Production and Interaction of Mesons at Very High Energies

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APPROXIMATELY 400 charged and neutral shower particles confined to a narrow (7.4°) cone and produced by a magnesium nucleus of 2×10^{14} ev provide a source of mesons whose interactions have been studied over an aggregate track length of about 3 meters in emulsion.

The well-defined total spread of the shower together with the requirement, that in the center-of-mass system, the angular distribution must be identical in the forward and backward directions, determines the primary energy as well as the energy of the shower particles in units of their rest mass. The angular distribution of shower particles is in very close agreement with that predicted for median impact parameter by Fermi's theory[1] (Fig. 1).

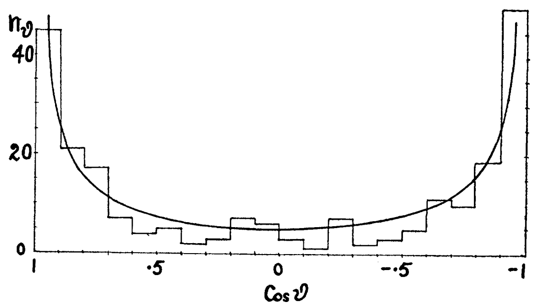

FIG. 1. The histogram gives the angular distribution of shower particles in the c.m. system. The smooth curve is the Fermi plot for the median value of impact parameter.

The angular distribution is not consistent with the assumption[2] that the charged shower particles are produced in pairs by the decay of a very short-lived parent meson slightly heavier than its products.

A total of 56 additional charged shower particles are created in ten secondary interactions, and the following conclusions can be drawn:

(a) The interaction cross section of charged shower particles is equal to the geometric area of the target nucleus.

(b) For an incident energy $\gamma_0\sim1000\ \mu c^2$, an average of 5–6 mesons are produced in secondary interactions.

TABLE I. Comparison of the number of heavy prongs accompanying meson produced meson showers with the number of heavy prongs obtained by Camerini *et al.*[a] for randomly selected meson showers of equal multiplicity.

Star no.	Number of shower particles n_s	Number of heavy prongs N_h	Average number of heavy prongs in randomly selected showers
1	4	1	11
2	4	1	11
3	5	3	12
4	5	8	12
5	5	0	12
6	6	1	12
7	8	5	13
8	8	9	13
9	11	2	14
Total	56	30	110

[a] Camerini, Fowler, Heitler, King, and Powell, Phil. Mag. **40**, 862 (1949).

(c) In a reference system in which the incident meson and a nucleon of the target have equal and opposite momenta, the secondary shower particles are preferentially emitted in the backward direction.

(d) Meson produced meson showers lead to much lower excitation of the target nucleus than nucleon produced meson showers of comparable multiplicity (see Table I).

(e) Some evidence is obtained that neutral particles different from neutrons and capable of producing meson showers are created in the primary collision.

The number of neutral pions can be determined accurately since all details of the charge multiplication process are visible in the 24 emulsions traversed by the shower. The ratio of neutral pions to the created charged shower particle is

$$n_0/(n_+ + n_-) = 0.86\pm0.1$$

a result which is in disagreement with the value 0.29 ± 0.08 recently reported by Daniel *et al.*[3] for high energy showers. In agreement with previous measurements the lifetime of neutral pions was found to be $\tau_0\leqslant10^{-14}$ sec.

From the observation of 15 electron-positron pairs produced by charged particles, the cross section for this process was found to be within statistical error in agreement with that calculated by Bhabha.[4]

A detailed account of these measurements and results will be published in the Proceedings of the Indian Academy of Sciences.

[1] E. Fermi, Phys. Rev. **81**, 683 (1951).
[2] Danysz, Lock, and Yekutieli, Nature **169**, 365 (1952).
[3] Daniel, Davies, Mulvey, and Perkins, Report of the Bristol Conference (1951).
[4] H. J. Bhabha, Proc. Roy. Soc. (London) **A152**, 559 (1935).