Central detector Integration - update

26th February 2024

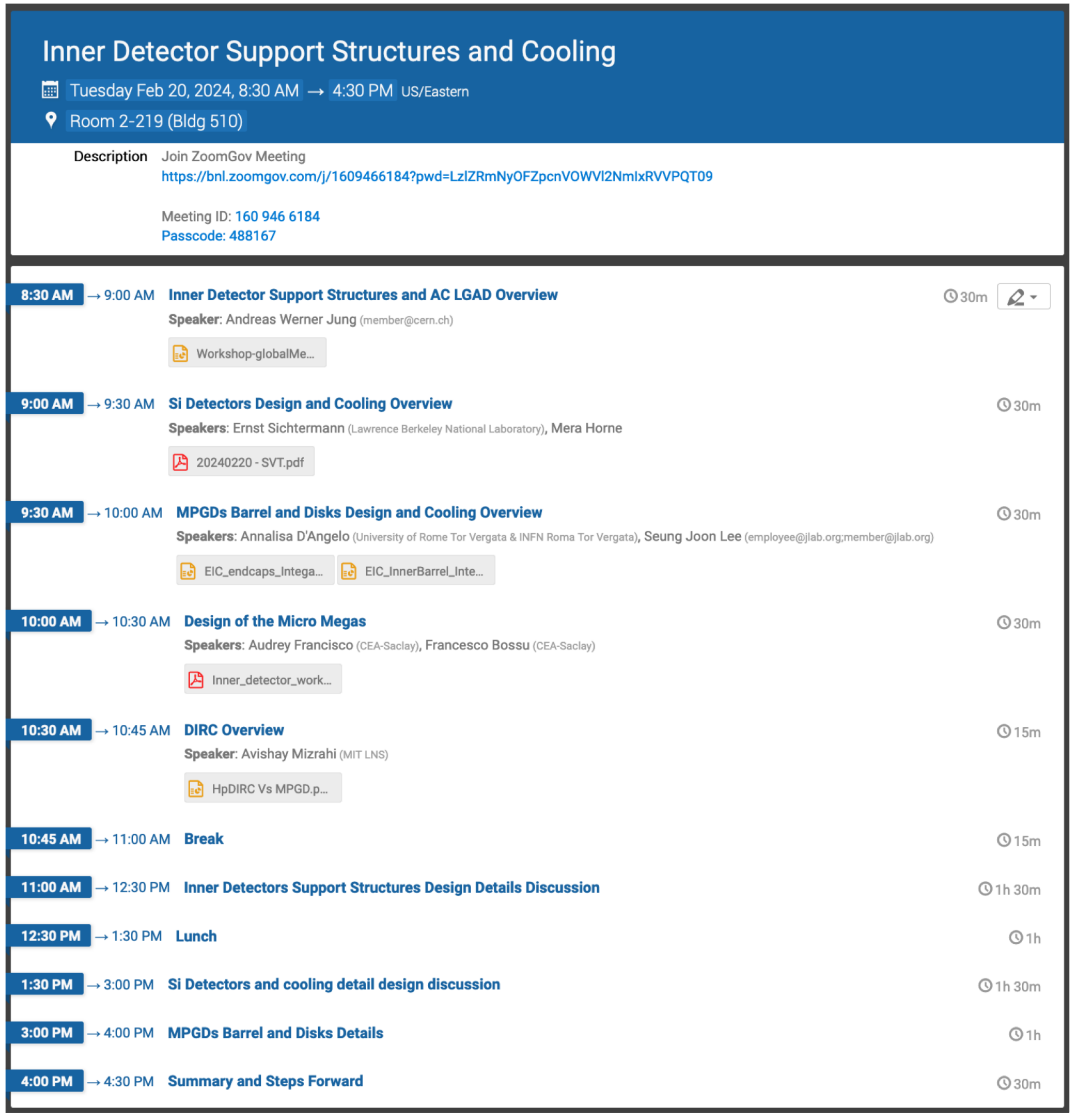
Andreas Jung, Sushrut Karmarkar and UG student team

Input from many others: Rahul, Dan, Roland et al., SVT via Ernst and also Eric et al., MPGD via Kondo et al., Elke, and others

Apologies for omissions…

Central Detector Region

- Whole day ad-hoc spontaneous workshop on Feb 20th: https://indico.bnl.gov/event/22387/
- Variety of subsystems able to join
- Discussing follow-up meeting ~end March and another whole day workshop day at Purdue in May
  - https://indico.cern.ch/event/1336746/page/32301-satellite-events



Inner Detector Support Structures and Cooling

Tuesday Feb 20, 2024, 8:30 AM → 4:30 PM US/Eastern

Room 2-219 (Bldg 510)

Description: Join ZoomGov Meeting
https://bnl.zoomgov.com/j/1609466184?pwd=LzlZRmNyOFZpcnVOWVl2NmlxRVVPQT09

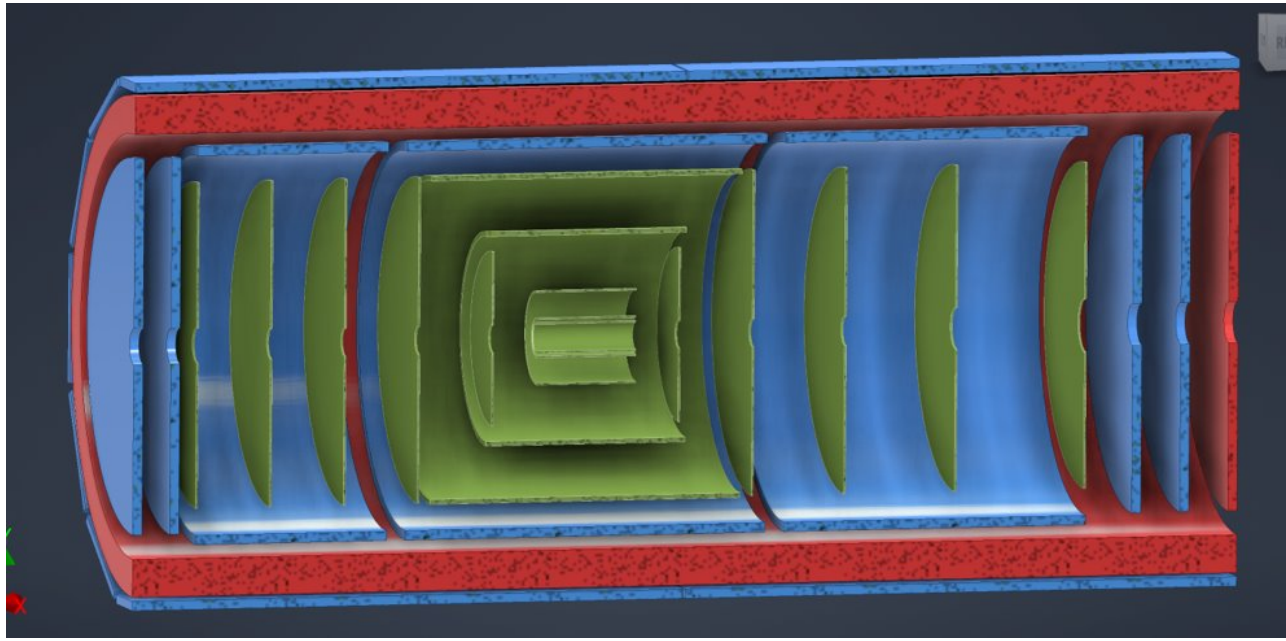
Meeting ID: 160 946 6184
Passcode: 488167

8:30 AM → 9:00 AM	Inner Detector Support Structures and AC LGAD Overview Speaker: Andreas Werner Jung (member@cern.ch) Workshop-globalMe...	30m
9:00 AM → 9:30 AM	Si Detectors Design and Cooling Overview Speakers: Ernst Sichtermann (Lawrence Berkeley National Laboratory), Mera Horne 20240220 - SVT.pdf	30m
9:30 AM → 10:00 AM	MPGDs Barrel and Disks Design and Cooling Overview Speakers: Annalisa D'Angelo (University of Rome Tor Vergata & INFN Roma Tor Vergata), Seung Joon Lee (employee@jlab.org;member@jlab.org) EIC_endcaps_Intega... EIC_InnerBarrel_Inte...	30m
10:00 AM → 10:30 AM	Design of the Micro Megas Speakers: Audrey Francisco (CEA-Saclay), Francesco Bossu (CEA-Saclay) Inner_detector_work...	30m
10:30 AM → 10:45 AM	DIRC Overview Speaker: Avishay Mizrahi (MIT LNS) HpDIRC Vs MPGD.p...	15m
10:45 AM → 11:00 AM	Break	15m
11:00 AM → 12:30 PM	Inner Detectors Support Structures Design Details Discussion	1h 30m
12:30 PM → 1:30 PM	Lunch	1h
1:30 PM → 3:00 PM	Si Detectors and cooling detail design discussion	1h 30m
3:00 PM → 4:00 PM	MPGDs Barrel and Disks Details	1h
4:00 PM → 4:30 PM	Summary and Steps Forward	30m

Central Detector Region

- Design of supports for MPGD, TOF-LGAD and SVT depends on support hierarchy and detector “integration” and assembly
- Dictates what structures are needed to support innermost SVT and how…
- Naturally, as light-weight as possible but services and “cooling” needs space and need to be considered
  - Need realistic numbers for power & heat loads to design mechanical structures!
- Lets first look at an integration sequence of **“inner detectors”**
- Nomenclature: large global inner detector CF support tube or GST

“Inner detectors” = inside of the large global CF support tube



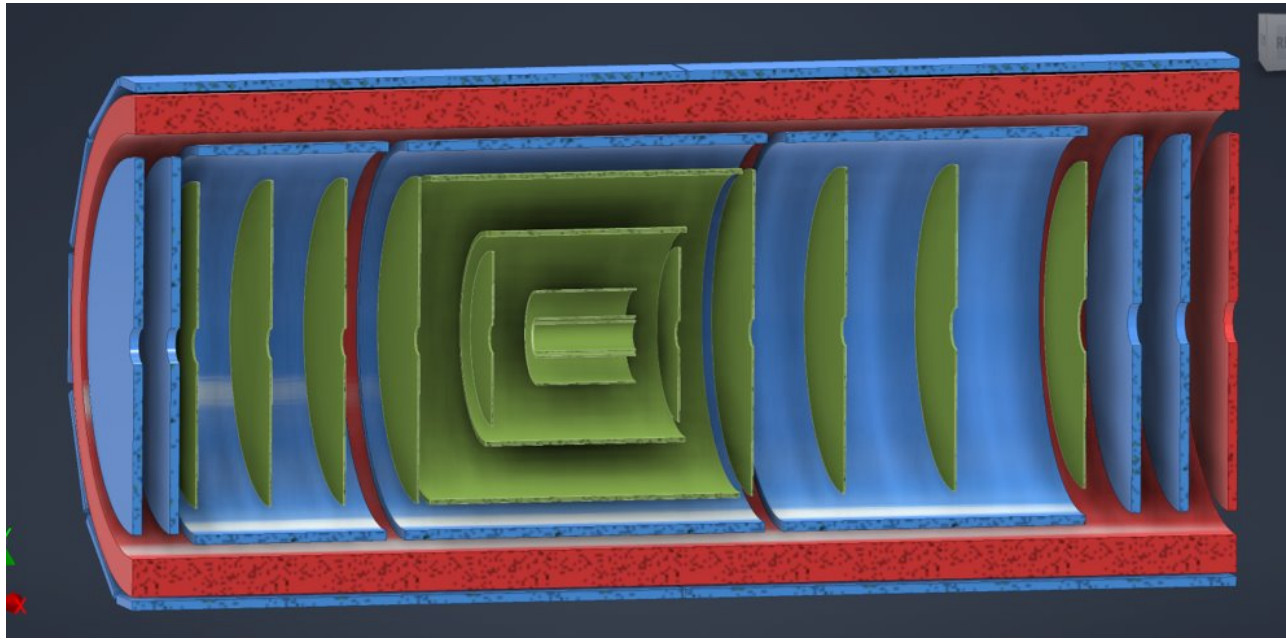
Central Detector Region & Integration: Thoughts

- Broad overview of integration sequence is ”two-fold”
  - Beam pipe and SVT sub-assembly
  - TOF-LGAD and MPGD sub-assembly
- Two large sub-assemblies independently integrated
  - SVT sub-assembly staying in one physical location
  - TOF-LGAD+MPGD sub-assemblies “slides” over SVT sub-assembly
- Next step is to add MPGD discs e and p directions as well as FTOF-LGAD
- Last step is to integrate whole inner detector region into GST / EPIC

Side remarks:

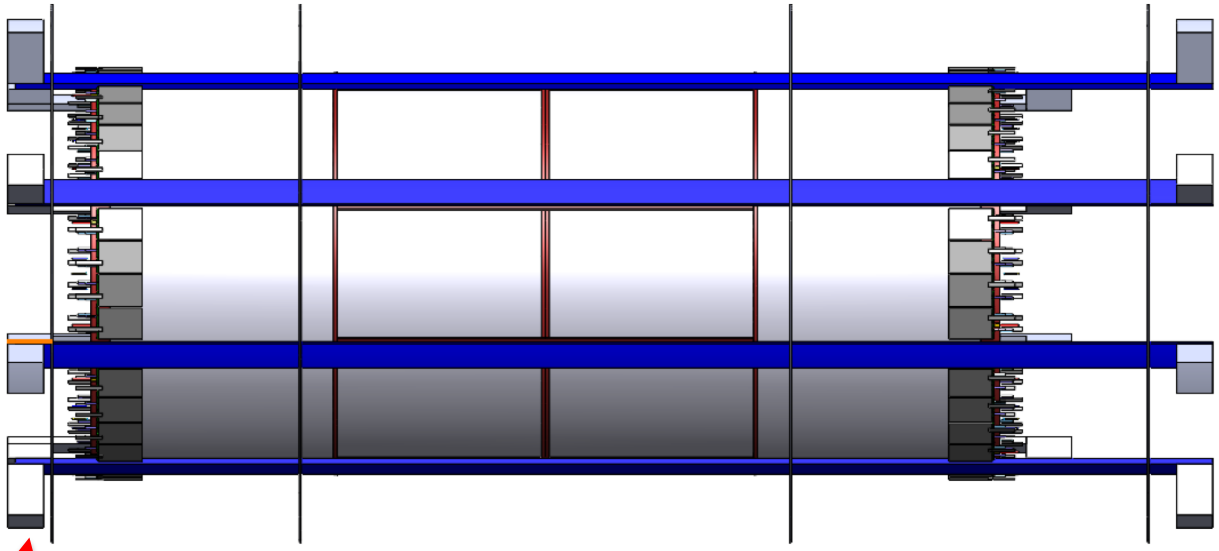
- Substantial amount of temporary supports needed for beam-pipe, service, cooling, etc
- Temporary structures needed to “slide” / integrate sub-assemblies together and also for final step into EPIC GST structure

“Inner detectors” = inside of the large global CF support tube

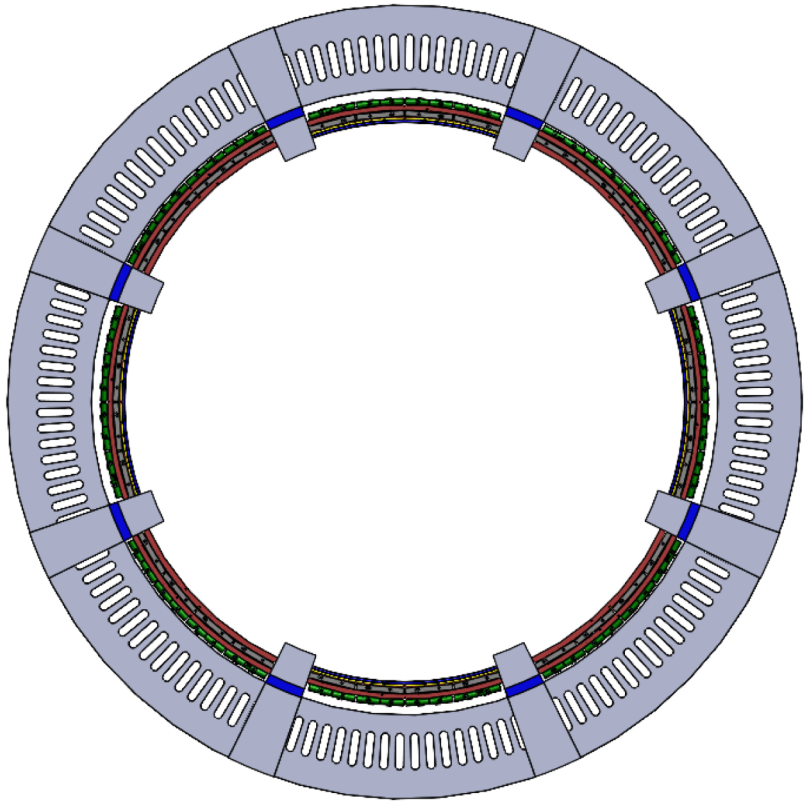


1st sub-assembly for inner detectors

1. Set of engagement rings mounted on inner rigid supports at off - 12, 3, 6, 9 o'clock positions for MPGD assembly
   - "stand-offs" (L-brackets) attach the structure in the last step to the GIST via inserts & screws



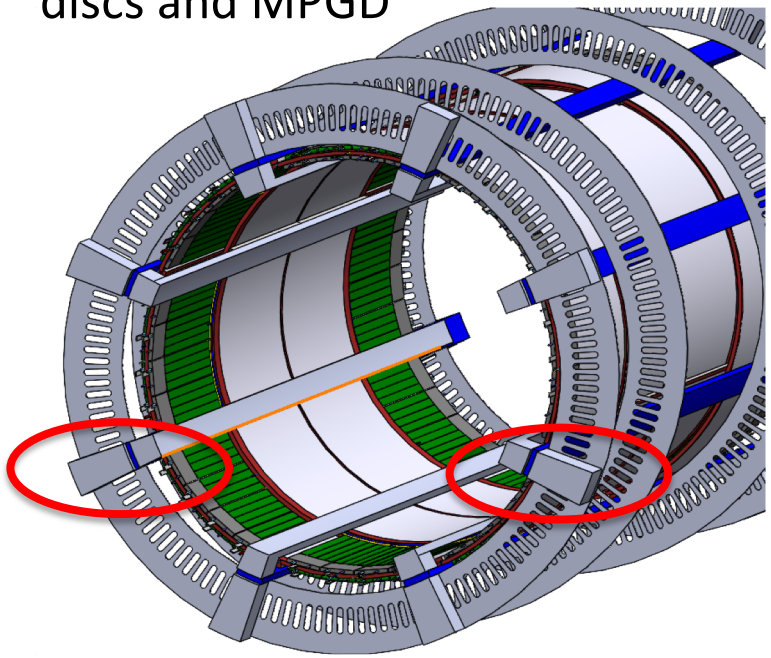
2. Mount inner MPGD on these "support beams/rails"
   - Needs temporary support to feed out mechanics



"stand-offs": for now looks very beefy and large, merely to have Enough space. "Mass-optimization" will happen **but can't prior to knowing masses and thermal loads!**

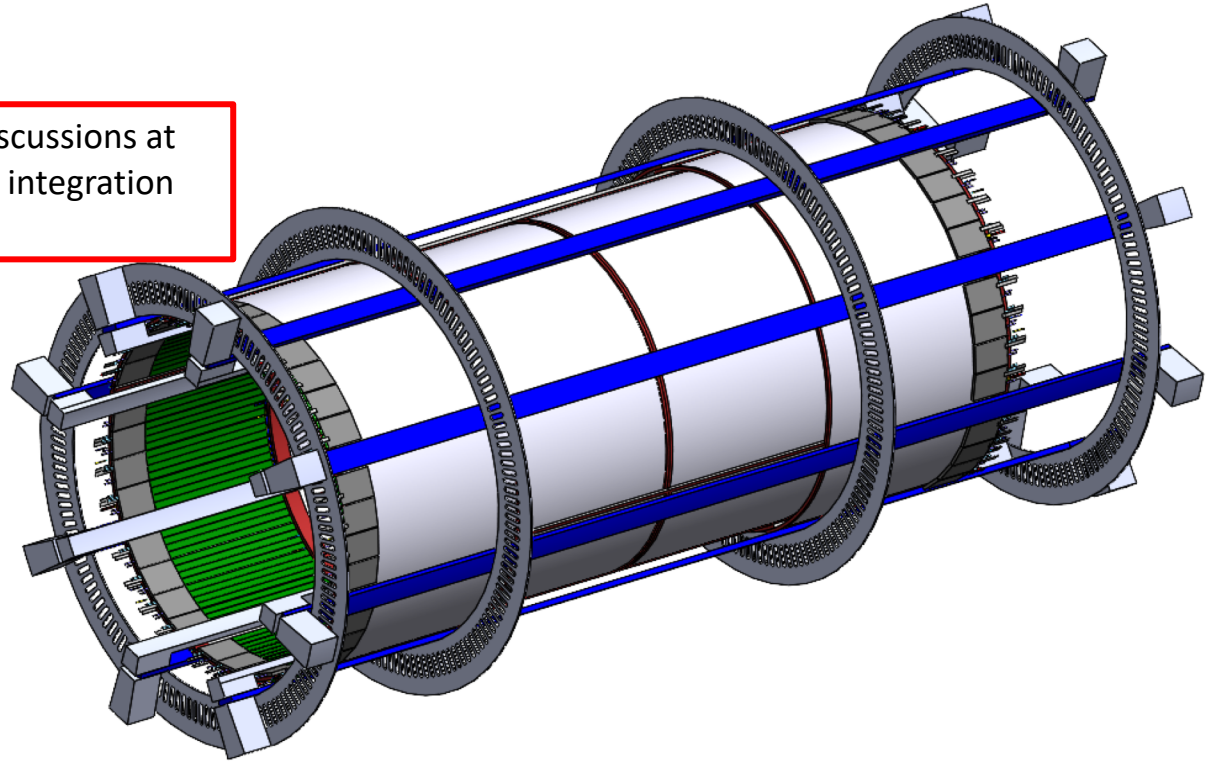
1st sub-assembly for inner detectors

3. Install inner tracks/beams per half/side to support SVT once MPGD integration is completed
   - **Total of 2 beams**/rails support SVT
   - Again L-brackets / standoff's
   - Supports a "Service Cylinder" for SVT barrel, discs and MPGD



→ Following discussions at the 20th ad-hoc integration workshop

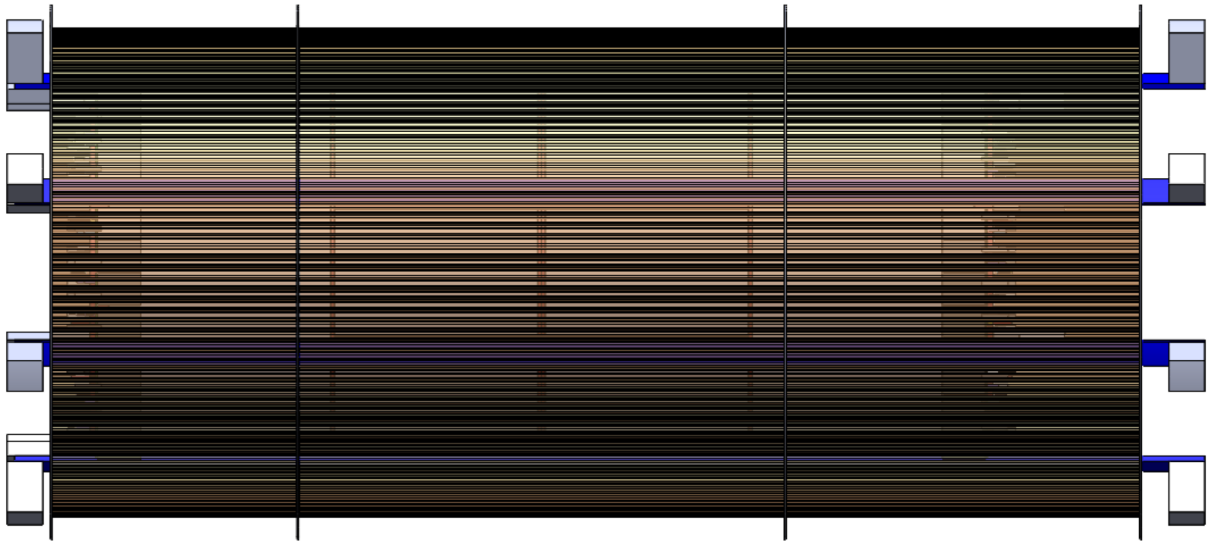
4. Final step is to slide this "integrated" structure over the inner SVT
5. SVT includes the beam pipe which needs temporary support



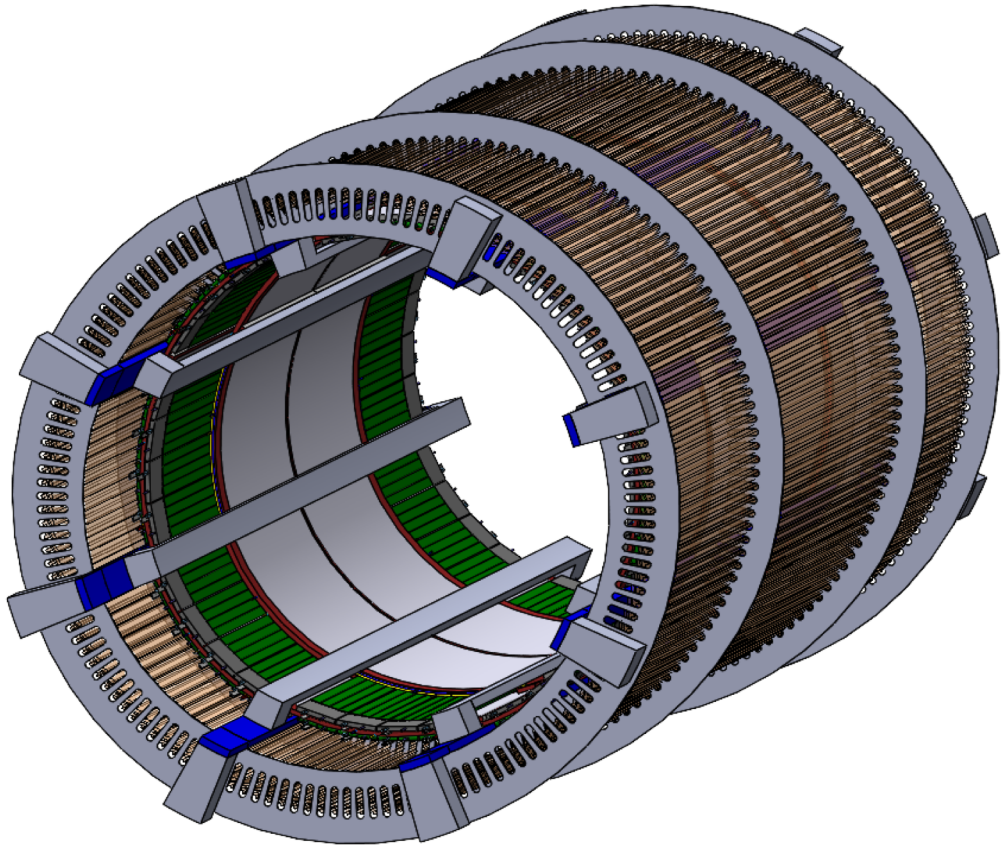
1st sub-assembly for inner detectors

3. LGAD is last in sequence prior to install whole inner detectors into EPIC

- Choice: prior to sliding over SVT sub- assembly or at the very end prior to inserting into EPIC
- temporary supports for services & integration



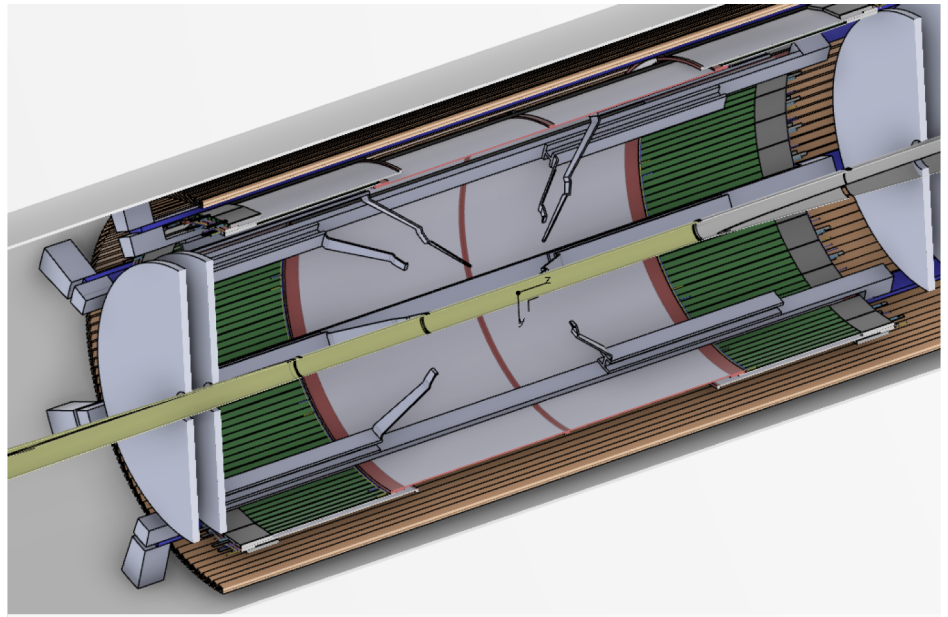
- TOF LGAD mounted on L-brackets or lips on engagement rings

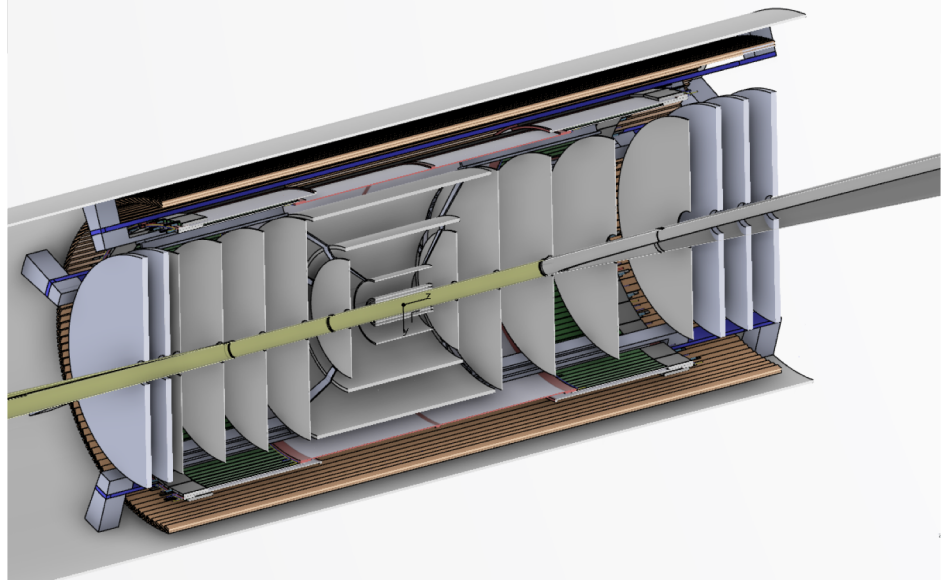


2nd sub-assembly for inner detectors

3. SVT
   - Introduce (half) - “Service Cylinders” (SC) to integrate SVT into 2nd sub-assembly
   - Based on Feb 20th outcomes and drawings not updated yet, shown here is more of a rib-cage and spider structure
     - Translates to SVT being consisting of more sub-parts, not ideal for integration of multiple projects
     - SC approach is more of all of SVT being supported, full circle and what I had proposed last year summer ☺.
   - Also based on discussion with Ernst, Laura, Georg at ANL meeting

- Beampipe and SVT Inner Barrel/pixel first into 1st half SC
- Integrate SVT Outer Barrel first, cable and service routing outward in designated ”arc-sectors”
- Add SVT-discs starting closest from IP, move outwards and cable and service routing in ”arc-sectors”
- Temporary supports for beam pipe and services
- Slide 2nd sub-assembly over this one and install MPGD discs, than integrate into EPIC / GST



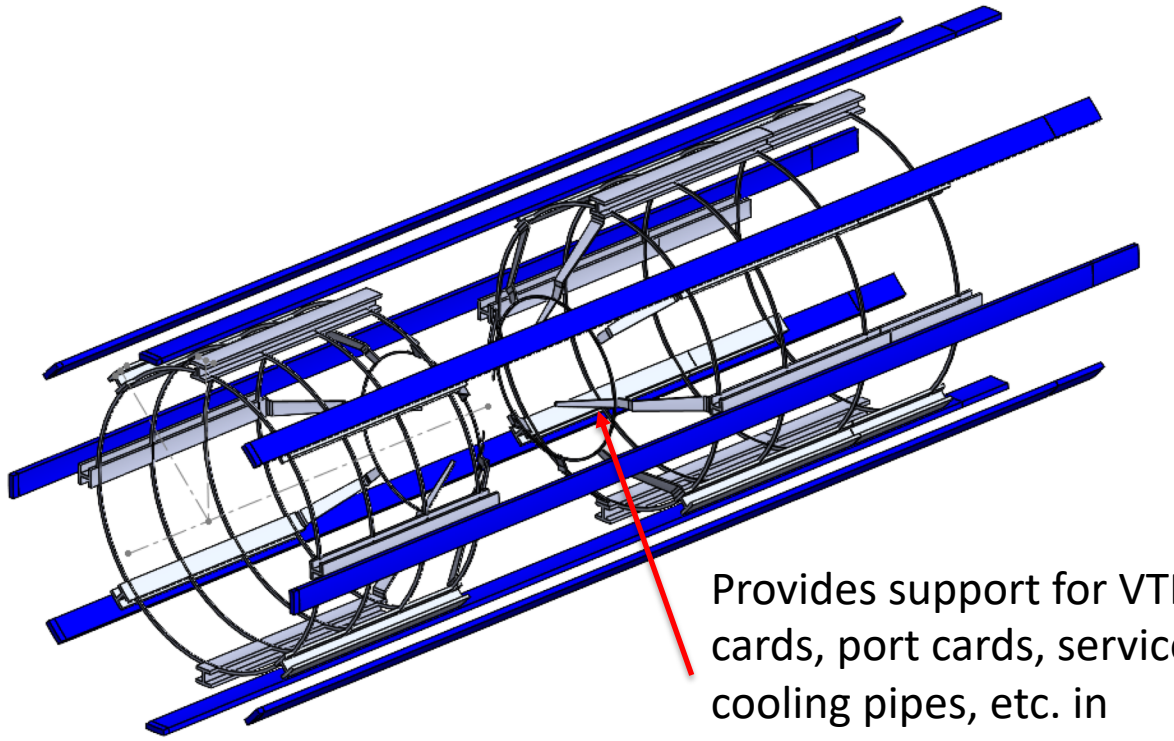


2nd sub-assembly for inner detector region

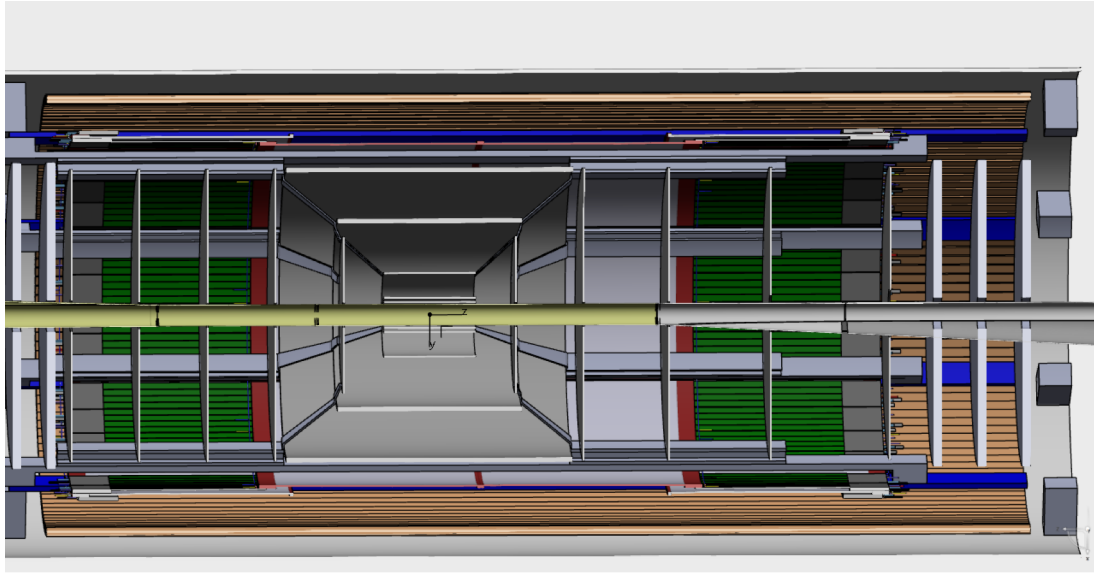
3. SVT support by system of rips and rings to form a cage like structure

– “Spider” structure to connect to local mechanics of SVT OB+IB, discs

→ Following discussions at the 20th ad-hoc integration workshop
→ Outdated for SVT!
→ Change to half - “Service Cylinder” based 2nd sub-assembly

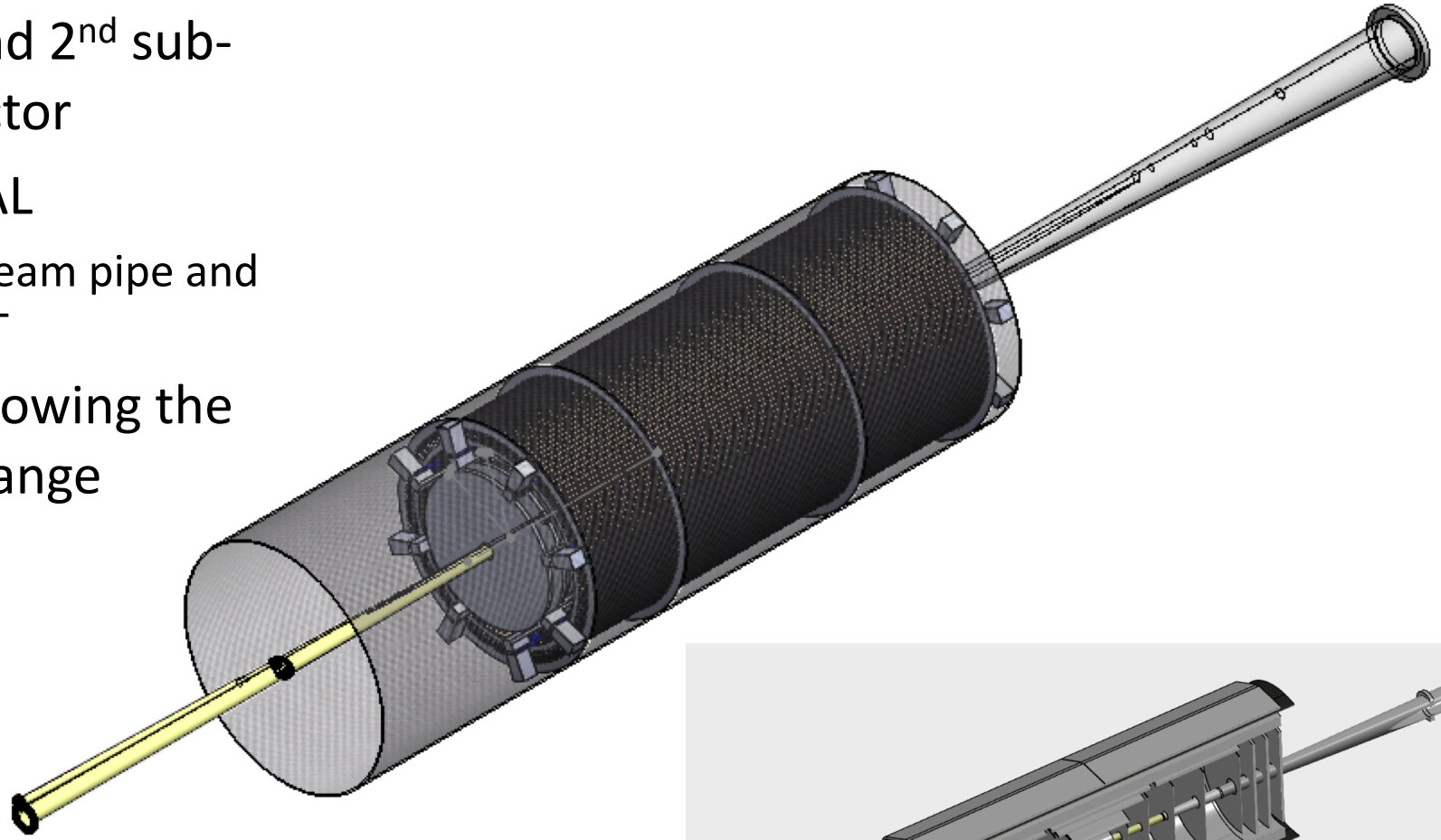


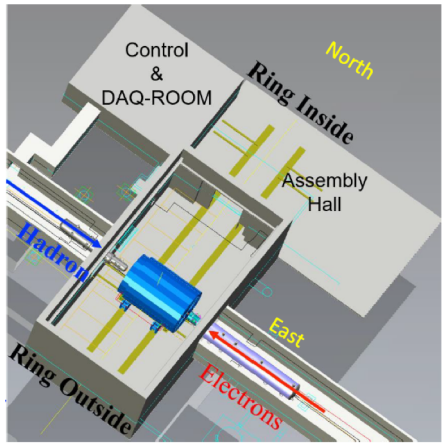
Provides support for VTRx cards, port cards, services, cooling pipes, etc. in shape of angled “wheels”

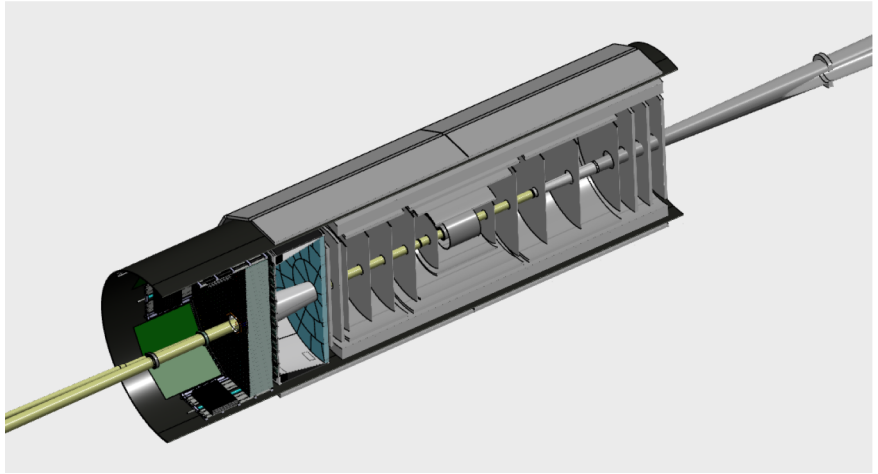


Last integration step of inner detector into EPIC

- Integrate the combined 1st and 2nd sub-assemblies of the inner detector
- Followed by pfRICH, than ECAL
  - needs temporary support for beam pipe and installation jigs to slide into GST
- Currently being discussed following the 20th workshop…subject to change
  - Role and “strength” of GST
- All @Assembly hall







Discussion / Next steps – developing…

- Minutes of 20th workshop under discussion
- To make progress towards realistic design of a support system for the inner detectors, we need:
  - Better understanding of envelopes and agreement to provide numbers/space (semi-realistic to get started), goes both ways: also supports need space and cannot violate defined envelopes
  - Heat/Power loads needed to mitigate:
    - Clear focus area: Need estimates by Silicon, MPGDs, and TOF-LGADs
    - Holistic approach can safe mass for each one instead of all individually "services"
    - Move service outward in r-phi as much as possible: use "stand-offs" at perimeter of discs when possible
  - Temperature stability (EMCAL) also is a point and may need "thin shielding", separation of envelope's ?
- These need to get to a rough +-25% number ideally or +-50% even so that more robust global mechanics and interface design can continue / start
  - Purdue team working with EPIC team and subdetectors to update the presented "rough design"
  - Hope to make more rapid progress towards a support system with envelops

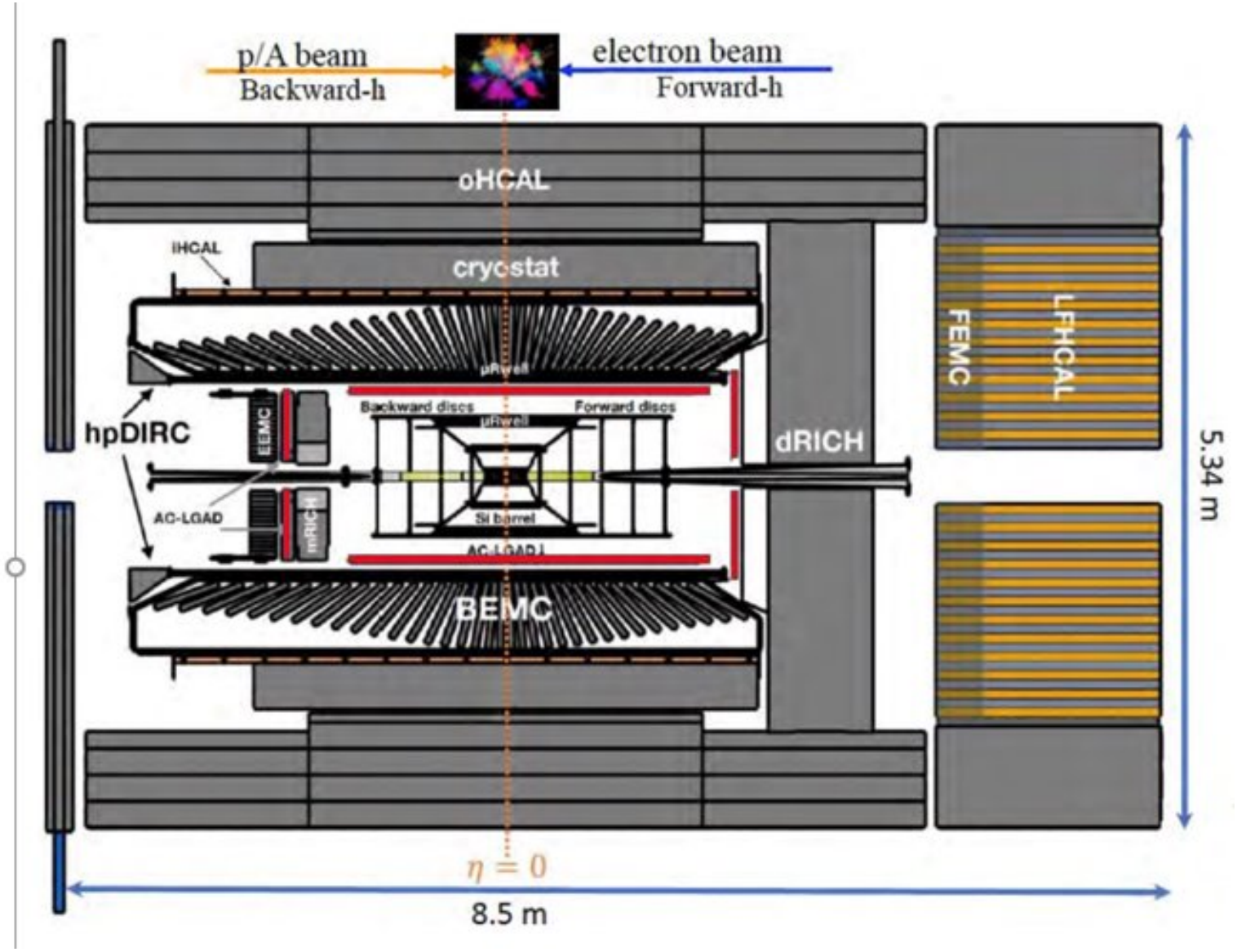
Advertisement

EPIC specific Mechanics workshop at Purdue

- Aimed specifically at Mechanics, global and subdetector level – not just SVT
- https://indico.cern.ch/event/1336746/page/32301-satellite-events
- Discussed with engineering team (Rahul et al.)
- Potential topics
  - pfRICH, TOF LGAD and SVT, others subdetectors too
  - Global mechanics
  - Integration & Assembly
  - Service & Mass optimization
  - Envision 1 days ahead of the FTDM
  - Project aspects / TDR etc.
- Ahead of the forum for tracking detectors, Tuesday 28th May: https://indico.cern.ch/e/ftdm24
- Informal announcement, official soon

Backup

Discussion


p/A beam
Backward-h
electron beam
Forward-h
oHCAL
cryostat
IHCAL
μRwell
Backward discs
Forward discs
μRwell
hpDIRC
EEMC
AC-LGAD
mRICH
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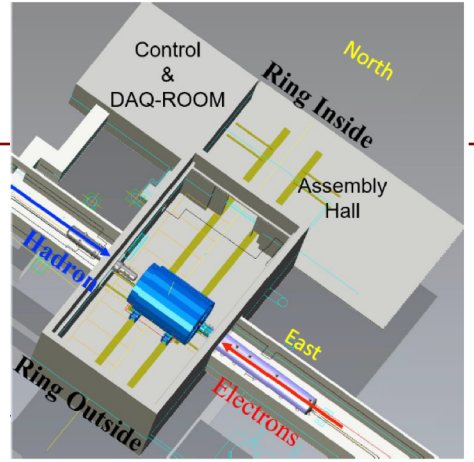
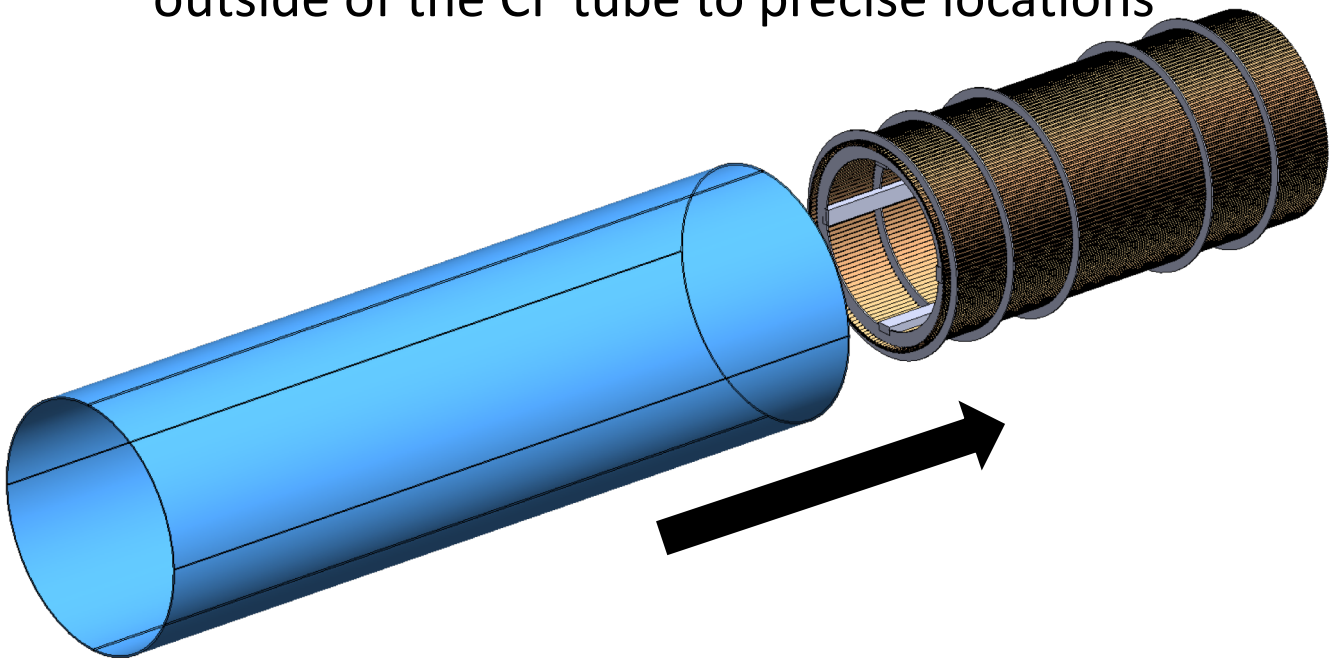
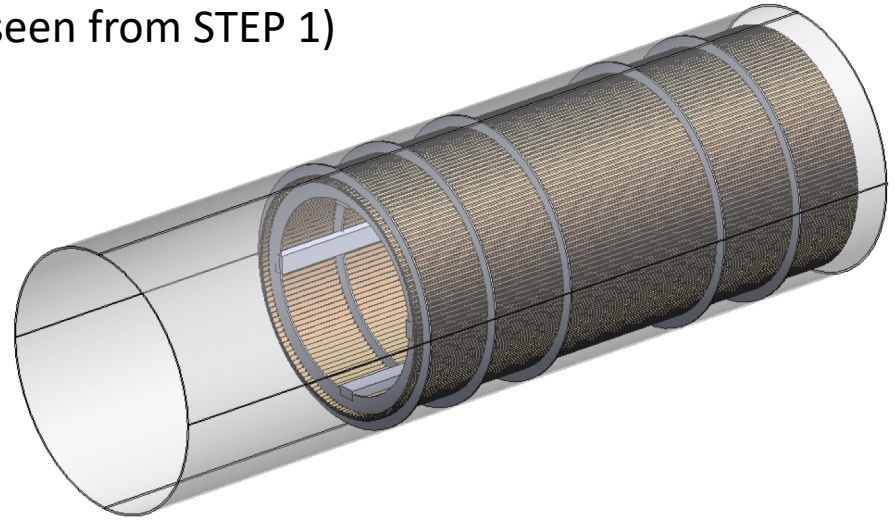
Integration sequence



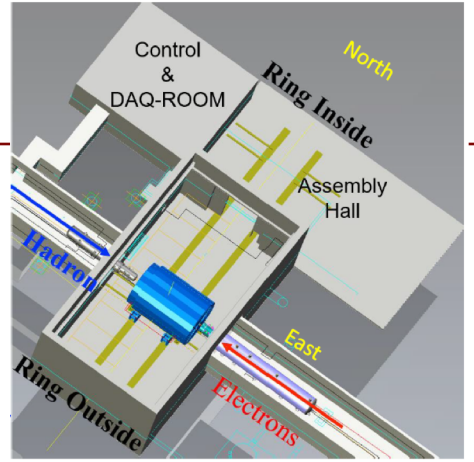
3. Slide in the CF support tube using temporary rails and other supports that can be removed later.
   - Installation "jig" and support for this task
4. Detailed FEA currently in process which may reveal adding "low-mass beams" connecting engagement rings
5. Fasten the engagement rings in place from outside of the CF tube to precise locations



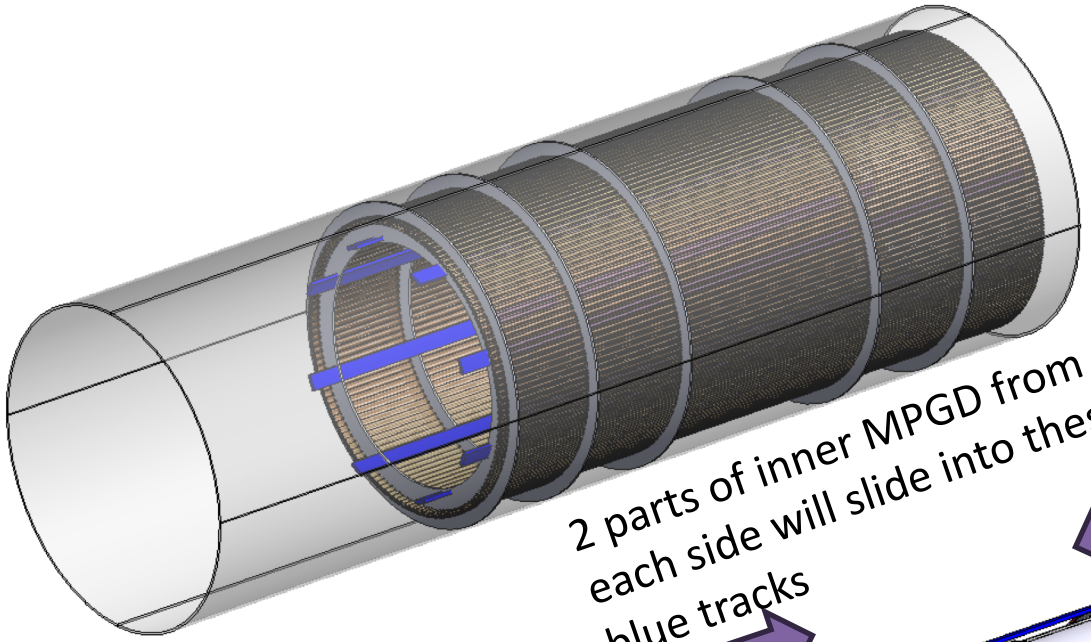
- Through-holes / threaded inserts allow to mount engagement rings
- Likely want to "de-couple" as much as possible
- Fasten the engagement rings and remove temporary inner supports (as seen from STEP 1)



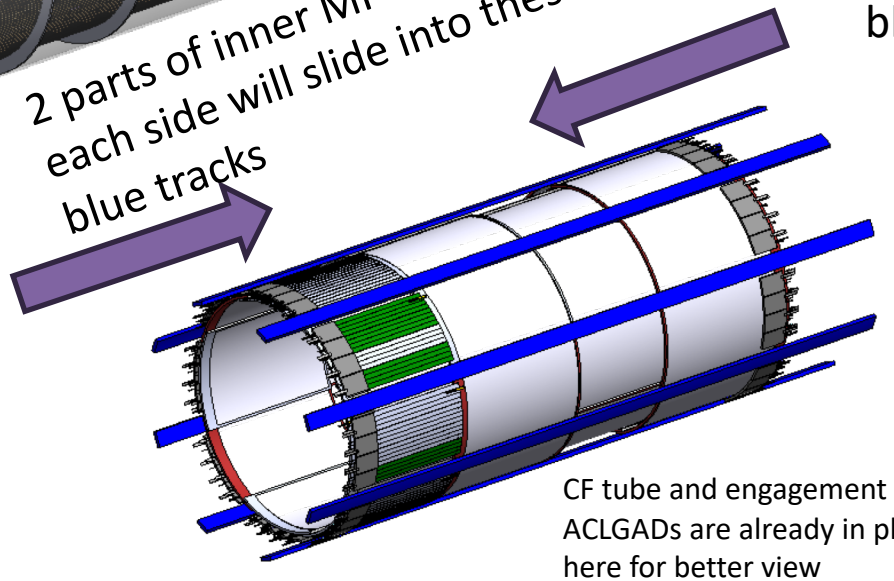
Integration sequence



5. Mount the blue inner MPGD supports on the engagement rings



2 parts of inner MPGD from each side will slide into these blue tracks



The MPGDs interface with the red supports from MPGD design onto this blue tracks that are load bearing

Temporary extension to blue tracks will be built to get those lengths all the way outside the CF tube

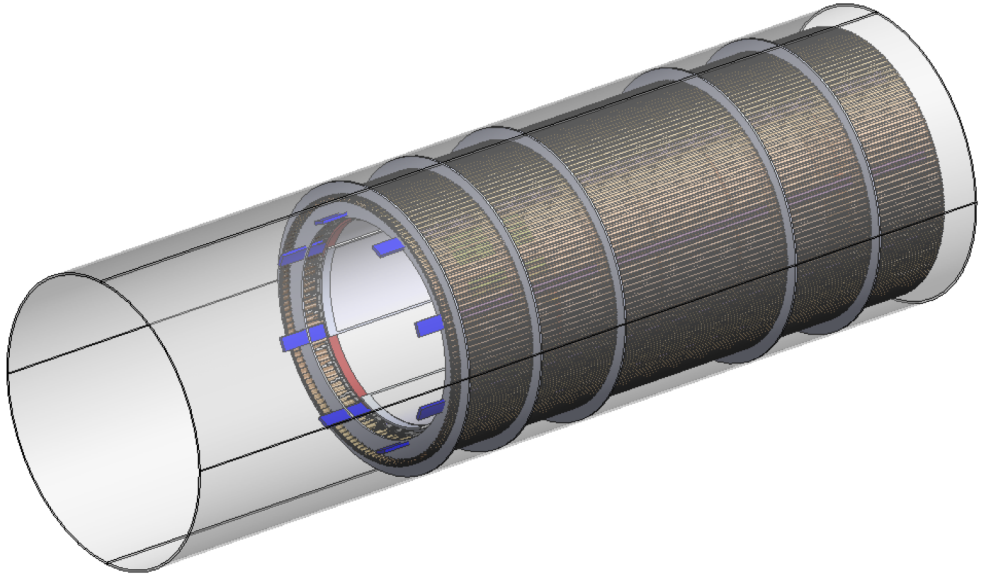
Note – this is barrelv4 – we are in the process of updating the CAD to barrelv3 – insertion concept will remain same

CF tube and engagement rings and ACLGADs are already in place – hidden here for better view

Integration sequence

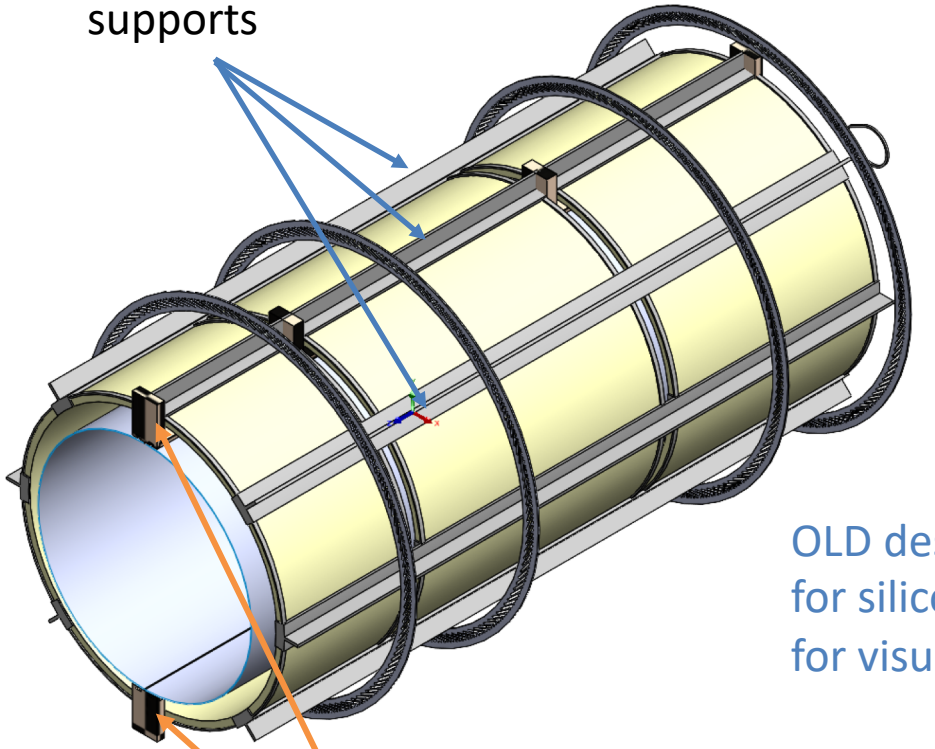
6. Wire up the inner MPGDs on electron and hadron side

- Temporary service supports might be needed



7. The rails and support structure for vertex comes next

MPGD tray supports that connect to the engagement rings and “red” MPGD supports



OLD design of the rails for silicon tracker – just for visualization

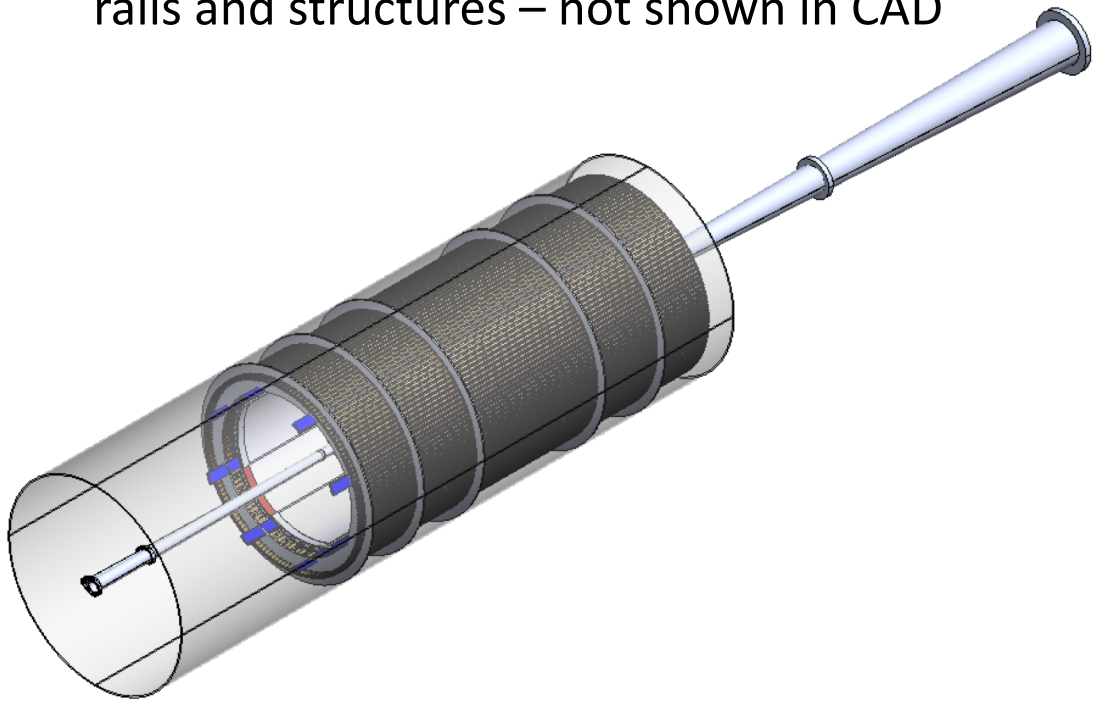
Silicon tracker can be mounted on rails to de-couple it from the MPGD support structure

Integration sequence

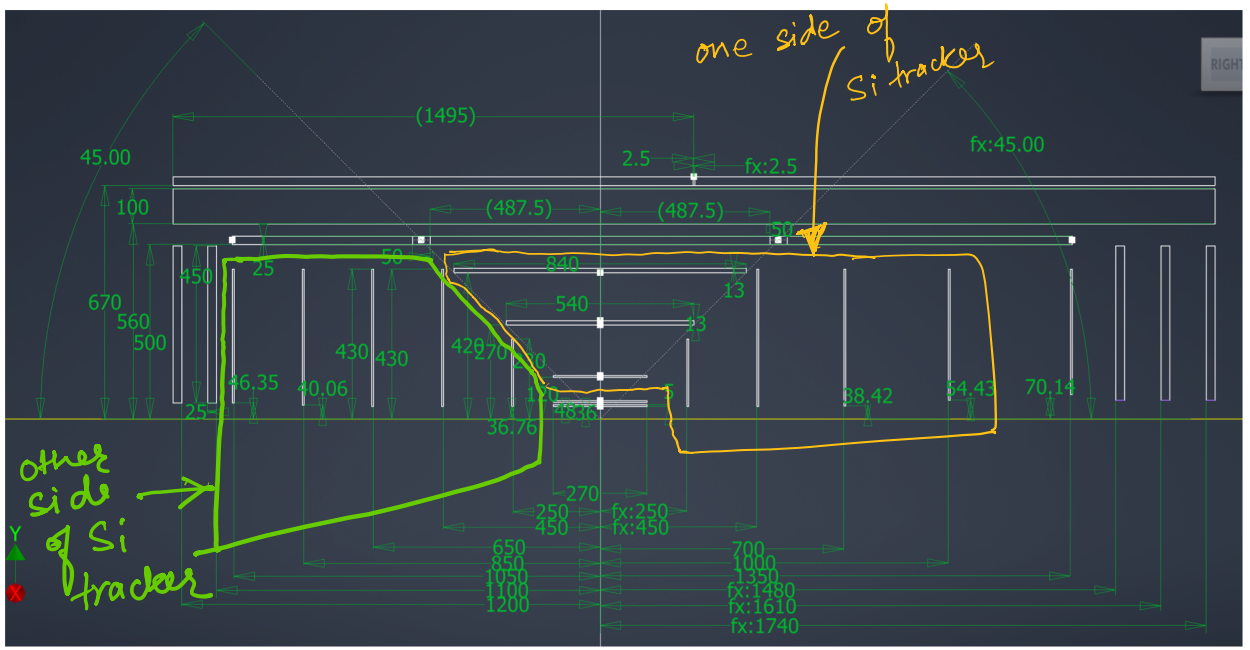
8. Beam pipe comes in next before the silicon tracker so that there is still enough room for bake out and other beam pipe installation sequence.

Caveat: **Requires full half hemispheres of SVT**

BEAM pipe is after the silicon tracker support rails and structures – not shown in CAD

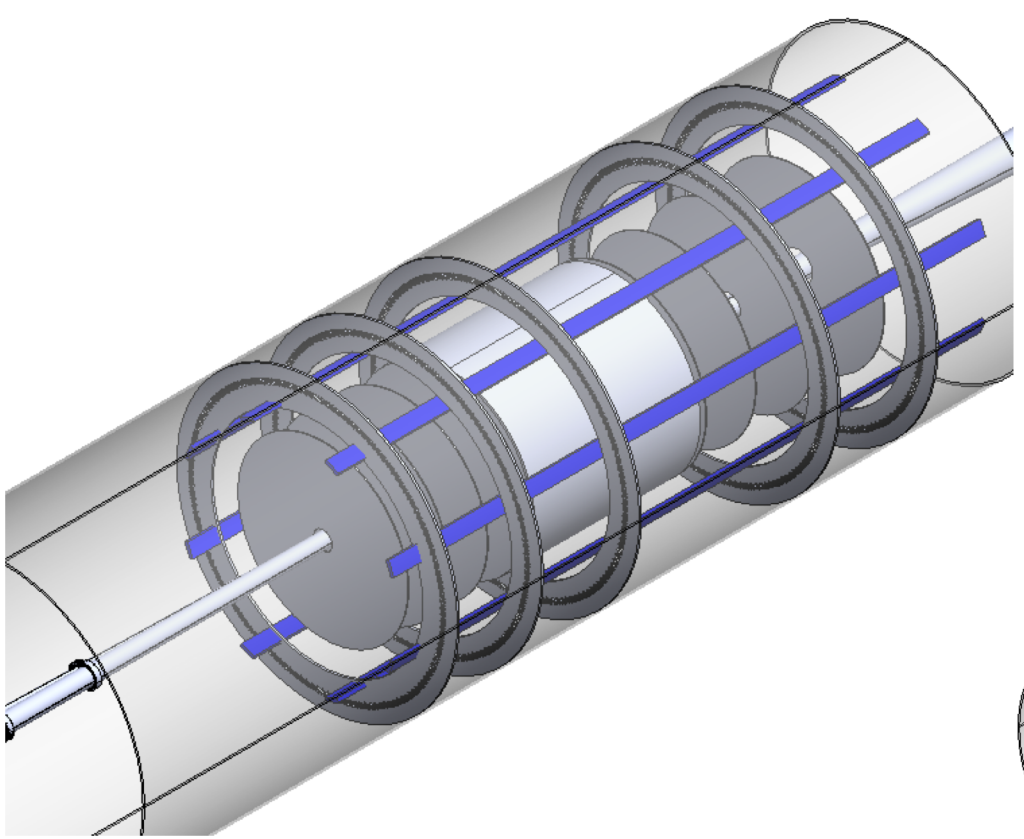


9. Inner silicon detectors are then slid on these rails from electron and hadron side – this is NOT symmetric – the structures will be split such that the changing diameter of the pipes is taken into account. A schematic is below.



Integration sequence

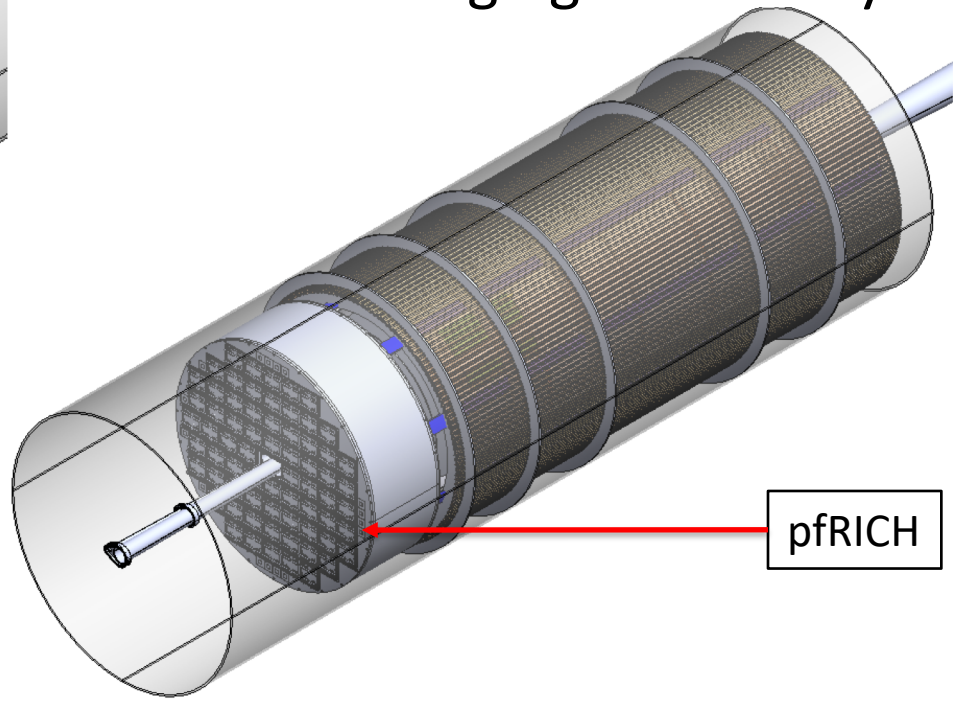
10. The outer discs of MPGDs come in next



11. All the services and wiring is pulled out till the ends of CF tubes

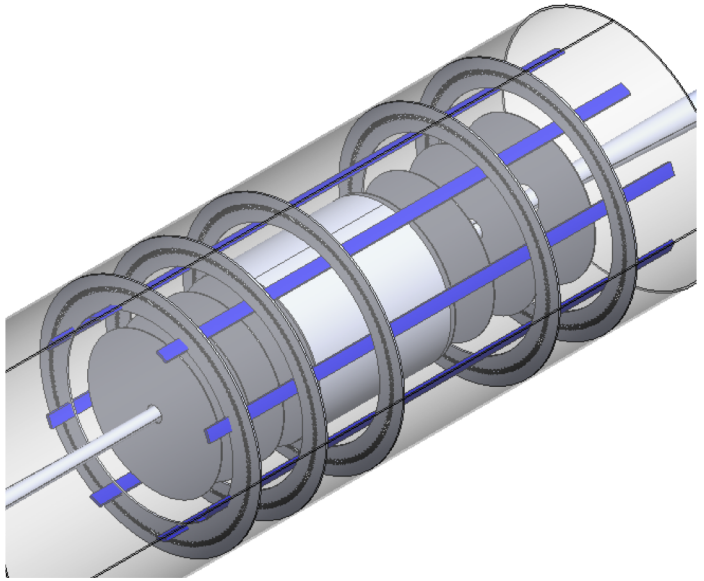
12. pfRICH and EMCAL in installed in the CF tube

- Needs “blocks” & brackets to avoid damaging the GST by EMCAL



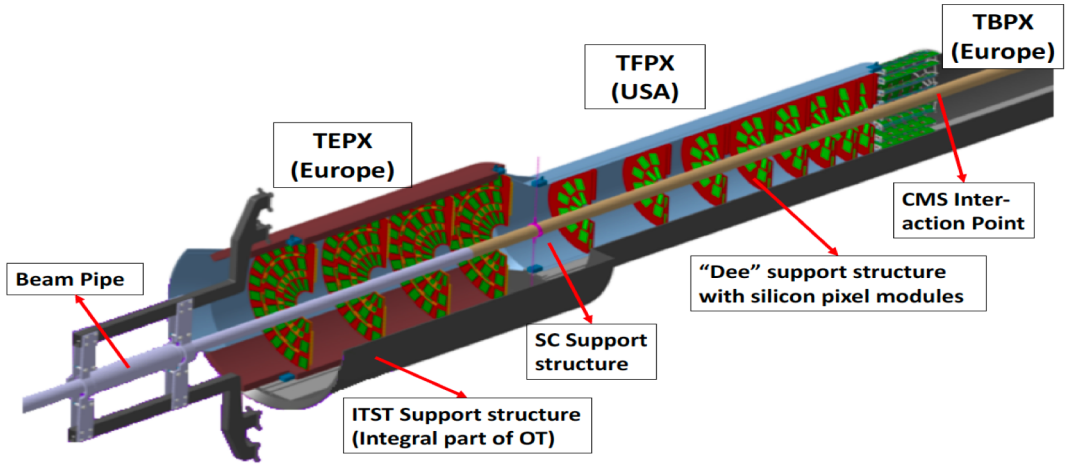
Next steps towards supports for SVT

- TOF supporting by engagement rings and GIST
- Work starts now to investigate if and how the currently devised TOF AC-LGAD support can work in SVT context
- Next steps: get ALICE ITS3 CADs and see how to integrate / support SVT via TOF

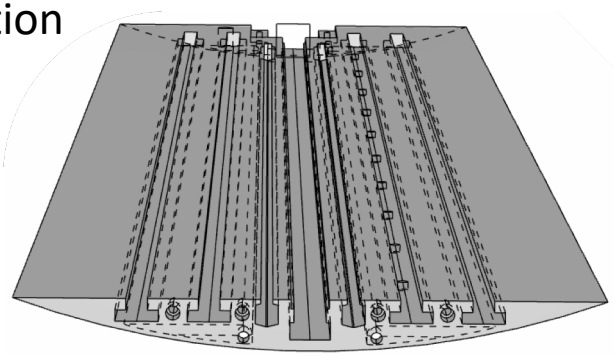


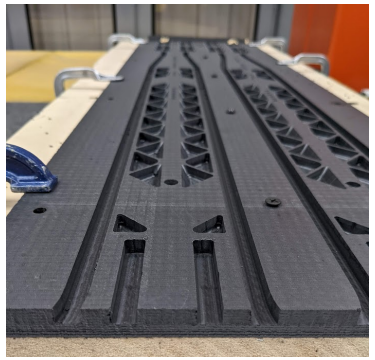
Supporting & Integration of SVT

- Design concept is to insert “half SVT” at a time
  - Requires reasonably rigid structure, at least temporarily supported with external structures

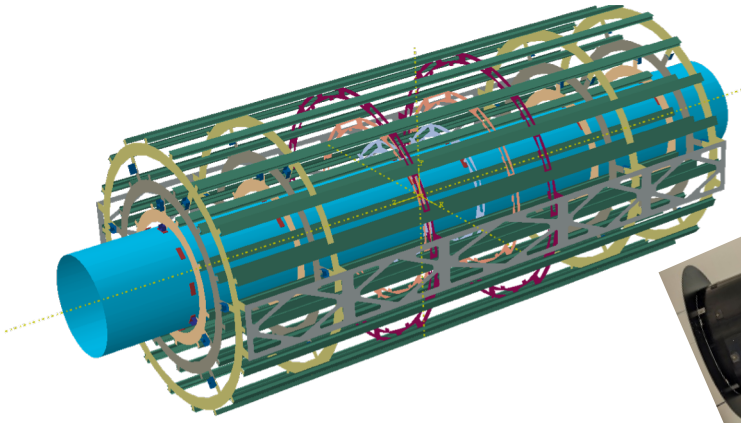


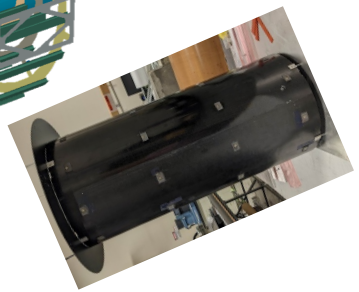
- Example “track” from CMS for SC support and insertion, incl. dry-gas injection



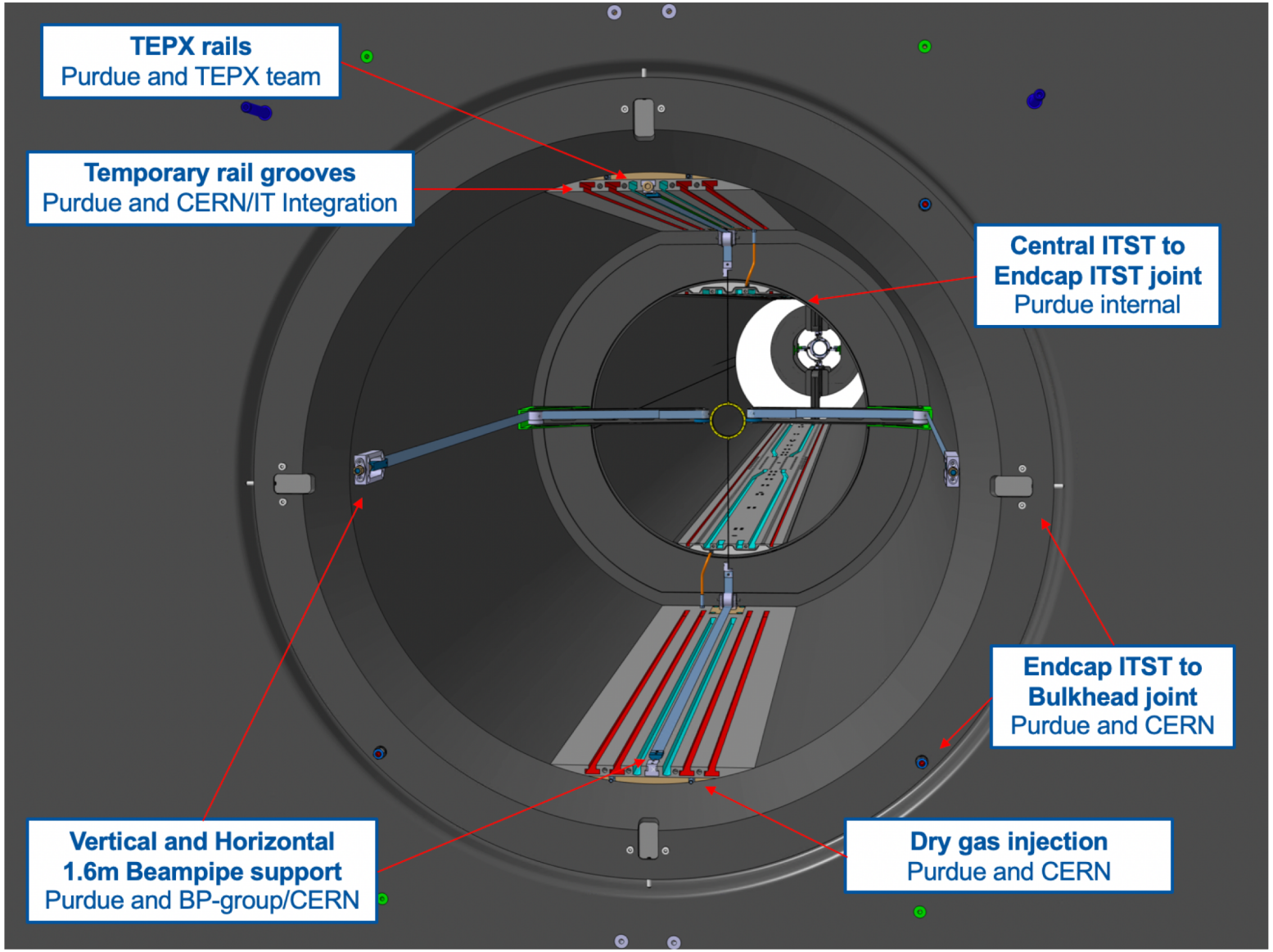


- Example from CMS, which is “inverted”
- The GST is outermost and engagement rings go inside with support rods as needed to provide enough support
- Low mass “tracks” to allow integration of SVT half-dectectors
- Reduces number of cylinders to 1 global (GST), none inside and no real half-cylinders either (if needed low mass, aka w lots of holes)



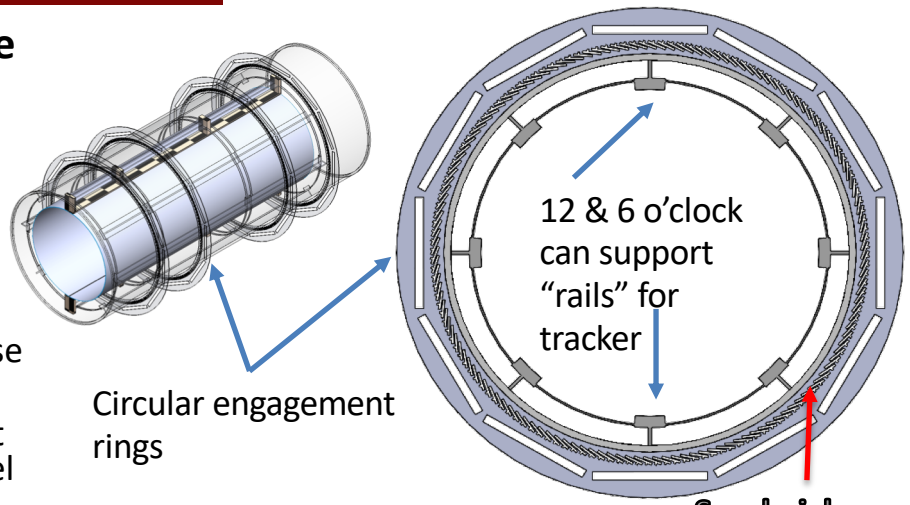


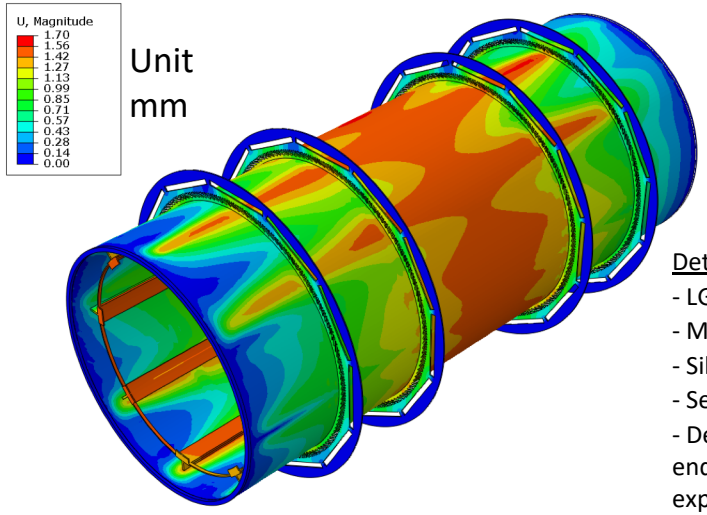
Example: IT pixel supports in CMS



Support structure for barrel TOF

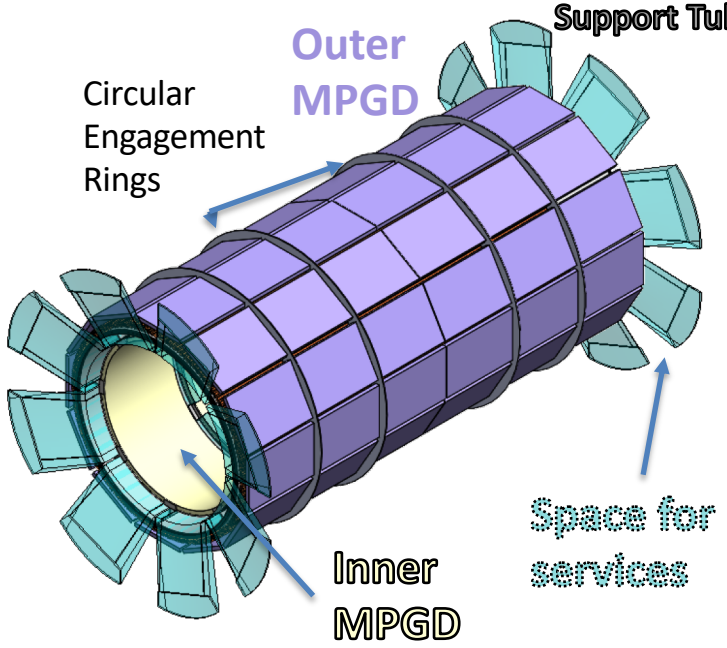
- **Concept idea of joined mechanics structure for barrel TOF, inner & outer MPGD layers, services, and even tracker**
  - 1+8+1 mm sandwich composite structure w “end-rings” to support beam pipe during installation & integration
- Integration
  - Move/Place end cap TOF closer to dRICH to ease access 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!





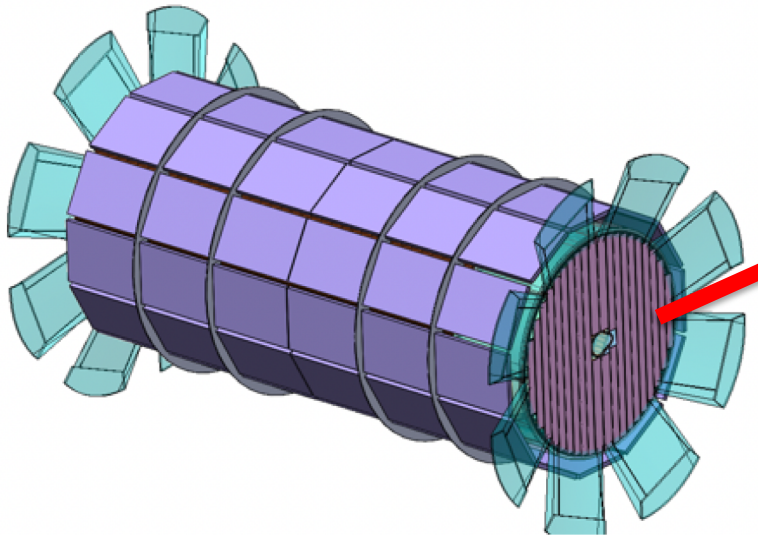
Unit mm

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

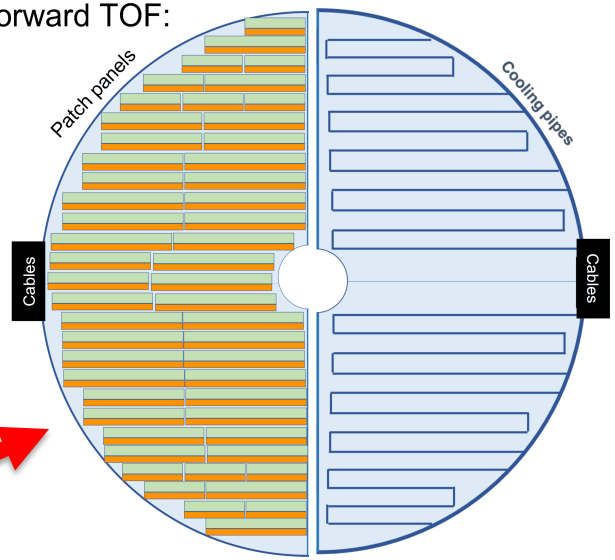


Endcap TOF

- 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



Forward TOF:



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