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THE EXPLOITATION OF THE ^{12}C BEAM FROM THE SC

B.W. Allardyce

1. Introduction

This note describes how it is proposed to distribute the ^{12}C beam from the SC to the various experimental groups who will use it. The proposal is the result of discussions with the groups and with SC staff, in order to accommodate the new experiments without causing too much inconvenience to the experimental groups already using the SC; budget considerations have also played a not inconsiderable role in its formulation. The beam optics were calculated by B. Hedin and the shielding estimates were made by J. Tuyn.

2. The experimental zones

The accelerated beam of $^{12}C^{4+}$ ions will be extracted from the SC and transported to the underground area for use by the Isolde group. Alternatively the beam may be stripped to the 6^+ charge state and then sent into the Proton Hall to either of two zones (A and C). Three experiments have already been accepted for installation in the C zone (SC 83, 84, 85) and one experiment, which is part of the Isolde programme, will be installed in the A zone. One further proposal has also been received but not yet accepted.

2.1 The underground area

No change is necessary to what already exists in order to transport the 85 MeV/N beam of $^{12}C^{4+}$ ions to the underground area. However for the use of the beam by Isolde the end window must be reduced in thickness to 25μ stainless steel, and the air path before the Isolde target has to be reduced.

2.2 The SC hall

Several modifications are necessary to the equipment installed in the SC hall in order to permit the carbon beam to be sent into the Proton Hall via the A pipe or the C pipe, whilst not compromising the beam possibilities of the groups who now use protons or ^{3}He. In addition, because the SC hall is a highly radioactive area, all interventions must be kept to a strict minimum.

The solution adopted is shown schematically in Fig. 1. The existing MP/LG chariot is used as at present for changes between Isolde and Proton Hall operation. In the case of Isolde the SC vacuum extends along the beam line to the Isolde area; in the case of Proton Hall operation the SC vacuum ends in a 25μ stainless steel window after the lens LF1. This window also serves to strip the beam to $^{12}C^{6+}$, which is necessary for transporting the beam to the Proton Hall since the lens strengths and magnet bending powers are limited.

For use in the Proton Hall the carbon beam is focussed to a small spot by the lenses LA1, LA2 and LF1, and a collimator of 4 mm diameter acts as the object point for the subsequent optics. The beam in this region passes through air for a distance of about 10 cm and then enters the secondary vacuum through another 25μ stainless steel window. If desired, for operation of the beam in the C zone, a degrader may be inserted in this air gap in order to reduce the energy. Tests will be made to determine how far the energy can be reduced in this way but in any case multiple scattering will result in the transport of a reduced intensity beam at lower energy.

The beam may pass straight through the magnet MP5 towards the A zone or alternatively it may be deflected 30^o towards the C pipe. The vacuum in these beam lines is provided by two-stage Rootes pumps, one in each branch, and it is anticipated that these will produce a vacuum of $\lesssim 10^{-3}$ torr in the line. An additional pump may, however, be added closer to the target in the C zone.

A quick change-over in the SC hall is possible between Isolde and either of the A or C beams, with only slightly more operator intervention than is necessary now for similar changes during proton or ^{3}He acceleration. The change-over between the A and the C beams requires no entry to the SC hall. Thus in a time of about half a shift (in normal working hours) it should be possible to switch between any of the beam areas.

2.3 The A zone in the Proton Hall

The proposed zones in the Proton Hall are shown in Fig. 2. It is intended that the A zone should be left in place when the SC returns to accelerating protons or ^{3}He. The (heavy concrete) shielding for the A zone is calculated to be adequate for a beam of 10^{11} ions/sec at the full energy of 85 MeV/N. The zone is covered with a roof of 1.2 m thickness and inside the bunker the ceiling is 2 m above the floor. The space available inside the zone is restricted due to the small dimensions of the Proton Hall, and to the maximum permissible floor loading. Any apparatus to be installed in the zone should be designed such that it may be removed through the door, or alternatively that it can stay in place for long periods once installed; this is because the opening of the roof is a time-consuming operation and one which, during carbon runs, will require the SC to be off.

It is intended that the A pipe (until now blocked with iron plugs when not in use) will be left open for the duration of a carbon period and that a liner tube will be installed inside the existing pipe in order to allow better vacuum conditions. This liner tube will be removed and the A pipe reblocked with plugs at the end of a carbon period, so that during proton or ^{3}He acceleration the A zone has no access restrictions related to the beam. During carbon acceleration, however, and once the A pipe has been unblocked, access to the A zone is only allowed when the SC beam is off. This may cause problems for the setting-up of an experiment in the A zone prior to a run. Such problems may be minimised by careful scheduling, for example by unblocking the A pipe only at the end of the first week of carbon running in Isolde (rather than at the beginning of the carbon period) and by co-ordinating access to the zone with scheduled machine stops.

The beam calculation for the A beam is shown in Fig. 3. This represents the envelope of the beam assuming an initial spot size of 2 mm in each plane (defined by the collimator after lens LF1 referred to earlier) and a divergence of 2.5 mrad in each plane (given by a combination of the assumed inherent beam divergence and the scattering produced by the two windows and the air gap). The inherent momentum spread of the beam in fast burst operation is expected to be of order ± 0.5 %. It will be seen that the beam is focussed at the target position, and this will be verified with a screen placed in air behind the end window, and viewed by TV.

2.4 The C zone in the Proton Hall

This zone, which is also shwon in Fig. 2, is much larger than the A zone in order to accommodate the counter experiments, the space available for apparatus being 3.8 m wide and about 5 m long. The shielding is designed to permit a beam of 10^{10} ions/sec at the full energy of 85 MeV/N. Lower energy beams (for example to 40 MeV/N or lower) may also be obtained in this zone, the degrader being placed after lens LF1 (see Fig. 1). The roof is constructed with 40 cm thick girders of heavy concrete placed so that everywhere over the experimental apparatus the ceiling is 2.4 m above the floor. If required, lifting tackle could be installed above the targets to remove scattering chamber cover plates.

As for the A zone, the construction of this zone requires the manipulation of a great deal of concrete, but unlike the A zone it can only be completed at the beginning of each carbon period and it must be partially dismantled at the end of each period in order to allow the installation of the beam lines for the proton users. This implies certain scheduling constraints at the start of a carbon period and means that the proton users will have no beam in the Proton Hall for about 2 weeks before and after each carbon period.

It is necessary for each experimental apparatus to be moved quickly into or out of the C zone, since at least three different groups will be using it. The end of the zone closest to door P1 will be dismantled each time an apparatus has to be moved, and this operation takes about half a day. Reconstruction of the zone will take about the same time. Each apparatus should be mounted on wheels so that it may be pushed into place, or alternatively a fork lift truck may be used to carry the equipment into the zone. Various alignment marks or sockets in the floor can be provided.

As noted previously, the beam line vacuum will be better than 10^{-3} torr provided by Rootes pumps, but it is understood that each group will provide additional pumping at its own apparatus, including fore-pumping. The scattering chambers will be connected to the beam line after a valve. An additional pumping part will be provided after the bending magnet MP7 to which further pumps may be attached if required.

A liner tube will be installed in the existing C pipe in order to obtain the vacuum of 10^{-3} torr, and thereafter the C pipe will never be blocked with iron plugs. Access to the C zone during a carbon run in that zone will be allowed only when the SC beam is off, but access will be allowed freely during

Isolde or A zone operation by virtue of the beam blocker and interlocks to be applied on the magnets MPI and MP5. When the machine returns to proton on ^{3}He acceleration, however, there will be constraints additional to those presently operating, due to the fact that the C pipe is not blocked. Beam changes between Omicron and μSR can then only take place when the SC beam is off, and this will have to be taken into account in the schedule.

The beam calculation for the C zone is shown in Figs. 4 and 5. Figure 4 shows the beam envelope with an initial spot size of 2 mm in each plane and an initial divergence of 2.5 mrad in each plane. As for the A beam calculation of Fig. 3 the initial spot size is defined by a collimator after lens LF1, and the divergence is a combination of an assumed inherent beam divergence and the scattering produced by the two windows and the air gap. The calculation includes a momentum bite of ± 1 % which is assumed to be the inherent momentum spread of the beam extracted using the Kim coil (i.e. with good duty cycle). The situation shown in Fig. 4 therefore represents what might be expected for the case of the full energy beam of 85 MeV/N delivered into the C zone to the counter experiments. In fast burst mode (poor duty cycle) the inherent momentum spread in the beam is expected to be ±0.5 %.

Figure 5 shows the envelope for different assumed initial conditions. The initial divergence of 7.5 mrad is defined by a collimator placed after lens LG2, and a momentum bite of ± 2 % is chosen. This represents what might be expected in a typical use of the degraded beam.

The momentum bite is selected by means of a remotely-driven slit placed after the main shielding wall where the momentum dispersion of the beam is 1.5 cm per %. A maximum momentum bite of ± 3 % is possible with this slit, within the divergence of 7.5 mrad defined by the LG2 collimator.

Two beam observation boxes for setting up the beam are included in the C line, one in the SC hall after magnet MP5 and one just upstream of the targets. These will be equipped with screens viewed by TV, or, if resources allow, with profile monitors in the form of planes of wires intercepting the beam and displayed via a CAMAC system. In addition, a TV will be available to view the spot produced at the target.

3. Time scale and schedule

The first tests of the $^{12}C^{4+}$ beam are scheduled to take place in June 1979 when various cross-sections and beam quality measurements will be made in the SC hall. No attempt will be made at this stage to send the beam into the Proton Hall.

It is hoped to have the first scheduled period of carbon operation towards the end of 1979. Thereafter the carbon periods will be scheduled by the Co-ordinator following requests from groups, but as a guide it is assumed at present that for overall efficiency of machine utilisation these would be about 2 months long and would recur about twice each year.

The first operational carbon period will be preceded by a shutdown of about 2 weeks' duration necessitated by the modifications in the SC hall described above. Subsequent periods would need shorter installation times of about a week. However, a carbon period will always start with Isolde or A zone operation since the C zone will not be ready.

4. Accommodation of the electronics for carbon users

It is seen clearly in Fig. 2 that there is no space available inside the Proton Hall for the groups themselves or for their electronics and computers. These must therefore be housed elsewhere, for example in caravans outside the hall. The SC does not possess its own caravans, but assuming these to be available at CERN, fig. 6 shows how they might be positioned near to the Proton Hall (in agreement with the site safety and transport groups).

5. Implication for other SC users

These proposals result in certain complications for other SC users which are spelled out below.

a) μSR

It is proposed to move the magnet containing the μSR target to a position about 1.5 m downstream of its present location. This new position is indicated on Fig. 2 where it will be seen that the apparatus is then unaffected by the construction of the C zone; it is only the beam line which is modified, and beam calculations will be required. The present cryogenic equipment of the group will have to be moved but the group intends in any case to make changes which can take account of the new C zone shielding. The μSR electronics will also have to be removed and it is proposed that this be housed in a caravan adjacent to the door P1 (see Fig. 6).

b) Omicron

The C zone requires side shielding additional to that presently separating the Omicron zone from the μSR zone. The installation of this shielding will require the Omicron magnet to be fixed at a certain angle, as shown in Fig. 2. However (subject to confirmation by the radioprotection service) access to the Omicron zone is allowed during carbon periods. The area occupied by the gas supply system for the Omicron chambers must be slightly modified, but this does not seem to be a problem. Finally the several racks of high voltage generators presently installed against the Salève wall of the Proton Hall may have to be removed since they will interfere with the detectors of the Orsay group working in the A zone.

c) CERN-CNEN

The bio-physics experiments carried out in neutron beams by this group can in principle be accommodated in the A zone, but it is not yet clear how much space will be available if the Orsay group's equipment stays in place at the end of the carbon period. In addition it should be noted that no sweeping magnet can be installed in the A zone.

d) Cagliari-Strasbourg-Turin

The group uses the B pipe to transport the pions produced when a ^{3}He beam interacts with a light-element target in the SC hall; these pions are of high momentum, up to 750 MeV/c.

A minor modification to the shielding of the new A zone is necessary for the installation of the group's equipment in the same place that it now occupies, and this does not seem to be a problem during a period of ^{3}He acceleration.

However, the group has also expressed an interest in making similar measurements with the carbon beam. Unfortunately, during carbon operation the installation of the group's equipment in the usual place is incompatible with the existance of the A and C zones in the Proton Hall. A solution might be for the group to use the C zone for their experiments, but it is not yet clear whether this would be acceptable: certainly there would be scheduling implications, since a beam change inside the SC hall would be necessary.

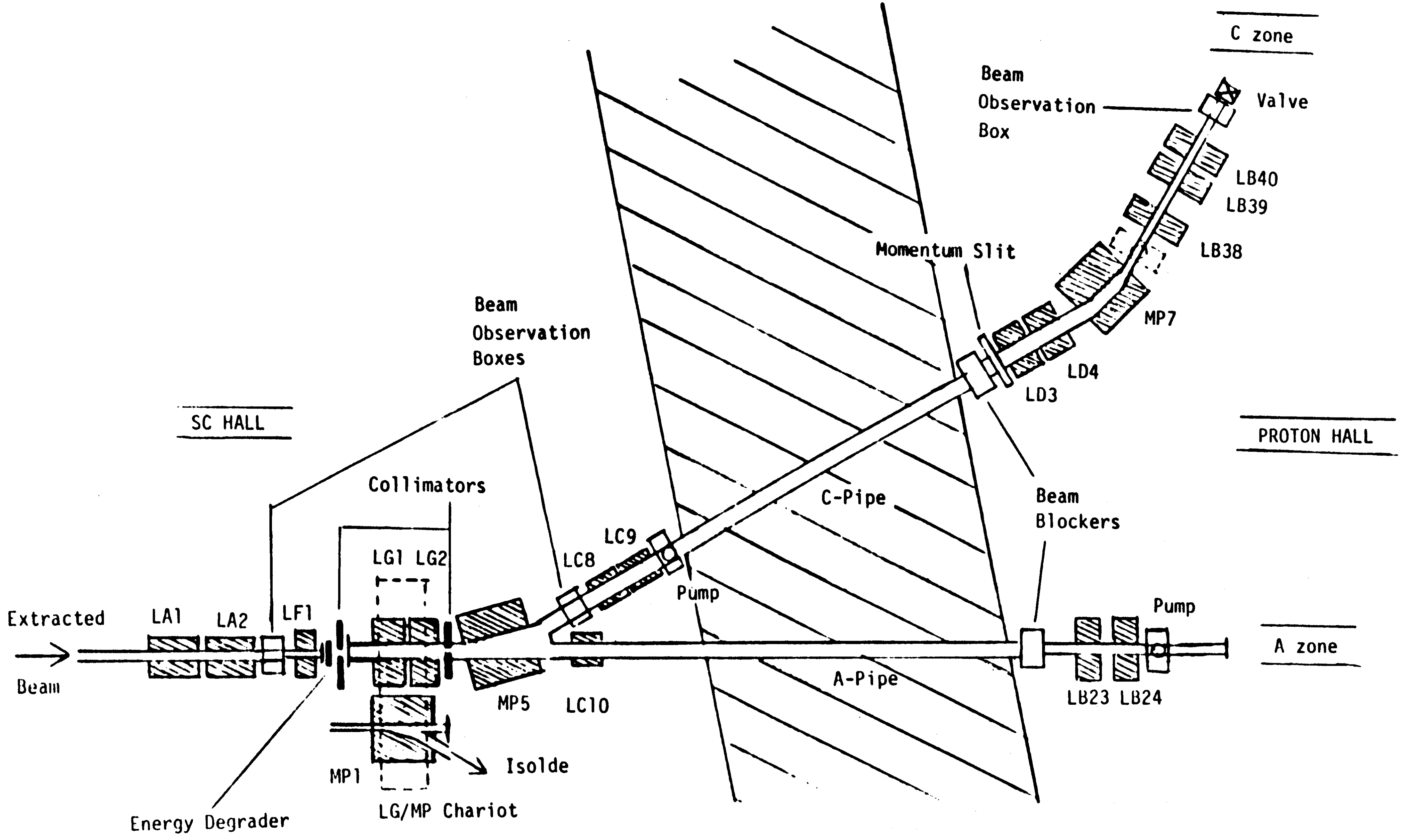


FIG.1

SCHEMATIC BEAM LAYOUT

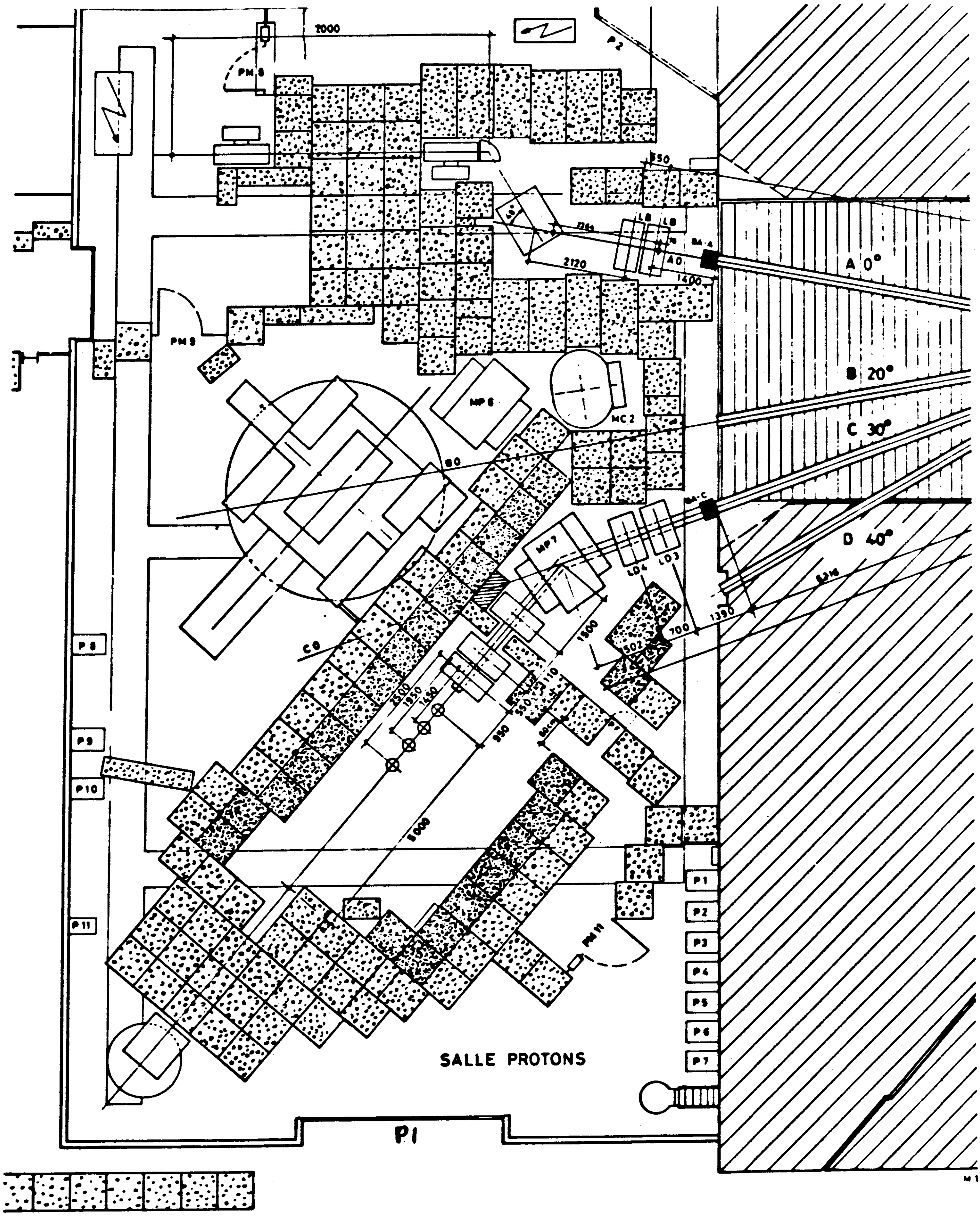
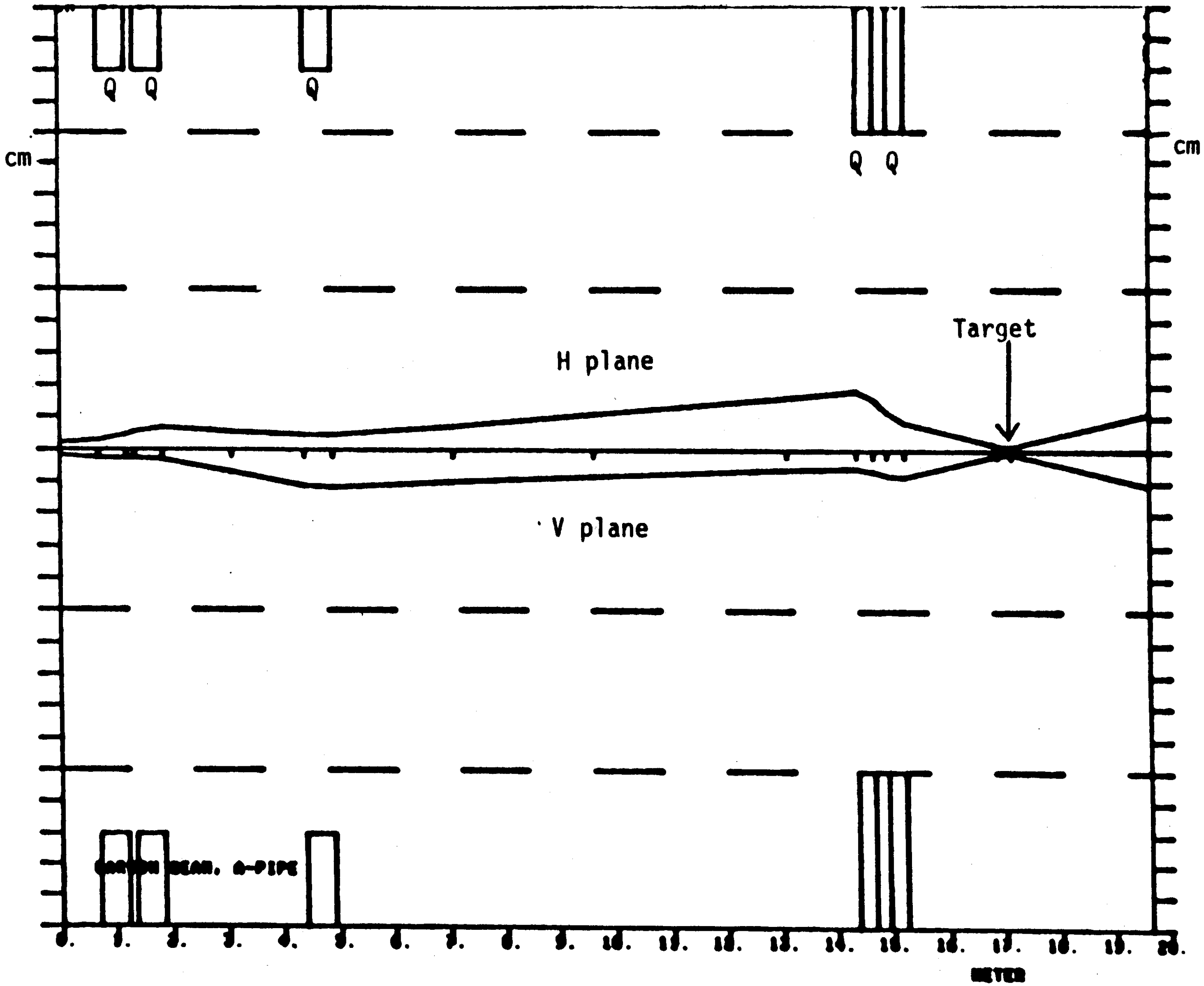


FIG. 2

BEAM LAYOUT IN THE
PROTON HALL

Assumed initial conditions:

size ±2 mm
divergence ±2.5 mrad
in both H and V planes.



Conditions at target:

size ±1.1 mm
divergence ±4.5 mrad
in H plane

size ±1.2 mm
divergence ±4.3 mrad
in V plane

Fig. 3 ENVELOPE OF "A" BEAM

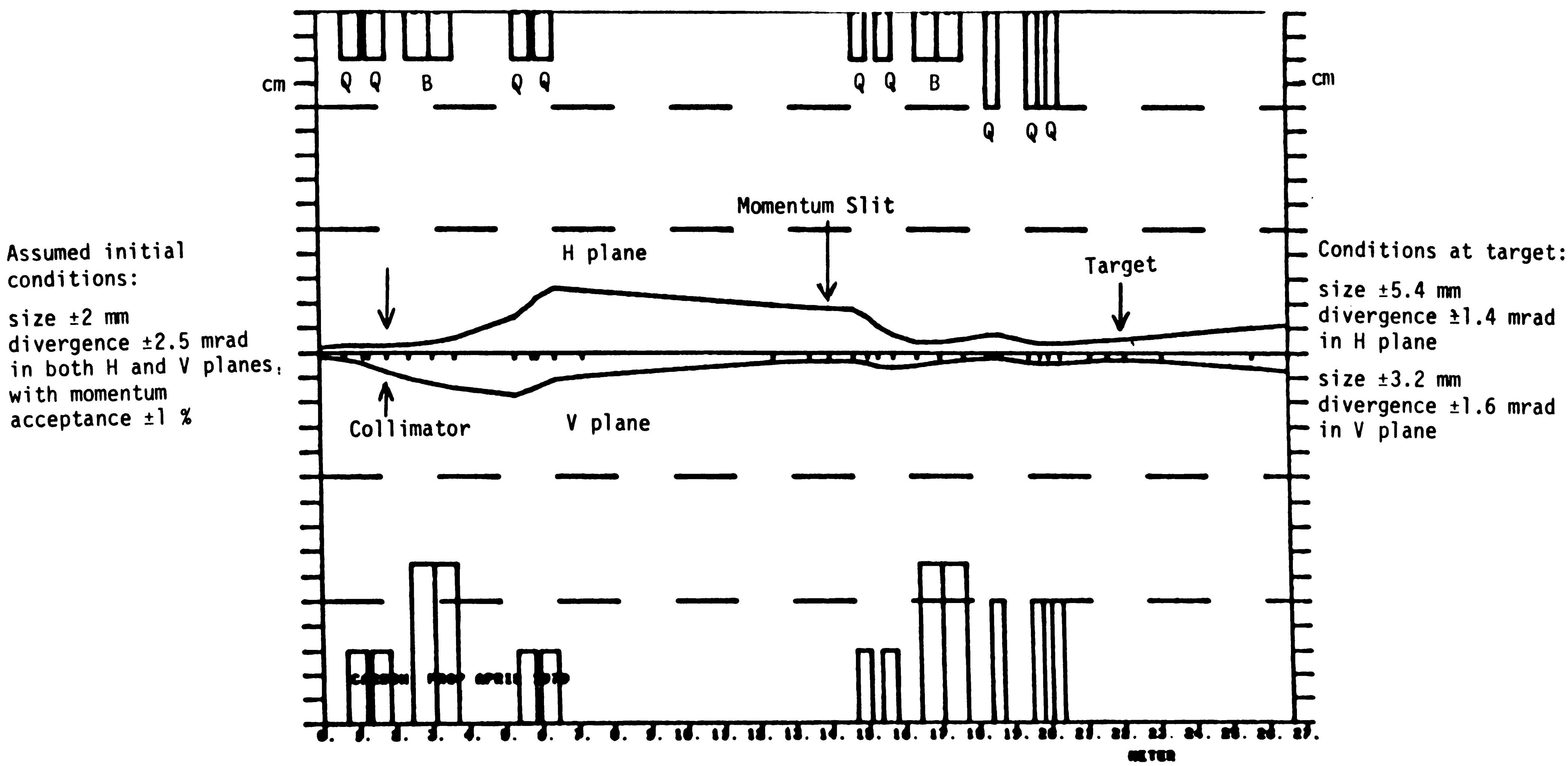


Fig. 4 ENVELOPE OF "C" BEAM

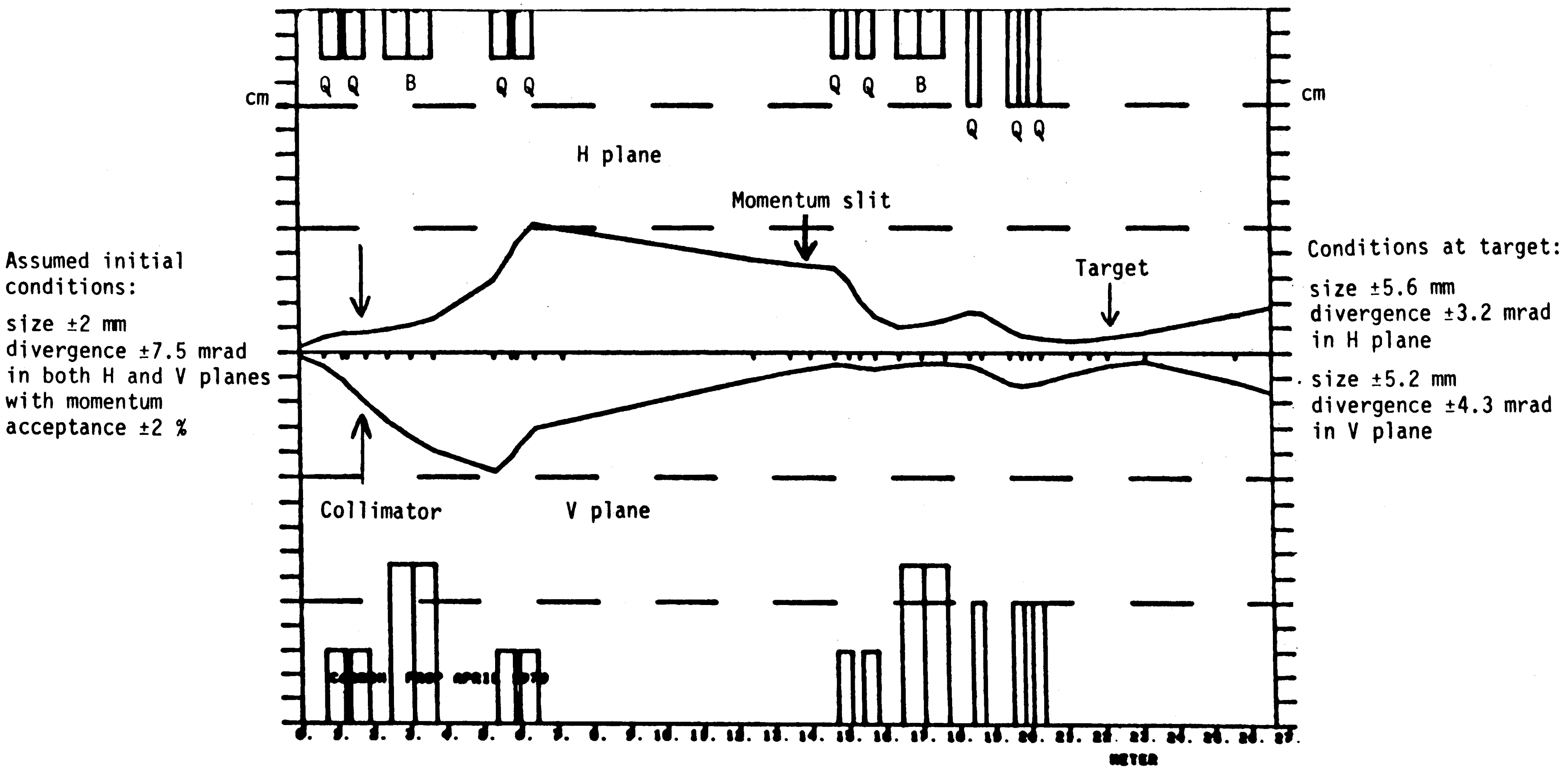


Fig. 5 ENVELOPE OF "C" BEAM

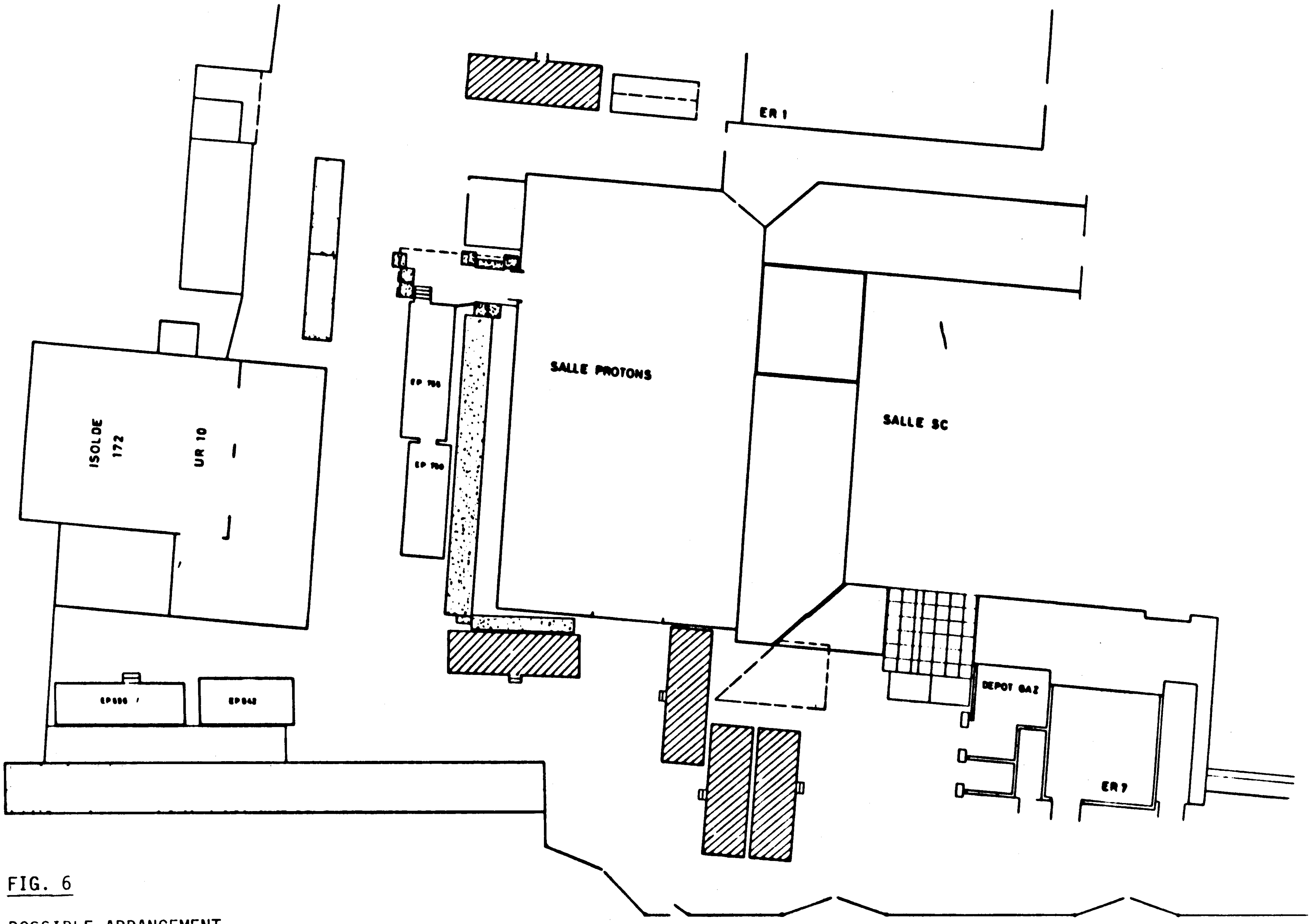


FIG. 6

POSSIBLE ARRANGEMENT
FOR THE CARAVANS