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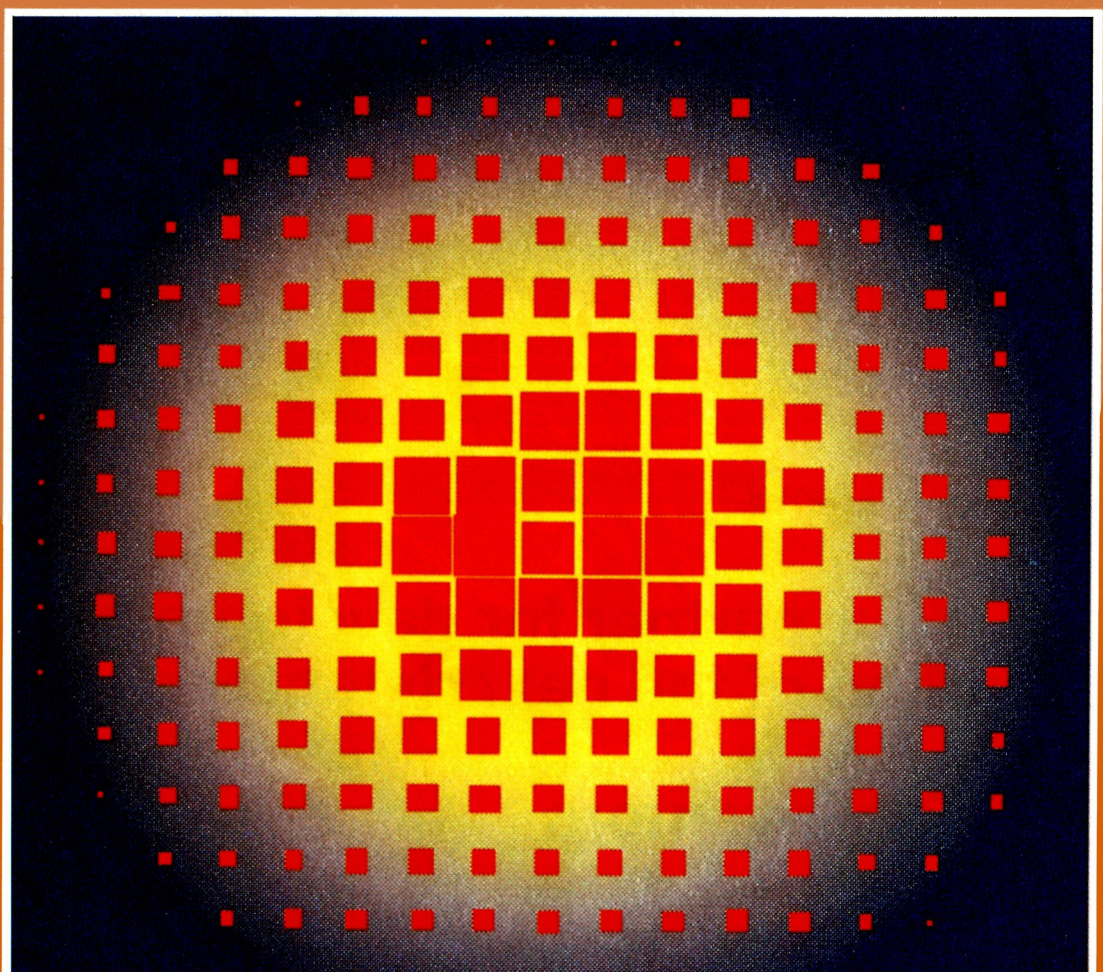

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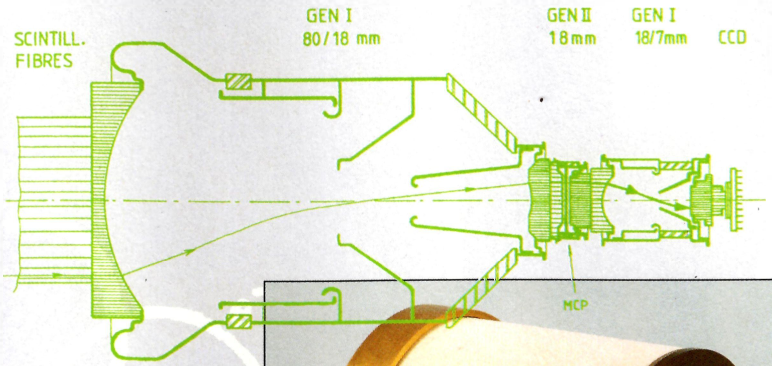

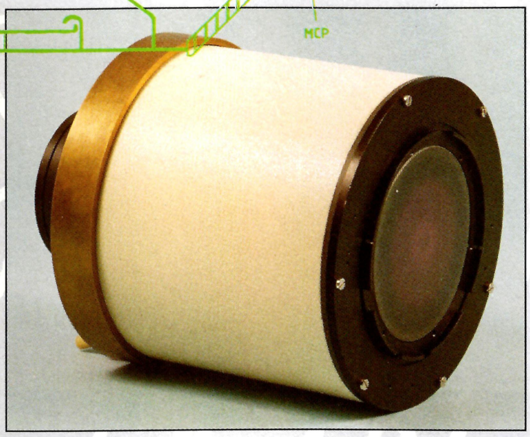

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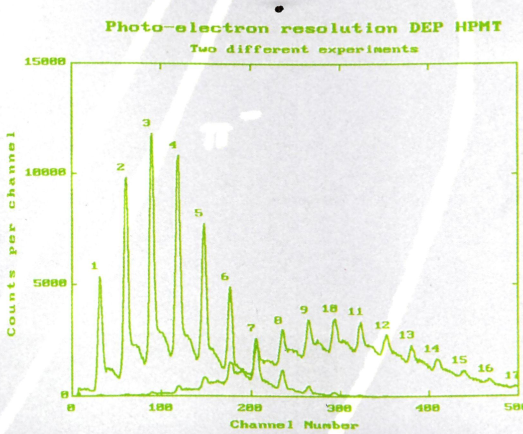

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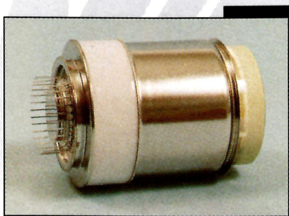

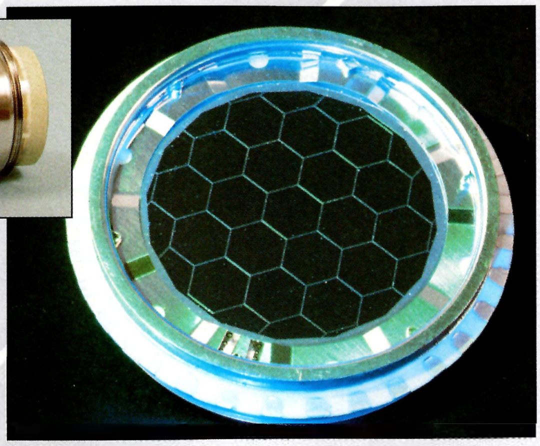

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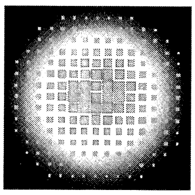
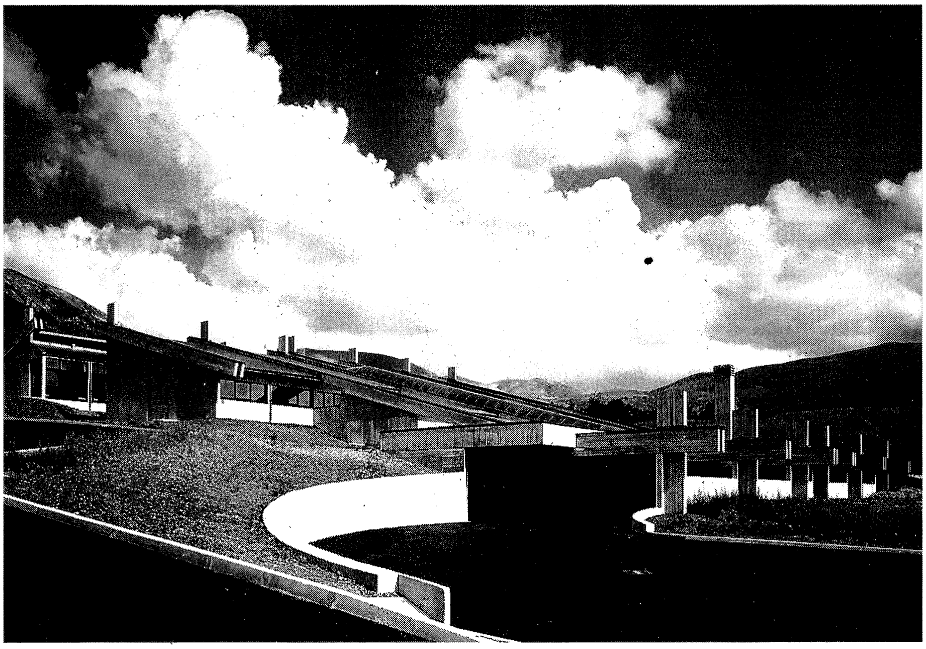


Cover photograph: Ring Imaging Cherenkov techniques come of age. Cherenkov radiation as seen by the NA44 heavy ion experiment, equipped with its novel Threshold Imaging Cherenkov detector, at CERN in the recent lead ion run (see April, page 17).

Around the Laboratories

The Gran Sasso Laboratory in the Gran Sasso mountain range near Rome is the site of a proposed 'long-baseline' neutrino experiment. A neutrino beam could be directed to Gran Sasso's underground experimental caverns 732 kilometres away in a search for neutrino oscillations.

CERN
Cracking the neutrino enigma



The neutrino is an enigmatic particle, but with a growing number of dedicated neutrino experiments around the world, its mysteries could soon be unveiled. At CERN, dedicated neutrino experiments CHORUS and NOMAD are in full swing, and first results are eagerly awaited. Looking ahead, a number of 'long-baseline' experiments are planned. These would fire neutrino beams from accelerator laboratories to underground detectors hundreds of kilometres away (September 1995, page 20).

The reason for all this activity is that the neutrino could solve several questions of cosmic-scale absenteeism. Where is the missing mass? We know there is more mass in the Universe than we can see, so could some of it be accounted for by neutrinos? What about solar neutrinos? We see fewer neutrinos coming from the Sun than theory tells us to expect. What has become of them? And what of the atmospheric neutrino anomaly, the observation that cosmic rays appear to produce a different ratio of electron-neutrinos to muon-neutrinos than we anticipate?

All of these questions could be answered by neutrino oscillations. This phenomenon, so far unobserved, but theoretically possible if neutrinos have mass, allows neutrinos to change flavour - oscillate between one kind and another. But to get to grips with neutrino oscillations, some more prosaic questions first have to be answered. Two recently approved CERN experiments, NA55 and NA56, are gearing up to do so.

The goal of the NA55 collaboration (Caltech/Stanford/CERN/Hahn-Meitner-Institut Berlin/Neuchatel) is to understand the process of neutron production due to muon interactions in the rock of the Earth's crust. Better knowledge of this process is important for all underground neutrino experiments, and in particular, for the atmospheric neutrino anomaly where neutrons are an important background. CERN's muon beam has an energy range comparable to that of cosmic ray muons, between 100 and 250 GeV, so the NA55 detector will sit in this beam downstream of the Spin Muon Collaboration, SMC, detector. Specially constructed neutron detectors will be used in conjunction with information from SMC.

But what is the anomaly? Naively, one would expect the ratio of muon-neutrinos to electron-neutrinos from primary cosmic ray interactions to be two to one, since each decaying pion or kaon produces one muon-neutrino and a muon which in turn decays into an electron, an electron-neutrino and a second muon-neutrino. More complex calculations produce slightly different ratios, but all are in stark contrast with the measured value of around 0.6. The difference might be explained by the neutron background, but if this turns out to be small, then neutrino oscillations will become the prime suspect. If muon-neutrinos could oscillate into tau-neutrinos, the atmospheric neutrino anomaly would no longer be a puzzle.

The NA56 'SPY' (Secondary Particle Yields) Australia/Belgium/CERN/Finland/Italy/Switzerland/USA collaboration is complementary to NA55, concentrating on accelerator-based neutrino physics. The goal is a precision audit of the flux of CERN's neutrino beam, and the existing detector of the NA52 collaboration, one of CERN's heavy-ion experiments, will be used. Data will provide input to current and

Fermilab Director John Peoples at the media meeting in April 1994 which presented first evidence for the long-awaited sixth ('top') quark. Run I at Fermilab's Tevatron proton-antiproton collider will go down in physics history for the discovery of the long-awaited sixth ('top') quark. The run, which began back in 1992, officially ended in February.

future CERN neutrino studies.

The CERN neutrino beam is produced from the decays of pions and kaons created when protons crash into a beryllium target. NA56 is motivated by uncertainty in the neutrino flux predictions, especially in the low energy region which is relevant to oscillation experiments.

CERN's neutrino flux calculation is based on measurements of pion yields from proton-beryllium collisions above 60 GeV. The low energy region is obtained by extrapolation. To fill in the gap, NA56 will extend the measurement right down to 7 GeV. The experiment will also measure the kaon-to-pion ratio. Since kaon decays give rise to electron-neutrino contamination in the muon-neutrino beam, this ratio must be precisely known if neutrino oscillations are to be better measured.

Ever mindful of its host detector, NA56 will provide important input for heavy-ion physics. The production rates of pions and kaons in proton-nucleus interactions are related to the propagation of hadrons through nuclear matter, and the kaon-to-pion ratio is particularly important. A kaon enhancement in nucleus-nucleus interactions over proton-nucleus interactions is possible signature for a phase transition to the quark-gluon plasma.

FERMILAB
End of a long run

In February, Run I at Fermilab's Tevatron proton-antiproton collider officially ended. It will go down in physics history for the discovery of the long-awaited sixth ('top') quark.

Run I had begun in August 1992, but there had been a year's pause for breath between March 1993 (end of run Ia) and January 1994 (beginning of Run Ib). The Tevatron recorded its first collisions on 13 October 1985, when the CDF collider detector was in place, but for Run I the collider operated for the first time with two major detectors, CDF and D0. Pre-Run I, in 1988-89, the Tevatron had supplied 9590 inverse nanobarns (almost ten inverse picobarns) of proton-antiproton collisions to CDF, enabling the experiment to contribute to a rich new harvest of new data on the Z particle, the electrically neutral carrier of the weak nuclear force. That year, 1989, also saw the initial runs at the big new electron-positron colliders - Stanford's SLC linear collider and LEP at CERN.

These early luminosities were eclipsed by what was to come in Run I, when an inverse picobarn per day was eventually attained. Back in 1988, CDF had been proud of 518 inverse nanobarns in a week. While precision Z physics became the speciality of the new electron-positron colliders, precision physics still relied on the Tevatron for the best measurement of the mass of the W, the electrically charged carrier of the weak nuclear force.

During the 1993 shutdown, the Tevatron benefited from installation of a new 400 MeV linac, but initial Run Ib collider performance had difficulty equalling what had been seen in Run Ia, until a misaligned

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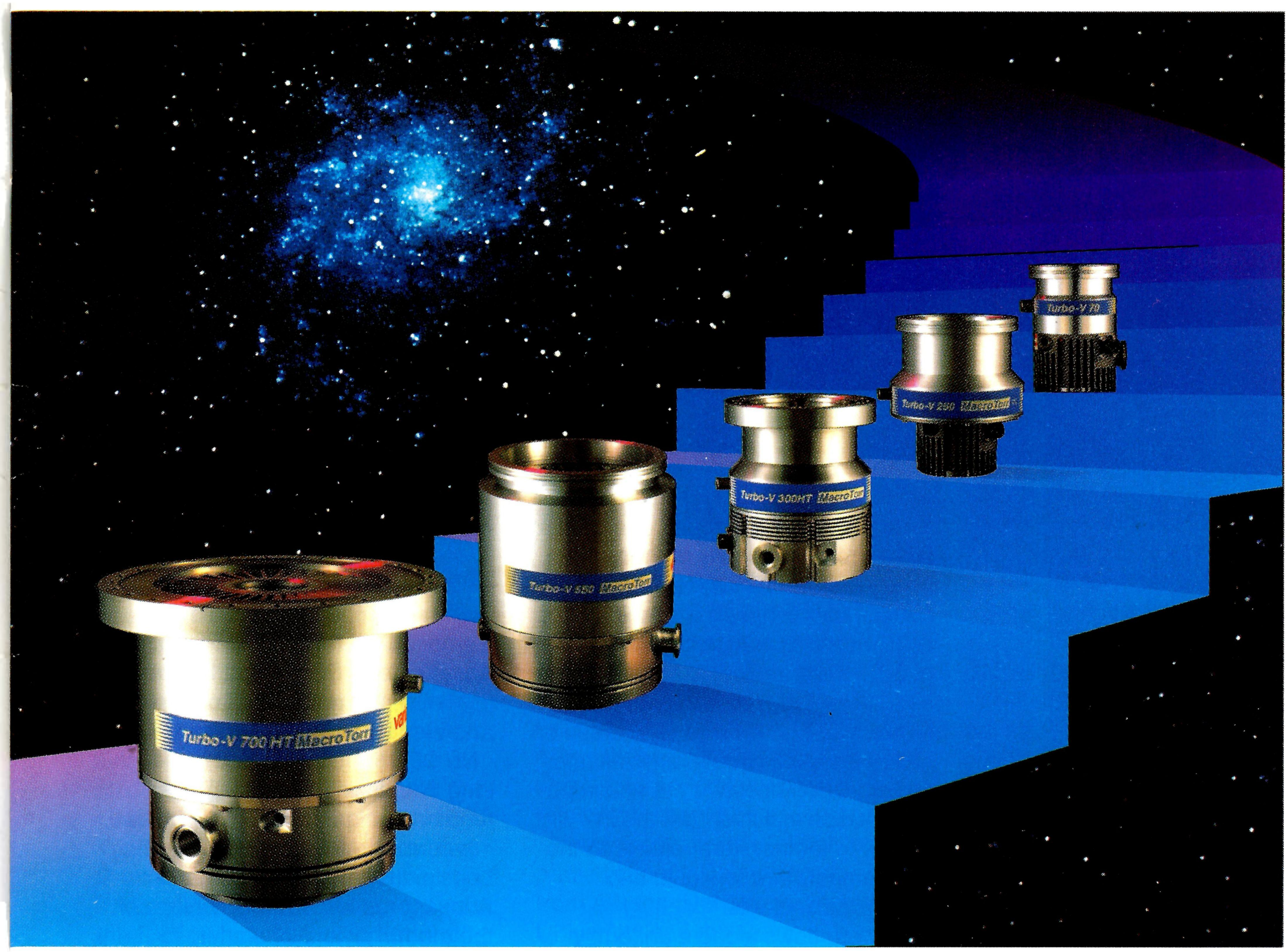

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magnet was spotted that summer and, with initial evidence for top quarks already in the can, the collision rate doubled. Tevatron collider running has been almost exclusively with 900 on 900 GeV beams.

Run II of the Tevatron collider will use the new Main Injector instead of the original Fermilab Main Ring.

RUTHERFORD APPLETON
Binary ice

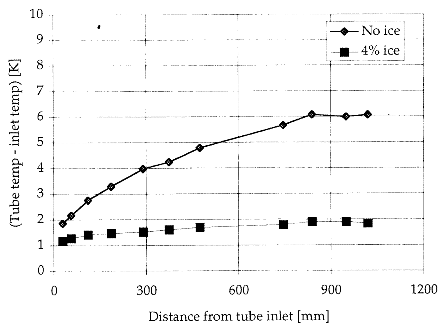
The Semiconductor Tracker (SCT) of the inner detector for the ATLAS detector at CERN's LHC proton collider will contain approximately 6.1 million channels of electronics coupled to the 16000 silicon wafers in the barrel and forward regions. The whole assembly must operate at a temperature of around -10C and the cooling system must remove about 24 kW of heat. To accomplish this, a novel system has been developed at the UK Rutherford Appleton Laboratory (RAL) which uses 'Binary-ice' cooling. The term refers to a suspension of ice crystals of sizes ranging from 50 to 500 microns in an aqueous medium containing a freezing point depressant. Almost all the heat applied to a bath of binary-ice fluid is absorbed by the latent heat of melting and thus results in near isothermal behaviour, in contrast to conventional cooling systems which operate with a substantial temperature gradient between inlet and outlet.

The binary-ice fluid is produced in commercially available generators, supplied by Integral Technologie GmbH. For the last two years, a 1.7kW machine has been operated at RAL. From the results of these tests, binary-ice cooling has recently been chosen as the baseline option for the SCT. In the current design, a mixture of 80% water and 20% methanol is used to provide the -10C operating temperature. The obvious benefits of binary-ice cooling over conventional cooling can be seen in the accompanying graph which shows the increase in temperature relative to the inlet temperature for liquid and Binary-Ice coolants.

The fluid flows along a uniformly heated 3 mm diameter pipe. The flow rate is about 5.5 ml/s and the total heat load is 48.5 W. In each case, the alcohol/water mixture is identical.

Binary-ice has a much higher effective heat capacity and a significantly better heat transfer coefficient than water but still benefits from the low density and long radiation length of that fluid. It is also able to cope with the intense radiation of the LHC intersection regions. Although the viscosity of the fluid is increased by the presence of ice crystals, any pressure drop increase is easily overcome by a small reduction in flow velocity. For ATLAS, the pipework inside the inner detector will be operated as a leakless cooling system, using a design developed at CERN.

To cool the Semiconductor Tracker of the inner detector for the ATLAS detector at CERN's LHC proton collider to a temperature of around -10C, the cooling system will have to remove about 24 kW of heat. To accomplish this, a novel system has been developed at the UK Rutherford Appleton Laboratory (RAL) which uses 'Binary-ice' - a suspension of ice crystals in an aqueous medium containing a freezing point depressant. The graph shows the benefits of binary-ice over conventional cooling.



To prepare for the design of the final ATLAS system, a team of scientists and engineers from RAL and the University of Oslo are studying the kinematic properties of these fluids, developing flow and ice concentration monitors and writing slow control and data acquisition software.

Greece

Continuing its survey of physics in its member states, the European Committee for Future Accelerators (ECFA) met in Greece in March, at the Demokritos Institute and the University of Athens.

No CERN member state has such a long and distinguished history in fundamental physics. In the 5th and 4th centuries BC Democritus, Leucipidus, Anaximander and Anaxagoras laid the foundations of the atomic picture of matter. 25 centuries later, Greece was one of the founding members of CERN, and particle physics is currently a key element in Greece's programme of basic research.

Thanks to CERN, Greek physicists are numerous and active despite limited home funding, but are dispersed in independent small groups over many experiments. There is as yet no national coordination, although Manolis Floratos, the new Director of the Demokritos Institute and CERN Council delegate, plans to improve the coordination of Greek experimental physics at CERN.

However sizable collaborations have formed for the Atlas and CMS detectors at CERN's future LHC proton-proton collider, where Greek

European Committee for Future Accelerators (ECFA) Chairman Enrique Fernandez with Christine Kourkoumelis of Athens, who hosted the recent ECFA meeting in Greece.

groups hope, with EU support, to contribute significantly to the development and construction of the detectors.

The NESTOR underwater neutrino project led by Leo Resvanis in Athens has developed into a major international collaboration and hopes to avoid the funding hiccups which have hindered the progress of underwater projects elsewhere. Funding for phase 1 is now complete, and further international collaboration is sought to extend the detector. NESTOR, like the Italian Gran Sasso underground laboratory, could later act as one distant station for a CERN neutrino beam, providing useful 'long baseline' data in the continuing search for neutrino oscillations.

About 50 experimental high energy physicists are currently working in Greece, with some 25 graduate students. They are affiliated with the University of Athens, the National Technical University in Athens, the Demokritos Institute, the University of Thessaloniki, the University of Crete, the University of Ioánnina and the University of Patra. Most of the experimental activity is related to work at CERN, with, over the past ten years, a significant contribution to detector component building in Greece, in particular in connection with the aptly named Delphi experiment at LEP. This has been helped by the development of companies with high-tech expertise. Greek experimentalists have long played a prominent role in research at CERN, in particular the discovery of prompt photons by an Athens/ Brookhaven/CERN/Syracuse collaboration at the Intersecting Storage Rings in 1979.

Particle physics contributed significantly to the revival of physics interest in Greece and a good number of university physics positions are occupied by particle physicists. Particle physics is bound to remain a very important and is certain to remain highly oriented towards international collaborations. Greece is increasingly acting as a scientific focus for the whole Balkan and Eastern Mediterranean region, a role which should be encouraged.

Numerically, there is significant participation in Delphi (20 physicists from Athens (University, Technical University and the Demokritos Institute) and CP-LEAR (13 physicists from Athens, Ioánnina and Thessaloniki), and at a smaller level in Aleph (5 physicists from Demokritos). The University of Athens collaborates in a number of CERN heavy ion studies . There is a strong commitment to CERN's future LHC with direct involvement in Atlas (Athens Tech., Athens and Thessaloniki) and in CMS (Demokritos, Ioánnina and Athens).

Continuing the illustrious traditions of Democritus, Leucipidus, Anaximander and Anaxagoras, there are about 45 well-known Greek theorists, of whom about 30% prefer to work overseas. There are at present 26 graduate students. Greek theorists have long used CERN as a base for advanced training and research. Many important papers by Greek theorists have been written at CERN and the healthy development of Greek theoretical physics has profited from CERN's fellowship and associates programme. The Theory Division long welcomed and supported many Greek visitors in the framework of an agreement with the Demokritos Institute.

There are theorists in all Greek centres involved in experimental research. Some work goes on in phenomenology and there are also important groups in field theory (Crete, Thessaloniki, Ioánnina and Athens Tech.).

While there is an important inflow of undergraduate students, many of them prefer to go to the US or Western Europe for their graduate studies, partly because of lack of financial support. In the past, a good fraction of these students did return, often after a stay at CERN.

Funding comes from two ministries, the Ministry of Industry, Energy and Technology and the Ministry of Foreign Affairs. The latter covers part of the Greek contribution to CERN (at present 3.75 million Swiss francs) in its support for international organizations. As happens periodically in many countries in these cost-con-

Physics monitor

scious times, the visibility of particle physics and its funding is looked at with envy in some sectors. National material support is at the level of only 1 million Swiss francs per year, insufficient to meet the needs of Greek CERN users. Special projects like NESTOR are financed by the Ministry of Education as well as benefiting from EU funding.

Greek industry is beginning to benefit from CERN contracts, with the industrial return factor having increased tenfold recently. This trend should continue with a new committee formed by the Chamber of Industry and Technology, and an Industrial Liaison Officer appointed at Demokritos.

The creation of the Institute for Accelerator Systems and Applications in Athens could be a focus for specialized small enterprises also supplying CERN. Its director is C. Papanicolas. The institute's microtron accelerator should be completed in five years.

Greece has long benefited from a special agreement under which its CERN contribution was only 40% of the nominal value (at present 0.4% of the budget of the Organization). However according to recent CERN Council decisions, the Greek contribution should increase progressively to its full value between 1997 and 2002.

Dark Matter in the spotlight

The mysterious 'dark matter' which could make up most of the Universe continues to intrigue scientists. The status of the search for an understanding of this enigmatic stuff was highlighted at the 2nd Symposium on Dark Matter in the Universe, organized by UCLA, held in Santa Monica, California, from 14-16 February with 100 participants. It was an exciting meeting, not only because of the new observations presented, but also because of the expectations of major clarification of the nature of the Universe in the near future.

The Symposium began with an overview of the current status of the Hubble Constant by Virginia Trimble (Maryland) and the Age of the Universe by B. Chaboyer (Toronto). The Hubble constant relates the velocity of recession of galaxies to their distance - the further away a galaxy is, the faster it appears to recede. The Hubble constant also gives a handle on the age of the Universe - the faster the expansion, the less time has passed since the Big Bang. While the Hubble constant is still highly uncertain, the age of the Universe seems to be at least 12 billion years. The Universe can live with this, and contrary to recent press reports, there is no real "age crisis" yet.

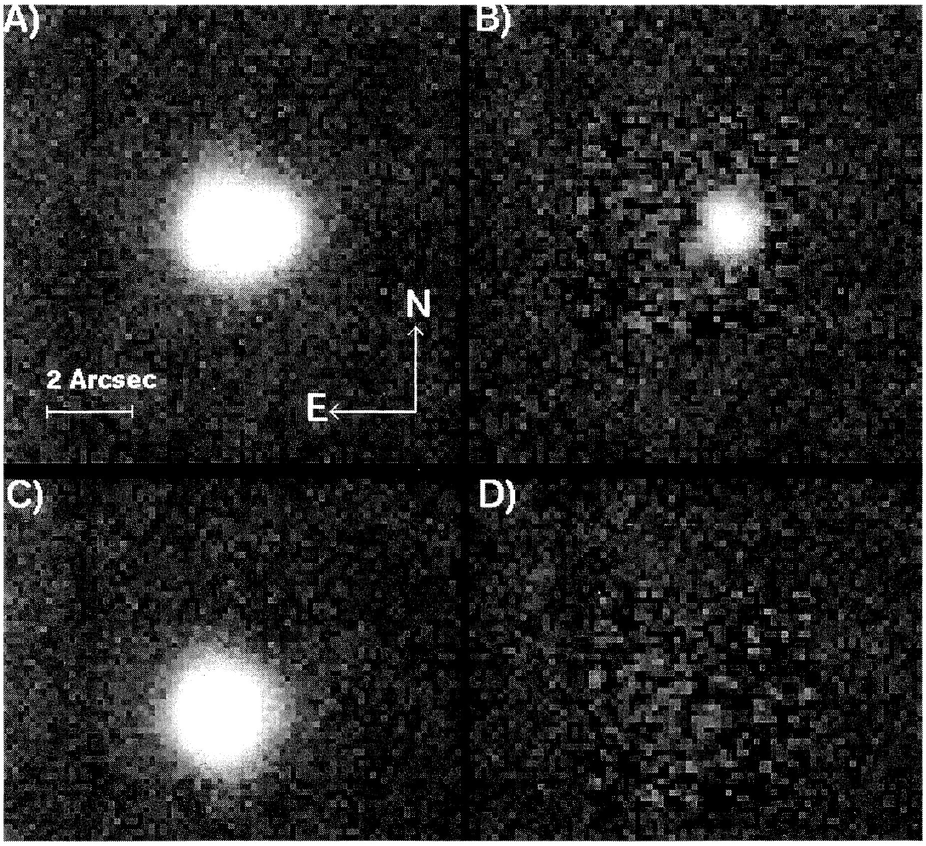
One of the most exciting results was the announcement by S. Perlmutter (Berkeley Laboratory) of the observation of seven very distant type-Ia supernovae (with a total of 11 more to be analysed) by the Berkeley-led collaboration. There is a real possibility of measuring the deceleration parameter (the deviation of the Hubble law from simple linearity) of the Universe, and to determine basic cosmological parameters using this technique. On the same note, the future detailed study of the cosmic background radiation angular fluctuations with a new generation of detectors on new satellites can also give these parameters. This was reviewed by A. Lange (Caltech) and E. Wright (UCLA).

An excellent, lucid review of the underlying theory was provided by Joseph Silk (Berkeley). Following the pioneering work of the COBE satellite, the inhomogeneity in the cosmic background radiation has now been measured at the 1-degree angle scale. New data is already providing important clues to the cosmological parameters of the Universe.

The discovery of a Brown Dwarf and more evidence for MACHOs (massive astrophysical compact halo objects) indicate at least two concrete sources of dark matter in our Galaxy. Both topics were represented at the meeting by S. Kulkarni (Caltech), who presented the brown dwarf discovery, while D. Bennett (Livermore) and other members of the MACHO team discussed the MACHO search status. They reported a total of eight events over two years of observation. The masses of the MACHO candidates are from 1/4 to 1/2 that of the Sun, leading to the obvious question of whether these are stars, white dwarfs, or what!

On the large scale, the use of gravitational lensing to measure the total mass of galactic clusters is now becoming a reality. In this technique, images of distant objects are distorted by intervening matter that is otherwise invisible. R. Blanford (Caltech) presented an overview of

In gravitational lensing, images of distant objects are distorted by intervening matter which is otherwise invisible. The top left image (A) shows a distant highly luminous quasar as seen by the European Southern Observatory's new 3.5 metre New Technology Telescope, with an elongated shape caused by the superposition of two images, one seven times brighter than the other. In frames B and C, each image is artificially subtracted to isolate the other. In frame D, both images have been removed. The extreme distance of the quasar shows that the intervening galaxies which cause the aberration were already in position several billions of years ago.



this exciting field. In the next few years, the comparison of the mass determined by lensing and conventional techniques could shed "light on the nature of the dark matter".

There were detailed discussions of the primordial nucleosynthesis of light elements (theory in good shape, although one group still claims discrepancies) and of the large scale structure of the Universe, which still implies hot dark matter suggesting a neutrino mass from 2 to 5 electronvolts, with results presented by Joel Primack (Santa Cruz) and C. Ma (Caltech). There are still suggestions that there may be a non-zero cosmological constant, as first introduced by A. Einstein. Including such a term in the cosmological equations gives an anti-gravity effect that can push matter apart. However, it was clear from the discussions that such conclusions are premature.

One of the interesting points to emerge was the search for indirect signals from dark matter annihilation. Perhaps the most interesting result was given by S. McKee (Michigan), who showed that the previously reported excess of cosmic positrons and antiprotons has gone away. The cosmic antiproton yield is now fully consistent with it being a secondary product of energetic cosmic rays.

The search for particle dark matter is entering a new, intense phase with major experiments to search for axions, WIMPs (Weakly Interacting Massive Particles), and neutrino mass coming on-line all over the world. Felix Boehm (Caltech) gave a general overview of the current search for neutrino mass and oscillations. The key experiments to search for a neutrino mass in the few-electronvolt range are LSND (Los Alamos), Karmen (Rutherford Appleton), Chorus (CERN), and Nomad (CERN), all of whom gave status reports at the meeting. While the controversial positive signal from LSND (June 1995, page 13) has not been confirmed (by themselves or others), the hope is still high that one of these experiments, as well as COSMOS at Fermilab, will be able to demonstrate neutrino oscillations in this mass range. While there is much progress, it is clear that this will be a long drawn-out process.

The major progress in the search for axions comes from the Livermore group, where an experiment is just getting started. The most promising form of WIMP is the supersymmetric neutralino. Unfortunately, the expected rates for supersymmetric WIMPs now falls into the 10^0 to 10^{-5} events/kg/day range, as was discussed by G. Kane (Michigan) and R. Arnowitt (Texas A&M).

Perhaps the most exciting news from the meeting is that detectors are about to start a real search for supersymmetric WIMPs in several underground laboratories.
It was generally agreed that this requires at least a kilogram of detector. The three different underlying methods were described by Peter Smith (Rutherford Appleton) for detectors operating above 100K, including sodium iodide, Blas Cabrera (Stanford) for low temperature detection, and David Cline (UCLA) for discriminating liquid-xenon detectors. A reported new limit from the sodium iodide detectors of less than 10 events/kg/day is at

the edge of supersymmetric WIMP expectations. The low temperature and discriminating liquid-xenon detectors may be able to attain the 10^{-1} to 10^{-2} event/kg/day rate in the next few years.

The meeting showed that the next key measurements to be made should be:

- a new satellite to make precise cosmic background radiation studies;
- more observations of the distant supernova Ias to measure the deceleration parameter;
- WIMP detectors in the 100 kg mass range; and
- resolution of the issue of the few electronvolt neutrino mass.

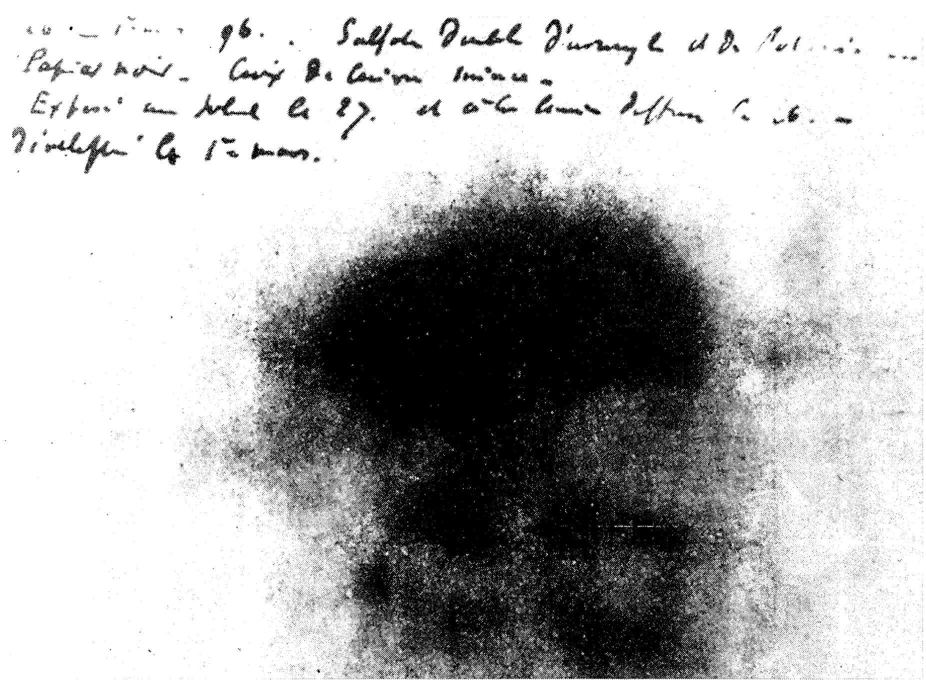
It is hard to imagine a more exciting discovery than that of supersymmetric WIMPs, implying that particle physics could once again be done in basement laboratories!

The proceedings of the symposium will appear in Nuclear Physics B this summer. The third meeting in this series will be held in Santa Monica, in February 1998.

Information from David B. Cline, University of California Los Angeles

One hundred years ago...

Marking a century of atomic physics, an occasional series of CERN Courier articles looks back to what was happening 100 years ago.



One of Henri Becquerel's historic 1896 exposures of radioactive material. Just visible is the outline of a metallic cross which had been placed between the sample and the photographic plate.

(Photo Commissariat à l'Energie Atomique)

Early in 1896, newspapers across the world were carrying the story of Wilhelm Röntgen's discovery of X-rays, illustrated with skeletal photographs of famous people's hands. In Cambridge, Charles T.R. Wilson detected ionization from X-rays in his new cloud chamber device. The evident spinoff applications of X-rays were not long in coming - that summer X-ray pictures were used for medical and dental examinations.

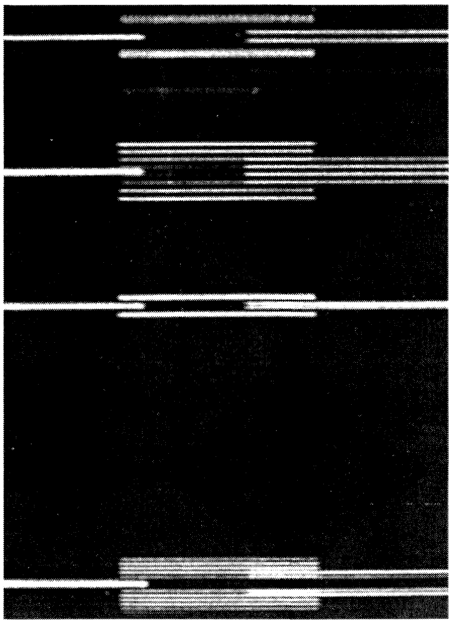
With the X-ray news, physicists all over the world stopped what they were doing and tried to understand the implications of the startling new developments. However this was difficult initially with only scanty press reports to go on. One of those interested was Henri Becquerel in Paris, the son and grandson of distinguished French physicists who had investigated luminescence.

Röntgen, aged 50, had covered a cathode-ray discharge tube with black paper and found that a fluorescent screen 2 metres away began to glow. Becquerel, aged 44, tried replacing the cathode-ray tube with a phosphorescent source exposed to sunlight. The source contained a uranium salt.

He wrapped a photographic plate in black paper to prevent fogging due to sunlight. The phosphorescent source was then placed on the wrapped plate and the whole exposed to the sun for several hours. The phosphorescent material cast a shadow on the plate, and this shadow could be affected by interposing an opaque object such as a coin between the source and the plate. Becquerel concluded that the phosphorescent substance emitted some kind of radiation capable of passing through the paper shroud.

Preparing another exposure with a copper mask between the source and the shrouded plate, Becquerel was disappointed when the sun went behind the clouds, preventing the standard exposure to induce phosphorescence, and hid the sample in a dark cupboard. But the clouds remained for several days, and Becquerel, tired of waiting, took

In 1896, Pieter Zeeman in Leiden acquired a precision diffraction grating and discovered the effect of magnetic fields on optical spectra. An ordinary spectrum (left) is split into many components.



out his sample and developed the plate. To his astonishment, the shadow of the copper mask was even sharper than those using sunlight-exposed plates. Needless to say he repeated the experiment several times. The source, even in the dark, emitted some mysterious radiation - Becquerel rays. This historic discovery was certainly helped by the dull weather in Paris in February 1896.

Becquerel systematically investigated their properties. Other uranium compounds which were not phosphorescent produced the effect, suggesting that the rays were due to uranium and not the phosphorescence, a suggestion confirmed by using metallic uranium.

The great Henri Poincaré summarized the puzzle in curiously prophetic words. Far from leading to a dead end, he declared 'one can think today that it will open for us an access to a new world which no one suspected,' and that other phenomena 'will doubtlessly... complete a picture of what we barely begin to see the outline'.

Becquerel's work motivated in turn Pierre and Marie Curie to begin their historic analysis of heavy elements. In 1903 Becquerel shared the Nobel Physics Prize with the Curies for their work on radioactivity. He died in 1908.

Elsewhere in 1896, Pieter Zeeman in Leiden acquired a new diffraction grating and discovered the effect of magnetic fields on optical spectra. Guglielmo Marconi demonstrated wireless telegraphy (so did several other people, see October 1995, page 21). Common to these discoveries and to Röntgen's watershed X-ray discovery of 1895 (and in several subsequent milestone experiments) were Heinrich Rühmkorff's coil, a transformer-like device for producing high voltages, and the vacuum tube developed by Johann Geissler of Bonn. Rühmkorff and Geissler's research and development work seeded fundamental physics at the dawn of the 20th century.

On the theoretical side, a hundred years ago the 'standard model' of basic physics was statistical mechanics, and the precision study of 'black-body' radiation was its testing ground. In Berlin, Wilhelm Wien, working in Hermann von Helmholtz' institute, analysed the radiation emitted by an electrically-heated furnace and formulated a promising new equation which related the radiation's wavelength and temperature. His phenomenological expression, and another contemporary version by Lord Rayleigh at Cambridge, were improvements on previous attempts, but precision tests showed them to be deficient at certain wavelengths. However the radiation measurements had required considerable experimental skill at Berlin, and this mass of precision data helped opened the door for Max Planck's subsequent equation and its quantum explanation. At lower wavelengths, Wien's and Planck's exponential equations do not look very different, but while Wien's approximation had two empirical constants, Planck's more complete version only had one.....

Albert Einstein, having failed the entrance examination for Zurich's ETH the previous year, studied at the Swiss cantonal school in Aarau before being admitted to the ETH in the fall of 1896.

'Solomon's House': Has particle physics made Francis Bacon's vision come true?

Francis Bacon, the English philosopher and politician who lived between 1561-1626, partly overlapping the reign of Queen Elizabeth I, was the first person to understand the importance of new knowledge and in particular the natural sciences to society. He considered the then dominant study of ancient philosophy as unproductive and retrospective, and believed that vast amounts of phenomena were yet unexplored. He was the first to argue that science ought to be organized, and the Royal Society of London, the earliest academy formally constituted in Europe, founded in 1660, adopted Francis Bacon's ideas (1).

During the last years of his life Bacon worked on his grand vision,

During the last years of his life, the English philosopher and politician Francis Bacon worked on his grand vision, New Atlantis *, published after his death. 'Solomon's House' was the most important element in this vision of an ideal society. On this distant, fantasy island, research was formally organized, with scientists collaborating in experiments or observing nature, and the fruits of this research were passed to society.*

a. Wildfires burning in water
b. Engine houses to study motion
c. Ability to fly in air
d. Instruments for seeing distant objects in the heavens
e. Light intensified and thrown great distances
f. Glasses to see small bodies perfectly
g. Perspective houses to study light and color
h. Pools to strain fresh water out of salt
i. Gardens bearing more speedily than their nature
j. Animals bred both greater and smaller than their kind
k. Fruit much larger than its nature
l. Aids to improve hearing
m. Sound houses for studying sound
n. Sound conveyed in tubes over distances
o. Deep caves for refrigeration
p. Ships sailing under water

New Atlantis (2), published after his death. 'Solomon's House' was the most important element in this vision of an ideal society. On this distant, fantasy island, research was formally organized, with scientists collaborating in experiments or observing nature and the fruits of this research passed to society. Publication was considered especially important.

Bacon wrote: "The End of our Foundation is the knowledge of Causes and secret motions of things; and the enlarging of the bounds of Human Empire, to the effecting of all things possible."

Much effort was devoted to setting up a formal structure of the Royal Society. The idea was that the academy should do science - its role should be more than to discuss, evaluate and accredit research carried out elsewhere. Its corporate membership was seen as actually doing research. Experiments should be carried out and tested in the presence of a large audience. Equally, the initiatives for new research should be formal and organized by the Society. The Royal Society founders had great faith in the strength of corporate research being superior to private, individual experimentation.

However, the Society soon began to favour research by individuals and the corporate activities dwindled - except for its weekly meetings. Time was not yet ripe for Francis Bacon's vision, with its two key elements; the organization of research, and corporate engagement in experimentation and publication.

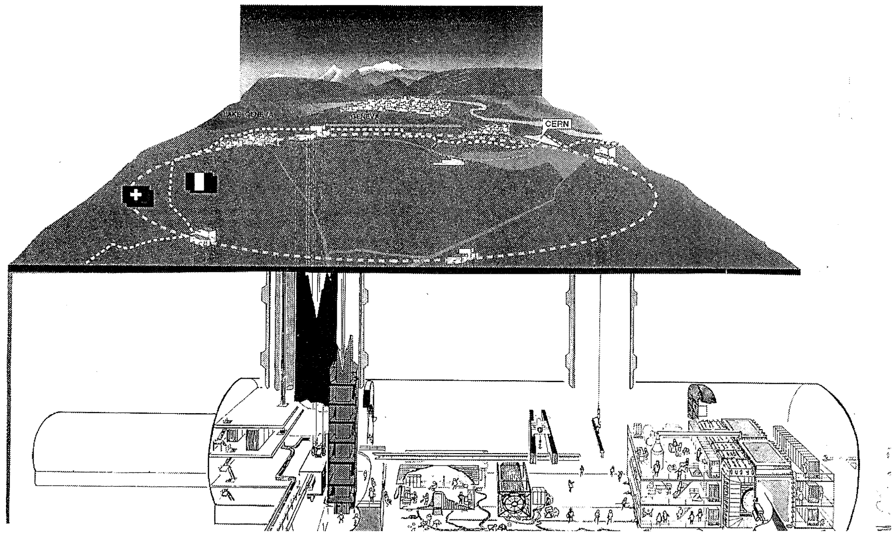
The need for organization has long been recognized and realized. Universities were there first, but university research is traditionally not organized in a corporate fashion. Academies like the Royal Society were created for the organization of scientific research, but later came industrial laboratories and research councils to offer leadership, and later still large institutes such as CERN.

The other element in Bacon's vision - corporate responsibility for the planning and carrying out of experiments and for the publication of the results and conclusions - has not been quick to emerge. However from the middle of this century, with the necessity for large teams to cooperate within certain basic research fields, the time for this New Atlantis element has finally arrived.

One such field is elementary particle physics, in which researchers have to work in large teams in an organized manner - bringing together individuals with a broad spectrum of knowledge, sufficient resources and a variety of skills.

Over the years the size of teams has grown from a few to the hundreds seen for example at the experiments at CERN's LEP electron-positron collider. Such a team is gradually formed around an attack on a set of important physics goals with complex instrumentation which has to be designed, tested, built and run over a long timescale. Planning and reporting is done within the large corporate body - with subgroups doing the preparatory work.

This is corporate research, much in the spirit advocated by Francis Bacon. In New Atlantis the research



A not so fantasy Solomon's House. An artist's impression of an experiment at CERN's LEP electron-positron collider.

in Solomon's House was carried out by a team of 36 experts, mostly organized in subgroups of three, joined by students and support staff. Bacon does not reveal how many they were in total, but a guess would be some 100 to 150. The first group of twelve experts were the 'Merchants of Light', who sampled knowledge from other countries, then came eight groups of three: 'Depredators', 'Mystery-men', 'Pioneers' or 'Miners' (experimentalists), 'Compilers', 'Dowry-men' or 'Benefactors' (applied scientists), 'Lamps' and 'Inoculators' (those doing new experiments), and finally 'Interpreters of Nature' (theorists). They met to report, plan and decide on future activities, including publishing plans.

Publication today is often a corporate activity with several hundred names on typical papers, grouped at LEP around four large teams - Aleph, Delphi, L3 and Opal. Corporate research exists elsewhere and is no longer a rarity. However, some scientists outside the field have deplored this deviation from tradition. Furthermore claims are voiced that publications with hundred of authors make it hard to notice and acknowledge the contributions of an individual.

This is today considered a problem also by a majority of those involved in a recent sociological study made by ECFA, the European Committee for Future Accelerators. The present publication habits are viewed as unsatisfactory, but no acceptable remedy has been suggested. Here, Francis Bacon does not offer a solution, since corporate research and corporate publication were his ideals, something useful and fitting to the needs of society. In his utopian land inventors were acknowledged by a statue, much as is done today when individuals are awarded scientific prizes.

The advent of Big Science can be said to have evolved in a way which revives Bacon's proposal of doing science, not only well organized, but fully corporate from initial plans through to publication.

The similarities between Solomon's House as envisioned by Francis Bacon and a major particle physics experiment are indeed striking. Even more striking is that this way of doing research was proposed already some 370 years ago, before organized research even existed!

by G. Ekspong, Stockholm, Sweden

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2 - Francis Bacon, New Atlantis, posthumously published 1627.
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RICH dividends

The Cherenkov Ring Imaging (RICH) technique for particle identification has gone through an intensive and rapid evolution since Jacques Séguinot and Tom Ypsilantis' 1977 paper which reported on efficient single ultra-violet-photon detection using a multiwire proportional chamber (MWPC) with benzene-doped operation-gas. In this technique, the photons radiated by a charged particle passing through a medium are focussed by mirrors to provide a ring image. The ring size, depending on the mass and momentum of the particle, can be used for particle identification - distinguishing one particle type from another.

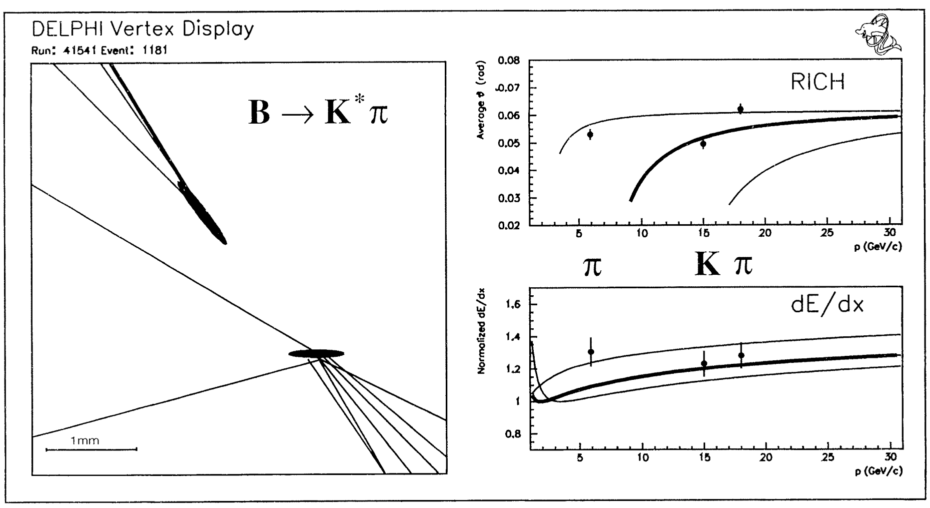
During the following few years a number of further fruitful ideas were put forward and successfully tested by several authors. Among these were the use of TEA and TMAE as doping vapours with lower photoionization thresholds, multistep avalanche chambers and MWPCs with partitions for enhanced single photoelectron detection, cathode strip read-out and time-projection chamber techniques for two- or three- dimensional reconstruction of the photon absorption point, optical schemes like proximity focussing and cupola optics for non-spherical, simplified detector geometries, and fluorocarbons as non-cryogenic liquid or gaseous radiators with small chromatic aberration.

By the early 1980s, sufficient progress had been made to propose several fixed-target and collider experiments based on the new technique- E605(1985) at Fermilab, UA2-RICH(1990) at CERN's proton-antiproton collider, Omega(1990) at CERN's SPS proton synchrotron, Delphi(1991) at CERN's LEP electron-positron collider and SLD(1995) at Stanford's SLC linear collider (the parentheses give the year of publication of the first RICH-based physics results). Over the past few years a rich harvest of new results has been obtained from these experiments in the areas of quark fusion and fragmentation, heavy quark production, hadron spectroscopy, rare decays and electroweak interactions.

Since this first generation of RICH detectors, further generic concepts have been developed, including the use of cathode pads for fast and unambiguous two-dimensional read-out, solid cesium iodide as robust photocathode material in multiwire proportional counters, multianode vacuum photomultipliers as imaging detectors, and new optical schemes like the quartz-bar system of DIRC for BaBar at SLAC, and the sawtooth radiator proposed for CLEOIII at Cornell to minimize detector depth. In particular the development of cesium iodide as solid photocathode has high potential and presently attracts much interest and attention (April, page 17).

With these developments a new generation of RICH-based experiments have emerged, some of which have already produced first physics results like NA 45/CERES (1993) at CERN's SPS, The CAPRICE (1995) balloon-borne cosmic ray experiment and JETSET(1995) at CERN's LEAR antiproton ring. Still others are in various stages of preparation - CLEOIII at Cornell, BaBar at SLAC, Stanford, HERA-B at DESY, CDF Upgrade at Fermilab, PHENIX and BRAHMS at RHIC, Brookhaven, HADES at GSI Darmstadt, and LHC-B and ALICE at CERN's LHC.

A representative picture of this lively and fruitful field of research was presented at the RICH95 Workshop in Uppsala. The workshop was the second of its kind - the first was held in Bari in 1993 - and gathered some 70 researchers from all parts of the world for four days of intensive exchange. The long list of experimental proposals based on novel ideas for Cherenkov light imaging shows that this field of research is as lively as ever. The Workshop Proceedings have appeared in Nuclear Instruments and Methods A (1 March 1996 issue).



A striking example of the use of particle identification with the Ring Imaging Cherenkov (RICH) detector of the Delphi experiment at CERN's LEP electron-positron collider for the physics of particles containing the fifth 'b' quark. On the left is the magnification of the vertex region of a candidate event of the rare 'charmless' decay of a particle containing a b-quark to one containing the 'strange' ('s') quark, showing, below, the initial interaction vertex and, above, the decay of the emerging b-quark particle. On the right, the response of the RICH and the Time Projection Chamber rate of energy loss (dE/dx) to the three tracks emerging from the displaced secondary vertex demonstrates the unambiguous identification of the decay of a B^- particle into a neutral K and a negative pion, the K* decaying quickly into a positive kaon (artificially bold track) and a negative pion. The 2mm gap between the two vertices shows the brief lifetime of the B particle.*

In 1969, Leon Van Hove encouraged the establishment of meetings on low transverse momentum physics. The 25th anniversary of these Multiparticle Dynamics Symposia testifies to this wisdom.

Off the beaten track - 25 years of multiparticles

The big scientific interest is in the all too rare events where the quarks and gluons deep inside colliding nucleons crash into each other, producing particles which swerve out of the beam direction. However most of the released energy appears as multiparticles - many particles, each with low transverse momentum.

Thus most physicists are interested in a minority of physics, leaving a minority of stalwart specialists to take care of the majority of physics.

Like the physics itself, the jamboree of these physicists - the Multiparticle Dynamics Symposia - keeps a low profile. However the recent celebration of its 25th anniversary testifies to the continual enthusiasm and dogged perseverance in this less fashionable physics.

High momentum transfer reflects powerful interactions - head-on collisions of particles - exciting physics which invites interpretation and even speculation.

Disappointed by the lack of interest in the harder-to-interpret low transverse momentum sector, in 1969 a group led by R. Lestienne, A. Krzywicki, R. Salmeron and R. Sosnowski, with encouragement from Leon Van Hove, organized a specialist meeting, held at the Ecole Polytechnique in Paris.

A problem was the choice of title, with 'Multiparticle Dynamics' being chosen as it could mean a lot of things - a wise choice as the accent has changed subtly over the years.

After this initial meeting, the aim was to alternate between venues in the West and in the East. As a compromise, the second meeting (1971) was held in Helsinki.

In succeeding years a clear pattern emerged. With Prince Malhotra proposing India as a venue for 1979, the West-East idea was extended to alternate between 'developed' and 'developing' countries. In this way new countries were introduced to the idea of holding international meetings.

Other adopted guidelines were:

• the meetings should be small, with less than a hundred participants. so ensure everyone got to know each other;

• in view of this the organization should be handled by one person responsible for everything;

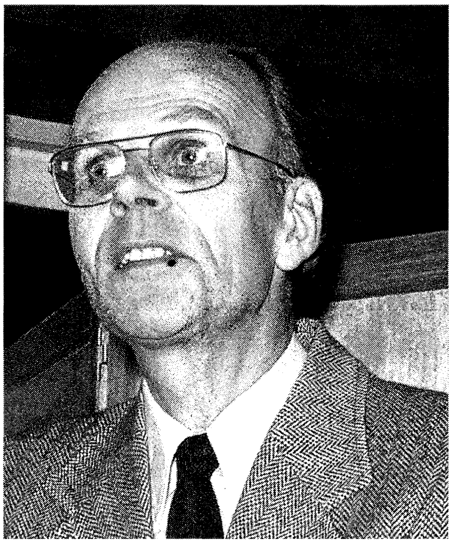
• to avoid distractions, welcome or otherwise, the meeting should not be held in a big city or a major laboratory;

• a close-knit atmosphere, with a single site for accommodation, talks and meals;

• the subjects should invite continuity from one meeting to the next, however the organizer had the right to play a trump card and devote half a day to a subject of local interest;

• attendance should be by invitation only, although anyone could apply. In practice the wide scatter of geographical location has ensured that only about 20% of the attendance at any one meeting have attended the previous one.

The initial meetings were essential presentations of experimental results. But new ideas were always being sought. One in those early years was Van Hove's concept of longitudinal phase space, where with transverse momentum more or less constant, variations in longitudinal momentum led to complex geometrical interpretations.



However over the years the advent of the Standard Model and its quantum chromodynamics (QCD) field theory of quarks and gluons provided a theoretical focus. This and the development of sophisticated simulations like the famous Lund model enabled experiments to make detailed comparisons of their data with theory.

Nevertheless, 'hadronization' - the way quarks and gluons formed in the interaction manifest themselves as particles - is still very much a grey area. A better understanding of hadronization remains one of the major goals of the symposia.

After the initial meetings in Paris and Helsinki, the third (1972) was in Zakopane, Poland, reflecting the high level of Polish interest in the subject. Then came Pavia (1973), Leipzig (1974), Oxford (1975), Tutzing (near Munich, 1976), and Kayserberg (Alsace, 1977).

At the latter, atmosphere was guaranteed by lodging participants with local inhabitants - Richard Feynman stayed with the local pharmacist.

Then came Tabor (Czechoslovakia,

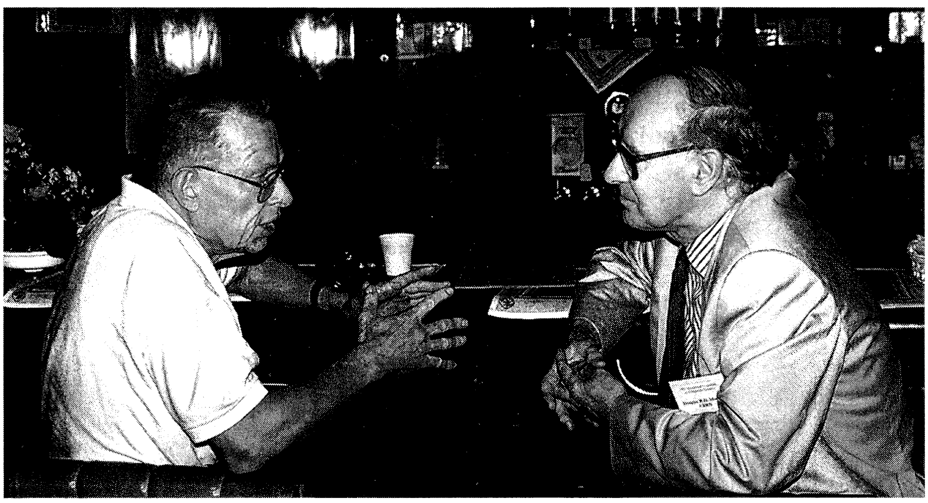
1978), followed in 1979 by Goa in India, the first time the symposium had been held outside Europe. This initiative of the late Prince Malhotra allowed many Indian physicists to attend their first international meeting and greatly helped the cause of Indian physics.

After the 1980 meeting in Bruges, Belgium, came the first US venue, Notre Dame, in 1981. Following Volendam (Netherlands, 1982) the symposium returned to the US in 1983 and the fresh mountain air of Lake Tahoe. The 1984 meeting in Lund underlined the importance of Lund physicists' contributions to hadronization.

In 1985 came Kiryat Anavim (Israel), then Seewinkel in Austria (1986), Tashkent, USSR (1987) and Arles, France (1988). The 1989 meeting had been scheduled for Wuhan in China, but the events of that year made many reluctant to attend. The meeting was cancelled, and replaced by Dortmund in 1990. Wuhan finally made it in 1991, with the most recent meetings having been held in Santiago de Compostela (Spain, 1992), Aspen (Colorado, 1993), Vietri sul Mare (Italy, 1994) and finally in 1995 Stara Lesna in Slovakia. The 1996 meeting will be held in Faro, Portugal, in September.

While these small meetings are far from the scale of the big international jamborees with upwards of a thousand participants, they underline the personal contacts which are so important in research. Long may they continue.

Information from Douglas Morrison



Norbert Schmitz (left) of Munich's Max Planck Institute and Douglas Morrison of CERN discuss organization of the Multiparticle Dynamics meeting at Stara Lesna, Slovakia, in September 1995.

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Half a century at Argonne

Underground Physics - Argonne's Ed May (right) and Steve Werkema from the University of Minnesota work on the Soudan 2 detector in a historic iron mine, 713 metres below the surface of northern Minnesota. Scientists from Argonne, Minnesota, Oxford, Rutherford and Tufts operate the one kiloton Soudan 2 detector which was designed to detect proton decay and is now also used for neutrino studies.

The pedigree of high energy physics in the atomic energy developments of the 1940s has been marked recently by a series of 50th anniversary celebrations at major national Laboratories. This year it is the turn of Argonne National Laboratory, one of the US Department of Energy's largest research centres.

Argonne is a direct descendant of the University of Chicago's "Metallurgical Laboratory," or Metlab, which in 1942 built the first nuclear reactor under the guidance of Enrico Fermi as part of the Manhattan Project.

Argonne has a long history of contributions to the physical sciences. Early research centred on the development of nuclear reactor technology, but Argonne's mission has expanded over the years to include many different fields of basic and applied science. Today, the laboratory has 4,500 employees, of whom 1,775 are scientists and engineers, and 800 hold doctorate degrees. Argonne's annual operating budget of $485 million supports more than 200 research projects, ranging from studies of the atomic nucleus to research on global climate change.

Argonne operates on two sites. The Illinois site is surrounded by forest preserve and is located about 25 miles southwest of Chicago's "Loop" downtown area. Argonne-West, about 50 miles west of Idaho Falls, Idaho, is home to most of Argonne's nuclear reactor research facilities. About 800 Argonne employees work there.

Argonne's current research programme falls into four broad categories:

• Physical Research includes high energy physics, nuclear physics, medium energy physics, materials science, chemistry, mathematics and computer science, the latter emphasizing high-performance computing and massively parallel systems;

• The Advanced Photon Source, now being commissioned, will provide the United States' most brilliant X-ray beams for pioneering research in many fields. Experiments are scheduled to begin later this year;

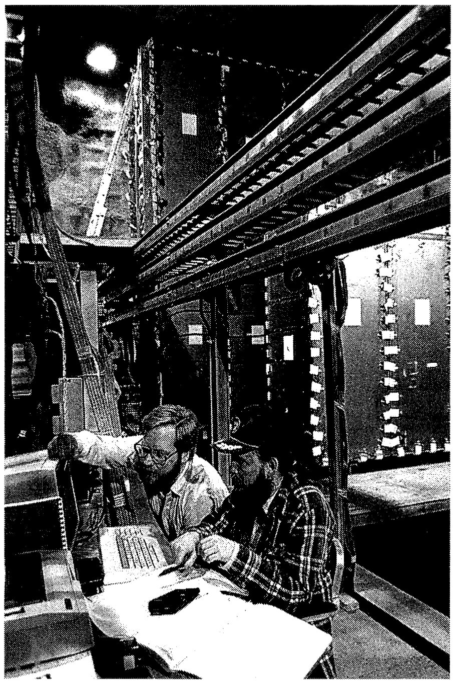
• Energy and Environmental Science and Technology includes research in biology, alternate energy systems, environmental assessments and economic impact assessments;

• Engineering Research focuses on advanced batteries and fuel cells, and advanced fission reactor systems - including electrochemical treatment of spent fuel, improved safety of Soviet-designed reactors, and technology for decontaminating and decommissioning ageing reactors.

Industrial technology development is moving Argonne's publicly funded research to industry to help strengthen the US technology base. Since 1984, Argonne has entered into many collaborative ventures with industry under the Cooperative Research and Development Agreement programme, and has been the source of a number of spin-off companies.

A central part of Argonne's mission is to design, build and operate national user facilities. At present, these include the Advanced Photon Source, the Intense Pulsed Neutron Source, the Argonne Tandem Linear Accelerator System (ATLAS), and the Argonne Wakefield Accelerator.

Beginning in 1964, a large community of university and Argonne physicists used the 12.5 GeV Zero Gradient Synchrotron (ZGS - the world's highest energy weak-focusing proton accelerator) for a diverse and productive programme of high energy physics experiments. Argonne was the first laboratory to build and use a superconducting magnet for a full-scale high energy physics experiment, in this case a bubble chamber. After the ZGS was turned off in 1979, Argonne high energy and accelerator physicists became major contributors to new detector facilities at other laboratories: the HRS at PEP (SLAC, Stanford), CDF at Fermilab, ZEUS at HERA (DESY, Hamburg), as well as the Fermilab antiproton source and the non-accelerator physics facility in the Soudan mine.

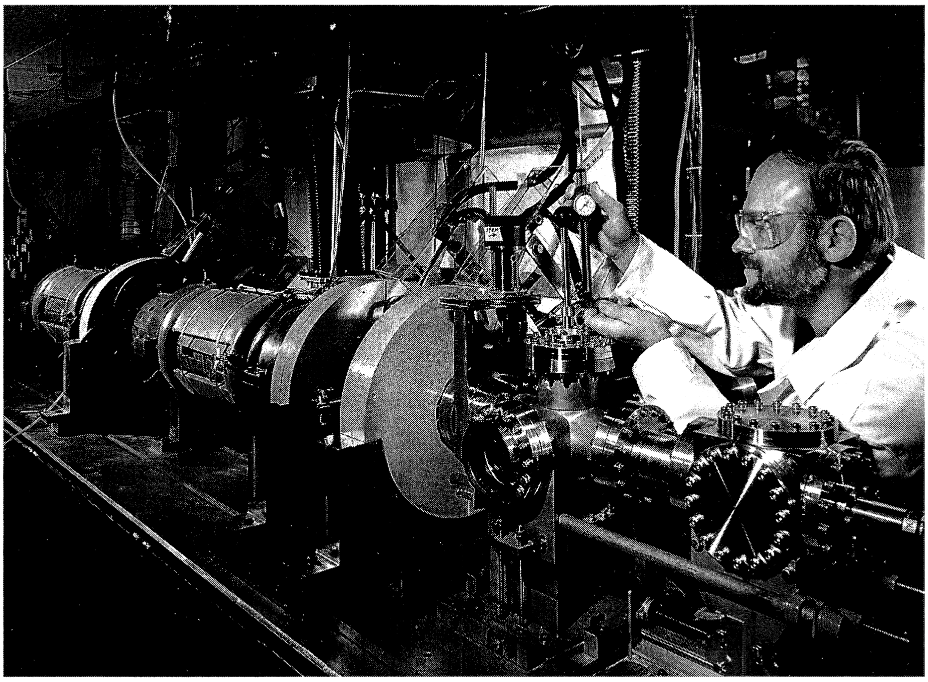


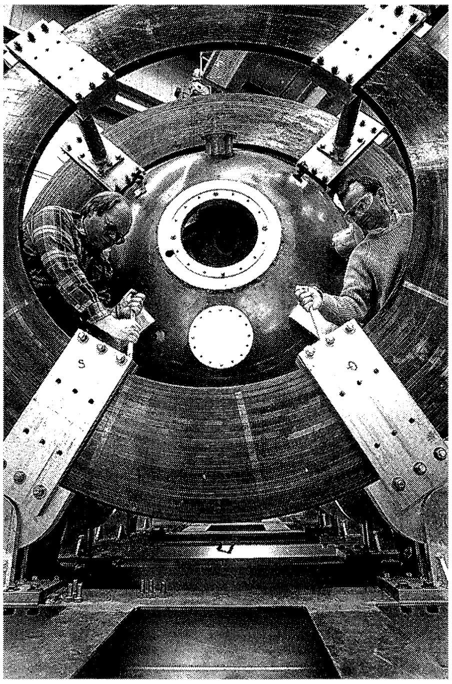
The 50th anniversary is being celebrated at Argonne with a year-long programme of special events. These include the dedication of the Advanced Photon Source in June, talks by many notable speakers including Jim Cronin and Hans Bethe, and a special open house for the public in September.

Argonne's facilities are owned by

Wakefield Accelerator - Engineering Specialist Richard Konecny aligns the recently completed first stage of this Argonne facility. This accelerator uses the energy of an intense, pulsed electron beam to produce fields on which other particles "surf" and build their momenta.

Probing Peaks - Argonne's Russell Betts (right) and Princeton University's Aksel Hallin lock in magnetic coils in the ATLAS Positron Experiment (APEX). The device is using beams of ions accelerated by ATLAS to investigate unexplained peaks of energy observed in previous experiments at GSI (Darmstadt).





the US Department of Energy and operated by the University of Chicago. (More information about Argonne's programmes and history is available on Argonne's World Wide Web site: http://www.anl.gov.)

Physics milestones at Argonne

1958 - Soon after the Mossbauer effect was discovered, Argonne scientists identified a particular nucleus (iron-57) for which the effect can be used as a practical tool. Argonne scientists played a leading role in using the Mossbauer effect for fundamental studies in nuclear physics, hot-atom chemistry, materials science and general relativity experiments.

1963 - Physicist Maria Goeppert Mayer shared the 1963 Nobel Prize for her research at Argonne that led to the shell model of the atomic nucleus.

1964 - Argonne's 12.5 GeV ZGS, the world's highest energy weak-focusing proton accelerator, began operation.

1964 - Argonne was the first laboratory to build and use a superconducting magnet for a full-scale high energy physics experiment.

1969 - The first demonstration in a high energy accelerator of charge exchange injection using negative hydrogen ions was done at the ZGS. This became the standard injection mode at the ZGS and was subsequently generally adopted.

1970 - The first observation of a neutrino interacting in a hydrogen bubble chamber was found in a photograph from the 12-foot bubble chamber at the ZGS. At the time, the bubble chamber and its superconducting magnet were the world's largest.

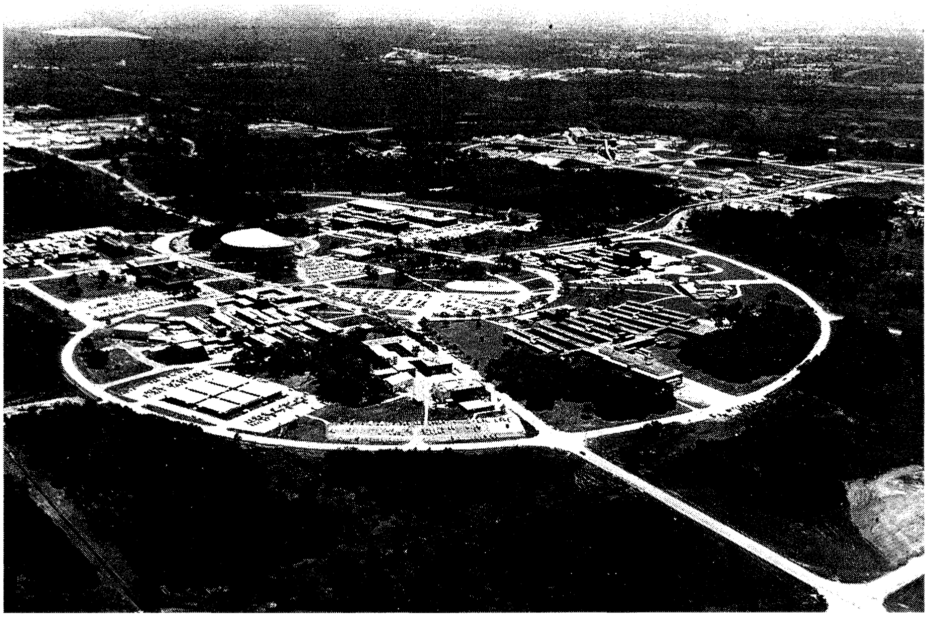
1973 - Accelerator experiments at ZGS proved it was possible to inject polarized protons and accelerate them to high energy while retaining their polarization. This made possible the study of previously unobservable aspects of high-energy proton-proton interactions.

1985 - The Argonne Tandem Linear Accelerator System (ATLAS) was dedicated. ATLAS is the world's first superconducting linear accelerator for nuclear research with ion beams. Acceleration is provided by superconducting resonators which use technology developed at Argonne, yielding high quality beams over a broad range of projectile energy and mass. ATLAS can now accelerate ions up to uranium to energies as high as 1.9 GeV.

1987 - The first demonstration of wakefield acceleration in structures and in plasmas was achieved at Argonne's accelerator test facility. The wakefield concept promises to accelerate subatomic particles to higher energies in substantially shorter distances than is possible by conventional techniques.

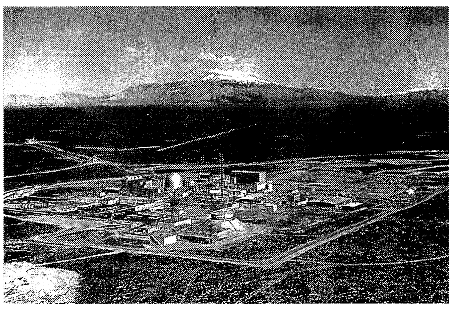
1995 - The 7 GeV Advanced

Photon Source reached design current for the first time, and produced 500,000 watts of X-ray power.

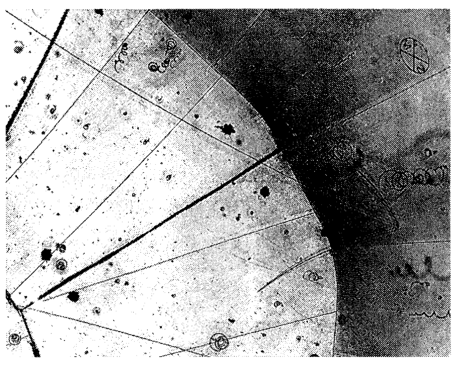


Argonne-East - Argonne's Illinois site is surrounded by forest preserve about 25 miles southwest of Chicago's "Loop" downtown area. About 3,700 employees work on the wooded, 688-hectare site, which also houses the Department of Energy's Chicago Operations Office.

Argonne-West - The laboratory's Idaho site occupies 364 hectares about 50 miles west of Idaho Falls, Idaho. The home of most of Argonne's nuclear reactor research facilities, about 800 Argonne employees work there.



Neutrino Event - The first observation of a neutrino interaction in a hydrogen bubble chamber is recorded on this 1970 photograph from the 12-foot bubble chamber at Argonne's Zero-Gradient Synchrotron. The invisible neutrino strikes a proton where three particle tracks originate (lower right). The neutrino turns into a muon, the long centre track (extending up and left). The short track is the proton. The third track (extending down and left) is a pion created by the collision.



Bookshelf

From Quarks to the Cosmos by Leon M. Lederman and David N. Schramm
ISBN 0-7167-6012-6 (pbk)
1989,1995.

Leon Lederman, who shared the 1988 Nobel Price in physics for the discovery of the muon neutrino, has also played important roles in the discoveries of the long-lived neutral kaon and the bottom quark. David Schramm is best known for his work in bringing together elementary physics and big bang cosmology. The authors set up an astrophysics group at Fermilab, and, stimulated by the unique collaboration between this group and particle physicists at Fermilab, wrote this popular book on the connections between the inner space of subatomic physics and the outer space of the vast universe.

The book was first published in 1989, but a second edition includes updates and new results, particularly the top quark discovery and the ripples in the cosmic background radiation.

The interrelations between particle physics and astrophysics through the Big Bang cosmology are explained in a simple way requiring no expert knowledge and may easily trigger a young reader's interest in natural science.

The best part of the book is the story of the evolution in our understanding of the microworld linked to the spectacular and often interrelated evolution of experimental tools from Galileo's telescope to the Hubble Space Telescope, and from Coulomb's torsion balance to the enormous detector complexes at high energy particle colliders. The astrophysics part, more superficial and strongly tied to big bang cosmology, could have been ex-

People and things

panded, with, in a similar way to the microworld explanations, more on how our understanding of the macrocosmos has evolved. Problems like solar evolution and the solar neutrino puzzle are omitted.

The book could also have benefited from more material on experimental particle physics outside the United States and on the future possibilities of the LHC and linear colliders, rather than "The sad story of the SSC..."

Egil Lillestol

The Particle Hunters (2nd edition) by Yuval Ne'eman and Yoram Kirsch, Cambridge University Press, 300 pages, ISBN 0 521 47686 0 paperback, £14.95; 0 521 47107 9, hardback £40

The first English edition of this pleasant and readable book (originally published in Hebrew in 1983) appeared in 1986. It has since also appeared in Italian and German versions. The second edition includes brief details of recent developments such as the demise of the US Superconducting Supercollider (SSC) and the discovery of the top quark, together with a sketch of the emerging particle physics scenario worldwide. The authoritative chapter on quarks and the eightfold way, in which Yuval Ne'eman played an important role, is particularly lively.

Julian Schwinger, The Physicist, the Teacher, and the Man, edited by Y. Jack Ng, World Scientific, 194 pages, ISBN 981-02-25318 (hbk) £27, 981-0-25326 (pbk) £11

Julian Schwinger, who died in 1994, was one of the major architects of quantum electrodynamics, itself one of the major scientific achievements of the century. He was an impressive intellect, setting new standards in erudition and sophistication, and attaining a new stratosphere of reasoning. Legend has it that as a child he was reading Encyclopaedia Britannica from cover to cover, but was sidetracked at 'Physics'. In addition to his own physics contributions, the list of his graduate students reads like a 'Who's Who', including two who went on to win the Nobel prize themselves - Sheldon Glashow and Ben Mottelson (Schwinger shared the prize with Feynman and Tomonaga in 1965). This book puts together a number of Schwinger tributes, together with two papers by Schwinger at the University of Nottingham in 1993 to mark the 200th anniversary of George Green (of Green's functions). Many of the contributions make fascinating reading. Sheldon Glashow's account of how he was set on the path to electroweak unification is one of them.

Books received

Fortran 90/95 Explained, by Michael Metcalf and John Reid, Oxford University Press, ISBN 0-19-851888-9, 368 pages, £16.95 (hbk).

Michael Metcalf of CERN and John Reid of the Rutherford Appleton Laboratory provide complete revision of their original 1990 standard text Fortran 90.

On people

Among those elected members of the prestigious American Academy of Arts and Sciences this year are Sau Lan Wu of CERN and Wisconsin, and Helen T. Edwards and Michael Turner of Chicago and Fermilab.

Sam Ting of MIT and a long-term visitor to CERN was awarded the 1996 Engelberg Forum Prize for his contributions to physics.

Herbert Lengeler retires

Enthusiasm, versatility and selflessness have marked the multi-faceted career of Herbert Lengeler at CERN. Arriving from Aachen's Technische Hochschule in 1964, he helped develop radiofrequency separator systems for early secondary beams. Under a new CERN-Soviet agreement he formed part of CERN's effort to build special equipment for the new Serpukhov machine. Returning to CERN, his

Herbert Lengeler - high technology enthusiasm and versatility

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Inquiries for the rest of the world:
please see page III

UNIVERSITY OF OXFORD
Department of Physics

Fixed Term University Lecturership in Experimental Particle Physics

Applications are invited for a University Lecturership in Experimental Particle Physics, tenable for a fixed period of three years from 1 October 1996. The stipend will be according to age on the scale of £15,154 to £28,215 per annum. Further particulars (containing details of the duties and range of emoluments) can be obtained from the Deputy Administrator, Department of Physics, Nuclear and Astrophysics Laboratory, Keble Road, Oxford, OX1 3RH.

The present experimental Particle Physics research programme includes the DELPHI experiment at LEP (CERN) and ZEUS experiment at HERA (DESY), the SOUDAN 2 and MINOS experiment (USA), the Sudbury Neutrino Observatory (SNO) project (Canada), the development of cryogenic detectors and the CRESST experiment (Gran Sasso) plus the development of the ATLAS and LHC-B experiments in high energy pp physics. The appointee will be expected to participate in one of the above programmes, and preference will be given to candidates wishing to collaborate in the Sudbury experiment. The activities of the Oxford SNO group are concentrated on the development of software for the simulation and analysis of SNO data and on water treatment systems for the purification and assay of heavy and light water to one part in 10^{15} of dissolved uranium, thorium, and their decay products.

Letters of application should be sent to the Deputy Administrator at the above address, to arrive no later than 30 June 1996. The letter should be supported by a curriculum vitae, list of publications, a statement of research interests and teaching experience, plus the names of three referees. The referees should be asked to send references directly to Dr. G. Myatt, Acting Head of Particle and Nuclear Physics, at the above address to arrive by the closing date.

It is expected that short-listed candidates will be interviewed in Oxford in July 1996. Applicants are asked to indicate an e-mail address or fax or telephone number where they can be contacted.

The University exists to promote excellence in teaching and research and is an equal opportunity employer.

The formal approval of CERN's LHC proton-proton collider by CERN's governing body, Council, in December 1994, included provision for generous additional contributions from CERN's two Host States, France and Switzerland. The substantial French contribution, mainly earmarked for LHC, is the subject of a special agreement between CERN, the French Atomic Energy Agency (CEA) and the National Institute for Nuclear and Particle Physics (IN2P3). At the formal signing of this agreement in Paris in February were (left to right) IN2P3 Director Claude Detraz, CEA Administrator General Yannick d'Escatha and Guy Aubert, Director of the National Scientific Research Council (CNRS).

attention turned towards the demanding technology of superconducting radiofrequency acceleration cavities, where his efforts, with Philippe Bernard, helped blaze a long and sometimes difficult trail which eventually led to the development of the modules now being installed to boost LEP's energy. En route, Herbert Lengeler's special expertise in this sector has been shared by a number of major Laboratories eager to exploit this new technology.

Most recently, dividing his time between CERN and Jülich, he has become a guiding light in the new European Neutron Spallation Source project. In parallel with his technological achievements he has been a prominent voice in CERN affairs, safeguarding the interests of others. Looking back on his high technology accomplishments with justifiable pride.

Herbert Lengeler acknowledges the challenges of physics, and the skills available at CERN met them. Coming from a German-speaking minority in multi-cultural Belgium, Lengeler explains that he was pre-sensitized to the international CERN environment.

Chalk River Accelerators

On 7 March Atomic Energy of Canada announced that, as a result of reductions in funding from the Canadian Federal Government, all funding for the accelerator physics program at the Chalk River Laboratories (CRL) would end at the end of June.

The CRL Accelerator Physics Branch was formed in 1967 during the days of the ING (Intense Neutron Generator) accelerator programme. Over almost three decades it has concentrated on high-power cw linacs, superconducting cyclotrons and industrial applications of accelerators.

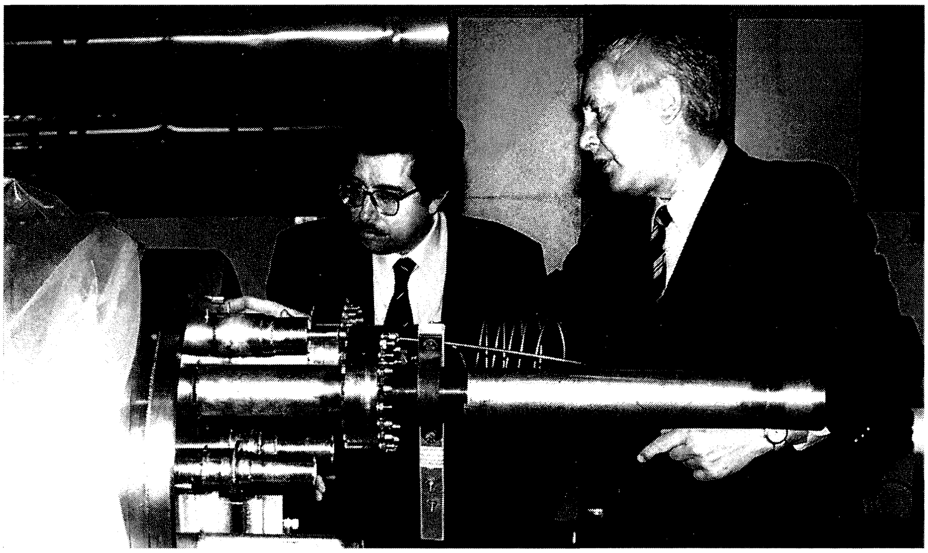
The small group of CRL accelerator physicists were often staffed below the critical size required to generate in-house many of the sophisticated "tools" (beam and cavity codes, fabrication techniques, etc.) needed for accelerator R&D and have been dependent on the generosity of the international community in sharing their knowledge and expertise.

On behalf of the past members of the Branch and the ones now leaving the exciting profession of accelerator physics, Jim Ungrin, last head of the CRL accelerator group, expresses his gratitude to the community for its assistance and support and for its past collaborations.

Igor M. Ternov (1940-1945)

Distinguished Russsian theorist Igor M. Ternov died on April 12 after a sudden heart attack. A World War II veteran, he graduated from Moscow State University in 1951 and spent his entire career there. A world renowned expert in the theory of synchrotron radiation, Igor Ternov was the author of more than 300 scientific papers, 5 monographs and 10 textbooks. He developed a new field - the theory of quantum processes in strong external fields based on exact solutions of relativistic wave equations. His investigations led him to the discovery of new quantum effects in macroscopic particle motion: quantum fluctuations of electron trajectories in accelerators, the effect of radiative polarization of electrons and positrons in a magnetic field (Sokolov-Ternov effect), dynamic character of the electron anomalous magnetic moment, "spin light", etc. An outstanding organizer of education and research at MSU, the chairman of MSU Physical Society, and for 15 years the vice-rector of MSU, he was first the head of quantum theory, then of the theoretical physics departments. Although he said, self-deprecatingly, that he did not have a good feel for experiments, he took a lively interest in new developments and attended many of the biennial high energy spin physics symposia. He is reported to have been 'delighted' that the spin effects he helped predict have been put to good use at LEP at CERN and

Portuguese Minister for Science and Technology Jose Mariano Gago (left) inspects a prototype superconducting magnet for CERN's forthcoming LHC collider with LHC Project Director Lyn Evans. As prominent particle physicist, Professor Gago played a vital role in his country's decision to join CERN.



at HERA at DESY. A brilliant lecturer, he was popular with many generations of students. Igor Ternov was a warm-hearted man with a highly developed sense of humour, always ready to extend help. He lives in the memory of all of those who worked with and admired him, and his scientific school will remain as a lasting monument.

Thomas L. Collins 1921-96

Thomas L. Collins, a veteran of the Cambridge Electron Accelerator (CEA), died in January, age 74. Joining Stanley Livingston's team at the CEA in 1957, he went on to introduce a method for integrating long straight sections equipped with quadrupoles into the architecture of strong focusing rings. In 1967 he was one of the first to join the Fermilab payroll, where he played an important role in analytic optics. Retiring from Fermilab in 1988, in 1994 he was awarded the American Physical Society's prestigious Robert R. Wilson Prize for his particle accelerator work.

Alfred Fridman 1932-96

Alfred Fridman, a driving force in French physics, died suddenly in Mexico on 24 March where he was spending a few months as the guest of the Polytechnic Institute. Graduating from the Ecole Spéciale de Mécanique et d'Electricité, he switched to physics research after attending Zurich and Neuchatel, where, in 1964, he submitted his thesis on strange particle production, researched at CERN. But it was at the Centre for Nuclear Research (CRN) in Strasbourg where his scientific work really gained momentum and where he set up the first group there to analyse photographs from light-liquid bubble chambers, including exposures to antiproton beams at CERN and Brookhaven, and joint efforts with European, Israeli, American and Russian laboratories. CRN's reputation in high energy physics stems first and foremost from his group.

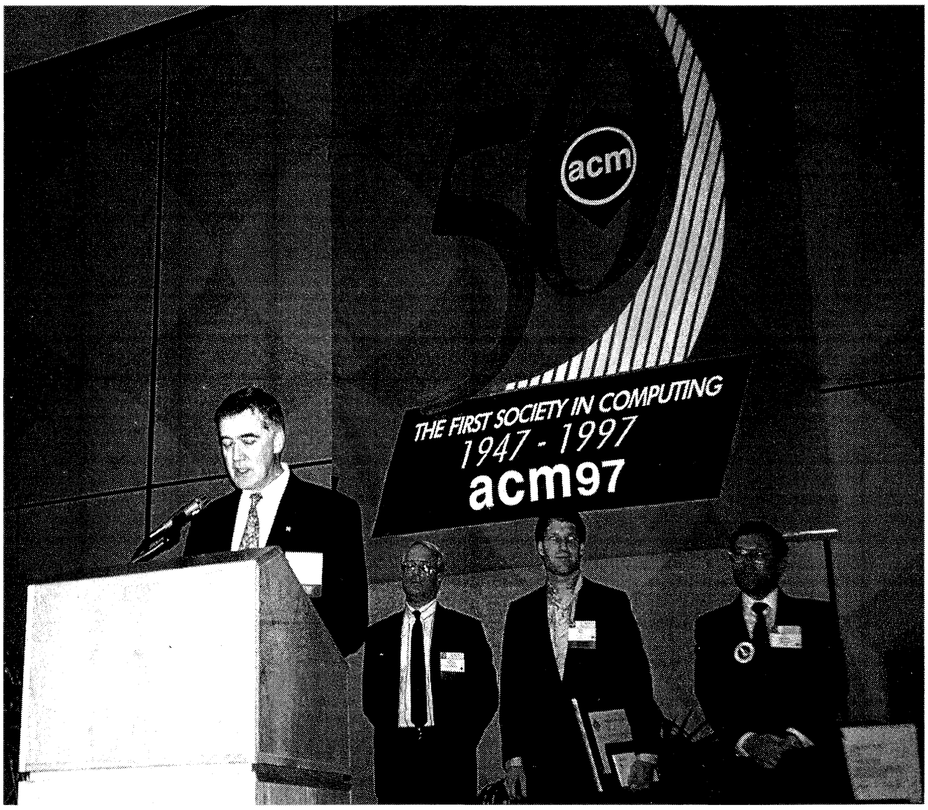
After leaving Strasbourg in 1978, he worked on neutrinos at Argonne, and since 1980 on electron-positron interactions at DESY and SLAC. He was well respected for his pioneering investigations of new ideas and experimental possibilities. Ultimately Research Director of the Laboratoire de Physique Nucléaire et des Hautes Energies at the Pierre et Marie Curie University, Paris VI-VII, and seconded to CERN, his novel contributions to preparations for a deeper exploration of B physics at CMS were greatly appreciated for their originality.

He was a gifted teacher, not only through his training of research physicists (supervising over twenty doctoral theses), but through his lecturing. His passion for physics led him to organize many international conferences, the last in Strasbourg in September 1995, with collaboration from CERN, CRN and DESY, on beauty, charm and hyperons, and was Chairman of a conference on the same theme to be held in Montreal in August. He was also playing a key role in groundwork for a teaching programme at a future European Scientific Institute.

Alfred Fridman 1932-96

Victor Ogievetsky 1928-96

How the Web was won. CERN's Robert Cailliau speaks at the 1995 awards ceremony of the Association for Computing Machinery (ACM), where he shared the prestigious Software System Prize with Tim Berners-Lee, formerly of CERN and now at MIT, for their invention of the World Wide Web. Behind Robert are (left to right) Gene Hoffnagle of IBM, Eric Bina of Netscape, who shared another ACM prize with Marc Andreessen for their development of the NCSA Mosaic Web browser, and ACM President Stuart Zweben.



Victor Ogievetsky 1928-96

Victor Isaakovich Ogievetsky, a leading Russian theoretical physicist who specialized in the application of symmetry principles to particle physics, died in Moscow on 23 March. Born in Dnepropetrovsk, he received his PhD at Moscow's Lebedev Institute and after 1956 spent most of his working life at the Bogoliubov Laboratory of Theoretical Physics at the Joint Institute for Nuclear Research, Dubna. During his long and distinguished career he

The World Wide Web was designed to enable physicists to access information, wherever they were or wherever they worked. With the Web quickly outgrowing its physics origins and going on to become the Internet sensation of the 1990s, in many sectors CERN has become best known as 'the home of the Web'. The dizzy rate of Internet and Web progress has its own special timescale - at CERN, the 'Next' cube on which the first Web browser was developed in 1990 is now a museum piece.

The Paul Scherrer Institut (PSI) is a national, multidisciplinary research organization for science and engineering. In order to complement the existing research installations it is now envisaged to build a 2.5 GeV Synchrotron Lightsource for Switzerland (SLS) at PSI. This facility will provide electromagnetic radiation of unprecedented brilliance for research fields in physics, chemistry, biology, medicine and material science.
The planning phase of this project has now started. We seek to recruit for our planning team a

PHYSICIST/ENGINEER

for design, specification and procurement of the beam diagnostic elements (electron- and photonbeam position monitors, current monitors, tune- and profilmonitors).
We expect the successful candidate to hold an university degree in physics, electronics or optics and to have several years of professional experience on particle accelerators, preferably in beam diagnostic. The candidate shoud be fluent in German and English and should have good capabilities in supervision, organization and teamwork.
The position requires full dedication to the project and leaves ample space for own initiatives. It opens the possibility to co-shape the SLS project right from the beginning.
If this is the challenge you looked for then send your application including curriculum vitae, diplomas, list of publications and references to
Paul Scherrer Institut, Personnel Division, reference code 0200/039, CH-5232 Villigen PSI

E.O. Lawrence Berkeley National Laboratory

POSTDOCTORAL POSITION IN PARTICLE PHYSICS

The Physics Division at E.O. Lawrence Berkeley National Laboratory has an opening for a postdoctoral physicist in the BaBar group. The BaBar experiment is currently in the construction phase, with first data expected in early 1999. Berkeley has major commitments in the following areas: BaBar silicon vertex detector, DIRC particle ID system, DAQ, trigger and computing (on-line, simulation, reconstruction).

Applicant should have a Ph.D. in particle physics and demonstrate strong potential for outstanding achievement as an independent researcher. This is a two-year appointment with the possibility of renewal. The salary is $3135-$3960/month. Please submit a resume together with a publication list and at least three references to: **Dr. Morris Pripstein, c/o Personnel Administrator, Job #4179, E.O. Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Mail Stop 50E-301, Berkeley, CA 94720.**

Applications will be accepted until Oct. 1, 1996, or until the position is filled. *LBNL is an affirmative action/equal opportunity employer. Minorities and women are encouraged to apply.*

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DESY

The Theoretical Particle Physics Group of the **Höchstleistungsrechenzentrum HLRZ**, with locations at KFA-Jülich and DESY-Zeuthen, announces the opening of a

Postdoctoral Position

for a period of 2 years (with the possibility of extension to a third year), starting from October 1996.

The interest of the Group lies in nonperturbative and numerical quantum field theory. Its main focus is on large scale QCD simulations on massively parallel computers, aiming at the determination of the static properties of the elementary particles.

The Group has access to a 140-node Paragon and 512-node Cray T3E, both operated by KFA in Jülich, and two 256-node Quadrics QH2 parallel computers operated by DESY in Zeuthen. It participates, together with DESY-Zeuthen and the Universities of Wuppertal and Bielefeld, in the development of a teraflop computer led by the INFN groups in Rome and Pisa.

The candidate is expected to actively collaborate in the APEmille teraflops computer project, while being integrated into one of the QCD physics projects running on Quadrics hardware. An APEmille development board will become available in summer 1997. The position will be based in Zeuthen near Berlin.

Applicants should send their curriculum vitae with a brief description of their research interests, and arrange for two letters of reference to be sent to:

Prof. K. Schilling
Group Leader - Theoretical Particle Physics Group
HLRZ c/o KFA Jülich
P.O. Box 1913
D-52425 Jülich, Germany

Application materials shoud be received no later than **21.06.96.** For further information, please contact (schillin@hlrserv.hlrz.kfa-juelich.de). **Handicapped applicants with equal qualifications will be prefered. DESY encourages especially women to apply.**

On 19 March, an event at CERN's Theory Division marked the 70th birthday of Yoshio Yamaguchi (left), who many years ago was one of the first Japanese to work at CERN and who over the years has played a vital role in promoting CERN - Japan relations. Seen here with Yoshio and his wife Yoriko is CERN Theory stalwart Torleif Ericson.

published some 160 papers and created an active school.

In the 1960s he introduced new approaches to gauge fields and later showed how Einsteinian gravity can be interpreted in terms of non-linear realizations of certain groups. Following its appearance in the early 1970s, he made notable contributions to supersymmetry, including a geometrical formulation of supergravity. In the early 1980s he and his group introduced the fruitful notion of harmonic superspace. He received the Tamm prize of the USSR Academy of Sciences in 1987 and the von Humboldt award in 1992.

ITEP School of Physics

The XXIV ITEP School of Physics (the third year of the school in its international format) took place from 20-28 February not far from Moscow at Snegiri on the river Istra.

This time the school was mostly devoted to the theoretical side of high energy physics: basics and recent advances in gauge and super-symmetric theories, field theory at finite temperature, critical phenomena and baby universes, different problems of high energy scattering as well as supernova formation. Both experimental prospects and theoretical aspects of higgs physics were covered. About 75 students and professors from eleven countries participated. Beside main lecture courses there were short presentations by students on their research activity.

Accelerator Schools

The CERN Accelerator School (CAS), with the Laboratorio de Instumentaçao e Fisica Experimental de Particulas, Lisbon, is organizing an Introduction to Accelerator Physics, to be held from 21 October - 1 November in Cascais, Portugal. This course is aimed at staff in laboratories, universities and manufacturing companies associated with particle accelerators.

Further information from Mrs. S. von Wartburg, CERN Accelerator School, AC Division, 1211 Geneva 23, Switzerland. E-mail cas.estoril@cern.ch, fax +41 22 767 5460, WWW http:/www.cern.ch/Schools/CAS/

The Joint CERN-US-Japan Accelerator School is organizing a course 'Frontiers of Accelerator Technology: RF Engineering for Particle Accelerators' from 9-18 September in Shonan Village, Hayama-machi, Japan. Further information from e-mail cas.japan@cern.ch or as above.

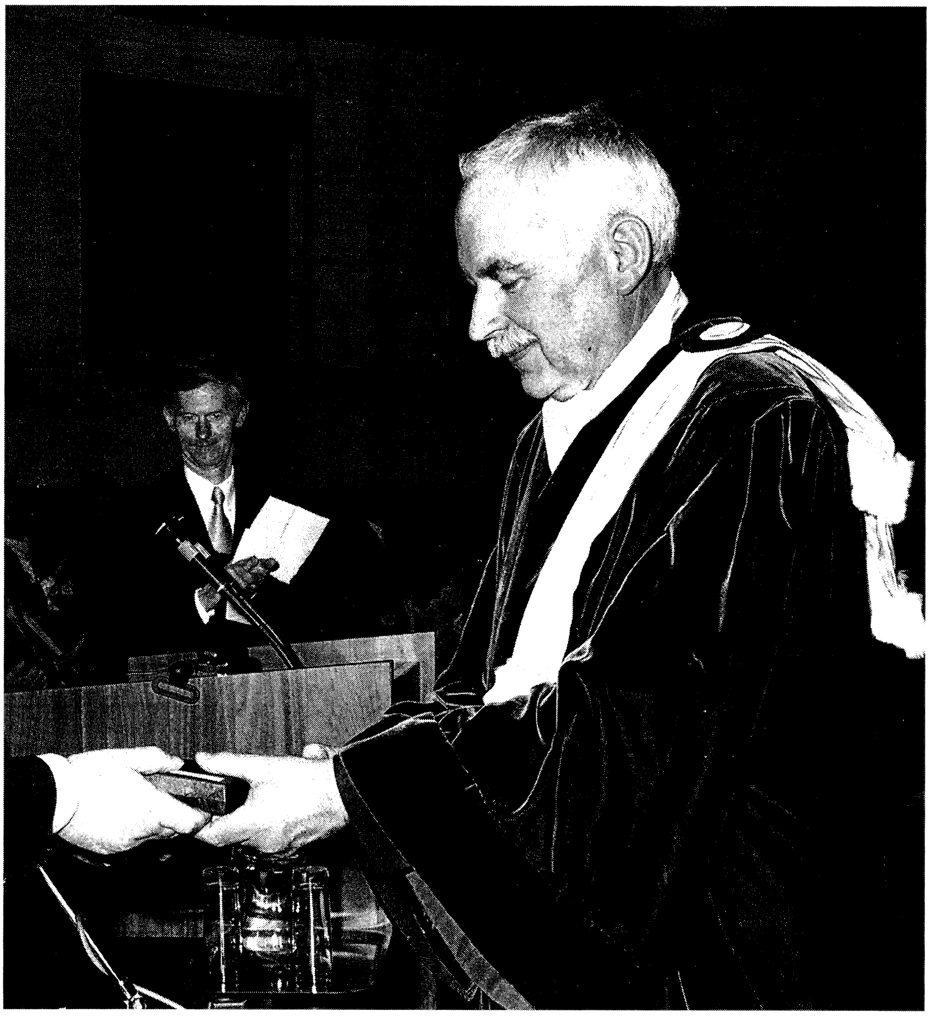
Bruno Pontecorvo Prize

The 1995 and first Bruno Pontecorvo Prize, established by the Joint Institute for Nuclear Research (JINR) Dubna, was awarded to Ugo Amaldi on 19 January (March, page 29). The 1996 Bruno Pontecorvo Prize awarding ceremony will take place next January. The prize is awarded to a single scientist, or exceptionally to a group of up to three scientists, for outstanding research in particle physics.

Those wishing to be considered should send a brief abstract of their research, if possible enclosing copies of major papers, to be received not later than 1 August, to:
Prof. S.Bunyatov, Joint Institute for Nuclear Research, Laboratory of Nuclear Problems, 141 980 Dubna, Moscow region, Russia.
Phone: (709621) 65880,
Fax: (709621) 66666, E-mail: bunyatov@ljap9.jinr.dubna.su

Meetings

The (Euro)conference International series in Quantum Chromodynamics, QCD 96, will be held from 4-12 July in Montpellier, France.
Contact: S. Narison (chairman): narison@lpm.univ-montp2.fr or QCD secretariat: qcd@lpm.univ-montp2.fr LPM, Université Montpellier 2, Place Eugène Bataillon, 34095 Montpellier Cedex 2, France.



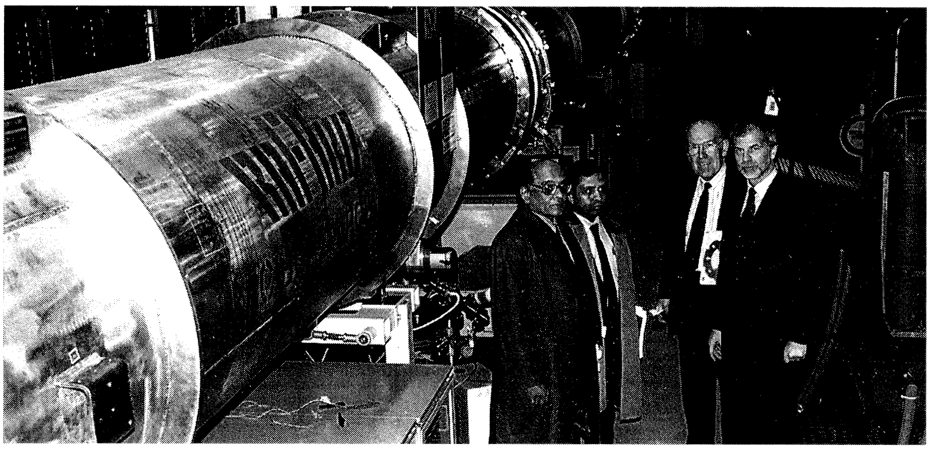
Achim Richter, Director of the Institut für Kernphysik at Darmstadt's Technische Hochschule and Chairman of CERN's ISOLDE Experiments Committee, received an honorary doctorate from the University of Gent, Belgium, on the occasion of the University's 'Dies Natalis' on 22 March for his work in nuclear physics and his continuing efforts to support high quality basic research at CERN's ISOLDE on-line isotope separato.

A Topical Workshop on Neutrino Physics will be held at the Institute for Theoretical Physics at the University of Adelaide, Australia from October 31 until November 6. Information is available at the WWW site (http://www.physics.adelaide.edu.au/itp/workshops/neutrino.html) or from the director Prof. A W Thomas email sjohnson@physics.adelaide.edu.au fax: +61 8 303 3551.

The third International Conference on Physics and Astrophysics of Quark Gluon Plasma will be held at Jaipur, India, from 17-21 March 1997. This conference is a continuation of a highly successful series organized in India, first in 1988 at Bombay and in 1993 at Calcutta. Further information from ICPA-QGP '97, Variable Energy Cyclotron Centre, 1/AF, Bidhan Nagar, Calcutta 700064 (India). Tel: 91 33 3370032/1230, Fax: 91 33 3346871. Telegram: VECBARC CALCUTTA, Telex: 21-4526 VECC IN E-Mail : icpaqgp@veccal.ernet.in

Help!

During a short visit in Madagascar, Stephan Narison was very disappointed by the conditions under which physicists (nuclear, solid states, solar energy, geophysics) there are working. A future access to internet is being planned by the government within the next few months. However, there is also a strong need for traditional information such as reviews and books. If anyone has some of these reviews and materials which they do not need anymore, Madagascar physicists will be happy to use them. Contact Stephan Narison, LPM, Université Montpellier 2, Place Eugène Bataillon, 34095 Montpellier Cedex 2, France, email: narison@lpm.univ-montp2.fr



R. Chidambaram (left), Chairman of the Indian Atomic Energy Commission, with Deputy Secretary V. Ashok admires the string of prototype superconducting magnets for CERN's LHC collider with CERN's LHC Division Leader Jean-Pierre Gourber and Roberto Saban (extreme right).

(Photo CERN HI 14.03.96)

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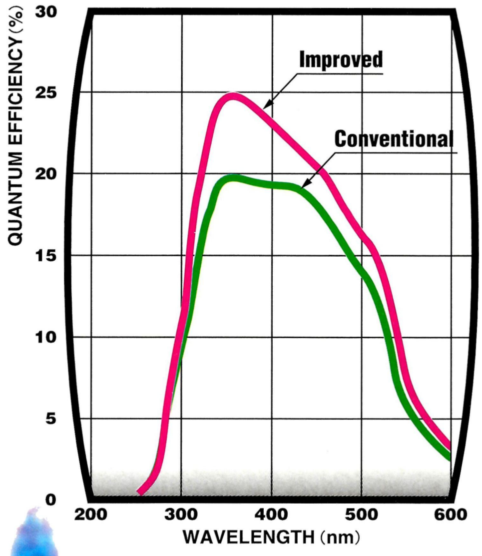

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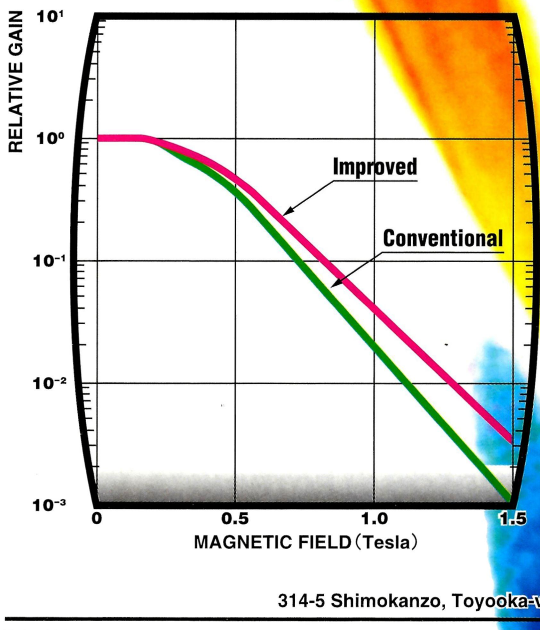
- TOF COUNTER
- CALORIMETER



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