Comment on "Possible Observation of Light Neutral Bosons in Nuclear Emulsions"

In a recent paper, de Boer and van Dantzig[1] claim the existence of new bosons of mass in the MeV range, which decay to e^+e^- pairs, partly on the basis of results of Anand[2] in 1953 on analysis of pairs associated with cosmic-ray-induced disintegrations in nuclear emulsion. Since I had originally proposed this experiment to Anand as his thesis topic, I feel some responsibility to comment on the matter. I believe the Anand results can be perfectly well understood in terms of known processes, namely, the production of neutron pions followed by their "Dalitz" decay in the mode $\pi^0 \rightarrow e^+e^-\gamma$.

Anand observed 62 e^+e^- pairs originating within 10 μm of the vertices of some 3000 interactions. From the measured charged-pion rate, and the 1.2% branching ratio for $\pi^0 \rightarrow e^+e^-\gamma$, one can estimate that 80–90 Dalitz pairs should have been expected. In addition to the 62 pairs, Anand found 20 single-electron tracks from the interactions, and most of these can be attributed to pairs in which one partner was at large angle to the other, and had high energy, so that it would be indistinguishable from tracks due to charged pions in the same events (the average number of such pions was 6 per event). Such features are consistent with the known distributions in the Dalitz decay process, as established experimentally by Samios[3] and theoretically by Joseph.[4]

Anand was attempting to measure the lifetime τ_{π^0} by measuring the distance δ from the vertex of the interaction to the first *discernible* grain in the tract of the e^+e^- pair. He found $\bar{\delta}(\text{pair}) = 4.9 \pm 0.5$ μm. As control, he used secondary protons of twice minimum ionization—and hence of the same nominal grain density as a pair—and found $\bar{\delta}(\text{proton}) = 3.7 \pm 0.3$ μm. Attributing the difference to a finite path length before decay, he deduced $\tau_{\pi^0} \simeq 5 \times 10^{-15}$ sec, nearly 2 orders of magnitude bigger than the present value $(9.0 \pm 0.3) \times 10^{-17}$ sec.

With the benefit of hindsight, we can remark that the above discrepancy is only just above 2 standard deviations (from $\tau_{\pi^0} = 0$). Genuine differences in $\bar{\delta}$ could also arise from subtle systematic effects, due to different degrees of optical obscuration from other tracks near the vertex, associated with different dip-angle distributions for the pair and the proton samples (proton secondaries are very common and "flat" tracks would have been selected).

de Boer and van Dantzig point out correctly that the measured distribution in fractional energy f carried by one electron of the pair, instead of being flat as expected, is peaked towards $f \sim 0.5$ (equal energies of the pair). However, Anand only measured both electron energies for 26 pairs out of the sample of 62. In the other cases, one track was too short or the electron energy too high to give a reliable energy estimate using the multiple Coulomb scattering technique. If this fact and the above losses of (up to 20) high-disparity pairs are taken into account, it is not obvious that any anomaly would remain. It also has to be noted that the mean energy of the close pairs is equal within errors to that of pairs from external conversion of γ rays due to $\pi^0 \rightarrow 2\gamma$ from the same interactions, as expected if the close pairs are due to $\pi^0 \rightarrow e^+e^-\gamma$.

In summary, the Anand events of 1953, on the basis of the information available today, appear to be compatible with $\pi^0 \rightarrow e^+e^-\gamma$, a process which we know must occur. There is no feature of the data positively requiring any new particle or hypothesis.

de Boer and van Dantzig also comment on results from El-Nadi and Badawy,[5] presented in the Letter adjacent to theirs, on pairs associated with 4.5-GeV/c α-particle interactions in emulsion. The number of events is very small, little information is given about experimental resolution or technique, and no control data are presented for comparison. However, it can be said that the number of pairs reported is again quite compatible with that expected from the Dalitz decay of neutral pions and their production rate at the energy employed.

D. H. Perkins
Department of Nuclear Physics
University of Oxford
Keble Road
Oxford, OX1 3RH, England

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