TOF Detector Engineering Efforts
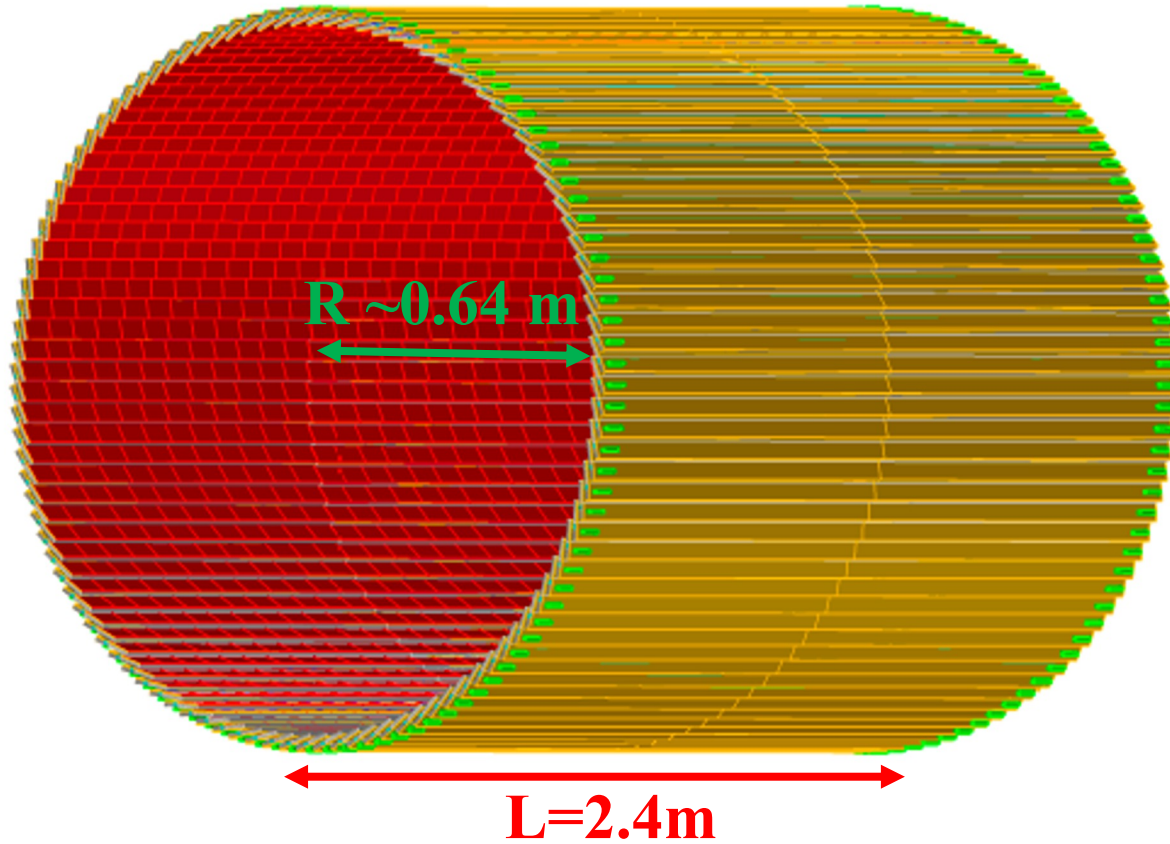
Constantin Loizides (ORNL), Franck Geurts (Rice), Wei Li (Rice), Zhenyu Ye (UIC)
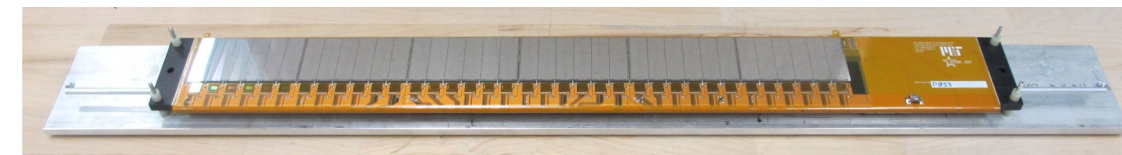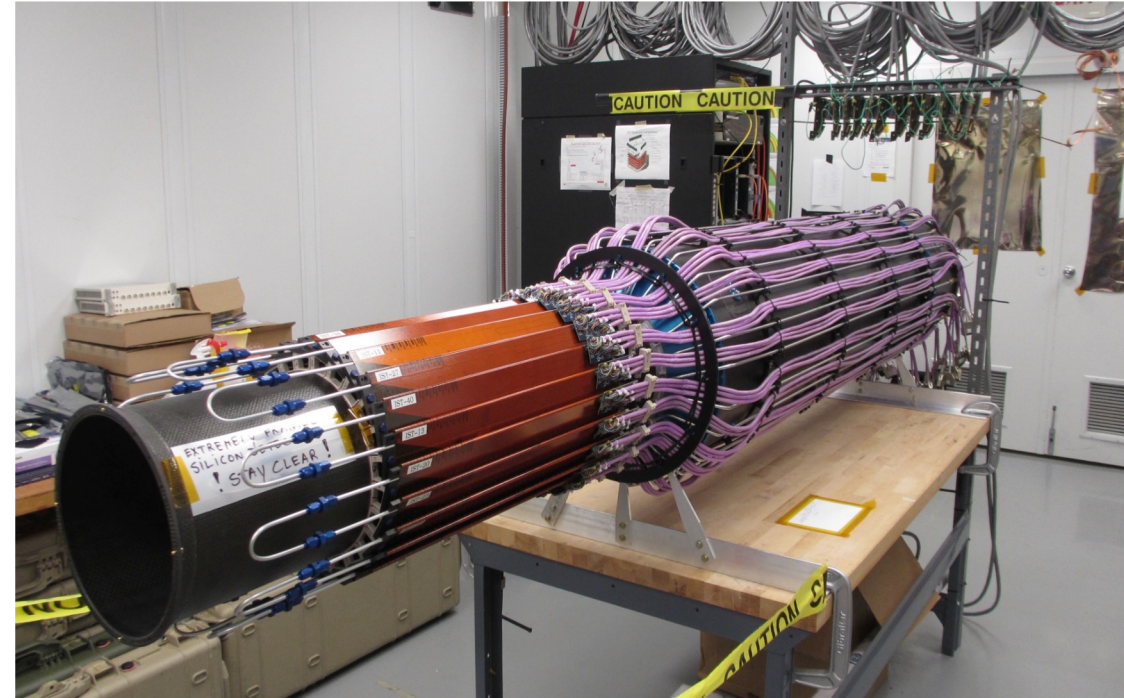
Barrel TOF Layout

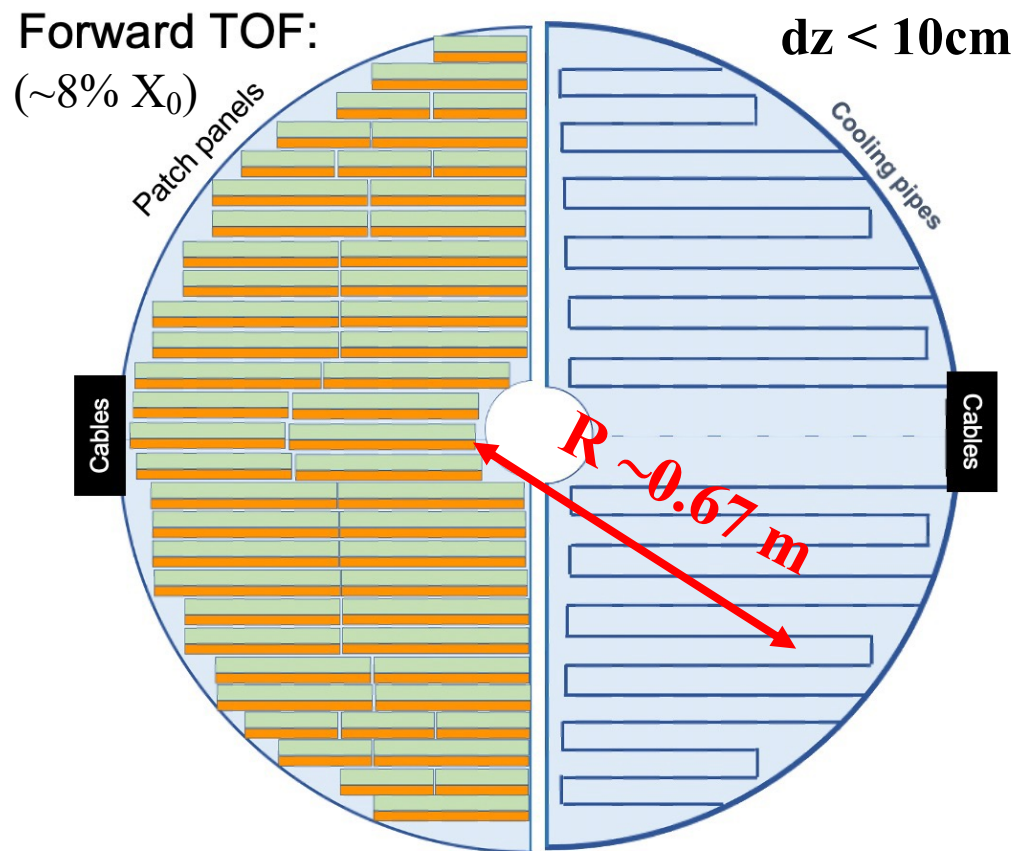ePIC Barrel TOF (~1% X_0)
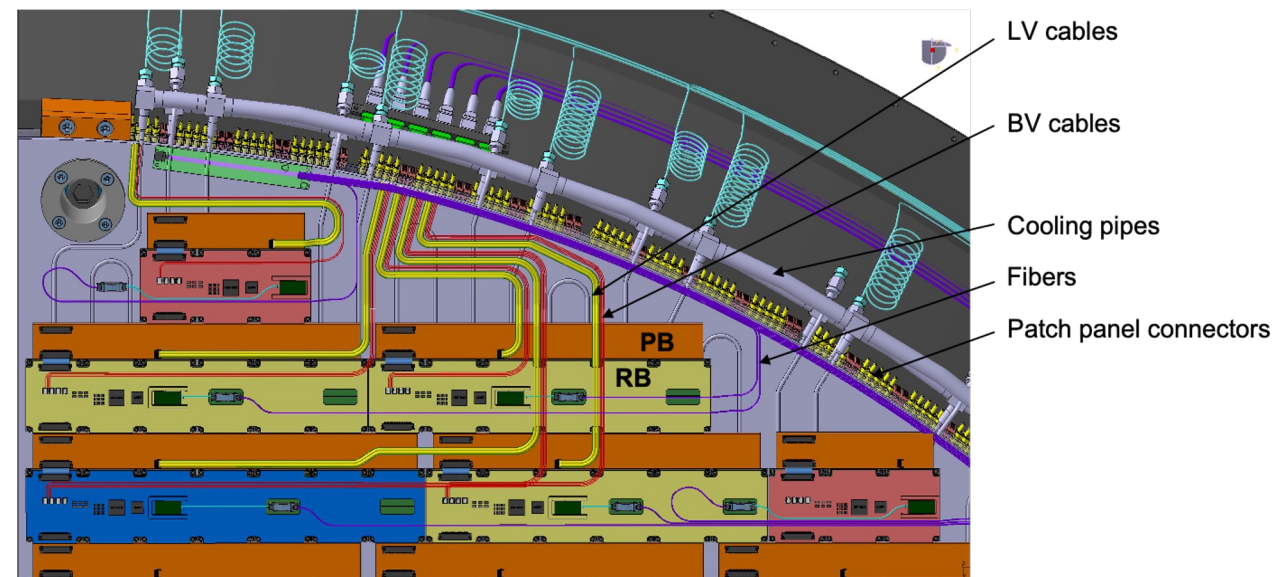

R ~0.64 m

L=2.4m

STAR Intermediate Silicon Tracker

- 288 staves, each with 32 strip sensors wire-bonded to 64 frontend ASICs on low mass Kapton flex and CF support

- Power consumption: ~4 kW for 500μm x 1cm strips (2.4 kW for ASIC, 1.0 kW for DC-DC, 0.6 kW for sensor+cable+RB)

Forward TOF Layout

Forward TOF:
($\sim 8\% X_0$)

dz < 10cm

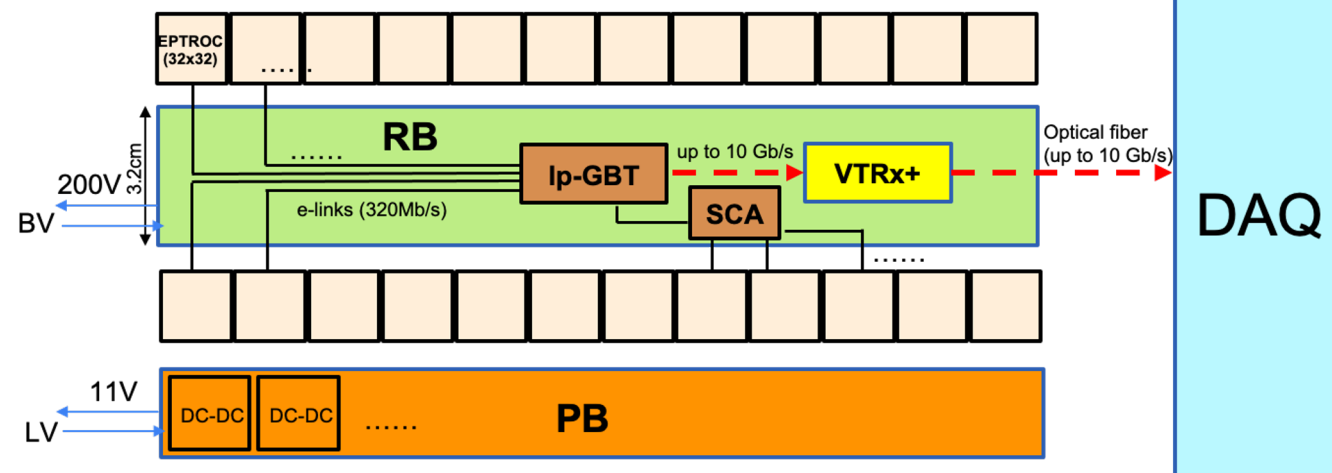**CMS Endcap Timing Layer**

- 212 modules, each with 24 to 96 bump-bonded pixel sensor + ASIC assemblies on Al disk

- Power consumption: 13 kW for 500x500 μm^2 pixels (6 kW for 800 x 800 μm^2)

Zhenyu Ye @ UIC

On-going/Planned Work

[1] https://wiki.bnl.gov/EPIC/index.php?title=TOFPID
[2] https://www.overleaf.com/read/vftxyvjtjrvp
[3] https://wiki.bnl.gov/conferences/index.php/ProjectRandDFY23

Simulation [1]

- DD4HEP geometry, digitization, reconstruction (**ORNL, UIC, Hiroshima, BNL, OSU**)
  - Timing resolution requirement
  - Spatial resolution requirement
  - Material budget requirement

Project Engineering and Design (PED) [2]

- Mechanical engineering (**ORNL, NCKU/Purdue**)
  - Mechanical support and services
  - Cooling system
- Electric engineering (**BNL within DAQ WG**)
  - Precision clock distribution (<5 ps)
  - Timing chips and streaming readout
  - Readout board

eRD112 [3]

- Sensor (**BNL-IO, UCSC, UIC/Fermilab, LANL, ORNL, Rice**)
  - BNL-IO, HPK and FBK productions
  - Lab/beam test, irradiation
- Sensor-ASIC integration (**UIC**)
- Module mechanical structure (**NCKU/Purdue**)
 - Low-density composite structure

eRD109 [3]

- Frontend ASIC:
  - EICROC (**IJCLab/OMEGA, BNL**)
  - FCFD (**Fermilab**)
  - Fast/HPSoC/ASROC (**UCSC**)
- Frontend electronics
  - Low-mass flexible Kapton PCB (**ORNL**)
  - Barrel TOF service hybrid (**ORNL**)
  - Endcap TOF service hybrid (**Rice**)

φ and θ resolution vs material budget

- Angular resolutions (θ and φ) determined
- Multiple material budget variations:
  $\rightarrow$ only sensors (no mat.) to factor 5 in overall material
- θ resolutions less affected (only in extreme case fwd)
- φ resolution unaffected in barrel
- Strong material budget dependence for φ in fwd!
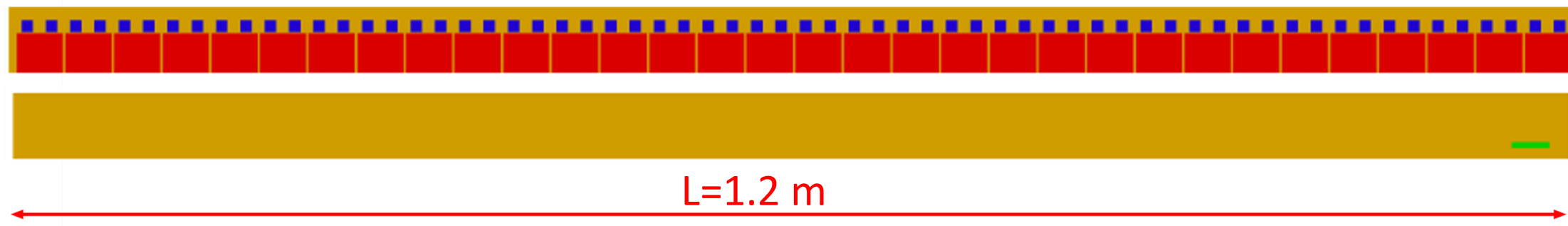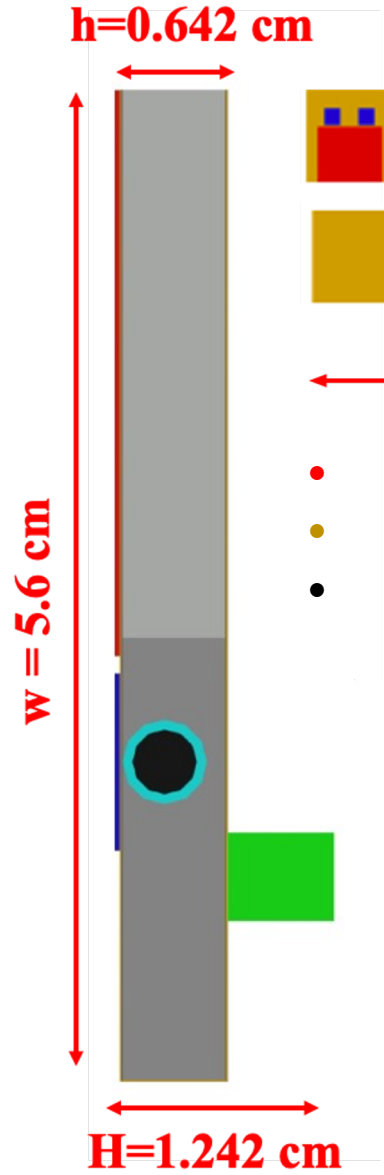
NEW!

Nicolas Schmidt (ORNL)
More details: https://indico.bnl.gov/event/18902

Zhenyu Ye @ UIC
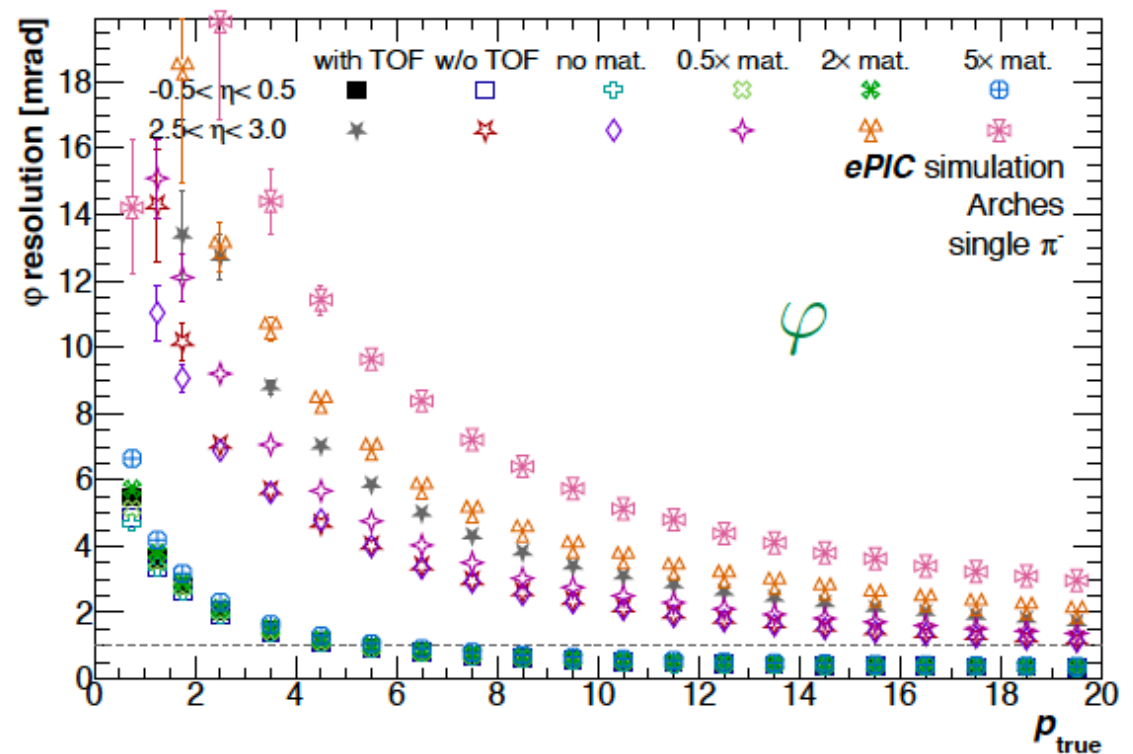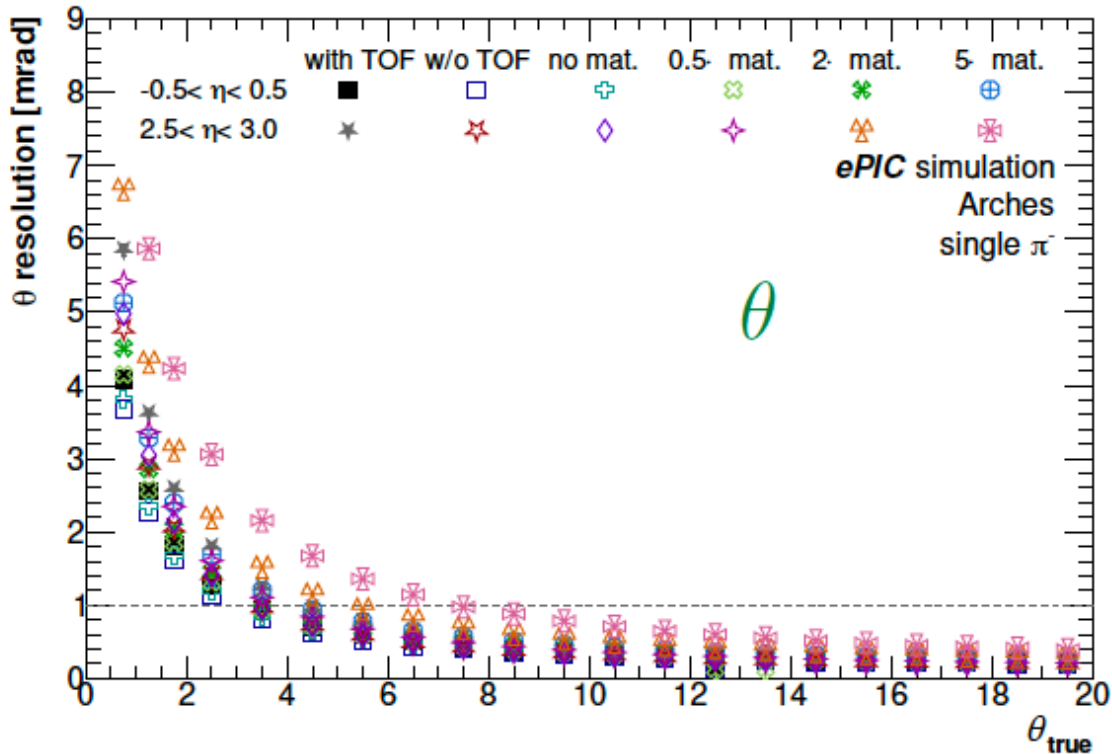
Barrel TOF Layout and Integration

h=0.642 cm

w = 5.6 cm

H=1.242 cm

L=1.2 m

- **32 AC-LGAD sensors**, each 3.2*4 cm^2 read out by **2 ASICs**
- **Low mass flexible Kapton PCB** distributes power and I/O signals from a low mass connector(s) at the edge
- **Liquid coolant** in **Al cooling tube** takes away heat from the ASICs
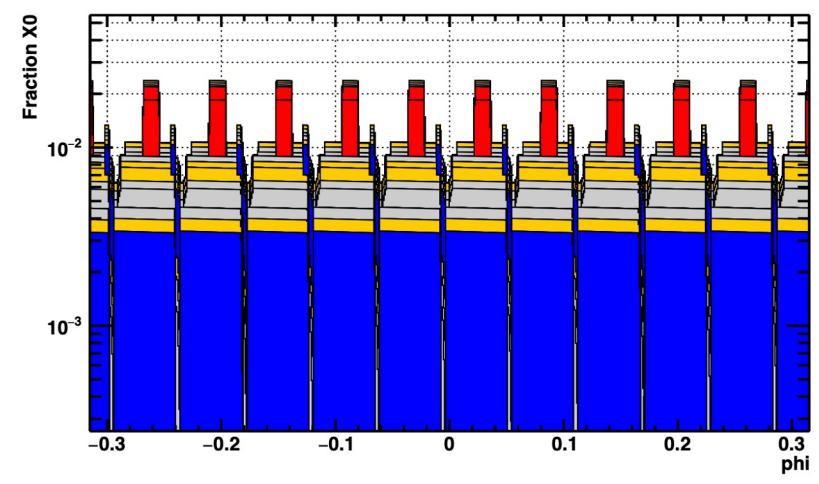
288 modules, each powered and read out by 1 service board with

1 LV+HV cable, 1 fiber to DAQ, 1 liquid cooling line

Total weight: ~70 kG

Total power consumption: ~4 kW (2.4kW for ASIC, 1.0kW for DC-DC, 0.6kW for sensors+cables+RB)

https://indico.bnl.gov/event/17336/

Forward TOF Integration

More details: https://indico.bnl.gov/event/17336/
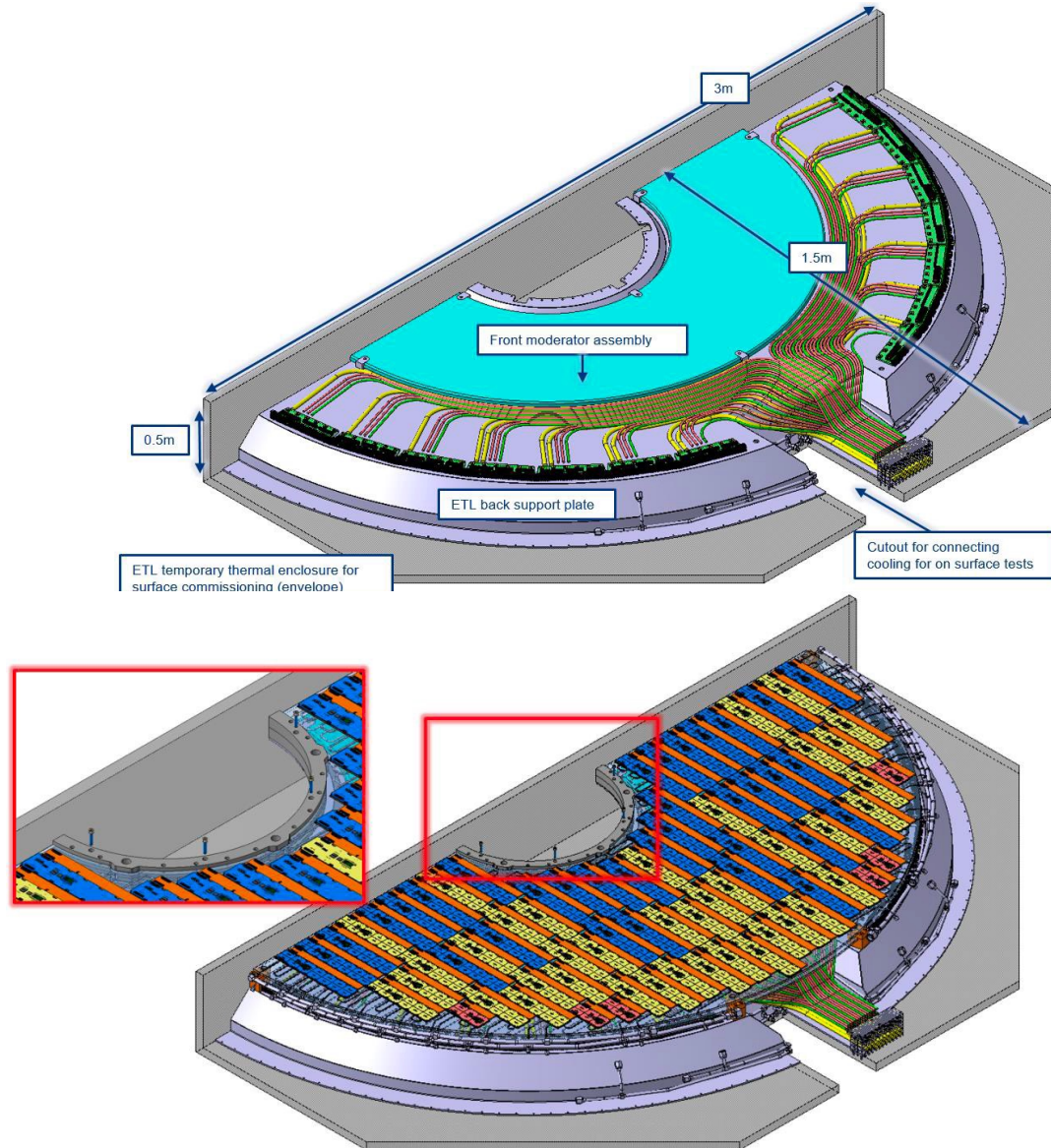
Services (baseline)	Forward
Sensors/ASICs	8704
LV cables	424
HV cables	424
Fibers	212

Power Consumption	Forward
500x500 micron^2 (baseline)	13kW
800x800 micron^2 (possible alternative)	6kW