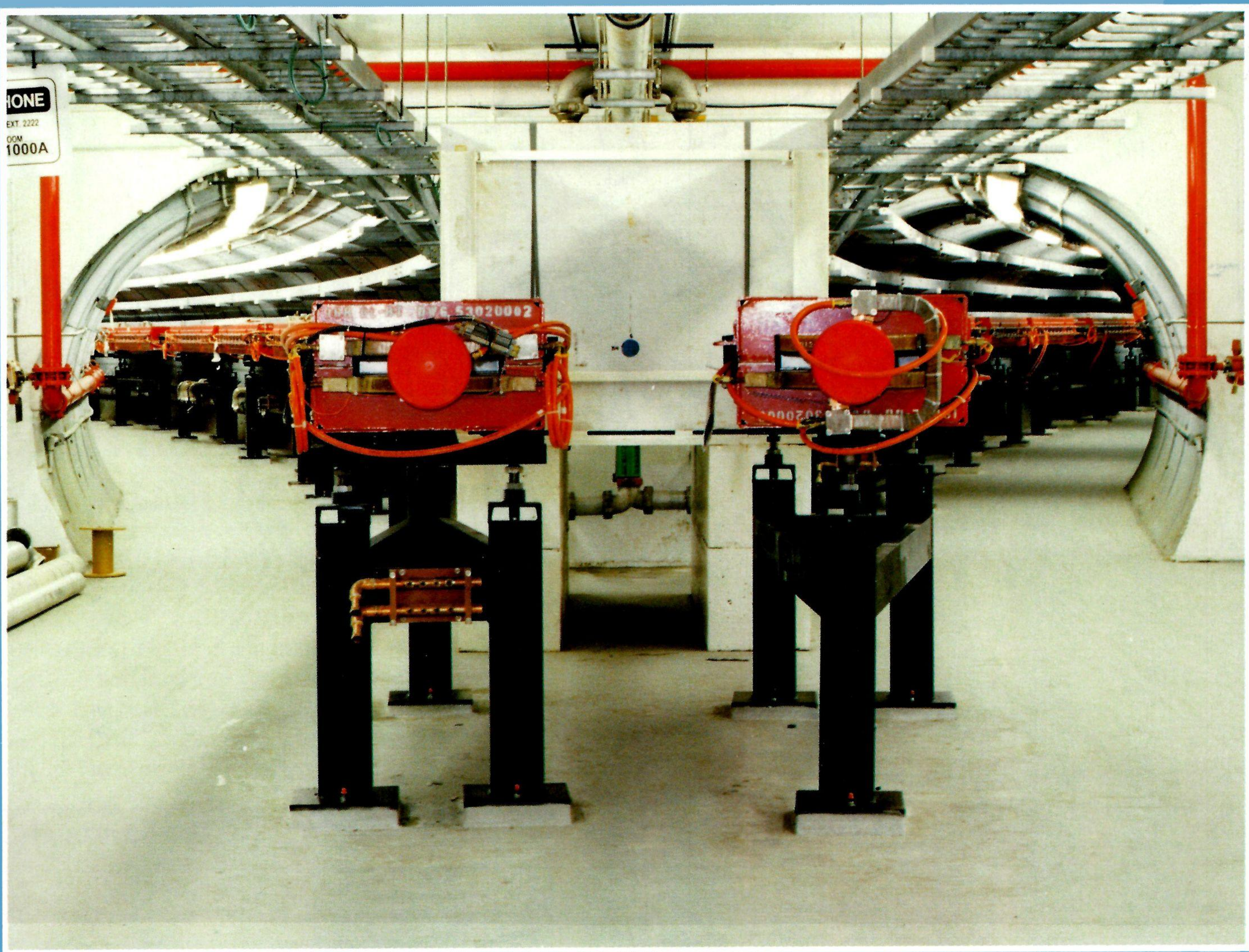
CERN COURIER

INTERNATIONAL JOURNAL OF HIGH ENERGY PHYSICS

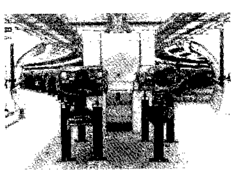
VOLUME 35 **7** OCTOBER 1995



ISSN 0304-288X

Volume 35
No. 7
October
1995

Covering current developments in high energy physics and related fields worldwide



Cover photograph: Installation is now complete of the magnets in the injector arcs for the RHIC heavy ion collider under construction at Brookhaven. The photo shows the beginning of these two arcs of combined-function non-superconducting magnets. Upstream, the transfer line from the Alternating Gradient Synchotron should soon be complete.

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

Laurie Daddona
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 affiliated 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

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.

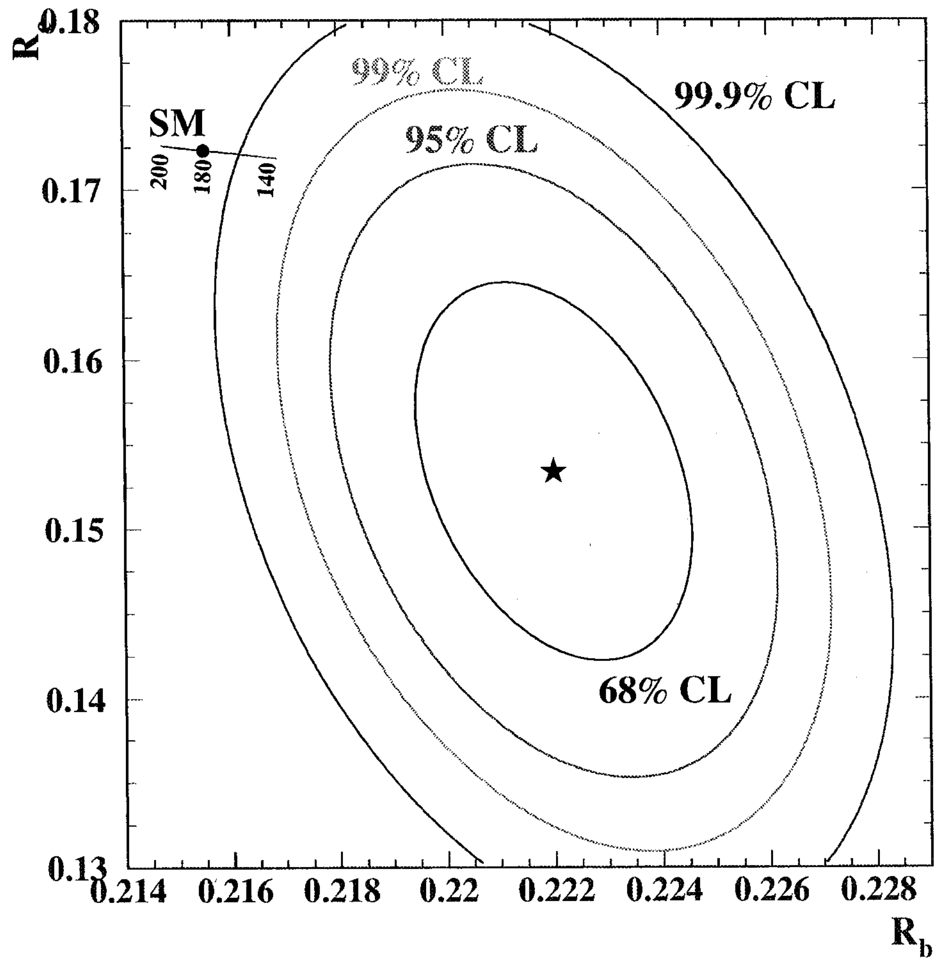
Printed by: Drukkerij Lannoo nv
8700 Tielt, Belgium
Published by:
European Laboratory for Particle Physics
CERN, 1211 Geneva 23, Switzerland
tel.: +41 (22) 767 61 11,
telex: 419 000 CERN CH,
telefax: +41 (22) 767 65 55

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

USA: Controlled Circulation
Second class postage paid at Batavia, Illinois

Physics monitor

A chink in the Standard Model? The fraction of Z particles seen decaying into particles containing the fifth ('b') quark (R_b - horizontal axis) and the fourth ('c', or charm) quark (R_c - vertical axis), showing successive statistical levels of confidence contours around the experimental result, compared with the prediction of the Standard Model (SM) for different values of the sixth ('top') quark mass.



SUMMER CONFERENCES
Heavy on flavour

A focus of attention at the major international high energy physics conferences this summer in Brussels and in Beijing was the latest batch of precision information from major experiments at electron-positron colliders - the four big detectors at CERN's LEP storage ring and the SLD experiment at the SLC linear collider at SLAC (Stanford). These experiments study the decay of the Z particle - the electrically neutral carrier of the weak nuclear force - produced when the colliding electron and positron beams are tuned to the Z resonance.

This precision data is a stringent test of the six-quark Standard Model, and as the weight of evidence builds up, physicists look hard for any cracks in the theoretical foundations.

In 1994, the LEP experiments almost doubled their accumulated score of Z particles (an integrated luminosity of 64.5 inverse picobarns in 1994 compared with 93.5 in the previous 4 years). In addition to the increased mass of data, improved precision came from better determinations of key parameters (beam energy, luminosity, electromagnetic coupling strength,....). SLD Z data has more than doubled over the past year. SLC also provides spin oriented (polarized) beams and the machine's polarization level has improved from 63 to 77%. The intercorrelation of the different parameters of the six-quark Standard Model was also boosted this year by the discovery of the sixth ('top') quark at Fermilab's Tevatron proton-antiproton collider (April/May, page 1).

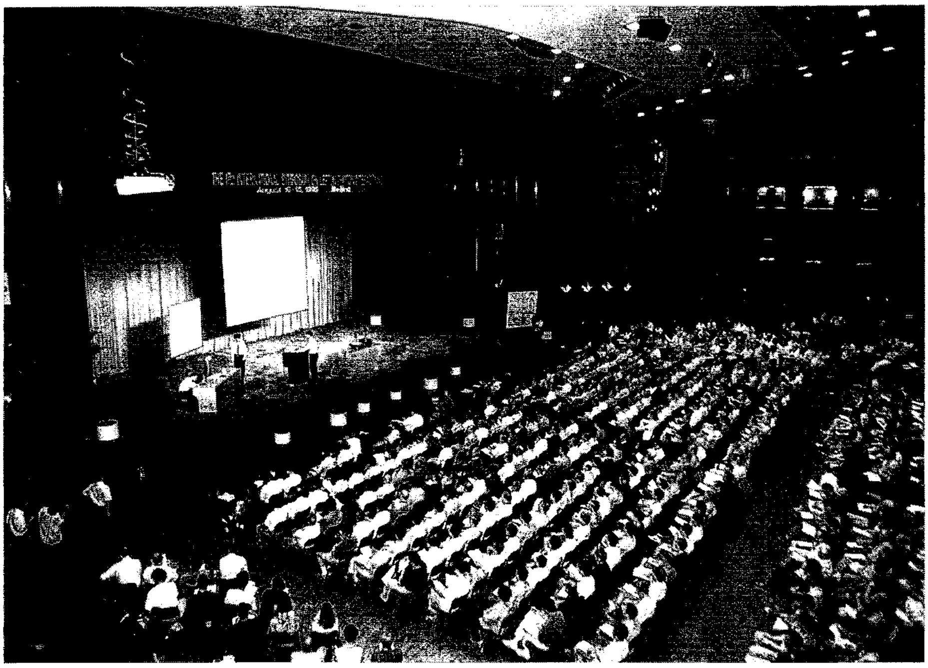
In the electron-positron sector, although the LEP experiments provide the mass of the data, the SLC's polarized beams mean that the delicate asymmetries seen in SLD provide the most precise single measurement of the vital electroweak mixing parameter.

Last year, it was difficult to reconcile these SLD asymmetry results from those from LEP, and some people were whispering about possible nonconformist physics effects, but with a year's additional data, the gap between the two sets of results has narrowed.

To correlate contributions from the different experiments, LEP Working Groups take results from all four - Aleph, Delphi, L3 and Opal - to furnish a useful pan-LEP result.

Precision information comes from analysing the different decay channels of the Z - giving various kinds of lepton pairs and different patterns of quark flavour. In particular the asymmetries of lepton pairs (electrons, muons or taus) or quark-antiquark pairs reflect the interference of different weak effects. In this precision work, the spin orientation (polarization) of the tau lepton provides a useful additional handle.

With the decays of the Z into heavy quarks providing especially useful information, a special working group pulls together results in this sector from the four LEP experiments and



Plenary sessions only - the floor at the International Symposium on Lepton-Photon Interactions, held at Beijing in August.

from SLD at the SLC. The Standard Model predicts exactly the Z decays into different quark-antiquark pairs.

Each of the four LEP experiments has so far seen about half a million examples of Zs decaying into B particles containing the fifth (b) quark. Combining these with results from SLD, the fraction of Z decays into B pairs, compared to decays into all quark flavours, is slightly too high for Standard Model comfort - 22.19% compared with an expected 21.56%. At the current level of LEP/SLC precision, this disagreement of about half a percent is practically a yawning gap. Already some physicists are talking about a possible breakdown of the Standard Model foundations, which have so far remained firm for more than a decade.

One important source of background for the b quark measurement is the fourth quark, charm (c). Particles containing c quarks can sometimes be misidentified, and this has to be taken into account. Overall, the fraction of Z decays into charm quarks is slightly on the low side, but if the Standard Model predicted value is used instead of the experimental result, the world-average b quark fraction comes down to 22.05%. The gap between theory and experiment is still uncomfortably large, but some people point to the inter-quark coupling strength lurking in the background and which could affect the interpretation of the data. At Beijing, Kaoru Hagiwara of the Japanese KEK Laboratory suggested how this could be done.

In his summary talk at Brussels, Don Perkins drew attention to this b quark disagreement, recalling a 1973 remark by Richard Feynman '....when everything is so neatly wrapped up....., with all experiments in exact agreement with each other and with the theory - .... one is learning absolutely nothing! On the other hand, when experiments are in hopeless conflict - or when the observations do not make sense according to conventional ideas, or when none of the new models seems to work, ... - ... one is really making progress and a breakthrough is just around the corner!'.

The top quark mass measurements from the CDF and D0 Tevatron experiments now provide important additional Standard Model constraints. After the long wait for its discovery, top quark physics is now underway in earnest. With precision results in several other sectors, the remaining room to maneuver is cramped, with implications for LEP2 - the push to increase the collision energy at LEP (September, page 6).

However the extension of the Standard Model to include supersymmetry is now almost discounted. Supersymmetry has twice the number of particles, with sleptons and squarks supplementing the standard fare of leptons and quarks (see next story). At Beijing, John Ellis looked forward to forthcoming Lepton-Photon Symposia becoming Slepton-Photino meetings!

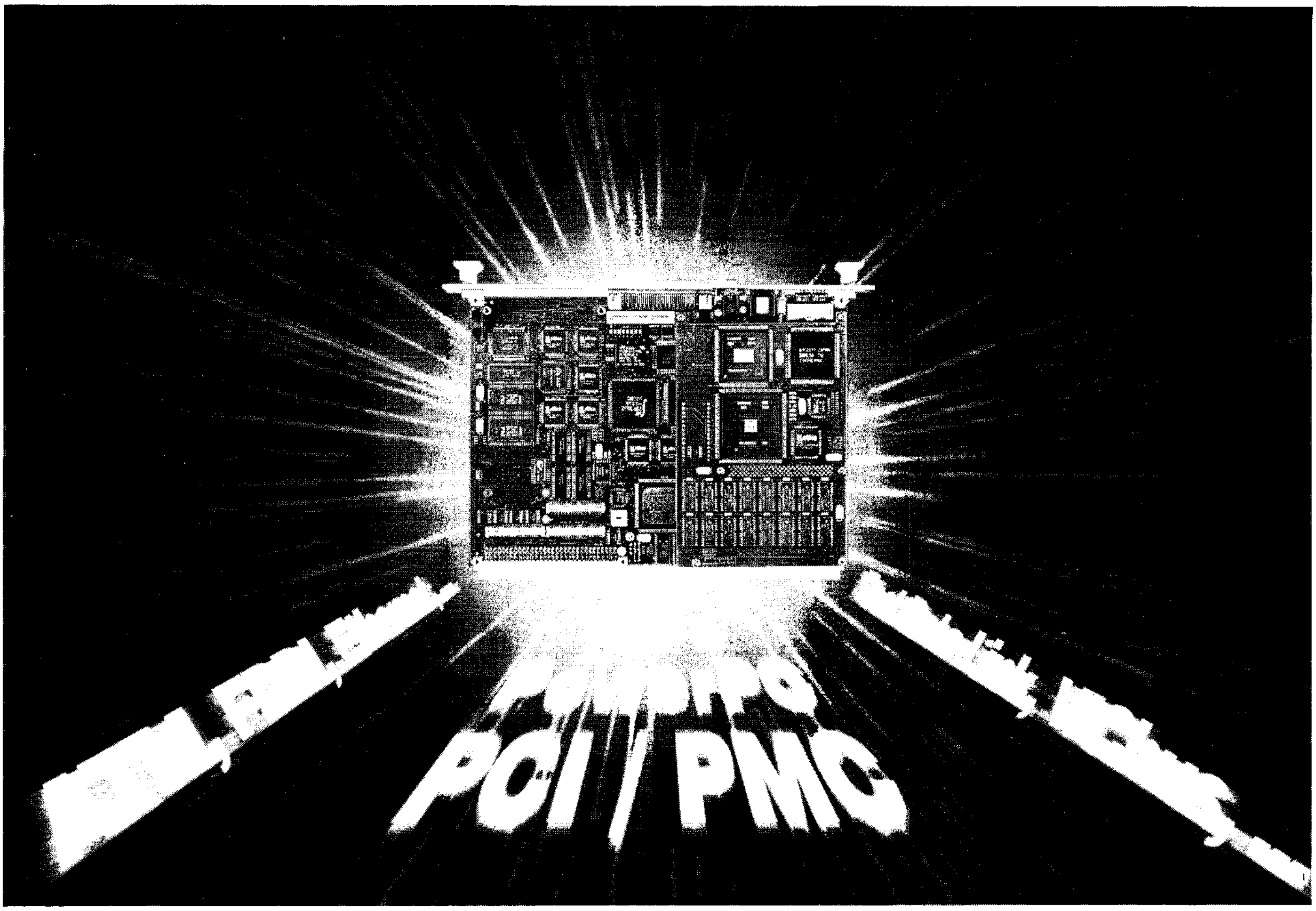
Still missing completely from the experimental picture is any hint on the mass of the long awaited 'higgs' particle, the source of electroweak symmetry breaking and responsible for particle masses.

Although these effects have not yet been seen directly, they are nevertheless playing a role in the underlying quantum mechanisms, where they contribute transiently with 'borrowed' energy (April/May, page 10).

The implications of the accumulated Standard Model evidence (including electron-positron, proton-antiproton and neutrino data) for the higgs are still fuzzy. Nevertheless, the emerging picture suggests that higgs effects could easily set in below the scale of a few hundred GeV, with implications for LEP2.

Another natural focus of attention is

Seeking a Real-Time System for Data Collection, Transmission, Distribution and Processing over VME ?



PowerPC Processor Boards:

- PowerPC 603 at 66 MHz up to 604 at 100 MHz
- Optimized for Real-Time operation
- L2 cache / Block Mover Accelerator
- Sophisticate Interrupt structure
- 1 or 2 PMC slots
- Software support for VME, VIC, FDL, CAMAC, FASTBUS
- VxWorks, Lynx-OS

PMC Mezzanines:

The most performant mezzanine standard
- VSB master 40 Mbytes/s
- ATM 155 Mbits/s
- FDDI Single Attachement
- SVGA
- HP 16500 Logic Analyzer

Fast Data Link (FDL):

- Easy to program intelligent peer-to-peer network
- Fast: 100 Mbytes/s (local 50 Mbytes/s VME transfers)
- Multidrop: 15 nodes copper, 225 nodes fibre, full duplex
- Deterministic: 1 μs guaranteed response time
- Autonomous transfer operations

VME Intercrate Connection (VICbus):

- Best combination between speed and ease of integration
- Transparent memory mapped remote resources
- Connects up to 31 crates or workstations on 100 m
- Interfaces to VME, CAMAC, FASTBUS, Macintosh, PC, SUN, ...
- Up to 12 Mbytes/s low-latency data transfers

CES, at the leading edge in Real-Time systems conception

Visit CES on WWW at http://www.ces.ch/CES_info/Welcome.html

Quality Management System

Certified ISO 90

CES Geneva, 70 Route du Pont-Butin, P.O. Box 107,
CH-1213 Petit-Lancy 1, 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

CREATIVE ELEC

the results continuing to emerge from the HERA electron-proton collider at DESY, Hamburg, where the Zeus and H1 experiments look deep inside the proton, showing that its gluon content increases as the momentum fraction decreases. With a large kinematical range now covered, these results correlate well with data from fixed target experiments.

The two HERA experiments continue to see 'rapidity gaps', where events pile up in kinematical bands. Many people have understood this in terms of the incoming electron bouncing off a proton constituent in a 'colourless' way ('colour' is for the quark-gluon force what electric charge is for the electromagnetic force). Recently on the market is a new idea explaining rapidity gaps with a full-colour quark-gluon mechanism.

Also for proton structure, the enigmatic spin content of proton constituents is underlined in additional data from experiments at SLAC and at CERN (July 1994, page 19).

The neutrino sector is difficult to summarize, as invariably somewhere a result refuses to conform. The muon-neutrino content from cosmic ray interactions in the atmosphere is still significantly less than expected. This year has also seen much controversy in the continuing search for neutrino oscillations (June, page 13). Klaus Winter attempted to paint a tidy picture at Beijing and looked forward to new results.

Heavy quark effective theory, where heavy quarks are assumed to be infinitely heavier than the lighter ones, is now a useful calculation tool, getting answers right to within ten per cent.

Summarizing the physics scene at Beijing, Sam Ting enumerated the results coming in and compared them with the declared objectives of the world's major Laboratories. T.D. Lee drew attention to the need for future studies to understand CP violation - the delicate asymmetry between matter and antimatter.

Information from Klaus Mönig and Clara Matteuzzi

Spotlight on quantum black holes

Particle theorists are getting unusually excited these days as new ideas and different approaches converge in the search for a picture which describes all the underlying mechanisms of Nature.

Although the final picture has yet to emerge, the outline is becoming clearer. While the intellectual mountain range to be crossed was once intimidating, these new developments are beginning to point to a way over.

A series of recent topical workshops have highlighted these developments and leap-frogged ahead - including String 95 at the University of Southern California, Los Angeles, this spring and a conference on Mirror Symmetry and S-duality held in June at Trieste's International Centre for Theoretical Physics. Closing the Trieste meeting, prominent theorist Ed Witten said "this is one of the most exciting conferences in which I have ever participated".

With profound problems to be overcome, the new ideas now on the market at first look very unconventional. Classical electromagnetism exploits the parallels between electricity and magnetism but accepts the everyday wisdom that free magnetic charges (magnetic monopoles) do not exist. Particle theorists are not so sure, and for a long time magnetic monopoles have been tentatively included on the theoretical menu. The role of these monopoles has now become crucial.

Also playing a central role is the idea of supersymmetry. In a quantum theory, basic particles, like quarks and leptons (fermions), interact through force-carrying particles (bosons) like the photon of electromagnetism, the W and Z of the weak nuclear force and the gluon of the strong inter-quark force. In supersymmetry, each fermion has additional boson partners, and vice versa.

So far, no evidence for supersymmetry has been found, but the underlying ideas are so convincing that its existence is almost taken for granted among theorists. Supersymmetry would have governed the mechanics of the Big Bang, but as the temperature fell, supersymmetry 'froze' out and became almost invisible.

In the late 1970s, Klaus Montonen and David Olive pointed out that if magnetic monopoles are included in a supersymmetric quantum picture, the electric and magnetic sectors are in some respects mutually complementary. Magnetic charges provide additional calculational leverage, sidestepping the traditional problem of having to solve the equations of the theory through sometimes unsatisfactory approximations.

Subsequently, the ideas were enlarged to include 'dyons' - particles having both electric and magnetic charges, providing a much richer scenario.

Theories with sufficient numbers of supersymmetric particles can provide an appealing correspondence ('duality') between different sectors of the theory. These theories are naturally finite, with no troublesome infinities thrown up by the calculations. While this looks superficially attractive, real physics unfortunately does not behave so nicely, and 'renormalization' constraints have to be imposed to remove unwanted infinities.

Last year, Nathan Seiberg and Ed Witten wrote a milestone paper (December 1994, page 3) in which massless monopoles in a field theory with less supersymmetry (and therefore requiring renormalization) ensured that quarks were automatically 'confined' in larger particles. While quarks are the natural constituents of all nuclear particles, they are never encountered as free particles, and one of the big puzzles was always how to ensure that these quarks are automatically locked inside nucleons. Seiberg and Witten's toy model of quark confinement made theorists sit up and take notice. As well as providing physics insight, the new picture also suggested a simpler way of handling the underlying four-dimensional geometry.

Including electromagnetism and the strong and weak nuclear forces is not the end of the story. To get right back to Big Bang conditions, theorists have to bring in gravity too. Gravity - operating over very large distances and always attractive - is very different to the other forces of Nature. With such widely different behaviour, from the long-range gravitational pull between galaxies to the intricate inter-quark mechanisms at work inside nuclear particles, putting all these forces together is an intimidating prospect.

In trying to do this, many theorists have come to believe that the basic elements are not pointlike particles at all, but even smaller two-dimensional 'superstrings' in multi-dimensional spaces (usually ten dimensions).

For the first time, superstrings offer the possibility of a full quantum theory of gravity, a goal which has long eluded theorists.

In physics, writing down a set of basic equations is not the bottom line. Solving them is quite another problem. Many physicists are convinced that the compelling features of these superstring theories could provide a natural framework for the equations of a Theory of Everything. The revolution in quantum electrodynamics resulting from Richard Feynman's introduction of simple diagrams in the late 1940s is a good example of how an intuitive ingredient can make a difficult theory more assimilable.

The ten dimensions of superstrings include the four of conventional space-time, complemented by a six-dimensional internal (Calabi-Yau) space, which at some stage has to 'compactify' - curling up on itself to become invisible. The invisibility of these additional dimensions was originally a handicap, as they could curl up in all sorts of ways and their role in the underlying unified theory was not clear.

The big question was how to apply the Seiberg-Witten ideas to superstrings. Seminal ideas by A. Sen of Bombay's Tata Institute were followed by recent advances by C. Hull and P. Townsend in the UK. At the Trieste meeting, A. Strominger of Santa Barbara explained how certain kinds of multidimensional superstring can 'compactify' to four-dimensional space-time scenarios.

Previous efforts to reconcile invisible internal geometries had come across singularities - places where the mathematics breaks down. Singularities are awkward to handle, but often indicate that deeper down in the theory, something significant is happening.

With gravity an essential part of the superstring picture, quantum black holes can occur. Classically, black holes are concentrations of matter so dense that nothing can escape from them. On the scale of Big Bang dynamics, even these black holes, classically at least several times larger than the Sun, can happily exist as massless objects. These quantum black hole ideas had been seeded early in the 1980s, but the implications of this leap in imagination are only now being appreciated.

The new work has shown that presence of massless black holes can sidestep some of the problems of the internal six-dimensional spaces. These holes help iron out troublesome topological twists when the six-dimensional internal spaces curl up. Building on these ideas, S. Kachru and C. Vafa from Harvard have been able to show that the Seiberg-Witten results extend to a class of string theories with the same amount of inbuilt supersymmetry as the theories considered by the latter in their seminal work, demonstrating how these valuable results can be extended to obtain exact answers in theories including the long-sought goal of quantum gravity and with complicated dynamics.

With these ideas in place and their implications beginning to be appreciated, theorists can glimpse the first outlines of a Theory of Everything.

Time out at the of 10th proton-antiproton workshop, held at Fermilab from 9-13 May.

Proton-antiproton workshop

Coming just two months after Fermilab announced definitive discovery of the sixth ('top') quark, the 10th proton-antiproton workshop, held at Fermilab from 9-13 May, provided a useful overview of this important physics sector.

With the sixth quark in place, the conference opened with an eye to the exotic, beginning with searches at the Tevatron for phenomena beyond the Standard Model. Experimenters from CDF and D0 showed the latest lower bounds on masses for leptoquarks, new heavy gauge bosons, gluinos, squarks and other aspiring particles. Limits were raised, and new areas explored, but nothing new seemed to be stirring. Theorists, like expectant parents, showed their latest predictions for where particles would appear and how they would behave, but at the end, the Standard Model was still standing defiantly on its own two feet.

The focus then turned to fifth ('bottom', b) and fourth ('charm') quark production, where, ironically, theory and experiment showed some disagreement. Both CDF and D0 presented results for b quark production which agreed with each other but remained higher than theoretical predictions (perturbative quantum chromodynamics, QCD, using next-to-leading-order).

On the charm front, the prompt production of psi-prime particles was shown to be anomalously high, many times higher than theoretical predictions. Latest results for the lifetimes of B particles (containing the b-quark), quarkonia production and neutral B mixing were also presented. Closing the session, Jonathan Rosner of Chicago gave a theoretical overview of B physics at the Tevatron, and presented prospects for measuring the violation of CP (matter-antimatter) symmetry in the b sector.

For the top quark, neither CDF's nor D0's results had much changed since their 2 March discovery announcement (April, page 1). Interesting discussions centred on the differences between the two experiments' methods of measuring the top mass. Clearly the collaborations had shifted out of discovery mode and had begun to study the top's properties. Stephen Parke of Fermilab described how particles beyond the Standard Model could decay into top quark-antiquark pairs, increasing the yield.

Proton-antiproton physics provided the first Zs and Ws more than ten years ago. Although the Z baton has now passed to electron-positron colliders, W physics is still in the proton-antiproton domain. After a review of the latest W mass measurement (80.41 GeV) by the CDF experiment, Young Kee Kim of Lawrence Berkeley Laboratory discussed plans to improve it to an accuracy of 100 MeV with more statistics. Since the advent of the Tevatron, understanding of the underlying theoretical QCD picture has grown considerably. Jet production, now measured with increased precision, and multijet production rates both showed remarkable agreement with leading order QCD calculations. Talks also covered jet shapes, inclusive photon physics, soft gluon resummation, as well as recent results from the HERA electron-proton collider at DESY, Hamburg. The QCD session closed with a discussion of the recently observed 'rapidity gap' phenomena (kinematical clustering) at the Tevatron and at HERA.

Striking an optimistic note for the future of proton-antiproton physics at Fermilab, schemes for raising the luminosity to 10^{33} or running with polarized proton beams were aired. (We hope to have a review of these Fermilab ideas in a future issue.) CDF and D0 reported on the current detector upgrades, as well as proposals for next-generation detectors at the Tevatron after the year 2000. Attendees also heard reports on prospects at CERN's LHC proton-proton collider using the ATLAS and CMS detectors. Mel Shochet of Chicago closed the meeting with a well-balanced reflection.

The next workshop, to be held in Padua, Italy, next summer, will be titled "11th Topical Workshop on Hadron Collider Physics" to explicitly include the LHC. The 10th workshop was organized by a committee headed by Rajendran Raja and John Yoh of Fermilab.

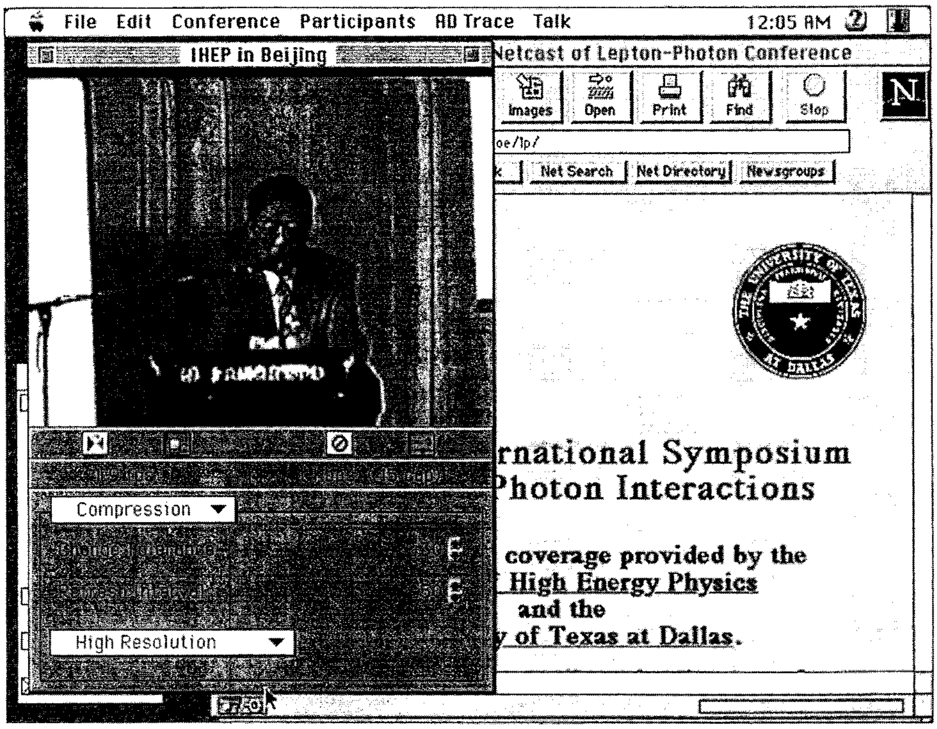
Tau-charm factory...

In addition to hearing the latest experimental and theoretical developments at the 17th International Symposium on Lepton Photon Interactions in Beijing, delegates were brought up-to-date on the substantial progress towards the realization of a Tau-Charm Factory in the Chinese capital.

Opening the Symposium, Zhou Guangzhao, President of the Chinese Academy of Sciences, expressed a commitment of the Chinese government to basic research and its interest in the continuing development high energy physics in China. Following the very successful construction and operation of Beijing's Electron-Positron Collider, BEPC, the Chinese government has provided 5M yuan ($US 600,000) for a feasibility study by the end of 1996 for a Tau-Charm Factory at Beijing's Institute of High Energy Physics (IHEP). Professor Zhou expressed his belief that, once approved, such a factory would greatly enhance high energy physics in China. He warmly welcomed international collaboration both in the construction of the accelerator and in the experimental programme. His comments were reinforced in the following welcome speech by IHEP Director Zheng Zhipeng. Conference delegates had the opportunity to inspect the BEPC injector and collider, built almost entirely by Chinese industry.

The International Committee for Future Accelerators (ICFA) met during the Symposium, with Tau-Charm Factory business on the agenda. In his subsequent report, ICFA Chairman John Peoples said that a Tau-Charm Factory provides a unique experimental environment for the precision studies of tau, charm and light quark-gluon spectroscopy, and that some issues in these fields are not satisfactorily addressed solely by B Factories or fixed-target experiments. The committee expressed a strong interest in seeing a Tau-Charm Factory built and noted the serious interest, especially in China, and looks forward to operation and exploitation by the international physics community.

In their Beijing summary talks, both Sam Ting and T.D. Lee underscored the need to have a Tau-Charm Factory during the next decade. In particular, they stressed the unique sensitivity of a Tau-Charm Factory to shed fresh light on the origin of the mysterious CP violation of matter-antimatter symmetry by searching for subtle effects in tau lepton decays.



Zhou Guangzhao, President of the Chinese Academy of Sciences, opens the 17th International Symposium on Lepton Photon Interactions, held in Beijing from 10-15 August. This computer image comes from the Internet broadcast of the conference, set up by Joe Izen of the University of Texas at Dallas (UTD). A tape-delayed audio/visual feed was transmitted from the Institute of High Energy Physics (IHEP) in Beijing to a UNIX-based reflector at UTD over IHEP's 64 kbs international link. The signal was then retransmitted from UTD to a network of secondary reflectors across the world. Macintosh or IBM/PC users were able to follow the conference using CU-SeeMe software (ftp://cu-seeme.cornell.edu/pub/cu-seeme/). UNIX users were also able to view the netcast using the MBone tools nv and vat (ftp://ftp.parc.xerox.com/pub/net-research/, and ftp://ftp.ee.lbl.gov/conferencing/, respectively). Further information about this netcast and CU-SeeMe may be found at http://wwwpub.utdallas.edu/~joe/lp/.

...for tau-charm physics

Precision experiments, probing vital corners of the Standard Model, have become an important part of our quest for a deeper understanding of particle physics. In this context, a broad spectrum of basic questions regarding the tau lepton, the charm quark, charmonium (a charm quark and antiquark bound together), and light hadron spectroscopy remains to be addressed by dedicated experiments collecting large amounts of high quality data.

As part of this effort, teams in China, Europe, Russia, and the US are currently working on designs for Tau-Charm Factories, which would involve a high luminosity electron-positron collider operating at energies between 3 and 6 GeV, providing about a hundred times the statistical precision of measurements so far.

In a three-day workshop held this summer at Argonne and co-organized by the Institute of High Energy Physics in Beijing, the status of these collider designs was assessed, and the physics case for Tau-Charm Factories discussed in the context of recent developments, particularly its complementarity to other physics programmes.

Jasper Kirkby of CERN presented an overview of the design requirements and the broad physics potential, in particular the implications of the very high production rates and the clean experimental environment to constrain or perhaps extend the Standard Model.

Precision studies of the tau-lepton are one of the main motivations. In addition to studies of the mass of the tau and its branching ratios, rare decays, and electroweak couplings, there was considerable discussion of strategies to search for the CP violation of matter-antimatter symmetry in tau decays (currently hardly touched by experiment) using both polarized and unpolarized beams.

In the charm sector, the search for neutral D particle mixing and CP violation was extensively discussed. Since the Standard Model prediction for either rate is very small, even for the projected reach of a Tau-Charm Factory, any observed signal would point to new physics. However recent calculations suggest that direct CP violation in the decays of charged D mesons may be within reach at a Tau-Charm Factory. In addition, such a factory would provide precision data on charm decay branching ratios, form factors and quark mixing. This could also have an impact on physics at much higher energy scales; for example, as discussed by Morris Swartz, the calculation of the electromagnetic coupling constant at the Z mass is still limited by imprecise knowledge of what happens hadronically in the tau-charm threshold region.

Finally, there was extensive discussion on the potential impact on charmonium spectroscopy and on light hadron spectroscopy, in particular the spectrum of glueballs and hybrids. Tao Huang showed new results from Beijing on the decay branching ratios of the xi(2230), which appear to be consistent with a glueball interpretation.

At the workshop, T.D. Lee presented a philosophical appreciation of "Symmetries and Asymmetries" which brought together Chinese art, P and CP violation, heavy ion physics, and a Tau-Charm Factory.

Following presentations of collider designs, a lively round-table discussion chaired by Maury Tigner defined important open questions. Despite an ambitious design luminosity of 10^{33} per sq cm per s, the technical feasibility of such a collider was not seriously contested. During the discussion, Shu Hong Wang outlined the aggressive schedule of the Tau-Charm Factory feasibility study funded by the Chinese government (see previous story).

The broad research spectrum was reemphasized in the summary talk given by Fred Gilman. He concluded "A Tau-charm factory merits and needs an international effort. The time has come to choose a site, develop machine and detector designs, and start construction."

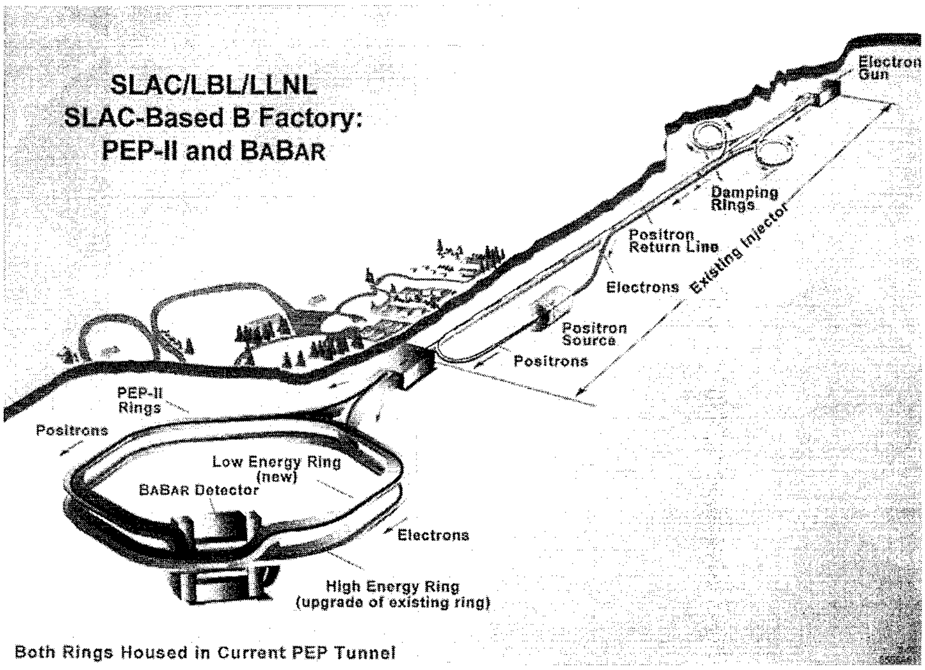
Pep for PEP-II

The major B-factory project at the Stanford Linear Accelerator Center have(SLAC) is well underway and moving along smartly, en route to commencement of operations in September 1998. Called PEP-II, the new facility is a joint venture of three California laboratories: Lawrence Berkeley Laboratory (LBL), Lawrence Livermore Laboratory (LLNL) and SLAC.

Housed at SLAC in the tunnels and buildings built for the original PEP electron-positron collider in the late 1970s, it involves no conventional civil engineering. In fact, PEP-II is a recycling project in more ways than one: for example, most of the original PEP magnets have been renovated for reuse in the PEP-II high-energy ring. While some of them require substantial rework (to change their length, for instance), many of them merely require repainting and remeasuring.

The work of building the hardware is divided up among the three laboratories. LBL is primarily responsible for the low-energy ring; LLNL is building most of the interaction region, the complicated part where the high and low energy rings come together; and SLAC is responsible

Schematic of the PEP-II B-factory project under construction at the Stanford Linear Accelerator Center (SLAC). Right, the two-mile linac, upgraded for the SLC linear collider serves as a high-power injector. The two PEP-II rings are housed, low energy ring above high energy ring, in the existing PEP tunnel.



for the rest.

Proposed by President Clinton as a "presidential initiative" (December 1993, page 2), the project was given a four-year funding profile. The total cost of $177 million, excluding the BaBar detector (September, page 16), was planned by the US government to be entirely provided during the present administration, the last increment coming in the final quarter of 1997. Happily, the first two increments have been forthcoming as planned and the third is faring well in US Congress.

The PEP-II design is based on two intersecting storage rings, one carrying 9 GeV electrons and the other 3.1 GeV positrons, operating with high beam currents (a few amperes) to produce a luminosity of 3 x 10^{33} per sq cm per s. The asymmetry in the energies of the colliding particles means that the centre-of-mass of the electron-positron annihilation system moves rapidly in the direction of the higher energy beam.

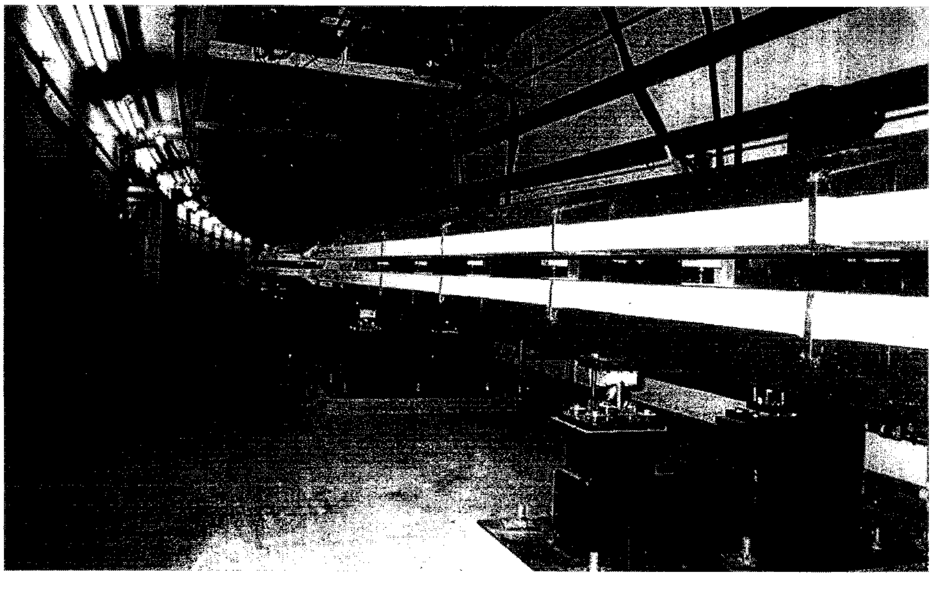
A frequent result of the collisions will be a pair of neutral B mesons. The neutral Bs live long enough for the particles to propagate a visible distance before decaying, and this effect is boosted by the motion of the centre-of-mass. As a result, the delicate CP matter-antimatter asymmetry in the B-meson system will become measurable.

Renovation is quicker than building from scratch, so the project can be completed in less than five years. Construction started when funds became available in January 1994, and already in August of this year, half the high-energy ring bending magnets had been installed. The first half of the electron and positron injection channels was also installed this summer.

The low-energy ring is a completely new ring being built from scratch; although some installation will begin earlier, most of the low energy ring will be installed after the high-energy ring is completed. PEP-II takes advantage of the mighty two-mile SLAC linac - enhanced by its improvements for the SLC (Stanford Linear Collider) - as a full-energy storage-ring injector. The linac will operate as a dedicated PEP-II injector, filling both rings in about six minutes.

While many PEP-I magnets are to be reused, many more new magnets must be designed and built to equip

Bending magnets for the PEP-II high energy ring installed in the PEP tunnel.



the low-energy ring, parts of the high-energy ring, the injection system and the interaction region. Under collaborative agreements, some of these magnets are being supplied by the Institute of High Energy Physics in Beijing, China, and the Budker Institute of Nuclear Physics in Novosibirsk, Russia.

The interaction region where the two rings come together is the trickiest part of the PEP-II optics. The design calls for head-on collisions of the unequal energy beams, and as in any colliding-beam interaction region, elaborate precautions must be taken to guard against stray particles and synchrotron-radiation photons striking inside the detector.

The radiofrequency accelerating system - the same for both rings - is based on "warm" technology, with copper cavities. The first prototype cavity is under high-power test. R.f. power at 476 MHz will be supplied primarily by wide-bandwidth klystrons built in industry, although a klystron meeting the specifications has been produced at SLAC, and SLAC-built tubes may also be used.

The vacuum chambers are based on several technologies. The arcs of the high-energy ring use copper extrusions; those of the low-energy ring use aluminium antechambers with copper photon stops; and the straight section chambers are stainless steel.

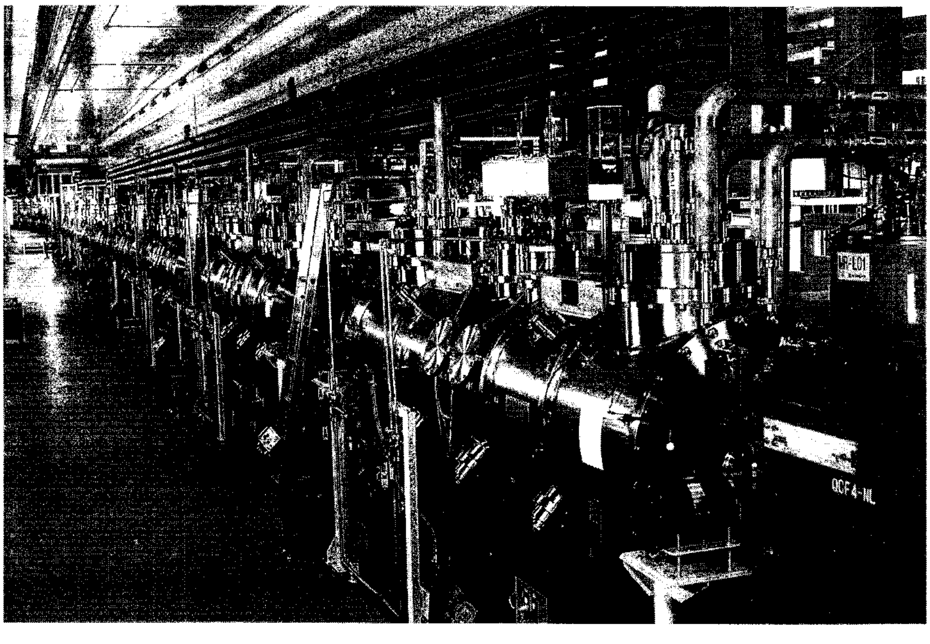
Both transverse and longitudinal beam feedback will be based on a novel system developed by the PEP-II group and using fast programmable digital signal processing. The system has been very successfully tested on the Advanced Light Source at LBL, and continues in use there.

Commissioning plans call for phased start-ups: Injection system testing will begin soon with extraction and transport of the electron beam. The high-energy ring (HER) will begin its commissioning in Spring 1997. Use of the tunnel will alternate between HER commissioning and LER installing. Low-energy ring commissioning will begin in Spring 1998.

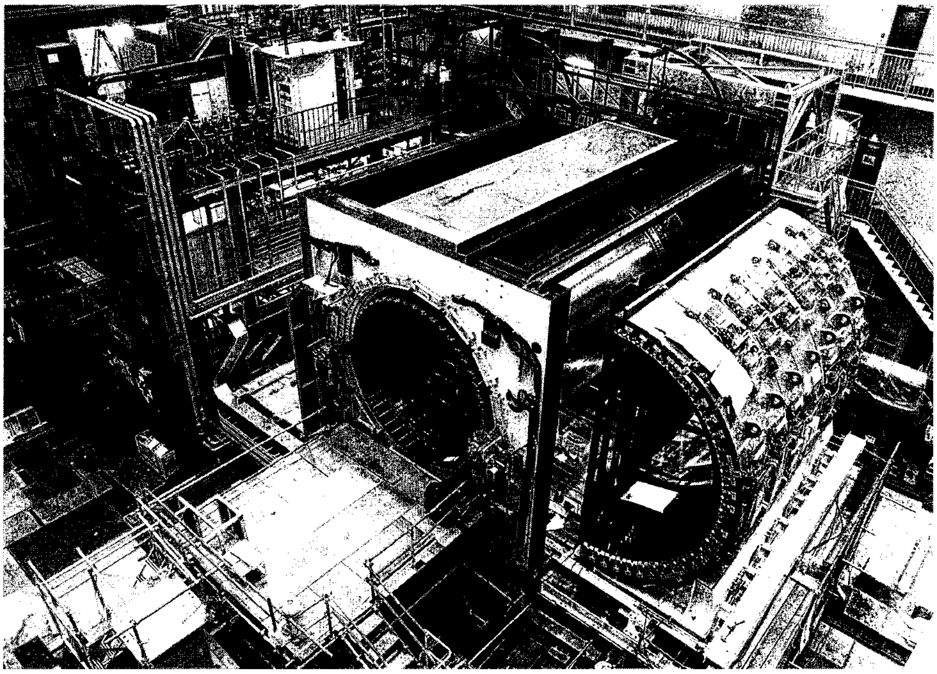
TRISTAN - mission complete

The high energy physics mission of the TRISTAN electron-positron collider at the Japanese KEK Laboratory ended in May. TRISTAN was the first accelerator in Japan at the high energy frontier, and its success owes a great deal to help and encouragement from the world high energy physics community. Its success also marks the first step toward the KEKB project now underway and the subsequent Linear Collider scheme.

TRISTAN began operation in November 1986 with a collision energy of 50 GeV, the world's highest electron-positron collision energy at that time. With the addition of superconducting radiofrequency cavities, the energy was continuously



The TRISTAN electron-positron collider at Japan's KEK Laboratory was the first machine to make large-scale use of superconducting radiofrequency cavities.



The VENUS detector under construction at TRISTAN, showing the central drift chamber and one half of the barrel electromagnetic calorimeter.

increased, reaching a maximum of 64 GeV in 1989.

In this exploratory era, the three large detectors - AMY,TOPAZ and VENUS - together with the smaller SHIP group made a rapid survey of particle phenomena in this new energy range. The sixth ('top') quark was first on the list of wanted particles, but the three large groups concluded that there were no new quarks below 32 GeV. The CDF and D0 Collaborations at Fermilab's Tevatron recently reported the top quark as being six times as heavy as TRISTAN's physics reach.

Although initial experimental results suggested that the event-shape distributions of multi-hadron events were broadly consistent with the production of the five known quarks, the production rate of hadrons, compared to muons, was seen to rise with energy. The increased energy reach of TRISTAN increased the visibility of the subtle virtual effects of the Z (the electrically neutral carrier of the weak force) produced through the interference of weak and electromagnetic interactions.

The rise was found to be slightly larger than expected from five quarks and a Z mass of 92 or 93 GeV, the accepted value at that time. This hinted that the Z mass had to be smaller, as later verified when the SLC and LEP electron-positron colliders at SLAC (Stanford) and CERN respectively came into operation in 1989.

Besides the top quark, "standard" types of new particles were systematically searched for, including fourth-generation, supersymmetric and higgs particles. In addition, TRISTAN data definitively settled questions regarding some little understood sightings. Among them was the so-called "MARK-J phenomenon", an observation of excess multi-hadron production accompanied by muons in a direction isolated from the rest of the hadrons. This was reported by the MARK-J group at the PETRA electron-positron collider at DESY near the end of PETRA running, and was left for TRISTAN to investigate. Another case was a possible narrow two-photon resonance at around 58 GeV mass, suggested by L3 at LEP in 1992, which was subsequently ruled out by all three TRISTAN experiments and by the other LEP experiments.

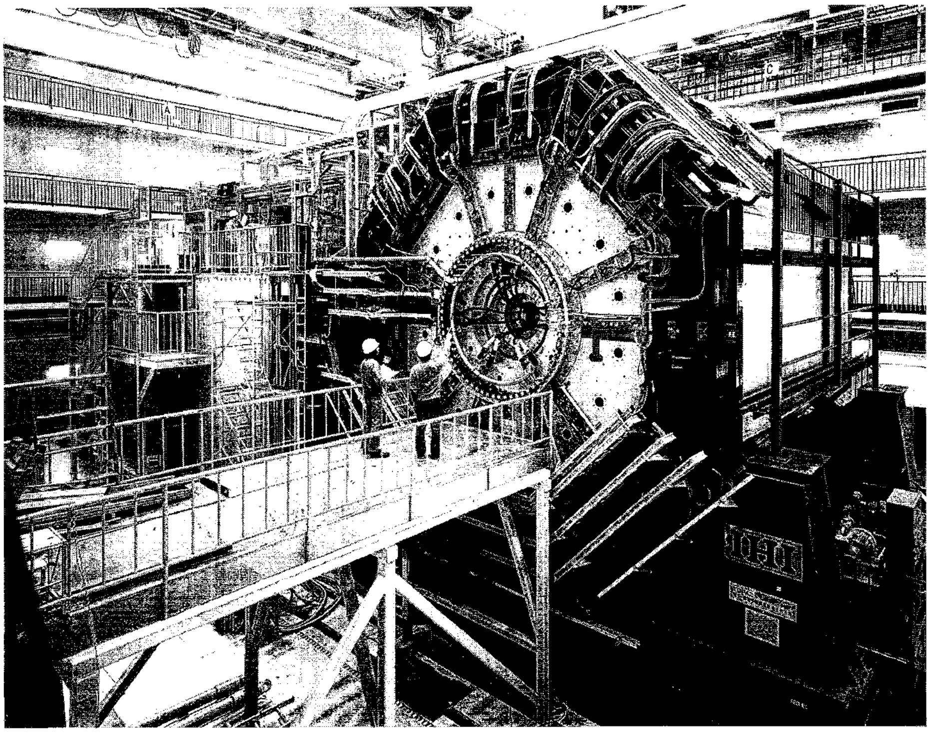
After LEP and SLC took over the high energy frontier, TRISTAN experiments turned toward deeper and broader studies of electroweak and quark-gluon (quantum chromodynamics - QCD) processes. The storage ring was operated at 58 GeV, high enough for the interference between the weak and electromagnetic interactions to be large, for the machine to operate stably with ample margin, and where maximum integrated luminosity could be provided to the experiments.

In fact the interference effects, observed as forward-backward asymmetries in the production of lepton or quark-antiquark pairs, all showed a dramatic increase compared with the previous measurements at PEP (SLAC, Stanford) and PETRA (DESY, Hamburg), in precise agreement with the standard model predictions. The agreement of these new measurements with predictions underlined the validity of the simplest form of the electroweak model in the TRISTAN energy region. In particular, the measured b-quark asymmetry was definite evidence for the existence of the third quark doublet.

Because of the low electroweak rates at 58 GeV, efforts to increase the luminosity continued, reaching about 5×10^{31} per sq cm per s. Each group collected some 350 to 400 inverse picobarns of data.

On the technological side, TRISTAN was the first machine to make large-scale use superconducting radiofrequency cavities,with 32

The TOPAZ detector at TRISTAN during its final assembly.



units of five-cell cavities providing 40% of the total accelerating voltage.

Initial difficulties characterized by cavity trips were gradually corrected in three ways: by moving the masks protecting the cavities against synchrotron radiation, by realigning quadrupole magnets near the cavities, and by degassing the cavity walls. The installation of superconducting quadrupole magnets for mini-beta insertions, completed in January 1991, doubled the luminosity. The SAD computer program (Strategic Accelerator Design), developed at KEK, played a decisive role in this work.

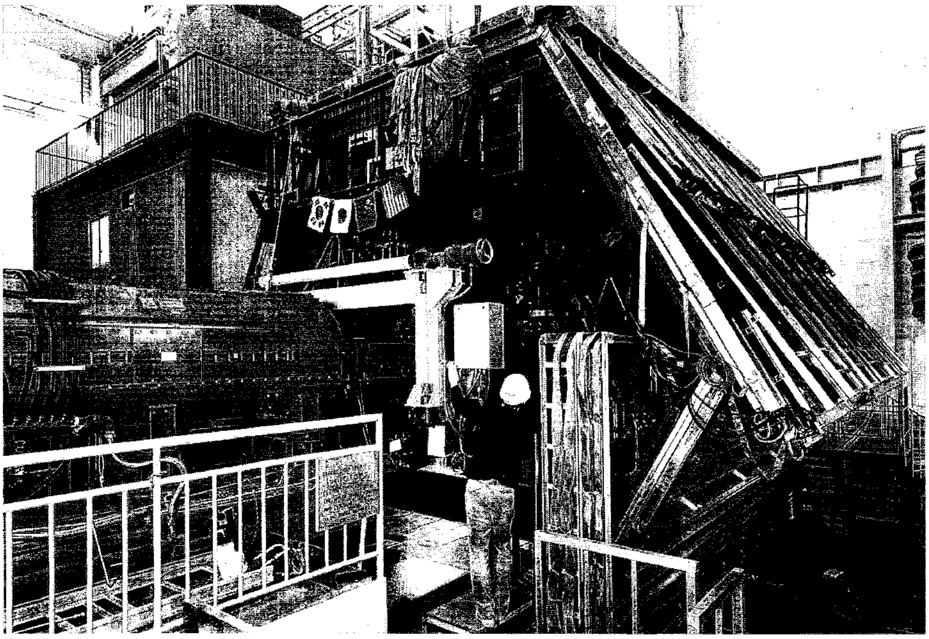
Despite the massive flow of new results from the LEP experiments at CERN, the TRISTAN experiments diligently continued in their mission to test the electroweak and quark-gluon pictures in as many ways as possible - efforts that still continue. One important early result was the first clear evidence that the three-jet fraction in multi-hadron events decreases with energy, suggesting a decreasing effective quark-gluon coupling.

When attention then turned to angular correlations with four emerging jets, good agreement was found only for second-order predictions with coloured gluons. Thus a basic feature of QCD theory, that the gluon can couple to other gluons, was directly verified by the TRISTAN experiments.

A related contribution to QCD studies was a number of precise measurements of the quark-gluon coupling (alpha-s). With theoretical uncertainties dominant, the precision of the TRISTAN results is similar to that of the LEP results. A unique approach was successfully developed at TRISTAN for obtaining the value of alpha-s using the parton shower scheme, and by adopting next-to-leading order calculations.

TRISTAN turned out to be well

The AMY detector in position at TRISTAN. The focussing quadrupole in front of the detector was subsequently replaced by a superconducting mini-beta system to squeeze the colliding electron and positron beams.



matched to the QCD aspects of two - photon processes. Compared with PEP and PETRA (lower energy), the production rate is higher and hadronic jets are easier to identify. The larger production rate at LEP includes a huge background from the Z production. Recognizing these advantages, the three groups have concentrated a significant fraction of their recent data analysis on two-photon processes. These efforts led to the first verification and a deeper understanding of the so-called "resolved-photon " processes, results subsequently confirmed by experiments at the HERA electron-proton collider at DESY, and LEP.

These hard scattering processes between quarks and gluons within the photons increase hadron production in two-photon collisions. Such processes provide a novel probe of the gluon content in the photon, a part of the photon's hadronic makeup that can not be accessed by the usual measurements based on deep inelastic electron-photon scattering.

Since QCD calculations become more reliable with heavier quarks, the experiments fully exploited their detectors' capabilities for tagging the charm quark. The measured reaction rates are in reasonable agreement with QCD calculations when higher order processes are included and when proper gluon density distributions are chosen. The need for including higher order effects was also demonstrated by studying inclusive production of lambda hyperons, expected to be favourably produced in gluon jets.

The TRISTAN project has provided immeasurable benefits to Japanese high energy physics research. The KEKB (B Factory) project is now set to continue this tradition. Valuable experience gained at TRISTAN is being fully exploited in the construction of both the asymmetric electron-positron collider and the BELLE detector, a combination best suited for B-meson physics. Meanwhile accelerator research and development continues to make impressive progress en route to Japan's Linear Collider project.

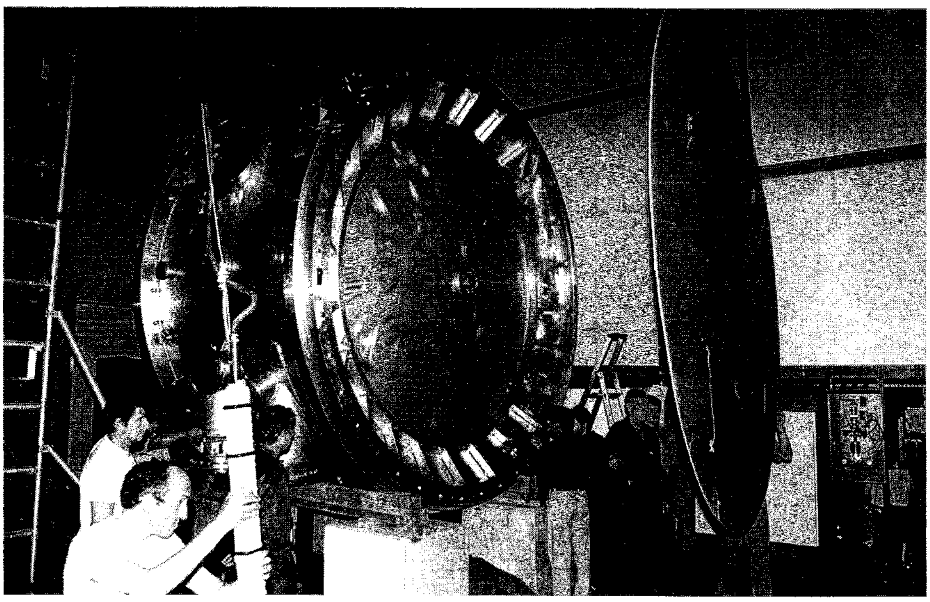
Around the Laboratories

CERN
From Russia with krypton

A recent arrival at CERN is a cryostat built under the auspices of theInternational Science and Technology Center (ISTC), a programme funded by the European Union, Japan, Russia, and the US which aims to promote the integration of former Soviet Union scientists and industry into global research and development activities.

The new cryostat, built by Moscow-based Krunichev Enterprises, better known for its involvement in the "Proton" space rocket and the "Mir" space station, will form a vital part of the NA48 experiment at the SPS synchrotron.

NA48, a Cagliari/Cambridge/CERN/ Dubna/Edinburgh/Ferrara/Mainz/



Unpacking a Russian-built cryostat for the NA48 experiment at CERN. (Photo CERN EX16.7.95)

Orsay/Perugia/Pisa/Saclay/Siegen/Turin/Vienna collaboration, aims to study the small asymmetry in the properties of matter and antimatter known as CP violation, and should be fully ready to collect data next year.

Through its links with Dubna's Joint Institute of Nuclear Research (JINR), near Moscow, NA48 has launched a number of initiatives designed to involve Russian physicists and industry in the experiment. The bargain 22 tonnes of krypton for NA48's energy-measuring calorimeter were manufactured at a specially-built factory in Russia. INTAS, the European Union-backed scheme for the promotion of cooperation with former Soviet Union scientists, provides funds for Dubna physicists to visit Western Europe. INTAS will also provide computing and networking infrastructure allowing the Russian physicists to participate fully in NA48's programme.

As well as the cryostat, NA48's collaborating institutes have placed other orders with Russian suppliers. INFN Pisa has ordered 14,000 electrical feed-though contacts from the Budker Institute in Novosibirsk, whilst Saclay has placed contracts elsewhere for vacuum and other equipment.

The new cryostat forms part of a joint project of INFN Pisa and CERN, involving scientists from Dubna, Edinburgh, and Saclay. The Russian part was built by Krunichev Enterprises in collaboration with ENTEK, a large institute of the Russian Federation's Atomic Energy Ministry. The cryostat will be assembled together with an internal cryostat built by INFN Pisa, and will eventually house NA48's krypton calorimeter. The calorimeter will be fully assembled by the middle of next year.

At the 25th anniversary of the Gesellschaft für Schwerionenforschung (GSI) heavy ion research Laboratory in Darmstadt (left to right) - Hessian Minister for Science and Art Christine Hohmann-Dennhardt, Chairman of the GSI Board Hartmut Grübel, CERN Director General Chris Llewellyn Smith, President of the Deutsche Forschungsgemeinschaft Wolfgang Frühwald, and Dirk Schwalm, Managing Director of the Max Planck Institute for Nuclear Physics in Heidelberg.

(Photo Jürgen Schmidt)

GSI DARMSTADT 25 years

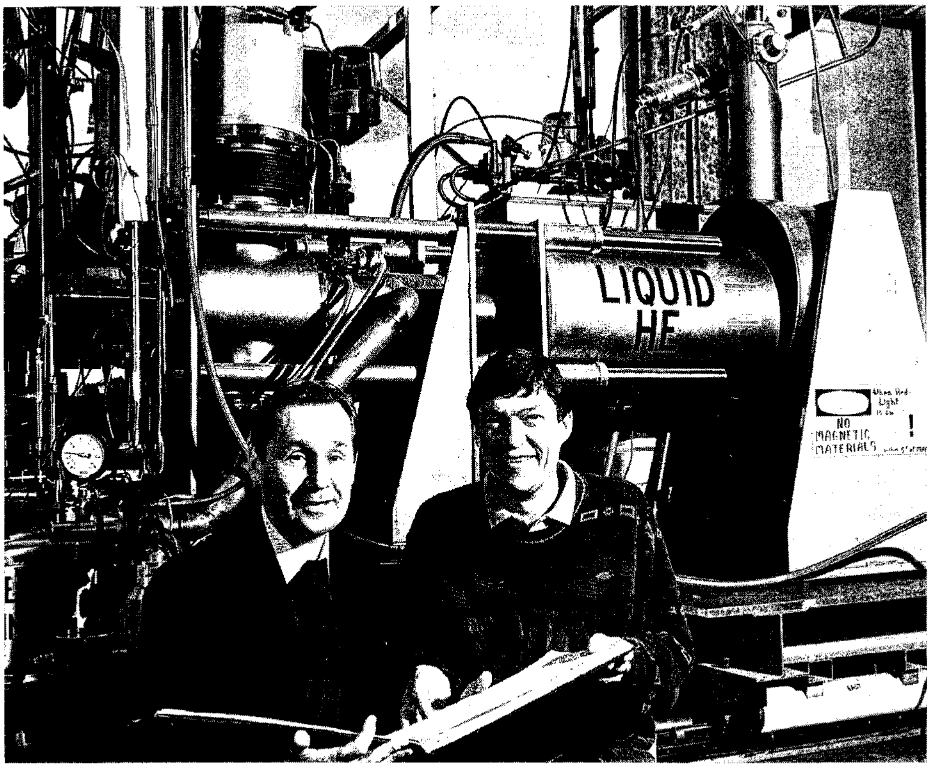
On May 12, Hans J. Specht, Scientific Director of the Gesellschaft für Schwerionenforschung (GSI), welcomed an audience of more than 500 to celebrate the 25th anniversary of the Darmstadt heavy ion research Laboratory. Warm greetings and best wishes from Jürgen Rüttgers, Federal Minister for Education, Science, Research and Technology were presented by Hartmut Grübel, Chairman of the GSI Board. The Hessian Minister for Science and Art, Christine Hohmann-Dennhardt, pointed out that the promotion of various fields of research cannot be judged only by the expected return for everyday life. Joachim Treusch, the Chairman of the Association of National Research Centres, went further by stating that basic research, driven by curiosity and not aiming at short term applications, is a necessity.

Darmstadt Mayor Peter Benz expressed his pride in having such a prestigious Laboratory in the city and looked forward to a new element named after it.

CERN Director General Chris Llewellyn Smith underlined the growing importance of international and inter-regional scientific collaboration and paid tribute to the role of German physicists in general and GSI in particular in CERN's work. GSI is a major partner in the international lead ion programme at CERN which came into operation last year, a scientific and technological success which provides a useful role model for future international partnerships. After pointing to interesting parallels between the two Laboratories - both basing new projects on existing facilities, and both serving large user communities - he thanked GSI for its valuable contributions to CERN.

Highlights from the 25 years of GSI were summarized in a talk by Dirk Schwalm, Managing Director of the Max Planck Institute for Nuclear Physics in Heidelberg. Among other points he presented the unique accelerator facility and the discovery of the five heaviest elements. He stated that many dreams from the founding period of GSI had become a reality, and even what one had not dared to dream of is on its way to becoming reality, e.g. tumour therapy with ion beams.

In a very well received talk, Wolfgang Frühwald, President of the Deutsche Forschungsgemeinschaft, discussed the relation between basic and applied research. He stated that the rules for technological innovations cannot be applied to basic research which in contrast must continue as an open science. While innovation and basic research are separate, nevertheless each needs the other to advance.



The DAPNIA (Saclay, France) and Argonne transportable polarized target used in 1989-1990 for a Fermilab experiment has been used in a new experiment at Dubna. Gilles Durand from DAPNIA (right) and Yuri Usov of Dubna's Joint Institute for Nuclear Research (JINR) were responsible for construction.

RUTHERFORD APPLETON
What's in a name?!

The initials 'RAL' are well known in the world of particle physics, but recently the official name of the Laboratory has undergone several transmogrifications. To further complicate matters, the funding body for Particle Physics within the UK has changed too!

On 1 April 1994 the Rutherford Appleton Laboratory combined with the Daresbury Laboratory to become a combined laboratory known as the Daresbury and Rutherford Appleton Laboratories (DRAL). At the same time the old Science and Engineering Research Council (SERC) was wound up, and funding was channelled through the newly formed Particle Physics and Astronomy Research Council (PPARC). Also, and just for an interim period, DRAL became part of the new Engineering and Physical Sciences Research Council (EPSRC).

One year later a more profound change occurred when DRAL became a Research Council in its own right, and the legal entity created by Royal Charter was named 'The Council for the Central Laboratory of the Research Councils', abbreviated to CCLRC. On 1 April 1995, DRAL became 'The Central Laboratory of the Research Councils' , and the abbreviation CLRC may be used.

In spite of the changes to the official name, the laboratory sited at Chilton, Oxfordshire, will continue to be known as the Rutherford Appleton Laboratory, or RAL.

DUBNA
Spin effects

Earlier this year, a collaboration of Russian, Ukrainian and French laboratories measured the difference between the polarized neutron and proton total reaction rate (total cross section difference) at slightly higher energies than previous experiments, providing an interesting hint of an effect predicted by theory. This was measured using a beam of longitudinally polarized neutrons and a longitudinally polarized proton target with parallel and antiparallel polarization directions.

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	2150	2040	1950	1840
1/2	185 x 130 90 x 265	1280	1200	1100	1020
1/4	90 x 130	750	680	630	590

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)	2000 SwF
Cover 4 (one colour)	2500 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	60 l/cm (150 English) Advertisements cancelled after 1st of month preceding cover date will be invouced.

These rates are effective for the year 1995.

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.

The polarized neutron beam, from the break-up of polarized deuterons, was accelerated by the Synchrophasotron at the Joint Institute for Nuclear Research (JINR) Laboratory of High Energies, Dubna (Russian Federation). The polarized target, 20 cm long and 3 cm in diameter, provided by DAPNIA (Saclay, France) and Argonne (USA), had also been used in 1989-1990 at Fermilab for the E704 experiment. Equipment from Saclay and Argonne was shipped to Dubna and work started in June 1994.

The International Association for the Promotion of Cooperation with Scientists from the Independent States of the Former Soviet Union (INTAS) supported the construction and improvement of the target in a suitable transportable form.

The target was mounted in the JINR Laboratory of Nuclear Problems (LNP) by experts from DAPNIA (Saclay), JINR Dubna (LNP, LHE and Laboratory of Particle Physics - LPP), Gatchina (Russia), RAS-Moscow and the Kharkov (Ukraine) laboratories. The Saturne National Laboratory (Saclay), helped with computer programmes for the NMR target polarization measurements.

Apparatus was tested in early February. The beam of 2×10^9 polarized deuterons produced 10^6 polarized neutrons at 3.6 GeV. The neutron beam polarization was about 52%. The new superconducting Nuclotron accelerator should allow the beam intensity to be increased and beam quality improved after an upgrade of the injection system.

Preliminary results for the polarized neutron-proton cross section difference at neutron kinetic energies of 1.2, 2.5 et 3.6 GeV, underline that spin effects decrease with energy and tend to zero in agreement with the prediction of a nonpertubative quantum chromodynamics (QCD) model, where the strong fluctuations of vacuum gluon fields (instantons) provide the main contribution. The rapid vanishing of neutron-proton difference, observed for the first time, suggests that the prediction is valid for both isospin 0 and 1 states. It will be interesting to take measurements using a transversely polarized beam and target, where different behaviour is expected.

With the polarizing solenoid shipped to Mainz for another experiment, the JINR setup needs a new solenoid and superconducting coils for transverse target polarization. Construction has begun in Dubna and Kharkov, respectively. Additional INTAS financial support will be requested.

Applying artificial intelligence

The increasing use of artificial intelligence techniques in physics is clear when the fourth workshop in the artificial intelligence in high energy and nuclear physics (AIHENP) series, AIHENP95, held in Pisa earlier this year broke all previous attendance records with a total of 19 countries being represented.

The standard workshop format of three parallel sessions was a challenge this year because of the unprecedented number (80) of contributions submitted to the Artificial Intelligence/Neural Networks session, calling for additional parallel AI/NN sessions on two days. With such a busy schedule, the workshop programme on some days covered up to 12 hours.

The workshop's traditional focus is new computing techniques in physics, in which scientists strive to apply artificial intelligence techniques in such areas as: automated calculation

Participants at the fourth workshop in the artificial intelligence in high energy and nuclear physics, AIHENP95, held in Pisa earlier this year.

of Feynman diagrams; development and coordination of large software packages; fast online pattern recognition for triggering and data analysis; new approaches to accelerator control; and lattice gauge theory calculations.

It was clear from the Software Engineering session that object-oriented techniques are starting to take hold. There were several presentations from new experiments such as the Sloan Sky Search and HERA-B, in which object-oriented techniques will be an integral part of computing from the start. This year there were also talks on formal methods from experts outside of physics.

The Symbolic Manipulation session covered recent developments on automatic computation of Feynman diagrams, including the first one-loop implementations and the extension to supersymmetric models. Advanced techniques for the 2-loop corrections were extensively discussed. New approaches based on knot theory and superstring model techniques were proposed for solving even higher order loop corrections.

The workshop aspect of the meeting was aided by a pre-workshop session in Moscow and by setting up working groups to specify a standard for automatic computation packages and event generators. This latter activity will continue until the next workshop.

For the first time the AI/NN session was the largest of the three sessions. Neural network techniques have now become a standard tool for electron identification (SLD, Zeus) and for such analysis problems as higgs searches and tagging heavy quarks. There was a significant increase in the number of applications of hardware neural networks for triggering. Digital neural network implementations were presented for the level-2 triggers of a number of ongoing and planned experiments (for H1 using the CNAPS chip; for WA92 using the MA16 chip, for CPLEAR using the DSP implementation, and ATLAS using DECPeRLe active memory and DSPs). On the analog side, there was a new report on the ETANN hardware of the CDF experiment for triggering on tau leptons, and two presentations involving the use of a new superfast analog NN chip (NeuroClassifier) for the H1 level 1 trigger and as a possibility for vertex detection on CDF.

There seems to be a trend towards greater use of genetic and evolutionary algorithms in physics, while fuzzy logic, particularly when implemented in fast hardware, is also beginning to look interesting.

The Pisa workshop was fortunate to have invited contributions from acknowledged experts, including F. Fogelman (neural networks, President of European Neural Network Society), P. Nason (symbolic manipulation), and F. Rapuano (lattice gauge theory).

The organizing committee agreed on the need to 'fuzzify' the boundaries between the different sessions, and to broaden the workshop's scope, so as to profit from solutions for similar problems in other scientific areas or in industry. Efforts will be made to accomplish this for the next workshop, probably to be held in Lausanne next year.

In the meantime, a wealth of information on the AIHEP workshop series can be found on URL: http://lapphp0.in2p3.fr/aihep/aihep.

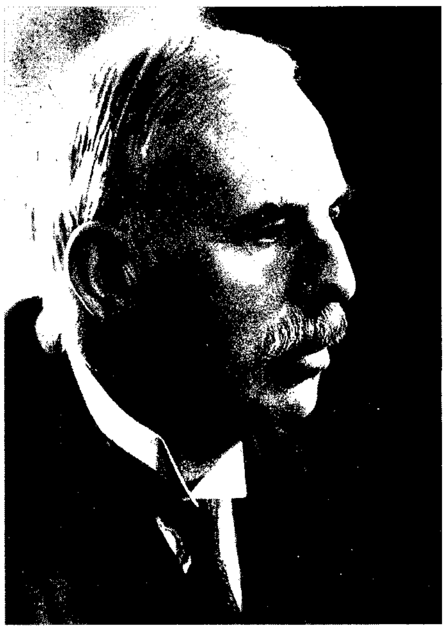
The AIHENP95 proceedings are currently in press at World Scientific, and should appear in November. A special edition of International Journal of Modern Physics C will include selected papers from the workshop.

From Bruce Denby and Denis Perret-Gallix

One hundred years ago.....

In 1895, exactly one hundred years, ago, a chance discovery in Würzburg, Germany, marked the dawn of a new science - atomic physics. Other discoveries and new insights followed quickly. Apart from interruptions for two World Wars, this rapid succession of breakthroughs continued for 88 years. A new series of occasional articles in the CERN Courier will look back to what was happening one century ago.

One hundred years ago, Ernest Rutherford briefly held the world record for radio telegraphy transmission.



In Würzburg on 8 November 1895, Wilhelm Conrad Röntgen became an immortal legend. Interested in the effects of ultra-violet radiation, he covered a cathode-ray discharge tube with black paper and darkened the room. With the glow from the tube hidden, Röntgen was surprised to see a fluorescent screen two metres away light up. For several weeks, Röntgen hid in his laboratory, finding out more about the mysterious penetrating 'X' rays, produced when the cathode rays hit the end of the discharge tube.

Since the time of Faraday, the glow produced in an evacuated tube when an electric current was passed through had intrigued physicists and entertained the public. Nobody understood what these cathode rays were. William Crookes in the UK, who had narrowly missed making the Röntgen discovery, surmised they were a new 'fourth state' of matter. Some scientists said the phenomena were due to radiation, others said particles.

Also in 1895, a young physics student named Ernest Rutherford arrived in Britain from New Zealand with a scholarship for further study. The scholarship, awarded to a New Zealand student only once every few years, had initially been given to a young chemist, but who decided at the last minute to get married and stay in New Zealand. The scholarship passed to Rutherford, who, thanks to a change in regulations, was able to use it at the Cavendish Laboratory in Cambridge, under J.J. Thomson.

In New Zealand, Rutherford had carried out experiments on radio telegraphy. He took his transmitter to Britain and at Cambridge continued his pioneer investigations. In 1895, Guglielmo Marconi was carrying out his first experiments on radio telegraphy in Bologna, but according to J.J. Thomson, it was Rutherford who held the world record for radio telegraphy transmission at that time.

On learning about the discovery of X-rays, J.J. Thomson plunged into this branch of research, using Rutherford as his assistant, who appeared to take the abrupt change in research topic in his stride. Whatever the loss for radio telegraphy, it became a gain for fundamental physics: Rutherford earned the Nobel chemistry prize in 1908 for his work on radioactivity; the following year Marconi shared the physics prize for his work on radio telegraphy.

Also at the Cavendish Laboratory in 1895, Charles T.R. Wilson began the study of cloud formation which led to his development of the cloud chamber, the pioneer detector of subnuclear physics.

Another scientific preoccupation of the times was the 'ether', postulated as filling all space and through which light and other electromagnetic radiation was believed to propagate. In 1887 the Michaelson-Morley experiment had shown that light always propagates at the same speed, irrespective of the velocity of its source. In 1895 George Fitzgerald in Dublin and Hendrik Lorentz in Leiden pointed out how this could be explained if moving bodies contracted along their direction of motion. Also concerned about these matters was the young Albert Einstein, at school in Aarau, Switzerland. In 1895, at the age of 16, he wrote an essay 'On the examination of the state of the ether in a magnetic field', which was never published.

In Berlin, Max Planck, who had succeeded Kirchoff in 1889, and in Vienna, Ludwig Boltzmann, who had succeeded Stefan in 1894, were among those looking hard at what was soon to become the standard model of the time - statistical mechanics.

Paris in 1895 was the scene of many interesting developments: Jean Perrin showed that cathode rays carried negative electric charge, settling once and for all the long-standing controversy whether cathode 'rays' were particles or radiation; a young Polish student named Eva Sklodowska married her Professor, Pierre Curie; after seeing a demonstration of Edison's massive 0.5 tonne 'kinetoscope', Auguste and Louis Lumière developed the lightweight *cinématographe* moving-picture projector and gave its first demonstration; and Louis Pasteur died.

Viewpoint

Gustav-Adolf Voss - with everybody following their pet idea, it is hard to see how an international collaboration can be formed.

Retiring after a distinguished career, including 14 years at the Cambridge (Massachusetts) Electron Accelerator and 22 years as Head of the Accelerator Department at the DESY Laboratory in Hamburg (March/April, page 6), Gustav-Adolf Voss was invited to give a 'Personal Perspective of High Energy Accelerators' at the Particle Accelerator Conference in Dallas, Texas, in May, of which we publish an abbreviated version.

At the beginning of this year I retired as Head of the Accelerator Department at the Deutsches Elektronen Synchrotron, DESY, in Hamburg, a position I had held for 22 years. An invitation to talk gives me a chance to thank my teachers, colleagues and friends from the 37 years I have been working in the accelerator field.

My first teachers were Stanley M. Livingston, Ken Robinson and Tom L. Collins. It is widely known that Livingston built the first working cyclotron as his PhD thesis under Ernest Lawrence. It is also known that Lawrence was inspired with the cyclotron idea by reading Rolf Wideroe's pioneer linear accelerator paper in 1927. Rolf Wideroe, although 93 now, is still full of ideas, which he sometimes tries out on me. Accelerator science does not have a long history.

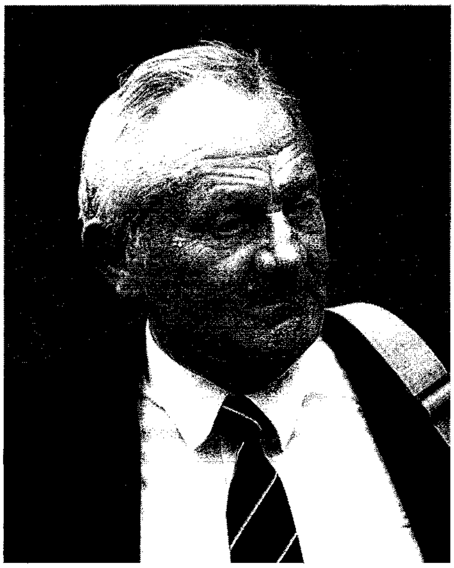
Ken Robinson was the legendary genius who developed most of the theory of electron synchrotrons and storage rings single-handed and in whose unpublished papers, found after his death, the basics of the free electron laser had been developed, a full 10 years ahead of time. Tom Collins was Assistant Director at the Cambridge Electron Accelerator (CEA), my first real workplace. He developed the 'Collins Straight Section' and furthered my technical education.

Among my CEA colleagues and friends were also Karl Strauch, John Rees, Ewan Paterson, Herman Winick and Albert Hofmann.

When I started in the accelerator field, life was different. The first atomic bomb had been exploded not much more than a decade earlier and the prestige of the nuclear physicist was much higher than today. The goals of particle physics were less questioned and there was less competition for research funds. For accelerator builders, bureaucracy had not yet arrived, at least in the US.

Accelerator science and technology were in their infancy. Strong focusing had just been invented by Courant, Livingston and Snyder and independently by Christofilos, but there was hardly anyone who understood tolerance problems, nonlinear resonances, dynamic apertures and other aspects of theoretical machine physics, and, at the same time, appreciated the engineering aspects of those machines, their costs and potential technical pitfalls. With no single person with at least a rudimentary understanding of all these aspects, it is difficult to make the right compromises in accelerator building. Now, some of these early machines look awkward.

It was Bob Wilson, I believe, who, as the first all-round accelerator builder, set a new style. He was a penny-pincher, surpassed perhaps only by Wolfgang Paul of Bonn (who built the first strong focusing synchrotron in Europe). Both these outstanding physicists are still my heroes. Paul was very unhappy when he saw money squandered 'as if it were play money in a game of Monopoly', and for Wilson it was a challenge to cut



technical corners and save money.

Project leaders like Wilson and Paul had to have a good understanding of the risks they were taking when they trimmed their machines to the bone, and put others at ease by taking full responsibility.

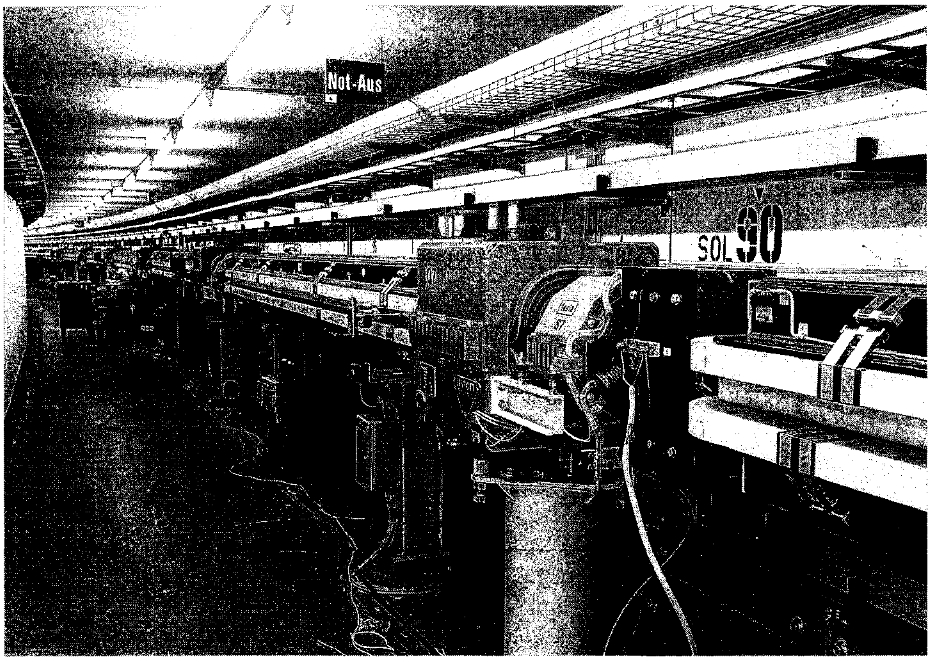
What happens when there are no project leaders with full authority to decide how the money is spent? The first result is usually a cost overrun. People do not want to be blamed if the machine does not work, so insist on generous safety margins, which cost money. Then the project starts to slip as these changes proliferate. This sorry state of affairs is not helped by imposing organization experts or military brass from outside. Frequent reviews and many reviewers cannot save the situation.

A challenge on the other hand is a situation with little money but the chance to do new and exciting physics with a new machine. Highly competent machine physicists can cobble together the resources to build their project as quickly as possible, at a bargain price and in record time. Some of our most productive electron rings have been built this way.

But I do not want to give the impression that I have a contempt for wealth. Wealth provides opportunity - tunnels which were originally built with five times the cross-section then needed can now accommodate a second or even a third machine. Laboratories used to ample budgets can now build new machines cheaply. Stepping into such a situation and making use of these opportunities can make you a hero overnight.

Wealth can be in buildings and money and also in staff. Many Laboratories spend more money on salaries than on power and new equipment. Manpower has to be focused on the problems at hand. The rapid-cycling Princeton-Penn synchrotron had a staff of 300 and one day were told to close down. One year later they had reduced the staff level to 25, while still running a full proton programme and at the same time developing techniques for heavy ion acceleration!

After 14 years at the CEA I moved to DESY. For me, and I hope for the DESY staff, the PETRA 20 GeV electron-positron storage ring was an exhilarating experience. Scheduled for a four-year construction period, the staff became so concerned with the schedule that everyone worked ahead to leave ample time for unforeseen problems. There were not many of these, so the schedule could be advanced. PETRA was turned on just 2 years and 8 months after authorization. Staying with the imposed 100 million DM budget had become such an overriding issue that only 80% of this amount had been committed when the first beams were stored, leaving a comfortable reserve for subsequent improvements. Wilson's rule seemed to be true also in this case - construction time and project costs go hand in hand.



Under Voss' guidance, the PETRA electron-positron collider at the DESY Laboratory, Hamburg, was turned on just 2 years and 8 months after authorization.

Over the past 30 years, accelerators have become more efficient and more economical. Comparing inflation-adjusted prices of the first GeV machines with those of today, we have gained a factor of at least ten in GeV per dollar. This is due not so much to new technologies like superconducting magnets and radiofrequency cavities, but more to a better understanding of what is really necessary in accelerator building.

Where do we go from here? How can we build tomorrow's accelerators with ten times the energy at a cost which the taxpayer can afford?

One school believes this needs new ideas to produce ultra-high accelerating gradients. Their dream is a table-top multi-GeV accelerator. But it is cost, more than size, which has to be minimized. Many people investigating ultra-high accelerating gradients overlook that luminosity, as well as energy, has to be increased. At very high collision energies, extremely high luminosities have to be achieved to provide the physics conditions. And this translates, for a variety of reasons, into very high beam power, and in turn the overall power efficiency of the machine becomes important. None at all of the new accelerating ideas (and I have contributed to this effort) shows much promise in this respect.

So we are left with the traditional approaches - superconducting storage rings for proton-proton colliders and more or less conventional linear accelerators for electron-positron colliders. Building a machine for ten times the collision energy at a reasonable cost can only be achieved by an extreme economy of standard technology, together with an enveloping international collaboration, and some good fortune. The LHC has just passed this hurdle, and I trust that it will manage to sidestep the missing magnet proviso under which it was approved.

The problem for building the next

linear electron-positron collider looks more formidable. Despite a large number of international workshops, I have not seen much convergence of ideas over the past six years. With everybody following their pet idea, it is hard to see how an international collaboration can be formed and approval obtained.

Part of the problem might be that linear collider studies have not yet matured to the degree where a proposal can be written. We may have to wait until detailed technical specifications and in particular prices become more concrete before ideas and designs can merge. Such convergence has to happen before international consensus can be reached. Its basis, I believe, must be proven technology and economics. As long as these two aspects cannot be substantiated by hard facts and numbers, one cannot write a proposal, let alone get it approved.

I very much hope that such an international consensus can soon be found. I remain fascinated by this science, even if the gap between machine physics and the latest theoretical ideas like superstrings seems to diverge and the energies needed to verify a 'final' theory seem unattainable. There are important open questions to answer within the energy range within reach in the next decade. As long as the field continues to attract bright and motivated young people, then we have no cause for concern.

Living in large experiments

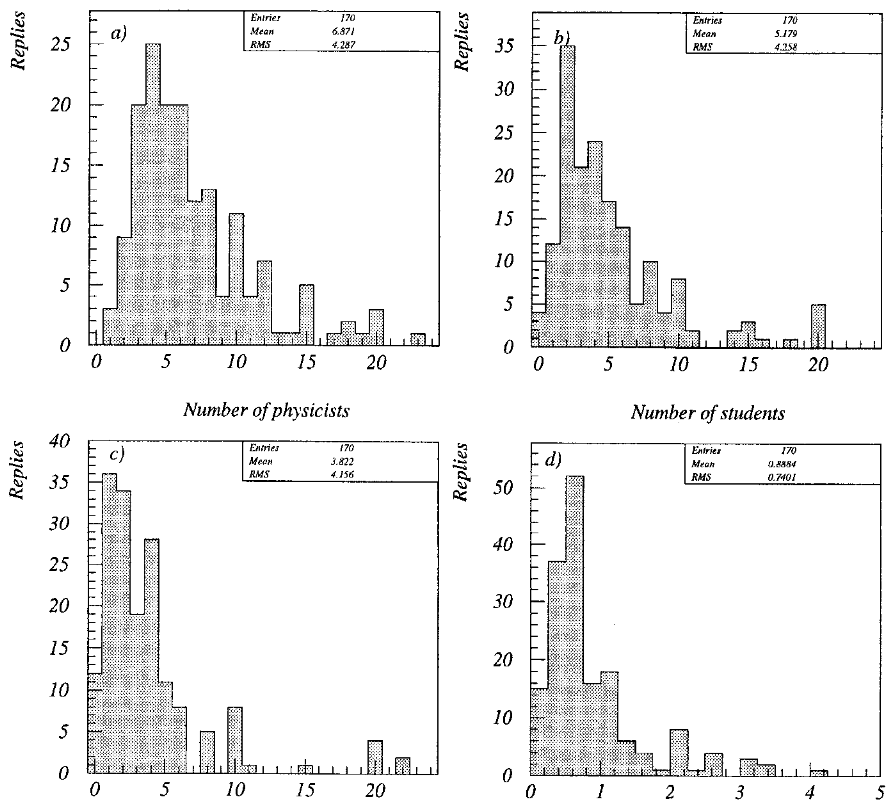
ECFA report

The European Committee for Future Accelerators (ECFA) plays an important role in shaping the physics programme in Europe, especially around major facilities which attract increasingly large numbers of users. How happy are physicists working in these scientific Towers of Babel? Apart from making physics discoveries, what are their requirements? Following a suggestion of CERN Director General Chris Llewellyn Smith, to provide an updated answer to these questions ECFA Chairman Günter Flügge initiated a survey on the sociology of large experiments. It fell to Bjarne Stugu of Bergen, as the youngest member of ECFA, to lead an ECFA subcommittee to carry it out.

A similar ECFA survey, carried out back in 1979/80, was influential in preparing infrastructure and thinking for the LEP experimental programme.

In the past 20 years, high energy physics collaborations have grown from typically 20 persons at fixed target experiments to around 500 for current major detectors at large colliding beam facilities.

The high complexity and cost of the two general-purpose experiments for the LHC require even larger collaborations, approaching 1500. With these two experiments alone - ATLAS and CMS - absorbing a considerable fraction of the entire high energy physics community, it is



How big is a physics research group? A survey on the sociology of large experiments carried out by the European Committee for Future Accelerators (ECFA) gives a detailed answer - a) is the number of physicists, b) students, c) technicians, and d) students per physicist.

ECFA/95/171 - The ECFA report on Sociology of Large Experiments, available from the ECFA Secretariat, CERN, CH-1211 Geneva 23, fax +41 22 782 3011, e-mail grantn@cernvm.cern.ch

timely to review the organizational and sociological aspects of large experiments.

ECFA recently sent a questionnaire to research groups involved in large collaborations in LEP (CERN), HERA (DESY) and the LHC (CERN). Each group leader was asked to reply, but to get a balanced view, a younger member of the group was also requested to return the form. The replies were anonymous.

The questionnaire was distributed to as many groups as possible, and 182 forms were returned. 90 replies from people working at LEP, where the four experiments include 159 groups, corresponds to a response rate of 28.3% with two forms returned. Similarly, 48 replies from the 87 institutions participating in the two main HERA experiments gives a response of 27.5%. The number of physicists per group is typically around 7, including about 5 students.

Publication

Current publication practice is to credit all members of the collaboration in alphabetical order. When these author lists become long it is difficult to assess the work of an individual by consulting 'his' list of publications. About 70% of the replies find this unsatisfactory and want to do something about it. Of these replies, around 80% think that the present system creates difficulties in giving proper credit for work done, and in promoting candidates for positions.

Of those wanting a change, about 75% favour putting increased weight on internal notes and reports. Around 40% propose schemes where the author lists are limited to parts of the collaboration, e.g. to an analysis team. Among other suggestions, the most frequent include ordering author names by importance of contribution, or highlighting the names making the most important contributions.

Other suggestions include citing everyone for the first three years and then move to more restricted lists - an inter-experimental LHC note series, for example. One person remarked that as publications are for the transmission of scientific results, long author lists do not provide information and could be omitted.

On the other hand many replies conclude that there is no feasible alternative to the present practice of a full 'author' list. Funding is dependent on the number of people in the collaboration, so long author lists are inevitable for large experiments. Other replies point out that it would be unfair to restrict author lists, since many people must devote a lot of time to tasks which, although vital, do not directly produce results.

Long experiments

The construction and operation of large detectors require massive manpower. During the long construction phase, there is no possibility for physics analysis. Data taking lasts many years.

The survey shows emphatic support for technicians, students and physicists all taking active part in the operation of the detector. This is the only way to obtain the necessary understanding of the detector.

The long timespans involved may also affect the recruitment of students. 40% of replies report difficulties in this sector, however this reply was highly country-dependent, with recruitment apparently more of a problem in some of the smaller countries. Bleak career prospects are thought to be a dominant cause of low recruitment. There was some indication that this problem has more serious implications for the future experiments at the LHC than for those presently operating at LEP and HERA.

It does not seem too difficult to recruit students for hardware-oriented subjects. However half of the replies recommend, given the possibility, to allow students to do some analysis work within a suitable experiment in parallel with hardware work for another.

The idea of letting students focus on physics by keeping them away from hardware is strongly disfavoured. Instead, many recommend that technical subjects should be acceptable for PhD theses, already current practice in many institutes.

Use of group resources

About 27 % of physicists feel they spend too much time away from research work, hindering active involvement in research. This complaint is independent of the size of the group. About 75% of replies report that technical personnel and students function well within the group.

Although the high fraction of group leaders suggests a risk of bias, the answers show no age dependence. At the same time 41% of the replies indicated a problem in at least one of the three categories of personnel (physicists, students or technicians), so there is clear room for improvement.

Although networking has improved working conditions, communication problems still exist and the distance from the home institution to the Laboratory is a major obstacle. With high travel costs, this can be a financial problem. Lack of communication can be a general problem, either within the group or within the collaboration.

Many of those satisfied with how their group functions commented that good organization and leadership is vital, as is good flow of information. Some also stress that parallel hardware and analysis activity pays dividends.

Group size also plays a role. Big groups may be hard to organize, and pose problems for individuals. However, a minimum size is necessary to take on meaningful tasks and to provide motivation.

Conclusions

There is much dissatisfaction with long author lists. Many alternatives were suggested, but it seems difficult to reach a consensus on how the current practice could change. Calibration and operation of the detector will always require the active and devoted participation of particle physicists. Because of this major effort, it would be unfair and dangerous to restrict author lists.

The use of internal notes is recommended to overcome some of the problems of long author lists. However the quality of these notes should be assured by internal refereeing within the collaboration.

While the questionnaire was not explicit in asking who should take part in construction, it is widely held that this phase requires devoted commitment from physicists and students. The ECFA report recommends that technical topics should be acceptable for a PhD thesis, ensuring at the same time a balanced physics education. If the group participates in experiments at different stages of evolution, one way is for the thesis to contain two topics; analysis from one experiment and hardware studies from another.

The recruitment of students appears to be a serious problem in some countries and could also be a little harder for LHC experiments than for existing studies, but firm conclusions cannot be drawn. Although some students will hesitate at PhD topics which concentrate on hardware, this is not what causes the lack of students. It is more the poor career prospects in some countries which deter students from high energy physics. The marked differences in recruitment between different countries probably reflect the job prospects in that country. The satisfactory student recruitment in many countries demonstrates that there is no underlying lack of interest.

Questioning on the effective use of personnel shows how well the group functions within the collaboration. Overall, personnel adapt well. However 41% of the replies indicate that this could be improved, for at least a subset of the group members. An agreeable working atmosphere and a well organized group is important, especially for younger researchers.

A large collaboration certainly appears intimidating. This requires a continuous effort towards improving conditions, on the part of the collaboration and of the host Laboratory, as well as the component group. At the group level is helpful to have some connection between its hardware, software and analysis contributions.

If all this works smoothly, then all collaboration members should feel comfortable.

Bookshelf

The Quantum Theory of Fields Volume 1: Foundations by Steven Weinberg, Cambridge University Press, 1995, ISBN 0 521 55001 7

Steven Weinberg is celebrated for his many contributions to quantum field theory and its applications to elementary particle physics - most notably, for developing the electroweak theory, the unified model of the electromagnetic and weak forces that forms part of the Standard Model that has explained essentially all accelerator data on the behaviour of elementary particles. This is the culmination of the developments in quantum field theory that started in the early days of quantum mechanics and came to maturity with the development of quantum electrodynamics in the late 1940s.

Quantum field theory is the basic theoretical framework for research in particle physics as well as in many areas of condensed matter physics. No wonder the community has been waiting with anticipation for Weinberg's exposition of the subject in the form of a two-volume textbook - the more so since, despite the existence of many textbooks, few of them are written with the insight and detail that are needed for a thorough understanding. The community will not be disappointed, at least on the basis of this first volume - Volume 2 is due to appear next year. Volume 1 is 600 pages of meticulous exposition of the fundamentals of the subject, starting from a historical introduction and the canonical formulation of quantum field theory to modern path integral methods applied to the quantization of electrodynamics and a first discussion of renormalization. In addition to a superb treatment of

all the conventional topics there are numerous sections covering areas that are not normally emphasized, such as the subject of field redefinitions, higher-rank tensor fields and an unusually clear and thorough treatment of infrared effects. This is only the basics - Volume 2 promises to develop the subjects at the cutting edge of modern research such as Yang-Mills theory, the renormalization group, symmetry breaking, anomalies, topological issues and superconductivity.

Not only has Weinberg been a leading figure in the developments in the modern era of quantum field theory, which gives him exceptional stature as an expositor of the subject, but he is also famous as the author of several outstanding books - among them, his *First Three Minutes* is an exemplary popular book on the early Universe, while *Gravitation and Cosmology* became a standard textbook. This latest book reinforces his high scholarly standards. It provides a unique exposition that will prove invaluable both to new research students as well as to experienced research workers. Together with Volume 2, this will become a classic text on a subject of central importance to a wide area of theoretical physics.

Reviewed by Michael B. Green

La Lumière des neutrinos, by Michel Cribier, Michel Spiro and Daniel Vignaud, Editions du Seuil, Paris, 1995, ISBN 2-02-014393-3

This book (in French) is a review of neutrino physics from the "invention" of the neutrino by Wolfgang Pauli in 1930 to the most recent experimental and theoretical developments and their implications in particle physics, astrophysics and cosmology, and is addressed to the general public.

It does not require any knowledge of particle physics and uses few graphs and diagrams and almost no mathematical formulae. Nevertheless, to the reader wishing a deeper understanding, the book frequently offers more detailed and technical discussions embedded in the text. Easily identifiable, these parts, requiring a higher level of attention and knowledge, could be skipped without losing the thread of the subject. A few technical appendices for more exacting readers and a glossary of the most commonly used terms are also included. The book, written in the style of a novel, does not follow the chronological order of events and often uses flashbacks. It opens with a bang - the appearance of Supernova SN1987A in the southern hemisphere during the night of February 23, 1987, accompanied by the detection of neutrino bursts in the Kamiokande and IMB underground detectors. Even the most cynical reader will be captivated.

Chapters 2 - 7 describe a series of phenomena involving neutrinos : the Big Bang, leading to a Universe full of neutrinos which might represent as much as 90% of the Universe's total mass; Supernova explosions; the possible production of very high energy cosmic neutrinos by quasars; solar neutrinos and their detection, leading to the well known solar neutrino problem which is one of the centrepieces of today's particle physics; and neutrino production by natural radioactivity in the Earth and by nuclear reactors.

Finally, chapters 8 - 12 describe the role of neutrinos in modern particle physics, from the use of neutrino beams to study the structure of the nucleon to the searches for double beta decay and to the attempts to measure directly the neutrino mass.

This is a fascinating book. Among popular science books I have read, only two gave me comparable pleasure: *"The First Three Minutes"* by Steven Weinberg and *"The Hunting of the Quark"* by Michael Riordan. It should be recommended to students completing a high school scientific education, and/or embarking on a college one.

The book will also increase the general public's interest in science, particularly important today at a time which witnesses the development of a negative attitude towards science and a revival of interest in astrology and other similarly irrational activities.

Reviewed by Luigi DiLella

Books received

Large Facilities in Physics, published by World Scientific, Singapore, ISBN 981-02-2157-6.

Now available are the Proceedings of the European Physical Society's 5th International Conference on Large Facilities in Physics, held last September in Lausanne, and which attracted a large audience. The Chairman of the meeting was Herwig Schopper, Co-Chairman Maurice Jacob, and Local Chairman Claude Joseph.

People and things

Time's Arrows Today - Recent Physical and Philosophical Work on the Direction of Time, Edited by Steven F. Savitt, Cambridge University Press, ISBN 0 521 461111

Most of the contributions in this volume were presented at the 'Time's Arrows Today' conference at the University of British Columbia in 1992. Most of the 12 contributors are philosophers of science: three are physicists (A.J. Leggett, P. Stamp, W. Unruh, and one (R. Douglas) a mathematician.

Gentner-Kastler Prize

The prestigious Gentner-Kastler Prize, jointly awarded by the French and German Physical Societies, goes this year to Walter Schmidt-Parzefall of DESY, formerly leader of the Argus group at the DORIS electron-positron collider at the DESY Laboratory Hamburg, which has made many significant contributions to heavy quark spectroscopy. Subsequently he joined Hamburg University, and has recently played a prominent role in establishing the HERA-B experiment at DESY's HERA electron-proton collider. Before working at DESY, Schmidt-Parzefall spent some time at CERN's Intersecting Storage Rings.

Thirty ISR years

A discreet lunch event at CERN marked the 30th anniversary of the historic decision to go ahead with the Intersecting Storage Rings (ISR) at CERN. Among those present were Victor Weisskopf, CERN's Director General at the time, and Mervyn Hine, responsible for CERN's long-term planning under Weisskopf. The ISR, the world's first proton collider, came into operation in 1971, ahead of schedule, but was shut down in 1984, also ahead of schedule, as part of the bid to divert funds to LEP construction. The ISR, which used the idea of particle stacking to build up the stored beam intensity, was long regarded as a masterpiece of accelerator building, and blazed a trail for CERN's future accelerator projects. Many CERN specialists cut their accelerator teeth at the ISR.

ICTP Dirac Medal

The International Centre for Theoretical Physics (ICTP), Trieste, is awarding its 1995 Dirac Medal to Michael Berry of Bristol for his discovery of the non-integrable phase that arises in adiabatic processes in quantum theory. This

BROOKHAVEN

Japanese collaboration

The Japanese RIKEN Laboratory is contributing $20 million to the RHIC Relativistic Heavy Ion Collider now being built at Brookhaven. In return, RIKEN will participate in research at RHIC. More news in our next issue.

Felicitas Pauss (left) explains the challenges of LHC physics to Verena Meyer, President of the Swiss Science Council.

The Physics Department of Princeton University announces the 1996 competition for the

ROBERT H. DICKE POSTDOCTORAL FELLOWSHIPS

A fellowship program named for Robert H. Dicke has been established to provide opportunities for outstanding young physicists to work in the field of their choice.
Research may be carried out independently or in collaboration with members of the Physics Department. The Fellowships provide an annual stipend of $ 39,000 along with a $ 5,000 annual allowance for research support. The Fellowships are awarded for two years with a nominal starting date in September of 1996. There is the possibility of an additional year at Princeton by mutual agreement. Applicants will also be considered for available postdoctoral positions. Current areas of research include:
• Atomic Physics and Optical Pumping • Biophysics • Condensed Matter Experiment • Condensed Matter Theory • Cosmology • Gravitational Physics • Mathematical Physics • Nuclear Physics • Nuclear Astrophysics • Pulsar Physics • High Energy Experiment • Theory of Elementary Particles & Strings

Candidates should send a letter of application and the supporting materials listed below to the DICKE FELLOWSHIPS COMMITTEE, c/o Prof. A.J.S. Smith, Princeton University Physics Department, P.O. Box 708, Princeton, NJ 08544, USA.
Applications must be received **no later than December 18, 1995.**

1. Curriculum Vitae
2. List of publications and preprints
3. Brief statement of research interests and goals
4. Names and addresses of three referees familiar with the candidate's work (the candidate should arrange to have the letters of recommendation sent directly to the address above).

Princeton University is an Affirmative Action/Equal Opportunity employer and particularly welcomes applications from women and members of minority groups.

FACULTY POSITIONS IN PHYSICS

University of California, Berkeley

The Physics Department of the University of California, Berkeley intends to make two faculty appointments effective July 1, 1996. Candidates from all fields of physics are encouraged to apply. Appointments at both tenure-track assistant professor and tenured levels will be considered.

Please send a curriculum vitae, bibliography, statement of research interests, and a list of references to **Professor Roger W. Falcone, Chairman, Department of Physics, 366 LeConte Hall 7300, University of California, Berkeley, CA 94720-7300, USA**, by Monday, November 27, 1995. *Applications submitted after the deadline will not be considered.* The University of California is an Equal Opportunity, Affirmative Action Employer.

EXPERIMENTAL ASTROPHYSICS

The Physics Department at the University of Utah is seeking qualified candidates for a tenure track position in experimental astrophysics at the assistant professor or associate professor level. We seek candidates with strong commitments to both teaching and research. Successful candidates will be expected to initiate their own research program and/or contribute to existing research efforts as well as teach undergraduate and graduate courses in Physics. The department has a strong research program in experimental astrophysics/cosmic ray physics which includes the High Resolution Fly's Eye, balloon based experiments, ground arrays (CASA/MIA and others), and satellite-based observations.

Candidates should submit their curriculum vitae, list of publications and three letters of recommendation by February 1, 1996 to:

EXPERIMENTAL ASTROPHYSICS FACULTY
SEARCH COMMITTEE
Department of Physics
201 James Fletcher Bldg.
University of Utah
Salt Lake City, UT 84112, USA

The University of Utah is an Affirmative Action Equal Opportunity Employer. It encourages applications from women and minorities and provides reasonable accommodations to the known disabilities of applicants and employees.

A new building has been approved and is expected to be complete for the 1996 summer programme at the Aspen (Colorado) Centre, a traditional venue for US particle physics meetings.

effect was first detected in 1986 in an optics experiment by Tomita and Chiao in which the rotation of the polarization plane of a wave propagating in a twisted optical fibre was interpreted as a Berry phase. In the same year it was found that the frequency splitting in the nuclear quadrupole resonance spectra of a slowly rotating nucleus could be ascribed to a Berry phase phenomenon.

The Berry phase is now known to play a significant role in many different areas of microscopic physics ranging from chemistry and molecular physics to optics, nuclear and solid state physics and relativistic quantum field theory. In all these areas the recognition of the non-integrable phase has led to a deepening of our understanding of the underlying quantum dynamics.

ICTP instituted the Dirac Medals in 1985. They are awarded for contributions to theoretical physics and mathematics, but are not awarded to Nobel Prize or Wolf Foundation Prize winners.

Aspen facelift

A traditional focal point for US particle physics is the Aspen (Colorado) Centre, where, summer and winter, researchers come to compare notes and swap ideas. The trustees of the Center have launched a fund-raising drive to raise money for new buildings on the campus. Initial contributions come from Aspen resident Gerald Hosier and the Smart Family Foundation, as well as from members and friends of the Center. A new building has been approved and is expected to be complete for the 1996 summer programme.

Award of the Association of the Friends and Sponsors of DESY 1995

The Association of the Friends and Sponsors of DESY (Hamburg) announces a prize to recognize an outstanding PhD thesis based on research at the Laboratory. Nominations are invited on behalf of candidates whose theses meet the following criteria: it must have been completed and submitted in 1995; it must describe research in particle physics (experimental or theoretical), in accelerator physics or in the application of synchrotron radiation; and the research must have been wholly or partially carried out at DESY.

The prize will be accompanied by an award of DM6000 and may be shared by two candidates. The winner will be chosen by the Directorate of the "Verein der Freunde und Förderer des DESY" on the recommendation of an international review committee. Nominations should be sent to Professor E. Lohrmann, II. Institut für Experimentalphysik, Universität Hamburg, before December 31, 1995, including a detailed justification and accompanied by seven copies of the thesis.

Meetings

The NATO Advanced Study Institute on Techniques and Concepts of High Energy Physics will be held from 11-22 July, 1996, in St. Croix, U.S. Virgin Islands. Attendance is limited to about 60 advanced graduate students and recent PhD recipients in experimental high energy physics. Application Deadline: February 1, 1996.Applicants should send letter, vita and recommendation from advisor. Email is acceptable. Contact: C. Jones, Dept. of Physics, ASI-96, University of Rochester, Rochester, NY 14627 USA; email: connie@urhep.pas.rochester.edu. The Institute's Director is Prof. T. Ferbel, University of Rochester, and is sponsored by the NATO Advanced Study Institutes Program, the US Dept. of Energy, National Science Foundation, Fermi National Accelerator Lab, and the University of Rochester.

Deputy Russian Science Minister G. Kozlov speaks at the opening of the International Symposium on LHC Physics and Detectors, held at the Joint Institute for Nuclear Research (JINR), Dubna, near Moscow, in July. With him are (left to right) A. Poliakov, representing the Moscow civic authorities, JINR Vice-Director A. Sissakian, Deputy Minister of Atomic Energy L. Ryabev, CERN Director General Chris Llewellyn Smith, JINR Director General Vladimir Kadyshevsky, and M. Ciosek, Polish Ambassador in Moscow. Poland is a Member State of both CERN and JINR.

The Fourth International Winter School in theoretical physics "QCD: Perturbative and Non-Perturbative Topics" will be held at St.Petersburg Nuclear Physics Institute, Russia, from 3 - 17 February. Lectures will be at the postgraduate and postdoc level and include such topics as low x physics, theory and phenomenology of heavy quark decays, confinement, new developments in the dynamics of supersymmetric Yang-Mills theories, polarized deep inelastic scattering, dynamics of Wilson loops, and colour transparency. Among the lecturers are Profs. Anselm, Braun, Dokshitzer, Eides, Migdal, Lipatov, Petrov, Uraltsev, Webber, Yung. Further information from Nikolai Kivel, e-mail: kivel@thd.pnpi.spb.ru

---

Subrahmanyan Chandrasekhar 1910-95

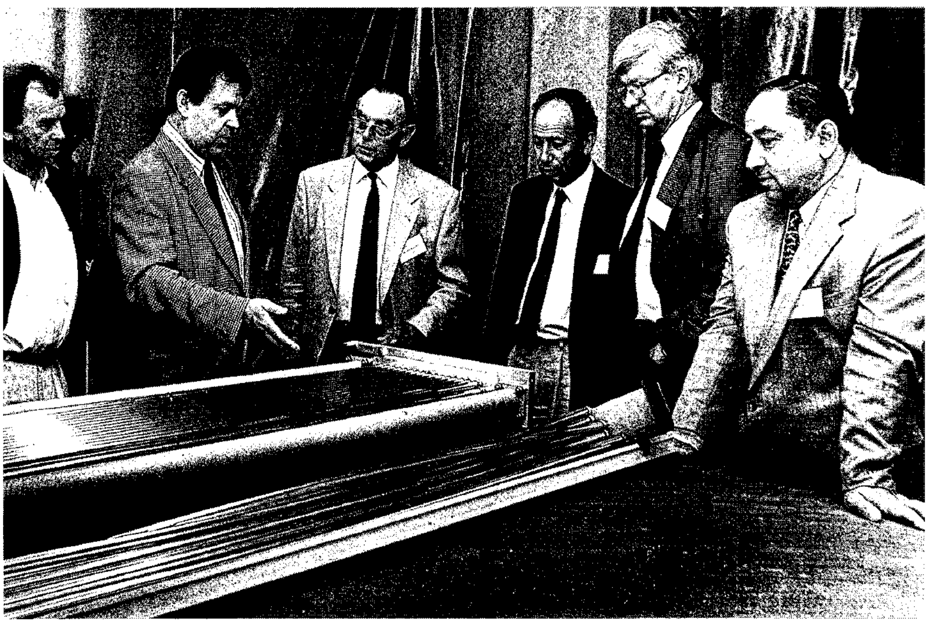
Renowned astrophysicist and cosmologist Subrahmanyan Chandrasekhar died in August, aged 84. Born in Lahore, then part of India, he did his first research at Cambridge and Copenhagen. The legend goes that during the long sea voyage from India to England he had the idea that when stars run out of nuclear fuel, they become crushed by their own gravity if they are large enough. This famous 'Chandrasekhar limit' is about 1.5 times the mass of the Sun. At Cambridge, such revolutionary ideas initially did not find favour with Sir Arthur Eddington.

In 1936 Chandrasekhar moved to the US, where he spent most of his career at Chicago. He made many major contributions to astrophysics and wrote several authoritative works on the subject. In 1970 he suggested how gravitational radiation can affect rotating stars. In 1983 he shared the Nobel Physics prize with William Fowler, who died earlier this year (September, page 50), for their contributions to stellar evolution.

John Malos

Well known as a colleague to many at CERN, the Rutherford Appleton Laboratory and DESY, John Malos died recently after a heart attack at his home in Bristol at the age of 67. A sympathetic tutor and memorable lecturer familiar to many generations of physics students at Bristol, he was also a committed political activist who will be remembered in the Labour Party both in Bristol and further afield.

He came to Bristol from his native Australia in 1962 to work with Cecil Powell's cosmic ray group, but when the Nimrod proton synchrotron was built he became involved in its ex-

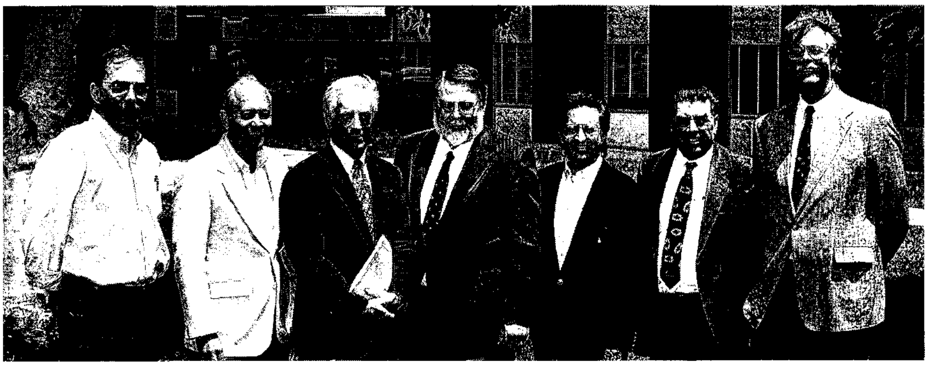


On a tour of JINR during the International Symposium on LHC Physics and Detectors (see top photo), Igor Golutvin, Russia and Eastern Countries coordinator for the CMS detector for LHC, explains research and development work on large area precise position gaseous detectors to (left to right) CERN-Russia coordinator Nicolas Koulberg, CERN Non-Member State coordinator Jim Allaby, CERN Research Director Lorenzo Foa, CERN Director General Chris Llewellyn Smith, and JINR Vice-Director Alexei Sissakian.

Beauty is attractive! Beauty '95, the third in a series of International Workshops on B-Physics at Hadron Machines, took place this summer in the appropriately beautiful surroundings of Wadham College, Oxford, where in the 17th century the founders of The Royal Society first met. Three hundred years later, Beauty '95 began with B physics results from LEP (CERN), the Tevatron (Fermilab) and CLEO (Cornell), as well as theoretical work on the decays of B particles. The workshop's main concern was development work for B physics in the different environments of HERA (DESY) and the LHC (CERN). Triggering and vertex detection will be crucial in all these experiments. In addition, the physics programmes for future B facilities at Cornell, KEK (Japan) and SLAC (Stanford) were also reviewed. The proceedings will appear in a future special issue of Nuclear Instruments and Methods. Seen here are (left to right), Harry Lipkin (Weizmann Institute, who talked on penguins, trees and things), together with conference organizers Neville Harnew (Oxford) and Peter Schlein (UCLA).

perimental programme specializing in the development of novel detectors, making full use of his talents for electronic design. After the closure of Nimrod he moved on to the NA11 and NA32 experiments at CERN and later the ZEUS experiment at DESY. His retirement saw the redirection of his enthusiasm into a project to develop wind energy for generating electrical power on the Greek island of Kythera from which his parents had originated.

At this year's Users' Meeting at Brookhaven (left to right) - Users' Executive Committee Chairman Hank Crawford (LBL); Brookhaven Physics Department Chairman Peter Bond; US National Science Foundation Nuclear Physics Program Director Jack Lightbody; US Department of Energy Office of High Energy Physics Director John O'Fallon; Brookhaven Laboratory Director Nicholas Samios; US Department of Energy Office of Nuclear Physics Director Dave Hendrie; and Brookhaven High Energy and Nuclear Physics Associate Director Thomas Kirk.



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)
R. Frosch

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

Jan Hendrik Bannier 1909-1995

Jan Hendrik Bannier, who died on 7 September, was one of last surviving members of the gallant band of CERN founding fathers who pushed through, against all odds, the establishment of a European Laboratory in the difficult immediate post-war period.

As a physicist and Director of the Dutch Organization for the Advancement of Pure Research (ZWO) he represented, together with C.J. Bakker, the Netherlands at the intergovernmental conferences during the early 1950s when the idea of establishing a European laboratory was proposed and discussed. In 1952-3, he was Chairman of the provisional CERN Council, and it is his signature which appears for the Netherlands on the 1954 CERN Convention.

From 1958-60, he served as Chairman of CERN's Finance Committee, and during Victor Weisskopf's 1961-5 mandate as Director-General led a working group to study the Laboratory's budgeting procedures. Until then, large organizations had always reviewed and fixed their budgets each year for the next. Faced with long-term projects which required careful planning and budgeting over several years, this was a continual problem. Bannier's group pointed out the advantages of a rolling scheme - budgets should be fixed for the forthcoming year, together with a provisional plan to cover succeeding years. This long-term scheme, known in CERN as the 'Bannier procedure', is still the envy of many other organizations, straitjacketed by being able to budget only from one year to the next.

From 1964-66 he was President of CERN's Council, overseeing the ambitious preparations to extend CERN's activities with the Intersecting Storage Rings (ISR) and the '300 GeV project' which was to become the SPS.

Not only did he help guide the Organization into being, but he moulded its statutes to ensure that it would be able to carry out its difficult mission. More than 40 years later, the continuing success of CERN is a lasting tribute to his wisdom and foresight.

Publication: CERN Courier
Date: October, 1995