CERN COURIER

NO. 6 VOL. 16 JUNE 1976

CERN COURIER, Journal of High Energy Physics, is published monthly in English and French editions.

Copies are available on request from:

Federal Republic of Germany —
Frau I. Schuetz
DESY, Notkestieg 1, 2 Hamburg 52

France —
Mme Detoeuf
IN2P3, 11 rue Pierre et Marie Curie, 75231 Paris Cedex 05

Italy —
INFN, Casella Postale 56, 00044 Frascati, Roma

United Kingdom —
Elizabeth Marsh
Rutherford Laboratory, Chilton, Didcot Oxfordshire OX11 0QX

USA/Canada —
Margaret Pearson
Fermilab, PO Box 500, Batavia Illinois 60510

Other countries —
Marie-Jeanne Blazianu
CERN 1211 Geneva 23, Switzerland

Editor: Brian Southworth

Assistant Editors: Henri-Luc Felder
Michel Darbin

Advertisements: Micheline Falciola

Printed by: Presses Centrales Lausanne
1002 Lausanne, Switzerland
Merrill Printing Company
765 North York, Hinsdale, Illinois 60521, USA

Published by: European Organization for Nuclear Research,
CERN, 1211 Geneva 23, Switzerland
Tel. (022) 41 98 11
Telex 23698

Contents

Heavy ion programme at Berkeley 207
Features of the experimental programme at the Bevalac, the world's highest energy heavy ion accelerator, including research in nuclear physics, radiology, chemistry and biology

The meeting on the World Machine 210
News from the Study Group at Serpukhov in May which discussed the construction of a very big accelerator (VBA) by a world-wide collaboration

Still more new particles from SPEAR 211
Discovery of a particle of mass 1.865 GeV which is a likely candidate for the first charmed meson to be clearly identified

POPAE design study 211
Proposal for the construction of 1000 GeV proton storage rings for construction at Fermilab comes from an Argonne/Fermilab collaboration

Around the Laboratories

CERN: SPS nearly there / Labelling particles in the nucleus 213
400 GeV proton synchrotron on the brink of reaching design energy / Research with hypernuclei conveys unique information on nuclear behaviour

LOS ALAMOS: 110 microamps in experimental area 214
Higher intensity 800 MeV proton beam from LAMPF is fed to the main experimental area

FERMILAB: Acceleration to an energy of 500 GeV / Polarized target comes into operation 215
New world record energy is reached at the proton synchrotron / First polarized target at Fermilab begins experimental programme

PADUA: Conference on Computer Assisted Scanning 217
Review of applications of flying spot devices in high energy physics and other fields

STANFORD: Streamer chamber 218
Description of streamer chamber facility and its future development

NIJMEGEN: PEPR for physics and medical applications 218
Scanning system used for bubble chamber film measurement and in tests for automating cervical smear cancer screening

CORNELL: Superconducting r.f. 219
Further results on the application of superconductivity in radio-frequency accelerating cavities

People and things 221

Tracking the elusive quark 224
Physics fantasy by Lewis Grossberger

Cover photograph — Blessed are they who stand in front of the new BEBC piston structure and position their head at the axis. Emile Gastaud, a welder from the CERN workshops, had worked on the stainless steel structure of a new piston for the 3.7 m European bubble chamber, BEBC, when an observant photographer achieved this beatification. The piston is scheduled to be installed in the next few months prior to operation of the chamber with beams from the 400 GeV synchrotron. (Photo CERN 180.5.76)

Heavy ion programme at Berkeley

The high energy heavy ion programme at the Lawrence Berkeley Laboratory has progressed substantially since its inception two years ago (see June COURIER 1974). The Bevalac facility has had its ups and downs since the Summer of 1974 but by now accelerator operations have settled to a stable level, providing heavy ion beams both for nuclear science and biomedical experiments. This was achieved by innovations, dedication and hard work from the accelerator crews at both the SuperHILAC heavy ion linac and the Bevatron synchrotron.

The Bevalac consists of the SuperHILAC acting as an injector into the Bevatron at energies of about 8.5 MeV/nucleon. Once in the Bevatron, the ions can be accelerated up to a maximum energy of 2.1 GeV/nucleon. At present, the heaviest ion has been argon (^{40}Ar) with average intensities of 1 to 2 × 10^8/pulse and the next heaviest has been neon (^{20}Ne) with intensities of 1 to 2 × 10^9/pulse. In the near future, either iron (^{56}Fe) or krypton (^{86}Kr) should be available for experiments with expected intensities in the range of 10^4 to 10^5/pulse.

There has recently been an explosion of experimental and theoretical interest in heavy ion interactions at relativistic energies. The most exciting topics have involved the possibility of observing new phenomena associated with nuclear collisions at high energies — among the suggestions are abnormal nuclei, pion condensates, and nuclear shock waves. The key element in these speculations is that the phenomena are associated with abnormally high nuclear densities.

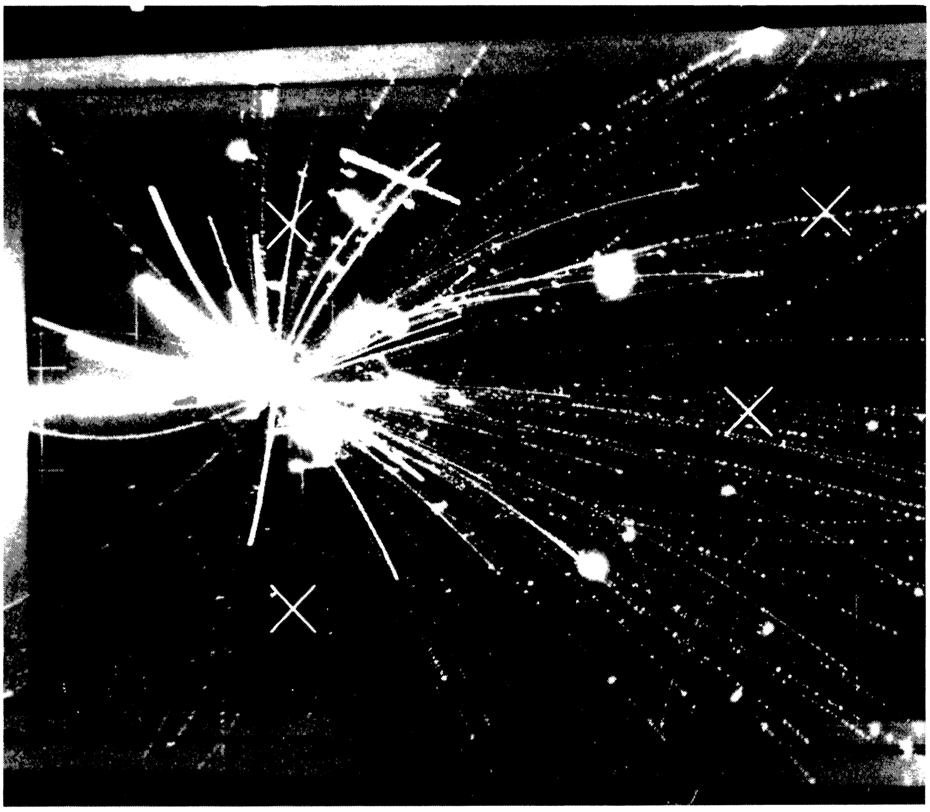
The possible new phenomena are, of course, the subject of intense debate both in terms of the necessary experimental techniques and of the theoretical interpretation. Some feel that relativistic heavy ion central collisions may be the way to probe the behaviour of nuclear matter in extreme conditions of density and excitation energy. The experimental techniques to look for such central collisions vary widely from electronic to visual.

A collaboration from LBL, GSI Darmstadt, and the University of Marburg has started a series of electronic experiments to look for events with large transverse momentum transfer by studying the emission of high energy helium fragments (30 to 300 MeV/nucleon) from the interactions of protons, helium (^4He), oxygen (^{16}O) and neon (^{20}Ne) ions on aluminium and uranium at bombarding energies of 250 MeV/nucleon to 2.1 GeV/nucleon. Recently, they have added an array of multiplicity counters and by selecting high multiplicity events they hope to enhance the central collision content of their data.

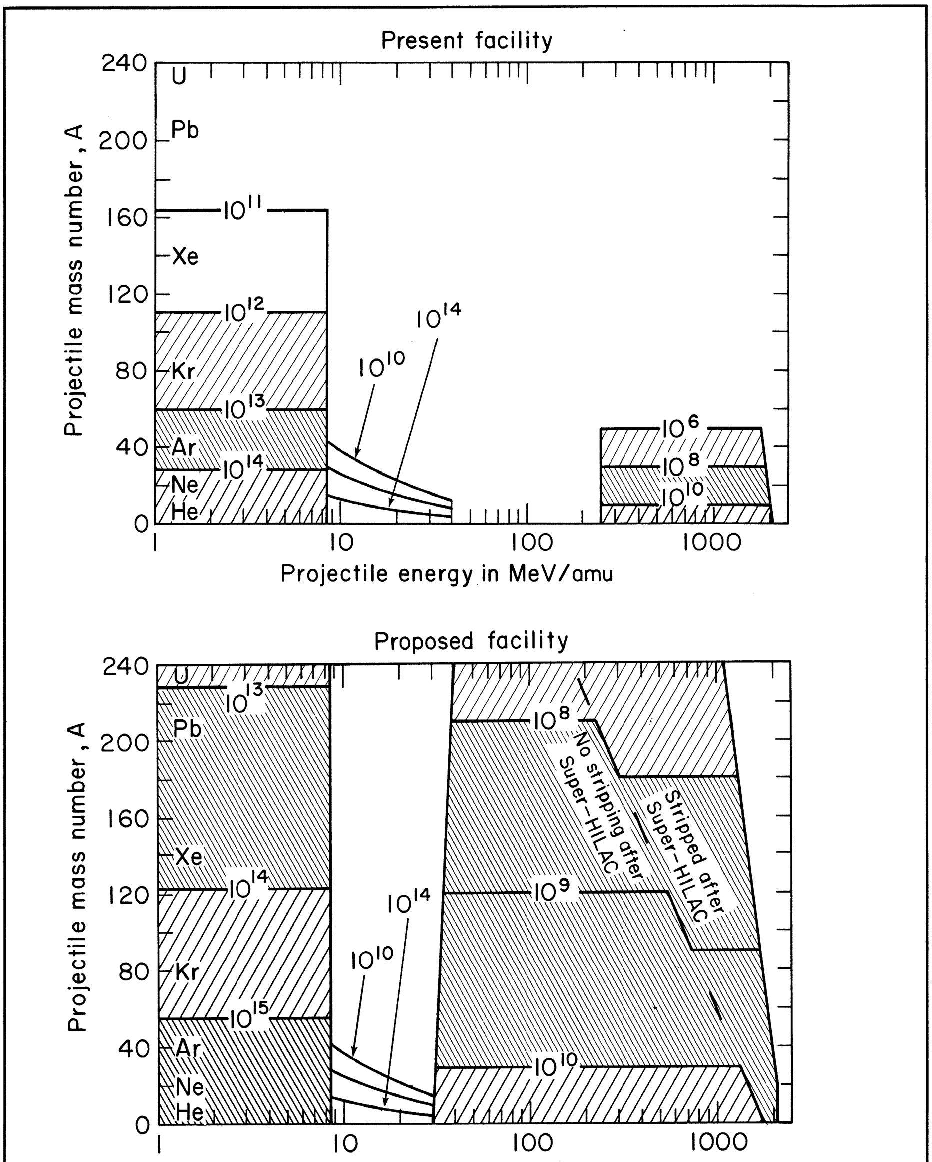
Using visual techniques, a University of Frankfurt group has exposed AG-CL detectors to various heavy ion beams at energies from 250 MeV/nucleon to 2.1 GeV/nucleon. Their early work, in which they observed peaks in the angular distributions of light fragments (most likely proton and helium) changing with beam energy in a manner which suggested the particles originated from shock waves, caused considerable excitement in the nuclear science community.

After being used for several high energy physics experiments, the LBL streamer chamber has recently been adapted for use with heavy ions and a collaboration from U.C. Riverside and LBL has demonstrated that it can be used with heavy ions. The group has begun a systematic survey of nucleus-nucleus collisions. In a recent run with 1.8 GeV/nucleon argon ions on a lead oxide target, charged particle multiplicities of over 100 have been observed.

It is clear that the search for new phenomena will occupy a large part



A spectacular collision between a 1.8 GeV/nucleon argon nucleus and a lead oxide target — more than 70 charged tracks are visible. This photograph was taken in a streamer chamber during a UC Riverside/LBL experiment to study nucleus-nucleus collisions at relativistic energies.



Available heavy ion beams from the present (above) and the proposed (below) Bevalac facility. The major improvements, giving the greater range of accelerated ions and higher beam currents, would come from the installation of a new vacuum liner in the Bevatron and from a third injector for the SuperHILAC.

of the experimental programme at the Bevalac. In addition to work on central collisions, there is widespread interest in projectile fragmentation studies, ranging from astrophysical applications to testing such high energy physics concepts as scaling and limiting fragmentation. A spectrometer for this purpose has been developed by a group at LBL and the UC Space Science Laboratory, who also use it to calibrate cosmic ray detectors before they are flown on balloons or satellites.

A Tokyo/Osaka/LBL collaboration is concentrating on detecting gamma rays from heavy ion collisions. Many discrete gamma rays have been observed and their yields provide unique information on the reaction mechanisms of certain peripheral collisions. This same principle is also being applied in an experiment which extends to very large transverse momentum transfers in the projectile system. A spectrometer put together by a UCLA/LBL collaboration and originally used to study elastic scattering in the proton-helium (^4He) system has recently been augmented by an array of multiplicity detectors. It is at present being used to study the multiplicity and momentum transfer distributions of projectile fragments produced in collisions of 1.05 to 2.1 GeV/nucleon argon and carbon ion beams with beryllium and copper targets.

Basic research in the biomedical applications of heavy ion beams is an important part of the research programme, accounting for about a third of the Bevalac operation and support. The primary emphasis is on pre-therapeutic studies of the radiation effects on normal and cancerous tissue in animals. Beams of neon and argon in the 300 to 600 MeV/nucleon range have been used to irradiate specimens of skin, lung, and spinal cord tissue as well as tumour tissue and cells in tissue culture. Another investigation concerns the diagnostic potential of heavy ion beams, using the sensitivity of the ion range to local electron density changes to pinpoint tumours. The basic studies involve radiological physics, chemistry, and biology on a cellular level.

Heavy ion beams by virtue of their extremely dense ionization, or linear energy transfer (LET), should offer significant advantages over traditional x-ray treatments. A heavy ion will deposit most of its energy just before stopping, and since heavy ions have a well-defined range, the energy of the beam can be chosen to make the ions stop at a tumour site. Thus one can deliver the dose of radiation exactly where it is needed with minimal damage to healthy surrounding tissue. X-rays show a simple exponential attenuation and are thus much less selective in their cell destruction.

Not all types of ionization are

equally effective in destroying cells for a given energy absorbed. The ratio of the energy absorbed using x-rays compared to the energy absorbed using the test radiation to produce the same effect, is called the Relative Biological Effectiveness (RBE), which is a convenient figure of merit for radiological applications. The RBE for heavy ion beams can be much greater than one and the precise measurement of this factor for skin, lung, spinal cord and tumour tissue is one of the major efforts of the Bevalac programme.

The RBE is not the whole story in radiation therapy however. Various cells can show large differences in their recovery or resistance to destruction by ionizing beams. One cause for this resistance seems to be related to the oxygen content of the cell and it has been noted that cells which are low in oxygen (hypoxic) are much more resistant to radiation than oxygenated cells. Radiation biologists often speak of the Oxygen Enhancement Ratio (OER) defined as the dose required for destruction of a hypoxic cell divided by that for an oxygenated cell. Unfortunately, tumorous cells can be hypoxic, making them typically three times more resistant to x-radiation (OER = 3). On the bright side, the OER factor is not the same for all types of radiation and for the very large LET obtainable with heavy ions, the OER decreases to near one. This gives a double-barrelled advantage to the heavy ion beam. Not only can the ion deliver more radiation more selectively but it is more effective in destroying tumorous cells. A cancerous tumour can be destroyed with much less total dosage to the patient.

The LBL biomedical programme is concentrating on measuring the basic parameters needed for heavy ion therapy and one can look forward to the day when the technique will be widely used. Special biomedical accelerators, much smaller and less costly than existing machines, are envisaged and may make heavy ion therapy available at future treatment centres.

Two major improvements, now in the planning stage, should extend the capabilities of the Bevalac considerably. One is the installation of a new liner inside the Bevatron vacuum vessel to improve the machine vacuum to around 10^{-9} torr, thus allowing much higher beam currents. The second is the addition of a third injector to the SuperHILAC. LBL has requested six million dollars from ERDA for these improvements and hopes for funding by FY 1978. With the full facility, ion beams all the way up to uranium could then be accelerated.

The Bevatron synchrotron, among the most famous and productive accelerators ever built, has found new life with the heavy ions. The availability of the SuperHILAC as heavy ion injector and the skill of the accelerator specialists enabled a 6 GeV proton machine, which had been overtaken by higher energy machines elsewhere as the scene of front-line physics, to come back with a unique experimental programme. It is still early days in the Bevalac's life. The proven and potential abilities of the facility promise a broad range of good physics for many years to come.

Herman Grunder, one of Berkeley's leading heavy ion specialists, spoke on 'Very High Energy Heavy Ion Accelerators' at the Gatlinburg Conference on Heavy Ion Sources in October 1975. He concluded his talk with 'The ten commandments of a heavy ion accelerator builder' —

1. *Thou shalt begin with the reliable creation of a large congregation of ions, densely packed and as naked as possible.*
2. *Thou shalt separate the chaff from the wheat fast, or convert the chaff into wheat, so that all may be equal.*
3. *Thou shalt surround thine congregation of densely packed equal ions with great nothingness so that they may remain equal.*
4. *Thou shalt encourage the congregation to leave the place of birth rapidly (10 MV/m is about right).*
5. *Thou shalt provide 2, 4, 6 and 8 poles to keep the congregation together.*
6. *Thou shalt, after an appropriate travel, encourage the congregation to shed unnecessary clothing so that the congregation may reach a higher energy more comfortably.*
7. *Thou shalt not give the congregation an opportunity to tangle with its stationary neighbors or they will never reach relativistic speeds.*
8. *Thou shalt be humble if the congregation falls apart prematurely, or the experimenter doesn't know what he is doing. Thou shalt be rewarded in heaven.*
9. *Thou shalt not exceed $\beta = 1$, or Einstein will become unhappy.*
10. *Thou shalt perform all the above miracles within budget, fast and reliably or Saint George will become very unhappy.*

The meeting on the World Machine

As reported in our May issue, experts from all the regions in the world where high energy physics is done gathered in Serpukhov near Moscow from 17-25 May as a Study Group for discussions on future accelerators. The main theme was the possibility of worldwide collaboration on the construction and exploitation of a 'Very Big Accelerator (VBA)'.

A series of speakers at the Study Group (M.A. Markov, J. Bjorken, Leon Lederman, A. Rousset, Ugo Amaldi, Y. Prokoshkin, S. Gerstein, Guy von Dardel) covered the physics interests of future generations of machines, illuminated particularly by the spectacular discoveries of the past two years.

The meeting had reports on new machines under construction — the DESY 19 GeV electron-positron storage ring PETRA, the Berkeley/Stanford 15 GeV electron-positron storage ring PEP (both reported by Gus Voss) and the Novosibirsk 7 GeV electron-positron storage ring VEPP-4 (A. Skrinsky). This was followed by other projects which are at the proposal stage — the Brookhaven 200 GeV proton-proton storage rings ISABELLE (Mark Barton), the Fermilab 1 TeV proton synchrotron Energy Doubler (Bob Wilson), the Serpukhov 2 TeV proton synchrotron UNK (V. Yarba), the KEK proton-proton-electron storage rings TRISTAN (Y. Yamaguchi), the Argonne/Fermilab 1 TeV proton-proton storage rings POPAE (Bob Diebold) and the Novosibirsk proton-antiproton storage rings (A. Budker). Finally, the CERN studies were described on higher energy proton-proton storage rings LSR and on their electron-proton option (Kjell Johnsen). These have not been taken to the proposal stage.

There was general agreement in the Study Group that the next stage in machine building could be confronted on a regional basis with collaborations of the extent that exist at present. Thus, in the USA, USSR and Japan there are proposals which, it is believed, are within the capabilities of the individual regions. There is no definite proposal in Europe but Kjell Johnsen has led preliminary studies on proton and electron storage rings and Pierre Darriulat is presently heading a study of physics with electron-positron storage rings. The European Committee for Future Accelerators, ECFA, has established a Committee for Accelerator Studies which will consider the options for a next Western European machine.

The belief that the immediate future generation can be tackled on a regional basis was coupled, however, with two broader considerations. The first was that the selection of the range of new regional facilities should ideally be made in close collaboration so as to ensure coverage of the broadest possible programme of research. The Study Group also recommended joint studies of new technology, such as superconductivity and new particle detection methods. The second was the importance of joint utilization of all such facilities by scientists of different countries.

The Study Group stressed that, beyond this stage, will come the requirement for an accelerator complex significantly more powerful that those planned for regional facilities. It is too early to define such a VBA at this stage but the scale is set by thinking of a proton synchrotron of 10 TeV or over (discussed by David Thomas and Bob Wilson) or electron positron storage rings of 100 GeV or over (Kjell Johnsen). Such machines are in the 5 to 15 km radius range. It is expected that such facilities would be so large that their realization would be possible only by pooling the resources of all the regions into common international projects.

Creation of a VBA would involve complicated scientific, technical and organizational problems requiring several years of discussions. The Study Group recommended that these discussions should begin in the near future with a view to starting design in about ten years. They would extend the existing international collaborations and to meet the organizational need of a body to keep the 'world machine' flame alive over the coming years, the Study Group decided to ask the IUPAP (International Union of Pure and Applied Physics) Division of Particles and Fields to become involved. The IUPAP Division could oversee the organization of working groups and set up further meetings like the one at Serpukhov.

In addition to the speakers mentioned above, other participants at the meeting were — A.A. Logunov, A.A. Vassilyev, V.A. Glukhikh, L.D. Soloviev, I.V. Tchuvilo, A.Ts. Amatuni, N.A. Monszon, A.A. Naumov, V.A. Vassiliev, N.E. Tyurin, V.F. Kuleshov (USSR), K. Lanius, V.P. Djelepov (Dubna), V.F. Weisskopf, D. Eulian (USA), D. Husmann (CERN Member States).

Still more new particles from SPEAR

The electron-positron storage ring, SPEAR, at Stanford continues to improve its already high physics/dollar ratio. The latest announcement is of the observation of a particle at a mass of 1.865 GeV which looks a likely candidate for the first 'charmed' meson ever to be clearly identified.

At the end of 1974, SPEAR was the scene of the discovery of the 3.1 GeV particle, J/ψ, simultaneously with Brookhaven. This particle, and its relations found with SPEAR and with the DORIS storage ring at DESY, has been interpreted in terms of a new particle property called charm. J/ψ is explained as a charmed quark — charmed antiquark combination.

If this explanation is correct, we can expect the existence of families of charmed particles where the charmed quark is in combination with some of the familiar quarks (the proton, neutron and strange quarks). For reasons that we will not repeat (see April issue 1975, page 106), a charmed meson, usually called a D particle, is anticipated at around 2 GeV and is expected to decay predominantly into a strange particle (like a kaon) plus other particles (like pions).

The search for charmed mesons and charmed baryons has been under way for over a year. From Brookhaven, CERN and Fermilab there are a collection of bubble chamber photographs recording events which cannot be explained by 'conventional' physics and which can be interpreted in terms of the production and decay of a charmed particle. With one exception, the events have emerging neutrinos and it is not possible to get at the masses of the charmed particles which might be involved. The latest news from Stanford seems to bring precision to bear for the first time.

The Berkeley/Stanford team using the famous SPEAR magnetic detector have amassed 20 000 events in a run between September 1975 and January 1976 over the centre of mass energy range 3.8 to 4.5 GeV. In this data they have about 300 events (above background) in which the mass/energy of a cluster of particles adds up to 1.865 ± 0.005 GeV. This is the classic route to unearthing the existence of a particle of such a mass which has decayed to give the particles which are observed. The clusters of particles which have been seen by the detector are $K^+ \pi^-$, $K^- \pi^+$, $K^+ \pi^+ \pi^- \pi^-$, $K^- \pi^+ \pi^- \pi^+$. The mass resolution of the detector gives masses accurate to 30-60 MeV depending on particle momenta. It is likely that the 'width' (which corresponds to the stability) of the 1.865 GeV particle is less than 15 MeV.

The data has had to be analysed carefully to ensure that the decays were not from known K^* resonances. Setting SPEAR at energies to produce the ψ' (3.7 GeV) particle gave many K^*s but no events corresponding to 1.865 GeV. It was only on moving into the higher energy ranges that the particle appeared and the clean threshold effect seems to rule out K^*s.

It looks as if SPEAR is producing a neutral charmed meson, D°, in the interaction $e^+ + e^- \rightarrow D^\circ + \overline{D^{\circ *}}$ or $\overline{D^\circ} + D^{\circ *}$. The D° then decays into, for example $D^\circ \rightarrow K^+ \pi^+ \pi^- \pi^-$. The $D^{\circ *}$ is more difficult to pin down because of the additional ways in which it can decay but by considering the remaining energy involved when a D° is produced, there might be another particle at 2.02 GeV.

POPAE design study

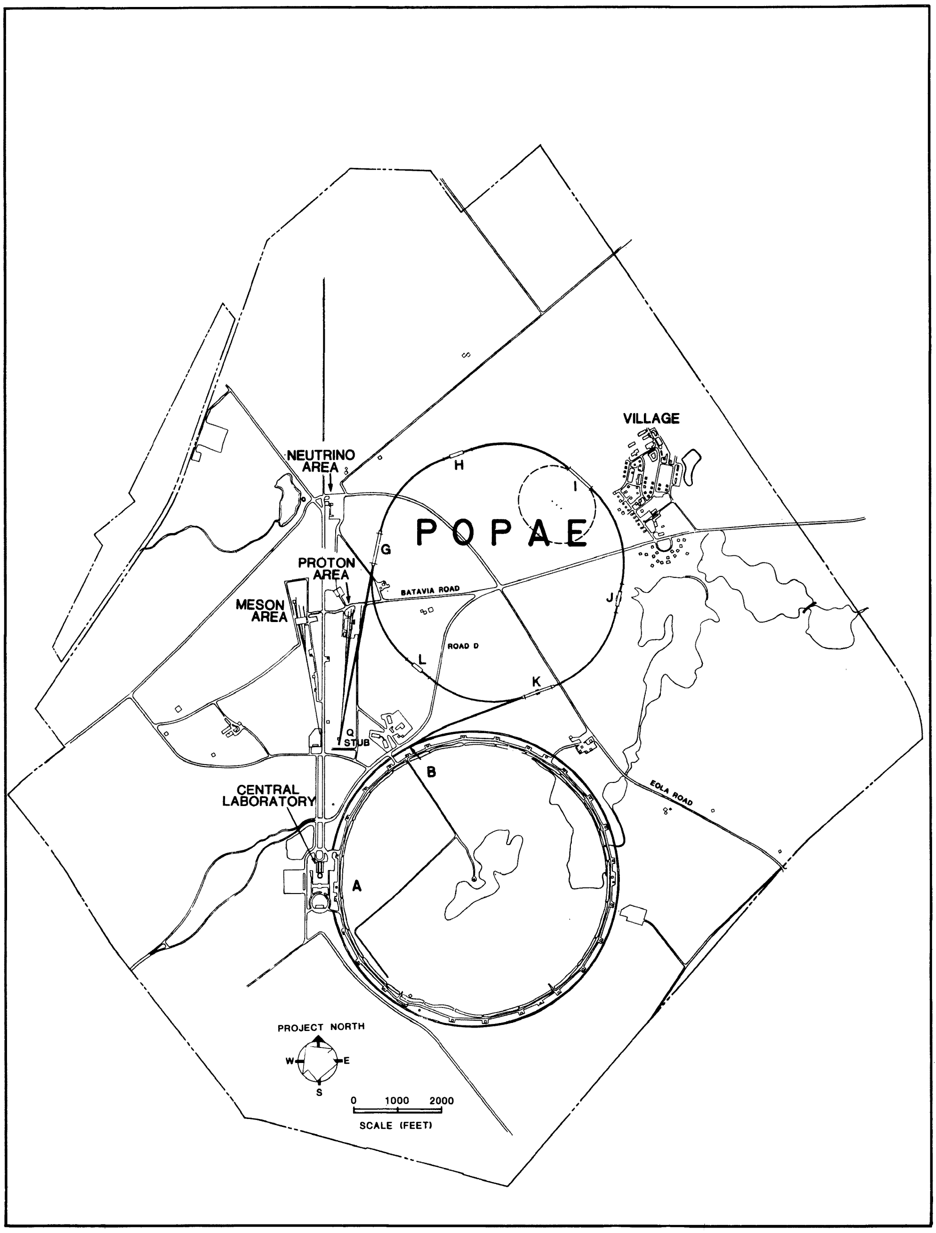
A design study for a 1000 GeV on 1000 GeV colliding proton beam storage ring facility to be located at Fermilab has recently been completed and submitted to ERDA in the form of a proposal. Work on the study was started in the fall of 1975 under the direction of Robert Diebold and has been done as a collaboration between Argonne National Laboratory and Fermilab.

The construction of such a colliding beam facility (denoted by the acronym POPAE — Protons On Protons And Electrons) at Fermilab would take advantage of the substantial national investment in the facilities of the Laboratory. The present accelerator is itself a uniquely suitable device for filling storage rings with high energy protons and completion of the Energy Saver/Doubler will increase the available proton energy to 1000 GeV. The research capabilities of Fermilab would thus be extended in a natural and complementary way by the addition of the proposed storage rings.

High energy storage rings are being considered at other Laboratories. Brookhaven National Laboratory has proposed a 200 GeV on 200 GeV proton-proton colliding beam facility, ISABELLE, which would accelerate the protons from a 30 GeV injection energy. CERN has studied the possibilities of 400 GeV on 400 GeV storage rings, LSR, which like POPAE would receive protons from an accelerator at the desired energy.

At present, the ISR at CERN are the world's only proton-proton colliding beam machine. It has given an enormous increase in useful energy over that previously available, up to an energy equivalent to that of a 2000 GeV fixed-target accelerator. However, this energy has since been approached by Fermilab, which is now running routinely at 400 GeV and will achieve 1000 GeV with the Energy Saver/Doubler.

Proposed location for POPAE — Protons On Protons And Electrons storage rings — on the Fermilab site. New beam lines are shown as heavy black lines and the letters G, H, I, J, K, and L indicate the experimental areas at beam intersections.



For further energy increases, colliding beams quickly outstrip the useful energy of fixed target machines, even those that might conceivably be built as part of a world-wide collaboration. In terms of equivalent fixed-target machine energy, POPAE would provide a factor of 1000 increase over the ISR. The phenomena found in the energy range spanned by the previous factor of 1000, going from 2 GeV (two protons at rest) up to a fixed-target equivalent of 2000 GeV at the ISR, have profoundly changed our understanding of Nature encompassing the whole history of particle physics. There are some ideas of what may be found as the frontier advances beyond present energies, but considering the surprises in the previous factor of 1000 it seems probable that these expectations will pale beside the phenomena which will actually be discovered.

The interest in colliding beams at Fermilab goes back to the site-selection days when one of the criteria was that space be available to accommodate future storage rings. Indeed, the State of Illinois went to great expense in the purchase of land to provide this capability. In 1968, some of the Laboratory staff, working with other physicists, carried out a colliding beam design exercise and in 1973 various possibilities for colliding beams at Fermilab were considered at a lively and productive summer study. Out of this study grew the recommendation that a system of pp and ep colliding beams be pursued. Although other Laboratory needs were pressing, the work initiated at the summer study was continued by a small group at Fermilab through 1974 and into 1975, resulting in a Phase I design report.

In the fall of 1975, Robert Sachs, the Director of Argonne, suggested that Argonne and Fermilab collaborate in a joint design study. This suggestion was welcomed by Robert Wilson, the Fermilab Director, and since that time an Argonne/Fermilab team has been developing the detailed conceptual design and writing the proposal. Although the present design does not include detailed provisions for electron-proton collisions (being more of a POP than a POPAE), an electron storage ring may be added later with a minimum of disruption and cost.

The two rings of POPAE would be housed in a common tunnel of circumference 5.5 km (slightly smaller than the 6.3 km of the Main Ring). The machine would be located in an area, bounded by the Main Ring, the Proton Laboratory and the Village, which is rather level and free of obstructions. This results in nearly straight injection lines to the storage rings. These lines would consist mainly of buried vacuum pipe with quadrupole doublets every 150 m for focusing, and would be relatively inexpensive both to build and to operate. One of these lines would originate at the 'Q stub', located in the Proton Laboratory beam line, and the other from a new extraction point at the B straight section. Each storage ring would be composed of six 720 m long curved sections, separated by 200 m long straight sections where the beams are focused and intersect one another.

For a storage ring system, the luminosity is second in importance only to the energy. For operational ease, POPAE would initially be tuned with fairly gentle focusing in the interaction regions. Later, stronger focusing would permit the luminosity to be increased to a design value of 4×10^{33} per cm^2 per s. This is two orders of magnitude higher than obtained at the ISR since, even with a lower proton current, thanks to the high energy, the beams would be smaller in size and a smaller crossing angle can be used without the beam-beam tune shift becoming excessive. The high

* *On 17 June the SPS reached 400 GeV.*

Around the Laboratories

luminosity should help considerably in experiments looking for rare processes. For example, at this luminosity a process with cross section 10^{-38} cm^2 will yield a few events per day. There appears to be no hard limit on the stored proton current, and it may eventually be possible to store more than the design current of 5 A giving luminosities of over 10^{34} per cm^2 per s.

To fill one ring to the design value of 5 A would take 6×10^{14} protons, corresponding to 66 accelerator pulses at 10^{13} per pulse. The time to do this would range from a few minutes at low energies to less than an hour at 1000 GeV. Each ring would be able to store high beam currents at energies between 100 GeV and 1000 GeV, and unequal-energy operation would be possible if required by experiments. Although the attainable luminosity falls with decreasing energy, some experiments should be possible even below 100 GeV.

Superconducting magnets have been specified for POPAE since the magnet technology has been moving ahead in the past few years to the point where one can confidently predict its successful application to high energy storage rings. A field of 6 T at 1000 GeV has been used in the design, somewhat higher than the 4 to 4.5 T design of the Energy Saver/Doubler and of ISABELLE. A 6 T dipole magnet of a design rather similar to that proposed for POPAE has been built and operated by H. Desportes and his colleagues at Saclay and this field strength appears to be a reasonable goal for the next step in accelerator technology. For POPAE, this high field would result in both cost savings and a better behaved machine compared to lower field designs. The Saclay magnet used eight flat racetrack coils bent up at the ends to pass over a 9.2 cm bore tube. After some modifications to the end clamping, this magnet reached its design field of 6 T without iron and with good uniformity. It showed only a few percent training and the superconductor operated at 97 % of the short-sample current.

The POPAE vacuum is proposed to be primarily a cold-bore system, with warm-bore only in the straight sections. This is a natural choice for superconducting magnets and takes advantage of the extremely high pumping speeds available at liquid helium temperatures. With high vacuum preparation of materials, a vacuum of about 10^{-11} torr could be obtained in the warm-bore sections, while better than 10^{-13} torr is anticipated for the cold-bore regions. With the high pumping speed of a cold-bore system and the relatively low beam current, it seems possible to avoid the pressure bump problem seen at the ISR. Although a cold-bore system may be less flexible than a warm-bore one, it is attractive due to simplifications of construction, low heat leak, very low residual gas density, and large reduction in the number of conventional vacuum pumps required. Such considerations have led to its adoption in the Energy Saver/Doubler and in the Lawrence Berkeley Laboratory ESCAR project.

The total construction cost of the facility, including engineering and architectural costs, contingency, etc., is estimated to be $245 million in 1976 dollars. A scaled-down version of POPAE capable of 500 GeV in each ring, using 3 T magnets but the same tunnel as in the 1000 GeV version, is estimated in the report to cost $155 million.

CERN *
SPS nearly there

With the inevitability which dogs the life of journal editors, the big event just follows Press Day. It looks as if our June issue is just missing first acceleration to full beam energy at the 400 GeV proton synchrotron, the SPS. Protons have already reached 200 GeV and no serious hindrance seems to stand in the way of 400 GeV.

In our May issue we reported successful injection and circulation of the beam at the touch of a button. Since then life has been harder. The first attempts at acceleration brought no joy — protons were lost at about 15 GeV. On 26 May it was found that the dipole magnets and quadrupole magnets in the ring were not tracking together — the bending and the squeezing of the beam were not keeping properly in step as the fields were increased. Immediately the appropriate adjustments were made, the beam sailed through the tricky transition region (just over 20 GeV) and was soon out to 80 GeV which was the maximum possible with the two power supplies then hooked up.

On 4 June, more supplies were in circuit and currents giving fields equivalent to a 200 GeV beam were available. The first pulse had protons at 200 GeV. By 9 June there were still more supplies hooked up bringing 400 GeV within reach. Some tidying up is needed to get the power supplies operating correctly together.

Obviously in a machine of such complexity there is more tidying up to be done elsewhere — drawing the best out of the magnificent computer control system, sorting out some beam losses, getting the tracking perfect, bringing the ejection systems into action etc... But all the indications so far are that CERN has a fine machine on its hands.

Labelling particles in the nucleus

In 1953 two Polish physicists, M. Danysz and J. Pniewski, analysed an event in nuclear emulsion as being due to the decay of a 'hypernucleus' — a nucleus in which a lambda particle has joined the usual protons and neutrons. This was the start of a method of investigation which has a unique feature since it is the only way of labelling a particular particle in the nucleus.

Hypernuclei can be formed by converting a neutron into a lambda following a collision between the nucleus and a strange particle such as a negative kaon. The lambda is very like the neutron — it is only slightly heavier, it has no electric charge and has the same spin. The distinguishing feature is that the lambda has the property of strangeness and, though it can live in the nucleus in the place of a neutron for a long time (on nuclear time-scales), it can be seen when it decays because the nucleus will then emit a particle such as a pion which a non-strange nucleus could not do. Thus in a hypernucleus the place normally occupied by a neutron is tagged by the strangeness property of the lambda.

Through to the end of the 1960s experiments continued in nuclear emulsions. They revealed the binding energies with which the lambdas were held in ground state (state of lowest energy) hypernuclei. Then high intensity kaon beams became available and made it feasible to look at higher energy states of hypernuclei.

A Heidelberg team (Max-Planck-Institut für Kernphysik and Physikalisches Institut der Universität) has developed a technique at the CERN proton synchrotron involving sending negative kaons at targets and producing hypernuclei via the interaction $K^- + n \rightarrow \pi^- + \Lambda$ which was suggested by M.I. Podgoretski (Dubna) and H. Feshbach and A.K. Kerman (MIT). With a very refined magnet system the Heidelberg team can pick out when they have converted a neutron into a lambda in a recoiless (or near recoiless) fashion. They have used 900 MeV/c kaons and recorded the emerging pions travelling in the same direction as the kaons leaving the lambdas behind with no recoil. The technique has been used to investigate hypernuclei of beryllium, carbon, oxygen, sulphur and calcium.

The probability of the interaction taking place depends upon the energy (some tens of MeV) to establish the binding of the lambda in the nucleus in some allowed energy state. Thus for each element a spectrum is obtained which gives information on the energy states which can be occupied.

There are two distinct theoretical approaches as to what might happen. The 'single particle model' considers the individual effects, in each energy shell, of swopping a lambda for a neutron. This approach predicts a series of peaks in the energy spectrum, each peak corresponding to an energy state and is a good test of the shell structure which is inaccessible by other means. All the spectra observed by the Heidelberg team with the exception of calcium, show such a structure and can be qualitatively explained using the single particle model.

The other approach, developed particularly by H.J. Lipkin, is the collective model which assumes that all neutrons in the nucleus contribute to the effect on the lambda so that no matter which neutron is replaced the energy involved will be the same. The spectrum would then show a single broad peak (sometimes called the strangeness analogue resonance). The Heidelberg calcium spectrum is tending this way but not conclusively.

Calcium was the heaviest nucleus investigated and it may be that collective effects begin to dominate as the number of neutrons in the nucleus goes up. The Heidelberg team, joined by a Saclay group, will be collecting more data and may be able to select between the two approaches more clearly in future experiments.

LOS ALAMOS
110 microamps in experimental area

On 1 June the 800 MeV proton linear accelerator, LAMPF, passed another milestone in its programme to achieve higher intensity operation when a full energy beam of about 110 μA was delivered to the main experimental area. The test run lasted for about two hours and all targets were in the beam. The purpose of the test was to check out diagnostic instruments, beam transport and radiation shielding.

The Director of LAMPF, Louis Rosen, noted that the facility has now demonstrated the capability to reach its immediate objective of routine operation at 100 μA by the fall of 1976. The accelerator has previously completed successful test runs with an intensity as high as 165 μA but the June run was about twice the previous record for beam delivered to the experimental area.

Since resuming regular research operation on 5 April, LAMPF has maintained its schedule of increases in beam level while running all secondary channels. During the last two weeks of May, it operated smoothly at a current of 35 μA with a beam availability of 80 %. The June research programme will run at 50 μA and regular operation at 100 μA is scheduled to be reached by September.

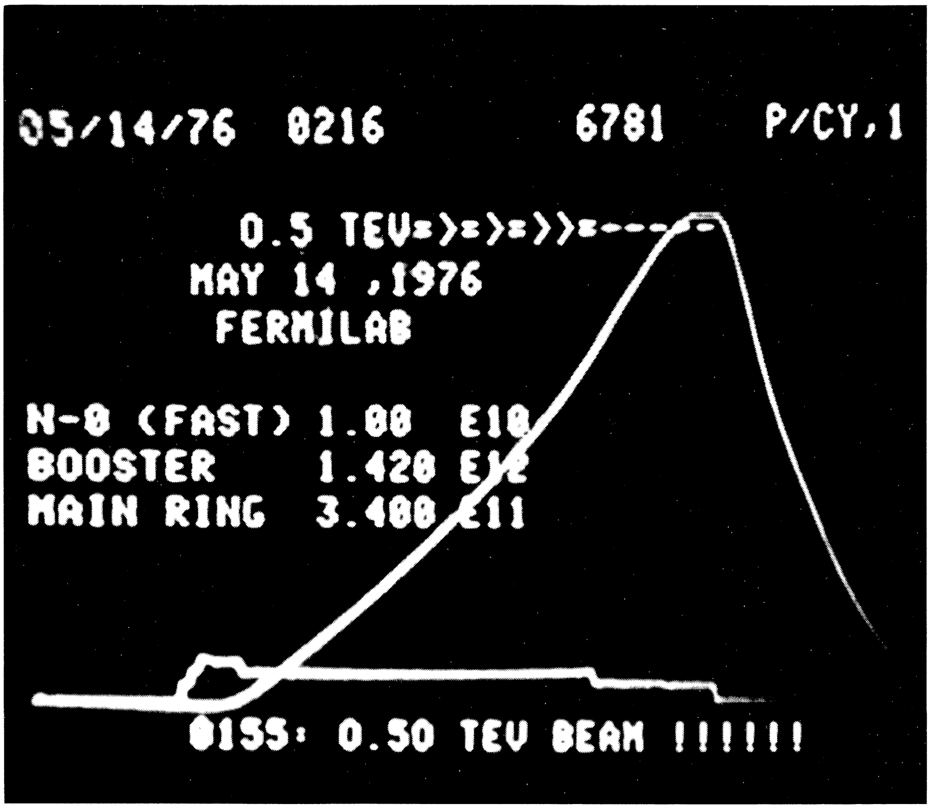
During April and May, the accelerator delivered about 18 000 μAh of

Anxious faces (Helen Edwards, John McCarthy and Robert Webber) in the control room watch beam creep out to the new record energy of 500 GeV at the Fermi National Accelerator Laboratory. Below, the TV screen picture proudly recording protons at 0.5 TeV on 14 May.

(Photos Fermilab)

800 MeV protons exceeding the total delivered during the 1973-74 operating period. In addition to the established secondary channels, the EPICS pion channel is now in operation (but without its spectrometer) and beam checkout runs to both the HRS, high resolution spectrometer, area and the pulsed neutron lines have been carried out.

About thirty-five experiments have received beam since the end of the 1975 shutdown and twelve have already finished taking data. Among those completed are experiments on direct lepton production in proton-proton collisions, total pion cross sections, mesonic x-rays, pion production in neutron-proton collisions and pion forward elastic scattering.

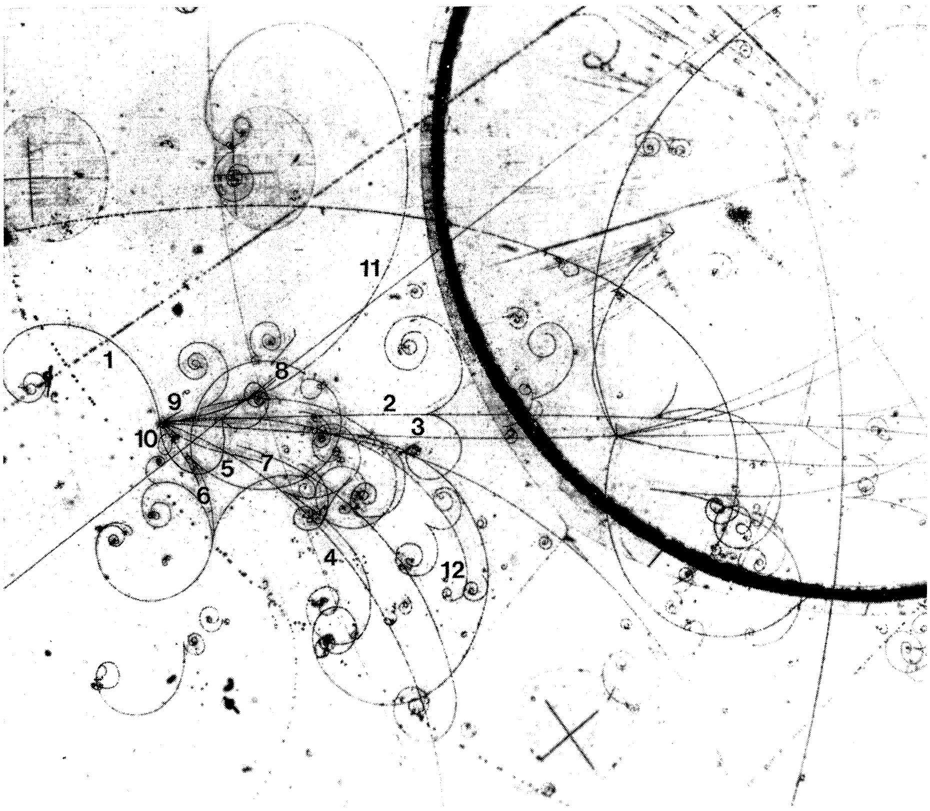


FERMILAB
Acceleration to an energy of 500 GeV

On 10 April 1970 Professor R.R. Wilson, Director of the Fermi National Accelerator Laboratory, had more than usual impact on a Users' Meeting which was pulling together the experimental programme for the 200 GeV proton synchrotron then under construction. He announced that the magnet design that had been evolved, coupled with advances in power supply technology, made it possible to envisage a peak machine energy of 500 GeV. On 14 May 1976 the operators coaxed this world record from the accelerator for the first time.

Over the past few years the Fermilab machine has experienced a series of 'three steps forward and two steps backward' in moving from 400 GeV, which has become the normal operating level, to the 500 GeV goal. The essential improvements that have finally done the trick are the installation of a new primary transformer, a capacitor

An antineutrino event in neon (77 mole %) — hydrogen in the 15 foot chamber with 500 GeV protons on the target. Track 1 ends in a positron and might start as a positive pion decaying to a muon. Track 5 in a clear pion-muon-positron decay. Track 2 may be a muon. Tracks 3, 4, 6, 7 are hadrons (probably pions); tracks 8, 9, 10 are stopping protons from the shattered neon nucleus. Tracks 11 and 12 are an electron-positron pair from gamma conversion. A Berkeley/Hawaii/Washington collaboration is analysing the antineutrino events while a Columbia/Brookhaven collaboration is analysing the corresponding neutrino events.



tree as part of the system which buffers the impact of the power swing at the accelerator on the electricity grid, new high voltage power lines, better magnet cooling and revised computer control programs for the power supplies.

Armed with this new ammunition, the operating crew went into action on 11 May. Reaching 450 GeV was no problem and the magnet ramp was then set for 480 GeV. This is where the coaxing began. The power supply team under Jim Hogan circled the service buildings around the main ring nursing the 60 power supplies up to the new level. In the control room Howie Pfeffer had the job of getting the required performance out of the capacitor tree. On the night of 12 May, 480 GeV was mastered and by the next morning this had been nudged to 492 GeV where it looked stuck.

To prise out the last bit of power, the tune of the machine was lowered so that the power needs of the focusing quadrupoles could be reduced to the benefit of the peak field in the bending magnets and thus the peak energy of the machine. At 1.55 h on 14 May protons were accelerated to 500 GeV. Phil Livdahl's Accelerator Division dropped the GeVs and moved to the new energy unit TeV — tera-electronvolt — a million million electronvolts. They have a 0.5 TeV machine.

The accelerator ran reliably for six hours at the new energy. The repetition rate was low and intensities were at the few 10^{12} protons per pulse level but two experiments were able to take data. A Stony Brook/Columbia team looked at $p + p \rightarrow p + X$ using an internal target and beam was ejected to the Neutrino Area where a California / Hawaï / Washington / Berkeley team took pictures in the 15 foot bubble chamber.

It is particularly in neutrino interactions that the physics interest of the newly available peak energy is likely to lie. Russ Huson, Deputy Head of the Accelerator Division, predicts that experiments at 450 GeV could be scheduled in six months' time and at 500 GeV in the spring of next year.

Polarized target comes into operation

The first polarized proton target at Fermilab has come into operation in the M1 beam line at the Meson Laboratory. A collaboration of 'old hand' polarization experts from Argonne, Berkeley, Fermilab, Harvard and Yale are mounting the experiment. The first data run is now under way at 100 GeV/c and the apparatus is working well.

The target follows polarization techniques that have been in use for several years. The target, 2 cm × 2 cm × 8 cm long, consists of millimeter-size balls of frozen ethylene glycol which are initially transferred into the target container at liquid nitrogen temperature. It is cooled with an open helium-4 loop and a closed helium-3 loop to its operating temperature of 0.4 K. Target polarizations of 80 to 90 % are achieved. The cryogenic system was developed at Argonne; the polarizing magnetic field is furnished by the Zoltan magnet which was used for many polarization experiments at Berkeley in the 1960s.

The polarization of the target is perpendicular to the scattering plane. Both the forward scattered and the recoiling particles are detected and momentum analyzed in magnetic spectrometers. Information from proportional wire chambers is used in a fast trigger to suppress events resulting from interactions involving bound protons in the target material, which are not polarized.

The experiment is planning to

During the Conference on Computer Assisted Scanning, the participants had the traditional taste of Italy's cultural riches. Some of them are seen here at the ancient theatre (built in the 16th Century) of Padua University.

(Photo Rinaldi)

measure the polarization parameter for elastic $\pi^{\pm}p$, and pp scattering at incident momenta from 50 to 200 GeV/c. Some data, although of reduced statistical accuracy, will also be obtained for $K^{\pm}p$ and $\bar{p}p$ scattering. At these energies, the polarization is expected to be only a few percent. Hence, the apparatus has been designed to handle very high beam rates and every effort is being made to keep systematic errors to a minimum.

PADUA Conference on Computer Assisted Scanning

About 120 people attended an International Conference held in Padua from 21-23 April on the analysis of images, in high energy physics and other fields, by random access flying spot devices. A Conference on the same topic was held in Oxford two years ago (see June COURIER 1974). The Conference was hosted by the University of Padua and by the Centro Culturale Cardiologico at Villa Contarini (now Simes) whose 16th century architecture and magnificent parks made a fine setting.

Many CRT devices for measuring bubble chamber film are routinely operating at a highly reliable and stable level in large Laboratories and in small University centres. The measuring rate and the quality for standard bubble chamber films are both completely satisfactory. However, no substantial technical improvements have emerged recently.

First results on the use of CRT devices for measuring film from the new large bubble chambers were reported and it seems that many difficulties, due to the very high noise level on the image and the confused patterns, are still present. Experience is limited to only a few Laboratories up to now and the main difficulties are not in 'reading' the film but in reducing and processing the data. The problems connected with experiments in hadron physics at energies of hundreds of GeV were also discussed. In particular the hybrid spectrometer at Fermilab and that foreseen at CERN were reviewed, together with the problems of measuring the high multiplicity high energy events.

Possible applications of computer aided scanning techniques in fields different from high energy physics were among the main topics at the Conference. Some examples of the recent developments in this area are:

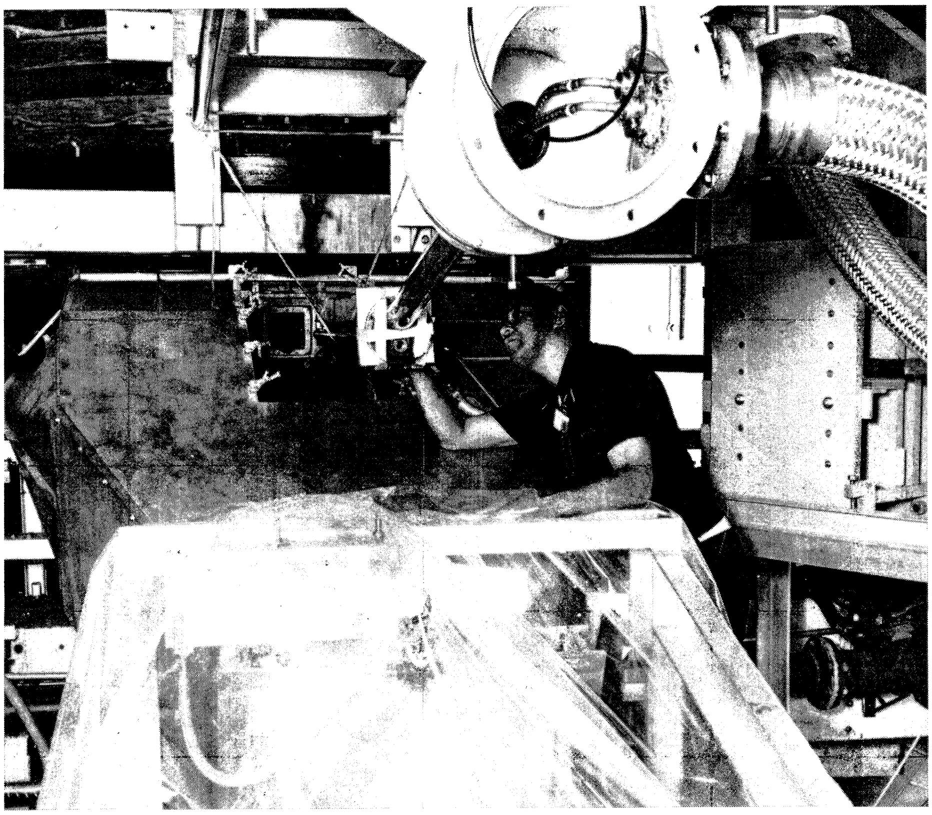
At Nijmegen a PEPR is being used to study the feasibility of automated analysis of photomicrographs of cervical smears for cancer screening (see page 218).

At Oxford a system based on a PEPR for reading microfilmed rain charts has been in operation for two years on behalf of the British Meteorological Office.

The 'Traitement de l'information techniques nouvelles' Company at Morangis in France has been involved, since 1971, in image analysis problems. They have built a flying spot scanning and measuring system for nautical maps (called CARTAS), a laser scan device for chromatographic measurements on colour documents and a photodiode linear array digitizing system for very large charts.

At Padua a PEPR scanner is being used to study the feasibility of automatic measuring of contour lines on geographic maps.

Other topics discussed at the Conference were the analysis of biomedical samples, the scanning and measuring of plates of astrophysical interest, low price CRT scanners and high speed parallel processing of data by microprocessors.



Beam's eye view of the end of the 2 m streamer chamber at Stanford with its magnet (a coil is visible top left) and its high voltage pulse transmission line. The 1.5 m target 'straw' is shown receiving attention withdrawn from the chamber. Cameras view charged particle tracks from above through a hole in the upper magnet coil and through the wire mesh electrodes of the chamber itself.

(Photo SLAC)

STANFORD
Streamer chamber

The 2 m streamer chamber is a major facility available to experimenters at Stanford. SLAC Group D has used it in a series of collaborations with outside users and the latest experiment was a collaboration of Indiana/Vanderbilt/Purdue searching for exotic mesons in the reaction $\pi^- + d \rightarrow p$ (spectator) $+ X^{--} + p$ (forward). The experiment used a downstream magnet, wire chambers, and a Cherenkov to trigger the chamber on the forward proton. About 200 000 triggers were obtained, giving an exposure of 900 events per microbarn.

The chamber size generally used is 2 m × 0.8 m × 0.6 m. It sits in a 2 m conventional magnet viewed in three camera stereo through an open upper pole. Experiments are normally done with a 1.3 T field although (with justification and 6 MW of d.c. power) 1.6 T is available. The chamber is accessible from the sides, thus lending itself to a variety of triggers. Firing of the chamber must take place within a few microseconds after an interaction, hence the trigger logic must be 'hard-wired' and computer intervention is not possible. Beam line 23, which is incident on the chamber, has been used for pion, kaon, and muon beams and has a maximum momentum of 17 GeV/c. At modest cost, it is also possible to supply high energy photons and electrons. The chamber has been used with hydrogen and deuterium targets up to 60 cm long and 1.5 m is probably the maximum possible target length. The streamer chamber has shown appreciably better momentum and mass resolution than bubble chambers where ultimate accuracies are limited by multiple Coulomb scattering.

A new experiment by a UCSC/SLAC collaboration to study direct muon pair production in pion interactions is beginning to take beam. To date, lepton pair experiments have been done with poor mass resolution (about 200 MeV) and, as a result, a detailed study of possible mass states has been impossible. This experiment will have a resolution of about 1 % of the mass involved and a large solid angle acceptance. Its data rate will be such that it will be sensitive primarily to masses below 1 GeV.

A beam of 17 GeV/c pions will be incident in a 1.5 m liquid hydrogen target. A trigger will consist of any two particles of over 2 GeV penetrating a wall of lead downstream of the chamber. In the approved running time of 400 hours it is expected that about 4 000 direct muon pair events will be obtained. Three quarters of the data will be taken with negative pions and the remainder with positive pions.

In the same run approximately 100 000 pictures will be taken using the same apparatus but requiring only a single particle trigger. This is a follow-up on an earlier search for charmed hadrons performed with the streamer chamber. Tentative evidence for a few new mass states was obtained warranting a new effort with considerably increased sensitivity.

SLAC Group D plans two developments for the chamber. The first is a filmless readout technique where efforts are being concentrated on the use of CCD (Charge Coupled Device) arrays. The physical stability of such an array makes it possible, in principle, to preserve the inherent accuracy of the chamber. Available sensitivities are apparently adequate if the signal-to-noise ratio is improved by cooling. Such devices would not only have the major merit of eliminating the film step but also may give improved measurement of ionization.

Secondly, the research programme of the group requires the development of large size downstream neutral detectors. The group would welcome assistance in this project which it feels will be applicable to a large number of experiments.

NIJMEGEN
PEPR for physics and medical applications

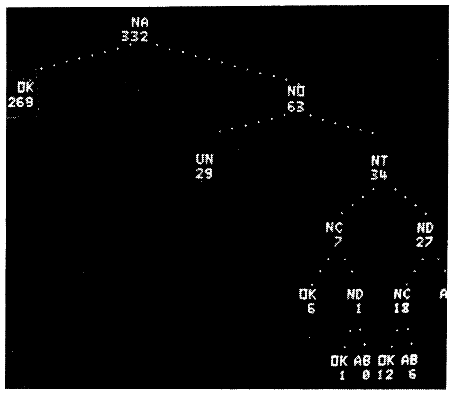
The PEPR scanning system at Nijmegen University matured in 1975. Using a modest 32 kword PDP-9 computer some 108 000 bubble chamber events were measured from a 4.2 GeV/c negative kaon-proton exposure in the CERN 2 m bubble chamber involving the Amsterdam/CERN/Nijmegen/Oxford collaboration. The photographs contained a wide variety of topologies.

Since coming into operation, the

1. The Nijmegen PEPR displayed these statistics in the form of a hierarchical tree from a cervical smear of a patient with a carcinoma. The nuclear area (NA) of 332 cells was examined. 269 showed small nuclear area (OK). 63 showed large area and 29 of them were identified as being due to nuclear overlap (UN). Of the remaining 34 optical texture (NT), nuclear/cytoplasmic ratio (NC) and optical density (ND) measurements indicated 15 (6+9) abnormal (AB) cells.

2. A normal cell (magnification 800) with the resulting PEPR data displayed below it. On the left statistics are presented numerically. Upper right is the nuclear/cytoplasmic picture, below left the nuclear overlap and below right the nuclear texture.

3. An abnormal cell with the corresponding data displayed as for the normal cell. This cell indicates a carcinoma in situ and is clearly picked out by the PEPR scan.



1.

PEPR has measured a quarter of a million events, about two thirds using a 5 inch CRT Astrodata-scanner and point guidance. The remaining third were measured on a newly developed homebuilt 7 inch CRT scanner using vertex-guidance. In this latter mode the vertex is predigitized in one or two views, with an accuracy varying between 0.5 and 0.2 mm. The average speed of measurement now obtained varies between 40 and 80 events per hour with efficiencies varying between 70 and 90% depending on the topology.

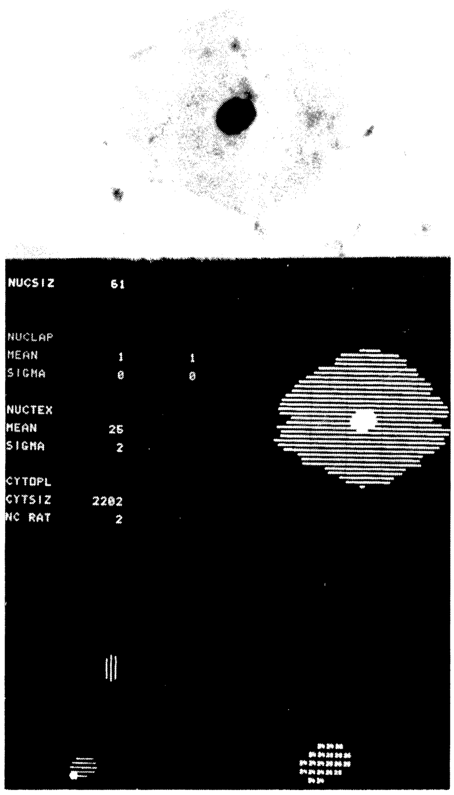
In the future, the 7 inch CRT is to be adapted to measure film from the 30 inch chamber at the Fermilab and from the BEBC European bubble chamber. Several hardware and software improvements for this next step are well under way. In addition, a replacement of the PDP-9 by a PDP-11/70 has been requested.

The 5 inch CRT is retiring from physics. Since February 1975 it has been used several hours a day for a medical application and it will be dedicated to this work from July. The application concerns the use of a CRT-scanner on Pap-smears to screen for cervical cancer. The increasing awareness of the value of screening for cancer of the cervix and the difficult and time consuming nature of manual microscopic analysis of cervical smears makes automation of this examination highly desirable. During the past year some very encouraging results were obtained. They were reported at the Padua Conference on Computer Assisted Scanning mentioned on page 217. The work is supported by the Queen Wilhelmina Cancer Foundation.

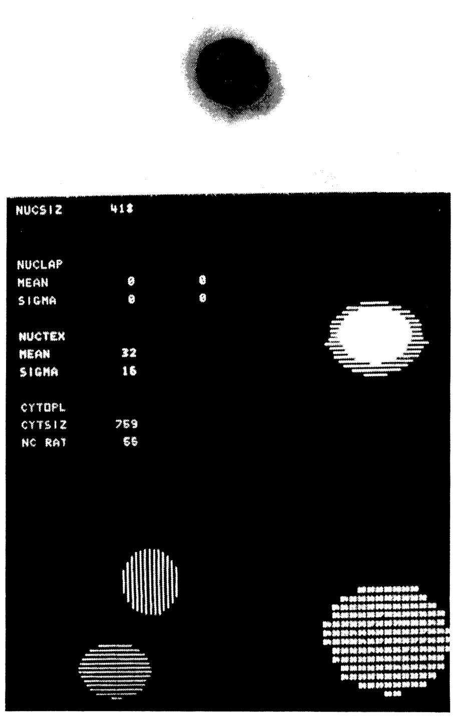
When scanning smears, PEPR is used in both a high speed sweep mode, in which objects are located and their widths are measured, and in a point strobe mode, in which optical density information is obtained. Software has been developed to measure nuclear area, nuclear optical density, nuclear optical texture, and nuclear/cytoplasmic ratio. In addition an algorithm has been developed to identify overlapping nuclei which may imitate an abnormal cell. These algorithms are invoked through a hierarchical tree strategy in order to optimize speed and efficiency. The figure shows statistics from a patient with a carcinoma in situ.

The Nijmegen results are still preliminary. The initial results were obtained with carefully prepared smears and further development is needed to bring the specimen preparation factors under control. So far, no thorough analysis of efficiency or of the false results has been made. However, the hardware and software have now evolved to the point where a system seems possible with the speed required for an automatic cervical screening device, i.e. capable of analysing a patient (about 10 000 cells) in less than a minute. The best contemporary experimental systems, based on automatised microscopes, typically require 10 to 15 minutes per patient.

Two important factors contribute to achieving this speed. First, film will be used as an intermediate medium allowing the screening of a complete smear with adequate resolution in just one or two frames, avoiding the inherent slowness connected with having to move the smear mechanically across the microscopic. Secondly, a new dedicated computer (PDP 11-40) with a high speed interface will be installed and the scanning electronics upgraded by the end of 1976.



2.



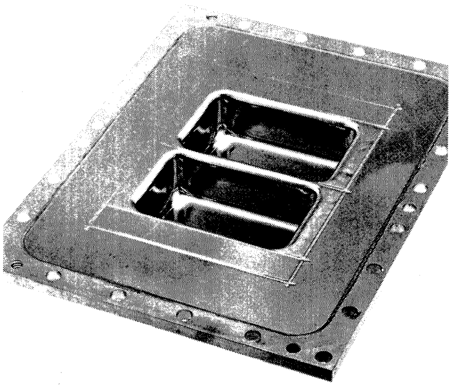
3.

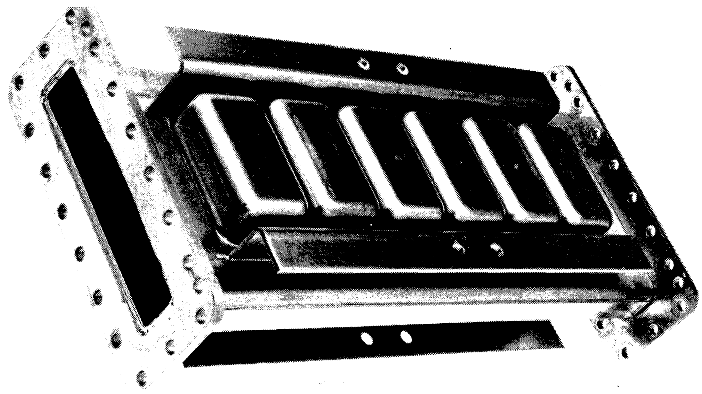
CORNELL Superconducting r.f.

The potential of superconducting materials in the construction of r.f. cavities has been under investigation

Superconducting r.f. cavity structures from Cornell. On the left is one half of a 2-cell 'muffin tin' cavity made of 1.6 mm niobium sheet. On the right is a complete 6-cell cavity also of the sheet-metal muffin tin variety. Rigid structural members are welded on to give mechanical rigidity.

(Photos Cornell)





for many years. After encouraging results on small cavities there has been a long period of frustration while trying to extend the production techniques to 'life size' accelerator or separator cavities. There are now clear signs of the light at the end of the tunnel with good results from Cornell on accelerator cavities and Karlsruhe on separators. The new, and proposed, electron synchrotrons and storage rings, where colossal amounts of r.f. power are soaked up in coping with losses due to synchrotron radiation, are crying out for the much lower power requirements that superconductivity could give them.

As reported in the March 1975 COURIER, a superconducting r.f. accelerating cavity was installed for tests in the Cornell electron synchrotron at the end of 1974. It was a 60 cm long, 11 cell S-band standing wave cavity made of niobium and was successfully operated during 1975 before being removed from the synchrotron. The cavity was used by itself to accelerate the synchrotron beam to 3.3 GeV and in concert with the normal r.f. system to accelerate the beam to 12 GeV for several eight hour periods. During this initial phase, the unloaded quality factor, Q_0, remained at its initial value of 1.1×10^9 and the effective accelerating field went up to 4 MeV/m.

During May 1975, the cavity was operated continuously at 1.8 K for ten days. The accelerating field was maintained at 3.3 MeV/m while accelerating the beam during normal operation of the synchrotron for high energy physics. As Q_0 and the field level had not deteriorated during this time, an accelerated life test was made in June 1975, by shutting off all the vacuum pumps in the neighborhood of the test section so that the cavity surfaces accumulated frozen material. After five hours, Q_0 had deteriorated by 30 %. This gas exposure corresponded to a normal operating period of 12 months and allowed an average thickness of 30 molecular layers to build up on the surfaces. The principal components of the frozen gas were air and water.

To study other possible harmful effects due to exposure to a synchrotron environment for extended periods of time, the structure was maintained in the synchrotron at room temperature until November 1975. At the end of this period Q_0 had deteriorated by a factor of 100. Upon removing the cavity and rinsing it with various solvents (heptane, trichloroethylene, acetone, and methanol), laboratory tests showed that Q_0 and the field were restored to their original values. A scanning electron microscope analysis of the dust obtained after evaporating the rinsing agents showed the chief culprit to be titanium compounds (possibly from two ion pumps mounted in an inverted position in the differential pumping manifold). It is encouraging to note that the contaminants did no permanent damage to the cavity and that no extensive chemical reprocessing was necessary.

Before applying superconducting technology to a synchrotron on a large scale, it is necessary to develop a fabrication method that is more economical and easier to execute than machining cavities out of solid niobium. With this goal in mind, several 1-cell, 2-cell, and 6-cell 'muffin-tin' style cavities have been fabricated out of 1.6 mm sheet niobium. Individual cavity cups are deep drawn and then electron beam welded into a single unit. Without any heat treatment the 6-cell cavities achieved Q's between 3×10^9 and 6×10^9 and accelerating field gradients up to 3 MeV/m. Apparently the stresses introduced by the deep drawing technique do not seriously inhibit r.f. superconducting properties. After firing at 1900°C in a high vacuum furnace at Brookhaven, Q values between 6×10^9 and 1.5×10^{10} and field gradients between 5 and 8 MeV/m were reached. Comparable Q values and significantly higher field values (up to 10 MeV/m) were obtained in the 1-cell and 2-cell cases.

Prior to firing, breakdown was determined to be due to 'thermal run away' at imperfections in the welds located at the irises between cups. After firing, field values were limited by multipactoring and associated heating. The possibility of inhibiting multipactoring by coating the niobium surface with a thin layer (10 to 20°A) of titanium or titanium nitride is under investigation.

An alternative economical method of fabricating large scale superconducting accelerating structures involves the deposition of a superconducting layer upon an easily fabricated substrate such as copper or aluminium. As a first step, it is important to prove that the deposition technique can produce adequate surfaces. Tests have been made with single cell cavities (fabricated out of niobium for the time being) on which a surface layer of niobium was deposited by sputtering. The sputtering was performed by the Cornell Department of Applied Physics in one case and by Battelle Northwest in another.

R.f. tests were made without any polishing or etching of the sputtered layers. In the first case the vertical sidewalls of the cavity were not covered by the sputtered layers. Nevertheless a Q of 6×10^8 and a field gradient of 2 MeV/m was obtained. In the second case, a layer of niobium 125 μm thick was deposited using a special high rate sputtering process and a target whose shape was tailored to achieve a uniform coating. A Q of 3×10^9 and a field gradient of 4.3 MeV/m was achieved. Although there is much room for improvement, these results seem to demonstrate that the sputtering technique is capable of producing surfaces of useful quality. The next step will be to deposit niobium on copper and aluminium surfaces and to improve the performance of these surfaces.

Experience at Cornell and other Laboratories has shown that the prospect of achieving even higher field gradients at S-Band (or L-Band) frequencies is beset by multipactoring problems. At high surface electric fields, electrons can be 'field emitted' and accelerated in the r.f. field. Upon impact with the cavity walls, secondaries are produced, and these in turn are accelerated and multiplied. At certain discrete field levels, determined by the geometry and frequency of the cavity, these multiplication effects can lead to resonances, i.e. multipactoring. At higher frequencies these resonances are shifted to higher field levels since the electron mean free path, which is comparable to the dimensions of the cavity, is shorter. Advantage can be taken of this effect to achieve much higher field gradients with X-band cavities, as has been reported by other Laboratories. Cornell are now making X-band muffin-tin cavities using their sheet-metal techniques and, if this method is successful, such cavities could form the basis for a high energy, high duty cycle linear accelerator.

Another project being pursued is the fabrication of niobium-tin cavities since the compound superconductor has a transition temperature of 18 K (compared to 9 K for niobium). If the r.f. properties of this material prove favourable, it would open up the possibility of operating cavities at 4.2 K instead of 1.8 K, the temperature at which niobium cavities are presently operated, giving significant saving in refrigeration cost.

People and things

Physics awards

The French Physical Society has awarded its physics prizes for 1976. Among the recipients are Jacques Prentki (Prix Robin for work in theoretical physics), who is Professor at the Collège de France and becomes Head of the Theory Division at CERN on 1 July, and A. Quinzer (Prix Esclangon for work in experimental physics) who is at the Laboratoire de l'accélérateur linéaire at Orsay.

Tribute to Bernardini

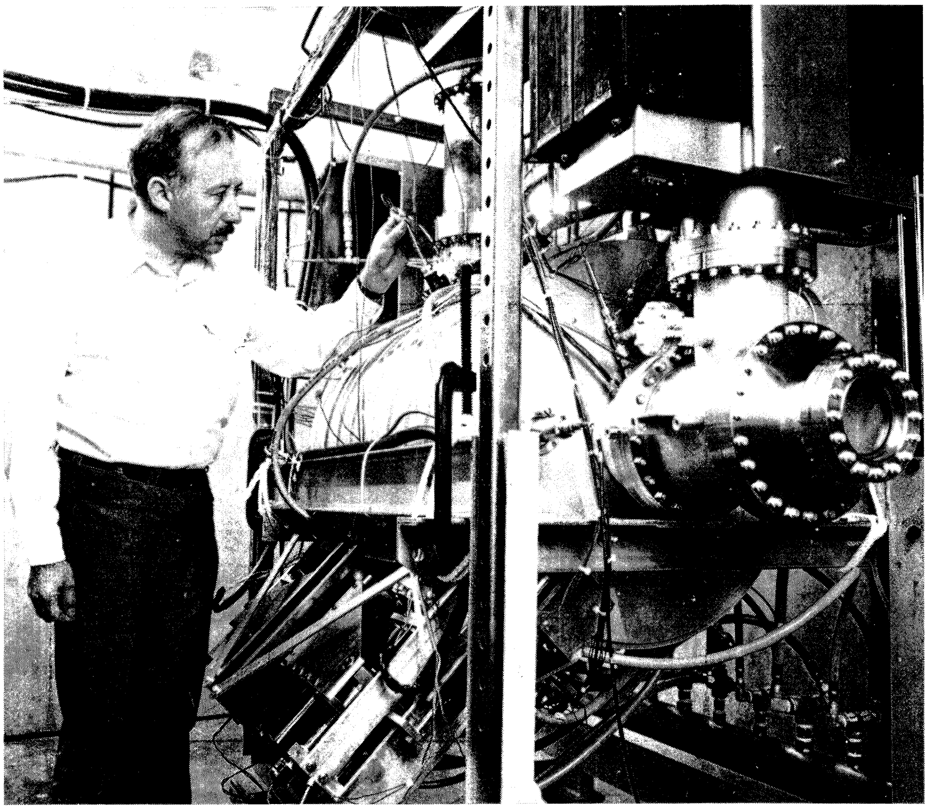
On 4, 5 June an intimate Conference on 'Frontier Problems in High Energy Physics' was held at Pisa in honour of Gilberto Bernardini (photographed below during his years at CERN) who is leaving the Pisa Scuola Normale Superiore at the age of 70 after many years as Dean. Over a

Matt Allen examines a 2-cell 353 MHz accelerating cavity model for the PEP storage ring. PEP requires a 5-cell cavity capable of dissipating 500 kW. The 2-cell model has run up to 200 kW and the results show that 100 kW per cell is possible. The cavity is powered by a klystron designed and built at SLAC.

(Photo SLAC)

Arbor Day in the United States is celebrated in late spring with the planting of trees and has become a happy tradition at Fermilab. The Laboratory has gone to a great deal of effort to preserve the original trees including the 'Grand Bois' — a grove which has a recorded history that extends back to the first French explorations of the Illinois area. Thieves once tried to take several beautiful black walnut trees from the site but the felled trees were discovered before they could be removed. The walnut was used to provide the elegant trim that now graces the atrium of the Hi-rise and the foyer of the Auditorium. The picture shows Soviet visitors Tonia Nomokonova (left), Sherzod Nigmanov, Vassiliu Nomokonov, Khabiba Nigmanova (front) and Erna Morozova at work at this year's plantings in May.

(Photo Fermilab)



hundred friends, students and colleagues gathered to pay tribute to this remarkable man — one of the CERN pioneers, founder of the European Physical Society and physicist of broad culture.

75 % polarization at TRIUMF

Initial acceleration of 40 % polarized protons in the TRIUMF cyclotron was reported in March. Work on the Lamb-shift polarized ion source has since resulted in the polarization of the extracted beam rising to 75 % which is close to the maximum expected from the source itself. This improvement followed repair of a solenoid short and careful adjustment of the magnetic field in the zero-crossing region, where the polarization of electrons in hydrogen atoms is transferred to the protons. The source has been delivering about 200 nA of polarized H^- ions to the cyclotron every second week for the past four months with good reliability; of this about 15 % or 30 nA is delivered to the experimental stations, at various energies between 210 and 516 MeV. The BASQUE group (a British-Canadian collaboration) has been measuring the Wolfenstein parameters for p-p scattering at small angles, and transfer parameters for the D(p,n) reaction. A British Columbia group is studying asymmetry in pion production and an Alberta group has preliminary evidence for correlation of asymmetry with energy for the outgoing protons in the (p,2p) reaction on oxygen.

PEP Policy Committee

A PEP Policy Committee, for the Berkeley/Stanford 15 GeV electron-positron storage ring now under construction, has recently been formed. The members are: Barry

Members of the delegation from the People's Republic of China being escorted by John Adams (left) on a tour of the SPS 400 GeV proton synchrotron.

Art Greene has been appointed Assistant Director for Program Planning and head of the re-established Program Planning Office at Fermilab. He will work with Ned Goldwasser on planning and scheduling the Research Program. The Program Planning Office is responsible for setting schedules and for conducting the biweekly, Monday All Experimenters' Meetings and the weekly Scheduling Meetings.

Barish (Cal.Tech), David Caldwell (UCSB), David Cline (Wisconsin), Donald Coyne (Princeton), Benjamin Lee (Fermilab), Chris Llewelyn-Smith (Oxford), Fred Mills (Argonne), Paul Reardon (Princeton), Karl Strauch (Harvard) and Harold Ticho (UCLA). The charter for the Committee is still being formulated but in general terms it is to advise the Directors of LBL and SLAC on policy matters, user relations, and facility development for PEP.

Physicists from China at CERN

A group of physicists from the People's Republic of China has been at CERN since mid-May studying the construction of large accelerators. They are led by Tu Tung-Sheng (a theoretical physicist who is a member of the Revolutionary Committee of the Institute of High Energy Physics at Peking). Other members of the delegation are Tang Shiao Wei, Wang Shu Hung, Yen Tai Hsuan and Pan Hui Pao (from the Institute for High Energy Physics), Chang Chih Chieh (from the Institute for Automatic Control at Sheng-Yang), Wang Jen Chuan (from the Bureau of Foreign Affairs of Academia Sinica) and Cheng Chi (from the Institute for Machine Research). They are specialists on various aspects of accelerator technology (r.f., magnet design, computer control systems, etc.) and experimental and theoretical high energy physics. The visit seems to be a great success. The CERN staff have welcomed the delegation with enthusiasm which has been most warmly received by the Chinese physicists. This is a further step in the strengthening of scientific relations between CERN and the high energy physics community in China.

New intensity record for polarized protons

At the end of May a new record intensity for accelerated polarized proton beams was achieved at the Argonne ZGS, with a peak of 2×10^{10} polarized protons per pulse at 6 GeV/c. The beam polarization was approximately 70 % and extracted beam peaked at over 0.8×10^{10} per pulse. The previous peak circulating intensity was approximately 0.8×10^{10}, achieved at both 6 GeV/c and 12 GeV/c, so that the new record is an improvement in intensity by a factor of 2.5.

Heisenberg Memorial Lecture in print

On 30 March a 'Werner Heisenberg Memorial Lecture' was given at CERN in tribute to the memory of the famous scientist who contributed so much to the development of physics in this Century. The title of the lecture was 'The birth of quantum mechanics' and the speaker was Jagdish Mehra from the Instituts Internationaux de Physique et de Chimie Solvay, Brussels and the University of Geneva. The lecture has now been printed as a CERN Yellow Report number 76-10 and is available from the Scientific Information Service, CERN, 1211 Geneva 23.

HPD II — alive and kicking

Eighteen months ago, CERN phased out operation of its HPD measuring systems for bubble chamber film and HPD II was snapped up by Imperial College, London which already had an operating HPD of its own. With connection to a dual processor DEC KI10 computer buffered through a PDP11, it is back in the role it played so successfully at CERN — measuring film from the 2 metre chamber, currently from an exposure to fast neutral kaons. The original local machine is thus free to measure 70 mm film from a BEBC antiproton exposure and from the SLAC 40 inch hybrid bubble chamber facility.

CERN Annual Report

The 1975 CERN Annual Report is now available on request from the Scientific Information Service, CERN 1211 Geneva 23.

Tracking the elusive quark

Lewis Grossberger

This breathtaking story appeared in the 10 May issue of 'The New Yorker'. It betrays a nice insight into the personalities and the jargon of the world of particle physics and an elegant sense of humour.

No man has ever seen a quark. How, then, do we know they exist? The circumstantial evidence is overwhelming. We have seen the incredibly tiny bubble tracks. We have heard the eerie cries in the night. (Not even a charging neutrino makes a sound quite like that.) And there are the ancient legends: the tales of human sacrifices to assuage the terrible anger of the quark gods, the chants of the shamans, who believed that quarks made the sun rise and fall, the seasons change, the rivers flow home to the sea, and that they were available in three colors and four flavors. We do not believe that, of course, and yet we know there is something out there . . .

Dr. Gaddis Quigley, of the Iota Institute, set out in June to track the elusive quark to its lair. I was pleased to be included in his party. Also chosen were Dr. Fenton Balbanian, the eminent rudimentologist; Soy Chavann, the controversial infinitesimalist and cynic; and Jankowski, the kid from Brooklyn, a rehabilitated punk, whose task was carrying equipment and providing comic relief. Oddly, nobody in the group was more than five feet tall.

Dr. Quigley was admirably frank in explaining the dangers inherent in our quest. Yet not a man among us — nor Eleanora Grommet, our physician and the only woman aboard, recruited at the last minute in response to picketing by a protest group — flinched at the prospect of facing the dread quark. All of us were qualified. Dr. Quigley had hunted the snipe, the snark, and the carbuncle without qualm. I had once faced an excited hadron alone and unarmed, and spent my college vacations spelunking through black holes. We were all handpicked for calm under fire, and we would certainly need it while hunting the quark, with its unpredictable nature, its low boredom threshold, and its most uncanny natural defense mechanism — a life span of one-thousandth of a billionth of a second. 'This will make it extremely difficult to get off an accurate shot,' Dr. Quigley warned us. 'You will not have a second chance.'

Dr. Filbert Cranshaw, of Scintilla University, our theoretician and public-relations man, was excited — perhaps overly so — at the possibility of our unearthing a 'charmed' quark. Recent sightings had been reported, but I and the others questioned their authenticity. Like such pop apparitions as the Indomitable Slow Man, the Big Mouth of the Rockies, and the Landlocked Nester, the existence of the charmed quark seemed more wishful than thinking. 'Cranshaw can't tell a particle from a cuticle anymore,' scoffed Chavann when the grand old man's back was turned. I was inclined to agree, but I was ready for anything. Or so I thought.

After a week of provisioning and taking on hydrogen, we boarded our bubble chamber and moved out into the vast Subatomic Field, setting up a base camp in the forbidding Vector Meson. Our initial excitement was soon replaced by a pervasive unease, and, sheltered from the raging elements by our Quonsets, we spent a nervous first night. Jankowski played an endless quadrille on his ocarina until Chavann yelled for quiet. Dr. Grommet went in to calm the boy, and was able to lull him to sleep by softly reciting the periodic table.

At dawn, we made directly for quark country, fanning out in a semicircle. It was a wild, luminous landscape, filled with lowing herds of muons, which scattered at our approach. Hyperons chattered overhead as we cut our way through the thick nuclei, and in the distance we could hear the mournful howl of the ever-dangerous lepton.

The hours passed, and we searched on until we were bleary-eyed. With dusk approaching, we finally turned back toward camp. Above, the quasars were pulsating dimly. Clumsily, I almost stepped on a sleeping proton and it sent up a shower of sparks. I was silently resolving to be more careful when suddenly I heard it — that unforgettable aching cry. It stopped me cold — the querulous, full-throated croak of the adult bull quark. Even though I'd heard only Dr. Cranshaw's faculty-tea imitations, I recognized it instantly. Then came a metallic flash. Quigley was shouting, 'There! Behind the electron cloud.' I saw something move and squeezed off a laser beam. But I was rattled and it caromed harmlessly off a huge graviton.

Cursing my ineptitude, and thinking that probably we'd lost our quarry, I began running toward the spot where the flash had come from. Then, so quickly that I didn't realize what was happening, Soy Chavann was down, clutching at his toe and howling. The incredible was taking place. He was being squelched by a charmed anti-quark, apparently the mate of the quark we'd just flushed. She was trying to protect her young.

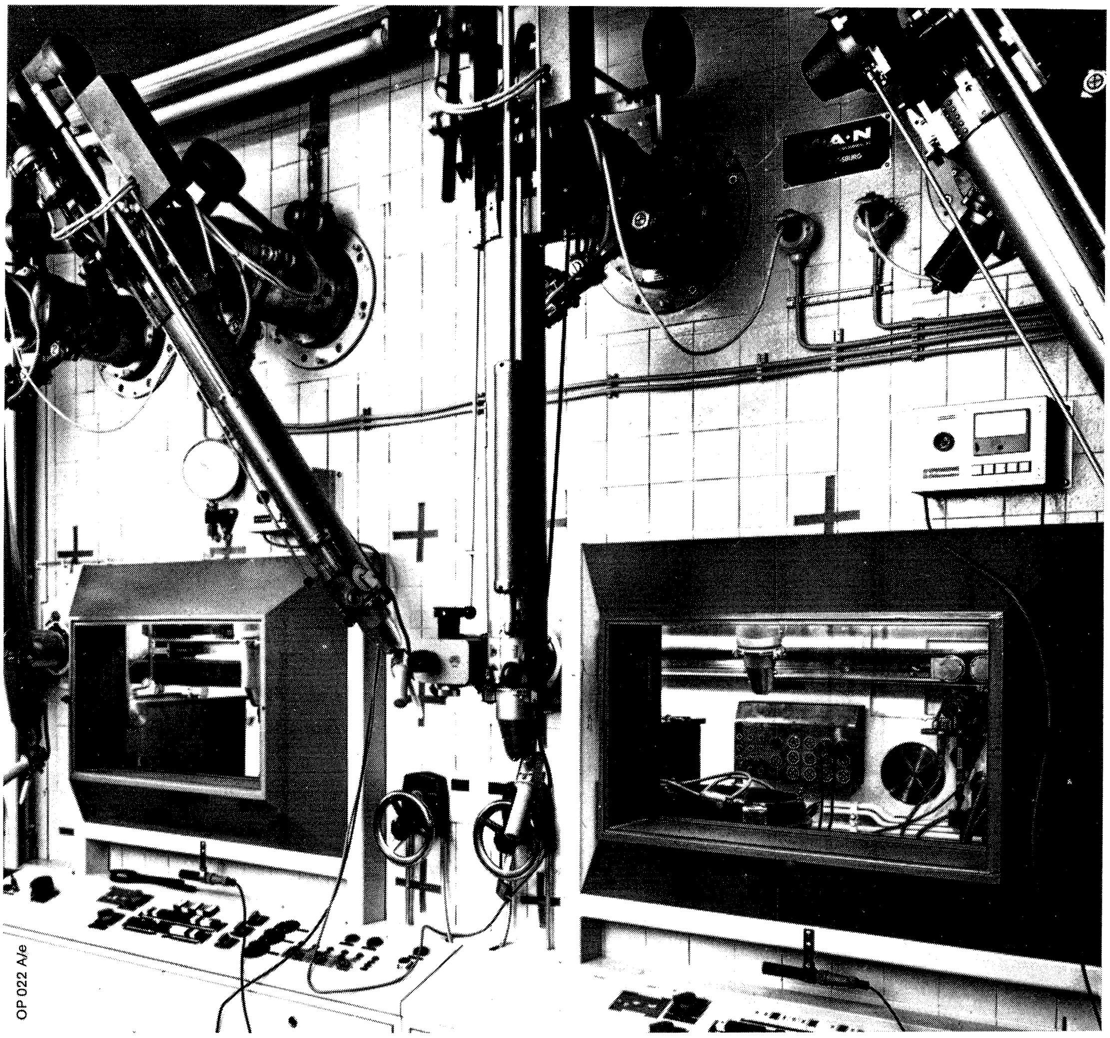
I couldn't get off another beam, because Balbanian was between Chavann and myself and his Quantum Theorizer had jammed! It was young Jankowski, unarmed but for his ocarina, who got there first, and courageously flailed at the ground with his instrument. Too late. She was gone as soon as she had come, if not before, and Chavann lay shaking, a wan smirk on his lips.

'Cranshaw was right,' he said in a horrible whisper. 'I had her in my microscope cross hairs, just for a millisecond. She exists — the charmed anti-quark!'

'But now you must rest,' ordered Dr. Grommet, kneeling to give him a quinine shot.

As Dr. Quigley came huffing up, Chavann beckoned for him to draw near. 'Leave me here,' he said. 'I'm done for. You must return immediately to make the fall issue of *Particle Quarterly*.'

Dr. Quigley looked stricken, but his voice was firm. 'Don't be foolish, son,' he said. 'You're going to pull through. It's just a question of mind over matter.'


Hot Cells in the Karlsruhe Atomic Energy Research Establishment

Safe viewing with SCHOTT

In atomic energy research you cannot depend on guesswork. Especially not in the design of Radiation Shielding Windows. Safety must be calculated in advance, so that viewing remains free from risk. SCHOTT's years of experience guarantee this. Atomic energy research in all parts of the world relies on SCHOTT.

SCHOTT constructs all types of Radiation Shielding Windows, including dry windows. Our experienced personnel are at your disposal at all times to help solve your problems. Our publication No. 3201 will supply you with initial information about technical details, possible uses and construction examples.

SCHOTT | JENAer GLASWERK SCHOTT & GEN., MAINZ
(West Germany)

Advertisements in CERN COURIER

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	6 insertions	11 insertions
1/1	184 × 267	1300	1200	1100
1/2	184 × 130 88 × 267	700	650	600
1/4	88 × 130	380	350	320

Supplement for
one colour 950 SwF
four colours 3800 SwF
Covers :
Cover 3 (one colour) 1450 SwF
Cover 4 » » 1780 SwF
Publication date End of month of cover date
Closing date for
positive films and copy 1st of month of cover date
The cost of making films and of translation for advertisements are charged in addition
Screen (offset) 60 or 54 Swiss (150 English)
Advertisements cancelled after 1st of month of 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.

All enquiries to :
Micheline FALCIOLA / CERN COURIER - CERN
1211 - GENEVA 23 Switzerland
Tel. (022) 41 98 11 Ext. 4103 Telex 2 36 98

Use EEV spark gaps.

LAP 93

You name it. EEV spark gaps can stop it from happening.

Our range covers any voltage from 400-40,000V and handles powers up to 15 kilo joules. Types are available in glass or ceramic envelopes.

EEV spark gaps are very rugged and will work in any environment, unaffected by dust, damp or atmospheric changes. They are also compact, consistently dependable and long-lasting.

We make 2-electrode and 3-electrode types, and the whole range covers many applications including:

Flash-over protection. Crowbar protection circuits. Protection from transient phenomena. Protection circuitry for s/c drives for thermionic tubes.

Capacitor discharge circuits. Firing circuits. Relaxation oscillator circuits for gas ignition equipment. Quench circuits. TIG welding equipment.

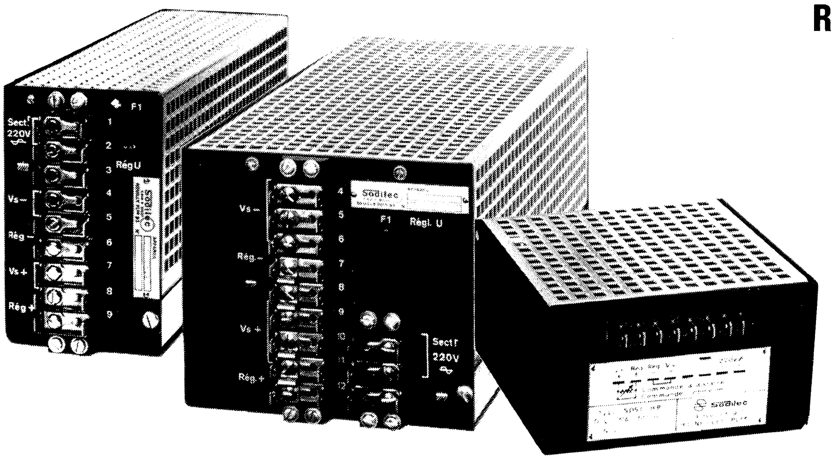
For data and any help you need, write or 'phone EEV at the address below.

Right, GXQ400, a crowbar protection device and GXU40, for protection circuits in ground/air communications equipment.

EEV and M-OV know how.

THE M-O VALVE CO LTD, Hammersmith, London, England W6 7PE. Tel: 01-603 3431. Telex: 234356. Grams: Thermionic London.
ENGLISH ELECTRIC VALVE CO LTD, Chelmsford, Essex, England CM1 2QU. Tel: 0245 61777. Telex: 99103. Grams: Enelectico Chelmsford. GEC

Alimentations sans transformateur secteur



Rapport Puissance / Volume très élevé

Fonctionnement à fréquence inaudible (> 20 KHZ)
Branchement en série et en parallèle
Protections contre courts-circuits, surcharges et surtensions en sortie
Rendement : de mi-puissance à puissance max. (à tension secteur et tension de sortie nominales).
70 % pour SDHR 5.20 et 5.40 et SDSI-HR 5.10
72 % pour SDHR 8.12, 8.25, 15.8 et 15.15
74 % pour SDSI-HR 15.4
78 % pour SDHR 26.4, 26.8, 48.2,3, 48.4,5 et SDSI-HR 26.2

AGIGROUP 633

SDHR 5.20	5 V ± 10 %	20 A
SDHR 8.12	5,5 à 10 V	12 A
SDHR 15.8	10,5 à 16,5 V	8 A
SDHR 26.4	20 à 32 V	4 A
SDHR 48.2,3	40 à 60 V	2,3 A

Dimensions : 120 mm × 75 mm × 300 mm

SDHR 5.40	5 V ± 10 %	40 A
SDHR 8.25	5,5 à 10 V	25 A
SDHR 15.15	10,5 à 16,5 V	15 A
SDHR 26.8	20 à 32 V	8 A
SDHR 48.4,5	40 à 60 V	4,5 A

Dimensions : 120 mm × 140 mm × 300 mm

SDSI-HR 5.10	5 V ± 10 %	10 A
SDSI-HR 15.4	10,5 à 16,5 V	4 A
SDSI-HR 26.2	20 à 32 V	2 A

Dimensions : 120 mm × 70 mm × 125 mm

Sodilec

7, avenue Louise, 93360 NEUILLY-PLAISANCE
Tél. (1) 927.38.07
Télex : 220429 F FRANCE

CANBERRA ELEKTRONIK

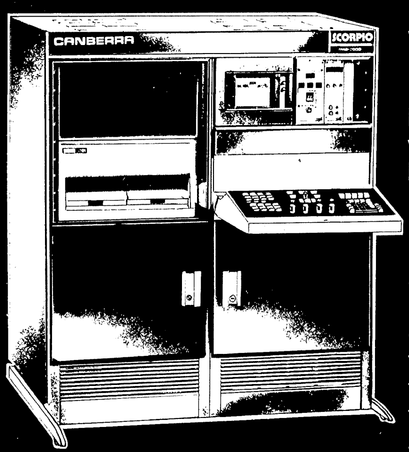
SCORPIO
Multichannel Computer Analyzer

Introducing SCORPIO, a complete family of Multichannel Analyzing Computers. From the stand-alone MCA-1000 to the Multi-input Multi-task MCA-3000,SCORPIO sets new industry standards for performance, flexibility, and ease of use. And all at an unbeatable performance-to-price ratio.

The secret to SCORPIO's performance and flexibility lies in its unique system architecture; an internal PDP-11 CPU provides overall system control, with individual function processors assigned to specific tasks such as data acquisition, data display, and I/O. The net result is a special purpose computer designed specifically for the acquisition and analysis of multichannel data – a Multichannel Analyzing Computer.

No computer system, regardless of type, can be considered complete until it has adequate software. SCORPIO is complete. Off-the-shelf software is available now for all configurations, including Canberra's RT/CLASS and SPECTRAN II for systems with mass storage. This ensures proven analytical performance from the day the system is delivered.

But that's only half of the SCORPIO software story. All SCORPIO software is RT-11 FORTRAN-IV compatible, providing the researcher with the ultimate in software flexibility and power. The SCORPIO MCA systems place no artificial barriers – either hardware or software – between the researcher and his experiment.



SCORPIO's hardware and software provide performance and flexibility; ease of use is ensured by the unique function control console. A powerful Multichannel Analyzing Computer can be operated as easily as a stand-alone MCA.

OMEGA I
The Portable Multichannel Analyzer

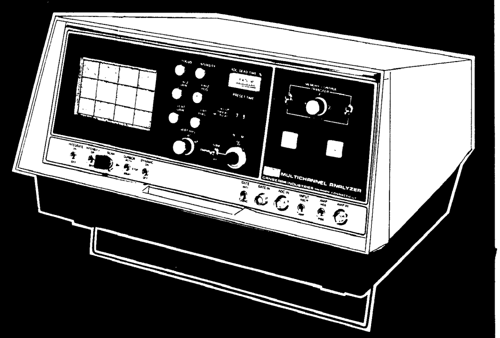
SIGNAL PROCESSING
Internal Spectroscopy Amplifier and SCA 50 MHz, 2048 Channel ADC with Digital Offset and Coincidence Gate
Optional Detector Bias HVPS

MEMORY
256, 512, or 1024 Channel Semiconductor Memory
10^6–1 Counts full scale
Add, Subtract, and Non-Alter Modes

DISPLAY
4½ inch rectangular CRT
Internal X–Y Plotter Interface
Optional Character Generator
LIVE or DYNAMIC data display

DATA ANALYSIS
Variable Ratio Analog COMPARE
Visual Spectrum STRIPPING
Optional Dual Cursors for ROI Selection
Optional Digital INTEGRATOR

The portable Analyzer



CANBERRA ELEKTRONIK GMBH
Geleitsstr. 25
D-6000 Frankfurt 70
Telefon 0611 / 62 40 74 / 75
Telex 41 60 37

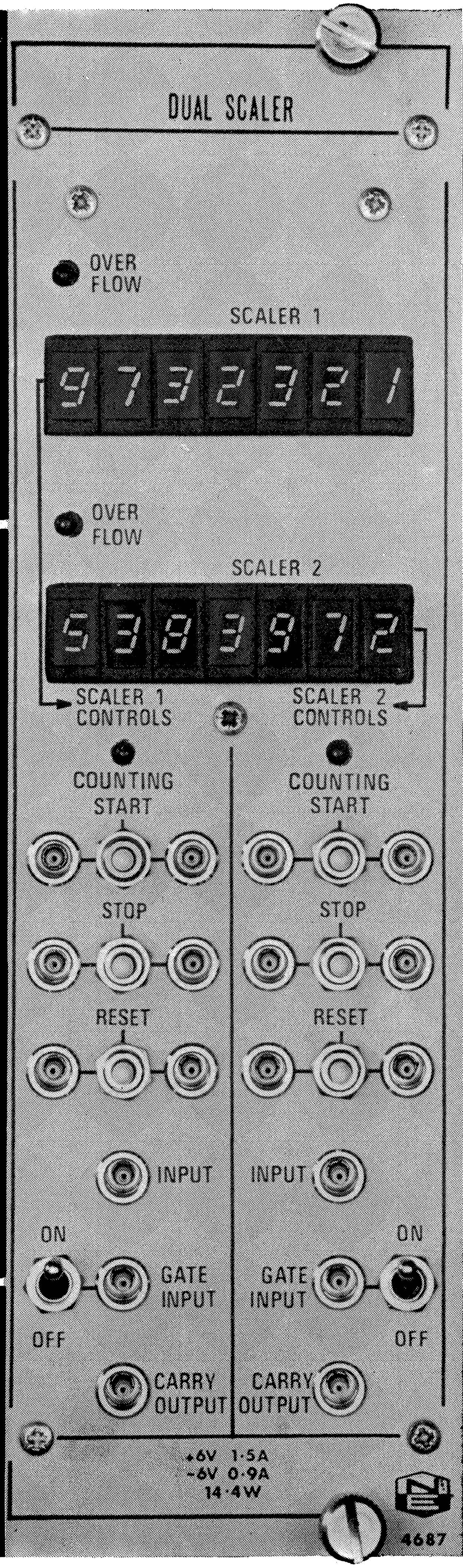
CANBERRA ELEKTRONIK GMBH
Schwalbenstr. 25G
D-8012 Ottobrunn
Telefon 089 / 60 30 57 / 58
Telex 52 43 76

CANBERRA-STOLZ AG
Bellikoner Str. 218
CH-8967 Widen-Mutschellen
Telefon 057 5 40 78
Telex 54 070

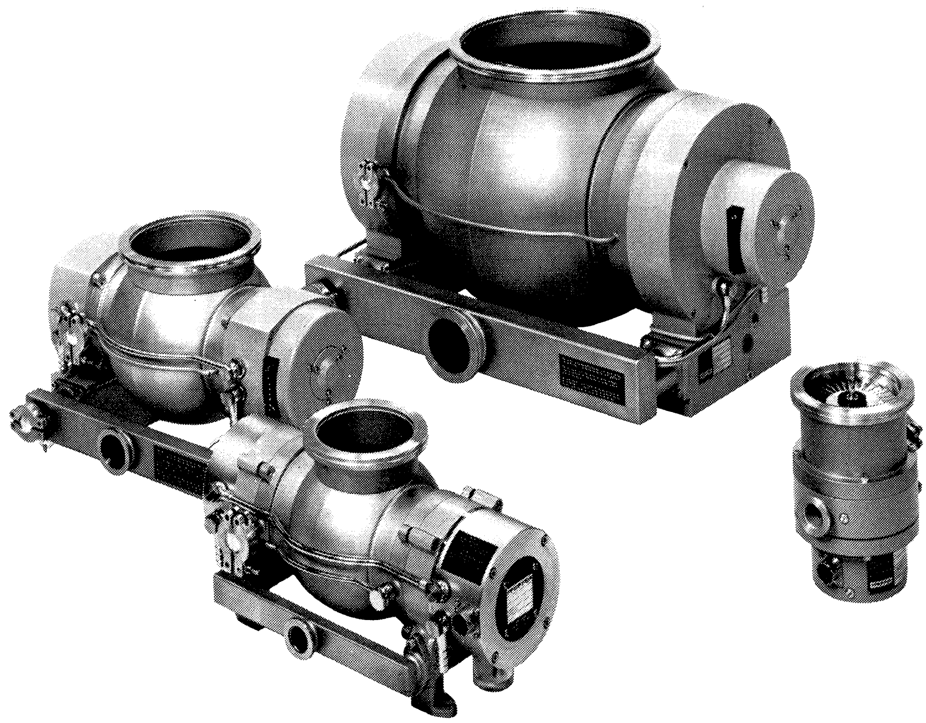
INGLOMARK Industriebel.
Mariahilfer Str. 133
A-1151 Wien
Telefon 0222 83 05 08
Telex 1393

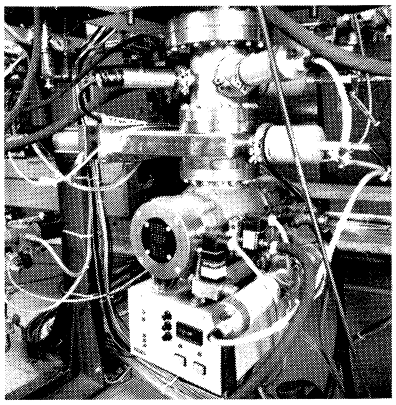
POSITRONIKA B.V.
Pisanostraat 34
Eindhoven 4500
Niederlande
Telefon 0331 / 40 44 08 85
Telex 044-51 744

CANBERRA INSTRUMENTATION
9, Av. d'Arromanches
F-94100 St. Maur
Telefon 00331-2835790
Telex 230 622



DUAL SCALER
OVER FLOW
SCALER 1
9732321
OVER FLOW
SCALER 2
5383972
SCALER 1 CONTROLS
SCALER 2 CONTROLS
COUNTING
START
STOP
RESET
INPUT
ON
OFF
GATE INPUT
CARRY OUTPUT
+6V 1·5A
-6V 0·9A
14·4W
4687





Announcing HP 9825-and seven entirely new standards of performance for desk-top calculators.

1. "Live" keyboard. While a program is running, you can interact with it and calculate.
2. Priority interrupt. Easy to program. Two-level interupt gives you superior control over instruments and peripherals.
3. Speed. HP-designed N.MOS processor for internal speed: 0.8μ-secs cycle.I/O speed up to 400K 16-bit words on direct memory access.
4. Data cartridge. Bi-directional search, high-speed, high performance. 250K bytes for data and program storage.
5. Multi-dimensional. Up to 26 multi-dimensional arrays-increasing facilities for handling large amounts of data.
6. Advanced Language. HPL (Hewlett-Packard Language) offers FORTRAN-like power and ease of BASIC.
7. New display. Upper and *lower* case read-out on 32 character display.
And many other important features:
Power.8K to 32K byte user memory and slots for 4 ROMS.
Interfacing. I/O channels control all major interfacing systems, including HP-IB (1EEE 488-1975). Most existing 9800 series peripherals simply plug in.
Vast Program Library. Access to over 1,000 proven programs through the HP Calculator Users Club.

HEWLETT hp PACKARD

Sales and service from 172 offices in 65 countries.

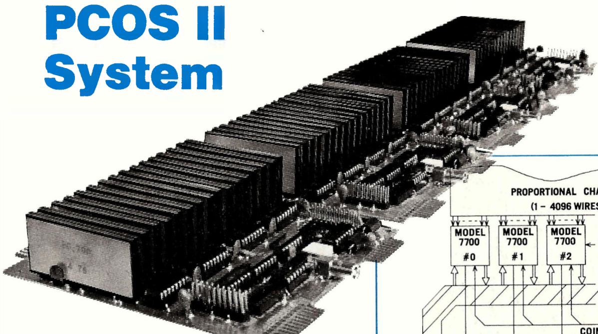
For full details contact your nearest Hewlett-Packard office:

AUSTRIA Hewlett-Packard Ges.m.b.H., Handelskai 52/3, P.O. Box 7, A-1205 Vienna. **BELGIUM** Hewlett-Packard Benelux S.A./N.V., Avenue du Col-Vert, 1 (Groenkraaglaan), B-1170 Brussels. **DENMARK** Hewlett-Packard A/S, Datavej 52, DK-3460 Birkerød. **FINLAND** Hewlett-Packard OY, Nankahousuntie 5, P.O. Box 6, SF-00211 Helsinki 21. **FRANCE** Hewlett-Packard France, Quartier de Courtaboeuf, Boite postale No. 6, F-91401 Orsay. **GERMANY** Hewlett-Packard GmbH, Vertriebszentrale Frankfurt, Bernerstrasse 117, Postfach 560 140, D-6000 Frankfurt 56, **ITALY** Hewlett-Packard Italiana S.p.A., Via Amerigo Vespucci, 2, 1-20124 Milan. **NETHERLANDS** Hewlett-Packard Benelux N.V., Van Heuven Goedhartlaan 121, P.O. Box 667, NL-1134 Amstelveen. **NORWAY** Hewlett-Packard Norge A/S, Nesveien 13, Box 149, N-1344 Haslum. **SPAIN** Hewlett-Packard Española S.A., Jerez No. 3, E-Madrid 16. **SWEDEN** Hewlett-Packard Sverige AB, Enighetsvägen 1-3, Fack, S-161 20 Bromma 20. **SWITZERLAND** Hewlett-Packard (Schweiz) AG, Zürcherstrasse 20, P.O. Box 64, CH-8952 Schlieren-Zürich. **UNITED KINGDOM** Hewlett-Packard Ltd., King Street Lane, Winnersh, Wokingham, Berkshire RG11 5AR. **EUROPEAN HEADQUARTERS** Hewlett-Packard S.A., P.O. Box 349, CH-1217 Meyrin 1, Genève.

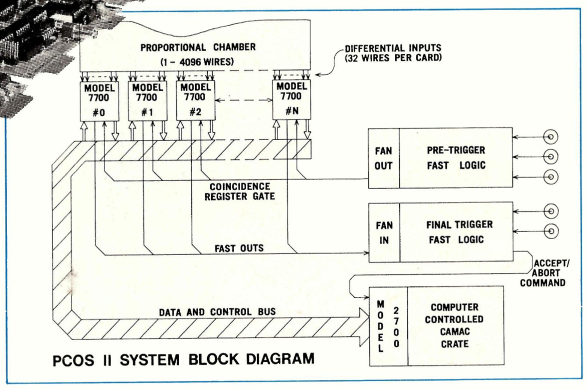
Choose an off-the-shelf readout system that meets your own multiwire proportional chamber needs...

As a research physicist, you are undoubtedly aware of the significant proportion of time typically devoted to *instrumenting* multiwire proportional chambers. Different chamber sizes, different wire spacing, different gas mixture requirements . . . All the time and effort spent on building appropriate readout electronics detract from the time one could spend on actual experimental research. — Well, *you* can be different! Now, two systems available *off-the-shelf* from LeCroy provide you with the flexibility and cost effectiveness you need — save you the time and drudgery — in setting up your own particular wire chamber system. Look . . .

PCOS II System



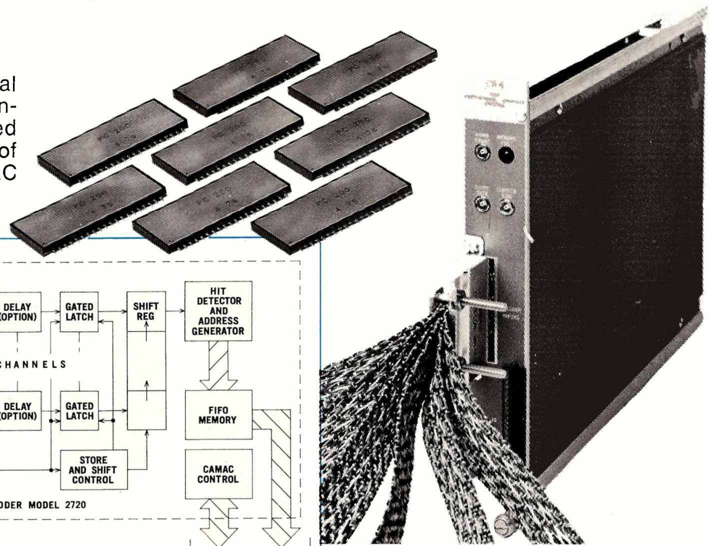
Designed to fulfill substantial requirements at CERN, this system consists of a series of 32-channel chamber-mounted amplifier/discriminator/delay/register cards and a special CAMAC controller linked to the front ends by a serial transfer data highway. A single controller handles up to 4096 wires, storing the center address and the size of hit clusters in FIFO memories for CAMAC transfer to the computer. The PCOS II System features:



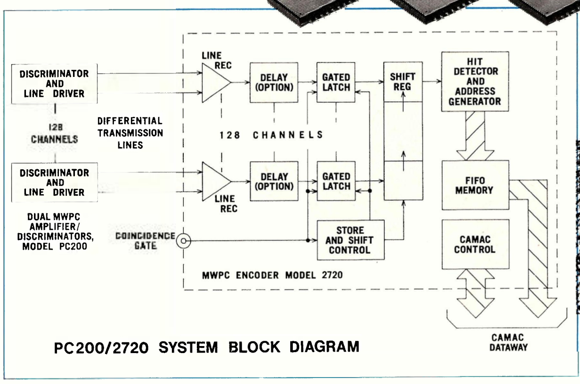
- —1 μA minimum threshold
- 200 Ω input impedance
- Differential inputs
- 10 nsec slewing, 2X to 20X
- Dual monostable to permit 30 nsec double-pulse resolution
- Fast open collector latch outputs
- Model 7700 32-channel chamber card, ready for chamber mounting
- Low, low cost

PC200/2720 System

This system consists of individual front ends (Model PC200 Dual Discriminators) and the Model 2720 CAMAC 128-Channel Encoder, which receives the differentially transmitted standardized wire signals from the PC200's and stores up to 80 addresses of hit wires in a built-in FIFO memory for readout onto the CAMAC Dataway. The PC200/2720 System features:



- Differential signal transmission
- 5 kΩ input impedance
- —200 μV minimum threshold
- Fast analog outputs
- 10 μsec average encoding time
- Compact hybrid size, permitting user-determined layout to match chamber characteristics
- Individual front and back ends
- Cable delays to eliminate excessive deadtime
- Event accumulation for high rate situations
- Fast cluster sum for additional trigger logic



LeCroy RESEARCH SYSTEMS

Call or write for details. Note our new address and telephone number.

Innovators in Instrumentation

LeCROY RESEARCH SYSTEMS CORP.; 700 S. Main.; Spring Valley, N.Y., U.S.A.; (914) 425-2000; TWX: 710-577-2832 • **LeCROY RESEARCH SYSTEMS SA;** 81 Avenue Louis-Casai; 1216 Cointrin-Geneva, Switzerland; (022) 34 39 23 • **LeCROY RESEARCH SYSTEMS LTD.;** 74 High Street; Wheatley, Oxfordshire OX9 1XP, U.K.; (08677) 3540 • **LeCROY RESEARCH SYSTEMS G.m.b.H.;** 6900 Heidelberg; Treitschkestrasse 3; W. Germany • **TOYO TRADING CO.;** 2, 1-chome, Hongoku-cho, Nihonbashi, Chuo-Ku; Tokyo 103, Japan; (03) 279-0771 • **OFFICES THROUGHOUT THE WORLD**