Intermediate Silicon Tracker for STAR HFT Upgrade

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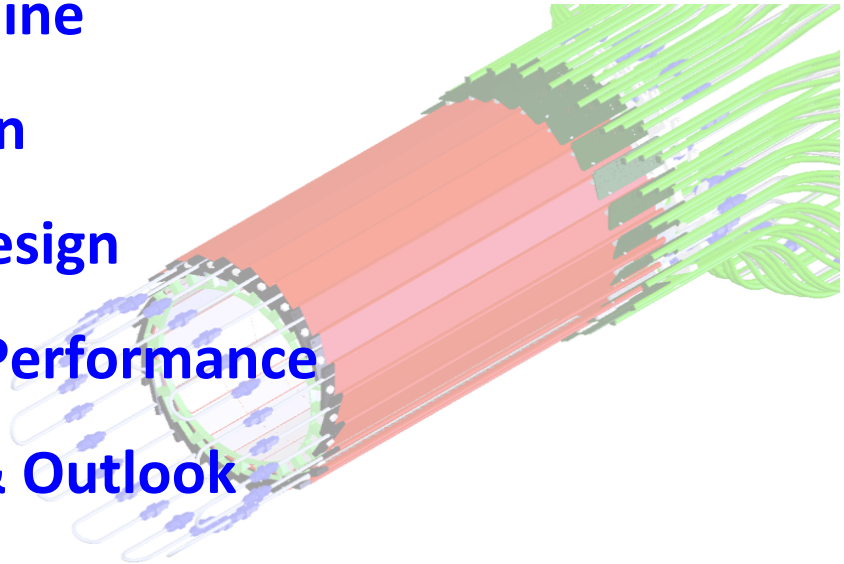
Outline

- **Introduction**
- **Detector Design**
- **Prototype Performance**
- **Summary & Outlook**



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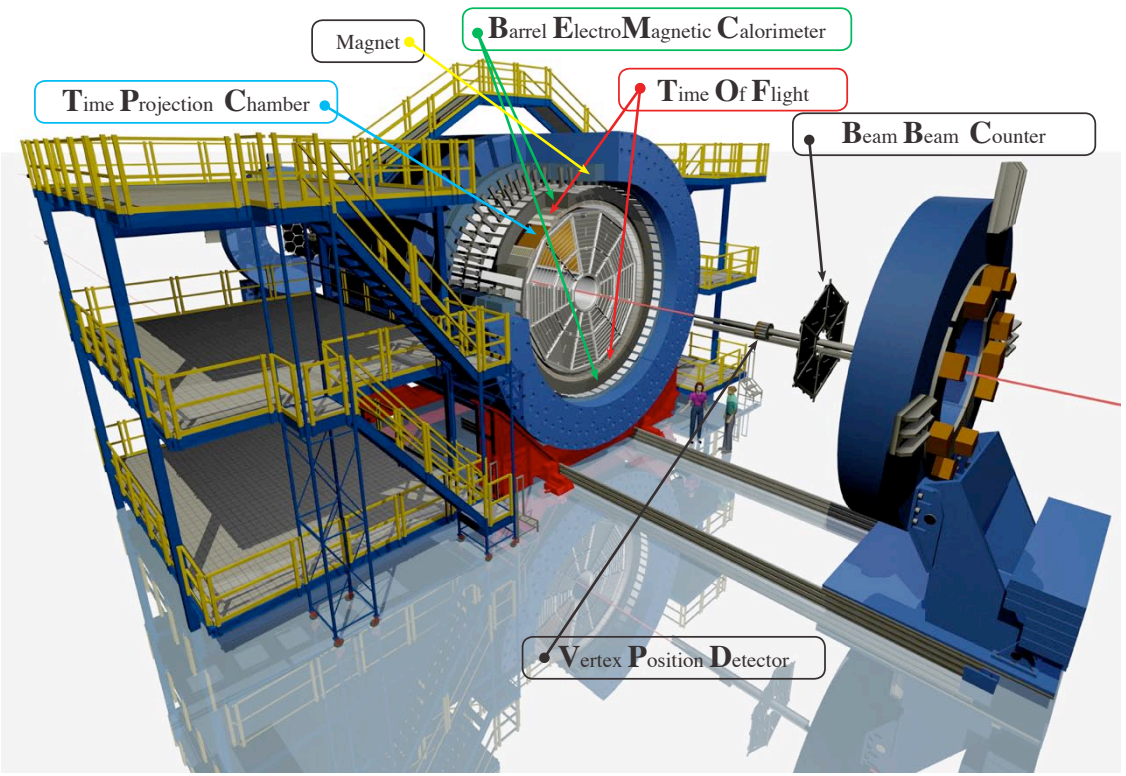
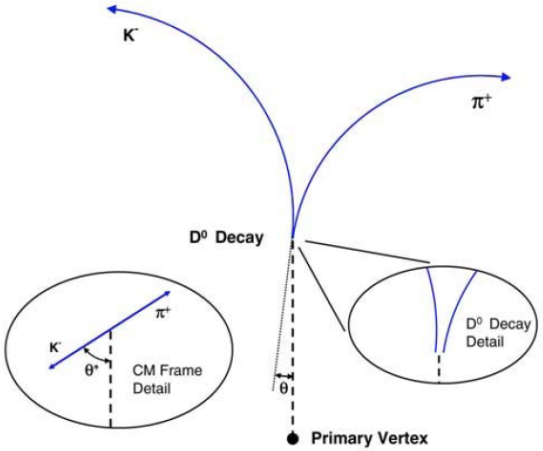
Solenoidal Tracker At RHIC



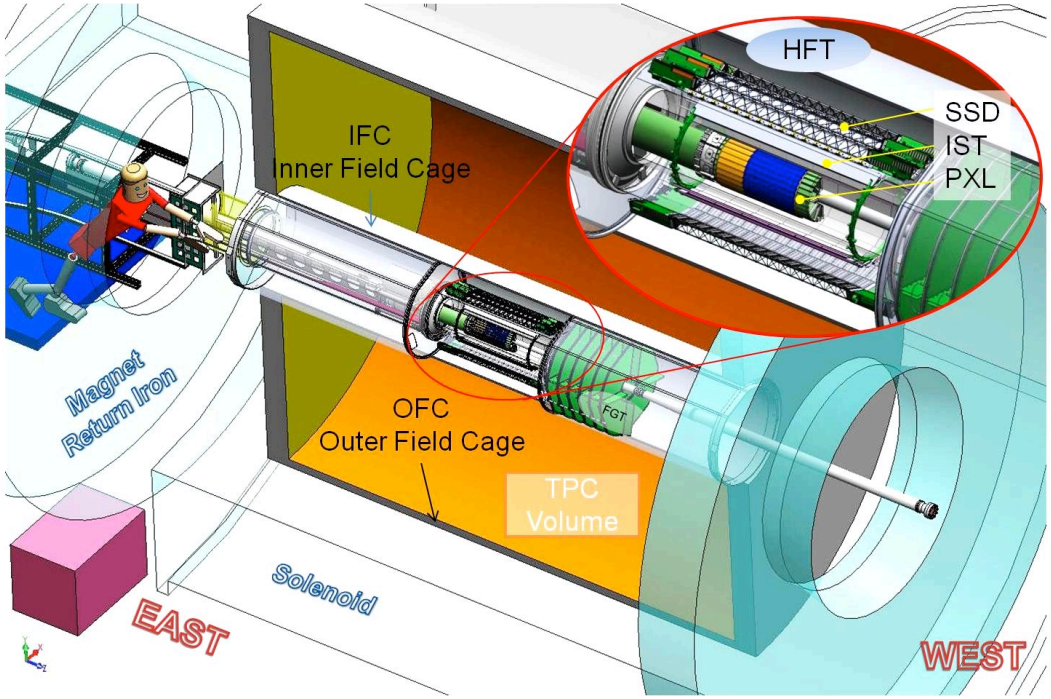
STAR has been taking data at RHIC for over 10 years.

Full azimuthal tracking and PID coverage in midrapidity ($|\eta|$ <1).



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.

Introduction – HFT @ STAR



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	~0.4 %X_0
	2.5	12 / 12	~0.4 %X_0

PIXEL

- 2 layers of thin monolithic active pixel sensors, integration time ~ 180 μs
- 18.4x18.4 μm pixel pitch
- Provide ultimate pointing resolution that allows for direct topological identification of charm.

IST (Intermediate Silicon Tracker)

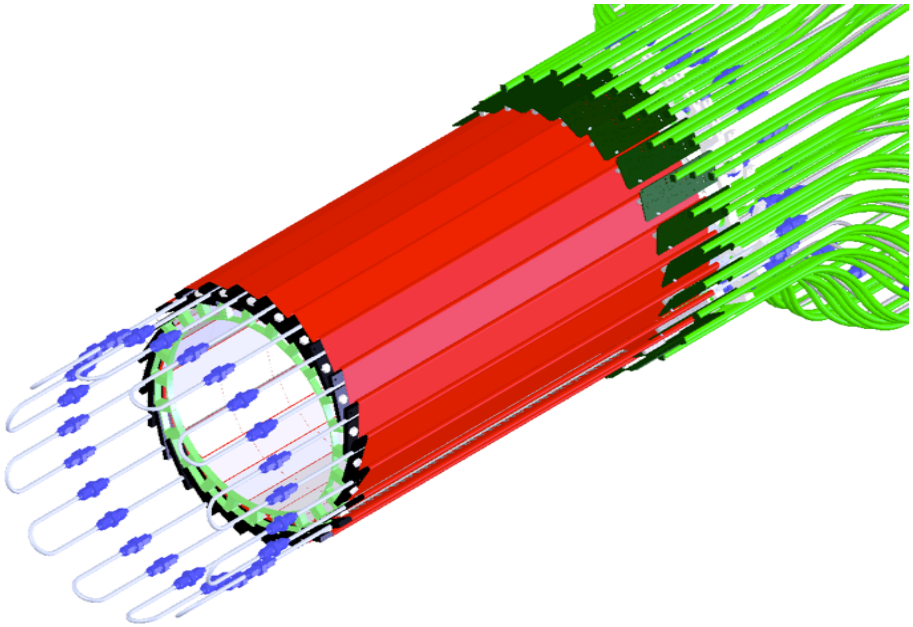
- 1 layer of silicon pad sensors
- Guiding tracks from the SSD to the PIXEL
- Operate without significant event pile-up for 200 GeV Au+Au

SSD (Silicon Strip Detector)

- Existing single layer of double sided strip sensors (electronic upgrade)

Track inward from TPC with graded resolution:

Detector Design – Overview



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	596 μm

Deliverables:

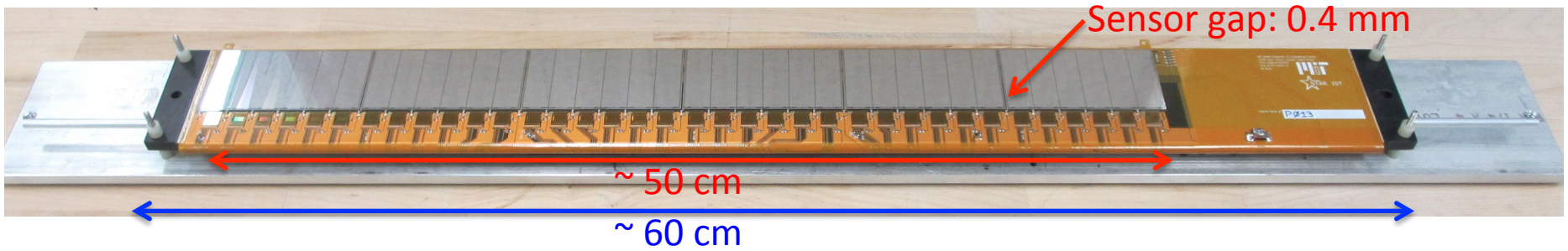
-24 IST staves will be installed in STAR

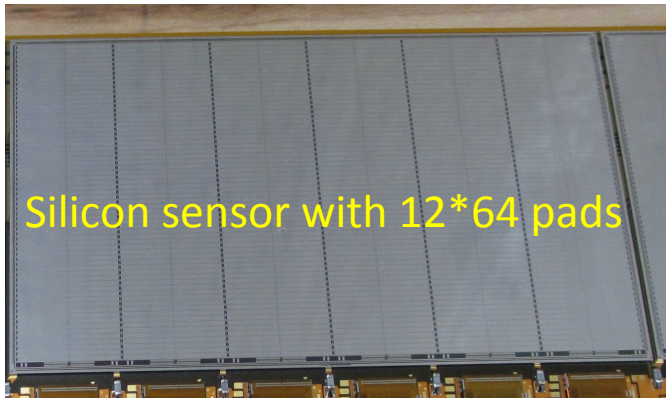
-Commercial bias supply from Wiener

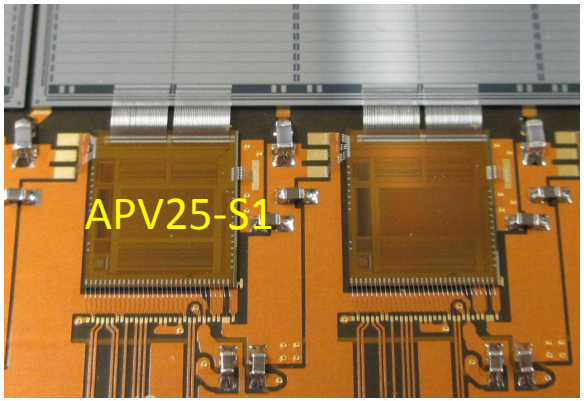
-Customized readout system

-Cabling and Cooling Services

Detector Design – Sensor & Readout chip







Silicon sensor:

- Sensor from Hamamatsu Co.
- Full depletion voltage ~ 70 V
- Thickness: 300 µm
- Sensor area: 40.0*76.9 mm^2
  Active area: 38.0*75.3 mm^2
- Pad dimensions: ~0.6*6.3 mm^2

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

Electrically divided in 3 units to reduce chance of failure of a full stave

APV25-S1:

- 0.25 µm CMOS, radiation hard
- 128 channels parallel sampling
- 40 MHz sampling rate
- 4 µs analogue pipeline
- < 30 µs dead-time for 20 MHz 3-sample readout
- > 15:1 signal to noise ratio

Detector Design – Readout system & Cooling

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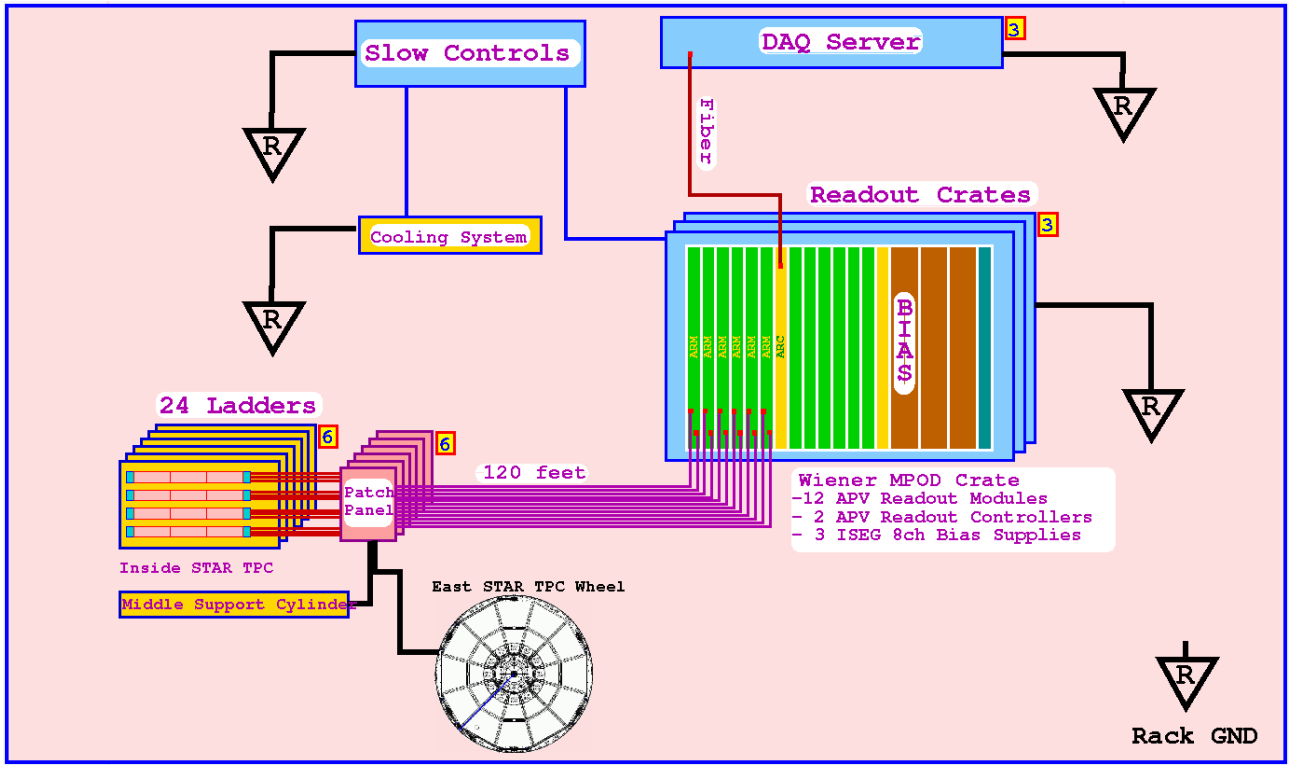
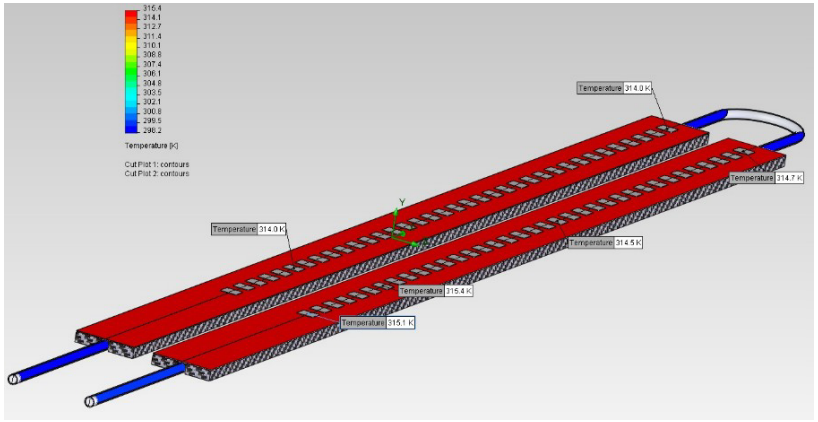


Readout system:

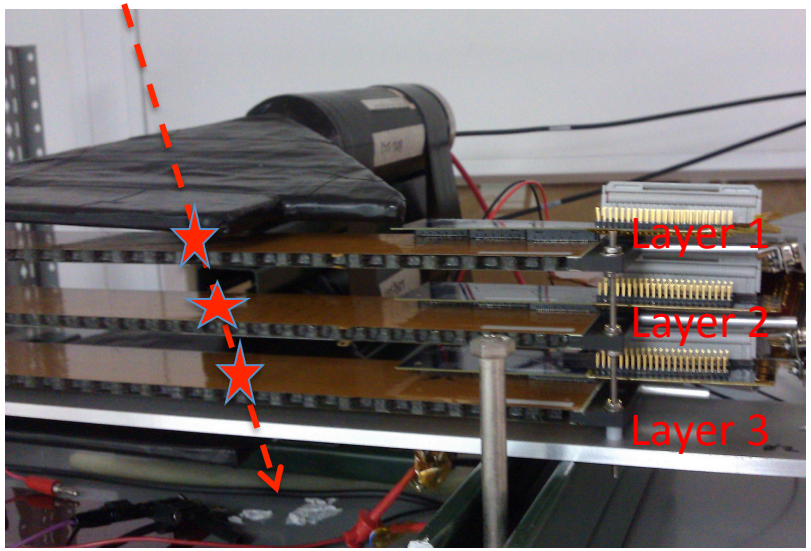
- 3 readout crates
- Each crate has
  - 3 ISEG 8-channel Bias Supplies
  - 12 APV Readout Modules (ARM)
  - 2 APV Readout Controllers (ARC)

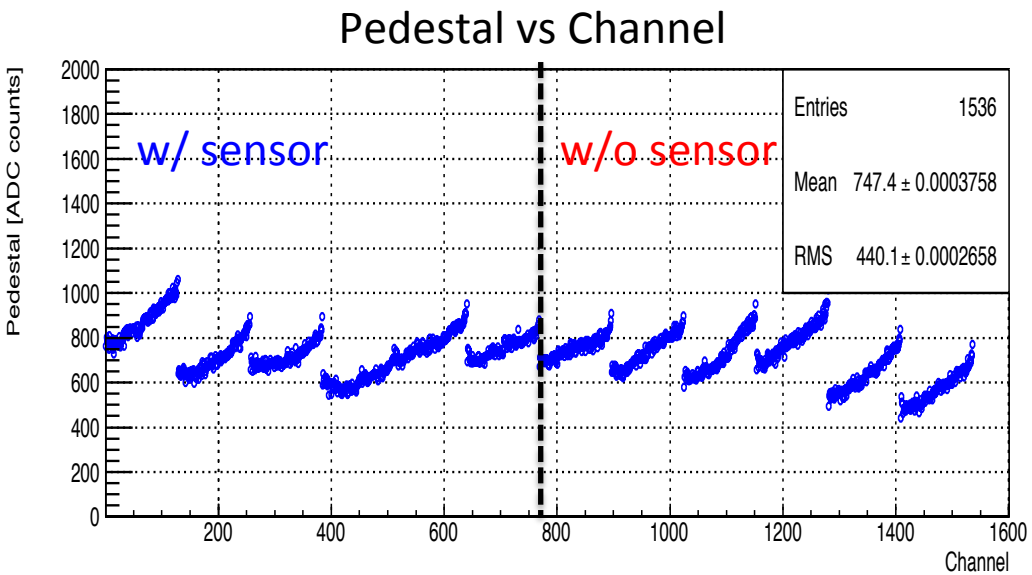


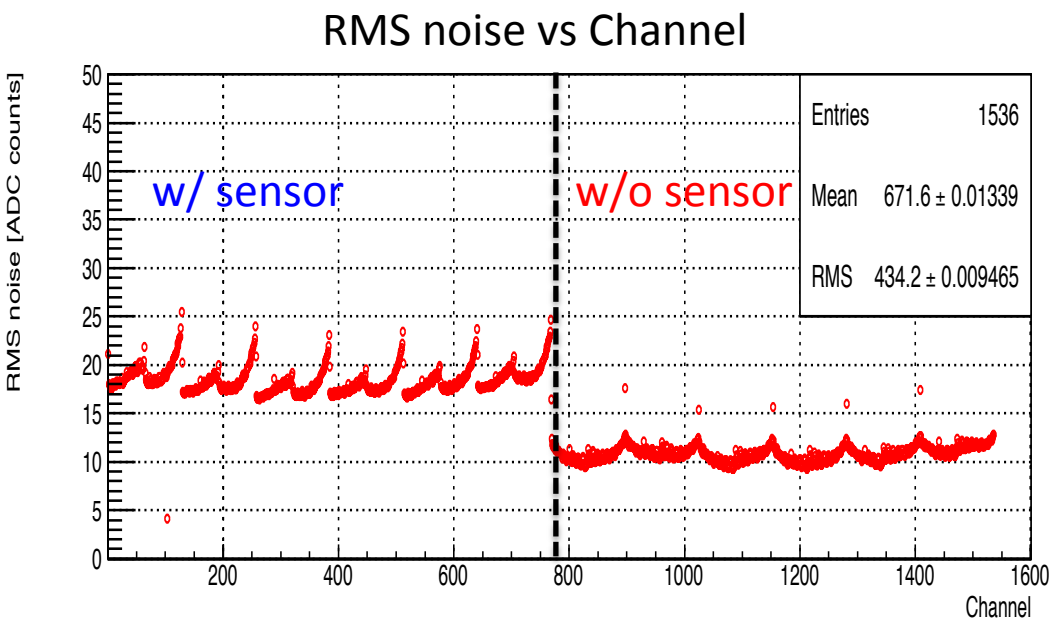
Cooling:

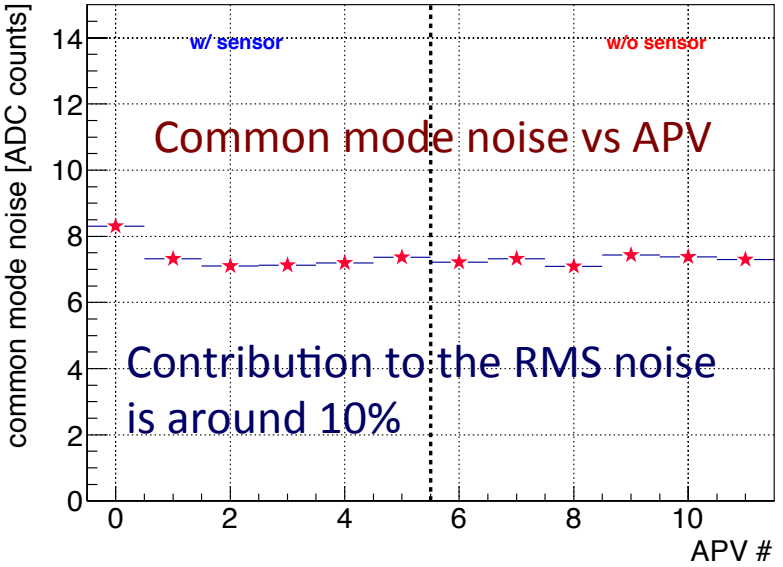
- Low radiation environment (< 30 kRad/year)
- 0.3 W/chip (264 W for the whole IST cooling)
- Integrated Aluminum cooling tube
- Cooling 2 staves in series with 3M Novec 7200 at 25 ^{o}C, and 1 liter/min at 20psi

Prototype Performance – Pedestal & RMS/CM noise









Prototype Performance – Cluster ADC spectrum

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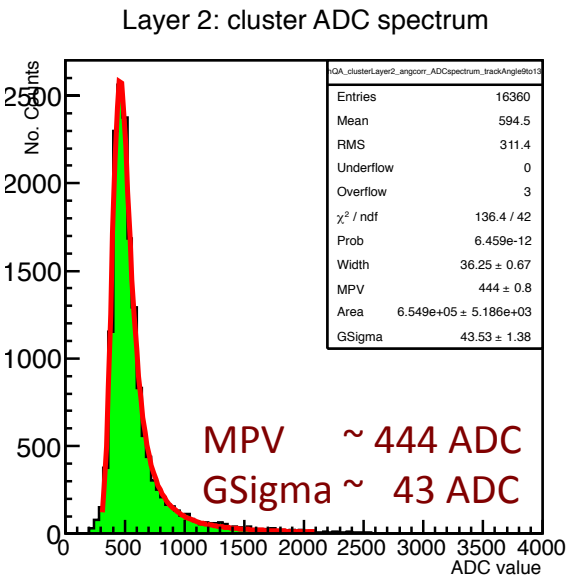
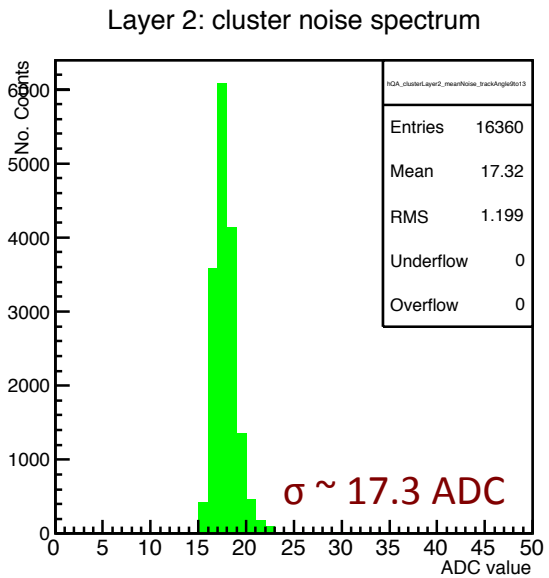
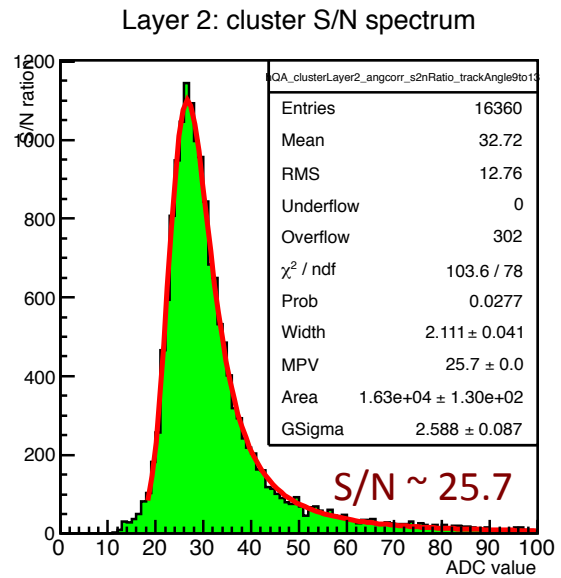
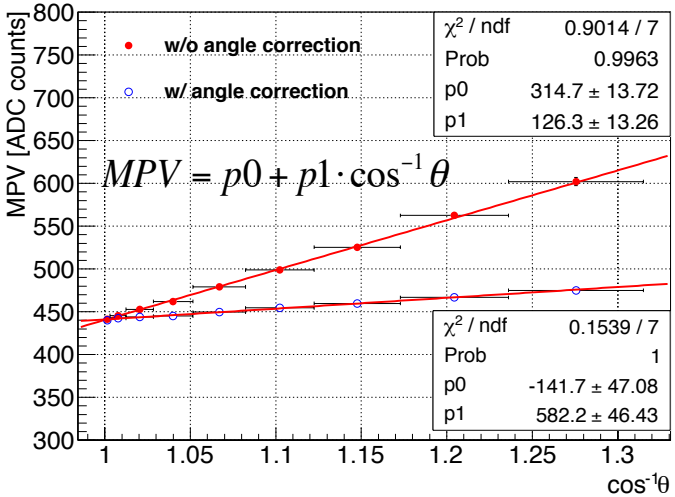
The cluster ADC spectrum was corrected by track angle.



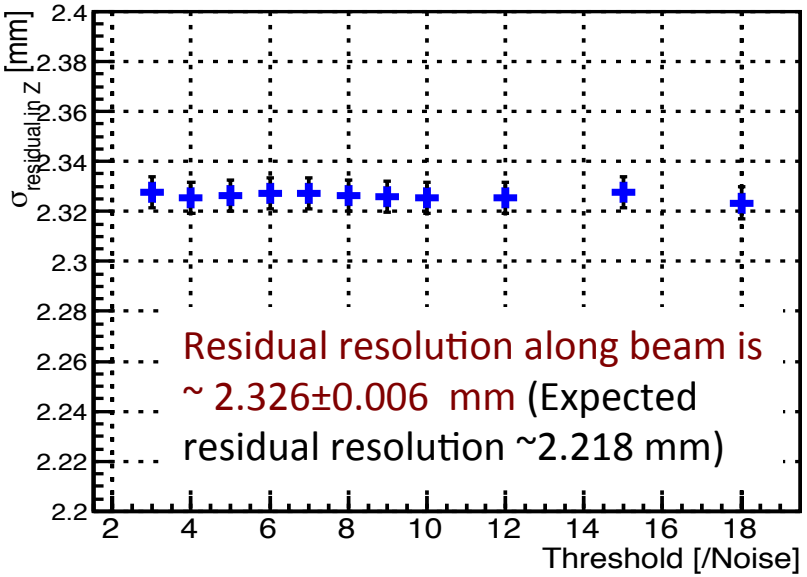


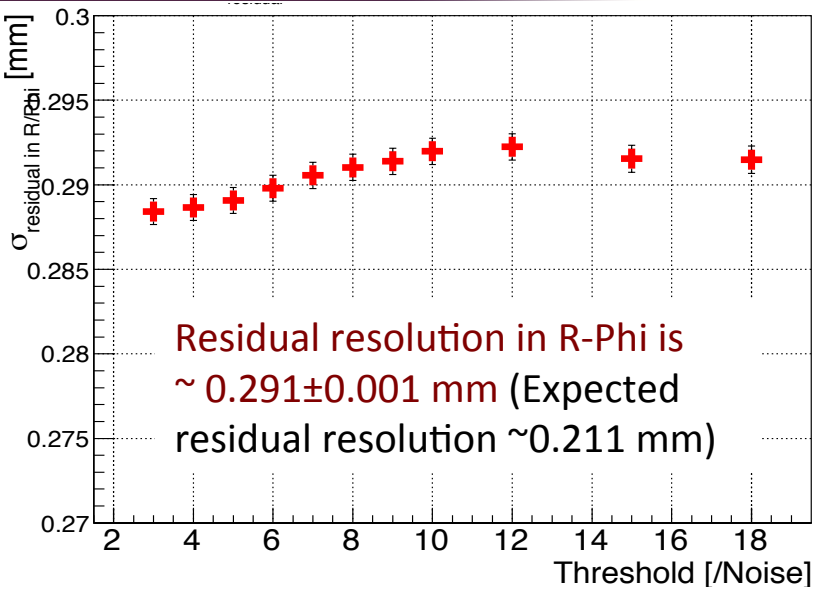


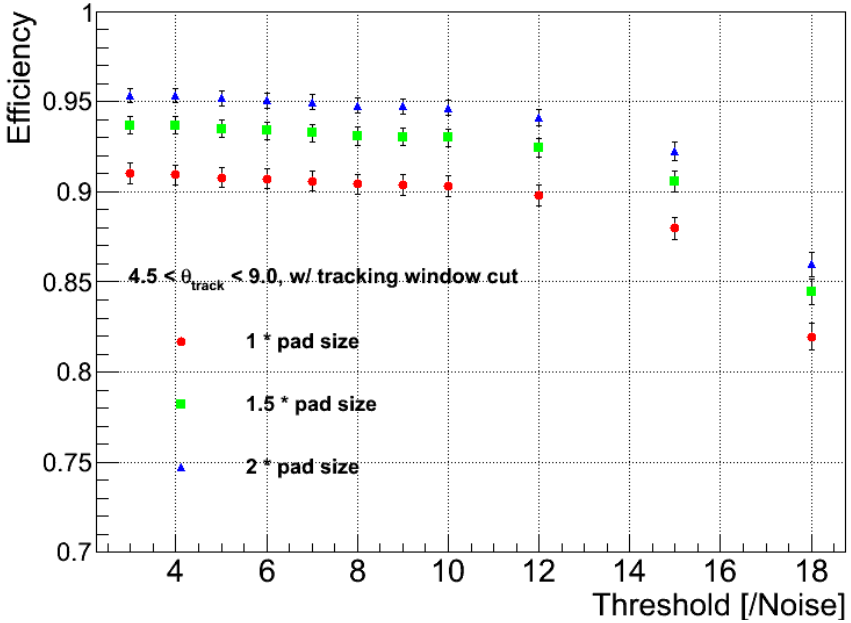


- MPV has a linear dependence on $\cos^{-1}\theta$ as expected
- After track angle correction, MPV vs. $\cos^{-1}\theta$ is not flat due to misalignment
- dE/dx resolution better than 10%

Prototype Performance – Residual & Tracking efficiency







- Residual resolution increases vs threshold, close to expected values
- Efficiency decreases vs threshold, ~95% with 2 pad size tracking window cut

Summary & Outlook

STAR HFT

- HFT is designed to enhance STAR's capability for heavy flavor studies.
- IST is a sub-detector system of the HFT:
  - Based on silicon micro-strip detector technology
  - Fast readout and reasonable position resolution
  - Performance of the IST prototypes meets our design goals
- HFT is now in production phase, aiming for installation in fall 2013 and data taking in 2014.

Stay Tuned!