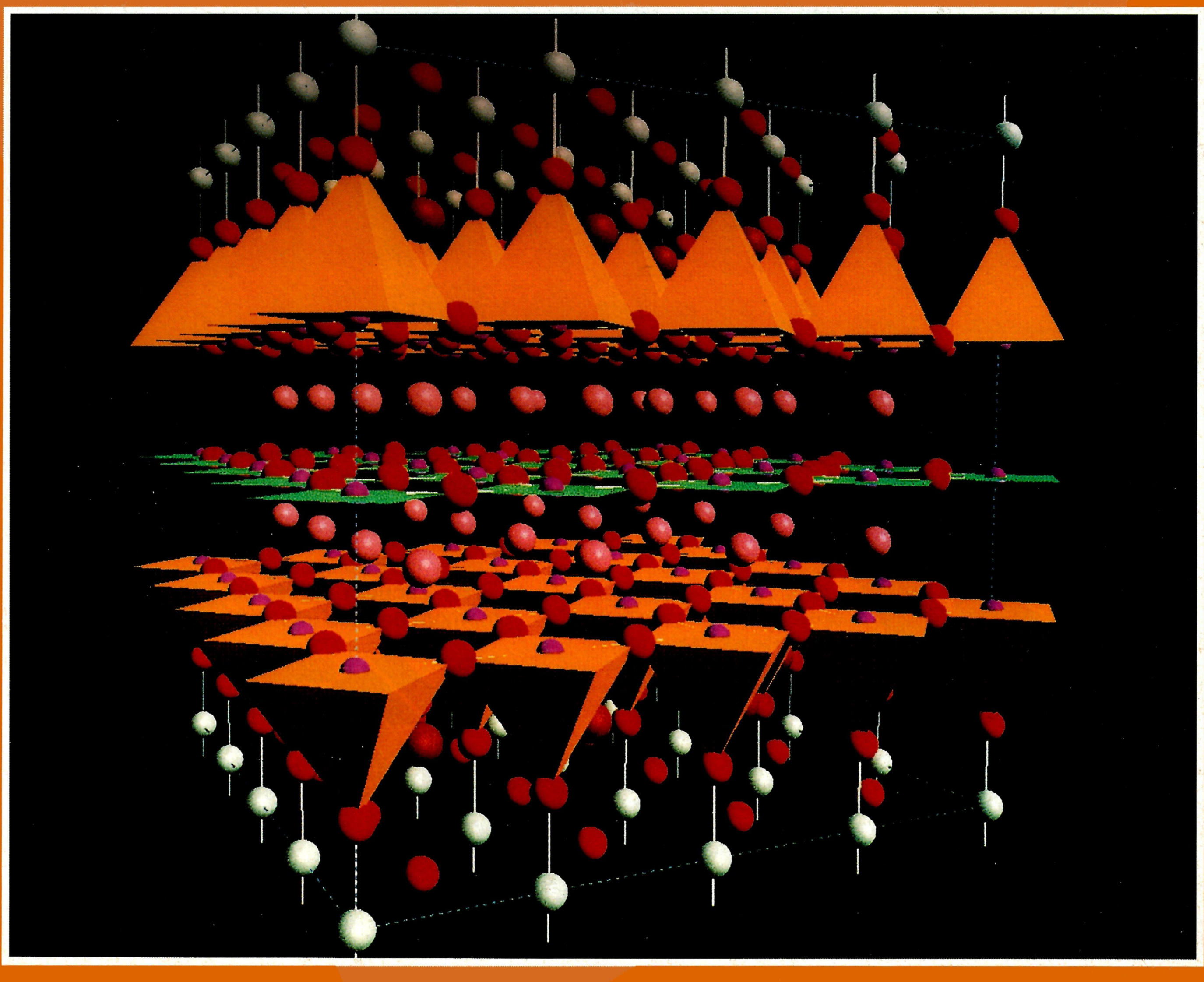
CERN COURIER

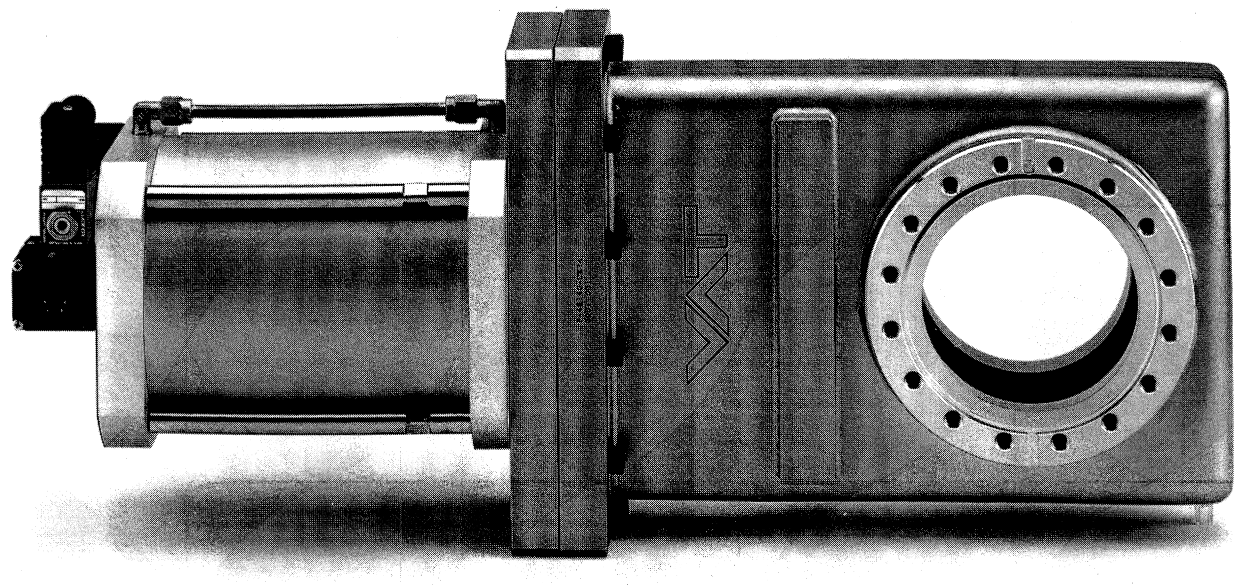
INTERNATIONAL JOURNAL OF HIGH ENERGY PHYSICS

VOLUME 36 | 3 | APRIL/MAY 1996



All-metal Gate Valves

compact
reliable
unique



- the worldwide proven standard, industrially manufactured (ISO 9001)
- full range from DN 16 to DN 400
- many options available, specials on request

Ask for the catalogue
«VAT Vacuum Valves 96»
for more detailed information.

VAT Vakuumventile AG
CH-9469 Haag, Switzerland

Tel (081) 771 61 61
Fax (081) 771 48 30
Tlx 855 162 vat ch

Advertising enquiries

Europe

Micheline Falciola
Advertising Manager
CERN
CH-1211 Geneva 23, Switzerland
Tel.: +41 (22) 767 4103
Fax: +41 (22) 782 1906

Rest of the world

Guy Griffiths
Advertising Manager, USA
Gordon and Breach Publishers
820 Town Center Drive
LANGHORNE PA 19047
Tel.: (215) 750-2642
Fax: (215) 750-6343

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, to request copies or to make address changes contact :

China

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

Germany

Gabriela Heessel or Monika Stuckenberg
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

Janice Voss
Creative Mailing Services
P.O. Box 1147
St. Charles, Illinois 60174
Tel/Fax: 708-377-1589

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

Printed by: Drukkerij Lannoo nv
8700 Tielt, Belgium

Published by:

European Laboratory for Particle Physics
CERN, 1211 Geneva 23, Switzerland
tel.: +41 (22) 767 61 11,
telex: 419 000 CERN CH,
telefax: +41 (22) 767 65 55

CERN COURIER only:
tel. +41 (22) 767 41 03,
telefax +41 (22) 782 19 06

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

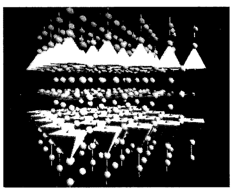
ISSN 0304-288X

Volume 36
No. 3
April/May 1996

CERN COURIER

Covering current developments in high energy physics and related fields worldwide

Editor: Gordon Fraser CERN.COURIER@ CERN.CH
Production and Advertisements:
Micheline Falciola
@ macmail.cern.ch
Advisory Board: E.J.N. Wilson (Chairman), E. Lillestol, H. Satz, D. Treille; with L. Foà, E.M. Rimmer
World Wide Web http://www.cern.ch/CERN/Courier/



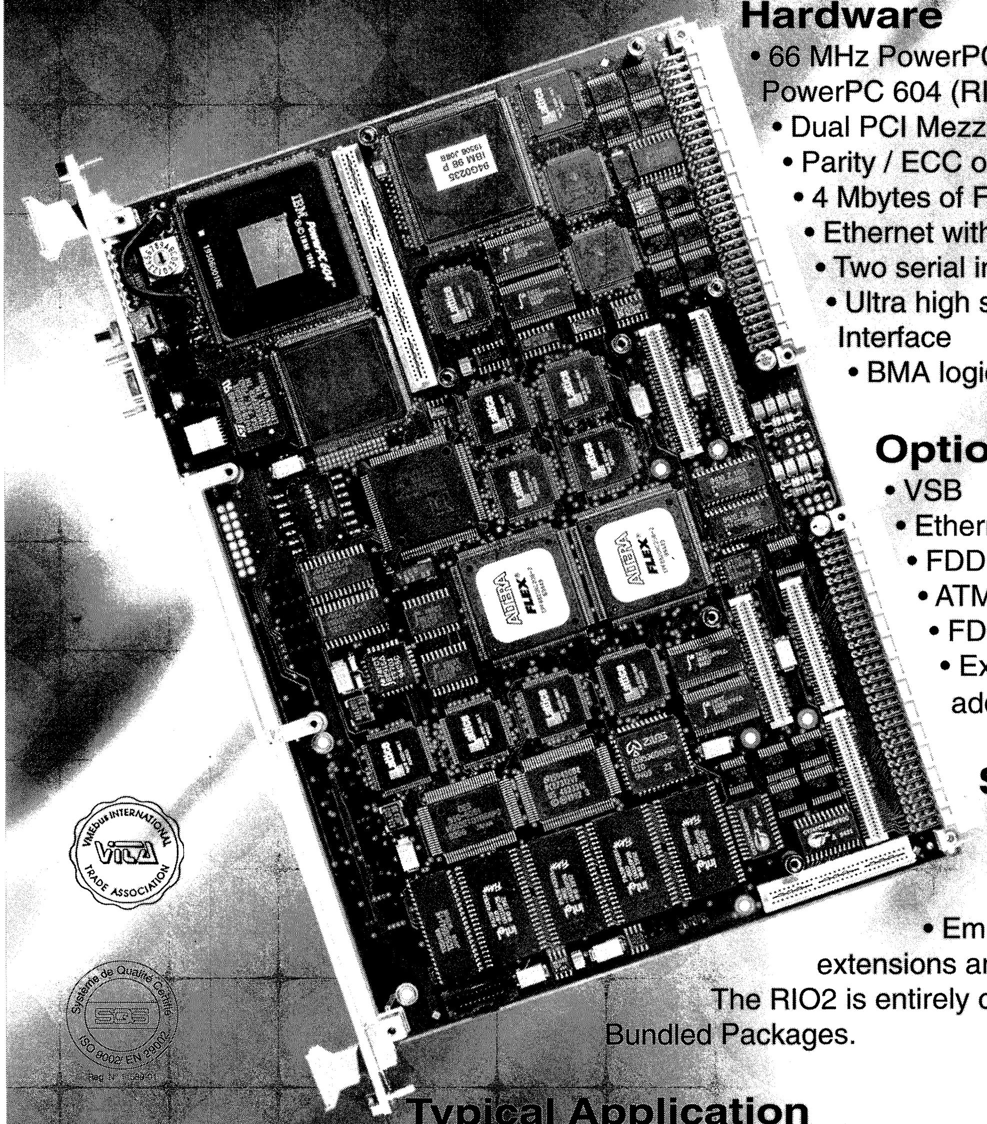
Cover photograph: High-temperature superconductivity has taken centre stage in physics, chemistry and materials science with the discovery of new compounds based upon copper-oxygen sheets that become superconducting well above the boiling point of liquid nitrogen. Since the initial discovery of these materials a decade ago, there has been an unprecedented breadth of research aimed at understanding the mechanism of high-temperature superconductivity, increasing the transition temperature and improving the materials properties for use in device applications. Neutron scattering has been prominent among experimental techniques used to study these materials (see page 21). A wide variety of different neutron experiments on these "warm" superconductors has provided a detailed microscopic view of their structure and fundamental excitations. Recent high pressure diffraction measurements at the Rutherford Appleton Laboratory's ISIS spallation neutron source on the highest temperature mercury-based superconductor have given a structural insight into the remarkable increase in superconducting temperature with applied pressure and may provide clues for yet higher temperature superconductors.

CES PRESENTS:

The companion of the RTPC 8067:

RIO2 8060 - RIO2 8061

VME PowerPC Real-Time Platform for PCI Mezzanines (PMC)



Hardware

- 66 MHz PowerPC 603 (RIO2 8060) or 100 MHz PowerPC 604 (RIO2 8061)
- Dual PCI Mezzanine slots
- Parity / ECC on the entire memory
- 4 Mbytes of Flash EPROM
- Ethernet with 10baseT
- Two serial interface ports
- Ultra high speed VME Master / Slave Interface
- BMA logic with chained block transfers

Optional PMCs

- VSB VSB 8464
- Ethernet ETH 8477
- FDDI FDDI 8466
- ATM ATM 8468
- FDL FDL 8440
- Extension module for 2 or 4 additional PMCs PEB 6406

Software

- PPCMON: Powerful plug & play monitor with PCI and PMC commands
- Embedded Lynx with CES extensions and drivers.

The RIO2 is entirely compatible with RTPC Lynx Bundled Packages.

Typical Application

- Accelerators Controls
- Development platform for custom PMCs in new generation DAQs.

Contact CES directly or visit us on WWW at http://www.ces.ch/CES_info/Welcome.html

Your Real-Time Partner

For any additional information about this product or our complete VIC, VME, CAMAC and FASTBUS line, do not hesitate to contact us.

CES Geneva, Switzerland Tel: +41-22 792 57 45 Fax: +41-22 792 57 48 EMail: ces@lancy.ces.ch

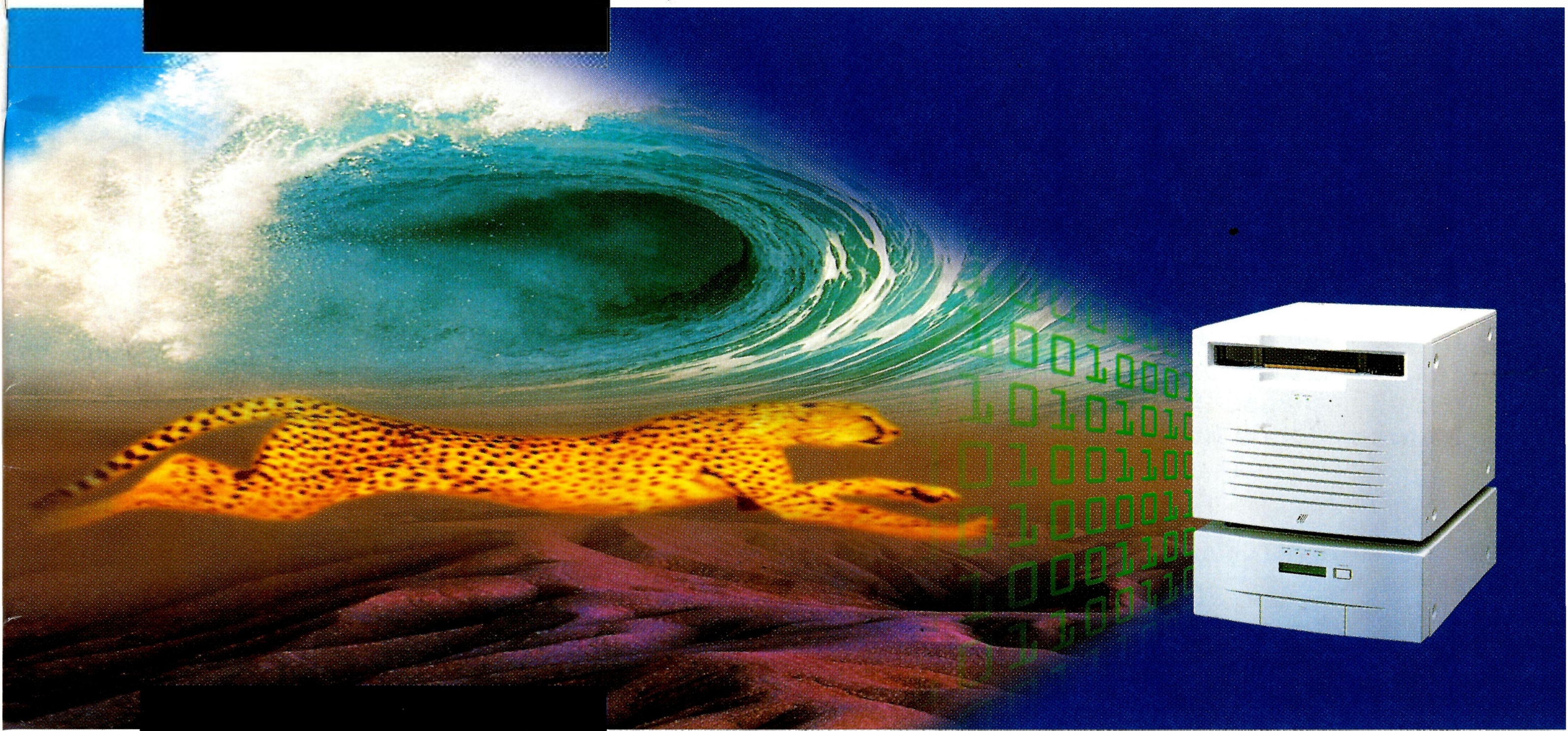
CES.D Germany Tel: +49-60 55 4023 Fax: +49-60 55 82 210

CES Creative Electronic Systems SA, 70 Route du Pont-Butin, P.O. Box 107

CH-1213 PETIT-LANCY 1 SWITZERLAND

CES

CREATIVE ELECTRONIC SYSTEMS



Around the Laboratories

At the GSI heavy ion laboratory, Darmstadt, the team led for more than 20 years by Peter Armbruster recently discovered the element with atomic number 112, currently the heaviest ever produced. Proudly displaying the decay chain of the new element are (left to right) Victor Ninov, Sigurd Hofmann and Peter Armbruster.

(Photo Achim Zschau, GSI)

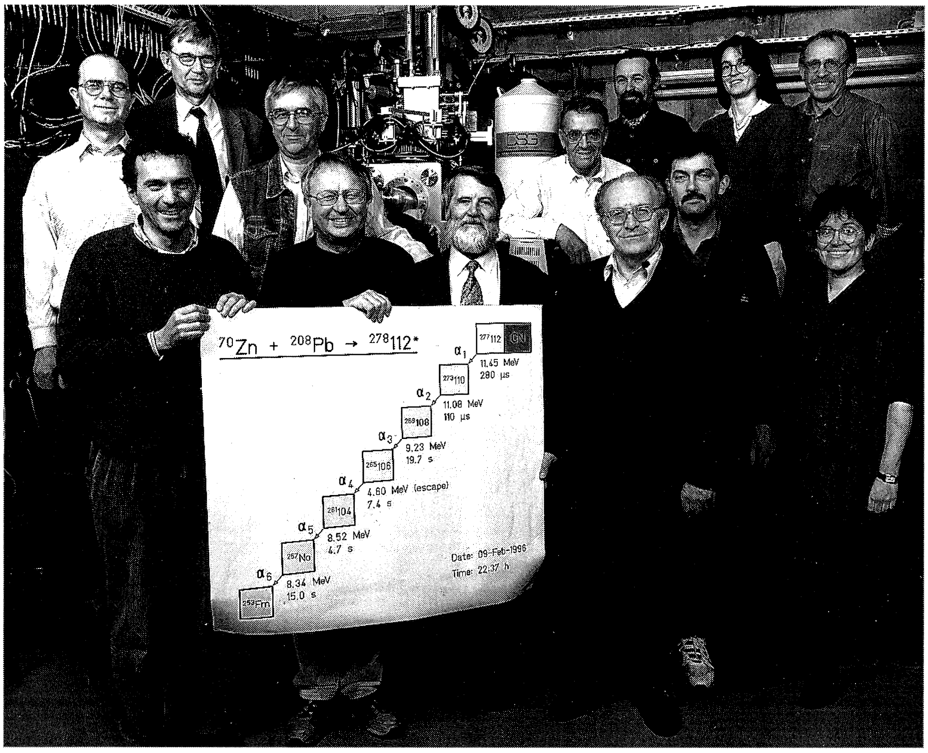
DARMSTADT
Element 112

On February 9 at the GSI (Gesellschaft für Schwerionenforschung) Laboratory, Darmstadt, Germany, the team led for more than 20 years by Peter Armbruster discovered its sixth element. With atomic number 112, this is currently the heaviest ever produced and its production has been eagerly awaited as it confirms ideas on nuclear stability.

The international research group, including Sigurd Hofmann and other scientists from GSI, the Joint Institute for Nuclear Research (JINR), Dubna, Russia, and the universities of Bratislava (Slovakia) and Jyväskylä (Finland), succeeded in conclusively identifying the new element in a three-week experiment.

The identified isotope is now the heaviest atom ever produced artificially and has an atomic mass of 277. Chemically, element 112 should be a heavier brother of zinc, cadmium, and mercury. However, in contrast to the lighter elements, it decays after a fraction of a thousandth of a second by emitting alpha particles (helium nuclei), first becoming a new isotope of element 110 with atomic mass 273, and then a new isotope of hassium with atomic mass 269. After three more alpha-decays into known isotopes, the trail of the decay chain is lost at fermium - atomic number 100 and atomic mass 253.

The alpha particle energies allow a very important theoretical prediction to be verified. Because of their inner structure, atomic nuclei with 162 neutrons should be more strongly bound than their neighbours. Already



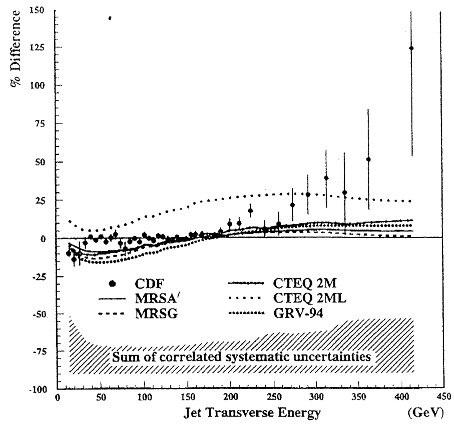
30 years ago such structure phenomena led to the prediction that superheavy nuclei with a neutron number near 184 could exist, and this structure explains the existence of the six heaviest elements, all of which have been discovered at GSI. The decay chain, which demonstrates stability at 162 neutrons, confirms this understanding of nuclear structure.

The new element was produced by fusing a zinc atom with a lead atom. To achieve this the zinc atom was accelerated to high energies by GSI's UNILAC heavy ion accelerator and directed onto a lead target. This rare reaction occurs only if the zinc projectile has a very specific velocity. Over several weeks many billions of billions of zinc atoms had to be shot at a lead target in order to produce and detect a single atom of element 112. This atom was selected by a velocity filter and intercepted in a detector system where it was identified by its characteristic decay chain.

The production of element 112, coming after the production of elements 110 and 111 in 1994 (January 1995, page 8), suggests that even heavier atoms can yet be produced.

FERMILAB
Smaller than a quark?

One year after the historic formal announcement of the discovery of the sixth ('top') quark by experimental teams at Fermilab's Tevatron proton-antiproton collider, comes speculation that data from the CDF Tevatron experiment may hint at a new type of particle behaviour, possibly due to a still deeper layer in the substructure of the Universe.



Smaller than quarks? More subnuclear debris (data points) is produced from the CDF experiment at Fermilab's Tevatron proton-antiproton collider above 200 GeV transverse momentum than can be accounted for by conventional quark theory (curves).

The Tevatron collider experiments look at the subnuclear fragments produced when 900 GeV proton and antiprotons - the world's highest energy particle beams - are smashed into each other.

One valuable clue to the invisible quark-gluon mechanisms deep inside the colliding protons and antiprotons comes from 'jets' - confined sprays of subnuclear debris produced when quarks and gluons hit head-on.

Looking at the jet production rate and comparing the results with the standard field theory of quarks and gluons (quantum chromodynamics - QCD), CDF sees an excess for violent collisions resulting in higher jet energies perpendicular to the direction of the colliding beams, above 200 GeV transverse energy. The data comes from 1992-3 Tevatron running, with 1192 jet events above 200 GeV.

The more violent the interaction, the deeper the colliding particles penetrate into each other. Hence the speculation that the transverse jet excess is the first sign that something smaller even than quarks and gluons could be making its presence felt.

According to the conventional wisdom of today's 'Standard Model', the Universe around us is built on a bedrock of six kinds of quark and six kinds of lepton. Experiments have determined that these particles are smaller than 10^{-17}cm, at least ten thousand times smaller than a proton. If quarks and leptons are not the ultimate building bricks of Nature, then physicists will ultimately find cracks in this conventional bedrock, where theoretical predictions no longer work. Explaining the deeper strata underneath would require a new theoretical picture.

However it is too early to substantiate any such evidence. Theoretical predictions, with extrapolations of the quark/gluon structure data, are extremely difficult for the conditions of Tevatron experiments. Massaging the input can help reconcile the jet excess, but care has to be taken not to spoil agreement with other experiments - it appears difficult for the predictions to explain all the different experimental results all the time.

The suggested additional mechanism behaves as though quarks and gluons had inner structure. (For this reason the additional mechanism is known as 'compositeness'.) However the effect might be the first sighting of another form of interaction which complements conventional quark-gluon physics, becoming noticeable only under special conditions, rather than actually underlying it.

If two dogs barked during the night, Sherlock Holmes was always tempted to suggest that the two barks were somehow connected. Last year, experiments at major electron-positron colliders - CERN's LEP ring and the SLC linear machine at Stanford (SLAC) - highlighted anomalies in the production of particles containing heavy quarks (October 1995, page 1). This too has been greeted by some as a possible deficiency in the Standard Model picture.

Pulling the Tevatron and electron-positron Standard Model barks together, two groups of European theorists have suggested an additional force-carrying particle. This would complement the Standard Model Z carrying the electrically neutral component of the weak nuclear force. The theorists postulate a heavy Z, about 800 GeV, which couples preferentially to quarks rather than leptons. With this heavy 'hadrophilic' or 'leptophobic' Z, both the electron-positron and proton-antiproton anomalies can be explained, say its proponents.

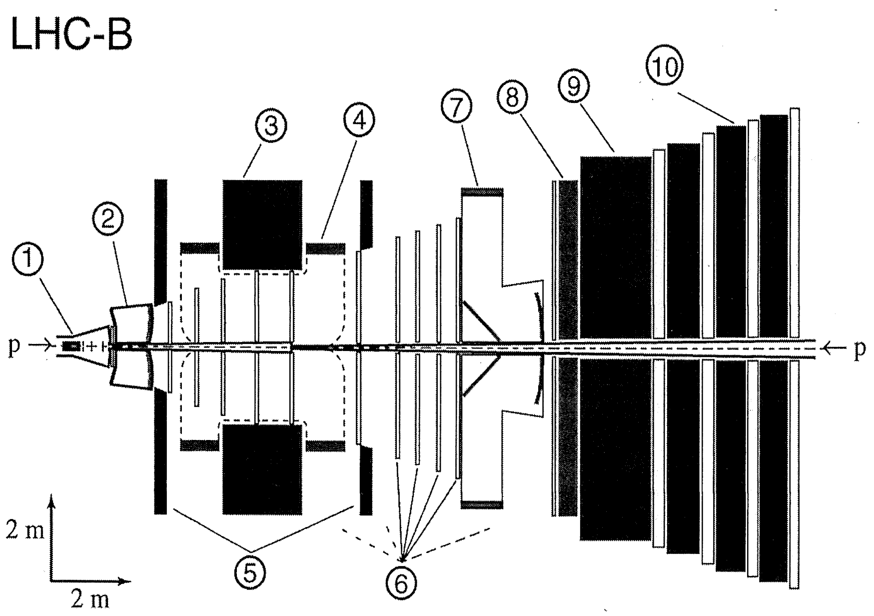
For many, this act is no less sacrilegious than composite quarks and gluons. Supersymmetry might be a less sacrilegious option. However the CDF paper states the data 'provide powerful constraints on QCD, and demand a revaluation of theoretical predictions and uncertainties within and beyond the Standard Model'. Time and more Tevatron data will tell.

CERN
Beauty for LHC

The stage being set for CERN's LHC proton-proton collider (September 1995, page 3) includes a place for an experiment - LHC-B - to study the physics of B particles, containing the fifth (beauty, or 'b') quark.

The Letter of Intent for this experiment has been reviewed by the appropriate committees, who recommend that the collaboration should now proceed to a vigorous

The scenario being prepared for CERN's LHC proton-proton collider includes a place for an experiment - LHC-B - to study the physics of B particles, containing the fifth (beauty, or 'b') quark. The detector components are: 1 - vertex detector; 2 - aerogel and gas RICHs; 3 - magnet yoke; 4 - coils; 5 - magnet field shielding; 6 - tracking chambers; 7 - gas RICH; 8 - electromagnetic calorimeter; 9 - hadron calorimeter; 10 - muon system.



research and development programme for the various detector components en route to a full technical proposal.

LHC-B is a considerably smaller experiment than its big brothers - ATLAS, CMS and ALICE - at the LHC and will be able to profit from their technical development programme. The HERA-B experiment at DESY will also provide valuable input and experience. However in several areas, notably triggering, particle identification over a large momentum range, and radiation hardness, the LHC-B challenges warrant special investigation.

The Standard Model of six quarks and leptons, grouped pairwise into three separate generations, is coming under detailed scrutiny. All three generations are being precision probed in the hunt for clues as to what makes the Standard Model tick.

The LHC's proton-proton collisions will be a prolific source of B particles, containing b quarks (these, together with t - top - quarks, make up the third quark generation). Here, a major goal will be the detailed study of CP violation in the neutral B system. CP violation - the subtle disregard of an otherwise perfect symmetry of a combined particle-antiparticle and left-right switch - has been known for 30 years and only seen in the decays of neutral kaons. Its origin is still a mystery but it is widely believed to be responsible for the Universe's matter-antimatter asymmetry. The Big Bang initially produced equal amounts of matter and antimatter but a CP-violation mechanism would have tilted the balance in favour of matter as we know it.

The Standard Model can generate CP-violation with complex elements of the Cabibbo-Kobayashi-Maskawa (CKM) matrix which describes inter-quark mixing. So far this matrix cannot be calculated from any theory and its elements have to be measured by experiments.

In addition, physicists want to understand what makes the CKM matrix work. The CP-violation effects expected from the Standard Model are not necessarily sufficient to create our matter-oriented Universe and larger CP-violations could help explain the marked matter-antimatter asymmetry we now see around us. Additional information from B decays will give a new, and hopefully illuminating, perspective on the mystery of CP violation.

To complement the B physics capabilities of LHC's big detectors (ATLAS and CMS), this dedicated B-physics experiment is planned for the initial phase of the LHC experimental programme. Originally three groups submitted ideas based on different experimental approaches:

- colliding two proton beams at the full LHC 14 TeV collision energy;
- an internal gas jet target intercepting one circulating proton beam at 114 GeV;
- a fixed target experiment using a proton beam extracted from the LHC ring.

By the time the LHC is operational, the B meson system will have been extensively studied elsewhere - in the B factories being built at SLAC (Stanford) and at KEK, Japan, at Cornell's revamped CESR ring, at the HERA-B experiment at DESY, Hamburg, and at Fermilab's Tevatron.

The LHC-B experiment will therefore be a second-generation study. While all three initially-submitted approaches had different appealing features, the collider route, exploiting the full B production rate, was thought to be the most attractive for mature physics.

CERN therefore encouraged all participants in the initial B-physics ideas to collaborate in a fresh design for a collider-mode experiment. The result is the LHC-B collaboration, which currently groups almost 200 researchers from 40 institutes in 15 countries, and is growing.

Its generic design, now being optimized, foresees a forward magnetic (dipole) spectrometer surrounding the LHC beams, with successive layers of microvertex detector, tracking chambers, aerogel and gas ring-imaging Cherenkov (RICH) counters for particle identification, calorimetry and muon detection.

Close to the beam, at a distance of 1 cm, the microvertex detector will fix the decay point of the B-particle. However it has to contend with potential radiation damage. RICH counters will provide particle identification over the full momentum range.

Taking note of ideas from the original approaches, the event selection ('triggering') system in particular has been designed in a very flexible way, to accommodate studies of many different B decay channels. With B particles not particularly heavy compared with the total collision energy, separating these particles from the background is a challenge.

While the LHC's stated luminosity goal is of the order of 10^{34} per sq cm per s , LHC-B is optimized to operate at lower levels (some 10^{32}).

CERN School of Computing

Last year, the 18th CERN School of Computing in Arles, France, from 20 August to 2 September brought together 22 lecturers and 68 students from 17 different countries and of 21 different nationalities, and was organized in collaboration with the Institut National de Physique Nucleaire et de Physique des Particules (IN2P3). The varied programme included 47 one-hour lectures, supplemented by tutorials. Proceedings, produced as a CERN Report, were ready for distribution on 25 October 1995!

The opening ceremony included addresses by President of CERN Council Hubert Curien and IN2P3 Director Claude Detraz. Tony Hey of Southampton, Chairman of the Advisory Committee to the CERN Schools of Computing, gave an overview of the School's aims. For the first time, the School was largely oversubscribed (by a factor two) and severe selection criteria had to be applied.

The 1996 CERN School of Computing, to be held in Egmond aan Zee, Netherlands, from 8-21 September, and organized by CERN in collaboration with ASCI and NIKHEF, will be a little different from usual. In recent years the programme has been structured into a number of important themes for modern computing systems, with the first week devoted to themes of general relevance both inside and outside particle physics, while the second has explored a number of themes in more depth with particular reference to the current particle physics computing challenges.

This year the first week of the school is being organized jointly with ASCI, an Inter-University Graduate Research School set up by Dutch universities to coordinate research and training in computing and imaging systems. The first week of CSC'96 will therefore be combined with the ASCI Summer School. The programme for the School this year covers seven themes: Imaging, Parallel and Distributed Computing, Networks and Electronic Highway, Data Acquisition Systems, Collaborative Engineering and Simulation, Detectors/Imaging, and Modern Programming Language Trends.

This year's CERN School of Computing, combined with the Advanced School of Computing and Imaging (ASCI), is open to post-graduate students and research workers with a few years' experience in elementary particle physics, in computing, imaging, or related fields. The number of participants will be of the order of 110; about 70 from CERN or from laboratories closely associated with CERN ("non-ASCI" students) and about 40 students from laboratories belonging to ASCI ("ASCI" students). Most of the ASCI students will participate only in the first week.

Updated information is on WorldWideWeb URL http://www.cern.ch/Physics/Conferences/C1996/CSC/ Non-ASCI candidates should forward the completed application form and formal letter of reference to: Miss J. Turner, CN Division, CERN, 1211 Geneva 23, Switzerland or via the Web (see above), tel. +41 22 767 5049. fax +41 22 767 7155 e-mail: school@cernvm.cern.ch

ASCI candidates should forward the completed application form to:

Dr. J.F.M. Tonino, Advanced School for Computing and Imaging (ASCI), Department of Computer Science, Delft University of Technology, P.O. Box 356, NL-2600 AJ Delft.
E-mail asci@twi.tudelft.nl
Telephone +31 15-2788032
Telefax +31 15-2787141 or via the Web (see above).Deadline for receipt of applications is 31 May.

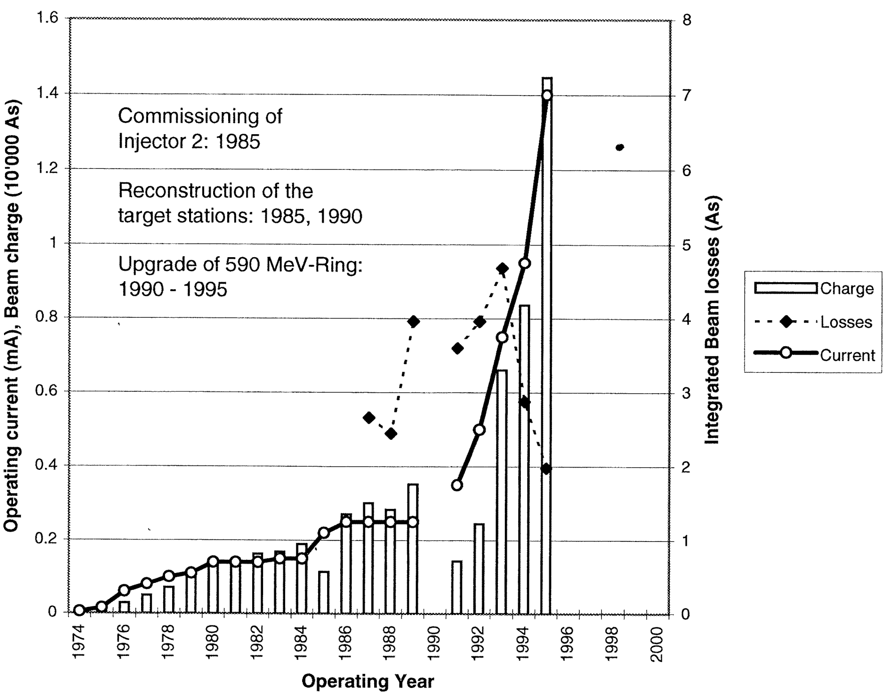
VILLIGEN
World record cyclotron beam power

Record cyclotron power levels have been attained at the Swiss Paul Scherrer Institute (PSI - formerly SIN). PSI operates a cyclotron originally built to produce intense beams of pions and muons for nuclear and particle physics experiments. Protons are accelerated in two cyclotron stages to 590 MeV before being guided onto two consecutive pion production targets and finally stopped in a beam dump.

The 590 MeV ring, a separated-sector cyclotron with eight magnets, four powerful accelerating cavities and a flat-top cavity, was developed and built by PSI, whereas the injector machine (Injector 1) was a versatile commercial cyclotron built by Philips (NL).

Commissioned in 1974, the facility soon reached 100 microamps, progressing continuously to routine currents of about 200 microamps in the early 80s. At that time the beam current was limited by several factors: the available radiofrequency-power of the ring, the Philips injector itself and the meson production targets. Nevertheless, it became evident that the main ring was potentially capable of accelerating beam currents in excess of 1 milliamp, extracted with very low losses.

Performance of the 590 MeV-Ring at PSI



590 MeV operation from 1974 to 1995 at the Swiss PSI cyclotron facility, showing beam current during routine operation together with annual integrated beam current and integrated extraction losses. Injector 2 was commissioned in 1985 and the ring upgrading programme came into effect in 1991.

This promising outlook for a high current future at PSI initiated many challenging new experiments in particle physics, particularly on rare and forbidden decays. It also enabled the construction of the SINQ spallation neutron source for research in solid-state physics and materials science, commissioning of which is planned for October 1996.

Full exploitation of this new facility needs proton currents in excess of 1 milliamp. This has led to an upgrading programme with the goal of providing beam currents of 1.5 milliamp, corresponding to a beam power of almost 1 MW. The main stages of the upgrading programme were:

- Replacement of the original Philips cyclotron by Injector 2, a 72 MeV cyclotron specially designed for high beam currents. Injector 2 was commissioned in 1985 and reached 1.5 milliamp of beam current with small extraction losses in 1990. (The Philips cyclotron is still in use for low-energy experiments, for medical applications and occasionally as a source of polarized protons for the 590 MeV ring.)
- Adaptation of the two meson production targets (in 1986 and 1990 respectively) to the future megawatt beam, as well as improvements to the secondary beamlines and the installation of a portion of the beam line to SINQ.
- For the 590 MeV ring this evolved in several steps during the annual

shutdown periods between 1990 and 1994. The most important item was the increase of available r.f.-power to the four accelerating cavities. This accounts for the dramatic increase in beam power and allows an increase of more than 50% in cavity voltage. New injection and extraction elements as well as new diagnostic equipment capable of handling the high beam power were also installed. The control system was also updated.

In a high beam power proton cyclotron, it is vital that the beam losses, occurring mainly at the extraction septum, are kept as small as possible to allow for the safe operation and maintenance of the machine. The increase in the accelerating voltage enhances the beam extraction by increasing the separation between neighbouring turns and by reducing the effect of longitudinal space charge forces. This is therefore a mandatory measure to keep the extraction losses at a tolerable level (below 1 microamp).

The figure (page 5) shows 1974 - 1995 beam current performance of the PSI proton facility during routine operation, as well as the integrated beam current and losses. From the start of the ring upgrading programme in 1990, the beam current during routine operation was increased from 0.25 to a delightful 1.4 milliamps, while the integrated beam losses were considerably reduced. On September 18 1995, the PSI crew reached 1.52 milliamps on target, corresponding to a beam power of 900 kW !

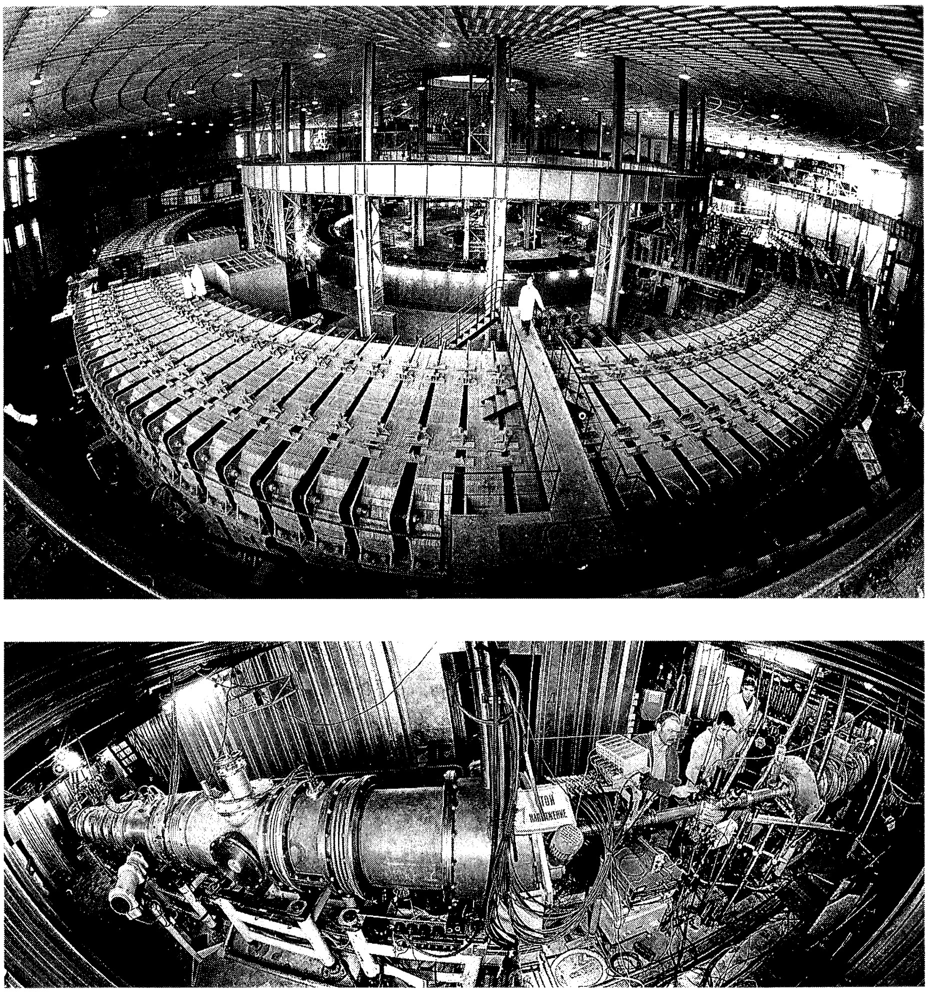
With this demonstration of a world record for beam power from a cyclotron, PSI is prepared for the start of the SINQ era in the near future. It also shows that cyclotrons have to be considered for new developments in nuclear techniques, such as energy amplifiers and for transmutation.

DUBNA
Anniversary time

March 26 marks the 40th anniversary of the establishment of the Joint Institute for Nuclear Research (JINR) - the international intergovernmental scientific organization at Dubna, near Moscow.

JINR today is an internationally recognized research centre for fundamental studies, which unifies the efforts of scientists of 18 Member States (Armenia, Azerbaijan,

The old and the new at the Joint Institute for Nuclear Research (JINR), Dubna, near Moscow, which celebrates its 40th anniversary on 26 March. Top, the 10 GeV synchrophasotron, which was the highest energy accelerator in the world when it was commissioned in 1957. Below, the new superconducting Nuclotron.



Historic JINR photograph: left to right, Director of the Laboratory of Neutron Physics I.M. Frank, JINR Vice-Director M. Danysz, Director of the Laboratory of Nuclear Problems V.P. Dzhelepov, JINR Vice-Director V. Votruba, JINR Administrative Director V.N. Sergienko, JINR Director D.I. Blokhintsev, Director of the Laboratory of High Energies V.I. Veksler, Assistant to JINR Director A.M. Ryzhov, Director of the Laboratory of Theoretical Physics N.N. Bogoliubov, Director of the Laboratory of Nuclear Reactions G.N. Flerov.

JINR Directorate today: left to right Vice-Director Ts. Vylov, Director V.G. Kadyshevsky, Vice-Director A.N. Sissakian.

Belarus, Bulgaria, Cuba, Czech Republic, Georgia, Kazakhstan, North Korea, Moldova, Mongolia, Poland, Romania, Russia, Slovak Republic, Ukraine, Uzbekistan, and Vietnam) and plays a key role in the scientific cooperation between West and East (December 1994, page 7).

The main fields of JINR's activity are theoretical and experimental studies in particle physics, nuclear physics, and condensed matter physics. Available for these researches at Dubna is a unique choice of accelerators and fast neutron pulsed reactors - highly competitive sources of charged particles, nuclei and neutrons in a wide range of energies.

One of the main themes of JINR's activity is its extensive international scientific and technical cooperation. A bright example is the long-standing collaboration between JINR and CERN, which contributes to a range of theoretical and experimental work in high energy physics.

The Joint Institute for Nuclear Research is developing as a large multidisciplinary international scientific centre incorporating basic research in the field of modern nuclear physics, development and application of high technologies, and university education in the relevant fields of knowledge.

External correspondents

Argonne National Laboratory, (USA)
D. Ayres

Brookhaven, National Laboratory, (USA)
P. Yamin

CEBAF Laboratory, (USA)
S. Corneliussen

Cornell University, (USA)
D. G. Cassel

DESY Laboratory, (Germany)
P. Waloschek

Fermi National Accelerator Laboratory, (USA)
J. Cooper, J. Holt

GSI Darmstadt, (Germany)
G. Siegert

INFN, (Italy)
A. Pascolini

IHEP, Beijing, (China)
Qi Nading

JINR Dubna, (Russia)
B. Starchenko

KEK National Laboratory, (Japan)
S. Iwata

Lawrence Berkeley Laboratory, (USA)
B. Feinberg

Los Alamos National Laboratory, (USA)
C. Hoffmann

Novosibirsk Institute, (Russia)
S. Eidelman

Orsay Laboratory, (France)
Anne-Marie Lutz

PSI Laboratory, (Switzerland)
P.-R. Kettle

Rutherford Appleton Laboratory, (UK)
Jacky Hutchinson

Saclay Laboratory, (France)
Elisabeth Locci

IHEP, Serpukhov, (Russia)
Yu. Ryabov

Stanford Linear Accelerator Center, (USA)
M. Riordan

TRIUMF Laboratory, (Canada)
M. K. Craddock

Physics monitor

Most-cited high energy physics papers - all-time favourites

There is no official 'best seller' list of physics papers, but the number of times a published paper is subsequently referred to is one indicator of its scientific impact. Hrvoje Galic of the Stanford Linear Accelerator Centre (SLAC) has carefully analysed these citations. Last month (March, page 21) we published his 'hot topics' list - journal articles with the most citations in the last three years.

This month we continue with 'all-time favourites' - the 25 articles with the most citations in the last two decades. The tables reflect the situation on December 31, 1995 using information from the HEP-PREPRINT database (Ref. 1), a joint project of the SLAC and DESY libraries. Comparing the 'hot topics' lists shows the evolution of physics interest.

Theoretical fashion clearly plays a role and makes some themes more popular, even over a period of time. Experimental work is grossly undercited, probably because important results seem to be considered 'common knowledge' by the majority of non-experimentalists, and the use of convenient 'catch-all' references to the Review of Particle Properties. Papers published in smaller or non-English-language journals are generally less available and less cited. Finally, the database only collects citations found in preprints, and many otherwise important citations from non-preprinted articles are not included.

The 'all-time favourites' list shows the 25 journal papers with the most citations in the HEP-PREPRINT database since 1974. The most fruitful period in this field, according to the list, was the early seventies: seven articles from the list were published in just two years, 1973 and 1974. Some of the 'all-time favourites' are standards which have stood the test of time and figured among the 'hot topics' list .

The electroweak unification of electromagnetism and the weak nuclear force, followed by the Standard Model marriage of the electroweak picture with quark/gluon field theory, has had the most profound effect on physics in the last 20 years.

Thus Steven Weinberg's "Model of Leptons" which introduced electroweak unification is by far the most popular work. As recognized by the 1979 Nobel award, this work was foreshadowed by Sheldon Glashow's 1961 article on gauge symmetries, high on the list at fifth position. (The 1979 Nobel award was shared by Glashow, Abdus Salam and Weinberg. Salam's version of electroweak unification was not published in a journal but in a book, and its citations are thus not registered in the database). Second place on the list is held by the classic work by Glashow, Iliopoulos, and Maiani, which introduced the 'GIM' mechanism for the cancellation of divergences, demonstrated the need for a fourth quark, and extended the electroweak picture to cover both the quark and lepton sectors. Also important for the electroweak unification was 't Hooft and Veltman's proof of renormalizability, in position 23.

The Kobayashi and Maskawa treatment of CP violation in the Standard Model and the generalization of the Cabibbo matrix at position 3 is another 'evergreen' which also features in the 'hot topics' list.

There are several classic papers on the quark dynamics of the Standard Model. Two milestone papers, by Politzer in 13th position and by Gross and Wilczek in 18th, introduce quark-gluon field theory (quantum chromodynamics - QCD), pointing out the two very different aspects of quark behaviour: permanent confinement in hadrons and what came to be known as 'asymptotic freedom', when the conditions allow quarks to be liberated from their hadron confinement. Stressing these two very different aspects of quark behaviour is Wilson's work on quark confinement, at number 6 on the list, immediately followed by Altarelli and Parisi's article on the asymptotic freedom side of the quark coin. The theory and phenomenology of QCD as applied to resonance physics by Shifman, Vainshtein, Zakharov appears in 9th position.

Having established the Standard Model, another lasting preoccupation is to look beyond it and extend the unification of physics forces to include strong interactions as well. The classic Georgi and Glashow paper which introduces the simplest template - SU(5) based Grand Unified Theory (GUT) is at fourth position. Another heroic attempt to unify all the forces of physics was that of Pati and Salam, at position 8 in the list. In position 25 is Nilles' useful review paper, carrying the flag for a supersymmetric extension of the Standard Model.

Another perennial focus of interest is dynamical symmetry breaking. Coleman and Eric Weinberg at position 10 present very general

All-time HEP favourites: the 25 most-cited high-energy physics papers based on the number of citations in the SLAC-SPIRES database between 1974 and 1995 inclusive

1) A Model of Leptons
S. Weinberg
Phys. Rev. Lett. 19 (1967) 1264
4480 citations

2) Weak Interactions with Lepton-Hadron Symmetry
S.L. Glashow, J. Iliopoulos, L. Maiani
Phys. Rev. D2 (1970) 1285
2560 citations

3) CP Violation in the Renormalizable Theory of Weak Interaction
M. Kobayashi, T. Maskawa
Progr. Theor. Phys. 49 (1973) 652
2509 citations

4) Unity of All Elementary Particle Forces
H. Georgi, S.L. Glashow
Phys. Rev. Lett. 32 (1974) 438
2086 citations

5) Partial Symmetries of Weak Interactions
S.L. Glashow
Nucl. Phys. 22 (1961) 579
1982 citations

6) Confinement of Quarks
K. G. Wilson
Phys. Rev. D10 (1974) 2445
1964 citations

7) Asymptotic Freedom in Parton Language
G. Altarelli, G. Parisi
Nucl. Phys. B126 (1977) 298
1739 citations

8) Lepton Number as the Fourth Colour
J. C. Pati, A. Salam
Phys. Rev. D10 (1974) 275
1678 citations

9) QCD and Resonance Physics. Theoretical Foundations
M.A. Shifman, A.I. Vainshtein, V.I. Zakharov
Nucl. Phys. B147 (1979) 385
1587 citations

10) Radiative Corrections as the Origin of Spontaneous Symmetry Breaking
S. Coleman, E. Weinberg
Phys. Rev. D7 (1973) 1888
1584 citations

11) Computation of the Quantum Effects due to a Four-Dimensional Pseudoparticle
G. 't Hooft
Phys. Rev. D14 (1976) 3432
1579 citations

12) Infinite Conformal Symmetry in Two-Dimensional Quantum Field Theory
A.A. Belavin, A.M. Polyakov, A.B. Zamolodchikov
Nucl. Phys. B241 (1984) 333
1572 citations

13) Reliable Perturbative Results for Strong Interactions?
H.D. Politzer
Phys. Rev. Lett. 30 (1973) 1346
1542 citations

14) Dynamical Model of Elementary Particles Based on an Analogy with Superconductivity. I.
Y. Nambu, G. Jona-Lasinio
Phys. Rev. 122 (1961) 345
1458 citations

15) Symmetry Breaking through Bell-Jackiw Anomalies
G. 't Hooft
Phys. Rev. Lett. 37 (1976) 8
1457 citations

16) Vacuum Configurations for Superstrings
P. Candelas, G. T. Horowitz, A. Strominger, E. Witten
Nucl. Phys. B258 (1985) 46
1433 citations

17) Quantum Geometry of Bosonic Strings
A.M. Polyakov
Phys. Lett. B103 (1981) 207
1423 citations

18) Ultraviolet Behaviour of Non-Abelian Gauge Theories
D.J. Gross, F. Wilczek
Phys. Rev. Lett. 30 (1973) 1343
1416 citations

19) Axial-Vector Vertex in Spinor Electrodynamics
S.L. Adler
Phys. Rev. 177 (1969) 2426
1400 citations

20) Review of Particle Properties
Particle Data Group (K. Hikasa et al.)
Phys. Rev. D45 (1992) S1
1364 citations

21) Supercollider Physics
E. Eichten, I. Hinchliffe, K. Lane, C. Quigg
Rev. Mod. Phys. 56 (1984) 579
1342 citations

22) Inflationary Universe: A Possible Solution to the Horizon and Flatness Problems
A. H. Guth
Phys. Rev. D23 (1981) 347
1334 citations

23) Regularization and Renormalization of Gauge Fields
G. 't Hooft, M. Veltman
Nucl. Phys. B44 (1972) 189
1321 citations

24) Pseudoparticle Solutions of the Yang-Mills Equations
A.A Belavin, A.M. Polyakov, A.S. Schwartz, Yu.S. Tyupkin
Phys. Lett. B59 (1975) 85
1287 citations

25) Supersymmetry, Supergravity and Particle Physics
H.P. Nilles
Phys. Rept. 110 (1984) 1
1264 citations

arguments for establishing a spontaneous symmetry breaking mechanism. Another popular mechanism for symmetry breaking (positions 11 and 15) is 't Hooft's studies of instanton-induced quark interactions. Adler's paper on the fundamental anomalies which drive this idea appears in position 19. Dynamical generation of fermion masses, fermion condensates, and pseudoscalar mesons as Goldstone excitations are described in the Nambu and Jona-Lasinio paper (position 14). In 24th position is Belavin, Polyakov, Schwartz, and Tyupkin's demonstration of instanton solutions.

String ideas - the generalization of zero-dimensional particles to one-dimensional strings in a larger space - is a minor industry among theoreticians and is naturally also well represented. At position 12 is the Belavin, Polyakov, Zamolodchikov paper on the basics of two-dimensional conformal field theory. Two representative fundamental string theory articles are grouped together: Candelas, Horowitz, Strominger, and Witten in position 16 and Polyakov just ten citations away.

The 'hot topics' list of current papers published in the March issue was headed by citations to the Review of Particle Properties. However in the more general list, this review comes in 20th position.

The 1984 opus by Eichten, Hinchliffe, Lane and Quigg (position 21) provided the theoretical motivation for the next generation of proton colliders.

The increasing importance of particle physics ideas in cosmology is underlined by Guth's pioneer paper on the exponential 'inflation' of the early universe, in position 22.

A more complete version of the table, listing the 50 most cited articles, is posted at SLAC's Web server (Ref. 2).

Information from Hrvoje Galic, SLAC Library Databases

References:
1) http://www-spires.slac.stanford.edu/find/hep
2) http://www-spires.slac.stanford.edu/find/top40.html

BEIJING Tau-charm factory workshop

From 5-9 February, an international meeting at the Institute of High Energy Physics (IHEP) in Beijing reviewed the progress on the feasibility study for the Beijing Tau-Charm Factory (BTCF - October 1995, page 8).

The next generation of particle accelerators are pursuing two complementary paths in their quest to crack open the Standard Model: one is the traditional high energy frontier being pushed by machines like the LHC and the linear colliders, and the other is the high precision frontier of the phi, tau-charm and B factories.

Interest in factory machines has grown in recent years since they address fundamental puzzles in the Standard Model such as why are there three fermion families, why do the quarks mix but apparently not the leptons, and what is the origin of CP violation?

The BTCF is designed as a dedicated experimental tool for the tau lepton and charm quark. In addition to extremely high statistics, its particular strengths are the experimental environment at production threshold, which provides lower backgrounds than other machines, experimental measurement of the backgrounds (by operating the machine below threshold), and access to high-rate calibration sources for the detector (J/psi and psi prime). These and other features should allow tau and charm experiments that are either unique or cannot be performed elsewhere with comparable precision.

In an opening speech at the workshop, Zhou Guang- zhao, President of the Chinese Academy of Sciences, expressed the importance to China of high energy physics and the high regard for the IHEP research programme. With the good experience of Beijing's electron-positron collider, and recognizing the broad and exciting BTCF physics programme, the Chinese Academy of Sciences fully understands the enthusiasm for building the BTCF, and supports the project. He welcomed the active participation of the international high energy physics community in the accelerator and experimental programme.

After the plenary introductory talks, the real work began in the parallel working sessions, with physics groups organized by T. Huang, Joo Sang Kang and A. Pich. Among the initial priority physics goals are CP violation in tau lepton decays, CP violation and mixing in charm decays, the masses of the tau-neutrino and tau leptons, and mapping the spectrum of gluonic particles in charmonium decays. In addition the BTCF would allow precision measurements of the tau lepton and

Tau-Charmers at the February workshop in Beijing.

the various charm and charmonium states. These will provide stringent tests of the Standard Model as well as providing important input for extracting physics at higher energy machines - and they may potentially reveal new physics beyond the Standard Model.

Considerable progress was made on the machine design, reflecting an especially strong group of machine physicists under the capable organization of S. Kurokawa, Y.Z. Wu and M. Tigner (who is spending the year at IHEP working on the BTCF design). The priorities for the machine performance are seen as, in order: 1) a peak luminosity of 10^{33} per cm per s at 4 GeV, and a primary energy range of about 3-5 GeV; 2) longitudinal polarization of one or both beams near 3.67 GeV (the prime energy for tau physics) and possibly at other energies; and 3) to maintain the potential for future luminosity increases and for operation with monochromator optics.

Longitudinally polarized beams are considered essential for the study of CP violation in tau decays - a programme that may be uniquely accessible at the BTCF. Longitudinal polarization is desirable at other energies also, since symmetry violations may be uncovered in other channels and since polarization is equivalent to higher luminosity. Much attention was focused on the schemes for polarization generation and rotation, and the initial indications are encouraging. Given the physics priority, it was recommended that the necessary polarization hardware be included in the reference design and installed at the outset.

The detector groups were organized by J. Kirkby, W. Li, J.M. Ma and L. Price. The detector design benefits from the R&D programmes of the B Factory detectors and the advanced data acquisition systems pioneered by experiments at Fermilab, DESY and elsewhere. Significant advances in the detector design were made in areas such as the particle identification system (a combination of time-of-flight and aerogel counters), the superconducting solenoid (suitability of the TOPAZ solenoid), and the muon polarimeter. Informal discussions took place on the framework for international collaboration on the machine and detector. Several accelerator laboratories are interested in collaborating, especially in challenging areas such as the superconducting radiofrequency cavities.

A large international community of physicists will be required to build and operate the detector and to analyse the physics. Representatives were present at the meeting from each of the main potential regions for international participation: Asia, Europe, North America and Russia.

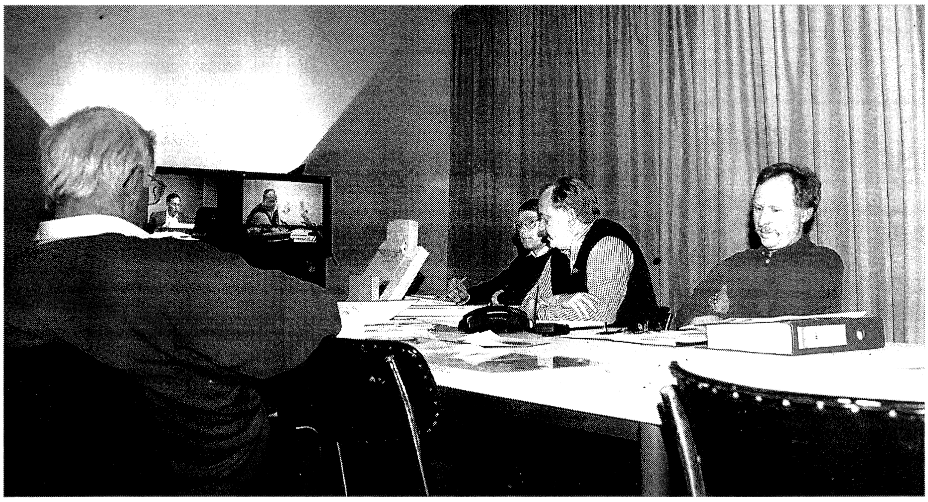
The optimum timescale is a two-year period for R&D and preparation of the detailed design (1997-1998) followed by a four-year construction period (1999-2002), with the first collisions by the end of 2002. With the feasibility study due to be completed by October this year and a decision on the study expected soon after by the Chinese authorities, the high energy physics community eagerly looks forward to the "promising future" for the BTCF seen by Zhou Guang-zhao.

The meeting, organized by Z.P. Zheng and S.H. Wang, brought together a large group of theoretical physicists, experimentalists and accelerator specialists, numbering about 220 in total, including 60 from abroad.

Video conferencing

In many fields, video conferencing is becoming an increasingly popular way to do business, avoiding the need to travel long distances, and being immune to such phenomena as heavy fog and rail strikes. It is only natural that particle physics, with its large international collaborations, both in terms of numbers of people and geographical extent, should be

A few of the participants at a CMS collaboration video conference. The room they are using is equipped with a system donated to CERN by the US high energy physics community and has a capacity of 30 people.



an active player in this new communications medium.

Already widely used across the vast distances of the United States, video conferencing made its debut at CERN in October 1994, and has rapidly found favour.

There are two ways in which the physics community is exploiting video conferencing. The first uses the commercial Integrated Services Digital Network, ISDN, whilst the second runs over the internet. Both have their advantages. With ISDN, bandwidth (see box) is guaranteed, giving an assurance of reliable performance. Typical ISDN systems are designed for dedicated conference rooms although cheaper PC-based systems are available. Many desktop workstations are well equipped for informal conferencing over the internet, but the current internet bandwidth is insufficient to support unrestricted use. At CERN, internet video conferencing technology is most frequently exploited in a limited number of dedicated conference rooms.

CERN currently has two rooms equipped for ISDN video conferencing. The largest has a capacity of 30 and is equipped with a system donated by the United States physics community to facilitate communication with the growing number of American physicists working at CERN. These rooms play host to about 20 conferences each month, frequently involving physics groups on both sides of the Atlantic.

Many transatlantic conferences pass through a gateway at the Lawrence Livermore National Laboratory in California. To hold a conference with several US sites a European participant has to make a single call to Livermore which currently costs120 Swiss francs/hour. Within Europe, conferences are co-ordinated by a local machine and cost around 90 Swiss francs/hour. Charges are falling, and with European telecommunications deregulation in 1998, video conferencing should become considerably cheaper.

With over a year of ISDN experience, CERN experiments are finding video conferencing to be a valuable supplement to face-to-face meetings, rather than an alternative. One reason is the large distances involved. CMS, one of the big global experiments preparing for physics at CERN's Large Hadron Collider, holds weekly management video conferences. With participants from California to Oxfordshire taking part, finding a convenient time for everyone is not easy. Fermilab near Chicago is the CMS reference point, with conferences starting at 9 am Illinois-time. This corresponds to 7 am in California, and 4 pm in Europe. Clearly, if Japanese groups were involved, a convenient time for everyone would simply not exist.

Video conferencing also requires a strict code of conduct. Free and open discussion such as might take place in a room is not possible. Current systems are sound-activated, with attention focusing on whoever makes the most noise! There is also a slight time delay between saying something at one site, and being heard elsewhere. For these reasons, speakers have to know when they are supposed to speak, and they must leave clear pauses for other participants to comment. Background mumbling is, of course, out.

Despite these drawbacks, CMS finds the weekly conferences indispensable, and also uses the system for specific conferences as necessary. Recently, the experiment's 'parameter committee', which has the task of fine-tuning the detector design to the nearest millimetre without squashing any cables, found that video conferencing made their task considerably easier. Another use has been found by the Michigan group on the L3 experiment

Bandwidth

In telecommunications, bandwidth is the range of frequencies covered by a transmission. A single frequency (zero bandwidth) is just a pure note. The richer the information which has to be conveyed, then the wider the bandwidth required - for example video transmission requires a higher bandwidth than audio. Pictures require more bandwidth than text, and moving images require more bandwidth than still photographs. In more general terms, any method for transmitting information has a natural bandwidth. The natural bandwidth of the postal system, for example, is the amount of information which can be put in a letter. The average bandwidth of the CERN Courier is 44 pages per month.

at CERN's LEP electron-positron collider who use regular ISDN conferences to allow students, whilst they are at CERN, to keep in touch with their supervisors in the US.

Video over the internet is still in its infancy. Video broadcasts or video conferences with very many participants rely on a virtual network called MBONE running on top of the internet. Video conferences involving a small number of participants can use the internet directly.

MBONE is based on a series of routers which try to overcome the bandwidth problem by reducing the amount of information transmitted. For example, if a site in Europe sends a packet of information to fifty sites in the US, MBONE will send a single packet from a Europe-based router to another in America before sending individual copies to each recipient. The internet alone would send fifty copies across the Atlantic.

MBONE has to compete for bandwidth with other internet services like FTP and the World-Wide Web, and because it needs to transmit in real-time, is at a disadvantage. With the Web, a crowded network means slow transmission; lost packets are resent later. But for video conferencing, lost packets are potentially disastrous; there is no point resending a syllable spoken 2 minutes ago.

Many people are already making use of MBONE technology. NASA broadcasts space shuttle missions in this way. But sometimes as many as 50% of packets are lost as seen from Europe, making the sound and video incomprehensible. CERN broadcasts certain important committee meetings on MBONE, and the other big LHC experiment, ATLAS, transmits its plenary meetings over the network. Although MBONE is often more congested than the underlying internet, even point-to-point videoconferences over the internet suffer from congestion and packet loss.

Nevertheless, video conferencing on a workstation has many attractive features. It is very easy to move computer-based documents into a common 'white board' which everyone can see. Here, the protocol does resend lost packets, and the full information is always transmitted. In this way, conference participants can work together on text, graphics, and computer programs. Another feature is that the whole conference can be recorded on disk and replayed later through a Web browser.

Long term solutions to the bandwidth problem may come with an expanding internet, or with the arrival of point-to-point networking technology such as the much-touted Asynchronous Transfer Mode, ATM. But in the short term, more innovative solutions have to be found.

Scientists at CERN and the California Institute of Technology are working on a way to reserve bandwidth on the heavily used internet link between CERN and the US; Caltech will equip a conference room at CERN for use with the reserved bandwidth. Another solution is to leave the internet altogether, and run the internet video conferencing protocols over ISDN, but then commercial telecommunications charges come into play.

Video conferencing is proving to be essential for the global collaborations preparing for CERN's LHC collider. It is impossible for all collaboration members to get to plenary meetings, but anyone with access to internet video conferencing can at least follow them. However, with current bandwidth problems, broadcast information is sometimes lost, and internet based conferencing is better suited to impromptu one-to-one conferences. The ability to share computer-based documents quickly and easily coupled with the low end-user cost of conferencing over the internet make it extremely attractive. But for the time being at least, the quality of audio and video over the internet is unpredictable, and where guaranteed bandwidth for a large number of users is needed, ISDN is the safest bet.

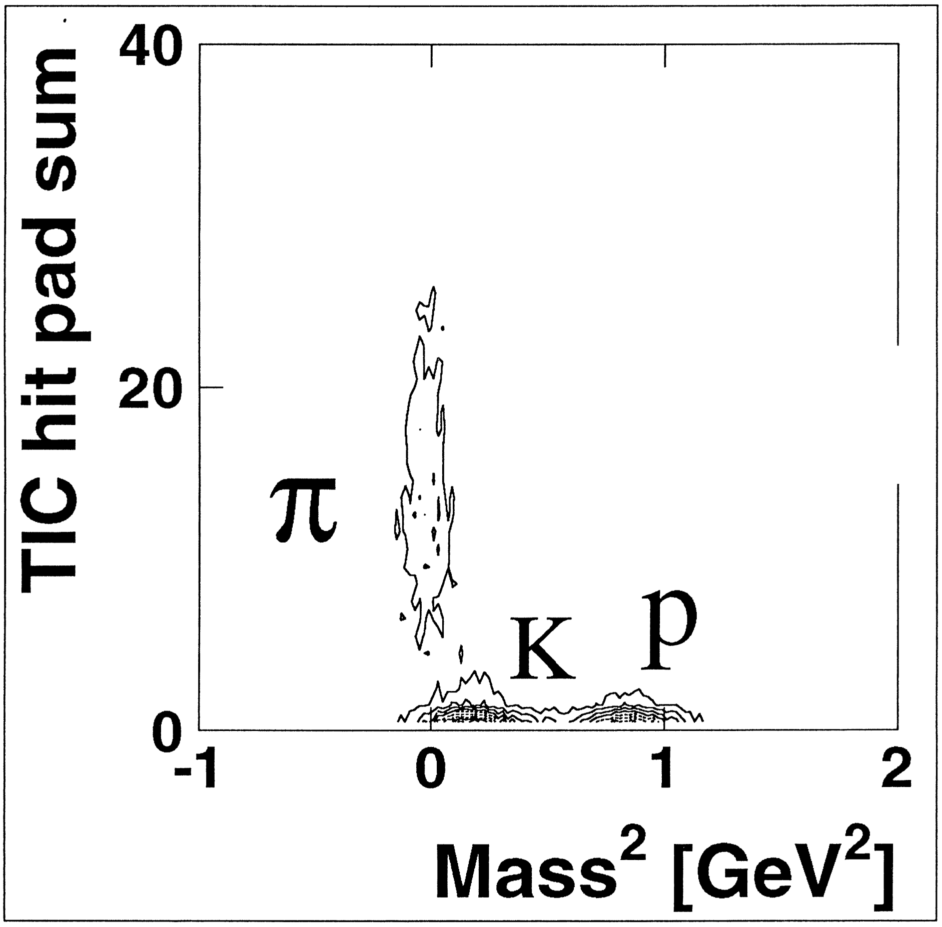
For information on ISDN video conferencing, see:

http://www.cern.ch/CERN/Video/Welcome.html

http://cmsdoc.cern.ch/teleconf.html

The Network Research Group at

2-dimensional iso-contour plot from the NA44 Threshold Imaging Cherenkov detector. Low mass pions produce many hits, while protons and kaons, below Cherenkov threshold, produce no pad hits and are distinguished by their mass. The technique gives a good resolution between pions and kaons which would not be available from time-of-flight information alone.



Lawrence Berkeley Laboratory has produced the majority of the internet video conferencing tools:
http://www-nrg.ee.lbl.gov
For MBONE conferencing in general:
http://www.best.com/~prince/techinfo/mbone.html
or at CERN:
http://ecponion.cern.ch/multimedia/welcome.html

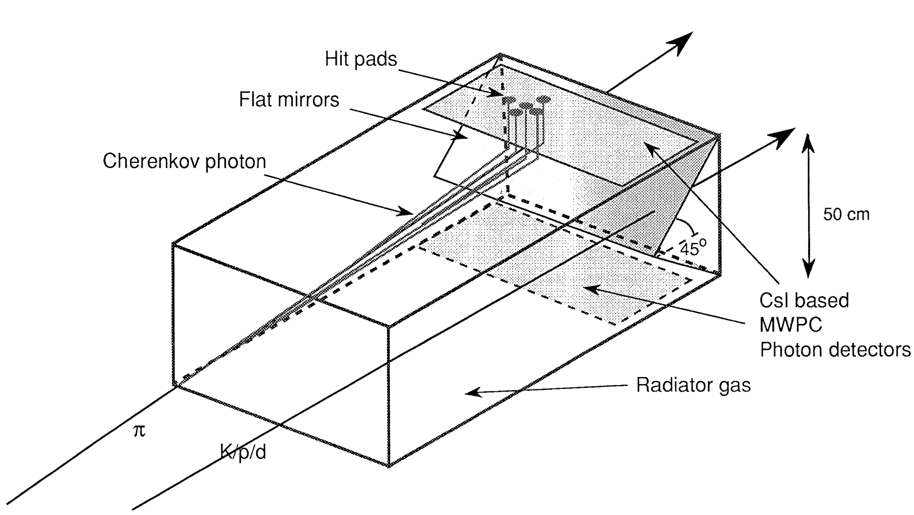
Cesium iodide photocathodes come of age

For its upgrade the NA44 heavy ion experiment at CERN has stressed the improvement of particle identification for the multiple tracks encountered in lead-lead collisions, and a novel detector based on threshold Cherenkov radiation emission has been constructed - the Threshold Imaging Cherenkov (TIC).

This is based on two-dimensional detection of Cherenkov light emitted in a metre-long isobutane gas radiator by particles with velocities above the threshold Cherenkov radiation (the optical shock wave produced when particles force their way through a medium faster than the velocity of light in the medium).

The Cherenkov photons are reflected by mirrors towards detectors outside the track acceptance region. This imaging, in conjunction with surrounding tracking

TIC (Threshold Imaging Cherenkov) Detector



Schematic view of the detector

Schematic of the NA44 Threshold Imaging Cherenkov detector. For each track above emission threshold, mirrors reflect Cherenkov light onto planes of photon detectors, equipped with cesium iodide photocathodes, on the top and on the bottom of the module.

by pads and strip chambers, allows pions to be distinguished from heavier particles (kaons and protons), which themselves are below Cherenkov threshold in the momentum range 3-8 GeV.

For each track, a fiducial circle is constructed in the photon detector around the projected point of impact, corresponding to the base of the emission cone of Cherenkov light. If photons are detected within this circle, the track is attributed to a pion. If the circle is empty the track is attributed to a kaon, a proton or a deuteron, differentiated in turn by time-of-flight.

The concept was tested in the lead ion run in 1994 with Cherenkov-photon detection using multi-wire counters with a pad cathode and TMAE gas. The results were very satisfactory, but the large conversion gap for photons in TMAE limited the rate of beam on target since background radiation increased the current in the counter to unacceptable levels.

Meanwhile encouraging progress had been made by the RD26 research and development collaboration in the development of large cesium iodide photocathodes for use in a Ring-Imaging Cherenkov (RICH) detector. This would be used for particle identification at high momenta at CERN's future LHC collider when operated with heavy ions. With this work producing large area photocathodes for detecting Cherenkov rings with good quantum efficiency (15 detected photons per ring with a 10mm liquid radiator), NA44 decided to replace TMAE with a solid cesium iodide photocathode in the 1995 SPS heavy ion run. This approach offers, among other things, a reduction in the active volume of the chamber (less background), faster response and easier operation.

Both TIC chambers were equipped with 25x80 cm^2 cesium iodide photocathodes and with the newly developed GASSIPLEX chip for frontend multiplexed analog readout. These photocathodes are among the largest produced so far and are the first to be used in a physics experiment. The detectors successfully operated during the 1995 lead ion run, and the success with cesium iodide photocathodes is an important milestone towards their future use in big detectors.

Bookshelf

Dirac in print

The Collected Works of P.A.M. Dirac, 1924-1948, edited by R.H. Dalitz, Cambridge University Press, ISBN 0 521 36231 8, £175/$250

Paul Dirac (1902-1984) was one of the great physicists of the 20th century. Although he was not one of the pioneers who 'discovered' quantum mechanics, he developed a firm mathematical foundation for a subject notoriously difficult to understand for those handicapped by overexposure to ordinary 'everyday' logic.

Dirac's approach, as enshrined in his book 'The Principles of Quantum Mechanics', became universally acknowledged as 'the' way to handle and understand this otherwise sometimes impenetrable formalism.

Now published is a collection, carefully edited by Richard Dalitz, of Dirac's most influential work. (A second volume will cover the post-1948 period.)

Most of Dirac's papers are produced in their original form, beginning with his early work under R.H. Fowler at Cambridge. In 1925 Heisenberg gave a seminar at Cambridge, and Dirac's attention soon concentrated on a personal formulation of this incisive, but sometimes baffling new theory which was to become quantum mechanics. Like Richard Feynman after him, Dirac preferred to think things out for himself, his thought patterns evolving into firm intellectual stepping stones on which others could subsequently tread.

The book includes the contents and introduction of Dirac's PhD thesis on 'Quantum Mechanics'. This is widely supposed to have provided the template for his famous book, but Dalitz points out that while the chapter headings in the two works bear a superficial resemblance, the book material is substantially reworked.

In any case the first edition of the book (1930) proved especially hard to swallow, and Dirac embarked on a

substantial rewrite, published in 1934. The prefaces to these various editions are included in the book. Later editions of 'Principles' traditionally use only extracts from these early prefaces.

Naturally prominent is Dirac's work leading towards the formulation of a fully relativistic picture of the electron - what is now known as the 'Dirac equation'. This presaged the existence of antiparticles, and in a 1930 article in 'Nature' (included in the book) Dirac speculated that the proton could somehow be the antiparticle counterpart of the electron. He subsequent relinquished this point of view.

With attention focused on the World War II Manhattan Project, of which Dirac was not formally a part, his wartime work as a member of Peierl's group at Birmingham is little known. Included in the book are several revealing contributions on centrifugal isotope separation, however Dirac's now formally declassified papers on actual bomb problems which were despatched to the US have not been found.

The 1300-page book adds substantially to our knowledge of an already impressive figure.

Theoretical Nuclear and Subnuclear Physics, by J.D. Walecka, Oxford University Press 1995 (ISBN 0-19-507214-6) 610 pages, hard cover, price £50

This is a comprehensive textbook by an eminent expert on topics at the interface between nuclear and particle physics. It is particularly adapted to the needs of the community of physicists around CEBAF, but it is also of great interest to any physicist working at this interface. It is based on lecture notes from three separate lecture courses that Dirk Walecka gave when he was Scientific Director at CEBAF: Graduate Quantum Mechanics, Advanced Quantum Mechanics, and Field Theory an Special Topics in Nuclear Physics.

The primary goal is the pedagogical one of providing a clear, logical and unifying treatment of many diverse topics of modern nuclear theory together with the necessary tools. The topics range from the non-relativistic many-body problem to the Standard Model of the strong, electromagnetic and weak interactions. There are four key subjects in the book: basic nuclear structure, the relativistic nuclear many-body problem, strong coupling QCD and electromagnetic interactions with nuclei. The book is written so as to give graduate students a basic understanding of modern nuclear physics and its numerous theoretical techniques as a preparation for research work. In addition it is an excellent refresher and reference for working physicists. The book has a large and superb set of instructive problems. A drawback is the absence of an alphabetical list of author references. The book will be a classical reference in the field for many years to come.

By Torleif Ericson

Books received

The Quantum Theory of Radiation, by E.R. Pike and Sarben Sarkar, Oxford University Press, ISBN 0 19 852032 8, Price £55

In the Oxford series of International Monographs on Physics, this book has the same title as Heitler's classic work which fuelled earlier generations of radiation theorists, before the advent of modern quantum electrodynamics. Designed as a sequel to Heitler, this book deals with quantum electrodynamics, spontaneously broken symmetries, and modern quantum optics.

Calorimetry in High Energy Physics (Proceedings of the 5th International Conference), edited by H.A. Gordon and D. Rueger, World Scientific, ISBN 981-02-23811, Price £78

Proceedings of the meeting at Brookhaven, 25 September - 1 October 1994, and as such a good survey of state-of-the-art techniques.

Frontiers of Fundamental Physics, Edited by Michele Barone and Franco Selleri, Plenum Press, ISBN 0-306-44825-4, Price $178

Proceedings of the 1993 Olympia Conference, covering Astrophysics, Relativity, Geophysics, Particles and Fields, and Quantum Physics.

Pulsed spallation neutron sources -
Scientific applications

An article by Jack Carpenter of Argonne in the previous issue (March, page 4) introduced the growth area of proton accelerators for neutron production. This sequel goes on to describe the growing range of scientific applications to which these neutron sources have been and are being harnessed.

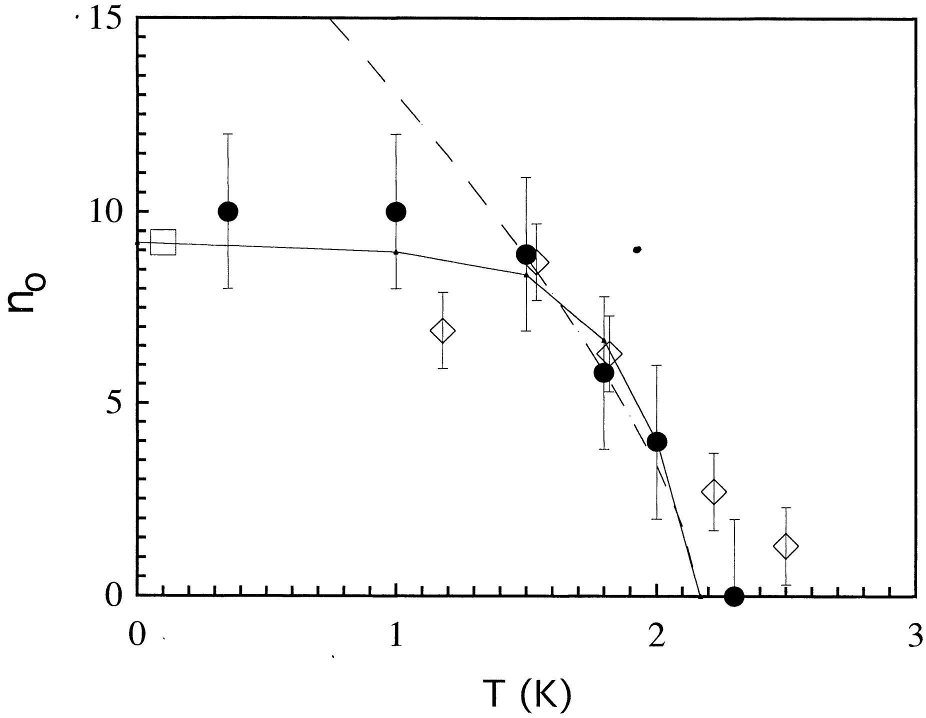


Figure 1a. Neutron scattering in action. The superfluid Bose condensate fraction n_o as a function of temperature at constant density 0.147 g/cc (filled circles). Also shown are theoretical calculations of n_o from Green's function (square) and path integral monte carlos (diamonds). The dashed line is a plot of the renormalization group theory with a critical exponent 0.7 derived from thermodynamic measurements. The solid line is a prediction based on depletion of the condensate fraction by thermal excitation of atoms.

From auspicious beginnings at the early research reactors, studies using neutrons have gone on to provide much of the microscopic understanding of condensed matter that is the basis for modern technology. This progress continues at an ever-increasing rate, now extending to the investigation of engineering materials, biological systems, and fundamental physics.

The high yields from pulsed spallation neutron sources have already contributed considerably to a wide range of sciences and are set to further extend and complement the reactor investigations in the future.

Fields that have already benefited from neutron beams from spallation sources, and which stand to profit further from new high-power sources, span the broad sweep of condensed matter science, taken in the general sense.

There are bright prospects for advances in an impressive range of frontier studies, for example:
biologically active molecules for pharmaceuticals;
high-temperature superconductors for electric transmission lines;
hard magnets for electric motors;
fast-ion conductors for battery components;
amorphous solids for optical and solar energy devices;
polymers for adhesive films;
complex fluids for chemical separations and environmental restoration;
catalysts for industrial processes;
engineering components under stress;
fundamental physics;
and ultra-cold neutrons.

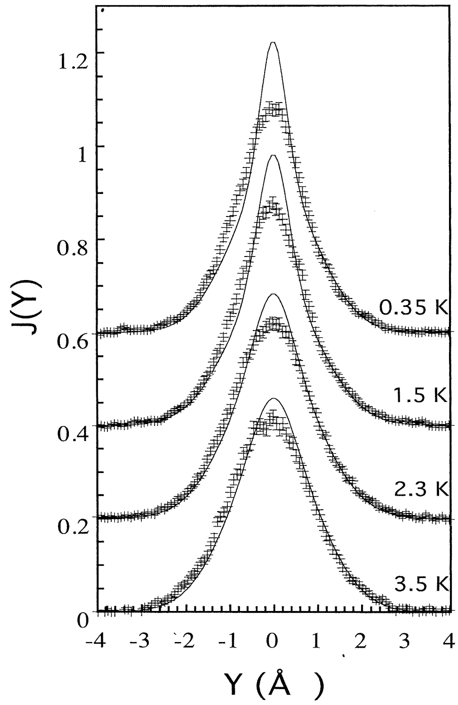
The enduring value of neutron beams in all these applications springs from a number of advantages, including:
deep penetration;
volume sampling and container penetrability;
sensitivity to light elements;
hydrogen-deuterium substitution;
isotopic sensitivity with chemical site labeling;
sensitivity to magnetic structures and excitations;
sub-microvolt energy resolution and slow diffusive motions;
precise space resolution;
simplicity of probe-sample interaction and ready interpretation of measurements.

Steady sources continue in the tradition of reactor investigations, but avoid their sometimes negative environmental connotations, while pulsed sources provide unique access to high energies and a wide range of kinematical conditions.

Application shop window

What gives high temperature superconductors their special properties? The use of pulsed source powder diffraction for study of the high temperature superconductors is already well known. Its wide wave vector range, ease of sample environment control, and sensitivity to the crucial oxygen component

Figure 1b. Neutron scattering from liquid helium-4 as a function of reduced energy transfer, Y, for various temperatures and a density of 0.147 g/cc. The solid lines are the reduced atomic momentum distribution J obtained by deconvoluting the effects of instrumental resolution and final state effects. The results have been shifted vertically for clarity.



have made major contributions to understanding the relationship between structure and function of these new materials.

Pulsed source chopper spectrometers operating with neutrons in the electronvolt energy range and providing measurements in the high-momentum-transfer "deep inelastic scattering" or "recoil" limit have already provided long-sought information on superfluids. These measurements exhibit a broad component of the scattering, the "normal" fluid component but broadened by initial atomic momentum distribution of the struck particle, and a narrow component which represents the superfluid component - the Bose condensate (November 1995, page 12) - having zero initial momentum (Figure 1b).

Recent theoretical advances that account for "final state" effects enable these two components to be separated and the condensate fraction determined directly. Such measurements extend to the temperature and pressure dependence of the condensate fraction and challenge the developing theory of the superfluid state.

Future measurements run to highly-absorbing helium-3 (fermion) mixtures and to measurements in porous geometries. Figure 1a shows the condensate fraction number in liquid helium-4 plotted as a function of temperature at saturation density. The superfluid transition occurs at 2.2 K.

A powerful, popular new class of instrument developed in the last decade, the neutron reflectometer, is providing fresh information on the chemical and magnetization density profiles at surfaces. Here, neutrons incident at glancing angles are totally or partially reflected from a surface. The reflection probability depends on the variation of the index of refraction, thus upon the isotopic composition or magnetization density as a function of depth, which can be extracted from the data. Spatial resolutions of about 10 A (10^{-7} cm) and a range of a few thousand A are accessible.

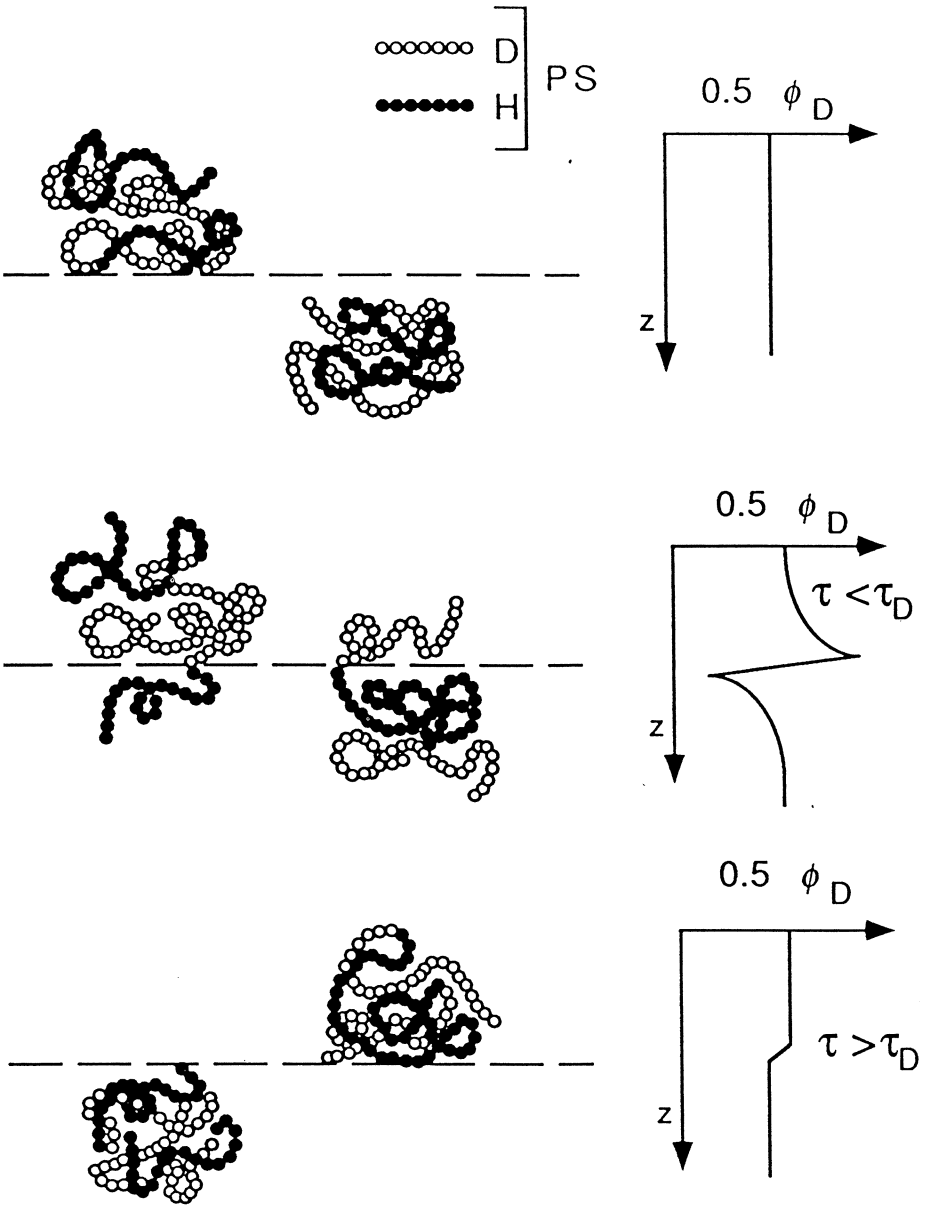
A recent measurement directly verified the "reptation" model of polymer diffusion. Two layers of polystyrene chains were laid down, each with 50% of the protons replaced by deuterium, having the same scattering length density and no contrast between them. The layers differed in that the block copolymers of one consisted of polystyrene deuterium labeled at the ends (DHD), while the other was reversed (HDH). Initially there was no contrast between the two layers.

On annealing at high temperature, the chains diffuse across the initially-sharp interface. If the polymer motion were the same for each portion of the molecule, there would remain no contrast; however, because of longitudinal motion, a concentration ripple forms at the interface, seen in the reflectivity. This direct observation (Figure 2) correlated exactly with predictions from reptation theory. The result unequivocally demonstrates the theory of snake-like motion that is fundamental to understanding polymer diffusion and has wide-ranging technological implications.

Pulsed spallation sources also have important implications for fundamental physics. For example, in the study of neutron decay and searches for any violation of time-reversal symmetry from the neutron electric dipole moment (EDM - still below presently detectable limits), bottled ultra-cold neutrons (UCNs) of the highest possible density are required (now, about 100 per cc). Because the pulsed sources can provide instantaneously higher cold neutron phase space densities than the steady sources used to date, the prospect is for some two orders of magnitude improvement in the stored UCN density. This would yield correspondingly greater sensitivity to EDM and decay asymmetry measurements.

Applications beyond the realm of neutron scattering for which the spallation sources are now useful and for which improved sources will provide significant new capacity are in radiation damage studies for special purposes, isotope production (including positron emitters), and activation analysis.

Other valuable contributions include the provision of pulsed and steady muon sources for physics and for



solid state science applications, and neutrino sources. Substantial efforts for both these approaches have been made at ISIS at the UK Rutherford Appleton Laboratory.

The new neutron sources on the horizon promise even wider and more substantial advances.

Figure 2. Interdiffusion of two layers of polystyrene according to the reptation model. On the right, the predicted and measured deuterium concentration profile.

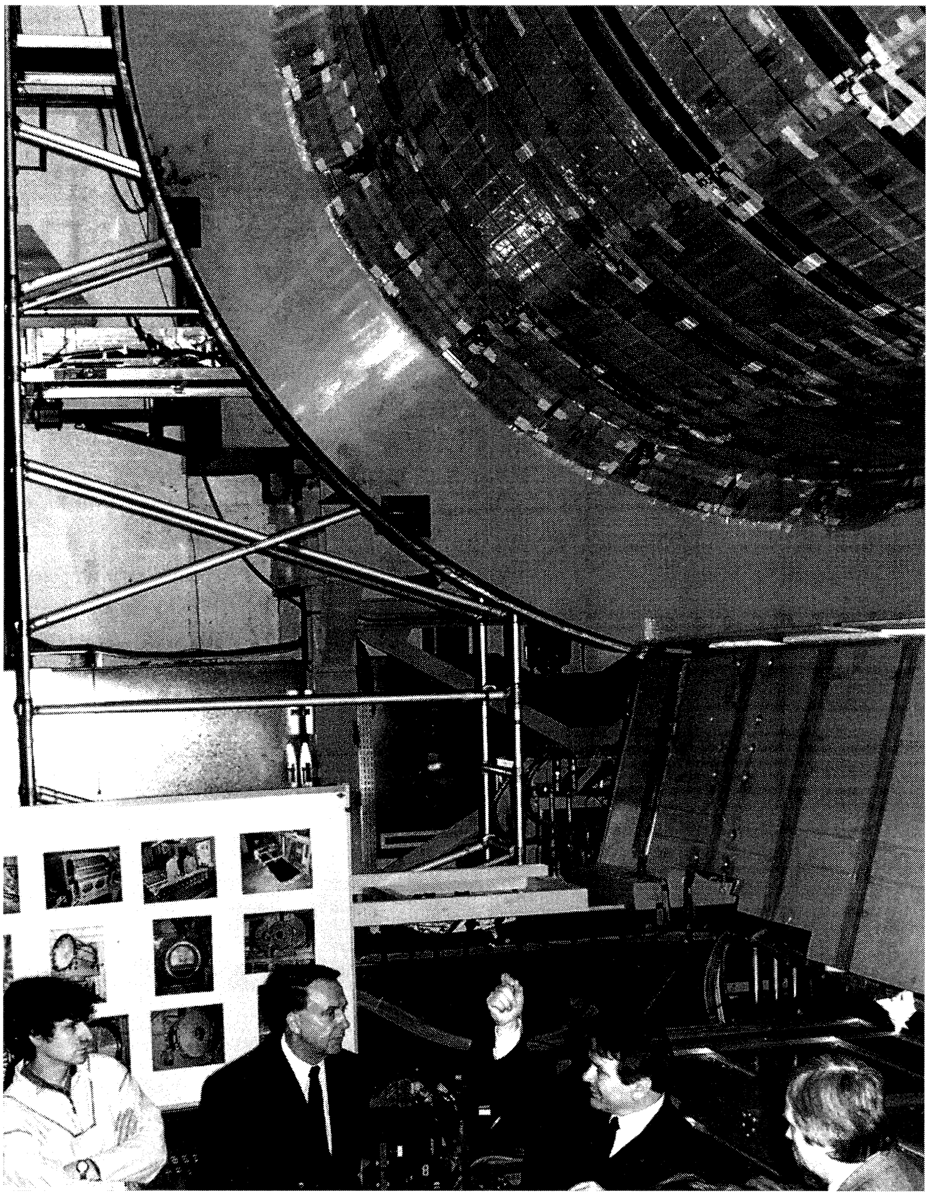
People and things

Karl Ove Nielsen (1920-1996)

The Danish experimental nuclear physicist Karl Ove Nielsen died on February 21, aged 75, in Birkerod, north of Copenhagen. He was one of the pioneers in the techniques of on-line isotope separation, and developed ion sources and separators at the Niels Bohr Institute in Copenhagen in the 50s. His experience from that work made him a driving force behind the creation of the ISOLDE on-line isotope separator at CERN in the 60s. He came to Aarhus as professor of experimental physics in 1961 and within ten years made Aarhus a world centre for small accelerators in atomic and solid state physics. After a few years the first

Danish Minister for Research and Information Technology Frank Jensen (left) admires a robot for target manipulation at CERN's ISOLDE on-line isotope separator with Helge Ravn of CERN.

(Photo HI17.2.1996)



CERN Research/Technical Director Horst Wenninger explains CERN's activities to Bernd Neumann, Parliamentary Secretary of Germany's Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie.

(CERN Photo HI19.2.1996)

experimental breakthrough came with the discovery of the channeling effect (correlated ion scattering in crystalline targets). These studies have recently been carried to the highest energies at the CERN accelerators and crystal channeling is now a realistic option for bending TeV proton beams.

Karl Ove Nielsen retained his connection to CERN. From 1973-82 he was delegate to CERN Council and from 1980-82 was chairman of the Finance Committee. In 1982 he joined the CERN staff for two years . His wife Gunn Rudjord (who died last fall) was the artist who created the large weaving displayed in the lobby of the CERN Hostel (Building 38).

Hans Henrik Andersen

Mikhail Isaakovich Podgoretsky

Last October, a special seminar at the Laboratory of High Energies, Joint Institute for Nuclear Research (JINR), Dubna, was held in memory of Mikhail Isaakovich Podgoretsky, who died last year, aged 76.
Born in Zaporozhe, Ukraine, he graduated in physics at Moscow in 1941. After the Second World War, he joined Veksler's cosmic ray team at the Lebedev Institute.
From 1955 he shared his time between JINR and Moscow, making many contributions to nuclear and particle physics, including suggesting the study of hypernuclei using relativistic heavy ions beams. Following his classic 1972 paper with G.I. Kopylov, Podgoretsky was for many the 'godfather' of meson interferometry.

From Jerzy Bartke

Korean prize

Wonyong Lee has won the prestigious Korean Ho-Am prize, awarded by the Samsung Welfare foundation, for his 'monumental contributions to the advancement of high energy physics'.

Argonne Advanced Photon Source passes major milestone

The 7 GeV Argonne Advanced Photon Source recently produced more than 500,000 watts of X-ray power for about 20 minutes, meeting a milestone toward full operation. The stored beam current reached the design performance goal of 100 milliamps during tests shortly before midnight on 12 January. Associate Laboratory Director David Moncton started and stopped the last two beam injections before bringing the test to a halt and breaking out the champagne. The accomplishment moves the APS another step closer to routine operation. The next milestone is expected to be reached next fall, when the US Department of Energy declares that the facility is "operationally ready," said John Galayda, director of APS Accelerator Systems Division. "We are looking forward to providing beam to a growing community of users, and we're expecting a busy summer," he said.

Emily Pelton, of the US President's Office of Science and Technology Policy precedes Kerri-Ann Jones, Deputy to the Associate Director for US National Security and International Affairs, down the ladder after admiring prototype magnets for CERN's LHC collider, escorted by (bottom) CERN Research Director Lorenzo Foà and LHC Project Leader Lyn Evans.

(Photo CERN HI 23.1.96)

ATM networking

The European Synchrotron Radiation Facility, ESRF, in Grenoble is the world's most intense synchrotron radiation source. ESRF experiments range from life sciences to nuclear physics, but they all have one thing in common; all produce huge quantities of data. As a result, ESRF networking engineers have equipped the laboratory with France's first Asynchronous Transfer Mode, ATM, network.

ATM is to networking what Concorde is to the civil aviation industry. It is a technology of the future, allowing much faster rates of data transfer than today's Ethernet technology. It works by replacing Ethernet's 'loop' architecture with a switched point-to-point system.

When the ESRF decided to opt for ATM, each of the experimental stations, or light lines, needed to transfer 20 million bits of information per second (Mbps) to analysis computers. The next generation of detectors will produce data even more rapidly, but already the Laboratory's Ethernet was saturated.

Several alternatives were considered, and ATM chosen for its high capacity and potential for future expansion. ESRF's current ATM backbone comes from American company Fore systems and was installed in autumn 1994 by Grenoble-based Silicomp Ingenierie. After a pilot period, the ATM network has been fully operational since the middle of 1995. The system currently has a capacity of 155 Mbps, with plans upgrade to 622 Mbps.

Meetings

A workshop entitled 'The Standard Model and Beyond' will be held from 5-11 August in Tbilisi, Georgia, organized by the Georgian Physical Society and Tbilisi State University, shortly after the International Conference on High Energy Physics in Warsaw (25-31 July).. Further information from the scientific secretaries: T. Bibilashvili and A. Kobakhidze, e-mail SMAB@gps.org.ge

The 6th Topical Seminar on "Experimental Apparatus for Particle Physics and Astrophysics" will take

Against a backdrop of the Geneva flag, Guy-Olivier Segond, President of Geneva's State Council, speaks at the formal inauguration of the renovated building which formerly housed CERN's first accelerator, the Synchrocyclotron, closed in 1990. Behind him are CERN Director General Chris Llewellyn Smith (left) and Geneva State Council Vice-President Jean-Philippe Maître. Funded by a generous Geneva donation, the renovation provides convenient 'new' premises at a time when CERN is pressed for office accommodation.

(Photo CERN HI 10.2.96)

place in San Miniato al Todesco, Italy, from May 20 - 24, organized by F.-L. Navarria of Bologna and P.G. Pelfer of Florence, and sponsored by INFN, Bologna, Florence, and the Tuscan region.

It will focus on advanced technologies in particle physics collider experiments and in cosmic ray astrophysics experiments, emphasing their correlations. Industrial representatives will comment on future developments. Reviews will summarize progress in complex R&D projects and major facilities. Shorter talks will cover specific items.

Attendance is by invitation only and will be limited to approximately one hundred. Information from e-mail: kaos@bo.infn.it, sm96@fi.infn.itmail: P.G. Pelfer, Dip. di Fisica, Largo E. Fermi 2, I-50125 Florence, tel. +39 55 230751 fax +39 55 229330

CERN Courier contributions

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

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

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

A Gigagaggle. Fermilab photographer Reidar Hahn catches winter geese basking on the temperate waters of the Illinois Laboratory's Swan Lake, part of the accelerator cooling system.

TENURE-TRACK FACULTY POSITION
EXPERIMENTAL HIGH ENERGY PHYSICS
THE OHIO STATE UNIVERSITY

The Department of Physics invites applications for a tenure-track faculty position in Experimental High Energy Physics, effective October 1, 1996. Our goal is to expand our High Energy Physics program and to start a group preferably working in hadron collider physics. The successful candidate will lead this effort. Depending on the applicant's qualifications, the appointment will be made at the Assistant, Associate or Full Professor level.

The Ohio State University physics department currently has 46 faculty members covering research areas in experimental and theoretical atomic, molecular, condensed matter, nuclear and high energy physics, and theoretical astrophysics. The experimental high energy group presently consists of six faculty members who are conducting experiments in electron-positron annihilations with the CLEO collaboration and in electron-proton collisions with the ZEUS collaboration at DESY, Germany. Future commitments of our current faculty include proton-proton collider physics with the CMS collaboration at the LHC, and the CLEO-III upgrade at Cornell.

Interested applicants should send a resume, a description of scholarly achievements and research interests, and at least three letters of reference to: Professor Klaus Honscheid, Department of Physics, The Ohio State University, 174 West 18th Avenue, Columbus, OH 43210-1106. Applications should arrive no later than May 1, 1996 to receive full consideration. The Ohio State University is an Equal Opportunity/Affirmative Action Employer. Qualified women, minorities, Vietnam-era Veterans, disabled veterans and individuals with disabilities are encouraged to apply.

Mutual benefits

In Delhi on 29 March CERN Director General Chris Llewellyn Smith (right) and R. Chidambaram, Chairman of the Indian Atomic Energy Commission and Secretary of the Department of Atomic Energy signed copies of the Protocol to the 1991 Co-operation Agreement between the Department of Atomic Energy of the Government of India and CERN. This Protocol concerns India's participation in CERN's LHC proton collider project and provides for a contribution to LHC construction with a net value to CERN of $12.5M.

CERN's LHC proton collider will spearhead world particle physics into the next century. Currently scheduled to begin physics experiments in 2004, the LHC sets a new scale in international scientific collaboration. As well as researchers and engineers from CERN's 19 European Member States, the programme also attracts scientists from all over the world. In fact non-Member State representatives make up nearly half of the scientists involved in the preparations for its physics experiments.

Prominent among these non-Member State participants are those from the United States, the US being in fact the largest user nation in LHC physics. This heavy US involvement is seen as being of particular benefit to the experimental programme. In addition, the US accelerator physicists are keen to apply their skills and expertise to the LHC machine effort, and a US contribution to the machine – together with contributions from other non-Member States – could hasten the day when the new accelerator reaches its full energy.

Transatlantic collaboration is seen both by CERN and the US funding authorities – the Department of Energy and the National Science Foundation – as mutually profiting research at European and US universities. In addition to the major US participation in the LHC programme, considerable numbers of European physicists have traditionally been involved in the research programmes at major US Laboratories, although the balance of transatlantic traffic has changed and there is now a net eastward flow.

The LHC, however, is at the limit of what Europe can afford. With the contributions pledged by the CERN Member States, the collider can only be constructed in two stages, as a "missing magnet" machine. In these circumstances, CERN considered it fair to ask non-Member States with substantial numbers of physicists signed up for the LHC experiments to contribute in order to speed up the project to the benefit of all the users. In itself, the decision of non-Member States to contribute to the construction of the LHC will constitute a major advance in global collaboration in particle physics.

Last year the Japanese government generously contributed five billion yen (about 50 million dollars) to help finance LHC construction, and contributions covering the whole construction period have been agreed with Israel and India (see photo). It is expected that Agreements will also soon be signed with Canada and Russia.

A US contribution to the machine, as well as the experiments, was already recommended in 1994 by the US "Future Vision" panel chaired by Sid Drell. US-CERN negotiations are now converging towards an overall 'umbrella' agreement covering separate accords for the LHC accelerator, the detectors, and the accompanying legal provisions, and three corresponding working groups have been set up. US teams are visiting CERN to gather the information needed to support a formal budget request. On the CERN side, the definition of the US commitment is seen as vital to this year's key decisions regarding LHC detectors, and will be a major element in CERN's Council 1997 decision which will set the pace for the LHC schedule.

While negotiations continue, initial indications point to a contribution towards LHC machine construction which will cost the US Department of Energy of the order of $225 million, with a similar sum for contributions to the two major LHC detectors - ATLAS and CMS. The US National Science Foundation will also contribute towards the detector effort. A menu of possible contributions to the accelerator is currently being worked out, the aim being to seek a compromise between maximizing the value for CERN while enabling US Laboratories which will take responsibility for designing and fabricating components to maintain and improve their technological capabilities. Once agreed with the Department of Energy, and accepted by the CERN Council, the US contributions would ultimately have to gain the approval of Congress.

CENTRE DE PHYSIQUE DES PARTICULES DE MARSEILLE
IN2P3/CNRS - UNIVERSITE AIX-MARSEILLE II

The CPPM is expecting to recruit an engineer to work in the field of high level triggering and DAQ for the experiments at the future LHC collider (CERN).

The candidate should have experience with complex DAQ systems in high energy experiments.

The understanding of current technologies and the ability to play a leading role in the research and development of future systems are required.

Applications with CV, should be addressed to :
C. BERNARD - CPPM -
Case 907 - 163 avenue de luminy
13288 Marseille cedex 09 - Fax: 91 82 72 99
e-mail : bernard@cppm.in2p3.fr

Advertisements in CERN COURIER

Format A4 **Monthly publication**

All advertisements are published in both English and French editions. Second language versions accepted without extra charge.

Space (page)	Actual size (mm) width by height	Cost per insertion (Swiss Francs)			
		1 insertion	3 insertions	5 insertions	10 insertions
1/1	185 x 265	2200	2100	2000	1900
1/2	185 x 130 90 x 265	1300	1200	1100	1020
1/4	90 x 130	750	700	650	600

These prices include no entitlement to special placing.
Supplement for:
- -one additional colour .... 1500 SwF
- -1/2 page .... 800 SwF
- -Covers:
  - Covers 2 and 3 (one colour) .... 2200 SwF
  - Cover 4 (one colour) .... 2700 SwF

Publication date .... 1st of month of cover date
Closing date for positive films and copy .... 1st of month preceding cover date. The cost of making films and of translation for advertisements are charged in addition.
Screen offset .... 60l/cm (150 English). Advertisements cancelled after 1st of month preceding cover date will be invouced.

These rates are effective for the year 1996.

Inquiries for Europe:
Micheline FALCIOLA / CERN COURIER - CERN
CH - 1211 Genève 23 Suisse
Telephone: 022/767 41 03
Telefax: 022/782 19 06

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

Postdoc Positions at HERMES

The Netherlands National Institute for Nuclear Physics and High-Energy Physics (NIKHEF) is searching well-qualified postdocs for experimental work in hadronic physics. The research work will be carried out at HERMES, the new polarized internal target set-up at DESY (Hamburg). The experimental programme of HERMES is aimed at measurements of the spin and flavour distributions of quarks inside the nucleon.

A successful candidate will participate in the on-going (semi-inclusive) deep-inelastic electron scattering experiments. Special attention should be given to the development and operation of the Vertex Chambers (a large array of Micro-Strip Gas Chambers), for which NIKHEF is responsible.

A significant amount of time should also be spent on the data analysis, where the emphasis will be on the semi-inclusive data taken on various target nuclei. As an example of the type of results that could be obtained, we mention the envisioned studies of quark-propagation effects. By detecting leading hadrons on various target nuclei the attenuation ratio can be measured over a large kinematic range (in Q**2 and nu). From such measurements quantitative information on the FORMATION TIME of hadrons can be obtained. Up till now no such data exist.

For the second candidate the work will be aimed at the development and possibly construction of new detectors supplementing the existing HERMES set-up. Recoil detectors in the backward hemisphere, for instance, could be used to tag deep-inelastic scattering events off neutrons.
Extensive simulations have to be performed, in collaboration with other (European) groups active in this field.

A two-year contract will be offered. One of the two positions will be in the framework of the recently approved EC-TMR network on the subject of 'Hadronic Physics with High Energy Electromagnetic Probes'.
For the TMR position only European nationals are egligible. Further information can be obtained from Dr. G. van der Steenhoven (e-mail: gerard@nikhef.nl., telephone +31-205922145, fax +31-205922165).
Applications should be addressed to the NIKHEF personnel department, to the attention of T. van Egdom, NIKHEF, P.O. Box 41882, 1009 DB Amsterdam, The Netherlands (e-mail: pz@nikhef.nl, telephone: +31 - 205925077, fax +31 - 205925170).

NIKHEF

STANFORD UNIVERSITY

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

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

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

Lawrence Berkeley Laboratory

Postdoctoral Position in Particle Physics

The Physics Division at LBL has an opening for a postdoctoral physicist in the D0 Group. LBL built a calorimeter and vertex chamber for the D0 Detector at the Fermilab Tevatron Collider, is deeply involved in electroweak and top quark physics analyses, and is collaborating on the new silicon tracker for the upgraded detector. We seek candidates who are exceptionally talented and deeply interested in analyzing present D0 data and in upgrading the D0 detector for its highest luminosity run.

Applicants should have a Ph.D. in particle physics and demonstrate strong potential for outstanding achievement as an independent researcher. This is a two-year appointment with the possibility of renewal. Salary range is $3135-$3820/month.

Please submit a letter of application, resume, publication list and three letters of reference to:

Dr. Ronald J. Madaras
c/o Personnel Administrator, Job PHY/3911
Lawrence Berkeley Laboratory, MS 50-256
University of California
1 Cyclotron Road
Berkeley, CA 94720

LBL is an Equal Opportunity Employer