On the Effect of Lead above Apparatus for the Detection of Low Energy Mesons

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SEVERAL experiments conducted at this laboratory have involved observations concerning low energy mesons.[1,2] It has been known for some time that the maximum in the differential energy spectrum of mesons at sea level occurs considerably above the low energy region,[3] and it is therefore customary to attempt to increase the number of low energy mesons by placing lead above the apparatus. While it is possible in principle to calculate the increase thus obtained by use of a given amount of lead, the calculations would not be able to take into account any effects beyond the ordinary absorption and decay in the atmosphere and lead, such as photo-meson production, if such should turn out to be a real factor. It was therefore considered worth while to make a direct experimental measurement of the effect of placing lead above the apparatus of a slow-meson-detecting device in order to determine the magnitude of the effect and the optimum thickness of lead for observations concerned with a particular range of meson energy.

In the experiment described here, measurements were made of the counting rate for mesons having momenta between 10^8 ev/c and 2×10^8 ev/c as a function of the thickness of lead above the detecting apparatus. The apparatus is shown schematically in Fig. 1. Counter sets 1 and 2 consisted of 3 counters in parallel. Set 3 consisted of 5 counters in parallel, and set 4 consisted of 19 counters in parallel. Counter set 5 in the figure represents an alternative position for set 3. Counters 6, 7, 8, and 9 were single counters. Sets 1, 2, and 3 were arranged in coincidence, and sets 4, 6, 7, 8, and 9 in anticoincidence. The counters in sets 1, 2, 6, 7, 8, and 9 were 1 inch in diameter and 3 inches in effective length. The counters in set 4 were 1 inch in diameter and 9 inches in effective length. The lead block A was 1.7 cm thick, block B was 5.8 cm thick, and block C varied in thickness from zero cm to 42.7 cm. Position B' was an alternative position for block B. A count was recorded when at least one counter in each of the coincidence sets 1, 2, and 3 was tripped and no counter in the anticoincidence set was tripped. This in principle counted a

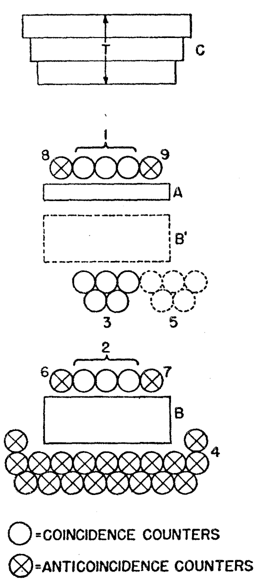

FIG. 1. Counter telescope.

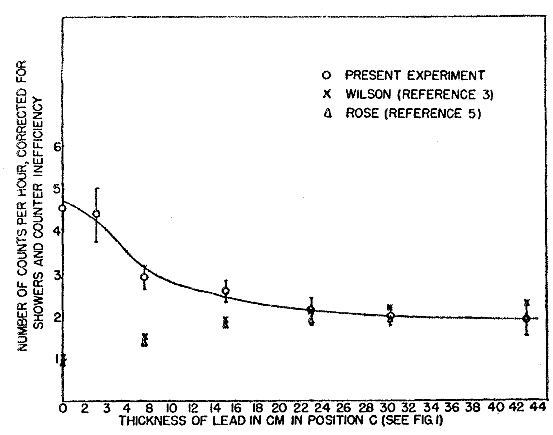

FIG. 2. Number of mesons which penetrated the lead in C (Fig. 1) with momenta between 10^8 and 2×10^8 ev/c.

[1] T. Sigurgeirsson and A. Yamakawa, Phys. Rev. **71**, 319 (1947).
[2] W. Y. Chang, accompanying paper.
[3] J. G. Wilson, Nature **158**, 414 (1946).

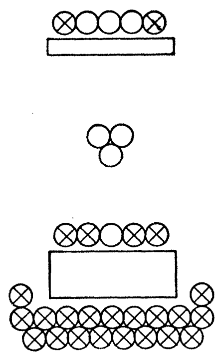

FIG. 3. Alternate counter telescope.

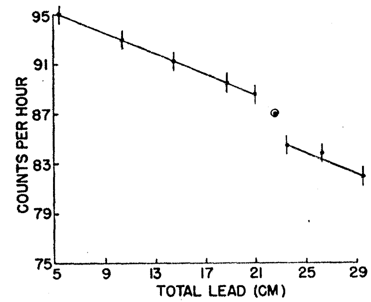

FIG. 4. Aiya's results (reference 4).

meson entering the region below C able to penetrate 1.7 cm of lead (momentum greater than 10^8 ev/c) but not able to penetrate an additional 5.8 cm of lead (and therefore of momentum less than 2×10^8 ev/c). The counting rate so obtained for various thicknesses of the lead in position C was corrected for counter inefficiency by remeasuring the rate with lead block B in position B'. Shower corrections were obtained from the counting rate with lead in A, B, and C, and with counter set 3 in position 5. The data thus obtained are shown by the solid line in Fig. 2. The ordinate of Fig. 2 gives the number of mesons detected per hour which had passed through the lead in C and were then able to penetrate 1.7 cm of lead, but unable to penetrate 7.5 cm of lead—i.e., the number of mesons which penetrated C with residual momenta between 10^8 ev/c and 2×10^8 ev/c. The abscissa of Fig. 2 gives the thickness of the lead in C.

The data for lead thickness less than 15 cm indicates that electrons were not excluded by means of the anticoincidence counters. This is contrary to the experience of Aiya[4] and therefore it was decided to recheck the low energy end of the spectrum by means of the configuration indicated in Fig. 3. This configuration should have been fully as effective as that described in reference 4 in eliminating electrons, but the results showed that electrons were still being counted. Of course, a more definite identification of a particle as a meson is possible by making use of the decay process of the meson, but the present experiment was in part designed for the purpose of comparison with other experiments not using the decay criterion. The data represented in Fig. 2 indicate that 9 inches of lead above the apparatus yields as great an increase in meson counting rate as can be obtained for practical purposes for mesons of the selected energy range. The data were normalized to the counting rates of Wilson's[3] observations and Rose's[5] calculations by means of the integral counting rate obtained by the threefold coincidence sets 1, 2, and 3 with lead in positions A and B' and with 30 cm of lead in position C. The present measurements are seen to be in good agreement with the earlier results for lead thicknesses greater than 20 cm, indicating that the presence of lead above the apparatus does not increase the counting rate in any unexpected way for these thicknesses. In this regard, however, the point at 15.2 cm of lead thickness is of some interest. It is not considered that enough electrons could get through 15 cm of lead to account for the measured counting rate at that point. Because of the way in which the present measurements were taken, a "band" of mesons in an appropriate energy range could result in such a high value. Such a band has been indicated before by Aiya,[4] whose results are reproduced in Fig. 4. If the point at 15.2 cm in Fig. 2 is assumed to represent a correct counting rate for mesons, then the present data would give a point in Fig. 4 shown by the circle in the gap of the curve.

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[4] S. V. Chandrashekhar Aiya, Nature **153**, 375 (1944).

[5] M. E. Rose, J. Franklin Inst. **236**, 9 (1943).