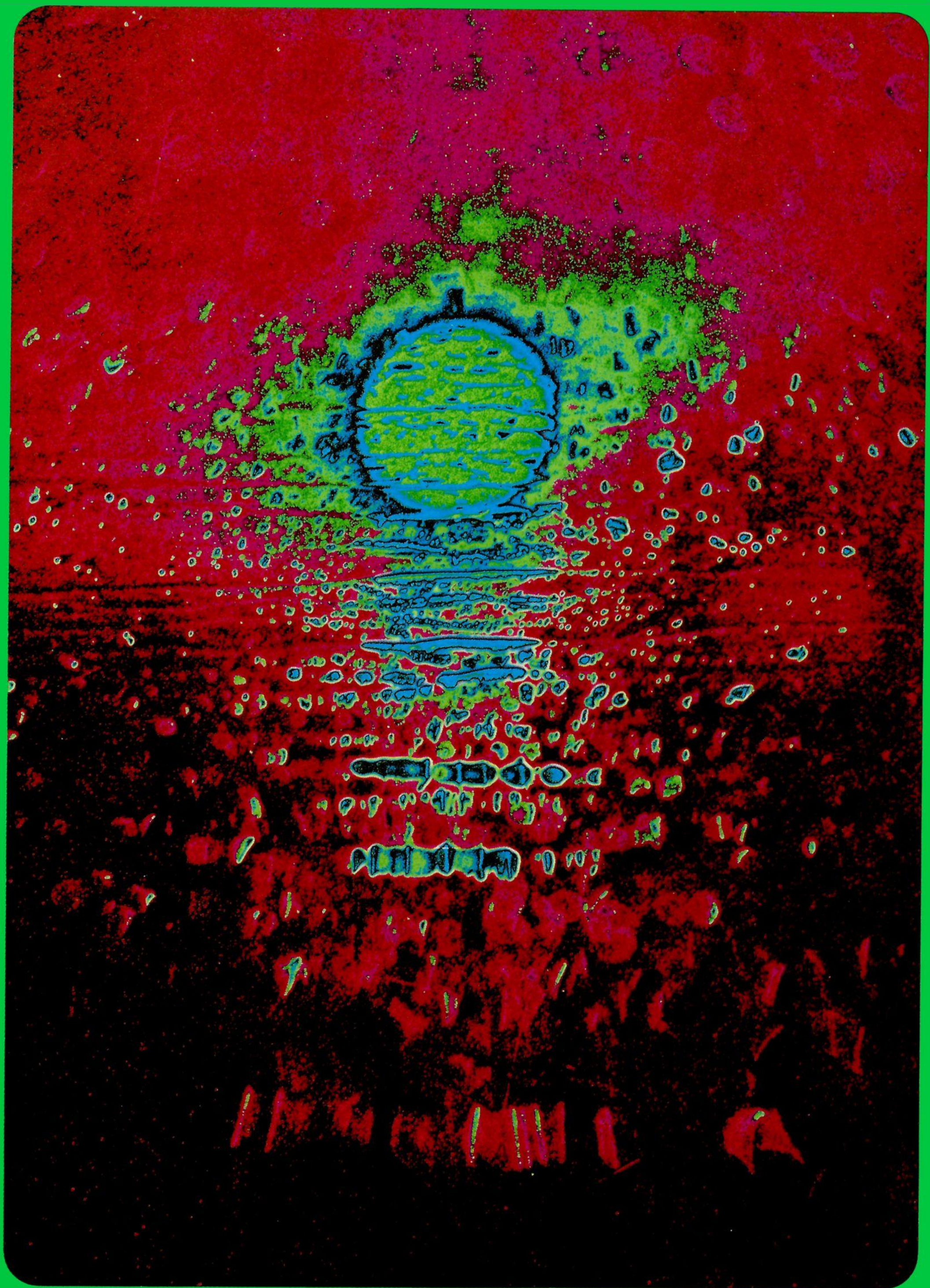
CERN COURIER

International Journal of High Energy Physics



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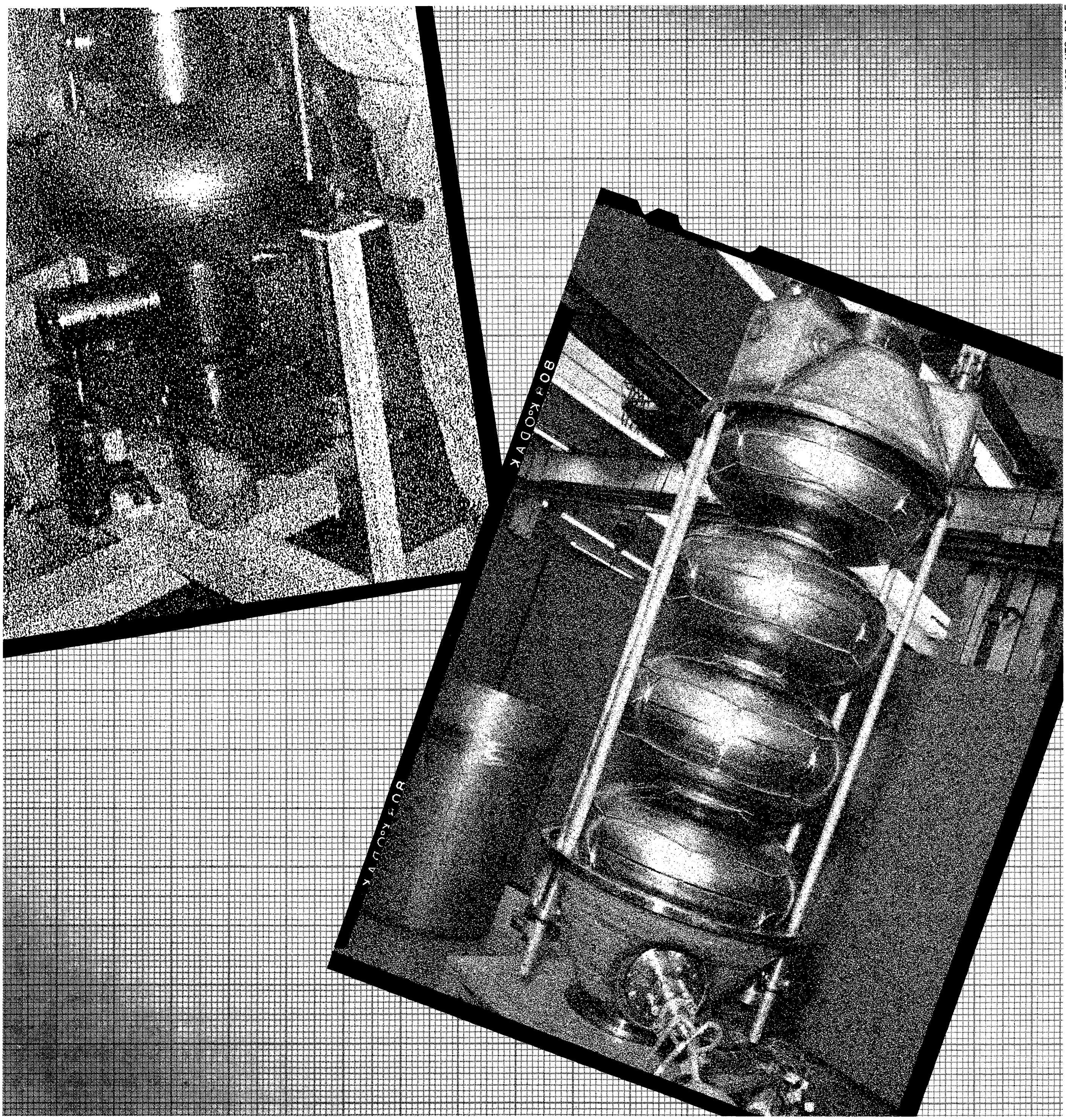

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CERN COURIER

International Journal of High Energy Physics

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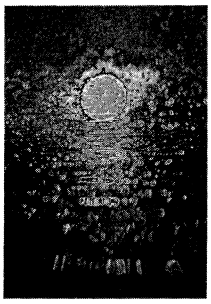


Cover photograph:
The solar neutrino puzzle — detectors looking for neutrinos from the sun do not find enough — see page 26. (Photo P. Loïez, CERN)

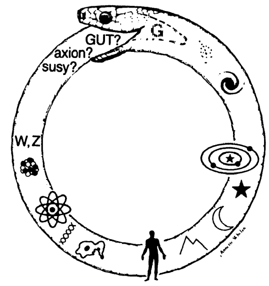
New Books in Physics

Weak and Electromagnetic Interactions in Nuclei

Proceedings of the International Symposium Heidelberg, July 1-5, 1986

Editor: **H. V. Klapdor**

1986. 555 figures. XXXI, 1110 pages.
Hard cover DM 149,–. ISBN 3-540-17255-6



The international Symposium on Weak and Electromagnetic Interactions in Nuclei held in Heidelberg in July 1986 brought together leading experts in the fields of nuclear and elementary particle physics, astrophysics and cosmology. While concentrating on various recent problems in nuclear physics (weak and electromagnetic nuclear properties, electroweak interactions in nuclei, exotic nuclei) the most fascinating contributions to this book arise from the crossfertilizing interaction of the following subjects:

- Lepton number violation and neutrino mass
- Muon physics
- Weak interactions and fundamental symmetries
- Fundamental decays
- Basic experiments for GUTs
- Weak interactions and astrophysics
- GUTs, SUSYs and the early universe

The book demonstrates in a comprehensive way that nuclear physics is channelling its energies into new directions.

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P. A. Krupchitsky

Fundamental Research with Polarized Slow Neutrons

Translated from the Russian by V. I. Kisin

1987. 42 figures. Approx. 150 pages.
Hard cover DM 87,–. ISBN 3-540-16996-2

Contents: Introduction. - Game-Theoretical Control. - The Differential Game of Convergence-Evasion. - The Existence of a Value for Positional Differential Games. - Dynamic Programming. - Extremal Aiming. - Extremal Aiming for Non-Linear Differential Games. - A Priori (Prior) Stable Sets. - Qualitative Problems of the Theory of Differential Games. - Mixed Strategies in Differential Games. Lower and Upper Differential Games. - Differential-Functional Games. - Appendix. - References.

Concepts and Trends in Particle Physics

Proceedings of the XXV Internationale Universitätswochen für Kernphysik Schladming, Austria, February 19-27, 1986

Editors: H. Latal, H. Mitter

1987. 48 figures. IX, 325 pages.
Hard cover DM 87,–. ISBN 3-540-17372-2

Contents: *M. Blau, W. Thirring, G. Landi:* Introduction to Kaluza-Klein-Theories. - *J. Wess:* Supersymmetry/Supergravity. - *W. Kummer:* Supersymmetric Yang-Mills Fields and Noncovariant Supergauges. - *G. Veneziano:* From Strings to Superstrings. - *G. C. Segrè:* Superstrings and Four-Dimensional Physics. - *R. D. Peccei:* Mass Issues in the Standard Model. - *H. Satz:* Critical Behaviour in Statistical QCD. - *H. Satz:* Critical Behaviour in Radom Field Gauge Theory. - *L. M. Lederman:* Experiments Beyond the Standard Model.

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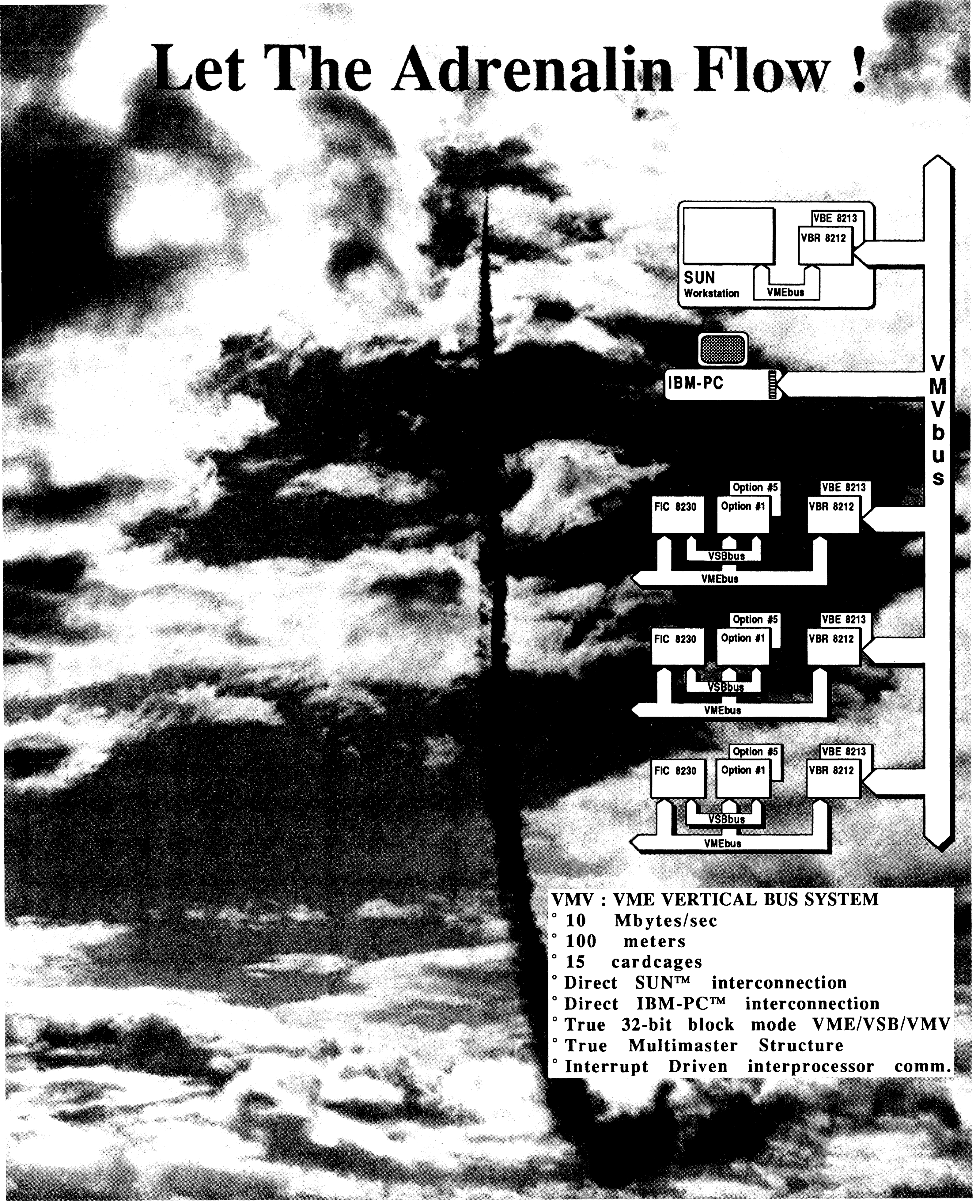

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Supernova particles

Cosmic cataclysm — the 1987a supernova

(Photo European Southern Observatory)

Early in the morning of 24 February, a diligent Canadian astronomer working at the Las Campanas observatory in Chile saw Something. A brilliant new light — many millions of times brighter than the sun — had lit up in a nearby galaxy (the Large Magellanic Cloud).

The light is due to a new supernova, routinely named 1987a but the brightest seen in recent history, resulting from the death throes of a star 30 times larger than the sun and 160 000 light years away.

Astronomical observations went on to show that the emitted light contains hydrogen streaming out at some 15 000 kilometres per second as the fireball, its nuclear fuel spent, moves towards a new composition as a neutron star.

But this time astronomers and astrophysicists were not the only ones interested. Instead of being blinded by the supernova's outer incandescence, for the first time physicists were equipped to pick up the particles produced by the gravitational collapse of its core.

Motivated initially by a quest for proton decay and other unusual phenomena, new large underground particle detectors have been built in recent years. With the proton apparently reluctant to decay, these giant installations have gone on to open up new physics horizons, including particle astronomy — the detection of penetrating particles from identifiable cosmic sources.

The monumental release of gravitational energy deep inside a supernova such as 1987a spews out particles, the visible light resulting from the heating of the outer layers. Accepted models of stellar collapse enabled astrophysicists to calculate the effects of this several second burst of some 10^{58} neutrinos with average energy around 10 MeV, which should have arrived before the light from the expanding hot gases.

According to this picture, the big terrestrial detectors should have intercepted a burst of neutrinos a short time before the onset of the optical supernova, the number of neutrinos snared depending of course on the size of the detector. The physicists operating large underground detectors eagerly scanned their data to see if anything unusual was picked up around 24 February.

The 150 ton LSD Liquid Scintillator Detector operated by an Italian/Soviet team in the Mont-Blanc road tunnel under the Alps reported a cluster of five neutrinos within the space of seven seconds, one day before the optical sighting.

Excitement at Moriond

The meetings in the 'Rencontres de Moriond' series organized by Jean Tran Thanh Van are frequently stimulating, but the session held at Les Arcs in the French Alps from 8-15 March was especially memorable. Two major new physics effects were presented for the first time — the supernova 1987a (see page 1) and particle mixing in the neutral B_d mesons (article next month).

This was the first full international meeting of astrophysicists and particle physicists after the new supernova became active on 23 February (160 000 years ago!), and there was a veritable star-studded galaxy of astro-speakers. This followed the Moriond tradition of having two parallel meetings with some joint sessions to stimulate inter-disciplinary interactions.

Sessions were interrupted when speakers heard that for the first time the neutrino burst from a supernova core had been intercepted, and new information was continually received and eagerly discussed at breakfast, lunch and dinner, and late into the night.

A final four-hour joint astroparticle session brought together speakers from the four neutrino detectors (Mont-Blanc, IMB, Kamioka and Baksan) and from the European gravitational wave detector, together with reports of optical and X-ray sightings from telescopes and satellites, and a confrontation with supernova theory.

The news of neutral B particle mixing provoked discussion as the data from the ARGUS detector at the German DESY Laboratory, presented by R. Schroeder, was especially convincing. Earlier strong indications from the UA1 (CERN) and MAC (Stanford Linac) collaborations were presented by T. Muller and R. Hurst. There was a lively exchange of views as to why theoretical analysis had suggested that mixing would be observed in B mesons containing a strange quark (B_s) rather than a down quark (B_d).

From Douglas R. O. Morrison

Also before the optical sighting but 4.5 hours after the Mont-Blanc burst, a cluster of neutrinos was recorded by the rebuilt Kamiokande experiment in Japan. About a dozen neutrinos in as many seconds were picked up by this huge detector using several thousand tons of water to catch particles, with the first events tightly grouped. Energies ranged from 7.5 to 36 MeV. The Kamiokande detector can also see which direction neutrinos come from — most of the hits were due to untrackable antineutrinos, but a few came from neutrinos and provided a pointer to 1987a.

Effectively at the same time as the Japanese signal, a distinct neutrino burst was also recorded in the world's other multi-thousand ton water-filled neutrino watcher, the Irvine/Brookhaven/Michigan (IMB) experiment in Ohio. Most of the events occurred in a 2.5 second interval with energies up to about 40 MeV.

The 4.5 hour difference between the Mont-Blanc signal and the Kamioka/IMB pulses is not explained. (However the Mont-Blanc detector sees a small effect at the later time, while Kamioka intercepted a few neutrinos at the earlier time! Both of these signals are compatible with background.) Some neutrinos at around the later time were also picked up by the Soviet Baksan Neutrino Observatory using its array of 3000 liquid scintillators.

The similarity of the signals seen in the two big detectors — Kamiokande and IMB — suggests that here indeed was particle physics from a supernova.

(A special supernova session was hurriedly organized at the Moriond meeting on Electroweak Interactions and Unified Theories. T. Kajita presented the results from Kamiokande and J. van der Welde from the IMB detector. A. Pomanski reported the Baksan observations.)

As well as corroborating the optical observations and probing the theory of supernova explosions, the neutrino effects also test our understanding of this enigmatic particle.

Has the neutrino, long assumed to be massless, a vestigial mass? With laboratory experiments giving contradictory results (see October 1986 issue, page 4), all additional information is welcome. On the basis of the limited bunch spreading over the 160 000-light year flight path, the electron-type neutrino cannot weigh more than a few tens of electron volts.

Exploiting the initial grouping of the supernova neutrinos caught by the Kamiokande and IMB detectors, John Bahcall and Sheldon Glashow conclude that the mass of the electron-type neutrino is likely to be less than 9.5 eV, a stronger limit than has been achieved in several decades of laboratory neutrino experiments.

Could the neutrino also be unstable? The mere detection of neutrinos from such a source also tells us that the particles live for at least 10^5 years.

The explosion of a star should also radiate gravitational waves, however even with the most optimistic assumptions the expected output falls below the sensitivity of today's gravitational antennae. Nevertheless an effect was recorded at the big cryogenic gravitational wave antenna operated at CERN by a Rome group. The cautious physicists prefer to attribute it to a random seismic effect rather than to new astrophysics.

At the special Moriond session, Maurice Goldhaber of Brookhaven and the IMB experiment declared, 'there are small discrepancies between absolute time observations, which can probably be resolved. These data will certainly be squeezed for all they are worth for a long time — perhaps until the next close supernova comes along. The near agreement with theory for this awesome phenomenon must be considered as a triumph for the input sciences — nuclear physics, particle physics and astrophysics, and increases confidence in the Big Bang calculations'.

Meanwhile the sparse data has sparked off a frenzy of activity, with many interpretations based on the the details of the neutrino observations. However astrophysicist Dave Schramm warns of the dangers of pressing these meagre statistics too hard.

Coming in from the cold

The minimal electrical resistance of superconducting materials provides an 'easy' way to high currents if the associated cryogenics problems can be mastered — conventional superconductors require ambient temperatures close to absolute zero. The discovery of new superconducting materials operating at much higher (but still cryogenic) temperatures brings the potential rewards much closer.

This article, specially written for the CERN Courier by a specialist in the field, gives an inside story on these latest developments. Meanwhile fresh 'warm' superconductor news continues to arrive. A team at Berkeley reports that an as-yet unnamed substance shows a dramatic drop in electrical resistance at about −39°C, a 'temperature close to a winter's day in Fairbanks, Alaska'.

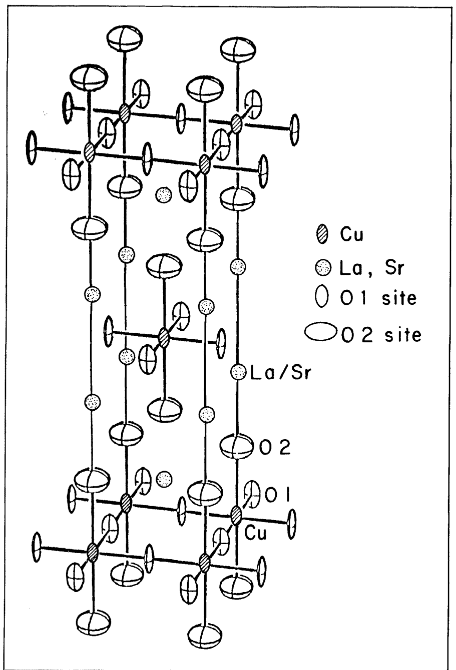
New high temperature superconductors

by David C. Larbalestier

Enormous interest has been aroused by the report of Georg Bednorz and Alex Müller of IBM's Zurich laboratories late last year of high temperature superconductivity in a mixed oxide of lanthanum, barium and copper. (Superconductivity, the abrupt fall of electrical resistance at low temperatures, was discovered by Kamerlingh Onnes in 1911, using mercury at liquid helium temperatures — 4.2 K.) The report of possible superconductivity at around 30 K was initially received somewhat sceptically. The phase responsible for the superconductivity was quickly identified by a Tokyo group as a layered 'perovskite' of approximate composition $La_{1.8}Ba_{0.2}CuO_4$.

These layered perovskites are related to better-known perovskites such as barium titanate, a ferroelectric. The Tokyo group and a group at Houston presented results of their work at the Materials Research Meeting in Boston in early December. They were able to document the two independent properties characteristic of superconductivity: zero resistance and flux exclusion. The scientific community was convinced and the hunt was on. Three months later, many hundreds of scientists are working on the new oxides.

The search for new superconductors with higher transition temperatures (T_c) and with possible new mechanisms has always been an exciting one. However the previous advance dates from 1973 when workers at Westinghouse and at Bell Labs advanced T_c from about 21 to 23 K with niobium-germanium films. A large effort was subsequently put into synthesizing niobium-silicon which appeared to be the logical next step



Crystal structure of one of the new 'warm' superconductivity candidates — the layered perovskite $La_{1.8}Sr_{0.2}CuO_4$. The cell is tetragonal, the height of the cell being about 13.3 A and the width of the cell about 3.8 A. The basal planes at top and bottom are believed to be those where superconductivity is favoured. These contain the copper and oxygen ions.

in the line from niobium-tin. Predictions of the T_c of niobium-silicon ranged from around 25 to 35 K. However it refused to form in the desired A15 crystal structure at the stoichiometric (3:1) composition and all efforts have so far proved fruitless. Reports of high temperature superconductivity in other more exotic compounds claimed T_c values of greater than 100 K but none proved verifiable. After 15 years of static T_c, there was a feeling of scepticism about further advances. Possibly for this reason, Bednorz and Müller were modest in their initial claim. They observed zero resistance only at 12-13 K; however they observed a distinct decline in resistance at around 30 K and they speculated this might be the signature of percolative superconductivity, where islands of superconductivity are weakly coupled together. Now we know that they were right.

Exciting as this report was, it was only the prelude to a more spectacular result. Following the Boston meeting, many groups took notice and many similar compounds (there are at least several hundred known layered perovskites) were fabricated. Very quickly a Bell group found that $La_{1.8}Sr_{0.2}CuO_{4-y}$ (the y is uncertain because there are an undetermined number of oxygen vacancies in the structure) had a T_c of 36-40 K. The Houston group found the original barium oxide to have an onset T_c of up to 52 K under pressure and the race was really on. In early February, a joint team led by C. W. Chu (Houston) and M. K. Wu (Alabama) reported superconductivity at about 90 K. Reports of this work appeared in Physical Review Letters on 3 March. The compound is similar to the La-Ba-Cu oxide, lanthanum being replaced by yttrium. However, the proportion of barium is greater, $Y_{1.2}Ba_{0.8}CuO_{4-y}$ and the crystal structure is not yet determined.

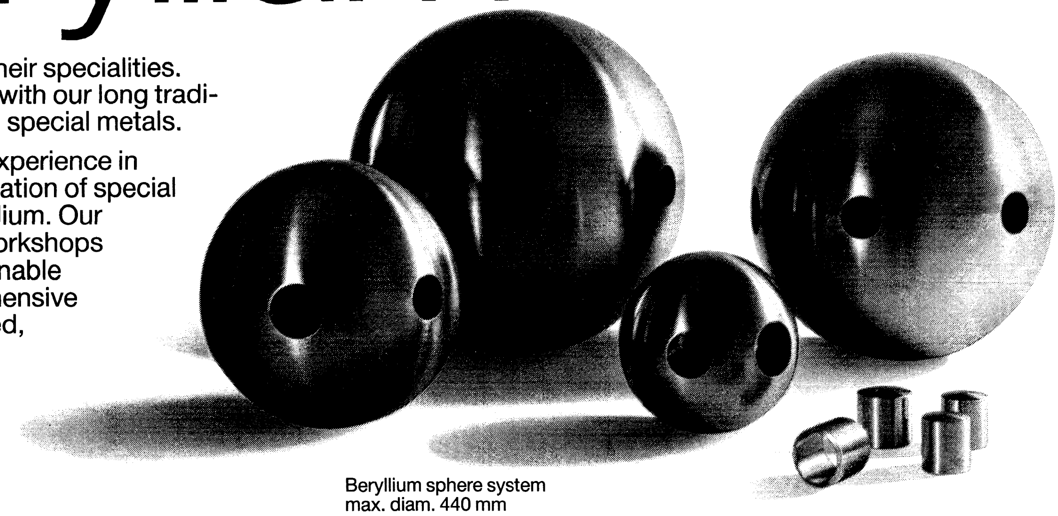
The appearance of superconductivity at temperatures accessible to liquid nitrogen cooling (77K) is of course of tremendous interest. The low latent head of vaporization of helium (2.9J/cm^3) and the low specific heat of materials at liquid helium temperatures make for instabilities. Liquid nitrogen has a much larger latent heat (159J/cm^3) and is about ten times cheaper than helium. Superconducting magnets operating with liquid nitrogen should be very stable and it is natural to speculate whether a revolution in superconducting technology is imminent.

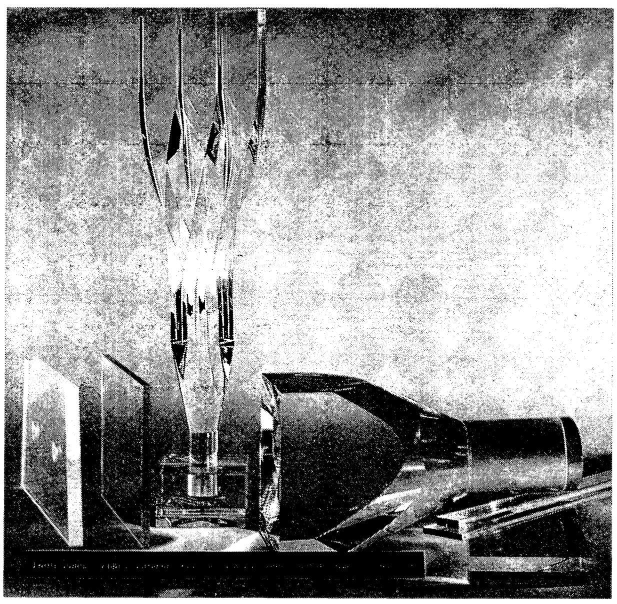
Given such dramatic discoveries and such a rapid advance, it is difficult to make a definitive view of the technological impact of these materials. However let me make some comments appropriate at the time of writing (5 March), with the reservation that developments in the following weeks and months may invalidate these remarks.

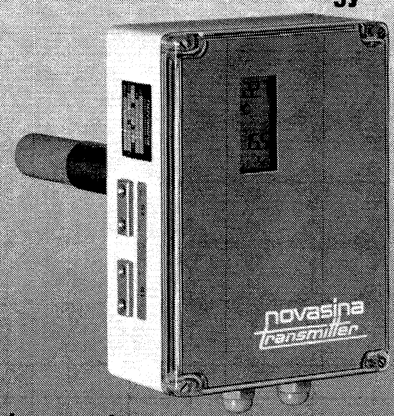
These materials appear to be BCS superconductors (that is, their properties appear to be explicable in terms of the traditional Bardeen-Cooper-Schrieffer theory of superconductivity), albeit very strongly coupling ones. Strong coupling means the BCS picture is modified to make the basic Cooper pair coupling stronger. This is consistent with the atomic structure of the layered perovskite, in which the copper ions are surrounded by an octahedral oxygen array. The most favoured present explanation for the properties is that the substitution of a divalent cation such as Sr^{2+} for a trivalent La^{3+} ion produces partial transformation of Cu^{2+} to Cu^{3+}. The extent of this depends on the oxygen vacancy concentration; if no vacancies exist, each substitution of a Sr^{2+} ion converts a Cu^{2+} ion to a Cu^{3+} ion. The mixed valence state produces metallic conductivity; the unsubstituted La_2CuO_4 is a semiconductor. In this model, it is believed that a strong electron-phonon interaction exists, these conditions being favourable to high temperature superconductivity.

Given that they are BCS-like superconductors, we should expect high critical fields to go with the high critical temperatures. Many workers have now measured the critical field slope at T_c to be of the order of 2T/K and rather sensitive to measurement conditions. According to standard theory, this indicates that the critical field at which superconductivity is destroyed could be around 50 to 150T at 0 K. No such DC fields presently exist to check the predictions. However measurements by a group at MIT and Bell do suggest at least 45T at 4.2 K. Unfortunately the transition is of order 20T wide.

A very broad transition is common to all the measurements presently known to me, including our own attempts to pass transport currents through the Ba and Sr oxides. Attempts to pass current densities of much more than about 10A/cm^2 produce very extended transitions. The most favoured



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present explanation for this behaviour is that superconductivity exists in many discrete regions within the sample but only weak coupling exists between these regions. This weak coupling is strongly diminished by an external field. Electromagnetic and structural characterizations of these compounds are proceeding furiously and we may soon expect to know whether this percolative nature of the superconductivity is inherent in the material or results from the way present samples are being prepared.

The long timescale needed to produce acceptable conductors of niobium-tin (10-12 years) following its discovery in 1962 inevitably comes to mind in assessing the potential timescales for developing high field magnets with the new materials. These new oxides, like niobium-tin and the other A15 compounds are inherently brittle and this is bound to affect their application in magnets, just as large scale construction of niobium-tin magnets has lagged behind their ductile niobium-titanium counterparts. But superconductivity above 77K provides a powerful stimulant to solve the technological problems of dealing with brittle materials. The next few months could give us many more surprises in an area where none were suspected only a few months ago. The discovery of Bednorz and Müller has given a profound new stimulus to superconductivity and the last discovery has surely not yet been made.

The A to Z of accelerators

With great skill, the organizers of the 1987 Particle Accelerator Conference arranged a vast programme to run through nearly 700 papers from Session A to Session Z. They took in en route the latest on construction and plans for the high energy machines for particle physics but this information was surpassed in volume by reports from the many other areas where accelerators now play a key role.

US Superconducting Super Collider Central Design Group leader Maury Tigner — aiming at the highest possible energies.

Synchrotron light sources are now illuminating the world in almost thirty Laboratories. Free electron lasers are confirming their promise for the creation of undreamed of fluxes of electromagnetic radiation. 'Star wars' machines are now openly discussed. Reports on other actual or potential applications in medicine, food processing, fusion, etc., underlined how the seemingly esoteric technology developed for the study of particles has continued to ripple into everyday life. (Already many people sit in front of a particle accelerator for several hours every evening!)

The Conference was held in Washington from 16-19 March and was the 12th in the North American series which began in 1965. The attendance of over 1100 was another reflection of the wealth of activity in the field.

Giorgio Brianti — pushing for a hadron collider in the tunnel now being completed at CERN for the LEP electron-positron collider. ▶

The debate on the big machines

Since the hot topic appeared in Session Z, not many people left the Conference early. In the wake

of President Reagan's endorsement of the Superconducting Super Collider and of the CERN Committee of Council's promotion of the Large Hadron Collider, there was no hiding the potential overlap between the two projects. It would clearly not make sense to build two similar machines of such size and cost (unless perhaps the lower energy machine could be completed much faster or one machine had significant capabilities inaccessible to the other).

Maury Tigner, who leads the Central Design Group on the SSC, gave the first talk, followed by Giorgio Brianti, deeply involved in the LHC work at CERN. Accompanying both proposals are invitations to other world regions to join in the construction and exploitation of the huge machines. Leon Lederman had a more delicate task than he could reasonably have anticipated when he accepted the title of 'The status and outlook for international collaboration on future accelerators' for the concluding talk.

Tigner outlined the main parameters of the SSC — 20 TeV per beam, luminosity of 10^{33}, six interaction regions, 6.6 T magnets, 85 km circumference, $ 4.4 billion cost (R and D, machine, detectors, computers), 8 ½ year construction time. Preparations are going well and, in particular, the dipole bending magnets, which are the most costly of the technical components, are comfortably exceeding design specification in the recent prototypes which have been tested.

Beginning in April, the site selection procedure is scheduled to filter out a small set of favoured sites by July 1988. The final choice is planned for end 1988 so that digging could begin early 1989. Congressional hearings for budget authorization were imminent at the time of the Conference.

Tigner quoted Abdus Salam on the importance of aiming at the highest possible energy and repeated the statement that participation from other countries could be envisaged with the machine ultimately open to qualified scientists from all countries.

While the Conference was in progress, a meeting of the American Physical Society in New York was in ecstasies about the newly discovered high temperature superconductors (see page 3). Tigner brilliantly fielded a question about the possible impact of these new materials on the magnet design for the SSC. As known at present, their current densities are a factor of 1000 down on those needed for the SSC; mechanical properties, feasibility of volume production, production costs are all unknown. From past experience, moving from this situation to the demanding environment of storage ring magnets is likely to take a very long time.

Brianti cited the LHC parameters — about 8 TeV per beam, luminosity of over 10^{33}, magnet fields up to 10 T in 'two-in-one' magnets, located over the electron-positron ring in the 27 km circumference LEP tunnel now being completed at CERN.

The attractions of the LHC stem from its much lower cost because of the existing tunnel and injectors, and from the unique physics potential of proton-proton, proton-electron, and even ion collisions. The final touches are now being made to the conceptual design and a cost estimate will be detailed at the same time.

Construction could proceed during the six months per year when LEP is not in operation (and the CERN machines are busy with antiprotons) and would not necessarily interfere with completion of LEP to its 100 GeV per beam design energy. The estimated earliest timescale for LHC is 1995. The CERN Committee of Council (see April issue, page 1) has proposed scientific and technical cooperation with non-Member States.

Leon Lederman — international collaboration on future accelerators.

Lederman recalled the history of the moves towards greater international collaboration since the World Laboratory/Very Big Accelerator (VBA) was first discussed in 1975. Following the formation of the International Committee for Future Accelerators (ICFA) a year later, which initially had the VBA as a potential mission, at every point in time one or other region was, to use Pief Panofsky's phrase, 'pregnant with a new machine'. What has happened in the intervening years has followed the 'leapfrog model' rather than full collaboration. ICFA has had to content itself with promoting international collaboration in exploitation of machines and in developing accelerator technology.

An alternative route has emerged in recent years and has become

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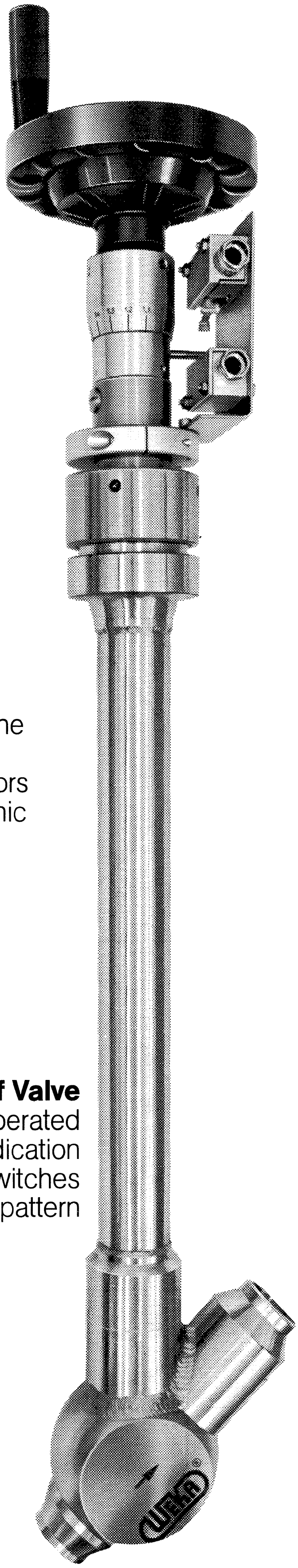

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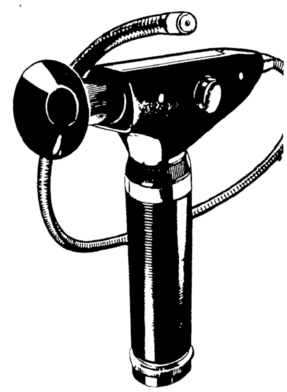

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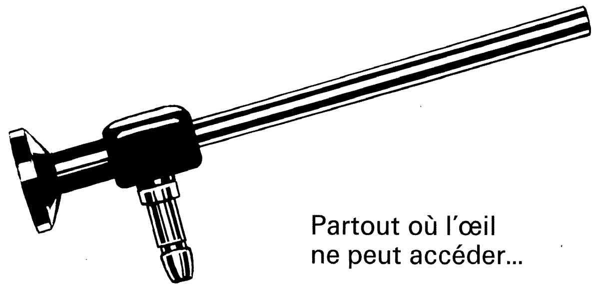

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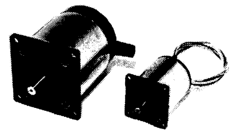

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known as the HERA model since it has been crucial to the building of that electron-proton collider at DESY. It involves the core of the responsibilities and costs remaining with the host country but with very extensive bilateral agreements for machine component construction and financing worked out for other countries.

Lederman recognized that the SSC proposal itself, when it first emerged, 'was a blow to hopes of a World Laboratory'. (In fact at that time it caused considerable dismay in ICFA since it was promoted without prior consultation or consensus amongst the different regions. The latest LHC proposal has been promoted in the same way.)

Lederman concluded with his personal thoughts on the present situation. He is concerned about the adequacy of the LHC to cope with the needs of all regions, particularly when constrained by LEP exploitation in the same tunnel. The SSC is likely to be at least double the cost but for double the energy (the European contention is that the interesting energy region would be reached at LHC).

A strong case can be made for going in either the SSC or LHC direction. Both regions are promoting their candidate with conviction, just as they have always done in the past.

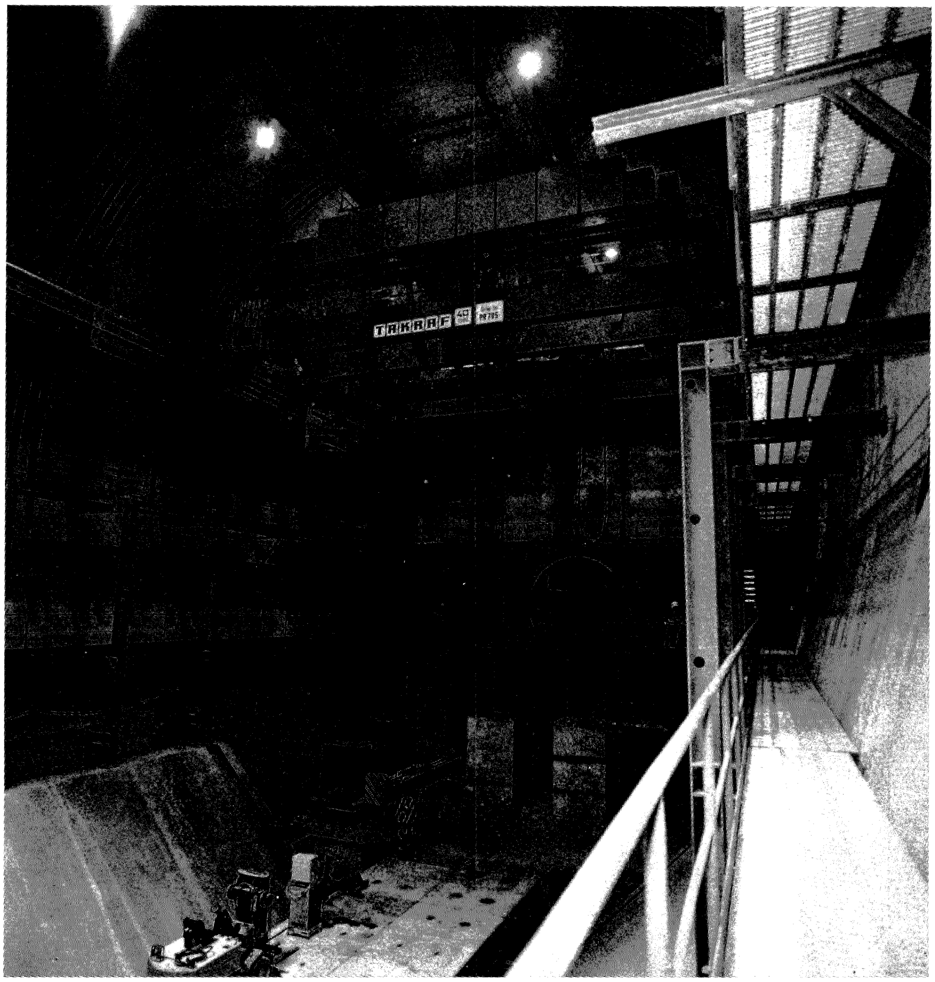
The present front-line machines

John Rees reported imminent operation of the Stanford Linear Collider (see page 31), to provide 50 GeV per beam electron-positron collisions via arcs at the end of the Stanford linac. Initial performance aims have been reduced compared to the design values (for example, the tiny beam spot size at the crossing point has been relaxed to 2.8 compared to 1.6 microns, the pulse rate is reduced to 120 rather than 180 Hz, initial energy is likely to be 47 GeV and so on).

There are some problems in the damping rings causing bunch lengthening which will require attention to the vacuum chamber and the pulsed magnets. In the linac the 'heroic efforts' on the r.f. klystrons have produced excellent results and there are now 200 of the 67 MW klystrons available. In June, Stanford hopes to attack the physics of the Z^0 (93 GeV), the neutral carrier of the weak force, discovered at CERN in 1983.

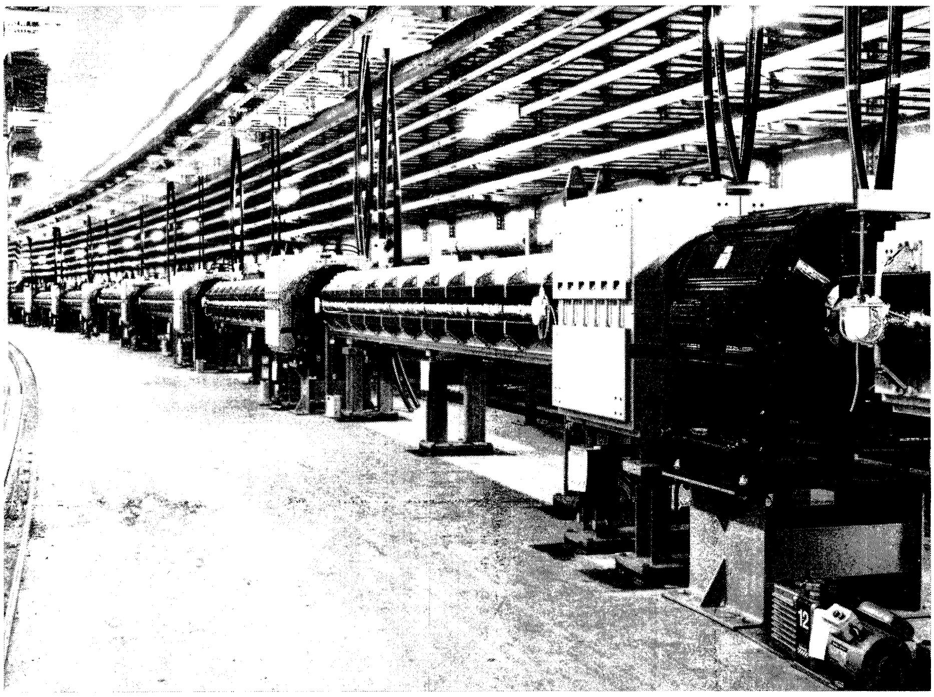
Installation work for the LEP electron-positron collider at CERN is well underway. This shows the pit to house the L3 experiment, with the tunnel opening in the background. At the Washington meeting Gunther Plass described LEP progress.

(Photo CERN 446.3.87)



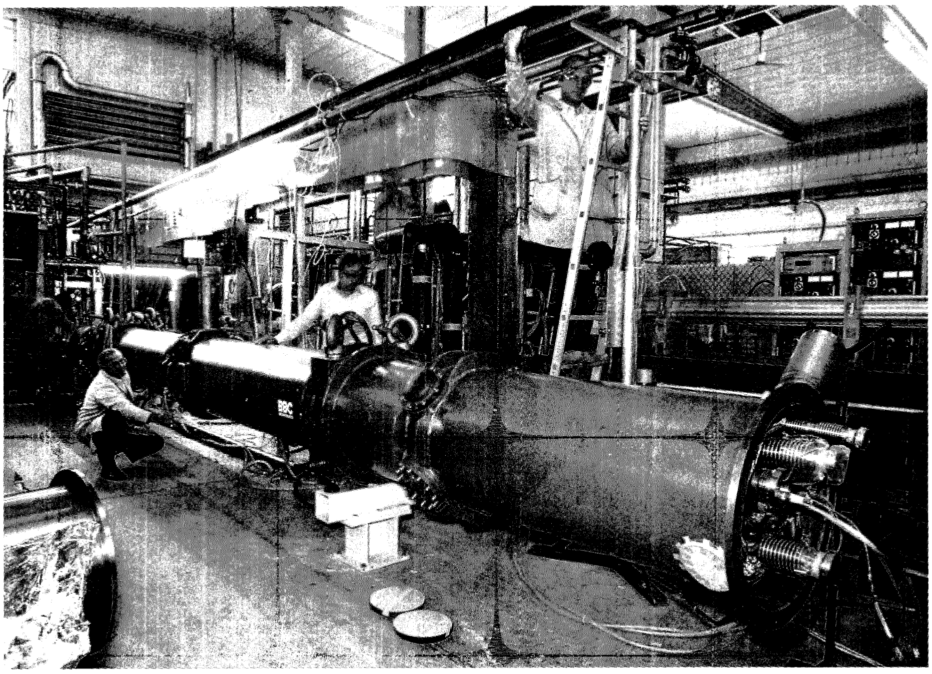
Gunther Plass talked about the other Z^0, and eventually W, factory — LEP at CERN. The first elements of the injection system have all reached or exceeded specification and the next stage will occur in July when electrons go into the SPS; the first transfer to LEP will be a year later. LEP operation is scheduled for mid-89 and completion of the machine to its full design energy of approaching 100 GeV could follow soon afterwards with the use of superconducting cavities.

The newcomer to the particle physics scene, the electron-positron collider, TRISTAN, at KEK in Japan, was greeted with particular appreciation when G. Horikoshi



A newcomer. The TRISTAN electron-positron collider at the Japanese KEK Laboratory operates at 25 GeV per beam, aiming soon for 28 GeV.

(Photo KEK)



Prototype superconducting magnet for the proton ring of the PETRA electron-proton collider now being built at DESY, Hamburg. Tests give promising results.

(Photo DESY)

gave his talk. They are now operating with 32 r.f. cavities, giving a peak energy of 25 GeV per beam. From July it is intended to nudge this to 28 GeV with more cavities, and vacuum improvements should extend the beam lifetime.

R. Kose reported on another Laboratory happy with electrons, DESY, where the new synchrotron, DESY II, is performing well. It is one of the injection elements for the electron ring of HERA which is under construction to collide 30 GeV electrons with 820 GeV protons. The HERA tunnel is three quarters complete and the four halls are finished.

The proton ring is the greatest challenge since it incorporates superconducting magnets. Five prototype 9 m dipoles have exceeded design field with good field quality. In fact the performance is so good that they could sustain a beam energy of over 1 TeV; conventional magnets in the ring limit the possible peak energy to 1 TeV. Similarly the energy of the electron ring may be taken higher by the use of r.f. superconducting cavities. If prototype cavities work well in tests on the PETRA ring, eight of them will be installed in the electron ring. Colliding beams are scheduled for 1990.

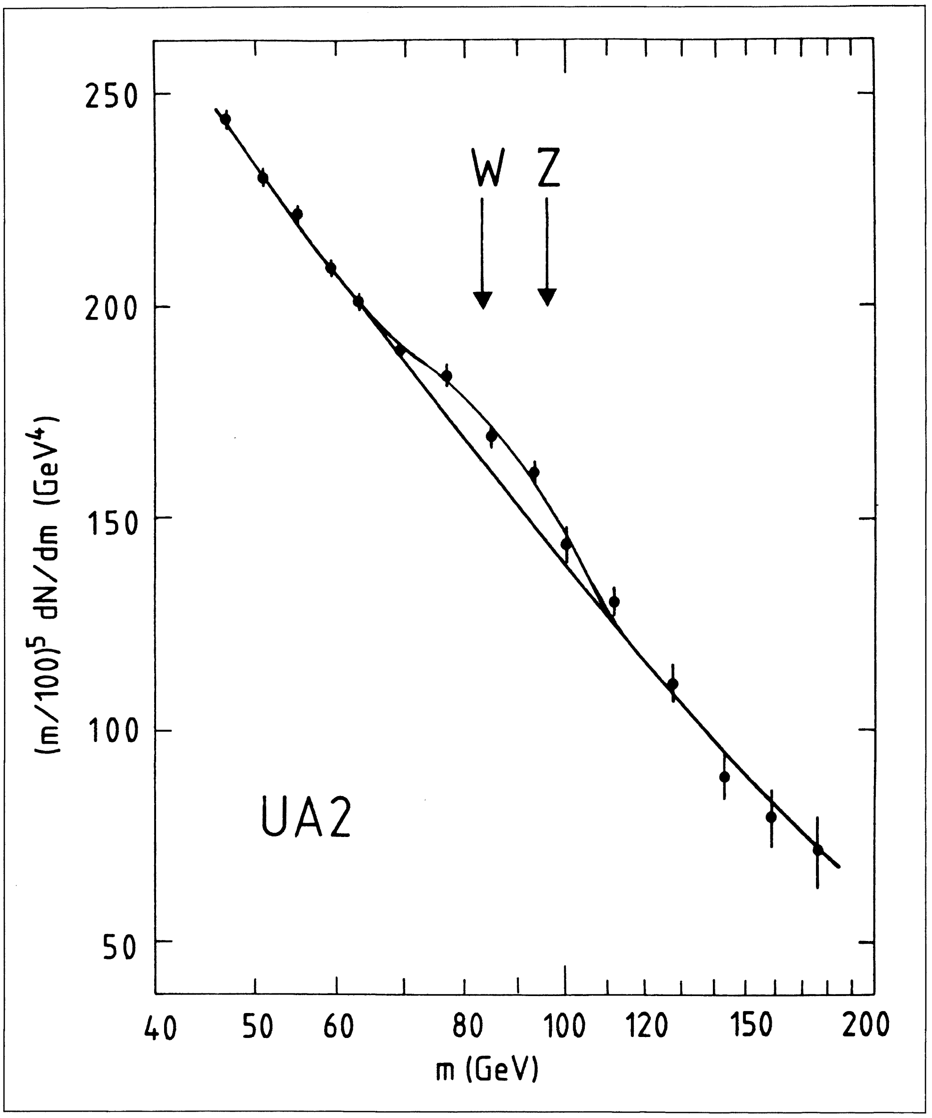
Roland Johnson reported on operation of the world's first superconduction collider — the Tevatron at Fermilab where proton-antiproton collisions have been achieved at an energy of 900 GeV per beam, the highest ever achieved. The antiproton source is now working excellently, stacking at the rate of up to 10^{10} antiprotons per hour, and has exceeded the performance of the CERN Antiproton Accumulator (though not of the improved source at CERN which will come into action later this year).

However it has proved difficult to profit from these healthy antiproton fluxes because a high proportion of the beam is lost prior to full energy interactions. Transmission through the conventional magnet ring is troublesome following a major revamp last year, including the construction of a seven metre-high by-pass to take beams over the Collider Detector Facility, CDF. The superconducting ring is sensitive to ramp history which introduces difficult operational problems. The CDF is, nevertheless, taking data at the highest proton-antiproton collision energies, with luminosities steadily improving.

At the CERN SPS proton-antiproton collider, preparations are well underway to cope with the increased intensities from the new antiproton source. Lynn Evans described the manoeuvres of beam separation all round the collider, and an additional 100 MHz r.f. system. An interesting experiment will be the use of stochastic cooling in the SPS itself with an optical link across the ring.

(continued on page 15) ▶

Mass spectrum of two hadron 'jets' seen by the UA2 detector at CERN's proton-antiproton collider, indicating the signal due to the W and Z particles above less interesting background. This is thought to be typical of the physics which will emerge at future higher energy colliders, and demonstrates the ability of such experiments to spot heavy particles through their decay into narrow 'jets' of hadrons — 'jet spectroscopy'.



Experimental challenge

With enthusiasm running high for big new machines to collide beams of strongly interacting particles (hadrons) at higher energies, interest focuses on how to exploit the exciting physics that these machines will open up.

Under these conditions the signals of many new phenomena are expected to be small, and moreover obscured by less interesting background effects. New physics will probably emerge only after stringent selection procedures.

The chances of seeing rare processes are increased by pushing up the collision frequency and/or the collision energy.

The target collision rates imply that a detector at a large hadron collider will have to cope with some 10^8 interactions per second, about a thousand times up on what is seen at today's hadron colliders.

Such high rates have important implications for new detector designs, especially for resistance to radiation, response speed, granularity of coverage, and triggering. Much of today's instrumentation technology will either be inadequate or at least have to be developed considerably.

The success of the experiments at CERN's proton-antiproton collider has underlined the usefulness of calorimetry — recording the detailed pattern of energy deposition around the collision point. Precision study of the narrow sprays or 'jets' of produced hadrons provides valuable information on the behaviour of the quarks and gluons deep inside the collisions. The 'missing transverse energy' approach — detailed analysis of energy emerging sideways from the colliding beams to search for any imbalances — has demonstrated its impressive ability to 'detect' inert particles, such as neutrinos, which otherwise fly through the apparatus without trace.

Important in this work will be the granularity of the detector (the fineness of the 'mesh' catching the debris emerging from the interaction point), its 'hermeticity' (no 'cracks' through which particles can emerge undetected), its calibration and its energy resolution. All these topics are being continually discussed, and developments reported.

While any future hadron collider will open up a wide and exciting new range of physics, instrumentation for this physics will be a challenge. A strong programme of detector research and development work is called for to exploit the new horizons.

From Peter Jenni.

▶ (from page 12)

Construction of the 3 TeV proton fixed target and, eventually, colliding beam machine, UNK, at Serpukhov in the Soviet Union aims for first full energy beams in 1992. Civil engineering is well underway and the remaining major decision concerns the choice of superconducting magnet design. Up to now, development has concentrated on warm-iron versions and prototypes have achieved good quality field at 6 T (in excess of the 5 T needed for 3 TeV beams). Heat loss is still uncomfortably high. Cold-iron versions like the HERA design are being studied and the decision will be taken by the end of the year. The magnet test facility is being installed.

For UNK, a colliding beam scheme had been envisaged between the 3 TeV superconducting ring and the 600 GeV conventional magnet ring acting as injector. However this is falling increasingly under the shadow of a higher energy collider project using a third ring. With big hadron colliders being pushed in Western Europe and the US, Soviet physicists point to the usefulness of a fixed target programme in the 1990s at energy beyond the present Fermilab Tevatron.

European Particle Accelerator Conference

The North American series of particle accelerator conferences has been successful for a variety of reasons. By comparison with the International series, now held once every three years, it allows a very much broader coverage of topics with considerable emphasis on practical applications. It also provides a forum for younger accelerator physicists and engineers who have limited outlet in the rarified spheres of the international meetings. Geography and the related travel expense also play a role, since the international Conference passes through a particular region only once every nine to twelve years.

The need for a local outlet, particularly for the younger scientists in accelerator technology, has been felt in Europe for some time. It has therefore been decided, particularly on the initiatives of the European Physical Society and the European Committee for Future Accelerators, to initiate a European series (though with US participation in the organizing committee).

The first European Particle Accelerator Conference will be held in Rome from 7-11 June 1988. It will follow the successful US model closely with emphasis on applications and, probably, an exhibition of related industrial products.

The big nuclear physics machines

Turning to major projects where machine parameters are selected for other areas of physics, particularly nuclear physics, we reach the enthusiastic talk at the Conference given by Hermann Grunder on the Continuous Electron Beam Accelerator Facility, CEBAF.

Studies of the quark-gluon system call for continous electron beams of high current at energies of a few GeV. CEBAF, via a 0.5 GeV recirculating linac, aims to provide such beams with 200 microamp current and energies from 0.5 to 4 GeV. Superconducting linacs would be used and Grunder paid tribute to the aid of many other Laboratories in mastering this thechnology. So well is this work going that 6 GeV peak energy may be feasible within the presently foreseen scope of the project. Four companies have built acceptable cavities and placing contracts in industry is therefore no problem.

The beam physics has received a lot of attention to avert the danger of beam break-up, which has proved to be a problem in the past. Tests have been carried out in the CESR machine at Cornell. Site clearing at Newport News started in February (see April issue, page 30). Full project authorization is still sought at a project cost of $ 255 million over a construction time of six years.

Mark Barton reported on the next in line in nuclear physics priorities in the USA — the Relativistic Heavy Ion Collider, RHIC, proposed at Brookhaven to make use of ions accelerated in the Alternating Gradient Synchrotron and collide them at up to 100 GeV per nucleon (for gold on gold) in superconducting magnet rings installed in the tunnel built for the abandoned ISABELLE project. The project is being approached progressively with ions

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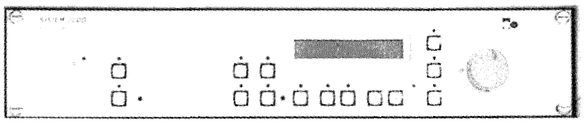

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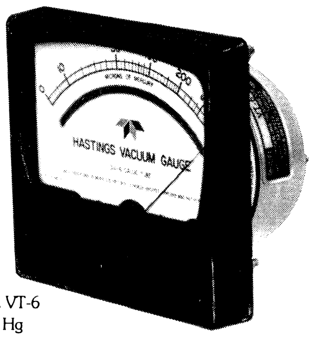

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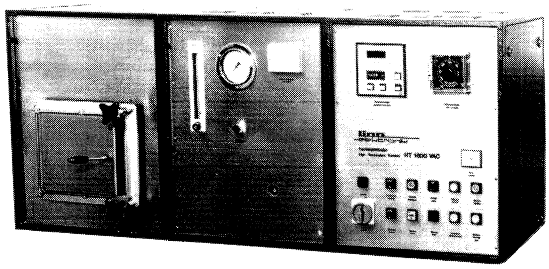

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in the AGS from tandems and the addition of a booster to achieve ions across the periodic table. Four dipole prototypes for RHIC have been tested with results above the 3.45 T design field.

Kaon factories (high intensity proton synchrotrons of several tens of GeV for copious production of kaons and other particles) were reviewed by Mike Craddock. Four such machines are at present on the table in Canada, Europe, Japan and USA but none has yet received construction authorization (see April issue, page 23).

Graham Rees reported on the operation of the ISIS intense neutron source at the UK Rutherford Appleton Laboratory. The high intensity proton synchrotron has been in action for just over a year and is now feeding six neutron beam instruments (four more are under development). Muon spin rotation work and a neutrino experiment should start soon. The machine intensity has reached 50 microamps and the operating energy is 550 MeV. This will be increased to 100 microamps and 750 MeV in the near future. (An interesting implication of dealing with such high intensities in the neutron source is that ISIS is one of the few machines in the world where the operators are keen to increase the beam emittance!) European co-operation (France, Germany, Italy and Sweden) is involved in longer term development options which include an additional target station and the rebuilding of the linac — the least reliable element of the machine at present.

Forthcoming attractions

This first report from the Washington Conference concentrates on news from particle/nuclear physics machines. In our next issue we will cover some of the accelerator news at the meeting from other fields.

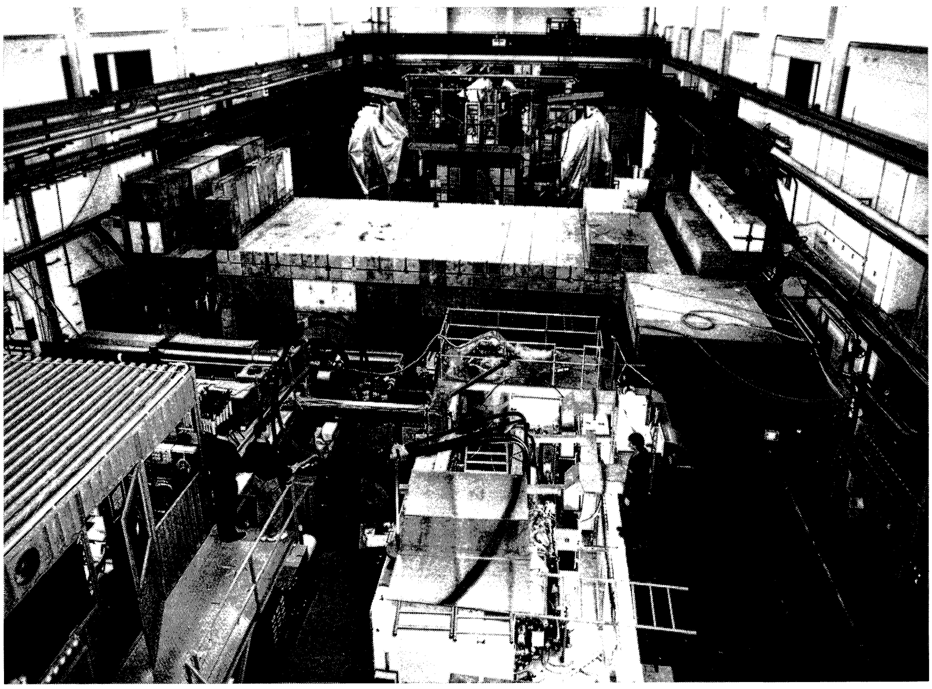
By Brian Southworth

Around the Laboratories

DESY
PETRA II

After the successful start for the new DESY II electron synchrotron at the German DESY Laboratory in Hamburg (see April issue, page 14), the PETRA ring restarted operations on 8 March as PETRA II. Both these second generation rings will be used to handle particles destined for the HERA electron-proton collider now under construction.

PETRA II is a substantial modification of the ring used from 1978 to 3 November last year (see January/February issue, page 23) for electron-positron collision physics.



With the CELLO experiment retired in the background, the beam pipe of the substantially modified PETRA ring is now encased in concrete blocks. In the foreground is a superconducting cavity test installation.

(Photo DESY)

Blazing a trail for protons

On April 1 at the DESY Laboratory in Hamburg, a 7 GeV positron beam produced by the new 'DESY chain' of machines (Linac II, PIA, DESY II and PETRA II) was fired into a beam dump in the still incomplete tunnel being excavated for the HERA electron-proton collider, blazing the injection trail for the HERA protons. In the meantime DESY's new proton source is being put through its paces, pending construction of the new DESY III synchrotron to handle the proton beams prior to injection.

After the shutdown, the four big experiments (CELLO, JADE, Mark-J and TASSO) were removed from the ring, together with the big focusing quadrupoles, the mini-beta high luminosity quadrupoles and the electrostatic beam separators. Of the four experiments, only the CELLO set-up was retained, out of the beam, as a standby for eventual future use. Concrete shielding was placed around the ring in the former experimental halls and 500 metres of new vacuum pipe added, together with ancillary vacuum equipment.

As well as taking care of electrons (and positrons), the new PETRA ring will also be called upon to handle protons. All radiofrequency accelerating cavities were removed from the PETRA North Hall and most of the remainder switched off. These will later find their way to the main HERA ring. To run PETRA with 14 GeV electrons, only 16 cavities are necessary. These will be positioned in the South Hall, but must be bypassed in future by the proton beam, taken to 40 GeV prior to injection into HERA.

The modified ring structure and the new beam optics required a different arrangement of focusing elements. In addition, septum and kicker magnets for particle ejection were installed in the North straight section. All this transformation work took only four months.

W goes West

On March 26, the first candidate W particle — the electrically charged carrier of the weak nuclear force — was seen in proton-antiproton annihilations at the Fermilab Tevatron by the big CDF detector. The Tevatron's luminosity figure was about 7×10^{28} cm^{-2} s^{-1}, about the same as CERN's collider when the first-ever W events were recorded towards the end of 1982. However the Tevatron is operating at 1800 GeV collision energy, compared with 540 GeV at CERN in 1982. The Fermilab 'new world' W gives a clean 36 GeV electron coming out almost perpendicular to the colliding beams.

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Short-lived study continues

According to the almost exact theoretical principle of combined charge conjugation/parity (CP) invariance — under which particles and antiparticles are interchanged and left and right are switched round — the neutral kaon comes in two forms, a short-lived variety, preferring to decay into two pions, and a long-lived one, disintegrating mainly into three pions.

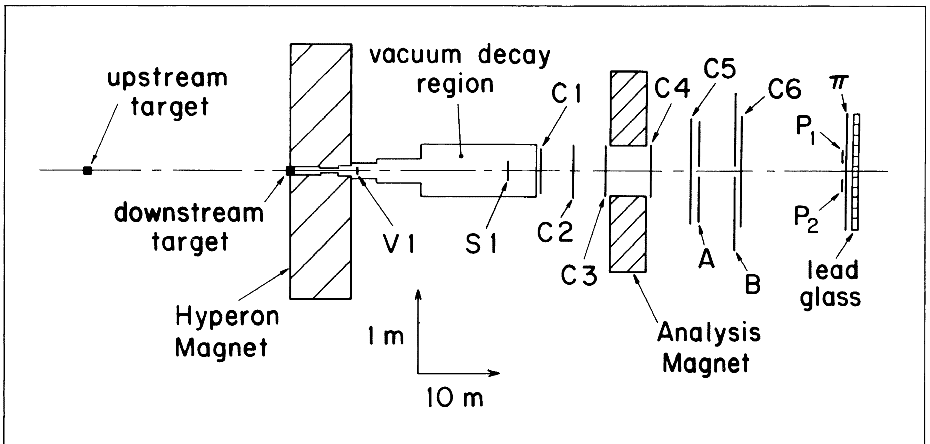
In 1964, the classic experiment of J. W. Cronin and V. L. Fitch at Brookhaven revealed that CP invariance was not exact. About one long-lived neutral kaon in five hundred was seen decaying into two pions. Subsequent CP-violation studies found other unusual decays of the long-lived neutral kaon. Now experiment E621 at Fermilab (a Michigan/Minnesota/Rutgers collaboration) has looked for CP violation through unusual (three pion) decays of the short-lived neutral kaon.

To make a beam of long-lived neutral kaons and study their CP-violating decays is relatively easy — just sit a long way from the kaon production target so that all the short-lived neutral kaons have gone. For the short-lived variety, this trick doesn't work, so CP violation has to be sought close to the production target in the delicate interference effects between the two kinds of kaons.

A 800 GeV proton beam from the Tevatron was split into two and led to two kaon production targets, one 25 metres upstream of the other, and the characteristics (acceptance) of the detector measured using the almost pure long-lived kaon decay sample from the upstream target.

E621 was the first experiment in the Proton Center beamline at Fermilab to run using 800 GeV

Apparatus of the Michigan/Minnesota/Rutgers experiment at the Fermilab Tevatron looking for unusual (CP-violating) decays of short-lived neutral kaons. The upstream kaon production target allows calibration measurements using long-lived neutral kaons. The set-up includes a vacuum decay region defined by scintillation counters (V1 and S1), 6 multiwire proportional chambers, a spectrometer magnet, three scintillation counter hodoscopes, and an array of 86 lead-glass blocks.



protons. In preparation for the higher energies, a new focusing enclosure was built and extensive modifications were made to the whole Proton Center beam. The experimental arrangement consisted of a vacuum decay region defined by scintillation counters (run in the vacuum) at both ends, 6 multiwire proportional chambers, a spectrometer magnet, three hodoscopes of scintillation counters, and an array of 86 lead-glass blocks.

In 1984, E621 amassed 200 000 three pion events, followed in 1985 by 3.2 million more. Although productive, this second run was not entirely smooth — part of the cable from the experiment to the electronics trailer was struck by lightning, frying some of the electronics, and a terrorist woodchuck attacked the same cables.

Analysis of the two data sets proceeds in parallel. About half the 1984 sample has been processed so far, but the characteristic bumps and wiggles of CP violation have not been found, giving an upper limit on the relative strengths of the short-lived and long-lived kaon decays into three pions (oppositely charged pair and a neutral) as about 0.03, a mighty improvement on the previous best limit (0.35).

The trigger used in the 1985 data collection was biased towards high momentum events, more sensitive to CP violation. This and the much larger sample should produce about a ten-fold increase in sensitivity. Theoretical predictions of the relative strengths of the decays vary from 0.002 to 0.004.

CERN
Man-sized detector

A new experiment now being prepared for the LEAR Low Energy Antiproton Ring has a very different look about it. Firstly, instead of using an extracted beam of antiprotons in the neighbouring experimental hall, JETSET will sit at the LEAR ring, the proton targets for the circulating antiprotons coming from a jet of hydrogen droplets squirted across the beam pipe.

In addition, the constraints of the experiment require a very compact 'man-size' detector, only 2 metres across, yet providing a wide range of detector functions. This is in marked contrast to the mammoth proportions of other general-purpose detectors. To achieve its objectives JETSET has adopted several new approaches which its designers believe could be of interest for experiments at proposed giant supercolliders where extrapolations of existing techniques could lead to 'dinosaur' detectors.

A collaboration of CERN, Freiburg, Geneva, Genoa, Illinois, Jülich, Minnesota, Oslo, Texas and Uppsala, JETSET has as its main physics objectives the study of the annihilations of protons and antiprotons at low energies into pairs of (electrically neutral) phi mesons and into pairs of short-lived neutral kaons, using both polarized (spin-oriented) and unpolarized hydrogen gas jets.

The production of pairs of phi mesons (containing strange quark-antiquark pairs) from the annihilations of protons and antiprotons (containing only 'up' and 'down' quarks and antiquarks) involves an intermediate state of almost pure gluons, the carriers of the inter-quark force. The hope is that detailed study of the phi pair spectra (deduced from the decay of each phi into a pair of charged kaons) will reveal signs of hybrid states containing gluons in addition to quarks, or the long awaited 'glueballs' — particles containing only gluons. Despite the success of the (quantum chromodynamics) field theory of quarks and gluons, the experimental evidence for gluons and gluonic particles is still meagre. LEAR could help since it provides an intense source of low energy gluons.

JETSET will also look at annihilations producing two short-lived neutral kaons (each decaying into a pair of charged pions). Combined with information from other LEAR

experiments studying annihilations producing pairs of charged kaons, this will provide significant insights into the way matter and antimatter annihilate, still poorly understood.

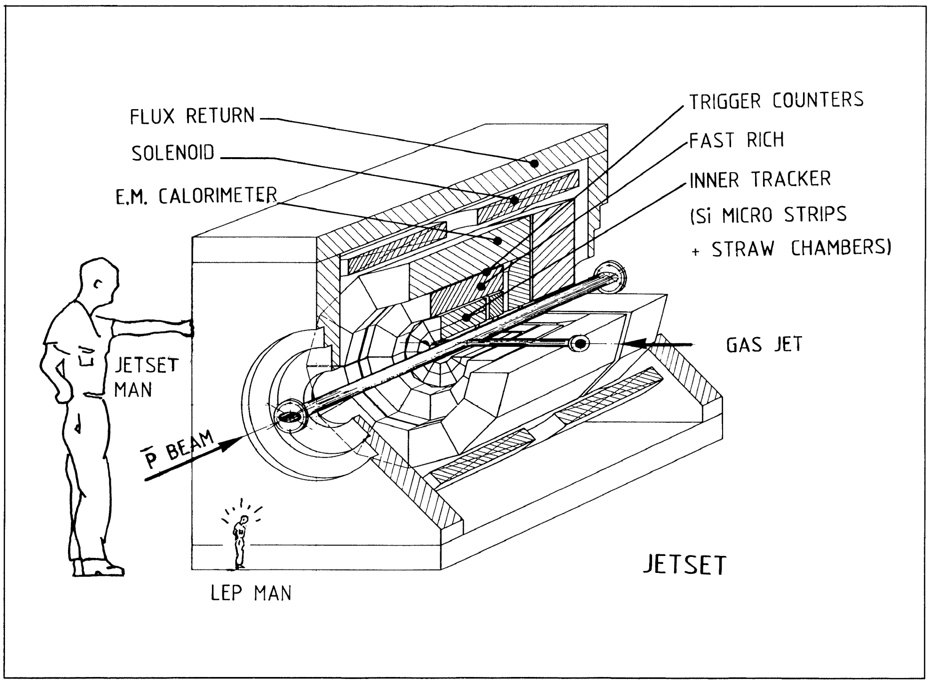
For this physics, JETSET will scan the mass energy range between 2 and 2.4 GeV, corresponding to antiproton beam momenta between 0.6 and 1.9 GeV. The experiment will search for resonances of widths between 1 and 200 MeV.

Initially, the hydrogen gas jet nozzle will produce some 8×10^{13} atoms per cm^2, so that 4×10^{10} antiprotons circulating in LEAR will give a healthy collision rate (1 GHz at a peak luminosity 10^{31} cm^{-2} s^{-1}). This, together with fast (Megahertz) triggering capabilities, gives good sensitivity to rare and interesting signals. For example the phi pair signal, making up only one interaction in a hundred thousand, is still expected to reach a million over a 25 day run.

JETSET's size is dictated by optimal operation of the gas jet mechanism, by the limited free space at the LEAR ring, and by the need to intercept the low energy unstable kaons from phi decay before they in turn disintegrate.

Surrounding the beam pipe will be a tracker to spot the particles emerging from the collisions. While the tracking chambers used in collider detectors extend to a metre or more around the beam pipe, the radius of JETSET's tracker is only 10 cm. The design uses three layers of silicon microstrips interleaved with 'straw' chambers of the type used widely at the PEP collider at Stanford.

Silicon microstrips (nowadays individual chips several centimetres across contain upwards of a thousand sensitive strips spaced by 25 microns) have already demonstrated their capabilities in fixed target experiments searching for short-lived particles, and their use is being extended to collider detectors.



JETSET's silicon 'microtracker' will pick up the points along the tracks of the emerging particles for precise measurement of their momenta.

Between the silicon wafers will be two arrays, each four layers deep, of straw chambers to help pinpoint the hits in the microstrips, to provide the main input to the off-line track recognition and to provide fast triggering information. These chambers consist of 7 mm diameter aluminized mylar straws containing a single 20 micron resistive wire. These are well adapted to difficult geometries and have shown themselves to be reliable and relatively simple to construct.

JETSET must discriminate quickly between pions and kaons. This will be handled by a 10 cm thick Ring Imaging Cherenkov (RICH) counter with liquid freon radiator, and a fast and compact photosensitive chamber consisting of a multiwire proportional chamber with pad readout. The outer surface of the RICH will be covered with a fine array of scintillators for triggering.

The initial experiment plans to include a lead/scintillating fibre electromagnetic calorimeter and a solenoid with two separate coils (for gas jet access). Subsequent upgrades could include an electromagnetic calorimeter using BGO crystals and a high field superconducting solenoid providing 3-6 Tesla.

As LEAR cannot be simultaneously optimized for gas jet running and for extraction of external beams, JETSET would need the machine to itself. First operation is foreseen for 1990.

The JETSET experiment for the LEAR Low Energy Antiproton Ring at CERN — a man-sized detector!

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Trapping nuclei

'Trapped' particles can be studied almost at leisure and many accurate measurements made, as long as the particles are stable. Such ion traps capture particles using a suitable arrangement of electric and magnetic fields. In the Penning trap, for example, an array of hyperbolic electrodes gives an equilibrium point where the particles can sit, prevented from slipping off by a strong axial magnetic field. These techniques are used in experiments at the LEAR Low Energy Antiproton Ring to study antiprotons (see November 1986 issue, page 25).

For nuclear physics, isotope trapping permits detailed spectroscopy and precision measurements. Extending these studies to rare unstable isotopes requires that nuclei from a suitable source have first to be isolated, cooled and guided into the trap.

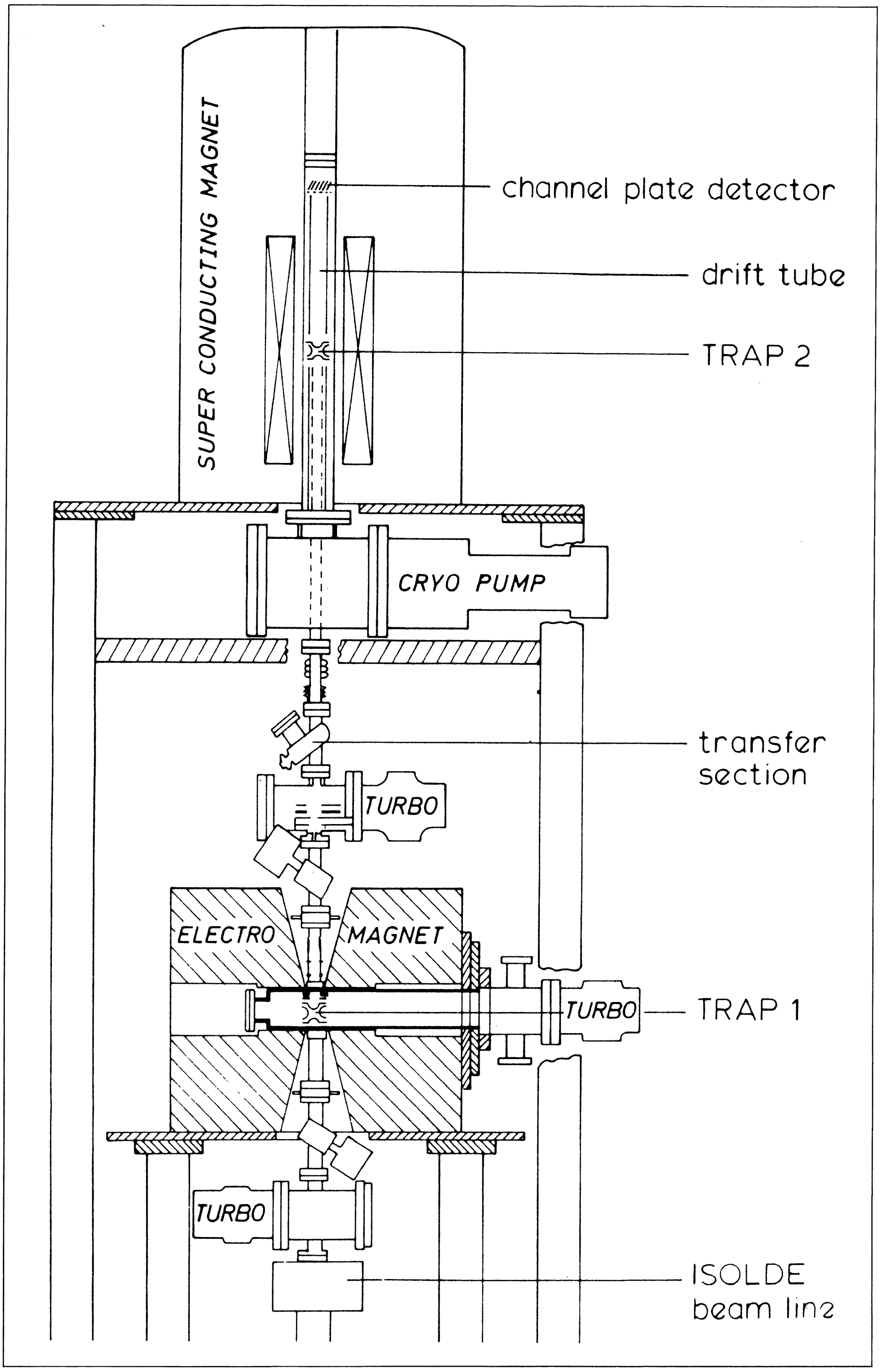
A team from Mainz (Germany) and McGill (Canada) working at CERN's ISOLDE on-line isotope separator succeeded in loading a Penning trap with highly unstable isotopes and measuring their masses from the cyclotron frequency of the stored ions.

Beams of neutron-deficient strontium and rubidium isotopes with half-lives down to 3.7 minutes were supplied by ISOLDE, with yields up to 10^{11} ions per second. A first Penning trap was used to bunch the continuous ion beam, and the bunches were electrostatically guided into a second trap.

The cyclotron resonance properties of these stored ions were accurately measured from their drift rates in an external magnetic field after exciting them with 200 millisecond radiofrequency pulses and nudging them out of the trap with an applied voltage.

The method has considerable potential for further precision measurements of unstable isotopes, picking up mass differences as small as 250 keV. As well as isotopes supplied directly by the separator, the technique could also be used for daughter nuclei formed in subsequent decays.

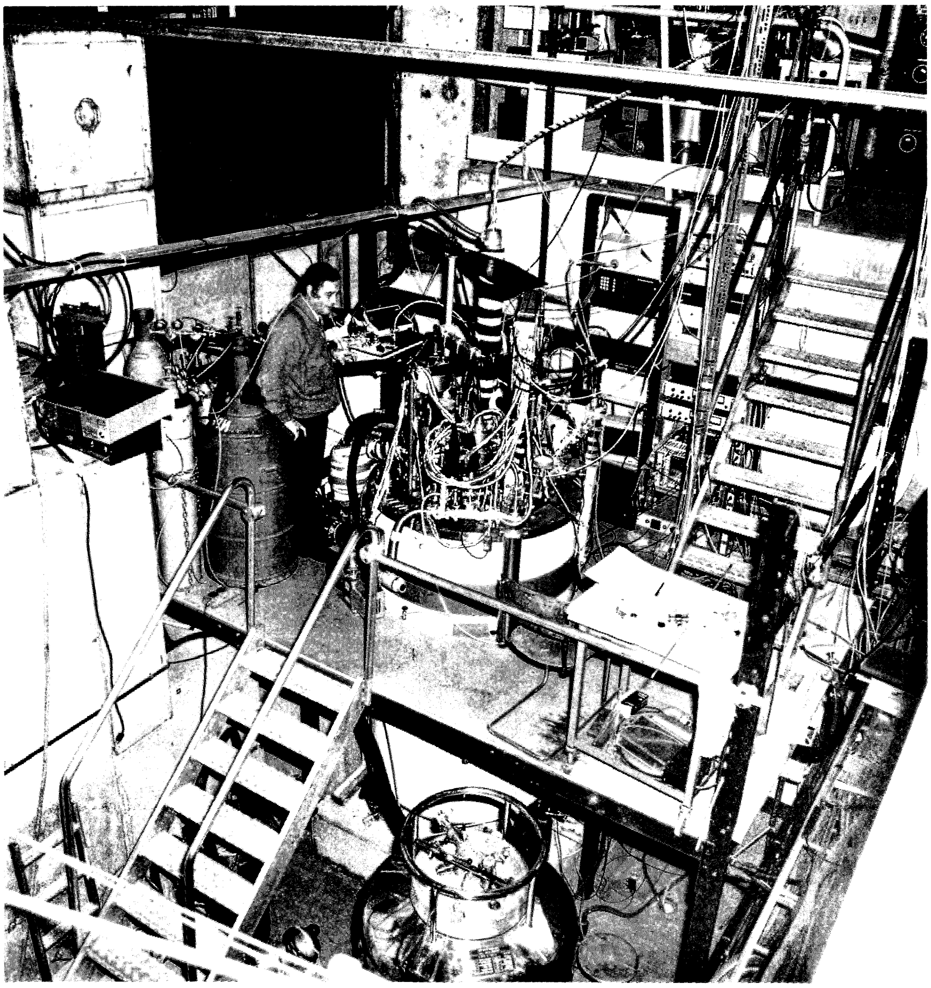
Set-up used at the ISOLDE on-line isotope separator at CERN to measure the masses of highly unstable isotopes.



Physics monitor

Preparations at CERN for the testing of a prototype liquid argon chamber for the Icarus solar neutrino detector to be installed in the Italian underground Gran Sasso Laboratory.

(Photo CERN 512.2.87)



Solar neutrinos Act 2

Two principal players, Gallex and Icarus, are now preparing for the second act of the great Solar Neutrino mystery, set in the new Gran Sasso underground Laboratory in Italy. These experiments could throw new light on fundamental physics questions, including our understanding of the neutrinos reaching us from the thermonuclear furnace of the sun's interior.

These solar neutrinos have several physics attractions. After many decades of study, the enigmatic neutrino stubbornly refuses to yield up its secrets. While much knowledge and understanding has been accumulated since Wolfgang Pauli postulated that 'invisible' massless particles were carrying off energy in nuclear beta decay, many questions remain unanswered. Do they have mass? Do the different neutrino types remain immutable, or do they mix?

The sun's collimated beam of low energy neutrinos traverses a long distance before reaching a terrestrial detector, and could reveal subtle new effects.

Astrophysicists think they understand how the sun burns and confidently point to a 'Standard Model' of solar thermonuclear processes. As a convenient and easily observable star, the sun provides valuable input for pictures of stellar evolution.

The initial solar neutrino clues came in Act 1 of the mystery, a long monologue for Ray Davies' epic study set in the Homestake mine in South Dakota. This monitored neutrino-induced transformations of chlorine nuclei into argon in hundreds of tons of chlorine-rich dry cleaning fluid.

After more than 60 exposures over fifteen years, this experiment does not find as many solar neutrinos as the standard theory predicts—hence the 'solar neutrino puzzle'.

However physicists are confident that the sun is pumping out neutrinos at the predicted rate. Either the solar particles are not picked up by a chlorine-based detector, or something happens to them before they reach the earth. According to recent resonant neutrino oscillation ideas, neutrino types could change as they pass through matter, so a detector looking for a specific neutrino signal might find something else.

The Gallex experiment, a collaboration of scientists from Brookhaven, Heidelberg, Karlsruhe, Saclay, Grenoble, Nice, Milan, Rome and Rehovot, will use 30 tons of gallium, better suited than chlorine to the spectrum of solar neutrinos. These would be detected radiochemically through transitions of gallium nuclei into germanium, and the technique was put through its paces in a pilot study using 1.5 tons of gallium.

Meanwhile a Soviet team is preparing a neutrino experiment using gallium in a tunnel in the Caucasus. Ideas on gallium detectors had been around for some time but remained a dream until gallium

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Organisation Européenne pour la Recherche Nucléaire

European Laboratory for Particle Physics
Laboratoire Européen pour la Physique des Particles

The Experimental Physics Division intends to make an appointment to the position of a

PHYSICIST

in experimental particle physics research. Candidates are expected to have an excellent record of successful work in this field, and to have the ability to provide leadership. Preference will be given to candidates under 38 years of age. The appointment will be made for a fixed term, and may subsequently become permanent.

The holder will play an important role in all aspects of the conception and design of experiments, and of the construction and the operation of detectors, and the development of on-line and off-line software and the analysis of data.

Please send letters of application, including the names of three referees, list of publications, a brief curriculum vitae and a brief description of research interests, to the

**Leader of the
Experimental Physics Division,
CERN
1211 Geneva 23,
Switzerland**

quoting reference EP/RE, before 15.6.87.

UNIVERSITY OF OXFORD

Department of Nuclear Physics

PHYSICST/PROGRAMMER

Research Support Grade 1A

Salary £8.020 – £12,780 (Under Review)

A vacancy exists for a physicist-programmer to provide softwear support for Nuclear Structure research, including experiment using the Nuclear Structure Facility at Daresbury. Preference will be given to candidates with a background in nuclear physics and/or experience with VAX or GEC computers. The post will be for a three year period in the first instance.

Applications giving details of qualifications and experience, and including the names and addresses of two referees, should be sent to

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Keble Road,
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England**

to arrive by 13th May 1987.

ISTITUTO NAZIONALE DI FISICA NUCLEARE
(I.N.F.N.)
LABORATORI NAZIONALI DI LEGNARO

TWO POST-DOCTORAL FELLOWSHIPS IN EXPERIMENTAL NUCLEAR STRUCTURE PHYSICS

Applications are invited for the above posts which are now vacant and are funded by the I.N.F.N. for the period 1 October 1987 – 30 September 1988. The fellowships are only open to non-italian citizens. The deadline for applications is 15 May 1987. The successful candidates will be expected to initiate and assist with research at the XTU Tandem Van de Graaff, wich is now operational at the National Laboratories of Legnaro (Padua).

Applicants are expected to hold a Ph. degree in nuclear structure physics and should have an aptitude for pursuing research in experimental physics. The salary will be 24 000 000 italian lire gross per annum corresponding to 1 600 000 net italian lire per month, plus travel expenses from home institution to Legnaro and return.

The cost of medical insurance is charged to students, as well as for any dependants staying in Italy. Insurance is obligatory either with a private scheme or through national health insurance which is equivalent to 7,5 % of gross income, except in the case of other existing international agreements.

Applications with a full C.V., the names of two referees and possibly a letter of introduction from a senior scientist should be sent to:

**Prof. Pietro DALPIAZ
Director
Laboratori Nazionali
di Legnaro dell'I.N.F.N.
V. Romea, 4
35020 LEGNARO (Padova) ITALY**

**Phone: 049/641200
Telex: 430384 LNL I**

ETH ZÜRICH

POSTDOCTORAL RESEARCH ASSOCIATE

Intermediate Energy Physics

The Institute for Intermediate Energy Physics of the ETH-Zürich invites application for a postodoctoral research associate.

This position, which is available immediately, involves research in few nucleon problems using polarized beams and targets at SIN.

Candidates should have experience in intermediate energy or nuclear physics using fast electronics and computers (PDP 11, VAX).

The position will be for three years with the possibility of a renewal.

Interested candidates should send their resume and arrange to have two letters of recommendation sent to

**Professor W. Grüebler,
Institute for
Intermediate Energy Physics,
ETH-Hönggerberg,
CH-8093 Zürich,
Switzerland.**

technology began to develop.

The Icarus experiment led by Carlo Rubbia will use an imaging detector using 6500 tons of liquid argon to look at, among other things, neutrino-induced events. These will be of two kinds—nuclear absorption producing recoil electrons, and direct scattering off electrons.

If the standard model of the sun is correct and the neutrinos are unaffected by their passage through the solar interior, several thousand detectable neutrino-electron scatterings per year should be produced, so that incisive results should emerge relatively quickly, revealing basic neutrino information such as mixing levels and mass differences.

Work is underway at CERN to complete testing of a prototype liquid argon detector.

Looking for new physics

Deep insights from powerful new theories can give the impression that physics is all understood. Such complacency was swept aside at a recent workshop in the Moriond series, held earlier this year in the French alpine station of Les Arcs, where attention focused on the search for new and exotic physics. With the Moriond tradition of brief presentations, there was no shortage of physics candidates. They ranged from phenomena still reconcilable with today's Standard Model — neutrino masses, violation of combined charge conjugation and mirror (CP) symmetry — to more unconventional possibilities, including new forces and departures from long cherished Newtonian ideas.

Confronting a fifth force at Moriond — left to right, standing, Riley Newman (Irvine), John Moffat (Toronto), Frank Stacey (Queensland); seated, Peter Thieberger (Brookhaven), Frederick Raab (Washington) and Ephraim Fischbach (Purdue).

(Photo Pascal Dolémieux)

In tests of the basic symmetries of physics, searches for time reversal non-invariance (so that action replays of particle interactions could not be run backwards) continue in atomic physics (testing electric dipole moments of atoms: the present limits of 10^{-26} e.cm could be extended out to 10^{-33}) and nuclear physics (neutron electric dipole moment measurements at the Institut Laue-Langevin, Grenoble and resonant neutron scattering correlations at Leningrad).

A whole day at the workshop was given over to very high energy gamma ray (photon) sources from outer space (reviewed by D. Fegan of Dublin) and to muon detection underground, and their possible correlation. The muon signals seen in different experiments (reviewed by G. Chardin of Saclay) seem to need a time label. T. Stanev of Delaware maintained that the extreme energy gammas from Cygnus X-3 remain a challenge, and transient bursts have been seen in other sources. To settle the point, contributions from improved detectors will be welcome.

The astrophysical evidence for 'dark matter' inert material making up the bulk of the universe — is overwhelming (M. Lachieze Rey of Saclay), and a new effort is being mounted to detect it, whatever it might be — weakly interacting massive particles (WIMPS), neutrinos, axions, strongly interacting particles,...... The new experiments (covered by P. Smith of Rutherford Appleton and B. Sadoulet of Berkeley) now being built will need a few years before they produce results. Recent alternative explanations of dark matter in terms of modifications to Newtonian mechanics at extragalactic scales seem ruled out by cosmological data (T. Jolicœur of Saclay).

Controversy still rages on limits for the mass of the electron-type neutrino. New limits on double beta decay seem to rule out recent newspaper reports of a new particle.

A. Smirnov from the Soviet Union described new oscillation calculations with implications for solar neutrinos. Another possible explanation for the missing solar

People and things

neutrinos is provided by having WIMPs in the sun's interior. WIMPs could also explain the observed pressure modes of the sun (C. Frohlich).

Gallium detectors are now being constructed to attack the solar neutrino question (see previous article). S. P. Mikheyev described limits on the flux of atmospheric neutrinos above 30 MeV measured at Baksan in the Soviet Union, one-third the level of the classic Brookhaven (chlorine) solar neutrino study. Other solar neutrino detectors were also described.

Roberto Peccei reviewed searches for new particles and exotica — superheavy atoms, quarks, magnetic monopoles, self-charge conjugate (Majorana) neutrinos, axions, etc.

The monoenergetic positron emission seen in heavy ion collisions at Darmstadt (see April 1986 issue, page 22) has been confirmed for a variety of nuclei, and there has been much discussion of a neutral 1.8 MeV particle. This was not seen in a beam dump experiment at the big Stanford linac.

Another talking point was Bjorken's contention that the Higgs mechanism in the electroweak picture (which accounts for the different behaviour of electromagnetic and weak nuclear forces) could be called a 'fifth force', rivalling the other forces in its complexity.

Finally, a whole day was given over to searches for violations of Newtonian mechanics ('who's afraid of Isaac Newton?' challenged Alvaro de Rujula), where there have been suggestions that geophysical gravity measurements can differ from those in the laboratory. Several new results have appeared, but the situation remains unsettled pending further results. Two new experiments also plan to measure the pull (or push?) of gravity on antiparticles—positrons (W. Fairbank) and antiprotons at LEAR.

From G. Fontaine and L. Oliver

Louis de Broglie 1892-1987

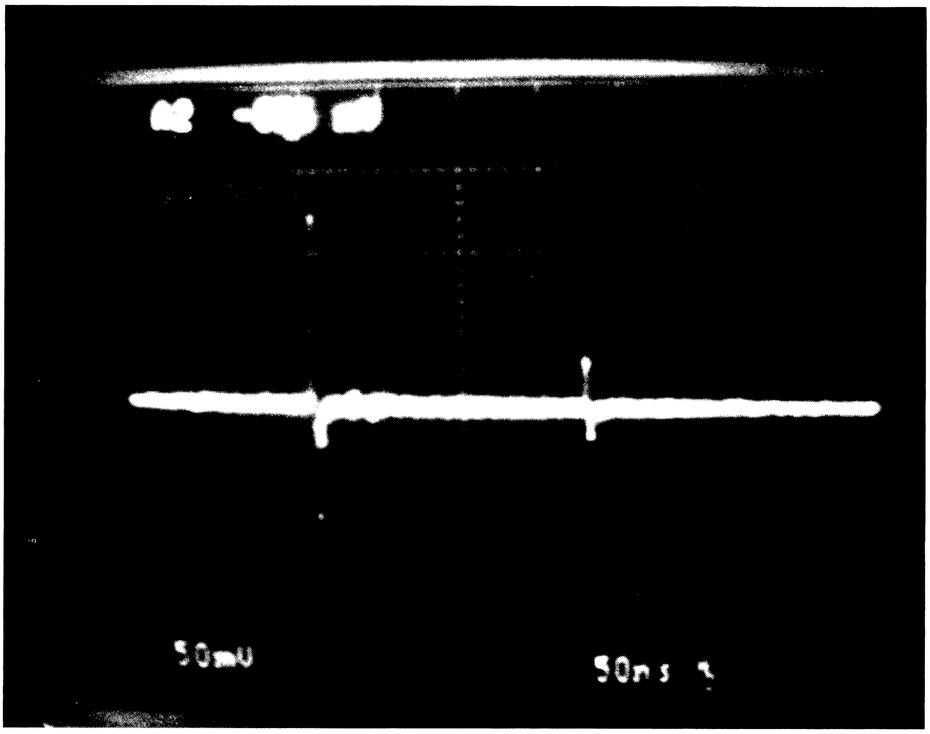
Louis de Broglie

One of the few remaining links with the birth of quantum mechanics was broken when Louis de Broglie died in March at the age of 94. By the early 1920s, the photoelectric and Compton effects had demonstrated the particle properties of radiation, and de Broglie in his 1924 thesis 'Recherches sur la théorie des quanta' postulated that particles should have wave properties. Electron diffraction was discovered soon afterwards, and the stage was set for modern quantum mechanics. De Broglie received the physics Nobel Prize in 1929.

His message to the European Cultural Conference in Lausanne in 1949 called for the establishment of a Laboratory where European States could collaborate in research beyond the means of individual nations. From this germ of an idea CERN was to grow.

UK Institute of Physics Awards

Among the recipients of UK Institute of Physics Awards this year are two former chairmen of the UK Science Research Council (now the Science and Engineering Research Council); Lord (Brian) Flowers (1967-73) receives the Glazebrook Prize and Sir Sam Edwards (1973-77) the Guthrie Prize. In addition, Michael Green of London's Queen Mary College is awarded the Maxwell Prize for his major contributions to supersymmetric string theories, and Stephen Hawking of Cambridge the Paul Dirac Prize for his many outstanding contributions to cosmological theory.



On 27 March, electrons (left) and positrons were brought together for the first time in the new SLC Stanford Linear Collider.

Stanford Collider milestone

On 27 March, 47 GeV beams of electrons and positrons reached the interaction point of the new Stanford Linear Collider (SLC) on the same machine pulse (simultaneously). The Mark II detector will shortly move into the beams, and work in the meantime has concentrated on reducing the beamspot size, increasing the positron intensity, and many other refinements to ensure stable and efficient operation.

Fermilab reorganization

Following a five-year stint as Head of Fermilab's Accelerator Division J. Ritchie Orr has joined the Technical Support Section where he will be involved in the Laboratory's work for the proposed US Superconducting Supercollider (SSC). Helen Edwards, formerly Deputy Head of the Accelerator Division, becomes Head of the Division. John Peoples, formerly Head of the Antiproton Source Department, replaces Helen Edwards as Deputy Head of the Accelerator Division. Gerald Dugan leaves his position as Head of Accelerator Systems for the Antiproton Source to take on Peoples' former responsibilities. Charles Ankenbrandt becomes Head of the Accelerator Theory Department, while former Head Lee Teng joins the team designing a prototype medical proton-therapy accelerator for Loma Linda University Medical Center (see December 1986 issue, page 5).

IUPAP General Assembly

The XIX General Assembly of the International Union of Pure and Applied Physics (IUPAP) is to be held at the US National Academy of Sciences, Washington DC, from 29 September – 3 October. The theme of the scientific programme will be 'Physics in a Technological World', reflecting the IUPAP General Council's aim of emphasizing the role of industrial physics and improving relations between industrial and academic physics. This IUPAP event will be concurrent with the annual meeting of the Corporate Associates of the American Institute of Physics.

Advanced accelerator course

The CERN Accelerator School is organizing in collaboration with BESSY (the Berlin electron synchrotron radiation centre) the second of its biennial two-week courses on advanced accelerator physics. It will take place in West Berlin from 14-25 September. Further information from Mrs. S. von Wartburg, CERN Accelerator School, CERN, 1211 Geneva 23, Switzerland. Closing date is 1 June.

UNIVERSITY OF OXFORD

Department of Nuclear Physics

Applied Physicist/Engineer

Research Support Grade 1A

Salary £9,305 — £14,825

A vacancy exists for an applied physicist/engineer to work on the design and development of a wide range of detector projects associated with experiments in Nuclear and Particle Physics. Applicants should be qualified to degree standard or the equivalent, and have experience and/or interest in low density high precision structures, high electric field problems or high purity gas techniques.

The appointment will be for a three year period in the first instance. Applications, giving details of qualifications and experience, and including the names and addresses of two referees, should be sent to

The General Administrator,
Department of Nuclear Physics,
Keble Road,
Oxford, OX1 3RH
England

to arrive by 13th May 1987

FACILITY OPERATIONS MANAGER

The Department of Physics at the University of Illinois at Urbana-Champaign has extended the deadline for applications for the Facility Operations Manager position in its Nuclear Physics Laboratory.

The successful applicant will be responsible for managing the day-to-day operation of our 100 MeV, 10 microamp, 100% duty factor electron accelerator, its associated experimental facilities, and its technical support services. These services include an electronics shop, a machine shop, and drafting facilities. Our present accelerator is a 9-pass microtron. A proposal for the construction of a new accelerator at Illinois (450 MeV, 100 microamp, 100% duty factor) is pending before the NSF.

The Manager will have a major role in the development, construction, and operation of this new facility.

We seek an individual with technical expertise and aptitude, good judgment, and good management skills. Two (2) years of experience in management at a large-scale accelerator or similar highly technical facility is highly desirable. Minimum qualifications include an undergraduate degree in engineering or physical science. This is a full-time position on the UIUC academic professional staff. Salary will be competitive, depending on training and experience.

The starting date is Summer of 1987.

For full consideration, applications should be receveid by July 1, 1987. Interviews may take place prior to the applications deadline; no final decision, however, will be made until after that date.

For technical information, contact Professor Robert A. Eisenstein, Nuclear Physics Laboratory, University of Illinois at Urbana-Champaign, 23 Stadium Drive, Champaign, Illinois, 61820. USA. Telephone 217/333-3190.

To apply, please send resumes and the names of three references to

Mr. Raymond F. Borelli (NFOM),
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Telephone 217/333-0570.

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in accelerator physics

for non-italian applicants only. The duration of the fellowship is one year to be spent at the I.N.F.N. Laboratori Nazionali di Frascati, FRASCATI (Rome) Italy.

The salary will be 24 000 000 Italian lire gross per annum corresponding to 1 600 000 net Italian lire per month plus travel expenses from home institution to Frascati and return.

Applications are invited from accelerator physicists, to participate in the development programs on existing machines (350 MeV e± Linac and 1.5 GeV storage ring ADONE) and in the design of new facilities (superconducting R.F. cavities, single pass FEL experiments).

The application deadline is May 15, 1987.

Applicants should submit a curriculum vitae, including a list of publications and three letters of reference.

Send applications and requests for further information to:

Prof. Sergio Tazzari,
Director of the
Laboratori Nazionali di Frascati,
Via E. Fermi,
40 — 00044 FRASCATI (Rome)
ITALY.

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For one year, starting November 1987, for non-Italian citizens. The successfull applicants can pursue their research at the **National Southern Laboratory (Catania)** of I.N.F.N.

The applicants will be engaged in activities connected with the preparation of the experiments in nuclear physics, and the activities of the development programs of the machines in the National Southern Laboratory (Catania).

The annual gross salary will be 24 000 000 italian lire, corresponding to 1 600 000 net italian lire each month, plus travel expenses from home institution to Laboratory and return.

The application deadline is May 15, 1987.

Applicants should submit a curriculum vitae, including a list of publications and three letters of reference.

Send applications and request for further information to:

Prof. Nicola CABIBBO,
President National Institute
of Nuclear Physics (INFN)
Casella Postale 56
00044 FRASCATI (Rome) ITALY

Phone: 06/940 3437 Telex: 614291
Telefax: 9424125

UNIVERSITY OF OXFORD

Department of Nuclear Physics

REAL TIME PROGRAMMER

Salary £9.305 — £14,825 per annum

A vacancy exists in the Particle Physics group for an on-line programmer to work on the design and implementation of large scale data acquisition systems for experiments at CERN and DESY. This will involve programming in Fortran, Pascal and C, and assisting the development of specialised hardware modules. The system will be based on a network of VAXs connected to FASTBUS or VME-based data acquisition front ends containing embedded high performance micros.

The post will be for a three year period in the first instance, in Research Support Grade 1A. Applications giving details of qualifications and experience, and including the names and addresses of two referees, should be sent to

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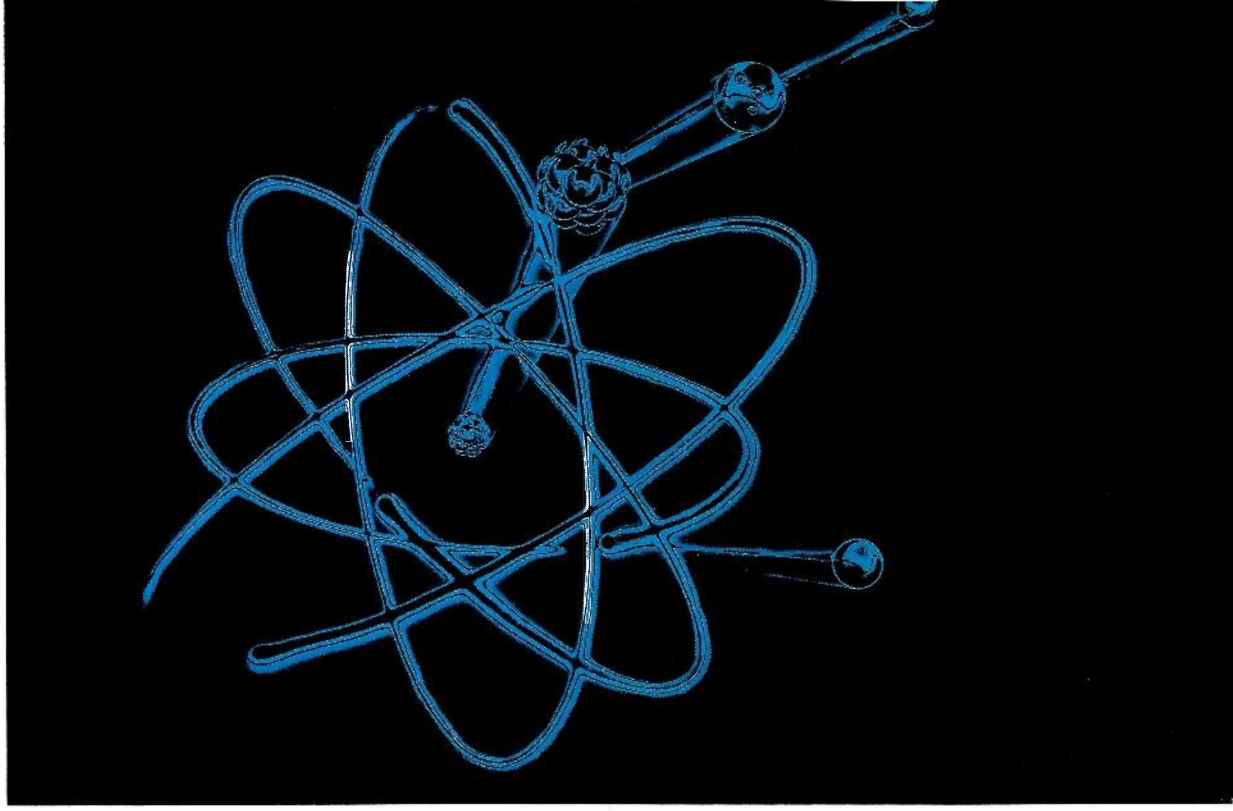

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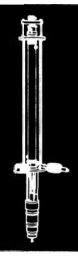

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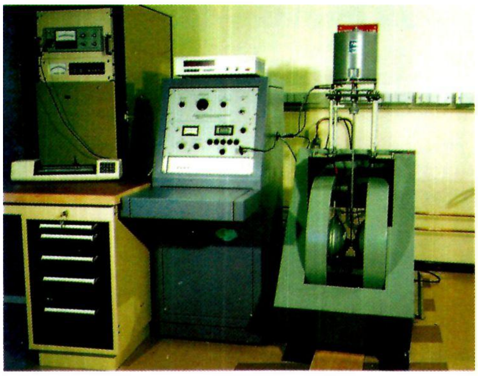

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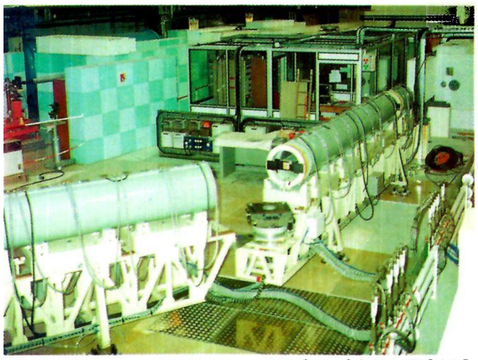

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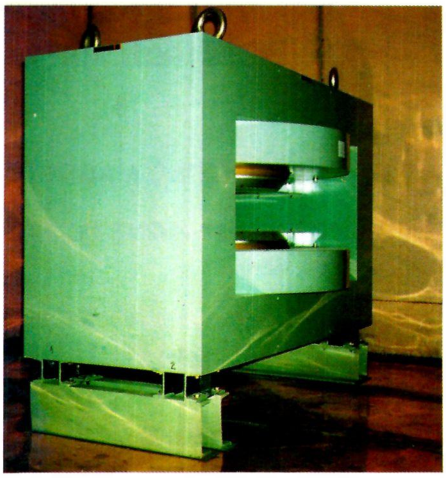
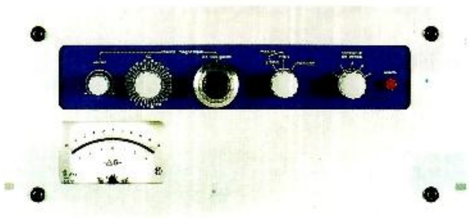
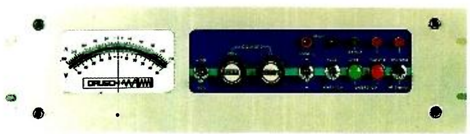
(Courtesy of CEN Saclay)



1.2T ELECTROMAGNET - 200 mm GAP FOR IN-VIVO NMR SPECTROSCOPY



HALL probe field regulation and measurement



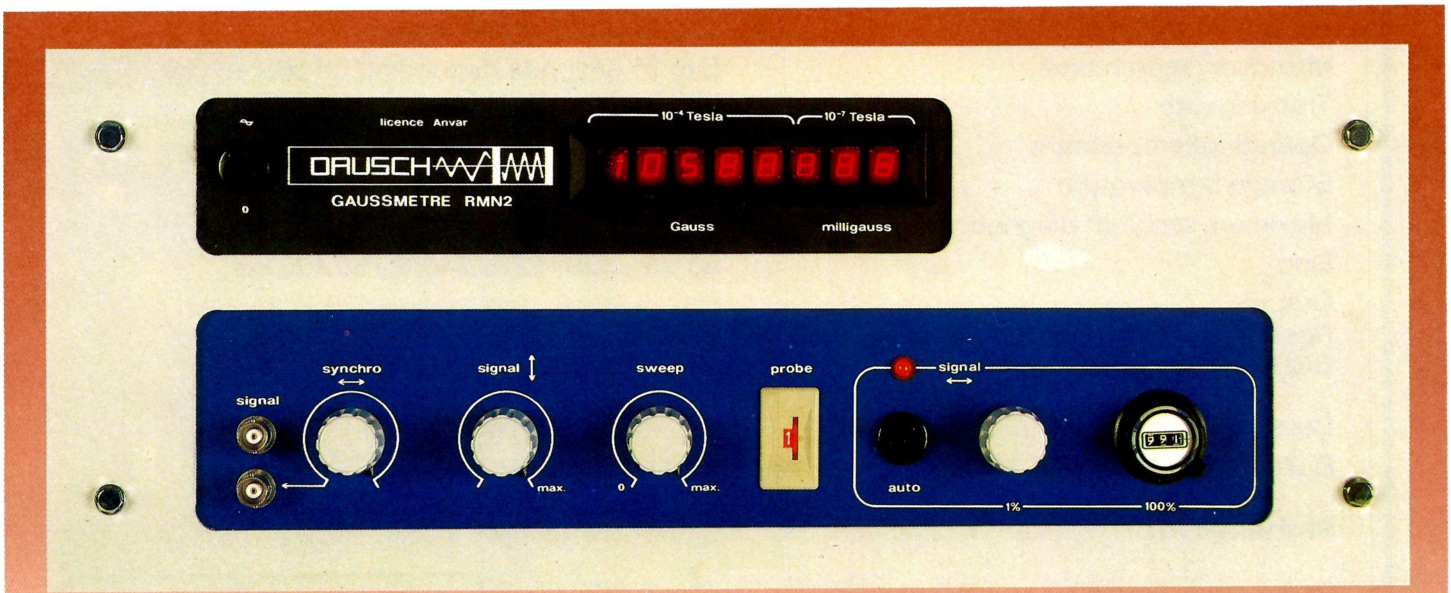
BIPOLAR high stability power supply

NMR field regulation unit TAO2

62, RUE GALLIENI - 92500 RUEIL MALMAISON - FRANCE - TEL 33 (1) 47 49 22 00

DRUSCH

RMN2
NUCLEAR MAGNETIC RESONANCE GAUSSMETER



- * Performing
- * Easy to use
- ** Automatic signal search
- * Fast signal tracking
- * Range : 0.03 to 9 tesla
- * Resolution : 0.1 microtesla
- * Read-out located up to 50 meters from probe
- ** Probe alignement in the field is not critical
- ** No magnetic field modulation

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DAUSCH

RMN 2

Specifications

Measuring range	: 0.03 to 9 tesla
Absolute precision	: better than 10^{-5} or 5 microtesla
Relative precision	: 5.10^{-7} or 0.5 microtesla
Display	: 8 digits
Resolution	: 0.1 microtesla
Automatic signal tracking	: 100 % of the probe range
Maximum search time	: 5 to 35 seconds depending on probe type
Tracking rate	: 0.01 tesla / second
Operating temperature	: 0 to 40°C
Storage temperature	: – 20 to + 70°C (including probe)
Maximum ambient magnetic field	: 0.2 tesla
Line	: 40 VA - 120 / 220 / 240 V - 50 / 60 Hz

Outputs :
Resonance and synchronization signals : BNC sockets
BCD serie, isolated interface for NMR magnetic field regulation with TA02

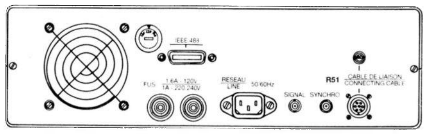
On option :

Built-in IEEE 488 or RS 232 interface (in lieu of BCD output)

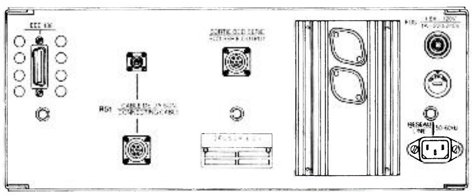
Probes (R 31)

Probe cable length : 2.5 m
Dimensions : 21.3 x 11.2 x 145 mm
Operating temperature : from – 10°C to 70°C

Type	Range
R 31.11 :	from 0.08 to 0.25 tesla
R 31.12 :	from 0.15 to 0.5 tesla
R 31.13 :	from 0.3 to 1 tesla
R 31.14 :	from 0.7 to 2.1 tesla
R 31.15 :	from 2 to 5 tesla
R 31.16 :	from 4 to 9 tesla



RMN2 Portable



RMN2 Standard

On option :

- Probe length up to 10 meters
- Low field probes
- Extended range probe with Bmax / Bmin = 5
- Special probes :
  Example : – probehead extension
  – reduced dimensions
  – special geometries

Mechanical specifications

	Portable unit	Standard model
Dimensions :	395 x 120 x 280 mm	rack 19" 4U depth 320 mm
Weight :	6 kg	8 kg

Additional products :

- **Probe switching unit :** up to 4 probes located in one or several electro-magnets can be switched locally or remotely.
- **TA02 NMR magnetic field regulator :** allow to stabilize to 10^{-7} a magnetic field for applications such as high resolution spectrometry.

Specifications are subject to change without notice