TOF Support Structure – next steps

10th January 2024

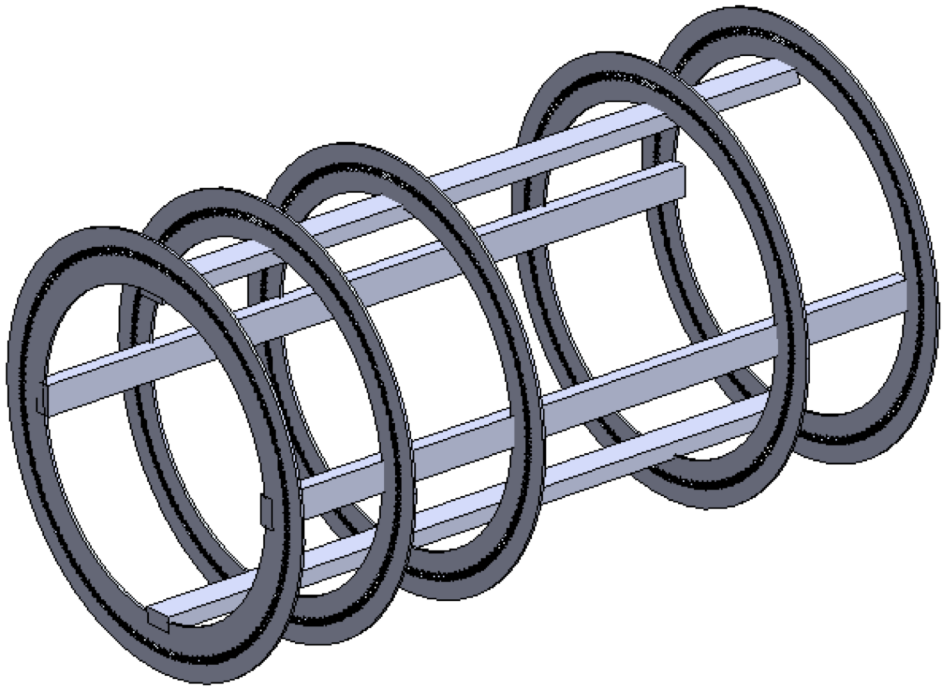
Andreas Jung, Sushrut Karmarkar and UG student team

“Global” support structure for TOF

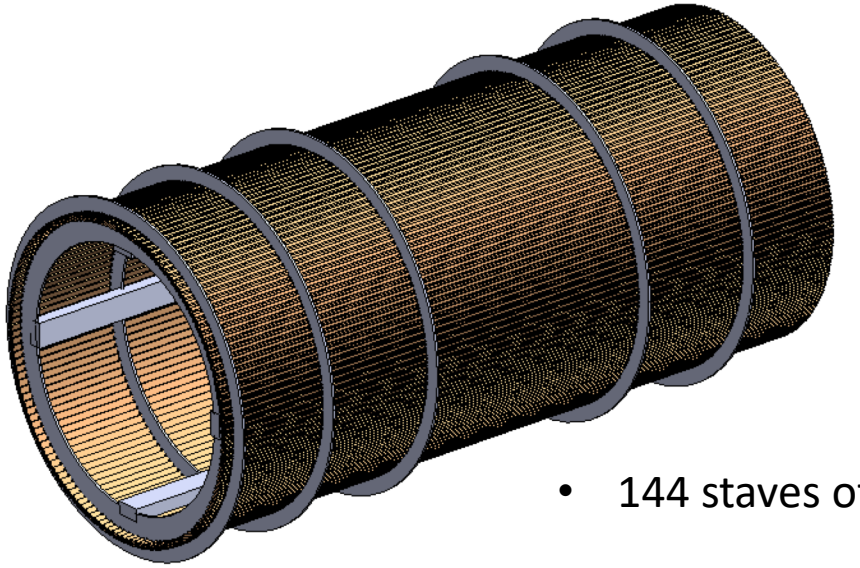
1. Set of engagement rings mounted on <u>temporary</u> inner rigid supports at 12, 3, 6, 9 o’clock positions for TOF assembly

<u>Nomenclature:</u>

- Stave = full length mechanical structure



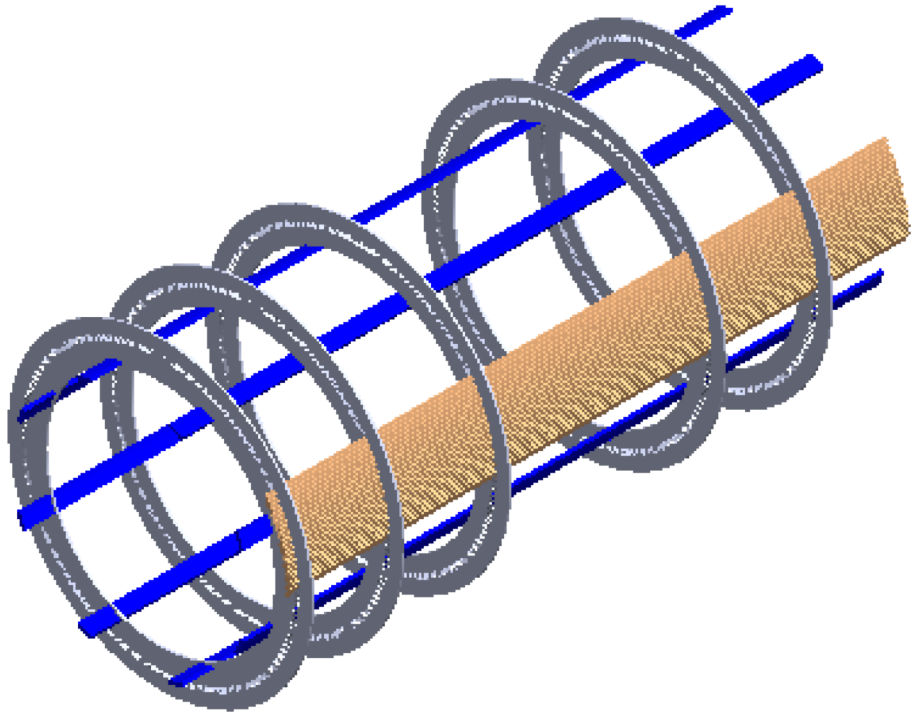
2. Completely mount and wire up the AC-LGAD staves when there is full access from inside and outside of these engagement rings
   - Permanent support for services via larger global CF support tube
   - Needs temporary support to feed out mechanics



- 144 staves of 2.7m length

Plan for the 30 arc length TOF structure

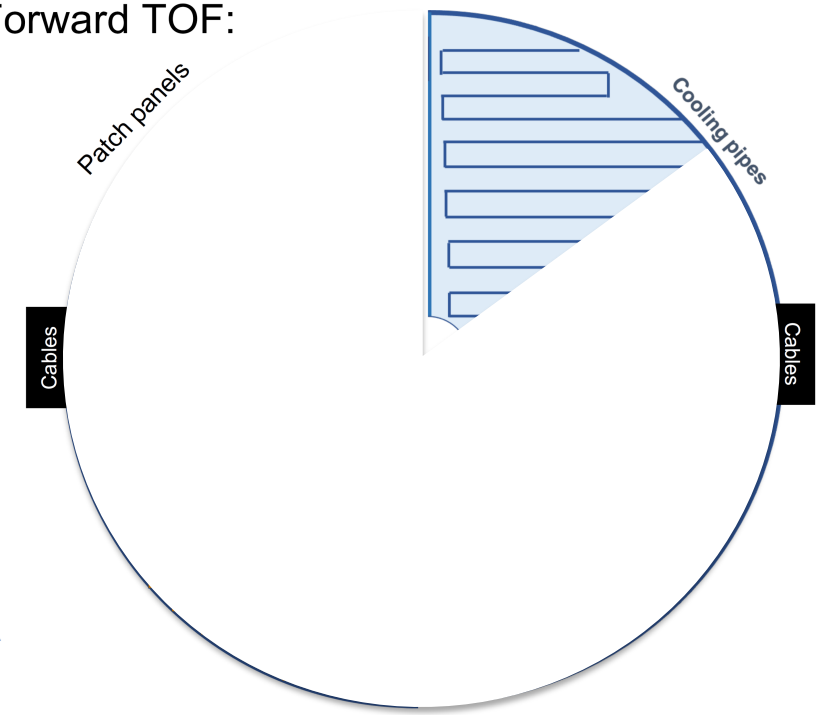
- BTOF Design & manufacture an arc section in terms of mechanically and dimensionally correct staves
  - 12 staves total, 2.7 m long
  - Only 1-2 would be fully functional
  - All staves include “cooling” connectors at ends to study service routing and supports (temp and perm)
- Full sized engagement rings, not just 30 degree
  - Allows to study supporting inner detectors, aka SVT
  - Allows to study MPGD mounting
  - Integration and deflection/loading tests
- Updates on thermal load which drives in the end the support design for thermal performance
  - Already discussed in previous session…follow-ups needed

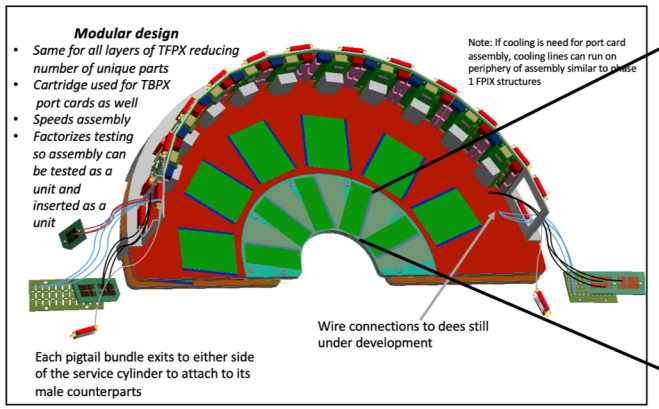


Plan for the 30 arc length TOF structure

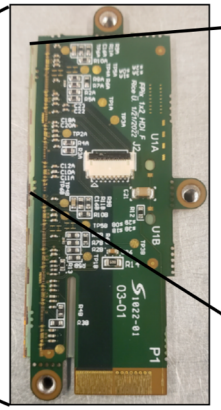
- FTOF 1-few “wedges” of FTOF disc
  - Designing for 13.6 kW, but not up-to-date
  - Again include a full 360 diameter ring to look at attachment to larger global CF supports
    - Also allows to offset cards / electronics to outer perimeter
  - Service routing & cooling
  - At least 1 wedge fully functioning in terms of cooling

Forward TOF:

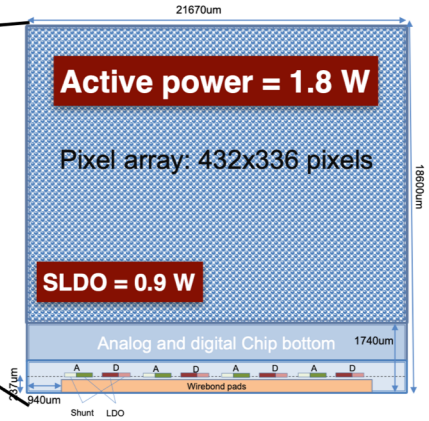




TFPX Cartridge housing Dee

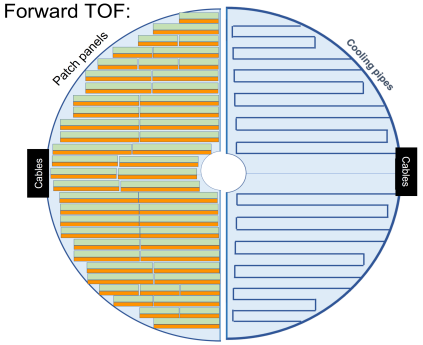


1x2 CMS-ROC module
HDI over ROC



Dissipation in one Readout Chip

Forward TOF:

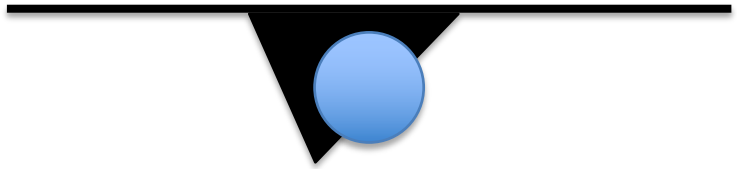


Material budget

- Started to collect information and optimizing for lowest X0
- Can converge fast once accurate inputs, allows to look at options and realize material savings
- Lots of experience to draw from: CMS, Alice, ATLAS, etc.
- Alternative designs possible, but consequences for global supports

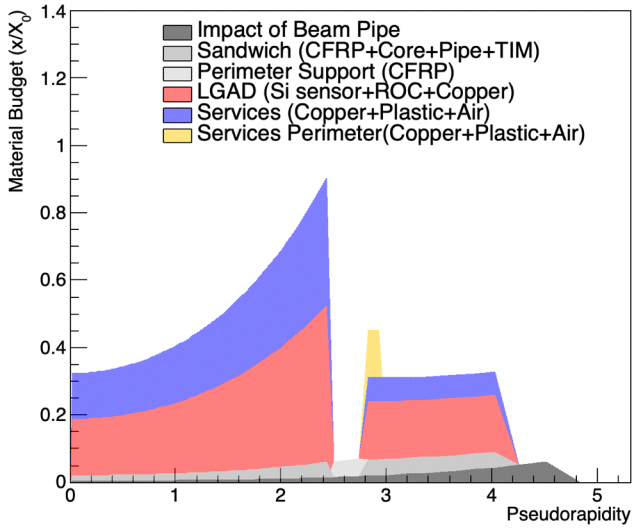
CMS tilted barrel

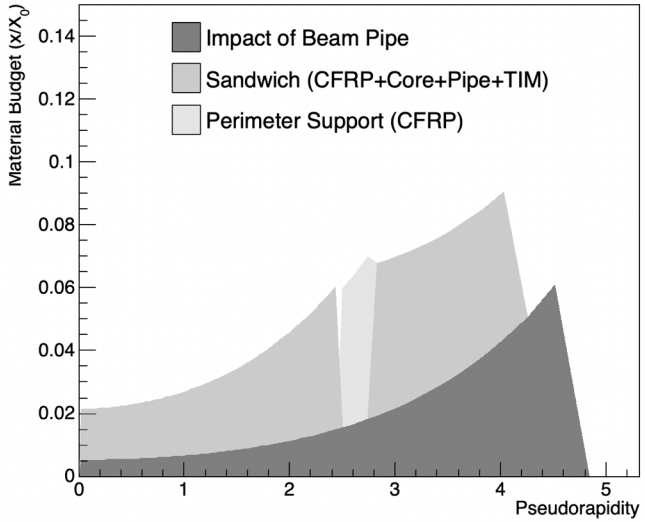
Al-CF triangle + pipe and 5-ply highly thermally conductive CF



Caveats:

- **No need to be scared, below is TOF/EIC geometry but CMS pixel assumptions for sensors and supports**
- **Means: global offset of being (much) higher**
- **Discussion started to run this with proper inputs**





Schedule for next ~ 12 months

- Schedule not up-to-date but gives a rough idea
- Pre-production is 3 months for staves, 6 months for barrel and another 3 months for global supports
- Enough time for changes and if need-be to accelerate

TOF LGAD endcap (for now standard sandwich structure)			
	Milestones	Plan start	Duration
	Pre-production & Prototype, earliest for 1st wegde available	9/3/25	4
	Finalize loads/BCs	1/1/26	0.5
	Current Design Review	1/16/26	0.5
	Final FEA & Coolant pipe layout	1/31/26	0.5
	Tool Preparation & Machining	2/15/26	1
	Practice Layup	3/17/26	0.25
	Final Manufacturing FEA	3/24/26	1
	3D print sub-parts	4/23/26	1
	Final adjustments to manufacturing	5/23/26	1
	First wedge layup	6/22/26	1
	First wedge part prep	7/22/26	0.25
	Tool Preparation & Machining	7/30/26	1
	Remaining wedges layup	8/29/26	2
	Remaining wedges	10/28/26	2
	Endcap assembly	12/27/26	2
	QA/QC + loading	2/25/27	1
	Total	3/27/27	19

TOF LGAD staves (cost savings via NCKU machine shop possible)			
	Milestones	Plan start	Duration
	Pre-production & Prototype, earliest for final stave available	1/1/25	3
	Finalize design & choice	4/1/25	2
	Purchase Consumables	5/31/25	0.5
	Practice Layup	6/15/25	0.5
	QA/QC	6/30/25	0.25
	Layups 1 to 72	7/7/25	2
	Layups 72 to 144	9/5/25	2
	Layups > 144 (spares)	11/4/25	2
	Pipe preparation	1/3/26	2
	Assembly/Gluing	3/4/26	2
	QA/QC	5/3/26	0.75
	Total	5/26/26	17

Summary & Discussion

- Expect pick-up of pace for the pre-production of TOF structures

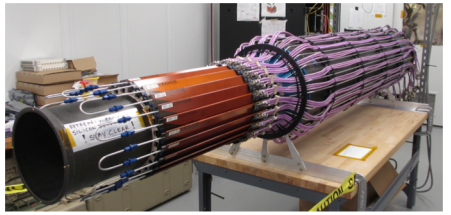
- For global mechanics need detailed FEAs: started
  - Closely connected to mechanics work in TOF LGAD (barrel and endcap)
  - Integrate and develop global mechanics for SVT to connect to
  - Establish hierarchy of supporting structure, i.e. which system supports whom
  - Establish better understanding of service masses and space, routing
  - General envelope's need to be refined

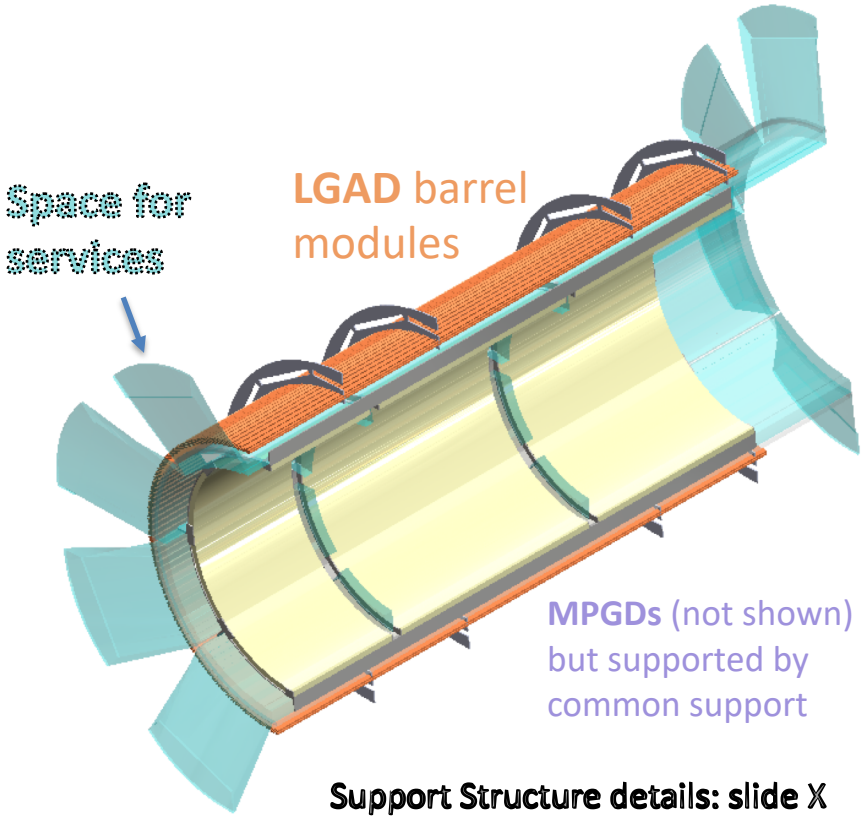
- Next high priority near time goals:
  - Make animation of the insertion with updated CADs for better understanding
  - Consistent FEA to understand EPIC inner detector supports better and optimize to lower mass solution where ever possible
- More tomorrow in SVT mechanics session…

Backup

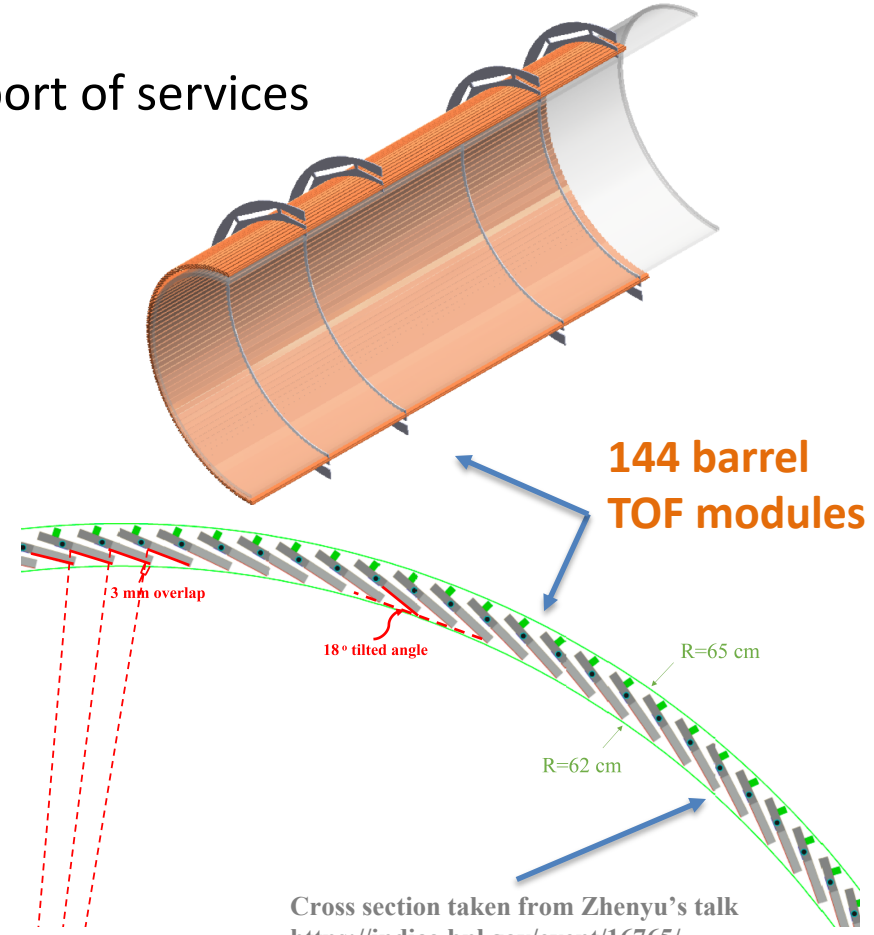
Barrel TOF

- Use similar concept of STAR IST (starting point)
- LGADs supported by “long staves”, next slide
- Common support structure
  - Barrel TOF, MPGDs, space & support of services



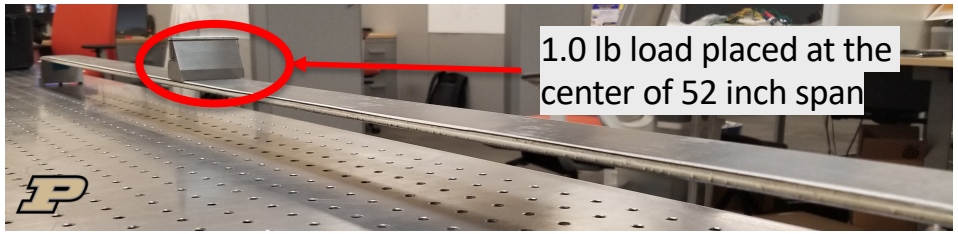


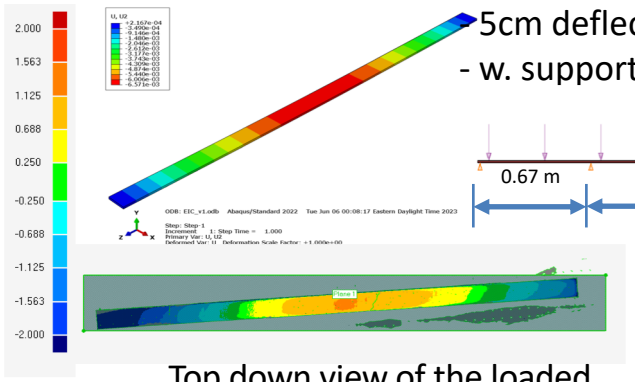
Support Structure details: slide X



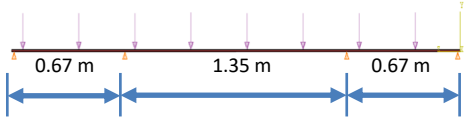
Barrel TOF

- Total of 144 barrel TOF modules
  - 9216 sensors, 18,432 ASICs, 2.4 M channels
  - Mass ~70kg and 4kW heat load
- 1st Preliminary stave structure made
  - FEA and prototype for full length
  - Deflection of 700 micron – further optimization possible





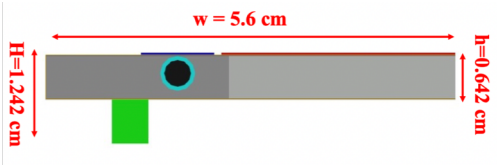
5cm deflection full length stave - w. supports down to 700μm

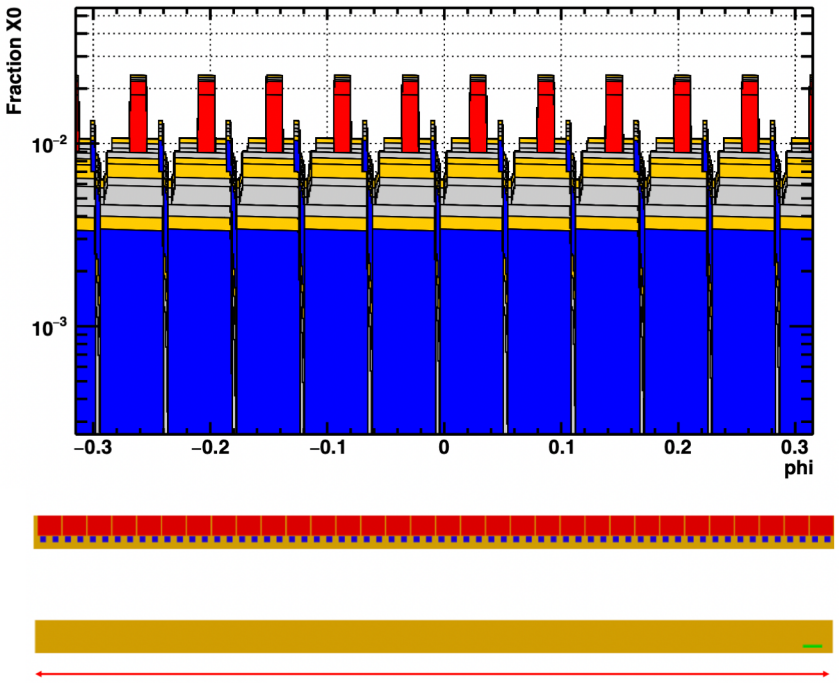


Unit: mm

Top down view of the loaded stave.

- AC-LGAD sensor
- Frontend ASICs
- Carbon foam+ Carbon honeycomb+ CF skins
- Al cooling tube
- Liquid coolant
- Kapton PCB
- Connector



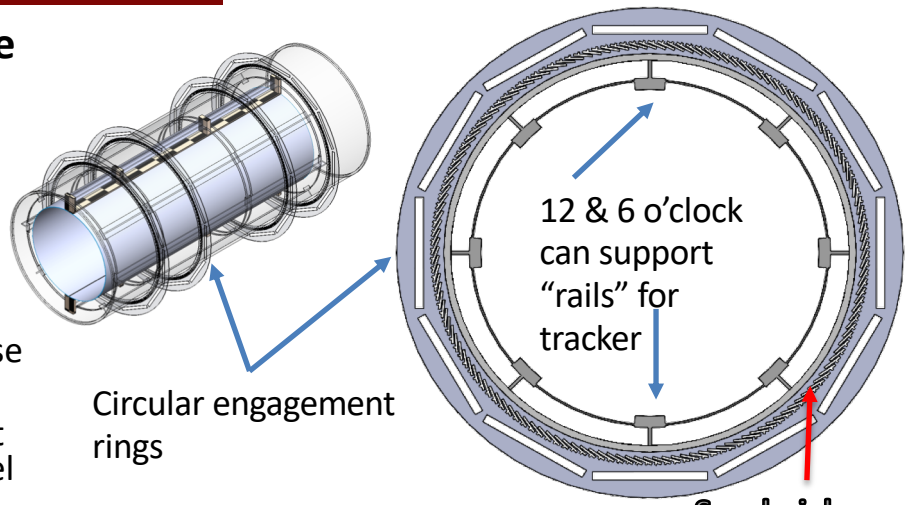


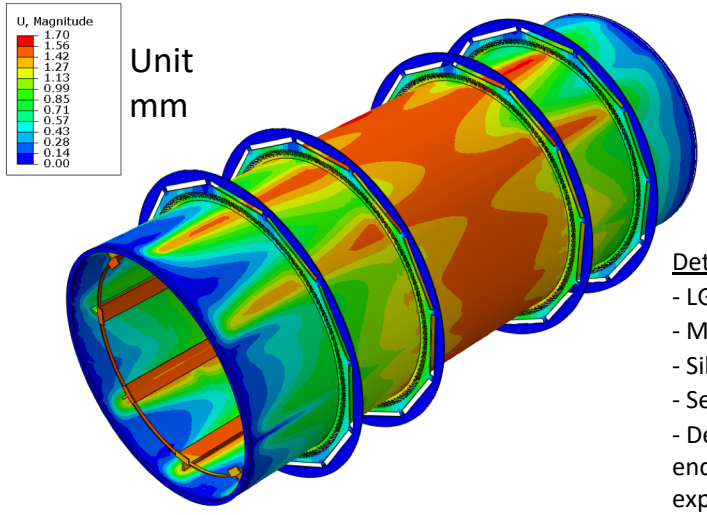
"Long stave" length ~ 2.4m

From Zhenyu's talk
https://indico.bnl.gov/event/16765/

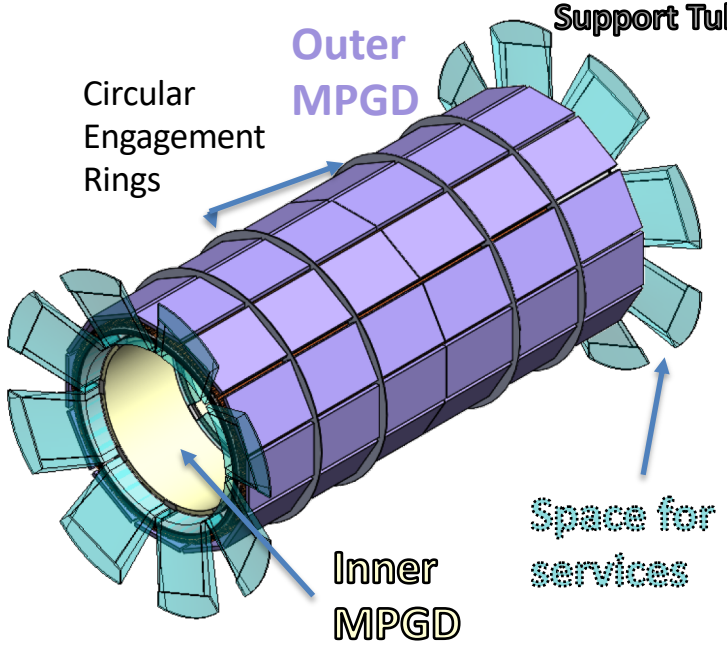
Support structure for barrel TOF

- **Concept idea of joined mechanics structure for barrel TOF, inner & outer MPGD layers, services, and even tracker**
  - 1+8+1 mm sandwich composite structure w “end-rings” to support beam pipe during installation & integration
- Integration
  - Move/Place end cap TOF closer to dRICH to ease access to inner tracking volume
  - ”Rail” system (internal and external) to support half-cylinders for tracker installation after barrel TOF system is in place
- First preliminary FEAs for this design
  - 1.7mm deflection and weak regions at engagement rings – needs to be optimized!



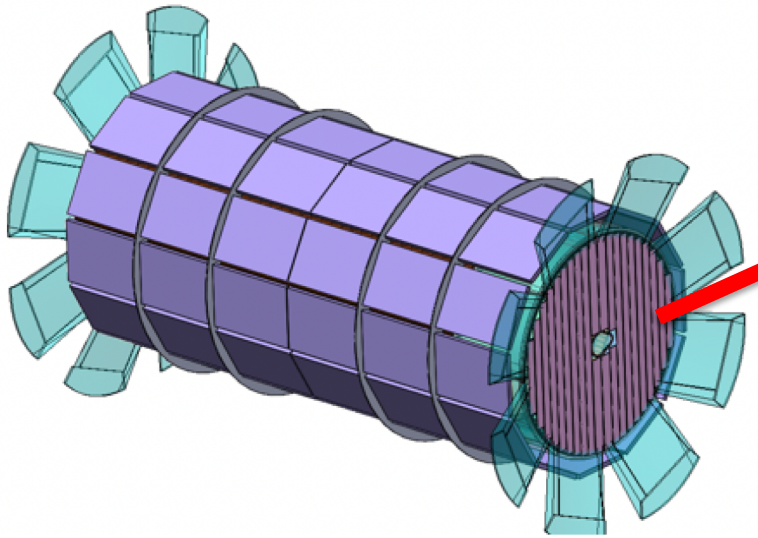


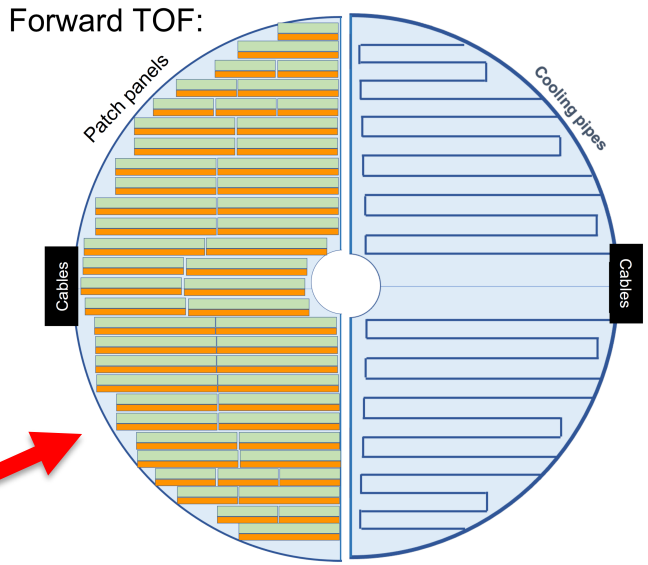
Details:
- LGADs = 70 kg
- MPGDs = 24 + 24 kg
- Silicone tracker = 10 kg
- Services (smeared) = 100 kg
- Designed engagement rings, end rings following CMS experience at Purdue



Endcap TOF

- Endcap TOF supported by common structure supporting barrel TOF system
- Under study: Integration & access to tracking volume eased if endcap TOF moved in front of dRICH





From the talk of Wei Li
https://indico.bnl.gov/event/16742/

- "Clam shells" or DEEs
  - Convenient for installation/maintenance
  - Each is patched by TOF modules (one or more types) on both faces
  - No backward TOF

Power Budget

	Endcap TOF [kW]
Sensors	0.6
ASIC	8.5
DC-DC	3.5
lpGBT, VTRx+, SCA	0.5
Power cables	0.5
Total	13.6