Intermediate Silicon Tracker For STAR HFT Upgrade

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for the STAR Collaboration

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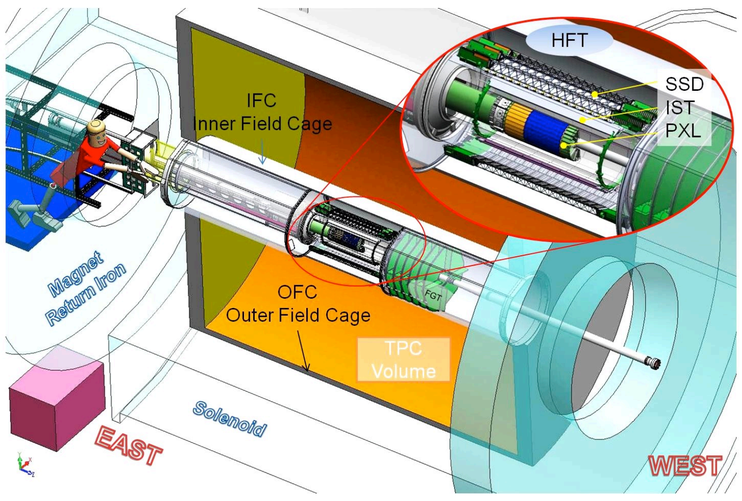
Abstract

The Heavy Flavor Tracker (HFT) has been installed in the STAR experiment at the Relativistic Heavy Ion Collider since January 2014. It greatly enhances the capability for heavy flavor studies by measurements of displaced vertices and direct topological reconstruction of open charm hadrons. The HFT consists of two inner layers of silicon pixel detectors, an intermediate layer of silicon pad detector and an outer layer of silicon strip detector. The Intermediate Silicon Tracker (IST) is the third layer made of silicon pad sensors, which have a position resolution of about 170 (1800) microns in the r-φ (z) direction. In this poster, we will present the design of the IST detector system, and its performance in the cosmic ray tests and ongoing physics data taking in Au-Au collisions.

1. Physics Motivation

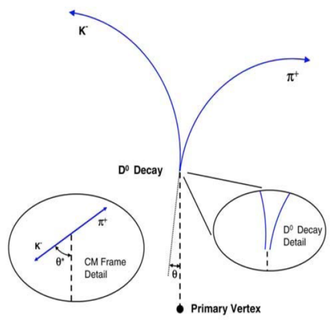


Detector	Radius (cm)	Hit Resolution R/φ - Z (μm - μm)	Radiation length
SSD	22	20 / 740	1% X_0
IST	14	170 / 1800	<1.5% X_0
PIXEL	8	12/ 12	~0.6% X_0
	2.9	12 / 12	~0.4% X_0

IST (Intermediate Silicon Tracker)

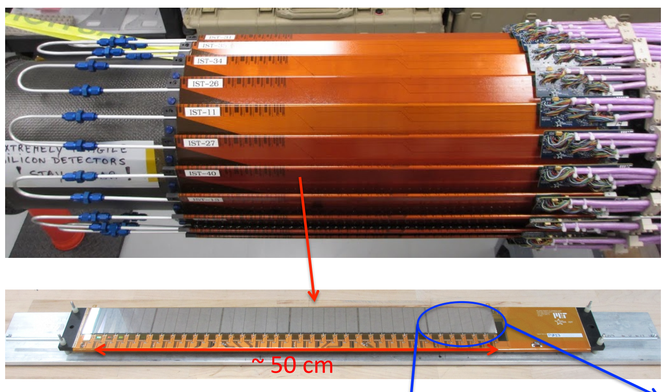
- 1 layer of silicon pad sensors
- Guiding tracks from the SSD to the PIXEL
- Fast readout detector (40 MHz sampling rate, 4 μs analogue pipeline)

Heavy Flavor Tracker (HFT) will greatly enhance the capability of STAR for heavy flavor studies (energy loss mechanism and partonic thermalization), allowing identification of displaced vertices and direct topological reconstruction of open charm hadrons.



$D^0 \rightarrow K^- \pi^+$, $c\tau \sim 120\ \mu m$

2. Technical Design

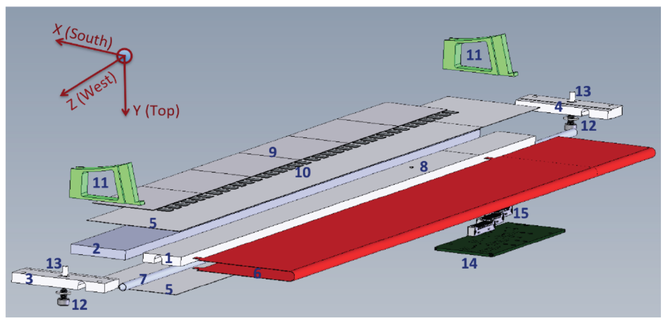


IST stave = Carbon fiber ladder
+ Kapton flex hybrid
+ Passive components
+ 6 silicon pad sensors
+ 3 x 12 APV25-S1 readout chips
+ Aluminium cooling tube
+ Liquid coolant (3M Novec 7200)

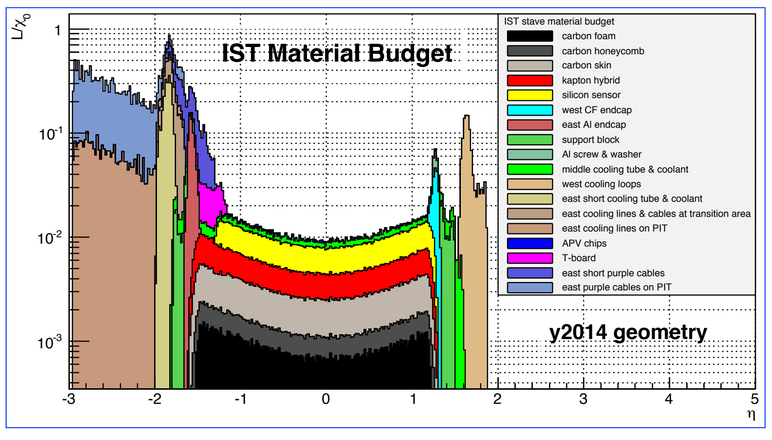
ϕ-Coverage	2π
|η|-Coverage	⩽1.2
Number of Staves	24
Number of hybrids	24
Number of sensors	144
Number of readout chips	864
Number of channels	110592
r-φ resolution	172 μm
Z resolution	1811 μm
R-φ pad size	594 μm
Z pad size	6275 μm

IST staves were assembled/tested/ surveyed at UIC/FNAL and MIT/BNL sites (18 staves produced at each site).

3. IST Geometry, Production and Survey

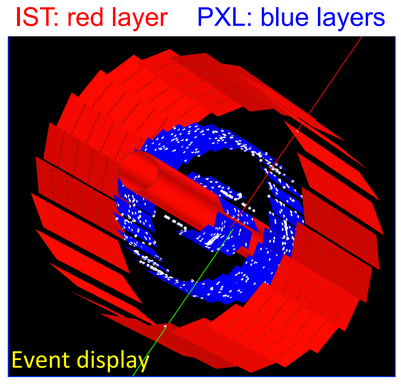


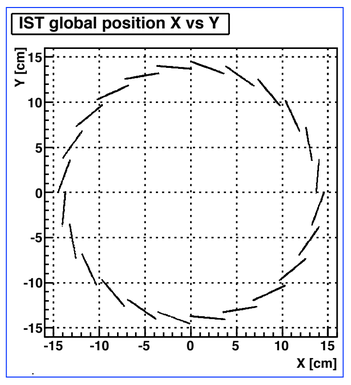
1) carbon foam 2) carbon honeycomb 3) west carbon end-cap 4) east Al end-cap 5) carbon fiber skins 6) Kapton hybrid 7) Al cooling tube with cooling liquid inside 8) thermal sensor 9) silicon sensors 10) APV chips 11) support blocks 12) screws with washers 13) spacers 14) transition board 15) readout connectors.



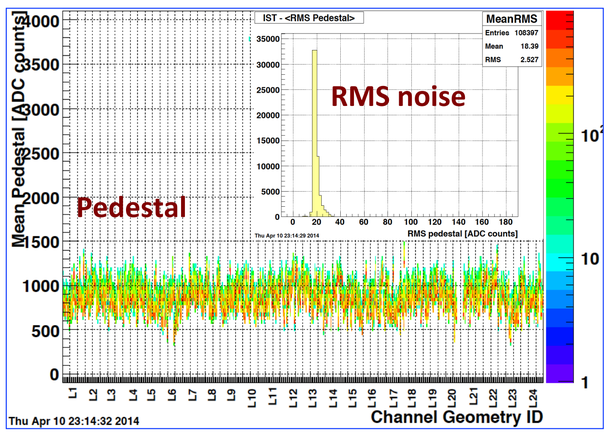
- Optical Gaging Products Avant 600 (Automated video measuring system with ~0.5 micron XYZ resolution)
- Two reproducible survey data sets for each stave with difference ≤ 3 (10) microns in X-Z (Y)

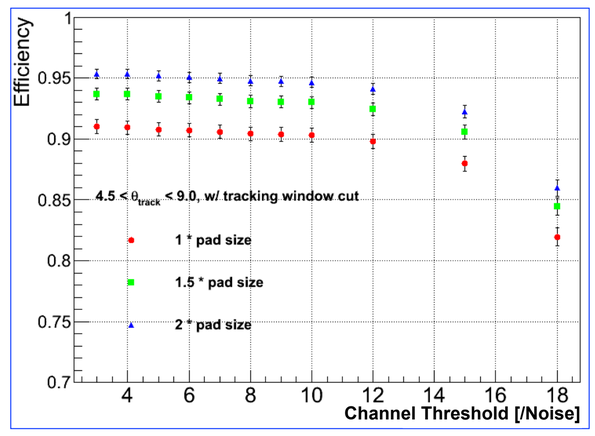
4. Performance of IST in Cosmic Run and Au+Au 200 GeV Collisions

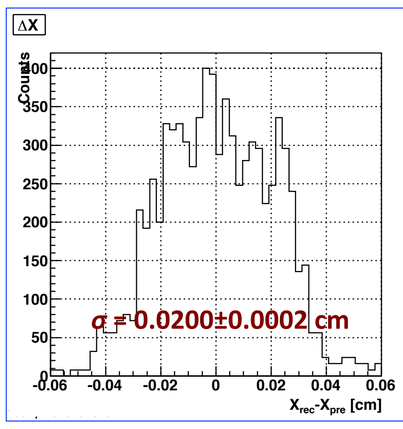


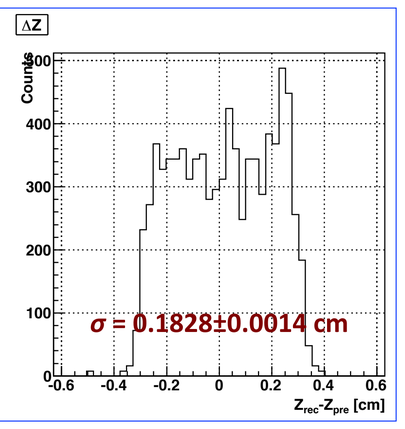


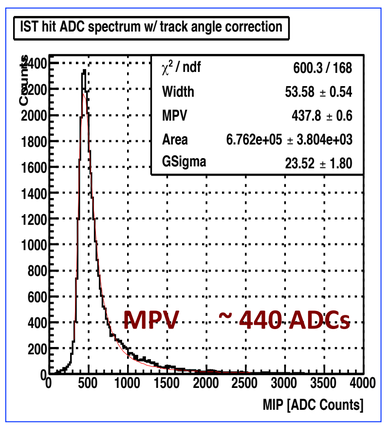
- IST hit finding efficiency decrease versus channel offline threshold, ~95% with 2*pad size cut
- Residual resolution matches design goal (Straight line projection to IST by 2 PXL hits, 2 back-to-back PXL tracks required each event. Survey data were used for IST ladder and PXL sector, and alignment data for others of top level)
- Signal-to-Noise ratio (typical value after track angle correction): 23:1



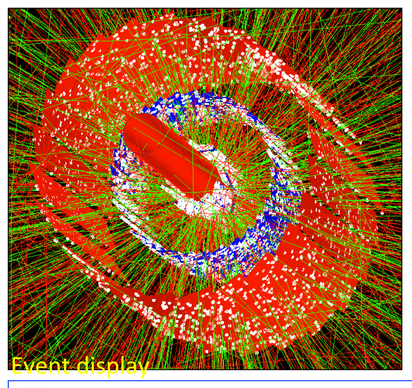






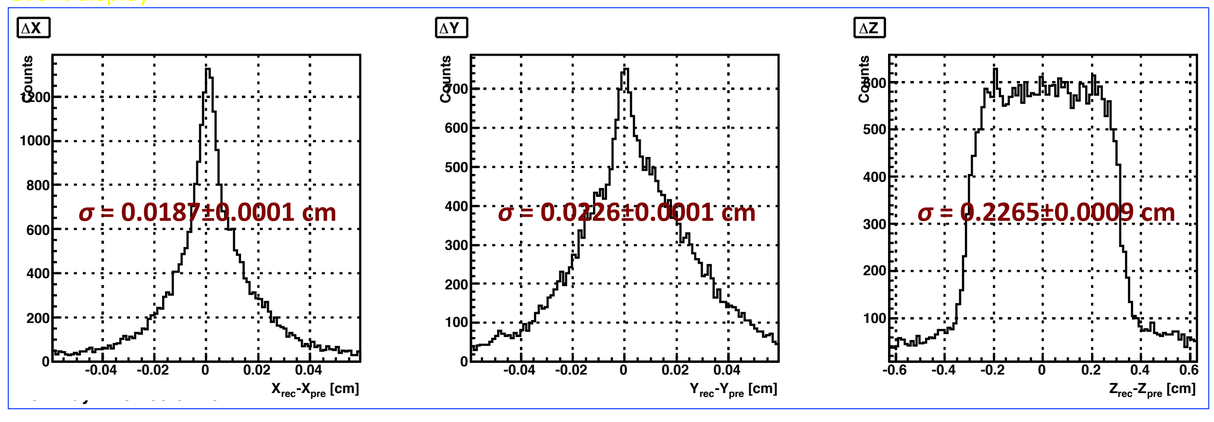


5. Performance of IST in Au+Au@200 GeV



The HFT has been collecting data in the RHIC Au+Au 200 GeV run. The IST performance is stable and good. Main performance is summarized below:

- Stable pedestal and RMS level over all channels (96.4% good chips, and 96% good channels)
- Reasonable Residual resolution (Helix projection to IST by TPC track reconstructed with 2 PXL hits included; Survey data were used for IST/PXL ladders and sensors, and alignment data for others of top level. – See details in Michael Lomnitz's poster



6. Summary

- HFT is designed to enhance STAR's capability for heavy flavor studies.
- IST is a sub-detector of HFT: (1) based on silicon micro-strip technology; (2) Fast readout and reasonable position resolution; (3) Performance of the IST meets design goals; (4) Data taking for Au+Au@200 GeV in 2014.