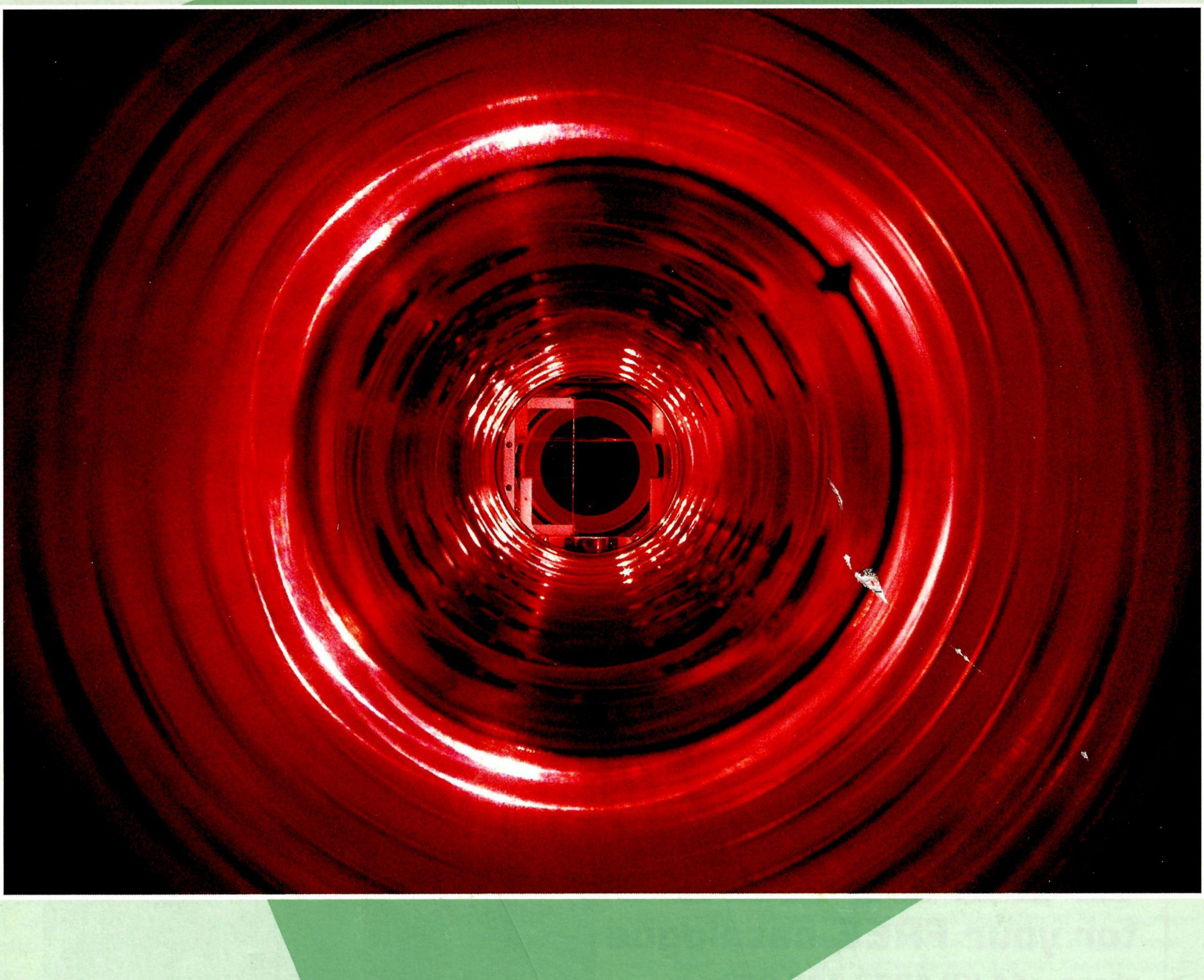
CERN COURIER

International journal of high energy physics

VOLUME 37 5 JUNE 1997



ISSN 0304-288X

Volume 37
No. 5
June 1997

Covering current developments in high energy physics and related fields worldwide

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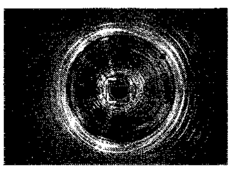

Cover photograph: A proton's view of the wire target of the HERA-B experiment at the DESY Laboratory, Hamburg. The proton beam travels along the centre of the beam pipe, which has an internal diameter of 38 mm. The interaction rate is tuned by moving the target wires into the beam. HERA-B is one of the key experiments in the continued exploration of the physics of B particles, containing the fifth - 'beauty', or b - quark (see page 8).

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Tel.: 630-377-1589 / Fax: 630-377-1569

CERN COURIER is published monthly except January and August in English and French editions. The views expressed in the Journal are not necessarily those of the CERN management.

Printed by: Drukkerij Lannoo nv
8700 Tielt, Belgium

Published by:

European Laboratory for Particle Physics
CERN, 1211 Geneva 23, Switzerland
tel.: +41 (22) 767 61 11,
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CERN COURIER only:
tel. +41 (22) 767 41 03,
telefax +41 (22) 782 19 06

USA: Controlled Circulation
Periodicals postage paid at St. Charles, Illinois

Physics monitor

More galactic antimatter

New maps of gamma rays from NASA's Compton Gamma Ray Observatory show evidence of a previously unknown and unexpected cloud of antimatter, in the form of positrons, extending 3,000 light years above the centre of our Galaxy.

The classic aroma of positrons is the 511 keV gamma radiation produced when positrons and electrons annihilate. Such radiation was first observed from the direction of the centre of our Galaxy in the early 1970s, and the new maps were expected to show a large cloud of antimatter near the galactic centre and along the plane of the Galaxy, caused by the explosions of young massive stars. The maps show that gamma ray activity, but also show a mysterious second cloud of antimatter well off the galactic plane.

On NASA's Compton Gamma Ray Observatory, launched in April 1991, one instrument, the Oriented Scintillation Spectrometer Experiment (OSSE), is sensitive to 511 keV gamma rays.

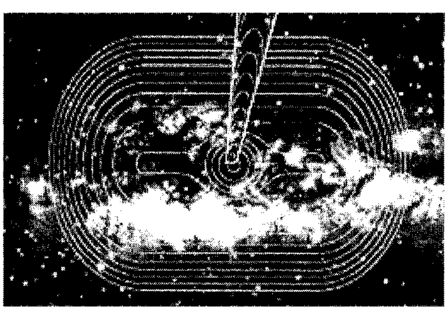
The centre of our disc-like Galaxy, about 25,000 light-years away in the direction of Sagittarius, is normally obscured by intervening interstellar dust and gas. However, this material is transparent to gamma rays.

Positrons, and antimatter in general, are thought to be relatively rare in the Universe. Positrons could arise through natural radioactive decay (positron emission) in massive stars having violent surface activity. However because these objects are relatively common in the Galaxy, the radioactive materials, and so the resulting positrons, would be distributed throughout the Galaxy, including the Earth, which is not the case.

Another way positrons might be created is when matter falls into a black hole. As matter is sucked into the gravitational pit, its temperature increases until it becomes hot enough to create pairs of positrons and electrons. This flow may be intermittent, changing abruptly as the black hole sucks in large fragments from nearby stars, while the number of positrons created by radioactive decay would be steady over long periods of time.

A third possibility is that within the last million years this region was the site of a massive galactic fireball caused by the merger of two neutron stars. Such events are widely believed to be responsible for the enigmatic gamma-ray bursts which have baffled astronomers for over twenty years and have recently been studied by the Compton Gamma Ray Observatory.

Because the Universe appears to contain more matter than antimatter, however, once the positrons are created it is only a matter of time before they are annihilated. 511 keV gamma rays were first observed from the direction of the centre of our Galaxy in the early 1970s, in the vicinity of a "Great Annihilator".



An antimatter 'fountain' discovered by NASA's Compton Gamma Ray Observatory spews out positrons from the centre of our Galaxy. The contours show the fountain superimposed on the usual distribution of positrons around the Galactic centre.

A century and its half

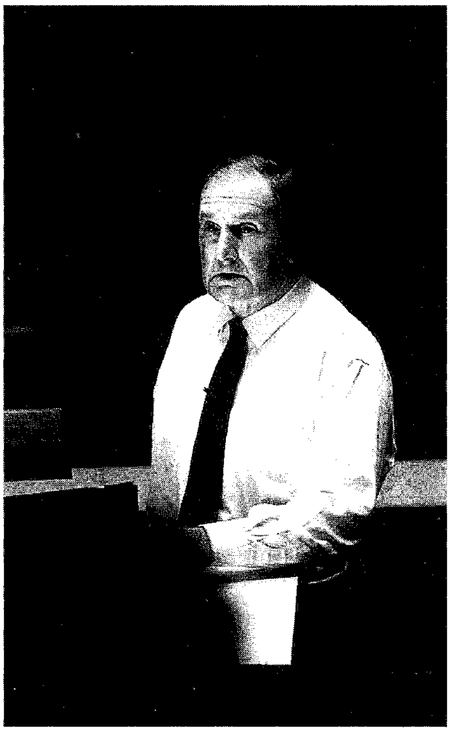
While 1997 is being widely celebrated as the hundredth anniversary of the discovery of the electron by J.J. Thomson at Cambridge (see page 6), the 50th anniversary of the 1947 discoveries of the pion by Cecil Powell at Bristol and 'V-particles' by George Rochester and Clifford Butler of Patrick Blackett's group in Manchester draw less attention.

J.J. Thomson went on to win the 1906 Nobel Physics Prize. His Cambridge contemporaries included Owen Richardson (1928 Physics Nobel), F.W. Aston (1922 Chemistry Nobel), C.T.R. Wilson (1927 Physics Nobel), G.P. Thomson (his son, 1937 Physics Nobel) and Ernest Rutherford (1908 Chemistry Nobel). After this initial proliferation of talent, it was under Ernest Rutherford, who took over from Thomson at the Cavendish in 1919, that the Laboratory went on to attain the apogee of its fame.

After Rutherford's death in 1937 the Cavendish came under the direction of W.L. Bragg, who firmly set the laboratory on a new course. This veered away from nuclear physics but eventually led to epic discoveries in molecular biology.

As products of the Cavendish Laboratory, it was Powell at Bristol and Blackett at Manchester who inherited the valuable Thomson-Rutherford legacy, and thus the 1947 discoveries of the pion at Bristol and the V-particles at Manchester can

Particle century - fifty years ago, in 1947, half a century after the discovery of the electron, Don Perkins, working at London's Imperial College, was the first to observe a clear example of what appeared to be the nuclear capture of a meson, producing a nuclear disintegration. On 17 April, Perkins gave a presentation at CERN on one hundred years of elementary particles. One half of this particle century is spanned by his own contributions.



trace their parentage back to 1897. Blackett was awarded the Nobel Physics Prize in 1948 and Powell in 1950. These discoveries were to be the last major particle physics revelations of a war-torn Europe. The next European milestone - the discovery of the neutral current in 1973 - had to await the establishment of CERN.

Sighting the pion and unravelling its decay liberated physics from more than a decade of dilemma, and the pion looked full of promise. Perhaps this new particle held the key to the mysterious forces which held the nucleus together. However this hope, cherished since the time of Yukawa, was not to be fulfilled, and the significance of the pion as a particle has diminished as our understanding of nuclear forces in terms of a deeper layer, quarks, has advanced. If the pion does play a special role, it is because it is the lightest strongly interacting particle.

More than anything else, the 1947 discoveries made physicists realize that the subnuclear world was more complex than had been suspected by looking at everyday nuclei. The discovery of the pion and its subsequent decay highlighted the role of the muon (discovered by Anderson and Neddermeyer in 1936), while the Vs were the first examples of 'strange' particles containing a third type of quark.

The following article by Owen Lock, formerly of Bristol, Manchester, Birmingham and CERN, recalls the pion discovery. Another article later this year will cover the discovery of V-particles.

Half a century ago - the pion pioneers

While the classic discoveries of Thomson and Rutherford opened successive doors to subatomic and nuclear physics, particle physics may be said to have started with the discovery of the positron in cosmic rays by Carl Anderson at Pasadena in 1932, verifying Paul Dirac's almost simultaneous prediction of its existence.

Anderson used a cloud chamber, expanded at random, in a high magnetic field. At the same time, Patrick Blackett at Cambridge was joined by an inventive young Italian, Giuseppe Occhialini, sent by a master of counter coincidence techniques, Bruno Rossi, then in Florence, to learn about cloud chambers. Very soon Blackett and Occhialini had built a counter-controlled chamber with which they discovered electron-positron pair production, a key prediction of Dirac's ideas.

Cloud chambers played a major role in cosmic ray studies in the following years, leading to the discovery of the 'mesotron' in 1937, originally identified as the nuclear force carrier postulated by Hideki Yukawa in 1935. However, several difficulties soon arose with this hypothesis, even though pictures of its decay to an electron, as postulated by Yukawa to explain beta-decay, were observed in cloud chamber pictures in 1940. In particular, the mesotron appeared to have a very weak nuclear interaction with matter, conclusively demonstrated by the counter experiments of Marcello Conversi, Ettore Pancini and Oreste Piccioni in Rome from 1943-1947.

A possible explanation of these difficulties had been put forward in Japan in 1942 and 1943 by Yasutaka Tanikawa and by Shoichi Sakata and Takeshi Inoue, who suggested a two-meson hypothesis with a Yukawa-type meson decaying to a weakly interacting mesotron. Because of the war their ideas were not published in English until 1946 and 1947, the journals in question not reaching the USA until the end of 1947.

Unaware of the Japanese work, Robert Marshak had put forward a similar hypothesis in June 1947, at a conference of American theoreticians on Shelter Island (off Long Island), and which he published later that year with Hans Bethe. None of the scientists at the conference knew that such two-meson decay events had already been observed some weeks earlier by Cecil Powell and his collaborators in Bristol, using the then little known photographic emulsion technique, but which in Powell's hands became a powerful research tool.

Powell had been a research student under C.T.R. Wilson at the Cavendish Laboratory in Cambridge, before joining the H.H. Wills Physics Laboratory, (also known as the Royal Fort), at Bristol University in 1928 as an assistant to the Director, Arthur Tyndall. They worked together on the mobility of ions in gases until 1935 when Powell became interested in nuclear physics, inspired by the discoveries in Rutherford's Cavendish Laboratory. Together with a young lecturer, Geoffrey Fertel, he embarked on the construction of a 750 keV Cockcroft-Walton accelerator, which they brought in to operation in 1939.

The original intention was to study low energy neutron scattering using a Wilson cloud chamber. However, in 1938 the theoretician Walter Heitler (then in Bristol) mentioned to Powell that in 1937 two Viennese physicists, Marietta Blau and Herta Wambacher, had exposed photographic emulsions for five months at 2,300 m in the Austrian Alps and had seen the tracks of low energy protons as well as 'stars' or nuclear disintegrations, probably caused by cosmic rays. Heitler commented that the method was so simple that 'even a theoretician might be able also to do it'. This intrigued Powell, and Heitler travelled to Switzerland with a batch of Ilford half-tone emulsions, 70 microns thick, and exposed them on the Jungfraujoch at 3,500 m. In a letter to *'Nature'* in August 1939, they were able to confirm the observations of Blau and Wambacher.

The half-tone emulsions could only record the tracks of low energy protons and alpha particles and Powell realised that to do useful work it was necessary to increase their sensitivity by increasing the concentration of silver bromide.

In the immediate post-World War II years, cosmic ray experiments using photographic emulsions at Bristol made historic discoveries. The picture shows Cecil Powell (standing) with M.G.K. Menon in the emulsion laboratory.

World War II interrupted the work, but with the existing emulsions Powell was able to show that for scattering studies they gave results superior to cloud chambers, as well as being much faster.

Blackett (who had been a contemporary of Powell in the Cavendish Laboratory) then played a decisive role through his influence with the Ministry of Supply of the 1945 UK Labour Government. He was largely responsible for the setting up of two panels, one to plan accelerator building in the United Kingdom (which he chaired) and one to encourage the development of sensitive emulsions (chaired by Joseph Rotblat, recently awarded the Nobel Peace Prize for his Pugwash work).

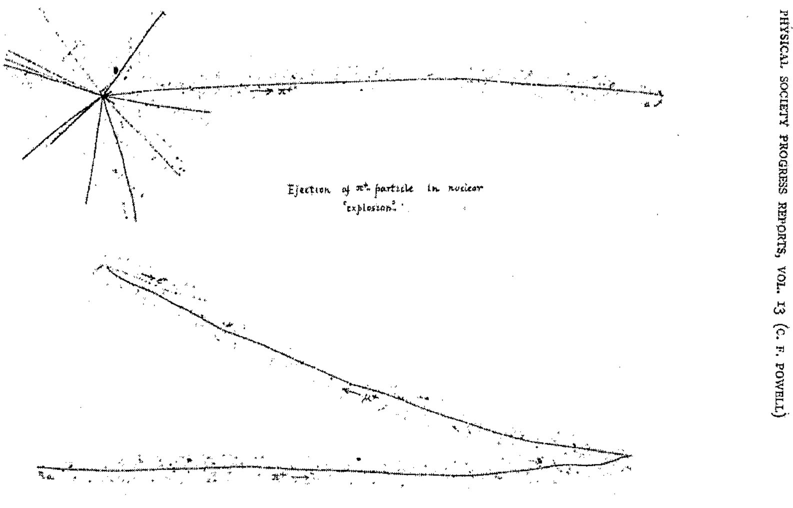
Towards the end of the war, Blackett had invited his erstwhile collaborator Occhialini, then in Brazil, to join the British team working with the Americans on the atomic bomb. Occhialini arrived in the United Kingdom in mid-1945, only to learn that, as a foreign national, he could no longer work on the project. Instead, he joined Powell in Bristol, becoming a driving force behind the development of the new emulsion technique. He was joined by one of his research students, Cesare Lattes, towards the end of 1946.

Photographic manufacturers Ilford were soon able to supply 'Nuclear Research Emulsions' and in autumn 1946 Donald Perkins, then at Imperial College, London, exposed some at 9,100 m in an RAF aeroplane, while Occhialini took several dozen plates to the Pic du Midi at 2,867 m in the French Pyrenees. At that time access to the Pic was by a rough track in summer and by ski in winter, a small telepherique only being brought into service in the summer of 1952, but Occhialini had been a mountain guide in Brazil .

Examination of the emulsions in Bristol and in London revealed, as Powell later wrote, "a whole new world. It was as if, suddenly, we had broken into a walled orchard, where protected trees flourished and all kinds of exotic fruits had ripened in great profusion". This new world became a subject of intensive investigation. Occhialini has well described the atmosphere at Bristol:- "Unshaved, sometimes I fear unwashed, working seven days of the week till two, sometimes four in the morning, brewing inordinately strong coffee at all hours, running, shouting, quarrelling and laughing, we were watched with humorous sympathy by the war-worn native denizens of the Royal Fort". . . . "It was a reality of intense, arduous and continuous work, of deep excitement and incredibly fulfilled dreams. It was the reality of discovery....".

Perkins was the first to observe a clear example of what appeared to be the nuclear capture of a meson in

A classic Bristol pion. The track of the positively-charged pion produced in the interaction 'star' (top left) has been cut in two to facilitate presentation. Bottom right, the pion eventually decays into a muon, which after some 600 microns itself subsequently decays, producing an electron. This full decay chain was recorded in electron-sensitive emulsion, available from 1948, even more sensitive than the specially-developed nuclear research emulsions in which the pion was discovered in 1947.



Mosaic of photo-micrographs of a nuclear explosion accompanied by the ejection of a π^+-particle. The track of the π^+-particle is given in two parts which should join at the point 'a'. The π^+-particle shows the transmutation $\pi \rightarrow \mu \rightarrow e$.

PLATE V.

the emulsion and producing a nuclear disintegration. Measurements of the multiple scattering as a function of residual range indicated a mass between 100 and 300 times that of the electron. Perkins' observations, published in January 1947, were confirmed by Occhialini and Powell, who published details of six such events only two weeks later. Mesons were easily distinguished from protons in the emulsion because of their much larger scattering and by their variation of grain density with range.

Yet another exotic fruit followed. In the spring of 1947 one of Powell's team of microscope observers, Marietta Kurz, found a meson stopping and giving rise to a second meson, which left the emulsion when nearly at the end of its range. Powell and a young Bristol graduate, Hugh Muirhead, were the first physicists to look at the event, which they immediately recognised as being two related mesons. Within a few days a similar event was found by Irene Roberts, the wife of the group technician, Max Roberts, who later worked at CERN for many years. In this event the secondary meson ended in the emulsion, with a range of 610 microns.

The two events gave such convincing evidence for a two-meson decay chain that Lattes, Muirhead, Occhialini and Powell published their findings in '*Nature*' in the issue of 24 May, 1947. Commenting on the problems surrounding the identification of the cosmic ray mesotron with the Yukawa nuclear force meson, they wrote:- "Since our observations indicate a new mode of decay of mesons, it is possible that they may contribute to a solution of these difficulties".

More evidence was needed to justify such a radical conclusion. For some time no more two-meson events were found in the Pic du Midi emulsions and it was decided to make exposures at much higher altitudes. Lattes proposed going to Mount Chacaltaya in the Bolivian Andes, near the capital La Paz, where there was a meteorological station at 5,200 m. Arthur Tyndall recommended that Lattes should fly BOAC to Rio de Janeiro. Lattes preferred to take the Brazilian airline Varig, which had a new plane, the Super Constellation, thereby avoiding a disaster when the British plane crashed in Dakar and all on board were killed.

Examination of the plates from Bolivia quickly yielded ten more two-meson decays in which the secondary particle came to rest in the emulsion. The constant range of around 600 microns of the secondary meson in all cases led Lattes, Occhialini and Powell, in their October 1947 paper in '*Nature*', to postulate a two-body decay of the primary meson, which they called π or pion, to a secondary meson, μ or muon, and one neutral particle. Subsequent mass measurements on twenty events gave the pion and muon masses as 260±30 and 205±20 times that of the electron respectively, while the lifetime of the pion was estimated to be some 10^{-8} s. Present-day values are 273.31 and 206.76 electron masses respectively and 2.6 x 10^{-8} s.

The number of mesons coming to rest in the emulsion and causing a disintegration was found to be approximately equal to the number of pions decaying to muons. It was, therefore, postulated that the latter represented the decay of positively-charged pions and the former the nuclear capture of negatively-charged pions. Clearly the pions were the particles postulated by Yukawa. This led to the conclusion that most of the mesons observed at sea level are penetrating muons arising from the decay in flight of pions created in nuclear disintegrations higher up in the atmosphere.

Powell was awarded the 1950

Nobel Physics Prize for his development of the emulsion technique and for the discovery of the pion; Occhialini was awarded the 1979 Wolf Prize (shared with George Uhlenbeck) for his contribution both to the pion discovery and to that of pair production with Blackett, who obtained the 1948 Nobel Physics Prize.

By Owen Lock

One hundred years ago.....

Marking a full century of subatomic physics, an occasional series of CERN Courier article looks back to what was happening exactly one hundred years ago.

All over the world, this year is being celebrated as the centenary of the discovery of the electron by J.J. Thomson at the Cavendish Laboratory, Cambridge, in 1897. At a time when sovereignty interests in science were much to the fore, it is surprising that this discovery has earned such universal recognition. It was not as if the electron came out of the blue.

The saga is described in Abraham Pais' masterpiece 'Inward Bound' (Oxford University Press). Despite having been investigated for many years, cathode rays were still controversial. Were they rays or particles? In 1895 Jean Perrin in France had revealed that they carried negative electric charge.

In 1897, Emil Wiechert in Konigsberg, after carrying out cathode ray experiments, said that cathode rays had to be carried by negatively-charged particles, assuming they had unit charge, carrying only a small fraction of the mass of a hydrogen atom. Walter Kaufman in Berlin was puzzled by the result that the charge/mass ratio of the cathode ray particles appeared to be the same, no matter what gas was used.

Thomson also measured this charge/mass ratio, and, like Wiechert, suspected that it was so small because the cathode ray particles themselves were small. Unlike Wiechert, Thomson had the temerity to state: 'Thus ... we have in the cathode rays matter in a new state, a state in which the subdivision of matter is carried very much further...'.

Two years later, Thomson had measured the charge on what would soon be universally called electrons (he preferred 'corpuscles') and had also investigated their photoelectric role. As several other researchers were to do in the ensuing century, Thomson took the baton of discovery and ran with it.

Emboldened by his electron discovery, he also proposed in 1897 that his electric corpuscles were a component of all atoms, the first step in what was to become his famous 'plum-pudding' model of the atom which was not overthrown until Rutherford's epic discovery of the nucleus some fifteen years down the line.

Thomson directed the Cavendish research with a firm hand, and the direction of Cavendish research had been profoundly altered by Röntgen's 1895 discovery of X-rays. In 1896 Thomson had published, with his student Ernest Rutherford, a classic paper on gas ionization by X-rays. For his part, in 1897 Rutherford was working on the 'Becquerel rays', discovered in Paris the previous year, and soon to become better known as radioactivity.

Elsewhere in physics, two topics were much discussed, both of them in connection with empirical formulas whose deep meaning would not become apparent for some time. In 1885 the Swiss scientist Jakob

Electron centenary

Many events are being organized to mark the centenary of the discovery of the electron by J.J. Thomson at Cambridge. Consult http://www.ioppublishing.com/Physics/Electron. However for a memorable guided tour through electron history, try the website prepared by the American Institute of Physics' Center for the History of Physics, http://www.aip.org/history/electron

This includes a recording of Thomson's venerable yet exultant voice from the soundtrack of the film, Atomic Physics, copyright © J. Arthur Rank Organization, 1948 - "Could anything at first sight seem more impractical than a body which is so small that its mass is an insignificant fraction of the mass of an atom of hydrogen? - which itself is so small that a crowd of these atoms equal in number to the population of the whole world would be too small to have been detected by any means then known to science." Thomson died in 1940, three years after the death of his famous pupil, Rutherford, who was 15 years his junior.

Balmer wrote down a formula which described the wavelengths of the spectral lines of hydrogen. This remarkable relation 'fitted the data extremely well', as today's physicists would say, but nobody could explain why. It was also an infinite series. The mystery of the Balmer series, which was examined by Lord Rayleigh, Thomson's predecessor at Head of the Cavendish Laboratory, in 1897, was only partially explained by Niels Bohr's quantum picture in 1913. The underlying explanation of the empirical infinite series had to await the arrival of quantum mechanics proper and the solution of the hydrogen atom problem by Schrödinger in 1925.

The other hot topic one century ago was black body radiation, where the precision results at Helmholtz' laboratory in Berlin defied detailed explanation. Different empirical formulae seemed to break down at some wavelength range or other. Diligently exploring this road, Max Planck in Berlin embarked on a series of papers 'Vorlesung über Thermodynamik' which would eventually culminate in his famous 1901 proposal of the quantum hypothesis.

Elsewhere, the installation of the big telescope at Chicago's new Yerkes Observatory heralded a new chapter in astronomy.

Distinguished Indian physicist M.G.K. Menon inaugurates the 7th International Symposium on Radiation Physics in Jaipur, India, in February. After participating in pioneer cosmic ray experiments in Powell's Bristol laboratory (see page 2), M.G.K. Menon went on to become Director of the Tata Institute, Bombay, and has served as senior government advisor in India as well having been a member of many international committees. Right is Bikash Sinha, Director of Calcutta's Saha Institute of Nuclear Physics and the Variable Energy Cyclotron Centre, who is the new President of the International Radiation Physics Society.

Radiation in Rajastan

The exotic Indian city of Jaipur in arid Rajastan was the setting for the recent International Symposium on Radiation Physics. Opening the meeting, the distinguished Indian physicist M.G.K. Menon described the underground experiment at the Kolar Gold Fields, an early player in the worldwide search for proton decay, predicted by Grand Unified Theories.

In a keynote address, Founding President of the International Radiation Physics Society and neutron detection specialist P.K. Iyengar focused on the latest developments in neutrons and their application, as well as plasma and laser technology.

Compton scattering, a key discovery early this century in the interrelation of matter and radiation, remains a cornerstone of radiation physics. Symposium contributions came from S. Manninen of Finland and Malcolm Cooper of Warwick.

On the applications side, the use of beams for cancer therapy was illustrated with experience from the 250 MeV proton beams in Cape Town, South Africa, while C.J. Roberts described the management and disposal of nuclear waste.

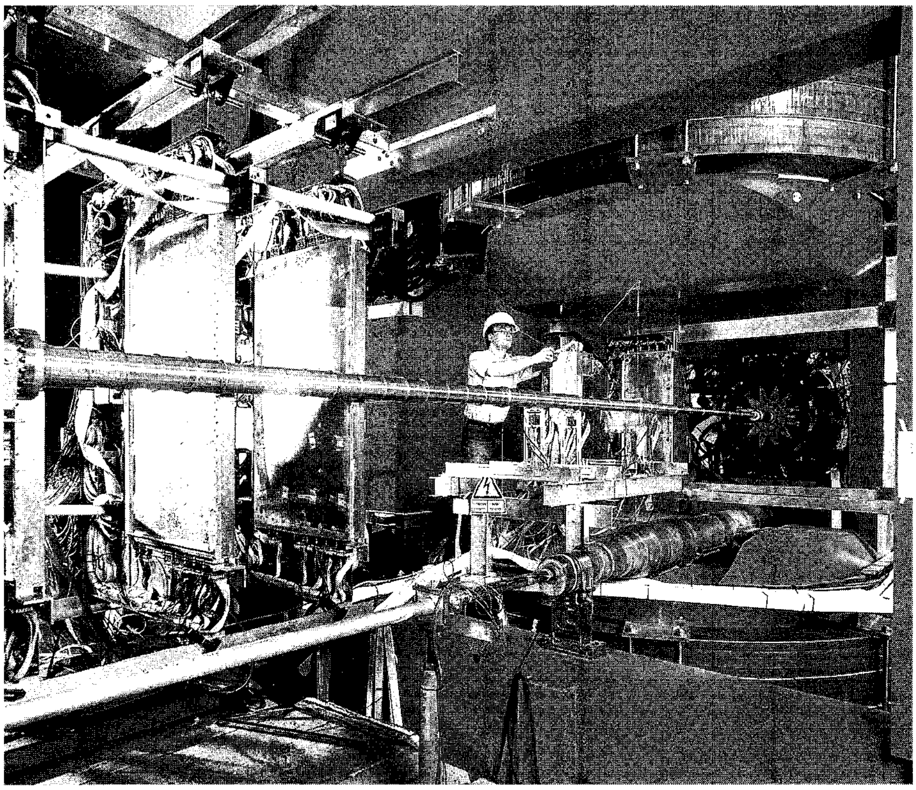
Indian researchers are very active in this wide-ranging field of physics, involved in sophisticated detectors to measure photon multiplicity at CERN (January 1995, page 14), in a radioactive ion beam project to extend the nuclear range of Calcutta's Variable Energy Cyclotron, and in X-ray studies for materials science.

Extraterrestrial radiation, in the shape of the enigmatic neutrino signal from the sun and the all-pervading cosmic radiation, was described by S.M. Chitre of the Tata Institute.

On a lighter note for an evening lecture, Bikash Sinha, Director of Calcutta's Saha Institute of Nuclear Physics, traced the evolution of Indian science from 450 BC to the present day. Sinha is the new President of the International Radiation Physics Society, taking over from John Hubbell of the US National Institute of Standards and Technology, Gaithersburg. Dick Pratt of Pittsburgh continues as Secretary.

The HERA-B experiment at DESY, now under construction and expected to start running in 1998, will add to our knowledge of B particles, containing the fifth - 'beauty', or b-quark.
The recent photo shows the forward part of the HERA-B detector. The HERA protons travel along the newly installed upper beam pipe, an aluminium prototype with a wall thickness of 0.5 mm. The particles produced during the interactions come out of the vertex vessel on the right to enter tracking chambers (prototypes of which can be seen on the left).
As HERA-B does not use the electron beam of the HERA electron-proton collider, the electron beam is protected from the magnetic field of the HERA-B magnet by a compensating coil on the lower beam pipe.

(Photo Manfred Schulze-Alex)



VIEWPOINT: Bs for a bright future

B particle physics has matured into a major player on the physics stage. Twenty years ago, the discovery of the upsilon particle by Leon Lederman's group at Fermilab was the first evidence for particles containing a fifth - 'beauty', or b-quark.

The upsilons are bound states of a b-quark an anti-b-quark, so that the net beauty content is zero. However, after some tentative sightings at hadron machines, within a few years beauty came out into the open with the discovery of B particles, containing a single b quark, at the electron-positron colliders PETRA at DESY, Hamburg, and CESR at Cornell. Early collider vertex detectors allowed the first measurements of the B-meson lifetime to be made at the PEP electron-positron collider at SLAC, Stanford. B spectroscopy began to be explored in detail and B physics became a major 'industry'.

The subsequent arrival of CERN's LEP electron-positron collider and Fermilab's Tevatron proton-antiproton collider furthered the scope of B experimentation although, traditionally, this B physics has been just one item on much larger varied menus.

After exploiting such general purpose detectors, the next step will be higher rate experiments entirely dedicated to B physics, although the large upgraded CDF and D0 experiments at the Tevatron still have rich futures in front of them.

The BaBar experiment at SLAC, Stanford (September 1995, page 6), and the BELLE experiment at the Japanese KEK laboratory's B factory will attempt to push the electron-positron collider approach to its limit and hope to observe and measure the so-far unobserved CP violation in the decays of B particles. The CLEO experiment at Cornell is undergoing a major upgrade that will greatly enhance its capabilities to study B physics.

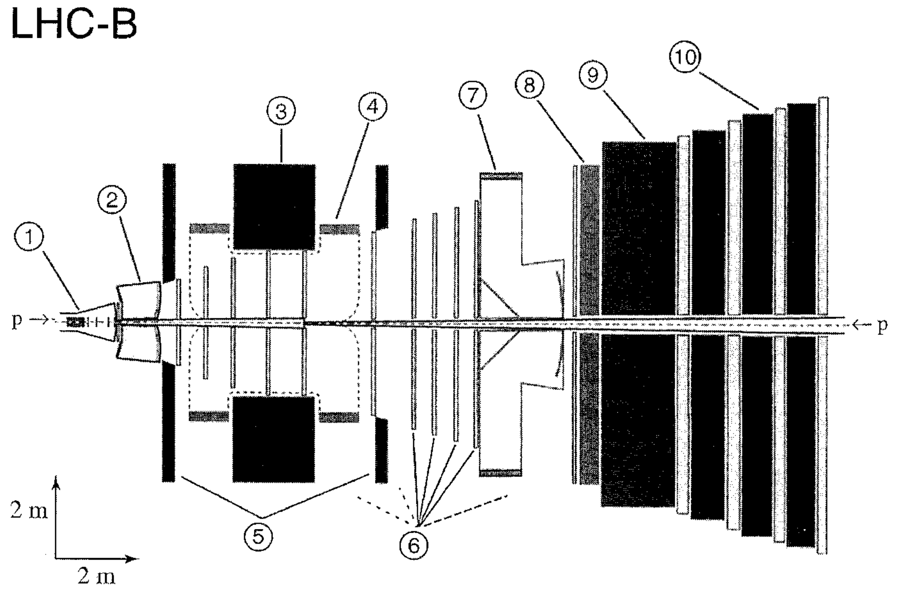
Though most of our present knowledge of B decays has come from electron-positron colliders, their limited B production rate puts severe statistical limitations on the measurement of crucially interesting quantities such as the CP-violating asymmetries. However, the community's perceptions have been awakened to the likelihood that the "ultimate" B experiment, which will test the constraints of the Standard Model to the limit, will be done at the hadron collider which yields the largest production rate for B-mesons.

With our present outlook, this would be done at CERN's LHC proton collider by the LHC-B experiment (April 1996, page 2), which is expected to produce b-quark pairs about 20,000 times more frequently than is possible at an electron-positron collider, albeit with somewhat reduced detection efficiency.

An earlier dedicated 'B-TEV' experiment at Fermilab's Tevatron could already take "giant steps" in this direction. Support for the B-TEV experiment is growing in the US and Fermilab has taken some important initial decisions.

Awaiting these developments, we have the pioneering hadronic HERA-B experiment at DESY, Hamburg (June 1995, page 20) which, although technically a fixed target experiment, is conducted at a proton storage ring and must meet the same

With a high production rate for B-mesons (particles containing the fifth - 'beauty', or b-quark) the LHC-B experiment (April 1996, page 2) at CERN's LHC proton collider is perhaps the nearest approach to the "ultimate" B experiment. The proposed detector components are: 1 - vertex detector; 2 - aerogel and gas RICHs; 3 - magnet yoke; 4 - coils; 5 - magnet field shielding; 6 - tracking chambers; 7 - gas RICH; 8 - electromagnetic calorimeter; 9 - hadron calorimeter; 10 - muon system.



challenges as a collider experiment. It is expected to have a 'CP-Reach' comparable to that of the BaBar and BELLE experiments.

HERA-B is a modern 'cousin' of the first large aperture forward spectrometers at CERN's Intersecting Storage Rings and utilizes a highly sophisticated adaptation of the P238 silicon microvertex detector which was pioneered for CERN's SPS collider. HERA-B is under construction and is expected to start running in 1998.

Much in the way of technical R&D and subtle simulation calculations has been accomplished to prepare for the new era of dedicated B experiments at hadron storage rings and in determining the B capabilities of the future general purpose collider experiments at the LHC - ATLAS and CMS.

These achievements, as well as the latest B-physics results from current experiments, plans for future hadron (and electron-positron) collider B-experiments and summaries of relevant theoretical topics have been documented in successive proceedings of the annual 'Beauty' conferences, which are now a regular feature of the physics calendar.

First held in 1993 in the Liblice Castle outside Prague, successive ones were held in Mont-St.-Michel, Oxford and Rome. Beauty'97 will be held at UCLA, Los Angeles, from 13-17 October (March, page 24). The Proceedings of these conferences are published as regular volumes of the journal Nuclear Instruments & Methods in Physics Research A, the most recent (Beauty'96) being the 21 December 1996 volume.

However, due to a number of factors, the birth of dedicated hadron B experiments has been and remains difficult. For very good reasons, based on past successes and future prospects, most of the world's B-experimentalists have signed up for electron-positron experiments at Cornell, CERN, SLAC (Stanford) and KEK (Japan), or in the large hadron collider experiments at Fermilab. At the LHC, most physicists are concentrated around the ATLAS and CMS experiments which, because of the large communities involved, have funding priority in both the US and in Europe.

Thus the stalwart hadron B-community focused on dedicated experiments at hadron machines is small, and this is reflected in the available funding. The dedicated hadron B physics experiments in Europe (HERA-B and LHC-B) and the US (B-TEV) will complement each other, but for this to happen, increased US-European collaboration will be required, both to underpin funding and to promote the necessary prior research and development work.

Major HERA-B R&D projects are tackling the critical triggering, tracking and particle identification needs of high-rate experiments at storage rings. Before long, the running high-rate HERA-B experiment will add real-time experience and perspective to these areas. This work is of great potential benefit at Fermilab and at CERN, where similar R&D projects are already underway.

An ideal scenario in this exciting new field would be the sequential implementation of HERA-B, B-TEV and LHC-B by an increasingly overlapping transatlantic collaboration.

Peter Schlein

Around the Laboratories

BROOKHAVEN
Big changes

The international physics community reverberated with news about Brookhaven National Laboratory in late April and early May. First, the Laboratory announced on 28 April the appointment of an interim management team to succeed retiring Director Nicholas Samios. Just three days later came the surprise announcement by the US Department of Energy (DOE), which owns the Brookhaven site and provides most of the lab's funding, that it was terminating its contract with Associated Universities, Inc., the nonprofit organization that has managed Brookhaven for DOE for all of Brookhaven's 50 years.

The DOE's move was attributed to concerns over the management of environmental, safety and health programmes at Brookhaven, which Energy Secretary Federico Peña said put "science before safety."

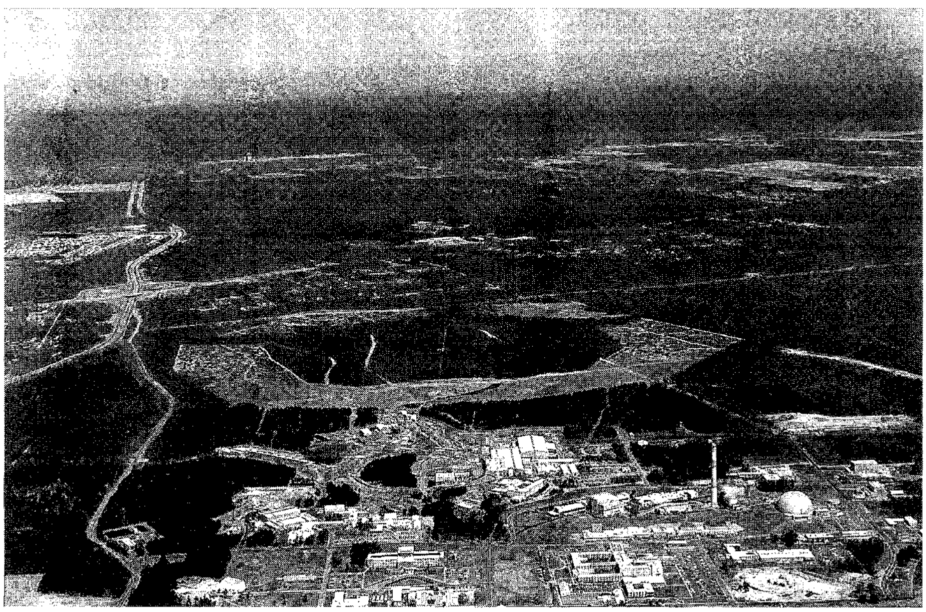
The Laboratory will continue to operate, and its scientific programmes and facilities are not directly affected by the announcement. But DOE will select a new Brookhaven contractor by early November and is expected to stipulate that the contractor improve Brookhaven's environment, safety and health programmes and better integrate them with scientific pursuits.

In their inaugural address three days before the DOE announcement, Brookhaven's Interim Director Lyle Schwartz and deputies Peter Bond and Michael Bebon had described their own plans to integrate environment, safety and health programmes with the Laboratory's scientific programmes; they are continuing with those initiatives while DOE proceeds with contractor selection.

The Laboratory has come under considerable fire by DOE, elected officials and the local community recently for its handling of a leak of tritiated water from a 68,000-gallon pool used to hold spent fuel from the Lab's High Flux Beam Reactor (HFBR). The leak has created a plume of tritiated groundwater that is slowly flowing south from the reactor, but has neither left the Lab site nor affected local drinking water. The plume, discovered in early 1997 but now suspected to be over 10 years old, is now being aggressively addressed to prevent any significant off-site impact.

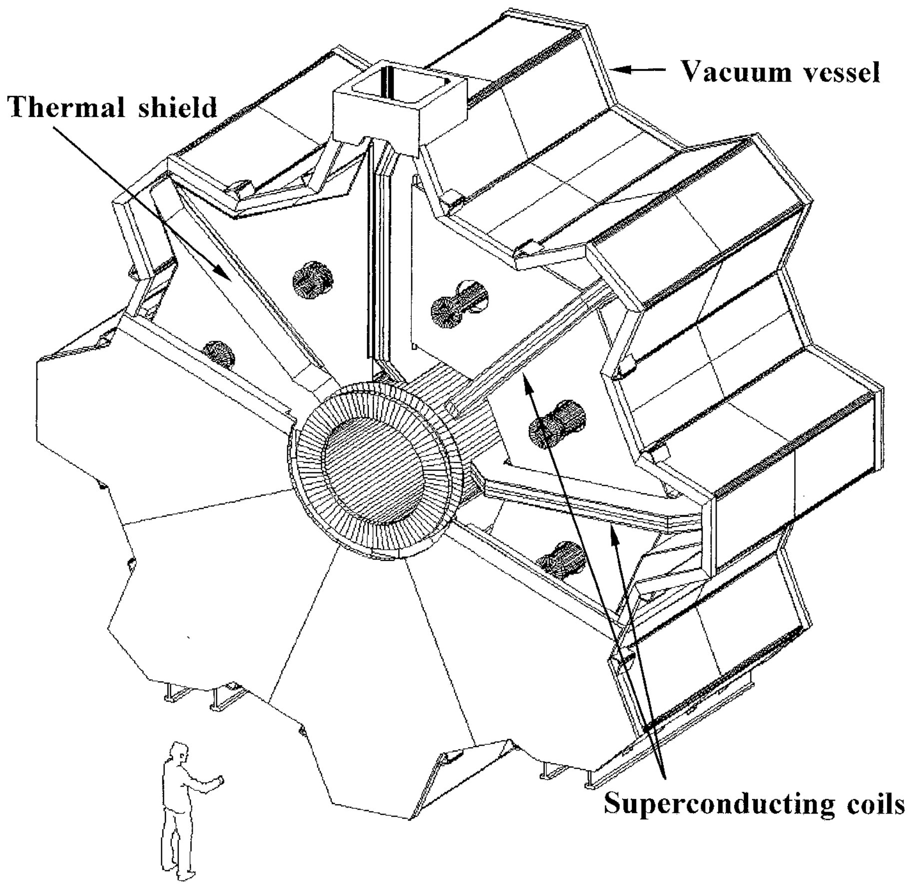
Over 300 scientists a year performed research in solid state physics and other fields at the HFBR, but the reactor is currently off line while the tritium crisis is handled, and its ultimate fate is yet to be decided amid the public furore. The operations of other Brookhaven facilities, such as the Alternating Gradient Synchrotron, and work on the RHIC Relativistic Heavy Ion Collider and its related experiments, are not affected, though additional safety and environmental impact reviews are proceeding throughout Brookhaven.

Kara Villamil



Aerial view of Brookhaven National Laboratory on New York's Long Island, with Long Island Sound in the background. The dome of the Laboratory's High Flux Beam Reactor, the source of a minor but awkward leak of tritiated water, is visible bottom right. Centre foreground is the ring of the Alternating Gradient Synchrotron (AGS), with, behind, the site of the 3.8 kilometre RHIC Relativistic Heavy Ion Collider.

A cutaway view of the endcap superconducting toroid for the ATLAS experiment at CERN's LHC proton collider, showing the vacuum vessel, thermal shields and the superconducting coils and cold mass structure. Designed by the UK Rutherford Appleton Laboratory (RAL), these magnets will be assembled at CERN under RAL supervision.



RUTHERFORD APPLETON
Design of the ATLAS forward toroids

In March this year a cooperation contract was signed between CERN and the UK Rutherford Appleton Laboratory (RAL) concerning the forward super-conducting toroid magnets for the ATLAS experiment at CERN's LHC proton collider, together with an execution contract for the first stage, the engineering design. Three further contacts are foreseen which will culminate in the commissioning of the toroids in the ATLAS cavern.

RAL already has considerable experience in superconducting magnet technology, having designed and built the solenoids for Delphi at CERN's LEP electron-positron collider and for H1 at DESY's HERA electron-proton collider.

The ATLAS muon spectrometer consists of three large air-cored superconducting toroids: a long 'barrel' and two endcaps. Toroids have the advantage that, at least in the ideal case, the magnetic field is always perpendicular to the trajectory of the muon, making optimal use of the magnetic field, and that large volumes of iron flux return are not needed since the toroidal field is contained by the coils.

Each toroid is made up of eight flat 'racetrack' coils symmetrically distributed about the beam axis, the endcaps rotated with respect to the barrel so that the coils interleave. The coils of each endcap are connected together mechanically by bracing structures to form a cold mass which can contain the large magnetic forces which act radially inwards.

The conductor itself, designed to carry 20 kA, is essentially a scaling up from conductors used for smaller magnets. The superconducting 'Rutherford cable' is clad in high-purity aluminium to produce a cross-section of 41 mm x 12 mm; a total of over 25.6km will be required for the endcap toroids. Each coil consists of four layers of windings, two each side of a continuous central plate.

Although the coils are large, they are within the capability of conventional winding techniques. The coils are cooled to, and maintained at, 4.5 K by pumped helium circuits; a radiation shield around the cold mass maintained at 80 K, together with layers of superinsulation, restrict the thermal load on the refrigeration plant to 0.5 kW at 4.5 K and 1.6 kW at 80 K.

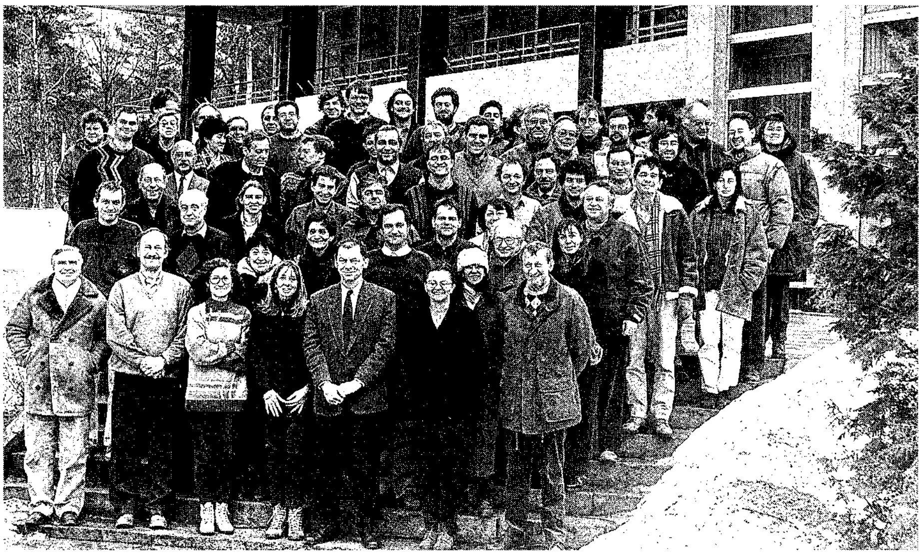
Each toroid is enclosed in its own large (10 m x 5 m) cryostat of castellated shape, inserted into the end of the barrel toroid on the main support rails of the ATLAS experiment.

The chief novelty of the toroid system is the size and unusual configuration. Careful finite-element analysis of magnetic, gravitational and thermal stresses has been made to validate the design. Quench propagation, conductor stability and the behaviour of the magnet system under extreme fault conditions have all been studied extensively, and experimental work has investigated the response of composite insulation materials to high tensile and shear stresses.

The design has been the subject of two separate reviews and is described in its own ATLAS Technical Design Report. The large size of the toroids requires the assembly at CERN of industry-supplied components such as individual coils, cryostats and radiation shields.

Each assembled toroid will be fully tested on the surface, in CERN's West Area, prior to installation as a complete unit into the ATLAS cavern. The details of this assembly procedure have been studied with a virtual reality simulation, to identify any problem areas and find suitable solutions.

The realization of the project is a major engineering challenge for all the ATLAS participants, involving expertise from RAL and other laboratories in mechanical, electrical, electronic, vacuum and cryogenic technology. The team has confidence that the challenges can be met and that the toroids will make a big contribution to the future success of ATLAS.



The NA48 experiment at CERN is poised to beging another attack on the measurement of CP-violation. About 70 NA48 physicists got together in Dubna, Russia, at the end of February for their final collaboration meeting before the 1997 run.

CERN CP-violation revisited

One of the great unanswered questions of particle physics is under attack as the NA48 experiment gets underway at CERN, joining Fermilab's E832 study which started taking data in October 1996. Both of these experiments have the goal of measuring CP-violation, one of nature's most subtle effects, to one part in a thousand, several times better than their 1980s predecessors.

Charge conjugation, C, and parity, P, are symmetries of particle interactions. C represents replacing a particle by its antimatter counterpart while P corresponds to looking in a mirror which reverses all three spatial coordinates. Physicists once thought that each of these symmetries was conserved in particle interactions, but then in 1956 physicists were startled to learn that P could be violated in weak interactions. In the search for a good symmetry, the CP combination was then thought to be good, but this too proved not to be the case.

Paradoxically, although CP-violation is small, it could nevertheless be responsible for some of the biggest effects in the Universe. It is one of three conditions postulated in 1964 by Russian physicist Andrei Sacharov to account for the observed imbalance of matter and antimatter around us. Without it, we simply would not be here. According to Sacharov, CP-violation is the result of a fundamental difference between matter and antimatter.

CP-violation was first observed in the laboratory by James Cronin and Val Fitch at Brookhaven in 1964. Their experiment showed that long-lived neutral kaons, K_L, which normally decay into three pions, occasionally decay into two, a CP-violating process. Neutral kaons are considered to be a quantum mechanical mixture of CP-even and CP-odd labels, labelled K_1 and K_2 respectively. These do not exist as physical particles, but different mixtures of the two make up short- and long-lived versions of the neutral kaon, K_L and K_S.

There are two possible mechanisms for CP-violation. Firstly the K_L is a mixture of K_2 and a small amount of K_1, which decays into two pions - CP-allowed for the K_1 but apparently CP-violating for the K_L. In the second mechanism, known as direct CP-violation, the CP-odd K_2 state decays directly into two pions. To unravel these separate and extremely delicate effects requires careful measurement - the ratio of K_L decays into two charged pions to K_L decays into two neutral pions, divided by the same ratio for K_S decays, provides an accurate measure of direct CP violation.

It is this double ratio which CERN's NA31 experiment and Fermilab's E731 set out to measure in the

1980s. Both experiments made 1% measurements, but their results were inconclusive, and it became clear that greater precision was needed. Because of the subtlety of CP-violation, the technique employed by NA31 of taking separate runs with K_L and K_S beams was not sufficiently precise. Accuracy was limited by possible differences in the detector from one run to the next.

The decisive difference with NA48 is that charged and neutral data is collected with both beams at the same time. To do this, part of the SPS synchrotron beam makes a K_L beam, and the remaining protons are channelled through a crystal lattice to be collided with another target further downstream making the beam of K_S particles. Time-of-flight techniques, accurate to better than 300 picoseconds, reveal whether the decay pions seen downstream in the detector came from a K_L or a K_S. Another important difference with NA48 is that it is installed in CERN's highest intensity proton beamline to allow much more rapid data collection than NA31.

At Fermilab, the E731 experiment was already geared up to take data with simultaneous K_L and K_S beams. Their technique relied on the curious property of neutral kaons that if a beam of these particles is forced to pass through matter, the number of short-lived K_S particles increases, rather than decreases, a process known as regeneration. E731 therefore used parallel beams of kaons, moving a regenerator between the beams at regular intervals. This technique worked well in the 1980s, and has been retained by E832. Where the new experiment improves on its predecessor is by taking the charged pion data at the same time as the neutral pion data. E731 collected charged and neutral data separately for most of the time.

With E832 already more than halfway through its foreseen datataking period and NA48 confidently expecting to exceed NA31's entire data sample this year alone, the questions left open by these experiments' 1980s forerunners should soon be answered.

DUBNA
Honouring a pioneer of space biology

Earlier this year an International Symposium "Problems of Biochemistry, Radiation and Space Biology" held in Moscow and Dubna under the auspices of UNESCO honoured the memory of Academician Norair Sissakian (1907-1966) who would have turned 90 this year. An outstanding biochemist, Academician Sissakian was one of the founders of space biology. After beginning at the RAS Presidium in Moscow, the Symposium transferred to Dubna, acknowledging JINR's major role in research on radiation safety for space flights.

Prior to embarking on manned space missions, it was necessary to

This 1961 photo of a press conference at the USSR Academy of Sciences shows (left to right) pioneer cosmonaut Yuri Gagarin, President of the USSR Academy of Sciences A.N. Nesmeyanov, and Norair Sissakian, then leader of the Soviet space medicine programme.

At the International Symposium "Problems of Biochemistry, Radiation and Space Biology" which honoured the memory of Academician Norair Sissakian (1907-1966) - left to right: V.P. Dzhelepov, E.A. Krasavin, O.G. Gazenko, G.M. Arzumanyan.

simulate the effect of galactic cosmic radiation. This could be done at JINR's synchrocyclotron, synchrophasotron and heavy ion accelerators.

Sissakian supervised the work of radiobiologists from different institutes, and these investigations preceded the first manned space flight by Yuri Gagarin in 1961, in the preparation and implementation of which Sissakian took an active part.

An eminent organizer of science and international cooperation, in 1964 Sissakian was elected President of the 13th UNESCO General Conference. His name is also inscribed on a tablet in UNESCO's headquarters in Paris, and in the garden nearby a tree planted by him carries a memorial board. His contribution to space science has also been marked by naming a lunar crater after him. Norair Sissakian was the father of current JINR Vice-Director Alexei Sissakian.

The Symposium was organized by the Russian Academy of Sciences (RAS) and the Joint Institute for Nuclear Research (JINR), Dubna, in cooperation with other scientific organizations from Russia and Armenia.

MOSCOW Meson Factory Linac in action

In its last two production shifts (November/December 1996 and March/April, 1997) the Moscow Meson Factory Linac of the Institute for Nuclear Research, Russian Academy of Sciences, provided 1500 beam hours.

The accelerated beam was delivered for the first time to the main experimental area and observed at the input of the intermediate beam dump, which can absorb the full beam power (average 1 mA current of 600 MeV protons). With 20 klystrons available, the energy of the proton beam was upgraded from 420 MeV to 502 MeV.

The remaining accelerating modules and their additional klystron (which would take the energy up to 600 MeV) have been tuned and conditioned, moving the klystron from module to module to test them at full radiofrequency power.

Reliability was improved significantly with the development of serial new automatic computer control procedures. In particular, a special technique prevented the vacuum pipe from being burned by the high intensity beam. The average beam current of 60 microamps can make a hole in the 3 mm thick stainless steel wall in just 0.1 s, which happened twice in the isotope production channel.

Another important innovation is rapid automatic restoration of the high power transmitters after accidental switchoff. A great deal of production time was thus saved. A new procedure to adjust the phases in accelerating tanks provides high beam quality and low beam losses.

The plan for the next two years is to reconstruct the injector complex with the aim of increasing the beam pulse length to 200 microseconds.

The experimental programme of fundamental nuclear physics includes experiments to investigate subthreshold pion production in atomic nuclei using the charged pion range telescope spectrometer PLASMAS, and a search for supernarrow dibaryons in proton-deuteron interactions using the TAMS two-arm mass spectrometer. In parallel, applied experiments include radioactive isotope production for medical use and irradiation of an electronics components for space apparatus.

AUSTRIA/SLOVAKIA National surveys

Continuing its eternal round of surveying physics in CERN Member States, the European Committee for Future Accelerators (ECFA) had a twin fixture in April, visiting first Slovakia and then proceeding to Austria (Vienna).

The European Committee for Future Accelerators (ECFA) recently visited Slovakia, meeting at Smolenice castle, near Bratislava.

The Slovak Republic became a CERN Member State in 1993 following the devolution of Czechoslovakia, which had become a Member State in 1992. While Slovakia counts many competent physicists who can greatly contribute to research at CERN, their home support is extremely limited by CERN standards. At a political level, CERN is probably seen more as a driving force for Slovak industry than the place to do particle physics research.

There are some 40 Slovak experimental physicists, including 10 graduate students, split evenly between Bratislava and Kosice. The former are associated with the Comenius University, while those in Kosice are associated either with the Institute of Experimental Physics of the Academy or with the Safárik University. Some engineers are working both in Bratislava and in Kosice.

Some of the graduate students are expected to find a permanent post in a research group or university. Others will go to industry, where there are good prospects in new computer companies. Particle physics has an appeal to students and part of this success is due to its highly international character.

Participation at CERN started with Kosice work in NA34 (Helios), following a visit of CERN Director General Herwig Schopper in 1983, and the success of Helios had much to do with the subsequent rapid integration in research at CERN.

A Kosice group is now participating in the NA 57 heavy ion experiment after working on the Omega spectrometer, and two Bratislava groups are participating in Delphi at the LEP electron-positron collider and in NA 49 (also heavy ions). There is also some emulsion work.

Interest in CERN's LHC proton collider has led to several R&D programmes, while sizeable groups from both Bratislava and Kosice are involved in the ATLAS and ALICE detectors.

Besides work at CERN there is some Slovak activity at the Joint Institute for Nuclear Research (JINR), Dubna, and a participation in the H1 experiment at DESY's HERA electron-proton collider by a Kosice group.

It is hoped that the home support for particle physics research granted until recently by the Office for Development Strategy of Society, Science and Technology will be continued by the Ministry of Education. However the average research support per physicist is rather low.

On the theory side, there are about 10 researchers at the Institute of the Academy in Bratislava, 10 at the Comenius University, and 5 in Kosice. Many are working in phenomenology in close contact with their experimental colleagues. Regular regional meetings such as the "Triangular" meetings organized from Vienna have been very useful.

Despite the grim economic situation, the Slovak-CERN Committee, chaired by B. Sitar, is trying to rally special Government support for research at CERN. This committee is a coordination and advisory body which was linked to the Office for Development Strategy of Society, Science and Technology, but full responsibility for particle physics has now been transferred to the Ministry of Education.

The eventual success of the Committee in securing good funding is likely to depend on the industrial return of CERN contributions to Slovakia.

The return coefficient for supplies was initially very low, but the appointment of a liaison officer (L. Kovac from Kosice) and the establishment of a sub-committee of the Slovak-CERN Committee is now responsible for industrial cooperation with CERN. An order for cables resulted in a very good return coefficient (2.2) for 1994, but this reflected

At the ECFA meeting in Slovakia, prior to a series of high level meetings in Slovakia and Austria, CERN Director General Chris Llewellyn Smith (left) was presented with the Gold Medal for Physics and Chemistry of the Slovak Academy. Right is Slovak Academy President Professor S. Luby.

the low value of the initial contribution. The 1996 return coefficient for supplies was 0.90. Slovakia has large industrial complexes (steel, heavy machinery, cables....) and an important military component which the country is keen to diversify.

The future is likely to see an increase in collaboration with Vienna, also participating in Delphi. This could become much stronger if the regional AUSTRON neutron source is built, when a regional centre could then act also as a staging post for CERN.

Special funds have been recently granted for the installation and operation of a cyclotron given by Russia as a partial debt payment. Use of such a machine for the production of medical radioisotopes could perhaps lead to new collaboration possibilities for imaging work.

The Slovakian CERN contribution, at present of the order of 0.72 million Swiss francs and estimated to be 35% of the full value, should rise to its full level by 2002. The contribution is paid through the Ministry of Foreign Affairs. The Academy is funded directly from the state budget. Research funds for the universities come from the Ministry of Education.

The Academy operates a special grant system for research. At present, funds for research come mainly from the current budget of the universities and of the Academy. Establishing a special budget for support of the CERN-oriented activities is in the process of being set up. The present financial situation of the research groups is at present rather critical.

It is hoped that Slovakia could be helped by European support for technical work and CERN-related technical training.

Austria

From Smolenice castle near Bratislava, ECFA moved to Vienna to survey the Austrian scene.

30 Austrian experimentalists in particle physics have a permanent position. Most are in Vienna at the Institute for High Energy Physics of the Austrian Academy of Sciences (HEPHY), which also has 6 technical staff members. There is a smaller university group in Innsbruck. Of the 15 or so graduate students, about a third can expect to obtain a research or academic position. Oddly enough there is indeed no full professor in high energy experimental physics. Physicists from the Academy are, however, involved in university teaching.

Austrian work at CERN is concentrated on the major NA 48 CP violation experiment and on Delphi at the LEP electron-positron collider (about 15 physicists). There is increasing participation in CMS and LHC-related R&D work, especially in advanced, circuitry for triggering and data acquisition. There are about 8 persons from Vienna at CERN at any given time. The small Innsbruck University team is in Aleph at LEP, with LHC participation in ATLAS.

While there are relatively few experimental nuclear physicists in Austria, there is a relatively strong medium-energy group at the Academy (10 persons) involved in muon catalytic fusion at PSI, Villigen, and TRIUMF, Vancouver, and with kaonic atoms at DAPHNE, Frascati.

Austria continues its illustrious tradition in theory, but at the Vienna universities, particle physics research is restricted to theory. Of the nation's 30 theorists, most are in Vienna, at the University Institute (until recently led W. Thirring), the Technical University (W. Kummer) and the Academy. There are also small groups in Graz and in Innsbruck.

Perhaps because of the relative absence of experimentalists, there has been a strong shift in interest towards more formal aspects of theoretical physics. The CERN fellowship programme is also well known in Austria and much appreciated.

The experimentalists look to the future with moderate optimism. The budget has been stable with replacements for departures, however salary pressure due to increasing seniority leads to a slow decline of material funding.

The relative importance of the high energy physics budget exacerbates tensions within the Academy, and a push for the creation of University Institutes of experimental particle physics appears to be difficult in the present context.

Particle physics depends on the

Federal Ministry of Science and Transport (until recently the Ministry of Science, Transportation and the Arts), which has reflected the particle physics community's support for the LHC and national support for CERN. The Ministry of Science and Transport also pays the Austrian contribution to CERN (national contribution 22.8 million Swiss francs - MCHF). High-energy funding represents only a fraction of the ministry's responsibilities but is the second largest cash entry.

Funding through the Academy to its High Energy Physics Institute (OeAW) runs at the level of 5 MCHF/ year (including salaries), with materials amounting to about 1 MCHF/year. This funding has to compete with other fields. Funding for university groups is via university allocations from the Research Council.

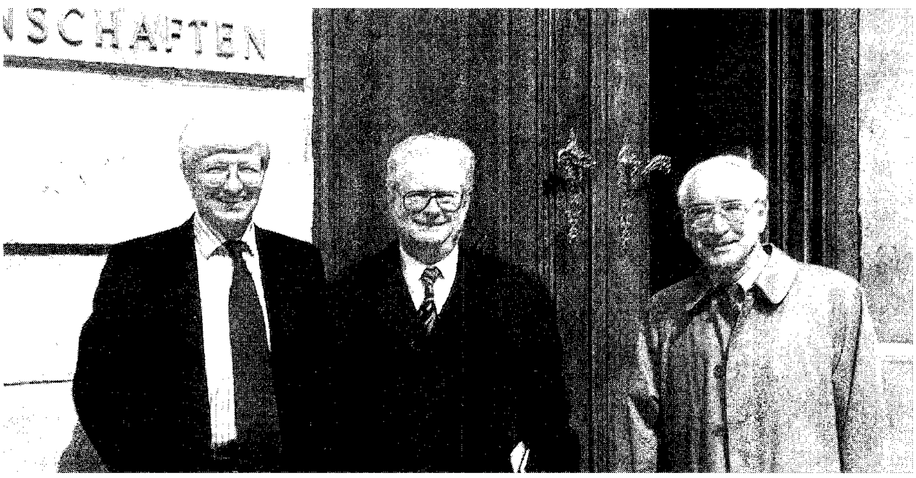
Special funding can also be granted directly through the Ministry, independently of the Academy, but is insufficient for major projects. Special funding for CMS is expected to come mainly from such a specific allocation.

The return coefficient for CERN supplies is 0.57 and needs to be increased, and liaison officers have been appointed. Austria has a strong electromechanical industry. ELIN participated in the early LHC R&D, building with Holec (NL) a 10m dipole prototype, but it has unfortunately given up this activity. Austria has several active small- and medium-sized enterprises working with CERN, a good example being Alge (electronic assembly).

Austria is involved in the development of the AUSTRON project for a 1.6 GeV neutron spallation, where there is collaboration with CERN. Austria is seeking partners for the project's estimated cost of 500 MCHF. Attached to the AUSTRON is a medical facility with its project office in Wiener Neustadt (Med-Austron).

A new technical student programme should build up a stronger base for CERN support. Four years ago a Technical Doctoral Student programme was launched for students working at CERN and paid from Austrian sources. At present 30 are at CERN, with a turnover of about 10 new people per year, each coming for two years.

Manfred Regler organized the Vienna ECFA meeting



At the Austrian Ministry of Science and Transport, left to right, CERN Director General Chris Llewellyn Smith; R. Kneucker, Director of International Cooperation at the Ministry; and W. Majerotto, Director of the Institute for High Energy Physics of the Austrian Academy of Sciences.

Bookshelf

An Introduction to Gauge Theories and Modern Particle Physics, by Elliot Leader and Enrico Predazzi: Cambridge University Press, Volume I hardback, ISBN 0521464684 £90, Volume I paperback ISBN 052146840X £32.50, Volume II hardback ISBN 0521496179 £85, Volume II paperback ISBN 0521499518 £30

The first volume of this book (close to 500 pages) covers electroweak interactions, the "new particles" (with the discovery of charm beauty and the tau) and the parton model. The second volume (about 450 pages) deals with CP violations, QCD and hard processes.

Reading it, the first impression is of a saga. The book traces the excitements and discoveries which characterized the fruitful period in particle physics during the seventies and the eighties, when our Standard Model of fundamental particles and their interactions took shape and was verified by experiment to high precision. This precise adherence to the Standard Model has subsequently continued and increased, despite careful searches for any deviations.

The presentation sometimes traces actual developments, with an almost chronological presentation of results which gradually brought a better understanding, but overall the book prefers a more global viewpoint to ensure a good conceptual understanding. The particularly clear presentation also often follows a phenomenological approach, emphasizing analysis of the data as they became available.

Rather than an introduction to gauge theories, it is more the story of the success of the particular gauge theories which constitute the Standard Model - the Electroweak Theory and Quantum Chromo-dynamics - including most of the necessary technical details.

While, with hindsight, one can cover much ground while remaining at a relatively simple theoretical level, there are many subtle points, associated in particular with renormalizability and vacuum degeneracy, which cannot be avoided. The presentation of these points tends to be rather brief. However the authors do acknowledge this and make a genuine effort to present clear pictures of such complex topics so that the unfamiliar reader could at least appreciate the importance of these questions, the techniques needed to handle them, and/or their practical consequences.

A good knowledge of relativistic quantum mechanics is needed. Some quantum field theory, only briefly covered in the appendices, would also help.

The book is primarily a presentation of past successes. This could have been achieved more compactly, but it is good to have such an authoritative phenomenological compilation of the dramatic progress during two decades.

The book is however very brief when looking beyond the Standard Model, in particular about supersymmetry, which, while still controversial, has many followers and already extensive putative phenomenology. The book also does not cover in any detail the future expectations when colliding constituents at the TeV level, neither does it present rationale behind the effort to search for the quark-gluon plasma or for neutrino oscillations.

While not speculating very much about future directions, the book does provide a very good pedagogical survey of the recent and very rewarding past.

Maurice Jacob

New Cosmology

Now available is the third edition of Cosmology by Michael Rowan-Robinson of London's Imperial College (Oxford University Press, ISBN 0 19 851885 4 hbk, 0 19 851884 6 pbk).

In the quarter-century since the appearance of the first edition of this book, cosmology has become an increasingly experimental science with the impact of space-borne observatories as well as new ground-based stations. The subject remains as controversial as ever - the book's epilogue lists twenty ongoing controversies.

Books received

Theory of Nuclear Reactions by P. Fröbrich and R. Lippenheide, Oxford Science Publications, ISBN 0 19 85377783 2 hbk £65

In the Oxford Studies in Nuclear Physics Series, the presents the theoretical formalism of nonrelativistic nuclear reactions, covering potential scattering, formal theory, direct reactions, the compound nucleus, and dissipation and fluctuations.

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please see page III

People and things

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Project Director Lyn Evans (left) explains progress for CERN's LHC proton collider to US House Science Committee Chairman F. James Sensenbrenner during a visit to CERN on 18 April.

Thomas Weiland, eminent accelerator physicist and Professor at the Department of Electrical Engineering of the Technical University of Darmstadt, and formerly also at CERN and DESY, receives one of the 1997 Philipp Morris Research Prizes for his work on the numerical modeling of electromagnetic fields in all kinds of everyday electrical equipment. This work derives from his special technique for solving Maxwell's equations numerically which has considerably helped the treatment of many accelerator problems.

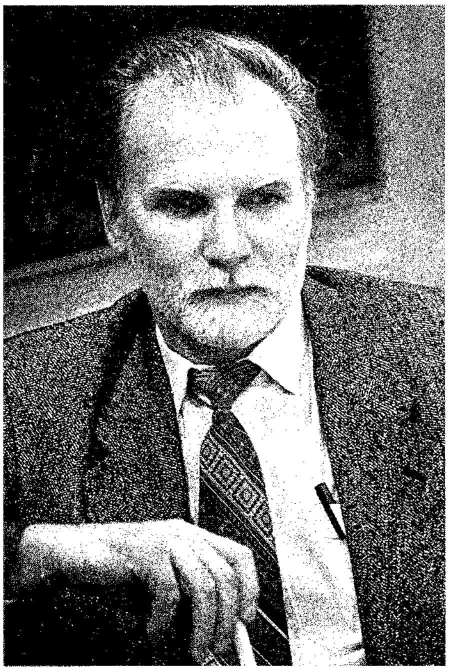
Charles Alcock of Livermore receives the prestigious E.O. Lawrence Physics Award of the US Department of Energy for his work in observing Massive Compact Halo Objects (MACHOS) in the search for Dark Matter.

Flerov Prize

This year the G.N. Flerov Prize of the Joint Institute for Nuclear Research (JINR), Dubna, is awarded to S. Hofmann (GSI, Germany), Yu.A. Lazarev (JINR, Dubna) and A. Sobiczewski (Soltan Institute, Poland) for "The Experimental and Theoretical Study of the Superheavy Elements Properties which Resulted in the Discovery of a New Domain of Nuclear Stability near Z=110 and N=162". The G.N.Flerov Prize is awarded biennially to Russian and foreign scientists for outstanding achievements in nuclear physics.

Thomas Weiland - Philipp Morris Research Prize

Vladimir Kadyshevsky, Director of the Joint Institute for Nuclear Research, Dubna, near Moscow, celebrated his 60th birthday on 5 May.



In a recent meeting, the Programme Advisory Committee for Particle Physics at the Joint Institute for Nuclear Research (JINR), Dubna, near Moscow, approved recommendations on the JINR research programme till the year 2000, covering JINR participation in preparation for experiments at CERN's LHC, as well as for the accelerators of JINR and IHEP(Protvino), DESY, Fermilab and Brookhaven. Seen here (left to right) are Programme Advisory Committee for Particle Physics members G.Zinovjev, V.Penev, T.Hallman, A.Sissakian, P.Spillantini, M.Della Negra, J.-E.Augustin, N.Giokaris, and R.Voss.

Vladimir Kadyshevsky 60

5 May marks the 60th birthday of Vladimir Kadyshevsky, Director of the Joint Institute for Nuclear Research, Dubna, near Moscow. As research student of N.N. Bogoliubov, he began his professional career in 1962 at JINR's Laboratory of Theoretical Physics, going on to become its Head from 1987 to 1992, when he became JINR's Director.

His research interests cover particle physics, quantum field theory, and group theoretical and geometrical methods in field theory. As well as leading JINR, he also lectures at Moscow State University and is President of the International 'Nature, Society, Man' University at Dubna, and is also President of the Union of Russian Scientific Societies

Dubna participation in the LHC

In the framework of the Agreement on Cooperation between CERN and the Joint Institute for Nuclear Research (JINR), Dubna, near Moscow, CERN Director General Chris Llewellyn Smith and JINR Director Vladimir Kadyshevsky have signed a Protocol concerning JINR's participation in the LHC project, covering joint research for the forthcoming decade and promotion of the traditional fruitful cooperation between the two major international organizations.

The Protocol was initiated by the JINR-CERN Cooperation Committee co-chaired by JINR Vice-Director Alexei Sissakian and CERN Collaboration Coordinator Jim Allaby.

Lepton-Photon Symposium

The 18th International Symposium on Lepton and Photon Interactions will be held from July 28 to August 1 in Hamburg, Germany. More information can be found on http:/www.desy.de/lp97. The e-mail address of the Symposium is LP97@desy.de

Helge Ravn (right) explains CERN's ISOLDE on-line isotope separator to Danish Minister for Research and Information Technology Jytte Hilden during a visit on 18 April.

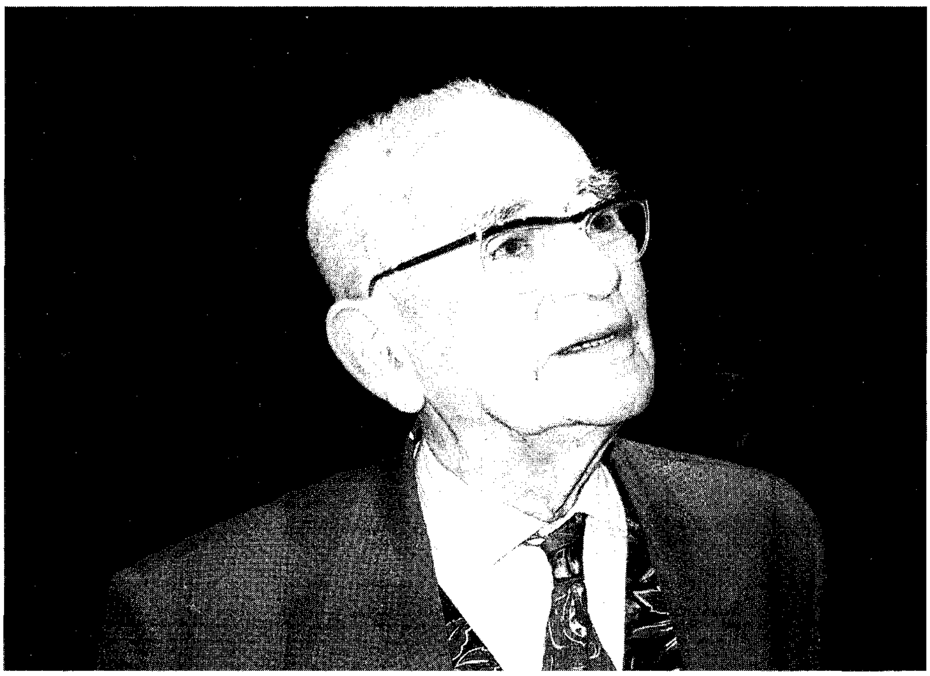
Swiss Ambassador to the UN and International Organizations in Geneva Walter Gyger (left) recently hosted a reception to honour Jacques Vernet (second left) on his retirement as Swiss delegate to CERN Council. M. Vernet has been a staunch CERN ally and his vigorous defence of the Organization's interests at Council sessions will be long remembered. With him in the photograph are CERN's Research/Technical Director Horst Wenninger (second right) and Swiss delegate to CERN's Finance Committee Michel Gottret (extreme right).

Meetings

The DESY Theory Workshop 97 will take place from September 24 - 26 at DESY, Hamburg, and will be devoted to "Recent Developments in QCD". For further information, see the "Conferences" item on the DESY homepage at http://www.desy.de/

The 8th Workshop on Radio-frequency Superconductivity will be held from October 6 - 10 at Abano Terme, Italy, sponsored by Istituto Nazionale Di Fisica Nucleare, Laboratori Nazionali di Legnaro. Topics include: Superconducting Cavities for High Energy and Heavy Ion Accelerators, Cyclotrons, FELs, High Intensity Proton Superconducting Machines, The Push for High Accelerating Gradients, Cavity Fabrication Techniques and Novel Ideas, Ancillary Equipment, Cryogenics, Couplers, Niobium Properties, Thin Films, Innovative Materials, Surface Impedance of Superconductors, RF Superconductivity Non-Accelerator Applications and HTCS Materials from Research to Application. Information from Dr. V. Palmieri, Chairman, INFN LNL, Via Romea 4, Legnaro (Padua) Italy;
Fax: +39-49-641925;
e-mail: Abano@lnl.infn.it;
Internet:
http://axplnl.lnl.infn.it/~abano/rfsuperconductivity.html

The Xth IEEE Real Time Conference will be organized in France from 22 - 26 September under the auspices of the Commissariat à l'Energie Atomique (CEA) and Institut National de Physique Nucléaire et de Physique des Particules (IN2P3/CNRS). It will be devoted to the "Impact of modern technologies in Real Time systems" for small as well as large present and future scientific embedded apparatus or experiments. Nuclear, High Energy, Astroparticle, Astrophysics and Plasma Physics will be covered, as well as applications in medical, biology, aerospace and other industrial disciplines. Contact Mme Nicole Mathieu, Laboratoire de l'Accélérateur Linéaire (LAL), Université de Paris Sud - Bât 200 FR - 91405 Orsay, Cedex France
Phone: (+33) (0)1 64 46 84 37
fax: (+33) (0)1 69 07 15 26
e-mail: rt-97@in2p3.fr Web URL :
http://www.in2p3.fr/rt97



A well-attended event at the Ecole Polytechnique, Paris, on 3 April marked the 96th birthday of Louis Leprince-Ringuet and the transfer of the Leprince-Ringuet scientific archive to the institute's library. As well as his numerous contributions to physics, Leprince-Ringuet has been a long-serving member of CERN's Scientific Policy Committee, its Chairman from 1964-66, and is still a frequent visitor to the Laboratory.

EPFL

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

THE SWISS FEDERAL INSTITUTE OF TECHNOLOGY LAUSANNE (EPFL) INVITES APPLICATIONS FOR THE FOUR FOLLOWING POSITIONS OF

ASSISTANT PROFESSOR in

1. **Environmental engineering at the Rural Engineering Department**

The new collaborator will have teaching and research responsibilities for environmental biothechnology, particularly in modern biological treatments of industrial effluents. He/she must have the necessary skills within a pluridisciplinary team to develop new technologies of intensive treatments designated to biodegrade xenobiotic compounds in liquid or gazeous industrial effluents at their point of emission.

2. **Soil microbiology applied to the management and remediation of degraded soils at the Rural Engineering Department**

The new collaborator will have to develop high level research and teaching in the following areas; soil microbiology, biological detoxication of contaminated soils, qualitative remediation of degraded soils by restoration of biodiversity, operational management of unstable anthropic soils. He/she must have outstanding qualities as an experimenter and model developer. The scientific approach will be the one of an engineer able to create, realize and manage projects at a very high level.

3. **Biomaterials at the Materials Science Department**

The new collaborator should have a high level of academic training with background both in materials science and engineering and medical/paramedical fields with knowledge of the interaction between synthetic materials and human tissue. He/she must have proof of his/her originality and ability through scientific publications of the highest level, for example in biomaterials research.

4. **Chemical engineering at the Chemistry Department**

The new collaborator is expected to develop high level activities in the area of Multifunctional Processes/Reactors. He/she should have a strong interest in the teaching of chemistry and chemical engineering both at undergraduate and graduate levels.

For the four positions: the activities will take place within the concerned Departments and will also involve other of the EPFL as well as other Swiss and international academic institutions and manufacturers. An aptitude for teaching to students of graduate and undergraduate level and for conducting original and high level research projects is essential. The new collaborators will also be called on to supervise and guide students on semester projects, on engineering degrees and Ph.D. degree work. They should possess a confirmed skill in leading projects. Candidates are invited to propose and send an original research program together with their application. Applications are encouraged from people who fulfill the requirements of the Swiss program for ensuring the continuity of competent university faculty. *Deadline for applications: September 26, 1997.* Starting date: as mutually convenient.
Applications from women are particularly welcome. For further information, please ask for the documentation and the application form by wriging to: *Présidence de l'Ecole polytechnique fédérale de Lausanne, CE-Ecublens, CH 1015 Lausanne, Switzerland.*

U.S. DEPARTMENT OF ENERGY

SENIOR PROGRAM OFFICER (PHYSICIST)

**FACILITIES OPERATIONS TEAM,
DIVISION OF HIGH ENERGY PHYSICS
OFFICE OF HIGH ENERGY AND NUCLEAR PHYSICS
OFFICE OF ENERGY RESEARCH**

**$75,935 to $98,714 per annum
PN-97-ER-76-20-165**

The U.S. Department of Energy is seeking applicants for the position of Senior Program Officer (Physicist), Facilities Operations, Division of High Energy Physics (DHEP), Office of High Energy and Nuclear Physics (HENP), in the Office of Energy Research (ER). The incumbent supervises, organizes and coordinates those DHEP activities concerned with the operation of accelerator, colliding beam and experimental research facilities at each of the DOE national accelerator centers. Develops, recommends, and implements strategies, milestones, policies, and near- and long-range plans for the operation of high energy physics laboratories, and their accelerator and experimental facilities both existing and under construction. Makes recommendations on the suitability, performance, and utilization of high energy physics accelerator and experimental facilities and assesses the capabilities and priorities of proposed new ones. A thorough knowledge and understanding of high energy physics, as well as extensive background and experience based on training and substantial research experience in high energy physics are necessary.

To be eligible for consideration, applicants must submit a completed application or resume, and/or an Optional Form 612, "Optional Application for Federal Employment". Details of all information required to apply and further information should be obtained from the address below.

Applications must be postmarked no later than July 11, 1997, and should be sent to the U.S. Department of Energy, HR-331.4, Room F-125, 19901 Germantown Road, Germantown, Maryland 20874-1290. To obtain a copy of any DOE Public Notice via FAX, please call (202) 586-1705. *The Department is an equal opportunity employer. U.S. Citizenship is required.*

Staff Member

Experimental physicist or electrical engineer to work as a member of the Accelerator Physics and Engineering Group in the LANSCE Division on a variety of novel and interesting accelerator projects. Primary emphasis will focus on the design, tuning, and testing of normal and superconducting RF cavities for linear accelerators, storage rings, and beam transport systems. Interact with linac and beam transport physicists, electrical and mechanical engineers, mechanical designers, fabrication technicians, and test technicians to define the technical requirements and carry out the design, fabrication, and testing RF accelerator cavities. Provide technical direction to engineers, designers, technicians, and subcontractors for the development and production of linear accelerator hardware. Create technical specifications for in-house and subcontract development and production of RF accelerator cavities.

Requires a Ph.D. in physics or electrical engineering plus seven years' relevant experience or equivalent combination of education and experience. Experience in RF and microwave engineering and resonant cavity physics from 100 MHz to 25 GHz. Significant experience in RF structures measurements. Strong experimental background in a lab environment. Experience with computer-based data acquisition and cavity modeling codes (e.g., SUPERFISH, MAFIA, HFSS, MICAV). Ability to create applications code in FORTRAN and/or C. Job #972447-L97048.

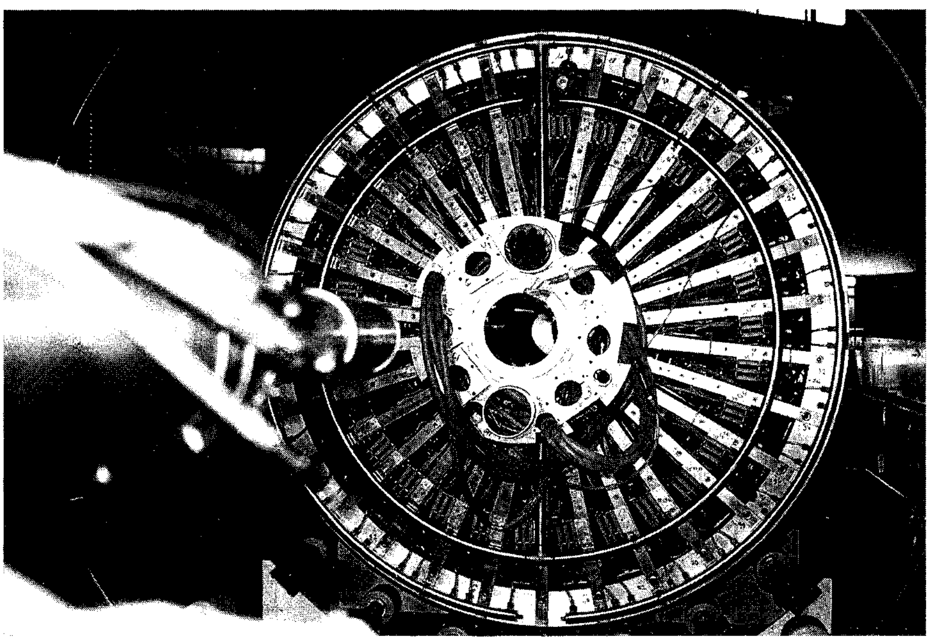
For consideration, please e-mail your resume and publication list to: jobs@lanl.gov; fax: (505) 665-1079; or mail to Human Resources Division, Los Alamos National Laboratory, Job #, MS P286, Los Alamos, NM 87545. Note: appropriate job # must be inserted. Explore our web page to learn more about Los Alamos National Laboratory: http://www.hr.lanl.gov EOE

Los Alamos National Laboratory
Science Serving Society

Still Making History

A recent special colloquium at the GSI Laboratory, Darmstadt, marked the retirement of Peter Armbruster as Head of GSI's celebrated Nuclear Chemistry Department, known throughout the world for its contributions to the synthesis and exploration of transuranic nuclei. Armbruster (left) is seen here with other transuranic pioneers Glenn Seaborg of Berkeley (to Armbruster's left) and Yuri Oganessian of JINR, Dubna. On the right is GSI Director Hans J. Specht. GSI's Nuclear Chemistry Department is now under the direction of Gottfried Münzenberg.

The International Conference on Non-Euclidean Geometry in Modern Physics, co-organized by the Bogoliubov Institute for Theoretical Physics, Academy of Sciences of Ukraine, will be held between 13-16 August in Uzhgorod (western Ukraine), followed by a satellite conference devoted to the Centenary of the Electron, to be held at the same site between 18-20 August. Further information from the Conferences secretariats: BITP, Kiev-143, Ukraine; Fax: 38-044-2665998; E-mail: jenk@gluk.apc.org

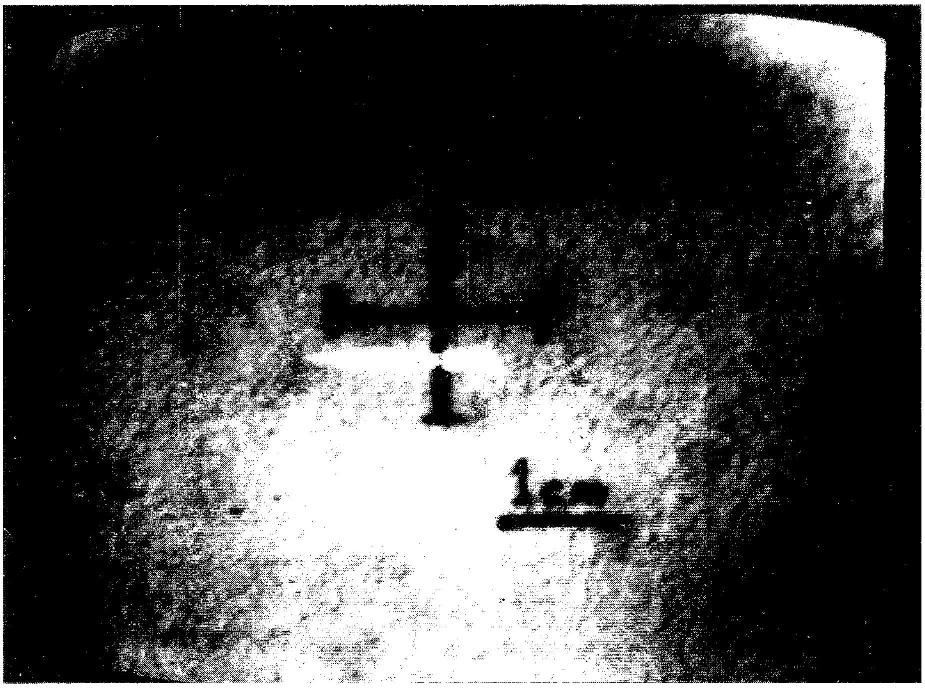


When CERN's LEAR Low Energy Antiproton Ring closed in 1996, many experiments reached the end of the road, but for the Crystal Barrel detector, seen here with its target assembly withdrawn, there is life beyond LEAR. Currently being dismantled, Crystal Barrel will soon be sent to Bonn where it will perform experiments for at least another three years.

Crystal Barrel began in 1986 with the aim of identifying and studying light mesons in the range 0.14 to 2.3 GeV. The goal was to find glueballs, particles containing only gluons. But years of patient detective work have paid off for Crystal Barrel, providing concrete evidence for gluons. Crystal Barrel will now be loaned to the University of Bonn. At the University's 3.5 GeV Electron Stretcher Accelerator, ELSA, Crystal Barrel will join forces with the TAPS detector to study photoproduction of mesons and the excitation of nuclear resonances.

PEP-II is coming!

In the wee hours of Saturday morning 10 May, the first electron beam was injected into the high energy ring the PEP-II B Factory at the Stanford Linear Accelerator Center, SLAC. The photo shows the cross section of the 9 GeV beam on a luminescent screen just before the interaction region where the BaBar detector will go. This feat was achieved in the first few hours of commissioning, without use of any corrector magnets or beam monitors. More to come in a future article.



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 opened the 'Atoms for Peace' photo exhibition at the UN's 'Palais des Nations', Geneva, marking the 40th anniversary of the Joint Institute for Nuclear Research, Dubna, near Moscow (April 1996, page 6).

Eidgenössische Technische Hochschule Zürich

Ecole polytechnique fédérale de Zurich
Politecnico federale di Zurigo
Swiss Federal Institute of Technology Zurich

Institute of Particle Physics
Laboratory for Nuclear Physics
Prof. Dr. J. Lang

POSTDOCTORAL POSITION in Experimental Particle Physics

A postdoctoral position is available at the Institute of Particle Physics of the Swiss Federal Institute of Technology (ETH) in Zürich, Switzerland.

Candidates should have some research experience in particle or nuclear physics (Ph. D.). They are expected to take an active part in all aspects of the preparation and realization of our experiments. Some experience in data acquisition and/ or online computing would be an advantage. The duration of the contract is two or three years with a possible extension of a further two years. The salary will depend on age and experience.

The experiments will be done mainly at the Paul Scherrer Institute in Villigen, Switzerland. We use the recently developed powerful neutron source (SINQ) or the high intensity muon beams to investigate fundamental symmetries of the weak interaction (time reversal violation, right handed currents, limits to scalar and pseudoscalar couplings).

Candidates should send a curriculum vitae and arrange for two letters of reference to be sent to:

Prof. J. Lang
Institute of Particle Physics
ETH Hönggerberg, HPK
CH - 8093 Zürich - Switzerland

For additional information contact please: lang@particle.phys.ethz.ch

VETENSKAP OCH KONST

KUNGL TEKNISKA HÖGSKOLAN

The Physics Department at the Royal Institute of Technology (KTH), Stockholm, has a vacancy for a

RESEARCH ASSOCIATE PARTICLE/ASTROPARTICLE PHYSICS

The particle physics group participates in the ATLAS experiment at CERN and in particular in the Liquid Argon Calorimeter group. In astroparticle physics the group is involved in balloon and satellite experiments measuring cosmic ray antimatter. Further information on the on-going research can be given by Tom Francke, francke@particle.kth.se (astroparticle projects) and Bengt Lund-Jensen, lund@particle.kth.se (ATLAS experiment).

The successful candidate will have held a PhD for not more than five years at the time of application and will be given an initial contract of two years duration extendable for a second two year period. Part-time involvment in the undergraduate teaching is possible in which case the contract can be further extended up to a maximum of six years.

Further details on employment conditions and application procedures can be obtained from either of the above contact persons or from the head of the department, prof Per Carlson, carlson@msi.se. Application must reach the Head of Physics Department, Royal Institute of Technology, S-100 44 Stockholm, Sweden, by 31 July 1997.

PAUL SCHERRER INSTITUT

PSI

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 team a

Physicist/Engineer (Controlsystem)

for the collaboration in the design, construction and operation of the SLS controlsystem particularly in means of real time systems. Specification and procurement of hard- and software components. Layout, construction and operation of the interface for the SLS accelerators hardware.

We expect the successful candidate to hold an university degree in physics, mathematics or computer science, to have several years of professional experience in experiment controls, data acquisition or accelerator controlsystems. Excellent skills in analysing and development of innovative solutions for control problems are mandatory. Experience in working with synchrotron light experiments would be appreciated. Knowledge of German and English would be of advantage.

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 0200/071, CH-5232 Villigen PSI