations of these lattice fields is generated on the computer by a Monte Carlo algorithm. Various observables can then be measured on each configuration and averaged over the set of configurations to yield quantum mechanical expectation values.

The current state of the art was reviewed by Richard Kenway of Edinburgh, who revealed that the most recent calculations, in the so-called 'quenched approximation' which ignores the possibility of creation and annihilation of transient (virtual) quark-antiquark pairs, suggest that the statistical errors inherent in such Monte Carlo calculations have been reduced sufficiently to expose any systematic discrepancies.

The results of different groups seem now to be in agreement with one another and with the predictions of quark potential models, but only appear to work at unrealistically large values of the quark mass if finite lattice size effects are to be kept under control. Including the dynamics of the quarks makes the computations much harder and will certainly have to await very much more powerful machines.

One of the remarkable features of non-Abelian gauge theories, such as QCD, is that the gauge fields themselves interact, even in the absence of quarks. Unlike the electrically neutral photon carriers of the electromagnetic field, the gluons of QCD themselves carry (colour) charges.



Quark field theory simulations need powerful computers such as CERN's Cray X-MP/48.

(Photo CERN 60.11.88)

Lattice simulations provide theorists with a testbed where this hypothetical world of gluons without quarks can be explored in an attempt to understand the underlying dynamics. Chris Michael of Liverpool described how this pure gauge theory has been solved in the past few years. The interaction between static heavy quarks turns out to be consistent with theoretical expectations based on spectroscopic models. The lattice even predicts broad new charmonium (charm quark-antiquark bound states) above 4 GeV, beyond the threshold for production of D mesons.

The gluon bound states ('glueballs') have also been extensively studied and there is now agreement that the lowest lying state carries zero spin and positive quantum numbers (0^{++}) with a 2^{++} next. Unfortunately, the mixing between

The ESRF is constructing a state of the art storage ring for 6 GeV electrons and/or positrons to be operated as a high brilliance synchrotron radiation source in the field of X-rays from 1994 on. The objectives of the ESRF are to support scientists in the implementation of fundamental and applied research on the structure of condensed matter.

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these pure glue states and quark-antiquark states with the same quantum numbers has not yet been computed and so it is not possible to make reliable mass predictions.

The electroweak sector has also received attention from lattice theorists. Brian Pendleton, also from Edinburgh, explained the paradox that non-perturbative methods can be needed to study weak interactions, where perturbation is normally a safe bet. The problem is in the Higgs sector (symmetry-breaking dynamics supplying mass) where the self-interaction of the Higgs particle can become strong if the Higgs particle is heavy.

Speculation has been rife for some time that very high energy heavy ion collisions might be able to produce energy densities sufficient to induce a phase transition from the usual state in which quarks and gluons are confined in conventional nuclear matter to a deconfined phase, creating the long-awaited quark-gluon plasma. Frithjof Karsch from CERN gave a review of recent theoretical developments. Observable consequences would be a large latent heat at the transition temperature and screening of the heavy quark-antiquark potential so that there would be no heavy quark bound states in the plasma phase. Recent lattice computations suggest that the transition temperature is reduced from its value of roughly 200 MeV in the quenched theory to perhaps 150 MeV, leading to a critical energy density of roughly 1 GeV per cubic fermi.

In the final talk Chris Sachrajda covered the progress towards the calculating hadron transitions using lattice QCD. Notable successes include obtaining values of some meson decay constants to within 15 % of experimental values, pion form factor and structure function determinations, weak form factors of charmed mesons, and proton decay probabilities. More disappointing are efforts to understand isospin selection rules, where enormous numerical cancellations in the calculations obscure the results.

However the general message is an upbeat one; many fundamental quantities in strong interaction physics are being computed from first principles and meaningful phenomenology from the lattice is beginning to be possible. Reduction of systematic errors is the prime goal and that requires computational resources far in excess of what is currently available to individual research groups. The way forward needs international cooperation to establish facilities comparable to those enjoyed by experimentalists.

By Ken Bowler

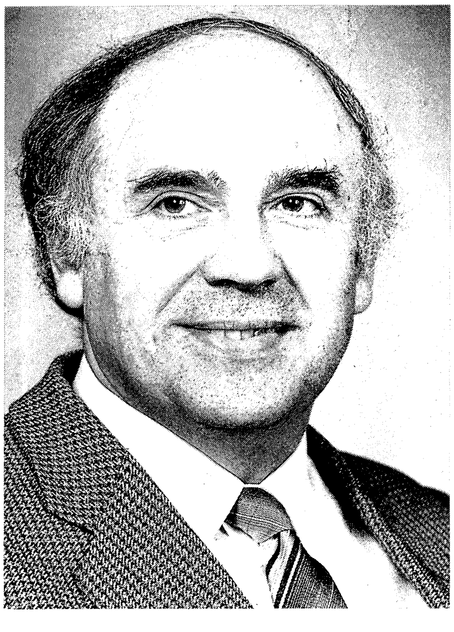
People and things

Finland joining CERN

At a specially-arranged session of CERN Council on 27 April, the delegates of CERN's 14 Member States voted unanimously in favour of admitting Finland as the Organization's 15th Member State. Ratification should be complete in time for Finland's accession to be effective from 1 January 1991. The country's contributions to the CERN budget will increase on a sliding scale, eventually reaching their full level in 1995. In the meantime the Finnish Government intends to increase substantially its support for the national programme in high energy physics research.

On people

Vernon Hughes of Yale has been selected for the 1990 Bonner Prize in recognition of his important work on polarized electron beams and his contributions toward measuring the spin dependence of the nucleon quark content (structure functions).



Erwin Gabathuler of Liverpool and formerly CERN Research Director has been elected a Fellow of the Royal Society, London.

Visiting CERN on 25 April, Vladimir Shatalov (right), Director of the Soviet cosmonaut preparation centre, and V.A. Denissenko, Vice-Director of the Institute of the Earth, Moscow, had an inside view of the Delphi experiment at the LEP electron-positron collider. Accompanying them (left) was Delphi spokesman Ugo Amaldi.

(Photo CERN 135.4.90)

Fred Reines of Irvine is to receive the 1990 Michaelson-Morley Award from Case Western Reserve University in recognition of his 1956 discovery of the neutrino (with Clyde Cowan) and his continued forefront work in neutrino physics.

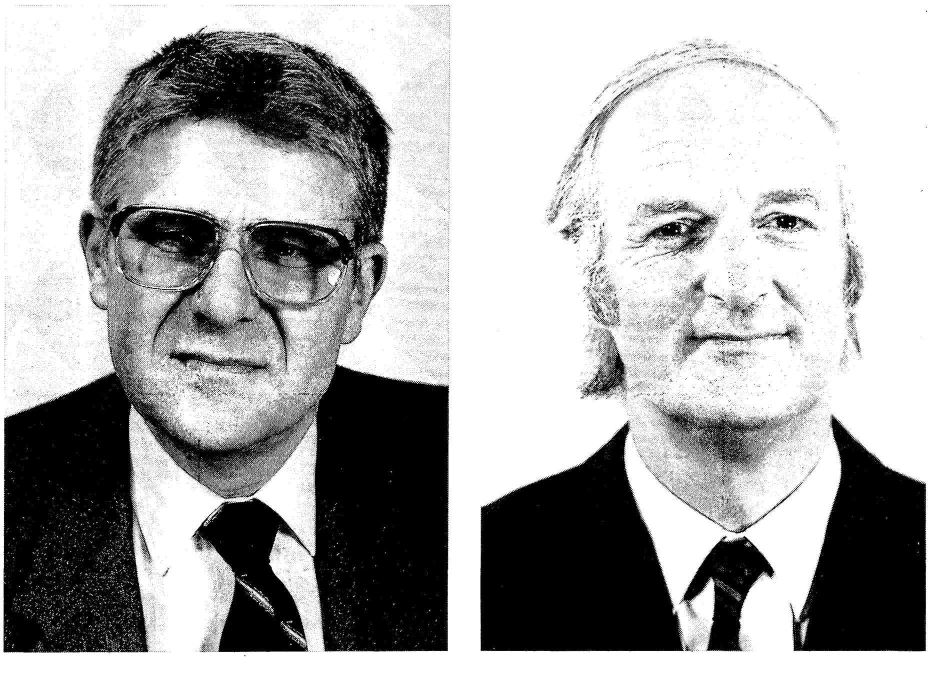
New Director for Swiss PSI Laboratory

On 1 April Anton Menth became Director of the Swiss Paul Scherrer Institute, Villigen – Würenlingen, succeeding Jean-Pierre Blaser. After beginning his physics career with solid-state research at ETH, Zurich, Menth moved into Swiss industry, taking on a series of key roles with first the Brown Boveri and then the Oerlikon concerns. He is now also Professor of Physics at ETH Zurich.

Jean-Pierre Blaser has been Director of the Schweizerische Institut für Nuklearforschung (SIN) since its inception as a meson factory in 1968. After presiding over the initial phase of the merger of SIN with the neighbouring Eidgenössiches Institut für Reaktorforschung (EIR) he became first Director of the combined Laboratory, renamed the Paul Scherrer Institute, in 1988. For several years he was also Swiss representative to CERN Council.

CEBAF injector operates at 5 MeV

In an April 19 test, the initial 5 MeV superconducting section for the injector of the Continuous Electron Beam Accelerator Facility being built at Newport News, Virginia,



Anton Menth (left) becomes Director of the Swiss Paul Scherrer Institute, succeeding Jean-Pierre Blaser (right).

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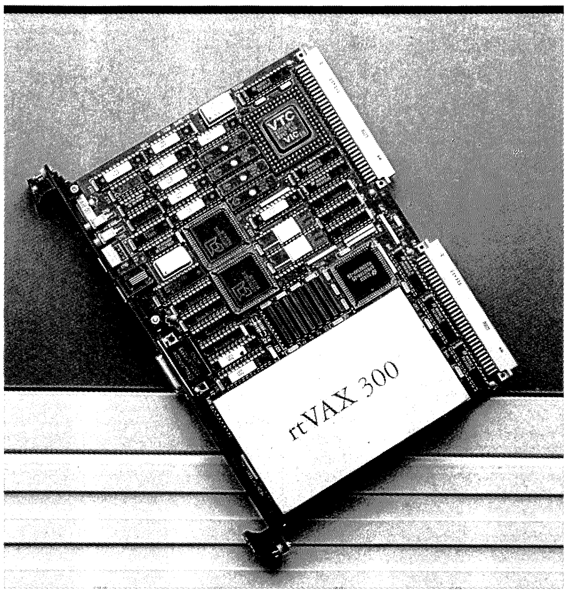

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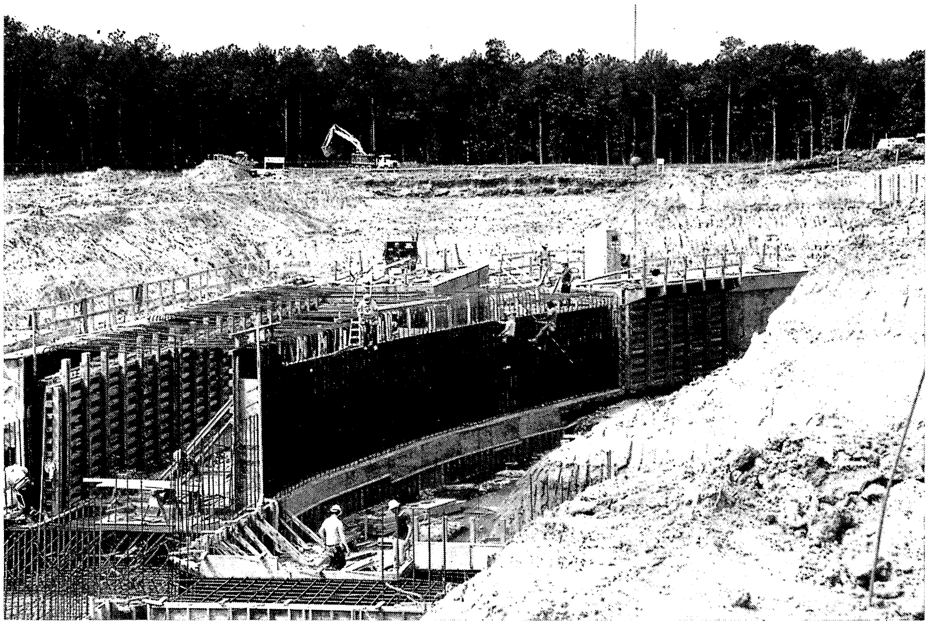
accelerated an electron beam to design energy. This superconducting quarter-cryomodule – of the same design as the full cryomodules to be used in both the 4 GeV accelerator itself and the rest of the 45 MeV injector – contains a hermetically joined pair of accelerating cavities immersed in 2K helium. Continued 5 MeV operations will test beam current, position, and profile monitors as well as pre-production radiofrequency control units and associated hardware.

In another development earlier in April, Robert Gay Construction Company of Jacksonville, Florida, began building CEBAF's three end stations. Gay's $11.8 million contract calls for circular, partially underground concrete halls 30, 46, and 53 metres in diameter.

Construction work underway for the Continuous Electron Beam Accelerator Facility (CEBAF), Newport News, Virginia.



Superconducting equipment for Brazil

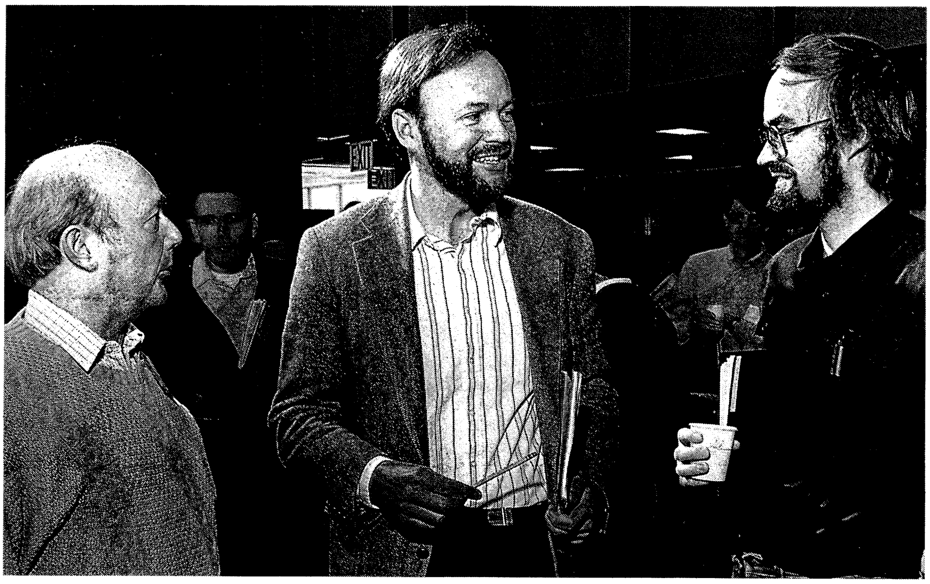
Thirteen superconducting niobium-sheathed radiofrequency accelerating modules of the type developed at Argonne for ATLAS (Argonne Tandem Linear Accelerator System) are to be supplied to Sao Paulo, Brazil, to upgrade the university's electrostatic accelerator.

Oscar Sala (left) of Sao Paulo, Brazil, and Lowell Bollinger, head of Argonne's ATLAS accelerator, with one of the superconducting accelerating units developed at Argonne for ATLAS. 13 such units are to be supplied to upgrade Sao Paulo's electrostatic accelerator.

Waiting for RHIC

With construction of the RHIC Relativistic Heavy Ion Collider expected to get underway at Brookhaven in October 1991 (April, page 16), preparations for the experimental programme move into top gear.

Discussing heavy ion physics results from the Alternating Gradient Synchrotron at Brookhaven – (left to right) Ole Hansen, Miklos Gyulassy and Flemming Videbaek.



The Fourth Workshop on Experiments and Detectors is scheduled for Brookhaven from 2-7 July, immediately following the International Conference on Particles and Nuclei (PANIC) in Cambridge, Massachusetts (further information from the RHIC office, bitnet rhicuser at bnldag).

Meanwhile accomplishments so far with heavy ion beams at Brookhaven's Alternating Gradient Synchrotron (which will act as the RHIC injector) were surveyed at a workshop at Brookhaven from 5-7 March.

At Berkeley, the Nuclear Science Division has set up a Relativistic Nuclear Collision Group under Art Poskanzer to cover preparations for RHIC and ongoing heavy ion studies at CERN and at the local Bevalac.

At CERN, supplier of the world's highest energy heavy ion beams (sulphur-32 ions at 200 GeV/nucleon), plans are being groomed for an international project to supply beams of lead ions. In addition, the LHC idea for a proton collider using the existing 27-kilometre LEP tunnel (December 1989, page 1) could take heavy ion beams on board.

Meetings

A workshop on tau neutrino physics to be held at Orsay from 24-27 September, organized jointly by the French IN2P3 (CNRS) and CEA, will cover experiment, theory, and ideas for the future. Attendance (about 100) is by invitation only. Contact Tau workshop, c/o Nicole Mathieu, Universite Paris-Sud, LAL Bat 200, 91405 Orsay Cedex, France, bitnet orsaytau at frcpn11

Top papers of the 1980s

In the analysis of a decade of particle physics papers to find the most frequently cited results of the 1980s (April, page 7), a big one unfortunately slipped through the net. The 1984 Reviews of Modern Physics paper by E. Eichten, I. Hinchliffe, K. Lane and C. Quigg stressed the importance of a physics programme exploring the 1 TeV (1000 GeV) scale for interactions at the quark and lepton level and looked at the probable outcome, based on Standard Model physics. With 785 citations, this was the most referred-to phenomenology paper and should have been included in the top ten papers.

A misprint which hindered some subsequent citations obscured references to the 1985 Nuclear Physics B paper by L. Dixon, J.A. Harvey, C. Vafa and E. Witten on 'Strings on orbifolds', which looked at the 'compactification' of unwanted dimensions in superstring theory.

Our apologies to all the authors.

The amended top twenty in full

The initial figure is the citation score:

1102 P. Candelas et al: *Nuclear Physics B258* (1985) 46
969 D.J. Gross et al: *Nuclear Physics B256* (1985) 253
925 A.M. Polyakov: *Physics Letters 103B* (1981) 207
897 D.J. Gross et al: *Phys. Rev. Letters 54* (1985) 502
893 Particle Data Group: *Physics Letters B170* (1986) 1
842 A.H. Guth: *Phys. Rev. D23* (1981) 347
828 M.B. Green, J.H. Schwarz: *Physics Letters 149B* (1984) 117
811 A.A. Belavin et al: *Nuclear Physics B241* (1984) 333
764 J.H. Schwarz: *Physics Reports 89* (1982) 223
754 E. Eichten et al: *Rev. Mod. Phys. 56* (1984) 579
652 E. Witten: *Nuclear Physics B223* (1983) 422
598 D. Friedan et al: *Nuclear Physics B271* (1986) 93
592 G. Arnison et al (UA1): *Physics Letters 126B* (1983) 398
585 P. Bagnaia et al (UA2): *Physics Letters 129B* (1983) 130

582 G. Arnison et al (UA1): *Physics Letters 122B* (1983) 103
542 A. Albrecht, P.J. Steinhart: *Phys. Rev. Letters 48* (1982) 1220
537 A.D. Linde: *Physics Letters 108B (1982) 389*
523 M. Creutz: *Phys. Rev. D21* (1980) 2308
518 L. Dixon et al: *Nuclear Physics B261* (1985) 678
507 D.J. Gross et al: *Nuclear Physics B267* (1986) 75
505 E. Witten: *Nuclear Physics B258* (1985) 75
495 M. Banner et al (UA2): *Physics Letters 122B* (1983) 476
478 E. Witten: *Commun. Math. Phys. 92* (1984) 455
470 E. Witten: *Nuclear Physics B268* (1986) 253
466 Particle Data Group: *Reviews of Modern Physics 52* (1980) S1
446 A.M. Polyakov: *Physics Letters 103B* (1981) 211
426 H.P. Nilles: *Physics Reports 110* (1984) 1
423 D. Friedan et al: *Phys. Rev. Letters 52* (1984) 1575
413 L. Alvarez-Gaumé, E. Witten: *Nuclear Physics B234* (1984) 269
408 E. Witten: *Nuclear Physics B223* (1983) 433
406 Particle Data Group: *Physics Letters B204* (1988) 1
404 P. van Nieuwenhuizen: *Physics Reports 68* (1981) 189

Posters for schools

On the initiative of Meinhard Regler from the High Energy Physics Institute in Vienna, a series of thirteen posters on accelerators and particle physics have been printed for use in schools. They are in three sets: I-IV on Accelerators and Colliders, prepared by Brian Southworth; V-VIII on Detectors, prepared by Meinhard Regler; IX-XIII on Theory prepared by Wolfgang Lucha with Herbert Pietschmann. Marcel Sturzinger helped with graphics and the posters were printed by Sappl in Kufstein, Austria.

The posters on accelerators take the historical route to high energies to cover the different techniques of particle acceleration. They begin with 'General principles' – definition of the electronvolt, TV tubes as an example of the basic elements of an accelerator, and the distinction between fixed target and colliding beams. They move on to 'DC machines and cyclotrons' – from Crookes' tube, via the Cockcroft-Walton and Van de Graaff to the cyclotron. Next come the machines for relativistic particles 'Synchro-cyclotrons, linacs, synchrotrons' with illustration of the principles of alternating gradient and of phase stability. They conclude with 'Colliders' covering electron-positron, proton-proton and proton- antiproton machines.

The posters on 'Detectors' concentrate on the most up-to-date techniques for particle detection. They begin with a comparison of 'Fixed target/collider experiments' using schematic representations of both types. 'Wire chambers' are covered moving from the Geiger counter and proportional chamber to drift chambers and time projection chambers. 'Particle identification' is illustrated via Cherenkov light devices and the energy loss methods. These posters conclude with 'Calorimeters' with diagrams of various types of such devices such as a sandwich structure calorimeter and a hadron calorimeter for a fixed target experiment.

The posters on 'Theory' begin with 'Fundamental particles' with their dual role as building blocks of matter and transmitters of force, their interactions via particle exchange, and the quantum mechanical understanding of atomic structure. 'Elementary particles' classifies particles into bosons and fermions and introduces the concepts of quantum numbers and of antiparticles. 'Standard theory' summarizes present knowledge of particles in the standard model. 'Quark model' explains the properties of the strongly interacting particles, the hadrons, in terms of their quark and gluon constituents. The final poster on 'Fundamental interactions' illustrates the fundamental interactions found in nature.

The posters are aimed at pre-university school classes and could also be useful in postgraduate education of teachers, introductory lectures in physics courses and in popular science lectures. They can also serve in other general presentations of particle physics and its associated technologies.

The posters are 70 x 100 cm in full colour. The English version is available from CERN at a cost of 350 Swiss francs for the full set. Requests should be addressed to Petra Pamblanco, Publications Section, CERN, 1211 Geneva 23, Switzerland. The German version is available from the printer at a cost of 4160 Austrian schillings for the full set. Requests should be sent to Paul Sappl, Eichelwang 15, 6332 Kufstein, Austria. (Reduced costs could be negotiated for large orders for either language version.) It is probable that a French version will be produced before the end of the year. People interested in helping to organize production in other languages should make contact with Brian Southworth at CERN.

Users' corner

The May issue (page 27) outlined how the European Committee for Future Accelerators (ECFA) has set up nine detector and three physics working groups for exploring in detail the physics possibilities for the Large Hadron Collider (LHC) proposed for CERN (December 1989, page 1).

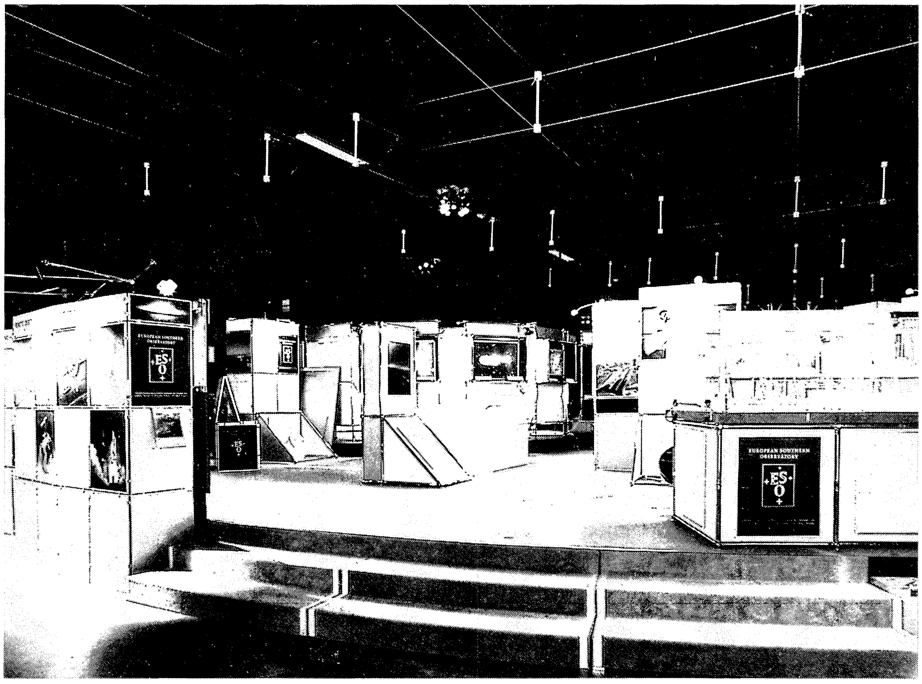
To promote rapid dissemination of information from these working groups, a new news feature, LHCWG NEWS, will soon be installed on the CERNVM and CERNVAX computer systems.

LHCWG NEWS can be accessed at any time from CERNVM by typing NEWS (LHCWG To see this news regularly, add the line 'EXEC NEWS (LHCWG UNSEEN' at a suitable point in your PROFILE EXEC file. This will show any such news issued since the previous login. On the central VAX cluster this news may be read by typing NEWS LHCWG

Those interested but not having an account on the CERN computers should send their electronic mail addresses to the CERN Users' Office – CERNUO at CERNVM or PATTISON at CERNVM mentioning LHCWG

Those without access to electronic mail should write to Bryan Pattison, Users' Office, CERN, 1211 Geneva 23, Switzerland.

There will be an Intermediary Meeting of all the ECFA LHC Working Groups in the CERN Auditorium on 18-19 June.



The European Southern Observatory's travelling astronomy exhibition 'Discoveries in the Southern Sky' is spending six months at CERN's 'Microcosm' exhibition centre. The choice of ESO as Microcosm's first guest exhibitor is especially apt: new physics insights are finding increasing common ground between astronomy – the study of the large-scale structure of the Universe – and particle physics – which looks at the infinitely small; and ESO underlines its close links with CERN, where it had a temporary home while waiting for its Garching, near Munich, headquarters to be built.

(Photo CERN 529.3.90)

Bernard D. Hyams

At the end of April, Bernard D. Hyams 'retired' after 32 years at CERN, only to continue his normal activities the next day. Joining CERN in 1958 after cosmic ray work at Manchester, his first experiment, conducted in the Lötschberg tunnel, showed that the nucleon lives longer than 2 x 10^{26} years, the significance of which was only recognized many years later. In one of the first experiments at the CERN PS, he demonstrated that in pion decay the muon spin behaved as expected. After a study of vector meson decays into muon pairs, he spent several years on precision pion measurements. With the discovery of charmed particles, he pioneered the application of the silicon microstrip technique for high precision vertex measurements, developing during a sabbatical year at SLAC the VLSI chip for microstrip readout. While continuing his research work, he was Leader of CERN's Experimental Physics Division from 1984-87.

From Peter Weilhammer
and Friedrich Dydak

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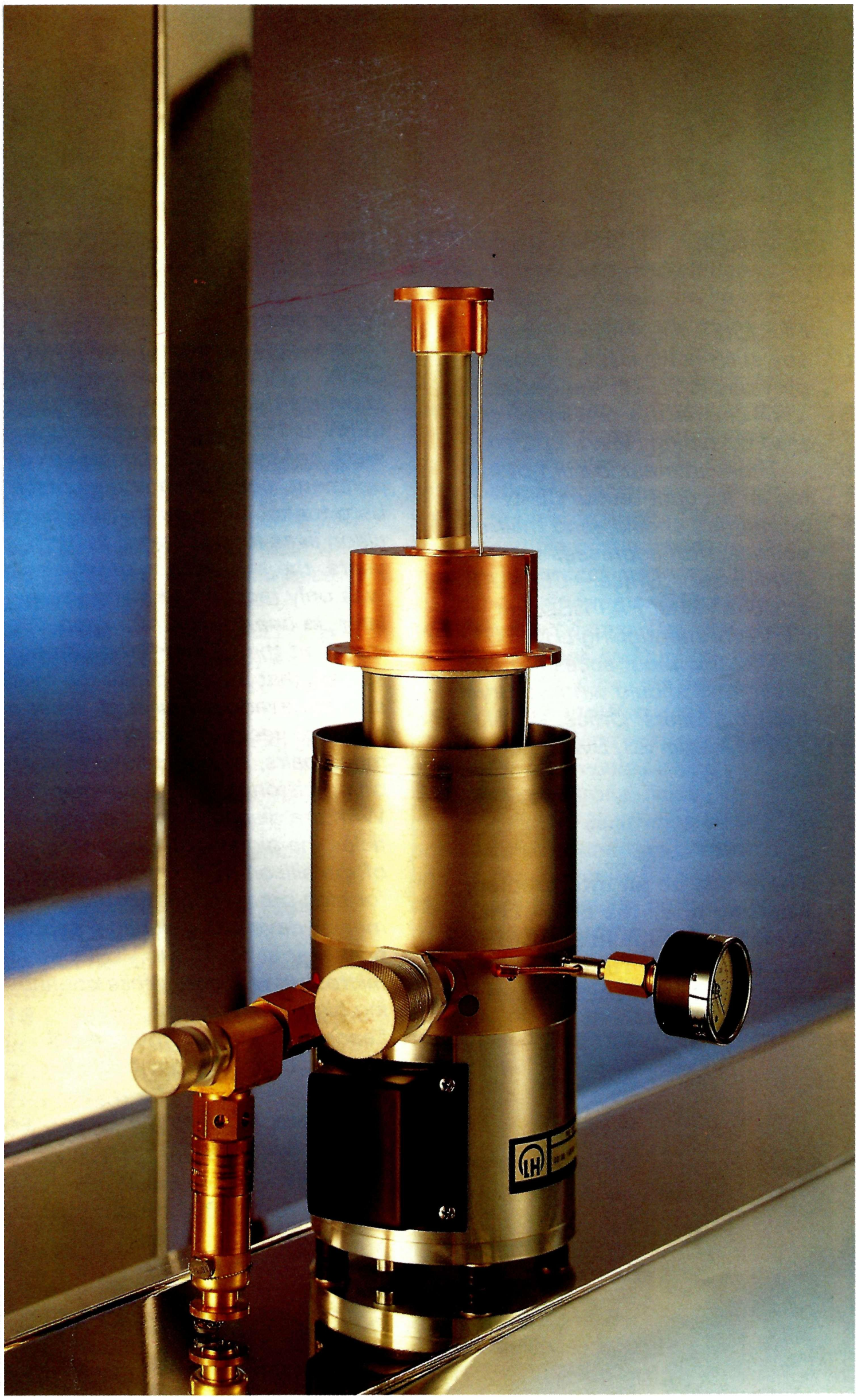

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