CERN COURIER

INTERNATIONAL JOURNAL OF HIGH ENERGY PHYSICS

VOLUME 36 **5** JULY/AUGUST 1996

CES PRESENTS:

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Distributed to Member State governments, institutes and laboratories affilliated with CERN, and to their personnel.

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St. Charles, Illinois 60174
Tel.: 708-377-1589 / Fax: 708-377-1569

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,
telex: 419 000 CERN CH,
telefax: +41 (22) 767 65 55

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

ISSN 0304-288X

Volume 36
No. 5
July-August 1996

Covering current developments in high energy physics and related fields worldwide

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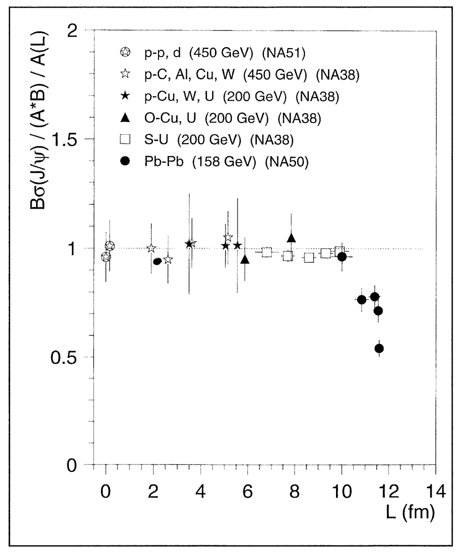
World Wide Web http://www.cern.ch/CERN/Courier/

Cover photograph: Thomas Jefferson (1743-1826), third president of the United States (1801-1809), had a lifelong devotion to science. At the dedication the new Thomas Jefferson National Accelerator Facility at Newport News, Virginia, formerly known as CEBAF - the Continuous Electron Beam Accelerator Facility - on 24 May, a Thomas Jefferson lookalike was among the guests of honor (see page 18). The real Jefferson studied at the College of William and Mary and later founded the University of Virginia, both now members of the university consortium that manages the Thomas Jefferson National Accelerator Facility - or Jefferson Lab for short.

Physics monitor



The first glimpse of quark-gluon plasma formation? J/ psi production in different collisions, normalized to pre-resonance absorption A(L) in normal nuclear matter, as reported at the 1996 Quark Matter Conference held in Heidelberg from 20-23 May, showing the strongly reduced J/ psi production in lead-lead collisions now observed by the NA50 collaboration at CERN . The path length L through such matter also provides a measure of the average energy density achieved in the collision.

Report of a little bang

These days major physics conferences do not often bring something new and unexpected, a potential breakthrough. To many participants, the 1996 Quark Matter Conference held in Heidelberg from 20-23 May appeared as one of these exciting occasions, providing what could turn out to be the first glimpse of the ultimate aim of their research: a laboratory little bang producing the long-awaited quark-gluon plasma - the state of matter which briefly existed in the aftermath of the Big Bang before nuclei 'froze' out..

The meeting was the 12th in the series of International Conferences on Ultra-Relativistic Nucleus-Nucleus Collisions; it was organized by H. J. Specht and brought a record 550 physicists to Heidelberg. In over fifty presentations, they heard the first comprehensive overview of results from truly heavy ion collisions, using the 160 GeV/nucleon lead beam from CERN's SPS and the 12 GeV/ nucleon gold beam from Brookhaven's Alternating Gradient Synchrotron (AGS).

Previous studies of light projectiles on heavy targets had shown a number of effects indicating possible collective behaviour; but collisions of two large, heavy nuclei provide the best chance to produce strongly interacting matter in the laboratory.

Do the new data now confirm the production of such matter? The simplest way to answer this question is to consider the emerging system as a mini-universe and test whether at the end of its strong interaction era, when it breaks up into non-interacting hadrons, the relative abundances of the different species are determined by temperature and baryon density, similar to the abundances of the light elements in our universe.

The present hadrosynthesis status was summarized by Johanna Stachel. In the past year, detailed studies of silicon-gold data from Brookhaven experiments E866 and E877 have shown that the most abundant particle species are indeed in accord with those expected to be emitted from such equilibrium. A first look at data from Brookhaven gold-gold collisions also seems supportive, although both for these and for corresponding lead-lead data at higher energies from CERN, further results are needed before the production of equilibrium matter at freeze-out can be fully established.

If high energy heavy ion collisions produce systems which are ultimately equilibrium hadronic matter, one can begin to explore the unknown earlier stages of higher temperatures and densities - with the ultimate aim of reaching the plasma of deconfined quarks and gluons predicted by quantum chromodynamics - the field theory of quarks and gluons.

Johanna Stachel - hadrosynthesis

Below the critical boundary separating the confined and the deconfined state of matter, in a dense hadronic medium, the properties of hadrons may change, and an observation of such changes would provide important evidence for earlier states of higher density, as emphasized in a survey by W. Weise. The deconfinement transition should be associated by a drop of the effective quark mass from its constituent quark value to its nearly vanishing observed value, and this may well induce hadron mass changes.

Both the now completed HELIOS 3 experiment and the CERES collaboration had first reported an excess of dilepton production below the rho peak, observed in sulphur-gold collisions. All attempts to explain this low mass dilepton enhancement in terms of interactions between hadrons of the usual vacuum properties have so far failed; only an

Axel Drees - low mass lepton pairs.

in-medium change of the rho-meson mass is able to reproduce the effect, as noted at Quark Matter '95 by C. M. Ko and B. Friman.

The first and still preliminary lead data from CERES, presented by T. Ullrich, were therefore eagerly awaited. They again show a pronounced low mass dilepton enhancement; further analysis and increased statistics are needed to establish its strength and impact parameter dependence, as underlined in the summary of A. Drees.

The striking result presented at the meeting was the strongly reduced J/ psi production in lead-lead collisions, observed by the NA50 collaboration at CERN, reported in Heidelberg by M. Gonin.

Suppression of J/ psi production in nuclear collisions was predicted ten years ago as a signal of deconfinement. A considerably reduced J/ psi production was observed shortly afterwards in oxygen-uranium and sulphur-uranium collisions, but a similar reduction occurs as well in proton-nucleus interactions, suggesting a common origin in normal confined matter.

Today one can in fact understand all J/ psi suppression in different proton-nucleus interactions and up to the most central sulphur-uranium collisions as due to the absorption of pre-resonance charmonium in normal nuclear matter, as shown by C. Lourenco in a systematic study of NA38/NA51 data from CERN and E772 data from Fermilab. Such pre-resonance charmonium fits well into the theory of quarkonium production by hadronic collisions, summarized by E. Braaten.

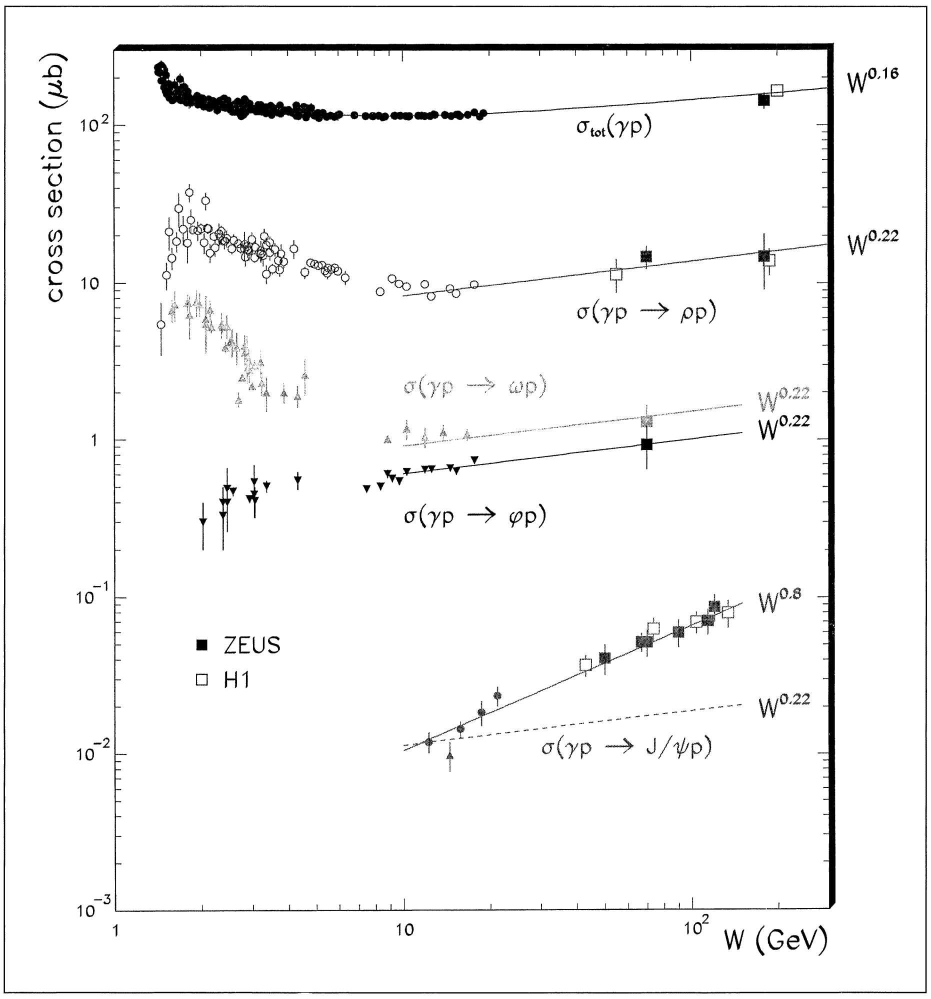
One had therefore expected a corresponding suppression also in lead-lead collisions. However the production rates observed late last year by the NA50 collaboration instead show a factor two stronger reduction, and this anomalous J/ psi suppression moreover sets in quite abruptly just slightly above central sulphur-uranium or the most peripheral lead-lead collisions.

QCD calculations presented by D. Kharzeev show that J/ psi dissociation by collision with hadrons is essentially excluded at present momenta. Taken together with the sudden appearance of the anomalous suppression, this therefore suggests the onset of some kind of at least local deconfinement. In a short contribution, J.-P. Blaizot noted that the anomalous suppression can be understood if all J/ psis produced in the hot central part of the lead-lead interaction just melt. His question therefore summarized what many participants were wondering: is this the first glimpse of quark-gluon plasma formation?

As pointed out by Kharzeev and by Lourenco, it is very reassuring that the two points crucial for a definite conclusion - the sudden onset of the

Helmut Satz of Bielefeld (right), eager to see NA50 experiment spokesman Louis Kluberg's new results on J/psi suppression in lead-lead collisions from the at CERN's SPS before the recent Quark Matter conference at Heidelberg. A meeting at Bielefeld just before the Quark Matter conference marked Satz' 60th birthday. In 1982, Bielefeld was the scene of the first meeting on triggering for heavy ion collisions at the SPS.

Photoproduction over a wide energy range as seen at the HERA electron-proton collider at DESY, Hamburg. It shows the collision energy (W) behaviour of total photoproduction together with that of the diffractively produced vector mesons. For the light vector mesons the energy behaviour follows the gentle energy dependence expected by a soft Pomeron exchange process, while with the heavier J/psi, there is a transition to a hard process with a sharp energy increase.



suppression and the transparency of confined matter to J/ psis, can both be tested experimentally: the former by precision studies of more peripheral lead-lead collisions, the latter by an "inverse kinematics" experiment with a lead beam incident on a hydrogen or deuterium target.

The next steps in the search for the quark-gluon plasma thus appear to be quite well-defined. The production rates of the different hadron species and corresponding correlation studies will provide the information needed about the collective properties of the medium at freeze-out. Further studies of the low mass dilepton enhancement will determine to what extent the properties of hadrons are changed in a dense, strongly interacting medium. And precision measurements of quarkonium suppression will provide the necessary tool to probe colour deconfinement. Depending on the answers to these questions, Heidelberg 1996 could be remembered as the first report of a little bang.

From Helmut Satz

HERA's hard diffractive scattering

The unique research at the HERA electron-proton collider at the DESY Laboratory, Hamburg, was highlighted at the conference on "Hard Diffractive Processes" held in Eilat, Israel, from 18-23 February, and the second such conference in Israel to be devoted to HERA physics, the previous meeting in February 1994 having been devoted to "Deep Inelastic Scattering and Related Subjects". Of the 81 physicists from 13 countries, the largest delegation was from Germany and numbered 17 participants.

The unexpected observation of 'rapidity gaps' in deep inelastic electron-proton interactions by the ZEUS collaboration in 1993 (September 1993, page 6), in which the proton emerges almost unscathed and the secondary reaction products pile up on the electron, rather than the proton, side had rekindled an interest in the long neglected subject of diffractive scattering, and for good reasons.

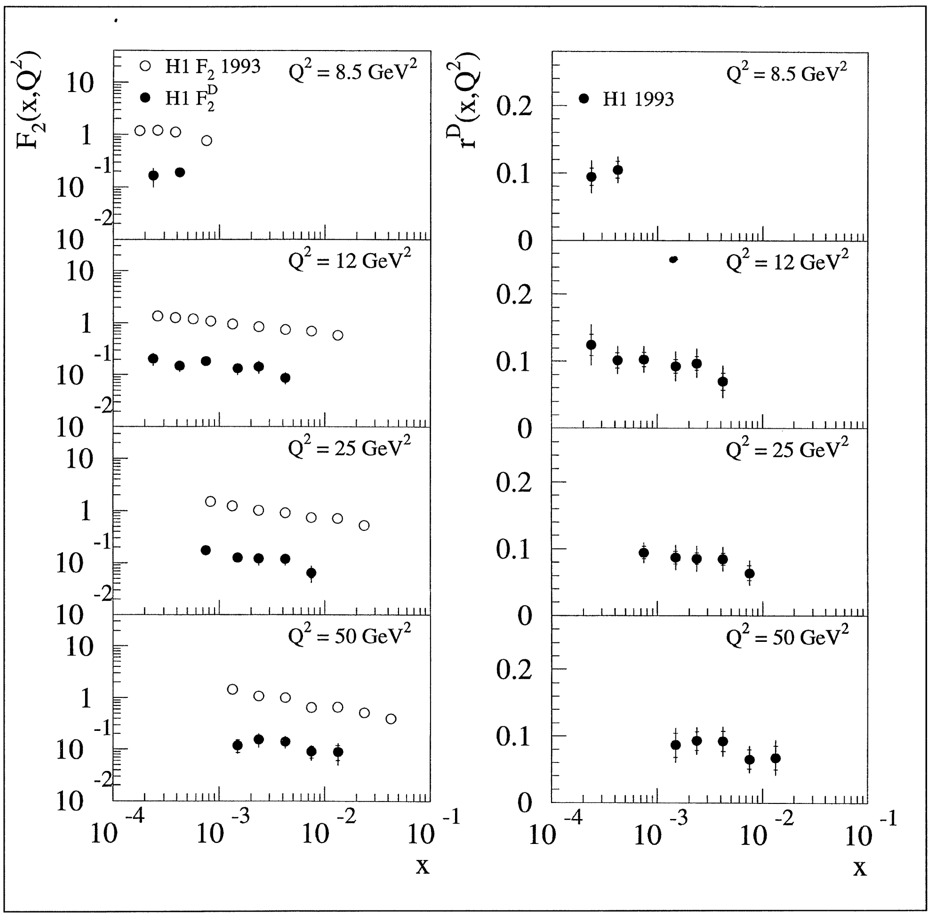
Quantum Chromodynamics (QCD) has long since been established as the field theory of quarks and gluons and forms part of the 'Standard Model', on the same footing as the unified theory of electroweak interactions.

The underlying QCD symmetry is that of 'colour', the equivalent of the electric charge in electromagnetic interactions. The constituents of hadronic matter are coloured quarks and the carriers of strong interactions are gluons. What makes QCD different from the electromagnetic interactions is that the gluons also carry colour. A direct consequence is 'asymptotic freedom' - the interaction between two coloured objects decreases the shorter the distance between them, while it becomes stronger the further they are apart. This makes it possible to predict the properties of strong interactions in the perturbative QCD regime.

The pointlike structure of hadrons in terms of quarks and gluons finds a natural explanation in QCD, and is described by 'structure functions' - the density distribution of quarks inside the hadron.

On the other end of the scale, confinement of colour is believed to be responsible for the fact that the only observable strong interacting particles are colourless. The validity

Quark-gluon content as seen with HERA. On the left is the inclusive structure function F_2 (open dots) as function of Bjorken x, for 4 values of Q^2. The rise of F_2 with decreasing x is evident. The full dots are for the diffractive structure function, the contribution to F_2 of diffractive events.
On the right, the values of the ratio of the two structure functions is plotted as a function of Bjorken x for fixed values of Q^2. One sees that within the statistics the ratio is Q^2 independent and very slowly varying with x, if at all.



of perturbative QCD has been established in many measurements, allowing the strong coupling constant to be determined.

However little is known about QCD in the regime where the quark-gluon coupling constant becomes large and none of the phenomenologically successful models of strong interactions can be as yet derived from first principles of QCD.

One of these models is the Regge theory where the interaction between hadrons is described through the exchange of particles which lie on 'Regge trajectories'. However one trajectory, responsible for the bulk of the interaction and transferring no quantum numbers, is the 'Pomeron' and has no known corresponding particles.

Given the nature of strong interactions and the underlying microscopic picture it is natural to assume that the Pomeron somehow consists of gluons. A major theoretical focus is to understand the nature of the Pomeron. In hadron-hadron interactions the dependence of the total reaction rate is determined at high energies by the properties of the Pomeron.

Reactions which can be easily identified as due to Pomeron exchange are elastic scattering (where no new particles are formed) and diffractive scattering, where only one of the hadrons scatters inelastically off the Pomeron while the other emerges almost unaffected. The emerging initial hadron and the products of the Pomeron-hadron interaction are very distinct - there is a large 'rapidity gap'.

In deep inelastic interactions, in which a pointlike lepton like an electron, muon or neutrino penetrates deep inside a hadron, the parton picture suggests that the intermediate boson emitted from the lepton is absorbed by a quark in the hadron. Structure functions thus display the absorption of these virtual bosons by quarks. QCD predicts that the number of quarks in the proton depends on the fraction of the proton momentum x carried by them and on the resolving power of the intermediate boson, on its virtuality.

This is contained in the Dokshitzer-Gribov-Lipatov-Altarelli-Parisi (DGLAP for short) equations for the structure functions. Thus in deep inelastic scattering we have two pictures, one of the virtual boson-quark interaction where all the properties are known but for the initial number of quarks and gluons in the hadron at some scale, and the other of a virtual boson-hadron interactions which should be mediated by some form of Pomeron.

With the observation at HERA of events with large rapidity gaps in deep inelastic scattering, a phenomenon known from soft hadron-hadron interactions suddenly appears in a domain in which the most general characteristics of the interaction are well described by quarks and perturbative QCD. The hope is that this diffractive scattering will become the testing ground for understanding QCD dynamics in the high energy limit and will uncover the nature of the Pomeron.

At Eilat speakers representing the UA8 (CERN), CDF and D0 (Fermilab), H1 and ZEUS (DESY) and Brookhaven experiments presented new results on diffractive processes, ranging from seemingly soft processes like vector meson production in photoproduction at high energies, through the pioneering measurements by UA8 (presented by Peter Schlein of UCLA) in which the diffracted proton system consists of high transverse momentum jets (March 1992, page 4), to deep inelastic scattering off a colourless Pomeron emitted by the proton.

The variety of results presented do not yet provide a complete picture, mainly because of inconsistencies still in the data. However, a few facts were established. The appearance of quark/gluon substructures is underlined by a range of observations. HERA results have shown how the nucleon quark-gluon structure can be followed over a very wide kinematic range, as summarized by J. Stirling (Durham). J. Bartels (Hamburg) pointed out that the standard quark-gluon field theory interpretation cannot lead to production of large rapidity gaps with the observed probability. The question remains whether the predicted evolution (as in the successful approach of Gluck, Reya and Vogt) is compatible with the observed frequency of large rapidity gaps.

Since the diffractive phenomena are intimately related to high energy phenomena, their appearance in the regime where perturbative quark-gluon field theory is in principle applicable may lead to a better understanding of the interplay of soft and hard physics, and thus to a better understanding of strong interactions in terms of QCD.

Al Mueller (Columbia) proposed an elegant formulation of a new classification of high energy processes based on the size of interacting particles. Soft hadron interactions in which two large objects collide are described by the exchange of the classical (Regge) Pomeron. Deep inelastic scattering is an example of an interaction in which a small virtual photon collides with a large hadron. The basic physics is determined by the evolution from a small object to a large one, and thus an interplay between soft and hard QCD is expected. This interplay is bound to lead to a significant violation of factorization (expressing the scattering amplitude as a product of two terms) typical of Pomeron exchange. Balitsky-Fadin-Kuraev-Lipatov dynamics predicts a fast increase of the reaction rate at high energy, and is expected to dominate the collisions of two small objects. Following this classification, the importance of non-perturbative QCD effects in hard diffractive phenomena was strongly argued by A. Capella (Orsay) and P. V. Landshoff (Cambridge). These are an inherent part of the aligned jet model proposed by J. D. Bjorken back in 1970. A semi-classical framework for a better theoretical understanding of this picture was proposed by W. Buchmueller (DESY) and A. Hebecker (SLAC).

Various hard diffractive processes for which one can derive QCD expectations were presented, such as exclusive vector meson production at high Q^2 (L. Frankfurt, Tel-Aviv), large momentum transfer semi-inclusive vector meson photoproduction (J. Forshaw, Manchester) and diffractive electroproduction of high transverse momentum jets (J. Bartels, Hamburg). M. Strikman (Penn State) argued that QCD at large longitudinal distances can be investigated most effectively in hard collisions on nuclei. The experimental programme planned for testing these new phenomena was summarized by E. Piasetsky (Tel-Aviv). Striking features of bremsstrahlung when a charged particle traverses a medium were presented by Y. Dokshitzer (CERN).

The overriding question "Is diffraction evidence for soft QCD or hard perturbative QCD ?" led to a heated debate, with P. V. Landshoff (Cambridge) advocating the soft approach. He was opposed by E. Levin (Rio de Janeiro) who claimed that diffractive processes could be explained by perturbative QCD. After a two-hour session and further informal discussions, the question still remained open. A final touch was given by K. Eggert (CERN) and C. Taylor (Cleveland) who summarized the physics interest of pursuing studies of the forward region at future high energy colliders with a particular proposal for CERN's future LHC collider.

The Eilat meeting was sponsored by DESY, Tel Aviv University, and the Israel Academy of Science and Humanities. The members of the local organizing committee who ensured the smooth running of the conference were Halina Abramowicz, Lonya Frankfurt, Errol Gotsman and Aharon Levy, all from Tel Aviv University.

Depolarizing Resonances : If you can't beat them, spin-flip them

Polarized beam experts now believe that magnetic 'Siberian snakes' should allow polarized (spin oriented) protons to be accelerated in the world's highest energy proton rings.

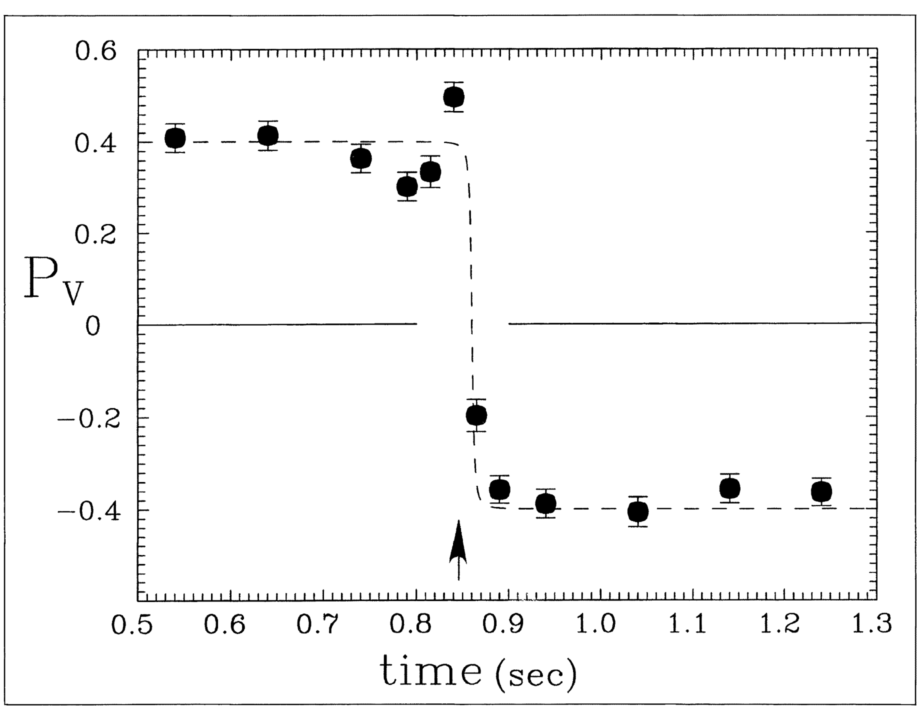
A series of Michigan-Indiana-KEK-SLAC-Fermilab experiments at Indiana's Cooler Ring have shown that a full Siberian snake should easily overcome all depolarizing resonances by rotating each proton's spin by 180 degrees and thus making each depolarizing resonance cancel itself.

The Cooler Ring team and a team from the Brookhaven Alternating Gradient Synchrotron (AGS) also studied partial Siberian snakes which rotate each proton's spin by typically 10 degrees. These partial snakes easily overcome the many "imperfection" depolarizing resonances in medium energy proton accelerators, but only work partially for the less numerous "intrinsic" depolarizing resonances caused by the proton's transverse beam oscillations.

Full Siberian snakes can easily overcome these "intrinsic" resonances. However full snakes become rather large and expensive in medium energy "injector" accelerators such as Brookhaven's AGS, DESY's PETRA, IHEP-Protvino's U-70, and Fermilab's Main Injector and in Indiana's proposed 20 GeV LISS ring. Indeed, the clever Siberian snake, invented around 1978 by Yaroslav Derbenev and Anatoli Kondratenko (Novosibirsk), may be the only accelerator device which becomes simpler and cheaper as the protons approach the speed of light.

In March, a Michigan-Indiana-Stockholm team, led by Alan Krisch (Michigan), finally succeeded in finding a way to more easily overcome the "intrinsic" depolarizing resonances in medium energy proton rings. They pulsed a small transverse dipole magnet for about 500 nanoseconds to give each proton in Indiana's Cooler Ring a large coherent vertical beam oscillation. This "kick" made the "intrinsic" depolarizing resonance so strong that almost every proton flipped its spin when it accelerated through the resonance energy. Thus, the spin flip kept the beam fully polarized.

For several decades polarized beam enthusiasts Alan Krisch and Larry Ratner (Argonne/Brookhaven/Michigan) have tried to somehow overcome these troublesome "intrinsic" depolarizing resonances by making them either stronger or weaker. They had managed to overcome these resonances by using fast pulsed quadrupoles at both the 12 GeV ZGS at Argonne and the 28 GeV AGS; however, each of the



The 'Siberian snake' may be the only accelerator device which becomes simpler and cheaper as the protons approach the speed of light. These magnetic devices rotate the spin of an orbiting particle by 180° on successive orbits, cancelling out the effect of troublesome depolarizing resonances.

In a test at Indiana's Cooler Ring, when a transverse dipole was pulsed to perturb the beam before crossing the "intrinsic" depolarizing resonance, each proton's spin was flipped by the strong resonance to a +40% polarization. When the dipole was pulsed after the resonance crossing time (shown by the arrow), then the resonance remained very weak and the polarization remained near the -40% level.

twelve AGS pulsed quadrupoles required a 1.6 microsecond 22 MW power supply, which cost about $500,000. Around 1975 they tried to make the ZGS "intrinsic" resonances weaker by "shaving" the outside of the beam to reduce the oscillation size; unfortunately they failed to change the polarization. Around 1985 they tried to make the AGS depolarizing resonances stronger; unfortunately they failed again to change the polarization.

During the early 1990s the team considered several different ways to strengthen the intrinsic resonance at the Cooler Ring. One proposal was to use the new pulsed transverse tune-measuring dipole; this was tried in October 1995, but it failed. In March 1996, it finally worked!!

ECFA memoirs

In December 1995, Günter Flügge of Aachen stepped down after three years as Chairman of ECFA - the European Committee for Future Accelerators. In this specially-commissioned article, he recalls the responsibilities of ECFA, the decisions taken, and their impact.

When ECFA, the European Committee for Future Accelerators, was mentioned to me for the first time, it meant little, probably a committee designing new accelerators.

This ignorance was rectified after I had served on this committee for some five years, part of the time as Secretary, and then some three years as Chairman until stepping down the end of 1995. Now I know much better what ECFA really does: it cares about most things in European high energy physics - except designing new accelerators!

ECFA was set up in 1963 as a representative body of European high energy physicists, independent of any laboratory or government. Its first Chairman was Edoardo Amaldi. Its independence is unique compared to similar organizations inside and outside high energy physics and is essential to its success.

ECFA's two bodies, Restricted ECFA (R-ECFA) and Plenary ECFA (P-ECFA), are composed of elected representatives from the 19 CERN member states, one per country in R-ECFA, several in P-ECFA, depending on the size of the national community.

Furthermore, the ESF (European Science Foundation), CIS (Commonwealth of Independent States, the former Soviet countries), Israel and the Joint Institute for Nuclear Research, Dubna, near Moscow, have observer status in plenary ECFA.

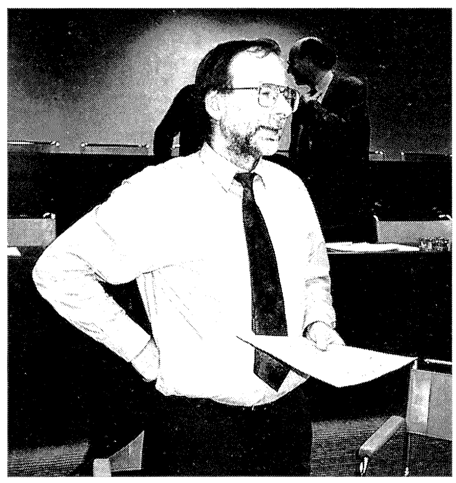
In addition, the CERN and DESY Director Generals (the official title at DESY is Chairman of the Board of Directors) are ex-officio members. The regular presence of the two Director Generals in my experience is necessary to the success of ECFA. For this reason, ECFA Chairmen have always strived to ensure the regular presence of the Director Generals. Since ECFA has no executive power, this dialogue is important as it expedites the establishment of a consensus among the community and the laboratories.

In my experience this process of dialogue and consensus is the main task of ECFA. It is time-consuming and of course many other people and bodies are involved. But it works very well in Europe and has helped pave the way for major projects like LEP, HERA and now the LHC.

The aims of ECFA were formulated in its 1976 guidelines (amended slightly in 1981), but they still are impressively valid when read today:

- The long-range planning of European high-energy facilities - accelerators, large-scale experimental equipment and computers - adequate for the conduct of a valid high-energy research programme by the community of physicists in the participating countries and matched to the size of this community and to the resources which can be put at the disposal of high-energy physics by society. Duplication of similar accelerators should be avoided and international collaboration for the creation of these facilities should be encouraged if essential and efficient.
- Equilibrium between the roles of international and national laboratories and education in high-energy physics and other fields.
- Adequate conditions for research and a just and equitable sharing of facilities between physicists, irrespective of nationality and origin, as conducive to a successful collaborative effort.

To meet these aims, ECFA acts in close contact with other institutions like the CERN and DESY laboratories (whose Scientific Policy and other committees are attended ex-officio by the ECFA Chairman), the European Physical Society, HEPCCC (the European Computing Co-ordination Committee), NuPECC (the European Nuclear Physics Committee), ICFA (the International Committee for Future Accelerators), and HEPAP (the US High Energy Physics Advisory Panel).



Günter Flügge - ECFA memoirs.

ECFA and the national communities

In my view, the most important task of ECFA is a permanent dialogue between national communities, their representatives and the laboratories. Restricted ECFA has therefore visited CERN member state countries since 1977. From sporadic beginnings, these visits intensified and have become a regular three countries per year habit since 1990. Thus all CERN member states have been visited, most twice or more.

These meetings give a thorough presentation and in-depth discussion of the activities in the various countries. After each meeting, short reports with an assessment of the situation and possible recommendations are sent to the appropriate funding agencies or government authorities. These reports have turned out to be helpful - in particular in small countries - in negotiations with funding agencies. Also, in some cases, they helped CERN management and CERN Council assess resources and their proper use in national communities.

These visits also update the valuable ECFA Survey Reports, in particular for new member states. Two comprehensive surveys of the European HEP user community have been carried out, in 1978 and 1988. A complete update of the latest survey was on the agenda during my chairmanship. These surveys, and even their updates, are a tremendous task and although I failed to finish the latest update, work is on the right track.

Over the past two years, these regular ECFA visits have served as a basis for CERN Courier reports on national high energy physics communities. This goes back to an idea of John Dowell and is handled by CERN Courier Editor Gordon Fraser and CERN Member State affairs coordinator Maurice Jacob.

ECFA and CERN

The most challenging time during my Chairmanship came of course in 1993-94 when the decision to approve CERN's future LHC collider was at stake. ECFA had been involved from the start with the idea of a proton collider in the tunnel built for the LEP electron-positron collider. ECFA co-organized the workshop in Lausanne in 1984 and the workshop in La Thuile in 1987 where a comprehensive comparison of the physics potential and technical feasibilities of proton-proton colliders (at that time the US SSC project and CERN's LHC) and electron-positron linear colliders (at that time CLIC) were made.

The outcome was that SSC, with its higher energy, and LHC, with higher luminosity, were regarded as competitive in most areas, and that a 2 TeV electron-positron collider like CLIC would be quite complementary to a proton-proton collider.

However, it was felt that the technology for a 2 TeV linear collider would not be ready in the near future. When CERN followed the recommendation of the Rubbia committee on the long-term future of the Laboratory to head for the LHC, ECFA gave strong support, but many people remained uneasy with the overlap between the LHC and the SSC.

With the demise of the SSC in 1993, large areas of the American physics community were vitally affected and the shock threatened to propagate. In this delicate situation, the solidarity of the worldwide community, and in particular the international role of ICFA, restored stability. Following an initiative of Yoshio Yamaguchi, ICFA Chairman John Peoples and others initiated a series of emergency meetings which were attended by the leaders of all major particle physics laboratories. It was during those meetings in Fall 1993 and early 1994 that a worldwide consensus emerged for the LHC as 'the correct next step for particle physics at the high-energy frontier'.

ECFA and DESY

The groundwork had shown that electron-positron collider will have an extremely intriguing physics potential, complementary to a proton-proton collider. Since the top mass is around 170 GeV and several arguments seem to favour low masses for the Higgs particle(s), an intermediate energy linear collider of around 0.5 TeV total energy may be an extremely interesting option. The technical challenge at this lower energy, while reduced, remains considerable.

The push for an electron-positron linear collider led in 1993 to the formulation of an Interlaboratory Memorandum of Understanding for a worldwide collaboration on research and development towards a TeV linear collider, initiated by DESY (Germany), KEK (Japan) and SLAC (USA) but signed by many collaborators worldwide. The general understanding is for an intermediate step at an energy of 0.5 TeV before attacking the final goal of 1 - 2 TeV. This memorandum was strongly supported both by ECFA and ICFA.

To aid these developments, ECFA has set up a panel for new accelerating techniques to closely monitor progress in research and development work towards a linear electron-positron collider.

Also, for the first time, a Plenary ECFA meeting was held in DESY to examine the efforts going into linear collider developments. An important part of this work is concentrated at DESY's TTF (Tesla Test Facility). Recently ECFA also decided to have regular Plenary Meetings at DESY (normally every two years), reflecting the increasing European and international role of DESY.

Being Chairman of ECFA may not be a very difficult job (although it sometimes is), but it is a very time-consuming one. I tried to count how many days I was away from Aachen in a busy year, say 1994, when the decision on LHC was pending. After going through my January diary, I decided it was easier to count the days I was in Aachen that year - 173, including weekends! This is barely enough to take care of an Institute, lectures, projects, and family, not to forget homework for ECFA. Still my ECFA Chairmanship was a challenging and exciting experience I would not have wanted to miss. However at the end of my term I was concerned to find how little this work was respected or even realized by many of my German colleagues.

EPS Accelerator Prizes

One of the European Physical Society's Interdivisional Group on Accelerators (EPS-IGA) Prizes goes this year to the DESY feedback group headed by Rolf Dieter Kohaupt for achievement and innovation in the accelerator field, for work on the theory of multibunch longitudinal and transverse feedback systems, the development of multibunch systems using digital techniques, its verification at DESY machines, and its wide significance for future machines.

The other EPS-IGA prize goes to Jeffrey Hangst of Aarhus for his work on bunched beam laser cooling at the ASTRID ring, Aarhus, and subsequently at Heidelberg. This latter award is traditionally for a young physicist or engineer having made a significant original contribution to the accelerator field in the past six years. The awards were made at the European Particle Accelerators Conference, Sitges, Spain, on 10 June.

The Kohaupt group award is in recognition of work done during the last eight years on the theory and application of multibunch longitudinal and transverse feedback systems in synchrotrons and storage rings. The ideas were successfully verified at several DESY machines, leading to greatly improved performance and even enabling the machines to exceed their design parameters. It has a wide significance for future machines, such as beauty factories. The principle consists of picking up a signal from a circulating particle bunch to register any deviation from its equilibrium orbit. The amplified signal generates a correction pulse on a fast kicker magnet or a fast

Rolf Dieter Kohaupt - multibunch feedback

cavity to correct transverse and longitudinal deviations for each bunch - provided an accuracy better than 2 ns is achieved throughout.

Specialists on digital data handling and ultrafast hardware contributed to the final success of the system, which is now well established in DESY machines - HERA , DORIS and PETRA as well as the injection synchrotrons - which would only be able to achieve a small fraction of their beam currents without their feedback systems. The system will now be tested with protons.

At Aarhus, Jeffrey S. Hangst has been developing laser cooling of fast ions in storage rings, in particular lithium and magnesium ions in Aarhus' ASTRID storage ring, and first proposed and demonstrated the laser cooling of a bunched beam, specifically magnesium.

Since a laser force repels ions, two lasers (one counter- and one co-propagating) are needed to longitudinally confine ions. As well as making it possible to handle the bunched beams of synchrotrons and storage rings, Hangst's work also

obviates the need to have two lasers - for a bunched beam, the radiofrequency cavity provides the second force. The laser cooling is so strong that the beam is longitudinally space-charge dominated, as shown by direct measurements of bunch lengths and velocity spread. The direct measurements of velocity spreads using a laser is another accomplishment of the laser cooling group at ASTRID, now headed by Hangst.

The motivation for laser cooling is to study and approach the ultimate state of an ion beam in an accelerator - an ion crystal. Application of bunched beam laser cooling is already seen as a way of obtaining the short bunches needed for heavy-ion-driven fusion.

(J.S. Hangst et al., Phys. Rev. Lett. 74 (1995) 4432)

VIETNAM
Preparing the ground

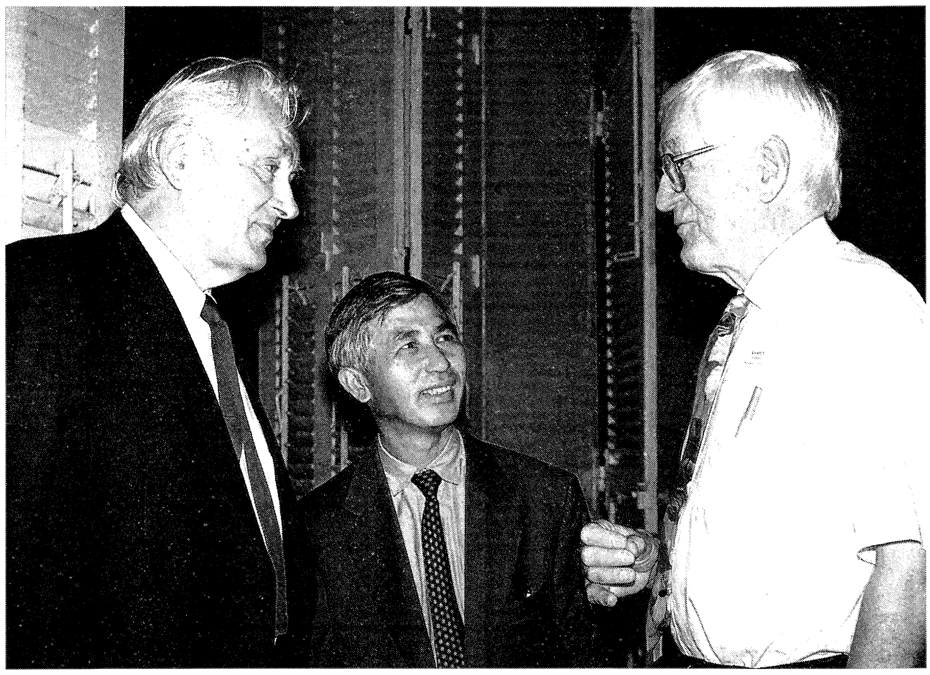
Physicists, unlike the physics they study, cannot operate in a vacuum. The stimulation and exchange of ideas needed for front-line research is difficult in isolated centres in developing countries. The arch example of this is Abdus Salam, who returned to his native Pakistan in 1951 after making his initial field theory contributions at Cambridge. Starved of research stimulation, Salam did not remain in Pakistan for long, and soon returned to Europe, for good, as it turned out.

Another example is the 'Rencontres du Vietnam', now held regularly in Ho Chi Minh City, and an established event on the international physics calendar. The first meeting, in December 1993, attracted 140 physicists from 23 countries. Last October, the second meeting attracted 230 physicists from 40 countries. Organized in two streams, particle physics and astrophysics, the meeting concentrated on two main themes of current interest. Introductory plenary talks were followed by more detailed parallel sessions. Common seminars emphasized the increasing interplay between these two themes.

The particle physics meeting - Physics at the Frontiers of the Standard Model - reflected emphasis on precision data on the three quark/lepton families. The astrophysics meeting - The Sun and Beyond - covered the continuing study of the Sun as a typical star, and an overview of the composition and evolution of other stars, together with the increasing awareness of the important role played by invisible 'dark matter'.

The presence of world authorities at these meetings and the high scientific standard of presentations helps avoid scientific isolation and provides a useful opportunity to make contacts and even to catalyse scientific collaboration. In this way Vietnamese scientists are able to make research progress without having to become scientific emigrants.

As well as the physics conferences,



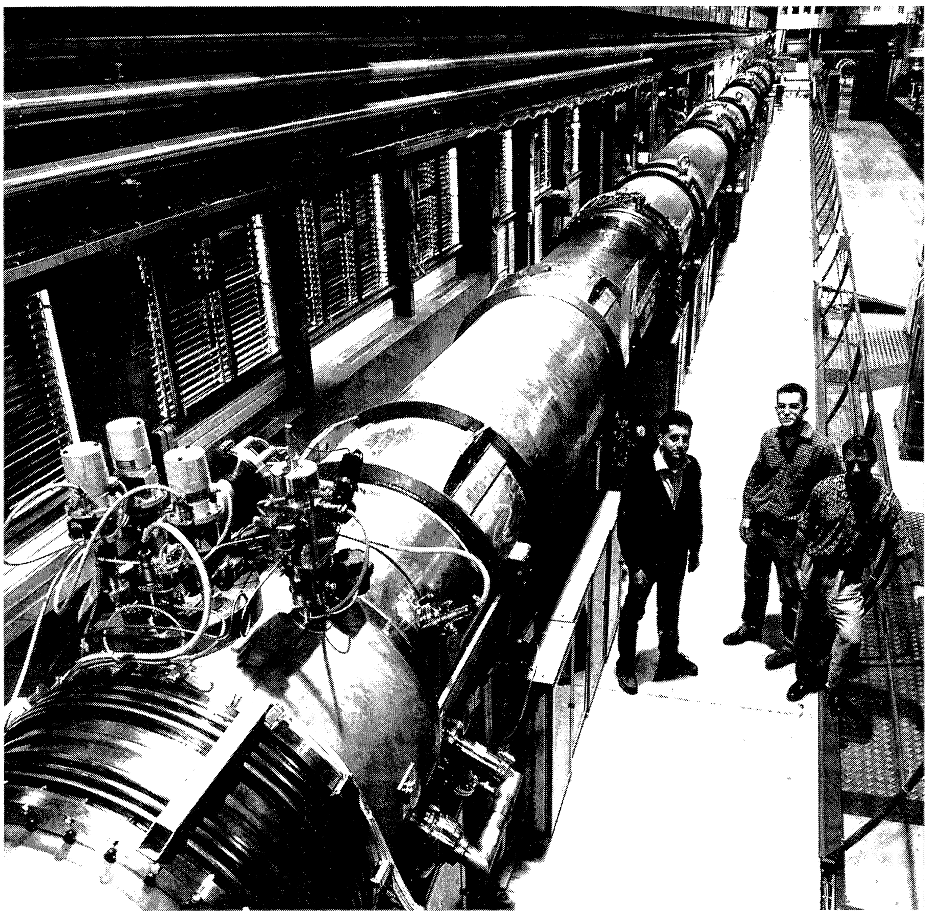
Nobel rencontre at the 'Rencontres du Vietnam'. 1992 Physics Nobel Georges Charpak (left) and 1989 Physics Nobel Norman Ramsey (right) with Jean Tran Thanh Van, the driving force behind the meetings, which have sparked considerable physics interest in Vietnam.

two physics schools have also been organized, one on particle physics and the other on advanced silicon technology and its applications to signal treatment. These special schools provide additional contact.

The Second 'Rencontres du Vietnam' received financial support from the European Union through the Cooperation with Third Countries and International Organization, from the French Foreign Ministry, from the US National Science Foundation and from the International Centre for Theoretical Physics, Trieste, Italy.

The Vietnam Rencontres are the brainchild of Jean Tran Thanh Van, who for many years has also organized the Rencontres de Moriond, which traditionally provide a glimpse of new results before the summer conference season.

Around the Laboratories



Now lengthened by the addition of a third 10-metre dipole, the 50 metre string of superconducting magnets for CERN's LHC collider has been tested for more than 1500 hours at its superfluid helium temperature of 1.9K.

CERN
Longer LHC string

Having operated for more than 1500 hours at its superfluid helium temperature of 1.9K, the string test of superconducting magnets for CERN's LHC collider continues to provides valuable information. Including also a quadrupole prototype and dummy correctors, the string, now lengthened by the addition of a third 10-metre dipole, takes up 50 metres, and resembles a half-cell of the final machine.

Mounted on a 1.4% slope, the steepest gradient in the 27-kilometre LHC ring, to rigorously test cryogenic flow, the string has been taken to magnetic fields of up to 9.1 tesla before quenching, compared to the LHC design field, now 8.3 T. A new feature will soon be an on-line monitoring link between the string test and the future LHC control room several kilometres away, to approach actual running conditions and for cycling tests to simulate ten years of LHC operation.

Four more 10-metre 'long models' of LHC magnets are under construction, while the first of two prototypes of 14.2-metre dipoles of the type envisaged for the LHC is scheduled to arrive at CERN for testing next summer.

Meanwhile CERN has been collaborating with cryogenics specialists Oxford Instruments to develop high temperature superconductor leads to feed high currents to LHC magnets. Using high temperature superconductor opens up the possibility of considerably reducing the cryogenic load.
The experimental lead assembly, designed by Oxford Instruments and incorporating BSCCO-2212 material from Hoechst, with 4K cooling at the base and 70K cooling at the top, has achieved 13kA on several occasions without performance degradation.

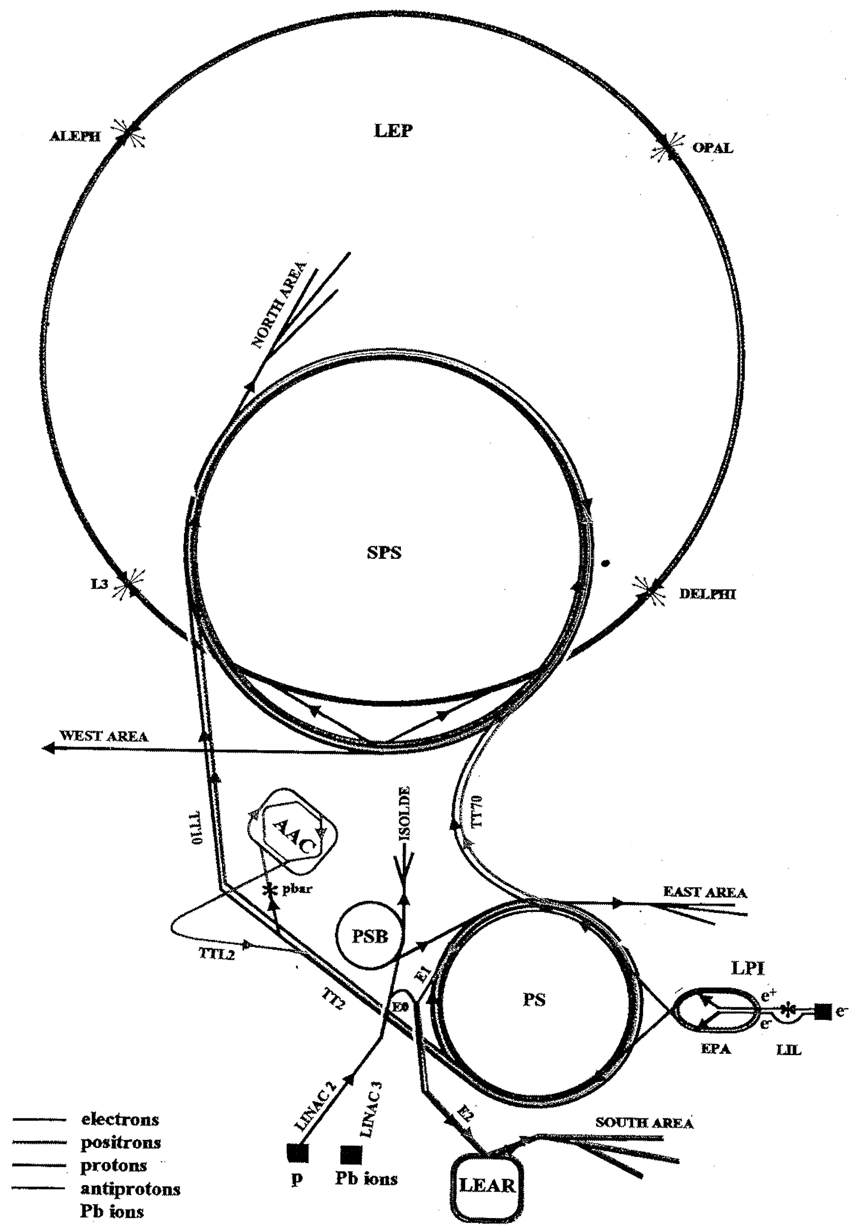
Still versatile after all these years

Almost forty years after its startup in 1959, when it accelerated protons from a 50 MeV linac, CERN's Proton Synchrotron remains the kingpin of CERN's complex particle beam system. In a branch of science where 40 years can mean ancient history, this is a remarkable achievement. It is as though one of Ernest Lawrence's original cyclotrons were still helping to investigate the Standard Model. (However with Brookhaven's Alternating Gradient Synchrotron, the sister machine of the CERN PS, also still going strong, it is clear that the right choice was made at the right time.)

The history and future plans of the PS closely track the history and aspirations of CERN itself. From its modest beginnings, the CERN PS has evolved to cover a complex of machines, with the PS itself serving a subtly interleaved menu of protons, antiprotons, electrons, positrons and lead ions of various energies and intensities. Far from deteriorating as it reaches middle age, PS performance continues to improve all round.

The main role of the 630-metre circumference machine is the injector for CERN's other main machines, operating for about 80% of each year to send beams to the 7-kilometre SPS proton synchrotron ring, and to the 27-kilometre LEP electron-positron collider via the SPS.

Throughout its history, the PS has had to learn new skills to adapt to fresh situations and as new requirements have emerged. Many ingenious beam manipulation techniques have been perfected - vertical/longitudinal recombination, bunch merging and splitting, control-



Schematic (not to scale) of CERN's existing interconnected beam system, with the PS at the hub.

led longitudinal blow-up, harmonic sweep,..... - while new ones are continually being developed. Now the PS complex has to face another new role as the proton and ion injector for CERN's future LHC collider.

The machines

The combined-function PS machine itself has three radiofrequency systems (9.5, 114 and 200 MHz), together with four injection and four extraction channels, and routinely processes five types of particles (protons, antiprotons, electrons, positrons and lead-53+ ions) at energies from 0.6 to 26 GeV and at intensities between 10^8 and 2.5 x 10^{13} particles per pulse (ppp).

The remainder of the PS complex consists of four injectors and two attendant machines served by the PS.

The four injectors are:

- Linac 2, providing protons since 1979 and currently producing 50 MeV pulses from 10 to 150 ms with an intensity of up to 180 mA on a constant 1.2 s repetition rate using a 50 MeV Alvarez three-tank structure operating at 200 MHz. Protons are produced by a duoplasmatron source coupled to a 750 keV RFQ (radiofrequency quadrupole);

- Linac 3, the most recent of the attendant PS machines, with a 100 MHz RFQ accelerating lead-27+ ions to 250 keV/nucleon, followed by a cascade of three interdigital-H structures (a variant of the original Wideröe technique) structures (one at 100 MHz, the other two at 200 MHz). Lead ions are injected from an ECR source supplied by GANIL, France, running in afterglow mode. After stripping by a carbon foil, Linac 3 delivers 25 mA of 4.2 MeV/nucleon lead-53+ ions in 400 ms pulses;

- the PS Booster (PSB), which will celebrate its 25th anniversary next year, using four vertically-stacked synchrotrons of 50 m diameter to accelerate the proton linac beams to 1.69 GeV and lead ions to 0.43 GeV/nucleon. Proton beam intensities range from a few 10^{10} to 3.10^{13} per 1.2 s cycle, while typical lead beam intensity is of the order of 3 x 10^8 ions per pulse. R.f. gymnastics in the Booster and transverse recombination in the extraction line allow for 5 to 20 bunches to be injected either into the PS or the ISOLDE on-line isotope separator; and

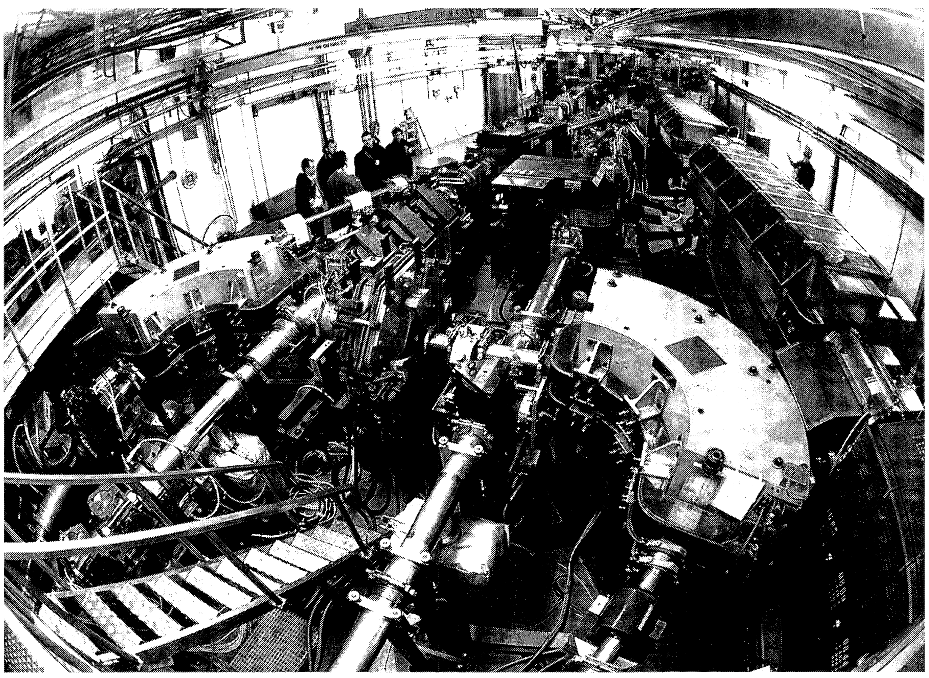
- The LEP Pre-Injector (LPI), a double (LIL-V and LIL-W) 100 Hz Linac providing alternate low current 500 MeV electron or positron beams to the EPA racetrack-shaped accumulator.

The two attendant machines are:

- the Antiproton Accumulation Complex (AAC), consisting of the original 1981 antiproton accumulator (AA), supplemented in 1987 by an antiproton collector (AC). Nine stochastic cooling systems are used in each ring. Up to 10^{12} antiprotons can be stacked in the AA for gradual extraction towards the PS; and

- the LEAR low energy antiproton ring, a unique 80 m synchrotron and storage ring for protons and

Fisheye view of a PS beam junction, showing from left to right, the proton injection line from Linac 2 leading to the Booster, the heavy ion injection line from linac 3 to the Booster, the ejection line from the PS to the LEAR low energy antiproton ring, the end of a 180° bend enabling particles from the linacs to be fed to LEAR, and finally a portion of the PS ring itself on the right (highly distorted due to the fisheye lens)



antiprotons equipped with six stochastic cooling systems, an electron cooler, a gas-jet target, and both fast and ultra-slow extraction systems.

The beams

For *protons*, the PS machine provides fast extracted protons to the antiproton conversion target or as test beam to the East Hall physicists. To serve the SPS, protons are extracted in a continuous transfer mode. The PS protons arrive via the Booster, but in addition to feeding the PS, a major role of the Booster is to provide dense 1 GeV proton beams to the ISOLDE on-line isotope separator.

Batches of $5x10^7$ magnetically-separated *antiprotons* produced in an iridium target are first cooled for 4.8 seconds in the AC, then transferred to the AA. Once sufficient 3.5 GeV antiprotons have been stacked, a single bunch is radiofrequency captured and ejected to the PS for deceleration to 609 MeV before being sent to LEAR.

To feed LEP, the 2A 180 MeV LIL-V *electron* beam produces positrons in a tungsten target. The 12 ns electron and positron beams are further accelerated to 500 MeV by LIL-W and longitudinally stacked in one of the 8 EPA buckets. While 5×10^{11} electrons are collected within a PS basic period of 1.2 s, it takes a full PS supercycle (from 14.2 - 19.2s) to accumulate the same amount of positrons. As EPA's circumference is one fifth of that of the PS, transfer between the two machines is achieved by firing the EPA extraction kickers eight times over five turns. The eight positron (and 1.2 s later electron) bunches are accelerated to 3.5 GeV in the PS with a dedicated 114 MHz system, then transferred to the SPS in 2 batches spaced by 30 ms, each batch consisting of 4 bunches.

Adapting the PS, designed to handle protons, for electron and positron work required some ingenuity. As the PS has a combined function lattice and a long acceleration cycle, beam stability is achieved by Robinson wigglers. The same wigglers and the 10 MHz proton r.f. system are used to match the longitudinal bunch size to the SPS requirements. Chromaticity and tune adjustments are achieved via main magnet pole face windings which also help with horizontal damping.

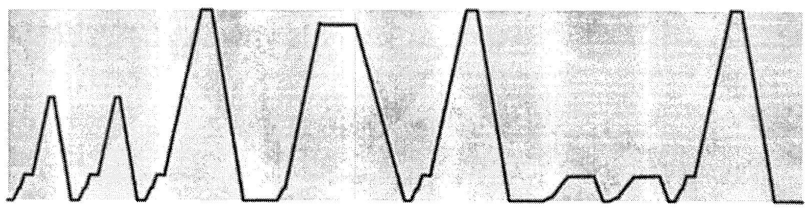
The 4.2 MeV/nucleon lead-53+ *ions* from Linac 3 are first accelerated to 95.4 MeV/nucleon in the Booster, where radiofrequency harmonic change is needed to cope with the large variation of beam velocity. The PS accelerates the ions using a dedicated, high sensitivity beam control, then extracts the 20 bunches to the SPS. They are fully stripped to lead-82+ by a 1mm aluminium foil in the transfer line.

Operation

The different PS clients are catered for simultaneously. The carefully designed PS 'supercycle' contains interleaved but separate component magnetic cycles, with one or several cycles allocated to each user. A typical supercycle during lead ion operation lasts 19.2s, but when protons replace ions for SPS fixed target physics, the supercycle is reduced to 14.4s.

For the pulsed machines, most parameters - several thousand for PS or Booster - must be refreshed from cycle to cycle to provide appropriate beam characteristics. Such 'pulse to pulse modulation' has regularly increased in complexity and flexibility during the past 20 years. Nowadays

14.4 sec. duration - PS SUPERCYCLE

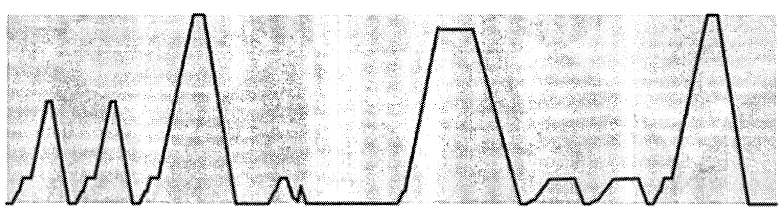


particle								
PS Energy (GeV/c)	14	14	26	24	26	3.5	3.5	26
user	SPS	SPS	AAC	EAST HALL	AAC	SPS LEP	SPS LEP	AAC
intensity	2.3E+13	2.3E+13	1.6E+13	3.E+11	1.6E+13	2.E+11	2.E+11	1.6E+13
PSB user & intensity			ISOLDE 2.9E+13	ISOLDE 2.9E+13	ISOLDE 2.9E+13	ISOLDE 2.9E+13	ISOLDE 2.9E+13	ISOLDE 2.9E+13

The different PS clients are catered for in a 'supercycle' containing interleaved but separate component magnetic cycles. The supercycle profile changes frequently during a run. In this example, the supercycle contains 2 proton cycles to feed the SPS and three proton cycles, spaced by 4.8 seconds, for antiproton production (AAC). Between these three cycles are a proton cycle to supply the PS' own experimental area (East Hall), and two cycles to feed LEP, one containing electrons, the other positrons. Cycles from the Booster not required for the PS feed the ISOLDE on-line isotope separator.

When LEAR wants antiproton beam, the PS supercycle automatically adapts, the East Hall cycle shifting by 2.4 seconds to insert a LEAR feed after a cycle for antiproton production. Meanwhile ISOLDE gets a bonus cycle.

14.4 sec. duration - PS SUPERCYCLE



particle				pbar					
PS Energy (GeV/c)	14	14	26	3.5 0.6		24	3.5	3.5	26
user	SPS	SPS	AAC	LEAR	ZERO	EAST HALL	SPS LEP	SPS LEP	AAC
intensity	2.3E+13	2.3E+13	1.6E+13	2.E+09 to 5.E+10		3.E+11	2.E+11	2.E+11	1.6E+13
PSB user & intensity			ISOLDE 2.9E+13	ISOLDE 2.9E+13	ISOLDE 2.9E+13	ISOLDE 2.9E+13	ISOLDE 2.9E+13	ISOLDE 2.9E+13	ISOLDE 2.9E+13

a menu of up to 24 beams can be accessed and instantly slotted into the supercycle.

The supercycle profile changes frequently during a run according to the pre-established accelerator schedule or even in real time, to adapt to users' requests. If a particular user stops taking beam, other main users can accept or decline the beam and, in the latter case, a backup user is automatically selected. This happens, for example, when the supercycle is temporarily modified for occasional antiproton transfers.

The scheduled running time of the PS Complex for 1996 exceeds the all-time record of 6800 hours, with about 5600 hours devoted to antiproton physics (4900 in 1995). The annual fault rate of each machine is currently between 1% and 5%, making the PS the most reliable of CERN's machines.

Future

The future of the PS reflects CERN's ongoing research plans. LEP energy is scheduled to increase up to a maximum of 96.5 GeV/beam in the middle of 1999. Leptons need then to be delivered until or slightly later than the year 2000. If the LEP-LHC electron-proton collider option is exercised, leptons will be again needed later.

For LHC protons, solutions have been designed to meet stringent requirements of the beams with limited modifications to the PS complex itself. The major issues are the increase of the Booster to PS transfer energy from 1 to 1.4 GeV and the installation of new r.f. systems in the Booster and the PS. Following the demonstration of the feasibility of the proposed scheme in 1993 (March 1994, page 8), installation is due for completion in 1999. A continuing programme of fixed target physics in the SPS North Area and probably neutrino physics with 450 GeV primary protons will maintain a strong pressure for proton beams of increased intensity from the PS complex well after 2005.

For lead ions, a low energy ion accumulator ring is foreseen, stacking multiple pulses from Linac 3 running at 10 Hz, and increasing beam density in all planes with electron cooling. Some demonstration tests have already been carried out using the LEAR ring and more are foreseen before LEAR shutdown early in 1997.

For the PS experimental area itself, requests for beam time after the year 2000 are increasing, mostly for calibration of LHC detectors. A project for upgrading the East Area has been submitted for approval.

For antiprotons, the present antiproton facility with its three dedicated machines (AC, AA and LEAR) will stop delivering beam at the end of this year. A low-cost installation, the Antiproton Decelerator (AD), is proposed for the existing hall, using parts from the AA and AC. Mostly run by physicists, it would collect, cool, decelerate and eject a tenth of the present antiproton flux to a small number of precision antiproton experiments.

Ten years from now, when the PS will be nearing its half-century, it will still be the hub of CERN's particle beam system.

Micro-strips in action

With the experimental conditions expected at CERN's future LHC collider posing all manner of challenges, a vigorous detector research and development programme launched at CERN in 1990 is blazing a wide trail towards LHC experiments. One overriding concern is that the emerging particle fluxes will largely exceed the capability of most existing position-sensitive detectors.

A major thrust to overcome this obstacle was summarized in the final status report of the RD-28 collaboration, presented at the February meeting of the LHC Committee, covering three years of intensive and successful research on a new family of fast position-sensitive detectors: the Micro-Strip Gas Chambers (MSGCs).

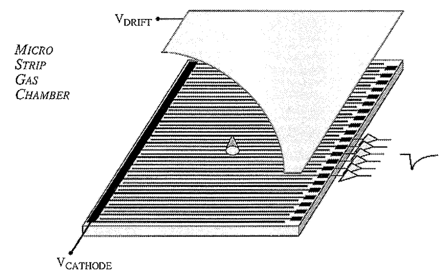
Invented in 1988 by Anton Oed at the Institut Laue-Langevin (ILL) in Grenoble, MSGCs consist of two sets of thin interleaved metal strips (anodes and cathodes respectively), engraved on an insulating support, and of a gas volume, the sensitive region, delimited by a drift electrode, as shown in the diagram. Suitably chosen potentials allow ionization trails released in the gas by radiation to be to collected, amplified and detected.

The structure is reminiscent of the "old" Multiwire Proportional Chamber introduced by Georges Charpak twenty years ago, and since used extensively in various disguises. However photo-lithographic techniques achieve a density of ten strips per millimetre, an order of magnitude better than what can be achieved with wires.

Rate capability and multiparticle resolution are correspondingly improved, making MSGCs suitable for use at high luminosity colliders like the LHC: a full tracker can be assembled with a large number of plates mounted in suitable geometry (20,000 modules are foreseen for the CMS experiment). Two-dimensional localization can be obtained by engraving pickup strips on the back of thin supports, opening up the exciting possibility of using the device for high rate medical imaging with X-rays.

It is a very promising device ....except for one fundamental detail: at high rates, electrons and ions, copiously produced by the avalanches in the gas, tend to stick to the insulating substrate, inducing distortions in the electric field and a rapid deterioration in performances.

The obvious solution is to use a substrate with moderate surface conductivity to leak and neutralize these unwanted charges. Simple considerations show the desired resistivity to be around 10^{15} ohms/square. Unfortunately this is just in between a bad conductor and a good insulator: such materials are difficult to find and are anyway inappropriate for photo-lithography. A major effort of the RD-28 collaboration and the other groups investigating this problem has been to find suitable supports or surface-conditioning technologies to satisfy these requirements. In the RD-28 collaboration,



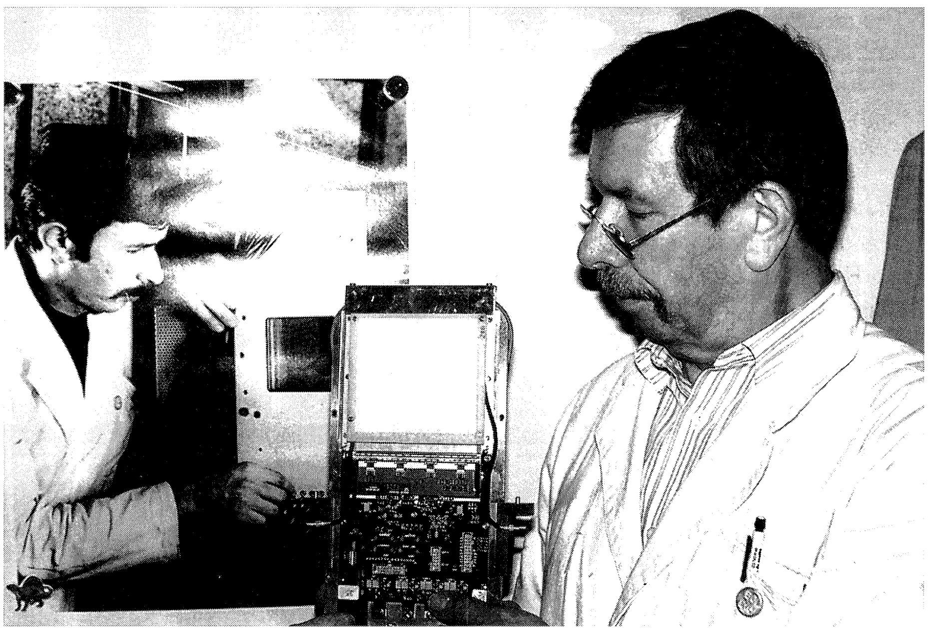
Micro-Strip Gas Chambers (MSGCs) promise to be able to handle the high data rates expected at CERN's future LHC collider. MSGCs consist of two sets of thin interleaved metal strips (anodes and cathodes respectively), engraved on an insulating support and a gas volume delimited by a drift electrode. Suitably chosen potentials allow ionization trails released in the gas by radiation to be to collected, amplified and detected.

this line of research is pursued by the Budker Institute of Nuclear Physics, Novosibirsk.

Very good results have been obtained with electron-conducting, or Pestov glass (so named after the Russian physicist who developed this special material for a different family of detectors, the Resistive Spark Counters). This is a valid option, but thin, inexpensive resistive glass is still under development and is not yet industrially available.

Of many alternatives, the most promising has been developed jointly by the CERN-PPE-GDD group (led by Fabio Sauli) with two industrial partners, Surmet Corp. of Burlington, MA (USA) and IMT Masken und Teilungen AG of Greifensee, Switzerland. Using a proprietary process, Surmet is able to coat standard thin boro-silicate glass with a diamond-like layer 100 nanometres thick and the desired resistivity. 'Diamond' coating has recently become a standard technique for hardening tools. The layer is built up by passing a low-pressure discharge in gases containing carbon (e.g. methane). Plates 12 inches square can be treated at present with a process that is simple, cheap and could be used industrially for coating surfaces up to square metres, but for position-sensitive detectors it is important to achieve a sufficiently high resistivity.

The MSGC structure is reminiscent of the Multiwire Proportional Chamber introduced by Georges Charpak twenty years ago. However photo-lithographic techniques used with MSGCs achieve a density of ten strips per millimetre, an order of magnitude better than what can be achieved with wires. Here Roger Bouclier holds a fully equipped MSGC ready for installation. In the background is a similar picture of Bouclier taken in 1968 with the first Multiwire Proportional Chamber.



MSGCs manufactured on diamond-coated glass have successfully passed a complete set of endurance tests simulating LHC conditions. The stability in time of resistivity has been verified in a wide range of ambient conditions, and in standard accelerated irradiation tests the detectors have shown no degradation after a dose equivalent to ten years of continuous operation at LHC. The data rate capability of the diamond-coated detectors, several MHz/mm^2, largely exceeds the challenging physics requirements.

A set of full-size detectors using this design has been built by the CMS-MSGC tracking group, and is presently installed in a high intensity beam at CERN for a long-term test aimed at acquiring operating experience.

In one of the possible choices, gold is used as metal for the strips, making the gold-on-diamond chambers a rather ornamental item. However the quantity of precious materials used (less than one tenth of a gram for the whole active area of the CMS tracker) should discourage burglars!

Thin diamond-coated resistive electrodes are robust, cheap to manufacture and radiation hard; the range of surface resistivity that can be obtained spans over many orders of magnitude, 10^9 to 10^{16} ohms/square. This would allow the technology to be applied to other detectors whenever surface charge problems are encountered, such as Resistive Plate Chambers, or where the electrodes need to be partly 'transparent' to the signals detected on external readout electrodes (Cathode Readout Chambers). Applications in these related fields are being investigated by the CERN-GDD group, and may lead to alternatives to existing solutions for LHC detectors.

From Fabio Sauli

JEFFERSON/CEBAF Dedication

24 May saw the dedication by US Secretary of Energy Hazel O'Leary of the Thomas Jefferson National Accelerator Facility at Newport News, Virginia, formerly known as CEBAF - the Continuous Electron Beam Accelerator Facility.

Laser development underway

The new Thomas Jefferson National Accelerator Facility at Newport News, Virginia, formerly known as CEBAF - the Continuous Electron Beam Accelerator Facility - has begun developing high-average-power, wavelength-tunable free-electron lasers (FELs) based on superconducting radiofrequency (SRF) electron-accelerating technology.

The lab's 4 GeV SRF accelerator came on-line for nuclear physics experiments in November 1995 (March 1996, page 12). The FELs are being developed for cost-effective production applications in manufacturing and for basic and applied research related to directed-energy weapons technology. In principle, coherent, high-brightness, monochromatic laser light offers an efficient, spatially and chemically precise, and environmentally benign way to process materials, as in surface-modifying polymers and metals and in micromachining.

However, cost, capacity, wavelength, and pulse-length constraints have limited progress with these and other conventional

Top - on 24 May, US Secretary of Energy Hazel O'Leary dedicated the new Thomas Jefferson National Accelerator Facility at Newport News, Virginia, formerly known as CEBAF - the Continuous Electron Beam Accelerator Facility.

Below - a proud day for Thomas Jefferson National Accelerator Facility Laboratory Director Hermann Grunder (left), with 1995 Nobel laureate Martin Perl, who, with D. Allan Bromley of Yale, was among the speakers at the inauguration ceremony.

(Photos David Ellis)

light sources. It is expected that overcoming these constraints would lead to new or improved products ranging from cheap, easily disposable packaging and natural-texture polymer fabrics to improved components for information technology and electronics.

Corporations including DuPont, 3M, Lucent Technologies (a new spinoff of AT&T and Bell Labs), IBM, Xerox, and Northrop Grumman believe SRF-based FELs hold substantial promise for overcoming the constraints, and have joined with research universities and Jefferson Lab to develop them.

Planning has been underway for some time (September 1994, page 20), and a high-brightness CW photoemission electron source has been under development for two years, both in preparation for building a demonstrator FEL and as part of an electron-source development program for the main accelerator.

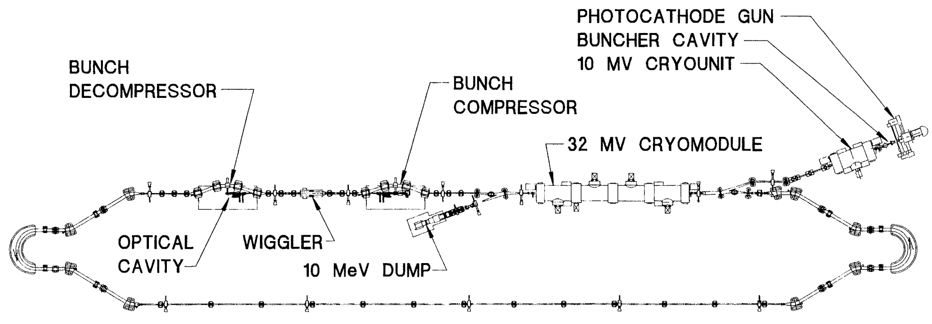
The industrial FEL goals are a kilowatt-scale ultraviolet demonstrator FEL, to be followed by scale-up to a 100 kW prototype device for cost-effective use at industrial sites. The UV wavelength range of interest is 190 to 350 nanometres, especially wavelengths below 250 nanometres. Because of a substantial congruence with the industrial FEL's technical goals, the US Navy has recently provided some $8.1 million to build a kilowatt-scale infrared demonstrator FEL with wavelengths from 3.0 to 6.6 micrometers. The device will be housed in a new two-story building on the Jefferson Lab campus. This user facility, funded with $3.6 million from the state of Virginia, is being placed near the main accelerator's 4.5 kW refrigerator to tap its excess liquid helium capacity. Construction is to begin this summer.

FEL R&D is being conducted as an activity synergistic with the lab's main mission of running - and over time improving - an SRF electron accelerator for physics experiments. The effort's key technical challenges lie in the continuing development of high-gradient, high-reliability SRF accelerating cryomodules and high-brightness electron sources.

The FEL linac and the FEL injector require, respectively, energy gain of 32 MeV (8 MeV/m gradient) in a single cryomodule and 10 MeV (10 MeV/m) in a cryounit (a quarter-cryomodule) - specifications considered attainable based on experience with cavities operating well above the 5 MeV/m originally specified for the main accelerator.

Average quality factor Q at 8 MeV/m has been 6 x 10^9, twice the Q needed for the FEL linac. Some of the cryomodule components are being modified to handle the FEL's higher peak and average current. FEL average current requirement is 5 milliamperes. The 10 MeV injector must provide CW beam at this current with bunch charge of 135 picocoulombs, bunch repetition rate variable by factors of 2 from 2.3 to 37.4 megahertz, normalized rms transverse emittance of 8 millimetre-milliradians, bunch length of 1.5 picoseconds at 1 sigma, and rms longitudinal emittance of 20 keV-degrees.

The injector's most technically demanding component is the 500 kV DC gallium arsenide photoemission gun. It has been designed in collaboration with the University of Illinois, based on experience with an earlier gun at SLAC. DC was chosen because room-temperature r.f. structures require very high-average-



In the Jefferson Lab (ex- CEBAF) infrared free-electron laser, 10 MeV electrons will be accelerated in an eight-cavity cryomodule before transiting a wiggler, where they will yield about 1% of their energy for the production of light in an optical cavity. Following recirculation to the injection point, most of the electrons' unspent energy will be recovered via deceleration and conversion back into radiofrequency power.

Superconducting radiofrequency and a free-electron laser

In a free-electron laser, unbound (free) relativistic electrons are transported from a linear accelerator to undulate transversely in the sinusoidal magnetostatic field of a "wiggler." The resulting light output is initially spontaneous emission, but the light bounces back and forth inside an optical cavity until it is amplified to saturation. Whereas a conventional laser typically produces a single wavelength, light from a free-electron laser (FEL) can be tuned throughout a wavelength range by varying the input electron energy or the magnetostatic field. With a continuous wave input beam, the FEL can produce its wavelength-tunable light at high average power. The linac that provides such a CW electron beam is the technological heart of an FEL, and a superconducting radiofrequency (SRF) linac can make the FEL cost-effective. SRF's high accelerating gradients translate into a compact design with lower capital cost than for a corresponding room-temperature linac. The negligible r.f. losses allow a high rate of recovery of the 99% unspent energy in the beam after it transits the wiggler. The energy-recovery process, with the beam returned to the SRF cavities for conversion back to r.f. power, translates into a lower operating cost.

power CW r.f. power sources and are thermally limited in gradient capability, and because the technology of CW r.f. guns based on superconducting cavities is not mature. The photoemission cathode was chosen to attain short pulse length and low emittance. Moreover, a thermionic emitter, with needed beam conditioning, would lead to emittance growth and would be very hard to scale later for higher-average-current beams. Use of gallium arsenide integrates with nuclear physics programme goals. To overcome the gun's technical challenges requires excellent vacuum conditions in the vicinity of the photocathode and limited field-emission currents from the electrode structures. Wiggler and optics requirements for the infrared FEL are substantially within the state of the art. On a schedule defined as quite aggressive, first light is planned for late 1997.

BROOKHAVEN Radiation biology

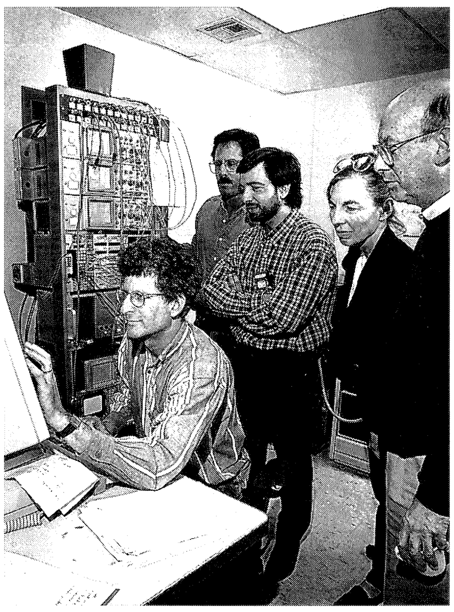
The Alternating Gradient Synchrotron (AGS), which began operations in 1960, added a new item to its répertoire when it carried out its first radiobiology experiments last October, using a 1.1 GeV/nucleon iron-56 (26+) beam for investigations on the effects of space radiation on biological systems.

Related physics experiments measured the interaction and transport properties of the beam interacting with tissue-equivalent and radiation shielding materials. These experiments will provide basic information on the effects of the radiation field produced by galactic cosmic rays and heavy ions incident on spacecraft and planetary habitats and their occupants, and the ability of organisms to resist and repair such damage. Iron is the heaviest element present in significant quantity in the galactic cosmic rays.

Biologists from Brookhaven, the Lawrence Berkeley National Laboratory, Los Alamos, the University of California, San Francisco, the Jet Propulsion Laboratory, the University of Maryland-Baltimore County, Colorado State, Georgetown, and the Johnson Space Center brought samples including isolated DNA, cultured mammalian cells and nematode worms for irradiation.

These experiments are expected to provide biological information on short term physiological effects as well as molecular alterations of DNA and genetic changes. The collaboration also included physicists from Berkeley, Colorado State, and Virginia State, with strong support from AGS physics and operations staff. The dosimetry and beam

Radiation biology gets under way at Brookhaven's Alternating Gradient Synchrotron. Ken Frankel (Lawrence Berkeley National Laboratory, seated) in the physics run control room monitoring beam parameters, observed by (left to right) Jack Miller (LBNL), Marcelo Vazquez (Brookhaven), Betsy Sutherland (Brookhaven), and Walter Schimmerling (NASA).



characterization, critical for accurate interpretation of biology experiments, used detectors and software developed for the Bevalac biomedical program, adapted for the AGS by the former Bevalac program staff.

A radiobiology target area and an experiment station containing a run control and dosimetry unit, a temporary animal-holding room, and a cell culture/biochemistry unit were constructed at the AGS for the run. After irradiation, samples were transported to home institutions or to long-term experimental facilities provided by Brookhaven's Medical Department. AGS liaison physicist Don Lazarus, Biology Department liaison radiobiologist Marcelo Vazquez and Medical Department liaison scientist Mike Bender provided scientific support. The AGS's Bill McGahern provided engineering support, and Ed Lessard (AGS) and Jim Bullis (Medical) supervised safety and training. Darcy Mallon (Medical) provided user administrative support for the run. Financing came from the Space Radiation Health Program, Life and Biomedical Sciences and Applications division of the National Aeronautics and Space Administration.

(Further information from either P. Pile, AGS, e-mail, Pile@bnldag.ags.bnl.gov or B. Sutherland, Biology Department, e-mail,Sutherl3@bnl.gov)

Betsy Sutherland

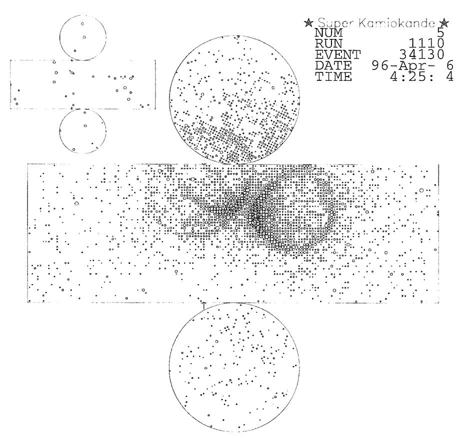
JAPAN
Super-Kamiokande sees its first neutrinos

After four years of construction, the giant Super-Kamiokande water Cherenkov detector began operations as scheduled on 1 April. A thousand metres underground in the Kamioka zinc mine in Gifu prefecture in central Japan, Super-Kamiokande is a joint Japan/US project to observe neutrinos from space and is operated by Tokyo's Institute for Cosmic Ray Research.

As well as neutrinos from the sun and from cosmic ray interactions in the atmosphere, Super-Kamiokande could, like its predecessor Kamiokande detector, also pick up neutrinos from supernova explosions. Kamiokande neutrinos from the 1987A supernova helped establish the new discipline of neutrino astronomy.

Super-Kamiokande, some 40 metres high and 39 metres in diameter and containing 50,000 tonnes of water, is equipped with about 11,200 20-inch photomultiplier tubes for the inner part of the detector (32,000 tonnes), supplemented by about 1,800 eight-inch tubes for the 18,000-tonne outer part of the detector.

Super-Kamiokande is currently operated at a trigger energy of about 6 MeV, which will be lowered below 5 MeV as the quality of the water improves. First atmospheric neutrinos have been picked up, and the group is looking forward to its first solar neutrino contributions.



Event display of one of the first atmospheric neutrino events observed with the new Super-Kamiokande water-Cherenkov detector, with the secondary particles producing three distinct Cherenkov rings. This expanded view of the cylindrical detector, some 40 metres high and 39 metres in diameter and containing 50,000 tonnes of water, shows the top and bottom of the detector, and its sides 'unwrapped'. The small circles show which of the 11,200 inner photomultiplier tubes have registered Cherenkov photons. The area of each individual photomultiplier circle is proportional to the charge output of the respective tube.

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please see page III

SERPUKHOV 70 GeV proton machine in operation

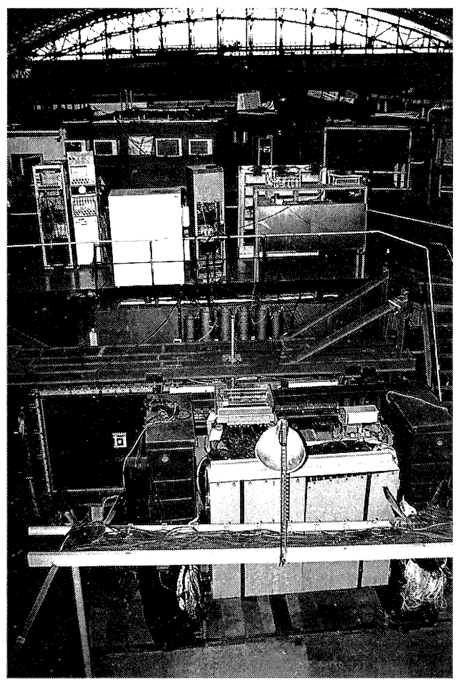
At the beginning of February, the U-70 70 GeV proton accelerator at the Institute for High Energy Physics (IHEP) at Serpukhov, near Moscow, started first 1996 run, an important event for IHEP and for Russian high energy physics.

The 14 months since the previous run had been used to upgrade the accelerator. So far 73% of the old goffered vacuum chamber have been replaced by a smooth one. 240 hours after its startup, the accelerator began to operate for physics with efficiency above 90%, and total running time with beam was more than 1200 hours.

Many groups of physicists from Russia, from the Joint Institute of Nuclear Research (JINR), and from CERN, the USA and Japan take part in the U-70 experimental programme. During this run four experiments finished data-taking.

The VErtex Spectrometer experiment (VES, IHEP) is searching for exotic mesons. The main goal during this run was to take as much data as possible on the 30 GeV negative kaon interactions. Secondary negative beam from an internal target at 20 mrad contains 3.5% of kaons. During 700 hours, 5×10^8 events of negative pion and negative kaon interactions on beryllium were logged. Such statistics give an opportunity to continue the VES search for exotic meson states where some interesting results had already been obtained on exotic states and rare decay modes.

During VES data-taking, the extraction of the U-70 proton beam



The VES - VErtex Spectrometer - experiment is searching for exotic mesons at the U-70 70 GeV proton accelerator at the Institute for High Energy Physics (IHEP) at Serpukhov, near Moscow.

using a bent crystal was also tuned. This technique is being increasingly studied for future high energy beam extraction.

The PROZA experiment (IHEP/ JINR/Tbilisi) setup is studying single-spin asymmetry of inclusively-produced negative pions on the polarized target. This run considerably increased the total statistics, which have now reached 2×10^7 events, allowing single-spin asymmetry to be studied up to a transverse momentum of 3 GeV.

EXCHARM (JINR) is studying the production of narrow baryon states by high energy neutrons (average energy 50-60 GeV). During the recent run this experiment also finished data-taking.

The IHEP-JINR Neutrino Detector is searching for electron-neutrino oscillations, with the usual wideband neutrino flux enriched by electron neutrinos. This gives lots of electron-neutrino interactions and the expected number of events is comparable with what is actually detected. This experiment has also finished data-taking. Besides physics data-taking, some research and development tests were performed for new detectors for the future UNK and LHC machines at IHEP and CERN respectively. GAMS-4π (a long standing study of exotic states and now a joint IHEP/ CERN/Japan experiment), SPHINKS (exotic baryon search), FODS (2-arm spectrometer), SVD (charm production) and the Target Neutrino Facility with its 600-ton liquid argon calorimeter have been tested with beam for the U-70 run planned for this fall.

BELGIUM Survey

Continuing its continual monitoring of particle physics activities in CERN Member States, the European Committee for Future Accelerators (ECFA) met in Brussels in March.

After the proposal for what would become CERN was launched in 1949, Belgium was one of the first countries to rally round the project, and ever since has remained a staunch supporter. Belgium's current contribution to CERN is 33.1 million Swiss francs (3.53% of the budget).

Belgian particle physics experimentalists now number of the order of 75, about 24 of whom are Flemish and 36 French-speaking, together with 15 Flemish physicists working on the ISOLDE on-line isotope separator.

At present experimental research is

In the early 1950s, Belgium was one of the first countries to rally round the CERN flag, and ever since has remained a staunch supporter. In more recent times Paul Levaux, Secretary General of the Belgian National Fund for Scientific Research and CERN Council President from 1975-77, has played a leading role in cementing CERN-Belgium ties.

mainly concentrated on Delphi at CERN's LEP electron-positron collider, the Chorus neutrino experiment at CERN's SPS synchrotron, the CMS experiment for CERN's new LHC collider, and at the HERA electron-proton collider at DESY, Hamburg.

Despite the full federal structure now implemented for research, there is a good collaboration among the research centres, ULB (Brussels), Louvain-la-Neuve and Mons on the French side, and VUB (Brussels) and Antwerp on the Flemish side. KUL (Leuven Catholic University) and Gent participate in the ISOLDE programme.

There are about 45 theorists, with three main groups: ULB-Brussels, Louvain-la-Neuve and KUL-Leuven, together with smaller groups at Mons, Liège, VUB-Brussels and Gent.

There is a very strong national involvement in the LHC, with the five laboratories active at CERN all collaborating in CMS, with special interest in the forward part of the central tracking detector and in microstrip gas counters. Some aspects of the associated research and development work are carried out in collaboration with the Public Technology Centre (IMEC, Leuven).

National 1995 funding showed only a 1% increase, which does not compensate for inflation, and there are only a limited number of new positions. Nuclear physics and related fields benefited from a strong development in the fifties and sixties which is reflected in staffing levels. Funding for large equipment comes from national lottery revenues.

Belgium has always tried to pool national research resources despite the federal system where research funding is well separated into cultural components (under the Ministry for Research and Culture). Belgium's contribution to CERN appears in the budget of the Ministry for Economic Affairs. Operating funds for particle physics research come predominantly from the National Fund for Scientific Research (whose Secretary General Paul Levaux was President of CERN Council from 1975-77) together with some money from the Universities.

Belgian heavy industry has been awarded significant CERN contracts (magnet coils, power supplies, magnet steel and air-conditioning). At present, there is interest in the production of materials and components for LHC magnets. The research institute (IMEC), with close links to KUL, is a European leader in customized integrated circuits, and the Belgian CMS collaboration plans to collaborate with them on silicon detectors. There is expertise in beam diagnostics at Louvain-la-Neuve, which is also a world-class centre for medical cyclotrons and their applications.

HEPiX

Videoconferenced live over MBONE, the latest meeting of HEPiX (the high energy physics UNIX users group - March 1994, page 18) was held at the Canadian TRIUMF laboratory in Vancouver from 10 - 12 April. Around 20 laboratories from Europe and North America were represented.

As well as familiar UNIX subjects such as file systems, mail agents and the like, the programme covered also included several theme sessions, for example on disk, tape and data storage, on methods for access to PC Windows applications from UNIX, a talk about LINUX, the public domain UNIX for PCs, and a full day devoted to UNIX batch systems.

A round table of experts explained how disk space management is handled in the major high energy physics sites and covered such areas as storage management, archiving of data, hierarchical storage methods, etc.

There was an open discussion session on interchanging experimental data between labs and user sites: an attempt was made to define some guidelines for standardization but it was felt that the tape market was moving too quickly just now to make a meaningful choice. None of the newer, larger tape media have the reliability we have come to expect from 3480s. This will be kept under review with the aim of giving guidance to smaller sites on hardware purchase.

On the other hand, it was agreed that recommending only 200MB files on tape probably did not make sense any more and that, barring technical side effects, high energy physics sites should consider raising this to something like a 1GB maximum filesize. Also, all sites were reminded that exported tapes should always have magnetic tape labels. There are several pieces of software available to help with this.

The final day was filled by sessions about batch systems. In the morning individual batch systems used at different sites were presented, a highlight being the CONDOR presentation by one of its authors. (CONDOR utilizes "spare" CPU cycles in workstations and desktops at a site, for example when the owners of workstations are not at their desks.)

In the afternoon, it was agreed to try to define a common user interface for batch since it was quickly realised that for various reasons, historical and financial, it would be extremely difficult to standardize on a single scheme for all major sites.

The minutes of the meeting are being written up but most of the overheads presented during the meeting can be consulted at URL http://www.triumf.ca/hepix96/program.html

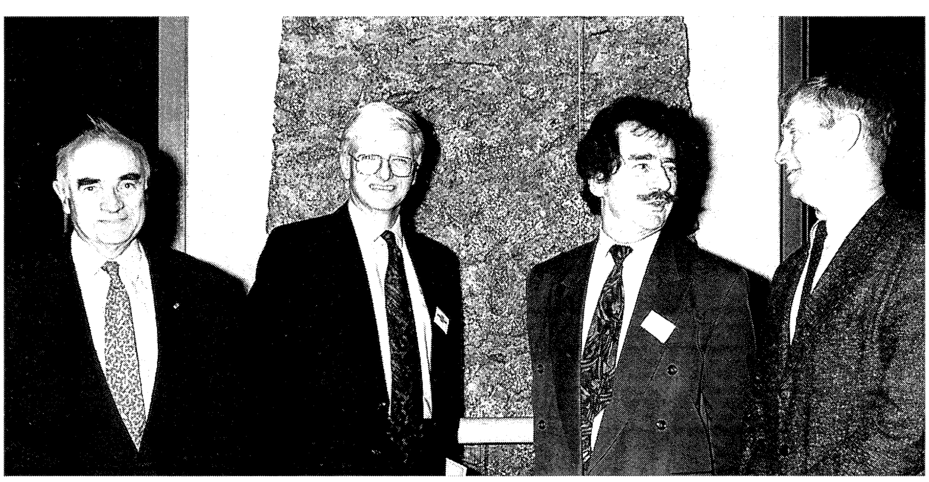
The next meeting of HEPiX will take place at CASPUR in Rome on 23-25 October. Featured themes will include X11, security and possibly mail. The day before, October 22, HEPiX will sponsor user tutorials on one or perhaps two topics. All information about the forthcoming meeting will be published in the HEPiX newsgroup, HEPNET.HEPIX, over the summer.

Alan Silverman, Chairman, HEPiX

FRANCE
IN2P3 = 25

The French National Institute for Nuclear Physics and Particle Physics, better known under its abbreviation IN2P3, celebrates its 25 anniversary this year. Born on 14 April 1971 under the direction of Jean Teillac, the creation of an institute under the umbrella of the Centre national de la recherche scientifique (CNRS), grouping university and CNRS resources, answered the need to manage projects of semi-industrial proportions in an increasingly international context.

To demonstrate the fruits of this decision after a quarter of a century, top scientific administrators from France and from Europe spoke on 10 April at the National Museum of Natural History in Paris. The event was opened by CNRS Director General Guy Aubert, who was followed by five speakers: former IN2P3 Director Jean Yoccoz describing the 'government' of the institute's laboratories; President of CERN Council and former minister for research Hubert Curien spoke of IN2P3's role in French research; Paul Kienle, former chairman of the NuPECC Nuclear Physics European Collaboration Committee, addressed IN2P3 contributions to nuclear physics: CERN Director General Chris Llewellyn Smith covered CERN-IN2P3 relations; and IN2P3 Director Claude Détraz concluded with a perspective on nuclear and particle physics research.



At the 25 anniversary celebrations of the French National Institute for Nuclear Physics and Particle Physics, better known under its abbreviation IN2P3. Left to right, President of CERN Council and former minister for research Hubert Curien, CERN Director General Chris Llewellyn Smith, IN2P3 Director Claude Détraz, and Edouard Brézin, Chairman of the Council of Administration of the Centre national de la recherche scientifique (CNRS).

(Photo CNRS - Nicole Tiget)

Bookshelf

Besuch im Teilchenzoo, Vom Kristall zum Quark. Pedro Waloschek, Rowohlt Taschenbuch Verlag, 1690- ISBN 3 499 19741 3

After his in-depth biography of accelerator pioneer Rolf Wideröe (October 1994, page 30), CERN Courier DESY correspondent Pedro Waloschek takes a lighter approach to add yet another feather to his literary cap with 'Teilchenzoo', a sort of 21st century update of Alice in Wonderland - or rather Barbara in Wonderland. The heroine, a non-scientist, is persuaded to enter a 'particle zoo', where all sorts of imaginary situations become real. Good idea, Pedro.

Quark-Gluon Plasma 2, edited by R.C. Hwa, World Scientific, ISBN 981-02-23994, 784 pages £58 hbk

The theme of colour deconfinement and chiral restoration, expected to occur in large volumes of strongly interacting matter at high energy density, is revisited in R. Hwa's second collection of theoretical monographs. A format of about 50 pages each gives the 13 authors ample space for a didactic introduction, an up-to-date review and for inclusion of fresh ideas and developments of their own, and most articles make good use of this to the profit of the non-expert reader. The articles are devoted about equally to the more fundamental aspects (lattice QCD, Resummation in high temperature field theory, Instanton physics, Parton cascades,...) and to treatises on observables of interest (Quarkonium physics, strangeness, Multi-Hadron correlations, Fluctuations and Critical Phenomena,...) A comprehensive source-reference for the experimentalist in the field, the book will undoubtedly meet the needs of many who are either currently working on aspects of ultra-relativistic collisions of heavy nuclei/large QCD systems, or wish to enter such research. With numerous and decisive new experiments in preparation at the Brookhaven and CERN Colliders, the Editor's somewhat remorseful statement that the book does not belong to the mainstream of high energy physics may not go unchallenged.

Reinhard Stock

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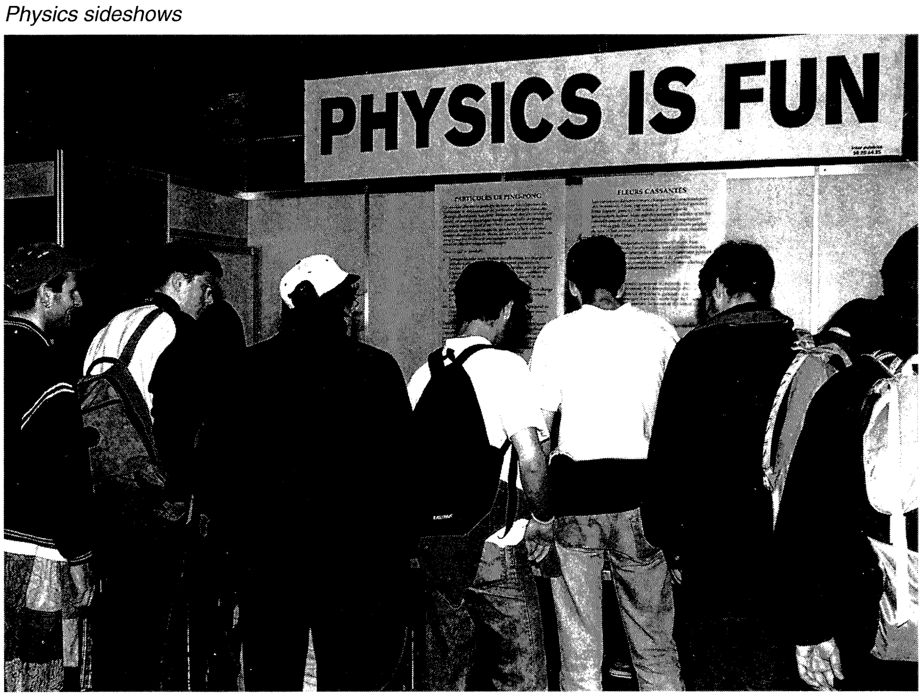
M. K. Craddock

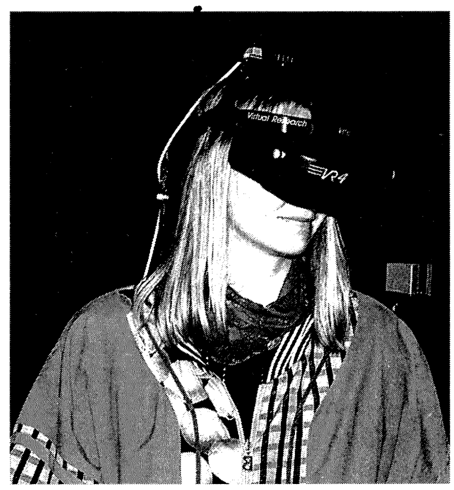
CERN Open Day 1996

On Saturday 11 May, an estimated 25,000 people got some idea of what CERN is all about.....

World-Wide Web

Physics sideshows

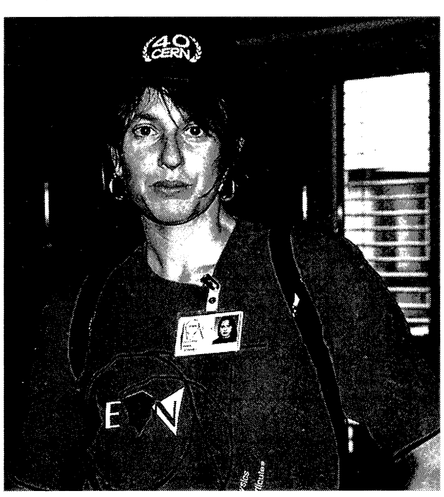




Virtual reality

Please enrol me for ATLAS

Thanks to Open Day coordinator Paola Catapano



People and things

After a distinguished career spanning many sectors of Laboratory administration, Norman Blackburne retired from CERN at the end of April.

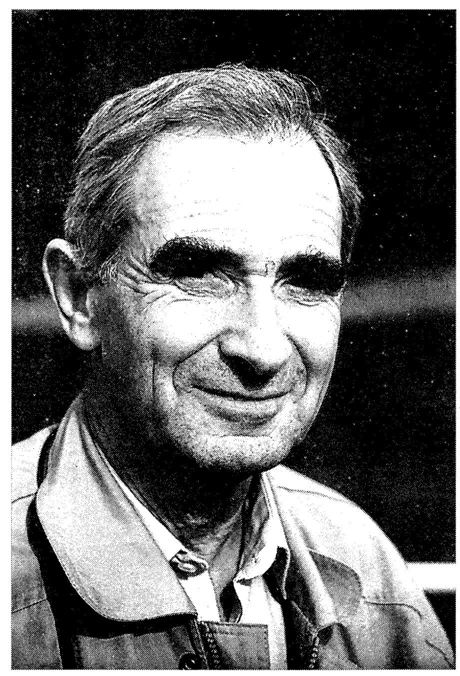
On people

Distinguished theoretician André Martin, who formally retired from CERN in 1994, becomes an honorary fellow of the Tata Institute of Fundamental Research, Bombay.

Every five years, the alumni circle of the Belgian University Foundation attributes awards to young Belgian scientists for outstanding achievements. The 1996 winner of the award for Physical Sciences is Albert De Roeck, now of DESY, who began his high energy physics career at Antwerp working on the NA22 experiment using the European Hybrid Spectrometer at CERN, subsequently moving to a position at Munich's Max Planck Institut at the start of HERA experiments at DESY and who until recently was physics coordinator for the H1 experiment at HERA.

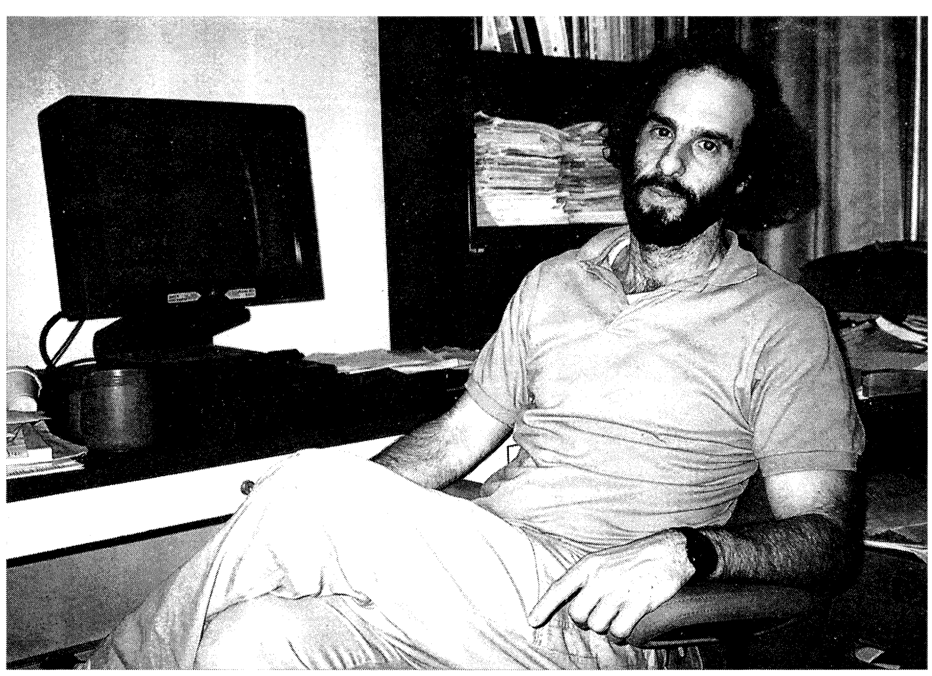
Meetings

A course on Exotic Nuclei under the auspices of the International School of Heavy Ion Physics will be held from 11-20 May 1997 in Erice, Italy at the Ettore Majorana Centre for Scientific Culture. Director of the Course will be P.G. Hansen, Director of the School will be R.A. Broglia. Director of the Centre is A. Zichichi. Applications (no special form is needed) and requests for information should go to Professor P.G. Hansen, National Superconducting Cyclotron Laboratory (NSCL), Michigan State University, East Lansing, MI 48824-1321, U.S.A. Telephone: 517/333-6433, electronic mail: hansen@nscl.msu.edu or to Ms. Shari Conroy, telephone: 517/333-6333 and e-mail: conroy@nscl.msu.edu.



Above - Early in July, a special seminar celebrated the 70th birthday of distinguished Russian theorist Boris Ioffe of Moscow's Institute of Theoretical and Experimental Physics.

Below - xxx.lanl.gov - Paul Ginsparg of Los Alamos at his workstation from which he manages his electronic bulletin board for physics publications and which has now developed into an electronic archive. From modest beginnings in 1991, this and other physics databases now serve over 35,000 researchers, processing more than 70,000 electronic transactions per day, and have revolutionized access to physics research information. With researchers sending their papers to a central server via the internet, 'subscribers' get regular summaries of new papers, from which they can select items for subsequent downloading.



Jefferson Lab

POST DOCTORAL RESEARCH ASSOCIATE

The Thomas Jefferson National Accelerator Facility (formerly CEBAF), located in Newport News, Virginia, USA, is a 4 GeV continuous wave electron accelerator, designed to explore the fundamental nature of nuclear matter with particular emphasis on strong interaction QCD. Experiments will be carried out in three halls simultaneously. The CEBAF Large Acceptance Spectrometer (CLAS) is a large solid angle, multiple-particle spectrometer based on a superconducting toroidal magnet located in Hall B. It consists of large drift chambers, time-of-flight, counters, gas Cerenkov counters, electromagnetic calorimeters, integrated with a high-speed trigger and data acquisition system. CLAS is expected to become operational in the fall of 1996. The CLAS physics program focuses on precision studies of electromagnetic transitions of baryons and mesons, the spin structure functions of the proton and neutron, and properties of the few-body system. Electron and photon beams will be utilized in these studies.

Applications are being invited for a Post-Doctoral Research Associate position for CLAS. The position requires a Ph.D. in Experimental Subatomic Physics. The successful candidate will participate in the commissioning of the experimental equipment in Hall B, and in the analysis of initial experiments. Demonstrated experience in hardware and/or software aspects of large acceptance detectors is preferred. The position will be for a one year term initially, with the possibility of extension for two additional years.

Interested candidates should send curriculum vitae and three letters of reference to: Jefferson Lab, ATTN: Employment Manager, 12000 Jefferson Avenue, Newport News, Virginia 23606. Please specify position #PT2107 and job title when applying.

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FACULTY POSITION IN EXPERIMENTAL PARTICLE PHYSICS

Department of Physics
University Of California, San Diego

The Department of Physics at the University of California, San Diego plans to make a tenured or tenure track faculty appointment in experimental particle physics, subject to availability of funds.

The current experimental program at UCSD includes collaborations in the CLEO, KTEV, L3 and LSND experiments along with a strong program preparing for the CP violation searches with the BABAR detector and the multi-TeV frontier with the CMS detector at the LHC.

This position is expected to begin July 1, 1997. Applicants should have a Ph.D in Physics, a clear record of research accomplishments and a strong interest in undergraduate and graduate instruction. Salary will be commensurate with experience and qualifications and will be based on the University of California pay scales. Persons interested in being considered for this position should send their curriculum vitae, a summary of research interests, a list of publications, and arrange to have three letters of recommendation sent to:

HEPX–Faculty Search Committee
Department of Physics, 0354
University of California, San Diego
9500 Gilman Drive, La Jolla, CA 92093-0354
email: search@hephp1.ucsd.edu

The deadline for applications is **30 September 1996**. UCSD *is an equal opportunity/affirmative action employer*.

UNIVERSITY OF GENEVA

The Department of Nuclear and Particle Physics has an opening for a

Research Associate
('Maître - assistant')

The position is available for participation in the AMS project on the International Space Station Alpha. Candidates must have a PhD degree in physics with appropriate experience in Particle Physics and knowledge of Si detectors. Candidates should not be more than 32 years of age. The position is available for a maximum of 4 years. Applications should be sent before August 15, 1996 to

Prof. M. Bourquin
Département de physique nucléaire
et corpusculaire
24, quai Ernest-Ansermet
CH - 1211 Genève 4

Jefferson Lab

FAST ELECTRONICS GROUP LEADER

The Thomas Jefferson National Accelerator Facility (formerly CEBAF), operates a 4 GeV CW Superconducting Electron Accelerator together with three large spectrometer systems to explore fundamental questions of nuclear and particle physics.

We are currently searching for a leader for the Fast Electronics Group in the Physics Division. The successful candidate will be responsible for providing technical expertise and supervision for the design, fabrication, and maintenance of the analog and digital electronic systems utilized in the experimental program. The position is also responsible for providing technical guidance on electronics issues to the physics user community, and the physics division detector and data acquisition groups. The successful candidate is also responsible for questions of staffing and budget for the group.

The minimum qualifications for this position are: BSEE or an equivalent engineering degree plus 10 years experience. In-depth knowledge of the state-of-the-art analog and digital electronics used in nuclear particle physics detectors and associated data acquisition systems. Two to three years of managerial experience in leading an electronics instrumentation group. Basic experience with construction of analog and digital electronics for different types of detectors.

Interested candidates should send curriculum vitae and three letters of reference to: Jefferson Lab, ATTN: Employment Manager, 12000 Jefferson Avenue, Newport News, Virginia 23606. Please specify position #PR3102 and job title when applying.

Proud to be an Equal Opportunity, Affirmative Action Employer

At the recent rededication of the Rockefeller Physics Building at Case Western Reserve University, Cleveland, Keith Robinson (left) of CWRU demonstrates the undergraduate teaching laboratory to (left to right), Sheldon Glashow of Harvard, Lawrence Krauss of CWRU and James Krumhansl of Cornell. Glashow gave the third annual CWRU Michelson Lecture on 'The Universe and the Particle: All Features Great and Small'. (Albert Michelson, of the Michelson-Morley experiment to measure the velocity of light, became CWRU's first professor of physics in 1881.) At the rededication event, Lawrence Krauss gave his 'Physics of Star Trek' talk, based on his best-selling book

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.

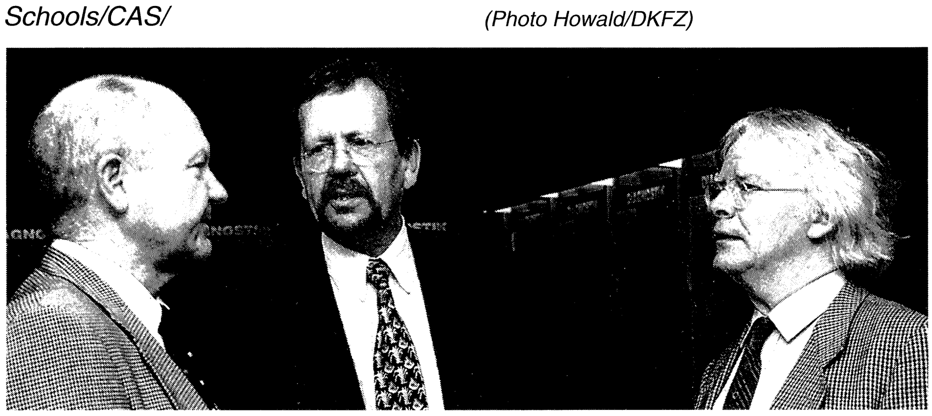
UNESCO support

Under a recently signed agreement between CERN and UNESCO, the latter is providing up to $60,000 this year to support young physicists from CERN Non-Member States, and particularly from developing countries, attending the three major CERN schools - the Accelerator School, the Computing School and the Physics School. The agreement will continue to run, and underlines the long-standing association between CERN and UNESCO. It was within a UNESCO framework from 1950-2 that the ground was prepared for the creation of what was to become CERN, which just two years later became a reality. In more recent times, the establishment of UNESCO's Physics Action Committee underlines its long-standing of physics as a model for basic science.

This year, the door is still open for applications to the CERN Accelerator School's Introduction to Accelerator Physics to be held from 21 October - 1 November in Cascais, Portugal. Further information from cas.estoril@cern.ch, fax +41 22 767 5460, WWW http:/www.cern.ch/ Schools/CAS/

'Hadrons for Health' - CERN's new technology exhibition on the medical applications of particle physics research was inaugurated on 5 June by H. C. Eschelbacher, Head of the German delegation to CERN. The exhibition is on show until 12 July at the German Cancer Research Institute, Heidelberg. Further venues for 1996 are CERN (for a hadron therapy symposium, 11-13 September), Vienna and Prague. Seen at the opening ceremony are, right to left, GSI Darmstadt Director Hans J. Specht, Medical Physics Department Director Wolfgang Schlegel, and Heidelberg Radiological Clinic Director Michael Wannenmacher.

(Photo Howald/DKFZ)



Imperial College of Science, Technology and Medicine London

Research Associate Positions in High Energy Physics

The High Energy Physics Group at the Blackett Laboratory, Imperial College, London, has vacancies for two Research Associate Positions.

The group has programmes with ALEPH at LEP, ZEUS at HERA, BABAR at SLAC and with the preparations for both the CMS and LHC-B experiments at the LHC. There is a strong tradition for both analysis and detector and electronics development.

The positions are for an initial period of two years. The starting date will be by negotiation between 1 Oct 1996 and 1 January 1997.
Salary, according to age, in the range £16,451 - £ 22,811 including London allowance.

Applications comprising a curriculum vitae, a list of publications and the names and addresses of two referees should be sent by Monday July 17 to:

Professor P. J. Dornan
Blackett Laboratory
Prince Consort Road
London SW7 2BZ

Late applications will be considered until the positions are filled.

The College is striving towards Equal Opportunities
At the leading edge of research, innovation and learning

STANFORD UNIVERSITY

The Stanford Linear Accelerator Center (SLAC) invites applications for an Assistant Professorship in accelerator physics. This is a tenure-track faculty position at Stanford University. The SLAC accelerator physics program focuses on electron accelerators for high-energy physics research and for synchrotron radiation-based research. Currently it includes Accelerator research and development with:

- the Stanford Linear Collider,
- the NLC, a next-generation linear collider,
- PEP-II, a high-current storage ring collider (B-Factory),
- advanced synchrotron light sources based on storage rings and linacs,
- new techniques for particle acceleration.

Candidates should have an outstanding research record which encompasses a combination of theoretical and experimental research and shows potential for major accomplishments. The successful applicant is expected to take a leading role in the ongoing activities at SLAC or in related accelerator physics research. Applicants should send a curriculum vitae, a publication list, and names of three references by August 1, 1996 to **Professor Ronald D. Ruth, SLAC MS/26, Stanford University, Stanford, CA 94309.** *Stanford University is an equal opportunity employer and welcomes applications from women and members of minority groups.*

PHYSICIST/ENGINEER

The Lawrence Berkeley National Laboratory (LBNL) is seeking a Physicist or Engineer to join the Beam Electrodynamics Group of the Center of Beam Physics, Accelerator and Fusion Research Division. The group is involved in the design, testing, and commissioning of radiofrequency (RF) and microwave systems and devices for control and diagnostics of charged particle beams.

The successful applicant will work primarily on R&D for the PEP-II B-factory but may also be involved in other projects. These projects include the multibunch feedback systems for the PEP-II B-factory and the Advanced Light Source, high power RF systems and components for PEP-II B-factory, RF and feedback systems design for the Next Linear Collider Damping Rings, and stochastic cooling and diagnostics studies for the Relativistic Heavy Ion collider. Will be responsible for the design and laboratory measurements of various devices and systems, using the facilities available in the Lambertson Beam Electrodynamics Laboratory at LBNL, and participate in measurements of the devices and systems in operating accelerators at various locations.

Qualifications include a Ph.D. or equivalent experience in Physics or Engineering, with 3-5 years of professional level experience as demonstrated by a strong publications record in relevant technical fields; basic knowledge of accelerator physics; and sound working knowledge of electromagnetism in application to accelerator diagnostics, instrumentation, and RF systems. Experience preferred in the following: RF and microwave measurements using standard laboratory equipment, including vector network analyzers, time domain reflectometers, and spectrum analyzers; practical accelerator operations and commissioning, especially for storage rings; high-frequency, 2-D and 3-D electromagnetic computer-aided design programs, particularly the MAFIA codes; and computer programming skills.

LBNL provides excellent benefits and compensation packages and the opportunity for career growth. Please mail your resume indicating **box #JCERN4265/AFR** to: **Ernest Orlando Lawrence Berkeley National Laboratory, Human Resources Dept., Bldg. 938A, One Cyclotron Rd., Berkeley, CA 94720.** EOE.

BERKELEY LAB

RESEARCH ASSOCIATE POSITION HIGH ENERGY PHYSICS THE OHIO STATE UNIVERSITY

The experimental high energy physics group at The Ohio State University invites application for a postdoctoral research associate position with our CLEO program at CESR. In addition to our ongoing data analysis effort in heavy flavor physics, we are also involved with the CLEO III upgrade program where we have major responsibilities for the design and implementation of the silicon vertex detector and the data acquisition system. Interested candidates should send a letter of application, vitae, list of publications, and three letters of recommendation to Professor K. K. Gan, The Ohio State University, Department of Physics, 174 West 18th Avenue, Columbus, Ohio 43210-1106. The Ohio State University is an equal opportunity employer and we actively encourage applications from women and minority candidates.

U.S. DEPARTMENT OF ENERGY
ASSOCIATE DIRECTOR FOR HIGH ENERGY AND NUCLEAR PHYSICS
Office of Energy Research
$100,526 to $122,688 per annum

The U.S. Department of Energy (DOE) is seeking applicants for the Senior Executive Service position of Associate Director for High Energy and Nuclear Physics. This person will be the principal official responsible for the development, implementation, and direction of DOE's High Energy and Nuclear Physics research programs. These programs encompass R&D at national laboratories, universities, and private institutions involving about 350 grants, contracts, and interagency agreements, with a budget in excess of $900 million, which funds more than 90 percent of the Federal effort in High Energy Physics and more than 85 percent of Nuclear Physics. The programs study the basic nature of energy and matter seeking an understanding of the ultimate constituents and structure of nuclear and sub-nuclear matter and the fundamental forces. These research activities typically use both domestic and international facilities and are often carried out through multi-institutional and multi-national collaborations. The position reports directly to the Director of Energy Research.

Exceptional difficulty in recruiting highly qualified candidates may be the basis for paying a recruitment or relocation bonus (up to 25% of base pay), and/or requesting approval of a dual compensation waiver for civil and uniformed service retirees.

Applications must be postmarked no later than July 22, 1996. Direct inquiries to: Office of Executive and Technical Resources, 4E-060, DOE, Washington, DC 20858, Attn: ERD-96-10. The vacancy announcement is available from the above address or through Energy Research's internet Home Page (HTTP://WWW.ER.DOE.GOV). DOE is an equal opportunity employer.

NATIONAL INSTITUTE FOR NUCLEAR PHYSICS

INFN

POST-DOCTORAL FELLOWSHIPS FOR NON ITALIAN CITIZENS IN THE FOLLOWING RESEARCH AREAS:

THEORETICAL PHYSICS (N. 10)
EXPERIMENTAL PHYSICS (N. 20)

The INFN Fellowships Programme 1996-97 offers thirty positions for non Italian citizens for research activity in theoretical or experimental physics.

Fellowships are intended for young post-graduates not more than 35 years of age at the time of application.

Each fellowship is granted for one year (which may start during the period from September to November 1997) and may be extended for a second year.

The annual gross salary is 30,000,000 Italian Lire, plus travel expenses for round trip transportation from the home fellows to the INFN Section or Laboratory. Lunch tickets are provided for work days.

Candidates should submit an application form and a statement of their research interests, including three letters of reference.

Applications should reach INFN not later than *October 31, 1996.*

Candidates will be informed by the end of April 1997 about the decisions taken bij INFN's committee.

The successful applicants may carry out their research activity in Italy, at any of the following Laboratories and Sections of INFN:

National Laboratories of Frascati (Rome), National Laboratories of Legnaro (Padua), Southern National Laboratory (Catania) and National Gran Sasso Laboratories (L'Aquila).

INFN Sections in the Universities of:

Turin, Milan, Padua, Genoa, Bologna, Pisa, Rome 'La Sapienza', Rome 'Tor Vergata', Naples, Catania, Trieste, Florence, Bari, Pavia, Perugia, Ferrara, Cagliari, Lecce and National Institute for Health (Rome).

Information, requests for application forms, and applications should be addressed to Personnel Office - Fellowship Service, National Institute for Nuclear Physics (INFN) - Post Box 56 - 00044 Frascati (Rome) Italy.

DESY

DESY announces several

`DESY Fellowships´

for young scientists in experimental particle physics to participate in the research mainly with the HERA collider experiments H1 and ZEUS or with the fixed target experiments HERA-B and HERMES. New fellows are selected twice a year in April and October.

DESY fellowships in experimental particel physics are awarded for a duration of two years with the possibility for prolongation by one additional year.

The salary for the fellowship is determined according to tarifs applicable for public service work (IIa MTV Ang.).

Interested persons, who have recently completed their Ph.D. and who should be younger than 32 years are invited to send their application including a résumé and the usual documents (curriculum vitae, list of publications, copies of university degrees) until 30 of September 1996 to **DESY, Personalabteilung - V2 -, Notkestraße 85, D-22607 Hamburg**. They should also arrange for three letters of reference to be sent until the same date to the address given above.

Handicapped applicants with equal qualifications will be prefered.

DESY encourages especially women to apply.

As DESY has laboratories at two sites in Hamburg and in Zeuthen near Berlin, applicants may indicate at which location they would prefer to work.

New standard photomultiplier tube from Hamamatsu for an operation under a high magnetic field at 1.5 tesla.
Improvement of the Q.E. by 25% possible to have better timing resolution than 100 ps in TOF counter.
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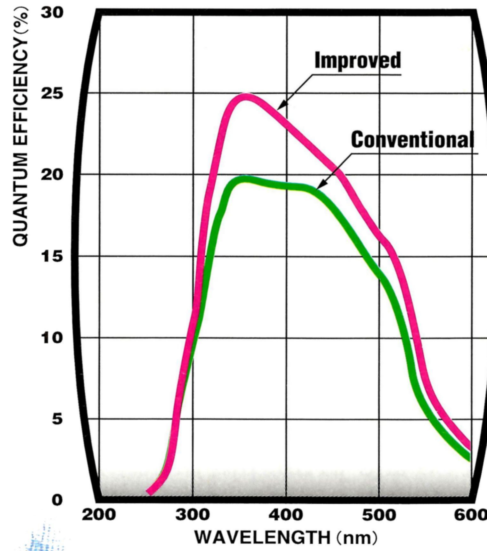
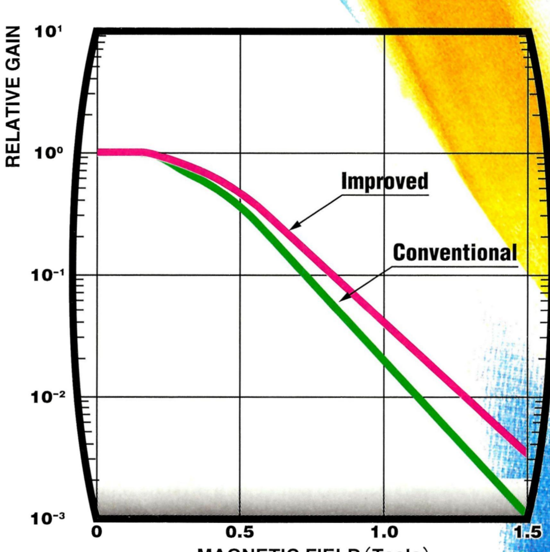
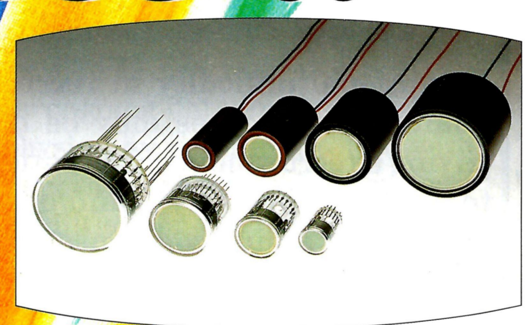
Hamamatsu is pleased to hear from you for our further step up to support next century.



New STANDARD at 1.5 tesla





APPLICATIONS
- CHERENCOV COUNTER
- TOF COUNTER
- CALORIMETER

HAMAMATSU

HAMAMATSU PHOTONICS K.K., Electron Tube Center
314-5 Shimokanzo, Toyooka-village, Iwata-gun, Shizuoka-ken, 438-01 Japan. TEL:81-539-62-5248 FAX:81-539-63-2205 TLX:4289-625

United Kingdom : Hamamatsu Photonics UK Limited. TEL: 44-181-367-3560 FAX: 44-181-367-6384
North Europe : Hamamatsu Photonics Norden AB TEL: 46-8-703-29-50 FAX: 46-8-750-58-95
Italy : Hamamatsu Photonics Italia S.R.L. TEL: (39) 2 935 81 733 FAX: (39) 2 935 81 741
Spain : Hamamatsu Photonics Espana SL. TEL: (34) 93 582 44 30 FAX: (34) 93 582 44 31
U.S.A. : Hamamatsu Corporation TEL: 1-908-231-0960 FAX: 1-908-231-1218
Germany : Hamamatsu Photonics Deutschland GmbH TEL: 49-8152-3750 FAX: 49-8152-2658
France : Hamamatsu Photonics France S.A.R.L. TEL: (33) 1 69 53 71 00 FAX: (33) 1 69 53 71 10
Switzerland : CERN Liaison Office TEL: (41) 31 879 13 33 FAX: (41) 31 879 18 74