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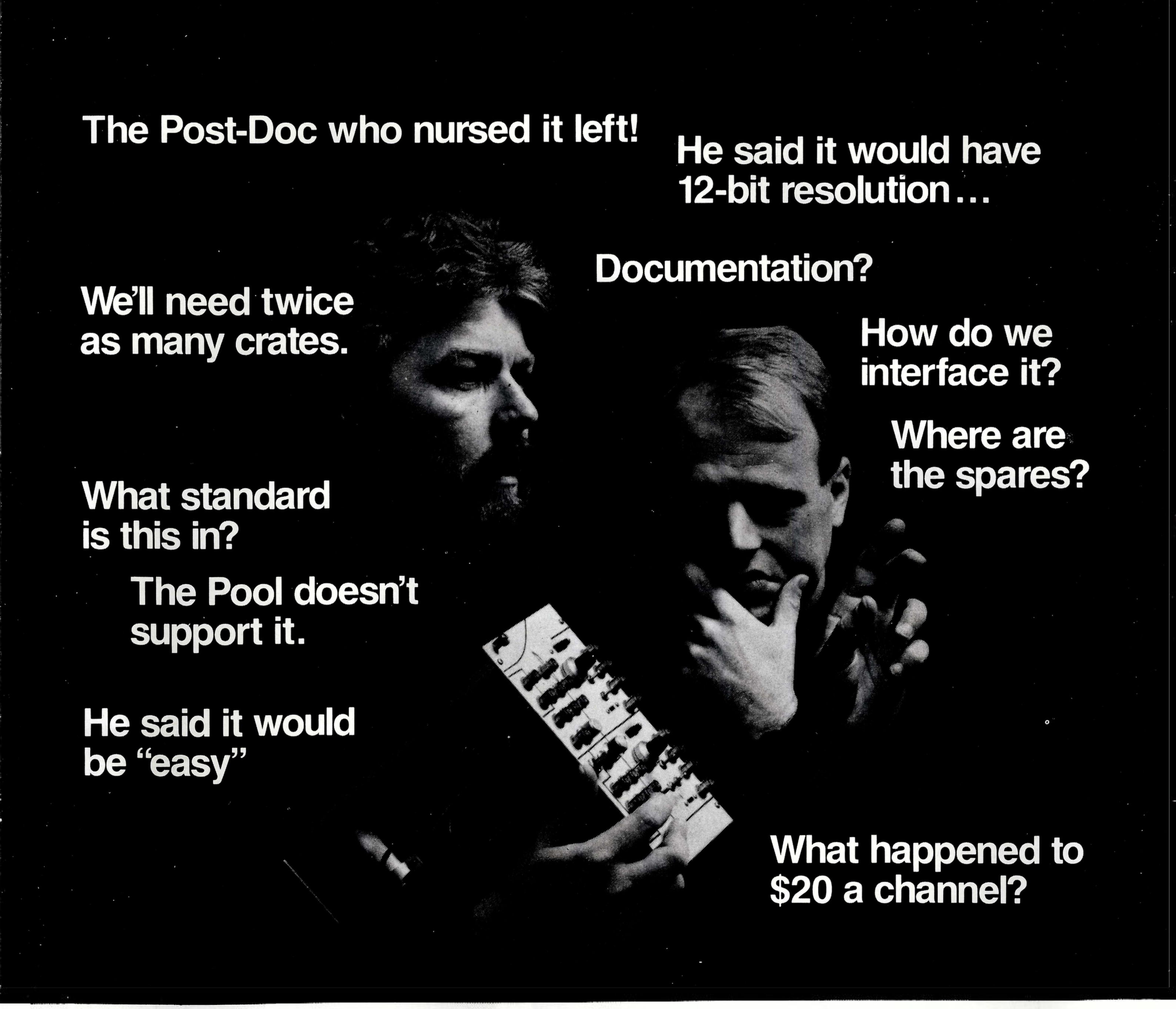

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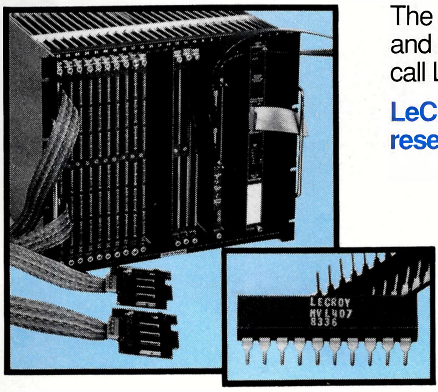

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Covering current developments in high energy physics and related fields worldwide

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Exploratory drilling for the 87 kilometre Superconducting Supercollider (SSC) to be constructed in Ellis County, Texas (see page 6).

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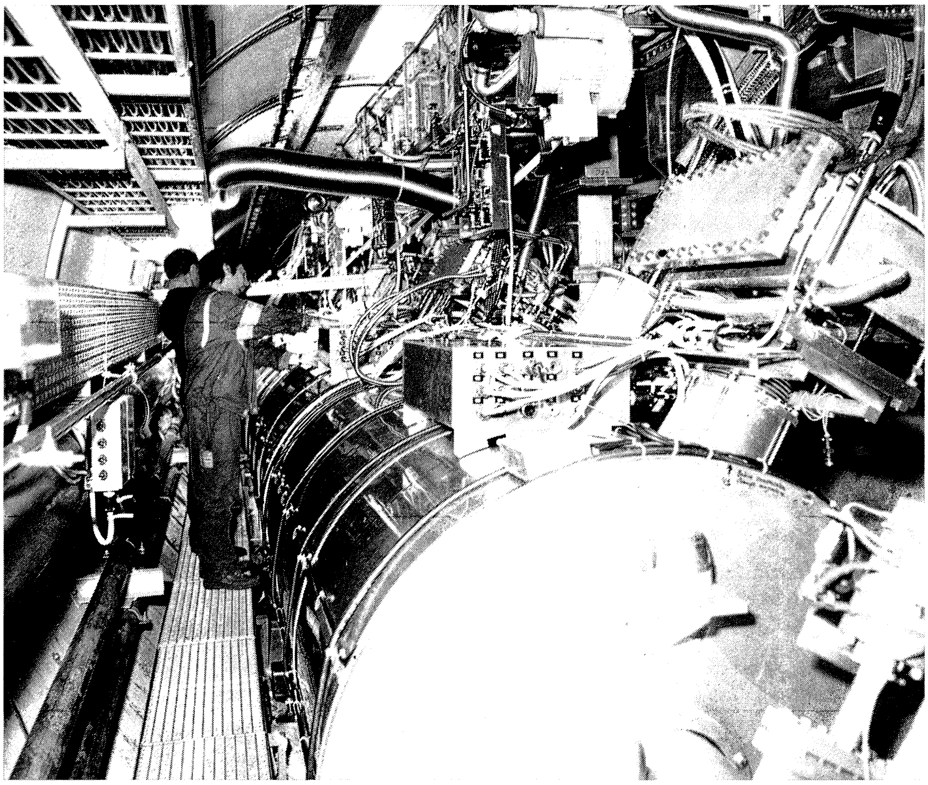
Around the Laboratories

The first superconducting radiofrequency accelerating cavities have been installed in CERN's LEP electron-positron collider. The plan is to boost beam energies from 50 to 90 GeV by 1994.

(Photo CERN 359.1.90)



CERN
LEP in action again

On 25 March, electron and positron beams were colliding again in LEP, CERN's new 27-kilometre electron-positron collider, marking the end of the winter shutdown and the commencement of a hefty run scheduled to last, with only minor interruptions, through to the end of August.

High in the list of priorities is to increase LEP's collision rate and push the luminosity towards the design figure of 1.7 x 10^{31} per sq cm per s (best so far 4.9 x 10^{30}) by squeezing the colliding beams tighter together, by increasing the beam current, and by improving beam quality (reduced horizontal emittance). Another goal is to improve setting up procedures and minimize turnround time in refilling the machine, the overall aim being a maximum number of accumulated electron-positron collisions.

Among new features of the machine are four superconducting solid niobium radiofrequency cavities, installed at Point 2, as the first components of the future superconducting acceleration system. Precious experience of superconducting cavity operation will be gained this year, allowing the fine tuning of important details before ordering series production. Over the next few years LEP's superconducting accelerating power, using mainly niobium-coated copper rather than solid niobium cavities, will be progressively increased to take the beams from their present level around 50 GeV to about 90 GeV by 1994.

At these higher energies, the colliding electrons and positrons will be able to produce pairs of W particles, the electrically charged carrier of the weak nuclear force, discovered at CERN in 1983. So far, W physics has been the exclusive province of the experiments at the CERN and Fermilab proton-antiproton colliders (see page 3). The debut of precision W studies at the four LEP experiments, Aleph, Opal, Delphi and L3, will provide important new physics insights.

The superconducting radiofrequency cavity installation programme foresees eight niobium-coated cavities at the beginning of next year. These will be the first cavities of this type to operate in the LEP environment and the experience will again be valuable in view of the start of series cavity production in the fall of that year. The following year will see 24 more solid niobium cavities arrive to provide the full complement of 32 in Point 2. In 1993, the first major consignment of niobium-coated units, 32 of them, will be installed in Point 6, with 128 more arriving the following year, foreseen for Points 4 and 8.

The necessary cryogenics will be in place before the cavities are installed, with an initial cooling power of some 12 kW at the even-numbered intersection points. The additional power to run LEP magnets at the higher fields needed to guide the more energetic beams should be in place by 1992.

Civil engineering will get underway at Points 4 and 8 for the 212-metre underground galleries to house the additional klystrons to drive the local radiofrequency units, with groups of 16 cavities powered by each 1 MW klystron. With average accelerating fields of 5 or 7 MV/m, it will be possible to store beams of 4 or 2.9 mA respectively.

Research and development work for superconducting radiofrequency cavities began at CERN ten years ago, when LEP was still on the drawing board. Two lines of attack were chosen – cavities made from solid niobium sheet, and from copper sputter-coated with a thin superconducting niobium layer (November 1988, page 14).

On the solid niobium front, useful accelerating fields were attained, but it became clear that performance was at the mercy of local 'hot spots' due to impurities in the metal. This can be avoided with copper coated with niobium, which conducts heat four times better than solid niobium. This solution at the same time minimizes susceptibility to small magnetic fields, eliminating the need for magnetic shielding.

The coated cavities promise performance as good as, if not better, than that available from highest quality niobium. With a kilogram of niobium costing about a thousand Swiss francs, there are also considerable cost savings.

The production of the coated cavities will involve considerable 'technology transfer' from CERN to industry. As already mentioned, eight cavities built at CERN will be ready for installation in the LEP ring next January. After tenders this year, selected suppliers will have one year to deliver prototype industrial cavities before authorization to proceed with series production.

From four, the number of superconducting radiofrequency accelerating cavities in LEP will eventually reach 192.

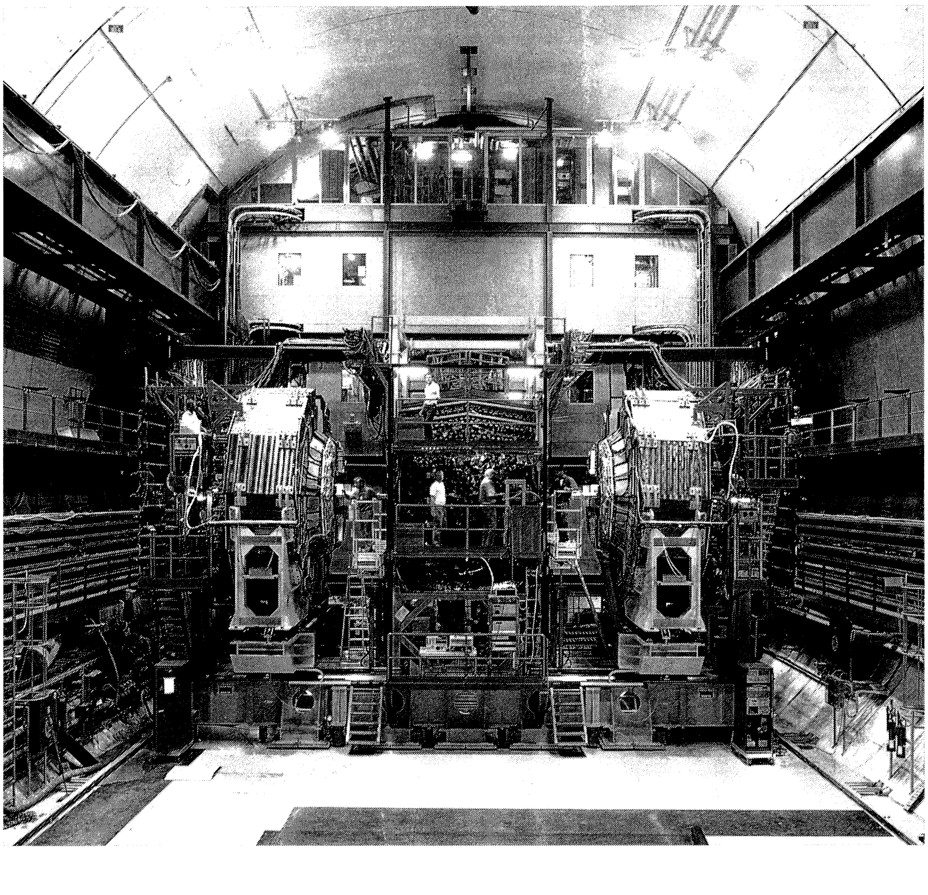
Keeping W watch

With the Z, the electrically neutral carrier of the weak nuclear force, in such good shape after the measurements by the four experiments at CERN's LEP electron-positron collider (December 1989, page 18), and by the Mark II detector at Stanford's SLC linear collider (November 1989, page 1), physicists are careful not to overlook its electrically charged counterpart, the W. Both W and Z parameters are needed to fix the electroweak theory completely.

The W is seen more frequently than the Z in proton-antiproton collisions and is about 10 GeV lighter. However it would have to be produced in pairs (carrying zero net charge) in electron-positron annihilations. At least for the time being, neither LEP nor SLC can raise enough steam to reach the W-pair threshold, and the W thus continues to be the preserve of high energy proton-antiproton collider studies. The particle is picked up through decays producing among other things a lone lepton (electron or muon) at a wide angle to the collision axis (high transverse energy) accompanied by the delicate footprint of a neutrino.

As neutrinos can only rarely be detected, they usually have to be inferred by pooling the transverse energy picked up in the detector and looking for a mismatch, or 'missing energy', indicating that something has escaped unseen.

The UA2 experiment at CERN made a big effort to upgrade and extend its calorimetry (measure-



The UA2 experiment at CERN's proton-antiproton collider (Photo CERN 286.8.88)

ment of energy deposition) to improve missing transverse energy measurements and to refine electron identification procedures. Thanks to the smooth running of CERN's Antiproton Accumulator Complex and with record proton-antiproton collision rates (luminosities up to 3 x 10^{30} per sq cm per s), UA2 had a lot of data (7.4 inverse picobarns) under its belt. All this has paid off with a new W mass measurement which provides an important new benchmark for the electroweak picture.

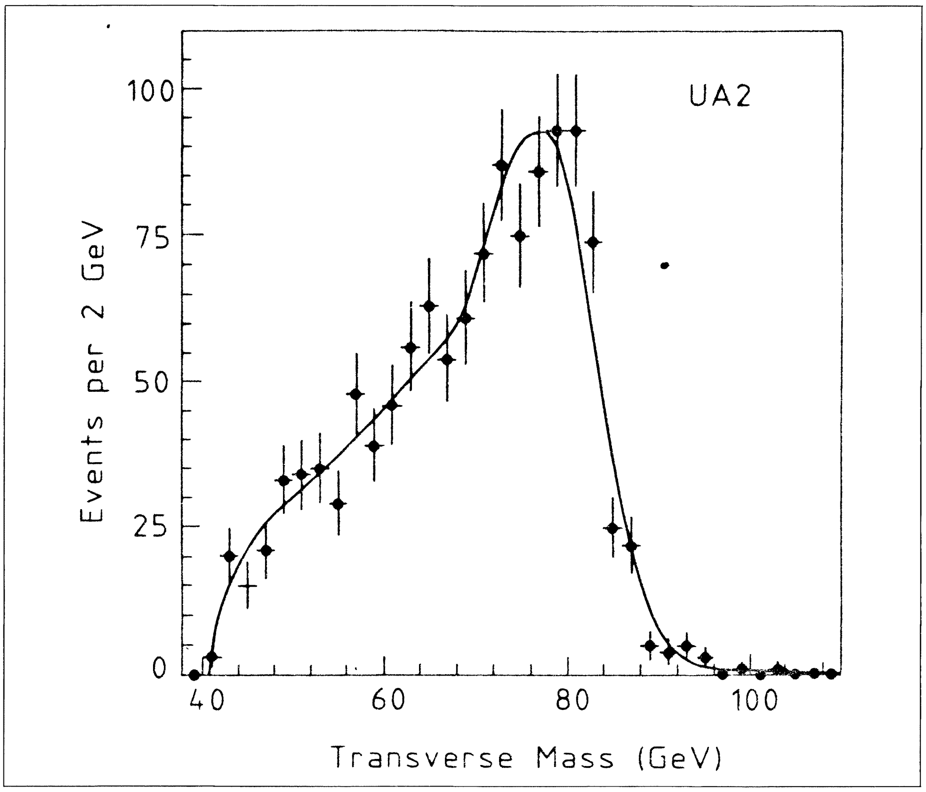
From a sample of 54 Z decays into electron-positron pairs with both leptons in the fiducial region of the central calorimeter, and 94 with one or other of the leptons in this region, careful analysis gave the Z mass as 91.49 GeV with a statistical error of ± 0.35 GeV, a systematic error of ± 0.12 GeV and a scale error of ± 0.92 GeV reflecting the uncertainty in the energy calibration of the central calorimeter.

The W results are based on a background-free sample of 1203 examples of decays into an electron and a neutrino, and extensive simulations to evaluate systematic uncertainties. The W mass result is 80.79 ± 0.31 ± 0.21 ± 0.81 GeV, the errors being statistical, systematic and scale respectively, as for the Z.

The energy scale uncertainty cancels out for the ratio of the W and Z masses : 0.8831 ± 0.0048 (statistical) ± 0.0026 (systematic). Using the precision Z mass from LEP and SLC experiments as input gives a rescaled W mass, the most precise so far, of 80.49 ± 0.43 ± 0.24 GeV.

Later this year CERN's proton-antiproton collider should be in action once more, this time with new quadrupoles compressing the beams even further to boost collision rates.

Mass spectrum for the W particle from the UA2 experiment at CERN's proton-antiproton collider. When combined with the mass measurements of the companion Z particle, this gives a precise W mass figure centred around 80.49 GeV.



Fermilab's Tevatron proton-antiproton collider is not scheduled to run this year, but the CDF facility which saw its first collisions in 1985 has a lot of data to work on, while in the wings the D0 detector is being prepared (March, page 6).

Bending beams by crystals

The steering and deflection ('channeling') of particle beams by the atomic symmetry of crystals has long been studied at low energies and is being increasingly investigated at high energies. At several Laboratories (December 1989, page 24), bent silicon crystals have been used to guide particle beams.

At CERN, an Aarhus/CERN/Strasbourg team, using a 4 cm-long, 0.9 mm-thick curved silicon crystal, have bent a 450 GeV proton beam from the SPS synchrotron through 7.4 milliradians, equivalent to a beam bending power of 11 tesla-metres, normally requiring a conventional bending magnet about six metres long.

About 15 per cent of the protons are deviated, ensuring a useful level of emerging particles. Due to the highly parallel incident beam, this bending efficiency is orders of magnitude higher than that seen earlier, reaching close to the theoretical maximum for bending through channeling, allowing a crucial test of model calculations. In addition correlated scattering with crystal atoms, with critical angles of about 7 microradians, ensures that the emerging beam is highly parallel.

By doping the entry and exit faces to form diode detectors, the crystal could be precision aligned with the beam and the bending monitored.

The development has aroused the interest of experiments needing two parallel beams to compare the behaviour of different particles.

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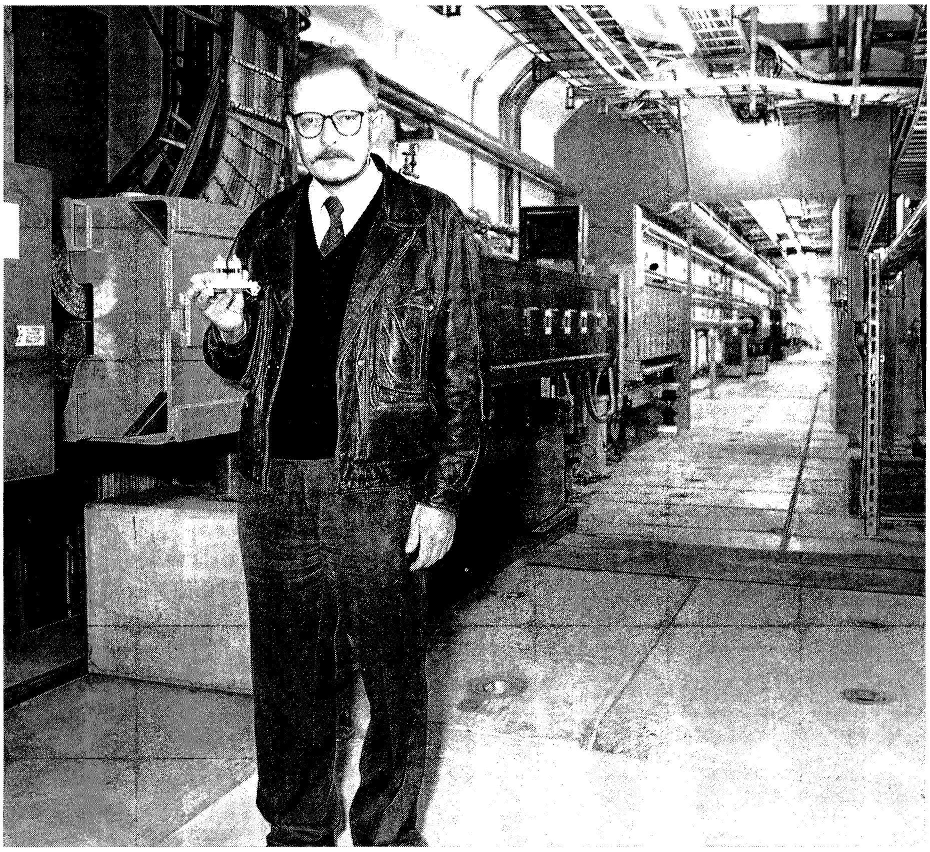


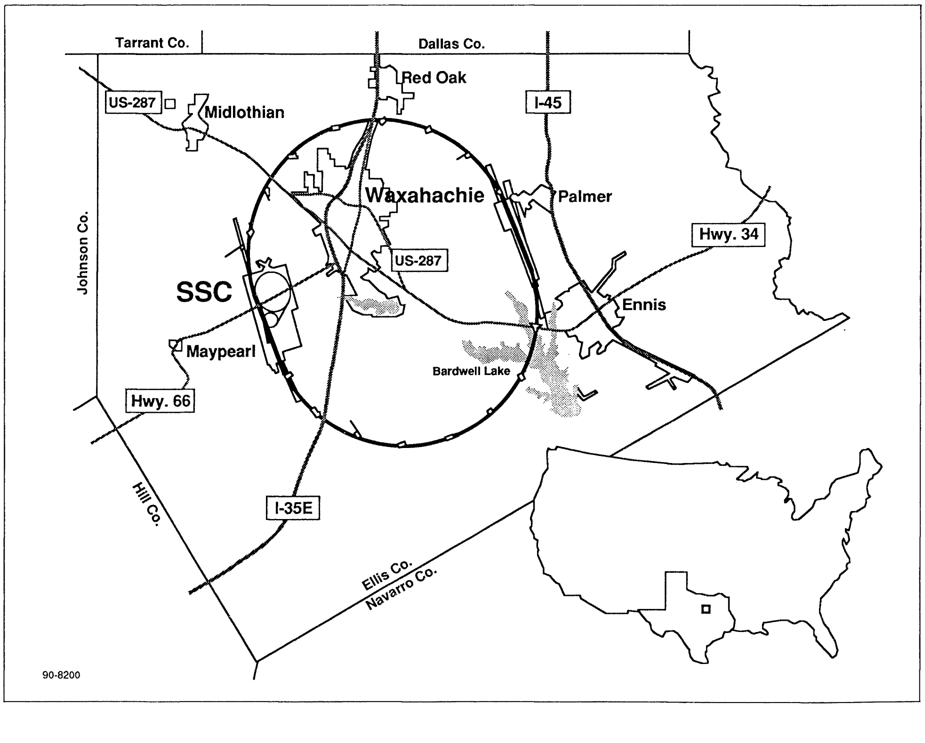
SUPERCOLLIDER Footprint approved

With the 'footprint' – the precise location of the 87-kilometre US Superconducting Supercollider, SSC, and its ancillary buildings – now approved, teams of specialists commissioned by the State of Texas swing into action to procure the 17,000 acres (69 million square metres) of land covered by the project.

With the SSC Laboratory in Ellis County and the US Department of Energy (DoE, the overseeing government agency) both hiring manpower for this project to collide 20 TeV (20,000 GeV) proton beams before the end of the century, the host State of Texas is providing a helping hand.

Speaking at the SSC's 2nd annual International Industrial Symposium in Miami in March, Ed Bingler of the Texas National Laboratory Research Commission described the State's role as 'doing anything we can do to facilitate SSC construction'. Land and service procurement are notable examples.

The DoE, both in Washington DC and on-site, retains the primary



The final 'footprint' of the 87-kilometre Superconducting Supercollider (SSC) for construction in Ellis County, Texas.

formal interface with the State of Texas, providing eventually more than 50 people for programme and project management.

For the SSC itself, the intricate programme of bids, contracts and work is already underway. Parsons, Brinkerhoff, Quade and Douglas Inc of New York, and Morrison Knudsen Corp of Boise, Idaho, with CRSS of Houston have been preselected for negotiations for civil engineering design and construction.

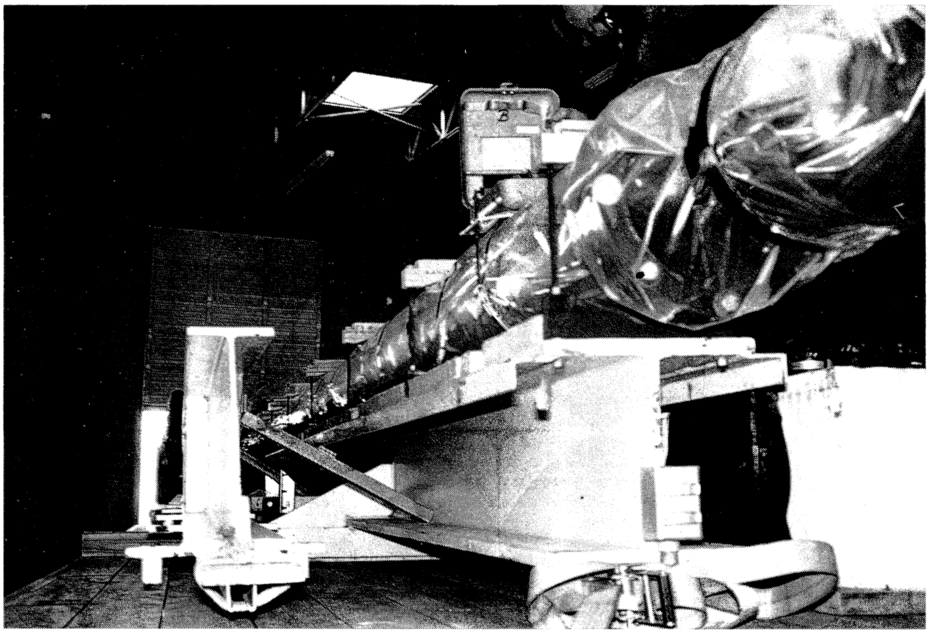
With virtually a 'green field' site, campus buildings are an early priority. With first superconducting magnet prototypes arriving on site from Brookhaven and Fermilab, another early decision will be to appoint a contractor to continue the SSC dipole building programme at Fermilab and establish a regular initial supply of magnets.

A challenging goal on the superconducting magnet front is the testing of a short string of dipoles and a quadrupole above ground in July 1992, followed by a similar test 75 metres below ground before the end of that year.

While the initial SSC magnet design foresaw dipoles 17 metres long with the inner diameter of the magnet coil 4 cm, detailed design considerations (April, page 12) have changed these figures to 16 metres and 5 cm.

Major US contractors are jostling for position for the prestigious work of constructing and equipping the SSC. With the changing face of Eastern Europe and the evaporation of the cold war suggesting reductions in defence spending, traditionally defence-oriented suppliers are eager to find fresh pastures.

'The world has changed,' declared US Congressman James Hayes of Louisiana at the Miami meeting. With the decreasing emphasis on military power, 'we have to be leaders in other fields'.



Superconducting dipole magnet for the SSC arrives at the Texas site from Fermilab for testing.

With work for SSC detector technology still at an early stage, some noteworthy suppliers have already made important contributions to ongoing design studies. The large-scale collaboration between industry and the SSC has been facilitated by recent US legislation on technology transfer from National Laboratories.

Meanwhile interested physicists have been invited to submit 'expressions of interest' for SSC experiments by 25 May for evaluation by the SSC Program Advisory Committee under Jack Sandweiss of Yale.

The SSC is also seen as playing a vital role in improving the quality of science education in the US. 'Science and mathematics are vital to US competitiveness,' said John Toll, President of Universities Research Association, the SSC parent organization. Even at this early stage in the SSC's evolution, resources have been mobilized to exploit this educational potential.

The first annual SSC National Fellowships, funded by the Texas National Research Laboratory Commission, were awarded in March. Under this arrangement ten junior faculty members and ten postdocs will spend a year working on SSC-related research, while remaining at their home institutions.

STANFORD
SLC back in action

During January, Stanford's SLC Linear Collider began producing Z particles again after the major disruptions in October due to the Loma Prieta earthquake. What's more, the pulse repetition rate climbed smoothly from 60 to 120 Hz as part of the ongoing collider improvement programme. Although the SLC luminosity has not quite returned to its best pre-quake levels, the collider managed to produce enough Z particles to permit Mark II physicists to test their newly installed Vertex Detection System (VDS).

The painstaking realignment of more than three miles of accelerator components had taken a month, being completed by late November. After that, alignment crews began working on the Mark II vertex detectors installed during the October shutdown. With this work finished by mid-December, an attempt was made to restart the SLC, but no collisions were obtained before Christmas.

Fortunately, SLAC Director Burton Richter had extended the Mark II run by a month to help compensate for the time lost due to the tremor, and by the middle of January a steady trickle of Zs began to appear inside Mark II, enabling physicists to begin checking out the VDS.

This system has two principal components – an inner silicon strip vertex detector (SSVD), surrounded by a drift-chamber vertex detector (DCVD). About the size of a beer can, the three-layer SSVD rests directly on the beam pipe, which has a radius of only 2.5 cm. A high-precision drift chamber operating at about two atmospheres, the DCVD extends out to a radius of 17 cm. The SSVD is designed to measure positions of charged particles very accurately, and the DCVD determines their angles precisely.

Together these two devices distinguish whether the tracks of charged particles emerged directly from the SLC interaction point (the primary vertex) or from a secondary vertex slightly offset from it. In the latter case, a Z boson must have given birth to a heavy particle – a tau lepton, or a hadron containing a charmed or bottom quark – that can travel several hundred microns before disintegrating in turn.

Another important SLC advance was the increase of the machine's rhythm to 120 Hz, twice last year's best pulse repetition rate. The transition went extremely smoothly, with no significant problems in beam monitoring or control, and the SLC began producing Z particles at its new cadence about a day later.

By the end of January the peak luminosity had almost returned to its best pre-quake level, despite problems with the positron beam. The two beams approached their best prior intensity levels, but physicists were unable to focus the positrons as well as before. This problem is being attacked during the current three-month shutdown, when a new high-power positron target, together with many other improvements and upgrades, is being installed. (see photo page 32)

FERMILAB Linac upgrade

The Fermilab linear accelerator (Linac) was conceived 20 years ago, produced its first 200 MeV proton beam on 30 November 1970 and has run without major interruption ever since. Demands have steadily increased through the added complexity of the downstream chain of accelerators and by the increased patient load of the Neutron Therapy Facility.

Major improvements have been the conversion from protons to negative hydrogen ion working, a new control system, and replacement of the radiofrequency control monitoring system.

Last year a revamp of the Linac got underway as the first stage of a major Laboratory upgrade (June 1989, page 15) to provide more protons and antiprotons.

The final four of the nine drift-tube tanks in the present Linac will be replaced with seven new accelerating modules operating at a higher frequency and higher accelerating fields to increase the final beam energy from 200 to 400 MeV.

The radiofrequency power to drive the new modules will be supplied by seven 12 MW 805 MHz klystrons installed in an expanded gallery. The higher energy will reduce the tune spread due to beam space-charge forces at injection in the 8 GeV Booster accelerator, thereby improving performance.

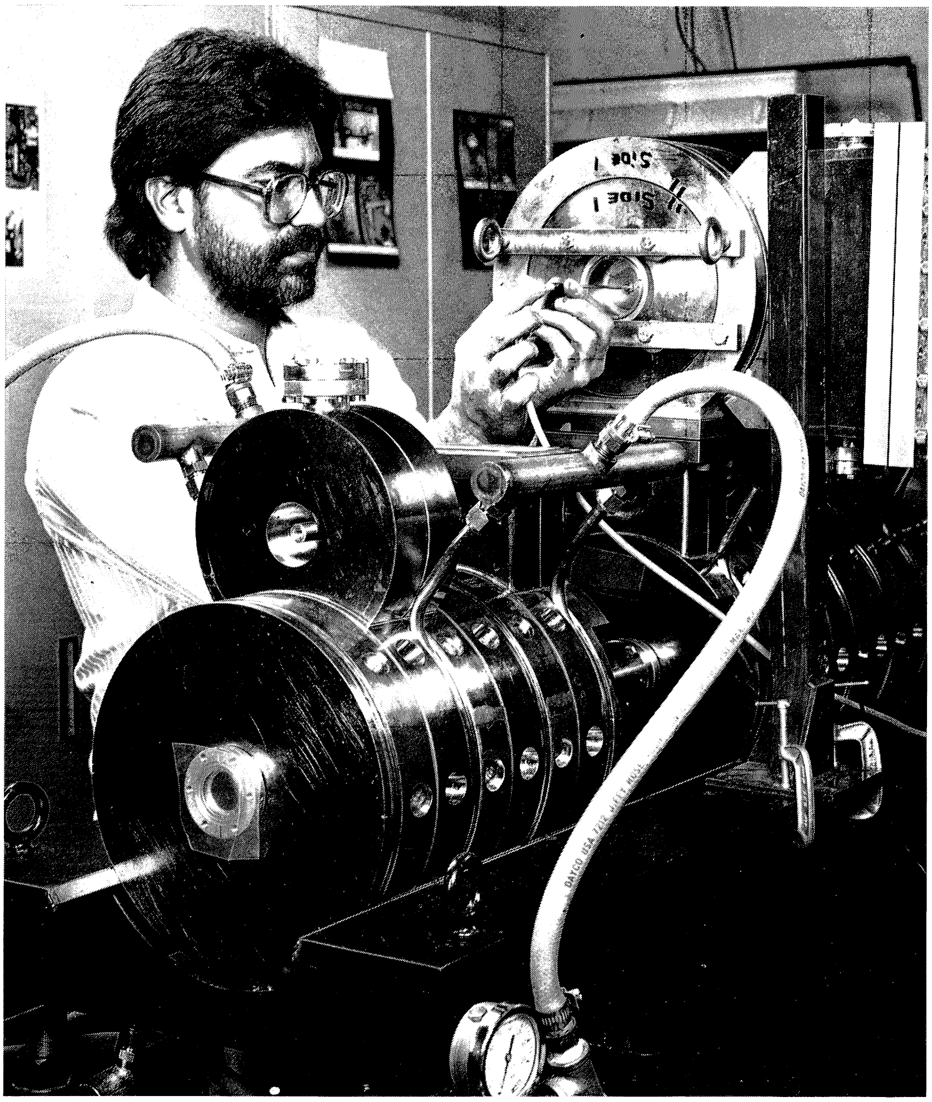
The past year saw an ambitious R&D effort take shape for the Linac upgrade. This will continue until the summer, when accelerator fabrication will commence, using the side-coupled cavity structure design originally used on the Los Alamos Meson Physics Facility (LAMPF) linac 20 years ago.

The basic unit for the new linac is a set of coupled resonant cavities brazed together into a 16-cavity section. Four such sections are connected in series to form a module powered by one klystron. There will be a total of 448 cavities, each providing an energy gain of about 600 keV.

Because of the high electric fields (7.5 MV/m), a special six-cavity test model was built in a collaboration between Fermilab and Los Alamos to test sparking and X-ray production. Power tests at Fermilab last year indicated that voltage conditioning with 6 million r.f. pulses (5 days of conditioning at 15 Hz) would bring the sparking rate down to less than one spark per hundred pulses in the new linac. Continued voltage conditioning leads to a steady reduction in sparking.

A second six-cavity model was fabricated at Fermilab to explore

Technician Rene Padilla making adjustments in a full-scale prototype side-coupled accelerating structure fabricated by Fermilab for the Linac upgrade.



improved machining and tuning techniques and power tested in February. After 20 million r.f. pulses, the sparking rate extrapolated to a full linac was less than one spark per thousand pulses.

Fabrication also began last year of a complete prototype accelerator module, mechanically and electrically equivalent to the first of the seven needed for the new linac. This module is scheduled for completion by July and will be power tested using a 12 MW prototype r.f. system, the modulator portion of which was fabricated in the Fermilab linac gallery during 1989 and successfully operated into a diode load at full power and the specified 15 Hz repetition rate. The prototype klystron comes from Litton Industries.

The 400 MeV linac is scheduled for operation by the fall of 1992. Its total estimated cost is $22.8 million, opening up a further 20 years of reliable operation.

From Robert J. Noble

GANIL
New beams and facilities

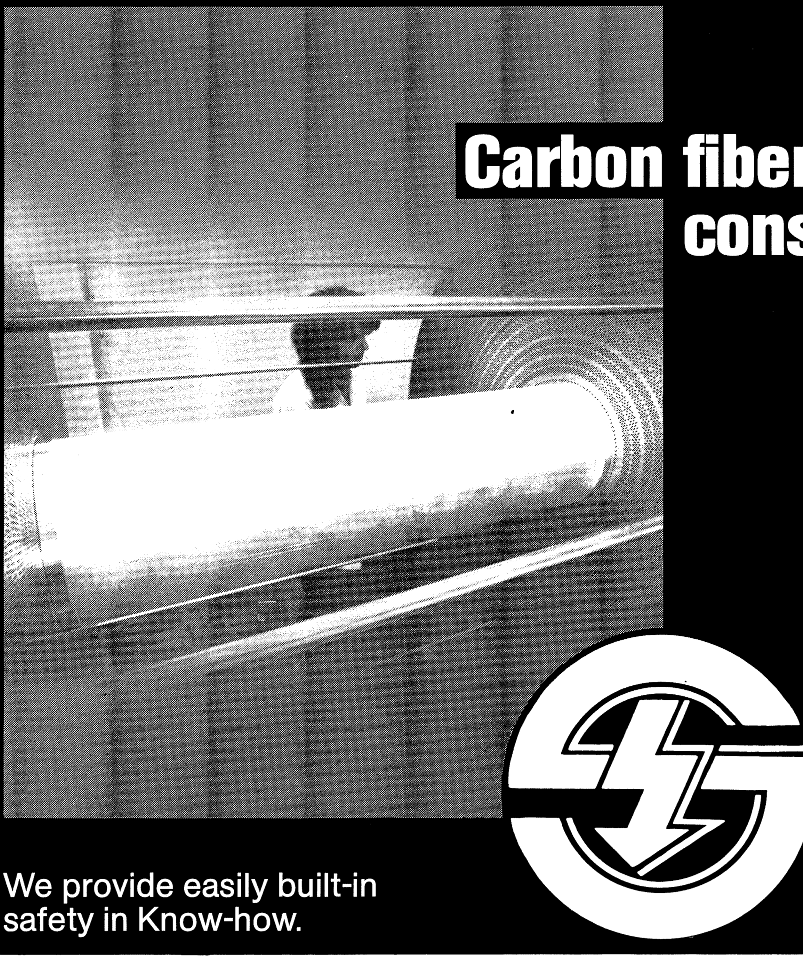
Last year, the French GANIL National Laboratory in Caen successfully completed an energy upgrade to consolidate its position in the forefront of heavy ion research in the medium energy domain (20-100 MeV/nucleon).

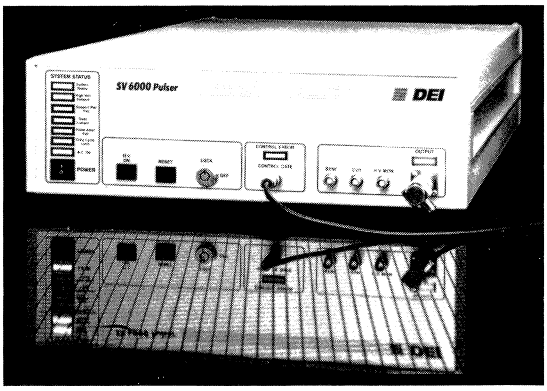
Main modifications included installation of a new electron cyclotron resonance (ECR) source (Caprice 2B at 10 GHz), a recasting of the injector cyclotron and of the buncher in the low energy line, a change in the ion stripping ratio (from 3.5 down to 2.5) between the two separated sector cyclotrons, and replacement of injection elements in the second SSC.

This upgrade now allows not only a substantial gain in intensity for the previously available beams to 1.4 x 10^{11} for krypton and xenon, but also a significant increase in beam energies (to 60 MeV/nucleon for krypton, 44 MeV/nucleon for xenon). Beams up to uranium are now available at interesting energies – a 29 MeV/nucleon lead beam (intensity 4 x 10^9) was delivered to an experiment in December.

In parallel, two major new experimental facilities have been designed and built. An electrostatic separator has been added downstream of the existing doubly achromatic LISE spectrometer. This new set-up, LISE3, can select a given mass and charge from the products of a heavy ion interaction, useful for experiments with secondary beams as well as studies using exotic nuclei up to the limits of stability.

The second new facility is TAPS – Two Arm Photon Spectrometer

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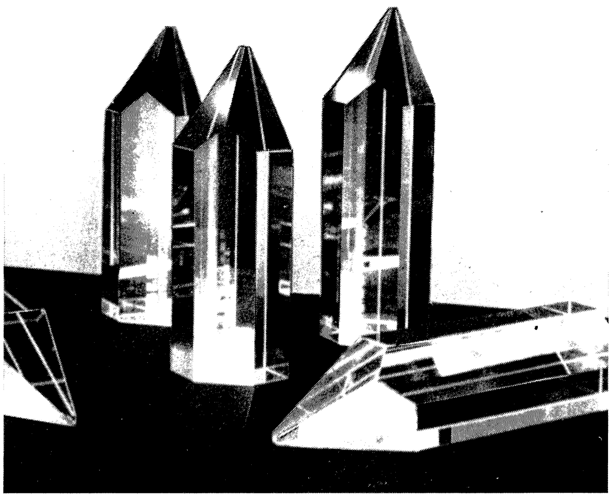

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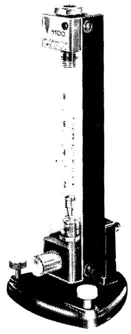

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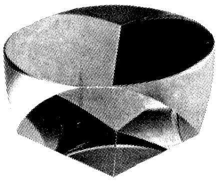

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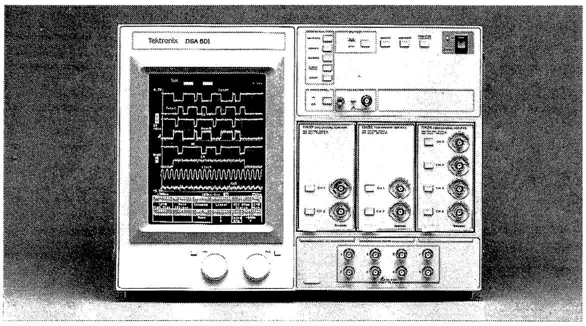

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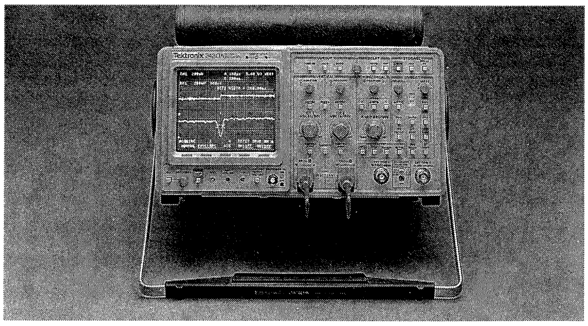

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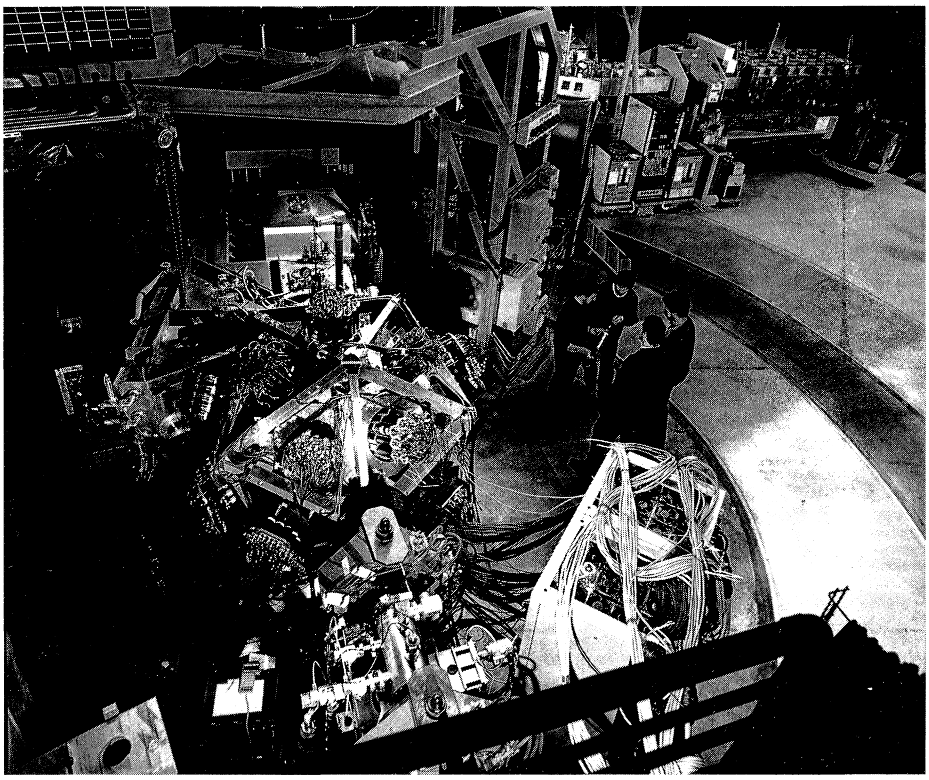
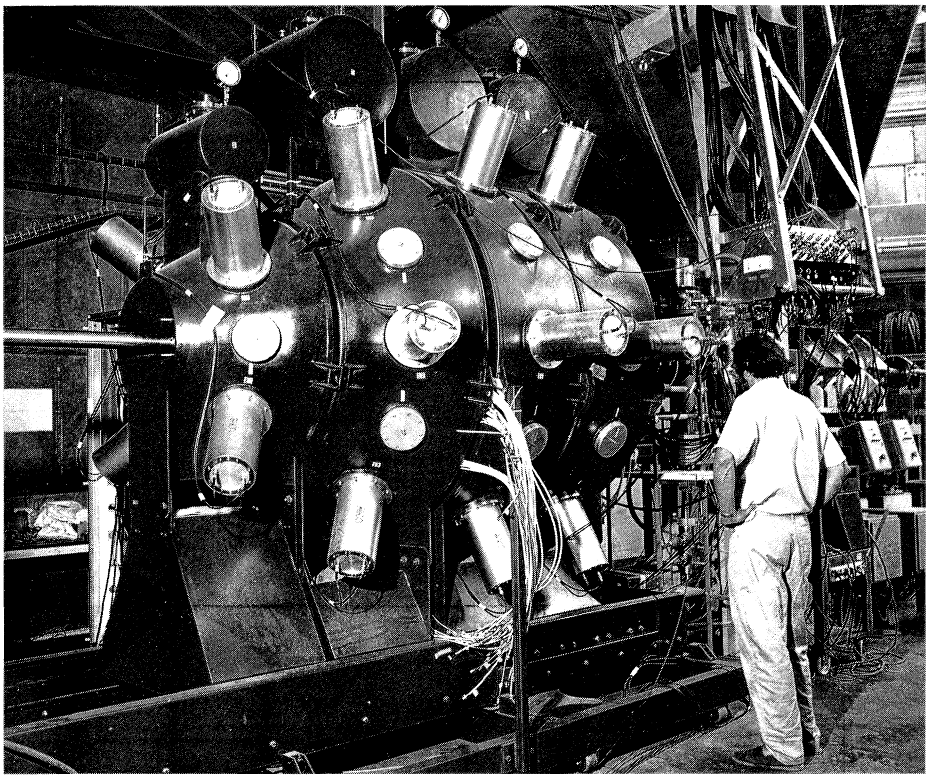
Top, TAPS – Two Arm Photon Spectrometer – developed by a European collaboration departs for experiments at German Laboratories after initial operation at the French GANIL heavy ion Laboratory.

Below – the ORION detector at GANIL picks up neutrons over the full solid angle.

(Photos Desaunay)





– an array of 361 barium fluoride crystals developed by a collaboration of GANIL, GSI (Darmstadt), Giessen and Münster Universities (Germany), and KVI of Groningen in the Netherlands, with readout electronics provided by an Orsay/Grenoble team. After initial operation at GANIL, TAPS departs for a tour of German Laboratories.

Investigations of 'hot' nuclei benefit particularly from the upgrade. The first lead beam experiment set out to investigate the properties of 'semi-infinite' hot nuclear matter using the ORION full solid-angle neutron detector.

The complexity of this physics demands sophisticated instrumentation, and a new, almost full solid-angle detector called INDRA is under construction for an event-by-event study of high multiplicity reactions.

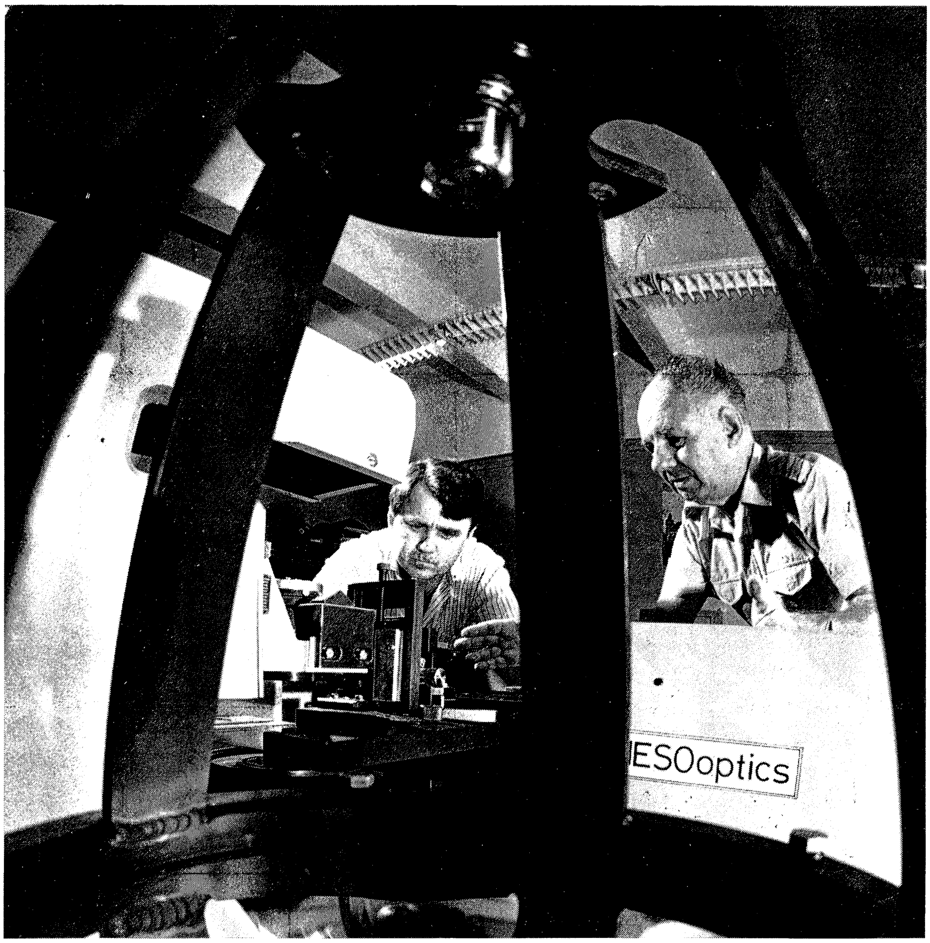
DUBNA
In depth viewing

As part of the USSR-Hungary scientific collaboration programme, scientists working at the international Joint Institute for Nuclear Research (JINR) at Dubna, near Moscow, have developed a 'Meso-Optical Fourier Transform Microscope' (MFTM) to resolve particle tracks recorded in blocks of emulsion.

Traditionally, finding particle tracks in exposed emulsion required time-consuming scanning of many successive layers. However the emulsion technique has earned a new lease of life in hybrid systems where counts due to reaction fragments picked up in downstream detectors can be used to vector in on the emulsion interaction vertex.

Developed by a Soviet-Hungarian collaboration at the Joint Institute for Nuclear Research, Dubna, near Moscow, the Meso-optical Fourier Transform Microscope aims to give three-dimensional information on emulsion tracks from measurements at a fixed position.

(Photo Yu. Tumanov)



Another line of attack has been diligently followed at Dubna, using a diffraction microscope to recast geometrical track information. The aim is to get three-dimensional output without systematic depth scanning, and speed up the analysis of the whole emulsion sample.

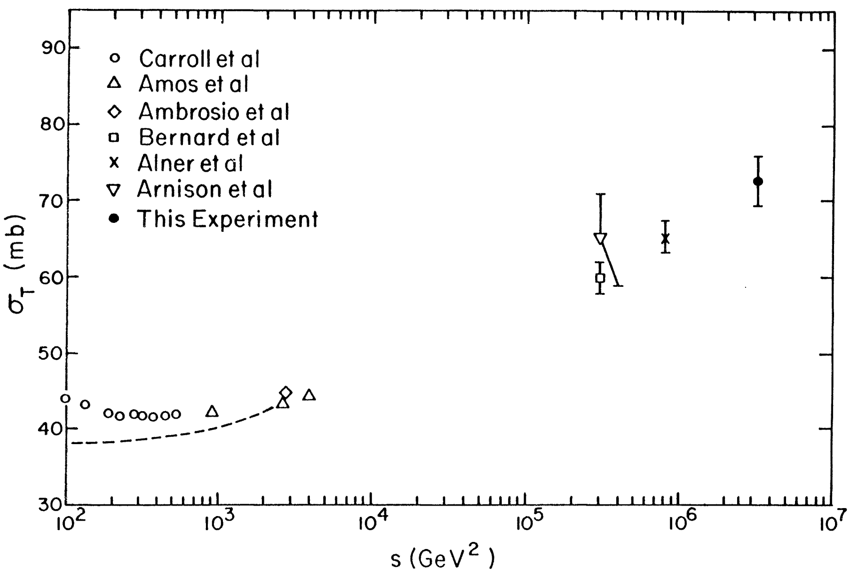
Using a circular stereo effect, such three-dimensional track information can be measured without moving the MFTM. Initial results are encouraging, and ongoing tests concentrate on looking at minimum ionization tracks against an intense background of randomly distributed photosensitive grains.

Physics monitor

FERMILAB
Bigger protons

Elastic scattering, when particles 'bounce' off each other like billiard balls, may not be the most fascinating facet of high energy physics, but when fresh high energy results show that any long-awaited 'asymptopia' is still as far away as ever, unexpected discoveries at higher energies cannot be discounted.

The highest laboratory proton energies are those supplied by Fermilab's Tevatron, where Experiment 710 (a Bologna/Cornell/Fermilab/George Mason/Maryland/Northwestern) collaboration looks at the elastic scattering of protons and antiprotons at a collision energy of 1800 GeV. These results step up from similar measurements made at CERN's proton-antiproton collider in the mid-80s.

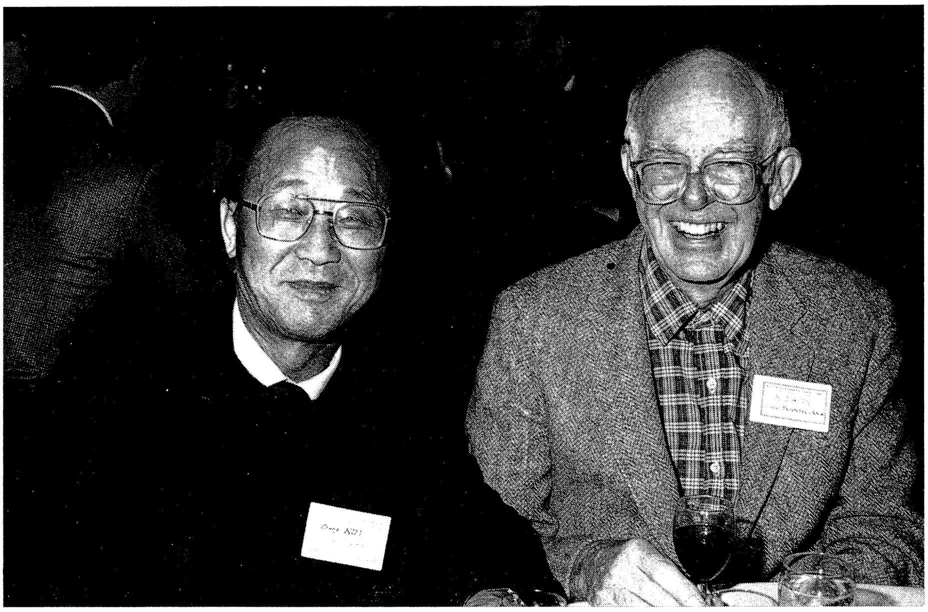


Total proton-(anti)proton reaction rates (cross-sections, vertical axis) stubbornly continue to grow with energy. On the right is a new measurement from the Fermilab Tevatron, supplying the world's highest energy proton beams. The previous energy ceiling (in the s range 10^5 GeV^2) was provided by CERN's proton-antiproton collider. S is the square of the collision energy.

Elastic scattering and total reaction rates (cross-sections), the latter effectively measuring the 'size' of the colliding particles, are related by very general ideas, the so-called 'optical theorem'. At the Tevatron, the total proton-antiproton reaction rate continues to grow, showing that the proton stubbornly refuses to plateau. Instead, the proton's size increases almost as fast as allowed by general principles (the Froissart bound).

The ratio of elastic to total reaction rates also continues to increase at Tevatron energies, showing that the proton not only becomes larger, but more absorbent.

Solar neutrino pioneer Ray Davis of Pennsylvania, right, with Chung Kim (Johns Hopkins).



WORKSHOP
Neutrino telescopes

Despite being the most elusive of the known particles, neutrinos provide vital new physics insights. Most neutrino knowledge so far has come from studies using beams from reactors and accelerators, but in recent years important new contributions have resulted from investigation of natural neutrinos from cosmic rays, nearby stars (the sun), or distant sources, such as the 1987 supernova (page 18). The supernova observations marked the start of a new era in neutrino astronomy, but neutrino telescopes were anyway assured of an important ongoing role.

Achievements and aspirations were reviewed in Venice from February 13-15 when about 100 physicists met in the ancient palace of the Istituto Veneto di Scienze, Lettere ed Arti, who co-sponsored with INFN and Padua University the Second Workshop on Neutrino Telescopes, organized and chaired by Milla Baldo-Ceolin.

Modern physics ideas hint that neutrinos from different sources and stages of the evolution of the Universe should be very abundant around us. New dedicated experiments are needed to detect these so-far unseen particles and resolve problems in cosmology (dark matter), in astrophysics (high energy particle acceleration mechanisms, origin of cosmic rays) and in elementary particles physics (neutrino mass, oscillations, magnetic moment).

The first instrument to look for extraterrestrial neutrinos was installed in the South Dakota Homestake mine more than twenty years ago. This showed that the rate of solar neutrino interactions has been lower than expected, the so-called 'solar neutrino puzzle'. At Venice R.Davis (Pennsylvania) presented the latest results of his pioneering experiment, now confirmed over the past two years by the Japanese Kamioka detector (A.Suzuki).

Davis' data, in the long time span of his measurements, show an anticorrelation of the solar neutrino flux with the solar surface activity (sunspots). This unexpected result makes the solar neutrino problem even more puzzling. This year data from both experiments will be taken with solar activity at a maximum and could show a clear minimum in the neutrino flux.

Complying with Davis' remark 'You don't really believe it unless you understand it', R. Barbieri (Pisa) described a possible explanation with the varying solar magnetic field acting on an as yet unmeasured neutrino magnetic moment – spin flip would make the neutrino sterile and therefore undetectable.

New information will be provided shortly by two detectors, one in Baksan (USSR), the other (Gallex) in the Italian Gran Sasso Laboratory (May 1989 issue, page 1), both using gallium as target, where the very low energy threshold will explore different production reactions.

T.Kirsten (Heidelberg), discussing Gallex, showed how precisely the neutrino rate will be measured and the neutrino oscilla-

Modern physics in a classical setting – the Neutrino Telescopes Workshop in Venice's Palazzo Loredan.

tion hypothesis tested. Next step forward would be, as emphasized by S.Bilenky (Dubna), the ability to observe neutral current reactions and to measure the energy spectrum of the charged current interactions from solar neutrinos. For this, experimental proposals and prototypes have been developed using boron, indium and heavy water detectors.

Picking up high energy neutrinos from distant sources is a major goal for the underground detectors (muons induced by atmospheric neutrinos are seen and their spectra are in reasonable agreement with calculations). The expected mechanisms for particle acceleration in binary stars and other systems, together with present data from high energy gamma ray telescopes, require that detectors intercepting neutrinos from distant point sources would have to be very large, bigger than 10^4 sq m, with good angular resolution, one degree or better, for the induced muons.

One natural solution to have cheap large area and volume is to go deep underwater and detect the muons by means of Cherenkov light. The DUMAND collaboration, after a successful test demonstrating the feasibility of an experiment 4000 m deep (June 1988, page 29), is about to set up its nine-string array off Hawaii. Meanwhile Soviet groups are at work in Lake Baikal and in the Mediterranean, and a US proposal aims at instrumenting an Arkansas lake for a combined neutrino- and gamma-ray telescope.

On dry land, other Cherenkov radiation approaches include tests of antennas to detect radio signals from the products of ultra-high energy neutrino absorption in the Antarctic ice, and prototypes of large track chamber arrays. Together these experimental efforts amount to a dozen projects all over the world.

Coherent insights into the evolution of the Universe need improved limits on neutrino mass and lifetime, even to the extent of actually measuring these quantities. This was the plea to experimentalists by E.Kolb (Fermilab) reviewing neutrinos and cosmology.

The round table concluding the workshop stressed the importance of establishing a network of complementary neutrino telescopes for both for low and high energy extraterrestrial neutrinos, building on the existing international effort. As well as giving new clues to understand current problems, such a programme, underpinned by powerful detector techniques, could reveal unexpected phenomena and provide new insights.

FRANCE New horizons for nuclear physics

The increasing realization that the underlying mechanisms of nuclear physics are controlled by the inner quark structure of nucleons rather than the nucleons themselves is blurring the once fairly distinct frontier between nuclear and particle physics.

Thus nuclear physicists are awaiting new high energy machines, notably CEBAF, the US Continuous Electron Beam Accelerator Facility now under construction in Newport News, Virginia (March, page 21), while particle physics facilities such as the LEAR low energy antiproton ring and the high energy muon beams at CERN are gaining popularity with the nuclear physics community.

With the French nuclear physics community making smoke signals for a 4 GeV electron machine, Minister of Research and Technology Hubert Curien asked the Académie des Sciences to commission a study on the future of fundamental nuclear physics to recommend what new facilities would be required.

Under the chairmanship of Georges Charpak, recently retired from CERN, the study group felt that a 4 GeV electron machine was scientifically inappropriate. To explore the furthest frontiers of nuclear science, a continuous accelerator, going beyond CEBAF energies, attaining 10-15 GeV, would be a better bet.

Although catalysed in France, the group envisaged the new project as an essentially European exercise, with contributions in expertise and material from other interested nations, much along the lines of the HERA electron-proton collider now nearing completion at the German DESY Laboratory in Hamburg.

To provide a platform for major European nuclear physics projects, the group recommended the establishment of a body analogous to ECFA, the European Committee for Future Accelerators, established in the early 60s as an independent 'mini-parliament' of particle physicists and which has played a major role in the emergence of all Europe's subsequent major particle physics projects.

Supernova neutrinos

In the first part of his in-depth article on the 1987 supernova (SN 1987A – April issue, page 1), David Schramm of the University of Chicago and the NASA/Fermilab Astrophysics Centre reviewed the background to supernovae, the composition of massive stars and the optical history of SN 1987A, and speculated on what the 1987 remnant might be.

In such a Type II supernova, gravitational pressure crushes the atoms of the star's interior producing neutron matter, or even a black hole, and releasing an intense burst of neutrinos. 1987 was the first time that physicists were equipped (but not entirely ready!) to intercept these particles, and in the second part of his article, David Schramm covers the remarkable new insights from the science of supernova neutrino astronomy, born on 23 February 1987.

For more than twenty years, physicists have anticipated that the gravitational collapse of Type II supernovae, forming neutron stars or black holes, are also copious sources of neutrinos.

As explained in the first part of this article, massive stars evolve to about 1.4 solar mass iron cores surrounded by layers of silicon, oxygen, neon, carbon, helium and hydrogen. The core of such an object will inevitably collapse, but the details of how this collapse produces a neutron star or a black hole and how the outer material is spewed out in a supernova outburst are still matters of much debate.

The two most popular scenarios are either a prompt direct shock caused by the bounce of the collapsing iron core when it hits incompressible nuclear matter densities, or a delayed shock resulting from neutrinos emitted by material subsequently falling on the baby neutron star and driving off the outer mantle.

Regardless of these details, compressing about 1.4 solar masses of neutrons into a dense star releases about 10^{53} ergs, while the total light and kinetic energy of a supernova outburst is 'only' about one per cent of this enormous figure. The difference must come out in some invisible form, either neutrinos or gravitational waves. Numerous arguments have shown that gravitational radiation can only carry about one per cent of this, so that the bulk of the energy is released as neutrinos.

It is also well established that for densities greater than about 2 x 10^{11} g per cc, the collapsing core is no longer transparent to neutrinos. For electron neutrinos, the 'neutrinosphere' source temperature corresponds to an average particle energy around 10 MeV. Because of the significant masses of the muon and the tau lepton, muon- and tau-type neutrinos and their antiparticles only interact at these temperatures via neutral rather than charged current weak interactions, so their neutrinosphere is deeper inside the core, and their spectra are correspondingly hotter than those of the electron neutrino.

The electron antineutrino opacity will initially be governed by charged current scattering off protons, but as the protons disappear, neutral current effects come into their own. Thus the temperature of electron-type antineutrinos changes

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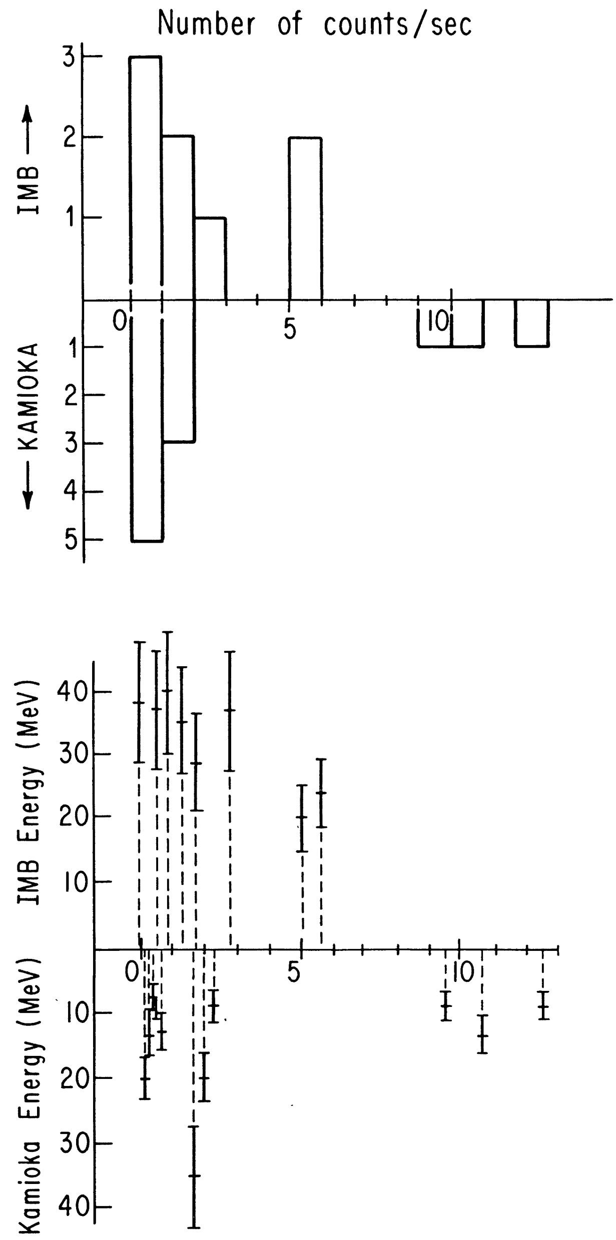
from that of electron neutrinos to that of muon- and tau-neutrinos. The peak energies of the emitted neutrinos are very insensitive to model parameters – electron neutrino temperature and energy around 3 and 10 MeV respectively, and temperature and energy of the other neutrino types around 6 and 20 MeV. Starting out with charged current interactions and ending with only neutral currents, the time-averaged electron antineutrino temperature is about 4.5 MeV with an energy of about 15 MeV.

A collapsing core has some 10^{57} protons that are converted to neutrons with release of electron neutrinos to form a neutron star. Each of these neutrinos carries away on the average 10 MeV, supplying in total about 1.3×10^{52} ergs, not more than about ten per cent of the energy release. The remaining neutrinos (of all types) come from thermal processes such as electron-positron annihilation into neutrino-antineutrino pairs, muon- and tau-type neutrino production occurring only via neutral currents. The realization in the 1970s that the significant neutrino energy release comes via neutral currents was an important advance in understanding.

The initial neutronization burst of electron neutrinos is much earlier (after less than a hundredth of a second), with the bulk of the flux subsequently being emitted during several seconds of diffusion. More than half of the thermal neutrinos are released in the first one or two seconds, the remainder coming out over the next few tens of seconds as the hot newborn neutron star cools down to become a standard cold neutron star. Detailed models suggest that because of neutral currents the thermal processes do not favour any particular neutrino species.

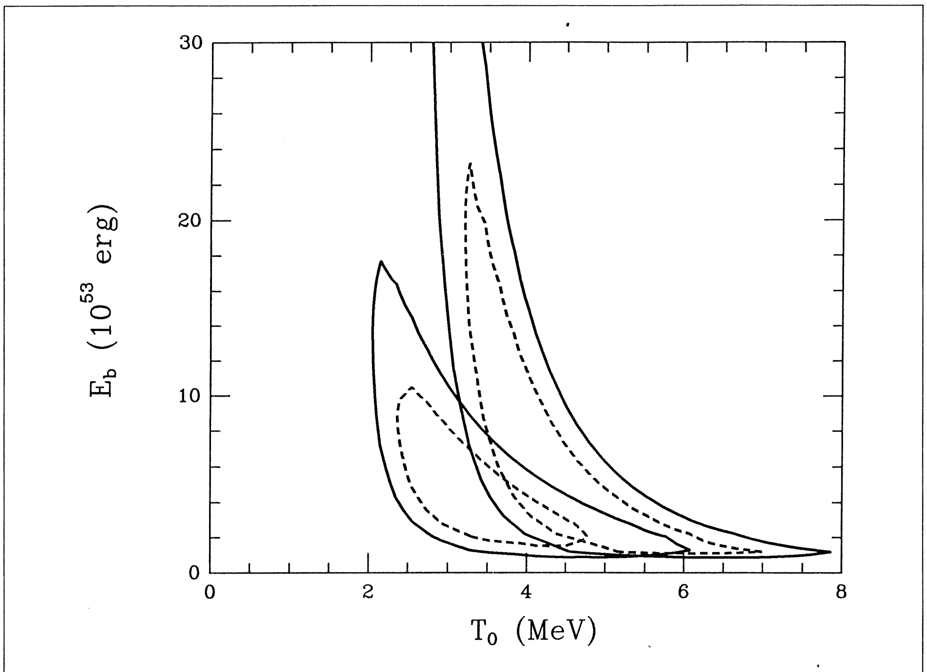


Energy and timing of the supernova neutrino counts from the Japanese Kamioka and the Irvine/Michigan/Brookhaven (IMB) detectors.

Simple arguments give estimates for the counting rates expected for large shielded detectors such as the 6000 tons of water of the Irvine/Michigan/Brookhaven team and the 2200 tons of water in the Japanese Kamiokande detector. Such underground detectors are mainly sensitive to the reaction where an incoming electron antineutrino converts a proton into a neutron, releasing a positron.

Prior to SN 1987A, estimates were made for a supernova in the centre of our galaxy at about 10 kiloparsecs (30,000 light years). These can be reduced by the square of the increased distance (some 50 kps) to the Large Magellanic Cloud where SN 1987A was born to yield about 11 counts for the Kamioka detector, and for the Mont Blanc detector with its 0.09 kilotons (of hydrocarbon scintillator rather than water) about 0.6 counts. IMB is a little more difficult because its threshold is not below the peak electron antineutrino counting rate, however a reasonable estimate, using efficiencies, thresholds, etc. gives some seven counts.

Supernova energy release and temperature implied by the IMB (higher temperature curves) and Kamioka experiments. The dashed lines are 68% confidence and the solid lines 95% (Tom Loredo, University of Chicago).



equations of state.

The IMB/Kamioka results show that neutrino emission lasted for about ten seconds. This duration varies in different models of collapse, and until we have a collapse in our galaxy with a more detailed time evolution, it will be hard to make detailed statements.

Constraints on neutrino physics

Independent of detailed collapse models, the SN 1987A neutrino signals (about 10^{10} neutrinos passed through every square centimetre of the earth in the first second) are a powerful constraint of neutrino properties – lifetime, mass, number of possible types, charge and magnetic moment.

The neutrinos were clearly durable enough to make it over 160,000 light years. The absence of gamma rays in coincidence with the neutrino counts means that no neutrino radiative decays happened on the way. The fact that the (fermionic) neutrinos reached the earth within a few hours of the (bosonic) photons from the initial light burst provides a good test of the equivalence principle of general relativity – all uncharged bodies moving through free space follow the same trajectories.

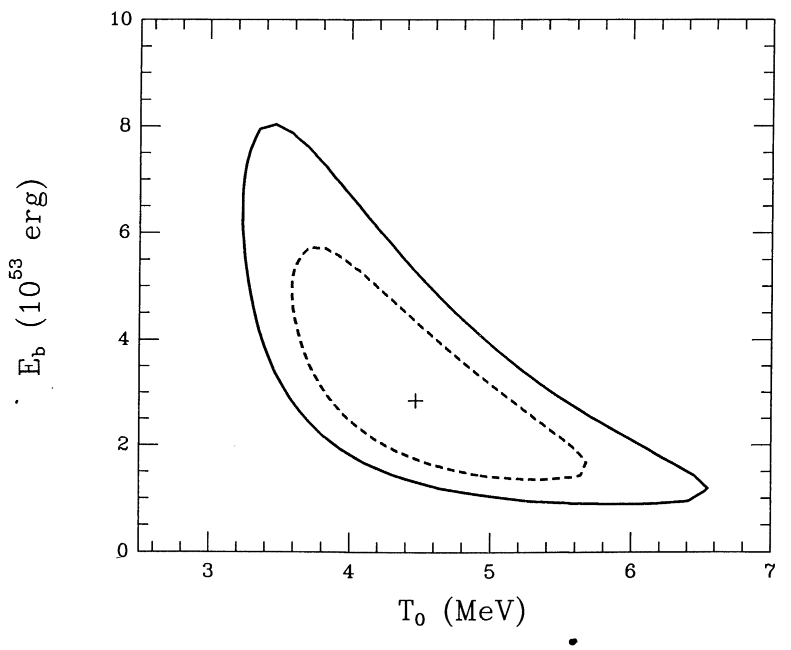
The narrow timespread of neutrino bursts, despite the energies being spread out over a range of about a factor of two, means that the electron neutrino cannot be very heavy. The key here is to decide how to treat the counts to get the time and energy spread, and to estimate the intrinsic spread in the neutrino burst, and these assumptions have yielded more neutrino mass preprints than neutrino events observed! The current limit using maximum likelihood tech-

Neutrino observations

The neutrinos seen on 23 February 1987 near 7h 35m UT marked the debut of extra solar system neutrino astronomy. An additional report from the Mont Blanc group of five events at –2:52 was not substantiated by the other detectors. (Seven months later, this group saw a background burst of five counts in about ten seconds – it has been pointed out that in order to be from the Large Magellanic Cloud and still avoid coincidence in other detectors, the early Mont Blanc signal would have required more than 10^{55} ergs emitted as low energy neutrinos – more than the rest mass of the entire Sanduleak star! We prefer to quote astronomer Sir Arthur Eddington: 'Observations should not be believed until confirmed by theory!').

Ignoring the marginal signals from Mont Blanc and the Soviet Baksan detector, the well established Kamioka/IMB burst spans just the first few seconds, as expected in stellar collapse. The number of counts and mean energies can be used to determine the implied temperature of the detected neutrinos and energy released by the supernova, the latter being assumed to be six times the energy radiated as electron antineutrinos.

While IMB might be expected to measure a slightly higher temperature due to its higher threshold sampling only the high temperature tail of the distribution, there is nevertheless a region of overlap where both IMB and Kamioka yield the same temperature and energy. It is particularly satisfying that this overlap falls exactly where a standard gravitational collapse is expected, with an energy release of 2 x 10^{53} ergs and a temperature of 4.5 MeV. Using the luminosity-temperature relationship gives the radius of the neutrinosphere as a few tens of kilometres, in reasonable agreement with neutron star



Result of combining the IMB and Kamioka data, showing good agreement with standard supernova expectations (Tom Loredo, University of Chicago).

niques and allowing for background variations is less than 25 electronvolts, in good agreement with laboratory findings.

The more neutrino types (flavours) there are, the smaller is the yield per flavour. Detection of electron antineutrinos, one flavour, says immediately that dilution by flavour did not make this luminosity undetectable. This implies less than seven neutrino flavours, not as strong as LEP or SLC nor the cosmological prediction, but at least consistent.

This argument can be used to limit any hypothetical particle that might be emitted by the supernova and dilute the neutrino energy share. Particles such as axions or majorons could escape from the higher temperature central core even though neutrinos cannot, providing further restrictions on axion and majoron couplings.

Any neutrino electric charge would spread the neutrino burst, and the results limit any such charge to less than 10^{-17} of that of the electron. Several authors argue that if the neutrino had a magnetic moment of more than 10^{-11} of that of the electron, it would yield unobserved effects such as more rapid proto-neutron star cooling and large numbers of more energetic neutrino events. These limits may be useful for the solar neutrino problem, where one solution proposes neutrinos flipping in the sun's magnetic field.

Collapse rates

Over the last thousand years there have been only five visual supernovae in our Milky Way galaxy, implying at first glance a rate of one every 200 years. (They were the 'Chinese' observation in AD 1006, the Crab Nebula in 1054, one in 1181, and the events witnessed by Tycho Brahe in 1571, and by Kepler in 1604.) However if we look at other galaxies, like our own, supernovae show up every 15-100 years. Our galaxy's low rate is probably due to most of it being obscured by dust in the disc. In fact the five historic supernovae were all in our sector of the galaxy, implying an enhancement factor of about five.

Now that we can detect collapses by neutrinos alone, we don't need to worry about obscuration of our disc, so the rates in galaxies sampled across their entire disc might be more relevant. However direct counting of supernovae is fraught with uncertainties. For example SN 1987A, neutrinos apart, would probably have been missed in other galaxies because it was not very bright.

Pulsar formation rates, massive star formation rates, and supernova remnant statistics do not help much since they have so many possible systematic errors. A recent idea is to use nucleosynthesis yields from gravitational collapse objects to estimate average rates. If the two per cent heavy element content of our galaxy came from such collapses and if one or two solar masses of such material are ejected per collapse, then the 10^{11} solar mass disc requires some 2 x 10^9 ejections over the 15 x 10^9 year history of the galaxy, giving an average collapse rate of about one every ten years.

From the constancy of such radioactive nucleochronometers it can be argued that the current best galactic evolution models seem to have roughly constant nucleosynthesis rates, so that the average may not be a bad estimate of the current rate. If it is higher than the rates observed in similar galaxies, it probably means that many collapses, like SN 1987A, were not that bright and were missed.

The supernova in the Large Magellanic Cloud has supplied some of the most exciting astrophysics of the century and has taught us a lot about supernovae. Now we know that blue as well as red stars collapse, but are less bright. The cobalt-56 gamma ray lines supplied direct evidence of nucleosynthesis at work. Supernova neutrinos were seen for the first time and showed that our understanding of gravitational collapse is in good shape provided all the neutral current effects are included. Now that we know what such a neutrino burst looks like, we should be able to pick up and recognize any collapses in our galaxy, regardless of their optical visibility.

People and things

Continuing CERN's policy of drawing up bilateral agreements to cover ongoing collaboration with countries outside the existing network of Member States, Director General Carlo Rubbia (left) and Vice-President of the Czechoslovak Academy of Sciences Armin Delong signed an accord at CERN on 26 March.

Physicists and German reunification

The Physical Societies of West and East Germany, with 18,000 and 2,000 members respectively, have agreed in principle to initiate a merger.

More light on dark matter

The confirmation by electron-positron collider experiments at LEP and Stanford that there are only three kinds of light neutrino has considerably boosted confidence in the understanding of how nuclear material was formed in the Big Bang. These and other implications for 'dark matter' – the invisible mass of the Universe – were a talking point at the recent astrophysics workshop in the Moriond series, and a focus of the meeting 'LEP and the Universe' at CERN organized jointly by CERN and the European Southern Observatory (ESO). Details in the next issue.

DESY Theory Workshop

This year's DESY Theory Workshop from 1-3 October will be on 'Waiting for the Top Quark'. Further information from Andrzej Buras at Munich Technical University (bitnet T2101BD at DMOLRZ01) or Martin Luescher at DESY (bitnet TOOFRI at DHHDESY3).

Visiting CERN at the same time in March were two eminent mathematicians – Alain Connes (left) of the Collège de France and Institut des Hautes Etudes Scientifiques, and Sir Michael Atiyah of Oxford.

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– Kennziffer 063/90 –

Aufgabengebiet : Mitarbeit bei der Entwicklung und Durchführung von Mittelenergieexperimenten am LEAR/CERN und COSY-Jülich, insbesondere bei der on-line-Datenaufnahme.

Anforderungen : abgeschlossenes Hochschulstudium, möglichst mit Promotion; fundierte experimentelle Erfahrungen auf dem Gebiet der Mittel- und Hochenergiephysik, im Umgang mit Szintillationsdetektoren, Drahtkammern, Magnetspektrometern und Cerenkovzählern; gute Sprachkenntnisse in Englisch und Französisch; Erfahrungen in der Zusammenarbeit mit internationalen Forschungszentren erwünscht.

Die Vergütung und Sozialleistungen erfolgen nach den Bestimmungen des Bundesangestelltentarifvertrages (BAT).

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Denis Keefe 1930-1990

Denis Keefe 1930-1990

Denis Keefe of Lawrence Berkeley Laboratory, a pioneer in heavy ion inertial confinement fusion, died suddenly at his home on 11 March. A native of Dublin, Ireland, he began his physics work at University College there, studying cosmic rays. After coming to Berkeley in 1959, he became interested in accelerators, working in the 200 BeV Study Group and leading the Electron Ring Accelerator experimental group. Keefe's interests later turned toward fusion energy, particularly inertial confinement fusion using heavy ions as a driver. In 1976 he formed a research group that continues to explore this subject in theory and experiment. Keefe was active in both the scientific and civic communities. In 1985 he became editor of Particle Accelerators, and he was a founding member of SOS, Scientists for Sakharov, Orlov, and Scharansky, which campaigned on behalf of Soviet dissidents.

Ben Feinberg

Physics and detectors for LHC

To explore in detail and update the physics possibilities for the Large Hadron Collider (LHC) project at CERN (December 1989, page 1), the European Committee for Future Accelerators (ECFA) is now preparing for an LHC Workshop to be held in Aachen from 4-9 October.

All the options for physics studies are covered, together with ideas for the detectors, and the requirements for experimental areas and data handling techniques.

Two kinds of working groups have been set up. Scientific evaluation working groups will consider the physics potential of proton-proton, electron-proton and nucleus-nucleus collisions in the light of recent experimental and theoretical developments. The conveners (theorists and experimenters) for these three working groups are respectively: G. Altarelli, D. Denegri and F. Pauss; R. Ruckl, W. Bartel and J. Feltesse; H. Satz and H. Specht.

On the detector side, the following topics and conveners have been selected: event generators, detector simulation and software engineering – R. Brun, D. Denegri and F. Pauss; signal processing, triggering and data acquisition – S. Cittolin, G. Manfredi and A. Walenta, vertex detection – H. Heijne, B. Hyams and M. Tyndel; tracking – M. Giorgi, H. Leutz and D. Saxon; calorimetry – M. Albrow, J. Colas and R. Klanner; electron identification – T. Akesson and E. Fernandez; muon identification – P. Duinker and K. Eggert; consultants on radiation hardness – H. Schonbacher and F. Wulf; consultants on experimental areas – L. Leistam and K. Potter. Machine experts for the three collision options will be W. Scandale (proton-proton), G. Guignard and A. Verdier (electron-proton), D. Brandt (nucleus-nucleus).

The ECFA-LHC Working Groups and Workshop Organization is chaired by J.E. Augustin, G. Jarlskog coordinates detector R&D and G. Flugge is the local organizer for the Aachen workshop. There will be a two-day intermediate meeting of the working groups at CERN on 18-19 June.

Books

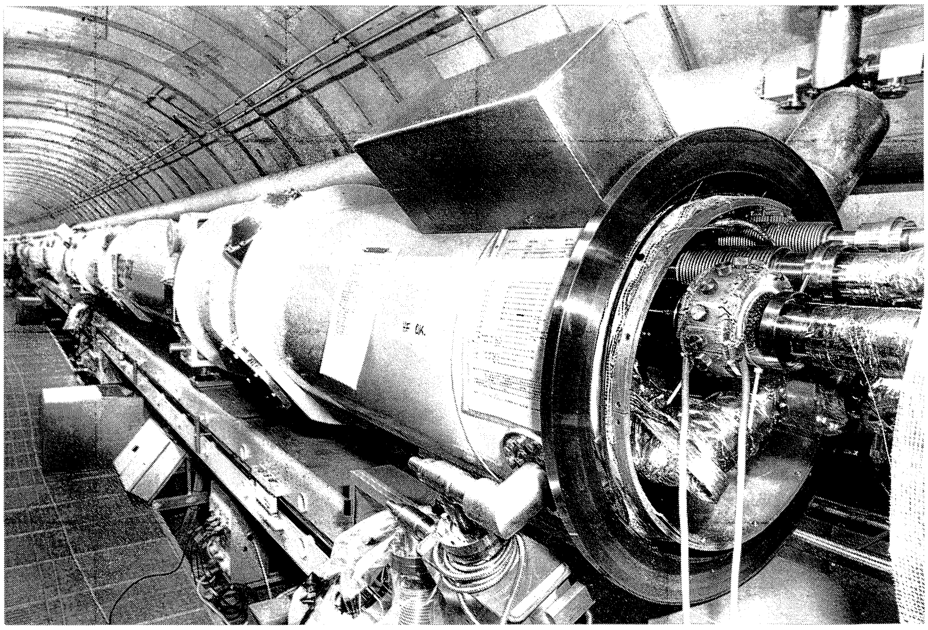
'Physics in the Making', a collection of Essays on Developments in 20th Century Physics, edited by A. Sarlemijn and M.J. Sparnaay and published by North-Holland, marks the 80th birthday of H.B.G. Casimir. The multi-part book reflects Casimir's important and impressively diverse contributions to science: Part I covers his early quantum physics work with Ehrenfest in Leiden, Bohr in Copenhagen, and Pauli in Zurich; Part II describes the contributions of the mature scientist in basic quantum physics, electrodynamics, thermodynamics, groups and symmetries, etc, many signposted by relations, operators and effects which bear his name; Part III, on physics in industrial laboratories, is a token of Casimir's additional claim to fame as Director of Philips' industrial laboratory.

Electron-Positron Annihilation Physics, edited by B. Foster of Bristol and published by Adam Hilger, provides a comprehensive introduction to this important field, with chapters on the Standard Model and QCD, Fragmentation, Heavy Quark and Gluon Physics, and 'Where do we go from here?'. The book is de-

dicated to the PETRA machine at DESY, once a prolific source of this physics but now preparing for a new role as injector to the HERA electron-proton collider.

Sau Lan Wu has been appointed Enrico Fermi Distinguished Professor at the University of Wisconsin.

Final installation for an octant of superconducting magnets for the proton ring of the HERA proton-electron collider at the German DESY Laboratory in Hamburg. The octant has been cooled to 4.4K and first results are eagerly awaited.



High field dipole workshop

A workshop on 'High Field Niobium-Tin Dipole Magnets' will take place at DESY, Hamburg, from 3-4 July. Information from Peter von Handel, DESY, D-2000 Hamburg 52, bitnet F35BLU at DHHDESY3

HERA cooldown

An important milestone for the HERA electron-proton collider being built at the German DESY Laboratory in Hamburg was passed early in April when the turbines of the HERA refrigeration plant were switched on to cool down the first octant of the superconducting proton ring (the 612 m from Hall West to Hall South, equipped with 52 dipoles and 26 quadrupoles) to 4.4K.

CERN Theory Division Leaders past and present at a surprise birthday party for Tatiana Faberge of the division's secretariat - left to right – Leon Van Hove, Bruno Zumino, Maurice Jacob, current leader John Ellis, Tatiana, and Jacques Prentki.

The University of Iowa
Department of Physics & Astronomy

Postdoctoral Associate

The University of Iowa Department of Physics and Astronomy has recently established a group in High Energy Physics. Qualified applicants are invited to apply for a postdoctoral position in Experimental High Energy Particle Physics. The appointment is for an initial two years with possible extensions. Presently, members of the faculty are participating in three fixed target experiments at Fermilab radiative hyperon decay (E761), photoproduction of high p_t jets (E683), and experiments with polarized protons and antiprotons (E704). The group will also participate in testing key elements of an experiment to study production and decay mechanisms of charmed baryons (E781). Research and development opportunities for SSC experiments are also being explored. Applicants should have a recent PhD in experimental particle physics. Interested persons should apply to :

Professor Y. Onel
Chair, Search Committee
Department of Physics & Astronomy
The University of Iowa
Iowa City, Iowa 52242
USA

The University of Iowa is an equal opportunity/affirmative action employer. Women and minorities are encouraged to apply.

STAFF SCIENTIST
Lawrence Berkeley Laboratory
University of California

The Advanced Light Source (ALS), a new facility based on third-generation electron storage, is currently under construction at the Lawrence Berkeley Laboratory. The technical components of the source comprise a 50 MeV linac, a 1.5 GeV booster synchrotron, and an electron storage ring optimized for operation at 1.5 GeV, but capable of operation between 1.0 and 1.9 GeV. Machine commissioning will start with the injection systems (linac and booster) early in 1990. The Exploratory Studies Group seeks a staff scientist to work on high-level applications programming and operational phases of the project.

Responsibilities include: developing algorithms to control the behavior of the beam in the accelerators; interpreting the data gathered by the diagnostic system; and developing fault-finding procedures in the event of abnormal conditions. NOTE: Candidate selected will move into a position within the accelerator operations group of the ALS. Demonstrated experience in computer control applications and working knowledge of FORTRAN and PASCAL. Knowledge of accelerator physics and experience in an acclerator-based laboratory. Experience with Modula 2 and C desired. A PhD in Physics or closely related field preferred.

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To apply, send two copies of resume to: Lawrence Berkeley Laboratory, 1 Cyclotron Road, 90/1042, Box A5722, Berkeley, CA 97410, USA. EEO/AA.

Survey Engineer & Engineering Assistant

The Vacuum and Mechanical Engineering Group at Argonne National Laboratory is seeking two talented professionals for its 7-GeV Advanced Photon Source Project. As construction is soon to begin, we are seeking an experienced and an entry-level survey Engineer.

Primary responsibilities include accurately positioning the APS accelerator, storage ring and experimental area components; evaluating, testing and providing instruction for the use of state-of-the-art optical and electronic position measurement equipment; and performing error analysis and reductlon via computer programs.

A Masters degree or equivalent is required in Geodetic Science or Photogrammetry and a strong management background for the experienced Survey Engineer. For the entry-level Engineer, a Bachelors degree or equivalent is required in Engineering. Both positions require an educational emphasis on survey science and statistical analysis; a working knowledge of computers, global positioning systems, industrlal survey, geodetic and micro geodetic techniques; and good report-writing skills. Occasional travel is also required.

Argonne offers excellent professional growth potential, a competitive salary commensurate with experience and comprehensive benefits.

For consideration, please send resume and salary history, indicating position of interest, to:

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Edward E. Smith
Box J-APS-36618/81231-88
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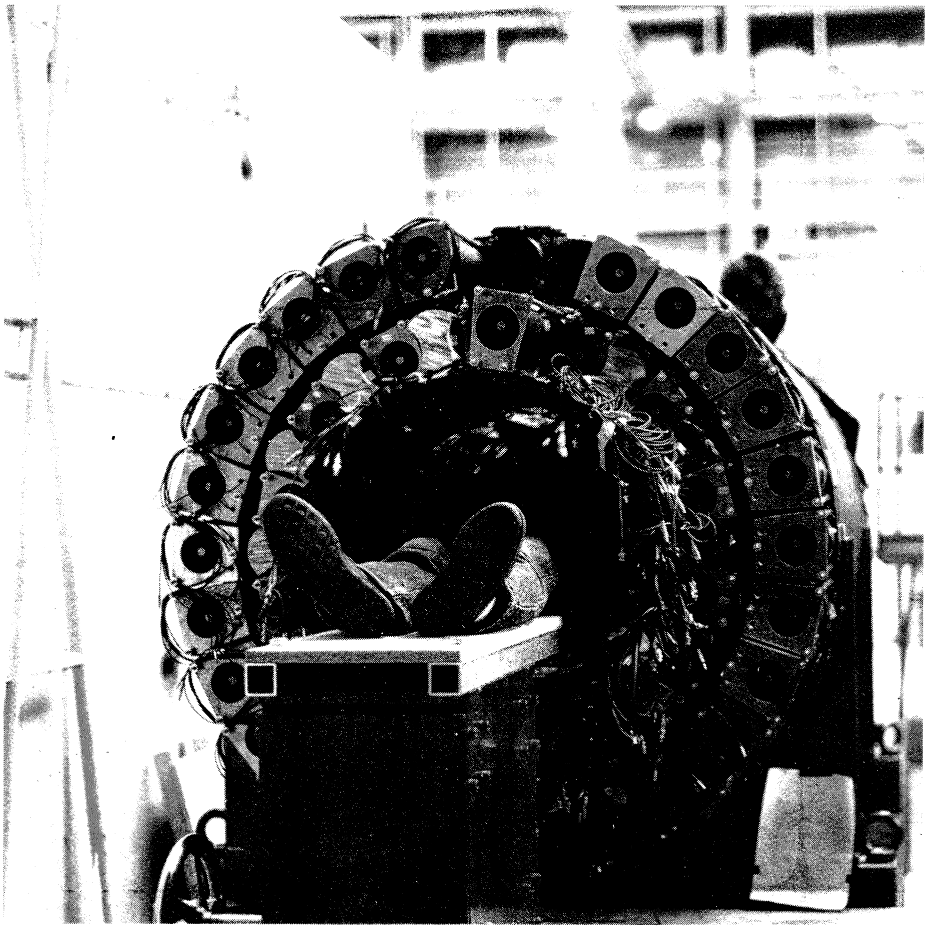


Without a leg to stand on. The dynamics of absorption are one of the remaining unsolved puzzles of lower energy pion interactions with nuclei, where recent evidence for multi-nucleon reaction modes has created a lot of excitement. They will be studied at the Swiss Paul Scherrer Institute (PSI) by a Basle/Karlsruhe/Los Alamos/Maryland/MIT/NAC/ New Mexico State/PSI/Zagreb teams using this LADS (Large Acceptance Detector System) detector.

(Photo Markus Wildi)

Engelberg Forum

This year saw the inception of the Engelberg Forum, a new platform for interdisciplinary communication between science, technology and economics. From its site in the geographical and cultural centre of Switzerland, the forum sets out to help germinate the fertile seeds sown by European cooperation in many different areas.

For its initial year, the theme was 'The stakes involved in scientific research: from decision making to application', with physics and the machine industry selected as scientific and technological keynote topics.

With the recent completion of the LEP electron-positron collider and the start of its experimental programme, CERN in nearby Geneva provided a natural illustration of modern physics.

Underlining the strong links between pure science and the technology which becomes part of people's lives, Sam Ting pointed out in the forum's introduction a characteristic 30-year time difference between basic physics discoveries and their mass spinoff benefits – X-rays, lasers, superconductivity, nuclear power...

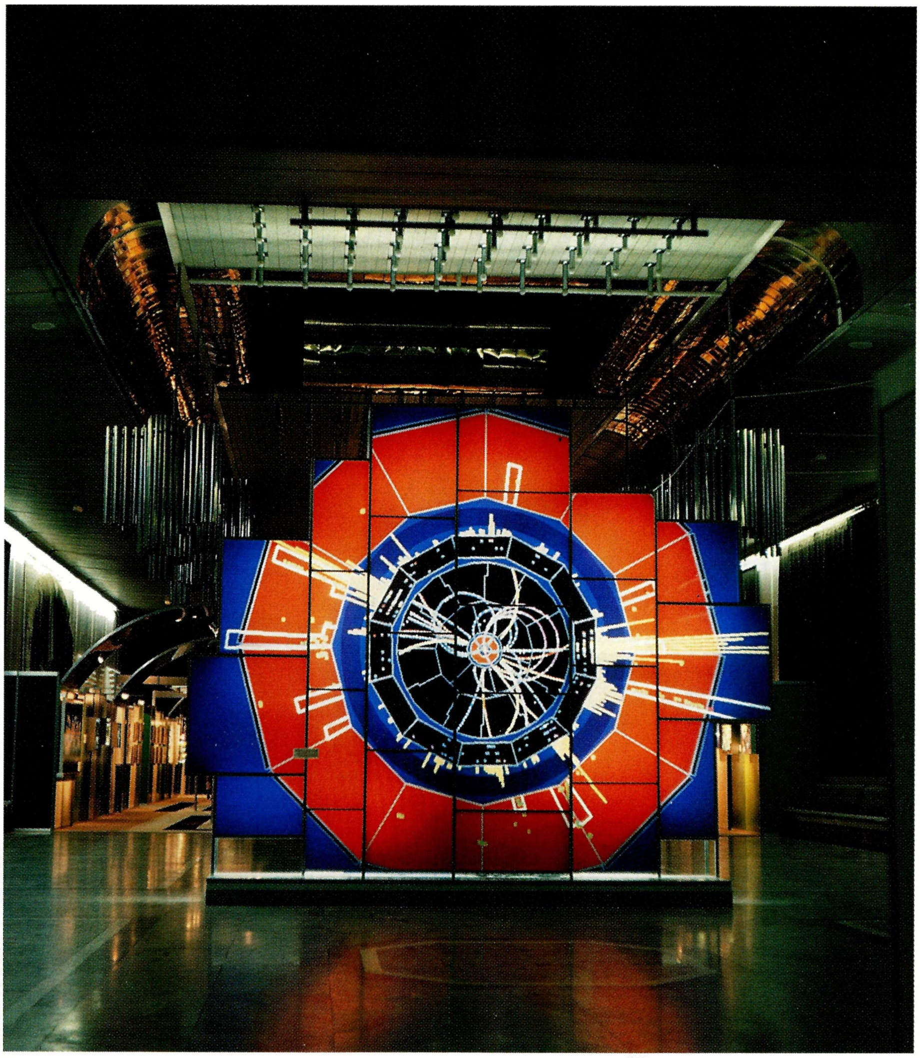
Continuing the CERN theme were Emilio Picasso and Maurice Bourquin, respectively describing LEP construction and exploitation, and Giorgio Brianti on technology transfer.

For science already at work in technology, specifically microelectronics, Heinz Schwaertel of Siemens was of the view that simulation studies bring deepened understanding and hasten the development of an optimal end-product.

For the future, former CERN Director General Herwig Schopper described a rich evolving scenario of particle physics, while Roy Schwitters, Director of the US Superconducting Supercollider (SSC) Laboratory in Texas, was on hand to personify US commitment to build an 87-kilometre proton collider.

Evandro Agazzi, President of the International Academy for the Philosophy of Science, gave an appreciation of Schopper's role in the realization of LEP, while Arnsinn Graue, Rector of Bergen University and Chairman of CERN's Finance Committee, proposed a vote of thanks to all who had participated in LEP construction.

In summary, Forum Chairman Franz Muheim examined the achievements and aspirations of major scientific projects, using CERN as an example, with their deep implications for international, industrial and intellectual collaboration, and looked forward to the continuation of the Engelberg Forum next year, when the spotlight will turn to biology and to technological spinoff.



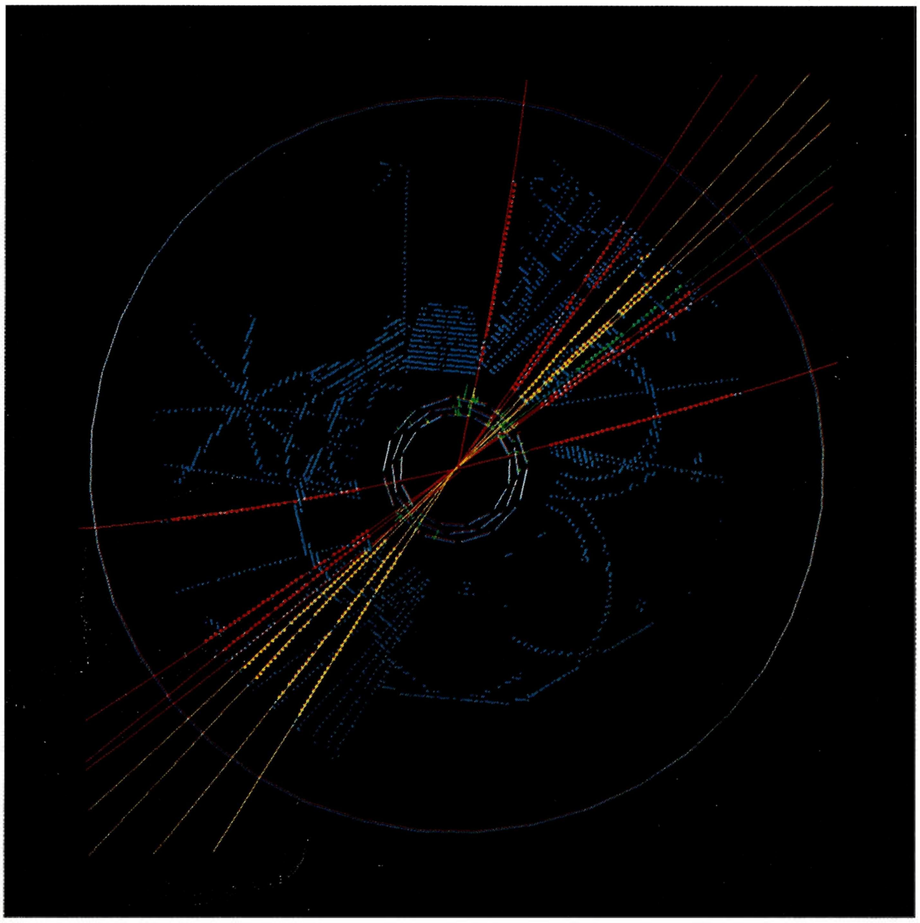
In particle physics, the fifth quark is not the only thing that can carry beauty.

Just over four metres high, this illuminated 'stained glass' reproduction of the decay of a Z particle as seen by the Aleph detector at CERN's LEP electron-positron collider had its first public showing when CERN's travelling exhibition visited Ljubljana, Yugoslavia, in March. It is exactly half the size of the actual detector.

(Photo Georges Claude)

SLAC Summer Institute

This year's SLAC Summer Institute will be held from 16-27 July with the general theme of Gauge Bosons and Heavy Quarks. Further information from Nina Adelman Stolar, SLAC Bin 62, PO Box 4349, Stanford, CA 94309 USA, bitnet SSI at SLACVM.



Decay of a Z particle as seen by the Mark II detector at Stanford's SLC Linear Collider. Yellow tracks are hadrons from a secondary vertex (subsequent to the Z production), red are hadrons from the primary production vertex, and a muon is shown green. Hits in the inner silicon strip vertex detector are also in green, while counts in the surrounding drift chamber are blue.