

News from abroad

H.A. Bethe (left) who was awarded the 1967 Nobel Prize for physics, mainly for his work on the energy processes in stars, tours the magnet ring of the 10 GeV electron synchrotron at Cornell accompanied by the Director of the Laboratory, B.P. McDaniel.

(Wide World Photo)

Cornell

Last year, the highest energy electron synchrotron in the world was brought into operation at Cornell University, USA. The project had been instigated and led by Professor R.R. Wilson prior to his moving to Batavia to direct the 200 GeV project. In tribute to his leadership, the Laboratory housing the synchrotron has been named the Wilson Synchrotron Laboratory and a Dedication Ceremony was held on 10 October.

Advantage was taken of the coming together of electron scientists from many centres to hold a short conference on the day of the dedication, at which reports on electron research were heard from Cambridge, Cornell, Daresbury, DESY, Frascati and Stanford.

At Cornell, the machine is performing well. The maximum operating energy is 10 GeV with beam currents of 3×10^{10} electrons per pulse, 60 pulses per second. The total number of people employed to operate and maintain the facility has grown to 25 with a further 20 providing various service facilities. Sixteen eight-hour shifts for experiments are run per week and an average of 85% useful running time is achieved from the scheduled hours. An external electron beam is planned for the summer of 1969.

The experimental programme began immediately electrons could be squeezed from the machine, before the machine buildings were complete, and results have already been reported. By now the programme is well under way and four other centres are collaborating with Cornell in experiments. This outside involvement is strongly encouraged and is expected to grow as use of the machine develops. The experimental programme has drawn heavily on the experience of electron Laboratories such as Cambridge and DESY, and many of the experiments are extending their work into a higher energy range. The programme is also largely complementary to that of Stanford, tackling particularly those experiments which benefit from the longer duty cycle of a synchrotron.

Experiments on the floor at present include three to test the limits of quantum electrodynamics. Two of them — wide angle bremsstrahlung, and muon pair pro-

duction — are taking data; the third — wide angle pair production — is being prepared. Measurements of rho photoproduction — are taking data; the third — energy range 4-9 GeV and this experiment is being continued to study phi production and leptonic decays. Eventually these measurements will be extended using polarized photon beams. Another experiment is looking at omega photoproduction. Finally, there is an experiment looking at pions and kaons produced near 180° over the energy range 3-10 GeV.

Stanford

Operation of the 20 GeV electron linear accelerator at Stanford USA is going very well. In a test run, the peak energy was pushed to 21 GeV and 20 GeV is the usual operating energy. The intensity is now 45 mA, which is with 90% of the design figure (compared with 15% when operation began over two years ago). This means that about 10^{12} electrons are accelerated per pulse at a repetition rate of 360 pulses per second.



Five pictures per accelerator pulse taken on the Argonne 30 inch hydrogen bubble chamber.

1. Scope traces of the ZGS field, slow Q, and beam spills.
2. Scope trace of the bubble chamber pressure drops.
3. The five pictures.

(Photo ANL)

There have been major advances in the experimental facilities during the year. A 'high-Z' spark chamber has been added to the streamer chamber set-up (see CERN COURIER vol. 7 page 219). The high-Z chamber makes it possible to detect neutral particles and thus compliments the streamer chamber making the whole complex a universal particle detector.

Two hydrogen chambers are now in operation. A 42 inch chamber has taken over 2 million photographs. An 82 inch chamber (currently the largest in the world), which came into operation in March of this year, has taken over 700 000 photographs. This chamber is, in fact, the famous Berkeley 72 inch chamber enlarged (see the story on L. Alvarez, page 315).

An important beam feeding this chamber is a high energy polarized photon beam which has been quickly brought in to use at Stanford by J. Murray, P. Klein and C. Sinclair following the announcement of a new technique for producing polarized gamma rays. The technique was developed simultaneously at Tufts University, USA, by R. Milburn and at Lebedev Institute, USSR, by M.N. Yakimenko. It involves the Compton scattering of the photons of a laser beam on relativistic electrons. The photons effectively bounce off the electrons picking up very high energy but retaining the polarization properties of the incident laser light. Polarized gamma rays of GeV energies are thus made available. The technique has been taken up at Cambridge Electron Accelerator and at Stanford and is under consideration for Adone at Frascati.

So far, eleven experiments have been completed at the 20 GeV machine and

many results were reported at the recent Vienna Conference. The current research includes 17 experiments and the programme has involved more than 100 scientists from 15 American Universities.

Argonne Multiple Pulsing

On 18 November, the 30 inch hydrogen bubble chamber at Argonne was successfully 'quintuple pulsed' in an engineering run. In this mode of operation the chamber is expanded and photographed five times during each pulse of the Zero Gradient Synchrotron (ZGS).

In an earlier test in October, the chamber expansion system was successfully tested in this mode. In the new test, the accelerator targetting system, beam-line logic, magnetic shutter and computer monitoring, as well as the bubble chamber systems, were all tested together in the five pulse mode. The interval between pictures was 160 ms and the time between ZGS pulses was 3.8 s. With some modifications to the beam shutter and camera data box, physics runs in the five pulse mode are expected to start early in 1969.

The 30 inch chamber has been the work-horse bubble chamber at the ZGS, having taken over eight million pictures so far. It is cylindrical in shape with a volume of 200 litres, has three vertical pistons, and operates in a highly uniform magnetic field of 32 kG. It was constructed at MURA and came into service in an electrostatically separated beam at the ZGS in 1964. Picture output has increased from 0.4 million in 1965, to 1.9 million in 1966, 2.4 million in 1967, and 3.5 million during the past year. In the last period a total of 18 experiments were completed, with hydrogen or

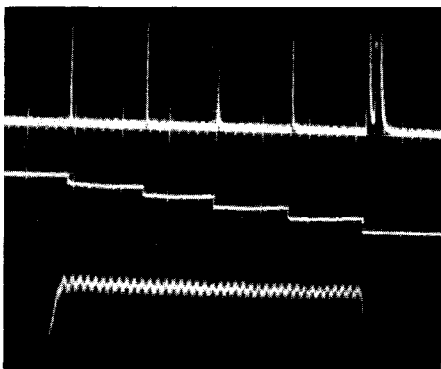
deuterium, with 70 mm or 35 mm film format, and with or without tantalum converter plates in the chamber. Double pulsing, with beam spills at the beginning and end of the ZGS 600 ms flat-top, was introduced in 1966. Triple pulsing, with an additional spill in the middle of the flat-top, was introduced last year. Up to 67 400 pictures per day have been recorded in this mode.

It has proved possible to maintain essentially the same chamber operating conditions, from single up to quintuple pulsing, with fully automatic temperature and pressure stabilization of the chamber. Set points used for hydrogen are 26.5°K, or vapour pressure of 64 psi, with the static pressure 20 psi above and expanded pressure 20 psi below the vapour pressure. Further tests are planned for higher multiple pulsing rates and optimized operating conditions.

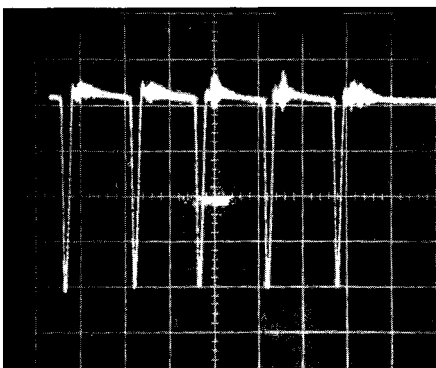
Batavia

On 1 December, a 'ground-breaking' ceremony took place at the National Accelerator Laboratory where the USA 200/400 GeV accelerator is being constructed. Over 1000 people came together, despite the snow, to attend the ceremony which took place at the intersection of the linac and the booster ring.

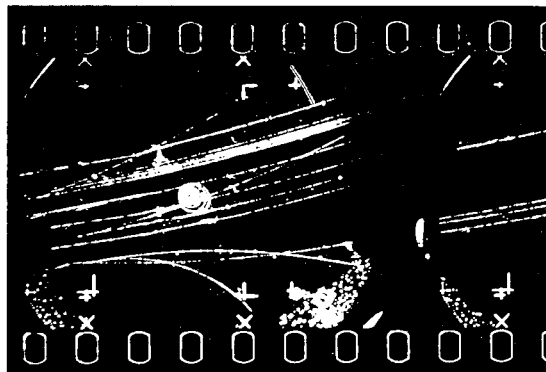
Construction of prototype underground enclosures for the Booster Ring and for the Main Ring are under way. The Main Ring prototype is 200 foot long, half the length being of steel and half of concrete to compare the two types. The detailed design of the Booster building has been completed. The building is scheduled to be ready by May 1970 to enable the



1.



2.



3.

Booster to produce 10 GeV beams by July 1971.

Storage Rings

We now have more information on the storage rings studied at Batavia which were briefly mentioned in the last issue (p. 291).

An intensive effort to design a proton-proton colliding beam facility for the 200/400 GeV accelerator began in July. In addition to the NAL staff, many accelerator physicists and high energy physicists from various universities and laboratories in the USA and a few people from CERN (G. Cocconi, E. Keil, B. Montague, W. Schnell) participated.

The bypass — storage ring concept, which had been developed during the summer of 1967, was abandoned early in the study, chiefly because the accelerator would be inoperable for normal experiments during the time that colliding beams were in use. A design involving two concentric rings with six beam intersections was adopted.

A maximum energy of 100 GeV at a maximum magnetic field of 20 kG was chosen; this field is attainable with an iron magnet, and the energy is sufficiently higher than that of the CERN ISR to make the NAL facility uniquely interesting. This choice also leaves open the possibility of using high-field (40-80 kG) superconducting magnets to store beams of higher energy (200-400 GeV) with the same ring geometry. Since the construction of the storage rings is unlikely to begin for many years and since superconducting technology is progressing rather rapidly, this may well be technologically and economically feasible at the time of construction.

Some of the other main features of the design are as follows: the average ring radius is fixed as 1/3 km. A separated function FODO lattice is used for economy. Momentum and β matching magnets are inserted in all six beam crossing regions to produce the desired beam properties at the intersection. Two of the six crossing regions, where the beams are travelling outwards, are used for injection (one for each ring). In the same regions two beam dump systems using fast kicker magnets are to be installed to dump the beams whether on command or by interlock, in case of component failure. The remaining four beam crossing regions are to be used for experimentation.

It is expected that a minimum of 20 pulses from the accelerator, at 5×10^{13} protons/pulse, could be stored in each ring to give a stored beam of 10^{15} protons (equivalent to a current of 23 A). This gives a luminosity of about $2 \times 10^{32}/\text{cm}^2\text{s}$. With an average pressure of 10^{-9} torr in the rings, the stacked beam lifetime is between 12 and 120 hours depending on the mode of operation required by the specific experiments in progress.

For the 20 kG iron core magnet either conventional copper coils or superconducting Nb-Ti coils may be used. The preliminary cost estimate for the rings, not including equipment for experiments, gives about \$ 80 million using magnets with copper coils and about \$ 70 million using magnets with superconducting coils.

Synchro-cyclotron conversion

The eighteen-year old, 380 MeV synchro-cyclotron at the Nevis Laboratories of the

University of Columbia, USA, is to be upgraded with the help of a \$4.4 million grant of the National Science Foundation.

The energy of the machine will be increased to 500-600 MeV and, by adding a spiral ridge configuration to the magnet and increasing the repetition rate from 70 to 300 Hz with a new r.f. system, the average beam current will go from 1 μA to 10-50 μA . Other improvements will include a new vacuum chamber, more shielding to cope with the increased intensity, a new extraction and beam transport system, and an enlarged experimental area.

It is hoped that the new components will be ready for testing at the end of 1969. They could then be installed in 1970 and the experimental programme restarted at the end of 1970 or the beginning of 1971.

Physicists from the TRIUMF cyclotron project in Canada (see CERN COURIER vol. 8, page 136) have carried out tests on negative hydrogen ion stripping in high magnetic fields using the 50 MeV proton linear accelerator (PLA) at the Rutherford Laboratory. Negative hydrogen ions were accelerated to the full PLA energy and were stripped in a field of 23 kG. The purpose was to check the hydrogen ion lifetime at the electric field strengths they will experience in TRIUMF; the lifetime was well known only for higher electric fields.

The tests indicated that the ions have a lifetime about three times shorter than estimated. The original design of the cyclotron had allowed for such a contingency and only minor adjustments are required to maintain the original beam specifications of 100 μA of 500 MeV protons.

