Geometry Calibration of the SVT in the CLAS12 Detector

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Introduction

The Silicon Vertex Tracker (SVT) is one of the subsystems designed to measure the trajectory of charged particles as they are emitted from the target at large angles (35°-125°) in a 5 T solenoid magnetic field. The information gathered is used to reconstruct the path of an identified particle and calculate its 4-momentum at the target position. The SVT is the smallest detector in CLAS12, boasting a beam size of 33.792 readout channels at 512 channels per module. It is designed for a beam luminosity of 10^{32} cm^{-2} s^{-1}.

The sensors of the SVT consist of long, narrow strips of p-type silicon with aluminium electrodes on n-type, bulk silicon substrate. There are 256 strips in a sensor, with a readout pitch of 156 μm, and a stereo angle of 0-3 degrees. [Fig. 2]

The location of the sensor strips must be known to a precision of a few microns in order to accurately reconstruct particle tracks with the required position resolution of 60 μm.

Ideal Geometry

Two sensors are paired with opposite stereo-angle orientation in a module. [Fig. 3] The pairs of sensors are arranged into sectors in four circular regions, centred on the target. [Fig. 2, 4]

Two sets of fiducial points were computed from the core parameters that describe the SVT, such as the radius and position along the beam of the regions. Another set of fiducial points were read from a Computer Aided Design (CAD) model based on the technical drawings. The latter was used to verify the former, and the ideal geometry is now well defined within 2 μm resolution of the design specification. [Fig. 7]

The first step toward calibrating the geometry was to compare an early version of simulated geometry to the technical design drawings. [Fig. 5] Several inconsistencies were discovered. The location of the sensor layers was not the same for the simulation and the reconstruction, and the backing structure did not match.

Alignment Shifts

Software was developed to apply alignment shifts to the ideal design geometry from two sources:

- Survey of fiducial points on the structure that supports each pair of sensor modules.
- Analysis of reconstructed cosmic tracks using linear least-squares fitting with many parameters.

The fiducial points were used to form plane vectors that represented the data. The raw points from the survey were fit to three circles for each region to minimise the overall shift of each module.

Conclusion

- Geometry has been well defined according to the design specification.
- Aligned the SVT using real cosmic data.
- The simulation and reconstruction software now receive the same geometry from one source.
- Future work:
  - Further alignment studies using non-Type-1 tracks.
  - Processing the fitted fiducial survey data into alignment shifts.
  - Testing the common geometry.

References