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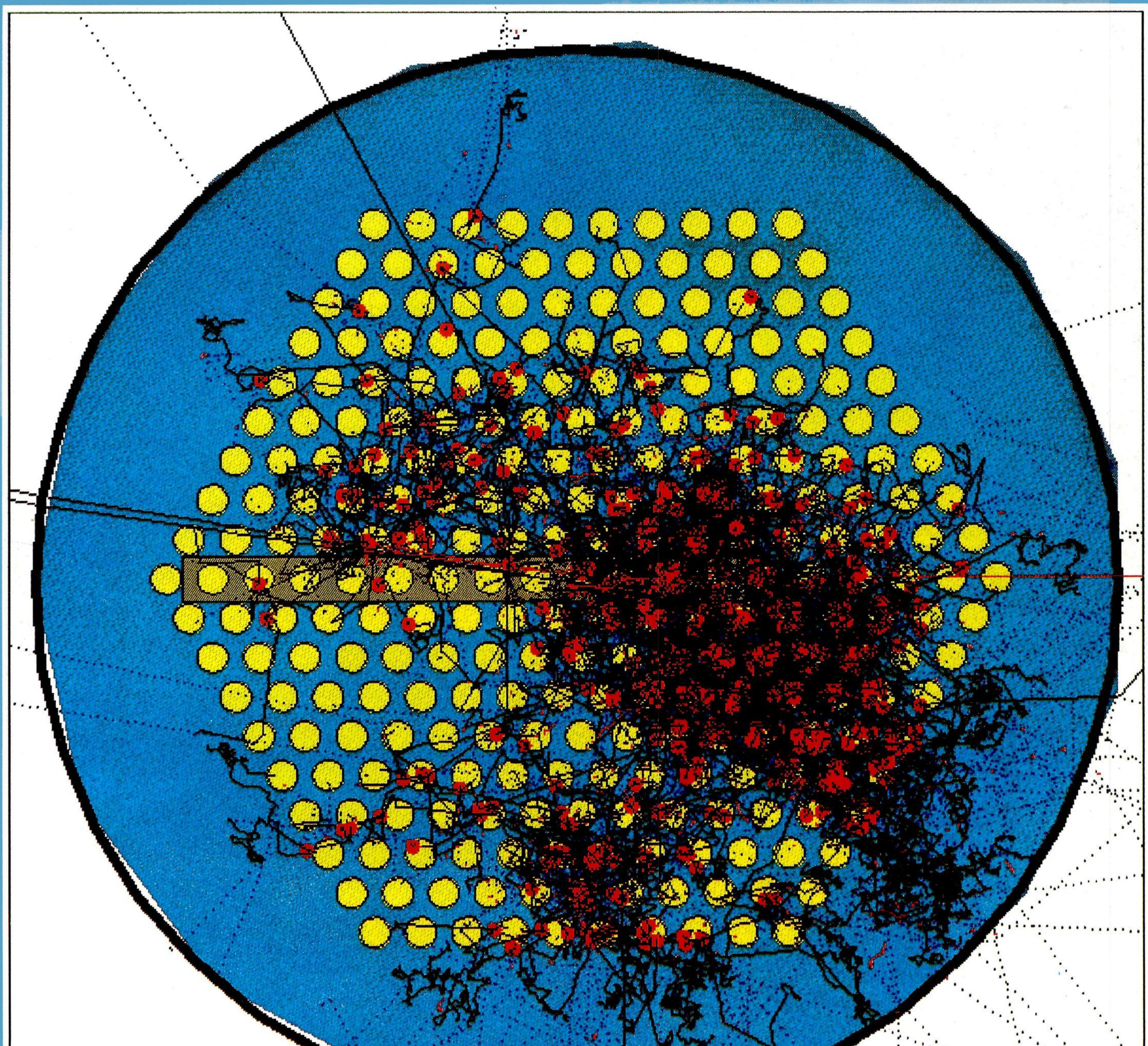

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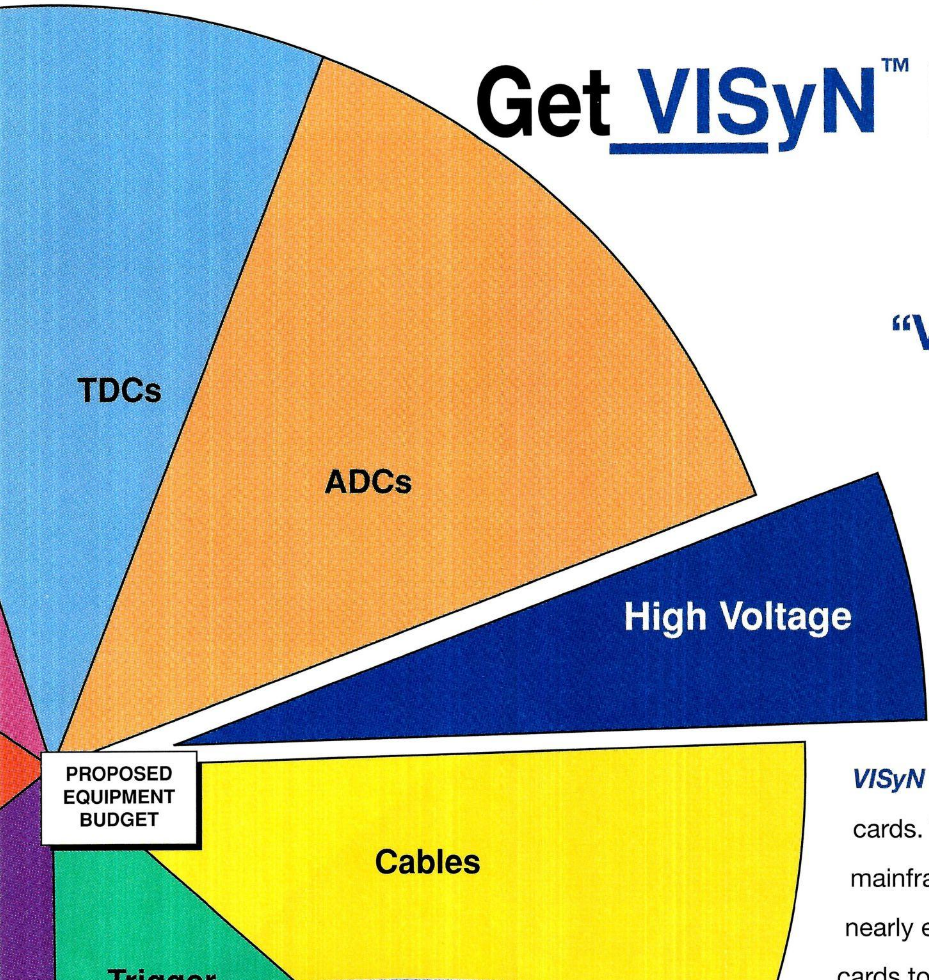

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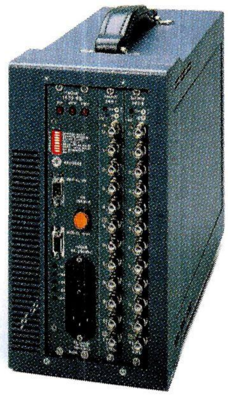

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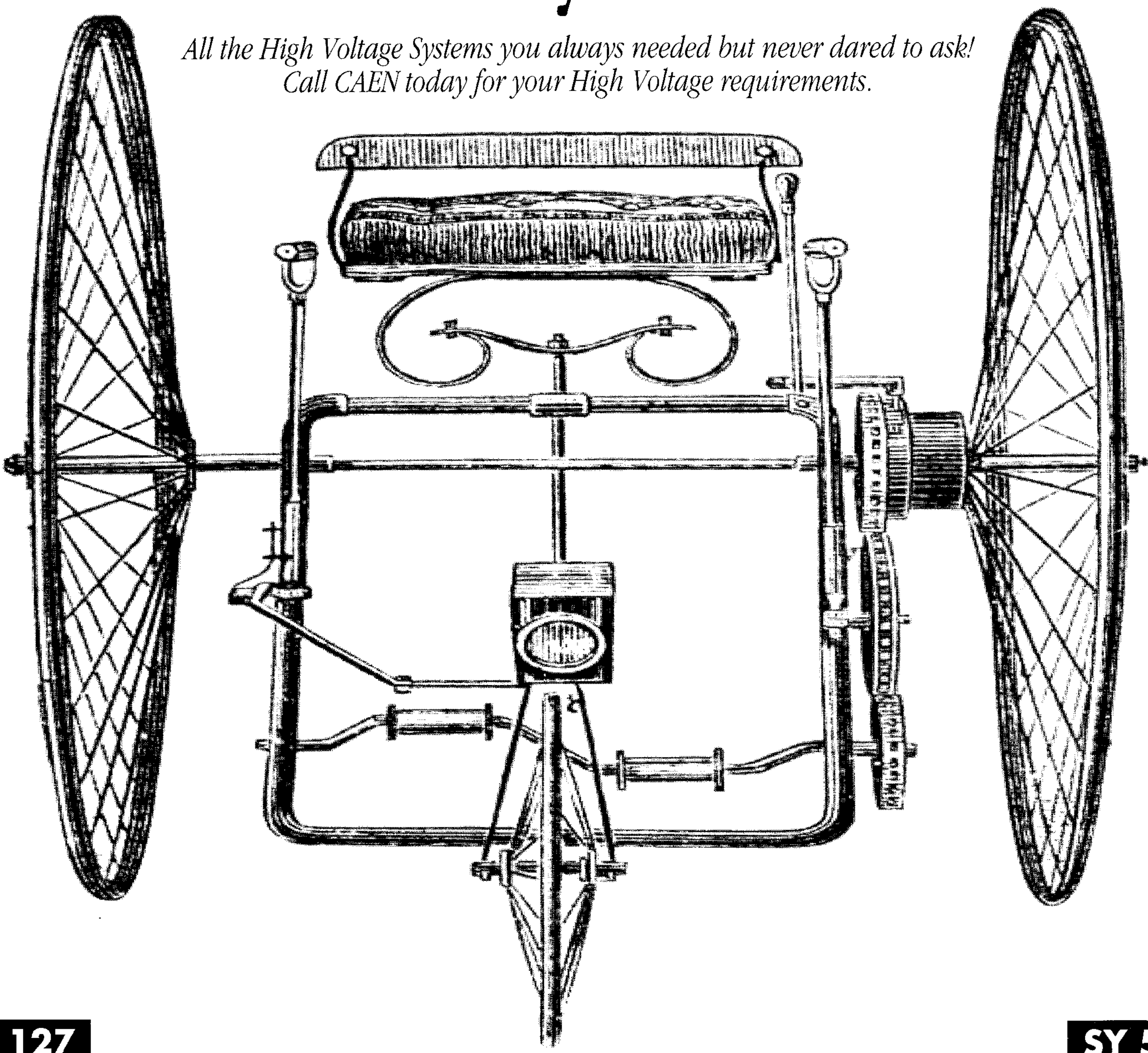

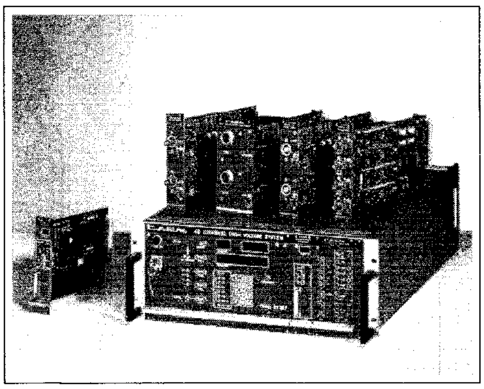

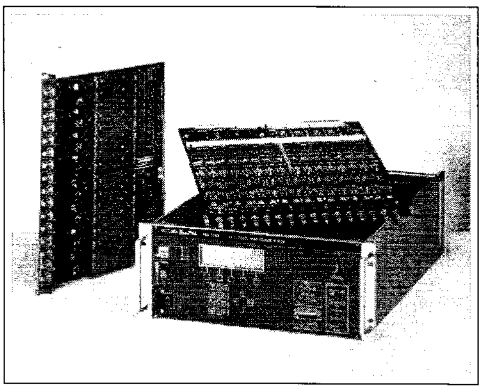

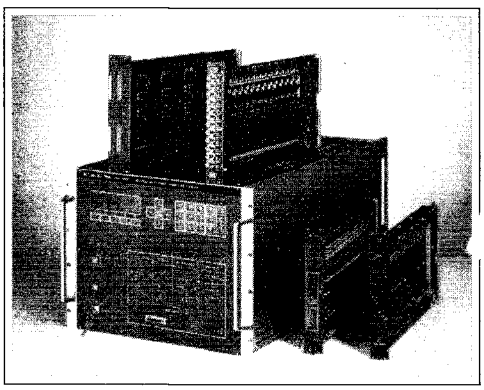

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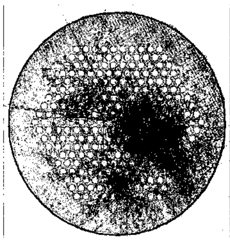
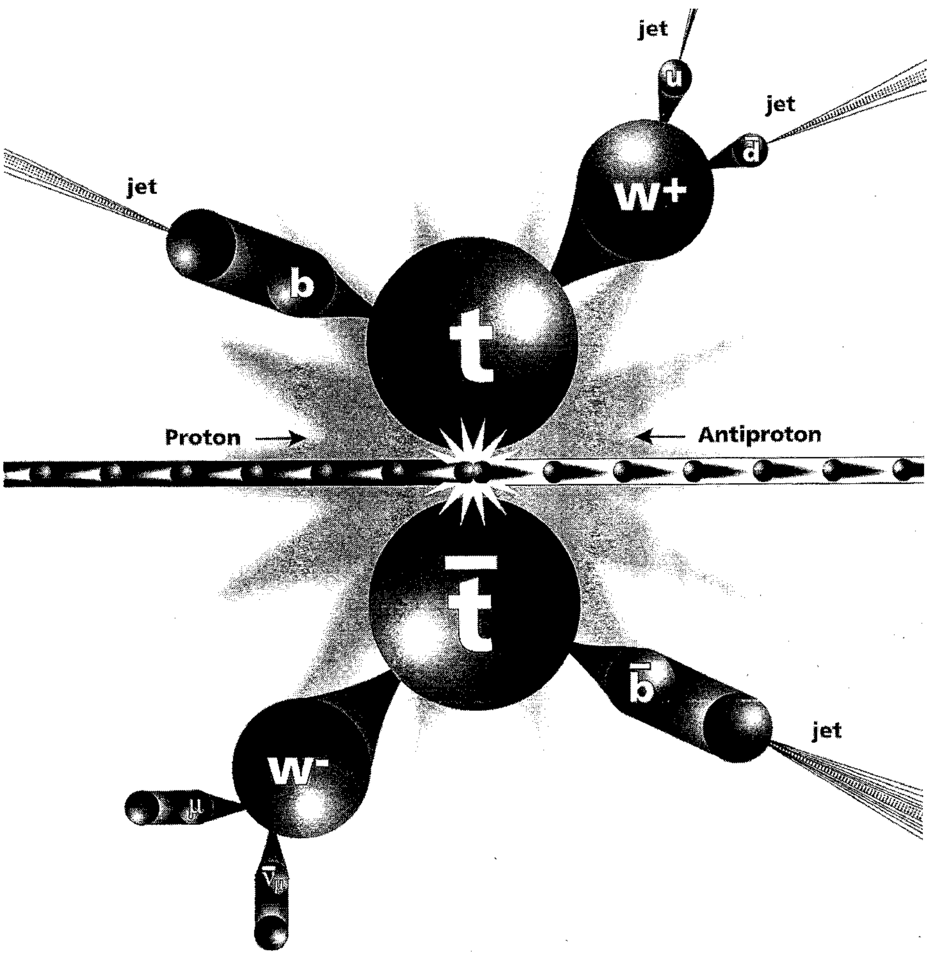


Cover photograph: A future energy source ? Simulations of neutron production in a fuel/moderator matrix, showing a burst of fission neutrons following injection of a proton beam from an accelerator to generate neutrons by spallation. Development work for Carlo Rubbia's 'Energy Amplifier' is described on page 7.

Top quark discovered

Schematic of a decay pattern for the top quark-antiquark pair formed when a high energy proton and antiproton collide. Analysing the emerging particles, physicists can track back to the top quark dynamics.



Nine months after a careful announcement of tentative evidence for the long-awaited sixth 'top' quark, physicists from the CDF and D0 experiments at Fermilab's Tevatron proton-antiproton collider declared on 2 March that they had finally discovered the top quark.

Last year (June 1994, page 1), the CDF experiment at the Tevatron reported a dozen candidate top events. These, said CDF, had all the characteristics expected of top, but the difficulties of extracting the tiny signal from a trillion proton-antiproton collisions made them shy of claiming a discovery. For its part, the companion D0 Tevatron experiment reported a few similar events but were even more guarded about their interpretation as top quarks.

Just after these hesitant announcements, performance at the Tevatron improved dramatically last summer. After the commissioning of a new linear accelerator and a magnet realignment, the machine reached a new world record proton-antiproton collision luminosity of 1.28 x 10^{31} per sq cm per s, ten times that originally planned. Data began to pour in at an unprecedented rate and the data sample grew to six trillion collisions. Luminosity has subsequently climbed to 1.7 x 10^{31}.

The top quark is the final letter in the alphabet of Standard Model particles. According to this picture, all matter is composed of six strongly-interacting subnuclear particles, the quarks, and six weakly interacting particles, the leptons. Both sextets are neatly arranged as three pairs in order of increasing mass.

The fifth quark, the 'beauty' or 'b' quark, was also discovered at Fermilab, back in 1977. Since then physicists have been eagerly waiting for the top to turn up, but have been frustrated by its heaviness - the top is some 40 times the mass of its 'beautiful' partner. Not only is the top quark the heaviest by far, but it is the only quark which has been actively hunted. After the quarry was glimpsed last year, the net has now been closed.

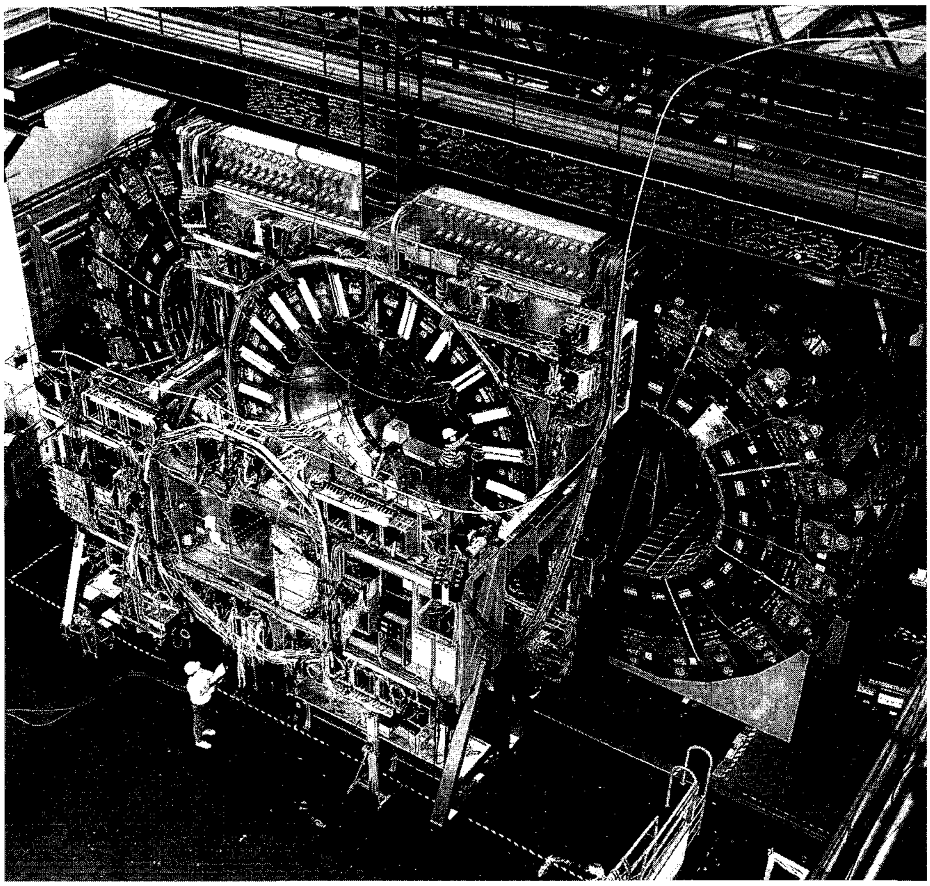
The painstaking analysis of the top quark data was the highlight at major meetings last summer. At the Glasgow conference (October, page 2), Hans Jensen of CDF cautiously said 'This gives evidence for the top quark but does not firmly establish its existence.' For D0, Paul Grannis stated their sample had a small excess over expected background, but nevertheless was consistent with no top production. When other scientific discoveries are claimed on the basis of much more flimsy evidence, the objectivity of these Tevatron experiment analyses was widely admired.

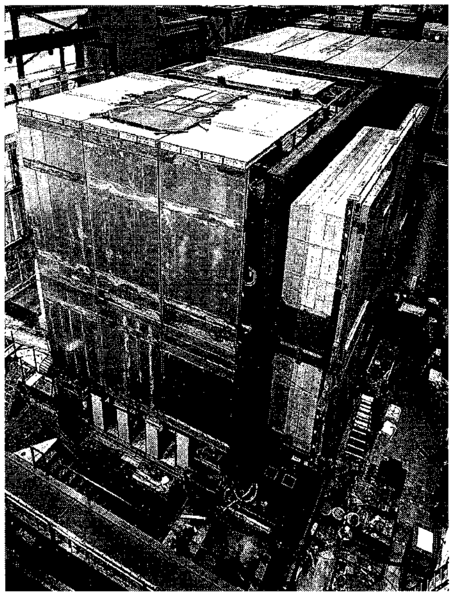
Meanwhile a lot more Tevatron proton-antiproton collision data have been scrutinized. As well as the 1992-1993 run (Run Ia) which provided the initial samples, data from the subsequent 1994-1995 run (Run Ib) have become available.

After carefully trimming the raw 6 trillion collision sample to 40 million promising events, this information was painstakingly sifted, looking for

Below, the CDF experiment (seen here in the 'exploded' maintenance position) at Fermilab's Tevatron has seen 43 examples of top quark production in six trillion proton-antiproton collisions.
(Photos Fermilab)

Right, at Fermilab's Tevatron proton-antiproton collider, the D0 detector (seen here in its assembly position) has, with its partner Tevatron experiment CDF, finally produced hard evidence for the long awaited sixth 'top' quark.





signs of the daughter particles into which the top quark decays. The two experiments see these events distributed among the different types of decay expected after a top quark-antiquark pair is formed in a proton-antiproton annihilation.

There are several such decay signatures. One occurs when both the top quark and antiquark decay (each via a W boson) to produce an electron and an electron-neutrino or a muon and a muon-neutrino. The resultant electron and/or muon (dilepton) pairs provide a clean source of top signals.

More probable but less clean is the process in which one top quark (or antiquark) decays as above while its partner gives, via a W, another quark pair. These quarks produce characteristic confined 'jets' of particles. However this top decay channel is easily polluted by background, and to clean up the sample the experiments look for signs of the b-quark or for special event patterns expected from top production. The b-quark can be recognized either by its characteristically short decay time (picked up as a short track stub between the original proton-antiproton collision and the secondary decay) or by its (semileptonic) decay products.

CDF found 43 top events, 6 with dilepton pairs, compared to an expected background of 8 events from other processes which could 'fake' a top quark signal. Recent CDF analysis has benefited from an improved microvertex detector which picks up particle tracks close to the proton-antiproton collision point. D0 found 17 top events, including 3 dilepton pairs, against an estimated background of about 4.

Careful analysis of the decay kinematics of a suitable subset of top events reveals the mass of the decaying top quark. Finding the expected patterns of top decay is one thing, but the mass analysis is another. The decay patterns would be meaningless if they did not point to a narrow mass band.

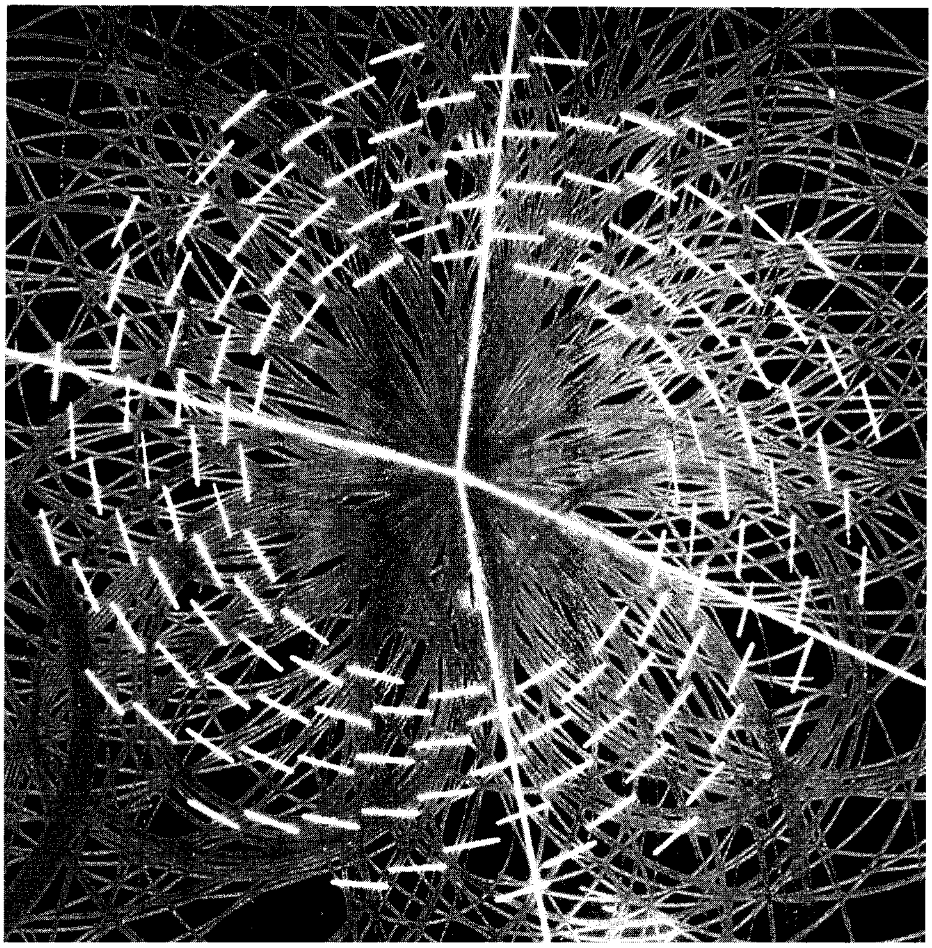
CDF reports a mass of 176 GeV, with an overall uncertainty of $\pm$ 13 GeV. This overlaps with the 174 GeV $\pm$10% claimed last year, and is totally compatible with the accumulated Standard Model data (November 1994, page 5). D0 gives a slightly higher top quark mass of 199 $\pm$ 30 GeV, but still bracketing the Standard Model prediction.

In physics-speak, the statistical significance of the new top quark measurement is expressed in likelihood units of about 4.7 standard deviations for each detector. This means that the overall possibility of some fluctuation in the background count is less than about one part in a million for either experiment.

The experiments expect to amass twice the current data by December, when the Tevatron will be temporarily shut down for routine maintenance and to prepare for upgrades to the experiments to work with the still higher collision luminosities expected in the era of Fermilab's Main Injector.

LHC preparations change gear

Simulated higgs bonanza. The decay of a higgs particle into 4 high energy muons, superimposed on the dense background of secondaries from LHC proton-proton collisions, as it would appear in the silicon pixels of the CMS central tracker.
(Photo EX 20.10.1994/01)



After the formal approval by CERN Council in December (January, page 1) of the LHC proton-proton collider for CERN's 27-kilometre LEP tunnel, preparations for the new machine change gear. Lyndon Evans becomes LHC Project Leader, and CERN's internal structure will soon be reorganized to take account of the project becoming a definite commitment.

On the experimental side, the full Technical Proposals for the big general purpose ATLAS and CMS detectors were aired at a major meeting of the LHC Committee at CERN in January. These Technical Proposals are impressive documents each of some several hundred pages. (Summaries of the detector designs will appear in forthcoming issues of the CERN Courier.) The ALICE heavy ion experiment is not far behind, and plans for other LHC experiments are being developed.

Playing an important role in this groundwork has been the Detector Research and Development Committee (DRDC), founded in 1990 to foster detector development for the LHC experimental programme and structured along the lines of a traditional CERN Experiments Committee.

Established under the Director Generalship of Carlo Rubbia and initially steered by Research Director Walter Hoogland, the DRDC has done sterling work in blazing a trail for LHC experiments. Acknowledging that the challenge of LHC experimentation needs technological breakthroughs as well as specific detector subsystems, DRDC proposals have covered a wide front, covering readout electronics and computing as well as detector technology. Its first Chairman was Enzo Iarocci, succeeded in 1993 by Michal Turala.

DRDC's role was to evaluate proposals, and make recommendations to CERN's Research Board for approval and resource allocation, not an easy task when the LHC project itself had yet to be formally approved.

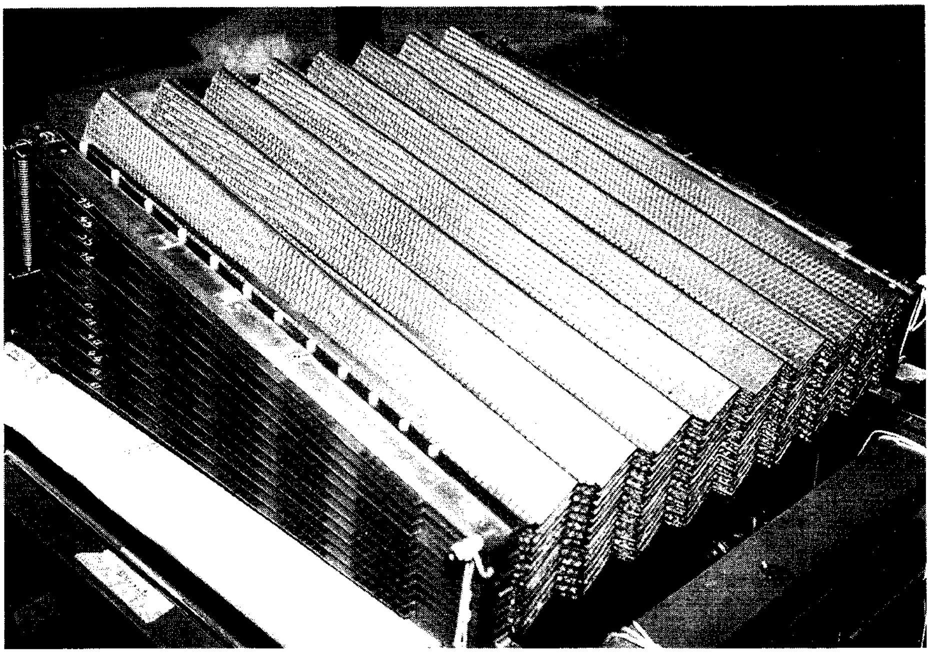
Over the years, a comprehensive portfolio of detector development has been built up, much of which has either led to specific LHC detector subsystems for traditional detector tasks such as tracking and calorimetry, or has fed through positively into the thinking behind new approaches.

Over the years, this has covered 59 separate proposals, involving more than 2,000 physicists from some 250 institutes and industrial centres, a third of which are from non-Member States of CERN. An 'average' project includes 60 researchers and 11 institutes.

Now, with LHC approved and with first Technical Proposals for detectors tabled, the immediate task of the DRDC is seen as accomplished, and very successfully. After the final DRDC meeting at CERN on 26-27 January, the task of overseeing ongoing LHC-focused R&D passes to the LHC Committee (LHCC), helped by a new infrastructure.

Three sub-committees, LHC Review Boards for Computing, Electronics and Detectors (respectively LCRB, LERB and LDRB, the first two having been formed one year ago) will now share common open sessions. Thus the valuable R&D forum

The ATLAS experiment for LHC has chosen a liquid argon route to the important task of electromagnetic calorimetry. The problems of signal transportation and shaping have been solved by arranging the plates in an 'accordion' pattern.
(Photo CERN EX 32.9.1993/4)



that DRDC provided will continue. As well as monitoring ongoing R&D, these bodies will provide technical assistance to the LHCC, particularly to referees of technical proposals.

History

When plans for a new generation of proton supercolliders began to be discussed in the 1980s, first in the US and then in Europe, it became clear that the experiments that would exploit these beams would have something to reckon with.

The sheer scale of these experiments explored new territory - even the mighty underground caverns constructed for LEP were not big enough. On these scales, the granularity and precision of detectors, and their installation (alignment) and operation (cooling), as well as the civil engineering itself, all pose special problems.

This extends across the whole detector front - particle tracking and identification, calorimetry, and muon detection. Many problems are exacerbated for work with the heavy ion beams which will produce a thicket of thousands of tangled tracks from each collision.

In addition to event complexity, the actual event rates needed to open up this physics had special implications. At the US Superconducting Supercollider, with a planned luminosity of some 10^{33} cm^{-2} s^{-1}, physicists had to grit their teeth. But CERN's LHC, constrained by the existing LEP tunnel to smaller ring than the planned SSC, had to trade its lower collision energy for higher event rates, pushing for higher luminosities, above 10^{34}.

It took the foresight and drive of Carlo Rubbia to first shout LHC's high luminosity warcry, and the DRDC ensured that the initially daunting implications of this message fell on fertile ground.

To handle such event rates, with kilowatts-worth of secondary particles produced in each detector, elements must withstand intense radiation levels. The tight bunching (25ns) of the LHC beams means lots of events, with hundreds of particles in each crossing of the beam bunches. To disentangle separate events and handle all this data needs electronics working reliably in the high Megahertz region and on-line processing to digest data on the Terabit (10^{12}) scale.

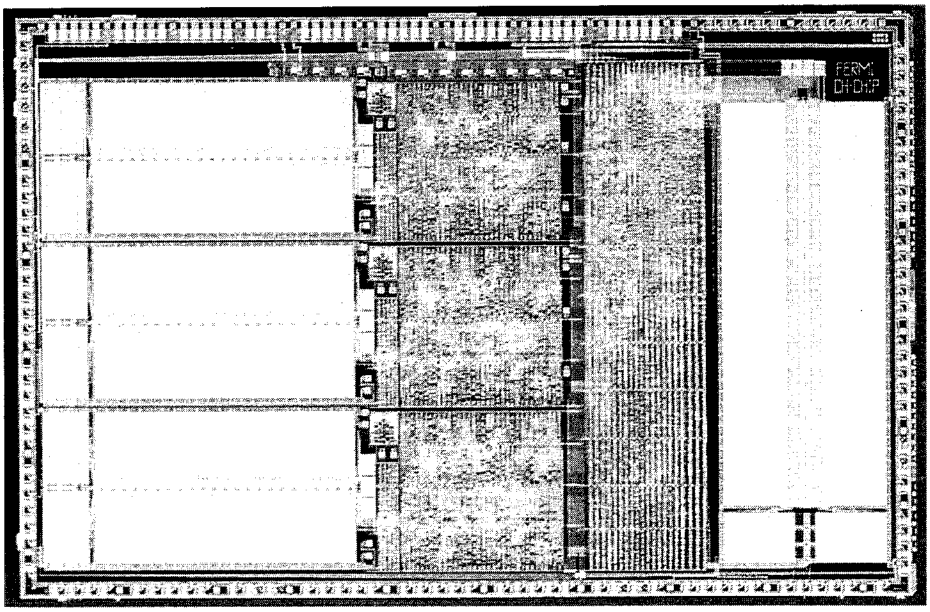
'At these event rates, it is like trying to locate one person in the whole world every few seconds,' says Michal Turala, now head of CERN's ECP (Electronics and Computing for Physics) Division, where much of this development work is now focused.

Huge detectors pulsating with Megahertz signals would broadcast unwelcome interference, and new signal switching and transmission techniques have to be sought.

While plans for SSC detectors in the US pushed ahead, in Europe the Italian-funded LAA scheme, launched in 1987, was the first new effort to focus specifically on the challenge of LHC physics. A special workshop organized by ECFA (European Committee for Future Accelerators) in Barcelona in 1989 provided the first major gathering of specialists, soon followed by the milestone ECFA LHC workshops in Aachen in 1990, and at Evian in 1992, which provided the first sketches of how LHC detectors might look.

As well as technical goals such as new detection techniques, radiation hardness and high processing and transmission rates, this work had to take in its stride the rapid evolution of modern technology. Planning for experiments to take the floor ten years from now means forecasting with some confidence how techniques will develop and exploiting how price/performance ratios will (hopefully) continue to work in users' favour.

Application-Specific Integrated Circuit (ASIC) developed for the FERMI readout microsystem for LHC calorimetry, containing 930,000 transistors on a chip 17x11 mm. This work has already aroused interest in other areas of nuclear instrumentation, as well as video systems and radar imaging. (Photo CERN EX 7.8.94)



The DRDC effort so far has involved a total of 2,100 physicists and engineers, representing some 250 research centres. Besides taxing the ingenuity of physicists to develop new detectors which provide high precision and high speed, as well as being radiation resistant, this work also calls for close collaboration with industrial specialists, and it is in this area where DRDC has been particularly influential.

Such technology includes revolutionary areas such as growing new crystals, exploiting new semiconductor materials, etching fine detector structures, the replacement of wire conductors by optical fibres, the development of applications-specific integrated circuits (ASICs), and a deep reappraisal of the role of software, always very manpower-intensive.

Examples

The terrain covered by the 40-odd proposals on the DRDC books is so wide and diverse as to defy summary. However the ATLAS and CMS Technical Proposals include many lessons learned from the DRDC programme, together encompassing the outcome of over 40 DRDC projects. In calorimetry for example, CMS is looking at crystals while ATLAS favours a liquid argon approach. The 'menu' originally included 'spaghetti' and 'shashlik' calorimetry, using scintillating optical fibres, but which find limited application in the LHC environment.

Across a wider front, pixel and semiconductor strip detectors, microstrip gas chambers, straw tubes and many other designs are no longer viewed as audacious and are available virtually off-the-shelf for new requirements.

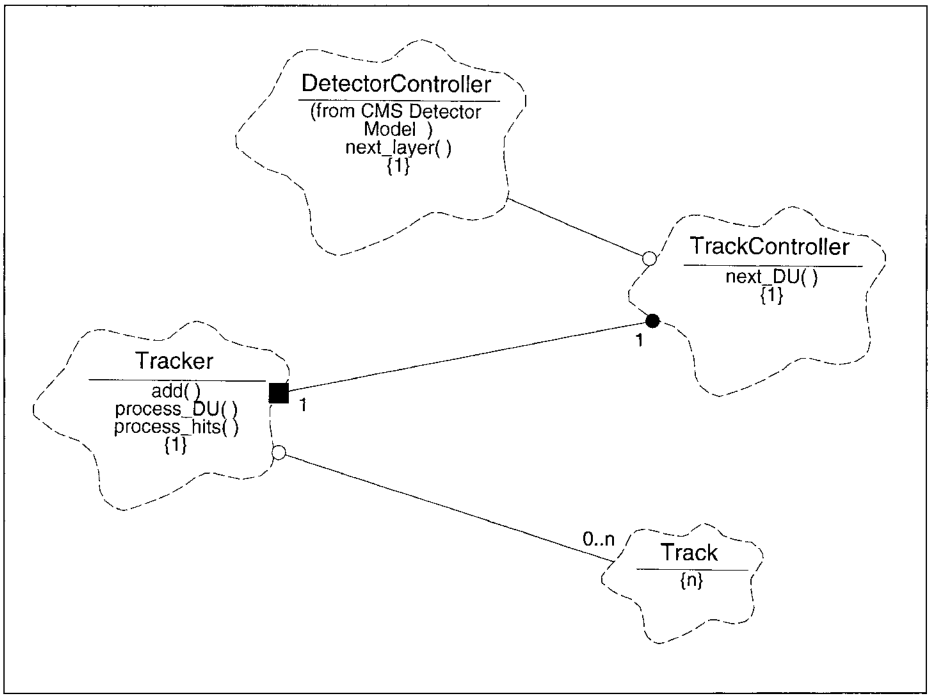
For particle tracking close to the beam pipe, semiconductor sensors and pixel technology can help pinpoint individual particles fast and with micron precision inside dense jets. A promising newcomer is the microstrip gas chamber design, with two-dimensional or pixel readout. These designs resemble semiconductor technology rather than conventional gas detectors and provide good space resolution, avoiding the instabilities when conventional chamber wires become overcrowded.

Although so-called 'straw' tubes are still also considered somewhat innovative, they are based on the classic Geiger-Müller tube geometry, suitably rescaled for today's use. With a radius of a few millimetres and appropriate gas and electric field configuration, they provide a relatively simple solution to good and fast space resolution in a harsh radiation climate.

While many of the proposals attack specific solutions for LHC detector subsystems, other studies are more generic. Microelectronics is one such particular theme. With the development of miniaturization, more and more processing power can be installed on chips directly inside the sensitive detector elements, obviating the need to carry the signals outside for subsequent processing, reducing both cabling and power dissipation.

However in LHC these chips will have to operate in a very hostile environment, constantly bombarded by high energy particles. Space research and military applications have pushed industrial development, and attractive new ranges of radiation-resistant chips available both in the US and in Europe could be exploited for particle physics.

Handling the rapidly-arriving LHC signals and coordinating and synchronizing the triggering procedures needs fresh approaches. Despite the use of laser drivers, optical fibre connections and optoelectronic receiver packaging are too bulky for the confines of a particle physics detector, and new, miniature solu-



As the subject of research and development work are the object-oriented software techniques required to handle the complexities of LHC collisions. This shows the subtasks of track reconstruction for the CMS central tracker. Each 'object' encapsulates specific tasks, or responsibilities, which are linked in a global architecture or 'object design'. The different responsibilities can be 'messaged' when requested.

tions have to be found.

The detector readout chain needs temporary data storage (buffering) at a number of levels. Memory management for buffering uses microprogrammable sequencers.

With a ten-year lead time, software, and particularly software documentation, has additional implications. The routines still have to be transparent and flexible even if the software author has departed long ago. Object-oriented languages and Computer Aided Software Engineering (CASE) tools have to be extensively used, and these skills are being introduced into the physics environment.

Overall, the size and complexity of both LHC experimentation and the machine itself needs sophisticated control systems to safeguard operation and optimize performance. Ongoing R&D work at CERN looks at the expertise available, or being developed for power plants, satellite monitoring and other complex automation systems. This work, which involves industry, foresees a 'cortex' approach with a highly distributed heterogeneous control system.

Five years down the line, the DRDC's goal of significant intellectual, professional and technological progress has been achieved. The challenge of LHC experimentation has been met, and plans for detectors are well advanced. Beyond LHC, the potential of some techniques has been realized for a wide range of studies, including medical applications.

(A detailed 316-page summary of DRDC results - The CERN Detector R&D Programme 1990-1994, CERN/DRDC 94-48 is available from Mme. A. Anton, CERN AS/SI, CH-1211 Geneva 23, e-mail anton@cernvm.cern.ch)

Physics monitor

CERN
Energy amplifier

Even under the heavy burden of responsibility as CERN's Director General from 1989-3 the fertile mind of Carlo Rubbia the scientist was never still. A long-time Rubbia 'hobby' has been the search for new sources of nuclear energy, exploiting knowledge and skills from high energy physics.

An initial objective was to adopt heavy ion techniques to induce controlled thermonuclear fusion, but in 1994 this quest changed direction. Putting the problems of thermonuclear fusion aside, Rubbia began to explore an alternative route to energy production through controlled nuclear fission.

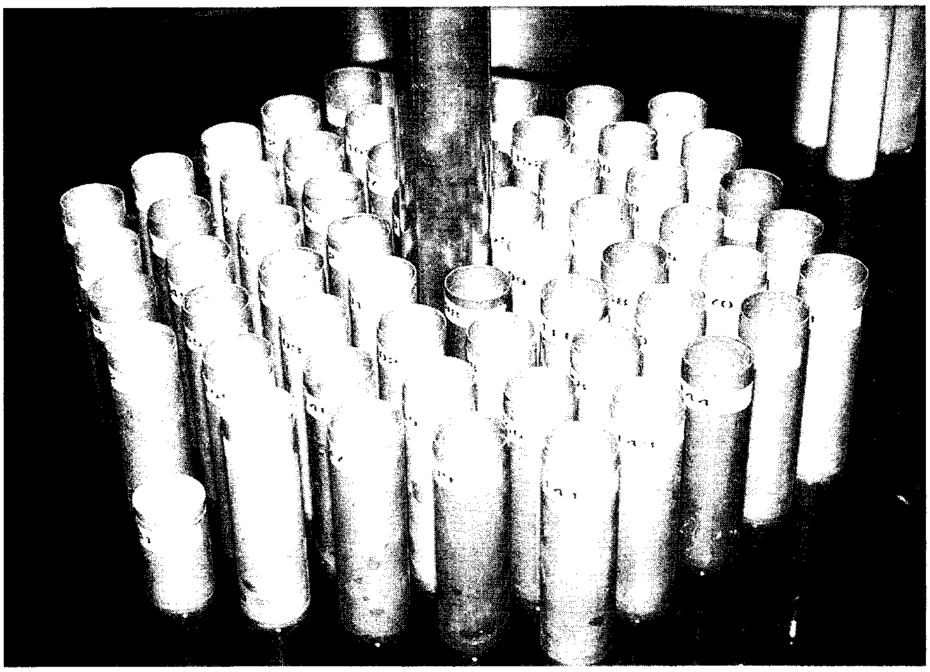
The idea is to use a particle accelerator producing neutrons by spallation (interaction of particles with a target) to feed a fuel/moderator assembly where the neutrons multiply by fission chain reactions. If the energy liberated becomes substantially greater than that needed to drive the accelerator, the process has a net gain and becomes self-supporting. Hence the name "Energy Amplifier" (EA).

Similar systems for energy production or for nuclear waste incineration have been proposed at Los Alamos and in Japan and Russia, but appear to require the prior development of innovative linear accelerators. For Rubbia's Amplifier, the requisite accelerator is a reasonable extrapolation of an existing cyclotron such that at the Swiss Paul Scherrer Institute.

Moreover, the EA would require fuel rods very similar to those of conventional reactors, rather than demand-

A test using a beam from CERN's PS proton synchrotron underlined the potential of an idea of Carlo Rubbia to achieve controlled nuclear fission. A proton beam produces neutrons by spallation to feed a fuel/moderator assembly where the neutrons multiply by fission chain reactions. Seen here is part of the subcritical spallation target assembly used in the test with rods of natural uranium (contained in aluminium sheaths) in a tank of demineralized water, with in the centre, the radioactive rod used as a calibration neutron source.

(Photo CERN EX 76.9.94)



ing new technology using liquid fuel loops (molten salts) with on-line separation of radioactive products.

Unlike a reactor, the EA's fission reaction is not self-sustaining: it is sub-critical and needs a continuous supply of neutrons from the accelerator. This makes Chernobyl-type meltdowns unlikely: if the accelerator stops, the reaction stops too. Another major advantage is that the old dream of using thorium as a fuel is now made possible. Thorium is not itself fissile, but under neutron bombardment can be transformed into highly fissile uranium 233. This fission yields neutrons which, in addition to maintaining the fission chain, in turn regenerate uranium 233 from thorium. This cannot be achieved practically in a normal thermal reactor since the number of neutrons is too small.

Calculations show that in the EA, uranium 233/thorium equilibrium is soon established. In this thorium cycle very little plutonium is produced - 1000 to 10,000 times less than in conventional reactors. Thorium, more abundant in the Earth's crust than uranium, is fully used in the cycle (unlike natural uranium where only the 0.7% sliver of isotope 235 is fissionable). Thorium energy reserves appear to be practically inexhaustible.

To illustrate the case, for a beam energy of 7 Megawatts (7 mA protons produced by a state-of-the-art 1 GeV cyclotron) the EA would produce 280 MW of thermal energy, corresponding to about 100 MW of electrical power. As the power needed to operate the accelerator does not exceed about 20 MW, there would thus be a net production of over 80 MW. (A normal nuclear power station produces about a Gigawatt.) During 1994 an irradiated sub-critical assembly has been tested in a beam from CERN's PS proton synchrotron at a very low power (of the order of one watt).

Rubbia has also simulated using lead as moderator. This involves working with neutrons of higher energy than in normal fast neutron reactors where the less agreeable liquid sodium is the moderator. Calculations show that reactivity using lead remains very constant since the effect of fission products (poisons) is considerably reduced. This allows more complete combustion before the fuel rods have to be reprocessed (they could stay in place for four years instead of a year with the light-water variant). Moreover, the constant reactivity opens up the prospect of energy gain increasing from about 60 to 100 or 120, with the assembly remaining sub-critical.

Fast neutrons open up interesting opportunities for the reprocessing of the irradiated rods. This reprocessing will be limited to the separation of the fission products since all actinides become combustible, sidestepping the plutonium problem. The only EA actinide waste (0.5%) comes from imperfections in the separation process.

Fission products can be recycled in the rods, the neutron flux transforming them into non-radioactive elements. However, unlike the fission of actinides, this transformation consumes neutrons and reduces energy production. A compromise solution would be to reserve this costly processing to sensitive elements such as cesium 135, iodine 129, etc., which are long-lived (several million years) and potentially polluting.

A study carried out on the thermal version (the fast neutron version, probably even cheaper, has not yet been costed) corroborated by experts from the Laboratoire d'Economie de l'Energie in Grenoble indicates a unit price slightly higher than that of French nuclear power stations, but much lower than other sources (German nuclear power stations, coal, French natural gas).

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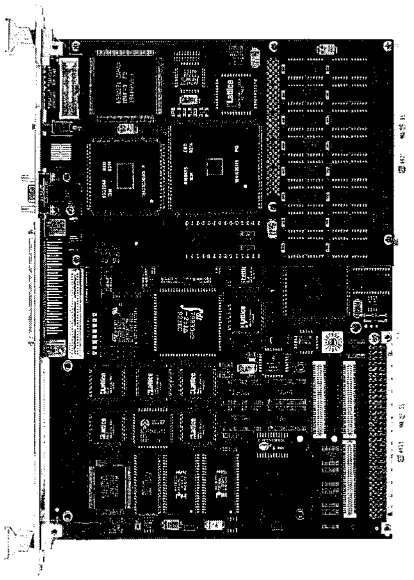

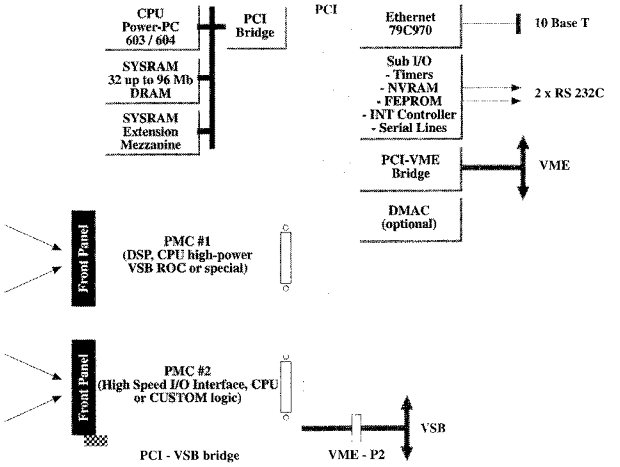

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CREATIVE ELECTRONIC SYSTEMS

This may seem surprising ("you're adding a cyclotron, how can you be cheaper?"), but the relative additional investment is offset by the lower fuel cost (no isotope separation) and ease of operation, with less frequent fuel rod manipulation.

To drive the assembly would require a 1 GeV cyclotron with an intensity of 10 mA or more - an entirely feasible prospect. The experiment at CERN, using a beam from the PS, shows that an energy of 800 MeV to 1 GeV is optimal.

The main objective of the test was to confirm computer simulations. The Universidad Politécnica of Madrid provided a subcritical assembly used for teaching purposes with 3.6 tonnes of natural uranium in a tank of demineralized water, which could be used with only minor modifications to take a spallation target. Operation used low intensity (1/100,000 of the PS proton production rate) to minimize radioactivity.

In this test rig, energy production was of the order of 1 watt, giving a temperature rise of the order of 1/100 of a degree, requiring careful thermometry. To prove that the heating was due to fission, plastic sheets (Lexan) were exposed in the thermometric probe sites. The characteristic etching produced by fission fragments on such plastic can be developed and observed under the microscope. The correlation was perfect.

From these local measurements, carried out at four different distances, the rise in temperature could be established from the fission density distribution. This relied on the computer simulation and a detailed mapping from 200 electronic fission-product detectors. These silicon solar diodes or ionization counters in pressurized argon count the fragments emerging from thin calibrated deposits of uranium and show the time dependence of the fission rate following a short pulse of protons.

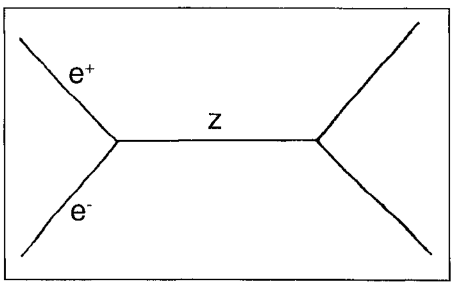
The measured energy gain is of the order of 30, consistent with the simulation predictions.

The test rig was far from optimum. Simulation shows that a larger device would give a gain of about 60, sufficient for 600 MW of thermal energy, i.e. about 200 MW of electrical power, from a 10 mA 1 GeV cyclotron.

The dependence of gain on incident proton energy has been studied between 600 MeV and 2.75 GeV. Above 1 GeV the gain hardly increased while below 800 MeV it decreased markedly. By the end of the year, the CERN group expects to have a detailed feasibility report for a pilot energy production facility.

Elsewhere, several groups - Los Alamos, Brookhaven, Japan (JAERI) and Russia (at least seven institutes around ITEP, Moscow) - are planning accelerator-driven fission for a range of applications (waste and plutonium destruction, tritium production, energy production from thorium, uranium or plutonium). A joint report will be drawn up this year under the aegis of the International Atomic Energy Agency.

With the heavy ecological implications of present nuclear and conventional energy sources, it is surprising how little R&D work is being invested anywhere in this potentially rewarding alternative energy solution.



STANDARD MODEL The elephant, the tiger, the penguin and the unicorn

Experiments at Fermilab's Tevatron proton-antiproton collider have discovered the long-awaited sixth - 'top'- quark (see page 1). The top quark was the only missing link in the framework of today's Standard Model of three pairs of quarks and three pairs of leptons (June 1994, page 4).

Unlike Fermilab's antiproton-proton collisions, the electron-positron collisions at CERN's LEP machine do not make it possible to produce and observe the top quark, for lack of energy. In the context of the Standard Model (SM), however, LEP has provided a value for its mass which, at the end of the 1993 season, was 172 ± 20 GeV, agreeing well with the average value from the Fermilab experiments, 180 ± 12 GeV.

While the SM includes the top quark, it gives no indication of its mass. The SM provides a mathematical framework making it possible, from three basic quantities, to calculate all the observable effects in the electroweak interaction sector. The three quantities are selected according to the precision with which they are known. The ones now adopted are the electromagnetic coupling constant, the muon decay coupling constant, and the mass of the Z, newly promoted on account of the extreme precision with which it

Basic diet of CERN's LEP electron-positron collider - the formation of a Z from an electron-positron pair and its subsequent decay.

has been obtained at LEP.

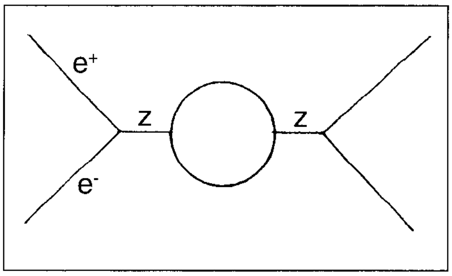
It might thus be thought that, at LEP or lower energies, well below the top quark production threshold, this quark could be forgotten and the observed phenomena accounted for without worrying about it, by calculating all the "observables" from the aforementioned three basic values.

Quantum nature, however, is more complex and more interesting! It acts like a bank which lends energy, all the more if it is repaid quickly. This approximate metaphor is a simple paraphrase of Heisenberg's uncertainty relation. The "loan" makes it possible for particles, although too heavy to be actually released in a reaction, to take part in the process just the same.

For instance in the production of a Z at LEP, the intermediate state may fluctuate towards a top-antitop quark pair. The top quark, which belongs to the third family of quarks and thus has privileged relations with the fifth (b, or beauty, quark) also affects the rate of decay of the Z particles containing the b quark. As well as the top quark, any object with suitable quantum numbers may contribute similarly.

Remarkably, these processes can be measured, for they slightly modify the observed effects, in particular the reaction rates. Here again, the Standard Model provides the tools for calculating these modifications. These changes, however, now depend on the mass of the object considered, so that precise measurements provide access to this mass. Thus the ultra-precise measurements of the properties of the Z at LEP, supplemented by other results, particularly from neutrino scattering and on the W mass, have made it possible to obtain the mass of the top quark within the context of the Standard Model, without actually producing one.

The Z can be affected by a transient loop of a "virtual" top and antitop quark pair. Although the top quarks cannot be seen their presence can be felt in precision Z measurements.



It is natural to wonder whether the other great missing feature of the Standard Model, the higgs boson, could be similarly tracked down. As well as an outer framework of quarks and leptons, the SM has inner mechanisms that provide its motive power - the electroweak interaction, the strong quark-gluon force, and the mysterious 'higgs' particle which gives the essential electroweak symmetry breaking.

The higgs particle may also take part in loop processes. Unfortunately, the expected effects are very small. At LEP, for example, they are much weaker than those of the top quark. As long as the latter are not precisely known they will certainly mask the influence of the higgs boson. To develop an analogy of Guido Altarelli, tracking the higgs boson alongside the top quark would be like a bush hunter, with his ear to the ground, trying to detect a tiger's footsteps while an elephant is tramping around nearby.

An essential pre-condition therefore is to determine the mass of the top quark precisely and make allowance for it. Once the elephant has been stilled, shall we be able to hear the tiger's footsteps?

The conditions required are, unfortunately, really strict. The mass of the top quark would have to be determined to an accuracy of about one per cent. It would also be necessary to make at least one other measurement of equivalent quality. For example, the value of the electroweak mixing angle parameter would have to be obtained with an accuracy of about one part in ten thousand or better.

Both greatly outstrip current possibilities. To reach them would require new machines and programmes (a linear electron-positron collider or a collider of the LEP type with high luminosity and highly polarized beams). At this level of precision we even come up against the residual uncertainty of one of the basic values of the SM, the electromagnetic coupling constant, or, more exactly, its value at the scale of the Z mass. Obtaining the necessary precision would require a vast world programme of measuring electron-positron annihilation into hadrons at low-energy machines, desirable but, alas, unlikely.

If all these measurements were made, we would obtain a welcome but only approximate value for the higgs mass. Furthermore, such a deduction would assume the strict validity of the SM, and this is precisely what we want to prove. How is it possible to ensure that any slight deviation is caused by the higgs boson and not by some new physics? Are we detecting the footsteps of a tiger or of some as yet unknown beast?

Given the intricacy and the unavoidable ambiguities and limitations of such a programme of indirect measurements, the real solution is the direct exploration of the mass range in which the higgs particle is expected. This is the prime purpose of LHC, succeeding LEP2.

Just as the unicorn is a superposition of ideas not seen together but which nevertheless look appealing when combined, so in physics supersymmetry (SUSY) relates bosons (normally force-carrying particles) and fermions (which normally feel the forces). In supersymmetry, bosons could have fermion counterparts, and vice versa. SUSY could turn out to be a lot less mythical than the unicorn

However certain high-precision measurements made at relatively low energy may still be highly effective. They make it possible to refute theories which stray too far from the SM. Thus LEP measurements give a hard time to a class of theories which attempt to go beyond the SM by advancing the hypothesis that objects like the higgs boson are composite, built from deeper layers of constituents. These "Technicolour" theories predict greater deviations from the SM than those tolerated by the LEP measurements and are therefore in serious difficulty. These models do, however, have a large number of variants and it is not impossible to concoct a viable solution.

What can one say about supersymmetry from accurate measurements? Supersymmetry (SUSY) relates bosons (normally force-carrying particles) and fermions (which normally feel the forces). In supersymmetry, bosons have fermion counterparts, and vice versa.

SUSY, especially in its minimal form (MSSM), is now considered the most attractive theory beyond the SM. Precision data from LEP added confidence to extrapolations to higher energy regimes (April 1991. page 3). MSSM accounts for the present data as well as the SM does. SUSY predicts the existence of a new set of objects mirroring that of the SM. These have not yet been observed because, it is claimed, they are relatively heavy. In addition, SUSY needs several higgs bosons. This rich phenomenology makes LEP2 a promising machine, especially to observe the lightest of these bosons, while LHC will offer a horn of plenty if supersymmetry is real.

Would it be possible, however, to infer the existence of these particles from their effects at low energy? There again the situation is not very promising. Due to the mathematical structure of SUSY, the heavy partners have an annoying tendency to decouple from lower-energy phenomena, and do not markedly modify observable quantities like the properties of the Z.

After lengthy studies, the conclusion is that any marked deviation can arise only from the existence of light supersymmetrical partners at the threshold of the field currently being explored. These would be observable at LEP2 and the Tevatron.

This possibility of a direct look is welcome since measurements at LEP1 have not yet attained sufficient precision to give a firm answer, and probably never will.

At still lower energies, the precise measurement of rare ('penguin') modes, like the radiative decay of the B (October 1994, page 12), is generally regarded as a window on possible new phenomena. This and other remarkable measurements have set strong limits on some unusual theories, such as those which depart from the SM by having two doublets of higgs bosons.

However, the supersymmetry theory itself is more complex: several types of new objects are capable of modifying the radiative decay rate of the B and, according to SUSY's choice of free parameters, their effects may compensate or be added to one another so that it has so far been impossible to draw any firm conclusion on supersymmetry from this channel.

Precision measurements of various electroweak processes, of which the famous anomalous magnetic moment (g-2) of the muon is still the archetype and where LEP I is distinguishing itself, constitute a rich and promising field to be exploited as thoroughly as possible.

They have made it possible to confirm the internal coherence of the Standard Model in its subtlest points. For theory builders they provide guidelines on what is allowed and even more on what is forbidden. It would, however, be wrong to overemphasize them and overestimate their predictive power. The direct exploration of the TeV mass field remains utterly essential.

Collision energy in the TeV range between constituents - quarks and gluons - is high enough above the electroweak scale to ensure that a new field of physics is going to be explored. In relation to the 14 TeV of the collisions between protons in LHC, seen here as quark and gluon bags, this energy is still low enough for such collisions to occur at a suitable rate.

Following LEP2, exploring this field by means of LHC is the only way of providing a convincing answer to the current problems, and answering them by looking for the tiger and, as has so often happened before, finding the equivalent of a unicorn in some as yet unidentified species.

By Daniel Treille

CONFERENCE Quark Matter '95

High energy heavy ion collisions have become one of the major growth areas of modern physics. Providing common ground between particle and nuclear physics, it has produced a wave of new interest and a series of major projects to provide beams of higher energies and increasing nuclear complexity.

Reflecting this interest, and despite record rainstorms, over 450 enthusiastic high energy heavy ion followers met in Monterey, California, at the 11th International Conference on Ultra-relativistic Nucleus-Nucleus Collisions.

Named Quark Matter '95, the meeting was characterized by its own flood of new results from experiments studying collisions of gold nuclei at the Brookhaven Alternating Gradient Synchrotron (AGS) and with silicon beams at the CERN SPS synchrotron, as well as preliminary results from the first run with lead beams at CERN late last year (December 1994, page 15).

A striking aspect of the Conference was the growth in attendance and, in particular, the large number of young physicists who attended the meeting, underlining the vitality and appeal of this important field.

CERN

The new preliminary data from CERN experiments NA44, NA49, NA52, WA97, and WA98, made available with remarkable speed following the initial lead beam run in November and December 1994, represent a significant step in the study of heavy ion collisions. Physicists have finally come close to conditions where it is possible to consider event-by-event analysis of these very complex final states. The importance of this emerging approach to relativistic heavy ion collisions was emphasized by Reinhard Stock (Frankfurt) and other speakers in a pre-conference workshop devoted to physics with the collider detectors at big new projects now in the pipeline - RHIC at Brookhaven and LHC at CERN.

The study of collisions of heavy nuclei at relativistic energies is dominated by the search for the Quark-Gluon Plasma, the 'soup' of free quarks and gluons expected to have played an important role in the early Universe. This plasma results from a phase transition and is predicted by calculations using lattice quantum chromodynamics.

Although the Quark-Gluon Plasma has not yet been found, the experiments reported a number of signatures incompatible with the picture of simple hadron-hadron interactions in these nuclear collisions. The signatures, enhanced strangeness and enhanced dilepton production, were reviewed by Carl Dover (Brookhaven) and Itzhak Tserruya (Weizmann).

Brookhaven AGS

The results from the AGS, presented by speakers representing experiments E810, E859, E866, E877, and E878 indicate a considerable level of nuclear stopping in gold-gold collisions at 10.9 GeV per nucleon beam energy. As a result, there are a large number of multiple collisions between participating nucleons leading to an intermediate state rich in baryonic resonances. The study of this new form of matter will be the focus of a continuing programme of experiments at Brookhaven. Preliminary results from E859 also indicate a slight shift in the phi meson mass. If confirmed, this will be the first evidence of the modification of hadronic properties inside dense matter.

In one of the opening lectures at the 11th International Conference on Ultra-relativistic Nucleus-Nucleus Collisions, held in January in Monterey, California ,T.D. Lee (Columbia) overviewed the physics expected at the RHIC collider now under construction at Brookhaven.

These and other experiments at Brookhaven and CERN seek to understand the conditions created in collisions of heavy nuclei at relativistic energies. An understanding of the thermodynamic and other properties of hot, dense hadronic matter under these conditions is a critical stepping stone towards the discovery and characterization of the Quark-Gluon Plasma in heavy ion collisions at the future RHIC and LHC accelerators.

Theory

The conference included a number of excellent talks by theorists who described important developments in the understanding of hadronic and quark/gluon matter at the very high energy densities that are and will be available. These calculations are based on a wide range of points of view including thermodynamic, hadron cascade, and quark/gluon cascade models that seek to describe the creation and evolution of high energy density hadronic and quark-gluon matter.

In addition, theorists described a number of fascinating phenomena including the formation of disordered chiral condensates (coherent pion fields) and strange matter. The importance of an intimate interplay between theory and experiments was emphasized by a number of speakers and was an important aspect of intense hallway conversation between participants throughout the meeting.

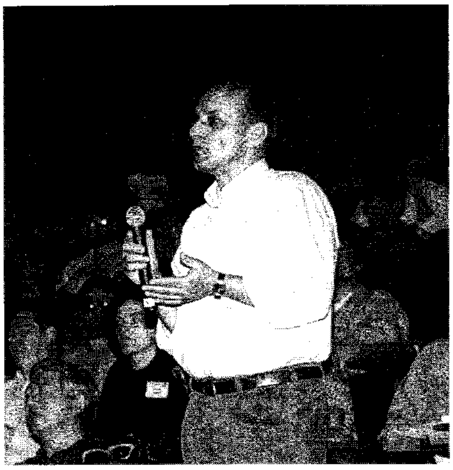
Highlights

Highlights of the conference's six plenary, six parallel, and extensive poster sessions included the introduction by Berndt Mueller (Duke) describing the current state of the field, and T.D. Lee (Columbia) emphasizing the importance of the changes in the quantum mechanical vacuum state that could be induced by heavy ion collisions at RHIC collision energies and above.

Also, there was a comprehensive talk by Gordon Baym (Illinois) describing the properties of high density nuclear matter in neutron stars. Concluding, Miklos Gyulassy (Columbia) reminded participants of the tremendous achievements the field has seen and pointed out the exciting future in store.

Helmut Satz (Bielefeld) who spoke on "Hard Probes of Dense Matter" at Monterey, also probed from the floor.

(Photos LBL)



Organization

The conference, held every 1 1/2 years, was impressively organized by Art Poskanzer (Lawrence Berkeley Laboratory), and the local committee. The pre-conference workshop was organized by Tim Hallman (UCLA) and Jim Thomas (Lawrence Livermore National Laboratory). The Conference made extensive use of the World Wide Web, where all abstracts were posted.

The companions program, arranged by Lucille Poskanzer, included a talk by a local Steinbeck expert, a description of the search for the Quark-Gluon Plasma in layman's terms, and a discussion of the challenges of "Living With the Big Brained." (The CERN Courier would have appreciated receiving summaries of these latter two talks.)

Participants are eagerly looking ahead to the next Quark Matter meeting which will be hosted in May 1996 by the University of Heidelberg and the GSI Laboratory, Darmstadt.

From Jay Marx and Xin-Nian Wang

Delayed neutrinos

The KARMEN (KArlsruhe/Rutherford Medium energy Neutrino) experiment at the UK Rutherford Laboratory's ISIS accelerator/neutron source began running in 1990, and among other contributions has provided the first examples of nuclear excitations via neutral current interactions. As neutrino statistics continue to pile up, intriguing new effects appear to emerge from the data.

ISIS fires a dense 800 MeV proton beam into a thick target of heavy metal, producing neutrons by spallation. While most of the ISIS protons convert into neutrons, about one in twenty radiates a charged pion, which decays to produce a muon and a muon neutrino.

In contrast to a normal neutrino experiment, where the neutrinos are produced by the decay of secondary pions (and kaons) in flight, KARMEN's pions get no further than the dense neutron source/target. This acts like a 'beam stop', absorbing most of the secondaries usually seen in high energy reactions, leaving only highly penetrating particles, like neutrinos, which pass through material relatively unscathed.

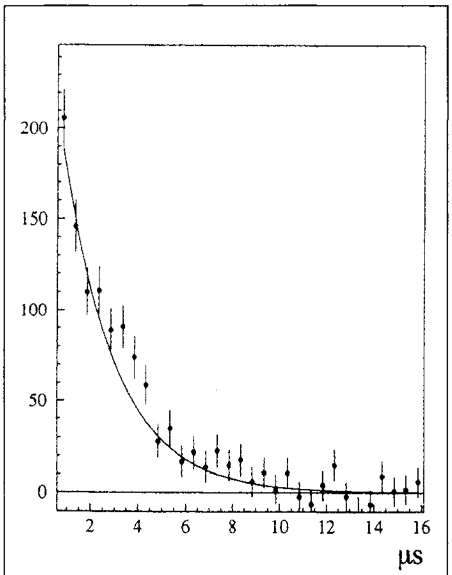
Captured in the neutron production target, the secondary charged pions decay at rest, producing muons and monoenergetic (30 MeV) muon-type neutrinos. The former subsequently decay too, producing electrons and both muon- and electron-type neutrinos. With three emerging particles rather than two, the energy of the neutrinos from muon decay has a continuous spectrum (as in beta decay), cutting off at 53 MeV.

KARMEN's 56-tonne liquid scintillation calorimeter, 17.5 metres downstream from the target assembly and swathed in its 6000 tonne iron mantle

to screen off background effects, monitors the emerging particles. During normal running, about 1 or 2 neutrinos per day are intercepted, with some 1500 neutrino counts having been amassed so far.

By comparing the arrival time of the neutrino counts with the proton clock, neutrinos from the two different sources can be separated. The electron neutrinos from muon decay broadly reflect the 2.2 microsecond muon lifetime, but the experiment sees a slight shoulder in the decay spectrum, broadened towards 2.7 microseconds.

With neutrinos reluctant to interact with matter, neutrino data are notoriously difficult to amass, so that results are continually at the mercy of statistical fluctuations. However the delayed shoulder in the KARMEN spectrum has now lasted for several years. It could mean that something else, a massive neutrino-like particle produced in a rare form of pion decay beyond any conventional theory, is making its presence felt. Only several years more neutrino running will tell.



Another objective high on KARMEN's list is the search for neutrino oscillations, where neutrinos would periodically switch roles, for example from electron- to muon-type and back. KARMEN is extremely sensitive to such effects, but so far has seen nothing, drawing valuable frontiers of neutrino mass and other parameters beyond which such oscillations have to be confined.

(This report is drawn from a story first published in the German Physical Society's excellent monthly physics magazine Physikalische Blätter.)

The arrival time of neutrino counts (horizontal axis) in the KARMEN experiment by a German/UK team at the UK Rutherford Appleton Laboratory's ISIS machine reflects their muon parentage, with a mean decay time around 2.2 microseconds. However a slight broadening of the spectrum near 2.7 microseconds suggests that something else could be happening too.

Around the Laboratories

PROTVINO
U-70's first long run

The Protvino 70 GeV proton synchrotron (U-70), commissioned in 1967, was for five years the world's largest proton machine. In all, more than 170 experiments at U-70 have been carried out, more than 50 being joint experiments with physicists from the European, USA and Japan laboratories.

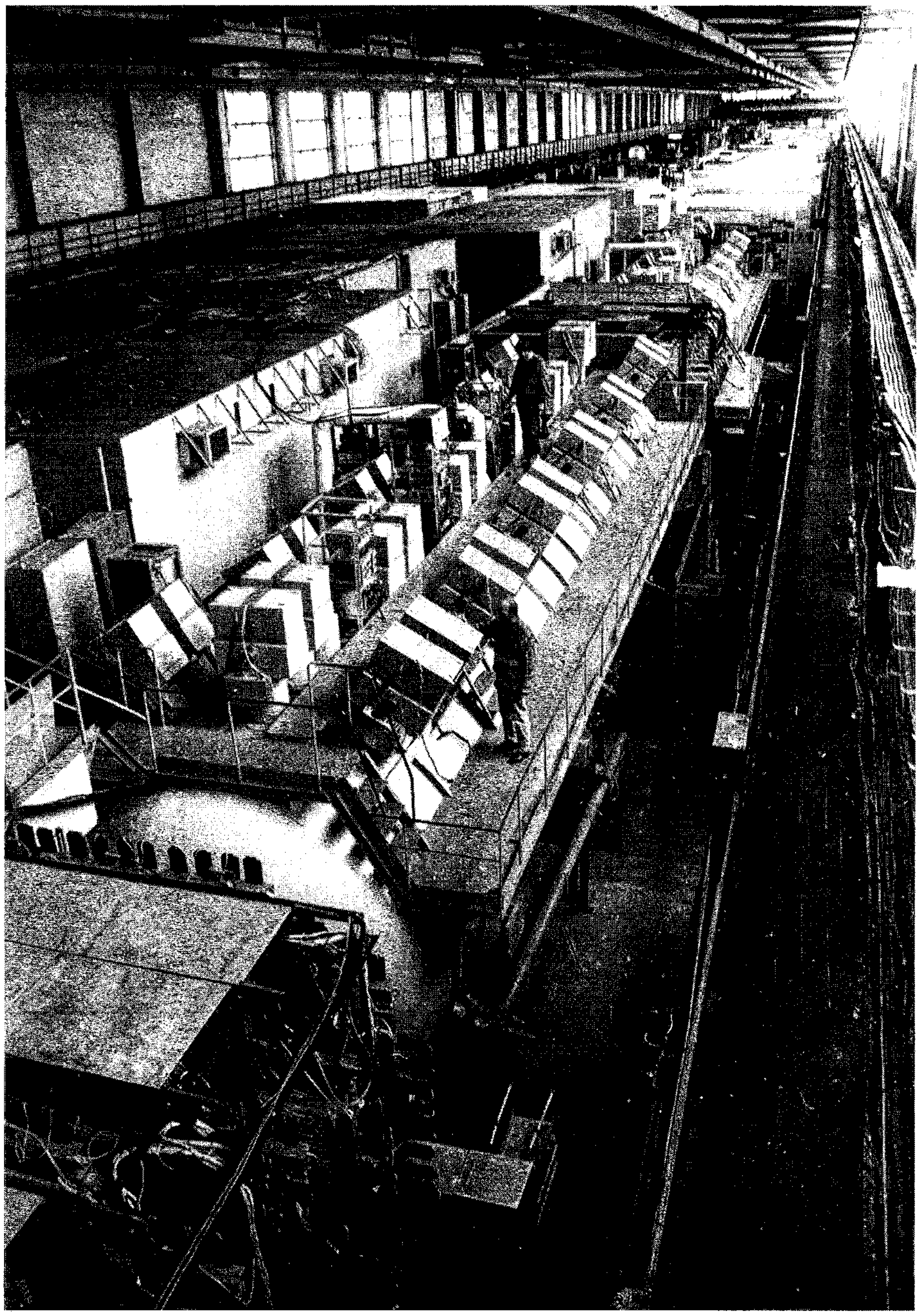
Under the Russian government, the Protvino Institute for High Energy Physics' high scientific authority was last year accorded the title of State Scientific Centre, denoting that it is the major laboratory in Russia carrying out a high energy physics programme actually in the country.

In keeping with this status, U-70's traditional running schedule has been boosted. Before 1994, U-70 was scheduled for four or five runs, each of about 40 days, each year.

Meanwhile a major upgrade of the IHEP machine had been launched. Among its main goals were the replacement of many U-70 systems to increase the proton beam intensity and the machine's operational reliability, to carry out a new physics programme at 70 GeV, and to obtain the beam conditions necessary for the big UNK machine under construction.

The U-70 upgrade includes: total replacement of the goffered vacuum chamber by a smooth one; improvement of all 40 radiofrequency stations; design and construction of a new diagnostic and control system; and design and construction of a new 60 MeV radiofrequency linac to allow acceleration of negative hydrogen ions and charge exchange injection.

At the same time U-70 was con-



The Tagged Neutrino Facility at the U-70 proton synchrotron, Protvino, near Moscow, one of the focal points of the recent major U-70 run.

verted for longer running periods, with two longer runs per year with a summer break for maintenance, upgrades and installation.

In 1994, despite the adverse financial situation which Russian science and particularly high energy physics is undergoing, the first stage of the U-70 upgrade was completed and, for the first time in IHEP's history, a three-month (October-December) run was scheduled. This run yielded the full harvest of expected data and all accelerator systems operated reliably under the new conditions.

The experimental programme included: a study of the nuclear dependence of charmed baryon production (EXCHARM experiment); a study of rare decay modes and precise measurements of certain kaon decays with the ISTRA setup; further study of kaon physics at the MIS-ITEP setup; and initial asymmetry measurements with the FODS-2 setup using a completely new U-70 polarized proton beam.

In addition, particular attention was paid to the Tagged Neutrino Complex, an international programme involving scientists from IHEP, JINR Dubna, Germany, and Italy, where important progress has been made both in operations and in obtaining initial physics data.

As well as its physics yield, the successful run was of vital importance because it gave an opportunity to sustain high energy physics all over Russia, developing its experimental basis and providing valuable experience for young researchers.

Awaiting the turn of the tide in Russian funding for high energy physics projects, the main IHEP objectives have to remain well defined.

From A.Bougorski

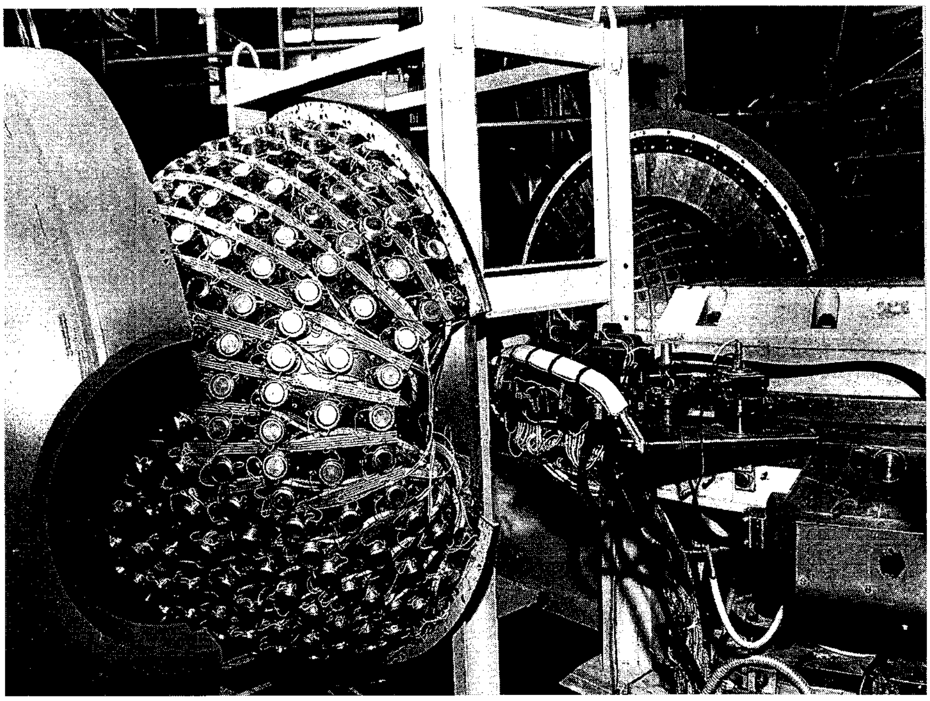
NOVOSIBIRSK
New detector starts taking data

A new nonmagnetic Spherical Neutral Detector (SND) has started operation at the low energy VEPP-2M electron-positron collider at the Budker Institute, Novosibirsk. This complements the CMD-2 detector built at Novosibirsk in collaboration with Brookhaven, Yale, Boston and Pittsburgh (November 1994, page 9).

SND's main component is a 3.6 ton three-layer electromagnetic calorimeter containing 1680 separate NaI(Tl) crystals covering 90% of the solid angle. The spherical shape provides uniform response over the solid angle, important for reducing systematic errors. In many respects SND looks similar to the famous Crystal Ball detector (originally used at the SPEAR electron-positron ring at Stanford/SLAC and transferred in 1981 to DORIS at DESY Hamburg), but its three layer structure allows better electron/pion and photon/kaon separation to be achieved and photon directions to be measured.

A ten layer drift chamber with charge division readout provides good tracking for events with charged particles, while the outer system facilitates selection between muons and pions.

Opened up for inspection is the new nonmagnetic Spherical Neutral Detector (SND), which recently started operation at the low energy VEPP-2M electron-positron collider at the Budker Institute, Novosibirsk. SND's main component is a 3.6 ton three-layer electromagnetic calorimeter containing 1680 sodium iodide crystals.



The physics programme of experiments with SND in the collision energy range 0.4 to 1.4 GeV is strongly aimed at the investigation of multiphoton final states and states with both charged particles and photons. This would continue a fruitful series of experiments with the Neutral Detector performed by the same group in 1982-1987 which resulted in precision measurements of magnetic dipole radiative decays of rho, omega and phi into an eta meson and a photon or into a neutral pion and a photon which dominate the current data (Physics Reports, Vol. 202, 1991, p.99).

The new detector can improve the precision of these measurements and perform a sensitive search for the decay phi into eta prime and a photon as well as electric dipole radiative decays of rho, omega and phi. For heavier quarkonium these decays have been studied in detail, while for their lightest partners none of these decays have been observed. The predicted branching ratios for the decays of phi into $a_0(980)$ or $f_0(980)$ plus a photon are in the range 10^{-4} - 10^{-6}. Observation of these decays will clarify our knowledge of the lightest scalar states and their possible mixing with four-quark states.

Another highlight is a careful study, complementing that of CMD-2 , of hadron production in electron-positron annihilation, which makes important contributions to the anomalous magnetic moment of the muon (g-2), to decay widths and spectra of the tau lepton, and to hadronic vacuum polarization effects at the Z boson, as well as various quark-gluon sum rules.

The vast domain of kaon physics and fuller investigation of CP-violation is left for the next generation experiments at phi factories.

AARHUS
Exotic charge states in ASTRID

Ions are atoms from which one or more orbital electrons have been detached. This removal can be done, for example, by impact of other electrons. Today beams of bare ions - nuclei without any electrons - are available, for example at the GSI heavy ion Laboratory, Darmstadt, even for the heaviest elements.

Molecules too can be ionized by removal of one electron and these molecules can be accelerated to form high energy beams. Molecules are, however, generally not expected to be stable when more than one electron is missing, since there is too little negative charge to bind the positive nuclei.

It was therefore a surprise when a stable doubly-charged molecular ion was found at experiments at the ASTRID storage ring, Aarhus, Denmark. The aim of the experiment was to measure lifetimes of expected metastable states of doubly-charged carbon monoxide, CO^{++}. The CO^{++} ions were produced in an ion source and the accelerated beam injected into the storage ring. The circulating intensity was then monitored by detecting neutral species produced in restgas collisions at the end of a straight section.

For CO^{++}, a fraction of the beam survived for tens of seconds, with a lifetime around 4 seconds. This lifetime was dominated by restgas collisions. The base pressure was around 2×10^{-11} mbar. In order to avoid contamination from molecules with the same mass/charge ratio, e.g. singly-charged nitrogen-14, the

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Applications are invited for a number of current or imminent Research Assistant vacancies within Particle Physics. The successful applicants will be assigned to one of the research groups in a large, international and varied programme of research. Experiments supported include DELPHI at CERN, ZEUS at HERA and Soudan II in the USA. Development work on Cryodetectors, Dark Matter and Neutrino experiments plus experiments for the LHC are also major parts of the programme. Appointments, funded by PPARC, will be to 30 September 1998 initially.

Applicants must have or are about to obtain a Ph.D and have experience in research in the field of Particle Physics. Letters of application, including a concise indication of research interests, supported by a full CV and the names and addresses of 2 referees should be forwarded to Mr P F Dobbs, Deputy Administrator, Department of Physics, Nuclear and Astrophysics Laboratory, Keble Road, Oxford, OX1 3RH (e-mail: p.dobbs@physics.oxford.ac.uk) to arrive by 19 May 1995.

The University exists to promote excellence in education and research, and is an equal opportunities employer.

UNIVERSITY OF COPENHAGEN

Niels Bohr Institute
for
Astronomy, Physics, and Geophysics

Post Doc Position in
Experimental High Energy Heavy Ion Physics

A post doctoral position at the Niels Bohr Institute in Copenhagen, Denmark, will be open from August 1, 1995, in high energy heavy ion experimental physics. The position is for two years, possibly renewable for a third year.

The heavy ion group in Copenhagen counts three staff members in experiment, one in theory and a long term guest in theory. The group is involved in experiment NA44 at Cern, primarily concerned with two particle correlations. The group is responsible for building a time-of-flight hodoscope aimed at the clean detection of two and three baryon and anti baryon systems. The group is also a member of the BRAHMS collaboration at the Relativistic Heavy Ion Collider at Brookhaven.

The successful candidate should have a Ph.D. in experimental nuclear or high energy physics. Prior experience with high energy heavy ion physics is advantageous but not a requirement.

Further information can be obtained from J.J. Gaardhøje (gardhoje@nbi.dk) or from H. Bøggild (boggild@nbi.dk). Application with a CV and three names for references should be sent to **Gaardhøje, Niels Bohr Institute, Blegdamsvej 17, DK-2100 Copenhagen Ø**, where they must be *received before May 31, 1995, at 16:30 hours (Danish Time).*

RESEARCH ASSOCIATE IN ACCELERATOR TECHNOLOGY

CORNELL UNIVERSITY
LABORATORY OF NUCLEAR STUDIES

We anticipate an opening for a Research Associate in accelerator technology to work on the development, installation and operation of the RF systems for the Cornell electron-positron colliding beam facility, CESR. Over the next few years, the major activities of the Laboratory will be the operation and upgrade of CESR with the goal of substantially improving the luminosity of CESR. R&D is in progress on major components such as klystron controls, RF power distribution, superconducting RF cavities, high power input power couplers, higher order mode dampers, cryostat, refrigeration and distribution, high power RF components, instrumentation and controls. Research Associates generally participate in one or more of these activities.

This is a 3-year appointment with the expectation of renewal, subject to mutual satisfaction and the availability of funds under our NSF contract. A PhD in Physics/ Engineering is required, with at least 3 years post-PhD experience in a combination of the areas outlined above. Candidates with an MS degree in Physics/Engineering should have at least 7 years experience. Please send an application with at least two letters of reference to H. Padamsee, Newman Laboratory, Cornell University, Ithaca, NY 14853. Electronic mail inquiries can be sent to HSP@CESR10.cornell.edu. Cornell University is an equal opportunity/affirmative action employer.

UNIVERSITÄT DORTMUND

Im Fachbereich Physik ist sofort eine

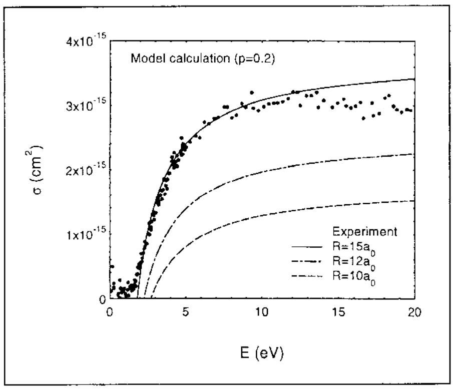
Universitätsprofessur (C3)

mit der Fachrichtung Experimentelle Elementarteilchenphysik wieder zu besetzen. Der Forschungsschwerpunkt der Bewerber/innen sollte auf dem Gebiet

»ZERFÄLLE DER ELEMENTARTEILCHEN«

liegen. Eine entsprechende apparative Grundausstattung ist vorhanden. Es wird erwartet, daß sich die Bewerber/innen an Forschung, Lehre und Selbstverwaltung angemessen beteiligen sowie zu dem Graduiertenkolleg »Erzeugung und Zerfälle von Elementarteilchen« beitragen. Zu den Lehrverpflichtungen gehört außer der Ausbildung von Studenten im Studiengang Physik auch die Durchführung von Lehrveranstaltungen für andere, insbesondere technische Fachrichtungen der Universität Dortmund.
Habilitation oder habilitationsadäquate Leistungen werden vorausgesetzt. Die Einstellungsvoraussetzungen richten sich nach §49 UG des Landes NRW.
Die Universität Dortmund strebt eine Erhöhung des Anteils von Frauen in Forschung und Lehre an und bittet deshalb Wissenschaftlerinnen nachdrücklich um ihre Bewerbung. Die Bewerbung geeigneter Schwerbehinderter ist erwünscht.
Bewerbungen mit Lebenslauf, wissenschaftlichem Werdegang, Publikationsverzeichnis und Angaben über die bisherige Lehrtätigkeit sind bis zum 30.5.1995 zu richten an den Dekan des Fachbereichs Physik der Universität Dortmund, 44221 Dortmund.

No sign of doubly-charged negative ions at the ASTRID storage ring, Aarhus, Denmark, using a stored beam of negative deuterium ions and measuring the electron impact detachment using electrons from the electron cooler. It shows a threshold at 0.75 electronvolts, but no indications of resonances elsewhere, indicating the non-existence of D^{--}.



carbon monoxide used was based on the naturally rare isotope carbon-13 rather than the abundant carbon-12.

Many atoms can also bind an additional electron and form negative ions. Several negative ions are metastable, and lifetime measurements performed at ASTRID and elsewhere produce accurate results important for comparisons with theory. Double-charged negative ions could in principle exist, and indications of metastable states of H^{--} and O^{--} were seen some years ago as resonances in the electron bombardment of negative hydrogen ions.

This process was recently studied at ASTRID by storing a beam of negative deuterium ions and measuring the electron impact detachment using electrons from the electron cooler. The heavier isotope deuterium was chosen to facilitate the ring operation, and the D^- beam produced in a duoplasmotron source.

The production rate was measured from zero relative energy to 20 electronvolts. It shows a threshold at 0.75 electronvolts, but no indications of resonances elsewhere, indicating the non-existence of D^{--}.

Molecules may also exist as negative ions, and ASTRID has also been used to measure the lifetime of such species. An important example is the metastable negative ion of the helium-2 molecule. These ions are produced by charge-exchange of a beam of positive helium-2 molecules in a sodium vapour. For this fundamental system, a lifetime of around 0.1 milliseconds was measured. These studies, only feasible in a storage ring, will continue.

From Soren Pape Møller

People and things

CDF spokesmen

Spokesmen at the CDF experiment at Fermilab's tevatron proton-antiproton collider serve two-year terms. Most recently Mel Shochet (Chicago) and Bill Carithers (LBL) were co-spokesmen. Before the recent round of elections, Mel declared that he did not want to run again, having served for six and a half years (following the departure of Roy Schwitters to the SSC). Bill Carithers (who replaced Alvin Tollestrup two years ago) did decide to run again. Through a complicated process, a long list of nominees was narrowed to six candidates and an election held via the World Wide Web. Results were announced on January 19: Bill Carithers was re-elected for another term, and Giorgio Bellettini (Pisa) becomes his new cospokesman. *(see 'Top discovery' - page 1)*

CERN School of Computing

CERN's traditional annual two-week School of Computing, is held each year in a different member state of the Organization during August or September. The 1994 School, organized in collaboration with the KFKI Research Institute for Particle and Nuclear Physics in Budapest, took place at Sopron, Hungary, brought together 21 lecture and 48 students from 12 countries. The 1995 School will be held in Arles, France, from 20 August to 2 September and will cover: Human Computer Interfaces; Collaborative Software Engineering; Information Super Highways; Trends in Computer Architecture/Industry; Parallel Architectures (MPP); Mathematical Computing; Data Acquisition Systems; WorldWideWeb for Physics. Up to date information is on WorldWideWeb URL http://www.cern.ch/Physics/Conferences/C1995/CSC/
Application forms from J. Turner, CN Division, CERN, 1211 Geneva 23, Switzerland, or via the Web (see above), tel. +41 22 767 5049, fax +41 22 767 7155 e-mail: school at cernvm.cern.ch. Applications, together with a letter of reference, must arrive by 31 May.

Career milestone - Lucien Montanet

Officially 'retiring' from CERN is Lucien Montanet, whose impressive career spans a wide range of physics interests and is characterized by his ebullient enthusiasm. Joining CERN in 1957 for cosmic ray experiments, he went on to participate in pioneer CERN investigations using bubble chambers and using antiprotons, going on in the 1960s to play a prominent role in the discovery and investigation of hadron resonances, and becoming a key figure in the international Particle Data Group. His objective review talks on the complex hadron resonance scene became a feature at international meetings. In the 1970s he pushed the development of the European Hybrid Spectrometer project and

DATA SYSTEMS ANALYST

The Continuous Electron Beam Accelerator Facility in Newport News, Virginia is searching for a Data Systems Analyst to lead the software development and evaluation of state-of-the-art parallel batch systems for on-line and off line data replay and reduction for the experimental program at CEBAF. As a member of the CEBAF Computer Center, the successful candidate will design, implement, and manage batch processing facilities in a UNIX environment, monitor use of the systems and software, provide customizations as required to integrate the batch processing facilities with the computational and networking environment at CEBAF, and provide support to users of the data reduction facility. A Bachelor's Degree in Computer Science or other related field and three to five years experience with code development/ maintenance in a UNIX environment is required. Preference will be given to those with previous experience developing and managing high end CPU farms and/or multi-processor environments in a scientific or engineering environment. Salary depends on the level of appointment and is commensurate with experience. Newport News is located in southeastern Virginia, a region of mild climate with quick access to the Chesapeake Bay, the Atlantic Ocean, Colonial Williamsburg, and Virginia Beach. For further information, contact Dr. Roy Whitney (804)249-7536, whitney@cebaf.gov. Applicants should submit a resume specifying postion #PR2010 to Employment Manager, CEBAF, 12000 Jefferson Ave., Newport News, VA 23606, USA. An Equal Opportunity, Affirmative Action Employer.

CEBAF

The Continuous Electron Beam Accelerator Facility

EPFL

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

SWISS FEDERAL INSTITUTE OF TECHNOLOGY - LAUSANNE (EPFL)

Applications are invited for the following position at the Department of Physics:

Assistant-Professor of Theoretical Physics

The new Assistant-Professor will develop researches, and supervise doctoral thesis, in the field of Statistical Mechanics or Condensed Matter Physics. It is expected that his/her research activities will initiate and stimulate collaborations with experimental groups of the Physics Department and other Departments of the EPFL.
Responsabilities include the teaching of basic and advanced courses, at the undergraduate and graduate level. The candidate should have a record of successful original research and the capability to lead high standard projects.

Women candidates are especially encouraged to apply.

The deadline for the receipt of applications is:
August 1st 1995

Preferred start date on: to be discussed

Interested candidates should ask for the application form to: **Présidence de l'EPFL, CE - Ecublens - CH-1015 Lausanne, Switzerland**

The Physics Institute at the UNIVERSITY OF BONN

has a

Professorship (C4) for Theoretical Physics

and a

Professorship (C3) for Experimental Physics

to be filled for the academic year 1996/97. In the case that the current hiring freeze is extended, the positions will be filled for the following academic year.

The C4 professorship involves the usual teaching and research responsibilities in theoretical physics. The principle field of research is expected to be elementary particle physics.

The teaching duties associated with the C3 professorship will involve courses for students who are not majoring in physics. The research activities of the Institute currently include experiments at HERA and LEP, medium energy physics and synchrotron light experiments with ELSA, and also atmospheric physics. Particularly adapted for this position are physicists who are interested in research at the electron-proton and the future proton-proton storage rings at CERN, are familiar with particle physics research techniques, and who have experience with the development of novel particle detection techniques.

The conditions of employment are described in the §49 of the North Rhine-Westphalian University Law. The University of Bonn particularly encourages applications from qualified women. Applications from handicapped individuals will also be given priority.

Applications with the usual documents should be sent before 30.4.95 to: **Vorsitzender der Fachgruppe Physik-Astronomie, Endenicher Allee 11-13, D-53115 Bonn.**

Associate Scientist

FERMILAB ACCELERATOR

The Fermilab Accelerator Division is seeking an Associate Scientist for a three-year initial term appointment with possible extension. The Associate Scientist will be focused on applications of accelerator physics required to further the Fermilab program, with some opportunity for self-directed research. The beam physics applications include the opportunity to understand and control the beams in the Tevatron, Main Ring, Main Injector or Antiproton Source.

To be considered, applicants must have a Ph.D. in Physics or its equivalent and demonstrated excellence in post-graduate work. Previous experience in the field of accelerator physics, accelerator technology or a related field is desirable, but not required.

We provide our employees with opportunities for personal and professional growth, competitive salaries and an attractive benefits package. Applicants are requested to forward their curriculum vitae and a list of at least three references to: **Dr. David A. Finley, FERMI NATIONAL ACCELERATOR LABORATORY, P.O. Box 500, MS-306, Batavia, IL 60510-0500 USA.**
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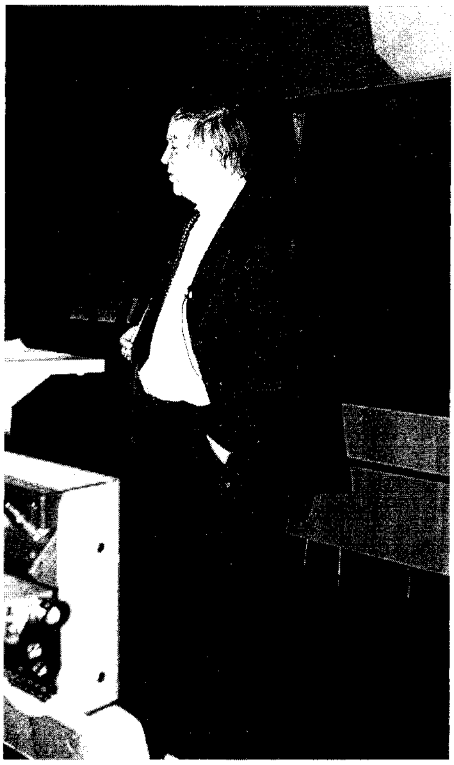
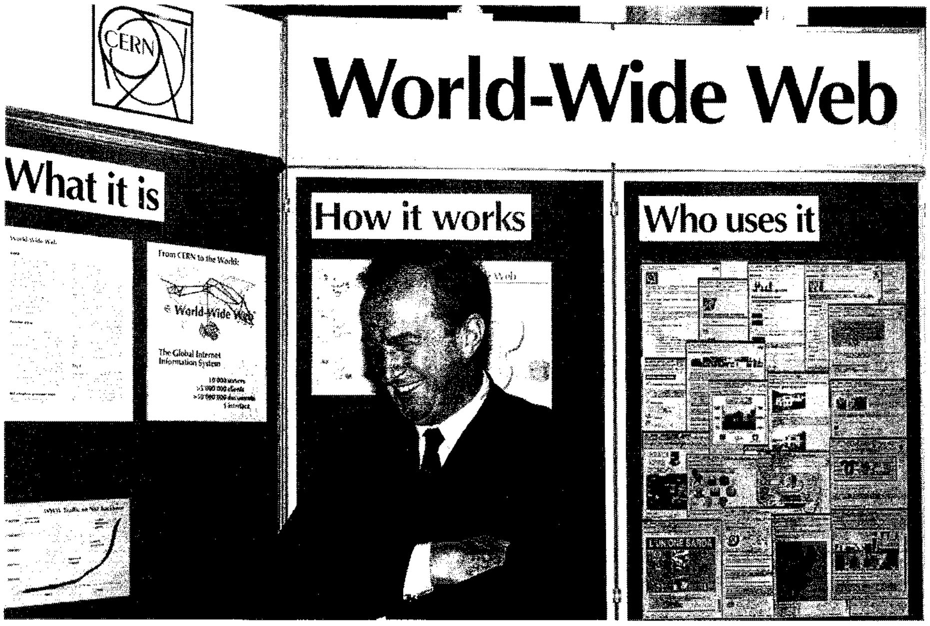
Fermilab

Sergei Kapitza of the Russian Academy of Sciences' Institute for Physical Problems visited CERN in February at the invitation of Gert Harigel to give a memorable series of lectures on the history of 20th century physics. With Kapitza's multidisciplinary background providing penetrating insight and his family background (his father was 1978 Nobel prizewinner Piotr Kapitza) ensuring a plentiful supply of anecdotes, these lectures captured the essence of an eventful century. (Photo CERN GE16.2.95/4A)



On 8 March, UK Minister for Public Service and Science David Hunt was at CERN to open the CERN World Wide Web Days. World Wide Web (W3), developed at CERN and a remarkable spinoff from particle physics research, is now the largest single Internet system, dominating the explosion in electronic information traffic. A report on the W3 meeting by James Gillies will feature in our next issue.



went on to join the L3 and Crystal Barrel collaborations at LEP and LEAR respectively. As well as experimental physics, he has also contributed to theoretical work (with Francis Low) and phenomenology (with Leon van Hove). In 1985 he became the CERN-Russia coordinator, a demanding responsibility now inherited by Jim Allaby as coordinator of CERN Non-Member State affairs.

More AGS protons

En route to its declared goal of 60 x 10^{12} protons per pulse, in February, Brookhaven's Alternating Gradient Synchrotron (AGS) set a new intensity record of 50.5 x 10^{12} ppp, with an average intensity of 49.8 x 10^{12} ppp. The machine is routinely running at over 45 x 10^{12} ppp. (See November 1994, page 12.)

Winding up in more ways than one

The winding up of the 87-kilometre US Superconducting Supercollider (SSC) terminated by Congress in 1993 is not completely destructive. A technique proposed to wind SSC correction coil magnets was seen as a way of maximizing the SSC investment. Although no further funds were available, Billy Yager, using discarded material, was able to perfect the new system, which is well suited to complex winding patterns, such as those in 'Siberian Snake' magnets. A patent has been applied for, and the technology has been licensed to American Composite Education (ACE), Stuart, Florida. Further information from John Morena, phone +1 407 288 9996.

Bruno Pontecorvo Prize

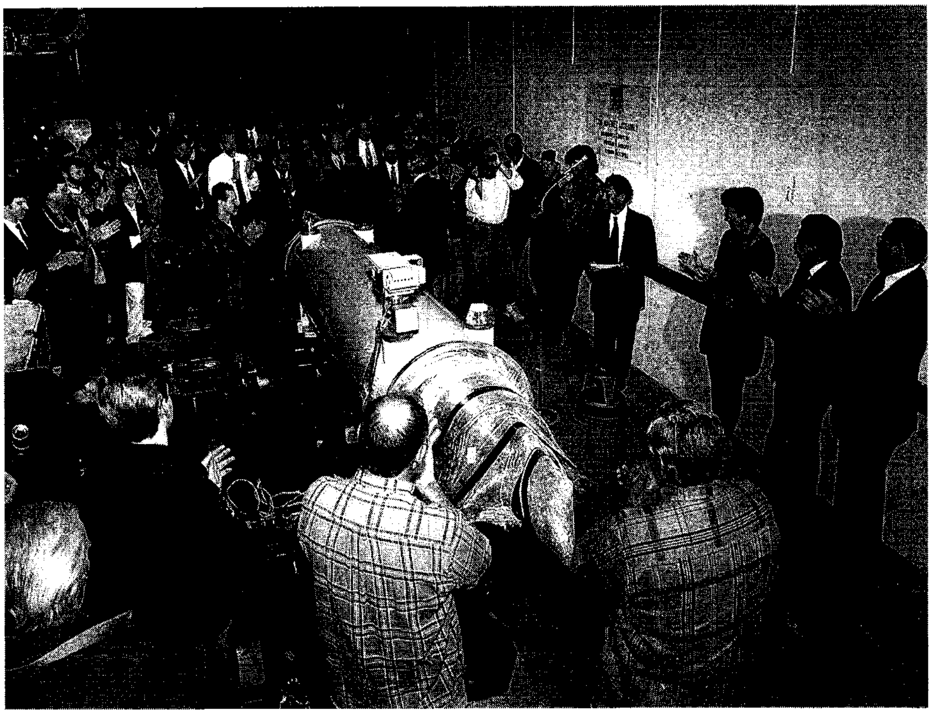
On August 22 the Joint Institute for Nuclear Research, Dubna, near Moscow, will award the Bruno Pontecorvo Prize to the winner of a contest for outstanding research in particle physics. The contest is for individual participants only. The winner will also receive a cheque for US $500.

Participants should send a brief abstract of their research, if possible enclosing copies of major papers, to be received no later than June 10, to: Dr. V. Bednyakov, Joint Institute for Nuclear Research, Laboratory of Nuclear Problems, Dubna, Moscow Region, 141980, Russia. Phone: (7 09621), 62121 Telex: 911 621 DUBNA SU, fax (09621) 666 66 e-mail: bedny@nusun.jinr.dubna.su

Meetings

The 6th International Symposium on Heavy Flavour Physics will be held at Palazzo dei Congressi, Pisa, Italy, from 6-10 June, sponsored by the Istituto Nazionale di Fisica Nucleare (INFN), the Societa Italiana di Fisica (SIF), the European Physical Society

On 26 January, the first corrector-quadrupole-sextupole magnet assembly for the RHIC Relativistic Heavy Ion Collider, RHIC, at Brookhaven was formally unveiled in the 3.8 kilometre collider tunnel. Presiding were (left to right) RHIC Project Head Satoshi Ozaki (under sign), Cherri Langenfeld, Manager of the US Department of Energy's Chicago Operations Office, Brookhaven Director Nick Samios, and Dennis Kovar of DOE's Nuclear Physics Division.



(EPS) and the University of Pisa, and will cover: - Top Quark Search - Charm and Beauty Spectroscopy - Production and Decays of Heavy Quarks and the Tau Lepton - Heavy Flavours in Z Decays - B Lifetimes - Determination of CKM Matrix Elements - Mixing - Rare Decays - CP Violation, LHC and Hadroproduction - New Technologies for Heavy Flavour Physics. Attendance by invitation. Information from: Ms. Lucia Lilli INFN, Sezione di Pisa, Via Livornese 1291 I-56010 S. Piero a Grado (PI) tel. +39 50 880237 fax. +39 50 880317 e-mail: hfl95@pisa.infn.it

A Workshop on the Development of Technologies and Machine Issues for Muon Colliders will be held from 15-20 October in Montauk, Long Island, New York. It will include working groups on: Muon Production; Muon Cooling; Beam Dynamics; Detectors; and Physics (at 250 + 250 GeV and 2 + 2 TeV). Further information from Robert Palmer, Chair (palmer@slacvm.slac.stanford.edu), Juan Gallardo (gallardo@bnlaxp.bnl.gov), Kathleen Tuohy, Secretary (tuohy@bnlcl1.bnl.gov).

Journals for Viet-Nam

Several science libraries of Viet-Nam (in Hanoi, Hue, Dalat and Ho Chi Minh city) are looking for collections of science journals from 1980 onwards. Of particular interest are: Nuclear Physics A, B; Physics Letters A, B; Physics Reports; Zeitschrift für Physik A to D; Physical Review A to D; Physical Review Letters; Reviews of Modern Physics; International Journal of Modern Physics A to E; Modern Physics Letters A, B; Nuclear Instruments and Methods; Astronomy and Astrophysics; Astrophysical Journal; Astronomical Society of the Pacific.

External correspondents

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Published from CERN, Switzerland, it also has correspondents in the Laboratories of Argonne, Berkeley, Brookhaven, Cornell, Fermi, Los Alamos and Stanford in the USA, Darmstadt, DESY and Karlsruhe in Germany, Orsay and Seclay in France, Frascati in Italy, Rutherford in the U.K., PSI in Switzerland, Serpukhov, Dubna and Novosibirsk in Russia, KEK in Japan, TRIUMF in Canada and Beijing in China.

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RESEARCH ASSOCIATE IN EXPERIMENTAL ELEMENTARY PARTICLE PHYSICS

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LABORATORY OF NUCLEAR STUDIES

The high energy physics group at Cornell University has an opening for a Research Associate to work on the CLEO experiment at the Cornell Electron Storage Ring (CESR). Our research concentrates on the physics of the B meson, as well as charm, tau, and two-photon physics. We are also designing a new drift chamber as part of a major detector upgrade, and anticipate that the person filling this position will contribute to this project.

This is normally a three-year appointment with the possibility of renewal beyond that, subject to mutual satisfaction and the availability of funds under our NSF contract. A Ph.D. in experimental elementary particle physics is required. Please send an application including curriculum vitae and publication list and arrange for at least two letters of recommendation to be sent to:

Prof. Ritchie Patterson
Cornell University
Newman Laboratory
Ithaca, NY 14853-5001

E-mail to: SEARCH@LNS62.LNS.CORNELL.EDU

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At an imaginative wine-tasting to mark his 65th birthday, CERN physicist Douglas Morrison was presented with a book 'Life in Collaboration' containing 280 papers with his name prominent among the list of collaborators. Of the 811 researchers listed, almost 300 were located and were able to sign the book. As well as his contributions to physics, Morrison, a careful researcher of the conventional school, plays, and hopefully will continue to play, a valuable role as an independent and authoritative scientific 'policeman' who slaps parking tickets on results whose claims outweigh their credibility.

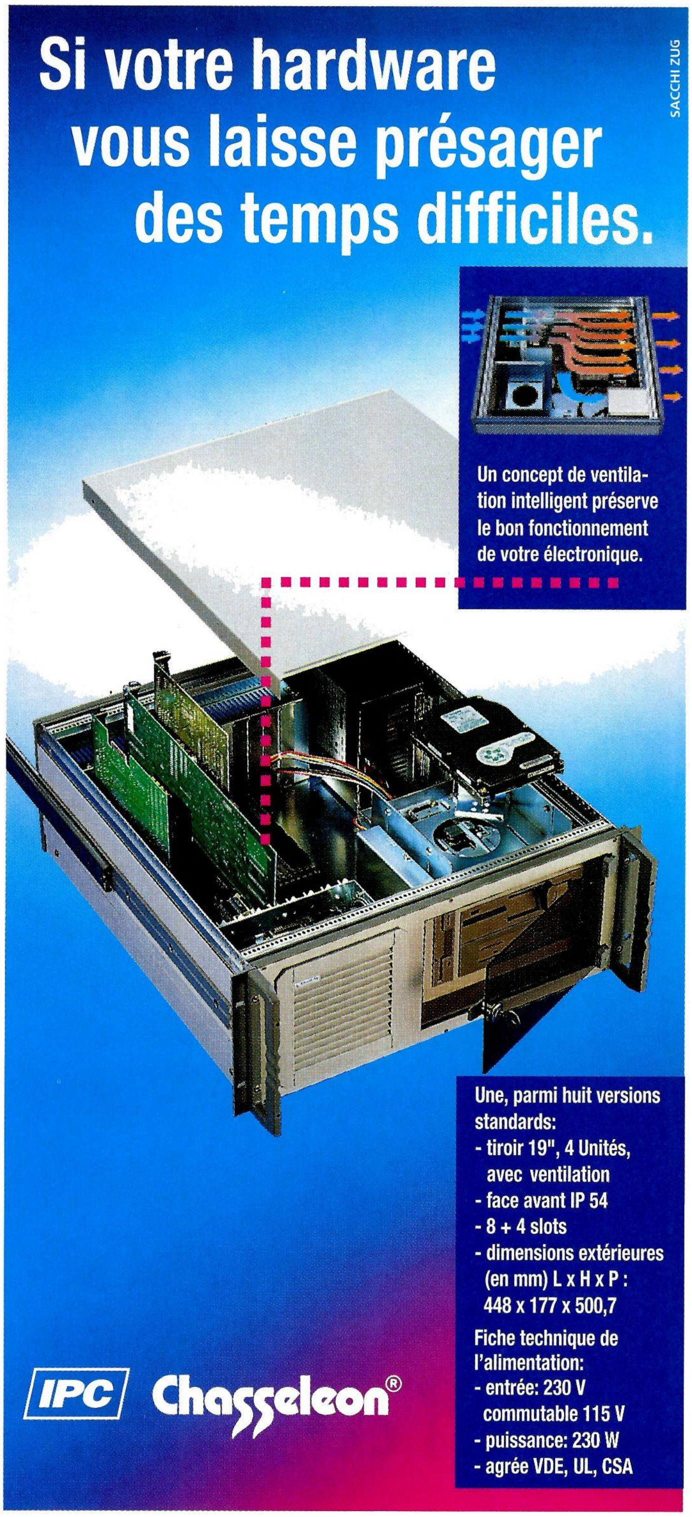
Please contact Pham Xuan Yem (PHAM@LPTHE.JUSSIEU.FR), LPTHE, Université Pierre et Marie Curie, Tour 16, 1er étage, 4 Place Jussieu, F-75252 PARIS Cedex 05.

Proceedings available

The Proceedings of the Summer School on Hadronic Aspects of Collider Physics, held in Zuoz (Engadin), Switzerland, last August, are available from Christine Kunz, Paul Scherrer Institut, ZG/C59, 5232 Villigen PSI, Switzerland, Fax: 056 99 32 94, e-mail: ckunz@psiclu.cern.ch

For many generations of theorists, Tatiana Fabergé was the CERN Theory Division Secretariat. After a lifetime looking after the more practical side of theory, Tatiana left CERN in March. Seen here with present and former colleagues at a memorable party are (standing, left to right) Jeanne Rostant, Helga Schmal, Maud Johr, Gisela Maus, Tatiana, Sheila Navach, Nanie Renault, Oksana Bilenky, and seated, Marie-Noëlle Fontaine. Visible in the background is distinguished theorist Martinus Veltman, and less visible, hidden behind Tatiana, is Suzy Vascotto.

(Photo G. Guichard)



Le PC dans un environnement industriel, c'est souvent un pur défi. S'il doit en être ainsi, intègrez le dans un boîtier Chasseleon. Ce robuste tiroir 19", qui existe également en boîtier de table, est la protection idéale de votre PC. De cette manière, la mécanique, l'électro-mécanique, et le câblage proviennent d'une même source. Il vous reste à intégrer vos disques et platines. Cela se fait en un tour de main. Il n'y a ni plus simple, ni plus sûr.

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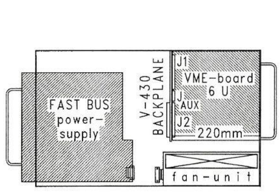
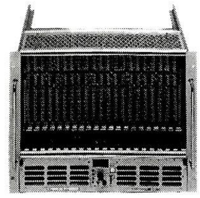
Output protection:	Global Trip-Off of all voltage within 5msec. at any bad status, overload, overvoltage, overheat, line error and switch-off mains. (Outputs discharged with crowbars).





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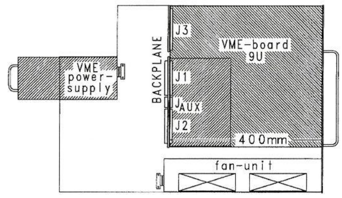
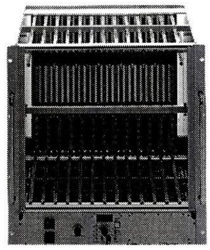
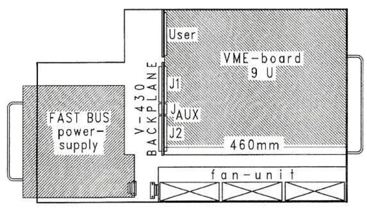
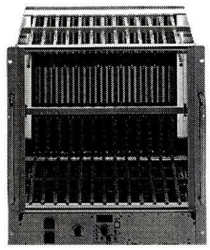


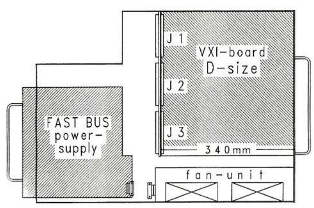


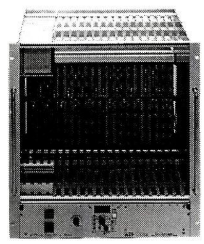
VMEbus-Crate / CERN-Spec. in process / **VME 64**





VMEbus-Crate with +5 V, -5,2 V, -2 V, +12 V, -12 V. Slot 1-4 for standard VMEbus-boards, slot 5-21 for big size 9U x 460 mm.





VXIbus-Crate with +5 V, -5,2 V, -2 V, +12 V, -12 V

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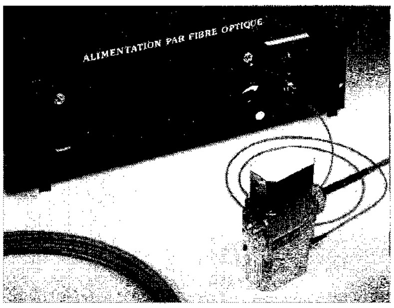

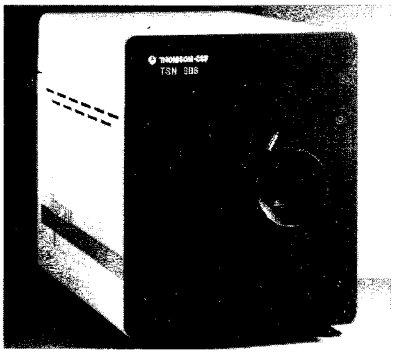

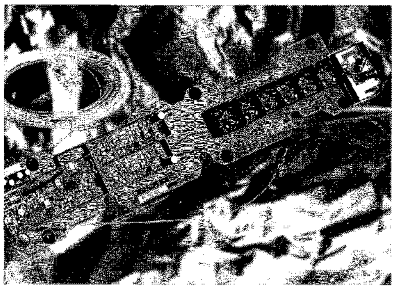

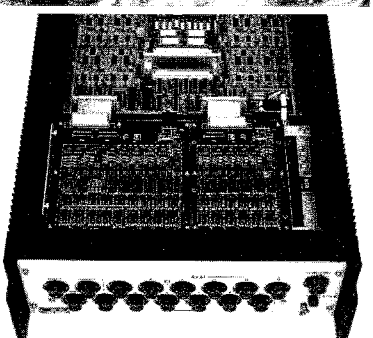

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