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Cover photograph: From 5-22 September, over 200 000 people passing through the vast Balexert shopping precinct in Geneva had the chance to see a specially-mounted exhibition arranged for CERN's 25th anniversary which conveyed to CERN's 'host' population something about the research done at CERN and about CERN as an international organization. (Photo 25.9.79)

Gluons

With PETRA running at total energies around 30 GeV, latest results on the jet analysis of hadron production in high energy electron-positron annihilations were eagerly awaited at the Fermilab Lepton/Photon Symposium (see page 308).

The big question was the existence of the sixth quark, but none of the four groups taking data at PETRA produced any evidence for a new quark production threshold, either from the hadronic production rate or from the topology of the observed events.

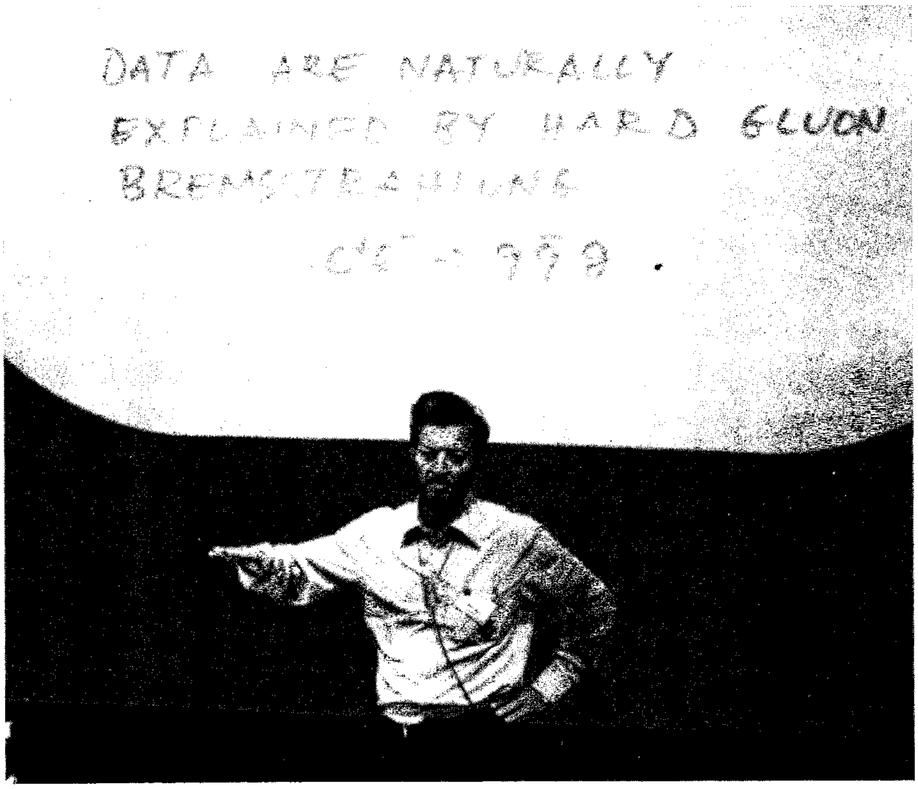
However jet analysis by the JADE, Mark-J, TASSO and PLUTO teams now confirms preliminary evidence first presented at the Geneva conference in June (see September issue, page 246).

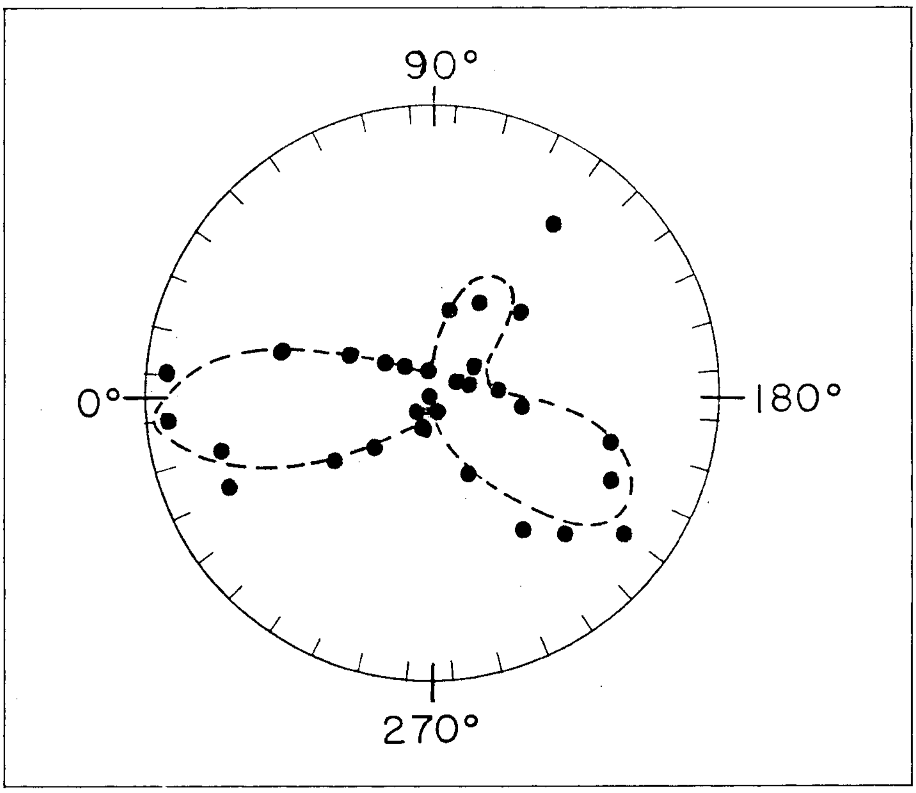
At 13 and 17 GeV collision energies, the two-jet structure seen at lower energies is reproduced, indicating a quark and an antiquark emitted in opposite directions, producing back-to-back hadron fragments. At 30 GeV, another process becomes visible as one or other of the emitted quarks probably radiates a gluon (bremsstrahlung) which also fragments into hadrons.

Since jets are not labelled to indicate their origin, some sort of phenomenological analysis is required to see what is going on. Away from resonances, the bulk of hadron production in electron-positron colli-

Günter Wolf of the TASSO collaboration at DESY presents his evidence at the Fermilab Lepton/Photon Symposium on gluon emission in high energy electron-positron annihilations.

(Photo Fermilab)





Three-jet event energy distribution from the Mark-J detector at PETRA looking at high energy electron-positron annihilations. It suggests two large jet streams of energy due to fragmentation of quark-antiquark pairs, and a smaller flow of energy from gluon fragmentation. The radial distance is a measure of particle energy. The plot comes from 40 events in the kinematical region where hard gluon effects dominate and displays the consequences of gluon emission. According to Sam Ting, at this high energy a phase space distribution is inconsistent with this shape and with the results from jet analysis.

sions produces two mutually opposite jets, giving typical cigar-shaped events.

As the energy is increased, one of these jets is seen to grow wider, but in a very special way. Rather than simply getting fatter with a cylindrical profile, it becomes planar, and at higher energies the jet clearly splits into two, giving an overall event with three coplanar jet components.

The observed frequency of these events agrees with quantum chromodynamics (QCD) calculations on the emission of hard gluons. The events are incompatible with pure quark-antiquark formation and cannot be reconciled by a simple 'phase space' model which assumes a purely statistical decay pattern.

Both theoreticians and experimentalists have shown vivid imagination in inventing procedures and names to describe this jet analysis, but the underlying structure is clear by simple visual inspection. Quantitative analysis is less clear-cut, but the results of all the PETRA groups are in line with QCD.

Another scene of QCD predictions is still the decay of the upsilon into hadrons, as measured by PLUTO at DORIS before its move to PETRA. While the neighbouring off-resonance behaviour is in good agreement with a simple quark-antiquark model, the resonance decays show a totally different behaviour.

Collinear back-to-back jets are ruled out as the dominant effect, but the data is in good agreement with a three-gluon decay model in which the gluon fragmentation is assumed to be similar to that of a quark. This three-gluon process is the lowest order QCD contribution to the decay of upsilons into hadrons, and is now clearly distinguishable from a simple statistical phase space description.

Lepton/Photon highlights

The Lepton/Photon Symposium held at Fermilab at the end of August was dominated by the results of jet analysis in PETRA electron-positron annihilations (see above). However many other important results emerged which were highlighted by Leon Lederman in his summary talk.

PETRA, as well as giving the new evidence for gluon production, has also shown that quantum electrodynamics is as good as ever, even at high energies.

The continued non-appearance of the sixth quark flavour at PETRA is not yet a problem, but it is unfortunate that no firm indications of this quark mass are available from theory, unlike the intermediate bosons of weak interactions where confident predictions can be made. Other new data from PETRA comes from two photon exchange mechanisms, while at SPEAR, the two photon process has been used to measure the eta prime lifetime.

The candidate beauty signal seen at CERN (see September issue, page 249) qualified for inclusion in the Symposium because the experiment triggers on lepton pairs, and although no new information was available, it was still a feature.

New results on neutrino-electron scattering came from the fine-grained calorimeter of a Virginia / Maryland / Oxford / Pekin collaboration. This is the first time that data on this reaction has been available from a large counter experiment, and the results underline yet again the success of the Weinberg-Salam model. Preliminary results on antineutrino-electron scattering were also presented from the fine-grained calorimeter of the CERN / Hamburg / Amsterdam / Rome / Moscow ('CHARM') collaboration.

Charmed baryons have been reported before, but now they have been pinpointed in electron-positron collisions at SPEAR. These precision measurements could open up the field of charmed baryon spectroscopy, where information so far has been scanty. Also from SPEAR came news of a candidate pseudoscalar (spin zero, negative parity) charmonium state at 2980 MeV. A previous pseudoscalar charmonium candidate at 2820 MeV from DESY had not been confirmed at SPEAR and a new level is therefore welcome (see September issue, page 246).

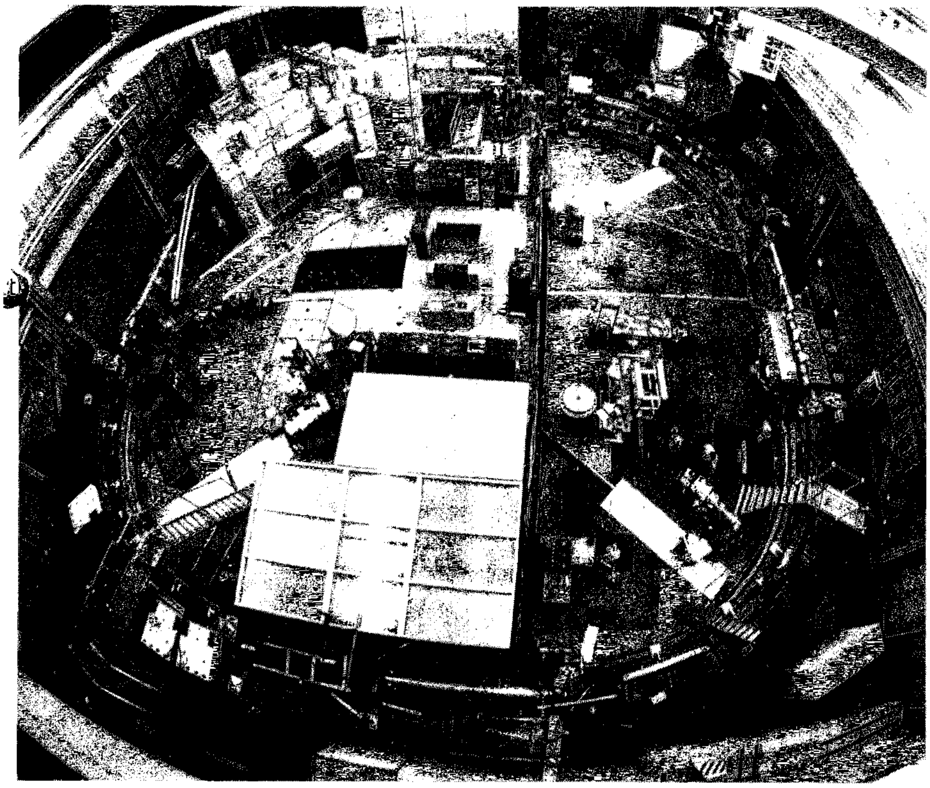
An unexpected contribution was the new signal seen by the CHARM detector in a neutrino beam dump experiment at CERN (see page 313). While others preferred to adopt a cautious wait and see attitude, Lederman was in more optimistic mood, pointing out that here might be the first signs of the tau neutrino.

These Lepton/Photon Symposia started in a modest way at MIT in 1963 to cover a specialized area of particle physics research, but have now grown to cover the most exciting developments, as was demonstrated by the Fermilab meeting.

Electron cooling in ICE

General view of the ICE (Initial Cooling Experiment) ring at CERN — now scene of successful tests of both stochastic and electron beam cooling techniques.

(Photo CERN 80.9.78)



Electron cooling tests started in the ICE (Initial Cooling Experiment) storage ring at CERN in May and the results obtained so far are very encouraging. Beam quality can be greatly improved (for example the six-dimensional phase space density can be improved by a factor of 10^7), cooling times are short (0.3 s and 1.2 s in momentum spread and betatron amplitude respectively) and beam losses are down to the level corresponding to scattering on residual gas.

The technique of electron cooling was first promoted by Gersh Budker at Novosibirsk where successful tests were carried out in the NAP-M ring in 1974-76. CERN and Fermilab decided to follow up the Novosibirsk work in connection with their projects to collide high energy proton and antiproton beams. Beam cooling is needed to achieve high intensity antiproton beams and give luminosities high enough for colliding beam experiments.

At CERN the storage ring previously used for the g-2 experiment (giving a very precise measurement of the muon magnetic moment) was converted for cooling tests by a team led by Guido Petrucci and became known as ICE. Emphasis swung to stochastic cooling, the alternative technique invented by Simon Van der Meer at CERN which had given encouraging results in the Intersecting Storage Rings. The excellent performance of stochastic cooling in ICE was reported for example in the April 1978 issue, page 112. Nevertheless, the effort to test electron cooling was continued in the group led by Frank Krienen and has now also emerged with excellent results.

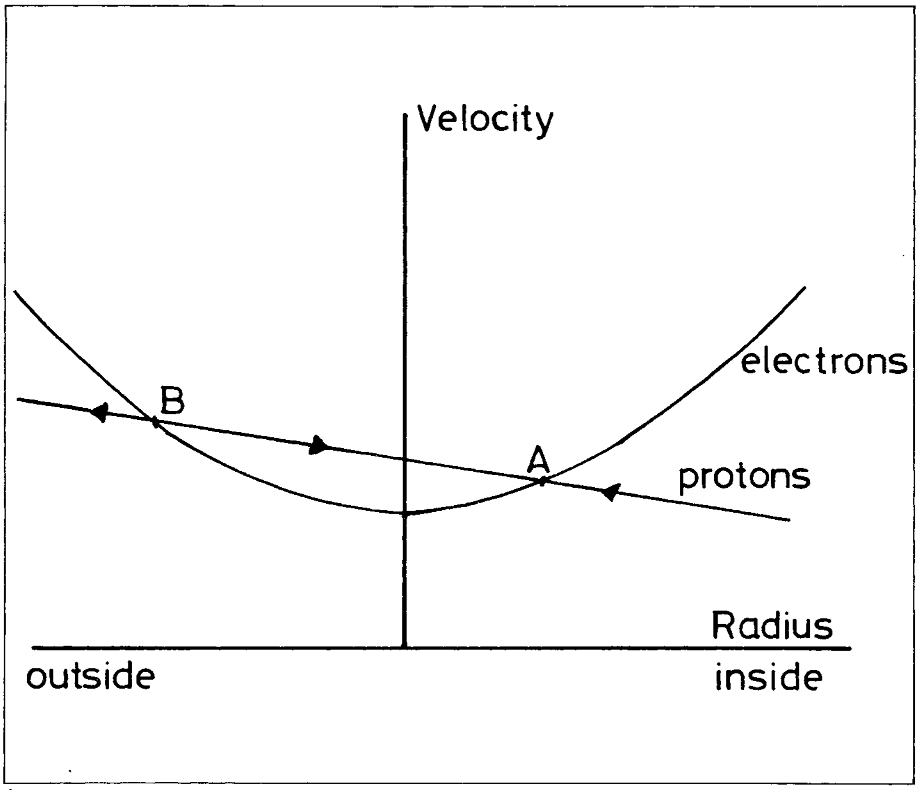
Electron cooling is based on repeated interactions of the particles to be cooled (protons, antiprotons or, in general, heavy ions) with a dense and cold electron beam. 'Cold' in this context means that the energy spread around the required energy in the electron beam is very small. In practice this is done by introducing the electron beam in a straight section of a storage ring where the heavy ions are circulating. The electron velocity matches that of the ions.

The generation of a cold monoenergetic and parallel electron beam in the energy range around 100 keV is best achieved by an electron gun (using thermal emission and electrostatic acceleration). Parallelism is obtained by guiding it in a solenoidal magnetic field.

In the rest frame of the electron beam, the electron temperature is anisotropic, the transverse temperature (normally a few electronvolts) being several orders of magnitude larger than the longitudinal temperature. In this frame the velocities of the circulating ions can initially be quite high, and their temperature may amount to hundreds of electronvolts. Due to Coulomb interactions, ions transfer energy to the electrons without observably heating the electrons because the electron beam is continuously renewed. Cooling times are determined by the highest ion velocity, whereas the ultimate phase space reduction is determined by the energy spread in the electron beam and by multiple scattering on residual gas.

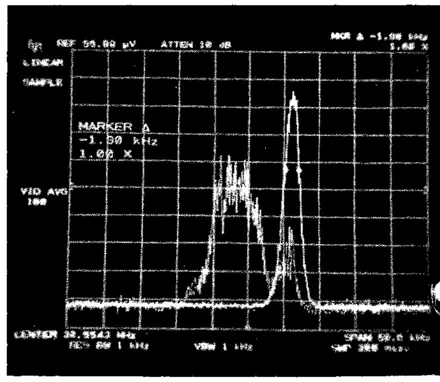
The experiments at Novosibirsk were made with beams of small emittance and small momentum spread. The objective at CERN was to cool a beam of larger phase space, such as an antiproton beam emerging from a target, in order to test the feasibility of high luminosity with proton-antiproton colliding beams.

The tests performed in ICE used a proton beam which had effective



1.

Figure 1: The velocity variations with radius of the electron and proton beams in the ICE storage ring. For cooling to take place, the velocity profiles must intersect. Cooling tends to accumulate the protons around the radius and velocity corresponding to intersect A. Protons to the left of intersect B are accelerated by the electrons and pushed outside the cooling region.
Figure 2: Longitudinal cooling of the proton beam demonstrated by the Schottky noise technique.
Figure 3: Transverse cooling of the proton beam demonstrated by recording beam profiles at 0.4 s intervals.



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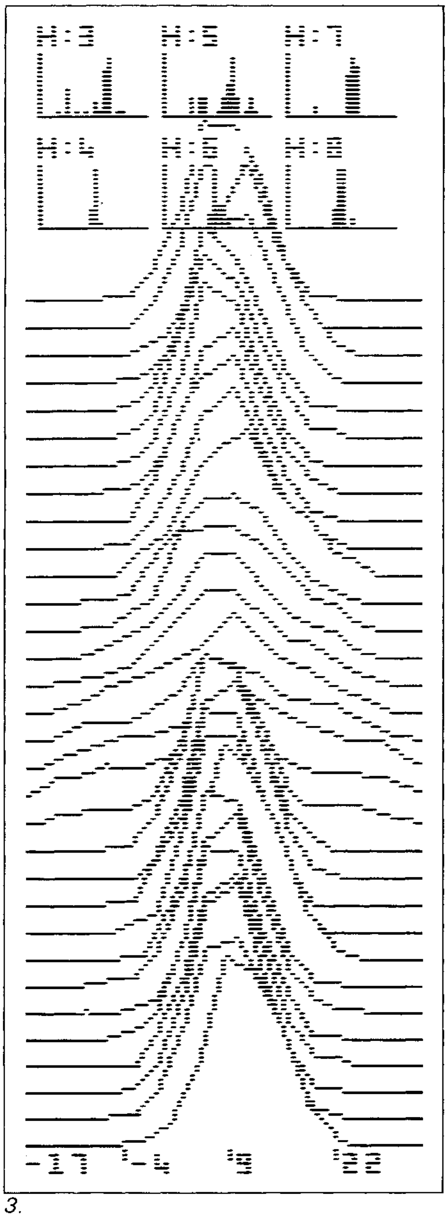


3.

initial properties as follows: a momentum spread of ± 0.25 per cent, a horizontal emittance of 60π mrad mm and a vertical emittance of 30π mrad mm. The main parameters at which the experiments were performed were: electron energy 26 kV matching 46 MeV protons, electron current 1.3 A, electron beam diameter 5 cm, cooling length 3 m and magnetic field 500 gauss.

The conditions in the ICE ring are such that, due to the space charge potential of the electron beam, the electron energy (and hence the electron velocity) varies with the radius giving a parabolic potential well across the beam. There is also a velocity variation (approximately linear) of the protons in the median plane of the storage ring as a function of the radial position of their equilibrium orbits. The essential requirement for cooling to occur in ICE is that the two velocity profiles intersect. This is shown graphically in Figure 1.

The tests in ICE

Construction of the electron gun started at CERN in the summer of 1977. It was installed in the ring in April 1979 and the first test started in May. Cooling effects, both in longitudinal and transverse dimensions, were observed on the first day as soon as the electron and proton beams were aligned and their velocities matched.

Further optimization was obtained by adjusting the gun parameters to minimize the microwave radiation produced by the electrons. Cooling was then strong enough to produce longitudinal bunching of the proton beam. Finally the betatron frequencies of the ICE ring were modified to move the transition energy above the operating energy. The bunching effect then disappeared and the best cooling conditions were obtained. The proton beam size could be reduced from 2 cm to less than 1 mm and the momentum spread from 2×10^{-3} to 4×10^{-5}.

Longitudinal cooling is demonstrated in the second figure by means of frequency analysis of the Schottky noise spectrum of the proton beam. The frequencies are displayed around a harmonic of the revolution frequency and are proportional to the particle momentum; the vertical signal is proportional to the square root of the particle density.

The broad spectrum is obtained in the first second after injection and already shows proton accumulation at the low energy (high frequency) side, whereas the narrow peak corresponds to the equilibrium spectrum after cooling and was taken about a minute after injection. The accumulation at the lower end of the momentum scale corresponds to the

Figure 4: The layout of the electron cooling system of the ICE storage ring: 1 – the straight section with a solenoidal field; 2 – a 36° toroid; 3 – the solenoid of the electron gun; 4 – ion pump; 5 – sector valve; 6 – the collector where the electrons are decelerated and absorbed; 7 – the line of the circulating proton beam; 8 – high voltage Faraday cage.

position of the intersection point A of Figure 1. The narrow peak shows a reduction of momentum spread from 2×10^{-3} down to 3×10^{-4} and a density increase of about a factor of three.

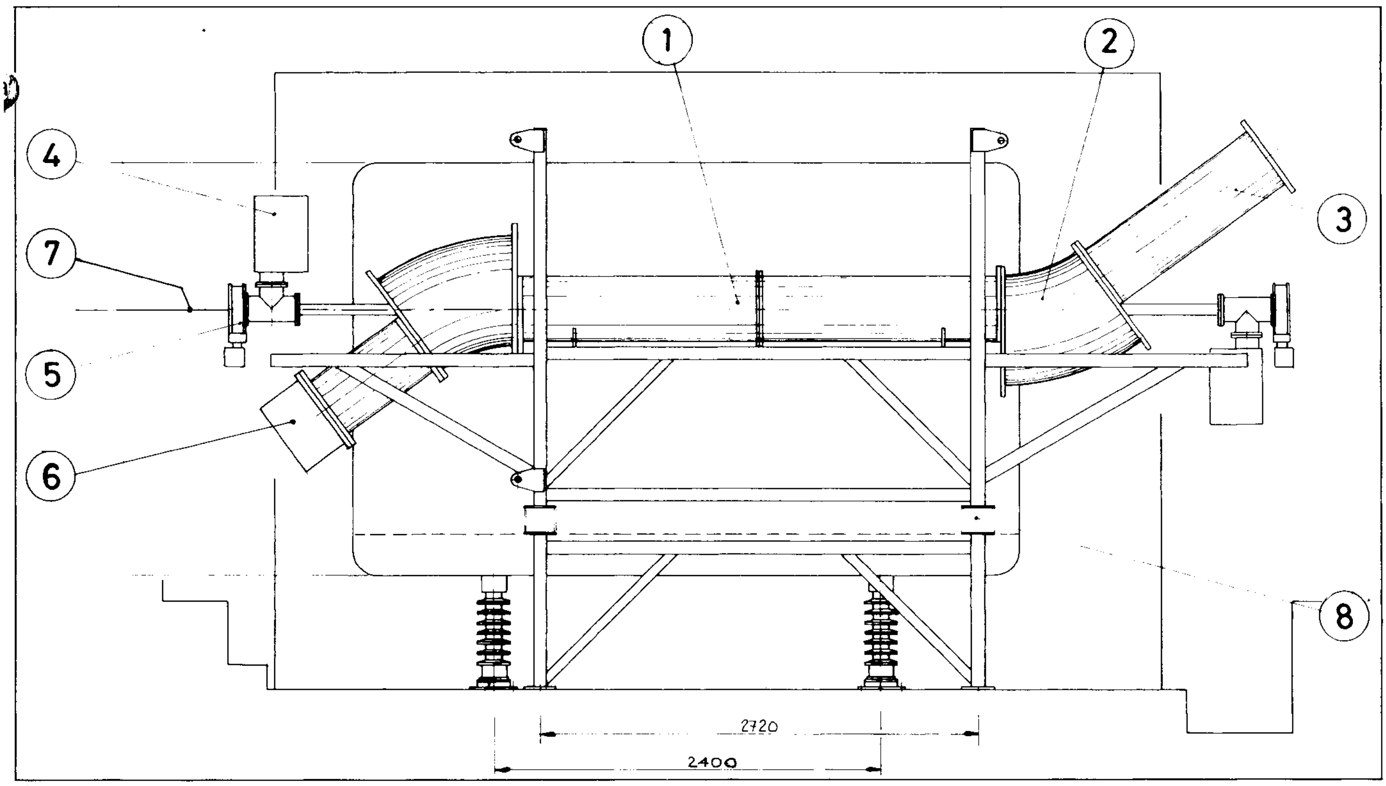
The change in the transverse dimensions of the proton beam is slower and the beam profile can be depicted in successive stages. This is shown in Figure 3. In this case a horizontal kick of 2 mrad is given to a previously cooled proton beam. The time interval between recording the horizontal beam profiles is 0.4 s.

A way of monitoring the electron beam is by detecting hydrogen. Protons and electrons can combine to form neutral hydrogen atoms. The effect is strongest when the relative velocities between the two species is smallest and the temperature of the electron beam can be estimated by counting the hydrogen production rate. The highest rate observed up to now was 650 atoms per second and per 10^8 circulating protons. This is in excellent agreement with the computations on the electron beam.

The electron gun may be considered as consisting of five parts: the gun proper where the electrons are produced and accelerated, the straight drift sections where the cooling takes place, the two bends and, finally, the collector where the electrons are decelerated and absorbed. The electron beam is immersed in a magnetic field, which extends from the gun to the collector, fully confining the flow of the electrons. The field in the bends is toroidal and matched to the adjacent solenoidal fields.

In the collector the electrons are decelerated down to a potential only about 3 kV above the cathode potential and are absorbed on a large water-cooled surface. About 98 per cent of the current lands on the collector and the overall power efficiency is about 92 per cent.

In the near future, further cooling tests will be performed, aiming to increase the precision of the measurements and to extend them to higher intensities. The present results, however, already open the way to applications of this technique. For example, the cooling of low energy antiproton beams in the LEAR project (see September issue, page 260) would add to its physics potential and the relativistic cooling of antiprotons in the high energy proton-antiproton collider could help to improve the quality of the beams.



4.

Looking for antiproton decay

According to our present understanding of particle physics, the proton and its antiparticle should be equally stable. If it turned out that the antiproton were nowhere near as stable as the proton, then theorists would have to have a major rethink.

In a physics experiment with the ICE ring last summer, 240 antiprotons were stored to see what happened as time passed (see September 1978 issue, page 294). Although the antiproton level did fall over several days, the loss was consistent with scattering on residual gas molecules in the ring.

Such antiproton lifetime measurements are limited by this beam-gas interaction and so give only lower limits. However this first experiment demonstrated clearly that antiprotons do indeed live long enough to make the CERN antiproton project possible.

Another way of getting information on the antiproton lifetime is to look for antiproton decay products. This is not limited by beam-gas interaction problems as the ring can be refilled to compensate for losses. However it does depend on the decay products being looked for. As antiproton decay has never been seen, decay products can only be conjectured.

One surmised decay mechanism is quark fusion, where two antiquarks produce a quark and a negative lepton. This quark would then combine with the surviving antiquark in the antiproton to give a neutral pion. There could be other decay channels too, so that the pion plus lepton mode should be given a branching ratio corresponding to the relative probability of this decay channel.

A high number of antiprotons was vital for this experiment so that many bunches had to be stacked. It was the first time that particles were accumulated in a storage ring using stochastic cooling.

Antiprotons were produced by 18 GeV protons from the CERN Proton Synchrotron (PS). For each PS pulse, about a hundred 2.1 GeV antiprotons were injected into the ICE ring, where they were stochastically cooled down to a momentum spread of $\pm 3 \times 10^{-6}$, and bunched into a third of the ring by an r.f. system working at the revolution frequency of the particles.

Subsequent antiproton pulses could then be injected into the empty space around the bunch and progressively transferred to the r.f. bucket using the stochastic cooling process. The injection and storage procedure were repeated at five minute intervals until 1.5×10^4 antiprotons had been accumulated. The average number of antiprotons stored at any time over the ten days of the experiment was 7.2×10^3.

The event rate detected by scintillation and Cherenkov counters was comparable to the expected cosmic ray background, so that no evidence for antiproton decay was seen. This establishes a new lower limit for the antiproton lifetime of 1700 hours times the branching ratio for the surmised decay.

In the near future, beams containing more than 10^{11} antiprotons will be available, so that the antiproton lifetime limit should be pushed far beyond its present limit.

Around the Laboratories

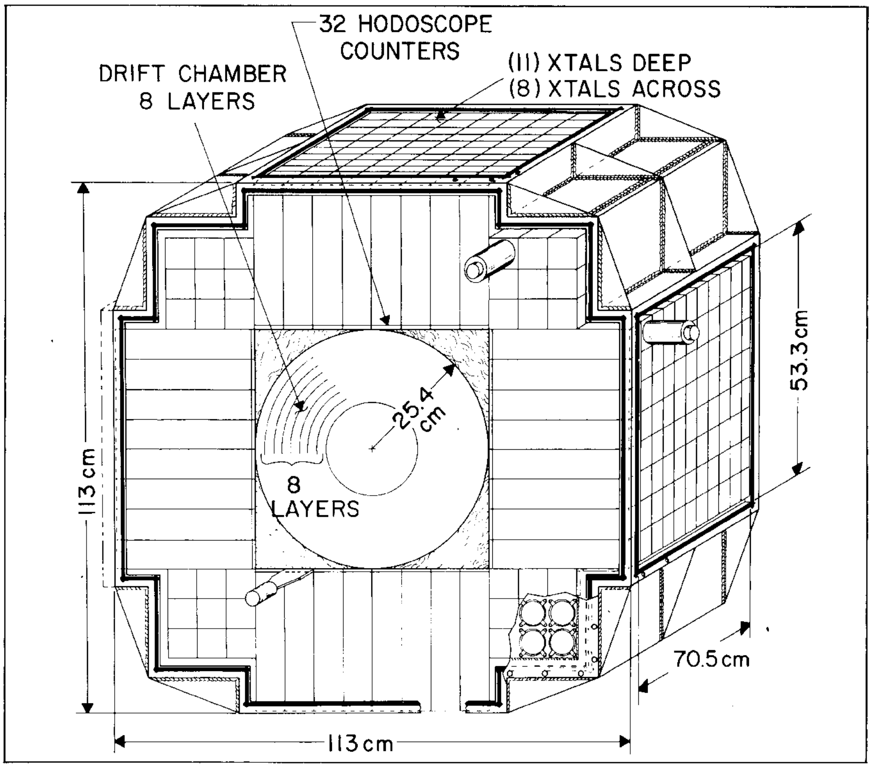
LOS ALAMOS
Crystal box for rare decays

A new experimental facility is being prepared at the 800 MeV proton linear accelerator LAMPF at Los Alamos to study extremely rare processes. The apparatus, referred to as the Crystal Box, consists of a large solid angle modular sodium iodide detector, surrounding a wire chamber and trigger hodoscope. A collaboration of physicists from Los Alamos, Stanford University and the University of Chicago will search for the lepton flavour changing decays of the positive muon to $e^+\gamma$, $e^+\gamma\gamma$ and $e^+e^+e^-$ with a sensitivity to branching ratios as low as 10^{-11} to 10^{-12}.

As the classification of the basic constituents of matter has emerged in recent years, interest has developed in lepton flavour changing processes. It is known that the families e, ν_e, u, d and μ, ν_μ, c, s (and the third family τ, ν_τ, t, b) are connected by quark flavour changing interactions but no lepton flavour transitions have been observed to date. In this scheme muon to electron flavour changes are the analogue of charm and strangeness non-conservation. Predictions for these transitions are made in most of the unified gauge theories now in vogue. In particular, searches for the decays of the muon into $e\gamma$, $e\gamma\gamma$ and three electrons are of paramount importance to test these models.

Previous experimental upper limits fall at least an order of magnitude short of the levels predicted by the theories, the most stringent limit of 1.9×10^{-10} on the decay of the positive muon to $e\gamma$ being set by a previous Los Alamos/Stanford/Chicago experiment. A complementary effort is emerging in renewed searches for proton decays (see May issue, page 116) where the observation of quark/lepton mixing is the experimental goal.

Conceptual drawing of the Crystal Box detector which will search for rare decays at LAMPF. The modular array of sodium iodide crystals surrounds the experimental target, a cylindrical drift chamber and trigger counters. Its first application will be a search for lepton flavour changing muon decays.



The Crystal Box covers a solid angle of more than 2π steradians, which is essential to ensure high acceptance for the three body decays, and will be exposed to stopping muon fluxes of 10^6 per second with a 7.5 per cent duty factor in the LAMPF Stopped Muon Channel. It consists of 352 sodium iodide modules, 6.35 cm × 6.35 cm cross-section and 30.5 cm (12 radiation lengths) long, plus 36 corner crystals 6.35 cm × 6.35 cm and 70 cm long giving a total mass of approximately 2000 kg. The design energy resolution of 4 per cent at 52.8 MeV provides strong rejection of unwanted backgrounds.

The crystals are packaged in a single housing arranged around a central rectangular volume 50 cm × 50 cm and 70 cm long. The central region contains the muon stopping target, a cylindrical drift chamber and trigger hodoscopes. The drift chamber will have narrow angle stereo and is designed to present as little material as possible to the electrons and photons traversing it. The hodoscope, directly in front of the crystals, will provide an electron trigger when taken in coincidence with signals from the crystals. Photons will be identified by detecting energy deposited in the sodium iodide when there is no response from the scintillators.

The three reactions will be studied simultaneously. They will be selected by a hardwired processor designed to use both the analog and digital information from the detector to trigger on allowed geometries and kinematics, within 250 ns. This speed will enable the apparatus to operate at the high instantaneous fluxes mentioned above and provide immediate suppression of accidental coincidences from the ordinary decays of several muons.

The apparatus appears to be well suited to the study of a number of rare pion decays as well. Final installation is expected by mid-1980 and a long career in pursuit of some of nature's most elusive interactions is anticipated.

CERN
Something new in neutrinos?

An unexplained effect has been seen in neutrino interactions by the detector of the 'CHARM' — CERN / Hamburg / Amsterdam / Rome / Moscow — collaboration in a beam dump experiment and was reported at the recent Lepton/Photon Symposium at Fermilab (see page 308).

In the well-known beam dump technique, a large metal block is used instead of the usual primary SPS target. In this block the secondary kaons and pions are quickly absorbed before they have a chance to decay weakly to produce neutrinos.

In this way the usual neutrino flux is reduced by a factor of about a thousand, but any additional penetrating particles, such as neutrinos coming from the decay of short-lived parents, are relatively unaffected. While normally these additional particles would be swamped by neutrinos from kaon and pion decay, under beam dump conditions they might show up.

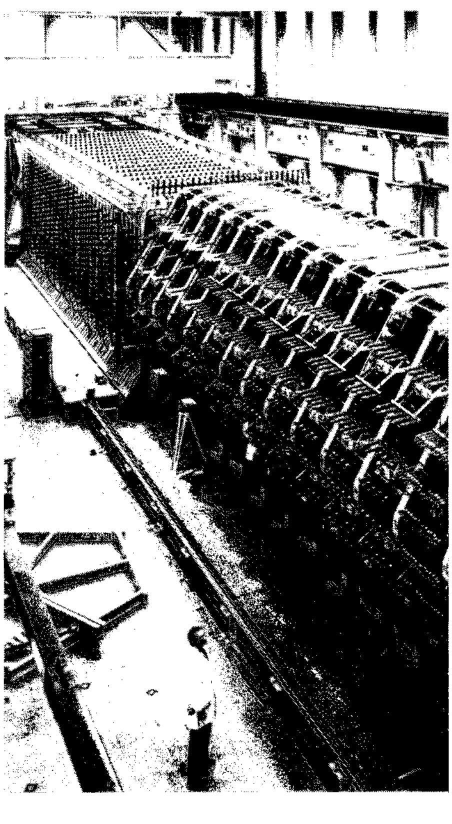
This was the motivation behind the first neutrino beam dump study at the SPS (see January/February 1978 issue, page 16). This saw the first indication of prompt neutrino production, however there was some disagreement between the results from the BEBC and Gargamelle bubble chambers and the CERN / Dortmund / Heidelberg /

Saclay (CDHS) counter experiment. Thus it was decided to rerun the experiment to obtain better statistics.

In the meantime, the fine-grained calorimeter of the CHARM collaboration had been installed in the neutrino beam (see July/August issue, page 193) and was able to supplement the data collected by BEBC and the CDHS counter.

In the beam dump experiment, the detectors basically look for hadron showers associated with no muons, and for showers associated with a single muon. The zero muon showers include those due to neutral current interactions, while those with an accompanying muon enable the charged current rate to be gauged.

The observed numbers of zero muon showers are in excess of what would be expected from neutral current interactions, even after allowance has been made for interactions due to electron neutrinos from conventional sources, which naturally produce no muons. The excess zero muon shower signal is attributed to electron neutrinos coming from highly unstable particles which can decay before they are absorbed by the beam dump.



These highly unstable particles probably carry charm, as these are known to decay sufficiently rapidly. This 'prompt' electron neutrino signal had already been established in the first CERN neutrino beam dump at the SPS.

A first analysis of the data from the new beam dump experiment revealed that the previous discrepancies between the results from different detectors had been ironed out, and all three experiments were in broad agreement on the electron neutrino spectrum attributed to the decay of charmed particles.

In previous work, analysis of the produced hadron showers had been subject to a low energy cut-off, however the CHARM detector with its fine-grain calorimeter and closely packed components enables much less energetic hadron showers to be detected and analysed.

In a subsequent analysis, the conventional 10-20 GeV cut-off was removed from the CHARM data, and a surprisingly large number of hadron showers were found with energies between 2 and 20 GeV (282 with no muon, 463 with a single accompanying muon). These were carefully analysed to avoid possible confusion between neutral current and charged current behaviour, and contamination from cosmic ray events.

Top left, the fine-grained calorimeter of CERN / Hamburg / Amsterdam / Rome / Moscow ('CHARM') collaboration in the CERN neutrino beam, which has seen unexplained effects in low energy hadron showers in a neutrino beam bump experiment. Upstream (bottom right) is the detector of the CERN / Dortmund / Heidelberg / Saclay team.

(Photo CERN 16.12.78)

Even so, a large number of zero muon showers remained. This could have been due to an unexpectedly high ratio of neutral to charged current events in this energy region but a separate analysis of low energy hadron showers in a subsequent run using the normal wide band neutrino beam showed no evidence for this.

Because of the ability of the CHARM detector to distinguish between the development of electromagnetic showers (produced by electrons) and hadron showers, the level of zero muon shower events containing an electron, and therefore due to electron neutrinos, could be accurately estimated.

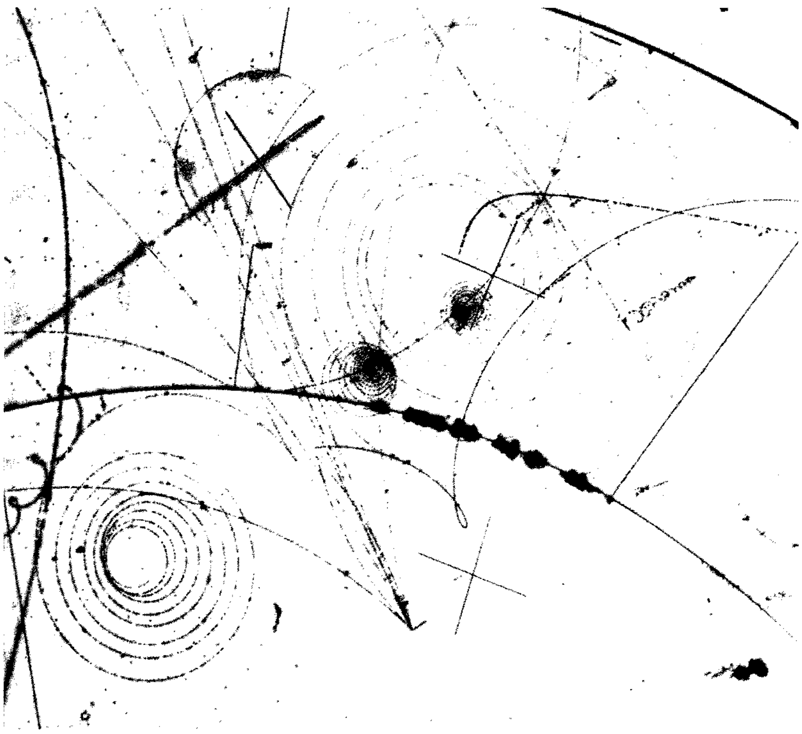
After all corrections, the remaining zero muon showers could be attributed to neither muon nor electron neutrinos, and looked to be something different.

One possibility is that the effect is due to tau neutrinos. F mesons (carrying charm and strangeness) decay to produce tau leptons and tau neutrinos. The tau leptons subsequently decay into a muon plus a tau neutrino and a muon (anti)neutrino, giving in all a double tau neutrino production spectrum which could be responsible for the newly-discovered signal.

In the decay of the tau lepton, the existence of two neutrinos in the final state could make for a detectable momentum imbalance between the observable particles. Several events have been found which show this imbalance, and provide an additional clue.

While the existing data could still reveal more information, more detailed studies will be required before a definite result emerges.

One of the first examples of a high energy antineutrino interaction in deuterium, seen in the 3.7 m BEBC bubble chamber. The invisible incident antineutrino strikes a neutron in a deuterium nucleus, producing eight charged particles — four positives bending away to the left, and four negatives to the right. In addition, at least one neutral particle is produced, as shown by the electron-positron pair seen a few centimetres from the primary vertex. The proton from the struck deuteron remains as a spectator, and is seen as the short stub track at the right of the primary vertex.



Bubble chamber spectators

This summer the 3.7 metre BEBC bubble chamber finished its first run filled with deuterium, providing 126 000 excellent quality photographs with neutrinos and 60 000 with antineutrinos during a 30 day period. This was the first time that a deuterium-filled bubble chamber had been exposed to high energy antineutrinos.

Just before the start of the run, work had been completed to upgrade the neutrino shielding in the West Area at CERN, allowing the use of primary proton beams at maximum SPS energies.

Part of the old earth shielding had been replaced by a 4 x 4.6 x 36 m cast-iron plug, and a toroidal magnet, 6 m in diameter and about 10 m long, inserted in the existing iron shield to focus muons onto the new plug. Previously, the primary proton energy had been limited by problems of muon background.

Tiny bubbles are seen in the pictures due to electrons from the beta-decay of the tritium contamination in the deuterium sample. However the heavy water used at CERN to provide the deuterium for BEBC is extremely pure, with a tritium level less than 3×10^{-15}.

The deuterium nucleus consists of a loosely-bound proton and neutron. This allows reactions on both types of nucleons to be studied in the bubble chamber without the secondary effects that often obscure what happens with heavy liquid targets.

This is particularly useful when the neutrinos interact with the neutrons from deuterons. In these reactions, the companion protons simply spectate, seeing what happens in the interactions, but without being affected themselves.

The short stub tracks caused by the recoil of these spectator protons enable the direction and momentum of the neutrons at the time of collision to be determined, making detailed kinematical analysis possible.

SACLAY Scintillating developments

Physicists are using increasing numbers of scintillators in particle physics experiments. For instance, they are used in calorimeters for measuring the total energy of a particle by means of the light produced by secondary bursts passing through layers of scintillators.

Until 1975 most scintillators consisted of a substrate of polyvinyl toluene (PVT), an aromatic substance which emits a great quantity of ultra-violet radiation when traversed by a particle. Fluorescent products thinly spread throughout the substrate convert the radiation into blue light. The substance is sandwiched between two glass plates having the high grade surface finish needed to collect the light through total reflection on the surfaces.

It is, however, too expensive to manufacture PVT-based scintillators for extensive use in calorimetry. A new type of scintillator was developed at CERN with the help of industry in 1975. This type (called 'Plexipop', see November 1975 issue, page 346) consists of non-scintillating plastic (polymethyl methacrylate or PMMA) containing naphthalene, an aromatic substance which produces the primary ultra-violet and fluorescent substances which transform the radiation into blue light. This scintillator, which is also sandwiched between glass plates, is much cheaper than the PVT-based types, but it gives out only a quarter of the quantity of light. It was developed for experiment NA3 at the CERN SPS (see September issue, page 257), but is now being used in calorimeters for a large number of other experiments.

Together with industry, the Elementary Particle Physics Department at Saclay has developed two alternatives for use in the proton-antiproton colliding beam experiments UA1 and UA2 at the SPS.

Using PMMA as the substrate, the first has provided a scintillator with a light output some three times higher than Plexipop at the same price. The main feature of this new scintillator, dubbed 'Altustipe', is the incorporation of a large quantity of naphthalene (up to 15%). Its mechanical properties are similar to those of Plexipop.

Although initially intended for calorimetry, the development has resulted in four industrial products, all of them cheap and suitable for a specific purpose — Altustipe UV for coupling to a wavelength converter (BBQ); Altustipe blue for direct read-out via a photomultiplier; Altustipe yellow giving high transparency; Altustipe fast emitting less light but with a fast response.

Altustipe UV will be used in two important experiments. CERN has ordered thirteen tons for the axial field spectrometer (AFS) calorimeter at the ISR, while six tons will be used in some of the calorimeters for experiment UA2. Further information may be obtained from Mr. Bourdinaud at Saclay.

The other development has led to the perfection of a new type of scintillator and a new manufacturing process. The scintillator consists of polystyrene, an aromatic product providing the primary ultra-violet, and fluorescent products changing this radiation into light of 'any desired colour'. The light output of polystyrene is very close to that of polyvinyl toluene and these scintillators are therefore highly luminous — about five times more so than Plexipop.

Unlike PVT, polystyrene is a highly diffusing plastic material. Industry supplies it in granular form, which is injected into moulds or extruded at temperatures close to 200°C. Saclay has opted for the extrusion method of manufacture. In an initial operation, the scintillating product is incorporated into the granulate, which is then extruded into plates and passed between polished steel rollers. Plates with highly uniform characteristics (luminosity, transparency, surface finish and thickness) are produced at the rate of about 250 kg per hour.

The scintillator is much cheaper than the Plexipop type, while the light output and transparency are similar to those of the best PVT scintillators coupled with a wavelength converter and with the same emission spectrum. The lengths of the scintillator plates are not limited, and remarkable precision can be obtained on the thickness.

Fifteen tons of this ultra-violet radiation emitting substance have been ordered for experiment UA1. 500 kg of the blue-light emitting type will also be produced for direct coupling to a photomultiplier. A document on the characteristics of this scintillator is being prepared and further information may be obtained from J.C. Thévenin at Saclay.

These two types of product are complementary. Altustipe may be made in large thicknesses, but to a standard tolerance, while in the polystyrene extrusion process, although narrower tolerances are possible, there is a practical limit to the thickness.

FERMILAB
New computer system

Late in July, the Fermilab Computing Center completed its transition to a new system. Three Cyber 175 central processors delivered over the previous eight months were linked together in a loosely coupled fashion using a modified operating system. The system has access to 6 billion bytes of disk memory, 24 tape drives, communications processors and the usual complement of input/output equipment. The three central processors function symmetrically, and there is enough capacity to ensure that failure of any unit will not interfere with the rest of the system, although performance might be reduced.

In the early days, the relatively small amount of computing that Fermilab required was satisfied by the nearby Argonne National Laboratory. For a while this was an acceptable solution, and remote job entry terminals plus a daily courier service were sufficient for the accelerator design work, for the small amount of particle physics then in progress and for administrative computing.

As the accelerator came into operation and the first physics experiments began, it was clear that this initial arrangement would be inadequate. With the tight funding of the early 70s, it was decided to introduce older equipment, available as a result of modern machines being delivered to other Laboratories. Thus, the PDP-10 from the old Princeton/Pennsylvania Accelerator and a CDC 6600 from Berkeley were delivered in 1971 and 1973 respectively. With this equipment and the continued use of Argonne, *Central console of the new Fermilab Computing System, incorporating three Control Data Corp. Cyber 175 processors.*

(Photo Fermilab)

the Laboratory was able to satisfy its needs.

Most of the scientific activity gravitated to the more powerful 6600, which was upgraded over the years by the addition of disk and tape units. Eventually a second CDC 6600 and CDC 6400 were added. These acquisitions plus associated peripherals enabled capability to keep pace with the growing demand.

At the same time, an effort was made to obtain support for a major new Fermilab computing facility. In 1978 $12 million was allocated for a modern facility adequate for future needs.

Since existing equipment was old and had already given good value for money, it was relatively easy to specify a new computer configuration which did not necessarily rely on any of the equipment already installed. The only (nontrivial) problem was that of program conversion. The primary aim was to acquire a system at least three or four times larger than its predecessor. There were relatively few other constraints apart from the need for the manufacturer to aid in the software conversion process.

All major US computer manufacturers were invited to bid and the chosen configuration was based upon three Cyber 175s from CDC. By agreement, the equipment was delivered in stages, beginning in October of last year with two of the central processors and a good fraction of peripheral equipment. No additional space was available, so the older equipment had to be replaced gradually, at the same time ensuring that service was maintained. In April of this year, the third central processor was delivered along with most of the additional peripheral equipment. Its acceptance in July meant that the transition phase was over.

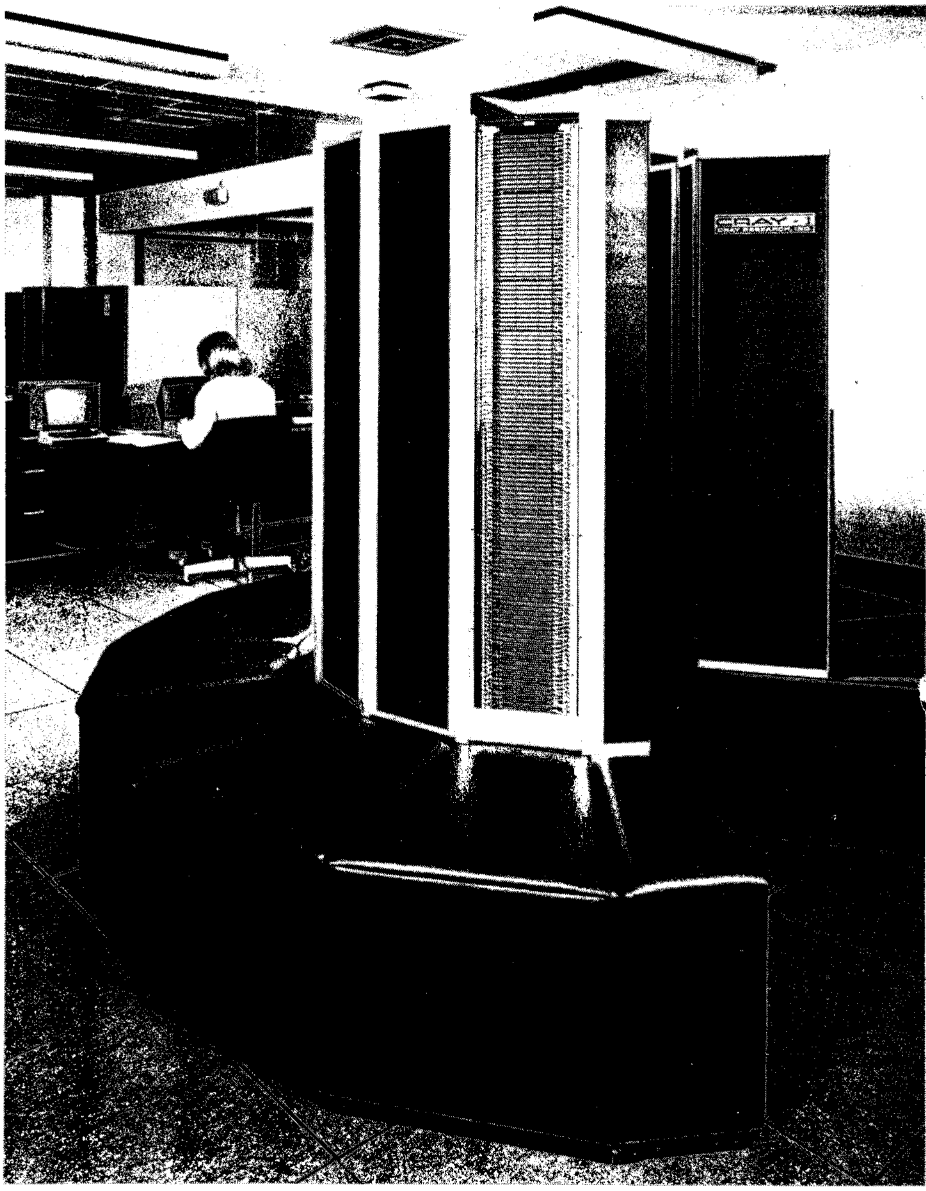
During this transition period the system was operated in both the old and the new mode. Previously Fermilab had been committed to the mature CDC SCOPE operating system, currently called NOS/BE. With the new equipment, it was decided to make the transition to the more modern, better supported NOS operating system from CDC. This has many advantages over the older system, but inevitably there were some nice features in the older system that were not exactly reproduced by its successor. Thus it was necessary to run both systems to help convert programs. The conversion burdened many users and was less transparent than had been hoped, but the total inconvenience was not too bad.

The limited capacity of the older system excluded interactive use and only a limited remote job entry batch capability was supported. Two of the major improvements are a relatively large interactive facility and a strong remote job entry system. Another major enhancement is a high density (6250 bits per inch) tape system. The number of tape drives and the amount of disk space have been increased substantially over what was previously available.

A Calcomp Automatic Tape Library (ATL) will also be integrated into the new system. Currently available mass store devices manufactured by IBM, CDC and Ampex are expensive and not easily integrated. On the other hand, the ATL, an older device marketed by Calcomp, is relatively inexpensive when used with high density tape units and is much more easily integrated into a CDC Cyber system. It is capable of storing up to about 10^{12} bytes of information and will come into use sometime next year.

The Cray 1 computer installed at Daresbury, showing in the centre the processor and memory, and at the base the comfortably upholstered power supplies.

(Photo Daresbury)



Other new facilities include a 3M microfiche system which has both an alphanumeric and graphical capability with 4096 by 4096 resolution. The microfiche system will operate off-line with its own tape drive. Two new fanfold Calcomp plotters will be connected directly.

The three processors share half a million words of extended core storage for communicating between the three machines and for system residency. Common input/output queues are maintained, and all file storage is available to any of the three Cybers. At any given moment, one acts as the front end, although any of the three can do the job.

The three machines are not quite identical. Two are Cyber 175-200s, each with 192K 60-bit words of memory. The third is a Cyber 175-300 with 256K words of memory. The 175-300 with its higher performance memory has a benchmarked throughput about 15 per cent higher than the 175-200. Total capability is very close to that of two CDC 7600 computers, and it is expected that the new system will meet Fermilab's computing demand into the early 1980s. With enhancements of peripheral equipment and with additional central processors, the system should be able to satisfy needs beyond the mid-1980s.

DARESBURY
Exceptional computing power

The UK Science Research Council is buying time on a Cray 1 computer, recently installed at the Daresbury Laboratory. For some types of calculation it is substantially more powerful than the computers hitherto available in the UK and it will be used by selected groups of scientists whose work can justify the use of exceptional computing power.

The Cray 1 was switched on at Daresbury in June and several groups are already using it. It will soon be linked to the Laboratory's IBM 370/165 and will then be accessible from workstations on the SRC's computer network.

The Cray 1 is a very fast computer designed to handle vector quantities as well as scalars. It achieves high performance by being physically compact (thereby reducing the time electrical signals take to move across the machine), it uses fast memory and logic components and it can support a considerable degree of parallel operation. It can execute instructions at the rate of several tens of millions per second, depending on the vector content of the programs. It accepts programs written in standard Fortran and the Fortran compiler tries to optimize the code so as to use the vector hardware as far as possible.

Progress in many scientific fields has been closely allied with progress in computing. This is particularly true in the exploration of scientific models where the extent to which a model can be explored by computer depends, among other things, on the number of calculations which can be performed in a reasonable length of time. Over the years, scientists have exploited the increasing power of computers to study more complex phenomena or to add detail to approximate calculations. At any stage the available computing power imposes some limit on the scale of calculation which it is practical to undertake and, inevitably, interesting and important phenomena are always thought to be frustratingly just out of computational reach.

Towards the end of last year an

Making particle scattering data available through computer terminals is the job of the Particle Data Group at the University of Durham, UK. Seen here, left to right, project director Fred Gault, coding assistant Liz King, applications programmer Alan Lotts and data base manager Brian Read.

(Photo Durham)

SRC working party concluded that the provision of a very powerful computing facility would open up new and worthwhile important research problems for which computational techniques have been developed but which could not be tackled on existing computers. The problems are in fields as diverse as protein crystallography, astrophysics and engineering.

Examples of advances which might be made are increasing the dimensionality of models (for example, in plasma physics where the present one-dimensional codes are inadequate to model laser-plasma interactions, or in engineering where it is not yet possible to analyse the behaviour of some complex structures in three dimensions), extending present techniques into more complex areas (for example, refining the structure of larger protein molecules, or studying the collision processes of heavy ions), reducing mesh sizes in fluid or particle dynamics problems and introducing dynamics into problems which have hitherto been studied only statically.

DURHAM
Data from your terminal?

Elementary particle scattering data could be as close as your nearest computer terminal as a result of a project to make all scattering data available through computer-searchable data bases. The data and documentation reside on the Rutherford Laboratory computers and the system is designed to display data in tabular or graphical form, or to transfer it to the user's files. A simple enquiry language helps to retrieve the data required from the data files, or to scan the associated bibliographic data base.

The work of compiling the data and making it easily available is coordinated from the University of Durham (UK) where Brian Read manages the various data bases, Alan Lotts writes graphics software, and Liz King codes data and looks after the bibliography and correspondence. The actual compilation work is done by people working with the data and the group is always looking for new participants.

At Rutherford, Dick Roberts compiles hadron inclusive and lepton production scattering data and structure functions, both weak and electromagnetic, and helps with documentation and publicity. At Glasgow, Ron Crawford is the group's two-body photoproduction expert, and the rest of two-body scattering and electron-positron inclusive data are handled by Brian

Read. Geoffrey Fox at Caltech contributes a range of data and coordinates the plans of the Particle Data Group at Berkeley to publish the UK data along with various other compilations on microfiche with an introduction and indexes. This document (LBL-92) is intended as a once-only archive for libraries rather than as a working tool for physicists.

Since the project received the support of the UK Science Research Council in 1975, most elementary particle scattering data with a beam momentum greater than 2 GeV has been fed into the data bases. Any remaining gaps, mainly in older experiments, are gradually being dealt with and are filled immediately if there is a demand. Once the data is coded and stored in the data bases it is available on the Rutherford network throughout the UK and at CERN and DESY. Other networks extend the availability in Europe and the USA.

The project grew out of separate compilation efforts of Caltech, Durham and the Particle Data Group (PDG) at Berkeley and a recognized need to archive data before the experimental group which produced it dissolved. The PDG was committed to the Review of Particle Properties (LBL-100) and to its Compilation of High Energy Physics Literature (LBL-90) and would have needed extra effort if scattering data was also to be compiled, so the project was based at Durham where a compilation group already existed.

Access to ARPANET for the exchange of software and data removed the problems of geographical separation, and the installation of the Berkeley Database Management System (BDMS) at Rutherford made it possible to manage and retrieve compiled information. A uniform coding standard was maintained by using the Particle Physics Data Language (PPDL).

The top priority of the project, and of project director Fred Gault, has been not just to store information but to get it to people who want to use it. It is also a policy to store all the scattering information from a single published paper, or preprint, in one record. This ensures that it appears as the experimentalists presented it and, in effect, provides a 'marketing organization' for experimental data. This avoids the problem of users citing the compilation rather than the original paper and encourages them to read the paper if they need more information.

Regularly updated computer-searchable data bases supported by informed commentary are taking their place as a research tool for elementary particle physicists. This tool could become progressively more important as printing costs rise and hinder the publication of large tables of data.

DESY
PETRA performance at 30 GeV

Up to 20 August, when a routine maintenance shut-down began, over 1500 electron-positron annihilation events were collected at PETRA between 27.4 and 31.6 GeV total energy. The four experimental groups — JADE, Mark-J, PLUTO and TASSO — were able to analyse this data in time for the Fermilab Lepton/Photon Symposium (see page 307).

PETRA performance has now surpassed that of DORIS. Twice it has been able to attain (for each of the four interaction regions) an integrated luminosity of more than 100 nb^{-1} in 24 hours, and once 44 nb^{-1} were collected in only five hours.

These luminosities were reached with only two bunches per beam. The peak current after injection is now about 10 mA per beam (5 mA per bunch). With these initial currents and after acceleration to 15 GeV, the luminosity is over 3×10^{30} cm^{-2} s^{-1}. Each filling lasts for many hours, and refilling is quicker thanks to the newly-available PIA ring (see September issue, page 252).

A run was carried out while one of the powerful 550 kW (cw) klystrons of the PETRA r.f. was replaced. In addition to normal data-taking, measurements of the beam polarization were made using back-scattered laser photons. This electron polarization is transverse to the orbit and is due to the emission of synchrotron radiation. Studies of this polarization, using both the laser method and the analysis of electron-positron collisions, are still under way.

Physics monitor

Who will succeed in rescuing the quark damsel confined in her tower? Alvaro De Rújula's view of the current scene in particle theory.

QCD roadshow rolls on

Is quantum chromodynamics (QCD) the ultimate theory of hadronic phenomena? Or, put more sceptically, can one tell QCD from a hole in the ground? This is the title of a new theory roadshow, which after a successful premiere at CERN went on to attract a large audience at Erice, Sicily, during the recent international school of subnuclear physics.

Conceived, written and directed by Alvaro De Rújula, John Ellis, Roberto Petronzio, Giuliano Preparata and Bill Scott and presented by Mary K. Gaillard, the spectacular — a drama in five acts — covers the development and present status of our understanding (if at all) of deep hadronic structure.

The plot involves a new religion (Quod Cern Demonstraturum) attempting to impose itself upon an imaginary world. Its proponents and defenders struggle to decide whether QCD describes reality, whether it can be proved that it does so, and whether its much-publicized 'miracles' are fake.

The characters are: The Ayatellis (played by himself) — a prophet of QCD who, as if by divine inspiration, knows the ultimate truth all the time; Biscotte (alias experimentalist Bill Scott) — a sorcerer's apprentice in the form of a Deus ex (400 GeV) machina who performs the prodigious feats which prove the prophet's most recent truth; De Oracle (played by himself) — interpreter of the dogma and arbiter of the tournaments, who preaches to the masses and predicts the past; Giuliano Bruno (played by himself) — a heretic who castigates QCD and harasses its blind followers; Pestilonzio (also played by himself) — an infidel and devil's advocate who attempts to undermine QCD from within.

The Ayatellis wears a coat of many colours and a peculiar hat. He carries with him a small bell, which he rings to herald his many important pronouncements. Biscotte is armed with a large briefcase containing much computer output together with transparencies and a hand calculator. During the play, he is kept busy displaying experimental evidence. De Oracle wears what appears to be a torn sheet and seats himself behind a large sign 'Theatrical Division'.

Giuliano Bruno wears a conical hat labelled 'light cone' which has 'future' inscribed on the front and 'past' on the back. Pestilonzio has horns on his head and wears a black cape from which emerges a long black tail. He carries a multicoloured pitchfork.

The quantum chromodynamics prophet Ayatellis (alias John Ellis) preaches to the masses. The other characters in the divertissement are (left to right), the experimentalist (played by Bill Scott), the heretic (Giuliano Preparata), the infidel (Roberto Petronzio) and the oracle (Alvaro De Rújula).

(Photo CERN 296.6.79)

The action begins at the 'dawn of prehistory', way back in 1967 when a great prophet in the West, after meditating for many days in the wilderness of Palo Alto, revealed the deep inelastic truth.

It is prophesied that hadrons undergoing deep inelastic scattering appear to behave like bundles of free particles, called partons. Thus under these conditions, strong interactions are solved — they simply do not exist! How can this paradoxical result be reconciled with a field theory of hadron constituents?

Scene Two marks the Coming of Gauge, when new prophets arise who show how field theory can be reincarnated, the trick being to disregard conventional Abelian principles and go non-Abelian instead. This is hardly surprising as apparently the original Abelians were an ascetic sect who practised chastity after marriage and therefore died out.

In response to objections from the heretic, the prophet then embarks on a quest for the 'Wholly Scaling Variable' which takes account of the finiteness of the nucleon mass and other complications. This enables dramatic new tests to be made which purport to demonstrate the power of QCD, but there is heated debate as to whether the experimental data is evidence for or against QCD.

'Are moments magic?' is the title of the fourth act where the latest experimental data comes under further scrutiny. Telegrams arrive from far and wide pointing out that QCD predictions can be reproduced by more general arguments or that the experiments have the wrong kinematics.

No matter what evidence or argument is put forward, the Ayatellis skilfully manages to manipulate it to work in his favour. On the other hand, the long-suffering heretic claims to have been vindicated, but gloomily assumes the QCD proponents will continue to deny the facts and 'twist' their theory to fake the right answer. If only they would stop burning their opponents at the stake!

The play comes to an end with the question still in doubt, but nevertheless there is a happy ending because all the characters are happy. The Ayatellis, convinced that QCD cannot be questioned, goes on to more exotic pastures. Pestilonzio says that the QCD proponents are following the correct path, despite having jumped to too many conclusions in the past. De Oracle holds that quantitative QCD is in its infancy and there is lots of work to keep everyone busy. The heretic, having dissociated himself from the QCD throng, is happily gathering experimental evidence to support his ideas, and the experimentalist is already working on his next project.

Mathematics and Physics in Lausanne

Physics has always needed mathematics to find solutions to its problems, and conversely, the most fruitful stimulus for mathematics has been the need for new tools to handle physical problems. A good example was the birth of quantum mechanics, when the theory of partial differential equations and of Hilbert spaces provided essential tools for physicists, and where mathematicians were led by the needs of physics to develop certain noncommuting algebras (Von Neumann algebras).

Res Jost (left) of ETH Zurich, converses with S.T. Kuroda of Tokyo during the recent Lausanne International Conference on Mathematical Physics.

(Photo E. Baumgartner)

The same pattern is seen in today's particle theory. The hopes for understanding the 'confinement' of quarks and gluons are based on recent developments in non-Abelian gauge theories. Attempts to unify descriptions of bosons and fermions have led to the study of supersymmetry, or as the mathematicians call them, graded Lie algebras. In addition, recent progress in the theory of dynamical systems may lead on to developments in accelerator theory.

With this in mind, Walter Thirring, the outgoing president of the International Association of Mathematical Physics (IAMP) asked Philippe Choquard, from the Ecole Polytechnique Fédérale in Lausanne, to organize an International Conference on Mathematical Physics from 20-25 August.

The organizers tried to present a programme which attracted as wide an audience as possible in the time available, so as to stimulate interaction between different fields. While this inevitably posed restrictions, poster sessions provided a valuable outlet for those who were not allocated speaking time.

The topics selected were Schrödinger operators (where a lot of progress has been made in the last few years in the study of the good old Schrödinger equation), statistical mechanics, where particular emphasis was placed on the quantum and classical theory of Coulomb systems and on topological methods in the study of defects in crystals and liquid crystals, quantum field theory in all its various approaches, dynamical systems, gauge theories and supersymmetries, and C* algebras — a new mathematical tool for studying systems with an infinite number of degrees of freedom.

The session organizers — B. Simon, E. Brézin, J. Fröhlich, A. Trautman, J. Scherk, D. Ruelle and H. Araki (now president of IAMP) did a very good job in selecting short communications. All the main talks were of high quality and the speakers were evidently well prepared.

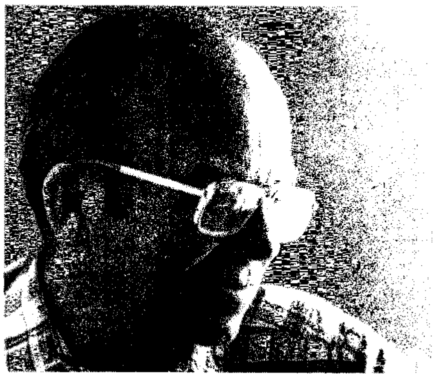
Particular mention can be made of W. Hunziker's presentation on quantum particles in electric and magnetic fields, E. Lieb's talk on Coulomb systems, O. Landford on time-dependent effects in statistical mechanics, A. Jaffé on constructive field theory, J.P. Eckmann on the mappings of the unit interval onto itself, D. Olive on non-Abelian magnetic monopoles, G. Toulouse on topology and defects, I.M. Singer on gauge theories, P. Van Niewenhuisen on supergravity, and finally the very entertaining talk of J. Scherk, the 'Superman of Supersymmetries'.

The Lausanne conference was the fourth of a series (Moscow 1972, Kyoto 1974, and Rome 1977), and the new next meeting will be held in Berlin in 1981, when maybe the problem of quark confinement will have been solved!

(We are grateful to André Martin for this report.)

People and things

Pief Panofsky



Cartoon drawn by Bob Gould on the occasion of Pief Panofsky's 60th birthday, showing Pief hauling the SLAC 'Wizard' up the mountain.

Fermi Award to Pief Panofsky

It was announced in mid-August that Pief Panofsky, Director of the Stanford Linear Accelerator Laboratory, has received the Enrico Fermi Award. This award is given by the Department of Energy with the approval of the President and is the highest award in the USA for achievements in nuclear science. The award was also given to Harold Agnew, the former Director of Los Alamos.

Pief, who celebrated his 60th birthday amid much rejoicing in May, is held in much admiration and affection throughout the world of high energy physics. The citation on the Fermi Award is a good summary of why this should be so — 'For his many important contributions to elementary particle physics; for his leading role in advancing accelerator technology evidenced in the success of the SLAC 20 BeV, SPEAR and PEP machines; for his positive influence on and inspiration of younger scientists; and for the depth and thoughtfulness of advice he has so generously given the United States government...'

The fund which was set up in memory of John Rutherglen is used to finance an annual award to a postgraduate student in experimental particle physics from one of the universities associated with the old electron synchrotron NINA at Daresbury. The award for 1979 will be divided between S.H.P. Geer of Liverpool and W.J. Haynes of Sheffield.

Kjell Johnsen has left his position as Director of IRAM (Institute for Radio Astronomy in the Millimetre Range) and in August moved to Brookhaven to spend some time on the ISABELLE 400 GeV proton-proton colliding beam project as deputy to the project leader Jim Sanford.

Talking to Science Writers

Giving the principal address at the recent meeting at Fermilab of the Chicago chapter of the US National Association of Science Writers, Fermilab Director Leon Lederman said some of the most important tools society uses today have come from basic research, from the work of gifted scientists who were not looking for useful end products, but who were rather attempting to extend the frontiers of knowledge.

One such example is the development of high vacuum. Without this technique there would be no television tubes, no X-rays, transistors, integrated circuits, microprocessors or computers.

'The roots of our technology are based on the past doing of things we are doing at Fermilab', said Lederman. But the knowledge gained by this basic research may not be needed by society until well into the following century.

Lederman cited superconductivity, where much pioneer work has been done at high energy physics Laboratories, as a development whose application might become widespread in the years to come.

Chris Quigg, Fermilab's theory head, reviewing the history of particle physics, had high praise for some of the thinkers who centuries ago had made observations about the make-up of matter with startling accuracy. For example Democritus

Resplendent in CERN 25th anniversary T-shirts — your CERN COURIER team. Left to right, Henri-Luc Felder, editor who takes care of the French edition, Monika Wilson who looks after journal distribution and other administrative matters, Brian Southworth Editor, Micheline Falciola, responsible for the advertisement pages and liaison with the printers, and Gordon Fraser, editor who takes care of production of the English edition and who writes most of the high energy physics articles.

(Photo CERN 213.8.79)

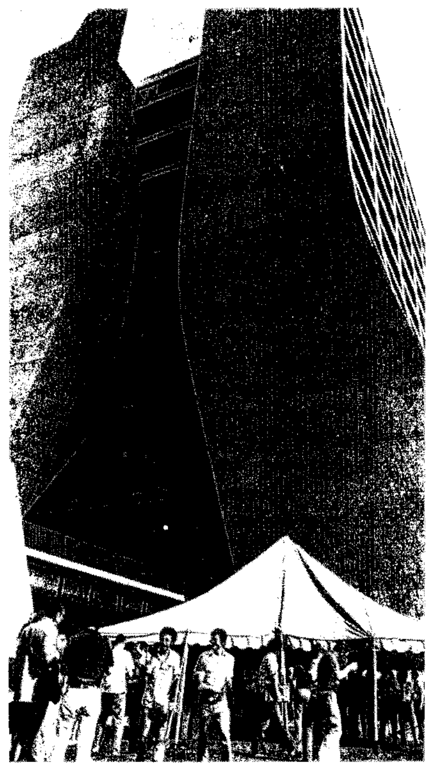
apparently said around 450 BC, 'the only existing things are atoms and empty space — all else is mere opinion'.

SRS booster in action

The booster of the Synchrotron Radiation Source under construction at Daresbury Laboratory is in operation and already providing electron beams that would be adequate to fill the storage ring in a few minutes. The Booster synchrotron has achieved over 600 MeV peak energy and is regularly accelerating beams of 25 to 30 mA. The extraction system has been used and is giving efficiencies close to those anticipated. Components of the storage ring itself are being installed and everything is on schedule to start SRS commissioning in April of next year.

Another possible radiation source is being tentatively investigated at Daresbury. The linac once used on the NINA electron synchrotron might be operated to put 40 MeV, 20 A pulsed electron beams through a 5 m periodic transverse magnet structure to provide radiation tunable over some range in the 70-150 μm region. The proposal is known as FELIX (Free Electron Laser Interesting eXperiment) and interest in design, construction or use of such an infra-red radiation device should be made known to Jerry Thompson at Daresbury.

1.



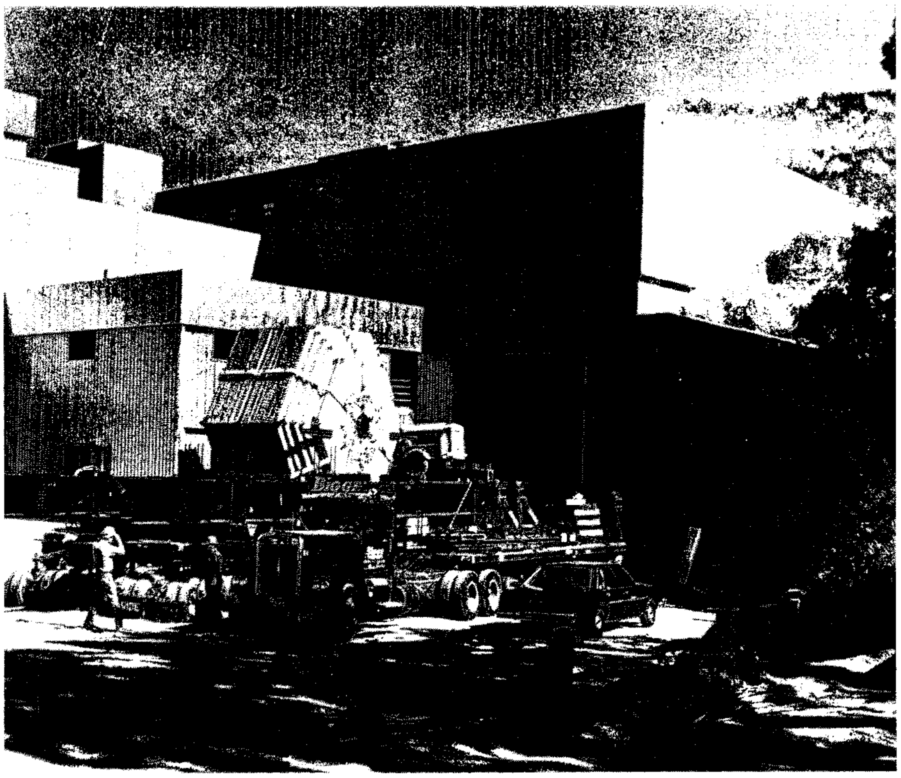
2.

3.

Photo scrapbook from the recent Lepton/Photon Symposium at Fermilab (see page 308): 1. – Conference Organizer John Peoples summons delegates with the aid of a cowbell, 2. – coffee time, 3. – delegates applaud Leon Lederman's concluding talk. As well as hearing all the latest developments in this fast-moving field, delegates were also able to enjoy a packed programme of social events.
(Photos Fermilab)

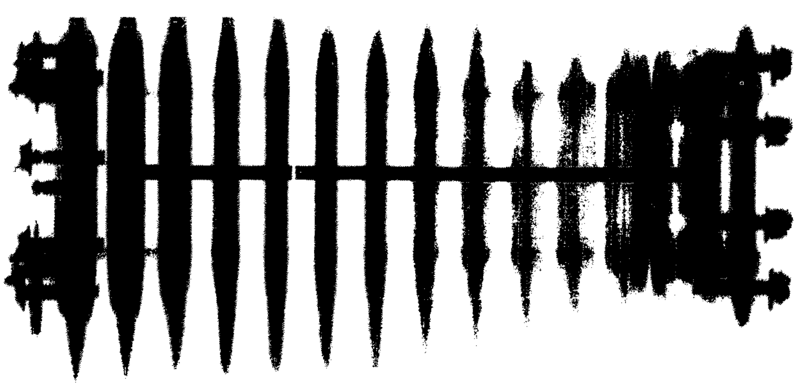
Experimental apparatus is moving into the PEP electron-positron storage ring under construction at Stanford. Seen here are the two end sections of MAC, a large magnetic calorimeter, being moved into interaction region I-4 (the large concrete building to the right). The smaller metal-clad building will house the experiment electronics. MAC will be used as a lepton detector and hadron total energy detector by a Colorado/ Northwestern/SLAC/Wisconsin/Utah collaboration.

(Photo Joe Faust)

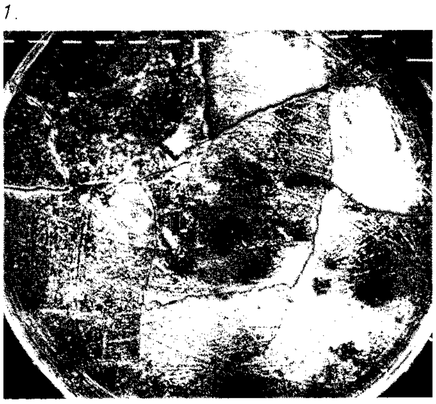


Thanks to a further modification of its radiofrequency system and to a redesigned ion source, the CERN synchro-cyclotron has produced an extracted beam of carbon-12 ions carrying 85 MeV of energy per nucleon. Several experiments are in active preparation to exploit this potentially interesting energy, and in a future edition of the CERN COURIER we plan to report in detail on these latest developments at CERN's oldest accelerator.

A letter recently arrived at the CERN COURIER office asking for more information on a high intensity 'moon beam' at a well-known national Laboratory. We guess they really meant muon beam, unless somebody is looking to start an experiment to measure moon pair production, or to measure parity violation in moon decay, or to check moon number conservation.



1.



2.

3.

The target which will yield the antiprotons for the antiproton accumulator ring in the CERN collider project has to take the 26 GeV proton beam from the PS at full intensity over extended periods of time. A model target of eleven tungsten rods, each 10 mm long, 3 mm diameter, designed to dissipate 1 kW and withstand temperatures of 3000° C, was tested for ten hours at the PS. An immediate X-ray examination (photo 1 which also shows the structure of the target with its graphite sleeve and aluminium cooling fins) revealed no structural damage. Opening the target two months later when radioactivity had died down revealed cracking and pitting of the tungsten (photos 2 and 3) but the rods had been held by the graphite sleeve and target efficiency did not decrease.

University of Dortmund

Theoretical High Energy Physics

There will be one or two postdoctoral positions available in theoretical particle physics at the University of Dortmund. Preference will be given to young postdocs with some research experience in gauge theories and/or in (perturbative) QCD.

Applications should be sent to:

E. A. Paschos or E. Reya,
Institut für Physik,
Universität Dortmund,
Postfach 500500, **4600 Dortmund 50,**
West Germany

University of Illinois at Chicago Circle Department of Information Engineering

Assistant/Associate Professor Position

is available for September 1980. Duties include undergraduate/graduate teaching and research. An earned Ph.D. in electrical engineering or physics is required. Prefered area of specialization is as follows:

1) Charged particle beam transport.

Commitment to engineering must be evident for previous employment history.

Send resume, selected publications and three references by March 1, 1980 to:

Professor Bruce H. McCORMICK
Head Dept. of Information Engineering
UNIVERSITY OF ILLINOIS
CHICAGO CIRCLE
Box 4348
CHICAGO/Ill. 60 680

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Work on new projects, including the 1000 GeV superconducting Tevatron and the $\bar{p}p$ colliding beams facility.

We welcome inquiries from Physicists whose experience is not specifically in the above areas, to work in the advanced technology environment characteristic of particle physics research.

Staff members have the opportunity to devote some of their time to individual high energy physics research. Salary and term of appointment will depend on qualifications, ability and experience.

Research associate positions in high energy and accelerator physics are also available.

Applicants should submit a resume, list of publications and the names of three referees whom you have asked to send letters of recommendation to:

Dr. Roy Rubinstein, Secretary
Fermilab Committee on Scientific Appointments
Fermi National Accelerator Laboratory
P. O. Box 500
Batavia, Illinois 60510

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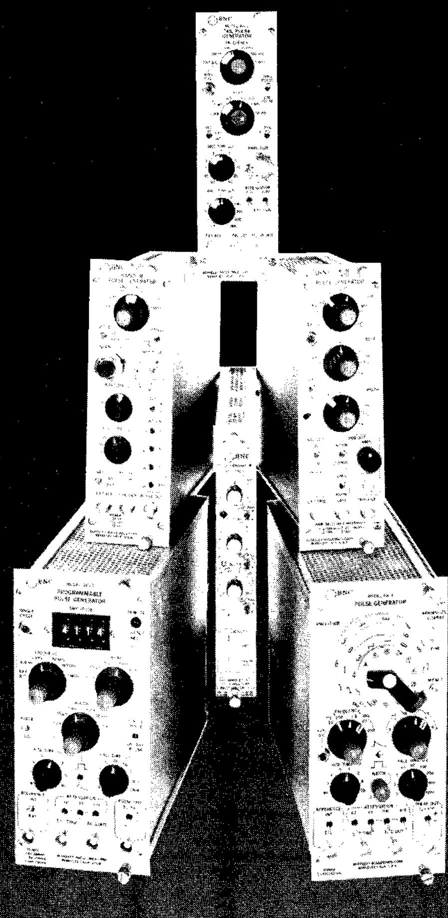

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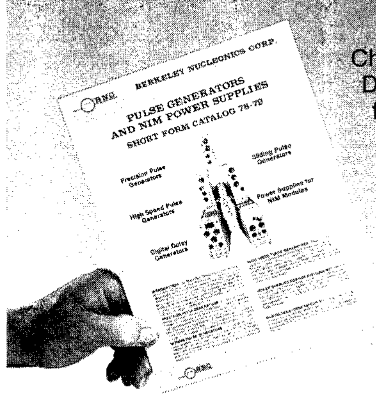

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Assistant Professor

Department of Physics

University of British Columbia

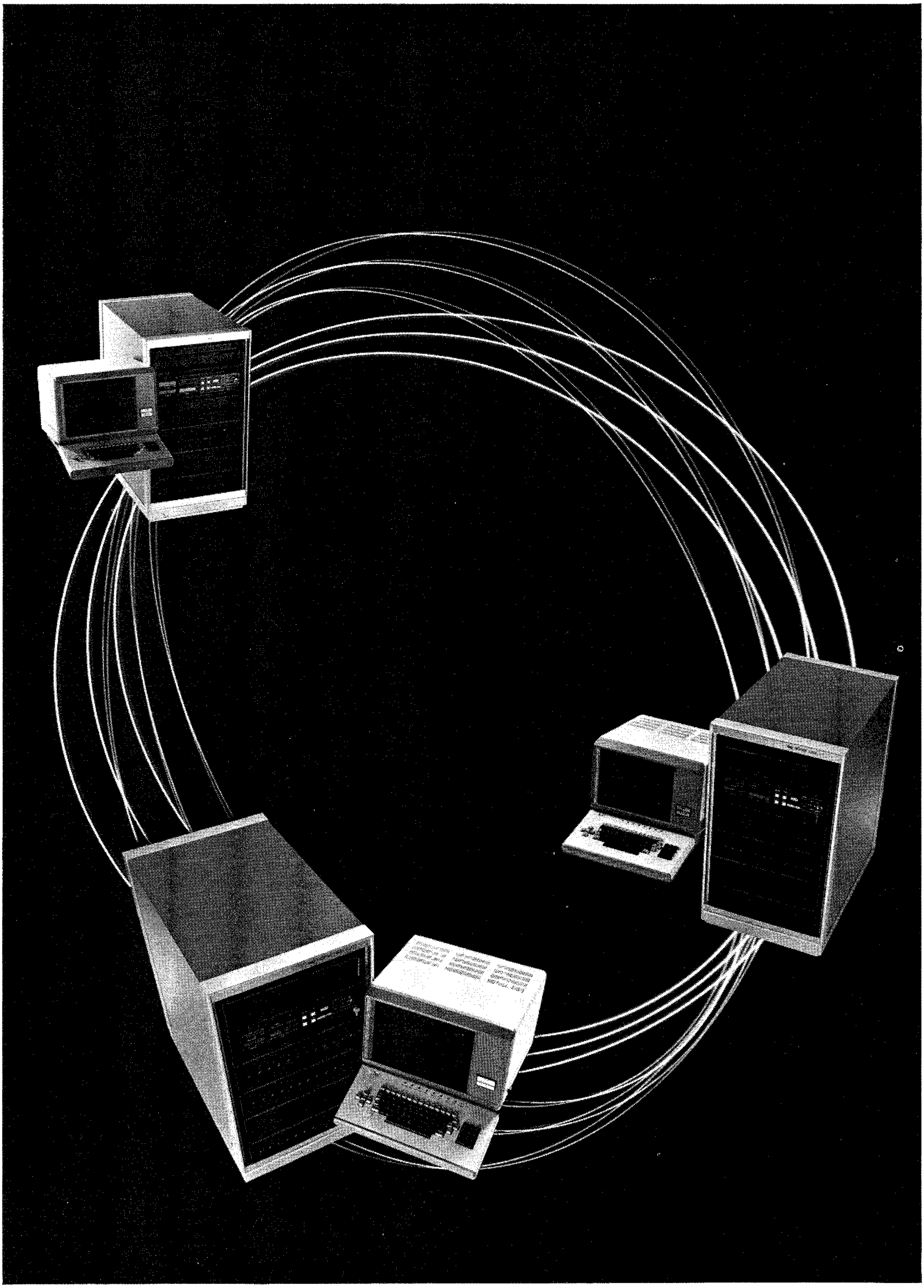
The University of British Columbia in Vancouver expects, subject to the usual budgetary confirmation, to make a tenure-track appointment at the Assistant Professor level in the Physics Department commencing July 1, 1980. Primary consideration will be given to applicants with research interests in Intermediate Energy Physics centred around the TRIUMF meson facility situated on the U.B.C. campus. Outstanding candidates in other fields are also invited to apply.

The successful candidate will be expected to teach effectively at both the undergraduate and graduate levels.

The closing date for applications is November 30, 1979.

Send resume, bibliography and the names of three professional references to:

Professor Garth Jones
Chairman
Committee on Initial Appointments
Department of Physics
The University of British Columbia
2075 Wesbrook Place
Vancouver, B.C., V6T 1W5
Canada



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- Fast development cycle
- user-oriented dialogue
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- automatic powerfail restart

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- hardware options e.g. DMA
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Resident:
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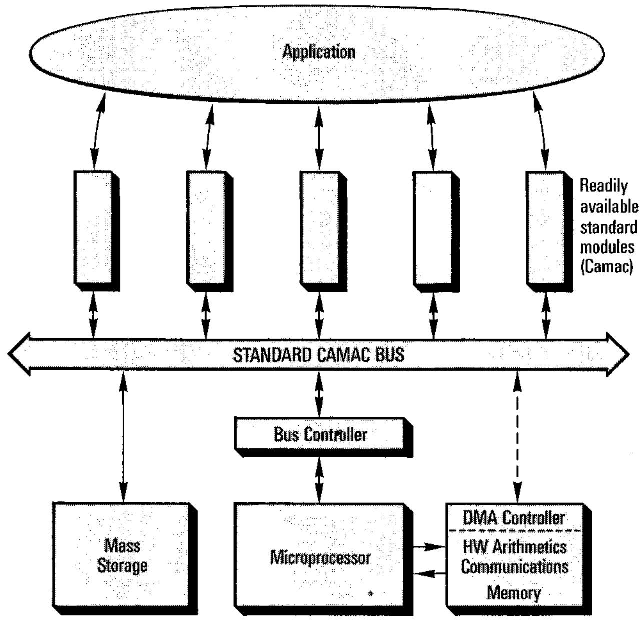
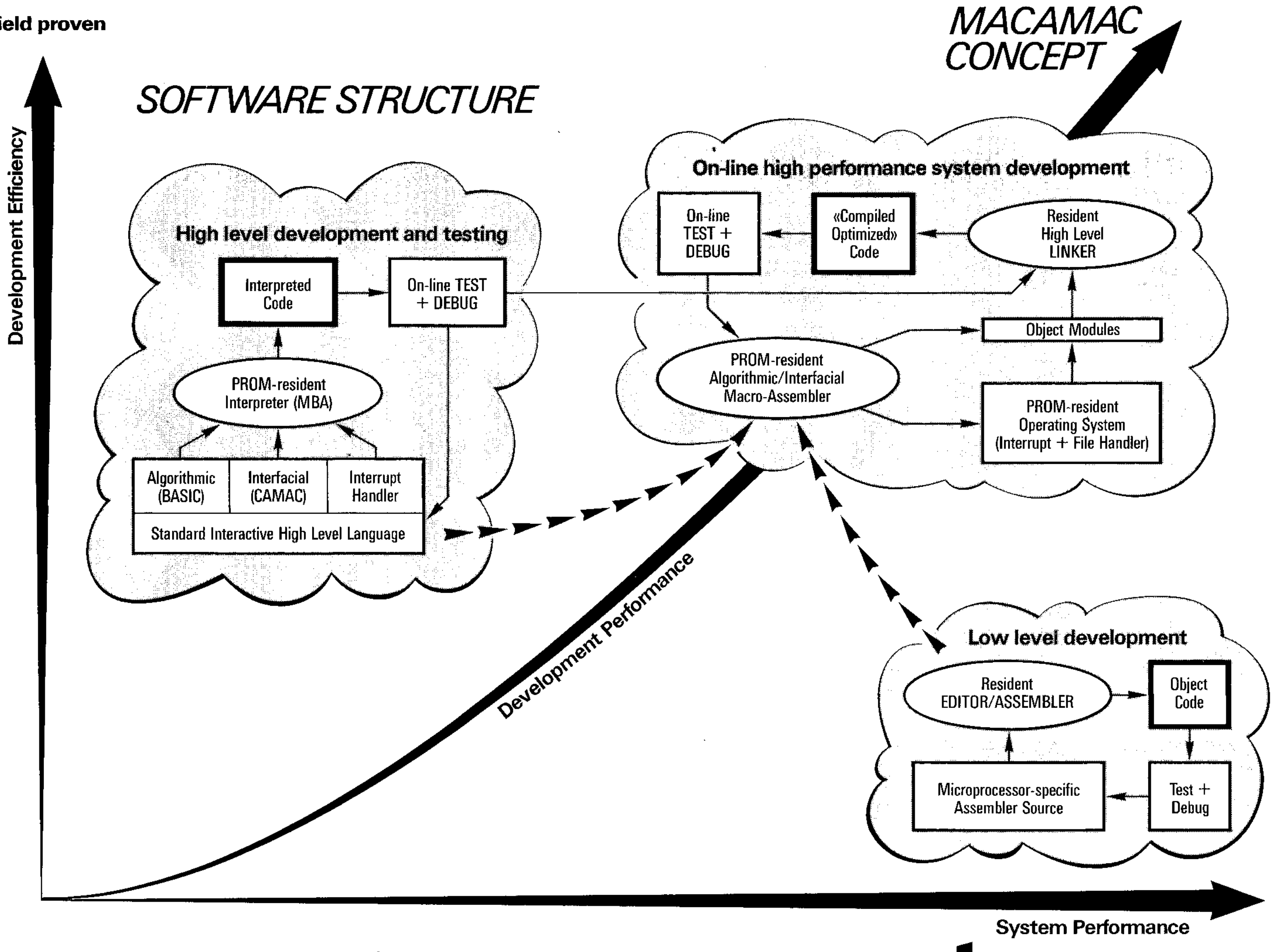
Field proven

HARDWARE CONFIGURATION



SOFTWARE STRUCTURE



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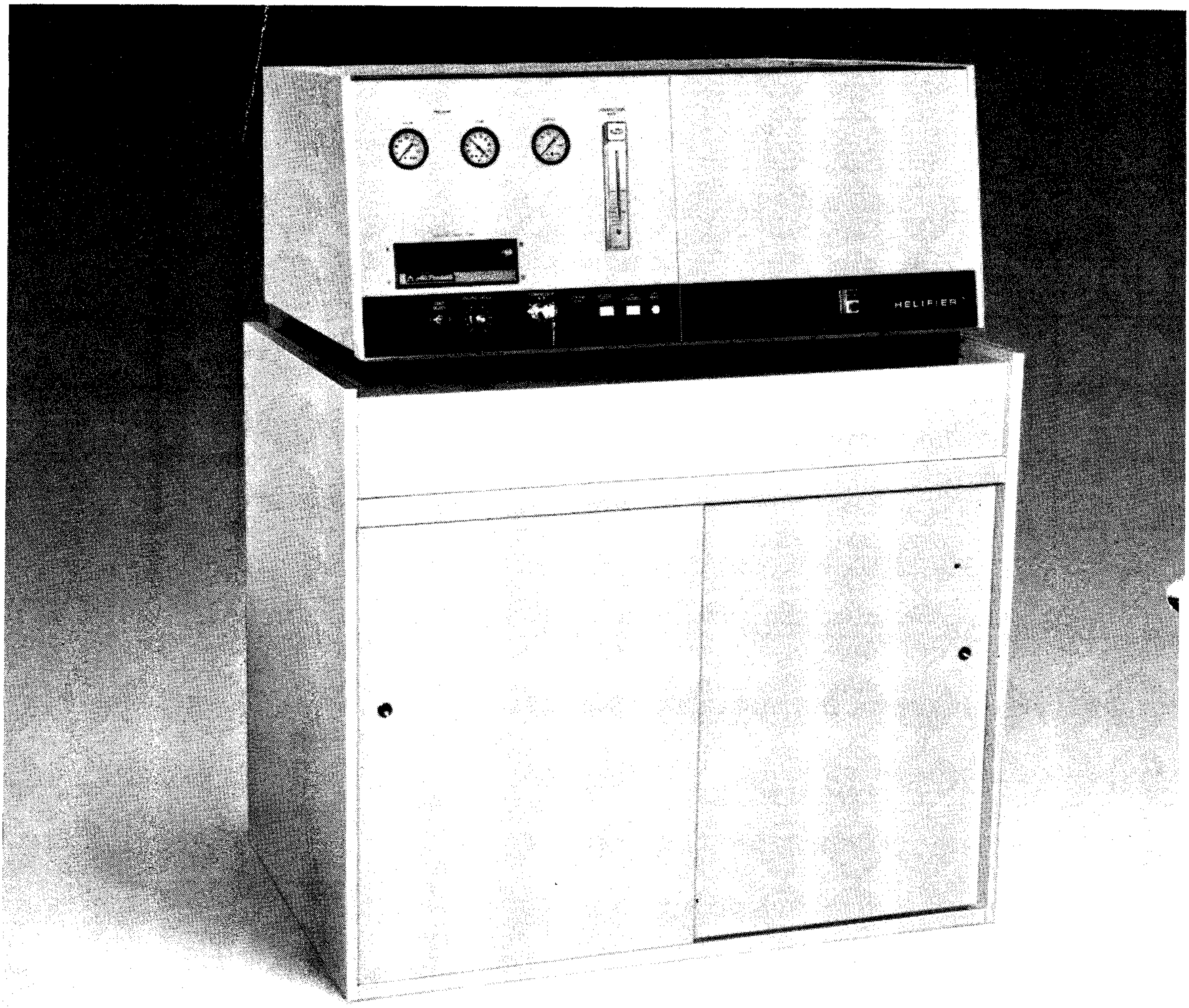
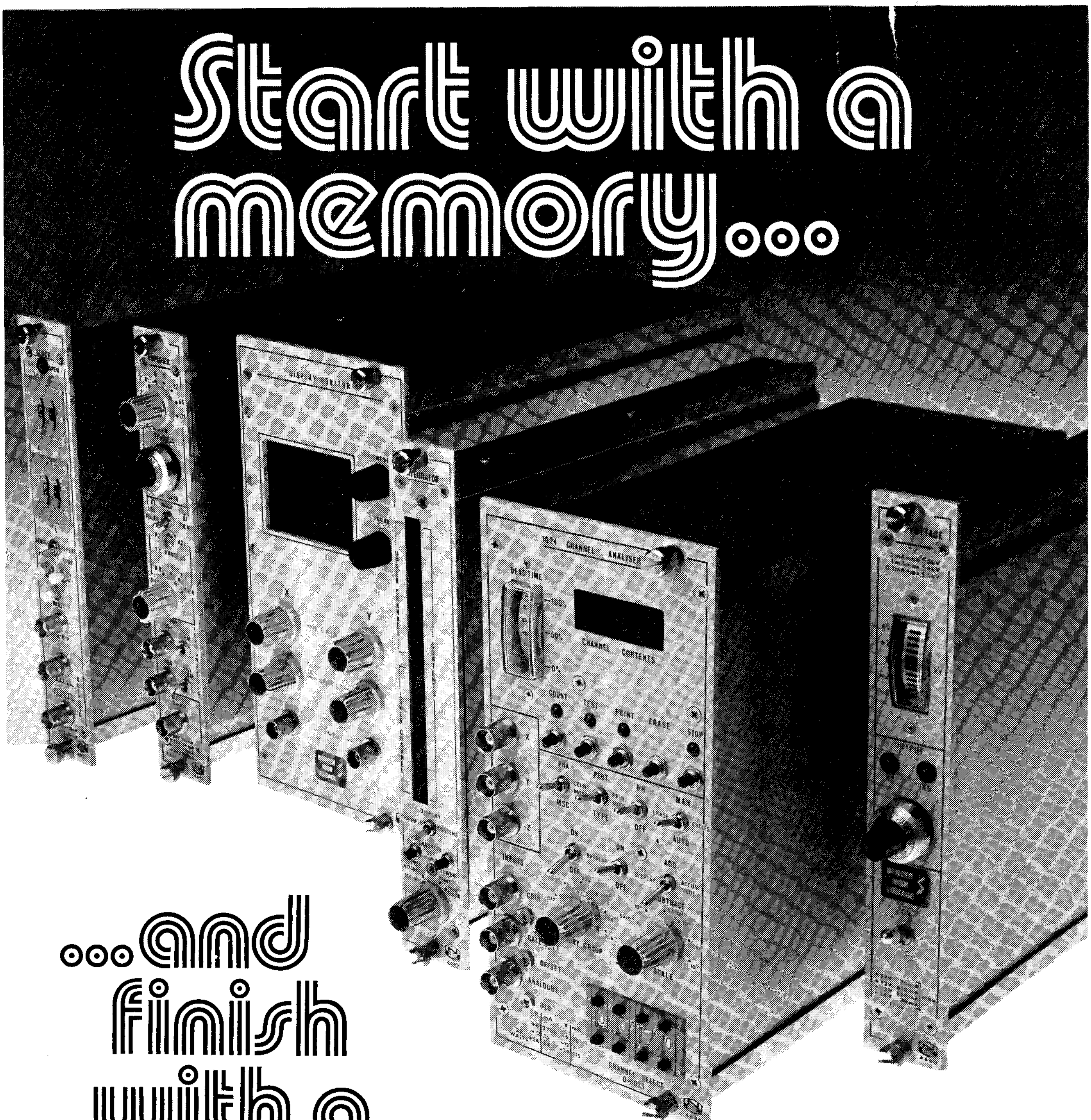


Start with a memory...



...and finish with a Spectrometer

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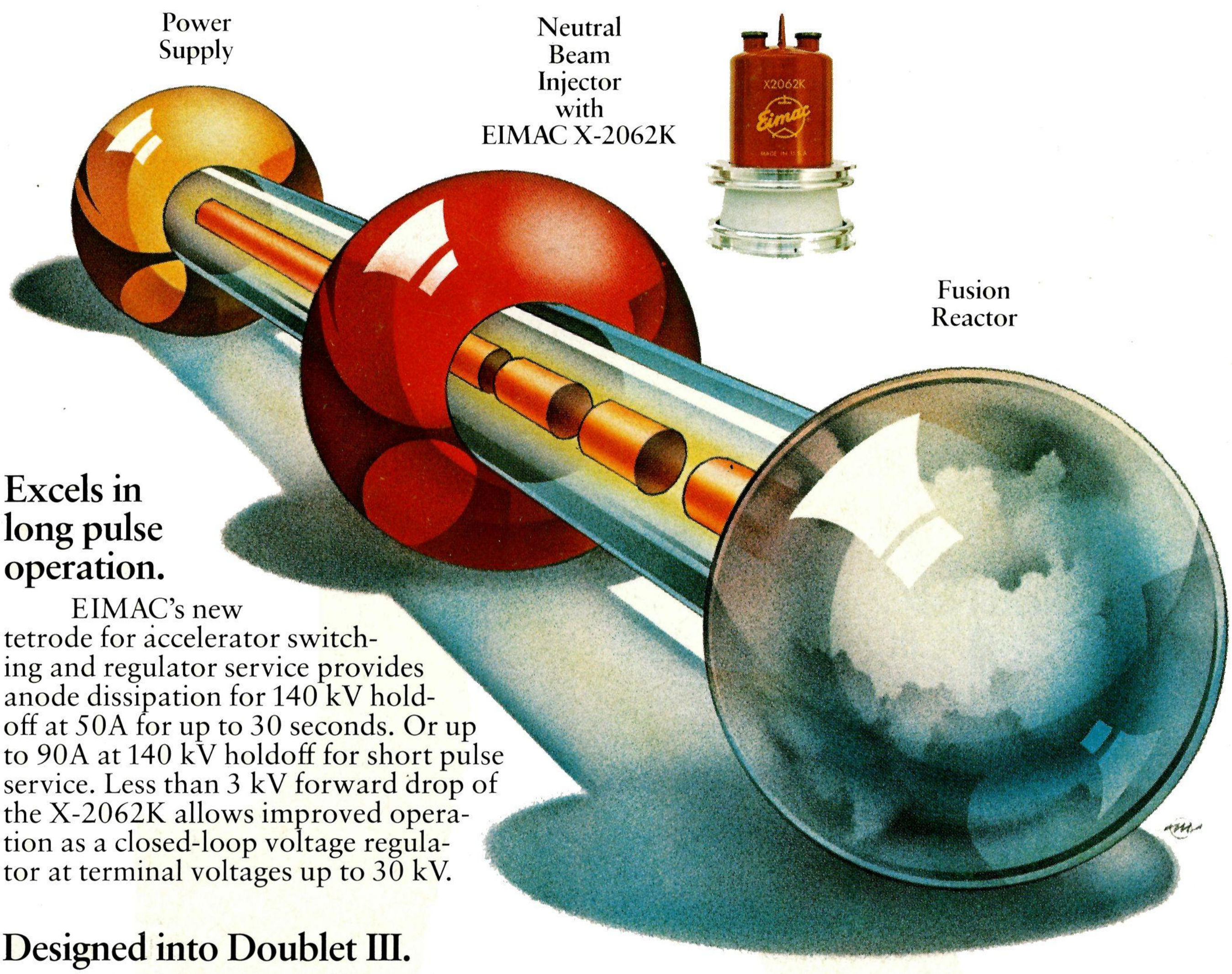

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