Comment on "Observation of Bhabha Scattering in the Center-of-Mass Kinetic-Energy Range 342 to 845 keV"

In a recent Letter von Wimmersperg *et al.*[1] presented a search for resonant e^+e^- scattering. Such searches with positrons of around 2 MeV kinetic energy become urgent since they might shed light on the puzzling e^+e^- pairs observed in superheavy (e.g., U+U) collisions.[2] von Wimmersperg *et al.* restricted the event registration to center-of-mass angles $\pi/2$ and to center-of-mass energies between 310 and 850 keV. They used a pencil beam of β^+ rays from ^{27}Si decays without monochromatization. Energy selection was done by variation of the angle $\theta=\theta^+(e^+)=\theta^-(e^-)$ for exclusively symmetric scattering events around 30.7°. When the target electrons are assumed to be at rest, the fixed two-body kinematics allows a unique correspondence between the angle θ, the center-of-mass kinetic sum energy Δ, the kinetic laboratory energy $E^k=E^k_{\rm inc}=E^k(e^+)+E^k(e^-)$ before and after scattering (still neglecting energy losses), and $m_Xc^2=[2mc^2(E^k+2mc^2)]^{1/2}$. Here, m_X is the mass corresponding to a possible resonance and m the electron rest mass. Figure 1 reproduces Fig. 5 of Ref. 1 with added horizontal scales for θ, E^k, and m_X. For an infinitely narrow incident beam, infinitely thin targets, and infinitely sharp detector aperture (three conditions) the energy resolution is given by

$$dE^k/d\theta=-4mc^2/(\sin^2\theta\tan\theta).$$

Changing the angles $\theta^+=\theta^-$ by 1° already changes the selected energy E^k by 0.23 MeV. Unfortunately, there are influences which erode the resolution, the dominating one being multiple scattering in the thick target.

Let us consider the angular spread $\Delta\theta_C$ before the Bhabha-scattering event inside the thick target and the spread $\Delta\theta_D$ after this event. The first spread $\Delta\theta_C$ is due to the opening of the channel C (specified in Fig. 1 of Ref. 1) *and* due to multiple scattering of the incident positrons. It causes that now no longer $\theta^+=\theta^-$, but its influence is softened by the kinematics of the following Bhabha scattering with $E^k=2m(\cot\theta^+\cot\theta^--1)$. The second spread $\Delta\theta_D$ is due to the detector aperture (not specified in Ref. 1) *and* to multiple scattering of the ejectiles. Its influence is not softened by correlations. When the Bhabha scattering occurs near the exit side of the target, then the incident e^+ particles traverse 67 mg/cm^2 of $(CH_2)_n$ with 1.8 MeV kinetic energy. From established Molière scattering and scattering data[3] it is learned that the mean scattering angle will be about 13°. This angle adds to $\Delta\theta_C$ and may broaden the resolution ΔE^k to 0.45 MeV.

When the events originate near the entrance side, then the two ejectiles have to traverse $\simeq$77 mg/cm^2 at typically 0.9 MeV, adding a scatter of more than 20° to $\Delta\theta_D$. Taking a detector aperture of 1°, a white incident spectrum, and not yet taking into account energy straggling inside the target, a small Monte Carlo simulation showed us that a resolution as indicated on the θ axis of Fig. 1 (1.5° in θ or 0.35 MeV in $E^k=E^k_{\rm inc}$ is already approached with a target of 0.5 mg/cm^2).

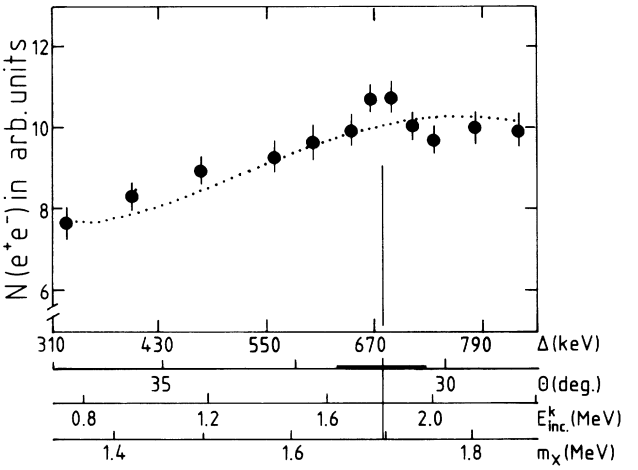

FIG. 1. Observed e^+e^- events as a function of various energy parameters. Indicated on the θ axis is a resolution of 1.5° corresponding with $\Delta E^k\cong0.35$ MeV and requiring a target thickness of $\simeq$0.5 mg/cm^2.

In conclusion, the spread in θ will be more than the full angular range of Fig. 1. This implies that the suggested resonance around $\Delta=700$ keV is too narrow for a realistic effect. The polyethylene target should be thinner by 2 orders of magnitude.

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