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ISR BACKGROUND STUDIES III:-
SHIELDING MEASUREMENTS AT THE PS

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Measurements of the flux of particles from beam-gas interactions at the PS have already been reported and used to estimate the background to be expected at the ISR[1, 2, 3]. This note gives some results of a study of the effectiveness of shielding in this flux.

The previous measurements showed that the secondary particles from beam-gas interactions are emitted primarily at small angles to the forward direction. Because of this the background at the ISR will be predominantly from several metres upstream, particularly as the vacuum there may be 10^{-9} torr instead of the 10^{-11} torr hoped for at the intersection region itself.

The quantity of shielding required to reduce this background to an acceptable level will depend on the type of particles present. In particular, the presence of μ-mesons will require a large quantity of shielding. If secondary π- and K-mesons can be absorbed before they decay then the amount of shielding required will be less. In order to do this, absorber must be placed as close as possible to the beam as the secondary particles are emitted mainly at small angles. The effectiveness of placing shielding very close to the beam has been tested at the PS.

A counter telescope was set up inside the PS ring alongside magnet 20 in the position shown in Fig. 1. This portion of the PS was chosen because magnets 18, 19 and 20 are all open on the inside. The telescope consisted of three scintillation counters, 1 cm wide and 3 cm high, placed on a rotating table at the height of the PS beam. The telescope could be rotated from a position with its axis perpendicular to the vacuum pipe, $\Theta = 90^{\circ}$, to a position parallel to the vacuum pipe, $\Theta = 0^{\circ}$. The angular resolution of this telescope was approximately 2° in the horizontal plane and 6° in the vertical plane.

Laminated lead shielding blocks were made 10 cm long by 14 cm deep and high enough to just fit between the coils of the PS magnets when placed on special aluminium supporting plates as shown in Fig. 2. In this position the fronts of the blocks were 15 cm from the PS beam. Measurements were made with 24 of these blocks placed in each of magnets 18, 19 and 20.

Thea were distributed as evenly as possible along the magnets and filled approximately two-thirds of their total length. A small quantity of extra lead was used to fill "holes" in the shielding which occurred at the ends of the magnets.

The telescope count as a function of angle with and without lead in position is shown in Fig. 3. The general form without shielding is as obtained previously[2] except for a deep dip at $\Theta = 6°$ due to the shielding effect of a PS focusing element between magnets 19 and 20.

The two curves of Fig. 3 were obtained under similar machine conditions with 5×10^{11} circulating protons. Counts were made during a 300 msec gate with the PS beam coasting at 19 GeV, a dump target in straight section 84 being used at the end of the flat top. In order to allow for machine fluctuations the coincidence rate of two 10 cm $\times$ 10 cm scintillation counters alongside magnet 10 was used as a monitor. The flux of secondary particles at all angles is substantially reduced by the shielding, the ratio of the areas under the two curves of Fig. 3 is 12 : 1. The peak of the curve at $\Theta = 3°$, which corresponds to particles from 10 to 15 m upstream, is in fact reduced by more than a factor of 20. This will be the most important region at the ISR because of the higher residual gas pressure.

Essentially, all the particles counted came directly from the vacuum chamber. Therefore the singles rates of a scintillator should be proportional to the integrated area under the curves of Fig. 3. The effect of the shielding was apparent in the singles rates of the three counters. However, it is not measured so readily because of the very large contribution (80%) to singles from induced radioactivity. After subtracting the singles due to this source by taking counts between PS acceleration cycles a reduction of a factor of about five was found in the rate of a single counter, during the flat top, due to the lead shielding. Singles counts from radioactivity should not be a problem at the ISR where there will be no targeting and beam extraction. The observed different effect of the shielding on triple and single rates may indicate a flux of low-energy particles leaving the lead. This point needs further investigation.

The total weight of lead needed to reduce the beam-gas secondaries from a 15 m length of vacuum pipe by more than a factor of ten was only 1500 Kg. It is suggested that this would be an extremely convenient method of shielding to use upstream of intersection regions at the ISR as it has the advantage of being easily adjustable once suitable supports have been provided in the machine magnets. An upper limit to the degree of shielding obtainable has not yet been found. It is likely that a further reduction of three to ten could be obtained by increasing the depth of lead before the background of penetrating μ-mesons is reached. In achieving even a factor of ten reduction small leaks from unshielded magnet ends had to be blocked effectively. Therefore, at the ISR, it would be necessary to provide shielding on both sides of accessible straight sections but extra shielding should not be necessary on the yoke side of the main machine magnets. The deep dip in the distribution shown in Fig. 3 due to the small yoke of a quadrupole magnet suggests that the magnet yokes themselves will give effective shielding.

This type of shielding is probably an easier solution to beam-gas background problems than a further reduction in the ISR vacuum by a factor of ten.

REFERENCES

1. B.D. Hyams, V. Agoritsas,
"Background in ISR", AR/Int SG/65-29, 29 November, 1965.

2. B.D. Hyams,
"ISR Background Radiation", CERN/68 ISRU/121, 2 December, 1968.

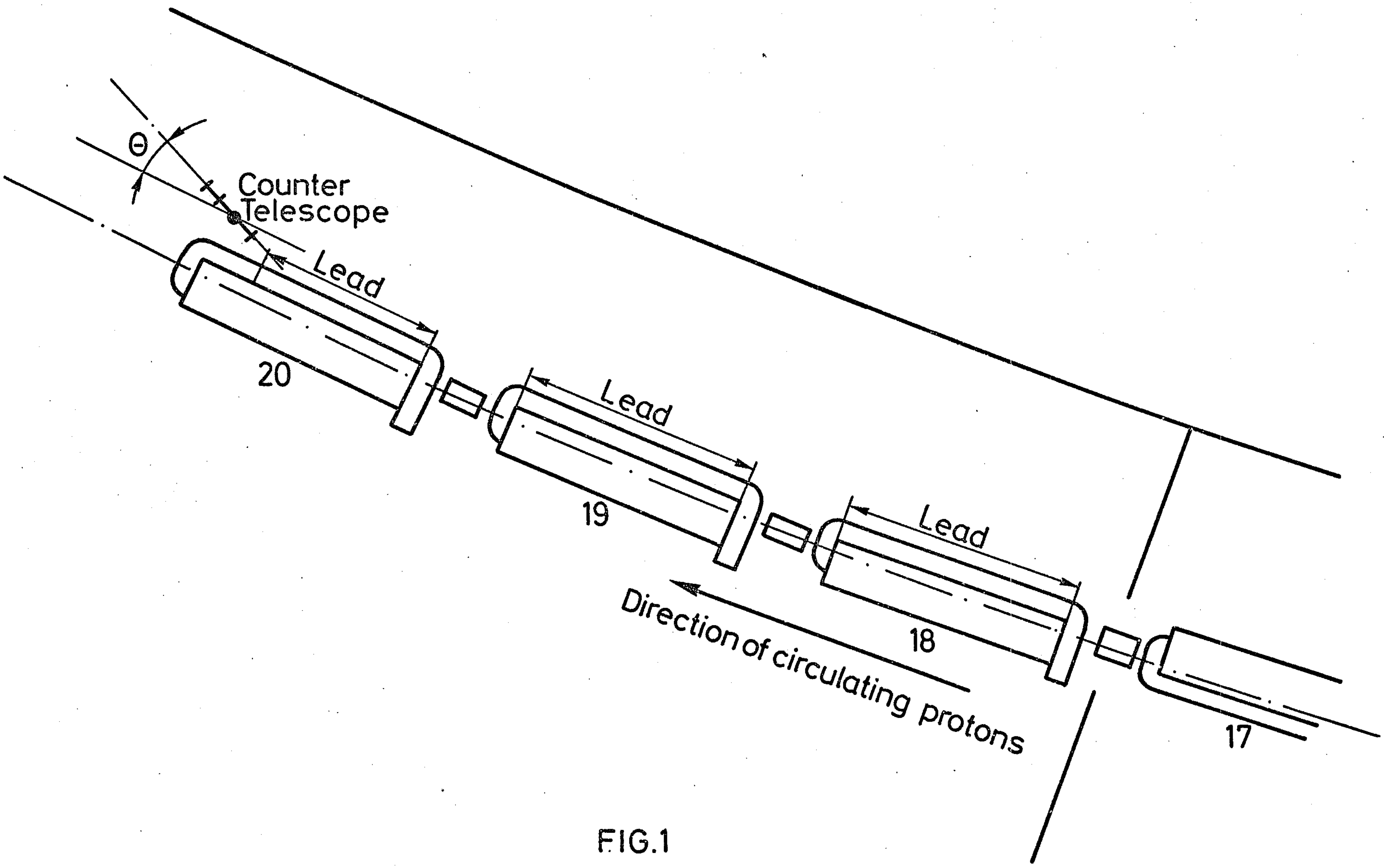
3. V. Agoritsas, M. Bott-Bodenhausen, B.D. Hyams,
"ISR Background Studies at the PS", NP/Internal Report 69-8, 2 May, 1969.

FIGURE CAPTIONS

Figure 1 The position of the counter telescope and lead shielding in the PS ring.

Figure 2 A vertical section through a PS magnet showing the position of a lead shielding block relative to the vacuum chamber and magnet pole faces.

Figure 3 The telescope counts as a function of angular position with and without lead shielding in position. Counts per six seconds with 5×10^{11} circulating protons and normal PS vacuum.



Θ
Counter
Telescope
Lead
20
Lead
19
Lead
18
Direction of circulating protons
17

FIG.1

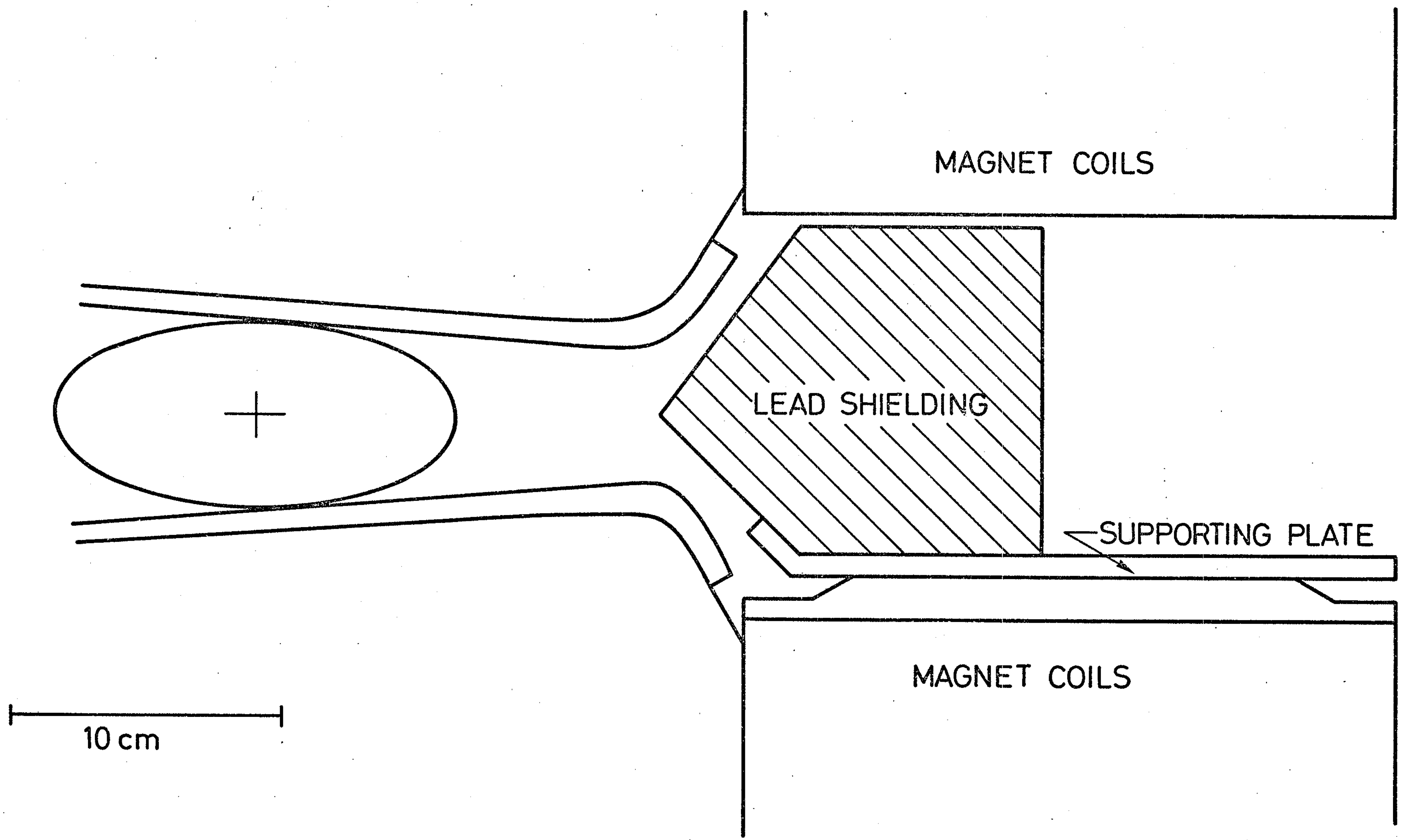

MAGNET COILS
LEAD SHIELDING
SUPPORTING PLATE
MAGNET COILS
10 cm

FIG.2

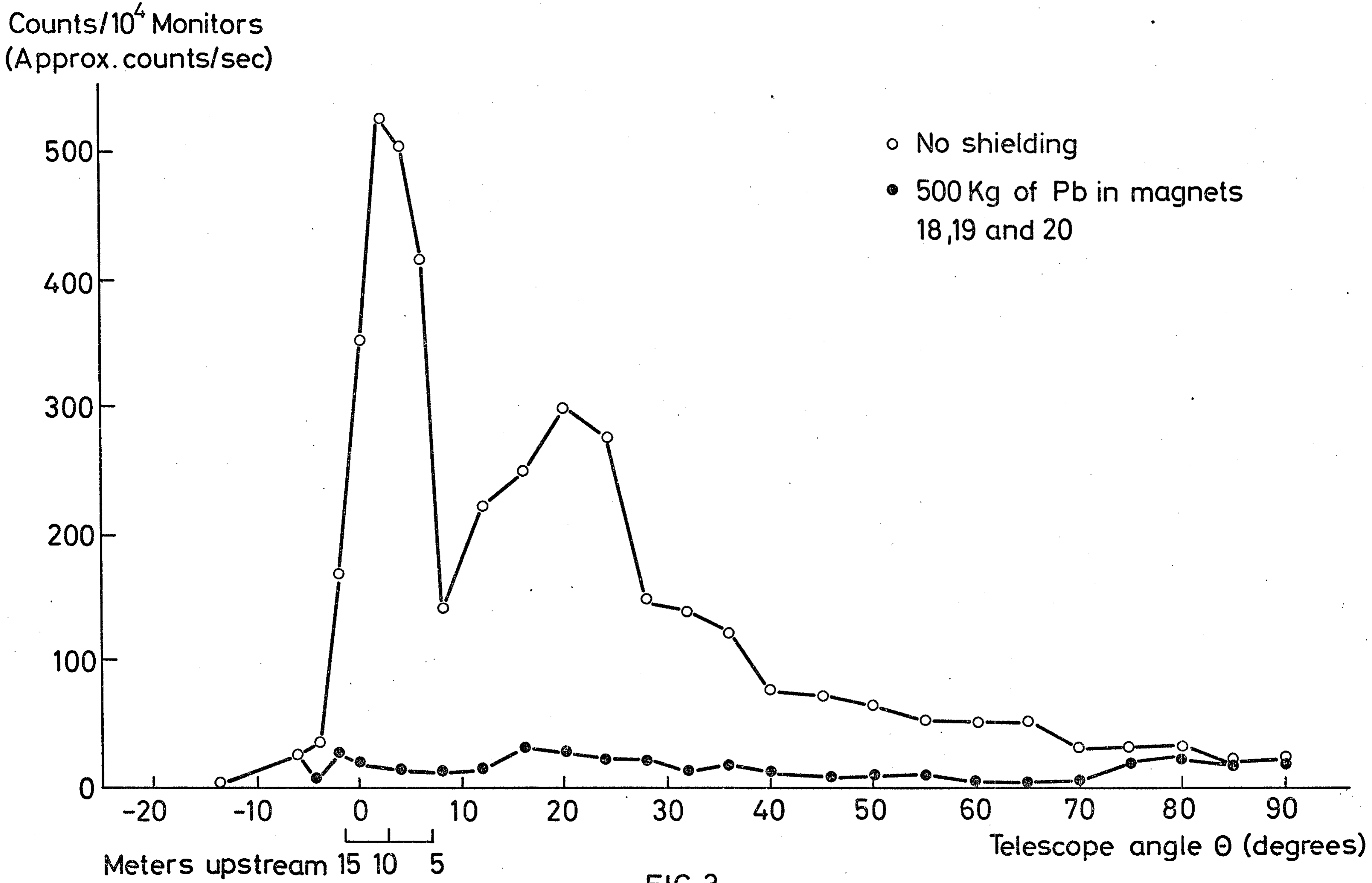

Counts/10^4 Monitors
(Approx. counts/sec)
500
400
300
200
100
0
-20
-10
0
10
20
30
40
50
60
70
80
90
Meters upstream 15 10 5
Telescope angle Θ (degrees)
No shielding
500 Kg of Pb in magnets 18,19 and 20

FIG. 3