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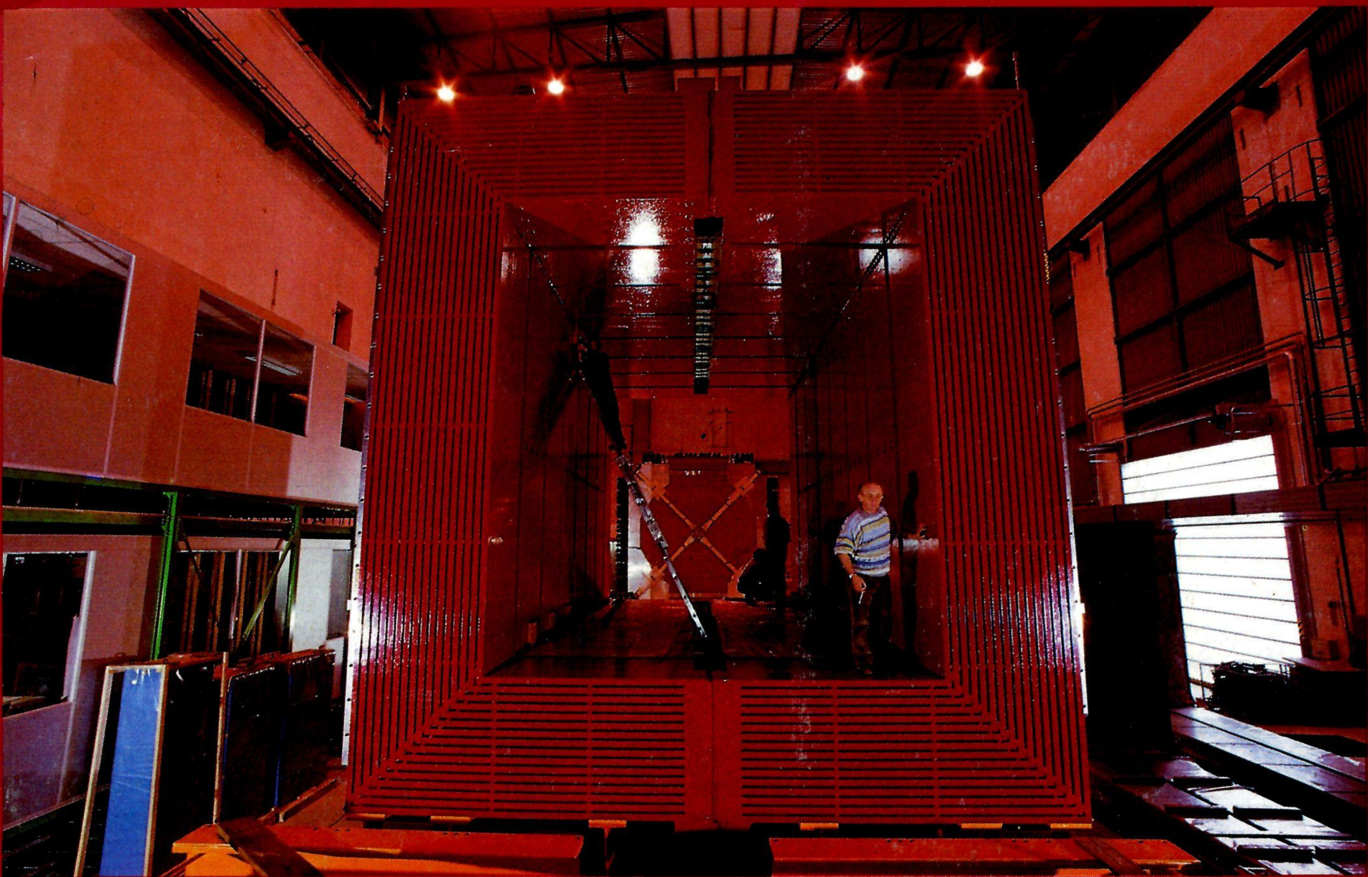

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Physics monitor

Around the Laboratories

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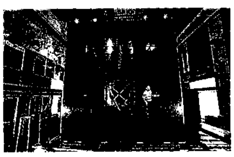

Cover photograph: Preparations for the next round of neutrino experiments at CERN's SPS synchrotron, viewed from downstream. In the foreground is the framework for the Nomad experiment, using the magnet from the famous UA1 experiment at CERN's proton antiproton collider. In the background (upstream) is the spectrometer magnet for the Chorus experiment.

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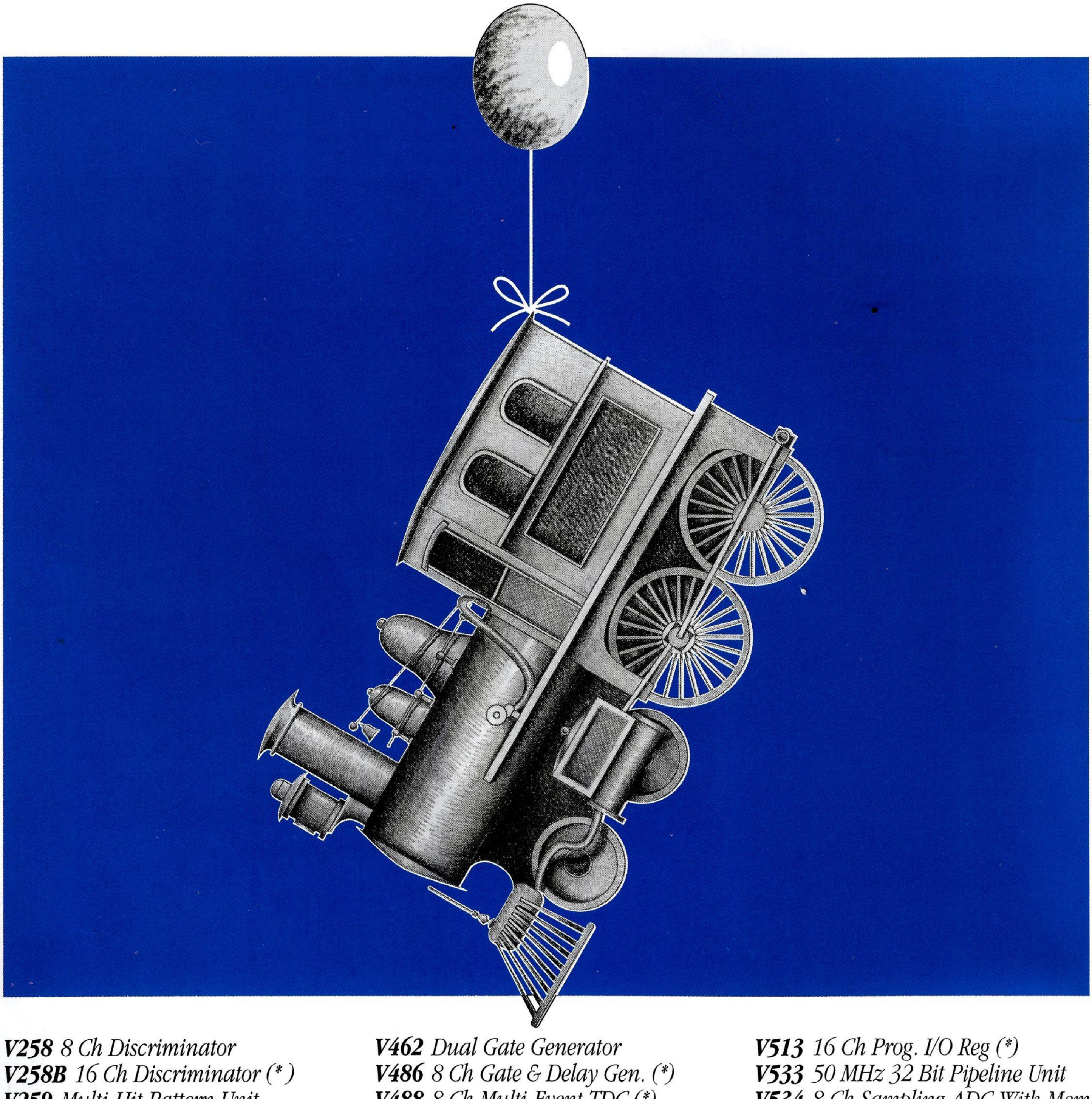

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Physics monitor

A decade of heavy light

Ten years ago, in May 1983, the UA1 experiment led by Carlo Rubbia at CERN's proton-antiproton collider saw the first Z particle, the heavy (91 GeV) electrically neutral carrier of the weak force. The press announced the discovery of 'heavy light', a highly apt description which has unfortunately fallen into disuse.

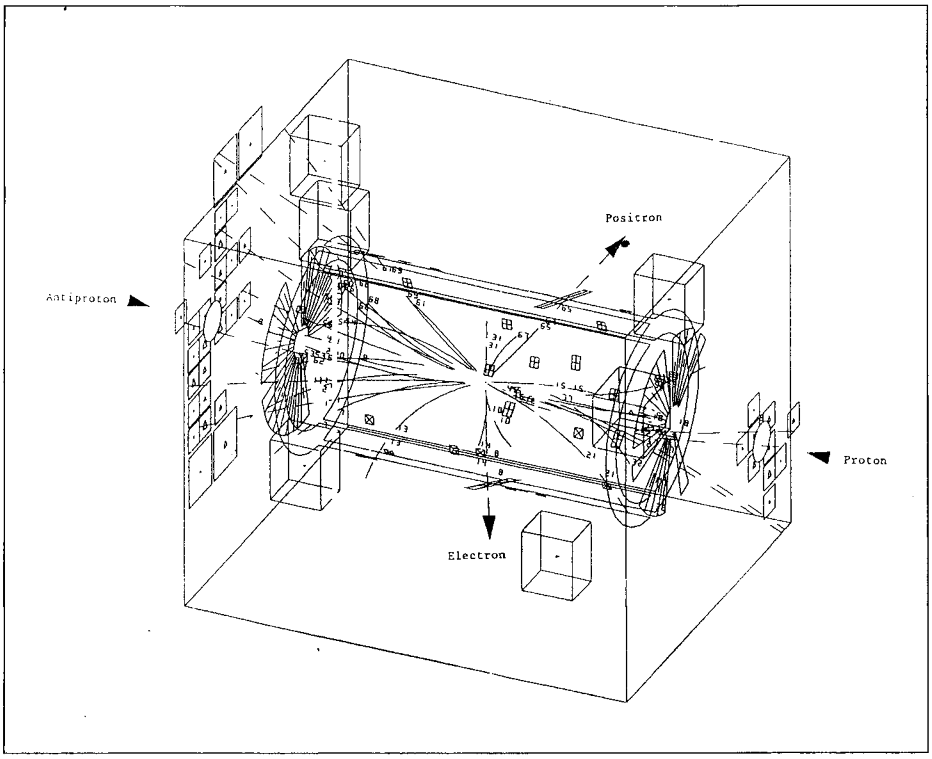
The weak force comes in two varieties - one which permutes electric charges (the classic example being the beta decay of a neutron into a proton and an electron), and a neutral variant which does not. Each has its carrier particle, and both were discovered at CERN - first the charged W, in January 1983, and then the Z, a few months later.

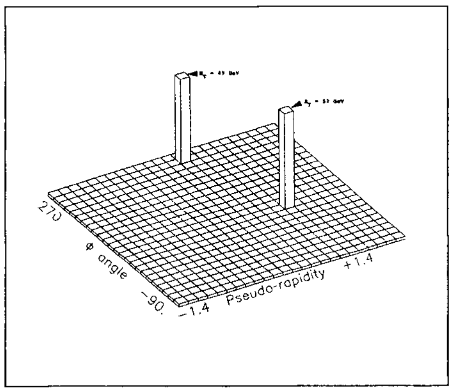
For both experiment and theory, the Z discovery was the culmination of a long and diligent quest without parallel in the history of modern physics. The missing piece of the 'electroweak' jigsaw finally clicked into place, and for ever after electromagnetism would be firmly linked with the weak nuclear force.

It was the twentieth-century remake, with a much bigger cast, of the story which began in 1864 when James Clerk Maxwell wrote down his four famous equations linking electricity and magnetism. This was the birth of a new science - electromagnetism.

But Maxwell's equations suggested also that electromagnetic effects could be transmitted as waves travelling at the speed of light. As well as light itself, a complete spectrum of wavelengths should exist. Ten years later Heinrich Hertz' famous experiment revealed a new, invisible, component of electromagnetic radiation.

Forerunner of millions to come. The first-ever Z decay, as seen by the UA1 detector at CERN's proton-antiproton collider in May 1983. Top, an high energy electron-positron pair, produced by the decay of a Z particle, emerges from the collision debris. Below, the clean 'lego plot' of the electron-positron pair.



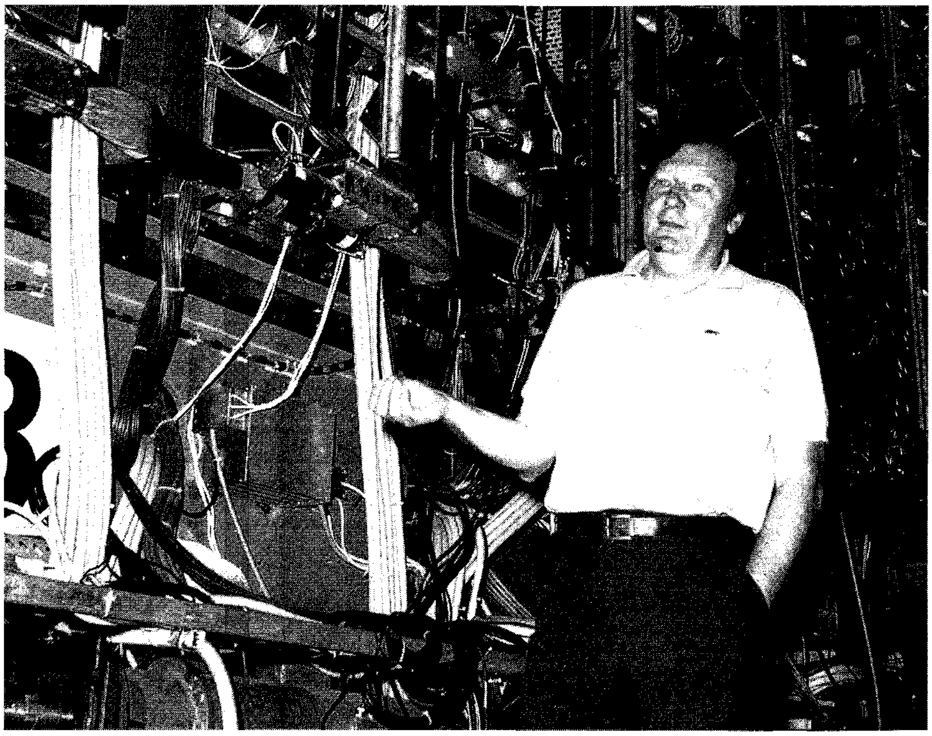


Extending Maxwell's electromagnetic unification (in quantum terms the emission and absorption of photons), the gauge theory ideas of twentieth century physics culminated in the 1960s in the work by Sheldon Glashow, Abdus Salam and Steven Weinberg which unified electromagnetism with the weak force. This idea had first been proposed in the 1930s and had regularly resurfaced, but a successful conclusion had to wait until all the necessary techniques were firmly in place.

Until then, all weak interactions were seen to switch round electric charge, but the Glashow/Salam/Weinberg picture predicted a new aspect to the weak force, the 'neutral current'. In 1973 - exactly twenty years ago (page 4) - this previously unseen mechanism was found at CERN. Neutrinos passing through the Gargamelle bubble chamber had jolted other particles in their wake.

The Uncertainty Principle says that the range of a force is inversely proportional to the mass of its carrier particle. The photon, the carrier of the long range electromagnetic force, is massless, but the W and Z 'radiation' of the short range weak force, had to be heavy, so much so that they were out of reach of conven-

A constant driving force in CERN's antiproton project, from inception through scientific discoveries, was Carlo Rubbia, seen here at his historic1983 stamping ground at the UA1 detector. In 1989 he became CERN's Director General.



tional experiments. New techniques were needed, and the CERN proton-antiproton collider, with its huge detectors was the solution.

A special session of the European Physical Society's International Conference on High Energy Physics in Geneva in 1979 marked CERN's 25th anniversary. Describing CERN science, CERN's Research Director-General at the time, Leon Van Hove, compared Hertz' discovery of electromagnetic radiation with what hundreds of people at CERN were busy doing.

'All you have to do,' joked Van Hove, 'is to replace Hertz' rudimentary radiation emitter and coil detector with, respectively, the proton-antiproton collider now being constructed at CERN's 7-kilometre SPS proton synchrotron and the huge UA1 and UA2 detectors!'

As well as embodying the difference between 19th-century and 20th-century science, that big CERN project also marked the dawn of a new era in particle physics. Building on Simon van der Meer's suggestions for beam cooling, it showed that the beam gymnastics required for new physics goals required careful planning and teamwork as well as consummate skill. Physics experiments broke new ground in sheer scale and complexity, with hundreds of people involved in the design, installation and operation of huge detectors and the analysis of the recorded data.

With Van Hove's challenge met, the 1984 Nobel Prize for Physics was awarded to Carlo Rubbia and Simon van der Meer 'for their decisive contributions to the large project which led to the discovery of the field particles W and Z, the carriers of the weak interaction'.

As well as being crowned with success, the proton-antiproton achievements also prepared the research community for the next stage - colliding beam projects with even larger detectors, such as those for CERN's LEP electron-positron collider.

From May 1983 to June 1989, high energy proton-antiproton colliders were the only source of Zs. Fermilab joined the hunt in 1985, when the big CDF experiment captured its first events at the Tevatron collider.

Meanwhile big new projects were taking shape. To cash in on electroweak physics, CERN was building its 27-kilometre LEP electron-positron collider, the world's first Z factory, while at Stanford the two-mile linear accelerator was adapted to become the SLC - Stanford Linear Collider - the world's first electron-positron linear collider.

In the summer of 1989 the upgraded Mark II detector at SLC saw several hundred Zs, a large number when the total count at the two proton-antiproton colliders at the time was less than a thousand. Rather than simply catching Zs, an electron-positron collider can be tuned to sweep across the Z resonance. The first glimpse of the Z profile at SLC suggested strongly that there are only three neutrino decay channels open for the Z. With its three quark pairs and three types of lepton, the Standard Model looked to be capped.

Later that summer LEP turned on, and before the end of the year its four experiments - Aleph, Delphi, L3 and Opal - had bagged some ten thousand Zs. The lid was sealed on Standard Model particles. Since then LEP has not looked back, with the current Z score 4.5 million.

Although out of the running for sheer numbers of Zs, the SLC has the so far unique ability to make Zs from polarized (spin oriented) beams,

providing added value to the data sample.

Z physics has come a long way since May 1983.

Thirty Years of Weak Neutral Currents!

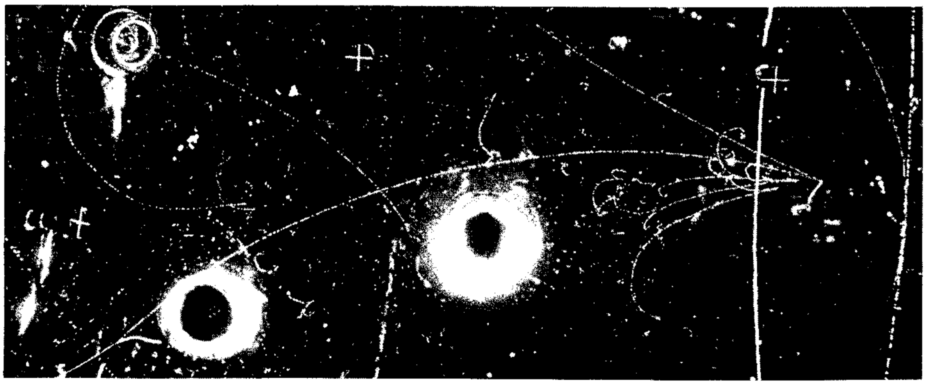
Twenty years ago at CERN, a new form of interaction, the neutral current, was discovered. However for the preceding ten years physicists already had been searching for variants of this interaction, so a symposium held on February 3-5 by the Pacific Ocean in Santa Monica, California reviewed a total of thirty years of neutral current research.

The meeting began with an overview of the development of the understanding of weak interactions from the 1930s to 1950s. Laurie Brown (Northwestern) led this discussion, which was followed by a tribute to the milestone accomplishments of the late Ben Lee and J.J. Sakurai (UCLA).

In the Weak Neutral Currents (WNC) discovery, neutrinos were seen to interact with target particles but still continued on their way as neutrinos. This was the first time that the weak interaction had revealed a disdain for electric charge - previously all weak interactions had been seen to permute the electric charges of the participating particles. It opened the door to new synthesis and un understanding.

The discovery had followed a decade of careful search, in which one major target had been Flavor Changing Weak Neutral Currents (FCWNC) - in which neutral current interactions would be accompanied by transitions of the strange quark. David Cline (UCLA) looked at the initial unsuccessful attempts to detect WNC at Brookhaven and CERN in the 1960s and the early search for FCWNC.

Ten years of searching preceded the discovery of the neutral current at CERN in 1973.



The absence of strange quark transitions set the stage for the introduction of a fourth quark ('charm') - the GIM mechanism - and the subsequent emergence of the Standard Model.

The era of the WNC discovery in 1973 was described by science historian Peter Galison (Harvard). Dieter Haidt (DESY) represented the Gargamelle Collaboration at CERN credited with the discovery, while Al Mann (Penn), representing the Harvard-Penn-Wisconsin-Fermilab (HPWF) collaboration, put the observations in the context of Fermilab's appearance on the physics scene, with a new detector in an unexplored neutrino energy range.

Lively discussion between the audience and members of the Gargamelle and HPWF groups recalled the experiences of 1973. Paul Langacker (Penn) gave an overview - "The Five Phases of Weak Neutral Currents."

Sid Bludman (Penn) described the first gauge theory of weak interactions as well as the success of the Weinberg-Salam-Glashow model. Nicola Cabibbo (Rome) described the early days of quark mixing, recounting how he came to invent the first quark mixing theory. His talk was followed by George Snow (Maryland) recounting early data from hyperon decays and the then new Cabibbo model.

In 1974 came a seminal paper on charm by Ben Lee, Marie K. Gaillard and Jon Rosner. Two of the authors were at Santa Monica: Marie Gaillard (Berkeley) described a model of strong WW interactions, while Jon Rosner (Chicago) spoke on the current status of mass constraints on the sixth ('top') quark.

The meeting then changed direction to discuss the implications of neutral currents in astrophysics. David Schramm (Chicago) and James Wilson (Livermore) explained how supernovae explode, while George Fuller of San Diego looked at how supernova data can restrict electron-neutrino/tau neutrino mixing.

For the arrival on the scene of proton-antiproton colliders and the discovery of the W and Z particles at CERN by the team led by Carlo Rubbia, Andy Sessler (Berkeley) gave a beautiful review of the history of colliding beams concepts from invention (1957) to the idea of stochastic cooling by Simon Van der Meer (1968). A review and discussion of the development of the proton-antiproton colliders at Fermilab and CERN and the important discoveries at CERN was led by

David Cline - reviewing thirty years of neutral current research.

D. Cline. The discussion centred on why Fermilab failed to get the early collider programme started, thus failing to compete for the big discoveries, and the brilliant CERN accelerator team that made the proton-antiproton collider a reality.

An interlude was speculation on the role of neutral currents in a possible connection between the chirality (left-right handedness) of life. Dilip Kondepudi (Wake Forest) presented an interesting study of the mechanism by which a small symmetry breaking WNC interaction in the prebiotic period on earth could be amplified into the full chiral symmetry breaking observed in all life forms. Hangyo Wang (UCLA) showed new simulations on the same theme.

Carl Wieman (Colorado) surveyed the past and future of atomic physics parity violation measurements. These beautiful table-top experiments will soon provide new precision in this field.

Sandip Pakvasa (Hawaii) recalled the confusion and developments during the period 1974-1978 until the Standard Model was finally established. Robert Burman (Los Alamos) described neutral current studies with low energy neutrino beams and the observation of W/Z interference effects.

Turning to the future, Vernon Barger (Wisconsin) peered beyond the Standard Model, emphasizing the phenomenology of supersymmetry, and Mark Ito (Princeton) described past and future searches for new decay modes in K decays. Ahmed Ali (DESY) looked at the b quark sector and the observation of neutral B meson mixing by UA1 and ARGUS.

Participants enjoyed the informal discussion and informed recollections of an exciting period in particle physics, a period when small groups of scientists made major breakthroughs, a contrast when imminent experiments at the SSC and LHC will involve groups of 500 to 1000 people.

The proceedings of the meeting, published by American Institute of Physics, will be edited by D. Cline and A.K. Mann.

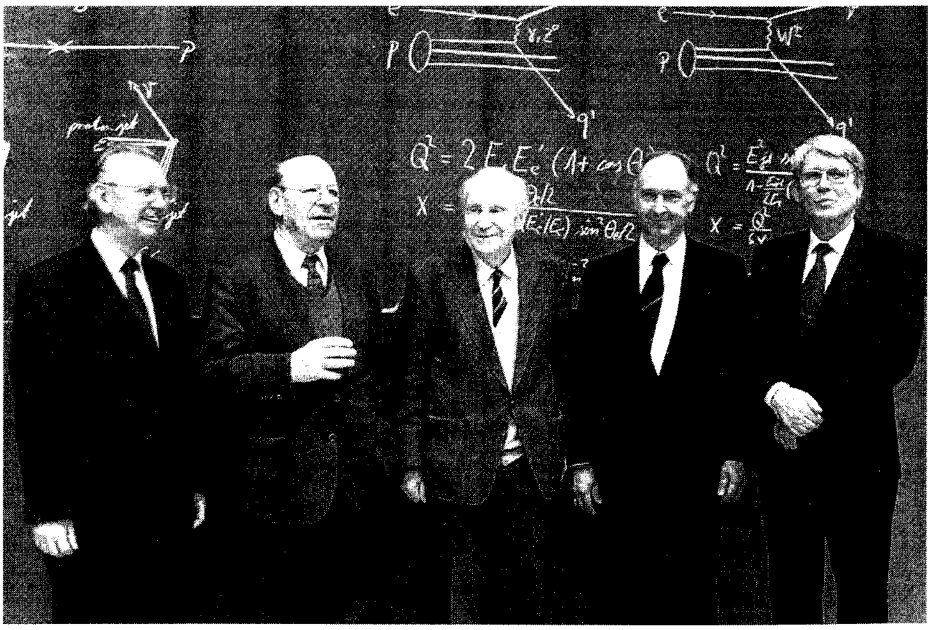
From David Cline (UCLA)

Twelve years at DESY

As reported in our previous issue (page 27), on 28 February Volker Soergel stepped down after serving as Chairman of the Board of the DESY Laboratory in Hamburg since January 1981, when the previous chairman, Herwig Schopper, moved to become Director General of CERN. DESY is now headed by Bjorn Wiik.

During the twelve years of Soergel's mandate, DESY substantially evolved and progressed. Dominating the landscape was the big HERA electron-proton collider - the world's first - proposed, approved, constructed and commissioned under Soergel's leadership. As well as pioneering electron-proton collisions, HERA also broke new ground in international collaboration. At the approval of the project by the German government, it had already been made clear that both the machine and its experiments had to be built with full international cooperation, using material contributions from foreign institutes. With the difficult task of transforming these require-

Historic picture by Pedro Waloschek of all the Chairmen of DESY's Board of Directors since the foundation of the Hamburg Laboratory in 1959. Left to right - Herwig Schopper (3rd), Wolfgang Paul (2nd), Willibald Jentschke (founding), Volker Soergel (retiring), Bjorn Wiik (current).



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 Circle advertisement number on reader service form ments into hard reality, Volker Soergel succeeded brilliantly. The 'HERA model', with interested countries pledging contributions in equipment and/or manpower, established a new route to major project involvement.

For HERA, the substantial Italian contribution, organized by Antonino Zichichi, was vital to the success of the project.

Attesting to the success of the HERA preparations, physics results from the big H1 and Zeus detectors were presented last year and the machine is rapidly approaching its design performance.

Away from HERA, the PETRA electron-positron collider continued to operate for physics until 1986, when it embarked on a new career as HERA injector. The observation of gluon jets and deep studies of quark/gluon field effects were PETRA's main physics claim to fame.

Electron Laboratories are inextricably linked with synchrotron radiation (SR) schemes. At DESY, the SR potential of the DORIS ring, in use since 1974, was extended with a new hall, inaugurated in 1981, a building added for X-ray angiography and medical research, another for molecular biology, and finally a new curved section on one side of the ring providing additional space for extracted beams. DESY now provides an impressive array of SR facilities.

Meanwhile the Argus experiment continued as the flagship of DORIS particle physics, providing many valuable results in heavy quark physics.

Away from physics, the Laboratory also played its part in German reunification. The Institute of High Energy Physics in Zeuthen, south of Berlin, formerly in East Germany, is now part of DESY, under an agreement between the Federal Government, the City of Hamburg and the 'Land' of Brandenburg.

Even before the iron curtain was drawn back, DESY in general and Volker Soergel in particular fostered good relations with Laboratories in Eastern Europe. While political obstacles have been removed, economic ones remain, and the tradition of cooperation with Eastern Europe will be maintained in this important transition period.

The Soergel era also saw closer ties with universities, where he cultivated a university-like atmosphere in the big Laboratory.

In these and many other issues, Soergel's pragmatic and direct approach was continually fruitful, as concurred by the scientists, politicians and DESY staff who took part in the retrospective event in his honour held at DESY on 25 February.

While he has returned to the University of Heidelberg, Volker Soergel remains in close contact with DESY as a member of the Laboratory's Scientific Council.

Around the Laboratories

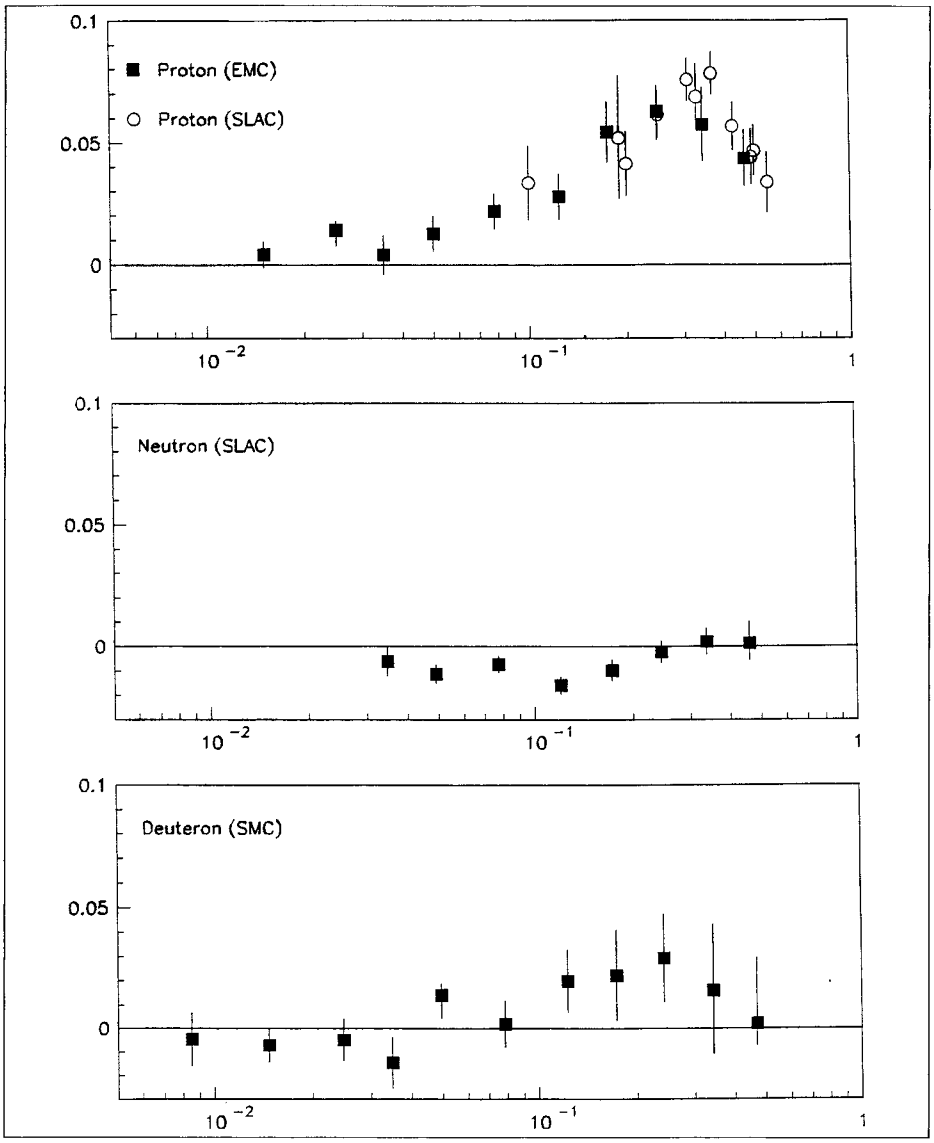
CERN/STANFORD
And now, what makes the neutron spin?

The annual Rencontres de Moriond in the French Alps traditionally provide a clothes line on which to hang interesting new physics results while they are still wet. This year's meeting, from March 20-27, saw exciting news on nucleon spin structure, with the Spin Muon Collaboration (SMC) from CERN and the E142 experiment from Stanford announcing results from data taken in 1992.

Both experiments were proposed shortly after the 1987 surprise from the European Muon Collaboration (EMC), when the combination of EMC and earlier Stanford (SLAC) data indicated that little of the proton spin is carried by valence quarks. Spin - the proton's main space-time quantum number - seemed to come mainly from the 'sea' of accompanying quarks and gluons.

The SMC and E142 experiments have investigated the spin structure of the neutron, and have tested for the first time the Bjorken sum rule. This is a fundamental prediction of quark-gluon field theory (quantum chromodynamics - QCD) which relates the difference between proton and neutron spin structure to well known coupling constants from neutron beta-decay.

At Moriond, SMC showed the spin structure of the deuteron from spin-oriented (polarized) muons probing deep inside polarized deuterons, over a wide kinematical range (x, the fraction of the nucleon momentum carried by quarks, running from 0.006



Spin structure function of the proton (top), neutron (centre) and deuteron (bottom) as measured in experiments at CERN (EMC, SMC) and at Stanford (SLAC).

to 0.6). SMC uses the CERN high energy (100-200 GeV) polarized muon beam with a polarized deuteron target made of two separate cells with opposite spin directions. Typical deuteron polarization was about 40%. The spin direction was reversed every eight hours to reduce systematic errors.

The SMC result shows that the contribution of quark spins to the deuteron (proton-neutron system) spin is small, and supports the original EMC proton spin findings. Using the proton data, the difference between the spin structures of the proton and the neutron is in good agreement with the prediction of the fundamental Bjorken sum rule. E142 used 19, 23 and 26 GeV polarized electron beams and a helium-3 target with a typical polarization of 40%. To a good approximation, this target can be considered as just polarized neutrons. In the x range 0.03 - 0.6, these data have an impressive accuracy due to high electron flux and 120 reversals/second of the beam spin direction. Combining the EMC proton data with its own neutron data, E142 observes a deviation (2 sigma) from the Bjorken sum rule, and attributes half the proton spin to quarks; results were still preliminary at Moriond.

These experiments with muon and electron beams have now probed the spin dependent structure function of the neutron over a broad kinematic range, providing reasonably complete data on the spin structure of the neutron. The SMC neutron data agree with the E142 data in the kinematic range where they overlap. A combined analysis of the two sets of experimental data is now eagerly waited. However the accuracy of the proton data must be improved before reaching firm conclusions. The origin of the proton and neutron spins remains a mystery.

SMC will improve its experimental precision by a factor of two by taking new data on the proton and the deuteron this year and next year. At SLAC, a new experiment - E143, will measure the proton and the deuteron spin structure next fall.

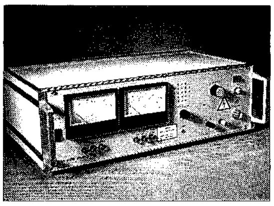
CERN Superhigh electromagnetic fields

Relativity can amplify the tiny electromagnetic fields inside crystals to gigantic proportions.

In a crystal, the regularly spaced rows of atoms act coherently. This behaviour is already well known through channeling. When an electron moreover moves very fast through a crystal, the coherent field it 'sees' is amplified by the relativistic (Lorentz) factor, giving such strong fields (10^{16} V/cm) that particle-antiparticle pairs can be created in the vacuum. Sparks begin to fly (literally) and the physics looks very different.

Normally slow moving particles are gently steered ('channeled') by the electromagnetic fields along crystal axes and planes, but when the channeled particles acquire relativistic energies, new processes become possible. For example 150 GeV electrons passing through a germanium crystal just a millimetre across can radiate 80 per cent of the total

Insulation test set ensures safety and reliability



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High performance 1.7kV converters feature less than 0.02% ripple

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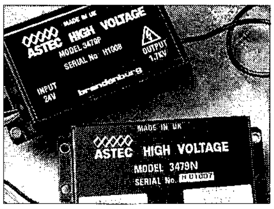
There are 30 different output current/voltage modules in this range, with 12V and 24V input. There are also positive or negative output polarity types, PCB mounting or fly-lead options. All weigh just 200g.



HV lab source now offers RS232

Intended primarily for precision research and development work, Brandenburg Alpha III bench power supplies provide up to 30kV at 1.5mA with very low ripple and a drift figure of less than 20ppm over 15 minutes.

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Positive or negative outputs are selectable, as are two operating modes providing either constant voltage or constant current. An optional interface allows computer control via an RS232 interface.

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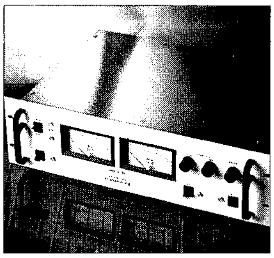

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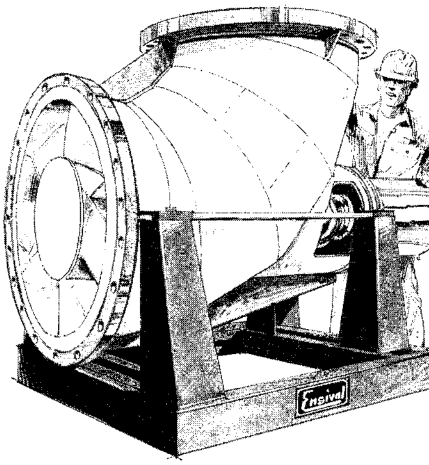

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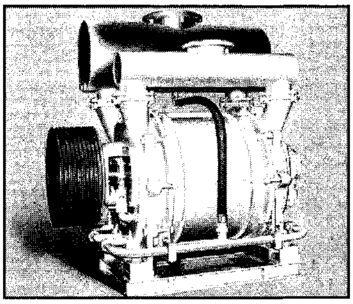

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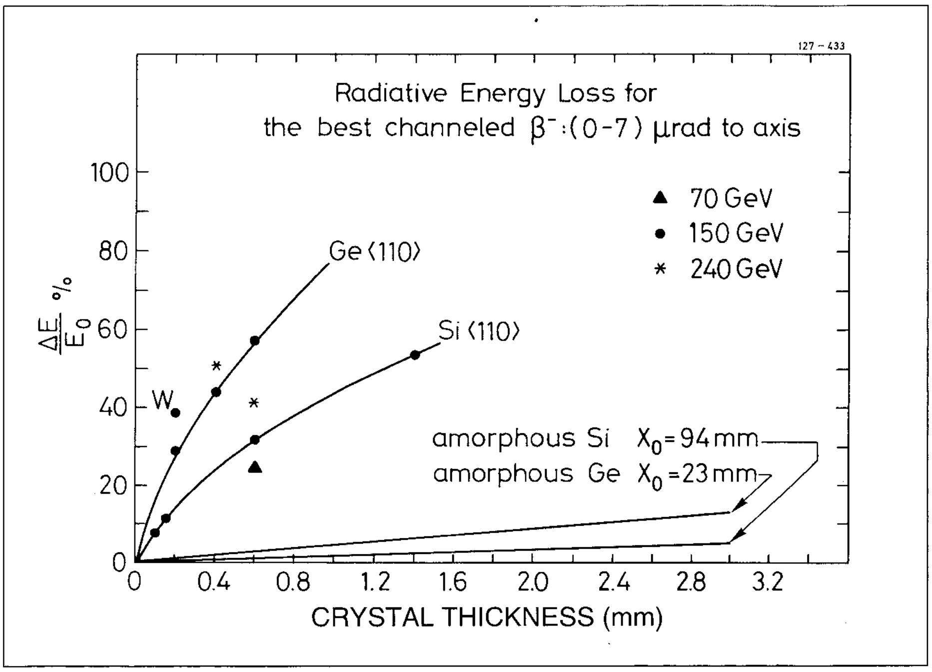

High energy electron beams passing through crystals can lose up to 80 per cent of their energy, producing characteristically 'hard' photon beams pointing along the direction of motion of the incident particle.

energy, producing characteristically 'hard' photon beams pointing along the direction of motion of the incident particle.

Conversely, the natural electron-positron pair production by photons is boosted by relativistic internal fields, making the photons lose energy faster, and reducing radiation lengths by factors of 20-50 along crystal directions.

V.N. Baier, V.M. Katkov and V.M. Strakhovenko of Novosibirsk, pioneer theorists in this field, say that these studies could demonstrate hitherto unobserved effects of an external field on fundamental quantum electrodynamics processes.

As well as making for interesting experiments, this opens up the possibility of lightweight calorimeters to pick up extraterrestrial gamma rays. With these effects very sensitive to direction, the radiation direction could be pinpointed to within a milliradian.

First results from new ISOLDE

Last year, CERN's ISOLDE on-line isotope separator, with a quarter of a century of history behind it, began a new lease of life in its new home at the Proton Synchrotron Booster (July 1992, page 5). Initial physics results are already emerging.

The first new ISOLDE Booster study, on nuclear beta decay, was extremely compact for a beamline experiment, occupying altogether less than one cubic metre! In the beta decay of marginally bound excited nucleons, the large spatial extent of their orbits should affect the decay rates.

At ISOLDE, the beta decay of neon-17 (10 protons) into the first excited state of fluorine-17 (9 protons) was compared to the well known mirror decay of nitrogen-17 (10 neutrons) into the same state of oxygen-17 (9 neutrons). In one of the largest beta-decay asymmetries ever seen, neon was found to decay about twice as fast as nitrogen. This suggests that the produced fluorine-17 is an oxygen-16 core with a remote 'halo' proton, and demonstrates the usefulness of beta decay for probing outlying nuclear structure.

A somewhat larger installation taking data last year was a laser spectroscopy experiment to investigate a wide range of properties, from charge radius to magnetic dipole moments, of very unstable isotopes. Hyperfine structure information comes from the resonances in atomic transitions induced by a tuned laser beam collinear with the ISOLDE beam.

First results covered the isotopes argon-32 to 35 and argon-45. These delicate beams required a new sensitive detection technique, based on selective ionization followed by radioactivity measurement.

Users are increasingly using the almost unlimited choice of ISOLDE beams to investigate very low concentrations of impurities in materials. Due to its considerable technological and economic importance, the major topic is impurity implantation in semiconductors, where the localized impurities essential for electronic functioning can also be responsible for semiconductor deterioration. A range of modern techniques, from lattice channelling to conversion electron spectroscopy, is used to examine the sites of implanted atoms, lattice defects and atomic motion.

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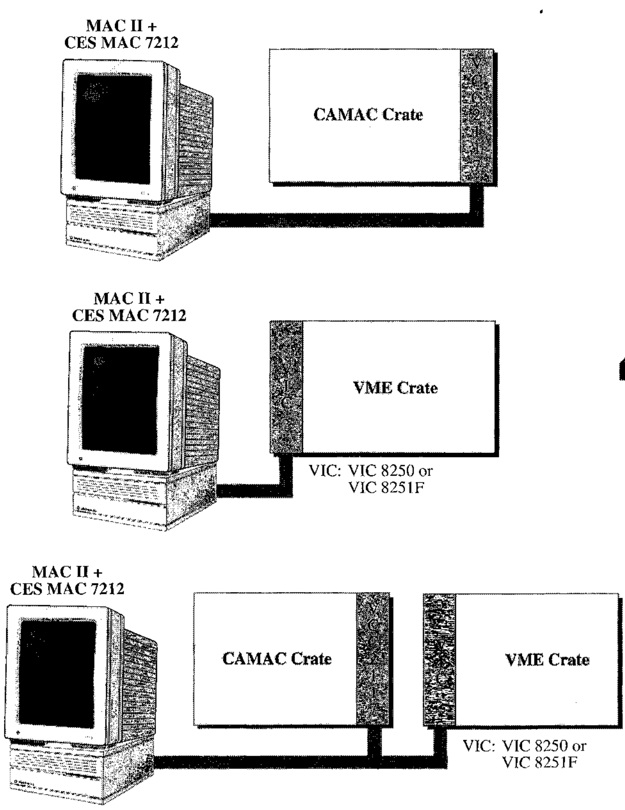

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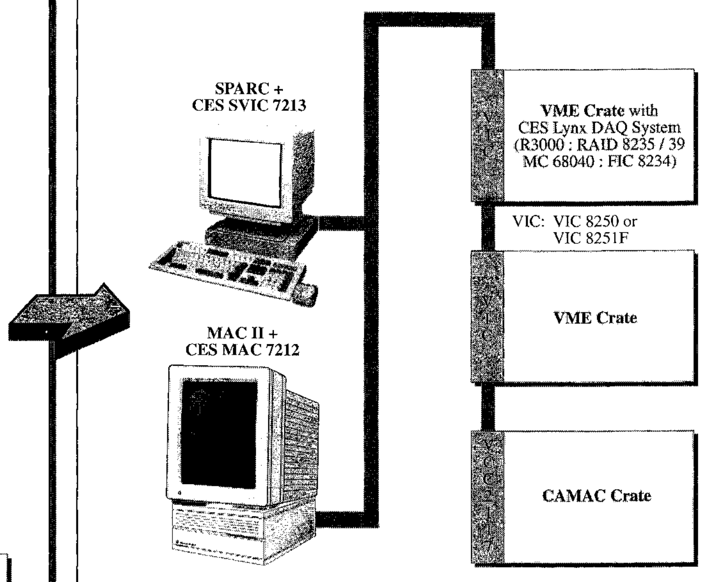

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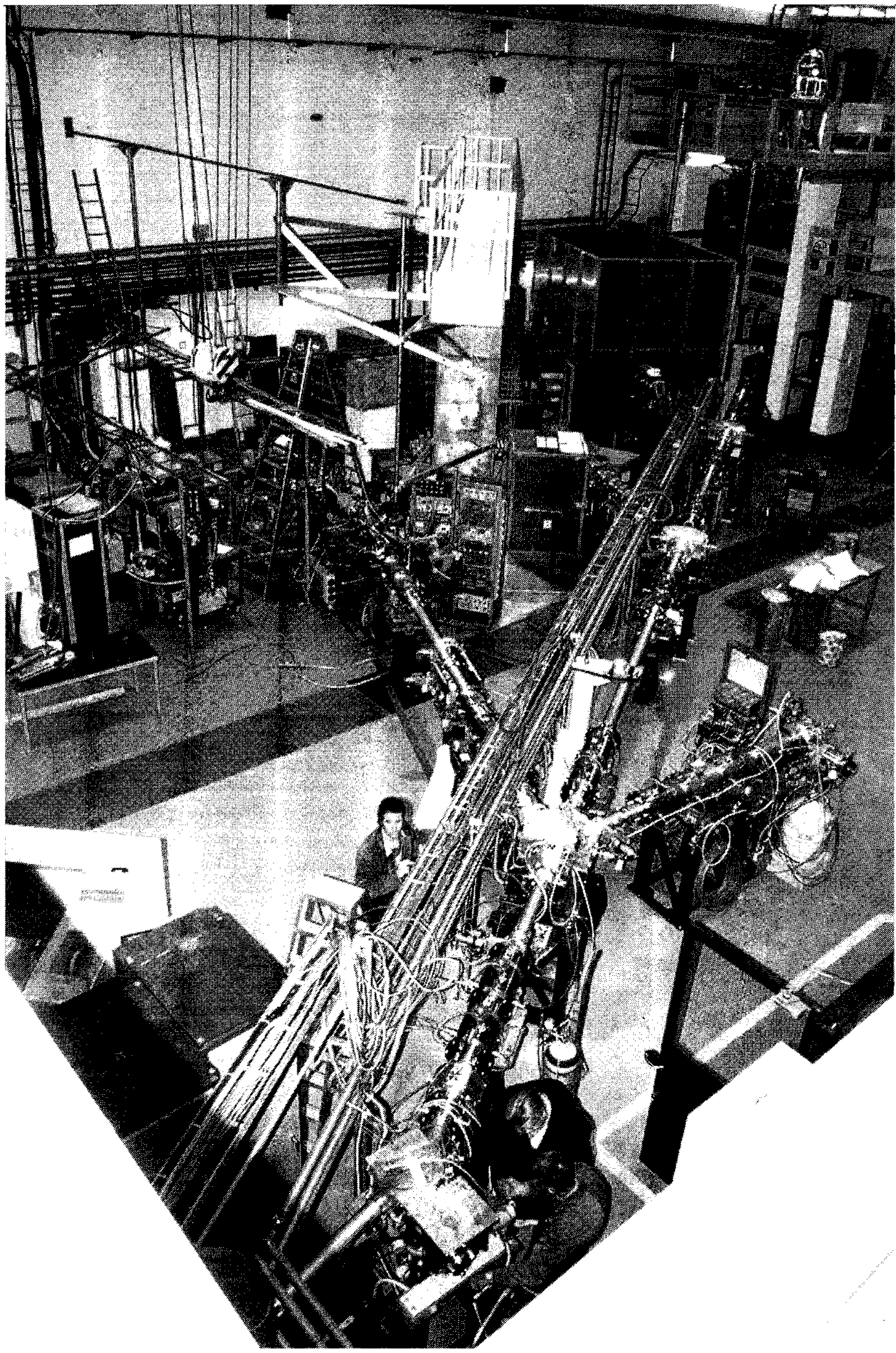


The laser beam for ISOLDE experiment 304 enters the experimental hall in a safety tube about 5 m above ground. Concrete provides vibration-free support for a mirror to deflect the beam towards the apparatus.
(Photo CERN EX 73 10 1992)

One experiment studies lithium defects in silicon and diamond (carbon). Lithium is the only known impurity acting as an interstitial donor when implanted in diamond, sitting between the 'resident' atoms in the crystal and introducing 'free' electrons into the lattice to produce n-type semiconducting diamond.

These modest steps are only the beginnings of a wide range of new ISOLDE research, which will go on to make valuable contributions to astrophysics and radiopharmaceuticals as well as materials science and the classic topics of atomic and nuclear physics

FERMILAB
Collider detectors -2

Last month's edition (April, page 12) included a status report on data collection and preliminary physics results from the 'newcomer' D0 detector at Fermilab's Tevatron proton-antiproton collider. This time the spotlight falls in the 'veteran' CDF detector, in action since 1985 and meanwhile significantly upgraded. Meanwhile the Tevatron collider continues to improve, with record collision rates.

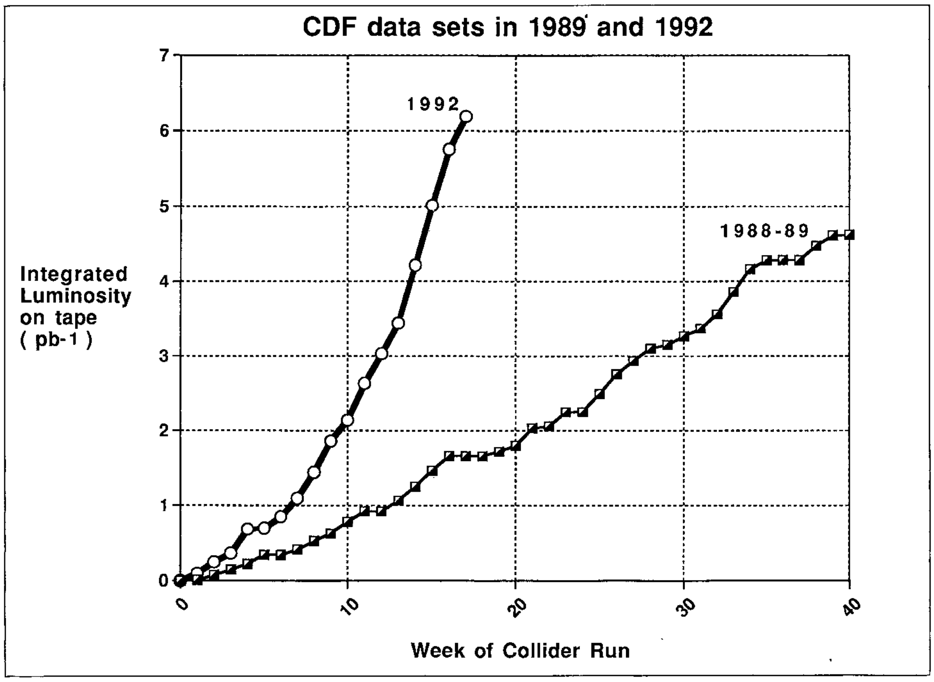
CDF

On December 9 last, the CDF Collaboration at Fermilab's Tevatron proton-antiproton collider reported that a total integrated luminosity of 4.69 inverse picobarns had been written to tape during the 1992 Collider run. This equals the data sample collected in the 1988-89 run and signals a solid new beginning to ongoing Fermilab collider operations. By March 21, more than 14 inverse picobarns of integrated luminosity had been collected on tape, tripling the 1988-89 score. Data is still coming in fast, and the run is expected to continue until June.

The upgraded CDF detector was rolled into the B0 Collision Hall at the end of March 1992, and collisions were seen the following May. Studies with the Tevatron and detector continued until August 26 when CDF declared the detector commissioned and the data quality sufficient to begin the top search. With increased Tevatron luminosity and increased CDF efficiency, data which took 272 days to accumulate in 1988-89 took only 106 days in 1992. It took only another 47 days to double the data set. Following a scheduled January maintenance period, and an unscheduled ice storm, the data was tripled in another 34 days.

Extensive changes have been made to CDF since 1989 to keep the detector functioning efficiently at anticipated peak luminosities of 10^{31} (record so far 8.59 x 10^{30}) - ten times the design luminosity of the original

Collisions take off. Integrated Luminosity recorded on tape by the CDF detector at Fermilab's Tevatron proton-antiproton collider, showing the much faster data accumulation rate being achieved in the current run.



detector. A replacement Vertex Time Projection Chamber with short (4cm) drift spaces was installed, the central muon system hardened with 630 tons of additional steel and new chambers, the data acquisition system throughput rate increased fourfold with new front-end electronics and additional system parallelism, the second level trigger system speed doubled, and the computing power in the third level trigger increased by a factor of 25.

Additional upgrades improved physics capabilities. A 46,000-channel silicon microstrip vertex detector was added around the beampipe to detect secondary decay vertices, pre-radiator chambers were brought in just behind the solenoid cryostat for neutral pion/gamma separation, and the central muon system extended.

The CDF Collaboration has increased dramatically since 1989. Sixteen research centres have joined to double the number of collaborating institutions to thirty-four, with a total of 419 physicists, up from "only" 187 in 1989.

The shift crews are composed of a Scientific Coordinator (dubbed the "SciCo"), an "Ace" - an expert (usually a graduate student) on the data acquisition system, and two "consumer operators" who monitor data quality with online programs. All members participate in shift work, serving 10-day rotations.

The physicist crew is supplemented by Fermilab personnel responsible for the cryogenic solenoid, the gas systems, and the safety systems. A rota of "Operations Managers" coordinate detector operations around the clock and liaise with the Accelerator Division. A Trigger Working Group meets every week and keeps the total trigger cross-sections under control as the luminosity of the Tevatron increases. The collaboration assembles every other week at Fermilab in a series of meetings to coordinate the physics analysis. Co-Conveners steer this analysis in four working groups - QCD, Electroweak, Heavy Flavour, and Exotic physics.

The detector is functioning well. The operational uptime of the detector is about 80% (still short of the

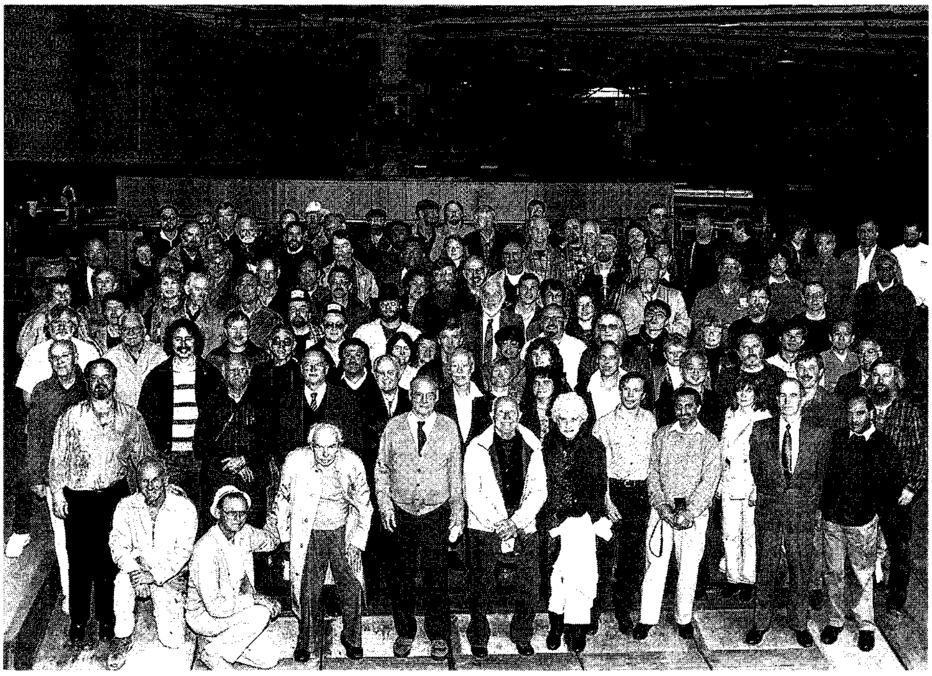
136 members (only 1/3) of the CDF Collaboration gathered for a picture at a recent collaboration meeting.

collaboration's goal of 90%). Trigger plus readout live time is 90% at luminosities of $7x10^{30}$, as planned. The W and Z production rates in the older detector systems are comparable to 1989, while additional Ws and Zs are seen in the newly upgraded muon systems and in the gas calorimeters.

Detector thresholds have been lowered to give nearly five times the J/psi rate into muon pairs. Secondary vertices have been seen with the new silicon detector, opening up new measurements with b-quarks.

The top quark is being searched for in every conceivable channel, with the new secondary vertexing tool being heavily employed.

About 100 current and former Lawrence Berkeley Laboratory employees standing on top of the Bevatron shielding after the final Bevatron "turn off."



BERKELEY
Farewell to the Bevatron/Bevalac

Nearly a hundred current and former Lawrence Berkeley Laboratory employees gathered at the Bevatron accelerator on 21 February to watch Ed Lofgren turn off the beam for the last time. Lofgren, in charge of the venerable machine from its completion in 1954 until his retirement in 1979, pushed a button that someone long ago labeled "atom smasher offer", bringing to an end four decades of accomplishment in high energy and heavy ion physics.

Owen Chamberlain, who shared the 1959 physics Nobel with Emilio Segré for the discovery of the antiproton at the Bevatron, was among those present at the closing ceremony. The shutdown came 39 years to the week after Bevatron beam first circulated, and a touching moment came just after Lofgren shut the machine down when the poignant strains of the "Taps" salute wafted out over the PA system.

The Bevatron - or Bevalac, as it was called after being linked to the SuperHILAC linear accelerator in the 1970s - made major contributions in four distinct areas of research: high energy physics, heavy ion physics, medical research and therapy, and space-related studies of radiation damage and heavy particles in space.

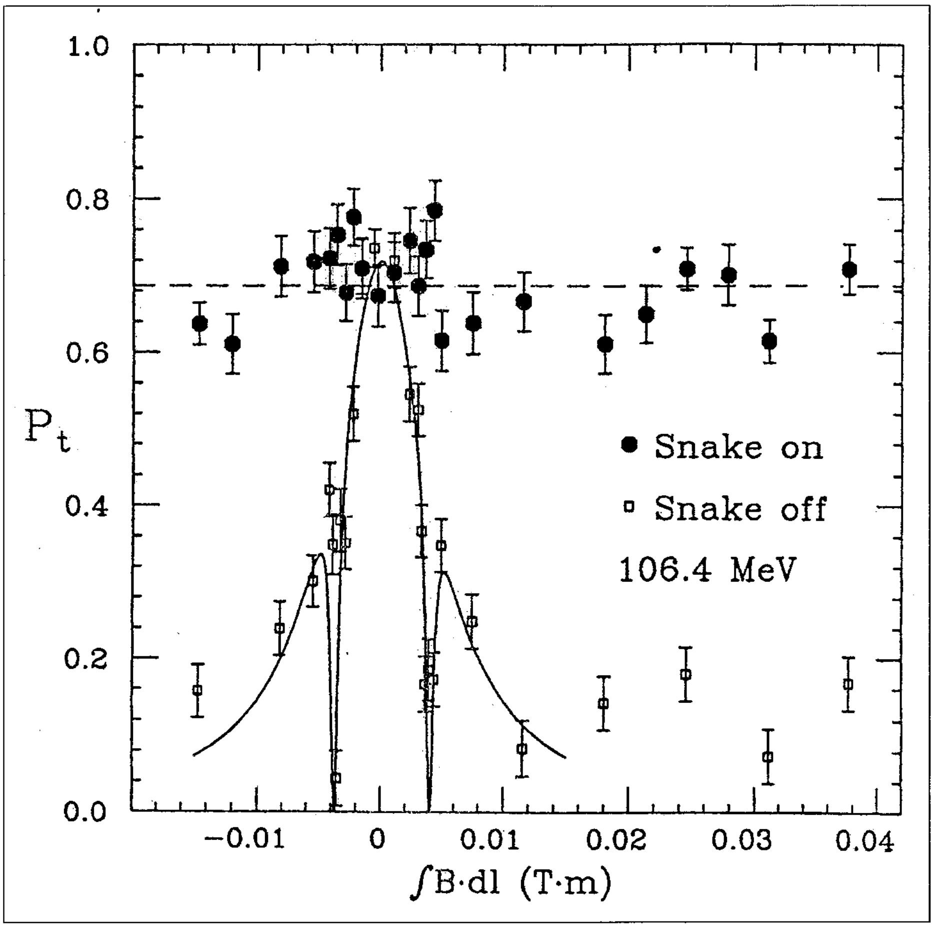
As well as the discovery of the antiproton, the early years of the Bevatron saw classic studies of the kaon, leading to a deeper understanding of both strong and weak interaction physics. With Luis Alvarez' development of Donald Glaser's original bubble chamber idea into a prolific physics technique, the Bevatron was a major focus of the heady days of resonance hunting in the late 1950s and early 1960s.

Most recently the Bevalac (Bevatron-SuperHILAC combination) pioneered relativistic heavy ion physics. The central focus of this research programme was the production and study of extreme conditions in nuclear matter. Highlights include the first definitive evidence of collective flow of nuclear matter at high temperatures and densities, studies of the nuclear matter equation of state and multifragmentation, a systematic study of dilepton production, and measurements using secondary beams of light radioactive nuclei, culminating in the observation of the "neutron halo" of lithium-11. (This nucleus consists of nine central nucleons surrounded by a relatively distant and weakly bound neutron pair.)

After the pioneering work at LBL, the relativistic heavy ion baton was taken up at still higher energies by Brookhaven and CERN, while Brookhaven's RHIC collider, now under construction, will provide the next energy step.

During the past year, the impending

'Siberian Snakes' save spin. The total transverse proton beam polarization at the Indiana Cooler Ring plotted against the imperfection magnetic field integral with the Siberian snake device on (circles) and off (squares). The solid line is a fit to the imperfection depolarizing resonance peak and radiofrequency resonance dips; the dashed line is a constant fit to the snake-on data.



shutdown of the Bevalac concentrated research on the properties of nuclear matter, especially dilepton production and studies of reaction dynamics using the new Equation Of State (EOS) Time Projection Chamber. The last experiment to be run was led by a collaboration from Japan, headed by Isao Tanihata, measuring the properties of radioactive beams near the proton drip line. Physics analysis of the large volume of data accumulated during this intensive year of running is now in full swing.

MICHIGAN/INDIANA Siberian Snakes strike again

Siberian snakes are showing themselves to be even more deadly than expected in killing their prey, the depolarizing resonances which would make it very difficult to accelerate polarized protons to TeV energies at accelerators such as the Tevatron, UNK, LHC, and SSC.

The snake concept was proposed in the mid-1970s by Siberians Yaroslav Derbenev and Anatoly Kondratenko at Novosibirsk, but the snakes lay almost dormant until Owen Chamberlain, Ernest Courant, Alan Krisch, and the late Kent Terwilliger organized the 1985 Superconducting Supercollider (SSC) polarized beam workshop in Ann Arbor, which highlighted the need to test the concept.

The idea is to rotate the spin through 180° on each turn in the ring. With such successive spin flips, the depolarizing effects seen in one turn should be cancelled by an equal and opposite perturbation on the subsequent turn.

The new Cooler Ring at the Indiana University Cyclotron Facility then seemed an excellent test site for these eager but untested serpents. The Michigan/Indiana/Brookhaven team led by Krisch constructed the world's first snake and found that it could easily overcome its initial enemy, the imperfection depolarizing resonances caused by ring magnet imperfections (January/February 1990, page 20). In the next few years the growing team of "herpetologists" showed that Siberian snakes could overcome all kinds of depolarizing resonances, including the intrinsic kind (caused by the vertical betatron oscillations which keep the beam focused) and the synchrotron resonances (caused by synchrotron oscillations in energy).

The team also discovered a new type of snake that was inadvertently built into the cooling section. This so-called type-3 snake rotates the spin around the vertical direction. A full type-1 snake (such as the team's superconducting solenoid magnet) rotates the spin by 180° around the beam direction; a type-2 snake rotates the spin around the radial direction.

Despite this display of serpentine power, the snake experts still questioned the ability of a Siberian snake to overcome all depolarization problems at TeV energies. At very high energies, the depolarizing resonances may become so strong that they are even wider than their normal 523 MeV separation, and would then overlap.

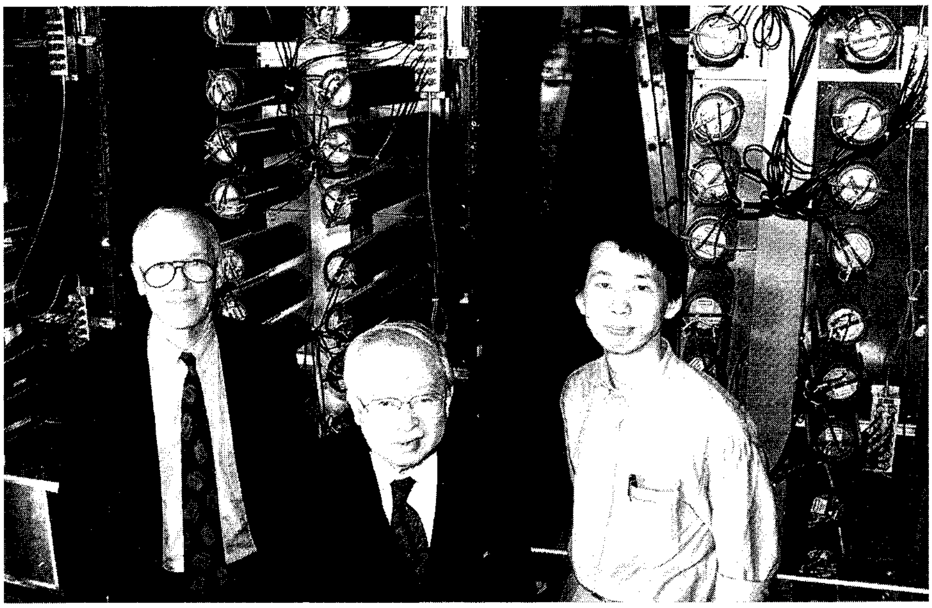
The snake team decided to study overlapping depolarizing resonances by building a 25 kV radiofrequency solenoid magnet to create an depolarizing resonance in the Indiana Cooler Ring. This new resonance was then forced to overlap with the nearby imperfection depolarizing resonance by varying the solenoid's frequency. The experimenters found a sharp destructive interference between the two overlapping resonances; while this still cannot be calculated theoretically, such effects are well known in physics. Fortunately the Siberian snake was powerful enough to overcome completely both overlapping resonances and all their interference effects, keeping the beam fully polarized.

The potency of these serpents is being closely followed at accelerator laboratories around the world.

Meanwhile, Krisch and his colleagues assembled the SPIN Collaboration to encourage the use of Siberian snakes at TeV accelerators. This Collaboration (Michigan/Indiana/Fermilab/North Carolina/IHEP-Protvino/JINR-Dubna/Moscow/INR-Troitsk/KEK/Kyoto) contains about 40 accelerator experts, 40 spin experimenters and one theorist. The SSC's 20 TeV lattices could include more than 50 empty straight sections, typically 20 metres long, for subsequent installation of many Siberian snakes.

For Fermilab, SPIN produced a 146-page report - Accelerating Polarized Protons to 150 GeV in the Fermilab Main Injector- and has just started work for a similar report on the possibilities for accelerating and storing polarized protons in the Tevatron Collider.

People and things



In March, Jiro Kondo (centre), President of the Science Council of Japan, visited CERN, where he was shown the muon spectrometer of the new Chorus neutrino experiment by Klaus Winter (left) and Shigeki Aoki of Kobe. (Photo CERN HI22.3.93)

On people

CERN Director General Carlo Rubbia, together with François Gros, Director of the Institut Pasteur in Paris, and distinguished Belgian chemist Ilya Prigogine, will advise European Commissioner for Research and Educational Policies Antonio Ruberti on new directions for European Community research policy. Carlo Rubbia's special concern will be the internationalization of research and the development of major world-scale projects.

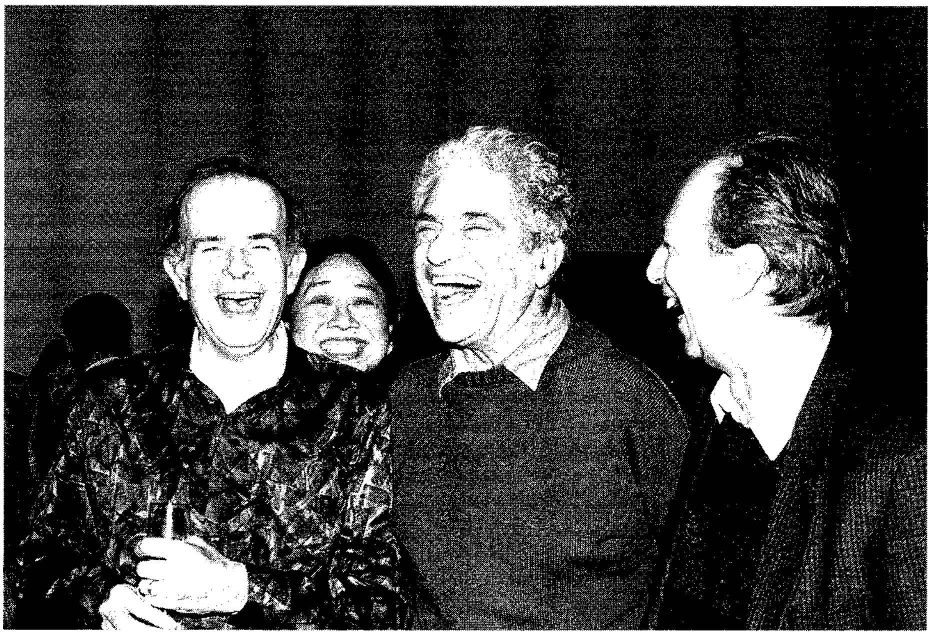
US awards

Prominent astrophysicist David N. Schramm of Chicago has been awarded the 1993 Julius Edgar Lilienfeld Prize of the American Physical Society. As well as recognizing contributions to physics, the prize is awarded for skills in presenting science. Schramm's citation reads 'For his manifold contributions to nuclear astrophysics and his ability to communicate the joy and excitement of science to a diversity of audiences.'

Recent American Institute of Physics awards included the Compton Award to Victor Weisskopf, doyen of the world particle physics community, recognizing his 'leadership throughout the world in advancing science, promoting peace and seeking solutions to world problems'. The citation underlined his roles as CERN Director General from 1961-65 and as founder of the US High Energy Physics Advisory Panel (HEPAP) as well as his contributions as teacher and author. In the 1930s, Weisskopf worked with Schrödinger, Heisenberg, Bohr and Pauli before moving to the US in 1937.

The American Institute of Physics Science Writing Prize has gone to author and science historian David Cassidy for his book 'Uncertainty, The Life And Science of Werner Heisenberg' (W.H. Freeman, 1991).

Aleph laugh. Successive spokesmen of the Aleph experiment at CERN's LEP electron-positron collider enjoy a joke - original spokesman Jack Steinberger (centre), his successor Jacques Lefrançois (left) and newly appointed Lorenzo Foa (right). Aleph notable Sau-Lan Wu also saw the joke.



Retirements

Earlier this year Bill Kirk retired from SLAC after 37 years. Starting as assistant to Edward Gintzon in 1956, he went on to serve unobtrusively but with total dedication in a number of key roles. The prose of the 1957 proposal for the two-mile linear accelerator was largely his work.

In 1974 he launched Beam Line, SLAC's commendable in-house journal, and went on to take charge of all SLAC's information activities. A keen sportsman, he helped organize the Laboratory's strong tradition of participator sport.

Machine specialist Donatus Degèle has retired from DESY after 32 years. After valuable contributions to the building and operation of the DORIS and PETRA storage rings, he played a leading role in the design and construction of proton facilities for the HERA electron-proton collider.

Polykarp Kusch 1911-93

Polykarp Kusch, best known for his measurement of the electron magnetic moment, for which he shared the 1955 Nobel Physics Prize with Willis Lamb, died on 20 March, aged 82. After starting his teaching career in 1936, he was diverted into wartime research. In 1946 he joined Columbia, where he was twice Physics Chairman and was voted the Great Teacher Award by students in 1959.

Physics teaching

In several regions of the world, there is increasing awareness of the importance of physics teaching. For its part, the European Physical Society has set up a 'Forum on Education', under the joint chairmanship of particle physicists G. Tibell (Uppsala) and G. Marx (Budapest).

External correspondents

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

TRIUMF Laboratory, (Canada)
M. K. Craddock

The recently established Edoardo Amaldi Foundation is calling for applications for a prestigious new award, the Amaldi International Prize for a High School Physics Textbook. Nominations to the Prize Secretariat, Via Mazzini 62, 29100 Piacenza, Italy.

Meetings

The 3rd London Conference on Position-Sensitive Detectors will take place at Brunel University, Uxbridge, from 6-10 September. Further information from PSD3, D.C. Imrie, Department of Physics, Uxbridge UB83PH, UK, fax +44 895 272391, e-mail imrie@uk.ac.brunel.ph

The 5th conference in the series 'Intersections of Particle and Nuclear Physics' will take place from 31 May-6 June 1994 in St. Petersburg, Florida. Further information from the Conference Secretary, Elly Driessen, TRIUMF, 4004 Wesbrook Mall, Vancouver BC, V6T 2A3 Canada, fax (604) 222-1074, bitnet driessen@triumfcl

1993 CERN School of Computing

The 1993 CERN School of Computing will be held from 12 to 25 September in the Scuola Superiore G. Reiss Romoli in L'Aquila, Italy. Various aspects of computing in particle physics will be covered in more than 40 lectures by 16 lecturers. The topics range from LHC triggers to object-oriented databases. Artificial neural networks, genetic algorithms, access to information (World-Wide Web), asynchronous transfer mode, high speed interconnects, extensions to Unix and the Posix standard, storage technology, physics analysis, visualization and animation will also be covered. Practical sessions will be devoted to tools for preparing presentations. An excursion to the nearby Gran Sasso Laboratory is also planned. Full details of the 1993 School can be obtained from Mrs. Ingrid Barnett, CN Division (e-mail barnett@cern.cern.ch). The deadline for applications is 31 May.

90 mA in ALS storage ring

Commissioning of the Advanced Light Source at Lawrence Berkeley Laboratory is progressing rapidly. The first beam, 6 mA, was stored on 17 March, and the stored current reached 90 mA on 26 March, an auspicious beginning. Full story next month.

Penguins at Cornell: see June issue

At an Academy of Turin meeting in honour of Gian Carlo Wick, who died last year, eminent Turin theorist Vittorio de Alfaro displays the signatures on Wick's university certificates.

UNIVERSITY OF GENEVA

The Department of Nuclear and Particle Physics has an opening for a position of

Research Associate

to join a group involved in the WA98 Experiment at CERN in heavy ion collisions. The candidate must have a Ph.D. in experimental particle physics and should not be more than 32 years old. **This is a non-permanent position limited to a maximum of 6 years**, starting November 1st, 1993.

Applications should be sent to

Prof. M. Martin
Département de physique nucléaire et corpusculaire
24, Quai Ernest-Ansermet
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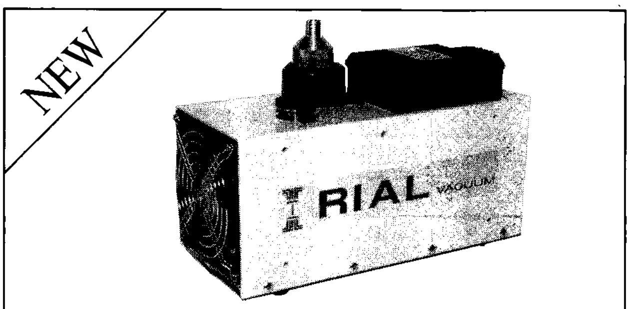

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