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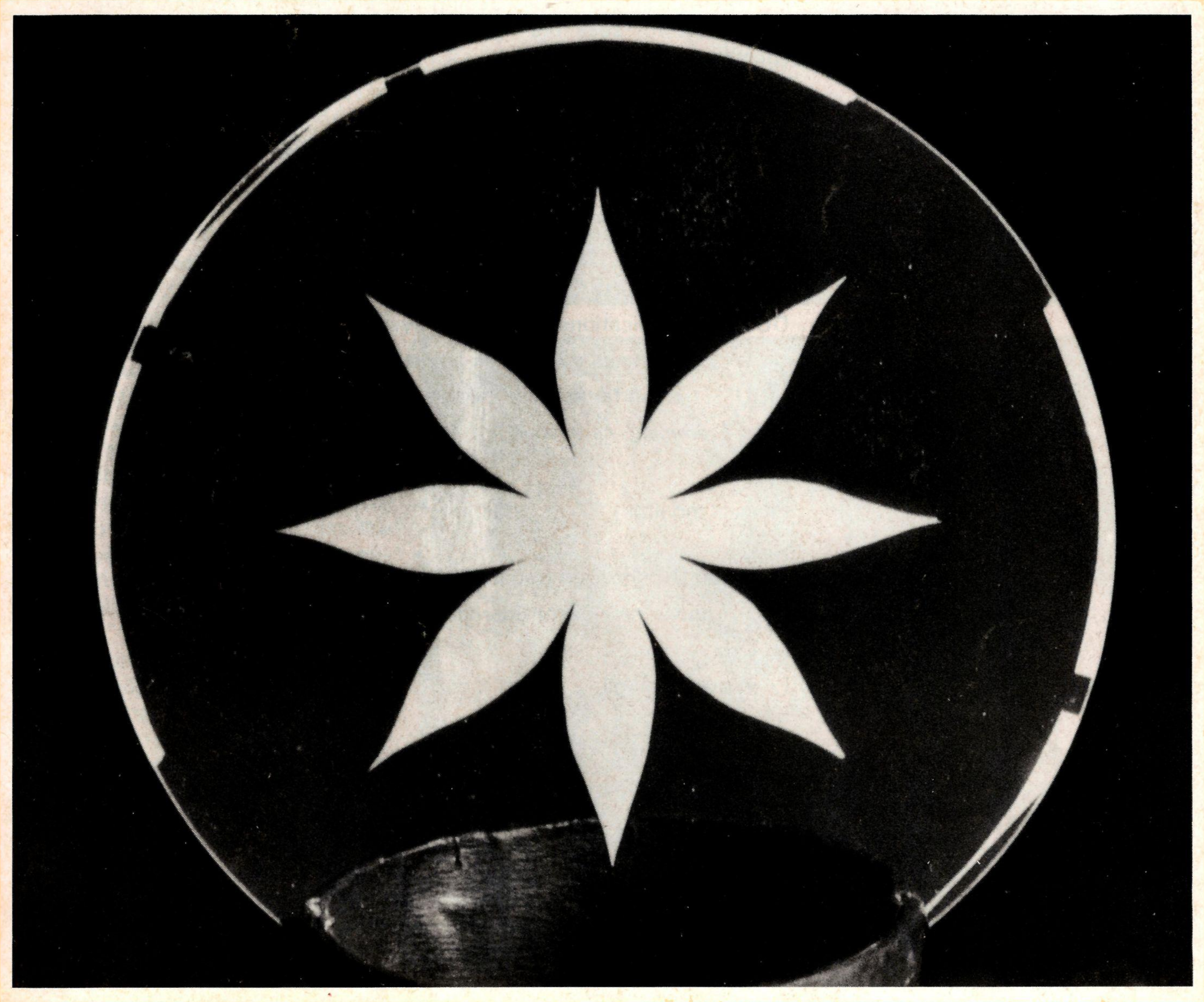

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Around the Laboratories

Physics monitor

Cover photograph: An aluminium coating on the quartz window for a gas Cherenkov produced this flower pattern. The counter is part of the apparatus built by a Princeton/Saclay/Torino/Brookhaven collaboration to study hadronic charm production and antiproton interactions at Fermilab. (Photo Fermilab)

Looking back over the 1970s

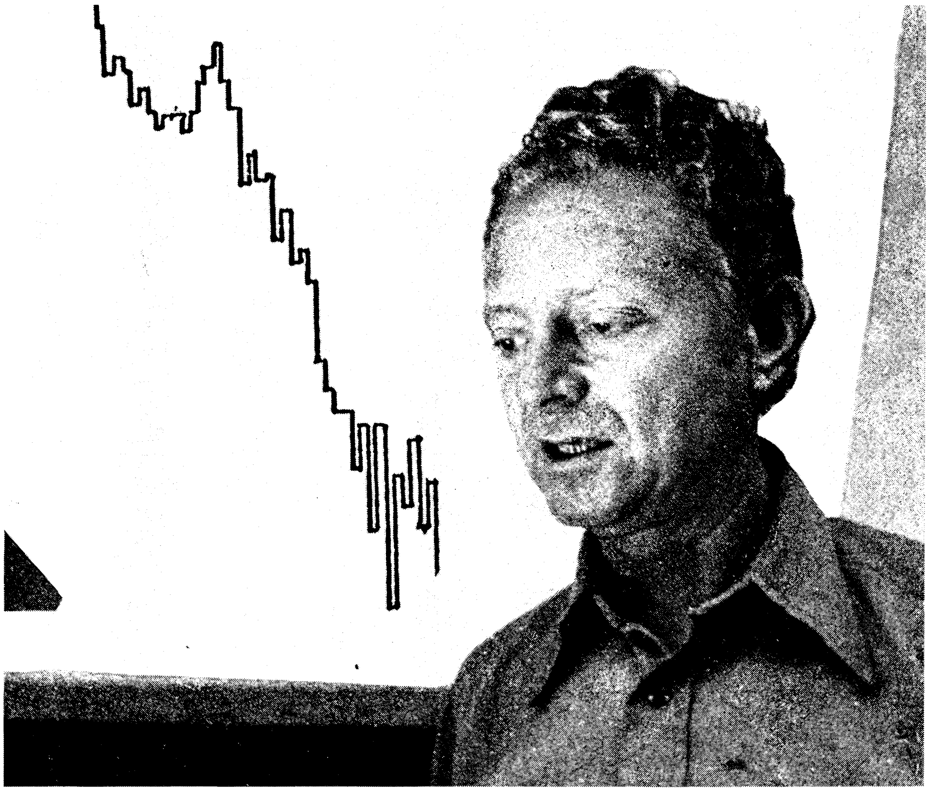
As we prepare to enter a new decade, it is traditional, and instructive, to look back and review the accomplishments of the last ten years, which have been particularly eventful for particle physics. Rather than trying to cover in detail all the developments which have taken place, this review is intended as a broad historical survey.

The 1970s could go down in the history of science as some of the most momentous years in the study of particle physics and in the development of our understanding of the basic interactions of nature.

At the end of the 1960s, the stage had been set by the experiments at SLAC which showed that for electromagnetic interactions there are small hard scattering centres deep inside the proton. This was the counterpart for nuclear matter of Rutherford's classic 1911 experiment which discovered the existence of atomic nuclei. Just as Rutherford's experiment opened up the interior of the atom, so the SLAC result revealed a deeper layer in the structure of matter.

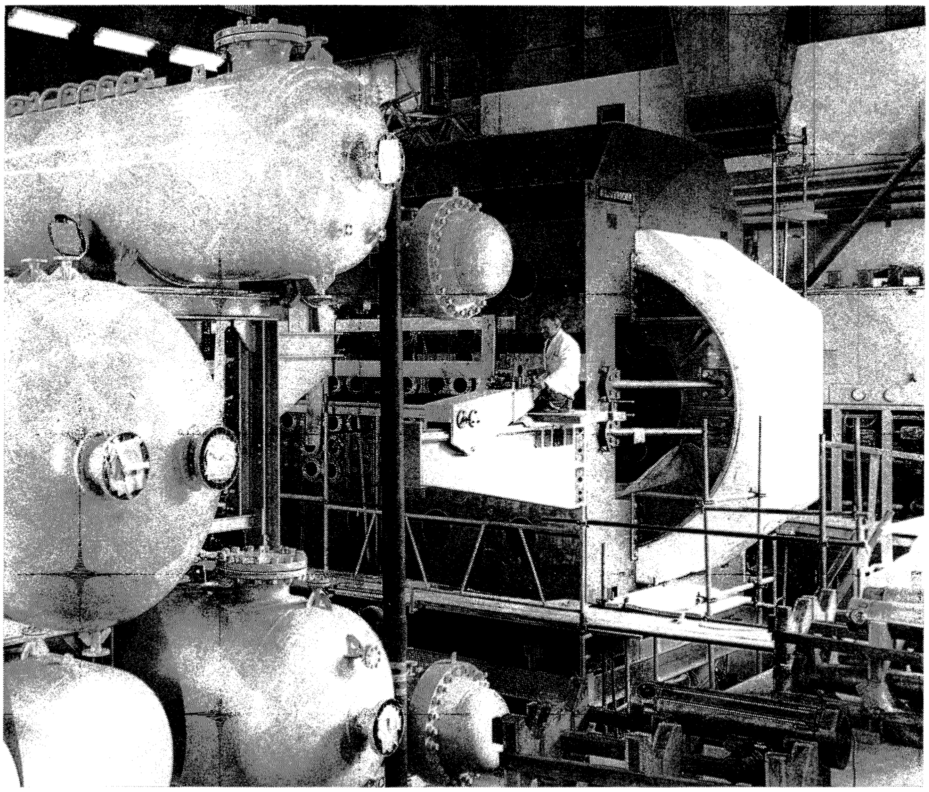
Early in the 1970s, experiments at CERN found similar behaviour using neutrino beams, showing that the constituents hidden deep inside nuclei could interact through the weak as well as the electromagnetic force.

Since the 1950s, theorists had been working on the idea that strongly-interacting particles are built upfrom small numbers of building blocks, called quarks, which give the particles their static properties. While quarks were a powerful idea



At the Budapest Conference in July 1977, Leon Lederman announced the discovery of the upsilon in experiments at Fermilab.

(Photo A. Montvay)



The Gargamelle heavy liquid bubble chamber under construction at CERN in 1969. Four years later, this detector saw the neutral currents of weak interactions, so opening the door to electroweak unification.

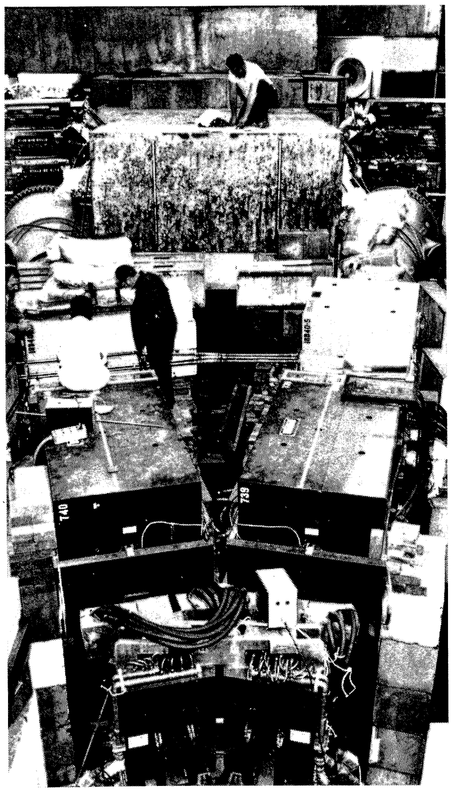
(Photo CERN 95.9.69)

1. The detection system which spotted the J/psi at Brookhaven in 1974.

(Photo Brookhaven)

2. The apparatus at the SPEAR storage ring at Stanford which also discovered the J/psi.

(Photo Stanford)



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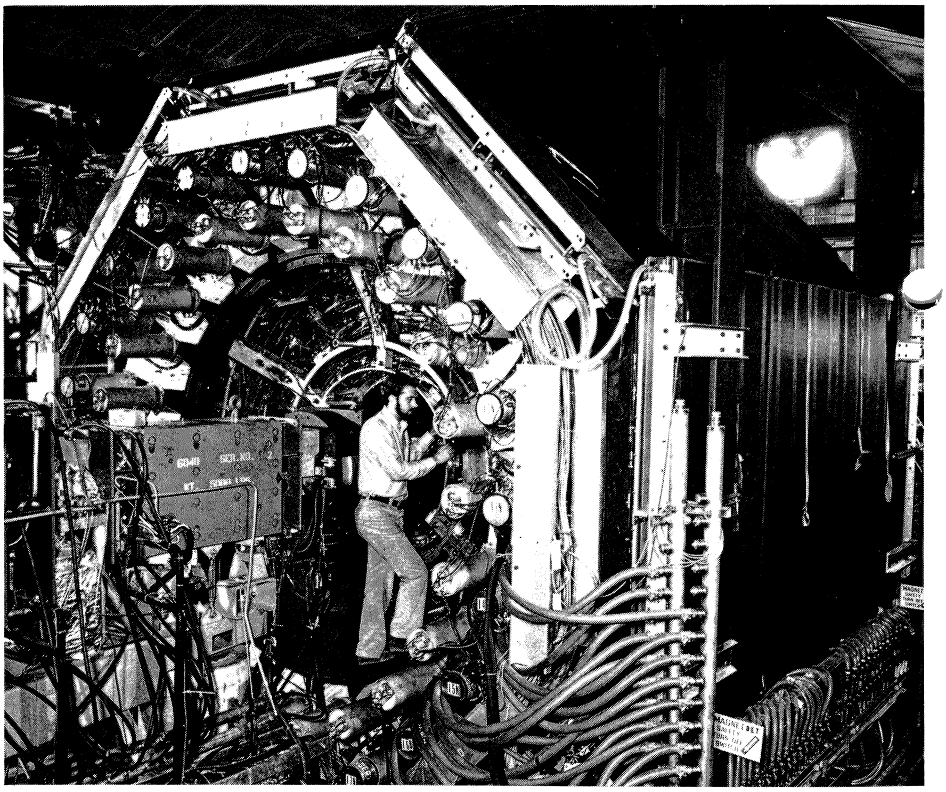


2.

on paper, no trace of them had been found. But the neutrino experiments of the early 1970s showed that the hard subnuclear scattering centres have exactly the properties expected of quarks. Quarks became real.

Further experiments with electron, neutrino and muon beams, as well as probing the distribution of quarks in nuclear matter, have begun to measure their interactions. At the same time, theoreticians have been developing quantum chromodynamics, a theory of inter-quark forces, and the agreement between theory and experiment shows that quark dynamics is beginning to be understood.

A brief summary of the particle physics developments of the 1960s would have mentioned little, if anything, about the formulation of a model by Sheldon Glashow, Steven Weinberg, Abdus Salam and others which attempted to unify the electromagnetic and weak interactions of leptons. One necessary consequence of this model was a 'neutral current' of weak interactions, through which the weak force could operate between particles without permuting their electric charges. Such behaviour had never been seen. The new ideas, when extended to cover quarks, also implied the existence of a fourth type of quark. Ten years ago, this ambitious unification scheme and its developments lay dormant.

Then the 1970s saw a series of experimental and theoretical breakthroughs which transformed this abstract model into a physical theory. First Gerard't Hooft showed how the formalism could be made to handle calculations in a consistent way. In 1973 came the discovery at CERN using the Gargamelle bubble chamber of the neutral current of weak interactions.

Then came the dramatic discovery of the fourth quark—charm—in simultaneous experiments by the groups of Sam Ting at Brookhaven and Burton Richter at SLAC. Subsequent experiments underlined the new theoretical ideas and the measurement at SLAC in 1978 of the delicate interference between weak and electromagnetic effects in electron-nucleon scattering provided further impressive evidence.

With charm, it looked for a brief time as though all of nature could be described in terms of four leptons—the electron and the muon together with their attendant neutrinos—and four types of quark—up, down, strange and charmed. These eight particles fitted nicely together.

Then came the sighting at SLAC and at DESY in 1976 of the tau particle, a lepton like the electron and the muon, but much heavier. This did not fit into the existing pattern, and hinted that there might be some more quarks to find.

This was confirmed in 1977 with the discovery by Leon Lederman's group at Fermilab of the upsilons, which appeared to be due to another type of quark, now called beauty. The upsilon is explained as the bound state of a beauty quark and its antiquark, in the same way as the J/psi discovered by Ting and Richter is made from a charmed quark and antiquark. Just as the J/psi heralded the discovery of many more particles carrying charm, so the upsilon hinted that there were yet more particles, this time carrying beauty. The first of these looks to have been seen in a 1979 experiment at CERN.

Even with the addition of beauty, there should be yet another quark in order that everything becomes tidy again. Many theoreticians are reluctant to have a list of twelve basic particles, not counting the extra ones responsible for their mutual interactions. Perhaps there could be an even deeper level in the structure of matter, and that the 'basic' particles now known are really the spectroscopy of something smaller still. Only time, and higher energies, will tell.

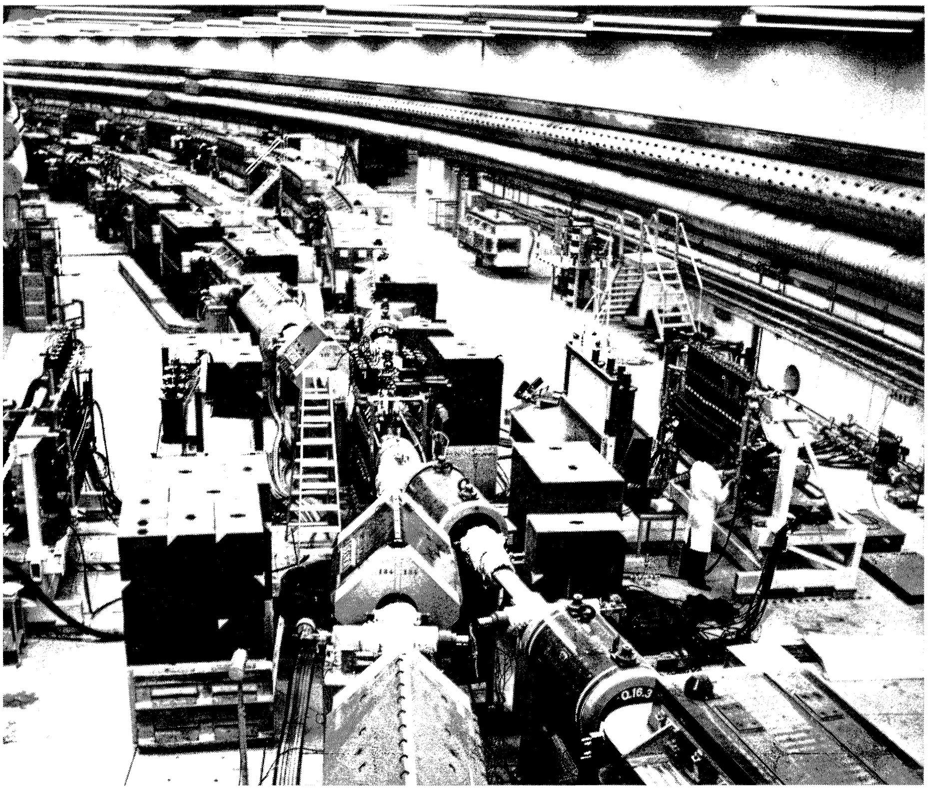
With the underlying theory of particle interactions seemingly in good shape, it is tempting to make predictions for the future. When reviewed in 1990, such predictions could display more about our current ignorance than our understanding.

However the great particle physics achievements of the 1970s are certainly reflected in the range of new accelerator projects under construction or being planned. This enthusiasm bodes well for continued progress in the 1980s.

Accelerators in the 1970s

As usual, the advances in our understanding of the nature of matter during the past decade have leaned heavily on the availability of high energy accelerators which have both revealed new phenomena and enabled theories to be exposed to experiment. There have been many advances in technique, many new approaches, many new ideas on accelerator applications and many splendid new machines brought into operation. We pick out three themes to characterize how accelerators have progressed in ten years.

The first is in the understanding of the behaviour of charged particle beams and of the techniques to control this behaviour. Accelerator physics is by now a most thoroughly understood science. It was in good shape ten years ago but no-one then would have dared to make the great projections into the future for the accelerator projects which are now

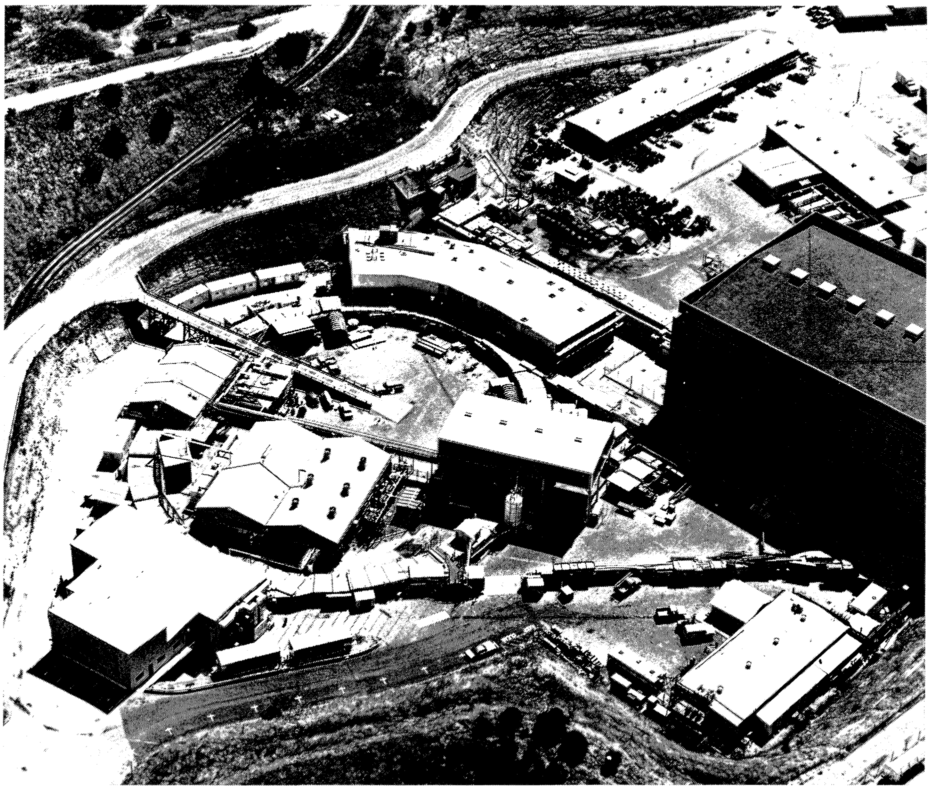


The Intersecting Storage Rings at CERN did much to establish the concept of colliding beams as a fruitful route to higher energy experiments. One of the eight intersection regions can be distinguished here.

(Photo CERN 141.5.75)

Aerial view of SPEAR, the electron-positron colliding beam machine at Stanford which has been the scene of some exciting physics during the past decade. The buildings on the two arcs house synchrotron radiation experiments—an application of accelerators which has grown tremendously in recent years.

(Photo SLAC)



voiced with confidence at the discussions of ICFA (International Committee for Future Accelerators). Nobody then would have proposed beams of hundreds of amperes such as are mooted for heavy ion fusion projects. And so on.

There seems to be hardly any limit, other than that of resources, to what accelerator physicists could provide in one form or another to meet the demands of high energy physics. Their abilities have been demonstrated and they confront all future challenges with a confidence which rests on the achievements of the past decade.

To pick out a single technique which has emerged in the 1970s and which will have its impact in the 1980s, we should mention beam cooling—both electron cooling invented at Novosibirsk and stochastic cooling invented at CERN. Many consider cooling to be the most important advance in accelerator technology since the idea of alternating gradient focusing.

A second theme in the accelerator field during the past ten years has been the advent of storage rings. In the early 1970s several projects were under construction but the enthusiasts for the colliding beam route to high energies were thin on the ground compared to the fixed target adherents. Now we have the CERN Intersecting Storage Rings (probably the most perfect device ever built from the machine physics point of view), SPEAR at Stanford and DORIS at DESY (where the crop of physics at these two electron-positron machines has been spectacular), and PETRA and PEP as newcomers. The acceptance of storage rings has, of course, depended on the proof that they could be used for good physics. The mastery of accelerator techniques has enabled sufficiently high luminosities to be achieved to ensure fruitful experimental programmes.

The ISR in the proton-proton colliding beam field pointed the way to the Brookhaven ISABELLE project. SPEAR and DORIS in the electron-positron field pointed the way (in addition to their immediate successors) to the LEP project for Europe. The other storage ring novelty for the 1980s may well be the first electron-proton colliding beam machine at DESY.

The third theme is the explosion in the applications of accelerators for disciplines other than high energy physics. This too has its roots in the mastery of accelerator technology. It is almost impossible to move anywhere these days without tripping over a synchrotron radiation source and yet the use of the remarkable properties of the light emerging from electron storage rings is still in its infancy. Accelerators as neutron sources have emerged quite recently and they will take over from reactors for neutron-based research in th next decade.

Small accelerators have long been in use in hospitals but recent years have seen a variety of studies of other applications in medicine for diagnostics and treatment. The use of proton, neutron, pion and heavy ion beams in cancer therapy are all under investigation and require accelerators of substantial size. Accelerator techniques in radiocarbon dating is a newcomer to the list of applications which may well take off spectacularly in the coming years.

Leaving aside many other uses of smaller scale, we should mention the potential of heavy ion accelerators in the field of thermonuclear fusion. The serious study of this potential dates back only four years and it is a huge challenge for the next decade. The possibility of this route to a vast energy source is, however, of such tremendous importance that it could prove the most dramatic of all the applications of accelerators.

Having picked out the themes of advance and achievement, we should also mention a major frustration of the 1970s — the slow progress in the exploitation of superconductivity in accelerators for both magnets and r.f. cavities. The promise of superconductivity has been known for over a decade since the work with magnets at Rutherford in 1966. But realizing this promise has proved extremely difficult. Considerable advances have been made but at nowhere near the rate which was anticipated. Let us end on a positive note with the prediction that in the 1980s superconductivity will extend the abilities of accelerators both for high energy physics and for the many other disciplines which profit from the developments which the needs of high energy physics have initiated.

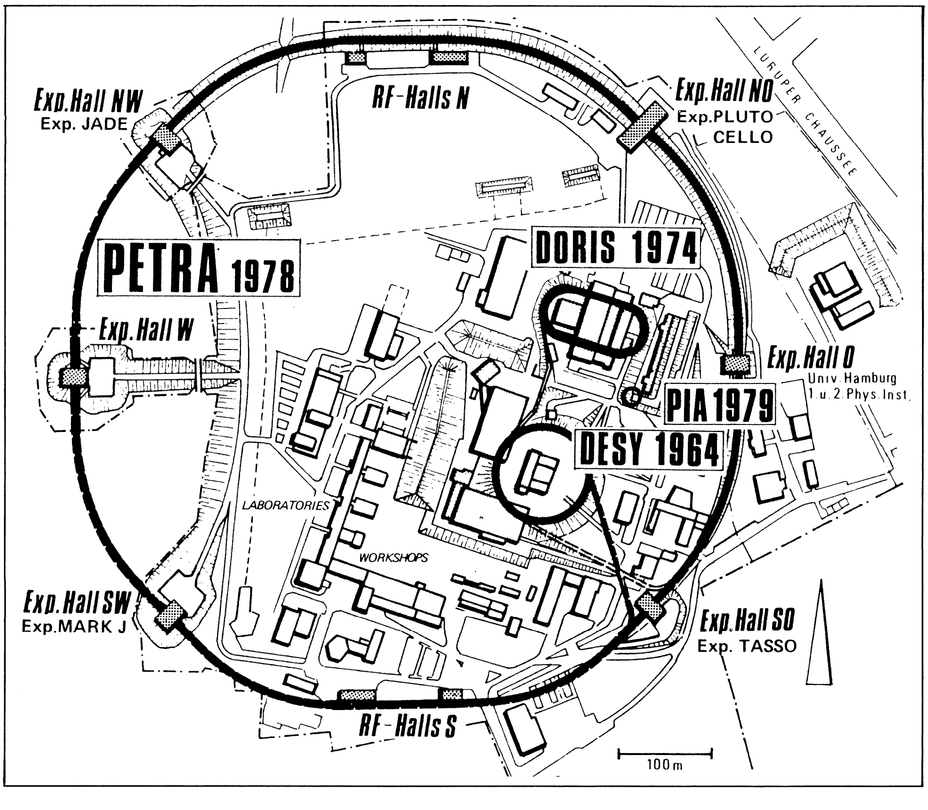
Around the Laboratories

DESY
Anniversary time

Twenty years ago, on 18 December 1959, the agreement marking the founding of DESY was signed by representatives of the German Federal Republic and the city of Hamburg. DESY celebrates its 20th anniversary during a period of particularly fertile research which leaves little time for lavish festivities.

The 20 years since its humble beginnings have seen the growth of DESY into one of the world's leading accelerator centres. DESY began with the construction of a 5 GeV electron synchrotron, and the first beam, produced in February 1964, was successfully circulating in the synchrotron long before the official inauguration — a style of doing things which has been maintained up to the present. The PETRA storage ring was inaugurated nine months after its first beam-run.

DESY was jointly established and is financially supported by the Federal Ministry for Science and Technology (90 per cent) and the city of Hamburg (10 per cent). DESY was organized as a foundation, which leaves the directorate and the Scientific Council relatively free for planning and executive duties. The Scientific Council, whose members come exclusively from outside universities and Laboratories, controls the scientific and technical programme. An Administrative Council with representatives from Bonn and Hamburg makes final decisions and establishes the general framework for activities. Ten years ago an Advisory Committee was added, a portion of whose membership is elected by the employees of DESY. An international Physics Research Committee (PRC), advises the direc-



Steps in the evolution of accelerators at DESY. The years indicate the first operation of each machine.

Willibald Jentschke (left) shakes hands with Hans-Otto Wüster after the first successful beam test with the DESY-Synchrotron on 25 February 1964.

(Photo DESY)

torate on the experimental programme.

DESY was originally established as a large experimental facility available to German universities. This primarily national role was modified with PETRA to provide a large electron-positron storage ring accessible to all researchers. Half of the scientific staff and half of the financial support of DESY experiments is at present contributed by Laboratories from twelve foreign countries.

The charter provisions called for the general expansion of machine capabilities over a period of several years. A step in this direction was taken in 1968 with the raising of the synchrotron beam energy to its present value of 7.4 GeV. In 1971, the beam current was increased to 40 mA after the installation of the 400 MeV Linac II.

In the early days of DESY, research groups interested in electron and photon interactions were on the outside of a particle physics scene dominated by proton machines. It took several years before international conferences on electron and photon physics came into fashion. Today, proton and electron accelerators complement each other.

Many results of the DESY synchrotron era were quite fundamental, such as the experiments on electro- and photoproduction, the nucleon form factor determinations and the tests of quantum electrodynamics.

The first large-scale expansion of the DESY facilities began in 1969 with the construction of the DORIS electron-positron storage ring. The new project was completed at the end of 1973—just in time to join in on the J/psi bonanza of 1974. DORIS contributed many interesting charmonium results.

Subsequently DORIS reached new heights with the discovery of the F particle (carrying charm and strangeness) and of the weak decay mode of the D particles, offering conclusive evidence for the existence of the charmed quark. Another highlight was the confirmation of the tau heavy lepton.

As with the synchrotron, steps were taken to increase the beam energy of DORIS. This process was made possible because the bending magnets were capable of sustaining more power than originally provided for in the design energy specifications.

In the spring of 1978, the DORIS beam energy was pushed upfrom its initial value of 3.5 GeV to 5 GeV. With this increased energy DORIS was able to clarify the nature of the long-lived upsilon particle and its first excited state, and to demonstrate that it consists of a bound quark-antiquark state with quark charge ***V3***. Since then, DORIS has amassed a wealth of information on the upsilon states, in particular on the three-gluon decay mode.

Meanwhile, construction of the electron-positron storage ring PETRA began in November 1975, and after only two and a half years, on 15 July 1978, the first beams were already happily circulating. Since then, PETRA has been busy confirming quantum electrodynamics on an extremely small scale as well as producing interesting jet events (see November 1979 issue, page 358).

CERN
Installing STELLA

STELLA—Satellite Transmission Experiment Linking Laboratories—is now taking shape. This interesting project will explore the possibilities of transmitting data accurately over large distances and at high speeds using the European Space Agency's OTS-2 communications satellite launched last year (see June 1978 issue, page 199).

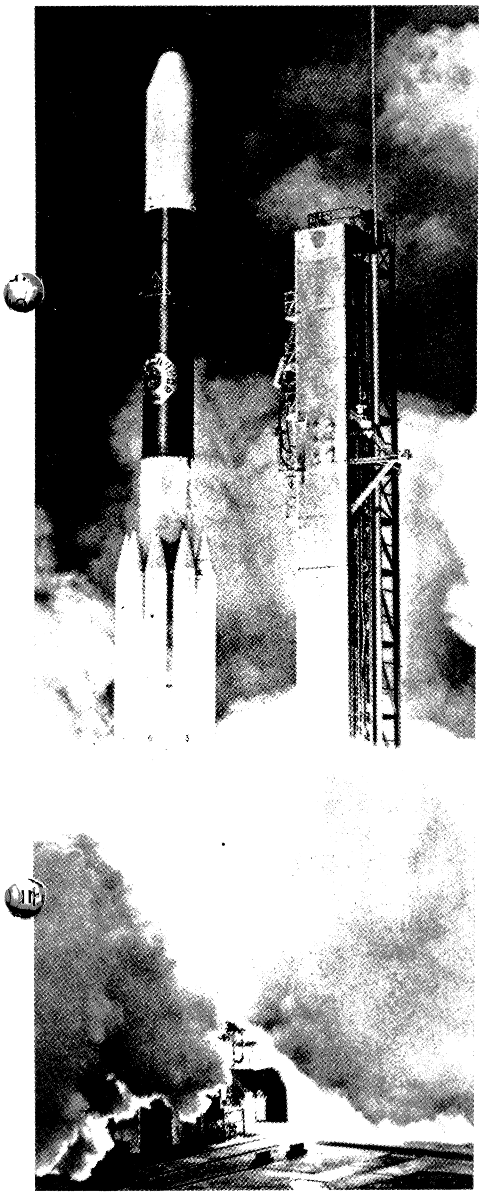
With STELLA, physics Laboratories are pioneering the use of high speed data communications by satellite in Europe. The project will link CERN, the Rutherford Laboratory in the UK, DESY in Germany, Saclay in France, Pisa in Italy, Dublin in Ireland and Graz in Austria, and is supported by the European Space Agency (ESA), the European Economic Community (EEC) and the post and telegraph (PTT) authorities in the respective countries.

AT CERN, the three metre diameter antenna for a transmitting and receiving station and the computing and interfacing equipment to handle the 1 Megabit per second data communications were installed late last year. First data transmission experiments should begin soon.

Computer software and interface

The launch of the European communications satellite OTS-2 at Cape Canaveral, Florida, on 11 May 1978. The satellite is 35 900 km above the Equator at W°E.

(Photo European Space Agency)



A fir-tree adds a seasonal note as the antenna is installed at CERN for the STELLA satellite communications project.

(Photo CERN 196.11.79)

equipment designed by Rutherford and CERN is now available as required for the earth stations. The station at the Rutherford Laboratory is now in contact with the satellite, and the station at Pisa should shortly be operational, with DESY and Saclay following soon after.

The CERN/Rutherford satellite link should soon be operational, with other stations coming on line by June. As an extension to the experiment, the CERN earth station will be moved in 1981 to the Swiss PTT site at Loèche and data sent from CERN by high speed landline.

Data from CERN experiments will provide the bulk of the transmissions until the 'big shutdown' when SPS experiments stop and work begins to adapt the SPS for its new role as a proton-antiproton collider. For the remainder of the year, DESY will be the main user, with data for Rutherford and Saclay. With STELLA, participating authorities will be able to gain valuable experience in the use of satellites for multipoint high speed data links and in the development of European data transmission schemes. Physicists at CERN will be able to explore the advantages of sending large samples of experimental data from Laboratories to home institutes at a rate comparable to the processing speeds of large computers.

This will enable physicists, both at CERN and at the home institutes, to monitor experiments at CERN without using the CERN computers. The implications of this for future physics at LEP are now being studied.

PTT plans for similar satellite data services for public use have been evolving. The French are to have their own data communications satellite Telecom I, which could serve up to 400 small earth stations all over France. The UK Post Office has plans for a European wide system. In the USA, four such services will be available in the next few years.

Seeing the proton beam

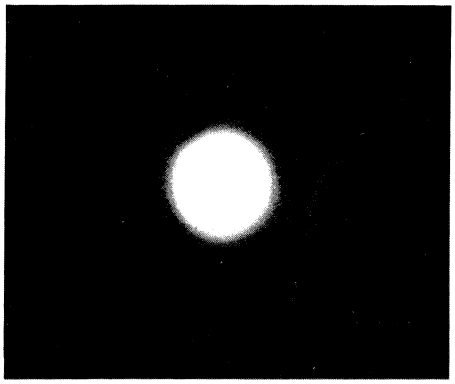
Just over a year ago we reported the first ever observation at the CERN SPS of synchrotron radiation from an orbiting proton beam (see September issue 1978, page 294). The SPS Beam Monitoring Group have now refined their light detection system to an extent that beautiful information on the beam profile is being obtained by means of the synchrotron light.

Though this technique of observing a beam is standard on electron machines, it had never been dreamed of for proton machines of present energies because the proton mass pushes the synchrotron light spectrum far into the infra-red. It was R. Coisson from Parma University who suggested that at discontinuities in the magnetic field (the edge of a magnet) the spectrum could extend into the visible range at comparatively low energies.

The new system at the SPS detects the light emerging at the end of a magnet and has a system of mirrors to manoeuvre the light to a camera in a rather crowded location. The sensitivity has been improved by the use of a silicon intensified target where one incident gamma on the photocathode is converted into 0.1 electrons at the target. With the system, a beam intensity of 10^{13} protons and energies of 240 GeV and above give healthy signals. Accuracies of around 0.1 mm on the beam profile can be achieved and beam density scans in both planes are readily accomplished.

This is a new tool for 'non destructive' beam observation in proton machines and will be of particular importance in the near future for the proton-antiproton collider project at the SPS. Some further improvement so as to be sensitive to the lower intensities (about 1×10^{12}) of the antiproton beam will be needed bu it has just been shown that the use of an 'intensified silicon intensified target' will make this possible. Proton beams of 3×10^{11} were seen at 270 GeV with a TV camera.

Information on the proton beam profile in the CERN SPS drawn from the synchrotron radiation light emerging from the beam at a magnet edge: 1.- the beam spot 2.- the vertical distribution of the protons with the curves representing the intensity of different slices of the beam, 3. - the horizontal distribution of the protons, 4.- profiles recorded at different beam energies.



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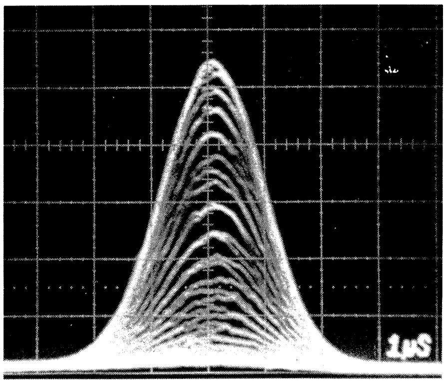

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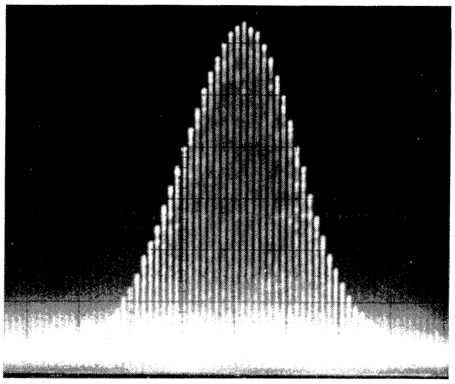

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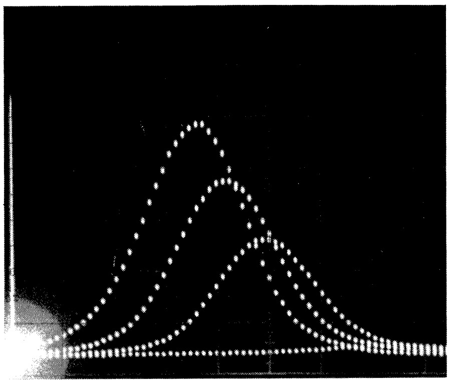

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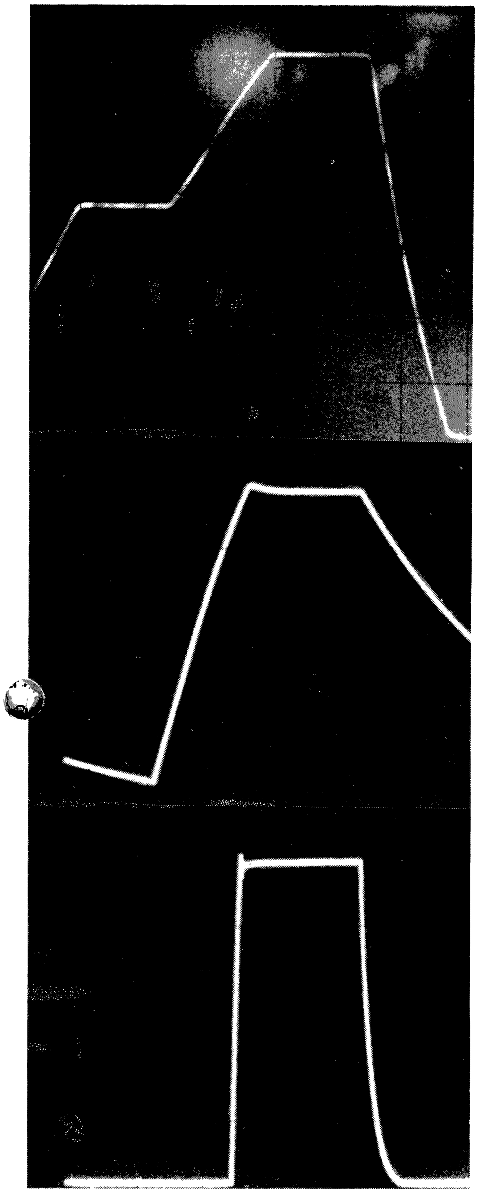
Pulsed beamlines

In these energy-conscious times, it is good to report that considerable energy savings have been made by powering the beamlines in the North Experimental Area to coincide with the pulses supplied by the SPS.

In previous generations of accelerators, the beamline magnets were powered continuously, even though they only received their particles in pulses. If instead the beamlines can be pulsed in time with the arrival of the particles, then energy savings are possible.



Pulsing of the beam line magnets at the North Area of the CERN SPS. The top trace shows a portion of the SPS machine cycle including a 1.5 second flat top. The second trace shows the corresponding current in three bending magnets in serial while the profile for a quadrupole magnet is seen at the bottom.

The SPS is connected directly to the French public electricity network, and to keep power and voltage fluctuations within acceptable limits, a reactive power compensator is used.

The beamlines in the North Area were designed with pulsed operation in mind, and the opportunity arose when a second compensator became available as backup for the first. (The increase in SPS energy to 400 GeV and above has meant that the second compensator has now also to be used for the machine itself, but there is still enough capacity available to handle the beamlines.)

The system has been in operation for several months, and power consumption in the beamlines has been reduced by about 50 per cent. In d.c. mode, power consumption at maximum energy is about 19 MW, and this is reduced to 10 MW when the beamlines are pulsed. In practice, the beamlines are not all run at maximum energy, but proportional savings are still achieved.

Because of their construction, the big spectrometer magnets of the experiments themselves cannot be pulsed. However for an experiment by an Ecole Polytechnique/Strasbourg/Zurich collaboration to study muon pair production by intense pion beams in the new North Area underground experimental hall, the apparatus is being designed for pulsed operation.

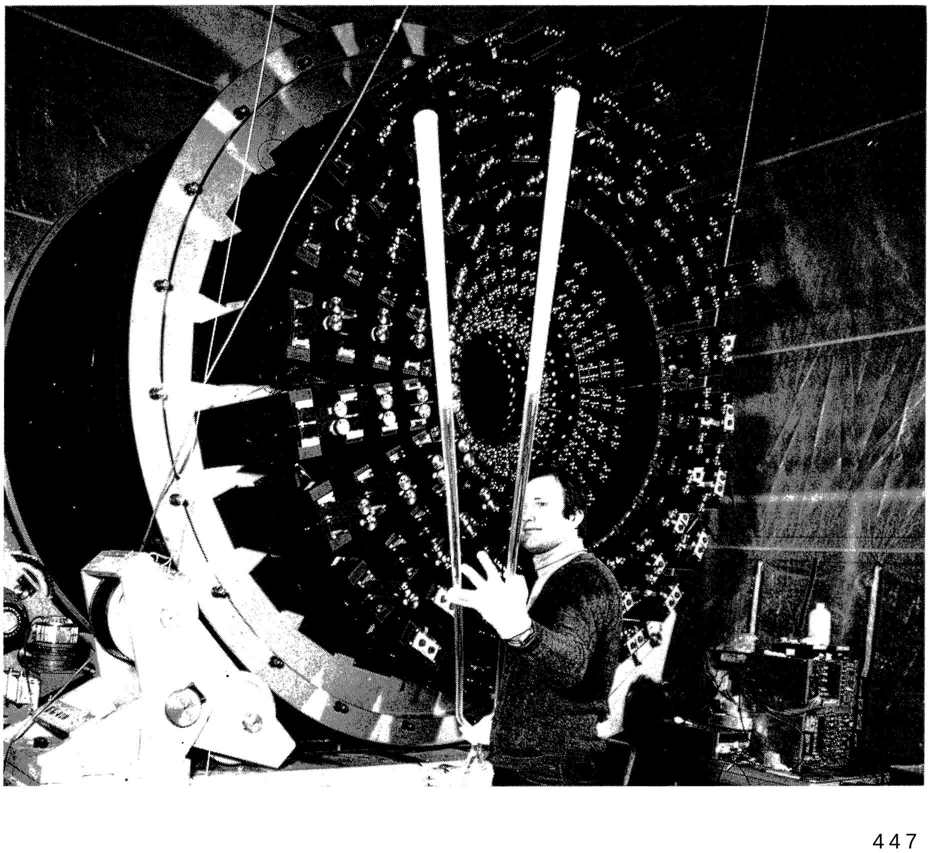
For the beamlines in the West Experimental Area, some of which were originally used for PS experiments, more extensive modifications are required to achieve pulsed operation. However this work will soon begin and should be complete for the restart of SPS experiments in 1981 after the big shutdown to adapt the SPS to its new role as a proton-antiproton collider. Total annual savings should then amount to about 3 million Swiss francs.

Detector sees the light

An interesting new detection system is now in regular use in the North Area of the SPS 400 GeV proton synchrotron. The experiment is being carried out by a Bari/Cracow/Liverpool/Munich(MPI)/Nijmegen collaboration to study 'hard' collisions between hadrons when energetic particles emerge at wide angles to the collision direction.

This compact photon and hadron calorimeter, built by Bari and MPI Munich for an experiment at the CERN SPS, uses long acrylic rods to draw information from many scintillator cells and to distinguish between signals from the photon and hadron sections of the calorimeter.

(Photo CERN 25.5.79)



A hydrogen target within a streamer chamber and inside a magnet observes what happens at the collision vertex. This is backed by magnetostrictive chambers and a cylindrical detector which provides both hadron and photon calorimetry and acts as the trigger.

This detector has novel features. It uses plastic scintillators to determine the total energy of the photons or badrons, and a new method of light collection permits a compact construction with all the photomultipliers well away from the magnetic fields. Special fluorescent converters give colour to the light so that the photons and hadrons can be readily distinguished.

The light collection system involves acrylic rods passing at right angles through the slabs of scintillator (which are interspersed with slabs of lead or iron). Light from a large number of scintillators can thus be brought to a single photomultiplier. In addition the section of the rods which passes through the photon calorimeter (the front end of the detector) is doped so that the transmitted light is coloured yellow. The section which passes through the hadron calorimeter is doped to colour the transmitted light green. In this way a single rod can feed two photomultipliers via light filters and convey signals corresponding to the location of the origin of the light.

This detector, built by Bari and the Max Planck Institute, Munich, provides very fast calorimetry, covers wide angles because of its compactness, allows fine granularity of the scintillator cells and gives 'unbiased' information, since it can trigger on jets over a large solid angle. The ideas are being taken up by other teams.

New effects seen in atomic X-ray spectra

A series of precision experiments by a CERN/Jülich group at the CERN 600 MeV synchro-cyclotron (SC) have measured a number of new effects in the atomic X-ray spectra of heavier elements.

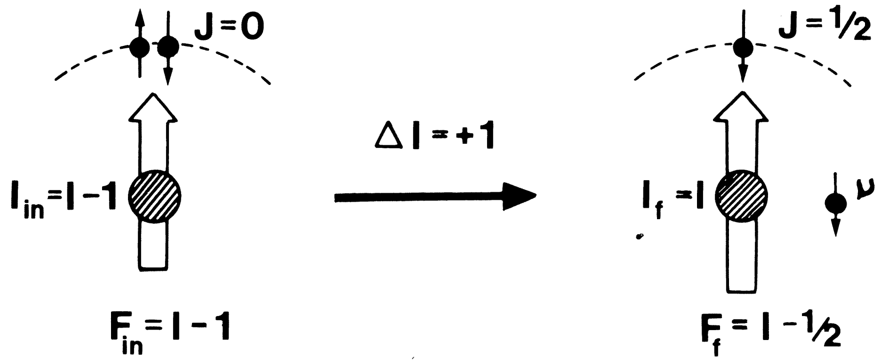
For more than a decade it has been known that the X-ray energies from inner electron transitions (the K-spectra) in atoms of heavier elements depend to a small extent on isotopic and chemical composition. The small isotope shifts are the result of the perturbation of the atomic levels due to the size of the nucleus, and can be used to give information on nuclear radii. The chemical shifts are the result of changes in the screening due to valence électrons.

The experiments at CERN have pointed to several additional contributions to the energies of K X-rays, typically involving shifts from 100 millielectronvolts (meV) to a few eV, and a precision of 10-100 meV is therefore required.

This has been achieved with a crystal diffraction spectrometer of the DuMond type. A new design of the source holder together with the extremely intense and almost point-like sources produced by the ISOLDE separator at the SC have been essential for the success of these difficult measurements.

Stig Sundell with the crystal diffraction spectrometer used in the CERN/Jülich measurements of atomic X-ray spectra at the CERN synchro-cyclotron. This instrument, based on a new design principle, measures shifts in the energies of K X-rays with a precision of more than one thousandth of the natural line width (10-50 eV for the atoms being used). The laser beam seen in the picture serves to steer the heavy detector shielding (front) relative to the angular position of the quartz crystal (centre). The X-ray source is seen at the rear.

(Photo CERN361.10.76)



The F selection rule (F denotes the sum of nuclear and atomic angular momenta) for the population of hyperfine levels was predicted in 1958 by I. Bernstein, T.D. Lee, C.N. Yang and A. Primakoff. The initial state has a nuclear spin of 1-1 and orbital angular momentum (J) of zero. The nucleus undergoes beta decay, with capture of an electron, to a state with nuclear spin 1=1. The neutrino carries away half a unit of angular momentum, so that the remaining inner electron can only have its spin antiparallel to the nuclear spin. The hyperfine component with the inner electron spinning parallel to the nucleus is not formed.

The first experiment compared the energies of K X-rays from the electron capture radioactivity of caesium-131 and 132. The energy difference of 112 ± 11 meV was interpreted as a contribution from the previously unobserved hyperfine shift of the lowest-lying (1 s) atomic state.

(The hyperfine shift arises from a minute magnetic interaction between the nucleus and the atomic electrons. As the splitting of the 1s atomic state due to this effect is very much smaller than the natural width of the spectral line, the shifts are normally not detectable, although their presence had been demonstrated in 1973 by a Leningrad group, which showed that isotopes with large magnetic moments had slightly broader K X-ray lines.)

The hyperfine shift became observable in the CERN experiments because the X-rays were produced not by the usual method of photoionization, but. from beta decay radioactivity. In this case there is a selection rule in the atomic and nuclear angular momenta which leads to a selective population of certain hyperfine components. This 'F selection rule' was predicted in 1958 by I. Bernstein, T.D. Lee, C.N. Yang and A. Primakoff.

In a second experiment, the CERN / Jülich group compared the energies of the K X-rays produced in photoionization of gold with those from electron capture decay of mercury-197. Even after allowing for hyperfine and nuclear volume effects, the photoionization X-rays were about 200 meV more energetic. This is attributed to the shake-off of outer electrons in photoionization.

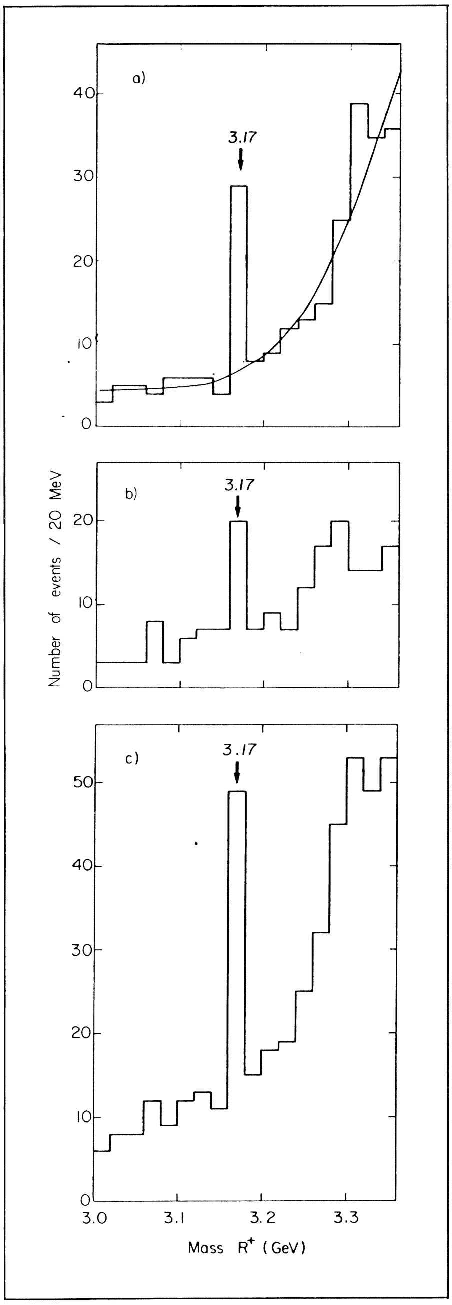
In yet another series of experiments, the group found a third effect, which reflects the difference in atomic structure between a pair of neighbouring elements.

In electron capture beta decay, one atom is transformed into another with one less proton in the nucleus, while the outer electron configuration is retained. The resulting atom therefore has an additional electron, which affects the X-ray spectrum. These atomic structure effects in atoms produced by electron capture in the nucleus should be especially large when inner electron shells are being filled, as in the rare earths.

The atomic structure effect was demonstrated by the CERN / Jùlich group using the pair of rare earths erbium and holmium. In this experiment, the energies of photoionization X-rays from holmium were compared with those from beta decay in the neighbouring rare earth metal erbium. As these metals have essentially the same crystal structure, it is reasonable to suppose that chemical shifts are not to be seen. The experimenters were able to pick up the weak X-ray spectral lines due to transitions from outer electron levels, which gave a clear 'fingerprint' of the additional electron in erbium.

Theoretical calculations show that the measured shifts can be understood if the additional electron is assumed to be in the 4f level — just where chemists and solid state physicists would like it to be.

In the experiments now under way, the CERN / Jûlich group is investigating another group of metals — the 5d series from hafnium to platinum. In the three pairs of elements studied so far, the measured effects resemble each other, but the 'fingerprints' cannot be understood in terms of the three mechanisms which explained the rare earth behaviour. The group suspects that something new is contributing, which is likely to owe more to solid state physics than to atomic or nuclear physics.



Observation of a new heavy hyperon in negative kaon interactions in (a) the CERN 2 m bubble chamber, and (b) the Argonne 12 foot chamber. The smooth curve in (a) shows the estimated background, and (c) shows the effect of combining the two sets of data from the different experiments. This very narrow state, which decays into many strange particles, could be an 'exotic' baryon containing more than three quarks.

CERN/ARGONNE New kind of hyperon?

Two high statistics bubble chamber experiments using negative kaon beams have seen a new hyperon at 3.17 GeV with a width of not more than 20 MeV.

The first evidence came from a Birmingham / CERN / Glasgow/ Michigan State/Paris collaboration studying interactions of 8.25 GeV negative kaons with hydrogen in the CERN 2 metre bubble chamber. The result has been confirmed by a Cambridge/Michigan State collaboration using 6.5 GeV negative kaons in the Argonne 12 foot hydrogen bubble chamber.

Both experiments looked for reactions where the kaon hits a proton, producing a pion and a hyperon, which then decays into many particles, of which more than one carries strangeness.

A sharp signal was seen in the five and six body decays at a mass of 3.17 GeV, while no corresponding effect was seen with just one strange particle in the final state. The new heavy particle also appears to come out forwards, which to the initiated suggests that baryon exchange is responsible.

The dominance of final states containing many strange particles, together with the exceptionally narrow width of the signal, suggests that the new hyperon could have an unusually complex internal structure.

Recently theoreticians have predicted the existence of 'exotic' baryons containing a quark-antiquark pair in addition to the usual complement of three quarks and which would not behave like normal baryons. The new hyperon could be one of these exotic states.

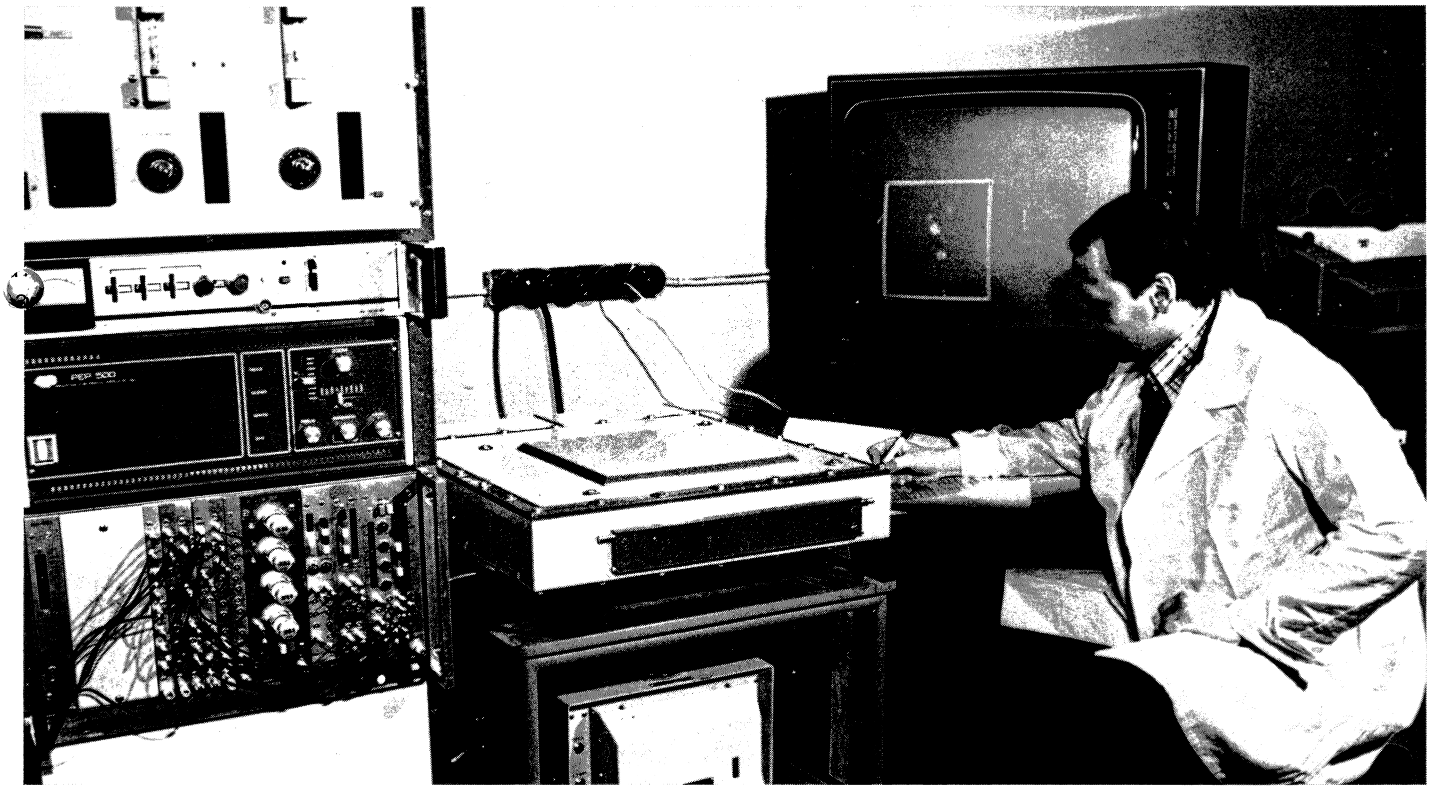
STANFORD Microprocessors at work

With physics experiments probing higher energy regions where more particles are produced, and with physicists continually looking for rarer types of interaction, more and more computing power is needed to filter interesting data from the mass of collected information.

Traditionally, this demand has been met by bringing in more and bigger computers, but recently the availability of microprocessors (in effect a whole computer on a small 'chip') offers a new solution. A substantial amount of computing power can now be installed in the experimental set-up to process data immediately after it has been selected by a hard-wired trigger (see July/August 1979 issue, page 192).

An example of this trend is the 168/E microprocessor which has been developed for the Large Aperture Solenoid Spectrometer (LASS) at SLAC. This detector can record events on magnetic tape at the rate of one every ten milliseconds, while it can take ten times as long to process the event on the central computer.

To avoid this bottleneck, data processing specialists first attempted to use fast logic or hard-wired units to handle routine operations and filter the raw data. Then suddenly it was found that only a small number of all the instructions available in an IBM 370 computer are used in a typical FORTRAN program. This meant that using microprocessor techniques it was possible to build a small arithmetic unit containing just the few dozen or so instructions needed to emulate the IBM.



The goal wqs to run the LASS track finding and fitting programs interchangeably on the main computers or the emulator. In this way the diagnostics on the main computers could be used to check out the micros, and identical programs could be run and the results compared in detail. All the software resources of the main computers would be available to the LASS system.

The development of the 168/Es, together with a controller to link the micros to the main computers, a translator to convert main machine code to microcode, and diagnostics and other aids, was a challenging task, but the system is now working.

The processing power of each 168/E is half that of a mainframe IBM 370/168, while the supervision of the micros accounts for only about two per cent of the IBM's workload.

In the Interfacuity Problem Laboratory for molecular biology and bio-organic chemistry at Moscow State University, the processing of lamellar radiochromatograms is carried out with high-speed automated equipment produced in the High Energy Laboratory at JINR Dubna.

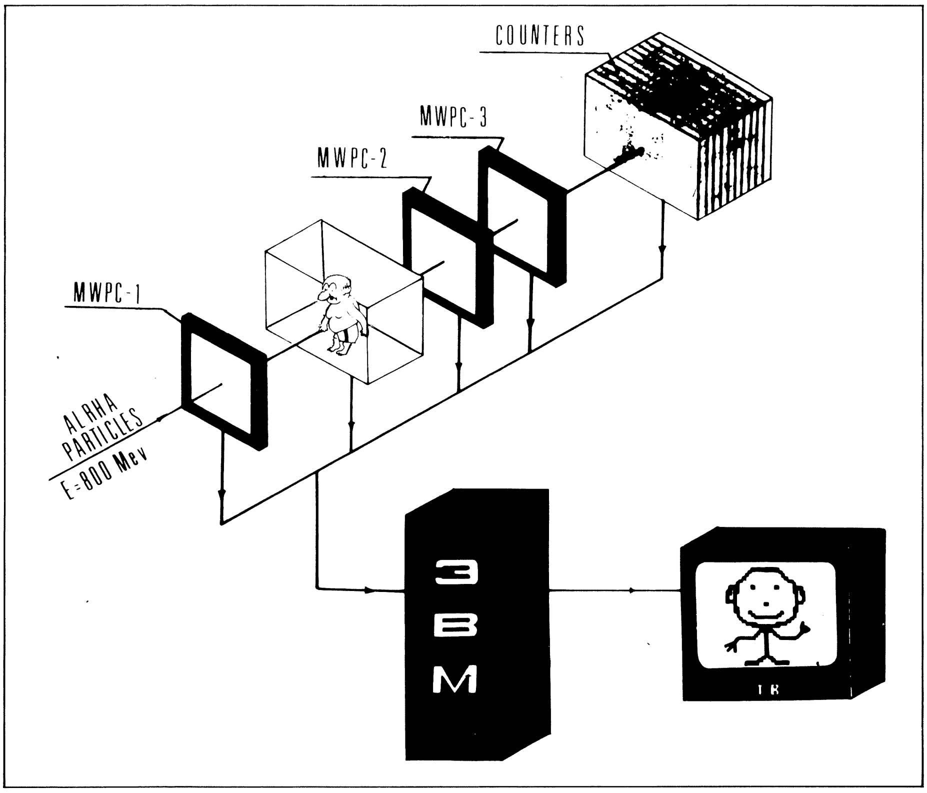
The cost of the system is changing rapidly with the cost of memory, but at present each processor costs about $15 000 and is driven by a memory unit (called the 'Bermuda Triangle') which costs about $30 000. Up to six processors can be handled by a single controller.

Initially six 168/Es will be used with LASS. In addition, the processor is also foreseen for other groups at SLAC, for DESY (TASSO and PLUTO) and Tokyo. At CERN, a first 168/E processor has been constructed and work has begun on the Bermuda Triangle memory system. When complete, it is intended to use the set-up for analysing data from the European Muon Collaboration.

DUBNA
Applications of particle physics techniques

At the Joint Institute for Nuclear Research, Dubna, work is proceeding successfully on the application of particle physics techniques to medico-biological research. One of the topics of interest is the use of wire chambers in molecular biology. These detectors considerably shorten the processing of lamellar radiochromatograms.

Usually radiochromatograms are processed by autoradiography involving liquid scintillation counters or scanning devices. This takes many hours. In 1977 a method was devised at Dubna based on multiwire proportional chambers which offers several advantages. It makes



A layout of the apparatus used for radiography with the helium beam from the Dubna synchrophasotron. The helium ions pass through the object being investigated and the multiwire proportional chambers before stopping in the proportional counter block. Data on the co-ordinates and stopping point of the particle is transmitted to the computer and the processed information is displayed on the TV screen.

it possible to process simultaneously many chromatograms measuring up to 200 x 200 mm². This method is non-destructive and preserves the substance being investigated for further work. The processing of radiochromatograms is speeded up some 10 to 100 times compared to usual techniques.

The new device consists of a two-dimensional position-sensitive detector, electronic recording apparatus, memory and television monitor. The position-sensitive detector uses proportional chambers with drift gaps, intended for recording beta-radiation over a wide energy range. It works with a gas mixture of argon and carbon dioxide. The lamellar radiochromatograms fit directly into the detector body. Information from the proportional chambers is processed and transmitted to the computer memory with subsequent output on the TV monitor.

In a single analysis of a lamellar chromatogram, the device provides a display on the monitor screen of the location of radioactive areas containing hydrogen-3, carbon-14 and phosphorus-32. It also identifies given isotopes and measures the total activity of any chosen area in the chromatogram. The device is sensitive to activity down to the level of ten picocuries per cm². The total time for such an analysis is about twenty minutes.

At present the device is used for research at the Interfaculty Problem Laboratory for molecular biology and bio-organic chemistry at Moscow State University.

Another area of research is ion radiography. By applying multiply charged ions to radiography considerably more information can be obtained than with X-rays—the degree of contrast of the image is better and the necessary radiation dose considerably lower.

In 1978 the Dubna synchrophasotron accelerated a beam of helium ions to an energy of 200 MeV per nucléon, at that time the highest energies for these ions achieved in Europe. Radiography equipment was tested in this beam and estimates could be made of the bask parameters which are necessary iwt using the technique.

The principle is precision measurement of the residual range of the particles which pass through the object being studied. The apparatus consists of multiwire proportional chambers, complex electronics, an on-line computer and a television monitor displaying the information which is gathered.

During exposure to the beam of helium ions, various objects (phantoms) were studied and it was demonstrated that the method has high sensitivity at low radiation doses. The density resolution was better than 0.1 per cent and the spatial resolution was about 2 mm with millirad radiation doses.

TRIUMF Kaon factory workshop

Running parallel to the Vancouver ICOHEPANS Conference (see December 1979 issue, page 409) was a workshop, sponsored by TRIUMF and attended by over 180 delegates, on the physics that might be done at a kaon or antiproton factory. The characteristics of possible machines were also described, the primary one being of course high intensity—typically 100-1000 times higher than available now from proton accelerators in the 8-30 GeV range.

There are two strong thrusts for the experimental programme. One is the study of resonance and particle properties, particularly the negative kaon/nucleon system, and the rare decays of the kaons and hyperons. The other (emphasized perhaps by current activity and the nuclear leanings of the main conference), is to explore nuclear physics problems from a fresh angle, using the very different properties of the negative pion, the positive kaon and the lambda as probes, the first rich in its capacity to excite resonances, the second poor — a feebly interacting hadron, the third a 'strange' tagged neutron — the seed for the rapidly blossoming field of hypernuclear physics. All in all it appears that the kaon factories would open up an exciting new realm of physics, just as the pion factories are doing now.

In particle physics, discussion centred around a number of important fundamental questions which can only be tackled with the help of more intense beams. Searches for possible muon number non-conserving kaon decays (into a muon and an electron, for example) would complement in the strangeness non-conserving sector searches for reactions such as muon decay into an electron and a photon, and set limits for such violation within modern gauge theories. Precision measurements of usual kaon and hyperon decays would be useful as would detailed studies of the various rare decay modes which test our understanding of the effects of higher order weak and electromagnetic interactions. CP violation is not yet understood and investigations of CP violating correlations in kaon decays might elucidate the mechanism responsible for such violation. In a slightly different area, detailed studies of the spectrum and decay properties of hyperon resonances (particularly the negative kaon/nucleon system, rich in resonances of all degrees of reliability) could test crucial ingredients of current theories of quantum chromodynamics.

Participants at the recent International Conference on High Energy and Nuclear Structure (ICO HE PANS) in Vancouver (see December 1979 issue, page 409) were at one stage confronted with some enthusiastic demonstrators who had (wrongly) assumed that the visiting scientists were planning a new reactor.

(Photo Nanaimo Daily Free Press)

Consideration was also given to possibilities for experiments with antiprotons. Here the new LEAR project at CERN will give orders of magnitude improvement over existing facilities. The spectroscopy of baryonium and protonium, searches for $qq\bar{q}\bar{q}$ quark states, quasi-nuclear nucleon-antinucleon bound states, proton-antiproton annihilation reactions, and exotic channels such as antiproton plus lambda are just a sampling of the rich field of antiproton physics dependent on higher intensities.

In the area of hypernuclear physics, negative kaon beams can supply lambdas essentially at rest in nuclei. Already a good start has been made on a periodic table of such hypernuclei and some excited states have been observed, with the best resolution being achieved by the Strasbourg / Saclay / Heidelberg group at CERN. Such information opens new areas of nuclear spectroscopy. Does the lambda behave simply as a 'strange neutron' forming lambda-neutron hole excitations ? Do the strangeness analogue resonances, generalizations of the usual isobaric analogue states, exist? A whole host of interesting questions can be explored. To obtain detailed excitation spectra, however, coincidence experiments detecting the decay photon will be needed, as will strangeness exchange experiments at larger momentum transfers so as to allow higher angular momentum transfer. For both of these more intense beams are essential.

Hypernuclei also provide information on the basic lambda-nucleon force, and already indications are that the spin-orbit component is much weaker than the nucleon-nucléon case. Clearly a basic understanding of hyperon-nucleon interactions is extremely important, and may enhance our understanding of the more familiar nucleon-nucleon force.

Another area of discussion dealt with the elastic and inelastic scattering of kaons from nuclei and the kinds of nuclear information which can be obtained. Negative kaons are strongly absorbed on nuclei, leading to the production of a large variety of relatively narrow Y* resonances whose spectra and decay properties can be studied. One can also investigate the propagation of such strange resonances in the nuclear medium in analogy with, and using similar formalisms as, e.g., the isobar doorway formalism, used to study non-strange resonances in nuclei.

On the other hand, positive kaons are very weakly absorbed, with a long mean free path and no 'true' absorption, and are potentially simpler than the pion and very useful for exploring nuclear densities via elastic and inelastic scattering. Some beautiful new data for both positive and negative kaon scattering from the Carnegie-Mellon/Houston/Brookhaven collaboration was shown at the workshop together with relatively successful analyses in terms of kaon-nucleus optical models. More information is needed on the kaon-nucleon amplitudes which serve as input for the calculations but clearly the first steps have been taken toward making the kaon, like the pion, a very useful nuclear probe.

Studies for improved low momentum kaon beams were reported from Brookhaven and KEK, in the former case integrated with a high resolution spectrometer. Both designs are aiming at short channel lengths (8-1 0 m) to reduce the decay losses (at KEK by the help of superconducting combined function current sheet magnets). At Brookhaven, the hope is to gain a factor ten in kaon flux over existing lines on the AGS synchrotron while maintaining a pion to kaon ratio of less than ten. The beamline itself will probably provide the dispersing system for the energy loss spectrometer; the aim is for an energy resolution of 200 keV at 800 MeV, with a momentum bite of 6 per cent and angular coverage 0-140°. (It now seems that this project may be funded in the early 1980s.)

For slow antiproton physics it seems that the immediate future will be dominated by the recently funded LEAR project at CERN (see September 1979 issue, page 260). This 0.1-2 GeV storage ring, fed by beam decelerated from the antiproton accumulator, will considerably increase low energy antiproton beam intensities over those now available, and will eliminate beam contamination.

Although most present-day multi-GeV accelerators provide proton beams of no more than a fraction of a microamp, it appears to be technically feasible to construct accelerators capable of giving 30 JIA at 30 GeV, or even 400 |iA at 8 GeV (energies suitable for production of antiproton and kaon beams respectively). However at Fermilab the 8 GeV fast-cycling booster synchrotron has already reached 7 |iA (see May 1979 edition, page 112) and could eventually produce 12 |iA at 10 GeV. It was pointed out that although the present duty factor is too small for coincidence experiments, it could be lengthened either by slow resonant extraction or by the use of a 'stretcher' ring.

The virtues of fast-cycling synchrotrons were also recognized by LAMPF and TRIUMF in their afterburner proposals, the former based on a machine for 50 |iA at 16 GeV, the latter on one for 80 jiA at 10 GeV. In TRIUMF's case (see April 1 979 issue, page 74) a second stage slow-cycling synchrotron with superconducting magnets was proposed to accelerate 30 |iA to 30 GeV for antiproton production. An alternative proposal, which would not compete directly with th^, strong effort going into antiproton physics at CERN and Fermilab, was for a two stage isochronous ring cyclotron ('CANUCK' — Canadian University Cyclotron for Kaons) to accelerate 100 — 400 |iA protons first to 3 GeV and then to 8 GeV for kaon production. SIN also reported starting a design study for a 4-5 mA 2-3 GeV ring cyclotron as a high flux spallation neutron source, with the possibility of this feeding into a 100-200 |iA 8 GeV cyclotron kaon factory.

From this workshop and similar ones held elsewhere, it is clear that orders of magnitude more intense kaon and antiproton beams would open up exciting possibilities in boO particle and nuclear physics, ana moreover that the machines to produce them are technically feasible.

(The proceedings of the workshop will appear as a TRIUMF report.)

Physics monitor

European Synchrotron Radiation Facility (ESRF)

As a result of the recent upsurge of interest in the use of synchrotron Radiation, the European Science Foundation set up an Ad Hoc Committee for Synchrotron Radiation. Its main preoccupation over the past eighteen months has been to investigate and make a preliminary design for a possible next generation X-ray source. These studies culminated in two weeks of intense activity in May when, at the alpine retreat of Aussois near the French-Italian border, representatives from many European Laboratories produced a four volume report which has now been published. The volumes spell out in detail the Scientific Case, the Storage Ring Design and the Instrumentation Requirements of a European Synchrotron Radiation Facility (ESRF).

The uses of synchrotron radiation extend over an enormously wide field of physics, chemistry and biology, and the main spectral range of interest is from below 0.1 to above 2000 a.u. The longer wavelengths are best provided by relatively small, low energy electron storage rings (less than 1 GeV) and such machines exist, or are planned in several countries. The shortest wavelengths require higher electron energies and the machine becomes quite expensive— hence the interest in a possible European collaboration. If this were built, it might be highly desirable and convenient to provide a smaller machine on the same site, and this is also a topic of discussion.

The X-ray source now being proposed is a 5 GeV electron storage ring with a circumference of 604 m and 48 synchrotron radiation ports of three types. Thirty-six of the beamlines emerge from normal bending magnets and have the usual synchrotron radiation spectrum with a characteristic wavelength of 1 a.u. This wavelength defines the position of the 'knee' on the spectrum and a useful rule of thumb is that there is a good photon flux extending to a quarter of the wavelength and a usable flux, at least for some experiments, to a tenth. Each of these beams has a horizontal angular width of 16 mrads and the electron beam at a typical tangent point has a cross-section of 0.60 mm by 0.35 mm and a divergence of 0.30 mrad by 0.02 mrad.

In addition, six beams are planned emerging from short, superconducting wigglers with a characteristic wavelength of 0.25 a.u. and six beams from undulators up to 5 m long. In the wigglers the beam cross-section is even smaller than in the bending magnets, whilst in the undulators the beam divergence is made very small to achieve a narrow line-width. An undulator is a long multipole magnet, with typically 50 to 100 periods, designed to produce quasi-monochromatic radiation tun-

Through the Anglo-Soviet Agreement for Cooperation in Science and Technology, joint seminars on synchrotron radiation are organized annually between the two countries. The second of these seminars was held at Daresbury Laboratory between 16-19 October 1979 when a delegation of seven Soviet scientists attended. Seen here in the storage ring tunnel of the Daresbury Synchrotron Radiation Source is D.J. Thompson (right) of Daresbury with three of the Soviet visitors, left to right, E.P. Stepanov (Institute for Physical Problems, Moscow), S.P. Kapitza (Institute for Physical Problems, Moscow and vice chairman of the Synchrotron Radiation Commission of the USSR Academy of Sciences) and V. Galatskii (Kurchatov Institute of Atomic Energy, Moscow).

(Photo Daresbury)

able by varying the magnetic field and/or electron energy. In the ESRF various undulators will be provided, covering the range 1 to over 100 a.u.

To achieve very low beam emittance and the various beam sizes and divergences required, a lattice with rather many quadrupoles has been devised. The beam intensity is limited by the ability of the vacuum chamber walls to absorb synchrotron radiation, and this thermal capacity limit has been assumed to be 10 kW/m average in the bending magnets and implies a maximum beam current of 565 mA.

However beam instability problems will be severe, particularly with the very short bunch lengths preferred by some experimenters. A double r.f. system will allow some variation of bunch length to permit optimization— longer bunches when maximum intensity is the most important requirement, and vice versa.

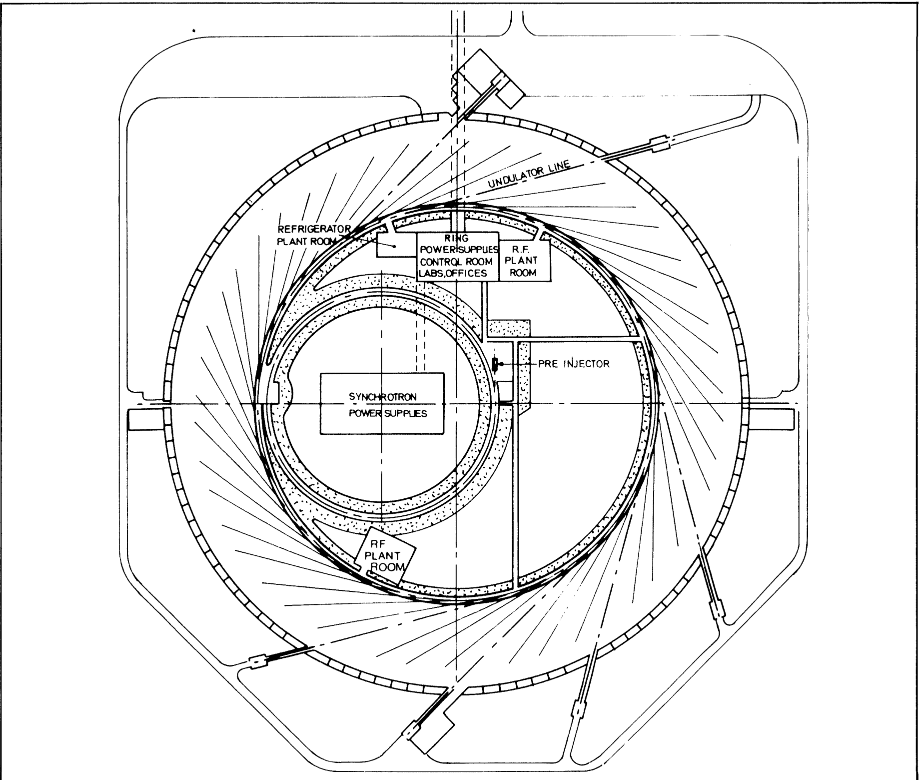
For various reasons, particularly to ensure good positional stability of the beam and to achieve very high currents, a full energy injector synchrotron is planned, with a circumference approximately half that of the storage ring and using many of the same components.

A major feature in the planning of such a project must be a large experimental hall with many well-equipped experimental stations (several per beamline). Good support facilities for the expected large numbers of users are also necessary.

There has not yet been any serious discussion of possible sites for the new Laboratory. The first requirement is to decide whether Europe wants its own synchrotron radiation source and is agreed on the form it should take.

Parameters of the Proposed European Synchrotron Radiation Facility

Energy	5 GeV
Circumference	604.38 m
Number of cells	12
Bending radius	22.36 m
Number of dipoles per cell	4
Length of dipoles	2.93 m
Field in dipole	0.74 T
Seven types of quadrupole,	
length	0.7 or 1 m
gradient	8.2 to 11.3 T/m
Beam current	565 mA
Energy loss per turn	2.66 MeV
Total beam power loss	1.57 MW
Main r.f. system frequency	500 MHz
Total r.f. power	1.88 MW
Harmonic system frequency	1 500 MHz
Bunch length	16-48 mm



An overall view of the proposed European Synchrotron Radiation Facility. The storage ring and injection accelerators are housed in concrete tunnels, but the experimental area would be of a much lighter construction. It would probably be designed in modular form so that it could be extended as demand increased until finally all 48 beamlines shown here were in use.

People and things

John Cumalat and David Neuffer, first Robert R. Wilson Fellows at Fermilab. The Wilson fellowships are special three year appointments awarded annually at Fermilab to outstanding young physicists in the fields of accelerators and particle physics.

On people

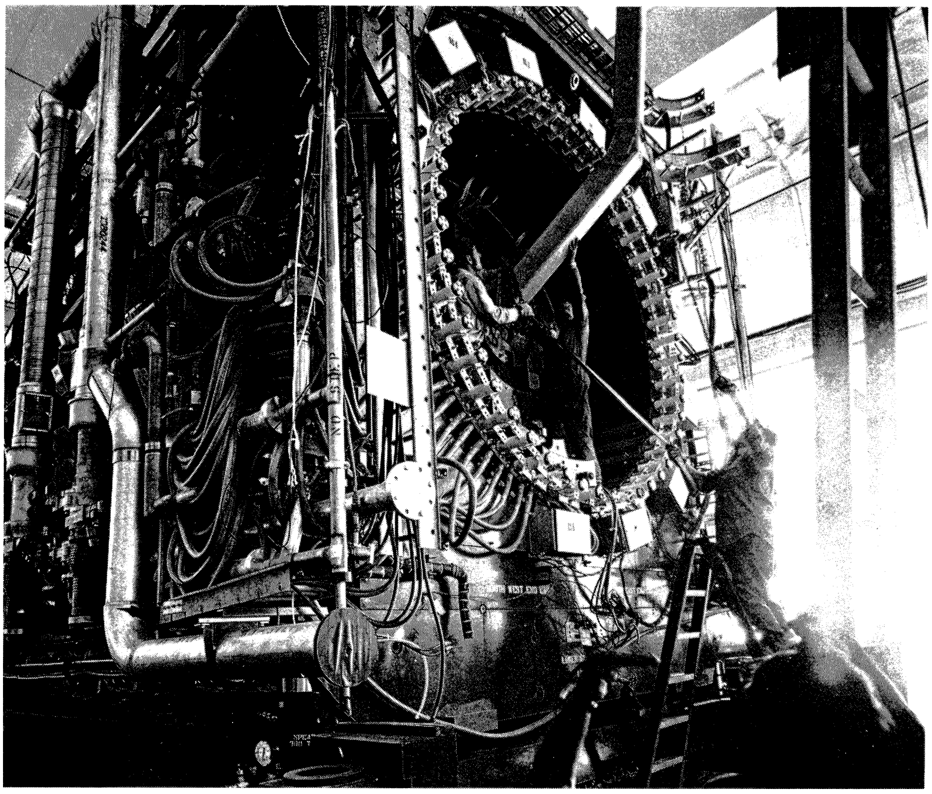
Accelerator specialist Ernie Courant is the recipient of the 1979 Boris Pregel Award for Applied Science and Technology. The presentation was made at the annual meeting of the New York Academy of Sciences on 6 December.

Giving cancer treatments at TRIUMF

The first treatment of cancer patients began at TRIUMF in November using the negative pion beam from the biomedical channel. In this first series, patients with multiple skin tumour nodules are receiving ten daily treatments. In order to assess the effect of negative pions on human tissue, some of the nodules are being treated with pions and others with X-rays. Only when this is known can treatment of larger, deep-seated tumours commence. The treatments at TRIUMF have been preceded by comprehensive pre-clinical investigations including both physical and radiobiological studies, the latter including cultured cells, mice and pigs.

Conferences on the horizon

The Sixth International Conference on Experimental Meson Spectroscopy will be held at Brookhaven on 24-25 April. The Conference will cover experimental results in light and heavy quark spectroscopy, relevant theory and spectrometer systems. For further information please contact CU. Chung or S.J. Lindenbaum, Brookhaven National Laboratory, Upton, New York 11973.



The Mark II detector, previously used in experiments at SPEAR, seen here being installed in one of the experimental areas of the new PEP electron-positron collider.

(Photo Stanford)

Rutherford Laboratory Director Geoff Manning wields a pneumatic drill in the 'turf cutting' ceremony for the target station of the new Spallation Neutron Source on 5 November, aided and abetted by colleague Geoff Stapleton, in traditional 5 November 'guise'.

(Photo Rutherford)

The 1980 CERN School of Physics, which is being organized in collaboration with DESY, will be held at Malente, Federal Republic of Germany from 8-21 June. Its aim is to present various aspects of high energy physics, especially theory, to young experimentalists coming mainly from the CERN Member States.

The main programme will include lectures on Gauge theories, QCD and its applications. Electron-positron physics, Deep inelastic scattering and Hadron interactions. There will be additional lectures on special topics and reviews of the experimental programmes in some major Laboratories. Further information may be obtained from Miss D.A. Caton, Scientific Conference Secretariat, CERN, 1211 Geneva 23, Switzerland.

The Eleventh International Conference on High Energy Accelerators, sponsored by IUPAP, will take place at CERN from 7-11 July 1980. Participation will be restricted to 350 people and will be by invitation only. The following subjects will be included in the programme: Beam dynamics including beam cooling, Superconducting magnets for accelerators, Superconducting r. f systems, Injection, extraction, beam transport and dumping, Controls and instrumentation, Novel methods of acceleration and new projects.

In addition, speakers will be invited to review the progress of the large accelerator projects under construction or having recently come into service, and to report on proposals for new projects. Reports will also be given on the workshops to be held at Karlsruhe and Serpukhov on superconductive r. f. systems and accelerator magnets which will take place just before the International Conference.

All correspondence should initially be addressed to Miss D. A. Caton, Scientific Conference Secretariat, CERN, 1211 Geneva 23 Switzerland.

ESO's Munich headquarters nears completion

On 8 November at Garching, near Munich, the traditional fir-tree marking the completion of major construction work was put up on the new office building for the European Southern Observatory (ESO).

Among those participating in the ceremony were Lodewyk Woltjer, ESO Director General since 1975, C. Zelle of the Federal German Ministry of Science and Technology and a member of ESO Council, and R. Lust, president of the Max Planck Society.

The Max Planck Society has made available to ESO the land on which the new building stands, while the Federal government is financing the construction work.

ESO was set up in 1962 as an intergovernmental organization with six Member States-West Germany, Belgium, Denmark, France, the Netherlands and Sweden, and has a present staff of about 270. Since 1976, ESO has been using a 3.60 m telescope, one of the largest in the world, at its 2400 m altitude observatory at La Si/la, Chile, in the Atacama desert 600 km north of Santiago.

During ESO's formative years, especially during the design and construction work for the big telescope, many of its members have been using CERN as a base, providing a temporary, but very interesting diversification to the range of scientific work carried out on the CERN site.

TRIUMF/University of British Columbia

Research Associates in Intermediate Energy Physics

Research Associate positions are available for research in Experimental Physics at the TRIUMF 500 MeV Cyclotron. Candidates should have completed a Ph.D. in nuclear or particle physics within the past two years. Graduate students expecting to complete their degree in the next few months will also be considered.

The successful applicants will be engaged in the University of British Columbia research programme at the Cyclotron.

These appointments can be renewed annually (subject to the usual budgetary confirmation) up to a maximum period of three years. Salary will depend on experience, with a minimum of $ 1 6,500 per annum.

Send curriculum vitae, list of publications and names of referees to:

Dr. G. Jones
Department of Physics
University of British Columbia
6224 Agricultural Road
University Campus
Vancouver, B.C., Canada
V6T2A6

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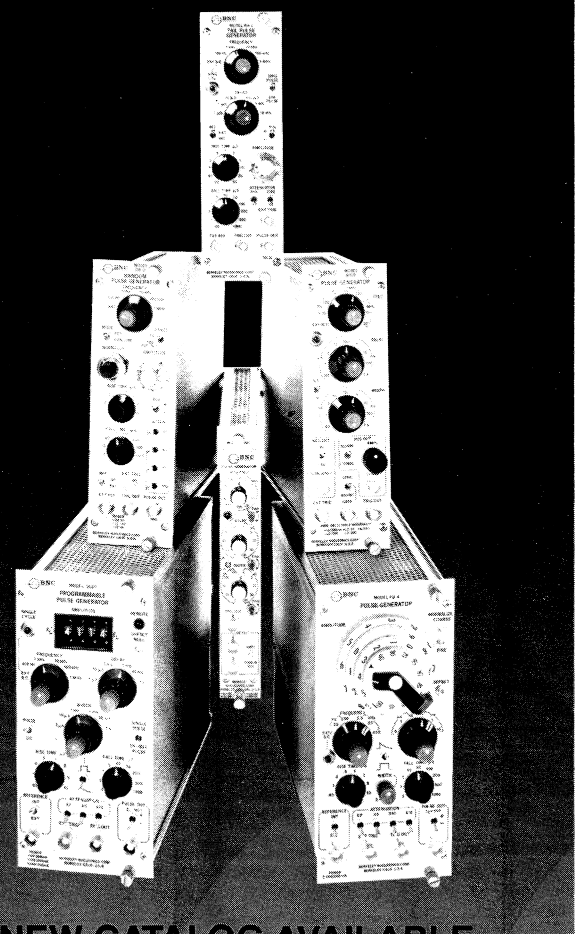

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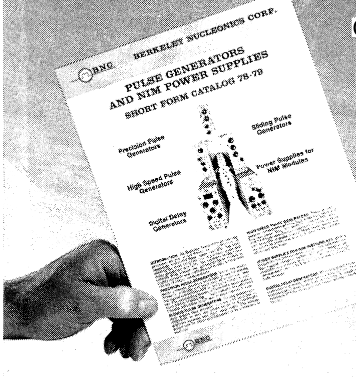

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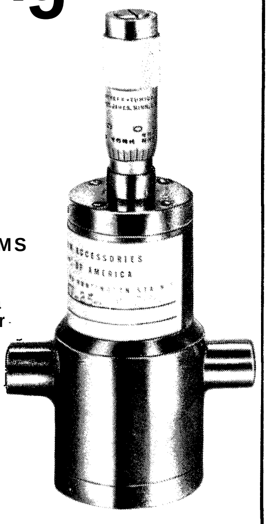

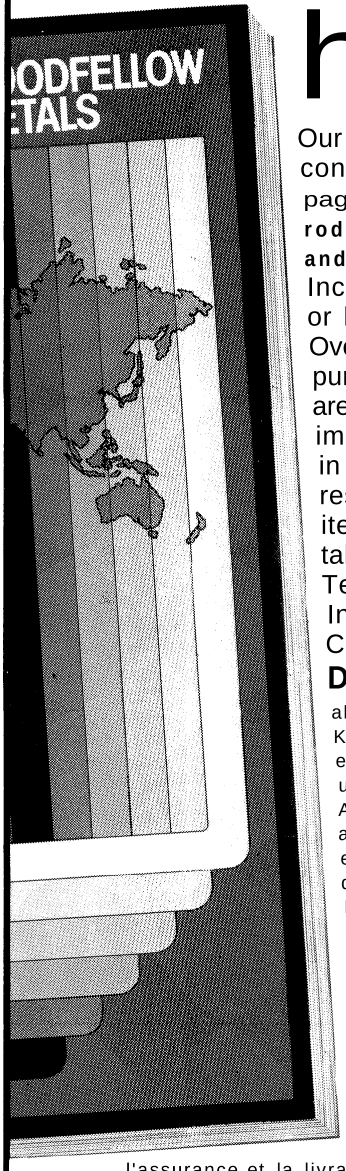
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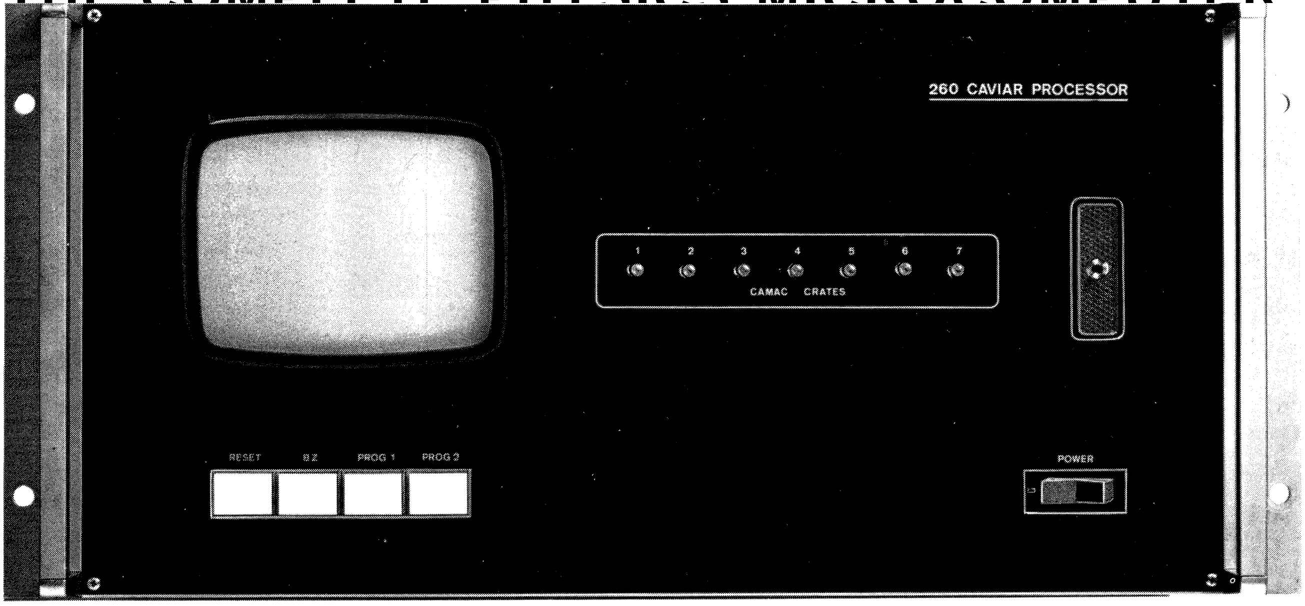

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Type 260 CAVIAR (CAMAC Video Autonomous Read-out) Processor is an inexpensive multi-purpose microcomputer for the interactive development, on-line control and monitoring of multi-crate CAMAC and GPIB systems.
CAVIAR is an integrated stand-alone instrument comprising:

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CAVIAR firmware includes the minicomputer-compatible interpreter BAMBI, which decodes a conversational language similar to BASIC. Through pre-run compilation BAMBI achieves execution speeds substantially faster than BASIC interpreters.
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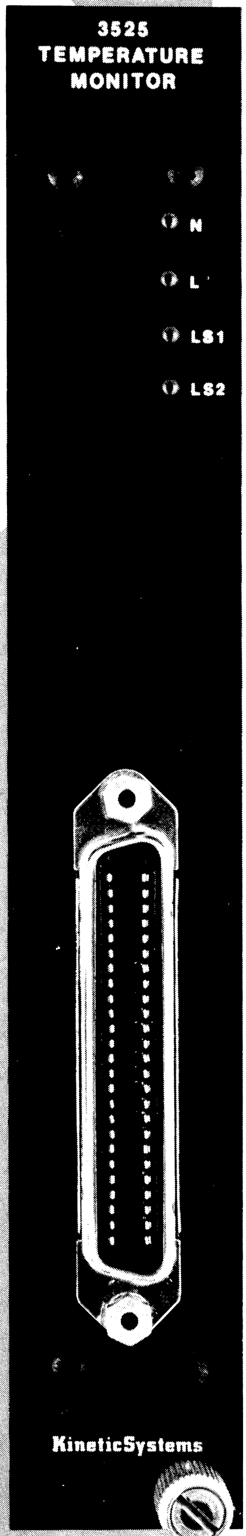

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description

During the past few months we have introduced the various elements of the new SEN Controller system : in this issue we wish to describe the software and typical applications.

The heart of the system is a powerful ***16-bit microprocessor*** (TMS 9900) associated with 16K-RAM, 2K-EPROM and TTY interface, located on a single CAMAC PC-bpard which is found in each of the intelligent units of the system (ACC 2099, ACC 2103 and STACC 2107).

Front-end processing in a typical problem of large CAMAC process - control and data collection systems. The ACC provides the best solution to this problem due to its processing power and easy implementation in the system-***both hardware andsoftware.***

On the hardware level, the ACC 2099 or ACC 2103 is compatible with all commonly used controllers-the A2 parallel controller, the L2 serial controller and the NORD 10 dedicated controller. Due to its very high density, a minimum of CAMAC space is lost to achieve front-end processing as fast as the main computer.

Software implementation is achieved by simply adding-on the front-end programs to your existing software. The front-end programs can be either assembly programs or high level programs loaded down-line through the crate controller into the ACC RAM memory, or resident in the ACC EPROM memory. Assembly programs are normally written on the host computer using cross assemblers: high-level programs in NODAL - a BASIC with floating point arithmetics - are written, either on the NORD 10 main computer using a cross-compiler*, or locally at the ACC level using an EPROM resident NODAL interpreter. Debugging facilities are available at the ACC level.

Test and stand-alone systems have the common problem of simulating the exact environment of the under-test device. Our new CAMAC controller system is able to test the device through the same controller used in the experiment and under the same software. The front-end system can be converted into a stand alone system simply by placing the CAMAC branch off-line. Test programs are loaded from a floppy disc connected directly to the ACC (ACC 2103 only). For permanent stand-alone systems, the STACC 2107 (Stand-Alone CAMAC Computer) combines the functions of a microprocessor and a controller. A floppy disc resident software is also available.

* available from CERN, div. SPS

for more details, please contact SEN ELECTRONIQUE

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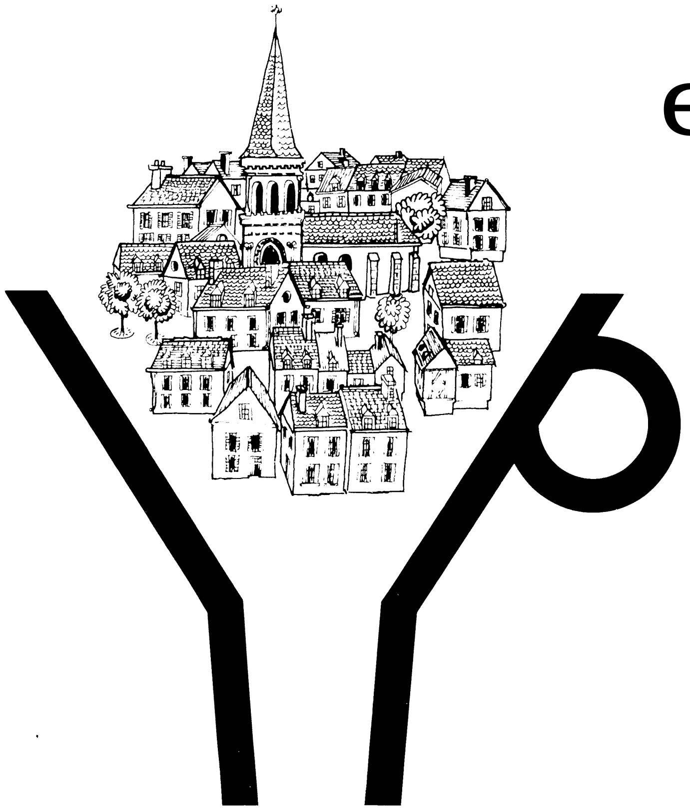

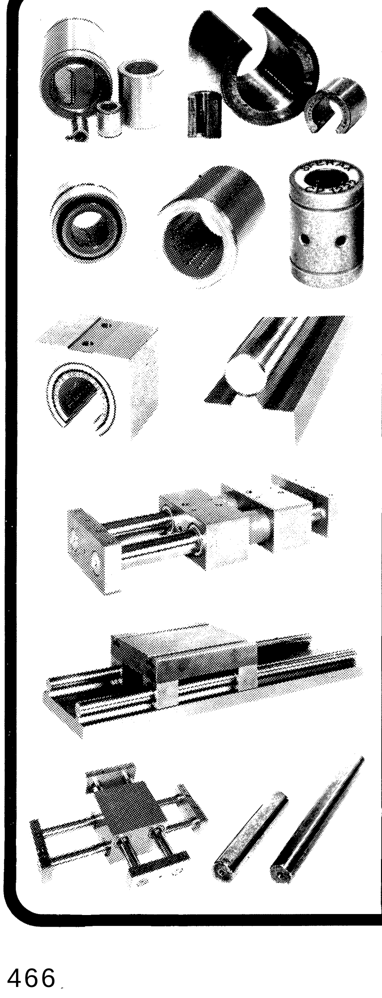

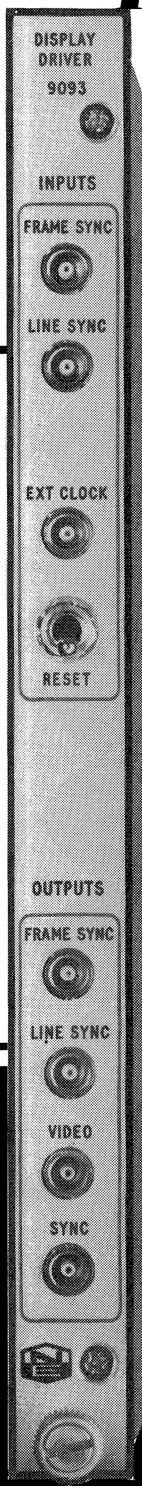
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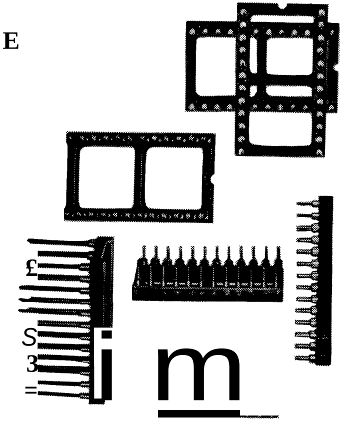

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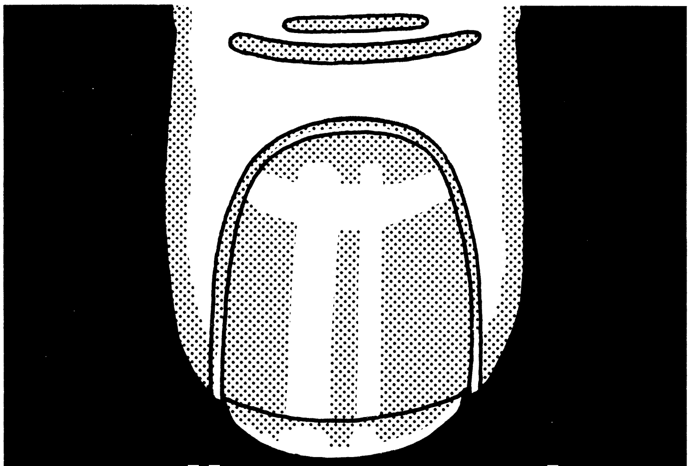

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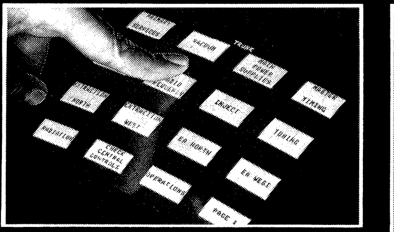
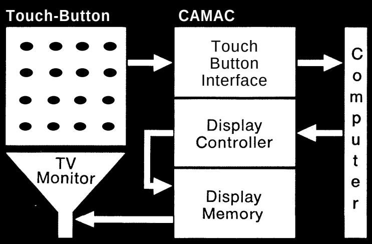
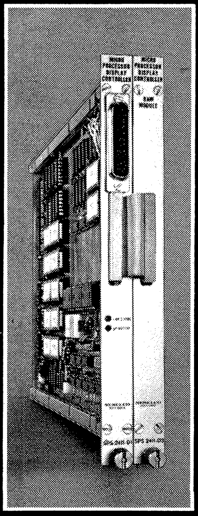


The Touch-Panel used for central control of the SPS-accelerator at CERN.



Touch-Button Control System, diagram.



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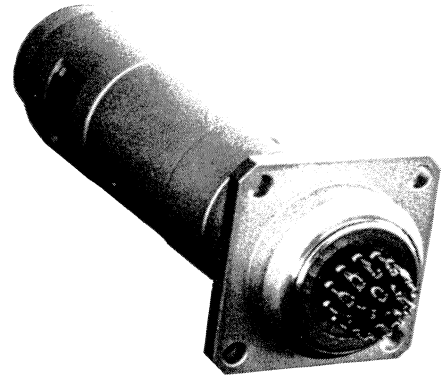

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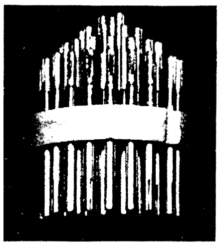

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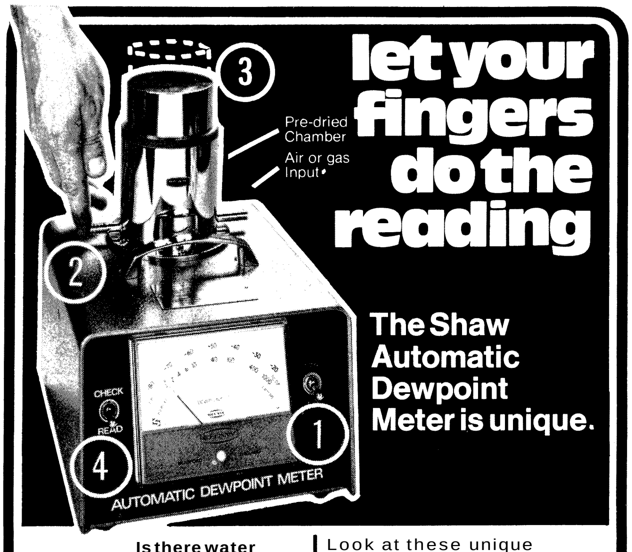

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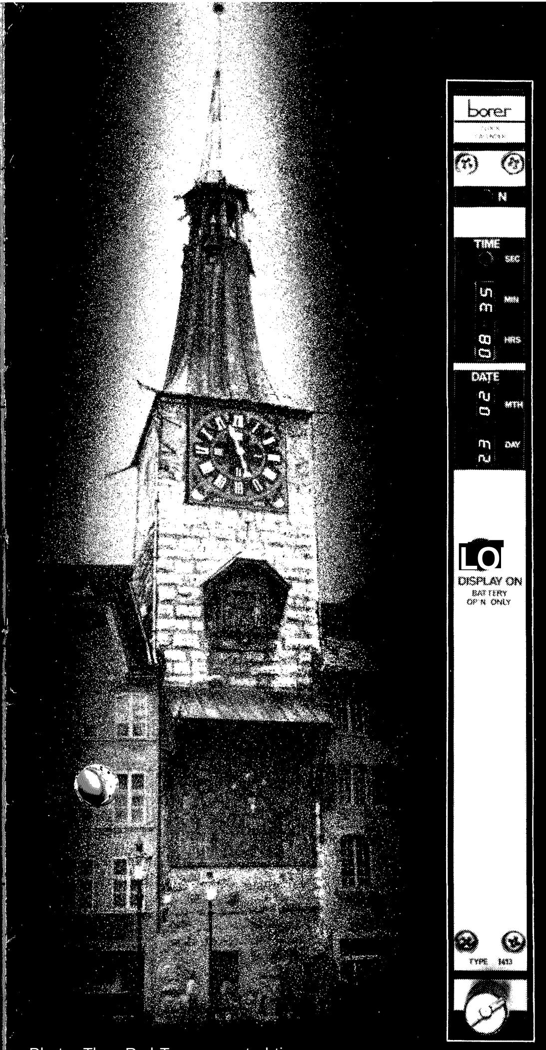
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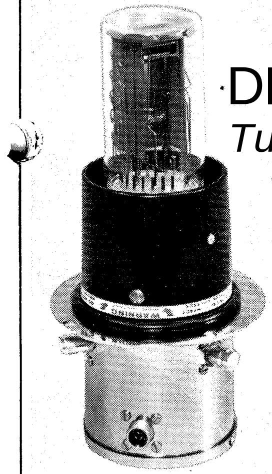

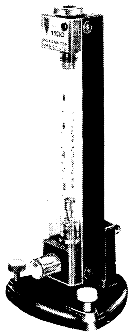

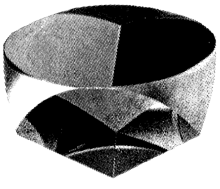

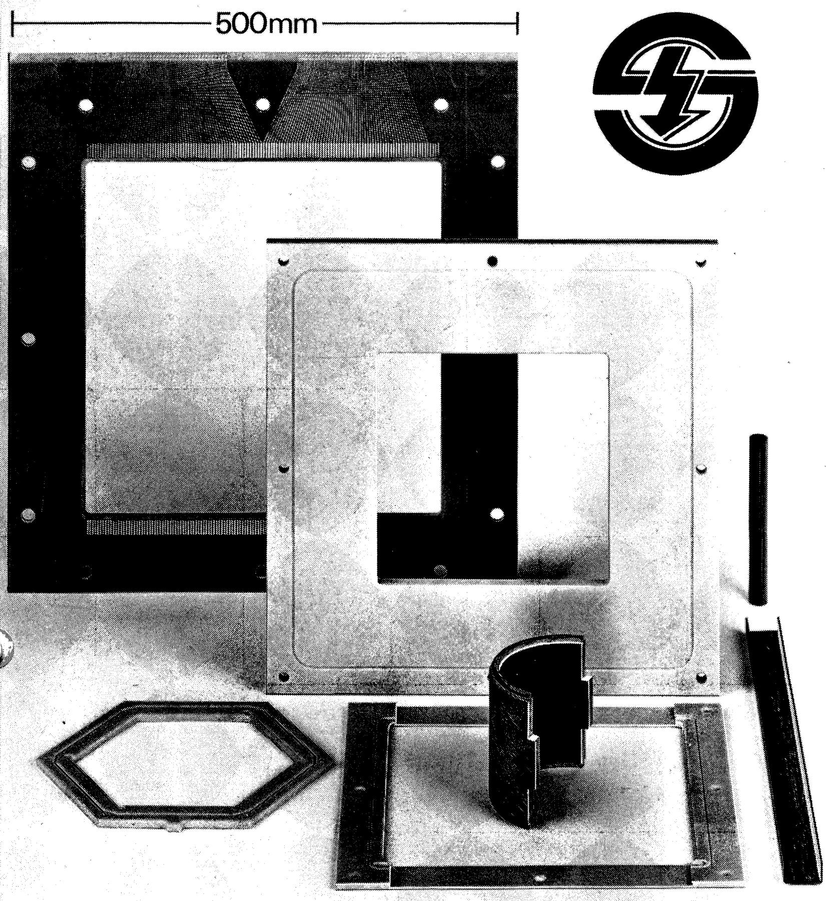

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32001	4.5	40	3600	ESL < .020 μH Case Size: 11 x 14 x 25 Weight: 220 lbs.	32501	6	40	4800
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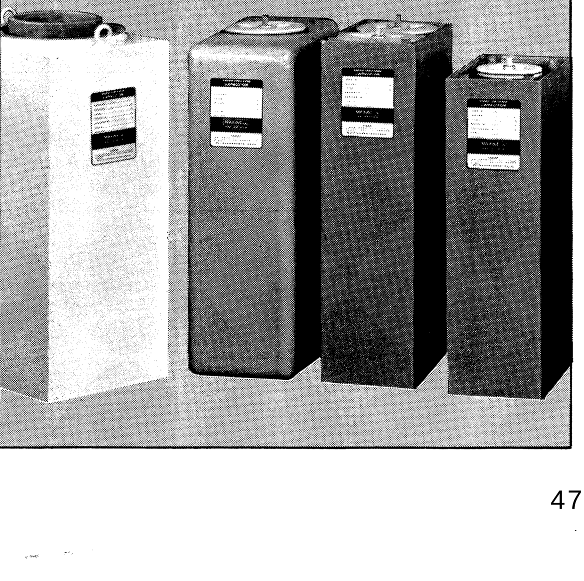

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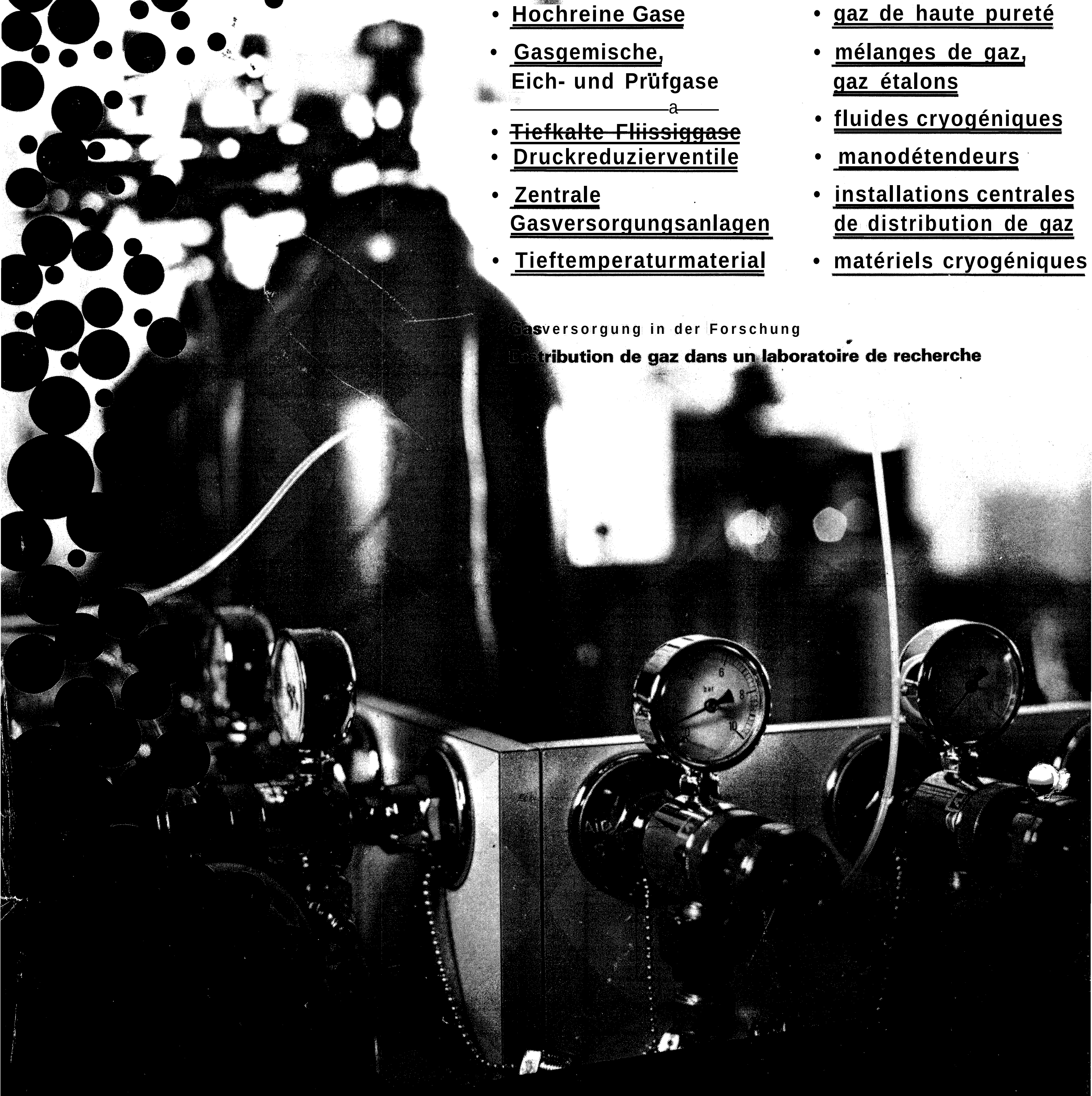
- installations centrales de distribution de gaz
- matériels cryogéniques



Gasversorgung in der Forschung

Distribution de gaz dans un laboratoire de recherche

Division scientifique

Carbagas

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