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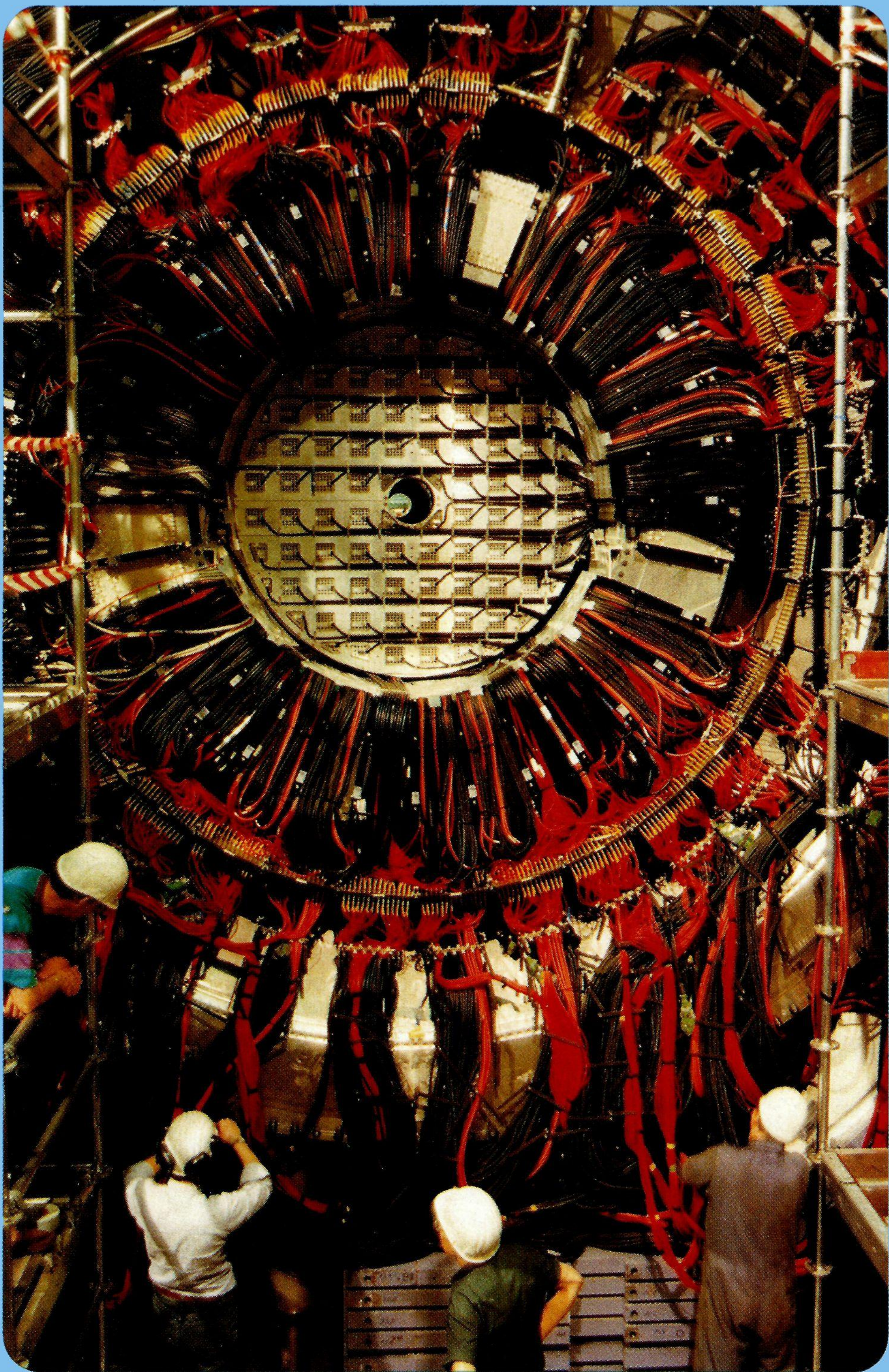

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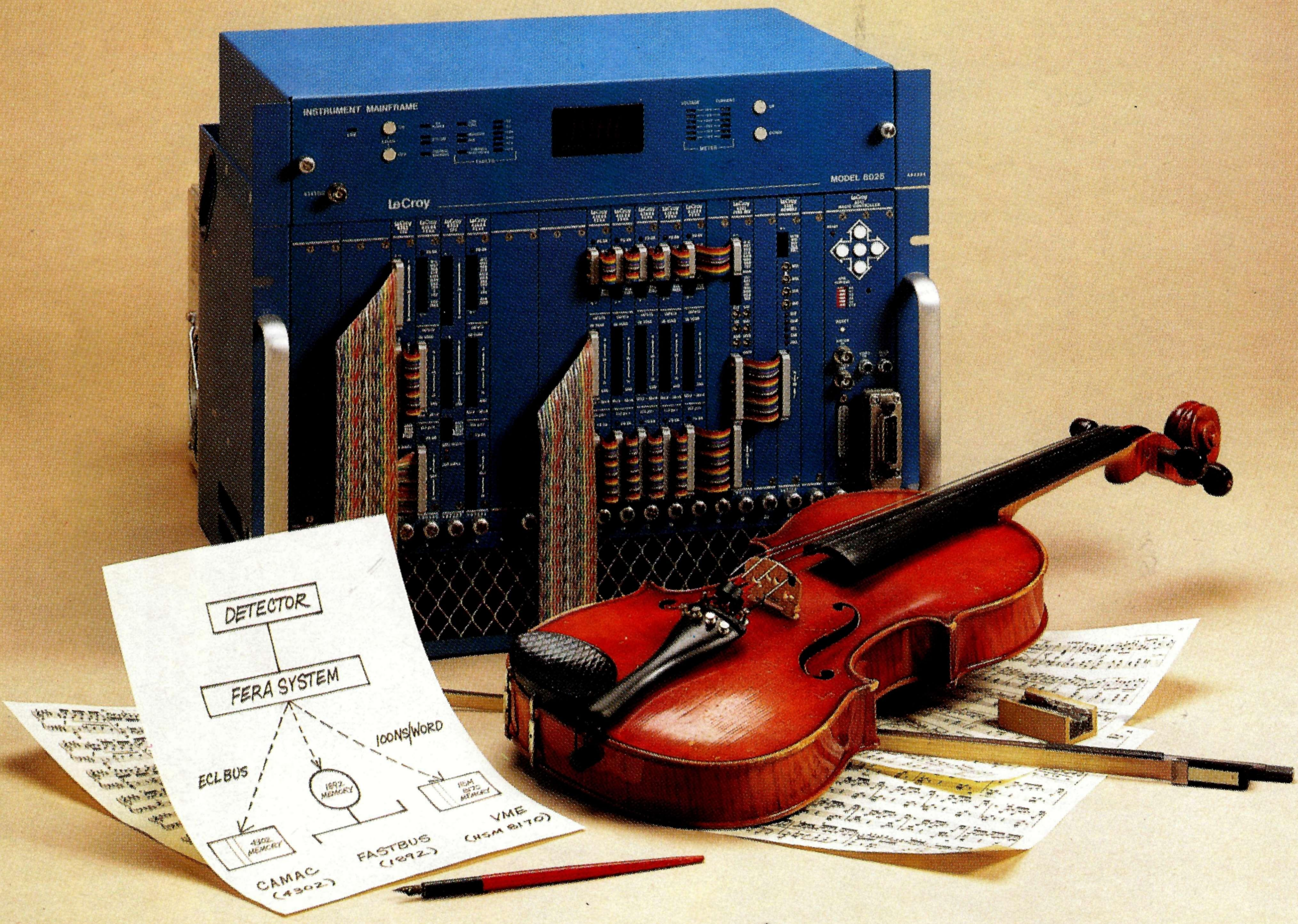

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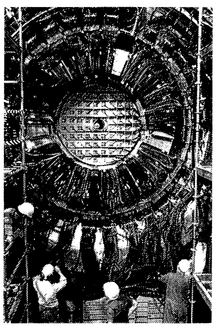
Around the Laboratories

Physics monitor



Cover photograph:
Cabling for the H1 detector being readied for the North Area of the HERA electron-proton collider, at the Hamburg DESY Laboratory (see page 3, photo Pedro Waloschek).

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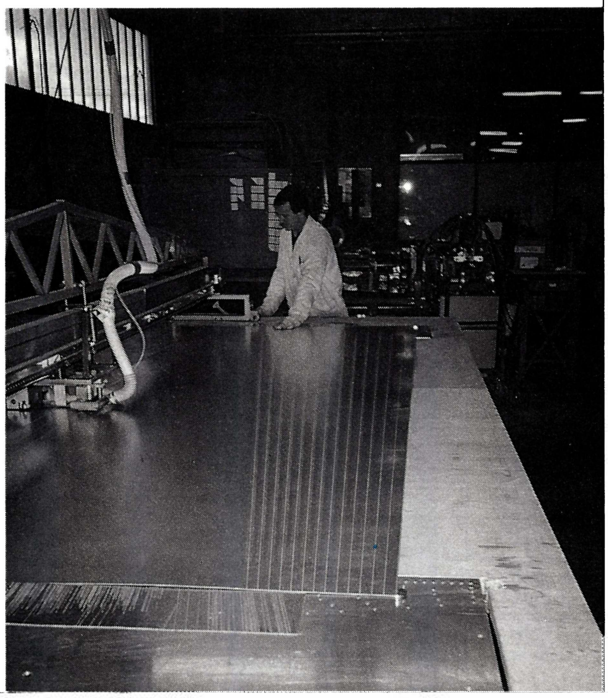

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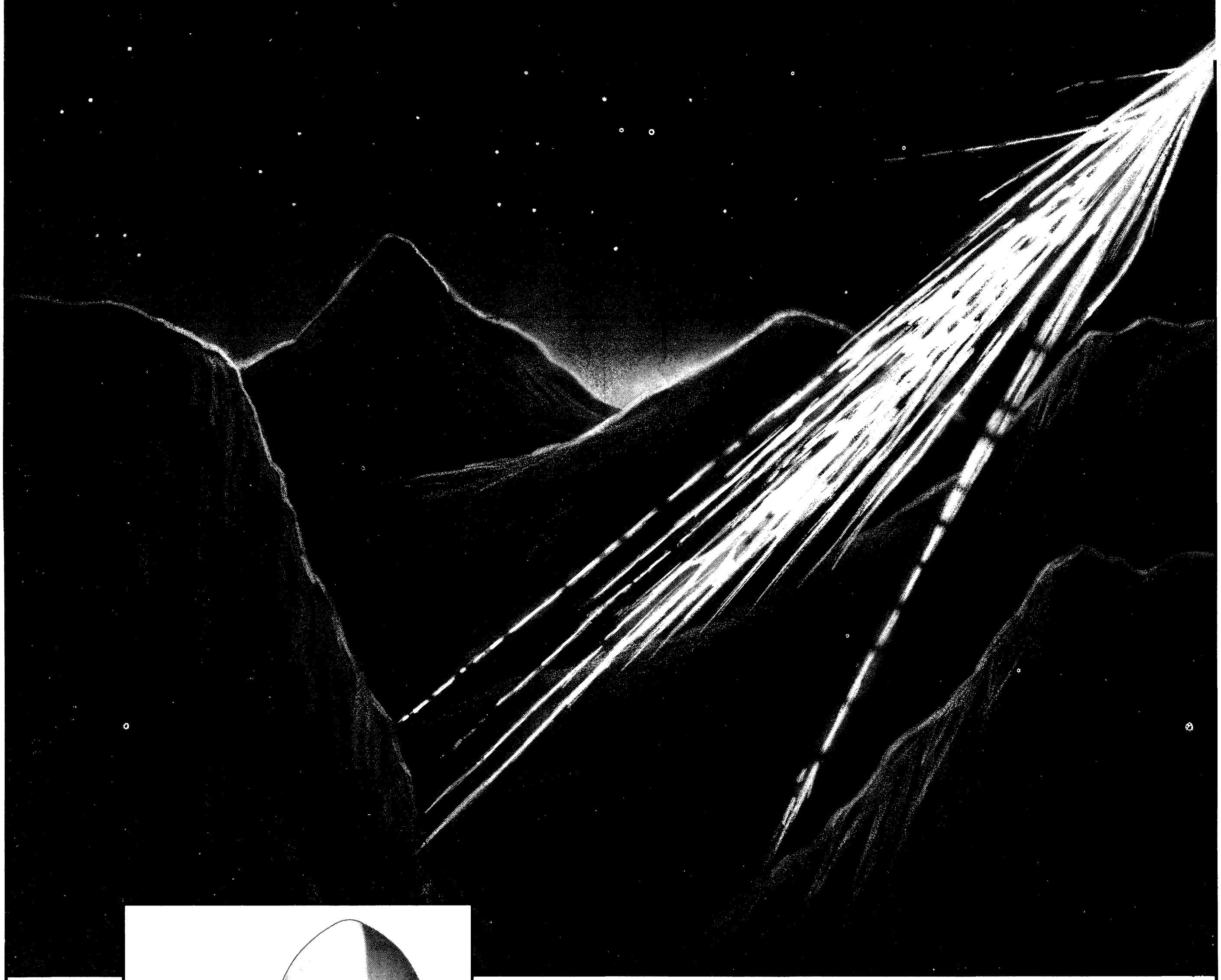

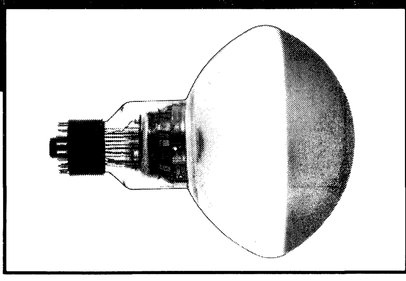

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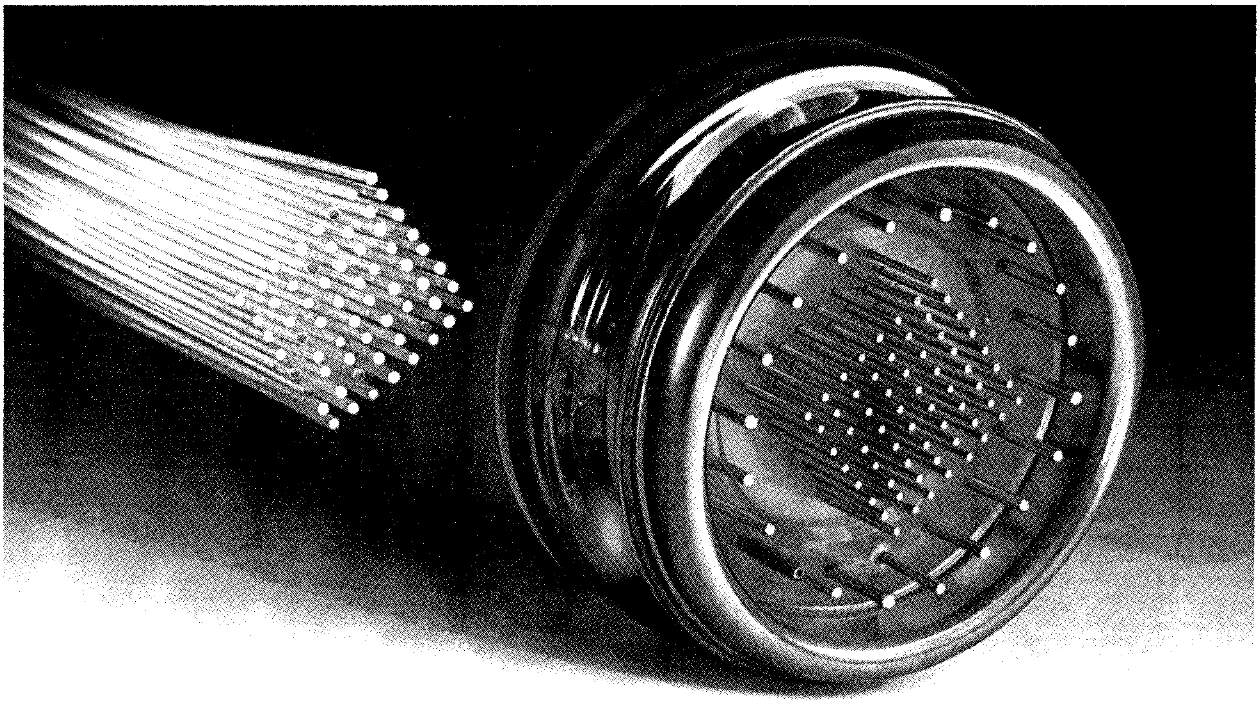

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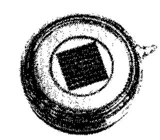

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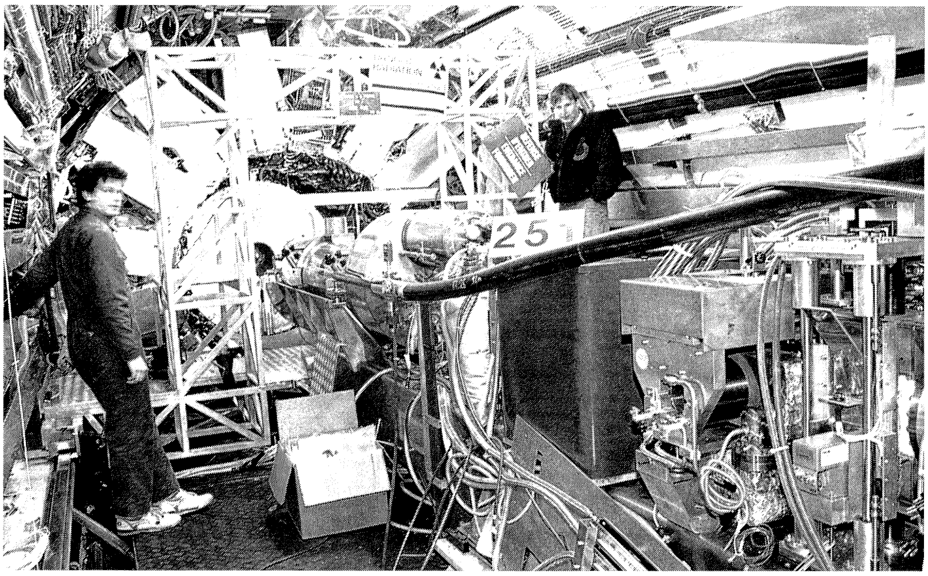


One of the superconducting ('low-beta') magnets which squeeze LEP's electron and positron beams to boost the collision rate. These magnets have already performed well, compressing the beams tighter than originally foreseen.

(Photo CERN 74.2.91)

CERN
A big year for LEP

In April this year's data-taking period for CERN's big LEP electron-positron collider got underway, and is scheduled to continue until November.

The immediate objective of the four big experiments – Aleph, Delphi, L3 and Opal – will be to increase considerably their stock of carefully recorded Z decays, currently totalling about three-quarters of a million.

Interspersed with the data-taking sessions will be machine development periods to prepare the big machine for longer-term aims – higher collision rates, increased collision energies and polarized beams (March, page 1).

From LEP data collected so far, one major talking point is the implications of the precision results for so-called 'Grand Unified Theories' (GUTs). With the current Standard Model of particle physics in such good shape, GUTs go a step further, putting the two hitherto separate elements of the Standard Model – the electroweak picture (of electromagnetism and the weak nuclear force) and the field theory of quark interactions (quantum chromodynamics) – together into a single unified description of the three forces.

According to GUT ideas, the three distinct force couplings characteristic of the current Standard Model should gradually converge towards a single value – the GUT limit – at about $10^{14\text{-}16}$ GeV, an energy from which the three forces went their separate ways after the Big Bang.

LEP experiments give new precision values for the three couplings of the Standard Model, in particular the strength of the inter-quark force. Taken together, the information does not point to an easy unification.

If GUTS are to be in accord with today's data, some new physics has to lurk between the region currently explored by LEP and the GUT limit. One contender is supersymmetry (April, page 2), and imposing a convergence of the three different coupling strengths indicates that first signs of supersymmetry should be seen at about 1000 GeV. Or the new physics could come from some other source.

Whatever the new effects are, all this is extremely good news for planned or projected proton colliders like CERN's LHC for the LEP tunnel or the US Superconducting Supercollider (SSC) which aim to attain this energy region.

It also increases confidence in solving the 'dark matter' enigma of cosmology and astrophysics. For some time it has been clear that there is not nearly enough matter in the Universe to stop the Big Bang expansion continuing for ever, while analyses of galactic motion cannot be accounted for by visible matter alone.

Supersymmetry also provides a good candidate for this so-far invisible matter, with the lightest supersymmetric particles remaining as cosmological relics of the Big Bang. If these particles were electrically charged, they would have taken up residence in nuclei. However searches for anomalous abundances of heavy isotopes show nothing, so attention turns to electrically neutral super-particles.

No sign of such particles has been seen so far at LEP, implying they must be heavier than about 10-20 GeV. Plausible estimates of cosmological abundances show that these neutral super-relics could supply enough gravitational pull to hold the Universe together.

Some 500 years ago, Copernicus startled the world by showing that it is not the centre of the Universe. Having learnt to live with that, we may now have to reconcile ourselves to the realization that we are not even made of the same stuff as most of the rest of the Universe.

* see also page 26

In the meantime the LEP experiments have their work cut out to sharpen the picture at currently available or accessible energies and provide a more confident basis for extrapolations to simulate the evolution of physics after the Big Bang.

DESY 40 GeV protons in PETRA*

In February protons were accelerated for the first time in the PETRA ring at Hamburg's DESY Laboratory to the 40 GeV needed for injection into the new HERA electron-proton collider.

The next step is to increase the intensity and quality of these PETRA proton beams prior to injection into HERA's 6.4 kilometre ring of superconducting magnets.

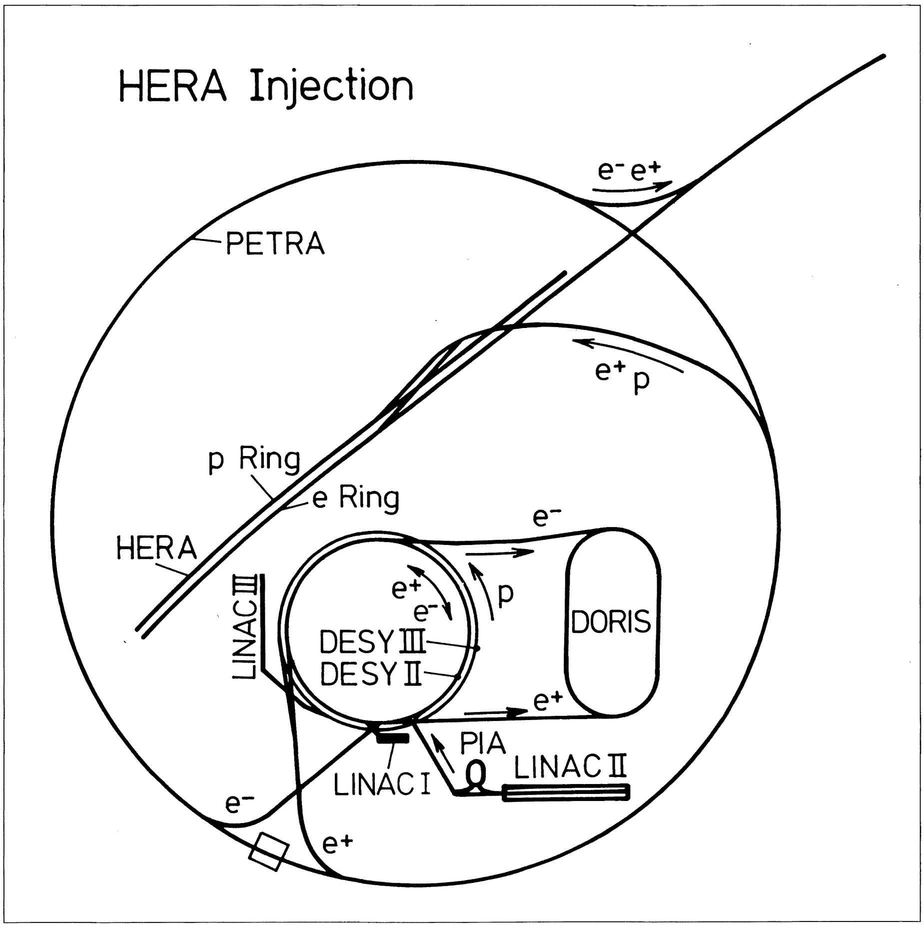
The PETRA ring, built as an electron-positron collider, came into operation in 1978. The physics programme terminated in 1986 to prepare the ring for its new career as HERA's injector of both electrons and protons.

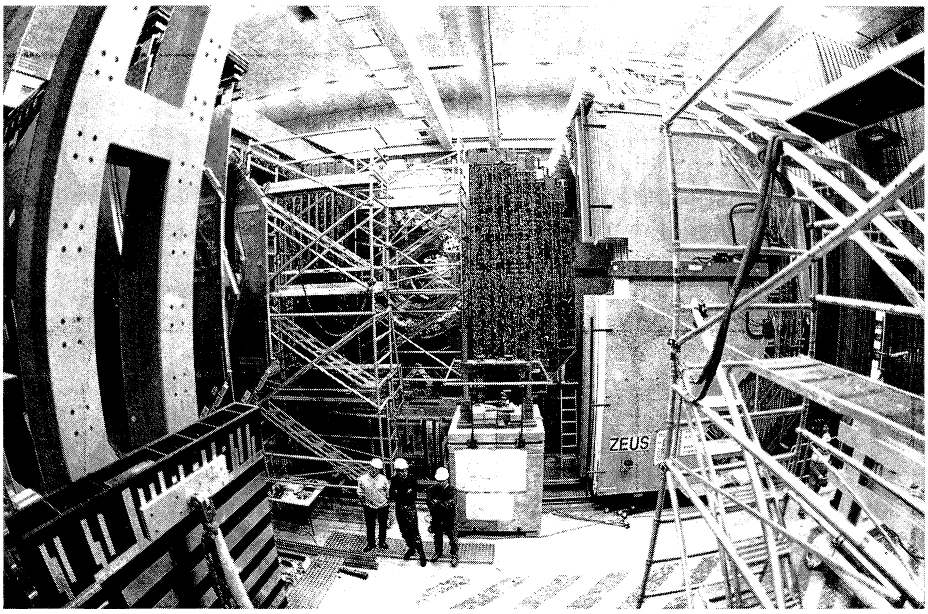
The complete 'DESY chain' of electron machines was tested in 1989, with electrons being taken to 14 GeV in PETRA and above 27 GeV in the HERA electron ring.

Zeus

Installation work is in full swing for the two big detectors – H1 (April, page 10) and Zeus for the HERA electron-proton collider soon to be

The 'DESY chain' of injectors preparing electron and proton beams for the HERA electron-proton collider soon to begin operations at the DESY Laboratory in Hamburg.





Now taking shape in the South Hall of the HERA electron-proton collider at DESY, Hamburg, is the Zeus detector.

(Photo Nick Wall)

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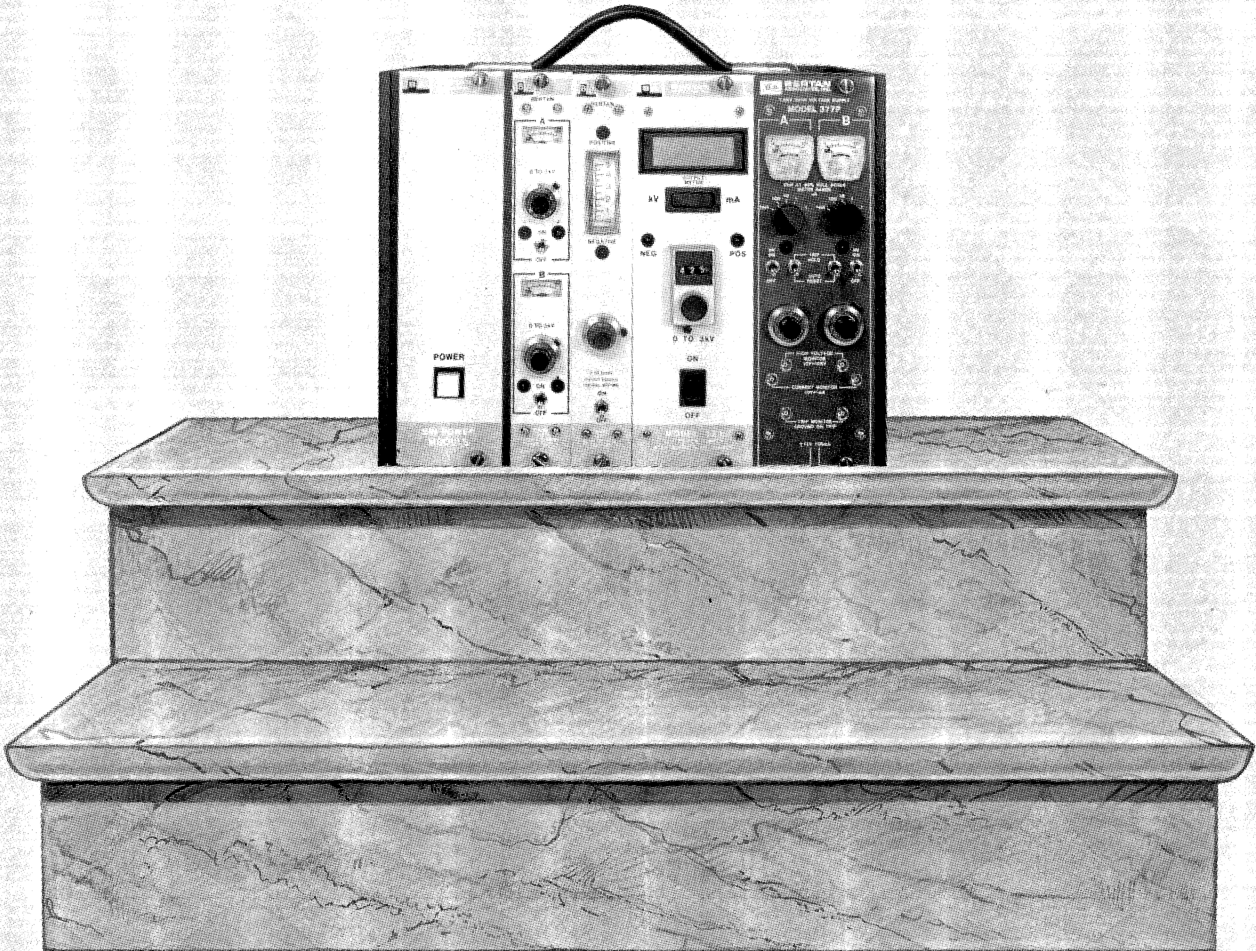

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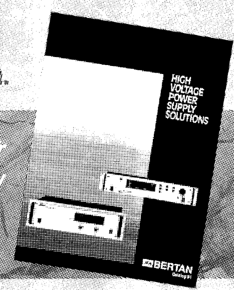


commissioned at the Hamburg DESY Laboratory.

Zeus' iron magnet yoke and the superconducting solenoid and compensator have been in place for some time and successfully tested. Uranium-scintillator calorimeter elements began to go in last November, initially for the forward (proton direction) and rear modules, and installation of the central barrel is now underway. All proportional-tube chambers for the backing calorimeter in the iron yoke are in place.

The toroids of the forward muon detector have been mounted and operated. All drift chamber planes have been installed as well as two of the four limited-streamer tube planes for the trigger. The inner chambers of the muon barrel are in place and mounting of the outer layer has begun.

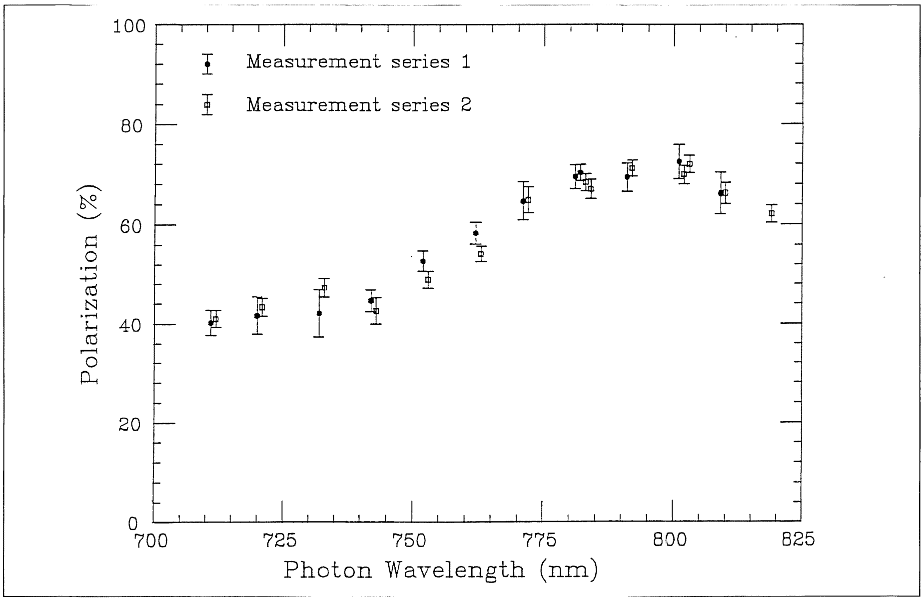
The inner tracking system – vertex detector, central drift chamber and planar drift chambers alternating with transition radiation elements in the forward direction, together with its special section of beam pipe – is taking shape.

After initial installation to ensure its compatibility with HERA machine components, the luminosity monitor has been removed awaiting the availability of well-controlled beams.

KEK
Producing highly polarized electrons (1)

With the Japan Linear Collider (JLC) electron-positron project having highest priority in Japanese high energy physics planning, many associated research and development tasks are underway at the Japanese KEK Laboratory. Despite a relatively recent appearance on the scene, work on a polarized (spin oriented) electron source has nevertheless made significant progress.

Work at the Japanese KEK Laboratory has shown how to obtain highly polarized electron beams from a laser-irradiated treated semiconductor photocathode. Shown here is the variation in polarization with laser wavelength.



After a brief but intensive spell of work to find the optimal superlattice photocathode structure, an impressive polarization level, 71 per cent, has been achieved for a solid-state photocathode at room temperature by a team of researchers from KEK, Nagoya and NEC Corp (see also page 6).

This should go on to pay dividends in a future research programme. In the electroweak picture of electromagnetism and the weak nuclear force, 'handedness' plays a vital role. Particularly when the weak force is in action, Nature cares about the direction in which things happen, and a reaction open to left-handed electrons can be totally blocked for their right-handed counterparts.

With particles spinning in their direction of motion (clockwise) being right-handed, and those spinning against the direction of motion being left-handed, polarized particles provide a powerful probe of these effects.

Thus polarized beams are a major goal in electron-positron colliders. In conventional storage rings, orbiting particles become transversely polarized due to radiation emission – for example, polarizations of about 40 per cent were observed at 29 GeV at KEK's TRISTAN ring (December 1990, page 11) and 10 per cent at 50 GeV at CERN's LEP (November 1990, page 3). But this effect depends strongly on machine parameters and is difficult to control.

In contrast, in a linear collider such as JLC, once polarized electrons are injected, the spin could be maintained through to an interaction point, provided depolarizing effects are avoided. Thus a key requirement is a highly polarized electron source.

The conventional source is bulk gallium arsenide with a negative electron affinity surface, illuminated by circularly polarized monochromatic photons from a laser. But the polarization obtainable this way

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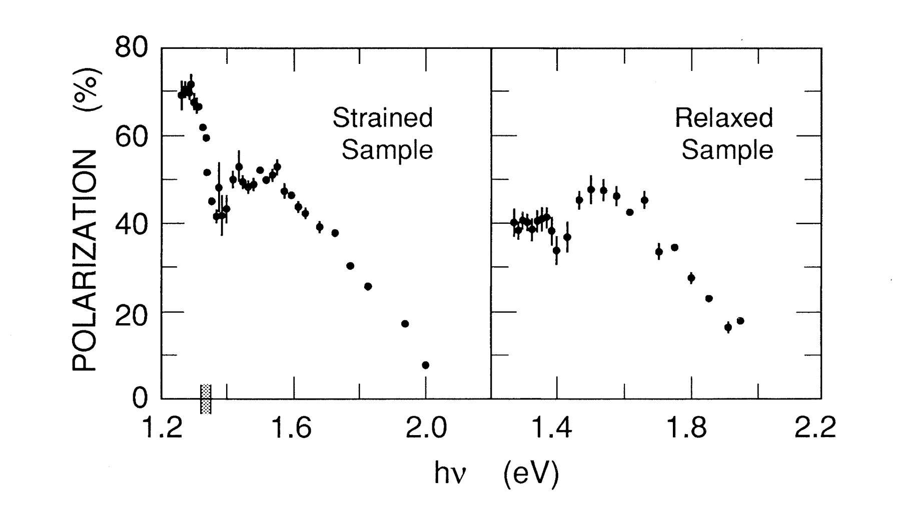
never exceeds 50 per cent because of spin degeneracy. One way to eliminate this intrinsic limit is to remove the degeneracy by a suitably arranged periodic potential in a superlattice structure. If the level splitting is made larger than the thermal noise level, selective pumping from a single state will be possible. Subsequently the pumped electrons need to be efficiently transported from superlayer to superlayer, with minimal depolarization in transit.

The important first step was an optimization study of GaAs-AlGaAs superlattice parameters such as layer thicknesses and Al content. The first photocathode resulting from this study was tested last year with a titanium/sapphire tunable laser, and 53 per cent polarization was quickly seen.

Careful examination of this result led to a second sample with thinner superlattice layers. First measurements gave 71 per cent polarization at a wavelength of 802nm. Greatly encouraged by this achievement, the collaboration is aiming for even better production polarized electron sources for JLC.

Polarized electron sources

These two articles, from the Stanford Linear Accelerator Center (SLAC) in California, and from the Japanese KEK Laboratory, highlight the world-wide effort underway to develop new techniques for the next generation of electron-positron linear accelerators.



Highly polarized electron sources at Stanford. Left, a thin (0.1 micron) indium gallium arsenide layer on a gallium arsenide substrate, when irradiated, shows increasing electron polarization, eventually attaining 71 per cent. At about 1.34 eV, the spectrum shows the onset of the selective pumping of electrons from a higher energy valence band to the conduction band (see text). Right, a 'thick' 1.14 micron layer with no crystal strain shows no similar effects.

STANFORD
Producing highly polarized electrons (2)

Electron spin polarization above 70 per cent by photoemission from a specially prepared semiconductor has been achieved by T. Maruyama and E. Garwin of the Stanford Linear Accelerator Center (SLAC), R. Prepost and G. Zapalac of Wisconsin, and J. Walker and S. Smith of Berkeley.

Since the first use of a gallium arsenide photocathode at SLAC for the historic 1978 experiment which saw left-right asymmetry in electron scattering, semiconductor photoemitters have become standard for linear accelerators. These sources give high peak currents and short pulses, for example satisfying the 16 ampere/2.5 nanosecond pulse requirement for Stanford's SLC linear collider.

The conventional cathode material, gallium arsenide, has a theoretical maximum polarization of 50 per cent due to its crystal structure. In practice, polarization levels of about 40 per cent are achieved with bulk gallium arsenide, while thin epitaxial layers can approach the theoretical 50 per cent limit.

For over a decade much effort has gone into investigating other semiconductors to avoid this inherent limit due to valence band degeneracy. This degeneracy can be broken by deforming the crystal structure or by engineering suitable quantum wells or superlattice structures, opening up the possibility of 100 per cent polarizations by selective pumping of the higher energy valence band.

The SLAC/Wisconsin/Berkeley group has looked at indium gallium arsenide layers grown epitaxially on a gallium arsenide substrate, with the indium giving about a one per cent lattice mismatch. If this top layer is thin enough, the resulting crystal has a compression strain that splits the valence band degeneracy by some 50 meV.

Two samples were studied – an 0.1 micron indium gallium arsenide layer thin enough to give a high quality strained structure, while a 'thick' 1.14 micron layer without strain provided a control.

The thin strained sample showed a dramatic increase in el-

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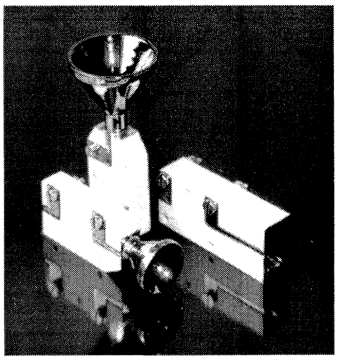

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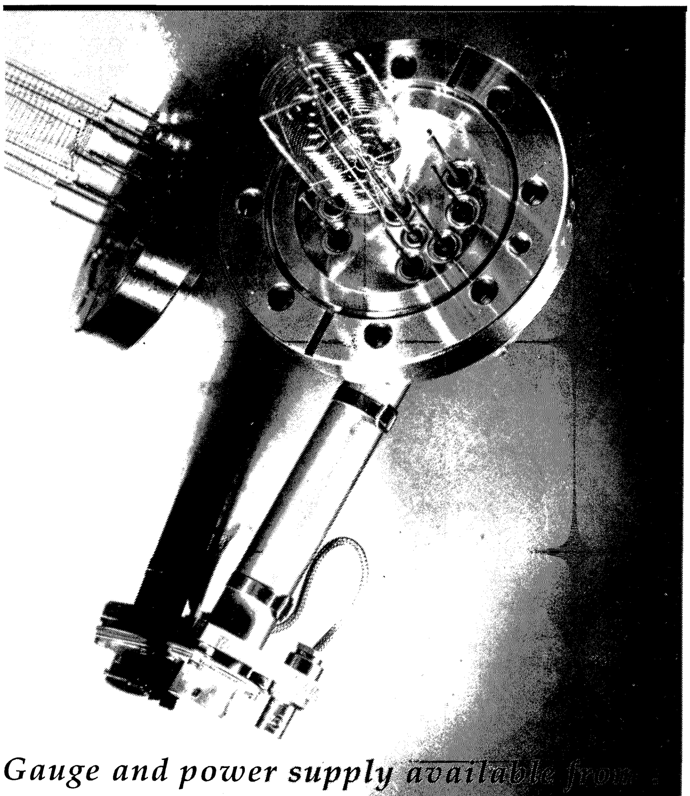

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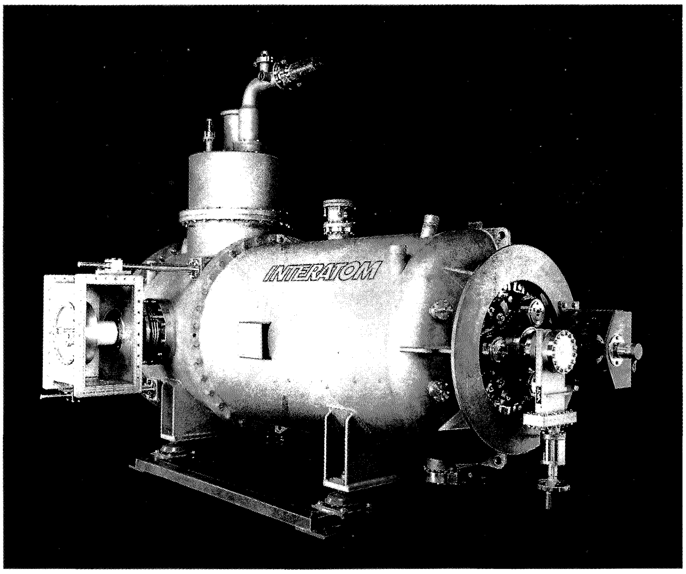

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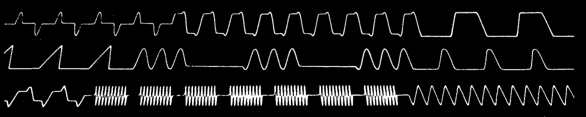

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**** A big new solar neutrino detector is also being constructed in the Baksan Laboratory in the Soviet Caucasus. A report will be included in our June issue.***

ectron polarization, eventually attaining 71 per cent at 1.26 eV. The thick sample showed no such enhancement.

A way is open for high polarization and high quantum efficiency photocathodes for linear accelerators.

JAPAN Super-Kamiokande goes ahead

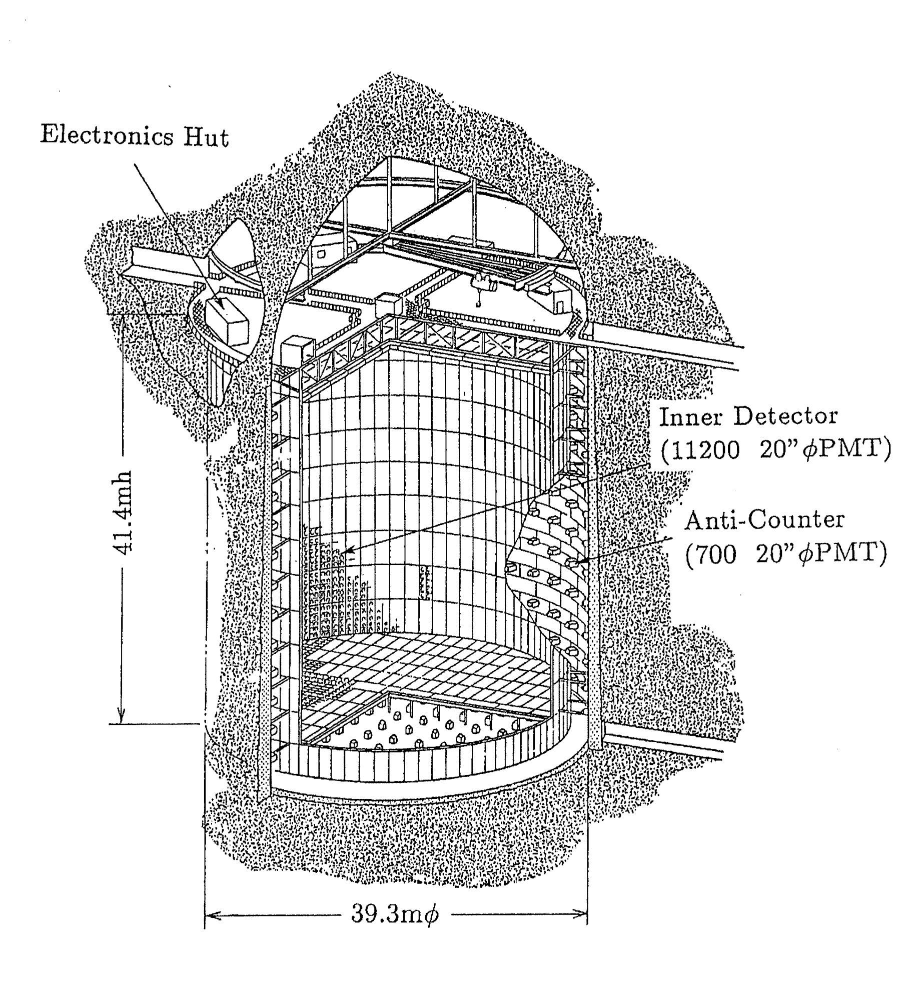
Now approved and funded is the Japanese Super-Kamiokande project for a greatly enlarged underground neutrino detector. Costing 8.7 billion yen ($62 million), construction is getting underway now and will continue until early 1996.

The detector will contain 50,000 tonnes of water, viewed by 11,200 50-cm diameter photomultiplier tubes to pick up Cherenkov radiation from traversing particles.

Underground physics began in the Kamiokande mine in the mid-80s, the existing detector using some 3,000 tonnes of water.

Neutrino observations from the 1987 supernova showed that neutrino astronomy has now an important role to play, while the ongoing goal of solar neutrino studies is to establish a complete picture of neutrino emission from the Sun.

The motivation for many underground experiments came from Grand Unified Theories (page 1) and their prediction of an unstable proton. With no sign of this instability yet found, the big new detector will be able to probe longer decay times (10^{33-34} years).



Sketch of the Japanese Super-Kamiokande underground neutrino detector, scheduled to come into operation in 1996.

SUPERCOLLIDER Preparing for experiments

Following an initial selection of two experiments from the letters of intent submitted last year (March, page 3), preparations for the research programme at the planned US Superconducting Supercollider (SSC) continue.

A two-detector scenario consisting of the SDC Solenoidal Detector Collaboration led by George Trilling and the L* collaboration led by Sam Ting has now been endorsed by the SSC Laboratory as providing opportunities for an outstanding initial scientific programme with significant complementarity, but which will need the full participation of the international community.

The next stage is submission of a technical proposal/design report from each of the two experiments by April next year, showing that its total cost will not exceed $500 million unless firm commitments from overseas expand the budget envelope.

This financial ceiling has serious implications in particular for the L* proposal, where an independent assessment indicates costs considerably in excess of $500 million. Cost reductions of some 15 per cent in the basic detector design are being sought.

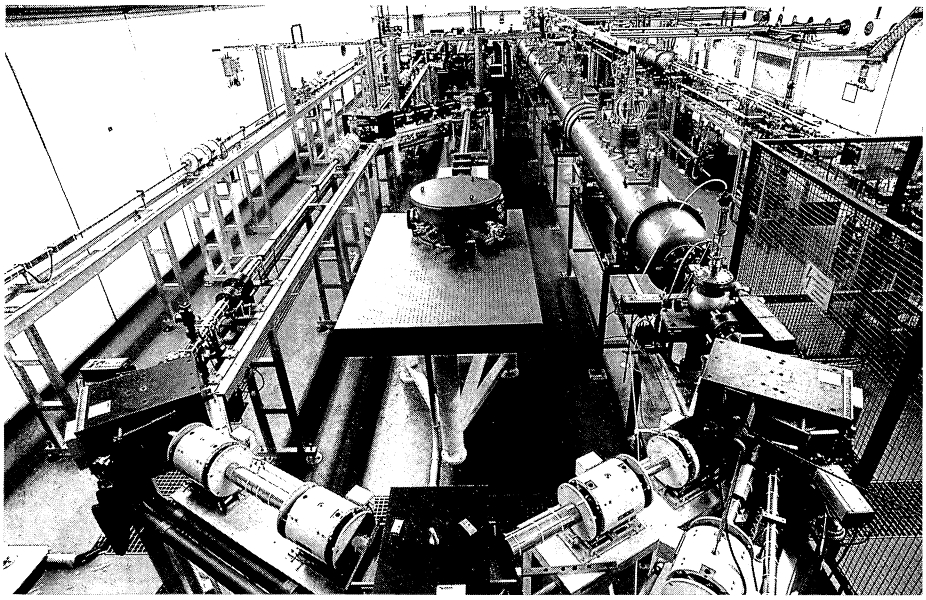
In addition, a revised L* management structure has been proposed, with an Executive Committee led by spokesman Sam Ting, and a new Management Board whose Chairman will also act as leader of the US groups in the collaboration. Barry Barish of Caltech has been elected to this new position.

Meanwhile the now traditional SSC Industrial Symposium, held this year in Atlanta, attracted strong interest. Department of Energy SSC Project Manager J. Cipriano and SSC Laboratory General Manager E. Siskin stressed that building the 87-kilometre ring and associated infrastructure to the proposed budget and schedule will be a major challenge, for which any delays would add about a million dollars per day.

'We're going to build what we said we would build and we're going to be relentless in doing it,' insisted Siskin. From the perspective of the IISSC meeting, the project resembles somewhat a major defence-style project than a traditional approach to physics facility construction.

The big meeting mirrored the enthusiasm and momentum now behind the SSC project in the wake of Gulf War successes. The initial physics community which launched the SSC idea is now only a part of what has become a major national undertaking, backed by impressive resources and widespread commitment from the US Administration, from Congress, from local authorities, from the educational sector, and especially from industry.

The S-DALINAC superconducting electron accelerator at Darmstadt. Right is the pre-acceleration and injection beamline into the 10 MeV injector. After an initial pass through the 40 MeV linac (centre right), the beam is recirculated twice using the two beamlines on the left. The electron beam can also be deflected from the first recirculation beamline into the undulator of a free electron laser (background). The tunable infrared laser beam's 15 m optical cavity is seen centre.



DARMSTADT
Superconducting electron accelerator in operation

In December, the S-DALINAC superconducting radiofrequency electron accelerator at the Nuclear Physics Institute of Darmstadt's Technische Hochschule was completed. This pioneer continuous-wave (c.w.) machine passed a major milestone several years ago when it accelerated its first low energy electron beam (September 1987, page 34).

The S-DALINAC consists of an injector and a main linear accelerator where the electron beam is accelerated three times (an initial acceleration pass and two subsequent recirculations). It has been operated so far with beam energies of 6, 29, 52 and 75 MeV, and after initial acceleration tests will be slowly tuned up to its rated energy of 130 MeV.

With the CEBAF electron machine (to provide continuous electron beams at 4 GeV) now under construction at Newport News, Virginia, and with European nuclear physicists pushing for high energy electron machines (January/Februa ry, page 22), initial S-DALINAC performance will be followed with much interest.

The Darmstadt accelerator, designed mainly for nuclear physics and free electron laser (FEL) research, was originally planned by a collaboration between Wuppertal's Gesamthochschule and Darmstadt's Technische Hochschule.

Built at the latter institution by a enthusiastic team comprising a small scientific staff, a lot of students and only a few technicians, its successful completion shows how an advanced and sizable technical project can still happen at a University laboratory.

(Another recent example, also Germany, is the MAMI continuous electron source at Mainz, using conventional accelerating technol gy – April, page 12).

The Darmstadt accelerating ca ties – one 0.25 m 5-cell cavity a capture section in the injector and ten 1 m 20-cell cavities behind it – are made of niobium metal and are of a now standard design.

However in contrast to the cavities now being used or introduced in high energy electron machines throughout the world, the S-DALINAC cavities are operated at a higher frequency (2997 MHz) and a lower temperature (2K, using supercooled liquid helium). The high frequency and thus small cavities result in a very economic cryostat and a slim accelerator.

The S-DALINAC delivers a continuous (c.w.) beam current and, with the continuous variation of input power in the injector and the recirculating linac, a wide range of beam energies (2-130 MeV), while beam currents and their time structure can be varied to suit different needs.

For nuclear physics experiments beam currents of 20 microamps with a bunch spacing of 334 ps are available, while average beam currents of 60 microamps are used to drive the infrared FEL (tunable between wavelengths of 2.5 and 5 microns). In the latter case the electron bunches are 100 ns apart, corresponding to a 10 MHz repetition rate. Peak current in the bunch is then as high as 2.7 A.

Increased reliability and stability have resulted from recent developments including the use of new high purity 20-cell niobium cavities manufactured at Dornier, Friedrichshafen, and tuned for high field flatness at Darmstadt. These cavities are operated with accelerating fields well in excess of 5 MV/m.

Furthermore, a microprocessor-controlled radiofrequency system to operate these cavities has been constructed. Tuners with magnetostrictive elements integrated into the r.f control have been developed and are now used routinely with all cavities .

The accelerator has so far been operated for 2600 hours with low energy beams for nuclear physics and channeling radiation experiments. These studies are continuing with higher energies, while the FEL facility, whose undulator is now in place, is also being put through its paces.

The main accelerator development programme will concentrate on bringing the machine up to higher energies, in gaining long-term operational experience and in testing new superconducting cavity types for very high energy superconducting accelerators in the context of the TESLA (TeV Energy Superconducting Linear Accelerator) collaboration (April, page 16).

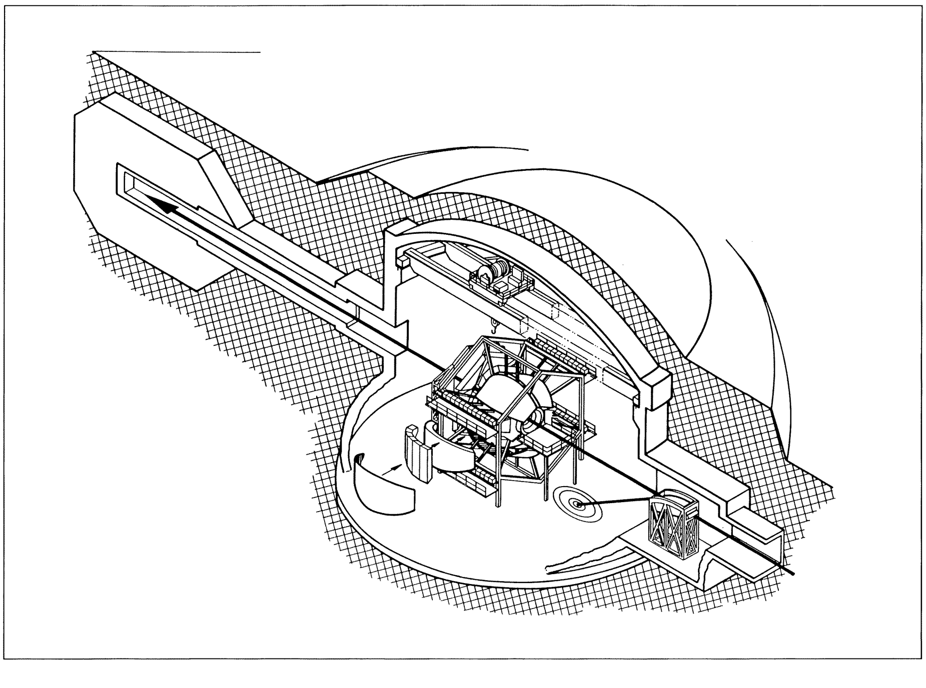
A 9-cell 5 GHz cavity fabricated at Cornell and finished at Wuppertal will soon be installed and tested with electron beams. Since the Darmstadt accelerator can provide true c.w. beams with narrow and large bunch spacing both with and without a superimposed macrostructure, a 'collider-like time structure' of the beam is possible.

CEBAF First experimental equipment

The Continuous Electron Beam Accelerator Facility (CEBAF) under construction in Newport News, Virginia, has ordered its first major piece of experimental equipment: the superconducting toroidal magnet for the CEBAF Large-Acceptance Spectrometer, CLAS.

This large instrument will detect multiparticle final states in nuclear physics experiments in one of CEBAF's three experimental halls. Six

First experimental equipment to be ordered for the CEBAF electron accelerator under construction at Newport News, Virginia, is the Large-Acceptance Spectrometer.



superconducting coils arranged symmetrically around the beam beamline will generate CLAS' magnetic field.

The $6.54 million contract went to Oxford Instruments of the UK. Eight experiments for CLAS have been approved, with another six conditionally approved.

Equipment procurement is also advancing for the other two CEBAF halls, one to have a pair of high resolution spectrometers, the other a high momentum spectrometer with complementary instrumentation. The halls themselves are half finished.

BROOKHAVEN RHIC intent

With construction of the Relativistic Heavy Ion Collider (RHIC) imminent and its physics programme expected to start in 1997, a call for Letters of Intent for experiments was issued last year.

Nine letters were submitted by collaborations from over fifty universities and research centres, represented by over 300 researchers from the US and abroad. The proposed detectors varied in their scope and physics focus, but all were designed with high segmentation to cope with the 10,000 or so secondary particles expected from each collision of gold nuclei at 100 GeV per nucleon per beam.

Such segmentation, and bunch crossings every 114 nanoseconds, put high demands on the density and speed of the readout electronics. The detectors also aim to utilize RHIC's flexibility to accelerate ions ranging from the light (protons) at 250 GeV to the heavy (gold) at 100 GeV per nucleon, and colliding different beams at several energies.

These detectors will provide the first look at the new domain of extreme nuclear densities that is RHIC's hallmark. Each is designed to focus on multiple indicators of the formation of the long-awaited quark-gluon plasma (QGP) and the liberation of quarks from their confinement inside hadrons. These heavy ion collisions are expected to approximate to the conditions of the microsecond following the Big Bang, thus providing a new link between particle physics and cosmology.

The Letters can be grouped in three broad categories – electron and photon detectors augmented with tracking for hadron identification, tracking detectors that stress particle production spectra, and one muon detector.

Three letters belong to the first category. TALES, proposed by a Japanese-led collaboration, plans a two-arm photon and hadron spectrometer with two conventional dipoles for momentum analysis, time projection chambers for tracking, electromagnetic calorimetry for photon and electron detection, and ring-imaging Cherenkov counters augmented by time-of flight counters for particle identification. The detector aims to pick up electron pairs, a good probe of the quark-gluon plasma since they are not prone to final state strong interactions.

The OASIS letter, submitted by a collaboration led by Columbia and Brookhaven, proposes a very large axial field spectrometer, possibly utilizing recycled magnet iron from the Gatchina cyclotron in Leningrad. The ambitious programme attempts to identify several quark-gluon plasma signatures simultaneously: a high resolution liquid argon calorimeter of novel design for electron and photon detection; transition radiation trackers, time-of-flight scintillators and Cherenkov counters for hadron identification and studies of jet production; and finally silicon strip as well as silicon drift detectors for vertexing and global event characterization. The detector is tailored to measure low mass electron pairs and high transverse momentum direct photons as well as jets.

The third letter in this category comes from a Stony Brook-led collaboration that uses a six-coil superconducting air toroid configuration with cesium iodide and lead-glass calorimetry of varying levels of energy and spatial resolution for electron and photon measurements augmented by transition radiation tracking detectors for electron and hadronic tracking, and silicon strip detectors for vertexing and multiplicity detectors. The emphasis again is on jet physics, direct photons and electron pairs at high transverse momenta.

The next group of letters emphasize hadron tracking and particle production spectra in both transverse momentum and angular distribution. A forward, variable angle spectrometer is proposed by a Brookhaven group, with septum dipoles, a time projection chamber for tracking, and Cherenkov counters to measure particle yields. The projected coverage extends from the very forward baryon-rich region well into the baryon-free region expected from quark-gluon plasma formation. The sought-for signatures are particle/antiparticle ratios as well as the relative yields of various quark flavours, such as kaon to pion ratios.

A complementary experiment, MARS, led by a group from MIT,

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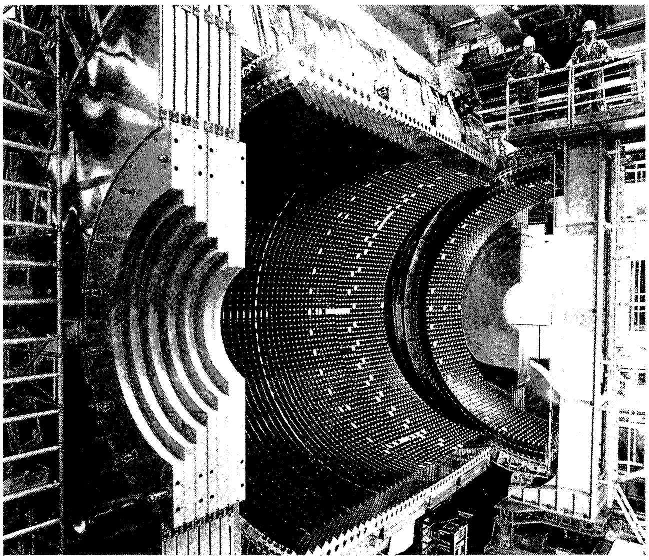
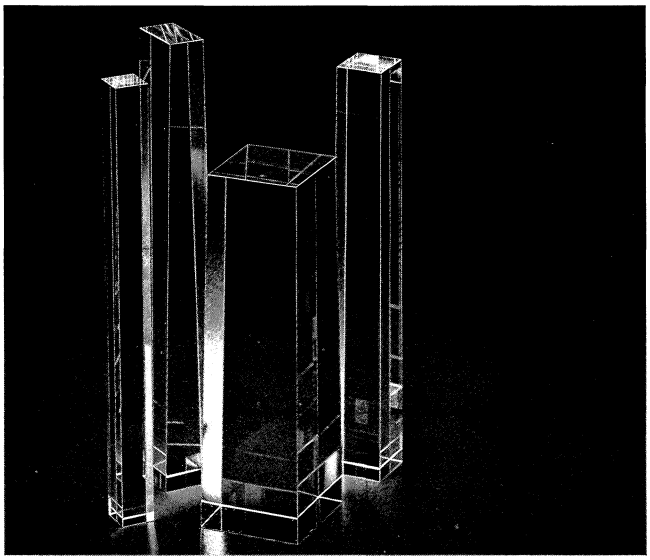


(Photo: CERN)



In search of the structure of matter, energies and directions of myons need to be determined. Quarks, as they are called, and other instable fractional parts of atoms are generated when highly accellerated electrons and positrons collide.

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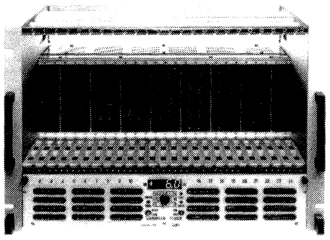

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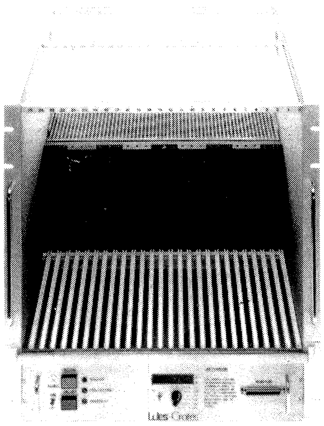

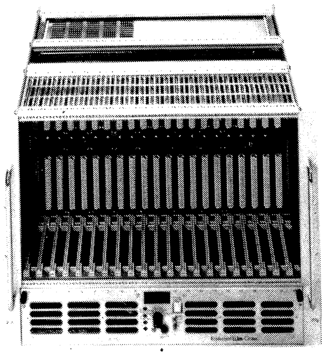

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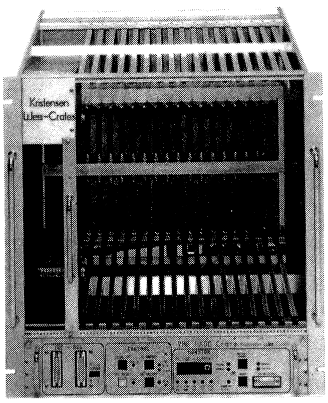

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chose a superconducting axial magnetic field with a full ring of 'straw' drift tube tracking and time-of-flight counters to measure particle yields in the central region. The design stresses modular construction with a potential for expansion should the physics warrant it.

Two large tracking detectors propose measuring particle yields using the time projection chamber technique. A Berkeley-led collaboration chose a superconducting solenoid surrounding a time protection chamber to measure particle spectra, hard jet processes, and meson production as well as two-particle correlations indicating the size of the QGP interaction volume. The time projection chamber would be augmented by a silicon strip detector to handle vertexing and multiplicities, and an electromagnetic calorimeter for photon detection in addition to a time-of-flight system.

The second time projection chamber, from users of the Brookhaven AGS multiparticle spectrometer, chose a dipole magnet with nearly complete solid-angle coverage in tracking, and time-of-flight systems in the forward directions. The detector is designed to provide full event characterization, as QGP formation will produce remarkably different particle spectra to those of normal hadronic interactions.

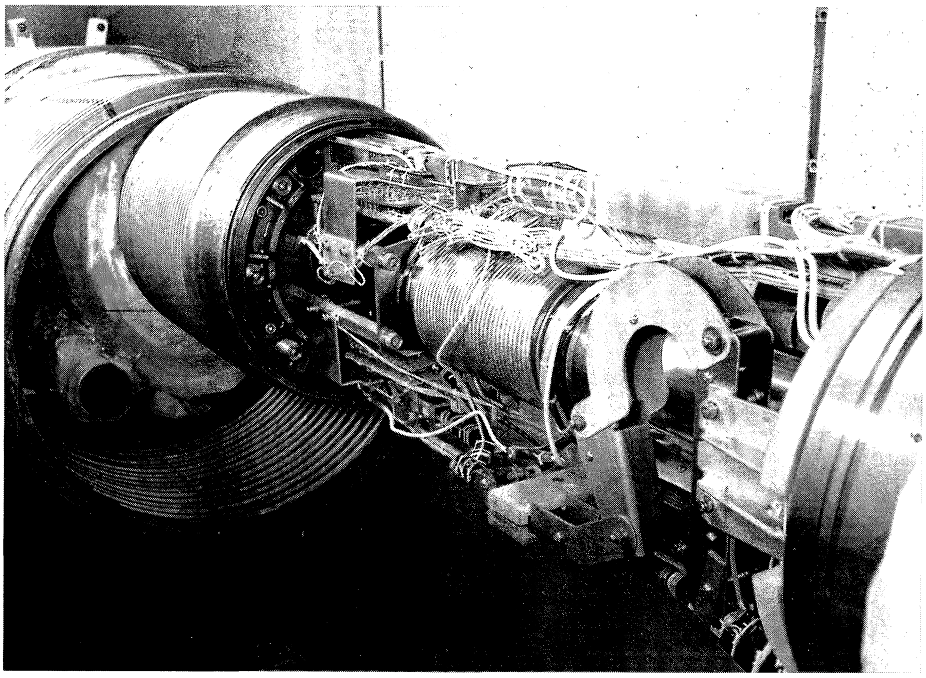
Finally, a detector proposed by a collaboration led by a group from Oak Ridge will concentrate on muon pair detection. The design utilizes superconducting toroids in the central as well as the end-cap regions filled with steel and alumina absorbers to stop hadrons and provide a clean sample of muons. The heavy detector is segmented into a central system and two end-caps. A small 'port spectrometer' has no absorber and is equipped with tracking and calorimetry to study hadronic as well as direct photon production at high transverse momenta. Silicon strips provide vertexing as well as tracking in the port spectrometer.

The physics programme for all these detectors involves studies of proton-proton, proton-nucleus and nucleus-nucleus collisions to study the evolution of QGP signatures with increasing nuclear density.

The RHIC project is funding research and development in readout electronics, triggering and data acquisition, silicon strip detectors, time-of flight systems, photon calorimeters, and hadron absorbers.

In addition to the plans for heavy ion experiments, a letter submitted by a Brookhaven-led collaboration proposes to use the colliding proton option to study proton-proton reaction rates at collision energies up to 500 GeV. While proton-antiproton reaction rates have been measured elsewhere at collision energies up to 1.8 TeV, proton-proton rates have only been studied at much lower energies, and RHIC can fill this gap. The proposal calls for scintillator fibre detectors a few millimetres from the beam to measure scattered protons at the lowest possible momentum transfer.

Two or more medium/large detectors would be the ideal RHIC scenario, but final decisions have to be matched to the resources available. After looking at the letters of intent, Brookhaven management is looking for a consolidation of effort to achieve as many physics objectives as possible with the initial detector complement allowed by the available funding. A meeting at Brookhaven on 19-20 April explored these possibilities.



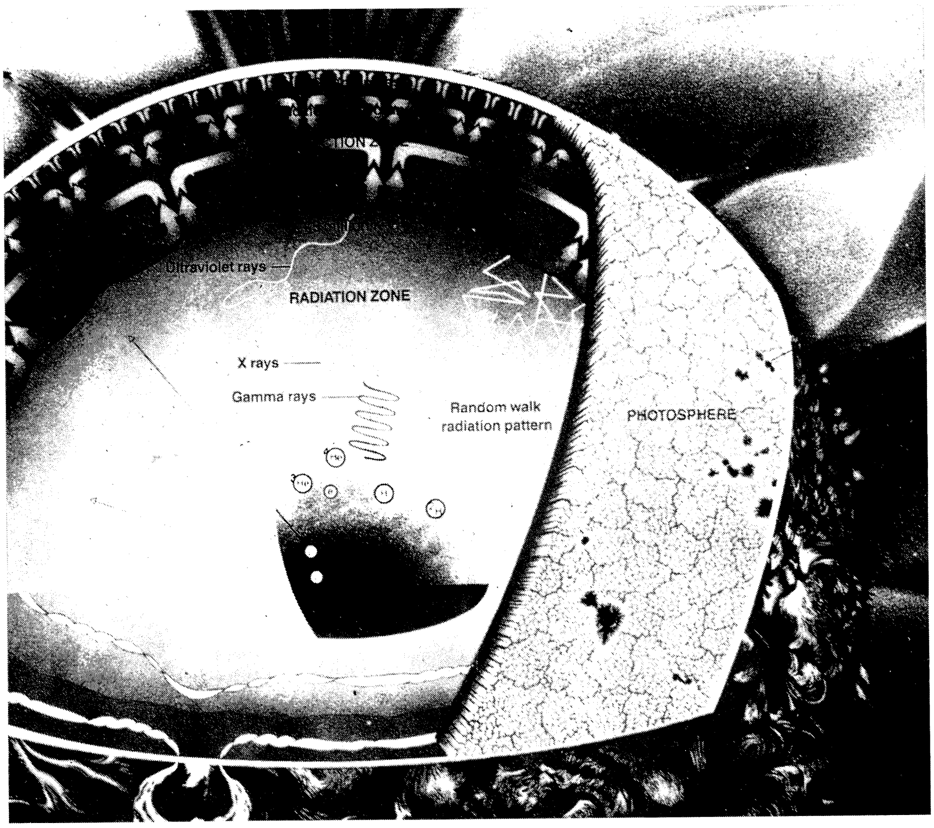
Interconnection between dipole magnet (right) and quadrupole/sextupole assembly for the RHIC high energy ion collider to be constructed at Brookhaven.

RHIC magnets

The first prototype superconducting magnets for Brookhaven's RHIC Relativistic Heavy Ion Collider have successfully passed initial performance tests. RHIC will use 1600 such magnets, some 400 of which will be built by Brookhaven, the remainder coming from industry, but based on the Laboratory's prototypes.

A ceremony on 12 April marked the beginning of RHIC construction. Keynote speaker was Presidential Science Advisor D. Allan Bromley.

Physics monitor



The temperature of the incandescent gas (mainly hydrogen) ball of the Sun ranges from 6000 degrees at the surface to 15 million degrees at its centre, where proton nuclei fuse together into deuterium, liberating a positron and a neutrino. Subsequently other reactions produce additional neutrinos, but most solar neutrinos emanate from the central fusion process.

Electromagnetic energy (photons) from nuclear reactions deep inside the Sun can take millions of years to migrate to the surface and escape. Neutrinos on the other hand give a unique glimpse deep into the Sun's interior, but the interpretation requires a representative sample of these elusive particles.

NEUTRINOS
Moriond spotlight

The regular 'Rencontres de Moriond' meetings in the French Alps, which celebrate their 25th anniversary this year, have a strong tradition of reflecting new trends in physics thinking and January's session on 'Tests of Fundamental Laws in Physics' was no exception. The spotlight this time fell on the neutrino sector, a branch of physics frequently in evolution, if not controversial. Currently the solar neutrino problem is still a preoccupation, while a wave of new heavy neutrino results also awaits clarification.

The Moriond neutrino sessions began with a review by D.Vignaud of the status of the 'solar neutrino problem' – the discrepancy between theoretical predictions (based on solar model calculations) and the experimentally observed fluxes of neutrinos from the Sun.

So far solar neutrinos have been detected in two experiments: the pioneer study led by Ray Davis, which began data-taking in 1970 and continues to run, and the Kamiokande II collaboration, operational in Japan since 1987.

The former uses the chlorine-37/argon-37 radiochemical method for detecting solar neutrinos, suggested in 1946 by Bruno Pontecorvo and somewhat later independently by Luis Alvarez. Neutrino capture in chlorine-37 has a threshold energy of 0.816 MeV. Davis' team uses a tank filled with 615 tons of perchloroethylene, and the observed average rate of argon-37 production over 20 years is approximately one atom every two days.

A remarkably efficient radiochemical method had to be developed to extract and detect the precious few unstable argon-37 atoms (half-life 35 days) produced by the solar neutrinos during exposures ranging typically from 35 to 60 days.

The Kamiokande II collaboration looks for Cherenkov radiation from neutrino interactions in a tank containing 3000 tons of water, of which only 680 tons are used for solar neutrino detection. The detector is presently capable of registering solar neutrinos above 7.5 MeV.

Both studies register neutrinos supposedly emitted in the decay of boron-8 with energies up to 14 MeV. According to current wisdom, boron-8 neutrinos are only a small fraction (one in ten thousand) of the total flux of solar neutrinos on the Earth's surface – approximately 6 x 10^{10} per sq cm per s.

The predicted value of the boron-8 neutrino flux is extremely sensitive to the temperature in the Sun's core where these neutrinos are thought to be produced.

Approximately 14 per cent of the argon-37 production rate seen by Davis' team is predicted to be due to monochromatic 0.86 MeV neutrinos produced with lithium-7 by electron capture in solar beryllium-7.

The solar-neutrino-induced event rates observed by Davis' team and Kamiokande II are typically several times smaller than predictions based on detailed solar model calculations. Estimates of the uncertainties in these calculations indicate that the discrepancy between the predicted and the observed event rates could actually be smaller.

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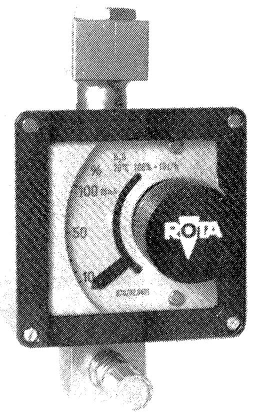

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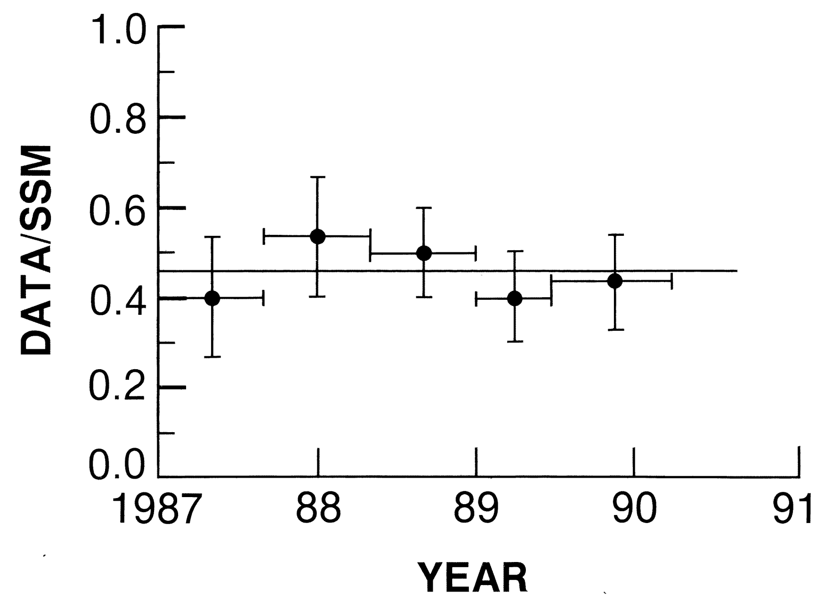
The solar neutrino flux (compared with the predictions of the Standard Solar Model – SSM) as seen by the Kamiokande II detector in Japan shows no appreciable time variation. Some hypotheses call for the solar neutrino signal to be linked with the sunspot cycle.



G.A. Bazilevskaya et al. that the solar neutrino flux detected by Davis' team varies in time, being (anti)correlated with the solar activity. A measure of the Sun's activity is the number of sunspots on its surface, in turn related to the strength of the toroidal component of the solar magnetic field. The latter is known to vary over a 11-year half-cycle, the last two maxima of the sunspot number having been in 1979-1980 and in 1989-1990.

D. Vignaud presented the results of four independent statistical analyses of data from Davis' team, all reporting evidence for (anti)correlation, although at very different levels of statistical significance.

The results of the Kamiokande II collaboration on possible variation of the solar neutrino flux from 1987-1990, presented by Y. Suzuki, show no time variations.

Solar neutrino studies have been boosted recently by the arrival of two new detectors – SAGE (Soviet-American Gallium Experiment in the Baksan Neutrino Observatory – June 1990, page 16) and Gallex (built by a collaboration of scientists from France, Germany, Israel, Italy and the US and installed in the Italian Gran Sasso Laboratory, January/February, page 10).

Rather than looking at a remote fringe of the solar neutrino spectrum, the major aim of these two experiments is to detect the major portion of the solar neutrinos – those accompanying proton fusion into deuterium, with a maximal energy of 0.42 MeV. This fusion is the first of a series of reactions eventually producing helium-4 and providing more than 98 per cent of the Sun's energy.

Measurements of this part of the solar neutrino flux would test basic ideas about the processes taking place in the initial stage of stellar evolution. Since these neutrinos come from a reaction which plays a fundamental role in the solar energy balance, their flux can be calculated more accurately than that of boron-8 neutrinos.

The theoretically predicted gallium-71/germanium-71 conversion rate in SAGE and Gallex due to solar neutrinos is approximately one atom per day, requiring the perfection of very efficient techniques to extract and detect the few germanium-71 atoms produced in the 30 ton detectors during typical exposures of 20-30 days.

Results from the first five physics runs of the SAGE collaboration, which took place between January and July last year, were presented at the Workshop by V. Gavrin. The observed rate of germanium-71 formation was found to be slightly above that expected due to background processes, with an upper limit of 74 SNU (each Solar Neutrino Unit – SNU – represents 10^{-36} solar neutrino captures per second per atom of target), smaller than the theoretically predicted rate of 132 SNU. (The contributions due to proton fusion, beryllium-7 and boron-8 neutrinos in the calculated rate are 71, 34 and 14 SNU, respectively.)

A crucial step in the interpretation of these results will be measurements of germanium-71 produced by neutrinos from a calibrated source.

A status report of the Gallex experiment was given by D. Vignaud. Here data-taking is not possible for the time being because of contamination of the detector by an unexpectedly large amount of radioactive germanium-68. This isotope was probably produced when the gallium-71 source material for the detector was stored for a certain time prior to installation underground without being protected from cosmic rays. This problem is being attacked.

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La qualité qui communique

The solar neutrino results of the Davis, Kamiokande II and SAGE experiments could have important implications for particle physics, signalling unconventional neutrino properties (like nonzero mass and mixing and/or a significant magnetic moment). The latter could imply partial conversion (due to vacuum or matter-enhanced oscillations and/or spin-flavour precession) of solar electron-type neutrinos into neutrinos of a different kind, undetectable by the current experiments, the transitions occurring during the solar neutrinos' journey from the central region of the Sun to the Earth's surface.

Hopefully new results from SAGE and Gallex over the next four years will help identify the cause of the solar neutrino problem, now more than fifteen years old.

With the Japanese Government's December approval for the improved 'Super-Kamiokande' detector (see page 9, reviewed at Moriond by Y. Suzuki), there are three more solar neutrino experiments in preparation (the other two being the Sudbury heavy water experiment in Canada – January/February 1990, page 23, and the Baksan chlorine-37 experiment, five times bigger than Davis').

All three are expected to accumulate much higher statistics than their predecessors. Although sensitive only to boron-8 and beryllium-7 neutrinos, they will be capable of measuring the total flux and spectrum of boron-8 neutrinos with high accuracy. The first results on this spectrum from Kamiokande II gave an initial glimpse of its shape.

Talks by R. Lannou, G. Zacek and R. Gaitskell on new methods of solar neutrino detection heralded the dawn of low energy threshold, high statistics, real-time detectors capable of measuring the spectrum of solar neutrinos from proton fusion.

Measurements of the overall solar neutrino spectrum and its different reaction components, which probably will not materialize before the end of the century, will reveal nuclear reactions deep inside the Sun, giving new information about solar physics.

The 17 keV neutrino (April, page 9) made a reappearance at Moriond, the first evidence (in the beta decay of tritium) having been presented by John Simpson in the January 1986 session. Subsequently, six spectrometer experiments looking for possible distortions of the beta-spectra of sulphur-35 and nickel-63 due to the emission of a 17 keV mass neutrino were performed between 1985 and 1989, all reporting negative results.

Meanwhile two additional experiments (with tritium and sulphur-35 implanted in semiconductor detectors) by Simpson and his student Andrew Hime confirmed the 17-keV sighting. Searches for a 17 keV neutrino continued by Hime and Nick Jelley at Oxford (with a sulphur-35 source), by Eric Norman's group at Berkeley (with a carbon-14 source), by a group at Zagreb (with germanium-71), all using semiconductor detectors and by a group at Caltech using a sulphur-35 source with a spectrometer.

Initial data from all these experiments were reported at the Workshop, the first three of seeing distortions in the beta spectra compatible with emission of a 17 keV neutrino, while the Caltech-based group gives a negative result.

With the electron coupled to a 17 keV neutrino as well as a massless (or lighter than 10 eV) neutrino, a new scenario is called for. In the neutrino mass and mixing hypothesis the electron-, muon- and tau-type neutrinos do not have definite masses, but rather are superpositions of at least three neutrino states of definite mass, at least some of which are nonzero.

The standard electroweak theory has only massless neutrinos, so that observation of a 17 keV neutrino could be the first evidence for the incompleteness of this theory.

Nonzero neutrino masses and mixing imply a remarkably rich spectrum of possible neutrino properties, a whole 'new world' of elementary particle physics. In particular, the electrically neutral massive neutrinos can be Dirac-type (having distinct antiparticles) or Majorana-type particles (coinciding with their own antiparticles), the type being determined by the symmetries of the underlying theory.

Dirac neutrinos can have intrinsic characteristics like magnetic and electric dipole moments which are zero for the Majorana neutrinos. Phenomenological considerations indicate that the 17 keV neutrino should be a Dirac particle if there are only three massive neutrinos and the neutrino oscillations are the cause for the solar neutrino problem. It can be a Majorana particle if, for instance, there are more than three neutrinos with definite mass. In this case at least one more 'heavy' Majorana neutrino should exist.

A 17 keV neutrino cannot be stable: cosmological arguments suggest that it should decay sufficiently fast into, e.g., three light neutrinos, or a light particle and neutrino. It should also show up in oscillation experiments with electron neutrino (and antineutrino) beams, leading to effects (for example the 'appearance' of tau neutrinos) of the order of one or two percent.

*** The June issue will include an article on the COBE results.**

Also reported at the Workshop were new results from cosmic ray studies; searches for dark matter, deviations from Newtonian gravitation, time-reversal violation in beta decay, the electric dipole moment of the neutron, and neutron-antineutron oscillations; strong field tests of gravitational theories and other subjects.

For the first time the session had an interdisciplinary character, with an invited lecture by Ed Fredkin on 'Digital Mechanics: the Universe as a Computer'. The improvised evening concert of classical music, given by attending physicists Michael and Myriam Treichel, Jim Faller, Elisabeth Ribs and Tibault Damour added to the pleasant informal atmosphere which is one of the elements of Moriond success.

By S.T. Petcov

ASTROPARTICLE PHYSICS
New synergy

Two major recent experimental results have further strengthened the links between particle physics and cosmology. These are the confirmation by experiments at CERN's LEP electron-positron collider that there are only three species of light neutrino, as predicted by Grand Unified Theories and needed for primordial nucleosynthesis, and the results from the US Cosmic Background Explorer (COBE) satellite that show beyond any doubt that the cosmic background radiation is primordial.*

With this in mind, a new international school was initiated recently by Houston's Advanced Research Center (HARC) and co-sponsored by the nearby Superconducting Supercollider Laboratory. It attracted many distinguished speakers in this rapidly evolving field, resulting in a wide-ranging and stimulating scientific programme.

CERN's John Ellis discussed the Standard Model of Particle Physics and beyond, and the implications of recent LEP data (April, page 1). Rocky Kolb of Fermilab gave an introduction to the Standard Big Bang, while School Director Dimitri Nanopoulos of Texas A&M and HARC presented a unified view of the two fields.

David Schramm of Chicago discussed the important issue of primordial nucleosynthesis, with the observational basis covered by Greg Shields of Texas (Austin). Robert Wagoner of Stanford examined probes of the Universe at all scales, from nuclei to supernovae. Andre Linde, now at Stanford, looked back to the very early stages of the Universe, including the inflation mechanism linking the initial Big Bang to present large-scale structure.

Mark Srednicki of Santa Barbara reviewed the need for Dark Matter, leaving his colleague David Caldwell to look at experimental searches for it. George Smoot of Berkeley discussed the beautiful COBE results confirming the nature of the cosmic background radiation, while Alan Dressler of Mt. Wilson and Las Campanas Observatories reviewed the intriguing large-scale structures, including the great attractor, the great wall and similar concentrations of matter, revealed by recent astronomical surveys. Nicola Vittorio of D'Aquila and Joe Silk of Berkeley tried to make sense of it all.

Neutrinos are never far from the physics headlines – currently solar neutrino observations are in a state of flux and there is a spate of reports on 17 keV neutrinos (see page 21). John Bahcall of Princeton was among the neutrino speakers at the Texas meeting.

Dimitri Nanopoulos – strengthening links between particle physics and cosmology

The status of Big Science was illustrated in talks on the US Superconducting Supercollider (SSC) from Fred Gilman, SSC's Associate Director of Physics Research; on NASA's role from Venon Jones; on the European Space Agency's work from Giacomo Cavallo; and on Hubble telescope from Peter Stockman of the Space Telescope Science Institute.

The meeting showed that while the 'Standard Models' of both particle physics and cosmology were doing fine, some refinements are necessary, especially for the Big Bang picture, at a loss to explain new large-scale structure. New simulations show that even cold dark matter, until now the best candidate for the missing material of the Universe, may not fit the bill. New observations over the next few years will help to clarify many of the major issues in both particle physics and cosmology. Hopefully a clearer picture will emerge before the second school in this series.

From Dimitri Nanopoulos

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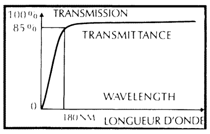

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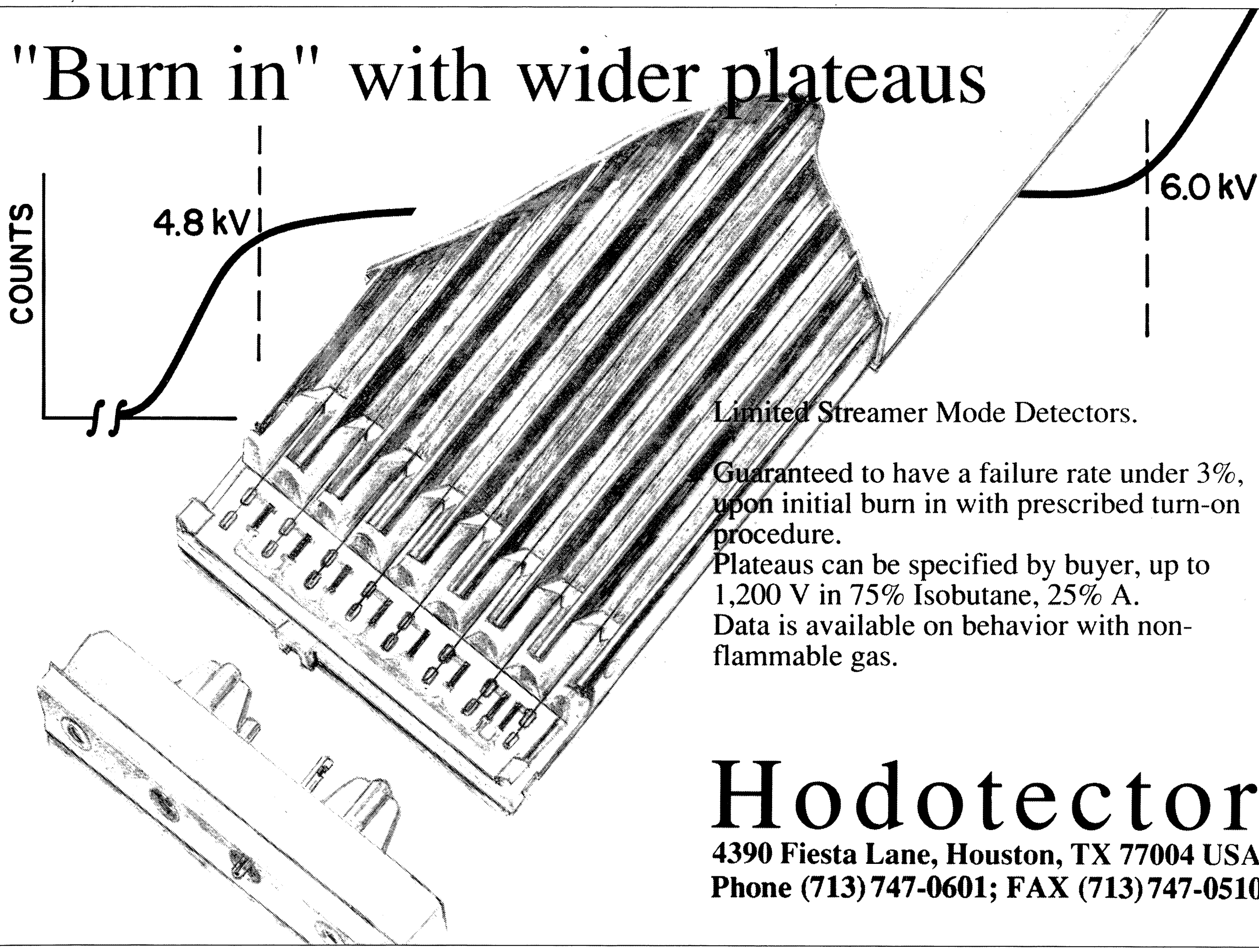

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Participate in research and development for the SSC detector components, design of the related experimental facilities to support of the SSC experimental program, and ongoing HEP research.

Qualifications: Ph.D. in experimental particle physics. Experience with large detector systems preferred.

Computational Physicist/Engineer

Perform magnetic field computations in support of the SSC magnet design and construction program.

Qualifications: An advanced degree in Physics, Electrical or Mechanical engineering; experience with the commonly available computer codes for magnetic field calculations. Experience with FORTRAN (preferably in a scientific computing environment) and with UNIX and VMS.

Collider Injector Physicists and Engineers

Take part in the accelerator design, and specification and implementation of the engineering systems.

Qualifications: Degree in Physics or Engineering; equivalent experience with modern computational methods; significant experience in accelerator construction and operation desirable; ability to work within a team and to interact with and communicate with other technical groups.

Magnet Test Physicist

Participate in the SSC superconducting magnet test program at FNAL, BNL, and SSCL.

Qualifications: Ph.D. in experimental physics (particle physics preferred). Experience with hardware and software; ability to plan and carry out testing programs.

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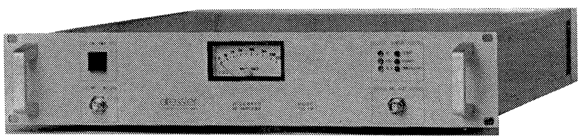

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HERA book

The HERA electron-proton collider soon to be commissioned at the DESY Hamburg Laboratory is the subject of a new book (in German) by DESY staffer Pedro Waloschek.

'Reise ins Innerste der Materie' (Journey into Innermost Matter) published by DVA recounts the building of the 6.3 kilometre collider and explains its scientific goals.

As well as being a distinguished scientist and author, Waloschek has faithfully served as DESY's CERN Courier correspondent since 1979. Since then scarcely a month has gone by without him keeping the CERN Courier, and thereby its 25,000 readers throughout the world, up to date on developments at DESY.

Quark Matter 91

'Quark Matter 91', the Ninth International Conference on Ultra-Relativistic Nucleus-Nucleus Collisions, to be held 11-15 November in Gatlinburg, Tennessee, will be dedicated to the memory of Leon Van Hove, Research Director General of CERN 1976-1980 and pioneer in studies of the quark-gluon plasma, who died last year.

As in earlier meetings, the emphasis will be on experimental and theoretical investigations of the production and properties of the long-awaited quark-gluon plasma. Franz Plasil is Chairman of the Organizing Committee. Further information – Quark Matter 91, Building 6003, MS 6372, Oak Ridge National Laboratory, PO Box 2008, Oak Ridge, Tennessee 37831-6372, phone (615) 574 4681, fax (615) 576 2822, bitnet QM91 at ORPH01

CERN Courier index

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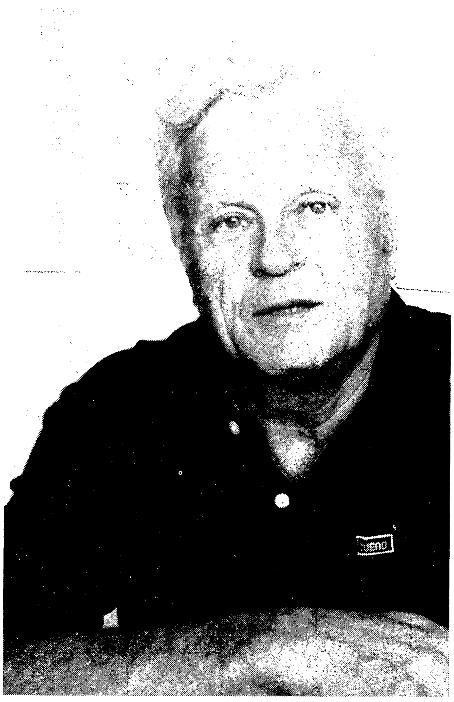
Nobuyuki Tanaka 1937-1991

Noby Tanaka, scientist and international research collaborator at the Los Alamos Meson Physics Facility (LAMPF) died on 23 February after a brief illness.

Noby came to LAMPF in 1969 after a doctorate from Tufts and became a key member of the High Resolution Spectrometer team. He subsequently joined in many collaborations on HRS and other LAMPF spectrometers, especially in the face of difficult challenges, such as mounting polarized targets in the spectrometers, and Noby's role brought him the friendship and esteem of colleagues from abroad. Subsequently he worked on polarized target experiments at Fermilab and was involved in planning for spin physics at the UNK machine being built at the Soviet Institute for High Energy Physics, Serpukhov. LAMPF founder Louis Rosen said 'Noby's death leaves an empty place in our hearts as well as our plans'.

Klaus Steffen 1925-1991.



Klaus Steffen 1925-1991

Klaus Steffen, well-known accelerator expert and one of the early staff members of the DESY Laboratory in Hamburg, died on 17 March. He had retired from DESY last year but continued to work enthusiastically on several new projects.

After eighteen months at the US Cambridge Electron Accelerator, in 1958 he began his Hamburg career in high energy electron accelerators and beam optics with Willibald Jentschke. After being involved in the construction of the 6 GeV DESY synchrotron (in particular the magnets for the experiments) and the 450 MeV linac, his masterpiece was the DORIS electron-positron storage ring, commissioned in 1974 and still in operation.

His knowledge of beam optics and magnet design proved invaluable in the construction of other accelerators. In particular he developed the 'mini-beta' focusing system for the PETRA storage ring and the spin rotators for the new HERA electron ring.

The direct and clear way he expressed opinions, proposed solutions and pointed out problems – always constructively and objectively – was highly appreciated, making him an ideal partner to discuss new ideas and projects. His excellent contacts included colleagues from Laboratories all over the world.

Sakharov-70

The 21 May would have been the 70th birthday of Andrei Sakharov, who died on 14 December 1989 (January/February 1990, page 29). The anniversary is being celebrated by some conferences in the USSR, and the reminiscences of colleagues will be published in a book 'Andrei Sakharov – Facets of a Life' (ISBN 2-86332-096-3) to be issued by Lebedev Physics Institute and Editions frontières.

The contributions follow pivotal periods of Sakharov's life, revealing both scientific and humane aspects of his personality. Many documents are published for the first time. The collection underlines the man's remarkable impact on the intellectual and moral foundations of the modern world.

A special May issue of the review journal 'Uspekhi Fizicheskikh Nauk' is also devoted to Sakharov, containing his main scientific papers and other revealing contributions, providing a natural complement to the new book.

First protons in HERA

On the night of 14/15 April, the first protons (at 40 GeV) were stored in the new 6.3 kilometre superconducting ring of the HERA electron-proton collider at the DESY Laboratory, Hamburg. The single bunch was held for about a minute, making several million turns.

The radiofrequency value did not have to be changed, meaning that the circumference of the ring is correct. The quadrupole and sextupole correction magnets were not brought into action, as the machine's working point and chromaticity were at their expected values.

The next stage is to attempt an initial beam acceleration.

TEXAS ACCELERATOR CENTER

Associate Directors

Positions are open for Associate Directors at the Texas Accelerator Center (TAC). TAC is a division of the Houston Advanced Research Center (HARC), a nonprofit research institution linked with 8 collaborative universities. Created in 1983, HARC has six research centers and a staff of 125. The mission at TAC is to perform research in accelerator physics including relevant spin-offs and training of physics students. It is anticipated that an Associate Director would be eligible for a parallel regular faculty appointment at one of the collaborative institutions and be able to advise Ph.D. graduate students. Technology transfer to industry is an important consideration at TAC.

The required qualifications are the same as for the director, since they would, as associate directors, be expected to function as director in his absence. These responsibilities include directing existing research projects, initiating new research, interaction with funding agencies, and administrative duties as director. TAC has a research staff of 10 physicists, 10 engineers and 15 technicians.

Present research at TAC includes:

- design, construction and testing of the ion source, the low energy beam transport and the radio frequency quadrupole for the SSC:
- design and testing of superconductor for superconducting magnetic energy storage (this is in collaboration with Bechtel and General Dynamics);
- design of a complete compact synchrotron light source and construction and testing of one superconducting magnet for the ring.;
- development of high field NMR for medical diagnostics including the construction of a 4 tesla, 1-meter-bore, self shielded solenoid;
- development of very high gradient cavities for future accelerators;
- R&D on greater than 25 Tesla superconducting magnets;
- development of a superferric self-shielded magnet for magnetically levitated trains;
- theory including non linear beam dynamics; and
- particle research on D0 at FNAL and SDC at SSC.
- TAC frequently collaborates with FNAL, ANL and BNL.

There are currently 12 physics graduate students doing their Ph.D thesis work at TAC on the various projects. TAC has a special collaborative relationship with Rice University, Texas A&M University, University of Houston, The University of Texas at Austin, Sam Houston State University, Prairie View A&M University and the Baylor College of Medicine MR Center. TAC is located at HARC in The Woodlands, Texas near Houston Intercontinental Airport. For more information contact:

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SURFACE SCIENTIST

Requirements include a Ph.D. in Chemistry or equivalent and two years experience with experimental and analytical surface science studies at a large light source installation. Knowledge of physical chemistry principles and practices; ultra-high vacuum system technology, design and analysis; fabrication and machining of materials; an understanding of machine drawings; and the ability to prepare sketches is also necessary. **(Box# 89271)**

VACUUM ENGINEER

A degree in Mechanical Engineering or equivalent and ten years experience are needed, along with excellent knowledge of ultra-high vacuum construction and measurement techniques, general lab instrumentation, and good skills in interpreting results. **(Box# 89281)**

DIAGNOSTICS GROUP LEADER

A Ph.D. in Physics or Electrical Engineering or equivalent, and comprehensive experience in the design of diagnostics hardware and electronics are required. Technical challenges include the designing of: extremely sensitive beam positron monitors for the storage ring, a broadband longitudinal damper system, and a complex feedback orbit control system. Will also be responsible for a budget of over eight million dollars, while recruiting approximately four additional group members. **(Box# 92412)**

ELECTRICAL ENGINEER

Requires a Master's degree in Electrical Engineering or Computer Science; 5-7 years experience designing and programming hardware interfaces, digital electronics, and data acquisition systems. Experience with 'C', Unix, and data communications using ethernet and VME are required. Knowledge of VXI and implementing the latest communications architectures, including MXI bus and FDDI is desired. **(Box# 37995)**

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Post Doctoral Position in High Energy Physics

The experimental high energy group at the University of Houston seeks a Research Associate. The group's present involvements include the Spin Muon Experiment, now running at CERN, the Large Volume Detector, now being assembled at Gran Sasso, and the L* detector for SSC, now being designed. In-house work includes both R&D, and production of streamer tubes at the Streamer Chamber Assembly and Research Facility (SCARF), and the development of high T_c superconducting permanent beam magnets. The appointment will not be reviewed until the third year. Candidates should have a Ph.D. in high energy physics, and be available as soon as possible, and no later than September 1991. Applicants should send a vita, list of publications, and the names of three references to Prof. Roy Weinstein, Institute for Beam Particle Dynamics, 632 SR1, University of Houston, Texas, 77204-5506. The University of Houston is an Equal Opportunity/Affirmative Action employer.

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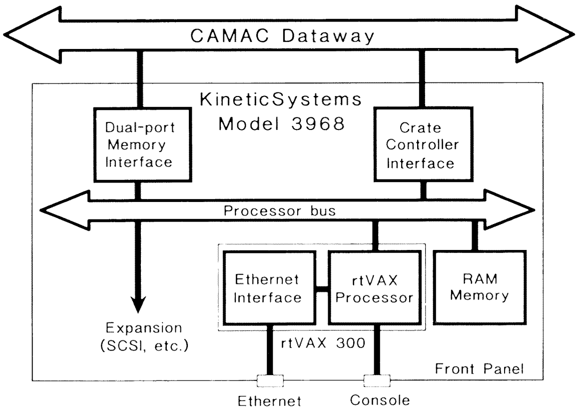

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The Stanford Synchrotron Radiation Laboratory (SSRL) is seeking two accelerator physicists to assist with the operation and development of SPEAR and its injector. SPEAR is a dedicated synchrotron radiation source that is now starting to operate with a newly built injector (Linac and Booster).

The successful applicants will work with a small group of accelerator physicists with responsibility for the accelerator physics studies of the SPEAR storage ring and its new injector.

Operating as a fully dedicated source, the SPEAR ring offers immense capability and potential as a synchrotron radiation source. Improvement plans include a low emittance optics, better beam stability, higher stored current and higher energy and several more insertion devices. The successful candidates will also be expected to contribute to the long-term upgrade of the facility involving state-of-the-art accelerator technology and to the studies of new and advanced concepts in the field of synchrotron radiation.

A Ph.D. in a related field is required. For a senior position, at least 5 years experience in accelerator physics is expected.

Applicants should write to Dr. Max Cornacchia, Stanford Synchrotron Radiation Laboratory, Stanford University, P.O. Box 4349, Bin 99, Stanford, CA 94309-0210, enclosing a curriculum vitae and names of at least two references.

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UNIVERSITY OF GENEVA

The Department of Nuclear and Particle Physics is involved in a program of detector development for the next generation of hadron colliders (LHC), and in particular at present a study of electron identification at high machine luminosities.

Applications are invited for the position of

RESEARCH ASSOCIATE

Responsibilities of the Geneva group in this program currently include electronic and mechanical aspects of detector design as well as associated physics simulations. Some involvement in an ongoing physics program may also be negotiated.

This post is limited to a maximum of six years, and applicants should have a PhD or equivalent in High Energy Physics. Applicants should send a resume describing their previous experience and major interests, before 31 May 1991, to

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Départment de physique nucléaire
et corpusculaire
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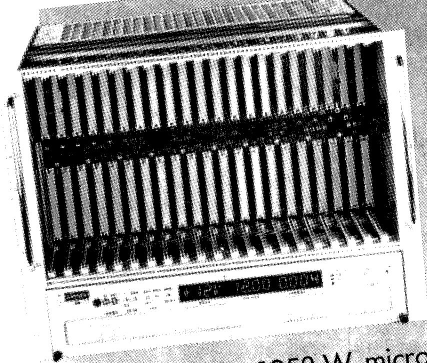

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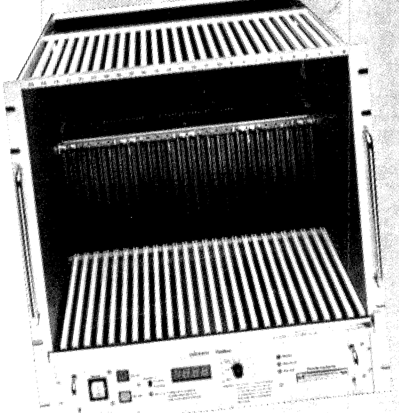

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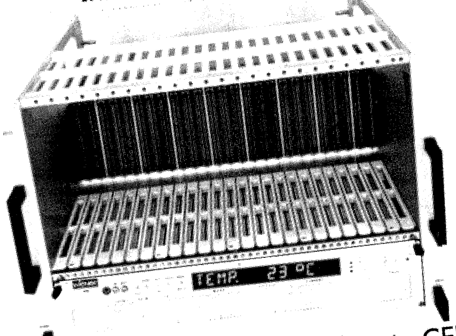

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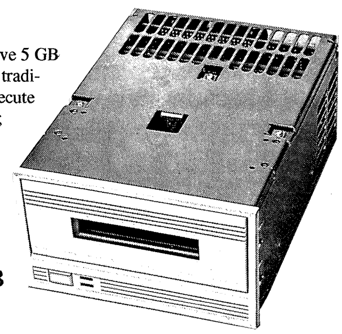

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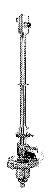

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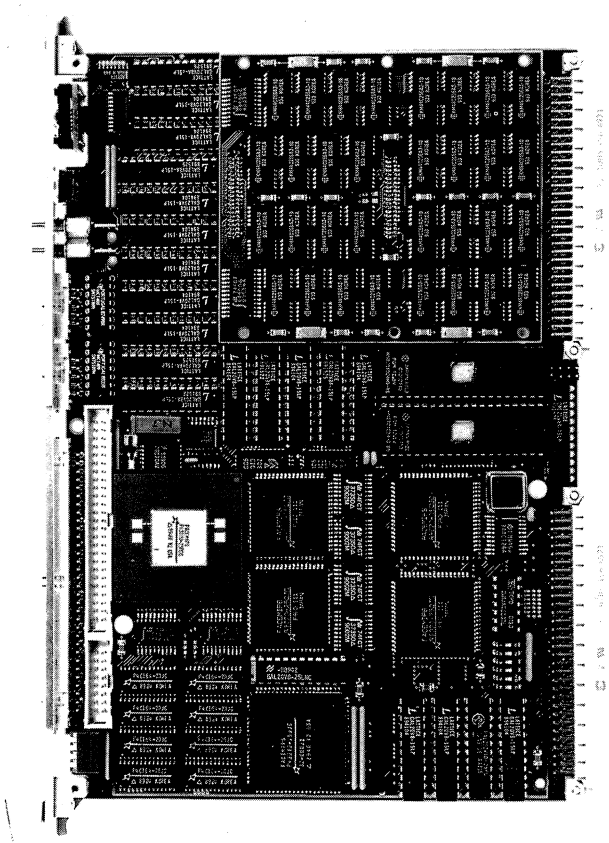

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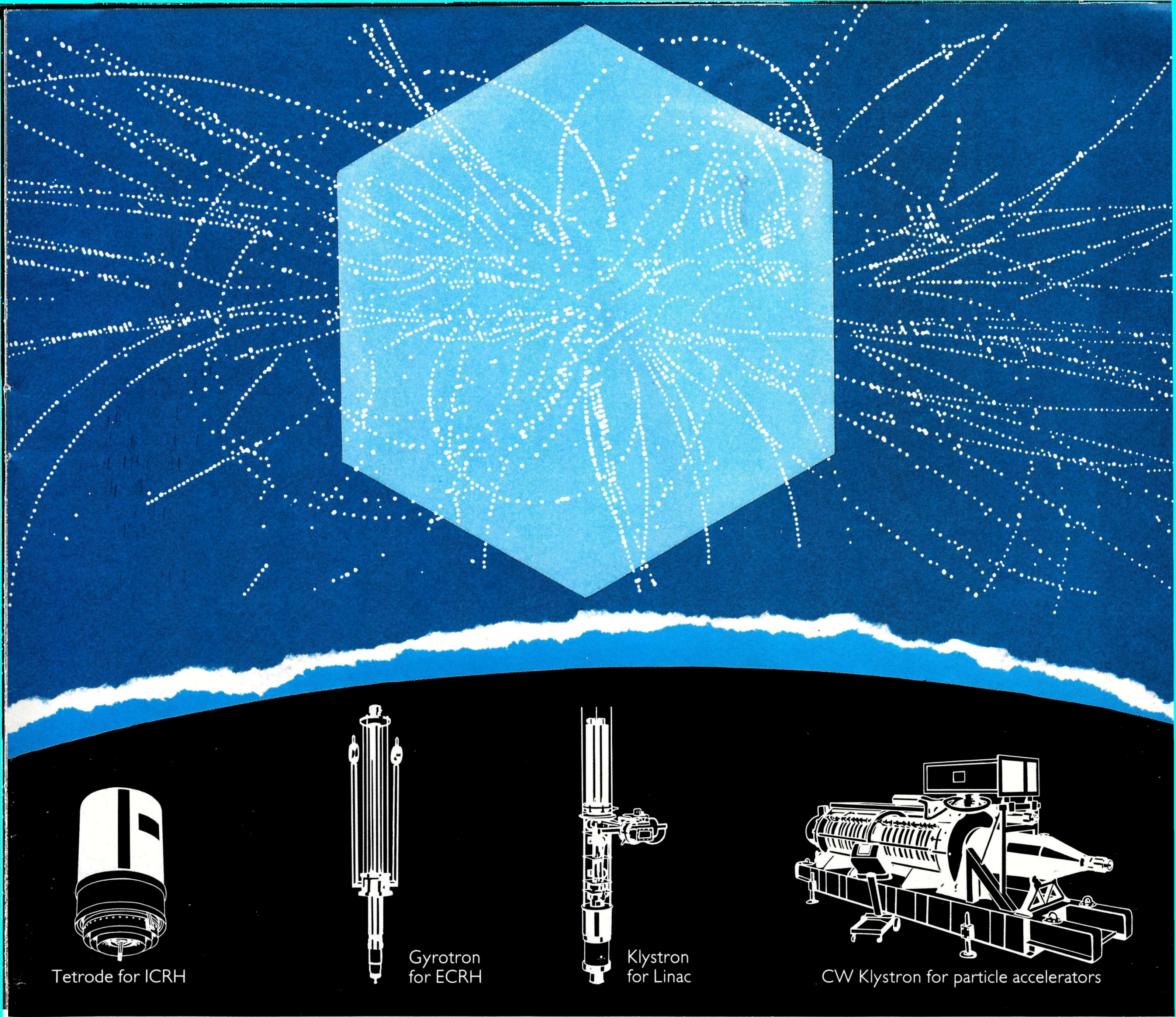

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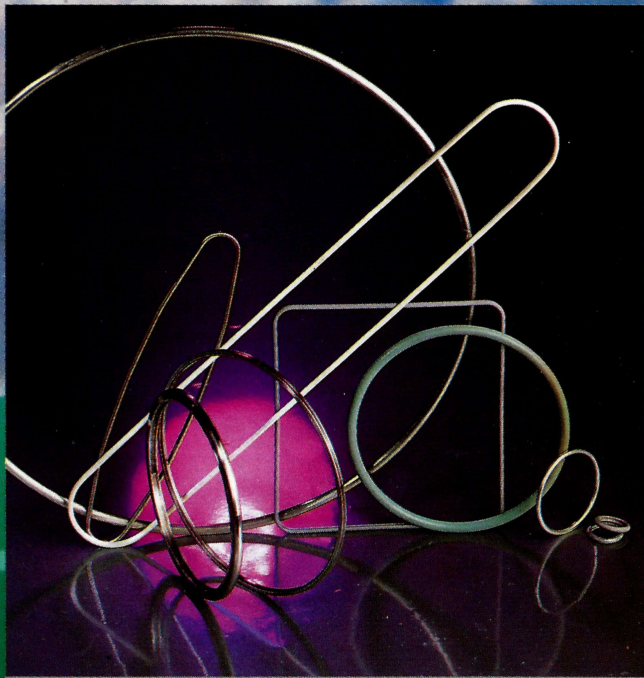

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