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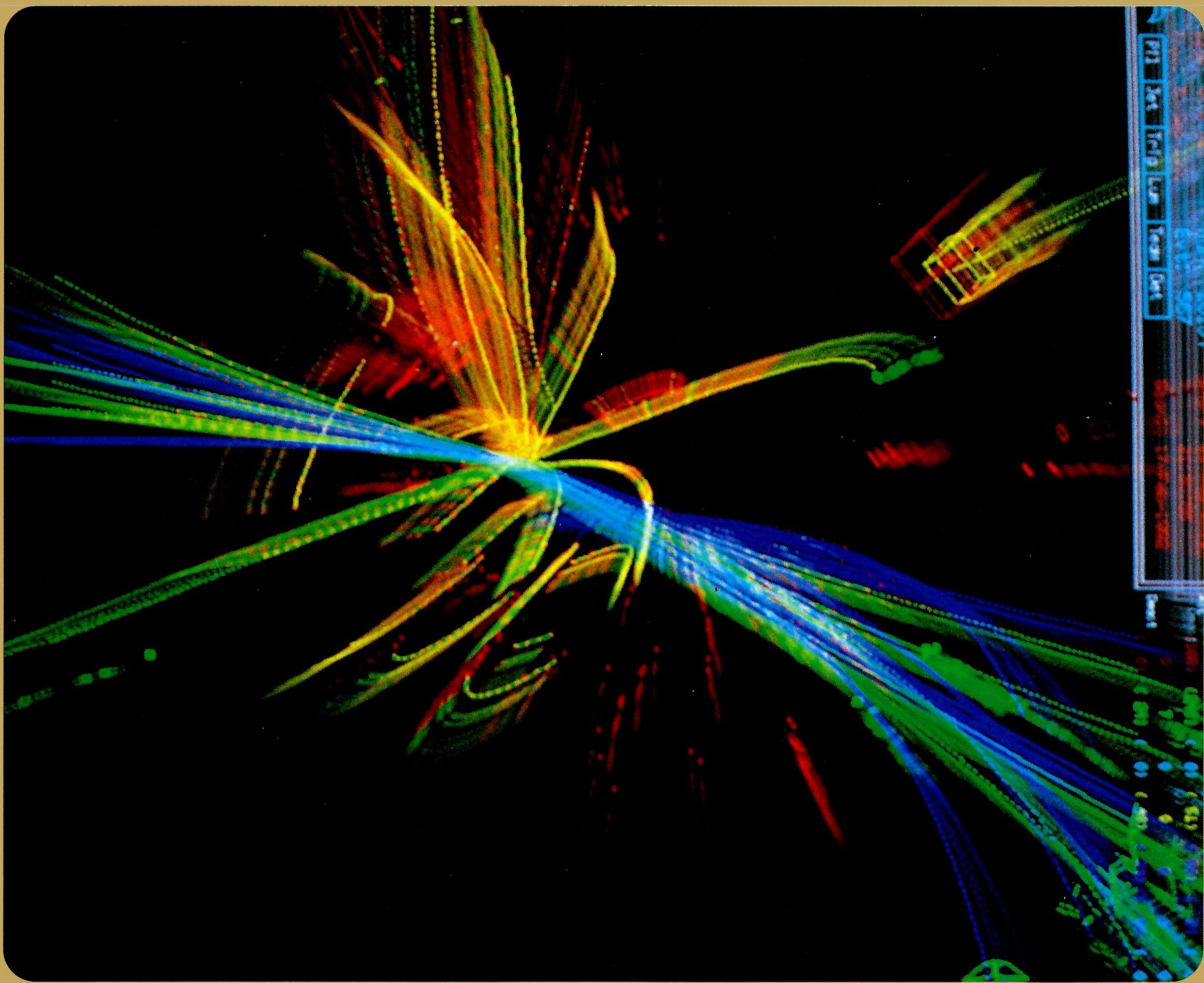

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Editor: Gordon Fraser (COURIER at CERNVM)*
French edition: Henri-Luc Felder
Production and Advertisements:
Micheline Falciola (FAL at CERNVM)*

*(Full electronic mail address... at CERNVM.CERN.CH)

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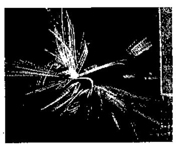

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Suitably treated, an event from the Delphi experiment at CERN's LEP electron-positron collider turns into art (Patrice Loiez).

Advertising enquiries

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

Rest of the world

Yvette M. Perez
Gordon and Breach Science Publishers
Frankford Arsenal, Bldg 110
5301 Tacony Street, Box 330
Philadelphia, PA 19137
Tel.: +1 (215) 537 7262
Fax: +1 (215) 537 0711

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Dr. Qian Ke-Qin
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P.O. Box 918, Beijing,
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Rutherford Appleton Laboratory,
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USA/Canada

Cyndi Rathbun (B90904 at FNALVM)
Fermilab, P.O. Box 500, Batavia
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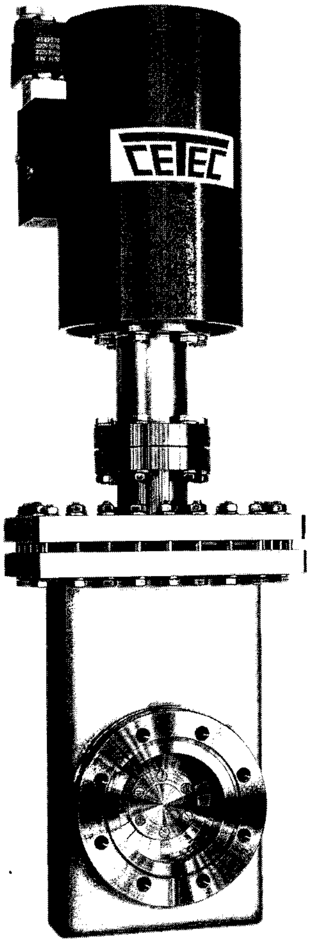

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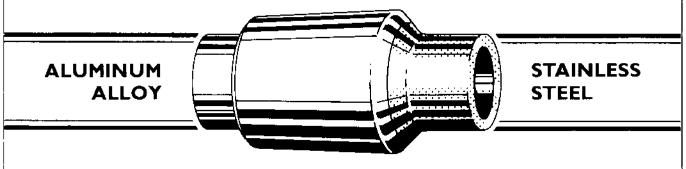

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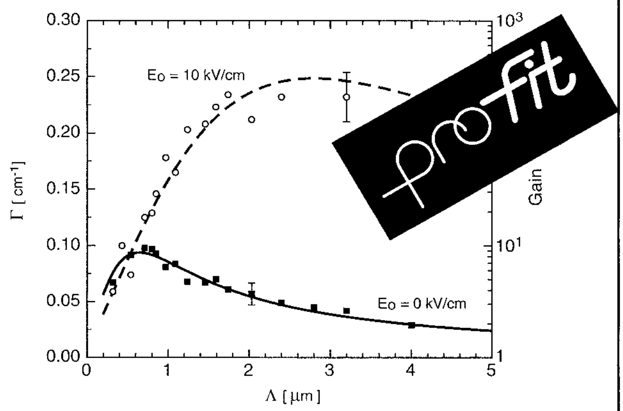
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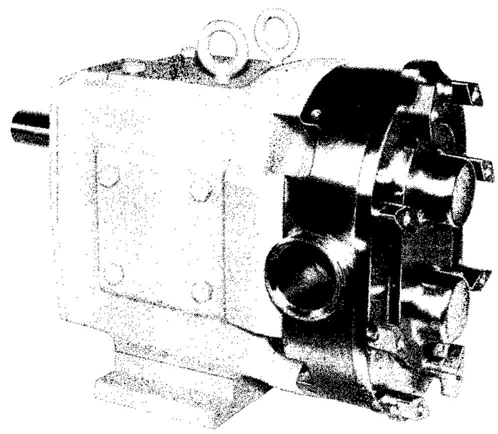


Towards LHC experiments

From 5-8 March, Evian-les-Bains on the shores of Lake Geneva was the scene of a major meeting on the experiments for CERN's planned LHC proton collider in the 27-kilometre LEP tunnel.

As plans for the LHC proton collider to be built in CERN's 27-kilometre LEP tunnel take shape, interest widens to bring in the experiments exploiting the big machine. The first public presentations of 'expressions of interest' for LHC experiments featured from 5-8 March at Evian-les-Bains on the shore of Lake Geneva, some 50 kilometres from CERN, at the special 'Towards the LHC Experimental Programme' meeting. (A report from the meeting will be included in our next issue.)

This event followed soon after CERN Council's unanimous December 1991 vote that the LHC machine, to be installed in the existing 27-kilometre LEP tunnel, is 'the right machine for the advance of the subject and for the future of CERN'. With detailed information on costs, feasibility and prospective delivery schedules to be drawn up before the end of next year, and now with plans for experiments under discussion, the preparations for LHC move into higher gear. The Evian meeting was a public forum for a full range of expressions of interest in LHC experiments, setting the stage for the submission of Letters of Intent later this year and cementing the proto-collaboration arrangements.

So that all interested physicists can eventually access LHC, another important aim of the Evian meeting was to acquaint the potential physics community with the full range of proposals and ideas. As well as plans for experiments, participants at the meeting also heard the latest news on LHC machine studies, and the thinking on preparations for experimental areas and LHC physics potential.

CERN is very aware of the challenges of the LHC for its detectors - handling collision rates more than a thousand times those of existing colliders and having to withstand intense radiation levels. In 1990, a special Detector Research and Development Committee was set up along the lines of traditional Experiments Committees, but this time with the objective of stimulating and fostering the new technology needed to reap the LHC physics rewards (November 1991, page 2). This scheme was deliberately set up before global detector designs emerged, so that the final configurations would benefit from this new technology.

As well as its main objective of proton-proton collisions, LHC also opens up possibilities for ion-ion collisions, for fixed target studies and eventually for electron-proton collisions as well. Most of these areas were covered at Evian.

LHC beams can in principle collide at eight points. Four of these coincide with the four big experiments at the LEP electron-positron collider. Of the remaining four points, one, deep under the Jura mountains, will have to be used for an LHC 'beam cleaning' system to ensure high performance by reducing troublesome beam halo. Another will be reserved for the beam dump where the LHC protons will be absorbed once the circulating beams are no longer required. This leaves room for two big new LHC collider detectors, plus the potential of the existing LEP experimental areas, using either adapted LEP experiments or new apparatus mounted in push-pull to alternate with LEP running.

At Evian, four major detectors for studying proton-proton collisions were being tabled, three of which are new, and one a development from an existing LEP experiment.

The ASCOT (Apparatus with SuperCOnducting Toroids) general purpose detector is proposed by a team from CERN, the UK (Edinburgh and Rutherford Appleton Laboratory), Germany (Wuppertal and Munich MPI and University), France (Saclay) and Russia (Moscow, Dubna and Protvino). It is based on a 24 metre-long superconducting toroid instrumented with drift tubes for precision muon detection.

Inside the magnet, the emphasis is

Prince K. Malhotra of Bombay's Tata Institute of Fundamental Research died while attending the Evian meeting. A tribute will appear in the May issue.

on electrons, with a lead/liquid argon electromagnetic calorimeter, and tracking through interleaved layers of scintillators and transition radiation detectors, with semiconductor pads close to the beam pipe. A 1.5T superconducting solenoid in front of the electromagnetic calorimeter distinguishes electrons and positrons. Hadron calorimetry uses iron and liquid argon.

The EAGLE (Experiment for Accurate Gamma, Lepton and Energy measurements) collaboration proposes a comprehensive detector to cover a wide range of physics, and already involves physicists from 14 CERN Member States, plus Canada, Russia, Australia, Brazil and Israel.

EAGLE foresees a powerful inner electron detector inside a 2T central superconducting solenoid. The design features high quality electromagnetic sampling calorimetry combined with fine-grained electron and photon preshower detection, a high precision vertex detector for lower collision rates, hadron calorimetry, and a conventional toroid muon spectrometer.

Many different detector technologies are under study, and a final choice of the specification for the various EAGLE components will be made when R and D work is complete.

The Compact Muon Solenoid (CMS) LHC detector is designed to be compatible with the highest LHC collision rates, and is built around a 15 m-long superconducting solenoid providing a 4T field. The strong field gives relatively compact muon measurement. R and D work for the muon detectors is looking at resistive plate chambers and parallel plate chambers for timing information and honeycomb strip chambers and wall-less drift chambers for spatial information.

The central tracker will use small cells, based on silicon (or gallium arsenide) strip detectors and microstrip gas chambers, to ensure good pattern recognition under the stringent LHC conditions. Also inside the coil is a high resolution electromagnetic calorimeter and a hadron calorimeter.

CMS involves a team from 12 CERN Member States, plus Byelorussia, Bulgaria, Estonia, Georgia, Hungary, Russia and the US. A wide range of ongoing R and D work examines the possible detector technologies before deciding on final solutions.

The L3 experiment at LEP was originally designed for use at both LEP and LHC, with a large experimental hall and magnet. Upgrade for LHC would involve improving the muon resolution, adding a fine-grain hadron calorimeter, increasing the magnetic field, and being able to lift the detector 120 centimetres from the LEP position to the LHC beams above. For the work, 39 institutes from the L3 LEP line-up have been joined by 20 more, mainly from China and the former Soviet bloc.

Supplementing the main proton-proton LHC programme are a range of other experiments, including fixed target studies. Expressions of interest received so far include ideas for two neutrino experiments and three studies concentrating on CP-violation in B-particle decays, one using a gas-jet target, one using extracted beams and one a colliding-beam setup.

Although not the spearhead of LHC physics, ion-ion collisions will still play a major role, continuing a CERN tradition in this field (page 8). For ion collisions, three teams are interested - one using CMS, another using the (suitably modified) Delphi experiment at LEP, and a third using a new dedicated detector.

Around the Laboratories

CERN
LEP in the Alps

With CERN's 27-kilometre LEP electron-positron collider shut down for the winter, LEP specialists met in Chamonix in the French Alps from 19-25 January to review the machine's 1991 performance (January/February, page 6) and to look at ways of improving it.

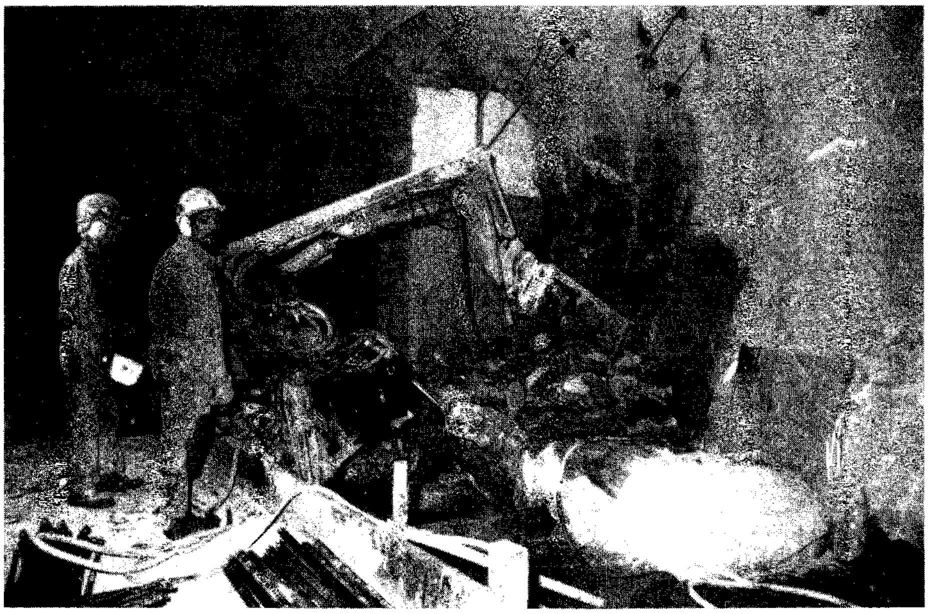
Nine specialist areas were covered - operations, instrumentation, machine optics, the 'pretzl' scheme to increase the number of colliding bunches, energy calibration and polarization, beam-beam interactions, optics for the LEP2 energy upgrade, and radiofrequency to power LEP2.

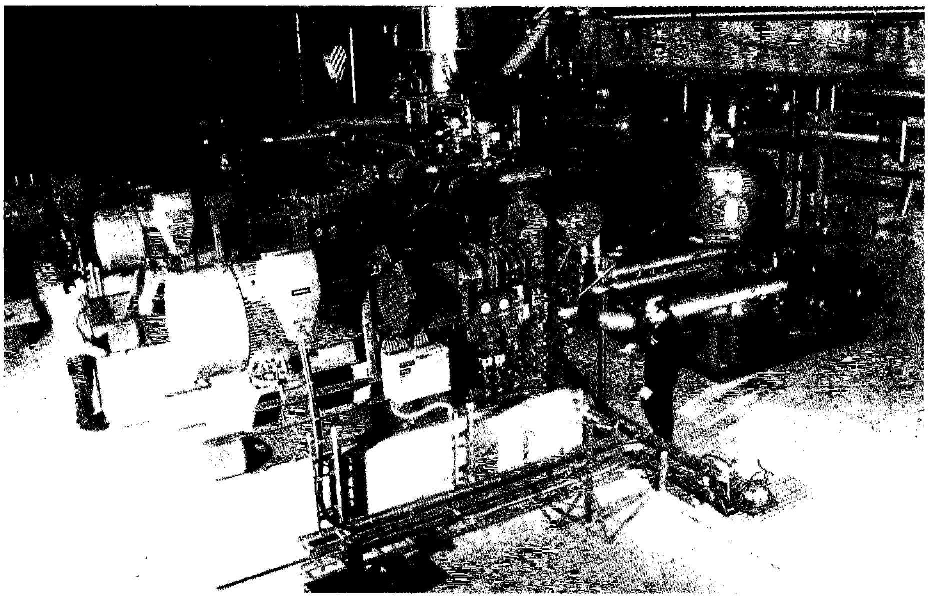
Operational experience had shown the machine's limitations. While the total number of collisions in 1991 was twice that of the previous year, actual beam intensity had not changed significantly. Experience had also shown the need for better measurements of machine optics parameters. A long list of problems await further investigation, and the machine physicists warn that experiments may have to learn to live with higher backgrounds if beam intensities are to be improved.

In the instrumentation sector, the specially developed streak camera had shown its worth in investigating little understood beam behaviour, and will be better exploited with a direct link to the control room.

From the start, LEP has continually tried different tuning schemes to find an optimal working point, with 'split' horizontal and vertical tunes being popular. Additional options are to change the phase of the transverse (betatron) oscillations. Each choice has advantages and disadvantages, CERN's LEP electron-positron collider is the scene of major activity to boost the beam energy from around 45 GeV towards 90 GeV to ensure mass-production of pairs of W particles in 1994. One major task is to install the necessary additional radiofrequency power. Here a new klystron gallery at Point 8 is being linked with the main LEP tunnel.

(Photo CERN)





This compressor for the 6KW cryoplant at LEP Point 2 is already running.

(Photo CERN 15.12.91)

but after careful consideration it was decided to go this year for an optimal 90-degree phase option, which was carefully explored in last year's machine development sessions. As well as reducing beam size and increasing collision rates, this choice should also benefit initial trials of the 'pretzl' scheme to increase LEP performance by handling more bunches per beam. As a foretaste of thing to come, LEP will try for eight bunches per beam sometime this year, instead of the normal four.

The main limitations to increased beam intensity are known to come from transverse mode coupling instabilities for a single beam, compounded with beam-beam interactions once two beams are in the ring.

Polarization studies last year (November 1991, page 12) were encouraging, with 20 per cent spin alignments on the cards. As well as the spin oriented beams, this work also gives a precision handle on the LEP beam energy, which has to be known as accurately as possible for physics. However improvements over a few parts per thousand might have to take into account tidal effects due to the moon's gravity!

In an effort to better understand troublesome beam-beam effects, some old octupole magnets left over from the Intersecting (proton) Storage Rings, closed in 1984, are being installed.

The LEP200 energy upgrade is a major push to boost the beam energy above the threshold to produce W particle pairs. Although the superconducting radiofrequency cavities are not arriving as quickly as expected, confidence is still high that industrial production will meet the planned 1994 deadline.

At the Chamonix meeting, specialists from the Japanese KEK Laboratory, where the TRISTAN collider has used superconducting radiofrequency since 1988, reported that accelerating power in the machine was frequently not as good as in bench tests.

To attain the W-pair threshold thus needs adequate radiofrequency volts, together with enough klystrons to ensure sufficient beam power. The initial LEP superconducting cavities, installed at Point 2, have been in regular use since October.

Meanwhile a major effort is continuing for everything LEP2 needs - cryo-

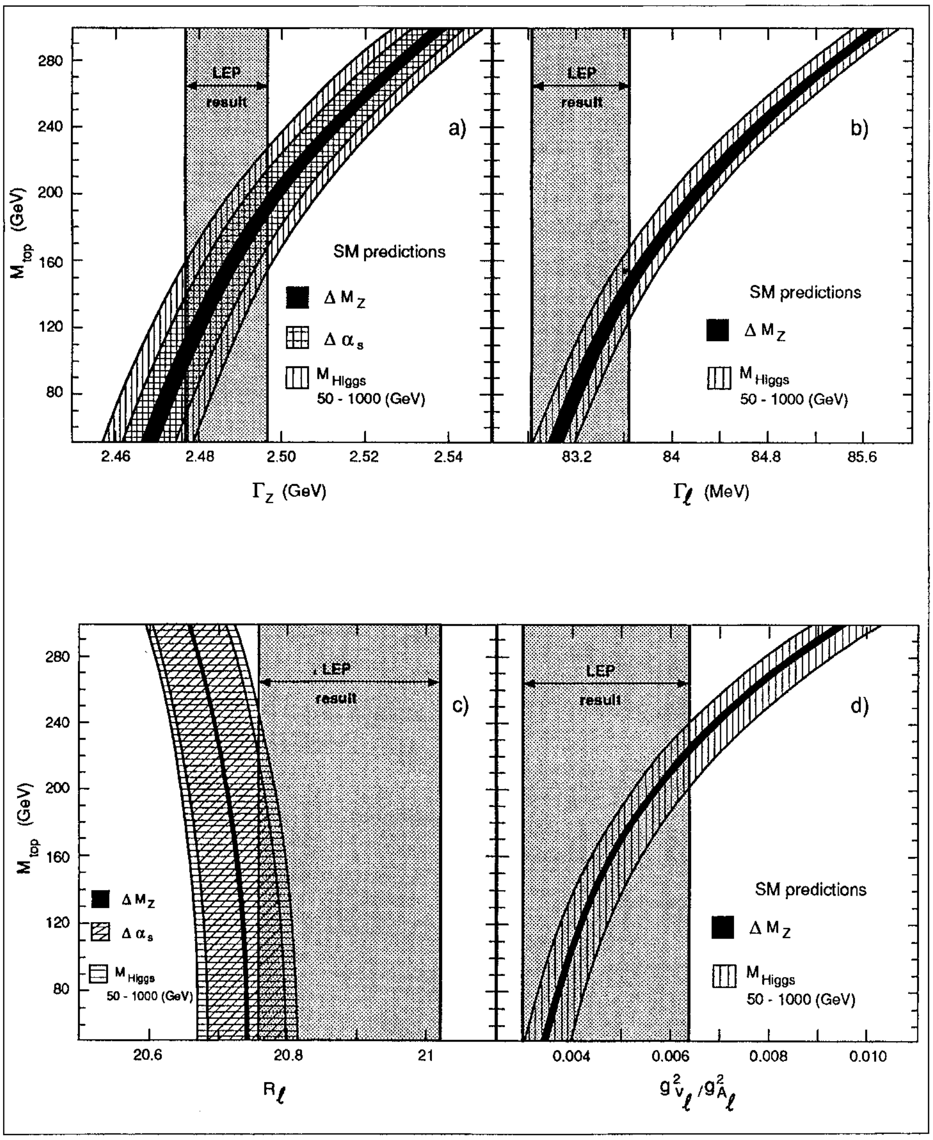
21b *Circle advertisement number on reader service form* genic plant, power supplies, civil engineering for new klystron galleries, additional cooling and ventilation, new (low-beta) magnets to squeeze the beams, vacuum, etc.

In some areas the work for LEP2 even surpasses what was needed for the initial machine configuration. LEP2's radiofrequency power requirements involve half as much work again as LEP1!

1992 LEP goals include introducing eight-bunch 'pretzl' running, and doing polarization studies during physics runs, while also aiming for another doubling of the recorded physics score. Other achievements cannot be ruled out, but no guarantees can be given.

The LEP Chamonix meeting was organized by Steve Myers, with each specialist stream having a Chairman and a Scientific Secretary (in fact the relevant LEP Engineer-in-Charge). A major effort ensured that session documentation was ready in advance. As well as LEP personnel, the meeting included invited specialists from KEK (Japan), DESY (Hamburg), and Cornell (US).

Pulling together data on the Z resonance from the four experiments at CERN's LEP electron-positron collider gives interesting consistency checks on the Standard Model, and in particular limits the mass of the long-awaited sixth ('top') quark (vertical axis). The implications of the mass of the Z and the inter-quark coupling strength (alpha-s), together with their remaining uncertainties, are plotted here against (a) the width of the Z resonance, (b) the Z width for decays into leptons, (c) the ratio of hadronic to leptonic widths, and (d) the ratio of weak interactions couplings, assuming a Higgs mass of 300 GeV (but with a possible variation between 50 and 1000 GeV). A top quark mass below 90 GeV has already been ruled out in searches at Fermilab's proton-antiproton collider.



Putting four LEP experiments together

Since they started taking data in August 1989, the four big LEP experiments - Aleph, Delphi, L3 and Opal - have been providing precision information about the Z particle, the electrically neutral carrier of the weak nuclear force and at 91 GeV the heaviest elementary particle known.

While the results reported by the four experiments have consistently been in step, they have almost always been presented separately by each experiment. Even at CERN, observers wanting a pan-LEP view have had to wait for summary talks at major international meetings. (Last year's major international conference in Geneva included several - September 1991, page 1.)

The four experiments continue to amass data and examine the Z and its decays in finer detail, but now an effort has been launched to combine their results. The move concentrates so far on pooling published data.

The results provide as yet unprecedented precision insights and wrap up even tighter the Standard Model - the current picture of particle physics with the electroweak unification of electromagnetism and weak interactions married with the (quantum chromodynamics) field theory of inter-quark forces.

Each LEP experiment measures in detail the shape of the Z resonance, charts its decays, and measures the delicate forward-backward asymme-

try due to interference between electromagnetism and weak interactions. The pan-LEP analysis collaboration took the 650,000 Z decays from the 1989 and 1990 data-taking periods (the combined score of the four experiments now exceeds two million). Systematic differences between the four experiments are small.

The combined results give better values for some Standard Model parameters and improved consistency checks, while showing graphically that the Model has room for only three types of particle families and three types of neutrinos.

The Z can decay in a number of different ways, including a pair of neutrinos. These particles cannot be observed directly, and normally can only be inferred by mismatches in the energy deposited by visible particles. However decays giving just neutrinos leave no trace at all, so this possibility only shows up when the total observable Z reaction rate is compared with the width of the Z resonance.

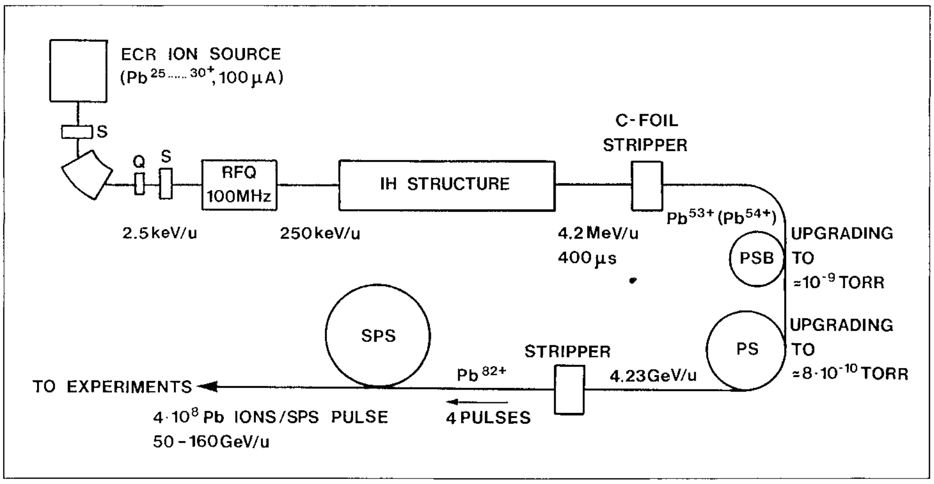
The width of a resonance is a measure of how easily it can decay - the more decay possibilities there are, the faster it can disintegrate. By measuring the total Z width and the separate widths due to decays into hadrons (strongly interacting particles) and visible leptons (weakly interacting particles), the experiments arrive at a remaining 'invisible' width due to the decays into neutrinos.

For the four experiments combined, the ratio of the invisible to leptonic width of the Z comes out to exactly three (assuming that the neutrinos are light). Alone, the fact that this number is an integer is dramatic confirmation of the underlying theory, while its value confirms the three-family picture.

However LEP does not measure everything. The Standard Model information pool has to be supplemented with measurements from neutrino experiments and with information on the W, the electrically charged companion of the Z, from proton-antiproton collider studies.

Taking all this data together gives consistency checks on those few corners of the Standard Model which have yet to be found - the Higgs particle at the origin of mass, and the sixth ('top') quark. While the sensitivity to the Higgs particle is small, the top quark does make its presence felt. Top looks unlikely to weigh more than 200 GeV, while searches at Fermilab's proton-antiproton collider have already ruled out energies below about 90 GeV. The top door is closing fast.

Schematic of the new scheme being planned to provide experiments at CERN with beams of heavier ions. In traditional CERN style, all the 'proton' machines are interlinked, and the scheme could ultimately go on to feed an even bigger link, the LHC collider in the 27-kilometre LEP tunnel.



Heavier ions

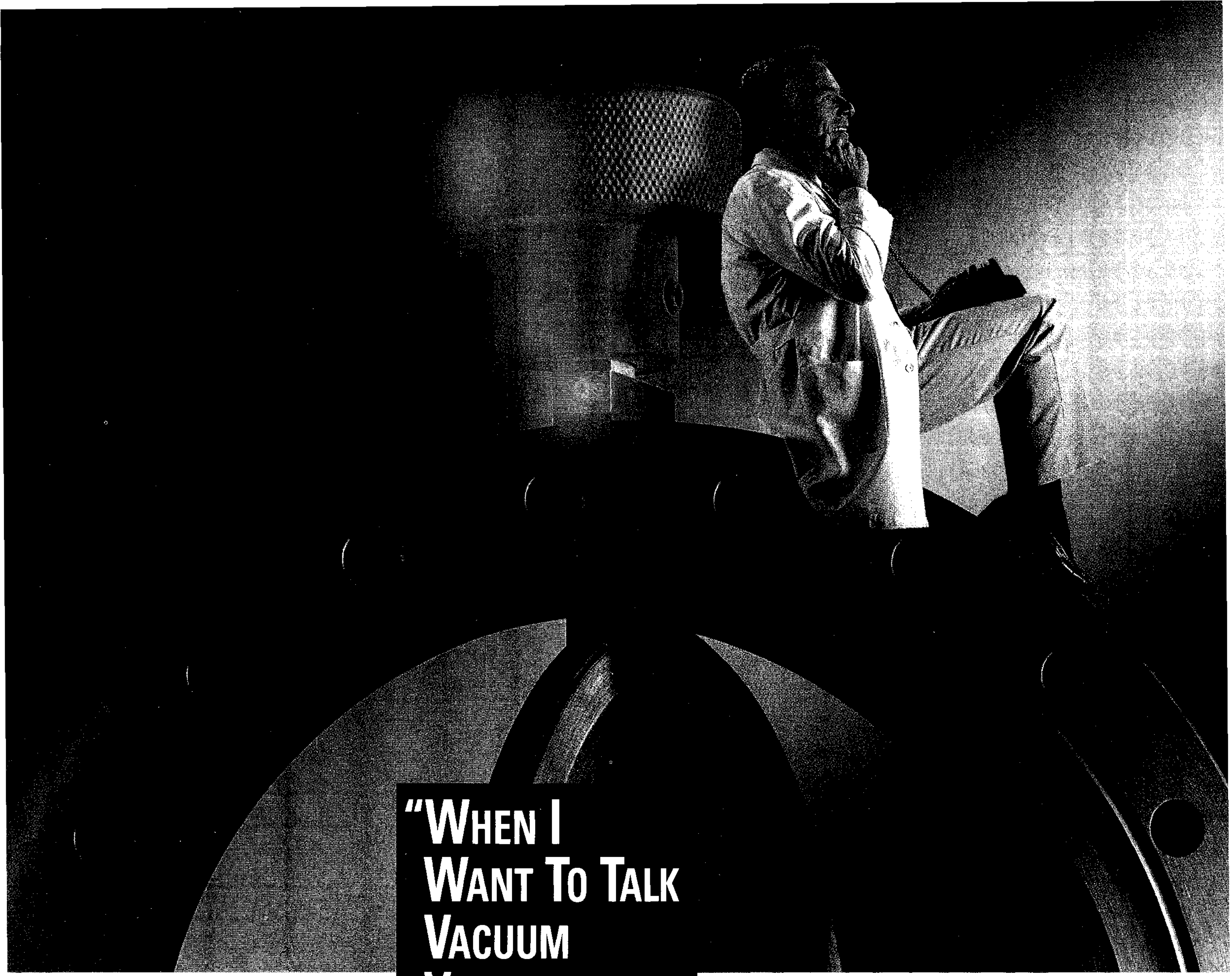
Work by a major international collaboration is progressing well for a new heavy ion system, capable of providing experiments at CERN with a wide range of heavy ions, extending up to the heaviest elements in the Periodic Table. First beams (of lead ions) should be available in 1994.

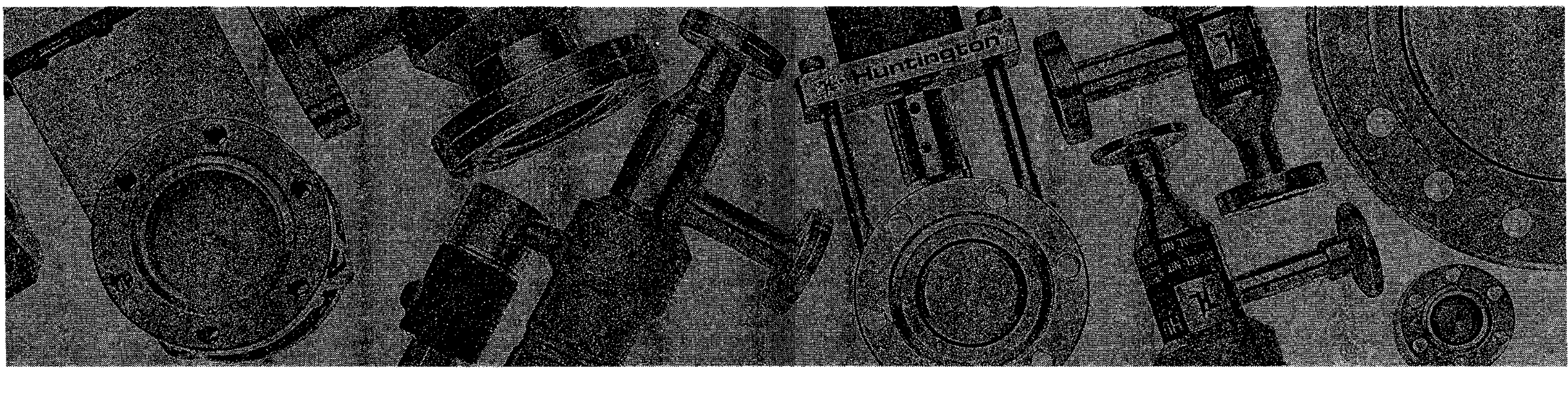
High energy ions have long featured on CERN's menu of charged particle beams - the Intersecting Storage Rings regularly used beams of deuterons and alpha particles. As well as continuing the studies using the SPS synchrotron, a long term aim is also to provide ion beams for the LHC collider to be built in the 27-kilometre LEP tunnel.

In a collaboration with heavy ion specialist Laboratories Berkeley and GSI Darmstadt, work got underway at CERN in the early 1980s to extend the range of ions. As a result ion physics at CERN took a new direction in 1986 with the availability in the SPS 'proton' synchrotron of beams of oxygen nuclei, with sulphur making a debut in 1987.

One of the main objectives in this area of physics is the search for new states of matter, when quarks and gluons break loose from their conventional confinement inside nucleons to form a quark-gluon plasma.

While these experiments have given some interesting physics, exploring the way nuclear matter behaves and interacts, it is clear that production of the long-awaited quark-gluon plasma demands the higher energy densities provided by much heavier ions slamming into targets.





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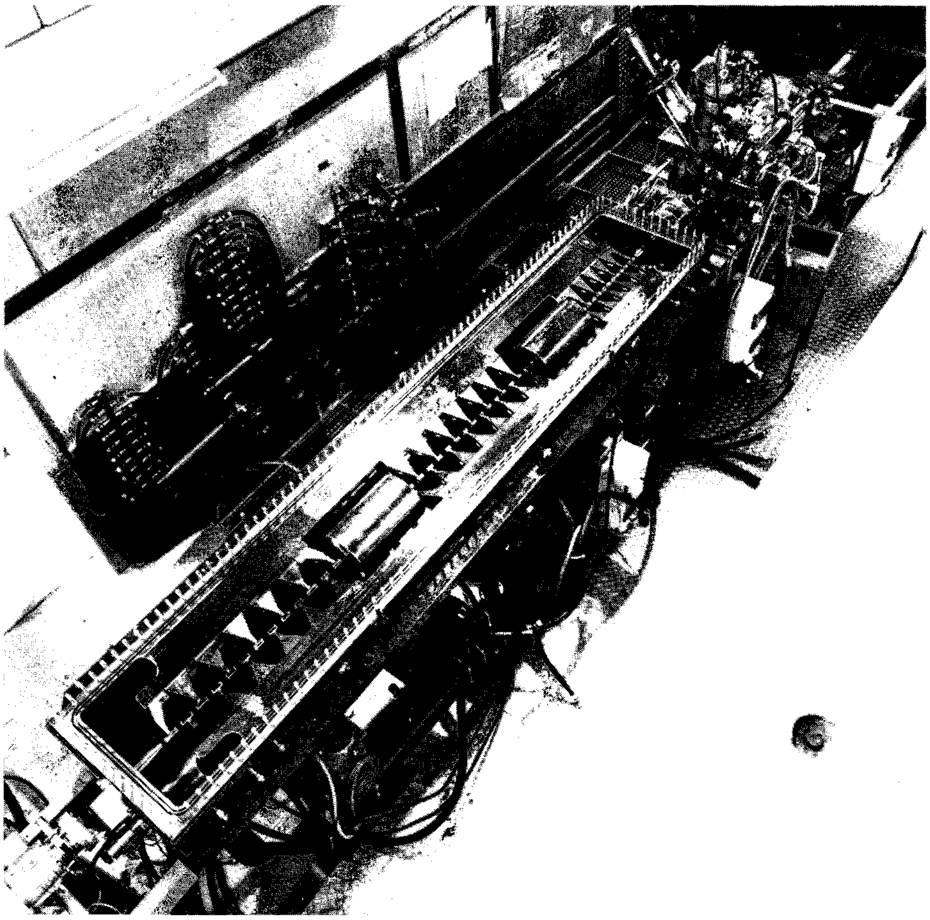


Interior of the interdigital-H tank for a high charge state injector at the GSI heavy ion Laboratory, Darmstadt, showing the special arrangement of staggered electrodes inside the radiofrequency tank. A similar device will be supplied by GSI for CERN's future programme using a full range of heavy ions.

(Photo A. Zschau)

As well as a special ion source, the ion scheme developed at CERN in the 1980s involved some upgrading of the proton machines, particularly the 'old' linac, fed by a radiofrequency quadrupole (RFQ). With this linac already pushed to its limits with 33% higher internal fields, handling heavier ions requires a completely new linac, together with substantial upgrading of the downstream machines and beamlines.

The new electron cyclotron resonance heavy ion source, provided by the French GANIL heavy ion Laboratory in Caen, will be an extrapolation of existing technology. It will feed a radiofrequency quadrupole (RFQ) taking the ions up to 0.25 MeV per nucleon.

The next energy kick, to 4.2 MeV/nucleon will come from a new linac, to be supplied by GSI, using the 'interdigital H' structure. This is a variant of the classical Wideroe accelerating technique, with a series of drift tubes inside a radiofrequency cavity arranged to give high shunt impedance - a minimum amount of power lost in the cavity walls.

The usefulness of interdigital H cavities, initially used to give particles emerging from Van de Graaff machines an additional energy kick, has now been extended to cover a wider energy range.

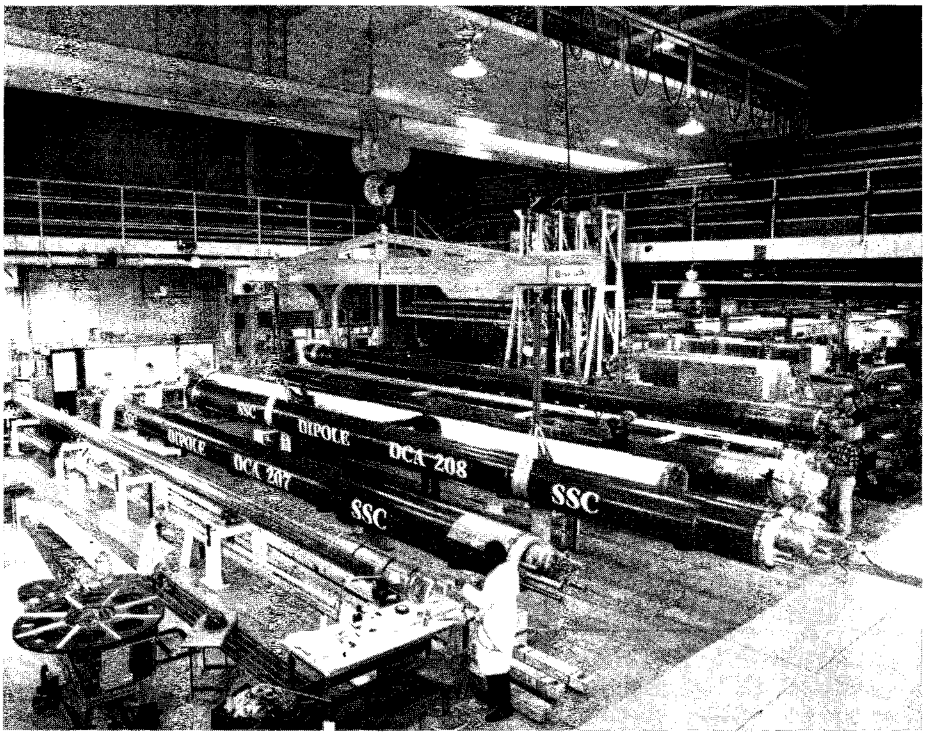
Software for the linac control system will be developed in India, a longtime enthusiastic user of CERN's ion beams. Other contributions to the new CERN scheme come from Italy, where Legnaro and Turin will respectively supply the low energy (including the RFQ) and high energy beam transport systems. Frankfurt's Institute for Applied Physics (IAP) will supply a debuncher to handle the beams after the linac.

The next stage will be the Booster synchrotron, where improved beam instrumentation and a complicated series of beam handling gymnastics will take the particles into the relativistic regime at 96 MeV per nucleon. Gymnastics will continue for the transfer and injection into the PS synchrotron for acceleration up to 4.2 GeV per nucleon. To handle the heavy ions, both the Booster and PS vacuum systems will have to be improved to attain the required 10^{-9} millibar level, the former from a few 10^{-8} millibars the latter from about 8 x 10^{-9}.

Finally the highly relativistic ions will be passed to the SPS where again ingenious methods of operation will be needed to take the particles towards the equivalent of about 160 GeV per nucleon for lead (a total of over 30 TeV for the lead nucleus!) ready for the waiting experiments. Turin will provide additional SPS beam instrumentation.

Taking the lead ions through this chain of machines will not be easy, but CERN's machine specialists are used to taking the challenges of new particles in their stride. Antiprotons, deuterons and alpha particles, oxygen and sulphur ions, and electrons and positrons have all been added to the beam menu in the past decade.

DCA 207 and 208 are the first industrially-assembled (Westinghouse) dipole prototype magnets for the Superconducting Supercollider (SSC, to be built in Ellis County, Texas) to be successfully tested at Brookhaven. Others have been tested by General Dynamics at Fermilab. SSC dipoles now use the larger (50-mm vs 40-mm) aperture. In the background is a pile of the older 40-mm aperture versions, with a 50-mm interior 'cold mass' being worked on in the foreground.



SUPERCOLLIDER
Industrial magnets

The first industrially-assembled dipole prototype magnets for the Superconducting Supercollider (SSC, to be built in Ellis County, Texas) have been successfully tested.

Following an earlier demonstration of laboratory-assembled magnets of the same designs at Fermilab and Brookhaven, industrial teams from General Dynamics and Westinghouse used the tooling at the Laboratories to assemble the industrial prototypes. All magnets tested to date operated at currents of at least 7000 amperes with little or no training, well above the design current of 6500 A.

The early development of these magnets was carried out at Brookhaven. The most recent design version features a larger (50-mm vs 40-mm) aperture. The improved design has now been tested successfully in two slightly different configurations developed concurrently at Brookhaven and Fermilab.

One magnet at each Laboratory was used to transfer the technology to General Dynamics and Westinghouse. Remaining units of the first prototype series are being assembled solely by the two companies, using the Laboratory tooling. General Dynamics is the lead contractor, assembling seven magnets at Fermilab, and Westinghouse is the follower contractor, assembling five magnets at Brookhaven. Of these first twelve industrially assembled magnets, five will be used in the string test next fall in the new ASST building (January/February, page 11) at the SSC Texas Laboratory.

After prototype tests and evaluations, General Dynamics and Westinghouse will begin magnet fabrication at their Hammond, Louisiana, and Round Rock, Texas, plants. General Dynamics will start by building 15 prototype magnets for test and evaluation in 1993. Each firm will then produce 35 preproduction magnets and then at an increasing rate, 251 magnets for actual installation. Ultimately 8600 magnets will be needed to equip the two 87-kilometre SSC rings, and both firms are expected to bid.

Westinghouse is also looking after development and initial production of superconducting dipoles for the High Energy Booster - the final SSC injector, feeding 2 TeV protons to the Collider. Westinghouse will produce 3 model magnets, 6 prototypes, 20 preproduction magnets, and 50 low-rate production magnets. Delivery of the first model HEB magnet is expected by the end of the year, and the first of the low rate production magnets is scheduled for delivery in mid-1996.

Meanwhile on the international front, following the visit of US President George Bush to Japan in January, a joint US-Japanese SSC working group has been formed 'to examine technical and other essential aspects of the project and to consider how it can be formulated as an international project to enable Japan to participate in it.' Under discussion is the possibility of a major contribution, such as one of the two rings of the Collider.

A laboratory-to-laboratory agreement has been signed with the Institute for Nuclear Physics in Novosibirsk, Russia. The details are being worked out in a series of technical annexes, covering the magnets and many other technical components of the Low Energy Booster, together with beam transfer lines between injector accelerators.

A GEM of an SSC detector

The SSC Laboratory has decided to support the GEM (Gammas, Electrons, and Muons) detector collaboration in the next stage of its work, development of a Technical Design Report. Initial ideas for GEM as the second major SSC detector were aired last year (October, page 12).

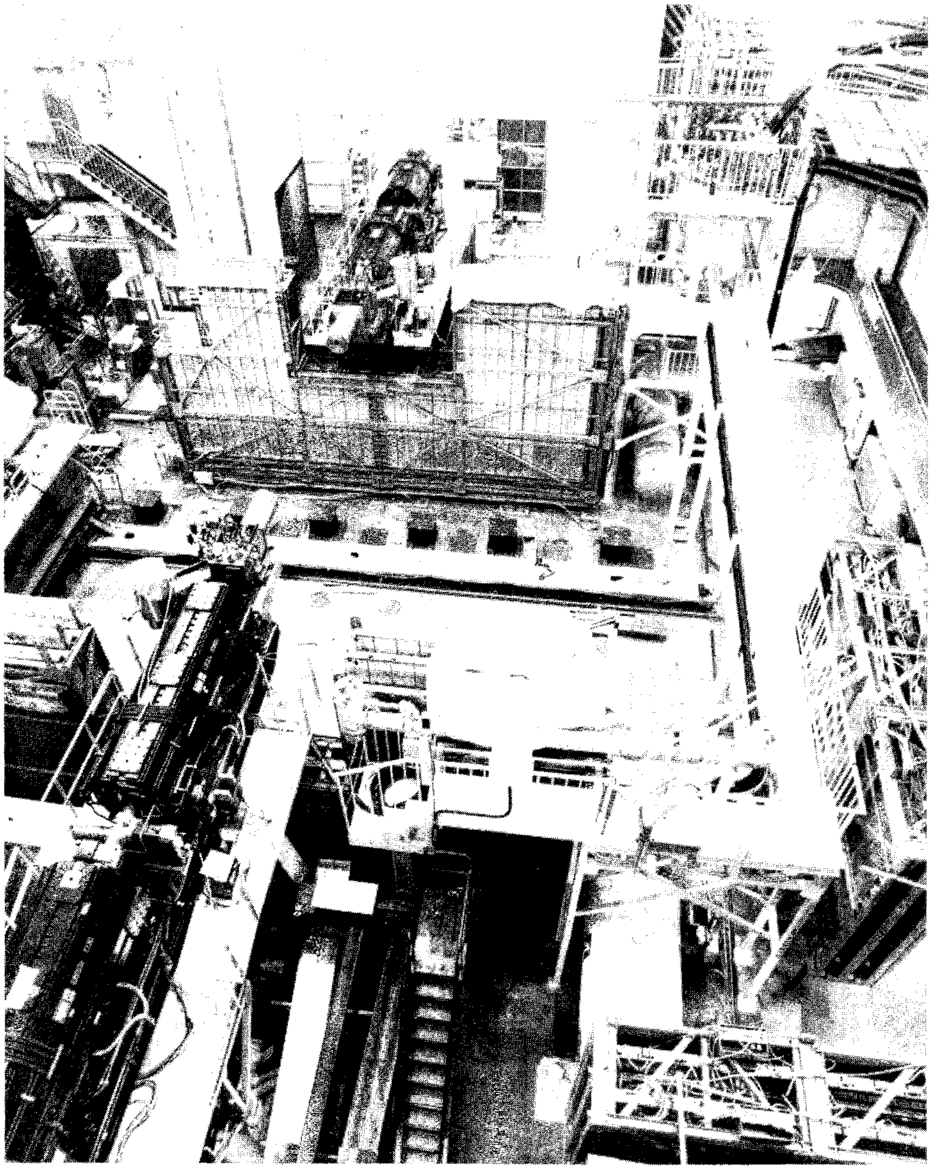
GEM has progressed significantly since its inception last June. Now numbering 605 physicists from 86 institutions in 15 countries, the collaboration proposes a detector emphasizing photons, leptons, and robustness at high luminosity. Two options are being examined for calorimetry: either liquid argon/krypton or barium fluoride (electromagnetic) combined with scintillating fibres (hadronic).

Muons will be tracked with a combination of drift tubes (barrel region) and cathode strip chambers (end caps), with resistive plate counters in the barrel region to trigger on muons and tag beam crossings. The chambers surround the calorimeters and fill a 16-metre diameter, 30 metre long, 0.8-tesla superconducting solenoid. Inside the calorimeters is a compact (1.5-m diameter by 3-m length) central tracker, where two options are being considered - silicon microstrips surrounded by either straw tubes or interpolating pad chambers.

Meanwhile, the Solenoidal Detector Collaboration (SDC) (March, page 13) is going through the intensive SSC review procedure.

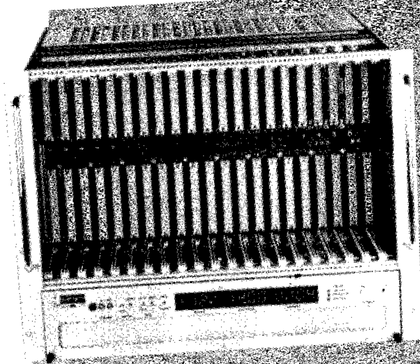
Geological studies have shown that the two major detectors should be located on the east side of the Collider ring, rather than the west side as had been planned originally. There, the floors of the large halls would have been too near the shale underlying the local chalk. This shale expands when decompressed by excavation, and its deflection properties are not well known. On the east side, the big halls for both major experiments can be founded in the chalk. Shallower halls for smaller experiments can be founded on the west side.

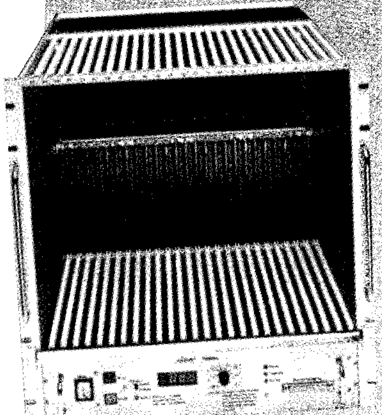
The experimental area for the VENUS detector at the Japanese KEK Laboratory's TRISTAN electron-positron collider with the detector temperarily withdrawn, showing the small cylindrical cryostats of the new 'mini-beta' superconducting quadrupoles on either side of the area. Further back are the larger cryostats of the previous low-beta optics.

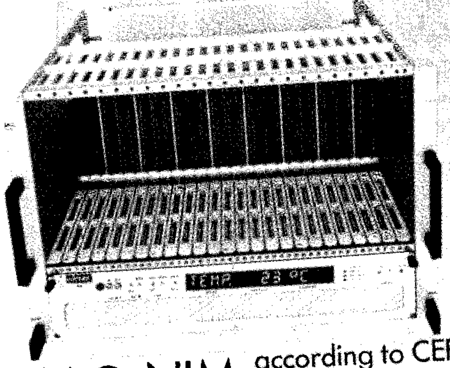


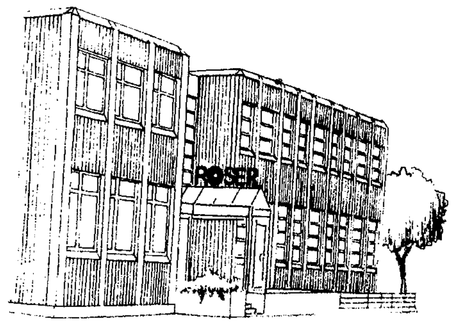
KEK
More collisions at TRISTAN ......

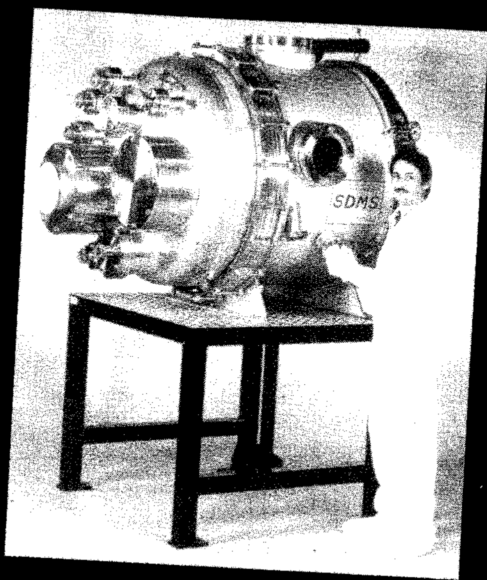
The TRISTAN electron-positron collider at the Japanese KEK Laboratory has recently made a quantum jump in performance, with the machine's luminosity (a measure of the











collision rate) being boosted to achieve the promised one inverse picobarn per day per experiment at 58 GeV collision energy. The key factor was successful operation of the new 'mini-beta' optics to squeeze the beams tighter at the interaction point (IP).

In the previous TRISTAN beam optics, the colliding beams were focussed with a doublet of normal conducting quadrupole magnets, the nearest 4.5 metres from the IP. With this 'low-beta' scheme, the highest delivered luminosity amounted to about 0.4 inverse picobarn per day (September/October 1990, page 31).

While this was sufficient for an initial energy scan, deeper physics needed something more. The beta function, one of the basic parameters of a storage ring, determines the beam spot size and the depth of focus at the IP. To make two crossing beam bunches collide as effectively as possible (maximum luminosity) beta should be as small as possible right at the IP. If everything else is OK, this 'mini-beta' promises more collisions.

The mini-beta luminosity improvement needed a special superconducting quadrupole design, 1.17 m long and providing 70 Tesla/m field gradient at 3400 A. It has no iron, allowing it to be installed in the strong solenoidal magnetic field of the AMY, TOPAZ and VENUS detectors, 2.3 m from the IP. This distance is a compromise between luminosity and detector requirements.

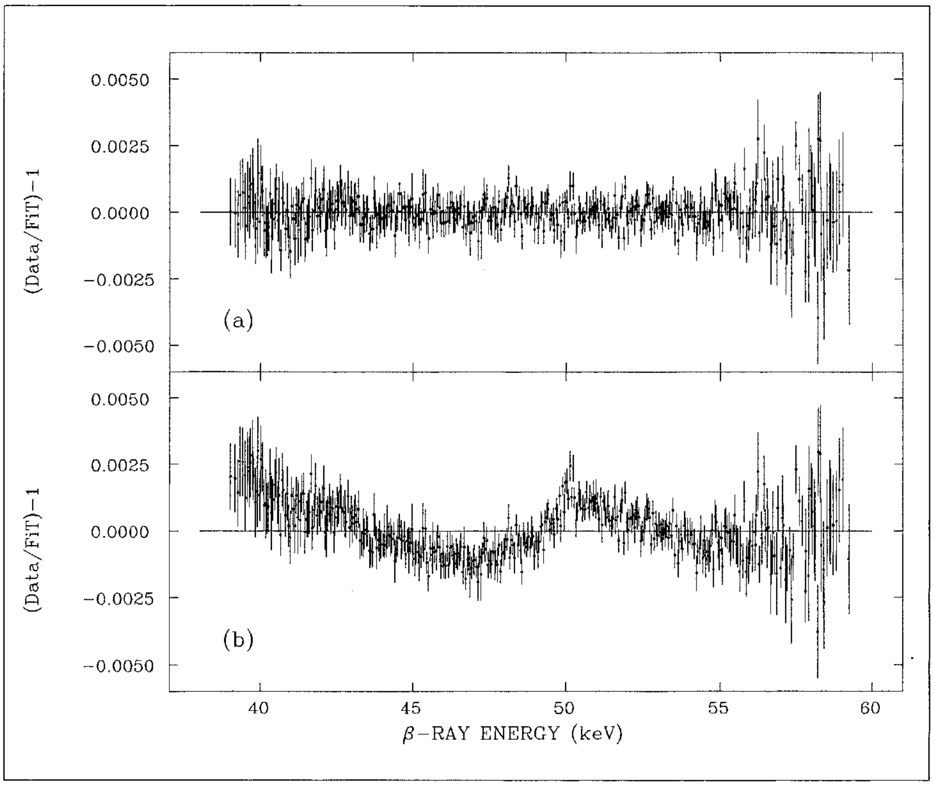
Initial problems were encountered due to rotational errors in the quadrupoles, resulting in intolerable vertical-horizontal coupling. Careful work was required to rotate the magnet body inside the cryostat to within 0.5 mrad and check the result.

Ironing out this problem revealed another at injection beam tuning when skew quadrupoles and detector solenoids were turned on. At this stage, happily the SAD computer program came to the rescue. SAD (Strategic Accelerator Design), written by KEK accelerator physicists, played a decisive role in understanding and solving the problems.

By following the SAD prescription, the beams were successfully focussed at the IP. The program also predicted that the existing skew magnets would limit the total current, so fresh skew quadrupoles were quickly built to fit the bill.

The result was a further improvement in performance. At the end of November, just in time for the second KEK Topical Conference on Electron-Positron Collision Physics, TRISTAN recorded its highest-ever luminosity - 3.7 x 10^{31} per sq cm per s and one inverse picobarn per day per experiment.

The three detectors (AMY, TOPAZ and VENUS) had already been upgraded anticipating such high luminosity runs, and look forward to the accelerator specialists supplying them with a further twofold increase in luminosity.



No 17 keV neutrino in Japan. The beta-decay spectrum of nickel-63 measured by a Japan-US group using a magnetic spectrometer. Above, the data are fitted to a single massless neutrino, and below, with a hypothetical 17 keV neutrino emitted one per cent of the time.

...... but no 17 keV neutrino

In the continuing effort to pin down a heavy neutrino at 17 keV, an experiment at the Japanese KEK Laboratory comes in with a 'no' vote.

Last year John Simpson's new beta-ray spectrum analysis at Guelph, Canada, again suggested a 17 keV neutrino mixed at one per cent level with the conventional electron-type neutrino. Similar results (April 1991, page 9) came in from Oxford, Berkeley and Zagreb groups, while negative results came from several others. With many researchers bored with endless Standard Model conformity, a 17 keV neutrino soon became controversial.

In Japan, a KEK-INS (Tokyo Institute for Nuclear Science) group set out to check out this result, forming an enlarged Japan-US team.

The heavy neutrino is suggested by a subtle kink at the corresponding kinematical threshold (the end-point energy minus the nonzero neutrino rest-mass energy), together with a small difference in the slope well above and below it in the beta decay spectrum (the so-called Kuri plot). But accurate measurement of the slope is hampered by a low energy tail due to electron backscattering in the beta source.

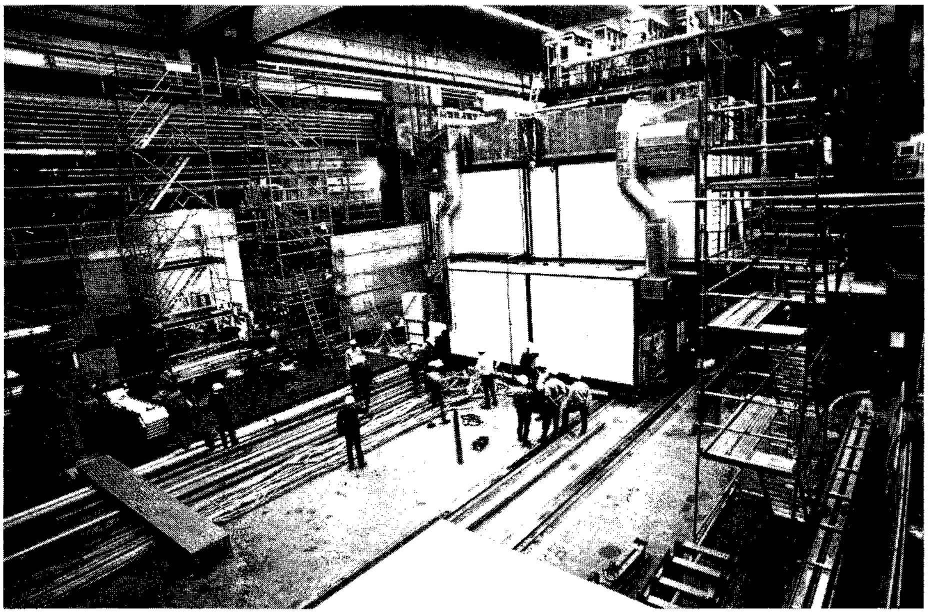
The experiment therefore searched for a sudden change in the spectrum near the expected threshold, accumulating lots of data in a narrow energy region and with good resolution.

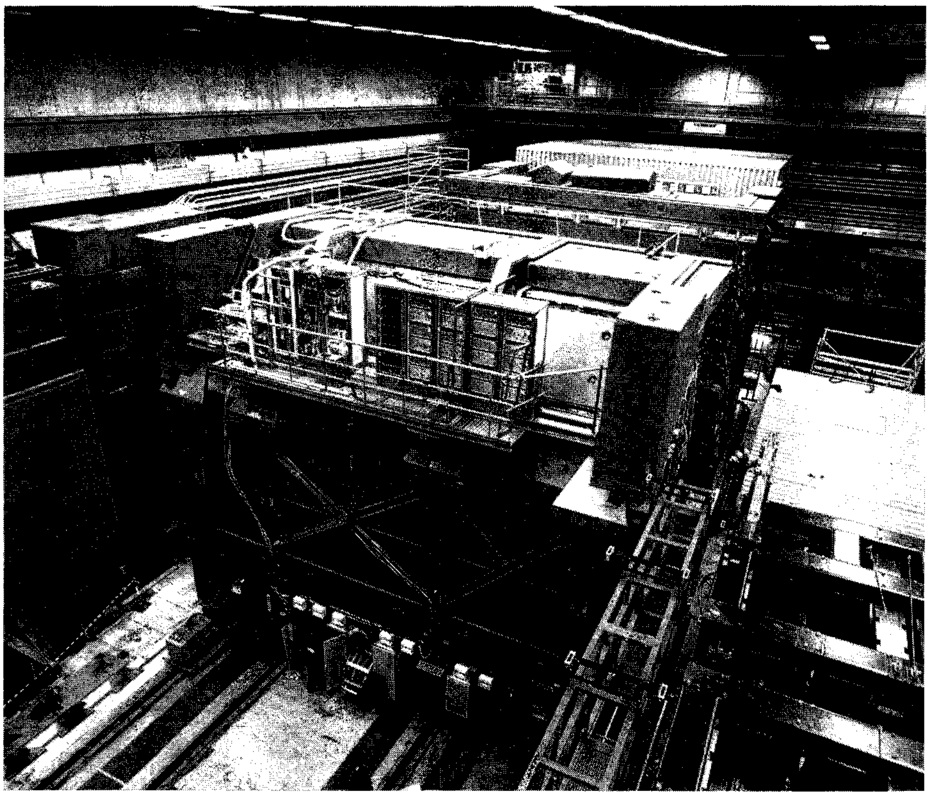
Beta-rays from a nickel-63 source with an end-point energy of 66.9 keV were energy-analysed by the large INS iron-free magnetic spectrometer and detected with a proportional chamber having 30 independent cells.

This spectrometer had been successfully used in a previous experiment with a thin tritium source to set a limit for the mass of the electron-(anti)neutrino.

In a series of runs over two months, 2.4 billion events were collected, distributed over 1800 data points between 40 and 60 keV. The signal-to-background ratio was as high as 1000 near the expected threshold energy.

After careful checks, the results show no hint of the distortion in the spectrum near 50 keV which a 17 keV neutrino would produce.





At the DESY Laboratory, Hamburg, the big detectors H1 (3000 tonnes, top) and Zeus (3500 tonnes) have been rolled into position for the first time in the HERA electron-proton collider. With the machine commissioned late last year, physicists are hoping soon to have their first glimpse of these new physics conditions.

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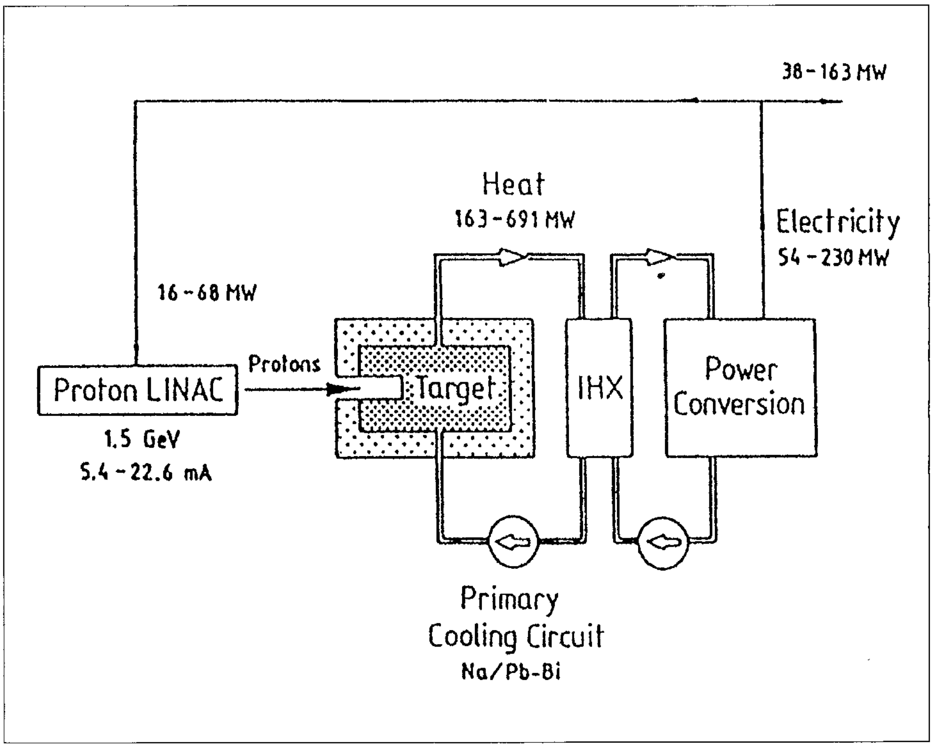
Physics monitor

Conceptual design of a system using a proton accelerator to transmute awkward radioactive isotopes produced in course of fission processes. It has been studied at the Japan's Atomic Energy Research Institute for several years. At Los Alamos in the US, similar ideas are being looked at.



Transmuting nuclear waste

With the problems of disposing of nuclear waste material increasingly the cause for widespread concern, attention is turning to possible new techniques for handling discarded radioactive material and even putting it to good use.

One possibility being examined, mainly in the US, Japan and the former Soviet Union, is to irradiate long-lived nuclear waste with particle beams, transforming it into shorter-lived isotopes and/or using it as a breeder reactor.

The idea of using a high energy particle beam to produce fissile material was first put forward by Ernest Lawrence in 1950. The idea then was to ensure a continuous supply of material for nuclear weaponry, irradiating lithium to produce tritium for fusion bombs, and uranium to produce plutonium for fission. In those days the US was anxious to insure its nuclear capability against any interruption in the import of uranium ore.

The idea led to the construction of the Materials Testing Accelerator (MTA) at Livermore, not far from Lawrence's Berkeley Laboratory. However market manoeuvres increased the price of uranium, making lower grade deposits in Colorado exploitable. The US no longer needed a backup plan to make plutonium from scrap uranium. MTA foundered, but the accelerator technology was put to good use at Berkeley.

Now thinking is returning to this idea, but with the emphasis on handling the output from nuclear plant rather than providing the initial input fuel.

This work is reported regularly at accelerator conferences, but was highlighted in an international meeting organized last year by the Moscow Radiotechnical Institute and attended by scientists from Japan and the US as well as the (then) Soviet Union who examined the problems and possible solutions. A draft conclusion written summarized the major objectives.

With the disposal of long-lived waste from nuclear power as one of today's most urgent problems, increasing the research and development efforts, combining expertise from different countries, is of prime importance, the conclusion recommends.

Today it looks fairly certain that an incinerator reactor based on a linear accelerator with an energy of 1.5 GeV and a current of 300 mA is practicable. But considerable effort is still needed to develop an accelerator to provide the necessary high proton flux.

As well as the accelerator, additional effort is required to develop schemes to separate out long-lived nuclides from the rest of the waste, to design a blanket target, to check reaction rates, and to obtain energy release figures.

However the use of a powerful accelerator for waste incineration seems quite practical and economically expedient. 'The whole complex of problems connected with radioactive waste handling should become an object for international cooperation'. The report ends by recommending increased international exchanges.

The summary did not indicate the work currently underway elsewhere, mainly in the US and Japan. As well as incinerating waste, either existing or future, these schemes could also provide new and more efficient routes to fission. Most of the ideas

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The MIT Laboratory for Nuclear Science invites applications for an immediately available Principal Research Scientist to assume a major role in the L3 experiment. Responsibilities will include: Developing software for event reconstruction and detector calibration, playing a leading role in the data analysis, participating in upgrades of the experiment, both in software and hardware developments.

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Please send curriculum vitae including a list of publications and a minimum of four letters of reference to: **Mr. Richard Adams, Laboratory for Nuclear Science, MIT 26-505, 77 Massachusetts Ave., Cambridge, MA 02139-4307.**

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currently under consideration use an intense 1.5 GeV proton beam to irradiate a target of liquid heavy metal (e.g. lead) generating neutrons which are subsequently thermalized in a heavy water blanket.

One major radioactivity problem is the actinide (heavier than uranium) isotopes formed in fission environments. However an intense thermal neutron flux would ensure that these troublesome isotopes act as a net producer of neutrons - acting themselves as nuclear fuel.

The other trouble spot is the fission products themselves, and here the intense neutron bombardment would transform many of them into other isotopes which decay in terms of days or even seconds, rather than months and years.

In the US, work is going on at Los Alamos and Brookhaven, while in Japan the Atomic Energy Research Institute has several projects for actinide burning and isotope transmutation as part of the national OMEGA - Options Making Extra Gains from Actinides and fission products - campaign.

In Europe there is interest but little cash encouragement in this potentially very rewarding venture.

Spin collaboration

What makes the proton spin? In 1988, results from the European Muon Collaboration (EMC) experiment at CERN suggested that the spin of the proton is difficult to explain in terms of quark constituents. A range of experiments is now underway to resolve the question.

In 1988, EMC looked at the violent collisions when a high energy spin oriented (polarized) muon beam hits quarks deep inside a polarized proton target, and found that the difference (asymmetry) between the reaction rates for two different spin orientations was not in line with theoretical predictions.

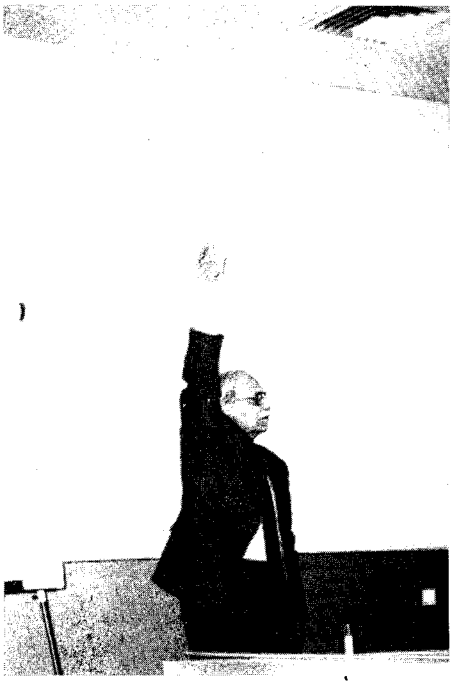
Combining the EMC results with previous SLAC data suggested that very little of the proton spin is carried by the quarks. If this is the case, where can the spin come from? Various ideas have been proposed but only new experimental information can provide the answer. Particularly important is companion data on the neutron.

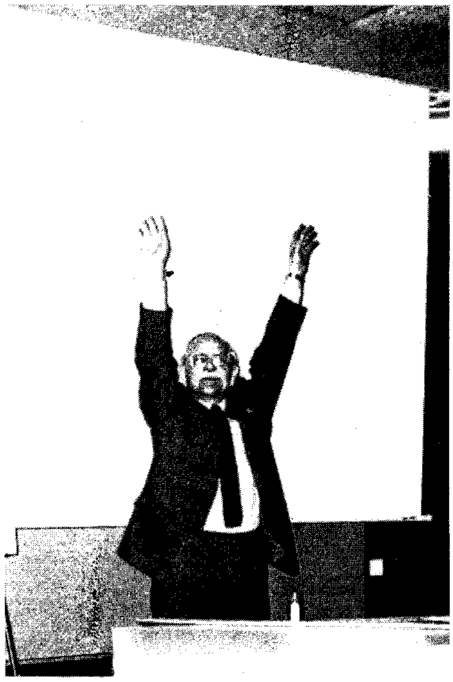
A fundamental test of the underlying theory is given by the Bjorken polarization sum rule which relates the proton and neutron spin-dependent structure functions to neutron beta decay parameters. Particularly important is accurate information when the struck quark carries only a small fraction of the proton momentum (small x) to improve the extrapolations needed to compare with theory.

Five new experiments using different techniques have been proposed to extend the measurements to the neutron, and to lower values of x. Some of these projects also plan to improve the accuracy of the present results on the proton.

Two experiments have been proposed for the 23 GeV beam at Stanford (SLAC). E-142, scheduled for this fall, uses a polarized helium-3 target at 10 atmospheres as an effective neutron target. E-143, scheduled for 1993, uses ammonia/deuterated ammonia targets. Both experiments will provide high precision data for x between 0.04 and 0.6.

Another experiment (HERMES) using a novel technique has been proposed for the 35 GeV HERA electron ring at DESY, Hamburg. Using a polarized atomic beam and a storage gas cell as an internal target, together with a polarized electron beam, this experiment, still awaiting approval, will explore the x range between 0.02 and 0.08. A letter of intent for the HELP experiment at CERN





At the recent Spin Muon Collaboration meeting in Paris, Anatole Abragam describes the mechanism of dynamical polarization, first for one spin up, then two.

(Photos T. Hasegawa)

proposes to use the 50 GeV polarized electron beam of LEP and a polarized jet of hydrogen and deuterium.

Continuing the EMC tradition at CERN, the Spin Muon Collaboration (SMC) experiment (March 1990, page 3) was launched. Including specialists from a broad variety of fields in atomic, solid state, nuclear and particle physics, covering 26 institutions from Europe, Japan and the United-States, the SMC experiment will run from 1991 to 1993, using CERN's high energy (100-200 GeV) muon beam, recently upgraded by a dispersion-free transport system.

The polarized nucleon target is a large frozen spin target at 50 millikelvin using butanol for protons and deuterated butanol for neutrons. An important feature is the possibility of exploring x down to 0.005.

The experimental set-up is an upgrade of previous muon beam experiments. The principal modification to the spectrometer is the replacement of 16 planes of drift chambers by a 32-coordinate streamer tube system built by the Universities of Houston and Munich, and 12 planes of drift tubes built by Dubna.

A new polarimeter will determine the polarization of the muon with an accuracy of about 5%. This polarimeter, developed by a Rice-Trieste-Saclay collaboration, will use the measurement of the positron energy spectrum from the muon decay in flight and of the asymmetry in muon-electron scattering in a magnetized iron target.

Together, these experiments with muon and electron beams will probe in detail the spin structure of protons and neutrons over a broad range of x, providing comprehensive and accurate data on the spin structure of the nucleon.

Electron beams promise a high statistical accuracy in a short time while muons offer the unique possibility of exploring the very small x region. Together, these extensive measurements will reduce experimental uncertainties due to systematic effects since they use completely different techniques.

From 16-18 December, 100 physicists met in Paris for the SMC workshop on the spin structure of the nucleon. The meeting focussed on the first data on the deuterium longitudinal asymmetry, obtained last year at CERN. Highlights were presented by Vernon Hughes (Yale). A great achievement for the collaboration has been the success of the polarized target, an upgrade of the EMC apparatus. This was the first time that such a large quantity of deuterated material has been polarized to about 30 %. The development of new electronics and new methods of analysis enables deuteron polarization to be measured to within a few percent.

Anatole Abragam (Collège de France) captivated the audience with his graphic descriptions of early developments on dynamic nuclear polarization, recalling in particular the success of his collaboration with specialists J. Thirion at Saclay and M. Borghini and T. Niinikoski at CERN. He demonstrated that polarized targets require a variety of talents in physics, fine jewellery, plumbing, etc.

The review of the theoretical situation by R. Jaffe (MIT) emphasized the urgent need for accurate experimental information and discussed the importance of measuring the transverse asymmetry to provide new information on quark-gluon interactions.

In 1993 a new SMC polarized target, 50% longer, will be introduced. This includes a new dilution refrigerator built by CERN, Helsinki, Munich and NIKHEF (Amsterdam), and a highly uniform field superconducting magnet built at Saclay. A dipole transverse field will allow rapid and frequent polarization switches as well as the measurement of transverse asymmetries.

This year the first results on the neutron spin structure should begin to shed further light on the puzzle of the origin of the nucleon spin.

Futurebus+

A special symposium held at CERN on 28-29 October, jointly organized by the ECP (Electronics and Computing for Physics) and CN (Computing and Networks) Divisions, and the most recent conference in the biannual US BUSCON series, held in Long Beach, California, from 4-6 February, reflected the status of Futurebus+, the most advanced backplane bus standard for physics data handling systems.

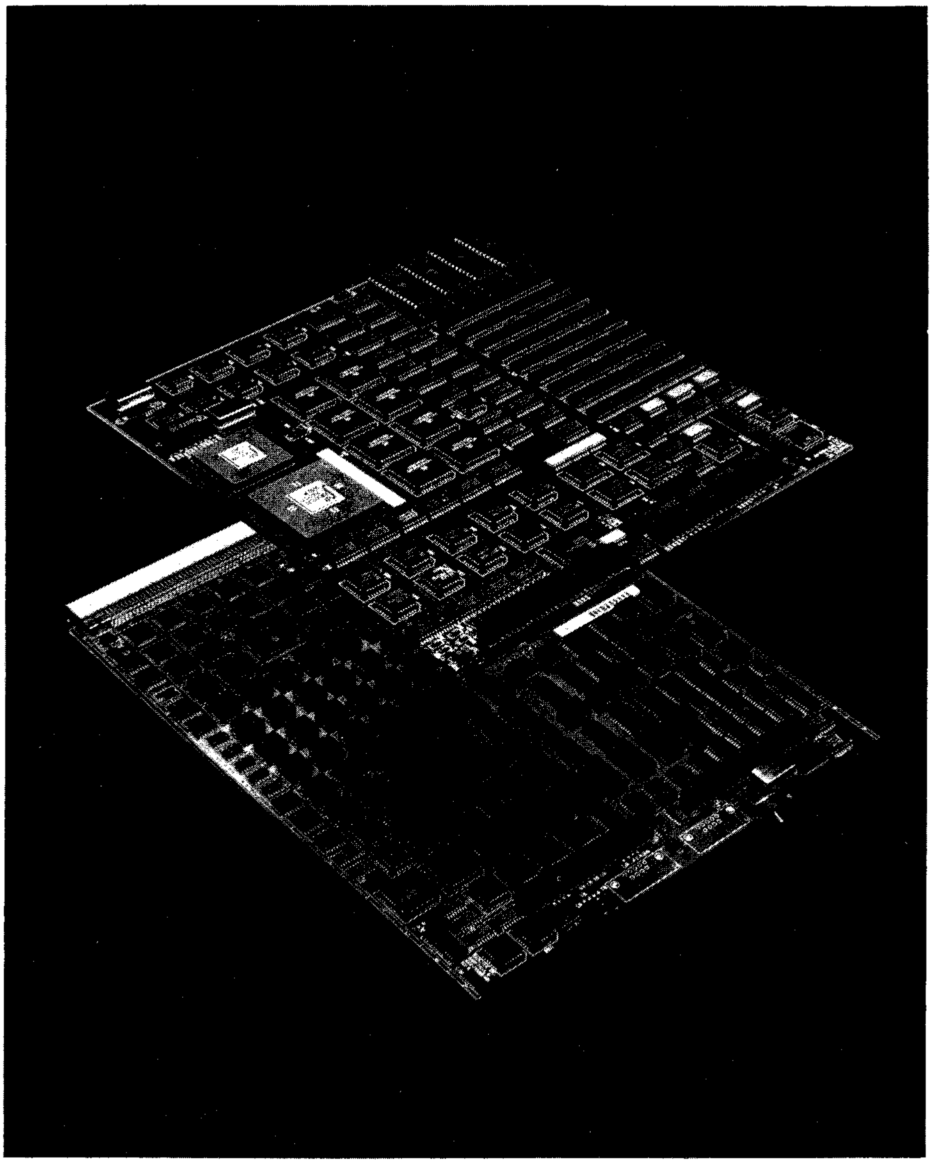
The standardization of Futurebus+ has made significant new progress. IEEE 896.1, the Logical Layer Specifications, and IEEE 896.2, the Physical Layer and Profiles Specification, are now official standards. A third document in the family of Futurebus+ standards, IEEE P896.3: Recommended Practices, has just been distributed for Sponsor Ballot.

Unlike other open bus specifications, Futurebus+ has a Logical Layer Specification independent of any specific implementation technology. The same logical protocols and functions can be implemented with different board, connector and bus driver technologies allowing Futurebus+ performance and cost to scale up and down according to user needs and technological development.

36 *Circle advertisement number on reader service form*

New manufacturer-supplied electronics with (below) a Futurebus+ board, the most advanced backplane bus standard for physics data handling systems. A range of Futurebus+ board products should soon start to become available from major suppliers.

(Photo Nanotek Inc.)



The Physical Layer and Profiles Specification(s) are the means to guarantee interoperability and interchangeability of boards from different manufacturers for a chosen technology and application area. The Recommended Practices document gives valuable information for the system integrator on how to use the rich set of basic Futurebus+ features for, amongst other areas, system initialization, fault management, test and maintenance. Of prime importance is also a detailed discussion of real-time schedulability (prompt execution) support in the Futurebus+ environment.

At the CERN symposium, participants first heard a tutorial on Futurebus+ by Joe George, President of Nanotek Inc, followed by talks on requirements for future bus systems in the high energy physics community, and presentations by Digital Equipment (DEC), Force Computers, Kontron Elektronik, and Nanotek on Futurebus+ products and developments. A lively panel discussion closed the event.

Several points emerged during these two days. First, among the profiles defined so far, Profile F is the hardware environment of Futurebus+ most likely to fulfil the needs of high energy physics. But Profile B, which will be used extensively by DEC as the input-output bus standard for their high-end systems, will be the Futurebus+ hardware environment most widely used and produced initially.

This apparent clash was deemphasized when DEC assured that cache-coherent profile F domains can still operate inside their profile B crates as long as data to be transferred to their system memory across the DEC bridge to Futurebus+ will not rely on cache coherency across this bridge.

The panel discussion revealed a first tentative timescale for the establishment of a real Futurebus+ market. Between them, more than ten companies should be offering more than 50 different board level products sometime during 1993. A big step in this direction will be the availability of good bus interface VLSI, expected this year.

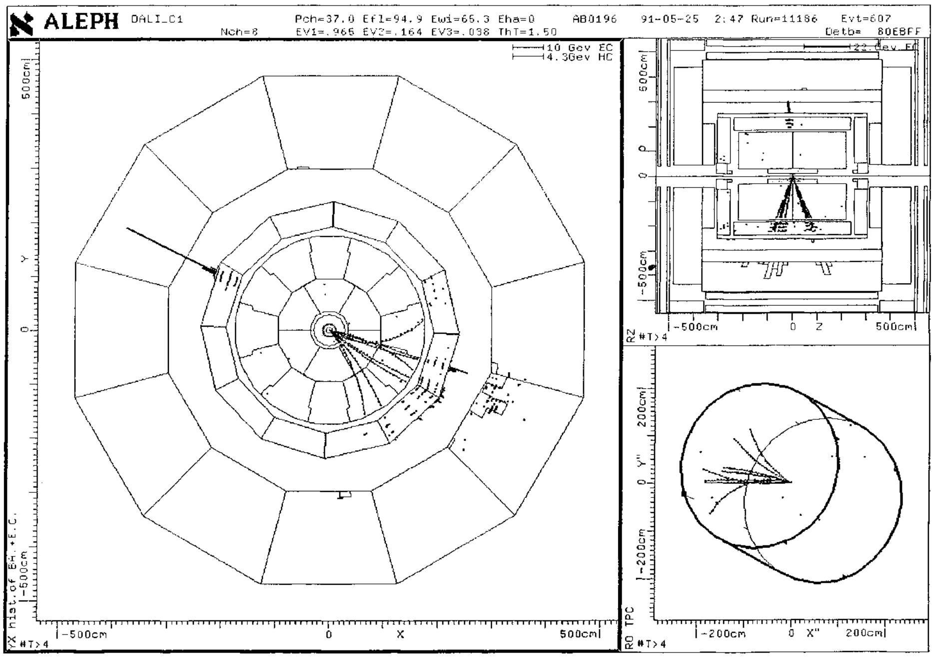
The BUSCON conference displayed the geographical extent of Futurebus+ activities. The development of the standard was mainly pushed from the US with some participation from Europe. Yet Japanese companies announced more than 20 Futurebus+ projects, followed by the US with 12-14 and finally Europe with 2-3 projects.

Considerable effort is going into the definition of a desktop profile, mainly driven by DEC, Hewlett-Packard and Sun, with IBM as observer. This profile aims at distributing stacks of credit-card-sized processor boards interconnected via cache-coherent Futurebus+ bridges on a workstation motherboard.

The chosen bus technology, CTL, should allow operation of the local buses at up to 400 MHz leading to overall performance of the stations in the 1000 Specmarks range (a Specmark is approximately equal to 1 original VAX Mips).

(From Christoph Eck)

Quark radiation from LEP



Radiation from quarks seen at CERN's LEP electron-positron collider by the Aleph experiment. The spike, upper left, is about 45 GeV deposited in the electromagnetic calorimeter by a single photon. The charged tracks and hadronic energy lower right are what emerges from the quark-antiquark pair resulting from a Z decay.

Like any other electrically charged particles, quarks should give out electromagnetic radiation (photons) when they vibrate. One of the physics results from CERN's LEP collider is the first clear observation of this quark radiation from electron-positron collisions. At lower energies this radiation could only be inferred.

This new evidence was a natural focus at the recent workshop on Photon Radiation from Quarks, held at LAPP, Annecy, attracting almost 100 theorists and experimentalists, including representatives from all four LEP experiments.

The meeting set out to summarize the status of experimental data and theoretical understanding, and to consider the prospects for improving both in the fairly near future.

Although single photon radiation from quarks has been studied in proton collisions for more than ten years, the clean conditions in LEP electron-positron collisions provide a new bonus.

The 1989-90 data from all four LEP experiments have been analysed and the results, although differing in fine detail, are in excellent agreement. Including data collected last year each LEP experiment has now recorded about a thousand examples of single photon radiation.

Although still comparatively rare, this process is a sensitive probe of what happens after a Z particle decays into a quark-antiquark pair, testing current quark field theory (quantum chromodynamics - QCD) models of this process and subsequently measuring quark couplings to the Z.

All experiments observe more events than predicted when the standard JETSET simulation of what happens when quarks materialize into hadrons is tuned to unbiased hadronic Z decays.

The related ARIADNE simulation, which uses the same (Lund) hadronization scheme but a different formalism to describe the quark/gluon cascade which precedes the final hadronization, gives around 30-40% more photons, in better agreement with the data.

The sensitivity of this electromagnetic process to QCD details, surprising at first sight, can be explained by the competition between gluon and photon radiation. Isolated photons thus provide a unique window on to the quark-gluon cascade before the hadronization stage.

This was discussed by proponents of the three principal simulation models (ARIADNE, JETSET and HERWIG). Explicit calculation of photon radiation from quarks provides a basis for QCD tests reported by the Opal collaboration in which the effective QCD coupling strength has been determined and the algebraic (non-Abelian) structure of the theory tested.

Based on this knowledge, both Opal and Delphi reported separate measurements of the electroweak couplings of up- and down-type quarks to the Z. The details of hadronization are also probed in the studies of neutral hadrons to assess the background to the photon signal: both L3 and Aleph show that current simulations considerably underesti-

People and things

mate the yield of isolated neutral hadrons.

However isolated photons could also come from some new mechanism. Together, the data from all LEP experiments shows no evidence for new processes, but experimentalists were encouraged to continue their search. It was emphasized that for Higgs particles heavier than 60 GeV, the decay of a Z into a Higgs and a photon is expected to be the dominant production channel for the Higgs at current LEP energies, and additional mechanisms (compositeness, supersymmetry or technicolour) may show up eventually.

Extolling the virtues of 'photons as QCD snipers' in his conclusion, Ronald Kleiss summarized how the workshop had served its purpose in demonstrating the interest and potential value of this comparatively rare process and looked forward to further experimental and theoretical progress.

From Susan Cartwright

On people

Among those receiving US National Medals of Science from President George Bush last year were Glenn T. Seaborg, associate director of the Lawrence Berkeley Laboratory, and Steven Weinberg of the University of Texas, Austin. The medals are the nation's highest award for scientific achievement.

Distinguished Italian theorist Gian Carlo Wick is one of this year's recipients, along with actress Caterina Boratto and publisher Guilio Einandi, of the Silver Plate Award of 'Il Circolo della Stampa di Torino', Awarded annually since 1980, these prizes recognize achievement by regional Piemont personalities. The only other physicist to have been so honoured was Tullio Regge in 1982.

A special colloquium at DESY, Hamburg, on 16 January marked the 80th birthday of Willibald Jentschke, who was the first Director of DESY and served as CERN's Director General from 1971-75. Speakers included W.K.H. Panofsky of Stanford on 'Willi Jentschke and the Evolution of Electron Machines'.

In memory of Edoardo Amaldi

On 25 January Italian physicists gathered in Piacenza, accepting an invitation from the local authorities to honour the memory of distinguished physicist and CERN founding father Edoardo Amaldi, who died on 5 December 1989.

The event ended in Carpaneto, the village where Edoardo Amaldi was born in 1908, with the dedication of the local school and the unveiling of a bronze bust. A report from our Italian correspondent Alessandro Pascolini will feature next month.

On 25 January in Carpaneto Piacentino, the local school was dedicated to the memory of distinguished physicist and CERN founding father Edoardo Amaldi, born in the village in 1908, and who died on 5 December 1989. Here at the unveiling of a bronze bust are members of the Amaldi family: left to right; Francesco, Mercedes, Ugo, local sculptor Rinello Brusi, Daniela Amaldi and town mayor Guido Bardi.

(Photo Bellardo)

Nikolai Nikolaevich Bogolubov 1910-1992

Laboratory correspondents

Argonne National Laboratory, (USA)
M. Derrick

Brookhaven, National Laboratory, (USA)
P. Yamin

CEBAF Laboratory, (USA)
S. Corneliussen

CERN, Geneva, (Switzerland)
G. Fraser

Cornell University, (USA)
D. G. Cassel

DESY Laboratory, (Germany)
P. Waloschek

Fermi National Accelerator Laboratory, (USA)
M. Bodnarczuk

GSI Darmstadt, (Germany)
G. Siegert

INFN, (Italy)
A. Pascolini

IHEP, Beijing, (China)
Qi Nading

JINR Dubna, (USSR)
B. Starchenko

KEK National Laboratory, (Japan)
S. Iwata

Lawrence Berkeley Laboratory, (USA)
B. Feinberg

Los Alamos National Laboratory, (USA)
O. B. van Dyck

NIKHEF Laboratory, (Netherlands)
F. Erné

Novosibirsk, Institute, (USSR)
V. Balakin

Orsay Laboratory, (France)
Anne-Marie Lutz

PSI Laboratory, (Switzerland)
J. F. Crawford

Rutherford Appleton Laboratory, (UK)
Jacky Hutchinson

Saclay Laboratory, (France)
Elisabeth Locci

IHEP, Serpukhov, (USSR)
Yu. Ryabov

Stanford Linear Accelerator Center, (USA)
M. Riordan

Superconducting Super Collider, (USA)
N. V. Baggett

TRIUMF Laboratory, (Canada)
M. K. Craddock

Nikolai Nikolaevitch Bogolubov 1910-1992

On 13 February, the eminent Russian theorist and mathematician Nikolai Nikolaevitch Bogolubov, Director Emeritus of the Joint Institute for Nuclear Research, Dubna, died aged 82.

A whole era of contemporary mathematics, mechanics and physics is connected with his professional life, which began when he wrote his first scientific paper at the age of 14.

He made pioneer contributions to the new field of non-linear mechanics, leading to applications for nuclear reactors, plasma stability, etc. After World War II he turned to theoretical physics, where his work on statistical physics, quantum field theory, superfluidity and superconductivity became classical. He also made fundamental contributions to the quark picture of elementary particles.

For over 25 years he headed the Joint Institute for Nuclear Research in Dubna, and led scientific seminars at other Institutes.

Meetings

The thAccird ECFA workshop on electron-positron linear colliders will be held from 25 July-2 August in Garmisch Partenkirchen, Germany, organized with the help of MPI Munich, DESY and CERN, and under the auspices of ICFA. Further information from Mrs. Z. Kircanski, Max-Planck-Institut fuer Kernphysik, Werner Heisenberg Institut, Foeringer Ring 6, W-8000 Munich 40, Germany, e-mail zak at dm0mpi11

CAMAC 92, the 15th International Symposium on Nuclear Electronics and Interfaces and related matters, will be held in Warsaw from 29 September to 2 October. Further information from Roman Trechcinski, Instytut Problemow Jadrowych im A. Soltana, 05-400 Otwock, Swierk, Poland. Fax (+48 22) 79 34 81.

1991 Physics Nobel prizewinner Pierre-Gilles de Gennes gave a lecture at CERN on 4 February on 'Soft matter'.

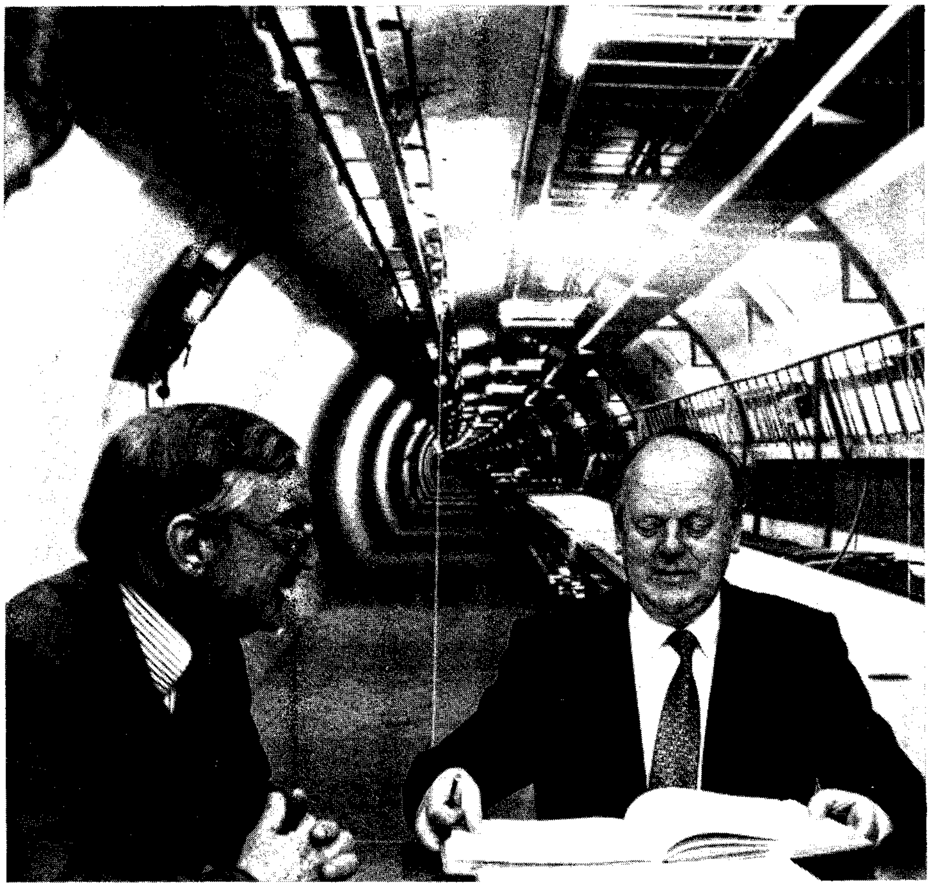
(Photo CERN 13.2.92)

On 4 February (top), a high-level Chinese delegation visited CERN. It was led by Vice-Minister of State Planning Gan Ziyu, seen here signing the VIP visitors' book, while CERN's Particle Physics Experiments Division Leader Jim Allaby, who is also CERN's regional coordinator for Far Eastern relations, looks on. The visit included the L3 experiment at LEP.

(Photo CERN 14.2 92)

Also on 4 February (below), CERN received a delegation from the Republic of Belarus (Bylorussia), led by Stanislav Shushkevich, Chairman of the country's governing body. Signing the VIP visitors' book, he is accompanied by Lucien Montanet, CERN's regional coordinator for the Commonwealth of Independent States. The visit included the Delphi experiment at LEP.

(Photo CERN 11.2.92)



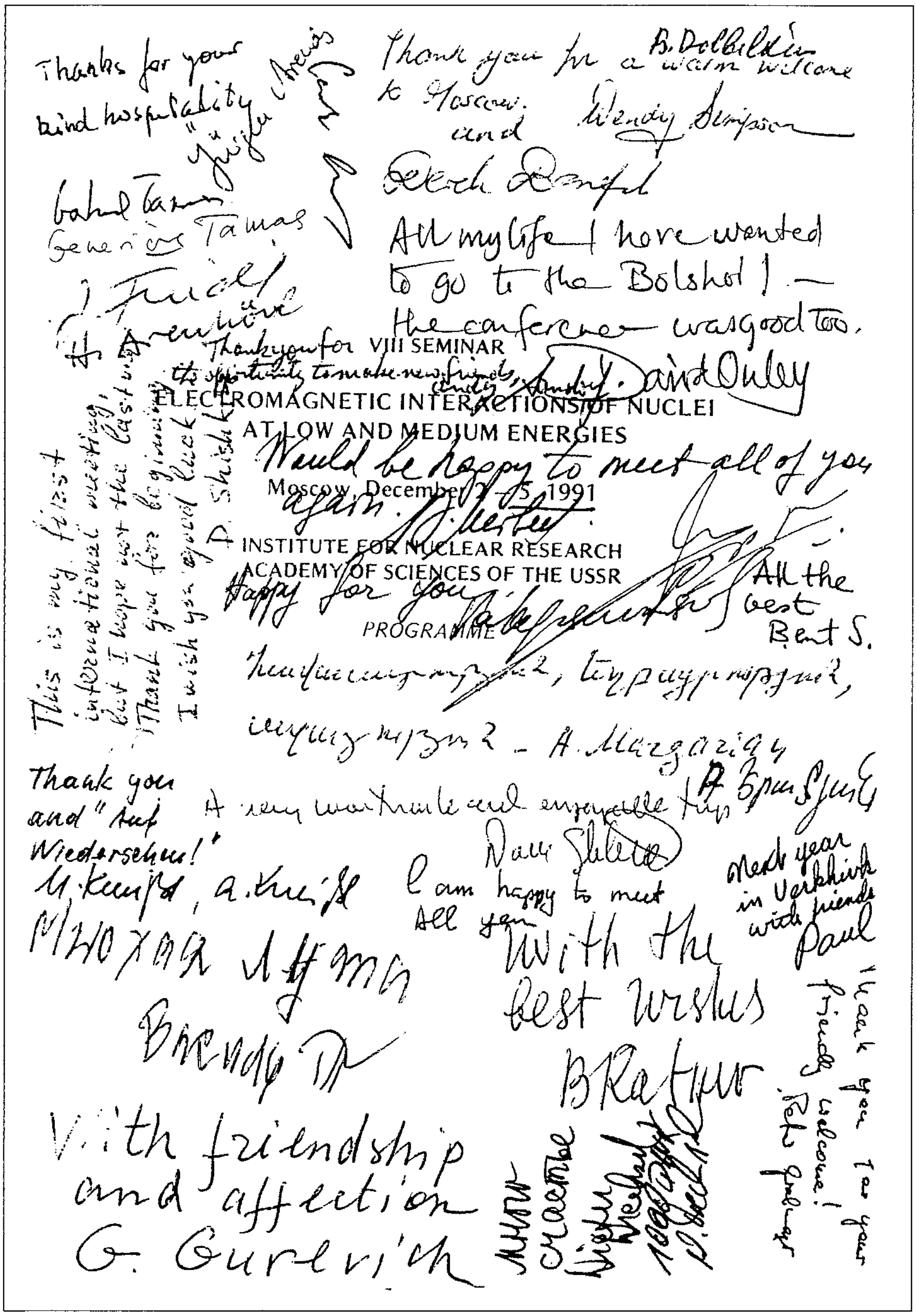
The Center for Particle Astrophysics of the University of California, Berkeley, will be hosting this year's Joint Texas Symposium on Relativistic Astrophysics and Symposium on Particles, Strings and Cosmology. (Texas/PASCOS) symposium from 13-18 December. Contacts: Bernard Sadoulet and Joe Silk, Center for Particle Astrophysics University of California, Berkeley, e-mail sadoulet at lbl.gov or silk at bkyast.hepnet

The 2nd International Conference on Physics and Astrophysics will be held from 19-23 January 1993 at the Variable Energy Cyclotron Centre, Calcutta, India. Further information from Santanu Pal, Variable Energy Cyclotron Centre, Sector 1, Block AF, Bidhan Nagar, Calcutta 700 064, India, fax (+91 33) 346871, international e-mail icpaqgp % veccal at shakti.ernet.in national e-mail icpaqgp % veccal at ncst.ernet.in The first meeting in this series was held in Bombay in 1988.

Nuclear Physics moves

The editorial office of the journals Nuclear Physics A and B has moved from Copenhagen to Amsterdam. Founded by Leon Rosenfeld in Manchester in 1957, Nuclear Physics followed its founder Editor in 1958 to Nordita, Copenhagen, where for 30 years the Journal profited from close collaboration with Nordita and the Niels Bohr Institute. In 1967 the journal split into two volumes, A for nuclear physics proper, and B for quantum field theory and particle physics.

The Journals now move to Amsterdam, close to NIKHEF. The Nuclear Physics Editorial Office is at Matrix Building, Science Centre WCW, Kruislaan 419, 1098 VA Amsterdam,



Messages left by participants at the Seminar on Electromagnetic Interactions in Nuclei, organized by the Moscow Institute for Nuclear Research last December. As well as looking at electromagnetic interactions as a means for studying the nucleon and nuclear structure, the meeting also covered some new proposals for existing machines, such as the 2.5 GeV Siberia-2 synchrotron light source at Moscow's Kurchatov Institute, and currently under construction, notably the CEBAF electron machine at Newport News, Virginia.

Netherlands. Phone +31-20-5618161, fax +31-20-6654969, e-mail npa at nikhef.nl or npb at nikhef.nl for Nuclear Physics A and B respectively.

Accelerator menu

Alert readers spotted the SSC Supercolliding 'Suppercollider' glitch on page iii of the April issue. The sheer size of this 87-kilometre ring makes it inevitable that the symmetry of its title will be spontaneously broken from time to time.

In the days before the SSC name was coined, the project was known for years as the 'Desertron'. In those pre-spellcheck days, US writer Gary Taubes was invited by 'Physics Today' to write about a spelling mistake. His 'Dessertron' turned out to be a machine for making high energy ice cream.

The Suppercolider is much more modest. With superconducting microwave ovens lining the 87-kilometre underground tunnel, raw higgs will be smashed into each other at temperatures approaching those of the Big Bang, recreating quark-gluon omelette and new open top delicacies, accompanied by a variety of rare (also medium and well-done) flavours according to Col. Einstein's famous recipe: energy equals mass times the speed of the chicken crossing the road squared.

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XP2971	23	10	110	2	2	80	3
XP2081	34	10	135	1	1	150	7
XP2201	44	10	120	1	1	150	8
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NOELL is currently developing 4 superconducting dipole magnets as prototypes for the planned LHC storage ring facility at CERN in Switzerland.

We also use our considerable manufacturing know-how to build components for the construction and operation of magnet storage facilities and remote handling systems for use in fusion technology such as at the Tokamak reactor in Princeton, U.S.A. or JET in Culham. U.K.

Please contact us if you require any information about components for magnet and fusion technology.

NOELL GMBH
Dept. V29
P. O. Box 62 60
W-8700 Würzburg 1
Germany
Phone 09 31/9 03-13 18
Telex 68 822
Fax 09 31/9 03-10 16

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