A' Separated Decay Vertex Search with Measurements in 2014-2015 Run

HPS Thesis Proposal

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November 20, 2013

The purpose of this proposal is to search for the A' gauge boson in regions of low coupling where the A' is identifiable by the separated decay vertex signature and the e+e- invariant mass resonance above the QED trident background. This analysis will use energy information from the Electromagnetic Calorimeter (ECal) and angular information from the Silicon Vertex Tracker (SVT) as measured in the 2014-2015 HPS run.

Justification

Observation of the A' boson is contingent upon the identification of a resonance peak in the e+e- invariant mass distribution (bump hunting) on top of the QED trident background. Bump hunting requires a high mass resolution to discern the resonance peak. This peak may or may not be characterized by an additional displaced vertex and depends on the strength of the A' coupling. At regions of low coupling, the observation of the A' is characterized by the separated decay vertex as the invariant mass resonance is more difficult to observe above the QED background alone. While high mass resolution is projected to be attainable with the installation of new Avalanche Photo-Diodes (APDs) on the ECal that will be used during the HPS run, a vertex cut from the SVT will allow the A' to be observed at low mass energies and low coupling. Vertexing will use the reconstruction from ECal energy measurements with SVT angular measurements and will complement mass resonance searches relying on bump hunting alone.

The primary purpose of the ECal is to provide the means to trigger, identify, and measure the e+e- particles passing through. Previous tests using components of the HPS ECal demonstrated an energy resolution of approximately 4.5 percent. Improvements to the ECal for the 2014-2015 run include changing out the original APDs (5x5 mm^2) for larger APDs (10x10 mm^2) with new amplifiers. Increasing the area of acceptance by a factor of four will yield four times the light intake from the crystal, reduce the statistical component of the energy resolution by a factor of two, and subsequently generate four times larger signals. Additionally, the larger signals can be generated without the use of high gain amplifiers which can decrease the electronic noise in the signal. From this improved quality of the signal, the threshold may be lowered to maximize low energy acceptance and yield an energy resolution of approximately 2-3 percent at the lowest energies HPS will explore (as observed in a similar calorimeter presently being tested). These changes will yield an improved energy resolution making the ECal a suitable device for measuring e+e- energies that can be used for bump hunting to improve the invariant mass resolution of the heavy photon. By searching for the mass resonance in decays characterized by a displaced vertex, it is possible to access the signal in a region where it would otherwise be lost in the QED background.