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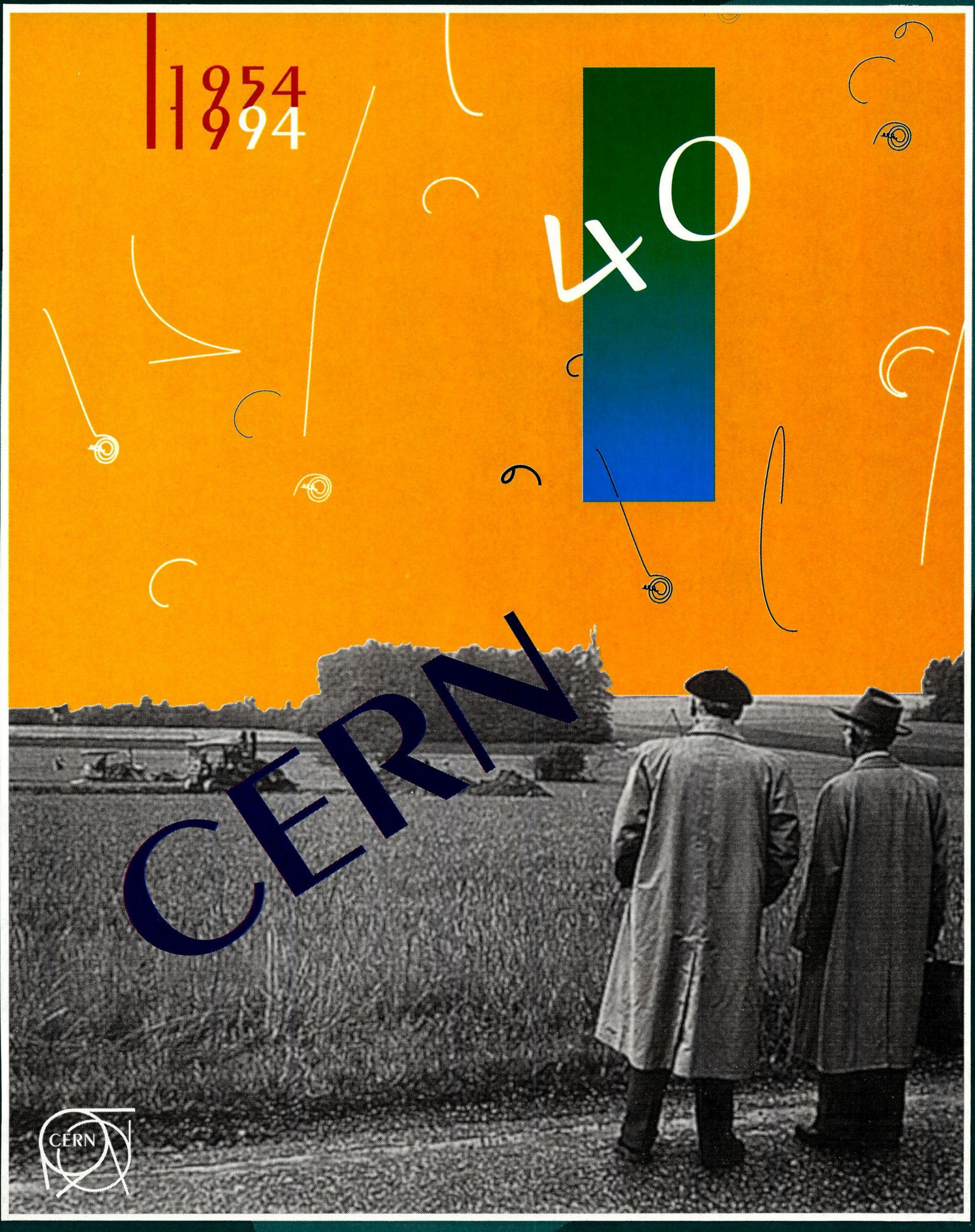

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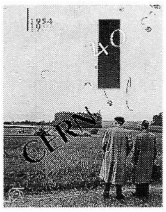

Cover photo: Poster/T-shirt/watch/wine label design for CERN's 40th anniversary, being marked by a special event on the CERN Site on Saturday 17 September. A report of the event will feature in a forthcoming issue. (Design: Sylvette Stillebacher)

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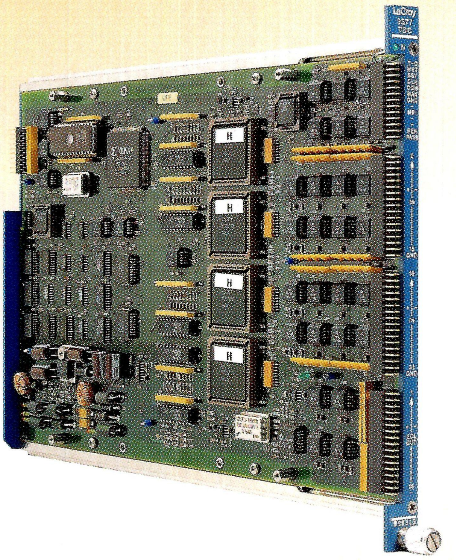

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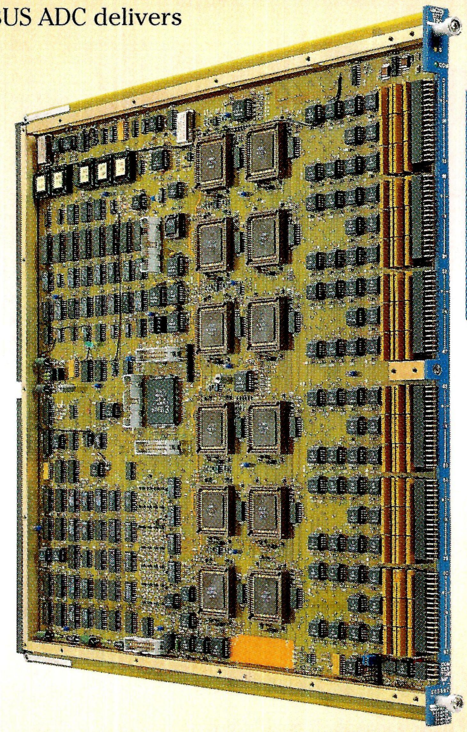

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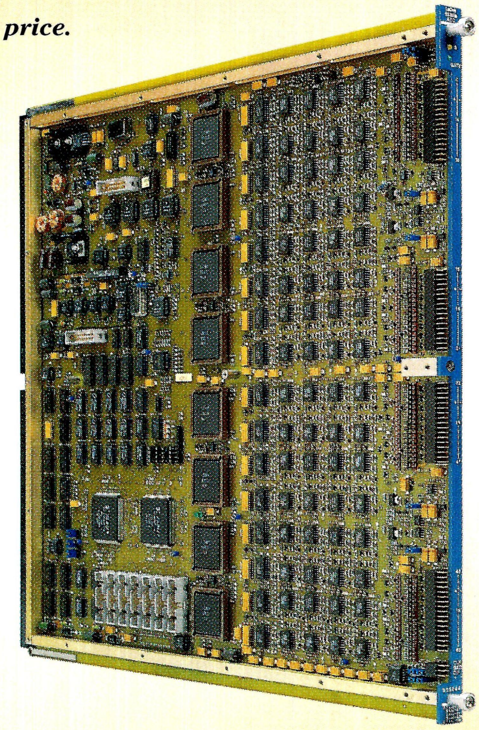

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Glasgow physics conference

Preliminary report

The third and heaviest pair of quarks, 'beauty' (b) and 'top' (t), were the stars of the International Conference on High Energy Physics, held in Glasgow from 20-27 July, the 27th in the series of traditional biennial 'Rochester' meetings which dominate the particle physics calendar. With all major new results in agreement, in recent years these meetings have also become a festival for the 'Standard Model' of particle physics, and Glasgow was no exception.

The beauty and top quarks are the heavy counterparts of the 'up' and 'down' pair which constitute nuclear matter in the everyday world, and the heavier 'strange' and 'charm' duo which come into play at higher energies. These six quarks, grouped in three pairs, are a central pillar of the Standard Model (June, page 4).

First evidence for the b-quark came in 1977 with Fermilab's discovery of the heavy upsilon resonance, and sightings of additional b-quark states (B particles) trickled out in the following years. However with the advent of new proton-proton and electron-positron colliders, the B trickle has become a steady stream.

As pointed out by Pierre Darriulat of CERN in his Glasgow summary, the impact of microvertex detectors at LEP experiments at CERN, at CDF at Fermilab's Tevatron and at SLD at SLC, together with the mass of data from CLEO at Cornell's CESR ring and final results from the now completed ARGUS study at DESY's DORIS ring, have brought a bumper new crop of detailed B results, to the point where exotic B processes can now be explored. Microvertex detectors are ideal for picking up the characteristic millimetre track stubs left by 'long-lived' B particles and figure prominently in the upgrade plans of several major detectors.

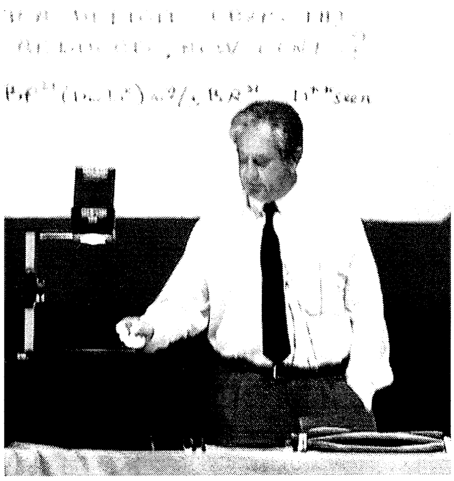
Evidence for the b-quark's partner - top - was unveiled earlier this year by the CDF collaboration working at Fermilab's Tevatron proton-antiproton collider (June, page 1). At Glasgow, Hans Jensen presented CDF's top evidence, 12 events against an expected background of six. Paul Grannis, speaking for the D0 experiment at the Tevatron, could also point to candidate top events but these are not yet sufficiently numerous to be visible against mundane background processes.

While the top production rate from the CDF signal overshoots the theoretical prediction, D0 is less fortunate, but it is premature to combine the two sets of data, at least officially. With the Tevatron's collision rate recently improved, physicists look forward to more data and more top.

Striking is the accord between the top quark mass from the Tevatron evidence and the limits emerging from the sum total of world Standard Model data, where the solid weight of precision results from CERN's LEP electron-positron collider plays a major role. As well as its mass, the strength of the top quark's interactions with the rest of physics could have important implications, surmised several speakers.

Also striking at Glasgow was the increasing complexity of the proton (and neutron). This humble particle, once thought to be composed of just three 'valence' quarks, has a complex accompanying 'sea' of attendant quarks and gluons. 'The structure of the proton continues to be a mystery,' said rapporteur Joel Feltesse.

The NA51 muon pair experiment at CERN and the comparison of positive- and negatively-charged W particles by CDF point to an unusual antiquark content in the proton. Another continuing proton puzzle is the origin of its spin, where latest results emerged in specialist meetings earlier this year (July, page 19).



Pierre Darriulat of CERN summarizes the Glasgow conference.

A new slant on the proton structure comes from the HERA electron-proton collider at DESY, Hamburg, which looks at the deep structure of the proton under hitherto unexplored conditions. When the struck quark contains only a tiny fraction of the parent proton's momentum, lots of constituent quarks and gluons (mainly the latter) show up. First reported at HERA last year, this effect is now even more marked.

The neutrino sector had been well covered at Neutrino 94 at Eilat (see page 2), but one new result at Glasgow was a Russian experiment on tritium beta-decay, where spectrum details could help explain the puzzling rash of negative mass-squared values reported by other experiments. The Russian experiment reports a new limit of 4.5 electronvolts for the mass of the electron-neutrino.

A full report of the Glasgow Standard Model fiesta, with its mass of detailed results, will feature in next month's issue.

Neutrino problems proliferate

Neutrino 94 conference report

The enigma of the neutrino continues. More than sixty years after its hesitant prediction by Pauli and forty years after its discovery by Reines and Cowan, the neutrino still refuses to give up all its secrets. The longer we travel down the neutrino road and the more we find out about these particles, the more problems we uncover en route.

The present state of the neutrino mystery was highlighted at the Neutrino 94 meeting in Eilat, Israel, from 29 May to 3 June. It was a distinguished meeting, with the first morning including one session chaired by neutrino co-discoverer Fred Reines, and an introductory talk by muon-neutrino co-discoverer Leon Lederman. One figurehead neutrino personality conspicuously absent this time was Bruno Pontecorvo, who died last year and had attended the previous conference in the series, in Grenada, Spain, in 1992. Samoil Bilenky gave an emotive appreciation of Pontecorvo and his contributions to this branch of physics.

Neutrino 1992 in Grenada had been dominated by a fresh development - the first results from gallium detectors of neutrino signals from the proton-proton fusion mechanism which provides most of the Sun's energy. But with neutrino results now coming in on a broad front, Neutrino 94 reflected a broader picture.

Looking back over the history of the neutrino in his introductory talk, Leon Lederman set out to convince his audience that neutrino physics is an experimental, rather than a theoretical, science, and in contrast to many reviews which point to Pauli's suggestion as the dawn of neutrino physics. Lederman stressed the long and painstaking search to understand the spectrum of electron energies emerging from beta decay.

With beta decay of a particular nucleus at first sight involving a daughter nucleus and an electron, it would be easy to jump to the conclusion that the electrons emerging from a particular decay channel would always have the same energy. Evidence that beta decay electrons had instead a spread of energies had begun to emerge before World War I, but this was not universally accepted for more than ten years. Only then was the scene set for Pauli's prediction. Lederman showed how even preparing the ground for the neutrino hypothesis had taken almost twenty years.

Recurring throughout the meeting was the major open neutrino question - its mass, or masses, which can drive both particle physics and cosmological effects.

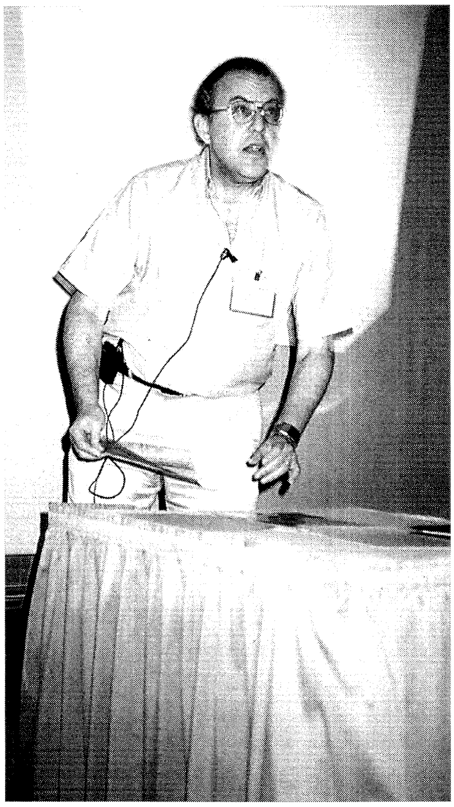
Reviewing neutrino properties in today's setting, Haim Harari of the Weizmann Institute homed in on the all-important mass limits. With the number of light neutrinos now firmly fixed at three (electron-, muon- and tau-types), any fourth neutrino has to be heavy, at least 45 GeV. For the light neutrinos, cosmological arguments imply a mass of less than about 20 eV.

With 110 neutrinos of each of the three types in each cubic centimetre of space, Harari had a ready supply of 'neutrinos in the street' to whom he could attribute his own erudite remarks.

Having neutrino masses that are very small but non-zero opens up the possibility of neutrino oscillations, with different neutrino types periodically switching their allegiance. The only way to measure such small masses, said Harari, is through the resultant oscillations.

Oscillation limits from laboratory experiments rule out a lot more territory for neutrino habitation, leaving only a few small islands.

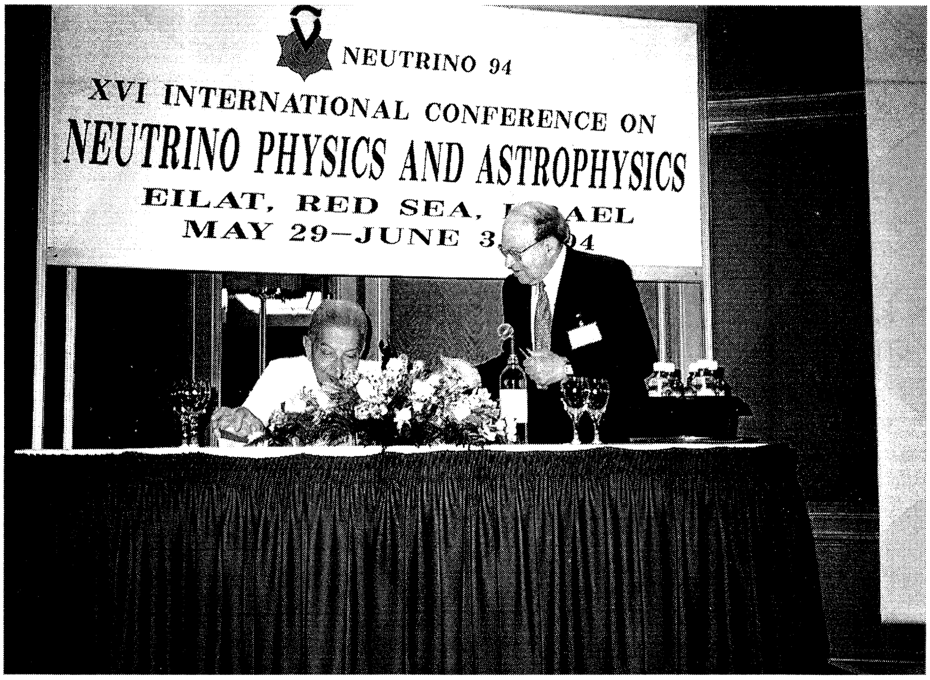
Haim Harari of the Weizmann Institute - neutrinos in the street



These oscillations and related effects could be at the heart of ongoing neutrino puzzles such as the solar and other neutrino effects, where the level of observed particles is less than expected.

(New results from pion decay at the Swiss PSI Laboratory give a new lower limit for the muon-neutrino mass, lowering it from 0.27 to 0.16 MeV - more news in our next issue. Also too late for Eilat but featuring at Glasgow - see page 1 - was news from a high resolution Russian tritium decay study which has improved the limit on the electron-neutrino mass to 4.5 electronvolts.)

The idea of invisible 'Dark Matter' making up the bulk of the Universe is now firmly entrenched. Evidence from different directions says that there has to be more mass in the Universe than meets the eye. Neutrinos are the only candidate Dark



The Neutrino 94 Conference was formally opened by the President of Israel, Ezer Weizman (seated), introduced by Yuval Ne'eman.

Matter candidate particles which definitely exist, remarked Harari. However with neutrino masses difficult to pin down on their own, he advocated a thorough investigation of neutrino oscillations. For this, the new Chorus experiment at CERN, with its emulsion target, is particularly well suited, he said.

Chorus and its companion Nomad experiment in CERN's revamped high energy neutrino beam are now underway, and progress was described by Klaus Winter later in the programme. At the next Neutrino meeting, the first Chorus and Nomad results should feature prominently.

For the neutrino's role in cosmology, Michael Turner of Chicago showed how useful neutrinos could be in the synthesis of nuclei in the aftermath of the Big Bang, with some cosmological 'mischief' with unstable tau neutrinos. An unstable tau neutrino returned later in the programme with Dennis Sciama of SISSA, Trieste, and Matts Roos of Helsinki, who both explored the cosmological consequences.

With the Hubble Space Telescope now bringing fresh results, Sciama boldly suggested a mass for the tau neutrino and hoped for more conclusive results by the time of the next Neutrino meeting, in 1996.

David Schramm of Chicago, speaking on neutrinos and the Big Bang, described the importance of having good input on the abundance of nuclei other than helium. Long aware of the importance of deuterium, Schramm advocated continued study of the abundance of this nucleus. New results from satellite-borne detectors and from ongoing ground-based telescope surveys suggest a higher deuterium abundance for very distant (and therefore old) objects.

Before the advent of mass-produced Z particles, the abundance of primordial helium was an important pointer to the number of possible neutrino types. A revised deuterium figure brings a message for non-baryonic dark matter, but more information is eagerly awaited.

In his talk on neutrino mass measurements, E.W. Otten of Mainz related how the neutrino mass question gained 'pole position' in a survey of open physics questions conducted by the German periodical *Physikalisches Blätter*.

While the mass limit for the electron-type neutrino is steadily being pushed lower, it is in fact the square of the mass which is probed. Many have been worried to see this mass squared coming in negative in a range of different experiments. However now there are signs that this number is approaching zero, said Otten.

A useful reaction is double beta decay, caused by two overlapping nuclear reactions. Michael Moe of Irvine reported that such reactions are now seen in 9 different isotopes, with lifetimes ranging from 10^{19}-10^{24} years.

Solar neutrinos

A whole Neutrino 94 afternoon was devoted to solar neutrinos, with latest measurements from the pioneer Homestake detector (chlorine based), the Kamiokande water Cherenkov detector and the two relative newcomers to the game, SAGE and Gallex, using gallium to be sensitive to neutrinos from proton-proton fusion.

T. Kirsten of Heidelberg reported the latest Gallex result of 79 solar neutrino units, while Vladimir Gavrin of Moscow, for SAGE, reported a slightly lower figure. However with their error ranges the two results are not incompatible. Gallex is calibrating with a neutrino source.

Homestake and Kamiokande, sensitive to less important fusion reactions involving boron-8 and beryllium-7, provide complementary input.

It is difficult to reconcile the levels reported by the different experiments, with their sensitivities to different solar reactions. Trying to correlate the solar neutrino fluxes measured by the Homestake and Kamiokande detectors, theorist John Bahcall of Princeton spoke of a beryllium-7 mystery. Others pointed to a boron-8 problem.

On the theoretical side, controversy and acrimonious exchanges made for a memorable, if not totally informative, end to the solar neutrino afternoon. Some relevant nuclear reactions can be complicated and further study could be useful.

While all experiments see roughly the right level of solar neutrinos, several experimental results, apparently lower than the predicted signal, have been acclaimed as indicating one or other solar neutrino problems. Some researchers, sensitive to the caprices of statistical fluctuations and the careful analysis of errors, maintain that it is premature to talk about a solar neutrino problem and now prefer to speak of an 'anomaly'. However no experiment has ever reported more than its predicted share of solar neutrinos.

So instead of one solar neutrino problem, we now have to live with several - the possible incompatibility of some of the measurements, the theoretical problem of understanding these reactions and making accurate calculations, and the overall discord between theory and experiment.

In his summary talk, Shmuel Nussinov of Tel Aviv looked forward to the advent of two major new solar neutrino detectors, the Japanese Superkamiokande experiment and the Canadian Sudbury Neutrino Observatory using a deuterium target

The stark setting of the Princess Hotel on Israel's Red Sea coast at Eilat, scene of the Neutrino 94 meeting. (Photos G. Fraser)

Electroweak sector

A useful probe of electroweak physics, high energy neutrino beams have provided many milestone results since their introduction in the famous 1962 Brookhaven experiment which discovered the muon neutrino.

The Eilat meeting provided a valuable snapshot of the current status of neutrino physics, with status reports from all directions, from the classical scene at reactors, through laboratory projects, and on to new possibilities for the future, including neutrino beams at CERN's new LHC machine, described by Horst Wenninger. For neutrino astronomy, one newcomer on the scene is the Amanda group installing detector modules in the South Polar ice cap.

However while the new generation of high energy neutrino beam experiments is only just getting underway, new electroweak physics results come in from other sectors. Günter Wolf of DESY described the latest batch of results from the HERA electron-proton collider at DESY, Hamburg, where the 1993 run netted a greatly increased data catch.

The new kinematic regions opened up by HERA give insights into the quark-gluon structure of the proton. Interesting behaviour in the very low x (momentum fraction carried by the struck quark) could need explanation, according to Wolf.

Carlo Dionisi, deputizing for Sam Ting on precision tests of the Standard Model from LEP, showed how the consistency of the data from the 8 million Z particles seen by the 4 LEP experiments gave a top quark mass of 172 GeV $\pm$ 10% (a figure continually being revised). If the polarization data from the Stanford SLC linear collider is included, this rises to 177 GeV.

Atmospheric neutrinos

As well as seeing solar neutrinos, underground detectors also capture neutrinos from cosmic ray interactions in the atmosphere. Originally these were troublesome background in the search for more interesting physics. However three major underground detectors - Kamiokande in Japan, and Soudan and IMB (Irvine/Michigan/Brookhaven) in the US - see that the muon-neutrino content of these interactions is significantly less than expected.

Although heralded as evidence for neutrino oscillations, this result has never really made the science headlines. Perhaps this will now change. At Eilat, Barry Barish, deputizing at the last minute for reviewer Don Perkins, declared that with this effect now seen at three major detectors it is 'unlikely to go away'. 'Other data from these detectors has been accepted, so why not this,' he maintained.

Another question is to decide whether the electron-muon imbalance is due to a shortage of muon-neutrinos or an excess of electron-type. The muon depletion scenario is favoured. The next stage, said Barish, is to check out this effect by comparing terrestrial signals from neutrino beams at two widely-separated points in 'long baseline' studies.

Dark matter and galactic structure

With neutrinos as one of the prime candidates for Dark Matter, accounting for the missing mass of the Universe figures prominently on any neutrino agenda. The traditional evidence for dark matter comes from looking at the rotation of galaxies, where invisible material has to be there to prevent the visible parts from flying apart.

New evidence comes now from gravitational lensing, where otherwise invisible matter in the path of more distant objects distorts their image. Dan Maoz of Tel Aviv showed how new surveys reveal remarkable concentrations of dark matter.

The MACHO and EROS microlensing surveys, which recently reported evidence for dark matter in the shape of small dark stars ('brown dwarfs' - December 1993, page 4), continue their analysis. The MACHO US/Australia collaboration has now also looked at 450,000 stars in the galactic bulge as well as 8 million in the Large Magellanic Cloud and sees new candidate variable signals to supplement the LMC sample. The French EROS survey is now analysing its CCD-recorded data as well as the original photographs, but as yet have no more candidate variable stars to report.

The final day of the meeting looked at evidence and understanding of the large scale structure of the Universe, where irregularities feature even at the largest scales. There seems to be no scale of distance on which the Universe looks uniform. The problem is to account for how such a 'lumpy' Universe emerged from an explosion.

The famous 1991 precision measurements from the COBE satellite of the cosmic background radiation provided the first clues of primordial seeds for such irregularity. However with COBE's job now complete, information accurate enough to help with further understanding calls for a new satellite, said NASA's Charles Bennett.

For the quest to chart the Universe's large-scale structure, George Blumental of Lick Observatory reviewed the status of large-scale structure measurements, where 'pencil' surveys drill deep holes in the sky and find more evidence for cosmic irregularities. This structure has to be reconciled with COBE's microwave ripples. With dark matter lurking below the horizon, the distribution of mass in the Universe may not necessarily reflect that of the visible galaxies, but there are signs that this in fact is the case, said A. Dekel of Jerusalem's Hebrew University.

With astronomical luminosity measurements notoriously unreliable, Gerson Goldhaber described how he and his colleagues have embarked on a search for distant supernovae to provide a 'standard candle' benchmark.

Tsvi Piran of Jerusalem proposed some candidate mechanisms for the mysterious continual gamma ray bursts when neutron stars merge.

But with neutrinos playing a vital role in particle physics and possibly cosmology as well, indulgence in astrophysics at a neutrino meeting is not a luxury.

Neutrino 94 was organized by a committee of physicists from Israeli universities and research institutes under the able chairmanship of Arnon Dar of Haifa's Technion.

By Gordon Fraser

CERN Council pauses for effect

LHC approval a step nearer

First vote for LHC. At the CERN Council meeting on 24 June, 17 of CERN's 19 Member States agreed that the LHC proton collider should be CERN's next major machine. (Photo CERN HI58.6.94/29)

A week of intense diplomatic activity which had high level telephones ringing across Europe culminated in an imaginative and unexpected move on 24 June, when delegates adjourned the 100th session of CERN's governing body, Council, to be reconvened at a later date.

On the Council table was the vote for CERN's next major machine, now universally agreed as the world focus of particle physics research for the start of the 21st century, the LHC proton-proton collider, to be built in CERN's 27-kilometre LEP tunnel, and the largest and most complex scientific joint effort ever undertaken in Europe.

On 24 June, 17 of CERN's 19 Member States voted to include the LHC in the ongoing basic programme of the Laboratory. However two of the major CERN contributors, Germany and the UK, while underlining their strong commitment to the LHC, could not approve the motion as tabled, insisting on prior preparatory work for the budget framework for the coming years, and for a special contribution to LHC construction of the two Host States - France and Switzerland - on whose territory CERN is built. As is usual when such a major project is at stake, several of the 17 approving Member States said their vote was conditional on eventually obtaining a general consensus.

However with the Council session only adjourned and not terminated, this vote will be retaken when the Council reconvenes to conclude its 100th session. This unusual procedural turn of events allowed the players to follow their governmental instructions without dousing the general mood of optimism.

Concluding the initial sitting of 100th session, Council President Hubert Curien said 'there are no major obstacles, but some more effort and a little time is needed' before the vote can move smoothly to a close when the session is reconvened.

The initial lack of unanimity on the LHC vote, while frustrating, is not without precedent, nor was the June session the first time a CERN Council meeting had been adjourned to reconvene at a later date. The December 1951 meeting, where the original motion to establish CERN as an international Laboratory was discussed, was adjourned for several months to allow more countries to vote. Likewise 19 years later, in December 1970, the vote to approve CERN's new Super Proton Synchrotron (SPS - then known as the '300 GeV project') was postponed until February 1971 to allow several more Member States to give their blessing.

In the intense competition for major commitments, individual nations are frequently preoccupied with special situations. This was also the case during the approval procedure for CERN's LEP electron-positron collider in 1981, when after nine Member States had voted in favour in the June Council session, the remaining three fell in line at a special meeting in October.

The interim LHC vote was the climax of a meeting which saw an eloquent plea from CERN Director General Chris Llewellyn Smith -'The LHC is ready for approval now and needs approval now'. Early approval is necessary, he maintained, for several reasons:

- for the advance of particle physics;
- to sustain the project's momentum and to change gear from R&D to preconstruction, as emphasized last year in the report of the LHC External Review Committee;
- to help European industry and its work on LHC prototypes;
- for prudent planning and optimal reconfiguration of CERN resources;
- and to help negotiations with Non-Member States.

With the LHC machine firmly embedded in CERN's unique system of interlocked particle accelerators, so the LHC should form an integral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part of CERN's basic programme in which all partners would collaborate, rather than an optional extra.

With the LHC catering for a world-wide community of particle physicists, potential non-Member State LHC partners play a special role. The world-wide participation in CERN's research programme already provides enormous intellectual input and added dynamism, as well as providing an effective vote of confidence in the Organization.

With LHC, this participation should increase. In December, Council recommended that this increased involvement should be 'on the understanding that usage on a significant scale must involve the provision of resources to suit both CERN and the non-Member States concerned'. Negotiations are underway with Canada, China, India, Israel, Japan, Russia and the USA. Most of these countries sent delegates to the 100th Council session, where they convincingly underlined the case for the LHC and explained how the seeds for their national contributions had been sown.

Particularly visible is the US, where in the wake of last year's cancellation of the SSC Superconducting Supercollider, recommendations (see July issue, page 1) push for additional funds to allow US participation in the LHC. In a rare but memorable US contribution to a CERN Council Session, this was explained by John O'Fallon of the US Department of Energy.

This international involvement would extend to the LHC machine itself as well as the physics experiments, and to machine design as well as funding. Llewellyn Smith, describing the resulting collaboration as European-led with countries in other regions of the world as full partners, said this would provide a 'wonderful development from all points of view, not only scientific and technical, but also human and political, an excellent precedent for future international megaprojects in particle physics and other fields of science'.

LHC and beauty physics

The Standard Model of physics, with its picture of six quarks and leptons grouped in pairs into three generations, is coming under detailed scrutiny as physicists try to understand what makes it work so well. This demands precision probes of all quark channels, rare as well as familiar.

The LHC will be a prolific source of B particles containing the fifth (beauty, b) quark, either in beam-beam collisions or using one of the high energy proton beams in a fixed target set-up. Obvious aims of the B-physics programme at the LHC are to investigate the mixing of neutral B mesons, the particle lifetimes and the spectroscopy of beauty baryons. However the main goal will be the observation of CP violation in the neutral B system (neutral mesons containing b with either d or s quarks).

CP violation - the subtle disregard of an otherwise perfect symmetry of a combined particle-antiparticle and left-right switch - has been known for 30 years and only seen in the decays of neutral kaons. Its origin is still a mystery but it is widely believed to be responsible for the Universe's matter-antimatter asymmetry. The Big Bang initially produced equal amounts of matter and antimatter but the tiny CP-violation mechanism was enough to tilt the balance in favour of matter as we know it.

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

- *colliding beams at the full LHC 14 TeV collision energy (the COBEX project);*
- *an internal gas jet target intercepting a circulating beam at the fixed target energy of 114 GeV (the GAJET project);*
- *a beam extracted from the beam halo by a bent crystal and a septum magnet for a fixed target experiment (the LHB project).*

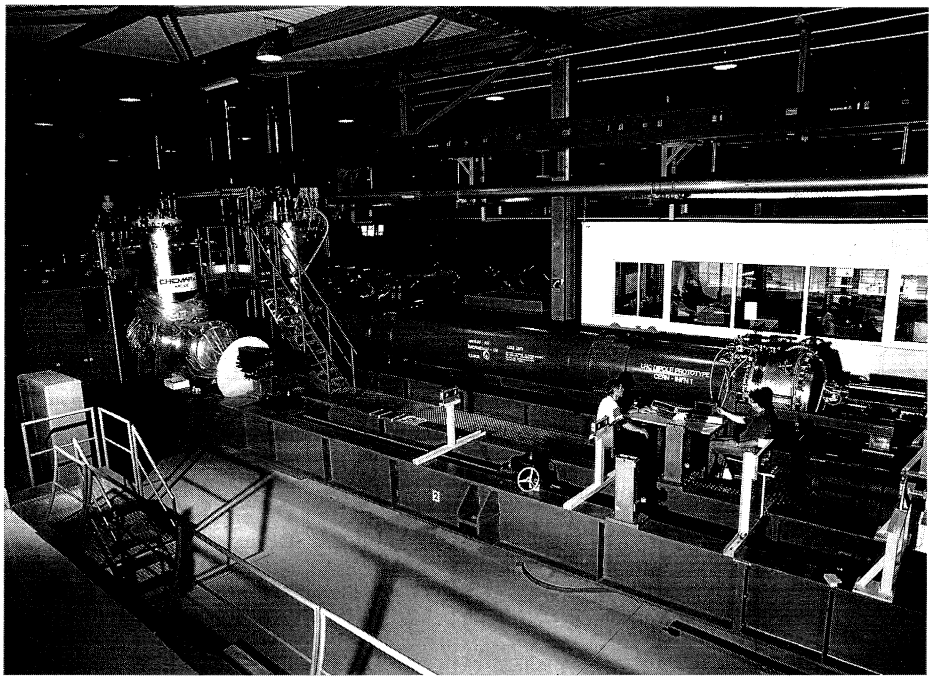
Considering these ideas, the LHC Experiments Committee pointed out that when LHC comes on line, initial measurements of CP violation in the B meson system will have been made by several ongoing projects. The LHC B experiment will therefore be a second-generation study. While identifying attractive features in all three Letters of Intent, the Committee was of the view that an experiment using the collider approach, handling the full production rate, is the most attractive.

The Committee, whose view was subsequently endorsed by the Research Board, encouraged all participants in the three Letters of Intent to join together to submit a fresh design for a collider-mode B experiment.

EPAC impact

European Particle Accelerator Conference report

For CERN's planned LHC proton collider, seven 10 m prototypes dipole magnets have been ordered from industry, and two have already been delivered. Early tests with the first prototype were very encouraging, exceeding 9.5 T, comfortably above the 8.65T design field.



A curtain rose on the current world accelerator stage at the end of June when almost 750 delegates gathered in London for the fourth biennial European Particle Accelerator Conference (EPAC). As well as reports from all major Laboratories on their latest accelerator achievements and future plans, a special session featured invited contributions on high intensity issues while a seminar covered the increasing transfer of technology between Accelerator Laboratories and Industry.

High Energy Physics

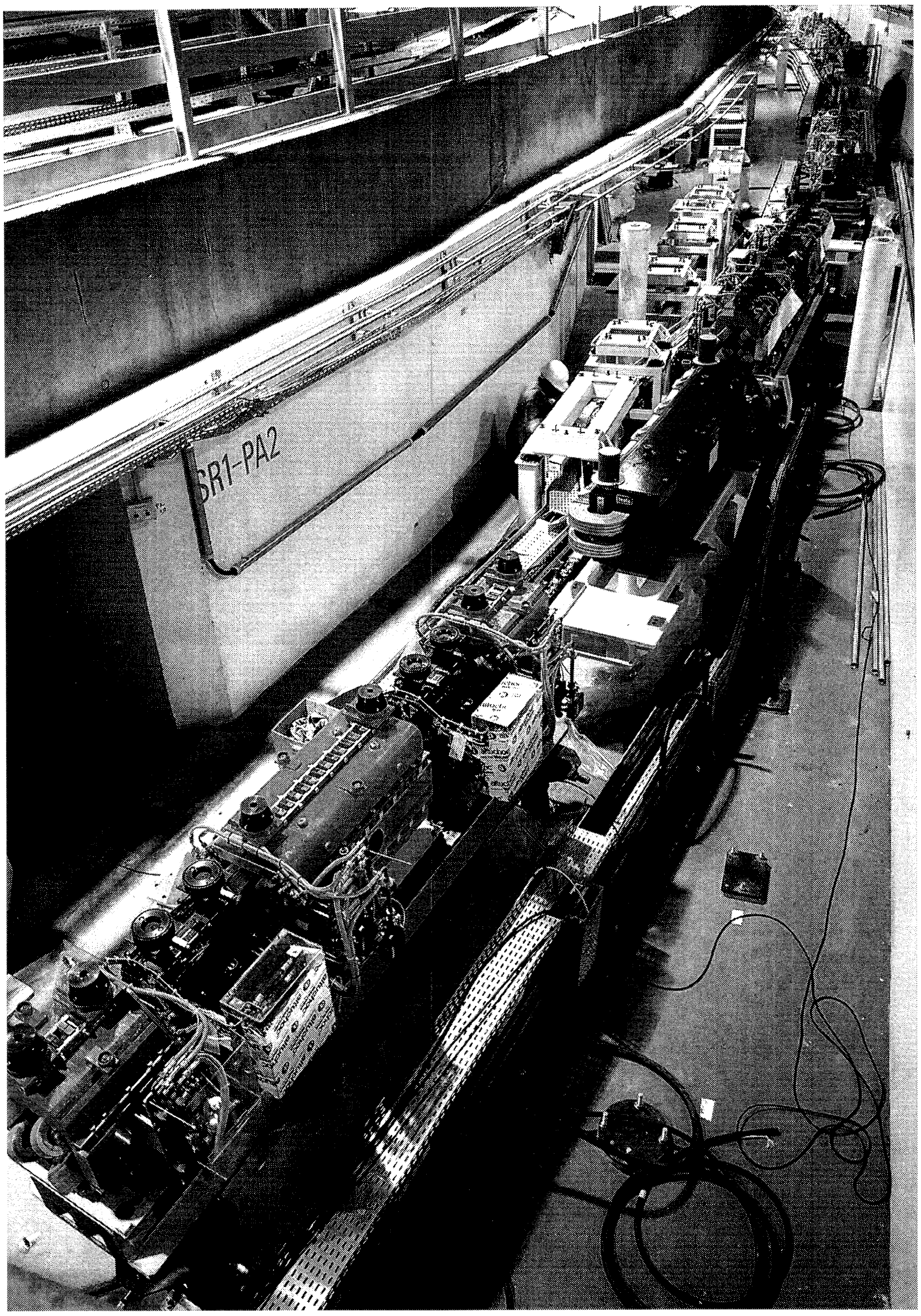
The first invited talk of the conference, by CERN Director General Chris Llewellyn Smith, concerned the future of high energy physics in Europe. Naturally this focused on the Large Hadron Collider project at CERN, which will open up important new physics frontiers for the 21st century.

The LHC will collide two 7 TeV proton beams and reach a luminosity of 10^{34} cm^{-2} s^{-1}. Handling such high energy beams in the 'restricted' circumference of the 27-kilometre LEP tunnel means that superconducting magnets are essential. Dipoles are currently designed to reach 8.65 T and are 13 m long, but specification details are still changing. Of the seven 10 m prototypes ordered from industry, two have already been delivered. Early tests with the first are promising, having exceeded 9.5 T after 15 training quenches.

The electron-proton collider HERA at DESY, Hamburg, is now approaching its performance design values. The luminosity is mainly limited by the amount of stored beam current in each of the two rings. The electron accelerator, which runs routinely at 26 GeV, has a multibunch threshold at 3 mA which can be overcome by using transverse feedback. More than 40 mA has been achieved. The electron beam also suffers from occasional periods of short lifetime, which have been tracked down to microparticles from the sputter pumps being caught in the path of the electron beam. Lowering the high voltage on the pumps has reduced this effect. The beam current limit in the proton ring is mainly due to persistent fields in the superconducting dipoles at injection energy. The difficulty is the time varying nature of these fields which makes compensation challenging. Despite this more than 50 mA has been achieved in 170 bunches.

Although CERN's LEP electron-positron collider has exceeded its design specification in terms of luminosity there are still areas where the performance can be further enhanced, explained Albert Hofmann. One of the limitations is the maximum amount of injected beam current possible. This limit is mainly due to the transverse mode coupling instability. A higher synchrotron frequency will improve this and will become possible when the new superconducting radiofrequency system is installed. Another limitation is the beam energy calibration, fundamental for Z physics. The energy is measured about every ten days but changes faster than this. Tidal effects have been accounted for, but there is still some residual variation. Although models exist for predicting this energy variation, accuracy will be further improved with more frequent energy calibrations.

New peak luminosity records for proton-antiproton collisions have recently been set by the Tevatron at Fermilab (thanks to magnet realignment - see page 42). Despite this success, there are still ambitious plans for increasing the luminosity even further. The collider currently operates at 900 GeV with six bunches of each particle. The luminosity is primarily limited by the



A newcomer to the scene is the European Synchrotron Radiation Facility, ESRF, in Grenoble, France, which has now attained its design goals.

ability to accelerate sufficient antiprotons. Increasing the number of bunches to 36 is expected to increase the luminosity by a factor of ten. Also the cryogenic system is currently being uprated so that the main superconducting dipoles can be run at a lower temperature enabling the collider to run at 1 TeV.

High intensity machines

The conference featured a special session on high intensity issues. The broad definition of a high intensity accelerator is one in which the beam power exceeds 1 MW. In fact one proposal has a beam power as high as 500 MW! The applications for these machines cover such diverse areas as transmutation, satellite recharging and materials research. One such machine is the European Spallation Source (March, page 15), to produce neutrons by smashing protons of up to 3 GeV onto a heavy metal target. The synchrotron will run at 50 Hz with a beam power of 5 MW.

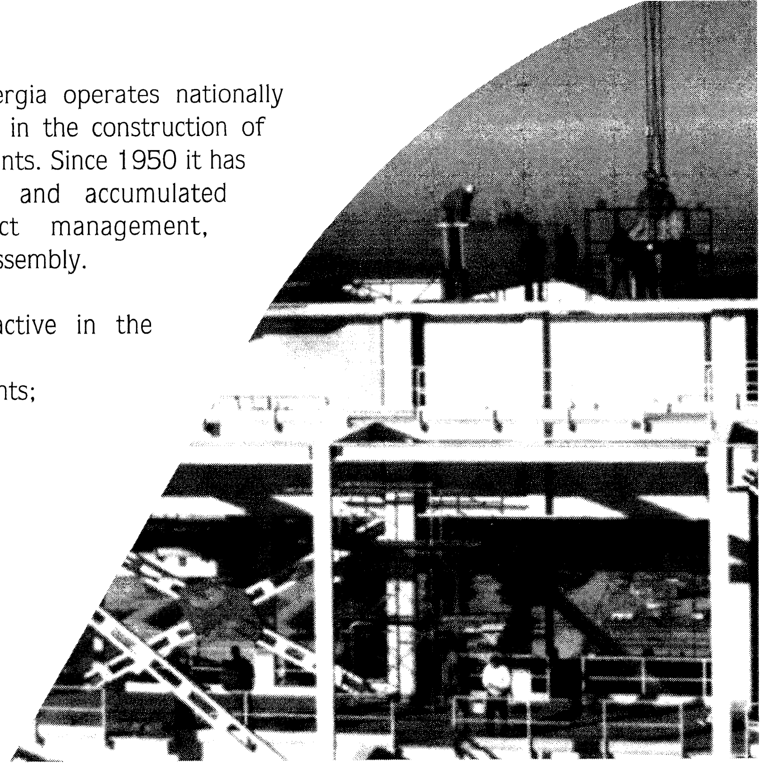
Although most of the intense sources are proton- or ion-based there are also plans for electron accelerators. The B factory proposals, of which two are funded (one at SLAC and one at KEK in Japan), will be used to study B physics in general and CP violation in particular. The factory is based upon colliding electrons and positrons of different energies (around 9 GeV and 3 GeV) with a very high luminosity of 3 x 10^{33}. Such luminosities will be reached by means of very high beam currents and many bunches. The beam current in the accelerators are planned to be between 1 and 3 A in each ring. Such high currents lead to instabilities that can only be solved by longitudinal and transverse feedback.

Photon Sources

One of the highlights of the conference was the series of reports from the latest generation of low emittance synchrotron radiation sources. No fewer than four sources have been commissioned since the previous conference, two in Europe (the European Synchrotron Radiation Facility, ESRF, in Grenoble, and ELETTRA in Trieste) one in the USA (the Berkeley Advanced Light Source, ALS) and one in the Far East (SRRC, Taiwan), and all have been commissioned with astounding ease. In most cases beam has been accumulated within days of switching on, setting new standards for all accelerators. Proposals for at least four more national light sources in Europe were also presented at the conference.

ESRF in Grenoble has now reached all its design goals despite running for more than a year with one of its 224 sextupole magnets connected with the wrong polarity! Almost double the design current of 100 mA has been reached and the beam lifetime of more than 50 hours exceeds the specification by more than six times. An 8 MW uninterruptable power supply is being installed to prevent beam loss due to frequent mains dips caused by lightening strikes.

The Italian ELETTRA light source has been commissioned during the last six months. Already more than 500 mA has been accumulated. The injection linac is run at 1.1 GeV



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A world of experience

At the EPAC conference, UK Astronomer Royal Arnold Wolfendale challenges accelerator specialists to attain energies already available in cosmic rays.

although it has reached 1.25 GeV, however since the ring operates at 2 GeV energy ramping is necessary. Three undulators have been installed and experiments have already commenced.

A similar story is true of the two latest non-European light sources. In the US, the 1.5 GeV ALS now routinely accumulates 400 mA with a lifetime of about 10 hours. The beam emittance has been estimated from an undulator spectral pattern to be 5 nm rad, agreeing well with the theoretical value. The overall operating efficiency of the source during the first four months of this year was over 90%. Taiwan's SRRC began commissioning in February 1993 and has since reached 450 mA, more than double the 200 mA design value. Rapid progress is being made in the installation of undulators and beamlines so that experiments may begin.

As well as synchrotron radiation sources, the Free Electron Laser is also being used as a photon source. There are now two of these operating as full user facilities within Europe, CLIO at Orsay, France, and FELIX, Nieuwegein, the Netherlands, and three more are either funded or proposed. These sources provide continuously tunable infrared wavelengths that are not available from conventional lasers.

Nuclear Physics

The VIVITRON in Strasbourg is now one of three electrostatic accelerators that operate with a terminal voltage of above 17 MV. Although the machine has been designed to go up to 35 MV it presently operates at around 18 MV. The limitation on higher voltages is due to the longitudinal insulating structure of the machine. These problems are being addressed with the use of a single stage 5 MV test generator.

Commissioning of the 4 GeV recirculating electron linac, CEBAF, is well under way even though the facility is still not fully installed (see page 42). The large accelerating gradient of 8 MeV/m has been reached with beam by the use of superconducting cavities, comfortably exceeding the design specification of 5 MeV/m. In all, 338 radiofrequency cavities have been installed and these depend upon one of the world's largest cryogenic systems to cool them to 2 K.

Industrial Links

The ever-strengthening links between accelerator laboratories and industry were highlighted during a seminar on technology transfer issues. In the past industrial firms acquired new techniques and skills when Laboratories passed on detailed specifications of novel devices during procurement exercises. However, in recent times the process has been much more of a collaborative approach. There are several successful examples of firms supplying complete accelerator systems rather than isolated items. For example in the UK, Oxford Instruments collaborated with Daresbury Laboratory to supply and commission the HELIOS X-ray source for IBM's advanced lithography facility at East Fishkill, New York State.

The UK Astronomer Royal, Arnold Wolfendale, brought the conference 'back down to Earth' with an entertaining closing presentation on high energy cosmic rays. The source of these particles, mainly protons, is still unclear though it now seems that those of relatively low energy (10^9 to 10^{14} eV) are galactic whereas those of higher energy maybe extragalactic. The highest energy particle so far observed is 3×10^{20} eV (March, page 17): 'beat that!' Wolfendale challenged the audience.

By Jim Clarke, Daresbury Laboratory, UK

Accelerator Prize

At the London EPAC meeting, the inaugural European Physical Society Interdivisional Group on Accelerators 1994 European Accelerator Prize was awarded to Håkan Danared of Stockholm's Manne Siegbahn Laboratory for having proposed, demonstrated and introduced a method that significantly improves electron cooling of ion beams, and to Igor Syrachev of the Institute of Nuclear Physics, Protvino, Russia for his work in demonstrating efficient radiofrequency pulse compression, satisfying the very high peak power requirements of high gradient accelerator structures.

Around the Laboratories

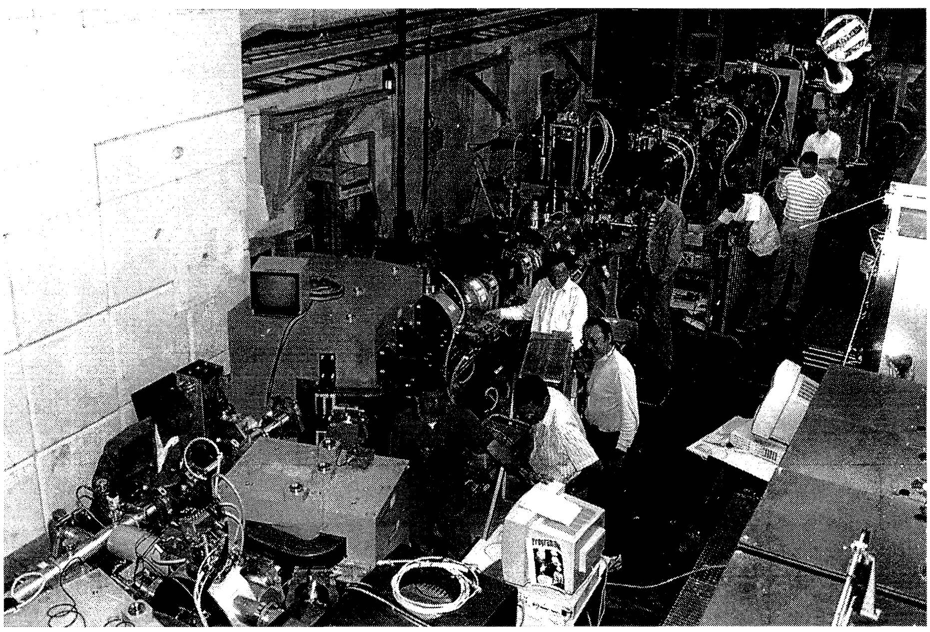
CERN
Lead time

One of the highlights of CERN's ongoing research programme is the Heavy Ion Facility developed by an international collaboration between CERN (infrastructure and 200 MHz RF), France (source), Germany (the Linac and 100 MHz RF), Italy (RFQ and low energy, stripper and filter beam lines), India (software and some vacuum equipment), Sweden and Switzerland.

In the years to come, its beams will extend to still heavier ions the programme which began at CERN in the early 1980s in collaboration with Berkely and GSI Darmstadt and led to a series of studies at the SPS synchrotron using first oxygen and then sulphur nuclei.

It has, as its key component, a new dedicated linac to accelerate highly charged lead ions (March 1992, page 8). Progress in the commissioning of this linac, whose installation has been aided by manpower from the Czech Republic, has been rapid since the acceleration of lead 27^+ ions to 250 keV nucleon in the radiofrequency quadrupole (RFQ) preinjector earlier this year. After installation, alignment and commissioning of the Linac, the first beam at 1.8 MeV per nucleon lead 208 (27^{+}) was observed on 25 May,and steadily increased to reach its design energy of 4.2 MeV/nucleon on 27 May. During all these steps, the energy was checked by an instrument developed in Russia. Finally a stripped beam of $Pb53^+$ was seen on 31 May. In June, 4.2 MeV/nucleon ions were fed into the next accelerator in the chain, the PS Booster, and several weeks later accelerated to 95.4 MeV/nucleon, the energy at which the ions will be fed into the subsequent stage, the PS.

CERN's new lead linac supplied its first beams in May.



SLAC
Final focus on nanometre beams

An international collaboration of physicists working at the Stanford Linear Accelerator Center (SLAC) passed a major milestone in the worldwide effort to demonstrate the feasibility of TeV-scale linear colliders when it produced an electron beam 75 nanometres high during the first dedicated run of the Final Focus Test Beam (FFTB - November 1990, page 11).

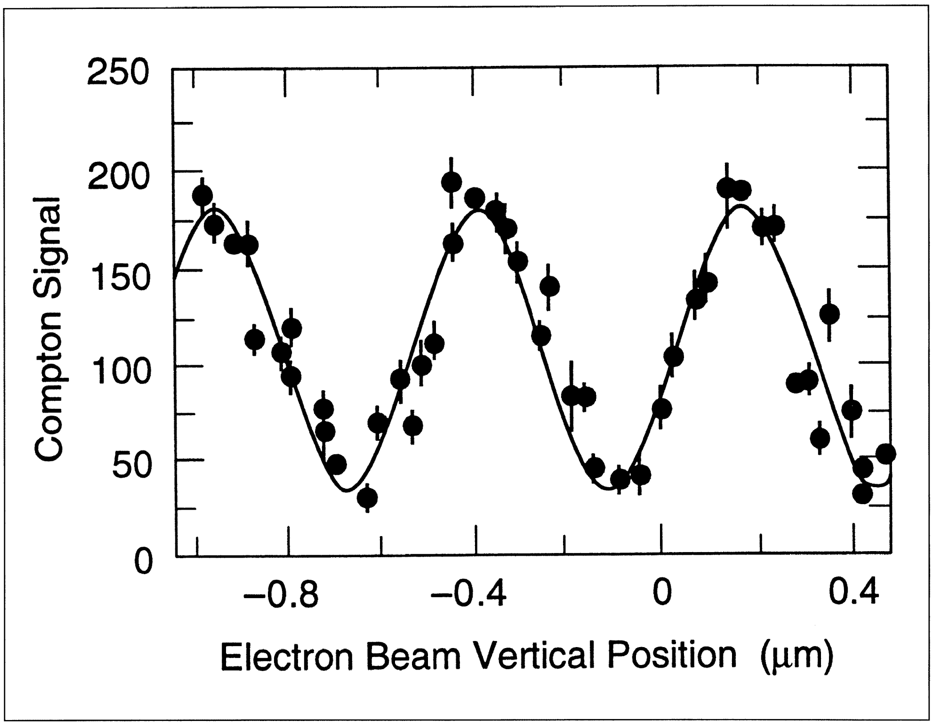
This achievement of beam sizes a tenth the wavelength of visible light proves that the large compression factors required for next-generation linear colliders can indeed be attained and that the challenge of controlling and measuring such narrow beams can actually be met.

Led by David Burke of SLAC, physicists from the Budker Institute (Novosibirsk), DESY (Hamburg), Fermilab (US), KEK (Japan), LAL (Orsay, France), MPI Munich and SLAC completed construction of this test beam in the summer of 1993 and took a brief shake-down run to verify radiation protection systems and the integrity of beamline components.

The first beam studies began in April of this year. New beam-based measurement techniques and precision magnet-movers were used to position magnetic elements to within 20 to 30 microns of their ideal coordinates, and a stretched-wire alignment system monitored movements of these magnets as small as a micron; final checks of the optical properties of this beamline were made using specially designed algorithms.

These tests all showed excellent

Scattering of laser photons by high-energy electrons as the beam is swept vertically across a laser interference pattern. The measured peak spacing agrees with the 500 nanometres expected from the wavelength of the laser light. The modulation depth (valley to peak) determines the height of the electron beam - 73 nanometres this particular case.



agreement with the FFTB design parameters, testifying to the craftmanship involved in the fabrication, installation and testing of its components. In May a low-emittance beam of 46 GeV electrons generated by the damping ring and linac of the Stanford Linear Collider SLC was injected into the FFTB and reduced by a factor of almost 1000 in the vertical dimension, successfully validating many of the principles needed to design focusing systems for future linear colliders.

The actual measurement of such tiny beam sizes was a major challenge. The electron beam is first compressed to a height of one micron, after which it is further reduced by chromatically corrected telescopic sections to the final spot size. Wire scanners like those used in the SLC are used to monitor the micron-size beam, but completely new instrumentation had to be developed to measure beam spots only several tens of nanometres high. Interactions of the densely focused electrons with jets of gas ions injected into the beam path allow rough tuning of the FFTB optics and provide a first estimate of the beam size.

Precision measurement of the smallest spots is made using an optical interference pattern. This innovative technique uses a laser beam, split along two paths and redirected to a common overlap, to create a "target" of light and dark fringes. Laser photons are Compton scattered by high energy electrons as the beam is swept across this pattern; the modulation of this process gives physicists an accurate determination of the beam size.

FFTB experiments continue with the goal of producing 50-60 nanometre beam sizes and developing techniques to control these narrow beams over extended running periods.

PROTVINO Mass-production of scintillator tiles by injection moulding

The technique of the segmented sandwich-calorimeters with wavelength-shifting readout, especially its large-scale application in big detectors, requires enormous quantities of a cheap scintillator tiles of moderate dimensions (20 x 20 cm^2).

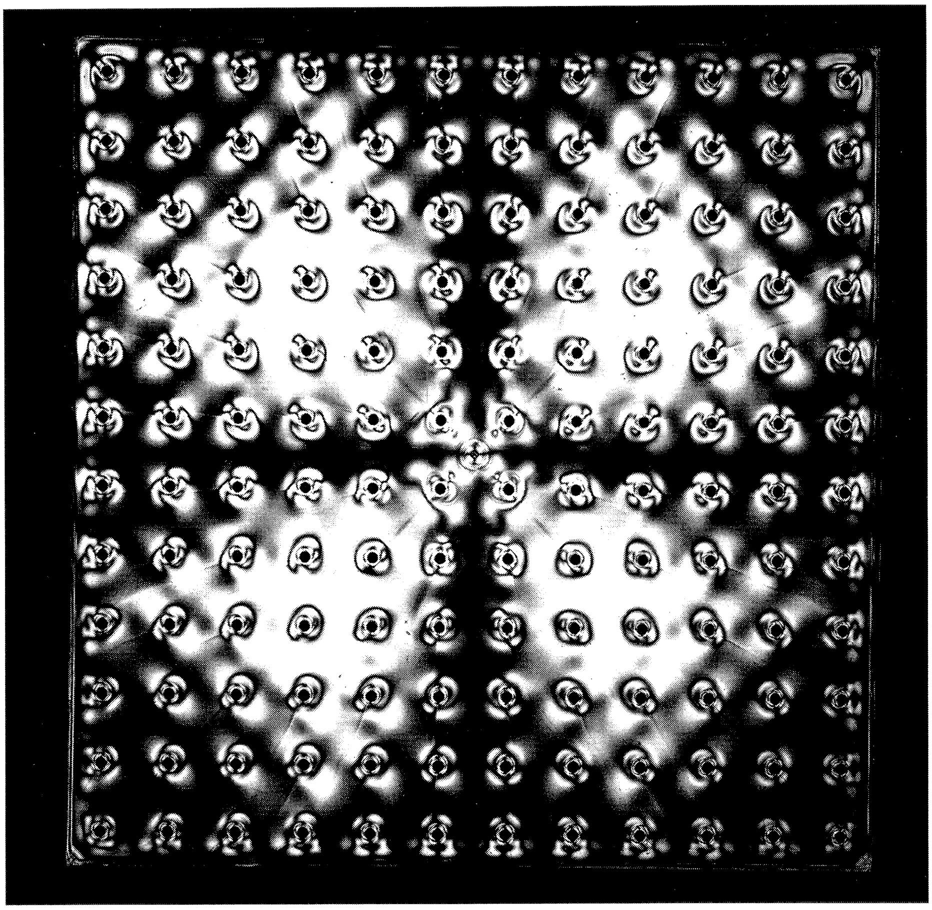
Initial trials carried out in the Institute for High Energy Physics (IHEP), Protvino, Russia almost ten years ago showed that manufacturing such scintillator tiles was possible using an ordinary commercially-available granulated optical polystyrene, an existing technology of plastic dyeing, and a well-known process of the injection moulding, used to produce plastic goods (like buttons!).

More than five tons of such "moulded" scintillator, representing about 150,000 tiles, have been produced at IHEP in recent years, where they were used for the hadron and electromagnetic calorimeters in the "Sphinx" and "Tagged Neutrino" experiments at the 70 GeV IHEP proton synchrotron, as well as in the "NEPTUN" experiment for the future UNK accelerator.

The light output, transparency, and uniformity of the new scintillator is comparable with that of the standard polystyrene-based scintillator manufactured by mechanical cutting and polishing from big blocks, produced by high temperature mass polymerization of styrene. Some important characteristics like aging, radiation hardness are better, not to mention cost and speed of production.

The new technology appeared to be especially suited for "Shashlyk", a

Moulded scintillator tiles with precision-positioned holes are mass produced in Russia for use in the "Shashlyk" sampling calorimeters with wavelength-shifting fibre readout developed recently by IHEP with INR (Moscow), and becoming of increasing interest for new detector applications.



type of sampling calorimeter with wavelength-shifting fibre readout developed recently by IHEP with INR (Moscow), where "perforated" scintillator tiles (see cover photograph, April 1993) with many precision-positioned holes.

The first Shashlyk-type calorimeters are in final phase of the construction and tests for the E-865 experiment at Brookhaven and for the STIC luminosity-measuring electromagnetic calorimeter for the Delphi detector at LEP. More ambitious Shashlyks are in the design stage for the Phenix set-up at Brookhaven's RHIC heavy ion collider and for CMS, one of the major detectors planned for CERN's LHC proton collider.

Recently the other proposed major detector for LHC, ATLAS, has tested a hadron calorimeter prototype with scintillator tiles moulded in sophisticated shapes. These were also produced in Protvino. The technique has also been used for grooved tiles, such as those once considered for the central calorimeter of the SDC detector at SSC.

It is claimed that this techology has not yet been adopted by any Western firm.

GRONINGEN/ORSAY First AGOR beam

AGOR (Accélérateur Groningen-ORsay) delivered its first beam on at Orsay on 12 April. This small-scale superconducting machine, to be used for nuclear physics studies, is the result of a particularly fruitful collaboration between the French Institut de Physique Nucléaire et de Physique des Particules (IN2P3/CNRS) and the Netherlands' Fundamenteel Onderzoek der Materie (FOM).

Built at a cost and on a schedule close to original estimates despite the innovative nature of the project, the facility is shortly due to be dismantled and reinstalled for use at the Kernfysisch Versneller Instituut (KVI) at Groningen, where French physicists will have 20% of the beam time.

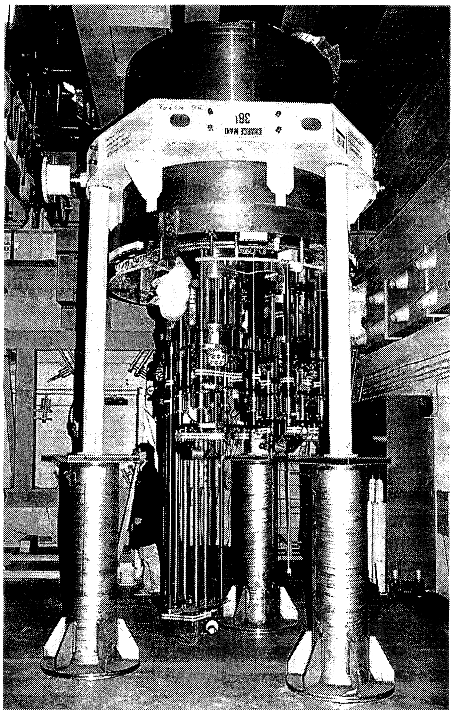
AGOR's debut marked the entry into service of Europe's first superconducting cyclotron, with a beam of double-charged helium atoms accelerated to 200 MeV.

As well as being a second-generation machine, AGOR is the only facility of its type in the world capable of supplying the whole range of ion beams, from hydrogen to the heaviest (lead, uranium) in a very broad energy range, attaining 200 MeV for hydrogen and 6 MeV per nucleon for the heaviest ions.

AGOR's capacity to accelerate beams of light ions such as protons that can be polarized as well as alpha particles has broadened the scope for research into nuclear structure. In the heavy ion field, it supplements a series of European facilities, notably GANIL at Caen and the Gesellschaft für Schwerionenforschung (GSI) at Darmstadt.

AGOR incorporates a number of technological innovations, in particular the use of superconducting coils of niobium/titanium alloy, superconducting at liquid helium temperature (4 K) to produce the magnetic field.

In addition, the superconducting wire is wound round a mandrel and the windings impregnated with resin, *Radiofrequency-equipped insertion for AGOR (Accélérateur Groningen-ORsay). This small-scale superconducting machine, to be used for nuclear physics studies, is the result of a particularly fruitful collaboration between the French Institut de Physique Nucléaire et de Physique des Particules (IN2P3/CNRS) and the Netherlands' Fundamenteel Onderzoek der Materie (FOM).*



a technique which allows the mandrel to be cooled by circulating liquid helium rather than by immersing the coil. This also avoids micro-movements which cause local overheating. High magnetic fields of 4 to 5 Tesla can therefore be achieved over a substantial distance (2 to 3 metres).

Its geometry, based on a design developed at Orsay's Institut de Physique Nucléaire (IPN) at the beginning of the eighties, enables the AGOR accelerator to also handle light ions.

The project was launched at the beginning of 1986 following the signing of the agreement between IN2P3 and FOM in December 1985. Under the terms of this agreement, the facility has been financed by the Netherlands at a cost of 90 million French francs and has been built by French physicists and engineers from IPN who had originally put forward this accelerator concept.

The construction team of about 50 has been supervised by a joint IN2P3/FOM Management Committee and has made extensive use of European industry in such varied fields as computerized control systems, power electronics, precision mechanics, composite materials, superconductivity and cryogenics.

CERN Accelerator School Cyclotrons, linacs and applications

When the CERN Accelerator School (CAS) was set up over ten years ago it was expected that its job of training a new generation of accelerator scientists would slacken off after a few years as recruitment eased back. It has therefore been a puzzle to explain why, a decade later, there is still a steady flow of 200 or 300 participants a year coming to CAS Courses.

The explanation seems to be that the "graduates" are from the many laboratories considerably smaller than CERN and from university physics departments and hospitals where accelerators are used. There are also factories and even production lines where small accelerators are produced.

This year CAS, whose purpose is to help train accelerator specialists throughout Europe and not just for CERN, decided to dedicate its specialist course to the interests of this varied community. The initiative was amply rewarded by the enthusiasm of the 64 participants and the 25 lecturers who came to the course called "Cyclotrons, Linacs and their Applications" in the IBM Centre in La Hulpe just south of Brussels. The location was close to the Catholic University of Louvain la Neuve and the IBA factory where cyclotrons are developed and manufactured. These organizations and the University of Ghent who arranged a visit to their linac, cyclotron and reactor, helped sponsor the course and handled local organization.

Small linear electron accelerators are widely used for cancer therapy, and the virtues of protons and other ions at a few hundred MeV whose sharp Bragg peak concentrates the deposition of energy with millimetre precision are well exploited. Complementing beam therapy is the use of radioisotopes for research, treatment and diagnosis in medicine. Isotope production worldwide is an industry with an annual output worth 1000 million dollars, about a third of which involves production with accelerators. With the number of hospitals with small cyclotrons to produce short-lived isotopes for positron emission tomography (PET) and other techniques mushrooming, factories have set up new production lines.

The catalogue of non-medical industrial and research applications of small accelerators - and this school did not include synchrotron radiation machines - is never-ending. It includes, polymerization, food sterilization, manufacture of micro-mechanisms, and removing noxious pollutants, not to mention ion implantation and semiconductor production.

New applications for intermediate size machines include nuclear waste disposal and energy production from sub-critical assemblies of thorium. In the even bigger league are proposals for linacs for heavy ion fusion. All these, and the various proposals for new spallation sources, tax the ability of the cyclotron and linac builder alike to produce higher intensities in the GeV range.

The next CAS - Basic Accelerator

Physics - will be in September in Austria at Baden-bei-Wien, followed in November by the Joint CERN-US school (this year also including Japan) in Maui, Hawaii with its subject "Frontiers of Accelerator Technology".

May 1995 will see a repeat of the Cryogenics and Superconductivity School near DESY, co-sponsors of this Hamburg event. September 1995 sees the sequel to the Basic Course, now called "Consolidation", to indicate a level less esoteric than the previous "Advanced School". This will be in the charming mountain town of Eger in Hungary.

Further details of these courses may be had by either sending an e-mail to USPAS@FNALV.FNAL.GOV for Maui, or for the Cryogenics and Superconductivity School to CASDESY @CERNVM.CERN.CH or by writing to Mrs. S. von Wartburg at CERN.

E. J. N. Wilson

Free-electron lasers considered for CEBAF

Spinoff development of industrial free-electron lasers is in prospect for an industry-university-laboratory consortium centred at the Continuous Electron Beam Accelerator Facility in Newport News, Virginia, site of the CEBAF 4 GeV superconducting radiofrequency (SRF) accelerator, now being commissioned (see page 42).

Together with several US corporations and universities, the Laboratory is now also addressing the potential of smaller SRF electron accelerators for "driving" free-electron lasers (FELs). The envisioned light sources, with variable wavelength and high average power, would tailor the surface characteristics of polymers, composites, ceramics, and metals for use in manufactured products.

Although conventional lasers have cost and performance limitations, laser light in principle has characteristics useful for industrial surface processing. Its high brightness and coherence can deliver high power densities onto material substrates. Its monochromaticity allows precise matching to typical narrow-band absorption. In short pulses, it modifies surfaces without the counterproductive side effect of bulk heating. Moreover, it is environmentally benign, unlike wet-chemical surface-processing methods that produce large amounts of waste.

A conventional laser typically produces a single wavelength determined by the lasing medium's atomic, ionic, or molecular structure. But an FEL, which electromagnetically manipulates a driver accelera-

Lasers in action. Laser-microroughened polyester surface. (Micrograph courtesy of M. J. Kelley, DuPont.)

CD-Bonn

	Semiconductor	Glass Coating and Industrial Applications	Research and Analysis
ANSI-Flange			
ISO-K Flange		X	
CF-Flange			X
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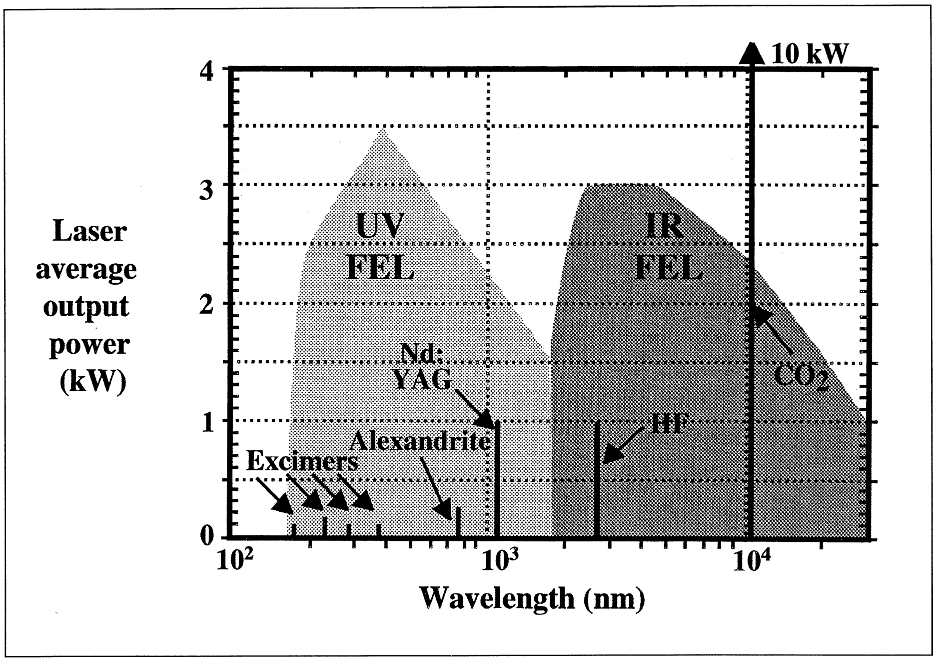
Innovative Vacuum Technology

Average power/wavelength yield for a planned technology-demonstrator free-electron laser by a consortium centred at CEBAF. Conventional excimer, alexandrite, Nd:YAG, HF, and CO_2 lasers have single, fixed wavelengths; the FEL produces a narrow line that can be tuned across the shaded area.



tor's beam of unbound (free) electrons, can be tuned throughout a wavelength range by varying the input electron energy or the electromagnetic field.

With SRF, an FEL would acquire the additional useful characteristic of high average power, thanks to the input beam's continuous-wave nature. SRF's virtual absence of ohmic losses allows high energy efficiency and the transport of high currents. Energy recovery - recycling most of the driver electron beam's energy - would further minimize power consumption and the production of waste heat and radiation. An SRF-based FEL would also deliver a picosecond pulse for precisely tailored energy absorption, as opposed to a conventional laser's tens of nanoseconds.

CEBAF's industrial collaborators expect SRF-based FEL light to prove useful for modifying a given material's near-surface region, making its structure, topography, or chemistry different to the underlying bulk. Often the state of the modified surface would be far from thermodynamic equilibrium. Commercialization possibilities include fibre and polymer film products, composite structures, metal finishing, and microelectronics.

The electron micrograph (page 20) depicts a polyester fabric surface microroughened by deep ultraviolet (248 nanometre wavelength) light from a conventional excimer laser. At this scale - ridges a few microns apart - laser microroughening imparts new friction, wetting, filtration, and appearance characteristics in a polymer film or fibre. If a cost-effective laser system were developed, these characteristics could be exploited commercially in areas such as better adhesion for forming multicomponent film products or composite structures, more effective fibres for use in filters, and improved "feel" in synthetic fibre fabrics. Industry collaborators in the CEBAF-centred proposing consortium include DuPont, 3M, Xerox, AT&T, and IBM. University members are Delaware, Hampton, North Carolina State, Old Dominion, and William and Mary. The consortium has proposed building an FEL user facility at CEBAF. A kilowatt-scale FEL with wiggler magnets for both infrared and ultraviolet output would demonstrate the technology, and an array of user laboratories would allow development of the prospective industrial applications. Based on this work, development would ensue on a scaled-up 50 to 100 kW prototype device for production use at industrial sites.

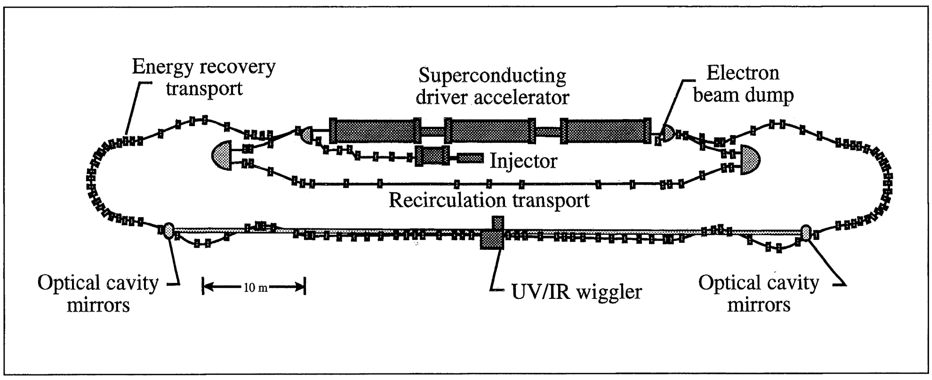
The accompanying graph illustrates the proposed kilowatt demonstrator device's wavelength-tunability and average-power advantages over conventional lasers. Of particular industrial interest are the deep ultraviolet wavelengths (below about 350 nanometres). To be fully realized in the 50 to 100 kilowatt scale-up is a cost per photon below a penny ($0.01) per kilojoule - a tenth to a hundredth of that for conventional lasers, and well within manufacturers' cost-effectiveness constraints.

The accompanying diagram shows the kilowatt demonstrator FEL system concept. An electron beam originates in a high-voltage DC gun (under construction at CEBAF) with a photoemission cathode. The beam then transits a two-cavity SRF quarter-cryomodule, reaches 10 MeV, and enters the driver accelerator, an array of three cryomodules containing a total of 24 cavities. Using recirculation transport arcs for a second pass, the driver accelerates the beam to an FEL input energy of up to 200 MeV.

Next the relativistic accelerated electrons undulate transversely in the sinusoidal magnetostatic field of either the infrared or the ultraviolet wiggler. The resulting light output is initially spontaneous emission, but the light bounces back and forth inside an optical cavity until it is amplified to saturation. The light is sent via optical beamlines to user areas for industrial applications development.

Typically about 1% of the electrons' energy is converted to light. The remainder undergoes energy recovery, being returned to the SRF cavities, where most of it is converted back to RF power at the cavities' resonant frequency. The decelerated beam is then dumped. CEBAF demonstrated energy recovery during a 1992 SRF recirculation experiment.

Although FELs have shown substantial promise for basic research, the CEBAF effort would be the first US attempt to introduce FELs in manufacturing. US National Aeronautics and Space Administration (NASA) head Daniel Goldin, recognizing potential SRF-based FEL applications for aerospace, sponsored a March 1994 peer review of this proposal. A panel of industry, accelerator, and light-source experts confirmed industry's need for the technology and strongly endorsed the consortium's approach.



The kilowatt demonstrator free-electron laser, with beam recirculation, energy recovery, and both infrared and ultraviolet output.

Computers go APE

A supercomputer is - in a nutshell - an enormously powerful computer. The APE (Array Processor Experiment) 100 supercomputer developed by Italy's National Institute for Nuclear Physics (INFN) performs one hundred billion arithmetic operations per second - around one hundred thousand times the speed of a personal computer, or ten thousand times the speed of the kind of workstation used by design engineers or many research labs.

This huge increase in performance opens the way to many applications inconceivable with a normal computer, such as simulating the behaviour of the earth's atmosphere to study climate change, or simulating the combustion process in a large power plant and observing in detail the development of each chemical reaction to obtain accurate estimates of pollutants.

Supercomputers also make it possible to create "virtual laboratories." Rather than analysing the aerodynamics of a vehicle or an airplane by building a model and studying its behaviour in a wind tunnel, with a supercomputer the airflow can be simulated. The test can easily be repeated whenever a design change is made, without having to build a new model.

Why have physicists studying elementary particles become involved in designing supercomputers? These machines are used in particle physics research to simulate the behaviour of quarks, the ultimate components of the atomic nucleus. The behaviour of quarks inside a proton, like that of airflow around a vehicle, is governed by relatively simple mathematical equations, but to date it has not been possible to obtain their complete solution.

This is where supercomputer simulation comes in, and in 1984 a team of Italian theoretical physicists associated with INFN embarked on a project to design a supercomputer. It was the inception of the first APE project, followed in 1988 by the APE100.

The APE project was conceived because computers with the desired performance were either not available, or available only at prices running into tens of millions of dollars. APE was a world pioneer in the field known as parallel computing, which attains extremely high performance by harnessing together a large number of computing units similar to those used in workstations.

The APE team devised a new construction architecture that allows more than 2000 computing units to be run in parallel at maximum efficiency, and a special microprocessor giving an extremely compact assembly. The APE100 supercomputer, with its 100 GFlops, the most powerful ever built anywhere in the world, fits into the equivalent of just four standard electronics racks.

The APE project is a fine example of how the results of advanced research can be transferred to industry. Alenia Spazio (a subsidiary

Physics monitor

of the Finmeccanica Group well known in the physics world for Ansaldo's superconducting magnets and radiofrequency cavities) acquired the design licence in 1992 from INFN and markets the machines under its Quadrics label. Alenia Spazio has around twenty orders for Quadrics machines to date, and has already delivered around ten to end-users.

Half these orders have come from Germany - an important sign of the recognition this Italian technology is gaining. A second interesting aspect is that the total computing power of APE/Quadrics machines either built or on order exceeds that currently installed in all supercomputing centres in Europe or in Japan, and is a close second to the total installed capacity in the United States. This clearly offers a great opportunity for promoting supercomputing applications in Italy and across Europe to attack the many industrial and research problems which can only be solved efficiently by these new techniques.

By Nicola Cabibbo

(As well as being a distinguished theoretical physicist, Professor Cabibbo is a former President of the Italian INFN and is now President of ENEA, the Italian agency for energy research and technological innovation. He was leader of the APE project.)

POLARIZED BEAMS 1 - Longitudinal electron spin polarization at HERA

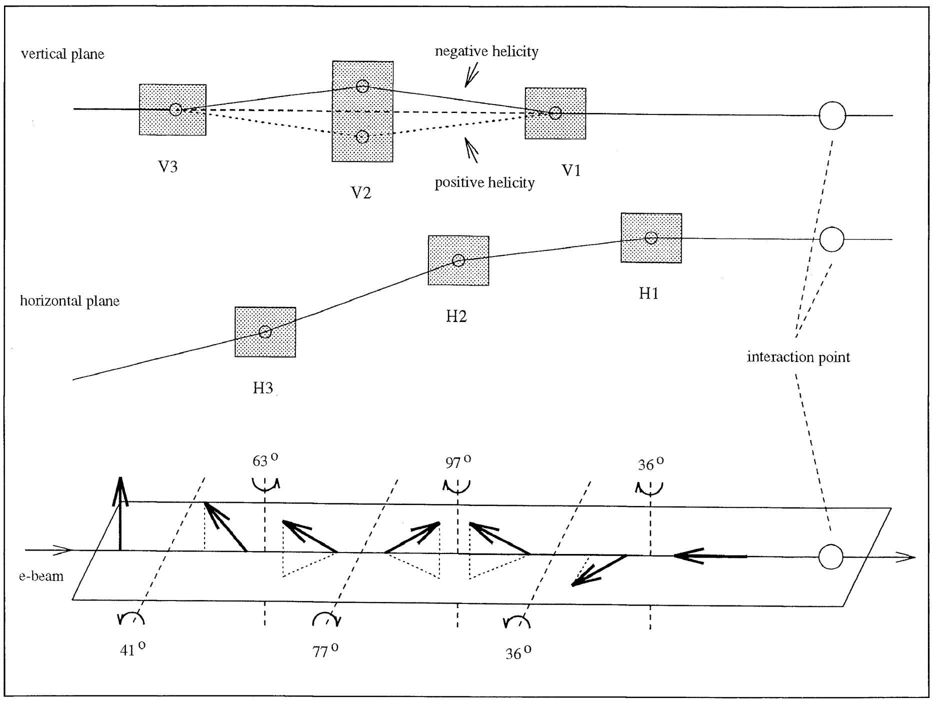
Wednesday 4 May marked a turning point in the art of the manipulation of spins in electron storage rings: longitudinal electron spin polarization (with the spins oriented along the electrons' direction of motion) was established in the electron ring of HERA, the electron-proton collider at DESY in Hamburg.

A polarization level of about 55% was obtained and polarizations of over 60% were reproducibly obtained in the following days. The beam energy was 27.52 GeV, corresponding to half integer spin tune of 62.5.

This is the first time in the history of high energy electron storage ring physics that the naturally occurring transverse spin polarization has, with the aid of spin rotators, been converted to longitudinal polarization. This opens up a wide new range of physics opportunities at HERA from spin structure functions to precision tests of the standard model of electroweak interactions.

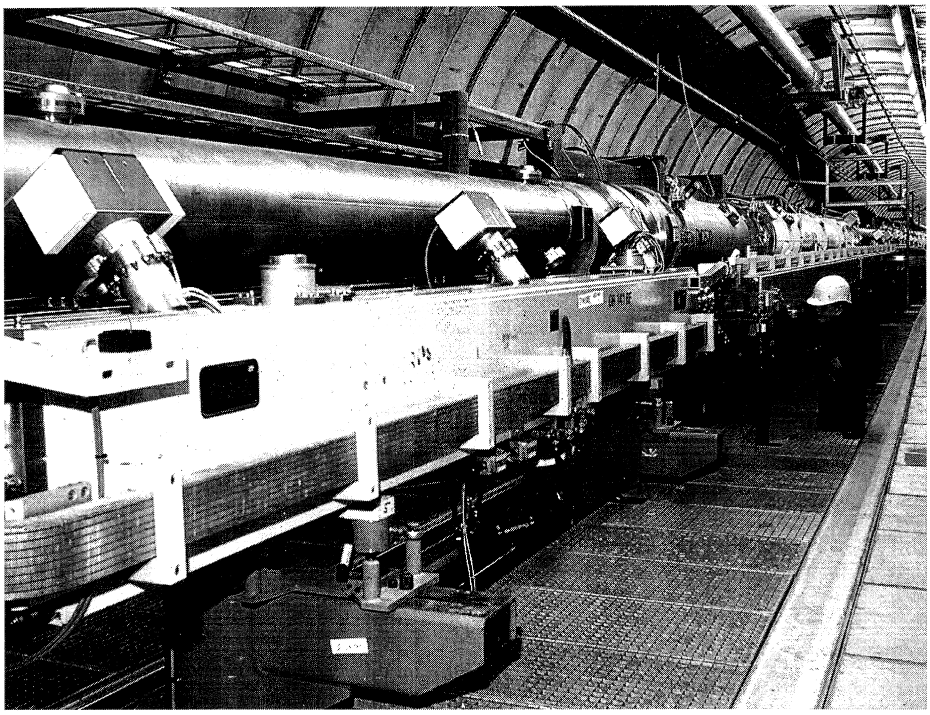
In electron storage rings the synchrotron radiation emitted as electron beams are bent by vertical guide fields can cause the spins to point opposite to this guide field direction. This effect was predicted by Sokolov and Ternov in the early 1960s. Initial (transverse) polarization was seen in HERA seen after commissioning (March 1992, page 18).

For longitudinal polarization, the equilibrium polarization direction must be rotated from vertical (in the arcs) to longitudinal just before the interaction region and then back to the vertical just before the arc. This provides the best of both worlds: the Sokolov-Ternov mechanism, which is only efficient if the equilibrium spin direction is in the bending field



How to handle spins. Schematic view of the HERA MiniRotators showing: (top) how a rotator manipulates the beam entering from the arc, and (below) how it manipulates the polarization direction so as to tilt the polarization into the horizontal with a minimum of design orbit distortion.

The MiniRotator magnets downstream of the HERMES experiment. In the foreground one can see the remotely controlled magnet supports and in the background the vertical bend in the beam is clearly visible.



direction, is maintained and the polarization is longitudinal at the interaction point.

The spin rotation is most efficiently produced by dipole 'spin-rotators' - strings of interleaved horizontal and vertical bending magnets. At high energy, the spin precession in a dipole magnet is much larger than the orbit deflection, the factor being 62.5 at the HERA energy of 27.5 GeV.

The design adopted for HERA is the 'MiniRotator' scheme of the late Klaus Steffen of DESY and Jean Buon of Saclay.

In this particularly elegant design, each rotator is only 60 m long (so that no focusing quadrupoles need to be included) and replaces a piece of the existing (curved) lattice.

The spin manipulations take place at the HERA revolution frequency of 47350 Hz for each of the 210 electron buckets. The rotator magnets, built and tested some years ago, were installed in the 1993-94 shutdown. As well as being short, these MiniRotators operate over the energy range 27 - 35 GeV by varying the magnetic fields and the geometry. In particular, each rotator is mounted on remotely controlled jacks so that by reversing the fields in the vertical bending magnets and inverting the vertical bend geometry, the longitudinal polarization at the interaction point can be reversed between electron fillings.

The jubilation can be better understood after looking at the nature of the depolarizing effects in an electron storage ring. Only about 10^{-10} of the synchrotron radiation power causes spin flip - the rest tends to randomize the orbital electron motion in the magnetic fields. This is a potential source of strong spin diffusion or depolarization. Depolarization can be particularly strong if the machine is insufficiently well aligned so that the equilibrium polarization direction is tilted by a few degrees from the vertical in the arcs. For that case special 'harmonic bump' schemes have been developed to correct the closed orbit and hence the tilt.

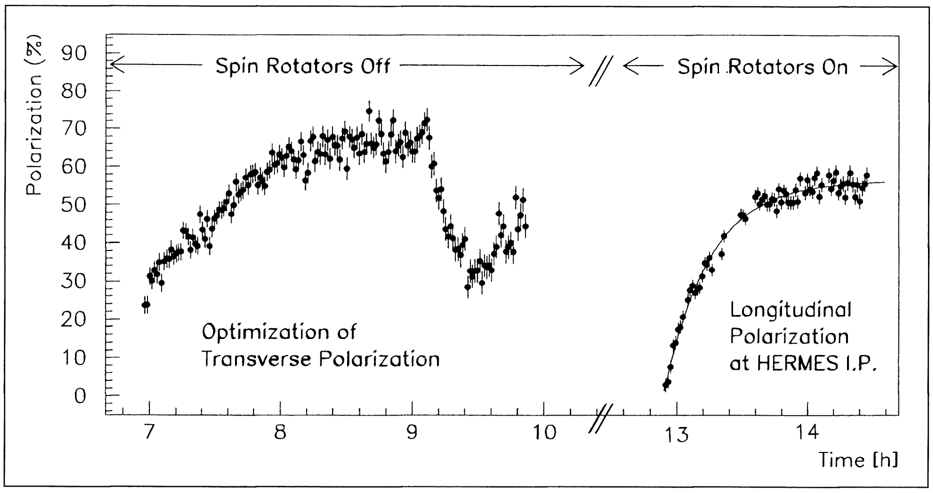
If there are places where, with the aid of spin rotators, the spins lie in the horizontal plane, as for example in the case of longitudinal polarization, one is really asking for trouble. Fortunately, a technique, 'spin matching', is available whereby the machine optic as defined by the quadrupole strengths can be arranged to strongly suppress spin diffusion. This procedure is greatly simplified by the absence of quadrupoles inside the rotators.

However, realistic calculation of depolarizing effects is notoriously difficult. Thus despite some predictions that depolarization could be controlled, it has long been an open question whether longitudinal polarization could indeed be achieved.

It is therefore remarkable how rapidly longitudinal polarization was obtained: the transverse polarization was optimized to about 65% with the rotators off on 3 May; in the morning of 4 May the spin rotators were moved to the 27.52 GeV position; electrons were injected at noon, accelerated to 27.52 GeV with an optic spin matched for 27.52 GeV. By early afternoon a longitudinal polarization of about 55% had been achieved and champagne flowed in the HERA control room.

As with the earlier measurements, these were carried out by a collaboration from the HERA Machine Group, the HERMES Collaboration and the ZEUS Collaboration, and the transverse polarization measured using the Compton polarimeter installed in HERA West (the size of the polarization is the same at all positions in the ring). With the rotators on, any significant deviation of the polarization from the longitudinal direction in HERA East would result in strong depolarization.

On the left: the HERA transverse polarization build up curve during optimization with the harmonic orbit bumps. On the right: the first polarization build up curve measured after the rotators had been activated for the first time and the beam ramped to 27.52 GeV.



With longitudinal polarization the way is clear for the HERMES experiment to investigate the spin structure of nucleons using an internal polarized gas target. Two more pairs of rotators are now on order for the H1 and ZEUS experiments for physics with longitudinally polarized electrons.

With this success longitudinal electron spin polarization in high energy storage rings has become a reality and a new tool for physics at storage rings created.

2 - Partial Siberian Snake rescues polarized protons at Brookhaven

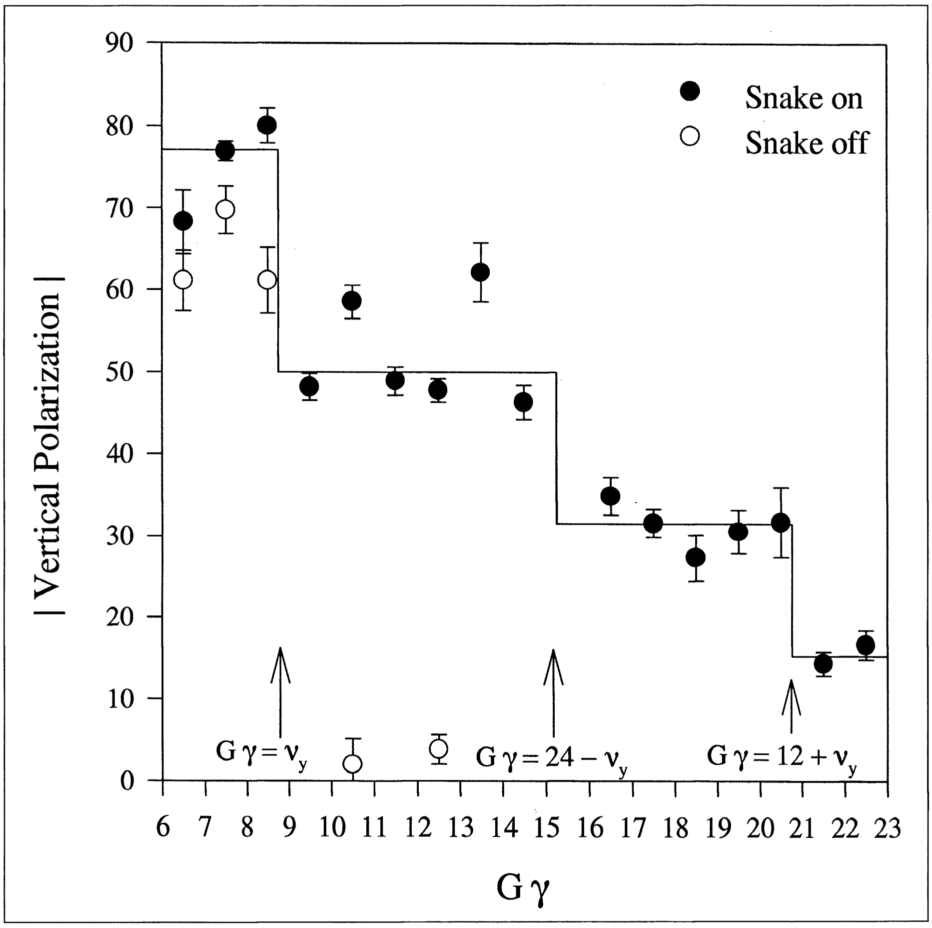
To boost the level of beam polarization (spin orientation), a partial 'Siberian Snake' was recently used to overcome imperfection depolarizing resonances in the Brookhaven Alternating Gradient Synchrotron (AGS). This 9-degree spin rotator recently permitted acceleration with no noticeable polarization loss.

The intrinsic AGS depolarizing resonances (which degrade the polarization content) had been eliminated by betatron tune jumps, but the imperfection resonances were compensated by means of harmonic orbit corrections. However, at high energies these orbit corrections are difficult and tedious and a Siberian Snake became an attractive alternative.

A Siberian Snake is a magnetic device which rotates the spin of a particle by 180° about an axis in the horizontal plane. The idea was first proposed by Novosibirsk scientists in 1974. The Snake can use either solenoidal magnets or a combination of transverse dipole magnets which produces only local orbit distortions.

For a low energy synchrotron, such as the Brookhaven AGS, transverse Snakes are not feasible because of the large apertures required for the dipole magnets. Therefore a solenoidal Snake is the only solution. However, the solenoid introduces a sizable linear betatron coupling, so the operation of a full Snake is difficult without proper corrections.

Beam polarization at Brookhaven's Alternating Gradient Synchrotron (AGS) has been boosted using a 'Siberian Snake' to overcome troublesome depolarizing resonances, three of which are shown here. The middle resonance was accidently located at the transition energy during this experiment. This can be avoided by shifting the tune.



At an Argonne seminar marking the 30th anniversary of the startup of the Zero Gradient Synchrotron (ZGS), Tom Fields and Roger Hildebrand (Chicago), two former Directors of Argonne's High Energy Physics Division, look over memorabilia from the ZGS research programme.

But this is not possible in the AGS because of the short straight sections. A solution to this problem was proposed by Tom Roser: overcome only the relatively weak imperfection resonances with a 9° partial Snake.

Although there have been many Snake experiments at the Cooler Ring of the Indiana University Cyclotron Facility (IUCF - January 1990, page 20), that ring is limited to a maximum kinetic energy of 500 MeV and the imperfection resonances at the IUCF are strong enough to induce complete spin flip by themselves. Thus a Snake experiment at the Brookhaven AGS is important to confirm the applicability of the partial Snake in a more demanding situation.

The 9° partial Snake was tested by an Argonne/Brookhaven/Fermilab/Indiana/KEK/TRIUMF collaboration led by S.Y. Lee of Indiana and Tom Roser of Brookhaven. Installed in an AGS 10-foot straight section, it had an effective length of 2.286-metres and total of 402 wire turns. The Snake could be ramped to 4.7 T-m in about 0.6 seconds and produce a 9° rotation up to 25 GeV. With beam accelerated up to 10.7 GeV, the Snake eliminated polarization loss as the beam passed through 18 imperfection resonances: the only losses were due to the three uncorrected intrinsic resonances in this energy range.

The intrinsic resonances could be overcome using a fast betatron tune jump. (The fast tune-jump quadrupoles were not energized during this experiment.) Another possibility is to pass through the intrinsic resonances slowly enough to allow complete adiabatic spin-flip. It may also be possible method to excite coherent betatron oscillations during the intrinsic resonance crossing followed by transverse damping. Experimental studies are planned.

The AGS partial Siberian Snake will allow the study of spin physics to be extended to polarized 250 GeV proton collisions in the RHIC ring now under construction at Brookhaven. This exciting and unique possibility should provide detailed information on the quark-gluon spin structure of the proton, allow for detailed QCD tests, and provide a sensitive and unique approach in the search for new physics.

by Haixin Huang

ARGONNE ZGS symposium

A symposium at Argonne on May 6 marked the 30th anniversary of the startup of the Zero Gradient Synchrotron (ZGS), the 12GeV weak focussing proton synchrotron with uniform magnetic bending field which operated from 1963 to 1979.

While a previous symposium had been held when the ZGS was turned off in 1979, the latest meeting provided an opportunity to examine its longer term legacy in several areas - applications of accelerator technology, further development of associated technologies (notably superconductivity), high energy physics and the subsequent accomplishments of the skilled teams that worked in the programme.

The ZGS was the basis of the first major science programme at Argonne that did not stem from the reactor science and technology that had been the *raison d'être* of the Laboratory since Fermi's first reactor in 1942, as was noted by Laboratory Director Alan Schriesheim in his opening remarks. The ZGS programme was also a pioneer in developing the organizational structure that is now normal in "big science" - strong user involvement in both the physics exploitation as well as strategic decisions.

The uniform ZGS magnetic field opened the attractive possibility of accelerating polarized protons and a

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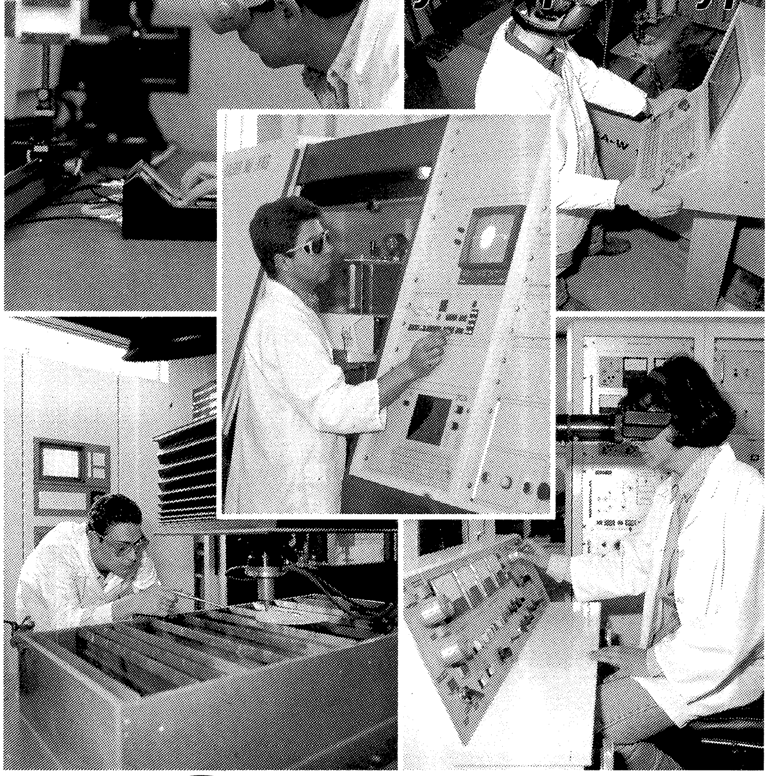

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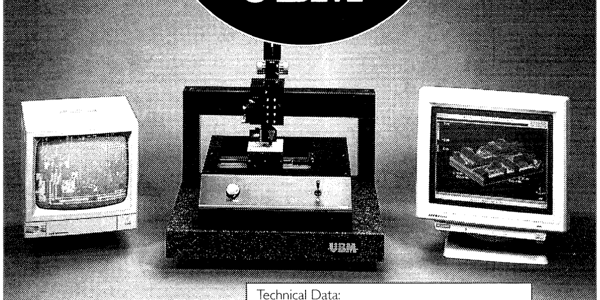

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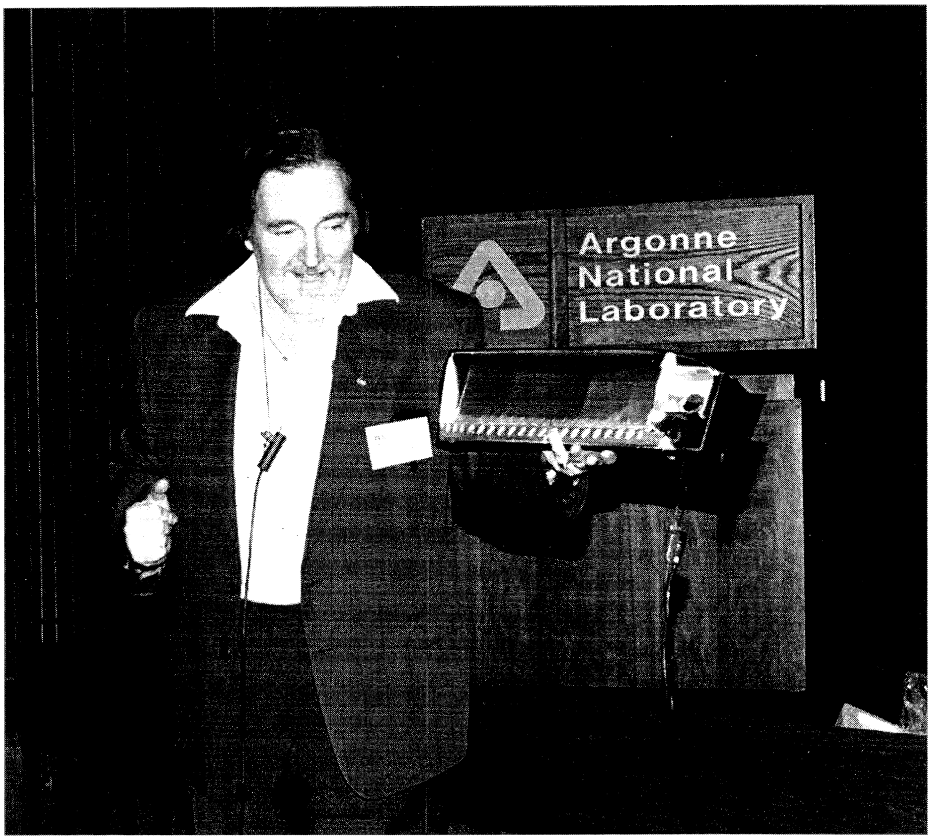
Particle physics spinoff - at an Argonne symposium Earl Swallow (Elmhurst College) shows the innards of a Ford Thunderbird tail-light assembly that uses a set of light-emitting diodes and compound parabolic concentrators.



full energy polarized beam was achieved in 1973. Most of the experiments in the last years of the accelerator used this unique capability. Alternating gradient machines pose a more difficult challenge, with many depolarizing resonances to be crossed during the acceleration cycle. Now, with the application of Siberian Snakes in which the polarization is continually flipped, the effects of depolarizing resonances that span many turns can be cancelled. This invention has revitalized interest in this physics, as was pointed out by Alan Krisch in his review of polarized proton beams. Ongoing work aims to provide polarized proton collisions in Brookhaven's RHIC heavy ion collider and to polarize the proton beam at Fermilab's Tevatron.

One of the continuing ZGS legacies at Argonne is the IPNS spallation neutron source that continues to operate after 13years and 9 billion pulses. It uses ZGS injection system to produce a short beam of 500 MeV protons on a uranium target. Jack Carpenter reviewed the somewhat tortuous developement activities that started in 1968 and resulted in a successful user facility. Notable amongst many scientific applications is the recent investigation of the structure of high temperature superconductors.

Argonne has had a long history of neutron diffraction studies, starting with the first reactors in the 1940s but accelerator-based sources had many potential attractions. Although IPNS was funded as an experiment to test the effectiveness of this neutron scattering route, a more ambitious "green field" source has so far not been funded in the US. There are several such sources elsewhere, notably the ISIS machine at the UK Rutherford Appleton Laboratory.

A number of design studies are currently underway in Europe,in Japan and in the US for much higher power facilities. The Argonne design builds on the IPNS but uses the ZGS ring building to house a 2GeV accelerator, saving $100M.

Yang Cho discussed several designs that the ZGS accelerator group have carried out since 1979. This group provided many members of the team that designed and built the Advanced Photon Source, the 7GeV synchrotron light source that is now nearing completion. This powerful X-ray facility will be a successor to the ZGS, catering for a large community of outside users.

Other accelerator applications in which Argonne specialists have played a role were reviewed by Ron Martin, former head of the ZGS Accelerator Division. Many of them exploit non-Liouvillian charge exchange injection. The basic idea was suggested by P.B. Moon in Birmingham in 1956, taken up in Novosibirsk and used for the first time as a routine injection system on the ZGS in 1970. Negative hydrogen ions were accelerated in the linac and stripped in a foil. The resulting beam was 100 times brighter and its stability was much improved. The technique is now standard for high energy proton accelerators and is also used for spallation sources and proton therapy machines.

Gale Pewitt, who had been in charge of construction of the 12ft bubble chamber - the first hydrogen-deuterium chamber to study neutrino interactions, discussed the pioneering development of superconducting magnets at Argonne. The group first built a 25cm bore magnet that pioneered many features that later became standard. In particular the windings used a cable made of niobium-titanium superconductor and copper, thus providing many parallel current paths, good stabilization and a twisted conductor. This magnet, designed by Charles Laverick, operated at 4.4T in 1964 and is now in the Smithsonian Institution, Washington D. C. .

Following this, it was natural to design a superconducting magnet for the 12 ft bubble chamber. The capital costs of a conventional or supermagnet were about the same, but the operating costs strongly favoured the latter. The decision was made in 1966 and the resulting magnet, with a 16ft diameter room temperature bore, proved the new technology on the largest scale. In the early 1980s the magnet was reused for the High Resolution Spectrometer at SLAC's PEP ring.

John Purcell,who led the 12ft bubble chamber magnet group, went on to build the coil for the Fermilab 15ft chamber.Other members of the group, notably Henri Desporte and Bert Wang, went on to apply this technology elsewhere. Large superconducting magnets are now a standard industrial product used in magnetic resonance imaging, in energy storage and in ore separation, amongst other applications.

A significant non-accelerator device, the Compound Parabolic Concentrator, a non-imaging concentrator of light, was reviewed by Earl Swallow. This was invented in 1965 by Roland Winston of the University of Chicago as a way of minimizing the number of phototubes needed in a Cherenkov counter array. "Winston Cones" have been used in many subsequent experiments in several fields of science but they have also found major application in nontracking solar concentrators. Concentrations as high as 84000 have been measured.

Perhaps the most dramatic incident at the meeting was when Swallow demonstrated a rear light assembly of a Ford Thunderbird car that uses a set of LEDs and associated CPCs - a remarkable spinoff from a high energy physics experiment!

Argonne high energy physicists have continued doing experiments at Fermilab,PEP,HERA and other accelerators. Many technical contributions have been made, notably in the calorimeters for HRS at PEP, CDF at Fermilab and ZEUS at HERA, as was reviewed by Brian Musgrave.

The interest in neutrino physics that started with the first study of neutrino interactions in hydrogen and deuterium using 1 GeV neutrinos from the ZGS has continued and is now focussed on electron-proton collisions in the ZEUS electron-proton collider at DESY, Hamburg.

Lower energy neutrinos are still under investigation at Argonne , the particles coming from cosmic ray interactions in the atmosphere and the detector being the Soudan nucleon decay detector in Minnesota. A proposed future experiment with this detector involves directing a neutrino beam from the Fermilab main injector to Soudan, a distance of 730km, to search for neutrino oscillations.

Although at its peak the ZGS program represented about a quarter of Argonne's total activity, the Laboratory took the termination of the programme in its stride by initiating important new projects in related areas of research and technology, building on ZGS successes where possible. Much of this activity relied heavily on the skills and resilience of the people who had worked on the ZGS.

CHARM2000

The fourth quark, charm, may not hit the headlines these days as much as its heavier cousins, but it has still a lot of physics to give. From June 7-9 over 100 attendees heard 35 plenary talks at Fermilab on the Future of High-Sensitivity Charm

How sensitive can one be to charm? Participants at the Fermilab CHARM 2000 workshop look at a possible extrapolation.

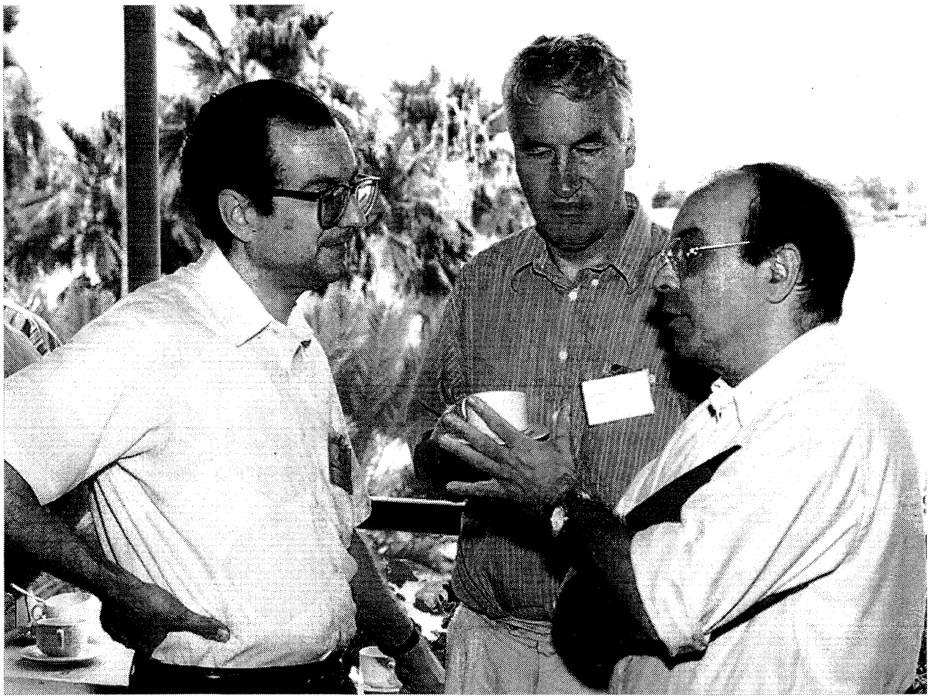
Experiments. Twelve working groups focused on the physics opportunities and technical challenges. Speakers representing the CLEO (Cornell), BES (Beijing), SLAC B-Factory, Fermilab E653, E687/831, E769/791, E781, and CERN WA82/92 and WA89 collaborations reviewed the current status and future prospects.

Exponential growth in charm sensitivity during the past decade, along with the rapid pace of advance in technology and computing, suggests the goal of 10^8 reconstructed decays (three orders of magnitude beyond current samples) for an experiment to run at the turn of the millenium.

This served as a unifying theme for the diverse areas of charm physics surveyed: spectroscopy, semileptonic decays, QCD tests, baryons, rare and forbidden decays, charm mixing and CP violation. In contrast with the fifth quark, beauty, for which the most exciting prospects are detailed tests of CP violation in the Standard Model, the grail for charm is physics beyond the Standard Model, for which the rates of flavour-changing neutral currents, mixing, and CP violation expected in the Standard Model present negligible backgrounds. Observable effects in one or more of these areas are expected in theories which make useful predictions about the fermion masses and mixings, such as supersymmetry, technicolour and left-right-symmetric, grand unified and multiple-Higgs theories.

Also discussed was progress in detector technology - pixel and diamond detectors, scintillating-fibre tracking, vertex triggers and other new techniques which make the promise of a 10^8-charm experiment realistic. Organizers John Cumalat of Colorado, Dan Kaplan of Northern Illinois and Simon Kwan of Fermilab and attendees were enthusiastic about the prospects for advancing the "programmatic" production, spectroscopy and decay physics by three orders of magnitude and achieving sensitivities of order 10^{-5} for mixing, 10^{-7} for rare decays, and 10^{-3} for CP asymmetries. A follow-up session is contemplated for the HQ94 heavy-quark workshop at Virginia, with ongoing work towards a technical proposal.

Lively discussions on electromagnetic physics at the Intersections Conference: from left to right Lawrence Cardman (CEBAF), Hans de Vries (NIKHEF-K) and Bernard Frois (CE-Saclay).



Particle-nuclear intersections

With the traditional distinctions between particle and nuclear physics becoming increasing blurred, the Fifth Conference on the Intersections of Particle and Nuclear Physics, held from May 31 to June 6 in St. Petersburg, Florida, brought together particle and nuclear physicists to discuss common research efforts and to define and plan a united approach.

The topics spanned an extremely large range (more than 15 decades in energy), from fundamental physics with ultracold neutrons to evidence for the top quark. Special emphasis was placed on testing the Standard Model at both the intensity and precision frontiers. The enormous range of energy is only one indication of the diversity of subject matter, which is underlined by a sample of the topics discussed (and the range of laboratories involved):

fundamental physics with cold and ultracold neutrons; parity violation and time-reversal invariance with epithermal neutrons; CP violation; conservation laws through rare and forbidden decays; nucleon form factors and spin structure functions with electromagnetic probes; particle physics aspects of relativistic heavy-ion collisions; physics of quantum chromodynamics and of quark and gluon distributions; search for exotics, hybrids and glueballs.

Bookshelf

In addition there was a whole host of non-accelerator based research, such as the questions of dark matter in the Universe, the solar neutrino problem and neutrino oscillations, ultra-high-energy cosmic rays and atomic parity violation.

Particular highlights were presentations on the evidence for the detection of the sixth ("top") quark, by Simone Dell'Agnello (Pisa) for the CDF collaborationat Fermilab, and on the disappearing evidence for the formation of anomalous electron-positron pairs in heavy-ion collisions by Aksel Lennart Hallin (Queen's) who gave first results of the APEX experiment at Argonne. The upper limit for muon to electron conversion continues to recede very significantly as presented by Andries van der Schaaf (Zurich).

While the Standard Model of quarks and leptons still reigns, questions remain on the generation of mass and the origin of CP violation.

As at previous conferences, plenary sessions were scheduled each morning, followed by parallel sessions on ten different topics in the afternoons. These parallel sessions functioned essentially as workshops or mini-conferences, with conclusions presented in a final plenary session. A special sessions on "Vistas of the Physics with Multi-GeV Hadron Facilities" focused on the need for new experimental facilities in the near and more distant future.

The chairman of the Organizing Committee was Willem T.H. van Oers (TRIUMF/Manitoba). Close to 350 delegates attended from 20 different countries and look forward to their next meeting, tentatively scheduled for the end of May 1997.

G.I. Budker, Reflections and Remembrances, edited by B.N. Breizman and J.W. van Dam, American Institute of Physics (AIP) Press, New York, 1994. ISBN 1-56396-070-2

This book celebrates the life and work of one of the revered figures of accelerator and plasma physics - Gersh Itskovitch Budker (1918-77) who called himself Andrei Mikhailov Budker, because these names 'sounded more Russian'. Brilliant scientist and science organizer, esteemed colleague, beloved teacher, charismatic leader; Jewish, orthodox communist (although never member of the party!) with an instinct for "money making" activities; always eager to try fundamentally new approaches, five " romances that all ended in marriage"...: the many facets of Budker's rich life are vividly portrayed in this book.

It opens with a series of popular essays through which we discover Budker as a most gifted science 'popularizer'. The ideas about the social and economic role of science are one "leitmotiv". In fact throughout his life Budker devoted much of his creativity and 25% of the efforts of his institute to the "commercialization" of "practical things" (from energy production to cancer treatment), which one can do with these "wonderful beams of particles" and plasmas. He did so, not principally to make money, but because he felt this was his duty to society.

Colliders, explained in simple language, are another theme or rather, at the time of being written, a dream, as difficult as "to arrange a rendezvous of the arrows of Robin Hood on Earth and William Tell on Sirius." Other topics include: the ardent 1968 plea for fusion research - "Get going "; his visionary 1969 article about proton-antiproton collisions and antihydrogen formation, which are of incredible immediacy some 25 years after they were written... It is a delight to read these tracts (most of which appear in English for the first time), for the expert as well as for a general public.

The essays are complemented by the memories of more than 30 of his peers and pupils. Taking diverse and often opposing views, they unite in honouring the extraordinary creator and organizer. Amusing, enlightening, just narrative or profoundly analytic, they nevertheless contain a certain amount of repetition (the famous roundtable is mentioned over and over again). A bit of editing might perhaps have helped. One can also regret that there are practically no Western European contributors (apart from Willibald Jentschke). Budker, who perceived science as a truly international enterprise, had many "contacts" at CERN or DESY, who could have added additional brush strokes to the portrait of this "enfant terrible".

The Russian texts are translated well and with flair (wordplay unfortunately being untranslatable). The English edition contains a curriculum vitae and a complete list of scientific papers. Numerous photographs illustrate Budker's 30 years of work. The publication is timely in many respects. Perhaps in these days, where the relation of pure and applied research is to be rethought, can we learn from this sage "who was ahead of his time both scientifically and politically"? A great book about a great man!

Dieter Möhl

"Neutrons, Nuclei and Matter" by J. Byrne, Institute of Physics Publishing, Bristol, 1994, xxviii+760 p., (ISBN 0 7503 0264 X)

Time was when a neophyte wanting to do experiments with neutrons would be told first to read D.J. Hughes' classic "Pile Neutron Research" (1952). The book by J. Byrne is in many respects a modern equivalent, although if you were to send your student away with it, you will risk not seeing him or her again for a considerable time.

What is immediately striking is that the book, rich in information and quite long, is cross-disciplinary and touches essentially all the main areas of modern physics. It covers parts of particle physics, such as the internal structure of the neutron, time-reversal violation as revealed by the (still hypothetical) electric dipole moment of the neutron, and the coupling constants for the weak interaction. From the field of basic quantum physics there are chapters on neutron optics, wave phenomena with neutrons and on the applications of these in solid-state physics. Other chapters again delve deeply into nuclear structure, nuclear reaction theory, as well as their applications: nuclear reactors and nuclear energy. At a time with specialization rampant and many physicists tending to believe that venturing outside their own cloisters is uninteresting and even dangerous, it is a pleasure to come across a book that is basically just about physics.

J. Byrne of Sussex has for long been active in neutron research at the British-French-German Institut Laue-Langevin (ILL) research reactor in Grenoble, where he has worked on subjects such as weak interactions and fundamental symmetries. He has clearly intended "Neutrons, Nuclei and Matter" as a vade-mecum that will allow the practitioner to find the necessary information and formulas. But I believe that many others not directly engaged in neutron research will gain new insight from its many examples. To take just one case, I had not been aware of the simple physical principles that permit cold neutrons to be stored in a bottle. (The main point is that a medium containing nuclei with positive scattering length presents a repulsive potential to (very) slow neutrons.) Teachers of modern physics should be able to find material for many inspiring examples and problem assignments in this text.

The neutron is one of the great experimental themes of this century. Discovered in 1932, it led to scores of other fundamental discoveries and uncountable applications inside and outside of physics. This book will allow many present and future colleagues to orient themselves in this vast field and will with its 44 pages of essentially one-line references help them to find further reading material.

P.G. Hansen

Quantum Fields on a Lattice, by Istvan Montvay and Gernot Muenster, Cambridge Monographs on Mathematical Physics, Cambridge University Press (ISBN 0 521 40432 0 hardback)

In four space-time dimensions, lattice regularization often represents the only non-perturbative definition of a quantum field theory. On this basis, and in connection with numerical simulation techniques and the spreading of powerful parallel computers, more and more realistic calculations are carried out. There has been a great need for a textbook for advanced students to enter this field. While the recent book by H. J. Rothe (Lattice Gauge Theories, Word Scientific) covers the more formal and analytic aspects, this new book provides excellent coverage of a large section of the field, including details of Monte Carlo simulations and algorithms. It is well suitable to prepare a student for reading reviews as they appear in annual proceedings of lattice conferences.

The book starts with an introduction to euclidean fields and path-integrals including nontrivial details like reflection positivity. Here the authors succeed very well in avoiding the use of both over-formal machinery as well as an unduly schematic and superficial presentation. Then several sections introduce lattice scalar, fermion, and gauge fields in the traditional division of field theory texts. Lattice specialties, like the semi-analytic Luescher-Weisz solution and the problem of fermion doubling, are enlarged on. Bridges toward current research are included in chapters on QCD and Higgs and Yukawa models. The book ends with practical considerations about algorithms, including hybrid Monte Carlo, and error analysis.

This textbook is an excellent introduction to present day lattice methods for particle physics. In its scope it is almost unrivalled and is a must for every student taking up the subject. The researcher in the field will value it as a standard reference and entry point to the literature.

U. Wolff

People and things

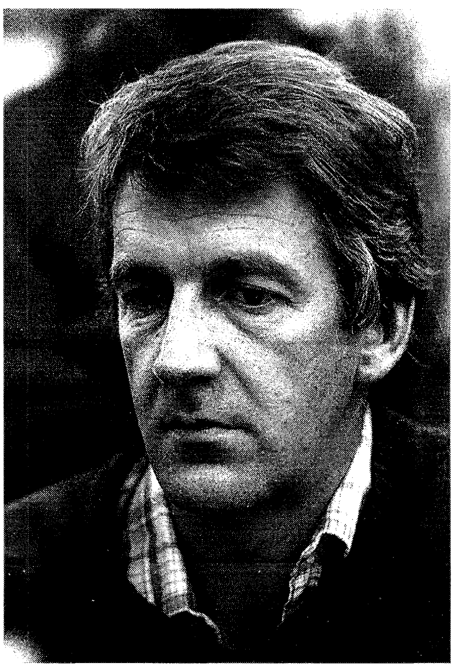
Books received

The Analysis of Space-Time Singularities by C.J.S. Clarke, Cambridge Lecture Notes in Physics, Cambridge University Press, 170 pages, paperback ISBN 0 521 43796 2, £17.95

Oscillations in Finite Quantum Systems by G.F. Bertsch and R.A. Broglia, Cambridge Monographs on Mathematical Physics, Cambridge University Press, 212 pages, hardback ISBN 0 521 41148 3, £30.

Pseudo-Relativistic Physics, written and published by Antonis Agathangeledis, Thessaloniki, 146 pages, paperback ISBN 960 220 358 7.

Roy Billinge 1937-94



Roy Billinge 1937-94

CERN accelerator physicist Roy Billinge died at his home on 31 July after a brief illness. Born in Buxton, England, Roy studied physics at King's College London and joined the UK Rutherford Laboratory in 1959, where he immediately became fascinated with building accelerators, playing an important role in bringing the 7 GeV NIMROD proton synchrotron into operation.

Roy came to CERN in 1966 for a year, seconded from the Rutherford Laboratory to the '300 GeV project' which went on to become the SPS proton accelerator. In 1967 he left to spend four years at the new Fermilab accelerator then being constructed under Bob Wilson. His task complete at the Fermilab 8 GeV Booster, he was asked by John Adams to lead the vital task of magnet construction for CERN's new SPS, at the age of 33 the youngest Group Leader in a young team.

Roy brought back to the Old World some of the spirit of adventure of the New, as well as a style of building a team into a family in which each member felt of equal importance. This became invaluable when the SPS was completed and he, together with Simon van der Meer, drew together diverse talents from all over CERN for the challenge of building the Antiproton Accumulator. Roy, always ready with a suggestion to simplify and resolve a setback, pushed the AA from approval in 1978 through to commissioning in 1980. As well as building a complex new machine in record time, this set CERN firmly on a new course.

For nine years (1982-90) he was Leader of the PS Division, ensuring that the PS, then already approaching accelerator middle age, could confidently assume its continuing responsibility as the kingpin of CERN's unique system of interlinked particle beams,

In his remarkable mastery of human and effective leadership, the main ingredient was his concern to understand and satisfy the needs and ambitions of the team of scientists and engineers under his charge. His wide professional experience and his gift for finding clear solutions which were both mathematically correct yet practical and sound in engineering terms earned everyone's respect.

After his term as Division Leader he moved to being an Associate Director of CERN, advising the Director General on the use of computers. He was also appointed to the Board of Overseers of the US Superconducting Supercollider (SSC) as Chairman of the SSC Machine Advisory Committee. His efforts in latter years to bring a larger community of nations, including the USA, behind the construction of CERN's LHC will surely be his finest memorial.

Roy was unusual in having worked for two giants of the accelerator world - Bob Wilson and John Adams - acquiring a wide repertoire of management skills. Despite their very different styles, both these mentors had enormous regard for Roy as do all who worked with him. Friends and colleagues all over the world were shocked and stunned by the speed of his passing.

He leaves behind his wife Rosemary and their children Mark and Fiona. Happily he had been able to meet and enjoy his granddaughter Emily before he died.

E.J.N. Wilson

Odd Dahl at 94.
(Photo Arne Nilsen - Bergens Tidende)

Odd Dahl 1898-1994

CERN lost another of its founding fathers when Odd Dahl died in Bergen, Norway, on 2 June at the age of 95.

With only a modest formal education, Odd Dahl had a remarkable career. At the age of 24 he was chosen by explorer Amundsen as a pilot for a polar expedition. To quote his later colleague Merle Tuve, "Fortunately the plane broke up during the attempt to take off from rough ice, so Dahl spent a couple of very long years making geophysical observations while locked in the ice off the New Siberian Islands."

During these ice-bound years, Dahl became a very competent instrument designer and maker. In 1926 this took him to the Carnegie Institute in Washington, DC, where he constructed, with Tuve and Lawrence Hafstad, one of the first Van de Graaf generators.

In 1936 he went to the Chr. Michelsen Institute in Bergen, where he built three Van de Graafs and a betatron. Immediately after the war, he became technical director for the construction of the first nuclear reactor to be built outside the original nuclear powers.

Internationally known, Dahl was invited by Pierre Auger and Edoardo Amaldi in the spring of 1951 to help in the preparatory work for what later became CERN, and from summer 1952 Dahl led the group studying the Proton Synchrotron project. In the early 1950s, the original plan for the fledgling CERN Laboratory had been to build a Cosmotron-like machine to reach energies of 10-15 GeV. The challenge of setting up a coordinated design group with members scattered all over Europe suited Dahl well, who had used a similar approach in his work for a Norwegian-Dutch reactor.

Since the new machine was to be a scaled-up Cosmotron, Dahl, with Group members Frank Goward and Rolf Wideroe, went to Brookhaven in August 1952 to see the Cosmotron and discuss the new European project. During this momentous visit they found that a new idea for focusing particles had been discovered by Courant, Livingston and Snyder. This alternating gradient (AG) focusing would greatly reduce beam apertures and thus open the door to much higher beam energies.

Dahl at once saw the implications and convinced his group that this was the way to go. All effort was immediately switched. That autumn CERN's Council was also convinced, and one of the most important decisions in CERN's history was made. Intuition governed the choice more than knowledge, but the reliability of his intuition was a feature of Dahl's professional life. It would have been much easier (as other Laboratories did and later regretted) to have played safe. Had CERN gone for a 10-15 GeV scaled-up Cosmotron, its future would have been very different.

It was also a very unselfish decision for Dahl, because the whole nature of the Proton Synchrotron Group's work changed. Instead of being essentially an engineering group scaling up an existing machine based on well-established principles, it became a physics group studying the theory of accelerators, only later returning to engineering design.

To lead this demanded full-time commitment, which Dahl could not give, and he returned to Norway. The initial plan had been for Frank Goward to take over, but the latter's untimely death in 1954 led to John Adams becoming the obvious choice.

After leaving CERN, Dahl made further reactor contributions. However his main subsequent scientific effort was his work in the design of payloads for scientific rockets launched in Northern Norway. He retained a key role in this international effort until his retirement at the age of 70, and even beyond, as a consultant.

Dahl has written his name into science history in many ways. However for CERN it is his crucial role in the PS which dominates, and with the machine, now 40 years after its inception still the focus of this remarkable Laboratory, it is with gratitude that we pay tribute to his memory.

Kjell Johnsen

Julian Schwinger 1918-94

Julian Schwinger, one of the leading physicists of the 20th century, died on 16 July of pancreatic cancer. He was 76.

In 1965, Schwinger shared the Nobel Prize in Physics with Richard Feynman and Sin-Itiro Tomonaga for their independent contributions to quantum electrodynamics. The theoretical achievements of Schwinger and Feynman in the late 1940s and early 1950s provoked a revolution in quantum field theory and laid the foundations for much of the spectacular progress in high energy physics and the ultimate structure of matter of the ensuing four decades.

Schwinger's career spanned some 60 years; his first scientific papers were published when he was 17, and he continued working intensively until a few days before his death. Born in New York City, Schwinger was educated at The City College of New York and at Columbia University, where he received his PhD at the age of 21. After postdoctoral studies at Columbia, Schwinger went to Berkeley to work with J. Robert Oppenheimer. Between 1935 and 1942, he made fundamental contributions to the emerging science of nuclear physics, which brought him international acclaim.

From 1943-46, Schwinger was a member of the wartime staff of the Radiation Laboratory at the Massachusetts Institute of Technology. Here he played a leading role in the development of radar that was crucial to the war effort. After the war, Schwinger became an associate professor at Harvard, moving to full professor in 1947 at age 29. Between 1948-1950, Schwinger published the monumental papers on quantum electrodynamics for which he later shared the Nobel Prize.

In 1972, Schwinger moved to the Department of Physics at UCLA, where he held the title of University Professor of the University of California. Beyond his Nobel prize-winning work in quantum electrodynamics, Schwinger made important contributions to other frontiers of modern theoretical physics. His total published work comprises nearly 200 papers, numerous books, and a large body of unpublished work.

A recipient of Sigma Xi award for distinguished teaching, Schwinger's accomplishments and his profound influence on the development of 20th-century physics have reached far beyond the research advances embodied in his own papers and books. Schwinger was, among physicists of his time, uniquely influential as a teacher and mentor. His lectures were elegant, lucid and inspiring. His course lectures form the basis for graduate instruction throughout the world. The mathematical techniques he developed are a part of every theorist's arsenal. He directed more than 70 doctoral theses and is the ancestor of at least four generations of physicists. To his own students he gave much more than guidance on their research. He gave them a depth of understanding and a mastery of the field that permitted each to become, not a Schwinger disciple, but an independent scientist, each in his or her own way.

Schwinger received numerous international awards and honours. In 1964, President Lyndon Johnson awarded him the newly created National Medal of Science. In 1949 Schwinger was awarded the US National Academy of Sciences "Nature of Light" prize and was a member of the academy for more than 45 years. In 1951, Schwinger shared the first Albert Einstein Prize with mathematician Kurt Godel.

A man of broad interests, Schwinger is remembered by colleagues for his love of music. He took piano lessons for decades; "If something is worth doing, it is worth doing badly," he once said of his piano playing. He is survived by his wife of forty-seven years, Clarice (Carrol) Schwinger.

(From Robert Finkelstein and David Saxon on behalf of their colleagues at UCLA.)

William Ash 1941-94

SLAC physicist William Ash died earlier this year. In addition to his varied physics interests, he was Editor of SLAC's 'Beam Line' magazine from 1982-85, and CERN Courier's enthusiastic SLAC correspondent from 1984-88. In that capacity he marked the beginning of an era in 1984 by being the first person to send us a contribution by electronic mail.

Michail Mescheryakov 1910-94

Michail G. Mescheryakov died on 24 May at the age of 84. A prominent follower of I.V.Kurchatov in 1938-1940, M.G.Mescheryakov created the first cyclotron in Russia at the Radium Institute, Leningrad, then was involved in the investigation of neutron absorption on nuclei and proton emission in deuteron-nuclei interactions.

From 1947 he was the scientific leader of engineering and construction for Dubna's 680 MeV synchrocyclotron. When this machine was put into operation in 1949, he became the head of the high energy physics research centre established around it, and transformed into the Institute of Nuclear Problems of the USSR Academy of Sciences in 1953. His main scientific interests was nucleon-nucleon interactions. In1955 he discovered the resonant character of pion production in proton-proton interactions, and the direct knock-on of deuterons from nuclei by projectile protons.

A gifted organizer, he was one of the founders of the Joint Institute for Nuclear Research in 1956. After the

Michail Mescheryakov 1910-1994

establishment of JINR's Laboratory of Computing Techniques and Automation under his leadership in 1966, he was LCTA Director until 1988. Despite his terminal illness, he continued to take an active part in Dubna's scientific and public life.

CERN Council

At the CERN Council meeting on 24 June (see page 8), a solution was adopted on the Spanish contribution to CERN in view of the country's economic difficulties and the commitment of paying back accumulated debt.
Riccardo Barbieri of Pisa was elected to the Scientific Policy Committee, while Michal Turala of Krakow will become Leader of Electronics and

1994 is a LEP year

At CERN's LEP electron-positron collider, peak luminosities were attained during August of 2.2 x 10^{31} cm^{-2} s^{-1}, well in excess of the machine's design figure and 1993's best of 1.6 x 10^{31}. With one inverse picobarn of luminosity in a 24-hour period and 5 in a week, 1994 operations look set to improve on 1993's harvest of 40 inverse picobarns (over 3 million Z particles).

Computing for Physics (ECP) Division for three years from 1 January 1995.

Fermilab luminosity record

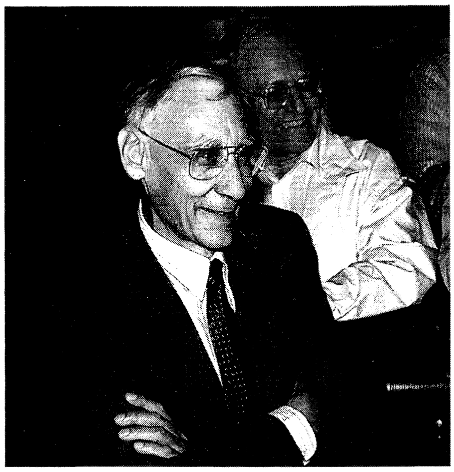
On July 23 the Fermilab Tevatron set a new world luminosity record for a proton-antiproton collider: 1.28 x 10^{31} cm^{-2} s^{-1}. This Tevatron luminosity in excess of 10^{31} is a factor of ten beyond the original design specification for the collider. The record store was immediately followed by stores with initial luminosities of 1.1 and 1.2 x 10^{31} over the next two days, going on to attain 1.67 x 10^{31}. Ultimately Fermilab expects to achieve luminosity in excess of 5 x 10^{31} following completion of the Main Injector project later this decade.

First Beam at CEBAF

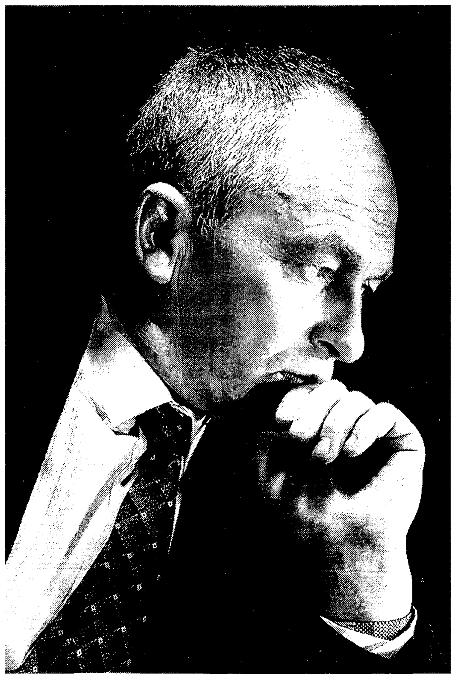
The Continuous Electron Beam Accelerator Facility (CEBAF) superconducting accelerator in Newport News, Virginia, delivered its first electron beam to an experimental target on 24 July. After 90 minutes of tune-up, a 65-hour run was begun, with 600 MeV beam on target 70% of the time for initial checkout and calibration of the High Momentum Spectrometer (HMS) in Hall C. The beam was accelerated in one pass - north linac, east arc, south linac - of the racetrack-shaped machine, which will eventually recirculate beam for five passes and 4 GeV.

Beam was steady and stable on target, and all instrumentation checkout and optics studies planned for the HMS run were accomplished. After the run, beam was sent through the second (west) arc for the first time, and the accelerator's path length was confirmed, verifying that second-pass reinjection will take

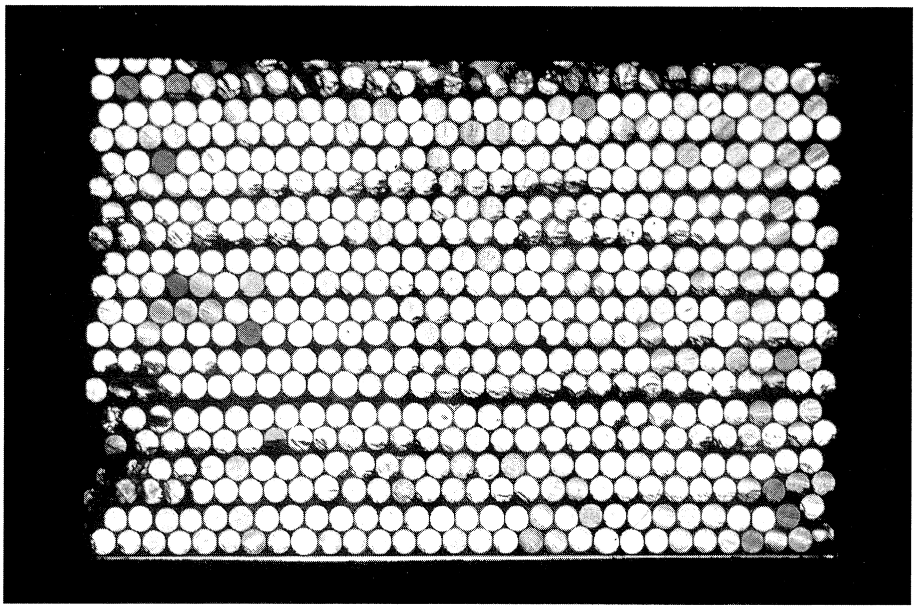
On 16 June, colleagues of radiofrequency specialist Wolfgang Schnell paid tribute to his distinguished 40-year career at CERN. The radiofrequency systems developed for the PS, ISR, SPS and LEP, as well as the new scheme proposed for the CLIC electron-psoitron collider project, testify to his ingenuity and technological mastery.



▼ On 15 June Dubna's Bogoliubov Theoretical Laboratory celebrated the 60th birthday of Garii Efimov, well known for his contributions to non-local and non-polynomial quantum field theories and leader of the scientific group at the Bogoliubov Laboratory of Theoretical Physics of the Joint Institute for Nuclear Research.



place on the radiofrequency field crest. Later, a final energy of 808 MeV was attained, with south linac cavities averaging several



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

Hans Gutbrod (centre) of CERN/GSI and spokesman of CERN heavy-ion experiments WA93 and WA98 received the degree of Doctor of Philosophy Honoris Causa of Lund University, Sweden, on 27 May . With him are Ingvar Otterlund (on his left) and Hans-Ake Gustafsson, both from Lund.

MeV/m above specification, even with r.f. power minimized for economical operation.

CEBAF's three end stations will serve nuclear physics. Commissioning started earlier this year after seven years of construction.

On people

C. N. Yang of Stony Brook receives the Benjamin Franklin Medal of the American Physical Society for 'profound and original contributions to physics - especially the discovery of the non-conservation of parity and of non-Abelian gauge fields, which laid the foundation for new intellectual structures - and a love of mathematical beauty'.

Hans Gutbrod CERN/GSI and spokesman of the SPS heavy-ion experiments WA93 and WA98 was awarded the degree of Doctor of Philosophy Honoris Causa of Lund University, Sweden, on 27 May.

American Astronomical Society

Among the 1994 awards of the American Astronomical Society, Vera Rubin of the Carnegie Institution receives the Russell Lectureship Prize for her work in extragalactic astronomy; John Bahcall receives the Dannie Heinemann Astrophysics Prize for his work on solar neutrino emission, and Raymond Davis of Pennsylvania receives the Beatrice M. Tinsley Prize for his work on solar neutrino detection.

Meetings

The proponents of the HERA-B experiment for a fixed target experiment in the proton ring of DESY's HERA electron-proton collider are seeking to enlarge their collaboration. An "Open Collaboration Meeting" at DESY from 4-6 October will be a major milestone towards the formation of the final collaboration and the assignment of responsibilities for the construction of detector components. The collaboration will submit a technical design report by the end of the year which should provide the basis for the decision about a final approval early in 1995. (An article on HERA-B will feature in our next issue.)

For further information: A.S. Schwarz, DESY-F15, Notkestr.85, D-22603 Hamburg, Phone:+49-40-89 98 2524; fax: +49-40-89 94 4306; e-mail: schwarza@x4u2.desy.de

There will be an informal two-day meeting on "Massive Two-Loop Integrals" at the University of Mainz on September 26-27. Further information can be obtained from the organizers - J.G.Koerner (koerner@vipmzb.physik.uni-mainz.de) and D.Kreimer (kreimer@vipmzb.physik.uni-mainz.de).

A workshop on "Heavy Quark Physics" will take place in the DPG Physikzentrum in Bad Honnef, Germany from 14-16 December. The workshop is sponsored by the WE-Heraeus foundation and the Heisenberg-Landau programme. Its main focus will be on theoretical

FACULTY OPENING IN PHYSICS
University of California at Berkeley

The Physics Department of the University of California at Berkeley, pending budgetary approval, intends to make one or more faculty appointments effective July 1, 1995. Candidates from all fields of physics are encouraged to apply. Appointments at the tenure-track assistant professor level are preferred, but tenure level appointments will also be considered.

Please send a curriculum vitae, bibliography, statement of research interests, and a list of references to **Professor Herbert Steiner, Chairman, Department of Physics, 366 LeConte Hall # 7300, University of California, Berkeley CA 94720-7300**, before October 21, 1994.
Applications submitted after the deadline will not be considered.
The University of California is an Equal Opportunity, Affirmative Action Employer.

Research Training Fellowship
Max-Planck-Institute of Physics Munich, Germany

The Max-Planck-Institute of Physics in Munich invites applications for Research Training Fellowships in the fields of silicon microstrip and pixel detector development, and ASIC electronics design.
The Fellowships are sponsored by the 'Human Capital and Mobility' Programme of the European Union.
The contract will be limited to 15 months.

Candidates originating from a European Community Member State other than Germany, or from an associated state, and holding a PhD or equivalent in physics, should send a curriculum vitae, a list of publications, a summary of past and present research interests, and the names of three referees to

Frau Ursula Grenzemann
Max-Planck-Institut für Physik
Postfach 40 12 12
Föhringer Ring 6
D-80805 MÜNCHEN
(Email URG@dmumpiwh.bitnet)

where also further information can be obtained. Applications should be sent as soon as possible, at the latest by 31 October 1994.

Rutherford Appleton Laboratory

Research Posts in Particle Physics

Fixed Term – 3 Years

There are, from time to time, vacancies for Researchers to work in the Particle Physics Department at the Rutherford Appleton Laboratory. Groups from this Laboratory are working on a variety of experiments at CERN, DESY, ILL, SLAC, and non-accelerator sites, as well as in theory/phenomenology.

Staff will be based at RAL or at the Laboratory where their experiment is conducted, depending on the requirements of the work. All experiments include UK university personnel with whom particularly close collaborations are maintained.

Appointment will be as a Higher Scientific Officer (Research Associate). Applicants, who should have a good honours degree, will also be expected to have at least 2 years post graduate research experience. It is envisaged that the successful candidates will be under 30 years of age. Appointment will be for a fixed term of three years, with a possible extension of up to two years. Starting salary will depend on age and experience and will be within the range £13,025 – £18,911 per annum. Progression up to £23,009 per annum can be achieved by a series of increases linked to annual performance assessments.

In some cases permanent employment may result from a fixed term post.

The Laboratory is a friendly community with its own restaurant and recreational facilities. We offer good working conditions and benefits include a non-contributory pension scheme.

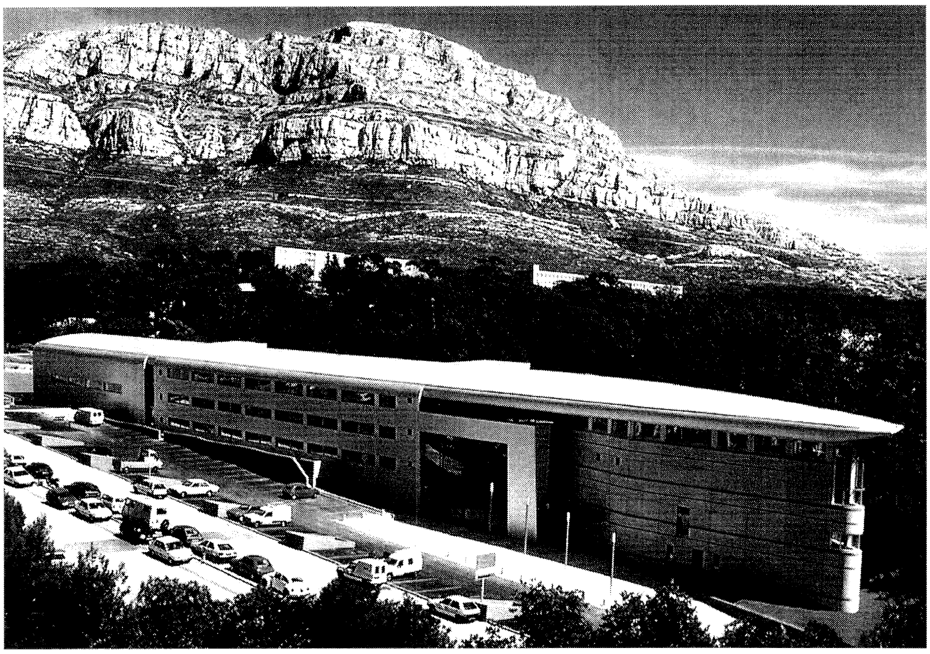
For an application form please contact the Recruitment Office, Personnel Division, Rutherford Appleton Laboratory, Chilton, Didcot, Oxon, OX11 OQX, England. Telephone (0235) 445435, quoting reference VN 1265.

DRAL is working towards equal opportunities and operates a non smoking policy.

DRAL
Daresbury Laboratory
Rutherford Appleton Laboratory

DRAL is part of the Engineering and Physical Sciences Research Council.

The Centre de Physique des Particules de Marseille, Luminy, was formally inaugurated on 1 July.



issues but there will also be some experimental review talks. Further information can be obtained from the organizers - J.G.Koerner (koerner@ vipmzb.physik.uni-mainz.de) and P.Kroll (kroll@wptu15.physik.uni-wuppertal.de).

The International Workshop on Collective Effects in Large Hadron Colliders in Montreux, Switzerland, from 17 to 22 October will review and discuss all aspects of collective single-beam and beam-beam effects, in past, existing, and future large hadron colliders. Further information from E. Keil, SL Division, CERN, 1211 Geneva 23, Switzerland, Phone: + 41 22 767 3426, Fax: + 41 22 783 0552, E-mail: LHC94@CERNVM.CERN.CH

PHOTON 95 (incorporating the 10th Workshop on Photon-Photon Collisions) will be held at the University of Sheffield, UK, from 8-13 April 1995. This workshop-style conference on the structure and interactions of the photon will focus on results from electron-positron and ep colliders and on related theoretical questions. Further information from F. Combley, Dept. of Physics, Univ. of Sheffield, Sheffield S3 7RH, UK e-mail: combley@cernvm.cern.ch

UNIX users

The next meeting of the North American Chapter of HEPiX (HEP UNIX users (March, page 18) will take place on 13 - 14 October at Fermilab. Local organizers are Matt Wicks and Judy Nicholls.

The next European Chapter meeting will be in Saclay from 24 - 26 September. Local organizers for this event are Pierrick Micout of Saclay and Alan Silverman of CERN. Details and agendas will be put together shortly and all offers of talks, site reports, presentations should be sent to Judy Nicholls or Alan Silverman, respectively for the US and European meetings.

Advance notice

The 14th International Conference on Cyclotrons and their Application will be held in Cape Town, South Africa, from the 8 - 13 October 1995, hosted by the National Accelerator Centre at Faure. Anyone wishing to have their name added to the mailing list should write or e-mail: Miss M. A. Herbert, National Accelerator Centre, P O Box 72, Faure, 7131 SOUTH AFRICA, E-mail: CYC95@NAC.AC.ZA giving full postal and e-mail addresses. The first announcement and call for papers will be mailed in October 1994. The present telephone and telefax numbers are: Tel.: +27 24 43820 Fax: +27 24 43525 As from November 1994 these numbers will change to: Tel.: +27 21 843 3820 Fax: +27 21 843 3525

Photomultiplier tubes

Published by Philips Photonics is a useful booklet 'Photomultiplier Tubes - Principles and Applications'. On seeing a review copy, users say it summarizes well the main characteristics of different types of photomultipliers and helps identify which photomultiplier is needed for a particular application. Philips Photonics, International Marketing, BP 520, 19106 Brive Cedex, France. Fax +33 55 86 37 73

Flerov Prize

On 2 March next the Joint Institute for Nuclear Research will award G.N. Flerov Prize to the winner of a contest for outstanding research in nuclear physics. The contest is for individual participants only. The winner will also receive US$500.

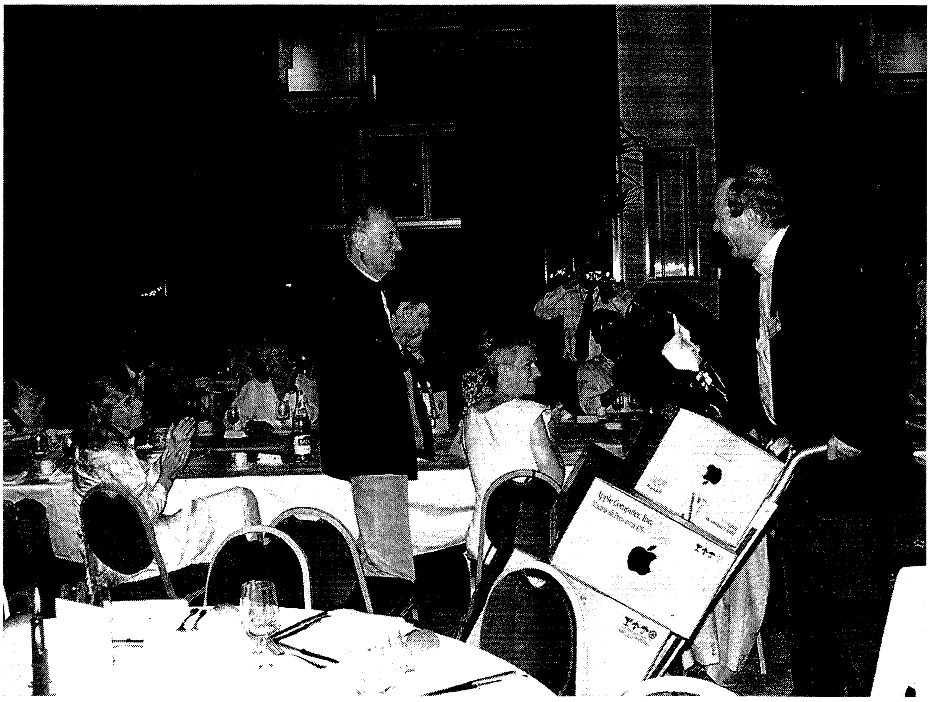
Participants should send a brief abstract of their research, if possible enclosing copies of major works, to be received not later than 31 January 1995, to: Dr.Pustylnik, B.I. Joint Institute for Nuclear Research, Flerov Laboratory of Nuclear Reactions, Dubna, Moscow Region, 141980, Russia Tel. (7 095) 924 39 14 Telex: 911621 DUBNA SU Fax: (7 096) 21 65083 E-mail: oyuts@ljar9.jinr.dubna.su

Quarks-94

"Quarks-94", the eighth in the series of "Quarks" International Seminars, was held in Vladimir (Russia) on May 11 - 18, organized by the Institute for Nuclear Research of the Russian Academy of Sciences (Moscow) and supported by Nuclear Physics Division of the Russian Academy of Sciences, Russian Foundation for Fundamental Researches and International Science Foundation. About 110 scientists from different countries attended.

Topics presented covered new results and approaches in quark model (A.Tavkhelidze, V.Matveev, P.LaFrance), problems of QCD - from the nucleon spin problem (B.Ioffe) to anisotropic high-energy asymptotics (I.Aref'eva). Other discussions on high-energy phenomena concerned multiparticle production (A.Ringwald, V.Rubakov, Yu.Makeenko). Recent evidence for the top quark led to interesting discussions on the Standard Model and its supersymmetric extension (N.Krasnikov). New achievements in conventional Standard Model - multiloop calculations (D.Broadhurst, K.Chetyrkin, S.Larin), phenomenology (A.Likhoded, D.Choudhury) and unexpected results in neutrino physics (N.Mikheev) - as well as ideas on physics beyond the Standard Model (G.Farrar, N.Weiss, M.Paranjape, R.MacKenzie, S.Chapman) - were presented. Some sessions were devoted to new mathematical methods of field theory (J. Van Holten, A.Chamseddine, Yu.Kubyshin). Probably the greatest attention was paid to field theory at finite temperature discussed both at the sessions (E.Mottola, J.Orloff, P.Arnold, L.Yaffe, M.Shaposhnikov, V.Eletsky) and around.

After the Seminar, a small topical workshop on electroweak baryon number violation and related topics was held at INR (Moscow). The next Seminar in the "Quarks" series will be held in 1996.



The NATO Advanced Research Workshop on Hot Hadronic Matter, held at Divonne-les-Bains, near Geneva from 27 June -1 July coincided with the 75th birthday of theorist Rolf Hagedorn, whose seminal ideas on complex high energy systems, made more than 30 years ago, have been influential in the recent study of heavy ion collisions. At the Divonne meeting, Hagedorn was presented with a home computer system.
(Photo CERN MI67.6.94)

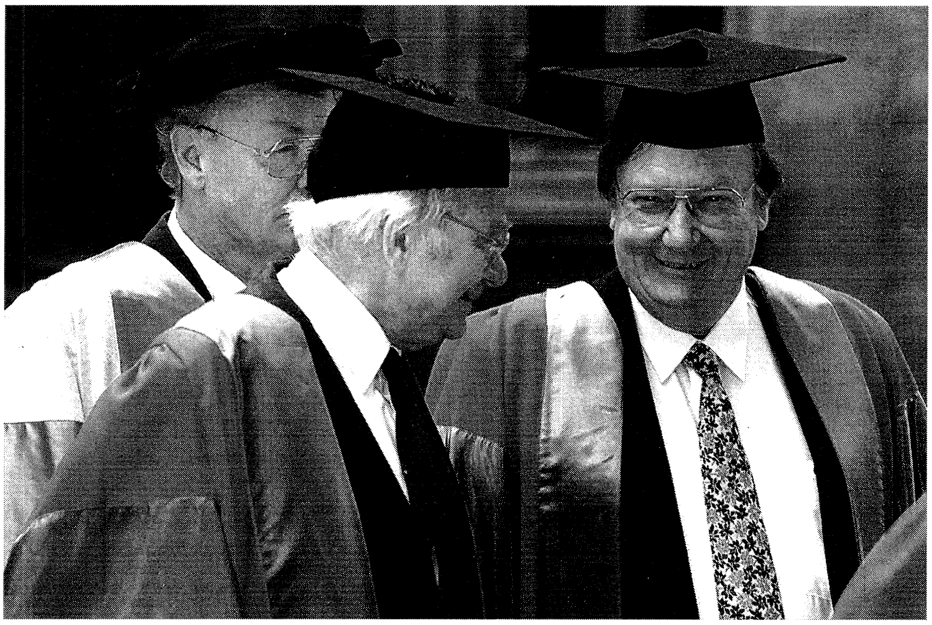
Honoris causa

In June, two notable particle physics personalities were awarded honorary degrees by UK universities. Former CERN Director General and 1984 Nobel Laureate Carlo Rubbia received an honorary doctorate from Oxford University, while Volker Soergel, former director of the DESY Laboratory, Hamburg, was honoured by Glasgow.

Carlo Rubbia received his Doctor of Science honoris causa *in Oxford's Sheldonian Theatre during the 1994 Encaenia, the university's major annual ceremonial occasion.*

Introducing Carlo Rubbia, Oxford's Public Orator said 'hospes noster, vir in primus acutus, novae formae machinam commentus, qua

On 22 June former CERN Director General Carlo Rubbia (right) received the Doctor of Science honoris causa *in Oxford's 1994 Encaenia, the university's major annual ceremonial occasion. He is seen here with fellow honorary doctorate recipients musical director and conductor Klaus Tennstedt (left) and vision physiologist David Hubel. (Photo Billett Potter)*



particulae minutissimae, alie apophatica aliae aienti via impulsae, oppositus cursibus ingenti velocitate confligerentur.'

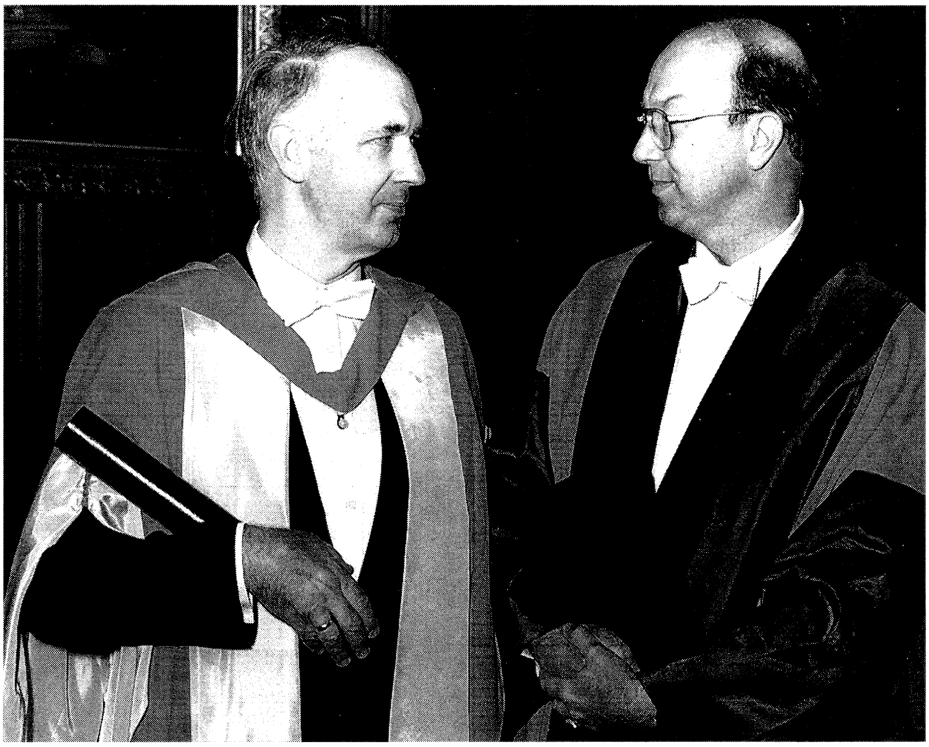
('He devised a most ingenious apparatus, by which protons and antiprotons were made to collide at very high velocities.') The University's Latin scholars had found a useful precedent in the 'apophetica' (negative) and 'aientia' (positive) of Cicero's Topica.

At a time when particle physics is looking to widen its international basis, Soergel's Glasgow citation refers to his role in creating the HERA electron-proton collider at DESY: 'Big Science demands the assembly of talent and resources from many countries. ....his initiative.... has found a new way of collaborating between nations. The stable centre was Germany. But major contributions, of the order of half a billion pounds, were needed from other countries. It is his achievement to have brought these together in a way which strengthened scientific ability in each of the nations, and enlisted the enthusiasm of governments, yet brought a cohesive effort to the central project. ...The flexible and creative way in which he achieved unprecedented international cooperation, and the evident success of the community so created, makes the "HERA model" an indicator of hope for international cooperation on future major scientific projects.'

Proton synchrotron record

The Brookhaven Alternating Proton Synchrotron (AGS) has set a new intensity record of 4 x 10^{13} protons per pulse. More news in the next issue.

On 15 June former DESY Director Volker Soergel (left) received an honorary doctorate from Glasgow University. With him is his sponsor, David Saxon, Glasgow's Kelvin Professor of Physics , a member of CERN's Scientific Policy Committee., and Chairman of the Project Team of the recent International Conference on High Energy Physics, held in Glasgow from 20-27 July (see page 1). (Photo Media Services Photographic, University of Glasgow)



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CERN Courier Index

The English index for Volume 33 (1993) of the CERN Courier is now available. If you wish to obtain a copy apply to CERN COURIER (Index) CERN 1211 Geneva 23, Switzerland

CERN Courier contributions

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

The address is courier@cernvm.cern.ch

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

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

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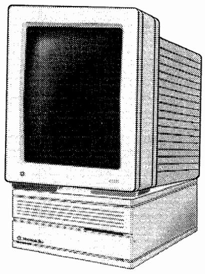

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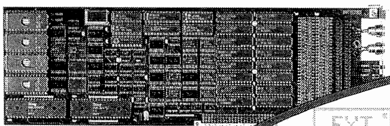

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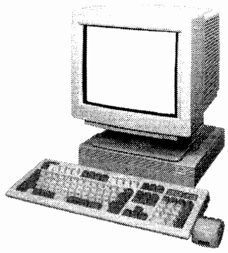

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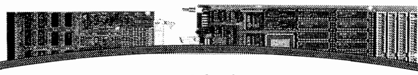

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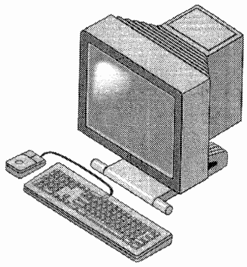

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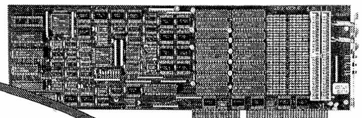

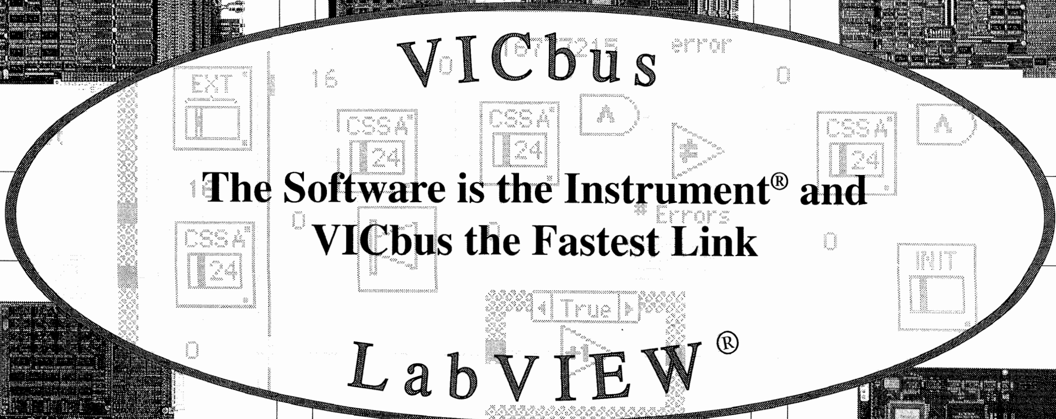

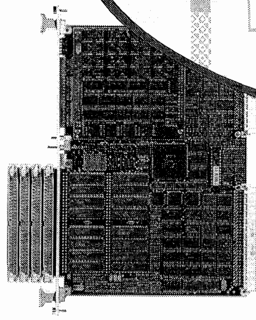

VIC 8250, VIC 8251, VIC 8252

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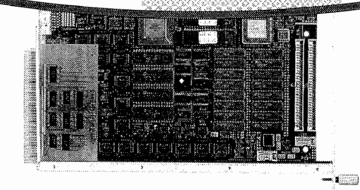

VCC 2117, CBD 8210

VCC Initialization, CDREG, CSSA, CSSA Repeat, Generate Z, Generate C, Clear Inhibit, Auto Scan, Q Repeat, LAM Sync, Wait LAM, ...

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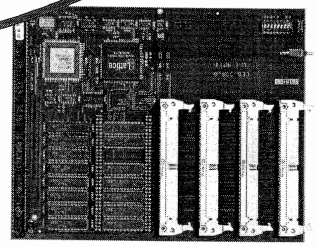

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