Monte Carlo Simulation of the EMPHATIC Spectrometer

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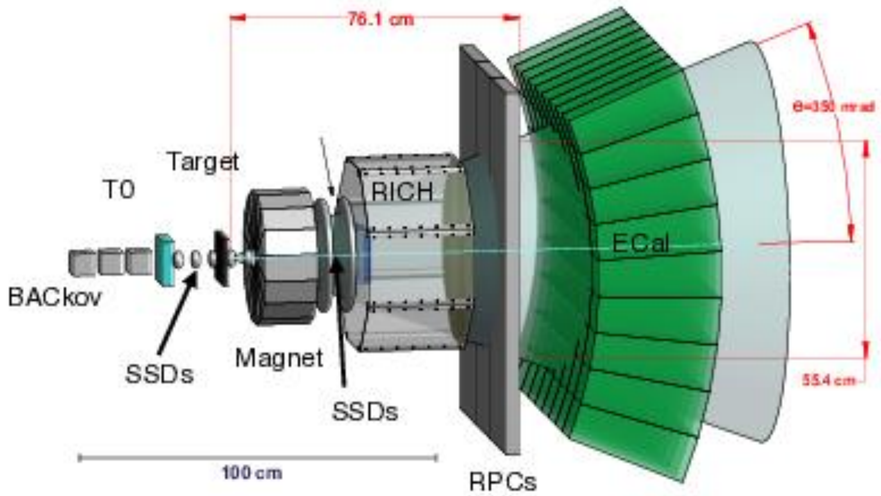
Introduction

The goal of the EMPHATIC collaboration is to measure hadron scattering and hadron production cross sections using a spectrometer. The purpose of this internship project was to simulate beam particles passing through the spectrometer using Monte Carlo event generators in a C++ toolkit called GEANT4, within the art framework.



The EMPHATIC spectrometer. The silicon strip detectors (SSD) are visible before and after the magnet.

Methods

The simulation uses random number generators with a gaussian distribution to generate incoming particles with realistic random positions and momenta. These particles are then propagated through the spectrometer and position information is recorded at the locations of the silicon strip detectors. The materials, shapes and locations of all detectors in the spectrometer are accounted for in the simulation. The simulation was done using GEANT4 and the art framework. Art is a software framework for managing reconstruction and analysis of data and simulation that was developed in-house at Fermilab. In the plots that follow, 1 million events were simulated of 120 GeV/c protons entering the EMPHATIC spectrometer and another set of 10k events of 8 GeV/c protons were simulated.

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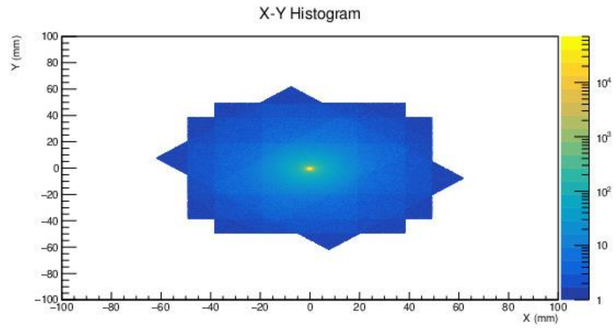
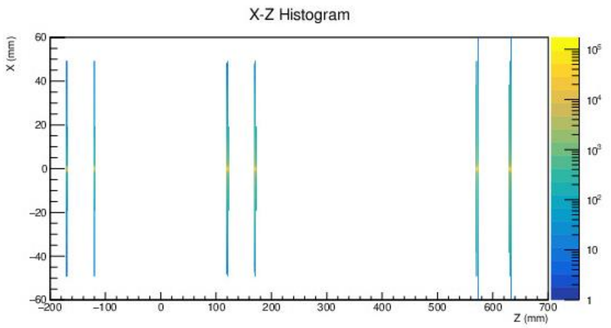
Analysis

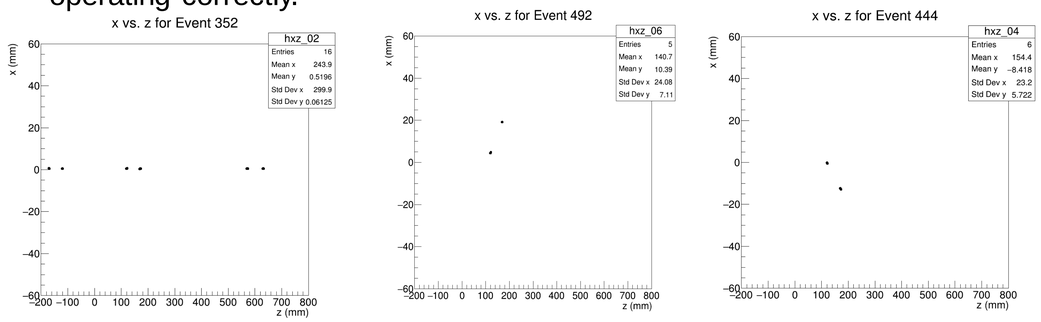


X vs Y histogram of the position of SSD hits on a Log scale.



X vs Z histogram of the position of SSD hits on a Log scale.

ROOT was used to generate plots of the simulation results. The particles that hit the silicon strip detectors (SSD) were recorded. The number of silicon strip hits per event was plotted on a histogram to better understand the frequency of SSD hits. The z histogram shows the multiple layers of SSDs in the geometry. Individual events for the 8 GeV run were plotted on graphs to determine if the magnet is operating correctly.



Graphs of the X-Z silicon strip detector (SSD) positions for single events run at 8 GeV.

Results

The generated histograms clearly show the silicon strip detector (SSD) layers. The result of this project is a GEANT4 simulation of the EMPHATIC spectrometer integrated into the art framework with a much more sophisticated geometry that can simulate SSDs. However, for many of the 8 GeV events there are no present SSD hits and little activity in the SSDs positioned ~700 mm into the detector, suggesting the magnet is not operating correctly. While the simulation can simulate SSDs, the graphs above for single events show that there are still some issues in the simulation to follow up with in future work