

Comment on ‘Search for new particles decaying into electron pairs of mass below $100 \text{ MeV}/c^2$ ’

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Abstract

A re-analysis of data from electron-pair production following $160 \text{ A}\cdot\text{GeV } ^{207}\text{Pb}$ bombardment of nuclear emulsions indicates the production and decay of neutral particles of significantly lower invariant mass and shorter lifetimes than previously claimed (*J. Phys. G: Nucl. Part. Phys.* **34** (2007) 129-138).

1 Introduction

Jain and Singh [1] report a study of electron-pair production following $160 \text{ A}\cdot\text{GeV } ^{207}\text{Pb}$ bombardment of nuclear emulsions, in which the energy and opening angles of pairs produced at distances greater than $50 \mu\text{m}$ from identified interaction vertices were analysed to determine the invariant masses of presumed neutral particles X decaying by the $X \rightarrow e^+e^-$ channel. Derived neutral particle masses from 2 to $84 \text{ MeV}/c^2$ were reported, with lifetimes ranging from 10^{-15} to 10^{-13} s (Fig. 1b, 2a, 3 and 4 of [1]). Such large derived masses do not appear to be consistent with the total pair energy and opening angle data that are reported (Fig. 1f of [1]). A re-analysis of the data presented in Fig. 1f indicates presumed neutral particle X invariant masses of 1.5 to $21 \text{ MeV}/c^2$, with lifetimes between 10^{-16} and 10^{-14} s. This mass and lifetime range are consistent with previous indications of light neutral particles decaying to e^+e^- from cosmic ray [2-3], emulsion bombardment [4-9] and nuclear decay [10-16] data.

2 Data and analysis

Figure 1f of [1] shows a scatter plot of total electron-pair energy E_{tot} versus opening angle θ . A total of 62 of the reported 1220 e^+e^- pairs fall above Borsellino’s [17] most probable opening angle ω_P at an invariant mass $1.02 \text{ MeV}/c^2$ as plotted together with the data in Fig. 1f of [1].

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These 62 events are, therefore, the only events that can be interpreted as indicating the decays of massive particles into e^+e^- pairs. The total energies and opening angles of these 62 events are reproduced in Fig. 1, together with plots of Borsellino's most probable opening angle ω_P and 1.5 times Borsellino's angle.

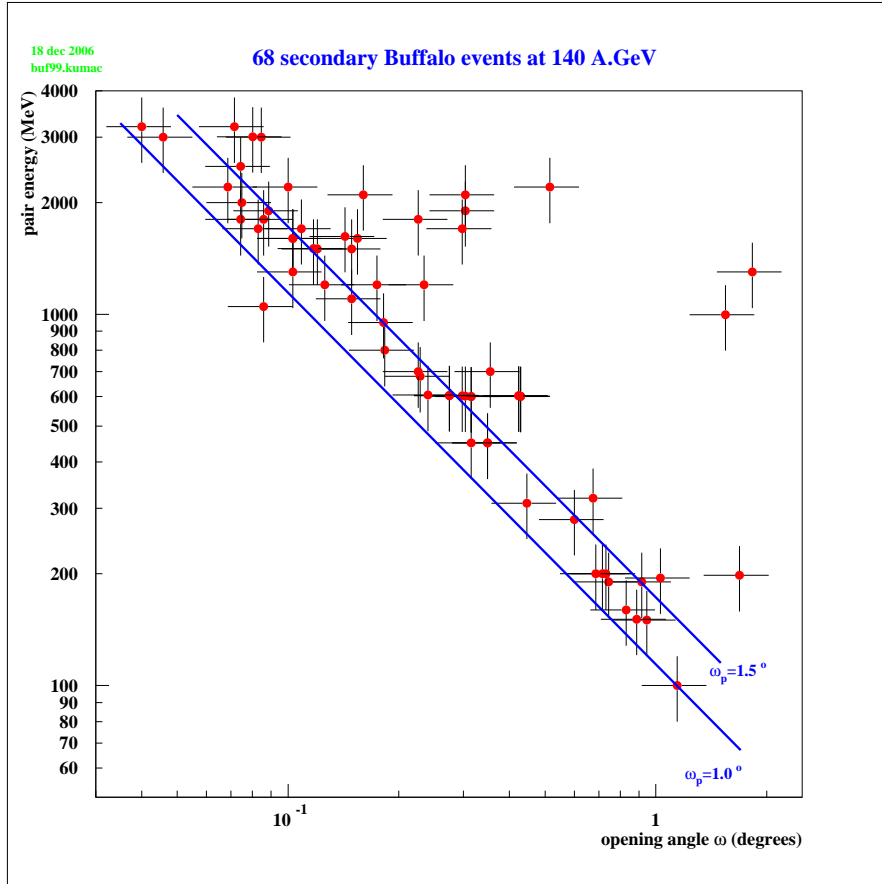


Figure 1: Total pair energy E_{tot} versus opening angle ω for the 62 events reported to be above the Borsellino line in Fig. 1f of [1]. Also shown are the Borsellino line $\omega_P = 4m_e c^2/E_{tot}$ (in radians) and 1.5 times the Borsellino line. Data were obtained manually from Fig. 1f of [1]. Uncertainties include the experimental uncertainties stated in [1] and the uncertainties associated with extracting the data from the published figures.

The invariant mass m_X for a presumed neutral particle X decaying to e^+e^- pairs was computed as:

$$m_X^2 = 2m_e^2 + 4E_1 E_2 \sin^2(\omega/2) \quad (1)$$

where m_e is the electron rest mass and E_1 and E_2 are the pair electron energies, here taken to be equal on the basis of the very small energy divergences reported in Fig. 1e of [1]. The computed invariant masses are shown in Fig. 2.

The X -particle lifetimes reported in [1] could not be confirmed directly, as the measured interaction vertex to pair vertex distances are not given and Figs 1b and 1f of [1] cannot be compared on

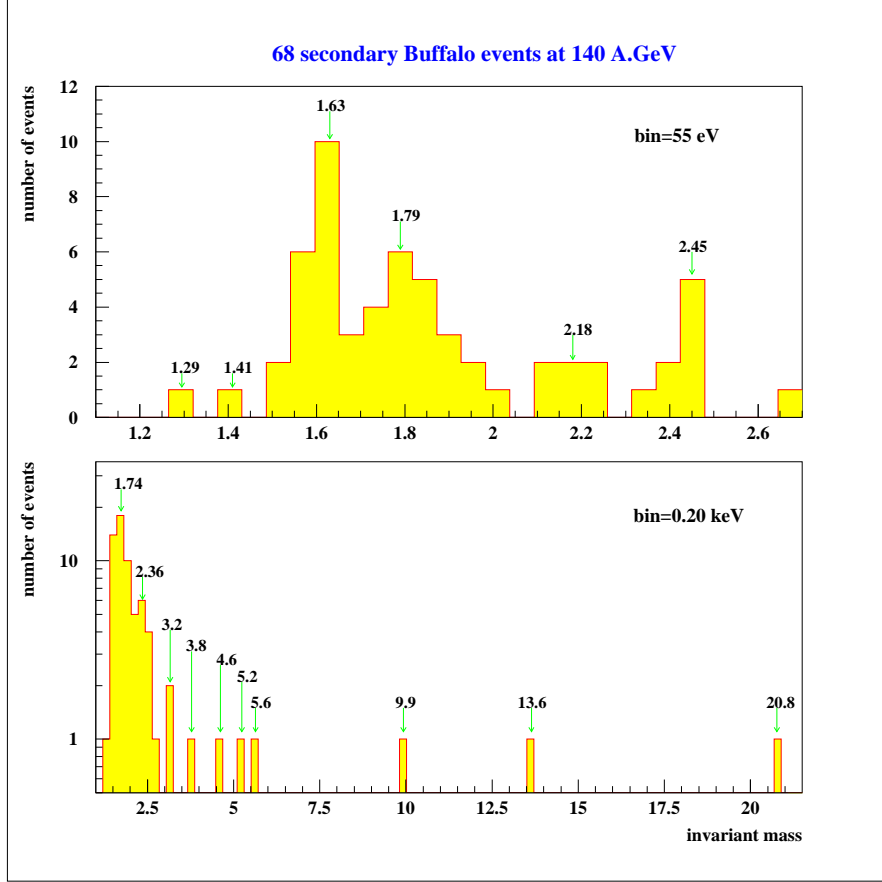


Figure 2: Computed invariant masses m_X of presumed neutral particles X decaying to e^+e^- pairs, as derived from Fig. 1 using Eqn. 1. (a) 59 events in the range $1.5 \text{ MeV}/c^2 \leq m_X \leq 6.0 \text{ MeV}/c^2$. (b) Full mass range, showing 3 events above $6 \text{ MeV}/c^2$.

a point-for point basis. The highest density of events is reported [1] to be between 50 and $300 \mu\text{m}$ of an interaction vertex, and this distance range was used to calculate X -particle lifetimes of 10^{-15} to 10^{-13} s [1]. From the mass range shown in Fig. 2, the X -particle lifetime τ_X can be estimated to be between 1.7×10^{-16} for a $1 \text{ MeV}/c^2$ X -particle travelling $50 \mu\text{m}$ and 10^{-14} for a $10 \text{ MeV}/c^2$ X -particle travelling $300 \mu\text{m}$, i.e. the revised mass calculations yield a median lifetime of approximately 10^{-15} s, an order of magnitude lower than reported in [1].

3 Discussion

Evidence for neutral particles with masses less than 10 MeV decaying into e^+e^- pairs has previously been reported from cosmic ray [2,3], emulsion bombardment [4-9] and nuclear decay [10-16] data. The structure of these particles is unknown. However, the angular distributions of e^+e^- pairs emitted in a 10.96 MeV $0^- \rightarrow 0^+$ magnetic monopole (M0) transition in ^{16}O forbidden to both single- γ and internal pair-conversion (IPC) modes indicates that an X -boson of approximately $10 \text{ MeV}/c^2$ is the primary decay product in this transition [13-14]. Similarly, the analysis

reported in [4,5] suggests that 1.1, 2.1 and 9 MeV/c² bosons are primary products of ¹²C and ²²Ne bombardments of nuclear emulsions. These candidate light neutral bosons have been tentatively interpreted as potential components of light dark matter [18].

The present re-analysis of the 160 A-GeV ²⁰⁷Pb emulsion data reported by Jain and Singh [1] brings the majority of events observed in these reactions into a mass and lifetime range consistent with earlier reports of light neutral bosons decaying into e^+e^- pairs. A comprehensive re-analysis of data from multiple sources indicating the existence of such particles is currently under way [19].

4 Acknowledgements

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5 Bibliography

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