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FURTHER STUDIES ON A COMBINED BUBBLE-SPARK CHAMBER HIGH-ACCURACY DETECTION SYSTEM FOR MULTIPARTICLE FINAL STATES AT 100 GeV/c

I. ALTERNATIVE SPARK-CHAMBER SPECTROMETER CONFIGURATIONS

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The spark-chamber spectrometer shown in Fig. 2 of Ref. 1 is designed to detect and measure accurately the forward cone of particles above 5 GeV/c emitted in a high-energy interaction. In its first incarnation, it is divided into two parts, an intermediate-energy section measuring momenta from 5 to 20 GeV/c and a high-energy section for particles from 20 GeV/c up.

This note presents a modification of the original design which comes closer to meeting the design specifications than did the original and also uses more realistic superconducting magnet designs. In addition, it explores several alternative designs covering the same momentum range but with hopefully lower cost.

Modification of Original Double Spectrometer

The design shown in Fig. 1 has the same aim as the original: to observe essentially all secondaries of momentum 5 GeV/c and above and to measure their momenta to an error less than 0.1 GeV/c. We have, however, included the entire cone out to a transverse momentum of 0.6 GeV/c at 5 GeV/c which corresponds to a production angle of 120 mrad. The fiducial volume for interactions in the bubble chamber is the first half-meter, and the precision of measurement is such that even at the downstream end of the fiducial interaction volume, an interaction producing a 5 GeV/c secondary will allow its measurement in the bubble chamber with sufficient accuracy. At the upstream end, a whole meter of track length is available, and tracks of momentum up to at least 8 GeV/c can be measured. Consequently the limits on the horizontal angle to be subtended by the intermediate-energy spectrometer can be set by these limiting cases:

Particle momentum	Interac. pt.	Produc. angle	Magnet defl.	Total defl.
5 GeV/c	Center	120 mrad	120 mrad	240 mrad
8	Front	75	150	225

Thus the intermediate-range spectrometer must be designed for a maximum horizontal divergence of ± 240 mrad. The vertical divergence is given by the production angle alone and is consequently considerably smaller.

A spectrometer design that fulfills these conditions, and in addition uses circular deflecting magnets rather than the schematic rectangular ones of the first report, is shown in Fig. 1. The current state of the art of constructing large high-field superconducting magnets favors the use of circular coils.

The gamma-ray detection chambers shown in Fig. 1 are detailed in Figs. 2 and 3.

Single-Section Spectrometer

Figure 4 shows an alternate design using only one spectrometer magnet. Somewhat larger in diameter (5 m), it covers the entire momentum range so that the system is simpler. A larger vertical magnet aperture, 3 m rather than 1.6 m, is required. Magnet cost saving is dubious.

Decreased Vertical Aperture

The vertical aperture required is determined by the largest emission angle of the secondary particles. Since the transverse momentum is constant, doubling the lower momentum limit from 5 to 10 GeV/c would halve the vertical aperture of the magnet, and thus approximately halve the cost, which is at present the largest single item in the system.

It is consequently legitimate to ask what is lost if we arbitrarily limit the vertical aperture. Referring to Fig. 5, suppose we halve the original vertical aperture, and ask what fraction of the beam contained in the original cone is lost. Taking into account the fact that we still have the entire Cocconi disk, a reasonable estimate is something like 10-15 percent for the lowest

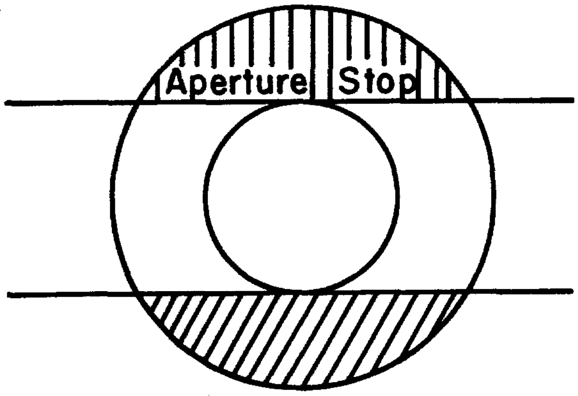

Fig. 5.

momentum particles (5 GeV/c) ranging down to zero loss at 10 GeV/c. The events involved are still visible, but the blocked particles must now be measured in the bubble chamber where the error in the momentum may exceed the admissible limit. Consequently, a correction for these missed events is not difficult to make. In the two-magnet spectrometer of Fig. 1, the aperture of the first magnet is halved; in a single-magnet spectrometer like that of Fig. 4, the vertical aperture is halved (see Fig. 6.).

Recent estimates of accuracy of determination of locations in wide-gap chambers of design similar to those proposed here indicate that accuracy of location better than 0.2 mm should be possible; if so, further shortening of the spectrometer, and corresponding scaling down of magnet apertures should be possible.

Increased Bubble-Chamber Field

Increasing the field of the bubble chamber will linearly increase the momentum measurable in the chamber; a 50% increase to 60 kG would raise the lower momentum limit to 7.5 GeV/c, keeping the horizontal bending angle constant. The smaller production angle then reduces the maximum horizontal angle somewhat, in this case from 240 mrad to 200 mrad. The spectrometer can then be reduced to a single magnet of 4 m diam, 1.4 m gap, as in Fig. 7 with full acceptance at 10 GeV/c or above.

Quadrupole focusing. Quadrupoles of sufficient size to accommodate the entire beam (= 240 mrad horizontally) are unreasonably large; and horizontal focusing alone would provide undesirable vertical defocusing.

REFERENCE

[1] T. Fields et al., NAL Summer Study Report A.3-68-12, 1968.

FIGURE CAPTIONS

Fig. 1. Hybrid bubble-spark chamber configuration covering 5-100 GeV/c. Angles are production angles. The intermediate and high-energy spectrometers are each 40 kG. Gamma-ray chambers subtend a large angle for high-energy gammas.

Fig. 2. Gamma-ray chamber No. 1 (see Fig. 1).

Fig. 3. Gamma-ray chamber No. 2 (see Fig. 1).

Fig. 4. A single-magnet spectrometer covering 5-100 GeV/c with 5 m diameter, 3 m vertical aperture.

Fig. 6. Single-magnet spectrometer with reduced (1.5 m) vertical aperture.

Fig. 7. Single-magnet spectrometer for 60-kG bubble chamber. Diameter 4 m, aperture 1.4 m.

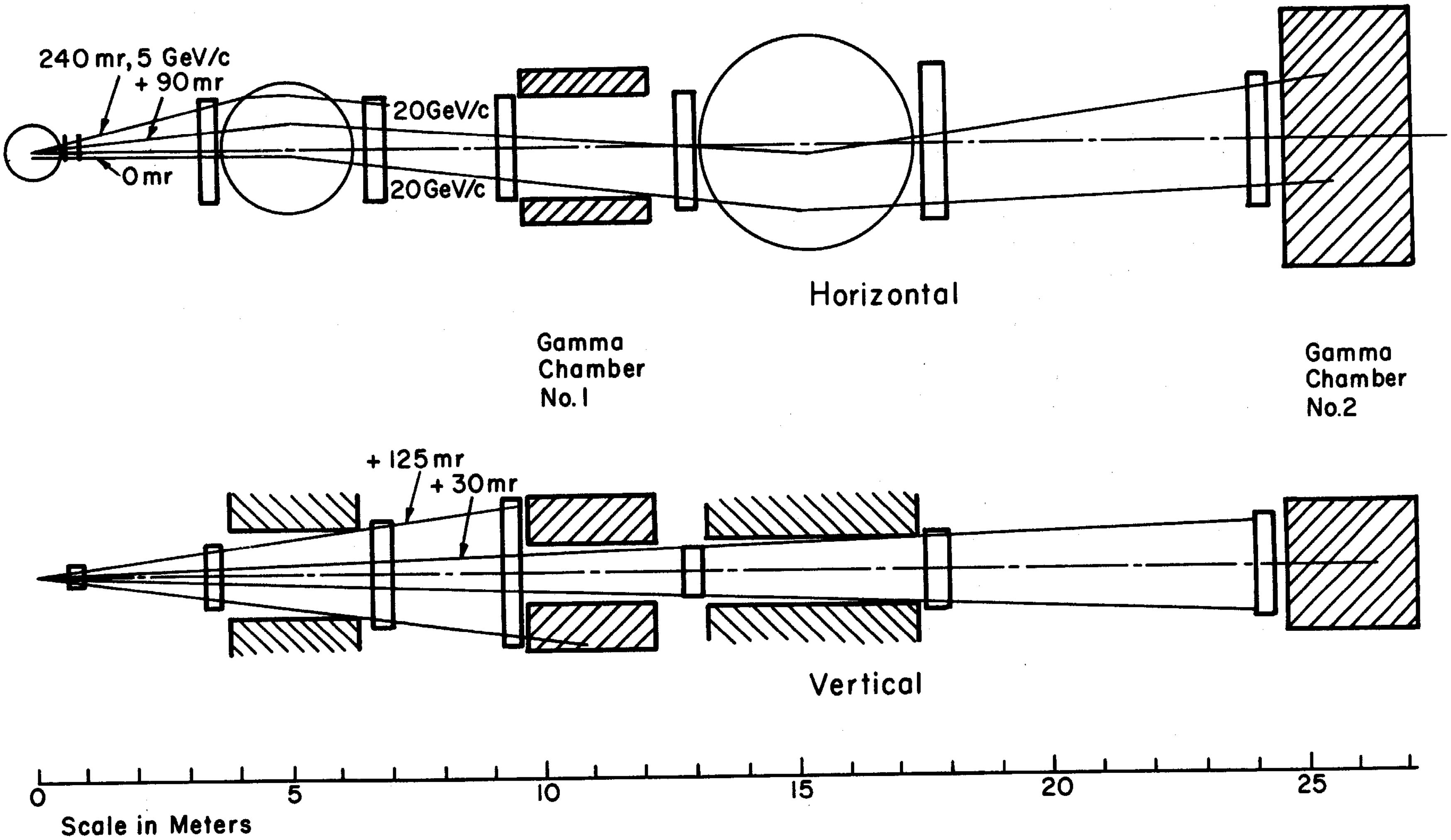
240 mr, 5 GeV/c
+ 90 mr
0 mr
20 GeV/c
20 GeV/c
Horizontal
Gamma Chamber No. 1
Gamma Chamber No. 2
+ 125 mr
+ 30 mr
Vertical
0
5
10
15
20
25
Scale in Meters

Fig. 1

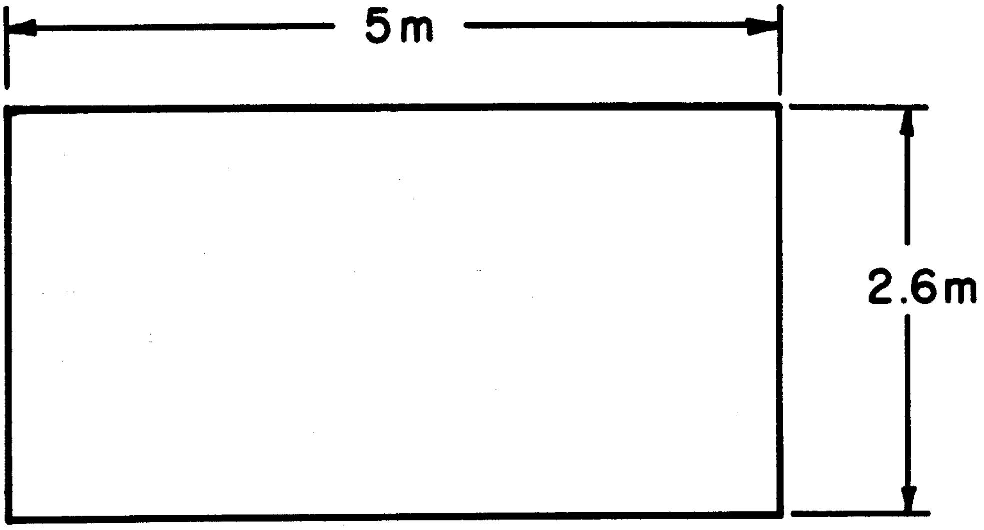

Fig. 3.

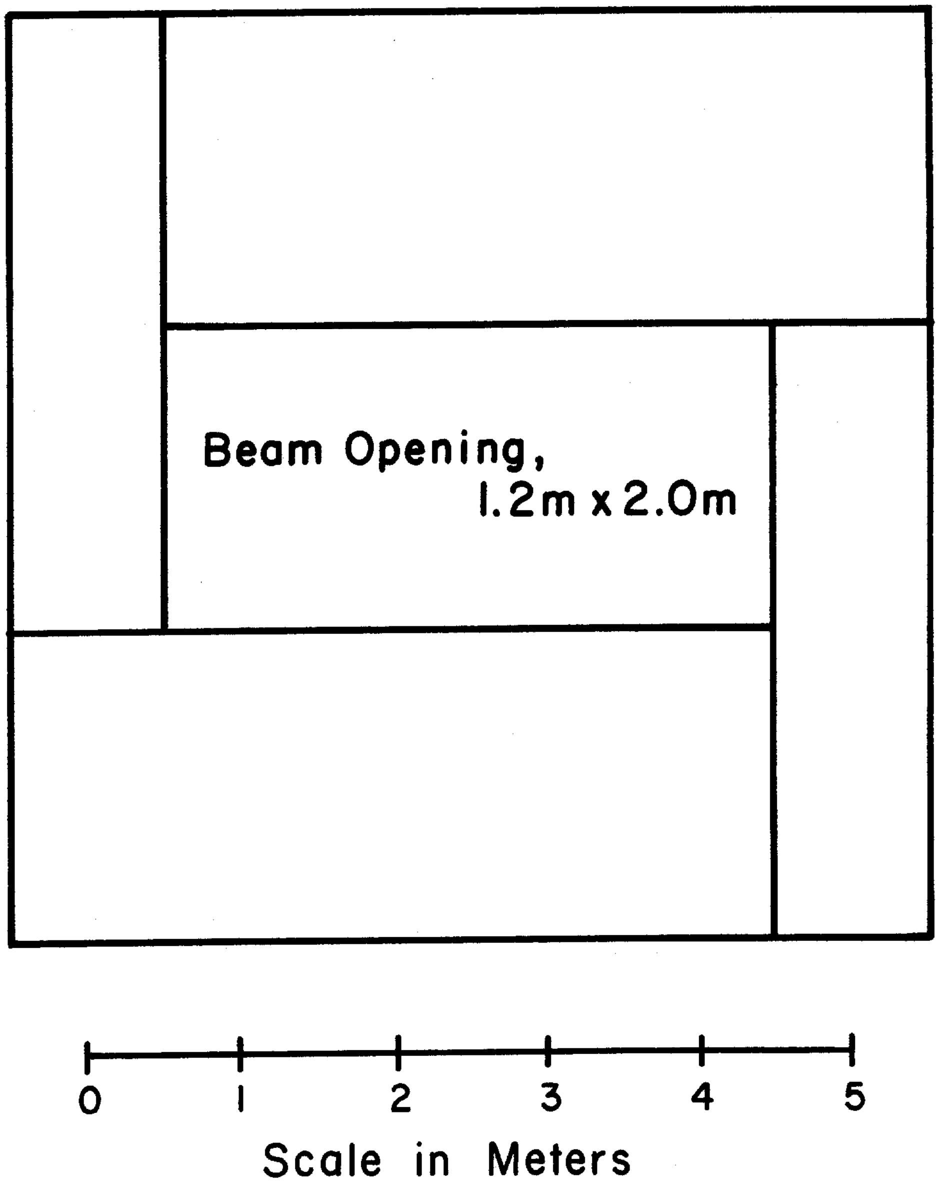

Fig. 2.

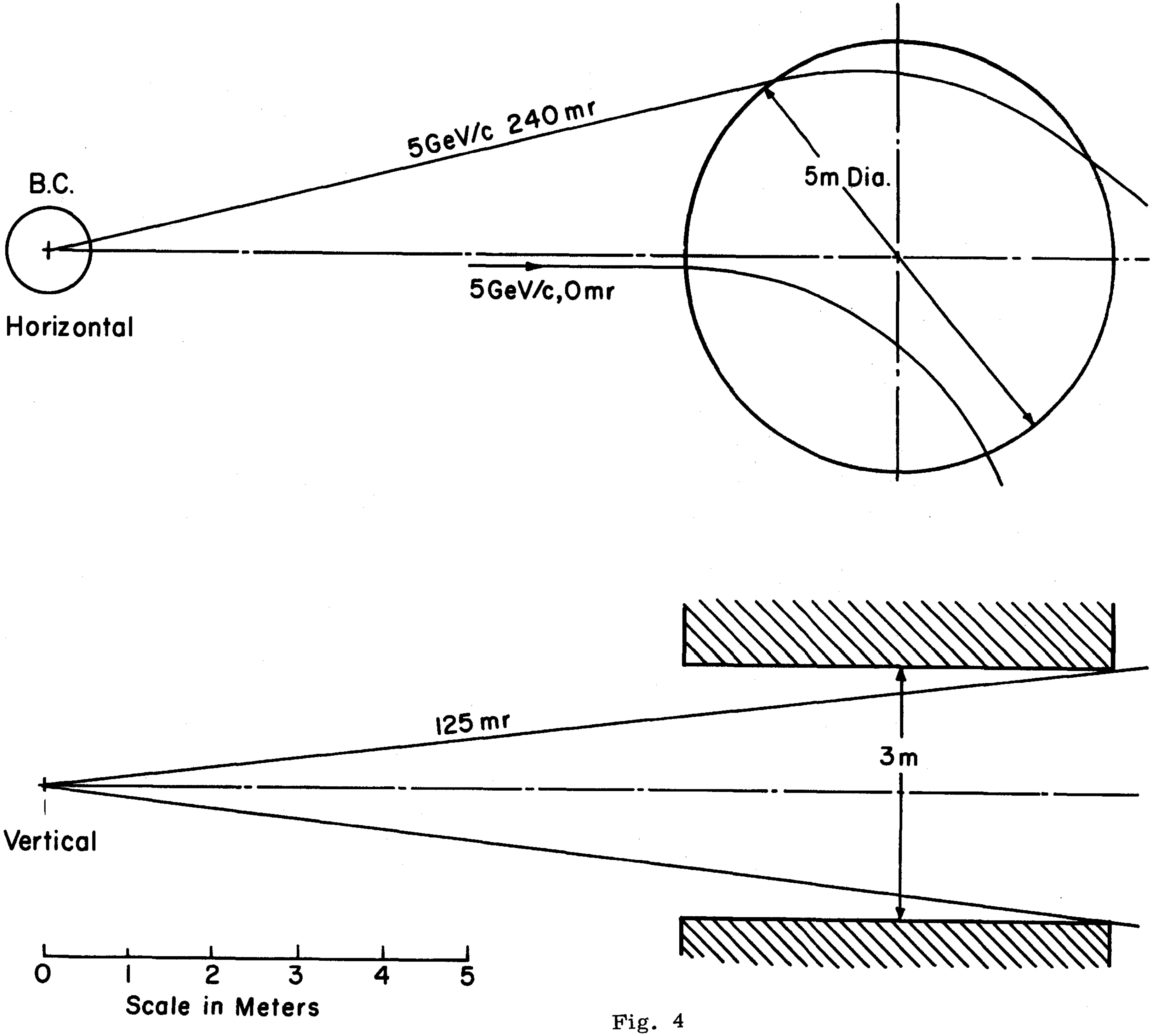
5GeV/c 240 mr
5m Dia.
B.C.
5GeV/c, 0 mr
Horizontal
125 mr
3 m
Vertical
0
1
2
3
4
5
Scale in Meters

Fig. 4

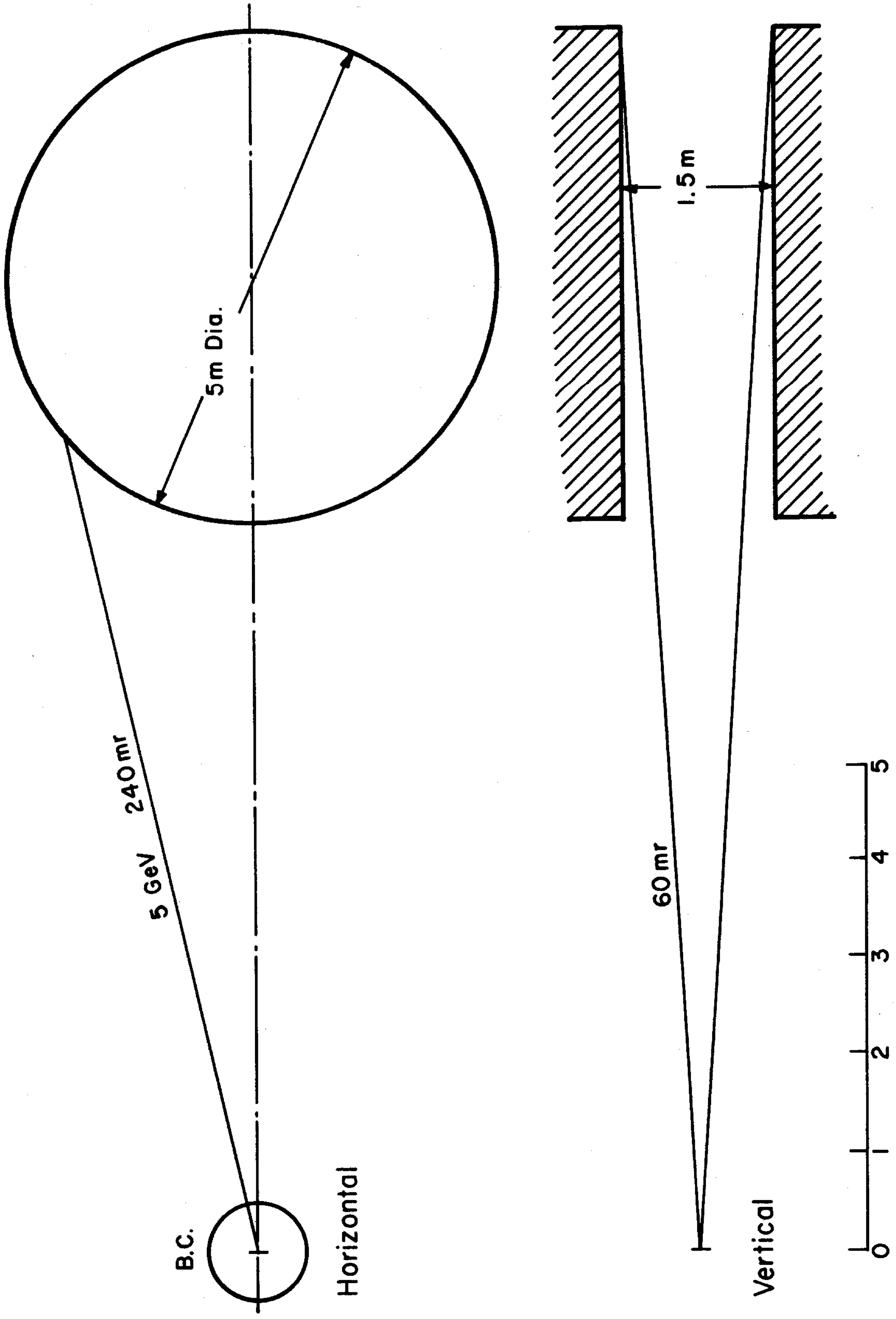
B.C.
Horizontal
5 GeV
240 mr
5m Dia.
60 mr
1.5 m
Vertical
0
1
2
3
4
5
Scale in Meters

Fig. 6

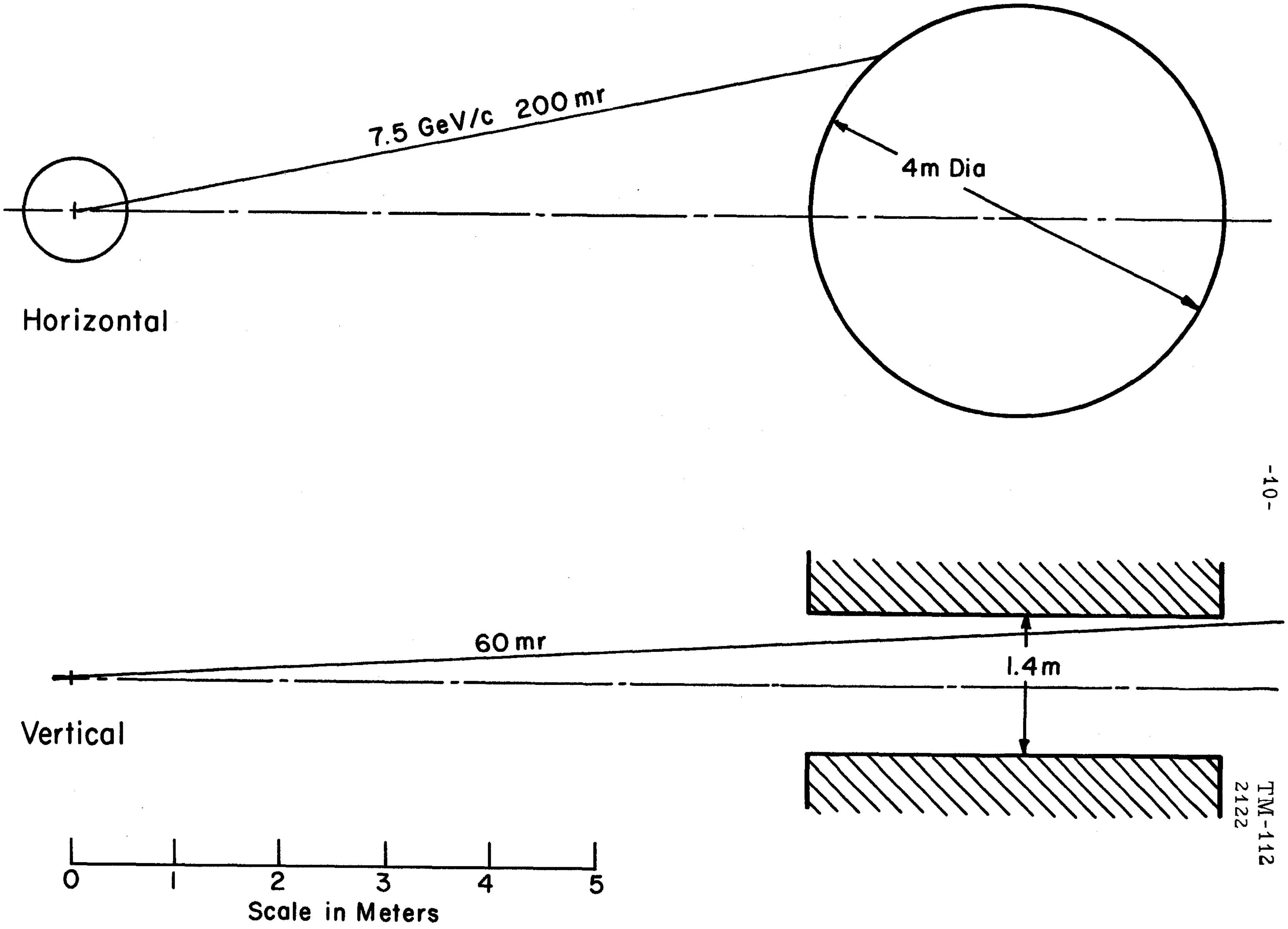
7.5 GeV/c 200 mr
4m Dia
Horizontal
60 mr
1.4 m
Vertical
0
1
2
3
4
5
Scale in Meters

Fig. 7