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On the Nature of Mesons in Penetrating Showers

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THE present experiment was performed at an altitude of 1750 meters at Campos do Jordão in order to obtain some information on the nature of the particles produced in penetrating showers. The penetrating showers were detected by a Geiger-Müller counter arrangement as shown in Fig. 1. The counter trays had an area of 500 cm² each and were connected in fourfold coincidence. The experiment consisted in comparing the penetrating power of showers produced in the atmosphere and showers produced in 21 g/cm² of gasoline located above the counters (see Fig. 1). The absorption of the penetrating showers was

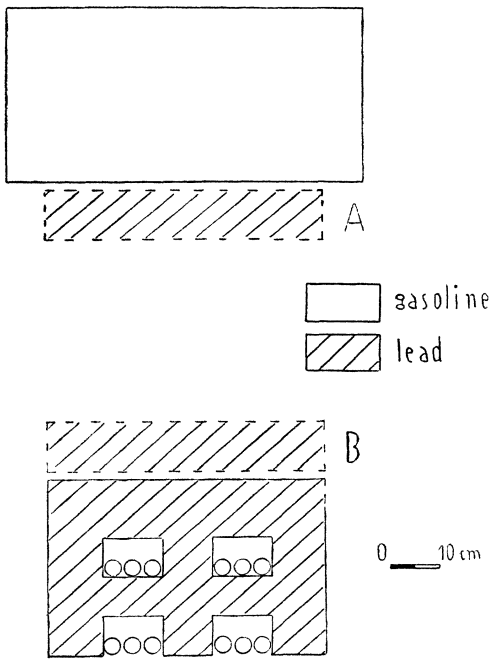

Fig. 1. Arrangement of Geiger-Müller counters.

Table I. Hourly rate of coincidences.

No material	3.37±0.16
Pb in position *A*	4.10±0.24
Pb in position *B*	3.35±0.22
Gasoline	4.16±0.19
Gasoline with Pb in position *A*	4.07±0.19
Gasoline with Pb in position *B*	3.50±0.19

obtained by 110 g/cm² of lead alternatively situated in position *A*, just below the gasoline, and in position *B*, just above the permanent shielding of the telescopes. Our results are shown in Table I. The frequency of the showers produced in the air is given in the first line. The lead placed in position *B* did not alter this frequency. This indicates that showers produced in the air are not appreciably absorbed in an additional protection of 10 cm of lead. This result has been checked by several independent experiments (to be published shortly—see also Cocconi and Greisen,[1] and Sazepin and Eydus[2]), so that it seems difficult to explain the constant frequencies by a compensation of production and absorption in the additional lead. When the lead was placed in position *A*, we noticed a production of 0.73±0.29 hr.$^{-1}$. Probably the production in *B* was not registered due to an unfavorable geometrical arrangement.[3]

The frequency of showers produced in gasoline alone is 0.79±0.25 hr.$^{-1}$, whereas the rate due to the compound effect of gasoline and lead in *A* is 0.70±0.25 hr.$^{-1}$. This effect is much smaller than the one we should expect due to the production in gasoline plus the production in lead, taking into account the reduction of the intensity of the shower-producing radiation in gasoline. On the basis of previous results we assume that nucleons responsible for penetrating showers are absorbed in gasoline with a coefficient ~60 g/cm².[4] Thus it seems to us that 76±41 percent of the showers produced in gasoline are absorbed in the additional layer of lead. Similarly we noticed that 84±31 percent of the production in gasoline is absorbed by the lead in position *B*.

We conclude that some of the shower particles produced locally above the counter arrangement are much softer than those of the penetrating showers produced in the atmosphere, the former being absorbed in 28 cm of lead. This result cannot be explained by theoretical arguments, since showers produced in gasoline should be more energetic than those produced in air.[5]

We are led to explain the experimental results by the following considerations based on some recent ideas about the properties of different types of mesons. The mesons produced initially in the penetrating showers are mainly π-mesons.[6] These mesons, responsible for the nuclear forces, should interact strongly with matter and in consequence be appreciably absorbed by the lead layer near to their production center. As the π-mesons are unstable with a mean life of ~10^{-8} sec.,[7] they should after a path of a few meters decay into μ-mesons, which are the usual mesons observed in cosmic radiation and which have a great penetrating power. Now, the main part of the penetrating showers produced in air have their production centers at a

greater distance than, e.g., 10 meters so that the particles constituting the showers are unaffected by the additional layer of 10 cm of lead.

We acknowledge our indebtness to Professor H. Stammreich and Mr. R. Salmerón for some helpful assistance with our experimental equipment.

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On the Beta-Particle Spectrum from the Decay of Tritium

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In an earlier letter we presented[1] unreduced data relative to the beta-particle spectrum from the decay of tritium; these data, taken from tracks of the beta-particles in a cloud chamber, were in the form of a differential distribution of plane-projected track lengths. A reduction of these data has now been completed, with the following interesting results.

By numerical solution of the rather complicated relevant integral equation, a differential distribution of true track lengths was obtained; this, after consideration of the small effects of straggling, was converted to a differential energy-distribution; finally, this last distribution was compared in the standard way with the theory of Fermi.[2] Extrapolation of the linear portion of the Fermi plot indicated an end-point energy which is 1.222 times that shown by the initial distribution of projections; this extrapolation was based upon the statistically satisfactory portions of the data, so the extrapolated end-point can be determined by the energy-range relation of von Droste.[3] Thus the cloud-chamber data now lead to an extrapolated end-point energy of $14.0\times1.222=17.0$ kev, which is in extremely good agreement with the 16.9 kev recently obtained[4] by Curran, Angus, and Cockcroft.

Figure 1 shows the distribution of energy in the decay of tritium, as determined by both experiments, on the assumption that both experiments indicate the same end-point energy. Although there are statistical limitations to the precision of the cloud-chamber data at energies near the end point, and observational limitations at very short ranges (both of which could be considerably reduced by obvious means), the agreement between the results of the two experiments, at energies between 6 and 13½ kev, is remarkably good. This agreement, incidentally, has a significant bearing upon the results reported recently[5] on the low energy portion of the beta-particle spectrum from the decay of RaE, for the RaE data were obtained with the same apparatus and the same detailed techniques, except that $Bi^{210*}(CH_3)_3$ was the molecule instead of tritiated water.

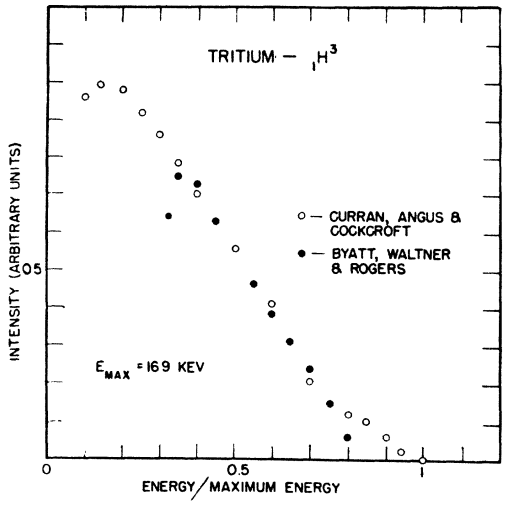

Fig. 1. Distribution of energies in the beta-decay of tritium.

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The Gamma-Rays Following Au^{198} β-Decay

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The question whether the decay of Au^{198} is simple or complex has been pointed up by much recent work in the literature. Levy and Greuling,[1] from spectrometer measurements, have proposed a complex decay scheme wherein ~15 percent of the transitions emit a β of 0.605 Mev, and γ's of 0.157 and 0.208 Mev. DuMond, Lind, and Watson,[2] by absorption in Sn, found low energy γ's in ~15 percent ratio to the precisely measured 0.4112-Mev γ-ray. These low energy γ's could explain the γ-γ coincidences of many recent measurements.[3,4]

In a spectrometer measurement of the β-shape Saxon[5] found the spectrum allowed down to 0.2 Mev, but no systematic search for the low energy γ's was made. Wilkinson and Peacock[6] also report a simple spectrum, while Jurney and Keck[7] found no γ-γ coincidences.

In view of the above conflicting measurements, it was decided to rerun the Au spectrum, with particular care in looking for low energy internal conversion lines from the 0.157- and 0.208-Mev γ's. The same source material used previously[5] was reactivated in the Argonne heavy water