Analysis of INTT survey data

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The sPHENIX experiment is a new collider experiment at RHIC. The tracking subdetectors of sPHENIX include the MVTX (maps-based vertex detector), INTT (intermediate silicon tracker), TPC (time projection chamber), and TPOT (time projection chamber outer tracker). The INTT is a silicon strip detector, and the exact positions of the sensors must be known to correctly analyze hit positions.

The INTT comprises 56 "ladders." Each ladder is a carbon-fiber stave that serves as a mounting point for 4 sensors, 2 Type A sensors (8×2 chip configuration) and 2 Type B sensors (5×2 chip configuration).

Final positions of the INTT sensors were obtained through a series of three surveys:

- The positions of the sensor and ladder marks are measured for each ladder
  - These were done using an OGP (Optial Gauging Products) Smartscope[a)]
  - (See Fig. 1)
- Reference points at the corners of each ladder are measured post assembly, pre-installation
- The ladders and endcap positions are surveyed again post-installation

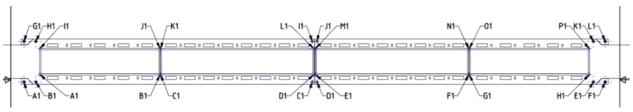

Fig. 1. Schematic of the ideal sensor positions on a ladder. The surveyed positions included the ladder endcap holes (Holes A1, F1, G1, and L1), and the sensor corners (all marks in the marks table). Note that the letters are used twice over; they are distinguished depending on whether they point to a mark (cross) or hole (circle).

The physical positions are provided via formatted text files, with the x, y, and z coordinates specified in different columns. Although there were three surveys, the data in the latter 2 surveys were combined into a single set of text files.

Ultimately, what are needed are the 3+1 augmented matrices that represent the ladder and sensor transforms. Corner position data provided by the survey were used to determine the offsets and orientations of the sensors and ladders using a method described in Fig. 2.

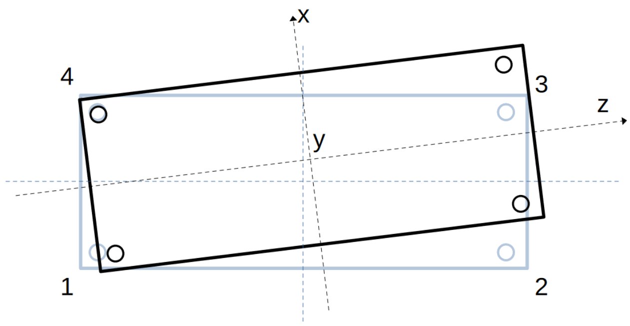

Fig. 2. An example of how a sensor's align transform is computed. The nominal position is shown with faint lines, and its actual position is shown with solid lines. The dotted lines indicate local coordinate axes and are obtained by linear combinations of the sensor diagonals, which are directly known through the measured corner positions (circles). The centers are considered as the average position of the 4 corners. By computing these for a sensor and a ladder with respect to a common reference frame, the affine transformation representing sensor to ladder is known through matrix inversion and multiplication.

These positions will be used in initial offsets in tracking reconstruction, but were also crucial for vertex position studies as this correction was needed to compare INTT's estimated vertex position against the same quantity for other subsystems.

Analysis of survey data also confirmed the sensor position on the ladders was within the 78 μm pitch. Across all ladders, the z displacement (parallel to long axis) of sensors had a standard deviation of $\sim$30 μm from nominal, and the transverse displacements of the sensors was $<$25 μm for each sensor type. Although both are precise, it is important to emphasize on the precision in the transverse alignment, which gives the INTT its high azimuthal resolution.

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a) https://www.ogpnet.com

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