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TARGET MONITORS FOR THE C.P.S.

Introduction.

A previous report (MPS/Int./VA 61-10) described the type of target monitor first installed in the PS ring to measure integrated burst shapes, principally for setting up targets and for beam sharing measurements.

This system proved useful and easy to handle but gave more qualitative rather than quantitative results and suffered from some disadvantages. The Čerenkov radiators were large (∅ 45 mm, 200 mm long) resulting in saturation effects and were unshielded from radiation from upstream targets and from protons scattered against the vacuum chamber. In addition the positions of the counters on top of the PS magnet units were not accurately fixed.

These shortcomings have been surmounted in the new arrangement presented in reports (MPS/Int./ALO 62-8) and (MPS/Int./ALO 62-12). The system described in this report, while not as comprehensive as the collimated scintillation counter telescope, has the main advantage of being a fixed installation in the PS ring so that it is not subject to change when a new secondary beam is built. It is also simpler using only one counter. This is a Čerenkov counter so that only high energy radiation (e.g. for plexiglass radiator in air, $\beta \geq 0.9$), from a small volume around the target, is detected. Also the existing cabling system from the ring junction box to the MCR is employed.

Description of Counter.

The Čerenkov counter is of the directional type (Hutchinson 1959). The arrangement is shown in figures 1 and 2. Four blocks of plexiglass, each 11mm x 11mm x 4mm, are mounted with their faces parallel and separated by air gaps in which light absorbers are inserted. The assembly is viewed by one photomultiplier (RCA 6810A) placed in optical contact with the edges of the plexiglass, the opposite edges being covered with light reflectors. Light is collected by internal reflection only, and refracted light is absorbed between each piece of plexiglass. Hence for a given radiator material in air, there is a minimum velocity β of particle detected if all the light cone is to be internally reflected, at normal incidence. For particles incident at a small skew angle a fraction of the Čerenkov light is refracted and therefore not detected. This effect is enhanced by shaping the back face of each block.

Ideally for a radiator of plexiglass in air detecting a parallel beam, there is an angular response of half angle of 6.3° (assuming 1.50 for the refractive index of plexiglass). The corresponding values for quartz-glass and fluorite are 3.4° and 1.5° respectively. The factors limiting the angular resolution include :

a) multiple scattering of the particles in the radiator.

b) dispersion of the radiator.

c) energy loss of the particles in the radiator, causing a decrease of the Čerenkov angle.

d) misalignment of the radiator, thereby tilting the Čerenkov cone with respect to the radiator-air interface.

e) diffused radiation incident on the radiator.

This last effect is significant for a counter placed in the PS ring area. When a lead collimator, however, is used to shield the counter more optimistic conditions are realised.

Location of Counters.

In order to make best use of the directional property of the Čerenkov radiator so that the counter subtends the minimum length of vacuum chamber, a counter position in a direction through the PS centre and the target being monitored (i.e. the vertical radial plane) is to be preferred. This was realised most easily at targets 01 and 06 where the counters are mounted on platforms secured to the inside wall of the PS ring, about seven metres radially from the targets, and about 2.5 metres above the horizontal plane of the PS. A lead collimator 60 cm long, shields each of the counters. A similar situation obtains at target 10 except the target-monitor separation is five metres and the installation is not permanent due to the physical lay-out of the secondary beams in that area. For the same reason the monitor for target 09 is at 45° to the proton beam direction. The arrangement of the counters in the target area is shown in figure 3, counters 1, 6, 9 and 10.

While monitors 01 and 06 occupy rather specialized sites, monitors which could be arranged in the more normal positions where the ring tunnel is narrow would be useful. One of the above counters has been used to monitor the chemists' target 82, placed behind a lead collimator twelve metres downstream against the inner ring wall at an angle of 18.5°. Such a monitor might be useful for setting up targets initially in the East Area.

Performance of Counters.

The behaviour of the counter was investigated in both the s_3 beam (1 GeV/c pions) and the ring area.

Ideally the characteristics of a directional Čerenkov counter should be studied in a parallel beam whose area is smaller than the face of the radiator. It was found that the s_3 beam was not too suitable for measuring the angular response of the counter. The beam width was in excess of the dimensions of the front face (11 mm square) of the radiator, and the angular divergence of the beam was a disadvantage too. Two methods were tried; one was to collimate the beam down to a suitable size, and then to observe the pulse height spectrum as a function of rotation of the counter in the horizontal plane. A typical spectrum for the forward direction is shown in figure 4 where the peak due to pions going through the radiator normally to the front face is evident. Secondly a defining coincidence counter was used without a collimator. The data were recorded on scalers with a high discriminator bias so that only particles giving maximum light output were accepted. The angular response of a quartz glass (Vycor glass) radiator with a photomultiplier with a quartz window was also studied with this arrangement. The results, given in figures 5 and 6, are a combination of the directional property of the counter and of the geometry of the coincidence arrangement chosen, resulting in an observed angular response which was narrower than that calculated from a consideration of the radiator alone. This was a useful guide in anticipation of the arrangement of the monitor behind a lead collimator in the ring where only about 1/3 metre of the vacuum chamber around the target was directly visible to the counter.

The pulse height spectrum from a monitor in the ring (shielded behind a lead collimator), while showing a well resolved but small peak at high light output, gave evidence for many particles traversing the radiator at a skew angle. Part of this difficulty was the accurate alignment of target, radiator and collimator, and also the imperfections in the plexiglass radiator. These measurements were made with a 100 msec beam burst, and the precaution was taken to gate the pulses so that the CDC Kicksorter only accepted the next pulse when the previous one had been analysed.

It was observed that an upstream target produced at least a 5 o/o effect on a downstream monitor under conditions of a short burst, but the magnitude depended on the distance between the operative target and the monitor, and on beam dynamics. An integrated burst shape signal of about 10 o/o was found from monitor 01 when a 1 msec beam was produced from target 10, but little was seen in monitor 82, for example.

The linearity of monitor 10 output was checked as a function of primary proton intensity. It was possible to count single pulses in the target area when long burst target operation ($\geq$100 msec) was used. However, only 10 o/o consumption of the proton beam (maximum of 40 x 10^{10} per burst) was permitted in a 1 msec burst if the linearity was to be preserved. It might be possible to improve this situation further by using even a smaller radiator and collimator, and by careful choice of type of photomultiplier and dynode chain. The observed counting rates were within a factor of ten of an estimate based on Brookhaven measurements (Fitch et al 1962).

Conclusions.

There is doubt whether it is profitable to expend more effort to improve further the monitor system described here. While it has been shown that it is possible to count single pulses from a counter inside the PS ring (using the advantages of a Čerenkov counter with a high threshold, shielded by a lead collimator, and by observing secondary particles from the target at 90°) the difficulties encountered with beam burst-lengths of the order of milliseconds place a severe restriction on the system.

The main advantage of this arrangement is that for target monitors 01 and 06 it is a permanent feature of the south target area, and it is also easy to use in the MCR.

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W.R. HOGG.

Distribution : (open)

Scientific Staff of the MPS

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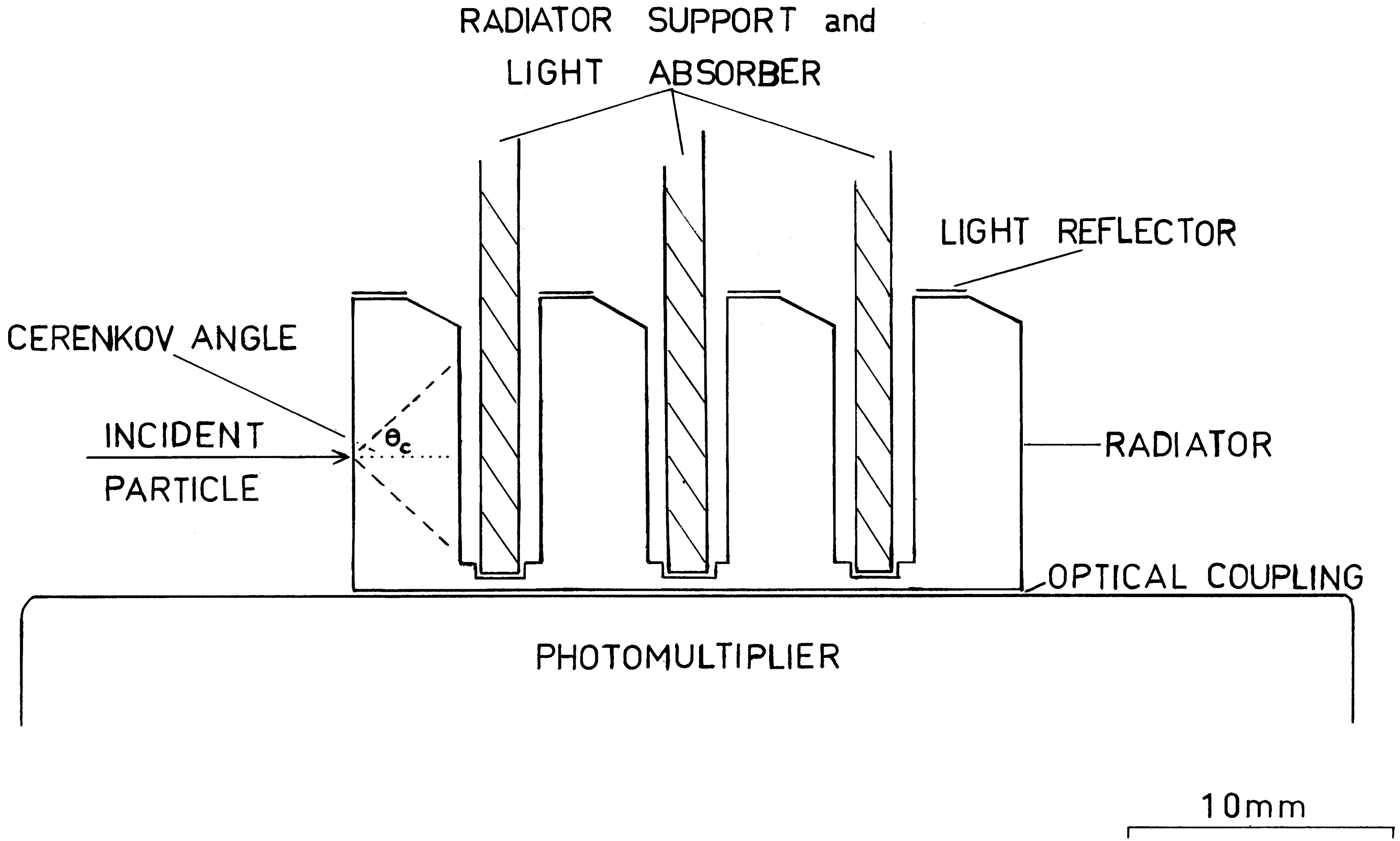
RADIATOR SUPPORT and
LIGHT ABSORBER
LIGHT REFLECTOR
CERENKOV ANGLE
INCIDENT
PARTICLE
θ_c
RADIATOR
OPTICAL COUPLING
PHOTOMULTIPLIER
10mm

Figure 1

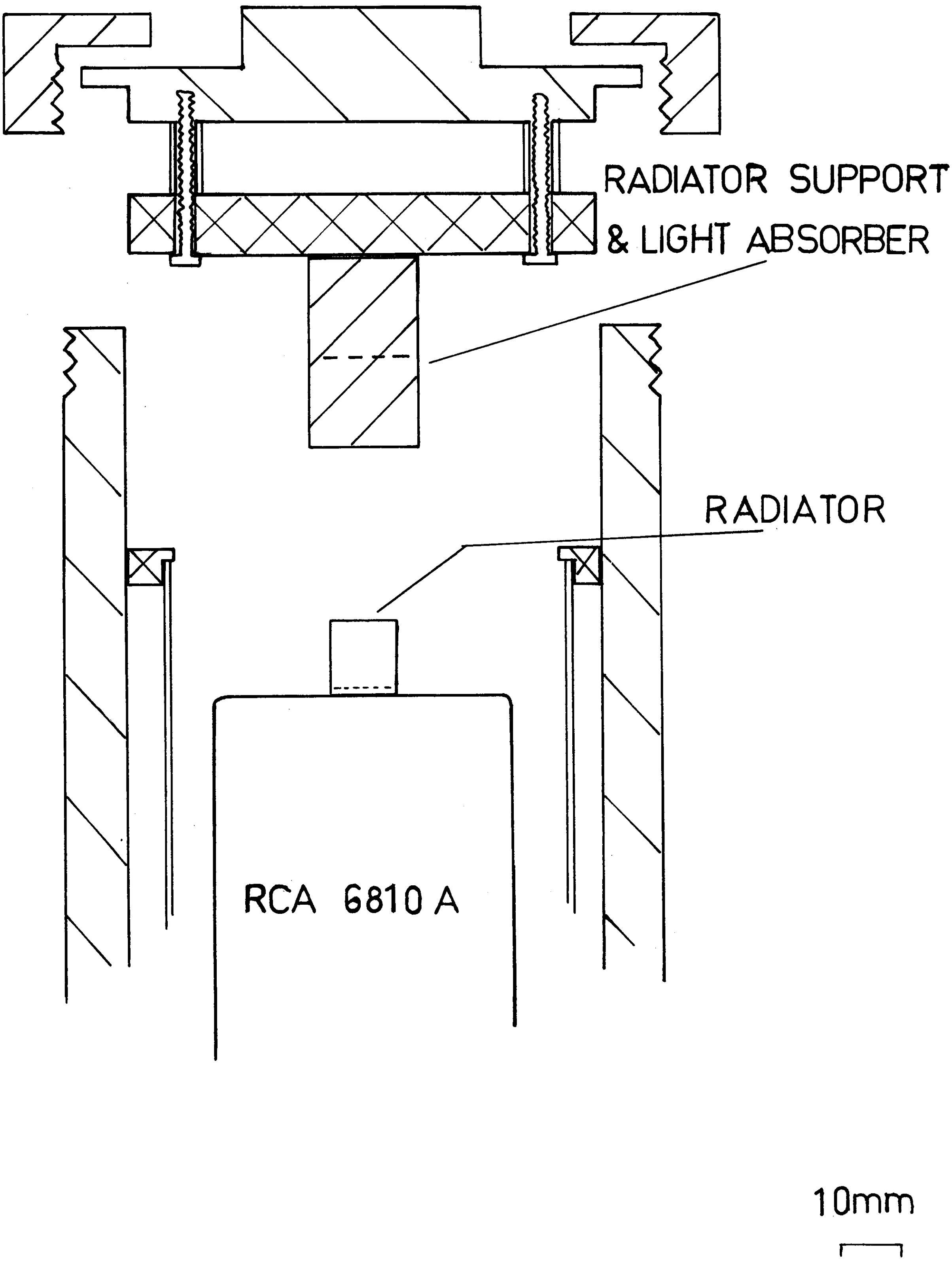

Figure 2

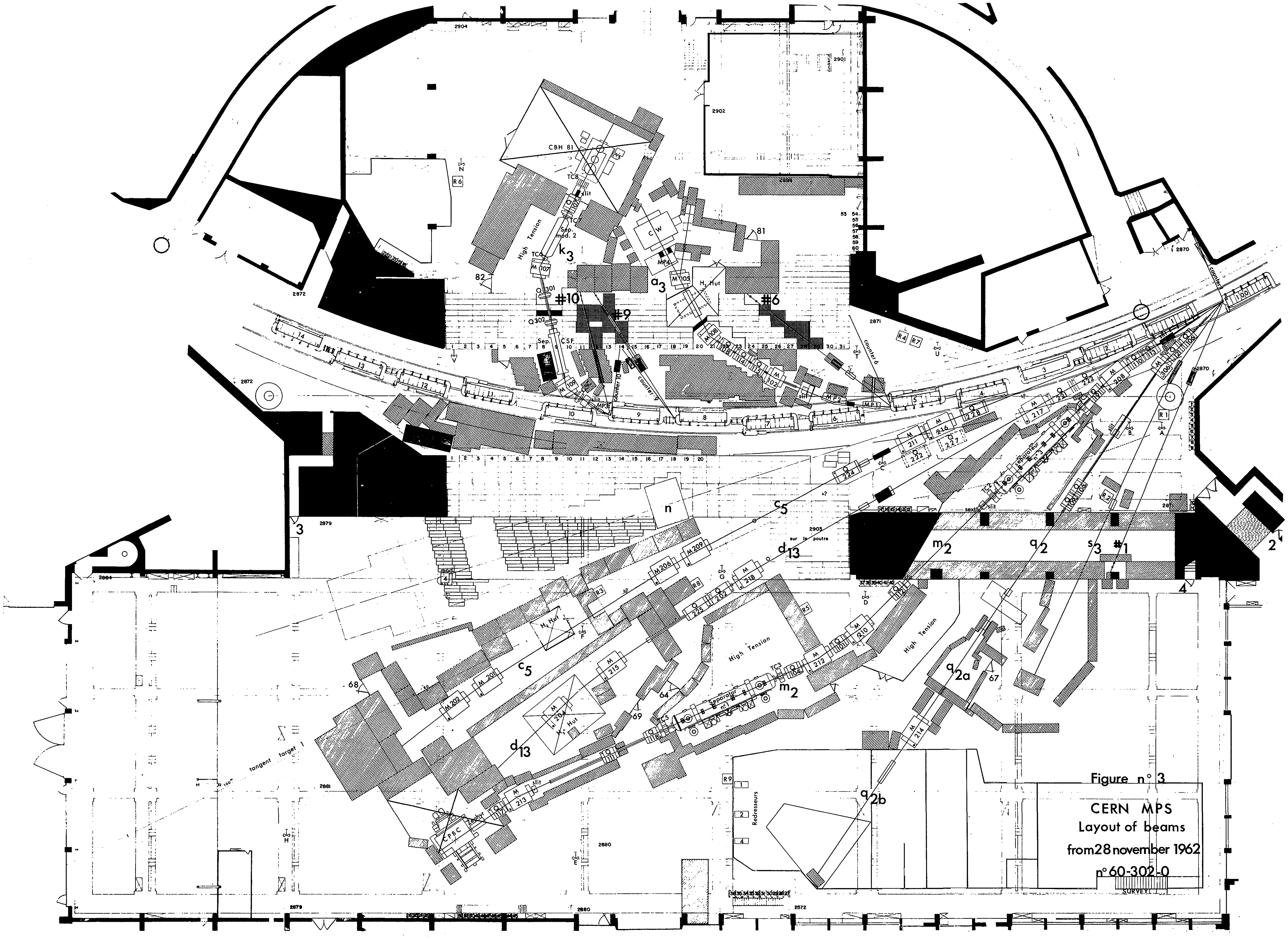

Figure n° 3

CERN MPS
Layout of beams
from 28 november 1962
n° 60-302-0

SIS/R/5381

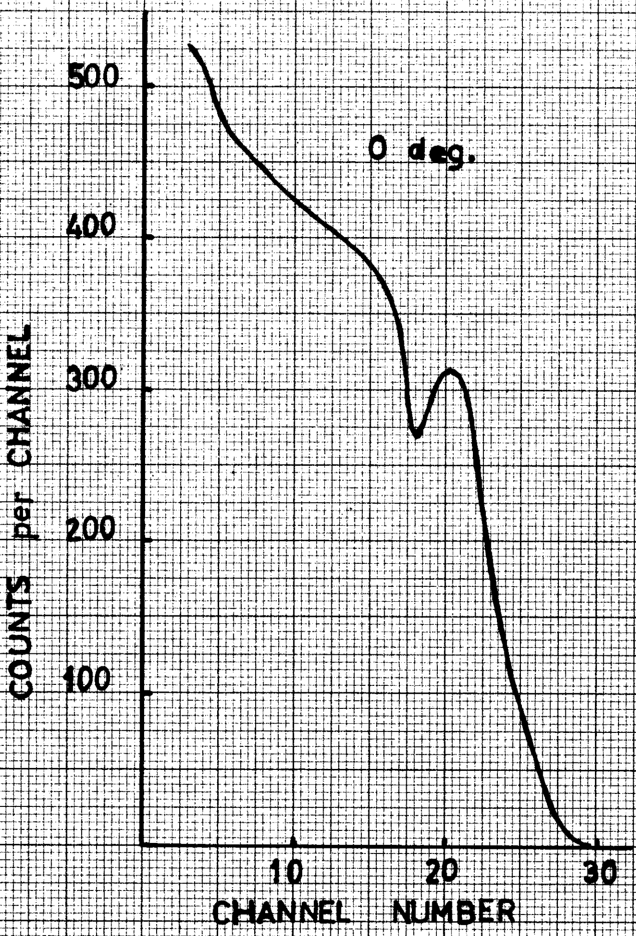

FIGURE 4

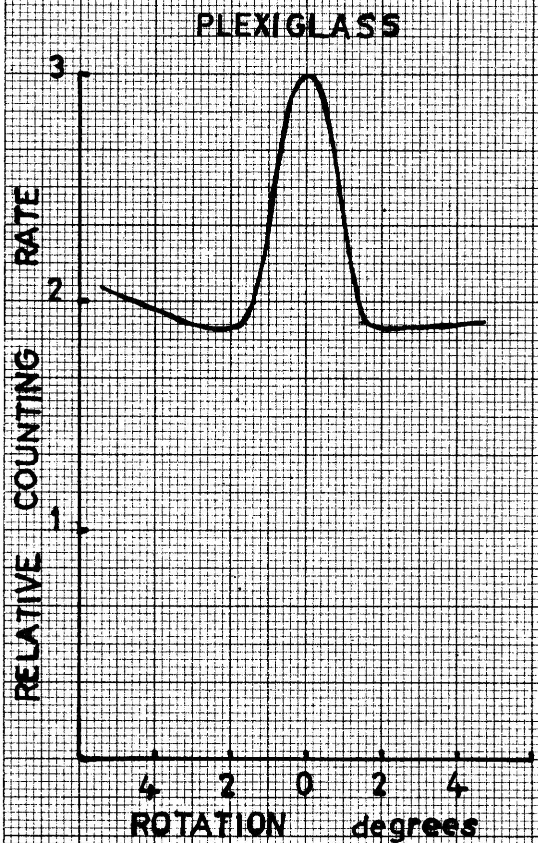

FIGURE 5

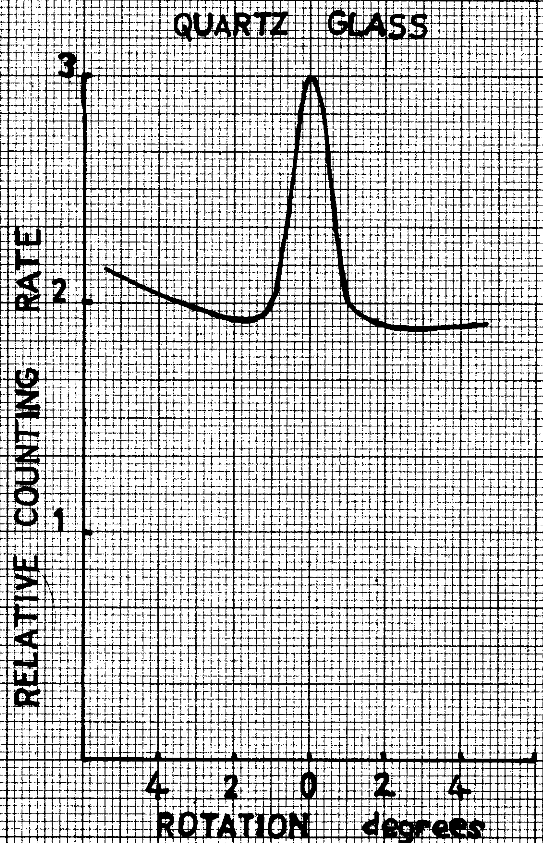

FIGURE 6