

# CERN COURIER

International Journal of High Energy Physics



VOLUME 25



JULY AUGUST 1985



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

VOLUME 25 N° 6

JULY/AUGUST 1985

### Laboratory correspondents:

Argonne National Laboratory, USA  
M. Derrick  
Brookhaven National Laboratory, USA  
N. V. Baggett  
Cornell University, USA  
D. G. Cassel  
Daresbury Laboratory, UK  
V. Suller  
DESY Laboratory, Fed. Rep. of Germany  
P. Waloschek  
Fermi National Accelerator Laboratory, USA  
R. A. Carrigan  
KfK Karlsruhe, Fed. Rep. of Germany  
M. Kuntze  
GSI Darmstadt, Fed. Rep. of Germany  
G. Siebert  
INFN, Italy  
M. Gigliarelli Fiumi  
Institute of High Energy Physics,  
Peking, China  
Tu Tung-sheng  
JINR Dubna, USSR  
V. Sandukovsky  
KEK National Laboratory, Japan  
K. Kikuchi  
Lawrence Berkeley Laboratory, USA  
W. Carithers  
Los Alamos National Laboratory, USA  
O. B. van Dyck  
Novosibirsk Institute, USSR  
V. Balakin  
Orsay Laboratory, France  
Anne-Marie Lutz  
Rutherford Appleton Laboratory, UK  
R. Elliott  
Saclay Laboratory, France  
A. Zylberstein  
SIN Villigen, Switzerland  
J. F. Crawford  
Stanford Linear Accelerator Center, USA  
W. W. Ash  
Superconducting Super Collider, USA  
Rene Donaldson  
TRIUMF Laboratory, Canada  
M. K. Craddock

Copies are available on request from:  
China —

Dr. Qian Ke-Qin  
Institute of High Energy Physics  
P.O. Box 918, Beijing,  
People's Republic of China  
Federal Republic of Germany —  
Gabriela Martens  
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 nec-  
essarily those of the CERN management

Printed by: Cranford Press  
Croydon, England.

Published by:

European Laboratory for Particle Physics  
CERN, 1211 Geneva 23, Switzerland  
Tel. (022) 83 61 11, Telex 419 000  
(CERN COURIER only Tel. (022) 83 41 03)  
USA: Controlled Circulation  
Postage paid at Batavia, Illinois

Vancouver Accelerator Conference .....	223
<i>Report of international machine meeting</i>	
Collision course .....	229
<i>Four years' experience at CERN's proton-antiproton Collider</i>	
A quarter of a century against the clock/Plans for the future .....	234
<i>25 years of Brookhaven's proton synchrotron</i>	
Around the Laboratories	
CERN: Two more Collider experiments/A beauty unveiled .....	237
<i>More ways of using antiprotons/Heavy flavour seen</i>	
DESY: HERA's electron ring .....	23
<i>Progress towards Germany's electron-proton Collider</i>	
CORNELL: Multi-bunch operation .....	239
<i>Getting the most out of the CESR electron-positron machine</i>	
People and things .....	241

Cover photograph: How to brighten up your Laboratory. A corner  
of this year's exhibition of work by the children of the CERN  
Nursery School (Photo CERN X571.5.85).

# Vancouver Accelerator Conference

*Michael Craddock, Chairman of the Conference, and Accelerator Research Division Head at the TRIUMF Laboratory gives the opening address at the 1985 Particle Accelerator Conference in Vancouver. He and his colleagues are to be congratulated on the very smooth organization of such a large gathering.*

Anyone who contends that particle physics is conducted in an ivory tower, not contributing to other fields of science or to humanity at large, should have attended the 1985 Particle Accelerator Conference in Vancouver. Over a thousand participants contributed 781 papers and only a fraction were actually related to accelerators for high energy physics. The majority of present developments are in the service of other fields of science, for alternative power sources, for medicine, for industrial applications, etc.

Nevertheless, it is the spur of high energy physics that has driven accelerator technology along. As Burt Richter pointed out, in some fifty years since the first Cockcroft-Walton accelerators were built, accelerator physicists have increased peak machine energies by a factor of a million and have reduced the cost per GeV by a factor of over ten thousand. Conference Chairman Mike Craddock rejoiced in his opening address that the contributions of the accelerator community had been so significantly recognized at the end of the last year with the award of the Nobel Prize to accelerator physicist Simon van der Meer, jointly with Carlo Rubbia, for his part in the success of the CERN proton-antiproton Collider.

## *The big machines*

Maury Tigner, Head of the Central Design Group based at Berkeley, gave an overview of progress towards the US 20 TeV Superconducting Super Collider, SSC. Their next major decision is the selection of the type of magnet, which of course carries a host of other parameters in its wake – particu-

larly the machine diameter.

Though there are variants – such as two-in-one (both beam apertures in a single yoke) or one-in-one designs – there are essentially two basic magnet types now under consideration. The superferric, low field type aims for simplicity and attendant low cost. Work on their design (reported by Russ Huson) is at the Texas Accelerator Centre where most impressive progress has been made for such a newly created team. They have built and tested a series of 1 m and 7 m magnets, concentrating mostly on a two-in-one design, and are now assembling a 28 m prototype (their aim is magnet units 140 m long, including dipoles 105 m long, of which there would be 1330 around the ring). Magnet performance has been good with no training, no quench-

ing problems, good cooling and with straightforward manufacturing processes.

Paul Reardon reported on the alternative high field type for which the initially separate proposals of Fermilab and of Brookhaven/Berkeley have now been amalgamated in what is called 'Design D'. They have built 4.5 m prototypes, 4 cm aperture, plus other prototypes for specific purposes, and have been encouraged by the recent improvements in superconductor cable quality (mentioned also in the recent story on HERA at DESY, see June issue, page 179) giving 25 kA/mm<sup>2</sup> rather than the 18 kA/mm<sup>2</sup> of the cable used for the Fermilab Tevatron, which makes higher fields accessible. Six 17 m magnets are now under construction; they are one-in-one, 4 cm bore, cold iron.



A look at operational considerations (Peter Liman) does not give a clear message on low field versus high field magnets for the SSC. The low field, larger ring would be some 5 to 10 per cent more expensive to operate. The high field is more susceptible to trouble from collective effects and from synchrotron radiation (new to proton machines) in cryogenic conditions. Some experiments are planned on the Brookhaven 'Light Source' to give better estimates of the potential radiation problems. To retain its key attraction, however, the low field type will have to retain comparative simplicity of construction. As designs advance, it is not obvious that this will definitely be the case.

Site selection for the SSC is the most 'political' of the project decisions, apart of course from the overall project authorization. Jim Sanford described the present thinking on site layout. A 'composite' site has been invented in order to spell out the needs and get a feeling for costs. The Department of Energy has set up a selection procedure (involving outside experts) and the hope is that the decision would be taken at the end of 1986. If everything goes according to schedule, and authorization for the project is forthcoming, construction could begin in 1988.

Of the big machines already under construction, we have reported recently on LEP (May issue, page 132), covered at the Conference by Herwig Schopper, and HERA (June issue, page 179), covered by Bjorn Wiik. The Stanford Linear Collider, to achieve 50 GeV electron-positron collisions and to prepare the way for very high energy lepton colliders, was covered by S. Eckland. All the tunnelling for the two

arcs, which will lead beams from the upgraded SLAC linac into collision, is complete and some 900 bending magnets for the arcs are available. The aim is to start commissioning of the arcs in the autumn of 1986. On the linac itself, the electron gun is giving over  $5 \times 10^{10}$  per bunch, the tiny damping ring has stored  $4 \times 10^{10}$  electrons, new focusing and guidance systems are being installed and the klystron and SLED upgrade of the linac is meeting specification.

The TRISTAN 30 GeV electron-positron collider project at the Japanese KEK Laboratory was mentioned in an overview of accelerator projects in Japan by Y. Hiras. The 2.5 GeV injector is operating and the accumulation ring is now being commissioned.

News from the big machines presently in operation concerned

*The 1985 Particle Accelerator Conference gets underway. The Conference, the eleventh in the series (based in the USA prior to this excursion over the northern border), was held from 13 to 16 May, attracting over a thousand participants.*



the CERN proton-antiproton Collider (Bas de Raad and Robin Lauckner) and the Fermilab Tevatron (G Dugan). The Collider performance climbed to an integrated luminosity of almost  $400 \text{ nb}^{-1}$  in 1984 (see page 229) and the current programme of improvements – particularly the construction of ACOL to give an order of magnitude improvement in the number of antiprotons stored per day ( $10^{12}$  rather than  $10^{11}$ ) and a change to six bunch operation – should take the luminosity to about  $4.4 \times 10^{30}$  per  $\text{cm}^2$  per s with coasting beams at 315 GeV. The recent pulsed operation of the Collider sacrificed luminosity to take a look at higher collision energies (up to 450 GeV) and, in a very successful machine run, provided 95 hours of physics.

Commissioning of the antiproton source at the Tevatron started

on 10 May. The antiproton yield with the lithium lens in operation has been measured as  $3 \times 10^{-5}$  per proton. Previously the debuncher ring was checked out with 8 GeV protons and beam was stored for the first time in April; now it is the turn of the accumulator ring where the stochastic cooling systems are installed. The superconducting ring has been tested as a storage ring with protons and has held beam for four hours. The hope is that antiprotons will be transferred to the Tevatron in July and that the first proton-antiproton collisions will be observed in August. Operation is likely to be at energies up to 800 GeV per beam, pushing to 1000 GeV later.

---

#### *Accelerator technologies for the future*

---

While the above paragraphs communicate that the accelerator community has much to keep it busy in the cause of particle physics for some years to come, there is also the realization that with LEP and SSC we are bumping into physical and fiscal limits in the climb to the ever higher energies demanded by the particle physicists. Thus, despite the burden of present projects, some hardy souls have started the very long term search for new methods of acceleration which would bring down the size and cost of the next century's machines.

The technologies need to be radically different. Recent advances, like the hard won mastery of superconducting magnets and radiofrequency cavities, do not take us far enough beyond previous techniques. We have de-

scribed some of the new ideas before (see, for example, December issue 1984, page 436), and several schemes remain in favour – particularly laser beat waves, wake field and two-beam schemes.

C. Joshi reviewed those involving access to the high accelerating field of laser beams (1 TV/m transverse). A number of exploratory experiments are underway or proposed at the UK Rutherford Laboratory, in Canada, and at UCLA and Los Alamos in the US. At UCLA a CO<sub>2</sub> laser experiment has achieved accelerating fields of up to 1 GV/m via beat waves in plasmas. Over the next few years it is hoped to demonstrate acceleration of electron beams with such beat waves. Joshi emphasized that this research with lasers will be fruitful in any case since the special characteristics of the laser fields will be applicable in other areas such as the focusing of beams, ion guns and power sources.

Tom Weiland described work on the wake field scheme at DESY. The immediate aim is to demonstrate that short pulses of high gradient fields (over 100 MeV/m) can be achieved in structures where the wake fields left by hollow beams in an outer channel are transformed through to a central beam aperture. A test unit to produce doughnut-shaped electron beams has had encouraging initial tests and it is hoped to have tried the wake field transformer principle by the end of the year.

Work based at Berkeley on the two-beam scheme was reported by Don Hopkins. They are benefiting from the availability of the free electron laser facility at Livermore where the first ever operation of a FEL as a high gain

microwave amplifier was achieved at the end of last year. The idea is to use a low energy, high current (few MeV, 1 kA) beam through a wiggler to produce copious microwave radiation (35 GHz) via the FEL mechanism. This radiation then passes energy to a second beam by activating a high gradient structure. Such a structure has been made for the experiment (requiring Swiss watch dexterity in manufacture and assembly) and tests should be underway at Livermore soon. If all goes well, there are dreams of a 30 m prototype by the end of the decade.

---

#### *Applications of accelerators in other areas of science*

---

If the above paragraphs are already a cursory summary of the flood of information communicated at the Conference, we now move to topics where the volume of presented papers was even greater. We, therefore, take a selective look at accelerator developments in branches of science other than particle physics concentrating on synchrotron radiation sources, neutron sources, heavy ion accelerators and kaon facilities.

The explosion in the use of synchrotron radiation from electron-positron storage rings, plus wiggler and undulator additions to extend the range of the light beam characteristics, was evident in the talks of Mark Barton, Lee Teng and Michael Knotek. Barton listed 23 operating facilities (18 of them dedicated light sources) in Europe, Japan, USA and USSR. Teng added about 20 others now under construction or proposed and it was pleasing to note that some of these are in countries outside the



*The main social event took the participants out to TRIUMF on the campus of the University of British Columbia where they could tour the Laboratory and enjoy a salmon barbecue, Indian style. The weatherman decreed that this should be the one rainy day of an otherwise sunny week, which drove the barbecue indoors. Even with this complication, the excellent organization ensured a very pleasant evening.*

above usual geographic locations – Brazil, China, India and Taiwan. To give an idea of just how heavy the demand is for the use of each of these light sources, the National Synchrotron Light Source at Brookhaven operates eighteen beamlines with seventeen more planned on the X-ray ring and thirteen beamlines with eleven planned on the ultra-violet ring.

The most advanced machines are 6 GeV, very high brightness proposals in the USA (designs from Argonne, Brookhaven and Stanford) to use full energy injection into the light source storage ring after a booster synchrotron, with many long straight sections for wigglers and undulators. Such a facility was recommended by the 'Seitz-Eastman Committee on Major Facilities for Materials Research', and preparatory Workshops have been held at Ames and the National Bureau of Standards. Almost equivalent thinking is behind the design proposed for a European Synchrotron Radiation Facility (reported in a poster session by S. Tazzari). The European design has electron energy of 5 GeV with thirty straight sections (we will have an article on the ESRF in the near future). Knotek commented that the availability of such machines will bring a revolution in X-ray science equivalent to that experienced when moving from the old X-ray sources to the first light beams from electron synchrotrons.

In addition to the great impact on all areas of materials research at the present light sources, research workers in other disciplines, such as biology (where the speed at which information can be gathered allows complex structures, like proteins, viruses, and



dynamic systems to be studied), medicine (just one potential application in preventive medicine is picked out below), industrial uses (crystal studies for the semiconductor industry, lithography, microscopy, etc.) are also benefitting from access to synchrotron radiation facilities.

David Gray reported on initial operation of the Spallation Neutron Source at the Rutherford Appleton Laboratory which is taking over from the neutron sources at Argonne, Los Alamos and KEK as the most prolific source of neutrons for research. Proton accelerators bombarding uranium targets surrounded by moderators are capable of neutron fluxes far higher than those of high flux beam reactors. The research programme at Rutherford started in June, continuing to the end of the year with

proton beam energies up to 550 MeV rather than the design 800 MeV (while awaiting installation of the last two of the six r.f. accelerating cavities). There is no development on the authorization of the spallation neutron source, SNQ, proposed at Jülich in Germany.

The acceleration of heavy ions is back in the news and Nick Samios spelled out some of the reasons why. The most intriguing for particle physics is that colliding high energy heavy ions could allow access to short distances between components in the nucleons where the force acting between quarks is weak (the quark-quark binding force increases with distance). Thus heavy ion collisions could open up for study a new state of matter – the quark/gluon plasma. Energies of some 100 GeV per nucleon are probably neces-

Lee Teng, seen here touring the TRIUMF installations with his wife, gave a Conference report on the booming area of synchrotron radiation applications.



sary but the colliding ion beam luminosities need not be very high ( $10^{26}$  per  $\text{cm}^2$  per s or less).

A. Ruggiero reviewed schemes to reach such machine performance. The Bevalac at Berkeley has been the front runner in heavy ion energies for many years reaching the range of 1 GeV per nucleon for fixed target physics. They have had the ambitious VENUS project on the table since 1979 (see December 1979 issue, page 406) to reach energies of 20 GeV per nucleon in colliding beams and, in the absence of authorization, have a more modest version (the 'Mini Collider') for colliding beams at 4 GeV per nucleon in rings with 4 T superconducting magnets. Oak Ridge have a proposal for a 10 GeV per nucleon collider using ions from their operating tandem into two synchrotron/storage rings

with superferric magnets.

Brookhaven are working hard on a 100 GeV per nucleon collider known as the Relativistic Heavy Ion Collider, RHIC. Beams from the existing tandem will be transferred to the Alternating Gradient Synchrotron (the transfer line is being built and the AGS r.f. system is being modified to accept ions). Eventually a booster synchrotron would be added to allow injection of fully stripped ions. From the AGS, accelerated ions would be fed to storage rings installed in the completed tunnel which was for the CBA/ISABELLE project. (Since, for some purposes, heavy ions could extend down to protons, it has to be acknowledged that RHIC is a most imaginative way of building the CBA!) A proposal has been put forward and construction could take off in 1988 after further

R and D. The size of the user community interested in such heavy ion experiments in the USA is estimated at up to 400 scientists.

In the meantime, there are some interesting intermediate developments in Europe. At CERN, oxygen 16 ions will be accelerated through the PS and SPS and the possibility of antiproton-ion collisions has not escaped attention. For a broader programme, D. Bohme reported that authorization has recently been given for the construction of a synchrotron, SIS, to be fed by the existing UNILAC linear ion accelerator at GSI Darmstadt (see June issue, page 181). UNILAC provides ions at some 20 MeV per nucleon; SIS will take energies to 1 GeV per nucleon for uranium ions. It will be linked to an Experimental Storage Ring, ESR, which is being designed. Construction time is some four to five years (dominated by the building construction).

Kaon factory proposals were reviewed by H.A. Thiessen. The aim is to build a high intensity proton machine in the 30 to 50 GeV range to produce (amongst other beam species) a flux of kaons some hundred times higher than those available from the CERN PS and Brookhaven AGS for research in nuclear and particle physics. The Los Alamos, TRIUMF, SIN, Brookhaven and KEK Laboratories have all looked at the possibilities; the first two have developed proposals. Project preparation is most advanced at Los Alamos where the LAMPF linear accelerator would be used as injector into a booster and fast cycling synchrotron. At TRIUMF the injector would be the existing cyclotron into booster, synchrotron and storage rings. TRIUMF have obvious interest in opening up a new programme;

the existing cyclotron has been in action for a decade (in fact there will be a celebration of 'Ten Years of Scientific Research at TRIUMF on 7, 8 July). Certainly, if they build kaon factories as well as they organize Conferences they would do an impressive job!

It was intriguing that heavy ion machines and kaon factories got so much attention at the Conference – they were second and third priorities, respectively, in the recommendations for the Nuclear Physics Advisory Committee concerning the facilities most appropriate for nuclear physics research in the coming years. The first priority machine, a recirculating linac to give 4 GeV electron beams, did not figure at the Conference though preparatory work is underway at the Virginia site of the Southern Universities Research Association, SURA, under the project name of CEBAF (Continuous Electron Beam Accelerator Facility).

#### *Some applications of accelerators*

To conclude, we mention a few of the Conference topics where accelerators are used or planned, not for particle physics or other areas of scientific research, but directly in 'practical' applications.

Medical applications have been a major spin-off ever since the first X-ray machines. Now accelerators are in use for isotope production, in radiography, and in particle beam therapy. For therapy, various accelerated particles are used – heavy ions (in particular at Berkeley), protons (2600 people have been treated at the Harvard cyclotron), pions (the TRIUMF Laboratory itself has a pion radiother-

apy facility) and neutrons (for example, at Fermilab – a total of over 4000 have been treated in the USA).

Because it is so elegant, we mention in addition one recent idea for a medical application which is under investigation – heart scans using synchrotron radiation (reported by H. Wiederman). What is needed is a small (1.2 to 1.5 GeV) high intensity (1 A) light source able to provide a high flux of photons of energy 33 keV. Iodine is introduced into the bloodstream and one scan of the heart (with some  $10^8$  photons per  $\text{mm}^2$ ) is done with the photon energy just below the iodine K absorption edge and a second with the energy just above. The readings of these scans are subtracted, one from another, via computer. The only thing that changed in the two readings is the photon flux absorbed by the iodine in the bloodstream. Thus, the coronary arteries appear with remarkable clarity while the rest of the anatomy 'disappears'. Such scans could readily give advance warning of potential heart troubles and the economic values of such warnings (quite apart from the humane social value) would be great. The technique is very much faster and more pleasant for patients than the presently used techniques.

It is impossible to report on an Accelerator Conference which concentrated mostly on the work of the USA community without a few words about a proposed practical application going in the opposite direction to medical applications – the Strategic Defense Initiative, SDI, beloved of the media as 'Star Wars'. One of the mechanisms to be studied under SDI for 'zapping' alien objects is the particle beam

weapon. There were a few papers at the Conference from laboratories clearly involved in such studies which mainly reported work aimed at improving the quality of low energy particle beams. There was certainly no open information which can yet move the particle beam weapon out of the category of science fiction.

The interest in particle beams to achieve commercially viable fusion reactors via the inertial confinement technique continues and there were review papers on light ion (M. Buttram) and heavy ion (Dennis Keefe) developments. The aim is to deposit several megajoules on the surface shell of a deuterium-tritium pellet in some 10 ns requiring accelerators delivering a few terawatts. (Buttram remarked that the calculations ranged 'from the optimistic to the conservative to the realistic'.) Sandia is concentrating on producing beams of 30 MV lithium ions. A 100 TW machine called PBFA-II is scheduled for operation early next year to study beam and target behaviour under single pulse conditions. They use a high power pulse compression scheme with laser triggered spark gaps.

For heavy ions, a bank of r.f. linacs cascading ions into an Alvarez linac, followed by transfer and storage rings, remains under study in Europe and Japan. The alternative scheme using induction linacs is pursued in the USA. An induction linac, MBE-4, to demonstrate current amplification with four caesium ion beams is under construction at Berkeley.

Also related to fusion reactor technology is the Fusion Material Irradiation Test (FMIT), a 35 MeV deuteron accelerator to provide intense fluxes of neutrons of fusion



# Collision course

reaction energies. These neutron beams will be used to study the behaviour of materials subjected to the bombardment they will receive in fusion reactors. Several papers reported progress on the machine development (for example, the successful operation at Los Alamos of appropriate radio-frequency quadrupoles for the FMIT injector; it is amazing how the new technology of RFQs has swept the board in accelerator injection systems in the space of a couple of years).

This report of the Vancouver Particle Accelerator Conference will give some feeling for the range and the volume of modern accelerator physics and technology.

*By Brian Southworth*

On 10 July 1981, Carlo Rubbia burst into the Lisbon Particle Physics Conference clutching the first recordings of high energy collisions of matter and antimatter in the CERN SPS ring. His announcement, the culmination of many years of intense and careful preparation, was greeted with spontaneous applause.

More than three years later, the SPS Collider's performance has improved more than a hundred-fold, but the applause has died down. With the collection of antimatter mastered and almost routine, Lyndon Evans and Vincent Hatton review the achievements to date and the lessons learned.

The Collider's peak luminosity (a measure of the instantaneous proton-antiproton collision rate) has been pushed up by almost

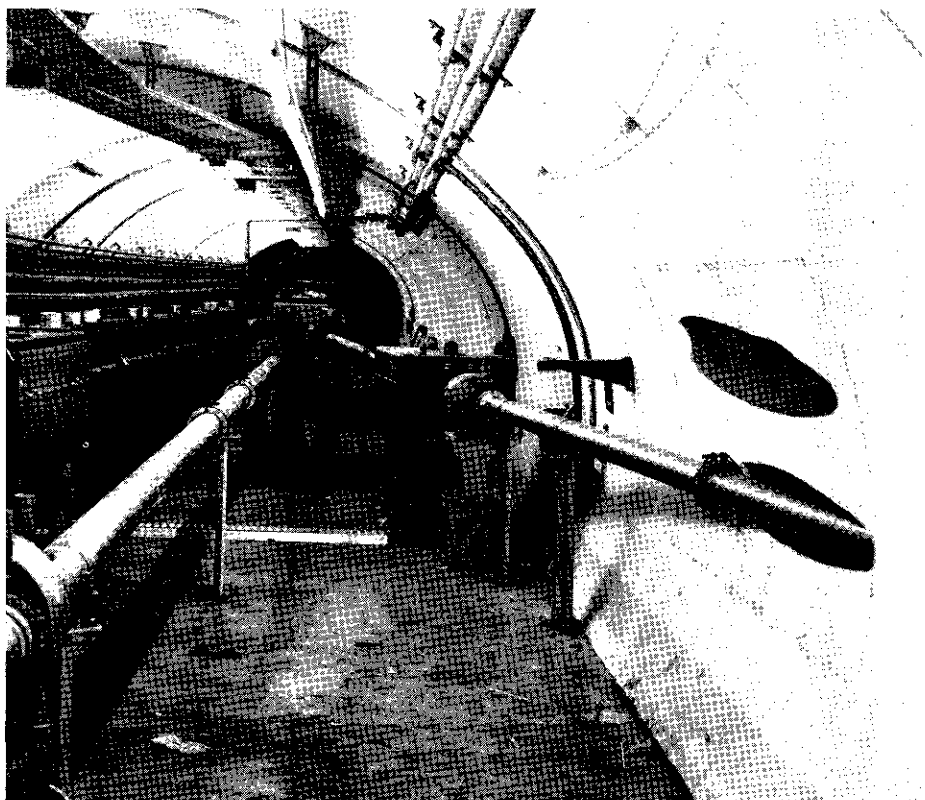
two orders of magnitude from  $5 \times 10^{27}$  per  $\text{cm}^2$  per s in 1981 to  $3.5 \times 10^{29} \text{ cm}^{-2} \text{ s}^{-1}$  in 1984. More important, the daily average performance (integrated luminosity) has increased by more than an order of magnitude.

In view of the scarcity of antiprotons, the reliability of the whole chain of injectors is of crucial importance. The SPS itself is particularly vulnerable to faults, due mainly to its large size and heavy demands on primary services.

After the first proton-antiproton collisions were recorded in the summer of 1981, the first physics run took place at the end of that year, when  $2 \times 10^{32}$  per  $\text{cm}^2$  ( $0.2 \text{ nb}^{-1}$ ) of integrated luminosity was produced. In the second run at the end of 1982 the peak luminosity was increased to  $5 \times 10^{28} \text{ cm}^{-2}$

*Emerging from the tunnel wall on the right is the beamline which feeds 26 GeV antiprotons from the PS to the CERN SPS. On the left are proton lines emerging from the SPS main ring.*

*(Photo CERN 38.4.81)*



*The control room – nerve centre of SPS operations.*

*(Photo CERN 169.6.83)*



$s^{-1}$  and a total integrated luminosity of  $28 \text{ nb}^{-1}$  was produced, enough to reveal the long-awaited W particle. In the spring of 1983 the peak luminosity was pushed up to  $1.7 \times 10^{29} \text{ cm}^{-2} \text{ s}^{-1}$  and a total of  $153 \text{ nb}^{-1}$  was produced in each of the two experiments. Finally in the latest big run (end 1984) the peak luminosity was further increased to  $3.5 \times 10^{29} \text{ cm}^{-2} \text{ s}^{-1}$  and a total of  $395 \text{ nb}^{-1}$  was produced in each experiment.

These runs used continuously stored (d.c.) beams, first at a collision energy of 540 GeV, then in 1984 at 630 GeV. This year (see May issue, page 131), a new technique was used in which the collision energy attained 900 GeV for brief periods.

The steady improvement in Collider performance reflects a gradual mastering of a complex chain

of accelerators. At least three days of stacking of antiprotons in the antiproton accumulator (AA) is required before making the first transfer to the SPS with an initial luminosity in excess of  $10^{29} \text{ cm}^{-2} \text{ s}^{-1}$ . Once the initial stack is established, equilibrium is reached where approximately 30 per cent of the stack is transferred to the SPS in three bunches. As long as the SPS can hold the beams for of the order of 20 hours, the AA then has time to replenish the stack ready for the next transfer.

The security of the transfer sequence is improved by using software. The nucleus is a high level job manager called the 'sequencer'. This controls the complex series of operations needed to prepare the SPS and its transfer lines and to control the antiproton injection process. It can abort the

transfer up to the very last moment if a fault is detected. Such elaborate software control is more reminiscent of a rocket launch than an accelerator operation.

In the first three years of operation, useful luminosity could be maintained for some 15 hours, being limited mainly by the antiproton beam lifetime. This is well suited to the cadence of one antiproton transfer per day. If the coast is terminated manually the SPS is prepared for the next injection as quickly as possible. Generally three or four hours are necessary to follow fully all the procedures, retune the machine, check the beamlines with protons, inject antiproton pilot pulses, etc. However, as will be shown later, at least one third of the coasts are terminated prematurely. In these cases it is often unattractive to

Erwin Gabathuler (CERN Research Director at the time, second from left) had promised a crate of champagne if the maximum proton-antiproton collision luminosity achieved in the SPS during the initial operations in 1981 could be increased tenfold in the 1982 run. Enjoying his generous offer with him are (left to right) André Faugier, Lyndon Evans (one of the authors of this article), Jacques Gareyte and Robin Lauckner. Luminosity has since been boosted considerably and more champagne has appeared from time to time.

(Photo CERN 209.11.82)



## Hitting a barn

*Integrated luminosity is a way of gauging the total number of collisions over a period of time. An area is imagined to surround an antiproton, say, and one asks how many times a proton went through this area. The nanobarn, the area commonly used in particle physics is tiny –  $10^{-33} \text{ cm}^2$ .*

*A 'barn' ( $10^{-24} \text{ cm}^2$ ) is the target area offered by big nuclei like uranium, and even in the old days of nuclear physics, hitting these giant nuclei was 'as easy as hitting a barn'. The name stuck.*

prepare quickly for a new fill since time is needed for the accumulator to replenish its stack.

There has also been a gradual increase in the percentage of time available for experimental physics compared to the total scheduled operating hours.

Other than providing beams for the experiments, there are four other time-consuming tasks: setting up for coasts, machine studies, access, mainly for the experiments, and fault diagnosis and equipment repair.

The efficiency of the Collider is judged by the experimental teams on the combined basis of total hours of colliding beam and luminosity. Thus the figure which really counts is the integrated luminosity. Its increase by a factor of 2.6 from 1983 to 1984 was more significant than the increase

in duty factor from 43 per cent to 50 per cent.

In the early stages of an experiment there is little demand for peak luminosity performance and it is the total number of hours with collisions which is important. This is also the case at the beginning of a new period of operation, and there are also demands for low luminosity calibration runs. The time requested for calibration and setting up runs in any year however is small, less than 10 per cent of the total scheduled time.

The average time for setting up in preparation for a fill is nearly six hours. This reflects the dependence on the number of antiprotons available in the accumulator rather than any inefficiency in the preparation. The time between fills is particularly long following the loss of a stack

due to a technical failure.

Access requests are grouped together and scheduled as much as possible in advance since full use has to be made of these relatively rare occasions. It is not unusual to have 30 people entering the UA1 zone for a four-hour access period. Shorter accesses between fills are also catered for.

Access for accelerator repairs is combined with access to experiments. Much of the power supply testing and improvement was done during access to the experimental zones.

Machine studies require a variety of beam conditions. In addition to studies on the end of a physics coast, time needs to be set aside for proton-only coasts and collisions with pilot (low intensity) antiprotons. Both these uses of scheduled time are neces-



sary for the efficient operation and development of the accelerator and the experiments and should not be considered as counterproductive.

Of the 77 coasts in the 13-week 1984 run, 25 were terminated prematurely due to technical failures. For the rest the average store duration was 17 hours. The 1984 record was 31 hours and the all-time record is 42 hours.

If a coast lasts longer than seven hours, the chances are it would be 'killed' by the crew at the end of its useful life.

The coast ceases to be useful for physics after the luminosity has fallen. The useful luminosity lifetime for most of 1983 and 1984 was less than 20 hours, typically between 13 and 15 hours. Of course any decision is dependent upon another fill being available. If there were problems with the proton/antiproton supplies, the coast was kept longer, hence the occasional exceptionally long coasts. At the end of the coast for physics, machine studies would frequently occupy another two hours.

There was a tendency to favour a 24-hour cycle of filling. Equipment that is used only during the transfer, injection and acceleration process can only be tested out of coast mode; it is more efficient to uncover problems during the normal working hours of the laboratory.

As the useful luminosity lifetime increased from 20 to about 26 hours and equipment reliability improved, the 24-hour cycle was abandoned in favour of increased coast time and higher integrated luminosity.

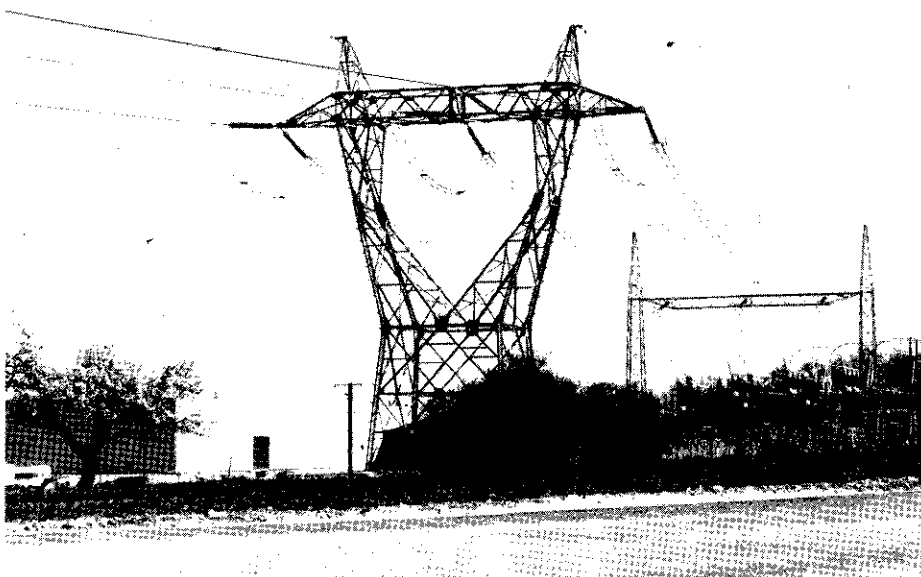
In 1983 and 1984, the majority of technical faults were caused by

random failures, mostly minor and unrelated. During fixed target operation (53 per cent of total scheduled time per year for physics) faults are analysed and repaired with the more stringent collider operation in mind.

Voltage dips on the mains supply (on an overhead line directly from a hydroelectric source at Genissiat, 50 km from CERN) contributed about 30 per cent of the technical failures in 1982 and 1983. In the latter part of the 1983 run and for the 1984 period, the system was desensitized to stand dips of up to 25 per cent on any of the three phases before the power supplies tripped. The SPS Collider never operates during the summer months. Evening thunderstorms are common in July and August and have caused serious perturbations even for fixed

*The most important single external perturbation at the SPS is voltage fluctuation on the main 380 kV overhead feeder lines, which are especially vulnerable during summer thunderstorms.*

*(Photo CERN 126.5.75)*



target operation.

For the increase from 273 to 315 GeV coasting energy in 1984, one modification was the installation of booster water pumps in all sextants of the ring. The upgrade was very successful, but two coasts were lost. Diagnosis and effective elimination of the fault can be hampered by human errors owing to the lack of familiarity with such new conditions. Striking a balance between reliable operation and the need to improve running conditions is a constant dilemma.

Care must be taken that all magnets acting on the primary beams are engineered to the same high standard as the accelerator components. Some coasts have been lost because detector magnets have failed to respond correctly (the necessary balance

---

between the magnet and its compensator magnets has sometimes not been observed).

---

### *Beam quality*

---

The SPS Collider's operation is restricted by the availability of antiprotons. The required degree of reliability of its equipment must be higher and loss of stored beam is more serious than in the case of a proton-proton collider.

But all colliding beam machines have to provide stable conditions with low backgrounds over long periods of time. This is beam quality.

Good operation needs good diagnostics. In the case of the Collider, the measurements of beam parameters and confidence in the results is of paramount importance. In fact the performance improvement has been closely correlated with the development of improved diagnostics. Uncertainty caused by a doubtful measurement can hinder an investigation, preventing a logical diagnosis. Without reliable measurements, problems of high background, for example, cannot be traced to a movement in the closed orbit due to magnet drifts or distinguished from a problem with the beam scraping system.

One high background problem was finally traced to a noisy linear potentiometer which controlled the position of a collimator block; once identified the problem was quickly solved, but many hours were spent following false trails.

Important in the search for improved beam quality is for the control system to accommodate flexible operation. New ideas and newly identified sources of diffi-

culty must be included in the software so that the human element can be minimized. Once an operational procedure is established it should never be overlooked and this logically means converting it into software.

For good beam quality and diagnostics it is important to have good databanks not only of the equipment parameters but also of the beam characteristics. Being able to study the evolution of a parameter over a number of shots is very important and encourages lateral thinking.

As in any other storage ring the operation of the SPS as a proton-antiproton collider imposes severe demands on equipment reliability. The scarcity of antiprotons in particular excludes fast refilling after equipment failure and makes the impact of such faults on the overall productivity particularly dramatic.

The Collider is particularly vulnerable to fluctuations in the primary services. The most important single perturbation outside the control of the SPS team is voltage fluctuation on the main 380 kV supply. This problem is accentuated by the long exposed overhead feeder lines to CERN, and excludes colliding beam operation in periods of thunderstorm activity (most of the summer).

The average time of 5.9 hours needed to refill the machine is mainly determined by the number of antiprotons available in the accumulator. Nevertheless, the achievement of the best possible beam quality, transfer efficiency, emittance, etc. requires a very careful, systematic setting-up for each fill, needing at least two or three hours.

While the performance improvements achieved so far at the SPS Collider are impressive, the ingenuity and resourcefulness of the operating teams is far from exhausted. We can hope to see many more antiproton milestones in the years to come.

# A quarter of a century against the clock

*25th anniversary time. Derek Lowenstein (left), chairman of Brookhaven's Alternating Gradient Synchrotron (AGS) Department, presents a backwards-running clock to Ernest Courant, one of the pioneers of the AGS, which produced its first counter-clockwise protons 25 years ago.*

Twenty-five years ago, on 17 May 1960, the gleaming new Alternating Gradient Synchrotron (AGS) at the Brookhaven National Laboratory, New York, got its first taste of protons. But it took a few more months to prepare the radiofrequency system which transformed the new ring from a toy into the most powerful particle accelerator in the world. On 29 July 1960, protons were whipped through the dreaded phase transition and accelerated to the 30 GeV design energy. The AGS had wrested the high energy crown from CERN's new Proton Synchrotron, which had achieved 24 GeV just five months previously.

The AGS was the first proton accelerator project to incorporate from the start the revolutionary idea of strong focusing. In 1952, Brookhaven's Cosmotron, an old-style weak focusing machine, had supplied its first 3 GeV protons – the first time the 1 GeV barrier had been breached. The same year, a group of European machine specialists (Edouard Regenstein, Frank Goward, Odd Dahl and Rolf Wideroe) from the infant CERN came out to see what was happening. They were toying with the idea of building a scaled-up version of the Cosmotron as the first big machine for their new Laboratory.

Cyclotron pioneer Stan Livingston organized a study group to consider what advice Brookhaven could give the Europeans. During the deliberations, Livingston had a brainwave. The Cosmotron magnets all faced outwards, making it easy to extract negatively charged particles from a target in the machine, but not positive ones. Livingston's idea was to have some magnets facing in-



ward, some outward.

The initial idea was just to get easier access to positive beams, but soon bigger payoffs became evident. Collaborator Ernest Courant found that rather than damaging the proton orbits, the new idea seemed to improve the focusing. Hartland Snyder recognized an analogy with optics, where alternate focusing and defocusing lenses of equal strengths are focusing, no matter which comes first. With the stronger focusing, magnet apertures could be cut from the 8 × 24 inches of the Cosmotron down to matchbox size.

(Unknown to the Brookhaven team, this idea had already been developed by a Greek lift engineer called Nick Christofilos whose hobby was particle accelerators and who read the Physical Review

in the American Library in Athens. On a trip to the US in 1952, he saw the classic strong focusing paper by Courant, Livingston and Snyder, and went along to Brookhaven to tell them he had done it all before. John Blewett (also part of Livingston's study group) writes 'at first we thought he was a phony but gradually facts emerged to support his claim. We changed our minds and offered him a job, which he accepted.'

The CERN team, which had unwittingly breathed hard enough down Brookhaven's neck to make Livingston and Co. come out with something special, hurriedly changed the design of their new machine in midstream. At Brookhaven, Leland Haworth persuaded the US Atomic Energy Commission, very concerned with secret work in those days, to let Brook-



haven publish the new ideas, and a modest six-page letter proposed the building of the machine which was to become the AGS. (At Cornell, the strong focusing technique was immediately incorporated into a new electron synchrotron which began operations in 1954.) The CERN team, under the direction of the late John Adams, went on to get their proton act together faster than Brookhaven.

After the suspense of the construction race, the AGS and the CERN PS machine embarked on their separate careers. There the story was different. At the AGS in 1962, a team led by Mel Schwartz, Leon Lederman and Jack Steinberger discovered that there were two types of neutrino. In 1963, James Cronin and Val Fitch made the AGS beams reveal the mys-

tery of CP-violation – the cunning way the neutral kaons break the rules of conventional physics. In the same year, an AGS experiment led by Nick Samios spotted the omega-minus particle, and a new way of looking at physics suddenly clicked into place.

Thanks to these and other discoveries in the 1960s, Brookhaven took over from Berkeley as the world's premier particle physics Laboratory. As if to confirm that the initial bumper crop of results was no flash in the pan, a 1974 experiment led by Sam Ting at a more mature AGS discovered the

*Pioneers of the AGS Brookhaven Alternating Gradient Synchrotron alongside an early scale model which showed the great reduction in AGS magnet aperture compared to that of the Brookhaven Cosmotron thanks to the invention of the alternating gradient focusing system. From left to right are a youthful Ernest Courant, Stanley Livingston, Hartland Snyder and John Blewett.*

J/psi particle and opened the door to charm and more new physics. (The J/psi was simultaneously discovered by Burt Richter at Stanford.)

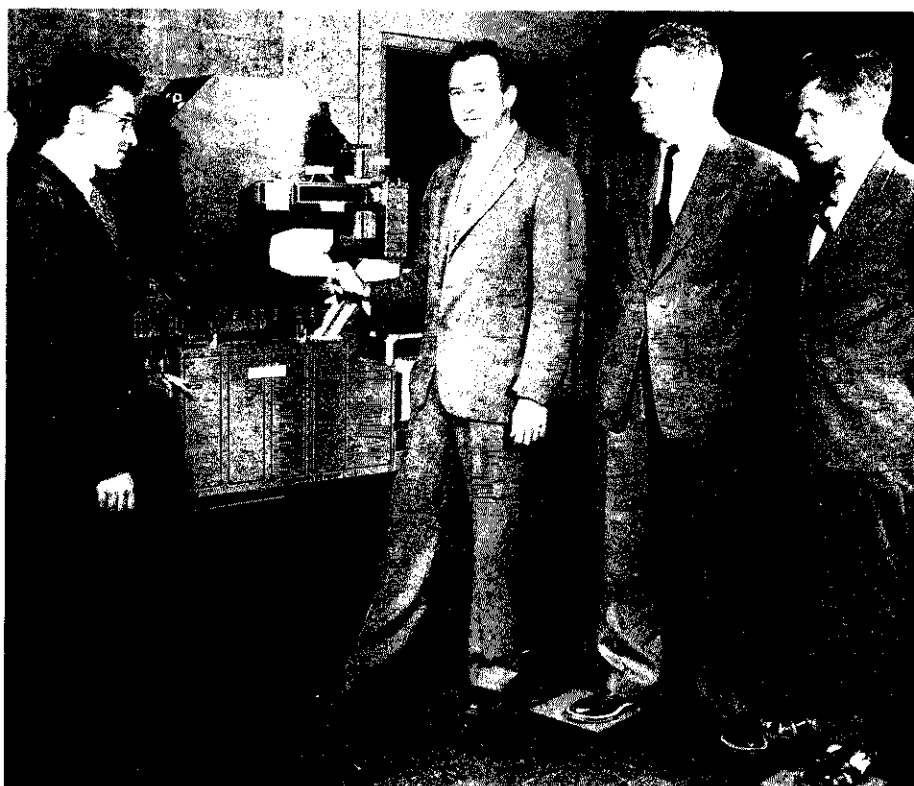
Against this impressive list of achievements, the CERN PS had only one of similar stature – the sighting in 1973 of the neutral current of the weak interaction. But by then the PS had embarked on a new career, supplying protons to the big SPS machine built alongside.

Towards the end of the 1970s, ambitious plans were again being formulated at Brookhaven and CERN. At Brookhaven, the AGS would feed the big ISABELLE proton-proton collider. At CERN, the SPS was already operating with particles from the PS. The plan was to adapt the SPS to work as a proton-antiproton collider as well as a proton accelerator. While ISABELLE foundered, the CERN project went from success to success, achieving in its first years of operation the heady achievements which had been the privilege of the AGS physicists in the early sixties.

However the spirit of the AGS physics teams remains indomitable. After 25 years, the machine's physics potential is far from exhausted, and a whole list of improvements is being pushed (see next story).

## Plans for the future

Brookhaven is committed to the continuation of its robust high energy physics programme and to the initiation of a comprehensive fixed target and colliding beam programme for high energy (relativistic) heavy ions. These initia-



tives result from the work of the AGS II Task Force (see June 1984 issue, page 194) and other committees.

The immediate particle physics plans centre on improvements to the 25-year old AGS – raising proton beam intensities up to  $5 \times 10^{13}$  particles per pulse, reliabilities from 75 to 95 per cent, and beam duty factors from 25 to 45 per cent; building a new booster injector; improving beamlines and detectors, and capitalizing on the spin physics capabilities which opened last year (see October 1984 issue, page 328).

After this, a stretcher ring is envisaged to increase duty factors to 90 per cent or more, and power supply and radiofrequency improvements to push intensities up towards  $10^{14}$  protons per pulse, together with further beamline

and detector upgrades.

The other string to Brookhaven's bow is heavy ions. Last year, work got underway to allow heavy ions to be transferred from the 16 MV tandem Van de Graaff to the AGS (see December 1984 issue, page 433). As well as the new transfer beamline, this requires modifications to existing beamlines and detectors, as well as to the AGS itself. Ten weeks of heavy ion running per year are foreseen.

Subsequently, the new AGS booster could be adapted for heavy ion work, while further modifications could allow a wider range of heavy ions (up to atomic mass 200) to be handled.

For the 1990s, the big Relativistic Heavy Ion Collider (RHIC) could be constructed in the tunnel originally made for the defunct ISA-

BELLE project. As well as building the RHIC itself, the AGS would have to be adapted for its new role as the RHIC injector.

However the particle physics content of the AGS programme is seen as continuing 'far beyond' the planned advent of the RHIC. The AGS is the world's richest source of kaons, and a programme of kaon physics would include looking for rare decays to test current ideas. Investigations of CP (charge conjugation/parity) violation, seen only in the neutral kaon system, are vital if this long-standing physics mystery is to be finally understood.

Other AGS particle physics objectives include the neutrino sector, where question marks still loom as large as ever, spectroscopy in the 1 - 3 GeV region, where important new information could yet be obtained, and the study of hypernuclei (nuclei with one or more nucleons replaced by heavier particles) to provide an additional lever on particle interactions. With polarized beams available in the AGS, the whole gamut of spin physics opens up. In addition, a new muon storage ring could be built to make even more precise measurements of the anomalous magnetic moment of the muon (see September 1984 issue, page 274).



*Well-wishers crowd the experimental area at the AGS 25th anniversary party.*

*(Photos Brookhaven)*

# Around the Laboratories

*The UA2 experiment at CERN's proton-antiproton Collider – big companion for a series of smaller studies.*

*(Photo CERN 84.9.81)*

## CERN Two more Collider experiments

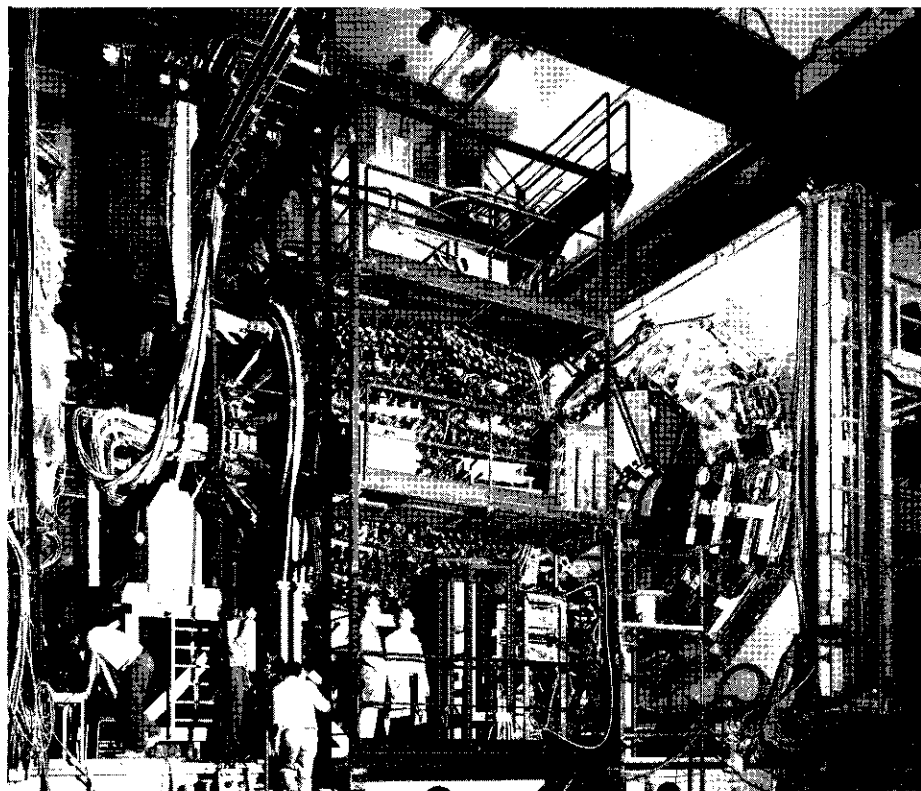
The unique physics conditions provided by the SPS proton-antiproton Collider (see also page 229) are explored by experiments mounted in the two large underground areas where the beams of protons and antiprotons are brought together.

In one underground site sits the mighty UA1 detector, described as the most complicated piece of electronics in the world. The other is the home of the UA2 detector which complemented UA1 in the famous hunt for the W and Z particles (see November 1983 issue, page 370). In this second underground area, UA2 alternates with the UA5 visual detector which provides a fast survey of new collision conditions (see May issue, page 131).

(The UA6 experiment at the Collider works in a different way, providing its own protons in the form of a jet of hydrogen gas which squirts across the path of the circulating antiprotons – see April issue, page 102.)

In the same underground area as the large UA2 apparatus is another experiment – UA4 (Amsterdam/CERN/Genoa/Naples/Pisa) – which studies elastic scattering, when the colliding protons and antiprotons 'bounce' off each other like billiard balls (see October 1984 issue, page 336).

Its initial aims accomplished, UA4 will serve as a springboard for UA7 – a brief new study this fall by a Naples/Japan group of neutral pions produced along the collision axis. The UA7 team will



install silicon/lead sandwich detectors in UA4's 'Roman Pots' to detect the photons coming from the decay of neutral pions which emerge from the proton-antiproton collisions close to the collision axis.

UA1 and UA5 have revealed interesting suggestions of new behaviour in the numbers of charged particles emerging from the collisions. These suggestions are interpreted by some as hints of the onset at SPS Collider energies of a long-awaited change of phase when matter containing particles 'boils', producing matter containing quarks and gluons (see, for example, the article by W. Willis in the January/February 1982 issue, page 179). Clues have been seen with particles coming off at large angles to the collision axis, and it is important to check if

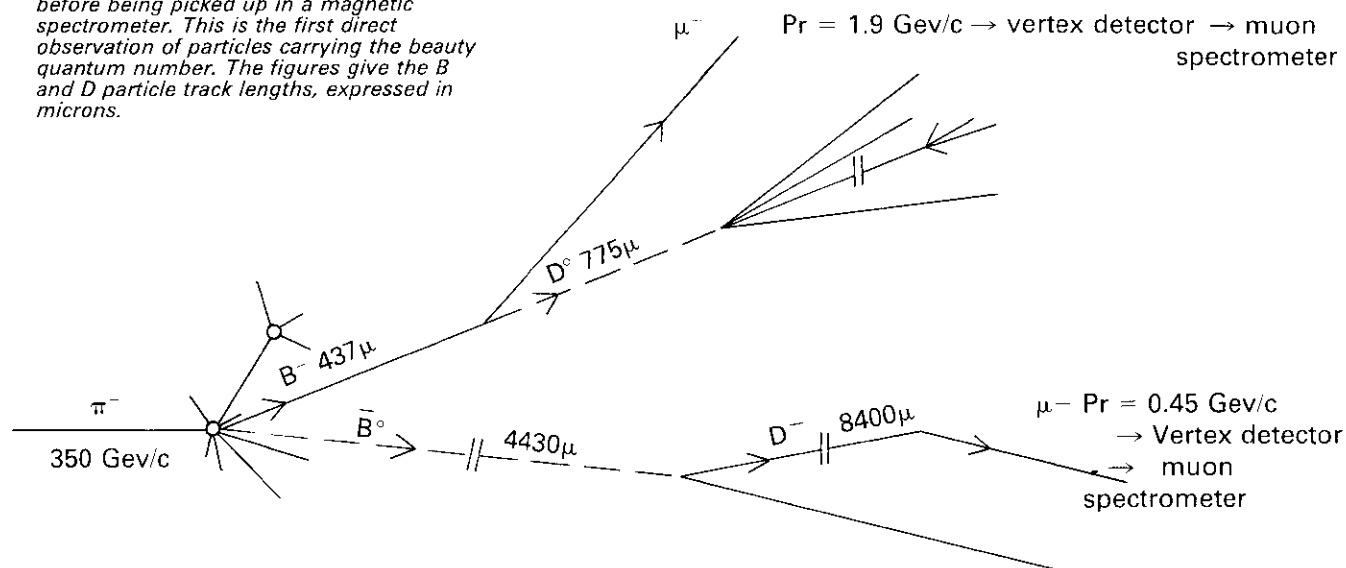
the same behaviour also occurs at small angles.

After UA7 completes its running this year, a new experiment, UA8, by a Los Angeles (UCLA) group will install a new 'mini-drift' wire chamber system in the Roman pots vacated by UA7. The UA8 team will look at the special 'diffractive' reactions which produce a fast forward proton (or antiproton) together with large transverse energy which may be in the form of 'jets'. The fast forward particle will be detected in the wire chamber system, as was done by UA4, while the transverse energy will be picked up by courtesy of UA2's large detector.

The fast forward particle most likely contains the three valence quarks (antiquarks) of the beam proton (antiproton). Therefore, the particles with transverse energy



*Beauty! Production and decay in an emulsion stack of two beauty particles,  $B^-$  and  $\bar{B}^0$ , each decaying in turn into charm particles ( $D^0$  and  $D^-$ ). The decay products are studied in a fine grain silicon microstrip vertex detector and the characteristic muons pass through 2 m of iron shielding before being picked up in a magnetic spectrometer. This is the first direct observation of particles carrying the beauty quantum number. The figures give the  $B$  and  $D$  particle track lengths, expressed in microns.*



would be produced in a 'collision' between the antiproton (proton) and what remains after the valence quarks (antiquarks) continue on their way. This remainder probably contains the so-called 'Pomeron', long believed to be the mediator of high energy elastic and diffractive interactions. (The name acknowledges Soviet physicist Y. Pomeranchuk who developed important theorems on high energy scattering.)

By studying the structure of such events at the very high energies available at the SPS Collider, the UA8 experimenters hope to open up the substructure of the mysterious Pomeron.

Appearance of electrons would signal production of heavy quark flavours (charm, beauty, etc.) in these diffractive interactions.

To efficiently select high mass diffractive events at the high collision rates which will eventually be provided by the ACOL antiproton collector now under construction, the momentum of the fast forward particle will be calculated between bunch crossings by new fast electronics.

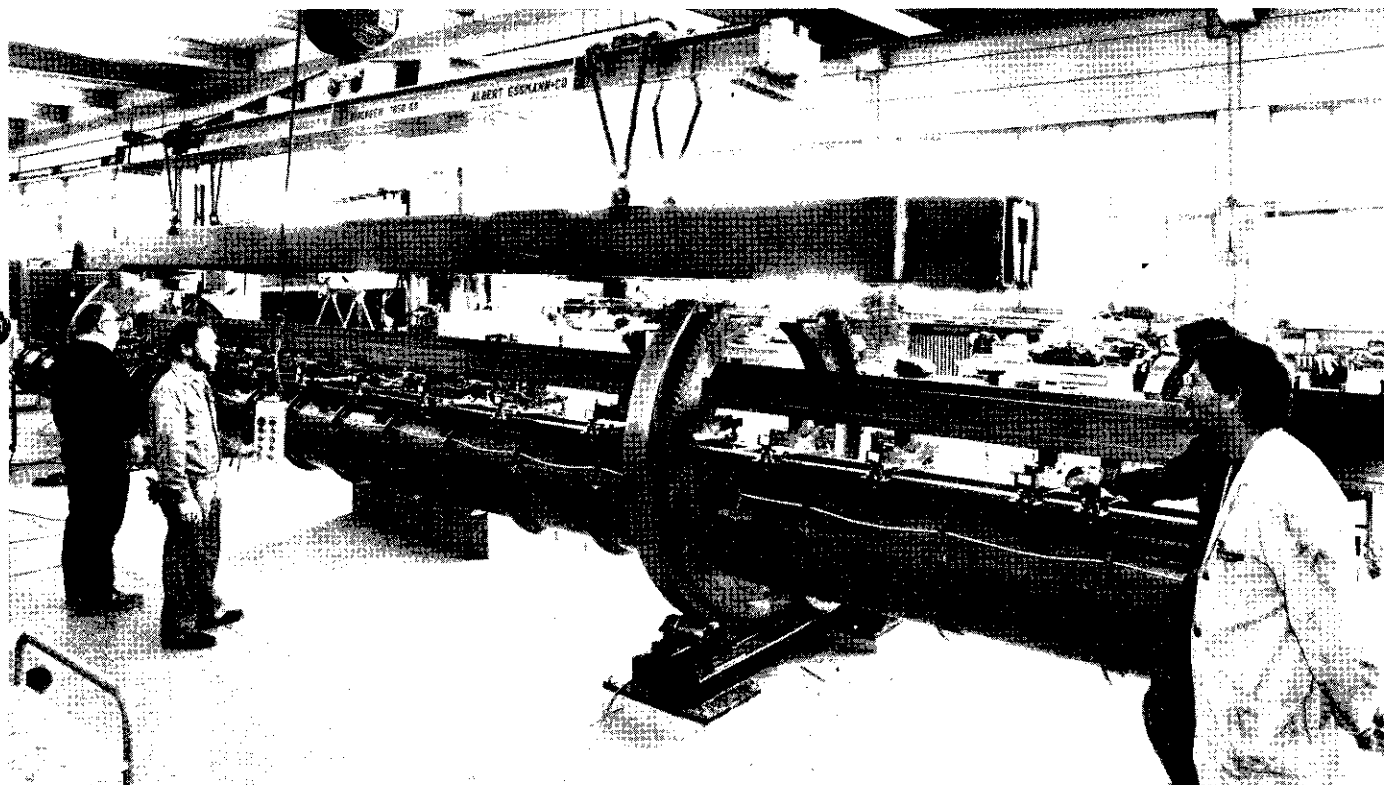
## A Beauty unveiled

*The WA75 Collaboration at CERN (Bari – Birkbeck and University Colleges London – Brussels – CERN – U.C. Dublin – Japanese Universities Groups – Rome – Turin) recently observed the decay of a pair of beauty particles ( $B$ ) both decaying into charm particles in a hybrid electronics-emulsion experiment. This is the first direct observation of such decays. Indirect observations were made previously in electron-positron rings at Stanford, Cornell and DESY-Hamburg. In the WA75 experiment, events are selected by a muon spectrometer with multiwire chambers and drift chambers placed around a big magnet. The events are studied in a vertex detector, made of 10 planes of silicon microstrips from 50 to 200 microns pitch and of multiwire proportional chambers, placed behind the emulsion target. A beam hodoscope composed of 6 planes of silicon microstrip locates the interaction in the emulsion stack to search for decays with a precision of 20 microns.*

*The event found is particularly significant since the 4 vertices of beauty and charm particles, as well as 2 like-sign muons, are observed. The calculated background for such a configuration is quite negligible. One high transverse momentum (1.9 GeV) muon is associated with the decay of one beauty particle. The other muon (transverse momentum 0.45 GeV) is associated with the decay of a charm particle. The lifetimes of the beauty particles are somewhat shorter than the average measured in previous indirect measurements ( $0.8 \times 10^{-13}$ s for the negative and  $5 \times 10^{-13}$ s for the neutral  $B$ ). Longer lifetimes have been making physicists feel less confident about their 'standard model'. As well as WA75, other CERN experiments are continuing the search for more explicit examples of beauty.*

*The first of the 416 9 metre-long bending magnets for the 30 GeV electron ring of the HERA electron-proton collider being assembled at the German DESY Laboratory.*

*(Photo DESY)*



## DESY HERA's electron ring

Work started in May on the tunnel for the new HERA electron-proton collider (see June issue, page 179), and just as soon as each tunnel section is complete, installation will start of components for the 30 GeV electron storage ring. Work for the 820 GeV proton ring will get underway later.

Work on electron ring components is thus well advanced. First deliveries of the 496 quadrupole magnets and 632 sextupoles should arrive at DESY in September and October respectively.

While the first 9 metre-long coil for the 'hybrid' superconducting magnets for the proton ring was being prepared for its cryostat at Brown Boveri, the first of the 416

9-metre bending magnets for the electron ring was assembled at DESY. These magnets will supply a field of 0.1849 Tesla, fed by a single aluminium conductor 10 cm square, running all round the 6.4 km ring. The bending magnets will be included in 12-metre modules, including also a quadrupole, one or two sextupoles and the correction magnets, all on a single support.

## CORNELL Multi-bunch operation

At its peak energy, the luminosity (collision rate) of an electron-positron storage ring is limited by the current which can be stored using the available radiofrequency power. Below the peak energy,

performance is limited by the beam-beam interaction in the ring.

The CESR ring at Cornell was designed for 8 GeV beam energy, but the physics programme has concentrated on the 5 GeV/beam region, with its rich upsilon physics. To overcome the limit imposed by beam-beam interaction, more bunches of colliding particles can be stored, which boosts the luminosity provided extra collision points can be avoided. Electrostatic separator elements are ideal for this purpose.

Multiple bunch running was implemented in CESR during the summer of 1983, and became standard practice from October of that year. Beams are electrostatically separated in the horizontal plane on either side of the interaction region. The

Plan view (not to scale) of multi-bunch operation as used in the CESR electron-positron collider at Cornell. Approximate bunch-encounter locations are indicated (solid bunches), with subsequent encounters at alternate points shown dotted. At the two interaction points for experiments (IP), the orbits coincide.

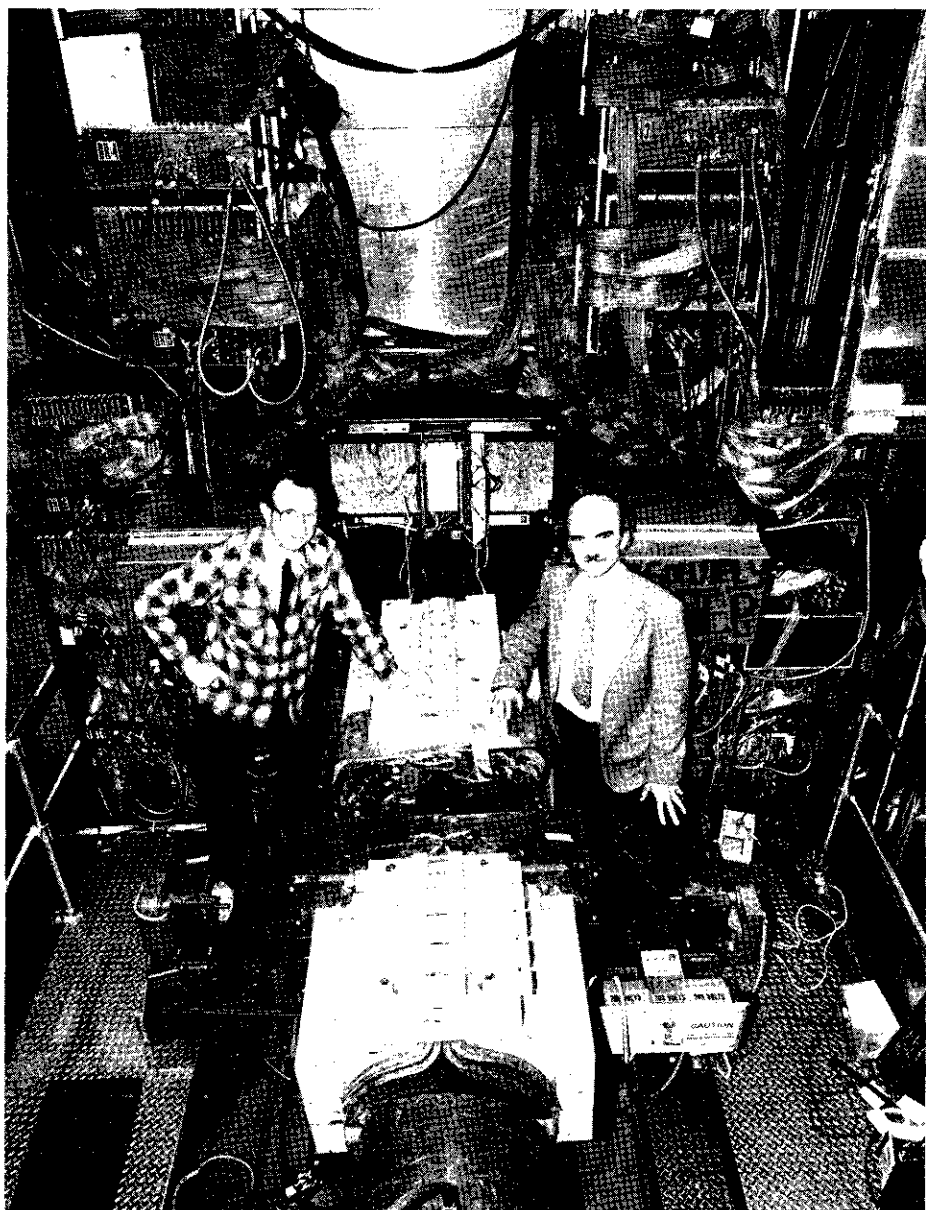
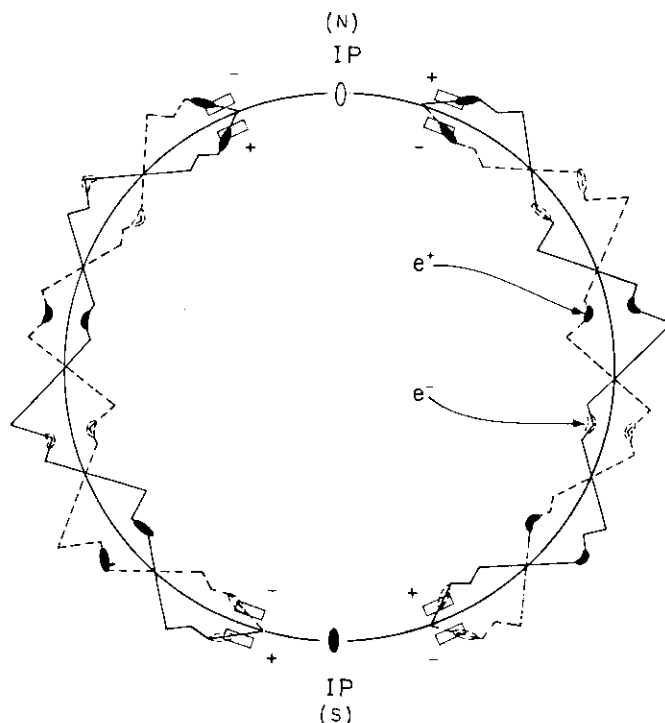
resultant 'pretzels' are phased so that the unwanted collisions coincide with maximum separation.

With CESR, it is possible to run with up to seven bunches. During the first week of seven-bunch running at the end of last year, peak luminosities attained  $3.6 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$  per interaction region and integrated luminosities of 1.4 inverse picobarns per day were recorded. This required total beam currents above 160 mA, calling for significantly more r.f. power and leading to increased higher order mode heating.

In early January, the demands of such currents on the r.f. system resulted in the failure of the cavity main power window. Although seven-bunch running has been temporarily halted pending improvements to the window, attaining such performance levels so quickly bodes well.

During 18 months of multiple bunch running, initially with three bunches and then with the maximum seven, the major limitations have been identified. These come from accelerator optics and the effects of field errors, the r.f. cavity problems mentioned previously, and new demands on the detectors.

In seven bunch running, the CLEO and CUSB detectors in the CESR ring have had to learn to trigger on bunch crossings only 365 nanoseconds apart. To handle this, new electronics have been designed and installed. In addition, the higher stored current has generally led to larger



Boyce McDaniel (left) and Karl Berkelman at the West pole of the CLEO experiment in the CESR ring. On 1 July, Berkelman took over from McDaniel as Director of Cornell's Newman Laboratory of Nuclear Studies.



# People and things

backgrounds from synchrotron radiation and degraded beam particles. After careful study, these backgrounds have been minimized by judiciously placed masks.

Looking further ahead, other improvement projects should push the luminosity to twice its present multi-bunch level. The first is to modify the injection system to provide more reliable injection. The second is to install rare-earth/cobalt permanent quadrupole magnets close to the interaction points to squeeze the colliding beams closer together. These projects should be completed in time for the arrival of the CLEO II detector (see April issue, page 106).

## Change at the top

Boyce McDaniel stepped down as Director of Cornell's Floyd R. Newman Laboratory of Nuclear Studies on 1 July. His 18 year period as Director included both the 12 GeV electron synchrotron and the CESR electron-positron collider. While on leave from Cornell in 1972, he served as head of the Accelerator Division at Fermilab during the commissioning of the (then) 400 GeV accelerator. McDaniel is a member of ICFA (International Committee for Future Accelerators), and is chairman of the Board of Overseers for the US Superconducting Super Collider (SSC) project. He continues as Cornell Professor of Physics.

New Cornell director is physicist Karl Berkelman.

## Future of CERN

Under the chairmanship of Carlo Rubbia, a 'Working Group on the Scientific and Technological Long-term Future of CERN' has been set up 'to explore various options for the long-term future of CERN, taking into account existing facilities (infrastructures), emphasizing respective pros and cons; in working out these options, realistic boundary conditions concerning financial and manpower limitations should be taken into account.' Members of the Group are Giorgio Brianti (CERN), Pierre Darriulat (CERN), Gösta Ekspong (Stockholm), Carlo Rubbia (Chairman), Abdus Salam (London and Trieste), Samuel C. Ting (MIT), Simon van der Meer (CERN), and Gus Voss (DESY). ECFA Chairman J. Sacton will attend the meetings of the Group as an observer. The first meeting took place on 5 June.



Carlo Rubbia – looking at the long-term future of CERN.

## Heavy neutrino?

A big question mark still looms over the mass of the neutrino. Is this particle truly massless, moving at the speed of light, or has it some small mass? For some time, bench-top experiments in Moscow and elsewhere studying beta decay have been suggesting that the electron-type neutrino weighs somewhere in the region from 20 to 45 eV.

One sensitive test for neutrino mass effects is the shape of the electron emission spectrum measured in beta decay. The detailed shape of the spectrum at the high energy end is governed by the mass of the electron-type neutrino. In a recently published result, John Simpson of the University of Guelph, Ontario, Canada, reports instead a distortion at the low energy end of the beta decay spectrum of tritium. Simpson, who has been studying tritium decay for four years, interprets this as being due to a heavy (17.1 keV) neutrino.

Such a mass, although very light compared to other particles (the lightweight electron is 511 keV), is unparalleled in neutrino circles, and will be sure to set the theorists thinking.

---

#### *Constant Tièche*

*Constant Tièche, retired head of CERN Finance and architect of much of CERN's financial administration, died on 27 May.*

---

#### *Mervyn Hine retires*

*Mervyn Hine, one of CERN's founder members, retired at the end of May. He came to the Laboratory, together with the late John Adams, in 1953 and played a leading role in the design, construction and commissioning of the 28 GeV Proton Synchrotron.*

*On completion of the machine, he began a ten-year period of major responsibility in the CERN hierarchy working with Directors General Adams, Weisskopf, Gregory and Jentschke. Viki Weisskopf, in particular, paid tribute to Hine as being the powerhouse behind the work of the CERN management at that time.*

*He has contributed to accelerator development, to project presentations, to establishing financial procedures and to promoting developments in the Laboratory infrastructure (like the use of big computers, networks, high speed data links and office automation). His thinking and his forward vision have helped CERN to be ready when 'the future' arrived.*

*Mervyn Hine is one of the pioneers who created CERN and who helped forge its particular character from which the Laboratory is now reaping the benefit.*

---

*Mervyn Hine*

---

#### *ATLAS at Argonne*

*ATLAS, short for Argonne Tandem Linear Accelerator System and the world's first superconducting heavy ion accelerator, was dedicated at the US Argonne National Laboratory on 3 June.*

*The new linac boosts the energies of particles emerging from a tandem Van de Graaff and provides a useful extension to the range of nuclear physics studies at Argonne. Similar machines are under construction at Florida State and Kansas State Universities.*

---

#### *French Academy of Sciences*

*Detector specialist Georges Charpak of CERN was recently elected a member of the prestigious French Academy of Sciences.*



*Georges Charpak*



The nuclear physics section of NIKHEF, the Netherlands' National Institute for Nuclear and High-Energy Physics, has openings in the PIMU group for

## TWO EXPERIMENTAL PHYSICISTS

at the postdoc level, who are interested to participate in the research of the group on pion absorption in nuclei and on pion charge exchange in pionic atoms. The experiments are performed at the pion/muon facility in Amsterdam and in some cases abroad.

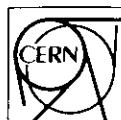
Several years of research experience in nuclear or (intermediate energy) particle physics are required, while a strong background in particle detection techniques and/or data processing (hardware/software) is desirable.

The duration of one contract is two years. For the other one it is one year with a possibility of one year prolongation. The appointment will be with the Foundation for Fundamental Research on Matter (FOM).

Information can be obtained from Dr. R. van Dantzig, tel. (020) 5920120 or 5922008.

Candidates are invited to apply within two weeks after appearance of this advertisement, while enclosing a curriculum vitae, also mentioning performed research and names of referees, to

**Prof. Dr. G. van Middelkoop,**  
Scientific Director of NIKHEF,  
section K, Postbox 41882,  
1009 DB Amsterdam, Netherlands.



European Organization for Nuclear Research  
European Laboratory for Particle Physics  
Organisation Européenne pour la Recherche Nucléaire  
Laboratoire Européen pour la Physique des Particules

The Experimental Physics Division intends to make an appointment to the position of a

## PHYSICIST

in experimental particle physics research. Candidates are expected to have an excellent record of successful work in this field, and to have the ability to provide leadership. The appointment will be made for a fixed term, and may subsequently become permanent.

The holder will play an important role in all aspects of the conception and design of experiments, and of the construction and operation of detectors, and the development of on-line and off-line software and the analysis of data.

Please send letters of application, including the names of three referees, list of publications, a brief curriculum vitae and a brief description of research interests, to the

**Leader of the Experimental Physics  
Division,  
CERN, 1211 Geneva 23, Switzerland  
quoting reference EP/RE, before 5.8.85.**

## DEPUTY, DIRECTOR, GENERAL SCIENCES Salary Open

**Duties:** Reporting to the Laboratory Director, the Deputy Director for General Sciences provides overall direction for Laboratory divisions in high energy physics, nuclear physics, accelerator physics, and fusion research. Major responsibilities include management oversight of these divisions, coordination of interdivisional programs and activities, establishment and implementation of goals consistent with the Laboratory's mission, interaction with policy and advisory committees to ensure the highest quality of scientific achievement, and management liaison with the University of California, the U.S. Department of Energy, and other external agencies.

**Requirements:** A distinguished record of scientific achievement and proven leadership in managing interdisciplinary programs in fields such as high energy physics, nuclear physics, accelerator physics, or fusion research. Proven success in interacting with academic institutions, scientific laboratories, private industry, and the federal government (especially the U.S. Department of Energy). Must have a Ph.D. in the physical sciences or equivalent experience. Requires strong management skills in areas of decision-making, problem-solving, interpersonal communications, staffing, funding, and facilities planning and utilization. "Position is subject to the financial disclosure requirements of the California Political Reform Act of 1974."

Please submit two copies of resume including salary history and names and addresses of references to:

**Chairman, Search Committee  
LAWRENCE BERKELEY LABORATORY,  
Employment Office, One Cyclotron Road,  
Building 90, Room 1012, Berkeley, CA 94720.**

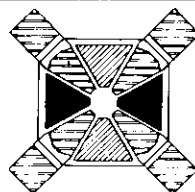
Refer to Job #B/3425.

Resumes must be received in the Employment Office by September 1, 1985, 5:00 p.m.

An Equal Opportunity Employer M/F/H.



**LAWRENCE  
BERKELEY  
LABORATORY**



## RESEARCH SCIENTIST POSITION IN EXPERIMENTAL NUCLEAR PHYSICS AT INDIANA UNIVERSITY

The Department of Physics at Indiana University invites applications for a project tenure-track position in experimental nuclear physics, to start in Fall, 1985, or early 1986, at the Indiana University Cyclotron Facility (IUCF). IUCF is a national user facility which provides intermediate-energy light-ion beams affording excellent opportunities for forefront experimental research, which is supported and complemented by the Nuclear Theory Center located in the cyclotron laboratory. Upon completion of the electron cooled proton storage ring now under construction, beams of unprecedented quality will be available for precision nuclear research and the application of novel experimental techniques. The position of Research Scientist comprises a 3-rank system at Indiana which is equivalent in structure and promotion criteria (with the exception of teaching duties) to the regular faculty ranks. Although opportunity for part-time teaching exists, the primary emphasis is upon research. Project tenure, when conferred, is with respect to the IUCF contract. Applicants must have a Ph.D., at least one year of post-doctoral experience, and should have demonstrated outstanding potential to lead a vigorous independent research program. Appointment at the Assistant Scientist level is anticipated, but appointment at higher rank will be considered for appropriate candidates. Salary will be commensurate with qualifications, experience, and rank. Applicants should submit a curriculum vitae, publication list, copies of recent publications, and arrange for three letters of recommendation to be sent to:

**Dr. W.W. Jacobs  
Indiana University Cyclotron Facility  
2401 Milo B. Sampson Lane  
Bloomington, Indiana, USA 47405**

as soon as possible, before the closing date of September 15, 1985.

**Indiana University is an equal opportunity/affirmative action employer.**

## UNIVERSITY OF OXFORD

### Department of Nuclear Physics

#### Appointment of Research Officer

The department will shortly appoint a Research Officer in Particle Physics. Whilst mainly a research appointment, the appointee will be required to undertake seventy-two hours a year of laboratory demonstrating and he/she will be encouraged to give graduate lectures. The research programme of the experimental particle physics group includes the Soudan II search for proton decay, a major contribution to the DELPHI detector for LEP (CERN), preparation for an experiment at HERA (DESY), and development of an indium detector for solar neutrinos.

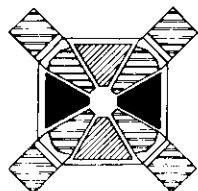
The appointment will be for three years with possible extension to five years. Salary will be on the lecturer scale £7520 - £15 390 (under review).

Applications with the names and addresses of two referees should be sent to

**Mr. M.S. Gautrey,  
Department of Nuclear Physics,  
Keble Road, Oxford**

from whom further particulars may be obtained.

**The closing date is September 5 1985.**



#### DIRECTOR OF THE INDIANA UNIVERSITY CYCLOTRON FACILITY

Applications are invited for the directorship of the Indiana University Cyclotron Facility (IUCF). IUCF is a major and growing national users' facility for intermediate-energy nuclear science with light ion beams. We seek a distinguished nuclear scientist to provide scientific leadership for the laboratory and its program. The director will serve a five-year term starting in the summer of 1986 and will receive a tenured full professorship in the Department of Physics. The five-year term of the directorship will see the start of experimental work with a new electron-cooling storage ring and the development of plans for the future growth of the facility. Salary will be commensurate with experience and qualifications. Applications with a complete resume, including the names of four references, and nominations should be sent as soon as possible, but not later than Nov. 1, 1985, to

**Professor S. E. Vigdor,  
Chairman, Search and Screen Committee,  
Research and Graduate Development  
Bryan Hall 104, Indiana University,  
Bloomington, Indiana 47405.**

**Indiana University is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minority candidates.**

#### EXPERIMENTAL HEAVY-ION NUCLEAR PHYSICS RESEARCH POSITION AT LAWRENCE BERKELEY LABORATORY

The Lawrence Berkeley Laboratory's Nuclear Service Division has an opening for a Staff Scientist 2 to participate in the Dilepton Spectrometer (DLS) Project at the Bevalac. This is a three year appointment with the possibility of conversion to career status.

Initial responsibilities involve the design and testing of the DLS electronic detection system, particularly in the drift chambers used for tracking leptons. After the construction phase, emphasis will shift to the experimental study of the dilepton signal in p-nucleus and nucleus-nucleus collisions at the Bevalac, including all aspects of data-taking and data analysis.

The successful candidate must have a PhD in nuclear or particle physics as well as research experience in this area as evidenced by a record of recent publications, with extensive background using detectors, computers and electronic equipment.

Applicants are requested to submit a curriculum vitae, list of publications and the names of at least three referees to:

**Dr. Janis M. Dairiki, c/o Employment Office,  
Mail Stop 90-1042,  
LAWRENCE BERKELEY LABORATORY,  
Berkeley, CA 94720  
as early as possible.  
Refer to Job # A/3407.**

*Lawrence Berkeley Laboratory is an Equal Opportunity  
Affirmative Action Employer M/F/H.*



**LAWRENCE  
BERKELEY  
LABORATORY**

#### KineticSystems Corporation (KSC)

##### Challenges YOU

We have positions open for:

- ★ DESIGN ENGINEERS
- ★ SALES ENGINEERS
- ★ MARKETING DIRECTOR

If you are presently working in a laboratory, university, or research environment and have knowledge of CAMAC or FASTBUS, you are of particular interest to us. KSC uses the CAMAC and FASTBUS standards in designing and manufacturing computer-based data acquisition and control systems for the scientific, aerospace/defense, and industrial markets.

When you join KSC you will find yourself in a friendly, stimulating, and creative environment. If you have the background knowledge, we will help you acquire the training you might need to design, market, or sell KSC's products.

We offer you an excellent salary/benefits package.

Please send your resume in confidence to:

**Laurie Pike  
Administrative Vice President  
KineticSystems Corporation  
11 Maryknoll Drive  
Lockport, IL 60441**

An Equal Opportunity Employer (M/H/F)



Lever, descendre, positionner, basculer, coulisser, ouvrir, commander...

## Entraînement Lineardo n° 1:

# Des hommes à tout faire

### Les avantageux vérins électriques

**Hasler 150/151** sont de puissants entraînements sans entretien qui conviennent pour tous les déplacements linéaires imaginables. Entraînements prêts à être raccordés, de course utile importante et de cotes d'encombrement réduites. Un système de construction sophistiqué comprimant les prix; même dans le cas de demandes spéciales et de fabrications unitaires.

**Pour le constructeur:** Course jusqu'à 500 mm, poussée jusqu'à 1200 N, vitesse de levée jusqu'à 120 mm/s, 220 ou 380 Vca, protection thermique, interrupteurs de fin de course fixes ou réglables. Documents, expérience, choix: 021-91 26 41

**Bachofen met en mouvement**

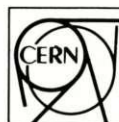


Technique d'entraînement d'il y a 500 ans: Machine à tailler les limes de Léonard de Vinci

Automation industrielle

**BACHOFEN-SA**

CH-8610 Uster Ackerstrasse 42 Tel.01/944 11 11  
CH-1033 Cheseaux s.L. Grands-Champs 4 Tél.021/91 26 41



**ORGANISATION EUROPÉENNE  
POUR LA RECHERCHE NUCLÉAIRE**

**EUROPEAN ORGANIZATION  
FOR NUCLEAR RESEARCH**

## MOVING?

Please remember to let us know in good time. All notices of change of address must be accompanied by old and new addresses. (Include label from magazine wrapper.)

Any enquiries regarding subscriptions should be addressed to:

**Monika WILSON  
CERN COURIER / CERN  
1211 Geneva 23 Switzerland**

## Advertisements in CERN COURIER

Format A4

Monthly publication

All advertisements are published in both English and French editions. Second language versions accepted without extra charge.

Space (page)	Actual size (mm) width by height	Cost per insertion (Swiss Francs)			
		1 insertion	3 insertions	5 insertions	10 insertions
1/1	185 x 265	1730	1680	1630	1530
1/2	185 x 130	960	930	910	860
1/4	90 x 265	550	520	500	480
	90 x 130				

Supplement for:  
— each additional colour

1500 SwF

— Covers:

Cover 3 (one colour)

2000 SwF

Cover 4 (one colour)

2750 SwF

Publication date

1st of month of cover date:

Closing date for

positive films and copy

1st of month preceding cover date

Screen (offset)

The cost of making films and of translation for advertisements are charged in addition.  
60 or 54 Swiss (150 English)  
Advertisements cancelled after 1st of month preceding cover date will be invoiced.

Advertising space is limited to 50% of contents and insertions are selected on a strict first-come first-served basis. These rates are effective for the year 1985.

All enquiries to:

**Micheline FALCIOLA / CERN COURIER - CERN  
CH-1211 Geneva 23 Switzerland  
Tel. (022) 83 41 03 Telex 2 36 98**

Lever, descendre, positionner, basculer, coulisser, ouvrir, commander...

## Entraînement Lineardo n° 4:

# Le spécialiste des courses courtes

### Les électroaimants de levée à courant continu GTC A de MSM

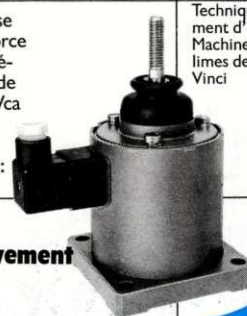
sont partout à leur affaire lorsque des déplacements linéaires courts et rapides doivent être réalisés. Dans les machines de conditionnement, textiles et autres de production, dans les commutateurs, vannes et mécanismes de verrouillage.

**Pour le constructeur:** Course jusqu'à 35 mm, 8 grandeurs, force magnétique jusqu'à 618 N, différentes variantes de fixation et de raccordement, 24 Vcc ou 220 Vca avec redresseur, autres sur demande. Documents, expérience, choix: 021-91 26 41

**Bachofen met en mouvement**



Technique d'entraînement d'il y a 500 ans: Machine à tailler les limes de Léonard de Vinci



Automation industrielle

**BACHOFEN-SA**

CH-8610 Uster Ackerstrasse 42 Tel.01/944 11 11  
CH-1033 Cheseaux s.L. Grands-Champs 4 Tél.021/91 26 41



# More kick for less pounds, francs, yen, deutschmarks pesetas or dollars.

Good news for particle accelerators.

EEV, a world leader in high energy switching thyratrons, has now developed a single cathode multi-gap tube that operates as a bi-directional switch.

Now you can double the power delivered to kicker magnets without substantial rebuilding costs.

This new tube, the CX1671, is a plug-in replacement for the CX1171. Its unique hollow anode design was originally developed by EEV to switch the severe inverse voltages occurring in pulsed gas discharge lasers.

When operating at an anode voltage of 80kV, it has proved capable of switching 2500 amps of reverse current in a 2 microsecond pulse, without any degradation in performance after 10 million pulses.

For further information on this state-of-the-art thyatron, contact EEV today.

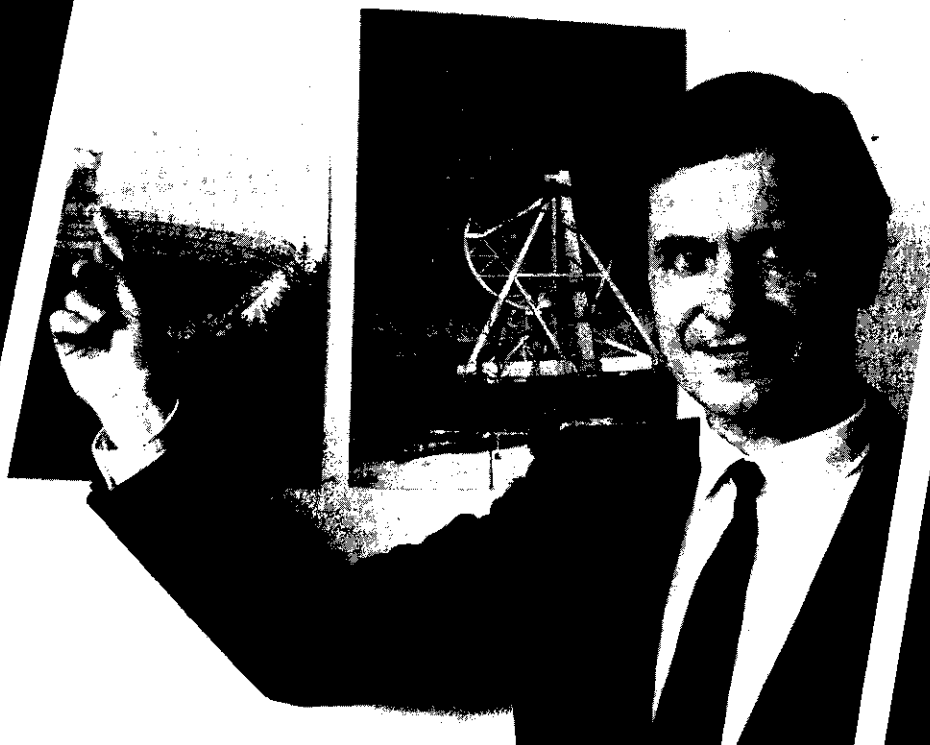


## EEV Thyratrons

EEV, Waterhouse Lane, Chelmsford, Essex CM1 2QU, England. Tel: 0245 261777. Telex: 99103.  
EEV Inc, 7 Westchester Plaza, Elmsford, NY 10523, USA. Tel: 914 592 6050. Telex 6818096.  
EEV Canada Ltd, 67 Westmore Drive, Rexdale, Ontario M9V 3Y6. Tel: 416 745 9494. Telex: 06 989 363.

# **High Technology needs Superconductors**

- in fusion research**
- in medical diagnosis**
- in radioastronomy**



*Dr Karl-Jürgen Best, Vacuumschmelze*

*The biggest radiotelescope is located at Effelsberg, Eifel, W. Germany. One of its highly sensitive receivers is a MASER – a quantum mechanical amplifier. For its operation a strong and homogenous magnetic field is necessary. It is provided by superconducting coils.*

*High-energy magnetic fields produced by superconductors VACRYFLUX® also help achieve top results in other disciplines, i.e. in fusion research or in nuclear spin tomography, which enables high resolution diagnosis without X-ray examination.*

® Registered trademark of VACUUMSCHMELZE GMBH

## **VACUUMSCHMELZE GMBH**

Grüner Weg 37, D-6450 Hanau 1 · Telefon: (061 81) 362-1 · Telefax: (061 81) 362 645 · Telex: 4 184 863  
Rhenaniastr. 9/17, D-1000 Berlin 20 · Tel.: (030) 3320 051 · Telefax: (030) 3320 051 App.04 · Tx.: 182 815

KI-05

**VAC**  
VACUUMSCHMELZE

# G64

## CARDS AND SYSTEMS



The **G64 bus** is based on the Motorola MC6809 processor and is the standard adopted by CERN for all 8 bit applications.

We offer a comprehensive range of cards and systems to meet most requirements. Please contact us for technical details and data sheets.

Other products include

**Video Overlay** – Overlays text and data on video

**Video Multiplexer** – Multiplexes up to 4 videos on a single coax.

**Data Multiplexer** – Multiplexes analogue and digital data on a single twisted pair cable

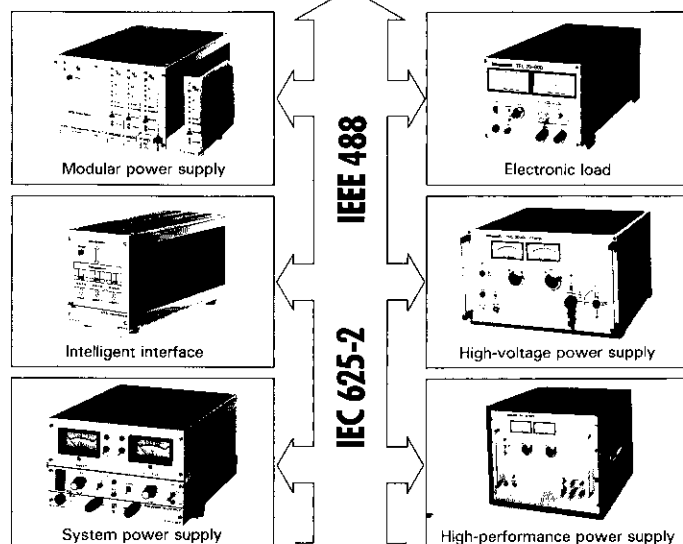
**Programmable Interface** – Front end controller for IEEE 488 bus

**Liebnitz-  
Lann Ltd**

**Nairn**  
Balmakeith Industrial Estate  
Nairn, Scotland IV12 5QW  
Tel: (0667) 54946  
Telex: 75688

**You need hands-on experience  
for programming...**

**...the same goes for power supplies**



If you want your system design to be in good hands, put it in ours.

We can supply customer adapted systems for you, down to the last detail. We guarantee that our designed to-day systems will still be up-to-date tomorrow.



**Dr. K. Witmer Elektronik AG**

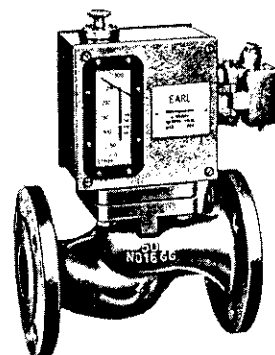
Seestrasse 141  
CH-8703 Erlenbach/ZH  
Tel. 01/915 35 61

Sales office for french part of Switzerland:  
3 rue Marteney, 1005 Lausanne  
Tel: 021/22 85 37

11

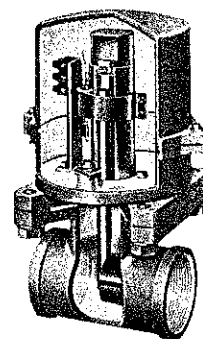
**Gase und Flüssigkeiten  
überwachen,  
messen,  
kontrollieren!**

**Strömungswächter, Durchfluss-Mengenmesser, Niveau-meter, Druckwächter** – auch ex-geschützt, SEV-geprüft. Wir beraten Sie gerne.



**Surveiller,  
mesurer,  
contrôler**

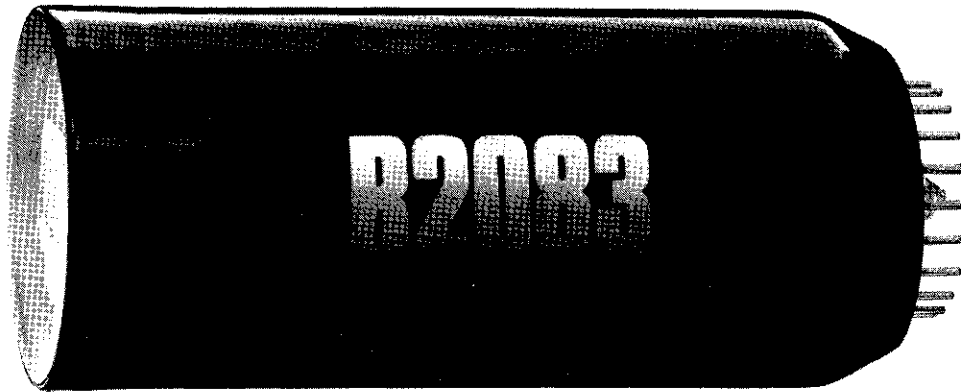
**gaz et liquides! Indicateurs de circulation, débitmètres, niveaumètres, contrôleurs de pression** – également ex. anti-déflagrantes, contrôlées ASE. Nous vous conseillons volontiers.



**TECHNOKONTROLL AG**

8049 Zürich, Imbisbühlstr.144 Telefon 01 56 56 33

# 2" Diameter Subnanosecond PMT



**Subnanosecond time response**  
(RT = 0.7 ns, TTS = 0.37 ns), 8-stage  
**For scintillation counting and**  
**high energy physics experiments**

The R2083 is a 2-inch diameter, 8-stage, head-on type photomultiplier tube developed specially for pulse counting applications. It features subnanosecond rise time, small transit time spread and high pulse linearity. The anode output signal is derived through a coaxial connector to preserve good signal quality.

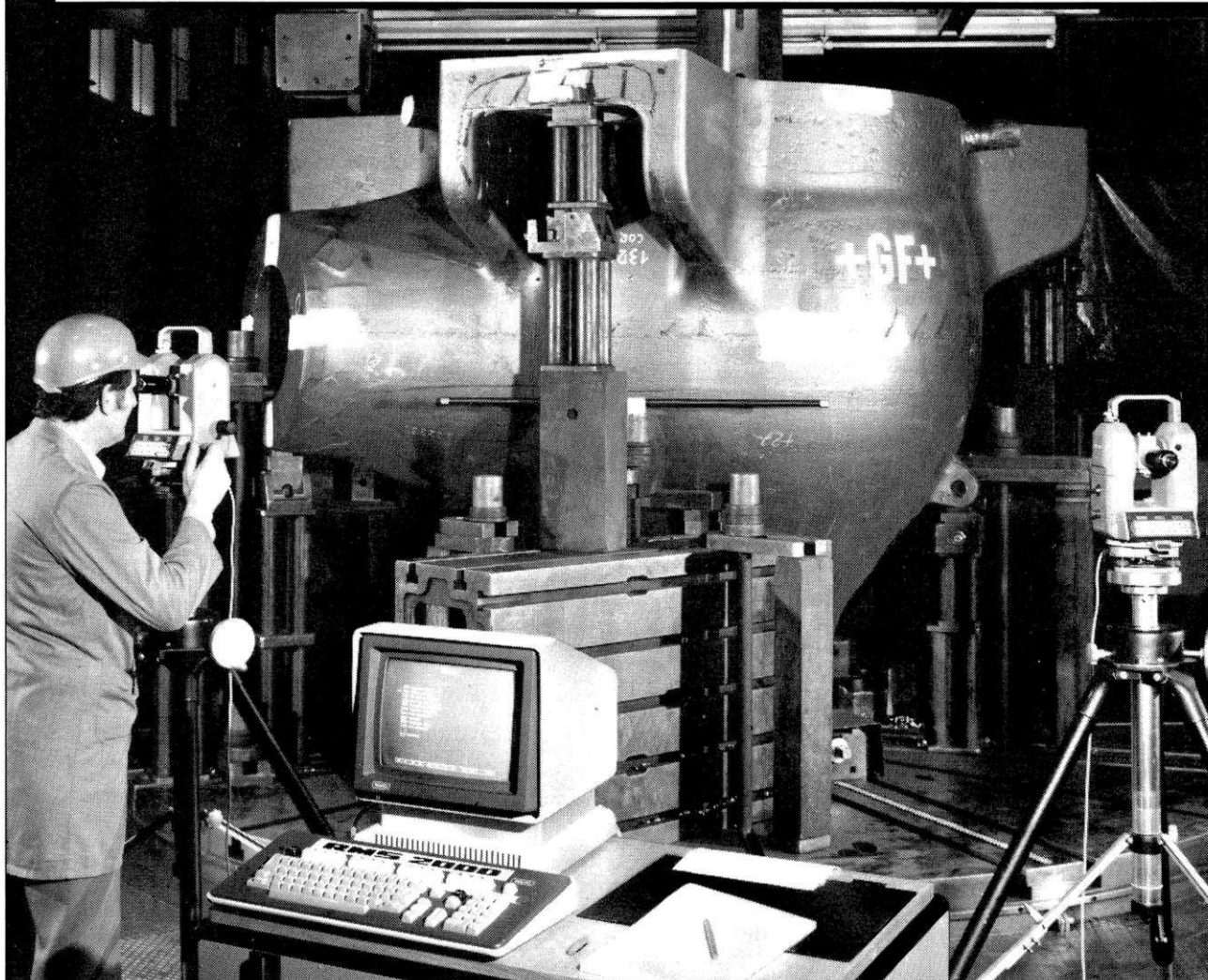
Call or write for Data Sheets.

## **HAMAMATSU**

HAMAMATSU CORPORATION • 420 SOUTH AVENUE • MIDDLESEX, NEW JERSEY 08846 • PHONE: (201) 469-6640  
*International Offices in Major Countries of Europe and Asia.*

## Wild-Leitz RMS2000:

### The vital step towards better quality-assurance



Wild Heerbrugg and Leitz Wetzlar are world leaders in optics and metrology. They have now combined their expertise to produce RMS2000, a fast, non-contact measuring system for quality-assurance and testing.

The system consists of two or more Wild T2000 or T2000S informatic theodolites and a desktop computer, which processes the measurements with software based on the well proven Leitz MESCAL.

RMS2000 offers quality-assurance engineers the following features:

- **Mobility:** RMS2000 can be taken to the object, thus saving time. The object may be any size.
- **Accuracy:** The easy-to-use electronic theodolites ensure high accuracy.
- **Real-time results:** Even the most complex elements can be computed immediately for comparison with nominal values.
- **Flexibility:** Objects sensitive to touch or located in hazardous environments can be easily and accurately measured. Many

industries, from shipbuilding to space technology, automotive manufacture to offshore oil construction, will find RMS2000 the quality-assurance system they need.

Contact Wild Heerbrugg or Leitz Wetzlar to find out what RMS2000 can do for your quality-assurance. ■

G 75-85

Wild Heerbrugg Ltd · CH-9435 Heerbrugg · Switzerland · Telex 881 222

**WILD**  
**HEERBRUGG**



# Throughout the World of Quality Optics **SCHOTT-GLASS**



## In search of the structure of matter with optical glass from Schott

Schott's SF 57 glass possesses excellent properties for the detection of high energy particles in Cerenkov counters.

- The high internal transmittance in the blue-violet spectral regions –  $\tau_i$  (400 nm) 0.30,  $\tau_i$  (440 nm)  $\geq$  0.80 at 100 mm thickness – permits evaluation of the more intensive portion of the Cerenkov continuous spectrum at 400 nm.
- In addition to offering good transmission the high refractive index of 1.85 guarantees a low threshold energy for the detectable particles.
- The high density of  $\rho = 5.51 \text{ g/cm}^3$  results in a short radiation length of 15.4 mm which allows the glass block to be smaller thereby lowering costs.
- Tight dimensional tolerances and angular accuracy allow for simplified assembly.

We also supply scintillating glasses, fiberoptic products and optical filters.



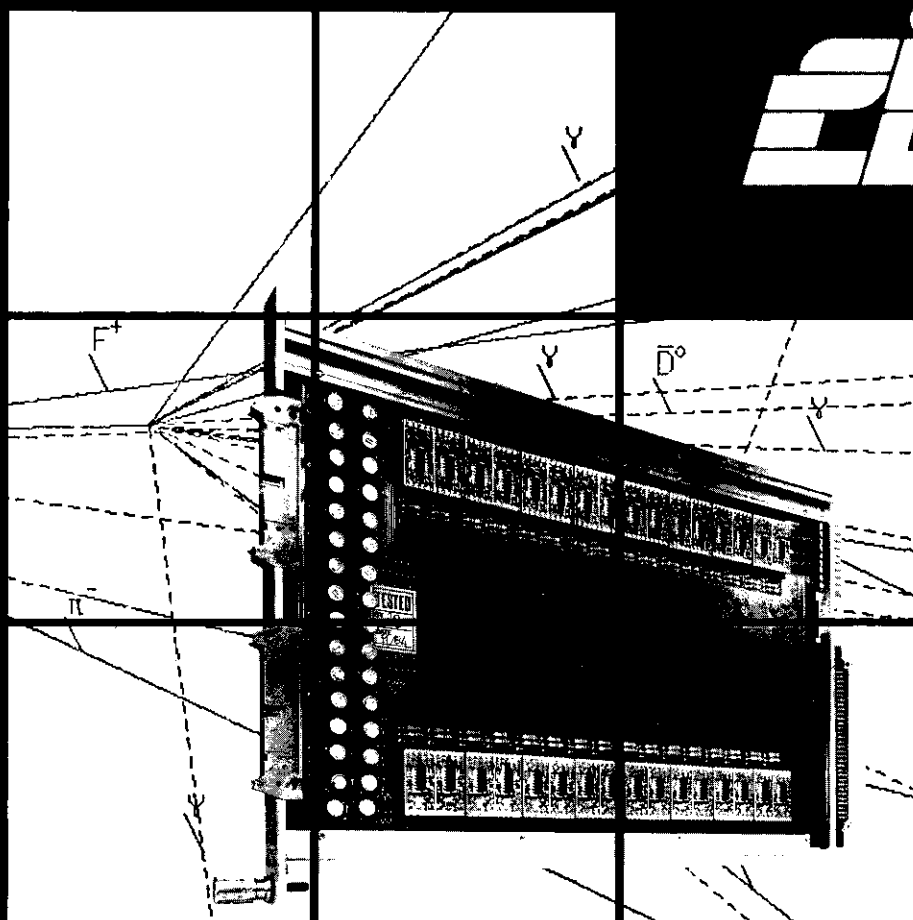
# SCHOTT

SCHOTT GLASWERKE  
Optics Division  
Product Group "Optical Glass"  
Hattenbergstraße 10  
D-6500 Mainz  
Telephone (06131) 66-0

# LABEN

introduces:

## the "32-channels amplifier" [CAMAC standard]



*LABEN laboratories and INFN\* developed something special for E 687 program at Fermi Lab.: a module with 800 components to amplify 32 microstrip channels with adjustable gain and pole zero cancellation. It is interfaced to LABEN preamplifiers but it is also compatible to other preamplifier types.*

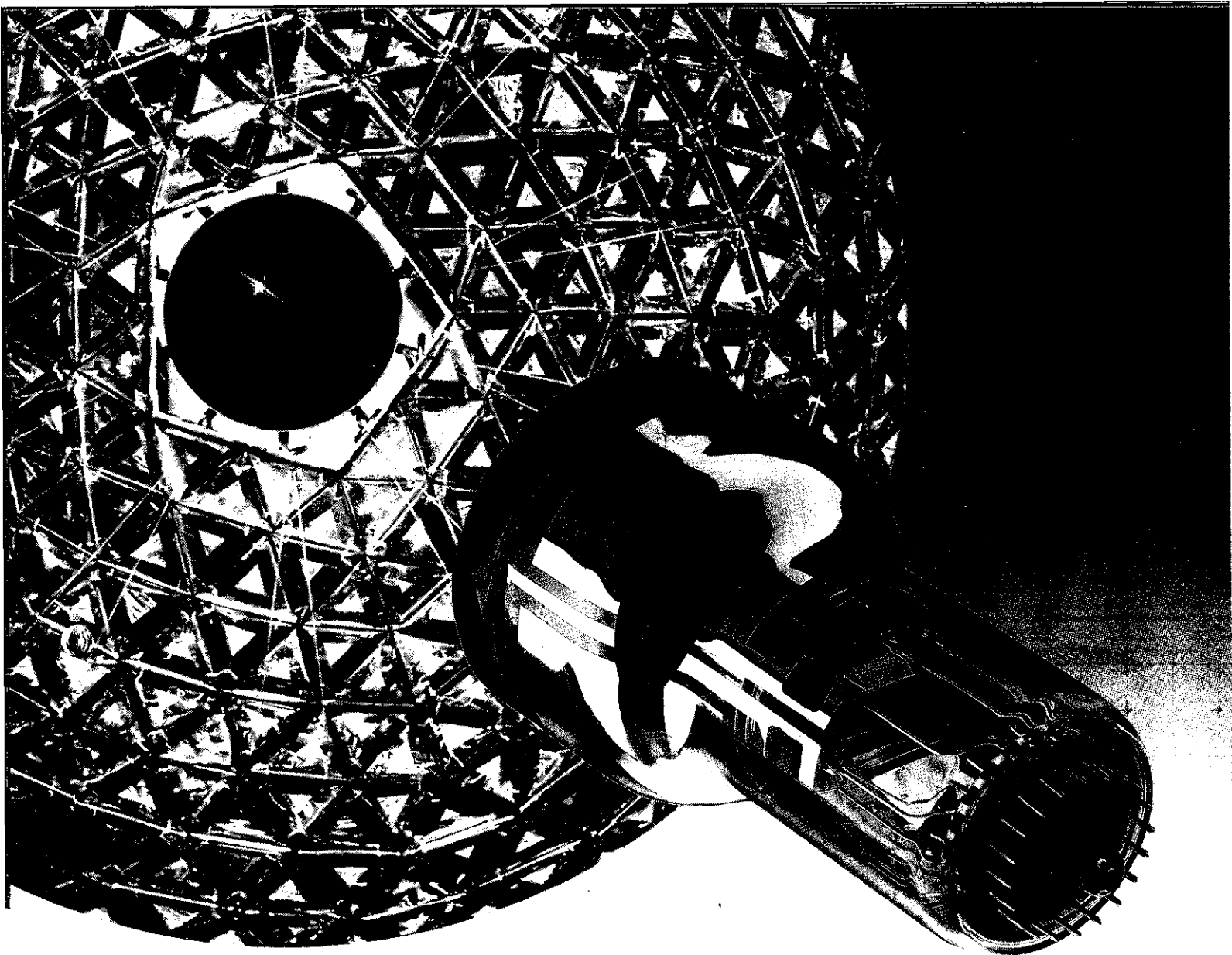
*\* Istituto Nazionale di Fisica Nucleare*

# LABEN

Division of



20133 MILAN (Italy) - Via Bassini, 15 - Tel. (02) 2365551 - Tlx 312451



# CRYSTAL BALLS?

## XP3462!

The unique answer to crystal ball requirements. Developed for KfK's neutrino experiment, the XP3462 offers a combination of rise time and energy resolution unequalled by other 3" PMTs.

$t_r$  = 3 ns, anode pulse rise time for delta-function light pulse  
 $R_E$  = 10% for  $^{57}\text{Co}$  and 3" x 3" NaI (TI) scintillator  
 $G$  =  $10^6$  at 1500 V  
 Pulse linearity within 2% up to 100 mA.

*Plastic ball photo courtesy of LBL/GSI*

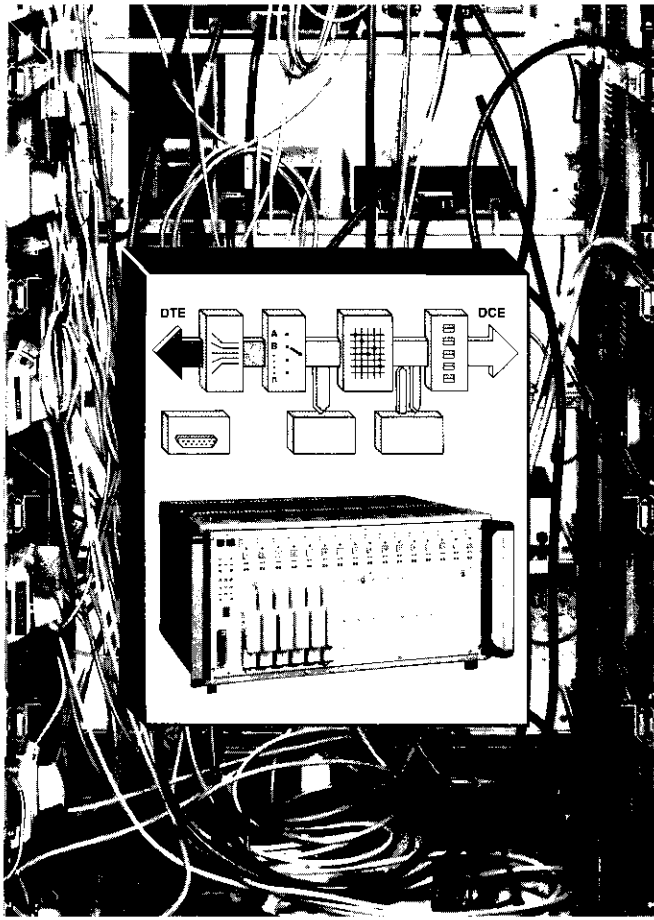
## We've set the standard for over 20 years

Philips Electronic Components and Materials Division, 5600 MD Eindhoven, The Netherlands. Telex 35000 phtc nl  
 In the U.S.A.: Amperex Electronics Corporation, Hicksville NY 11802, (516) 931-6200



Electronic  
components  
and materials

# PHILIPS



## Increase data network availability with the DNE Data Network Diagnostics System

Even medium-sized data networks have problems with modem cabinets that are overrun with cables. If there's a fault no one knows where to connect or loop-in test gear. How can one avoid interrupting the wrong line? All these difficulties are eliminated if you use the DNE Data Network Diagnostics System by Wandel & Goltermann. The DNE has the right interfaces, V.24/V.28 and X.20/X.21, so there will be no problems with interface compatibility later on. Our DNEs can be operated manually or remote-controlled via a VDU. The DNE has the following features:

- ★ "Tidies up" data lines
- ★ Central interface monitoring, alarm facilities, documentation
- ★ An analyser can be connected without affecting data traffic
- ★ Switching and patching facilities

★ Memory for back-up configurations—if there's a fault they can be implemented immediately using a single command. We give our customers complete systems not just hardware. Send off for a free DNE colour brochure.

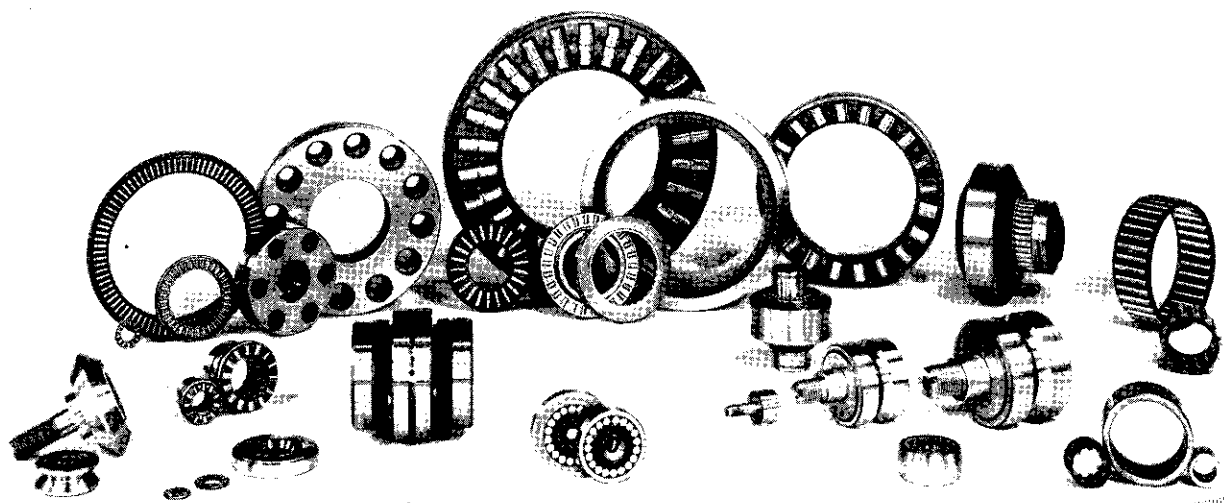
### Information Coupon

I would like  
☐ The DNE colour brochure  
☐ Your data measurement technology product guide

Name .....  
 Company .....  
 Street .....  
 Town .....  
 Tel. ....

**Wandel & Goltermann**  
 (Schweiz) AG  
 Postfach 254  
 CH-3000 Bern 25  
 Tel. (031) 42.66.44  
 Telex 32 112 wago ch

E 3289 K



Roulements à aiguilles  
 Nadellager · Needle Bearing

# NADELLA

it's "tailor made"  
 Bearings to suit the highest performances

## SKB

Fabrique de roulements S.A.  
 Route de Soleure 66-68, CH-2504 Bienne  
 Tél. 032/41 20 31, Télex 34169 skbna ch

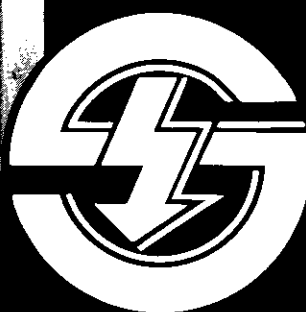
Sandwich-type semi-chamber  
for

## CERN experiment UA.1

composite  
construction type manufacture.

Please request detailed information. Mr H. Mauch will be glad to advise you personally.

We offer a range that is based on 25 years' experience and know how through successful collaboration with field specialists.



**Stesalit AG**  
**Kunststoffwerk**

CH-4249 Zullwil/SO  
Telefon 061/80 06 01, Telex 63182

W&amp;P

We provide easily built-in  
safety in Know-how.

**DIMENSIONS AHEAD IN SCINTILLATION  
CRYSTAL TECHNOLOGY**

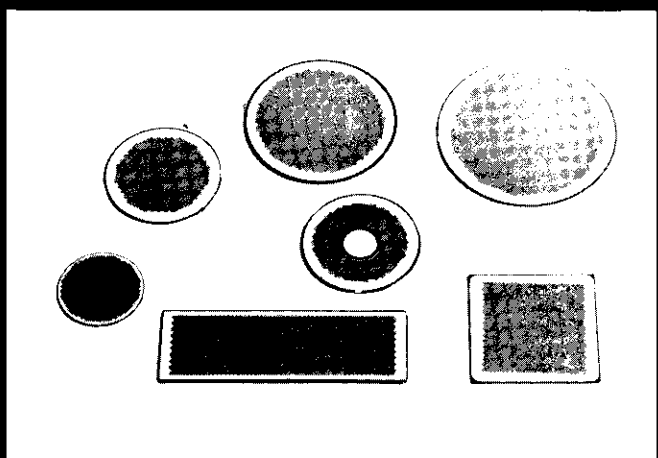
Crystal Materials for your applications.

**HILGER**  
**Analytical**

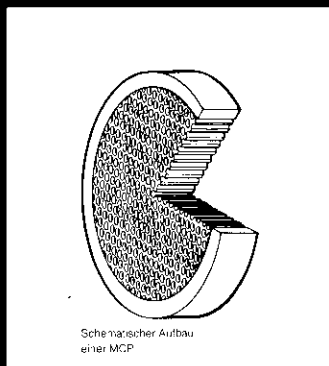
Hilger Analytical Limited  
Westwood Margate Kent CT9 4JL  
Tel: 0843 25131/24261 Telex: 96252



# HAMAMATSU



## Microchannelplates (MCP) Photomultiplier with MCP (PMT-MCP)

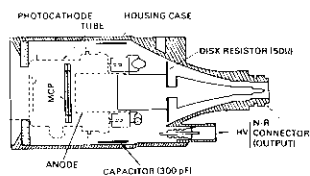


### Applications:

- High Energy Physics
- Mass Spectrometry
- Gamma Detection
- Spectrometry in UV and VIS-region

### Features:

- High gain
- Fast time response
- Immunity to Magnetic-Fields
- Low Power Consumption
- Small Size, Light Weight
- Sensitivity to charged Particles, UV and X-rays



Querschnitt eines MCP-PM



HAMAMATSU MCP-PM Typ R 1294 U

For further Information please contact:

Dr. R. Seitner · Mess- und Regeltechnik GmbH  
P.O. Box 11 55 · D-8036 Herrsching (Germany)  
Phone 81 52 - 30 25 · Telex 527719

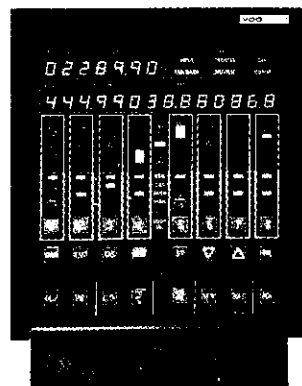
Represented at "CSI" XXIV.  
Garmisch-Partenkirchen, 15. - 21.9.1985

**DR. R. SEITNER**  
MESS- U. REGELTECHNIK GMBH



## MICON P200,8 Loop Controller

an important advance towards the ultimate in process control

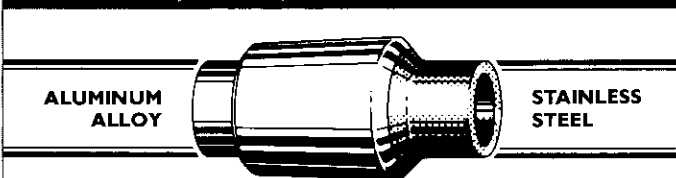


This microprocessor-based control system employs advanced techniques to control processes of any size and complexity and to satisfy special process requirements.

**RE MAG**  
AKTIENGESELLSCHAFT

3072 Ostermundigen 1  
Telefon 031/ 31 01 11  
Telex 911 779

## THEVENET CLERJOUNIE TRANSITION JUNCTIONS CEA SYSTEM FOR CRYOGENIC, VACUUM, NUCLEAR AND SPACE APPLICATIONS



THEY HAVE THE  
SAME MECHANICAL  
CHARACTERISTICS  
AS THE ALUMINUM  
TUBE AND CAN ALSO  
BE FABRICATED  
TO ANY MATERIAL  
SPECIFICATIONS

TOTALLY RELIABLE BIMETALIC

TRANSITION JUNCTIONS

FOR TUBULAR ASSEMBLIES

UP TO Ø 600 MM (24")

10<sup>-9</sup> atm. cm<sup>2</sup>. S<sup>-1</sup>

10 M Pa

0 to 573 K

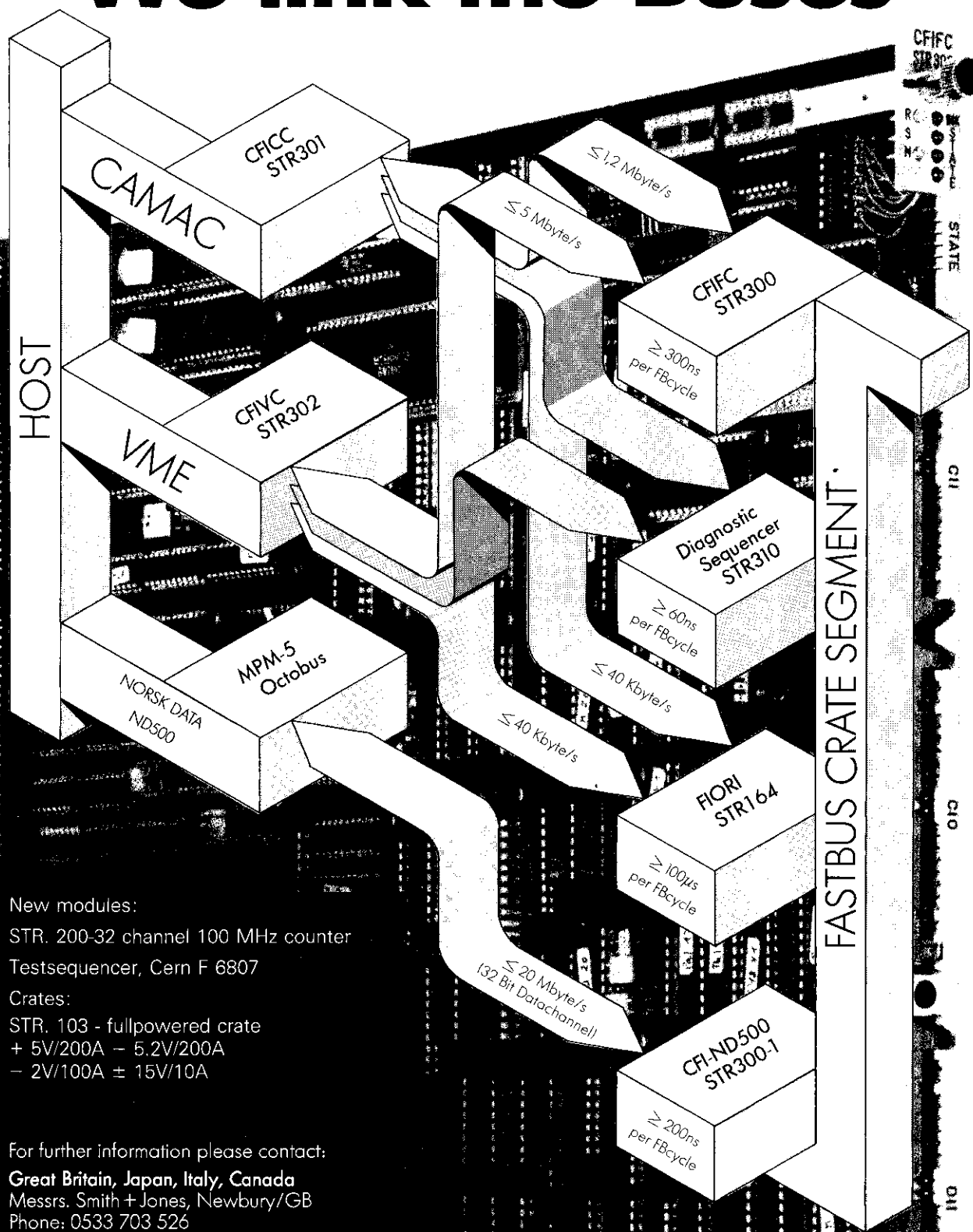
UNDER RADIATION



\* COMMISSARIAT A L'ENERGIE ATOMIQUE

CALL OR WRITE FOR DOCUMENTATION  
THEVENET CLERJOUNIE • DEPARTEMENT JONCTIONS TC  
CONTACT: M. ARMAND PINET, CONSULTING ENGINEER  
22, AVENUE FRANKLIN-ROOSEVELT • 69517 VAULX-EN-VELIN  
CEDEX FRANCE • TELEPHONE: (7) 849.54.64 • TELEX 380544 F

# We link the Buses



## New modules:

STR. 200-32 channel 100 MHz counter

Testsequencer, Cern F 6807

## Crates:

STR. 103 - fullpowered crate

+ 5V/200A - 5.2V/200A

- 2V/100A ± 15V/10A

For further information please contact:

**Great Britain, Japan, Italy, Canada**

Messrs. Smith + Jones, Newbury/GB

Phone: 0533 703 526

## Switzerland

Messrs. ANTARES AG, Nussbaumen/CH

Phone: 056 823783 - Telex: 58703

## Netherland, Belgium

Messrs. UNITRONICS, Nieuwegien/NL

Phone: 3402 38559

## Schweden

Messrs. Gunnar Peterson AB, Stockholm-Forsta/S

Phone: 08 939280 - Telex: 17944



## DR. B. STRUCK

2000 TANGSTEDT / HAMBURG GERMANY  
HAUPTSTR. 95 · TELEFON 04109/99 66/67  
POSTFACH 11 47 · TELEX 2 180 715 TEGS

# New standards of efficiency for Gamma Spectrometry

The 9256 photomultiplier sets a new standard for energy resolution, linearity and collection efficiency. With its new D400 electron optical design, high efficiency bialkali photocathode and a rise time of 2.5 ns, this tube is suitable for most scintillation counting applications, including those using plastic scintillators.

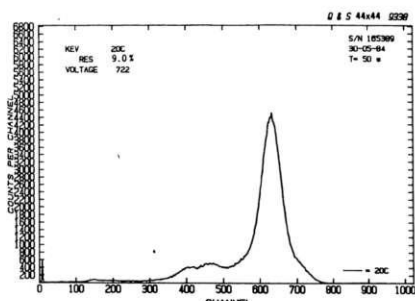
This tube is the first in a series where the main

benefit will be in gamma spectrometry, gamma cameras and counting assemblies.

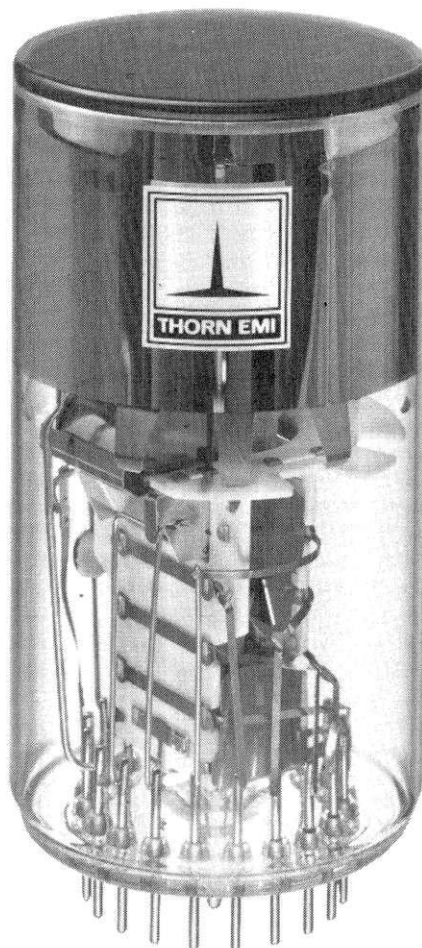
The 9256 is 52 mm in diameter, and is directly interchangeable with the established THORN EMI 9956.

Contact THORN EMI or local representative to find out how this new photomultiplier can benefit your application.

- Pulse height analyser spectrum for  $^{57}\text{Co}$ .



- Pulse height resolution:  
6.8% for  $^{137}\text{Cs}$ .  
9.0% for  $^{57}\text{Co}$ .
- Envelope of specially selected glass to minimise background contribution.



- High peak current linearity at anode currents in excess of 100 mA for a wide gamma ray energy range and versatile voltage divider design.

- Completely new, fast linear focused, 10-stage dynode structure of robust design, with gain of typically  $10^6$  at 800 V.

- 5 base configurations: solid pin, flying leads only, fixed cap, loose cap and integral voltage divider for large volume applications.



**THORN EMI**  
**Electron Tubes Limited**

Bury Street, Ruislip, Middlesex HA4 7TA, England.  
Telephone: Ruislip (08956) 30771. Telex: 935261.

NORTH AMERICA

**THORN EMI**  
**Gencom Inc.**

23 Madison Road, Fairfield NJ 07006 USA.  
Telephone: 201 575-5586. Telex: 221236.





# NEW FRONTIERS

## IN DATA ACQUISITION

### *Speed, Versatility, Sophistication through FASTBUS*

Build a data acquisition system that meets the large-scale requirements of modern experimental physics. The exciting new FASTBUS standard provides fast transfer and manipulation of data with a protocol for large complex systems. Highlights include:

- **High Speed Data Transfer**— 100 nsec/32-bit word or faster.
- **Use of Multiple Masters**— allows data scanning processors and host(s) to operate together.
- **Sparse Data Scan**— sophisticated protocol allows service requests from anywhere in the crate.

### *Economy and High Density through LeCroy*

LeCroy's FASTBUS line provides unsurpassed features, high packing densities, and low per-channel costs through the extensive use of custom monolithic technology and software-selectable control and features. Our list includes:

- **ADC's**— 96 channels/#1 FASTBUS. With 12 or 15-bit dynamic range.
- **TDC's**— 96 channels/#1 FASTBUS. Digital multihit encoding with least count to 2 nsec and  $\sigma$  to 600 psec, both time of arrival and pulse width.

- **ICA's**— Up to 32 channels/#1 FASTBUS. Samples pulses at rates to 100 MHz with amplitude resolution to 10 bits.
- **Interfaces**— Segment Manager/Interface operates at FASTBUS speed. Connection to CAMAC and UNIBUS®, and LeCroy Multiple Event Buffers now. More will follow.
- **Support**— A FASTBUS module extender, a CAMAC link and a new proto board are useful lab tools.

For details contact your local LeCroy representative.

700 S. Main St., Spring Valley, N.Y. 10977, (914) 425-2000; Geneva, Switzerland, (022) 82 33 55; Heidelberg, West Germany, (06221) 49162; Les Ulis, France, (6) 907.38.97; Rome, Italy, (396) 320-0646; Botley, Oxford, England, (0865) 72 72 75. Representatives throughout the world.

# LeCroy





## 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 communication 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 Foutenay-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

