Track reconstruction in the GlueX experiment with non-ideal cathode plane surfaces

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Introduction

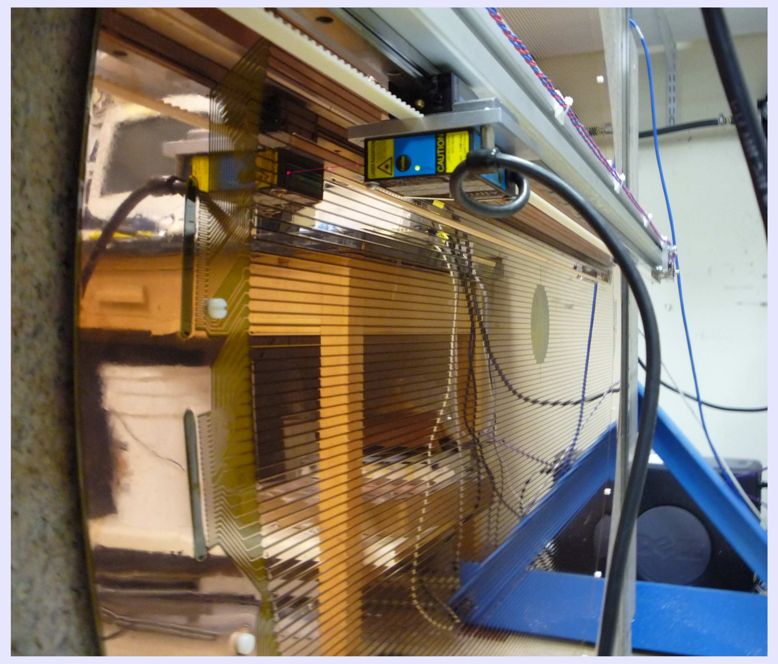
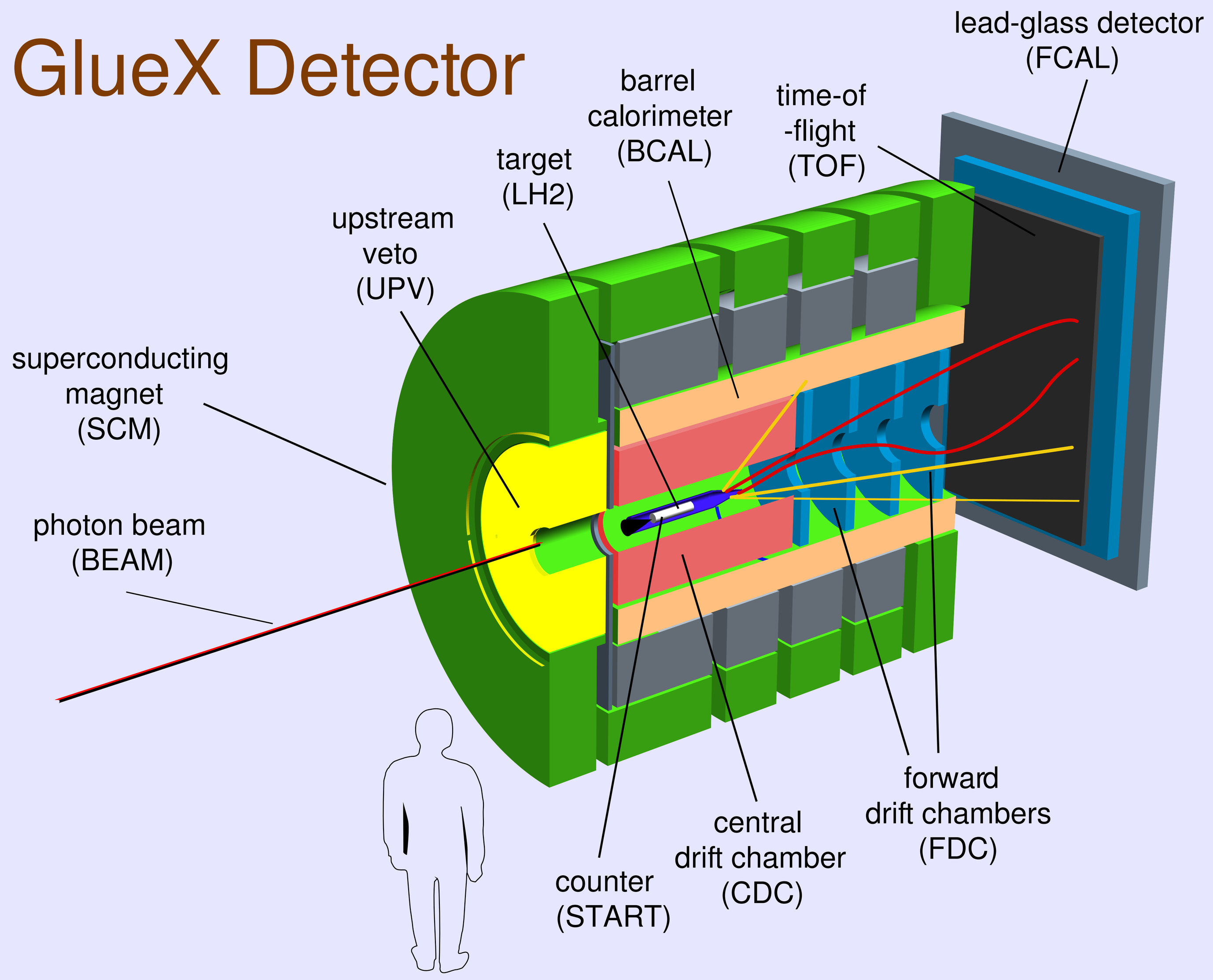


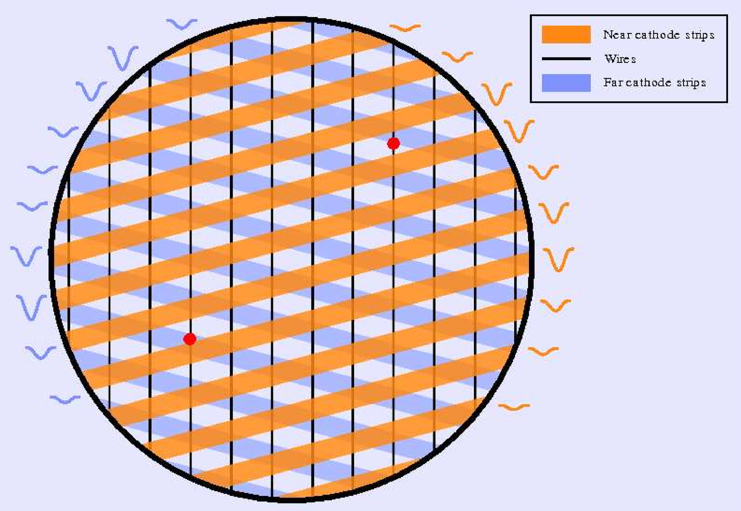
Figure 1: A laser measures the surface profile of a cathode plane, as a stepper motor pulls it along a metal track.

The GlueX experiment at Jefferson Lab requires a nearly hermitic set of detectors, in order to map out the spectrum of low energy exotic hybrid mesons. The detectors include calorimeters, drift chambers, a start counter, and a time-of-flight detector. The forward drift chambers are responsible for detection of charged particles downstream of the target.

As cathode plane surfaces in the forward drift chambers cannot be perfectly flat, it is necessary to study the effect of any divots or undulations that are present. A flatness measurement system has been developed, and simulations are being performed to understand the effect of non-flat cathode plane surfaces on track reconstruction.

The forward drift chambers





There are twenty-four forward drift chambers, divided into four packages of six (represented above as blue circular planes). Each drift chamber is made up of a wire plane sandwiched between two cathode planes (see figure at left). By rotating the cathode planes ± 75 degrees with respect to the wire plane, three-dimensional measurements can be made by reading the signals off of the cathode strips as well as the wires.

Why cathode plane flatness matters

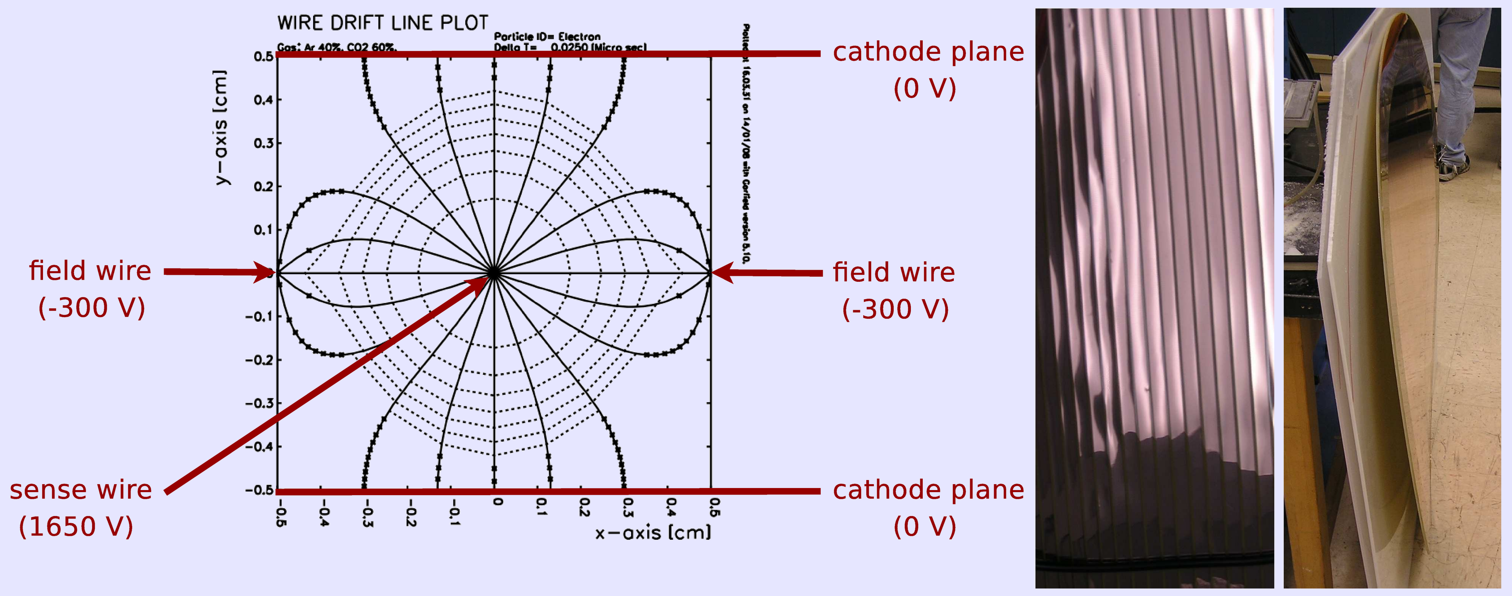
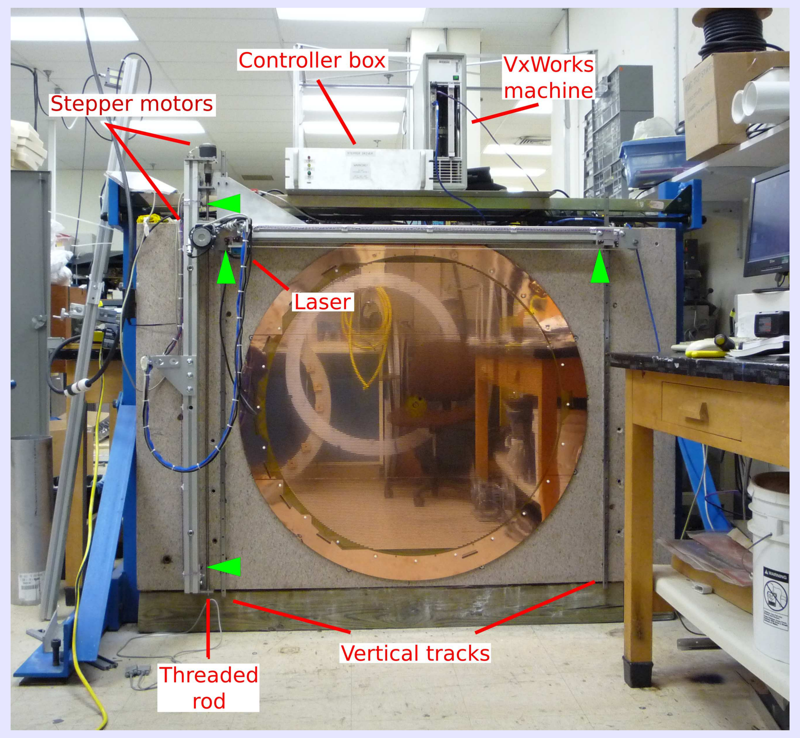


Figure 2: The field lines shown in the leftmost figure can be affected by cathode planes with local dimples or broad undulations, such as those photographed.

One intent of the forward drift chamber design is to produce the optimum field within each cell (see Figure 2). Imperfections in the design, such as dimples or broad undulations in cathode plane surfaces can skew the field, producing small offsets in detected particle positions. These offsets potentially impair track reconstruction.

Measuring cathode plane flatness



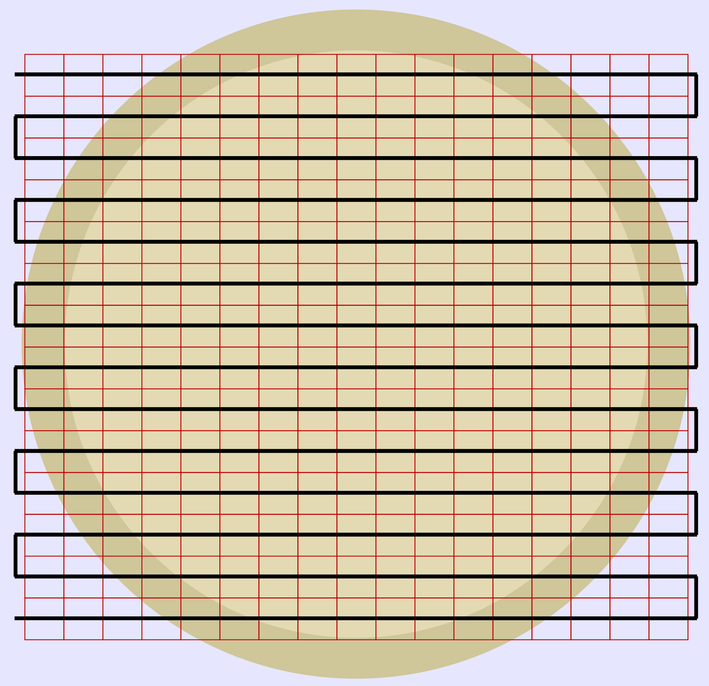
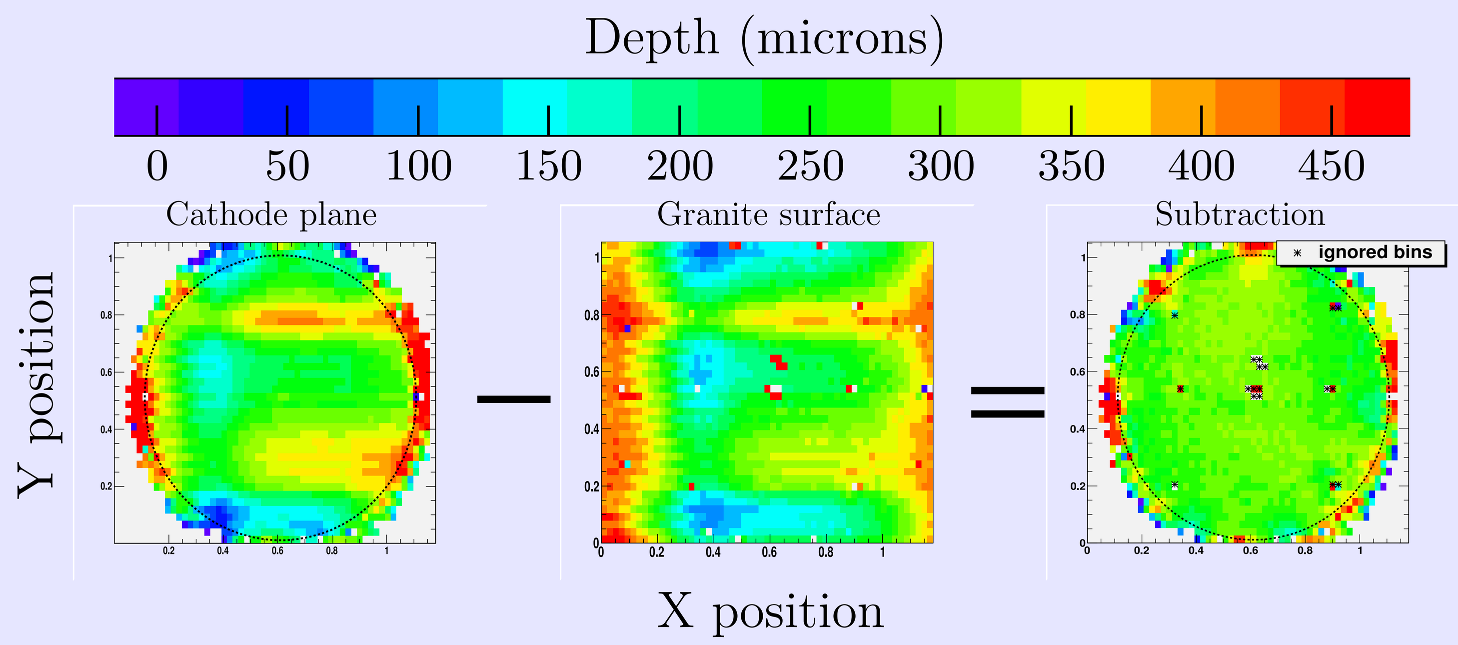


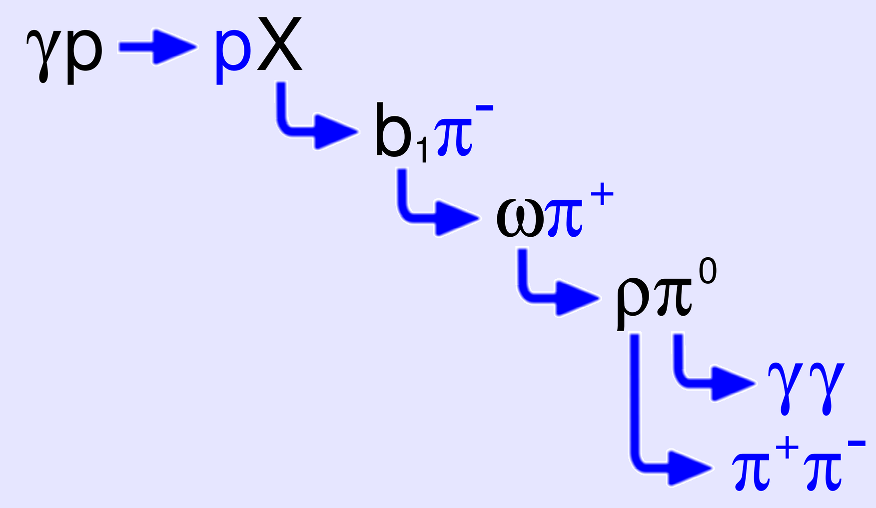
Figure 3: The flatness measurement system is at left (green arrows indicate positions of limit switches). The figure on the right shows the laser scan pattern in black lines. The data is divided into bins according to the red lines (not to scale).

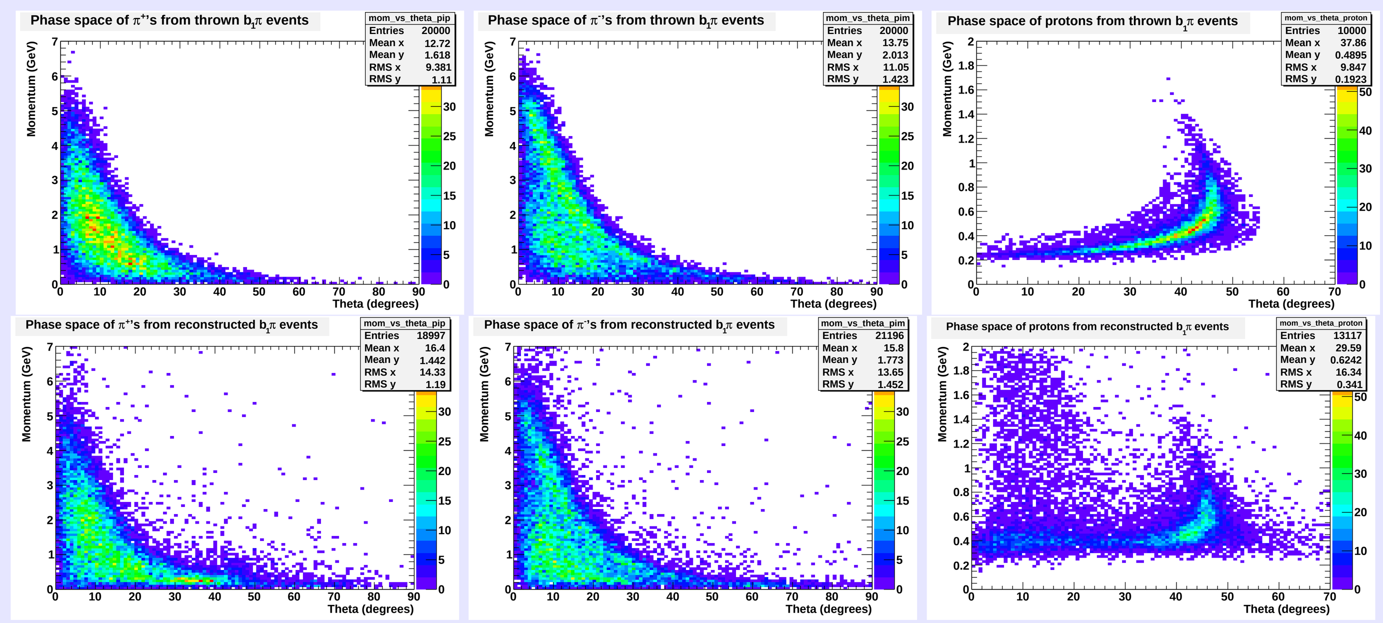
A flatness measurement system uses a laser displacement sensor to scan the surface of a cathode plane in the pattern shown above. Upon correcting for known issues with the measurement device, final profiles can be made as shown below.



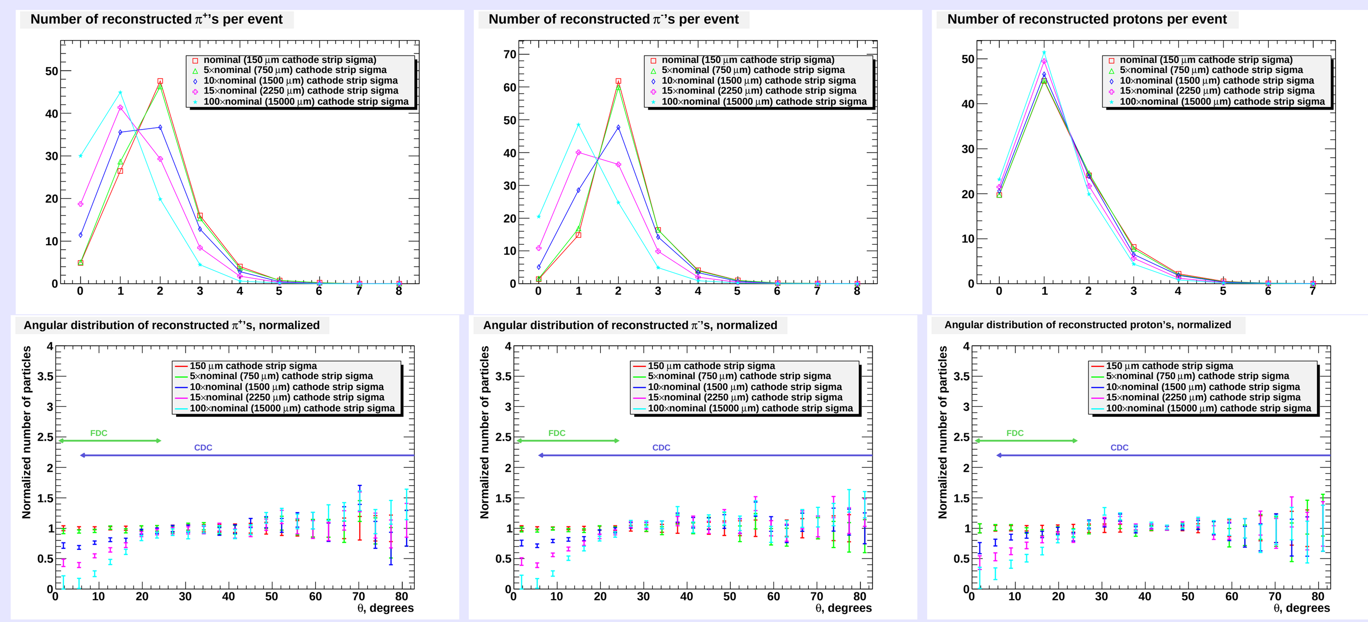
Track reconstruction

To better understand the effect of cathode plane flatness on track reconstruction, we simulate $b_1\pi$ events according to the image at right. Ideally, the GlueX detectors would detect all the final decay products in blue font.





The upper three plots above display perfect detection/reconstruction of charged $b_1\pi$ decay products. The lower plots above display the expected performance of the GlueX detectors and reconstruction software, without considering flatness effects.



Ideally, there would be one proton, two π^+'s, and two π^-'s reconstructed from each event. The plots above show the expected performance of track reconstruction as a red line. The other lines show the expected result of reconstruction in the presence of cathode planes with local divots. Flatness effects were simulated by adding an offset to the particle position, as measured by the cathode planes.

Additional resources

• The GlueX Collaboration. *GlueX Detector Review.* Technical report, Jefferson Lab, October 2004. GlueX-doc-346

• Daniel S. Carman and Curtis A. Meyer. *Hall D Forward Drift Chamber Technical Design Report.* Technical report, Jefferson Lab, March 2008. GlueX-doc-754-v10.