Intermediate Silicon Tracker For STAR HFT Upgrade

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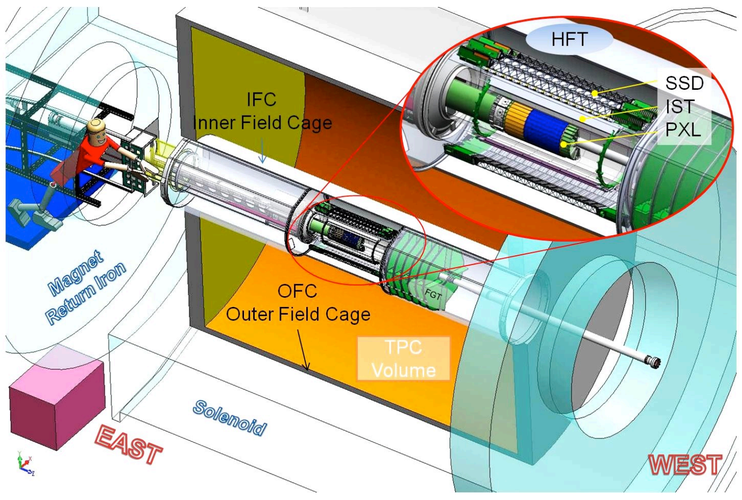
Abstract

A 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 with Au-Au collisions.

1. Physics Motivation

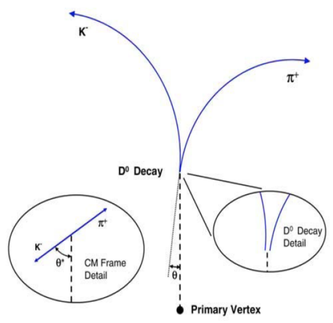


Detector	Radius (cm)	Hit Resolution R/φ - Z (μm - μm)	Radiation length
SSD	22	20 / 740	1% X_0
IST	14	170 / 1800	<1.5% X_0
PIXEL	8	12/ 12	~0.6% X_0
	2.5	12 / 12	~0.4% X_0

IST (Intermediate Silicon Tracker)

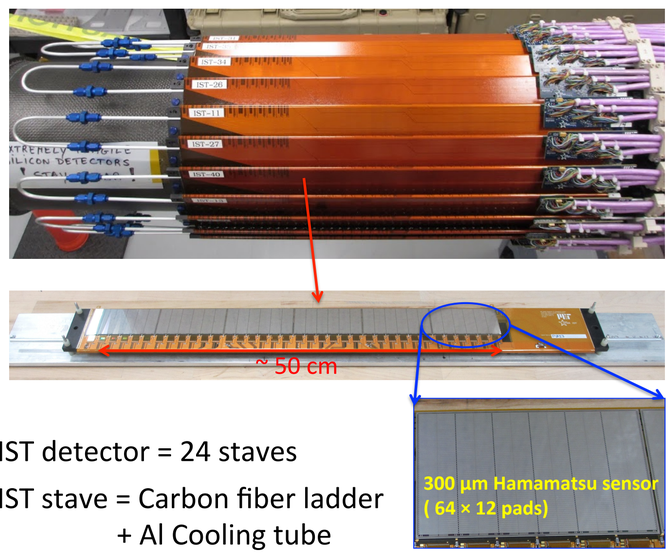
- 1 layer of silicon pad sensors
- Guiding tracks from the SSD to the PIXEL
- Fast readout detector (40 MHz sampling rate, 4 μs analogue pipeline)

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

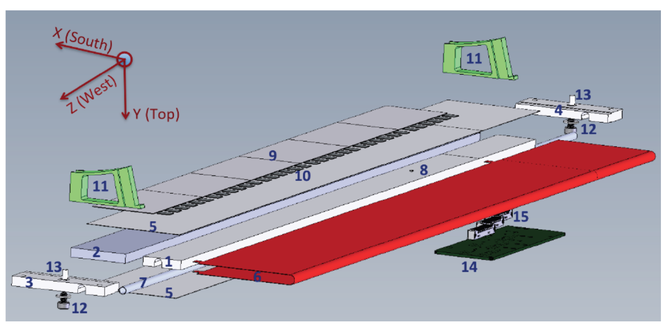


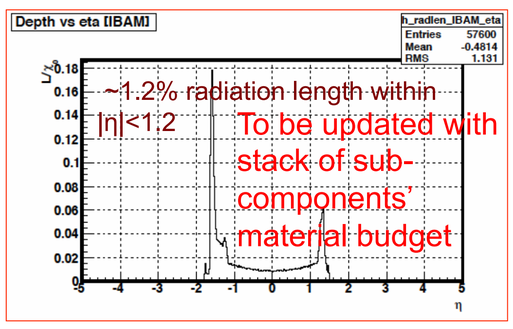
IST detector = 24 staves

IST stave = Carbon fiber ladder
+ Al Cooling tube
+ Kapton flex hybrid + Passive components
+ 6 silicon pad sensors +
+ 3 x 12 APV25-S1 readout chips

Radius	14 cm
Length	50 cm
ϕ-Coverage	2π
|η|-Coverage	⩽1.2
Number of Ladders	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
Z pad size	6275 μm
R-φ pad size	594 μm

3. IST Geometry, Production and Survey



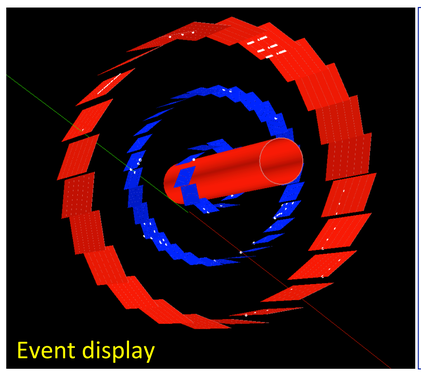


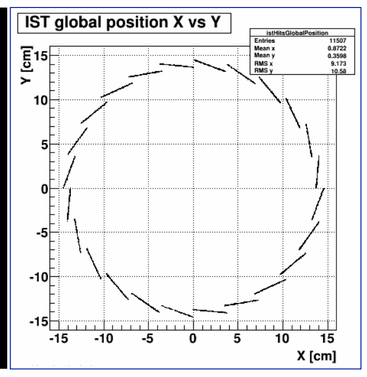
1) carbon foam 2) carbon honeycomb 3) west carbon end-cap 4) east Al end-cap 5) carbon fiber skins 6) Kapton hybrid 7) Al cooling tube with cooling liquid inside 8) thermal sensor 9) silicon sensors 10) APV chips 11) support blocks 12) screws with washers 13) spacers 14) transition board 15) readout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

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

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

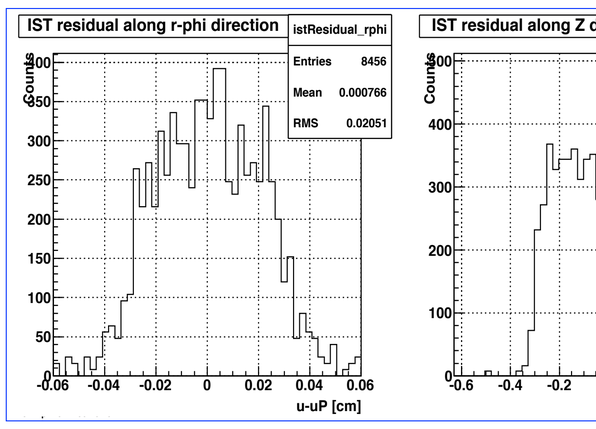
4. Performance of IST in Cosmic Run

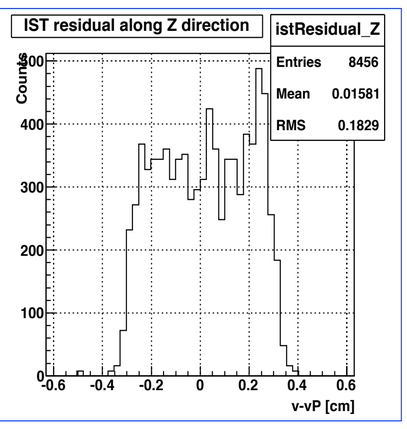


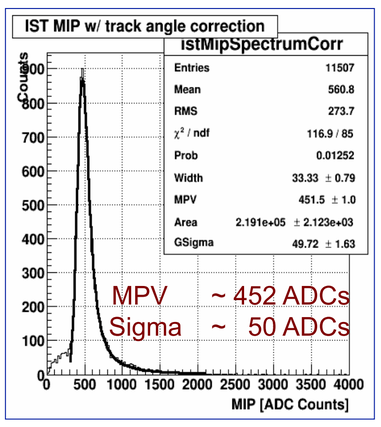


IST detector performance:

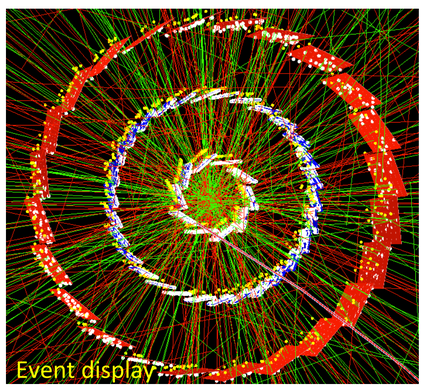
- Residual resolution matches design goal (Straight line projection to IST by 2 PXL hits from same sector, 2 back-to-back tracks required each event. Survey DB tables were used for IST ladder and PXL sector, and alignment DB tables for others of top level)
- Signal-to-Noise ratio (after track angle correction): 452/18 ≈ 25.0





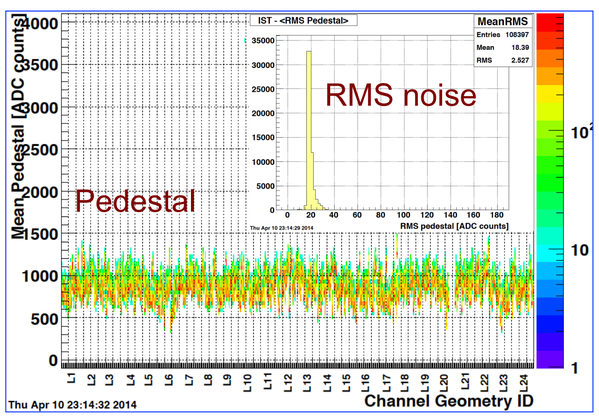


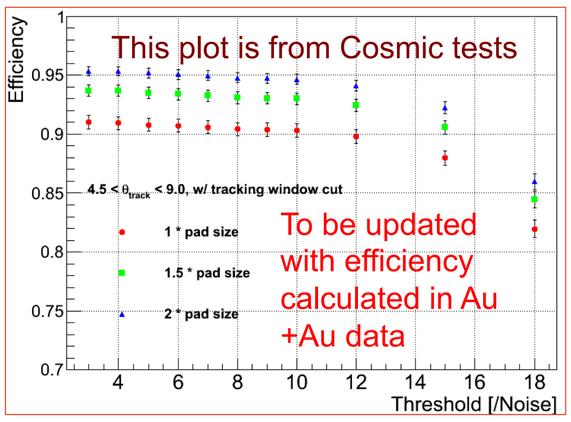
5. Performance of IST in Au+Au@200 GeV

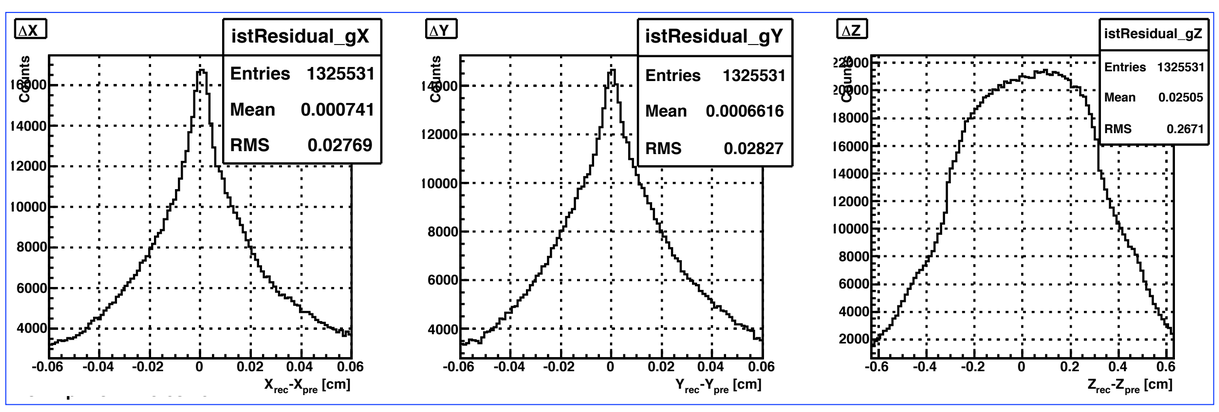


HFT detector has been participating in Au+Au collision @ 200 GeV for the STAR in run 14, and will help STAR to study properties of hot QCD matter with heavy flavors. In the Run 14, IST detector behaviors in good and stable status, and its performance was shown below:

- Stable pedestal and RMS level over all channels (96.4% good chips, and 96% good channels)
- Tracking efficiency up to
- Residual resolution (Helix projection to IST by TPC track reconstructed with at least one PXL hit included; Survey DB tables were used for IST ladders and PXL sectors, and alignment DB tables for others of top level)







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.