

What's on at the SC

The 600 MeV synchro-cyclotron began operation again on 11 July only a few hours behind schedule after a shutdown lasting from 8 May. The major items of work planned for the shutdown were all completed: the addition of extra shielding on the roof of the SC building, excavation work for the underground tunnel to take beams to the ISOLDE (Isotope Separator On-line Development) laboratory, modifications to the machine radio-frequency system, installation of new quadrupole lenses with remote-controlled positioning, and replacement of a variety of internal targets by a standard model.

The experimental programme, planned for the remainder of the year, can be divided into two parts according to the type of problem being investigated — nuclear structure and weak interactions.

1. Nuclear Structure

A team, led by G. Charpak, is using a positive pion beam on to targets of light nuclei (such as lithium). The interaction studied is then $\pi^+ + N \rightarrow 2p + N'$ and the energies and angles of the two emerging protons are measured. If, within the structure of the nucleus, a proton and neutron are bound, forming a quasi-deuteron, the incoming pion

moves, the slower go its 'clocks' — a phenomenon known as 'time dilation'. In the previous g minus 2 experiment, measurements were made with muons produced in the decay of pions from the 600 MeV synchro-cyclotron. They had energies of about 25 MeV and their velocity was not close to the velocity of light. Their average lifetime remained about 2.2 μ s and in fact the observation of the decays covered a time from 2 to 8 μ s.

Making use of the much higher energies available at the 28 GeV proton synchrotron, the muon storage ring experiment examines muons of energy around 1.3 GeV when their velocity is very close to that of light. The muons, by their own 'clocks' (their own internal decay mechanism), still decay after an average life of 2.2 μ s. But their clocks are going slower and relative to our clocks the average lifetime has increased to 27 μ s. It has been possible to watch the muons for times extending beyond 100 μ s and it is believed that the experiment has provided, by this observation, the first clear verification of time dilation in a circular or 'out and return' path.

Preliminary run

The experimental team are reporting in Nuovo Cimento in September the results of a preliminary run with the muon storage ring. They obtained a value for the anomalous magnetic moment of negative muons of $0.001\,165 \pm 0.000\,003$, which agrees with theory and with the result for positive muons from the previous g minus 2 experiment.

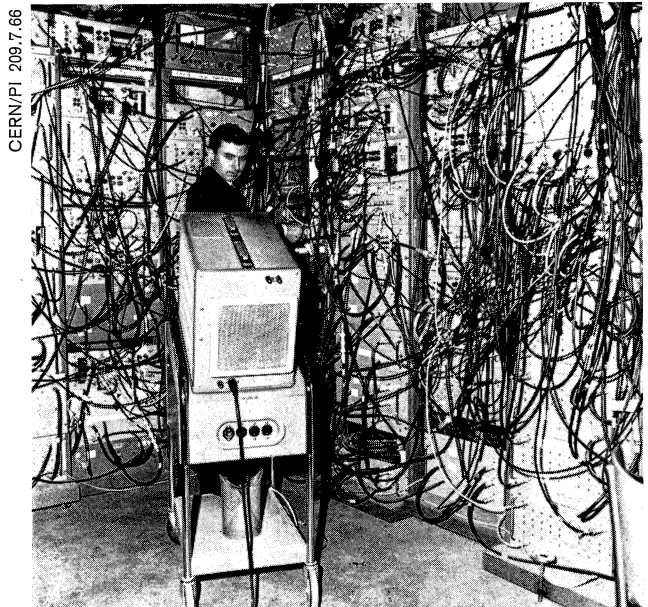
This preliminary result makes it possible to say something about the symmetry between the muon particle and antiparticle — as was already known, their average lifetimes are identical to better than one part in a thousand, their masses are identical to better than one part in ten thousand, and we now know that their g-factors are identical to better than one part in a hundred thousand.

More important is the fact that the muon storage ring is working as predicted and the team are now engaged in a run intended to achieve more accurate measurements. For the preliminary run, they used two of the twenty proton bunches from the proton synchrotron and one electron counter. They now take five bunches from the PS and use more counters, which should lead to a considerable increase in precision.

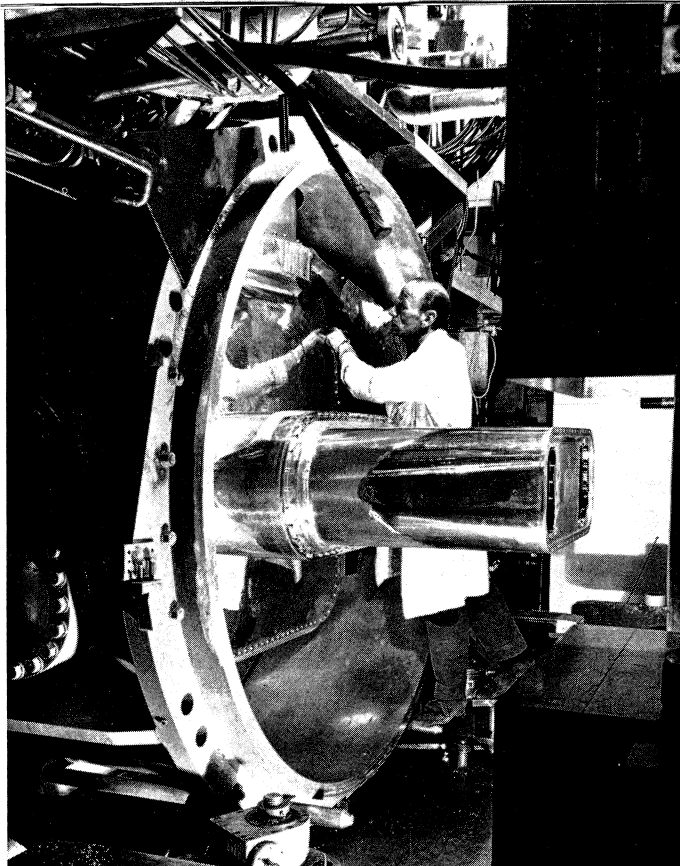
It is hoped in this way to take the accuracy of the measurement of the anomalous magnet moment an order of magnitude further. It may reveal a small deviation from the theoretical prediction. If a difference at this level of accuracy does show up, interpretation could prove difficult. It may mean that the muon is involved in some small force that the electron does not feel or alternatively that the limit of the laws of quantum electrodynamics has been reached. If no difference appears, the present muon-electron problem deepens still further and quantum electrodynamics will have been confirmed to shorter distances.

1. 'The Muon', by Sheldon Penman, Scientific American, July 1961.
2. 'g minus 2', CERN COURIER, vol. 2, no. 4 (April 1962) p. 3.
3. 'Measurement of the anomalous magnetic moment of the muon', Physics Review Letters, vol. 6 (1 February 1961) p. 128.
4. 'A new measurement of the anomalous magnetic moment of the muon', Physics Letters, vol. 1 (1 April 1962) p. 16.
5. 'The anomalous magnetic moment of the muon', Nuovo Cimento, vol. 37 (1965) p. 1241.

The familiar bird's nest of wires associated with electronic-counter experiments at particle accelerators. This particular set of equipment is being used at the 600 MeV synchro-cyclotron in an intricate experiment to examine the weak interaction by observing the capture of the muon in gaseous hydrogen. A brief description of the experiment is given on page 157.



CERN/PI 209.7.66



CERN/PI 3.6.66

Work in progress at the beginning of June on the 81 cm hydrogen bubble chamber. The chamber, which has been in operation at CERN on loan from the Saclay Laboratory in France since 1961, became the responsibility of CERN from 1 August. Since the chamber arrived it has taken over seven million photographs.

Further news about bubble chambers from France concerns a very large hydrogen bubble chamber, called 'Mirabelle', now being constructed at the Saclay Laboratory. As part of the Franco-Soviet collaboration agreement, signed during the visit of President de Gaulle to the Soviet Union in June, this bubble chamber will eventually be transported to Serpukhov to be used by joint teams of Soviet and French physicists for experiments at the 70 GeV proton synchrotron which is nearing completion.

The finishing touches being given in the West Workshop to a mirror made from plexiglass. The mirror is part of a large area Cerenkov counter assembly to be used in an experiment, being carried out by a CERN-Munich group, to investigate the electromagnetic decay of particle resonances. The Cerenkov counter makes use of the fact that the passage of a charged particle through a transparent material at a velocity greater than the velocity of light in the material sets up a 'bow-wave' of light at an angle to the direction of the particle. The detection of this light selects particles moving with velocities in excess of some fixed threshold.



CERN/PI 293.6.66

can interact with this deuteron complex. Such an interaction is characterized by the protons emerging with a unique combined energy for a particular angle. If therefore, the experiment reveals sharp peaks in the combined energy distribution, gives information about the groupings of nucleons within the nucleus. The experiment is being performed with the aid of counters and digitized spark chambers. The team obtained interesting results before the shutdown and is now extending the measurements with improved equipment.

A second team, led by C. Cernigoi, is starting a related experiment using a negative pion beam where an analogous interaction leads to two neutrons and the combined energy of the emerging neutrons is measured.

Before the shutdown, a team led by G. Backenstoss started a series of measurements on pi-mesic X-rays using a negative pion beam which is stopped in a target. Normal X-rays are emitted when electrons in orbits around the nucleus fall to lower energy levels closer to the nucleus. Pions and muons yield X-rays under similar conditions. The energy levels associated with the muons have recently been measured at CERN and other Laboratories to high accuracy. Pi-mesic X-rays have been known for a number of years, but present day pion intensities and means of analysis, particularly the invention of the lithium-drifted germanium detector with its high energy resolution, make it possible to improve substantially the existing information.

The interpretation of pion X-rays is complicated by the fact that pions, unlike electrons or muons, experience 'strong' interactions with particles in the nucleus. This results in an energy shift and a broadening of the lowest energy levels compared with the corresponding levels for the muon and yields information about the pion-nucleus interaction. For the higher levels, however, where the strong force is not predominant, it is possible to compare the results of pion and muon X-rays on the basis of purely electromagnetic forces and thus to measure the masses of the two particles.

A further experiment on the same topic is being carried out by a team led by S. Nilsson. They are using a crystal spectrometer in an experiment designed to achieve very high

accuracy. A recent pi-mesic X-ray experiment at Berkeley, USA, has yielded the accepted 'best value' of the mass of the pion. They hope to improve on the Berkeley value and also to learn something about other interactions affecting the pions.

A special beam has been set up (called the MSS beam after its designers R. Meunier, N. Spighel and J. P. Stroot) to give pion beams of very well defined momentum (± 1 MeV in 200 MeV). The beam will be used to bombard various nuclei and the energy spectra of the scattered pions will yield information about the energies which the pions give to the nuclei to lift them into higher energy states. Thus more knowledge about the excitation by pions of energy levels within the nucleus will be obtained. It is necessary to define the incoming pion beam with high accuracy and to observe the scattered pions with similar accuracy in order to differentiate between energy levels which are close together. The pion beam has now been developed to its final form.

A similar motivation, the desire to investigate the pion excitation of nuclear energy levels, is behind a series of experiments being done by a team from Oxford University led by N. W. Tanner, which concluded a first series of measurements before the shutdown. They also use a pion beam but, instead of looking at the energy spectrum of the scattered pions, they stop the bombardment and look at the β or γ rays emitted as an excited nucleus decays to a lower energy level.

2. Weak Interactions

Perhaps the most difficult experiment ever to be attempted at the SC is being carried out by a CERN-Bologna University collaboration led by E. Zavattini. The aim is to re-examine the weak interaction $\mu^- + p \rightarrow n + \nu_\mu$ where the μ^- is bound in a μp atom of total spin zero. The complications are many. In the first place the interaction happens only 1 in 1000 times as frequently as the muon decay interaction producing an electron; thus all the electron events have to be rejected. Secondly the 'muon capture' increases as the fourth power of the atomic number. Therefore, the slightest trace of heavier-element impurity in the hydrogen tends to hide the interaction that is being looked for. Thirdly, when the muon is captured by a proton it

can form a μp atom which diffuses through the gas like a neutron; if it hits the wall of the vessel containing the hydrogen it can simulate a capture event. Therefore, a way has had to be devised of preventing the mu-mesic atoms, μp , from reaching the walls.

The interaction was investigated at the CERN proton synchrotron some time ago using a liquid hydrogen bubble chamber where capture of the μ^- was observed as part of a more complex system — a $p\mu p$ molecule. The present experiment uses a volume of very pure gaseous hydrogen at eight atmospheres pressure as the target and a very clean muon beam from the accelerator. There are electrodes arranged inside the target shielding the walls and acting as a counter. All events occurring in the immediate vicinity of the electrodes are rejected. Before the shutdown, some examples of muon capture in the hydrogen were observed.

The following experiments have been approved:

A further experiment on weak interactions involving the partial capture of muons in boron by a team led by P. Macq.

An experiment on pion-proton scattering at energies around 50 MeV by a team led by P. Waloschek. It is hoped that this experiment will yield information vital to the interpretation of an experiment on the proton synchrotron where a Λ hyperon decays into a pion and a proton.

An experiment on the interaction between positive pions and deuterons proposed by E. G. Michaelis and D. F. Measday.

Administered by Computer

The contribution of the computer to scientific research is well known. Sub-nuclear physics in particular could not have reached its present state or maintain its rate of progress, were it not for the parallel development of large scale computing facilities. CERN is the biggest computer centre in Europe and its computing capacity is still growing.

Computers are also playing an increasingly important role in other fields including various aspects of administration. In 1965, a study group was set up, on the instigation of the Director of the Administration Department, G. H. Hampton, to examine the main administrative procedures in CERN and to make recommendations for the future. The study group (W. Lock, G. Minder, N. Spoonley and M. Wenner) looked at such administrative operations as purchasing and accounting, salaries, stock control, manpower statistics, budgetary forecasting and planning...

A view of the CDC 3800 computer soon after its installation at CERN in July. The operating console is in the foreground and behind can be seen the eight magnetic-tape units.



CERN/PI 189.7.66

Their conclusions, presented in April 1966, start with the observation that the existing staff and equipment will soon be insufficient to carry the rapidly increasing load and that more staff or equipment is only a short-term solution. They therefore call for a long-term solution, involving the use of a computer, to cover the foreseeable requirements of the 1970's. This is now known as the ADP (Administrative Data Processing) project.

The present CERN computers are not appropriate for the needs of the administrative operations and 13 European computer manufacturers have been invited to submit suitable systems. Representatives of these firms attended a seminar at CERN from 25–29 July to learn of the requirements and to gather the necessary information for the design of the system. It is hoped that it will be possible to decide between the various proposals by 30 November and to install the machine in the spring of next year.

Anyone fearing for his status in this increasingly electronic age may take comfort from an opening remark in the report of the study group. While recommending the computer as essential if the administrative services are to keep pace with the ever-developing activities on the site, they maintain that 'a computer per se is not a panacea for all ills; there are certain operations involving human judgement and decision that cannot be performed by the computer, and consequently... attention must be given to all parts of the system' not merely those to be performed by the computer.'

In accordance with the agreements reached between CERN and CDC at the end of March 1966, a CDC 3800 computer arrived at CERN on 16 July. (For an extended discussion of the plans for computing facilities at CERN, see CERN COURIER, vol. 6, no. 5 (May 1966) p. 90).

CERN has said goodbye to its first computer which was installed on the site in 1958. This was a Ferranti Mercury which remained the only computer at CERN until the arrival of an IBM 709 in 1960. It is still not lost to sub-nuclear physics; it has been dismantled and sent to Cracow University in Poland where it will be re-installed and used for high-energy physics calculations.

Conference organizer extraordinary

If it is a European conference and the topic is accelerators or sub-nuclear physics, there is a high probability that the administrative organization will be in the hands of Miss Steel from the CERN Conference Secretariat. Her experience and ability in this field has, this year, received a considerable tribute from the USA; she has been invited to take part in the organization of the International Conference on High Energy Physics, at Berkeley (31 August to 7 September). This conference is the 13th in the major series of conferences in our field of research, known as the 'Rochester Conferences' since the first seven of them were held at Rochester in the USA. The organizing committee approached IUPAP and then CERN to bring in Miss Steel in the capacity of 'consultant'. She left for Berkeley on 6 August.

Miss Steel began work at CERN in 1955 as Divisional Administrative Officer in the PS Division and in 1956 was involved in the organization of her first conference – a symposium on high energy accelerators and pion physics held at CERN. At the beginning of 1961, the Conference Secretariat was set up and conference organizing became a full time occupation. In 1962, she was joined by Miss Henry and together they have built up a team with wide and detailed experience in the organization of conferences. The total of conferences organized has now reached 20 and, in addition, there have been 5 CERN Schools. This tally includes such major events as the two Rochester conferences held at CERN in 1958 and 1962, the accelerator conference in 1959, and the first two of the European series of elementary particle physics conferences in 1961 at Aix-en-Provence and in 1963 at Sienna.

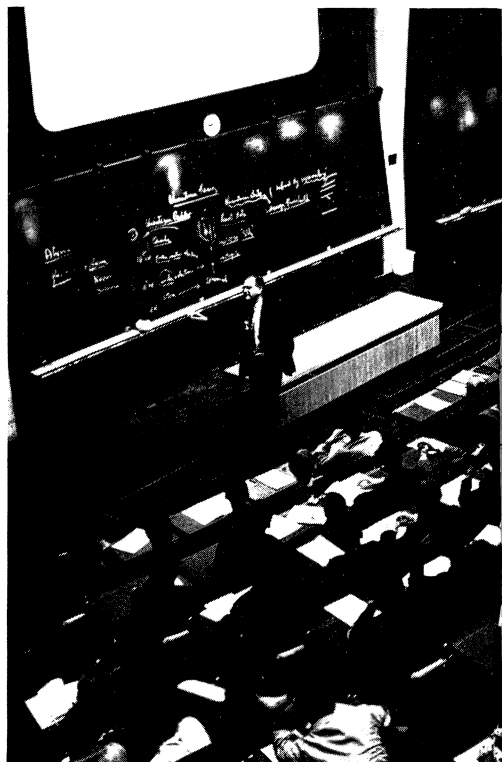
Correction

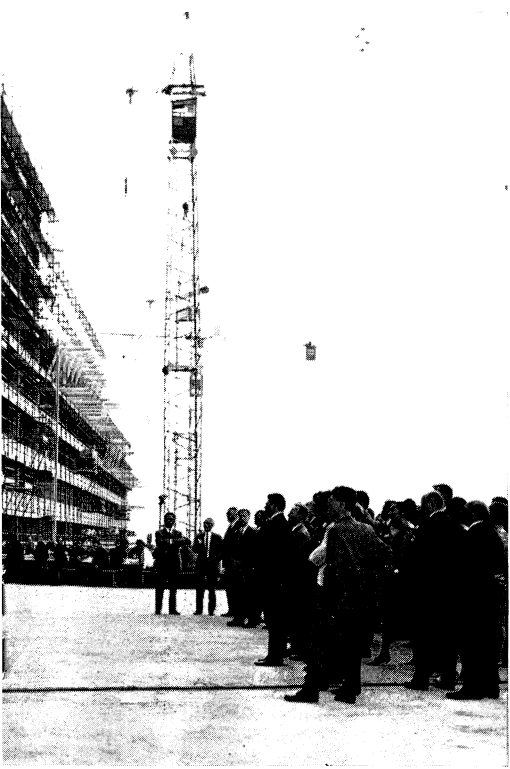
It will have been obvious to anyone who studied Figure 3 in the July issue very closely that, on one point, the ISR site layout did not agree with the figure caption and with the text. The figure showed the ISR tunnel expanded for experimental halls at beam crossing regions I4 and I5. This was a previous layout. The up-to-date figure which should have been used, shows the experimental halls at regions I1 and I4 as stated in the caption. We apologize for any confusion this error may have caused.



The scene at a ceremony to celebrate the completion of work on the housing development at Grand-Saconnex supported by the CERN. The lecture was a favour to the scientific research'. Professor Weisskopf, who has returned from the USA, arrived at CERN towards the end of June to select, from over 300 applicants, to take part in the course by their home practical research experience in the groups to which the lectures has been arranged for them. The series consists of programming, theoretical physics, experimental physics

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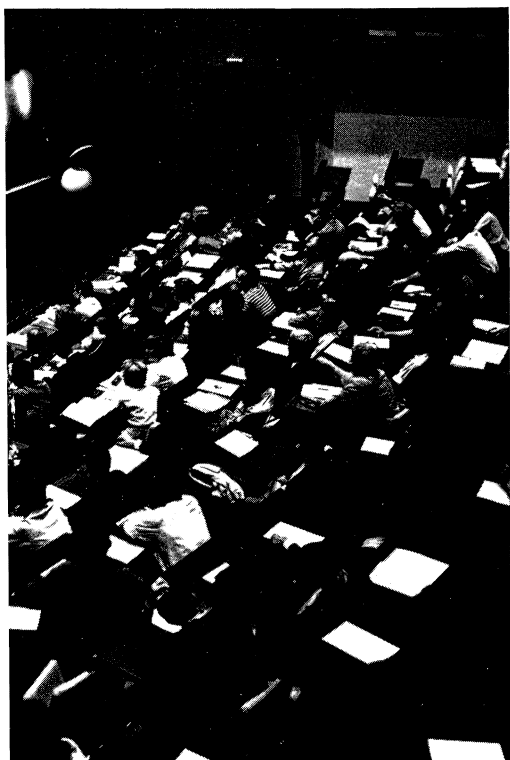


CERN/PI 208.6.66

major construction work on the first block of flats to be erected by the CERN Staff Insurance Scheme. The speaker (half of the contractors engaged on the project. The gathering (Staff Insurance Scheme), Mr. Jenny (the architect) and

end of 1965, giving an introductory lecture on 25 July to the topic of his — 'The place of high energy physics in modern science'. He was then transferred to his post at the Massachusetts Institute of Technology and several months working here.

ties and equivalent institutes in the member States were organized to receive students this summer. Another nine participants were assigned at the latter's own expense. The students gain experience at CERN. In addition, a special series of lectures of over 70 hours of lecturing time covering computer science and engineering subjects.



CERN/PI 203.7.66

Rooms at the Top

On 22 June, a ceremony was held at Grand-Saconnex to mark the completion of major construction work on the first block of flats in the housing project undertaken by the CERN Staff Insurance Scheme. The basic structure of all nine floors in this long block, which will house 284 flats, is finished and it is hoped that the first of the flats will be ready for occupation at the end of autumn this year.

Work started on the site at Grand-Saconnex on 26 April 1965. There will eventually be 550 flats in four blocks and it is intended to allocate about half of them to CERN personnel and members of other international organizations, the remainder being available to Geneva families.

The project is part of a planned programme of investment of the Staff Insurance Scheme. The programme was described in the Annual Report of the Staff Insurance Scheme for 1964. The CERN Scheme has invested 50 % of the necessary capital for the construction of the flats and the other 50 % has been raised by the Scheme outside Geneva. In this way it is helping to ease the housing shortage in Geneva, without drawing on the limited capital available in the city for building.

The ceremony was attended by Mr. Chavanne (Conseiller d'Etat in Geneva and Swiss delegate to the CERN Council), Mr. Rivoire (Mayor of Grand-Saconnex), as well as Mr. Jenny (the architect of the project), G. H. Hampton and several other representatives of the CERN Staff Insurance Scheme.

of the structure of the proton which gained Professor Hofstadter a Nobel Prize.

The improved version of the Mark III will have a beam intensity of 40 μ A (as opposed to the present 2 μ A) and a peak energy of 2 GeV. It will also have a longer duty cycle and better momentum resolution. The new machine will be built in an underground tunnel, 4 m in diameter and 200 m long, about 7.5 m below the existing machine. The earth shielding will then allow the accelerator to be operated 24 hours a day; at present, the Mark III can only be run at nights, week-ends and holidays because of the high radiation levels affecting the rest of the laboratory personnel.

A major item in the modernization programme is the construction of a very large spectrometer involving a magnet about 3.5 m radius. The spectrometer will be 12.5 m high and will be housed in an underground experimental area 60 m long, 22.5 m to 30 m wide and 18 m high. It will be possible to direct beams from the improved Mark III into this new experimental area or into one or other of the two existing areas.

An exciting prospect is that the new Mark III will be a superconducting accelerator — the first in the world. The Naval Research contract calls for further development of the research into superconductivity at Stanford and the possible application of its principles to the improved Mark III. Towards the end of last year, this research led to the acceleration of a beam of electrons in a small superconducting linear accelerator section for the first time (see CERN COURIER, vol. 6, no. 1 (January 1966) p. 15). If it can be applied successfully to big machines, it will result in higher energy for a given length of accelerator, in great savings in electrical power (though economically this will be offset by the cost of the refrigeration system), and, most importantly, in the ability to accelerate a continuous beam of particles instead of a pulsed beam. This last advantage could give a 10 000 fold improvement in the duty cycle of the Mark III.

Construction of the new machine still awaits official approval and is not expected to begin until the spring of 1968. Extensive studies of the problems connected with the underground tunnel will, however, begin at once. It is estimated that construction will take about four years.

News from Abroad

Stanford

It was announced on 30 June that the US Office of Naval Research has approved a \$ 4.4 million modernization programme for Stanford University's Mark III electron linear accelerator. The Mark III came into operation 15 years ago. It has a peak energy of 1 GeV and the most notable work with the machine has been the investigation