Munich conference

Don Perkins - Standard Model, triumph or frustration?

The Standard Model has survived mtact for another year/ declared Don Perkins of Oxford, summarizing the 24th International Conference on High Energy Physics held in Munich from 4-10 August. 'But is this a triumph or a frustration for physics?' he added.

The twin pillars of the Standard Model, the electroweak unification of electromagnetism and the weak nuclear force, and the field theory (quantum chromodynamics) of the quark-gluon interactions responsible for the strong nuclear force , have not trembled since the electroweak unification went to the textbooks in 1983, but from time to time small cracks have appeared which might have gone on to shake the theory severely, if not undermine it.

Major conference summarizers have got used to singing the praises of the Standard Model, but this year at Munich even detailed examination failed to reveal any serious cracks, while looking deeper into physics even some anomalous results hinting at gaps in understanding have either gone away or have diminished credibility.

Neutrinos

Given the job of summarizing 'non-accelerator' experiments, Yoji Totsuka of Tokyo had to cover a lot of material presented in the earlier parallel sessions. The enigmatic neutrino has long been the joker in the particle physics pack, but the latest crop of neutrino results shows it to be, at least by its own standards, remarkably well behaved.

Measurements of the mass of the electron-type neutrino, the lightest, are coming in from Moscow, Zurich, Los Alamos, Munich, Tokyo and Beijing. While most studies prefer to quote limits (as high as 30 and as low as 18 electronvolts), the Moscow (Institute for Theoretical and Experimental Physics) group underlines its longstanding positive result (26+6-5 eV). Perkins was pessimistic about the chances of any such experiment being able to rule out a neutrino mass below 10 eV.

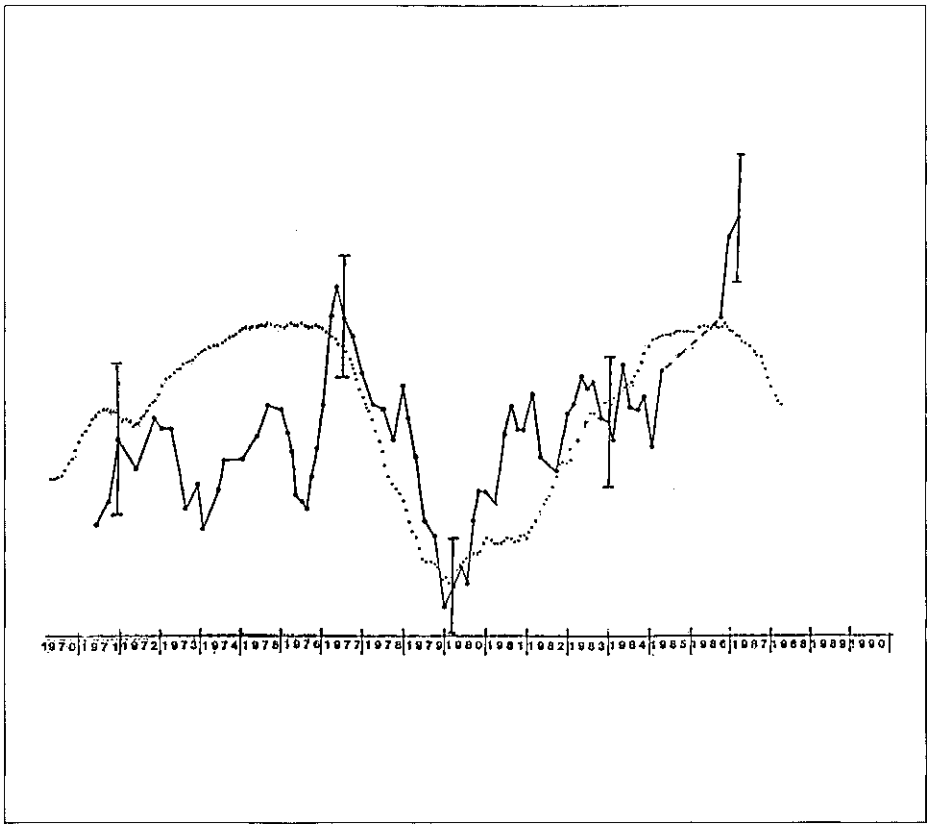
Other experiments show that the next neutrino, the muon-type, has to be lighter than about 285 keV, while the heaviest known neutrino, the tau, looks to weigh in at less than 35 MeV.

While the search goes on for double beta decay without any accompanying neutrinos, the past year has seen the sighting of a more conventional double beta decay (January/February issue, page 32). Elsewhere in the neutrino sector, evidence for 'oscillations' between different neutrino types has long been sought, using both terrestrial and extra terrestrial particles. At Munich, new evidence from the experiment at the French Bugey reactor now rules out oscillations, tying in with the negative results from other experiments at reactors and particle accelerators.

With extraterrestrial neutrinos, earlier this year the Japanese Kamioka experiment had announced a muon neutrino signal substantially less than expected (May issue, page 29), suggesting oscillation effects. However this is not confirmed by the Frejus experiment (France) or from preliminary results from the 1MB (USA) study.

Covered by Totsuka in both the

Is there any longer a problem with solar neutrinos ? For a long time, the only experiment monitoring neutrinos from the sun (led by R. Davis using a tank of chlorine-based absorber in a US mine) saw less particles than expected from confident estimates of solar neutrino activity. However a recent run (right) gives a sharply higher neutrino level, more in line with the predicted value. The dotted line shows sunspot activity - is the correlation superficial or is this a physics message ?.



plenary and parallel sessions was the 'solar neutrino problem'. An underground experiment led by Ray Davis of Brookhaven for a long time reported that the level of neutrinos reaching a detector from the sun was only a fraction of what is expected. However in a recent run, the level has increased to be almost compatible with expectations. In parallel, independent solar neutrino results have started to come in from Kamioka, which, according to Totsuka, are 'compatible' with the more recent Davis findings. In the meantime, a big push continues to prepare new solar neutrino detectors (see for example May 1987 issue, page 26) and additional results in this sector are eagerly awaited.

Several speakers pointed to suggestions that the measured level of solar neutrinos could tie in with sunspot activity.

Participants at the conference had been intrigued by press reports of a new force (the so-called 'fifth force'), suggesting that the pull of gravity might depend on the composition of a body as well as its overall mass. Totsuka also echoed the sentiments of C. Stubbs of Washington, one of the experimenters in this area, who pointed out the difficulties in reconciling results from different, and frequently highly ingeneous, experiments, concluding that 'no reasonable phenomenological picture can account for all the data,' and that although there was 'no compelling evidence for new physics', there was still some room left to manoeuvre before a null result could be concluded.

Heavy quarks

The present picture of particle physics is based on three families of quark doublets - 'up' and 'down', 'strange' and 'charm', and 'beauty' (or 'bottom', b) and 'top' (t). All these quarks ere known and now well studied, with the exception of top, but even here a series of limit have been charted fixing where it will turn up.

The most reliable limit comes from the level of hadronic (strongly interacting) particles seen in electron-positron annihilations. The world's highest energy fully operational electron-positron collider is TRISTAN at the Japanese KEK Laboratory. Here the collision energy has gradually been nudged upwards since the machine turned on in November 1986. At Munich, plenary speaker Tsuneyoshi Kamae of Tokyo showed how the hadron level shows no unexpected rise at the collision energies reached so far (up to about 28 GeV per beam), although the data points push tantalizingly close to the allowed limit if the top threshold has not been reached.

Another handle on top production comes from the detailed shape analysis of the 'jets' of produced hadrons, showing that TRISTAN is still in territory inhabited only by five sorts of quark. Next top limit (41 GeV) comes from the UA1 detector at CERN's proton-antiproton collider, followed by about 60 GeV from the observed 'mixing' of electrically neutral B mesons (containing b quarks). After an initial report on this mixing from UA1 in 1986, more information came last year from the ARGUS experiment using the DORIS ring at the German DESY Laboratory in Hamburg. The level of neutral B mixing looked to

At the opening of the plenary sessions of the International Conference on High Energy Physics in Munich on 8 August. Left to right, Organizing Committee Chairman G. Buschhorn, Bavarian State Government Minister for Science and Culture W. Wild, CERN Director General Herwig Schopper and CERN Council President J. Rembser.

(Photos Uni Munchen P.M. Schmidt)

be surprisingly large. At Munich, this result was confirmed by the CLEO group working at Cornell's CESR electron-positron collider. The mixing of the neutral B mesons is indeed huge/ commented Henning Schroder of DESY, in his report on the spectroscopy and decays of heavy quarks.

An upper limit for the mass of articles containing the top quark comes from comparison of Standard Model parameters coming from different approaches. The particles have to be lighter than about 250 GeV, and with some hopeful assumptions the limit can be clawed down to 180 GeV.

This means that top particles could be within reach of the proton-antiproton colliders at CERN and Fermilab. The latter has higher collision energy on its side (1800 GeV compared with CERN's routine 630 GeV), but CERN is pushing hard to boost the collision rate (luminosity). 'We could find top by next year, lei: alone the next Rochester Conference, commented Perkins.

The impressive results from proton-antiproton collision physics at CERN and Fermilab were summarized at Munich by Melvin Shochet of Chicago, staying close to the findings of the recent proton-antiproton physics workshop at Fermilab (September issue page 4).

Besides the top quark, the other missing ingredient of the Standard Model is the 'Higgs' mechanism responsible for the delicate symmetry breaking driving the electroweak unification. 'The Higgs is the most arbitrary part of the Model,' said Standard Model summarizer Paul Langacker of DESY. 'The only thing that can be said with complete certainty is that the mass of the Higgs particle, if it exists, must be between zero and infinity!' Undeterred, he looked at what a few assumptions could do for predictions in this sector.

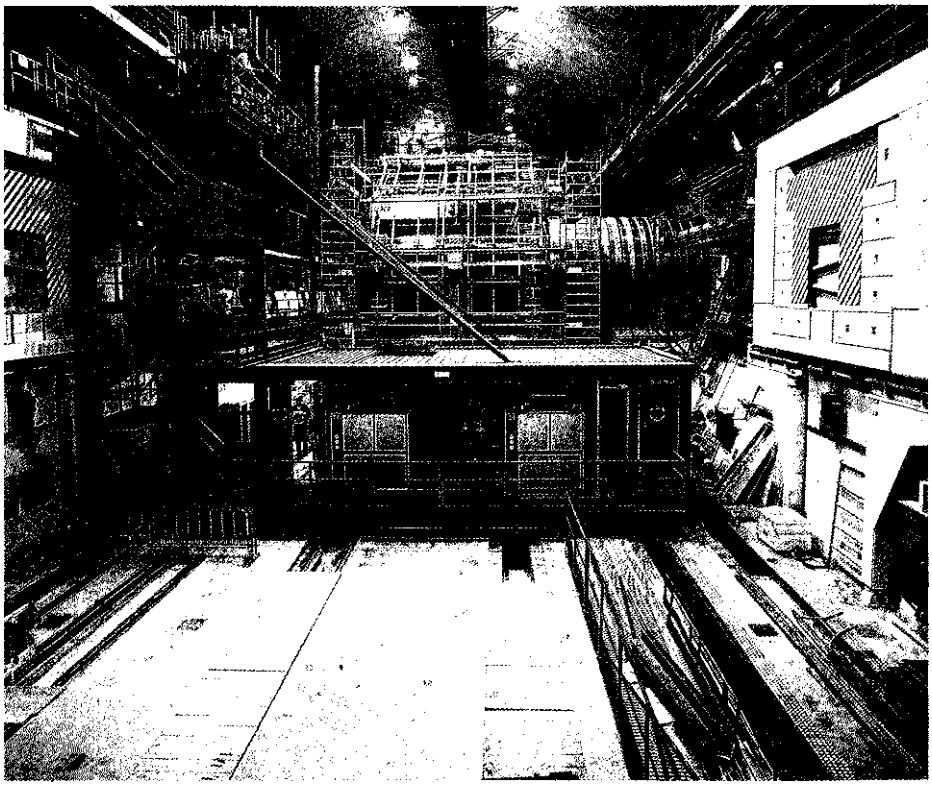
Putting undiscovered particles aside, Schroder underlined the importance of measurements on particles containing the b quark. Over twenty years ago, it was discovered that electrically neutral kaons have no respect for the classical invariance principle of particle/antiparticle permutation combined with left/right reversal. This 'CP violation' is still not understood, but can be accommodated into a six quark model. For this Cabibbo/Kobayashi/Maskawa scheme to be right, B particles (containing the b quark) should be able to decay into particles containing lighter quarks without passing through an intermediate stage involving charm quarks.

Last year, the ARGUS experiment reported such 'charmless' B decay, (September 1987, page 4) but the level of the signal surprised many specialists. After a further report from ARGUS in a Munich parallel session underlining their earlier findings, David Kreinick of Cornell described a 'diligent' search at the CLEO detector at CESR which failed to find any evidence for charmless B transitions - 'clear disagreement'. In his plenary talk, Schroder called for more data to resolve this 'discrepancy', looking particularly for simpler B decays more easily interpreted theoretically.

In his talk on CP violation and related matters, Konrad Kleinknecht of Mainz stressed the need to find charmless B decays, pointing out also that the long-awaited top quark should also decay predominantly into the b variety. He presented the latest CP violation results from the NA31 experiment at CERN (July/August issue, page 7). Earlier Hitoshi Yamamoto of Fermilab had sketched the Fermilab

At Munich, CERN Research Director John Thresher covered the impressive progress being made at CERN for the 27 kilometre LEP electron-positron collider and its four big experiments. Here the Aleph detector starts to take shape 150 metres below ground. In front and on either side of the assembly is the shielding where the LEP beams will enter the detector.

(Photo CERN 210.6.88)



E731 experiment also aiming for a precision fix on CP violation. After a substantial period of data-taking, initial results could emerge before the end of the year.

Plenary speaker Roland Windmolders of CERN, echoing what emerged from the parallel sessions, reported on the latest measurements from CERN, Fermilab and Stanford of the distributions of quarks and gluons inside nucleons (structure functions). While many results from different experiments appear to converge, certain structure functions measured at CERN using muon beams by the European Muon Collaboration (EMC) and the Bologna/CERN/Dubna/Munich/Saclay group do not agree. This makes problems for calculations using these structure functions as input. Ongoing studies at CERN and Fermilab could help resolve the problem, but Perkins remarked 'it is a shame that after ten years of work there are such clear discrepancies'.

Debuting at a big conference was the EMC measurement showing that between them the constituent quarks of the proton appear to carry almost none of the particle's intrinsic spin angular momentum (June issue, page 9).

Structure functions provide input to quark calculations, summarized by Keith Ellis of Fermilab. While bemoaning the disagreement between structure function measurements, Ellis was able to summarize 'a bumper year' of calculations which help to explain many of the details of particle production. One outstanding problem was to explain the EMC quark spin result.

Additional high energy input is coming in from the production of hadron jets at TRISTAN, throwing further light on the way produced quarks and gluons materialize as hadrons. Earlier Steve Olson of the AMY experiment at TRISTAN had drawn attention to 'dramatic' effects in the distribution of the leading particles in jets produced by gluons.

If enough energy is available, the quarks and gluons locked inside nucleons should eventually fuse into a quark-gluon plasma. Seeing hints of this plasma is one of the aims of the experiments at CERN and Brookhaven using high energy nuclear beams. Louis Kluberg of the Ecole Polytechnique, Paris, surveyed the results so far and the attempts to unravel possible quark-gluon plasma signals.

Machines

Introducing the Munich plenary sessions, CERN Council President J. Rembser sketched the world scenario of major machine projects, calling for a maximum of international collaboration. In special sessions, John Thresher of CERN described the impressive progress being made with the 27 kilometre LEP electron-positron collider, and its four big experiments, with a positron beam having been steered round the first completed octant of the ring (September issue, page 7). LEP is well on course for first colliding beams next summer.

After LEP, it was the turn of Bjorn Wiik of DESY to cover the status of the HERA electron-proton collider. Injection into the completed electron ring was imminent (see page 20), and the first octant of the 6.3 kilometre superconducting proton ring is scheduled for testing next spring en route to first colliding beams in October 1990.

***The Dr. B. Struck company*^ has extended its range of available VMEbus products by some very interesting modules. These include intelligent FADC readout systems using Digital Signal Processors as well as simple level converters.**

STR730 FDDP Fast Digital Data Processor

The STR730 System (INFN Torino) serves as a fast read-in and processing system for analog data. The VME-module STR730/DSP consists of the VME-interface and two identical logical units with a fast Digital Signal Processor (DSP) TMS32010 and 4 Kbyte program memory in each of these.

The DSP can read and process the data from a piggyback analog input card to perform e.g. programmable trigger decisions or on-line data reduction. The results are stored in a 512-word FIFO memory which an be read either through a front panel connector or the VMEbus. Additional FIFOs enable the exchange of data between adjacent logical units.

The piggyback input card STR730/AN1 comprises eight FADCs with 8 bit resolution (linear), 50 Ohms input impedance, 10 mV/LSB sensitivity and 200 ns conversion time. 4 channel FADC boards with 256 byte memory per channel and charge integrating ADC boards are under development.

DL400 Modular VME Front-End System

The DL400 system (Univ. of Heidelberg) is suited for applications where FADC sampling rates up to 100 MHz are necessary. The base module DL400 contains the whole VMEbus interface.

The DL401. submodule is a piggyback board which is placed onto the base module. It contains 4 Flash-ADCs with 8 it resolution. If a larger dynamic range is required, it is possible to run the FADCs in a nonlinear mode with an effective dynamic range of 10 bits. The maximum sampling rate is 100 MHz, controlled by the trigger input. For each FADC a fast 1024 byte memory will serve as intermediate storage. The data of the four memories can be read as one 32-bit word via the VMEbus to enable fast read-out of the data.

The DL403 submodule will generate all the necessary timing and control signals for the DL401 modules. The DL403 supports both, the common start mode and the common stop mode.

A Time-to-Digital converter DL404 is now available for the DL400 system. It has 16 analog inputs with programmable discriminator thresholds. The conversion is digital and the resolution is defined by the clock frequency (10 ns minimum). Different operating modes include multi-hit and multi-event capability. Depending on the operating mode the time range is 41|i s to 10.5 ms at maximum clock frequency.

DL410USBM

The DL410 ultra high speed buffer memory (USBM) submodule can record fast digital data. It has two 10-bit input channels with differential ECL input and a maximum input rate of 100 MHz per channel. Each of the two channels has a memory of 128 Kwords.

Its specific application is to record data from an external transient recorder (TEKTRONIX type RTD710, 10 bit, 200 MHz) and make it available to the VMEbus.

STR721 VSC

Tne VME module STR721 (UPL) is a scaler/counter with 32 16-bit channels or 16 32-bit channels. It contains 8 of the versatile AM9513A system timing controller chips on a single VME board. Four inputs of each chip are connected to the P2 connector via a signal conditioning circuit. The fifth counter in each chip may use the onboard crystal oscillator to provide gating signals for the other counters.

The main feature of the board is the facility to provide a number of different input conditioning options. This is achieved by the general purpose input configuration area. Two basic options are available: TIL or ECL inputs, either of them can be configured as single-ended or differential inputs. The ECL version can also be modified to give single ended NIM-level inputs. The input impedance and bias voltage can be matched to the requirements. An RC pulse stretching circuit is provided after the input buffers to allow counting of narrow pulses down to 10 ns at rates in excess of 6 MHz.

STR712 VIP Processor board

The STR712 VIP processor module (K. Honscheid) gives excellent performance for a reasonable price. It consists of an MC68010 processor with up to 768 Kbyte of static dual-port RAM, up to 256 Kbyte EPROM, two RS-232C interfaces and an Ethernet or Cheapernet interface. Simple interface boards can be used between the internal bus of the VIP board and the P2 connector to give different functions: A CAMAC branch interface (STR722) to drive up to seven CAMAC crates and an interface to the DL300 FADC system are available.

Another application is an add-on EEPROM card developed at CERN to store system parameters of the OS-9 operating system. A special OS-9 device handler simulates virtual floppy disks on a VAX or PC host, which is connected to the VIP via Cheapernet.

STR711 VME-TAXI Crate Interconnect

The STR711 VME-TAXI (E. Pietarinen) utilizes the TAXIchip (TM) set of AMD for fast data exchange between VME crates. The connection between the crates is done by coaxial cables (few meters), fibre optic links (up to 1 km) or monomode fibres with laser transmitters (up to 10 km). Each module has two input and two output links. A high performance MC68020 processor takes care of the communication protocol and a special hardware allows a continuous transfer rate up to 12.5 Mbyte/s between the fibre optic media and the VMEbus. The module is also useful as a general purpose processor for other data acquisition tasks.

The module contains 128 Kbyte of static dual port RAM (expandable to 1 Mbyte) for use as buffer and program memory and two RS-232C interfaces. It has a full 32-bit VMEbus as well as a VSB connection.

Block transfer between crates is very fast because only local flow control is necessary inside the crate. It is also possible to use the module in transparent mode to address any VME module in a distant crate. But because one cannot profit from pipelining in this mode the resulting speed is not as spectacular as it is for block transfer.

STR723 Differential VSB Extension

This is a small adapter board, which is plugged into the rear of a VSB backplane (GSI Darmstadt). It converts the VSB signals into differential signals to extend the VSB-bus over long distances up to 50 m.

One application at the GSI is to connect the VSB to an Aleph Event Builder. The interface on the FASTBUS side is connected to the Event Builder like an Event Memory. The interface has a maximum of 4 Mbyte static RAM which can be accessed independently from the AEB and the VSB. It contains several registers to enable and set interrupts on both ports and to control the data channels.

STR79x NIM Logic on VME boards

Very often there is the need for some NIM-level "glue logic" to build simple circuits. If one does not need a whole NIM crate and there is some spare room in a VME crate, Dr. B. Struck now offers an interesting alternative: NIM logic on VME boards. No connection to the VMEbus is made except for the power supply lines. The -5V supply is generated internally by a DC-DC converter. Following modules are available soon:

STR791 Fast AND, 8 AND gates with 2 inputs and 2 outputs each;

STR792 Fast OR, 8 OR gates with 2 inputs and 2 outputs each;

STR793 AND/OR-Unit, 4 AND gates and 4 OR gates with 2 inputs and 2 outputs each;

STR794 Fast FAN-OUT, 4 times 4-fold FAN-OUT, input via 1,2 or 4 inputs;

STR795 Fast FAN-OUT including inverting output, like STR794 but one additional mverting output for each of the 4 groups;

STR79616 channel TTL/NIM level converter;

STR797 NIM to differential ECL level converter.

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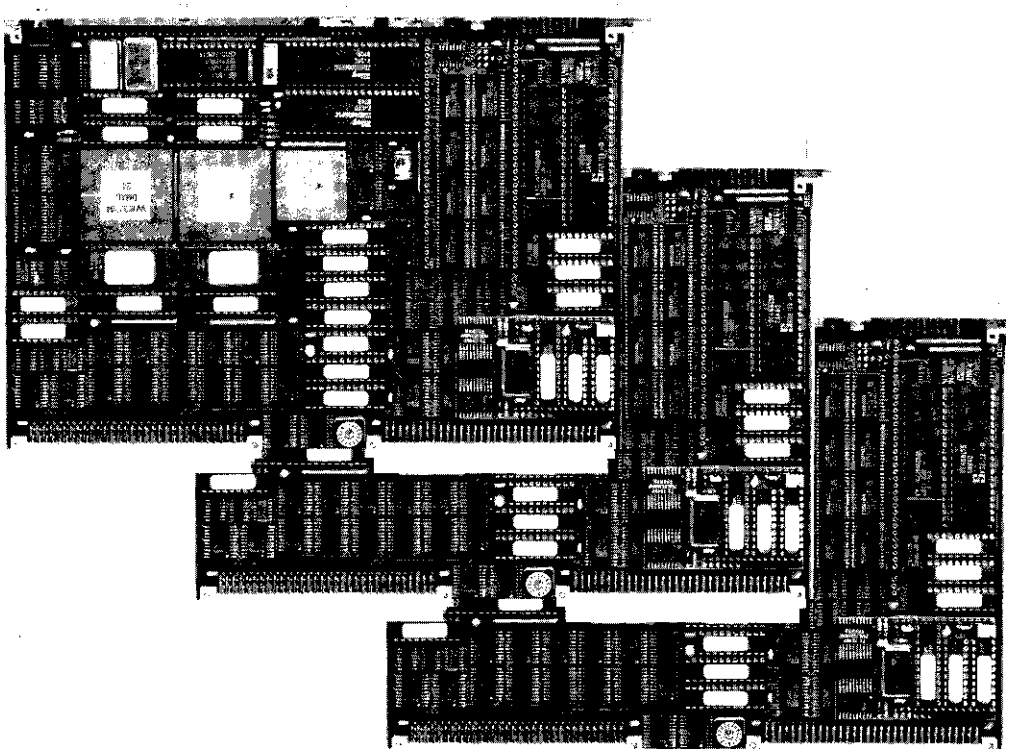

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CREATIVE ELECTRONIC SYSTEMS

Burt Richter of Stanford surveyed future colliders. Turning first to proton machines, Richter pointed out the progress being made at Serpukhov, USSR, for the UNK proton accelerator and collider, while the giant SSC Superconducting Supercollider in the US and the LHC scheme at CERN using the LEP tunnel were a step further in the future.

The published Munich schedule had included a slot for the new SLC Stanford Linear Collider now being commissioned. This slot was finally cancelled, but Richter claimed that as a 'proof of principle' the SLC had worked, although severe reliability problems in the veteran two-mile linac supplying the beams had prevented the SLC project from getting anywhere near its goal of manufacturing one Z particle (the carrier of the electrically neutral component of the weak nuclear force) per day.

Theory

With quark field theory calculations now a minor industry, Roberto Petronzio of Rome outlined the results coming in from lattice calculations using powerful computers. This work is beginning to provide important additional input, while encouraging initial progress is being made in analytical lattice approaches dispensing with the computers.

J. Frohlich of Zurich looked at the invasion of geometrical and topological ideas which aim at liberating field theory from the bondage of a series perturbation approach, not necessarily convergent. With superstrings being touted as the best bet for unified physics, David Gross of Princeton looked at the problems and the possibilities. These unifications of the forces of physics look like happening only at extreme energies, and Andrei Linde of Moscow believed that the cosmological mechanics of the Universe provided the only hope for seeing these effects. Exploiting the effects of cosmological 'inflation', Linde had some bad news for the fate of the Universe ('Is Mankind doomed to die inside a black hole?'), but the timescale (about ten to the power a thousand times the present age of the Universe) gave no cause for immediate concern.

A bit closer to home, Lawrence Hall of Berkeley looked at physics 'just beyond' the Standard Model as experiments begin to attack the TeV (1000 GeV) region, where one hope is to finally see hints of the long-awaited Higgs sector.

With no physics coming in from the SLC Stanford Linear Collider, the slot originally allotted to SLC in the Munich programme was taken over by Yoshio Yamaguchi, Chairman of the International Committee for Future Accelerators (ICFA), who outlined ICFA's current commitments (see September issue, page 14).

Organizing jumbo-sized conferences demands hard work and meticulous attention to detail. Perkins echoed the sentiments of all the participants when he thanked the Munich organizers, particularly Gerd Buschhorn and Klaus Pretzl of Munich's Max Planck Institute for Physics and Astrophysics, respectively Chairman and Secretary of the Organizing Committee, for their imaginative and unstinting work in making the event a success.

With so many arbitrary parameters, the Standard Model cannot be the last word in physics. With evidence for a deeper level of understanding reluctant to show up from laboratory experiments, Perkins looked forward eagerly to the next supernova, in the year 2003 ± 15!.

By Gordon Fraser

The Munich conference attracted exhibitors from industry.