

The PS

Five targets were available in the proton synchrotron for the first long experimental run, starting on 21 March. They produced secondary beams of a duration as short as a few hundred microsecond for bubble chamber work or as long as almost 50 millisecond for experiments using counters. What has this stage of target development involved and what are the plans for the future?

How to use the beam

For the nuclear experiments the accelerated protons may be used in a number of ways. Some experiments can be made directly with the circulating beam, others with a beam of secondary particles created by this beam; finally one can also eject the protons from the machine and let them fall on a target placed at a convenient distance; this target may be a bubble chamber, for instance.

In the first two cases the protons are made to hit a target brought into the ring vacuum chamber in such a way that the acceleration is not disturbed earlier on in the cycle. The present targets are of this type.

Depending on the kind of experiment, the target has to yield a short or long burst of secondary particles or of scattered protons, containing just a few or many particles.

To reach this aim one must select the correct target dimensions, taking into account the nature of the physical processes occurring in the target when the accelerated protons impinge on it.

The three processes of main interest for target operation occur when a proton hits a target nucleus, misses it very closely or passes by somewhat further away.

In the first case the energy of the hitting proton is partly used to create particles like mesons, antinucleons, hyperons and antihyperons (*).

In the second case the proton experiences an "elastic scattering" due to the nuclear forces which keep the nucleus together. The mean angle of the resulting deviation of the proton orbit is of the order of

1°, independently of the target material.

In the third case, the electric charge of the proton is acted upon by the electric field of the target nucleus. The resulting deviation of the proton orbit depends on the strength of the electric field, which increases with the atomic number as well as with the closeness of approach. Thus the "Coulomb scattering" is much stronger in a gold target than in a hydrogen one, even if both targets are made to contain the same number of nuclei.

Though not directly interesting for beam production, a further process has sometimes to be taken into account: the ionisation of the target atoms by the circulating protons, which causes a loss of their kinetic energy.

What is the effect of these processes in normal target operation? As the accelerated protons move with a high speed, most of the newly created particles come out of the machine in the forward direction, the most energetic ones in a cone of a few degrees half angle and the ones with lower energies in a cone of about 60° half angle.

A large fraction of the elastically scattered protons will also leave the ring vacuum chamber, through still smaller angles.

It depends on the target material whether many protons are scattered out of the chamber by multiple Cou-

P. Collet is one of those responsible for the mounting of targets in the PS vacuum chamber. Here, he is adjusting the drive for the radial positioning of the apparatus. In the left foreground is a lead wall, at an 180 angle from the vacuum chamber, intended to collimate a secondary beam of particles from the target.



(*) See "CERN COURIER" No 4, November 1959 - and, in this issue, the article on PS Measurements.

lomb scattering or whether they keep being trapped inside the chamber by the magnetic focusing field. According to calculations by M.G.N. Hine and J. Geibel, the former behaviour is expected for heavy targets, made from stainless steel or copper, the latter for lighter ones like aluminium or beryllium targets.

The energy loss in the target causes a shift of the proton orbits towards the ring centre, due to the strong focusing properties of the CERN proton synchrotron. This shift is so small however, that the protons will normally stay inside the vacuum chamber until the beam has been lost due to the processes listed above. In contrast to what happens in weak focusing machines like the Cosmotron, the Bevatron (USA), or Saturne (France), the protons therefore go on traversing the PS targets again and again until they have either been scattered out or made a nuclear interaction.

As the interaction in the target is a statistical process, a given proton may interact immediately after target and beam have come together or only after most of the beam has been lost already. There is a good chance that most protons have interacted i. e., hit a target nucleus after the beam has traversed about 100 gram of target material per cm² surface, at right angles to the beam.

The choice of targets

The following recipes for the choice of the target heads will now become understandable.

For an intense secondary beam of short duration one takes a thick head of a material with a low atomic number, like aluminium. A large head of 1 gm/cm² (4 mm thick) will give a burst of about 200 microsecond duration.

For obtaining particles at small angles to the circulating beam — a requirement which is important for steering the beam into some

the hill and how far they go at energies from 10 to 23 GeV.

It has been calculated that all particles from the neutral beam but the muons from the decay of neutral K₂ mesons (K₂⁰), will have been filtered out. The counters sunk in the hill beyond that region, will thus act as detectors of K₂⁰ entirely unaffected by other particles. It will thus become possible to measure accurately the properties of high-energy neutral K mesons, about which little is known. Charged K mesons will also be studied through this device.

PS Measurements

(Continued from page 5)

and flying in a backward direction (figure 2 on plan). The number of gamma rays and their energy distribution will give information about the production of neutral pi mesons by the 25 GeV protons hitting the nuclei of the target.

* * *

The so-called Mount Citron is the earth mound looming between the PS south experimental hall and the French border. Its thickness at the

base is about 52 metre in the general direction followed by the beams from the machine. Arne Lundby and his group - L. Gilly, B. Leontic, R. Meunier and J.P. Stroot—will, in collaboration with Prof. Peters of Copenhagen, conduct there one of the two experiments they intend to make around the PS (fig 6 on the plan). Twenty holes are being drilled vertically into Mount Citron down to the level of the beams coming out of the accelerator. Counters lowered into the holes will measure the number of muons (mu mesons) entering

targets

K. H. REICH

by PS Machine Group

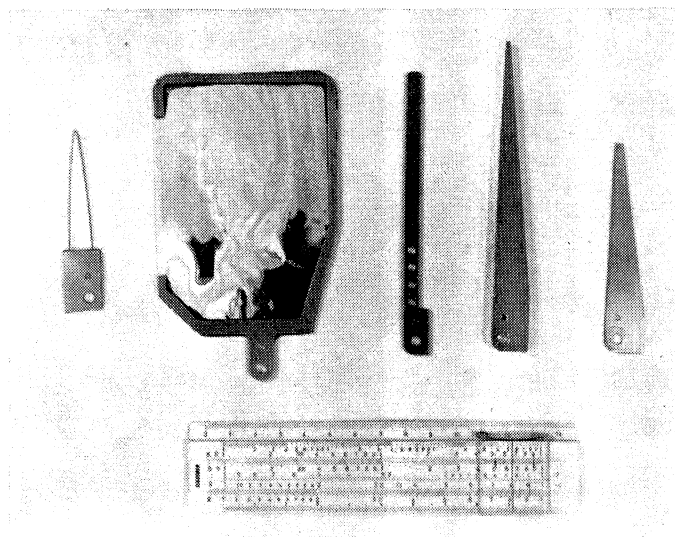
types of ejection apparatus or when making certain emulsion plate exposures—one selects the target on the basis of its scattering properties.

If in need of a long burst of particles, one uses a very thin target. A large aluminium foil of 10 milligram per cm^2 (about 0.04 mm thick) will give a burst of roughly 20 millisecond duration, while a foil of 1 mgr/cm^2 (about 0.004 mm thick) will produce a burst of about 200 millisecond.

For various reasons targets have often to be smaller than the cross-section of the vacuum chamber and then the rules of thumb given above no longer fully apply, since the protons will miss the target every so often. Again, the influence of the target operation on the radio frequency acceleration system has not been considered so far, though it may be of great importance.

Work on the present targets started late last summer under the direction of G.L. Munday. The target mechanisms were designed by H. Horisberger's drawing office and manufactured at the Main Workshop. Each mechanism contains two heads, which can be flipped into the beam by means of an electro-magnet. The transistorised controls allow one to choose the moment of flipping up and to vary the stay up time between 10 and 300 millisecond: the actual flipping takes only about 20 millisecond. Furthermore the final radial position of the target (or the vertical position if it is built in vertically) can be controlled from the main control room where the position of the head is also indicated.

From a great number of conceivable methods, two are mainly used now for bringing beam and flipped up target together: kicking the beam onto the target by means of the magnetic radio frequency deflector designed by M. Geiger, or letting



A set of target heads showing, from left to right: a 0.5 mm stainless steel wire and a 0.04 mm aluminium foil; the other targets are made 2 mm copper, 3 mm aluminium and 1 mm stainless steel.

the beam spiral onto the target under the action of the main magnetic field.

The first method is used for bursts of short duration, as it is easier to create and to control a rapidly increasing magnetic field than to create and control a correspondingly fast motion of a target weighing, say, 100 gram, the speed of which may reach several hundred km per hour.

The spiralling method is used for counter work, where it is important to remove the radio frequency from the beam. To this effect one takes away the action of the radio frequency system at the end of the accelerating cycle and then lets the debunched beam spiral onto a suitably placed target of aluminium about 0.01 mm thick. Incidentally, the best heads have been made so far of a foil previously used for wrapping up cigarette packages.

Another method designed to provide a burst of constant counting rate, is at present under study. It consists in bringing the beam onto the target by means of a servo-system acting on the control of the radial beam position which is steered from a counter telescope. Ch. Schmelzer and W. Schnell have already obtained interesting results from these and other beam gymnastics.

Besides the construction of faster and heavier targets the target programme foresees a detailed study of the effects of target dimensions and materials on the properties of the secondary beams, the elaboration of more refined methods for beam sharing, and production of bursts of constant intensity by means of radio frequency adjustments.

Future developments

Another line of development is the programming of the target controls. It is hoped to produce in the future not only several still shorter or still longer bursts from one pulse, but also to obtain them almost automatically in a prearranged order.

Looking further ahead one sees the ejection schemes come into operation. They are at present being worked on in C.A. Ramm's group by F. Krienen, B. Kuiper and G. Plass. In the not too distant future the Machine Group is expecting to see the main magnet power supply modified. It will then allow production of particle bursts of constant energy of several hundred millisecond duration. This will be of great interest to counter people.

Finally it must be said that the target work has already greatly benefited from the active co-operation of the physicists and with further joint efforts the CERN proton synchrotron will certainly be exploited more and more effectively.



Transmission measurements of negative mesons and antiprotons with energy above 15 GeV through hydrogen and deuterium targets is also prepared by the same group, independently from the Mount Citron affair. A target will be placed between magnets 1 and 2 (see plan) Measurements performed in the south experimental hall will be done mainly with a gas Cerenkov counter similar to the one used by the von Dardel group.

Simultaneously with some of the

preceding experiments G. Rudstam, E. Bruninx, P. Estrup and K. Goebel have made **irradiation experiments**, getting copper and aluminium targets irradiated and determining the yield of the different isotopes formed in them.

The large **150 cm cloud chamber** now being built, will later be used by another group of SC experimenters: Prof. Preiswerk, P. Astbury, R. Fortune, A. de Marco, L. Solinas, and C. Verkerk. Similarly C.A. Ramm and his group (J.J. Blee-

ker, P. Innocenti, G. Muratori, B. de Raad, L. Resegotti, R. Salmeron and R. G. Voss), will use the **1 m propane bubble chamber** now being assembled near the PS workshop.

Except for the last two, all the groups mentioned have already done some work with the machine either on duly allocated nuclear physics time of the machine, or "parasitising" each other or on machine running-in time, i.e. making use of the beam produced while the Machine operation Group conducts further tests of its accelerator ●

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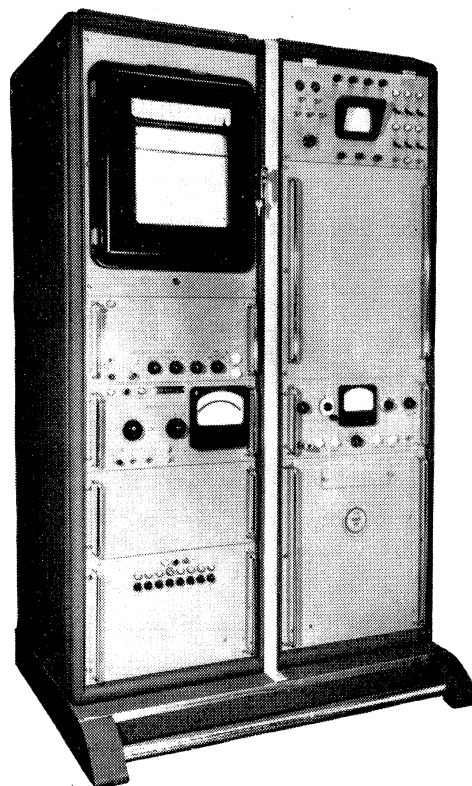
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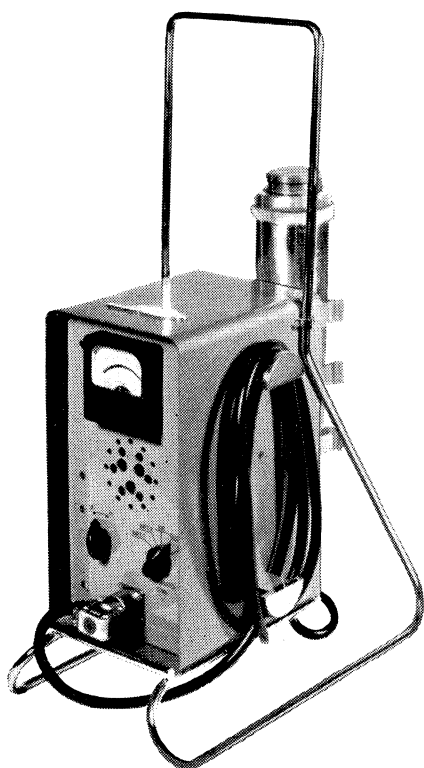
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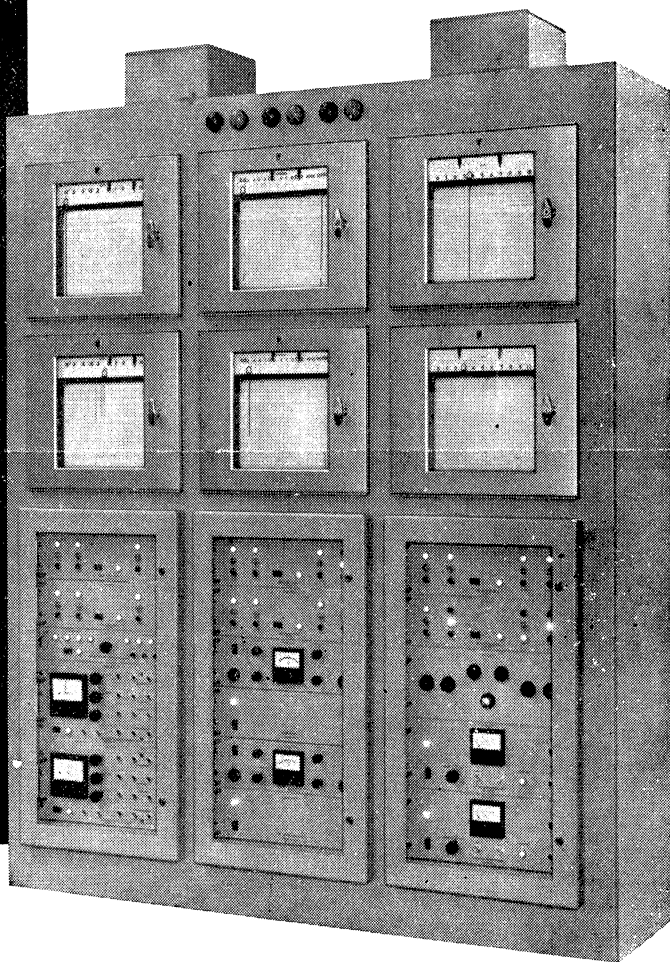
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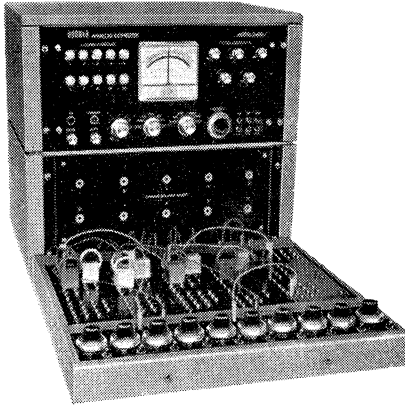
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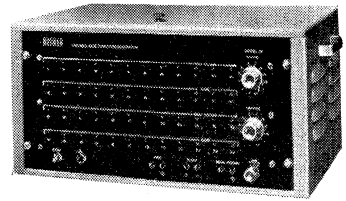
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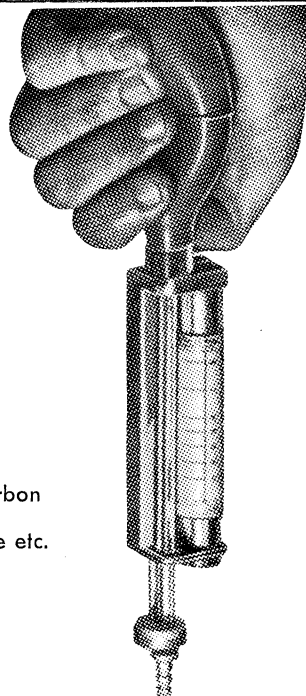
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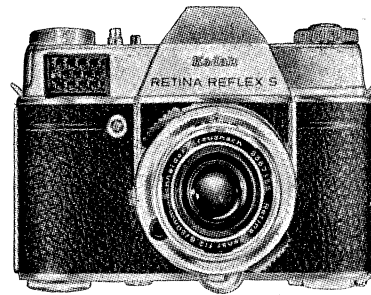


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