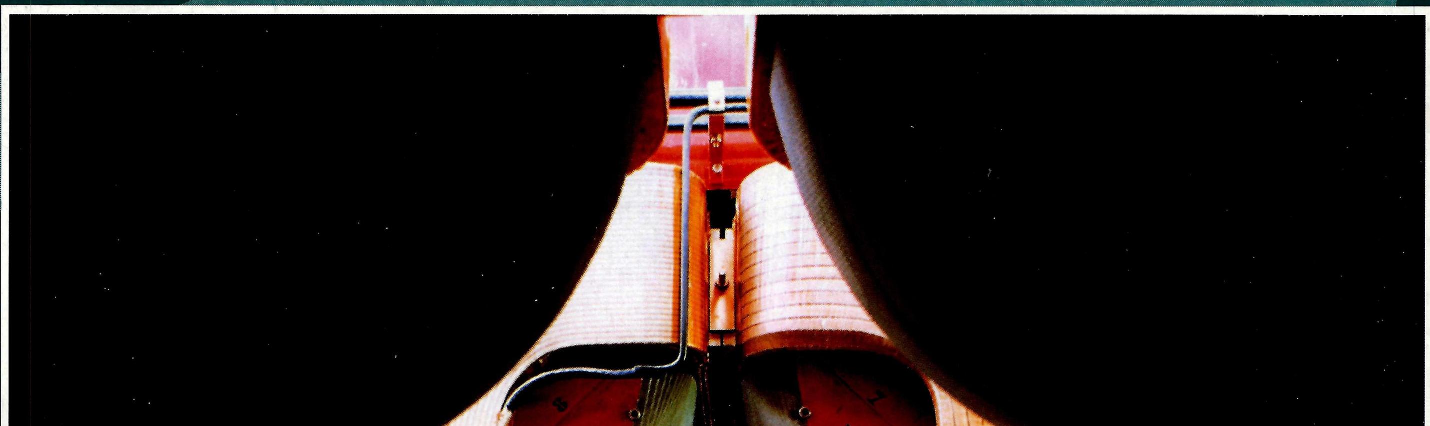
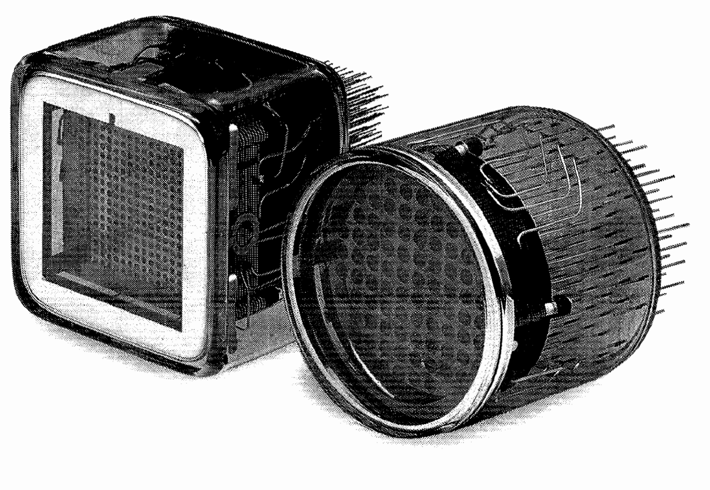
CERN COURIER

INTERNATIONAL JOURNAL OF HIGH ENERGY PHYSICS

VOLUME 34 **3** APRIL 1994





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

General distribution

Jacques Dallemagne
CERN, 1211 Geneva 23, Switzerland

In certain countries, copies are available on request from:

China

Dr. Qian Ke-Qin
Institute of High Energy Physics
P.O. Box 918, Beijing,
People's Republic of China

Germany

Monika Stuckenberg or Kerstin Techritz
DESY, Notkestr. 85, 22603 Hamburg 52

Italy

Mrs. Pieri or Mrs. Montanari
INFN, Casella Postale 56
00044 Frascati, Roma

United Kingdom

Su Lockley
Rutherford Appleton Laboratory,
Chilton, Didcot, Oxfordshire OX11 0QX

USA/Canada

Cyndi Rathbun (B90904 @ FNALVM)
Fermilab, P.O. Box 500, Batavia
Illinois 60510

CERN COURIER is published ten times yearly 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

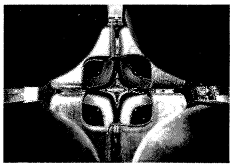
USA: Controlled Circulation
Postage paid at Batavia, Illinois

Volume 34
No. 3
April 1994

Covering current developments in high energy physics and related fields worldwide

Editor: Gordon Fraser (COURIER @ CERNVM)*
Production and Advertisements:
Micheline Falciola (FAL @ CERNVM)*
Advisory Board: E.J.N. Wilson (Chairman), E. Lillestol, H. Satz, D. Treille; with W. Hoogland, H.I. Miettinen

(Full electronic mail address... @ CERNVM.CERN.CH)



Cover photograph: The front end of a focusing quadrupole of the ESR heavy ion cooler ring at the GSI Laboratory, Darmstadt. This image is on the cover of a book by former GSI Director Paul Kienle 'Forschung im Focus', published by Edition Interfrom (ISBN 3-7201-5249-9). (Photo Achim Zschau GSI)

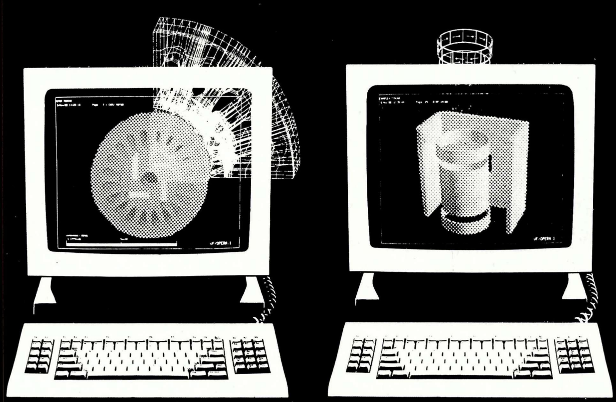
If you're looking for the highest performance – precision magnet power supply, with ultimate stability class rating – and inbuilt service "spotting" procedures, you can't afford not to use system 8000.

Probably the best magnet power supply technology you can buy...

DANFYSIK

DANFYSIK A/S · Møllehaven 31 · DK-4040 Jyllinge · Denmark
Tel.: +45 46 78 81 50 · Fax: +45 46 73 15 51
In USA: GMW Associates
Tel.: (415) 368-4884 · Fax: (415) 368-0816

Software for Electromagnetic Design



From

VECTOR FIELDS

Vector Fields Ltd
24 Bankside, Kidlington
Oxford OX5 1JE, England
Tel: (0865) 370151,
Fax: (0865) 370277

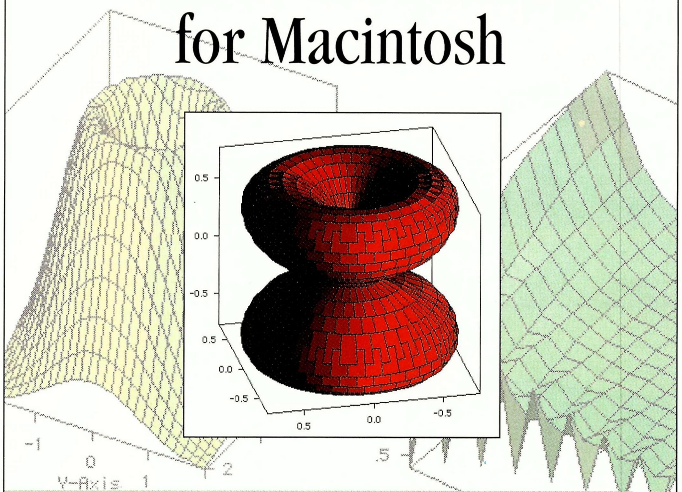
1992
THE QUEEN'S AWARD FOR TECHNOLOGICAL ACHIEVEMENT

Vector Fields Inc
1700 North Farnsworth Av
Aurora, IL 60505, USA
Tel: (708) 851 1734,
Fax: (708) 851 2106

New Native Mode PowerPC Version

HiQ®

Real-World Math for Macintosh



Virtual Notebook Interface

- Interactive analysis and graphics in a WYSIWYG notebook interface
- Insightful 2D and 3D graphics
- Annotation for technical reports, journals, and presentations
- Publication-quality output

Numerical Analysis Power

- More than 600 math, scientific, and engineering functions
- Efficient algorithms with optimal convergence
- User-defined error tolerances

Problem Solvers™

- Intuitive GUIs for solving sophisticated problems
- Automatic code generation

HiQ-Script™

- A language built for scientists, engineers, and mathematicians

Call for Your FREE Demo (512) 794-0100

NATIONAL INSTRUMENTS®
The Software is the Instrument®

6504 Bridge Point Parkway
Austin, TX 78730-5039 USA
Tel: (512) 794-0100
Fax: (512) 794-8411

Branch Offices
Australia 03 879 9422 • **Austria** 0662 435986
Belgium 02 757 00 20 • **Canada** 519 622 9310
Denmark 45 76 26 00 • **Finland** 90 527 2321
France 1 48 65 33 70 • **Germany** 089 714 50 93
Italy 02 48301892 • **Japan** 03 3788 1921
Netherlands 03480 33466 • **Norway** 32 848400
Spain 91 640 0085 • **Sweden** 08 730 49 70
Switzerland 056 27 00 20 • **U.K.** 0635 523545

International collaboration

In the wake of the demise of the US Superconducting Supercollider (SSC) project last year which empoverished both US and world science, some rapid scene shifting is going on. The SSC may be dead, but the underlying physics quest lives on.

In the US, the 'future vision' subpanel of the High Energy Physics Advisory Board (HEPAP), chaired by Sid Drell, is at work formulating its recommendations (March, page 7). On the international front, the International Committee for Future Accelerators (ICFA) at a special meeting in Vancouver in January drafted a statement.

In canvassing input for his subpanel, Drell cited an eloquent article by Energy Secretary Hazel O'Leary and Chairman of the House Committee on Science, Space and Technology George E. Brown recently published in the Los Angeles Times which said 'unless we are intent on stopping the pursuit of the knowledge that (the SSC) would have delivered, we must find a way to achieve a truly international framework for large scientific and technological projects'.

A recent statement by the International Committee for Future Accelerators (ICFA) said - 'Following the cancellation of the SSC, the Large Hadron Collider (LHC) at CERN now offers the only realistic opportunity to study multi-TeV hadron collisions' (the full ICFA statement is published on page 4).

To nurture the natural enthusiasm to continue this physics, contacts have been developing at several levels. In December, informal exploratory talks were held at CERN between spokesmen of the LHC experiments and their counterparts from the major SDC and GEM projects which were being readied for the SSC, and with CERN management. The object was to establish the common interest in multi-TeV physics at the LHC, and, once this is in place, to exploit valuable research and development work already accomplished and the high level of expertise achieved in the SSC framework.

A substantial number of US physicists involved in SDC and GEM could be interested in joining LHC experiments, together with a significant fraction of the 100 or so Japanese researchers involved in SDC. Many of the SDC Canadian contingent could also turn their sights towards Geneva.

Initial contacts late last year were followed up by a meeting at UCLA looking at possibilities around the LHC CMS experiment for additional collaborators, particularly from the US, while at CERN, the ATLAS experiment's collaboration meeting attracted many additional visitors.

The initial LHC/ex-SSC contacts led to a two-day Large Hadron Collider Workshop at Fermilab on 15-16 February, attended by several hundred US physicists. This meeting confirmed the strong interest in the US and elsewhere in LHC physics and sowed the seeds of a future US LHC User Group, seen as a necessary element in substantial US involvement in the experimental programme.

At this meeting, the Department of Energy's Director of Energy Research Martha Krebs pointed at the possibilities of the LHC route to international collaboration, and challenged the community to produce the 'compelling arguments' needed to convince Washington that this was the way to go. The Drell subpanel and its advisory bodies have an important role to play in this respect.

At this meeting, CERN Research Director Walter Hoogland reiterated the message which had been spelled

US Energy Secretary Hazel O'Leary - looking for a way to achieve a truly international framework for large scientific and technological projects.

out by CERN's governing body, Council, in December (January/February, page 3). With CERN's increasing role as a world, rather than a European, Laboratory, compounded with the tight financing of the LHC project, contributions from non-Member States would facilitate LHC construction. (Under a CERN fallback plan, LHC could still be built without non-Member State aid, but this would be more difficult.) CERN is now definitely a major world focus - there are as many physicists working at CERN from the US as from the UK, for example, the latter contributing some 15% of CERN's annual budget. Thus Council had concluded that it 'is conscious of, and welcomes, the world interest in the LHC project and encourages CERN to report back on the modes of involvement of non-Member States.....such involvement should be on the understanding that usage on a significant scale must involve the provision of resources to suit both CERN and the non-member States concerned.' These possibilities are being studied.

Hoogland emphasized the importance of confirmation of US interest in the LHC programme, through involvement in the LHC experimental collaborations (where an orderly integration in preparation work is better than a proliferation of scattered activity), through open meetings, and through official advisory bodies.

With integration signs already visible on the experimental front, it was a propitious time to begin dialogue on other common interests such as accelerator matters and computing. Around the Computing for High Energy Physics (CHEP) meeting in San Francisco will be a useful opportunity to air LHC computing issues. There is interest in the US on collaboration in research and development work on the design and construction of the LHC accelerator as well as its detectors.

Speaking at the Fermilab meeting on behalf of the Drell subpanel, Joel Butler recommended that US researchers take this opportunity to learn how to work in an international environment. 'If there is no vision, then retrenchment is your future,' he warned. Peter Lyman of Fermilab enumerated possible areas of CERN-US accelerator cooperation for further discussion.

However some US voices advocated a full exploitation of US national resources before migrating in mass to Europe.

Meanwhile the Executive Committee of the Division of Particles and Fields (DPF) of the American Physical Society has set up a number of working groups to examine various research opportunities in particle physics. This long term planning effort by the community itself will go on in parallel with the work of the 'Future Vision' subpanel chaired by Sid Drell, which has now had several meetings.

Roberto Peccei, Chairman of the Executive Committee in 1993 when the study was established, chairs the overall long range planning effort. The current chairman of the DPF Executive Committee is Michael Zeller of Yale.

These working groups are charged with formulating the broad range of physics questions in their respective areas, to discuss the means by which these questions might be best addressed, and relate these means to the exploitation of existing and future facilities, both in the US and elsewhere. Each group should arrive at a set of priorities, and the perceived priority of their area in the overall programme.

After preliminary contacts, the groups will convene at Johns Hopkins University at the beginning of May to present their preliminary assessments. A fuller assessment would follow at the DPF meeting at Albuquerque in August. A final written report is scheduled for January 1995.

The DPF working groups and their chairpersons are: Tests of electroweak theory (Frank Merritt, Chicago), Flavour Spectroscopy (John Cumulat, Colorado), QCD (Alfred Mueller, Columbia), CP violation and flavour issues (Helen Quinn, SLAC), Neutrinos (Paul Langacker, Pennsylvania), Electroweak symmetry breaking (Sarah Dawson, Brookhaven), Astroparticle physics (Michael Turner, Chicago/Fermilab), Structural issues (Ray Brook, Michigan State), and New accelerator techniques (Steve Holmes, Fermilab).

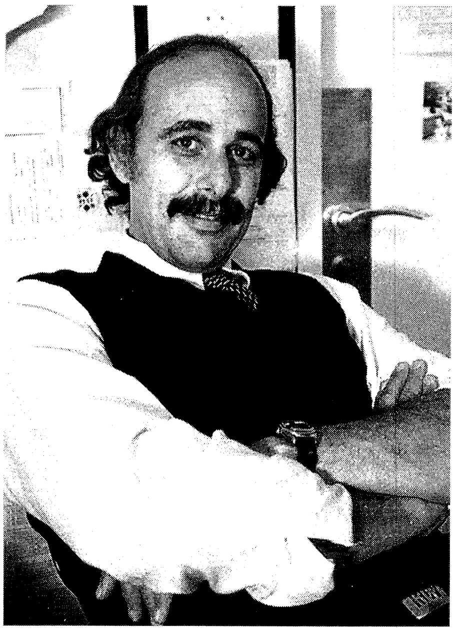
To monitor sentiment, 'town meetings' are being organized.
The agenda of these meetings will be set by the individual hosts, however identifiable issues for debate include:

- In terms of clearly defined scientific goals, and in the context of what is already planned and in progress worldwide, what should the US high energy physics programme be doing five and ten years from now?
- What opportunities are scientifically compelling for proton machines, for electron-positron machines, and for non-accelerator based research?
- How should the US divide its high energy physics resources between its domestic programme and foreign collaboration? How might it best pursue international collaboration in advancing our field and in construction of new facilities?
- What are the appropriate roles of universities and domestic laboratories in the future of high energy physics?
- In her report to Congress in July, the Secretary of Energy must "include recommendations as to whether high energy physics and other large research projects and programmes should continue to be pursued by the United States and, if so, for what purpose should they be pursued and how should they be funded and financed". What should the Secretary include in her report?

CERN Research Director Walter Hoogland - emphasizing the importance of confirming US interest in the LHC programme.

Away from the Laboratories, on January 26 the House of Repre-

Roberto Peccei, last year's Chairman of the Executive Committee of the Division of Particles and Fields of the American Physical Society, chairs the overall long range planning effort by the US particle physics community.



sentatives Subcommittee on Science held a three-hour hearing on the future of high energy physics research in the United States. After last year's termination of the SSC, there was general agreement among most hearing witnesses that the United States should participate with CERN in the construction of the Large Hadron Collider (LHC) or its detectors.

The LHC is now acknowledged (see the ICFA statement on page 4) as the only route open to the multi-TeV hadron collisions required to open up the symmetry breaking effects at the heart of Standard Model physics.

Among those testifying at the House meeting were HEPAP chairman Stanley Wojcicki, former chairman of the American Physical Society's Division of Particle and Fields Roberto Peccei, Fermilab Director John Peoples, Frank S. Merritt of Chicago's Enrico Fermi Institute, the Department of Energy's Director of Energy Research Martha Krebs, and Director of the Office of Science and Technology Policy John Gibbons.

Subcommittee chairman Rick Boucher (D-Virginia) acknowledged that the SSC's termination "is a watershed in this nation's commitment to supporting big science, and has thrown the field of high energy physics into turmoil." He continued, "we must assume that in future years, the high energy physics budget will have level funding, adjusted, if at all, for inflation only," perhaps leading to consolidation of existing facilities to free up money for new construction. Sharing the podium with Boucher was Sherwood Boehlert (R-New York), a former major SSC foe, who gave assurances that "we are united, I am sure, in our determination to maintain a vital US effort in particle physics." Boehlert had kind words about US participation with CERN in constructing the LHC. Much less enthusiastic about the LHC was Joe Barton (R-Texas), a strong SSC proponent.

First to testify was John Gibbons who stated, "The most logical and current steps for the US programme in high energy physics are:

- to complete in timely fashion the Fermilab Main Injector Upgrade and the Stanford B-Factory;
- to provide full operational funding for these facilities once they are completed, in order to achieve the most and best physics research; and
- to plan for US participation in an international consortium to build and operate 21st century accelerator facilities needed to push forward the high energy physics frontier." Gibbons did not cite CERN in his written testimony.

Martha Krebs spoke of a "vision for the future" which could include the LHC or the High Energy Linear Collider (also known as the Next Linear Collider).

The physicists were in general agreement that the US should explore participation in the LHC. All indicated that this would benefit both CERN and US high energy physics.

Of more immediate concern is assuring that US base programme funding to operate existing and planned facilities will be sufficient during the remainder of this decade. This funding, and a $500 million CERN contribution, would require a 10 percent increase in the high energy physics budget. While this is small compared to the SSC, it is nevertheless significant under current federal budget constraints.

At the recent meeting of the American Association for the Advancement of Science (AAAS) in San Francisco, House Science, Space and Technology Committee Chairman George Brown proposed three initiatives in a 'white paper' on 'Big Science and International Cooperation':

1 - in the short term, all research projects in excess of $50 million should be required to have Congressional support (unlike the ill-fated SSC);

2 - in the medium term, an official forecast of big science projects until 2010; and

3 - in the long-term, a G7-nation panel to establish big science priorities.

Also speaking at the AAAS, Director of the Office of Science and Technology Policy Gibbons said that a decision of US participation in the LHC is likely following the publication of the report of the Drell 'future visions' subpanel.

CMS in the US

To inform potential US collaborators about the design and status of the Compact Muon Solenoid (CMS)

To inform potential US collaborators about the design and status of the Compact Muon Solenoid (CMS) experiment at CERN's LHC proton collider, the CMS group organized a collaboration meeting at UCLA from 2 - 4 February. Only two weeks after the devastating earthquake in Los Angeles, more than 150 people from 12 European and 37 US institutions participated.

experiment at the LHC, the CMS group organized (through Th. Muller) a collaboration meeting at UCLA from 2 - 4 February.

It is a remarkable sign of the vitality and enthusiasm of high energy physicists that only two weeks after the devastating earthquake in Los Angeles more than 150 people from 12 European and 37 US institutions participated. After a welcome by Roberto Peccei, now Dean at UCLA, and introductory presentations including a status report of the LHC by W. Hoogland and of CMS by M. Della Negra, the meeting was organized into five sessions covering major CMS detector components.

Presentations were given on details of CMS as well as on experience with relevant SSC detector design. In four fields major US participation would be welcome: the endcap muon system (where presently four US groups - UC Davis, UCLA, UC Riverside and UT Dallas - are involved together with a group from Dubna) the trigger, the hadron calorimeter, and the central tracking system.

The CMS collaborators recognized the valuable experience of the groups formerly involved in the SSC, who were typically two years more advanced in technical design than their LHC colleagues, and warmly welcomed new participants.

Electron-positron route

While the proton-proton collider option is foremost in most people's minds, a TeV-scale electron-positron collider is acknowledged as a complementary route to new physics horizons, but with a longer lead time. Research and development work is underway at electron Laboratories all over the world, and continued international collaboration on this front is strongly endorsed by the International Committee for Future Accelerators (ICFA - see next article).

Future accelerators

Future accelerators is what ICFA (the International Committee for Future Accelerators) is all about. Following an emergency ICFA meeting at CERN early in December, the following statement was drafted for a subsequent meeting of ICFA Members and Laboratory Directors at the TRIUMF Laboratory, Vancouver, on 16 January.

High energy physics seeks to discover basic principles that underlie the workings of the physical universe through the exploration of the building blocks of matter and forces among them. World-wide effort over the past half-century has produced a remarkably successful theoretical picture describing all matter and energy as built of certain constituents, interacting through specific forces according to general principles of symmetry, relativity and quantum mechanics.

Yet the picture contains gaps - profound questions that can only be answered with new facilities. The answers to these questions hold the promise of yielding a historic unification of ideas and principles, as significant as those that have marked past revolutionary advances in scientific understanding.

Particle accelerators and detectors have served as experiments' most successful tools for this exploration of the subatomic world, and will do so for the foreseeable future. To probe matter and energy at the point where revolutionary discoveries are expected, particle accelerators of energies higher than are now available must be built. Drawn by the importance and the scientific challenge of such discoveries, high energy physics experimenters have traditionally pooled their resources to build detectors, across international boundaries, forming large regional

centres and scientific collaborations to meet the higher costs of advancing exploration.

The termination of the Superconducting Supercollider Project, the highest energy collider ever begun, is a very great loss at the world high energy physics community.

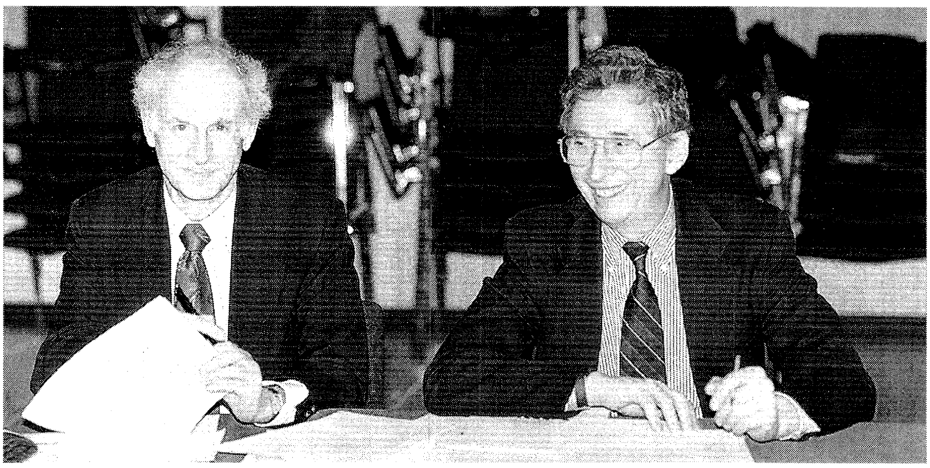
The outcome illustrates the need to make the construction of new large facilities the result of a worldwide strategy, in the same collaborative spirit that has characterized the construction of major experimental detectors.

Following the cancellation of the SSC, the Large Hadron Collider (LHC) at CERN now offers the only realistic opportunity to study multi-TeV hadron collisions. ICFA notes that the LHC project is now ready for approval and is currently being evaluated by the CERN Council. The energy and luminosity of the LHC represent a great advance over the Tevatron, now the highest energy collider in operation (seven times in energy and a thousand times in luminosity).

There are compelling arguments that fundamental new physics will appear in the energy domain that will be opened up by the LHC, including the origin of electroweak symmetry breaking (and hence the origin of mass). The LHC will remain a unique facility for the foreseeable future and ICFA considers that it is now the correct next step for particle physics at the high energy frontier. ICFA therefore hopes that the nineteen Member States of CERN will quickly approve the LHC for timely completion. ICFA notes the worldwide interest in participation in LHC and that the CERN Council wishes to bring non-member states into the project. ICFA urges that appropriate mechanisms and means be found to allow this to happen and that the LHC be available for research by the world particle physics community.

In the not-too-distant future, accelerator specialists will complete the research and development necessary to begin the design of an electron-positron collider capable of exploring the comparable mass region. As has been the case in the past, such an approach will be complementary to what will be done with proton-proton colliders. ICFA notes that the research and development for the design of a large electron-positron linear collider is being carried out under an inter-regional collaboration. The signatories of the memorandum of understanding among the participants of that collaboration have pledged to admit all institutions that are prepared to make significant contributions to the research and development effort. The participants further share a common vision of a facility that will be built as a worldwide collaboration. ICFA continues to strongly endorse the goals of this collaboration.

ICFA believes that the time has come for the governments of all nations engaged in the science of high energy physics to join in the construction of major high energy facilities, so that this unique human endeavour can continue to go forward.



At the ICFA meeting at the TRIUMF Laboratory, Vancouver, on 16 January - ICFA Chairman John Peoples (right) with Secretary Roy Rubinstein (Photo M. Pavan, TRIUMF)

Spinoff from high energy physics

by Hans Hoffmann

This year the CERN Courier is featuring the spinoff and technological benefits arising from research in fundamental physics. After initial illustrations in applied data processing sectors (January/February, page 25, and March, page 20), this article by Hans Hoffmann of CERN examines the rationale and underlying objectives of the 'new awareness' of the market value of basic science. He is the Chairman of a new panel on the subject set up recently by the International Committee for Future Accelerators (ICFA). The other members are: Oscar Barbalat of CERN, Hans Christian Dehne of DESY, Sin-ichi Kurakawa of KEK, Gennady Kulipanov of the Budker Institute (Novosibirsk), Anthony Montgomery, formerly of the SSC, A. H. Walenta of Siegen, Germany, and Zhongqiang Yu of IHEP Beijing.

High energy physics - the quest to find and understand the structure of matter - is mainly seen as an essential part of human culture. However this basic science increasingly has to jostle for funding attention with other branches of science.

Applied sciences aim for a rapid transformation of investment cash into viable market products. In times of economic difficulties this is attractive to funding agencies and governments, and economic usefulness and technological relevance also become criteria for a basic science like high energy physics.

Despite its primarily intellectual objectives, high energy physics does have a substantial track record of spinoff successes, but this is often overlooked when attention focuses on breakthroughs in understanding. An outstanding example of such a spinoff was the discovery of the production of X-rays by electrons by Röntgen in 1895.

But a good starting date for a review of modern accomplishments is around 1960, when major laboratories like Brookhaven (US) and CERN (Europe) became operational with new big accelerators and experiments. Important developments have resulted from the predominantly international culture of the field, with research institutes from all over the world collaborating on projects and experiments.

Achievements

Particle physics, with its large and complex tools - accelerators and detectors - is itself a very successful technology.

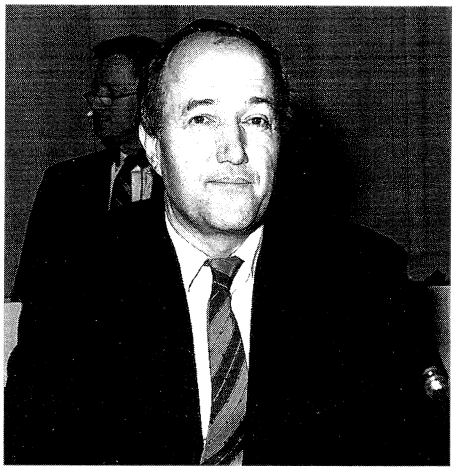
The advance of the field is measured by the steady increase in spatial resolution to find smaller and more fundamental building blocks of matter, and the associated ability to produce enough energy to create more massive fundamental objects. The particles now being routinely studied are as heavy as middleweight nuclei.

Although research capability as measured by these benchmarks still increases exponentially with time, the same does not apply to the resources in terms of money and people.

In the last twenty years these resources have at best remained constant, and in some cases are being reduced.

High energy physics is mainly an experimental science, and its strength is the global focus of attention on a few key issues. Successes in terms of new discoveries or new technologies are acknowledged by the fact that of the 33 Nobel prizewinners in physics of the last 15 years, more than one-half were particle physicists.

Hans Hoffmann of CERN - economic usefulness and technological relevance also become criteria for a basic science like high energy physics.



A combination of applied sciences

With experiments becoming more and more challenging, scientific breakthroughs frequently follow in the wake of new ideas and technology. A major fraction of particle physics activity is applied physics, technology and informatics work, where the goals of innovation, quality and improved cost-performance resemble those of industry.

The spinoff process works in both directions. Some technologies were driven directly by demands for high performance accelerators and detectors, where other fields have profited. In turn high energy physics has adapted many new technologies from industry or other fields of science.

Not that long ago, this kind of science was a relatively modest activity, but with experimental collaborations now involving hundreds of researchers from several continents, this has led to the development of a sophisticated infrastructure with high level of organization. Communications, both at high speed and involving large amounts of data, are commonplace and have pushed this technology to the limit.

The basic research engine - accelerators and detectors - must be very reliable. These central facilities are operated non-stop for substantial fractions of the year and hundreds of researchers are dependent on them for their livelihood.

Despite being highly complex, accelerators and detectors typically reach around 80% operating availability. Successful operation of an experiment means that at most 1-2% percent of its many thousands of electronic readout channels can be 'down' at any one time. The yearly running time of some accelerators (for example the 28 GeV PS proton synchrotron which is the kingpin of CERN's beam system, despite being some 35 years old!) exceeds those of baseload electrical power plants.

The complex experiments of particle physics, like Aleph at CERN's LEP electron-positron collider, have special technological demands (Photo CERN EX60.4.93)

Technologies influenced by accelerators

There is a long list of technologies which have benefited from accelerator know-how: superconductivity and cryogenics; ion sources; ultrahigh vacuum and related science; radiofrequency and microwave engineering; mechanical engineering; electrical engineering and power electronics; controls; instrumentation; and surveying, as well as accelerator technology itself. (We hope to cover this latter spinoff sector later this year.)

Technologies influenced by experiments

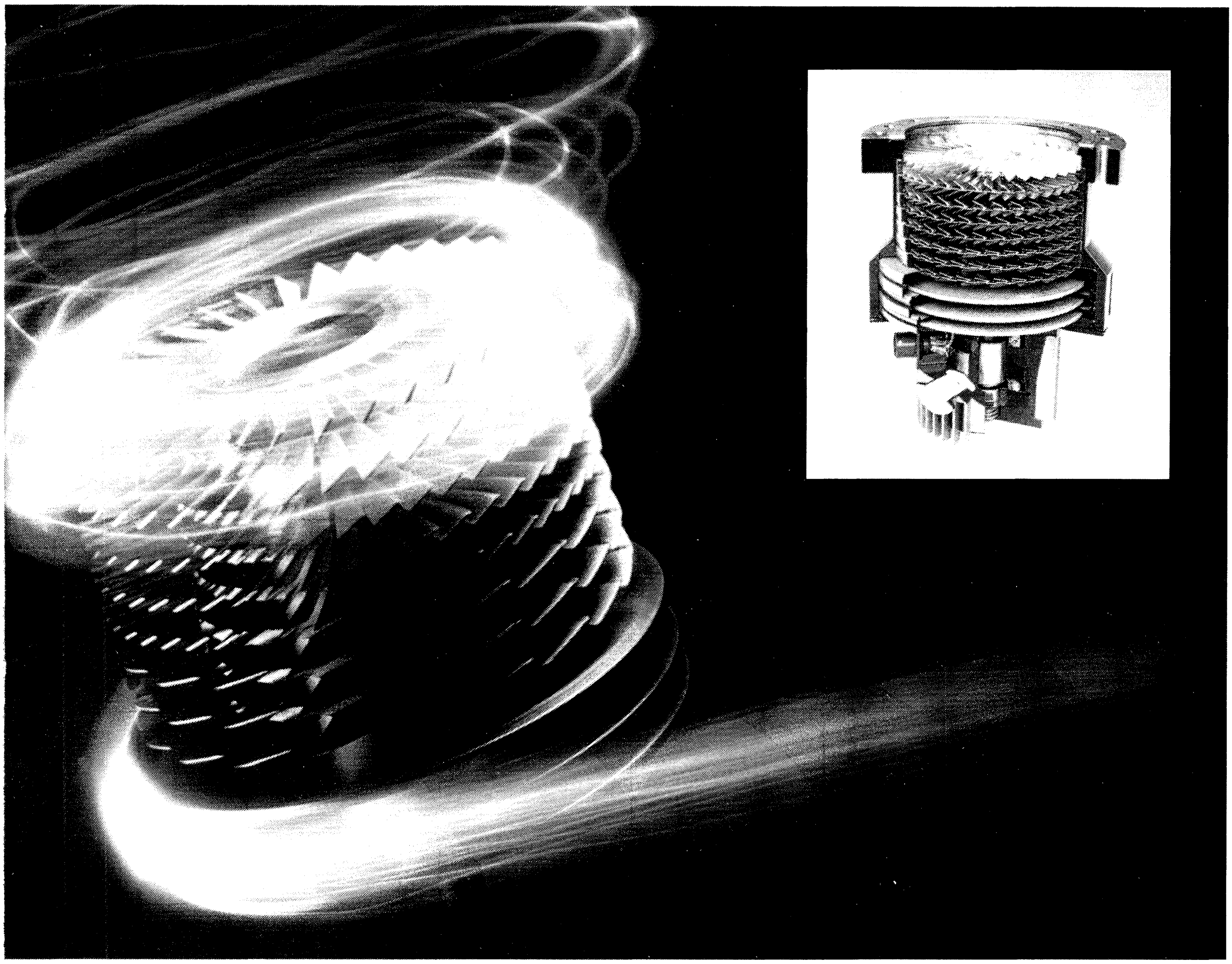
The benefits from physics experiment techniques make an impressive list, worthy of a major article. They include: measuring devices for ionizing particles (of which the Geiger counter was the first of many!); data acquisition systems; computer controls; on-line pattern recognition and data selection at very high rates; simulation work; computing and networking; analog-digital conversion; laser technologies; digital readout systems (CAMAC),.....

Accelerator applications

For those who can remember that far back, this was covered in a previous article by Oscar Barbalat (December 1989, page 13). As well as research in particle, nuclear and atomic physics, accelerator applications cover an impressive field - condensed matter and material sciences by synchrotron radiation; condensed matter and material sciences by ion beams; condensed matter and material sciences by neutrons from spallation sources; radiation for use in chemistry and biology; applications in medicine for diagnostics and radiotherapy; industrial processing such as ion implantation, radiation processing, food preservation, hygiene,....; power engineering and energy research; radioactive waste incineration;..........

Simulation

Once science was either theory or experiment. With the availability of high speed and powerful computers, simulation now offers a complementary approach. High energy physics institutes devote half of their sizeable computing capacities on simulations and have attained a very high level of expertise. Codes like EGS (Electron-Gamma Showers) developed in international collaborations and distributed by SLAC (Stanford) to more than a thousand users outside the field are prerequisites for example in all studies of cancer research and treatment by electron accelerators. Significant advances in understanding nuclear cascades have come from hadronic shower simulations. Such codes can now be used, for example, for spallation source designs and in inertial fusion research.



The European Synchrotron Radiation Facility (ESRF), Grenoble, France. Synchrotron radiation for studying the structure of matter - a direct spinoff from particle physics - is now a research industry in its own right.

Computing and networking

In the quest for rarer and rarer phenomena, physics has to work on larger data samples, requiring in turn higher and higher event rates. The high speed data flow inside the experiments at CERN's planned LHC proton-proton collider is comparable in bits/sec to the total public telecommunication rate world-wide! To cope with such immense data rates needs state-of-the-art and beyond in computers, pattern recognition devices and software for analysis and simulation.

With these high data rate experiments also involving large collaborations spread out across the world, an essential communications ingredient is computer networking, including the latest features of tele-cooperation, tele-operation of supervisory tasks in a detector and exchange of CAD and other digitized data. International data communication at an institute like CERN has an international throughput comparable to that of a medium sized European country!

At least half of the activities around a big experiment are concerned with informatics, many covering collaborations with industry. Pilot developments like the World Wide Web (CERN) providing quasi-simultaneous access to data held a range of computers world-wide have been adopted and developed further by specialist sectors.

Parallel processing and filtering of vast amounts data is being pioneered by high energy physics institutes.

Theoretical physicists at Rome have developed a computer of unprecedented capacity at very low cost. Designed for lattice gauge calculations, its is now being sold elsewhere.

Patents and Copyrights

Today funding agencies evaluating the technological potential of visible, large and expensive pure or applied sciences like to use "hard" indicators like patents and copyrights and the economic benefits derived from them. In applied science and industry on average 0.1 patents per scientist or engineer per year are expected. Funding agencies can then rate research institutes according to patent performance.

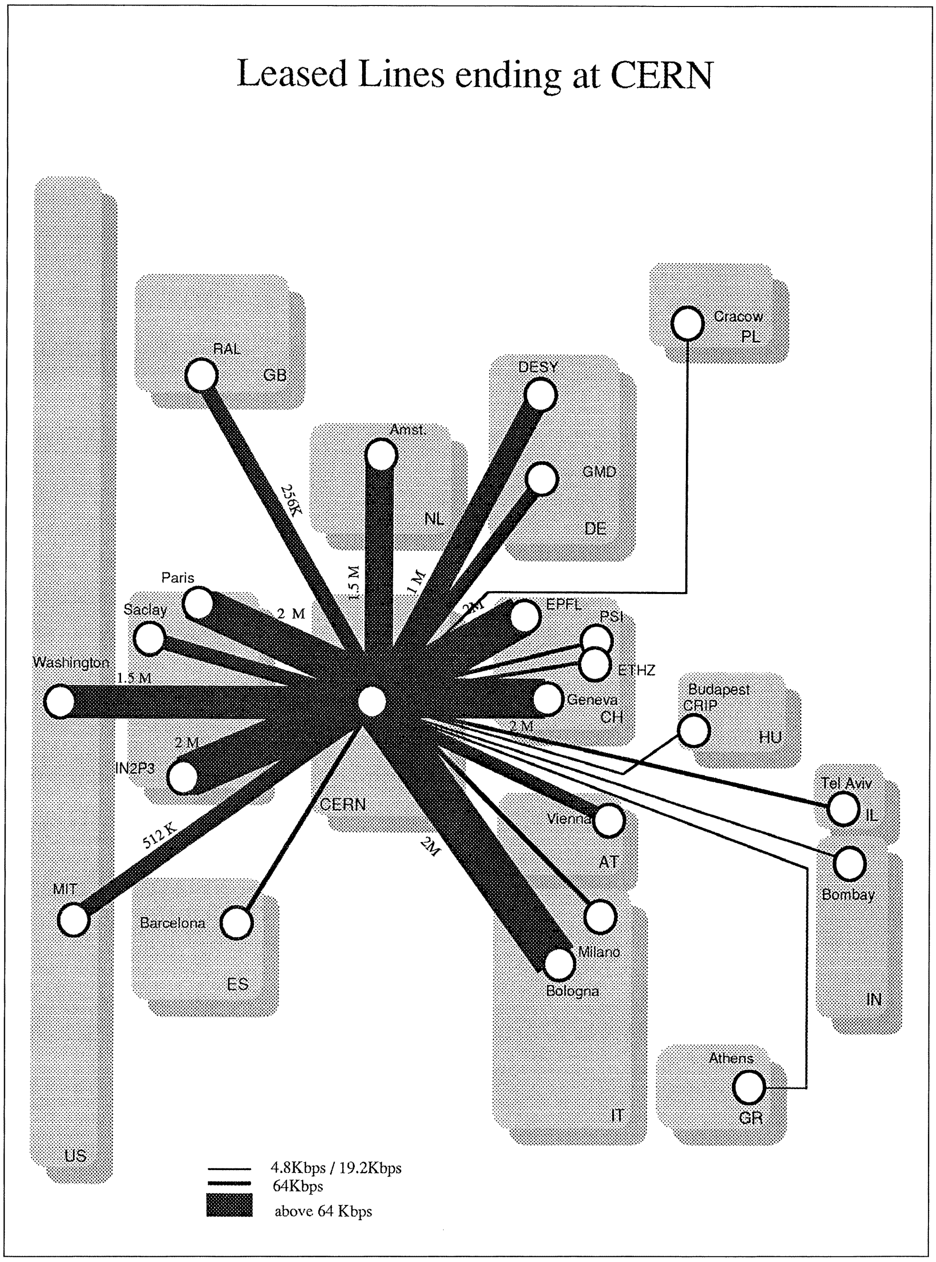
High energy physics does not file many patents. The principle reason is not so much a lack of interesting technological potential but the tradition of free collaboration, with results published in open and easily accessible journals.

Another reason is that direct application of a research idea is not obvious, even to the most far-sighted scientists. There is normally little incentive to get involved in the laborious and costly patenting procedure, and no funds available.

To solve the question of who owns intellectual property in large and international collaborations, a policy could be adopted along the lines used for authorship of published papers. Patents would then be owned by rather large groups. However patents taken in a scientific field should be available free of charge to the whole field to promote further progress.

Economic utility

CERN has commissioned studies (in 1975 and 1984) on high technology industrial contracts worth about 750MCHF. Industries were asked to estimate the economic benefit arising from what they had learned as a



International data communication at an institute like CERN has an international throughput comparable to that of a medium sized European country.

result of working with and for CERN . The average gain from subsequent sales to other customers was estimated to be three times the value of the 'seed' CERN contract.

A similar study has been carried out by in Japan by the KEK Laboratory, covering 1971-1991 purchases in industry of items each costing at least 5 million yen and totalling almost 100 billion yen. This corresponds to half KEK's material expenditure in that period. The results indicated sales increases of more than 10% in more than half of the cases and cost reductions of more than 10% in about half of the cases.

While interesting, such studies are not very convincing. Rather than the market itself expanding, the result is often a shift from one supplier to another.

Construction of Beijing's BEPC electron-positron collider made several Chinese industries deliver goods corresponding to Western standards in some key technologies. This was achieved in close collaboration with Beijing's IHEP Laboratory. The benefits were subsequently acknowledged by the industrial partners, who were able to go on to further challenging contracts, sometimes in consultation with IHEP staff.

While these advantages are now clearly established, there is no clearly established way of measuring economic utility. The benefits are often in special areas which do not impact significantly on the statistics used in major economic barometers. For example many physics spinoffs are in the field of measuring devices, which do not in themselves have a market like mass-produced items, but nevertheless play key roles in manufacturing processes and in sciences like medicine.

Another example is flight security, where new sensitive devices to monitor baggage and air cargo are based on high energy physics technology. To equip all airports with such devices does not in itself represent a major outlay judged by the yardstick of national GNP, but it has major implications for air traffic, which does.

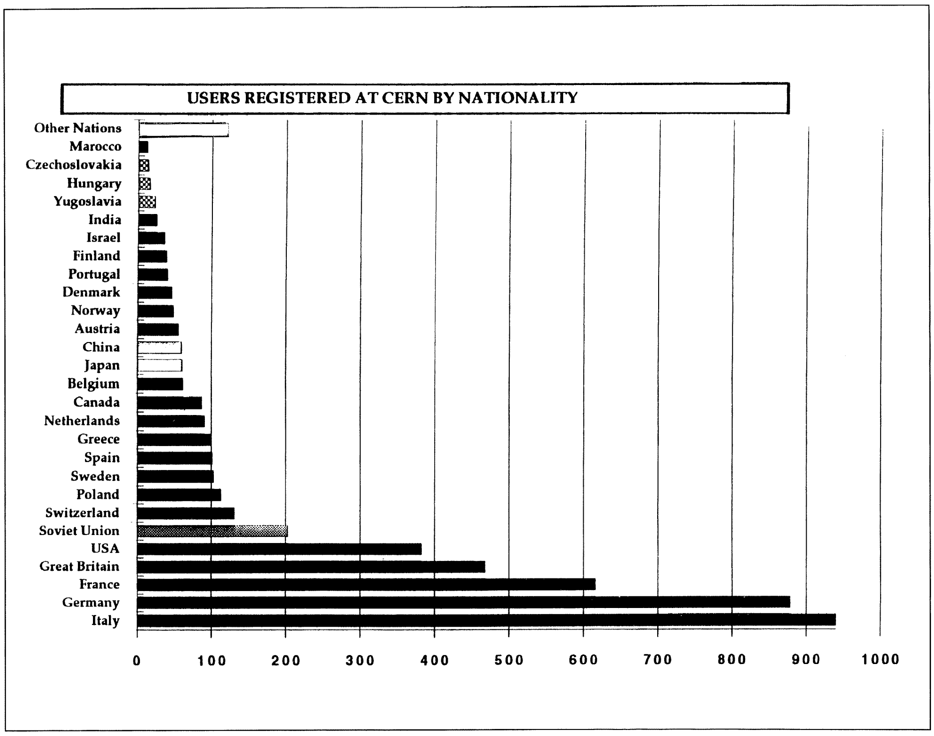
High energy physicists have collaborated very fruitfully with sectors - medicine, energy research, computing and networking and synchrotron radiation - making use of their special expertise and additional international involvement. In some cases these physicists have been the driving force in such a collaboration, an example being the European Supercomputing Initiative.

Several major firms have recognized that developing high-tech products for high energy physics is a good thing and are prepared to invest their own money.

Special arrangements

There are frequent personnel exchanges and consulting arrangements. Some firms (computing is a good example) maintain a permanent on-site presence at high energy physics institutes. In addition many other firms send specialists regularly to major research centres. The economic benefit of such activities has not yet been assessed, but at CERN there is now an attempt to follow these activities more closely.

The Budker Institute in Russia is supposed to earn half its income by selling products to other research institutes and to industry. They have



The average age of CERN's scientific users is around 25-30. While most of them (more than 60%) come from the four major CERN Member States (France, Germany, Italy, UK), the next largest contingents are from the US and the ex-USSR countries, with the remaining 25% coming from the smaller CERN Member States and elsewhere (Israel, India,....).

developed a number of radiation sources which can be applied in different sectors, such as the chemical industry and in waste suppression or conversion.
The Institute produces custom-built accelerators. and has successfully exported to countries like Japan and South Korea.

KEK (Japan) and DESY (Germany) sell synchrotron radiation beam time. KEK operates a cancer therapy centre using its proton synchrotron. Technologies developed there are also used now in the dedicated cancer therapy centre based on light ions. Using intense synchrotron radiation X-rays, DESY (and SLAC) have developed non-invasive angiography techniques.

A number of successful companies can be traced to physics origins ('Silicon Valley' near Stanford being a prime example). They are mostly active in the fields of electronics, controls, software and measuring devices.

The research centres

Although particle physics worldwide covers more than 200 university and other institutes, it is centred on a few major Laboratories in the US, Europe, Russia, China and Japan. These Laboratories reflect regional patterns of science, education and economic sophistication.

All of them are in the northern hemisphere and most in highly industrialized regions.

Because of the very different economic environments, it is difficult to compare the staffing levels of different laboratories and the responsibilities of their personnel.

For this purpose staff and users should be taken together. In Europe and the US the research is done by scientific 'users' and the community is continuously changing. In this framework the Laboratory provides the infrastructure and the accelerators - for example at CERN, which has the largest high energy physics user community in the world, there are only 100 pure research staff out of a total complement of some 3,000.

In Russia and China, the institutes form part of the respective academies of sciences, of which the research physicists are mostly members and therefore belong to the staff. Japan is an intermediate case.

Educational and international collaboration

At CERN about a thousand new scientific users 'enrol' each year. Their age is on average around 25-30 years. While most of them (more than 60%) come from the four major CERN Member States (France, Germany, Italy, UK), the next largest user contingents are from the US and the ex-USSR countries, with the remaining 25% coming from the smaller CERN Member States and elsewhere (Israel, India,....).

These students get thorough "hands on" training in many different technologies, project and quality control, teamwork, languages, in a highly competitive environment.
This experience is valuable in many walks of life.

About two-thirds of these young researchers finally turn to industry - chemicals and pharmaceuticals, communications, computing and networking, traffic systems, medicine, physics instrumentation, electronics, energy research, patent engineering,.... - as well as commerce - insurance, public relations and media, sales,..... However telecommunications, computing and network-

ing made up one third of the job placings.

This educational aspect and its associated internationalism is also the goal of the European "Human Mobility" programme which moves a comparable number of young scientists around Europe. High energy physics played a pioneer role in this sector.

Extending international collaboration

High energy physics institutes were the first and most visible post-World War II "big science" efforts. Their scientific success inspired the creation of other international projects, of which the best-known examples in Europe are the European Southern Observatory (ESO), the European Molecular Biology Organization (EMBO), the Joint European Torus (JET), the scientific branch (former ESRO) of the European Space Agency (ESA) and the European Synchrotron Radiation Facility (ESRF).

In general, such groupings reflect the scientific need for instruments or facilities (telescopes, accelerators, large lasers, synchrotron radiation sources, satellites, ...) beyond the means of individual nations.

It is the combination of pure science and large numbers of eager young university scientists, combined with industrial know-how which makes such facilities successful. The international collaboration creates a "critical mass" with sufficient visibility to attract the best people in the field.

There are now efforts to extend the international collaboration in physics institutes beyond specific regions. In fact a Memorandum of Understanding has been signed by several high energy physics institutes with a view to organize R&D around a next generation linear electron-positron collider. At the same time the demise of the SSC project in the US has catalysed a move for US physicists to get involved in ongoing projects elsewhere.

Industrial collaboration

At major research centres, there are important policy differences in the approach to in-house manufacturing, specialized engineers, technicians and manual craftsmen.

In Japan, complete collaboration of research with industry is the declared policy. So KEK has relatively few engineering and technical staff and no manual craftsmen. Operation of the laboratory, component and system production and the building of prototypes are done completely by industry, using the specifications and ideas of the laboratory and associated universities.

In such an arrangement technology transfer is not a problem. However there may be a cost problem for the funding agencies and the ease of development of technologies seen from the point of view of the scientist. The advantage of such an arrangement is that the scientists benefit fully from the experience and facilities of industry.

On the other hand, the institutes in China and Russia have large internal production capabilities which allow them to produce in-house a considerable fraction of the material required.

The US and European institutes are somewhere in between these two extremes. Their policy is to produce prototypes and to develop new accelerator ideas and detector components in-house. Therefore they still have significant production and technological capabilities on-site and use them extensively for development work. But the European trend, at least at CERN, is decisively in the direction of increasing industrial involvement.

This regional diversity of approach was one of the most interesting aspects of the ICFA Panel study. Each approach has its merits. Whether one is best, or whether some compromise solution should evolve, remains to be seen.

Computing - moving away from the mainframe

by David Williams

After many years of being the mainstay of major in-house computing services, machines based on a mainframe architecture are no longer a prerequisite.

After some 20 years of valiant service providing the mainstay computing services, machines based on a mainframe architecture are beginning to show signs of age. With the advent of personal computers, less expensive hardware and increased networking, mainframe systems providing a range of services for hundreds, even thousands, of users are being discarded in favour of distributed computing solutions.

During these twenty years, the traditional mainframe provided the inherent integration or 'glue' for major computing environments. This was particularly the case with high energy physics laboratories, handling enormous quantities of data. At CERN, the VM system (CERNVM) was, and still is, an integral part of CERN's day-to-day working environment, with some 15,000 tape mounts per week and a thousand logged-on users at peak periods.

However VM's days are now numbered, since CERN will phase it out over the next few years. To pave the way for this move, user migration to the new solutions, based on desktop machines and specialized services, has to be encouraged.

The plan is to move the bulk of the physics data processing load off the VM system by the end of this year (to tie in with the expiring lease on CERN's present IBM mainframe). The Laboratory would then use a smaller IBM mainframe to provide a general interactive service during 1995-6. By the end of 1996, the full community should have moved to new interactive desktop services.

Physics data processing

Physics analysis is being moved to clusters of UNIX workstations, where CERN's CN (Computing and Networks) Division and several major experiments have built up significant experience over the past three years. For example CERN's Central Simulation Facility (based on Hewlett-Packard 9000/735 workstations) and aimed at a computing-intensive workload, offers more than a hundred times better price/performance ratio than traditional mainframes.

SHIFT - Scalable Heterogeneous Integrated Facility - currently encompassing some 25 computers and 700 Gbytes of disk storage interconnected by a Gigabit/s network – handles input/output-intensive physics data processing, 5-10 times more economically.

While these new solutions are attractive, there is still a need for improvements, particularly in the areas of reliability of tape handling including access to the robots and the ability of solutions like SHIFT to handle a broad mix of batch jobs.

Interactive desktop services

With the advent of personal computers, most people's computing environment has rapidly developed into their desktop system, supplemented by a flexible network. The availability of special and often sophisticated desktop applications for mail, news, document handling, presentations, spreadsheets and graphics has very immediate appeal. Documents of all kinds can now be processed and prepared to highly professional specifications.

However many people are becoming concerned about the overall efficiency of such a system. With no central organization, much money and effort can be wasted in duplication, with multiple software installations and redundant overheads. The CN objective at CERN is to provide the infrastructure and the software environment so that users can simply plug in their desktop computer or workstation, and 'boot' it to obtain all required resources. Desktop services would provide the (licensed) applications and protect work with adequate backup. Initially this approach is to split into two separate streams for PCs (including Macintosh) and for UNIX workstations, although the hope is that over time industry will ensure that these two trends will converge.

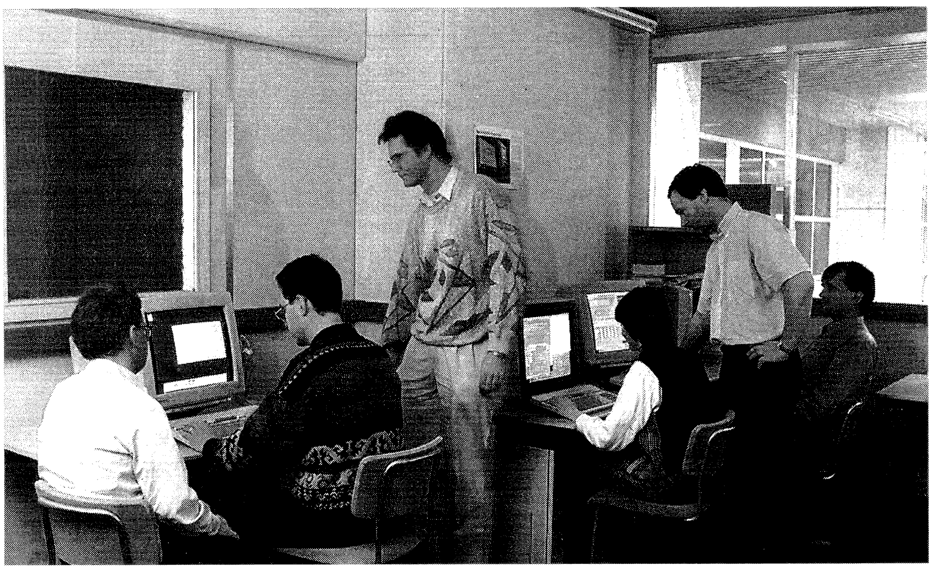
Networks

The network is the nerve system of a computer environment, ensuring timely transmission of vital messages and information. Normal operation of a computing environment, not just for physics, needs smoothly operating, high performance, reliable and well managed site-wide communications. The more distributed the approach, the more vital this becomes.

To ensure a high level of service, both the reliability and the manageability of the network need to be improved. Some measures to safeguard against 'software meltdown' are quite urgent and although technical, are not necessarily expensive. However the basic requirement is wiring, which in much of CERN needs total refurbishing. Todays solution with up to 30 offices linked to a single coaxial cable is not reliable and manageable. A better approach is structured wiring using twisted-pair cables from a wiring concentrator to each office. This offers precise diagnosis and good remote control, as well as speeds of up to 155 Mb/s. Such improvements are already underway in many places, including telephone wiring in the USA. Even taking into account work already underway, the complete transformation of the CERN site would cost many millions of Swiss francs.

For external networking, progress in and around Laboratories like CERN has to be carefully linked to user requirements and developments. Network connections are in constant evolution and and we have to be ready to adapt to changing international infrastructure, always keeping an eye to the future.

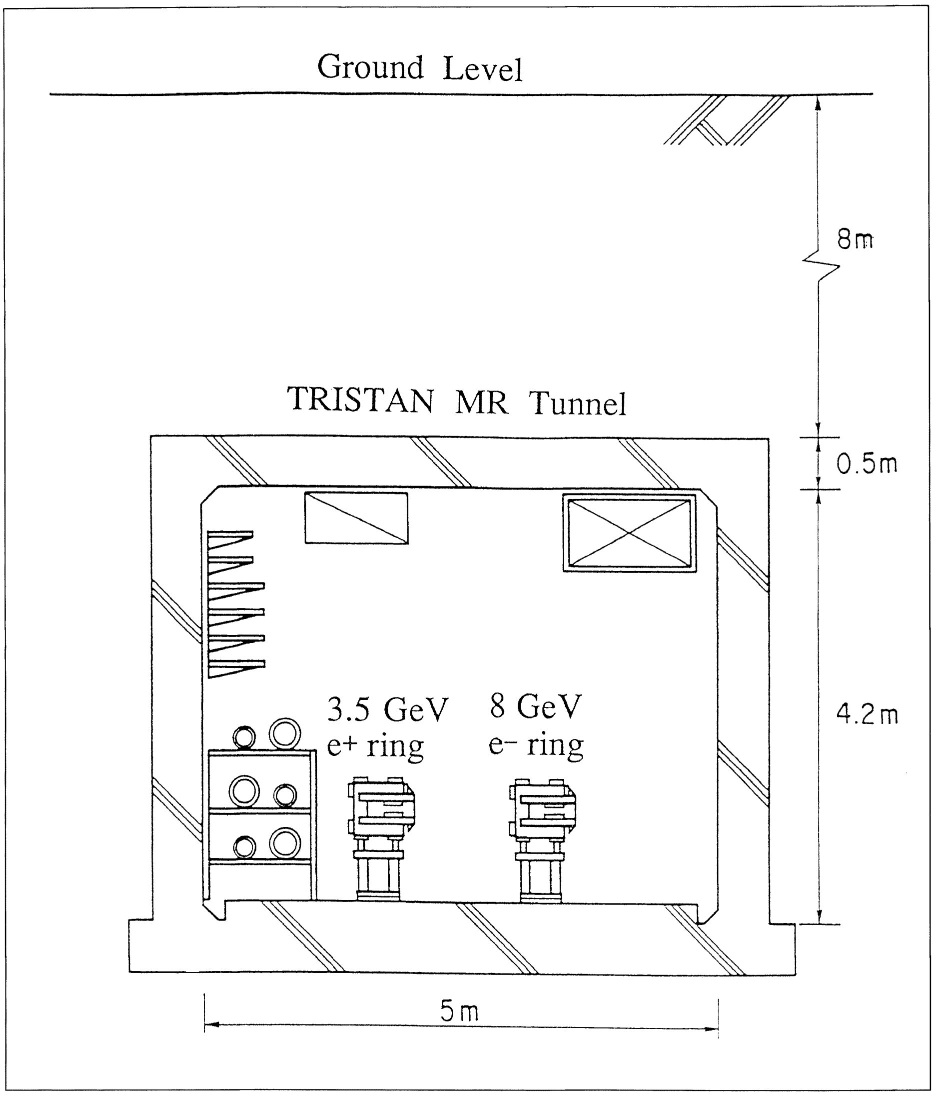
The departure of VM at CERN will be the end of an era - no more will big computers provide an across-the-board range of services. However it does not necessarily spell the end of big computers for high energy physics. Instead, large computers could be justified to fulfil the requirements of special applications.



With the advent of less expensive hardware and increased networking, other computing solutions are being found.

Around the Laboratories

For the new B-factory, the single ring in the present TRISTAN electron-positron collider at the Japanese KEK Laboratory will be replaced by two new rings.



KEK
B factory

After more than three years of intensive evaluation, the Japanese government has approved the conversion of the TRISTAN electron-positron collider at the national KEK Laboratory to a two-ring asymmetric B-meson factory. The project will take about five years to complete. Initial construction will proceed while TRISTAN experiments continue data-taking, expected to continue until summer 1995.

When it becomes operational in 1998, the new facility (TRISTAN II) will be capable of producing more than ten million B meson pairs each year. Detailed studies of their decay properties are expected to reveal answers to the long-standing puzzle of the violation of CP symmetry - combined left-right reversal and particle-antiparticle substitution.

According to the conventional (Kobayashi-Maskawa) picture of CP violation, certain rare decays of B mesons will give much larger CP violating effects than those seen so far (in neutral kaon decays). The theory predicts a well defined pattern of CP violating effects in several different decay modes.

TRISTAN has been operating since 1986 in the collision energy region between 50 and 64 GeV. During its initial stages of operation, when it was the world's highest energy electron-positron collider, TRISTAN experiments searched for new particles such as the top quark and Higgs bosons, establishing new limits.

After LEP at CERN and SLC at Stanford (SLAC) extended the energy frontier in 1989, TRISTAN experiments concentrated on precision studies of electroweak, quark-gluon, and two-photon processes.

The energy of TRISTAN II will be reduced to 10.5 GeV - the mass of the upsilon 4S resonance.

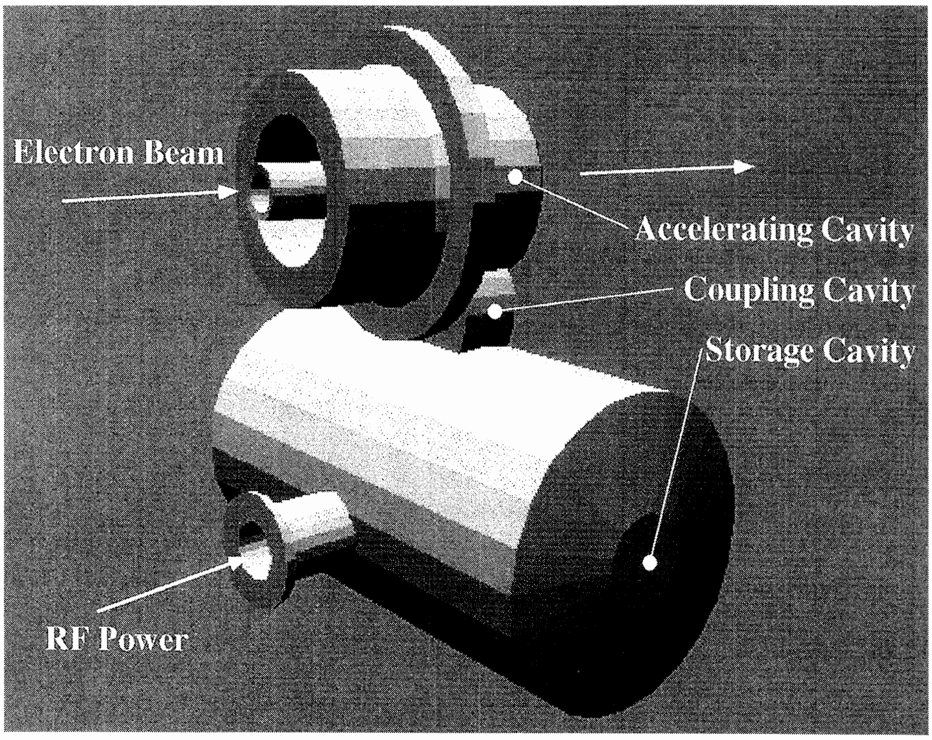
TRISTAN's single ring will be replaced by two new rings - a 3.5 GeV positron and an 8 GeV electron ring. The asymmetric collision energies will facilitate observation of the time-dependent asymmetries in B meson decays that would signal CP violation.

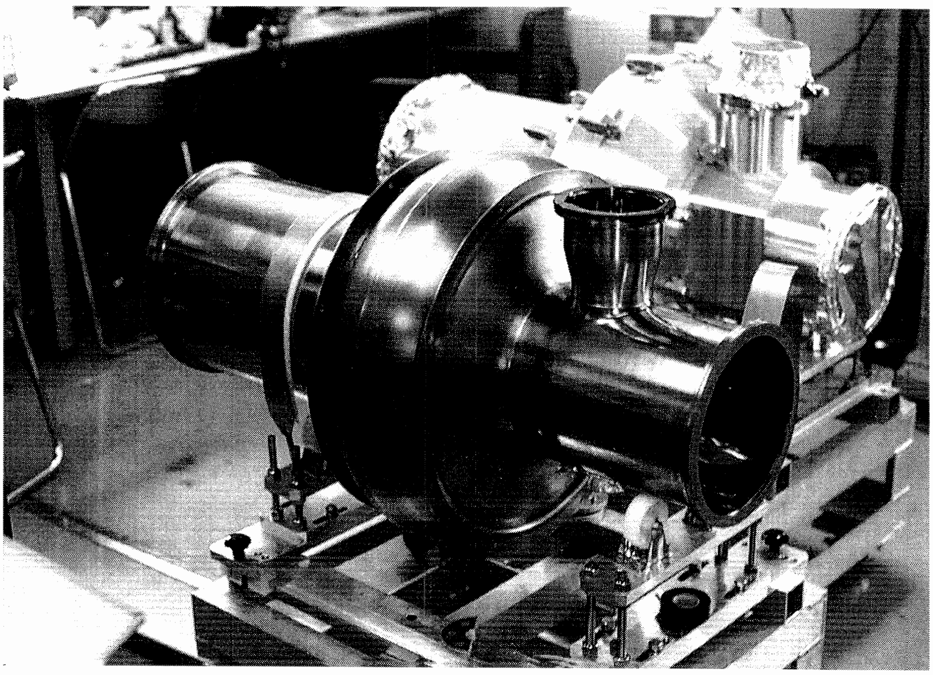
The energy of KEK's existing 2.5 GeV injection linac will be upgraded to 8 GeV to permit direct filling of the 8 GeV electron ring without the need for intermediate acceleration.

The production target for positrons will be located at the 4.5 GeV energy point of the linac, significantly higher than the 200 MeV point currently used for TRISTAN.

The linac upgrade has already begun. The increase to 8 GeV energy will be accomplished by increasing accelerating gradients from 8 to 20 MV/m. This will be done by increasing the number of accel-

At KEK, research and development work for for the new B-factory is underway. Prototypes of radiofrequency cavities are under performance tests for their ability to handle coupled-bunch instabilities. Above - normal conducting cavity resonantly coupled with an energy storage cavity. Below - superconducting cavity.





eration structures and by doubling the radiofrequency power.

The high luminosity needed to produce the large number of B mesons will be achieved by both reducing the size of the beam at the collision point and increasing the total circulating beam currents.

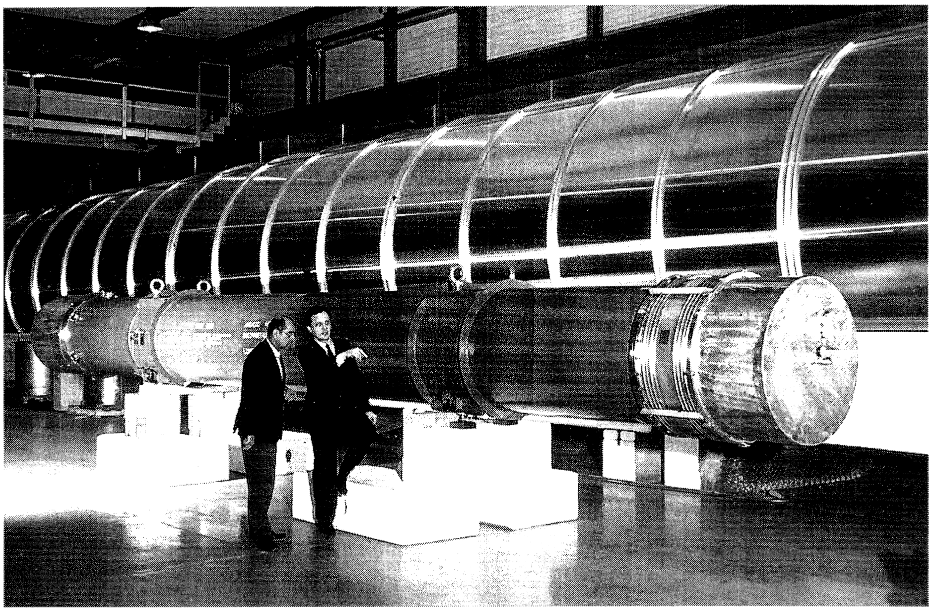
The TRISTAN II design emphasizes smaller beam sizes with modest beam currents. Even so, the total stored beam currents will eventually reach 2.6 A for the positron and 1.1 A for the electron ring. With such large beam currents stored in many bunches, strong coupled-bunch beam instabilities are excited. A radiofrequency cavity that minimizes the excitation of higher-order-mode fields by the passing beam must be used. KEK is developing both normal and superconducting versions of these cavities.

Eventually, the performance of the machine will be limited by the coupled-bunch instability caused by the accelerating mode itself. It has been known that a superconducting cavity can mitigate this problem because of its large accelerating field and large stored energy. Here, the past five year's operating experience with superconducting cavities at TRISTAN should prove useful. A normal cavity with an energy storage cell can potentially work as well as the superconducting type. Cavities of this type will soon be tested in the existing 8 GeV TRISTAN Accumulation Ring.

The design of the machine lattice is progressing. Since beam injection is expected to occur every half hour or so, the design looks for a horizontal dynamic aperture sufficiently large so as to avoid having to change the beam optics between injection and experimental data-taking. Such a scheme was tested in the TRISTAN Main Ring last year, and more tests will follow. Various devices for beam-monitoring are being tested at the 2.5 GeV Photon Factory Ring that routinely provides a multi-bunch 0.35 A positron beam.

Last summer, KEK hosted a meeting to inform potential worldwide users about the new facility. The Laboratory has stated that there will be one interaction region and the users were encouraged to form a

The first 10-metre twin-aperture prototype dipole for CERN's LHC proton collider was recently delivered to CERN for testing.



single collaboration. In response, a consortium of more than 36 institutions from six countries prepared a Letter of Intent for the March meeting of the TRISTAN Program Advisory Committee. Both the laboratory and the collaboration welcome experimentalists to join this effort.

CERN First LHC prototype dipole

The first 10-metre twin-aperture prototype dipole for CERN's LHC proton collider was delivered on 1 February for testing. It is the first of two prototypes supplied by the Italian INFN (Istituto Nazionale di Fisica Nucleare) in the framework of a collaboration with CERN on applied superconductivity.

The project is being managed by the Milan Section of INFN at its Laboratory for Applied Superconductivity (LASA) which worked mainly with Italian companies. The technical follow-up is being carried out by a CERN-INFN team.

The active part and cold mass of the magnet were manufactured by Ansaldo (Genoa); the cryostat was produced by Zanon (Schio).
A significant contribution was also made by LMI-Europa Metalli (Florence) in developing high current density superconducting cables with the requisite fine filaments.

The second INFN-CERN prototype is not far behind. Five more 10-metre-long prototypes from other collaborations are scheduled for delivery later this year.

CANADA TRIUMF support

Citing insufficient levels of foreign contributions, on 22 February Canadian Industry Minister John Manley announced the Federal Government's decision not to support further the KAON accelerator project for the TRIUMF Laboratory in Vancouver.

KAON was intended as a five-ring particle 'factory' using KAON's existing 500 MeV cyclotron as injector, producing a variety of beams a hundred times more intense than currently available sources. The mood had been optimistic in the late 1980s when development money came through both from the regional British Columbia administration and from Ottawa.

The previous Federal Government had made a commitment to contribute a third of KAON's construction and operating costs, equivalent to $608 million over ten years, provided sufficient support came through from overseas. Another third of the construction cost had been offered by British Columbia. Although contributions had been lined up from France, Germany and Italy (Canada had been one of the first to contribute to the German HERA electron-proton collider at DESY, Hamburg), the US and Japan remained aloof.

With the federal government preoccupied with cutting the budget deficit, KAON was an obvious target. However this does not spell the end for TRIUMF. Far from it. 'We will be asking TRIUMF management to develop options for its future role that will enable it to continue being a focal point for Canada's research in particle physics, and act as Canada's gateway to leading foreign facilities', said Minister Manley. Ottawa support for TRIUMF in the 1994-5 financial year is being boosted by $4 million to $33.25 million, offsetting recent cuts. Managed as a joint venture by a consortium of Canadian universities, TRIUMF is mainly funded through the Canadian National Research Council.

About 30 Canadian physicists had been involved in the SDC detector collaboration for the ill-fated US Superconducting Supercollider (SSC) project. Some 25 Canadians were on the SSC foreign visitor roll when the project was cancelled last October.

WORKSHOP
Beam cooling

Cooling - the control of unruly particles to provide well-behaved beams - has become a major new tool in accelerator physics. The main approaches of electron cooling pioneered by Gersh Budker at Novosibirsk and stochastic cooling by Simon van der Meer at CERN, are now complemented by additional ideas, such as laser cooling of ions and ionization cooling of muons.

In these techniques, the idea is to expose the disordered beams to a controlling influence which absorbs (in the case of electron cooling) the disorder, or applies suitable corrections (in the case of stochastic cooling).

Organized by CERN's Antiproton Rings Group, a workshop on beam cooling and related techniques held late last year in Montreux, Switzerland, attracted a useful audience.

It was the continuation of a series of earlier meetings - Karlsruhe 1984, Wertheim 1988, Legnaro and Tokyo 1990 - mostly given over to electron cooling.

To begin the meeting, the principles of the various techniques, their achieved performances and prospects were the subjects of a relatively formal series of presentations.

This was followed by a presentation on a proposal for Maser Cyclotron (CMC) cooling. In the ensuing discussion it emerged that the scheme required further work and analysis since the results achieved to date do not provide conclusive evidence for its feasibility.

Attention in the stochastic cooling presentations focused on beams, bunches and on the usefulness of devices with bandwiths covering much higher frequencies.

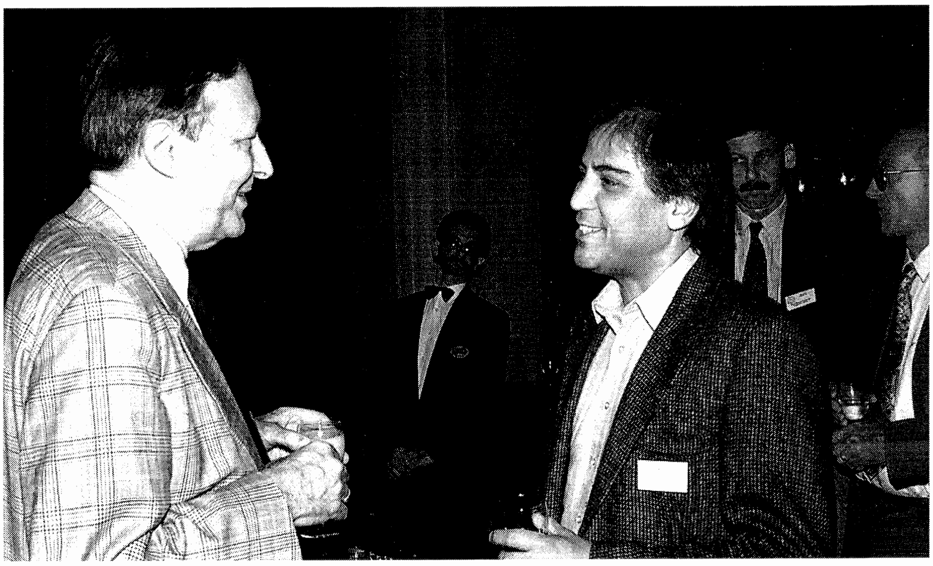
A device for the electron cooling of ions aroused considerable interest since all were agreed that the density limit had been reached and that a wide-band damper (100 to 500 MHz) was needed. Another very interesting conclusion was that the cooling speed of heavy ions by electrons depends on whether the beam is cold or diffused.

Several ideas were aired on the cooling of muons to increase density. These proposals are still being examined but given the limited lifetime of muons and the associated technical difficulties, they seem, for the time being, difficult to realise.

Some laboratories use laser cooling but, despite their many advantages, such devices have two important drawbacks: cooling only certain types of ion, depending on the characteristics of the laser used; and cooling only in the longitudinal plane.

To offset these shortcomings, a complementary transverse cooling system can be added (e.g. an electron cooling system) to improve performance.

Considerable interest was shown in prospects for applying cooling techniques for 'crystallizing' very cold beams. A prototype strong-focusing machine and a mathematical model was presented. The beam crystals are not always aligned but sometimes arranged in zig-zags. Applications of these devices for heavy ion accelerators and for crystallization were also examined.



At the ICFA meeting at the TRIUMF Laboratory, Vancouver, on 16 January - ICFA Chairman John Peoples (right) with Secretary Roy Rubinstein (Photo M. Pavan, TRIUMF)

Bookshelf

Advances of Accelerator Physics and Technologies (Vol. 12 of Advanced Series on Directions in High Energy Physics), Edited by Herwig Schopper, Published by World Scientific (ISBN 981-02-0957-6, in paperback 981-02-0958-4)

Particle accelerators have always drawn upon the most advanced technologies. For Cockcroft and Walton it was high voltages, while the cyclotrons and synchrotrons that followed depended upon acceleration systems designed in the race to perfect wartime radar.

As accelerators became too big for the university workshop to handle, the manufacturers of heavy electrical machinery were brought in to make hundreds of metres of electromagnets. They found the requirements of precision and reliability surpassed the quality of the best of their products and had to develop new methods of insulation and precision assembly. They now readily admit that in meeting our challenge they extended their own grasp of technology to the benefit of their less exotic customers; not to mention their shareholders.

The stimulation of industry did not stop there - the physicist, by the nature of his craft, is always the first to know of what has just become possible. In their turn many industries, from those which prospect for petrochemicals to others constructing the channel tunnel, have become the technological beneficiaries of this big science.

The latest of these technologies is of course that of superconductivity, and this is fully covered in this book. But in the many chapters which describe the state of the art of accelerator design, the reader will encounter numerous examples where the possible awaits an everyday application.

This excellent compendium of advances in the accelerator field is therefore obligatory reading for anyone in an industry striving to deserve the label of high-tech.

Not only does it for the first time draw together authoritative contributions by those who lead these technologies, but it explains how the large majority of today's accelerators are put to work to cure patients in hospital and to provide synchrotron radiation for a rich spectrum of new industrial applications. In addition there is much in the volume that is essential reading for the accelerator specialist. Until now books in this field tended to ignore practicalities and be entirely devoted to the mathematics of the subject.

The camera-ready typescript is varied but always legible - a comment that might equally apply to the quality of the prose. Happily, all of the more difficult chapters are nevertheless rewarding in their technical content. There is also one chapter, contributed by Montague, that is worth the price of the book for those who may delight in his humorous and ironic style.

Bravo to the editor, Herwig Schopper, for making a success out of a timely compilation.

E.J.N. Wilson

Early Quantum Electrodynamics - A Source Book, by Arthur I. Miller, Cambridge University Press, ISBN 0 521 43169 7)

Many people these days would say that quantum electrodynamics, the quantum picture of electromagnetic radiation, dates from 1947-8 with the work of Sin-itoro Tomonaga, Julian Schwinger and Richard Feynman. However this was the modern reformulation of a theory whose genesis was Paul Dirac's 1927 work on the quantization of radiation and was subsequently, and painfully, pieced together in the 1930s.

Until the Second World War, the science of quantum electrodynamics advanced steadily, driven for the most part by the intellects which had produced modern quantum mechanics - notably Dirac, Heisenberg and Pauli. After Dirac's 1928 relativistic theory of the electron, Heisenberg and Pauli went on to cast an initial quantum formalism for the interaction between radiation and electrons.

During this time many intellectual hurdles had to be crossed - the negative energy states predicted by Dirac's equation and their final identification as antimatter electrons (positrons), the whole problem of explaining quantum force mechanisms as particle exchanges, Fermi's explanation of beta decay, and Yukawa's explanation of the nuclear force. Heisenberg's invention of the S-matrix and his ideas on the transmission of nuclear forces through exchange mechanisms revolutionized both our picture of the quantum world.

These problems were not easy - several times during the 1920s even these intellects almost despaired.

A shadow across the subject was the continual problem of troublesome infinities in mass terms and elsewhere. It was not until the ordered renormalization recipes of the immediate post-war period that these infinities were finally hidden from sight.

Science historian Arthur Miller traces these developments in the first half of the book, and signals how these early developments were eventually to dovetail with the exciting new developments of the late 1940s. Supplementing the survey are eleven fascinating landmark papers by Heisenberg, Dirac, Weisskopf, Fierz and Kramers spanning the period 1930-8. Many of these were originally not written in English.

The availability of these difficult ideas in English in a single volume is itself valuable, offering fresh insights into these pioneer developments.

(Among them is Weisskopf's 1934 calculation of the self-energy of the electron, including the original version with the error and the subsequent correction. Weisskopf has related how, humiliated, he went to Pauli, his boss at the time, and asked whether such an error warranted him giving up physics. 'No,' replied Pauli adamantly. 'Everyone makes mistakes, except me.')

However the new approaches of the late 1940s which revolutionized the field are outside the scope of the book, considerably reducing its appeal.

As Heisenberg said, the new Feynman diagrams provide the intuitive appeal that previously had been so difficult. The pre-war history of quantum electrodynamics and related matters is also related in Abraham Pais' fine book 'Inward Bound' (Oxford University Press), which also goes on to cover immediate post-war developments, where precision spectroscopy measurements (the Lamb shift) provided fuel for accurate quantum electrodynamics calculations. In Dr. Miller's book, the emphasis is more on the need to understand which drove the pre-war efforts.

G.P.S. Occhialini 1907-93

G.P.S. Occhialini, a legendary figure for all who remember the very beginnings of cosmic ray particle physics, died on 30 December. Born on 5 December 1907 in Rossombrone, near Urbino, he studied in Florence. Here he met Bruno Rossi, whom, although only two years his senior, he always regarded as a master.

In 1932 Occhialini went to Cambridge where he worked with P.M.S. Blackett. They invented and perfected the counter-triggered Wilson chamber technique, recording cascade showers which confirmed the existence of the positron, discovered slightly earlier by Anderson, and demonstrating its symmetry with the electron. Their counter-triggered chamber technique was also to endow physics with the mesotron (later known as the muon), the neutral kaon, the lambda, and other strange particles.

In 1938 Occhialini left for the University of São Paulo in Brazil, returning to Britain in 1944 where he joined the Bristol group directed by C.F. Powell, studying nuclear reactions with the aid of photographic emulsions. Obsessed by cosmic rays, Occhialini rapidly realized that useful work in this field meant greatly increasing the silver bromide density in the emulsion to show particle tracks more clearly.

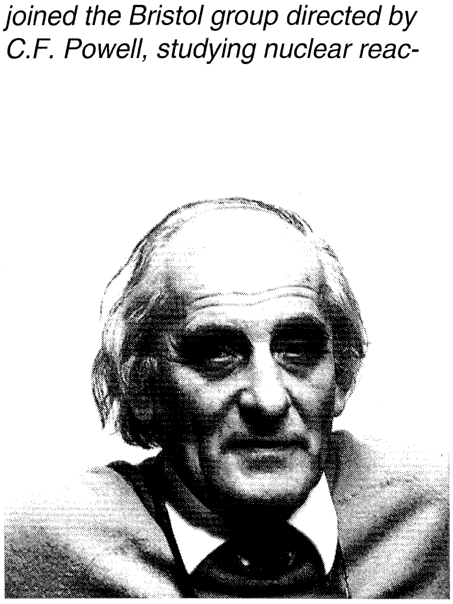
Urged by Powell and Occhialini, the Ilford company produced the desired emulsion in 1946.

That same year, a packet of plates coated with the new emulsion was set up at the Pic du Midi de Bigorre in the Pyrenees at an altitude of 2850 m. After six weeks the plates were returned to Bristol to be developed. In May 1947, Lattes, Muirhead, Occhialini and Powell published the first two examples of 'double' mesons - the decay of a pion into a muon.

In 1979 Occhialini was awarded the Wolf prize for his outstanding controlled chamber and emulsion contributions to cosmic ray and particle physics.

Shortly after the pion discovery he rendered another fundamental service to the emulsion technique. With the aid of C. Dillworth and R. Payne he heat-treated cold emulsions impregnated with cold developer. This made possible the uniform development of emulsions 600 mm and more thick, whereas those used for the pion-muon decay were only 50 mm thick. This elegant but little-known invention made the whole of post-pion emulsion physics possible, especially the study of charged kaons.

Occhialini abandoned elementary particles in 1960 and spent a year at MIT with his old friend Bruno Rossi and his team learning about the field that was to become space physics. In Italy, where he had become a professor at Genoa, and subsequently at Milan, he directed and organized the space operations of a number of the Italian laboratories.



G.P.S. Occhialini 1907-1993

People and things

He was a long-standing member of the Council of ESRO.

Everyone who encountered and liked "Beppo" were struck by the force of his personality and the wide extent of his knowledge and interests, which ranged from mountaineering, especially pot-holing, to literature and art. Extremely knowledgeable, he could discuss these subjects for hours, sometimes paradoxically but always intelligently. His friends used to say that he was the last Renaissance man.

Those friends covered a vast field, from Pyrenean pot-holers to artists and poets, and of course physicists, including famous names like Rossi, Blackett and Pauli.

He showed steadfast consideration for others, loyalty to his friends and honesty in science and, indeed, in everything.

Active before CERN even came into being, he made major contributions to the discoveries which motivated and justified the foundation of the Laboratory.

From C. Peyrou

Element 106

Element 106 has been confirmed. First discovered at the Lawrence Berkeley Laboratory's HILAC machine in 1974, element 106 has remained nameless because of disputes with Russian scientists. In 1992, the International Union of Pure and Applied Physics (IUPAP) finally gave credit for discovery to the LBL group, but a separate protocol in 1976 suggested that the naming of the element should await a confirmation experiment. Such a measurement has only now been made. Scientists using the LBL 88-inch cyclotron bombarded californium 249 atoms with oxygen 18 ions, forming element 106 (atomic weight 263), which decayed with a lifetime of 0.9 sec. into rutherfordium 259 plus an alpha particle.

Bernard Grossetête 1938-93

Bernard Grossetête, Director of the Laboratory of Nuclear and High Energy Physics (LPNHE), Jussieu, Paris, died recently at the age of 55. After studying at the Ecole Normale Supérieure in Paris, he obtained his doctorate at Orsay's linear accelerator Laboratory (LAL) under Pierre Lehmann, going to study electromagnetic properties, radiative corrections, and photoproduction. From 1974 he was a member of the Orsay team working at CERN's Omega spectrometer.

After a spell at CELLO at DESY, he took charge of the LPNHE, where his new dynamism led to the Laboratory's involvement in major new projects at CERN and elsewhere. He was keenly aware of emerging new trends, for example in large showers induced by cosmic ray photons or new techniques for acceleration. Very involved in university teaching, he was the author of several texts.

Bernard Grossetête 1938-93

SLAC Summer Institute

The XXII SLAC Summer Institute on Particle Physics, entitled Particle Physics, Astrophysics and Cosmology, will he held from 8-19 August at SLAC (Stanford Linear Accelerator Center). A seven-day school will be followed by a three-day topical conference in a package designed primarily, but not exclusively, for post-doctoral experimental physicists. Advanced graduate students are also welcome. Further information from the Conference Coordinator, Lilian Vassilian, SLAC, PO Box 4349, MS 62, Stanford, California 94309. Fax (415) 926-3587, e-mail ssi@slac. stanford. edu

Meetings

An International Symposium on Exotic Atoms and Nuclei will be held from 7-10 June 1995 in Hakone, Japan, in honour of the 60th birthday of Professor Toshimitsu Yamazaki, the director of Tokyo's Institute for Nuclear Study. The topics to be

discussed will include: Muonic atoms and molecules; Hadronic atoms; Hypernuclei; and High-spin states of atoms and nuclei. For further information contact Prof. S. Hayano, Physics Dept, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113, Japan, e-mail 41495::hayano or hayano@tkyvax

The IX International Workshop on High Energy Physics and Quantum Theory, sponsored by DESY, will take place from 16-22 September at Zvenigorod near Moscow. Further information from the organizer (or the Workshop Secretary): V.Savrin (Mrs.Valeriya Keshek), Nuclear Physics Institute, Moscow State University, 119899 Moscow, Russia. Fax: (095) 939 03 97; E-mail:qfthep@ npi.msu.su

An international symposium on strangeness and quark matter will be held from 1-5 September in Crete, covering 1. strangeness and quark-gluon plasma, 2. strangeness condensation, 3. strange astrophysics, 4. strangelets, 5. dedicated instrumentation for strangeness and quark matter, and 6. a symposium. Information from the Secretariat, University of Athens, Physics Dept., Nuclear & Particle Physics Division, Panepistimioupolis, Greece-15771 Athens, tel. (30-1)7247502, 7243362, 7243143, fax (30-1)7235089, email gvassils@atlas.uoa.ariadne-t.gr

The Nuclear Physics Division, Faculty of Science, Safarik University, Kosice, the Institute of Experimental Physics, Slovak Academy of Sciences, Kosice, the Institute of Physics, Slovak Academy of Sciences, Bratislava, the Faculty of Mathematics and Physics, Comenius University, Bratislava, the Union of Slovak Mathematicians and Physicists, Kosice, and the Slovak Physical Society, Bratislava are organizing the Hadron Structure '94 conference in Kosice, Slovakia, from September 19 - 23. Attendance is limited to about 60 participants. Main topics will be - Deep inelastic phenomena, High energy heavy ion physics, and Non-perturbative QCD and QCD motivated models. Please contact the following before April 30: Stanislav Vokal, Nuclear Physics Division, Safarik University, Jesenna 5, SK-041 54 Kosice, Slovakia. Fax: 0042-95-62.221.24 e-mail: hs94@kosice.upjs.sk

Beam Instrumentation Workshop

The 6th Beam Instrumentation Workshop will be held in Vancouver, Canada, 2 - 6 October 1994. The workshop is concerned with the engineering issues and design principles of beam diagnostic instrumentation for charged particle accelerators and beam transport lines. The program will include, in addition to invited and contributed papers, discussion sessions on topics chosen by registrants and tutorials at an introductory level. The Faraday Cup prize for innovative beam instrumentation is once again being supported by Bergoz, Inc. Further information: Maria Freeman, BIW94 Secretariat, TRIUMF, 4004 Wesbrook Mall, Vancouver, B.C., Canada V6T 2A3, phone: (604) 222-1047, fax: (604) 222-1074, e-mail: biw94@triumf.ca

CERN Courier contributions

The Editor welcomes contributions. As far as possible, text should be sent via electronic mail.

The address is courier@cernvm.cern.ch

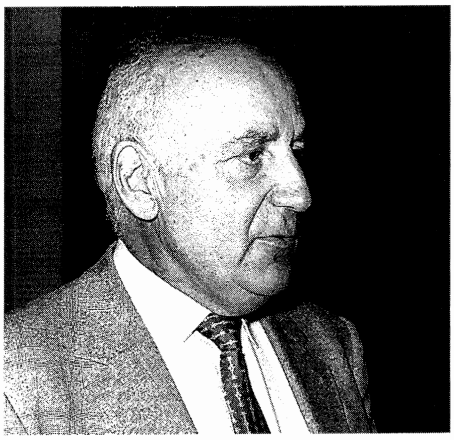
Plain text (ASCII) is preferred. Illustrations should follow by mail (CERN Courier, 1211 Geneva 23, Switzerland).

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.

Participants from Belarus, Canada, Germany, France, Kazakhstan, Poland, Russia and Japan at the VII International Workshop on High Energy Physics and Quantum Field Theory and III Workshop on Physics at VLEPP, held last September at Zvenigorod near Moscow. Despite the economic difficulties in Russia, sponsorship from DESY and MPI(Munich) ensured an optimistic mood at the meeting.

The Franco-Portuguese scientific meeting, organized in Paris by the Gulbenkian Foundation in January, had particle physics as one of the four keynote topics. Photographed outside the Paris Gulbenkian Centre by Maurice Jacob were (left) J.M. Gago of Lisbon and A. Policarpo of Coimbra.

Jean Teillac 1920-94



Former President of CERN Council Jean Teillac died on 10 March. He was elected to that post in June 1978, at a critical time for CERN as the President-elect, Bernard Gregory, had died in December 1977 before assuming office.

His presidency saw a major change in CERN's profile. As well as the experimental programme at the then new SPS proton synchrotron coming to fruition, Professor Teillac's historic 1978-81 mandate also covered the launching, approval and final commissioning of the ambitious programme to convert the SPS into a proton-antiproton collider which revitalized CERN science. Finally in 1981, under his presidency, CERN Council voted the construction of the LEP electron-positron collider.

After assuming the chair of nuclear physics at Paris in 1958, Professor Teillac took on a series of key roles - Director of the famous Institut du Radium and Director of Orsay's Nuclear Physics Institute. In the 1960s he founded the French National Institute for Nuclear and Particle Physics (IN2P3), and from 1975 went on to be High Commissioner for Atomic Energy. Concurrently with his presidency of CERN Council, he also had a parallel role at Euratom's Joint European Torus (JET). His national and international accomplishments earned him the accolade of Officer of the Légion d'honneur.

NORTHEASTERN UNIVERSITY

TENURE TRACK POSITION IN EXPERIMENTAL PARTICLE PHYSICS

The Physics Department at Northeastern University invites applications for a tenure-trakc position in Experimental Particle Physics at the level of assistant professor. We seek individuals with a demonstrated record of outstanding research, as well as a promise of excellent teaching, and with a capability to initiate and maintain a leading research program. The Department has ongoing funded research programs with L3 at CERN and with D0 at FNAL, as well as a program of detector development at Northeastern. We anticipate filling the position for the Fall 1994 quarter. There is no formal closing date. Applications, as well as three reference letters, should be addressed to : EPP Search Committee, c/o Yvette Randall, Physics Department, Northeastern University, 360 Huntington Ave., Boston, MA 02115-5096.

Northeastern University is an equal opportunity, affirmative action employer.

University of Copenhagen Niels Bohr Institute for Astronomy, Physics and Geophysics

Associate Professorship in Theoretical High Energy Physics

A position as associate professor (lektor) in theoretical high energy physics at the Niels Bohr Intitute for Astronomy, Physics and Geophysics (NBIfAFG) will be open from September1, 1994.
The permanent high energy theory staff at the Niels Bohr Institute has four members and in addition there is always a number of junior researchers, post doctoral fellows and long term visitors associated with the group. The present size of the group is 15 plus Ph.D. students. The activities of the group are fully integrated with those of the high energy group at the Nordic Institute for Theoretical Physics (NORDITA), and this brings the combined high energy theory group to a size of appr. 25 long term people. The active areas of research include conformal field theory, cosmology, lattice gauge theory, non-perturbative field theory, quantum gravity, random surface and string theory. Applications from people working in the areas of astrophysics/particle physics and phenomenology are also encouraged.
The chosen candidate is expected to play a leading role in research in one of the areas given above. He/she is further expected to participate in the University teaching program at all levels. This includes the supervision of Ph.D. students. The language of undergraduate instruction is Danish, but English will be accepted for the first two years of the appointment.
The application must include a *curriculum vitae* and a complete list of publications with a special indication of which publications are considered most relevant for this position. Information about teaching experience must also be enclosed.
The applicants' qualifications will be evaluated by a specially appointed Committee, and the entire report of the Evaluation Committee will be sent to all applicants. The Evaluation Committee may ask for supplementary material, which the applicant then must provide in the requested number of copies.
Information about research plans, facilities and staff may be obtained from the Director, Professor Ole Hansen, Niels Bohr Institute for Astronomy, Physics and Geophysics, Blegdamsvej 17, DK-2100 COPENHAGEN Ø, Denmark; telephone +45 35325292, fax: +45 35431087, E-mail : oleh@nbi.dk.
The position will be under a continuing contract as agreed between the Confederation of Professional Unions and the Ministry of Education. The annual salary depends on seniority and ends at a maximum of 326,558 DKK after contributions to the pension scheme.
The application, marked "05-221-68/94-5207 L/1-94" and written in English, must be mailed to the Faculty of Science, Blegdamsvej 3, DK - 220 Copenhagen N, Denmark.
Applications, in order to be considered, must have been received by the Faculty of Science no later than June 1, 1994.
Three copies of the application, and in addition three copies of a brief outline of proposed research, should be mailed to the Director of the Niels Bohr Institute for Astronomy, Physics and Geophysics. No further material should be forwarded until requested.

UNIVERSITÄT KARLSRUHE

An der **Fakultät für Physik** ist eine

Professur (C4) für Experimentelle Kernphysik

wiederzubesetzen.
Gesucht werden Bewerberinnen und Bewerber mit dem Arbeitsgebiet Elementarteilchenphysik an Hochenergiebeschleunigern. Erfahrung im Aufbau und in der Koordination von Großexperimenten an Hochenergiebeschleunigern sowie die Fähigkeit zur Leitung eines grossen experimentellen Bereichs werden vorausgesetzt, ebenso Habilitation oder gleichwertige wissenschaftliche Leistungen sowie Lehrerfahrung. Zu den Lehraufgaben gehört die Beteiligung an der Physikausbildung, auch für Studierende anderer naturwissenschaftlicher und ingenieurwissenschaftlicher Fachrichtungen.

Die Fakultät für Physik mit ihren beiden Schwerpunkten Festkörperphysik sowie Kern- und Teilchenphysik bietet vielfältige Möglichkeiten zur Zusammenarbeit, insbesondere mit bestehenden Gruppen der theoretischen und experimentellen Elementarteilchenphysik und dem Kernforschungszentrum Karlsruhe.

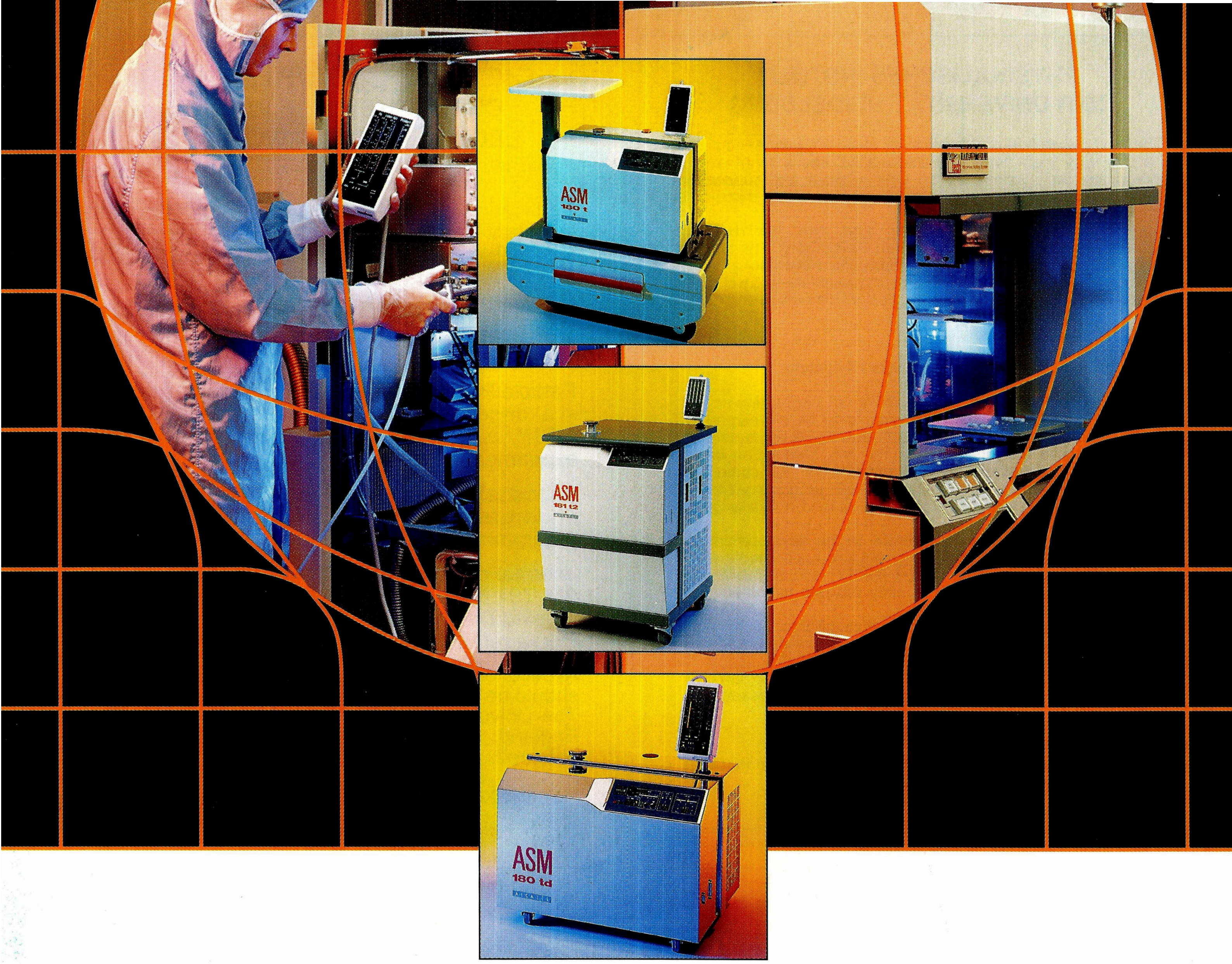
Die Universität Karlsruhe ist bemüht, den Frauenanteil zu erhöhen und ermutigt daher besonders Frauen, sich zu bewerben.

Bewerbungen und Unterlagen über die bisherige Forschungs- und Lehrtätigkeit sowie Sonderdrucke der wichtigsten Publikationen werden bis zum **30.4.1994** erbeten an den **Dekan der Fakultät für Physik, Universität Karlsruhe (TH), Postfach 69 80, 76 128 Karlsruhe.**

Professorship in Eyperimental High Energy Physics

The Ohio State University

The Department of Physics at The Ohio State University invites applications for a senior faculty position in Experimental High Energy Physics. Candidates should have significant accomplishments in this area. The chosen candidate is expected to initiate and lead a new research program, to supervise graduate students, to teach physics at all levels and to provide departmental leadership. The appointment will be at the rank of Full Professor.
The department currently has over 50 faculty members covering research areas in theoretical astrophysics and in experimental and theoretical atomic, molecular, condensed matter, nuclear and high energy physics. The experimental high energy group presently consists of six faculty members who are conducting experiments in electron-proton collisions with the ZEUS collaboration at DESY, Germany and in electron-positron annihilations with the CLEO collaboration at Cornell University. The department funds excellent electronics and machine shops which provide strong support for high energy research.
Interested applicants should send a resume, a description of scholarly achievements and interests and the names of at least five references to Professor Frank DeLucia, Chair, Department of Physics, The Ohio State University, 174 W. 18th Ave, Columbus, Ohio 43210. The Ohio State University is an equal opportunity employer. Qualified women, minorities, Vietnam-era Veterans, disabled veterans and individuals with disabilities are encouraged to apply.



ASM 180 SERIES

The most powerful, versatile, automatic, fail safe, compact, DRY and sensitive helium leak detectors

The most powerful leak detector family provides testing solutions for any of your possible needs. Featuring modular, conventional and even DRY oil free pumping capability, it will provide the best sensitivity and the shortest response time for large volume.

Its overall size and optional clean room compatible cabinet make it the product of choice for any semiconductor fabrication related maintenance requirements. Its flexibility and table top operation allow for an easy integration in any test environment.

The ASM 180 series will meet all your high-end applications.

ALCATEL
CIT

Alcatel CIT Vacuum Technology Division - 98, avenue de Brogny - BP 2069 - 74009 ANNECY - FRANCE
Tel: (33) 50 65 77 77 - Fax: (33) 50 65 77 89

USA
Alcatel Vacuum Products
Tel : (1) 617 331 4200

United Kingdom
Alcatel Vacuum Technology UK Ltd
Tel : (44) 494 44 84 44

Germany
Alcatel Hochvakuumtechnik GmbH
Tel : (49) 9342 870 0

Italy
Alcatel Vacuum Systems SpA
Tel : (39) 2 33 00 80 13

Japan
Alcatel ITS
Tel : (81) 3 334 788 41

UROCOM QUARTET Annecy - ALA324 - 01/94