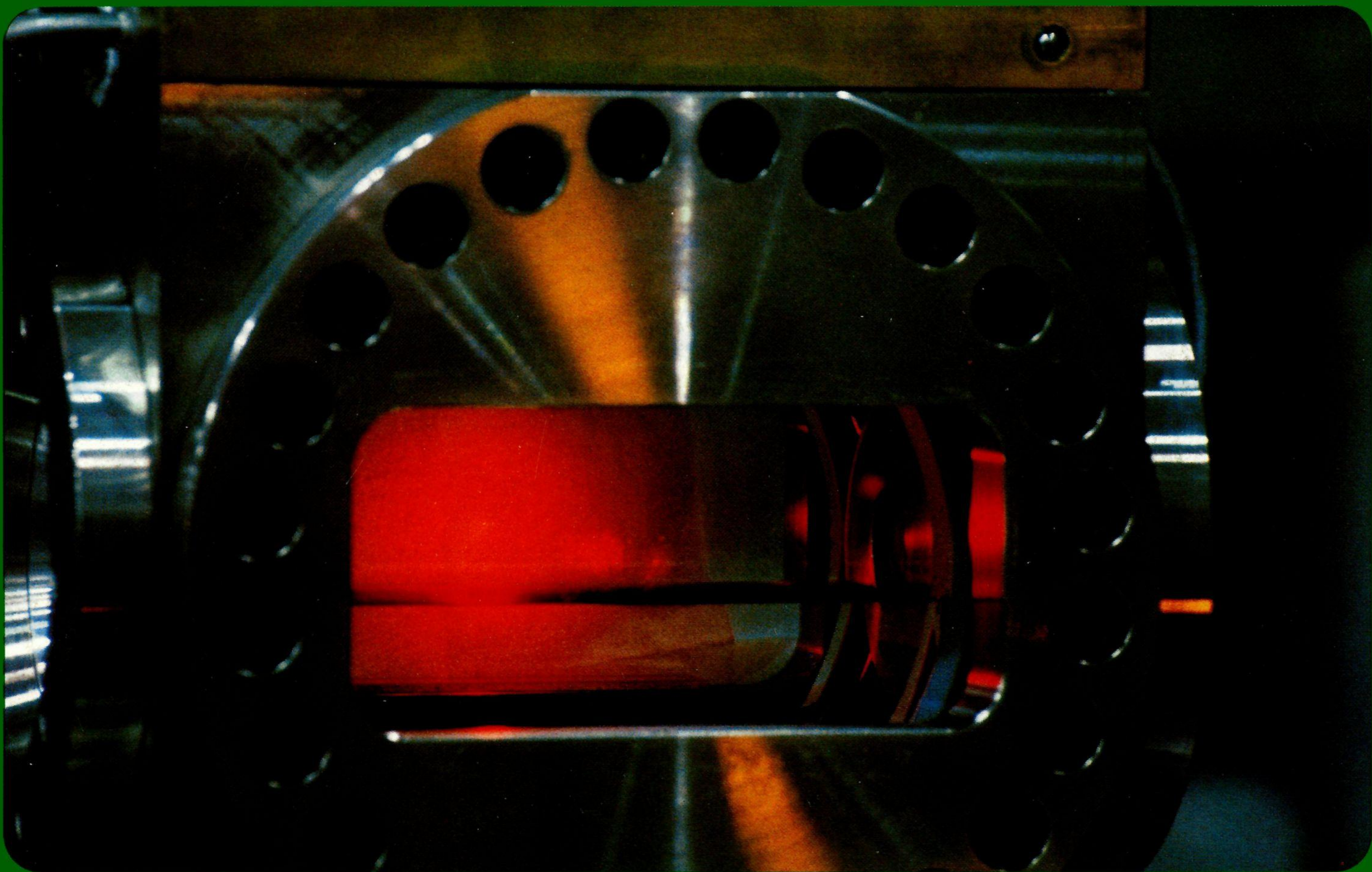
CERN COURIER

International Journal of High Energy Physics



VOLUME 23 3 APRIL 1983

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CERN COURIER is published ten times yearly in English and French editions. The views expressed in the Journal are not necessarily those of the CERN management.

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

Published by:
European Laboratory for Particle Physics
CERN, 1211 Geneva 23, Switzerland
Tel. (022) 83 61 11, Telex 23 698
(CERN COURIER only Tel. (022) 83 41 03)
USA: Controlled Circulation
Postage paid at Batavia, Illinois

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International Journal of the High Energy Physics Community

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VOLUME 23 N° 3 APRIL 1983

Cover photograph: The HOBC holographic bubble chamber being filled for a recent experiment at CERN. The effective volume of the chamber, filled with freon, is one third of a litre. The red laser beam is used for optics alignment. This experiment was the first time that holographic techniques had been used to collect data from particle collisions. (Photo F. Pothier)

Non-conservative physics

Participants at the recent International Colloquium on Matter Non-Conservation at Frascati were able to tour the excavations for the new Gran Sasso underground laboratory near Rome.

A new series of international physics meetings got under way last year with the International Conference on Baryon Decay and Nucleon Stability (ICOBANS), held in Bombay. The conference series continued in January this year in Frascati, Italy. However the growing scope of this kind of physics motivated the Frascati conference organizers to change the name to 'International Colloquium on Matter Non-Conservation' (ICOMAN). The meeting was sponsored by INFN, Frascati.

As well as getting the latest news from searches for proton decay, the 100 or so physicists who met in the beautiful Villa Tuscolana heard reports of searches for neutron-antineutron oscillations, for neutrino masses and neutrino oscillations, and for magnetic monopoles. There were also status reports on tests of lepton conservation and possible double beta decay, and summaries of recent progress in neutrino astronomy.

Other than pure aesthetics, there is no physics reason why baryon number (the sum of neutron and proton-like particles) has to be conserved. The proton does not necessarily have to live for ever. But over the years, passive experiments mounted deep underground had steadily pushed the limits on proton stability higher and higher, and most people thought that a stable proton was a safe bet.

Proton stability became open to question with the development in recent years of the 'grand unified theories' (GUTS) which attempt to extend the successful synthesis of electromagnetic and weak forces to include strong interactions as well. The unstable proton is a spin-off prediction from this work. Using the latest parameters from experiment, the lifetime comes out to be about 10^{30} years. This strains the ingenuity of experimentalists because it means that hundreds of tons of matter have to be amassed to stand a chance of seeing a few proton decays per year.

Candidate proton decay events have been found in two searches (the Kolar Gold Fields experiment in South India and the NUSEX fine-grained calorimeter in the Mont-Blanc road tunnel). At Frascati, neither the Indian nor the Mont-Blanc experiment had any new proton decay candidate events to report, so that the global sample of candidate events had not changed since last year's international physics conference in Paris (see October 1982 issue, page 312).

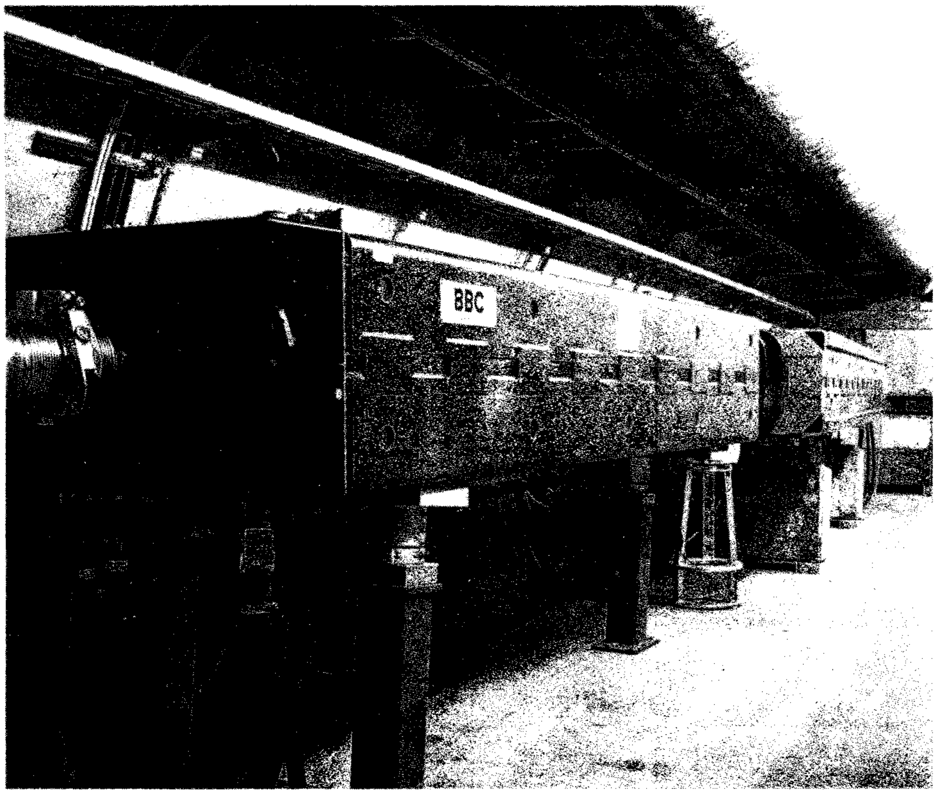
First results from the giant IMB (Irvine/Michigan/Brookhaven) experiment using 8 000 tons of purified water, monitored by 2048 phototubes, in an Ohio salt mine could report no proton decay candidates in the specific positron and neutral pion decay mode from 80 days of running. If this negative result holds up after more data taking, it will have serious implications for the theoretical models used to predict the proton lifetime.

This experiment went live last year after a heroic struggle to stop leaks in the plastic liner which contains the water. The liner has now been enclosed in concrete, and during the installation of the detecting equipment, valuable assistance was provided by divers from the University of Michigan.

Effort in the search for proton decay is measured in kiloton years (the mass of the detector times the running time), and several of the big experiments have yet to go live. The feeling is that it will take a bit longer before enough kiloton years can be amassed to provide reliable measurements of proton stability.

First customer for the CERN 28 GeV proton synchrotron when it came back in action after its winter break was the new beamline for the low energy neutrino oscillation experiments (see December 1982 issue, page 413).

(Photo CERN 387.2.83)



In addition to the IMB experiment, water-filled detectors are being developed by a Harvard / Purdue / Wisconsin team in a Utah salt mine and by a Japanese team in the Kamioka project. Both these are measured in kilotons. An earlier experiment by a Brookhaven / Pennsylvania team used a 'small' (300 ton) detector, and a bigger project has been proposed.

Calorimeter techniques, such as used by the Kolar and NUSEX teams, are also being employed by a French project in the Fréjus alpine tunnel. This 1.5 kiloton experiment, eventually to be ten times bigger than the NUSEX study, could go live with 500 tons of detector later this year. A small prototype electronic detector (30 tons) has been used by an Argonne / Minnesota / Oxford team in the Soudan mine in Minnesota, and a larger version (1 kiloton) is planned (see January/February 1982 issue, page 6). At least one detector in the several kiloton range will be installed in the new international laboratory being built in the Gran Sasso mountains in Italy (see July/August 1982 issue, page 224).

If baryon number is not conserved, neutrons and antineutrons could mix. (Such particle-antiparticle mixing also occurs, but for very different reasons, with neutral kaons.) An experiment has been constructed at the reactor of the Institut Laue-Langevin (ILL) in Grenoble by a CERN/ILL team, and other projects are afoot in the US and the USSR. As yet, no evidence for neutron-antineutron mixing has been found.

Grand unified theories have also given additional impetus to searches for possible vestigial masses of the neutrino, long thought to be a massless particle. The neutrino mass limits are slowly being pushed downwards. There are high hopes that the new low energy neutrino bear CERN will provide important nev formation (see December 198: sue, page 413).

The existence of magnetic m poles is another quest which been given added impetus by re theoretical studies. It was Dir quantum electrodynamics which put the idea on the map, but theo are now saying that there shoulc be monopoles left over from the tial 'Big Bang' when the Univ was formed.

A range of monopole searche: under way or being developed, there have been no positive re: since Cabrera at Stanford saw hi: signal last year (see July/Au 1982 issue, page 220). In the m time, further motivation has c from the 'Rubakov Effect' in w magnetic monopoles could cata proton decay.

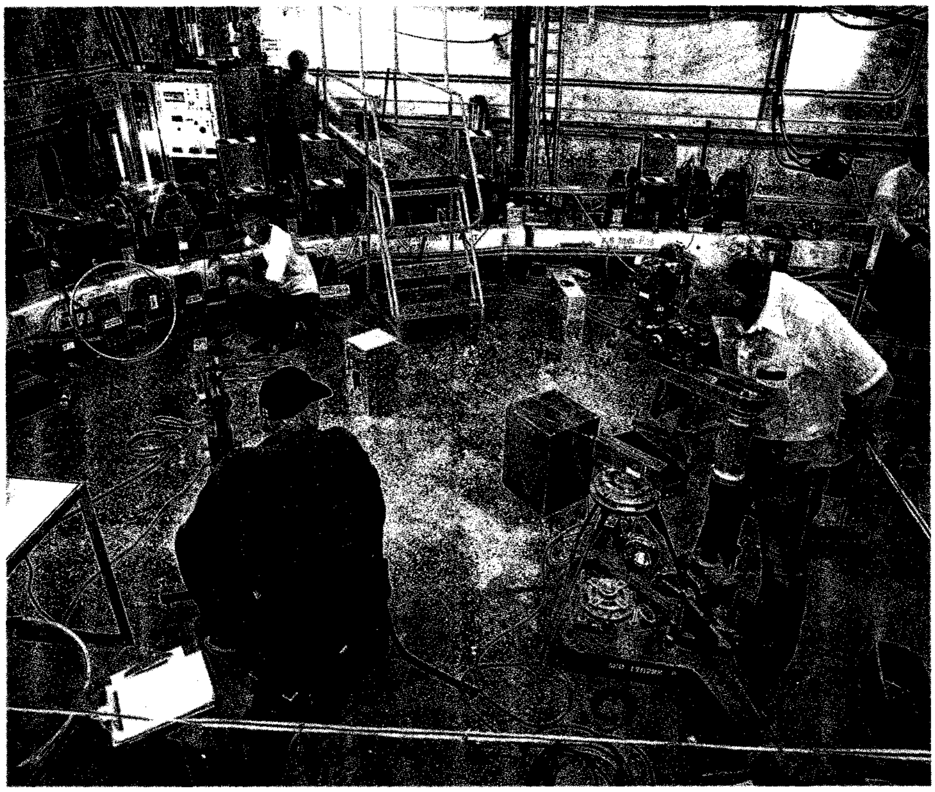
It will be interesting to moı progress in these physics proj which provide a refreshing chanç emphasis from the big experim at accelerator Laboratories. Th terest in this field was also un lined by the recent US meeting w discussed among other things possibility of setting up a US nati underground physics laboratory March issue, page 49).

(We are grateful to Don Cund) supplying us with information 1 the ICOMAN meeting.)

Confidence at SLAC

Preparations for the new linear collider at SLAC. Here a precision alignment team check a raft of magnets in the new Damping Ring. Beam has now been carried round the ring.

(Photo Joe Faust)



SLAC Director 'Pief' Panofsky had reason to be enthusiastic when he gave his traditional 'State of SLAC' speech earlier this year. Although at the time the US President's budget, even for fiscal year 1983 (which began on 1 October 1982), had not yet been passed by Congress, the news is far from bad. At a time when US public sector spending is being cut, high energy physics could have come off a lot worse. In particular, the SLAC Linear Collider (SLC) project has been recommended by the President for authorization in fiscal year 1984. SLC would provide 100 GeV energies by making electron and positron beams from a linac collide head-on, rather than using the conventional storage ring solution. (See January/February 1982 issue, page 8.)

'The most exciting part of the President's budget is that it recommends authorization to commence construction of the SLAC Linear Collider in fiscal year 1984. It specifically recommends that $40 million be appropriated for this first year of construction. This is very close to the amount which we had requested. Therefore, should the Congress follow the President's recommendations, we can say that the speed with which we can get SLC construction work under way will be limited mainly by our ability to perform, rather than by any external financial limitation.

Happily we should be able to move ahead with the SLC construction quite rapidly once the next fiscal year begins in October 1983, provided, of course, that the Congress has indeed acted favourably. In contrast to the situation which some of you remember in respect to the PEP ring, we will be able to complete this fiscal year, that is before October 1983, the detailed design of the various 'civil works' which are needed to house the SLC. Thanks to the work of our engineers, steady progress has been made in preparing final design drawings for the SLC tunnel and the junction of these tunnels into the SLAC beam switchyard. Thus, if things go as planned, we will issue competitive bids to the construction industry even before the end of this fiscal year to be able to get a running start on the work by this fall.

We also have been in good communication with our neighbours. We have in fact made several major modifications of the SLC layout in response to concerns expressed in various meetings with community organizations dealing with the possible impact of the SLC installation on the surrounding community. I am happy to report that the current design appears acceptable to almost everyone. We have submitted an Environmental Impact Assessment, and after the changes mentioned, have received a 'Finding of No Significant Impact' by the Department of Energy. All this means that we are not anticipating that environmental concerns will impede the construction in any way. I can assure our neighbours that we can build the SLC without causing them any problems. Let me note that SLC is a job roughly one-half the magnitude of PEP.

The SLC is technically an extremely difficult but also important and exciting undertaking. It pioneers a new direction to obtain very high energy electron-positron collisions and at the same time gives physicists from many institutions a new tool to reach what is currently believed to be the most critical energy region in which new phenomena are expected.

Just because the technology to reach both a new realm of energy at moderate cost and to do physics research with the SLC is so challenging, our ability to meet the schedule of completing all construction activities by the end of 1986 depends critically on pushing as hard as possible our current research and development programme designed to solve the technical problems. Thus we are faced with the dual task of advancing this effort rapidly while at the same time operating our facilities which support both our physics programme and that of many other institutions in the United States and abroad.

We hope to schedule the break-in into the SLAC structure and joining the SLC ring to that structure during our regular summer shutdown, similar to the procedure which we executed with PEP. Once this break-in and junction has been successfully accomplished, the technical interaction between the SLC and the ongoing SLAC activities will consist mainly of carrying out tests in the linear accelerator and making major revisions to its installations and control system. These improvements are necessary to have the SLC live up to its expectations, but will at the same time improve the performance of the 2-mile linac in its own right.

However, this is not all. In addition to giving the green light on the SLC, the President's budget also provides funding for two other important new projects: a very substantial growth in synchrotron radiation facilities and an off-axis injector that will make it possible to generate low energy beams in linac End Station A for nuclear-structure physicists and others needing beams of energy no greater than 3 GeV. At the same time the off-axis injector will make it possible to inject into the SPEAR electron-positron ring without having to power the entire accelerator. As a result of this new scheme it might well be possible in the future to operate SPEAR (and therefore synchrotron radiation experiments) together with the low energy programme in End Station A during the summer months, when we are highly restricted in the use of electric power. This should greatly increase our scheduling flexibility, in particular once SLC becomes operational.

Stanford Synchrotron Radiation Laboratory is planning to expand its operations substantially over the next few years. SSRL and SLAC are each independent laboratories reporting to the Stanford University administration, with each determining its own programme under th general policies of the Universit SSRL, although an independent lab ratory, depends on a reimbursab basis on SLAC for technical suppc in many areas. As SSRL expand questions are raised whether th type of relationship will continue serve the needs. Accordingly, tl Provost has just appointed a cor mittee under the chairmanship Sidney Drell, Deputy Director SLAC, to make recommendations the long-range future relationship b tween SSRL and SLAC.

All this means that SLAC staff v be involved in three major constru tion activities — the SLC, the off-a injector, and whatever help we c give SSRL in connection with t SPEAR upgrading programme support of synchrotron radiati work. Nonetheless, the ongoing p ticle physics programme will cont ue with highest priority. This com nation generates a major load SLAC's technical and administrat staffs, and I hope that the confider which the government has showr us in giving us the green light on al these ventures will be vindicated

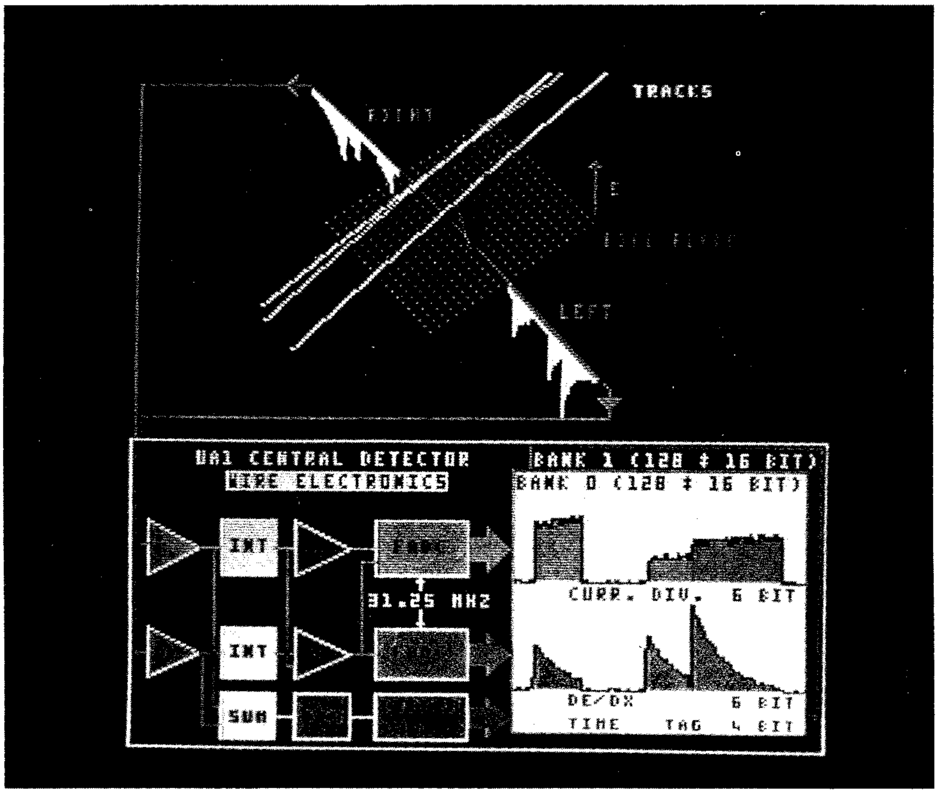
Fast work

One of the most impressive aspects of the initial evidence for W particles (see March issue, page 43) was how fast the evidence emerged from the mass of collected data. This was underlined by Leon Lederman in his conclusion at the recent Rome collider physics workshop.

The 1982 period of proton-antiproton collisions in the CERN SPS ring finished on 6 December. In the two month run, the big UA1 and UA2 experiments had each been exposed to some 10^9 collisions. By the time of the Rome collider workshop (12 January), the experimenters had been able to enjoy Christmas and to comb their recorded data for the handful of examples of lone high transverse momentum electrons 'balanced' by missing energy. These events are explained as the decays of charged weak bosons into an electron an neutrino.

These high energy proton-antip ton collisions are extremely co plex, producing sprays of second particles. However only a small fr tion are of immediate physics in est, and judicious triggering gre assists the subsequent data hand and timely extraction of physics sults.

Schematic of the readout system for one of the 6 000 sense wires in the UA 1 central detector. Output from the fast digitizing system is stored in a circular 128 16-bit word buffer.



The UA 1 system

The detector of the UA1 experiment has almost full solid angle coverage, with a series of detectors providing particle tracking, electromagnetic and hadron calorimetry (energy deposition), muon identification and magnetic analysis.

The triggering system is activated by a pulse produced by the approaching proton and antiproton bunches. This pulse starts a time-of-flight measurement which ensures that the outgoing particles originate within the detector, rejecting background at the trigger level. In addition, two fast processors decide if the data is to be read out before the next colliding bunch arrives. One processor can be programmed to select events with specific patterns of energy deposition in the calorimeters. The other picks out muons originating from the interaction (rather than the decay of other particles).

A more precise muon selection is planned for future runs, using the FAMP microprocessor system. But this second level trigger may cover many bunch crossings. Also on-line filtering of the data is envisaged using the 168E microprocessor (see January/February 1980 issue, page 450), to reduce the amount of data which has to be written to tape.

Most of the event data comes from the central detector, consisting of a large array of drift chambers with image readout. The fast digitizing electronics samples the wire pulses (energy loss and track position) and drift times every 32 ns and over 4 μs. For each event, this produces about 1.6 Mbytes of precise digital information, stored in a temporary buffer memory.

Initial data reduction is handled by a CAMAC crate including a special readout processor incorporating complementary microprocessors to handle data formatting and control functions. The number-crunching microprocessor is extremely fast, while the other is user-friendly and well supplied with interfaces. Each of the 110 crates handles 60 wires.

In fact the data processing power of the readout processor system is more than an order of magnitude larger than a large conventional computer and is well able to reduce the incoming primary information to simple coordinates (drift time, wire number, track position, etc.) to about 100 000 bytes per event.

With such a large and complex detector, equipment monitoring is also extremely important. Thus another vital function of the readout processor is to watch for malfunctions and take appropriate action so that precious running time is not lost. A lot of emphasis is placed on parallel processing.

After compaction, the data is read out to 200 CAMAC crates in a mobile control room. Data collection uses the CERN 'Romulus/Remus' method, based on branch drivers and crate controllers, linking the crates in a tree-like structure, carrying the data stream to a single branch driver.

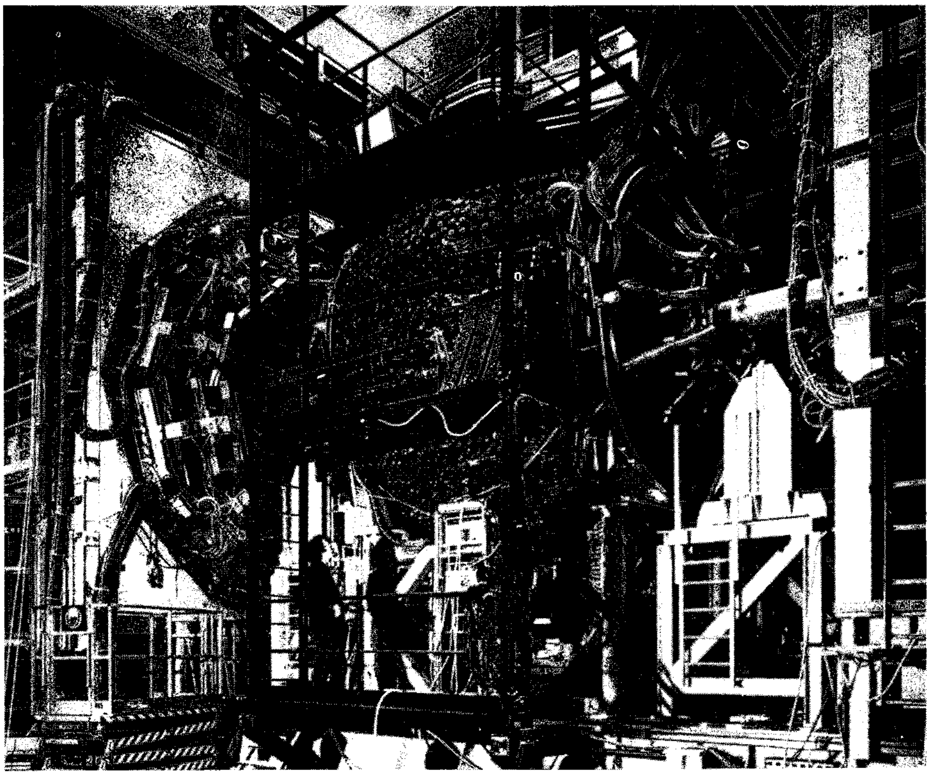
A router unit can switch the data between two separate vertical highways, permitting additional data acquisition and monitoring subsystems. SUPERCAVIAR microcomputers (see May 1980 issue , page 112) run monitoring and display programs.

At this level, parallel data acquisition takes about 5 ms. Data reduction takes about 15 ms. Full electronics dead time is from 20 to 30 ms, permitting a maximum of 30 events per second to be accepted at this stage.

After this parallel readout, the data

The UA2 detector, designed to study the properties of the hadronic jets and the leptonic decays of weak bosons produced in the high energy proton-antiproton collisions in the CERN SPS ring.

(Photo CERN 293.3.82)



is merged into five branches and passed to the main control room, one hundred metres downline. Before passing into the data acquisition computer, a system of routers with buffer memory allows data to be passed to different systems.

UA1 on-line computing is based on two pairs of Norsk Data 100/500 16 and 32 bit machines. In addition, two Hewlett Packard minicomputers provide special functions and SUPERCAVIAR micros look after equipment control and monitoring. There is a link to the main CERN computer centre. Off-line, a VAX 11 drives a Mekatek interactive graphic display, running the specially developed MERLIN system.

The Nord 100 runs a multiuser, multitasking virtual memory operating system, and a CERN-developed package (DAS) controls all aspects of data taking, reading the CAMAC and writing the data to tape. The powerful 32-bit Nord 500 uses the Nord 100 as a front end, and carries out full event analysis of sample events and accumulation of experimental statistics, as well as providing on-line event displays, such as the one on the cover of our January/February issue.

At current trigger rates of about one event every two seconds, there is no problem with tape writing. This would become a bottleneck if several events per second were being recorded. Further real time data reduction will be possible using the CERN-built 168E microprocessors in the extended trigger system.

In the 1982 run, some 10^9 proton-antiproton collisions resulted in data from some 10^6 events being recorded on tape. Three types of trigger — hadron jets, electrons and muons, all at high transverse momentum — were run in parallel, with less than 10 per cent dead time. The data filled 1000 magnetic tapes.

While the experiment was running, special tapes were written periodically to extract the mass of calibration constants for the different parts of the detector. These constants were used in the subsequent analysis of the raw data. The electron trigger and selected jet trigger data were analysed while the experiment was running with typically a few days delay. The remaining muon and jet trigger data are being worked on at CERN, Rutherford and Saclay, starting again from the stockpile of 1000 raw data tapes.

In the off-line analysis of the electron triggers, UA1 data was first subjected to a filter program to tighten up the trigger criteria and reconstruct with precision what happened in the calorimeters. Using the reduced data sample, other programs handled the reconstruction of events in the central detector and applied further filtering and checks.

Finally, from a sample of a few hundred events examined visually using the MERLIN system, 39 serious candidates remained and six of these were deemed to be 'clean'.

Off-line, a differently filtered data sample was analysed independently on the basis of missing transverse energy (expected to be due to an invisible neutrino), and provided the same six final events.

The UA2 experiment

The UA2 detector is designed to look at hadronic jets and the decays of the weak bosons. 240 individual lead-scintillator and iron-scintillator sandwich counters are clustered around the collision region, and the forward and backward cones contain additional lead-scintillator counters for electron identification, and magnetic spectrometers to measure the asymmetric charge distributions expected from the leptonic decays of W bosons.

The experiment benefitted from thorough initial testing and from the first SPS collider run in 1981. During the big run at the end of last year, continual testing and calibration ensured that everything was in good shape, and allowed rapid interpretation of the collected data.

The trigger logic is gated by the timing pulses from the SPS, and first level event selection is based on the amount and the clustering of energy deposition. The fast hardwired electronics does this with no appreciable dead time. In the 1982 run, about a million triggers were accepted, of which about 20 per cent were of the type which could contain electrons.

The data from these events (about 10 Kbytes per event) goes to the experiment's VAX 11/780 computer, which provides on-line capabilities for equipment testing, calibration and monitoring, event acquisition, display, writing to tape, etc.

All accepted events were collected on tape for subsequent off-line analysis. In addition, about five per cent of the data, containing potentially the most interesting events, were stored on an additional tape. In this way the results were examined day by day for suggestions of the weak bosons. The full trigger sample was used for the main off-line analysis.

Off-line, separate program modules, dealing with different parts of the detector, make for rapid analysis of the data. In the search for the high transverse momentum electrons, the calorimeter data was first subjected to a sophisticated analysis. This selected out 363 events, which were then exposed to the full power of the off-line programs. As a result, the handful of candidate events was obtained within a few days of the end of the run, and presented publicly in January. No final visual selection was necessary. Within a few weeks of the end of the run, all data on the production of hadron jets was processed, and detailed physics analysis in full swing.

The UA2 data acquisition and analysis system is not being pushed to its limits and could accommodate higher proton-antiproton interaction rates without too much trouble. There are no immediate plans to enhance the trigger system.

ECFA responds to its title

The European Committee for Future Accelerators, ECFA, is paying close attention to the adjective 'future' in its title with two major developments to prepare for particle physics in the years to come. These were discussed at the Plenary Meeting of ECFA in December.

The first is, hopefully, for the fairly near future and concerns the high energy electron-proton colliding beam machine, HERA, which has been proposed for construction at the DESY Laboratory (see page 90). ECFA, together with DESY and NIKHEF (the Amsterdam Laboratory), are organizing a Workshop with the title 'Experimentation at HERA', to be held in Amsterdam 9-11 June. This is a follow-up to the Wuppertal Meeting on 'Physics with Colliders' held in October 1981 (see January issue 1982).

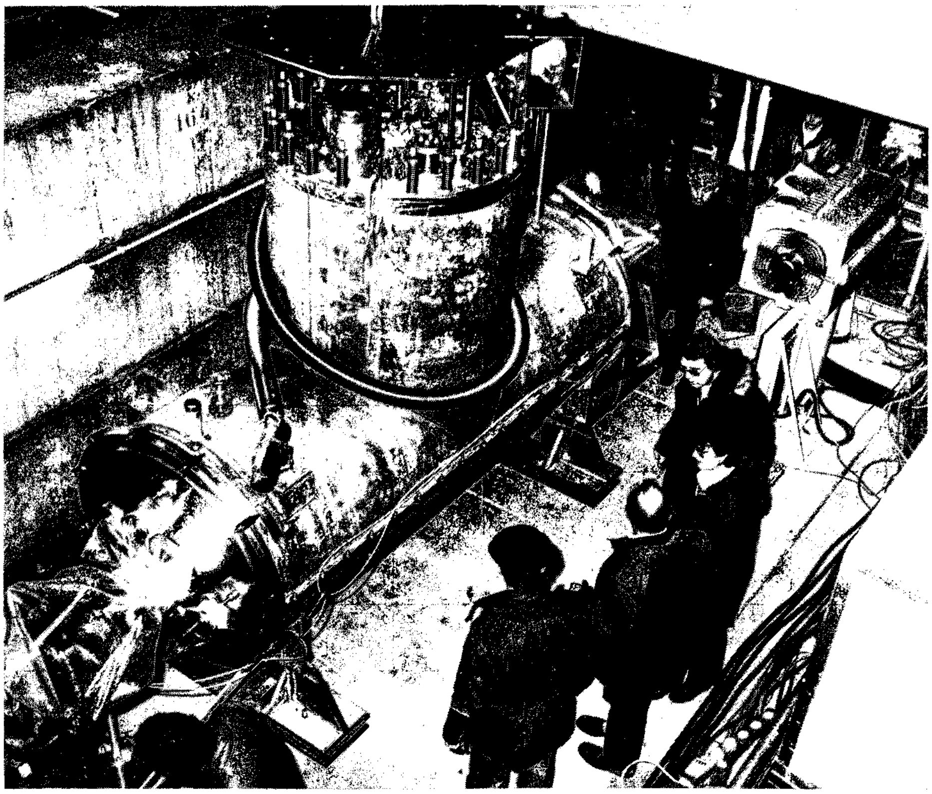
The Workshop will divide its subject under six headings — Technology for detectors, Requirements on intersection regions, Detection of photoproduction and small phenomena, Detection of charged and neutral current events and measurement of structure functions, Detection of exotic particles, Use of existing detectors.

The second development involving ECFA is a move to promote accelerator physics research in Europe with an eye on the very long term future. The need to stimulate research on new methods of particle acceleration for the machines which could be needed to tackle the physics of the next century emerged clearly from the Conference at Oxford on 'The Challenge of Ultra-high Energies' which was sponsored by ECFA and organized by the Rutherford Appleton Laboratory (see December 1982 issue, page 404). It is also a concern of the International Committee for Future Accelerators, ICFA, which considers the problems of particle accelerators in a worldwide context.

John Mulvey, the Chairman of ECFA, prepared a paper (ECFA/82/64 rev.) on the subject (from which the rest of this article is largely drawn), which was endorsed by ECFA at its December meeting. He first listed several technologies which might contribute to progress up to near the end of the century. Superconducting r.f. cavities offer the prospect of accelerating gradients of up 10 MV per metre and could help LEP to reach energies of up to 120 GeV with acceptable power consumption. Copper r.f. cavities in linear accelerators have been

An important preliminary to the achievement of higher energy electron/positron beams is the mastery of superconducting r.f. cavities. An important step in this direction is the tests with the Karlsruhe/CERN/DESY cavity seen here being installed in position in the PETRA ring at DESY.

(Photo DESY)



pushed to some 100 MV per m and could extend the energies of linear colliding beam schemes under study at Stanford and Novosibirsk. Superconducting magnets seem to have been mastered at last, and now a push to higher fields could open up higher energy ranges for proton synchrotrons with a given ring size. Another approach to higher proton energies, if the ring size is not crucial, could be to go for minimum cost accelerator components such as superferric magnets (see October 1982 issue, page 332).

The above list concerns essentially extensions of present accelerator technology but even with these extensions, limits of size, cost and power requirements are likely to be reached by the end of the century. Radically new ideas, such as were raised at the Oxford Conference, should then take over but a period of some fifteen years could prove an awfully short time to develop them from their present raw state to an accelerator technique which can be used in practice. At present very few resources are being assigned to advanced accelerator research and development and there is the added problem that, for some years, young people have not been attracted to accelerator physics.

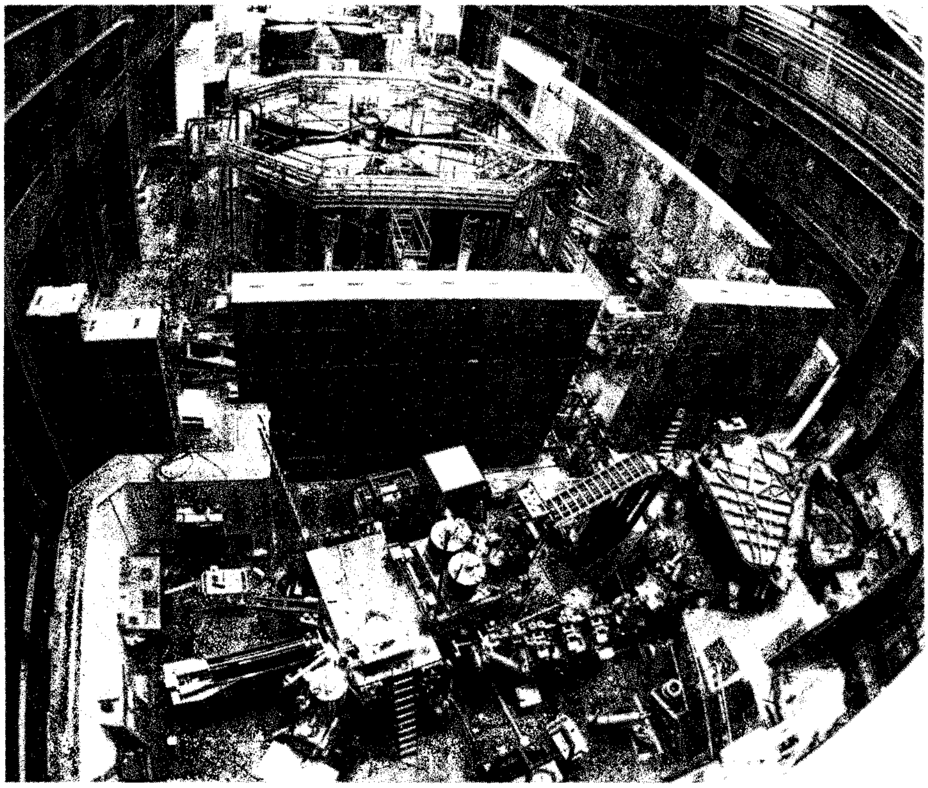
At a meeting in Paris in July, ICFA, together with a number of laboratory directors, confronted these problems and invited the Laboratories to participate in an internationally coordinated programme of accelerator research and development. In the course of 1983, ECFA will promote the cause of accelerator research. Individuals or groups with projects in this field are asked to inform ECFA. A discussion meeting will be held in the near future and a Workshop may be organized later in the year (which would also be preparatory for an ICFA Workshop planned for Japan in May 1984).

Accelerator Summer Schools have been launched in the USA (at Fermilab in 1981 and Stanford in 1982), and an Accelerator School has been established at CERN under the leadership of Kjell Johnsen (see March issue, page 60). CERN hopes to extend the concept of the School in collaboration with Member State Laboratories and universities, so that in addition to concentrated courses and related publications it will have a continuing function to promote knowledge of accelerator technology.

Another move at CERN to bring young physicists into the field is the opening up of more Fellowships, several of which will be specifically assigned to accelerator research. This development will be carried out in close collaboration with research institutes in the Member States and it is hoped that similar moves will be made in the Member States.

Summing up, ECFA encourages continued work on superconducting r.f. cavities with high priority, in view particularly of the needs at LEP, and vigorous development of high field superconducting magnets, and of the possibility of a 10 to 20 TeV proton-antiproton or proton-proton collider in the LEP tunnel. (The building of a superconducting ring for HERA would provide important first experience in Europe.) The efforts of ICFA to promote accelerator research are strongly supported and the various moves in Europe, which are cited above, to extend accelerator knowledge and attract young physicists are welcomed.

GANIL starts up



View of the GANIL cyclotron hall during the assembly period. The injector cyclotron can be seen in the foreground with the two separate sector cyclotrons in the background.

After six years of construction, the French GANIL (Grand Accélérateur National d'Ions Lourds) machine at Caen recently came on stream, accelerating a 50 nA beam of argon ions to an energy of 44 MeV/nucleon. (100 nA beams are now handled.) Today's physics interests amply confirm the thinking behind the launching of the GANIL project ten years ago.

GANIL's maximum energy varies from about 100 MeV/nucleon for light ions like carbon down to 10 MeV/nucleon for uranium. For each type of ion, it can supply beam from the maximum available energy down to about 5 MeV/nucleon.

GANIL is based on a sequence of three cyclotrons operating at the same frequency. The main difficulty with heavy ion acceleration is that the particles have to be sufficiently ionized for acceptable efficiency of the accelerator and magnet systems. The first two cyclotrons provide enough energy to ensure a large loss of peripheral electrons (the electric charge is multiplied on average by 3.5) when they pass through a carbon stripper, before being accelerated in the third cyclotron.

Cyclotrons 2 and 3 are of the separate sector type, providing good radial and vertical beam focusing, and with an injection radius of approximately 85 cm and ejection radius of 3 m, are virtually identical. The ratio between the radii is approximately the same as the factor by which the ion charge is multiplied during passage through the stripper. Cyclotron No. 1, the cyclotron injector, is considerably smaller and may be regarded as the centre of cyclotron No. 2, but located outside to improve access to the ion source. Cyclotrons 2 and 3 multiply energy by 13.6 and 12.3 respectively. A change in GANIL's output energy therefore involves adjustment of the entire machine including the source, cyclotron fields, r.f. frequency and the transfer line elements between the cyclotrons. This procedure is simplified by the control computers.

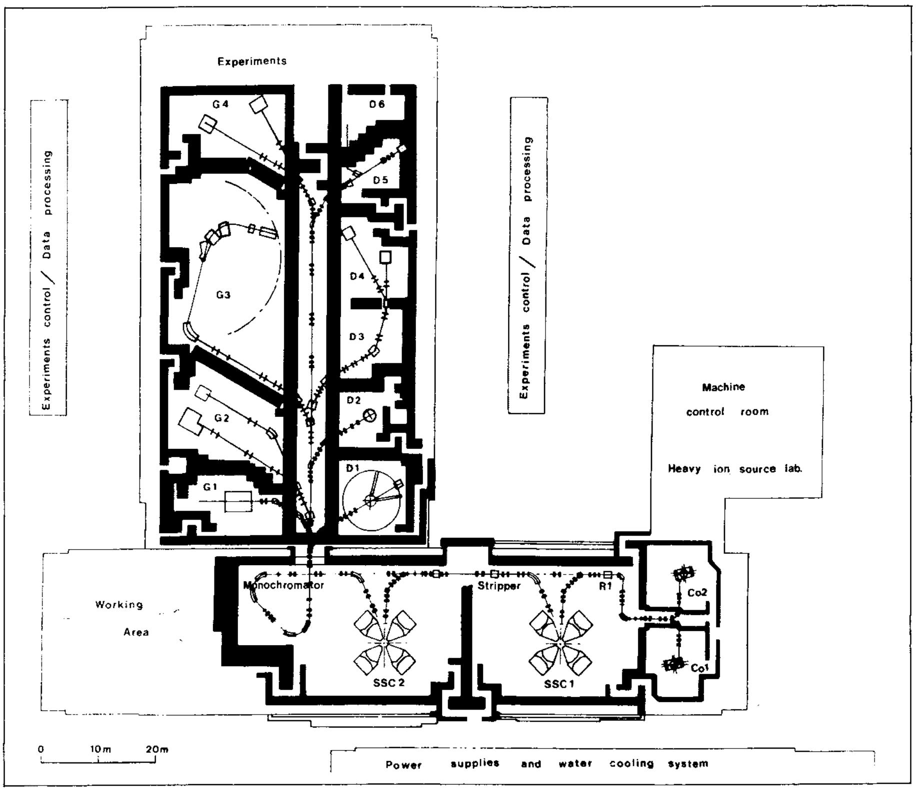
The major change to the original 1975 project is that, in the interests of beam usage, it was decided to have very small phase extensions, so that the flat-topping cavities, used to reduce energy dispersion and to provide comfortable phase acceptance, are no longer required. A phase compression process was evolved to reduce the natural energy dispersion by a factor of between 2 and 2.5 while conserving adequate phase acceptance. An alpha-shaped spectrometer was added to measure output energy dispersion and reduce it to a minimum of $\pm 5 \times 10^{-4}$.

Although GANIL is a classical machine using tried and tested techniques, its various components have presented a number of technical challenges.

The original project included the installation of two alternating injectors, but only one, a compact cyclotron with flat poles, has so far been built. The PIG-type ion source requires frequent replacement, but its automated installation and removal and total vacuum re-restablishment can be accomplished in less than an hour. All types of ions complete 14 orbits in the cyclotron. The maximum voltage on the dee is 90 kV. The central geometry of the cyclotron was studied on a specially converted model of the CERN synchrocyclotron. It is currently delivering 2×10^{12} charge 4 argon ions per second, in an emittance of 45 π mm mradian with an energy dispersion of 6×10^{-3}.

The second cyclotron injector, currently under construction, will differ only in its ECR Minimafios-type

General layout of GANIL.



source, now being built at the Centre d'Etudes Nucléaires at Grenoble. The source will naturally be located outside the cyclotron, into which ions will be injected axially. This type of source has two advantages: it has a very long life compared with the PIG sources, which have to be treated after some thirty hours of operation, and it provides charge states permitting constant operation at the maximum magnetic field imposed by the stripper. This means that the maximum energy of 100 MeV/nucleon can be conserved down to iron, that the energy of the semi-heavy ions can be doubled and that uranium can be obtained at 18 MeV/nucleon.

Each separate sector cyclotron consists of 4 magnetic sectors: two r.f. cavities in the 'valleys' between the sectors, the injection and ejection systems and the diagnostic systems. The four sectors complete with coils weigh 2 000 tonnes and consume 1 MW. The magnetic field in the sectors must ensure isochronous trajectories. Because of the relativistic correction, the field configuration must be modified from one energy to another. Both the sectors and the main coils are therefore filled with sheets of windings, each consisting of 15 so-called isochronism coils, in series on the four sectors, and of six independent correction coils. The coils of the sheets of windings, composed of pyrotenax conductors, are sealed in an envelope and the whole assembly is located inside the vacuum chamber. The conductors are fitted into grooves following the trajectories, a novel feature only possible with a numerically controlled machine.

To obtain a clear understanding of the magnets at different fields and different currents in the correction coils, 200 field maps of 36 000 points each were prepared using a Hall probe.

The magnet sectors, built by Alsthom Atlantique of Belfort, consist of eight horizontal laminations without bonding, each weighing no more than 60 tonnes so as to minimize handling difficulties. The polar block consists of 2 poles of 25 tonnes each. The air gaps are provided by three spacers and are linked to the yokes by three cross-frames cut to size after test fitting at the works (hyperstatic method). Under the effects of the magnetic field, each spacer bears an additional pressure of 200 tonnes and is compressed to between 2 and 10 mm. This induces relative movement between the magnets and the chamber which is absorbed by special antifriction devices (bronze micro ball bearings in a teflon/lead matrix).

The two identical vacuum chambers were designed at GANIL, in cooperation with an engineer seconded from CERN, and built by Neyrpic at Grenoble. They are one-piece mechanically welded assemblies with an average diameter of 9 m and a height of 4.50 m. The main joints were machined after all welding had been completed, necessitating very large machine tools. The chambers are made of stainless steel chosen for its non-magnetic qualities and its low out-gassing rate. Each weighs 57 tonnes and has a surface area of 230 m^2. The welding was checked by sweating at the works. Each chamber was carefully cleaned upon delivery at Caen, following its transportation by water via the Rhone and the Straits of Gibraltar.

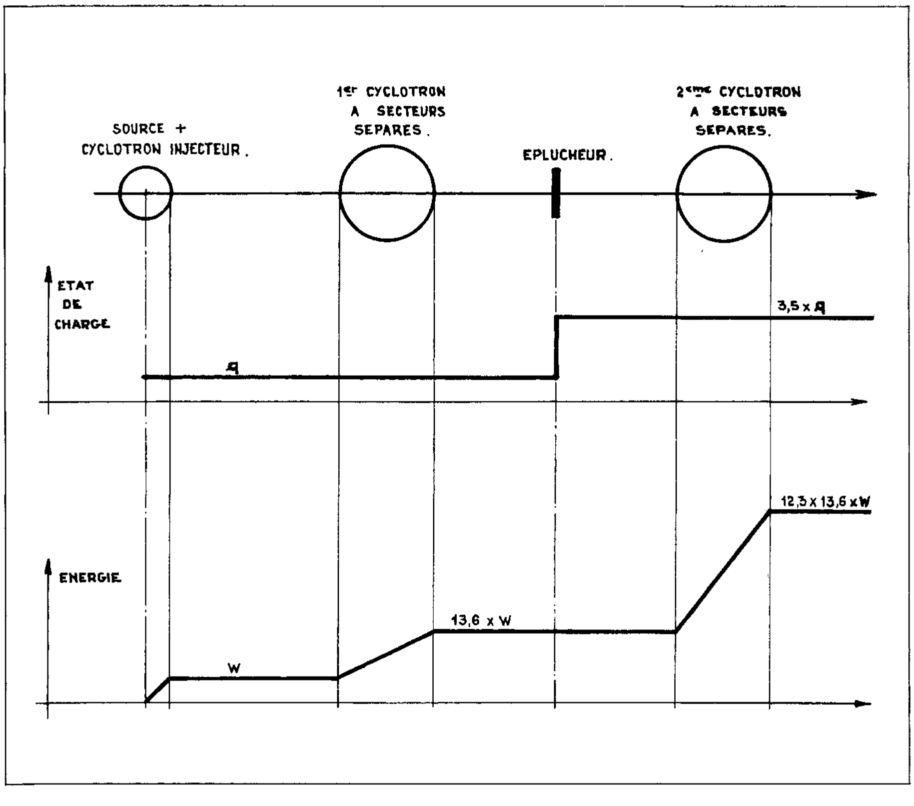
The chambers were designed using 'finite element' computer codes so as to minimize flange deformation during establishment of the vacuum. To improve vacuum quality, metal seals were used where possible in preference to elastomer ones, as they are far less prone to deformation. The vacuum required to accelerate the beam without loss (better than 10^{-5} Pascal : 1 atm = 1.013×10^5 Pascal) is most critical in the first separate sector cyclotron (SSC) and is achieved using seven cryogenic pumps at 20 K, without a liquid nitrogen screen, each with a pumping speed of 20 000 l/s for steam and 10 000 l/s for hydrogen. When air enters, the pressure climbs to 10^{-4} Pascal (which is enough for the r.f. power in the cavities) within two hours. After five hours, the pressure reaches 5×10^{-5} Pascal, which allows ions to be accelerated with a loss of only 20%.

GANIL incorporates seven r.f. cavities (two on each SSC, one on each cyclotron injector and a cavity acting as a buncher half-way between the injector cyclotrons and the first SSC) which can be tuned to any frequency within the 6.4 to 13.8 MHz range. Their novelty lies in their compactness, made possible by the use of removable capacitive panels, replacing the bulky quarter-wave lines normally used. They were built by SEIV in Paris following various technological studies at GANIL and technical research by CGRMEV.

The maximum voltage on the dee at the injection radius varies from between 100 to 250 kV, depending on the operating frequency. As the resonance ratio varies from 8 500 to 14 000, between 56 and 78 kW per cavity is required to obtain the maximum voltage. The cavities operate in continuous wave mode at a voltage stabilized at $\pm\ 10^{-4}$. The tuning of each cavity and the phase regulation of one cavity with respect to the others is guaranteed to within ± 0.1 of a degree. The copper cleaning techniques used have made possible a very low rate of out-gassing and no difficulties were encountered in passing the multipactor areas.

The accelerator is controlled by a MITRA 125 computer and 15 JCAM 10 microprocessors linked by a CAMAC network. Most of the 300 stabilized power supplies and stepping motors used are linked directly to the central MITRA 125 computer via the CAMAC.

(We intend to publish a further article, describing the physics at GANIL, in a forthcoming edition.)

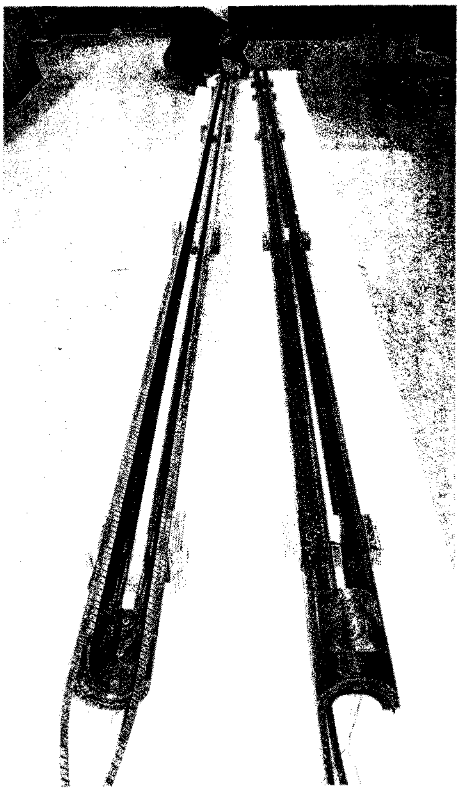


Operating principle of the new French GANIL heavy ion accelerating complex, showing how energy and ion charge are progressively increased.

Around the Laboratories

The two halves of the first complete six metre-long coil for a superconducting magnet for the proposed HERA ring.

(Photo DESY)



DESY
HERA clearer

The Federal German Ministry of Research and Technology has taken a fundamental policy decision regarding the future of the HERA electron-proton storage ring proposed for DESY. For the 1984 budget plans and the finance programme for 1985–7, it has been decided to make adequate arrangements to allow for HERA construction.

This decision has been taken in particular to permit DESY to continue negotiations with foreign countries on their participation in HERA, as this is seen as an important aspect of the project. Most of these contributions are envisaged as materials and components for the storage ring and for experiments.

The Government of the City of Hamburg welcomed the Federal Government's decisions. The DESY budget is financed normally by the Federal Government and the City of Hamburg in the ratio 9 to 1. For HERA, some special arrangements might be required. The basic assumption is that HERA will cost 660 million deutschmarks at January 1981 prices. Assuming an annual inflation rate of five per cent, this will grow to 960 million over the seven years of HERA construction. The City of Hamburg had decided much earlier to underwrite 10 per cent of the initially estimated cost, but this could be increased.

While the City of Hamburg has already included these expenses in provisional budgeting, the Federal Government will include the required initial HERA finance in 1984 if two conditions are satisfied — foreign participation has to be deemed sufficient, and the agreement with the City of Hamburg on the additional costs has to be definitely settled. The chances of fulfilling these requirements seem quite good. In the meantime all preparation work already authorized is being carried out according to schedule, particularly the development of the superconducting magnets for the proton ring.

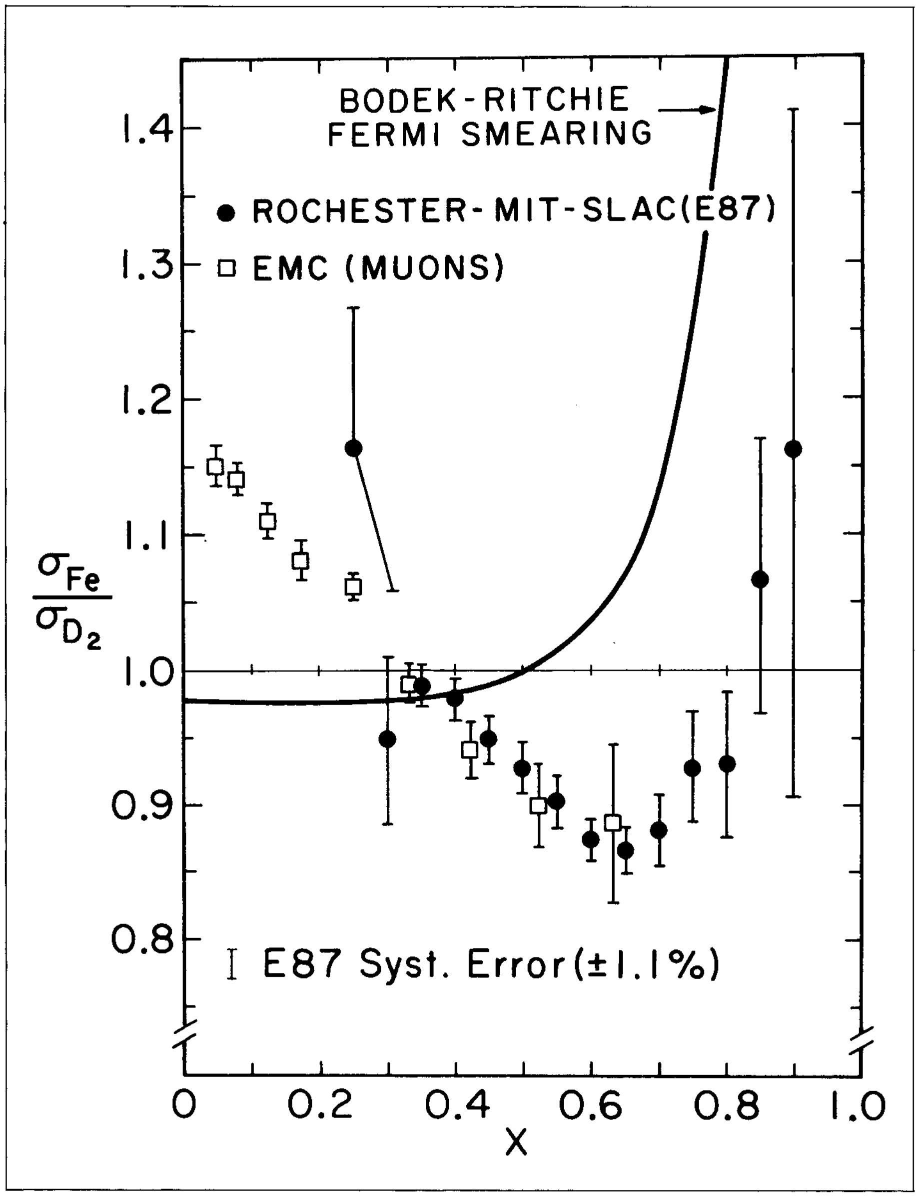
At DESY, the good news from the Federal Government was accompanied by several other happy HERA events. The first complete six metre-long coil for a HERA bending magnet made of superconducting wire was produced by a winding machine and assembling device built and installed at DESY. There was also a meeting of working groups preparing the Amsterdam 'Workshop on Experimentation at HERA', to be held from 9–11 June, organized jointly by DESY, ECFA and NIKHEF. On 25 February, a hundred enthusiastic participants (plus a lot of interested DESY people) grouped into six teams discussed specific problems. The groups were led by A. Minten (Technology), W. Bartel (Intersection regions), J. Engelen (Photoproduction, small momentum transfer), E. Longo (Currents, structure functions), R. Cashmore (Exotics) and M. Holder (Existing detectors). A second joint meeting of the working groups is scheduled for 25 April.

STANFORD
Physics archaeology

Recent results from high energy muon experiments at CERN (see November 1982 issue, page 362) indicate that there is a significant difference between the nucleon's quark structure (structure functions), extracted from data obtained from muon-steel and muon-deuterium deep inelastic scattering experiments. Now the same effect has been observed in data from deep inelastic electron scattering Experiment E-87 originally performed at SLAC in 1972. This difference exhibits a kinematic variation which is opposite to that expected from Fermi motion effects. A recent 'bag model' estimate by R. Jaffe (MIT), motivated by these results, suggests that the quark distributions in the nucleon become distorted in the nucleus via mechanisms such as six-quark states.

A comparison between the structure functions of nucleons bound in steel versus those of nucleons bound in the deuteron is important not only as a basic physics question, but also because high statistics muon and neutrino high energy scattering experiments utilize heavy nuclear targets. Nuclear corrections can affect the interpretation of the structure function results when compared to the predictions of Quantum

Comparison of recent results with high energy muon beams at CERN (European Muon Collaboration — EMC) with resurrected data using electron beams at SLAC (E87). The ratios of reaction rates on iron and deuterium from the two experiments show similar behaviour, at variance with simple ideas. This effect is now being interpreted as possible evidence for six-quark states in nuclei.



Chromodynamics (QCD), especially when data from different target nuclei have been combined in such a comparison.

Three of the physicists who were involved in the SLAC experiment (A. Bodek from Rochester, J. I. Friedman from MIT, and D. H. Coward from SLAC) realized that the E-87 empty target data (which were used originally to subtract the target wall contributions from the liquid hydrogen and liquid deuterium target data) could be used to verify the interesting effects observed at CERN in the steel/deuterium structure function ratio.

The raw empty target data were on an old disc backup tape made when IBM 2314 disc drives were used as part of the SLAC Triplex computer system. Because the computer system has undergone significant changes in the past ten years, the backup tape could no longer be read at SLAC. However the computer system at Argonne still had a few rarely used 2314 disc units and an operating system able to make them work. The 1972 data was thus recovered.

The luck of the physics archeologists continued. The entrance and exit walls of the old empty targets had been saved and pasted in the experiment's log books. As a result, a new and much more accurate measurement of the nucleon density in the stainless steel target was made. Thus the ratio of steel to deuterium structure functions has been determined with an estimated systematic error of ± 1.1 per cent.

The results show a significant difference between the steel and deuterium deep inelastic cross-sections per nucleon (and thus between the steel and deuterium quark structure functions) and are consistent with the CERN European Muon Collaboration results in the region of kinematic overlap. The behaviour of the results for momentum fraction (x) less than 0.8 is opposite to that expected from Fermi motion effects. However the SLAC results suggest that above 0.8, the effects of Fermi motion become dominant.

In the quark-parton model, the structure functions reflect the momentum of the quarks in the nucleon. Thus the results indicate that the quark momentum distributions in the nucleon become distorted in the presence of other nucleons in the nucleus. In view of these results, the Rochester / MIT / SLAC experimenters have begun the further analysis of another SLAC experiment in which an aluminium empty target was used and which covered a kinematic region extending to considerably lower values of x.

If the nuclear distortions are interpreted as evidence for six-quark states, then the results suggest that standard three-quark bags begin to coalesce even at normal nuclear densities. This may imply that quark-gluon plasmas, which are expected to form in high energy heavy ion collisions, may occur at lower densities than previously expected.

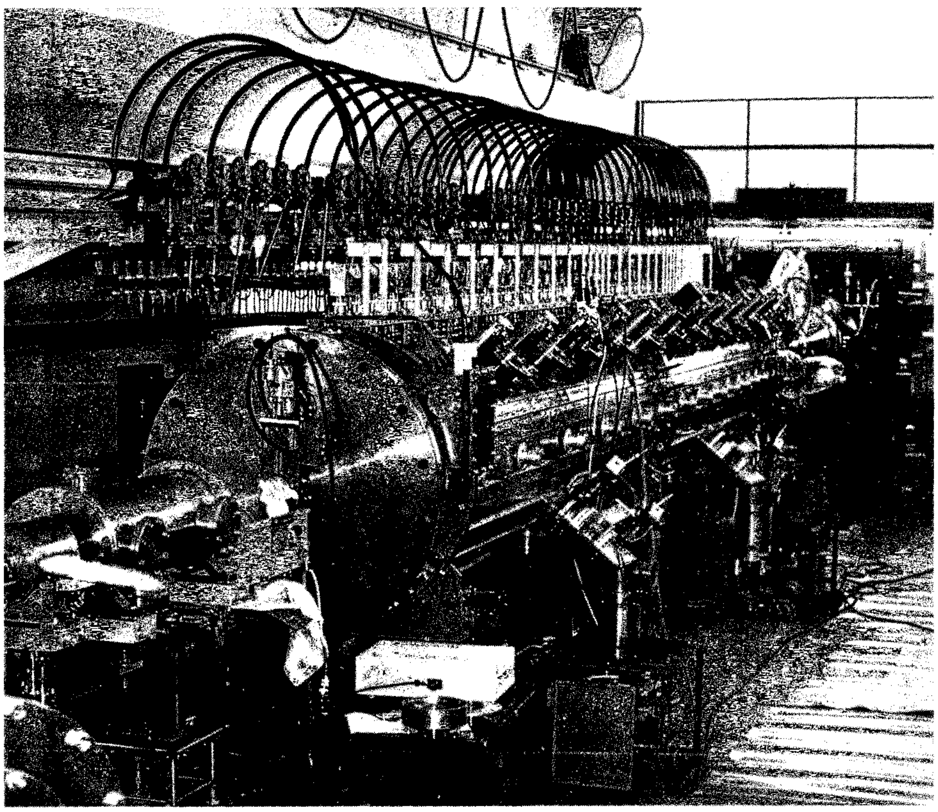
BEIJING
First 10 MeV proton beam

Construction of the Beijing Proton Linac (BPL) was completed at the end of last year at the Institute of High Energy Physics of the Chinese Academy of Sciences. After initially adjustments it began to produce proton beam of 10 MeV with intensity 14 mA (without bunchers).

This Proton Linac was originally planned as the first section of the injector of Beijing Proton Synchroton (BPS) which was cancelled later in 1981. However construction of the linac continued. Most of the equipment for the Linac was completed in 1980–1981, then installed and set up in 1982. The preinjector, a 750 keV Cockcroft-Walton, began to operate on 30 June. The low energy beam transfer system and the accelerating cavity was completed later.

Next step is to raise the beam energy to 35.5 MeV by adding some cavity sections and by use of available 5 MW r.f. power supply. This linac will be used to produce some isotopes for medical use and for neutron cancer therapy research. It is expected to go into operation in 1985.

The Beijing Proton Linac at the Institute of High Energy Physics of the Chinese Academy of Sciences, which has now produced 10 MeV proton beams.



BROOKHAVEN
Improved heavy ion beams

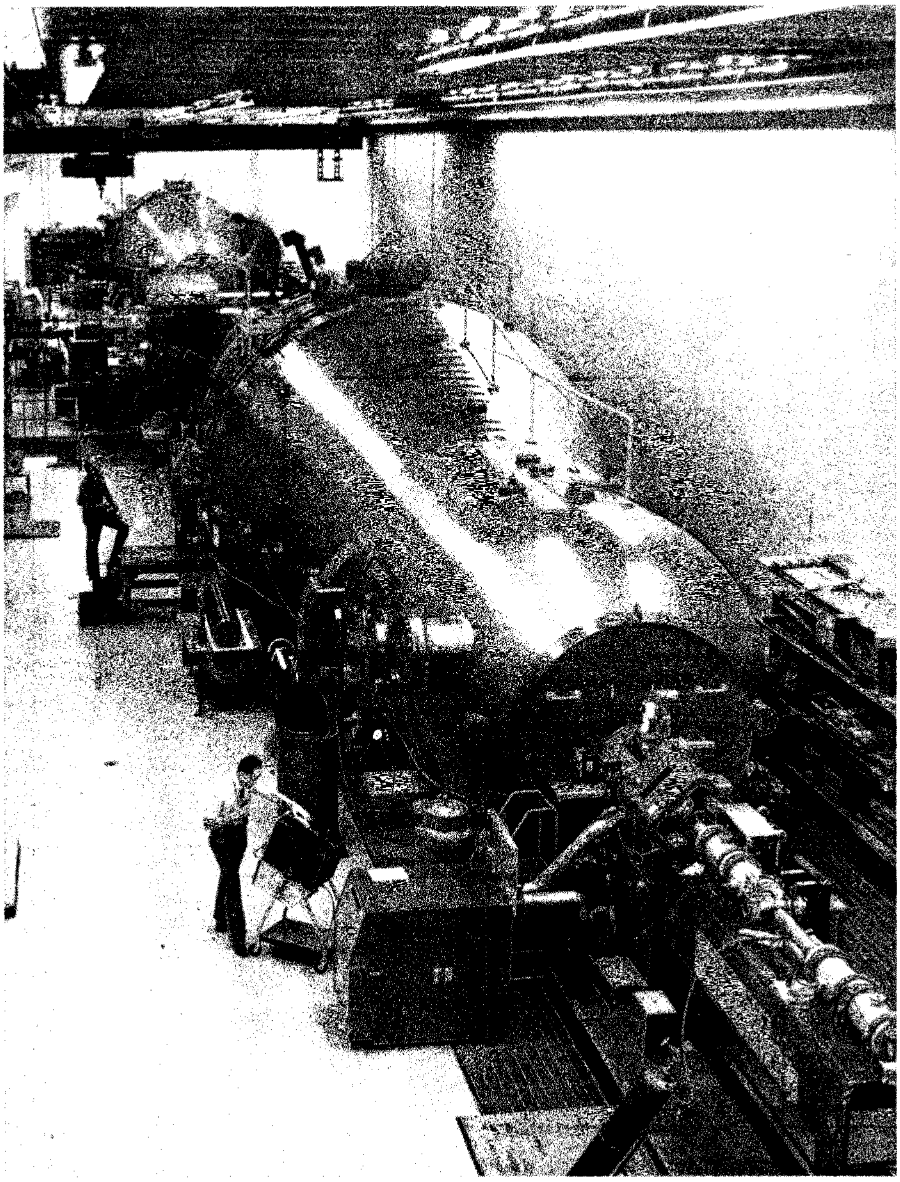
The Brookhaven Tandem Van de Graaff has provided a large variety of heavy ion beams for many years. The list of available projectiles has been steadily increasing and, to date, 65 different isotopes have been accelerated. Also, the energies have increased over the years, thanks to many large and small accelerator improvements, the last of which have led to reliable operation at voltages in excess of 16 MV for the main accelerator. Ion beams from a negative terminal machine operated at −11 MV can be used to inject the main Tandem accelerator and this combination is now roughly equivalent to a single 19 MV tandem.

Much higher heavy ion energies are on the Brookhaven horizon. A cyclotron has been designed, based on a large existing room-temperature magnet. This cyclotron would multiply the tandem energies by approximately a factor of 20. To get relativistic heavy ions, there is a proposal to inject the beams from this cyclotron into the Alternating Gradient Sychrotron (AGS), which could accept heavy ions up to iodine without any vacuum improvements. Some of the lighter beams such as oxygen or sulphur could be injected directly from the tandems.

Tandem Van de Graaff accelerators are well known for their excellent DC beam quality and stability, but also for the fact that intensities are low compared to beams normally injected into high energy accelerators. These machines accept injected current only for a small fraction of the acceleration period: the AGS, for instance, can accept the

View of the two model Tandem Van de Graaff accelerators at Brookhaven. The machine in the background can be used as a −11 MV injector for the main accelerator which has recently attained operation at terminal voltages in excess of 16 MV. This combination is now roughly equivalent to a single 19 MV tandem.

(Photo Brookhaven)



input beam during 200 µsec out of a 2 sec period, or 1 part in 10^4 of the time.

Could one operate the tandem with a pulsed beam many times more intense than the normal DC beams, and thus use it to inject heavy ions into the AGS? In principle, this seems possible because the capacitance of the accelerator structure should tend to preserve the voltages sufficiently during short times, even when the charging and voltage distribution systems would be totally incapable of sustaining them on a DC basis. There could well be other problems when very large beam bursts traverse the acceleration tubes, operated close to their maximum voltage gradients. For instance, it is easy to imagine how breakdowns or instabilities could be triggered.

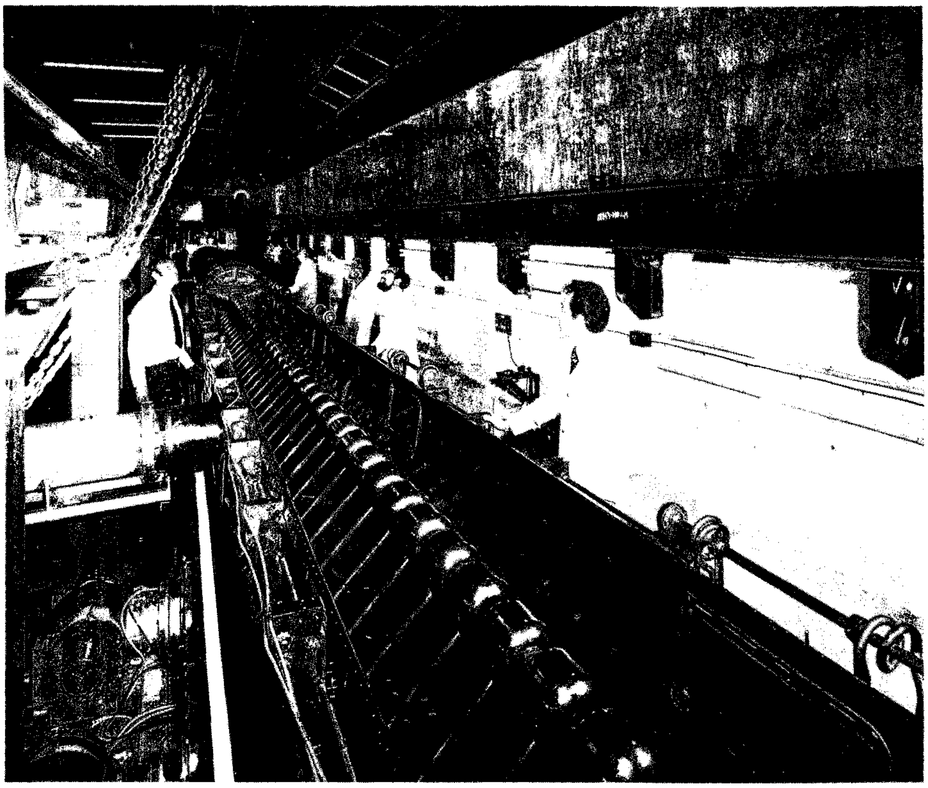
Development work received a boost with Roy Middleton's (University of Pennsylvania) new MARK VII sputter ion source which puts out over 200 µA for a variety of negative ions; an increase of more than one order of magnitude over older sources. In getting ready for beam tests at Brookhaven, it was soon found that this source could easily be pulsed by pulsing the high voltage on the central electrode, without affecting the beam quality or energy. Between pulses a low intensity DC beam is extracted and used for tuning the accelerator and the beam transport.

The results with the tandem were even better than expected. Instantaneous intensities were two orders of magnitude larger than normal DC beams. Even at ten pulses per second the 230 µsec beam bursts are short enough that the average beams were well below the accelerator capabilities. For instance, in the case of sulphur 32 a 170 µA negative beam was injected and the total instantaneous accelerator output current was 900 µA, of which 240 µA (27 particle µA) was in the most abundant charge state. The operation of the accelerator was completely normal, and the measured beam quality was excellent. From these results one can conclude that even higher intensities could be obtained. The very good beam quality would allow many more turns to be injected into the AGS than is customary. This, together with the now demonstrated heavy-ion intensities from the tandems, provides a large safety margin to assure that oxygen intensities of 4 × 10^{10} particles per pulse can be reached. For iodine beams, which require the cyclotron booster, the intensity would be 10^9 particles per pulse.

Beyond AGS injection and beams at 15 GeV/nucleon, people have looked at possible injection of heavy

The lid comes down on one of the four 'tanks' of the injector linac of the Spallation Neutron Source at the Rutherford Laboratory. Negative hydrogen ion beams were accelerated to design energy of 70 MeV in the linac for the first time in January.

(Photo Rutherford)



ions into the proposed Colliding Beam Accelerator. There appear to be no technical problems involved in accepting AGS heavy ion beams — passage of heavy ion beams through transition during acceleration can be accommodated by all presently considered CBA designs. The range of heavy ion beams with reasonable luminosities that would become available is truly impressive — involving centre-of-mass energies of order 10^5 GeV.

RUTHERFORD SNS injector achieves 70 MeV

In January the Spallation Neutron Source project reached one of its 'milestones' with the first acceleration to 70 MeV of a negative hydrogen ion beam by the injector linac.

This followed the successful commissioning of the last of the four accelerating cavities to full r.f. accelerating field level. A 10 MeV beam, first produced in April 1982, was re-established from the first tank and the beam energy was raised to 30 MeV with the operation of the second tank. In anticipation that the final critical items of equipment could be installed in time, an operational run was quickly scheduled for an attempt to operate all four tanks and achieve the design energy. The hard work of an enthusiastic crew was rewarded as the energy reached 70 MeV.

Although everyone is delighted with this result, much remains to be done before the SNS produces neutrons in 1984. The beam transport line to the synchrotron has to be installed, in parallel with completion of the synchrotron ring, prior to injection and acceleration studies later this year.

The target station of steel and concrete is being constructed ready to receive its uranium target around Eastertime 1984. The instruments, on which the experiments will be carried out, are being designed and built and some of them are being tested on the Harwell linac. 1984 should see the start of the experimental programme and hence, twenty years after the start of Nimrod and six years after its shutdown, a new accelerator, the SNS, will be in operation at Rutherford.

With the SNS, scientists from the UK and elsewhere will have unequalled facilities for studying the structure and properties of solids and liquids. This is of interest to a wide range of disciplines, from biochemistry through medicine, metallurgy and plastics technology to solid state physics. The SNS is attracting world-wide interest and an agreement has recently been signed with the Bhabha Atomic Research Centre in India for the provision of an instrument for use on the SNS. Discussions are being held with similar organizations in Germany and Italy.

UPPSALA Second renaissance of g-2 ring

A magnet ring from CERN is to move to Uppsala to serve in yet another area of physics. It is the ring constructed for the high precision measurement of the g-2 (anomalous gyromagnetic ratio) of the muon in the mid-70s. The unprecedented precision of this measurement remains one of the best confirmations of quantum electrodynamics.

In 1976 it was decided to use the

g-2 magnet for the 'Initial Cooling Experiment', ICE. The circular configuration was changed to include four straight sections with the magnets in the corners of the quadrant. This rebuilt ring was used to develop two schemes for cooling particle beams — stochastic cooling, invented at CERN by Simon van der Meer and electron cooling, invented at Novosibirsk by Gersh Budker.

At CERN the cooling of antiprotons has been a major success. They have been used in the highest energy experiments at the SPS collider and will soon be used at LEAR in the low energy range. The cooling technique also holds promises for the more conventional particles of low energy physics. At Indiana University a proposal to build a cooling ring for protons and other light ions was presented two years ago. It has recently been approved and the ring will be built during the next 3 to 4 years and connected to an existing cyclotron for 200 MeV protons and other light ions.

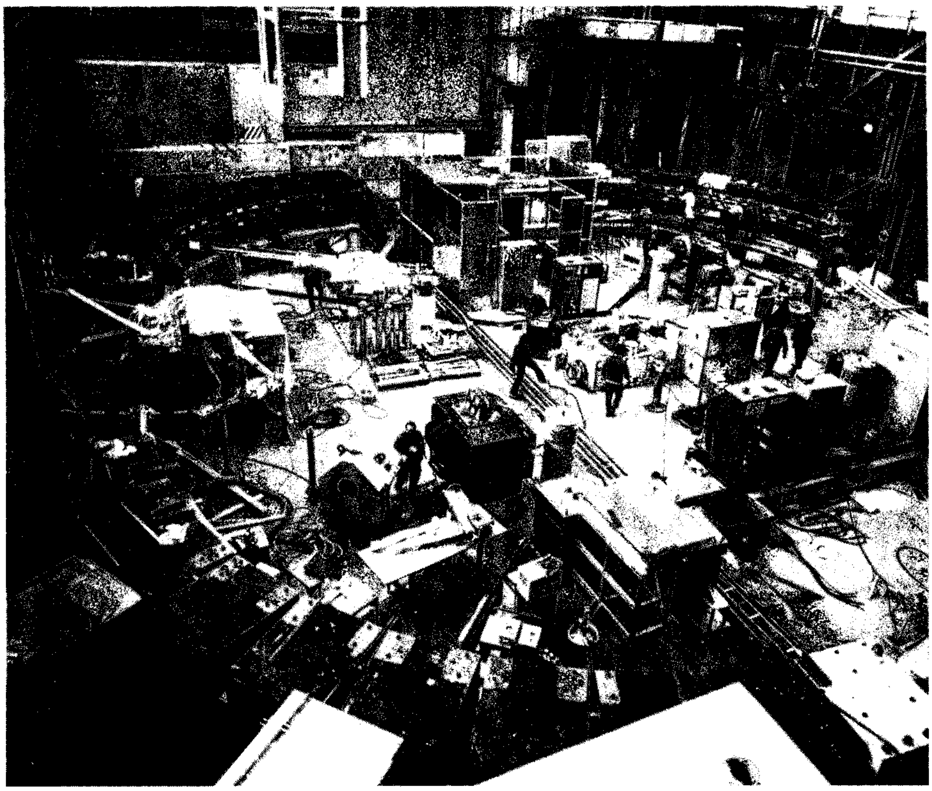
During the second half of 1982, it was proposed that the magnets of the ICE ring, which is no longer operative, could be moved to the University of Uppsala and connected to the synchro-cyclotron at the Gustaf Werner Institute (see September 1982 issue). The proposal also envisages a superconducting cyclotron with a K of 800 intended primarily for heavy ions. (The K value of a cyclotron multiplied by the charge-to-mass ratio squared gives the energy per nucleon.) With the existing K200 light ion cyclotron, the ICE ring and the K800 accelerator, an installation would be created that should remain competitive for many years. Light and heavy ions can be used in the conventional way or injected into the cooler ring with internal targets.

The accelerator situation in Sweden has been under investigation for many years. When new prospects were opened up by the availability of the ICE ring, the Ministry asked representatives from the accelerator laboratories in Uppsala, Stockholm and Studsvik to review the situation. This review resulted in the proposal submitted in November 1982. The location of the installation is proposed for either Uppsala, in the vicinity of the Tandem Accelerator Laboratory and the Gustaf Werner Institute or in Stockholm, linked to the Research Institute for Physics.

The Swedish budget, presented in January 1983, contained approval for phase I of the proposal, namely the reconstruction of the ICE ring and its connection to the Uppsala synchro-cyclotron. For phase II, which is basically the K800 cyclotron, there will be further studies on the budget, the organization, the Nordic interest for the proposed accelerators and the final location. A decision is expected early in 1984.

The development in Sweden is an example of how advanced technology at CERN can be transferred back to a Member State. The use of cooled ion beams and of internal targets should open a new era of high precision nuclear physics. Momentum resolution one or two orders of magnitude better than so far achieved, measurements in a new background-free environment, and unperturbed recoils from extremely thin targets are some of the interesting features of this proposed way of studying interactions at low and intermediate energy.

(We are grateful to Sven Kullander for providing this information.)

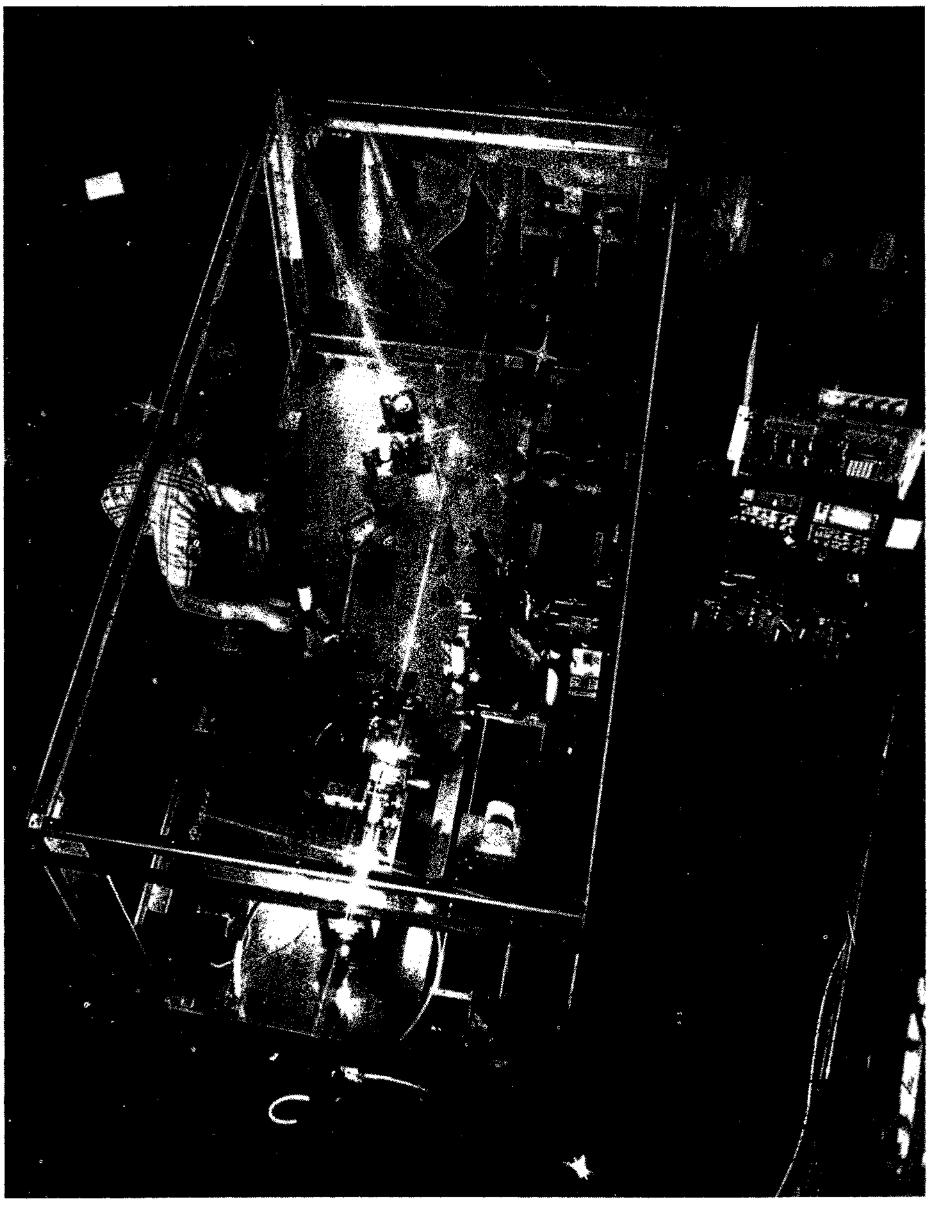


Rebuilding the muon storage ring of the 'g-2' experiment at CERN for ICE — Initial Cooling Experiment. Now the idea is to move the ring to Sweden for a third incarnation.

(Photo CERN 282.11.77)

One of the mass-separated beams at UNISOR is examined by a newly installed laser optical spectroscopy system, used to determine precisely the hyperfine structure of atomic levels resulting from the interaction of the nucleus with the atomic electrons. These measurements enable the researchers to determine nuclear properties such as the spins of odd-mass nuclei.

(Photo Oak Ridge)



OAK RIDGE Exotic nuclei at UNISOR

Three new ion sources have been developed for production of exotic nuclei at the UNISOR facility at Oak Ridge to extend the range of nuclei which can be studied. A thermal ionization source will reach temperatures in excess of 3000C, a 2200C source will operate in either a plasma or a thermal ionization mode and a hollow-cathode ion source will be used with a recently developed helium-gas jet system. UNISOR, the University Isotope Separator at Oak Ridge, is a division of Oak Ridge Associated Universities, a consortium of mainly southeastern US universities. Established as a user group in 1971, it is supported by ten member universities and the US Department of Energy.

Researchers study neutron-deficient exotic nuclei. By measuring the decay processes of these radioactive isotopes, physicists often get information which can be used to determine the validity of nuclear models and which can sometimes lead to the discovery of new structural effects.

The work is complemented by work at Brookhaven's TRISTAN online mass separator where neutron-rich isotopes are produced at the High Flux Beam Reactor (see December 1981 issue, page 450). Other facilities such as ISOLDE at CERN use high energy reactions to produce both neutron-rich and neutron-deficient isotopes.

UNISOR intercepts beams of heavy ions from the Oak Ridge isochronous cyclotron and new 25 MV tandem. The neutron-deficient nuclei are created when the heavy ions collide with targets, usually of some metallic foil such as tantalum or tungsten. Because of the large linear momentum of the ions, the product nuclei recoil out of the target, typically into a graphite catcher mounted in the wall of an ion source. The nuclei then diffuse into the ion source. Ion sources used in the past operated in the range of 1000-1800C. With the new sources, reaching as high as 3000 C, many of the isotopes more difficult to vaporize will be accessible.

In the helium jet system, product nuclei will be stopped in helium gas and pumped into the hollow-cathode ion source, eliminating the need for a catcher and the time necessary for vaporization. As a result, nuclei that are extremely short-lived and more of those difficult to vaporize can be collected.

The nuclei are extracted into the

separator where a sector magnet and defining slits select specific masses for study. The beams of nuclei are collected by simple transport systems which use continuous loops of common 8-track recording tape. The nuclei are transported to various detectors for energy spectra and timing measurements of gamma rays, X-rays, conversion electrons, and alpha and beta particles.

September 1982 marks the tenth anniversary of the first operation of UNISOR and during this first decade over 50 nuclides were investigated.

One important contribution has been the demonstration of nuclear shape coexistence in even-mass isotopes. This work was stimulated by the ISOLDE optical-pumping experiments which indicated sudden shape changes between adjacent mercury isotopes. The UNISOR group found prolate and nearly spherical nuclear shapes coexisting in mercury 184 and 186.

Researchers also noted nonaxially symmetric (triaxial) deformed nuclear shapes in the gold-mercury-thallium region. Work with odd-mass thallium and gold isotopes also revealed the deep intrusion of single-particle states from higher shells, indicating that the classic nuclear shell model gaps are accidental features of where the valley of stability lies.

Other work has provided confirmation for simple core-coupling models and has also demonstrated that the structure of gold nuclei can be well represented by the supersymmetric classification scheme of the Interacting Boson-Fermion Approximation.

(This information was kindly supplied by Russ Manning.)

People and things

Last December, Professor Theodoros Kouyoumzelis (centre) with members of his family, met the Greek community at CERN to mark the occasion of his retirement from CERN affairs after some 30 years as Greece's representative to CERN Council.

(Photo CERN 255.12.82)

On people

New President of the American Physical Society is Robert Marshak of Virginia Polytechnic Institute and State University. Former Fermilab director Bob Wilson is Vice-President, to become President-Elect in 1984 and President in 1985.

Among the UK Institute of Physics awards this year are the Guthrie Medal and Prize to Jeffrey Goldstone and the Charles Vernon Boys Prize to Roger Cashmore.

At MIT since 1977, Jeffrey Goldstone is one of the major architects of the complex structure of spontaneous symmetry breaking which lies at the heart of modern particle theory. Oxford experimentalist Roger Cashmore receives his award for his many original and outstanding contributions to physics. Recently he has played a prominent role in the TASSO experiment studying electron-positron annihilation at the PETRA ring at DESY.

Professor Theodoros Kouyoumzelis, representative of Greece to the CERN Council for some thirty years, retired from CERN affairs last December. He has played a fundamental role in the relations between Greece and CERN, and he is also largely responsible for the flourishing of nuclear and high energy physics in Greece. As professor at Athens, he devoted a large part of his time in teaching and in spreading the message of nuclear and high energy physics, in addition to his considerable scientific contributions, centred on the Raman effect. The number of established Greek physicists who at some time or another came under his influence is ample testimony of his success.

CBA progress at Brookhaven

The last week in February was one of the most encouraging yet in the history of Brookhaven's Colliding Beam Accelerator project (which used to be called ISABELLE). On 25 February, a full cell of the storage ring magnet lattice (consisting of six bending and two focussing magnets) was powered and reached the design field of 5.2 T, corresponding to 400 GeV beams. A few days earlier, a production series of eight bending magnets was completed, with all magnets providing not only the required peak field but also the required field quality. The decision has been taken that the Laboratory will con-

12 April marks the seventieth birthday of Venedikt Dzhelepov, Director of the Laboratory of Nuclear Problems at the Joint Institute for Nuclear Research, Dubna, USSR.

tinue to propose a 400 on 400 GeV proton-proton colliding beam machine of high luminosity ($2 \times 10^{32} cm^{-2} s^{-1}$), using two separate magnet rings.

Inverse picobarn party at PEP

Luminosity in the PEP electron-positron ring at SLAC has been steadily increasing in recent months. At the beginning of the year, average integrated luminosity rose above 700 inverse nanobarns per day. 1000 inverse nanobarns (one inverse picobarn) looked possible. In keeping with an old PEP tradition of celebrating milestones, SLAC Technical Director Burt Richter said: 'When we get an inverse picobarn in a day, we'll shut down the linac and PEP and have a party.'

For some weeks this goal was elusive, with efforts frustrated by many equipment problems. During the second week of February the luminosity started to climb. On 12 February the barrier was cracked with 1.005 inverse picobarns and the next day, a Sunday, it was shattered with 1.030. Peak luminosity has been increased to $2 \times 10^{31} cm^{-2} s^{-1}$. One inverse picobarn per day corresponds to a running average luminosity of 1.2×10^{31} over a twenty-four hour period.

With everything going so well, it seemed a pity to shut down the machines, but SLAC had a great inverse picobarn party on 17 February.

Meanwhile at DESY, the PETRA electron-positron ring has other things on its mind, with high energy being the main goal (see March issue, page 53).

1.2 mA at LAMPF

At the end of an eight-month period with currents at 600-700 μA, the LAMPF proton linear accelerator at Los Alamos had a demonstration run with an average current up to 1.2 mA at 10.5 per cent duty factor. The accelerator easily handled the 11.4 mA peak current. The adequate performance of the beam stop and a number of target cell components at LAMPF's design current of 1 mA in the meson area was also shown.

In the week preceding the demonstration, the production beam current was increased to 800 μA and the duty factor from 9 to 10.5 per cent. Reliability remained high. Concurrent delivery of 25 nA of polarized negative ions at 800 MeV was also achieved a few weeks earlier, nearly doubling the polarized beam current routinely available in the nucleon areas. A five-month shutdown has now begun which will be used for upgrading experimental areas and the installation of an improved transition region in the accelerator.

Daresbury Nuclear Structure Facility

1983 started well for the new Nuclear Structure Facility (NSF) at the Daresbury Laboratory in the UK. With stable operation at 18 MV, first major experiments have been carried out by scientists from Liverpool, Manchester, Copenhagen and Daresbury.

The NSF is a tandem electrostatic generator producing beams of heavy ions. Construction began back in 1974 and the 70 m concrete tower housing the accelerator is now a prominent local landmark. It is designed to operate initially near 20 MV, but the ultimate design goal of 30 MV is on the cards. The voltage will be slowly increased over the coming months as the evacuated accelerator tube becomes conditioned.

In principle the NSF can produce virtually all ion beams from hydrogen to uranium with good energy and spatial definition and over a range of energies. In commissioning and in the initial experiments, the beams have included oxygen (16 and 18), sulphur (32, 34 and 36), titanium 48 and calcium 48. Already three experiments have been completed with the TESSA (Total Energy Suppression Shield Array) gamma ray detector, and initial results show how increasing nuclear rotation affects the nuclear structure.

More instrumentation is being prepared to extend the range of experiments.

During a recent visit to Japan, CERN Director General Herwig Schopper visited the KEK Laboratory. Touring the Accumulator Ring tunnel for the new TRISTAN project, he was accompanied (left) by KEK Director T. Nishikawa, and (behind, left to right) by German Embassy Scientific Counsellor H. Schunck, and S. Ozaki and Y. Kimura.

(Photo KEK)

Meetings

The 6th High Energy Heavy Ion Study and the 2nd Workshop on 'Anomalons' will be held at Berkeley from 28 June to 1 July. The meeting will cover recent developments in the study of high energy nucleus-nucleus collisions, and the current status of the anomalous mean free path effect for projectile fragments. Further information from the Chairman of the Organizing Committee for this meeting, Lawrence Berkeley Laboratory, Berkeley, California 94720.

2000th patient at Cyclotron Laboratory

The Harvard Cyclotron Laboratory (HCL) recently treated its 2000th patient with proton beams. Specialized techniques for treating large and small tumours have been developed over the last 21 years, exploiting physical properties of the beam so the greater part of the radiation effect is concentrated in the tumour while minimizing the effect on healthy tissue. This improved dose distribution has allowed treatment of lesions adjacent to vital structures such as the spinal cord, the optic nerve and the brain.

Treatment of tumours in the head began in 1961. Irradiation of the pituitary gland was developed first. More recently, treatment of disorders known as arteriovenous malformations has been added to the expanding list of successful applications. These lesions are frequently inoperable and not well managed by other forms of treatment.

Malignant eye tumours known as choroidal melanomas have been treated since 1975 in collaboration with E. Gragoudas with excellent follow-up results of the proton beam for this type of tumour. In 1972 the HCL staff developed apparatus for treating larger tumours elsewhere in the body. Treatments were started in 1974.

At present, HCL has treated more patients than any other laboratory in the world engaged in heavy charged particle radiation therapy and, over the years, has contributed a number of innovations subsequently adopted at other radiation facilities. The Laboratory employs fourteen people under the direction of A.M. Koehler. The cyclotron was used for physics research in the 1950s but was converted for medical applications in the 1960s when funding and interest in this region of physics tapered off. However occasional physics research projects are still undertaken.

HCL is now supported almost entirely by fees charged for the irradiation services, and by some funding from the US National Cancer Institute. Acceptance of charges for two types of treatment by major medical insurance companies is evidence that proton irradiation is now considered accepted medical practice. Plans for eventual replacement of the 33-year-old machine are proceeding slowly, hampered by inadequate finance.

ITALY AT CERN

39 ITALIAN COMPANIES: LATEST EQUIPMENTS AND KNOW-HOW

22-25 MARCH 1983

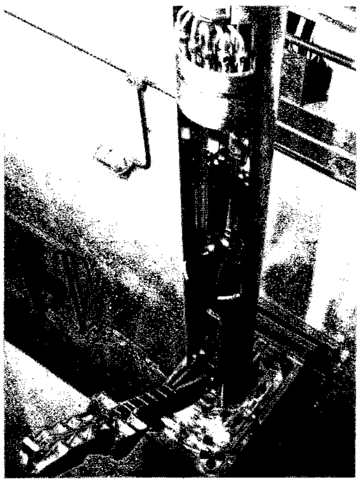
FIAT TTG

Via Cuneo, 20
10152 – TORINO
tel. 011/26001
telex 221050 FIATTG I

Production Line:

– Design and manufacturing of the mechanical and electromechanical main components of the nuclear steam supply system: Reactor internals, control rod drive mechanisms, control rods, mechanical parts of fuel elements, pumps, special valves and devices, fuel storage and hauling systems, experimental and testing loops.

Structural and piping engineering services.



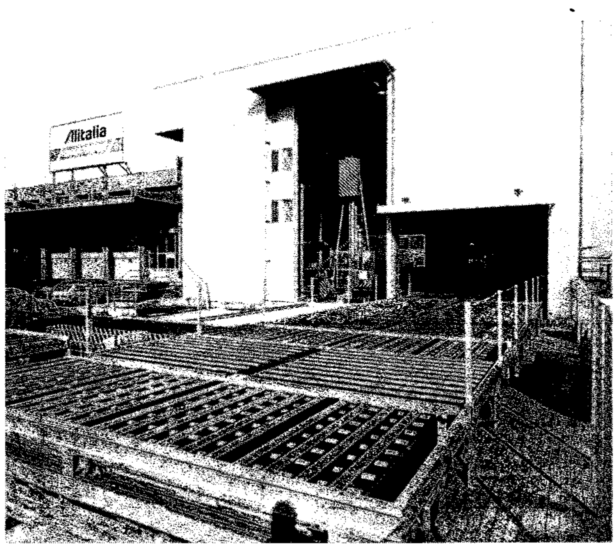
Core hold-down locking device for PEC Reactor (prototype). The PEC (Prova Elementi Combustibili = Fuel Element Testing) facility consists of a sodium-cooled 118-MWth fast-type reactor in erection at the ENEA Centre of Brasimone (Bologna, Italy).

FATA EUROPEAN GROUP

S.S. 24 km 12
10044 – PIANEZZA (Torino)
tel. 011/9673333
telex 212136 FATA EU I

Production Line:

Engineering design and full assistance from the planning stage to the system final setting up:
– Internal material handling systems
– Automated warehousing systems
– Robotized welding systems for bodywork lines
– Iron and steel foundry equipment
– Light-alloy foundry equipment
– Systems for the production of plastics components
– Aluminium rolling and converting systems
– Cable transport systems for persons and goods



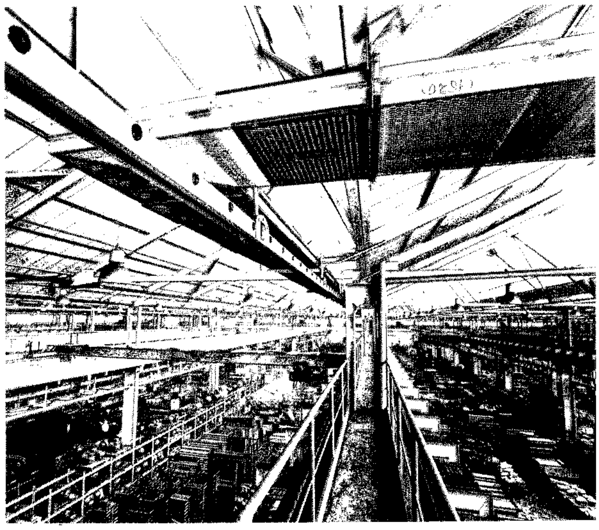
Goods handling system.

P. POGLIANO
dei F.lli. POGLIANO

Via Passo Buole, 160
10135 – TORINO
tel. 011/612034
telex 220039 PPEFTO I

Production Line:

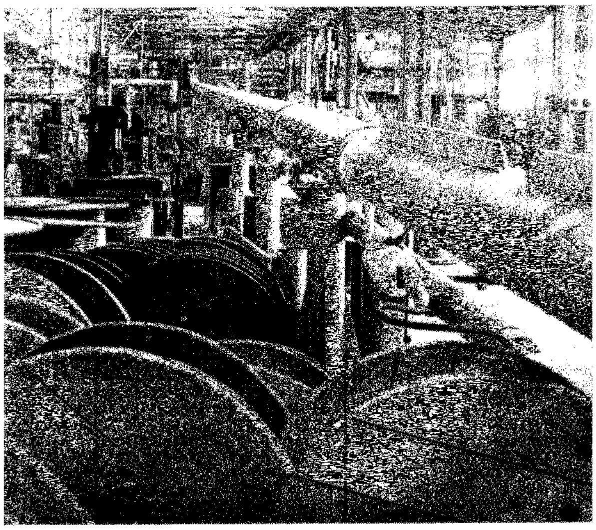
- Silver-plated aluminium bars
- Busbar trunking
- Electric cabins
- Civil and industrial plants
- Cable tracks
- Electronic plants



Busbar trunking systems.

DESSALLES E BORZINO

Via Casale, 21
10099 – SAN MAURO TORINESE (Torino)
tel. 011/8224124
telex 220524

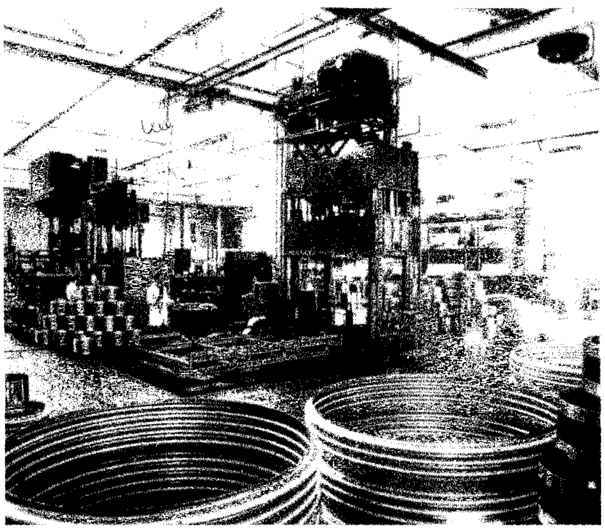


Production Line:

- Electric cables
- Rubber, xlpe, hypalon, fire resistant PVC insulated for low or medium working voltage up to 30 kV radet

GILARDINI

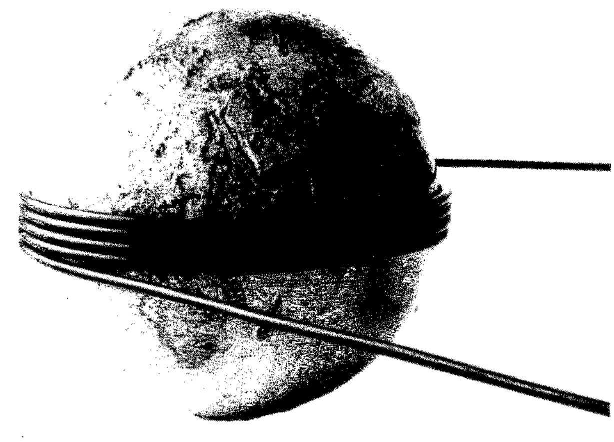
Divisione Flexider
C.so Romania, 501
10154 TORINO
tel. 011/2392
telex 221329 GILATO I

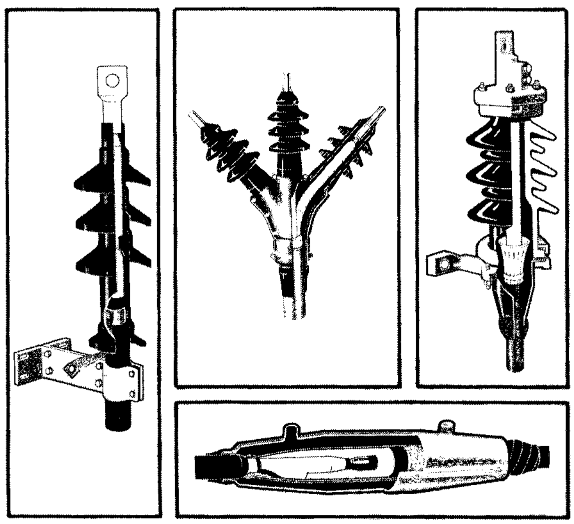


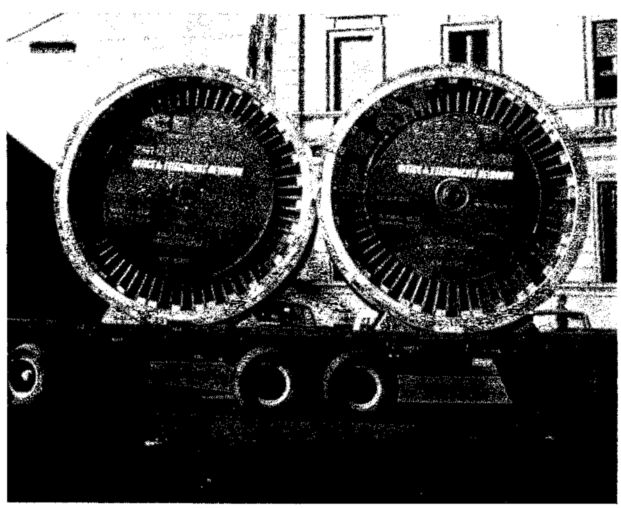
Production Line:

- Flexible Metal hoses
- Expansion joints
- Pipe hangers
- Bellows

Metal bellows for expansion joints.





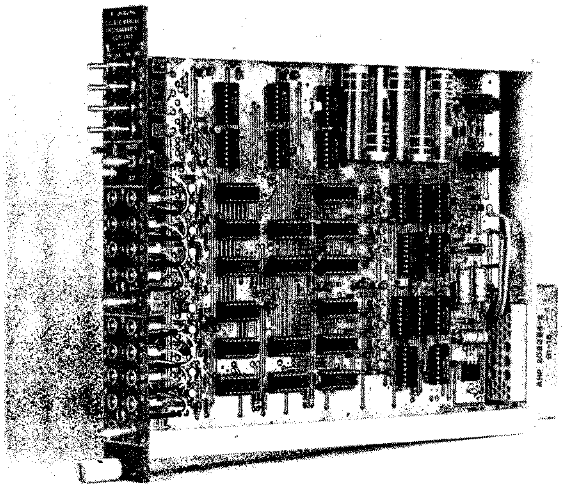


C.A.E.N. — Costruzioni Apparecchiature Elettroniche Nucleari

Via Aurelia Sud, 39
55049 – VIAREGGIO
tel. 0584/46110
telex 500454 BBI-I-CAEN

Production Line:

– Sophisticated electronics for high energy physics, in particular fast electronics instruments in both nim-camac standard, high voltage systems, micro-processor based interface systems for research and industry



Double manual programmable logic unit.

ELETTRONICA SAN GIORGIO-ELSAG

Via Hermada, 6
16154 – GENOVA SESTRI P.
tel. 010/60011
telex 270660 ELSAG I

Production Line:

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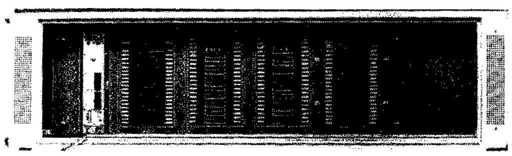
– Recognition Systems
– Robotics
– Multiprocessor for process control systems



Data acquisition system.

TELETECNICA

Via G. Matteotti, 6
06028 – SIGILLO (Perugia)
tel. 075/917120
telex 660176 IND PG I TELETECNICA

Production Line:
– Battery charging rectifiers
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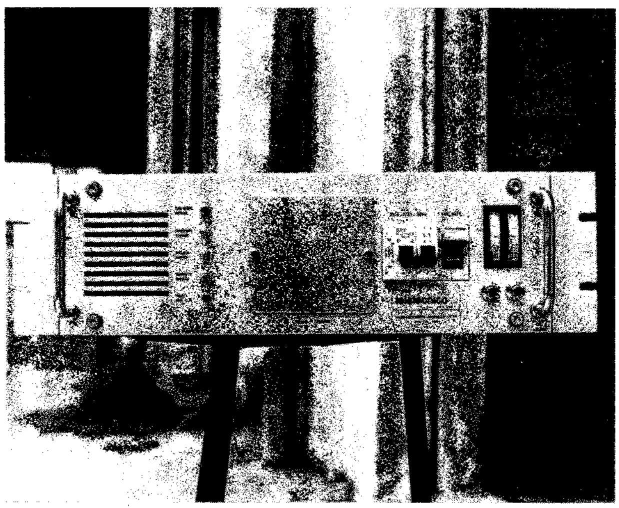
– AC-DC converters
– Small power DC-CC and DC-AC converters



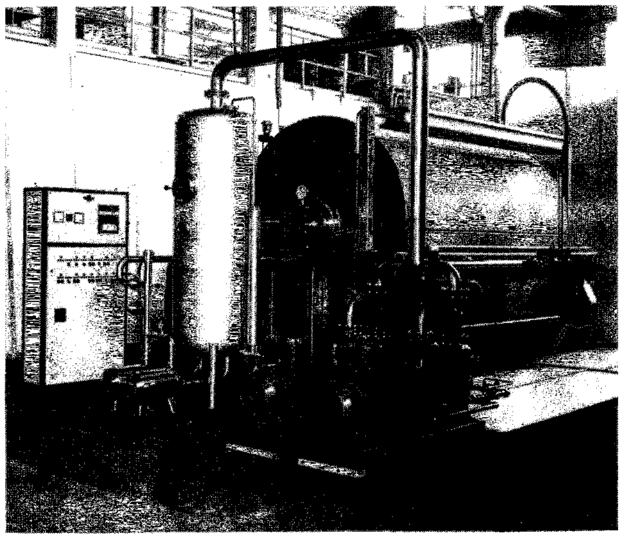
Rectifier for hermetically sealed PB-CA battery charging and for teletransmission plants feeding.

AMF — PADOVAN

Via dal Vera, 13
31015 – CONEGLIA VENETO (TV)
tel. 0438/23581
telex 410367 AMFPAD I

Production Line:

- Industrial filters
- Pressure leaf, vacuum drum, carton sheet, cartridge, filterpresses, process filtration



Vacuum drum filter.

BEMARI

Via di Santa Costanza, 27
00198 – ROMA
tel. 06/8313827
telex 680394 UNGRAN I

Production Line:
Control and protection of open areas
Each system is created to guarantee the observation of anomalous circumstances in due time and in particular: a preliminary analysis of the topographic boundaries / classifying areas in vital, reserved or in public access zones, thereby diversifying the degree of control and protection / verification of the various degrees of reliability of the existent systems available on the market / diverse solutions for the realization of plants with different methodologies so as to give the client a wider choice.
The fundamental aspects of security system are: high reliability / absence of false alarms.
The system is basically composed of the following parts: sensor-bearing fencing / closed-circuit television equipment (CCTE) / perimetral lighting installation / centralized alarm and control system

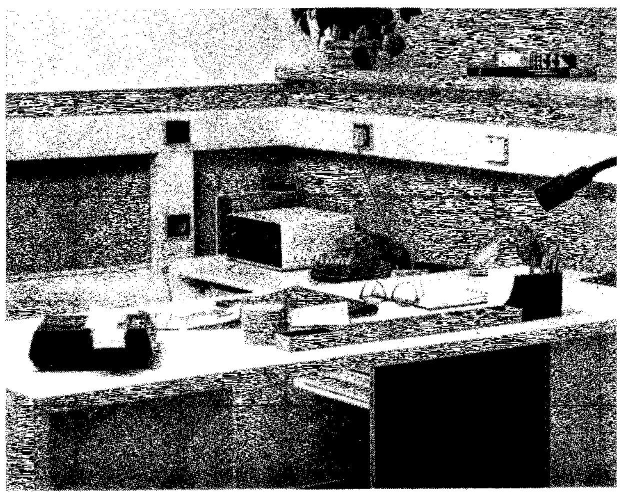
Fence protection system.

BOCCHIOTTI

Soc. per l'Industria Elettrotecnica
P.zza Dante, 8
16121 – GENOVA
tel. 010/589441
telex 571255 IBOCO I

Production Line:

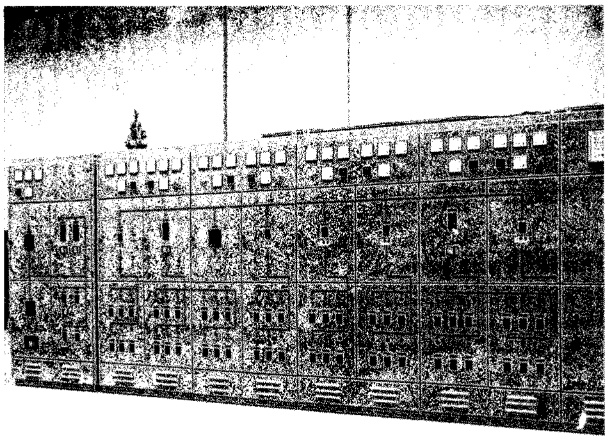
- Wiring ducts (Ductasystem)
- Installation (Conducta)



Thanks to the possibilities of assembling and its wide range of channels, this system of trunkings offers complete installation solutions.

I.M.E.S.A.

V.le dell'Industria
60035-JESI (Ancona)
tel. 0731/22284
telex 222352 IMESA I



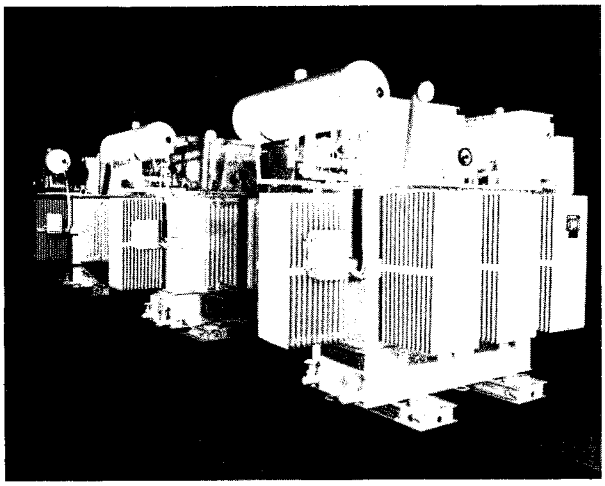
Low voltage switchboard of distribution.

Production Line:

- Modular low tension switchboards
- Modular prefabricated medium voltage switchboard 10–20–30 kV
- Copper-aluminium bus-bars
- Steel-copper pales
- Automatic power factor correction batteries

OFFICINE ELETTROTECNICHE COLOMBINI

Via R. Sanzio
20010 – INVERUNO (Milano)
tel. 02/9786023
telex 334378 COLTRA I



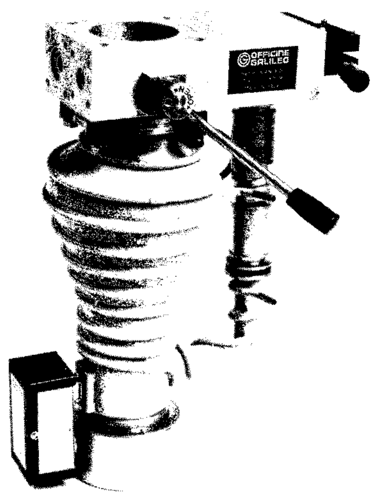
Oil immersed transformers

Production Line:

- Three-phase oil immersed transformers, 50 to 5000 kVA up to 60 kV

OFFICINE GALILEO

Via A. Einstein, 35
50013 – CAMPI BISENSIO (Firenze)
tel. 055/89501
telex 570126 GALILE I



ECOJET 63 diffusion pump with 'Manifold' valve group.

Production Line:

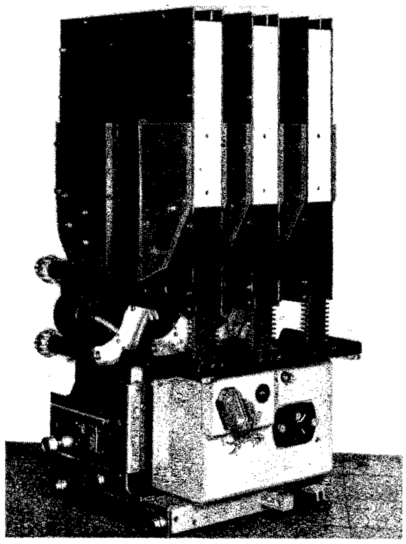
- High vacuum components

SACE
Costruzioni Elettromeccaniche

Via Baioni, 35
24100 – BERGAMO
tel. 035/395111
telex 301627 SACEBG I

Production Line:

- LV moulded case standard circuit breakers
- LV moulded case circuit breakers with high breaking capacity
- LV moulded case current limiting circuit breakers
- LV moulded case circuit breakers with earth fault protection
- LV air circuit breakers
- LV circuit breakers for specific uses
- Disconnecting switches and load-break switches for M.V.
- MV minimum oil circuit breakers (indoor and outdoor types)
- MV sulphur hexafluoride circuit breakers (indoor and outdoor)
- MV magnetic air circuit breakers
- A-enclosures for MV circuit breakers
- LV switchboards
- MV switchboards



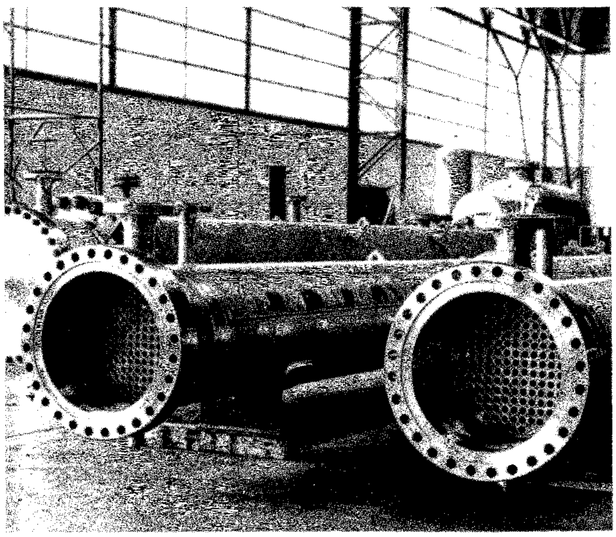
MV magnetic air circuit breaker — DIARC series.

S.C.A.I.
Soc. Costruzioni Apparecchiature Industriali

Via Europa, 7
24040 – SUISIO (Bergamo)
tel. 035/901142
telex 301350 SCAI I

Production Line:

- Pressure vessels, heat exchangers, components for nuclear plant



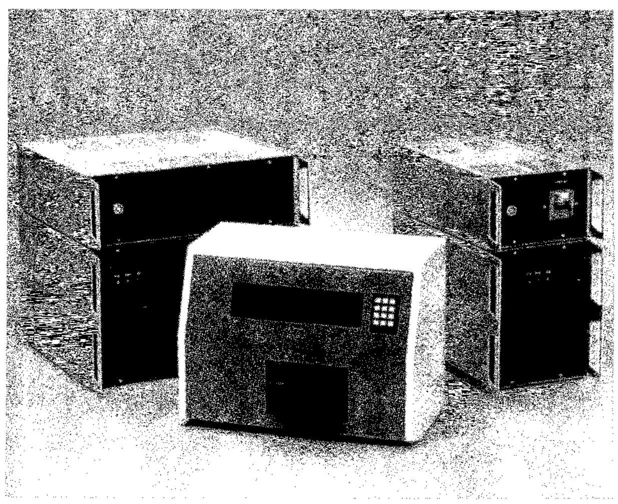
Components for nuclear field.

SOPIN — Società per l'Informatica

Via del Serafico, 200
00142 – ROMA
tel. 06/5477
telex 614132 SOPINR I

Production Line:

- Software application systems. Information systems. Office Automation.
- Security Systems (computer computed), badge readers for entrance and attendance control, video terminal, for Arabic speaking countries too.



Badge reader S 300 in conjunction with concentrator Unit S 400.

A.P.I.
SMALL INDUSTRIES ASSOCIATION
TORINO

ATLA
Lavorazioni Meccaniche Aeronautiche
Via Padana Inferiore, 44
10023 – CHIERI (Torino)
tel. 011/9472346

Production Line:
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CERRATO
Via Manzoni, 8
10092 – BEINASCO (Torino)
tel. 011/3498995
telex 221109 APITO I

Production Line: Resting or suspended bridge cranes with hoisting winch or tackle up to V FEM class / Portal cranes / Jib cranes with capacity up to 5000 kg with manual or electric rotation / Construction of intallations for material transport and storage, manual, semi-automatic or automatic travelling lifts for high-bay warehouses complete with store input and output conveyors / Oleodynamic lifting platforms, tippers / Motor-driven clutch roll conveyors step-by-step chain conveyors

E.E.D. — European Electronic Design
Via Brandizzo, 178
10088 – VOLPIANO (Torino)
tel. 011/9882778
telex 214489 EED TO I

Production Line:
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C.P.M. — Impianti Industriali
Via S. Luigi, 4
10092 – BEINASCO (Torino)
tel. 011/3497222
telex 224415 CPSI TO I

Production Line:
Internal handling system / Lifting plants / Soundproofing systems / Steel structures for industrial uses / Air conditioning plants

DEMA
Via Macello, 14
10060 – BURIASCO (Torino)
tel. 0121/56128
telex 211556 DEMATO I

Production Line:
Belt conveyors, slat conveyors, apron conveyors with metallic, hinged or overlapping pans / Overhead or floor monorail or twin-rail conveyors / Gravity, power or power-frictional roller conveyors / Platform elevators / Self moving trucks / Electrified monorails

DEMO ARMADI RACKS
C. so Lombardia, 52
10099 – S. MAURO TORINESE
tel. 011/244352/6/9
telex 213279

Production Line:
International standard 19'' size cabinets / Card baskets and containers with international DIN 41494 standards and consoles entirely made in aluminium

G.M.G. — Officina Meccanica
Strada dei Boschi, 14
10092 – BEINASCO (Torino)
tel. 011/3499280
telex 221109 API TO RIF 817

Production Line:
Prototypes / Test productions / Spare parts / Precision productions in small quantities / Automatic devices

ILMAS
Via Bruno Buozzi, 6
10090 – CASCINE VICA (Torino)
tel. 011/9592472
telex 221109 API TO I

Production Line: Mechanical high precision work for the aeronautical industry by machining centres and numerical control / Galvanic treatments as cadmium plating, alodyne, chromic anodic oxidation, black oxidation, stainstill passivation / Pickling and painting / Dimensional tests in air-conditioned room / Non-destructive test as penetrating inspection, magnetoscope, hardness test, nital

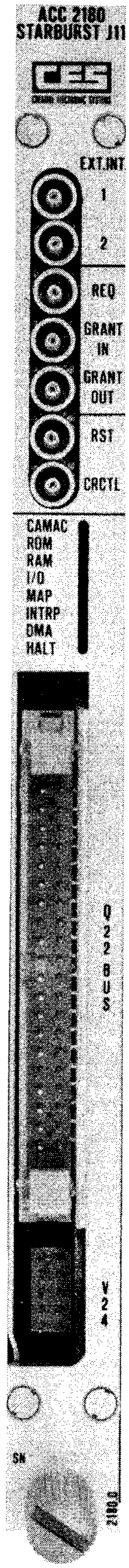
MG IMPIANTI
Via Salvador Allende, 8
10032 – BRANDIZZO (Torino)
tel. 011/9138409

Production Line:
Switchboards (carpentry and wiring), MT-BT, distribution, automation, programmable static control / On-site and shop assembly / Electric and electromechanic maintenance

PRIMA ELECTRONICS
Strada Carignano, 48/2
10024 – MONCALIERI (Torino)
tel. 011/644144
telex 212163

Production Line: Small and medium series of electronic products belonging to very complex systems / *Cards and Modules:* processing units, memories, peripherical interfaces, logical in-put/out-put, analog input/output, axis control units, power units, power supplies, racks and cabinets / *Complete Systems:* one axis numerical controls for automatic paint mixer, two axis numerical controls for optical metrology, three axis numerical controls for industrial sewing machines, four axis numerical controls for measuring robot, six axis numerical controls for welding robot, p.l.c. for automatic warehouses, testing units for cards and electronic systems / Last three years production: over 1000 systems and over 15.000 units

Creative Electronic Systems SA



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faster than a bit- slice processor?
running any PDP-11 standard software?

..then consider the new front-end processor from CES.

Super ACC 2180 Family

* CPU card providing:
  - 16/32-bit, 200ns-cycle DEC J-11
  - 64k 16-bit dual-port memory
  - RS 232C interface
  - Auxiliary Crate Controller logic
  - mixed EPROM/static RAM configuration
  - interval timer

* front- panel Q bus provides for extension cards eg.
  - coprocessors
  - crate controllers
  - memory extensions

* extensive use of CMOS technology for low-power requirements

The ACC 2180 is a single board CAMAC module built around Digital Equipment's latest 16/32-bit microprocessor, the J-11. This microprocessor is the most advanced in the PDP range; it's principal features are :

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- multiplexed data and address buses with a 32-bit internal data path
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- full PDP-11 instruction set
- 46 floating-point instructions,standard feature
- extended instruction set,standard feature

The memory bank is a full dual-port memory, i.e. it can be accessed independantly from CAMAC or from the CPU.The structure is such that the 64 K-16Bit memory can be tailored to user's requirement by mixing EPROMS and RAMs. The CAMAC addresses are memory mapped to ensure software compatibility with existing systems and for maximum throughput. The memory, CAMAC, peripherals and other resources are controlled by a PAL-based logic to ensure the fastest response time. This solution also renders the system extremely easy to "tune".

This processor is particularly suited to applications where formerly a host processor was required,such as floating-point data manipulation, or where previously only bit-slice processors have been fast enough.

The microprocessor bus is accessible on the unit's front-panel in Q22-bus form, providing easy connection of additional cards, such as peripheral controllers, memory extension cards, attached processors, etc.

The most important feature is that any PDP software can be executed in the ACC 2180 so long as it can be loaded into the ACC 2180's memory. The memory size and its flexibility in EPROM/RAM partitions renders the system extremely versatile. The unit can be used either as a runtime system without needing any additional system device, such as under MRRT-11 or RSX-11S, or as a development system with system devices attached to the Q-bus output, under RT-11, RSX-11M, RSX-11M+, etc. Application programs may be written in any DEC-supported language including the latest real-time concurrent micro-power PASCAL.

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North America:	Klotz Eng. Vancouver	Tel:(604)4647401	Japan:	Toyo Corp.	Tel:(03)2790771
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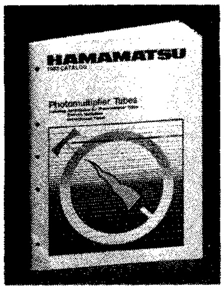
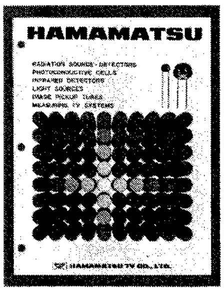
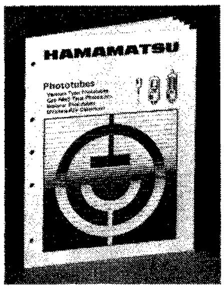


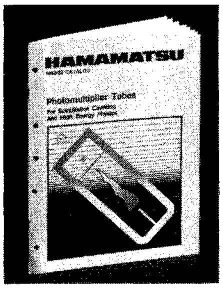
PHOTOMULTIPLIER TUBES FOR EVERY NEED This 56-page catalog details 18 PMT characteristics including spectral response, luminous sensitivity, ground polarity, dark current and hysteresis for the most complete line of head-on and side-on types, ½″-20″ in diameter. Selection guide with specifications and dimensional outlines help you make the best choice.



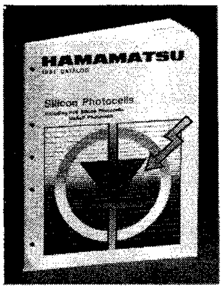
LIGHT SOURCES — High Light Output, Stability, Low Noise, Long Life This 12-page catalog provides photos, specifications, dimensional outlines, input to output characteristics and other specifications and characteristics for hollow cathode and deuterium lamps, electrodeless discharge lamps, image pickup tubes, and more.



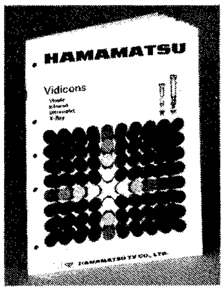
PHOTOTUBES — UVtrons, Vacuum Type, Gas-Filled, Biplanar This 12-page catalog includes a selection guide, spectral response charts, dimensional outlines and specification charts for more than 40 head-on and side-on phototubes, UV detectors, vacuum phototubes, gas-filled and biplanar phototubes.



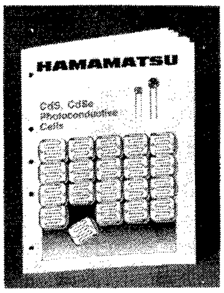
PHOTOMULTIPLIER TUBES FOR SCINTILLATION COUNTING AND HIGH ENERGY PHYSICS This 16-page catalog provides a quick reference of 25 PMT's ½″ to 5″ in diameter. Performance characteristics and replacement information are detailed.



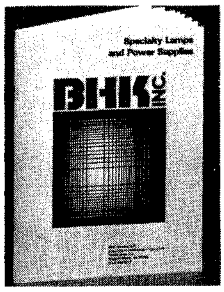
PHOTOCELLS—Silicon, PIN Silicon, GaAsP This 32-page catalog provides information about linearity, response time, leakage current vs. reverse voltage, and complete specifications for 69 UV to IR and visible to IR photocells.



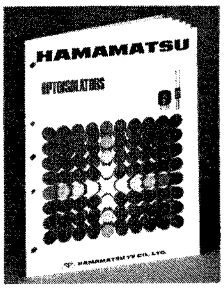
VIDICONS — Visible, IR, UV, X-Ray This 24-page catalog provides a cross reference of vidicon types and typical applications in addition to dimensional outlines, application photos and complete specifications.



PHOTOCONDUCTIVE CELLS CdS, CdSe This 16-page catalog describes performance characteristics and specifications of over 45 photoconductive cells.



SPECIALTY LAMPS AND POWER SUPPLIES This 16-page catalog describes a wide selection of lamp types including mercury lamps, germicidal lamps, grid lamps, and other specialty lamps and power supplies. A Special Lamps Request Form which allows you to specify your requirements for lamps not commonly available is included.



OPTOISOLATORS Single and multi-element LED-CdS optoisolators, LED phototransistors, Lamp CdS and opto-interrupters are described. Photos and diagrams illustrating physical characteristics and complete specifications are provided in this 12-page catalog.

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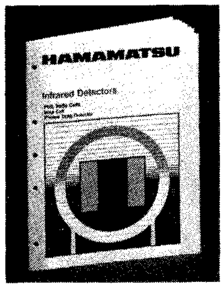

HAMAMATSU INFRARED DETECTORS —PbS and PbSe Cells, InAs Cell, Photon Drag Detector This 14-page Hamamatsu Infrared Detector Catalog features its quantum-type detectors which offer fast response time and high sensitivity. Extensive diagrams, graphs and a glossary accompany performance specifications.

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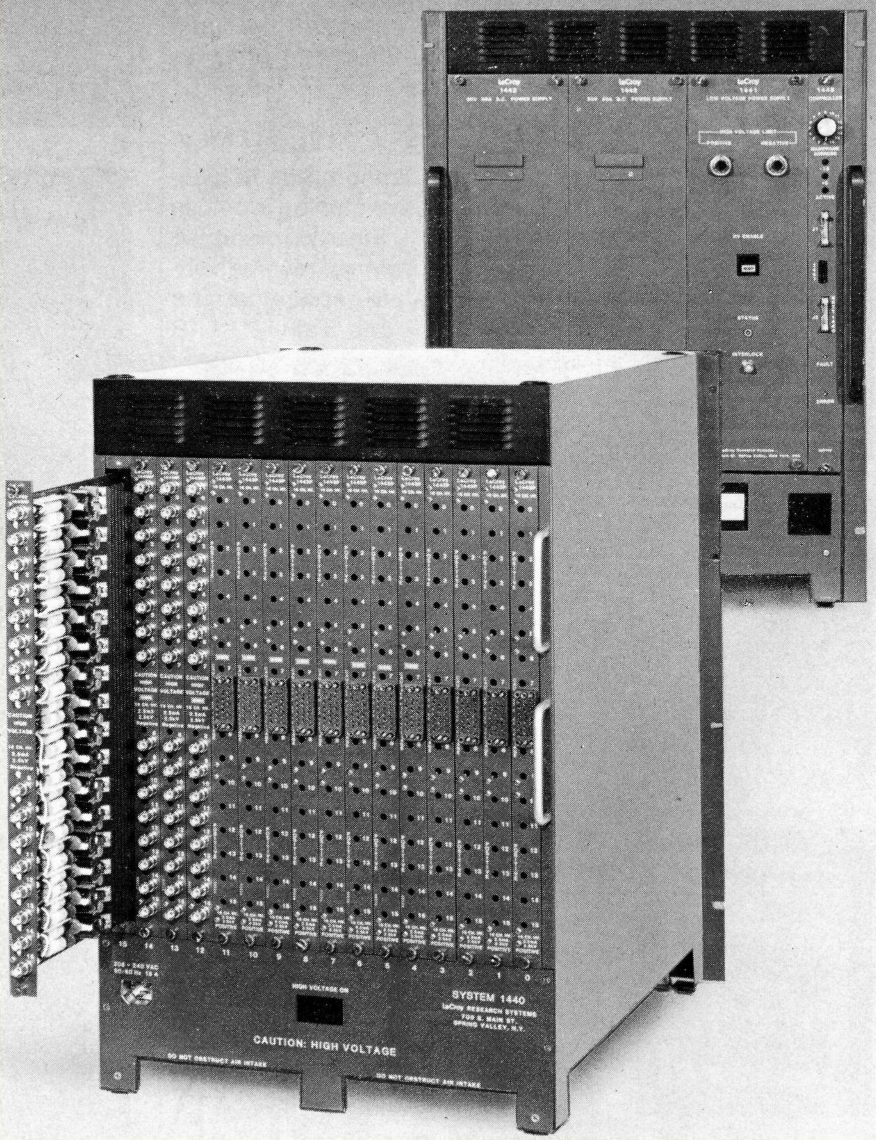

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