Funded in part by:

STAR Forward Silicon Tracker Upgrade Status

Xu Sun for the STAR Collaboration

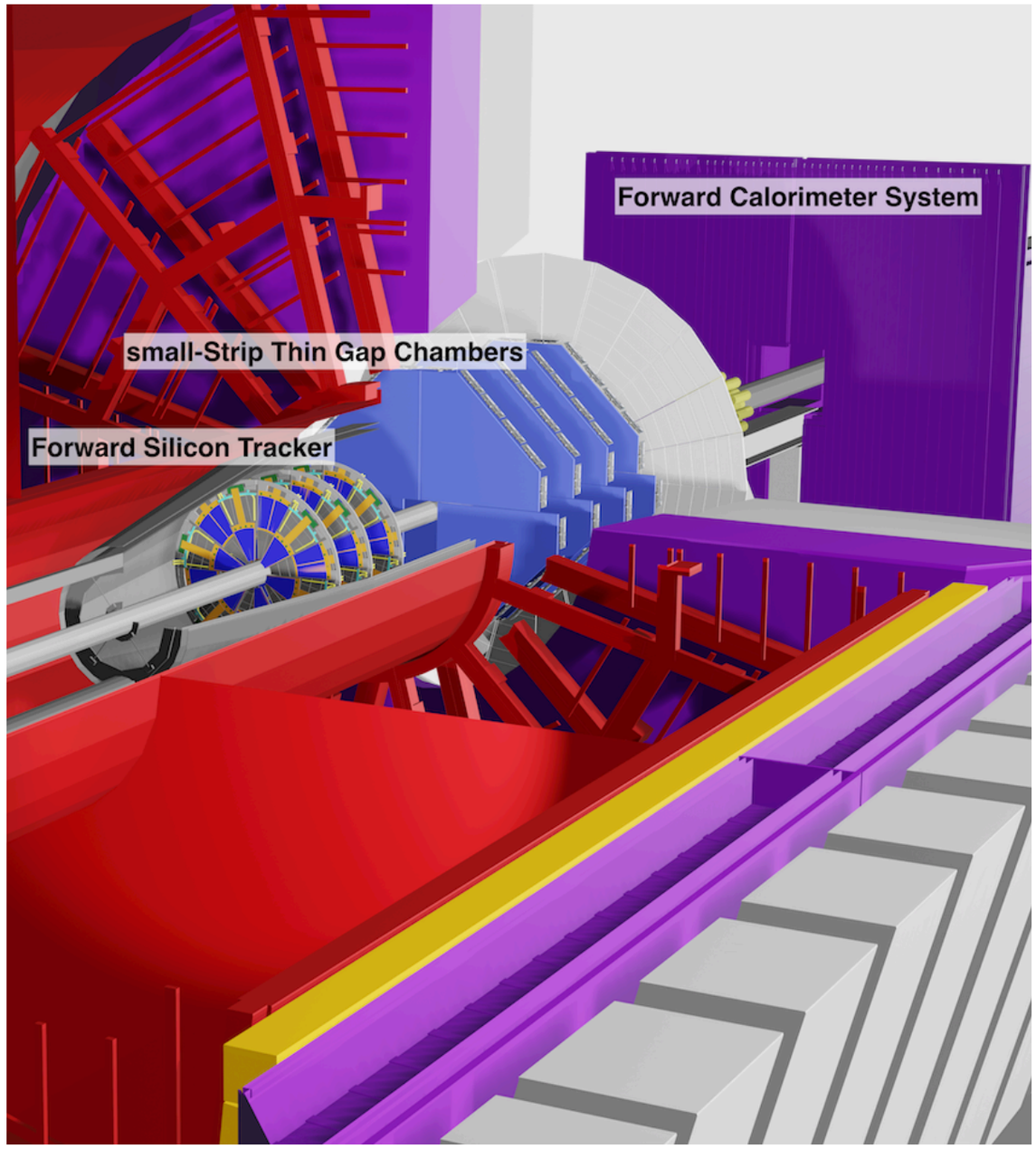
University of Illinois @ Chicago

STAR Forward Upgrade (2021+)

- STAR Forward Upgrade (2021+)
  - p+p: proton spin structure, ...
  - p+A: gluon saturation at small-x, ...
  - A+A: initial state conditions, ...

  with new tracking and calorimeter detectors in the forward direction ($2.5 < \eta < 4$)
- Forward Tracking System includes
  - 4 layers of small Thin Gap Chambers
  - 3 layers of silicon strip detectors

  inside 0.5T solenoidal magnet to provide
  - high tracking efficiency
  - charge separation
  - $\delta p_T/p_T \sim 20-30\%$ for $0.2 < p_T < 2$ GeV/c
- Forward Silicon Tracker
  - fine ϕ segmentation and coarser r segmentation
  - low material budget
  - cost effective - reuse existing infrastructure



STAR Public Note 0648: The STAR Forward Calorimeter System and Forward Tracking System beyond BES-II

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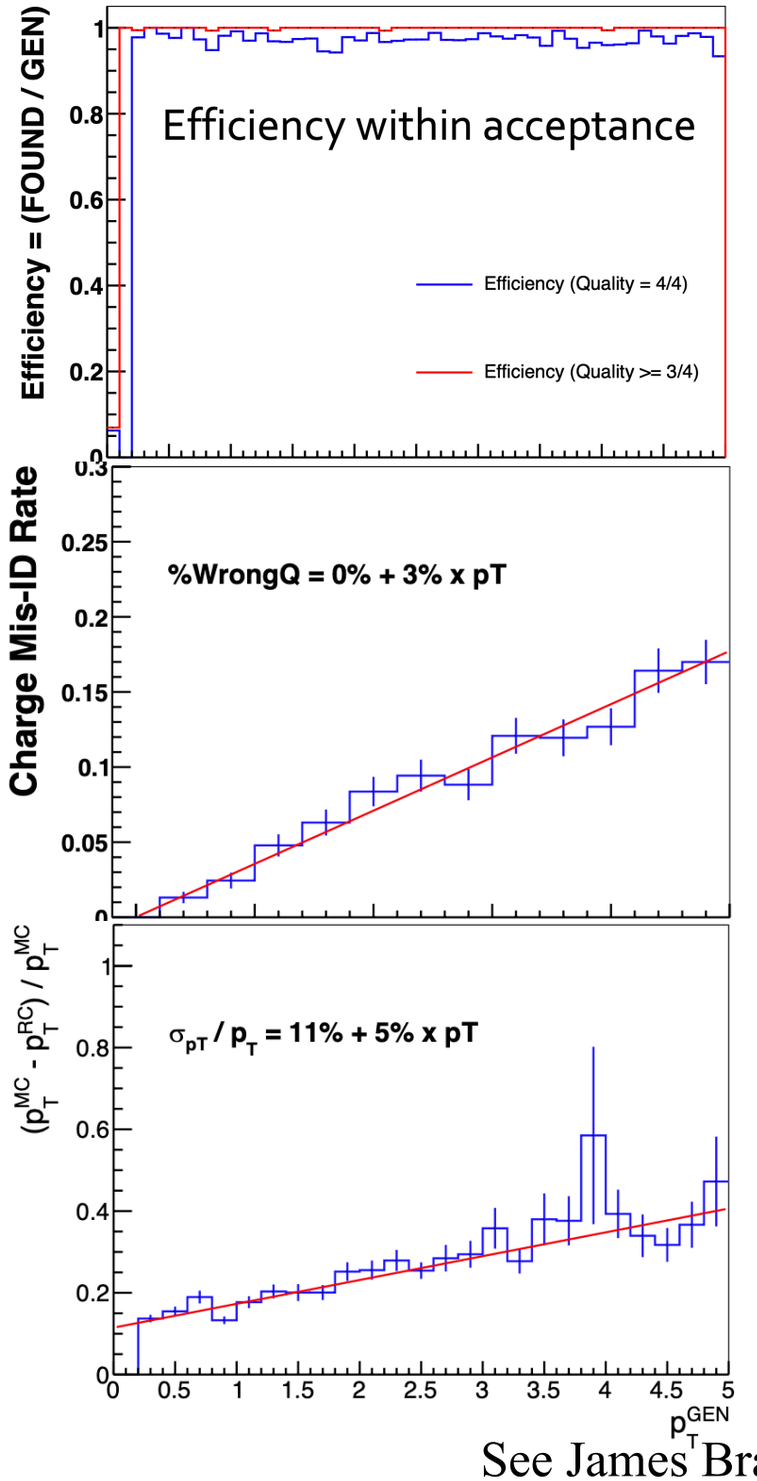

See James Brandenburg's talk.

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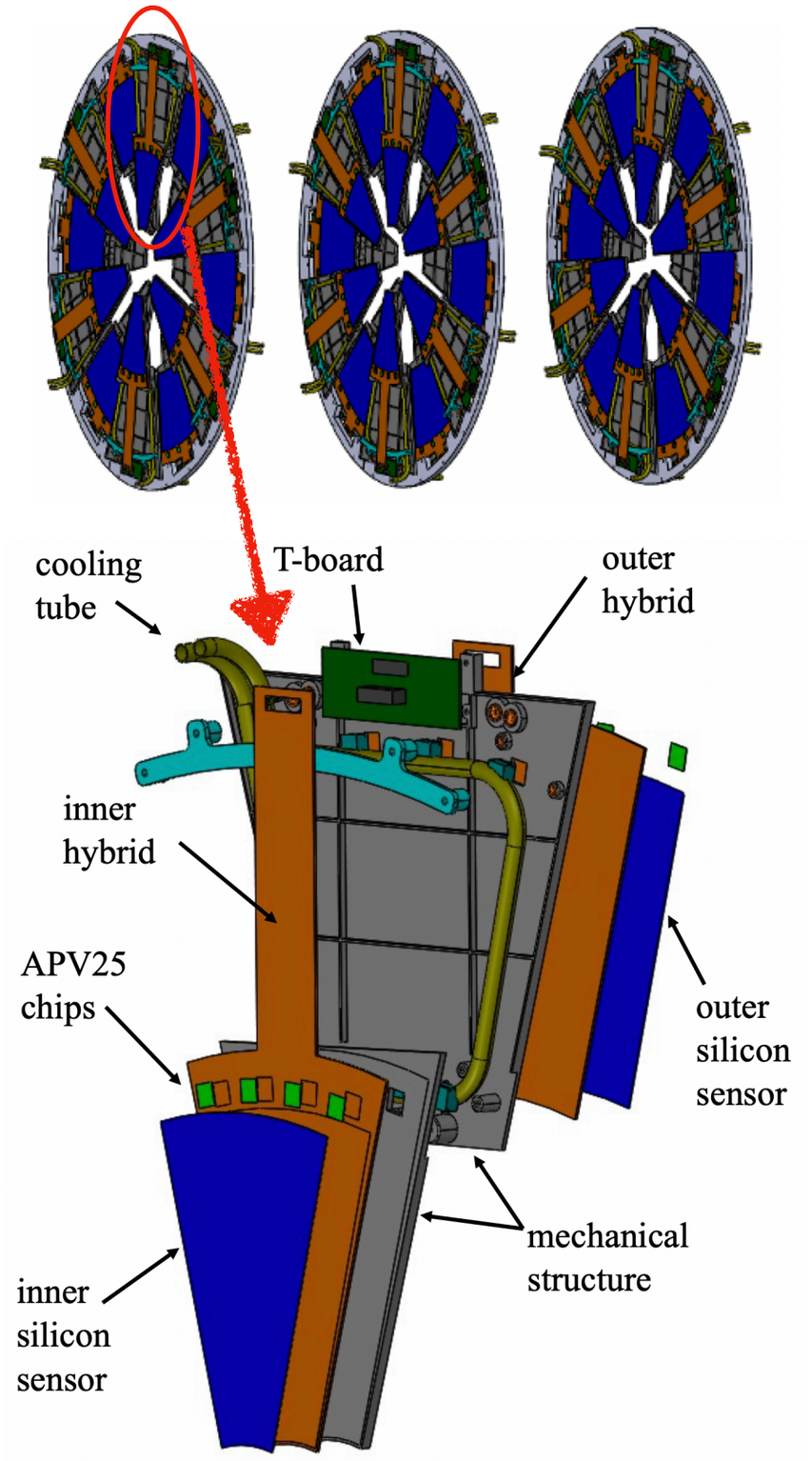
FST Module Design



Each module splits into two regions

- Inner-radius region: 5<R<16.5 cm
  - 1 Kapton flexible hybrid
  - 1 Si sensor: 128 × 4 (ϕ×R) strips
  - 4 APV chips
- Outer-radius region: 16.5<R<28 cm
  - 1 Kapton flexible hybrid
  - 2 Si sensors: 128 × 4 (ϕ×R) strips
  - 4 APV chips

Mechanical structure is made of

- PEEK (main structure, tube holder)
- Stainless steel (cooling tube)
- Aluminum (heat sinks)

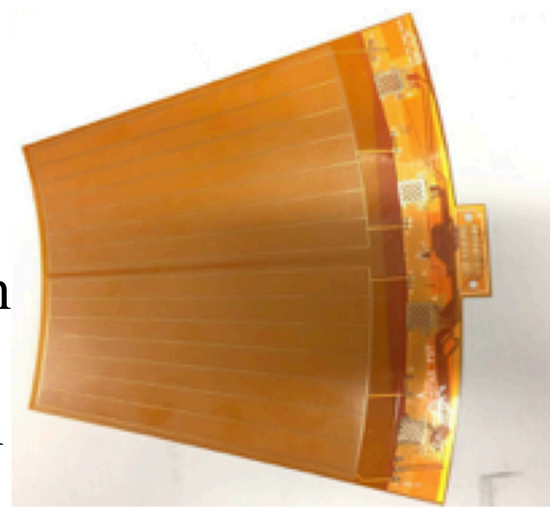
Module assembly is done at two sites

- TiDC (NCKU): gluing inner/outer hybrids and mechanical structures together
- FNAL (UIC): mount/wire-bond AVPs and Silicon sensors on hybrids

material budget: ~1.5% X_0 per disk

FST Module Design

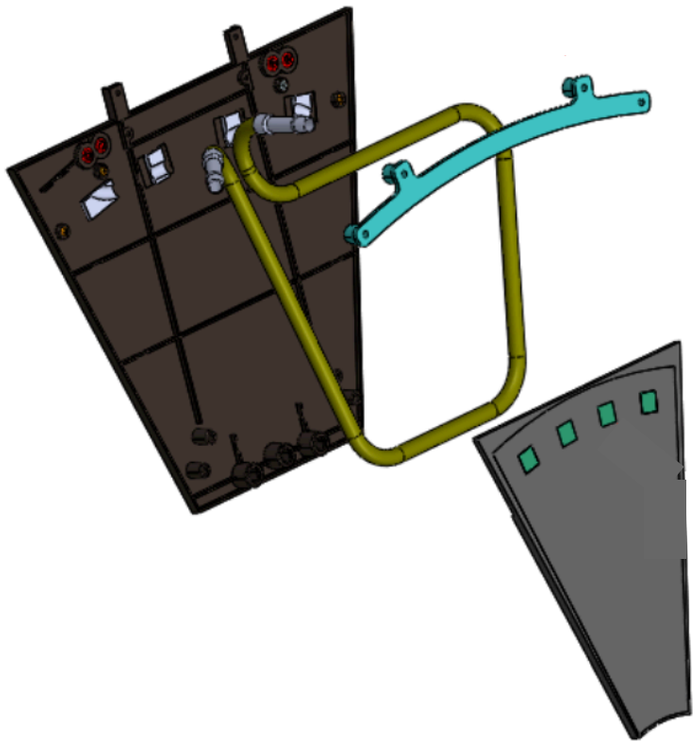
Inner hybrid
- Phi angle: 32°
- Inner radius: 49 mm
- Outer radius: 185 mm
- Tail length: 126 mm
- Thickness: ~0.30 mm



Outer hybrid
- Phi angle: 32°
- Inner radius: 164mm
- Outer radius: 300 mm
- Tail length: 20 mm
- Thickness: ~0.30 mm

Base material: Kapton with 3 copper layers

Mount with passive components (C, R, connectors)



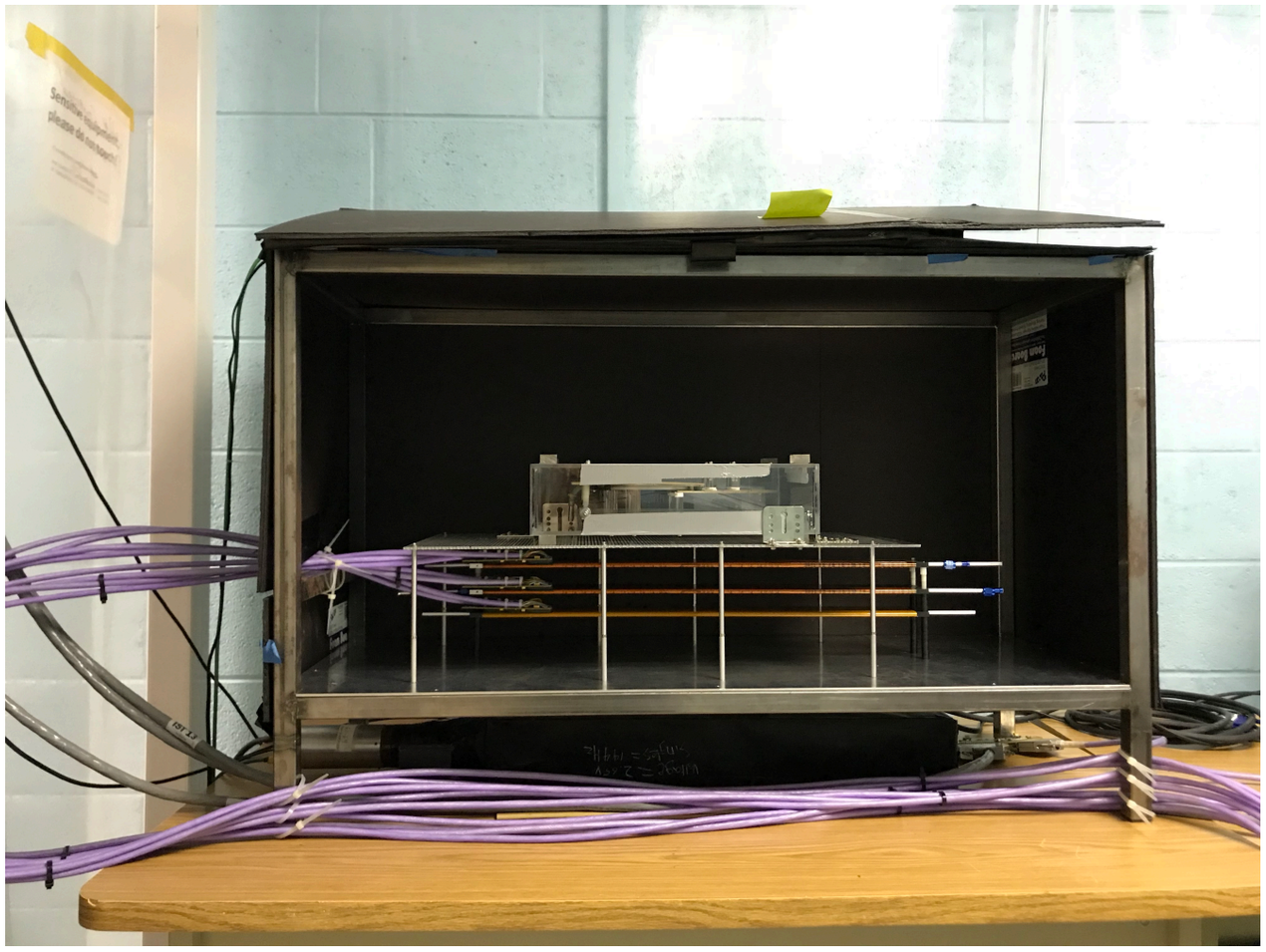
Main structure made by injection molding method.

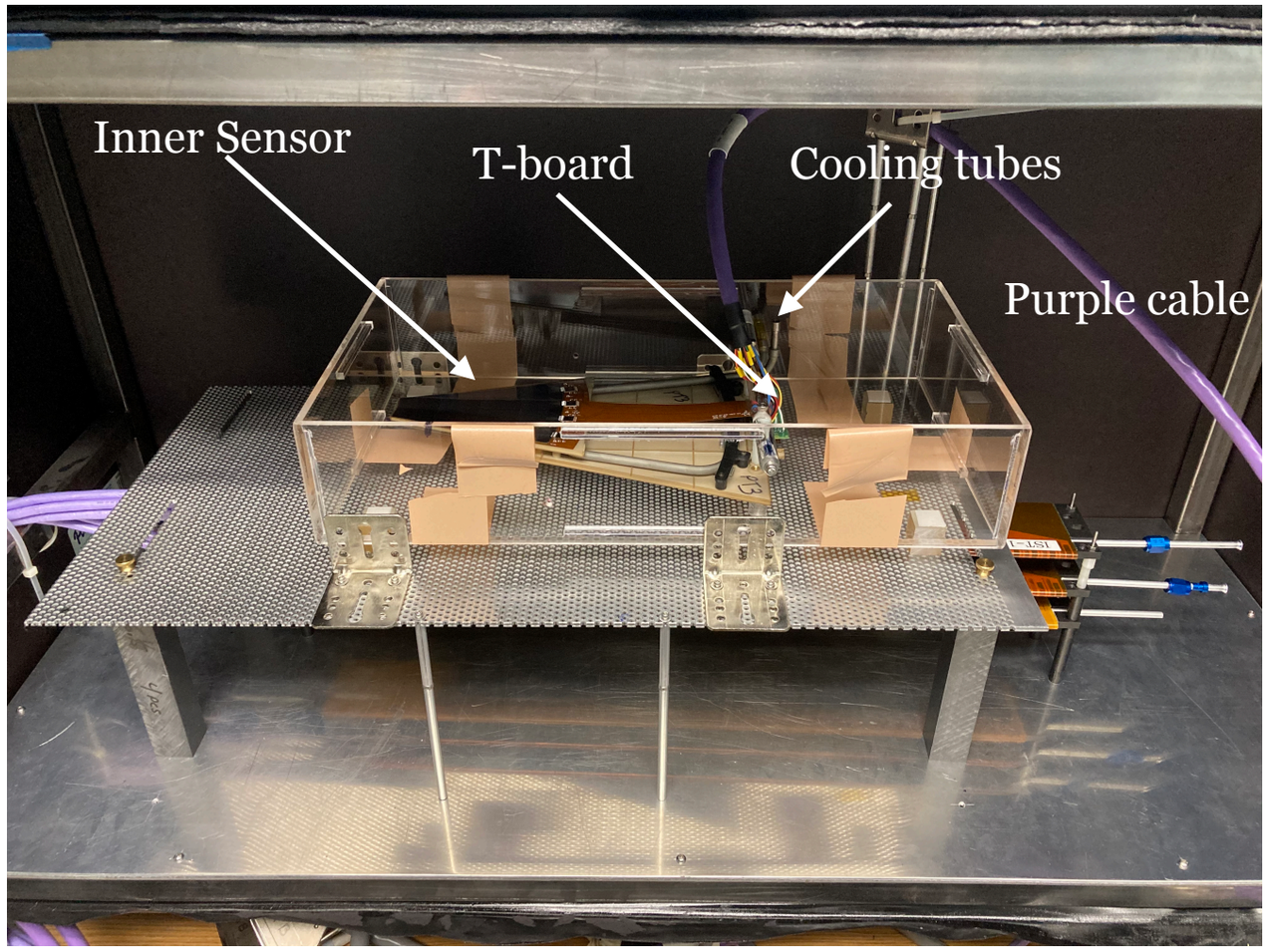
Challenges:

thin + large area + complex structure with many components embedded

Material:
- PEEK (main structure, tube holder)
- Stainless steel (cooling tube)
- Aluminum (heat sinks)

FST Cosmic Test Stand Setup

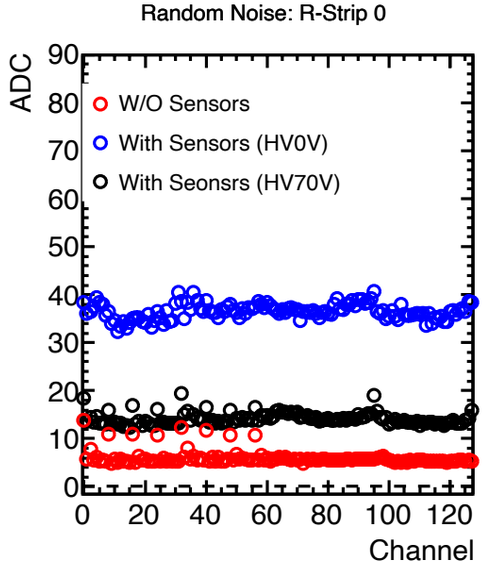


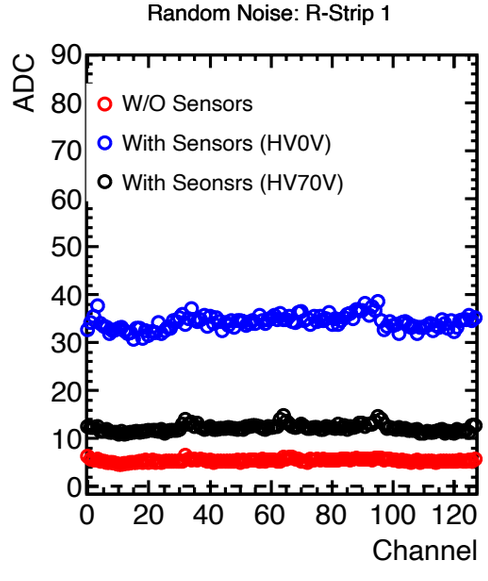


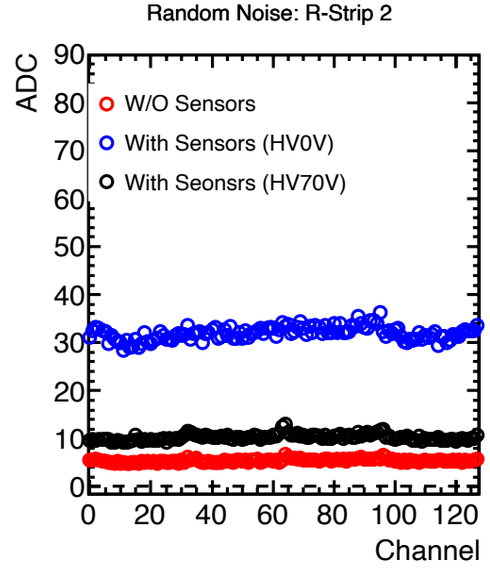
- 2 scintillators as trigger.
- 2 layer of IST stave as additional tracking layers.
- See Gavin Wilks's talk.

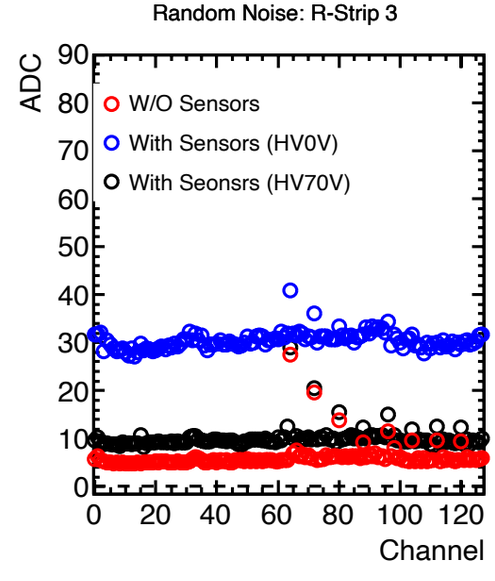
FST Prototype Readout Test

Inner Sector

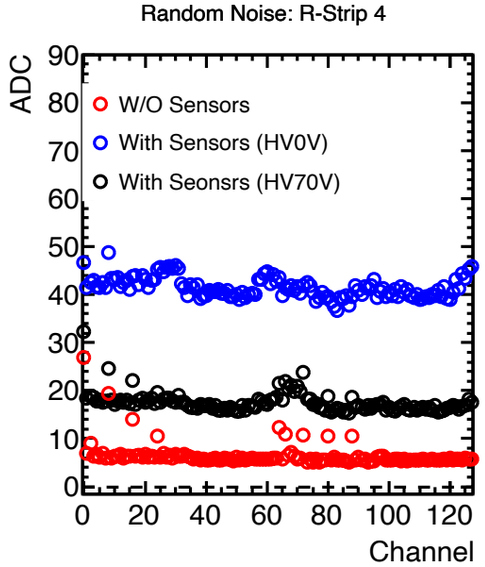


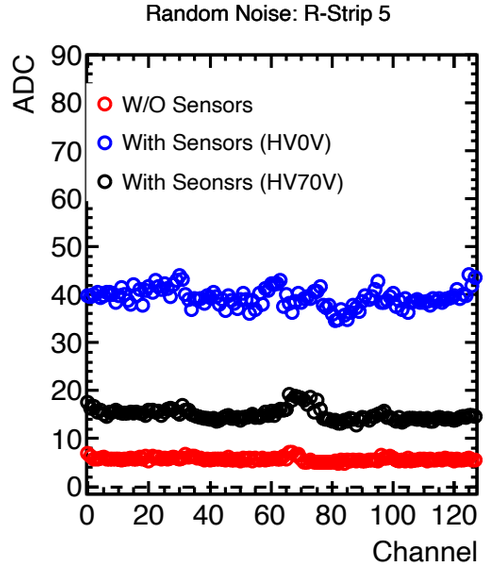


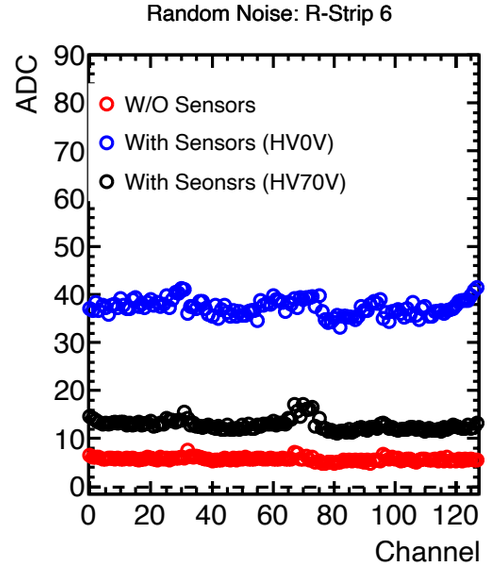


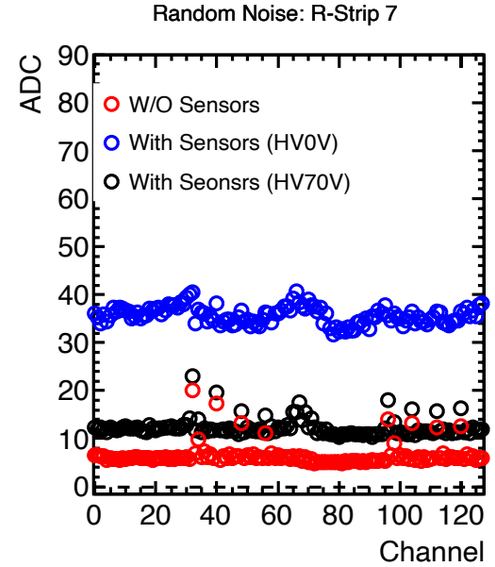


Outer Sector



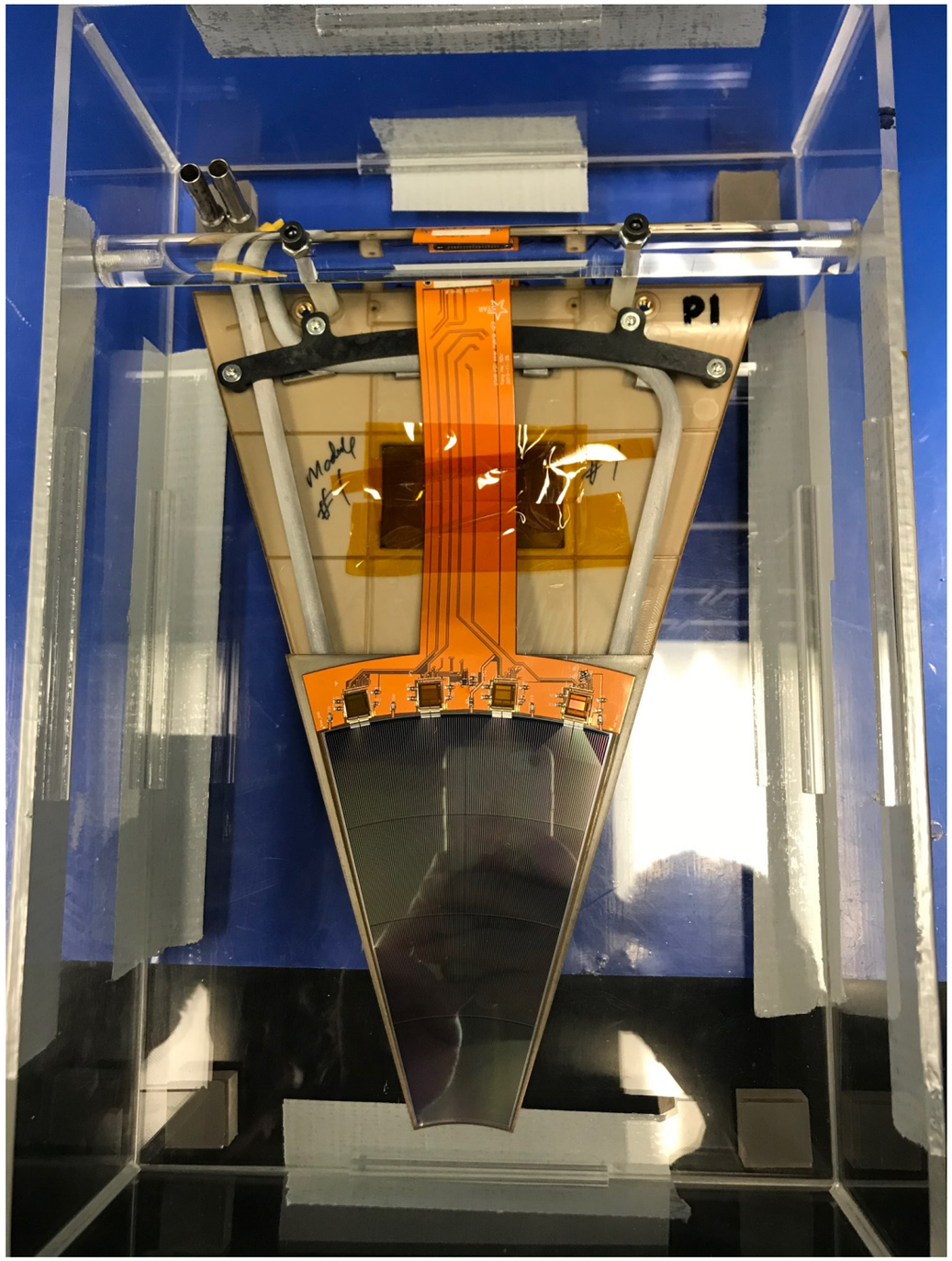




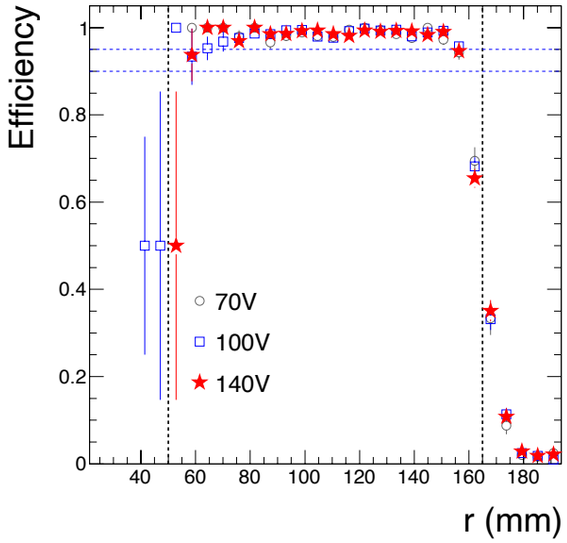


- Readout test before and after sensor mounting
  - Noise before sensor mounting (APV Chips only): 6-8 ADC
  - Noise after sensor mounting (HV0V): 30-40 ADC (inner) and 35-45 ADC (outer)
  - Noise after sensor mounting (HV70V): 10-15 ADC (inner) and 10-20 ADC (outer)
- Can read out all channels

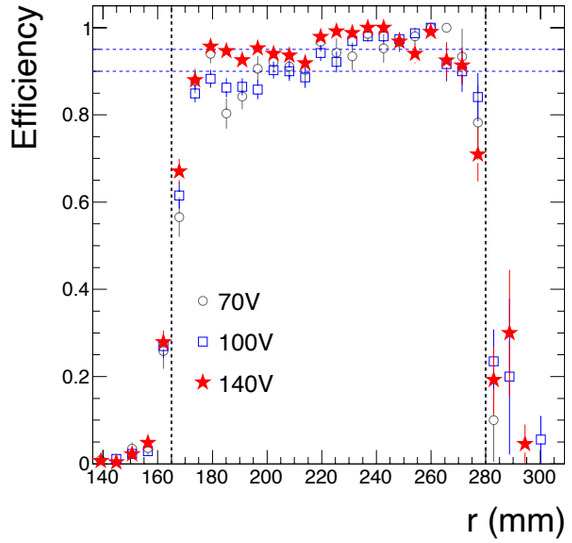
FST Prototype Module Performance



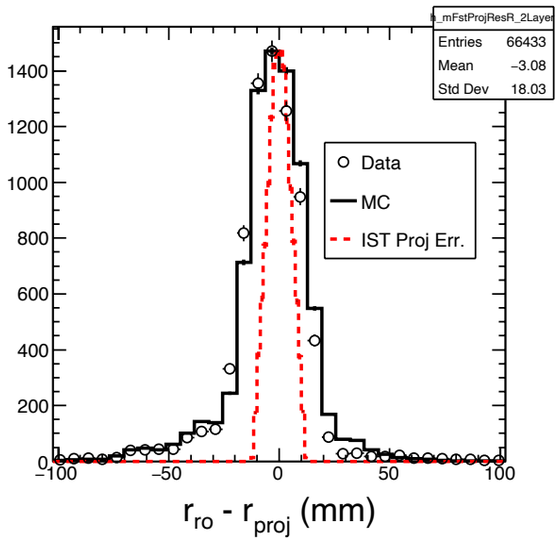
Inner Sensor



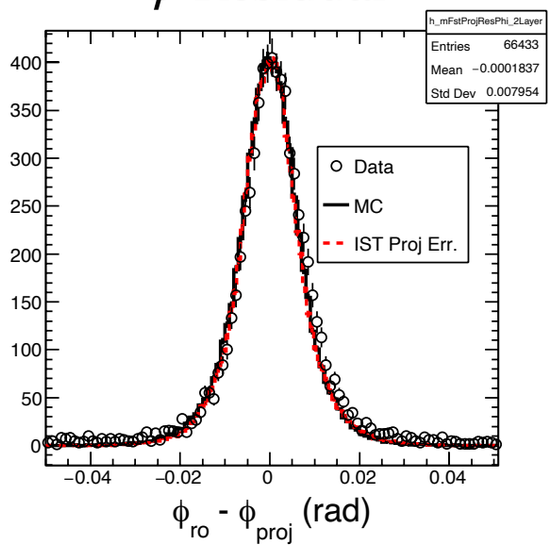
Outer Sensor



R Residual



ϕ Residual



Performance of two fully assembled prototype modules evaluated with cosmic ray:

- All channels can be read out
- Efficiency higher than 90%

FST Mechanical Support and Integration

Inner Support Structure:

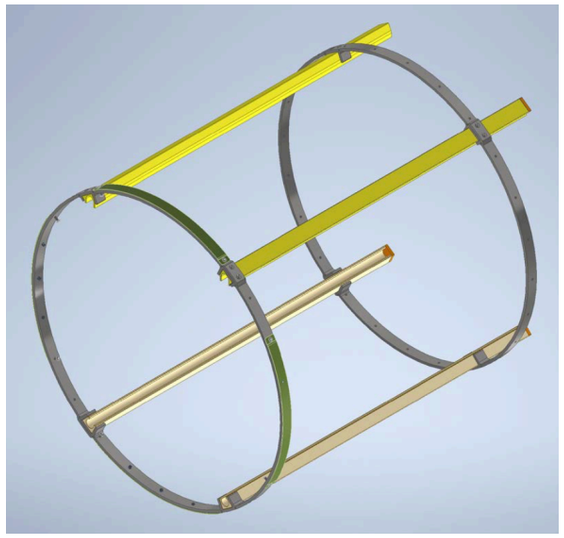
- Weight ~ 21lbs (9.5kg).
- Size: 24”W * 32”H * 19”L.
- Ring Diameter: 29.5”.
- Distance between rings: 30”.
- Material: Aluminum (both for rails and rings).

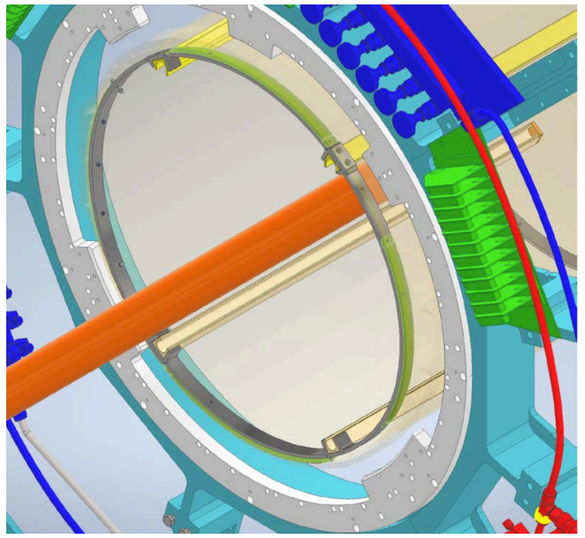
FST Installation Design Status:

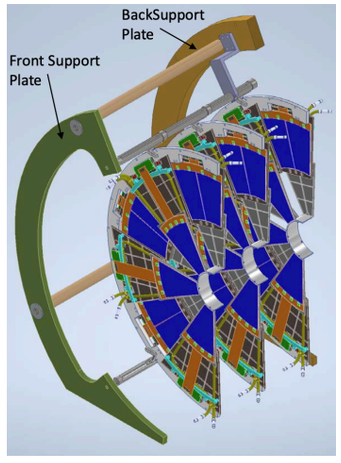
- Weight ~ 35lbs (16kg).
- Size: 24”W * 32”H *19”L.
- 3D Design complete.
- Detail Drawings under internal review.
- Will be assembled in the cleanroom then installed into STAR.

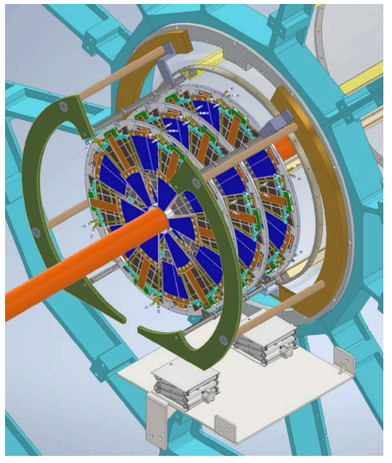
Schedule:

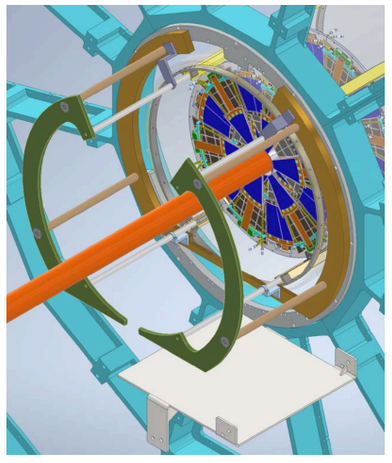
- Cleanroom Assembly: May-July 2021.
- Installation in STAR: August 2021.

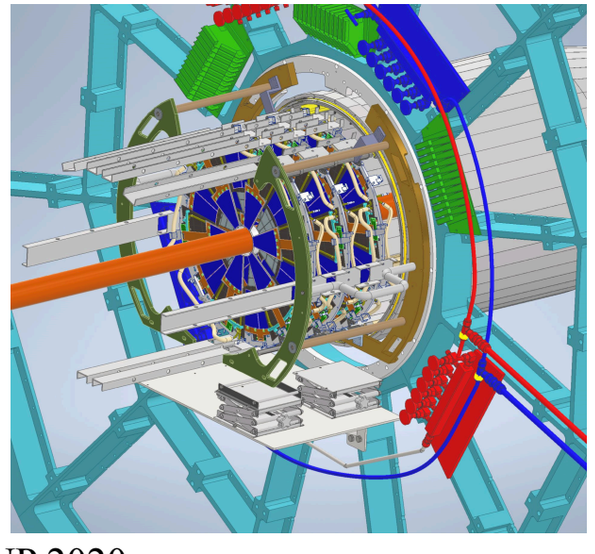


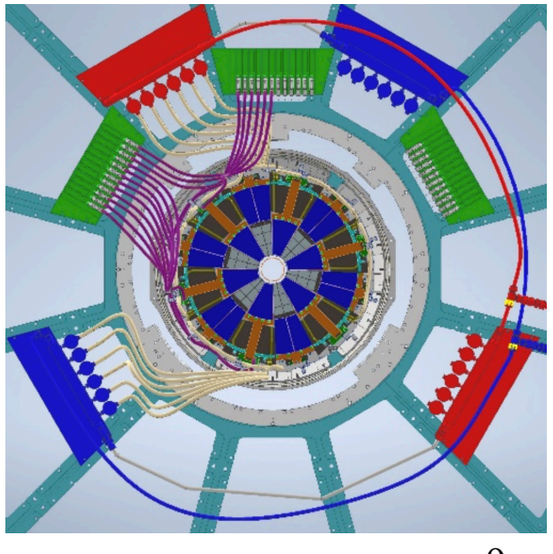












Summary and Outlook

- FST prototype modules are successfully assembled and met the key parameters requirements.
  - All channels can be readout properly.
  - Inner/outer sensor detection efficiency above 95/90%, respectively.

- FST production and installation.
  - FST module production: Sep. 2020 - Jun. 2021
  - Installation onto the supporting structure: Jul. 2021
  - Installation into STAR: Aug. 2021