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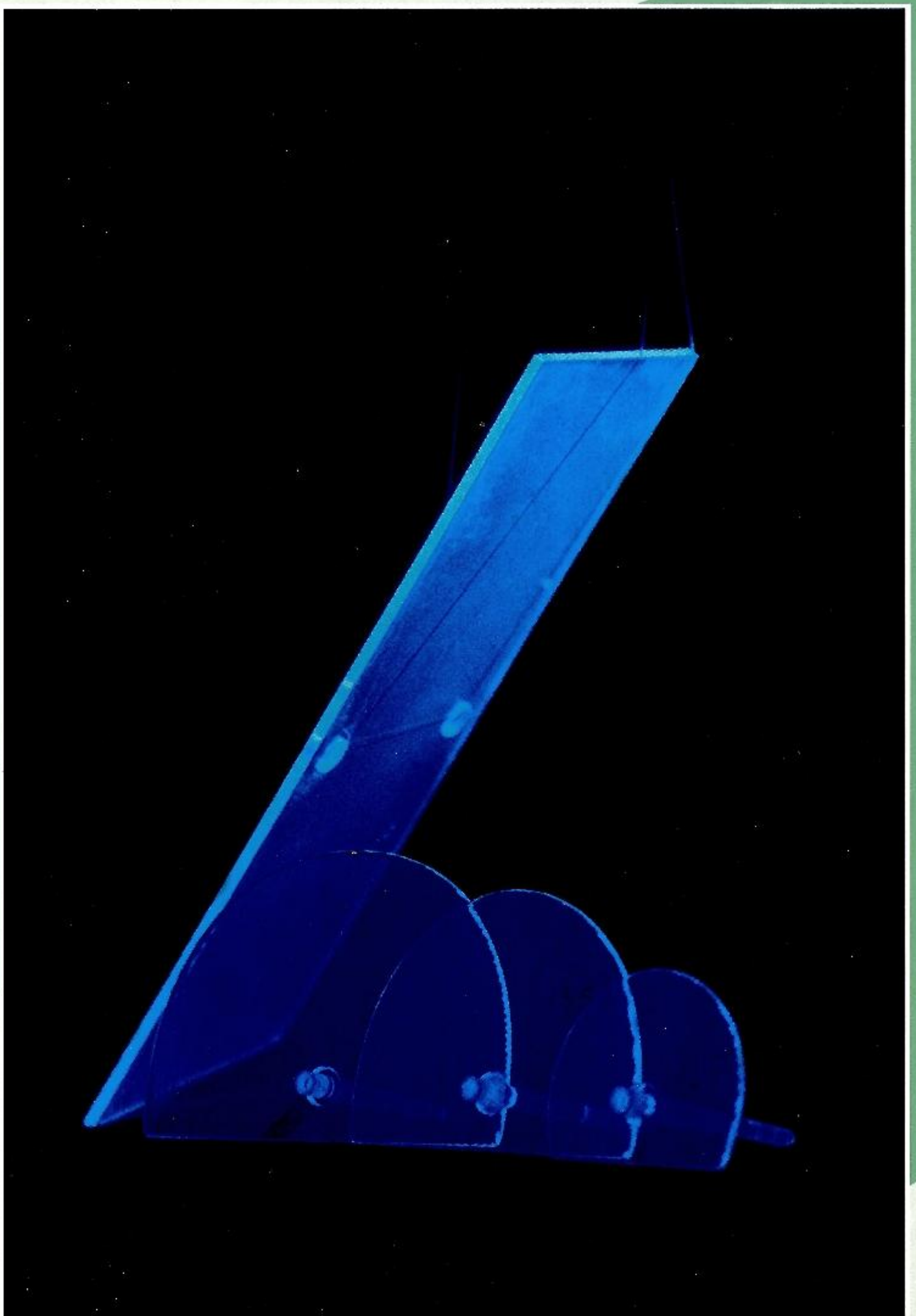

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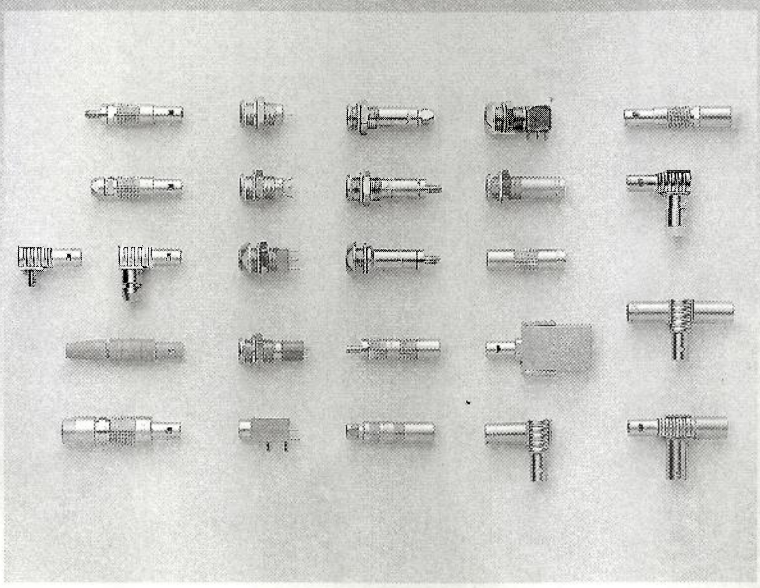

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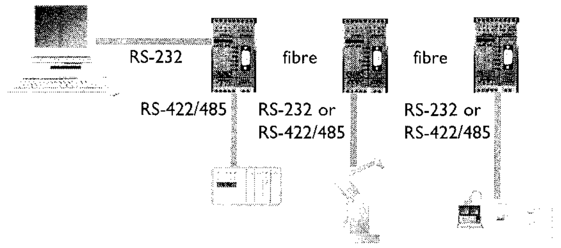

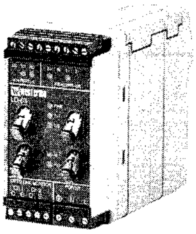

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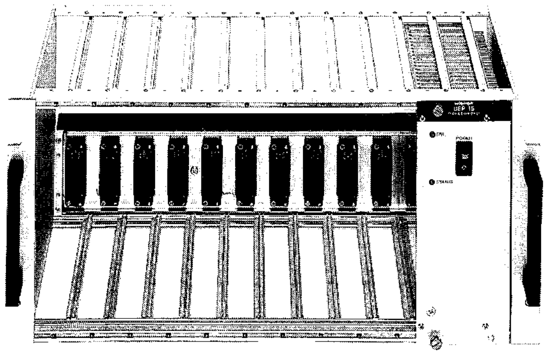

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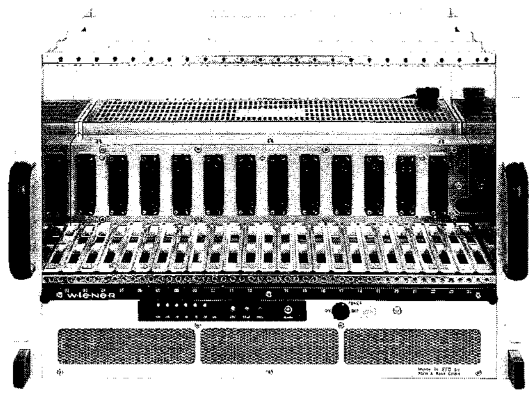

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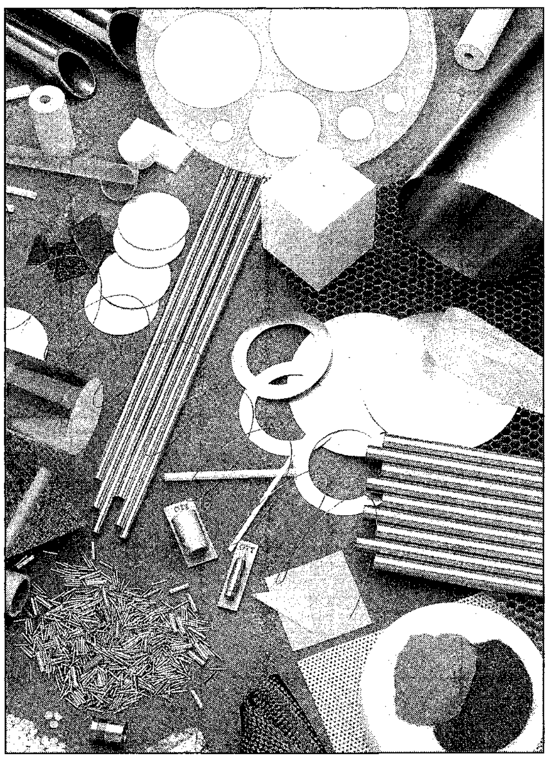

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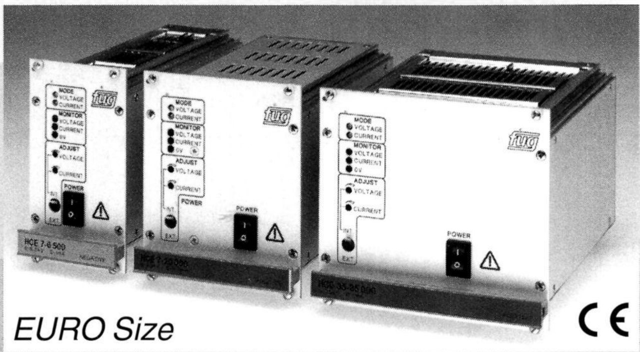

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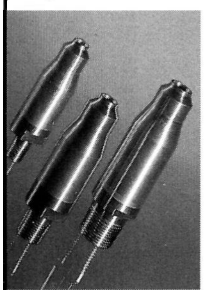

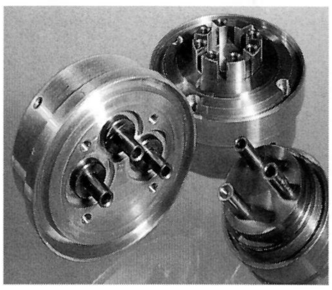

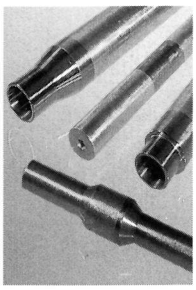

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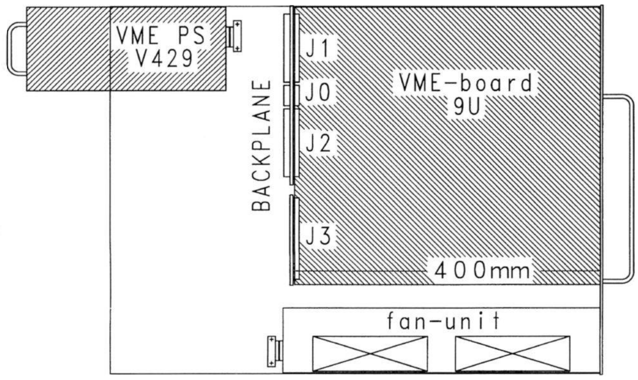

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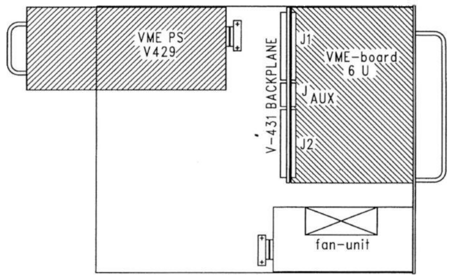

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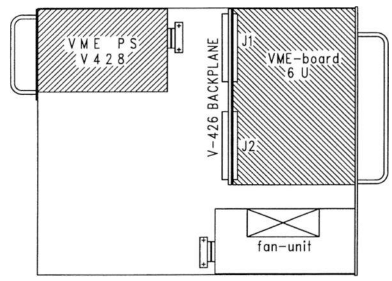

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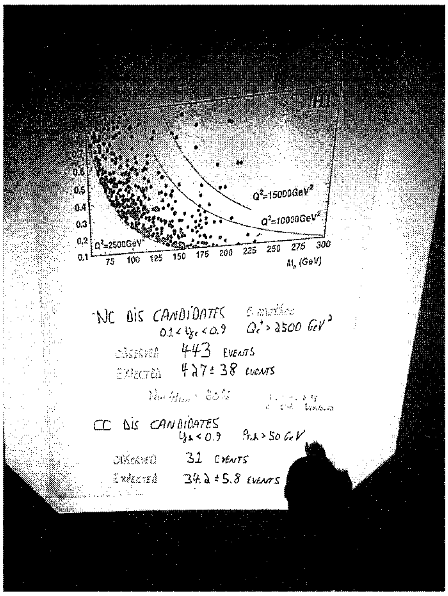
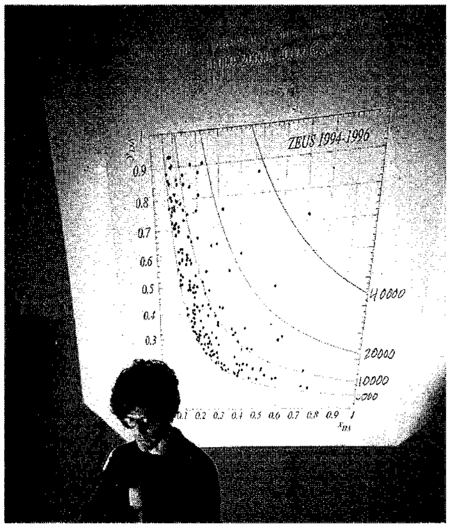
HERA's wide angle vision

At a seminar at the DESY Laboratory, Hamburg, on 19 February, Yves Sirois of Ecole Polytechnique, Paris, and the H1 experiment (left) and Bruce Straub of Columbia and the Zeus experiment described the unexpected yield of highly backscattered electrons (positrons) in the HERA electron-proton collider. The events, some of which are in previously unexplored kinematical regions, are visible on the right of the two scatter plots. (Photos Petra Folkerts)





Intriguing results based on several years of accumulated data from the HERA electron-proton collider at the DESY Laboratory, Hamburg, which probe more deeply than ever before into the underlying structure of matter have sparked a wave of speculation about new physics, perhaps even an additional layer of matter, even more fundamental than the tiny quarks hidden deep inside nuclear particles.

HERA collides high energy electrons (in fact positrons) with protons, and most of the time the two colliding particles brush past each other. However occasionally the electron (positron) slams into something hard and ricochets back the way it has come. These back-scattered positrons are the key to the mystery, the backscattering giving a lever on the violence of the collision process.

The dry-as-dust official DESY communiqué said "two HERA experiments, H1 and Zeus, observe an excess of events above expectations at high-x (or M = sqrt(xs)), y, and Q-squared. For Q-squared greater than 15,000 GeV-squared, the joint distribution has a probability of less than one per-cent to come from Standard Model NC DIS processes."

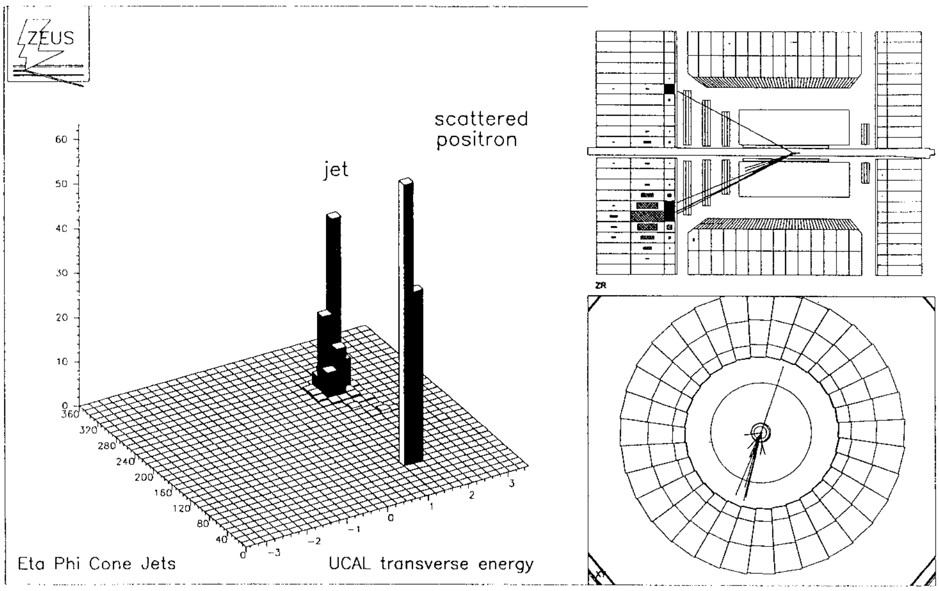
Peering behind this impenetrable jargon, it is tempting to recall the historic 1911 experiment by Rutherford, Geiger and Marsden which was startled to see that occasional alpha particles, instead of passing through a thin screen, bounced back the way they had come. Rutherford realized that a few alphas were encountering something small but solid deep inside the atom and recoiling backward. For the first time, physicists were seeing the effects of a new layer of matter, the atomic nucleus. The significance of the discovery was immortalized in Rutherford's imaginative remark 'It was as if a fifteen-inch shell fired at a piece of paper had come right back and hit you'.

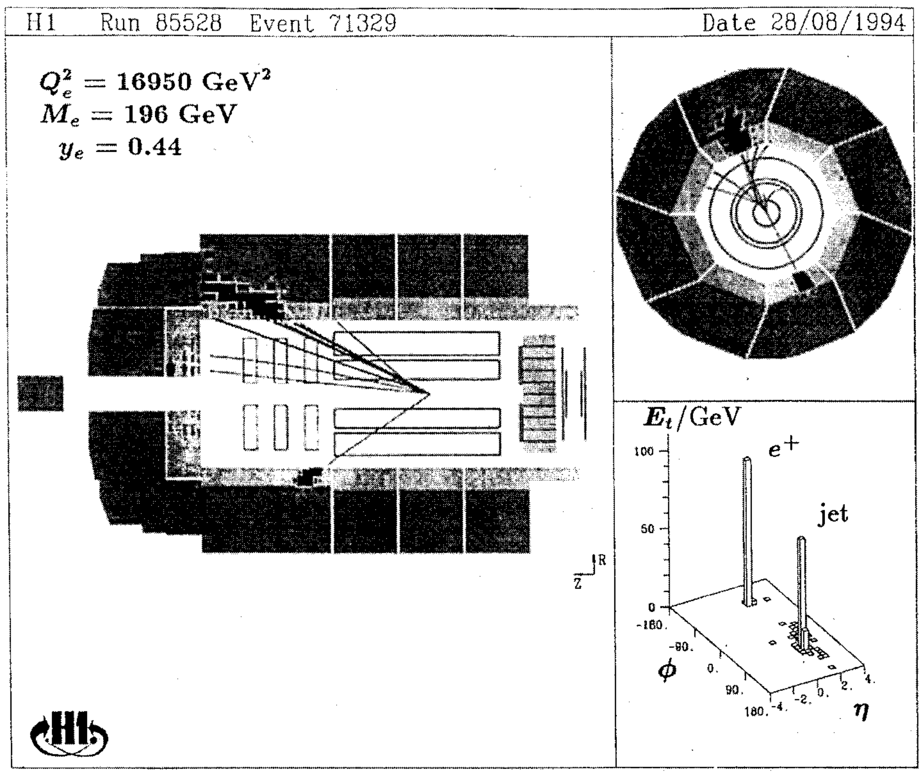
Half a century later, alpha particles had given way to electrons. Experiments by Robert Hofstadter at Stanford used electron beams to probe first the nucleus and then the nucleon. These electron scalpels revealed that the proton was not a point but had a shape and a form. Then in 1967 at the mighty SLAC two-mile linac came another epic discovery, this time using 20 GeV electrons, the highest electron energy in the world at the time.

Looking away from the line of the incoming beam, Jerome Friedman, Henry Kendall and Richard Taylor were surprised to see a lot more electrons than they expected. The electrons had been severely jolted by something solid deep inside the protons. It was a rerun of the Rutherford experiment at a lower rung of the substructure ladder, showing that the proton contains hard scattering centres, the 'partons', subsequently identified as quarks. Were quarks the bottom rung of the structure ladder, or is there a sub-quark 'basement'?

To explore this and other physics, the DESY Laboratory in Hamburg, in collaboration with research centres in ten countries, built the HERA electron-proton collider, with 820 GeV protons held in a 6.3 kilometre ring of superconducting magnets colliding with 27.5 GeV electrons. HERA began operating for physics in 1992, but since 1994 the collider has been operating with positrons, rather than electrons, to give better operating conditions.

In these asymmetric collisions, the penetrating power of the electron/positron beam gives it an unprecedentedly close view, down to 10^{-16} cm, of the quarks and gluons deep inside the protons of the high energy beam. With wavelengths a thousand times smaller than the proton, the photons and other messenger particles passing between the electrons and the quarks and gluons 'illuminate' the





Two examples of the events reported by the Zeus and H1 experiments at the HERA electron-proton collider at DESY, Hamburg, in which the electron (in fact a positron) appears to hit something very hard deep inside the oncoming quark and recoils back the way it came. The shock of the impact makes the struck particle inside the proton generate a tight cascade, or 'jet' of particles, which sweeps on in the direction of the proton. The recoil positron track is seen at the top in the Zeus event, above the jet, and at the bottom, below the jet, in H1. The experiments report many more of these events than can be accounted for by our current understanding of the quark/gluon structure of the proton

deep interior of the protons, revealing the constituents in much finer detail than has previously been possible.

An early discovery was the HERA-eye view at the so-called low-x region, where more quark-gluon content has been found than had been expected initially, heralded by some as evidence of an increased gluon content of the proton at these low momentum fractions.

Most of the time, HERA's two major detectors, Zeus and H1, see reaction products tending to sweep along with the more energetic protons. But even in the standard picture of the quark/gluon structure of the proton, a few high energy proton constituents are expected to send the incoming electrons (positrons) flying back the way they came. However both experiments see more positrons recoiling backwards than expected. The shock of the impact deep inside the proton dislodges the struck constituent particle, which bursts into a tight cascade, or 'jet' of particles as it leaves the proton. Many of these highly backscattered positrons result from collisions in previously unexplored kinematical regions, although the latest harvest of data from Fermilab's Tevatron proton-antiproton collider is awaited with interest.

H1 sees 12 backscattered positrons,compared to an expected 5, carrying a squared momentum transfer greater than 15,000 GeV^2. The statistical probability of seeing such a fluctuation is estimated to be six per mil. As well as these positron events, caused by the exchange of electrically neutral currents, H1 also sees a few very violent events with no emerging positron, these being mediated by charged currents, with the exchange of electrically charged particles.

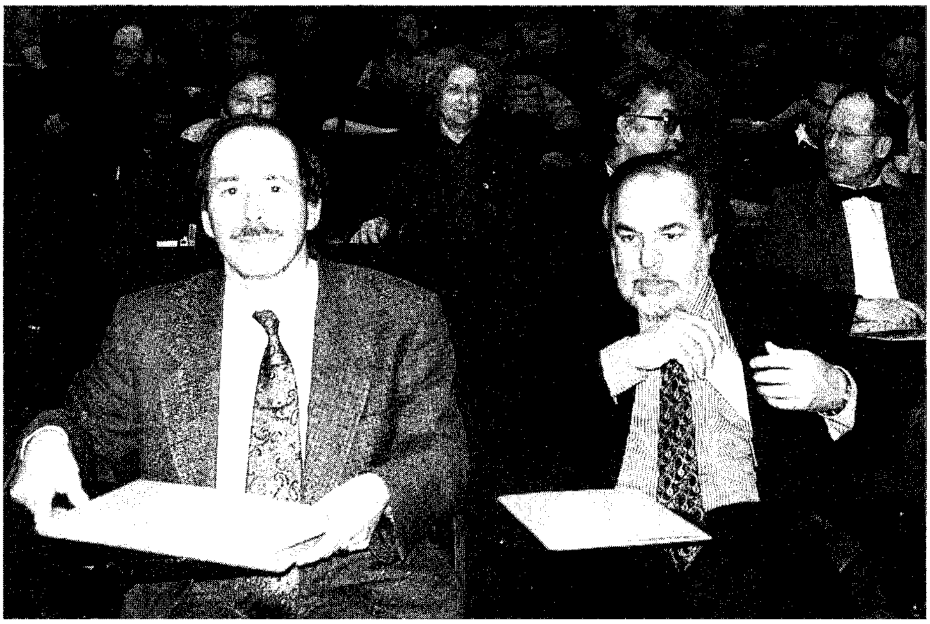
Looking at higher momentum transfers, above 35,000 GeV^2, Zeus sees two events where only a fraction of an event would be expected. A statistical analysis of more highly backscattered positron events again makes them look very unlikely (0.7%) based on conventional estimates. These positron events seen by Zeus are the largest neutral current effects ever seen in a laboratory.

In calculating these expected signals, the conventional quark/gluon structure of the proton has to be estimated over an interval where it has never been measured, extrapolating from better known kinematical regions. However the outcome seems to be relatively insensitive to unexpected variations at this level of structure.

The events point to a particle of mass around 200 GeV or more, too heavy to be accommodated by presently known physics. One possible scenario is the production of a leptoquark, where the positron and the struck quark fuse together to form a 'leptoquark' (see following article).

More data from this year's HERA

running period, which extends from March to October, will clarify whether the experiments have glimpsed new physics or have merely been the victims of a statistical mirage.



Speakers at the recent memorial meeting for Abdus Salam held at the DESY Laboratory, Hamburg, included Gerard 't Hooft (left) and Ahmed Ali.

(Photo Petra Folkerts)

A fitting memorial

A possible interpretation of the unexplained HERA results (see previous article) in terms of 'leptoquarks' provides a fitting memorial to the fertile imagination of Abdus Salam who died last November (January, page 11). In a larger unification scheme encompassing both quarks and leptons (weakly interacting particles), leptoquarks could be the carrier particles, transforming quarks into leptons and vice versa.

At a memorial colloquium to Salam held at DESY, Hamburg, on January 29 (which would have been Salam's 71st birthday) Ahmed Ali recalled his first post-doctoral years at Salam's International Centre for Theoretical Physics (ICTP), Trieste, and the physics issues on Salam's mind in the early seventies. Among the milestones of that era, Gerard 't Hooft in 1971 provided the first proof of the renormalizability of spontaneously broken gauge theories, proving the conjectures of Weinberg and Salam.

In the summer of 1973, first evidence of neutral weak currents was provided by the CERN-Gargamelle team. This was reported at the 1973 European high energy physics conference at Aix-en-Provence. At Aix, Weinberg gave the rapporteur's talk and in the comments invited by T.D. Lee, chairing the session, Salam, overwhelmed by the implications of work he had just finished with Jogesh Pati proposing proton decay, forgot about the 'old' excitement of the discovery of the neutral currents and jumped headlong into the implications of the proposed new gauge interaction!

This ebullience was typical of Salam, always ahead of his time, always seeking new frontiers in his quest for a grand view. In the same vein, another exciting paper of that era was Salam and Pati's paper - 'Lepton as the fourth colour'. This postulated a new kind of gauge bosons - leptoquarks - leading to effects in lepton-nucleon scattering. The two HERA experiments now see some unexplained events which could be interpreted in terms of such leptoquarks!

Also at the memorial meeting, Dieter Haidt, who figured prominently in data analysis leading to the neutral current discovery at Gargamelle, described the impressive chain of experimental milestones which placed the Weinberg-Salam model on the pedestal of the standard theory of electroweak interactions. Gerhard Mack of Hamburg reminisced about his ICTP post-doctoral years in the late sixties during the gauge revolution in particle physics to which Salam contributed significantly, and the afternoon concluded with a talk by Gerard 't Hooft on gravity as a universal cut-off. Gravitational theories were a recurrent theme in Salam's papers in the seventies. Following Salam's style of going for a grand view, 't Hooft turned to the status of current research on black holes, an inevitable source of new physics, and its possible influence at the Planck scale.

Salam will of course be remembered for his contribution to the Standard Model, but also in wider physics questions his seminal papers on proton decay and lepton-quark universality will remain a testimony to his fertile mind and imagination.

While proton decay has not yet been seen, the experiments originally

Around the Laboratories

built to look for it gave birth to the science of neutrino astronomy, while the idea of lepton-quark universality could now have arrived.

CERN
Green light for ALICE

ALICE, the LHC experiment specifically designed to focus on heavy ion physics, has received the green light to proceed towards final design and construction.

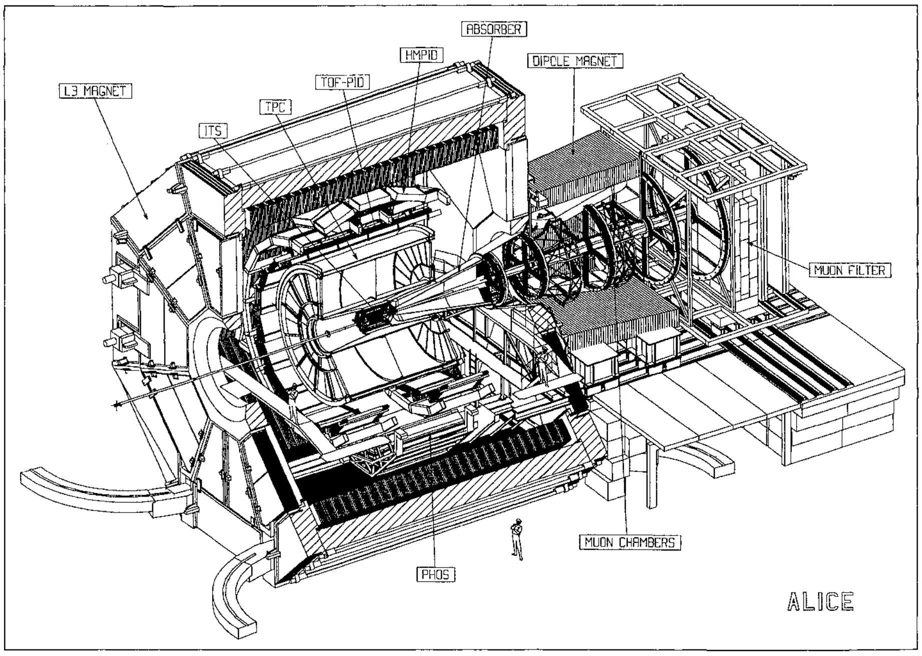
At the extreme densities reached in very high energy heavy ion collisions, it is expected that the quarks and gluons which constitute the nucleons will break loose into a new state of matter, the quark gluon plasma, recreating a small-scale version of the Big Bang from which the Universe was created some 15 billion years ago.

ALICE is the natural continuation, at CERN, of the SPS Heavy Ion program, initiated in 1986, which has recently provided exciting new results in the quest for the quark-gluon plasma (July/August 1996, page 1).

A trademark of heavy ion collisions is the vast number of particles ("multiplicity") produced in each collision ("event"). Up to fifty thousand charged particles are expected to be emitted in a lead-lead collision at the LHC, of which about ten thousand will go through the ALICE central detector. That is why the central tracking in ALICE is based on the Time Projection Chamber (TPC) technique, which has already proven its value in registering tracks in a high multiplicity environment within the NA49 SPS experiment. The LHC collision rate in heavy ion mode, modest if judged by "proton standards", is compatible with TPC drift times of around 100 microsec.

Inside the TPC, immediately around the beam pipe, will be the Inner Tracking System (ITS), a 6-layer silicon based detector merging three technologies: pixels, strips and drift. Again, these are well known detector techniques and already at use in present SPS experiments (WA97, NA50 and Ceres, respectively).

Particle identification (PID) over a



ALICE, CERN's LHC experiment specifically designed to focus on heavy ion physics, has received the green light to proceed towards final design and construction. With its prominent forward muon spectrometer and based on the magnet from the L3 LEP experiment, ALICE will open up a new phase in the study of quark matter.

wide kinematical range and for many different particle species will be available in ALICE thanks to an array of TOF counters, with a time resolution of 100 picosec or better. The baseline system uses Pestov counters and is the main ALICE item in new detector technologies. Work is underway to make sure everything works according to expectations. A fallback solution in the form of Parallel Plate Counters (PPCs) is also being investigated.

In the forward direction, within a 9 degree angle around the beam, ALICE will be equipped with a muon spectrometer, made of a sophisticated hadron absorber, a dipole magnet, five tracking stations (made of Cathode/Pad Strip Chambers) and two trigger stations (made of Resistive Plate Chambers). Measurements on muon pairs are an essential part of the ALICE physics programme, since heavy dileptons probe the early stages of the produced medium, hopefully the plasma of deconfined quarks and gluons, not being affected by the further evolution of the system (expansion and cooling) or by the quark-hadron phase transition.

With a good set of cards in hand, to be evaluated and confirmed by a long series of carefully delineated milestones, ALICE is en route to start operation at LHC start-up time. The ALICE collaboration will be ready to identify and systematically study the state of matter from which our universe was made, provided by the LHC's Little Bangs.

ATLAS calorimeter

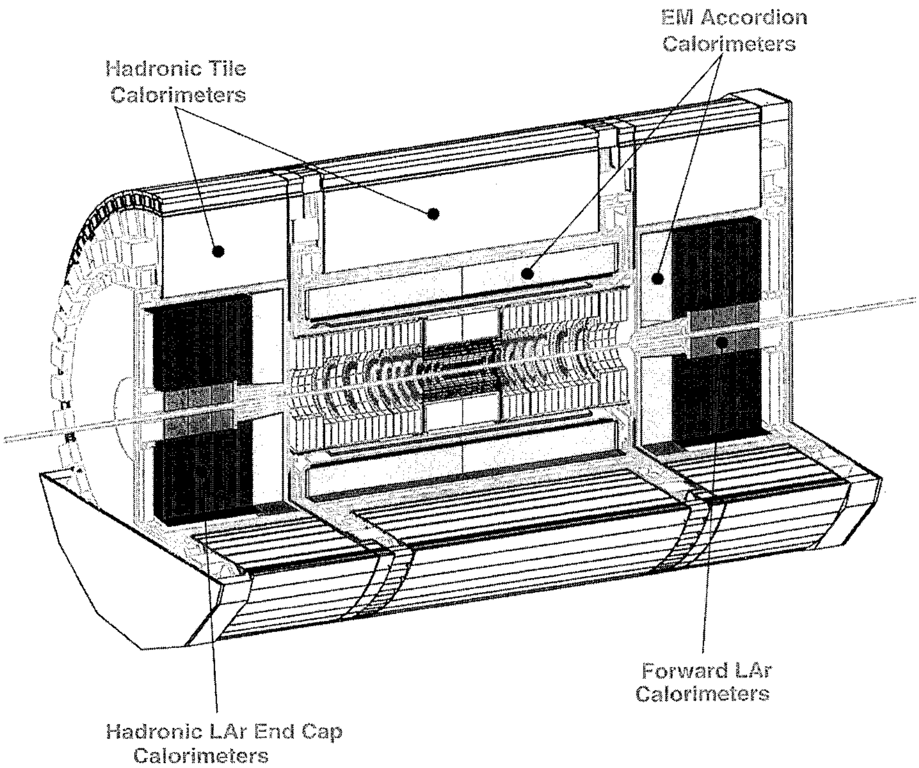
Design work and prototyping is well under way for the modules which will make up the large ATLAS detector for CERN's LHC proton collider.

One feature of the ATLAS design stresses very good electromagnetic calorimetry for electron and photon identification and measurements, complemented by accurate measurements of hadronic jets and missing energy.

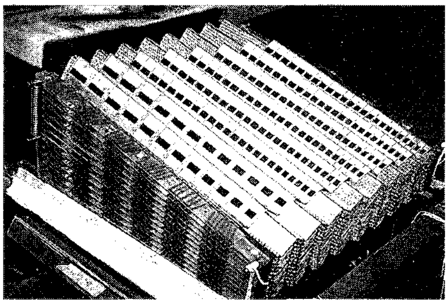
Arranged as a conventional central barrel with two endcaps, the inner part (including endcaps) uses the very radiation resistant liquid argon technique for electromagnetic measurements, contained in a 13-metre long cylinder with outer radius 2.25 m, surrounded by less expensive iron-scintillator tiles sampling calorimetry for the hadronic part, extending to a radius of 4.25 m.

In the inner part of the endcaps, liquid argon is also used for the hadronic calorimeter. Although it would have undoubtedly provided superior performance, an initial plan to use liquid krypton for the electromagnetic barrel calorimeter was dropped because it would have been too expensive and too complex. Cryogenics for the liquid argon barrel are grouped with those for the 2T superconducting solenoid for the inner detector.

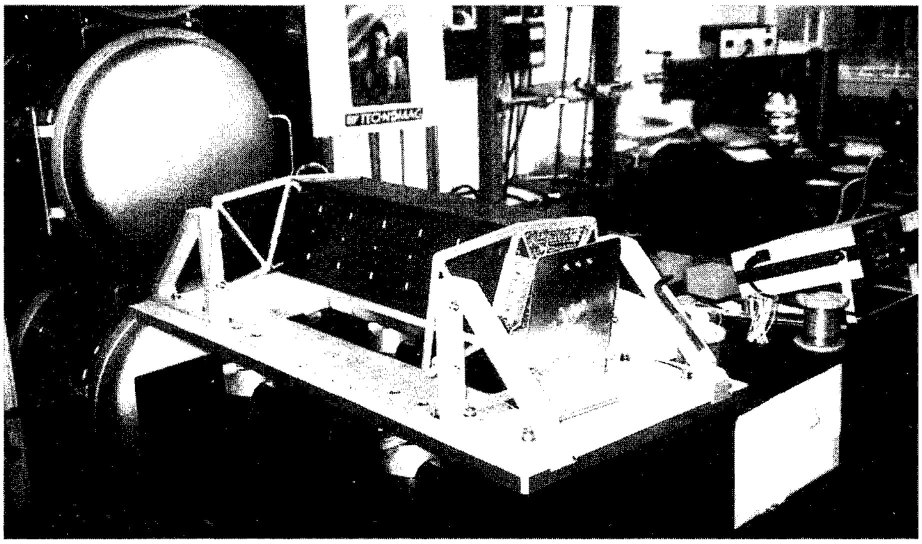
For the electromagnetic liquid argon part, the 1024 lead-stainless steel converters of the sampling calorimeter are arranged in a novel corrugated 'accordion' structure, with plates following the direction of the emerging secondary particles.



Schematic of the calorimetry in the ATLAS experiment for CERN's LHC proton collider, showing the arrangement with a central barrel and endcaps in liquid argon technology, surrounded by iron-scintillator tiles.



For the electromagnetic liquid argon part of the ATLAS calorimeter, the lead-stainless steel converters are arranged in a novel corrugated 'accordion' structure, with plates following the direction of the emerging secondary particles. (Photo CERN EX32.9.93/3)



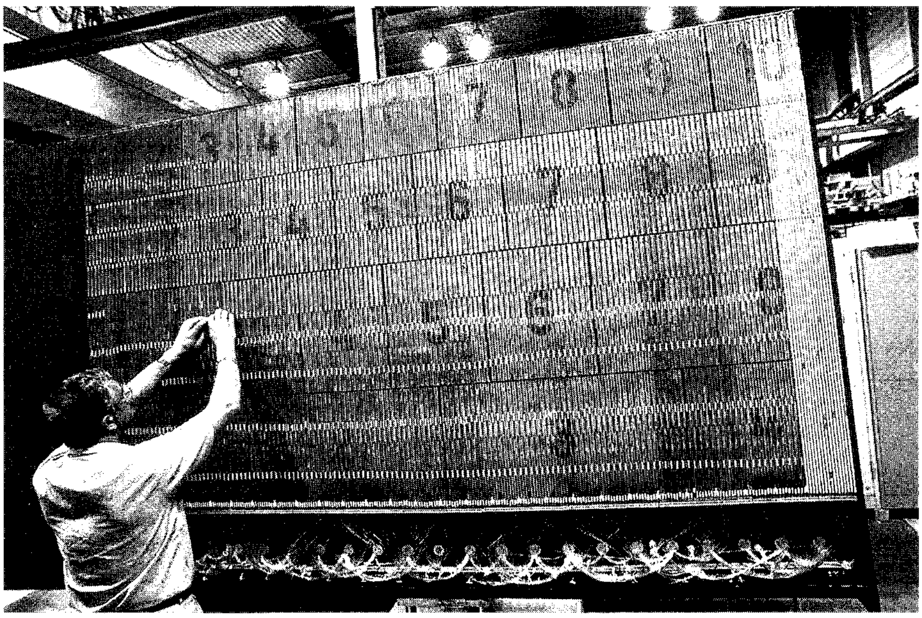
A CERN-built prototype of an ATLAS transition radiation tracker module. Surrounding the inner semiconductor tracking, this technique contributes to inner detector tracking and to electron identification.

With the calorimeter partially obscured by the interior cryostat wall and magnet coil, a 'presampler' is required to estimate and correct for energy lost before particles arrive at the calorimeter, and a suitable design has now been chosen, with a coarse-grained structure of liquid argon layers instrumented with electrodes.

Special requirements are needed for the forward calorimeter around the beam pipe about 5 metres from the collision point. Fully integrated with the endcaps, liquid argon is again the sampling medium of choice. The copper and tungsten absorber volumes contain a dense matrix of coaxial readout tubes, each with a thin annular gap of liquid argon, parallel to the beam direction.

The barrel hadronic calorimetry is provided by an active medium of 3mm-thick scintillator tiles (see next story), interleaved with absorber in the form of 14mm steel sheets, and fashioned as a large 2500-tonne cylinder to surround the liquid argon barrel and endcaps. Full-scale prototypes under test show promising energy resolution.

Scintillation light from the tiles is read out to photomultiplier tubes via wavelength-shifting fibres. To make best use of available space, new compact photomultiplier tubes have been custom-built for this particular application.

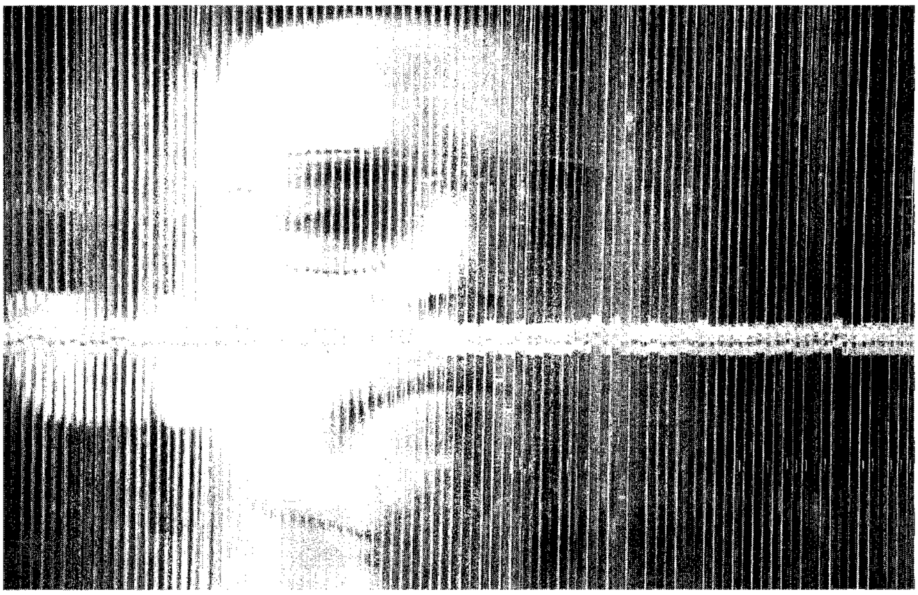


A full scale wedge-shaped module of the ATLAS iron-scintillator tiles calorimeter. (Photo CERN EX4.7.96)

Technology transfer on the tiles

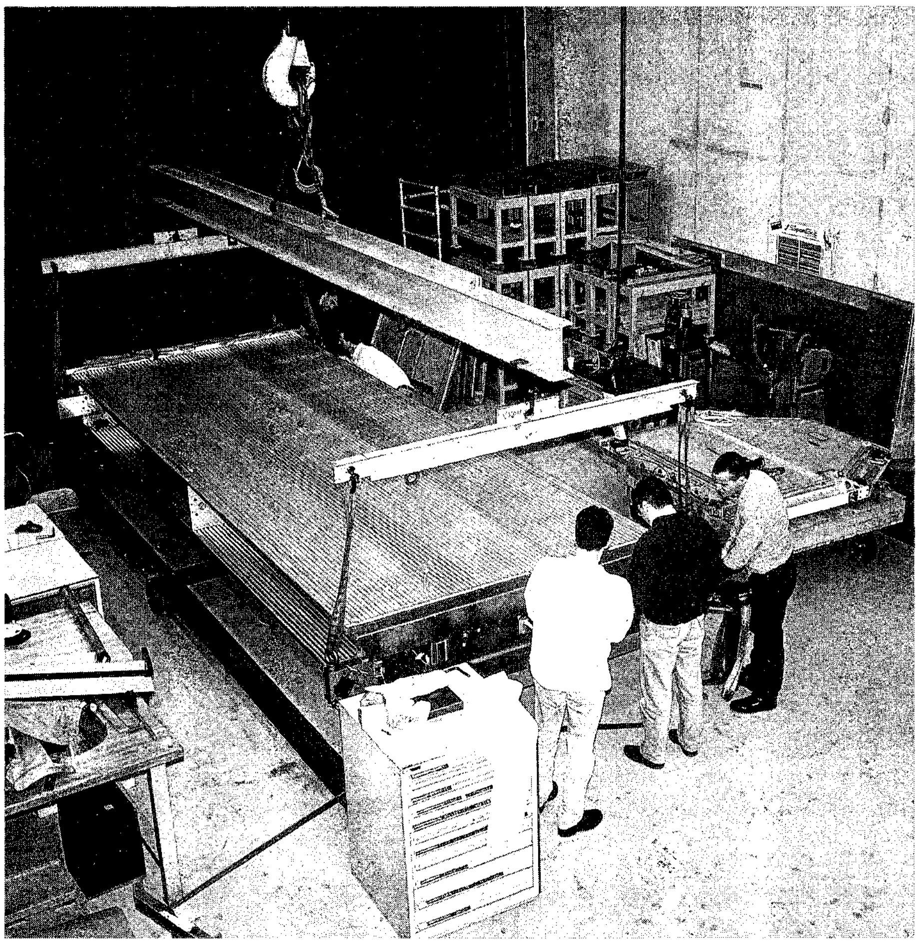
The large detectors for particle physics experiments often need large scale manufacturing techniques. A good example is the 80 tonnes of material needed to clad the hadronic calorimeter of the ATLAS detector at CERN's future LHC proton collider.

Transparency. The face of a young scientist is clearly visible through a stack of 10 cm thick scintillating tiles. The tiles, 3 mm wide (crossways in the photo) are being produced in Minho, Portugal, for the hadronic calorimeter of the ATLAS experiment at CERN's LHC proton collider.



At the Institute for High Energy Physics, Protvino, near Moscow, industrial techniques of plastic dyeing and injection moulding have been adapted to physics requirements (September 1994, page 16). For ATLAS, the Portuguese Laboratory for Instrumentation in Physics (LIP) took major responsibility for the scintillator, which has to be supplied as some half a million thin sheets, or 'tiles'. While the Portuguese plastics industry inherited much moulding expertise from earlier generations of glass specialists, the stringent demands of the ATLAS calorimeter for optical quality posed a problem.

To help boost Portuguese expertise, contact was made through the Protvino members of the ATLAS collaboration with Russian specialists from the ARI Chemical Technology Institute in Moscow and the SPO 'Luch' concern in Podolsk, and the project received the backing of the International Science and Technology Centre (ISTC), the agency funded by the US, the European Community and Japan to promote new science and technology projects in the former USSR and



In January this prototype of a driftchamber (5.5 m x 2.2 m) for the ATLAS muon spectrometer was transported from NIKHEF, Amsterdam, where it was built, to CERN. The muon spectrometer in the barrel region of ATLAS will consist of several hundreds of large drift chambers in three layers, each of which will measure a muon track segment. Prototypes of drift chambers from the middle and inner regions were built in MPI Munich and Munich University, Germany, in Frascati, Pavia and Rome, Italy, and in Protvino, Russia, and transported to CERN last year. With the arrival of this prototype of an outer region chamber, one single prototype ATLAS "muon tower" is complete. The performance of the chambers and the merits of two alignment-systems (RASNIK, developed at NIKHEF and ALMY, developed at MPI, Munich) will now be tested using cosmic-rays.

diversify the effort formerly channeled into military applications.

Under this new agreement, SPO 'Luch', with Portuguese participation, will design and produce moulds, and develop the polishing method and necessary control equipment. Moulding trough technology will be developed in Portugal, and accelerator tests of the new scintillator tiles will be carried out at Protvino and at CERN by Russian and Portuguese physicists respectively.

In this interesting example of international collaboration for technology transfer, the Portuguese traditionally strong moulding industry is being boosted by Russian expertise from a very different sector.

Putting more neutrons to work

Promising progress with Carlo Rubbia's Energy Amplifier scheme shows that this technique could go on to provide useful spinoff benefits as well as pointing to a new route to energy production.

The Energy Amplifier exploits beams from a particle accelerator to produce neutrons by spallation from a suitable target. These neutrons then feed a fuel/moderator assembly, in which the neutrons multiply by fission chain reactions. At a certain level, the liberated energy overtakes that needed to drive the accelerator, and this net gain is the key to energy production.

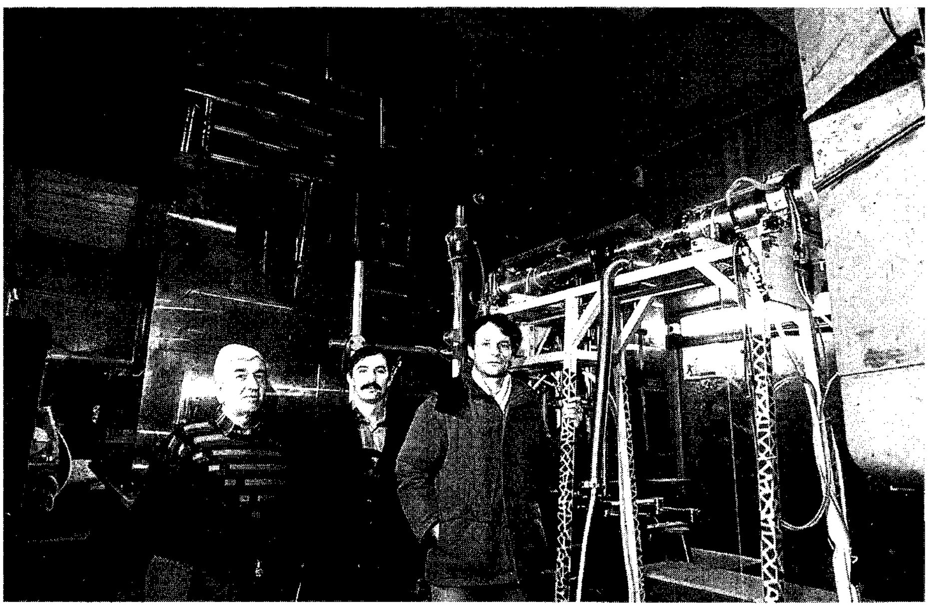
Feasibility first depended on showing that actual neutron yields corresponded to estimates from initial simulations, and an initial experiment, using low energy beams from CERN's PS proton synchrotron and an arbitrary target/moderator assembly of natural uranium and water produced an energy gain of 30, precisely as expected. A more optimal arrangement, geared to the needs of actual energy production, should attain much higher gains (100 - 150).

The next step was to use a large assembly of very pure lead, large enough to contain most of the produced neutron cloud, to investigate the capabilities of pure lead as a neutron spallation target and as a neutron moderator. Previously the behaviour of such a large moderator could only be simulated, and the complexity of the input data, in particularly the capture rates, demanded a thorough experimental test.

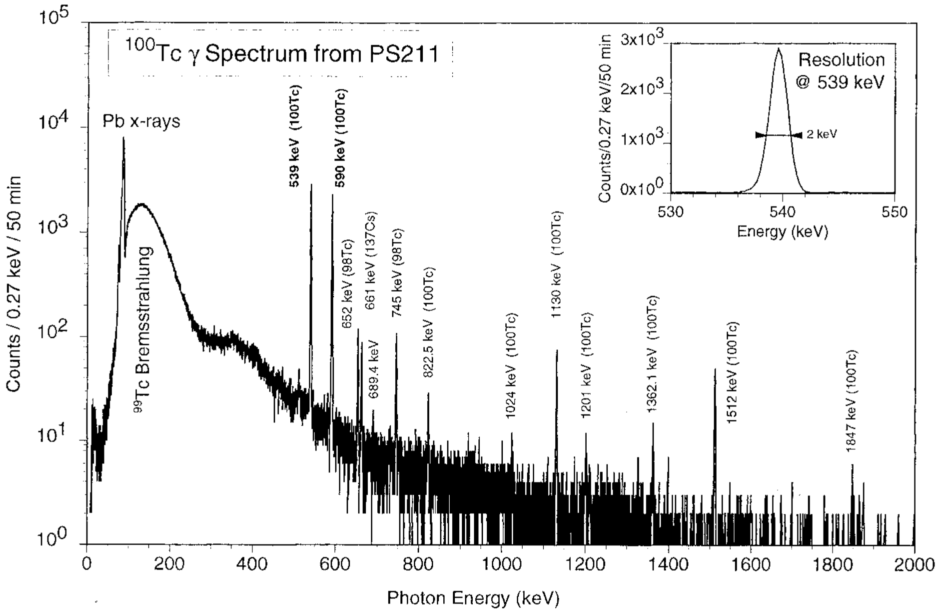
The objective of the Energy Amplifier is to use a target/moderator assembly of molten lead. The potential of molten lead for heat extraction will be investigated separately.

Pure lead has among the lowest capture rates of neutrons of any known element, as a result surviving for several milliseconds, during which time neutrons collide thousands of times with surrounding nuclei, losing energy only very slowly in the process. This contrasts with the case of neutrons in hydrogen, which attain thermal energies after only about 20 collisions.

Because of these tiny energy losses, neutrons in lead effectively cover a continuous range of energies



The TARC - Transmutation by Adiabatic Resonance Crossing - experiment, led by Carlo Rubbia, is looking at the intriguing possibilities of spallation neutrons in a lead target. Obtaining 334 tonnes of very pure lead, the largest quantity ever assembled, was an initial hurdle. Beams from a particle accelerator (the beamline is visible on the right) produce neutrons by spallation in the lead. These neutrons then multiply by fission chain reactions. At a certain level, the liberated energy overtakes that needed to drive the accelerator, and this net gain should allow the process to be used for electricity production. Seen here at the experiment are (right to left) Jean-Pierre Revol, Enrique Gonzalez-Romero, and Delecurgo Brozzi.



Burning up nuclear waste. In their 'adiabatic' slowing down process in lead, neutrons sweep through all the neutron capture resonances and smother them. This shows the tell-tale fingerprint of the transmutation of technetium-99 in such a neutron furnace. The nuclide would otherwise live for hundreds of thousands of years.

and will intercept narrow nuclear resonances. Hence the TARC - Transmutation by Adiabatic Resonance Crossing - experiment, a collaboration of groups from CERN, France, Greece, Italy and Spain, supported by the European Union.

In the neutronics trade, energy losses are measured in terms of 'lethargy', the logarithm of the ratio of successive neutron energies, and TARC attains tiny lethargy steps of some 0.01.

As well as promising an environmentally friendly assembly, a lead target/moderator could thus contain a cloud of neutrons to act as 'scavenger' particles, attacking the nuclear resonances of notorious pollutant fission fragments such as technetium-99 and iodine-129. Normally these survive for hundreds of thousands and millions of years respectively and have to be consigned to deep repositories.

The TARC experiment began last April. It uses 334 tonnes of very pure lead, one of the largest quantities ever assembled. A variety of techniques are employed to measure the neutron flux - silicon diode detectors using lithium-6 or uranium-233 targets; helium-3 counters using scintillation light; helium-3 ionization (wire) counters; activation of gold foils; thermoluminescence dosimetry; and measurements of the fission rates of thorium or neptunium.

To see if radionuclides are being eaten up, semiconductor detectors pick up the characteristic gamma rays from nuclear decays.

In the ingenious 'Rabbit' scheme, samples of the radionuclides, sealed in small containers, are fired by gas pressure through channels in the lead block, emerging at a measurement port for subsequent analysis in the 14.4 seconds between successive proton shots.

The results show the tell-tale signs of the transmutation of technetium-99 and iodine-129, showing that the proliferation of neutrons in the lead indeed can 'burn off' such nuclides.

The experiment has collected a lot of data which are now being analysed. With confidence in the neutron simulations, the Energy Amplifier's moderator and neutronics behaviour have now been demonstrated. As well as providing energy, these neutrons could also be used to 'burn' unwanted radionuclei, without disturbing the operation of the surrounding amplifier.

BROOKHAVEN Crystal Ball still bouncing

The famous Crystal Ball multiphoton and electron spectrometer, which has served with great distinction in studies of charm and beauty mesons, recently arrived at Brookhaven from SLAC, Stanford. It will be installed at the AGS Alternating Gradient Synchrotron and used as the centrepiece of a new extensive baryon spectroscopy programme. The detector is being equipped with a hydrogen target at its centre and with a fast data acquisition system. The upgraded detector will be exposed to beams of negative pions and kaons, producing a wide range of final states. Since the Crystal Ball covers a wide solid angle, the complete angular distributions of various reactions can be measured simultaneously.

The Crystal Ball, built by a SLAC/Stanford/Caltech/Harvard/Princeton collaboration, was the first multiphoton and electron detector of its kind. It was first used in measurements of the decays of particles made of a charmed quark and antiquark at SLAC's SPEAR electron-positron collider from 1978 to 1981.

The Crystal Ball spectrometer recently arrived at Brookhaven from SLAC, Stanford, for a third lease of life. Seen here with the detector are, (left to right) rear: Al Marusic (Ruder Boskovic Inst and UCLA), Sasha Starostin (St. Petersburg). Front; Brad Tippens (UCLA), Kelly Craig (Arizona State), Robert Karl, Fred Kobasiuk and Jim Johnson (all of Brookhaven), Ben Nefkens (UCLA), Volodya Bekrenev (St. Petersburg) and Steve McDonald (UCLA).

In 1982, the detector emigrated to Europe for a stint on the beauty-family at the DORIS electron-positron collider at DESY, Hamburg, subsequently returning to SLAC where it was kept in storage until being called into service for a third round of experiments, this time in baryon physics at the AGS.

The Crystal Ball consists of 672 tightly packed, but optically isolated, sodium iodide crystals. The outer diameter of the bare detector is a modest 130 cm, but about 2 m including phototubes and bases. A central 50 cm diameter cavity houses the hydrogen target with veto counters.

The geometry of the Crystal Ball is a mathematical challenge. The optimum solution turned out to be an icosahedron. Each of the 20 faces, called major triangles, is divided into four minor triangles constructed of nine triangular crystals of slightly different size, each crystal being shaped like a truncated triangular pyramid and pointing towards the hydrogen target. The overall shape of the Crystal Ball resembles the Epcot Center at Disneyworld, or the independence monument of the Grand Duchy of Luxembourg.

A complete icosahedron would have required 720 crystals. Of these, 48 are left out to make room for beam entrance and exit tunnels, leaving a total of 672. The efficiency for measuring photons is almost perfect and the high degree of crystal segmentation gives a good angular resolution.

The Crystal Ball has its own air-conditioned and well cushioned trailer, but moving it across the US was a major undertaking for which Brad Tippens and Tim Smart from UCLA deserve much credit. Accelerometers were installed to monitor vertical and horizontal movements. Temperature, pressure and humidity gauges were needed and a supply of dry nitrogen was used to flush the Crystal Ball box. Ben Draper, a student from Abilene Christian University, went "along for the ride" to keep a close eye on the gauges and

The Crystal Ball multiphoton and electron detector was first used at SLAC's SPEAR electron-positron collider from 1978 - 81. This 1982 picture shows the Crystal Ball en route to Europe for use at the DORIS electron-positron collider at DESY, Hamburg,

the speedometer of the truck.

The new Crystal Ball Collaboration covers 13 institutions in 5 countries - Abilene Christian University, Argonne, Arizona State, Brookhaven, George Washington University, Kent State, St. Petersburg Nuclear Physics Institute, Rudjer Boskovic Institute, Zagreb, UCLA, Colorado, Karlsruhe, Regina, and Valparaiso.

NIKHEF
Pionic atoms

In pionic atoms, an orbital electron is replaced by a negatively charged pion. If these pions are close to the nucleus, the atoms provide a tool for studying the strong interaction between pions and nuclei.

In a recent experiment at GSI Darmstadt (December 1996, page 8), pions were for the first time directly brought into a bound state through a novel method, using the nuclear reaction in which incident deuterons produced helium-3 nuclei. In this manner a low-lying pionic (2p) state in lead-207 was created, a major experimental step forward in this field.

Previous experiments on pionic atoms used the cascade-method: slow pions were captured in peripheral atomic states and then de-excited stepwise. From the late seventies, NIKHEF physicists, at the suggestion of Joop Konijn and Justus Koch, refined the detection techniques and made it possible to observe very low-lying states, such as the pionic 3d-states in lead-208 and bismuth-209, and to measure their binding energy and width*.

These states were the first to become known as 'deeply bound states'. To everyone's surprise, they were found to be surprisingly stable: their broadening due to the strong nuclear interaction was about half that expected from existing models. This was later confirmed by other groups.

Using improved optical potentials, predictions for the binding energy and width of other deeply bound states were made, among them the (2p)- and (1s)-orbits in lead. It will be interesting to see if the experiments in Darmstadt will confirm these predictions.

* C. de Laat et al., Nucl. Physics A523, 453-487 (1991)

At the recent session of the Scientific Council of the Joint Institute for Nuclear Research (JINR), Dubna, near Moscow, Russian Vice-Premier Vladimir Fortov (right) presents an Order of Friendship to former CERN Director General Herwig Schopper.

DUBNA
New Laboratory Directors

The 81st session of the Scientific Council of the Joint Institute for Nuclear Research (JINR) held in Dubna on 16-17 January included elections of Directors of JINR Laboratories: that of High Energies (LHE), the Flerov Laboratory of Nuclear Reactions (FLNR), and the Laboratory of Particle Physics (LPP). The Council elected A. Malakhov as Director of LHE to succeed A. Baldin, M. Itkis as Director of FLNR to succeed Yu. Oganessian, and V. Kekelidze as Director of LPP to succeed I. Savin.

At the session, several scientists were decorated with Russia's Orders of Friendship in recognition of their contributions to science and international cooperation and on the occasion of JINR's 40th anniversary, celebrated last year (April 1996, page 6). On behalf of the President of the Russian Federation Boris Yeltsin, the awards were presented by Russian Vice-Premier and the newly-appointed Russian JINR Plenipotentiary Vladimir Fortov, who is also Minister for Science and Technologies.

Among those decorated were members of the JINR Scientific Council and JINR's governing Committee of Plenipotentiaries: N. Amaglobeli (Georgia), U. Amaldi (Italy), S. Dubnicka (Slovak Republic), A. Hrynkiewicz (Poland), R. Mach (Czech Republic), Nguyen Van Hieu (Vietnam), G. Piragino (Italy), H. Schopper (Germany), and I. Vankov (Bulgaria).

Point of view

The shape of things to come?
by Roger W. Poultney

Over the last decade, something exciting has been "just about to happen" in the world of science publishing. But while visionaries continue predicting the imminent downfall of the publishing establishment, the status quo remains unshaken.

Does this mean that, despite a preponderance of new electronic journals, nothing in the basic mechanisms of publishing will really change after all? Nobody knows, but it does still seem a relatively safe bet that dramatic change could soon be round the corner. Since the beginning of the decade, new preprint distribution initiatives (such as Paul Ginsparg's famous Los Alamos preprint server http://xxx.lanl.gov/) have challenged the way particle physicists traditionally publish their work, with new results being routinely posted on the preprint servers for international distribution long before any kind of peer review has taken place.

But what does this mean for how physicists publish their work? Paul Ginsparg believes that the new developments will have some profound implications: "Since publication in a journal no longer gives a particularly useful guide, readers are forced to perform the majority of their selections by their own criteria. The current implementation of peer review should be entirely rethought in view of the new methods of electronic publication and dissemination." While some scientists may argue that without quality control an unprecedented proliferation of information will ensue, others believe that a fairer and more objective system of evaluation is now within their grasp. One proposal is to measure the citations that electronic preprints receive, but the main drawback seems to be that papers which are controversial (and not necessarily correct) invariably provoke an interested reaction; as such, initial citations alone are not a reliable indicator of quality.

Neither, indeed, is traditional peer review, which is often perceived to be an arbitrary and subjective process. Says Ginsparg: "One of the foremost problems at present is the large amount of information lost in the conventional peer review process, with the end result only a single, one-time, all-or-nothing binary decision. Although this may somehow be adequate for the purpose of validating research for job and grant allocations, it clearly provides little benefit to the average reader."

In reality, what will probably happen is the development of a "two-tier" system, where all work is systematically archived on the preprint databases, but with an indexed "front-end" guide to the literature taking readers directly to the most significant publications.

The situation is neatly summed up by Ginsparg: "Since there are now no financial or physical barriers to widespread dissemination, we can

Roger W. Poultney (ROGER@EAGLE.CO.UK) trained as an experimental high energy physicist at CERN, and is now a freelance science journalist and publishing editor for Eagle Intermedia. He was executive editor of the journal "Nuclear Physics B" from 1991 to 1994, and is currently involved in setting up new electronic journals and other internet-based projects for various European organizations.

imagine a relatively complete raw archive unfettered by any unnecessary delays in availability. Any type of information could be overlaid on this raw archive and maintained by any third parties." This approach has the advantage that while papers stored in the preprint archives are "written in stone", the front-end review systems are dynamic and can be changed to include papers retrospectively as fields evolve. This is especially true in high energy theory, where the true impact of new ideas may only show up years or even decades later. In this way the unwarranted rejection of important but unconventional papers should never happen. Good science will not be thrown away on the prejudices of editors and referees, and a more democratic method of appraisal should prevail. Several researchers and organizations are currently developing front-end systems along this new model. Examples include Paul Mende's "Virtual Review" (http://www.het.brown.edu/physics/review/index.html), , and Eagle Intermedia's "Particle Physics" (http://www.eagle.co.uk/ppj/home.html).

These systems work on similar principles, with volunteer "referees" nominating papers in their respective fields. In the "Virtual Review", papers are cited as hypertext links within a general review of a subject, whereas in "Particle Physics" discrete hypertext lists of selected works are compiled on a bi-monthly basis (but only after the original nominations have been endorsed by independently consulted editors).

The main difference here is that papers are initially nominated on an unsolicited basis (as opposed to traditional publication where authors actively submit their work for consideration by a paper journal). This means that authors are not held back by unnecessary delays in the editorial process, and are free to pursue simultaneous publication elsewhere.

Of course, there is little doubt that conventional peer review maintains standards by requesting revisions. This will always be required, though authors may arrange for it on their own initiative. Voluntary scrutiny already takes place when papers are produced by large international experimental collaborations (such as those at CERN). In most of these groups, internal committees check work before releasing preprints to the outside world. The result is that experimental papers rarely require revision before final publication.

With more emphasis being placed on preprints as the "finally accepted form" of an author's work, theorists may well follow the trend and "self-police" their own papers.

Generally, how the new culture takes off depends on existing traditions within different scientific disciplines.

Outsiders are very often surprised to learn that publishing traditions may be very different even between closely related fields. Bertrand Duplantier, a theoretical physicist at Saclay, collaborates with biologists on DNA macromolecule statistics. As an active editor, Duplantier is intrigued by the differences in publishing culture between physicists and biologists: "Preprint distribution is already widely accepted in the high energy physics community, and the new electronic systems have become very popular. But in biology there is a greater fear of plagiarism at the pre-publication stage, so preprint distribution is relatively less important."

Whether the momentum for change is driven by technology or by a genuine need for peer review reform, real opportunities to rethink the existing publishing mechanisms are now with us. Physicists should give new systems their full support, since much will ultimately depend on the dedication of individual practitioners. Only time will tell if those (Ginsparg included) who believe radical change is now inevitable are correct.

But without a high degree of "audience participation", important new initiatives could lose momentum. This would be a great pity for the high energy physics community (which after all invented the technology behind the World Wide Web), and for the world of science publishing in general.

[This text is an updated version of an article which originally appeared in Europhysics News No 27 (February 1996) p.24, and appears here by courtesy of the European Physical Society.]

Some useful URLs:

CERN preprint server - http://preprints.cern.ch/
Los Alamos National Laboratory (LANL) xxx preprint server - http://xxx.lanl.gov/
Particle Physics (front end review) - http://www.eagle.co.uk/ppj/home.html
Virtual Review (front end review) - http://www.het.brown.edu/physics/review/index.html

Physics monitor

Supporting fundamental science in the former Soviet Union

After the collapse of the Soviet Union, scientific infrastructure began to creak. Whatever its shortcomings, the system had assured the professional scientist of a certain status. When this traditional support suddenly began to wither, some of the cream of former Soviet science had to cry for help.

Fortunately the ingenuity and resourcefulness of this community has long been admired. As well as their great tradition in mathematics and theoretical physics and their highly visible achievements in space science and military applications, Soviet scientists have been a wellhead of valuable ideas which have continually stimulated their Western colleagues (who did not always accord their sources the full credit due).

Even before the fall of the Soviet Union an emergency had been foreseen. In September 1991 CERN Director General at the time Carlo Rubbia contacted French President François Mitterrand with the idea of creating an international foundation.

This trailblazing idea fell on initially fertile ground, and a 1992 G7 Summit Meeting encouraged the establishment of INTAS (International Association for the Promotion of Cooperation with Scientists from the Independent States of the Former Soviet Union), with an initial vote of 4 million ECU and a budget of 21 million for 1993-4. 25 million ECU was earmarked for international collaborations involving scientists from European Community countries and states of the former Soviet Union. Of this, some 600,000 ECU helped support the 'Journals for Russia' programme established by the European Physical Society (EPS), which also benefits from discounts granted by journal publishers, a scheme engineered by then EPS President Maurice Jacob. The European commitment to INTAS has now grown to 14 million ECU.

In the US, a Task Force set up by American Physical Society President Ernest Henley in 1992 to aid science in the former Soviet Union snowballed support. $100,000 from APS members was matched by equal sums from the Sloan and Meyer Foundations, and international financier George Soros soon contributed more than a million dollars.

The next problem was to get this money to where it was needed in a traditionally totalitarian country unused to customer banking.
The resulting administration and distribution system is itself a minor miracle, permitting cheques written in US dollars to be promptly converted into cash without undue deductions.

Using a private bank and the Soros Foundation Moscow office, $650,000 of support was deftly distributed to Russian scientists in this way. A comparable sum went to scientists in other former Soviet Union countries.

In December 1992, this timely effort was followed by the establishment by Soros of his $100 million International Science Foundation. Following thoughtful and rigorously applied guidelines, more than 25,000 individual $500 emergency grants were made. The most successful applications received

George Soros - bankrolling support for scientists in the former Soviet Union.

Carlo Rubbia - anxious about support for scientists in the former Soviet Union.

additional support for their co-workers and laboratories. Through a special travel programme, more than 200 scientists were able to attend conferences in the West. In 1993 this initial emergency aid was followed up by a scheme for long term research grants.

As well as cash, researchers need libraries and telecommunications. Under the ISF scheme, more than 100 journal titles are being distributed to libraries, mainly in Russia and Ukraine, but also in the Baltic States and Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Moldova and Uzbekistan.

The Soros schemes were adept at sidestepping bureaucratic red tape, but in the meantime more aid has built up. The Russian Foundation for Fundamental Research set up by Boris Yeltsin has disbursed the ruble equivalent of millions of dollars in some 6,000 grants each equivalent to some $5,000, many to ISF beneficiaries. Russian Prime Minister Victor Chernomyrdin pledged at least $12.5 million from his country to match Soros contributions.

The focus of Soros attention also shifted to the Cultural Initiative Foundation, extended to cover education not only in humanities but also in mathematics and natural sciences.

Another important driving force in this support is Germany, which in the wake of reunification inherited the obligations of the former East Germany and became the only Western nation to support the Joint Institute for Nuclear Research (JINR), in Dubna, near Moscow, and other institutions. Germany also underwrites some telecommunications links. There are many examples of smaller-scale contributions from Western Europe, including Moscow's newly-created International Centre for Fundamental Physics, set up by Nordita (Copenhagen) and the Lebedev Institute.

The other major pillar of support for the former Soviet Union is the International Scientific and Technological Centre (ISTC), which grew from a 1991 German initiative and with its backing from the US, Europe and Japan seeks specifically to diversify and reorient the huge effort formerly channeled into Soviet military applications.

Under an umbrella agreement between Russia, the European Union, Japan and the US, ISTC support has rapidly snowballed to 51 million ECU from the US, 45 million ECU from the European Union and 14 million ECU from Japan, together with additional support from Sweden. Kazakstan, Belarus, Armenia, Georgia and Kirgizstan are also involved.

This money has enabled 14,000 former-Soviet Union scientists and engineers, most of whom possess skills related to weapons of mass destruction or missile delivery systems, to become involved in non-military research. Over 300 projects, involving some 15,000 scientists, have been funded and about 9% of the work involves fundamental research. The pilot ISTC project at CERN was the krypton calorimeter for the NA48 experiment (October, page 16).

With physicists having played a vital role in setting up this aid infrastructure and pushing it through, the wide range of problems it was designed to attack have not yet gone away.

COSMIC RAYS
Concorde hits the fan

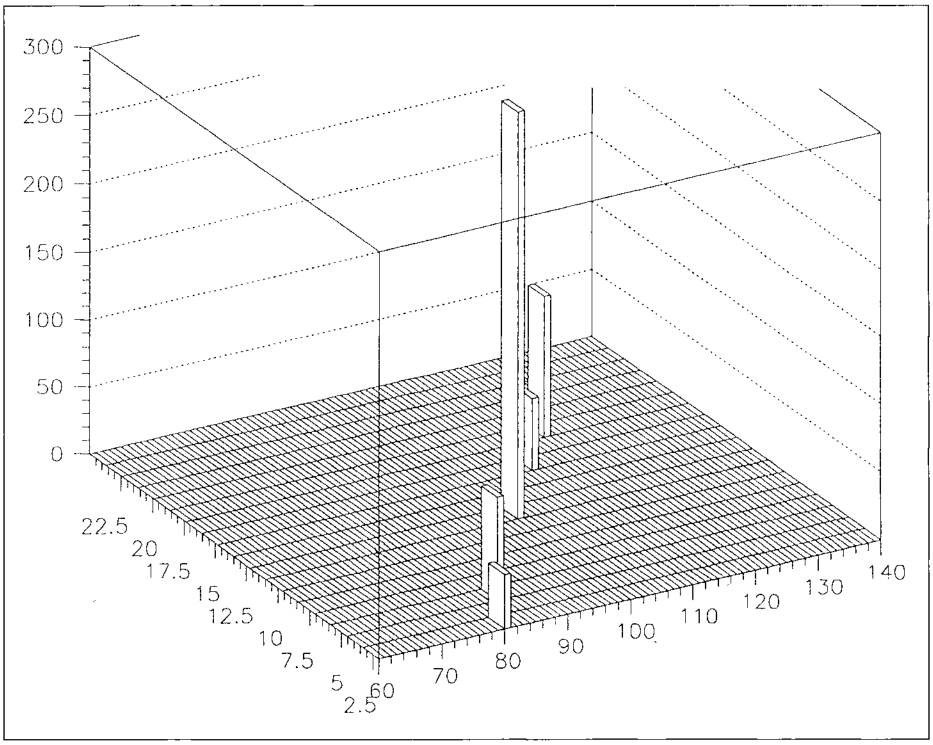
For the past 15 years, a Paris/Tokyo cosmic ray collaboration has been flying emulsion chambers on Concorde, typically exposing for 200 hours at altitudes of 17 kilometres.

While the event harvest has enabled the researchers to cover a wide range of physics - gamma ray flux, nucleon-nucleus collisions, fragmentation of heavy primaries, hyperstrange baryonic matter,......, one particularly intriguing event, corresponded to a stratospheric gamma ray shower at 10^7 GeV, containing over 200 gammas above 200 GeV (higher energy events, up to 10^{11} GeV, have been seen elsewhere).

At first, this high energy event, dating from 1982, was neglected. Only later did physicists notice the tendency for its gammas to slot together in a plane, or sheet, following suggestions reported from cosmic ray exposures at 4360 m in the Pamir mountains in Central Asia.

Taking another look at the high energy Concorde event last year, Jean-Noël Capdevielle of the Collège de France started to plot the gammas by hand, starting with the most energetic, and was startled to find they were on an almost perfect straight line.

The cosmic ray event, produced in the rare atmosphere about 100 metres above the Concorde cabin, produced its spectacular gamma shower as a fan, rather than the three-dimensional umbrella effect usually seen at lower energies. The Concorde-borne chambers are too insubstantial to intercept secondary hadrons.



Fan-like array of high energy gamma rays (photons) seen in a cosmic ray event recorded by a Paris/Tokyo collaboration flying emulsion chambers on Concorde at altitudes of 17 kilometres. The photon energies (vertical axis) are in TeV, while the horizontal pixels are 1 mm square.

Such sheet-like alignments are also seen in a dozen or so events by the large Pamir chambers (several hundred tonnes), which also see the emergent hadrons but are degraded by cascading in the dense atmosphere.

Will the LHC (whose collision energies will match some of those seen in cosmic ray experiments) also see such fans of particles?

Linear collision course

While attention is focused on CERN's LHC proton collider as the next major step for particle physics, the parallel electron-positron collider route is acknowledged as providing a complementary approach to many outstanding physics questions.

With CERN's 27-kilometre LEP electron-positron ring defining a feasibility limit for circular electron machines, research and development work for future electron-positron colliders concentrates on linear machines, where two mighty electron and positron cannons will fire their beams directly at each other to achieve collision energies of at least 500 GeV, upgradable to 1 TeV and beyond.

Major laboratories on three continents are actively exploring research and development avenues towards such machines, but to help correlate and coordinate this work, an International Linear Collider Technical Review Committee (ILC-TRC) was established in 1994, chaired by Gregory Loew of SLAC, Stanford, which has grown to include some 60 specialists. This committee compares designs and research progress, and issued its first report in December 1995. This document now resides at a web site (http://www.slac.stanford.edu/xorg/ilc-trc/ilc-trchome.html) where essential parts of it are updated on a regular basis.

Six major machine scenarios are being explored. One, the superconducting TESLA approach, is being pursued by an unofficial consortium of laboratories centred around DESY, Hamburg. The other approaches are the S-band or SBLC scheme, also at DESY; the Japan Linear Collider or JLC (with radiofrequency options at S-, C- and X-band) at KEK, Tsukuba; the Next Linear Collider or NLC at SLAC, Stanford; VLEPP at the Budker Institute, Protvino/Novosibirsk; and CLIC at CERN.

In addition to these specific machine designs, a matrix approach is ensured with the ILC-TRC working groups concentrating on technical aspects common to all designs: Injection Systems and Pre-Accelerators, Damping Ring and Compression Systems, Linac Technology, Beam Dynamics and Beam Delivery. (These matters were also discussed in a series of meetings last year by working groups organized by DESY and the European Committee for Future Accelerators (ECFA), January, page 34.)

To explore the new physics horizons, high collision rates are essential. The luminosity goal (a

Comparison of the parameters of the main routes electron-positron linear collider routes being pursued worldwide.

	TESLA		SBLC		JLC(S)		JLC (C)		JLC (X)		NLC		VLEPP		CLIC	
	TRC 12/95	Updated* 10/96	TRC 12/95	Updated* 10/96	TRC 12/95	Updated* 10/96	TRC 12/95	Updated* 10/96	TRC 12/95	Updated* 10/96	TRC 12/95	Updated* 10/96	TRC 12/95	Updated* 10/96	TRC 12/95	Updated* 10/96
Initial energy (c.m.) (GeV)	500		500		500		500		500		500		500		500	
RF frequency of main linac (GHz)	1.3		3		2.8		5.7		11.4		11.4		14		30	
Nominal luminosity (10^{33} cm^{-2} s^{-1})†	2.6	3.69	2.2	3.16	5.2	5.29	7.3	4.19	5.1	5.49	5.3	3.9	12.3	11.9	0.7-3.4	5.27
Actual luminosity (10^{33} cm^{-2} s^{-1})†	6.1	6	3.75	5.3	4.3	4.6	6.1	6.3	5.2	5.1	7.1	5.5	9.3	9.7	1.07-4.8	6.4
Linac repetition rate (Hz)	10	5	50		50		100		150		180		300		2530-1210	700
No. of particles/bunch at IP (10^{10})	5.15	3.63	2.9	1.1	1.44		1		.63	.65	.65	.75	20		.8	
No. of bunches/pulse	800	1130	125	333	50		72		85		90		1		1-10	20
Bunch separation (nsec)	1000	708	16	6	5.6		2.8		1.4		1.4		-		.67	1
Beam power/beam (MW)	16.5	8.2	7.26	7.25	1.3		2.9	3.2	3.2	3.67	4.2	4.8	2.4		.8-3.9	4.5
Damping ring energy (GeV)	4	3.2	3.15		2		2	1.98	2	1.98	2		3		2.15	
Unloaded/loaded (MV/m) ††	25/25		21/17		31/-		40/32		73/58	73/57	50/37	50/35	100/91		80/78	100/95
Total two-linac length (km)	29		33	32	22.1		18.8		10.4	10.5	15.6	17.6	7		8.8	7.5

measure of the collision rate) is above 103[3] per sq cm per s, which for all designs except VLEPP is attacked by using many bunches per r.f. pulse (VLEPP instead uses more particles per bunch).

The machines using lower r.f. frequencies have lower accelerating gradients and are therefore the longest - 32 kilometres for the two linacs of an S-band scheme compared to 11-18 km for X-band and 7.5 km for the CLIC scheme. However, the biggest challenge on the luminosity front is the small beam size required - down to a few nanometres in the vertical dimension at the collision point (the size of a large molecule)! So far, beam focusing experiments such as those at SLAC's Final Focus Test Beam Facility have compressed beams to about 70 nanometres in height, about the size of a virus, but still a factor of about ten too fat to attain the ultimate luminosity goals. Handling such tiny beams and keeping them locked onto each other means that ground motion effects may have to be compensated by feedback in the mechanical support systems and/or by steering the bunches as they emerge from the linac.

Another area where great ingenuity is required is in the development of r.f. power sources. Several designs use special klystrons to drive different configurations of accelerating sections, but CERN's CLIC scheme dispenses with the conventional klystron approach and instead provides r.f. energy from a parallel drive beam via an array of special transfer structures.

The ILC-TRC report also contains an important section on experimentation which examines the common physics potential of these colliders. The particle physicists who contributed to this section fortunately felt that any one of the machine approaches, if built to its design specifications, would enable them to perform the proposed repertoire of desirable experiments.

TESLA

Boldly discounting the challenge of developing affordable superconducting r.f. technology to a point where accelerating gradients of 25 MV/m can be attained reliably with Q (resonance) factors above 5 x 10^9, the TESLA option offers the lowest operating r.f. frequency (1.3 GHz) and the largest beam aperture (7 cm). These features govern the TESLA characteristics - long r.f. pulse and wide bunch spacing, with weak perturbing wakefields giving low susceptibility to alignment errors.

The required electron bunch train can be produced by a photoinjector, but a conventional positron source would not survive such an intense beam. The idea is to produce electron-positron pairs in a thin target from a photon beam obtained by firing the spent electron beam through an undulator magnet, and then discarding the electrons. Damping the long (240 kilometres!) bunch trains requires them to be compressed into two "dog-bone" shaped rings which each straddle the length of their respective linacs.

Even 500 GeV collision energies will require some 29 kilometres of linac; hence, upgrading to 1 TeV has to look towards boosting the accelerating gradient rather than lengthening the linacs.

S- and C-band Machines

Operating at about 3 GHz, the S-band (SBLC at DESY and JLC(S) at KEK) machines rely on proven technology developed over the years at SLAC and elsewhere, so that the S-band linacs are equivalent to 7-10 times that of the existing 3-kilometre SLAC machine.

The SBLC has the next-to-largest beam size after TESLA, and gets its luminosity at 50 Hz with 333 bunches per pulse spaced 6 ns apart and with 10^{10} particles per bunch, while the JLC(S) has smaller beams, 50 Hz, 50 bunches 5.6 ns apart and 1.44 x 10^{10} particles per bunch.

For multibunch operation, the SBLC accelerator structures are designed to damp undesirable transverse wakefields. Special lossy materials on the washer-shaped disks of the linac suppress unwanted resonance modes. Assembling the washer-shaped accelerating structures into linac modules requires 100 micron precision, with the supports accurate to 30 microns. Upgrading the SBLC to 1 TeV would mean doubling the number of klystrons and adding pulse compressors to double the accelerating gradient. The KEK scheme has no 1 TeV upgrade plan.

The KEK C-band design at about 6 GHz is similar to the S-band models but uses some innovations such as "choke-mode" linac cavities which selectively cause the higher-order wakefields to leak out transversely and be damped.

Higher Frequency Machines

JLC(X) at KEK and NLC at SLAC are designed to operate at 11.4 GHz while VLEPP in Russia proposes to use 14 GHz. The NLC envisages a linac gradient of 35 MV/m compared with 57 MV/m for the KEK design, the difference reflecting alternative approaches to peak power generation and distribution. The first two machines have broadly similar luminosities and bunch characteristics (about 90 bunches with $6x10^9$ electrons/bunch). Both laboratories are working on new klystrons, r.f. pulse compression systems to boost the peak power of the klystrons, and structures.

SLAC has recently succeeded in building a 60 MW periodic-permanent-magnet (PPM) focused klystron which saves a great deal of electricity, and both labs are working together on detuned and damped structures to minimize the effects of wakefields which can blow up successive bunches in each train. As mentioned earlier, VLEPP uses a single bunch per r.f. pulse, thereby sidestepping multibunch wakefield effects. However, the high charge that is needed per bunch can lead to high backgrounds.

For a 1 TeV upgrade, JLC(X) and VLEPP would simply be doubled to about 15-20 kilometres in length, while NLC, fitted with twice the number of klystrons and a 50% boost in power, would only need 20% extra length and would also end up with about 20 km of linac . Another future option (to be studied at LBNL) for the NLC is a two-beam scheme with an array of drive beams and transfer structures replacing the klystrons but installed in the same tunnel as the accelerated beam.

CERN's 30 GHz CLIC scheme is unique, with the highest r.f. frequency of all designs and the highest accelerating gradient (100 MV/m) and as a result the shortest linac length. Generation of r.f. power from a drive beam rather than from klystrons means no active r.f. components in the accelerator tunnel, which is therefore small (3.4m diameter). Wakefield levels are high but can be adequately compensated by precision alignment. Generation and preservation of the drive beam will be a major challenge. The upgrade to 1 TeV would be made by doubling the length of the r.f. linac. The 30 GHz operating frequency has the potential to go to even higher accelerating gradients for future high energy machines.

Impressive major test facilities at DESY, SLAC, CERN, the Budker Institute and KEK have been constructed and are being commissioned to experiment with many of the prototypes and technologies described above. Shaping the tiny beams of particles, and maintaining their slender threads through the whole chain of damping rings, bunch compressors, main linacs, beam delivery systems and final foci stimulates work in instrumentation, alignment and stability as well as in beam handling itself.

Whole new areas of beam dynamics are being explored. New systems are being developed to cope with mechanical vibrations over a wide range of frequencies. Finally, the fabrication of such demanding and delicate components has to be reconciled with the need to cut costs via efficient mass-production, and assembly over distances measured in kilometres.

Once more, particle physics is pushing technology to the limit. And the protagonists do not want just electron-positron collisions. By means of backscattered laser beams, they hope to collide photon beams as well!

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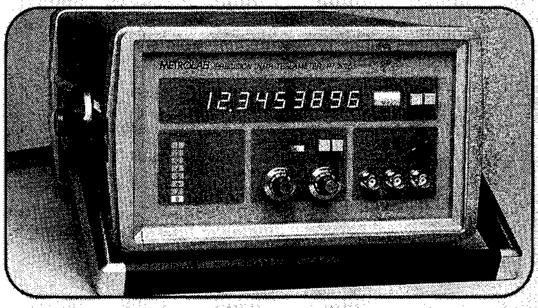

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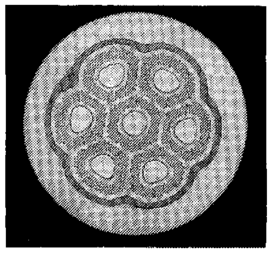

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People and things

Bookshelf

Conceptual Developments of 20th Century Field Theories, by Tian Yu Cao, Cambridge University Press, ISBN 0 521 43178 6 (hbk, £45/ $59.95)

With the mighty edifice of field theory standing as a monument to the achievements of 20th century physics, Dr. Cao's book is the result of more than a decade of diligent striving for academic excellence in the analysis of the evolution of modern field-theoretic ideas. Arriving on the scene, he picked up the accepted wisdom of field theory by the scruff of the neck, shook it hard, so that a few superfluous pieces fell off, and then looked at it from all directions. Rather than being a textbook, it is more a 'historico-critical exposition of the conceptual foundations of the theories'. Its three sections cover first the geometrical approach of relativity, then the quantum field approach with its early successes and its subsequent ups and downs, leading to its revival in the early 1970s, and finally gauge fields, terminating with a deep study of 20th century field theory as an example of how science develops. The book is required reading for any field theorist or admirer of field theory achievements, and already widely acclaimed as a masterly synthesis

Books received

Using REDUCE in High Energy Physics, by A. G. Grozin, Cambridge University Press, ISBN 0 521 56002 0 (hbk, £55/$80)

The use of the symbolic manipulation language REDUCE, described by a specialist from Novosibirsk.

During her visit to CERN on 24 February, Swiss Federal Councillor and Head of the Home Affairs Department Ruth Dreifuss (left) admired preparations for the LHC proton collider and its experimental programme. She is seen here talking to Felicitas Pauss of ETH Zurich, a member of the CMS experiment for the LHC.

(Photo CERN HI 28/2/97)

On people

Lyle H. Schwartz, Director of the Materials Science and Engineering Laboratory at the US National Institute of Standards and Technology, becomes President of Associated Universities Inc, the consortium which operated Brookhaven under contract to the US Department of Energy, succeeding Robert Hughes.

Max Born Prize

Robin Marshall of Manchester receives the 1997 Max Born Prize for his work on particle physics. This prize is awarded by the German Physical Society to a UK physicist in odd-numbered years, and by the UK Institute of Physics to a German physicist in the intervening years.

Chien-Shiung Wu (1912-1997)

Chien-Shiung Wu, one of the giants of modern experimental physics, died of a stroke in New York City on

C.S. Wu on the occasion of the celebration at CERN in 1992 of her 80th birthday in August 1992.

February 16. Born on May 31, 1912 in Liuhe, a small town near Shanghai, Wu received a BS degree from National Central University in Nanjing in 1934. She came to the US in 1936 and received her PhD from the University of California, Berkeley in 1940.

She taught at Smith College and Princeton University prior to joining Columbia University in 1944, where she spent 37 years doing research and teaching. Forty years ago on February 15, 1957, Wu and her colleagues E. Ambler, R.W. Hayward, D.D. Hoppes and R.P. Hudson of the National Bureau of Standards published their historic paper, "Experimental Test of Parity Conservation in Beta Decay" which established for the first time the non-conservation of parity (P) and the violation of particle-antiparticle conjugation symmetry (C) in physics, both of which had been taken for granted as basic laws of nature. This revolutionary overthrow of the conservation laws of P and C in the weak interactions opened up a vast new vista, dominated by the search for the origin and manifestation of symmetry violations.

The study of nuclear beta decay was a central focus of Wu's research. After Fermi's theory of beta decay was proposed in 1934, there were serious discrepancies between experiment and theory. Then, in 1949 and 1950, through a series of beautiful experiments Wu measured the allowed and forbidden beta spectra, corrected many previous mistakes, disproved the Konopinski-Uhlenbeck formulation and firmly established Fermi's theory. Almost single-handedly she cleared up the confusion in beta decay that had existed for one-and-a-half decades.

In 1963, she and her collaborators observed the weak magnetism,

thereby confirming the symmetry between the weak and the electromagnetic currents, setting the cornerstone for the later unification of these two basic forces into a single one, the electroweak force.

Wu's attitude towards physics was that of a serious, deeply committed and most enthusiastic scholar, in her case particularly of nuclear beta decay. Her experimental work was characterized by painstaking care, thoroughness and an uncompromising honesty, as well as by great skill and creativity. At various times in her career her active interests included positronium, muon physics, especially the spectra of muonic atoms and muon capture, and also biophysics problems.

Wu's personal warmth and deep concern for others will be sorely missed by her many friends and colleagues. When Madame Curie passed away, Einstein wrote, "At a time when a towering personality has come to the end of her life, let us not merely rest content with recalling what she has given to mankind in the fruits of her work. It is the moral qualities of its leading personalities that are perhaps of even greater significance for a generation and for the course of history than purely intellectual accomplishments. Her strength, her purity of will, her objectivity, her incorruptible judgement, all these were of a kind seldom found joined in a single individual. Once she had recognized a certain way as the right one, she pursued it without compromise and with extreme tenacity." All these words of Einstein about Madame Curie apply equally well to Chien-Shiung Wu. Chien-Shiung Wu is survived by Luke C.L. Yuan, her husband of 55 years, her son Vincent Yuan of Los Alamos who is a research scientist at Los Alamos National Laboratory and her granddaughter Jada Yuan who is a student at Yale College.

From V.W. Hughes, Yale and T.D. Lee, Columbia.

Meetings

The Fifth International Workshop on Topics in Astroparticle and Underground Physics (TAUP 97) will be held from 7 - 11 September at the Italian National Gran Sasso Laboratory. Further information from Ms. F. Masciulli at Gran Sasso, fax +39 862 410 795, e-mail taup97@lngs.infn.it

The XXV SLAC Summer Institute on Particle Physics will be held August 4-15 at Stanford, California. The theme of this year's Institute is Physics of Leptons. Inquiries should be directed to the SLAC Summer Institute, Stanford Linear Accelerator Center, P.O. Box 4349, MS 62, Stanford, California, U.S.A., and additional information can be obtained from the Web site "http://www.slac.stanford.edu/gen/meeting/ssi/next/."

On 7-8 February the International Union of Pure and Applied Physics (IUPAP) held a meeting of its Executive Council and the Chairmen of all its Commissions at CERN. Seen here are IUPAP President Jan Nilsson of the Wallenberg Foundation, Stockholm, (right) and Secretary-General René Turlay of Saclay.

(Photo M. Jacob)

The Seventh International Workshop on Polarized Gas Targets and Polarized Beams will be held 18-22 August, 1997 at the University of Illinois. Further information can be obtained from web site: http://www.npl.uiuc.edu/ptb/ or by e-mail: ptb@uinpluxa.npl.uiuc.edu. Inquiries can also be mailed to: Penny Sigler, Department of Physics, University of Illinois at Urbana-Champaign, 1110 W. Green Street, Urbana, IL 61801-3080; Phone +1217-333-3190, fax +1 217-333-1215.

The Seventh International Conference on Hadron Spectroscopy (Hadron 97) will be held at Brookhaven National Laboratory from 25-30 August. The deadline of submission of abstracts is May 15, and the deadline for registration is July 15. Further information: Conference Chairman: S. U. Chung (suchung@bnl.gov); Conference Secretary: S. L. Smith (hadron97@bnl.gov), http://hadron97.bnl.gov/

Le Colloque RX97 - Rayons X et Matières: Ecole Nationale Supérieure des Arts et Industries de Strasbourg, Strasbourg 14-16 octobre: Inscriptions - renseignements : Tel : (33) 03 88 14 47 37 (47 55) - Fax : (33) 03 88 24 14 90 - E-mail : rx97@ensais.u-strasbg.fr Informations : http://www-ensais.u-strasbg.fr/RX97/RX97.HTM

Le colloque (8me du nom) aborde les thèmes suivants : Techniques, Fluorescence et Diffraction X, Applications, Etudes de surfaces, Contraintes et textures, Utilisation du rayonnement Synchrotron etc...

The 2nd International Symposium on Symmetries in Subatomic Physics will take place at the University of Washington in Seattle from 25-28 June 1997. Contact Ernest Henley, Henley@phys.washington.edu, FAX: (206)685-0635, Physics Dept., Box 351560, University of Washington, Seattle, WA 98195-1560, USA

CERN Courier contributions

The Editor welcomes contributions. These should be sent via electronic mail to cern.courier@cern.ch

Plain text (ASCII) is preferred. Illustrations should follow by mail (CERN Courier, 1211 Geneva 23, Switzerland).

Contributors, particularly conference organizers, contemplating lengthy efforts (more than about 500 words) should contact the Editor (by e-mail, or fax +41 22 782 1906) beforehand.

CERN Director General Chris Llewellyn Smith with Netherlands Ambassador to the UN and International Organizations in Geneva Eveline Herfkens.

Zhu Xuan, Secretary General of the Chinese Academy of Sciences (right) with Jim Allaby, CERN's Non-Member State Coordinator, at the L3 experiment at CERN's LEP electron-positron collider.

(Photo CERN HI 22.2.97)

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M. K. Craddock

CERN-Asia Fellows and Associates

As announced in the March issue (page 23), a new programme offering three Fellowship positions and some short-term Associate positions at CERN each year has been opened for young scientists from named East, Southeast and South Asian countries to work in experimental and theoretical particle physics and accelerator technologies. Part of the CERN/Japan agreement signed in 1995 and supported by Japanese funds, it is open to candidates from Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia, China, India, Indonesia, Japan, Korea, the Lao Republic, Malaysia, the Maldives, Mongolia, Myanmar, Nepal, Pakistan, the Philippines, Singapore, Sri Lanca, Taiwan, Thailand, and Vietnam, and CERN looks forward to welcoming guests from among these countries. Instructions for applying for the first batch of awards was summarized in the March issue (deadline 7 April), and the applications procedure for subsequent years will be published in due course.

Forschungszentrum Jülich

The Research Centre Jülich is jointly operated by the German Federal Government and the North Rhine-Westphalian state government. It has a staff of about 4 500 and is a member of the Hermann von Helmholtz Association of German Research Centres (HGF). Our major research activities are Materials Science and Structure of Matter, Information Technology, Energy Technology, Environmental Research and Life Sciences.

We are seeking for our Department "Institut für Kernphysik (IKP)" a

Director (m/f)

for the "Institut für Experimentelle Kernphysik II".

The department IKP consists of two experimental institutes, a theoretical institute, and a division of Kernphysikalische Großgeräte that are committed to basic research in medium energy hadron physics. The main research facility is the cooler synchrotron COSY which provides phase space cooled beames of polarized protons and deuterons with momenta up to 3.5 GeV/c.

We are searching for applicants who are internationally renowned experts in experimental medium energy physics. The successful candidate should be willing to concentrate his future research activities on the use and further development of COSY and its experimental installations. Required are the ability to lead a large institute and the willingness to participate in directing the department. A close collaboration with other institutes of the Forschungszentrum Jülich, and with other research centres and universities ares expected.

We shall seek an appointment of the successful candidate to a chair at one of the universities in the state of North Rhine-Westphalia from where he/she will be seconded to take on his/her responsibilities at the Research Centre Jülich. The salary will conform to the C4 scale (full professor) of German universities. Candidates are required to have "Habilitation" or equivalent qualifications. The Research Centre Jülich would like to increase the number of women in leading positions and therefore especially encourages qualified women to apply.

Applications including a curriculum vitae, list of publications (with up to five offprints) as well as a brief summary of the candidate's scientific and professional career should be submitted by 25 April 1997 to

Vorstand der Forschungszentrum Jülich GmbH · D-52425 Jülich

FACULTY POSITION

The Stanford Linear Accelerator Center (SLAC) of Stanford University seeks applicants for the position of Assistant Professor in experimental elementary particle physics. This position is a non-tenured faculty appointment at Stanford University with the possibility of advancement to tenured rank in the future. Post Ph.D. experience in experimental particle physics is desirable. Research opportunities include work at SLAC using the SLC, the B-Factory currently under construction, the linear accelerator facilities and Gamma ray astronomy using EGRET and GLAST.

Applications should be directed to:

Professor Thomas Himel
Chair of the Assistant
Professor Search Committee
Mail Stop 17, SLAC
Stanford University
Stanford, CA 94309

Candidates should provide a curriculum vitae, publication list, and solicit three letters of recommendation. The deadline for application is July 1, 1997.

SLAC is committed to equal opportunity through affirmative action in employment. We strongly encourage qualified minority and women candidates to apply.

Max-Planck-Institut für Physik
Munich, Germany

Postdoctorial Position

The Max-Planck-Institute of Physics invites applications for a postdoctorial position for the HERA-B experiment at DESY.

The HERA-B experiment is designed to study CP-violation in the B-system. The detector is under construction. The Max-Planck-Institute is involved in development and construction of the silicon-vertex-detector. The successful candidate is expected to contribute to all phases of detector construction and commissioning. Participation in the analysis of first data and the preparation of the required software is also expected.

The contract will initially be for 2 years, with the possibility of extension for up to five years. Candidates should have good knowledge of experimental high energy physics, and should hold a PhD or equivalent in physics. Interested applicants should submit a statement of research interests, a curriculum vitae, a list of publications, and arrange for letters of support from three referees. These items and a letter of application should be sent to:

Max-Planck-Institut für Physik
Prof. V. Soergel
Föhringer Ring 6
D-80805 München

Further information can be obtained from Dr. Iris Abt
(EMail: isa@mppmu.mpg.de).
Applications should be sent as soon as possible, at the latest 6 weeks after publication.

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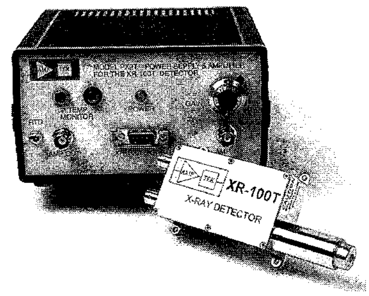

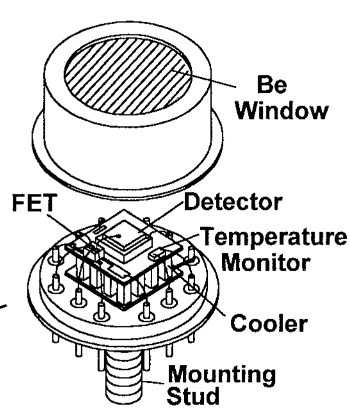

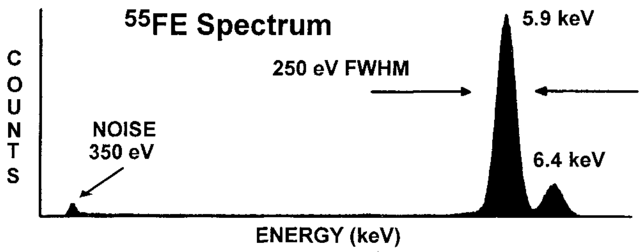

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We are searching for applicants who are internationally renowned experts in the field of accelerator physics with experience in constructing and operating synchrotron accelerators and storage rings for hadrons and electrons. It is expected that the successful candidate will efficiently direct the daily operation of COSY and actively participate in the development of the accelerator with its experimental installations. Required are the ability to lead a large division and the willingness to participate in directing the department. A close collaboration with other institutes of the Forschungszentrum Jülich, and with other research centres and universities are expected.

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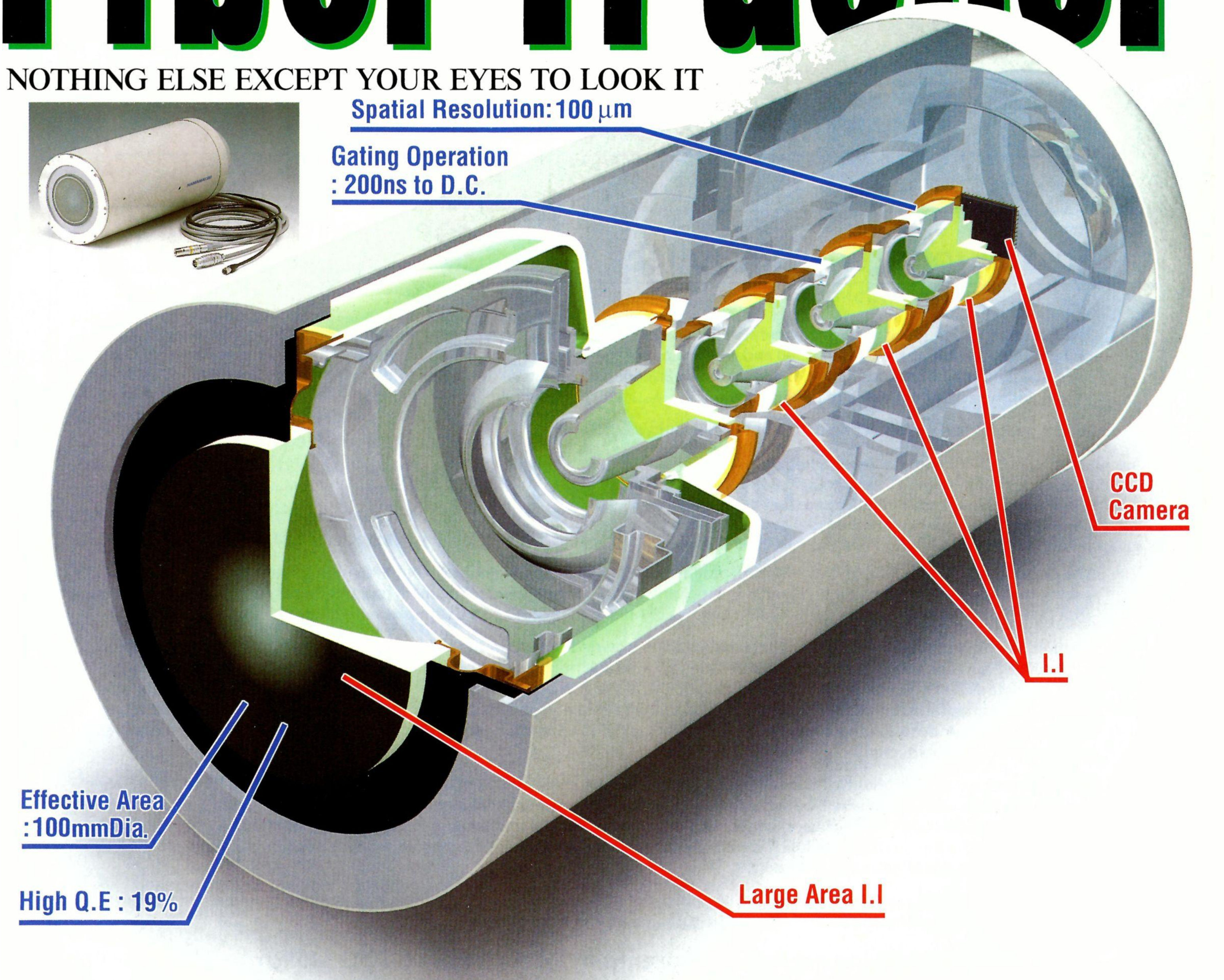

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