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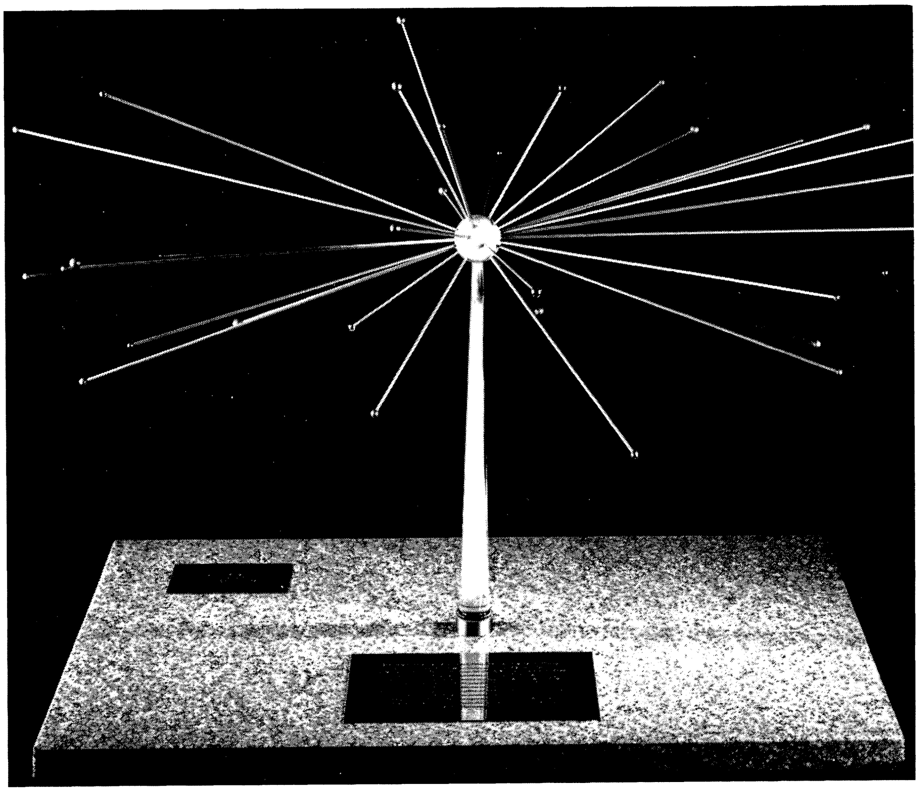
Cover photograph: Rather than embarking on a sedate bus tour during the recent meeting of the US/Japan High Energy Physics Committee, held in the foothills of Mount Fuji (see page 334), Dave Jackson and Roy Schwitters had other plans. Ignoring many warnings, the intrepid pair set out for the summit of the nearby mountain, 3900 m above sea level and the highest point in Japan. They took with them these crossed Japanese and US flags and photographed them framed by a weather-worn torii on the crater rim. (Photo courtesy LBL)

Paris Conference

(Further report)



A representation of a high energy proton-antiproton collision, presented to Pope John Paul II on his recent visit to CERN. Proton-antiproton collisions were also well to the fore at the Paris physics conference.

(Photo CERN 284.6.82)

From 26-31 July, the international particle physics community met for its traditional biennial 'Rochester' jamboree, held this time in Paris. While there were no major physics surprises, there was still plenty of interest for all and the ground that was covered amply demonstrated the progress which has been made since the previous round of international meetings.

The emphasis is very much on improving the already considerable level of agreement between different experiments and between experimental results and theoretical predictions. The conventional picture of the unified electroweak force is beginning to look almost unassailable. The description of intra-hadron behaviour (strong interactions) in terms of the promising new theory of quantum chromodynamics is gaining ground, despite some technical difficulties. Attempts to unify electroweak and hadronic behaviour, and even gravity, seem irresistible to theorists, even if success is not readily apparent.

With a multitude of adjacent lecture halls and auditoria, and with ample space for 1200 people to circulate, talk or relax, the meeting managed to avoid some of the logistics problems which have dogged earlier big meetings. Some people have voiced the opinion that these big international meetings have become too cumbersome. While they are necessary, they have been criticized for not stimulating direct personal contacts at a working level. But this did not seem to be the case at Paris, where in addition to the physics sessions there were numerous sideshows, including poster displays of big apparatus, a modest but well staged historical exhibition and a book fair, which helped to provide additional focii of interest.

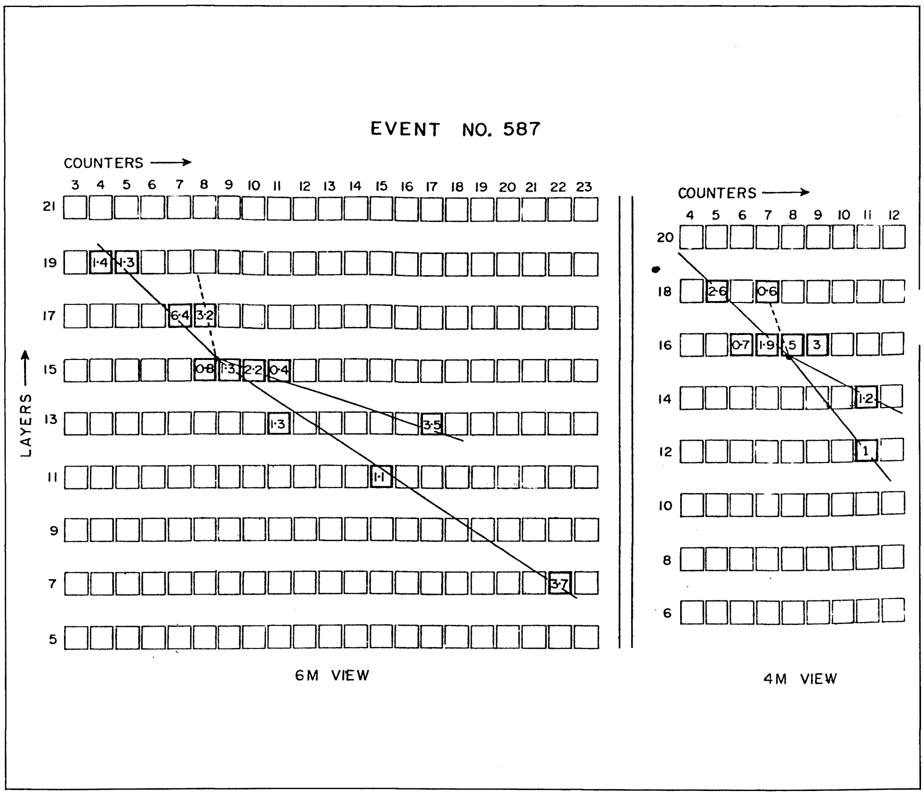
The social side was not forgotten either, and many people will remember their boat trip along the Seine, or their reception at the City Hall, or their buffet dinner at the Centre Pompidou. Full marks here to the organizers for their careful and imaginative planning.

There is a lot going on in particle physics these days, and this was reflected in the number and scope of the parallel sessions, of which there were up to five at any one time. The lengths to which specialization can go appeared to be amply demonstrated on the first afternoon, which featured parallel theoretical sessions, one dealing with perturbative field theory techniques, the other non-perturbative. However this did not appear to worry the theorists unduly!

With so many parallel sessions, it would have been comforting to think that the major results and topics of interest could be carried through into the subequent plenary talks. At Paris no such insurance was forthcoming, and anyone attending the plenary sessions alone would have missed a lot of ground which had been well covered in the parallel sessions. The plenary sessions were imaginatively planned, and contained a high proportion of fashionable and speculative topics. But a lot of interesting material and even controversy in the parallel sessions did not make it to the plenaries.

The major innovation on the experimental front this year was the impressive set of results from the experiments at the CERN SPS proton-antiproton collider. At last year's European physics meeting at Lisbon, Carlo Rubbia had been able to announce that the first proton-antiproton collisions had been observed at 540 GeV. This year, four experiments were able to report detailed findings. However by the standards

Two views of one of the new totally contained proton decay candidate events seen in the underground detector at the Kolar Gold Fields, India. The reported rate of observation of these candidate events agrees with theoretical predictions for the proton lifetime. However neutrino background may prove to have unpleasant effects in these experiments.



of the envisaged rate of logging proton-antiproton collisions in the SPS ring, the volume of data available so far is meagre. By the time of next year's conference season, these experiments will surely have a lot more to report.

One thing that is clear from the data amassed in all kinds of experiments is that the standard electroweak (Glashow / Salam / Weinberg) model is now almost home and dry. Almost all that remains to be done is to find the intermediate bosons of weak interactions at their predicted masses. Perhaps the experiments at the SPS collider will oblige. However lurking uncomfortably in the background are the Higgs mesons, also an essential part of the electroweak theory. No trace of Higgs particles has yet been seen, but the search continues.

Another conference novelty due to the commissioning of the SPS collider was the inclusion of a parallel session on the comparison of laboratory and cosmic ray data in a new energy range. (However this is not the first time that accelerator laboratory physicists have been able to confirm behaviour first seen in cosmic rays. Some of the major particle discoveries in the 1930s and 1940s were made with cosmic rays.)

Another newcomer parallel session was that on proton decay, which provided a lot of physics interest. M. Menon reported more candidate proton decays from the Kolar Gold Fields detector, installed 2400 m below ground in Southern India. With the tracks in these events fully confined in the observable detector volume, they are good candidates for the proton decays predicted by the new wave of grand unified theories. These events now supplement other Kolar Gold Field candidate proton decays reported previously. The proton lifetime calculated from the rate of observation of these decays is moreover in agreement with the theoretical prediction.

In addition, another candidate proton decay was reported by E. Fiorini from the NUSEX (NUcleon Stability EXperiment) experiment mounted in the Mont-Blanc road tunnel. In his subsequent survey talk in the parallel session, Don Perkins was in sceptical mood, and chose to attribute the observed proton decay candidates to the more mundane mechanism of neutrino background, which mischievously peaks near the proton mass.

The impressive proton decay searches being mounted in the US, Europe, India and Japan are capable of seeing proton decay in and around the value predicted by the 'simplest' versions of grand unified theories. But theoretical complications could easily push the lifetime out of sight.

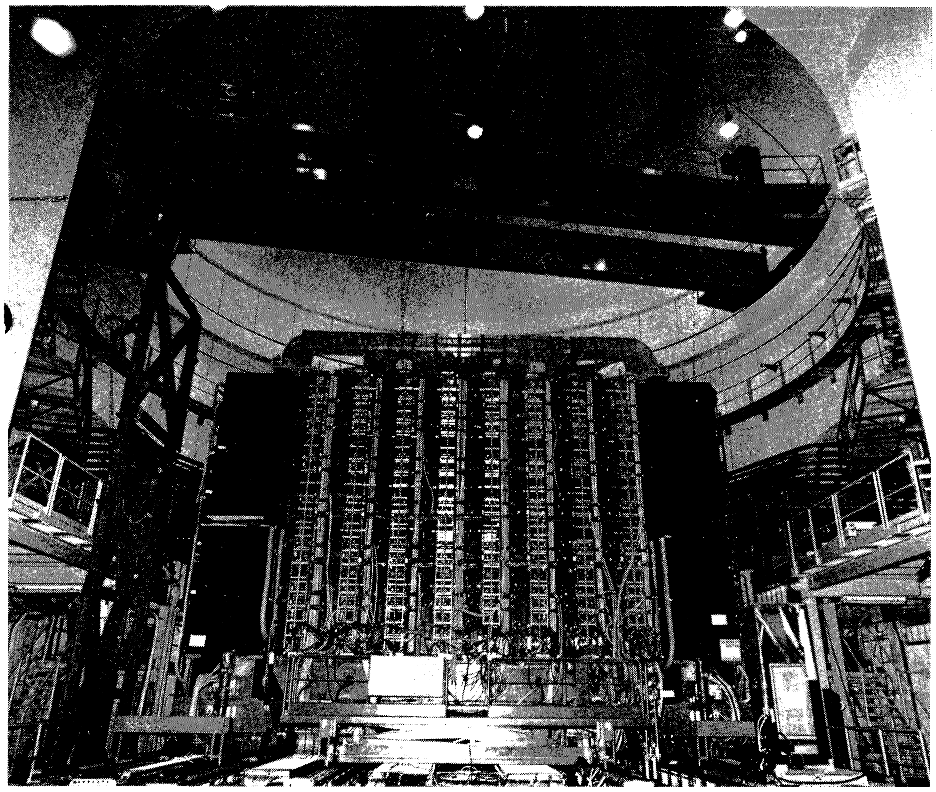
However proton decay will continue to be a focus of attention at these conferences for some time to come. Only a few experiments have yet logged any data, and a lot of careful preparation has yet to reap its rewards. Meanwhile theoretical speculation on grand unification continues unabated.

New particles

Another experimental sector where some new ground has been covered since last year is in the area of B (beauty) meson decays. These results are dominated by the efforts of the CLEO and CUSB groups working at Cornell's CESR electron-positron collider, which home in on the products of the strongly decaying 4S upsilon. Other contributions have come in from experiments at the PETRA ring at DESY and the PEP ring at SLAC. Many different B meson decays have been investigated and the

Results from the big detectors at the CERN SPS proton-antiproton collider UA1 (top) and UA2 (below) were given their first big international airing at Paris.

(Photos CERN 308.4.81 and 330.7.82)



evidence points to the validity of the conventional picture of six quark flavours and three types of lepton.

However rapporteur George Kalmus paused in his exhaustive coverage of the data to remind his audience that explicit evidence for B mesons has yet to be seen. But this does not deter experimentalists from making measurements. Even the lifetime of the B meson is now beginning to be probed, although the precision of the experiments has some way to go before the expected value is reached.

Also covered by Kalmus was the tau lepton. After initial measurements of the tau lifetime reported last year from the Mark II experiment at PEP, other detectors at PETRA as well as PEP give a value which agrees with the outcome of the assumption that all leptons behave in a similar way (lepton universality).

In previous years there had been talk that different charmed particles could have quite different lifetimes. This now seems to have abated. The factor of ten difference between charged and neutral D meson lifetimes has now shrunk to a mere factor of two.

F. Halzen surveyed the production of heavy flavours, this time from a more theoretical viewpoint. In his view, considerable progress in understanding is being made. The inferred high charm production levels seen at higher collision energies no longer cause people to lose as much sleep as they once did. However Halzen pointed to two clouds on the horizon which could cause trouble for conventional theory. These are the continued observation in lepton beam experiments of two produced muons of the same sign, and the difference in the muonic and electronic signals recorded in neutrino beam dump experiments.

In Halzen's view, the production of

psion pairs in the NA3 experiment at the CERN SPS could be interpreted as being due to the production of beauty particles, a point of view not universally shared.

The topic of new particles was also covered in a plenary session by Elliott Bloom, who devoted some time to the controversial subject of glueballs. Particles made up of gluons, rather than quarks, have long been expected on theoretical grounds, and a variety of states have been proposed. Candidates include various effects seen in electron-positron annihilations. At Brookhaven, an enhancement in the spectrum of two phi mesons, seen in an earlier experiment, is now underlined by more data, and is also being put forward for glueball election. However there is still nothing conclusive on the glueball front.

An interesting concrete result mentioned by Bloom was an accurate measurement of the upsilon mass at the Novosibirsk VEPP-4 electron-positron storage ring (see page 325). While the details of upsilon spectroscopy have been a speciality at the CESR ring, absolute mass levels have been elusive and only the spacings between levels have been accurately measured. Now the new Novosibirsk number helps to firm up the whole upsilon spectrum, recently enlarged by the sighting of the 'other' charge conjugation states by both the CESR detectors (see September issue, page 274).

Another topic which was largely lost at the plenary level was magnetic monopoles. These have been predicted as one of the outcomes of grand unified theories, and the subject was given a further boost earlier this year when a monopole-like signal was seen at Stanford (see July/August issue, page 220). Despite more experimental effort, no more monopoles have been seen. However the very properties of these free magnetic charges could make their detection difficult. Following an earlier suggestion by Russian theorist Rudakov, there was much discussion of the possibility of magnetic monopoles catalysing proton decays. If this idea holds water, then proton decay searches could pay additional dividends.

Registration.

(Photo J.-Y. Tournellec)

The observation of well defined clusters of secondary hadrons in electron-positron annihilation is now well established. However the situation in hadron-hadron scattering invited further investigation.

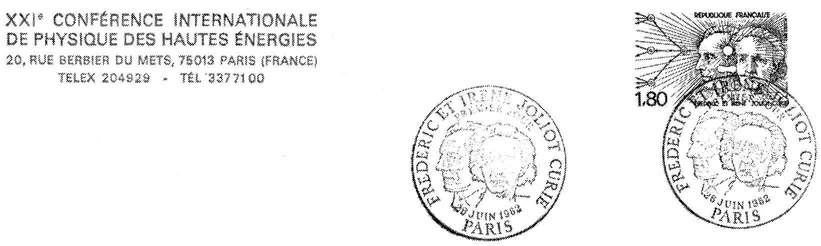
Production of high transverse momentum particles has long been seen at the CERN Intersecting Storage Rings, and the behaviour of these particles gave preliminary evidence for the production of jets. However there was a suspicion that these signals could have been written off as 'trigger bias', in that the triggering criteria were too selective. First results were eagerly awaited from calorimetry experiments to intercept as many as possible of the produced hadrons. The results from the NA5 experiment at the CERN SPS reported in previous conferences found no evidence for jets and cast a deep shadow across the jet scene. Moreover these findings have been largely corroborated by experiments at Fermilab.

However rapporteur Günter Wolf chose to discount these fixed target results as in his view under the prevailing conditions the products from the colliding quarks do not have a good chance to stand out from the products of their accompanying 'spectator' quarks. To catch sight of the colliding quark 'fragments', higher energies and/or high transverse momentum triggers are called for.

This appears to be underlined by a series of new results from hadron-hadron collision experiments, both with protons on protons at the CERN ISR and with protons on antiprotons at the SPS collider (see page 327). At the ISR, single high transverse momentum triggers in the Split Field Magnet have long given jet-like signals, and now there is additional evidence from both R807 and R108 experiments.

R807 (see May issue, page 145) looks at the shape of high transverse energy particle production in one of its uranium/scintillator walls and finds that the produced hadrons appear to start clustering together as the total transverse energy goes above about 10 GeV. R108 looks at high transverse momentum neutral pions coming off in opposite directions and finds that these pick up most of the produced hadronic energy. This means that to a first approximation the produced pions can be looked at as quarks. The resultant

First day cover of the recent Paris Conference.



angular distributions follow closely those predicted by quantum chromodynamics.

More jet evidence comes from the big experiments at the SPS collider. UA1 reports that high transverse momentum particles are produced about a thousand times more copiously than under ISR conditions. Triggering on high transverse momentum particles reveals indications of coplanar clusters of particles, both going in and recoiling away from the trigger direction.

Impressive evidence comes from the UA2 experiment which collects the total transverse energy deposited and sifts out the high transverse energy component. Above total transverse energies of about 50 GeV, this appears to contain a high proportion of jet-like behaviour, with some spectacular events at high transverse energies.

Away from the hadron-hadron sector, the two and three-jet behaviour of produced hadrons in electron-positron annihilation is now well established and gives a strong lever on the underlying theory. The JADE experiment at PETRA is reporting four jets, presumably due to the production of two gluons besides the quark and antiquark pair. Jet behaviour is also under study in fixed target experiments with lepton beams.

As well as the production of jets, rapporteur Wolf also touched on their composition. There appear to be suggestions of systematic differences in the make-up of jets due to quarks and jets due to gluons. These hints of higher baryon yields with gluons provide a challenge to theorists, who are not slow in responding.

SPS collider results

While nothing dramatic has emerged, it was still interesting to survey the physics produced by the CERN SPS proton-antiproton collider during its first year of operation, even with the relatively low collision rates which have been clocked up so far.

UA1 has looked at the distributions of produced particle multiplicities and has compared the behaviour to what is seen at lower energies. There is evidence for high multiplicity. The rate of production of high transverse momentum particles is very much up from ISR energies, and the mean transverse momentum also appears to increase with the multiplicity of produced particles. Selecting higher transverse momentum particles appears to increase the clustering of the produced particles, strongly suggestive of jet-like behaviour. Like the UA5 streamer chamber, UA1 finds no candidates for the Centauro phenomenon — exceptionally high charged multiplicity events seen previously in cosmic rays. But this does not mean that the events are ruled out under other conditions. Centauros apart, UA1's initial results are in agreement with what is found in cosmic rays. UA1 also has forward spectrometers close to the beam pipe and is able to produce a portion of the proton-antiproton elastic scattering spectrum.

UA2's impressive results on jet production were covered in several sessions, including the special session on SPS collider physics. As well as the data on produced neutral pions (see June issue, page 176), this experiment now has results on the production of charged particles.

UA5 reported that the production of photons is higher than that of charged particles. There appears to be an increase in the production of both the number of strange particles and of their transverse momentum. UA5 rules out Centauros under present collider conditions, but is keen to continue the search at higher collision energies, as the production threshold may not yet have been crossed. The UA4 experiment presented its elastic scattering data (see September issue, page 271).

The subject of gauge theory on a lattice (see July/August issue, page 220) has been mentioned before at major meetings. It attempts to escape from the confines of perturbation theory which hamper the application of theories like quantum chromodynamics. However at Paris, the subject really broke loose from the specialized parallel sessions. As well as pointing to a way out of the perturbation theory restrictions, the techniques also provide a lever on the observed spectrum of hadron masses, now including fermions.

The advertised schedule of plenary sessions on the topic of non-perturbative field theory techniques included talks by C. Rebbi and by A.

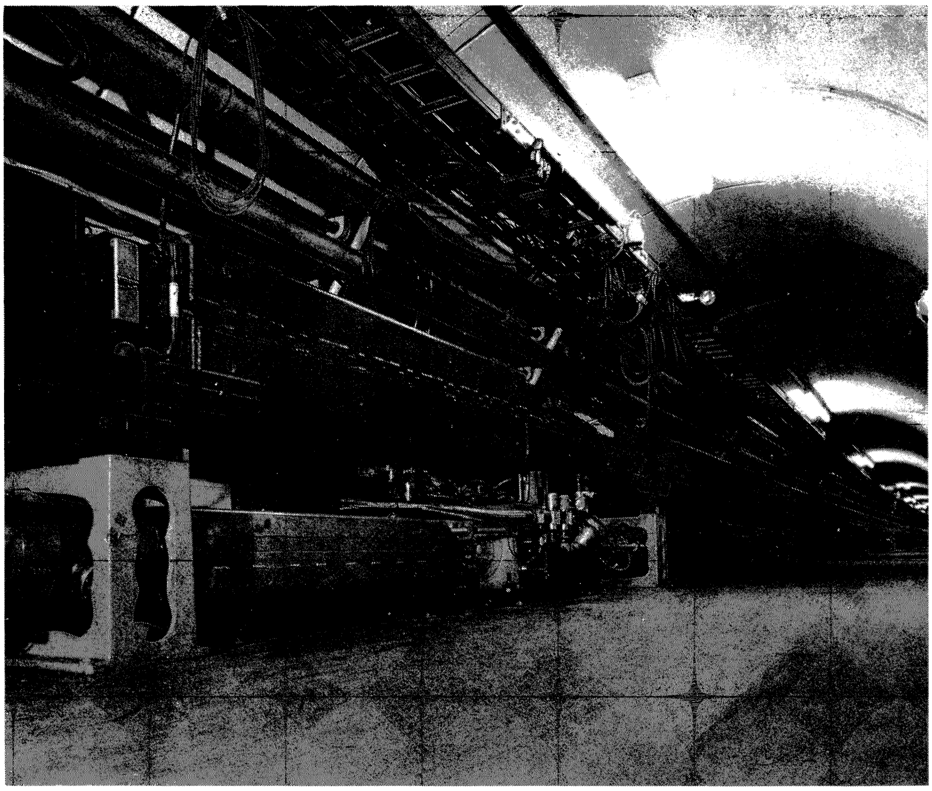
Polyakov. However the coverage was curtailed by the inability of Polyakov to attend the conference.

On the continuing confrontation between quantum chromodynamics and experiment, D. Politzer indicated many of the inherent weaknesses of QCD. These weaknesses lie in the techniques of handling the theory, rather than the underlying ideas. There have been many places where QCD could have failed, but it hasn't, and so it lives on. The mechanisms which cannot be constructed from perturbation techniques could be parametrized by studying special reactions. In this way, the theory could be cleared of some of the mystique of the non-perturbative 'higher twist' terms. Certainly these terms seem to be needed to explain the data, which do not comply with perturbative QCD alone. An exception is the photon structure function measured in photon-photon scattering.

Structure function rapporteur F. Eisele was able to report increasing agreement between results from different experiments, although studies using muon beams appear to produce some potentially interesting effects with heavy targets.

With the underlying theory looking in such good shape, then the intermediate bosons of weak interactions could soon be found at the correct mass, the sixth quark uncovered, and the reluctant Higgs particles located. Proton decays will continue to pile up around a lifetime of 10^{31} years, and theorists will master the techniques needed to made QCD work. If so, we shall be well and truly in the physics 'desert' long heralded by the ascetic devotees of minimalist theoretical ideas. In the continuing absence of these key observations, there is no shortage of ideas to avoid such a desert.

Fermilab moves on from 400 GeV



The superconducting magnets for Fermilab's new Energy Doubler/Saver thread their way through the stands of the conventional magnet ring. First injection of particles into the completed lower ring could be as early as next March.

(Photo Fermilab)

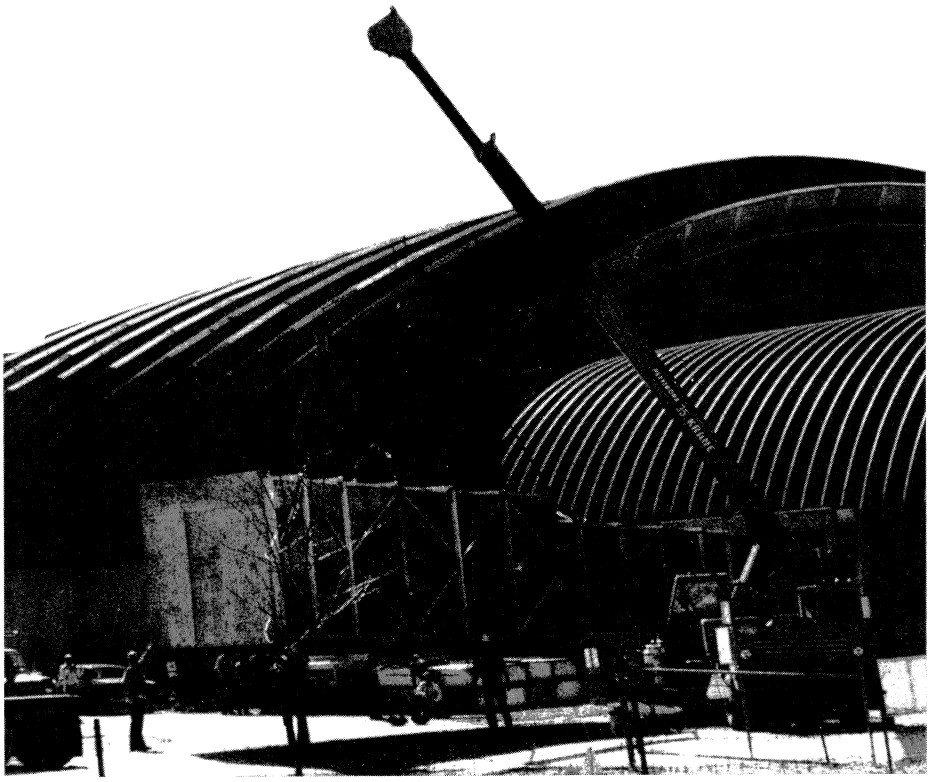
The proton synchrotron at Fermilab launched into a very long shutdown in June to convert the machine for higher energy operation and for proton-antiproton physics at colliding beam energies up to 1 TeV. Thus a distinguished era of operation at 400 GeV is over; it came to an end with a flourish — a world record beam intensity of 3.25 × 10^{13} protons per pulse on 31 May.

The first phase of this major improvement of the Laboratory's research facilities is the installation of a ring of superconducting magnets threaded through the stands underneath the existing ring. This phase is known as the Energy Saver and is going rapidly ahead bolstered by the confidence which came from the tests of a complete superconducting sector (sector A) in the first half of this year (see April issue, page 112). The magnets in the sector were kept cold from January to June and they pulsed with monotonous reliability up to field levels equivalent to 900 GeV (limited only by the use of a prototype satellite refrigerator). Cryogenic systems all worked well and the most severe quench tests caused no problems.

The quality of the dipoles emerging from the magnet factory is reliably good. By now about half of the superconducting ring is installed and there is no worry about availability of the remaining components to complete the ring to schedule. Further tests are planned when half the ring is in place and if all goes well in these tests, the boats will really be burned for the conventional ring with the

The Ring Imaging Cherenkov counter vessel for Fermilab experiment E605 is eased into the Meson Laboratory. This is the first experiment to use this technique on a large scale and should provide identification of hadrons at up to 200 GeV over a wide aperture.

(Photo Fermilab)



removal of the 400 GeV extraction system.

It is hoped that the first injection of rotons into the Saver will be possible by March 1983. The key to meeting this date is likely to be the completion of the hall at the B-O position in the ring (where the large detector for colliding beam physics will be built) rather than completion of the superconducting ring itself. Initial operation in the spring of next year will probably be at energies around 500 GeV to nurse the ring to its peak energies and to give more time for preparation of the experimental areas and detectors to receive 1000 GeV beams.

The upgrade of beamlines and experimental areas is known as the Tevatron II project. Some of this work has already been done — extension of the steel shielding to filter muons from the higher energy neutrino beam and commissioning of the superconducting 'left bend' beamline to the Meson Area. Work is under way on a wide band beam in the Proton Area (where this beam and a tagged photon beam will now be drawn from separate targets), a new muon beam, a new dichromatic neutrino beam and a new three-way split of the primary beams to the Meson Area. Next year additional halls will be built for prompt neutrino physics, wide band photon experiments, muon experiments, polarized proton experiments (to use a beam being built in collaboration with Argonne) and for an upgraded M6 beam in the Meson Area.

These new halls are scheduled for completion late 1984 and the full Tevatron II project should be complete in 1985. Fixed target physics at Fermilab will then use 1 TeV primary proton beams with slower pulse repetition rates (1 pulse per minute) but with higher secondary particle fluxes at energies of up to about 800 GeV and with a very long (20 s) flat-top improving the duty cycle by a factor of four.

The Tevatron I project aims to provide colliding proton and antiproton beams at a total centre of mass energy of 2 TeV with a luminosity of 10^{30} per cm^2 per s. The luminosity should in fact be exceeded when the full abilities of the antiproton source are mastered. The latest design of the source involves two rings (a debuncher and an accumulator) and uses only stochastic cooling. Protons at 125 GeV from the Main Ring are directed onto a target every 2 s to yield a flux of 8 GeV antiprotons which are focused by a lithium lens (developed at Novosibirsk). These antiprotons are fed to the debuncher ring where the bunches are rotated and given a first cooling in transverse phase space. They then pass to the accumulator ring where stochastic cooling is applied to build up antiprotons at the rate of 10^{11} particles an hour. Frequencies in the cooling systems are 2 to 4 GHz and there is thought of extending higher. Also the possibility of electron cooling is not totally abandoned. New electron sources developed for free electron laser research may improve their cooling efficiency.

Beams corresponding to a luminosity of 10^{30} should be accumulated in an hour and a half. The dense antiproton beam can then be injected into the Main Ring and, subsequently, the superconducting ring for acceleration to 1 TeV. Recent tests of some tricky r.f. gymnastics for these processes were carried out in the Main Ring with encouraging results. Detailed design of the antiproton source is scheduled to be complete by the end of the year so that construction can start early in 1983. Physicists from Argonne, Berkeley, Novosibirsk and Wisconsin as well as Fermilab are involved in the work. The aim is to achieve colliding beams by 1986.

Plans for the Collider Detector Facility, CDF, for proton-antiproton physics aim to have a usable detector ready to observe the first collisions. Assembly should start in the B-O hall next year. Design and use of the detector have been greatly simplified by the decision to build an overpass for the Main Ring so that only the Energy Saver vacuum tube will pass through the CDF. The experiment now involves some hundred physicists from about fifteen research centres including some in Japan and Italy who are contributing greatly to detector components. For example, the superconducting coil is being built in Japan; an excellent design has emerged providing a 1.5 T field with a thickness of less than one radiation length.

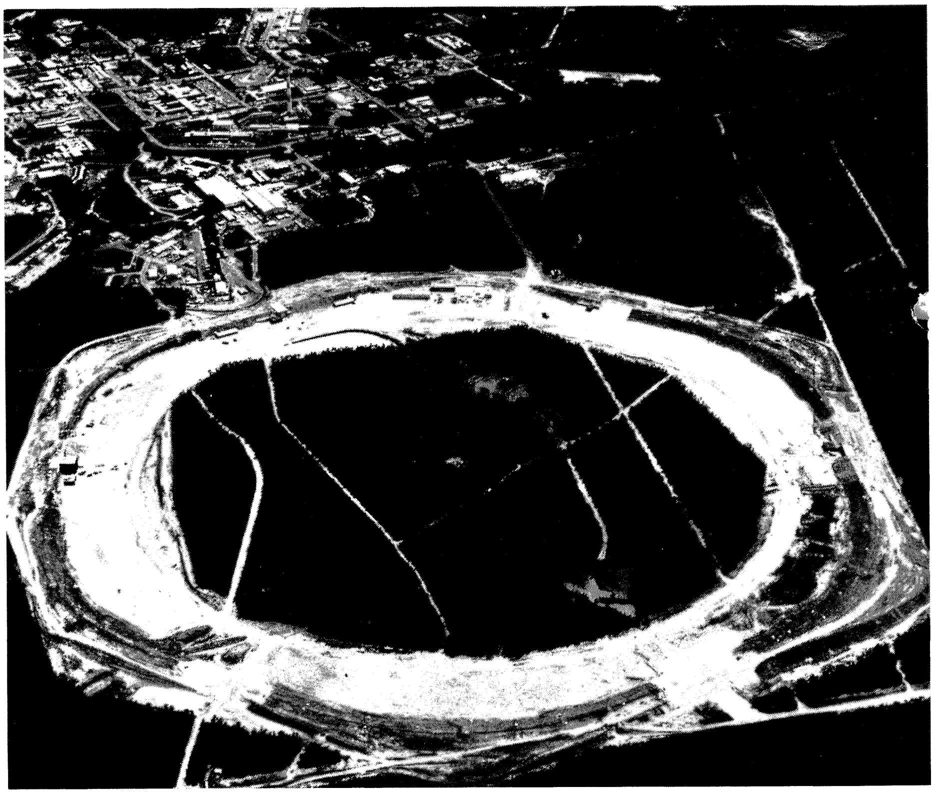
Letters of intent for an experiment to use a second colliding beam area (in the D-O position) have been called for by 1 November and proposals are required by 1 February next year. The possible hall volume is about 750 m^3 and the detector it accommodates must be easily removable. Two proposals to use the D-O area are already under consideration. One involves a large lead glass array. The other involves the construction of an electron ring to observe electron-proton collisions.

After all the frustrations of recent years with the development of pulsed superconducting dipoles, it is very satisfying to see the world's first superconducting synchrotron coming together. Its operation within the next year will be another demonstration of Fermilab's innovative work in accelerator design and construction.

How goes ISABELLE?

Recent aerial view of ISABELLE construction at Brookhaven. The ring tunnel and half the experimental halls are in place. The injection links with the existing Alternating Gradient Synchrotron are also ready to receive magnets.

(Photo Brookhaven)



There cannot be many people in the high energy physics community unaware that the ISABELLE project to build 400 GeV proton storage rings at Brookhaven has been in trouble for several years. The design incorporates two rings of 5 T superconducting magnets and, until late last year, the fabrication of these dipoles to the required quality was proving an intractable problem.

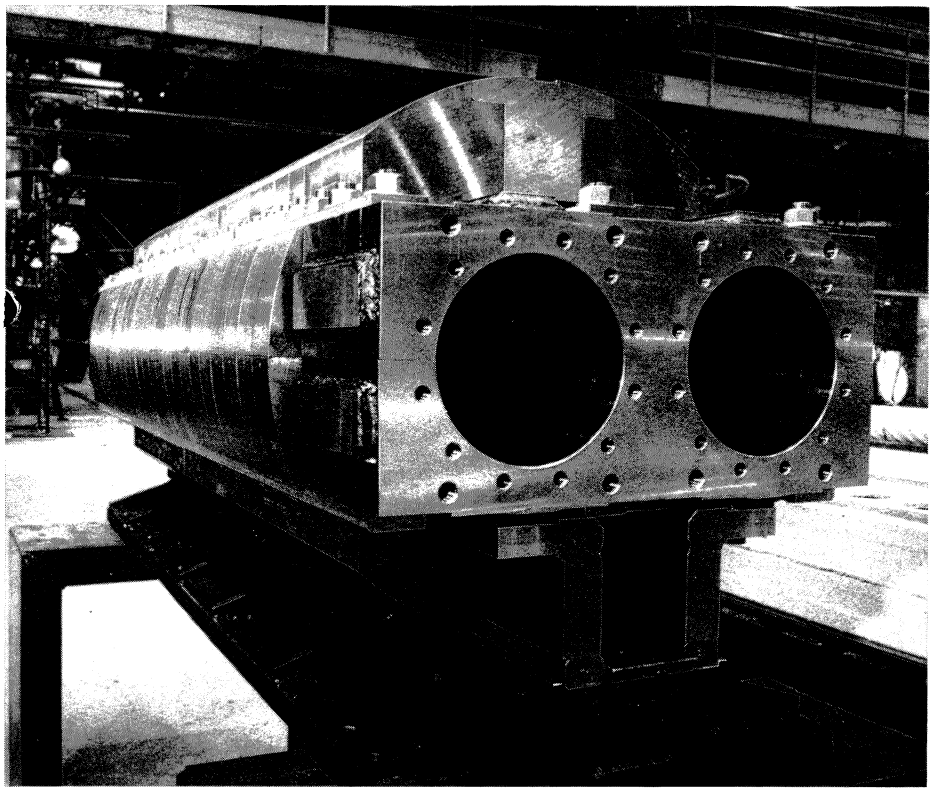
This year a long range planning report on the high energy physics programme for the USA concluded that, unless there is additional funding for the programme, it is difficult to see how the ISABELLE project, as at present conceived, can continue. This has frustratingly come at a time when the magnet problems seem to be convincingly overcome and when new management is reinjecting enthusiasm and confidence.

The dipole design consists of two layers of superconducting coil around a 'warm bore' vacuum chamber and constructed inside a cold laminated iron. The yoke is immersed in a cryostat and force cooled by supercritical helium at a maximum temperature of 3.8 K. The dipoles are 4.75 m long. A major contributor to the magnet problems was the initial choice to use braid for the superconducting coils. Since the change to cable in 1981, performance has improved. The flat cable has 23 multifilamentary twisted superconducting wires of the type developed at Rutherford and Fermilab. Another factor in the improved performance seems to be the introduction of a layer of teflon in addition to the kapton insulation between the inner and outer coils providing a low friction slip plane.

After the success of the first full size revamped magnet in November of last year, it was decided to complete six by the end of March 1982.

Yoke of the first 5 foot 'two in one' magnet built to test the idea of incorporating the two ISABELLE rings in one magnet structure. The magnet operated as expected and a full length version is now being built. The aim is to trim back ISABELLE costs in case of funding shortfalls in funding the US high energy physics programme.

(Photo Brookhaven)



This was successfully done and in tests in a bath of liquid helium at 4.5 K they all surpassed 5 T before their first quench, and exhibited very little subsequent training. The magnets were also tested at lower temperatures under forced cooling conditions and reached fields of 6 T which put them ahead of all other full size dipoles in terms of peak field performance. A first quadrupole has also been built and operated successfully.

Investigations of field quality were initially carried out on shorter 5 foot magnets. Progress is good and the 5 foot series is being concluded while quality studies are moving to the full size magnets. Previous troublesome eddy current effects have also gone away. Two features remain to be mastered — the trim coils to be incorporated into the dipole and an understanding of the mechanisms of quench propagation. The propagation is slower in supercritical helium; nevertheless, at the time of writing, all attempts to burn out a magnet because of inadequate propagation (so as to find where the limits are) have failed.

The next major aim of the dipole programme is to install and operate a fully equipped cell of the magnet lattice (six dipoles and two quadrupoles) in the ISABELLE tunnel by March of next year. Meanwhile the magnet assembly and testing facilities are being extended so that they will be able to cope with the production of a thousand magnets within five years.

The civil engineering work for the project is not far from completion. The ring tunnel and the injection tunnels are ready, three of the six experimental halls are built (inside angle hall, major facility hall and narrow angle hall). The cryogenic systems (including the building of the largest helium refrigerator) and r.f. acceleration systems are well advanced. Only the controls system has not yet received much attention.

Though the technical aspects of the project are now in very much better shape, there is still concern for the future of ISABELLE. This is because of doubt about the funding level for high energy physics which is likely to be obtained from the US government during the remaining years foreseen for construction of the machine. An examination of this situation was a major task of the 'Subpanel on long range planning' set up by HEPAP (High Energy Physics Advisory Panel) and chaired by George Trilling. Its report, presented earlier this year and usually referred to simply as the 'Trilling report', is now taken by the Department of Energy as its bible in determining use of high energy physics money.

The Trilling report recognized that the US programme needs a new facility, providing front-line physics and supporting a large number of users, to be in action by the end of this decade. At present ISABELLE is that facility. It would be unique in allowing high energy hadron experiments with high intensity (luminosities of some 10^{33} per cm^2 per s). Nevertheless completion of ISABELLE, as at present conceived, will require a further $500 million (in fiscal year 1982 dollars). The report maintains that to provide this money, while also sustaining viable programmes at the other USA Laboratories, and allowing completion of Fermilab and SLAC projects, requires an annual USA high energy physics budget rising to $440 million in 1984 or 1985. If the present level of $395 million cannot be increased, the report regretfully recommends termination of the ISABELLE project.

To complete a significant new facility by the end of the decade would require construction beginning in 1985. There is therefore not much time to review the various possibilities. At Brookhaven the aims are first to demonstrate the viability of the magnet system so as to confirm that ISABELLE can be built. At the same time, ways of cutting magnet cost are being investigated.

One of these is what is known as the 'two in one' magnet where two of the present coil configurations sit side by side in a single double aperture iron yoke. The machine would then have a single ring of double magnets rather than two separate rings. This would cut the number of yokes to be built by two and also halve the number of cryostats. A 5 foot model was rapidly put together and performed well in line with expectations. There are obvious concerns about magnetic and mechanical asymmetries, quench protection is more serious and the machine lattice is more difficult. Nevertheless, the potential saving on the magnet system may be as high as 20 per cent and the idea is being pursued. Construction of a full length 'two in one' magnet was authorized in July. The decision as to whether to adopt the approach will be needed by March of next year. A second magnet cost saving idea is to build a quadrupole and dipole into the same cryostat, eliminating quadrupoles, as separate units. This could save over 10 per cent of the magnet system costs.

To be ready for alternatives to ISABELLE, two working groups have been set up to look at an electron-proton option (chaired by Kjell Johnsen) and a heavy ion collider option (chaired by Mark Barton). The e-p option is required to allow extension to p-p at a later stage. The heavy ion option is conceived as a missing magnet ISABELLE and would use beam from the very successful Brookhaven tandem Van de Graaff boosted in energy by an intermediate cyclotron. In any of these scenarios a ring of superconducting magnets would find its way into the ISABELLE tunnel.

Despite these uncertainties there is no doubt that the Brookhaven team has found fresh enthusiasm since the success of the new magnet design. They have also been helped by the fresh stimulus of the appointment of Nick Samios as Laboratory Director. Samios has an ability to identify the silver linings in all situations and makes it difficult to remember the existence of the cloud. The whole world-wide high energy physics community is certainly behind him in hoping that the full unique abilities of ISABELLE will be realized.

Cornell: CESR and beyond

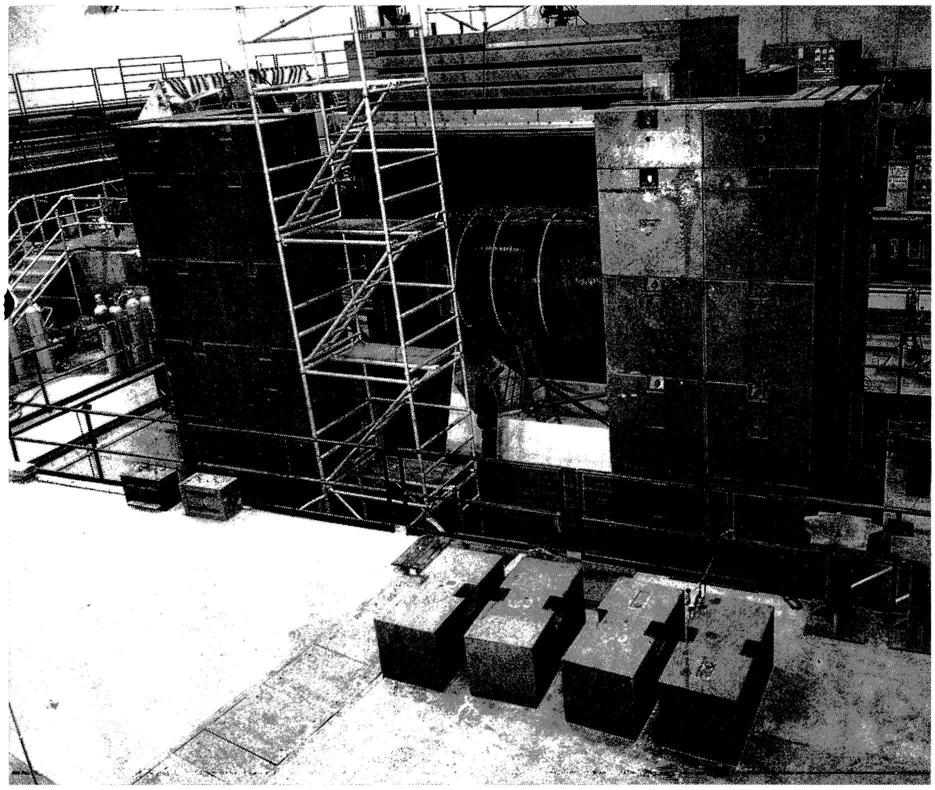
The electron-positron storage ring CESR, at Cornell is now operating regularly with a luminosity of over 10^{31} per cm^2 per s (400 inverse nanobarns) and, thanks to the money saved by operating the magnet of the CLEO detector with a superconducting coil, the number of hours available for physics is not restricted. The research remains concentrated around the upsilon resonances (operating the storage ring at just over 5 GeV per beam). After skimming the cream in this energy region, where CESR had unique access with good luminosity, extracting further physics is more difficult but there remain several years of good work in front of CLEO and the CUSB detector doing gamma spectroscopy in the machine's North area.

It is believed that the luminosity can be pushed higher by a factor of two or three. Machine physics experiments have reduced the mini-beta from 3 cm to 2 cm with further increase in luminosity but the CLEO magnet was not in operation and the existing magnet compensation scheme cannot cope. There are schemes for going to micro-beta by installing new quadrupoles at the interaction region, though these would probably limit peak energy to 6 GeV. A new injector for the Linac, using the triode gun developed at SLAC, will soon be in operation and should make it possible to put more particles in each bunch and possibly avoid the vernier filling scheme (see April 1976 issue, page 129) presently necessary to build up positron bunch intensity. There are also ideas on having more than one bunch per beam using electrostatic separators.

The CLEO detector will probably run in its present configuration for another year after which the inner detector is likely to be modified to give better particle identification, for example by installing a time projection chamber or some other energy loss measurement system. The CUSB detector may also replace its sodium iodide modules by the better BGO material to improve resolution.

The CLEO magnetic detector being installed at the CESR electron-positron ring at Cornell. The conventional aluminium solenoid has now been replaced by a superconducting coil.

(Photo Cornell)



Some hundred physicists, most of them from research centres other than Cornell itself, are now involved in the high energy physics research programme.

A very successful spin-off from the building of CESR is the synchrotron radiation facility CHESS (Cornell High Energy Synchrotron Source). It has two special parameters — the beam energy is higher than in radiation laboratories on other machines (allowing research further in the X-ray region with photon energies from 6 to 35 keV though the advent of 'wigglers' now makes this possible elsewhere) and the 10 ns burst of radiation from the circulating bunch each 2.5 ns (allowing experiments which benefit from such a time structure). There are now 75 experiments on or planned for CHESS using three photon beamlines (with further splitting). This has enabled several hundred more scientists to benefit from the building of CESR.

For the future the Cornell team has been studying CESR II, a higher energy electron-positron storage ring (50 GeV per beam) optimized for studying the Z^o intermediate boson. The presen design aims for a luminosity of 6×10^{31} per cm^2 per s in a ring of 5.5 km circumference with four intersection regions and four other straights for the r.f. acceleration cavities. Injection would be from a 20 GeV synchrotron. A site at Cornell has been investigated. The capital cost is estimated at $220 million and they believe that actual construction could be compressed into three years.

Crucial to the design and to low projected operating costs is the use of superconducting r.f. cavities giving accelerating gradients of at least 3 MV/m. Research and development on such cavities has been under way for many years culminating earlier this year in the successful operation of two 5-cell modules of their 'muffin tin' structure (see June issue, page 175). The Cornell superconducting cavities operate at the unusually high frequency of 1.5 GHz which keeps cavity sizes small and hence material costs low. No problem in operation at this frequency was experienced in the beam tests. Elliptical structures are now also under investigation to operate at the same frequency, and recent single-cell tests went up to 13 MV/m. Further work will search for economy in the mass production of structures of one type or the other.

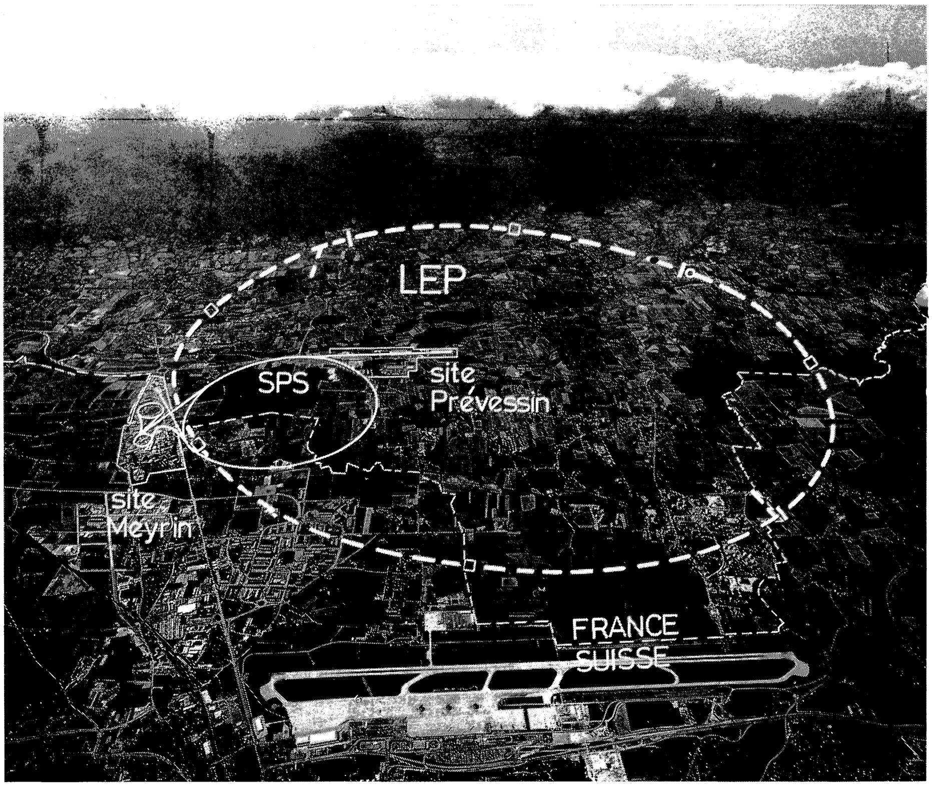
Beam stability in such a machine has required thorough study. Computer simulation techniques on single bunch longitudinal and transverse instabilities has been in convincing agreement with experience on presently operating electron storage rings. It is also believed that potential beam-beam and non-linear lattice instabilities are understood and would not be troublesome.

There was support for the building of a high energy electron-positron storage ring as part of the USA national facilities expressed at the recent Aspen meeting (see page 332). The excellent work done by the Cornell team with CESR I, with financial and manpower resources well below those customary at other laboratories, gives confidence that the machine would be in competent hands. However it is also clear that the resources needed for the construction and operation of a storage ring like CESR II would involve a change in the customary Cornell life style. Whether a significant expansion as a national Laboratory is feasible in the present financial climate will need a lot of discussion.

Around the Laboratories

Aerial view of the terrain around CERN, showing the proposed site of the 27 kilometre circumference LEP electron-positron ring in relation to the existing machines. The irregular dashed line indicates the international frontier between France and Switzerland. In the immediate foreground is Geneva airport, while the Jura mountains provide the backdrop.

(Photo Swissair)



CERN
LEP experiments

Earlier this year, a number of proposals were put forward for consideration as possible experiments for the first phase of exploitation of the LEP electron-positron collider, seen as coming into operation in about five years.

The immediate problem for both CERN and the physics community is to choose an optimal mix of experiments which would cover as wide a range of physics as possible, while at the same time catering for a maximum number of users. Budgetary realities are also a prime consideration. In addition, the experiments would have to be approved quickly. Construction work for these necessarily big detectors would have to begin early to ensure that the experimenters would be ready to exploit the initial beams from LEP.

With such a limited number of experimental sites and a large number of potential users, the business of selection is somewhat more tricky than usual. With the objective of arriving at a well balanced programme, the selection process involves more than judging individual experiments. Changes to many of the original proposals are being suggested to optimize the physics coverage of the whole LEP programme. In this way the first phase of LEP experiments should cater for a wide range of physics, while the detectors should achieve their stated aims and meet the proposed timescale. At the latest stage in the decision making process, few of the original proposals survive intact.

Six proposals are currently under consideration, although some initial indications of a possible selection have already been given (see September issue, page 285). However the final selection has yet to be decided.

The ALEPH proposal (Apparatus for LEP pHysics) is for a general-purpose detector and comes from a consortium of eighteen European research centres plus Wisconsin from the US. It consists of a large central detector and an electromagnetic calorimeter inside a superconducting magnet, the outer iron yoke of which would serve as hadronic calorimeter and muon filter. The basic design of the (cold) magnet coil follows that of the CELLO detector at PETRA. The central detector would use the Time Projection Chamber technique pioneered at Berkeley for use in the PEP ring. However the chamber proposed for LEP would be about twice the length.

The preferred design for the ALEPH electromagnetic calorimeter envisages alternate layers of lead and wire tubes operating in streamer or limited Geiger mode. An alternative design using lead and liquid argon is also proposed. Putting the electromagnetic calorimeter inside the magnet coil is expected to pay dividends. The outer hadron calorimeter would be cylindrical, composed of iron/streamer tube sandwiches. There would be a final outer shell of drift tube muon counters.

Another general-purpose detector is the OPAL (Omni Purpose Apparatus for LEP) scheme, a Europe/Canada/US/Japan project. This is based on a central wire chamber of the JADE type, surrounded by a superconducting solenoid. Then would come a lead glass electromagnetic calorimeter, an iron/scintillator hadron calorimeter and an outer drift chamber muon detector. OPAL uses conventional detector techniques, but on a large scale.

The DELPHI European project is based on a central Time Projection

Chamber only slightly larger than the Berkeley one already operational at PEP.

Hadron identification is achieved with DELPHI with the help of the novel Ring Imaging Cherenkov technique, yet to be used extensively in a major experiment (see March issue, page 49).

Another proposal has as yet no name. It is a Europe/US/China effort. As proposed, it consists of a magnet enclosing a high resolution vertex detector (time expansion chamber or microstrips) and a high performance photon detector based on bismuth germanate crystals (BGO). This would require an extensive supply of this new material. The electromagnetic calorimeter is surrounded by a considerable thickness of conventional hadron calorimetry, also acting as a muon filter. The muons would be tracked in layers of outer chambers inside a large magnetic volume.

The ELECTRA proposal comes from an essentially European team. It foresees very good electron identification, with high precision tracking immediately around a thin beryllium beam pipe. Also inside the warm coil solenoid would be a central tracking chamber, endcaps, transition radiation detector and scintillation counters, together with the electromagnetic shower calorimeters. The magnet return yoke would also act as tracking calorimeter and provide a first stage of muon identification. Emerging muons would be picked up in streamer tubes.

The LOGIC (LEP Open Geometry Imaging Cherenkov) proposal is a US contribution. It uses an open field magnet enclosing central tracking chambers. Outside the magnet would be Ring Imaging Cherenkovs for hadron identification. The detector would be completed by lead-glass electromagnetic calorimetry and additional counters for triggering and vetos.

It is hoped that the final versions of the LEP detector designs will soon emerge so that construction work can begin in earnest as soon as possible.

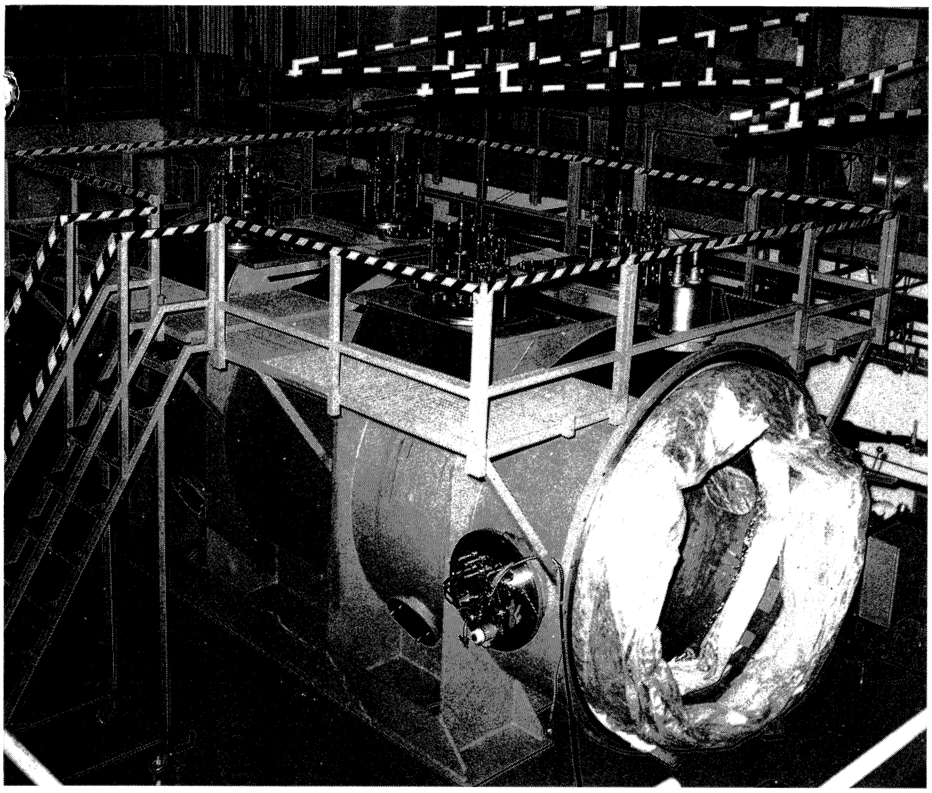
Making gravitational antennas

Einstein's general theory of relativity, as well as explaining the phenomenon of gravity, is also a monument to man's intellect. After its formulation earlier this century it won almost immediate acclaim through measurements on the advance of the perihelion of Mercury and on the effects of gravitational fields on light.

Einstein's picture of gravity is a field theory which strongly suggests that gravity is accompanied by its own radiation, in much the same way that Maxwell's theory of electromagnetism paved the way for the discovery of electromagnetic waves.

While Hertz' discovery of electromagnetic radiation followed relatively soon after Maxwell's theory was developed, it is now well over fifty years since Einstein's theory was formulated, and gravitational waves have yet to become a universally observed phenomenon.

If they exist, gravitational waves are ripples of geometry which shake any object in their path. However because of the extreme feebleness of gravity compared to the other forces at work in Nature, a search for these effects has to confront seemingly insurmountable problems. A



Cryostat for tests of a gravity wave detector at CERN. By going to extremely low temperatures, it is hoped to avoid problems due to thermal noise, which would mask the tiny oscillations due to gravity waves.

(Photo CERN 7.5.82)

Ground breaking at the end of May for the proton storage ring which is being added to the LAMPF 800 MeV proton linear accelerator at Los Alamos. Wielding the shovel are (left to right) Ed Knapp, then head of the Accelerator Technology Division who has now moved to the National Science Foundation, Louis Rosen, Director of LAMPF and John Browne of Physics Division.

(Photo Los Alamos)

metre cube of aluminium exposed to a significant level of gravitational radiation would oscillate to and fro with an amplitude much smaller even than an atomic nucleus! Detecting and measuring such tiny resonances calls for all the ingenuity of the experimenter and all the latest technological aids.

Such minute signals would be masked by noise within the detector due to the thermal motion of its molecules, and the latest searches are planning to use cryogenics to cool the antennas near to absolute zero and minimize this internal noise.

Signals suggestive of gravitational effects have been seen by some experiments, notably that of Joseph Weber of Maryland, who carried out a historic experiment with antennas being simultaneously monitored at Maryland and Argonne. Because gravitational effects would come from massive concentrations of matter in outer space, they should be observable by detectors mounted at several widely separated sites.

A programme for the development of highly sensitive gravitational wave detectors has been drawn up by a Rome / Louisiana State / Stanford collaboration. The Rome group has already built and successfully operated a 400 kg cryogenic detector at Frascati, and is now exploiting the facilities and technical know-how available at CERN. The ultimate objective is to construct a large detector containing several tons of aluminium, to be operated first at liquid helium temperatures and later below 0.1 K.

While the final cryogenic antenna is being constructed, tests are being carried out on a 2300 kg aluminium detector (3 m long and 60 cm diameter) with a view to perfecting the detection and data acquisition techniques and investigating the effects of spurious seismic and acoustic noise (particularly that produced by boiling liquids).

For these tests, mechanical vibrations are picked up by piezoelectric ceramics coupled to a solid state amplifier. Spurious vibrations are filtered out by suspending the antenna bar by a titanium alloy cable inside an iron ring, itself supported on aluminium alloy beams. The whole apparatus is contained inside a vacuum chamber, and data is written onto magnetic tapes. The apparatus is providing valuable information to optimize the construction and operation of the final cryogenic antenna.

For the cryogenic detector, the signals will be picked up by a superconducting magnetometer (SQUID device), exploiting the Josephson effect.

LOS ALAMOS
Future research facilities at LAMPF

The programme at the 800 MeV proton linac, LAMPF, at the Los Alamos National Laboratory has fully risen to the scenario laid down when preparing the accelerator in the 1960s. It is the largest nuclear science research centre in the world with LAMPF supporting some 400 users and usually feeding some ten experiments at a time on as many beamlines. Beam currents from the linac are now regularly at 600 to 700 μA and the emphasis is on reliable performance rather than on taking the intensity higher.

The programme is predominantly nuclear physics with, for example, thorough studies of the nucleon-nucleon interaction now aided by polarized beams and polarized targets and by use of the superbly engineered HRS (High Resolution Spectrometer) for proton-nucleus scattering experiments. Pion interactions benefit from intense pion beams and from the major detector facilities such as the EPICS spectrometer and the neutral pion spectrometer.

Experiments with muon beams use a stopped muon channel. Neutrons are available from the copper beam stop and from a pulsed proton beam to the weapons neutron research area. The use of pions for cancer therapy in a biochemical facility has now been stopped for lack of continuing support.

Particle physics has a significant part of the programme. Refined tests of charge symmetry are under way. Rare decays of pions (such as the neutral pion decay into three gammas — forbidden by C invariance — which was not found) and of muons (such as the positive muon decay into a positron and two gammas) have been or will be looked for. A new detector, known as the Crystal Box, will push the muon measurement further. A particularly fruitful series of neutrino experiments has given results on lepton number conservation, on one of the solar neutrino interaction cross-sections and on the upper limit for neutrino oscillations between the muon and electron neutrinos. These experiments have benefitted from particularly well understood neutrino beams emerging from the beam stop; negative pion absorption before they decay into muons cuts out the antielectron neutrinos and muon neutrinos.

The neutrino programme is being extended by a Los Alamos/UC Irvine group using a new fine-grained well-instrumented detector consisting of Nash tubes and scintillators. They are intending particularly to study electron-neutrino scattering (observing some two events per day) which is sensitive to interference between neutral and charged currents for which the Weinberg-Salam model makes specific predictions. The results could say whether additional types of Z bosons exist. They also hope to measure the cross-sections and hence the electroweak mixing parameter with high precision, to look with more sensitivity for neutrino oscillations, to look again for axions and to study neutrino-nucleus interactions via the interaction converting carbon-12 to nitrogen-12. There are also discussions about much improved neutrino experiments at the Proton Storage Ring (now being built) and at LAMPF II (a major development of the Los Alamos research facilities for the future).

Ground was broken for the Proton Storage Ring (PSR) in May. It is 90 m in circumference, situated in an underground tunnel to one side of the primary proton beamline from LAMPF. It will take intense negative hydrogen ion beams (100 μA or more — requiring major modification to the present LAMPF negative ion injector which provides only a few microamps), strip them in a magnet to neutral hydrogen for injection through the ring's magnetic field onto the desired orbit where they will be further stripped to protons by a foil.

Many turns can be stored and the ring will operate in two modes — either six short (1 ns) bunches, which can be ejected to yield fast neutrons from a target for nuclear physics experiments, or one long bunch (270 ns) which can be ejected to provide slow neutrons from a target for materials research in the weapons neutron research facility. Responsibility for construction of the ring is in the hands of the Accelerator Technology Division. It is intended to complete the tunnel by August 1983 and to have the storage ring ready to receive a beam in March 1985.

For the much longer term future, work has begun, particularly since the encouraging reaction at the LAMPF Users meeting at the end of last year, to develop the physics case for further facilities and to consider the features of the most appropriate machine to meet the physics need. At present the machine is envisaged as a fast cycling (60 Hz) proton synchrotron of energy 16 to 32 GeV. A ring about 150 m radius could be accommodated on the LAMPF mesa, could be fed by the existing 800 MeV supply and use the existing LAMPF experimental areas.

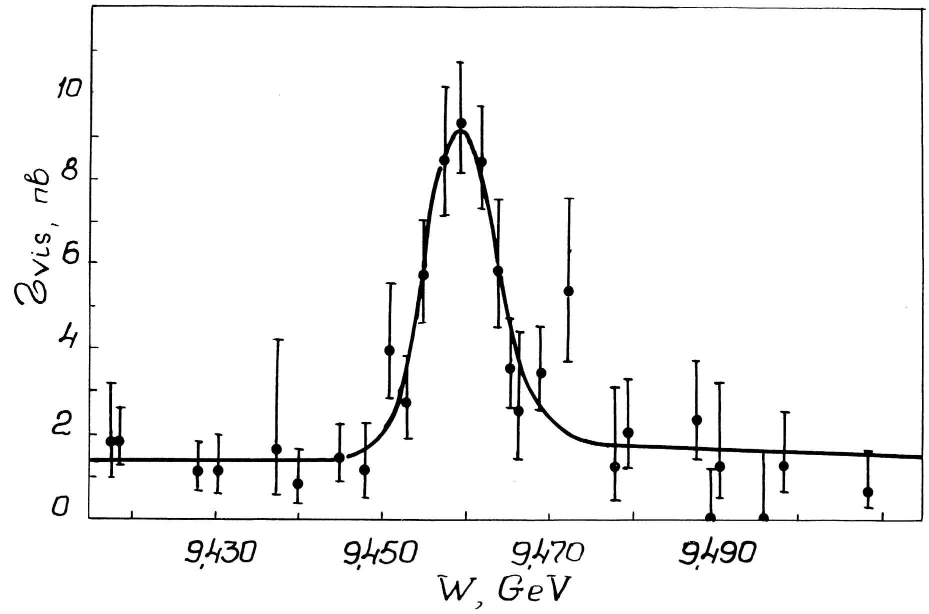
Accelerating 10^{13} particles per pulse would be equivalent to an average current of 100 μA and would yield secondary particle beams in general a hundred times more intense then those available in this energy range, for example, at the CERN PS or Brookhaven AGS. The present pion and muon programmes would be significantly extended. A kaon programme could be established and, as mentioned above, the neutrino programme would also gain greatly. The possibilities for polarized protons and for antiprotons would be left open as options for exploitation at a later time.

The project is now known as LAMPF II. It received further impetus at a Workshop at Los Alamos in July and the present aim is to prepare the formal proposal by 1983. It is hoped that a new era of physics using LAMPF II at Los Alamos could begin by 1990.

NOVOSIBIRSK Upsilon measurements

A systematic study has been started at the VEPP-4 electron-positron storage ring (see October 1980 issue, page 297) within the energy range of the upsilon resonances, using the MD-1 detector with a magnetic field perpendicular to the orbit plane. The precise measurement of particle masses was the first in this new range of energies. Just as in the previous measurements of the masses of the phi, psi and psi prime mesons, the absolute calibration of the energy of the storage ring was carried out by the method of resonance beam depolarization.

The polarization level was measured with a laser polarimeter and by the new method which uses, instead of laser photons, more energetic photons of synchrotron radiation from the opposite beam. During the initial studies, the level of equilibrium polarization of particles in the storage ring was no more than 30 per cent. After the compensation of the weak skew-quadrupole field in the storage ring cell, it was increased to 80 per cent. This enabled the beam depolarization to be observed reli-



The scan of the upsilon energy region with the VEPP-4 electron-positron ring at Novosibirsk, using the resonance beam depolarization method. This gives a firm value for the ground state upsilon mass and makes the whole of upsilon spectroscopy more explicit.

ably and the absolute energy of the beam to be measured with an accuracy of 0.1 MeV.

After scanning the upsilon region with accurate measurement of the energy of the beams at every point, the meson mass was obtained as 9459.7 ± 0.6 MeV, and the precision of this mass measurement was thus improved by one order of magnitude.

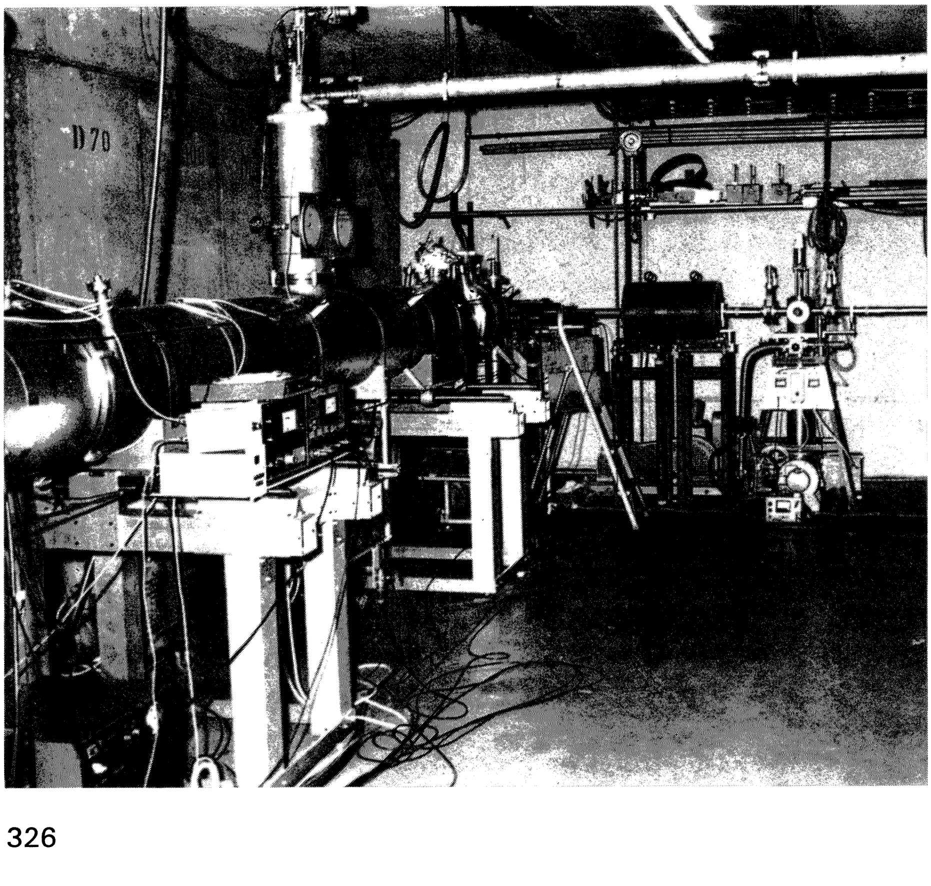
The studies were performed with the optical scheme of the experimental straight section with a vertical beta-function of 45 cm at the collision point. In this case, the peak luminosity was $0.8 \times 10^{30} cm^{-2} s^{-1}$ with 6 mA currents in each beam.

Upon completion of the experiment, the smooth variation of the experimental straight section optics with the coasting beams in the storage ring enabled the beta-function at the collision point to be decreased down to 20 cm. With the same beam currents, this made it possible to increase the peak luminosity to $1.5 \times 10^{30} cm^{-2} s^{-1}$. A further increase of luminosity awaits higher beam currents. A similar method for accurate determination of energies has been developed at PETRA, and will be described in a forthcoming article.

DARMSTADT / WUPPERTAL
Superconducting r.f. electron accelerator

Following the reports on progress in research and development of superconducting cavities for use in r.f. accelerating systems at CERN (see May issue, page 137) and on the successful tests made with prototype cavities at both the CESR electron-positron ring at Cornell and the PETRA ring at DESY (see June issue, page 175) successful tests have been made with a 5 cell prototype cavity in the Darmstadt/Wuppertal electron linear accelerator.

On 6 July an electron beam of 200 keV was injected into a cryostat which houses a 5 cell prototype superconducting r.f. cavity. Operating at an accelerating field of 4.4 MV per metre an effective energy gain of 620 keV has been reached. This energy gain has been measured by performing Mott scattering of the electron beam on a thin carbon target in a scattering chamber behind the linear accelerator. A c.w. beam of close to



The superconducting electron linear accelerator at Darmstadt (built in collaboration with Wuppertal). The liquid helium cryostat houses a 5 cell spherically shaped 3 GHz niobium cavity developed at Wuppertal. The first accelerated beam at an effective field gradient of 4.4 MV per metre was obtained in early July.

(Photo Darmstadt)

Physics monitor

1 μA has been accelerated. The accelerating field is so far the highest ever achieved in a multicell structure in a superconducting electron accelerator.

The 5 cell 25 cm long 3 GHz test cavity has been developed at Wuppertal and manufactured at Interatom, Bensberg, W. Germany. The cavity is of the spherical design, which is free of multipacting. Ten spherical half cells made from deep drawn niobium were electron beam welded. After appropriate surface treatment the 5 cell cavity was tested at Wuppertal and yielded at a temperature of 1.8 K an accelerating field of 5.8 MV per metre with a Q factor of 5 x 10^9. The cavity was then transported to Darmstadt and mounted into a 5 m long cryostat. After cooling with liquid helium the cavity had exactly the same properties as during the test in Wuppertal.

After the successful first acceleration tests more tests are scheduled in which the beam optics of the linear accelerator will be improved, experience in cryogenics will be gained and various adjustments of r.f. parameters carried out. This will probably result in a higher energy gain. The accelerator eventually will be optimized for continuous operation for atomic physics experiments. In Wuppertal a 20 cell 1 m long structure is presently being assembled and tested. This will also be transported to Darmstadt and operated in conjunction with the present 5 cell structure in the linear accelerator.

The present prototype accelerator is an experimental stage for the planned 130 MeV superconducting electron accelerator for nuclear physics research. This accelerator has already been funded and its construction is under preparation.

CERN
Jets set

One of the interesting features of this year's physics conference in Paris (see page 311) was the resurgence of confidence in the evidence for the production of 'jets' — well defined clusters of hadrons — in the debris emerging from high energy hadron-hadron collisions.

In the rare but violent interactions when the small constituents (quarks and gluons) buried deep inside the hadrons collide with each other, they are wrenched from their hadronic bonding. Under normal conditions, these do not exist as free particles, and the liberated hadron constituents are understood to 'fragment' into sprays of hadronic matter more or less along the direction of motion of the 'liberated' constituents. Other secondary particles are created by the 'spectator' constituents which are left behind.

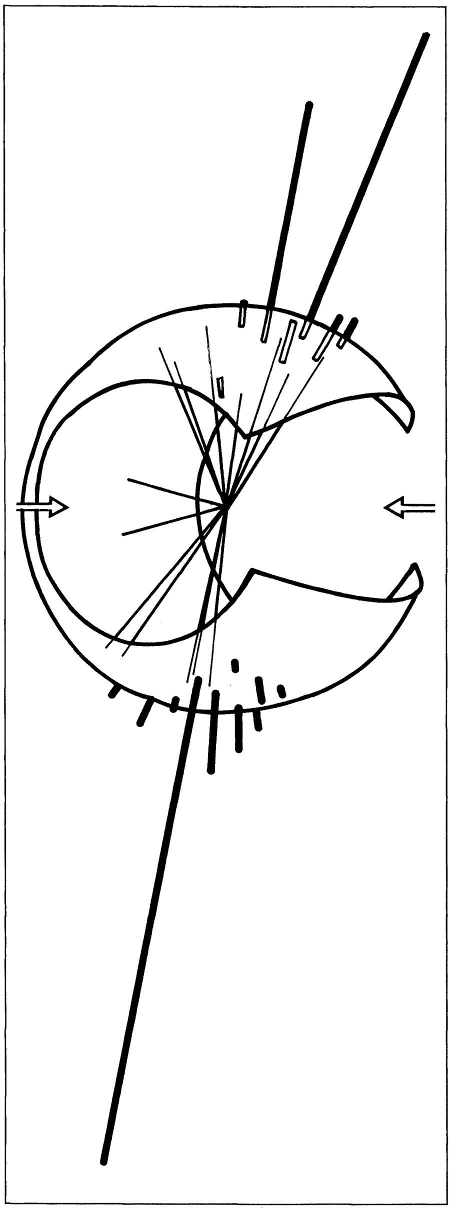
Much evidence has been accumulated for the production of hadron jets in electron-positron annihilations, and more recently in lepton-hadron scattering. However hadron-hadron scattering is much more complicated to study because of the relatively high level of accompanying 'soft' hadronic debris which could hide the quark or gluon jets.

Earlier experiments at the Intersecting Storage Rings (ISR) looked for those interactions in which the large transverse energy produced in the violent interactions between constituents is funnelled into a single particle. When triggering on these single particles, the experiments pick up an accompanying spray of hadrons with jet-like properties (see May issue, page 147).

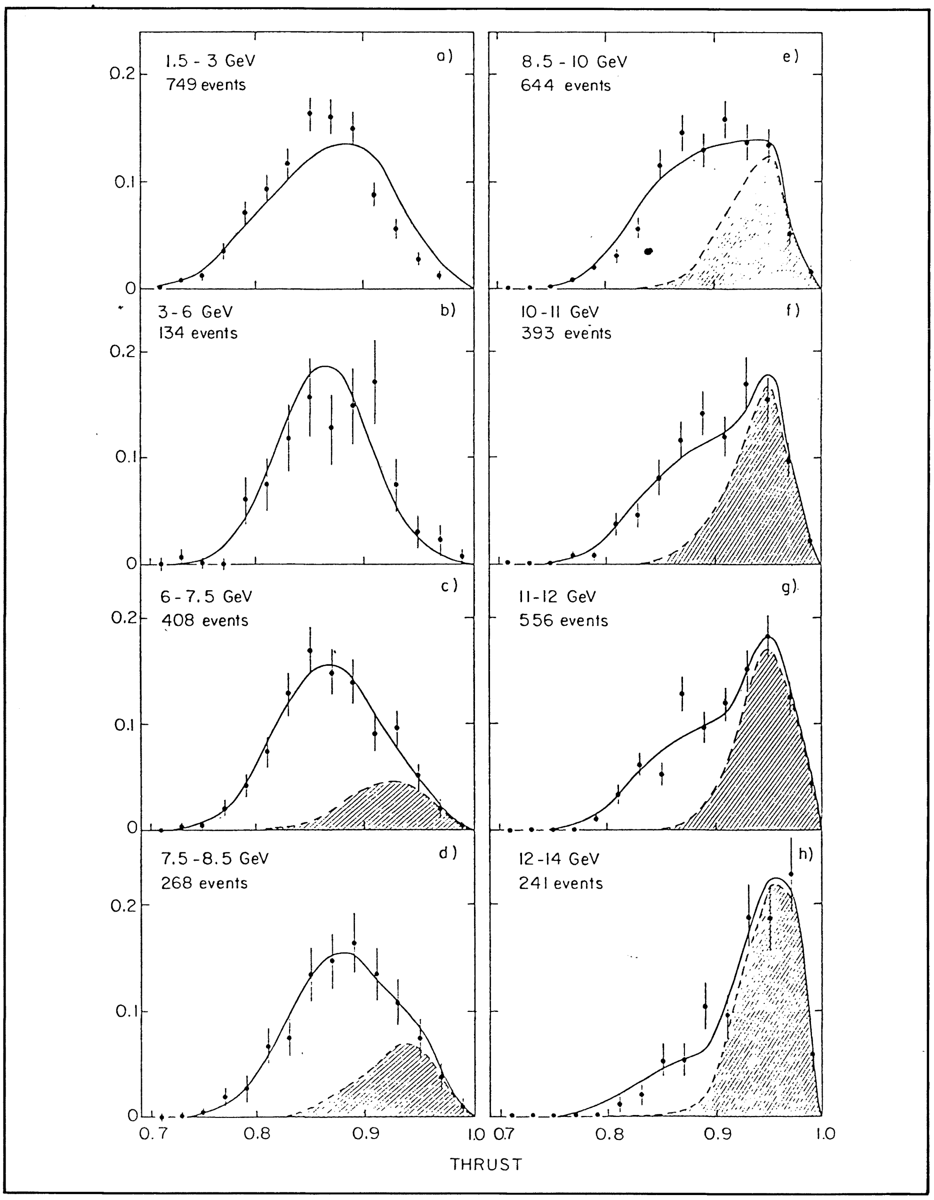
However triggering on a single particle does not necessarily give a representative sample of the total behaviour, and could introduce unwanted biasses of the event sample. These questions could be sidestepped if large calorimeters could be used to collect as much as possible of the produced hadron energy.

Initial such studies at the CERN SPS proton synchrotron found no evidence for jets (see May 1981 issue, page 155), and this has been underlined by subsequent studies at Fermilab. However these fixed target calorimeter experiments might not

Configuration of a spectacular event seen by the UA2 experiment at the SPS proton-antiproton collider, where 127 GeV of transverse energy is released. The lengths of the lines are proportional to the particle energies. In these initial studies, a wedge has been removed from the UA2 central detector for installation of a single arm spectrometer (see June issue, page 177).



Distributions of 'Thrust' ('jettiness') into one quadrant of the Axial Field Spectrometer at the CERN Intersecting Storage Rings. The shaded area shows the expected distribution for single jets of produced particles. This behaviour appears to separate out clearly as the transverse energy is increased.



have been able to see the wood for the trees. Under the prevailing conditions, the softer global behaviour of the big 'fluffy' hadrons still dominated the hard constituent interactions. To observe the violent inner collisions, different conditions are required.

One key quantity is transverse energy/momentum. If the collision energies are high enough, the transverse energy produced in the head-on constituent collisions can be large enough for the produced particles to be easily distinguishable from those originating from softer collisions between complete hadrons. From the appearance of initial results from the UA1 and UA2 experiments at the SPS proton-antiproton collider at CERN, these conditions could already have been attained.

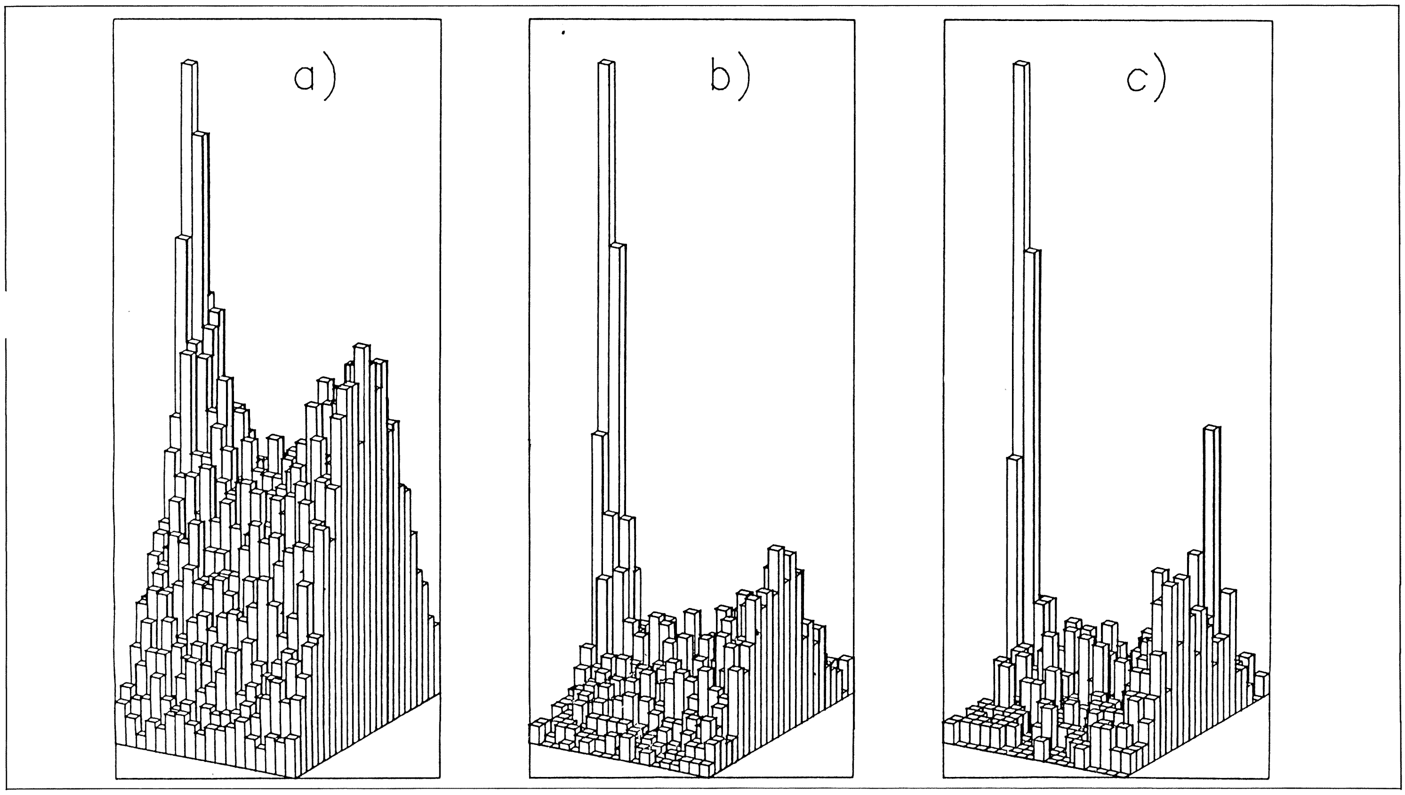
At lower collision energies, such as those of the ISR, higher overall transverse energies were initially difficult to measure. Other criteria had to be sought to filter out those events produced by hard scattering, such as the single transverse momentum triggers collected at the Split Field Magnet.

However new detectors and triggering methods at the ISR have enabled experimenters to look beyond the soft hadron behaviour to see the effects of the inner collisions.

The Axial Field Spectrometer at the ISR (Brookhaven / CERN / Copenhagen / Lund / Pennsylvania / Rutherford / Tel Aviv) now has evidence for the onset of jet production in 63 GeV proton-proton collisions. This evidence comes from events triggered by large deposition of energy in a wall of uranium/scintillator hadron calorimeter, with no requirement on the spatial distribution of particles within this wall. An oppositely mounted wall (see May issue, page 145) was used to record the recoiling particles. The amount of clustering in the hadronic showers was quantified by calculating the so-called 'thrust' of the events.

The observed thrust distributions show a uniform spread of energy flow for lower values of the transverse energy trigger, but as this trigger energy is increased, the shape of the energy flow starts to change. At about 10 GeV transverse energy in the trigger wall, the observed thrust distribution starts to show clear signs of well-collimated hadron clusters. This collimation improves as the trigger transverse energy is increased up to about 14 GeV, when most of the energy deposited in the wall is found to be contained in a relatively small solid angle. The same behaviour is seen in the signals in the floor calorimeter, which picks up the recoiling hadrons, and is similar to that seen in the particles recoiling from single high transverse momen-

Evidence for the clustering of high transverse momentum secondary particles as measured by the UA1 experiment at the SPS proton-antiproton collider. Left, the distribution of all secondaries accompanying a 4 GeV/c trigger particle. Centre, distribution of those secondaries above 1 GeV/c and right, above 2 GeV/c, for the same trigger.



tum particle triggers.

The same onset of jet behaviour is seen by measuring the distribution of produced charged particles in the experiment's central cylindrical drift chamber. As transverse energy is increased, the energy flow on the trigger side and the opposite side is seen to become narrower.

The calorimeter is being enlarged. Further studies should enable well-defined jet cross-section measurements and more detailed comparisons of these jets with those seen in electron-positron annihilation.

Elsewhere at the ISR, the CERN / Columbia / Oxford / Rockefeller group has adopted a different approach. High transverse momentum neutral pions are frequently found as part of a spray of accompanying particles. While this itself is an initial jet-like signature, the analysis goes further. It is found that these neutral pions carry 70 per cent or more of the total jet momentum, and are closely aligned with the jet axis. The analysis then concentrated on roughly back-to-back pairs of neutral pions, detected in oppositely mounted arrays of lead-glass Cherenkov counters.

The behaviour of these oppositely produced neutral pions can be used, to a good approximation, as a mirror of the behaviour of the inner colliding quarks. The observed behaviour of the pions, for instance their production rates and angular distributions, can be compared with the predictions of the theory (quantum chromodynamics) of quark and gluon interactions. The results are encouraging and hint that this type of approach could be usefully extended.

Although the initial collision rates are low, it is at the SPS proton-antiproton collider where the collision energies attain the levels where the produce of hard constituent scattering could be seen.

The highly segmented calorimeters of the UA2 experiment cover a large solid angle and are able to intercept a large proportion of all the particles produced in these 540 GeV energy collisions. Events were selected according to the total amount of transverse energy deposited in the calorimeter. For low total transverse energies, the event rate falls off with increasing transverse energy, as seen in lower energy experiments with fixed targets. However at the high total transverse energies captured by UA2, the event rate no longer falls off so rapidly. This is the first clue that some new behaviour is being seen.

Analysis of the clustering of this total transverse energy in the separate calorimeter compartments shows that as the total transverse energy increases, the events contain fewer clusters of particles, but each cluster contains higher transverse energies — the spread of the particles becomes less homogeneous and more jet-like. In particular, all events with total transverse energy greater than 60 GeV have two-thirds of their transverse energy contained in just two clusters of produced particles. 59 events are found containing at least one cluster carrying more than 20 GeV transverse energy.

For events containing two high transverse energy clusters, these clusters like to be back-to-back when viewed along the beam axis. However these events are only a small fraction of the total high transverse momentum sample.

The calculated rate of production of jets is in broad agreement with theoretical expectations. In the kinematical region covered by this experiment, most of the jets in fact result from the scattering of the gluons accompanying the quarks.

The UA1 detector had an initial sample of 48 000 events with a magnetic field of 0.56 T in the central detector, and another 39 000 events at 0.28 T. In this way the validity of the procedures used in data analysis could be checked. An initial clue that something special is being seen comes from the original observation that already at transverse momenta of 10 GeV, the secondary particle yield is a thousand times up on what is seen at the ISR. As well as the hadrons produced by 'fragmentation' of the colliding constituents, there appear to be indications that gluon radiation too plays a role in the particle production process.

In the angular distributions of particles produced relative to a single high transverse momentum trigger, a clear signal is seen as the particles cluster around the trigger. The effect becomes more marked if lower momenta particles are excluded. A similar phenomenon is also seen in the recoil direction. This provides initial qualitative evidence for constituent scattering. Further investigations will be possible when larger data samples are available.

Taken together, this provides impressive evidence that experiments are now able to isolate and study the interactions of the tiny constituents hidden deep in the interior of protons.

ARGONNE
Future proton decay experiments

Earlier this year over 70 physicists, with a common interest in searching for new phenomena in low background, deep underground experiments, gathered at Argonne for the 1982 Summer Workshop on Proton Decay Experiments. The Workshop focussed on plans for the next generation of proton decay experiments in the United States, and the US experiments, proposals, and detector development programs were, of course, well represented. In addition, active participation by proton decay experimenters from Europe, by physicists doing other types of underground experiments, and by the theoretical physics community, provided breadth and perspective to the discussions.

The Workshop was organized at the suggestion of the US Department of Energy Technical Assessment Panel (TAP) on Proton Decay, which met early this year to review recent developments and to consider proposals for three new US experiments. The TAP's main recommendation was that new experiments be delayed pending initial results from the large water Cherenkov detectors, which were in the final stages of construction. The TAP also felt that future planning of the US program would be helped considerably by further in-depth discussions, in the open format of a Workshop, of the optimum design, deployment, and timing of the next generation of proton decay experiments.

The week-long Workshop agenda was divided about equally between talks by the participants and the activities of five Working Groups which were charged with addressing specific questions raised by the TAP. These included defining a set of goals for the next generation of experiments, taking into consideration the expected performance of experiments already in operation or construction, and recommending a timetable for the start of the next round of experiments. A closely-related question dealt with the detection techniques to be used in new experiments and involved a critical comparison of the different types of detectors which have been proposed: the water Cherenkovs, the fine-grained iron-plate calorimeters, and the totally-active liquid-scintillator calorimeters. Here, the main conclusion reached was that the next generation should emphasize the detection of decay modes to which the present experiments will be relatively insensitive. Decays involving a single neutrino, and particularly the neutrino plus kaon mode recently predicted by supersymmetric models, will be difficult for any presently approved detector to distinguish from background.

In order to accomplish this, any new experiment should have fine-grained tracking and be able to tell the direction of motion of a particle along its trajectory (by timing and/or ionization measurements); also, good energy resolution and charge determination for muons and hadrons are required. Since the sensitivity of present experiments to some decay modes will be limited by background rejection rather than mass, the new generation will not necessarily need a big increase in detector mass: initial fiducial masses in the range of 1 to 3 kilotons will be adequate, with provision for later expansion to perhaps 10 kilotons. This, however, would still represent a substantial investment: the Working Group on detectors concluded that the sophisticated fine-grained experiments required will cost between $5M and $10M per kiloton of fiducial mass, depending on the level of flexibility and redundancy provided to insure adequate background rejection.

Perhaps the most significant conclusion reached at the Workshop was that the detector techniques needed for the next generation of experiments are already in hand, and several of the proposed new detectors meet all the requirements. Since the new experiments would be complementary to those now under way, a good case can be made for starting the next generation immediately, independent of results in the next few years. Even if present experiments do not find evidence for proton decay in the modes to which they are sensitive, decay mode predictions are quite uncertain and it will be essential to set good lifetime limits for all modes. On the other hand, if decays are seen, the measurement of branching ratios into all modes will play a crucial part in distinguishing among the different grand unified models. In this case even more sophisticated and expensive detectors would be justified, and continued work on the development of advanced techniques, such as dense time projection chambers using liquid or high pressure argon, was strongly encouraged.

One Working Group considered the question of depth of deployment, which is important for reducing the cosmic ray muon-induced backgrounds. While Europe is blessed with Alpine road tunnels which have provided several very deep sites for proton decay experiments, such existing deep laboratories are rare in the United States. New excavations are expensive, and the group concluded that funds would be more effectively spent on providing a veto shield of counters around a detector, which could be deployed at the modest depths which are readily accessible at several US sites. The criterion should be that residual background from muons must be much less than that from neutrinos; the latter is independent of depth.

The mysteries of nuclear effects – the absorption and scattering of proton decay products on their way out of the parent nucleus – were tackled by another Working Group. Although high energy physicists have already dealt with similar problems in the interpretation of neutrino data from heavy liquid bubble chambers, some uncertainties still remain in the calculations relevant to proton decay experiments. In particular, the advantages of detector size and event containment, achieved by building detectors of iron instead of lighter materials like water or scintillator, would be reduced if nuclear absorption effects were worse than anticipated.

The scale and technical sophistication of underground detectors are now approaching those of accelerator-based experiments, and initial discussions of the possible institutionalization of underground laboratory support facilities in the US has begun. This follows the example from Italy where the Gran Sasso Laboratory was recently approved. There was considerable debate among the Workshop participants about the advantages and disadvantages of providing a multipurpose laboratory to accommodate a wide range of underground experimentation. On the one hand, it is clear that a very large next-generation proton decay experiment will need technical support at the level normally found at accelerator laboratories; other, smaller experiments at the same site might benefit from having access to these facilities. On the other side, experiments differ considerably in their site requirements, and there are many good reasons for preserving the traditional free-wheeling independence which has always characterized underground experimentation.

One of the Working Groups discussed other physics which could be performed with proton decay detectors themselves. The multikiloton, fine grained proton decay detectors now being considered, as well as those experiments already under way, will be able to study a number of very interesting topics which would otherwise involve difficult and expensive dedicated experiments. These include the use of cosmic ray muons to determine the primary cosmic ray composition, searches for neutron-antineutron oscillations, astrophysical neutrino sources, and magnetic monopoles. While dedicated detectors would be optimized differently in most cases, proton decay experiments will often be able to make significant contributions, with little additional investment of resources.

The uninhibited discussion of the full range of technical and political questions among the Workshop participants proved to be extremely valuable. There was a remarkable degree of consensus on many technical issues, despite the differing approaches of the proponents of various detector techniques. The question of how to build the next-generation detectors was substantially clarified at the Workshop and there was general agreement that the time has come to begin this undertaking.

Aspen meeting looks at US programme

The Division of Particles and Fields (DPF) of the American Physical Society has for some time been discussing how it could best contribute to long-range planning of the high energy physics programme in the USA. In recent years such issues have mainly been addressed via ad hoc committees set up as sub-panels of the High Energy Physics Advisory Panel (HEPAP), the most recent being the sub-panel chaired by George Trilling which reported to the Department of Energy (DOE) earlier this year.

The sub-panels have usually had to confront rather immediate problems and really long-range planning has not been their major concern. Also the sub-panels have understandably drawn most of their input from the national Laboratories and all components of the high energy physics community in the country have not directly participated in the discussions. These weaknesses were recognized in the Trilling report which recommended greater DPF involvement.

The DPF, presently chaired by Charles Baltay, had already discussed the issues and had decided to have sessions on long-range planning but not to establish an independent planning committee in addition to those of DOE and the National Science Foundation. They have not yet decided whether to cosponsor a standing committee with DOE as opposed to the present ad hoc sub-panels. They did, however, decide to hold a summer study at Aspen in July. It was an open meeting which attracted some 150 people, about two-thirds of them being from the universities.

The programme had two physics topics ('testing the standard model' and 'beyond the standard model') and two technology topics ('limits of accelerator technology' and 'novel detection techniques'). Under each heading, comparisons between different facilities were explored – lepton-lepton colliders, lepton-hadron colliders, hadron-hadron colliders, fixed target machines, non-accelerator facilities. There was no attempt to pull out decisions or make recommendations but simply to provide a forum where people express their views on the various possibilities in high energy physics for the future. The following are some of the topics which stirred up particular interest.

There could be a lot of interesting physics 'beyond the standard model' when moving to the 1 TeV energy range. For example Goldstone bosons could start spilling out with masses of a few hundred GeV. High luminosity hadron colliders could then be important. The issue of whether detection systems could really cope efficiently with luminosities in the 10^{33} per cm^2 per s region (so that low cross-section events could be sifted from many high multiplicity interactions) is not clear, however. There is optimism that better detectors can be developed so that events happening in 10 ns time intervals can be separated, rather than the presently typical 200 ns intervals which would group some twenty events.

Vertex detectors had a lot of advocates as being important in many experiments. Such detectors getting as close as 1 cm to the interaction region with a spatial resolution of 10 to 20 μm could be used to trigger on quark jets making jet mass spectroscopy possible. The vertex detectors could help beat down the background of light quark jets.

There was a lively discussion on non-accelerator experiments (such as the underground laboratory proton-decay searches) as a high precision, low energy test-bed for very high energy phenomena. It was suggested that DOE might set up a committee to examine proposals for non-accelerator experiments to help ensure a balanced allocation of resources for experiments of this type (see previous story).

A facility to allow high energy electron-positron physics received a lot of support. There was also a first serious discussion of about a very large machine, in the 20 TeV energy region. This has already been called 'the Arizona machine' because it would need to be of very large diameter and Arizona is a state with large tracts of Federally-owned land. One trigger for this discussion was a recent test at Fermilab of a 'superferric' magnet, based on a concept of Bob Wilson and Leon Lederman.

It was a cold-iron, superconducting magnet to provide a low field (for a superconducting magnet) of 2 T. Construction and testing was done within a week with good results. The aim, in the context of a very large machine, is extreme simplicity to allow cheap mass production.

The summer study was regarded as a success. It allowed wide participation in the discussions and it allowed the people based in the Laboratories to talk about the broad picture of the future of high energy physics in the USA without being obsessed by their own immediate programmes. It is probable that the exercise will be repeated in two years time.

People and things

Watched by SLAC directors and group leaders, Dick Neal casts the first shovelful of earth to plant a tree on the occasion of his retirement as Director of SLAC's Technical Division. As well as being one of the originators of SLAC, Dick Neal has played a major role in the evolution of electron accelerator technology. The resultant reorganization at SLAC has already been announced (see September issue, page 285).

(Photo Walter Zawojski)

On people

President Reagan has nominated Edward A. Knapp, head of Accelerator Technology Division at Los Alamos National Laboratory, to be an assistant director of the US National Science Foundation, with responsibility for the mathematical and physical sciences. He will take leave from Los Alamos to fulfill these new duties.

Paris history colloquium

Some two hundred delegates from several different countries met for the History of Particle Physics Colloquium held in Paris in the old Ecole Polytechnique building from 21-23 July 1982 (see June issue, page 182).

The Colloquium was devoted to a survey of the research and results achieved in the field between 1930 and 1960. The organizers took the opportunity to invite speakers who were actually working at the time: E. Amaldi (weak interactions), M. Gell-Mann (strangeness), N. Kemmer (isospin), F. Reines (neutrinos up to 1960) and J. Schwinger (quantum electrodynamics).

Besides history, concepts and experimental discoveries, the Colloquium also highlighted the importance of instrumentation and scientific institutions — two factors in scientific endeavour that often do not receive the recognition they deserve.

Advances in science are of course closely connected with instrumentation development. The Wilson chamber, proportional chambers, Geiger-Muller counters, coincidence circuits and increasingly sensitive emulsions were used in cosmic ray experiments. In turn, the use of particle accelerators from 1950 onwards led to the development of new instrumentation starting with the bubble chamber.

The influence of institutions on scientific progress is often not fully appreciated. In the case of particle physics, however, it can be clearly observed. Particle physics started as a lightweight science — E. Goldwasser recalled how Lawrence built his second cyclotron for 800 dollars. But necessity together with the example of the Manhattan project (mentioned by S. Weart among others), caused it to become a heavyweight. Accordingly, new institutions came into being.

All these activities and their history were discussed at a round table with E. Amadi, E. Goldwasser, A. Messiah, V. Weisskopf and Y. Yamaguchi. In this context Pierre Auger described the pre-

British Prime Minister Margaret Thatcher visited CERN on 12 August. She saw developments for LEP and visited the UA1 proton-antiproton experiment in the SPS ring. She is seen below accompanied by Director General Herwig Schopper (right), and UA1 experiment co-spokesman Alan Astbury. However this was not the first time Mrs. Thatcher has visited CERN. As Minister for Education and Science, she came in 1970, when she was given explanations by Peter Standley (photo right).

(Photos CERN 116.8.82 and 399.9.70)

history of CERN (to which he made an important contribution) and gave some humorous advice to anyone thinking like him of setting up an international laboratory, in case history could repeat itself.

Physicists, including the younger generation, manifested a keen interest in the Colloquium. The talks and debates were well attended and there was a lot of discussion between sessions. A summary of the proceedings will be published soon.

USA/Japan Committee

The fourth meeting of the USA/Japan Committee on High Energy Physics was held on 24-25 May in the Fuji Institute of Education and Training in the foothills of Mt. Fuji.

J. Leiss, Director of the Office of High Energy and Nuclear Physics of the US Department of Energy (DOE), and T. Nishikawa, Director of the Japanese KEK Laboratory, were co-chairmen, as they have been since the first meeting following the signing of the original arrangement between DOE and the Japanese Ministry of Education, Science and Culture. The Arrangement falls under the general Agreement of Cooperation in Research and Development in Energy and Related Fields, drawn up by the two nations in May 1979.

Other members of the committee who attended the fourth meeting were D. Jackson, L. Lederman, W. Panofsky, N. Samios, G. Shigeto, T. Fuji, T. Kitagaki, G. Takeda and K. Kikuchi. In addition B. Hildebrand, R. Schwitters and S. Ozaki participated.

T. Nishikawa remarked on four years of excellent cooperation which have led to many fruitful results. He commented that, at the time when the programme for the first five years was discussed, it was agreed that plans for the second five years would be drawn up on the basis of experience, results and prospects. He noted that the time has come to assess the scope for further effective collaboration with funding which cannot be overly optimistic because of the worldwide economic situation.

J. Leiss quoted from the philosophy of the founder of the Fuji Institute — 'to train a man to think big, he must be trained in an open and free environment in the bosom of Mother Nature. From this viewpoint the foot of Mt. Fuji is an ideal environment'. Leiss said that major experimental research and development progress in Japan is playing an important role in advancing high energy physics. He suggested that it was an appropriate time to

Signing the record of the fourth meeting of the US/Japan Committee on High Energy Physics. Left to right, S. Ozaki, T. Nishikawa, J. Leiss and B. Hildebrand. Mount Fuji is visible in the background. For how the crossed Japanese and US flags made it to the top of Mount Fuji, see page 310.

consider broadening the scope of collaboration to include joint construction and exploitation of unique facilities and added that the time was ripe to initiate a joint study.

Reports on thirteen cooperative experiments at Brookhaven, Fermilab, KEK and Stanford were made by Japanese spokesmen.

US members commented on the reports and appreciated the important role of the US/Japan programme. D. Jackson described the progress of the Time Projection Chamber project and plans for a possible Berkeley participation in the TOPAZ collaboration at KEK's TRISTAN collider.

After these presentations the committee agreed on the 1982 programme, for which about 150 million yen was allocated, and on the budget request for financial year 1983.

The following sessions covered cooperation during the second five-year period. The Committee agreed upon the importance of continuing the agreement and recognized that the research is in a particularly exciting period. The Japanese mentioned that a considerable increase of the funding for the second five years might be difficult to achieve and, since TRISTAN construction is under way, the limited Japanese manpower would also make it difficult to initiate a new large scale project. The Americans expressed a strong view that the second five years should be approached with optimism. They agreed that the arrival of TRISTAN changed the traditional pattern but that the option of substantial joint undertakings should not be overlooked. Both sides agreed to appoint a sub-committee with three members from each country to make recommendations in January 1983 on cooperation for the period 1984-1988.

The next meeting will be held at Brookhaven around May 1983.

Meetings

Earlier this year, a seminar entitled 'Trends in Particle Acceleration Techniques' was held in Capri, Italy. As well as examining the various possibilities for reaching higher energies, the meeting also discussed the specific requirements of the Italian education system to ensure the future health of accelerator physics. The proceedings of the seminar are to be published and will be available from V.G. Vaccaro, Istituto Elettrotecnico, Via Claudio 21, 80125 Naples, Italy.

The 1983 Particle Accelerator Conference on Accelerator Engineering and Technology will be held from 21-23 March at Santa Fe, New Mexico, organized by Los Alamos National Laboratory. Further information from the arrangements chairman, G.A. Sawyer, Los Alamos National Laboratory, AT-DO, MS-H811, Los Alamos, New Mexico 87545, USA.

SPS Fixed Target Physics Workshop

A Workshop on SPS Fixed Target Physics for the years 1984-89 will be held at CERN from 6-10 December.

The CERN Management and the SPS Experiments Committee felt that it would be useful now, when the first generation of SPS experiments has just been completed, the SPS has started operation as proton-antiproton collider, LEP construction is going ahead, and the closure of the ISR planned, to

TOPIC	CONVENER	
Neutrino Physics	*D. Haidt*	*DESY-Hamburg*
Muon Physics	*J.J. Aubert*	*CPPM-Marseille*
New Particles and Decays	*L. Foà*	*Pisa*
Hadron Physics	*D. Treille*	*CERN*
Nuclear Beams and Targets	*W. Willis*	*CERN*

I. Mannelli (CERN) will co-ordinate the organization of the workshop.

review the SPS fixed target programme. Thus a workshop is being organized to give people an opportunity to bring forward proposals, ideas and opinions for the SPS fixed target programme in the years 1984-89. The results of the workshop will provide some guidance for the most effective allocation of resources to the various activities at CERN, by showing the way the SPS fixed target programme can lead to new physics, and by demonstrating how it can face the challenge of the Fermilab Tevatron and competition with the proton-antiproton colliders.

For convenience, there will be a subdivision into five main topics, and one convener has been appointed for each. He will take care of the organization of the respective sessions and will report the pertinent results in a summary talk during the concluding session on 10 December.

For those topics which would imply changes to the machine or new modes of operation, working groups will be set up to stimulate the necessary contacts and promote feedback.

All interested physicists — theorists as well as experimentalists — are invited to get in touch with one (or several) of the conveners, or with I. Mannelli, so that the workshop can be organized keeping in mind their suggestions and expressions of interest. The programme is expected to be subdivided into plenary sessions (generally in the morning), during which the main lines of possible research, including theoretical reviews, will be presented, and into parallel sessions for more detailed discussions, shaping up of proposals, etc. Due to the limited duration of the workshop it is clear that much work will have to be done ahead of time within specialized working groups. It is also planned to organize some special topical theory seminars. This preparatory work will of course represent a basic input to the plenary sessions.

Participation is open to all interested physicists; however, in order to help with the practical aspects of the workshop's organization, interested participants are requested to register as early as possible with Mrs. A.M. Bugge, DG Division, CERN, stating the period of attendance and their main field of interest. There will be no registration fee.

Neutral currents and neutrons

Data from recent deuterium fills of the BEBC bubble chamber at CERN and the Fermilab 15 foot chamber, exposed to wideband neutrino beams, has provided information on the coupling of the weak neutral current to neutrons. The results are in tune with electroweak predictions.

The standard electroweak theory, combined with knowledge of quark density distributions from earlier experiments, predicts the relative levels of neutrino-proton and neutrino-neutron neutral current events.

The Fermilab sample (Illinois Tech / Maryland / Stony Brook / Tohuko / Tufts) contained 264 neutrino-neutron and 260 neutrino-proton neutral current events. In the same film, 1188 charged current interactions on neutrons and 536 on protons were obtained. The CERN sample (Amsterdam / Bergen / Bologna / Padua / Pisa / Saclay / Turin) gave 3455, 2554, 3421 and 1899 events respectively for the same classes of interaction.

At SLAC, the annual theorists versus experimentalists softball game resulted for only the second time in history in a win for the theorists, so confirming that the previous theory victory in 1974 was no flash in the pan.

Gas sampling

A workshop on gas sampling calorimetry will be held at Fermilab on 28-29 October. More information from M. Atac at Fermilab.

Physics Institute of the University Zürich

The experimental group of the Physics Institute of the University Zürich working in collaboration with the ETH-Zürich at the Swiss Institute for Nuclear Research (SIN) is looking for a

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8001 Zürich, Switzerland

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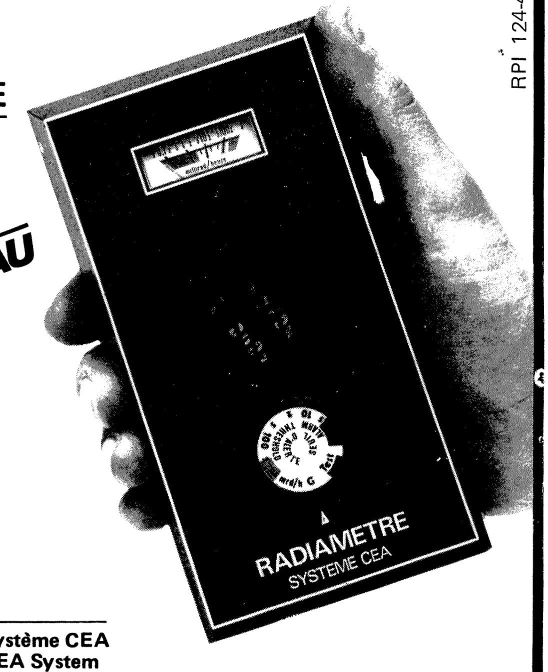

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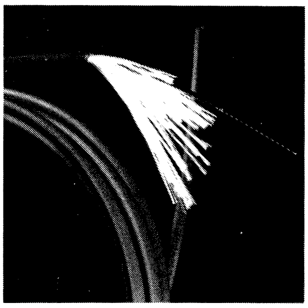

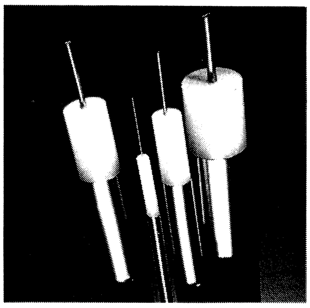

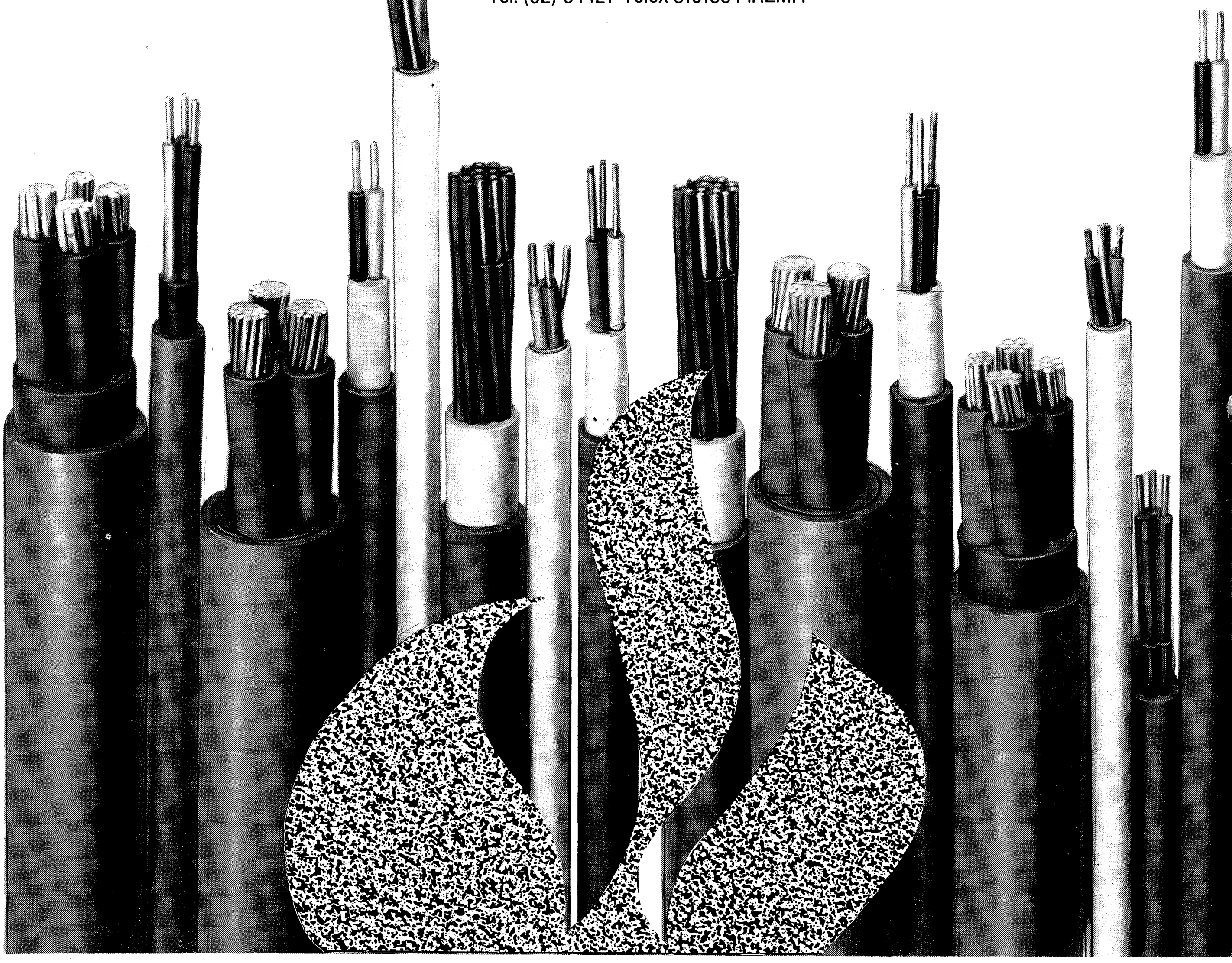

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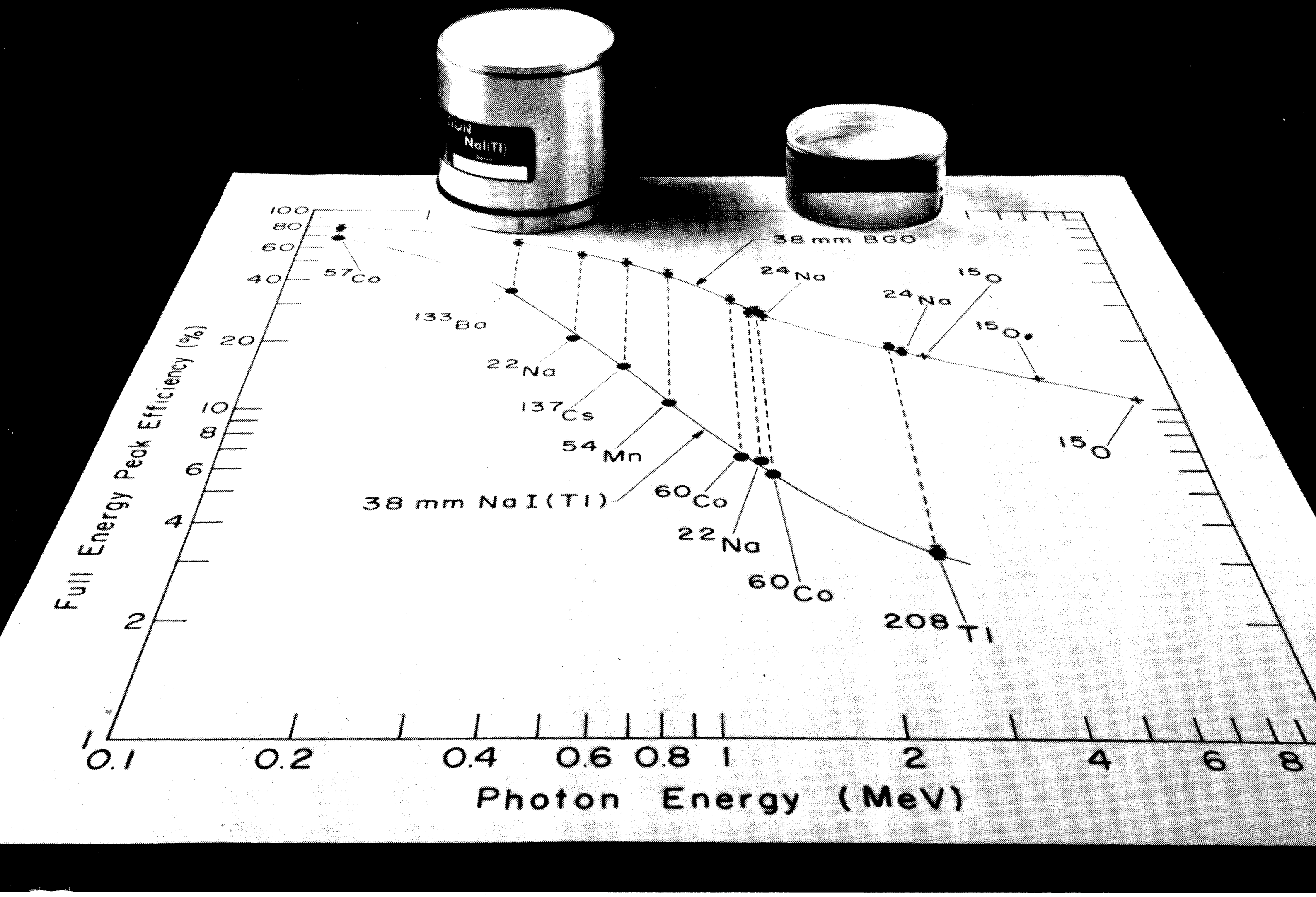


The Bismuth Germanate Scintillator.

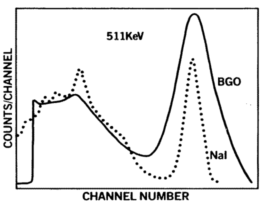
This special high-Z crystal has the highest stopping power and lowest afterglow of any commercially produced scintillator.

Non-hygroscopic Harshaw BGO simplifies handling and equipment. It eliminates the complexities and size increases of hermetically sealed housing required in NaI (Tl) scintillators.

Low afterglow performance, high-Z, and ease of handling make BGO ideal for industrial density gauging applications. The afterglow of a BGO scintillator is typically ±.005% within 3 ms.

BGO is suitable for pulse counting applications because of its high photopeak efficiency, excellent peak-to-Compton ratio and acceptable pulse-height resolution. For instance, it takes 8.5 cm. of BGO compared to 13.4 cm. NaI (Tl) to attenuate 99% of incident 511 KeV gamma ray.

Photopeak Efficiency



For performance specifications on efficient, rugged Harshaw BGO, call or write us. We're The Harshaw Chemical Company, Crystal & Electronic Products, International Operations, 1945 East 97th Street, Cleveland, Ohio 44106 U.S.A. (216) 721-8300. Telex: 98-5457. Cable: Harshaw — Cleveland.

Photon energy curve reprinted from "Gamma-Ray Response of a 38-mm Bismuth Germanate Scintillator", paper No. 2C-2, 1979 IEEE Nuclear Science Symposium, by Albert E. Evans, Jr.

HARSHAW

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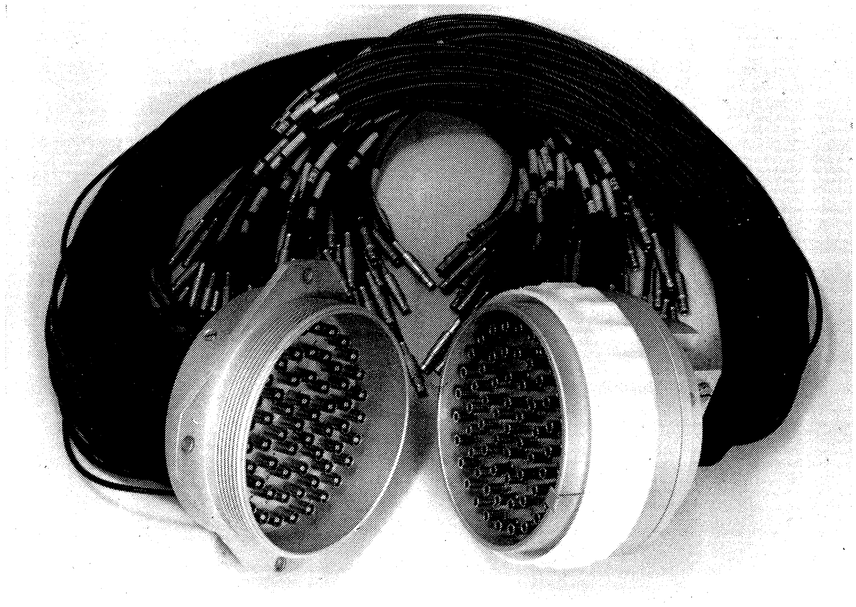
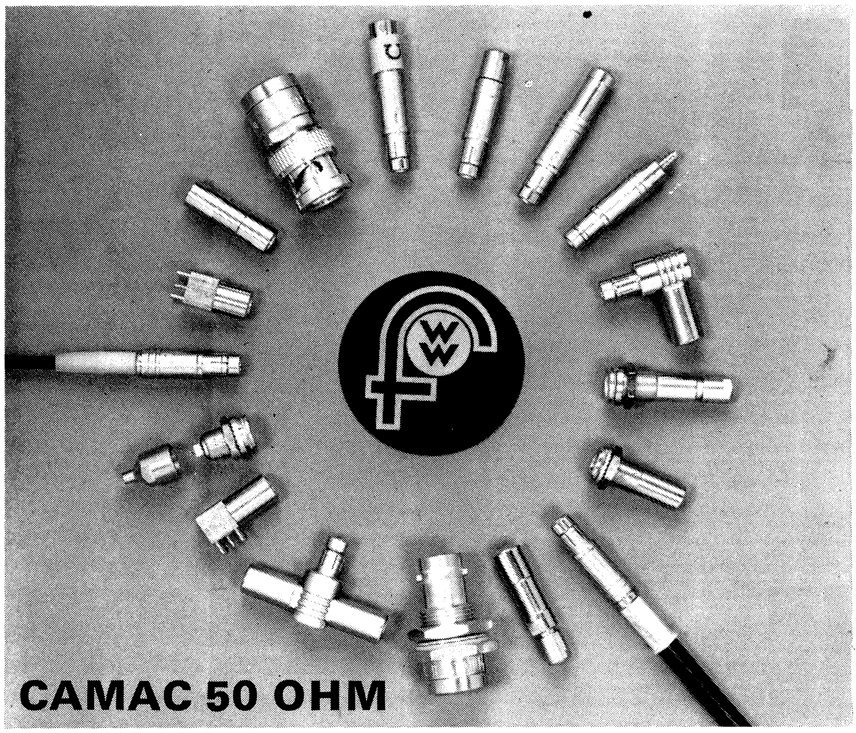


50 OHM MULTICOAXIAL CONNECTOR

FISCHER electric connectors with self-locking satisfy the most exacting requirements of modern technologies, such as nuclear research, atomic energy, space research, etc.
Their main characteristics are:

- robust construction and high precision
- dependable operation, self-locking
- simple keying
- simple and trouble-free mounting
- reliable positioning on different elements guaranteed by two half-shell shaped metallic guides
- high quality insulation, normally of P.T.F.E.
- pressure tight and high vacuum sealed designs
- sealed models resistant to radiation up to 10^8 Rad. and temperatures from − 60 to + 150 °C
- construction with ceramic insulating material resistant to radiation and to high temperatures
- special connectors for thermocouples

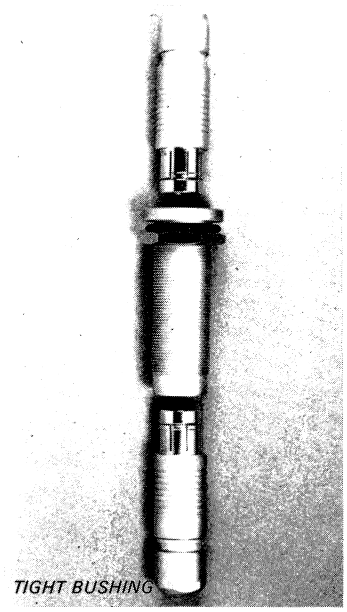


FISCHER connectors with self-locking can now be supplied in 8 different sizes and come in a very wide range:

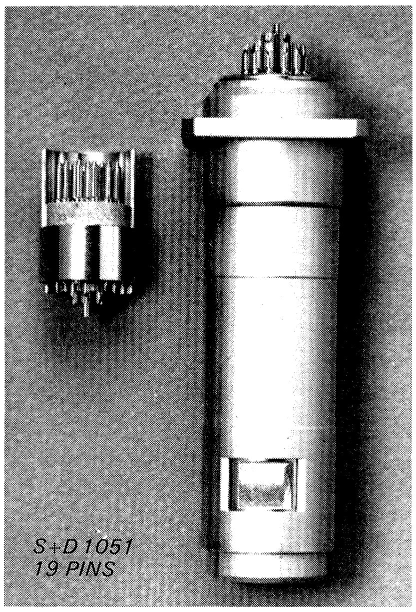
- coaxial connectors for high frequencies
- coaxial connectors for high voltages
- multiple connectors
- multiple connectors for high voltages
- compound connectors: high frequency and low voltage
- connectors for thermocouples
- connectors for Camac-Modules

Certain connectors for thermocouples can be supplied with contacts of special materials, e.g. chromel, alumel, iron, constantan, copper, etc.

Rapid and reliable construction of special connectors.



Residual leakage:
$< 10^{-9}$ m bar. l. sec.$^{-1}$



Connectors with CERAMIC insulating material resistant to radiation and to high temperatures

XP2008 and XP2012 contribute in UA1 and UA2 $\bar{p}p$ CERN experiments with

A complete range of modern PMTs for industry and physics							
PMT	cathode		number of stages	stability		pulse linearity (mA)	resolution ^{137}Cs (%)
	∅ (mm)	type		16h/0,3μA (%)	1-0,1μA (%)		
XP2008	32	super A	10	1	1	200	8
XP2012	32	bialkali	10	1	1	200	7,2
XP2202	44	bialkali	10	1	1	200	7,4
XP2212	44	bialkali	12	1	1	250	7,5
XP2030	70	bialkali	10VB	0,5	0,8	40*)	7,2
XP2050	110	bialkali	10VB	1	1	40*)	7,5

*) with a specially tailored bleeder

Stability
Linearity
BBQity
Consistency
Resolution
Economy

Matching the BBQ emission spectrum (BBQity), these PMTs meet the most critical parameter for system resolution: GAIN STABILITY.

We've set the standard for over 20 years

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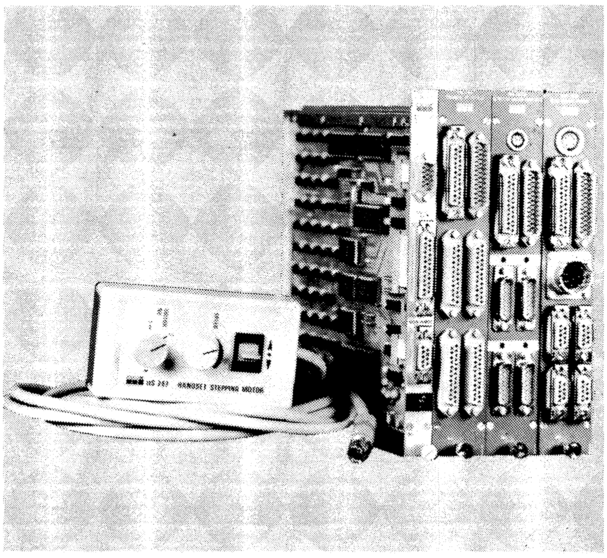
CAMAC/NIM

SEN PRESENTS THE NEW MODULAR

MOTOR DRIVER SYSTEM

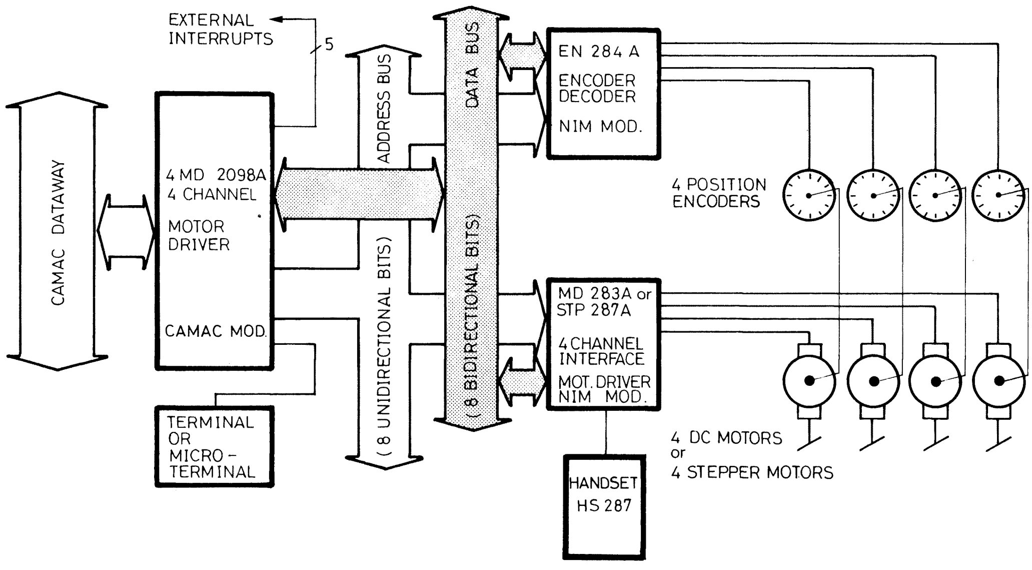


- AUTOMATIC POSITIONING OF 4 STEPPER MOTORS (3 or 4 phase) OR 4 DC MOTORS.
- PRECISION: UP TO 24-BIT RESOLUTION FOR THE MOTOR POSITIONING.
- COMPATIBLE WITH 3 TYPES OF POSITION ENCODERS.
- BUILT IN µ PROCESSOR.
- STANDARD SOFTWARE PAK.
- MANUAL CONTROL THROUGH TERMINAL OR MICROTERMINAL.
- REMOTE CONTROL OF MOTORS WITH OPTIONAL HANDSET MODULE (HS 287 or HS 283)

THE SYSTEM CONSISTS OF:

- 4-CHANNEL MOTOR DRIVER (CAMAC COMMAND MODULE): 4 MD-2098/A
- POSITION ENCODER-DECODER (NIM): EN 284/A
- DC or STEPPER MOTOR DRIVERS (NIM): MD 283 A or SMD 287/A
- HANDSET FOR MANUAL POSITIONING: HS 283 or HS 287 (OPTIONAL)

BLOCK DIAGRAM OF THE SYSTEM



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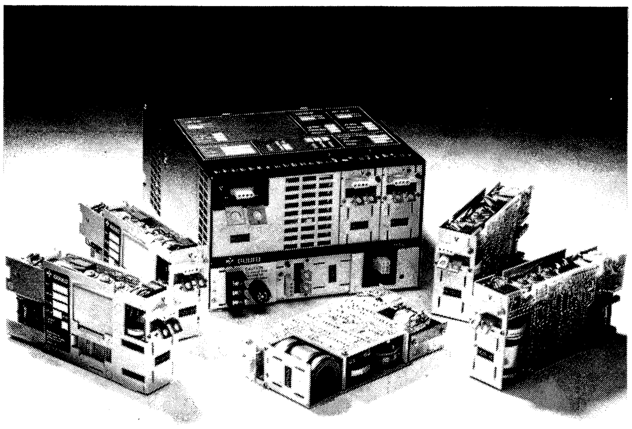

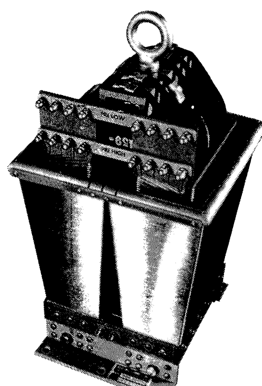

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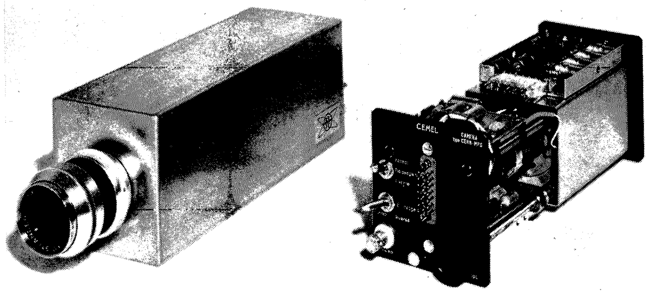
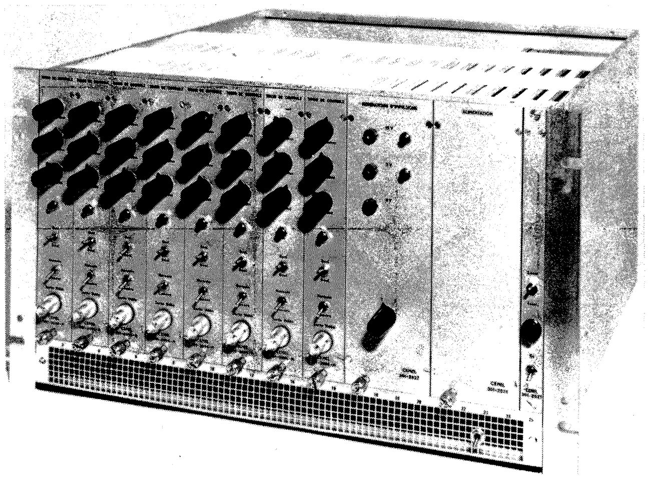


CAMERA HEAD



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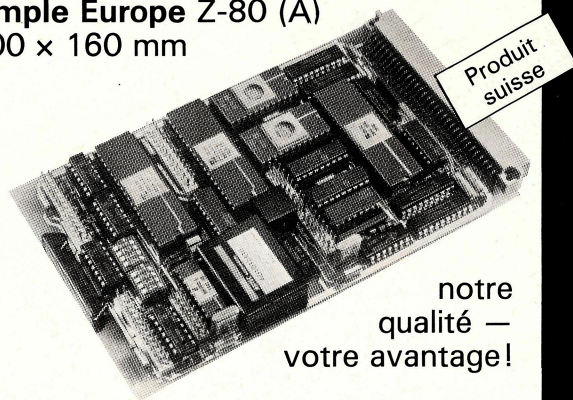

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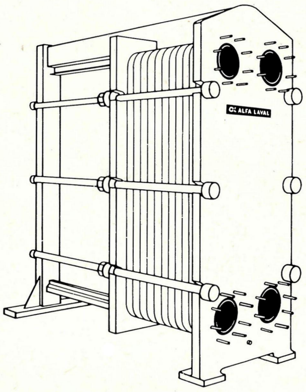
Some heated arguments for using the thermal specialists

If you have a thermal design problem, or are looking for ways of optimising your existing heat exchange equipment, here are arguments for using Alfa-Laval, the Thermal Specialists.

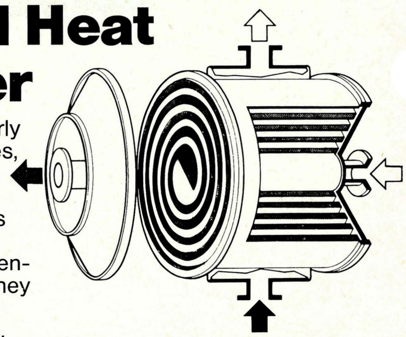
The Plate Heat Exchanger



Originally developed by us in the thirties, the plate heat exchanger is without doubt one of the most efficient methods of transferring thermal energy from one medium to another.

The Plate Heat Exchanger achieves heat transfer co-efficients of up to 5000 kcal/m^2 h °C at economic pressure drops. The high thermal efficiency gives a higher surface-to-volume ratio than the cumbersome shell and tube exchanger. The plates can be arranged in varying ways, materials and sizes to match your process specifications, the unit itself remaining compact and cost-saving.

The Spiral Heat Exchanger



This exchanger is particularly effective in handling sludges, liquids with solids in suspension including slurries, and a wide range of viscous fluids; it has replaced shell and tube in overhead condenser installations, saving money in the amount of corrosion resistent materials required.

The principle design feature of this all-welded assembly is a pair of concentric spiral passages along which the two media flow, giving the following advantages: higher overall coefficient than conventional heat exchangers; minimal fouling effect; saving in installation, servicing and capital costs.

To obtain further information about our thermal capabilities, or to discuss your own thermal design requirements, contact

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