CERN COURIER

NO. 2 VOL. 15 FEBRUARY 1975

CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto'. It acts as a European centre and co-ordinator of research, theoretical and experimental, in the field of sub-nuclear physics. This branch of science is concerned with the fundamental questions of the basic laws governing the structure of matter. The Organization has its seat at Meyrin near Geneva in Switzerland. There are two adjoining Laboratories known as CERN Laboratory I and CERN Laboratory II.

CERN Laboratory I has existed since 1954. Its experimental programme is based on the use of two proton accelerators — a 600 MeV synchro-cyclotron (SC) and a 28 GeV synchrotron (PS). Large intersecting storage rings (ISR), are fed with protons from the PS for experiments with colliding beams. Scientists from many European Universities as well as from CERN itself take part in the experiments and it is estimated that some 1500 physicists draw research material from CERN.

The CERN Laboratory I site covers about 80 hectares almost equally divided on either side of the frontier between France and Switzerland. The staff totals about 3200 people and, in addition, there are about 1000 Fellows and Scientific Associates. Twelve European countries contribute, in proportion to their net national income, to the CERN Laboratory I budget, which totals 410 million Swiss francs in 1975.

CERN Laboratory II came into being in 1971. It is supported by eleven countries. A 'super proton synchrotron' (SPS), capable of a peak energy of 400 GeV, is being constructed. CERN Laboratory II also spans the Franco-Swiss frontier with 412 hectares in France and 68 hectares in Switzerland. Its budget for 1975 is 237.9 million Swiss francs and the staff totals about 450.

CERN COURIER is published monthly in English and French editions. It is distributed free to CERN employees and others interested in sub-nuclear physics.

Public Information Office
CERN, 1211 Geneva 23, Switzerland
Tel. (022) 41 98 11 Telex 2 36 98

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

Contents

Cover photograph: The FermiLab paid a culinary tribute to the research at Stanford on the SPEAR storage ring last November which found the peculiar new particle which they called psi (ψ). This cake was eaten at Batavia in January when B. Richter, one of the leaders of the Berkeley/Stanford team, lectured there on the new particles. (Photo FermiLab)

In action again — the 600 MeV synchro-cyclotron

The CERN 600 MeV synchro-cyclotron has given its first protons for physics experiments following the major reconstruction of the machine during the past two years.

The improvement programme

The SC has become one of the main stays of nuclear physics in Europe and it was in order to continue to provide quality facilities for this research that a major programme of machine improvements was initiated a few years ago. To keep pace with the development of the physics and to remain competitive with the abilities of other machines in the world, it was necessary to increase the beam intensities available from the SC by about an order of magnitude.

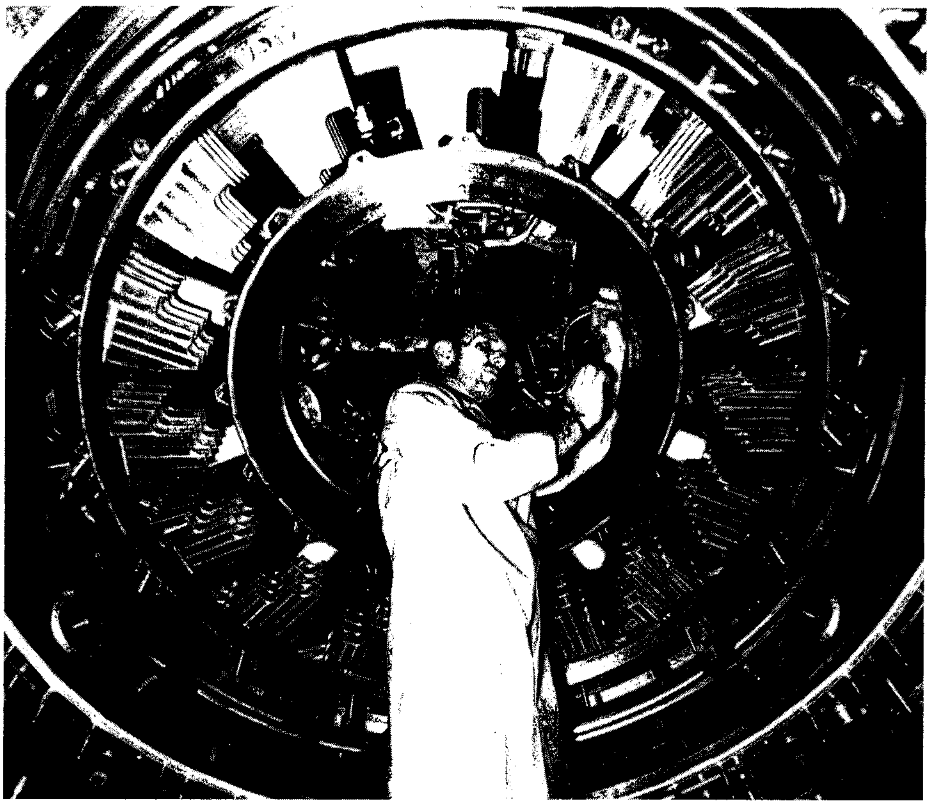
Prior to the modifications, the SC was accelerating a proton beam of between 1 and 1.5 μA with a pulse rate of 55 Hz. The ejection efficiency gave 100 nA of external proton beam and secondary beams of pions had fluxes of around 10^5 to 10^6 particles per second.

To take the beam intensities ten times higher required a series of improvements. The first was the installation of another type of ion source — a hot cathode, hooded arc source. This does not result in a much higher input intensity at the centre of the synchro-cyclotron but together with new focusing electrodes it gives beams of much better quality which can be manoeuvred through the machine more easily and, particularly, can be extracted more efficiently. The new source is inserted from below through a hole bored in the magnet yoke and necessitated a complete redesign of the central region of the machine.

The increase in intensity is mainly the result of the installation of a new radio-frequency acceleration system. The previous mechanical vibrating capacitor (a huge tuning fork) could not be developed to give much beyond its design repetition rate of 55 Hz or to reach the higher accelerating fields dictated by the new source. During each of these pulses, the system is required to produce a changing frequency for the r.f. field (from 30 MHz to 16.6 MHz) which appears on the Dee shaped electrode in the machine. This keeps the accelerating field in step with the protons as they spiral outwards gaining velocity and mass. The new system uses a rotary capacitor to meet these conditions. Rotary capacitors are now used by most synchro-cyclotrons but the CERN model constitutes a considerable development being designed to operate at a repetition rate of up to 500 Hz providing an accelerating voltage of up to 30 kV.

To use the increased number of protons, a regenerative beam extraction system supplemented by a current bearing septum 4 mm thick improves extraction efficiency. Radiation cooled internal targets accept bombardment from much higher currents (up to 20 μA). An additional Cee electrode makes it possible to have long bursts on internal targets or to produce a slow extracted beam of good energy resolution. Long bursts of extracted beam can also be obtained with a pulsed field coil (though at the cost of increased energy spread).

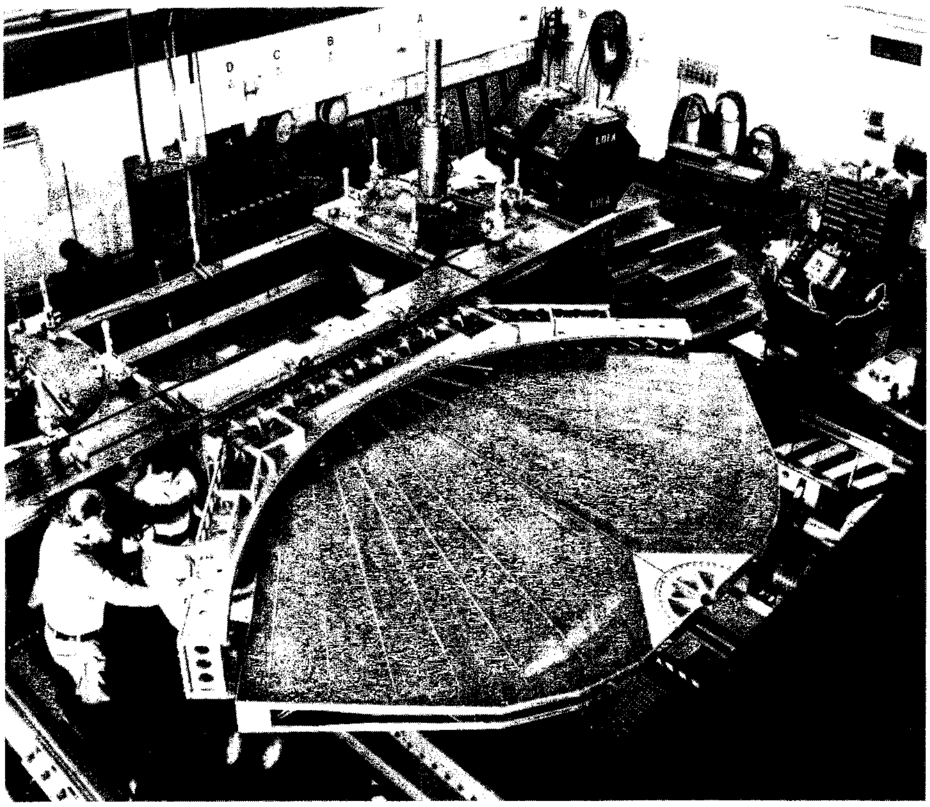
While these modifications were being carried out, a wash and brush up of the machine systems in general was carried out. For example, the magnet received new coils to replace the original ones which had taken a severe pounding from radiation since



CERN 197.11.73

Inside the rotary capacitor, which is the crucial element of the improvement programme at the 600 MeV synchro-cyclotron, showing the shaped stator blades all around the rim. The shaping gives the required change of capacitance with time as the rotor vanes rotate between the stator blades.

The offending Dee electrode prior to installation. Leaks on the Dee panels have been temporarily cured but, to avoid vacuum problems long term, the electrode will be re-panelled.



CERN 31.7.74

the SC first operated in 1957. Components have been adapted so that they can more easily be removed and serviced. Higher radiation levels need not then lead to longer maintenance shutdowns.

Present performance

The reconstruction began in June 1973 and protons were accelerated for the first time from SC2 on 30 September of last year (see October issue, page 334). By now virtually all the desired characteristics of the new machine have been successfully checked and attention has moved to systematic optimization of performance and improvements in reliability.

Many difficulties have been encountered and reliability still leaves much to be desired but the only awkward problem to have reared its head so far is that of leaks on the Dee electrode because of corrosion at some brazed joints. There has been some temporary patching and at present the vacuum is good (9×10^{-7} torr). However, these leaks are likely to be a source of trouble in the future. The Dee will therefore be removed and repannelled, which is a straightforward but tedious job, and, until this is done, the beam intensity is being held down at 1 μA so as not to make the Dee too radioactive.

The intensity is held down by running the rotary capacitor well below its design repetition rate. Development of the capacitor, which is the most technically complicated component of the machine, is continuing. Performance has been fairly good recently and it has given a voltage of 20 kV on the Dee, but further improvements are being carried out (linking the oil cooling automatically to the rotor drive, incorporating double joints with interjoint pumping, etc...) to ensure long term reliability.

The extraction efficiency is now at 50 % compared with 6 % in SCI. It is hoped to take it even higher by optimising such things as the ion source position. The work on extraction has been helped a lot by having a set of secondary emission probes which give information on the beam behaviour in the extraction region.

The future beams

The SC sends particles to three experimental zones — the Neutron Hall, the Proton Hall and the underground isotope separator laboratory. During the reconstruction some of the secondary beams have been considerably modified.

On the Neutron Hall side there are three beams coming from internal targets bombarded by the accelerated proton beam. This compares with eight beams previously but the new beams cover the entire range of available pion energies. They are: a low energy pion channel providing positive or negative pion fluxes of 10^6 per second in the energy range from 60 to 105 MeV, high resolutio channel where excellent beam optics can pin down particle energies to better than 1 MeV in the energy range 80 to 260 MeV and a muon channel providing up to 5×10^5 muons per second in the energy range from 50 to 190 MeV.

On the Proton Hall side the extracted proton beam is fired into an external target to produce intense beams of well defined momentum. Three beams have been built — neutrons produced from a deuterium target (400 to 600 MeV, 10^7 flux), a wide band and a double spectrometer beam for pions. The full extracted beam can also be bent below ground to the isotope separator.

The possibility of having beams of other particles has been investigated. It seems that the acceleration of deu-

Schematic layout of the beam-lines around the 600 MeV synchro-cyclotron. The machine feeds three experimental zones where there have also been major modifications during the improvement programme.

terons to 360 MeV or alphas to 720 MeV would not involve major difficulties. The ISOLDE teams would be happy to have ion beams of this type and they will probably be attempted within the next few years. For particles beyond helium, there are ion source and vacuum problems.

Experimental programme

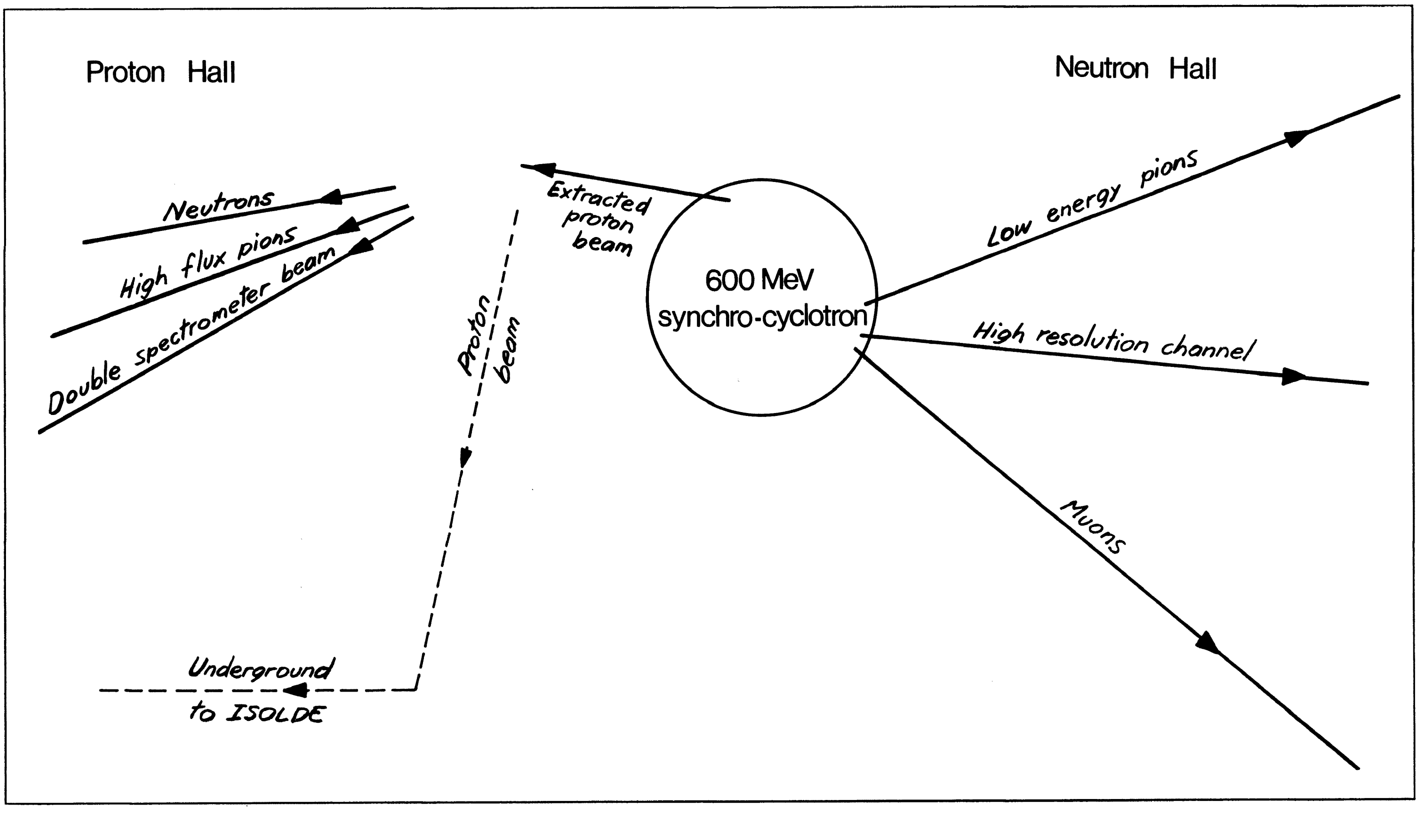
On 17 December the experimental programme at the synchro-cyclotron began again when protons were sent to the on-line isotope separator, ISOLDE. In January pions were observed in the Proton Hall.

ISOLDE has used the shutdown period of the SC to mount an improvement programme of its own (see March issue 1974, page 80). The separator has been rebuilt with a new target and ion source unit so that it can now cope with about 35 elements (instead of 10). Four different isotope beams can be fed to detection systems simultaneously using electrostatic deflectors. Since the beam on the ISOLDE target will be ten times more intense (5 μA compared with 0.5 μA) and the collection efficiency has been improved by two orders of magnitude, much higher ion currents will be available (up to several nA).

Among the many experiments planned for ISOLDE is a continuation by the Heidelberg team of the measurement of nuclear parameters using the optical pumping technique (see November 1971, page 321). They have already found some fascinating changes in the nuclear volume in passing through a series of mercury isotopes and will extend the measurements to other elements. Related experiments to determine the spin of isotopes will be carried out by the Gothenburg/Uppsala team using the atomic beam resonance method. In both these types of experiment, ions from the ISOLDE target are collected on foil and then evaporated as radioactive atoms. Radioactive material collected in this way is also intended to be transported to Van de Graaff accelerators for use as targets in other experiments.

A Karlsruhe/Trieste team will use a stopped pion beam in the Proton Hall to study the result of absorption of a negative pion in an oxygen nucleus. In particular they are looking at the events where two neutrons fly out of the nucleus when the pion is captured. Analysing these neutrons with time of flight detectors gives information on the residual nucleus. On the same pion beam a Louvain team will look for pion capture which results in the emission of two gamma rays. This also gives information on the energy states of the nucleus.

Several experiments are lined up for the muon beam. The same Louvain



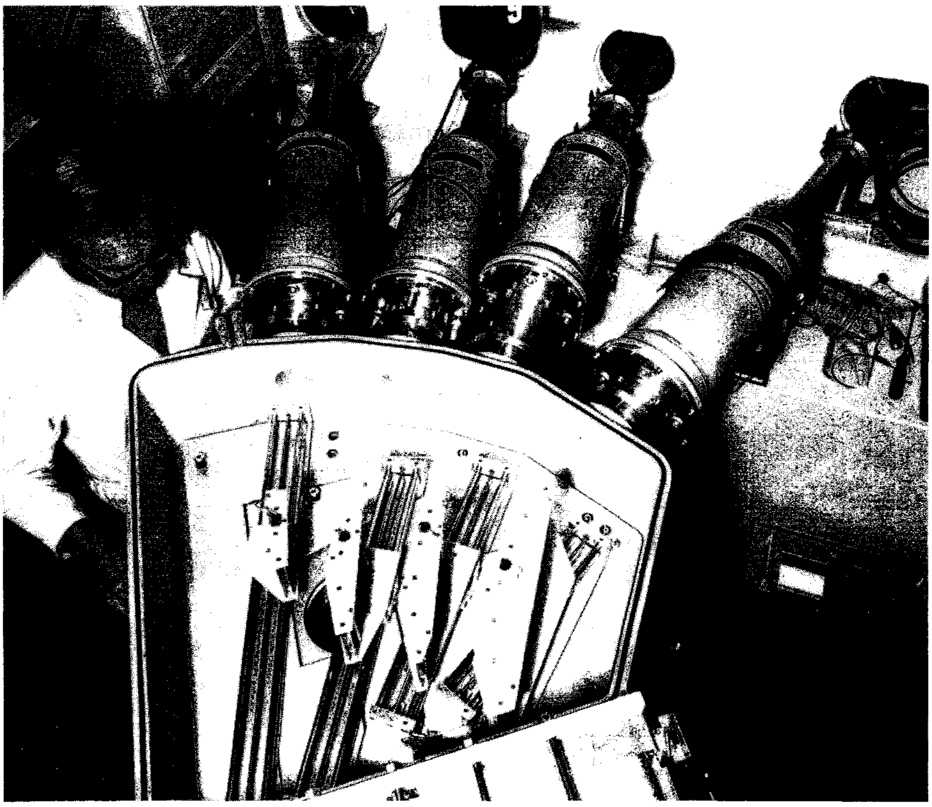
The isotope separator on-line, ISOLDE, has now been equipped to provide up to four simultaneous ion beams to the experiments. This 'switchyard' has electrostatic deflectors to bend ions down the beam pipes and through a thick shield wall to the experimental area.

team will attempt to measure the muon capture rate in lithium 6 which results in the formation of a helium nucleus. The transition between the two nuclear states is a very clean one and interpreting the measurement does not involve large corrections to take account of other possible interactions.

Muons will also be used to study refined effects of the electromagnetic interaction. A CERN/Pisa team will look at the Lamb shift in muonic helium using a pulsed laser beam to induce transition between the energy levels of the muon in orbit around the nucleus. Two teams (Bologna and Basle/CERN/Karlsruhe) will look for parity violation in the electromagnetic interaction by measuring the energy levels in muonic atoms.

On the neutron beam, some biological studies will be carried out by the CERN Health Physics Group. Also neutron counter calibration is in progress to check measurements made at the proton synchrotron. Many teams involved in the experimental programme at the PS, or preparing for the coming of 400 GeV protons from the SPS, use synchro-cyclotron beams to test their detectors.

The synchro-cyclotron will thus re-establish itself on the CERN physics scene when the improvement programme has been successfully completed. When the last few problems have been ironed out, it will, for the next few years, be again providing worthy competition for the other machines in its energy range.



CERN 131.12.74

Computing school

The 1974 CERN Computing school was held at Godoysund near Bergen in Norway. Sixty-two students (mainly from the CERN Member States but also from the German Democratic Republic, Hungary and India) attended. The majority were physicists from research Laboratories plus a sprinkling of more theoretically inclined computer science students.

Eleven lecturers covered three main topics — programming methods; computer systems architecture, both software and hardware; interactive computing. The broad first topic was further sub-divided into three series. The theoretical approach introduced methods for formal correctness proofs of programs. Though it seems desirable to abandon the conventional 'debugging' methods for tidying up programs, this theoretical approach can be very complex even when handling simple programs.

The practical side concentrated on 'state of the art' software with subjects such as structured programming, modular design, management of software projects and so on. The question of the language to be used for software brings different answers from two camps. The conservatives hold out for an established language such as FORTRAN for reasons of compatibility. The radicals promote new languages, such as Pascal or Mary, as a powerful way of increasing software quality.

The lectures on computer systems architecture described modern design features, both in hardware and sofware, with reference to existing computers where the various features have been implemented. In a special session, the design and implementation of the MU5 computer were described in detail. This experimental computer has been built at Manchester University above the top of ICLs new

Beam watchers for the PS Booster and the SPS:

1. A quadrupolar pick-up to observe the shape of the orbiting proton beam which has been installed in the 800 MeV Booster of the Proton Synchrotron during the present long shutdown. The pick-up consists of a ceramic tube, 150 mm diameter and 0.5 m long, metallised on the inside. The sinusoidal profiles of the pick-up electrodes have been formed by sand blasting using a very fine jet.

2. One of the beam monitors (of which there will be more than a hundred) to observe the beam in the 400 GeV proton synchrotron. The monitor is of the secondary emission type and can give information on beam position, intensity and density distribution. The head is flipped into the beam with the help of an actuating mechanism and a triple exposure, used to compose this photograph, shows its swing pendulum at three different positions.

range, 2900, and contains many interesting features in its architecture.

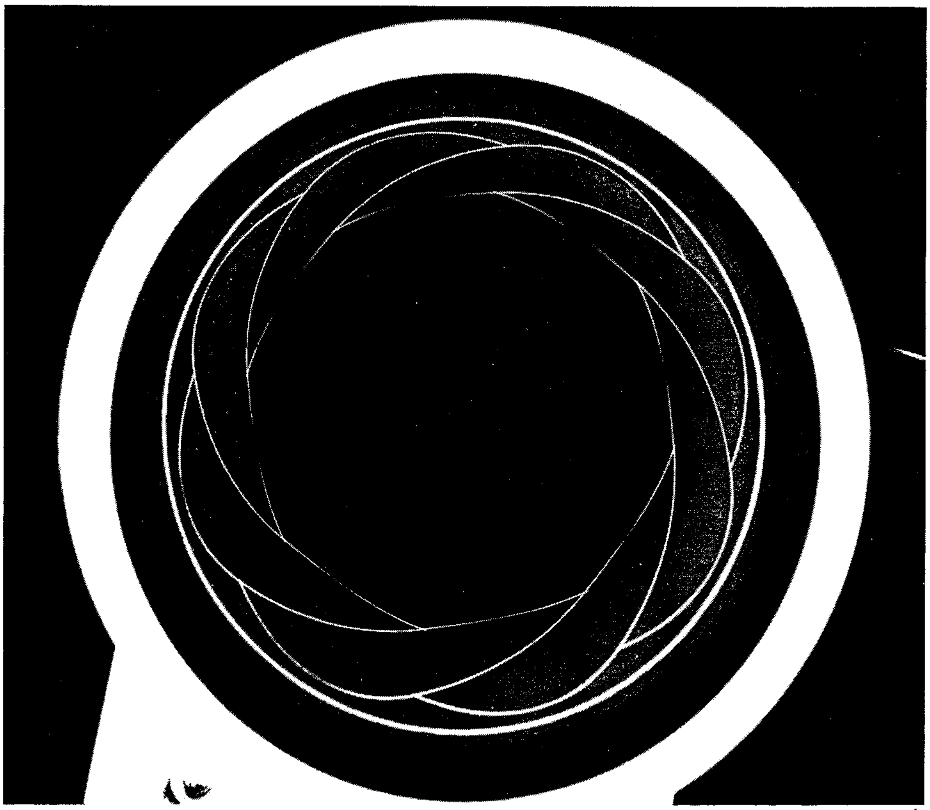
In complete contrast to the giant number-crunchers, are the new microcomputers and their special technology. Their relative power and versatility indicate a revolutionary future trend. Another route was treated in the lectures on special purpose processors (first described in the June 1973 COURIER, page 181). The modern physicist requires certain tasks to be done so rapidly that only specially constructed processors can cope. Examples were given on track recognition in electronic experiments and on histogramming scan data such as is collected in analysing film from the 3.7 m European bubble chamber.

Lectures on ERASME gave a very good view of the practical implementation of an interactive computing system. Furthermore, lectures on data presentation and analysis, which is one of the most important problems in high energy physics, showed that the ease of manipulation and the results depend highly upon the way in which data is presented. Several echniques were offered as excellent substitutes for the traditional histogramming method.

The idea of bringing together computer scientists and physicists for a fortnight's school bore fruit again.

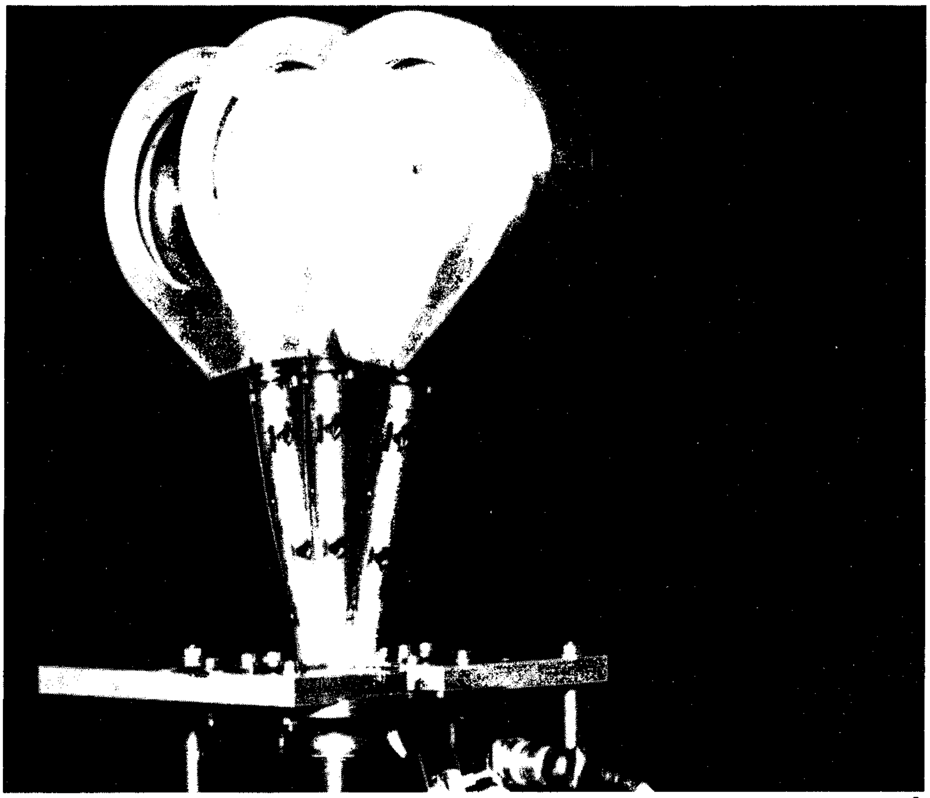
Pop prize

On 14 January, M. Crozon and P. Sonderegger received the 1974 Science Prize of the Foundation de France for organizing a series of events to popularize physics, during the International Conference on Elementary Particles held at Aix-en-Provence in September 1973. The events were under the general title of 'Physique dans la rue' and have since been usually referred to as Aix-Pop. For the story of Aix-Pop, see October 1973, page 297.



CERN 202.1.75

1.

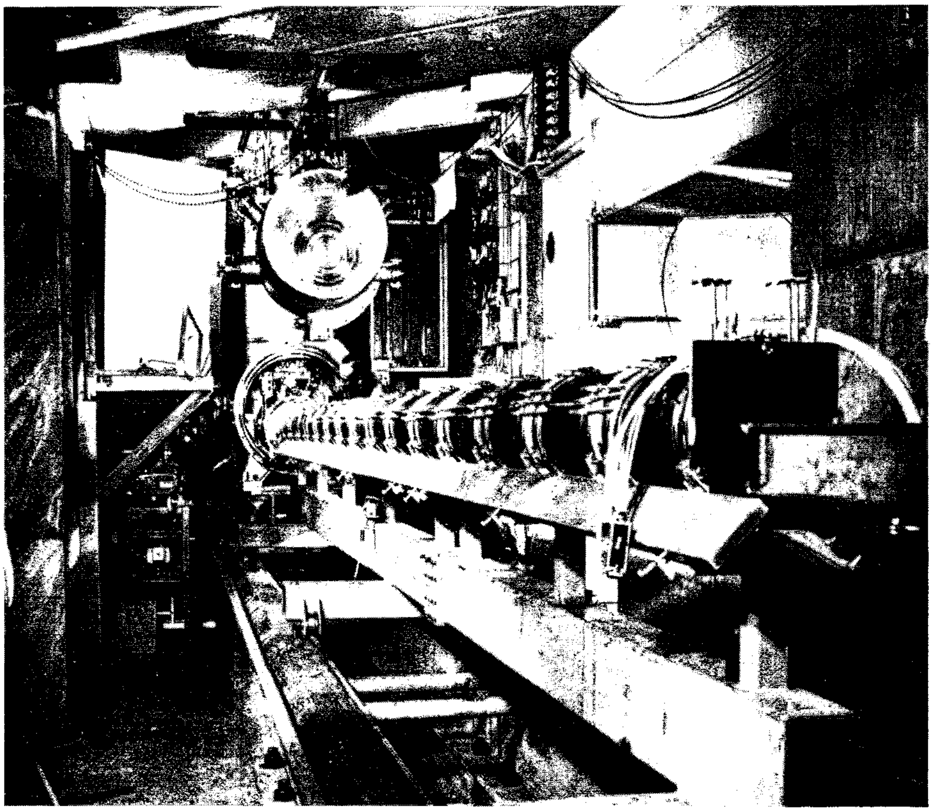


CERN 216.1.75

2.

Around the Laboratories

The long superconducting solenoid at the SIN cyclotron which has been installed in a beam channel which has yielded the world's highest fluxes of muons. The muon channel was brought into action remarkably smoothly in January and the superconducting solenoid is working perfectly.



VILLIGEN
Superconducting muon channel begins operation

Operation of the 590 MeV cyclotron at the Swiss Institute for Nuclear Research, SIN, is going very well. Following a shutdown towards the end of last year, during which various improvements were carried out, routine operation now achieves transmission efficiencies of the proton beam through the ring cyclotron of 80 to 85 %. This has been pushed as high as 90 to 95 % which is close to the theoretical maximum, with the existing extraction system, of 96 %. The highest proton beam intensity at the two external targets is 12 μA but beams of 5 μA are more commonly used.

During the shutdown, the experimental area received attention also. A high resolution pion channel was completed. Another pion beam, for biomedical research, was brought into action and has been used to irradiate the first biological specimens. More precise contamination measurements are now being carried out by a team from Karlsruhe and depth dose measurements, using lithium fluoride have been taken by a Zurich group. A programme of further dosimetry measurements, irradiations and physics with stopped pions is lined up for this biomedical beam.

An unpolarized neutron beam, with a 60 m time-of-flight path from the target to the experimental area, was also completed during the shutdown and a Freiburg group has carefully studied beam profiles in the experimental area and how they vary with the focusing applied to the proton beam prior to the target. But the most satisfying success in the realm of new beam-lines was the smooth start of operation of the superconducting muon channel.

Muon beam-lines at intermediate energies have almost always involved the use of a series of quadrupoles which focused the pions produced when the ejected proton beam hits a target and also retained some of the muons produced as the pions decayed. The idea of a solenoid is to give a beam of pions travelling close to the axis on large spirals with small radii so that the decay muons are much less likely to escape from the beam. Close on 100 % efficiency can be expected.

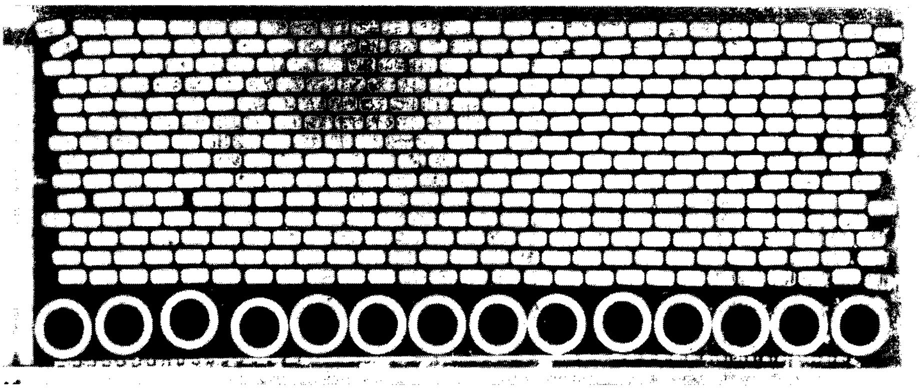
The problem is that long, large aperture solenoids are needed. The SIN solenoid, for example, is 8 m long with an aperture of 12 cm and a field of 5 T. To provide these conditions with a conventional magnet would involve a power consumption of 10 MW. The use of a superconducting coil was therefore imperative.

The solenoid uses copper stabilized niobium-titanium superconductor wound in sixteen identical sections. The conductor is wound on reinforced epoxy resin while the outer surface is in contact with a layer of copper pipes which carry the helium cooling. This is all enclosed in a thick walled stee tube which is a magnetic return path. Gas cooled current leads connect the solenoid to a 1 kA supply, the coil taking 870 A to give the design field. The cooling is by supercritical helium under a pressure of 6 to 10 atmospheres.

In the first test of the full solenoid in December, the current climbed to 690 A before a quench occurred due to a leak at one end of a coil which caused a temperature rise. After repair, the magnet immediately reached 5 T on 15 January and stayed there for days. Since then it has operated continuously without supervision and there have been no problems in following the shutdown and re-starts of the accelerator schedule. The measured losses are about 25 W, about 40 % less than anticipated.

Cross-section of one of the coils of the superconducting solenoid. The unusual design is described in the text.

(Photos SIN)



Pions are focused on the entrance to the solenoid. The great advantage of the solenoid technique is that it can take a wide range of momenta. By using a pion degrader before the channel and by stopping the muons internally in the high field, the densities of the stopped muon beams can be increased two orders of magnitude. (It is hoped to use this in studying muonic atoms much more thoroughly than ever before.) The muons emerge from the solenoid within a 20 cm^2 area and can be handled by conventional magnets to transport them to two experimental regions.

When the solenoid worked so well on 15 January, pions of 200 MeV/c were fed to the channel. The muon extraction was slowly brought down to lower momenta and at 180 MeV/c a pure muon beam was achieved (no pion contamination and only a slight contamination of electrons — 4% total, 2‰ at the muon stop). A strong polarization was demonstrated by observing positive muon precession a few days later.

Maximum muon flux was reached at 115 MeV/c. The design intensity was 2.4×10^7 muons per second. After only a preliminary turning 2×10^7 was achieved. Already the SIN cyclotron has the world's highest muon fluxes.

DESY The PETRA storage ring project

Last November DESY submitted a proposal for a 2×19 GeV electron-positron storage ring to its Administrative Council. The proposal had been worked out in detail during 1974 by a group at DESY with important contributions from scientists in German Universities and Laboratories and guests from Laboratories in other countries.

Also in November, the Scientific Council of DESY, whose members come from German Universities, recognized the strong scientific interest in such a project and unanimously recommended its construction. In December, the Administrative Council discussed PETRA and its implication for the long-term programme of the Laboratory. It was realized that PETRA is a natural continuation of the past and present scientific programme, which has always been devoted to electron physics, and, at the same time, a straightforward extension of the existing facilities. PETRA would make optimum use of the existing expertise and installations — an essential element is that the DESY-DORIS synchrotron-storage ring system is an ideal injection system for PETRA.

The project envisages four intersection regions being equipped with experimental halls initially. If European interest in participation is large enough, four more halls could be built. An experimental programme could start rather quickly by using, at higher energies, some of the big installations now operating at DORIS.

Ring Structure and Energy

PETRA is a single ring, 2.3 km in circumference, composed of eight identical curved parts and eight straight insertions. Four of these insertions are short and hold, in a symmetric arrangement, the four initially planned experimental halls. The other four are long; they accommodate the r.f. accelerating structure and can also be equipped for experimental use.

The aim is to have a storage ring at the highest energy feasible at the present time. To minimize synchrotron radiation and to cope with its effect, a large radius is needed plus a high energy gain per turn requiring long r.f. structure. For PETRA the bending radius is 194 m and the length of structure is 134 m. The magnet lattice consists of 192 identical half-cells comprising a 5.5 m bending magnet, an alternately focusing or defocusing quadrupole and a sextupole for correction of chromaticity. With the proposed r.f. system, this lattice allows a maximum beam energy of 19 GeV. 23 GeV could be reached by doubling the r.f. installations.

Luminosity

For energies up to 14 GeV, the PETRA luminosity is limited by beam-beam interaction which in turn depends on the energy and the beam cross-section. In a machine with constant tune, this results in a luminosity proportional to E^4. For variable tune operation, weaker focusing is used at lower energies, resulting in a beam cross-section nearly independent of energy and a luminosity proportional to $E^{2.4}$.

Aerial view of the site of the DESY Laboratory with the proposed location of the 19 GeV electron-positron storage ring, PETRA, drawn in. The link with the existing synchrotron is shown – the synchrotron (plus the DORIS storage rings) serving as injection system.

(Photo DESY)

The luminosity, in this range, is also proportional to the number of bunches. It is planned to have up to four bunches in each ring. These would meet only at the intersection points where, for maximum luminosity, the beams have a very narrow waist. In principle, the number of bunches could be raised to forty but then the beams would have to be separated outside the intersection points by electrostatic fields. Whether operation with so many bunches is feasible will depend mainly on the current limitation due to multibunch instabilities.

Between 14 and 17 GeV, the luminosity is limited by the beam-beam effect and by the available r.f. power. To obtain maximum luminosity, the number of bunches has to be gradually reduced with increasing energy. Above 17 GeV, the luminosity goes down rapidly due to the steeply rising energy dissipation in the r.f. cavities. Here, PETRA would run with one bunch in each beam.

The maximum luminosity of 1.2×10^{32} $cm^{-2}s^{-1}$ per intersection is at 14 GeV, with four bunches in each beam and an average current of 24 mA per bunch. At this energy, the radiation loss per turn is 17 MeV, and the radiated power per beam is 1.7 MW.

Radio-frequency System

In its first stage, PETRA has a total r.f. power of 4 MW. This corresponds to a klystron efficiency of about 40 % but 60 to 70 % seems feasible and a good reserve would therefore be available. At a frequency of 500 MHz (as in the synchrotron and DORIS) the power is generated in eight 500 kW klystrons and fed into the accelerating structure through a waveguide system. The r.f. structure is symmetrically placed in two diametrically opposite long insertions of the ring. It consists of individual resonators each with seven cylindrical half-wave cavities in one unit. The cavities may be either of the iris or of the inductively coupled drift tube type, the latter achieving a higher shunt impedance. New technologies and fabrication techniques are being investigated for a cheap cavity production from copper plated aluminium or stainless steel.

Injection

For injection, the existing DESY accelerator system is very suitable for the following reasons: In a storage ring like PETRA the main limitation of luminosity is beam instabilities at injection and difficulties with positron accumulation since intense positron sources are not available. PETRA benefits because electrons and positrons can be accelerated to an injection energy as high as 7 GeV in the synchrotron and, also, positrons can be stacked

and stored in DORIS to give a high number of particles per bunch.

The PETRA damping time is 125 ms at this energy, allowing every seventh synchrotron cycle to be used for injection. The other six cycles will not be lost for particle accumulation when the DORIS ring is used for intermediate storage. This will not only gain the corresponding efficiency factor of seven but also another factor of thirty by having 30 bunches simultaneously filled and stored in DORIS.

The overall injection scheme for positrons is then — 400 MeV bunches of positrons from Linac II are injected into the synchrotron which runs at 7.5 GeV maximum energy. After acceleration to 2.2 GeV they are ejected and stored in DORIS. The two upper half-rings of DORIS are coupled together to form a single ring having two points for injection and ejection, respectively. A fast kicker makes it possible to re-transfer a single accumulated bunch into the synchrotron within 25 μs after injection so that it can be accelerated to 7 GeV within the same synchrotron cycle. With programmed phasing and timing, any desired bunch sequence can thus be fed to PETRA. The positron filling time is about 7 min for the maximum current of 96 mA. For electrons, using the same transfer scheme, the filling time is much shorter. It is an important feature of this injection system that all its major components are already operative and do not involve any special development.

Cost

The PETRA construction costs are comparatively low because a wide range of facilities and equipment already at hand at DESY can be incorporated into the project. The complete injector system exists and also the magnet power supplies and cooling facilities, the control and laboratory building and equipment for the first physics experiments. Because of the existence of these facilities a saving of about 40 to 50 million DM is possible. Also, it is planned to restrict the double storage ring DORIS, after the commissioning of PETRA, to its original design energy of 3.5 GeV, whereas it is now equipped to go up to 5 GeV.

The costs for PETRA are estimated at 97.6 million DM, at October 1974 prices, including all technical components and buildings. PETRA can be built with the existing staff resources at DESY.

Further development

There is potential for further development. The magnet structure and power supplies are able to run up to 23 GeV and such an energy could easily be achieved by adding more r.f. power, if the physics interest should justify it. Also, if the physics should demand a future electron-electron option, an electron ring could be installed on top of PETRA. Four of the straight sections could be used as intersecting regions with this second ring.

The Administrative Council considered the PETRA project very favourably and approved funds for 1975 for the detailed planning of the storage ring, the buildings and the site survey. Hence the project can be carried on without delay in the planned schedule. If final approval is obtained during 1975, the storage ring would come into operation in 1979. Thus PETRA could enable European physicists to start electron-positron colliding beam physics at high energies in the near future with a minimum of expenditure and technical risk.

Information on the design of the proposed 14 GeV electron-positron storage ring, known as EPIC, can be found in the January issue, page 12.

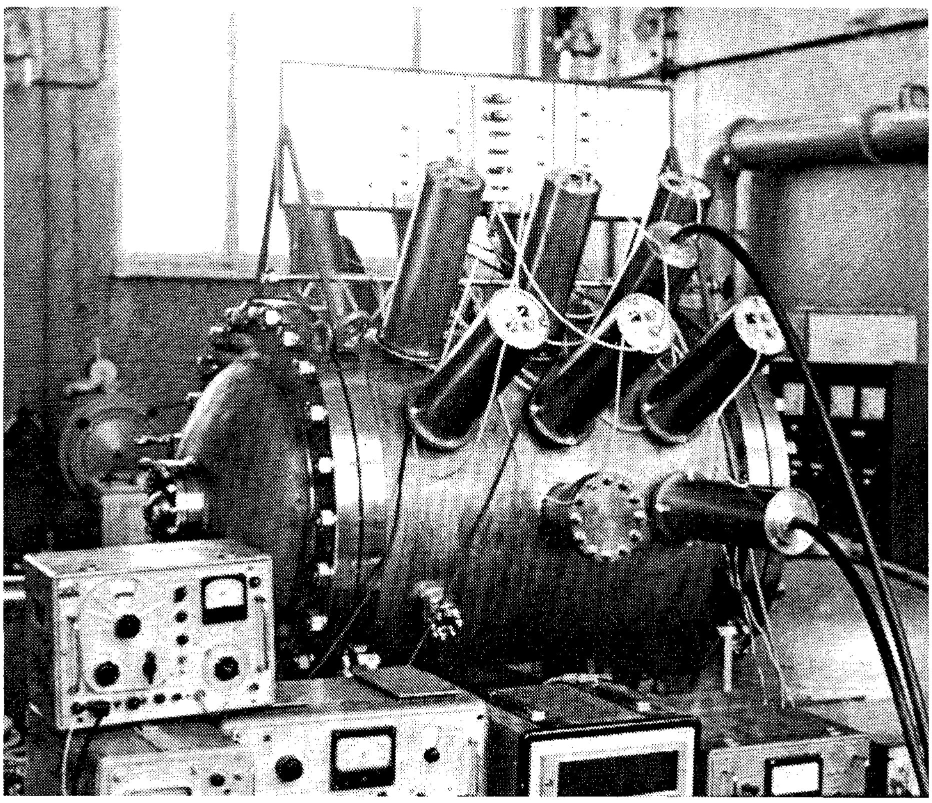
GATCHINA Collaboration in SPS experiment

Scientists from the Leningrad Nuclear Physics Institute at Gatchina will join a CERN, Clermont-Ferrand, Lyon, Uppsala collaboration in a high precision study of elastic scattering which has recently been approved for the experimental programme of the 400 GeV proton synchrotron. The team hopes to be ready on the H3 beam in the West Hall to receive particles just as soon as the SPS comes into action in 1976.

The Soviet scientists are bringing with them an ionization chamber which was developed in the laboratory of A. Vorobiev at Gatchina and which is currently in operation at the Serpukhov proton synchrotron.

The aim of the experiment is to investigate the scattering in the 'Coulomb interference region'. It involves studying the interactions where a beam particle brushes against a target proton and flies on at an angle very close to its initial direction while the proton recoils at a large angle. The collision involves the particles passing without getting very close together, and the Coulomb force due to their electric charges also influences the interaction, in addition to the more powerful strong force. It is thus possible to study the interference between the two forces.

There are different predictions as to what happens to a particle's total cross-section (its region of influence) as the energy of interaction increases. CERN ISR and FermiLab experiments (see March 1973, page 67 and July 1974, page 245) have shown that, to the highest available energies at present, the strongly interacting particle (the hadron) continues to grow as the energy increases. Measurements in the



The ionization chamber built at the Gatchina Laboratory for elastic scattering experiments. It is now in use at the 76 GeV proton synchrotron at Serpukhov and will later come to CERN for an experiment at the 400 GeV machine.

Coulomb interference region are used in interpreting the total cross-section results. They need to be carried out with very high precision (to 1 % or better) in order to distinguish between different predictions about the cross-section behaviour.

In the type of elastic collision described above it is not easy to get such precision from measuring the very narrow angle at which the beam particle emerges at high energies. The recoil proton however emerges at a wide angle to the beam direction and can be measured more readily. The ionization chamber measures both the energy and the angle of the proton in the following way:

The chamber is a cylinder 1.6 m long, 0.8 m diameter enclosing six cells with circular anode and cathode plates, 12 cm apart, perpendicular to the axis which is also the incoming beam direction. It is filled with hydrogen, which provides the target nuclei (protons) and also serves as detection medium. Protons recoiling in a cell ionize the hydrogen. The total charge collected is proportional to the proton energy (and can be calibrated using 5 MeV alpha sources mounted in the chamber) and the rise time of the pulse on the anode gives the polar angle of the proton.

The anode is shielded by an earthed grid. When the ionization occurs the cathode immediately records a signal which grows as the electrons move towards the anode. The anode sees no signal until the electrons appear through the grid and the signal will grow as more electrons arrive. The rise time is dictated by the different electron drift times due to an inclined recoil proton track.

A smaller chamber of this type was used successfully for elastic scattering measurements on the Gatchina 1 GeV synchro-cyclotron in 1972. The present chamber is being used in extending the measurements to higher energies at the 76 GeV proton synchrotron at Serpukhov this year. It will probably reach CERN about May 1976.

The synchro-cyclotron at Gatchina is supporting a healthy programme of experiments. About 4000 hours of physics are done each year with research in the various fields familiar in this energy range — particle physics (such as the experiment described above, polarization measurements, pion mass, charge exchange...), nuclear physics (pion production, isotope studies, spallation...) and some biology and medicine. An ISOLDE-type facility (on-line isotope separator) is being developed and is scheduled to be ready for experiments in the Autumn of this year.

The synchro-cyclotron is operating with accelerated beam intensities of about 1 μA. The extraction efficiency is about 30 % and pion beams of up to 600 MeV are available. Pion intensities at 400 MeV are around 10^5 for negative pions and 10^6 for positive pions.

BROOKHAVEN
Some thinking on heavy ions

The interest in high energy heavy ions did a quantum jump upwards in the course of 1974. The interest had been growing in any case, particularly following the developments at Princeton and Berkeley in 1971 which yielded ions such as nitrogen at multi-GeV energies. The jump came because of the provocative ideas of T.D. Lee, in collaboration with G.C. Wick, that abnormal, stable nuclei could be formed by crowding many nucleons together at high energies. The postulated nuclei would have several times the normal nuclear density and other peculiar properties such as a charge number about equal to the number of nucleons and zero effective mass.

To create such abnormal states of matter would require heavy ions (holding over 200 nucleons) to be collided at energies of several GeV per nucleon. The favourite candidate is the collision of two uranium ions of over 1 GeV per nucleon to give abnormal nuclei holding about 400 nucleons. Not everyone buys the idea of the abnormal nuclei, but no one doubts that, in any case, heavy ion collisions will bring fresh information about the nucleus. There are already theories on 'pion condensates' (from G.E. Brown), on 'nuclear hydrodynamics' (W. Greiner and P. Siemens), etc. which are added stimuli towards heavy ion research.

The leading facility at the moment is the Bevalac combination at Berkeley (see June issue 1974, page 213) where the combination of the Superhilac and the Bevatron is capable of yielding ions as heavy as krypton. They could go higher but at the cost of a new vacuum system for the Bevatron ring because very high vacuum is needed to preserve partially stripped ions. If a pressure of 10^{-9} was achieved, such ions could be accelerated up to about 2 GeV per nucleon.

The potential of other accelerator systems has also been discussed. At CERN for example, there is the tantalising prospect, if ions can be manoeuvred through the PS, of transferring them to the healthy vacuum of the Intersecting Storage Rings and bringing them into head-on collision. We may have more to say on these possibilities in the coming months. At Brookhaven, there has been a study of the potential of the Alternating Gradient Synchrotron (AGS) for heavy ion acceleration, led by K. Prelec and A. van Steenbergen.

The main problem with using existing machines is almost always that of vacuum. Protons sail happily through a pressure of 10^{-6} torr during a 1 s cycle but partially stripped heavy ions would not survive in any acceptable intensity. Charge exchange (the loss or capture of an electron) would cause ions to move out of the beam. However fully stripped ions would survive and the Brookhaven study concentrated on what would be necessary to achieve fully stripped uranium ions which could then be accelerated in the existing AGS with few modifications to its present components.

The preferred system involves an ion source, yielding ions with an average charge about 11, a 600 keV pre-injector and a short section of linac of the Sloan-Lawrence type (as used on the Darmstadt heavy ion accelerator, UNILAC). This would yield an energy of about 0.75 MeV per nucleon which, through a first stripper, would give ions with about 35 electrons removed. These ions would be fed to a fast cycling booster (a rebuild of the former Cambridge electron synchrotron with a smaller radius using 16 of the 24 magnet cells).

Operating at 30 Hz, where the rapid cycling time greatly reduces the charge exchange problem, this could feed ions through a second stripper to give fully stripped ions for injection into the AGS. About 100 MeV per nucleon is probably necessary to achieve full stripping of the electrons from the uranium ions but a higher output energy, 200 MeV, was selected so as to reduce the strain on the r.f. system in the AGS ring itself.

The uranium ions could then be accelerated to between 1 and 12 GeV per nucleon (close to 3 TeV total energy) and, with the booster operating at 30 Hz, a flux of 10^9 ions per second could be possible.

The preliminary study has not been carried through to any sort of formal proposal. The future programme at Brookhaven remains concentrated on high energy physics at the AGS and on the proposed construction of the ISABELLE proton-proton storage rings for very high energy colliding beam physics. Nevertheless, when heavy ion physics questions are in the air, it is good to have the accelerator answers at the ready.

STANFORD
On synchrotron radiation and the new particles

In the high energy physics excitement that the SPEAR electron-positron storage ring has managed to generate over the past year, we have neglected another large category of people who are involved in other branches of science. They are the research workers in physics, chemistry, biology, metallurgy and astrophysics who use SPEAR as a source of light.

The synchrotron radiation which inevitably emerges tangentially to an orbiting high energy electron beam has features, particularly in frequency range, intensity and in directional properties, which make it a unique research tool. This has been exploited for many years mainly at the DESY synchrotron in Hamburg and at the storage ring called Tantalus at the Wisconsin Physical Sciences Laboratory. Using the electrons in a storage ring can have advantages since they are intense broad energy spectrum sources. SPEAR is the highest energy electron ring currently in operation and is therefore an obvious candidate for a synchrotron radiation facility — all the more so since synchrotron radiation research can go on almost entirely parasitically to the high energy physics research.

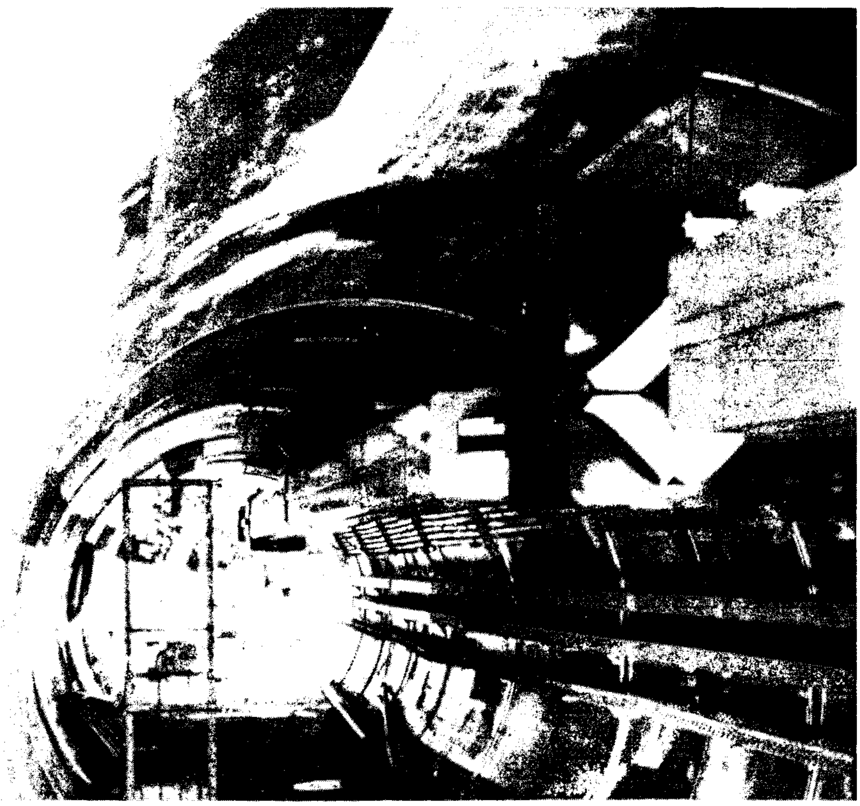
This was realized in the SPEAR

The major preoccupation for the future at the Stanford and Berkeley Laboratories remains the higher energy electron-positron storage ring, PEP. The photo shows a model section of the PEP tunnel with quadrupole and bending magnets suspended from the roof on the right. PEP is not in the USA President's budget for Fiscal Year 1976, which means that authorization for its construction is unlikely to be given this year.

construction days and a light outlet port was incorporated from the start. In July 1973 a pilot project began using this light. About the same time the National Science Foundation supported the construction of a National Synchrotron Radiation Laboratory at SPEAR. A building to house about six simultaneous experiments was constructed in ten months and the facility was in action in May 1974 well ahead of schedule.

Important results have already been obtained. Outstanding amongst them has been extended X-ray absorption fine structure analysis for probing chemical structures. The basic technique has been known for many years. When radiation of a range of frequencies is directed onto matter it is absorbed much more readily at those frequencies corresponding to the X-ray energy needed to liberate a core electron from the atom. The graph of absorption against frequency gives a sharp peak at this X-ray energy and then a series of wiggles due to interference between the outgoing electrons and the electrons scattered back by neighbouring atoms. Analysing these wiggles, or fine structure, gives detailed information about the local atomic environment of the absorbing atom.

In the past, with conventional radiation sources, many days or weeks were needed to obtain a single graph. Using synchrotron radiation from SPEAR, a graph, which is also of better quality, can emerge in half an hour. It is now possible to study atom locations in complex systems such as in the intricate molecules which play an important part in biological processes. The technique looks at the immediate atomic environment of a particular radiation absorbing atom and can, for example, watch the movement of the iron atom in a hemoglobin molecule as it conveys an oxygen atom from an oxygen-rich to an oxygen-poor environment.



Other work is concentrated on studying the electrons emitted from materials under radiation bombardment. These photo-electrons, carrying information on how electrons are held in the material, can be monitored by a time of flight method since radiation from SPEAR hits its target in well defined short bursts corresponding to the passage of the single bunch of electrons orbiting the ring.

Biological research may be greatly helped by the speed at which data can be collected at SPEAR. It is hoped to obtain diffraction patterns of biological systems, such as muscle or retinal tissue, with exposure times of less than a second so that rapid changes in the systems can be investigated. Rather than the conventional photographic technique for recording the patterns, the possibility of using multiwire proportional chambers (see April 1973 issue, page 113) is being examined.

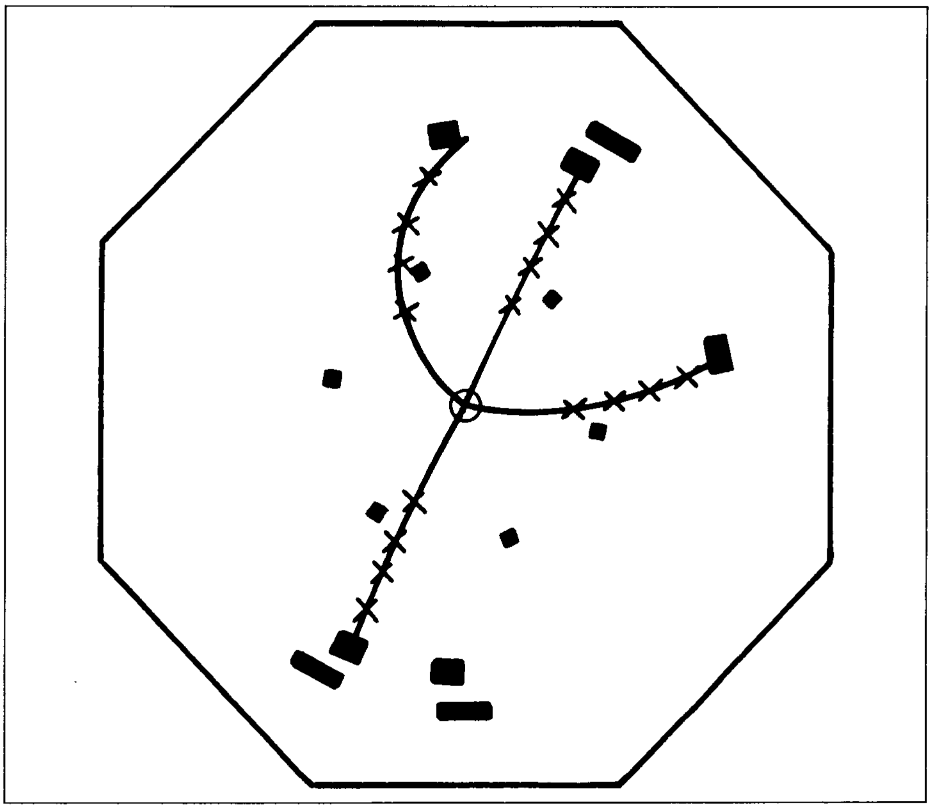
When the full higher energy, higher intensity potential of SPEAR II is realized, the synchrotron radiation facility will benefit enormously also. Compared with a radiation power of about 12 kW from SPEAR I, some 150 kW will be emitted. The research is therefore likely to go from strength to strength. It is directed by S. Doniach of the Hansen Laboratories at Stanford University with W. Spicer as Consulting Director. The details above are drawn mainly from information supplied by H. Winick.

More on the new particles

Meanwhile the high energy physics community at the Laboratory has been preoccupied with the new particles (see December 1973 issue, page 415). Since the discovery at the SPEAR storage ring of unusually stable particles of mass 3.1 (also discovered at

A slight error has been found in the energy calibration of SPEAR and this will lead to a small downward adjustment of the masses of the new particles.

The properties of the newly discovered particles continue to amaze the high energy physics community. They have now established themselves as the only ones that can write their own name. The Stanford/Berkeley team called them psi particles and the heavier of the two types obliged by writing the appropriate Greek letter in a computer reconstruction of its decay. The two curved arms are positive and negative pions from the decay of ψ (3695) into ψ (3105). The straight stem is the subsequent electron-positron decay of the ψ (3105).



Brookhaven where it is called the J particle) and 3.7 GeV, the experimental and theoretical work at Stanford has fastened onto learning more about their properties and on trying to understand them.

The first task was to scour carefully the energy region accessible to SPEAR to see whether there are any more of these curious objects lying around. A search was carried out varying the electron-positron collision energy between 3.2 and 5.9 GeV. This experiment used the large magnetic detection system of the Stanford/Berkeley team. Apart from the two particles previously observed there were no other narrow resonances (corresponding to stable particles) detected but some broader resonances might be there. In particular, something seems to exist at a mass of about 4.1 GeV.

By now, tens of thousands of decays of the two particles have been recorded both by the Stanford/Berkeley team and by a Stanford Physics Department/Stanford High Energy Physics Laboratory/Pennsylvania team who use large sodium iodide detectors at the other SPEAR intersection. They are able to study particle decays into gammas.

A few observations are already of interest. The 3.7 GeV particle has been seen to decay about 25 % of the time into the 3.1 GeV particle plus a couple of pions. The Stanford teams call the particles psi; the decay then reads (with masses expressed in MeV):

ψ (3695) $\rightarrow \psi$ (3105) $+ \pi^+ + \pi^-$

This strongly indicates that the particles are close relatives of one another.

When the ψ (3105) itself decays, it seems to prefer going to an odd number of pions rather than an even number of pions. Looking at the electric charges involved, this suggests that the neutral psi does not have positive or negatively charged equivalents.

A very important additional piece of information came from the FermiLab in January. The Columbia/Cornell/FermiLab/Hawaii/Illinois team led by Wonyong Lee used a photon beam onto a beryllium target and looked for production of the new particles. They saw the 3.1 GeV particle being produced plentifully (about ten a day), emerging in the forward direction as the photons were converted. This shows that the particles are hadrons (sensitive to the strong interaction) since the cross-section observed (about 1 μb) is typical of hadrons in photoproduction. It seems to rule out one of the main candidates to explain the new particles, namely that it is neutral intermediate boson, and leaves the properties of colour and charm as the front runners (see the December issue).

Other studies at SPEAR have not yet borne fruit at the time of writing but data is being analysed. One is an attempt to pin down the spin and the parity of the new particles. This is done by collecting data a few MeV below where the particle peaks appear so as to detect interference effects between the particle decays into two muons and 'normal' production of two muons. Another experiment is looking for evidence of single high energy gammas emerging from the decay of the heavier particle. Various attempts to explain the existence of the particles make predictions about such gammas.

So as not to be completely overshadowed by its storage ring appendage, the electron linear accelerator at Stanford has reached out to a new energy record. The peak energy is now 22.74 GeV and it is expected that this will continue to be nudged higher as the present 20 MW klystrons, which feed r.f. power to the accelerator, are replaced by 30 or 40 MW versions.

The linac is also beginning directly to feed experiments on the new particles. A Wisconsin/Stanford team are using the 20 GeV and 8 GeV spectrometers to spot electron and muon pairs from the decay of the particles. They can thus measure the photoproduction and electroproduction.

WISCONSIN
Research on Tantalus

There have now been over six years of research with the synchrotron light emerging from the 240 MeV electron storage ring, Tantalus, at Wisconsin. Much of the pioneering work on the use of synchrotron radiation has been done on this facility which is well established as one of the finest in the world.

Modulation spectroscopy, where the optical properties of the solid state are studied, has opened up a whole new field of research and Tantalus has had a fruitful year using this technique with synchrotron radiation at energies beyond the lithium fluoride cut off. In particular, some work on electroreflectance (D.F. Aspens, L.G. Olson, D.W. Lynch) unearthed fresh information on conduction bands. The work has been praised by M. Corboda who has written the bible in this field.

Studies are continuing on molecular bonding (J.W. Taylor, G.G. Jones) and on the fluorescence and photodissociation of atmospheric gases (L.C. Lee, R.W. Carlson, D.L. Judge, M. Ogawa). They have been joined by a new topic promoted by D.R. Huffman. He is attempting to explain the peculiarities of the spectrum of radiation which reaches us from interstellar space, by measuring the absorption and reflectance of likely interstellar matter such as silicates, garnets and spinels.

High resolution photo electron spectroscopy covering the energy range from 5 to 100 eV is now being carried out gathering more information from angular resolution and polarization. Chemisorption studies are a related development. In addition there is the 'bread and butter' work of compiling tables of band structures of elements and compounds over the whole range from ultraviolet to soft X-rays.

To round off the synchrotron radiation picture in this issue, there is news from two other centres. In the USA, the National Bureau of Standards 180 MeV electron synchrotron, where research with synchrotron light began about twelve years ago, has been converted to a storage ring with a peak energy of 250 MeV. The increase in energy and duty cycle has stepped up the brightness of the synchrotron light (per milliampere of orbiting electrons) by a factor of 100. (This project was described at the Stanford Accelerator Conference in May of last year by E.M. Rowe, M.A. Green, W.S. Trzeciak and W.R. Winter). In the U.K., the Science Research Council has given its blessing to the construction of a 2 GeV electron storage ring at the Daresbury Laboratory specifically as a facility for synchrotron radiation research. We may have more on this project in the near future.

DUBNA
Muons and pions

During the past two years research has been carried out at the Dubna synchro-cyclotron on the interaction of negative muons with fissile elements. New results were obtained on the probability of the fission of nuclei excited during non-radiative transition of muons in mesonic atoms. Comparison with results on the photo-fission of the same isotopes gives a better understanding of the structure of the fission barrier.

One of the results of the study of mesonic atoms of uranium was the discovery of X-rays with an energy 350 eV greater than that of 'normal' X-rays. This work was carried out in collaboration with scientists from SIN and Freiburg whose experiments at CERN with an iridium target also saw this effect.

It can be explained as being due to the incomplete shielding of a single atomic charge by the muon which is in the orbit of the mesonic atom with a sufficiently high principal quantum number. Subsequent work at Dubna made it possible to determine the energy shift of X-rays for thorium, lead, iridium and tantalum.

High intensity pion beam

A method of obtaining a high intensity pion beam using a solenoid lens with inhomogeneous axially symmetric field has been implemented at Dubna. In contrast to the traditional method of focusing paraxial charged particle beams by quadrupole lenses, essentially non-paraxial beams were used with the angles of the particles emitted from the target in relation to the focusing system as high as several tens of degrees. For a wide category of inhomogeneous, axially symmetric fields (enhanced at the ends or having a field distribution along the axis with a dip in the middle) there is always a family of trajectories for which wide-angle focusing conditions are satisfied with a solid angle of capture of about one steradian with small spherical and chromatic aberrations.

A pion lens was constructed having six excitation coils with a total of 2500 turns surrounded by an iron yoke. An intermediate yoke placed in the middle of the lens creates a sharp dip in the field while strongly increasing the field in the region of the target and focal points. A central shielding core with helical baffles is placed in a 450 mm diameter vacuum chamber to separate the particles coming from the target according to their charge sign. The total weight of the lens is 86 tons and its maximum excitation current is 900 A.

For negative pions with an energy of about 30 MeV, from a 670 MeV proton flux of 10^{12} per second striking a copper target, the following beam parameters were obtained — total intensity: 10^7 s^{-1}; flux 10^5 $cm^{-2}s^{-1}$, stopping intensity: $5 \times 10^4 g^{-1}s^{-1}$ in water. For a positive pion beam these parameters are about four times higher. The dose rate in the Bragg peak for a negative pion beam is about 3 rad/min.

It is intended to use the beam for radiobiological and clinical research and also for physics experiments in which it is important to have a high pion stopping intensity.

Conferences

Two meetings which may interest some of our readers:

16-21 June, 'Experimental Status and Theoretical Approaches in Physics at the High Energy Accelerators', The Institute of Particle Physics, International Summer School 1975, to be held at McGill University Montreal, information from — Secretary IPP, Department of Physics, McGill University, P.O. Box 6070 Station A, Montreal, Quebec, Canada H3C3 G1.

1-10 October, 'High Energy Radiation Dosimetry and Protection', to be held at Ettore Majorana International Centre for Scientific Culture, Erice, Sicily, information from — A. Rindi, Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720 USA.

ECFA Meeting

On 27 January, a meeting of the European Committee for Future Accelerators was held at CERN under the Chairmanship of W. Paul. There were two major items for discussion. The first concerned the electron-positron storage ring proposals in Europe, plus the ideas on higher energy proton-proton storage rings at CERN. The second concerned the report of an ECFA Working Group on the internal and the external relations of the European high energy physics community.

The designs of the two proposed high energy electron-positron machines have been covered in CERN COURIER (January, page 12, and this issue, page 37). EPIC was described at the Meeting by the Director of the Rutherford Laboratory, G.H. Stafford, and PETRA by the Director of the DESY Laboratory, H. Schopper. In a hard-hitting debate following the presentations, the scientists from the UK and from the Federal Republic of Germany displayed considerable skill in projecting the differences between the proposals — naturally, to their respective advantages.

In terms of their physics potential, they are largely the same machine. The problem is that, especially in the present economic and social climate, it is generally accepted that two such machines should not be built in Europe. EPIC is seen as essential to ensure the continued vitality of the Rutherford Laboratory and the future of particle physics in the UK, succeeding both the 5 GeV electron synchrotron, NINA, and the 7 GeV proton synchrotron, NIMROD, by 1980. PETRA is seen as vital for the future of the DESY Laboratory and a logical extension of the research on the 7 GeV electron synchrotron and the DORIS storage rings already under way. It is not easy for ECFA to play Solomon in this situation.

The message from ECFA is that there is a very strong physics case for building such a machine and this case has now been greatly reinforced by the discovery and investigation of the fascinating new particles on the SPEAR storage ring at Stanford (see December 1974 issue, page 415 and this issue, page 42).

Either EPIC or PETRA would keep Europe in the frontline of the field of electron colliding beam physics and complement the excellent facilities for proton physics built up at CERN. Both projects are seen as completely open to the full European high energy physics community.

Already Italian physicists, who now do not anticipate having a similar machine (Super ADONE) in Italy in the near future, have made known their intention of continuing to do research with electron-positron colliding beams if facilities become available in Europe well beyond the energy range of ADONE at Frascati. Other countries have also been invited to express their interest in EPIC and/or PETRA.

The report on future proton storage rings by K. Johnsen, was concerned with ideas for much longer term development. Following the Autumn Study (see October 1974, page 334) more detailed sets of parameters have been strung together for storage rings to hold protons up to an energy of 400 GeV and where the CERN 400 GeV proton synchrotron could be used as an injector. Rings built of conventional magnets or of superconducting magnets have been treated and their possible locations in relation to the SPS examined. The ideas are however a long way from being in the form of a proposal like EPIC or PETRA.

'ECFA Working Group 3' was set up almost two years ago to examine the relationships between the constituent parts of the high energy physics community and the relationship with the community as a whole.

The high energy physics community in Europe can be put into three boxes — the physics Departments in the Universities in all the Member States, the National Institutes and CERN. In the past twenty years the relationships between these component parts appear on the whole to have been very well managed. The success of the community, organizationally as well as scientifically, is often held up as a model. Nevertheless, it was judged right to take a hard look at the European scene, particularly since the general environment in which high energy physics is done is changing rapidly.

The Working Group made a series of recommendations at the end of its discussions and these were presented at the ECFA Meeting by the Chairman of the Group, J.C. Gunn.

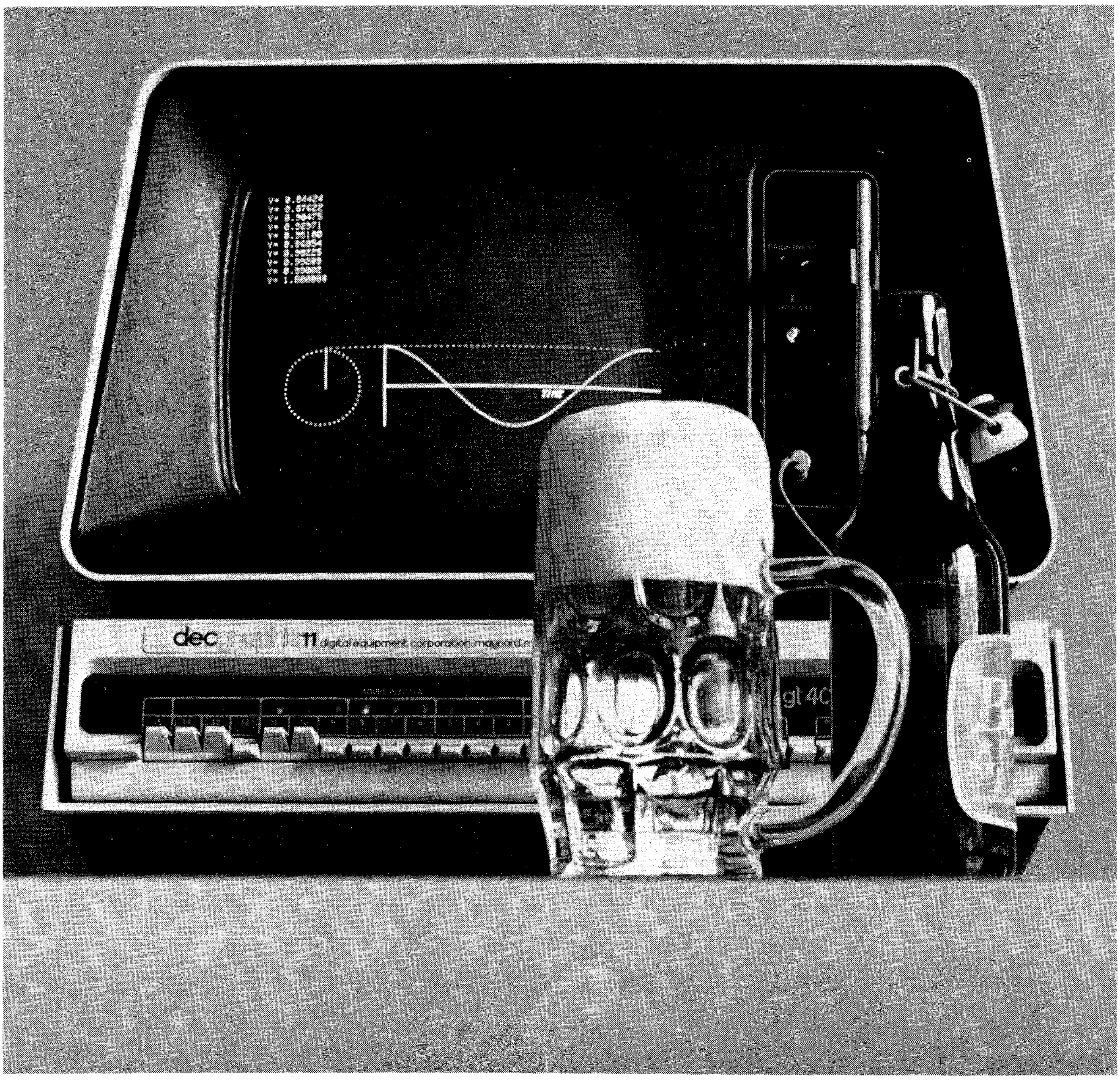
The first recommendations concerned the demographic problem of sustaining a vigorous community at a time when the total number of scientists involved is no longer growing. The Group stressed the need for national bodies and CERN to watch such things as the balance between temporary and permanent appointments in the field.

There were recommendations concerning the detailed problems confronted by visiting scientists working at CERN. While not suggesting any fundamental changes in the system, these recommendations aim to help smooth the mechanisms still further. In the subsequent discussion it was obvious that the scale of high energy physics experimentation is resulting in growing difficulties for scientists in some regions which do not have the support of large National Institutes.

On the relationship between the National Institutes and CERN there is concern about the high centralization of research facilities at CERN. This was seen by some as providing a further argument for the development of an electron-positron colliding beam machine elsewhere. Finally, it was felt that more could be done to project high energy physics to the rest of the community and there were recommendations for action in the field of education, on student programmes at CERN and on visits to research Laboratories.

Professor Paul has become Chairman of the CERN Scientific Policy Committee and Professor G. Von Dardel was elected to succeed him as Chairman of ECFA.

Graphics computing is no longer a rich man's tool.



Low-cost. Graphics computing used to be an expensive proposition. But this is no longer the case. Thanks to Digital's low-cost GT graphics computer systems which give you outstanding performance at ordinary prices. Which means that the benefits of graphics computing are now accessible in more applications to more people.

Powerful. Take your choice. From three multi-purpose systems that combine the convenience and flexibility of graphics display with the power of a Digital PDP-11 computer. To meet your exact price/performance requirements. Our GT-40 System is only S.Fr. 55.100. For growing needs, there's the expandable GT-42 System – just S.Fr. 66.500. Or, for even greater performance, our GT-44 System, S.Fr. 131.000.

Full-range. Depending upon the system, you get the power of a PDP-11/10 or 11/40 CPU. Plus your choice of peripherals and software. Including a special-purpose graphics display processor with hardware character and vector generator. Two 1.2-million word removable cartridge disk drives with controller. A 12- or 17-inch CRT monitor with light pen. And more. Plus Digital's standard operating systems including our unique LA-11 library of five laboratory applications modules.

Digital Graphics Systems. For the best of both worlds.

Please send me complete information about Digital's GT-40, GT-42 and GT-44 graphics computer systems.

Name ______________________

Position ______________________

Company ______________________

Address ______________________

____

Telephone ______________________

Digital Equipment Corporation International (Europe),
81, route de l'Aire,
CH-1211 Geneva 26,
Tel. (022) 42 79 50.

Cern

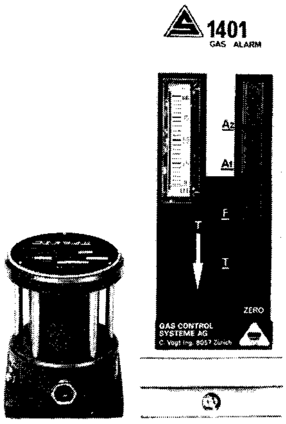
Offices in Reading, London, Birmingham, Bristol, Leeds, Manchester, Edinburgh, Munich, Berlin, Cologne, Frankfurt, Hamburg, Hannover, Stuttgart, Vienna, Stockholm, Gothenburg, Oslo, Copenhagen, Helsinki, Paris, Grenoble, Utrecht, Brussels, Geneva, Zurich, Milan, Turin.

digital

Gas-Überwachung mit System

Ob Messen, Überwachen und/oder Alarmieren – wir bieten das richtige System. Zuverlässig, sicher bewährt. Für jedes Projekt übernehmen wir auch die gesamte Projektierung und Installation sowie den Service.

GAS CONTROL SYSTEME AG
C. Vogt Ing.
Schaffhauserstrasse 210
8057 Zürich
Tel. 01 46 46 66
Telex 57 867

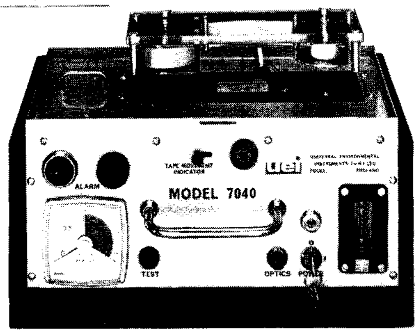


Sieger

Ein Begriff für stationäre Gasüberwachungs-Anlagen für den Explosionsschutz oder den Toxschutz. Einsatz für alle brennbaren Gase/Gas-Luft-Gemische

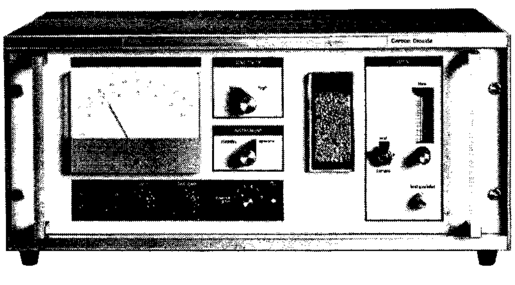
UEI

Überwachungs-Systeme. Stationäre oder tragbare Geräte zum Messen und Alarmieren von schwer erfassbaren Medien. Messbereich zwischen 0 bis 20 PPM/250 PPM.



UEI

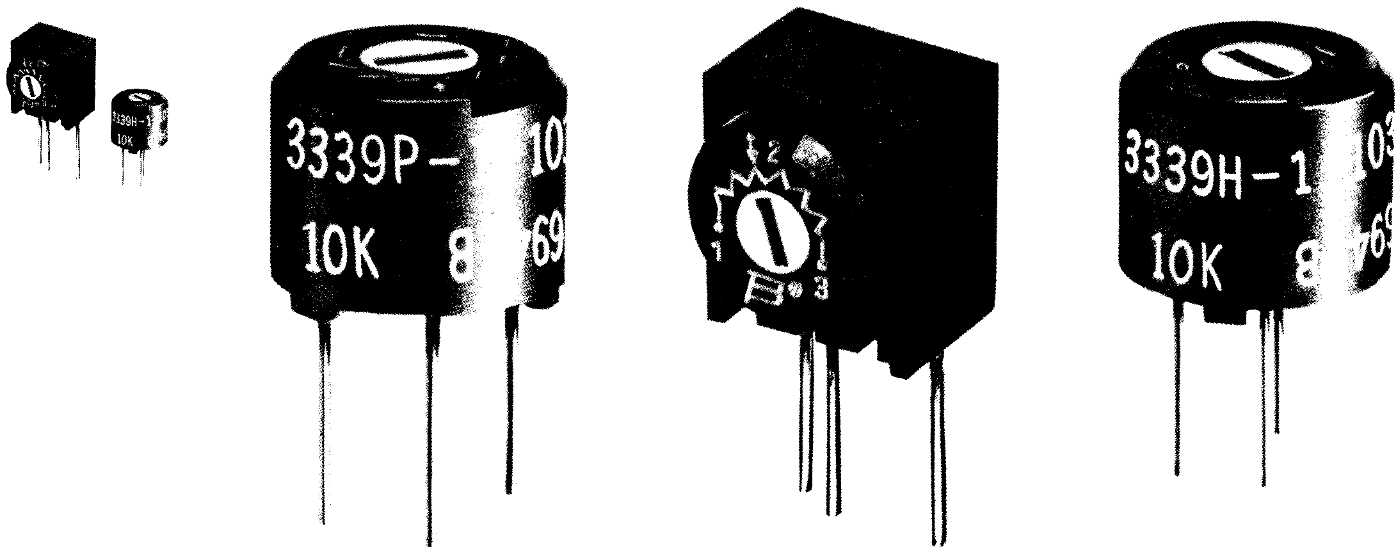
Zum Beispiel für TDI, Schwefelwasserstoff, Phosgen, Stickstoffdioxid, Chlor, Vinylchlorid.



Grubb Parson

Ein technisch interessantes Programm von Gasanalisatoren zum Überwachen von nicht oder schwer brennbaren Medien wie CO_2, CO, N_2O, NO, SO_2, Freon 12

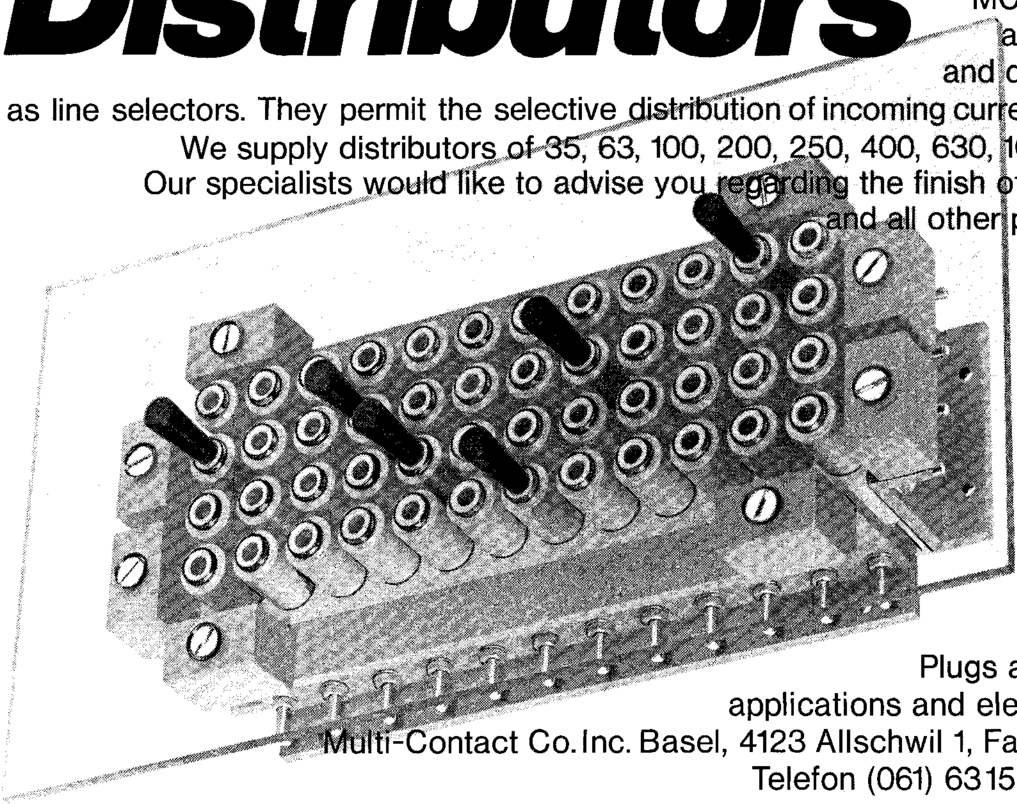
Multi-Turn Commercial Cermet-Potentiometer Trimpot® Model 3339



- Unique planetary drive offers precise wiper setting of a multi-turn in sigle-turn package size.
- Low cost commercial PALIRIUM® cermet four-turn.
- Space saving size: 0.30″ diameter × 0.25″ high.
- Low temperature coefficient: ±100 ppm/°C over entire temperature and resistance ranges.
- 0.5 watt power rating at 85°C.
- Sealed to withstand wave soldering and immersion cleaning process.
- Complete resistance range: 10Ω to 1 Meg.
- Meets performance requirements of MIL-R-22097.
- Available ex stock CERN !

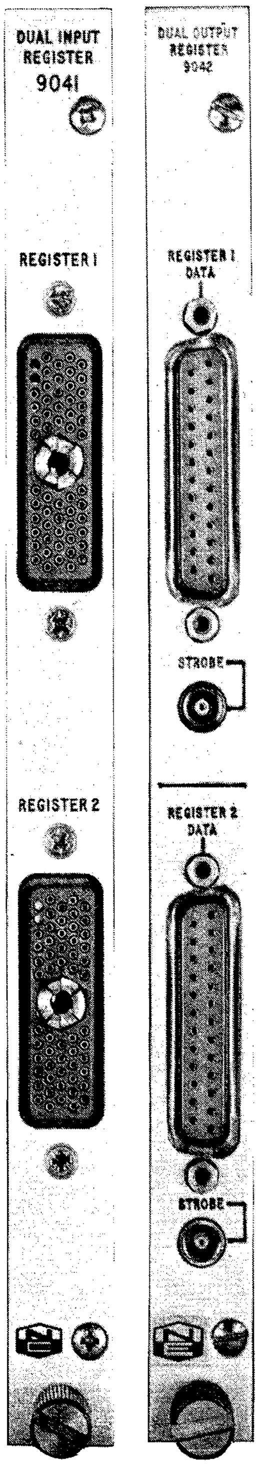
For complete details contact:

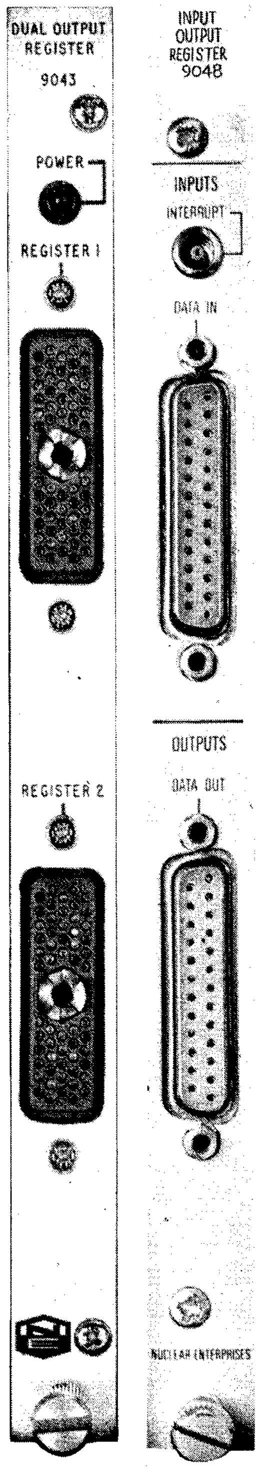
Bourns (Schweiz) AG Baarerstrasse 8 6301 Zug
Tel. 042 23 22 42 Telex 78722



CAMAC

NEW DUAL INPUT-OUTPUT REGISTERS





9041/AB Dual Input — 24 Bits

The 9041/AB accepts data via multiway front panel connectors, stores it in two 24 bit parallel entry registers and transfers it to the dataway in response to read commands. The transfer to the register is initiated by a data strobe which may be provided from an external source or from the dataway, and control signals are provided for use in handshake transfers.

9041/A: Accepts data via 100 ohm impedance terminated cables
9041/B: Accepts CAMAC unterminated signals

9042 Dual Output — 24 Bits

This module provides dual 24 bit outputs controlled by internal registers, which can be set and read by dataway command. Outputs are on dual 25-way Cannon sockets and are capable of sinking 40mA to earth.

9043 Dual Output — 24 Bits

This module provides dual outputs of 24 bits each, controlled by internal registers which can be set and read by dataway command. Data transfers to a peripheral can be controlled by handshake signals and can be initiated by the computer or the peripheral.

9048 Input/Output Register

This module is an updated version of the popular 9017 unit. It conforms with the revised 4100 specification, and also provides increased versatility at low cost.

Negative or positive logic output capable of sinking 450mA to earth or withstanding +60V with respect to earth.

Write for details and for 125-page CAMAC Catalogue No 66 containing full specifications of the most extensive range of units available from a single manufacturer.

NUCLEAR ENTERPRISES LIMITED

Bath Road, Beenham, Reading RG7 5PR, England. Tel: 073-521 2121. Telex: 848475. Cables: Devisotope, Woolhampton.
Also at: Nuclear Enterprises GmbH, Schwanthalerstrasse 74, 8 Munchen 2, Germany. Telephone: 53-62-23 Telex: 529938
U.S.A.: Nuclear Enterprises Inc, 935 Terminal Way, San Carlos, California 94070 Telephone: 415-593-1455 Telex: 348371.