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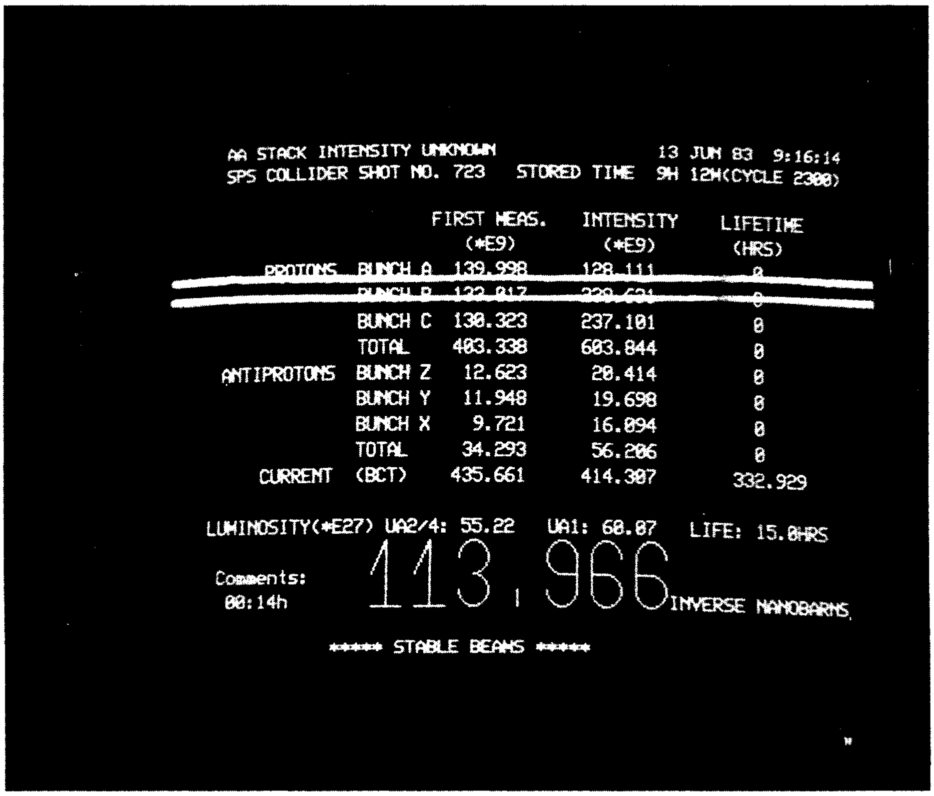
Cover photograph: Aerial view of the West Experimental area of the CERN SPS, now having its first taste of beams using the full energy of the machine. Peak energy was restricted previously to the North Experimental Area. At the bottom of the photograph a line of four large buildings marks the path of the SPS neutrino beam. Upstream is the main experimental hall, now also equipped with special beams for testing equipment for LEP and other large experiments. Just above and to the right is the mound covering the Intersecting Storage Rings, now nearing the end of its career. Beyond, backed by mountains, is the city of Geneva (Photo CERN 189.6.83).

An historic run



The SPS display proudly proclaims that the goal of more than 100 inverse nanobarns of integrated luminosity for proton-antiproton collisions has been surpassed.

(Photo CERN 98.6.83)

On 3 July, the high energy pulses of matter and antimatter circulating in opposite directions in the SPS ring at CERN were dumped, bringing to an end an historic period of physics experiment which will surely go down in the annals of science. No doubt the physics students of the 21st century will read avidly about the exploits of the machine specialists and the physics teams at CERN in 1983.

The scene was set with the SPS antiproton run at the end of last year. Over some two months, the big UA1 and UA2 experiments had been able to log proton-antiproton collision data at a substantial rate at 540 GeV, already the highest man-made particle collision energy ever achieved (see January/February issue, page 6).

During this time, the experiments amassed five hundred times the amount of data culled from the initial SPS proton-antiproton physics run in 1981, and hopes were high that important physics would emerge.

They did not have to wait long. Thanks to superb data handling techniques, the experiments were able to announce in January the discovery of the W boson, the particle which carries the electrically charged component of the weak force. These W particles had been predicted by the electroweak theory which unifies electromagnetism and the weak nuclear force, and the observed mass was in line with expectations (see March issue, page 43, and April issue, page 82).

The next step was to track down the companion Z^o particle, carrier of the electrically neutral current of the weak force, also predicted by the electroweak theory. However the Z^o was expected to be ten times harder to find than the W, and at least several times the amount of data collected in the 1982 run would be needed before the experimenters would have a good chance of catching some.

The integrated luminosity (the measure of the number of proton-antiproton collisions to which the experiments had been exposed) produced in each of the two collision areas was some 28 inverse nanobarus. At the time this was considered a major achievement.

After the champagne and the celebrations, the machine specialists knew that they would have to find some more stops to pull out if the experimenters were to get their Z^o particles. The goal was 100 inverse nanobarns.

The 1983 SPS proton-antiproton run got under way on 12 April. At first, things took time to settle down and the number of clocked-up collisions began to fall behind the target rate. But performance improved towards the end of April, and the 100 inverse nanobarn goal began to look attainable. Confidence grew, but there was still a long way to go.

On 16 May, the run was interrupted for a brief scheduled maintenance break. During all this time, the Antiproton Accumulator ring which stores the precious antiprotons (produced at the rate of about one per four million incident protons) had stored particles continuously for 808 hours — 33 days. This superb reliability assured the SPS ring of a steady supply of antimatter.

After the brief stop, the run soon got under way again. One standard trick used to boost the collision rate in storage rings is to use special (low beta) quadrupole magnets to squeeze the colliding beams together. By squeezing them tighter, the SPS luminosities (collision rates) began to creep higher. Soon, initial luminosities surpassed 1.3×10^{29} cm^{-2} s^{-1}, and a record figure of 1.6×10^{29} was achieved. On

6 June, the 100 inverse nanobarn target was reached, but still the machines marched on relentlessly.

Towards the end of June, technical difficulties coincided with the onset of the summer thunderstorms which periodically upset power supplies. The final integrated luminosity figure at the end of the run was 153 inverse nanobarns.

But this commendable achievement came as something of an anticlimax as the UA1 experimenters had already spotted their first Z^o candidate events towards the end of May (see June issue, page 167). More Z^o sightings followed in quick succession and the announcement of the Z discovery was made to the world's press on 1 June.

The big experiments at the SPS proton-antiproton collider were not the only beneficiaries of the antiprotons. Also at the SPS collider, the UA4 study of elastic and total cross-sections had a successful run. Antiparticles were fed into one ring of the Intersecting Storage Rings (ISR) for tests with the hydrogen gas jet target of a new experiment by a CERN /Genoa / Lyon / Oslo / Rome / Turin team. Another gas jet target is installed in the SPS by the UA6 group (CERN / Lausanne / Michigan / Rockefeller). Antiprotons were also decelerated for the new LEAR Low Energy Antiproton Ring, where 17 experiments will study the new physics frontier opened up by an abundant supply of low energy antiprotons.

What for the future? The next major proton-antiproton run in the SPS is scheduled for the autumn of next year, and a number of possible improvements could push the collision rate even higher. These include boosting the antiproton supply, increasing the number of colliding proton and antiproton bunches, and constricting the beams even tighter by 'supersqueezing' with the low beta magnets. The latter technique was successfully tested during quiet moments of the latest run.

The stored beams in the SPS are held at 270 GeV, but the experts are looking at the possibility of coaxing this a little higher without overtaxing the machine. Even a modest energy increase could significantly boost the event rate for interesting physics.

A separate project is to approach 1 TeV collision energies by ramping the beams up to the SPS working energy of 400-450 GeV. However these energies would only be available in short bursts at low luminosity, the idea being to use the UA5 streamer chamber to look for signs of phenomena only seen so far in cosmic rays. These high multiplicity effects are not visible at 540 GeV.

Looking further ahead, a high yield magnetically focused target could intensify the antiproton supply. A new dedicated Antiproton Collector ring to work in tandem with the existing Accumulator is being studied, however this project is still on paper.

But with the physics rewards at the SPS proton-antiproton collider successful beyond all but the most optimistic of expectations, the end of the 1983 run is a welcome pause for all concerned to catch their breath and reflect on what has been surely one of the most productive periods of physics this century.

Nerve centre of all operations at the SPS — the control room.

(Photo CERN 169.6.83)

More Z^o particles

It seemed a pity to dump such healthy particle bunches circulating happily in the SPS ring, and at the last minute the decision was taken to extend the proton-antiproton collider run. During this stay of execution, the UA2 experiment logged a gold-plated example of Z^o production and decay into an electron-positron pair. In a preliminary analysis of the data from the combined 1982 and 1983 collider runs, UA2 has collected four 'grade one' Z^os and four 'grade two' events, where some of the selection criteria have been slightly relaxed. For the four grade one events, the Z^o mass is centred on 91.2 GeV. The UA1 experiment reported its first Z^o candidates in May. Between them, the two big SPS collider experiments have now collected an impressive sample of events including W and Z particles.

Brighton Conference

Preliminary Report

The Brighton Centre, scene of the recent International Europhysics Conference on High Energy Physics.

The Brighton Conference, held from 21-27 July, was the first major international physics meeting to hear a full account of the discovery of the W and Z^0 bosons by the UA1 and UA2 experiments at the CERN SPS proton-antiproton collider.

But the W and Z^0 were not the only important results to emerge. The study of the hadron clusters ('jets') emerging from high energy collisions has also made great strides forward, thanks notably to new data from the SPS collider. Other Brighton highlights came from studies at the electron-positron rings at DESY and at SLAC, from low energy neutrino experiments, and from the big passive detectors waiting to catch signs of proton decay.

Sponsored by the European Physical Society and the UK Science and Engineering Research Council, and impeccably organized, the International Europhysics Conference at Brighton began with three days of intense parallel sessions. These covered a wide range of physics topics in depth and reflected the great progress which has been made in recent years in extending our knowledge of particle interactions and improving our understanding of the underlying mechanisms.

After the parallel sessions, it was the turn of the plenary speakers. But first, the 650 delegates heard presentations from the UA1 and UA2 experiments on their epic quest for the W and Z^0 particles which carry the charged and neutral currents respectively of the weak force.

In succinct and memorable presentations, K. Eggert described the UA1 search which so far has found six Z^0 candidate events — two producing muon pairs and four giving electron pairs — and J. Colas covered the 52 UA1 W events — high transverse energy lone electrons produced back to back with the missing energy indicative of a neutrino.

For UA2, G. Sauvage outlined the hunt which has so far caught 35 W events producing electron plus neutrino, and eight Z^0 candidates, four with less stringent selection criteria.

The Z^0 mass is given as 95.1 GeV by UA1 and 91.2 GeV by UA2, while the W mass is 80.9 GeV according to UA1 and 81 GeV by UA2. After this momentous introduction, subsequent plenary speakers mentioned the W and Z^0 discoveries only in passing. It was left to Carlo Rubbia, leader of the UA1 team and one of the architects of the CERN antiproton project, to underline these spectacular achievements in his concluding experimental talk.

For the first time in public, he amalgamated the UA1 and UA2 results, and displayed the impressive agreement between the experimental findings and the electroweak picture.

'The collider has apparently fulfilled its potential for "planned" discoveries,' he declared, but was confident that there was still a lot of physics to be covered.

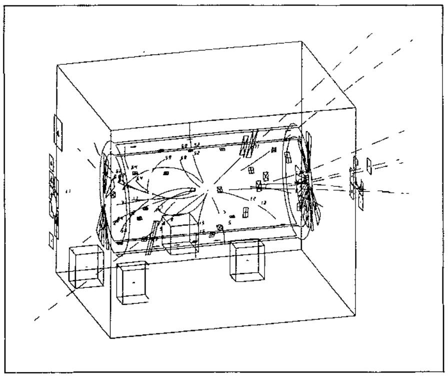
Chairing this final session, Abdus Salam, one of the authors of the electroweak theory, paid tribute to the CERN antiproton project which had made these historic discoveries possible.

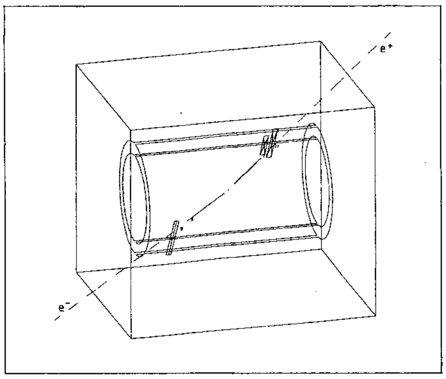
Throughout the Conference, UA1 and UA2 spokesmen refused to be drawn on the search for heavier quark flavours, usually saying that the subject was 'top secret'!

As well as the W and Z^0 news, the collider provided important results on jet production. These were covered amply in both the parallel and plenary sessions.

It is sobering to recall that the phenomenon of high transverse energy hadron clustering was far from uni-

How a Z^o looks in the UA1 detector. Left, display of a proton-antiproton collision, showing central detector tracks and calorimeter hits. After removing low energy signals, only the electron-positron pair produced by the Z^o remains (right). At the Brighton Conference, Karsten Eggert gave an admirable presentation of UA1's hunt for Z^os.





versally accepted until the Paris Conference last year. Then, a new harvest of results, including notably the striking UA2 signals, made jet physics respectable.

The jet evidence from UA1 and UA2 is now very impressive and opens up the field for much further study. UA2 in particular has recorded events where nearly half the available collision energy (540 GeV) is diverted from the incoming particles into hadron clusters emerging at large angles to the beams.

Collider jet results were reported at four levels — first the experiments themselves (K.Sumorok for UA1 and J. Schacher for UA2), followed by a mini-rapporteur session by H. Kowalski who compared the protron-antiproton and electron-positron results. Jet behaviour was summarized in plenary talks by P. Söding on quark and gluon fragmentation, and by R. Sosnowski on hard hadronic interactions.

There appear to be strong similarities between the electron-positron and proton-antiproton jet results, but systematic differences between the hadron jets produced by quarks and those produced by gluons are now appearing. The relative roles played by quarks and gluons in the CERN collider jets are especially interesting. These jets provide a new source of information for quantum chromodynamics — the emerging theory of quark and gluon interactions.

The collider jet results were also covered by Rubbia in his concluding talk. He said that the behaviour seen so far indicates that quarks are point-like down to 10^{-17} cm.

But Brighton was not just a showcase for the CERN SPS collider. The PEP electron-positron ring at SLAC has been recording data at prolific rates, and one of the pay-offs is a measurement of the B-meson lifetime by the MAC (G. Chadwick reporting) and Mark II (G. Hanson) detectors. (Next month's issue will include a full story.) At $10\text{-}20 \times 10^{-13}$ s, it looks longer than the typical charmed meson lifetime ($4\text{-}8 \times 10^{-13}$ s). This is of immediate interest for theorists constructing pictures of quark and lepton families.

This was covered by C. Jarlskog in her excellent rapporteur talk on weak decays. The suppressed B-decay hints at underlying selection rules. The effective top quark mass could be about 40 GeV, but this depends on the model and the number of quark/lepton families used. This input is surely of interest for those busily scanning the CERN collider data.

Also at SLAC, the Mark III detector at the SPEAR ring has produced its first results, and K. Einsweiler reported evidence for a new state seen in the radiative decays of J/psi particles. A distinct 2.2 GeV resonance is seen in the two kaon spectrum. The interpretation of this state is not yet clear, but as soon as the news was out, theorists began to speculate.

A range of experiments at PETRA and PEP show that there are differences in the way that charm and beauty quarks 'fragment' into hadrons. The b-quark description looks much 'tighter', possibly indicative of the heavy quark mass involved, hinted Söding.

Another Brighton talking point was provided by the ITEP (Moscow) group studying the beta decay of tritium (I. Lubimov reporting). An experiment from this group several years ago gave a non-zero mass for the electron neutrino. The study has now been refined and with substantially reduced backgrounds gives a lower limit for the electron neutrino mass at 20 eV. This has important implications for cosmology.

Spurred by the successes of electroweak unification, theorists are taking a long hard look at the next step — unifying the electroweak force with strong interactions as well. One spin-off of these 'grand unification' ideas is a slightly unstable proton.

The search for nucleon decay is very much in a state of flux. Rapporteur E. Fiorini had no news of further events from the Kolar Gold Fields experiment in India (still three events, now diluted by more data), but there is more data from the Mont Blanc experiment and the big Irvine / Michigan / Brookhaven study using Cherenkov detectors immersed in thousands of tons of water. Other new searches in the US and Japan have gone live recently, and at Brighton L. Sulak for the IMB team was not able to report on the analysis of all the data collected so far.

These experiments need time, and it will be a while before a definite result starts to emerge. But from the relatively meagre data processed so far, it looks as though the 'minimal' theory which attempts to bring together strong and electroweak interactions seems to be in trouble, and some other scheme is needed. However the theoreticians are far from being pessimistic, and there is a deep underlying confidence in the idea. 'Grand unification is no crackpot idea', said one expert. If the minimal theory seems to be off-target, the implications of the final form of a grand unified theory could reach further.

At Brighton, there was a lot to be optimistic about. If only supersymmetry could get airborne!

(First report by Gordon Fraser. A fuller version will appear in the October issue.)

Fermilab back in business

Jubilation in the control room as the new Fermilab superconducting ring pushes protons to 512 GeV, a new world record, but only a taste of bigger things to come.

After a shutdown lasting more than a year, Fermilab resumed business with a bang on 3 July when the new Energy Saver reached its primary design goal — accelerating protons to 500 GeV in the world's first big superconducting ring. In fact the energy attained was 512 GeV — a new world record — set only thirteen hours after the first serious attempts to accelerate beam beyond the 150 GeV injection energy.

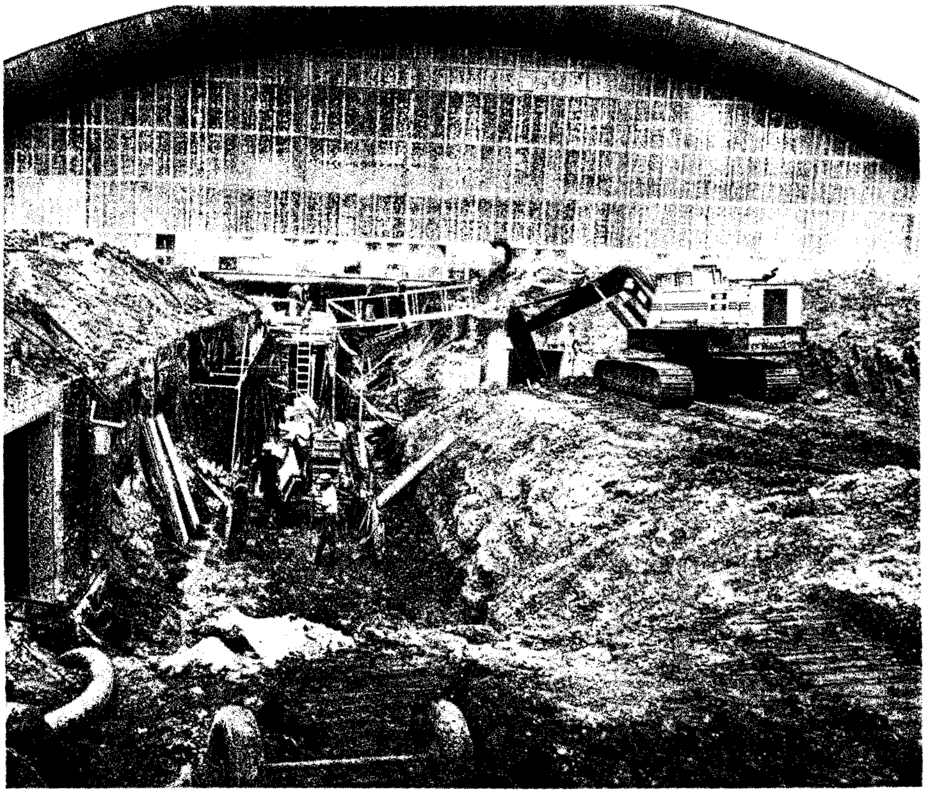
Previously, initial difficulties in maintaining coasting beam at 150 GeV were diagnosed as being due a misdesigned flange and a stray paper tissue left in the bore tube. With this rectified, storms and torrential rain delayed acceleration tests, but when all was ready, everything went smoothly. First 250, then 400 GeV were attained, and the 500 GeV goal surpassed amidst general jubilation.

A 400 GeV physics run is scheduled for October, and obtaining the required intensity and mastering the beam extraction to the experimental areas still requires a lot of work. However the heroic efforts of the Fermilab team were rewarded by the initial performance during the commissioning period, which also augurs well for the Energy Doubler and its target of 1000 GeV, or 1 TeV.

Eyes are now turning toward the Tevatron experimental areas. During the machine installation shutdown, work in these areas has also been pushed hard to prepare for the higher energy beams which will be available.

Significant progress has been made in completing the extraction system for the Tevatron. All of the required elements have been installed in the accelerator tunnel except for two electrostatic septa, which will not be installed until beam has been accelerated. Already in-

Drastic changes in the Fermilab landscape. For the Tevatron, the big Meson Experimental Hall becomes a Target Hall. New primary beam focusing enclosures are seen here under construction upstream of the hall. New experimental halls will be built downstream.



stalled are five Lambertson magnets in AO, three Doubler magnets that make up the extracted beam channel in the Transfer Hall, and ten air-core quadrupoles, some of which are pulsed to initiate fast resonant extraction and some varied under computer control to smooth the spill during slow resonant extraction.

The Switchyard for the Tevatron begins in the Transfer Hall and terminates with eight primary beams directed to the three big experimental areas. The major projects in the Switchyard include the superconducting Right Bend to the Proton Area, an additional primary beam to the Meson Area, an additional beam to the Neutrino Area, and upgrade of the beam electrostatic splitting stations to 1 TeV capability. The superconducting conversion of the Left Bend serving the Meson Area was done several years ago.

The Right Bend to the Proton Laboratory was the single largest effort in the Switchyard. It involved the replacement of 34 conventional dipoles with 14 Energy Doubler dipoles. It was also necessary to construct approximately 1000 feet of liquid helium transfer line and another 1000 feet of low pressure helium header. A satellite refrigerator was installed at the Switchyard Service Building. Helium connections were also made to the Main Ring A2 Service Building to make all of the Switchyard cryogenic systems part of the Energy Doubler system. This connection provides additional refrigeration to the Switchyard from the Central Helium Liquefier.

The second major task in the Switchyard is the upgrade of the beam splitting stations. This includes the construction and installation of twenty-one electrostatic septa. Most of these are at or near completion, but three septa to split the new muon beam from the neutrino beam will not be built and installed until next year.

The splitting station upgrade has also involved the implementation of a completely redesigned septum moving system that will eventually allow computer controlled alignment. It will also be possible to adjust beam splits by moving septa rather than adjusting the beam position on the septa with magnetic beam components. These improvements should result in greater beam stability for experimenters.

A last major effort for the Tevatron II upgrade of the Switchyard is the implementation of the new Tevatron control system. This work is well under way. The new system was used to control the Switchyard helium compressors during cooldown of the Saver.

For the Switchyard, no obstacles are presently seen which could hamper the delivery of beam to all three experimental areas in October.

The entire primary proton beam target plan for the Meson Area was changed for Tevatron physics. The old philosophy of having a single primary target viewed by several secondary beam transports has been scrapped in favour of a triple primary beam split and three separate target stations. It is much more economical in terms of protons to split up the primary beam and let each secondary beam enjoy forward particle production. In the case of Meson, there will be three primary targets in three separate target shielding piles located in the former Meson Experimental Hall. This building thus becomes the Meson Target Hall.

For the first Tevatron running period, an attenuation target in the old Meson target box will still be used. The target train for this interim system will serve in later runs as a primary beam transport and collimator system with one (or more) transmission targets to service a test beam.

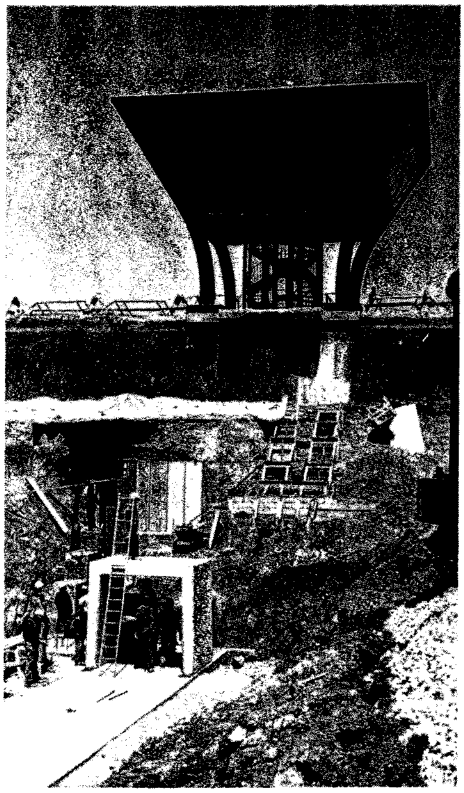
A great deal of effort has gone into the Meson cryogenics systems. A set of three Saver-type satellite helium refrigerators are grouped together in a single building, from which the seven cryo magnet strings in the Meson primary beam area will be controlled from common helium supply and return mains. The entire Meson cryogenics effort is on schedule and is expected to be ready for physics in October.

Downstream of the Meson Target Hall, new secondary beams have been worked out and two new experimental halls are being designed.

Work in the Neutrino Area has focused on bringing primary protons of 1 TeV into the Neutrino Target Hall for use in the three available beamlines, and work is progressing well. Plans for the Prompt Neutrino and Muon beams are essentially complete. Design work is under way on the civil construction, roads and utilities for these new beams. Additional buildings are under construction to house new experiments, notably those using holographic bubble chamber techniques.

Construction of the new Muon Laboratory has begun. This is a complicated operation since the large superconducting Chicago Cyclotron Magnet first must be moved into position, and the building then erected around it.

The neutrino experimental programme will start in the second Tevatron running period with a 600 GeV broad band triplet run. Construction of the triplet and dichromatic trains are proceeding steadily. It is expected that a test of a train at the end of the first running period will be possible. A new feature of neutrino beams in the Tevatron will be the



location of the primary target about 300 feet upstream of the old one. The new targeting method will not only increase neutrino yields via a longer decay path, but will also permit more effective monitoring of the parent hadron beam.

The primary beam handling for the upgraded existing beams in the Proton Area has already been completed and checked out, including a satellite refrigerator for superconducting bends. Cryogenics for the Proton Area are virtually complete.

A large amount of civil construction has had to be undertaken in the Proton Area, which will include the new Tevatron wide band photon beam. While design of the wide band beam itself is being finalized, design attention turns to the new experimental hall.

The Proton West high intensity beam will shortly be ready for primary protons up to 1 TeV. The secondary beam will go to 300 GeV and concentrate initially on negative pions and antiprotons.

Production of conventional and superconducting magnets for the beam areas is well ahead of schedule. All the Saver-type superconducting magnets needed for the fixed target upgrade are already completed and most are installed. A much larger number of new conventional magnets also had to be made. Preparation began two years ago and the magnets are now rolling off the assembly lines. If all goes as planned, all the magnets will be completed by next June, allowing Tevatron physics with the new secondary beams in advance of current plans.

To prepare for Tevatron beams, a lot of civil engineering work was required in the Fermilab Proton Area. Here an enclosure for the primary beam is being constructed under the Proton 'Pagoda'.

(Photos Fermilab)

The changing face of DESY

In more ways than one, the proposed HERA electron-proton collider looms large over future plans at the Federal German DESY Laboratory. Once final approval is obtained, a vast programme of civil engineering work and equipment construction would be launched. To accommodate HERA most of the existing DESY machines would be modified, and by 1990, when the new machine is planned to come into operation, DESY would have undergone an almost total facelift.

In the 6.5 km underground HERA ring, extending far beyond the boundaries of the DESY site, protons would be accelerated up to 820 GeV and electrons up to 30 GeV. International involvement in the project is being cultivated, with a 'shopping list' of requirements which could be supplied by other countries.

To develop the superconducting magnets for the HERA proton ring, a big effort has been mounted. Using the cold bore/warm iron (Fermilab-type) approach, a number of 1 metre dipole magnets have been built and measured extensively. These tests are continuing. However initial trials were encouraging enough for full-length 6 metre magnets to be built, and these too are undergoing stringent tests. Much was gained from the initial Fermilab experience with this type of magnet.

The present HERA warm iron design uses interlocking aluminium segments to form a rigid collar which grips the superconductor assembly and withstands the tremendous forces involved. Rather than being welded, these collars are closed by tie rods, so that the magnets are relatively easy to take apart.

The tooling for winding, compressing and assembling these magnets has been developed to the stage where it could be taken over by industry.

In addition, cold iron (Brookhaven type) dipole magnet design is being developed by industry. Quadrupole magnet design is being worked on at Saclay, and a scheme is being investigated at NIKHEF, Amsterdam, to mount correction coils inside the main magnets.

It is hoped that a final decision on the magnet design will be taken at the end of next year, leading to full production in 1986. The project would also require the biggest helium refrigeration plant in Europe and two designs are under study.

HERA civil engineering presents no apparent problems. The legal aspects of the project have been tied up to the satisfaction of all concerned, and there is wide experience of tunnelling for other large civil engineering projects in the Hamburg area.

Less clear at the moment are the plans for experiments at HERA at the four proposed intersection regions. Working groups have been set up, and periodic workshops have been held (see page 256) to examine the physics attractions of HERA.

Colliding high energy protons with lower energy electrons is highly asymmetrical, with the overall centre-of-mass very much on the proton side. However the proton's component quarks can carry much less momentum, and important physics should also be seen in the central region around the collision point in the laboratory.

Extensions of existing detectors could be attractive, and this is being studied by one working group. Another group looks at new purpose-built detectors. Rather than seeking general-purpose designs, the mix of detectors finally adopted could be complementary. As for LEP, much of the cost of the experiments would have to be carried by the participating institutes.

A full-length 6 metre prototype superconducting magnet for the proposed HERA ring at DESY. The fixed cryostat used for testing these magnets is in a pit in the floor.

(Photo DESY)

Existing machines

At the existing PETRA electron-positron ring, the push towards higher energy continues, undeterred by developments elsewhere. Thanks to the installation of additional r.f. equipment, the total collision energy is being nudged higher in 15 MeV steps in a careful scan for new thresholds. At each new energy step, a stipulated number of collisions are logged before the energy is increased once more.

At the end of the summer shutdown in July, the total energy reached 43 GeV. After installation of the maximum possible number of conventional r.f. cavities, the subsequent run will push up to the 45 GeV ceiling. The quest for higher energy in PETRA has dominated over luminosity (number of collisions). With finally some 200 metres of cavity in place, there are strong interactions on the beam which limit its current. The subsequent running conditions in PETRA have yet to be decided.

Even if nothing is found at the peak PETRA energies, the new r.f. cavities represent money well spent as the surplus cavities could be taken out (thus restoring lost luminosity) and used for the HERA electron ring.

PETRA is also the scene of valuable tests with new superconducting r.f. accelerating cavities (see May issue, page 129). Both DESY and CERN have a stake in this work, CERN's effort being geared to boosting the energy available from its new LEP ring. For DESY, superconducting r.f. could provide a way of maintaining PETRA at high energies without spoiling beam quality, and at less expense.

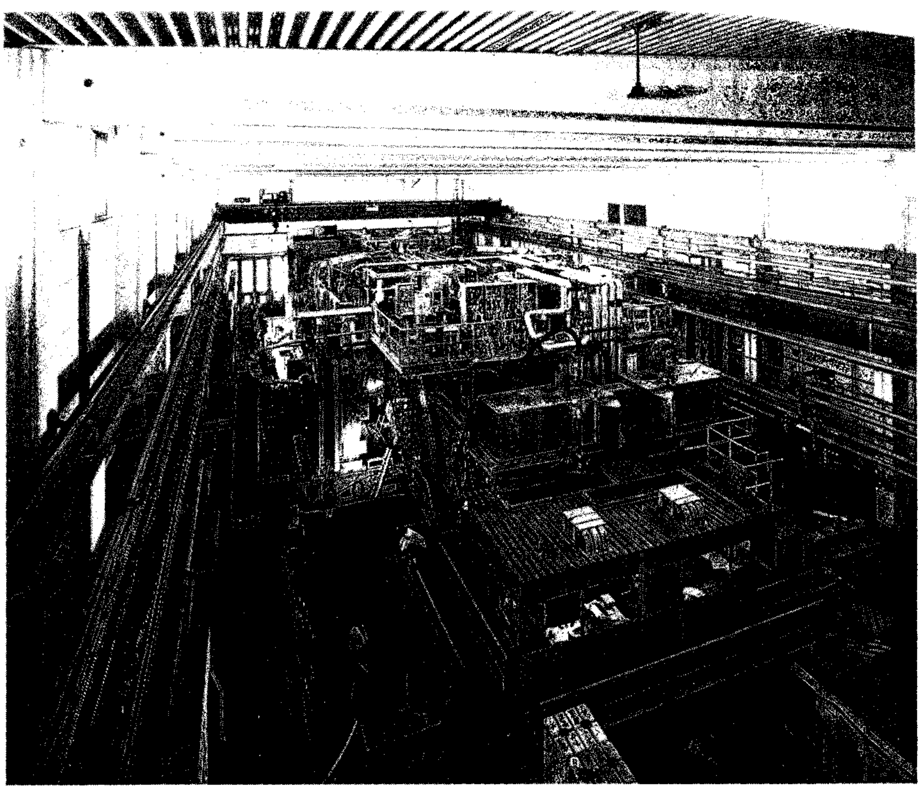
Because PETRA would be needed as the injector for HERA, the present physics programme is seen as having a limited lifetime. The four detectors currently installed (TASSO, Mark-J, CELLO and JADE) each have their own plans for natural development and improvement to extend the already impressive list of physics achievements. No major changes in the experimental lineup are foreseen. The PLUTO detector is now out of the ring for good and is currently being used in a passive study to look for signs of double beta decay.

Also with HERA in mind, the venerable 7.5 GeV electron synchrotron (DESY I), in service since 1964, is to be replaced by DESY II, a new 9 GeV electron machine to be built in the same tunnel. Installation is foreseen for winter 1984-85, with tests in 1985 and final connections in winter 1985-86. DESY I would then be transformed into the proton injector for HERA.

The rebuilt DORIS II ring is now working in the upsilon region, accumulating data at 100 times the rate at which upsilon events were seen at DORIS I back in 1978. After sitting at the narrow 2S upsilon, the plan is to move up to the wide 4S state to look at the B mesons which are produced. Between them, the Crystal Ball and Argus experiments hope to amass a wealth of data on upsilon spectroscopy and on decay processes. Crystal Ball contributed significantly to knowledge of charmonium spectroscopy at the SPEAR ring at SLAC, and is now covering the same ground for the heavier quark-antiquark bound states. The present DORIS II experiments are foreseen as continuing for several more years.

If HERA construction goes ahead, it is possible that for some time before the big machine comes into action there will be few experiments running at DESY. DORIS II will still be there, and PETRA could be made available at lower energy, except for a period of some three months. But there will be a lot to do, with a big new machine to be commissioned and the experiments for it to be constructed and tested. With such an ambitious programme, DESY will continue to be in the forefront of the international particle physics scene.

(Report by Gordon Fraser.)



The CELLO experiment at the PETRA electron-positron collider at DESY. At the rear of the hall, the PLUTO detector can just be seen. After sterling service at both the DORIS and PETRA rings, PLUTO is now being used in a passive search for double beta decay.

(Photo DESY)

Experimentalists prepare for HERA

At the Amsterdam workshop to discuss experiments for the proposed HERA electron-proton collider at DESY. In the front row is DESY Director Volker Soergel, and behind him is NIKHEF Director Walter Hoogland, who chaired the workshop organizing committee.

In June, over 200 physicists met in Amsterdam to discuss future experimentation at HERA, the 30 GeV electron — 820 GeV proton collider planned at DESY. The workshop was organized jointly by DESY, the European Committee for Future Accelerators (ECFA), and the Dutch National Institute for Nuclear and High Energy Physics (NIKHEF). The international interest in the HERA project was clearly illustrated by the fact that, apart from the large German delegation, about half of the participants came from eleven other countries.

After the opening speech by NIKHEF director Walter Hoogland, who chaired the organizing committee, Volker Soergel, chairman of the DESY directorate, outlined the present status and a future scenario for the HERA project. As a condition for definite approval, the German Federal Government demands a significant foreign contribution to the construction of the machine. Negotiations are under way with institutions in six different countries. According to Soergel, it is not unreasonable to hope for final approval by the end of this year. The civil engineering work on the construction of the tunnel and the intersection regions could then start early next year. In this scheme, the electron ring would be installed in 1987, two years later followed by the delivery of the superconducting proton ring. In 1990, the first electron-proton collisions could be brought about. As for HERA experiments, a call for proposals is expected after the final approval, with letters of intent examined next summer.

The physics to be studied with HERA was reviewed by Luciano Maiani and Don Perkins. In spite of recent successes at CERN, the present standard theory is not completely satisfactory, said Maiani. There are many particles and coupling strengths to be explained, and the standard theory could be extended. HERA could verify fascinating new ideas (supersymmetry, compositeness of quarks and leptons), provided that the corresponding mass scales are within its range. In any case, HERA offers a unique means of testing the theory of quark interactions (QCD) over a wide range of inter-quark distances. And HERA will open up the study of electron-quark interactions when the weak component of the interaction dominates the electromagnetic one. This could reveal new components in the weak interaction, in particular those involving the exchange of a right-handed boson. Don Perkins emphasized that all existing ideas are based on an extrapolation of present knowledge. HERA offers in the first place a new, unique and clean window to the world of subnuclear matter, and it is not at all certain what will be seen through it.

A major part of the workshop was devoted to the work of various groups set up to study aspects of experimentation at HERA. Adolf Minten reviewed the status of the technology for particle detection and identification. Apart from leptons, the latter aspect will be of minor importance at HERA. Most of the work performed by his group concentrated, therefore, on calorimetry. Several options were worked out, including a cost estimate. It became clear that a magnet is incompatible with an optimized hadron calorimeter.

Wolfgang Bartel's problem was how to achieve optimal conditions in the intersection regions. The group convened by him studied background rates and proposed solutions to reduce these to an acceptable level. They gave boundary conditions for magnetic fields maintaining a sufficient degree of beam polarization, essential for the study of electroweak interference effects, and proposed ways to monitor the luminosity, beam polarization and vertex position.

Jos Engelen emphasized HERA's capabilities for studying photoproduction at much higher centre-of-mass energies than existing accelerators. A large total cross-section and the separation of beam and target fragments would result. This type of experiment needs excellent electron tagging, down to the smallest scattering angles possible. The working group proposed silicon technology for this purpose.

The problems related to small angle lepton scattering were, obviously, the least of the worries of the group that examined deep inelastic processes. Emilio Longo summarized the impressive wealth of information gathered. It turns out that the design of an ideal detector strongly depends on the specific information required. Thus there are good reasons to equip HERA with detectors that are complementary to each other, rather than the ubiquitous general purpose detectors of electron-positron physics.

The detection of a now quite familiar list of exotic phenomena was covered by Roger Cashmore. This group met the same challenge as Longo's, namely how to compromise between the best possible hadron calorimetry and particle tracking in a magnetic field, the latter being needed to identify leptons and determine their properties.

After all these talks about exciting phenomena to be studied with ideal detectors, Martin Holder took the audience back to reality, reviewing possibilities for existing detectors to be transferred to HERA, and the minimal modifications needed. CELLO, JADE, TASSO and ARGUS (all serving at DESY) were examined.

Tini Veltman's summary talk covered the mysterious Higgs sector. He doubted that HERA would reach the precision needed to determine the radiative correction effects linked to the Higgs mechanism, which could clarify the situation. However he recommended the experimentalists to view with suspicion whatever the theorists might say. HERA, to his mind, is a new instrument to enter the unknown, a microscope that offers an order of magnitude increase in magnification over existing machines, and it should be used to carefully and systematically explore the new domain. Judging from the enthusiasm of the discussions, the physics community is very anxious to have a look.

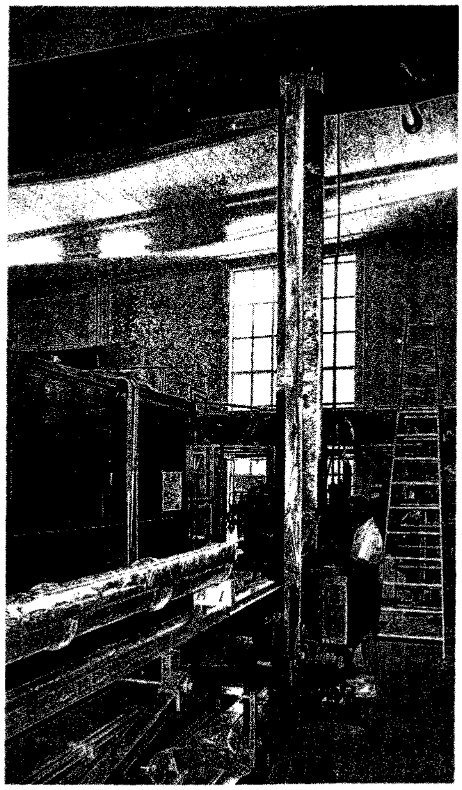
(We thank Richard Wigmans for this report.)

ECFA statement on future prospects

A Plenary Meeting of the European Committee for Future Accelerators was held at CERN on 8 June to take a look at medium and long term prospects. There were talks on the various projects (the antiproton programmes, SPS, LEP, PETRA and HERA) which are sustaining the present and potential future of high energy physics in Europe in such an exceptionally healthy state. The major concerns are to ensure the necessary resources to make fruitful use of the potential which has been so painstakingly built up.

ECFA has supported the LEP electron-positron project at CERN with first priority and, in recent years, has also supported the HERA electron-positron project at DESY. The June Meeting took a new look at future prospects in the light of the brilliant success with the CERN proton-antiproton collider and of the 'in principle' approval of HERA.

The Meeting concluded with a statement of which the following is a slightly condensed version, with a few additional explanatory notes in brackets.



At DESY, a 6 metre prototype superconducting magnet for HERA is gently lowered into its cryostat for testing. The 'in principle' support of the German government for HERA is one of the recent developments which led the European Committee for Future Accelerators (ECFA) to take a new look at the medium and long term future.

(Photo DESY)

Medium term, to 1988

The proton-antiproton collider experiments should continue to receive priority in the research programme in the period up to LEP operation, while maintaining a proper balance with the SPS fixed-target and LEAR activities. (CERN, in collaboration with other Laboratories, is studying the possibilities of a large increase in luminosity, perhaps involving a new Antiproton Collector ring in addition to improvements on the present system.)

Reductions in budget have already put the Research Programme under severe stress and will seriously impair the capacity of CERN to exploit this major success. ECFA therefore requests the CERN Council in future to grant the full cost variation index and over the next three years to make an additional sum available to enable CERN to increase luminosity and so reap the deserved rewards of this imaginative enterprise.

Following the agreement that no increase of budget would be made for the construction of LEP, the ISR programme will be prematurely terminated. However the effective decrease in the budget now endangers the SPS fixed-target programme. ECFA reasserts the importance of maintaining the quality of the SPS fixed-target and LEAR programmes; it must be remembered that these will continue to be a major source of physics results throughout the next decade and beyond. (Even when LEP begins operation CERN expects that some 800 physicists will remain involved in the fixed-target programme. LEAR — the low energy antiproton ring — has already attracted over 250 physicists to an experimental programme using antiproton beams of an intensity, purity and quality never obtained before.)

Long Term, 1988 onwards

The discovery of the Z^0 confirms that the physics at LEP will be as rich as anticipated. ECFA welcomes the progress already made towards its realization and stresses the need for completion by 1988.

HERA will provide a unique 'window' on fundamental processes in excellent complementarity to LEP and a necessary second base for European high energy physics through the 1990s. ECFA welcomes the step taken by the German authorities to give approval in principle for HERA, so continuing at DESY the excellent tradition established most recently by DORIS and PETRA. ECFA strongly supports the request for other countries to share in the construction and hopes that such commitments will be made in time to allow construction to start next year. (The electron ring could then be ready in 1987 and the proton ring two years later. A Workshop on Experimentation at HERA, attended by some 180 physicists, was held at NIKHEF Amsterdam from 9-11 June and made a good start on preparing the experimental programme — see page 256.)

It has always been foreseen that, after Phase 1 operation at about 100 GeV, the LEP centre-of-mass energy could be increased by introducing superconducting r.f. cavities. Recent successful tests of superconducting cavities (developed at CERN) operating in PETRA indicate that this advance would be possible.

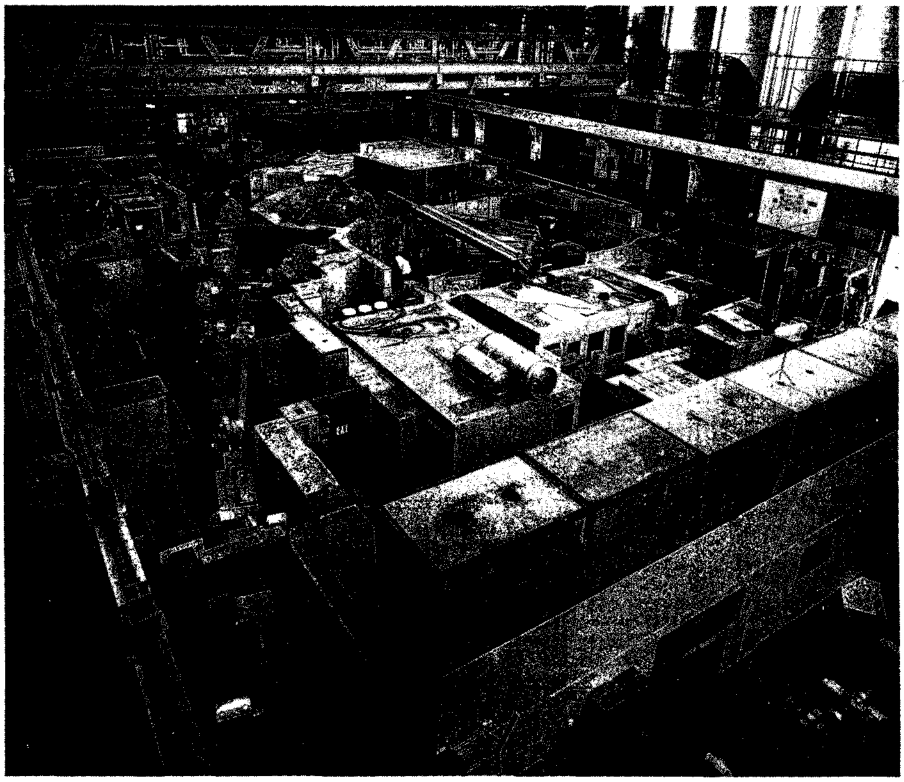
The demonstrated success of the proton-antiproton collider as a means of studying elementary processes at the quark and gluon level, opens up the prospect of using such collisions at much higher energies, about ten times the 2 TeV which will be possible at the Fermilab Tevatron. This would probe a new energy regime where new structure is expected. This prospect is of great interest and is receiving a lot of attention now in the USA (see next story). ECFA notes that such energies could be reached with superconducting magnets in the LEP tunnel and recommends that this possibility be investigated and that the development of the techniques for high field magnets, about 10 Tesla, should be supported in Europe.

Experimental high energy physics is a scene of dramatic progress and the prospects for the future are bright. The European Laboratories and physicists have demonstrated their capacity to lead the world in this field, but the downward trend of support both for CERN and in the Member States puts this at serious risk. In some countries the reductions now threaten the ability of physicists to take part in experiments. ECFA urges the European countries to reverse this decline in support so that we may take full advantage of the great possibilities before us.

Around the Laboratories

One of the big attractions of CERN's physics programme is the LEAR Low Energy Antiproton Ring. Seen here is the crowded experimental hall, housing 17 experiments involving some 260 scientists. First data has been taken.

(Photo CERN 1.5.83)



USA 'Forefront' programme

Official recommendations have been made which could change the face of US high energy physics. At the request of the US Department of Energy which funds most of the particle physics research in the US, a 'facilities subpanel' of its High Energy Physics Advisory Panel (HEPAP) studied the present situation and emerged with recommendations for the establishment of a 'forefront' USA high energy physics programme. A major influence in their decisions was the realization that the initiative in particle physics has passed, on many fronts, to the CERN and DESY Laboratories in Europe.

After visiting the major US Laboratories (Brookhaven, Fermilab and Stanford) the subpanel met at Woods Hole, Massachusetts in June under the Chairmanship of Stanley Wojcicki, to discuss their findings and formulate recommendations.

The major recommendation was an immediate start on a multi-TeV (10-20 TeV) high luminosity hadron collider. The machine has already gained its customary initials — SSC for Superconducting Super Collider. Some of the consequences of this major recommendation are hard. By a majority vote (10 to 7) the subpanel recommended the termination of the Brookhaven Colliding Beam Accelerator project. The CBA (formerly ISABELLE) had reached a healthy state after previously troubled years. The superconducting magnet development was mastered, much of the civil engineering was completed and managerial infrastructure established. The Brookhaven team is now hoping for significant participation in SSC and alternative uses for the CBA tunnel are being sought.

Other recommendations of the subpanel were — rapid completion of the Fermilab Tevatron and Stanford SLC and the upgrading of the Cornell CESR; no go for the Fermilab Dedicated Collider; strong support of advanced accelerator research and development.

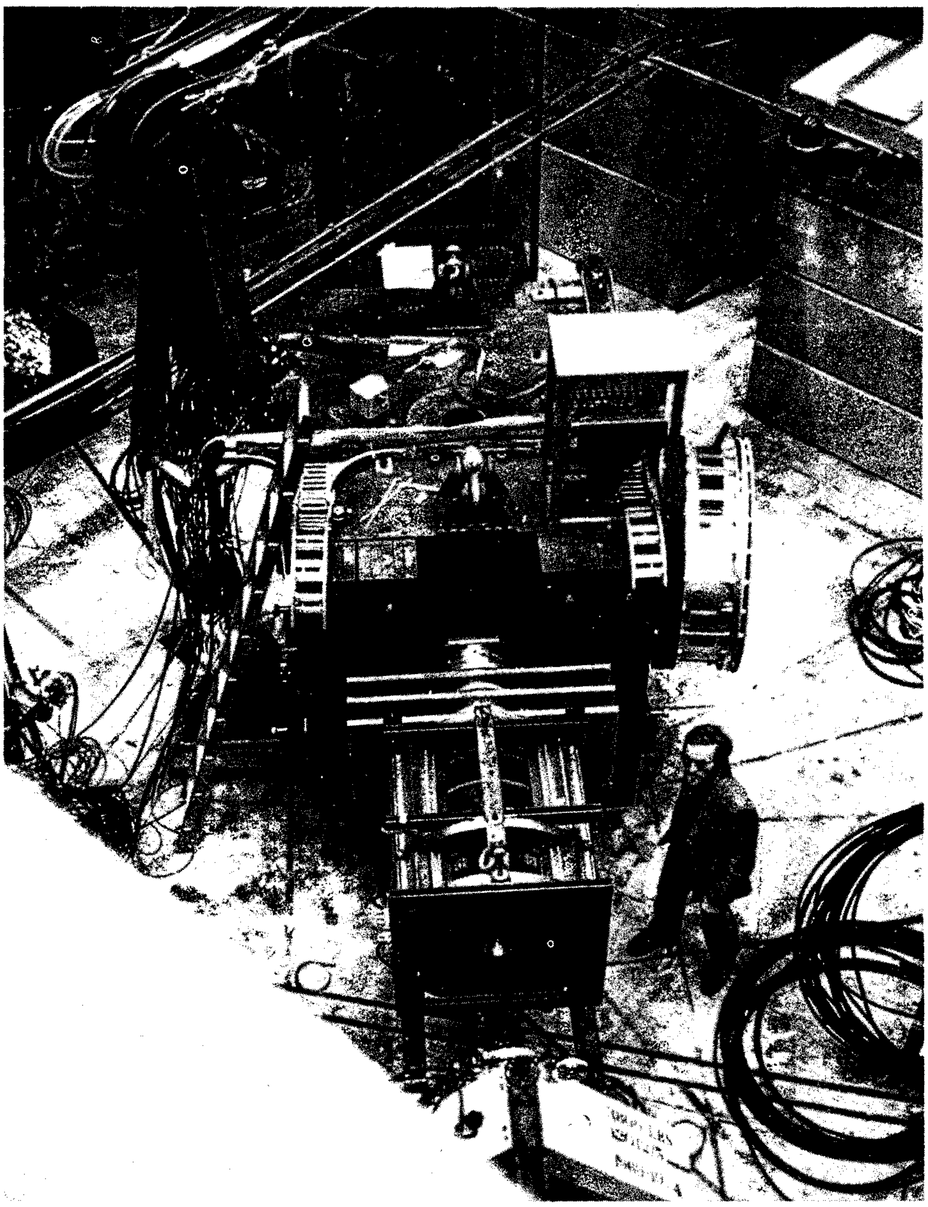
CERN Council Session

The two major items on the agenda of CERN Council when it met from 23-24 June under the presidency of Sir Alec Merrison were reports from Director General Herwig Schopper on recent progress at CERN and on the scientific programme foreseen for the next four years.

The first report was, of course, dominated by the discoveries of the W and Z particles. The Council asked that their congratulations be conveyed to the CERN staff. But there was also a lot to report about the physics elsewhere at CERN. There is an intensive programme to be completed at the Intersecting Storage Rings before the scheduled close-down of the machine at the end of the year (apart from charm spectroscopy using a gas jet target in a single ring). The fixed target programme at the SPS is under way once more. The low energy antiproton ring, LEAR, is beginning physics with beams of an intensity, purity and quality never before accessible. (As an example of what is to come, slow ejection tests achieved ejection for as long as thirty minutes — equivalent to one antiproton leaving the ring every two turns!)

The Proton Synchrotron has the prospect of a programme of heavy ion physics (see July issue, page 223). The synchro-cyclotron and the ISOLDE isotope separator

Muon polarimeter during assembly at TRIUMF. In the foreground is the solenoid which provides the muon spin-holding field and which focuses the decay positrons. In the background is the positron spectrometer consisting of the 'Sagane' magnet with drift chambers upstream.
This experiment has obtained a new upper limit on the coupling of charged weak currents to right-handed leptons.



continue to be the scene of some refined physics.

The coming years will be dominated by the building of LEP and the preparation for the four approved experiments. Construction of the underground ring tunnel to house the electron-positron collider will begin very soon and about half of the contracts for machine components have been placed. The four experiments, ALEPH, DELPHI, L3 and OPAL (see October 1982 issue, page 322) have been designed and costed in detail. Over 900 physicists are involved and contracts with the participating research centres are being drawn up specifying responsibilities and financial commitments. Thus the whole timescale and expenditure profile of the LEP project is now much clearer.

But during the same period, CERN is eager to follow up the glorious successes of the proton-antiproton collider and has plans for luminosity increases and detector improvements. There is also a vigorous programme of fixed target physics in front of the SPS. All together, CERN is presently providing physics research facilities for 2600 physicists from 190 universities and laboratories and these numbers are still rising. The available resources for this huge volume of work are strained to their limits and, in addition to the ISR closure, other cuts might be necessary.

The Council was pleased to learn that the formal ratification of the re-accession of Spain to CERN is imminent. After a unanimous vote in the Foreign Affairs Committee the Spanish Congress voted 95 per cent in favour at a plenary meeting on 21 June.

The Council approved a further Protocol to the original Agreement of July 1967 between CERN and the USSR State Committee for Atomic Energy. The Agreement concerns scientific and technical cooperation and has led particularly to CERN collaborations at the Serpukhov 76 GeV proton synchrotron and Soviet participation in experiments at the SPS. The new Protocol extends the scope so as to allow Soviet participation in LEP experiments on the one hand and CERN participation in experiments at the 3 TeV UNK proton synchrotron at Serpukhov at the other.

TRIUMF
Looking for right-handed currents

A Berkeley group in collaboration with B. Gobbi (Northwestern) and C. Oram (TRIUMF) has obtained a new upper limit on the coupling of charged weak currents to right-handed leptons. Operating in the

M13 surface muon channel at TRIUMF, the experiment is the first to measure precisely the endpoint decay spectrum for muons with extremely high average polarization.

The experiment was motivated by the apparent absence of charged weak currents with other than the conventional left-handed coupling. In the standard electroweak model, the left-handed charged weak current is carried by a W boson with a mass of about 80 GeV, as shown by recent measurements at the CERN proton-antiproton collider. Since reaction rates go as the inverse fourth power of the W mass, earlier data did not exclude the possible existence of a heavier, right-handed boson with a mass above 220 GeV.

As long as the momentum transfer is well below the conventional left-handed W mass, and the right-handed neutrino is light enough not to influence the kinematics, the effects of right-handed W exchange relative to those of conventional W exchange are expected to be energy-independent. In this context, precise low-energy measurements of purely leptonic decays can play an important role.

The measurement at TRIUMF is made possible by the nearly complete polarization of a positive muon beam derived from positive pion decay at rest near the surface of the target within which the pion is produced. (The first such 'surface' muon beam was developed at the Berkeley 184 inch cyclotron by the Arizona group a decade ago.) When the positive muon is fully polarized and only left-handed coupling is present, no positron should be emitted with maximum energy in a direction opposite to the muon spin. Conversely, for right-handed coupling, such decay is maximized.

Unlike higher-energy muons, the TRIUMF 4 MeV 'surface' muons have a precise range — if incident upon the CERN Courier, most would stop on the same page. The experiment's muon stopping targets were thin foils of pure aluminium, copper, silver, and gold, where the high concentration of free electrons screens the positive muons from the depolarizing effects of prolonged spin-spin coupling to particular electrons. Data were collected both with the stopped muon spin held by a 1.1 T longitudinal field, and with its spin precessed by a 70 gauss transverse field. The sharp edge at the endpoint of the positron momentum spectrum for the spin-precessed data was used for calibration.

The decay positrons were focused by a solenoidal field lens and momentum-analysed by a cylindrically symmetric focussing spectrometer based on the venerable 'Sagane' magnet. Constructed at Berkeley some three decades ago, where it was first used in a not totally successful measurement of the muon decay Michel parameter, the old magnet and its paper-insulated coils responded favourably to this new chance for redemption. With 200 micron measuring accuracy achieved in methane drift chambers at the spectrometer's conjugate foci, a positron momentum resolution of less than 100 keV was obtained within the 0.2 steradian acceptance.

Data recorded within four weeks of the experiment's first beam in the spring of 1982 have now been analysed and the results submitted for publication. (A larger sample was collected in late 1982.) In terms of traditional muon-decay parameters, the 90%-confidence limit shows more than an order-of-magnitude improvement over older measurements. This means that if a right-handed W boson exists at all, it has to be heavier than 380 GeV!

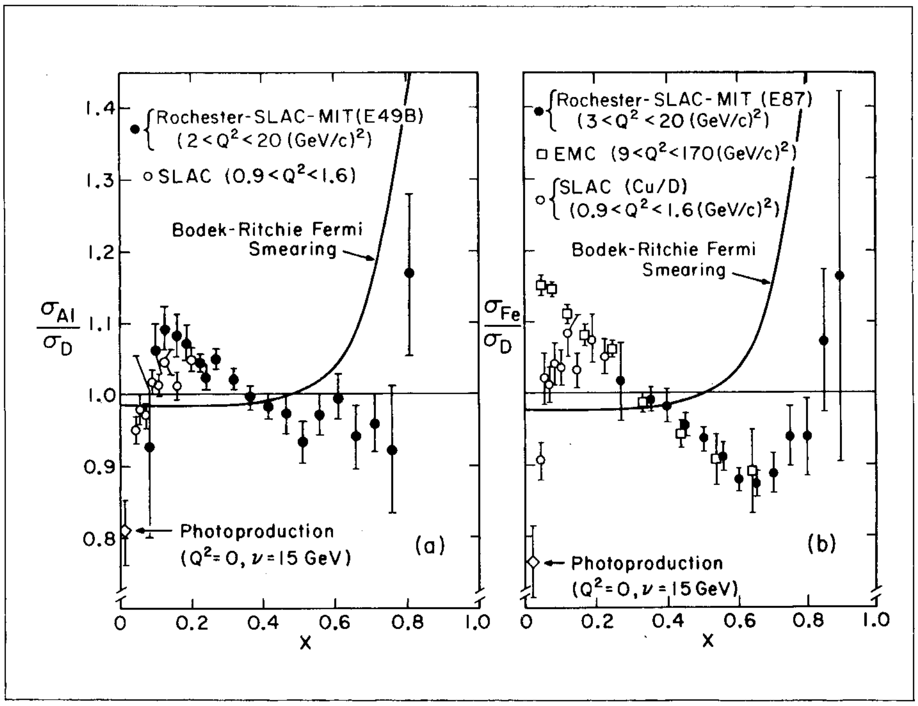
SLAC
More physics archaeology

Recent results from high energy muon experiments at CERN (see November 1982 issue, page 362) and electron scattering experiments at SLAC (see April issue, page 90) indicate that there is a significant difference between the nucleon's quark structure (structure functions) for nucleons bound in steel and nucleons bound in the deuteron. Now the same effect has also been observed for nucleons bound in aluminium using data from deep inelastic electron scattering experiment E49B, originally performed at SLAC in 1970. The data for aluminium were obtained by analysing the empty-target data which were used originally to subtract the target wall contributions from the liquid hydrogen and liquid deuterium data.

The data show a significant momentum fraction (x) dependent difference between aluminium and deuterium cross-sections in a manner opposite to that expected from Fermi-motion effects. Within the quark-parton model the x distributions, at sufficiently large momentum transfers (Q^2), determine the momentum distributions of the quarks in the nucleon. Thus the data suggest that the quark momentum distributions in a nucleon bound in aluminium become distorted.

When the data for aluminium are compared to lower Q^2 data taken at SLAC and to photoproduction data, it appears that at small x and small Q^2 the nuclear distortions are partially cancelled by nuclear shadowing effects. A similar cancellation is observed when the data for steel are compared to lower Q^2 data for copper and photoproduction data.

Particularly at large momentum fractions (x), there appears to be a systematic difference between the nucleon's quark structure (structure functions) for nucleons bound in deuterium and those in heavier nuclei. The effect, first noticed in by the European Muon Collaboration (EMC) at CERN, is now underlined by SLAC data on steel and aluminium.



These nuclear shadowing effects, which are presumably nuclear higher twist effects in the language of Quantum Chromodynamics (QCD), are expected, like higher twist effects in the nucleon, to be small at large values of Q^2. Therefore, the extraction of the strong QCD coupling parameter from structure function data taken with nuclear targets at high values Q^2 may not be affected by these terms.

Comparison of the SLAC electron and CERN muon data indicate that the nuclear distortions in steel and aluminium are similar.

The understanding of the mechanisms responsible for the distortion of the structure functions is still in a very qualitative state. Several recent theoretical papers have attempted to explain these observations using ideas such as six quark bags, pions and quasipions in nuclei, delta resonances in nuclei, diquark states, and percolation of quarks from nucleon to nucleon in a large nucleus. New studies will surely shed further light on this interesting new effect.

SIN
Channelled muon decay

One of the results reported at the recent Yamada meeting on muon spin rotation (see page 265) was the observation at SIN of the 'channelling' of positrons coming from the decay of muons implanted in a silicon crystal.

Channelling is the delicate steering of particle trajectories by the axes and planes inside crystals, and could offer new possibilities for studying stopped muons.

In the experiment by a Zurich / Konstanz group at SIN, positive muons are stopped in a silicon wafer bent into a spherical shell. (This arrangement allows a crystal axis at any point in the wafer to be brought to a unique focus at the centre of the sphere, thus allowing a large surface area to be studied.)

The decay positrons leaving the crystal near one of the principal axes fly 3.4 m before being picked up in a detector consisting of multiwire proportional chambers and scintillators. Comparing the recorded angular distribution with an X-ray diffraction pattern shows that positrons are blocked by certain crystal planes, with a central minimum caused by axial blocking.

This provides valuable information to help locate the interstitial site where the muon comes to rest. Channelling effects have also been seen in the particles from pion decay in an experiment by a Stuttgart group at SIN.

Carlo Rubbia (left) chaired the session on large passive detectors at the recent Pisa meeting on advanced detectors. At the overhead projector is G. Ernwein of Saclay. After an initial such meeting two years ago on miniaturized detectors, this year the organizers opted for the more ambitious title of 'Frontier Detectors for Frontier Physics'.

CONFERENCE
Frontier detectors

The Second Pisa Meeting on Advanced Detectors was held this year in Castiglione della Pescaia (Grosseto, Italy). It was the second of a series initiated in 1981 in Tirrenia, when the emphasis was on miniaturized detectors. This year the Organizers enlarged their scope, as emphasized by the title of the Conference, 'Frontier Detectors for Frontier Physics', which was chosen also in the hope, as Chairman of the Advisory Committee Giorgio Bellettini said in his opening address, to be able to hold a future meeting on 'Frontier Physics from Frontier Detectors'.

The Conference included a roundtable discussion with industrial suppliers of high energy physics instrumentation. This was a particularly interesting new initiative, chaired with competence and enthusiasm by Georges Charpak and Chris Fabjan.

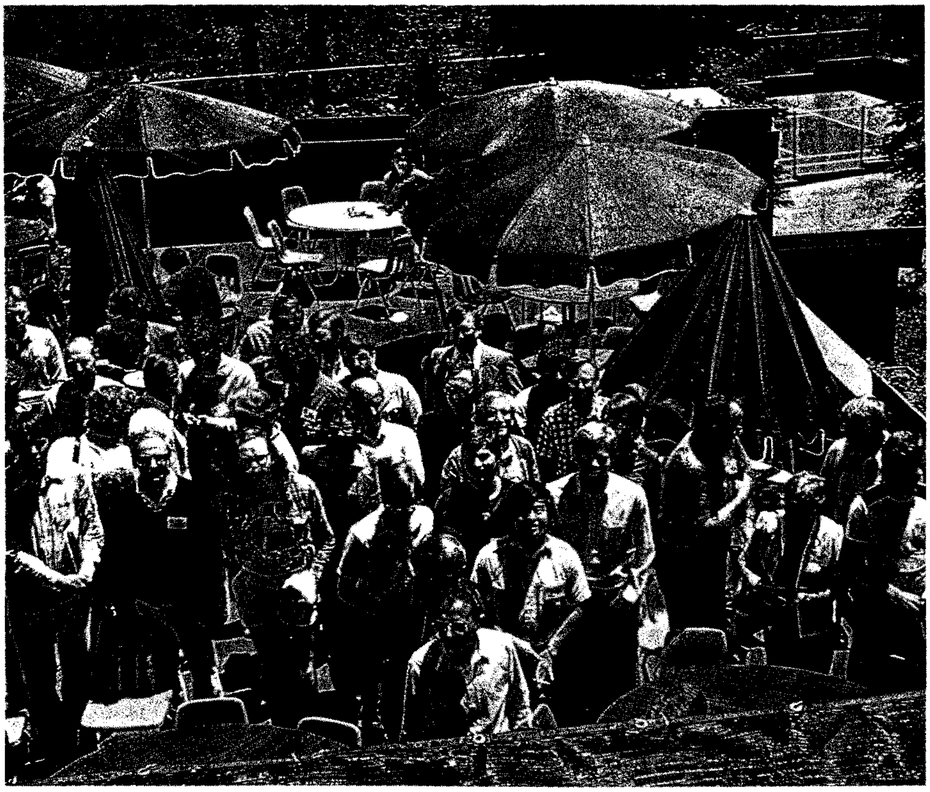
Over thirty suppliers from Europe, US and Japan were represented, covering photomultipliers and photodiodes, electronics, solid state detectors, scintillators and special optics. Despite the difficulties of such a novel and delicate initiative, it turned out a real success since contacts were strengthened and many new ones started. Europe is far from the integrated effort between research and industry which is so successful in Japan.

Various types of tracking detectors were discussed under the chairmanship of Hans Jensen of Fermilab. The emphasis was on large central detectors for proton-antiproton and electron-positron colliding beam experiments, based on existing designs. However new ideas like the Time Expansion Chamber — where space resolutions well below 100 microns are hoped for — were also discussed, as was improving the resolution obtainable with drift chambers.

The Sessions on Time Projection Chambers, chaired by Dave Nygren, and on Calorimeters, chaired by Enzo Iarocci, gave an impressive view of the effort which is being put into this type of detectors, in particular for LEP. Based on the pioneering Berkeley TPC, which is now being exploited at PEP, the new designs point at larger volumes and easier operating conditions, with atmospheric pressure and pulsed ion screens. Also small size TPCs are being operated successfully at Fermilab and TRIUMF, and mini-TPCs will be built for the vertex tracking of the detector for the Fermilab proton-antiproton Collider. Calorimeters are becoming a special art, and scintillator is by no means any more the standard choice of sensitive element. Proportional gas tubes are preferred for very massive detectors, like at LEP, since signal collection is easier, however the attempt to preserve linearity up to the highest energies seems to encounter basic difficulties.

On the other hand, enormous progress is being made on the granularity of detectors and consequently on their ability to resolve jet structure, with the number of channels approaching 100 K and extensive multiplexing solving the read-out problem. Scintillator tower calorimeters are still tops for energy resolution, like in the uranium/copper calorimeters of R807 at the CERN ISR or of L3 at LEP, or when one wants to preserve trigger capabilities at high rates as in the collider experiment at Fermilab. For photon/electron detection, a special role was played by sodium iodide and the new BGO crystal detectors, however the extreme interest in BGO calorimeters is still damped by the as yet unsolved problem of cost.

In the meantime, G. Charpak discussed a new concept of a calorimeter with proportional chambers of special design to allow extremely



Time out at the 14th International Symposium on Multiparticle Dynamics at Lake Tahoe, California.

(Photo W. Kittel)

good time resolution, and fluoride converter to allow excellent energy resolution. This detector is still to be tested and the present cost would be unbearable, but industry was alerted!

A lively session on visual devices, chaired by Volker Eckardt, proved that these techniques are still very useful, although in rather special fields. Using fast-cycling bubble chambers and/or fine-grained emulsions several experiments hope to see beauty decay both at CERN and Fermilab, while the streamer chamber has its usefulness for a qualitative study of high energy interactions at the CERN collider. Semiconductor devices are rivalling conventional visual techniques and gaining in importance as mini-vertex detectors for charm and beauty production and decay.

In an active session chaired by Eugene Haller of Berkeley and by H. Kraner of Brookhaven, various such 'active targets' were reviewed and a survey of mini-vertex detectors to be employed at LEP and at the large proton-antiproton colliders was presented. In this fast-expanding field, several commercial suppliers are increasing their commitment while new ones are appearing. Space resolutions are currently below 100 microns and aiming at 20 in some special designs. Associated preamplifiers are being miniaturized while noise is reduced below 10 keV and ample multiplexing implemented.

Particle identification was reviewed in a session chaired by Tom Ypsilantis. Besides energy loss, for which the JADE chamber still provides one of the most successful examples, Ring Imaging Cherenkov counters were extensively discussed. It is still hoped that these detectors will solve at least in part the thorny problem of particle identification within jets, however the implementation of this complex technique in a real experiment still has to be perfected.

An extremely interesting session, chaired by Carlo Rubbia, covered large passive detectors. The way to extend the flash-tube and the proportional tube technique for proton decay experiments from the Frejus/Mont Blanc to the Gran Sasso generation was indicated.

Thanks to the Pisa Organizing Committee under INFN Director Angelo Scribano, the Conference was a great success, and there was widespread enthusiasm for more such meetings.

CONFERENCE Multiparticles at Lake Tahoe

The fourteenth international symposium on Multiparticle Dynamics, held at Lake Tahoe (California) in June, enabled specialists studying lepton-lepton, lepton-hadron, and hadron-hadron collisions to compare notes.

In the electron-positron sphere, efforts to get the strong coupling constant from data on annihilation into three hadron jets suggests that the results are sensitive to the models used to describe the production of the hadrons from quarks and gluons (fragmentation). Differences between various approaches become smaller when correction terms (second order effects) are applied, but a model-independent clustering algorithm could be useful.

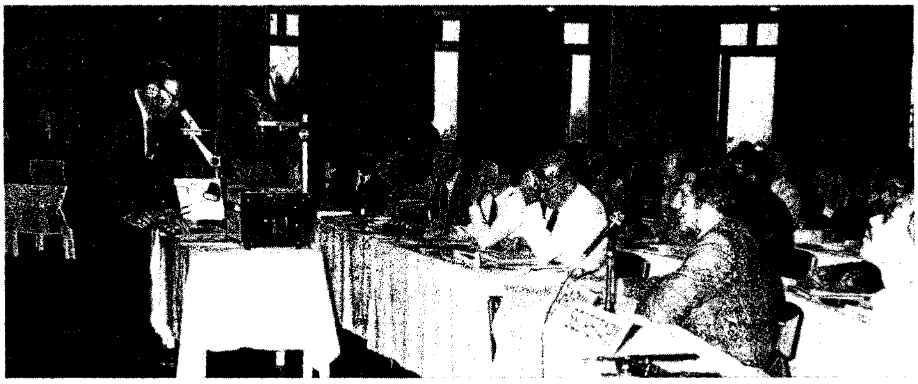
Clear differences have now been found between the jets emanating from quarks and from gluons, when compared at the same jet energy. Gluon jets carry more transverse momentum and more baryons.

Useful new results on high energy fragmentation come from jet studies at the SPS collider. The hadron jet production rate seems to agree with theory and the jet charge multiplicity is an extrapolation of what is seen in (lower energy) electron-positron annihilations. The fragmentation function itself ties in with results from electron-positron annihilations (the TASSO experiment at PETRA). Internal transverse momenta do not vary much with energy, and evidence exists for three-jet events.

There was much discussion of the 'EMC' effect — unexplained differences in nucleon quark structure when studied in different nuclei (see page 261). There is no shortage of models to explain the phenomenon, which presumably should be taken into account when interpreting data from heavy targets.

For low transverse momentum ('soft') hadron collisions, there is an increase of transverse momentum

At the recent Yamada Muon Spin Rotation Conference, solid-state theorist J. Kanamori of Osaka explains the effect of local magnetic fields on interstitial positive muons in ferromagnets.



and particle density up to CERN collider energies. The increase in particle density is also dependent on particle type.

Particle multiplicities in neutrino interactions, electron-positron annihilation and non-diffractive hadron collisions tie in together. However the high energy results from the SPS Collider show an abnormally large high multiplicity component.

Some of the effects being observed are suggestive of the onset of hadronic phase transitions.

The meeting demonstrated that the boundary between 'hard' and 'soft' physics has yet to be firmly fixed. Both have profited enormously by the advent of the CERN Collider, and progress should continue. There should be no shortage of topics for debate at the next Multiparticle Symposium, scheduled for Lund next June.

(We are grateful to W. Kittel for providing the material for this report.)

CONFERENCE
Muon spin rotation

The Yamada Conference on Muon Spin Rotation and Associated Problems (μSR83 for short) was held at Shimoda, Japan, from 18-22 April. The conference was organized by the Meson Science Laboratory of the University of Tokyo (UTMSL), which is now actively pursuing various experiments using pulsed muons (the BOOM line) at the 500 MeV booster synchrotron at KEK (see October 1980 issue, page 302). The conference was sponsored by the Yamada Science Foundation.

The city of Shimoda is the historic site where the first American consulate was established more than a century ago, forming a 'bridge' between Japan and the West. This μSR conference, like its predecessors μSR1 (Rorschach, 1978) and μSR2 (Vancouver, 1980), was intended to establish a similar 'bridge' between particle/nuclear physics and materials sciences like chemistry and condensed matter physics.

There were 117 participants from 12 countries, including 43 from Japan. In total, 134 papers were presented. The main subjects included local magnetic fields and fluctuations at the interstitial positive muons in magnetic materials, quantum diffusion and impurity-mediated trapping of positive muons in metals, muonium formation and behaviour in semiconductors and insulators, chemistry of muonium in gas and liquid phases, hyperfine structure of muonic atoms, electroweak interactions, etc.

From SIN, the MPI Stuttgart group and the University of Zurich (UZ) group reported successful results from channelling experiments (see page 262), where the locations of interstitial positive pions or muons and the zero-point motion characteristics were clearly revealed. Such experiments will be decisive in the resolution of ambiguities in other μSR data.

Also at SIN, a joint UTMSL/UZ collaboration achieved the first successful observation of the internal field felt by the negative muon bound to the host nucleus in a ferromagnetic material (in this case nickel). This field can be compared with the analogous field at the nucleus of a dilute cobalt impurity in nickel; a 'hyperfine anomaly' of -2.82 ± 0.08 per cent difference was found, reflecting the spatial distribution of inner-shell electron polarization outside the nuclear boundary. No other method can probe this distribution.

At TRIUMF (University of British Columbia group) and later at SIN (UZ group), μSR has been applied to surface science for the first time in studies of muonium interactions with the bare surfaces of ultra-fine silica powders.

A Berkeley group working at TRIUMF performed a precise measurement of the asymmetry at the endpoint of the positron spectrum from positive muon decay (the Michel parameter) in a search for right-handed weak currents (see page 260). The result implies that any right-handed weak boson must be heavier than 380 GeV. A similarly-motivated experiment to search for right-handed currents in kaon decay was reported by a Tokyo / KEK group. The precision achieved was not as impressive, but the new result is also consistent with maximal left-handedness.

The response of a solid to the introduction of such a simple point-like positive charge as the muon has been extensively studied by the

CERN / Uppsala / Jülich collaboration. Thanks also to their results on the diffusion in copper at very low temperatures, on the self-trapping and impurity-induced localization in niobium and aluminium and on the dynamic correlations in metal-hydrogen systems, it is possible to say that more is known about this model system than it is about the closest 'natural' analogue, the isolated hydrogen atom in a metal.

Also at CERN, the Parma/Rutherford Laboratory collaboration obtained the first complete picture of the static and dynamic magnetic properties of antiferromagnetic insulators by μSR. The anisotropy of the local field experienced by the muons was directly related to the site of localization in the lattice and found to agree with the spontaneous magnetization in the ordered phase. Use of a new wire chamber spectrometer paid dividends and will certainly open μSR to new applications.

At the KEK BOOM facility, the UTMSL group in collaboration with the Jülich group used pulsed muons to study zero-field (ZF) positive muon spin relaxation in pure copper at temperatures down to 0.09 K. Compared to the transverse-field (TF) techniques employed by the Uppsala/CERN group in 1980, the ZF method has a specific advantage: with time the ZF relaxation function recovers to a third of its original amplitude (the so-called 'Kubo-Toyabe tail') in the static case, and this 'tail' is directly sensitive to slow 'hopping' of the muon. Pulsed μSR gives the additional advantage of low-background data at times as long as 20 μs. The new results show clear evidence of enhanced positive muon hopping at temperatures below 15 K, indicating a new manifestation of quantum diffusion.

Magnetic resonance of the muon spin induced by a pulsed r.f. field is another rapidly-growing technique made possible by the ideal time structure of the pulsed muon facility at BOOM. Such facilities are being seriously considered for future development at the Rutherford/Appleton Laboratory and Los Alamos National Laboratory.

Numerous new applications of μSR to problems in magnetism, metal and semiconductor physics, chemical kinetics, radical chemistry, and now surface science continue to be discovered every year, further strengthening the role of μSR as an ambassador from the world of particle physics to the world of materials science. Such vigorous cross-fertilization emphasizes the importance of interdisciplinary fields like μSR. This year has seen a mature μSR technology return to its origins and make a significant new contribution to elementary particle physics: born in the discovery of left-handed parity violation, μSR has set a new limit on right-handed currents. It seems that the left hand knows what the right hand is doing after all!

(We thank T. Yamazaki for his report.)

Beat waves at Trieste

On the initiative of Abdus Salam, a 'Workshop on Laser and Plasma Collective Field Accelerators' was held at the International Centre for Theoretical Physics at Trieste on 31 May and 1 June. It was held in conjunction with a longer 'College on Radiation in Plasmas', which was then being held at the Centre, and was organized by B. McNamara with help from J.D. Lawson.

The aim was to sustain the emphasis on the need to explore new concepts in particle acceleration so as to prepare for the long term future when present techniques run into the boundaries of scale and cost (probably at around 300 GeV for electron colliders and 20 TeV for proton machines). This was the theme of the Oxford Conference (see December 1982 issue, page 405), organized by the European Committee for Future Accelerators and the Rutherford Laboratory, and remains a major concern of ECFA. In the course of the Workshop, John Mulvey, Chairman of ECFA, arranged a meeting to sound out interest in working in the field of collective acceleration techniques to achieve very high energies. Some work has already been organized in Europe, including a Study Group at Rutherford. Further Workshops are envisaged and ECFA may play an important role in the coordination of effort in scattered groups.

Although many methods of collective acceleration (and some non-collective variants) using lasers have been put forward, the main topic which has retained very high interest is the concept of plasma beat waves first proposed by T. Tajima and J.M. Dawson in 1979. This is because it holds out the promise of dramatically high accelerating gradients (up to several GeV per m). The concept had some encouraging early experimental support in the work of C. Joshi.

The idea is to fire two laser beams of different frequencies into a plasma so that they 'organize' the plasma in such a way that incoming charged particles see high accelerating fields. The two beams generate beat waves travelling through the plasma at a little less than the speed of light, which could match particle velocities.

At the Trieste Workshop, T. Tajima presented a more thorough analysis of the basic mechanisms with emphasis on the resulting physical features, such as trapping of back-

People and things

ground electrons, instabilities, heating and factors affecting maximum accelerating fields. An elegant simplified model of a beat wave accelerator has been developed by R.D. Ruth and A. Chao and was presented by Ruth. They select 1 micron wavelength lasers and a plasma density of 1.6×10^{16} per cm^3. The accelerating field is then found to be 5 GeV/m and a 5 TeV machine requires a hundred 10 m stages each absorbing 17 kJ per pulse while accelerating up to 10^{11} particles. It is recognized that this model, while being a useful starting point for studies, needs considerable refinement.

An important aspect is the 'staging' in different sections along a machine so that the beat wave will not fall seriously out of step with the particles as their velocity increases. It is not yet clear how efficiently this phase-slip problem can be overcome. There were new ideas on this presented by Joshi under the name of 'Surfatron'. The practical details of the necessary laser power and pulse rate are also yet to be determined. R. Bingham spoke on plasma instabilities, including the effect of trapped electrons, which will influence ideal laser power requirements.

Attainable luminosity was discussed and high values will obviously not come easily for lepton colliders, where 'beamstrahlung' is the primary limitation, but this would not be troublesome in hadron machines and much more optimistic values on luminosity can be put forward.

The subject is obviously at a very interesting stage and there is great enthusiasm to pursue the high promise of the beat wave technique. It is also refreshing that a multidisciplinary effort is needed and laser and plasma experts are being lured to the field of accelerator physics.

At the recent Shelter Island II Conference on Quantum Field Theory and the Fundamental Problems of Physics, Murray Gell-Mann (left) talks with A.D. Linde of the Lebedev Institute, Moscow. 36 years ago, the first Shelter Island conference grouped together prominent field theorists at the time when modern quantum electrodynamics was emerging. This time it was the turn of quantum chromodynamics, supersymmetry and grand unification to be discussed.

(Photo A. Martin)

CERN elections/appointments

At the June session of CERN Council, L.B. Okun and Abdus Salam were re-elected for further three year terms as members of the CERN Scientific Policy Committee. J. Andersson was re-elected for a further year as chairman of the Finance Committee. Reappointments were — G. Brianti as Technical Director, F. Heyn as Director of Administration, and E. Picasso as Director of the LEP Project — each for a period of three years as from 1 January 1984.

At the Council session, Erwin Gabathuler was thanked for his many contributions to the development of the CERN physics programme. He becomes Professor of Physics at Liverpool, and is succeeded as one of the two CERN Research Directors by Ian Butterworth of Imperial College, London.

At Fermilab

Ken Stanfield, presently Head of the Experimental Areas Department at Fermilab, will replace Bruce Chrisman as Business Manager and Head of Business Services about October, after the first phase of Tevatron beamline commissioning is completed. Chrisman has accepted an appointment as the Vice-President for Administration at Yale University. Roger Dixon, currently Deputy Head of the Tevatron II project, will succeed Stanfield as Head of Experimental Areas Department.

A Soviet-American workshop on gauge field theories was held in Yerevan from 9-23 June, organized by a Soviet-American committee for mutual cooperation in the investigation of the fundamental properties of matter, and sponsored by the USSR State Committee for Atomic Energy and the US Department of Energy. Several European physicists also took part. Soviet and US physicists hope that this kind of meeting could be held again, perhaps with continued participation from physicists working in other regions of the world.

For his work on particle detectors, Georges Charpak of CERN shares the 1982 Physical Science and Mathematics prize of the 'Comité du Rayonnement Français'.

A meeting of the Japan/US Committee on High Energy Physics at Brookhaven in May culminated in the signing of the fifth cooperative particle physics research agreement between the two countries.

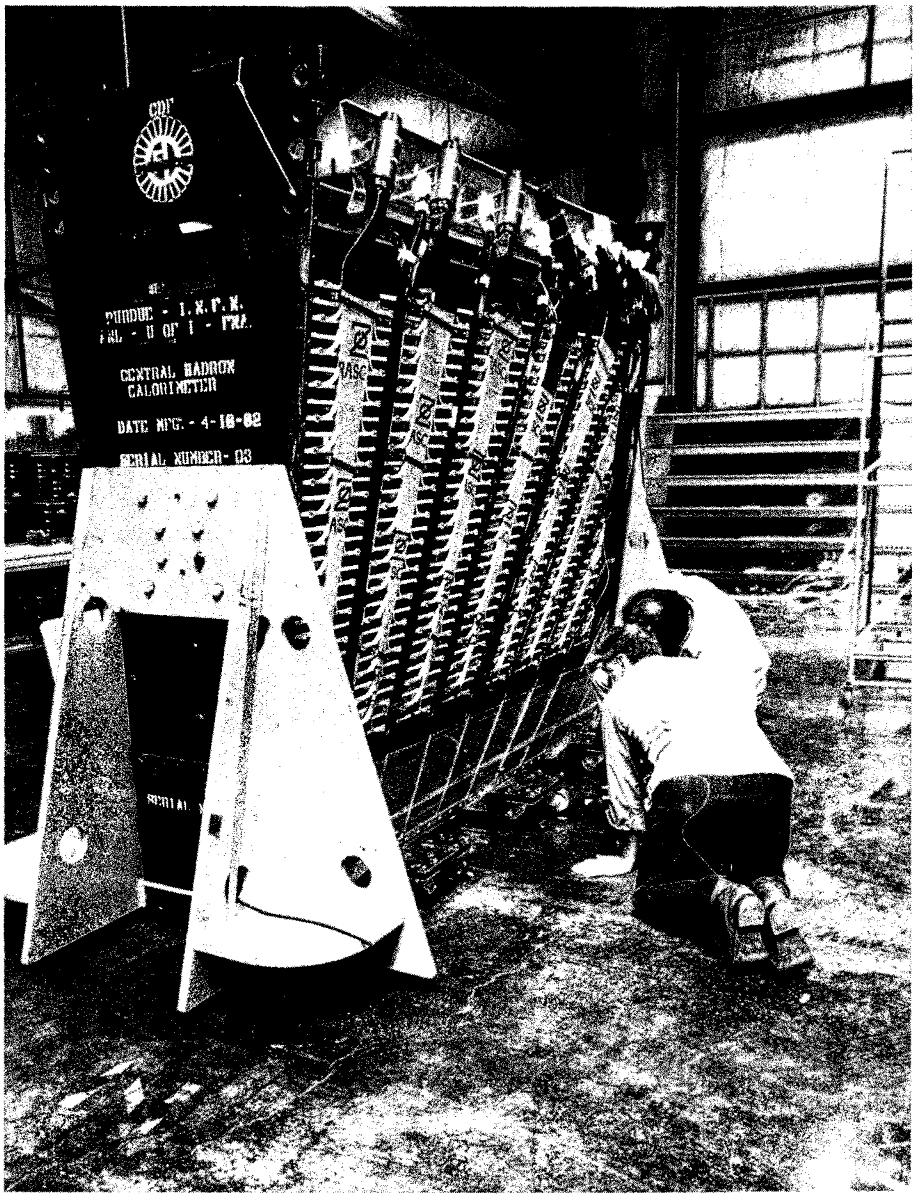
An example of the growing two-way Japan/US particle physics research effort is the proposal to move the High Resolution Spectrometer (HRS) from the PEP ring at SLAC to the new TRISTAN ring to be built at Japan's KEK Laboratory. A letter of intent has been approved in principle.

LEAR's here!

After the spectacular successes of the high energy proton-antiproton collision experiments in the CERN SPS, attention then turned to the other end of the antiproton energy scale. On 27 July, the experimental programme at the LEAR Low Energy Antiproton Ring began. After a short period of data taking, the ring pauses during the CERN Antiproton Accumulator shutdown, and resumes operation in the autumn. Our October issue will include a fuller report of LEAR's startup. First results of these low energy antiproton studies are eagerly awaited.

More neutrons at Argonne

Installation of a new proton source on the Intense Pulsed Neutron Source (IPNS) at Argonne has increased the accelerated proton current and hence the available flux of neutrons. Performance figures are — 13 microamp proton beam at a pulse rate of 30 Hz producing, by spallation on a heavy metal target, some 3.5 x 10^{14} neutrons per cm^2 per s in the energy range 0.001 to 10 eV. Over 100 scientists have used the facility so far for studies of the atomic and molecular structure of solids and liquids.



Assembly of the first production central calorimeter module for the Collider Detector Facility at Fermilab. The steel was cut and welded at Purdue University. The hadron scintillator and light pipes were cut and fabricated in Italy. The shower scintillator was made and cut in Japan. The shower counter light pipes were made at Argonne National Laboratory. The muon counters were made at the University of Illinois. All of these pieces finally came together and were assembled at Fermilab.

(Photo Fermilab)

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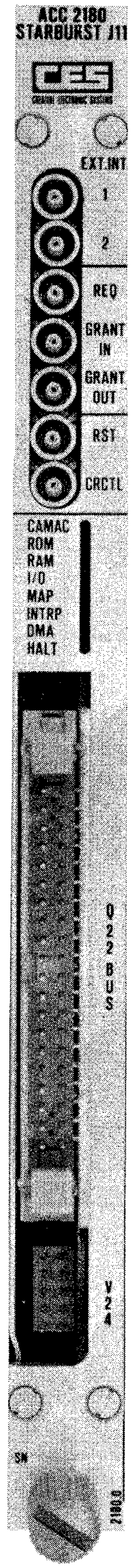

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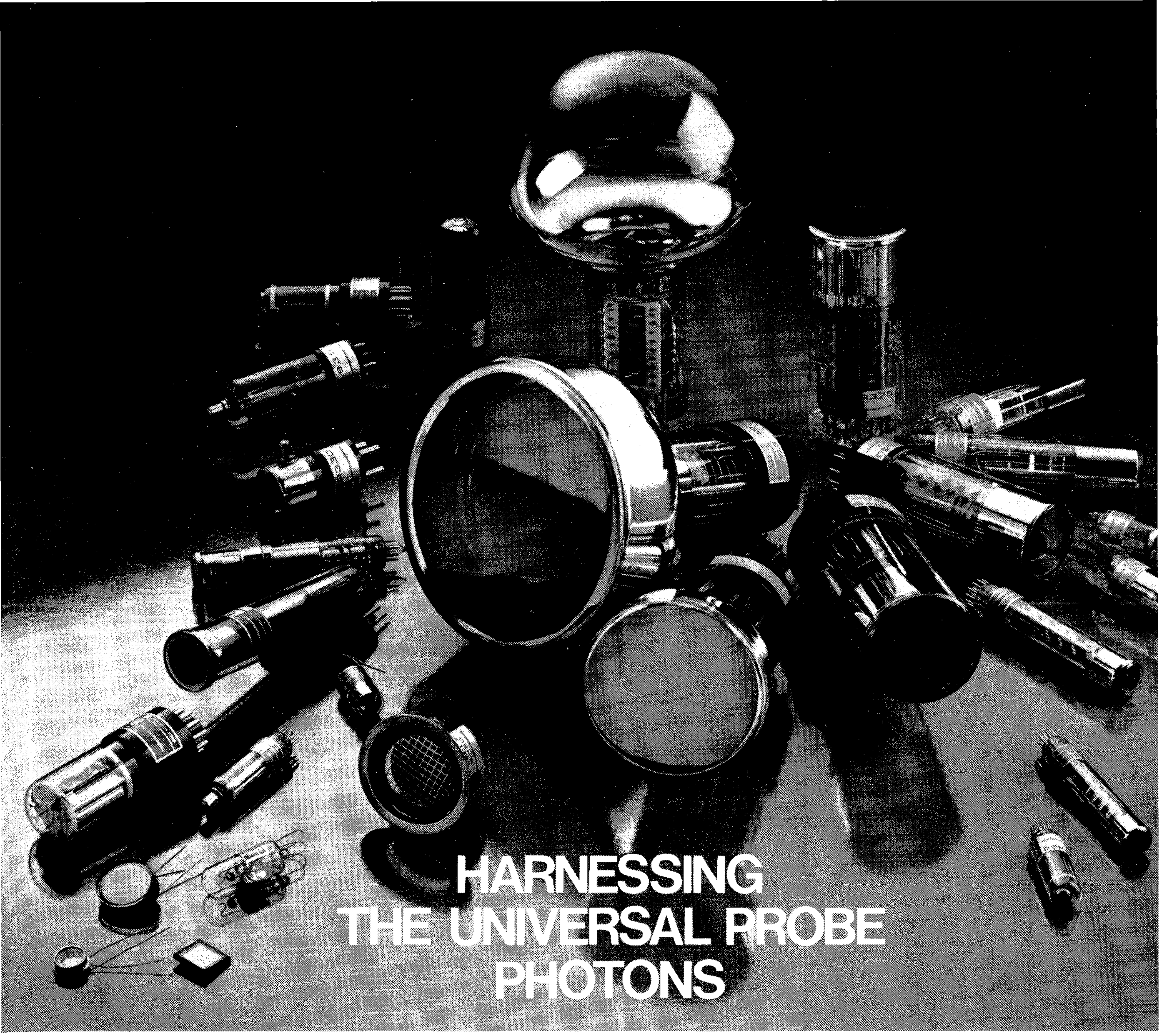
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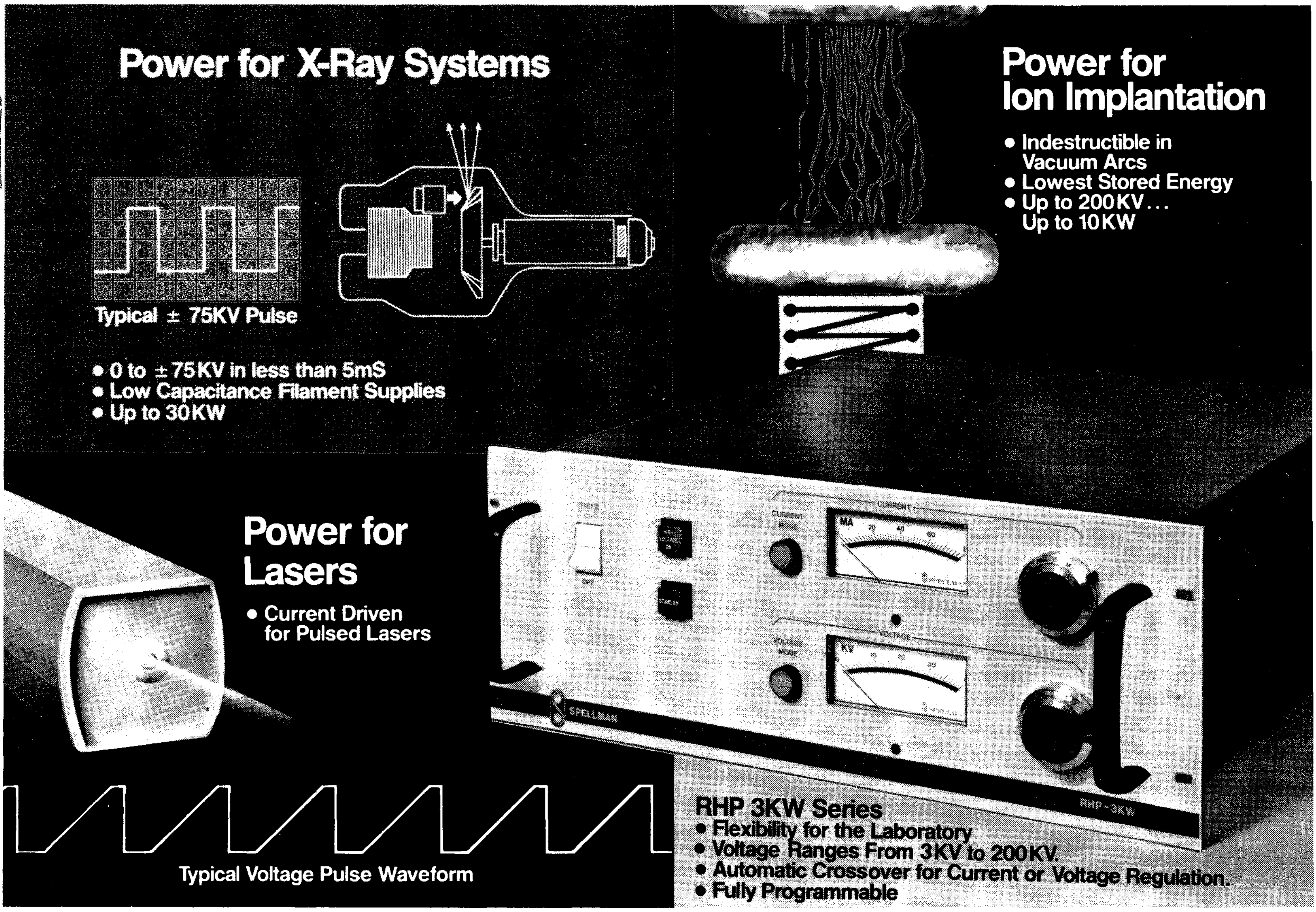

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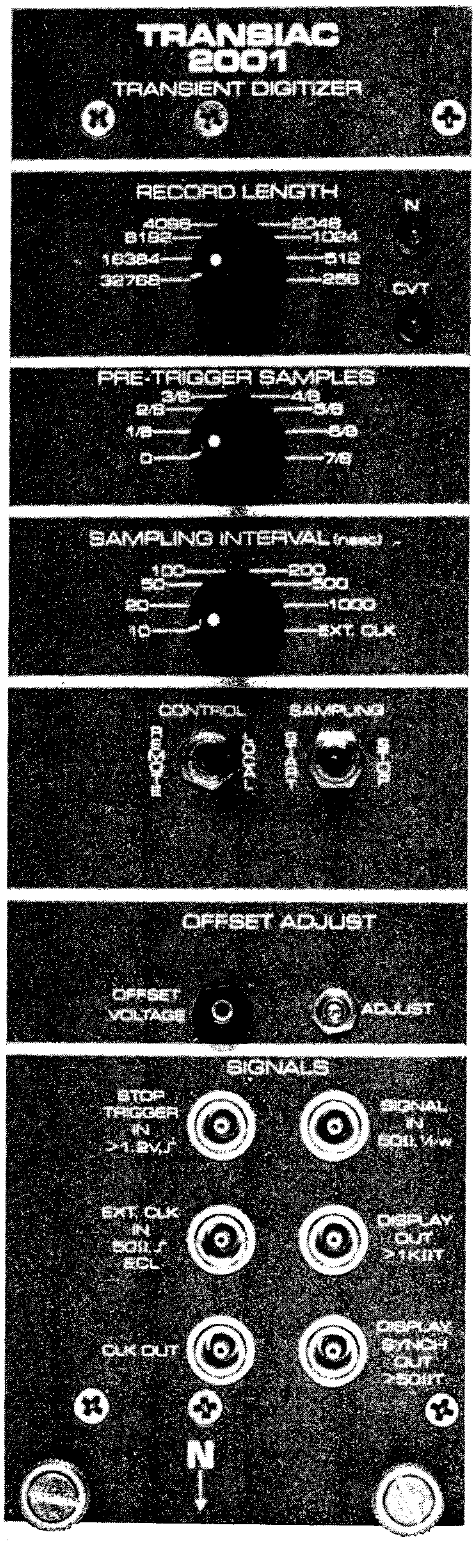

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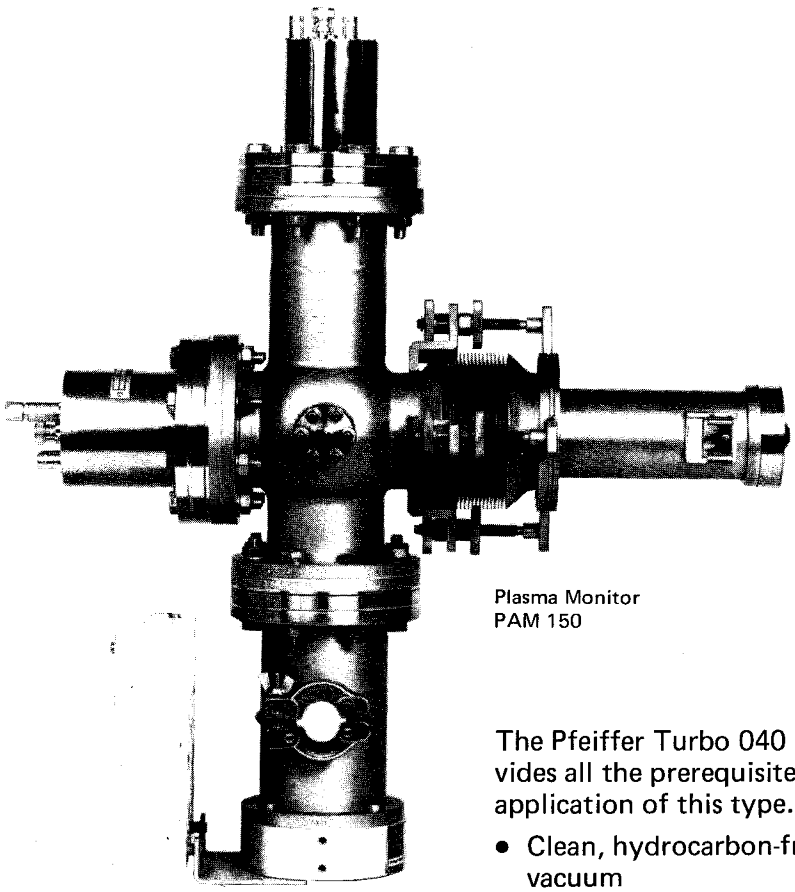

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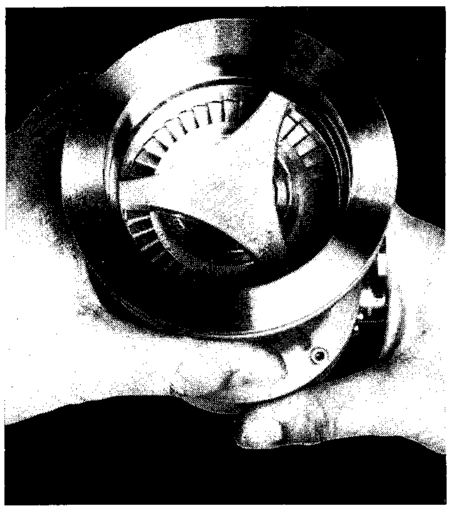

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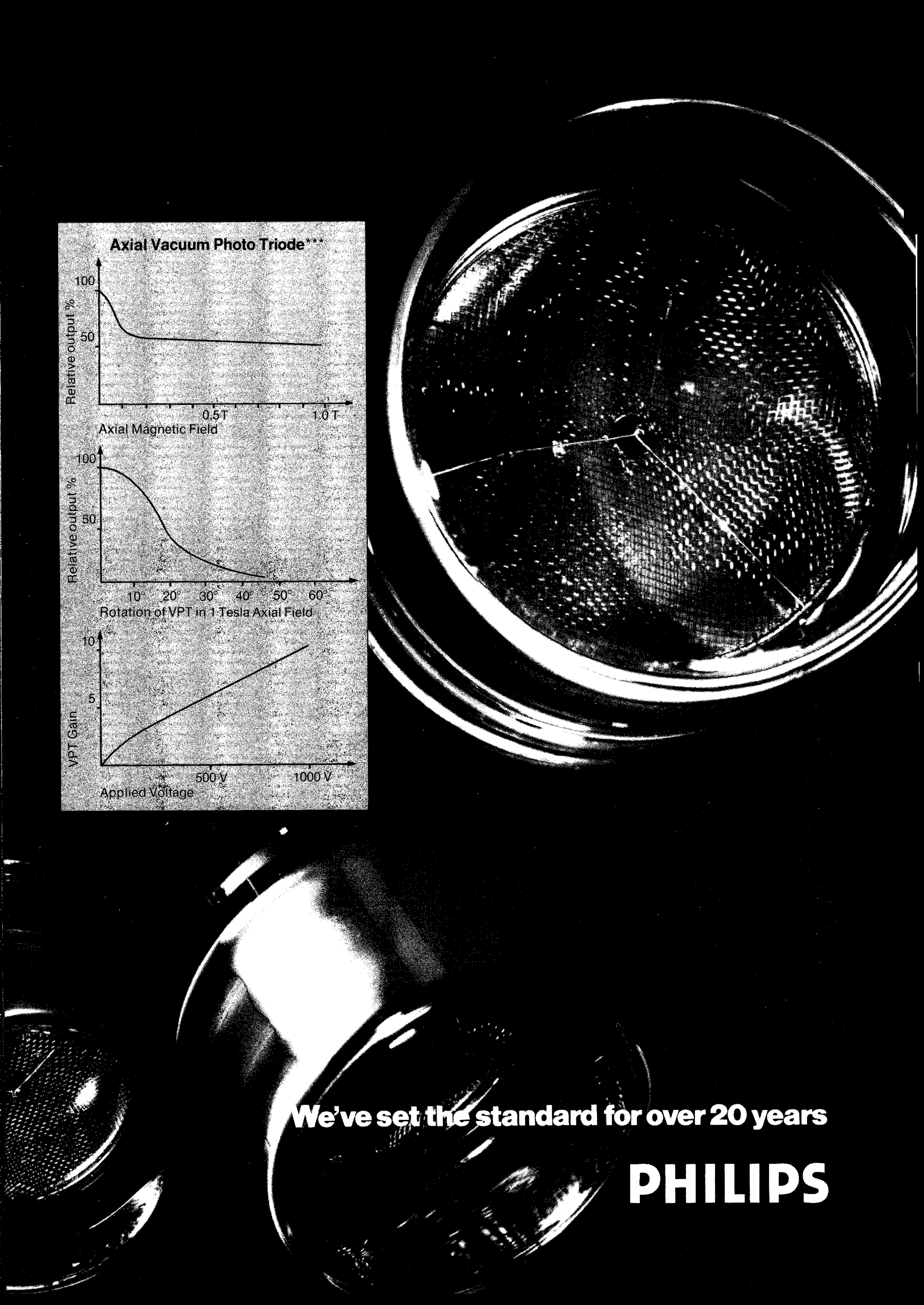
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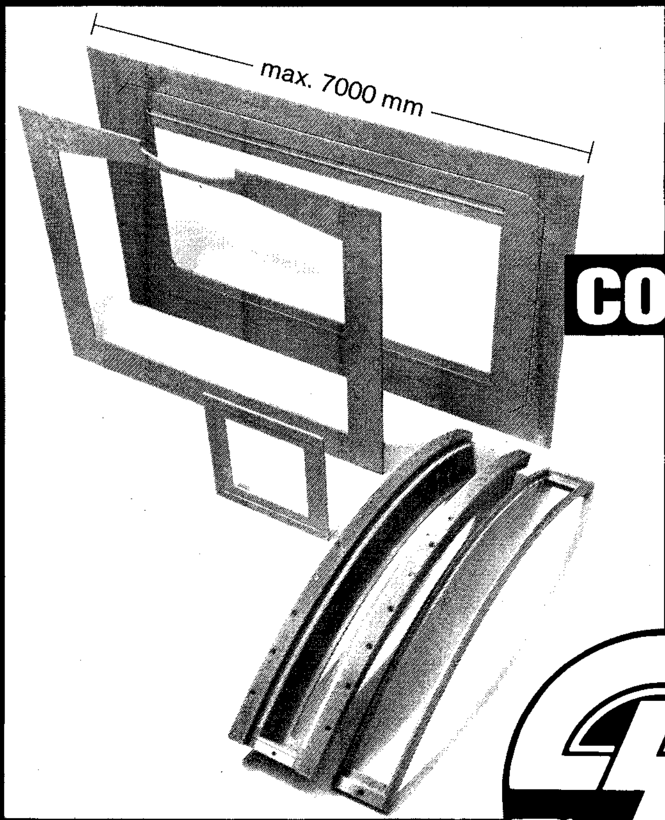

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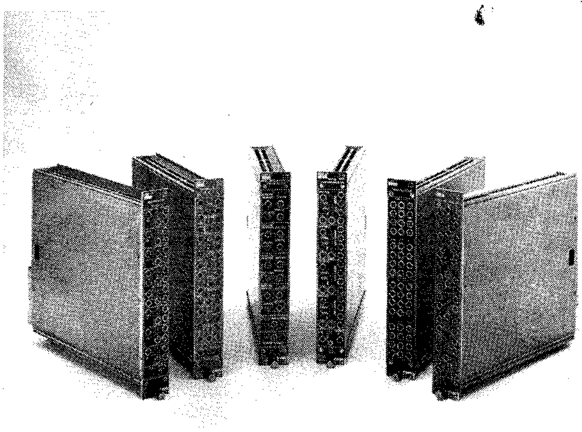

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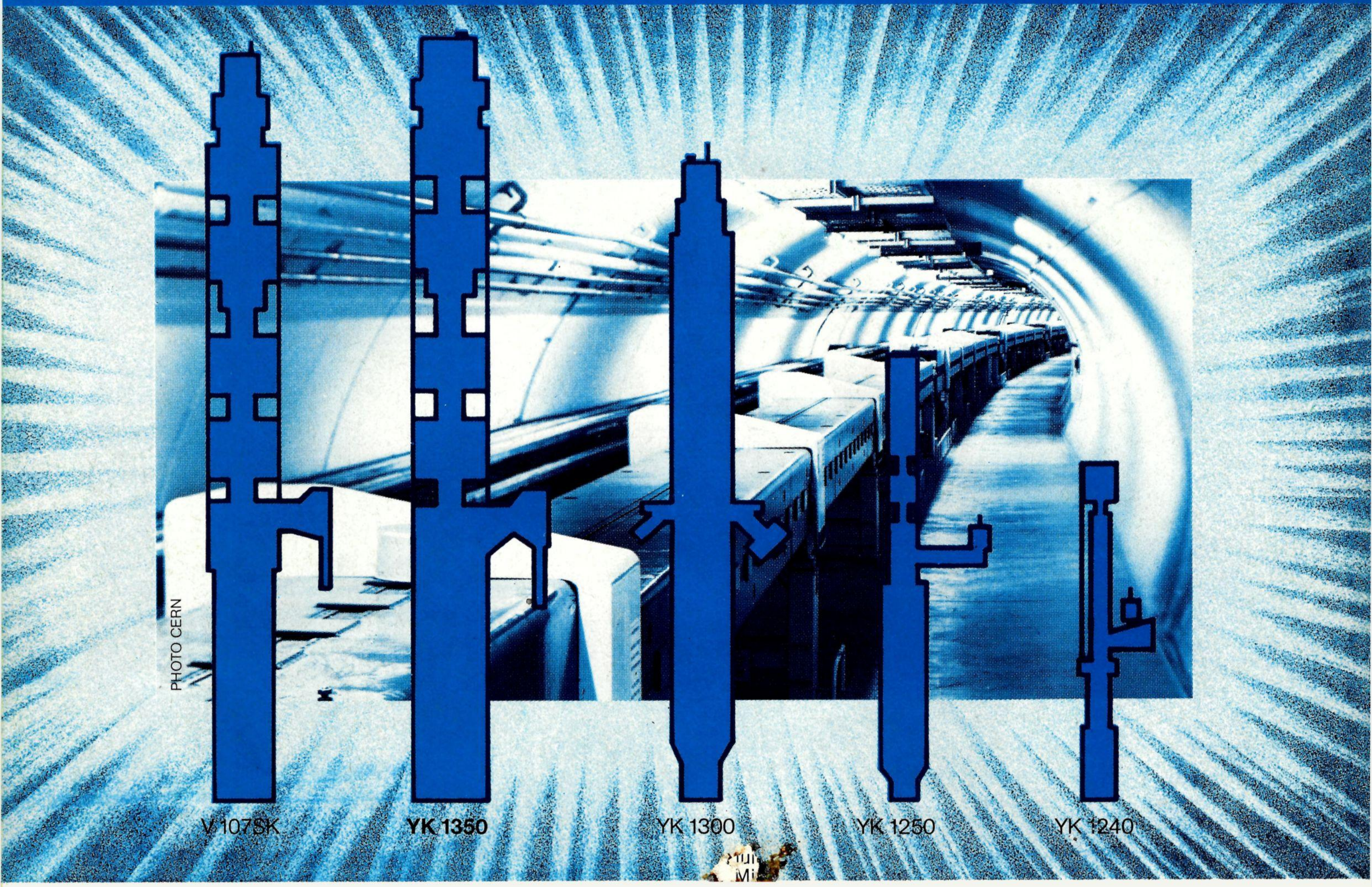
* IN2P3 ISN GRENOBLE PATENT

Electronics.
We provide the components.



More Big Klystrons for Big Science

Valvo herewith presents the largest big klystron for the Large-Electron-Proton-Ring LEP at CERN. This is our first klystron which remains in a horizontal position during its operational life. Klystron and support girder form an inseparable unit.

YK 1350 operates at 353 MHz and delivers a cw RF output power of nominal 1 MW. The main electrical values are: approx. 90 kV, 20 A and a nominal efficiency of 68 %. Due to the relatively low frequency and the enormeous dissipation of the collector the overall length of the klystron amounts to 3,9 metres.

Eight klystrons will be delivered from Valvo through the next two years to feed 8 MW RF power into the cavities of a section of the LEP ring.

Valvo is a member of the worldwide Philips organization. Please contact your nearest Philips representative.

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