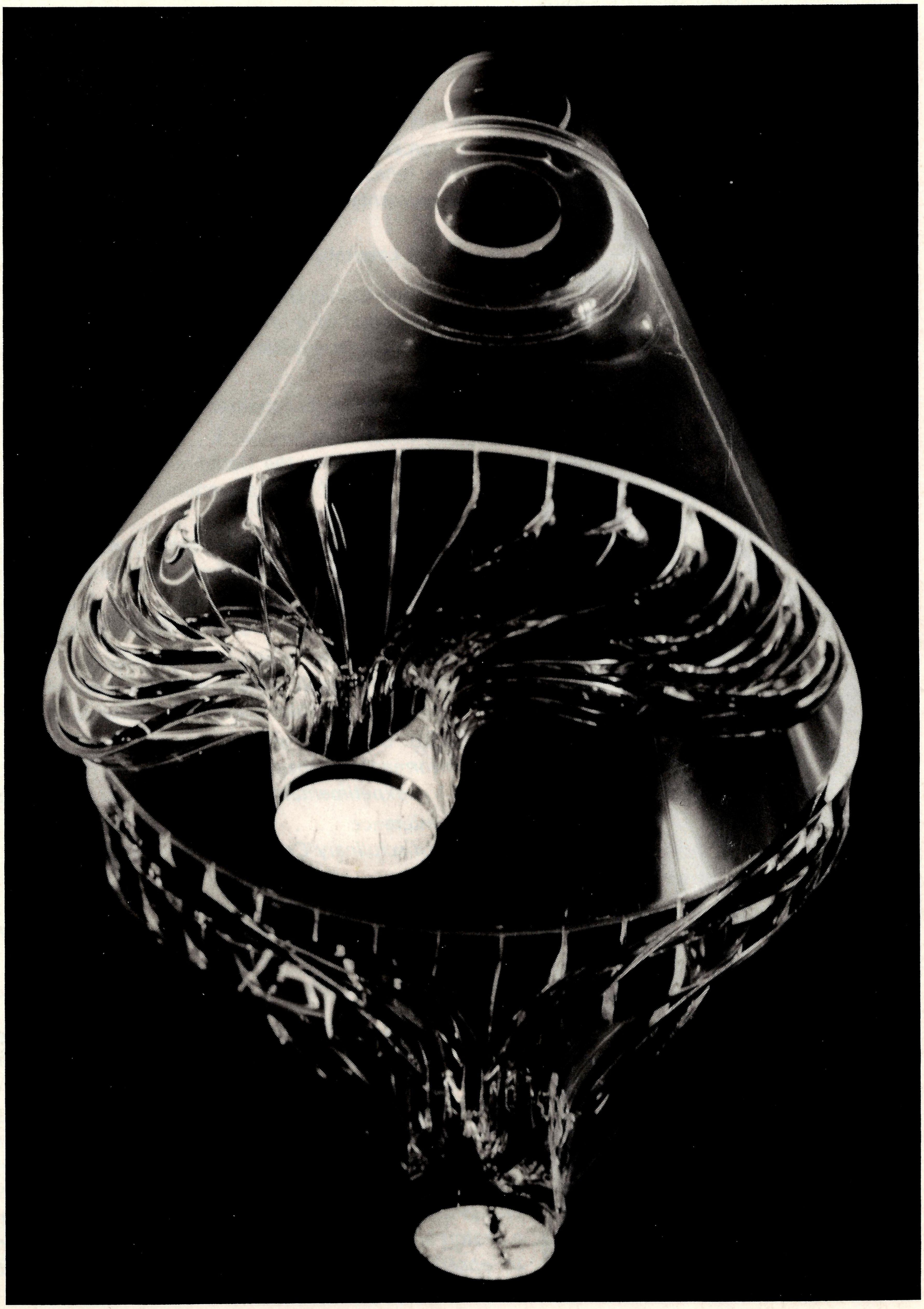
CERN COURIER

NO. 12 VOL. 15 DECEMBER 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.

Editor: Brian Southworth
Assistant Editors: Henri-L. Felder
Michel Darbin
Advertisements: Micheline Falciola
Photographs: PIO photographic section

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: This futuristic Christmas tree is a plastic scintillator cone which will be used by a CERN/Daresbury/Mainz/TRIUMF team in an experiment at the CERN 28 GeV proton synchrotron. Two groups of light guides convey any light signals, produced by particles passing through the plastic, to photomultipliers. The cone will slide close to a gaseous hydrogen target which will receive a beam of antiprotons. It allows through its 4 cm aperture (at the top in the picture) those particles which are aligned along the axis of the target where they may form protonium — a temporary union of a proton and an antiproton. The experiment will study this temporary union by observing the X-rays emitted as protonium 'de-exites' through its possible energy states. (CERN 414.10.75)

Quarks in the bag and other ideas

A mountain of information from experiments is telling us that the hadrons, the particles that feel the strong force, are built up of quarks. But, if that is so, why have we failed to break open a hadron and get at an individual quark?

Some twelve years ago, enough relationships had been found among the properties of the hadrons to point to some underlying reasons for the relationships. Just as the properties of the electron clouds in the atoms explain the similarities among the chemical elements, so the properties of three more basic objects, given the name quarks, seemed to explain the similarities among all the then known hadrons. (We need to throw in another quark to extend this explanation to cover the more recent discoveries — see the April issue.)

Hadrons come in two classes — baryons (like the proton and neutron) and mesons (like the pion and kaon). From combinations of three quarks we can build all the baryons; from combinations of two quarks (a quark and an antiquark to be more precise) we can build all the mesons.

In addition to this satisfying fact that we can build all our particles given a clutch of quarks, we can also 'see' quarks indirectly when we look at the structure of hadrons in particle scattering experiments. No matter what we fire at the proton, for example, the bombarding particle bounces off as if three grains exist inside the proton. Whether we shoot other protons, so that we are seeing where the strong force acts, or electrons, so that we are seeing where the electromagnetic force acts, or neutrinos, so that we are seeing where the weak force acts, they all scatter from the proton as if three quarks were sitting inside.

Nevertheless, we have never seen a quark directly. They should be very easy to spot because we believe that they carry a fraction (1/3 or 2/3) of the usual unit electric charge. Because of this, if one of them gets loose, it should write its name very large in many types of detector since the ionization it causes would be much smaller than that produced by a normal charged particle (ionization being proportional to the square of the charge). Using this fact, quarks have been hunted at accelerators and storage rings up to the highest available energies and among cosmic rays but it has so far proved impossible to create or to liberate a single quark.

During the past few years, theoreticians, frustrated by the failure of experiments to come up with a quark, have been busy thinking of reasons why it is impossible to come up with a quark. This might be called the inverse of the 'Feynman law' which states that if a thing can happen it does. The inverse is that if a thing does not happen then it cannot. Our theoreticians have a variety of ideas as to why we cannot have an isolated quark.

The most popular is the concept of a hadron as a 'bag' with such properties that the quarks that it contains cannot escape. The bag emerged particularly from work at MIT and SLAC and is in many ways an extension to three dimensions of some earlier work on 'strings'. The string model was first treated in 1968 and owes much to the simple bar magnet.

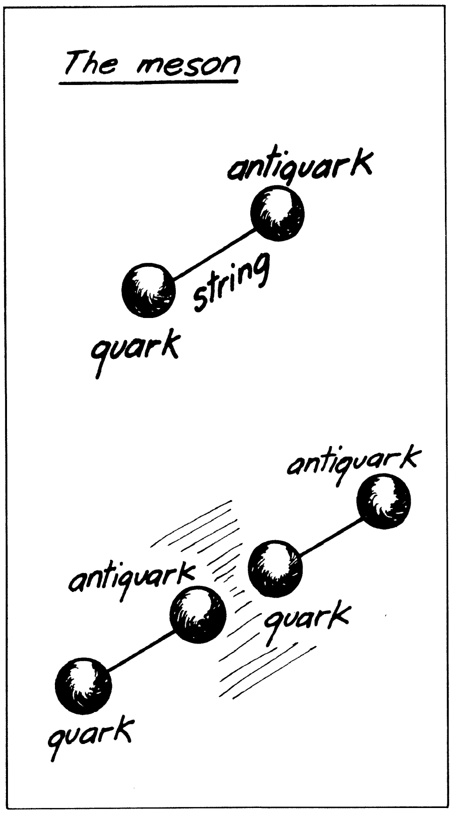
If we take a bar magnet and snap it in half we are left holding not a separated North pole and South pole but two bar magnets each with their North and South pole. We have never succeeded in isolating a single pole, or monopole. There is no obvious physics reason why this should be so (on the contrary, their non-existence in isolation introduces an uncomfortable lack of symmetry between electrical and magnetic phenomena). The parallel with quarks is rather obvious.

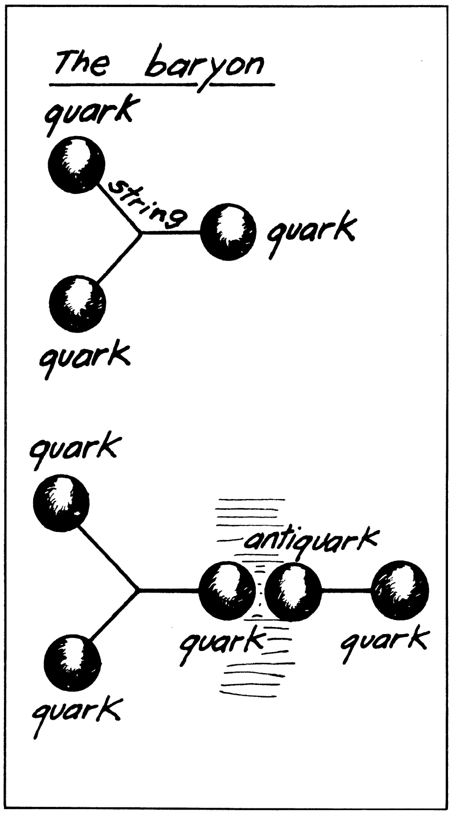
Let's suppose that the quarks are 'monopoles' linked by magnetic lines of force. From field theory (i.e. going back to the basic ideas which have proved so successful in explaining electromagnetism) we can see situations where the magnetic lines of force are compressed along the line between the quarks becoming like an elastic string which joins them. (Compression of lines into bundles along a particular direction in this way is nothing new — it is familiar, for example, in superconductivity.) What happens when we then try to snap off a quark? We extend the string and, when the energy involved is enough to create a quark and antiquark, the string breaks and we are left holding not a separated quark but a quark-antiquark pair (a meson). The diagram overleaf might make this clearer.

This model sees the meson as quark and antiquark sitting like monopoles on the end of an elastic string of magnetic flux lines and the hadron as three quarks similarly linked by strings. If we introduce the idea that the string could be spinning about its axis balanced by centrifugal force, we can come out with a series of particles or 'excited states' having regularly varying properties (lying on Regge trajectories) and so on. In other words, from the string model many of the features of particle behaviour that we can see in the 'real' world can be deduced. As far as quarks are concerned the model explains, beginning from some basic ideas, why quarks are 'confined' and do not appear in isolation.

The bag model carries over some of the ideas but begins at the other end — quark confinement is fed into it from the start rather than emerging from it. Within the three-dimensional bag, the quarks bounce around like 'free'

Why we don't see an isolated quark... One idea takes its philosophy from the familiar magnet and our inability to isolate a single pole. The meson is a quark-antiquark system and the baryon a three-quark system the quarks being linked in each case by some magnetic-type 'string'. If we pull hard, supplying enough energy supposedly to liberate a quark, all we do is to create a quark and antiquark where we 'snap' the string. This is analogous to snapping a bar magnet giving us an extra North and South pole.





particles (which is in agreement with experimental observations). But they do not leave the confines of the bag.

Within the bag we say that the quarks are exchanging particles amongst themselves. This is a familiar concept in particle physics (see April 1974 issue for a more extended discussion). Briefly: The electromagnetic force acts by the exchange of particles called photons. An electron knows that another electron is there because a photon passes between them. The strong force acts by the exchange of particles called pions. The atomic nucleus holds together because protons and neutrons are swapping pions. Associated with each particle there is a 'field' of such exchange particles which causes its interactions with other particles. In the electromagnetic case the field stretches out to infinity; in the strong case the field is of the dimensions of a nucleus.

Coming back to the bag — each quark is aware of the existence of other quarks via some exchange particles. They are glued together because of this which led to the quark exchange particle being called the 'gluon'. The extent of the bag in space is the limit of the gluon field — the dimensions of a hadron. We have to feed into our mathematical description of this the restriction that the gluon field does not go beyond the boundary of the bag.

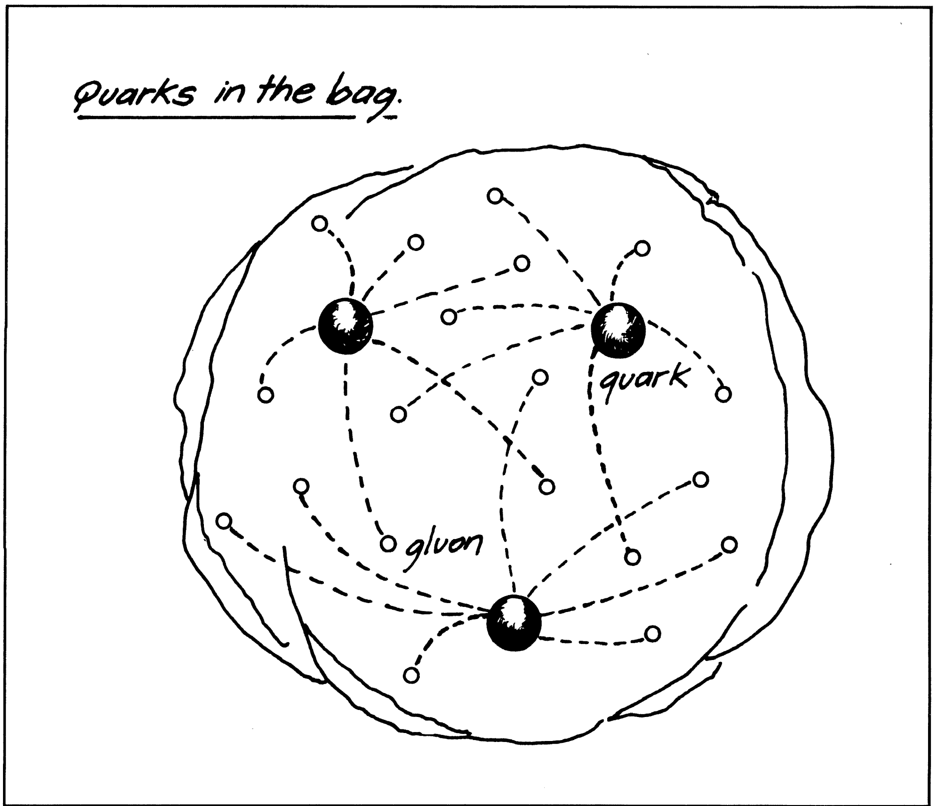
We ascribe a novel property to the gluons. It has been given the name 'colour' and comes in blue, red and yellow varieties. (Be careful to take these as arbitrary words to nickname a property. No one is actually assigning paint brushes to the gods.) We say that a gluon conveys colour from one quark to another but that the total colour of a hadron is zero. This can come about in a baryon by having a blue quark, a red quark and a yellow quark and in a meson by having quark-antiquark mixtures cancelling the colour out.

This picture of quarks and gluons is manageable by field theory, at least within the bag (leaving aside the confinement business) since it is not all that far from our standard ideas on particle interactions. Such calculations can give hadron properties like magnetic moments etc... which are in agreement with experiment. So the bag model remains popular.

There is another approach which brings with it the name 'soliton'. It is based on concepts that have been known for over a Century appearing first in hydrodynamics following a shrewd observation by Scott-Russell. He described this so elegantly that it bears repeating — 'I was observing the motion of a boat which was rapidly drawn along a narrow channel by a pair of horses, when the boat suddenly stopped — not so the mass of water in the channel which it had put in motion; it accumulated round the prow of the vessel in a state of violent agitation, then suddenly leaving it behind, rolled forward with great velocity, assuming the form of large solitary elevation, a rounded, smooth and well-defined heap of water, which continued its course along the channel apparently without change of form or diminution of speed. I followed it on horseback, and overtook it still rolling on at a rate of some eight or nine miles an hour, preserving its original figure some thirty feet long and a foot to a foot and a half in height. Its height gradually diminished, and after a chase of one or two miles I lost it in the windings of the channel. Such, in the month of August 1834, was my first chance interview with that singular and beautiful phenomenon.' People don't write about physics that way any more.

The singular and beautiful phenomenon comes mathematically as a

The bag theory has quarks confined within the particle. The forces between them are activated by the exchange of 'gluons' (just as charged particles exchange photons or nucleons exchange pions) but the gluon field does not extend beyond the boundary of the bag.



classical solution of a non-linear equation describing waves in a confined space. The conditions of confinement were just right in Scott-Russell's channel for the wave to go on for ever without dying away. Such a localized region of higher energy density (be it a wave or a particle) which can travel in a particular direction without changing with time is called a soliton. This persistence-with-time property can be expressed mathematically in terms of a topological quantum number.

Classical solitons concern only one space dimension and time. The connection between solitons and quarks is not very obvious except that the soliton concept carries this property of something existing forever. When theoreticians took a look at the soliton and tried to generalize so that it applied in three space dimensions, an intriguing fact emerged.

Using the all-pervading field theory, they found it necessary to use the sort of mathematical treatment (gauge theories) that has proved so successful in unifying the electromagnetic and weak forces. Also the forces involved need not be 'strong' even for the production of something like a quark. Solitons can result from the action of weak forces in special circumstances. They have monopole type properties and can be linked by compressed magnetic fields like the string model described above. Maybe solitons could pull the strong force under the same umbrella as the weak and the electromagnetic — a quite remarkable possibility considering the tremendous differences in their respective strengths.

Finally, there is another colour approach which is independent of the colour in bags idea we discussed above. It tries to show why quark and antiquark hang together, giving us our mesons, or three quarks hang together, giving us our baryons, but two quarks, four quarks, two quarks and an antiquark etc, do not hang together.

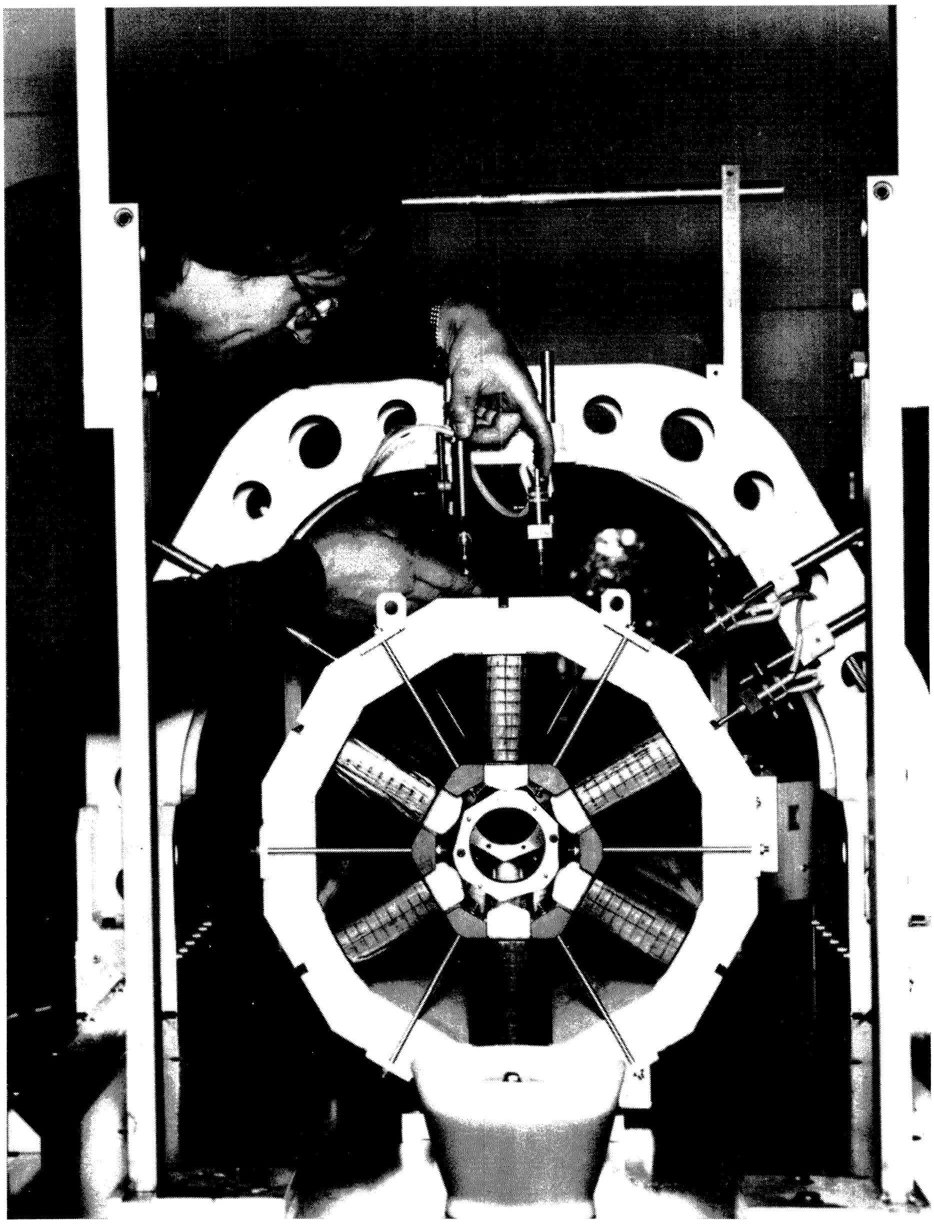
The name colour is given here to the property which causes attraction or repulsion between two quarks. Rather as in electromagnetism, where the words 'negative charge' on the electron and 'positive charge' on its antiparticle, the positron, are used in describing the strong attractive force between them, so colour and 'anti-colour' describes the hold that the quark and its antiquark have on one another.

The hanging together is permitted under 'infra-red slavery'. This is the opposite of 'asymptotic freedom' which says that at very short distances, or very high energies, particles behave as individuals — what is observed is then the outcome of the total behaviour of several free particles. Infra-red slavery says that at large distances or low energies several particles can act together as one. Perhaps our quarks act together as hadrons and not as individuals because our energy region is still too low for them to escape from infra-red slavery.

These models are different one from another and no way can they all be right. They all have some happy and some unhappy features. Only more experimental evidence or more development of the models is going to tell us which is nearest the truth. Alternatively, of course, one of these days we could knock a quark free somewhere... then we would not need any of them.

The SPS is nearly there

The work on the main magnets of the SPS will probably be complete by the time this article is in print. A thousand of them are sitting in the tunnel waiting for protons. Some of the correction magnets used for refined control of the behaviour of the particles in the machine remain to be installed and the photograph shows one of the sextupole type being measured.



CERN 231.10.75

It has become tradition in the past few years to report progress on the construction of the 400 GeV proton synchrotron, the SPS, in our December issue. This is the last time we will be giving this particular seasonal gift to our readers because the accelerator is on the brink of completion. During 1975 the construction of the machine has been successfully steered through a shoal of problems. The year opened with the mysterious breakdown of the insulation on the main ring magnets and continued with a variety of difficulties often originating in the general economic recession in Europe. Despite this, the project remains on schedule and, with luck, physics should be under way before the end of next year.

Let's begin at the beginning which for the SPS is the PS. We reported last month (page 349) that the smaller synchrotron is almost ready to fulfill its role as injector. It is required to send 10^{13} protons per pulse at 10 GeV shaved off during ten turns so as to fill 10/11 of the SPS ring (7 km in circumference). The remaining units to complete this 'continuous transfer' system will be installed in the PS during the end-of-year shutdown. The section of beam-line towards the SPS which is shared with protons heading for the Intersecting Storage Rings has been modified and successfully tested so that it can handle beam for the two destinations on alternate pulses. In the next section of beam-line, which tilts downhill towards the underground synchrotron, all the magnets are installed and are being tested.

Needless to say, the tunnel down to the machine and the tunnel for the machine itself is complete. In fact virtually all the underground civil engineering was finished during the year. This includes also the tunnels to let the accelerated protons back to ground level for use in the experimental areas. Electrical and cooling water installations have been keeping pace.

An important contract for the supply of electricity was concluded with Electricité de France in September. The SPS will take its pulses of power via a 380 kV line coming into the site from a strong point on the European electricity grid (at Génissiat). The line has been in service for just over a year which has helped to identify one or two problems comfortably in advance. Brief interruptions in the supply occurred during Summer storms and, to cope with this, stand-by power supplies have been ordered. They will be able to step in to make sure that the control computers stay in control in the event of such a mains power interruption.

The contract for the cooling water was also signed during the year with the Swiss authorities. Water is now

Inside the machine tunnel itself which is now looking highly equipped. This particular view is of the straight section holding units for ejection of the accelerated protons. The cylinders which are in line along the centre of the photograph house the ejection septum magnets. All the 'services' — air, cabling etc. — run along the wall on the right.

pumped from Lac Léman to two reservoirs (5000 m^3 each) on the SPS site. It has been passed through a system simulating the operating machine, involving the pumping station and cooling towers at CERN, before discharging into the Nant d'Avril stream. With some modifications, prompted by these tests, this vast cooling circuit is ready for action.

On 18 December the last main magnet, completing the ring of nearly 1000 bending and focusing magnets which will hold the protons while they are accelerated, will be taken to its position in the tunnel. This comparatively simple statement hides a year of heroic work by the Magnet Group. We reported in April (page 110) the un-nerving discovery that a fluid used to clean up the copper at brazed joints on one type of magnet was leading to breakdown. The fluid contained phosphoric acid which was eating its way through the insulation causing short circuits some weeks after the magnets had been given a clean bill of health in a series of tests.

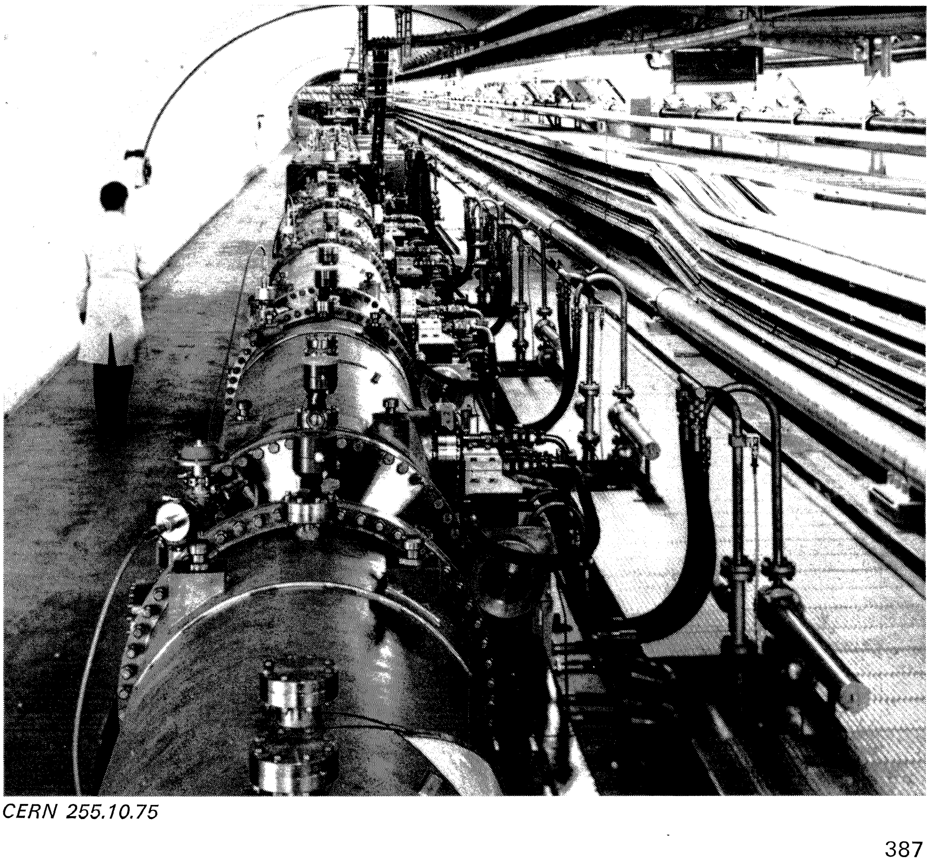
By the time the problem was discovered, 30 magnets had had their insulation destroyed and another 250 were suspect. All these magnets have been taken apart, re-insulated and re-assembled. Despite all this extra work, the magnet installation schedule has been met. Power tests have been under way on sextants (the machine is divided into six arcs of magnet separated by long straight sections) as they were completed. The tests have gone well and it appears that the design requirements on the magnet system have been exceeded in all respects. Already the design of the magnets has allowed a 400 GeV ring to be built with the original cost estimate for a 300 GeV ring. It is going to be interesting to see how high the peak field (and hence the peak energy) could be pushed while still retaining adequate field quality to hold a beam of acceptable intensity.

To accelerate the protons in the ring, two large r.f. cavities are installed in one of the long straight sections. In December, the second of these cavities was completed. High power tests have been under way since April as more and more cavity sections came together. The three power amplifiers and their feeder lines, etc. have been satisfactorily commissioned. Playing with r.f. always has a touch of witchcraft about it and it has not been without headaches that power tubes have been licked into shape and all parasitic modes of r.f. oscillation have been suppressed. Tests on the chains to both cavities, supplying power at a frequency of 200 MHz, have begun.

Getting the accelerated protons out of the machine is one of the most technically difficult tasks; a 400 GeV proton beam is very 'stiff' — it takes a lot to bend it from its orbit. The intricate sequence of many electrostatic septa and septum magnets has been described several times (see, for example, September issue page 267).

The extraction system to send protons to the North Area has been installed and tested. The trickiest components are the four wire septa each 3 m long made of tungsten wires 0.12 mm thick aligned to within 0.05 mm. They have to provide a field gradient of 100 kV/cm and during the tests 200 kV was sustained across a 17.5 mm gap (in other words, 115 kV/cm) with a breakdown rate of two sparks per hour. Components of the other extraction system, which will send protons to the West Area, are being assembled. Although the West Area will be the first to receive beam, the sequence in which the tunnel has been completed makes it the second extraction system to be installed.

Some of the magnets for the beamlines to the experimental areas have

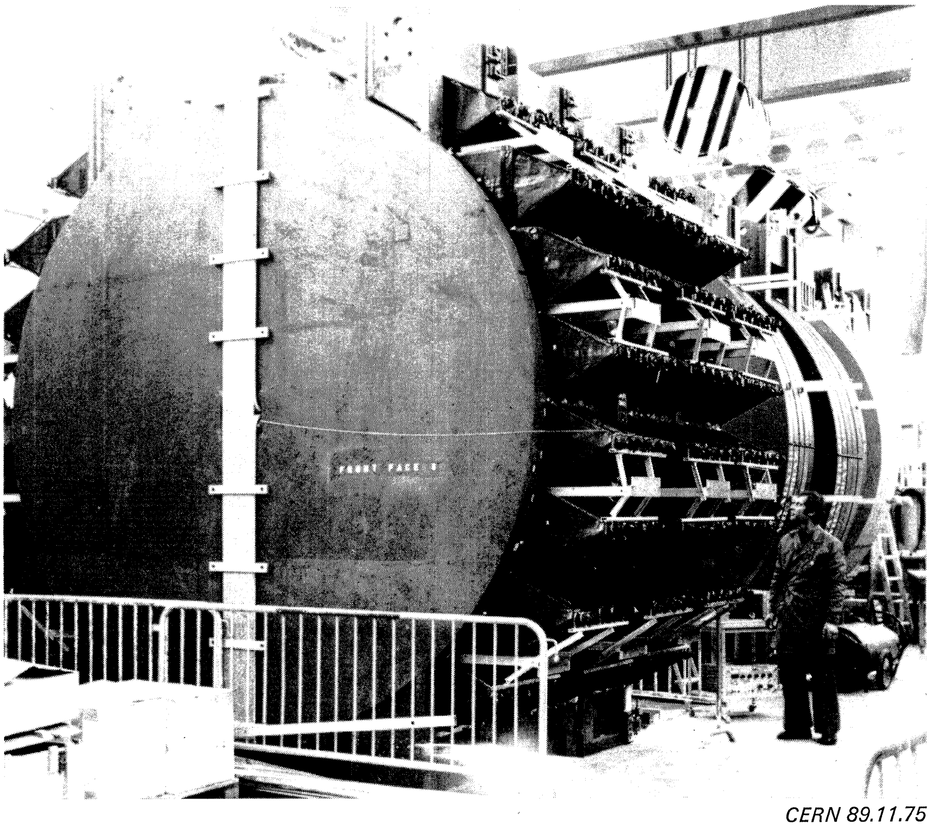


CERN 255.10.75

The control room is now frequently populated with people developing the computer programs which will keep the machine components in order. They can work on their units independently since the consoles are able to bring it part or all of the machine at will.

Things are beginning to come together for experiments at the 400 GeV proton synchrotron. This is a CERN/Dortmund/Heidelberg/Saclay neutrino catcher which will sit pointing at the ground behind the 3.7 m bubble chamber to receive neutrinos produced by the underground machine. The spectrometer consists of a toroidal magnet 20 m long weighing 1400 t divided in 19 sections. The magnet is built up of iron discs 3.75 m diameter which are interleaved with scintillator plates looked at by 2500 photomultipliers. This system will measure particle energies and drift chambers between the sections will measure particle directions.

CERN 137.10.75



CERN 89.11.75

arrived at CERN but there is a remaining worry concerning the focusing quadrupoles for these beam-lines. The rate at which they will be delivered is likely to dictate the date at which experiments can start.

The control system of the machine is the most advanced in the world of accelerators. Its abilities and its ease of operation should aid the commissioning, the regular running and the development of the SPS enormously.

During 1975, control computers have been installed in the Main Control Room and in the Auxiliary Buildings, which sit at the six access shafts above the long straight sections, and they are being worked up to the desired reliability. The computers are linked to the Message Transfer System for which all equipment is delivered and successfully tested. It has proved capable of transmitting strings of messages between ten computers at the maximum rate.

The vast quantities of associated electronics are coming together and those responsible for the different machine components have been able to steep themselves in the development of their own control programs. A 'tree' structure for linking and calling these programs has been established — it makes it possible, for example, to call in a system, then select a component, then select a particular part, then select particular parameters for monitoring and adjustment.

The control system is very refined but it has behind it a large volume of equipment. In addition to all the electronics units there are some ten thousand different cables totalling over ten thousand kilometers in length. Most of this cabling is now in place linked by several thousand junction and distribution boxes.

While the machine is coming together, the experimenters have been far from idle. The West Area is being prepared for ten experiments and many are likely to be ready to receive particles at the end of next year. We will be coming back to the programme in detail nearer the starting time so we just mention here that it includes such topics as studies of hyperons using a hyperon beam of energy over 100 GeV, tagged photon experiments with the Omega spectrometer, polarized target experiments, eutrino counter experiments, etc. . . .

The bubble chamber programme with the 3.7 m European chamber, BEBC, and the heavy liquid chamber, Gargamelle (whose move from the PS to the West Area is imminent), is not fixed in detail but it will be heavily neutrino biased. The use of a Track Sensitive Target (a hydrogen target within a hydrogen-neon mixture) is being pushed for BEBC and BEBC will also benefit from a separated hadron beam such as is not available at the Fermilab 400 GeV machine.

In general, the selection of experiments for the SPS has tried to extend or compliment the research that has already been done or is being done at the Fermilab. For example, some areas f neutrino physics and, particularly, muon physics, where the SPS has a considerable advantage, have received priority.

For the North Area, the timescale is a little longer since beams are scheduled to head North over a year later. Nevertheless, the building of the two large experimental halls with all the associated services is under way. Five experiments, including two muon experiments, are being prepared. One will probably involve a rapid cycling bubble chamber in a hybrid set-up.

It will probably not be long before we are hearing of the 400 GeV synchrotron again. If all goes well, the ring will be 'closed' before the Summer of 1976 and the SPS team can start accelerating protons.

On 13 November diplomats from the Chinese Mission in Geneva and Embassy in Berne (including the Ambassador to the United Nations in Geneva and the Chargé d'Affaires at Berne) were invited to visit CERN as a gesture of appreciation for their considerable help in organizing the visit of the CERN delegation to China in September. While their husbands busied themselves with things scientific and technical, the wives of the diplomats relaxed for a while visiting the CERN Nursery School where young children are prepared for integration into the local French-speaking education systems.

CERN 214.11.75

H. Martinsen (on the left) of the Federation of Danish Industries together with staff from the CERN Purchasing Office at one of the stands during an exhibition of Danish equipment at CERN from 25 to 28 November. The exhibition was organized by the Association of Electronic Manufacturers in Denmark and the Federation of Danish Industries in collaboration with the Royal Danish Consulate General.

CERN 38.1.11.75

Around the Laboratories

Mesons in the Soviet Union

Research in the intermediate energy range, usually counted up to the 1 GeV level, will receive a boost in the Soviet Union with the construction of a 800 MeV meson factory at Krasnya Pachra near Moscow. Building has started. The design is virtually complete; ion sources and a section of the wave-guide structure have been made.

The design concepts are close to those of the 800 MeV proton linear accelerator, LAMPF, at Los Alamos. There are five cavities of the Alvarez type followed by a wave-guide structure (though not of the side-coupled type used in LAMPF). Two experimental areas, fed by a series of targets bombarded in sequence by the proton beam, are foreseen and it is intended to add a storage ring as a 'beam stretcher' extending the duty cycle of available beams (giving long pulses of particles) since short duty cycles are often the major limitation in experiments at linear accelerators.

Two other particle sources are planned. Intense neutron beams could be produced by ploughing the 800 MeV proton beam into a beam stop rather as envisaged in the ING proposal at Chalk River (see May 1966, page 114). Neutrino beams could be produced by firing the proton beam onto a target contained in a 'magnetic bottle'. Many of the low energy pions which are produced will not escape from the region of the magnetic fields and as they decay the bottle will become a neutrino source.

While waiting for these exciting research facilities of the future, intermediate energy physics continues on the synchro-cyclotrons of Dubna and Gatchina. At Dubna the energy of the machine is 680 MeV. The internal beam intensity has been increased from 2 to 3 μA by shaping the blades in the rotary condenser. The machine operates at a repetition rate of 160 Hz. The experimental facilities include a system to give long bursts of particles, a beam for medical research, a special streamer chamber (long sensitive time, comparatively low voltage, no need for image intensifiers) where pion interactions in helium have been thoroughly studied, and an isotope separator to which irradiated targets are rapidly conveyed.

There is an improvement programme for the machine aiming to take the energy to 700 MeV, the internal current to 50 μA and the repetition rate to 250 to 300 Hz. It will be converted to a sector focused machine with the same arrangement of extracted beams as at present but with enlarged experimental halls.

The design is complete and manufacture of components has begun; building of the experimental hall extensions is under way. The new rotary condenser is scheduled for delivery in 1976 and the new vacuum chamber in 1977. It is in 1977 that the synchro-cylcotron will be shutdown for rebuilding.

More exotic thinking has been going into the design of a Super Cyclotron. The aim is for a 800 MeV machine with a beam intensity of 100 mA. It involves a rapid acceleration rate (2 MeV/turn) and the frightening problem of extracting such an intense beam is being studied in the context of a novel idea involving changing the field structure abruptly (playing with the 8th harmonic) so that the beam jumps a few centimetres in radius without destroying its quality. Having performed this jump the beam can be deflected out of the machine. The idea works on paper and has been successfully tested on an electron model.

The lively team of physicists at Gatchina continue to operate their 1 GeV synchro-cyclotron which normally has a beam intensity around 0.5 μA. They use external targets exclusively with the exception of one internal lead target which is used to generate a neutron beam.

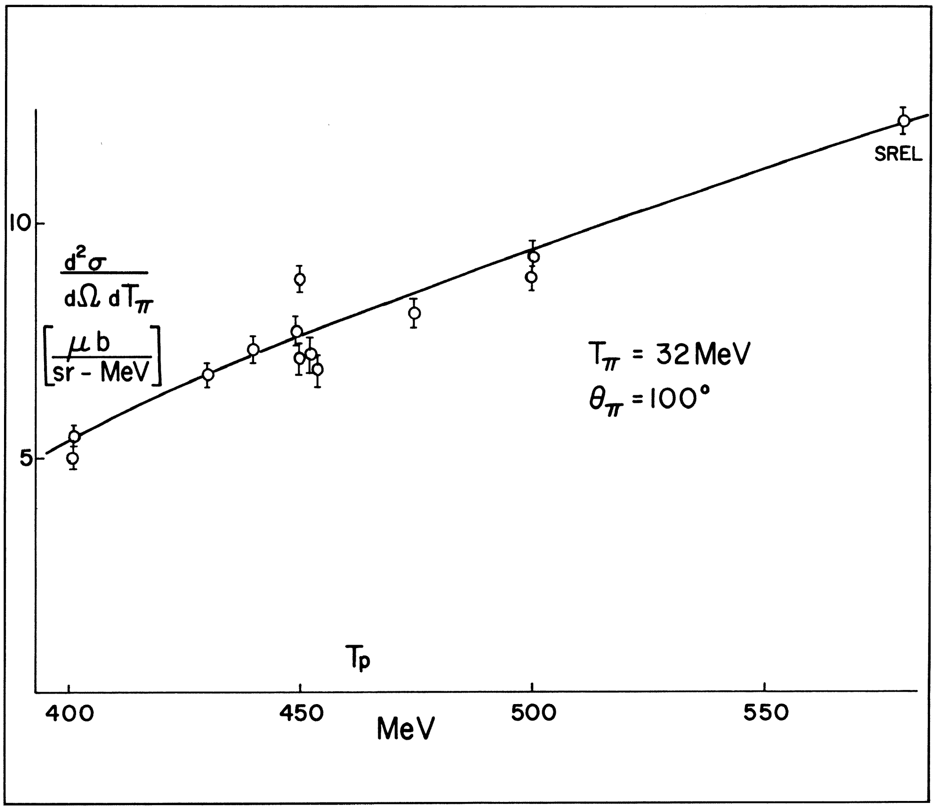
The treatment of the first patient in a medical beam has taken place recently. Since the comparatively low intensity of the proton beam would put the medical facility at a disadvantage if a stopped beam were used for tumour treatment, the Gatchina technique is to use high energy protons in a finely collimated beam and to rotate the patient in two planes so that the tumour volume is irradiated from many directions. In this way the tumour can be attacked without unduly damaging the surrounding tissue.

Meetings

11-14 May: The Sixth International Cryogenic Engineering Conference will be held in Grenoble, France. It aims for the exchange of information on problems of cryogenic engineering and its scientific aspects. Refrigeration technology, superconductivity and its applications, insulation, properties of materials, instrumentation and cryobiology will be covered. Further information from ICEC 6 Secretary, Centre de Recherches sur les Basses Températures, B.P. 166 Centre de Tri, F 38042 Grenoble.

14-17 September: The 1976 Proton Linear Accelerator Conference will be held at Chalk River, Ontario in Canada. It will cover such topics as applications of linacs, collective acceleration, high mean current structures, superconducting slow wave structures, electron linacs (including superconducting linacs), ion source development and status reports on operating linacs. Further information can be obtained from B.G. Chidley, Conference Secretary, Physics Division, Station 68, Chalk River Nuclear Laboratories, Chalk River, Ontario, Canada KOJ1JO.

First results from the TRIUMF cyclotron — the cross-section for the production of 32 MeV positive pions at 100° from a carbon target bombarded by protons. The proton energy is plotted along the x-axis. The results show no sharp rise of cross-section at 450 MeV as had previously been reported and thus undermine the possibility of pouring out a larger flux of low energy pions by choosing this particular proton energy.



TRIUMF Experiment number 1

TRIUMF has recently celebrated its first completed experiment — an investigation of low energy pion production by protons incident on carbon and copper. The experiment involved a group from the Universities of Victoria and British Columbia led by L.P. Robertson. It was performed in one of the two simultaneously extracted proton beams from the 500 MeV cyclotron.

The reactions that were studied, besides their practical importance as sources of high intensity positive pion beams, are of particular interest because, compared to those observed at neighbouring energies, high cross-sections had been reported at 450 MeV.

A counter range telescope was used sensitive to pions of between 20 and 100 MeV and covering the angular range 60° to 150°. The efficiency of the detector at various pion energies was deduced by observing pions coming from the reaction in which a proton interacts with a proton to give a pion and a deuteron for which the cross-section is well known. The incident proton intensity was measured by carbon 12 activation. The results show a smooth variation with both energy and angle, in general agreement with theoretical predictions which are based on averaging the pion production rate on free nucleons over target nucleon motion and including the effects of proton and pion absorption.

The hopes that there is some structure in the cross-section variation with energy (which could be carrying a message with it) were finally dashed during the last seven hour run of the experiment when the variable energy capability of the cyclotron was used to extract proton beams at seven different energies between 400 and 500 MeV. Using the carbon target and looking at 100°, there were no signs of bumps in the cross-section which rose smoothly with energy, extrapolating nicely to previous measurements carried out by the same group at 590 MeV at SREL and by a LAMPF group at 740 MeV at Berkeley. At 450 MeV the cross-sections were found to be a factor three or more smaller than those reported by earlier workers. Thus there appears to be no magic energy at which proton beams will give larger fluxes of low energy positive pions.

DESY At DORIS

Until the end of the year, the electron-positron storage rings, DORIS, will continue to run at energies which are required to produce the new particles. After long discussions about the various possibilities opened up by all the discoveries of the past year, the Research Committee has decided to give top priority to detailed measurements of the P_c and X particles, which were discovered at DESY some months ago (see October issue, page 317). During December, the collaborations working at the double arm spectrometer, DASP, and the Heidelberg/DESY experiment are building up their knowledge about the new particles.

Operation of the storage rings is going well after the rebuild of the injection system from the synchrotron. This rebuild, combined with a new variant of the storage ring optics, meant that it was almost like bringing a new machine into operation in October. An average luminosity of 5×10^{29} per cm² per s was reached with lower currents of electrons and positrons after a short time and confirmed that the reconstruction had gone well.

The main aim of the reconstruction was to be able to fill DORIS with particles at energies up to 4.3 GeV so that it would not be necessary to accelerate in the storage rings themselves. This goal has been reached and as from January both detection systems, DASP and the other detector, PLUTO, will be looking for new phenomena in the energy range up to 2 × 4.3 GeV.

Meanwhile the first orders have been placed for the 19 GeV electron-positron storage ring, PETRA. The construction gangs are coming together, and ground breaking is expected before the end of the year.

CORNELL
Honouring Hans Bethe

Physicists and friends from all over the USA assembled at Cornell University on 24 October to honour Hans Bethe on his retirement. Since 1 July, Bethe has been John Wendell Anderson Professor of Physics Emeritus after 40 years of teaching at Cornell.

Featured speaker at the event was R.C. Seamans, administrator of the Energy Research and Development Administration (ERDA). Other lectures were given by G. Brown from Stony Brook and M. Schwarzschild from Princeton. R. Marshak, President of the College of the City of New York, who worked with Bethe as a postdoctoral fellow, delivered the address at an evening banquet and Cornell President, D.R. Carson, announced the naming of the 'Bethe Auditorium' and the 'Bethe Seminar Room' on the top floor of the Clark Hall of Physics.

Bethe has made important contributions to the fields of atomic, solid state and nuclear physics, and to the development of the theory of radiation. The Nobel Prize in 1967 was awarded to him for calculations, published in 1938, explaining how a star uses nuclear fuel as its power source. It is now known that most of the starlight visible in the night sky is produced by the 'Bethe cycle'.

His research in the past 20 years has been devoted largely to explaining the structure of nuclei in terms of the forces which act among their constituents. He has also been interested in neutron stars, which are thought to be made up of matter closely packed at nuclear densities. He is now working on problems of nuclear physics as the Karl Compton Professor of Physics at the Massachusetts Institute of Technology.

CEA/IN2P3
Nuclear physics with GANIL

In the November issue we described the heavy ion accelerator GANIL which is now being built at Caen in France. It will extend the study of nuclear reactions by accelerating all nuclei of sufficient stability, from the lightest to those of uranium, to energies above the Coulomb barrier and with beam qualities which have not yet been achieved by other accelerators. Most of our knowledge in nuclear physics has so far been obtained by studying reactions resulting from bombardment by light particles (neutrons, protons, helium ions). More recently, the reactions induced by heavy ion beams have pointed the way to original methods of probing the nucleus.

The concepts of nuclear physics have emerged from the study of a number of stable nuclei, 500 at most, which are either those found in Nature or their close neighbours which it has proved possible to synthesize. This number might seem an acceptable sample of the 7000 or so which are theoretically predicted as 'energy-bound'. However, all these nuclides belong to the range which show the best equilibrium between the force of nuclear attraction and Coulomb repulsion and where the neutrons and protons are comparatively closely bound. It is important also to study nuclei outside these conditions of stability (exotic nuclei) where the measurement of parameters such as the mass and half-life is a good test of models of the nucleus. This is already under way, for example, with ISOLDE at CERN, and GANIL is well adapted to extend such research.

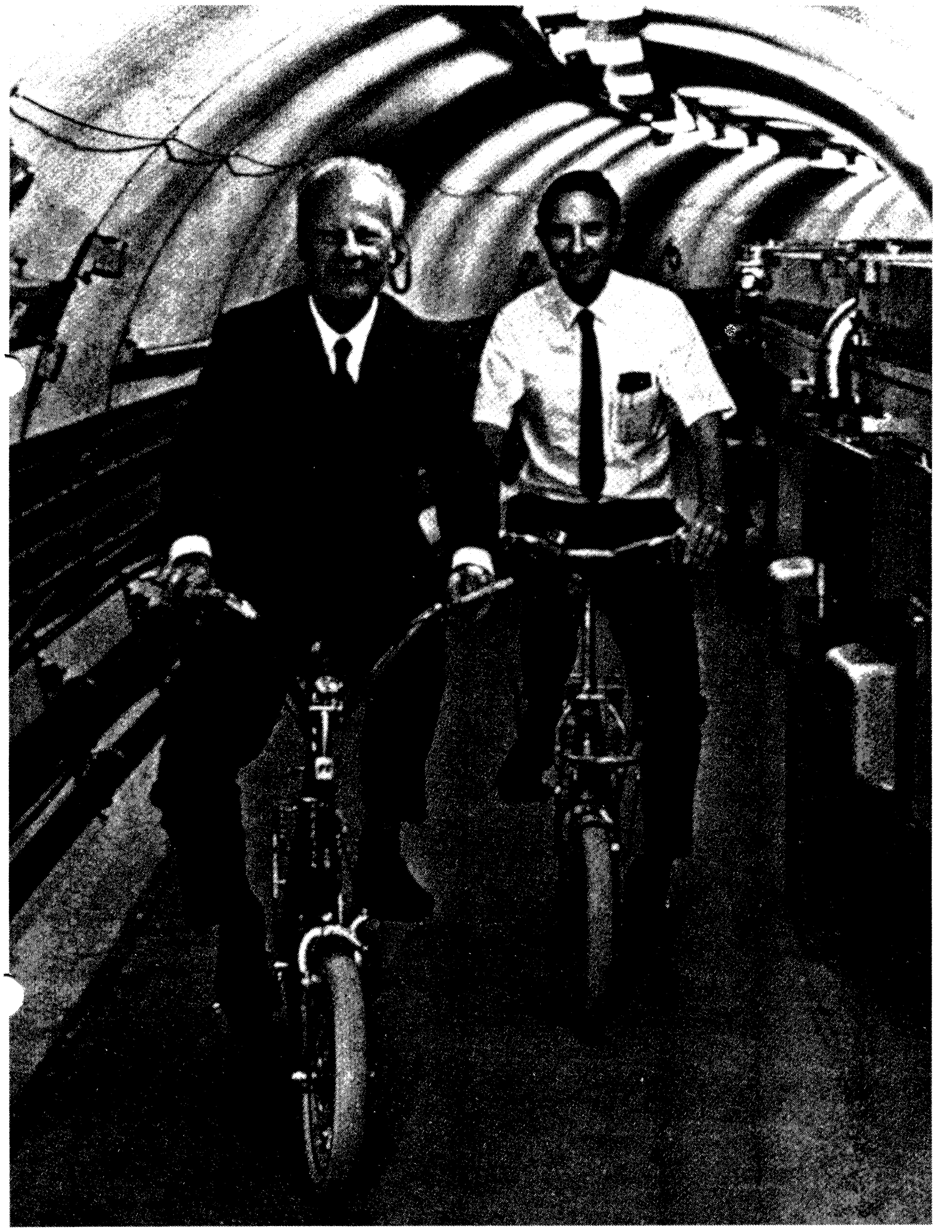
Another fascinating field is that of the hunt for 'super-heavy' nuclei. In reactions between a stable 'projectile' and a stable target nucleus, the heavier the projectile the smaller the probability of complete break-up of the compound nucleus which is formed for an instant. This phenomenon could perhaps be explained by reaction mechanisms involving the transfer of very large clusters of nucleons from one nucleus to the other. These experiments require high intensities and a very wide selection of projectile ions and target nuclei. GANIL can provide these conditions.

For the study of the interaction potential between heavy ions, elastic scattering is no longer enough to determine the optical potential, due to the high absorption. At low energies, it is necessary to analyse both the inelastic scattering and the reactions involving the transfer of one of two nucleons. The nature of the optical potential at several MeV above the Coulomb barrier is, as yet, little known, and this is a field which GANIL will be able to open up.

The value of using heavy ion beams for nuclear spectroscopy was demonstrated some years ago by experiments with tandem Van de Graaffs

Hans Bethe, who now retires from Cornell University, is photographed (on the left) taking a bike ride around the 12 GeV electron synchrotron at Cornell together with the Director of the Wilson Synchrotron Laboratory, Boyce McDaniel. This tour of the ring took place at the Dedication of the Laboratory in 1968.

(Wide World Photo)



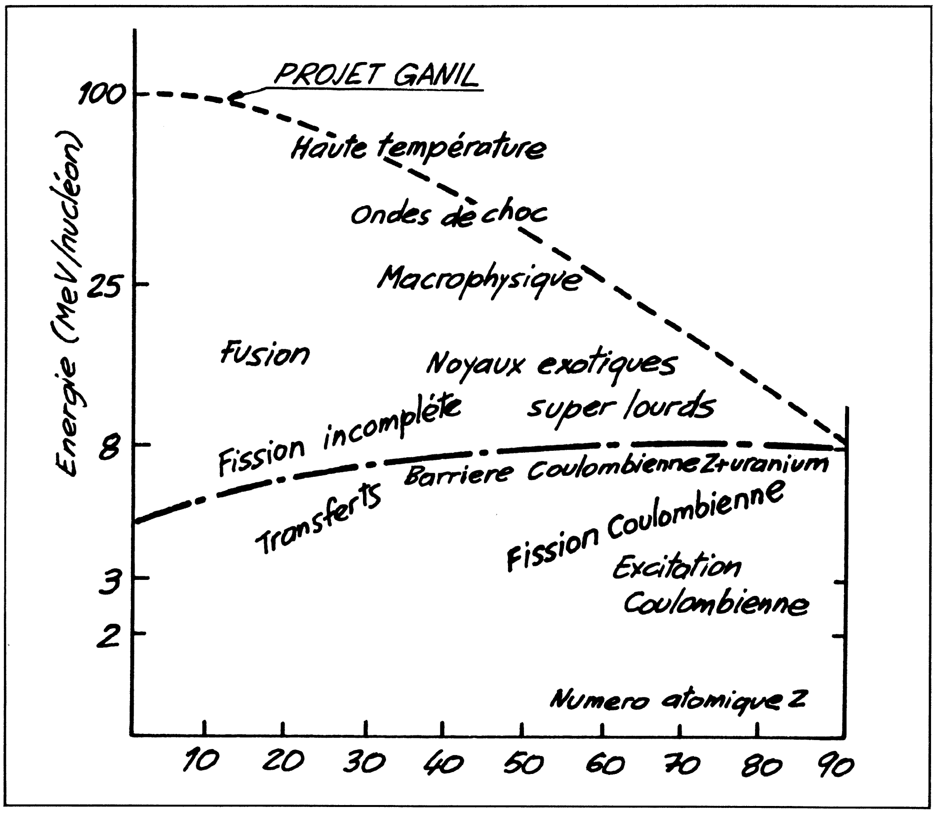
and cyclotrons. However, these machines can accelerate only light ions, such as carbon or oxygen to adequate energies and intensities. The possibility of accelerating all nuclei above the Coulomb barrier will greatly enlarge the field of spectroscopy studies.

The formation of a compound nucleus by a reaction between heavy ions is characterized by a great increase in angular momentum (creating high spin states). This has been exploited for sometime now by bombarding a target with heavy ions and observing the gamma cascade of the residual nuclei formed after neutrons have been emitted. The light ion beams available so far have made it possible to identify spins up to 22 h. Angular momentum of this order is enough to modify the structure of the nucleus, and indeed a sudden increase of its moment of inertia may be observed up to angular momenta of the order of 13 to 18 h, according to the nucleus involved. This phenomenon is due to the effect of the Coriolis force, which for lower angular momenta breaks up some loosely-bound neutron pairs and at the highest angular momenta causes a transition in the nucleus between a superconducting and a normal state. For angular momenta above 60 h (just before a medium mass nucleus reaches the point of fission under the effect of centrifugal forces) the nucleus is believed to take on an oblate shape as an increasing number of nucleons align their angular momenta. These studies need to be followed up with heavy ion beams.

For some years now, the acceleration of ions to energies of several MeV per nucleon has indicated new aspects of nuclear interactions. It appears that nuclei are not simply groups of nucleons whose structure can be discovered by delicate probes like electrons and protons. They also act like non-rigid condensed matter which has collective properties, such as viscosity and compressibility. Through effects which have been neglected hitherto, energy can be dissipated by friction or by collective deformation. A field of 'macro-nuclear physics' is opening up, which can be developed only by using a greater variety of tools — a wide range of beams with energies from the 10 MeV per nucleon, which is now available, up to a hundred or so MeV per nucleon.

It is difficult to form compound nuclei from those of medium, and especially heavy, mass with ions of mass greater than that of argon. This recent observation is of great interest, since it reveals unsuspected collective behaviour of nuclear matter. It is as though head-on collisions do not lead to complete fusion — contrary to what happens with lighter projectiles. This may be the effect of a

This diagram indicates some of the phenomena which may be studied using accelerated heavy ion beams. The beam energy (in MeV per nucleon) is plotted against the ion atomic number Z. The central dashed line is the limit of the Coulomb barrier for the ion on a uranium nucleus. The upper line demonstrates the capabilities of the GANIL heavy ion accelerator, which is now being built. The energy/ion regions which make various fields of research (described in the text) accessible are indicated.



non-compressibility of nuclear matter and thus of a repulsive core which appears only when the fragments of nuclear matter are over a certain magnitude. Collision speeds are still low at the beam energies presently available, increases from 20 to 100 MeV per nucleon should open up a major field of study in this direction.

Complete fusion of two nuclei seems to take place whenever they can interpenetrate up to a certain critical distance. If this distance is not reached, because of insufficient momentum for example, complete fusion is not achieved and other processes ensue which demonstrate the viscosity of the nuclei. It has been found that the projectile, not only loses a major part of its kinetic energy but also changes its mass and charge. There seems to be a braking action by the nuclear matter encountered as if the target nucleus were a viscous drop of liquid.

Study of these phenomena in depth should make it possible to define the terms of the momentum damping, i.e. the coefficients of radial and tangential friction between the two nucleonic fluids. At present, any theoretical explanation of this nuclear viscosity is only in the embryonic stage and requires analogies from the field of solid state physics, on the one hand, and experimental data of a more quantitative character on the other. This can be obtained only by the use of a variety of probes. A wide selection of 'projectiles' is required, accelerated to energies ranging from the average bonding energy of the nucleons to several times their kinetic energy in the nucleus.

GANIL has a lot to do when it comes into action at the beginning of the 1980s. Beams are expected from the first cyclotron in 1980 and from the two cyclotrons in tandem a year later.

FERMILAB
Using lots of protons

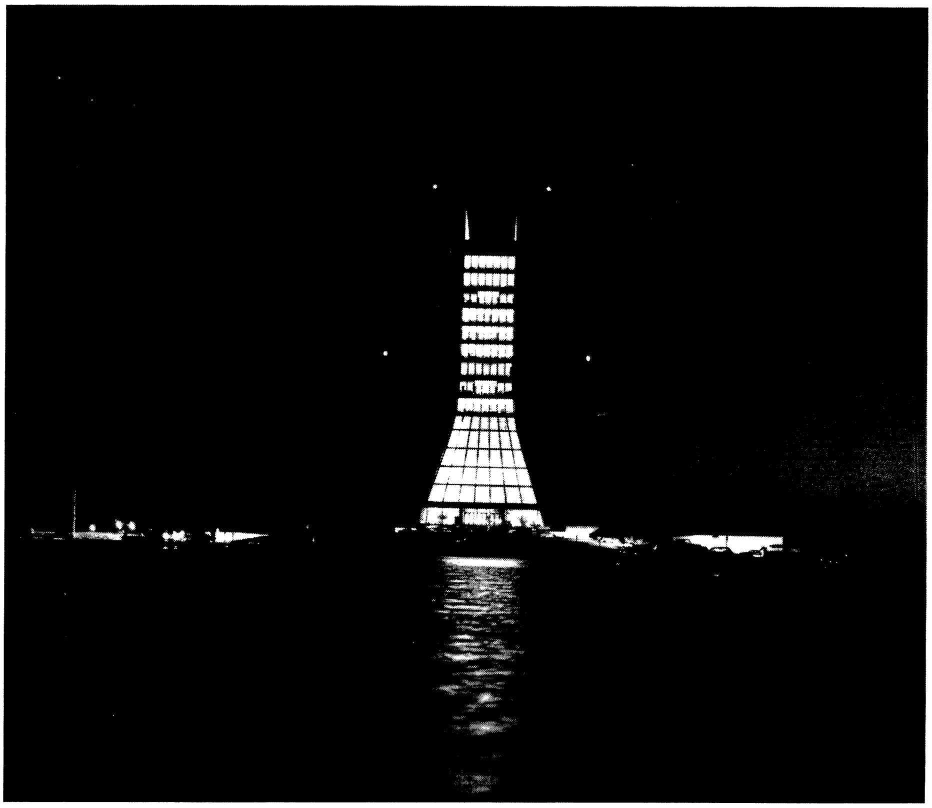
Since its summer shutdown ended on 1 August, the synchrotron at the Fermi National Accelerator Laboratory has been operating mainly at an energy of 400 GeV. Previously it was best described as a 300 GeV machine making occasional excursions to 400 GeV. It is now runnin just as efficiently at the higher energy averaging some 100 hours of physics out of the 125 hours scheduled each week.

There has been a shot at higher energies and 450 GeV was reached in a machine development run on 7 August. Mid-December, there will be an attempt at 500 GeV when a capacitor bank has come back into service. The intensity at 400 GeV has reached 1.72×10^{13} protons per pulse (compared with 1.75×10^{13} at 300 GeV). The power levels have gone up with the higher energy operation and the repetition rate is held down (one pulse per 8 or 9 s) so as not to exceed the peak power. Even so, the cables linking the sub-station to th magnet ring (which were initially designed to be comfortable at 200 GeV) are surviving the higher currents only with the help of additional cooling and by tapping on high voltages at the transformer. The work on the superconducting energy transfer system to take over from these cables (see September 1974) has slowed down.

Most effort is now going towards achieving higher beam intensities. A second preinjector is to be built to feed negative hydrogen ions into the linac. By stripping these ions into protons as they are injected into the booster, it will be possible to pack more protons into the same 'phase space'. This technique, proposed by G.I. Budker at Novosibirsk in 1959, is

The Fermilab Hi-rise building at night — a striking sight rising from the plains of Illinois.

Inside the Hi-rise, flora and fauna create a refreshing atmosphere. The Laboratory restaurant is on the ground floor to the rear in this picture and the coffee lounge is on the 1st floor cross-over. The Director of the Fermilab, R.R. Wilson, drew much of his inspiration in selecting this layout from the restaurant-coffee lounge area in the CERN Main Building.

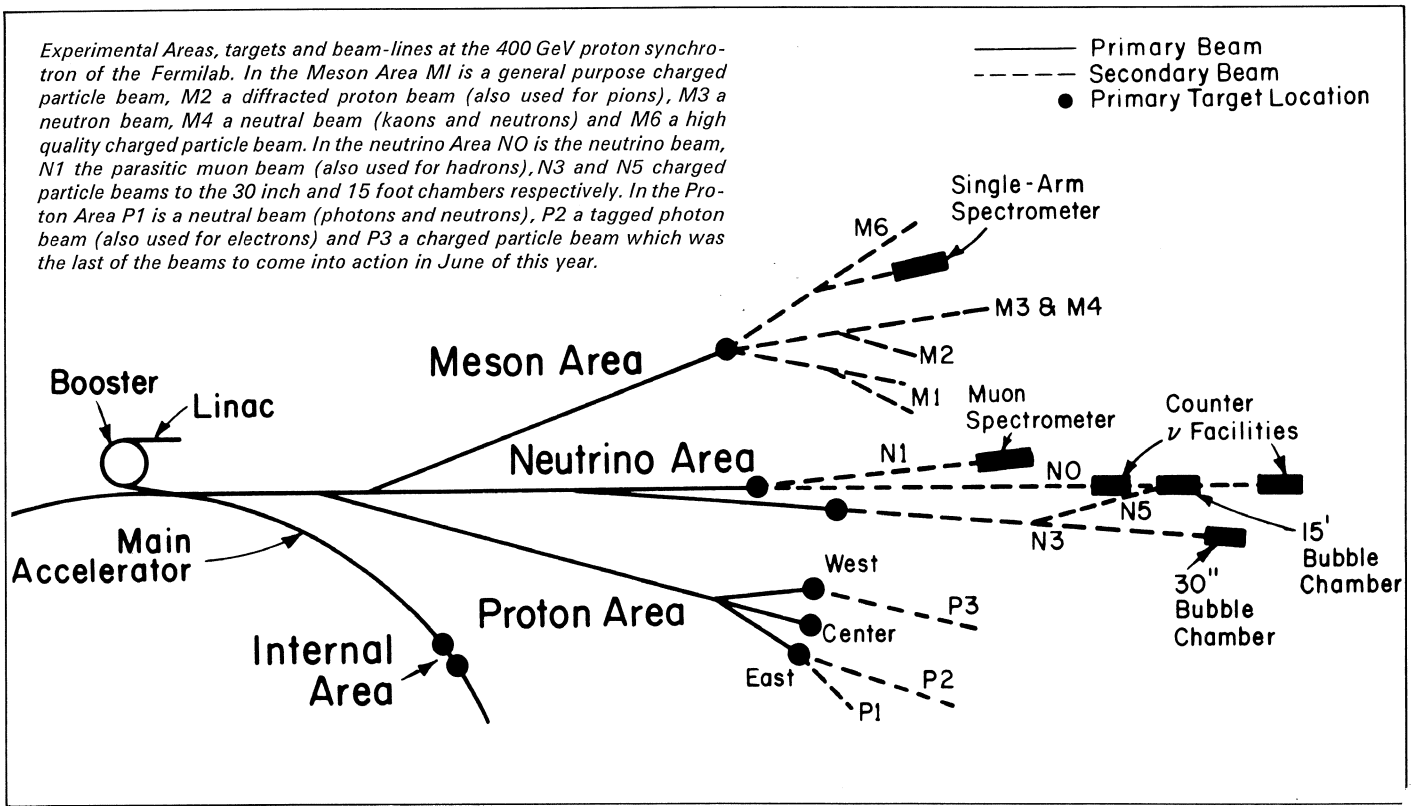


a speciality of the nearby Argonne Laboratory (see August issue 1969) and the new injection scheme is being developed with the co-operation of Argonne.

This should get more protons into the booster where already 2.5×10^{13} protons per machine cycle have been accelerated. 'Super-dampers' are being installed in the booster to limit transverse instabilities. Transmission efficiencies, which at present stand about 65 % between the linac and the booster and 85 % between booster and main ring, are also receiving attention.

The high energies and high intensities bring additional problems in their wake but they are all under reasonable control. The magnet failure rate causes little disruption to the machine schedule — about one magnet a month is exchanged. The electrostatic septa are more troublesome. Splitting over 10^{13} protons per pulse between all three experimental areas when they all want a slow spill, steps up the probability of burning out the wires in the septa. The alignment of the wires has been improved to 0.025 mm in 3 m, which has cut proton losses by 30 %, and the wires can be further protected by a shadowing wire downstream. But they are still easily damaged. Changes of the septa can be done in a single shift but a further two shifts are needed to pump to high enough vacuum for high intensity operation. You cannot get good things without a hard life.

With these quantities of protons pouring out of the machine, experimenters can be kept happy in all three experimental areas (Meson, Neutrino and Proton — see diagram) at once. It would not make interesting reading to list all the experiments so we will concentrate on two topics which are particularly lively at the present time. In so doing we leave aside some other



Experimental Areas, targets and beam-lines at the 400 GeV proton synchrotron of the Fermilab. In the Meson Area MI is a general purpose charged particle beam, M2 a diffracted proton beam (also used for pions), M3 a neutron beam, M4 a neutral beam (kaons and neutrons) and M6 a high quality charged particle beam. In the neutrino Area NO is the neutrino beam, N1 the parasitic muon beam (also used for hadrons), N3 and N5 charged particle beams to the 30 inch and 15 foot chambers respectively. In the Proton Area P1 is a neutral beam (photons and neutrons), P2 a tagged photon beam (also used for electrons) and P3 a charged particle beam which was the last of the beams to come into action in June of this year.

fine work. One example is the experiment of the Michigan/Rutgers/Wisconsin team in the Meson Area which has a beam rich in neutral hyperons — a thousand lambdas a pulse — doing total cross-section measurements up to 350 GeV; they have seen hyperon polarization that can now be used for better magnetic moment determinations. Another example is the photoproduction experiment of the Columbia / Fermilab / Hawaii / Illinois team who did the cross-section measurement on the newly discovered psi particles and fed the key information into the argument that these particles are hadrons. And so on . . .

Two subjects of major interest are the dimuon production and the charmed particle searches. The dimuon phenomenon was discovered at the Fermilab by the Harvard / Pennsylvania / Wisconsin / Fermilab team with a large calorimeter looking at neutrino interactions in the Neutrino Area. Their results were confirmed in the same Area by a Cal. Tech./Fermilab team. Both teams are to come back at this problem soon with improved detection systems.

They have seen a total of around 80 events where the neutrino interaction seems to have produced two 'prompt' muons (in other words, one of the muons did not come from the subsequent decay of a pion or a kaon, though some events of this type could have been recorded as dimuon events). The existence of one muon is easy to explain — the incoming muon-type neutrino converts to a muon in the interaction with a nucleon. The source of the other muon is a mystery.

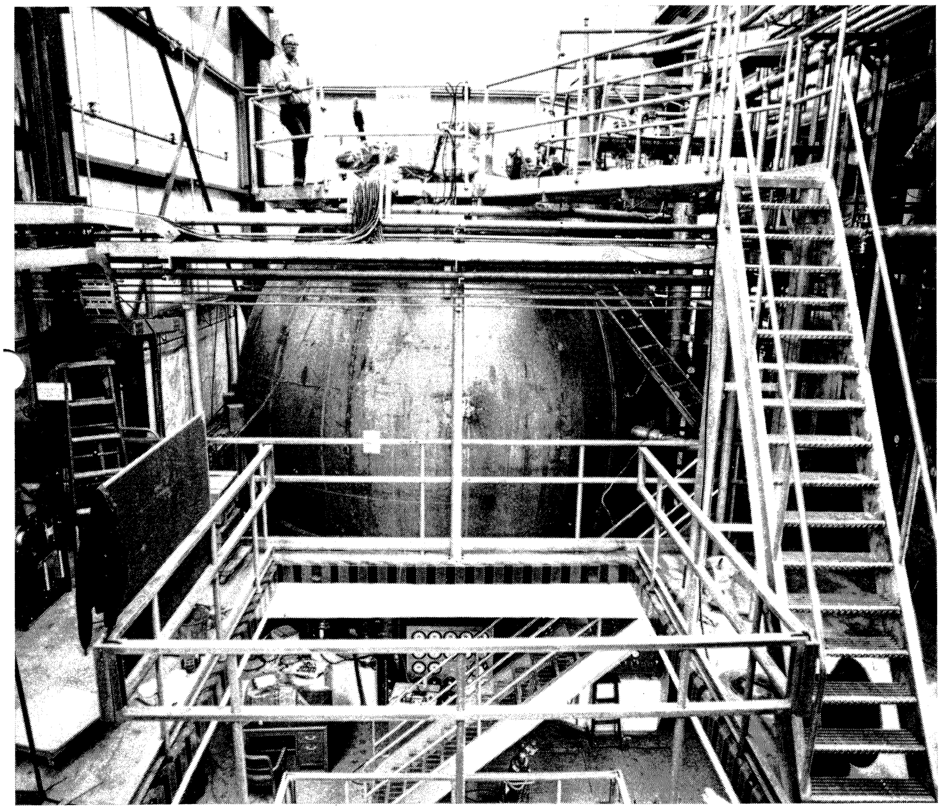
The dimuon production rate is about a hundredth of that of a single muon. A few events with both muons of the same charge sign have been seen. Their mass distribution is not consistent with their originating in the decay of a particular heavy lepton. Momentum calculations indicate that events are associated with neutrinos of energy above 150 GeV which ties in with a lower energy search at Serpukhov which saw no dimuons.

The other possibility is that the production of a charmed particle is at the root of the observation of the second muon. Some equations to explain how this can come about can be written down but the dimuon production rate looks uncomfortably high for such an explanation. This leads us into the other charmed particle searches. Obviously, every team with particles and a detection system has both eyes open for charm these days; we mention only those where tantalising indications (but not yet anything really convincing) have been seen.

A Carleton / Michigan / Chicago State team have a peak in the negative kaon, positive pion spectrum at about 2.3 GeV that they collected in the course of a heavy meson study in the Meson Area. The peak was spotted after completion of the experimental run and the experiment has now to be reassembled to take another more thorough look. (In the meantime a Fermilab/Michigan/Purdue team can scour the same region with a double arm spectrometer also in the Meson Area.) The main problem is the possibility that particles were misidentified; the detection system had good resolution and a peak can go away fast with different identification. In identifying the negative kaon a Cherenkov rejected negative pions but antiprotons might have crept in.

Another cliff-hanger is the neutrino experiment in the 15 foot bubble chamber by the Fermilab/Michigan team. They have events which look like neutrino plus nucleon going to lambda, muon and two charged particles which are probably positive pions. The enticing feature is that a few events calculating the lambda — two pion mass land exactly on the mass (2.4 GeV) calculated for the charmed particle candidate from the Brookhaven 7 foot bubble chamber (see April issue page 108). A run is now under way which will amass ten times as many pictures and should answer this question definitively.

There is a keen feeling of anticipation among the experimental teams. The results like the dimuon discovery give the sensation that there is something going on right under their noses which they only need one more clue



The 15 foot bubble chamber at the Fermilab is now double-pulsing, taking pictures for two different experiments during one machine pulse. One set of three cameras is taking pictures of interactions caused by a hadron beam into the chamber; another set of three cameras is taking pictures of interactions caused by a neutrino beam into the chamber.

to uncover. Perhaps next year that clue will be found.

INFN Conference

On 13, 14 November the Istituto Nazionale di Fisica Nucleare (INFN) held a second interdisciplinary Conference in Bari on the contributions of nuclear physics research to the development of advanced methods in informatics. Four general topics were discussed for the promotion of technology in this field — the handling of huge quantities of data, the technology of graphic displays, real time systems and the automatic measurement of photographic images.

Some 25 papers were presented, showing particular results obtained as fall-out from high energy and nuclear research on the one hand and showing how sophisticated methods of information handling help the progress in the nuclear physics on the other. During the Conference, a round-table meeting was devoted to the problems of technological research and industry in the field of informatics.

In the presence of the Italian Minister for Scientific Research and other personalities, Professor C. Villi (President of INFN) in his concluding remarks stressed the strong connections which exist between fundamental research and the improvement of techniques in many advanced fields of social and economic interest. He analysed the role played by INFN and the Universities in the development of the technology and know-how in the informatics field in Italy. He also gave the Italian community some hints for better exploitation of the interdisciplinary capabilities of fundamental research.

The COURIER from 1976

New methods of production and distribution of the COURIER will be operated as from the beginning of 1976. They result from discussions during the past year to see how the journal can better serve the high energy physics community. The guiding idea has been that the usefulness of the COURIER will be increased if it becomes more fully representative of the community at a time when the social and political climate makes integration of the whole field of research even more desirable.

The proposed developments were welcomed at the New Orleans meeting in March where many Laboratory Directors were present (see April issue page 123). Since then the editorial staff have received enthusiastic help within CERN and at other Laboratories in setting up mechanisms for bringing the ideas into effect.

There are two areas of change — one concerns information input and the other the distribution systems.

To cover activities throughout the world more efficiently, all major research centres in our field were asked if they were willing to assign a correspondent who will play a more active role in generating and transmitting information that has been called for in the past. In response to this request the following network of correspondents will be involved in producing the COURIER as from January.

Canada:	
TRIUMF	M. Craddock
Europe:	
DARESBURY	H. Sherman
DARMSTADT	H. Prange
DESY	I. Dammann
FRASCATI	M. Ghigo
INFN (Italy)	A. Pascolini
KARLSRUHE	F. Arendt
ORSAY	J.E. Augustin
RUTHERFORD	G. Stapleton
SACLAY	A. Zylberstejn
VILLIGEN	G.H. Eaton

Japan:	
KEK	K. Kikuchi
USA:	
ARGONNE	Ch. E.W. Ward
BERKELEY	W. Carithers
BROOKHAVEN	J. Spiro
CORNELL	N. Mistry
FERMILAB	R.A. Carrigan
LOS ALAMOS	L. Agnew
STANFORD	L.P. Keller
USSR:	
DUBNA	V.A. Biryukov

In welcoming many new collaborators we should also like to thank several who have very willingly participated in providing information in the past — W.W. Chupp (Berkeley), R.M. Littauer (Cornell), W.M. Regan (Los Alamos), P. Lehmann (Orsay), H. Norris (Rutherford), G. Neyret (Saclay), A. Strathdee (TRIUMF).

The new distribution systems have been set up in the belief that national centres are better able to judge where and how the journal will be useful than is possible from one centre such as CERN.

As from January, the Fermilab will take over the printing and distribution of the copies for the USA and Canada. Printing will run simultaneously to that in Europe using film flown out from CERN.

In Europe, the distribution within the Federal Republic of Germany will be handled at DESY, within France at IN2P3 (Paris), within Italy at INFN (Padua) and within the UK at Rutherford. Rather than the individual mailing from CERN, which has been the practice up to now, all the large research centres will receive the journal by bulk delivery for their internal distribution. 'Other language' copies (for example French edition copies for England or English edition copies for France...) will continue to be sent direct from CERN.

All those at present on the distribution list will continue to receive a copy of the journal without further request, though it may arrive by another distribution chain. The new systems should introduce little delay in delivery.

We have tried to ensure that the changes will not perturb the service to our readers — on the contrary, the aim of the exercise is to improve it considerably. If problems that have not already been covered do arise, we hope that, from CERN or from the national distribution centres (whose addresses will appear in the January issue), we shall be able to solve them smoothly.

Likewise on the information input side, we hope that after a few months of 'running in', we shall establish a better flow of news so that we can convey stories of what is happening in and around the field of high energy physics no matter where these stories emerge.

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

CERN ACADEMIC TRAINING PROGRAMME (1975-1976)

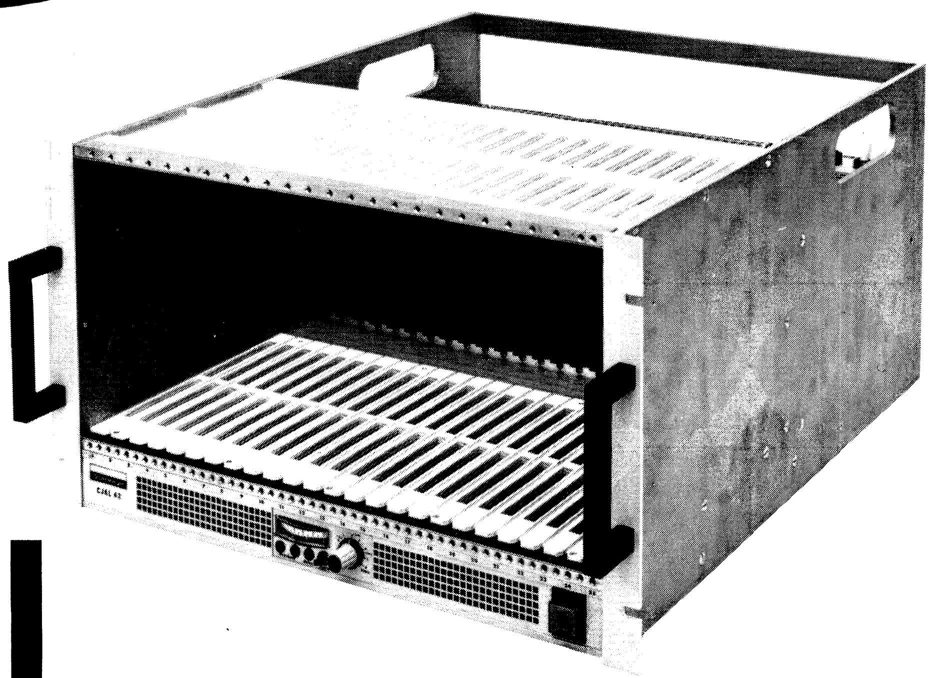
This Programme is organized each year by the Academic Training Committee. Details may be obtained from the Training and Education Service, CERN, 1211 Geneva 23 (Tel. 022/ 41 98 11, Ext. 2844). The programme for each term is published in the CERN COURIER (September, December and March issues).

2nd Term (February to April 1976)

February 3, 4, 5	Longitudinal stability of particle beams in synchrotrons and storage rings, by A. Hofmann
February 10, 11, 12, 13	Quark hadrodynamics, by G. Preparata
February 17, 18, 19	Final stages of stellar evolution, by F. Pacini
Date not yet fixed	Gauge theories, by J. Iliopoulos Renormalization groups, by A. Petermann Introduction to quantum electrodynamics, by E. de Rafael-E. Picasso
March 24, 25, 26, 30, 31	The $\pi\pi$ interaction, by J.L. Petersen
April 1, 2, 6, 7, 8	Plasma physics, by H. Wilhelmsson

These lecture series are given at 11 h. 00 in the Auditorium.

camac



power supply crate

CJAL 42

- ☐ Power supply block fitable to our NIM and CAMAC crates, easily removable from the bin .
- ☐ Maximum power : 300 W
- ☐ + 6 V/24 A
- ☐ – 6 V/16 A
- ☐ ± 24 V/ 6 A
- ☐ Wire wraped dataway
- ☐ Twisted pairs for Land N Lines

COMPTEURS SCHLUMBERGER - NUCLEAR DEPARTMENT
BP 47 - 92222 Bagneux (France)
Tél. (1) 655.22.11 - Telex : SAIPEX 25 075 F

COMPTEURS
Schlumberger

Camac dual preset counter

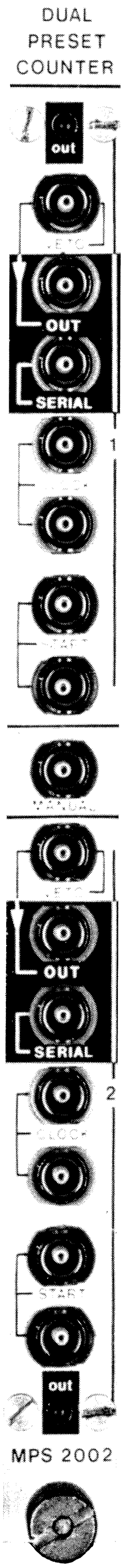
(CDPC MPS 2002)

DESCRIPTION:

A single width CAMAC module containing two 16 bit binary down counters suitable for use as a digital delay and using TTL Schottky integrated circuits. Almost 200 of these instruments are already in use at CERN in the MPS, ISR and TC Divisions.

SPECIFICATION:

RANGE	2 × 16 bit
CLOCK INPUT	
Pulse Repetition	25 MHz
Pulse Width	20 ns min.
Level	CAMAC terminated (NIM) or: CAMAC unterminated (TTL negative logic)
Connector	2 × strapped LEMO coaxial size 00.
START INPUT	
Trigger	negative edge
Min. Width	20 ns
Level	NIM or TTL negative logic
Connector	2 × strapped LEMO coaxial size 00.
OUTPUT	
Width	Pulse-100 ns Level — High while busy for TTL positive logic — Low while busy for TTL negative logic.
Drive Capability	NIM or TTL positive logic or TTL negative logic (max. + 27V. sink 100 mA at 0,4V.)
Connector	1 × LEMO coaxial size 00.
OUTPUT VETO	
Level	TTL Open = Ungated; Ground = Gated.
Connection	1 × LEMO coaxial size 00.
INDICATOR	
LED	On output pulse or busy level.
SERIAL OUT	
Pulse Train	Copy of the clock input for repetition and width Number of pulses equal to the preset value.
Level	NIM
Connector	1 × LEMO coaxial size 00.
MANUAL CONTROL	
Level	TTL open = Dataway N controlled. Ground = Takes N control.
Connector	1 × LEMO coaxial size 00.



HIGH ENERGY
& NUCLEAR EQUIPMENT S.A.
2, chemin de Tavernay
1218 Grand-Saconnex/Genève
Tel.: 98 25 82/3 Telex: 23 429

Établissements

B O U R G E O I S

S.A. capital 1 200 000 F.
34, rue de Liège
75008 PARIS
Télex 28 363 Cétaver Paris

Rubans, tresses, cordonnets, tubes, articles industriels spéciaux pour :

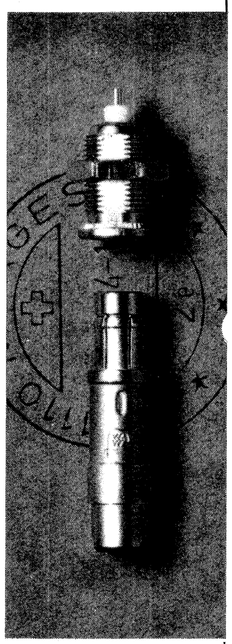
- emplois diélectriques
- frettages, enrubannages, etc...

Spécialisés en matières synthétiques :

- fil de verre (silionne et verranne)
- fil polyamide
- fil polyester rétractable ou non
- silice
- Kevlar
- fils thermostables (Nomex, Kermel) etc...

QUESTIONNEZ-NOUS

FISCHER electric CONNECTORS,
50 Ohm, for CAMAC SERIE 101 A004
(compatible with LEMO 00250
homologated by CERN-GENEVA)
These Connectors show the same characteristics than all the well known FISCHER–CONNECTORS with self-locking.



Plug for cable: to be soldered	type S 101 A004
Plug for cable: to be crimped	type S 101 A004-1
Socket	type D 101 A004
Cap for D 101 A004 type	101.00.315
Socket with cable-clamp	type DK 101 A004

This new type satisfies the most exacting customers.

Please ask for our special documentation concerning these new connectors and for our general catalogue concerning our range of coaxial, multiple and mixed Connectors.

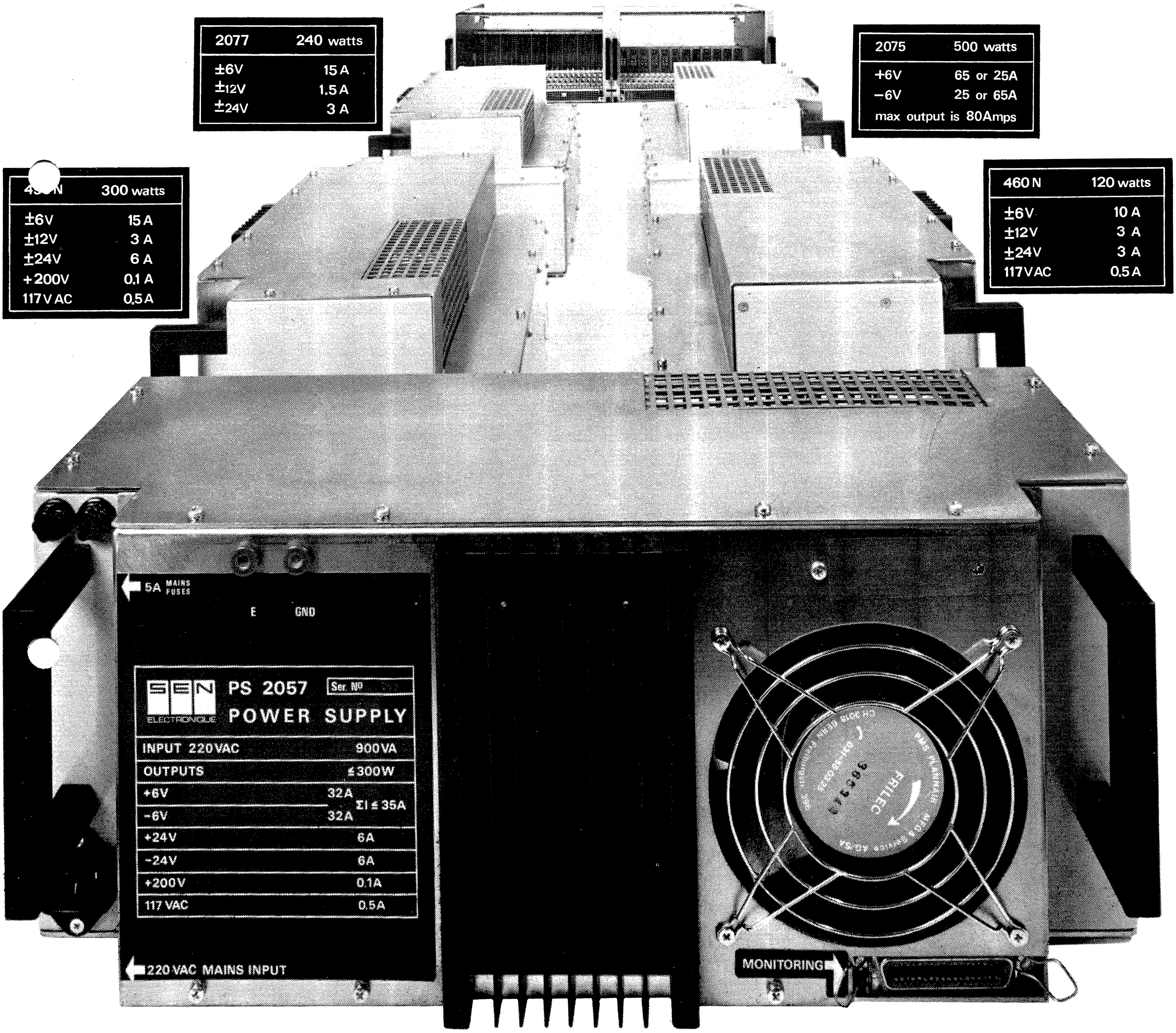
W. W. FISCHER

CH - 1143 **APPLES**

✆ (021) 77 37 11
Telex 24 259 fisch ch

interchange!

you can fit any of these compatible supply units into our NIM and CAMAC crates.



NIM high voltage units

For: Multi-wire Proportional Chambers, Semiconductor Detectors, Scintillation Detectors

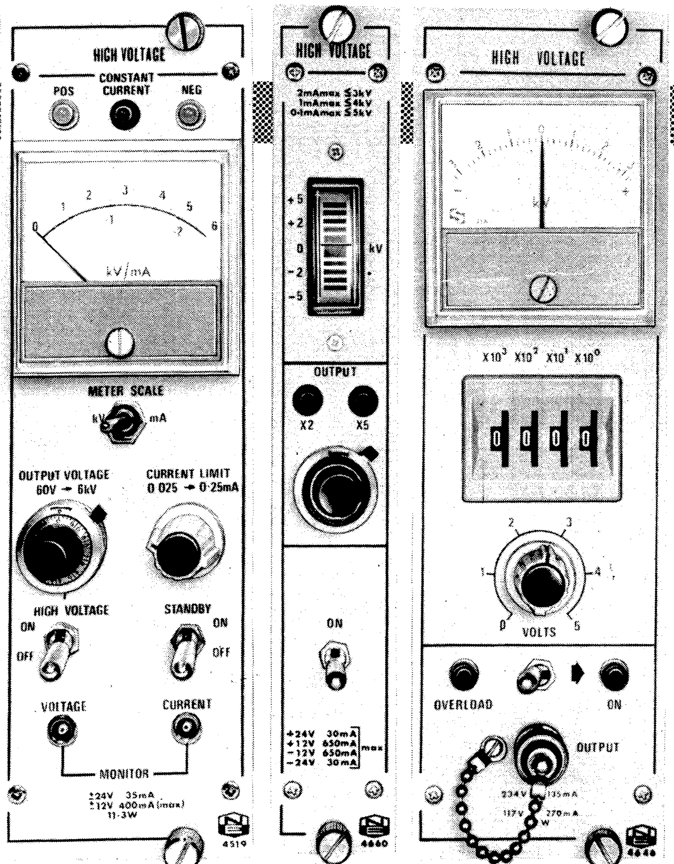
NE 4519 HIGH VOLTAGE

Is specially designed for use with multiwire proportional chambers. It has an output range up to 6 kV positive or negative, with a load current of 250 μA. The ripple content is 0.01% or 100 mV peak to peak, and regulation is 0.01%. Facilities include over current limiting, remote programming and overload logic output. This double width NIM module is powered from a standard NIM low voltage supply.

NE 4660 HIGH VOLTAGE

Operates with both semiconductor and scintillation detectors and may also be used to operate electron multipliers, proportional counters and ionisation gas counters. Two outputs are available: scintillation detector output: — 5 kV positive or negative with load current of 1 mA (at 3 kV the load current is 2 mA); and semiconductor output: 5kV positive or negative current limited by 10 Megohm resistor. This single width NIM module is powered from a standard NIM low voltage supply.

Full details on request.



4519 4660 4646

NE 4646 HIGH VOLTAGE

Provides a voltage output variable from 400 to 3200 V positive or negative at a load current of 5 mA. It is particulary suitable for applications where an array of scintillation detectors requires a higher current capability. Regulation is 0.01% over current range, and ripple is less than 60 mV peak to peak. This double width NIM module is powered directly from 117 or 234 V ac supply.

NUCLEAR ENTERPRISES LIMITED

SIGHTHILL, EDINBURGH EH11 4EY, SCOTLAND
Telephone: 031-443 4060
Cables: Nuclear, Edinburgh Telex: 72333

Associate Companies
Nuclear Enterprises GmbH, Schwanthalerstrasse 74, 8 München 2, Germany. Tel: 53-62-23. Telex: 529938.
Nuclear Enterprises Inc., 935 Terminal Way, San Carlos, California 94070. Tel: 415 593 1455. Telex: 348371.

L'AIR LIQUIDE

the leading european manufacturer of cryogenic equipment.

division matériel cryogénique

57, av carnot. 94500 champigny/marne
tel. 880.80.80. telex 23884 champal champ

micha pub.

New 9815–So much power: so much flexibility: so much value for money:

The big news on the elegant and compact 9815 programmable desk-top calculator begins with a miniaturised high-speed, high capacity data cartridge. And continues with a 472 step memory, a wealth of pre-programmed math and stat functions, easy programming, comprehensive editing facilities, large, clear display, alphanumeric printer and much more.

Options increase memory to over 2,000 steps and add I/O capability. And all this is compatible within the existing large family of 9800 series peripherals.

Although the new data cartridge is physically smaller than standard cassettes, its twin tracks store more data–96,000 8-bit bytes. It searches in either direction at 152 cm/sec. and always knows automatically which direction to search–with a resultant big saving in time.

Programming is another area in which the 9815 will save you time and trouble. Well-proven RPN (Reverse Polish Notation) logic, 4-level operational stack and simple machine language are enhanced in power and sophistication by many features you wouldn't expect to find in a calculator in this price range. Apart from comprehensive editing facilities, these include 'For Next' statements, computed and automatic branching and programmable flags.

There's a lot more to interest you in the remarkable 9815. For a full Facts File, contact your nearest H.P. office.

HEWLETT PACKARD

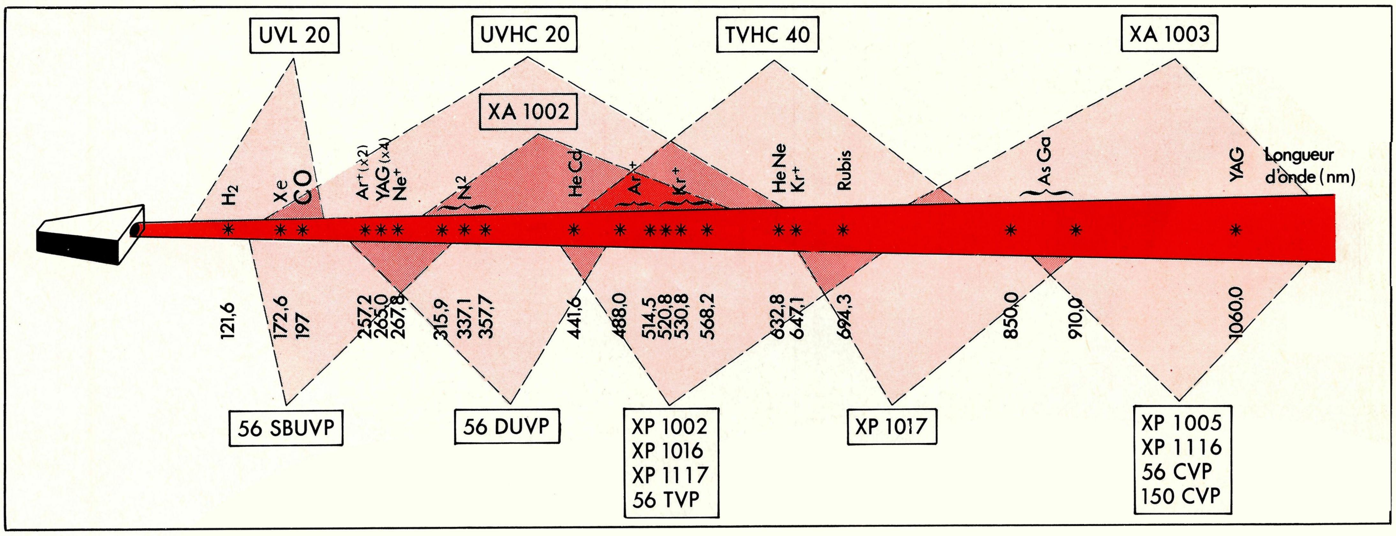
Sales and service from 172 offices in 65 countries.

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, I-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.

UN PHOTOTUBE R.T.C. POUR TOUS LES CAS DE DETECTION LASER.

De l'ultraviolet lointain au proche infrarouge et du continu aux impulsions subnanosecondes, les phototubes R.T.C., cellules et photomultiplicateurs, offrent un choix complet de récepteurs adaptés à chaque application, dans un domaine de puissances reçues allant du photon unique à plusieurs centaines de Watts crête.



Les photomultiplicateurs R.T.C.

permettent une amplification du signal lumineux incident supérieure à 10^6 avec un bruit négligeable et une bande passante dépassant 10^8 Hz. Ils sont utilisés dans toutes les applications où la puissance lumineuse reçue par le détecteur est très faible et doit être amplifiée sans bruit dans un large domaine de fréquences, telles que les systèmes de télémétrie, vélocimétrie, écartométrie, granulométrie, lecture optique...

Photomultiplicateurs pour applications lasers

type	photocathode	temps de montée (ns)	sensibilité de photocathode (mA/W)
XP 1116	S 1	3,5	1,6 (à 903 nm)
XP 1117	S 20	3,5	13 (à 698 nm)
150 CVP	S 1	3,5	1,4 (à 903 nm)
XP 1016	S 20	3,5	13 (à 698 nm)
XP 1017	S 20R	3,5	6,5 (à 858 nm)
56 CVP	S 1	2	1,4 (à 903 nm)
56 DUVP	DU	2	80 (à 401 nm)
56 TVP	S 20	2	15 (à 698 nm)
56 SBUVP	SB	2	15 (à 250 nm)
XP 1002	S 20	4	13 (à 698 nm)
XP 1005	S 1	4	1,4 (à 903 nm)

Les cellules R.T.C.

qui utilisent une photocathode opaque, plane et parallèle à une anode grille possèdent un temps de montée inférieur à la nanoseconde et une linéarité de plusieurs ampères. Elles seront employées dans tous les cas où l'utilisateur dispose d'une forte puissance lumineuse et recherche un temps de montée très faible associé à une grande dynamique. Par exemple mesures de niveau et de temps en physique des plasmas.

Cellules pour applications lasers

type	photocathode	temps de montée (ns)	linéarité (A)
UVL 20	Cs I	0,2	8
UVHC 20	S 5	0,2	5
XA 1002	S 4	0,2	5
XA 1003	S 1	0,2	1
TVHC 40	S 20	0,4	6

Ces phototubes ne constituent qu'un échantillonnage de nos fabrications, pour plus de détails consulter le guide de l'ingénieur "Tubes électrooptiques et photodétecteurs".

RTC

R.T.C. LA RADIOTECHNIQUE-COMPELEC 130, av. Ledru-Rollin, 75540 PARIS CEDEX 11, tél. 355.44.99