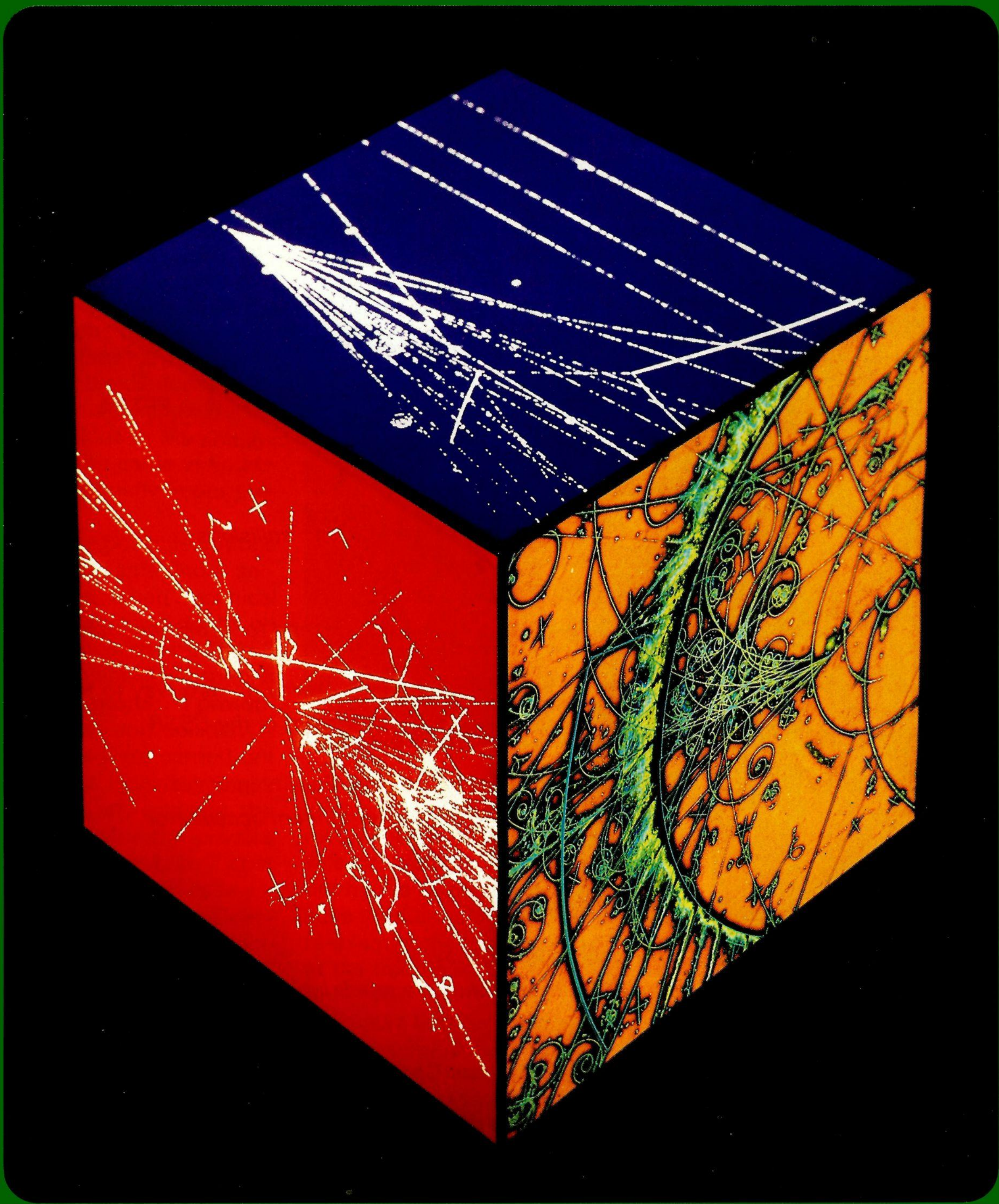
CERN COURIER

International Journal of High Energy Physics



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CERN COURIER

International Journal of the High Energy Physics Community

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Cover photograph: The many facets of particle interactions. The cube prepared by the CERN Visual Techniques team for the recent exhibition at London's Science Museum (Photo CERN 504.8.82).

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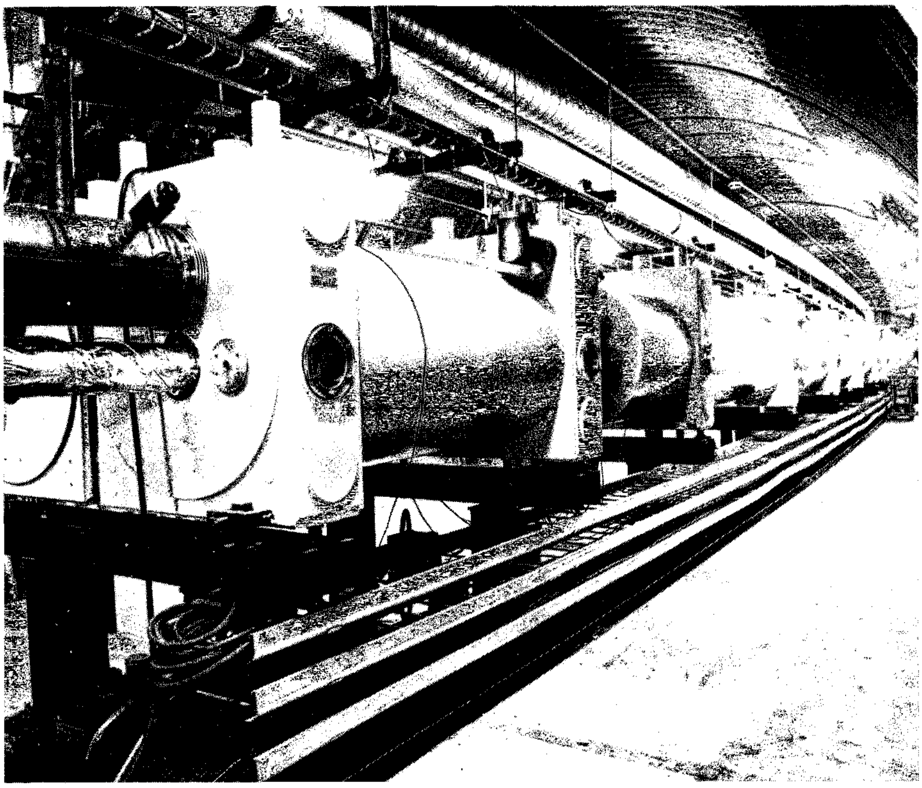
Around the Laboratories

A full cell of the Brookhaven Colliding Beam Accelerator consisting of eight superconducting magnets (six dipoles and two quadrupoles) installed in the completed ring tunnel. The cell was successfully powered to design field, corresponding to 400 GeV proton beams, on 25 February.

(Photo Brookhaven)



BROOKHAVEN
All the way with CBA

A series of important milestones in the Colliding Beam Accelerator project at Brookhaven have been passed ahead of schedule. These are the decision on the nature of the machine (which was due in April), a test of a full cell of the magnet lattice (due in March), and a demonstration that the required magnet field quality can be achieved (due in March). All these achievements came in February, as mentioned briefly in our previous issue.

There were three possible options for the CBA which came under serious consideration when technical and cost difficulties cast doubt on the reasonableness of the ISABELLE proton-proton project. The options were for a proton-proton, a proton-electron or a heavy ion collider. A number of studies were carried out by working groups including physicists from inside and outside the Laboratory, to examine the physics interest, technical feasibility, cost and time schedule for each case.

On 24 February Brookhaven Director Nick Samios announced the decision to go for a proton-proton collider as proposed in the original ISABELLE project. This choice was made because this would hopefully provide greater potential for important discoveries, because of the broader experimental programme it would make possible, and because of the greater interest in pp physics expressed by the high energy physics community. The cost savings with the other options would be modest and were not considered sufficient to compensate for the decrease in physics potential. The ep and heavy ion physics options may prove appropriate for extensions of the CBA in the future.

It is thus the proton-proton option which will be presented at a major review of the USA high energy physics programme now being carried out by the Department of Energy. In June the subpanel of HEPAP will also re-examine the Brookhaven proposal at the traditional meeting at Woods Hole. The main design parameters remain as 400 GeV per beam in two separate rings, luminosities up to 10^{33} per cm^2 per s with six interaction regions. The physics interest has been reinforced by the recent results from the proton-antiproton collider at CERN (see March issue) and there is growing conviction that detection techniques will be able to cope with the high event rate and complex interactions which the CBA would provide.

The major technical problem which had dogged the ISABELLE project was development of the superconducting dipoles for the storage rings. The February successes put the problem comfortably into the past.

The first magnet milestone was reached on 20 February when the eighth successive dipole of a production series was measured and proved to have, like its seven predecessors, the field quality required for storage ring operation. Thus the Laboratory now feels confident that the magnets not only reach or exceed the required peak field for 400 GeV operation but also have the field configuration to store beams for a long time and can be produced consistently with such parameters.

A few days later on 25 February, a full cell of the magnet lattice of the storage rings, consisting of six superconducting dipoles and two quadrupoles, was successfully powered to 5.3 T which corresponds to the design beam energy of 400 GeV. This field was sustained for four hours with a current of 3.77 kA in the coils at a temperature of 4.1 K while measurements were carried out. The current was then raised to 3.86 kA and the magnets quenched. This performance is satisfying in itself but also indicated that a good margin of safety should exist in terms of reaching design figures when the proper refrigeration system is used to take the operating temperature below 3.8 K.

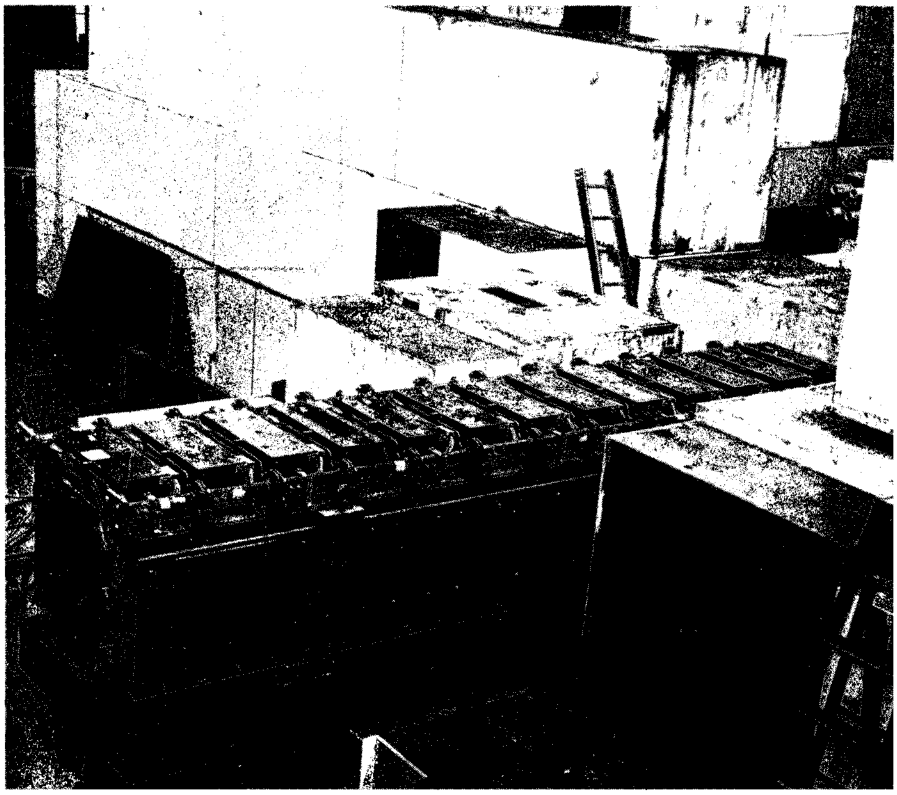
The time required to cool the cell to superconducting temperature is three days on the basis of the test, which is consistent with the estimated time for cooldown of the CBA. The initial powering of the cell was made at a cautious 0.5 A per s ramp rate but shortly afterwards it was possible to cycle the full field at a maximum CBA operating ramp rate of 8 A per s (corresponding to an 8 minute rise time to 400 GeV). Repetitive cycling of the magnets to full field was then carried out and, in addition, the cell was operated for 25 hours in the d.c. mode at full current.

The CBA project calls for peak rates of magnet production and testing to rise to eight magnets per week. A complete magnet factory plan has been prepared involving an area of over 6000 m^2. Production of the 60 dipoles and 20 quadrupoles for the first sextant is planned for February 1984 with the first magnet ready for testing by 1 October of this year.

Now that the CBA project has clearly got its technical act together, the deliberations of the HEPAP and DOE bodies which survey the USA high energy physics programme remain difficult but at least will be conducted with greater confidence. The CBA project will require about another $250 million and it will not be easy to ensure an appropriate rate of funding while at the same time pursuing the Stanford Linear Collider and the Fermilab Tevatron projects.

The downstream end of the new quadrupı muon channel at the Brookhaven Alternati Gradient Synchrotron. The magnet was salvaged from the US Space Radiations Effect Laboratory.

(Photo Brookhaven)

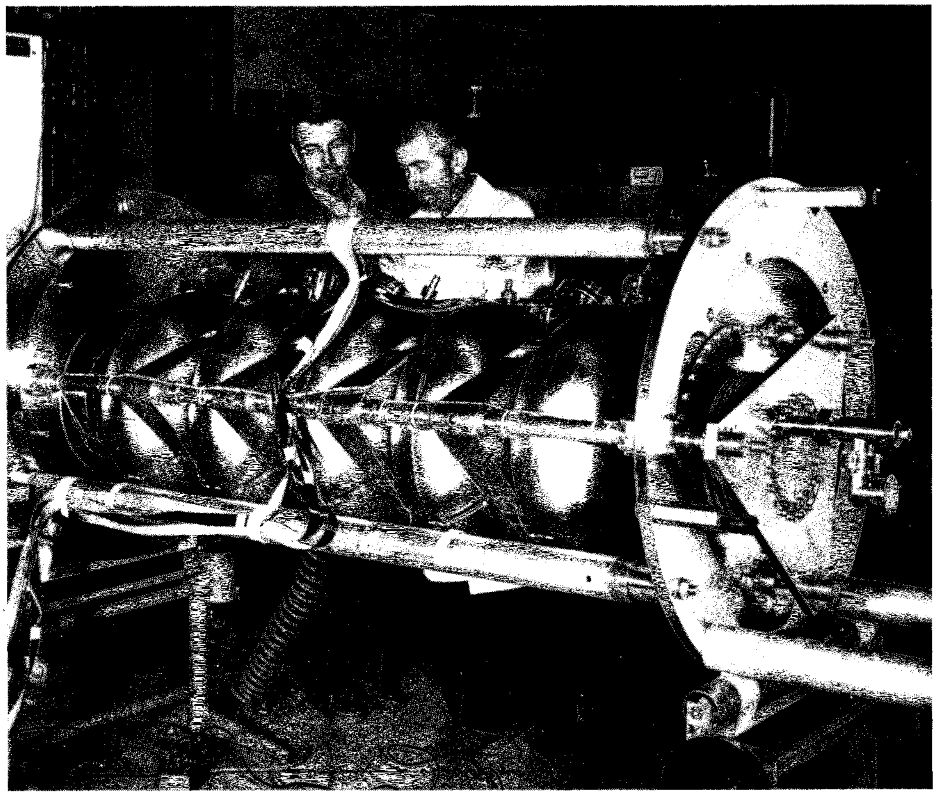


Stopping muons

The Alternating Gradient Synchrotron (AGS) has just brought into operation its latest experimental facility, the recently completed stopping muon beam (D2). This has been built in cooperation with Columbia University's Nevis Laboratory to provide a beam of some 0.3×10^8 negative muons per 10^{12} incident 120 MeV protons, resulting in some 10^6 negative muons being stopped per second per gram per cm^2 over a 24 cm^2 area. The unique feature is the use of the time structure of the AGS to produce a 20 ns pulse of pions or muons at instantaneous rates of 10^{15} per second. In this operating mode, the AGS delivers one of its 12 beam bunches of 10^{12} protons to the muon beam target at the D tarç station and the other 11 bunches the neutrino beam target at the U s tion. The beam can alternatively u the regular slow extracted beɛ mode and provide a muon flux witl 40% duty factor.

The first of two approved expe ments, E745 by a Columbia / CEI team (a test of quantum electroc namics by measuring the vacuum p larization in muonic helium), has b gun to use the beam to measι fluxes and backgrounds. For this ε periment, the beam will operate the single proton bunch mode. T second experiment, E754, a mu spin rotation study by a Bell Labs Brookhaven / George Mason / V ginia State / William & Mary tea will get its turn in the spring with t regular slow extracted beam.

The stopping muon beam has interesting history. It is a joint eff between Columbia and Brookhave and two funding agencies (US Department of Energy and the National Science Foundation), and uses components from four Laboratories — Argonne, Brookhaven, Nevis, and the Space Radiations Effect Laboratory (SREL). It required the demise of SREL to provide the quadrupole muon channel, the closing of the Nevis Cyclotron to provide the rest of the magnets, power supplies and shielding, and the end of the ZGS at Argonne to provide some of the proton beam transport and power supplies. One can truly say that old accelerators don't die, they just get recycled by the Brookhaven 'Used Accelerator Department'.



The CERN five-cell superconducting cavity which has now operated successfully in the PETRA ring at DESY, seen here removed from its cryostat. (In our April edition, on page 86, we erroneously attributed this cavity to a Karlsruhe/CERN/DESY collaboration.)

(Photo CERN 231.11.82)

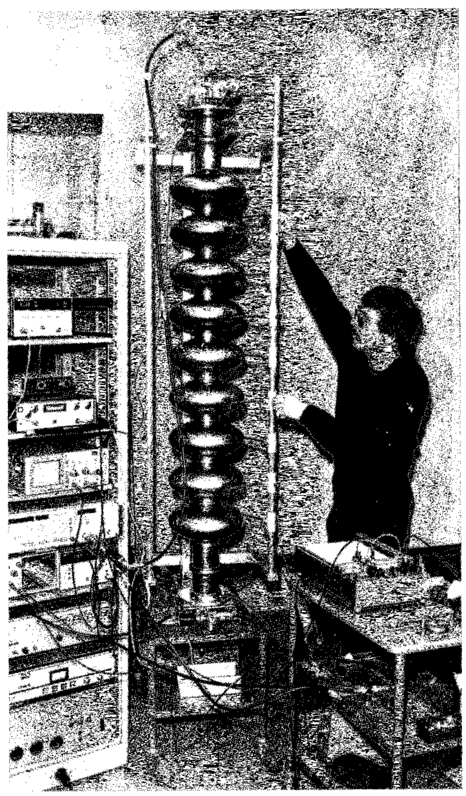
DESY/CERN
CERN's superconducting cavity in PETRA

In an important pointer to the future, a CERN superconducting r.f. accelerating cavity has operated successfully in the PETRA electron-positron ring.

Superconducting cavities require much less power than conventional copper r.f. cavities and provide higher electric fields to accelerate charged particles. They will be essential to move the peak energy at LEP beyond the 50 GeV per beam scheduled in Phase I. For the PETRA storage ring at DESY, assuming that an accelerating gradient of 3 MV/m can be achieved, the beam energy could be raised to 30 GeV. There is considerable optimism among the specialists that the necessary technology to go superconducting is at last being mastered.

An important argument in favour of superconducting cavities is economy. Even taking into account the costs of maintaining a cryogenic system, superconducting cavities provide an attractive alternative even for machines which in principle could work with normal cavities. Adding to this the positive results made with superconducting magnets at Fermilab and recently for HERA at DESY, one may conclude that the dream of an 'all-superconducting' accelerator is near. There are already projects for small inexpensive industrial storage rings for X-ray lithography running in a cryogenic bath.

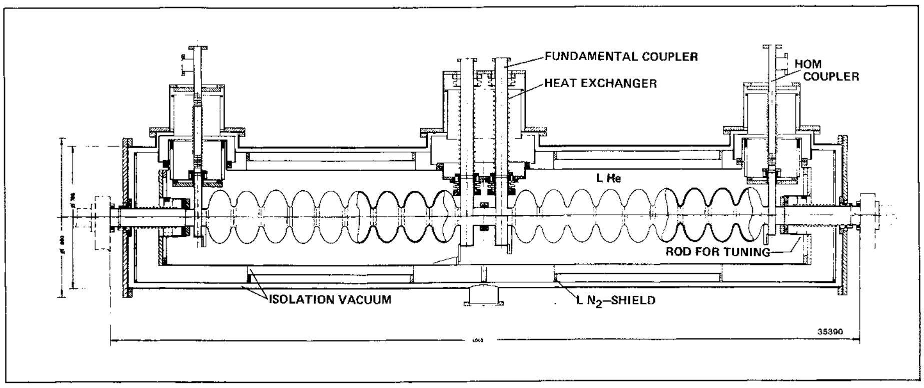
The first successful beam tests of a 1500 MHz structure in CESR and a 500 MHz single cell cavity in PETRA demonstrated that the storage ring environment does not degrade the superconducting properties of the cavities (see June 1982 issue, page 175). The 500 MHz cavity tested at



The first nine-cell cavity for a prototype superconducting r.f. module to be installed at PETRA towards the end of the year.

(Photo DESY)

Diagram of the double nine-cell superconducting cavity for PETRA.



PETRA had been built at the Kernforschungszentrum Karlsruhe in a collaboration with CERN and DESY.

On 16 February a superconducting cavity built at CERN was installed in the tunnel of the PETRA storage ring at DESY. At the end of the January/March PETRA shutdown, the cavity was well set up and ready to demonstrate its performance in the presence of stored beams.

The five-cell cavity is designed to run at the PETRA frequency of 500 MHz. It was tested earlier at CERN and provided an accelerating field of 2.8 MV/m. It is made of niobium sheet, electron-beam welded at the CERN workshops. It is equipped with all the facilities needed for operation within a storage ring—a high power coupler, higher order mode couplers and a tuner system.

Beam tests began at PETRA on 25 March. Initially the cavity was excited by the beam without applying r.f. power. A first survey of higher order mode excitations caused by the beam was made. In the evening of 28 March the crew was able to work for the first time with a DESY klystron. Later that night, the superconducting cavity took over the beam and stored it at 7 GeV. For these tests a field gradient of 2.2 MV/m was used and the maximum current stored in two bunches reached 1.7 mA.

The cavity was operated with a refrigerator from DESY. With its own cryostat and refrigerator control it is hoped to operate it in PETRA for several months and to be integrated as much as possible into the existing PETRA control system.

Meanwhile, possible parameters for a PETRA ring with superconducting cavities replacing the conventional units were presented at the recent Sante Fe Particle Accelerator Conference by a DESY-Wuppertal group. The dissipated beam power (due to synchrotron radiation at 30 GeV) of such a machine would require a new vacuum pipe. To obtain a reasonable luminosity, new quadrupoles, probably of the superconducting microbeta type, would be needed at the interaction points. Upgrading PETRA seems at present very questionable, particularly in view of the recent positive developments of HERA. However superconducting cavities may come in as energy savers and defray their installation costs by reducing the electricity bill, a factor which is also valid for HERA and other accelerators.

As a first step, a prototype superconducting module for PETRA is now being built. The mechanical and cryogenic design of this prototype module fulfils the space requirements of the existing PETRA tunnel. It was choosen to work at 1 GHz for several practical reasons. The 4.2 m space between quadrupoles at PETRA led to a double nine cell structure.

A single cell and a five-cell unit corresponding to the same frequency and dimensions had already been tested. While the single cell provided a relatively high accelerating field of 5.3 MV/m, the five-cell cavity gave an excellent value of 3.2 MV/m.

The first nine-cell unit was completed in the second half of March. These cavities are electron-welded by a German industrial firm and chemically polished at the Physics Institute of the University of Wuppertal. Cryogenics, r.f. components and windows, as well as the cryostat for the test module, are being prepared at DESY to be installed at PETRA in the winter shutdown.

In parallel with these developments, the 1000 inverse nanobarn per day mark was exceeded in March at the DORIS II ring, more than doubling its December performance. The two groups working there, Crystal Ball and ARGUS, are busy keeping up with the increased flow of data. The energy corresponded to the production of upsilon prime, at 5.016 GeV per beam.

Recent measurements at DORIS II demonstrated that the beams there can also be polarized, as was already suspected by the experimentalists. A value of 80 per cent was measured at the upsilon prime energy using the laser light method.

CERN
More jets

One of the highlights of last year's physics results was the new evidence for the production of hadron jets in the high transverse energy products emerging from particle collisions, both in the 62 GeV collision energy range at the Intersecting Storage Rings and the much higher collision energies available in the SPS proton-antiproton collider (see May 1982 issue, page 147, and October 1982 issue, page 327).

New results from the ISR now underline this phenomenon of clustering of the hadronic debris, interpreted as coming from the violent collisions which disturb the quarks (and gluons) sitting inside the target nucleons.

The CERN / Oxford / Rockefeller collaboration at Intersection 1 uses a superconducting magnet around a system of cylindrical drift chambers and lead-scintillator modules. Lead glass modules outside the magnet extend the coverage of electromagnetic showers. It is an improved version of the apparatus previously used by a CERN/Columbia/Oxford/ Rockefeller team.

All energies in the interior shower counters and the exterior lead-glass modules were summed, and data taking was triggered if this exceeded a specified level. Multiple events were rejected.

If attention is focused on high transverse energy (up to 30 GeV), there is a marked clustering of the detected neutral particles. This is confirmed by an analysis of each event, which shows clearly how the secondary particles group into two back-to-back sprays as the total transverse energy is increased.

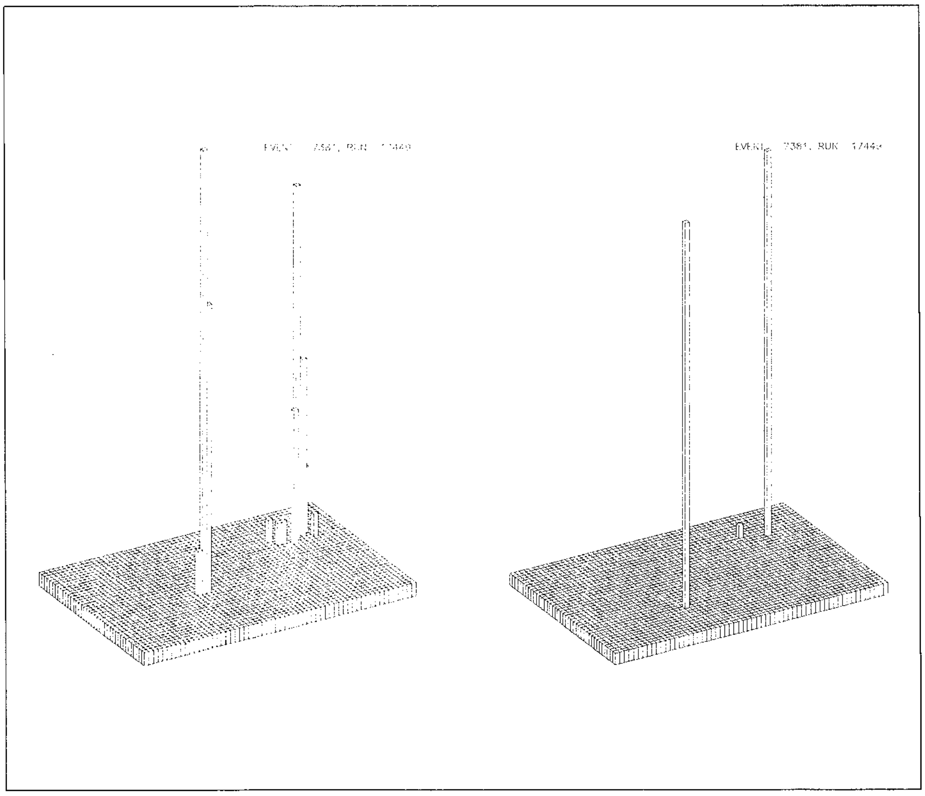
Interesting results are also coming in from the CERN / Dortmund / Heidelberg / Warsaw collaboration working with the Split Field Magnet in Intersection 4 of the ISR. These complement their classic jet studies using single particle triggers (see May 1982 issue, page 147).

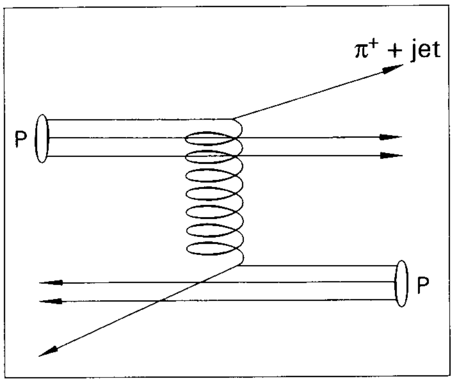
This group has long been among the stalwart supporters of the jet phenomenon. Their triggers select those events which include a single high transverse momentum particle. Although this represents only a small fraction of jet production, these single particle triggers have a clean signature and provide a convenient way of studying the composition of jet-like events.

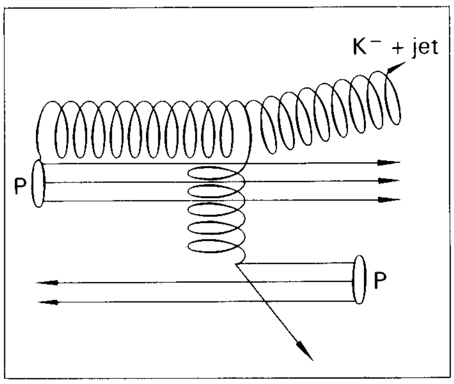
The CDHW team now has some further results from a systematic comparison of high transverse momentum positive pion and negative kaon production in proton-proton collisions at ISR energies.

While a positive pion ('up'quark bound with a 'down' antiquark) has quarks in common with the proton (up, up, down quarks), a negative kaon (strange, antiup) does not. However high transverse momen-

The neutral particle (electromagnetic) energy from a high transverse energy (34 GeV) event as seen by the detector of the CERN/Oxford/Rockefeller team at Intersection 1 of the CERN ISR. Such 'lego plots' are a way of 'unwrapping' the energy deposited over the full solid angle, and are becoming increasingly popular in jet physics. In the subsequent clustering analysis, signals from neighbouring counters get combined, so that the jets are especially clear (right). But even without subsequent analysis, the pattern of energy as received in the separate counters is jet-like enough (left).







Diagrams illustrating the difference between quark-quark (top) and quark-gluon interactions in the production of 'jets' of hadrons. The straight lines indicate quarks and the looped lines gluons. In both cases a gluon is exchanged. The quarks and gluons do not materialize as free particles, producing instead sprays of hadrons.

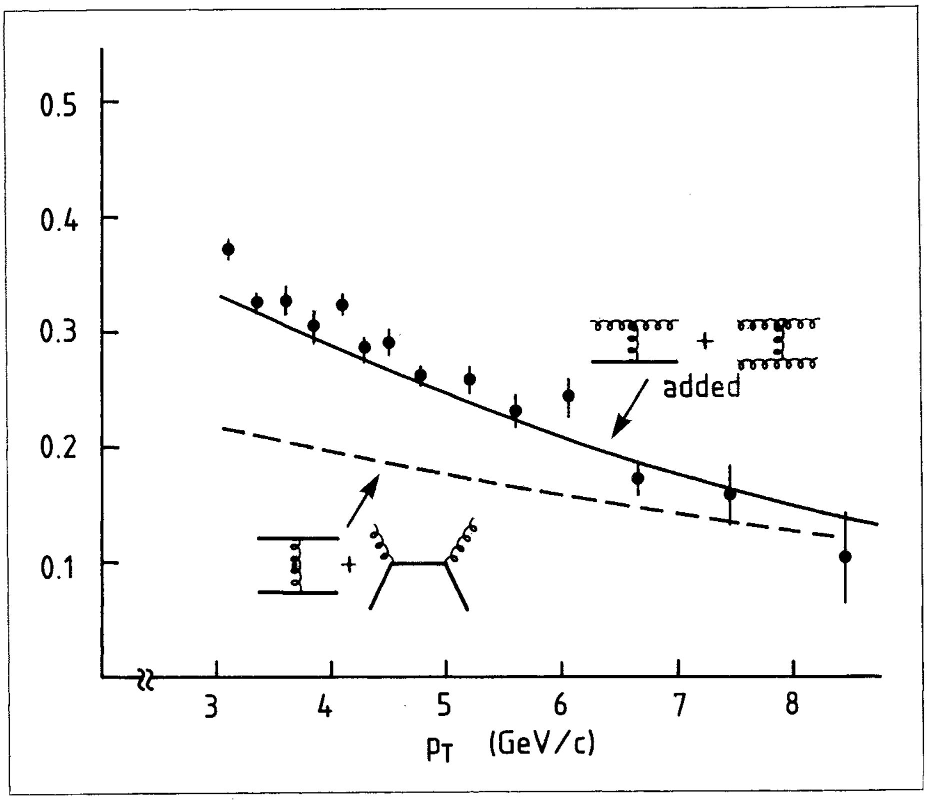
tum negative kaons are still frequently found in the hadronic debris emerging from these violent collisions in the ISR.

The behaviour of the accompanying particles is found to depend on the type of trigger particle used. In the pion case, two hadron jets are seen to come off predominantly back to back. However the jets in the kaon case are not mutually opposite, indicating that another mechanism might be at work.

As well as quarks, the colliding particles also contain gluons. Different quantum numbers are conserved in gluon and quark interactions (gluons, unlike quarks, carry no explicit 'flavours'). In addition, the quarks and gluons inside hadrons have different characteristics.

The properties of the jets in the two cases are seen to be very different. This systematic difference ties in with the quantum number restrictions and with the observation in neutrino experiments that the gluon component of nucleons is 'softer' than the quark component.

The relative levels of kaon and pion production is also consistent with calculations on the different mechanisms involved. This basic interaction of three gluons (field particles) at one space-time point is something unique to the underlying theory of quark-gluon interactions (quantum chromodynamics). The fact that this interaction can now be measured and successfully compared with predictions greatly extends the confidence in the underlying theory.



Ratio of high transverse momentum events triggered by negative kaons and pions, as seen by a CERN/Dortmund/Heidelberg/Warsaw collaboration at the CERN Intersecting Storage Rings. The observed behaviour ties in with calculations (solid line) which include the effect of three gluons interacting at one space-time point. Leaving out the three-gluon contribution spoils the agreement (dashed line).

STANFORD
Preparing for SLC

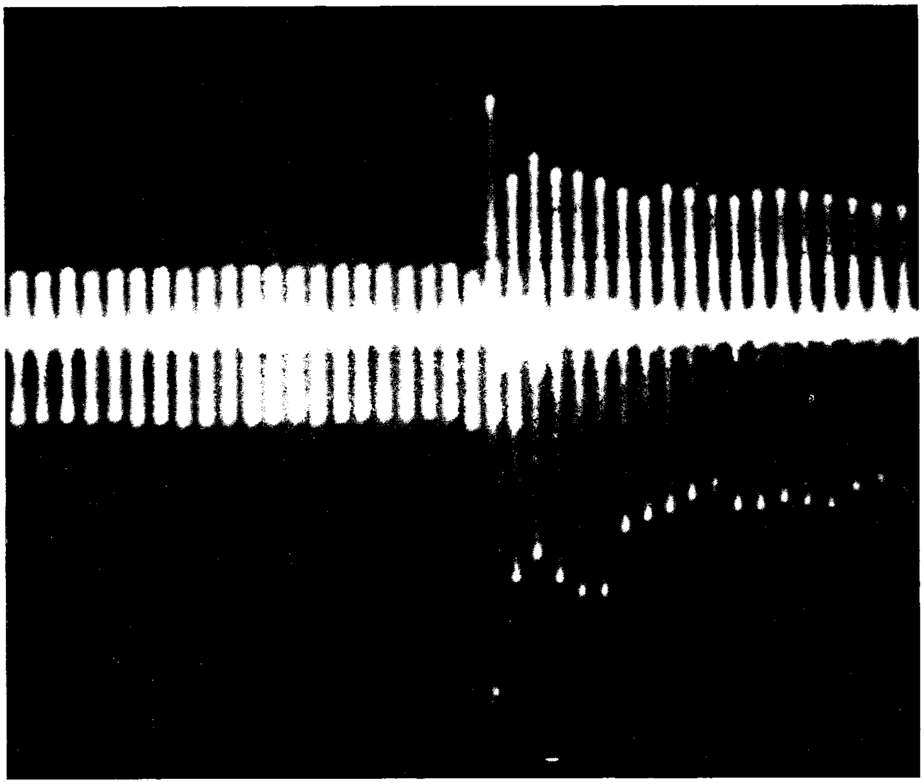
Preparations for the proposed Stanford Linear Collider (SLC) continue to go well. Two major components, the electron damping ring and the 50 Megawatt klystron performed well in first tests at the end of February. The damping rings are required for improving the beam quality before final acceleration of the bunches and the new klystrons are necessary to increase the final energy of the linac from the present 32 GeV to 50 GeV.

On Sunday morning, 27 February, SLC experimenters watched a beam circulate in the newly completed damping ring. The test followed a series of weekend runs. Although the distributed ion-pumps were not yet on, the beam lifetime was already longer than 3 minutes. In subsequent tests, this lifetime increased to nearly one hour.

In normal operation the electron beams will be stored for about 5 milliseconds between SLC pulses. The injected beam consisted of about 4×10^9 electrons from the PEP gun with about half the beam concentrated into one bunch.

A new 50 Megawatt klystron for the SLC was successfully tested on 25 February. The 6-cavity tube, operating at a repetition rate of 60 Hz with a 2 microsecond pulse width, produced 52.8 MW at the expected efficiency of 45 per cent. Meanwhile, a second tube has been completed and a third is in bake-out. The next step is to run these tubes with a 5-microsecond pulse and a repetition rate of 180 Hz. This requires building a pulsed high-voltage power supply (modulator) big enough to challenge the new klystrons. Tests are imminent.

First beam stored in the new damping ring for the proposed SLC linear collider at SLAC. The happily circulating electron bunch recorded a pulse each time it passed a monitor in the ring, giving the even pattern on the left. Then a new bunch was injected, and the variations in beam position began to be damped (right).



Late last year, the Mark II detector was chosen to be the first experiment to use the new machine. Letters of intent for a second experiment had then been invited, but this idea has now been shelved. Instead, the Experimental Program Advisory Committee will decide on one of two possible primary options. Broadly, one option allows for a second existing detector, suitably upgraded, which would alternate data-taking with Mark II until such a time as a completely new detector becomes available. The second option foresees an all-out effort to build a new advanced detector as quickly as possible. This would at first alternate with Mark II in the collision area, and eventually replace it.

Meanwhile, the PEP electron-positron ring at SLAC continues to break records (see April issue, page 98). Peak luminosity has been boosted to 3×10^{31} cm^{-2} s^{-1}, while daily integrated luminosity has attained 1400 inverse nanobarns.

A committee, distinctively christened 'PEP-Up', has been set up to examine alternative future programmes at PEP. It is chaired by Gerson Goldhaber.

DUBNA Superconductivity — highway or hard way to Nuclotron?

High energy physics with heavy ions (relativistic nuclear physics) began twelve years ago at the Laboratory of High Energies in Dubna. The acceleration of heavy nuclei (from deuterons to neon and recently polarized deuterons) at the Synchrophasotron has breathed new life into the machine which has been in operation since 1957.

Following this work a superconducting synchrotron of energy 15—25 GeV, called the Nuclotron, is considered of great interest for the further development of relativistic nuclear physics. To this end, the Laboratory of High Energies has been working on the technology of 2 to 2.5 T superconducting iron yoke magnets. Such magnets have some advantages over both conventional magnets and 5 T superconducting magnets.

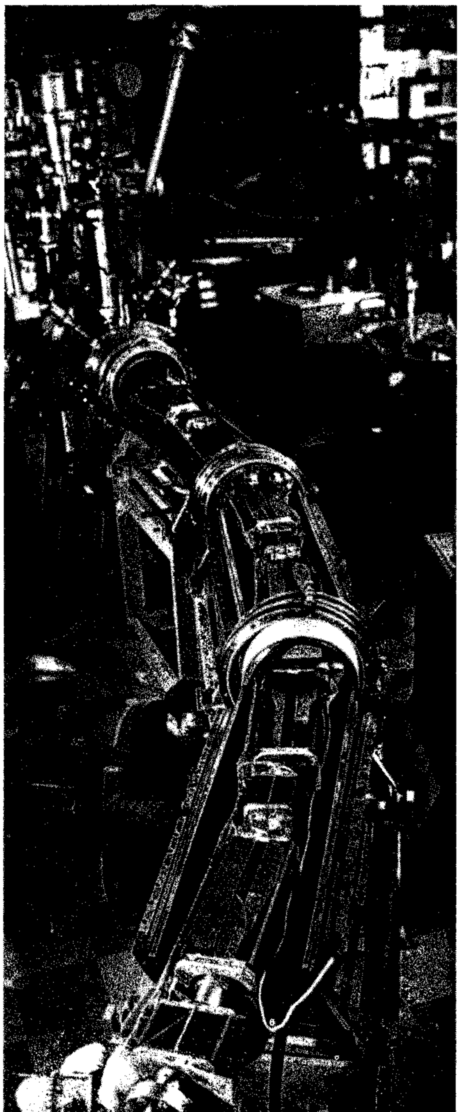
The weight of the superconducting magnet can be up to twenty times smaller than a 'warm' magnet of the same aperture due to the high current density in the superconducting coil (up to 500 A per mm^2). Moreover, because of the smaller energy consumption the operation cost is much lower even taking into account costs for the helium cryostat and refrigerator.

Comparing the Dubna magnets with 5 T superconducting magnets, the quantity of superconductor per magnet unit length is smaller by a factor of ten. This decreases energy losses under pulsed operation and field shape distortions, inherent in superconducting coils due to 'frozen' currents and so on. A closely wrapped iron yoke lowers the number of required ampere turns of the coil by a factor of two, shapes the field and shields external fields. It also acts as a restraining band to fix the coil geometry. The absence of a non-magnetic band makes the structure simpler and less expensive, as well as decreasing the stored energy. Lower stored energy affects both the necessary power supply for the accelerator magnets and their reliability, allowing easier evacuation of the energy in any accidental transition to normal state.

A further lowering of the cost is possible by eliminating the helium cryostat. The magnet is then force-

Three prototype cells for a model 1.5 GeV superconducting synchrotron being assembled at Dubna prior to successful tests. The 2.5 T magnets have been specially designed with a view to eventually building a synchrotron, called the Nuclotron.

(Photo Dubna)



cooled by liquid helium in hollow superconducting cable. This brings the Dubna magnets still closer to conventional types. The first pulsed superconducting magnet with forced two-phase helium circulation was successfully tested in 1980 and had excellent characteristics. The predicted field value was achieved without training and the same field was reached when the frequency of triangular cycles was as high as 1 Hz.

Besides the magnet design, the application of superconductivity in an accelerator leads to some problems of integration of the magnets with the r.f., vacuum, injection and extraction systems, etc. A model 1.5 GeV superconducting synchrotron is being designed at the Laboratory of High Energies to solve these problems and gain experience. The accelerator will contain more than 100 superconducting dipole and quadrupole magnets, in 24 regular FODO cells each 1.5 m long, and two matched 9 m straight sections.

The first step was the construction of three prototype cells which have been cooled and tested. Experience with the magnet system has answered many important questions not only concerning the design of the model synchrotron, but also the eventual construction of accelerators of the Nuclotron type for the acceleration of heavy ions.

DARESBURY Nuclear Structure Facility in action

As mentioned briefly in the previous issue (page 98), first major experiments have been carried out at the Nuclear Structure Facility (NSF) at Daresbury. Nuclear physicists working in the UK thus have a major new research tool.

The tandem accelerator at the heart of the facility has achieved stable operation with 18 MV on its terminal. The machine feeds a range of new experimental apparatus and a broad programme of studies is planned, including several important investigations of rapidly rotating nuclei.

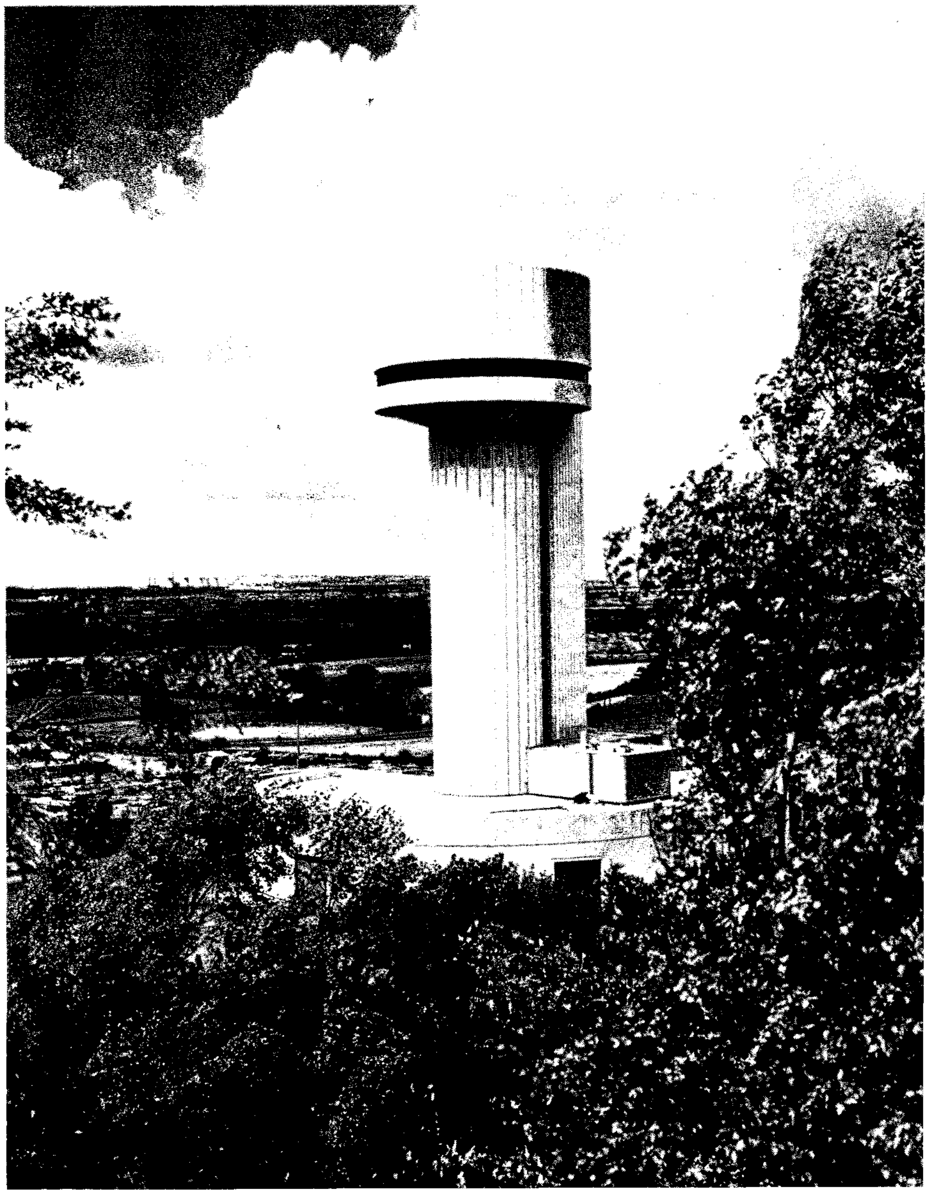
The NSF is an advanced version of the tandem electrostatic accelerator which for the past two decades has been used with great effect in many nuclear physics laboratories throughout the world. These machines are capable of accelerating a wide range of nuclear species and are noted for their excellent energy resolution and easy energy variability.

Construction began in 1974. The tandem is contained in a steel pressure vessel, 40 m long and 8 m wide, inside a 70 m high vertical tower. Initial operation will be with some 20 MV on the terminal, although electrostatic tests have shown that the ultimate design voltage of 30 MV can be reached.

The most critical component limiting this voltage is the evacuated tube through which the accelerated ions pass. So far, the tandem with the Mk I accelerator tube installed has been operated at 19.5 MV for short periods, and since last December has run reliably at 18 MV for experimental work. Over the coming months, the accelerator will slowly be taken to higher voltages as operating experience is gained and according to the needs of the experimental programme.

In parallel with the construction of the accelerator, there were preparations for the experimental programme in close collaboration with prospective users. Seven beam stations were approved for the first phase of operation. Three of them will be devoted to in-beam gamma ray spectroscopy and related studies. A precision 1 m diameter scattering chamber and a multi-element, high resolution magnetic spectrometer occupy two other beamlines which will support a wide variety of charged particle scattering and reaction studies. An isotope separator and a recoil separator have been specifically designed for the study of unstable nuclei.

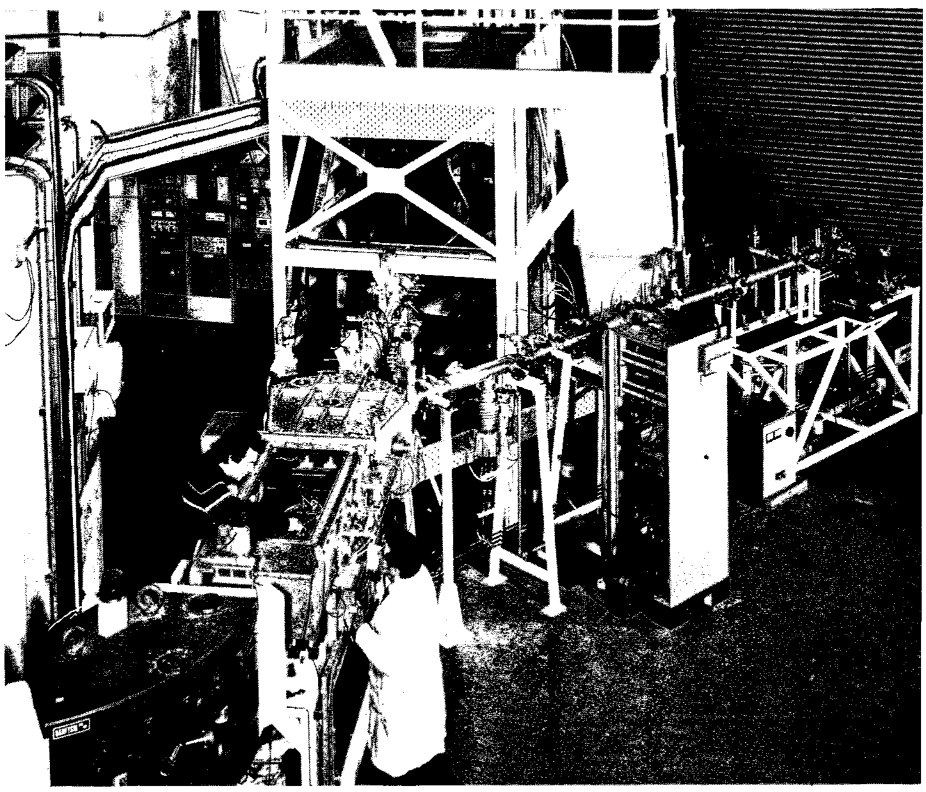
The recoil separator is a combination of two crossed-field analysers



A prominent local landmark — the 70 m high tower housing the Nuclear Structure Facility at Daresbury. The experimental programme at the NSF is now under way.

and a magnetic spectrometer. It is capable of detecting short-lived products of nuclear fusion reactions recoiling near zero degrees. Recent work in Germany has reawakened speculation that superheavy nuclei can be formed in fusion reactions. If this is so, the recoil separator coupled to the NSF tandem will be an ideal combination for studying them. The isotope separator is basically of conventional design and can be operated in both on-line and off-line modes. More unconventional are the associated laser equipment and dilution refrigerator. Shapes and sizes of nuclei can be deduced from studies of laser-induced resonance fluorescence. Measurement of the gamma decay of nuclei oriented at the low temperatures (about 6 mK) of the refrigerator yields basic information about nuclear excited states. The ability to apply these techniques to beams of ions from the isotope separator will provide unique facilities for studying short-lived nuclei far from the line of beta stability.

So far experimental work has concentrated on investigating the behaviour of nuclei subjected to a high degree of rotational stress. This has demanded the full capability and versatility of the NSF tandem. Accelerated beams of isotopically enriched titanium, sulphur and calcium ions have been used to produce nuclei spinning at record speeds, and the cascades of de-excitation gamma rays were detected and recorded using a unique array of gamma detectors called TESSA. Evidence has already been obtained which seems to confirm theoretical predictions that



General view of the NSF isotope separator. Ions are separated by the dipole magnet (foreground). The beamline on the left leads to a dilution refrigerator, while that on the right guides particles to a laser cell for resonance fluorescence experiments.

(Photos Daresbury)

Physics monitor

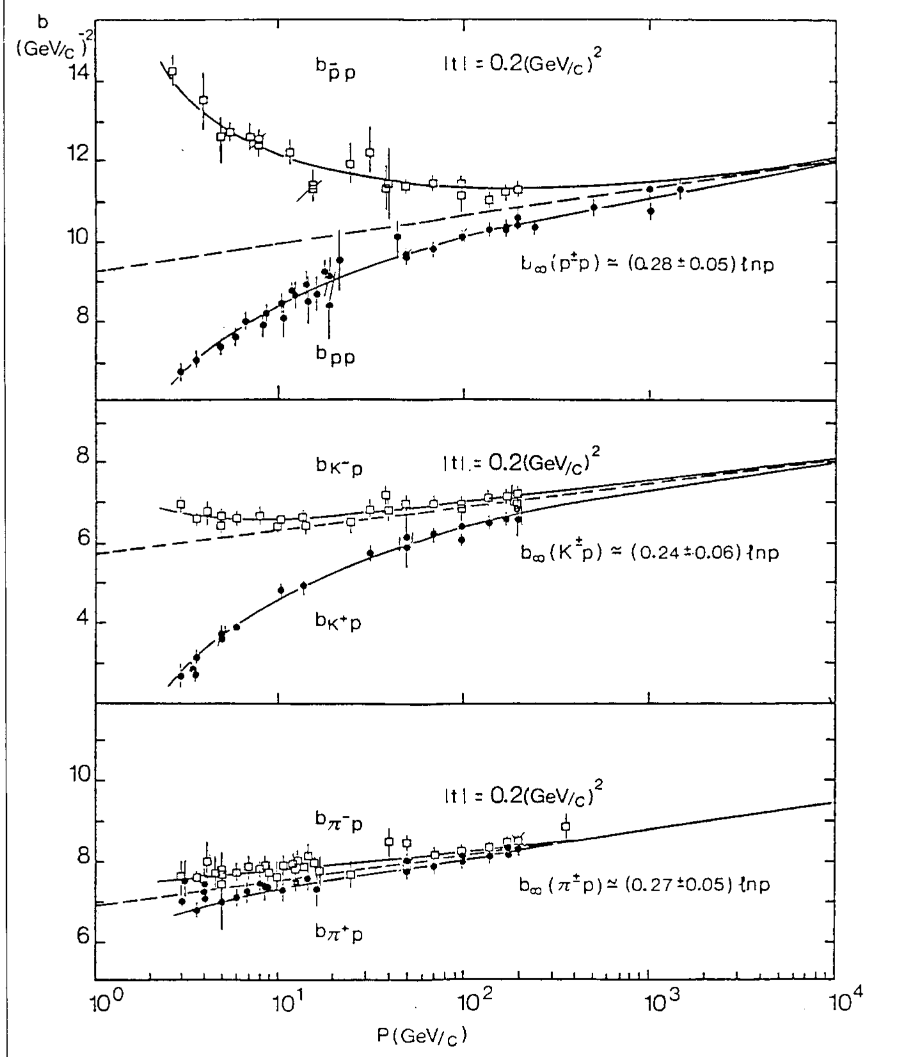
dramatic changes occur in the structure of a spinning nucleus at certain critical values of rotational frequency. In a normal nucleus, neutrons and protons move cooperatively in pairs, rather like electrons in a superconducting metal. However, as the nucleus rotates, the Coriolis force causes the pairs to break apart at given frequencies and tries to align the individual nuclear spins with the rotation axis. At very high spins, extensive realignment of the nucleons is expected. These effects are analogous to the quenching of superconductivity by an applied magnetic field. Scientists are encouraged by these early results and look forward to a period of rapid advance in understanding high spin phenomena in nuclei.

These first experiments are only part of the planned programme for research using the NSF and scientists from many UK universities will extend their studies into many different areas of nuclear physics in the near future as the other major pieces of equipment are commissioned and brought on-line.

Universal hadron behaviour

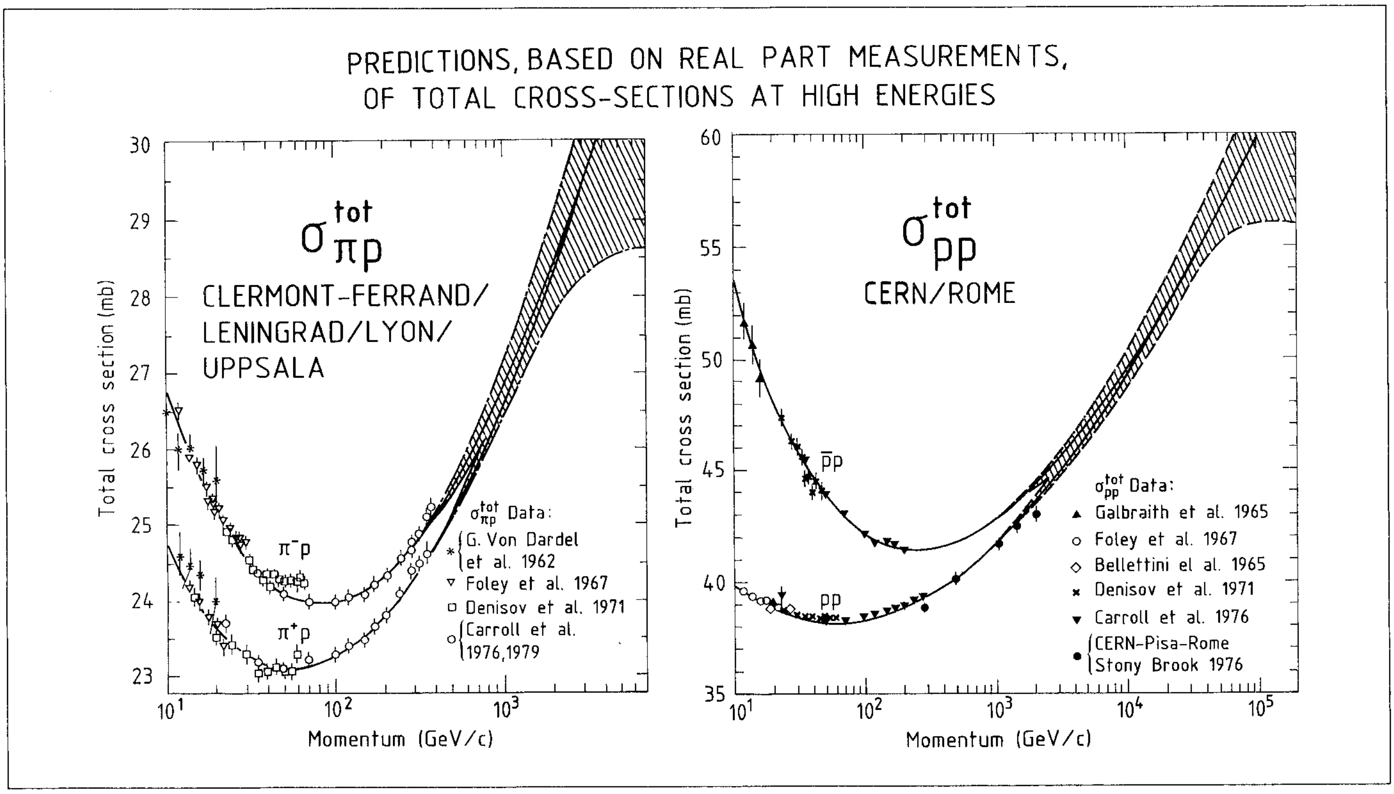
Current dogma says that hadrons (particles which interact through the strong nuclear force) are composite, with an internal quark structure. Naturally, recent experiments have tended to look more at the hard collisions when individual quarks crash into each other, rather than the soft collisions due to collective quark interactions.

However the soft collective interactions still have a clear physics interest. Axiomatics says that the laws of these soft collisions should follow certain fundamental theorems expressed as 'dispersion relations' (mathematical convolutions incorporating the natural assumptions of analyticity, unitarity and crossing symmetry). Each time higher ener-



A compilation of world data on the elastic scattering of protons on protons compared with protons on antiprotons (top), negative and positive kaons on protons (centre) and positive and negative pions on protons (below). The b parameter gives the exponential decrease with momentum transfer of the elastic scattering spectrum. These results suggest that at high energies b varies with momentum in the same way for all hadrons.

Left, direct measurements of the total pion-proton cross-section and the new extrapolation of these results to higher energies, based on measurements of small angle scattering by a recent experiment at the CERN SPS 400 GeV machine. The shaded area is the region within which the high energy behaviour has to be confined. On the right, the corresponding extrapolation for proton-proton scattering, from an earlier experiment at the Intersecting Storage Rings. Disregarding the scale, the similarity is striking.



gies become available, it is important to verify these theorems, as their breakdown above a certain energy would have far-reaching implications for our understanding. For instance, it could throw doubt on the concept of 'causality' — related cause and effect.

Total and elastic cross-sections are among the basic yardsticks of hadronic interactions. (For a given pair of hadrons, the total cross-section is a measure of how generally reactive the particles are, while the elastic cross-section measures to what extent the particles just bounce off each other, without otherwise changing their form.) The variation of these cross-sections with energy for pions, kaons and protons scattering from protons is known at the energies accessible in accelerator Laboratories. The comparison and contrast of these results provide valuable insights.

New information now comes from a recently completed study of small angle elastic pion-proton and proton-proton scattering by a Clermont Ferrand / Leningrad / Lyon / Uppsala collaboration which was the first joint CERN / USSR experiment at the CERN SPS 400 GeV proton synchrotron. The apparatus consisted of a forward magnetic spectrometer equipped with wire chambers, and the special IKAR hydrogen ionization chamber, built in Leningrad, capable of measuring the low energy proton target recoils down to energies as low as one MeV.

At very small momentum transfers, the level of electromagnetic effects is comparable to the hadronic, and this provides a useful probe of the hadronic interaction (determining the ratio of the real to imaginary parts of the scattering amplitude). As the momentum transfer increases, the hadronic behaviour dominates, and parameters of forward elastic scattering can be measured.

The pion-proton measurements were analysed with the aid of dispersion relations. Earlier experiments at lower energies had cast some doubt, but the new results come down in favour of the dispersion relation picture, and moreover show that it is valid up to at least 100 GeV beam energy.

Renewed confidence in the approach made it tempting to use the technique to extrapolate to higher energies, beyond those directly accessible at today's accelerators. The pion-proton total cross-section (related to elastic scattering through the so-called 'optical theorem') is predicted to continue rising (approximately as the square of the logarithm of the energy) up to at least 2000 GeV pion beam energy, when the cross-section reaches 28 mb (see diagram).

This pion-proton information can be usefully compared to that for proton-proton scattering measured by a CERN / Rome group at the CERN Intersecting Storage Rings. Interestingly enough, the rate of increase with energy is found to be similar in the two cases, but for proton-proton scattering an effective beam energy of 10 000 GeV is required to make the cross-section increase by 20 per cent above its minimum value, while in pion-proton scattering this already occurs by 2000 GeV.

The new measurements of the (logarithmic) slope of the pion-proton elastic scattering show an increased slope at smaller momentum transfer, as in proton-proton scattering. Looking at the energy dependence at fixed small momentum transfer, the slope increases with energy at about the same rate in the two cases — both forward elastic scattering peaks shrink with energy. A compilation of world data on different elastic scattering processes in fact reveals that at very high energies the same shrinkage will be seen for all hadrons.

These results indicate an underlying universal behaviour of the dynamics of collective quark interactions, independent of the quark composition of the colliding particles.

(We are grateful to T. Ekelöf for supplying us with this information. In a future article, we will go on to cover the comparison of proton-proton and proton-antiproton scattering data from the ISR and the data from the extreme energies attained in the SPS proton-antiproton collider.)

At the Vienna Wire Chamber Conference, Georges Charpak from CERN (left) now a 'father-figure' in the field as the inventor of multiwire proportional chambers and drift chambers, with V. S. Peskov from Moscow University who gave an excellent invited talk.

(Fotozentrum am Schwarzenbergplatz)

Vienna Wire Chamber Conference

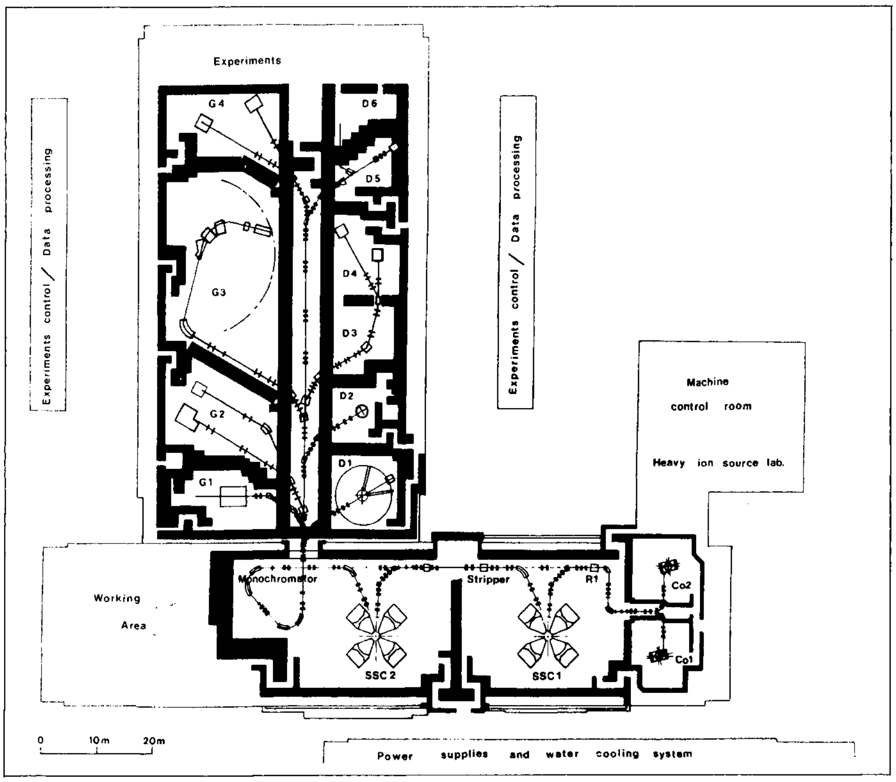
After those of 1978 and 1980, a third Wire Chamber Conference was held from 15-18 February in the Technical University of Vienna. There were about 190 participants from 25 countries, spanning from the East to the far West. The eight invited speakers — R. Bock, G. Charpak, J. Engler, A. R. Faruqui, E. Iarocci, I. Lehraus, V.S. Peskov, A. H. Walenta — covered the field from sophisticated applications in biology and medicine, via software, to the state of the art of gaseous detectors. In some forty other talks the speakers tackled in more detail the topics of gaseous detectors, calorimetry and associated electronics and software.

The number of participants working in fields other than high energy physics was higher than at the two previous Conferences in the series. Another positive sign was that, mixed in with the 'old' experts, there were a few young and brilliant newcomers giving talks on novel techniques like high density projection chambers, improvements of TPCs or calorimeters with barium fluoride scintillator.

The Vienna Coffee House celebrates its 300th anniversary this year and organizers from the Institute of High Energy Physics of the Austrian Academy of Science decided to schedule long coffee breaks. This had a useful side effect in that the poster section, with 25 presentations, was highly frequented and a real success. Social events included a concert in the old University and a Heurigen — an edifying evening, devoted to eight white wines, called 'Mess-Wein' since they are specially selected for consumption by priests...

Physics with GANIL

General layout of GANIL.



Last month (see page 87) we carried an article on the start-up of the French GANIL (Grand Accélérateur National d'Ions Lourds) machine at Caen. It is based on a sequence of cyclotrons operating at the same frequency, and today's physics interests confirm the imaginative thinking behind the launching of the project ten years ago.

GANIL is a national Laboratory open to both French and non-French physicists. Intensive use of the beam can therefore be expected, requiring high equipment reliability. The beam is shared in time and delivered to two parallel experiments in consecutive bursts.

The major elements of the experimental areas were planned jointly by the various French Laboratories, which then spread amongst themselves the research and development of specific components. At the beginning of 1983, four of the ten experimental halls planned were commissioned, although the purposes of all ten are already well defined (see plan):

- D1 houses a 1 m diameter scattering chamber linked to a 5 m time-of-flight base;
- D2, for the time being a general-purpose hall, will ultimately house the Cyrano scattering chamber giving measurements inside and outside the horizontal plane;
- G1 houses Nautilus, a large 3 m diameter chamber, designed to accommodate large detectors;
- G2, specially designed for the measurement of reaction-produced gammas, is a low intensity hall to avoid excessive background noise;
- G3 will house a large spectrometer (SPEG), scheduled to come into operation next year for precise studies;
- G4 is a general-purpose hall;
- D3 and D4 house the Super Stripped Ion Line (LISE) for atomic physics activities and the exotic nuclei search;
- D5 will house a mass spectrometer and also the irradiation installations for condensed matter physics, and has therefore been designed for high beam intensities.

Physics experiments began on 20 January, with atomic physics and condensed matter physics accounting for some 10 per cent of experimental time. Letters of intent and experiment proposals are divided into the nuclear and non-nuclear categories and then reviewed by separate experiments committees. By the end of January, 51 letters of intent for nuclear physics experiments had been received and 26 for non-nuclear activities. To date, 29 proposals for nuclear physics experiments have been approved for phase 1 of GANIL.

GANIL's performances will permit research of heavy ion nuclear reactions in the 20 to 100 MeV/ nucleon energy region where there is little available data (the SARA accelerator at the Institut des Sciences Nucléaires in Grenoble has been delivering light ion beams of up to 30 MeV/nucleon since summer 1982 — see July/August 1982 issue, page 234). This is a key region in nuclear physics because there is expected to be a transition between the collective nuclear behaviour, widely studied below 10 MeV/nucleon, and a 'nucleonic' behaviour, where the nucleus would behave as a loose assembly of constituent nucleons. This is also the region where the incident nucleons have velocities comparable with those of the nucleons in the target nucleus (Fermi motion) and to the speed of sound in nuclear matter.

It is hoped that the study of phenomena at the frontier between two well-studied types of behaviour and the observation of new types of reaction will improve our understanding of this transition.

GANIL's energy region is also ideal for the production of highly excited nuclei with a very high angular momentum and of new nuclear species, for which LISE is specifically designed.

The first batch of nuclear experiments approved for phase 1 of GANIL will chart a region hitherto only partly explored. The fields to be studied, depending on the incident energy and the projectile, are as follows:

- transfer of the incident momentum towards the target nucleus;
- evolution of the asymmetry degree of freedom during the transfer of nucleons;
- elastic or quasi-elastic scattering of nuclei;
- fragmentation of the projectile and the target during collision;
- production of neutral pions below the threshold;
- fusion and fission phenomena and the production of high-spin nuclei;
- the production of exotic nuclei.

In the field of non-nuclear physics, the approved experiments will study:

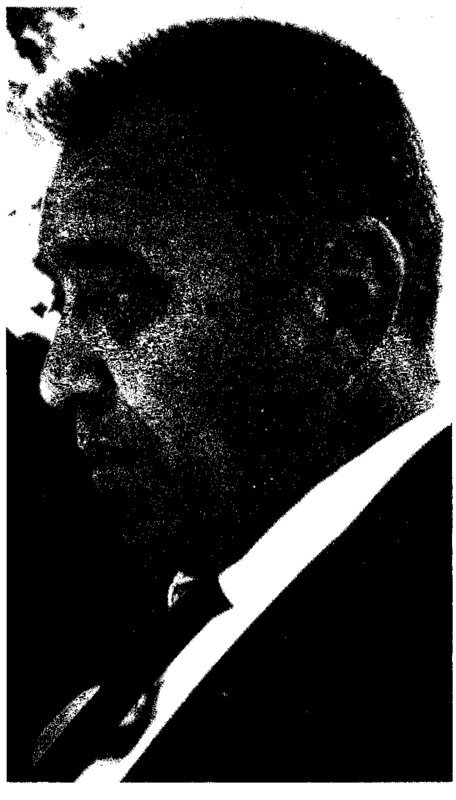
- the behaviour of materials irradiated by high-energy heavy ions (disorder production or, conversely, recrysallization);
- electronic transitions in heavy hydrogen-, helium- and lithium-like atoms;
- charge exchange mechanisms in high-speed collisions.

For phase 1, the Committee for Non-Nuclear Physics Experiments has also approved development of a series of ambitious experimental devices in anticipation of the considerable variety of reaction products expected at these energies.

The experimental data acquisition system consists of four MODCOMP (CLASSIC 7860) computers, each with a maximum acquisition rate of 100 000 words of 16 bits per second. The computers are linked to the data acquisition system via a CAMAC system containing special modules manufactured to the MBNIM standard and designed to select out interesting events and to control their rate of transfer into the computer.

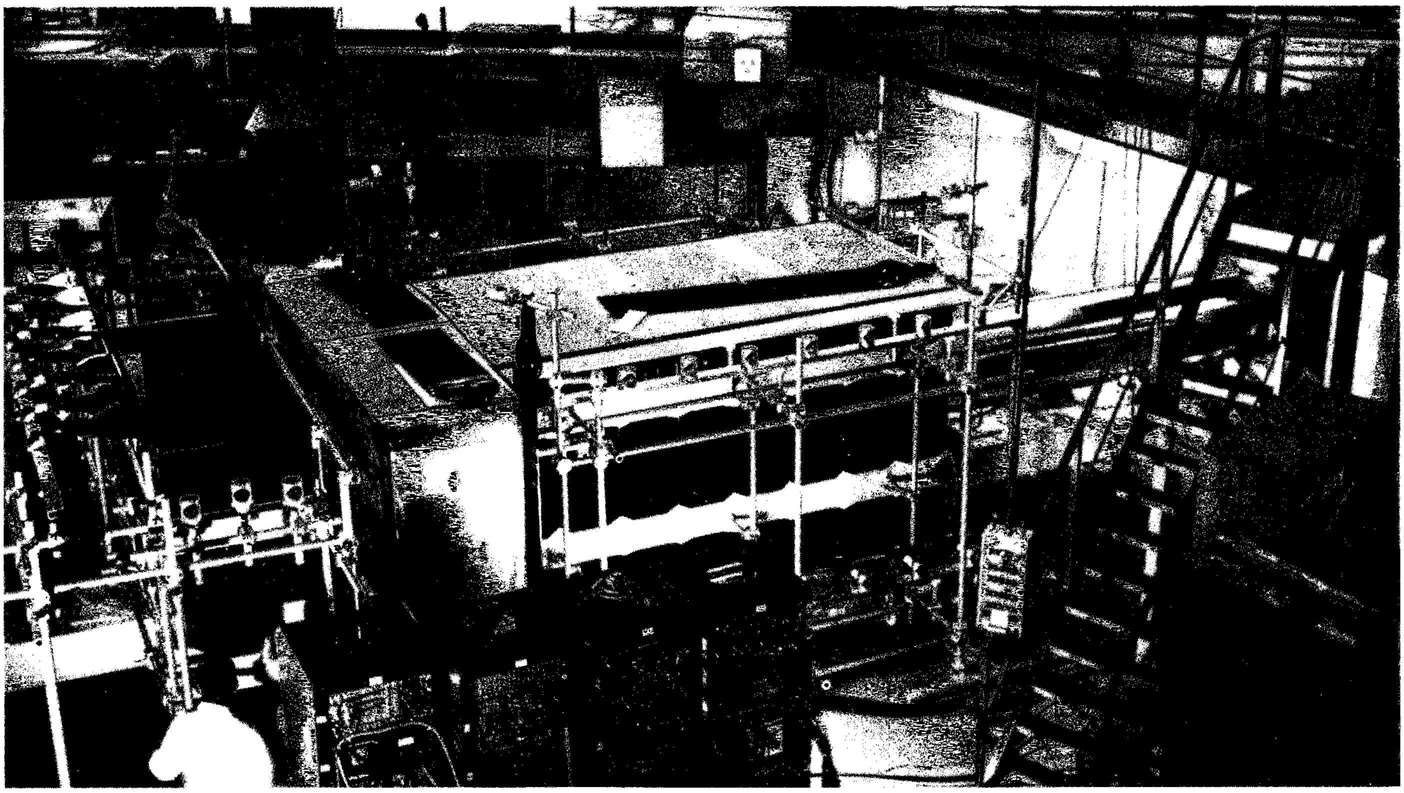
People and things

Marian Danysz, who died on February 9, was one of the best known Polish physicists. His major contribution to elementary particle physics was the discovery, together with J. Pniewski, of hypernuclei in 1953. He realized at an early stage that progress in science requires broad international cooperation. By the 1960s the Warsaw group worked in close collaboration with groups from Bristol, Brussels, CERN, Dublin and London, and also from Belgrade, Berlin, Budapest, Dubna and Prague. As the first deputy director of the Joint Institute for Nuclear Research at Dubna, he initiated the collaboration between that institute and CERN. It was also on his initiative that Poland became a CERN Observer State and he was the first Polish representative at CERN Council. Apart from his efforts to maintain international contacts



Marian Danysz

A view of the experiment at the reactor of the Institut Laue-Langevin (ILL), Grenoble, France, by a CERN/ILL/Padova/Rutherford/Sussex collaboration which looked for signs of neutron-antineutron oscillations. The experiment has recently been completed and preliminary results are emerging. There appear to be no signs of oscillations. (In our previous issue, we inadvertently attributed this experiment to a CERN/ILL collaboration.)



among physicists, he was very active in high energy physics research in Warsaw. He was a member of the Polish Academy of Sciences and the Heidelberg Academy. On his retirement in 1977 he received an honorary doctorate from Warsaw University.

Dr. J. Schutten, Managing Director of the Netherlands National Institute for Nuclear Physics and High Energy Physics (NIKHEF) at Amsterdam, died on 10 March. For ten years he was Technical Director of the Institute for Nuclear Physics Research (IKO), and in 1981 became Managing Director of NIKHEF, which now includes IKO. He personified the bond between the two sections of the Institute — Nuclear Physics (K) and High Energy Physics (H). He is sadly missed by his colleagues.

On people

Yuval Ne'eman is Israel's first Minister of Science and Development. Wolfson Professor at the School of Physics and Astronomy and director of the Sackler Institute of Advanced Studies at Tel Aviv, Ne'eman represents the Tehiya party in Israel's parliament, the Knesset, and is co-director of the Center for Particle Theory of the University of Texas, Austin. He is best known in physics for his description of hadron symmetries using unitary groups, for which he recently received the Wigner medal for work in group theory. This work, together with that of Murray Gell-Mann, helped pave the way for our present understanding of the 'flavour' properties of hadrons. He has also had a varied and distinguished career in other sectors.

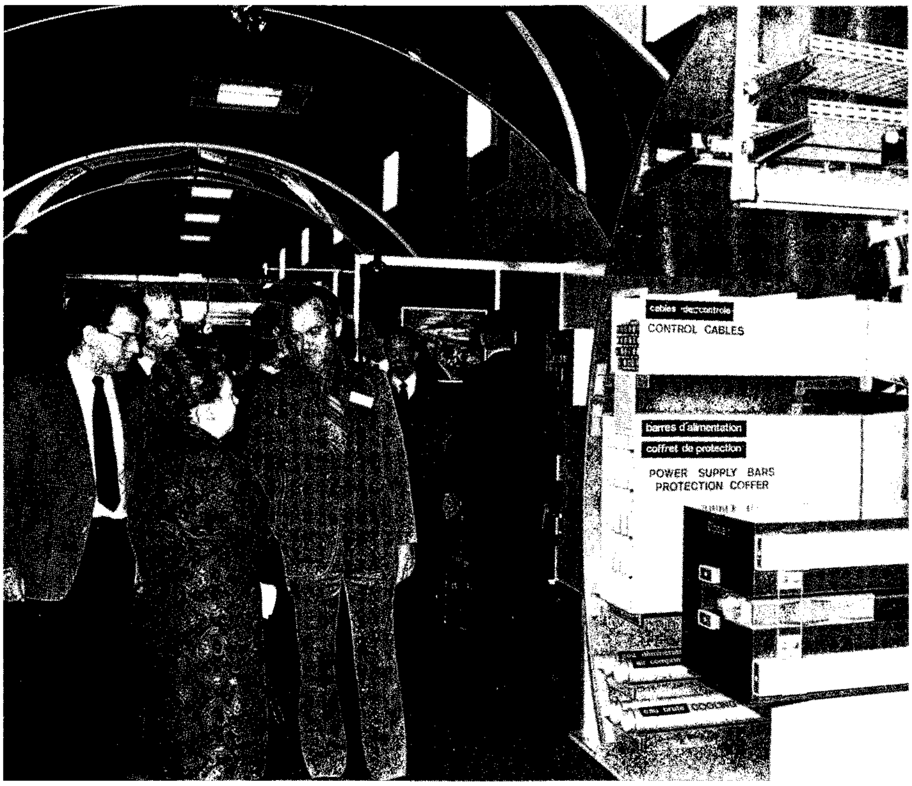
J. D. Lawson of the Rutherford Appleton Laboratory was recently elected Fellow of the prestigious UK Royal Society. The FRS accolade comes to John Lawson after many major contributions to particle beam physics, ranging from klystron development, through fusion (and the famous 'Lawson criteria') through to the basic physics of accelerators. As demonstrated at the recent Oxford conference on new acceleration techniques (see December 1982 issue), his broad knowledge is regularly sought in assessing new ideas.

Accelerator School developments

We reported in the March issue (page 60) that CERN is in the process of setting up an Accelerator School. A Provisional Advisory

Committee has been appointed to assist in the planning of various School activities. There is general agreement that the first course organized by the School should be on facilities for proton-antiproton collisions. With the recent exciting results obtained in this field, it is a good time to examine all the aspects of this kind of project in detail, emphasizing those that can lead to further advances. The course will last about two weeks and will take place at CERN in October. More details will be published in the near future.

The School and its Advisory Committee are also planning a second course, devoted to basic and general accelerator physics for the benefit of physicists and engineers entering the field. The tentative date is late summer 1984, but the location is still undecided. Other Accelerator School activities are still under discussion.



Dr. Hirta Firnberg, Austrian Minister for Science and Research, visiting the CERN stand at the Austrian Science Fair in Vienna on 26 February. She is in conversation with Reinhard Budde near a model of the tunnel for the proposed LEP electron-positron ring for CERN.

Superconducting cable exceeds rating

The superconducting cable project at Brookhaven continues to make progress. A 1000 MVA test unit for power transmission has two 130 m superconducting cables rated for 4 kA in a 138 kV three-phase system. Recent tests aimed at determining how high above the rated values the cables could go. The voltage was run up to 190 kV and held there for over twelve hours. After the overvoltage test, the current was run up to 6 kA and all went well for half an hour, until a termination component was damaged. After repairs, a remaining test aims to investigate whether the cables will sustain a voltage pulse of some 650 kV, such as might be experienced in a lightning strike.

CESR experiments

For the first time since electron-positron collisions were achieved in the CESR ring at Cornell in August 1979, plans are being prepared for a major reorganization of the experimental programme, providing new opportunities for individuals or groups not currently working at CESR. Although CESR's luminosity has reached 14 inverse picobarns per month, several efforts aimed at increasing the luminosity are already under way, and could improve performance by an order of magnitude.

Cornell is also inviting new proposals for experiments in the North Area, currently occupied by the CUSB detector. This would become available near October 1985. Interested groups should submit letters of intent by 1 July this year, and the complete proposal by 15 September. Further information on the CESR North Area is available from Karl Berkelman at Cornell, telephone (607) 256-4198.

Meanwhile the other CESR detector, CLEO, is constructing a new inner detector with vertex detector and drift chamber able to measure energy loss. A new outer detector to improve particle identification is also being considered. A Workshop is scheduled for 31 May — 4 June to launch a proposal for these outer detector improvements. Individuals and groups are encouraged to participate, and it is hoped that a broader collaboration will result. Information about the Workshop is available from Murdock Gilchriese, telephone (607) 256-5197.

It will be interesting to see what experimental plans emerge for future work at CESR.

More new radioactivity

Three kinds of radioactivity are common in the breakup of natural nuclei — alpha decay, beta decay and spontaneous fission. In 1981, an experiment at the UNILAC heavy ion accelerator at GSI Darmstadt discovered the emission of protons from the ground state of the new rare earth isotope lutetium 151.

Excited states of nuclei formed in beta decay, for example, can show other types of radioactive behaviour. In such 'beta-delayed' radioactivity, the excited nuclear states can emit other particles.

Several years ago, a team at the CERN synchro-cyclotron discovered the beta-delayed emission of two neutrons in the decay of lithium 11 to beryllium 11. Now a team at Berkeley has detected the beta-delayed emission of two protons in the decay of the highly unstable nucleus aluminium 22, which has a complement of only nine neutrons, compared to the 14 present in the stable isotope. With a halflife of only 70 milliseconds, the aluminium isotope was manufactured by bombarding a magnesium target with helium-3 beams from the Berkeley 88-inch cyclotron.

Solitons at Edinburgh

The Union Canal in Edinburgh, Scotland, skirts the boundary of Heriot-Watt University, near the spot where scientist and engineer John Scott Russell discovered the solitary wave in August 1834.

Although the phenomenon was largely ignored for some 130 years, the study of 'solitons' as they are now known, has boomed. So what better place for a recent soliton research conference and workshop than Heriot-Watt University?

One highlight of the meeting was the unveiling of two plaques on the banks of the canal to commemorate the 1834 discovery. Unfortunately an attempt to recreate a soliton in the canal failed, but the research programme continues undeterred.

Jean Groz receives 1 000 SFr from CERN Director General Herwig Schopper for an idea which saves considerable money and effort in processing CERN pay slips. This is the first award to be made in CERN's recently established Suggestion Award scheme.

(Photo 55.2.83)

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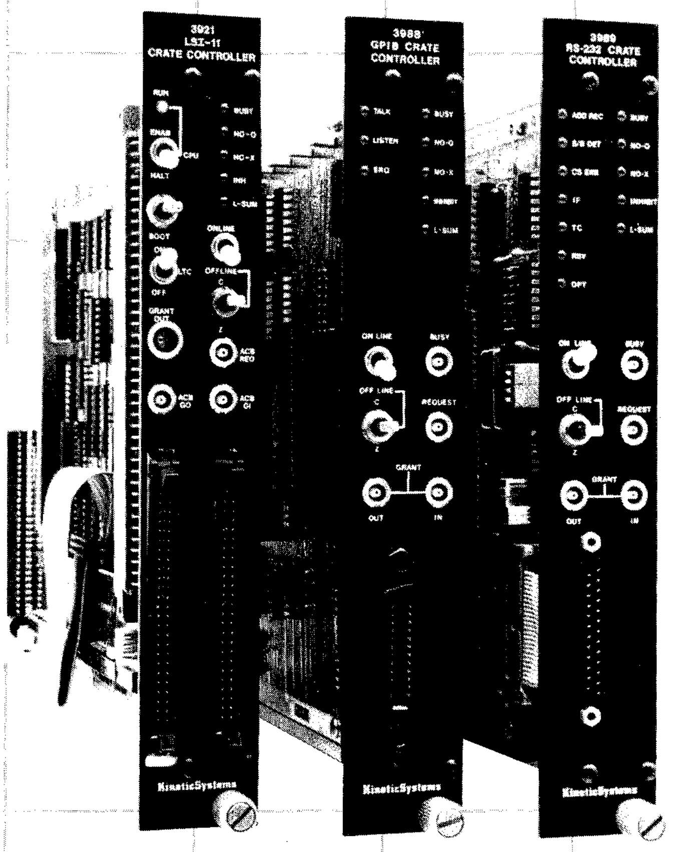

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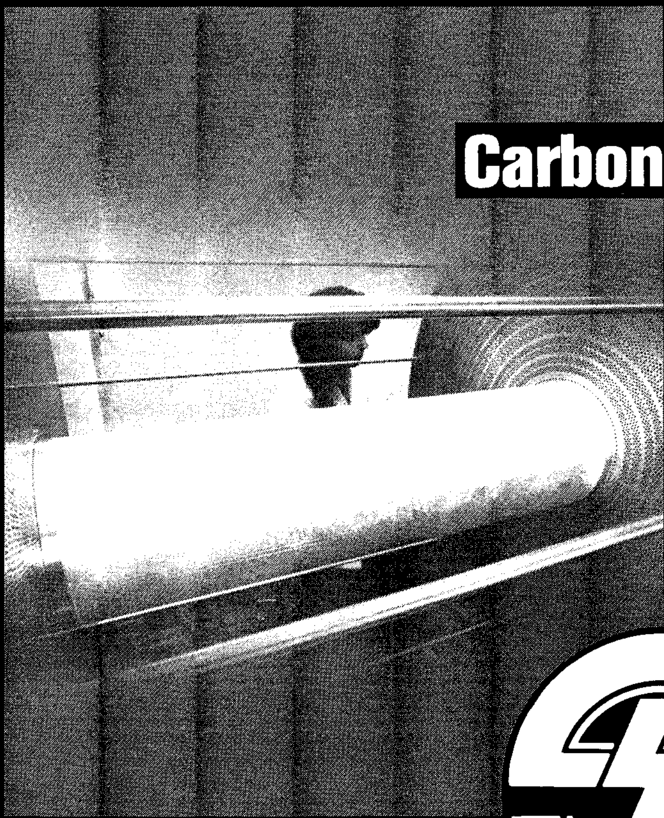

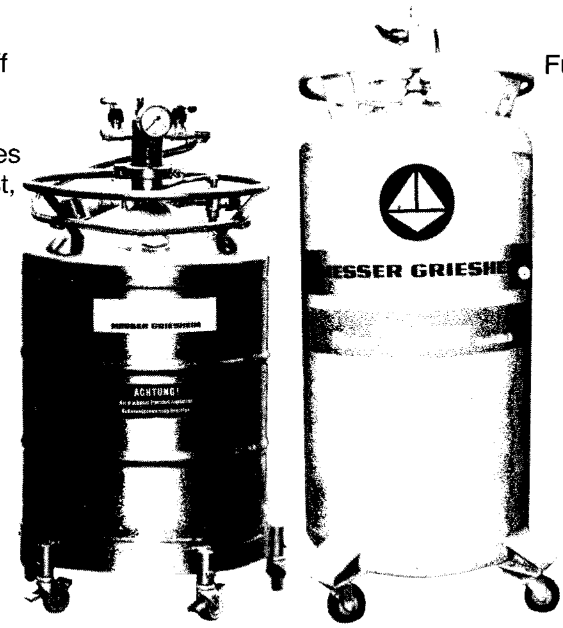
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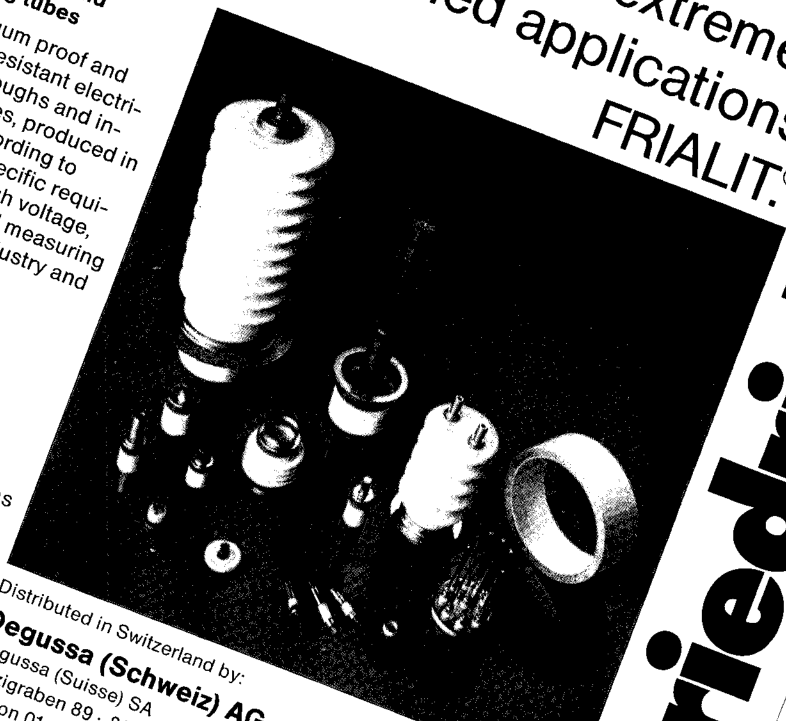

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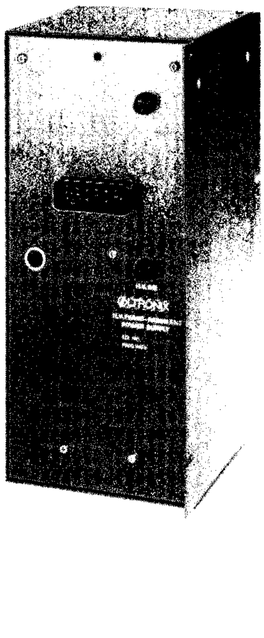

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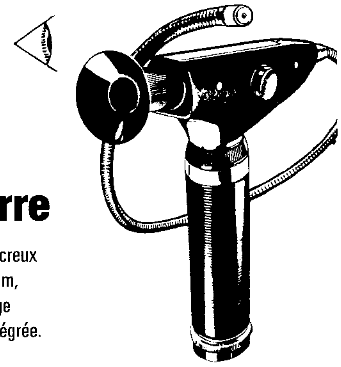

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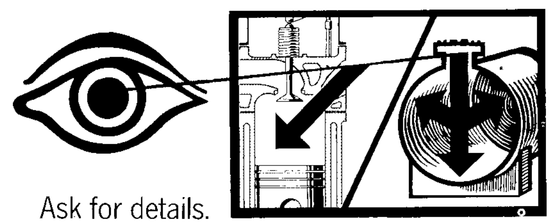

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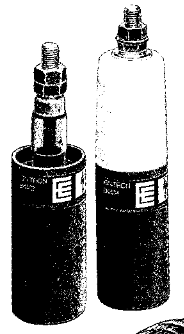

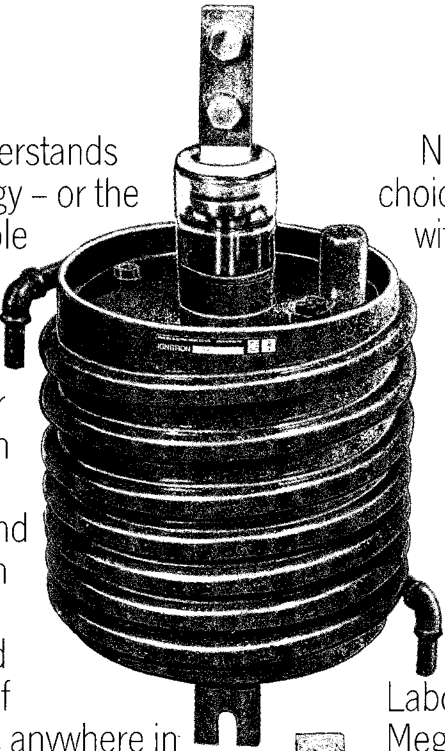

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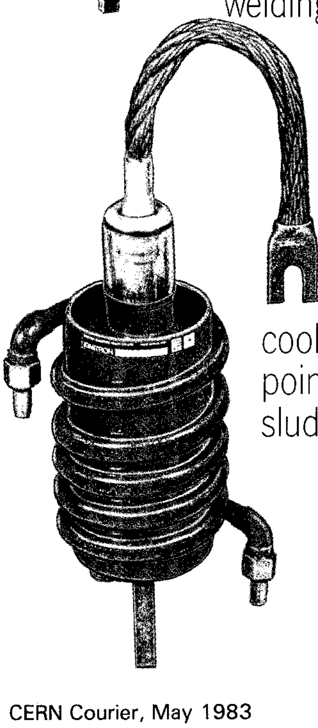

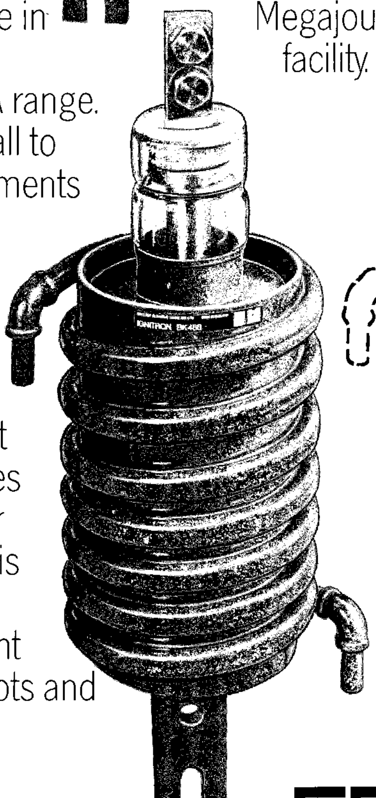

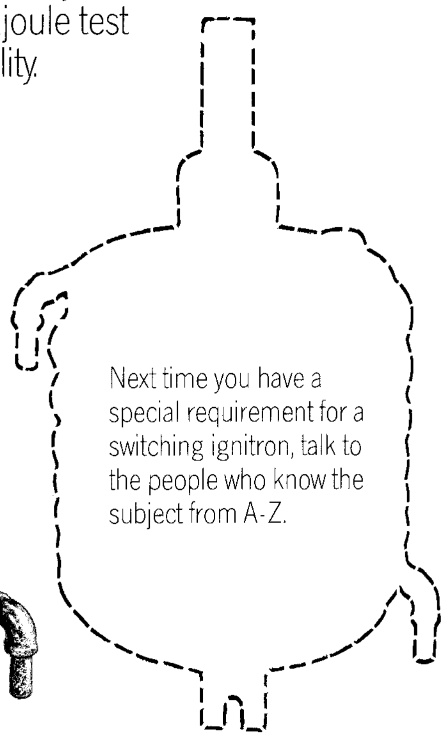

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