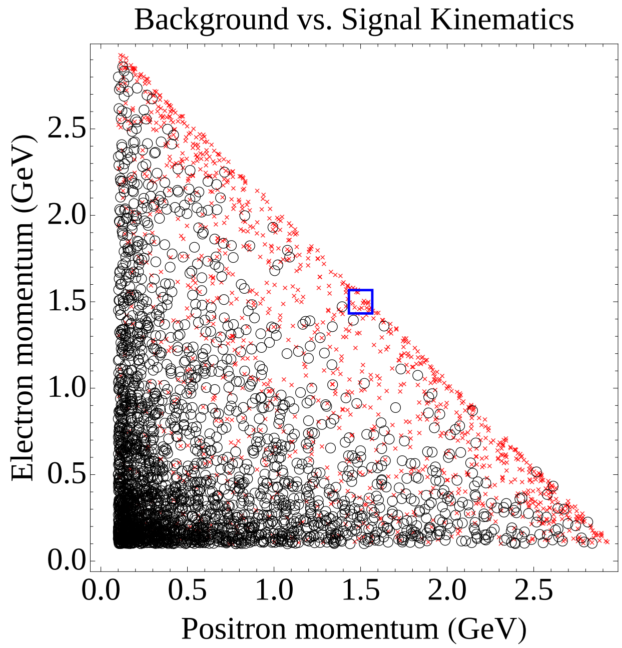

FIG. 9: Positron and electron momenta in A' signal events with $m_{A'} = 200$ MeV (red crosses) and in Bethe-Heitler background events, for a 3 GeV beam energy. Comparably sized signal and Bethe-Heitler samples were used to highlight the kinematics of both; in fact the expected signals are much lower than the Bethe-Heitler process (see Figure 11). The clustering of A' events at high momenta near the kinematic limit and of Bethe-Heitler events along both axes are evident. A spectrometer acceptance window that optimizes signal sensitivity is indicated by the blue box.

resolution).

A. Calculation of the ϵ reach

For all cross sections and rates of reactions described in this paper and [1], Monte Carlo based calculations were performed over a grid of beam energy settings and central spectrometer angular settings. Interpolation was used to extend this grid continuously to intermediate beam energies and angles — all rates exhibited expected power law behavior, thereby providing confidence in the reliability of an interpolation. Additional cross checks at specific points were performed to test the accuracy of our interpolation, which was generally better than $\sim 5\%$.

In order to calculate the α'/α reach for a particular choice of target nucleus, spectrometer angular setting, profile of wire mesh target, and momentum bite, the following procedure is performed:

- Monte Carlo events are simulated for the Bethe-Heitler, radiative tridents, and the continuum trident background including the full interference effects between the diagrams. The latter background is computationally intensive, and only a small statistics sample is generated, sufficient to obtain the cross-section from MadEvent.
- The cross-section ratio of the full continuum background (with interference effects) to the sum of the Bethe-Heitler and radiative tridents is calculated, and represents a multiplicative factor by which the latter must be multiplied to get the background cross-section.
- The rates of all reactions impinging the spectrometer acceptance were calculated by integrating over a chosen target profile, which usually extended from 4.5 to 5.5 degrees. For Bethe-Heitler, radiative tridents, and the continuum trident background, the calculation of the rate was performed as a function of the invariant mass of the e^+e^- pairs.
- Using the expressions in Appendix B, we calculated the mass resolution δ_m. We then tiled the acceptance region with bins of size $2.5 \times \delta_m$ in invariant mass.
- As a function of α'/α, the total number of signal (S) and background (B) events was calculated with the help of (18) for each bin.
- We then set $S/\sqrt{B} = 2$, and solved for α'/α.

This procedure was used to calculate the reach in the α'/α and $m_{A'}$ parameter space shown in §VII. Further improvements may be obtained by more sophisticated analysis cuts such as the use of matrix element methods (see e.g. [12]).

VI. BACKGROUNDS

In this section, we present the results of an analysis of the expected backgrounds for the A' search. Table II summarizes the expected singles rates, trigger rates, and coincidence rates. For more details on how we calculated the background rates we refer the reader to [1].

Important backgrounds come from electron, pion, and positron singles. There are three contributions to the electron singles rate in the HRS at the proposed momentum settings, namely inelastic scattering, radiative elastic electron-nuclei scattering, and radiative quasi-elastic electron-nucleon scattering. Our calculations of the electron, pion, and positron singles rates were checked against measurements made by experiment E03-012 for a 5 GeV electron beam incident on a hydrogen target, at 6° 2-GeV HRS setting. The final values of the electron and pion rates were obtained by means of the "Wiser" code [85]; positron singles rates from trident reactions were calculated using MadGraph and MadEvent [84], described in §V.

Using our calculations of the singles rates, we compute the rate of accidental coincident triggers arising from an e^+ in the HRS-R and an e^- in the HRS-L within the