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A data-driven method to estimate the antiproton background in the Mu2e experiment

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The Mu2e experiment will search for the CLFV process of coherent, neutrinoless $\mu^- \rightarrow e^-$ conversion in the field of an Al nucleus. The expected signal is a 104.97 MeV monochromatic conversion electron (CE). The signature feature of Mu2e is the superconducting solenoidal magnetic system that produces a high intensity pulsed muon beam. One of the backgrounds to the CE search is antiprotons produced by the proton beam interaction with the production target, making their way to the aluminum stopping target and annihilating to produce CE-like electrons. Although not a dominant background, it has a large uncertainty and cannot be suppressed by the timing cuts used to reduce the prompt background. The systematic error is dominated by the uncertainty on the antiproton production cross section for the Mu2e proton beam energy. We have developed a novel data-driven method to estimate the antiproton background. At Mu2e energies, $\bar{p}$ annihilation is the only source of events with multiple, simultaneous particles coming from the stopping target. From Geant4 simulations, only about 0.2% of the simulated $\bar{p}$ annihilation events have a signal-like electron. Meanwhile, $\sim 5\%$ of events have multiple reconstructible particle tracks. Therefore, we have devised a methodology to reconstruct the multi-track events and estimate the $\bar{p}$ background by exploiting the large ratio of the production rates of the two final states. The systematic uncertainty to this estimation stems from the uncertainty on the ratio of the two final states. This can be translated to the uncertainties on : (1) the pion multiplicity; (2) the shape of the inclusive pion momentum spectrum from $\bar{p}$ annihilation at rest. We have compared the values obtained from GEANT4 simulations to the measurements available from various past experiments. In this talk, I shall present the final results of this in-situ estimation of the $\bar{p}$ background in Mu2e.

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