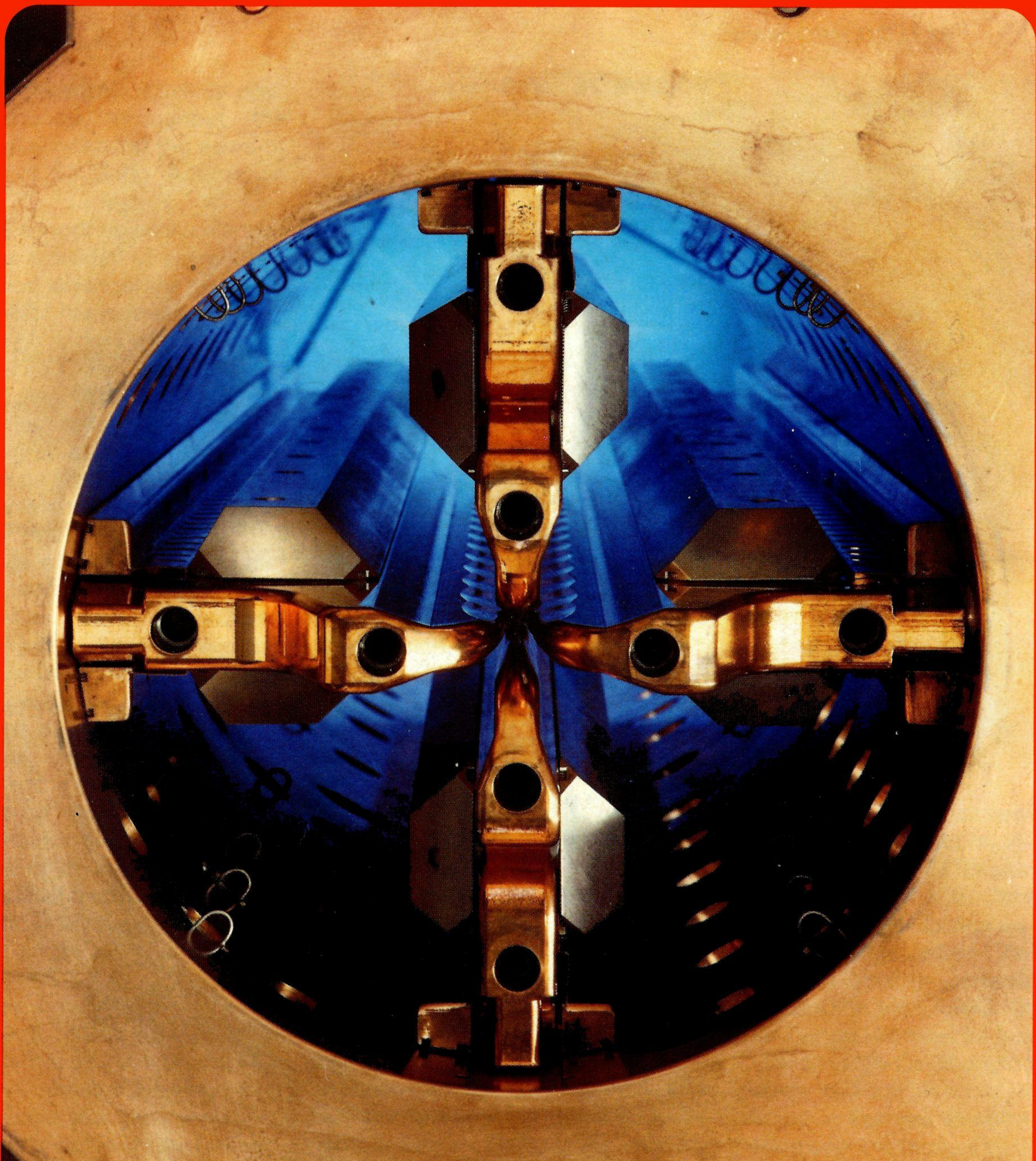
CERN COURIER
International Journal of High Energy Physics



VOLUME 24 3 APRIL 1984

Copies are available on request from:
Federal Republic of Germany —
Gerda v. Schlenther
DESY, Notkestr. 85, 2000 Hamburg 52
Italy —
INFN, Casella Postale 56
00044 Frascati
Roma
United Kingdom —
Elizabeth Marsh
Rutherford Appleton Laboratory, Chilton, Didcot
Oxfordshire OX11 0QX
USA/Canada —
Margaret Pearson
Fermilab, P. O. Box 500, Batavia
Illinois 60510
General distribution —
Monika Wilson
CERN, 1211 Geneva 23, Switzerland

CERN COURIER is published ten times yearly in English and French editions. The views expressed in the Journal are not necessarily those of the CERN management.

Printed by: Presses Centrales S.A.
1002 Lausanne, Switzerland

Published by:
European Laboratory for Particle Physics
CERN, 1211 Geneva 23, Switzerland
Tel. (022) 83 61 11, Telex 23 698
(CERN COURIER only Tel. (022) 83 41 03)
USA: Controlled Circulation
Postage paid at Batavia, Illinois

CERN COURIER

International Journal of the High Energy Physics Community

Editors: Brian Southworth, Gordon Fraser, Henri-Luc Felder (French edition) / Advertisements: Micheline Falciola / Advisory Panel: J. Prentki (Chairman), J. Allaby, J. Cronin, K. Hübner, E. Lillestøl

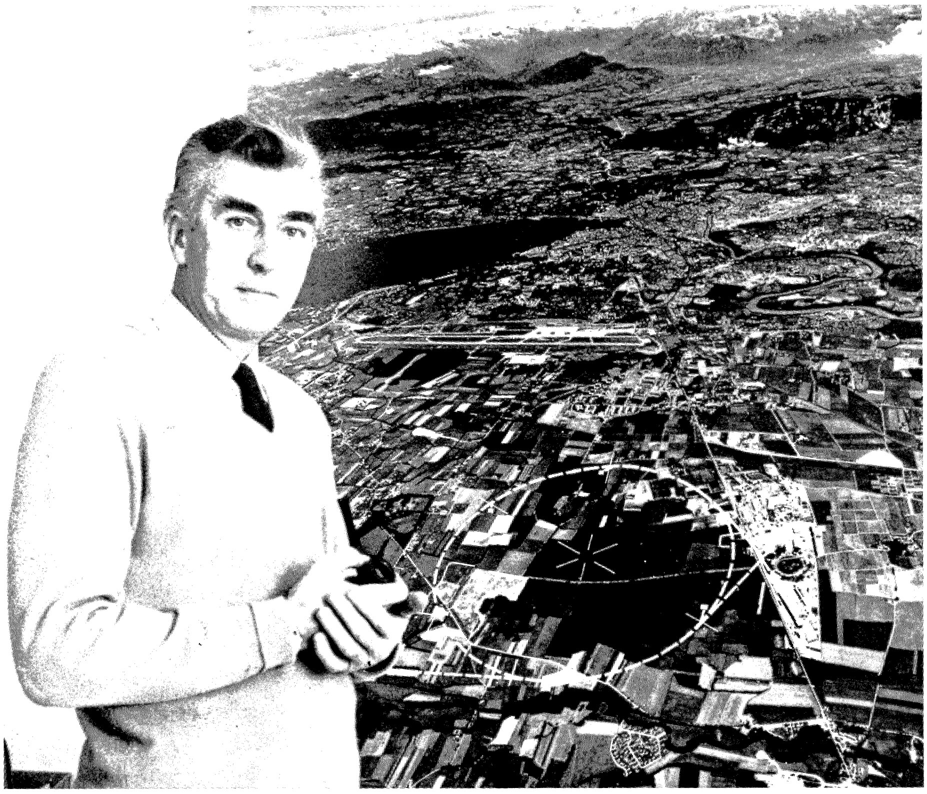
VOLUME 24 Nº 3 APRIL 1984

Cover photograph: A striking view inside the radio-frequency quadrupole (RFQ) recently used at Brookhaven to accelerate polarized ions from 20 to 760 keV — see page 100 (Photo Brookhaven).

Sir John Adams 1920-1984

The man and the project. John Adams with an aerial photograph of the Geneva region, showing the position of the 2.2 km diameter ring of the Super Proton Synchrotron. It was largely thanks to him that the project got under way in this form, satisfying the demands of the CERN Member States and securing the long term future of CERN.

(Photo CERN 117.11.73)



CERN, and the whole machine physics community throughout the world, were shocked at the news of the death of Sir John Adams on 3 March.

In his life's work as an accelerator builder and a leader of men, John Adams stood amongst the greatest. He was one of the pioneering group of machine physicists who moved to Geneva in 1953, under the auspices of the fledgling CERN Organization, to take up the challenge of designing and building an accelerator to reestablish Europe's scientific, and particularly physics, prestige, shattered by the war years.

At the age of 34, his abilities and leadership were already so apparent that in 1954 he was appointed Director of the Proton Synchrotron Division, to oversee construction of the new machine. Despite the additional complexities of operating in a novel international Organization and of having to lead a multinational team, he achieved all his objectives. The Proton Synchrotron reached its design energy of 25 GeV in 1959, the first machine of its type to operate, ahead of the equivalent machine being built by a more experienced team at Brookhaven.

It testifies to his skill that not only did the PS go on to exceed all its design parameters, but twenty-five years later, it remains the king-pin of CERN's accelerator complex, and will continue to do so for the foreseeable future. Despite the exigencies of new and bigger machines, the PS has continually risen to the occasion.

Following the sudden death of Cornelis Bakker in 1960, John Adams was appointed CERN's Director General for a brief period, leaving the following year to set up a new Laboratory for thermonuclear fusion research at Culham in the UK. This Laboratory developed into a flourishing concern, and is now the home of the JET — Joint European Torus — experiment. Although assured of a distinguished career in UK science policy management, John Adams was lured back to CERN in 1969, to become Director of the '300 GeV' project. This was in considerable difficulties at the time, but thanks to his skill and political acumen, the project was recast and proposed for construction alongside the existing CERN Laboratory, rather than at another site in Europe. As well as gaining the approval of CERN's Member States, this step ensured the future of CERN as a leading world Laboratory.

He was appointed Director General of this new 'CERN Laboratory II' to house the new accelerator, which came to be known as the Super Proton Synchrotron. Again, the design and construction of this mammoth project bore the stamp of his skill as a machine physicist and his stature as a team leader, despite a tight schedule and a strict budget.

When the two CERN Laboratories were united in 1976, John Adams was appointed Executive Director General, alongside Leon Van Hove as Research Director General. He held this position until 1980. During this third period in office, he helped steer CERN through the changing and frequently difficult financial and social climate in Europe. Despite this, the period saw the birth of both the antiproton project, which has produced such exceptional scientific fruit, and the LEP electron-positron project for the future.

As one who had built international projects with international teams, John Adams was a champion of internationalism, and made important contributions to world-wide scientific collaboration. No political or economic difficulties seemed able to deter him.

With such a distinguished career, John Adams was showered with academic and national awards — honorary degrees, scientific prizes and medals, fellowships of learned bodies, and his knighthood in 1981.

The success of CERN, both as a scientific laboratory and as an example of international collaboration, remains as a lasting tribute to John Adams, who contributed so much to the Laboratory, its development and its work.

Intersecting Storage Rings bow out

On 27 January 1971 at CERN, two proton beams collided for the first time in the newly completed Intersecting Storage Rings (ISR). Hadron colliders had arrived. The same date 13 years later saw the last meeting of the ISR Experiments Committee, marking, in CERN Director General Herwig Schopper's words — 'the formal end of a glorious chapter of CERN's history'.

The premature closure of the ISR came as a result of budget restrictions imposed by the construction of the LEP electron-positron ring at CERN. To build LEP within constant budgets, something had to go. Thus at the end of last year, the ISR had its final taste of colliding beams. However sophisticated experiments were taking data right up to the last minute, and the accumulated tapes could still turn up additional interesting physics results to add to the score. The machine went out in a blaze of glory, and did not suffer the humiliation of indifference and apathy.

The machine

The key development which paved the way for hadron storage rings was the invention of beam stacking by the US Mid-Western Universities Research Association (MURA) in the mid-1950s. This work was picked up at CERN's Accelerator Research Group (later Division) and led in turn to a study of a model 100 MeV electron machine, and later the CESAR electron storage ring, operated in the mid-1960s.

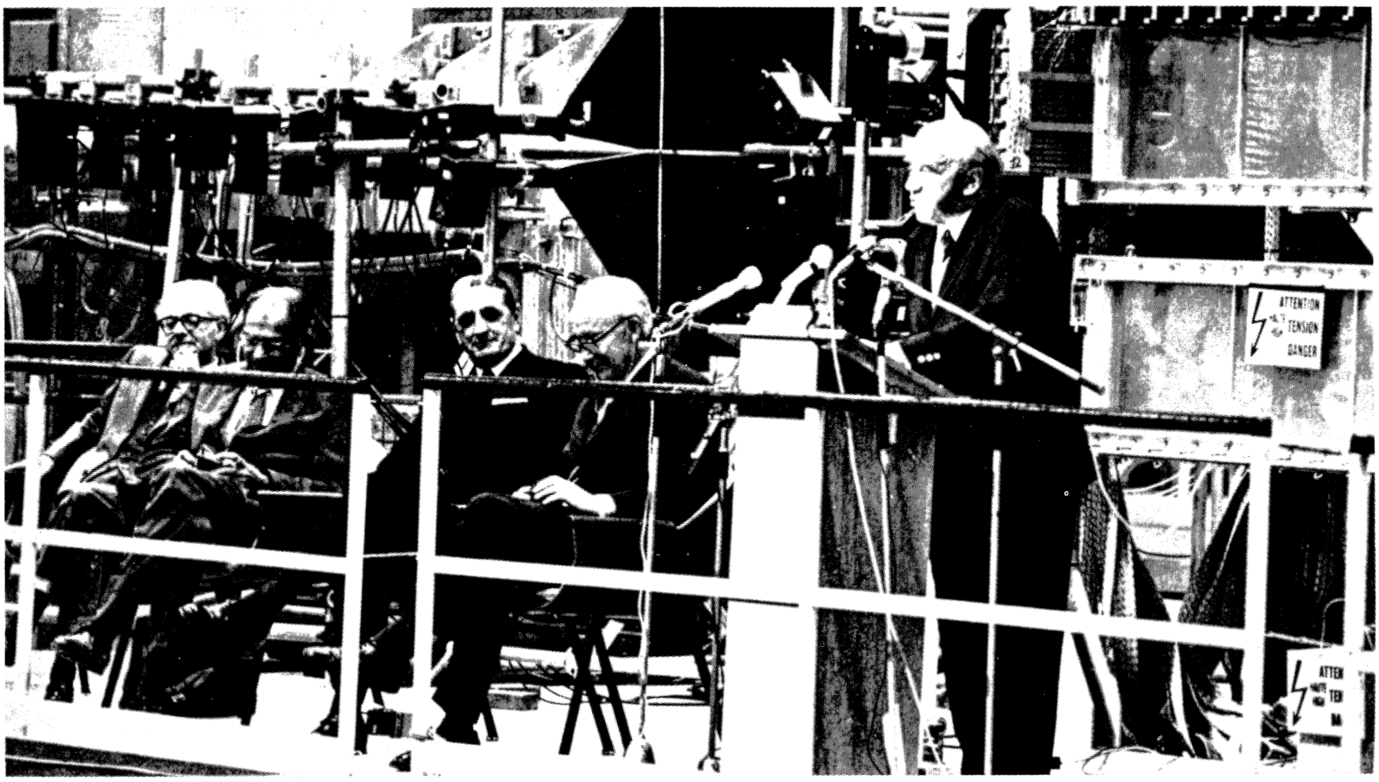
In the early 1960s, a formal CERN proposal was put forward for twin rings to store two 25 GeV proton beams from the PS (and possibly other particles too). This proposal gathered momentum, benefiting also from the French Government's

In the beginning. The bare ISR I8 intersection in 1970. Compare this with the photo on p. 96!

(Photo CERN 91.8.1970)

Werner Heisenberg speaks at the official inauguration of the ISR on 16 October 1971. With him on the platform are (left to right) Edoardo Amaldi, Viktor Weisskopf, Marcel Antonioz and Willy Jentschke.

(Photo CERN 348.10.71)



offer of additional land to extend the CERN site and provide a home for the new machine.

In 1964, a detailed design report of what was to become the ISR was put forward, and the following year received the blessing of CERN Council, thanks to vigorous promotion work by the then Director General, Viktor Weisskopf, and to the support of the European Committee for Future Accelerators (ECFA), formed in 1963.

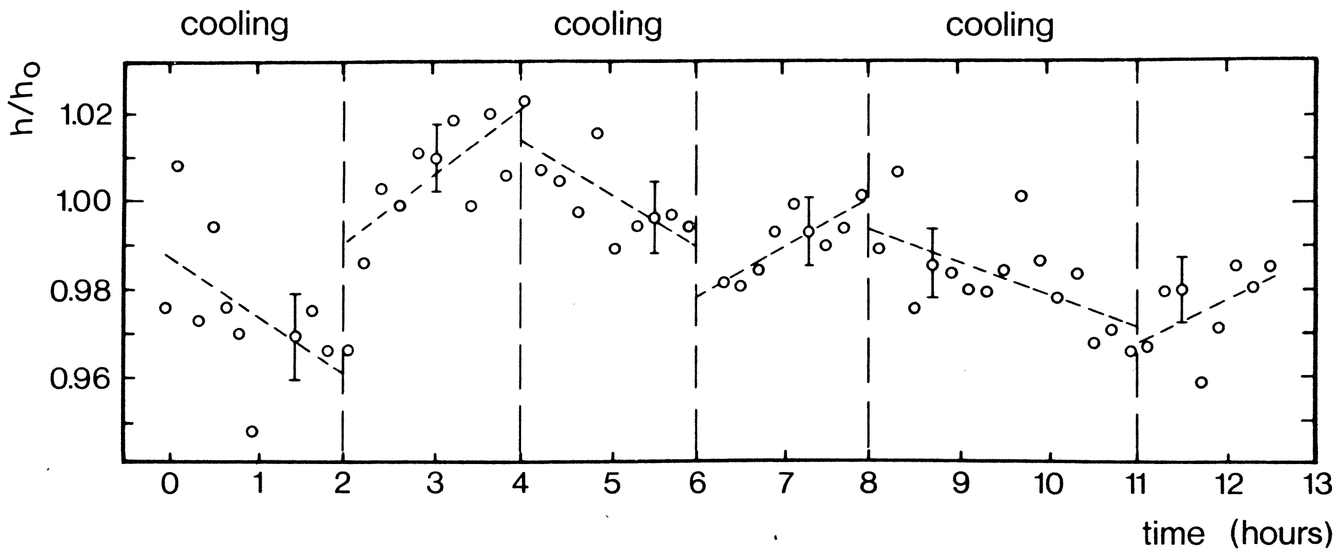
The caution with which such a novel and challenging project was approached is reflected in the meticulous plans for the machine's components. However this effort paid off. The machine's commissioning phase was impressively successful, and not only has the ISR's subsequent performance eclipsed all the design figures, but it has gone on to surpass even the most optimistic expectations. The construction and commissioning of the ISR, within both the proposed budget and the tight schedule, set exacting standards for later machines.

For the construction, tight tolerances were imposed everywhere — magnets, power supplies, vacuum. Although it was primarily a storage ring, the ISR also had its own r.f. system, primarily designed to stack the proton pulses, but which was later to allow the beams to be accelerated above their injection energy. Special attention was paid to diagnostics and control systems.

Over the years, ISR performance improved by leaps and bounds. The ambitious design value for the luminosity (proportional to the rate of particle collisions) was 4×10^{30} per cm^2 per s, achieved on 20 December 1972. This figure was eventually pushed routinely to 2×10^{31} and to a peak value of 1.3×10^{32} with the help of superconducting 'low beta' insertions. After two years, beam currents were typically just above 10 A, but with careful work were boosted to 30-40 A, with good luminosity. At these high beam currents, background noise in the collision points was tightly controlled with an impressive array of monitoring and diagnostic equipment. The record single beam current (no collisions) was 57 A.

The big initial selling point of the ISR was its collision energy, two proton beams from the PS hitting each other head on, equivalent to a fixed target proton machine inconceivable in those days and only now being approached in the Fermilab Tevatron. To push the ISR's collision energy still higher, in 1972 the r.f. 'phase displacement' technique was used for the first time, allowing the peak energy to be taken above the injection level. This gave proton beam energies in excess of 30 GeV

1974. Observation of stochastic cooling in the ISR, showing compressions of a few per cent in the effective beam height when the technique was applied. These modest beginnings were the precursor of the compressions by factors of several tens of millions routinely achieved in the CERN Antiproton Accumulator.



(maximum proton collision energy 62 GeV), equivalent to a 2 TeV fixed target proton machine.

As well as stacking protons, the machine also provided physics with deuterons, alphas, and towards the end of its career, with antiprotons. In 1980, the ISR stored 62 GeV alpha particle beams, and pushed its own world record collision energy to 124 GeV, a figure surpassed only by the SPS proton-antiproton collider, which came into operation the following year.

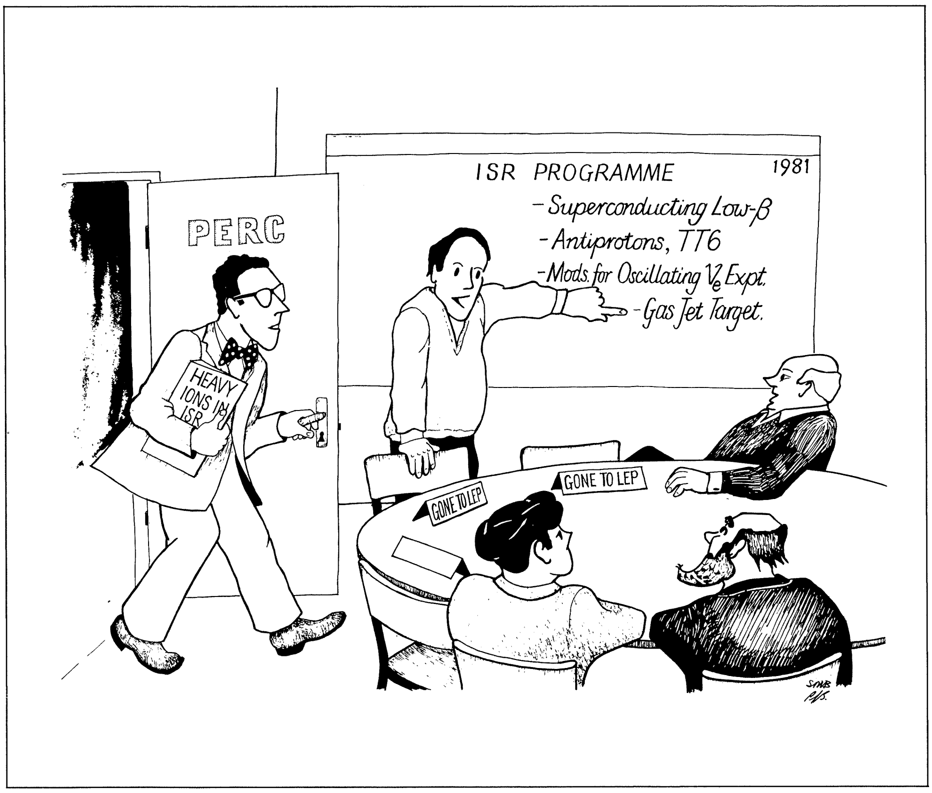
The reliability of ISR beams became legendary. Even in the early days, runs lasting several days were routine. But even this was overshadowed with the advent of beam cooling to further control low intensity stored beams and keep them literally for weeks at a time (record figure, 345 hours for precious antiprotons).

Special mention should also be made of the contributions of the ISR's vacuum development programme. With intense stored beams, it was clear from the start that high vacuum would be vital. Design levels were set for 10^{-9} torr in the ring and 10^{-11} in the intersections to limit background. As experience showed how important high vacuum really was for machine operation, new techniques pulled the level down to an average of 10^{-11} to 10^{-12} in the ring. For this feat, the ISR's vacuum group gained worldwide recognition.

Describing the ISR's contributions to accelerator physics in the special closing session, Kjell Johnsen, leader of the team which built the machine, was able to list an impressive number of achievements. During the first months, the resistive wall instability (the 'brick wall'), known only as a theoretical prediction, was observed and overcome. Ionization of residual gas caused both the famous 'pressure bump' instability and electron resonance lines which made the background spiky. Careful work showed how these and other problems could be systematically avoided and the solutions became standard accelerator practice. New techniques were developed along the way — as well as phase displacement acceleration, there were new diagnostics (Schottky noise scans), on-line space charge compensation, active feedback, low beta insertions to squeeze the beams and boost luminosity at the beam intersections, ... Superconducting elements were used for the first time in a storage ring.

Instabilities due to beam-beam interactions were a fact of life at beam currents above 30 A, and some of these problems were never completely solved. The last hour of colliding beam development time last

Back in 1981, the fate of the ISR had not yet been decided. The late arrival in this period cartoon by Phil Bryant was saying: 'Gentlemen, this is definitely the last project before we close the ISR!'



Maurice Jacob — coming to bury Caesar, not to praise him.

year had been reserved for a test of a new hypothesis, but the beam had to be prematurely dumped because of power consumption constraints. According to the final report on the subject, 'the ISR ghost disappeared with the last beam'.

While some ISR inventions were the daughters of necessity, others resulted from a vigorous programme of machine development. The highlight is the technique of stochastic cooling, enabling the particles in a stored beam to be controlled and arranged to unprecedented levels. This has gone on to become an integral part of machine physics, and in particular plays a vital role in the Antiproton Accumulator — the heart of the CERN antiproton project.

The remarkable mastery of machine physics in the ISR responsible for all these achievements has been an inspiration to many subsequent projects, challenging them to reach for ambitious new performance levels. The ISR will long be remembered as one of the most perfect examples of the accelerator art.

The ups and downs of ISR physics

At the closing ISR meeting, CERN Theory Division Head Maurice Jacob eloquently summarized the ISR's contributions to physics, casting himself in the role of Mark Antony in Shakespeare's 'Julius Caesar' — 'I come to bury Caesar, not to praise him. The evil that men do live after them, the good is oft interred with their bones. So let it be with Caesar.'

He quickly pointed out the evil — despite the ISR's high event rate, it missed both the J/psi and the upsilon. However in the mid-70s when these particles were discovered at US Laboratories, the ISR experiments were in a transition period. The simpler detectors of the early days had done their work, and their more sophisticated replacements were not yet fully operational.

Jacob pointed out three distinct stages in the ISR's career. At its 'brilliant start', the machine attracted many users. These studies with modest detectors were quickly fruitful, and the general features (cross-section, scaling, short range order) of the new energy region were quickly charted.

As a pointer to the future, rare events were spotted in which two protons, instead of just brushing past each other, collided head-on, producing particle fragments at wide angles (high transverse momentum) to the initial collision axis. These violent interactions are now understood to be due to the hard scattering of the protons' constituent quarks and gluons. Similar behaviour had been seen at SLAC using electron beams, but in 1972 the ISR provided the first purely hadronic examples, sowing the seeds of the subsequent 'jet' saga.

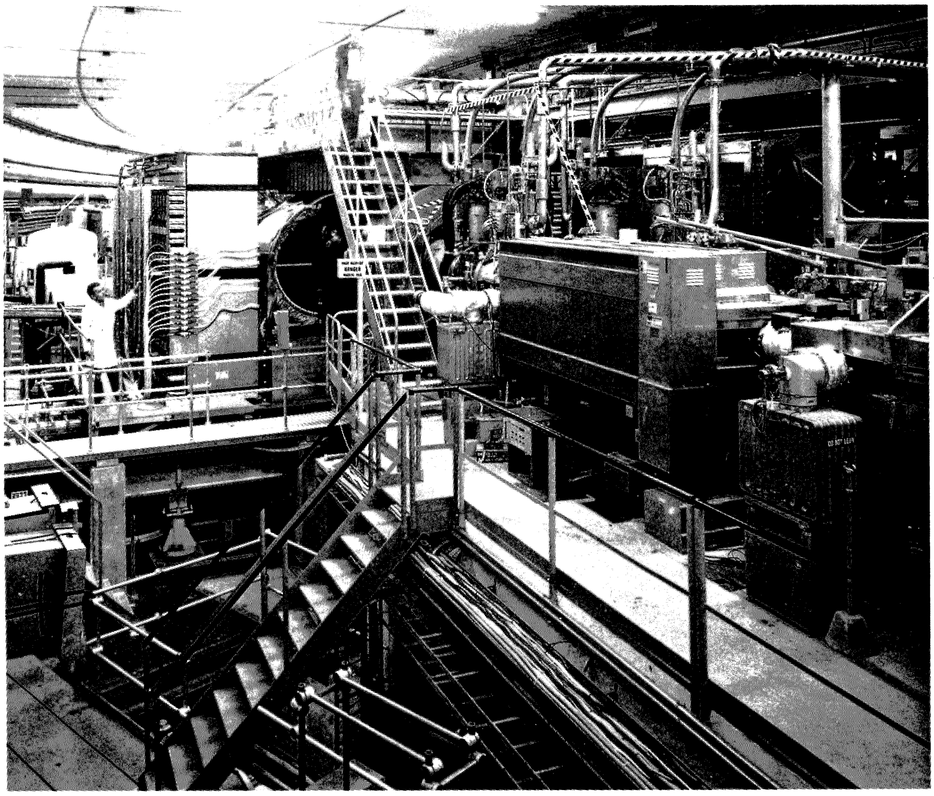
To exploit this new physics, new detectors were required, and this took time. While these big instruments were being developed, the SPS began operation, and Jacob suggested that this might have lured away some of the ISR population.

The big ISR detectors were operational in time for the attractions of the late 1970s and the start of the 80s — stored beams of antiprotons and alpha particles, and low beta insertions to push the already remarkable luminosity still higher. This pulled the crowds back for a sparkling finale, with alternate periods of proton-proton and proton-antiproton running. Even so, this was overshadowed by the drama at the new SPS proton-antiproton collider.

The SPS Collider had benefitted from ISR experience. Big detectors, collecting as many collision fragments as possible, were installed and operational almost from Day One. The SPS Collider experiments knew exactly what they were looking for and where to find it, and had made sure they were equipped with the right tools.

The final decor at I8, a good example of the big detectors developed for the final stage of ISR operations. This impressive assembly was used by a Brookhaven / Cambridge / CERN / Copenhagen / London (Queen Mary College) / Lund / Pennsylvania / Pittsburgh / Rutherford / Tel Aviv team. The apparatus was gradually extended to its final configuration, with four walls of uranium/scintillator hadron calorimeter (one wall here seen slightly drawn back) surrounding the central solenoid and detectors. On these walls, additional arrays of sodium iodide (from the USSR) were used by an Athens / Bonn / Brookhaven / Moscow / Novosibirsk team for a study of single photon production. The composition of these teams also reflects the success of the ISR in attracting international users.

(Photo CERN 295.10.83)



The jet saga

The changing fortune of ISR physics is well illustrated by the history of what came to be known as particle 'jets'. While the first signs of proton constituent scattering were seen at the ISR in 1972, by 1975 a new aspect of this behaviour was emerging. These violent collisions appeared to produce fragments in fairly well-defined sprays, or 'jets'.

This discovery could be compared with Rutherford's classic 1911 alpha particle experiment which discovered the wide angle scattering indicative of small hard nuclei buried deep inside atoms. However the interpretation of the early ISR jet-like signals in terms of proton constituents was not immediately universally accepted, and it took time for the true jet signal to be isolated from the accompanying background. In particular, there was 'trigger bias' — effects due to the data selection procedures imposed by the modest detectors, rather than the physics.

However the ISR stalwarts dug in their heels, confident that here was some good physics. It took some time until their steadfast faith was vindicated, but when it finally was, the 1982 results from the SPS Collider, with its higher collision energy, provided a cleaner picture of jet production. Although the ISR results, particularly their comparison with those from the SPS, were of great interest to the experts, once more the ISR was upstaged by its offspring!

A cross-section of physics

When the ISR came into operation, the exploration of reaction rates (cross-sections) in the new energy range was a major goal. Hints from lower energy suggested that particle scattering behaviour might stabilize, with little further change at increased energy.

Back in those early days, the world of particle physics held its breath while the first ISR results came in. The proton-proton reaction rate was seen to rise, implying that there was still a lot more to learn about the proton. These early studies also revealed a diffraction-like 'dip' in the angular distribution of elastically scattered protons, providing new information on the global behaviour of protons.

ISR studies surveyed the general properties of high energy hadron production. Subsequent studies of particle production in electron-positron annihilation and in fixed target experiments using lepton beams showed that this behaviour seems to be universal.

In its tenth anniversary year, the ISR added another string to its bow. In April 1981, it provided the world's first collisions between stored beams of protons and antiprotons, blazing the trail for what would follow a few months later at the SPS Collider. For the next two years, ISR experiments had the unique privilege of data-taking with proton-proton and proton-antiproton collisions.

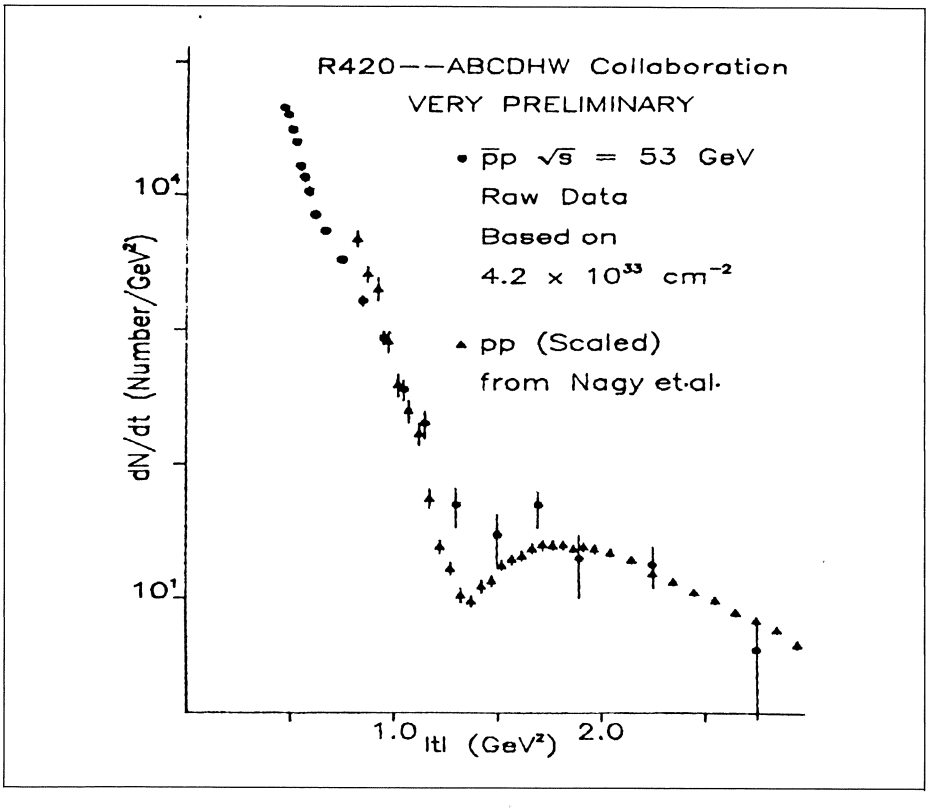
It is fitting that some of the final crop of ISR results covers the same ground as the historic early experiments, but this time for particle-antiparticle interactions. The comparison of proton-proton and proton-antiproton behaviour goes as expected, and is in tune with the high energy particle-antiparticle results from the SPS Collider. For elastic scattering, there appears to be structure in the proton-antiproton case, but less pronounced than for proton-proton. At high transverse momentum, photons appear to be relatively copious.

This and other valuable physics continued right up to the final run at the end of last year, and there are still many accumulated data tapes which could reveal additional interesting physics.

(Although the ISR has completed its work with colliding beams, an experiment by an Annecy / CERN / Genoa / Lyon / Oslo / Rome / Turin team will study charmonium states created when an antiproton beam circulating in one ISR ring hits protons from a gas jet target. First trials were carried out last year — see December 1983 issue, page 417.)

The history of ISR experiments also reflects the dramatic development of detector technology during this period. New detectors were developed to meet the demands of a new generation of physics. The ISR's high data-taking rates and delicate triggering requirements also provided an introduction to the sophistication of data handling systems for experiments at the big new colliders now being built or planned.

(For a more detailed account of ISR physics accomplishments from 1971 to 1981, see March 1981 issue, pages 58-62, which summarized the initial decade of the machine's operation.)

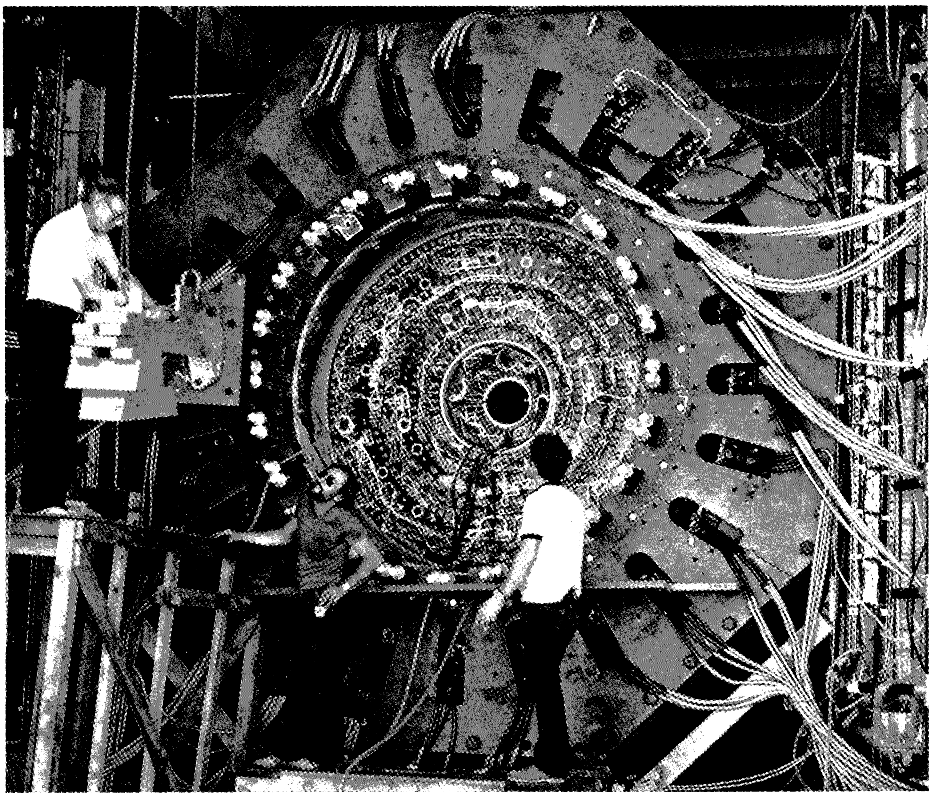


Preliminary results on proton-antiproton elastic scattering at 53 GeV collision energy, as measured at the ISR by an Ames / Bologna / CERN / Dortmund / Heidelberg / Warsaw group. The corresponding proton-proton data is shown for comparison. Similar results have been obtained by a CERN / Clermont-Ferrand / Saclay / UCLA team.

Around the Laboratories

The Mark III detector being installed at the SPEAR electron-positron ring at Stanford.

(Photo Joe Faust)



STANFORD
Money for new collider

In his traditional 'State of SLAC' talk, Director Wolfgang 'Pief' Panofsky was able to report that US President Reagan's budget for fiscal year 1985 proposes a $38.5 million increase in funding for the Laboratory. Most of this increase ($28.5 million) is earmarked for construction of the new SLAC Linear Collider (SLC), scheduled to turn on in late 1986 or early 1987.

However the proposed budget is still subject to review by Congress, who last year trimmed $8 million from the SLC construction money proposed originally. This year's SLAC budget includes $32 million for SLC construction. With the proposed increase, this would rise to $60.5 million in fiscal 1985 (year beginning on 1 September 1984).

It was thus on a SLC optimistic note that Panofsky was able to give his last 'State of SLAC' address. On 1 September he hands over the SLAC Directorship to Burt Richter. Further extracts from Panofsky's address will be published in our next issue.

Mark III

The Mark III detector at the SPEAR electron-positron ring presented its first physics results last summer, including some interesting new signals (see October 1983 issue, page 309). The results came mainly from the radiative decays of J/psis, thus continuing the illustrious tradition of its predecessors. The Mark I discovered the psi at SPEAR in 1974, and was replaced by the Mark II in 1977. After two years of valuable work, this detector moved to Intersection 12 of the then new PEP ring, leaving the West Pit at SPEAR for Mark III.

While many experimentalists have moved on to more fashionable topics since those early J/psi days, there is still a lot of physics potential in this area, as emphasized by Frank Close in his recent article on glue states (see January/February issue, page 6).

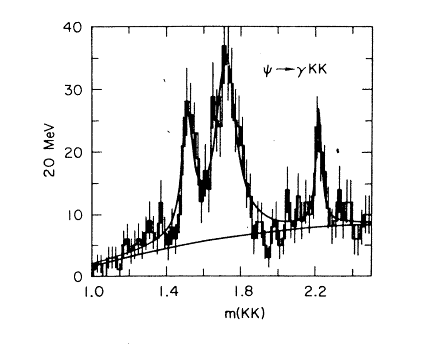
Mark III is a general purpose, solenoid-based magnetic detector, built by a Caltech / Illinois / Santa Cruz / SLAC / Seattle collaboration, and installed at SPEAR in 1981. Built specifically for complete reconstruction of exclusive hadronic final states, the large solid angle design emphasizes good momentum resolution for low momentum charged particles through reduction of multiple Coulomb scattering, good particle identification by means of time-of-flight and energy loss, and good detection efficiency for low energy photons, achieved by placing the shower counter inside the solenoid.

By comparison with events at higher energy storage rings such as PEP and PETRA, hadronic events produced at SPEAR are relatively simple, consisting, on average, of about four charged particles and an equal number of photons. This relative simplicity means that it is realistic to attempt to measure the momentum or energy and to identify all the final state particles in many events. When this much detail is obtained, it is possible to completely reconstruct the event and to identify the subsequent decay.

Experimental interest centres on several distinct resonances. The most spectacular of these states is the original J/psi, at 3097 MeV. At higher energies are the psi prime (3684), double prime (3768) and other less prominent structures. The J/psi, a bound state of a charmed quark and its antiquark partner, is relatively stable since the charmed quark mass is too large to allow it to appear explicitly in the decay process. The psi prime is an excited state of the J/psi, with many features in common. The psi double prime is heavy enough for charmed quarks to appear explicitly in its decay processes. These quarks appear as charged or neutral pairs of charmed mesons, the Ds. The psi double prime is the richest and purest source of D mesons yet found. Most of the data taken so far with Mark III has been at the J/psi and the psi double prime.

The data presented last summer for the first time concerns J/psi radiative decays, producing a photon, together with a group of hadrons. (There can be other photons in the event, coming either directly from the electron-positron interaction, or from the subsequent decay of neutral mesons.) These radiative decays, which make up about five per cent of all J/psi decays, are of special interest, for they allow production of other states which cannot be directly produced in electron-positron annihilations. One such state is the eta-c, where the charmed quarks' spins are oriented antiparallel to one another, rather than parallel as in the J/psi. The production of eta-cs from J/psis results in a photon of definite energy (observed directly at SPEAR by the Crystal Ball). Both the Crystal Ball and Mark II detectors were also able to fully reconstruct examples of these decays, with the eta-c decaying into hadrons. With the improved coverage and detection efficiency of Mark III, and the bigger data sample obtained (2.7 million J/psis), it has been possible to reconstruct previously seen hadronic decays with better statistics and to add some new ones. A total of five eta-c hadronic modes have now been seen, the most interesting of which produces a pair of phi mesons. By analysing the angular distributions of the two phi decays, it has been possible to fix the spin (one) and parity (positive) of the eta-c, as expected in the 'charmonium' model. This is the first time these eta-c properties have been measured.

The Mark III result which has aroused the most interest thus far is the discovery of a new narrow resonance in radiative psi decay, the 2220 MeV ksi. One of the simplest final states in psi radiative decay is that with two (oppositely) charged



The Mark III detector working at the Stanford SPEAR electron-positron ring has studied the decay of J/psis into a photon and a pair of kaons. The kaon pair spectrum clearly shows the f' (1550 MeV) and theta (1700) states observed previously. In addition, there is an intriguing new signal at 2220 MeV, the ksi, whose interpretation is not yet clear.

kaons accompanying the photon. Previous studies of this decay channel had found two resonances, the f' (1550) and the theta (1700). These are seen very clearly by the Mark III, with improved statistics and good resolution. At higher kaon pair masses, there is evidence for an additional resonance, unexpectedly narrow. This is the ksi.

The experimentally observed width of a particle depends on two factors. The first is the resolution of the detection apparatus, and the second is the lifetime of the state. The longer an unstable particle survives before decaying, the narrower its intrinsic width. For example, the muon, which decays via the weak interaction, has a decay width of some 10^{-9} eV, corresponding to a lifetime of two microseconds, whereas a typical width of a strong interaction resonance would be 100 MeV, corresponding to a mean life of 10^{-29} seconds.

What is unusual about the ksi is that the experimental width is very close to the resolution of the apparatus, indicating that the intrinsic width is quite narrow. The observed width of 30 MeV implies that the intrinsic width of the ksi is less than about seven MeV. This is surprisingly small, and indicates that the ksi lives an unusually long time before decaying, suggesting that the effective force responsible for the decay is weaker than that involved in a conventional resonance.

All that is known so far is that the ksi's width is substantially less than the experimental resolution. The question remains whether the ksi's width is just too small to see, indicating a strong decay inhibited for some reason, or whether it is very narrow, indicating a weak decay.

Should the decay be very narrow, the ksi could be a Higgs particle. This is a so far unseen object responsible for the appearance of massive bosons in the electroweak theory through 'spontaneous symmetry breaking'. The little we know about the ksi so far does not rule out such speculation, but confirmation, or otherwise, requires more data and/or more experiments. Searches for other decay modes of the ksi are under way, as is an attempt to measure its spin and parity. It appears to be produced more copiously in radiative psi decays than would be naively expected for the simplest Higgs models.

Other interpretations of the ksi have been put forward. Could it be a glueball (bound state containing gluons but no quarks) or a hybrid glue-quark state? In quantum chromodynamics, the candidate theory of quark interactions, the gluon is the force carrier, playing an analogous role to that of the photon in quantum electrodynamics. However unlike photons, in principle gluons can form bound states among themselves, or with quarks. Several candidates have been proposed. Among these are the iota (1440) and theta (1700) mesons, seen in radiative psi decay. The Mark III has also obtained new information on these states and further detailed analysis could shed more light on their interpretation.

This year's data-taking will enlarge the sample of psi double prime decays. This will produce in turn an impressive sample of decays of charged and neutral D mesons to probe the weak decay mechanism of charmed particles. For the future, the weak decays of other charmed particles (F mesons, baryons) remain to be studied.

(From D. Hitlin)

BROOKHAVEN
Polarized protons on the way

In late February two major milestones were reached in the AGS polarized proton beam project. On the evening of 14 February, the negative hydrogen ions from the 10 microamp polarized ion source were accelerated from 20 keV to 760 keV in the new Brookhaven radio-frequency quadrupole (RFQ). The RFQ worked beautifully on its first try and accelerated 40 per cent of the injected beam.

The RFQ is an exciting new concept in preinjectors for accelerators which has captured the interest of many Laboratories. It is typically a small linac about 1 or 2 metres long which is simultaneously an r.f. linac and a focusing quadrupole system. The Brookhaven one is being used to replace the Cockcroft-Walton preaccelerator, which is large and expensive and would require the complex polarized proton ion source to be placed in a dome at 760 000 V. The immediate and reliable operation of the RFQ suggests that within a few years these units may be replacing Cockcroft-Waltons in other applications. It is believed that this is the first RFQ which was used to inject beam into an operational accelerator. The RFQ project was headed by Sal Giordano, who is retiring later this year and the RFQ's great success is a fitting capstone to his career. (Meanwhile, RFQ trials at CERN are not far behind.)

The polarized ion source is an atomic beam-type source with caesium charge exchange to give polarized negative hydrogen ions. It is operating at more than 10 microamps, which is a world record for this type of source. The polarized ion source group, which is headed by Theo Sluyters and Jim Alessi, modified the old ZGS polarized proton source. With some help from collaborators at Argonne and Yale, they have had the source performing with good reliability and intensity since last July.

The second major milestone occurred early in the morning of 23 February, when a beam of polarized protons was accelerated through the AGS linac to 200 MeV for the first time. Within an hour, the polarization of the beam was measured to be about 45 per cent using the proton-carbon scattering polarimeter built and operated by the Rice University group headed by Jay Roberts. By breakfast time, the polarization was increased to 70 per cent by tuning the polarized ion source. By late afternoon, about 1 microamp of polarized protons was injected into the AGS, captured, and accelerated for a few milliseconds to about 250 MeV before being lost by the r.f. feedback system. Yousef Makdisi, who headed the group building the new low energy beam transport system between the source, the RFQ and the linac, played a crucial role in this part of the project.

The next step was to accelerate polarized protons in the AGS where many strong depolarizing resonances wait to be jumped (see below). This painful, but exciting job, requires the 48 correction dipoles built by Brookhaven and the 12 fast (1.6 microsec) pulsed quadrupoles built by Michigan, as well as the internal and high energy polarimeters built by Michigan. Larry Ratner, who is responsible for the main ring part of the polarized beam project, eagerly awaited the next weekly 36-hour polarized beam commissioning run, along with Henry Halama, who had overall engineering responsibility for construction, and Alan Krisch of Michigan, who has overall responsibility for commissioning the polarized beam.

Polarized proton beams have been accelerated at other machines, notably the old Argonne ZGS and at the Saturne at Saclay (see July/August 1982 issue, page 231). But handling a polarized proton beam at the higher AGS energies is a challenge, which, if it pays off, will provide Brookhaven with unique research facilities.

(From Alan Krisch. On 8 March, a polarized proton beam was accelerated in the AGS. Two depolarizing resonances were partially jumped. Polarization was 53 per cent at 4 GeV and 15 per cent at 6 GeV).

Horst Nesemann (centre) with Hans-Joachim Brosch (left) and Rainer Fischer at the controls of the DORIS-II storage ring during one of the recent high luminosity runs. Nesemann is currently DORIS-II coordinator, replacing Klaus Wille, at SLAC for a year.

(Photo DESY-PR)

DESY
Luminosity record for DORIS and energy record for PETRA

In February the DORIS-II electron-positron storage ring finished a brilliant data-taking run, achieving record luminosity. For several weeks there were more than 1000 inverse nanobarns per day and on February 19 the peak value of 1562 inverse nanobarns was registered.

The Crystal Ball and ARGUS experiments recorded in all about 330 000 events at a total energy of 10.023 GeV, corresponding to the upsilon-prime resonance.

DORIS can now be filled with two beams each of up to 50 mA and the average current over a day is kept near 30 mA. This is partly due to a new working point found by the machine group. The machine is very sensitive to resonances and careful tuning was required. In longer runs considerable advantages are gained from the fast refilling system used at DORIS-II. The experiments had no problems with background at the new high beam currents.

The synchrotron radiation users profited from the high stable particle currents. In single beam operation for synchrotron radiation studies the current can be pushed twice as high.

Towards the end of February DORIS started a run at a slightly higher energy (10.384 GeV) for an investigation of B (beauty) mesons.

At the same time the PETRA storage ring reached the highest energy ever obtained in electron-positron collisions — 46.2 GeV — about a GeV higher than the goal of the machine improvement programme launched a few years ago (see January/February issue, page 16).

The luminosity drops at the highest energies to less than about 100 inverse nanobarns per day. However it climbs back up again at slightly lower energies. The next physics run will probably be at a collision energy slightly under 45 GeV.

DATA COMMUNICATIONS
A GIFT for physics

Data communications are now an integral part of high energy physics activities. With big experiments working with high data-taking rates and populated by physicists commuting to and fro between institutes, access to and transmission of data and remote access to computers become of vital importance.

With this in mind, a subgroup of the ECFA working party on high energy physics data processing standards was set up some time ago to examine the data communications needs for tomorrow's high energy physics, particularly in the sphere of inter-laboratory communications. In parallel, a group was set up at CERN to study the specific data communications requirements of the LEP experiments.

Data communications in and around CERN have been developing quickly. Last year the CERN computers were connected to the Swiss packet switching network TELEPAC, which also allows access to several other networks using the X25 standard, such as TRANSPAC in France, DATEX-P in West Germany and PSS in the UK, together with TELENET and TYMNET in the US. The UK SERCNET university system can be accessed at CERN through the leased line to the Rutherford Appleton Laboratory, and the scope of this link is being extended.

Using the new public X25 services, an interactive terminal access system has been set up at CERN, allowing outside users to access CERN computers, and enabling CERN terminals to link with outside computers. This has proved very popular (the CERN COURIER has found the system useful for timely transmission of stories to beat deadlines).

For file transfer, the European particle physics community uses a number of different standards including CERNET within CERN, DECNET in Italy, SERCNET in the UK and UNINETT in Scandinavia. To enable files to be moved between systems following these standards, the 'GIFT' (General Internetwork File Transfer) project has been launched. This file-transfer gateway, to be based on a VAX machine at CERN, involves a collaboration between CERN, Rutherford Appleton, Oxford, INFN (Italy), Oslo and Trondheim.

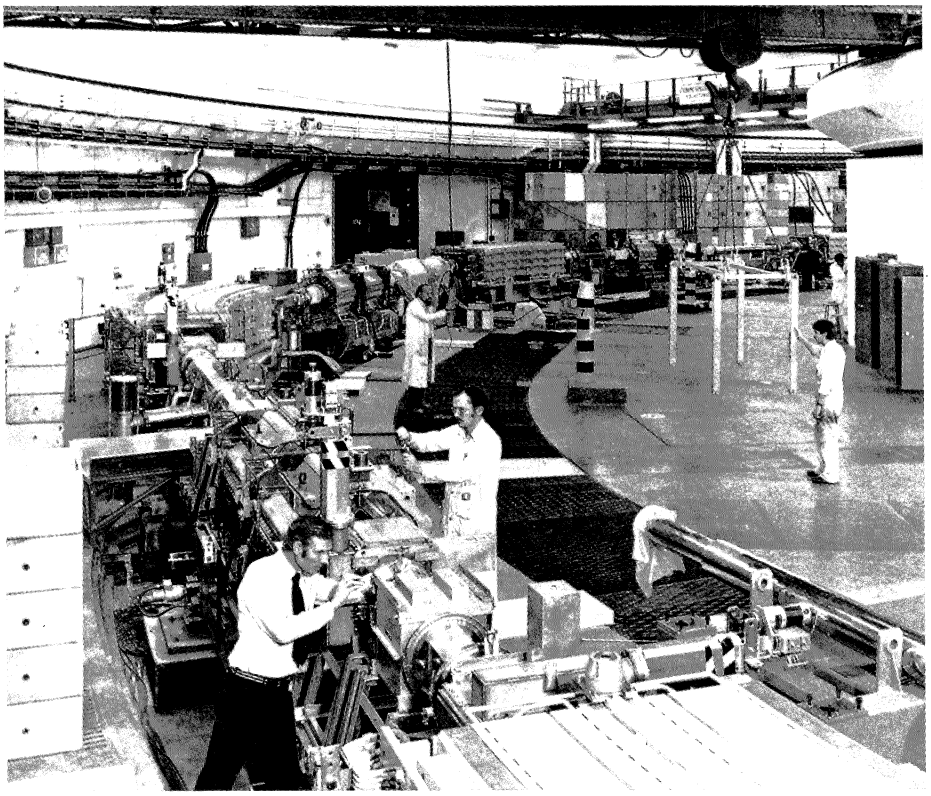
Satellite communications offer the possibility of high speed transmission of large amounts of data. The European STELLA experiment, now terminated, enabled high energy physics institutes to make a major early contribution in this important area. Further experiments are continuing, such as the French NADIR project, in which a group at Saclay will transmit data between there and CERN using the TELCOM 1 satellite.

Other aspects of computer communications are also under study, including electronic mail, teleconferencing, remote job entry, local area networks, etc. The range of problems is wide, but it is hoped that working groups can begin to tackle them fairly soon.

To supervise all this hectic development work and push through new projects, a High Energy Physics Computing Coordination Committee has been set up at CERN under the chairmanship of NIKHEF Director Walter Hoogland, and with members drawn from the management of the major European institutes.

Part of the new SNS synchrotron at the Rutherford Appleton Laboratory, showing a section of the machine's ten superperiods with dipole bending magnets and, in the straights, the focusing quadrupoles and the large quantity of diagnostic devices.

(Photo UK Central Office of Information)



RUTHERFORD Circulating beam in SNS synchrotron

In January the Spallation Neutron Source (SNS) reached the second phase of beam commissioning with 70 MeV protons circulating in the synchrotron. The last of the ten 4.5 m-long curved dipole magnets had been delivered in December. The first magnet had been used as a standard for comparing the effective magnetic lengths of all the dipoles, which proved to be within acceptable tolerance. To complete the synchrotron ring two dipoles had to be processed. This involved 50 Hz voltage testing, magnetic length measurement, fitting of the curved ceramic vacuum chamber and measuring the internal dimensions, fitting of the unique radio-frequency shield necessary for the SNS to reach its 200 microamp design current, vacuum testing, fitting cooling pipes and ring installation. Intense activity during a ten-day period enabled Rutherford Appleton Laboratory Director Geoff Manning to tighten the last vacuum joint on 15 December.

The vacuum system, with ceramic chambers in the 50 Hz magnets and stainless steel elsewhere, was commissioned without separation into sections, reaching its design level of 5×10^{-7} torr in two weeks. It is now running close to 10^{-8} torr. For final operation the four pulsed beam bump magnets in the injection straight will be pulsed at 14 000 A for 500 microsec and at 50 Hz. By Friday 13 January (not unlucky this time!) the magnets were up to 12 000 A, high enough to try for injection. Friday night and Saturday were spent in tuning up the linac and the transfer line to the synchrotron to produce the negative hydrogen ions which are converted to protons by the 0.25 micron alumina foil in the injection straight. The magnet system was powered DC by the power supply which will provide the bias for the 50 Hz magnet excitation. At 15.10 hrs on Sunday the 15th, a 1.5 microsec pulse of protons, equivalent to about half the circumference of the SNS, had been injected and was seen to circulate for some 300 turns before it became debunched and could not be detected.

A later run repeated the performance and betatron Q-values were measured for different magnet system fields and for different excitation of the Q-correction quadrupoles. The results proved as expected from the design. The magnet system has since been powered with its biassed 50 Hz waveform to the 550 MeV level which will be used as an intermediate energy towards the SNS design of 800 MeV.

The aim is to accelerate to 550 MeV and extract beam by the middle of the year, and to have first neutrons from the complex target station by the end of the year. After obtaining circulating beam at the first attempt, confidence is high.

(From David A. Gray)

CERN A survey of machines

Excavation under way for the CERN PS in 1967, showing the enormous amount of earth which has to be moved in such 'cut-and-fill' operations.

(Photo CERN 301.11.67)

During CERN's 30-year history, the size of particle accelerators and storage rings has increased 50-fold, from a diameter of 200 m for the 28 GeV Proton Synchrotron, to 8.5 km for the LEP electron-positron ring now under construction.

For geodesic work, such a scale explosion is challenging enough on its own. But for particle accelerators, the tolerances on the positioning of the magnets which guide the particles always demand accuracies to within a small fraction of a millimetre. For the geodesists who survey the terrain for these machines and the subsequent installation of their components, this calls for a demanding combination of precision measurement over long distances, frequently under difficult conditions, with literally pinpoint accuracy.

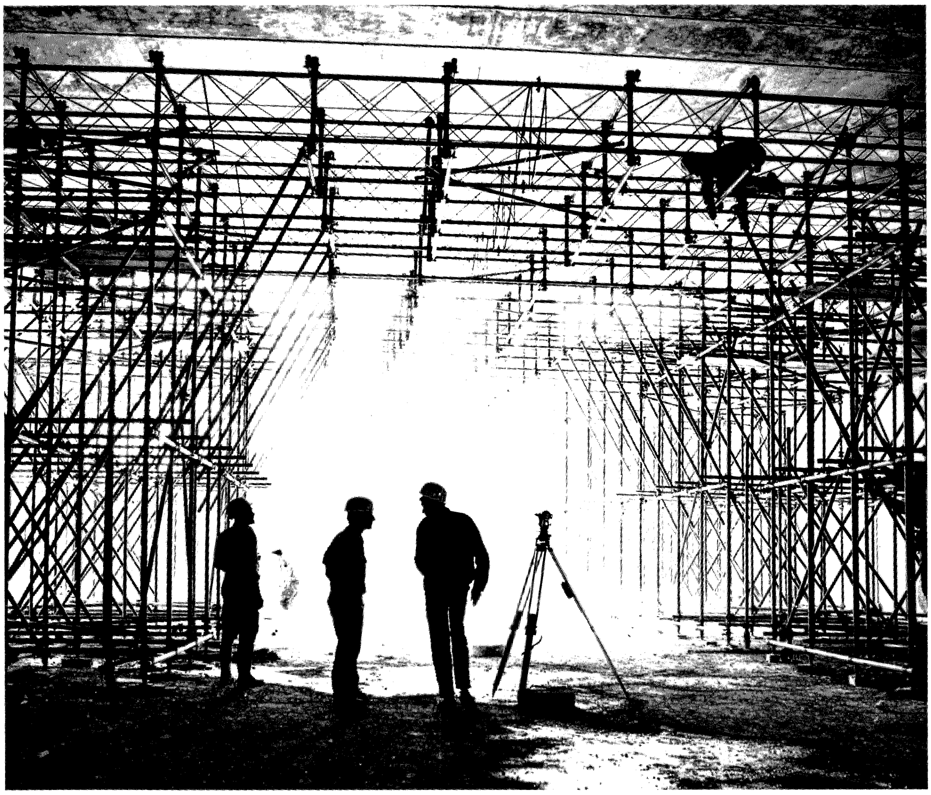
Over the years, the CERN Applied Geodesy / Survey Group under Jean Gervaise has never failed to rise to the occasion, providing solutions which have more than matched the exacting demands of the machine builders. As well as benefiting from technological progress made during this time, the group has made several ingenious contributions of its own, some of which have gone on to be used outside CERN.

For the construction of all particle machines, a geodetic system has to be set up at the start, and with the ring in place, the magnets then have to be accurately positioned. As tunnels encountered more difficult terrain, it became clear that 'cut-and-fill' was no longer the most economic solution. For bored tunnels, such as for the 450 GeV Super Proton Synchrotron and for LEP, a system is required to guide the tunnel builders.

When the PS was built in the 1950s, things were relatively primitive. Computers were still in their infancy, and least-squares adjustment required patient labour with calculating machines. Geodesy relied on angular measurement with theodolites. Thus for the PS, the geodetic reference system had to be based on the centre of the machine, requiring radial tunnels to permit the angular

A striking view of the tunnel being built for the CERN Intersecting Storage Rings in 1968. For the ISR, new measurement techniques and the advent of digital computers made their impact on geodetic work.

(Photo CERN 164.4.68)



For the SPS, survey results still had to be written down. LEP data will be recorded automatically.

(Photo CERN 162.1.74)

measurements to be made.

There were other restrictions as well. To avoid temperature gradients which would affect light by refraction, an expensive air conditioning system was installed. At the time, accurate distance measurement was only just making an appearance with the geodimeter (modulated light signals) and the tellurometer (infra-red signals).

For the Intersecting Storage Rings in the 1960s, the availability of new measurement techniques and the advent of powerful digital computers meant that it was no longer necessary to have access to the physical centre of the ring. To meet the ISR construction deadlines, tedious angular measurement was dispensed with, all distances being measured with the 'distinvar', a new automatic precision length measuring device, developed at CERN.

The next episode was the SPS. This work was complicated by several special factors. For the first time, a particle accelerator was to be built in a bored tunnel. This machine moreover would have links to existing machines, and would be built in hilly terrain where altitudes change by up to 50 m over a few kilometres. In addition, the wooded countryside made line-of-sight measurements difficult.

To guide the tunnel boring machines, a gyrotheodolite, using the earth's axis of rotation as reference, was employed. After being improved and automated at CERN, the accuracy possible with this initially awesome instrument was improved by a factor of two.

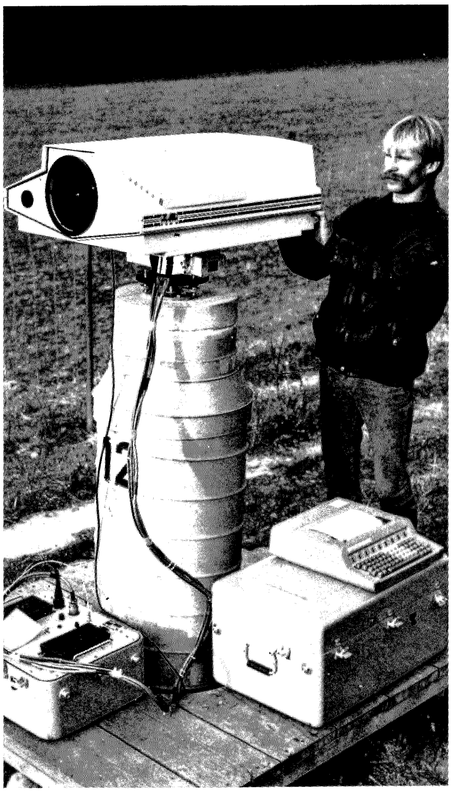
Inside the tunnel, magnets could be sited to within 0.1 mm. When the machine was switched on, the protons were able to circulate without any correction to the orbit, testifying to the remarkable mastery of precision tunnel boring and equipment positioning achieved in the project.

For distances on the LEP scale, additional complications enter. In addition, it is the first machine to be constructed on a slope. But the CERN tradition of supreme precision is nevertheless maintained. To achieve accuracies to within a few parts in ten million, use is made of a 'Terrameter', which takes measurements at two laser frequencies to produce a highly accurate value for the refractive index of air. This avoids the approximations inherent in earlier methods, and is a far cry from the PS, with its air-conditioning system!

Already with the SPS, complications arose due to the curvature of the Earth, requiring slight tilting of the magnets. For LEP, geodetical considerations have to go even further — due to the proximity of mountains and the lake of Geneva, the effective gravitational force changes round

The 'Terrameter' being used for LEP survey work at CERN. This instrument takes simultaneous measurements at two laser frequencies to compute the refractive index of air and permit measurements to a few parts in ten million.

(Photo CERN 125.12.83)



One of the Berkeley contingent in a Berkeley / Corvallis / Studsvik experiment at the CERN Synchro-Cyclotron is Glenn Seaborg, seen here (left) speaking with Chinese Premier Zhao Ziyang (right) when he visited Berkeley during his recent US tour.

(Photo LBL)

the ring, altering the verticals to an extent which produces a variation of over 10 cm across the LEP diameter.

For LEP survey work, manual methods will as far as possible be automated to simplify both the measurement procedures and the recording of the mountain of necessary data. At CERN, a microprocessor-driven unit has been developed which can be used by non-specialists and is programmable in easy-to-use BASIC. Frequently-used routines can be stored in memory and used as required. If necessary, the instrument can communicate with a computer through a standard (RS232) link.

The new techniques developed at CERN over the years have improved the reliability, speed and accuracy of geodetic measurements. Examples are the 'distinvar' device, special magnet alignment jacks, a self-aligning reflector for a laser interferometer, and an alignment system using nylon wire.

Thanks to superb instruments and accumulated expertise, the CERN geodesy experts are able to face each new challenge with confidence.

The new 'forty-niners'

Nucleus-nucleus collisions at intermediate energies (from about 10 - 100 MeV/nucleon) are of great interest to nuclear physicists and chemists. This is a transition region between low energy reaction mechanisms (below 10 MeV/nucleon) with long nuclear mean free paths, and higher energy mechanisms with the short mean free paths of nucleons in nuclear matter.

Increasing the projectile energy from 10 to 100 MeV/nucleon passes several important nuclear milestones (including the velocity of sound in nuclear matter and the Fermi energy) which may trigger changes in reaction mechanisms.

The oldest machine at CERN, the 600 MeV Synchro-Cyclotron (SC), which came into action back in 1957, is playing an important role in these studies. For the past four years, experimental teams from France, West Germany, Sweden, Norway, Denmark and the US have used its intense 85 MeV/nucleon carbon-12 beam to study such diverse phenomena as pion production below threshold, and projectile and target fragmentation.

Recently the SC Accelerator Group has added yet another attraction to the already impressive list of SC heavy-ion options (see next page) with a super intense (500 nA) beam of 49 MeV/nucleon carbon-12 less three electrons. On 9 February, this, the most intense intermediate ener-

CATALOGUE OF CERN SC BEAMS

	(MeV/N)	intensity (Parts./sec)
Proton	602	$> 3 \times 10^{13}$
$^{3}He^{++}$	303	$> 3 \times 10^{12}$
$^{3}He^{+}$	85	$> 10^{13}$
$^{12}C^{4+}$	85	$> 10^{12}$
$^{15}N^{5+}$	85	$> 10^{11}$
$^{18}O^{6+}$	85	$\sim 3 \times 10^{11}$
$^{16}O^{6+}$	107	5×10^{9}
$^{14}N^{5+}$	97	$\sim 10^{9}$
$^{20}Ne^{7+}$	94	$\sim 5 \times 10^{9}$
$^{20}Ne^{6+}$	70	8×10^{9}
$^{20}Ne^{5+}$	49	3×10^{11}
$^{12}C^{3+}$	49	$> 10^{12}$

gy heavy ion beam in the world, was delivered to the target of an experiment by a Berkeley / Corvallis / Studsvik team. This allowed detailed measurements of target fragmentation and incomplete fusion that were previously impossible.

The California-based contingent in this group (which includes Glenn Seaborg) has come to CERN to seek experimental treasures with 49 MeV/nucleon carbon ion beams and gold targets, and has earned the name 'the new forty-niners'.

As well as its high intensity, the new beam has a time structure permitting certain multi-detector experiments. There could still be a lot of gold in them thar SC hills!

(From Walt Loveland)

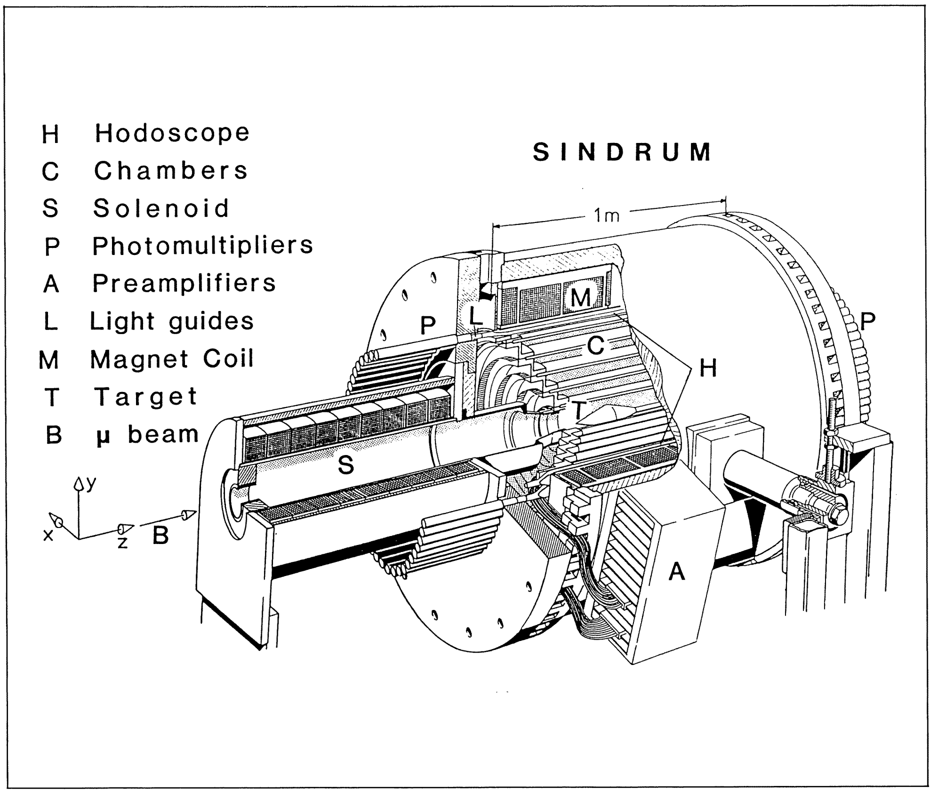
SIN
Muon SINDRUM

Electrons and muons like to go their own separate ways, and in all weak interactions observed so far, 'muonness' and 'electronness' remain unchanged. However any sign of an electron-muon affinity would be valuable fuel for new theories seeking to extend our understanding of particle behaviour, and would immediately open up a new horizon of physics.

Over the past two years, the SINDRUM spectrometer has been built at the Swiss SIN Laboratory to search for the classically forbidden decay of a positive muon to three electrons, eventually down to a sensitivity of one part per million million. This would be a thousandfold improvement on the present limit of 1.9×10^{-9} from a 1976 Dubna experiment.

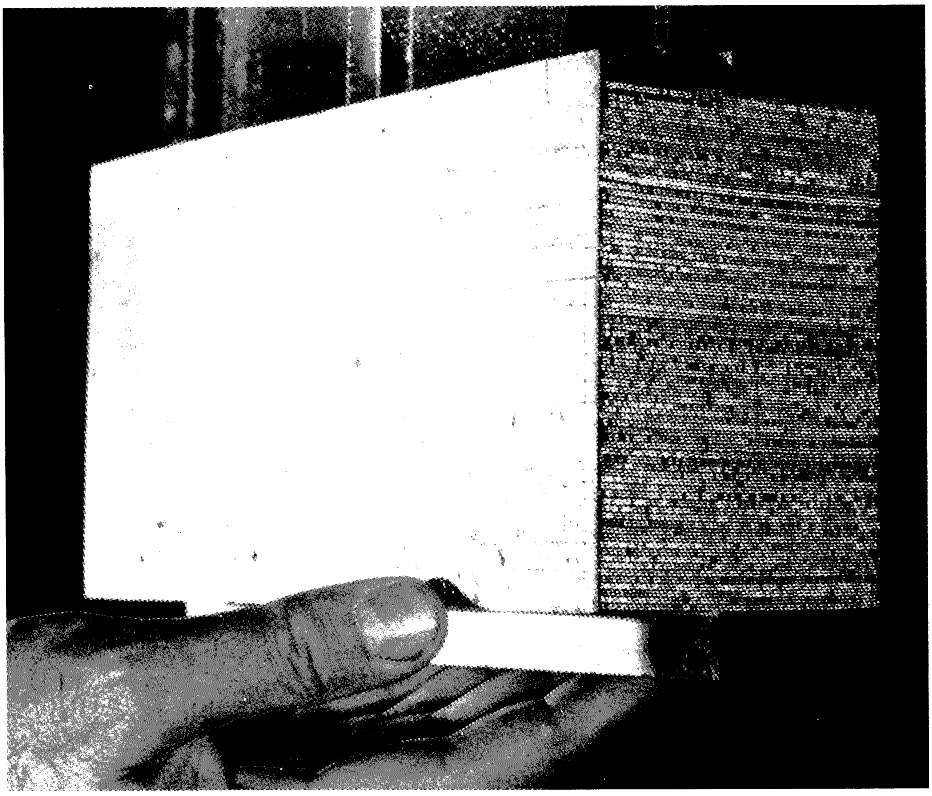
SINDRUM uses a solenoid coil producing a magnetic field of up to 0.6 T in a cylindrical volume 110 cm by 75 cm. The space and time coordinates of the decay electrons are measured in four concentric thin (30 mg/cm^2) wire chambers and a

Below, layout of the SINDRUM detector used at SIN to search for signs of the classically forbidden decay of a muon into three electrons.



Second Saclay prototype of scintillating fibres held in a lead alloy matrix. It contains 6400 1 mm-diameter fibres in 80 layers. The visible imperfections, due to the experimental method of construction, will disappear with large scale techniques.

(Photo Saclay)



scintillator hodoscope.

28 MeV momentum positive muons are brought to rest in a target. In the subsequent decays, any production of three electrons would be characterized by zero total momentum and by total energy adding up to the rest mass of the parent muon. Using a four-stage Fastbus fast electrons trigger, these criteria were applied in a first test experiment last September.

With 2.6 x 10^6 positive muons brought to rest per second, only 1.6 candidate events per second survived the initial selection and were written onto magnetic tape. From a total of 2.5 x 10^5 such events, 16 were found to be due to the rare but allowed decay into three electrons and two neutrinos (electron-type neutrino plus muon-type antineutrino), in agreement with the theoretically expected level. No neutrinoless events were found, giving a limit on the three electron decay of 1.6 x 10^{-10}.

This year, further SINDRUM experiments will use a fifth wire chamber and an improved muon flux (10^7 stopped positive muons per s), to improve this sensitivity by another two orders of magnitude.

SACLAY Scintillating calorimetry

The development at Saclay of specially clad scintillating fibres provides a new technique for fine grain calorimetry. The most promising approach consists of immersing regularly positioned fibres in a non-destructive, low melting point alloy. This gives a high density block, and the use of contiguous blocks would permit a large continuous surface to be covered.

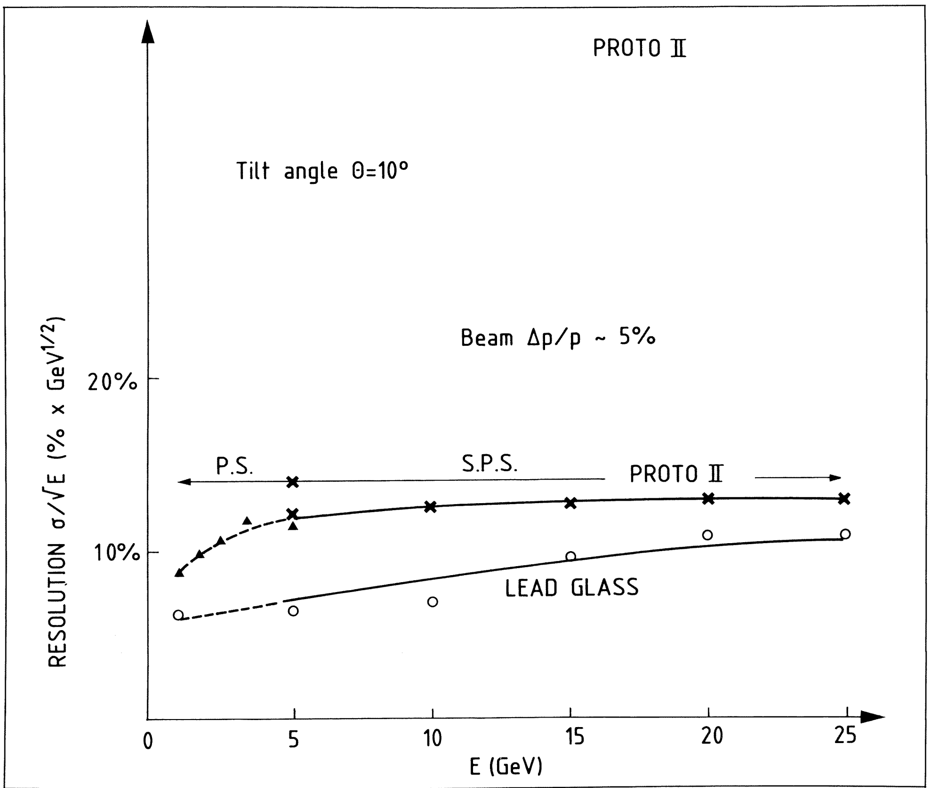
The approach offers several potential advantages: its smaller radiation length allows high energy showers to be contained in a limited space, it tolerates irradiation, and with appropriate light guides a reduced photosensitive area can be used. On the other hand, it is a new technology which still has to be carefully studied before large scale production can be undertaken.

Design and construction of two prototypes are under way at Saclay for the electromagnetic forward detector and small angle tagger for the DELPHI experiment at the LEP electron-positron ring at CERN. Tests and Monte Carlo computations were carried out by a collaboration including also Bergen, CERN, Padua, Santander, Torino and Valencia.

The scintillating fibres made in the laboratory use doped polystyrene. Usually they are 1 mm in diameter and give an average of six photoelectrons for a particle crossing at 1 m from the phototube. Typical attenuation length is one metre. They are immersed in a lead alloy (Wood's Metal) with a density of 9.75 and a radiation length of 7 mm. This is fluid at 80°C, while the fibres soften only at 90°. The attenuation length of the fibres is unchanged by this treatment.

A prototype unit contained 6400 1 mm-diameter fibres, with a measured filling factor of 51 per cent by volume. This leads to an overall density of 5.3 and global radiation length of 14.5 mm. Emerging fibres were cut to allow a lucite light guide to be used. This prototype was tested in a CERN electron beam from 5 to 26 GeV, without magnetic field.

The results are in good agreement with the simulation. The block produced about 5000 photoelectrons per GeV and the linearity of the pulse height was good. Energy resolution ranged from 9 to 13 per cent times



Energy dependence of the energy resolution of a scintillating fibre block. The block was inclined at 10° to the beam direction to avoid preferential development of electromagnetic showers along the fibres.

the square root of the energy in GeV, provided the incident particle was at more than 5° to the direction of the fibres. Use of a light guide reducing the photosensitive area by a factor of three resulted in a reduction of only 20 per cent in the light signal, thanks to the channelling of light by the fibres. Irradiation of bare fibres by a gamma-ray source at doses of up to 10^6 rad reveals no change in light output or attenuation length. As for spatial resolution, preliminary estimates give 5 mm for 60 x 80 mm blocks.

Tests should soon begin on a new prototype built using the techniques envisaged for large scale production.

(From M. Bourdinaud)

CONFERENCE
Nordic physics

Around 80 physicists from eleven countries fought heavy snowstorms and 20-below temperatures at the winter resort of Spåtind, Norway, for the 8th Nordic Meeting on Elementary Particle Physics in January. This biennial conference is a traditional meeting place for Nordic particle physicists, and especially for the young research students, but also draws participants from other countries. This year's meeting was organized by the Division of Particle Physics of the Swedish Physical Society.

The Spåtind meetings offer both extended review talks by prominent invited lecturers, shorter contributions with research news, and spontaneous evening workshops.

Maurice Jacob (CERN) told about the thrilling prospects for collider physics in the light of the present results, and Don Perkins (CERN) reviewed the status and future plans for the HERA machine at DESY.

John Ellis (SLAC and CERN) convinced the audience with his talk on grand unification and supersymmetry that around the corner there is a sparticle for every particle and a she for every he (which earned him a special prize at the table tennis tournament for 'best supersymmetric hit'...).

Helmut Satz (Bielefeld) reviewed the concepts behind the idea of quark-gluon plasma formation. Experiments at the CERN PS and SPS with light-ion beams could give important hints on the quark deconfinement mechanism in quantum chromodynamics. The formalism for theoretical work in this field has much in common with the theme of Peter Hasenfratz' (CERN) talk on lattice gauge theories. He reported a recent workshop at CERN to coordinate the enormous computer work necessary to estimate hadron properties using this promising approach.

When it comes to current experimentation, the word 'paradox' always whets everyone's appetite. In his review talk on heavy flavour production, Lucien Montanet (CERN) explained why it is difficult to explain the observed rates of charm production. Bill Scott (CERN) covered the remarkable results from the CERN proton-antiproton collider, including the unexplained Z^o events with energetic photons.

Equally mysterious are the protons that refuse to decay, but according to the review talk on baryon non-conservation by Don Cundy (CERN), there are still a few surviving candidate events which might save theories of grand unification.

Andy Parker (CERN) ended up with one of the most celebrated parad-

People and things

oxes of yesteryear when overviewing the data on nucleon structure functions — the so-called EMC effect discovered at CERN by the European Muon Collaboration. The fact that quarks in atomic nuclei behave differently from those in free nucleons made Parker conclude that one can no longer use any old objects as targets for high energy experiments. Meanwhile theorists are enjoying a honeymoon with the EMC effect. There are by now several dozen different models, and only further experiments will reveal which one is correct.

The shorter talks added up to a rich smorgasbord of interesting new results. A special session was devoted to the development of detectors for LEP, with emphasis on the DELPHI collaboration where the Scandinavian groups participate.

The intensive and inspiring week finished with the traditional cross-country ski competition. Among the many prizes awarded, one has almost become a tradition: that to Don Perkins for coming in furthest away from everyone else, by an impressive margin.

(From Sverker Fredriksson)

On people

Ian Butterworth of Imperial College, London, presently Research Director at CERN, was awarded the CBE in the traditional UK New Year's Honours List. Bob Voss, ex-Daresbury, became an OBE.

CERN Theory Division Head Maurice Jacob has been elected Chairman of the French Physical Society for 1985. This year he is Vice-Chairman.

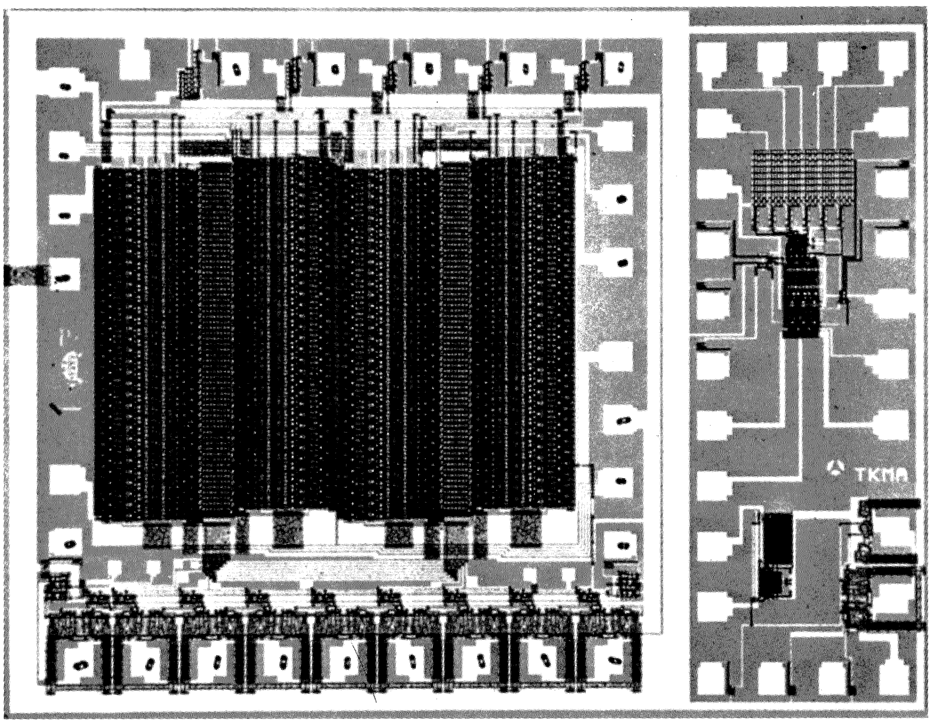
This year the Rutherford Medal and Prize of the UK Institute of Physics goes to Peter Higgs of Edinburgh and Tom Kibble of Imperial College, London, for their contributions to particle physics theory, particularly their work on spontaneous symmetry breaking in gauge theories, which is a cornerstone of the new electroweak picture.

American Physical Society

The composition of the American Physical Society's Division of Particles and Fields Executive Committee for 1984 is: John Peoples (Fermilab, Chairman), James Cronin (Chicago, Vice-Chairman), Gerson Goldhaber (Berkeley), Alfred Mann (Pennsylvania), Edmond Berger (Argonne), Gary Feldman (SLAC), David Nygren (Berkeley), Robert Palmer (Brookhaven), Chris Quigg (Fermilab and Chicago), Richard Taylor (SLAC), and Thomas Ferbel (Rochester, Secretary-Treasurer).

A microphotograph of the EF8308 chip, an 8-bit parallel (flash) analog/digital converter now available from Thomson Semiconductors in France. The EF8308, and its companion EF8408 8-bit digital/analog converter, are both designed to operate at speeds of up to 20 MHz, a performance level of potential interest for physics experiments with high data rates.

(Photo Thomson Semiconductors)



Steven Weinberg was the speaker at this year's Shulamit Goldhaber Memorial Lecture at Tel Aviv University. These lectures, an annual feature of the Tel Aviv calendar, began in 1965 after Berkeley colleagues of the late Shulamit Goldhaber set up a scholarship for a particle physics graduate student at Tel Aviv.

George H. Trilling becomes associate director and head of Berkeley's Physics Division on 1 July, replacing J.D. Jackson.

CERN Accelerator School course

The CERN Accelerator School, in collaboration with the Orsay and Saclay Laboratories, is organizing a 'General Accelerator Physics' course at the Ecole Supérieure d'Electricité, Gif-sur-Yvette, France, from 3-14 September. The lectures cover: a Historical Introduction and Present-day Accelerators, Introduction to Weak and Strong Focusing, Longitudinal Beam Dynamics, Transverse Beam Dynamics, Dynamics and Acceleration in Linear Structures, Image and Self-Space Charge Forces, Transition Energy, Imperfections, Resonances, and Linear Coupling, Beam Transfer Lines, Insertions, Stacking and Phase Displacement Acceleration, Transverse and Longitudinal Coupling Impedances, Injection and Extraction, Synchrotron Radiation, Beam Losses and Lifetime, Neutralization Problems, Luminosity Calculation and Measurement, a General Description of Collective Phenomena, and a review of the topics envisaged for a more advanced course to follow about a year later.

The 1984 course should be useful to designers, operators and users of all types of accelerators. It assumes a basic knowledge up to 1st degree level in physics, mathematics or electrical engineering. Further information and application forms are available from the CERN Accelerator School, c/o Mrs. B. Strasser, LEP Division, CERN, 1211 Geneva 23, Switzerland. Deadline for applications is 1 June. A registration fee of 1 000 FF will be charged, which covers some meals but not accommodation.

Scottish Universities' School

The Scottish Universities Summer School in Physics will be held in St. Andrews from 12 August to 1 September. This is the twenty-seventh school in a series of NATO Advanced Study Institutes organized by the Scottish Universities. The topic this year is 'Fundamental Forces', which covers the role of gauge theories in the unification of the interactions of quarks and of leptons and their extension beyond the Standard Model together with discussion of related experiments. The lecturers are: R.J. Cashmore, P. Darriulat, J.D. Dowell, H. Harari, C. Jarlskog, L.M. Lederman, C.D. Llewellyn Smith, M.L. Perl, G. Schierholz and T.F. Walsh.

As an essential relief to the round of lectures, seminars and discussions, a full programme of social events for all participants and their families is arranged.

It is aimed to attract outstanding second and third year post-graduates and young post-doctoral workers. The fee for the school is £325 and includes a copy of the Proceedings and full board at St. Andrews University. The closing date for applications is 15 May. Further information and application forms can be obtained from The Secretary: C.D. Froggatt, Department of Natural Philosophy, The University of Glasgow, Glasgow G12 8QQ, Scotland.

Wright Science Colloquia

From 10-14 September, Geneva University will host the first of a planned biennial series of scientific lectures, sponsored by Dudley Wright. The lectures will take place in the University's Piaget Auditorium under the title 'Man and his Universe'. The aim of the 'Wright Science Colloquia' is for eminent scientists to describe their research in a comprehensible way to an educated, but not specialist, public. There will be ample time at the Colloquia for questions and discussion. The speakers at the first event will be Francis Crick, Hubert Reeves, Eugene Shoemaker, Michael Sela and Viktor Weisskopf.

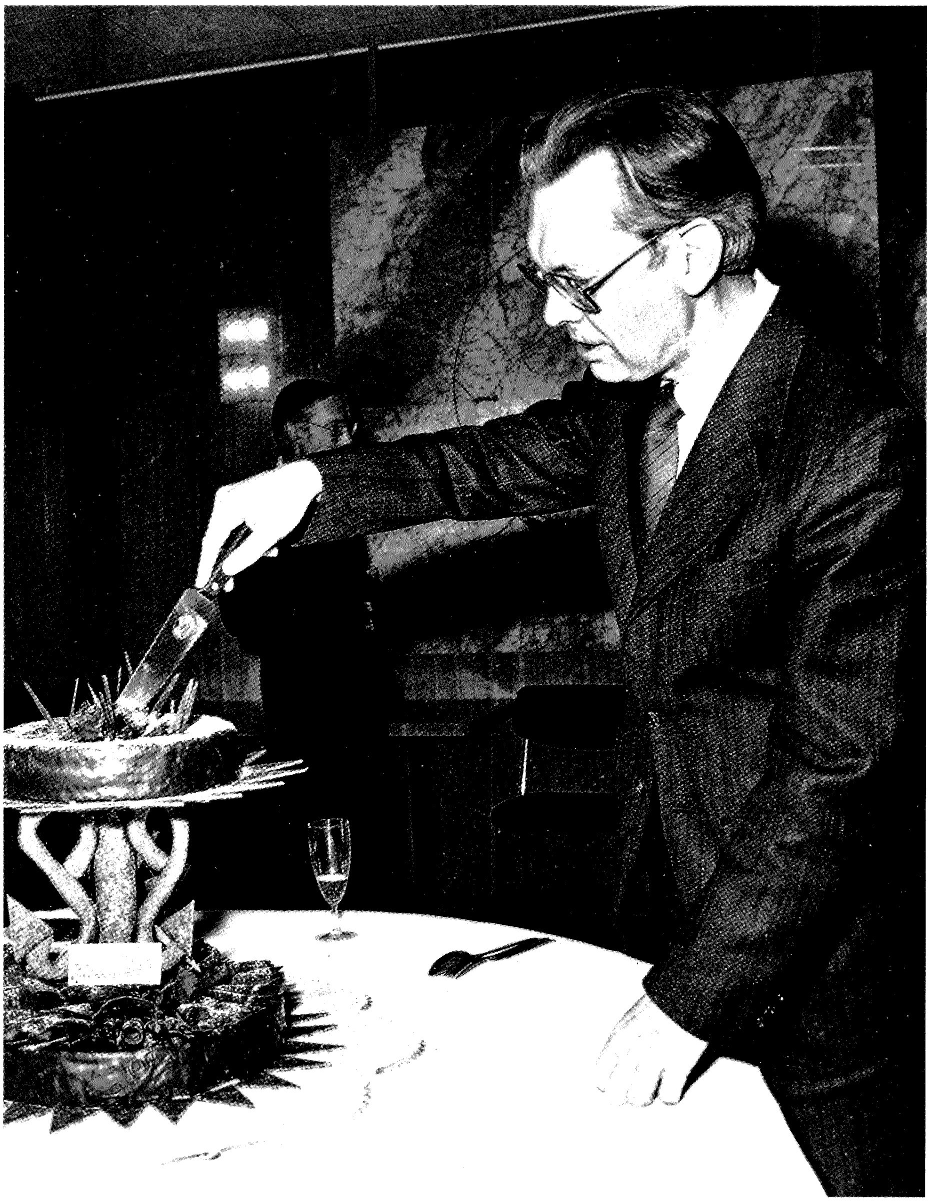
Particle and Nuclear Physics Meet

A Conference on the 'Intersections between Particle and Nuclear Physics' will be held from 23-30 May in Steamboat Springs, Colorado, USA. The meetings will focus on the physics interests of the many diverse groups who work in Particle and/or Nuclear Physics. The conference has been designed to promote dialogue between these groups, highlighting the importance of Nuclear and Particle Physics in the 1 to 100 GeV/c region.

The co-chairmen of the organizing committee are A.D. Krisch (Michigan) and M.H. Macfarlane (Indiana). The conference is sponsored by the AUA Trust Fund, the US Department of Energy, the US National Science Foundation, Argonne, Brookhaven, Los Alamos, Berkeley, TRIUMF, Indiana University, and the University of Michigan. There will be some scholarships available to encourage younger scientists to attend. For further information, contact the conference secretary: Mrs. Marion Heimerle, Bldg. 911B, Brookhaven National Laboratory, Upton, New York 11973, USA, telephone (516) 282-4776, telex: 96-7703.

Survey

A big thankyou to all those who took the trouble to complete and return the survey questionnaire published in the March issue. The replies are being sorted and analysed, but even at first glance they are providing us with valuable feedback. If you haven't done so already, please send back your form. There's still time!



CERN Director General Herwig Schopper cuts the cake at a small gathering on 24 February to mark his 60th birthday. His colleagues on the CERN Management Board presented him with an original of Einstein's famous 1929 paper 'Zur Einheitlichen Feldtheorie' (On Unified Field Theories).

(Photo CERN 564.2.84)

TRIUMF
MESON RESEARCH FACILITY
University of Alberta
Simon Fraser University
University of Victoria
University of British Columbia
Competition No. 435

ACCELERATOR PHYSICIST

The Cyclotron Division at TRIUMF has an opening for a physicist with experience in accelerator development to participate in the development programs toward new machine capabilities and higher beam intensities. Some of the projects currently being funded include devices for H-ion extraction, flattopping of the r.f. wave form with third harmonic, reliable electrostatic beam deflecting electrodes for the centre region, and novel beam diagnostic devices and instrumentation. The duties will require knowledge of electrostatic and magnetic fields, beam diagnostics and controls, r.f. cavities, ion optics, ion sources and vacuum systems.

Candidates should have Ph.D. in physics or engineering or equivalent and at least three years experience in an accelerator laboratory. A good theoretical background is required, together with a proven strong practical experimental attitude. Salary will depend upon qualifications and experience.

Please reply in writing as soon as possible, outlining qualifications and experience to:

TRIUMF Personnel (Competition Nr. 435)
Attn: Dr. G. Dutto
Head, Cyclotron Division
4004 Wesbrook Mall
VANCOUVER B.C. / Canada V6T 2A3

We offer equal employment opportunities to qualified male and female applicants.

Stanford University
Department of Physics

Assistant professorship in experimental particle physics

The Stanford Physics Department is conducting a search for a highly qualified candidate for a tenure-line track assistant professorship. The candidate should show both promise of making a substantial impact on the field and the potential of excellent teaching. The appointment can commence as early as next academic year.

Interested candidates should write to the:

Physics Department,
Stanford University,
Stanford, CA 94 305.
(an Equal Opportunity/
Affirmative Action Employer)
or contact: D. M. Ritson
(415) 854-3300, ex. 2626
S.G. Wojcicki
(415) 497-4348

Science & Engineering Research Council
Daresbury Laboratory

DETECTOR DEVELOPMENT SYNCHROTRON RADIATION

The Daresbury Laboratory, situated in North Cheshire, operates major national facilities for research into atomic, molecular and biological sciences, nuclear physics and computational sciences.

The Laboratory is expanding its work in the field of fast detector systems and has vacancies for:

1. **A SENIOR DETECTOR SPECIALIST** (Ref. DL/846) with experience in the development and exploitation of multi-wire proportional detectors or related devices. The successful applicant will be expected to make a major contribution in the development of high resolution high rate systems for x-ray imaging and subsequently to pursue developments in other regions of the electromagnetic spectrum working in close collaboration with a multi-disciplinary research community.

   Applicants should have a good honours degree (or equivalent qualification) in physics or electronic engineering and a record of achievement in research instrumentation.

   The appointment will be made within a salary range of £ 8,970 to £ 12,163 per annum according to qualifications and experience.

2. **A PHYSICIST/ELECTRONIC SPECIALIST** (Ref. DL/847) with a primary commitment to instrumentation to assist in the development of special purpose detector systems and their application to a wide variety of experiments.

   Applicants should have a good honours degree (or equivalent qualification) in physics/electronic engineering. Specialised experience in multi-wire proportional detectors is desirable though not essential, but a commitment to high speed analogue and digital signal processing is required.

   The post entails working in a multi-disciplinary environment and demands qualities of resourcefulness and adaptability.

   The appointment will be made within a salary range of £ 5,682 to £ 9,561 per annum according to qualifications and experience.

3. **AN ELECTRONICS TECHNICIAN ENGINEER** (Ref. DL/848) to assist in the construction and commissioning of complex detector systems and to take a major part in integrating these systems with experimental applications and in their subsequent development.

   Applicants should have an honours degree or HNC/HTC (or equivalent qualification) in an appropriate discipline. Experience with high resolution, high speed electronics applied to multi-wire detectors would be an advantage. A keen interest in research instrumentation is essential together with the ability to adapt successfully to a wide range of technologies.

   The appointment will be made within a salary range of £ 7,178 to £ 9,681 per annum according to qualifications and experience.

Appointment to each post allows for a non-contributory superannuation scheme and generous leave allowance. There is also a flexible working hours scheme in operation at the Laboratory.

Closing date: 16th April 1984

Further information on these posts may be obtained from Mr. J.S. Worgan on Warrington (0925) 65000 Ext. 225.

Application forms may be obtained from and should be returned quoting the appropriate reference number to:

The Personnel Officer,
Daresbury Laboratory,
Science & Engineering Research Council,
Daresbury,
Warrington,
Cheshire, WA4 4AD England.

If the standard connectors don't suit you then try the Series Gds A complementary ones. As required

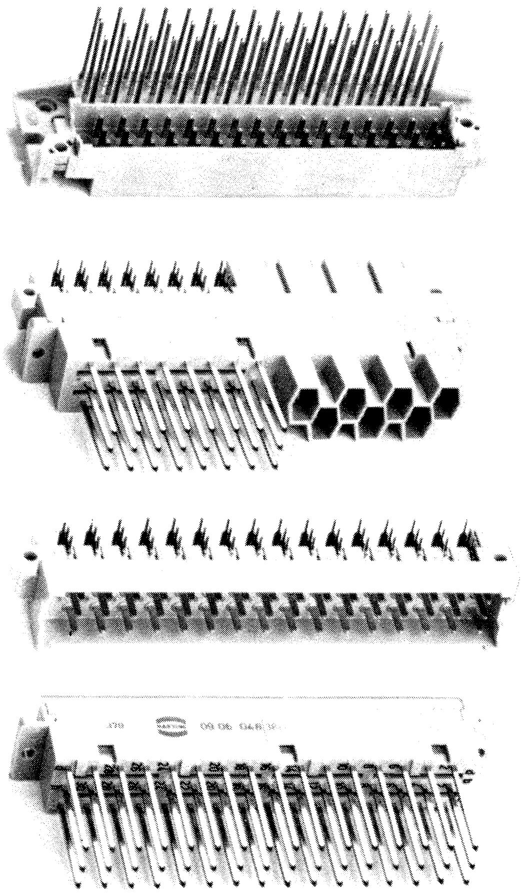
There are applications where you need connectors which cannot be covered by the ordinary DIN-standard types. In order to meet the special requirements of our customers we have developed printed-circuit connectors which complement the standard, in harmony with practical applications. It means you can always make the perfect connection – functional fast and reliable. For instance, BUS connections.

You'll find our complementary connectors in Series Gds A both for Types B and C and for D, E, F and H, whether it be the Gds A-MH combined connector, the interface connectors or the extensive, well-conceived housing range for all the DIN Types.

A comprehensive range you'll only find at HARTING. Solutions with practical applications in mind are simply part of our philosophy.

By the way, all Gds A connectors are now available under the new classifications according to DIN 41 612, Part. 5. Clearly defined qualities will also save you money. Check your specifications and select the right connectors to suit your requirements – it's worth it!

We're helping you to reduce expense by increasing the number of Types available and insisting on first-class quality.

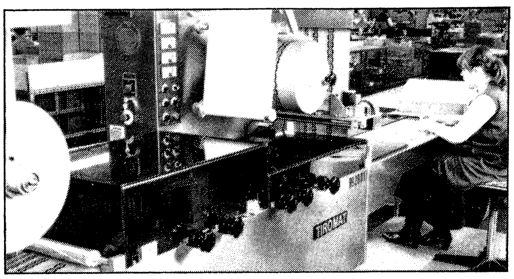


HARTING®

HARTING ELEKTRONIK GmbH
Postfach 1140 · D-4992 Espelkamp
West Germany

☎ (0 57 72) 47-1
Tx 9 72 310-11 he d

HARTING – experienced
electronic component specialists.



We set great store by convenient and reliable packaging so that our first-class products reach you in perfect condition and are easy to handle.

Subsidiary companies:
Belgium: N. V. HARTING ELEKTRONIK S. A., Industriezone Doornveld, Schapenbaan, B-1730 Relegem, Phone 02-465.42.40, Telex 645 73. **France:** HARTING ELEKTRONIK S.A.R.L., BP 24, F-94121 Fontenay-sous-Bois Cedex, Phone 877-06 26, Telex 212 583. **Great Britain:** HARTING ELEKTRONIK LTD., Airport Estate, GB-Biggin Hill/Kent TN 16 3 BW, Phone (0 95 94) 7 14 11, Telex 951 68. **Italy:** HARTING ELEKTRONIK S.P.A., Via Como, 2, I-20096 Pioltello (Milano), Phone 02-9 240 366, Telex 323 494. **The Netherlands:** HARTING ELEKTRONIK B.V., Mon Plaisir 89 D, Industrieterrein Vosdonk, NL-4879 AM Etten-Leur, Phone 01-608-3 54 00, Telex 5 4 754. **Norway:** HARTING ELEKTRONIK A/S, Nils Hansens vei 13, Bryn, N-Oslo 6, Phone 02-68 75 72, Telex 7 6 399. **Sweden:** HARTING ELEKTRONIK AB, Fagerstagatan 3, S-16353 Spånga/Stockholm, Phone (08) 7 617 980, Telex 15 090. **Switzerland:** HARTING ELEKTRONIK AG, Eschenstrasse 2, CH-8603 Schwerzenbach, Phone 01-825 51 51, Telex 54 340.

Foreign representatives:
Austria: Burisch Ges. m. b. H. & Co. KG, P.O.B. 24, A-1210 Wien. **Brazil:** ER COMERCIO E INDUSTRIA LTDA, P.O.B. 2456, 30.000 Belo Horizonte MG. **Denmark:** Knud Wexøe A/S, P.B. 35, DK-2840 Holte. **Finland:** SKS Suomalainen Kone Oy, P.O.B. 74, SF-00521 Helsinki 52. **Japan:** Yamaichi Electronics Co. Ltd., 3-chome Shibaura, Minato-ku, Tokyo 108. **South Africa:** Bowthorpe-Hellermann-Deutsch (Pty) Ltd., 80 Mimetes Road, Denver Ext. 9, Johannesburg. **Spain:** Elion S. A., Apartado Postal 7097, E-Barcelona 14. **Bulgaria, CSSR, Jugoslavia, Poland, Rumania, Hungaria:** Gebhard Balluff GmbH & Co., P.O.B., A-2346 Maria Enzersdorf-Südstadt/NÖ.

FAST
COINCIDENCES?

A complete range of fast 2" PMTs

Type	cathode	linearity	number of stages	t_r (ns)	t_w (ns)	σ_t (ns)	Δt_{ce} (ns)
XP2020	bialkali	280	12	1,5	2,4	0,25	0,25
XP2230B	bialkali	280	12	1,6	2,7	0,35	0,60
XP2262B	bialkali	250	12	2,0	3,0	0,50	0,70
XP2020Q	bialkali on quartz	280	12	1,5	2,4	0,25	0,25
XP2233B	trialkali	250	12	2,0	3,2	0,50	0,70
PM2254B	trialkali on quartz	280	12	1,5	2,4	0,25	0,25
PM2242	bialkali	350	6	1,6	2,4	–	0,70

t_r = anode pulse rise time for a delta light pulse

t_w = anode pulse duration FWHM for a delta light pulse

σ_t = transit time spread for single electron mode

Δt_{ce} = transit time difference centre-edge

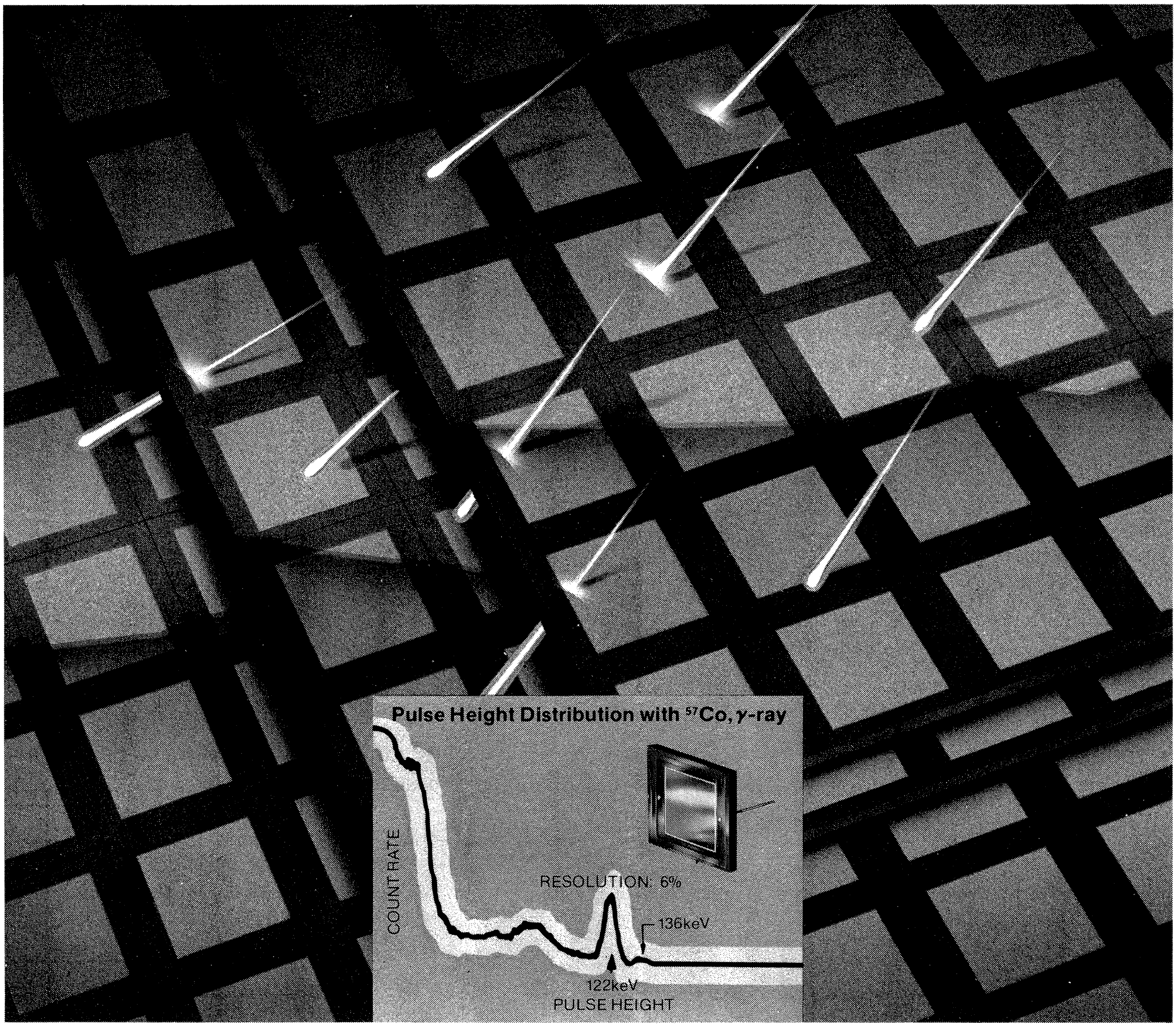
Other fast tubes: 3/4" PM1911, 1" PM2982, 3" PM2312, 5" XP2041

Philips Industries, Electronic Components and Materials Division, Eindhoven, The Netherlands

It's no coincidence: we've set the standard for over 20 years

PHILIPS Electronic Components and Materials

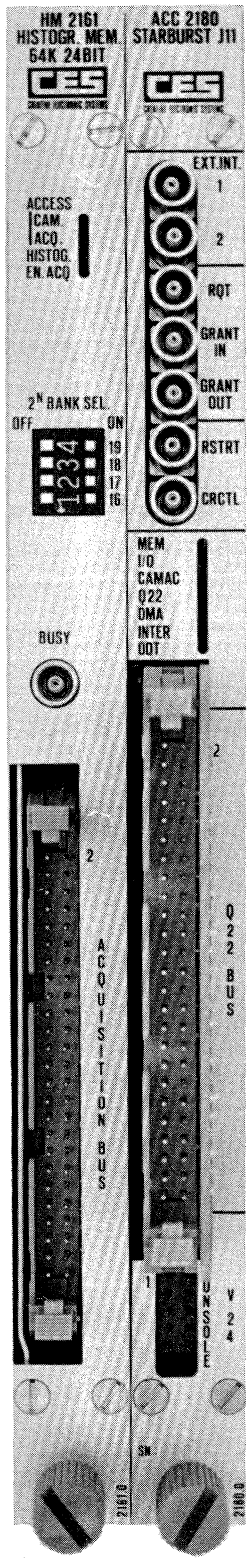
PHILIPS



Pulse Height Distribution with $^{57}Co, \gamma$-ray
COUNT RATE
RESOLUTION: 6%
136keV
122keV
PULSE HEIGHT

Creative Electronic Systems SA   CES

These two units are tops in their fields...
...just imagine what problems they can solve when combined!



High speed Histogramming memories HM 2161 series

Featuring:

- single width CAMAC module.
- dual-port high performance storage:
  1 Mhz operating speed & up to 64 K words of 24 bits.
- selectable operating modes:
  * histogramming mode on 16 or 24 bits
  * list mode
  * multiscaling mode
- selective erase facility for efficient memory partitioning.
- powerful CAMAC interface for ease of operation.
- interface configuration kits available for most existing ADCs.
- optional address routing unit.
- best price / performance ratio.

Powerful user-friendly fast processors ACC 2180 series.

Featuring:

- single width CAMAC module.
- DEC J-11 one-chip processor with PDP 11/70 performance
- built-in DEC DLART DC 319 console interface
- fast 128 Kbytes dual-port memory with mixed static RAM/EPROM.
- true ACC structure
- built-in programmable LAM grader
- optional Q-Bus interface
- portable hard disk subsystem.

The ACC 2180 outperforms current top-of-range micros and runs standard DEC software.

Typical systems based on these units include:

- on-line data reduction systems
- portable high performance data loggers.
- real-time pulse height acquisition systems.
- intelligent buffering systems to cope with high speed data packets.
- computer to computer links.

At CES, tomorrow's systems are available NOW

For more information contact us, or your local CES representative:

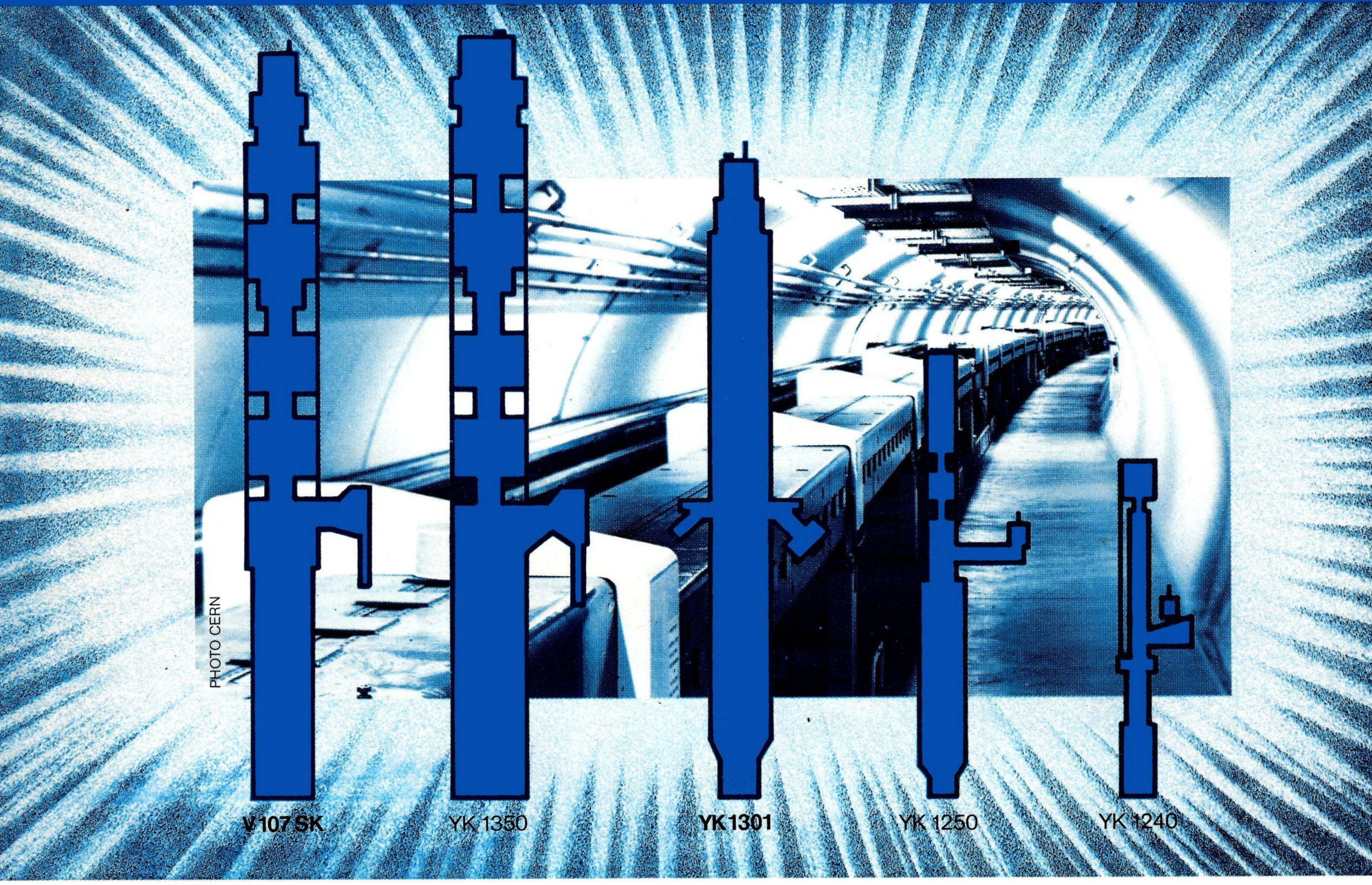
70,route du Pont-Butin Case Postale 122 1213 Petit-Lancy 1 Switzerland
Tel:(022) 92 57 45 Telex: 421320 CES-CH

CREATIVE ELECTRONIC SYSTEMS

Belgium:	Canberra Positronika	Tel:(54)321611	Netherlands:	Canberra Positronika	Tel:(040)416355
North America:	Bytech Eng. Vancouver	Tel:(604)7387784	Japan:	Toyo Corp.	Tel:(03)2790771
France:	AB+B	Tel:(76)905540	North Germany:	PCP	Tel:(040)802046
South Germany:	Silena	Tel:(060)554021	England:	Nuclear Enterprises	Tel:(073)5212121

Electronics.
We provide the components.

VALVO



More Big Klystrons for Big Science

Valvo herewith presents two further big klystrons out of our wide range of high power klystrons for research applications, both being significant examples for state of the art technology in the field of pulse and cw-RF amplifiers.

V 107 SK operating at 324 MHz and delivering 1.5 MW pulse power. This klystron has been developed in the course of a study on a spallation neutron source, where a gallery of 90 of these tubes delivers the RF-power for the proton-linear accelerator. The overall length of this klystron amounts to 4 metres.

YK 1301 operating at a frequency of 500 MHz and now delivering an increased cw output power of 800 kW. The main electrical parameters are: 76 kV, 17 A and a nominal efficiency of 63 %. 500 MHz has been the chosen frequency at DESY in Hamburg, where these klystrons feed the required RF-power into the cavities of the PETRA ring.

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

VALVO

A 1606c/2f

The world's best power tubes are used in the world's most important scientific programs.

Since 1971, when Varian EIMAC introduced the one megawatt X-2159/8974, we have been the world leader in design and manufacture of high power tubes for scientific and communcation applications.

Among the many users of EIMAC tubes in high technology fusion research, particle acceleration and other state-of-the-art investigations are:

▪ European Organizations for Nuclear Research (CERN) ▪ Fermi National Accelerator Laboratory ▪ Stanford Linear Accelerator Center ▪ Lawrence Berkeley Laboratory ▪ Los Alamos National Laboratory (LAMPF and FMIT programs) ▪ Oakridge National Laboratory ▪ Princeton Plasma Physics Laboratory ▪ TRIUMF Laboratory (University of British Columbia) ▪ GSI Darmstadt (FRG) ▪ Culham Laboratory (England) ▪ CEA Fountenay-au-Rose (France) ▪ Textor-KFA Julich (FRG) ▪ GA Technology (Doublet-3).

Power tubes developed and manufactured by Varian EIMAC used in the facilities mentioned include the 8973, 8974, X-2062K/9009 and Y676A/9013. These tube types will be joined by others in development to meet new program requirements.

More information is available from Varian EIMAC. Or the nearest Varian Electron Device Group sales office. Call or write today.

Varian EIMAC
301 Industrial Way
San Carlos, CA 94070
415 • 592-1221

VARIAN AG
Steinhauserstrasse
CH-6300 Zug, Switzerland
Tel: (042) 23 25 75
Telex: 868-841

varian