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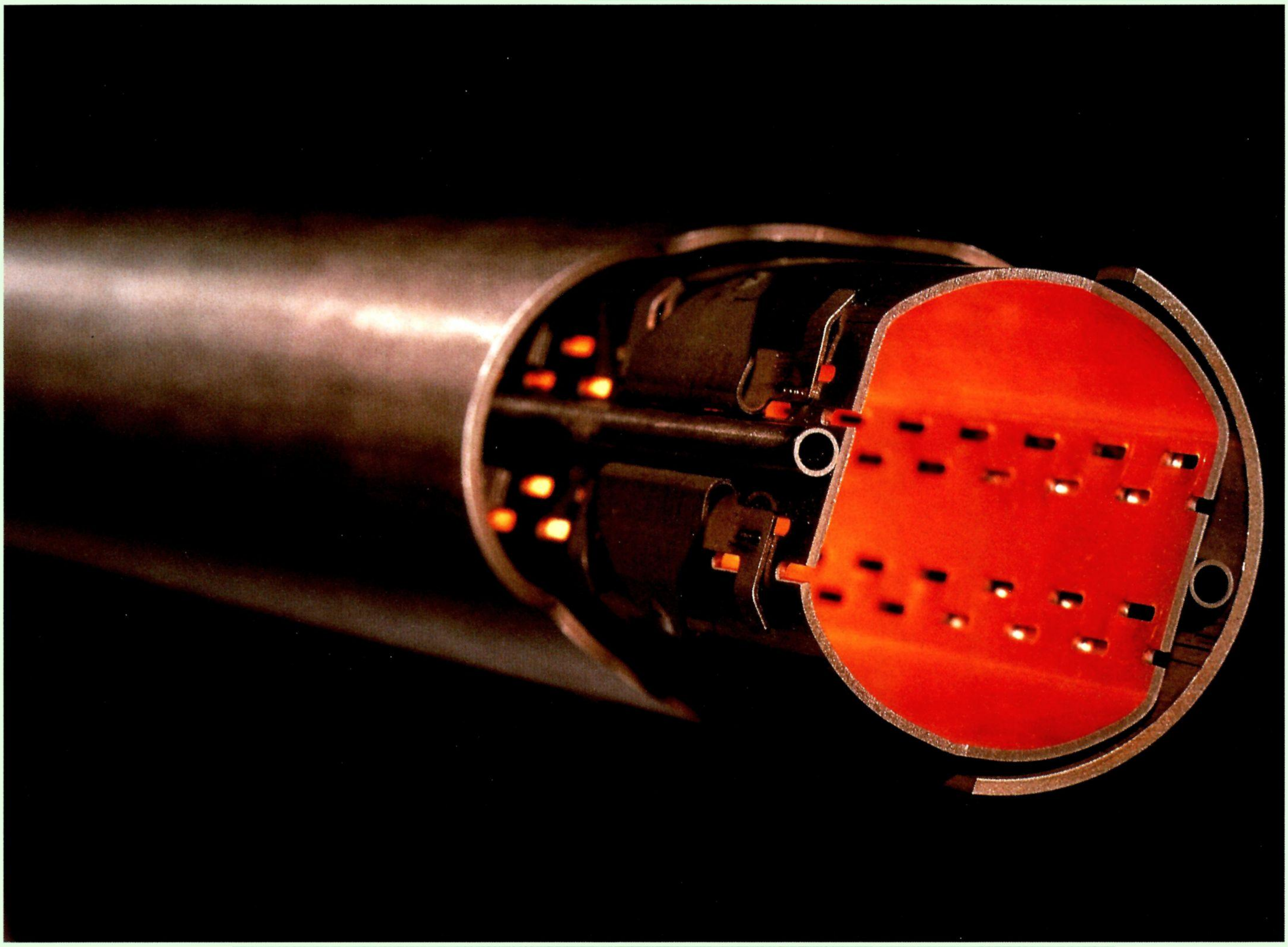

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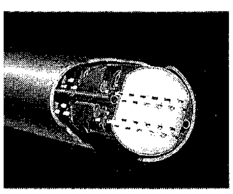
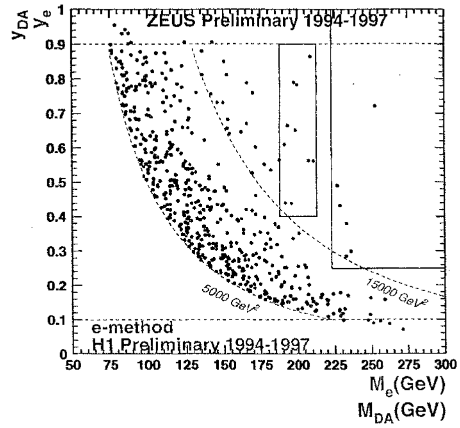


Cover photo: Screening the beams. CERN's LHC proton collider will be equipped with 'beam screens' to shield the surrounding superconducting magnets from radiation emitted by the beams. However the slits allow residual gas molecules to pass through and become 'frozen' to the walls of the ultra cold beam pipe (Photo CERN AC.15.5.97).

Standard Model hamburger

New physics or statistical mirage? Data from the H1 and Zeus experiments at the HERA electron-proton collider at DESY, Hamburg, surprised the world earlier this year by reporting an intriguing excess of backscattered electrons (positrons), suggestive of new structure deep inside the proton. With more data, the excesses are still there but less marked, and moreover the two experiments do not exactly agree. The left-hand box shows the kinematical region with the excess now reported by H1, in which Zeus sees only the expected number of events, while the right-hand box shows the kinematical region with the excess now reported by Zeus, in which H1 sees only the expected number of events!



At a major international physics conference in Munich in 1988, review speaker Don Perkins spoke of a 'festival of the Standard Model'. For almost a decade now, major physics meetings have continued to be festivals of the conventional picture of six quarks and leptons grouped pairwise into three families interacting via electroweak and inter-quark forces.

All physicists agree that the Standard Model cannot be the full picture, with too many free parameters that can only be measured by experiment, and with the observed pattern of particle masses unexplained. But like a quality waterproof watch, the Standard Model had no visible crack to prise the case apart and get at the mechanism inside.

However earlier this year (April, page 1), the Zeus and H1 experiments at the HERA electron-proton collider at DESY, Hamburg, reported an intriguing handful of excess of positrons recoiling backwards from collisions at 27.5 GeV with 820 GeV protons. The backscattering was suggestive of interactions with a new layer of matter deep inside the protons, deeper than the quarks themselves, at separations of 10^{-16} cm. Was this at last a crack in the hard Standard Model casing, or just a stain that would wash out with statistical rinsing?

This HERA data was collected from 1994-6, and with the collider performing better than ever this year (see page 18), an update of the backscattering effects was eagerly awaited. This set the stage for the International Symposium on Lepton and Photon Interactions, held appropriately in Hamburg from 28 July - 1 August. The 700-odd participants did not have to wait long - after the official opening, the first talk of the meeting, by Bruce Straub of Harvard, covered recent HERA results from an integrated luminosity (a measure of the number of collisions collected) which had increased from 14.2 to 23.7 inverse picobarns for H1, and from 20.1 to 33.5 for Zeus.

The earlier results had covered neutral current interactions (with the positron emerging unscathed) for both experiments, with 2 and 12 backscattered events, compared to an expected signal of a fraction of an event and five events from Zeus and H1 respectively. Earlier this year only H1 reported similar charged current interactions, with the incident positron swallowed up.

At Hamburg both experiments reported charged current effects, Zeus and H1 together seeing 28 backscattered events in a kinematical zone where 18 ± 4 are expected.

Turning to neutral current interactions, the new data from the two experiments is not totally coherent. The 2 and 12 anomalous events from Zeus and H1 have now been supplemented by zero and six more respectively. Superimposing the two signals, the accumulated excesses have little overlap and cannot be explained by a single resonance (see page 14).

Looking at each experiment's neutral current data separately, in one area H1 sees in total 8 backscattered events where 1.5 are expected, while Zeus observes 3 and expects 3. In another area H1 sees 5 where 1.5 are expected, while H1 sees 1 and expects 1.

Data taking continues to October, and should double the 1994-6 statistics, after which HERA will switch to its original plan of electron-proton collisions.

Cautiously welcoming the result in his Standard Model summary talk at Hamburg, Guido Altarelli of CERN underlined the mismatch between the H1 and Zeus effects. While pointing to possible new physics implications, in his view a statistical fluctuation was the best 'theoretical' explanation.

In other physics sectors, neutrino anomalies persist in non-accelerator data, suggesting that neutrino types are not immutable, and can mix, while some specific decay channels of B mesons (containing the fifth - 'beauty' or 'b' - quark) are not quite in order.

However the Standard Model still reigns supreme, and taking all results together, its self-consistency points to a mass of the higgs particle, responsible for electroweak symmetry breaking, as 121 + 119 - 68 GeV. However the consistency still has lots of room for manoeuvre.

A complete report of the Hamburg Lepton-Photon Symposium will be published in the October issue.

Energy and intensity at the Particle Accelerator Conference

"I go and it is done; the bell invites me.
Hear it not, Duncan, for it is a knell,
That summons thee to heaven or to hell."
These stark lines from Macbeth adorned the chairman's bell, presented to Michael Craddock at the beginning of the conference by Steve Myers, chair of last year's EPAC meeting in Barcelona.

If variety is the spice of life, then delegates at the 1997 Particle Accelerator Conference, PAC'97, in Vancouver were treated to a very piquant dish indeed. The conference, 17th in this biennial series which alternates with the European EPAC meetings, began with a plenary session in which the bread and butter of the field, particle physics, was accompanied by talks on more recent aspects of accelerator technology, synchrotron light sources and laser acceleration.

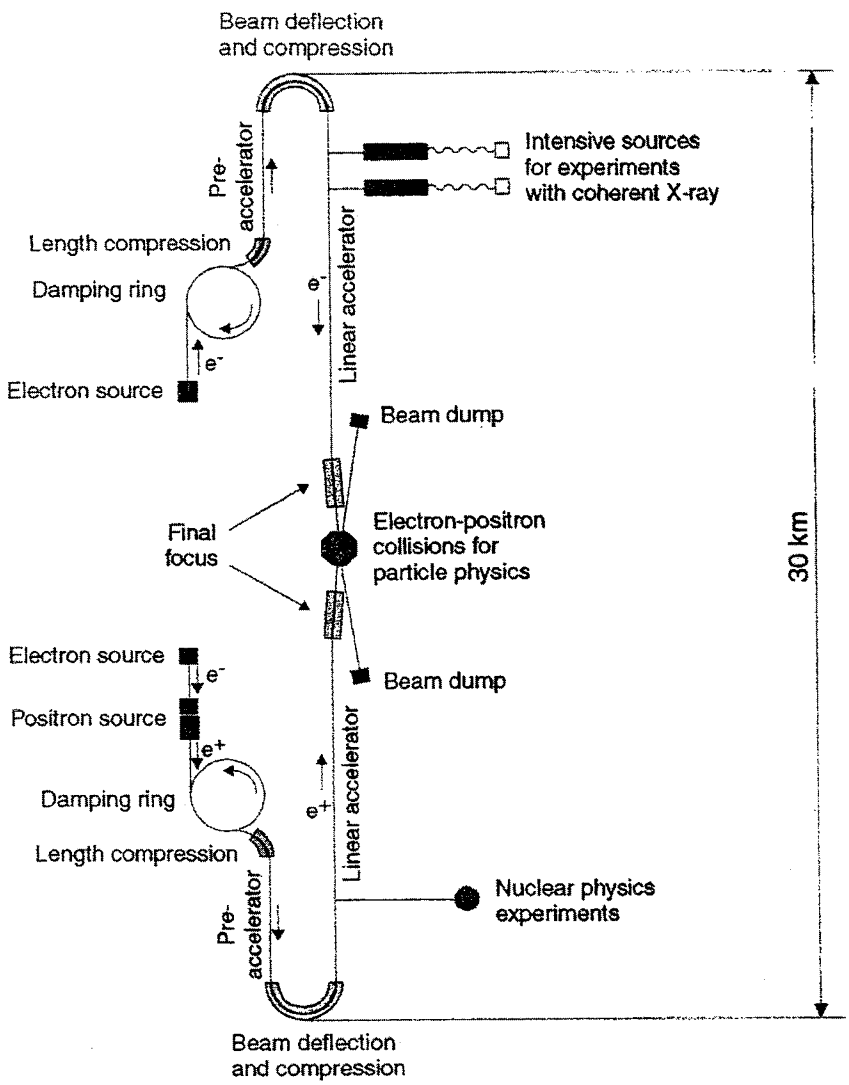
After a brief welcome from conference chairman Michael Craddock, Burton Richter of the Stanford Linear Accelerator Centre, SLAC, set the ball rolling with an overview of particle physics, the field which gave birth to accelerators. A map of Europe served to explain why circular electron-positron colliders have reached their limit, showing a TeV-scale machine with interaction points in Geneva and London. Linear colliders, said Richter, represent the realistic way forward, presaging a major theme of the conference. Global linear collider design efforts are co-ordinated through the International Linear Collider Technical Review Committee (April, page 16) which produced its first review in 1995, and is preparing an update for Autumn 1997. Richter concluded with the opinion that the early 21st century particle physics globe will be divided in two with a proton machine hemisphere centred on CERN, and a linear collider in the USA or Japan.

Returning to the present, CERN's Steve Myers painted a positive picture of the LEP2 electron-positron collider, with just a hint of a cloud on the horizon. LEP, he said, has achieved precision in luminosity and energy measurements over ten times better than foreseen, and the LEP2 energy upgrade is going well. The superconducting Radio Frequency (RF) system is fully operational, producing a gradient of 6 megavolts per metre with 4 milliamps in the machine. The cavities have a resonance Q_0 value at 4.5 K of greater than 3.2×10^9. In 1996, LEP2 operated at 86 GeV per beam and luminosity peaked at 3.4×10^{31}, 92 GeV is the new target for this year (see page 14). Amidst all this good news, the cloud appeared in the form of unexpected cryogenic losses. Cryogenic load increases with current, as expected, but it also rises with beam energy. Later in the week, CERN's Daniel Boussard, who received the US Particle Accelerator School prize at the conference, along with Chandrashekhar Joshi of UCLA, offered a possible explanation. He suggested the problem may be due to higher order modes becoming trapped in the bellows between accelerator components.

Japan's third-generation SPring-8 light source, a joint project by the Japan Atomic Energy Research Institute, JAERI, and the Institute of Physical and Chemical Research, RIKEN, was described by Hiromichi Kamitsubo of the SPring-8 project team. SPring-8 consists of a 1.2 GeV electron linac, an 8 GeV synchrotron, and a low emittance storage ring with 44 straight sections. Commissioning began in August 1996, and the first synchrotron radiation was seen on April 23. SPring-8's design goal of 10^{20} photons per second per square millimetre per square milliradian will make it the world's most brilliant synchrotron radiation source in the hard x-ray region when it comes on stream in October.

In the final opening plenary talk, Joshi gave a whirlwind tour of laser accelerators. With extremely powerful lasers becoming more readily available, their use to accelerate particles becomes increasingly attractive. A petawatt laser can generate a field of 0.8 TeV per centimetre, but the question is how to harness this for acceleration. Three schemes are currently under investigation, laser wakefield acceleration (LWFA), plasma beat wave acceleration (PBWA) and self-modulated laser wakefield acceleration (SM-LWFA). All rely on the fact that when a powerful laser beam traverses a gas it excites density waves in the electron plasma rather like sound waves. Potential differences between areas of high and low density can then be used to accelerate particles.

All three techniques have provided promising results. An LWFA developed by a KEK-JAERI-Tokyo collaboration has accelerated a 17 MeV electron beam up to 250 MeV. A UCLA PBWA experiment has produced accelerating gradients of 2.8 GeV per metre, and a Rutherford



The TESLA linear collider would continue DESY's tradition of providing beams for particle physics and synchrotron light sources. The TESLA test facility, currently under construction, will test both linac components and the free electron laser technology chosen for the light sources.

Appleton Laboratory-Imperial College-UCLA-Ecole Polytechnique collaboration using the SM-LWFA technique has accelerated electrons up to 100 MeV over a distance of 0.6 millimetres, corresponding to a colossal gradient of 160 GeV per metre. Joshi has an optimistic view, predicting that well ordered beams with good emittance, low energy spread and energies of up to a GeV will come within the next five years.

Lining up the linacs

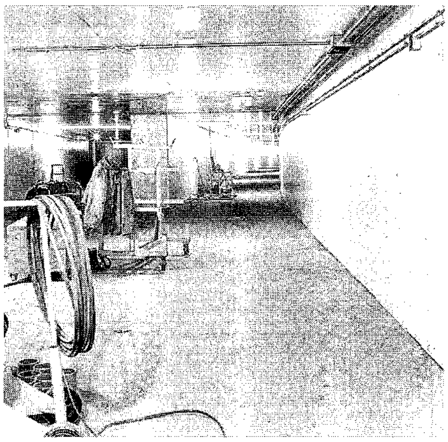
Kicking off the linear accelerator session was DESY's Dieter Trines who presented results from the laboratory's TESLA test facility. The TTF will test components required by DESY's candidate for a future high energy linear collider, TESLA. In its first stage, due for completion in 1999, it will produce 390 MeV beams using three superconducting accelerating modules. By 2002, it will be upgraded to 1 GeV with 8 modules. The TTF currently has just one module installed, and first beams are being exploited (July, page 1).

A recurring theme of the linac sessions was the importance of wakefields. Whereas wakefields might be vital for laser acceleration, the transverse fields following in the wake of particle bunches in linacs can be highly destructive. All the designs for future linear colliders demand closely grouped bunch trains to maximize luminosity. Transverse wakefields perturb the bunches, causing instability and blowing up the beams. These problems may be overcome by steering the beam precisely along the centre of accelerating structures, and Mike Seidel from SLAC suggested minimizing beam induced microwave signals. This technique has been successfully demonstrated at the SLC linac.

Staying with the same theme, Norman Kroll of the University of California, San Diego and SLAC described the damped detuned structures designed to minimize wakefield effects in SLAC's Next Linear Collider, NLC. These have been tested in the recently commissioned 0.5 GeV test accelerator for the NLC, the NLCTA. George Caryotakis joined the chorus of SLAC linear collider talks with results from the 'condor' X-band klystron. An RF peak power of 56 megawatts has been achieved with 60% efficiency and a pulse length of 2 microseconds.

Moving across the Pacific, the Japanese KEK laboratory also has an accelerator test facility with linear colliders in mind, the KEK ATF. Results on commissioning the ATF's damping ring were presented by Junji Urakawa from KEK. First beam was circulated for 1000 turns in January 1997 at 0.94 GeV with 6×10^9 electrons per bunch. By mid-April, beam spot measurements showed 76 microns in the horizontal plane and 113 in the vertical.

One aspect of CERN's interest in a future linear collider was presented by Gilbert Guignard with computer simulations of bunch behaviour under different cavity characteristics in CERN's CLIC framework. These show the sensitivity of wakefield development to differing accelerating structure design parameters, and will assist the development of accelerating structures for CLIC.



Seen in January 1995 at an early stage in its construction is the tunnel which will house Fermilab's new main injector and recycler. The 8 GeV injection line comes in on the left.

Accelerators for particle physics

Fermilab's Stephen Holmes opened the high energy hadron accelerator session with a status report on the Fermilab main injector and recycler project whose aims are to boost Tevatron proton-antiproton collider luminosity to 2×10^{32} and to provide a high intensity 120 GeV beam with 3×10^{13} protons per pulse for fixed target experiments. The project will be completed during a Tevatron shutdown beginning after the 1997 run and ending in 1999.

The new 150 GeV main injector will increase the antiproton production rate by a factor of 3 and improve the stacking rate at high stacks. The recycler's job is to recycle antiprotons at the end of a fill for use in the next one. It is an 8 GeV ring occupying the same tunnel as the main injector and using permanent magnet technology. The recycler received DOE approval in February this year.

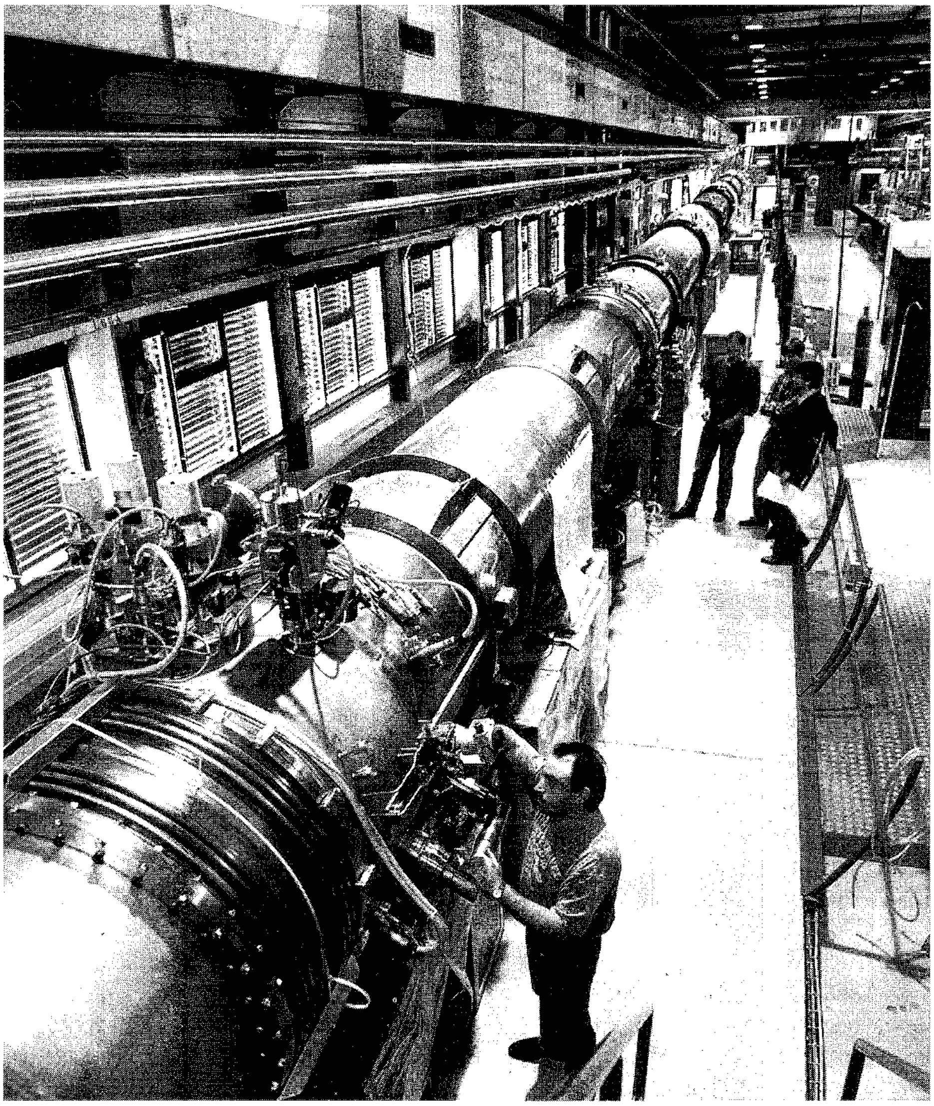
The status of Brookhaven's Relativistic Heavy Ion Collider, RHIC, was presented by Steve Peggs. All the dipoles, made by industry, have been deployed in the tunnel, and beam was successfully steered around the first sextant of the machine in February (March, page 1). Work continues on the in-house triplet magnets consisting of a corrector, a quadrupole and a sextupole. First heavy ion collisions are foreseen for 1999.

Crossing to Europe, a proposed luminosity upgrade for DESY's HERA electron-proton collider was described by Ferdinand Willeke. This will boost the machine's design luminosity from 1.5×10^{31} to 7.4×10^{31} by the year 2000. The improvement will be achieved largely by compressing the beams using magnets installed inside the detectors themselves. HERA is now approaching its present design luminosity having reached 1.2×10^{31} and delivering 4.5 inverse picobarns per month. Limitations are due to lower positron currents, 42 milliamps instead of the design 58, and fewer protons, 0.6×10^{11} instead of 1×10^{11}. A new RF system will soon boost beam currents and improvements to the injector chain should improve the proton intensity. A well publicized problem experienced by HERA is the short lifetime of electron beams. This has been traced to the vacuum system, and the present pumps are scheduled to be replaced with NEG getter pumps, similar to those used by CERN at LEP, in the next winter shutdown.

In a wide ranging discussion of CERN's LHC, Lyn Evans acknowledged the global support for the project which has allowed the start-date to be set for 2005. CERN's accelerators are being upgraded to form the new accelerator's injection chain. A testing programme continues to perfect the design of the main dipoles, and a cycling test recently simulated 10 years of LHC running on a prototype string of magnets, putting LHC cryogenic and quench control systems through their paces. Bids are currently out for major civil engineering work due to begin in 1998.

Looking to a more distant future, Brookhaven's Bob Palmer presented a compelling case for muon colliders. These, he said, would be compact, high luminosity machines, and since coupling to the long-awaited Higgs boson rises with mass squared, muons couple 40 000 times more strongly than electrons. But muon colliders are still on the drawing board, and the time has come, said Palmer, to build a machine. The first task would be to demonstrate ionization cooling, a technique whereby the beam is repeatedly passed through an absorber and then reaccelerated. As explained by David Neuffer of Fermilab, the absorber calms the beam longitudinally and transversely while the following acceleration adds only longitudinal momentum, thereby resulting in cooling. According to Palmer, if this technique works, a 100 GeV muon collider Higgs factory could follow soon after. Much higher energies could be hampered, however, by a rather surprising problem first pointed out by Bruce King, currently at Brookhaven. With machines of 4 TeV or more, the intensity of neutrinos from muon decay becomes a radiation hazard.

Andrew Hutton of the recently christened Jefferson Lab gave a status report on the CEBAF electron accelerator. Concentrating on work on the superconducting RF, he said that a gradient of 7.76 megavolts per metre has been achieved allowing CEBAF to exceed its design energy of 4 GeV. Experiments with 5 GeV beams are scheduled for November, and 5.5 GeV is expected next year. CEBAF's design current is 200 microamps, and 180 has already been reached at 4 GeV, correspond-



CERN's LHC test string consists of three prototype dipole magnets and one quadrupole. In 1996, it was used to put LHC systems through a simulation of 10 years of accelerator operation.

ing to a power of 720 kilowatts. The maximum so far delivered to experimental targets, however, is 120 microamps. At the other extreme, CEBAF has been run with currents as low as 200 picoamps, corresponding to just 2.5 electrons per bunch. Another CEBAF success has been scored with polarization, where 35% has been measured and development aiming for 80% is underway. In conclusion, Hutton said, CEBAF's user community is delighted, and busy working out how to deal with the huge power CEBAF can deliver.

With CP-violation, one of the necessary conditions for a matter dominated Universe, still a burning issue, two major facilities in Japan and the US are being built to address the question directly. These are both energy asymmetric electron-position colliders optimised to produced B-mesons in whose decays CP-violation is expected to be clearly visible. Japan's KEKB collider was presented by Yoshihiro Funakoshi who concentrated on problems associated with high currents. A major current limitation comes from coupled bunch instabilities from RF cavities. To address this, KEK has developed two new types of cavity, one normally conducting, the other superconducting. Both have been tested successfully in the TRISTAN ring, the normally conducting ARES cavity operating stably with a current of 500 milliamps.

Ulrich Wienands ran through progress at Stanford's PEP-II B-factory where the BaBar experiment is preparing to take data in 1999. PEP-II will collide 9 GeV electrons from a High Energy Ring operating at 1 amp, with 3.1 GeV positrons from a Low Energy Ring running at 2 amps. Commissioning is currently in progress, with beam injected into the electron ring for the first time on 10 May, just in time for the conference (June, page 29, and this issue, page 19).

Also in the lepton accelerator session, Cornell's Dave Rubin outlined a luminosity upgrade for the CESR electron ring which could boost the luminosity from 4.1×10^{32} to 3×10^{34}, and Yingzhi Wu described the proposed Beijing tau-charm factory which aims for a luminosity around 10^{33} in a new 2 GeV storage ring.

The FELgood factor

There are currently 42 operational synchrotron light sources in the world, said Herman Winick of SLAC in the closing plenary session, 13 more are under construction, and a further 17 are in the design phase. The key to the future, said Winick, is low emittance. Since emittance falls with energy in linacs, he predicts that linac driven free-electron lasers (FELs) will come to dominate the field, pointing in particular at self-amplified spontaneous emission, SASE, devices where only a single pass is needed to produce light.

FELs have come a long way since John Madey first thought of the idea back in 1971. From proof-of-principle experiments, they have progressed to become important synchrotron radiation sources, and are set to challenge the hegemony of synchrotrons in this field. The commissioning of Duke University's major FEL facilities (March 95, page 8), presented by Madey himself, is another important milestone along this path. DESY's Jörg Rossbach presented a project to build a SASE

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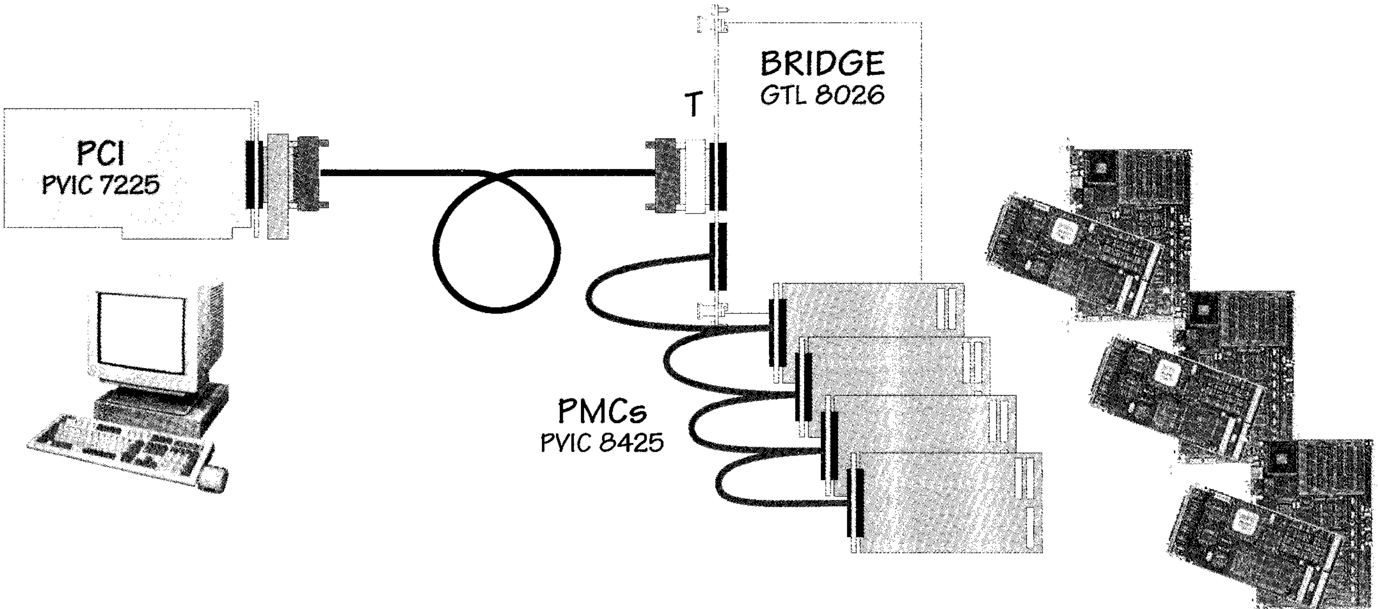

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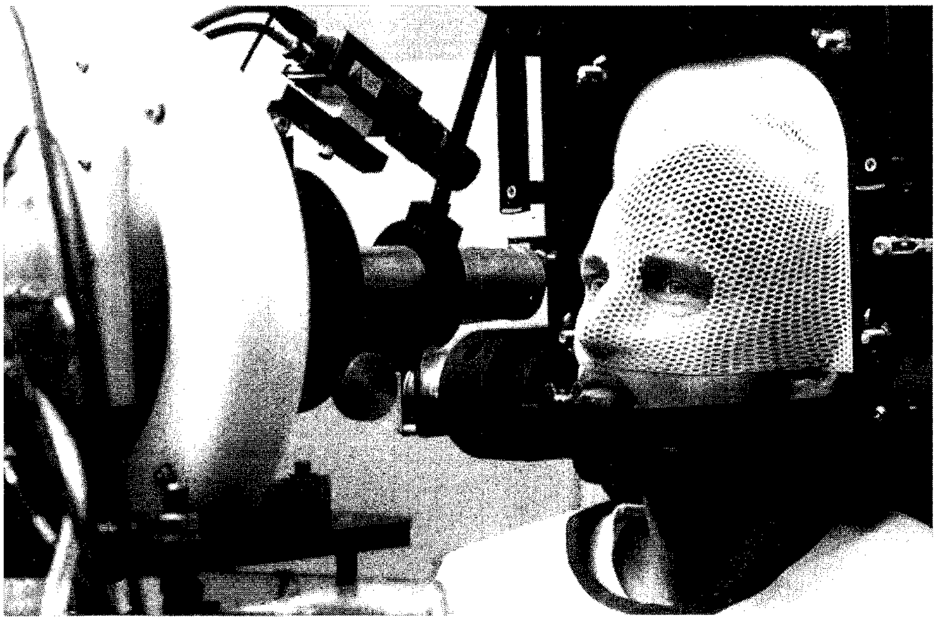


Proton beams are becoming increasingly important for medical therapy. The proton therapy facility at the Canadian TRIUMF Laboratory, Vancouver, is now in routine operation treating ocular tumours using 70 MeV protons.

FEL in the context of the TESLA linear collider project. The TESLA test facility FEL is planned in two stages, mirroring the development of the TTF itself. As well as performing research on FELs, both facilities will provide X-ray laboratories for research.

Wide ranging applications

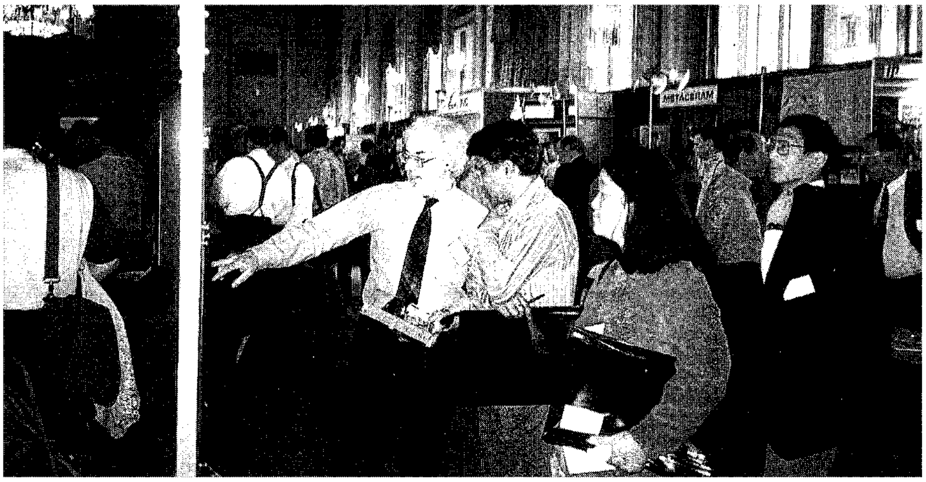
Perhaps history will honour heavy ion induced fusion, HIF, as the most important application of accelerators. Today, work concentrates on handling the huge beam currents, as large as kiloamps, needed for such machines. Progress at the Lawrence Berkeley and Lawrence Livermore Laboratories, and at the University of Maryland was presented by Berkeley's Joe Kwan. HIF works by bombarding a target with a number of beams simultaneously. This means that high intensity beams must be built up, split and focused on the target. Berkeley's work has concentrated on aspects of focusing, whilst Livermore has looked at beam transport through a 45-degree bending arc. At Maryland, the behaviour of space-charge dominated beams is being studied using low energy electrons. Simulation work for HIF was discussed by David Grote from Livermore who presented results of a 3-D package which agree well with the Livermore and Maryland observations, auguring well for Livermore's plans to build a full recirculating ring by 1999.

Tom Wangler of Los Alamos discussed developments in high power proton linacs. Such machines typically require 100 milliamps peak at an energy around 1 GeV. The highest intensity machine today, Los Alamos's LANSCE, produces the comparatively modest peak current of 17 milliamps at 800 MeV. One of the chief design requirements of high power machines is low beam loss, a few tenths of a watt per metre above 100 MeV at most, in order to allow hands-on maintenance of the machine. LANSCE manages this, the challenge now is to extend the achievement to more powerful machines. To give an idea of the difficulty, 60 milliwatts loss at 800 MeV corresponds to just one particle lost per bunch. The key, says Wangler, is understanding beam halo growth due to space-charge effects.

Turning to high intensity circular machines, Bill Appleton from Oak Ridge gave an overview of the US National Spallation Neutron Source, NSNS. Top priority project of the DOE's Office of Energy Research, the project is co-ordinated by Oak Ridge with responsibilities shared by 5 US national laboratories. Lawrence Berkeley has responsibility for the front end, Los Alamos for the 1 GeV proton linac, Brookhaven for the accumulator ring, and Oak Ridge for the target station. Argonne and Oak Ridge will collaborate on the design of experimental systems. A full validation review is scheduled by the DOE, and if all goes well, a request for construction funding could be made by 1999. In Europe, the Rutherford Appleton Laboratory is home of the world's brightest neutron source today, ISIS, and a successor machine, the European Spallation Source, ESS, is just entering the R&D phase.

Tokyo's Yoshiharu Mori described the ambitious Japan Hadron Project, an interdisciplinary facility formed by the merger of KEK with Tokyo University's Institute of Nuclear Studies (July, page 4). The new laboratory, to be built at the KEK site, consists of three accelerators, a 200 MeV proton linac, a 3 GeV synchrotron, and a 50 GeV synchrotron. Between them, these will supply beams for no fewer than 5 experimental arenas addressing topics as diverse as exotic ions and neutrino oscillations. Space-charge effects again dominate JHP R&D, since high intensities are foreseen. A new

Reflecting the growing commercial importance of accelerators, some 30 companies took part in an industrial exhibition at the conference.



material, fine crystal high mu-metal, has been chosen for the RF cavities. This has a permeability about 20 times higher than ferrites, making it ideal for the job. A prototype has been tested at a gradient of 10 kilovolts per metre.

Pierre Bricault of TRIUMF gave a rapid tour of the numerous radioactive beam facilities around the world. Their purpose is to produce intense beams of radioactive nuclei with extreme ratios of neutrons to protons. This allows a variety of research in pure and applied physics including the testing of nuclear models on unstable nuclei. TRIUMF's own radioactive beam facility, the Isotope Separator and Accelerator, ISAC, was presented by Paul Schmor. Primarily intended for studies in nuclear astrophysics, ISAC will deliver its first beams to experiments in 1999.

Perhaps the most versatile radioactive beam facility on the horizon is RIKEN's Radioactive Ion Beam factory, presented by Yasushige Yano. When complete in 2006, the facility will allow energies up to 400 MeV per nucleon to be produced in a range of over 2500 isotopes. A collider will also be built, making electron-ion collisions another attractive experimental avenue.

In Europe, CERN's REX-ISOLDE is less versatile than the RIKEN facility, but provides a specialized arena for studying neutron rich isotopes, according to Robert von Hahn of the Max Planck Institute in Heidelberg. The REX-ISOLDE hall is complete, and first beams are expected in 1999.

A more down to earth application was presented by TRIUMF's Bruce Milton. The Canadian laboratory in collaboration with America's Northrop Grumman has developed a new system for detecting concealed explosives and drugs. Since many such substances contain nitrogen, the system works by measuring nitrogen density. A 10 milliamp proton beam from a compact tandem accelerator is scanned across the interrogated package. 1.75 MeV protons are captured by carbon atoms releasing photons of 9.17 MeV which are resonantly reabsorbed in a 1 degree cone by nitrogen. A photon detector picks up these gammas, localizing regions of high nitrogen density. The main technical challenges were building a compact power supply for the tandem, and developing an electron-stripper. Due to the high currents, a foil was not practical, and a gas stripper has been developed. A prototype machine recently began tests at Northrop Grumman.

And so to New York

The growing importance of accelerators in many walks of life was reflected by the scale of the conference. Over 1200 delegates attended, and this review can only give a snapshot of the 76 invited papers, 120 contributed papers, and over 1300 posters presented. An important part of the proceedings was the election of new fellows of the APS and the IEEE, and the presentation of prizes. During the conference, Lawrence Berkeley's Andrew Sessler, who was awarded the prestigious Robert R. Wilson prize, gave an excellent review of the history of colliders from the early days at MURA to the LHC, and Linda Spentzouris from Northwestern University presented a new diagnostic technique based on non-linear phenomena in hadron beams which won her the APS award for outstanding doctoral thesis research in beam physics.

In the closing session, John Peoples looked forward to a new era of global collaboration in particle physics. His sentiments were echoed by Claus-Konrad Gelbke for the field of nuclear physics. Herman Winick speculated that in some not so distant future, the PEP ring, KEKB, and perhaps even the LEP tunnel might be converted for use as synchrotron light sources. Finally, Bill Weng pointed to an exciting future for ultra high intensity machines, with applications ranging from Spallation Neutron Sources to the Energy

Amplifier on the horizon. He predicted that the big topic in accelerator physics over the coming years will be halo studies aimed at keeping beam losses low. Bill Weng is organizer of the next PAC, to be held in New York in 1999. It was with relief and satisfaction that Michael Craddock handed on the chairman's bell, bringing the conference to a close.

By James Gillies

Did Sally Bowles really sing about quarks? Following the conference dinner and awards ceremony, Lynda Williams, the 'physics chanteuse', entertained delegates with a somewhat liberal interpretation of 'Cabaret'.

Spallation for Europe

A consortium of research institutions from seven European countries has completed a technical study for a next generation pulsed spallation neutron source - the European Spallation Source (ESS). In parallel the scientific case of neutron scattering methods and instrumentation has been assessed and the final reports covering the results of these studies have been released.

ESS has been costed with a 20% accuracy and presents in today's prices an investment for the source and neutron-scattering instrumentation of 935 million ECU (1400 million Swiss francs). The technical study has also identified further R&D work needed to complete the database for an engineering design and to reduce the technical risks associated with pushing the design beyond present-day technology. Five leading European institutions have agreed to go forward with a three-year R&D phase.

The neutron is a powerful and versatile probe of both the structure and dynamics of condensed matter, but contrary to other techniques, such as synchrotron radiation, its interaction with matter is rather weak. Neutron scattering has always been intensity limited and there remains a strong scientific incentive towards more intense sources.

There are two kinds of neutron sources: fission reactors; and accelerator-driven spallation sources where neutrons are produced by the interaction of GeV protons with a heavy material target. The power density in the core of high flux reactors is approaching a technical limit: further increases of neutron fluxes above the present values as represented, e.g. by the high flux reactor at ILL, Grenoble, are not expected.

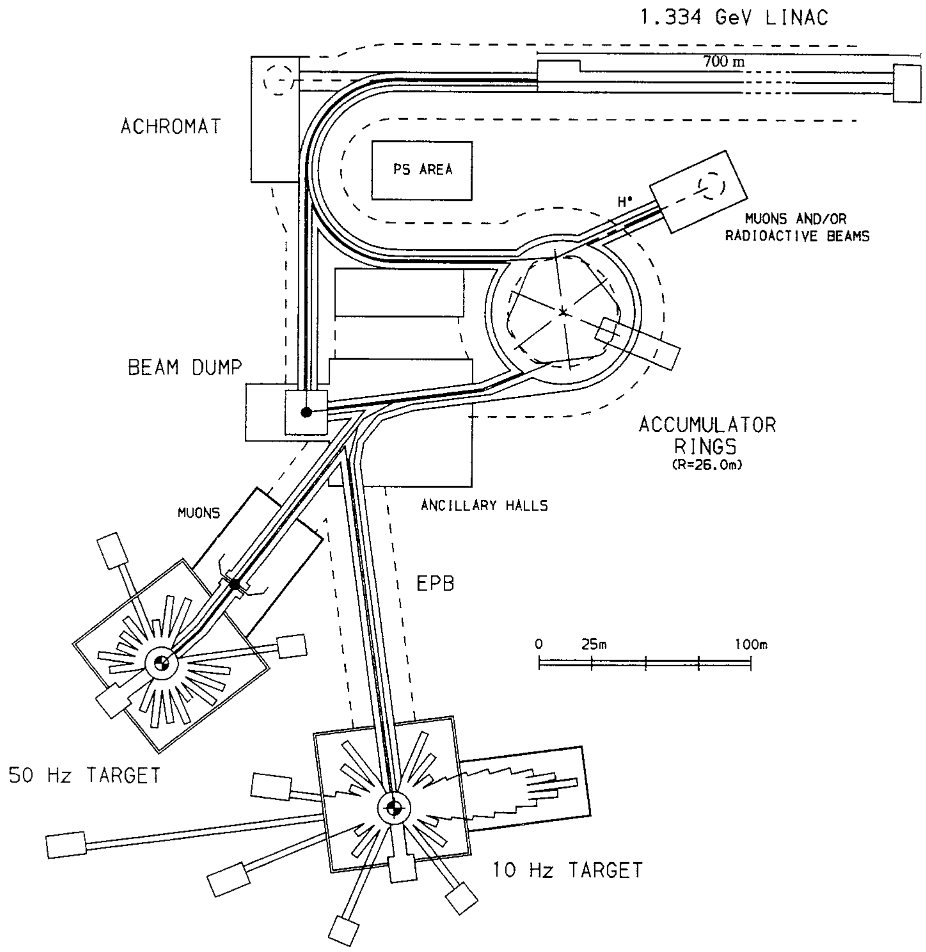
Accelerator-driven spallation sources have still a considerable development potential and have the additional advantage that they can be pulsed. By imposing a time structure on the proton beam, the neutron pulses can be compressed in a short time interval. Not only does this increase the peak intensities, but time-of-flight measurements can be used to determine incident neutron energies. It avoids the monochromatization used in continuous sources which decreases considerably the neutron intensity at the detector.

Time-of-flight measurements require very short pulse lengths (microseconds) and small repetition rates (less than 50 Hz) to avoid the overlap of slow neutrons from one pulse with fast neutrons from the next. For beam powers in the many 100 kW or MW range this goal cannot be achieved by a linear proton accelerator alone, and attention therefore turns to a pulsed linac combined with an accumulator or an accelerator ring filled by multiturn injection and emptied by fast one-turn ejection to reach the desired peak power and pulse lengths.

The last 20 years have seen a steady development of pulsed spallation sources at Argonne, Los Alamos, KEK (Japan) and the UK Rutherford Appleton Laboratory (RAL) where the most powerful source (ISIS) is operated with a beam power of more than 160 kW. Recently the SINQ continuous spallation source began operation at the Swiss PSI Laboratory with a beam power of 600 kW (March, page 2) to be upgraded to 900 kW.

Plans for even more powerful pulsed sources include the Austrian Austron (200 to 400 kW), KEK, and the Oak Ridge National Laboratory,

Neutrons as a powerful and versatile probe of both the structure and dynamics of condensed matter - schematic layout of the proposed European Spallation Source (ESS).



where a source of 1 MW with a possible later upgrade to 5 MW is under study.

The most ambitious project has been initiated in Europe - the European Spallation Source (ESS). In 1993, at the initiative of KFA, Jülich, and RAL, a collaboration was set up and soon joined by seven countries. From December 1994 to December 1996 the effort was supported by the European Community as a site-independent study. Similarly the scientific case for neutron scattering and instrumentation was supported by the European Science Foundation.

The following basic ESS parameters were proposed:

- 5 MW average beam power - 30 times that of ISIS, producing approximately 50% of the average thermal neutron flux at ILL with peak fluxes more than a hundred times higher;
- 1 microsec proton pulse length at the targets;
- two target stations, one operating at a repetition rate of 50 Hz up to 5 MW and a second at 10 Hz, 1 MW.

Accelerators

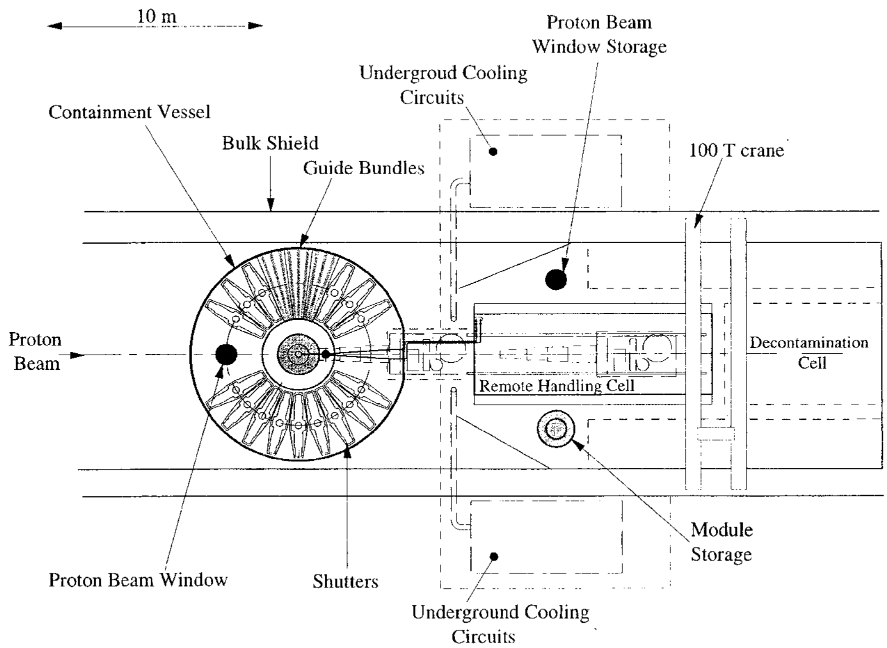
For the reference design, a proton energy range between 0.8 and 3 GeV was considered as a compromise between accelerator and target requirements as well as cost. There are a number of ways of meeting the short pulse specifications with a linac and either accumulator rings or with rapid cycling synchrotrons (RCS). The chosen accelerator option is a 1.334 GeV linac, which develops the full beam power of 5 MW at 50 Hz, followed by two accumulator rings which operate in parallel.

This combination has been selected because it is considered to be the most reliable option. The linac can be designed to avoid the space charge limit. The ring layout is simple, with constant field magnets, and the transverse space charge fields in the rings are relatively low. This layout is also thought to be near a cost minimum.

The dominant design principle for the accelerators and beam transfer lines is the minimization of beam losses, guaranteeing maintenance and repair at short notice and with short downtimes. Besides small beam losses (less than 1 nA/m) the linac has to be optimized for ring injection and this fixes most of its parameters.

Linac losses are reduced by the use of a double front-end and a funnel. This is also advisable for the negative hydrogen ion (H^-) sources which have not yet achieved the 140 mA peak currents at a duty cycle of 6% and at sufficiently low emittance. The front end is followed by a classical drift tube linac and a 700 MHz side-coupled linac accelerating particles to 1.33 GeV with an average accelerating field of 2.8 MV/m. This choice is based on an optimization of investment and operation cost. By increasing the tune with energy the linac operates in a non-space charge dominated regime. Extensive particle tracking predicts a small number of halo particles which are the dominant

Spallation source targets have to be robust. Each target station will be equipped for four moderators and will serve 18 neutron channels, some equipped with neutron guides.



sources of losses along the linac.

The option for a superconducting high energy linac section has also been studied although not yet in great detail. A frequency of 700 MHz and an average accelerating gradient of 8.3 MV/m is proposed. The reduced length and higher efficiency of the superconducting version could lead to substantial reduction of investments and operating cost.

Injection into the two rings will be by negative/positive hydrogen ion charge exchange using a thin foil. The injection scheme uses simultaneous 'painting' in the longitudinal and both transverse phase planes and reduces the average number of foil traversals (an important source of injection losses) to below 10. For sufficiently low injection losses, the halo of the injected H^- beam has to be carefully controlled and removed. A 180° achromatic bending region for momentum and transverse beam collimation is introduced in the transfer line between linac and rings. Extensive simulations have shown the viability of this design.

For the two accumulator rings (radius 26m, pulse duration 0.4 microsec) which have to handle 2.35 x 10^{14} circulating protons per bunch, minimization of losses around the rings and an efficient collection of losses in the injection and extraction region is crucial. Design values for uncollected losses are set as 500W per ring. The ring lattice contains six bends and six straight sections housing r.f., injection, extraction and beam collimation systems. A switchyard allows the extracted beam to be channeled to the two target stations. At the target an elliptical beam cross-section (200 x 60 mm2) is proposed.

The possibility of using the long linac pulse (1.2 ms) in combination with a third dedicated target station has been considered but not worked out in detail.

Targets

Targets have to withstand not only the large average beam power of 5 MW but also very short proton pulses (1 microsecond) with 100 kJ of energy. The deposited energy is absorbed predominantly elastically and produces shock waves in the target material. Targets are therefore subjected to a combined assault of high radiation damage, large temperature gradients and stress waves.

After an initial investigation of a water-cooled tantalum target, studies concentrated on a liquid metal target with horizontal beam injection. There are numerous arguments in favour of a liquid target - liquids are not affected by radiation damage, and thermal cycling and stress waves are confined to the target window and the target container. The absence of water cooling allows higher neutron yield and avoids electrolysis, corrosion and tritium production linked to the water circuits. Altogether a longer lifetime and a greater potential for high beam power is expected.

Mercury was chosen as a radically new target material instead of the earlier candidates of lead and lead/bismuth. Its rather high thermal neutron absorption rate is of no major concern for a pulsed source with short neutron pulses. An assessment of the hydrodynamical, thermal and neutronic properties of mercury and of material problems for windows and containers has shown the basic feasibility of a pulsed 5 MW source. Neutron yield calculations have shown that an increase of 30% can be expected compared to a water-cooled tantalum plate target with significantly less problems from afterheat.

Each target station will be equipped

Around the Laboratories

with four moderators and will serve 18 neutron channels, some equipped with neutron guides. Computed average thermal fluxes are 7 x 1014 n/cm^{2}s with peaks of 2 x 10^{17}n/cm^{2}s. With an expected 2000 neutron scattering experiments per year, the availability and reliability of the accelerators and target stations is of crucial importance and has greatly influenced the overall design.

The increase in source power and brightness will significantly improve the quality of condensed matter information. Time-of-flight methods will not only increase the efficiency of neutron use, but also allow a better signal-to-noise ratio. Experiments can be done for smaller samples, more complex structures or in more dilute systems. Time-dependent phenomena can be investigated more effectively.

Overall, a compelling new research scenario.

From Herbert Lengeler

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Vol. II - The scientific case
ISBN 090 237 6 608
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ISBN 090 237 6 659

from J. Kjems,
ESS Council Chairman,
Risø National Laboratory,
PO Box 49, 4000 Roskilde,
Denmark

CERN
LEP leaps back

With 1997 operation delayed after the recent fire (July, page 21), physics at CERN's LEP electron-positron collider recommenced in mid-July. After initial operation at the Z resonance, the machine, now equipped with 16 more superconducting radiofrequency modules, was ramped up to 92 GeV per beam, a new peak performance.

FERMILAB
Leptoquark limits

Leptoquarks are exotic particles predicted in many theories which extend the Standard Model, the current particle picture of six quarks and six leptons grouped pairwise into 'generations', the quarks interacting through the colour force and all particles interacting through the electroweak force.

A leptoquark (LQ) differs from all known particles because it carries both lepton number and colour. The absence of flavour-changing neutral currents constrains leptoquark decays to be within the same generation, i.e. a first generation LQ would decay to an electron or electron-neutrino, and either an up or a down quark.

When experiments at DESY's HERA electron-proton collider published their surprising excess of backward-scattered positron events earlier this year (April, page 1, and this issue, page 1), it led to speculation that the effect could be interpreted as being due to a particle mass of about 200 GeV. One explanation could be the appearance of a leptoquark decaying into a positron and a quark.

Because leptoquarks allow a direct interaction between leptons and quarks, it is natural to search for them in lepton-quark collisions such as those at HERA. However, if they exist, leptoquarks would also be produced in proton-antiproton collisions in Fermilab's Tevatron, where pair production of leptoquarks through the strong interaction is expected to dominate.

The two Fermilab collider collaborations, CDF and DZero, have carried out searches for leptoquarks using the data from the 1992-1996 Tevatron Collider Run. If leptoquarks exist in the mass range suggested by the HERA experiments, the Tevatron data should have shown signs of them.

The CDF collaboration had published a lower limit on the first-generation leptoquark mass in 1993 of 113 GeV, using 4 inverse picobarns of data from 1988-1989. The DZero collaboration had published in 1994 results using 13 inverse picobarns of data from the 1992-1993 run resulting in a lower limit on the first generation scalar leptoquark mass of 133 GeV. Preliminary results from a larger Dzero data set were presented earlier this year, raising the mass limit to 175 GeV.

Triggered by the news from DESY, both collaborations went into high gear to extend their limits. CDF rapidly analysed 110 inverse picobarns of 1992-1995 data. Their new leptoquark limit excludes scalar leptoquarks up to 210 GeV for a

100% branching ratio into electron-quark.

DZero used improved particle identification algorithms, optimized the sensitivity of the search to a particular LQ mass range, and performed a maximum resolution mass fit to candidate events. No candidates remained and in the scenario most likely to consistently explain the HERA data, the pure electron-quark decay of a leptoquark, the DZero result excludes masses of scalar leptoquarks up to 225 GeV.

These limits are insensitive to theoretical models, and combining the newly determined limits from the two experiments could push the limit to about 240 GeV, ruling out a simple leptoquark interpretation for the DESY excess (see page 1).

Main Injector milestone

In an important partnership with industry, Fermilab has completed construction of the dipole bending magnets for its new Main Injector ring.

With a total of 1,349 magnets, including 366 dipoles, the Main Injector will replace the Main Ring as the fourth stage of acceleration and the injector to the Tevatron, Fermilab's superconducting accelerator, providing higher luminosity, or number of particle collisions, to the experiments.

The total cost for dipole construction was about $30 million, with nearly 95% of the money going to the suppliers. The dipoles, which account for approximately two–thirds of the total magnet cost, came in under budget and three months ahead of schedule. This production process brought a new way of building magnets for the Laboratory, and Fermilab credits the five suppliers for the efficiency of construction and affordability.

Dipole design efforts began in 1989, and the first prototype was completed in September 1990, beginning a long research and development process. After numerous changes in design specifications, production began in earnest in early 1994.

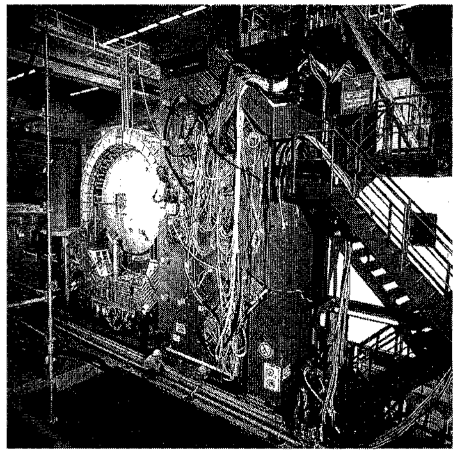
LTV, Inc. of Independence, Ohio, produced the steel, about 18 million pounds of it, and shipped it to Electro Metal Products of Skokie, Ill., who stamped it into laminations specified by Fermilab. SVF, Inc. of Rock Falls, Ill., stacked the laminations into the half-core, or shell, of the magnet and sent them to Fermilab. In parallel,

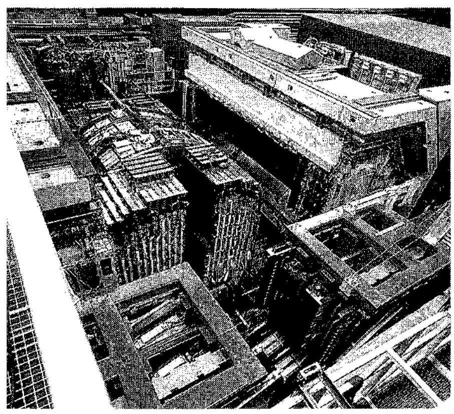
At a Fermilab event on 16 July, Injector Project Manager Steve Holmes explains how dipoles for the new Main Injector were completed ahead of schedule and under budget thanks to a successful technology transfer collaboration between Fermilab and industrial partners.

(Photo Jenny Mullins, Fermilab Visual Media Services)

Each of the 366 dipoles for the Fermilab Main Injector had its own design specifications paperwork, or "traveler", to ensure all design requirements were respected.
(Photo Fermilab Visual Media Services)

Whatever the outcome of the intriguing backward-scattered electrons which hint that something new might be going on at the quark level, the H1 (top) and Zeus (below) experiments at DESY's HERA electron-proton collider are already assured of a place in physics history having charted the quark-gluon structure of the proton in unprecedented detail.





Everson Electric of Bethlehem, Penn. wound copper coils and sent them to Tesla Engineering in England to be insulated. Fermilab completed the process by marrying the coils with the half-cores at the Laboratory. Design specifications paperwork, called "travelers", followed each component to ensure that all design requirements were respected.

Many of the suppliers said the partnership with Fermilab not only helped them improve their overall production processes, but added to their competitiveness by calling for new technologies, and with tight design specifications and controls.

DESY HERA vintage 1997

DESY's HERA electron-proton collider is operating with four experiments in parallel - the big H1 and Zeus detectors exploring electron-proton collisions, the Hermes study with a gas jet target in the electron ring, and the HERA-B using a wire target in the proton ring. DESY's Directorate Chairman Bjoern Wiik describes this achievement as a 'pleasant surprise'.

With more data under their belt, H1 and Zeus, running since 1992, are set to say more about the intriguing backward-scattered electrons which hint that something new might be going on at the quark level (April, page 1). Whatever the outcome, H1 and Zeus are already assured of a place in physics history having charted the quark-gluon structure of the proton in unprecedented detail.

Using polarized positron beams and running since 1995, Hermes is starting to make useful contributions to our still confused picture of what makes up the spin of the proton. HERA-B is the ongoing spearhead of an attack on the physics of B particles (containing the fifth, 'beauty' or 'b', quark). The apparatus is not yet complete, but test runs show that it appears possible to run such a complicated fixed target experiment so close to an operational collider. Running HERA with two collider experiments peacefully coexisting with two internal targets is a major achievement. For the long term future, one HERA possibility is to run with heavy ions.

HERA's electron ring is still handicapped by ion contamination problems and has to run with positrons. NEG (non evaporating getter) pumps, similar to those used at CERN's LEP electron-positron collider, will be installed in the HERA electron ring next winter. With HERA data so far using positrons, electron data will provide a useful comparison. In a bid to boost particle levels, HERA's radiofrequency and proton supply will be improved. Best luminosity (a measure of the collision rate) to date is 1.2×10^{31} per sq cm per s, approaching the design goal of 1.5×10^{31}. Accumulated HERA luminosity for this year should be twice last year's figure, thanks to a short winter shutdown and a rapid ensuing pickup, quickly reestablishing reliable operating conditions. New low-beta magnets will be installed in the winter shutdown 1999/2000 to compress the beams around the interaction points and further boost the collision rate.

One theme in upgrades for the big collision detectors is to improve precision and coverage in the forward electron (backward proton) direction, to pinpoint small momentum transfers where the behaviour of structure functions has proved especially interesting. On the other side of the coin, the unexpected back-scattered electron events reported earlier this year stirred up a hornet's nest of interest after particle physics had been devoid of surprises for so long. To confirm this effect as real physics or to discount it as a statistical fluctuation will require more attention at HERA.

DESY's status and future plans were extensively reviewed at a recent ECFA meeting at the laboratory.

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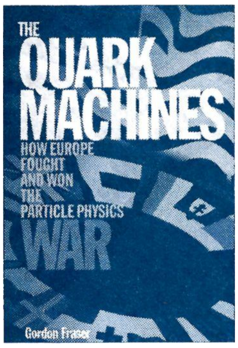

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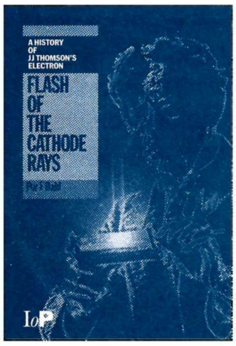

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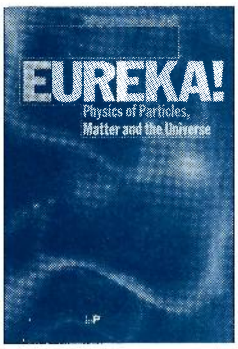

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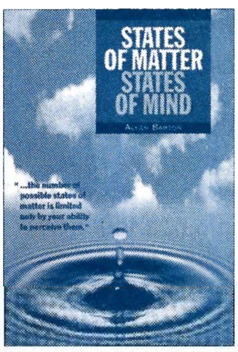

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The concept of fundamental nuclear forces emerged gradually during the start of the 1930's and reached our present level of description some time before the 1950's. The wish of the authors has been to make available to scholars a unified and comprehensive account of the history of this important part of the modern scientific world-view. This book thus represents a comprehensive, scholarly study of an important era in the development of modern physics. In addition, the sociological and philosophical aspects of the story are examined in the light of various theories of scientific development. The book contains analysis of published work, archival materials and original interviews.

Appealing primarily to historians of science and physicists interested in the roots of their field The Origin of the Concept of Nuclear Forces has been written by two of the foremost experts in this field.

Contents: Nuclear Forces Before the Neutron. Part A: Towards a Unified Theory of Nuclear Forces. Nuclear Structure and Beta Decay. The Fermi-field Theory. Cosmic Rays, Quantum Field Theories and Nuclear Forces. Part B: Yukawa's Heavy Quantum and the Mesotron. The Origin of Yukawa's Meson Theory. The Discovery of the Mesotron (1935-1937). The Development of the Vector Meson Theory in Britain and Japan (1937-38). Part C: The Meson Takes its Place Among the Elementary Particles. Decay of the Meson - Experiment Versus Theory (1937-41). The Meson Theory and Yukawa Circumnavigate the Globe. General Properties of Elementary Particles. Part D: Meson Physics from 1939 to 1950: the Meson Puzzle Resolved. Meson Theory During the War (West). Meson Physics During the War (East). The Meson Paradox is Resolved - and a Clear View of the Nuclear Forces Emerges. Epilogue. The Strong Nuclear Forces after the Pion. Bibliography. Index.

"A valuable insight into the history and confusion of an earlire epoch, full of historican anecdotes, providing a useful reminder that physics is human." CERN Courier

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✘ Effective Action in Quantum Gravity

I L Buchbinder, S Odintsov and I L Shapiro, Tomsk Pedagogical Institute, Russia

This book takes a unique and pedagogical approach to the topical area of quantum gravity and interacting fields in curved space. It assumes only a basic understanding of quantum field theory and general relativity. Beginning with simple examples, it progresses through more complex areas providing results of the latest research which support the effective action approach. Quantum interacting fields in curved space, renormalization and renormalization groups and quantum gravity in four and higher dimensions are explored.

Of great interest and value to advanced undergraduates, postgraduate students and researchers in theoretical high-energy physics, mathematical physics, relativity/gravitation and cosmology.

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✘ Ideas and Methods of Supersymmetry and Supergravity Or a Walk Through Superspace

I L Buchbinder and S M Kuzenko, Tomsk State University, Russia

This book provides a comprehensive, detailed and self-contained account of four dimensional simple supersymmetry and supergravity. It will be an indispensable source of reference for advanced graduate students, post-doctoral and faculty researchers alike working in quantum field theory, high energy physics, gravity theory, mathematical physics and applied mathematics.

The authors develop the subject in its superfield formulation but where appropriate for illustration, analogy and comparison with conventional field theory, they use the component formulation. Throughout the book the authors develop their material in detail with calculation and full discussions of the fundamental ideas and motivations. They discuss many subjects which until now could only be found in the research literature. In addition they present a plethora of new results. The result is the most comprehensive book yet produced on the fundamentals of supersymmetry and supergravity. After studying this book readers should be well prepared to pursue independent research in any area of supersymmetry and supergravity.

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✗ Proceedings of the XXVII International Conference on High Energy Physics, 21-27 July 1994, Glasgow, Scotland, UK (2 Volume Set)

Edited by P Bussey and I Knowles, Department of Physics and Astronomy, University of Glasgow, UK

Contains the invited and contributed papers from the 1994 "Rochester" conference on high energy physics. This most prestigious of the international conferences on high energy physics brought together over 1000 researchers in the field from leading universities and centres in 47 countries throughout the world. The invited papers contain comprehensive reviews of the latest situation in topics of current interest while the contributed papers give details of recent research results.

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✓ Neutrons, Nuclei and Matter

An Exploration of the Physics of Slow Neutron

J Byrne, University of Sussex, UK

Foreword by J M Robson, Emeritus Professor, McGill University, Canada

Neutrons, Nuclei and Matter is an encyclopedic work of reference coverin almost every conceivable aspect of neutron physics.

This is a major new compilation of fundamental properties and interactions, detailing both the neutron's role as a major element in tests of the Standard Model of astro-particle physics and its use in nuclear energy ge eration and the study of condensed matter systems.

The author, inventor of the Penning trap method for determining neutron lifetime, has produced a book that will interest anyone who uses the neu tron as a research tool or who attempts to investigate its nature either experimentally or theoretically. Jim Byrne has worked in neutron physics and allied areas for over thirty years and is a world authority in the field.

Neutrons, Nuclei and Matter differs from previous books. It does not restrict itself to interactions with nuclei, nor to applications, but includes detailed treatments of topics such as the strong, weak and electromagne ic properties of neutrons. Parallel developments in cosmology and astrophysics are also explored.

The book looks at the growth in interest in the wave properties of neutro following the development of the perfect crystal interferometer, and the way that this instrument has made it possible to demonstrate quantum behaviour very directly.

Everything has been placed in context within science as a whole, with dis cussion of the origins of different ideas and considerable attention to his torical detail.

"Jim Byrne's book is a must for libraries of all universities and laboratori which are engaged in nuclear physics, particle physics, nuclear energy, astrophysics or condensed matter research.....In this era of savage spec ization, it is heartening to see a book which contains enough matter for a dozen modern specialists, no two of which would be likely to find a subje of common interest to discuss.....Jim Byrne's Neutrons, Nuclei and Matte is an outstanding multidisciplinary introduction to the physics and applic tions of cold neutrons." **Physics World**

"It will also be of value for those engaged in any facet of neutron physics research, for Neutrons, Nuclei and Matter provides a first-principles disc sion of the fundamental neutron interactions... the writing is clear, and t explanations stress essential physical principles....The choice of materia Neutrons, Nuclei and Matter provides an excellent survey." **Physics Tod**

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American Scientist.

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Text

Symmetries in Quantum Mechanics:
from Angular Momentum to Supersymmetry

M Chaichian, University of Helsinki, Finland and R Hagedorn, CERN, Switzerland

This book provides a thorough, didactic exposition of the role of symmetry, particularly rotational symmetry, in quantum mechanics. The bulk of the book covers the description of rotations (geometrically and group-theoretically) and their representations, and the quantum theory of angular momentum. Later chapters introduce more advanced topics like supersymmetry, anyons, fractional spin and statistics. Everything is explained clearly and in depth making the book ideal for use as a course text for postgraduate and advanced undergraduate students specialising in theoretical physics. The book will also be useful for researchers looking for an accessible introduction to this important area of quantum theory.

Contents: Introduction. Symmetry in quantum mechanics. Rotations in three-dimensional space. Angular momentum operators and eigenstates. Addition of agular momentum. The representation D(j) of the rotation group. The Jordan-Schwinger construction and representations. Irreducible tensors and tensor operators. Peculiarities of two-dimensional rotations: anyons, fractional spin and statistics. A short glance at relativistic problems. Supersymmetry in quantum mechanics and particle physics. Appendices.

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Text

Hadron Interactions

P D B Collins and A D Martin, University of Durham, UK

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Intended for graduate students, advanced undergraduates and research staff in particle physics and related disciplines and will also be of interest to physicists not working in this field who want an overview of the present development of the subject.

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Flash of the Cathode Rays: A History of J J Thomson's Electron

P F Dahl, Lawrence Berkeley National Laboratory, USA

The electron is fundamental to almost all aspects of modern life. It controls the behaviour of atoms and how they bind together to form gases, liquids and solids.

Flash of the Cathode Rays tells the compelling story of the discovery of the electron and its elucidation as the first subatomic particle in nature. The book traces the evolution of the concept of electrical charge, from the earliest glow discharge studies to the final cathode ray and oil drop experiments of J J Thomson and Robert Millikan. It also provides an overview of the history of modern physics up to the advent of the old quantum theory around 1920.

Here you will find described, in Dahl's engaging style: the Continental and English race for the source of the cathode rays, culminating in Thomson's corpuscle in 1897; subsequent events leading to Millikan's unambiguous isolation of the electron; the simultaneous circumstances surrounding the birth of Ernest Rutherford's nuclear atom; the discovery of radioactivity in 1896; and the controversies over N-rays, Becquerel's positive electron and the famous Ehrenhaft-Millikan dispute over subelectrons.

The book consolidates recent scholarly material and incorporates new material uncovered by the author in historical archives primarily at Cambridge University. Dahl's account is scholarly, yet accessible to general readers with a basic knowledge of physics. Thus it should be of interest to historians of science, professional scientists and engineers, teachers and students of physics, and general readers interested in the development of modern physics.

Contents: J J Thomson and his contemporaries. Electromagnetic phenomena unravelled. Cathode rays take center stage. The English get going. Meanwhile, back in Berlin. The English keep going. From Paris to the Scottish highlands. From Liverpool to Princeton. The race for e/m. The charge and the mass. Leiden, 1896. The photoelectric effect revisited. The Beta particle. Evanescent rays: A French cottage industry. Positive rays. The electronic charge revisited, and one more controversy. Dawning of the atomic age. Epilogue: The next twenty years.

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✘ Superstrings and Supergravity

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✘

Radioactive Nuclear Beams 1991
Proceedings of the second international conference on radioactive nuclear beams, Louvain-la-Neuve, Belgium, August 19-21, 1991

Edited by Th Delbar, Université Catholique de Louvain, Belgium.

"Anyone seriously interested in the future of basic or applied nuclear physics should insist that there is a copy in their library"
Journal of Physics G

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✘ The Quark Confinement Model of Hadrons

G V Efimov and M A Ivanov, Joint Institute for Nuclear Research, Dubna, Russia

This book is devoted to a recently developed model of quark interactions, and deals with confinement effects in the low energy region of particle physics. It offers a unified treatment of several low energy phenomena, and valuable insight into problems related to the treatment of large distances with quantum chromodynamics. The book usefully fills a gap in recent works on low energy quark models, and will be of use to researchers and graduate students in both high energy and nuclear physics.

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G Fraser

The creation of CERN, the huge European particle accelerator laboratory which straddles the Swiss-French border near Geneva, has been one of the greatest triumphs of modern European science and co-operation, however its history has not been without controversy. This extensively illustrated popular science book written by the editor of the CERN Courier (CERN's in-house magazine) explains, in a clear and simple manner, the history and politics which have surrounded CERN from its original inception throught to its current research programmes.

Written in a lively, nontechnical and engaging style, the book will appeal to anyone interested in CERN, the work which has been conducted there and the trans-Atlantic rivalry which has spurred on much of its research.

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V L Ginzburg, P N Lebedev Physical Institute, Moscow, Russia and V N Tsytovich, General Physics Institute, Moscow, Russia

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✔ Electromagnetic Properties of High Spin Nuclear Levels

Proceedings of the Workshop held at the Weizmann Institute of Science, Rehovoth and at Ein Bokek

Edited by G Goldring and M Hass, Weizmann Institute of Science, Rehovoth, Israel

Annals of the Israel Physical Society Volume 7

1984 347 pages illustrated hardcover 0 85274 775 6 £39.00/US$70.00

Not available from Institute of Physics Publishing in Israel. Please contact Israel Physical Society

✘ Ultra-Cold Neutrons

R Golub, Hahn Meitner Institute, Berlin, Germany, D Richardson, University of Southampton, UK and S K Lamoreaux, University of Washington, Seattle, USA

This book is a complete and self-contained introduction and review to the field of UCN physics. It provides an insight into the many exciting and expanding areas of UCN research and covers existing and emerging applications.

The wide applications of UCN to both fundamental physics and condensed matter physics are covered in considerable depth. The historical development of the field is also discussed.

A useful compendium of results and techniques for postgraduates and researchers in fundamental and condensed matter physics. Of general interest to non-specialists in other areas of research.

"An excellent introduction to the production, handling, and uses of UCN. Focusing heavily on experimental work...with considerable attention to recent measurements and advances in UCN technology, this work is current and accessible to the nonspecialist...Those engaged in the planning of neutron facilities as well as potential users will benefit from this concise overview. It will be of particular interest to members of the neutron scattering community concerned with extending the applicability of their field." Science

"An excellent account of the development of UCN techniques...They have included a discussion of the theory of the interactions between neutrons and materials at a level suitable for postgraduate students and research workers, an essential part of the book...an informative account of past achievements in this limited field of physics and their very effective presentation of basic concepts and possible developments will be of great help to researchers who want to use UCN to study further the fundamental properties of the neutron." Contemporary Physics

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✗ The Weak Interaction in Nuclear, Particle and Astrophysics

K Grotz and H V Klapdor, Max-Planck Institut für Kernphysik, Heidelberg, Germany

This book forms a comprehensive presentation of the concepts of the weak interaction and its integration into modern theories of particle physics. It outlines the close connections between nuclear and particle physics, astrophysics and cosmology induced by the weak interaction.

Particular attention is given to the treatment of neutrinos and to research in this field. For graduate and postgraduate students and researchers in nuclear, particle and astrophysics.

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✗ Geoelectromagnetic Waves

A V Guglielmi and O A Pokhotelov, Institute of the Physics of the Earth, Russia

'Geoelectromagnetic Waves', a term coined for the first time in this book, examines waves of natural origin (both terrestrial and extra-terrestrial) which disturb the electromagnetic field of the Earth. The Earth's crust and ocean, atmosphere and ionosphere, magnetosphere and interplanetary medium are filled with waves of various lengths and frequencies and the study and observation of these waves allows us to better understand the world in which we live, thus providing the basis for useful practical applications.

This book provides a comprehensive and unifying treatment of the origin and application of geoelectromagnetic waves. Throughout the work the authors demonstrate a physical understanding of the phenomena with theoretical results compared against ground and satellite based data. In this way a practical picture is built up of the effects of geomagnetic pulsations.

Contents: Notation. Introduction. The Earths crust. Ocean. Atmosphere and ionosphere. The magnetosphere. Modulation. Instability. Nonlinearity. Fluctuational and critical phenomena. Hydromagnetic diagnostics and geoelectric prospecting. Epilogue: Geoelectromagnetic waves and man. Addenda. References. Index

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✗ Nuclear Physics in the Universe
Proceedings of the First Symposium on Nuclear Physics in the Universe held in Oak Ridge, Tennessee, USA, 24-26 September 1992

Edited by M W Guidry, Theoretical and Computational Physics Section, Oak Ridge National Laboratory, USA and M R Strayer, Department of Physics, University of Tennessee, USA

Interest in the interface between nuclear structure and nuclear astrophysics has been growing, following the development of new radioactive beam experimental facilities. These conference proceedings focus on new developments in the area, and particularly on the nuclear physics of the synthesis of the elements in the early stages of the universe.

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✓ Basic Ideas and Concepts in Nuclear Physics

K Heyde, Institute for Theoretical Physics and Nuclear Physics, Rijksuniversiteit Gent, Belgium

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A text aimed at final year undergraduates and postgraduate students, this volume has evolved from a course taught by the author and gives a balanced account of both theoretical and experimental nuclear physics. It is also ideal for researchers wanting an accessible introduction to the subject.

Emphasis is given to depth of treatment rather than skimming over topics and there are many diagrams as well as box inserts illustrating particular topics.

Contents: Part A: Knowing the nucleus: The nuclear constituents and characteristics. Nuclear global properties. General nuclear radioactive decay properties and transmutations. Part B: Nuclear interactions: strong, weak and electromagnetic forces. General methods. Alpha-decay: the strong interaction at work. Beta-decay: the weak interaction at work. Gamma decay: the electromagnetic interaction at work. Part C: Nuclear structure: an introduction. The liquid drop model approach: a semi-empirical method. The simplest independent particle model: the Fermi-gas model. The nuclear shell model. Part D: Nuclear structure: recent developments. The nuclear mean-field: single-particle excitations and global nuclear properties. The nuclear shell model: including the residual interactions. Collective modes of motion. Deformation in nuclei: shapes and rapid rotation. Deep inside the nucleus: subnuclear degrees of freedom and beyond. Outlook: the atomic nucleus as part of a larger structure. Appendices. Index.

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✗ Nuclei in the Cosmos
Proceedings of the Second International Symposium on Nuclear Astrophysics, held in Karlsruhe, Germany, 6-10 July 1992

Edited by F Käppeler, Institut für Kernphysik, Karlsruhe, Germany and K Wisshak, Institut für Kernphysik, Karlsruhe, Germany

This conference brought together astronomers, astrophysicists and nuclear physicists for a thorough discussion of nucleosynthesis, its role in the evolution of the universe and its intriguing possibilities as a diagnostic tool for stellar interiors. Nineteen invited papers provide a good review of nucleosynthesis topics conveniently gathered together in one volume.

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✓ Particle Astrophysics

H V Klapdor-Kleingrothaus, Max-Planck-Institut für Kernphysik, Heidelberg, Germany and K Zuber, University of Dortmund, Germany

As high energy particle physics experiments become increasingly difficult and expensive in conventional laboratories more and more researchers are turning to the cosmos to find examples of high energy particle physics.

Conceived as a more specialised follow-up to one of the author's earlier works (Non-Accelerator Particle Physics by Klapdor-Kleingrothaus and Staudt) this book gives a graduate level account of the physics of particle astrophysics and should prove extremely useful for researchers working in this rapidly expanding field.

Contents: The standard model of particle physics. Grand unified theories (GUTs). Cosmology. Primordial nucleosynthesis. The cosmological constant. Large scale structures in the universe. The cosmic background radiation. Cosmic radiation. Dark matter. Magnetic monopoles. Axions. Solar neutrinos. Neutrinos from supernovae. The creation of heavy elements. References.

September 1997 c500 pages
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✘ Non-accelerator Particle Physics

H V Klapdor-Kleingrothaus, MPI für Kernphysik, Heidelberg, Germany and A Staudt, Bayer AG, Leverkusen, Germany

The past decade has seen the emergence and rapid development of particle physics experiments performed in underground laboratories and other non-accelerator installations. Such work allows profound questions of particle physics beyond the capabilities of modern accelerators to be attacked.

At a time when elementary particle physics has reached a stage at which it places extreme requirements on new generations of accelerators, such work increases in importance. This book provides a comprehensive and accessible introduction to this interdisciplinary field of physics, bringing together research in particle and nuclear physics with astrophysics and cosmology.

The first three chapters describe the current Standard Models of particle physics and cosmology, including an account of the limitations of particle accelerators and the need for non-accelerator experiments to tackle many unsolved problems in fundamental physics and astrophysics.

Chapters 4-12 discuss in detail major open questions including proton decay, neutron oscillations and electric dipole moment, neutrino mass, double beta decay, neutrino oscillations, magnetic monopoles, dark matter, fractionally charged particles, the fifth force, and time dependence of natural constants. Each chapter gives the theoretical background and discusses experimental techniques currently being used or planned.

"... a remarkably complete overview ... Anyone interested in non-accelerator particle physics should at least have a look at this superb book."
Physicalia

This book is an outstanding and timely volume ... Virtually no topic of interest has been left out ... it is a superb new addition to the field of particle theory and phenomenology and it fills a gap in the literature in the field. It can be wholeheartedly recommended to all practising and aspiring particle physicists." **Journal of Physics. G**

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✘ Superheavy Elements

K Kumar, Tennessee Technological University, USA

Since the Manhattan Project nuclear chemists and physicists have been synthesising new elements. The periodic table has slowly been extended from the heaviest naturally occurring element uranium 92 to element 109. Around 15 years ago it was proposed that there might exist an island of relatively stable superheavy elements with atomic masses around 114 or 126. Various false reports of discovery sparked intersetion in the 1970's but failure to discover superheavy elements and a realisation of the difficulties faced in synthesising them led to a decline in this interest.

Today the search is still on; theoreticians and experimentalists are looking for these superheavy element. No one has cast serious doubt that there would be an island of relative stability, but where it is or whether the stability will be sufficient for the new elements to survive long enough has not established.

"This book represents probably one of the most complete works on SHE and is highly recommended for nuclear theorists and experimentalists. might well prove to be a turning point in the discovery of SHE!"
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Text

✔ A Unified Grand Tour of Theoretical Physics

I D Lawrie, University of Leeds, UK

A conducted grand tour of the fundamental theories which shape our modern understanding of the physical world. This book covers the central themes of spacetime geometry and the general-relativistic account of gravity; quantum mechanics and quantum field theory; gauge theories and the fundamental forces of nature, statistical mechanics and the theory of phase transitions. The basic structure of each theory is explained in explicit mathematical detail with emphasis on conceptual understanding rather than on the technical details of specialized applications. Straightforward accounts are given of the standard models of particle physics and cosmology, and some of the more speculative ideas of modern theoretical physics are examined.

This book is unique in bringing together the diverse areas of physics which are usually treated as independent. Designed to be accessible to final year undergraduates in physics and mathematics and to provide first year graduate students with a broad introductory view of theoretical physics, it will also be of interest to scientists and engineers in other disciplines who need an account of the subject at a level intermediate between semi-popular and technical research.

"The book is laced with penetrating little insights delivered with a wry wit which makes for an entertaining read"
The Times Education Supplement

"...it is perfect for an ambitious graduate student, an adventurous scientist in another field or even an ageing physics professor who has devoted himself to a speciality and would relish an excursion into unfamiliar territory
Physics Today

"Will be uniquely valuable in assisting and encouraging our graduate students...to see and exploit the fertile connections and analogies between different sub-disciplines, so that we all become better theoretical physicists." **Contemporary Physics**

"...recommended to everyone who wants to get an understanding of the modern theories of the early universe that goes well beyond a semi-popular account without requiring a full-scale assault on the technical literature." **Zentralblatt für Mathematik und ihre Grenzgebiete/ Mathematics Abstracts**

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✓ Electron Positron Physics at the Z

S L Lloyd, Queen Mary and Westfield College, UK, M G Green, Royal Holloway and Bedford New College, UK, P N Ratoff, University of Lancaster, UK, and D R Ward, University of Cambridge, UK

This book provides a comprehensive summary of studies of the Z boson in electron positron interactions. The results that have been obtained have achieved unprecedented accuracy and have firmly established the Electroweak Standard Model as the cornerstone of our current understanding of modern particle physics. The book introduces the background to the Standard Model and the role of the Z boson and describes briefly the accelerators and experiments involved in these results.

The five main chapters deal with the detailed measurements of the electroweak parameters of the Z, the study of QCD, heavy quark physics, tau lepton physics and the search for new particles.

Finally there is a summary and outlook to prospects of future accelerators. Most of the results are from the first six years running at the first phase of electron positron collider, LEP, at energies corresponding to the Z mass, but results from the SLAC Linear Collider and some new results at higher energies are also included.

December 1997 hardcover c300 pages illustrated
0 7503 0383 2 c£60.00/cUS$120.00

✓ Nuclear and Particle Physics 1993

Proceedings of the conference held in Glasgow, UK, 30th March - 1st April 1993

Edited by I J D MacGregor and A T Doyle, Department of Physics and Astronomy, University of Glasgow, UK

Institute of Physics Conference Series 133

1993 288 pages illustrated hardcover 0 7503 0289 5 £91.00/US$182.00

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✓ Photoelectronic Image Devices

Proceedings of the 10th Symposium on Photoelectronic Image Devices, 'the McGee Symposium' held 6 September 1991 at Imperial College

Edited by B Morgan, The Blackett Laboratory, Imperial College, UK

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1992 456 pages illustrated hardcover 0 85498 411 9 £94.00/US$188.00

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✓ EPAC 96

Fifth European Particle Accelerator Conference, Sitges (Barcelona), 10 to 14 June 1996

Edited by S Myers, CERN, Geneva, A Pacheco, IFAE, Barcelona, R Pascual, UAB, Barcelona, Ch Petit-Jean-Genaz, CERN, Geneva, and J Poole, CERN, Geneva

This set of three volumes, (also available on a CD-ROM provides a comprehensive overview of research, technology and special applications in the field of accelerators. It serves as a source for novel ideas and will familiarise researchers with advanced concepts. In order to reflect current developments of particular interest to the accelerator community three mini-sessions outlined the state of the art in third generation synchrotron radiation devices, linear collider test facilities, and superconducting accelerator systems.

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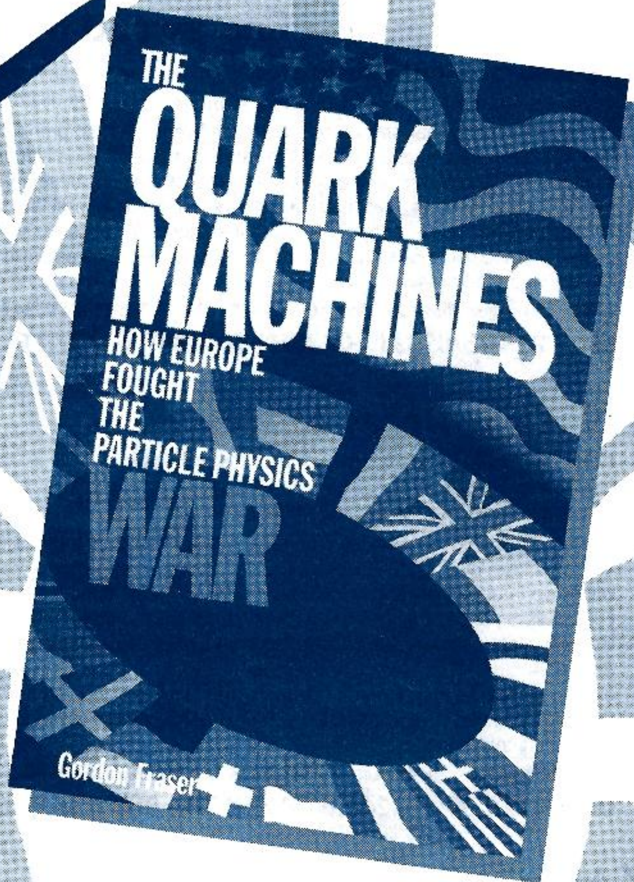

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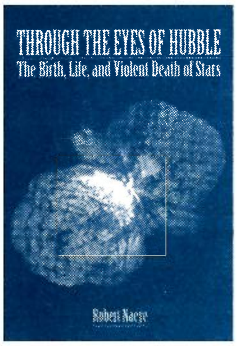

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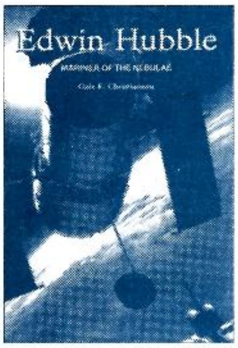

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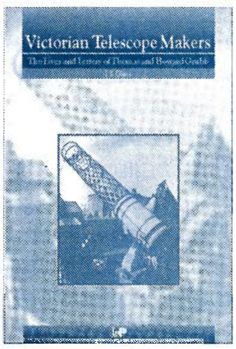

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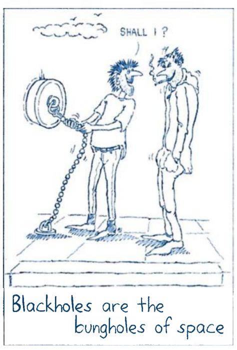

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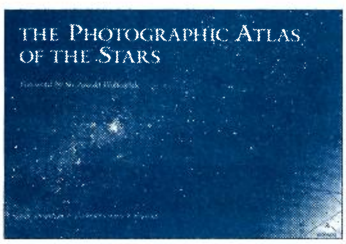

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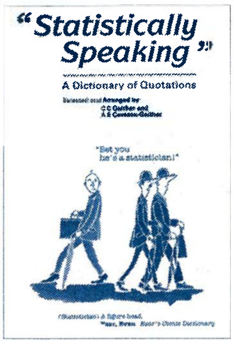

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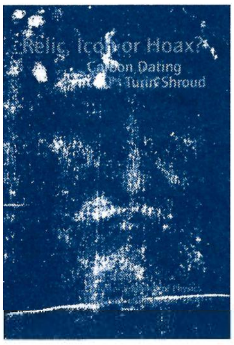

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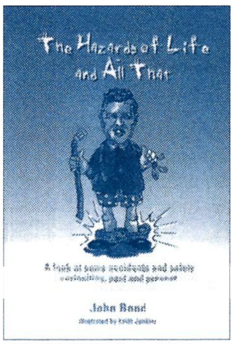

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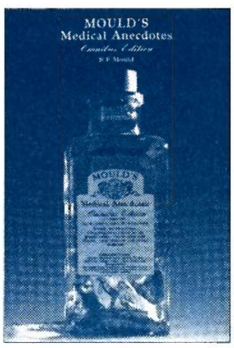

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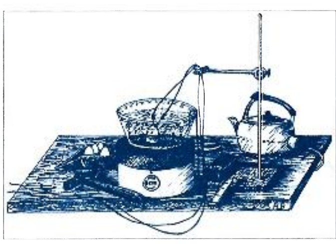

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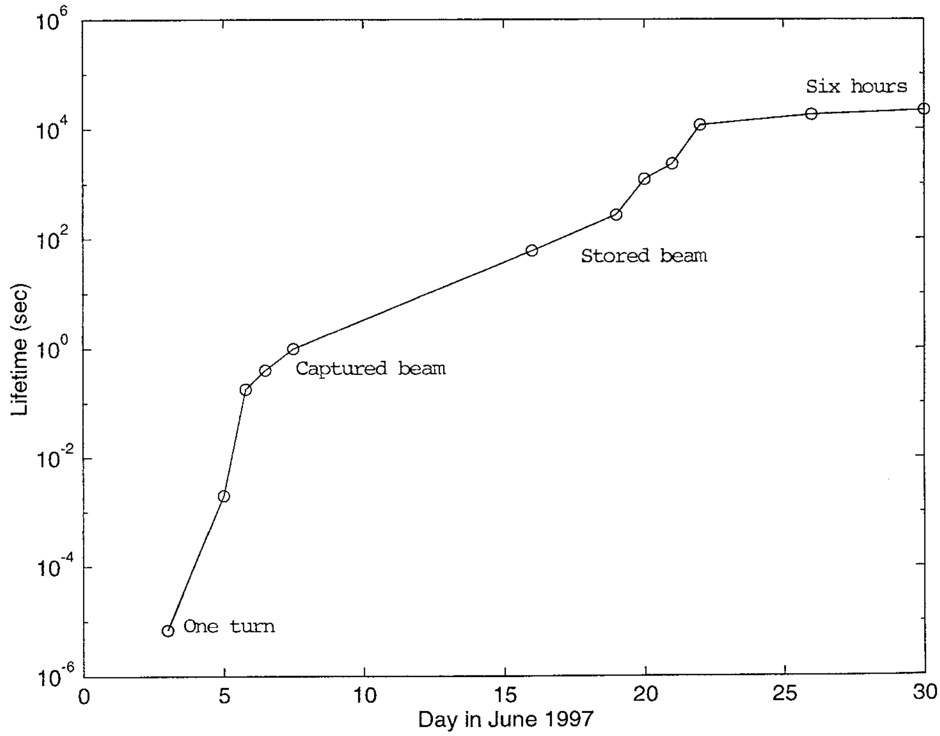
Lifetime of the electron beam in the High Energy Ring of the PEP-II B Factory at the Stanford Linear Accelerator Center (SLAC). The maximum lifetime of six hours was achieved with currents of about 40 ma.



STANFORD B Factory off to a great start

The commissioning of the PEP-II B Factory at the Stanford Linear Accelerator Center (SLAC) is off to an auspicious start. Stored currents of 60 milliamps were achieved in June, distributed among 18 bunches of electrons that circulated for nearly an hour in its high-energy ring (HER). Beam lifetimes of up to 6 hours were achieved at lower currents, and as many as 1000 bunches have circulated simultaneously.

Built using refurbished magnets from the original PEP storage ring but with new vacuum, radiofrequency and control systems, the high-energy, electron ring was completed in late May with insertion of a "golden bolt" by HER system manager Uli Wienands. A temporary transport line was set up in the interaction region where the BaBar detector (September 1995, page 16) will eventually sit. By June 5 an injected bunch of electrons had circulated for 13 turns with the r.f. power off. With two (of the eventual five) r.f. stations turned on and the beam energy set at 8.5 GeV, the lifetime inched up to a minute by June 16 and to 35 minutes five days later.

At that point the commissioning team, led by John Seeman, discovered that the sextupole magnets in the ring had all been systematically wired with the wrong polarity! After correcting this problem, they found that the beam lifetime exceeded 3 hours. They spent the remainder of June storing multiple bunches, boosting stored currents, and making various tests to understand the detailed optics of their magnet system. The control system, an extension of the control system of the SLC Stanford Linear Collider, worked very well, allowing position and beam-loss monitors to work from day one. Initial tests of the longitudinal and transverse bunch-to-bunch feedback systems were also successful. The per-bunch current has exceeded the design level required for full multi-bunch operations, indicating that there are no serious single-bunch instabilities.

Installation of magnets and vacuum chambers for the low-energy, positron ring is now under way, led by Tom Elioff of the Lawrence Berkeley Laboratory, with its commissioning scheduled for April 1998. Another round of operations on the high-energy ring will begin in September, this time with the full complement of r.f. stations powering its intense electron beam. The major goal of that run will be to boost the circulating current towards 500 ma.

Led by Jonathan Dorfan, the collaboration of scientists and engineers from Berkeley, Livermore and Stanford that is building the B Factory can be duly proud of their achievements. This upgrade of the PEP ring, funded by $177 million from the US Department of Energy, has proceeded on budget and on schedule — and so far shows every sign of performing as designed.

"The early performance of the high-energy ring has exceeded even our own lofty expectations," said Dorfan. "Most encouraging has been the robustness of all the hardware and the efficacy of the diagnostics. The PEP-II team has performed outstandingly well."

CERN
A wind of change for ISOLDE

Cold and dry, the Mistral blows south along France's Rhone valley, but this year it has lent its name to a new experiment at CERN's ISOLDE isotope separator. MISTRAL is abbreviated from the less romantic title 'Mass measurements at ISOLDE using a Transmission RAdio frequency spectrometer on-Line'. It can measure the masses of nuclides with half-lives under a second, and will see its first beams towards the end of this year.

Precise determination of atomic masses is important in fields as diverse as metrology, weak interaction physics, nuclear structure and stellar nucleosynthesis. The latter two, of particular interest to MISTRAL, require measurements of isotopes far from the so-called valley of stability. Such short-lived isotopes can only be investigated at facilities like ISOLDE.

MISTRAL works by comparing the frequency of revolution (cyclotron frequency) of an unknown mass in a uniform magnetic field with that of a reference mass. Ions are injected into the spectrometer and vertically deflected so that they make two spiralling turns inside the magnetic field. An applied radiofrequency voltage perturbs the trajectories of the ions such that only those with a particular mass escape from the spectrometer through a narrow slit. By varying the applied radiofrequency and counting the transmitted particles, precise mass measurements can be made. The resolution of the spectrometer can cleanly separate the transmitted peaks of isobars - radioisotopes of different elements with the same mass number.

With a transmission time of only about 50 microseconds, MISTRAL can measure very short-lived ions, the only limitation being the ISOLDE target release time. ISOLDE's prolific production will allow new mass measurements to be made on isotopes with half-lives down to milliseconds.

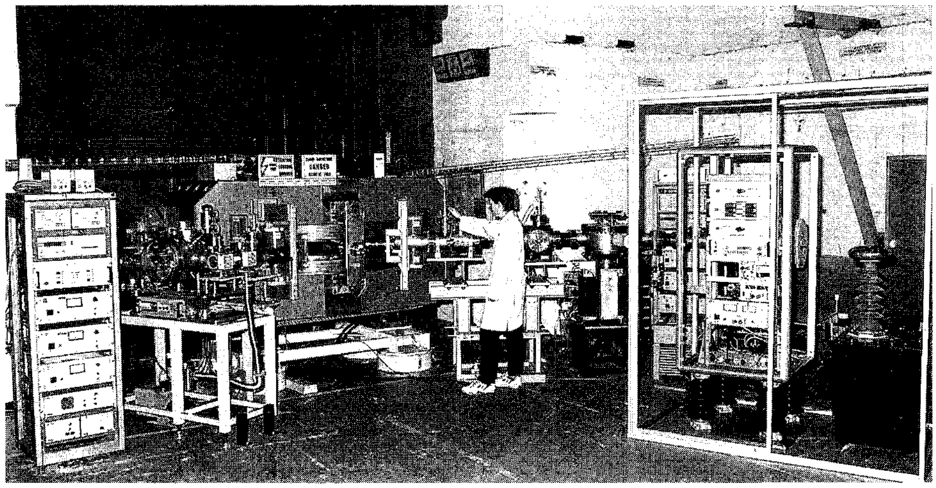
MISTRAL's ability to measure very short-lived isotopes means that it will complement existing mass measurement programmes, such as ISOLTRAP on a neighbouring beamline at ISOLDE. This tandem arrangement of Penning traps measures masses with unprecedented accuracy down to half-lives of about one second. MISTRAL will also build on results from other spectrometers like the cyclotron at France's GANIL facility which has already provided some data on very short-lived isotopes.

In 1996, the spectrometer underwent preliminary tests at the French Orsay Laboratory before being transferred to CERN in May this year. The initial programme will keep the collaboration busy for several years, but future developments at ISOLDE promise new possibilities. Cooling of the ion beam would allow either the slit size to be reduced, improving mass resolution, or higher transmission and hence, greater sensitivity.

Another improvement could come when ISOLDE's post accelerator, REX-ISOLDE, comes on-line in 1999. Highly charged isotopes from REX-ISOLDE would allow a wider range of masses to be measured without reconfiguring the spectrometer between runs.

A previous incarnation of the spectrometer was used in a pre-Penning trap era attempt at CERN's LEAR low energy antiproton ring to measure the proton-antiproton mass difference.

Mass measurements at ISOLDE using a Transmission RAdio frequency spectrometer on-Line - the MISTRAL spectrometer, seen here at Orsay, France, before its move to CERN's ISOLDE isotope separator in May.



SPACE
AMS: particle physics in space

The Alpha Magnetic Spectrometer, AMS, is about to take a giant leap for particle physics when it flies on the Space Shuttle next year. AMS (November 1995, page 8) is designed to look for antimatter in space. The project is headed by Nobel prize winner Sam Ting and involves researchers from Beijing in China to Turku in Finland giving the experiment an appropriately global nature.

NASA is the major contributor, providing the initial shuttle flight and subsequently three years aboard the International Space Station Alpha. The detector itself is largely being built in Europe, whilst European and Chinese space science laboratories ensure its spaceworthiness.

According to Big Bang theory, matter and antimatter were created in equal amounts. Fortunately for us a delicate imbalance has left behind only matter, at least in the vicinity of our Galaxy. But there's nothing to say that this imbalance happened everywhere, or that it happened in the same way all over the Universe. Perhaps there are entire galaxies made of antimatter. The only way to find out is to look for antimatter in space. Another AMS goal is to look for signs of supersymmetric particles which could show up via their antimatter-producing decays.

The AMS detector appears relatively modest compared to the terrestrial behemoths which populate accelerator laboratories. Weighing just two tonnes, it consists of a permanent magnet instrumented with silicon detectors, scintillators, and a Cerenkov detector. But appearances can be deceptive, and AMS is far more sophisticated than this tally suggests.

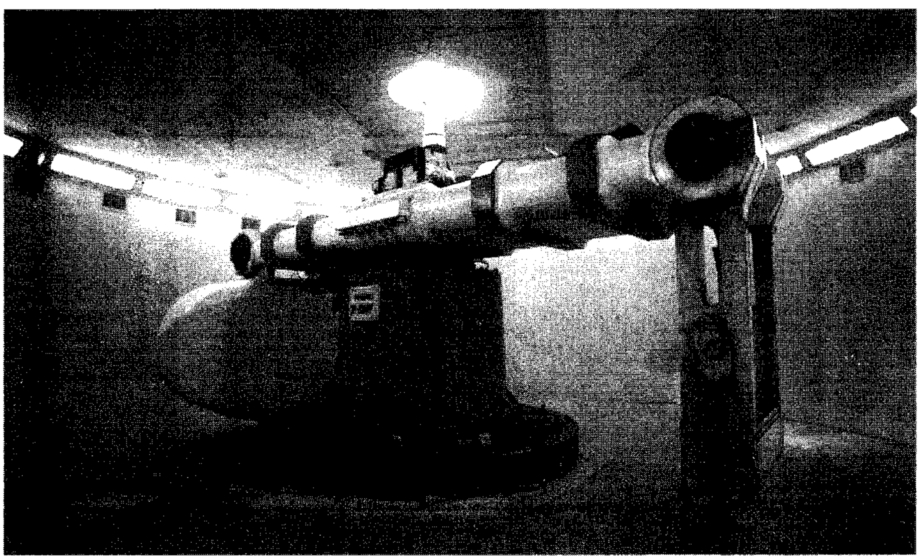
As Ting readily admits, particle physicists are not rocket scientists, and a trip on the Shuttle places demands on AMS which would make terrestrial detector builders shudder, literally! On takeoff, AMS must withstand an acceleration of 3 g with noise vibration up to a shattering 150 decibels. On landing, the detector will be subjected to a massive 10 g. And whilst in space, AMS's days will last a mere 90 minutes as the shuttle orbits at 28000 kilometres per hour.

In addition, the powerful neodymium-iron-boron material used for the magnet generates a field of 1.5 kilogauss. This has to be contained so that stray fields do not interfere with shuttle operating systems. NASA's limit is 60 gauss at 2 metres, the AMS magnet has a stray field of just 4 gauss. The magnet is constructed from blocks with their magnetic axes arranged to give a vanishing dipole moment. This is to avoid torque resulting from interaction with the Earth's magnetic field, but shear forces between blocks are as large as 4 tons, demanding an extremely robust structure.

Space qualification tests carried out on the magnet structure in China have subjected it to acceleration up to nearly 18 g, and vibration tests have shown both magnet and detectors meet NASA's stringent standards. On 21 March, the magnet was delivered to ETH in Zurich where detector components are being installed.

To make sure the particle physicists get it right, rocket scientists from China, Russia, and the US are assisting with AMS construction. With the magnet complete and detector installation underway, AMS is on schedule take particle physics' first small step into space on 29 May 1998.

The Alpha Magnetic Spectrometer, AMS, is scheduled for an initial flight on the Space Shuttle next year. As part of the careful preparations, this huge centrifuge at the Chinese Academy of Launching Vehicle Technology was used for AMS space qualification tests last year, subjecting the AMS magnet to forces of almost 18 g.



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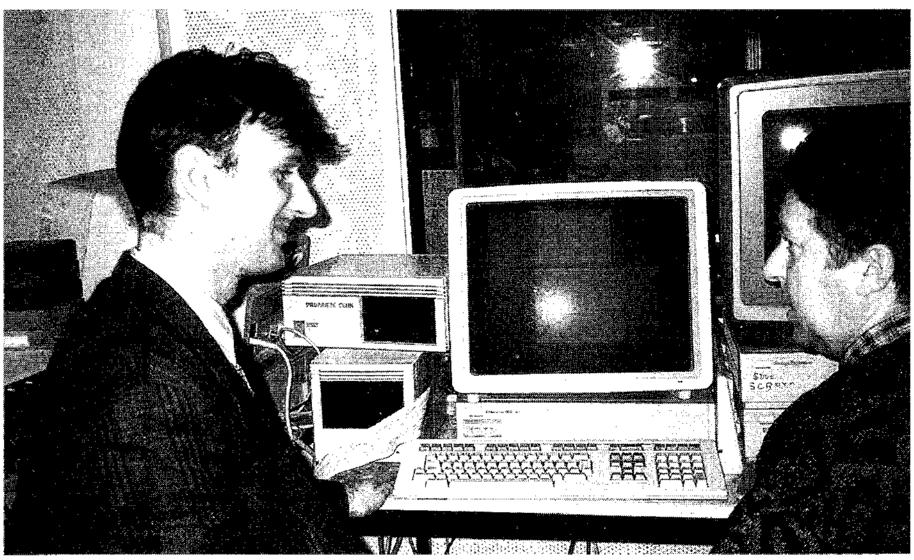
please see page III

SARAJEVO Physics with no frontiers

Last year, 30 scientists (half from Western Europe) attended a neutrino physics workshop in Sarajevo, the first international scientific event in the city after its 40-month siege, and witnessed its devastation. The event was organized by 'Physique-Sans-Frontières', a free association of mutual aid.

To help put the university back on its feet, the institutes which make up the Delphi experiment at CERN's LEP electron-positron collider decided on a special donation of computing equipment no longer needed for the experiment but not yet at the end of its useful life. A young Sarajevo engineer came to CERN to be trained as system manager for the equipment, which was assembled and transported with assistance from PSF, Delphi and CERN, and which constitutes a sizeable scientific computing unit.

Abdel Isakovic (left) from Sarajevo recently spent a month at CERN to be trained as system manager by Daniel Ruffinoni and other colleagues at the Delphi experiment at CERN's LEP electron-positron collider. This followed a donation of computer equipment from Delphi to Sarajevo.



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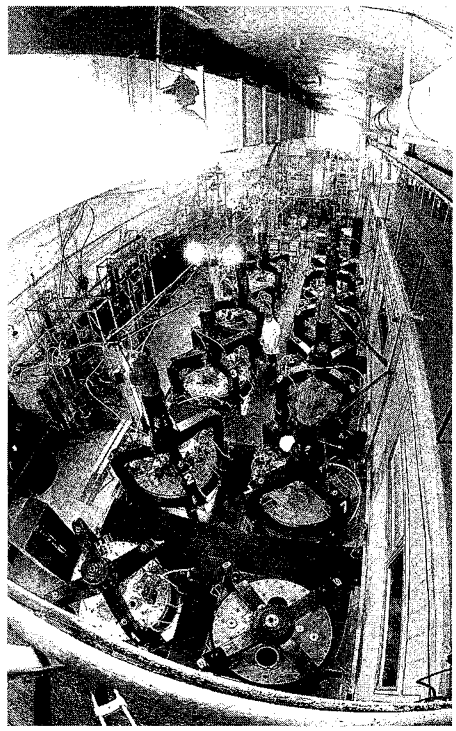


The chemical plant at the SAGE Gallium Germanium Neutrino Telescope, Baksan, Caucasus mountains.

Atmospheric neutrinos

Since 1961 physicists have known that neutrinos exist in several varieties, each associated with a different type of weakly interacting particle, electron, muon, or tau. However new results continue to suggest that neutrinos, long thought to be massless, have mass and can change their allegiance, or 'oscillate'.

Primary cosmic rays from outer space crashing into the Earth's atmosphere produce showers of particles which eventually decay via weak interactions, producing 'atmospheric' neutrinos. Both muon-like and electron-like neutrinos are produced, the former via pion decays into muons and from subsequent muon decay, the latter only from muon decay (a negatively-charged muon decays into an electron accompanied by an electron antineutrino and a muon neutrino). Thus detectors expected to see about twice as many muon neutrinos as electron neutrinos.

In the 1980s, a new generation of large underground experiments began to search for signs of proton decay, predicted to occur at a very low rate by 'grand' unified theories. However when these experiments saw no signs of proton decay, they turned their attention to neutrinos, and the observations of the 1987A supernova marked the advent of a new branch of physics - neutrino astronomy.

Atmospheric neutrinos might appear less intriguing than their cosmic counterparts, but soon several experiments reported a dearth of muon-like atmospheric neutrinos, some 40% down on the expected level.

This puzzle is now underlined by initial results from second generation studies, the Japanese Super-Kamiokande detector with 50,000 tonnes of water monitored by 11,000 large photomultipliers (July 1996, page 22), and the Soudan-II (Argonne/Minnesota/Oxford/Rutherford Appleton/Tufts) with a 960 tonne tracking calorimeter.

The signals picked up by these deep underground detectors are subject to a variety of background effects, including neutron production by muons in the intervening rock, and a new CERN experiment (June 1996, page 1) is setting out to better measure this.

However it is tempting to see such consistent deficiency of muon neutrinos as evidence for their oscillation into electron-like neutrinos en route. For Super-Kamiokande, the suggestion is amplified with a directional dependence observed by the smaller initial Kamiokande experiment now looking to be underlined by its big brother, with the deficiency most marked for particles entering the detector from below. Neutrinos can fly right through the Earth before hitting the detector, but these have travelled much further than those arriving from above, and have a correspondingly higher probability of converting if neutrino masses are around 0.1 eV.

While there is much speculation in the courtroom, the atmospheric neutrino jury is still out.

Particles and cosmology at Baksan

The international schools organized by the Institute for Nuclear Research of the Russian Academy of Sciences (INR) at Baksan Valley, Kabardino Balkaria, provide an unusual slant on particles and cosmology.

The Baksan Valley in the Caucasus mountains is the home of the Baksan Neutrino Observatory of INR with underground installations including the Gallium-Germanium Neutrino Telescope (SAGE), the Underground Scintillation Telescope and other low background facilities, as well as the Carpet and Andyrchi surface extensive cosmic ray air shower arrays.

The Baksan talks traditionally emphasize solar neutrinos. With the results of ongoing experiments, presented by V.Vermul (SAGE), J.Kiko (GALLEX) and K.Lande (Homestake), pointing to a particle physics solution of the solar neutrino problem, urgent need for fresh data on various parts of solar neutrino spectrum becomes even more evident. Developments of new solar neutrino detectors, reported by E.Resconi and R. von Hentig (Borexino) and C.Hargrove (Sudbury), as well as new techniques such as cryogenic counting of beryllium-7 for lithium experiments (M.Galleazzi), were appreciated.

If neutrino oscillations are found, an intriguing possibility would be the observation of CP-violation in these oscillations, pointed out by J.Arafune, who also emphasized the role of long baseline neutrino projects.

On the astrophysical side, C. Hargrove proposed additional supernova monitoring by a set of lead detectors which should be relatively easy both to construct and to run. Substantial progress of ongoing astronomical neutrino projects - Baikal and AMANDA - was reported by O.Streicher, who presented Baikal events interpreted as induced by atmospheric neutrinos from the other side of the Earth. New ideas and developments of other underwater detectors were presented by I.Zheleznykh (an acoustical detector near the Kamchatka peninsula) and S.Loucatos (the "Antares" Mediterranean project).

Another promising class of neutrino experiments uses neutrino sources made of radioactive isotopes. The first Baksan school coverage of this topic was coordinated by V.Gavrin and V.Kornoukhov. Positive experience with intense chromium neutrino sources used for the calibration of gallium solar neutrino telescopes was reported by E.Veretenkin (SAGE) and M.Cribier (GALLEX).

Among other talks at this session, D.Abdurashitov analysed the feasibility of artificial neutrino sources based on argon-37 and thulium-170, and by V.Matveenko who considered the prospects of production of intense (anti)neutrino sources at fast nuclear reactors.

For cosmic ray physics and astrophysics, one possibility is to study cosmic rays with underground installations, often in combination with surface arrays. This was discussed by V.Kudryavtsev (LVD) and Yu.Novoseltsev (Baksan), who emphasized the properties of muon bundles detected underground, as well as by G.Giacomelli, who reported from MACRO.

Another development is the observation of astronomical sources of gamma-rays, both at high energies - the EAS-TOP data were presented by F.Arneodo - and of low energies (gamma-ray bursters). The latter rapidly developing and still controversial topic was reviewed by V.Kurt.

At higher energies, the largest extensive air shower arrays have detected cosmic rays of primary energies 1020 eV and even higher. Future EAS arrays will be able to study this energy region.

Underground facilities like Baksan and Grand Sasso are also well suited for low background experiments, notably searches for dark matter and studies of double-beta decay.

The School coincided with the 30th anniversary of the Baksan Neutrino Observatory. Participants in the celebration events appreciated the multi-ethnic local culture. Baksan Neutrino Observatory support comes from the Russian Federation and from Kabardino-Balkaria and its Elbrus region, testified by the speech of Vice-President of Kabardino-Balkaria G.S. Gubin at the opening of the School, and financial support for the School from the Russian Foundation for Basic Research, Nuclear Physics Division of the Russian Academy of Sciences and the International Centre for Fundamental Physics in Moscow.

Information from V. Rubakov and D.Semikoz

COSMIC RAYS
A knobbly knee

The origin of the ultra-high energy cosmic ray particles arriving from outer space has long been a mystery. However new evidence from extensive air showers, the cascades of particles generated when fragments of high energy cosmic debris from the depths of space encounter a nucleus in the upper atmosphere, suggests that specific supernova remnants could be the source of the high energy particles.

The energies of primary cosmic ray particles go far beyond the TeV (1000 GeV) range attainable with terrestrial accelerators, extending even beyond 10^{20} eV, a hundred million TeV. However the chances of seeing cosmic rays falls off rapidly with their energy, and such extreme high energy particles are extremely rare.

However this steady energy falloff has a well known 'knee' at around 10^{15} eV, where the yield briefly flattens out before plunging again towards higher energies. This rapid falloff with energy is accompanied by a steady increase in the nuclear mass of the cosmic particle - rarer higher energy primaries appear to come from heavier particles.

The only nuclei produced by the Big Bang were hydrogen and helium - all heavier nuclei, including much of the material of life itself, were

Bookshelf

subsequently cooked in supernovae. As accreting stars become large enough to be crushed by their own gravity, new thermonuclear production lines open up as the internal temperature increases. Eventually the contracting star is blown apart by its core pressure, and its contents whirl around the supernova remnants, buffeted by mighty shock waves, before finally being flung out into space.

Taking a close look at results from extensive air showers, Tolya Erlykin of Moscow's Lebedev Institute and Arnold Wolfendale of Durham, UK, see structure around the knee region, with slightly increased production in two nuclear bands, corresponding to oxygen and iron. These nuclei are the characteristic aroma of supernova cooking.

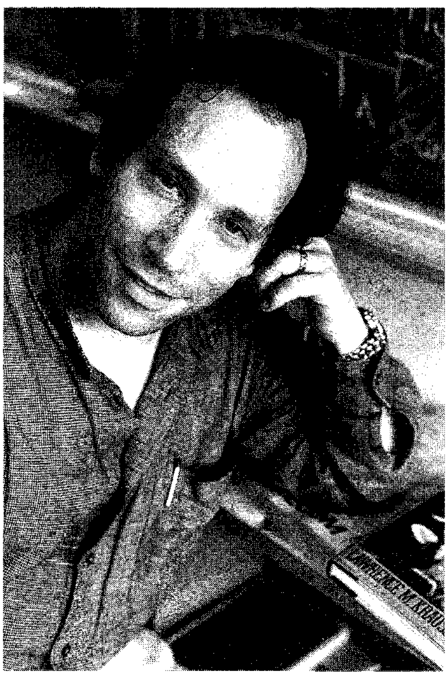
Looking at the acceleration of charged particles by supernova remnants, Erlykin and Wolfendale suggest that these tiny bumps in the cosmic ray yield are the fingerprint of a single nearby supernova whose particles were flung into space as the echoes of a mighty shock wave. Identifying which supernova is extremely difficult, as cosmic particles get tangled up in convoluted intergalactic magnetic fields and are condemned to follow tortuous paths.

As well as explaining aspects of cosmic rays, these results also open a new window on nuclear reactions in the energy region around 10^{16} eV, where iron predominates.

Krauss word puzzle

A recent visitor to CERN's Theory Division was distinguished scientist and best-selling author Lawrence Krauss, who has three claims to fame. Look up the name in the learned literature and one quickly understands why the 43-year old theorist holds the prestigious Ambrose Swasey Chair of Physics at Case Western Reserve University, Cleveland, Ohio. But the name is also prominently listed in literary catalogues as author of several famous popular science books*. His 'The Physics of Star Trek', drawing on the divergence between compelling science fiction and less easily assimilated science fact, has consistently appeared in best-selling lists since its launch in 1995 and has since appeared in 11 other language versions. A sequel 'Beyond Star Trek' will appear later this year.

Each of these claims to fame are



As well as holding the prestigious Ambrose Swasey Chair of Physics at Case Western Reserve University, Cleveland, Ohio, Lawrence Krauss is also author of several famous popular science books, including the best-selling 'The Physics of Star Trek'.

impressive in their own right, but the third claim - being able to handle two such apparently distinct and demanding career paths at the same time - is perhaps the most impressive, if only for the demands on his time. Being a best-selling author also brings a continual demand for public appearances.

While many physicists encounter difficulties in writing popular accounts of their work, Krauss points to many counter-examples - Gamov, Jeans, Einstein,.... - where scientists more eminent than most have contributed to contemporary culture without abandoning their scientific missions. He himself admits to having been particularly influenced by Steven Weinberg's book 'The First Three Minutes' (Basic Books, New York, 1977). As well as selling many copies, this milestone in scientific literature underlined the role of particle physics in the evolution of the Universe in the immediate aftermath of the Big Bang. Krauss set out to do just that with his first book, "The Fifth Essence', about the enigma of dark matter, possibly the ultimately Copernican revolution.

Krauss writes quickly and well, usually at night, and his approach has become more popular with time. This writing ability must be ultimately genetic in origin, but he modestly attributes it at least in part to having studied history ('where I learned how to write'). His first commission was for the book which would ultimately become 'Fear of Physics', but he put this aside to write 'Essence' first. However he points out that explaining a difficult concept for a wide audience can be just as much of a challenge as cracking an esoteric research problem.

Rather than being overwhelmed by having two apparently conflicting pursuits, Krauss claims that his writing can help focus his physics research ideas, and vice versa. 'It helps productivity,' he claims, explaining that he can be totally involved in both a book project and research at the same time.

He has always been interested in communicating ideas, and says that in putting his arguments across he feels his strongest duty is to be 'honest and accurate', with minimal fudging of difficult notions to make them easier to assimilate. Hence his critique of the Star Trek fables. However his view of Star Trek is not entirely tongue-in-cheek and he is aware that conventional scientific discipline must be tempered with imagination. As he says in 'Trek' - 'What does modern science allow us to imagine about our possible future as a civilization?' The result is that he maintains good relations with his scientific peers, remaining faithful to physics and avoiding unbridled pandering to popular taste that can be a recipe for intellectual exile. As well as being a popular book, 'Trek' is used by physics teachers to help motivate their students.

On the physics side, Krauss' continuing multiple interests are in the direction of cosmology and astrophysics, but he points out that physics is not an excuse to generate abstruse formalism. Physicists, even when speculating about the ultimate mysteries of the Universe, still have to keep their feet on the ground. However quantifying cosmology is not easy, and his research goal is to open up new fundamental directions, and perhaps even to find a way of detecting the ever-elusive cosmic neutrino background.

The Lawrence Krauss Library

The Fifth Essence: The Search for Dark Matter in the Universe (US, Basic Books, 1989, UK Vintage Books);
Fear of Physics: A Guide for the Perplexed (US, Basic Books 1993, UK Jonathan Cape);
The Physics of Star Trek (US, Basic Books 1995, UK Harper Collins);
Beyond Star Trek (to be published by Harper Collins later this year).

The Inflationary Universe, by Alan H. Guth, published by Addison Wesley, reviewed by Lawrence M. Krauss

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Alan Guth is a crystal clear thinker and writer, and it shows in this book. As a young, terminal-track postdoc, in 1979 he entered the field of cosmology from the fringes and managed to change it forever. This book is in one sense a history of his own cosmic voyage from formal field theorist to father of our modern picture of the early universe.

In the process, however, it provides an expansive account of the evolution of modern cosmology and particle theory through its great successes of the 1970s, including the development of Grand Unified Theories (GUTs) - the foundation stone on which Inflation was built. The book ends with discussions of speculative current notions such as wormholes and the creation of universes from nothing.

The breadth of this book represents both its success and weakness. Physicists will probably enjoy Guth's style - the logical framework, the meticulous attention to detail, and generous referencing. No idea is introduced until the proper background has been provided. However, I expect that some lay readers may find the details at times overwhelming, and may need to skim over some of the 300 or so pages of text, figures and charts -including three appendices and a glossary - on first reading. (I don't know how much readers will get out of the complete table of low mass baryons and mesons, for example.)

Those wishing to find out exactly what the inflationary universe idea is will have to first read almost 200 pages into the book - a wait which may prove frustrating for general readers (it was for the one reader I polled), although in the end, of course, the effort is worthwhile. While I believe the book could have been more heavily edited, the result is a comprehensive and personal view of a pivotal subject. And as Alan Lightman states in his otherwise uninspired foreword, many other books have appeared discussing Inflation in some detail (I count one of my own among the list), but only one can be written by Alan Guth.

Indeed, over 15 years since Inflation was unveiled, one might wonder what there is left to say. However, one gets in this book not only a grander and more careful introduction to the subject than is generally available, but one also gets a chance to witness the personal story behind it.

While the explanations are meticulous and clear, the book's uniqueness stems in part from Guth's own brand of humanity. Genuinely self effacing, often in awe of his more senior famous colleagues, Guth has written an honest book. Having known him, first when I was a graduate student and then as a postdoc, following his arrival at his first tenure track appointment at MIT in 1981, and having been present during many of the developments discussed in the second half of this book, it is refreshing to see a personal history written so objectively. Guth is a compulsive diarist. While many people write from the vantage point of dim memory, Guth has had the benefit of detailed documented diaries and notes to help affirm his comments.

There are also a few interesting revelations - in particular involving the events surrounding the famous 1982 Nuffield Workshop at Cambridge when the discovery that Inflation could explain the origin of primordial structures was made.

Most of the book is devoted to a pedagogical treatment of modern cosmology and particle theory, presenting a clear history of the subject. Moments which display Guth's warmth and humour do arise - my favourite instance is a scholarly footnote argument why a more proper acronym for Grand Unified Theories (conventionally GUTs) should be GUTHs!

An informative and enjoyable read, its immediate impact may have been greater had it appeared 10 years earlier, or perhaps been packed with a little less detail even now, but I expect this will be a good resource not only for physicists wanting to learn more about early universe cosmology, but also for graduate students, interested undergrads and motivated members of the general public who want to understand the excitement generated in cosmology over the past 20 years.

Particle Detectors by Claus Grupen: Cambridge University Press
ISBN 0-521-55216-8

Fifth in the Cambridge Monographs series on Particle Physics, Nuclear Physics and Cosmology, this book will make a useful addition to any experimental physicist's armoury. Professor Grupen's career has taken him from cosmic ray muons in the 1970s to CERN's ALEPH experiment today, and in writing the book nothing has been left out.

The first chapters cover essential physics, beginning with an overview of particle interactions with matter followed by a discussion of detector performance and radiation units. Detectors for track measurement are the first to be covered in a chapter which concentrates on gas-filled devices. Bubble chambers and emulsions are also discussed. The author points out that a particular type of detector does not make only one type of measurement, and chooses to leave solid state devices until later in the book. Subsequent chapters cover time measurement, particle identification, energy and momentum measurement, electronics, data analysis, and simulation. Each chapter ends with a comparative summary of different approaches; valuable information to anyone with a detector to build.

A final chapter on applications gives an impression of how varied the use of particle detectors has become. Applications from particle physics to 'x-raying' the pyramids with cosmic ray muons are discussed.

In summing up, Grupen justifies his coverage of apparently obsolete detectors, pointing to the recent development of holographic readout of vertex bubble chambers as an example of how new life can be breathed into old technology. Inevitably in such a fast moving field, much changes in the time it takes to write a book. The author himself admits that his book can be just a snapshot, but if this is the case then Professor Grupen has chosen a very fine grained emulsion for his work.

James Gillies

Flash of the Cathode Rays - A History of J.J. Thomson's electron, by Per F. Dahl, IOP Publishing,
ISBN 0 7503 0453 7, £29.50/$49.50

Per Dahl of Berkeley, an expert on superconducting magnets and son of the legendary Odd Dahl, who initially headed the project to build CERN's synchrotron, has produced a fascinating account of the twists and turns of particle physics prehistory. Leaving no archival stone unturned, his scholarly book covers the early history of atomic structure, carefully tracing the emergence of the particulate theory of electricity, through the discovery of the electron a hundred years ago, to Rutherford's revelation of the nuclear picture in 1911. The result is a valuable source of historical authority and wisdom. His diligence is underlined by almost a hundred pages of notes and fifteen pages of 'select' bibliography.

People and things

Books received

Quantum Mechanics and the Pomeron, by J.R. Forshaw and D.A. Ross, Cambridge University Press, ISBN 0 521 568880 3, £19.95 ($34.95) pbk

In the Cambridge series of Lecture Notes on Physics.

Wavelets - Calderón-Zygmund and multilinear operators, by Yves Meyer and Ronald Coifman, Cambridge University Press, ISBN 0 521 42001 6, £40 ($59.95) hbk

In the Cambridge series of studies in advanced mathematics.

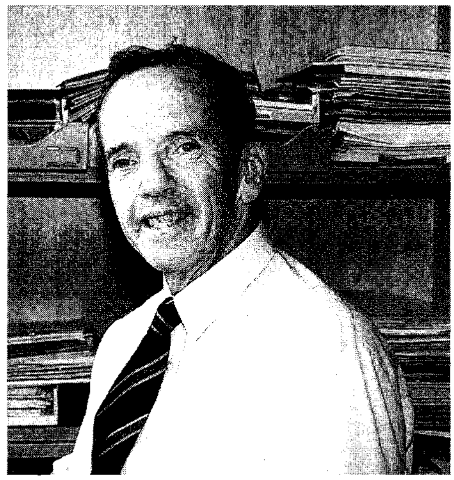
The Casimir Effect and its Applications, by V.M. Mostepanenko and N.N. Trunov, Oxford Science Publications, ISBN 0 19 853998 3, £55 hbk

The Casimir Effect derives from the distortions of the vacuum fluctuations of quantum fields in special topologies.

On people

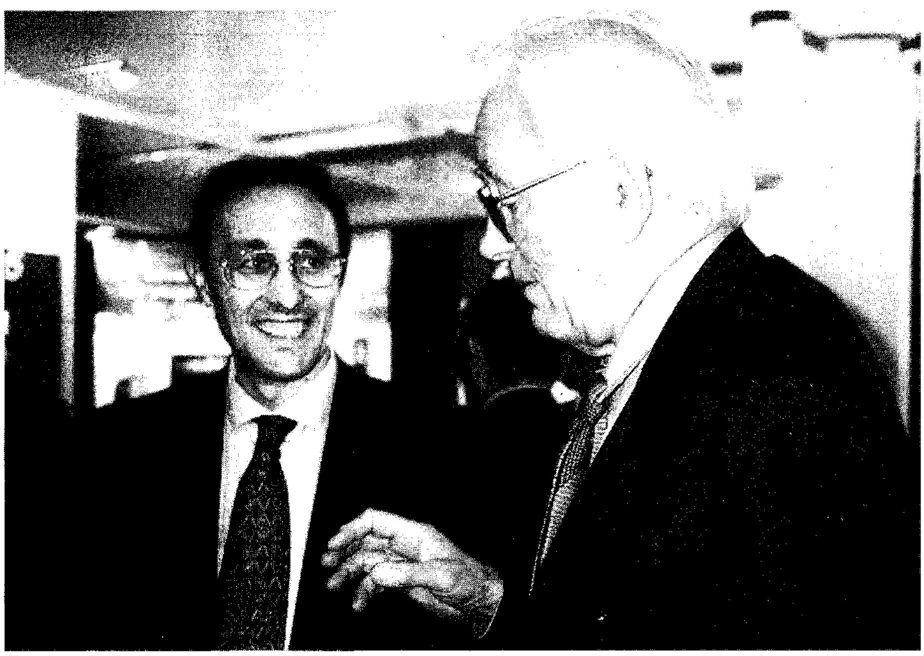
Richard Garwin receives a prestigious US Enrico Fermi Award for a lifetime's work. His 1957 experiment with Leon Lederman and M. Weinrich confirmed that parity was violated in nuclear beta decay, and his informed opinion on a wide range of scientific subjects has been widely in demand at high levels in both government and in industry.

Robin Marshall of Manchester received the 1997 Max Born prize of the German Physical Society for 'outstanding contributions to particle physics, particularly for work concerned with the electroweak interaction'. In odd-numbered years, the German Physical Society attributes this award to a British physicist, and the UK Institute of Physics reciprocates in even-numbered years.



Oscar Barbalat - transferring particle physics technology

Recently retired from CERN after a 36-year career is Oscar Barbalat, who became widely known through his valiant efforts to promote the transfer of the valuable technological spinoff from particle physics. According to one commentator, this transfer became so efficient that there was a danger of there not being enough technology to supply it! Oscar helped bring CERN and its



1991 Physics Nobel prizewinner Georges Charpak (right) at the opening of the recent 'France at CERN' trade show with Bernard Bigot, Director General of Research and Technology of the French Ministry of Education and Research.

An international meeting in Turin in June marked the 65th birthday of eminent physicist, mathematician, and astrophysicist Tullio Regge. Organized by the ISI foundation (Institute for Scientific Interchange), the topics reflected Regge's diverse interests, other than the 'poles', for which he is most widely known. Tullio Regge is seen here between Gabriele Veneziano of CERN (left) and Schu Martin.

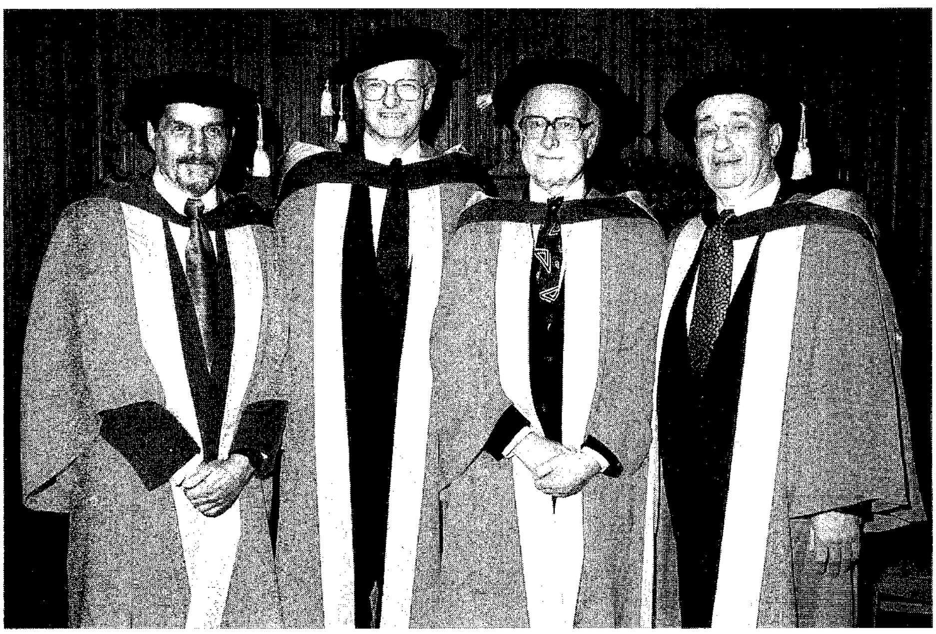
(Photo André Martin)

work to the attention of a much wider audience, and the promotion of technological spinoff has been influential in bringing more nations into the CERN fold.

Beirut Centre

The Beirut Centre for Advanced Mathematical Studies, modelled on the Institute of Theoretical Physics in Santa Barbara and the Newton Unistitute, Cambridge, aims to provide a national and regional centre and to act as a focus for visitors and for meetings. The centre is the brainchild of Nicola Khuri of Rockefeller, who is also a trustee of the American University of Beirut. Chairing the Centre's International Advisory Committee is distinguished mathematician Sir Michael Atiyah.

On 8 May CERN Director General Chris Llewellyn Smith (second from right) received an honorary doctorate of the University of Grenada. Left to right, Spanish theorist José Bernabeu, Rector of the University of Grenada Lorenzo Morillas, Chris Llewellyn Smith, Spanish theorist Francisco del Aguila.



Honorary PhDs at Bristol - left to right: Yakir Aharonov of Tel-Aviv, renowned for his contributions to basic quantum mechanics (the Bohm-Aharonov effect); CERN Director General Chris Llewellyn Smith; Peter Higgs of Edinburgh, whose name is eternally linked with spontaneous symmetry breaking; and Emil Wolf, famous for seminal contributions to optics.

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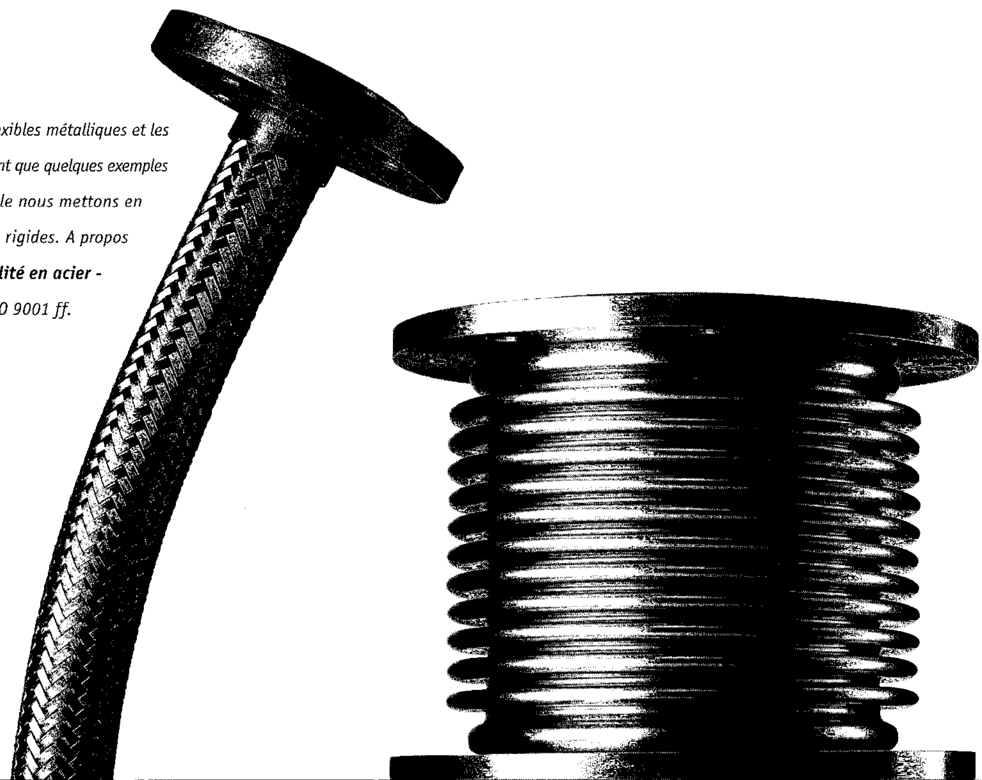

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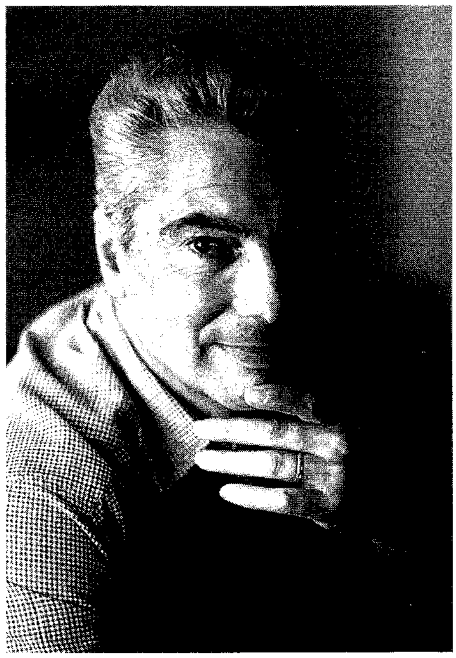
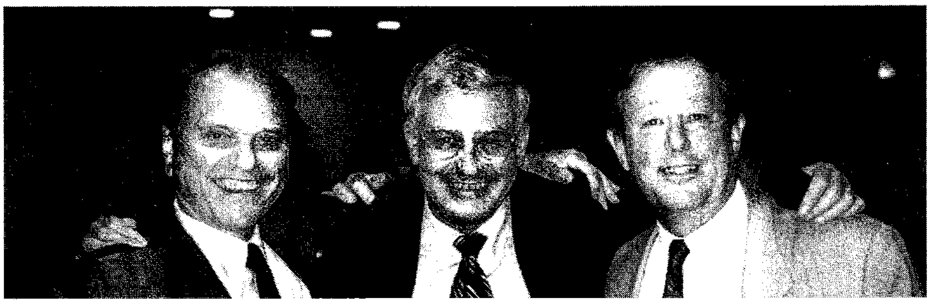
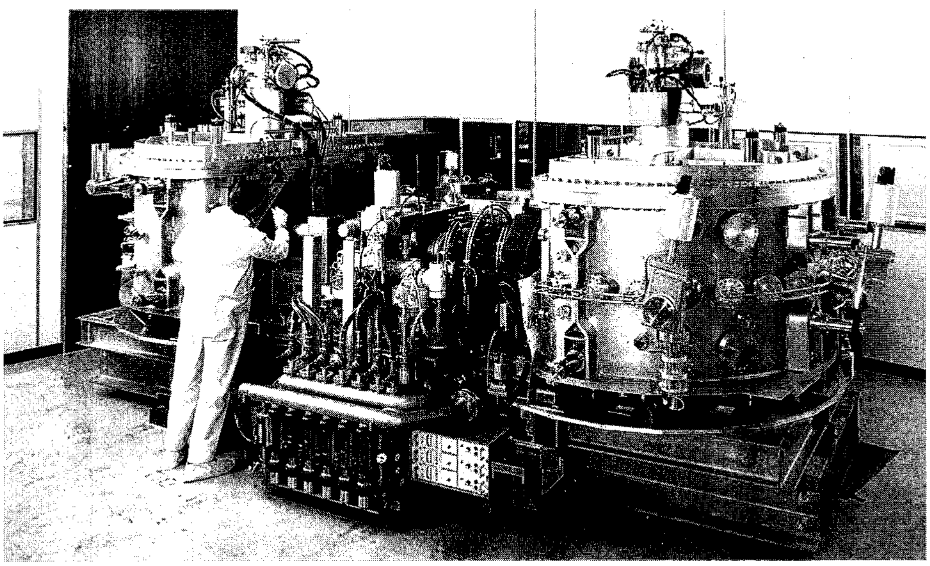
Alvaro de Rujùla (left) succeeds Gabriele Veneziano as Head of CERN's Theory Division.

Alberto Scaramelli becomes head of CERN's Technical Support (ST) Division, succeeding Fritz Ferger.



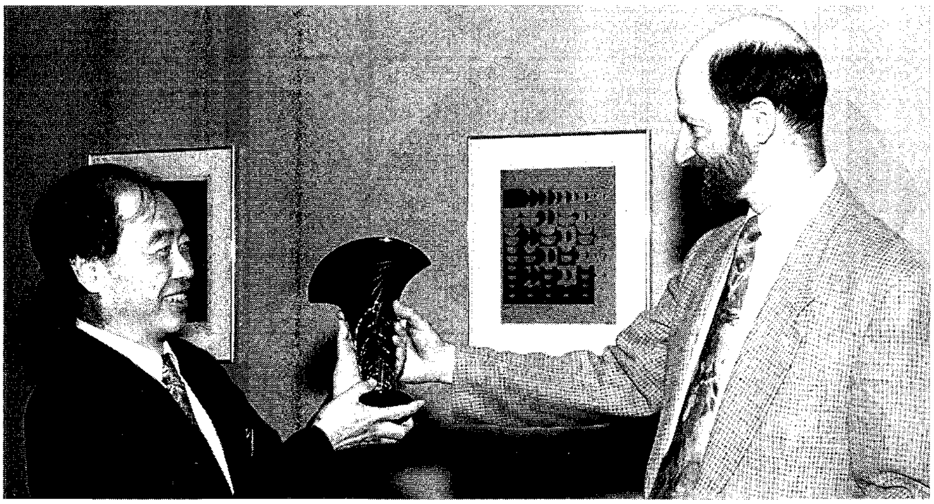


Retiring as members of their respective national CERN delegations this year were (right) Bjorn Brandt of Sweden, who served as Chairman of CERN's Finance Committee from 1992-94, and Arnfinn Graue of Norway (left), who served as Chairman of the Finance Committee from 1989-91 and also a special committee on conditions of employment. Wishing them well was Maurice Jacob (centre) responsible for CERN's Member State relations.



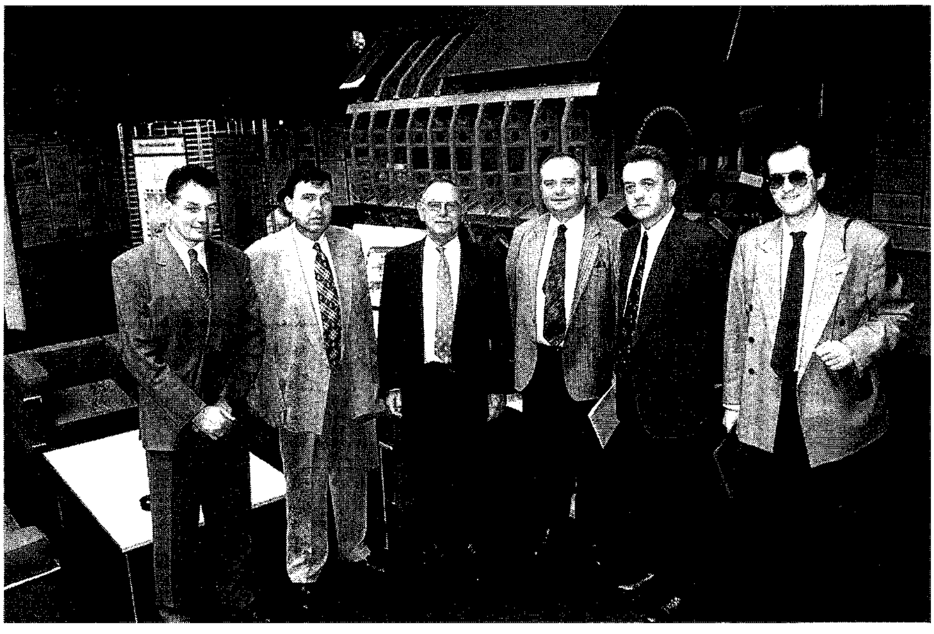
A second compact superconducting synchrotron - Helios 2 - from specialist supplier Oxford Instruments has been sold to the National University of Singapore for use in a new national synchrotron radiation facility. X-ray lithography is seen as a major applications area, as is the case with Oxford Instruments' Helios 1, supplied to IBM's East Fishkill laboratory, New York.

B-birthday: Below - Leon Lederman offers a slice of b for birthday cake at an Illinois Institute of Technology event to mark the 20th anniversary of the discovery of the upsilon particle - a bound state of a b quark and its antiquark - at Fermilab in 1977.



Right - Co-upsilon discoverer Dan Kaplan of the Illinois Institute of Technology presents a commemorative hand-blown art-glass upsilon-shaped vase to Makoto Kobayashi for his work with Toshihide Maskawa that showed the need for a fifth quark.

Right - Eminent theorist Sergio Fubini (centre) receives from Ernesto Olivero of the SER.MI.G charity organization in Turin the medal of 'Artignano della Pace' for his valuable work in bringing together Middle East physicists (January 1996, page 21). Looking on (right) is Mrs. Mercedes Bresso, President of the Province of Turin. The ceremony took place in the Novaleše Abbey at the foot of Mt. Cenis, once the site of the largest library in Christendom, and which inspired Umberto Eco to write his book 'The Name of the Rose'. The abbey has been restored by the local government and is viewed as an ideal site for international meetings seeking the furtherance of peace.



Serbian VIPs at CERN - left to right: Miroslav Kopecni, Director General of Belgrade's VINCA Institute of Nuclear Science; Dragan Popovic, Director General of Belgrade's Zemun Institute of Physics; Jim Allaby, responsible for non-Member State relations at CERN; Vladimir Davidovic, Serbian Deputy Minister of Science and Technology; Nebojsa Neskovic, Director of the TESLA Scientific Centre; Peter Adzic, leader of the VINCA particle physics group.

Universität Heidelberg

The Institute for High Energy Physics (IHEP) at Heidelberg University has immediate openings for

Two Postdoctoral Positions in Experimental Particle Physics

The first position (Ref. ATLAS-PD) is in the ATLAS group at the IHEP. The successful applicant will be working on the Level-1 calorimeter trigger of the ATLAS experiment at the LHC and in particular on the realization of a full size prototype for the trigger pre-processor system. The system employs modern electronics components like custom made ASIC's, Multi-Chip Modules and FPGA's. The position is located in the ASIC laboratory at Heidelberg University.
Experience in digital hardware, computer aided electronic design tools and data acquisition is required. A vital interest in LHC physics and the particular challenges of the first level trigger system is expected.
The second position (Ref. H1-PD) is in the H1 group at the IHEP. The successful applicant will be working on the operation of the H1 detector at the electron-proton storage ring HERA at DESY and in particular on the analysis of its data. The position is located at the Institute in Heidelberg but requires frequent travel to and occasional longer stays at DESY.
Experience in data analysis of high-energy-physics experiments and in particular the handling of large data volumes is required.
Both positions require a Ph.D. in physics and include teaching obligations. Appointments will initially be limited to 2 years with a possible extension to a maximum of 5 years. Provided superior performance, both positions offer the possibility to confer qualification as a university lecturer *(Habilitation)*.
Disabled applicants with equal qualifications will be prefered.
The Heidelberg University encourages especially women to apply.
Interested applicants are invited to send their application to:

Ruprecht-Karls-Universität Heidelberg
Institute for High Energy Physics
Ref.: ATLAS-PD or Ref.: H1-PD
Schröderstrasse 90
D-69120 Heidelberg, Germany

For additional information, please contact Prof. Karlheinz Meier,
e-mail: meierk@ihep.uni-heidelberg.de, phone: + 62 21 / 54 - 43 35.

DESY

DESY announces a

Post-Doc Position

The candidate is expected to play a key role in the design and commissioning of the rf control system for the 64 superconducting cavities of the TESLA Test Facility. The basic concept is based on a state of the art fast digital IQ controller which controls the vector-sum of 32 cavity voltages in presence of severe Lorentz force detuning, microphonics, and bunch charge fluctuations. The applicant will develop and implement control algorithms based on modern control theory, procedures for the calibration of phase and amplitude of the vector-sum, and cavity frequency control. Actual performance with beam will be measured until end of 97 resulting in suggestions for hardware and software improvements if necessary.

The candidate should have a Ph.D. in physics or equivalent science. He should have good working knowledge in at least one of the following areas: accelerator physics, control theory, digital signal processors, radio frequency systems for accelerators, programming languages and operating systems (such as UNIX, C, C++). Experience with particle accelerators, superconducting cavities or simulation programs such as MATLAB and SIMULINK are desirable.

Interested persons, who have recently completed their Ph.D. and who should be younger than 32 years are invited to send their application including a résumé and the usual documents (curriculum vitae, list of publications, copies of university degrees) until 30 of September 1997 to

DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY
Personalabteilung -V2-
Notkestraße 85, 22607 Hamburg, Germany

They should also arrange for three letters of reference to be sent until the same date to the adress given above. Code-number: 49/97

Handicapped applicants with equal qualifications will be prefered. Desy encourages especilly women to apply.

SYSTEMS ANALYST/ ADMINISTRATOR

Physics Department

Provide system administration for UNIX computer systems in a highly networked environment. Install, customize, and monitor hardware and operating system components to ensure security and performance; provide support of NIS, DNS, and similar protocols. Assist in compiling and enhancing of locally maintained software. Requires: BA/BS in Computer Science or equivalent and a minimum of 3 years of experience in UNIX system administration.

Please send cover letter and resume to Virginia Gregory, Boston University, Office of Personnel, 25 Buick Street, Boston, MA 02215. http://www.bu.edu/PERSONNEL

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EXPERIMENTAL GRAVITATIONAL PHYSICS

The Department of Physics at MIT is seeking candidates for a faculty position in experimental gravitational physics. MIT and Caltech are constructing the Laser Interferometer Gravitational Wave Observatory (LIGO), a national facility for the detection of gravitational waves from astrophysical sources. This NSF funded project will provide unique research opportunities in physics and astrophysics. The person fulfilling this position is expected to engage in undergraduate and graduate education, and may lead an independent research program or play a leadership role in the development of LIGO. Our hope is to fill a tenure track junior faculty position, but we encourage more senior, well established physicists to apply for a possible tenured appointment, in exceptional cases. In any case, we seek candidates who are accomplished in experimental physics and well versed in data analysis. Given the developing nature of this field, candidates with various experimental backgrounds (e.g., astrophysics, high-energy physics, nuclear physics, atomic physics, precision metrology, etc.) will be considered.

MIT

Applications are requested before October 1, 1997. Applicants should send a curriculum vitae, a brief description of their current research, and three letters of recommendation to: Professor Richard K. Yamamoto, Chairman, Search Committee, Department of Physics, RM 24-043C, Massachusetts Institute of Technology, 77 Massachusetts Ave, Cambridge, MA 02139-4307. MIT is an Affirmative Action/Equal Opportunity Employer and solicits applications especially from qualified women and minorities.

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UPPSALA UNIVERSITET
Faculty of Science and Technology

CHAIR IN APPLIED NUCLEAR PHYSICS

Applications are invited to a full professorship in experimental Applied Nuclear Physics. Ref. no. 3299/97. The professorship is intended to promote present developments and to create new fields in applied nuclear physics. The successful candidate who should demonstrate scientific excellence and pedagogical proficiency, is expected to pursue an active research program, supervise graduate students and engage in teaching. The candidate is also expected to chair the activities at the Department of Neutron Research.

Basic and applied research in nuclear physics at Uppsala University is conducted at the Department of Radiation Science and at the Department of Neutron Research. Major national facilities used are the The Svedberg Laboratory, a national facility for accelerator based research in nuclear and particle physics, the Tandem Laboratory and the Neutron Research Laboratory connected to the Studsvik research reactors. Examples of current research areas at Uppsala University, which are of interest in the context of applied nuclear physics, include fission energy technology comprising characterization of nuclear fuel by means of nuclear spectroscopy methods and accelerator driven transmutation of nuclear waste, fusion plasma diagnostics, medical therapy, production and use of radio nuclides, materials modification and characterization, and dating techniques.

Prospective candidates must contact the office of the faculty in order to receive the full announcement with instructions on how to apply. Please use fax no +46 (0) 18 471 1999 or e-mail: Christina. Lindberg@uadm.uu.se

Applications must be received on **October 31, 1997**, at the latest.

For additional information about the position, consult the dean of physics, prof. Bo Höistad, tel. no +46 (0) 18 471 3857, fax +46 (0) 18 471 3833 e-mail: Bo. Hoistad@tsl.uu.se

Uppsala University wishes to establish a more equal proportion amongst female and male professors and applications from women are encouraged.

Universität Zürich

The Faculty of Sciences (Philosophische Fakultät II) of the University of Zürich invites applications for a faculty position in

Experimental Physics

Condensed Matter

at the Physics Institute. Depending on age and experience, the appointment will be made at the full (Ordinarius) or associate (Extraordinarius) professor level.
Candidates should have demonstrated their ability to carry out independent research in condensed matter physics. There is a preference for candidates in the field of
Soft Condensed Matter, especially **Biological Systems,**
but candidates with other areas of specialization will also be considered, in particular if they complement the existing programs in surface physics and superconductivity. The use of the neutron spallation source (SINQ) and the synchrotron radiation source (SLS) at the Paul Scherrer Institute near Zürich as well as that of the existing NMR spectrometers at the Physics Institute is possible.
The successful candidate is expected to participate in the teaching of basic cour for medical and biology students and special courses in condensed matter or biological physics.
Applicants should send their curriculum vitae (publication list, indicating the five most important publications, a short statement of research interests, research plan, and teaching experience) before November 15, 1997 to the
Dekan der Philosophischen Fakultät II der Universität Zürich. Prof. Dr. H. Haefner. Winterthurerstr. 190, CH-8057 Zürich.
For further information please contact Prof. Dr. R. Engfer, phone +41 1 635 5720, fax + 41 1 635 5704. Suggestions for suitable candidates are welcome.

LABORATORI NAZIONALI DI FRASCATI DELL'INFN

EU Postdoctoral Fellowships (TMR Programme)

We invite applications for postdoctoral fellowships (one to two years) in theoretical, experimental physics (high energy physics, astroparticle physics, nuclear physics, synchrotron radiation and gravitational wave detection), and accelerator physics at the Laboratori Nazionali di Frascati of INFN (Istituto Nazionale di Fisica Nucleare).
The Laboratory is situated on a pleasant hill about 20km south of the centre of Rome. Some 150 researchers work here on the different activities. The 1 GeV e^+e^- machine DAΦNE (Phi factory), to study CP violation and hypernuclear physics, is currently under commissioning. Information on the Laboratory activities can be obtained from:
A. Antonelli, tel. 39-6-94032787, e-mail antonelli@lnf.infn.it and at the URL: http://www.lnf.infn.it/.

Applicants must be nationals of an EU member state (excluding Italy), or an associated state, age under 35 and have a PhD degree (or equivalent level of education) or 4 years' full-time research activities at post-graduate level. They should not have carried out research activities in Italy for more than 18 months in the last two years.

Fellows will be employed under the EU's general conditions governing research training fellowships (TMR Programme) and will receive an allowance in ECUs per month to cover subsistence and mobility expenses, tax and social security contributions and cost of attending conferences, travel expenses, etc. Global monthly allowance will be of about 3000 ECUs. More information on the TMR Programme are given at the URL: http://www.cordis.lu/tmr/home.html.

Candidates should send a letter of application (where the activity of interest must be specified), a C. V. and two letters of recommendation by 15 October 1997 to:

EU Fellowships Programme, Mrs. M. Cristina D'Amato, LNF-INFN
Via E. Fermi, 40 - 00044 Frascati (Italy)
tel.: +39 6 94032373, fax: +39 6 94032475, e-mail: damato@lnf.infn.it

The selected candidates will apply to the next round of EU selection which has the closing date of 15 December 1997.

DESY, one of the leading laboratories in particle physics and synchrotron radiation research is offering a position for an

Accelerator Physicist

in the accelerator physics group MPY. The position is permanent and the salary will be according to the German civil services Ib MTV Angestellte.

Experimental particle physics at DESY concentrates at the HERA storage ring facility. The H1 and ZEUS Experiments make use of colliding electron/positron proton collisions to study the structure of the proton. The HERMES Experiment measures the scattering of longitudinaly polarized positrons on a gas target of polarized atoms to study the spin structure of the nucleon. A fourth experiment, HERA-B, currently under construction, will investigate the CP-violation in the B-meson-system. B-mesons are produced on wire targets in the halo of the proton beam of HERA.

One of the near term future tasks of the accelerator division is to upgrade the HERA Facility in order to enlarge its scientific potential. Of special interest is the increase of the luminosity beyond the design values. For this purpose the entire interaction regions for H1 and ZEUS will be rebuilt. We are expecting the successful applicant to participate in this project. In addition the applicant should participate in the scientific shift services for all DESY accelerators.

Applicants should have a Ph.D. in physics, substantial knowledge of accelerator physics and should be experienced in field of large particle accelerators. Interested applicants with these qualifications should send their letter of application and three names of referees before 23.9.97 to:

DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY
Notkestraße 85, 22607 Hamburg, Germany Code-number 47/97
Telefon 49-40/8998-3628, Fax: 49-40/8998-4305

Handicapped applicants will be given prerference to other applicants with the same qualification. Women are especially encouraged to apply for this position.

POSTDOCTORAL POSITIONS AVAILABLE

The Relativistic Heavy Ion Group in the Physics Department at SUNY, Stony Brook, New York has several openings at the post doctoral level. We are collaborators in the PHENIX experiment under construction for the RHIC facility at nearby BNL. As one of the largest university groups in the RHIC program, we are involved in several key aspects of the PHENIX program. We have hardware responsibilities in the assembly of the Ring Imaging Cherenkov focal plane detector; assembly and test of the Drift Chambers; and production and testing of the Drift Chamber Front End Electronics. We are building up an analysis group to work in tracking and reconstruction efforts, with an emphasis on the extraction of early electron physics in search of signals of the Quark Gluon Plasma. Applications are invited from all qualified candidates to work with us on both hardware and software projects. Appointments and salaries will be commensurate with experience. PHENIX is expected to take its first data in 1999; our expectation is that these appointments will carry through the publication of first physics results. Interested applicants should send vitae and three letters of reference to:

Prof. Barbara Jacak
SUNY @ Stony Brook
Dept. of Physics
Stony Brook, NY 11794-3800

Applications from minorities and women are strongly encouraged. Stony Brook is an equal opportunity employer.

FACULTY POSITIONS IN PHYSICS
University of California, Berkeley

The Physics Department of the University of California, Berkeley intends to make one or more faculty appointments effective July 1, 1998. Candidates from all fields of physics are encouraged to apply. Appointments at both tenure-track assistant professor and tenured levels will be considered.

Please send a curriculum vitae, bibliography, statement of research interests, and a list of references to:

Professor Roger W. Falcone, Chairman
Department of Physics
366 LeConte Hall #7300
University of California
Berkeley, CA 94720-7300

by Tuesday, November 25, 1997. E-mail applications will not be accepted. Applications submitted after the deadline will not be considered. The University of California is an Equal Opportunity, Affirmative Action Employer.

OAK RIDGE NATIONAL LABORATORY

ACCELERATOR PHYSICIST

The Oak Ridge National Laboratory's Physics Division invites applications for a staff position in accelerator physics with the Holifield Radioactive Ion Beam Facility (HRIBF). This unique, newly commissioned facility uses two accelerators, the k=100 Oak Ridge Isochronous Cyclotron and the 25 MV tandem electrostatic accelerator, to produce accelerated beams of short-lived radioactive species, which are then used for research in nuclear structure physics and nuclear astrophysics. Operation, optimization, and improvement of the existing facility are now the primary missions of the HRIBF staff. ORNL's Physics Division will compete for the next-generation radioactive ion beam facility, proposed for future funding in the 1995 DOE/NSF planning document, Nuclear Science: A Long Range Plan. The Physics Division offers an excellent environment for research and development, including access to state-of-the-art computational facilities and opportunities for collaboration with guest scientists at the Joint Institute for Heavy Ion Research.

The successful candidate must have a PhD or equivalent experience in Physics or Engineering with 5+ years' professional experience in accelerator physics; demonstrated record of accomplishments in accelerator design and development; excellent communication skills; the desire to work in a team environment on technically challenging problems; and a working knowledge in such areas as: magnet technology, beam transport, RF systems, and superconducting cavities. Project leadership and facility management experience desired.

Qualified applicants are invited to send a current resume and arrange for 3 letters of evaluation to be sent to: **Dr. James R. Beene, Oak Ridge National Laboratory, PO Box 2008, Oak Ridge, TN 37831-6368 or e-mail a resume to:** jrb@ornl.gov

For more information about ORNL, the Physics Division, and the HRIBF, please visit our web sites at: **http://www.ornl.gov, http://www.phy.ornl.gov, and http://www.phy.ornl.gov/hribf/hribf.html**

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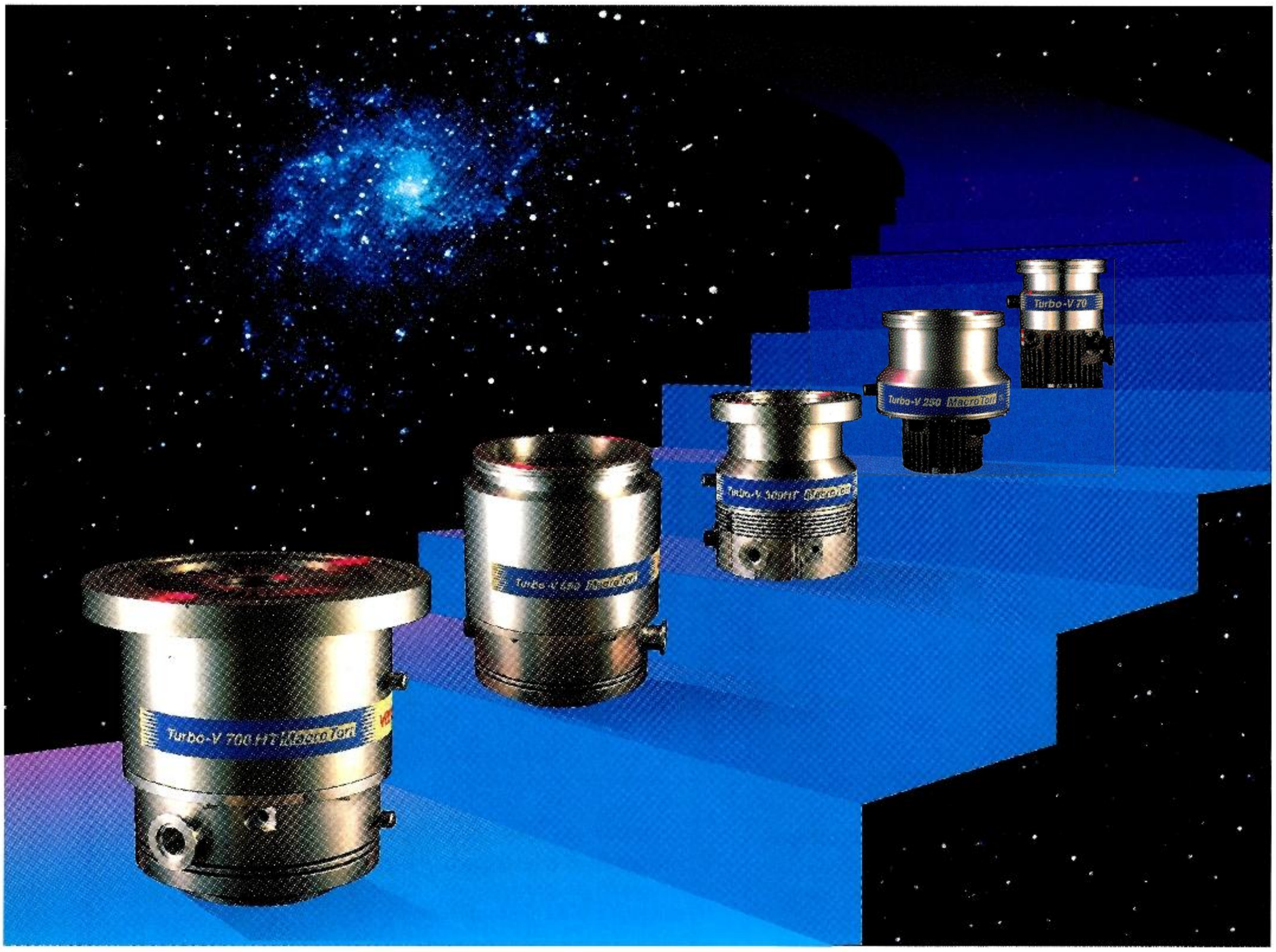

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