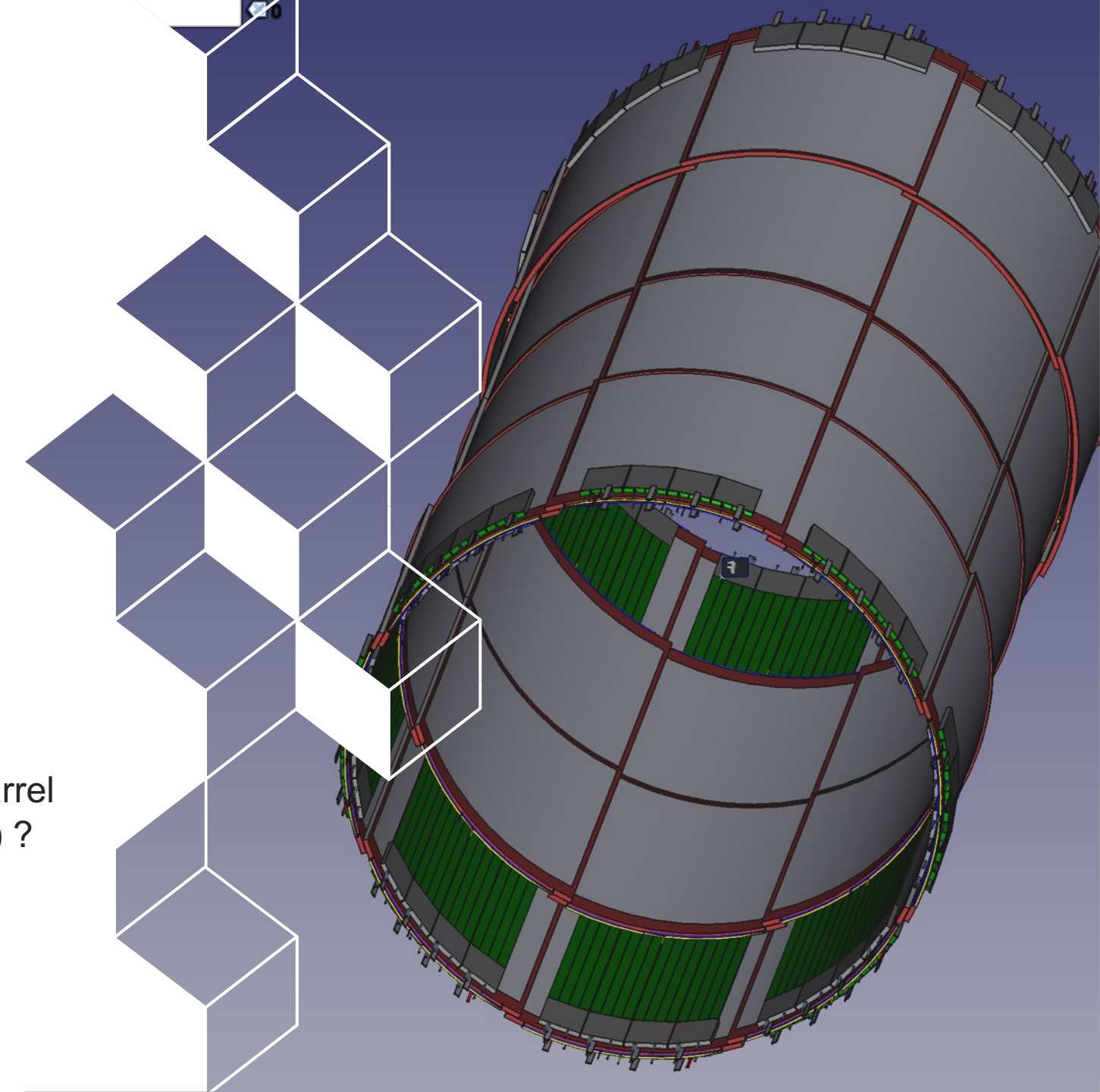
Inner MPGD CyMBaL

Alain Delbart, for the CEA/Saclay IRFU team

- A CyMBaL « resistive micromegas » tile
- The current baseline design of the CyMBaL barrel
- How to fit & fix it in EPIC - GST (towards PDR) ?
- Front-End Elecxtronics cards (FEB) cooling
- Services / cabling
- Summary of open questions to discuss

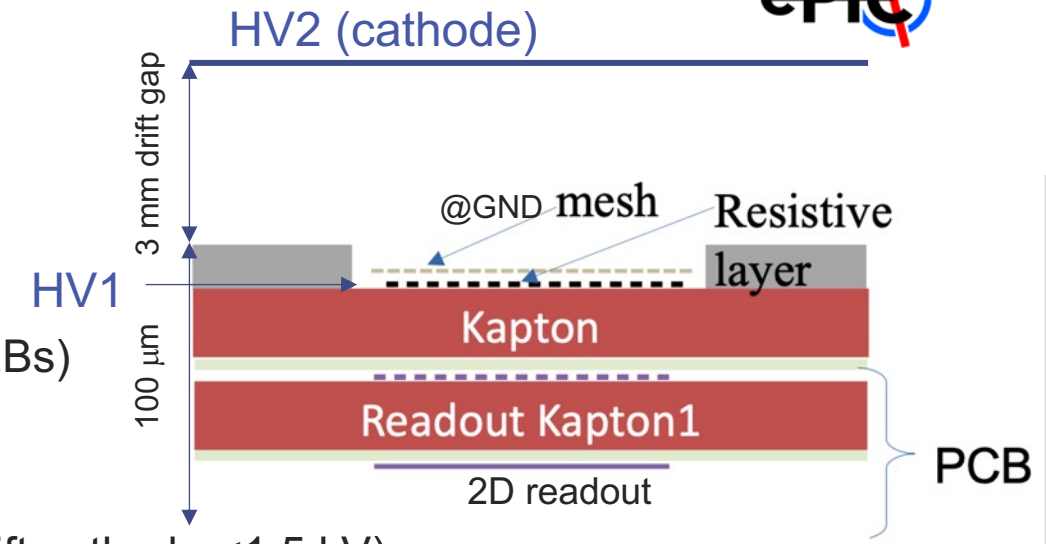
EIC/EPIC 3I GST workshop, 24 march 2025



The CyMBaL « resistive micromegas » module

Components

- Copper etched strips on Kapton (&/or FR4) (thick 250-300 μm)
- 316L ~30 microns thick Mesh electrode
- Kapton + Cu drift cathode
- 2-3 Aluminum or Carbon Fiber hoops and 2 longerons
- Connectors : HV, flat micro-coax cables to the Front-End Boards (FEBs)



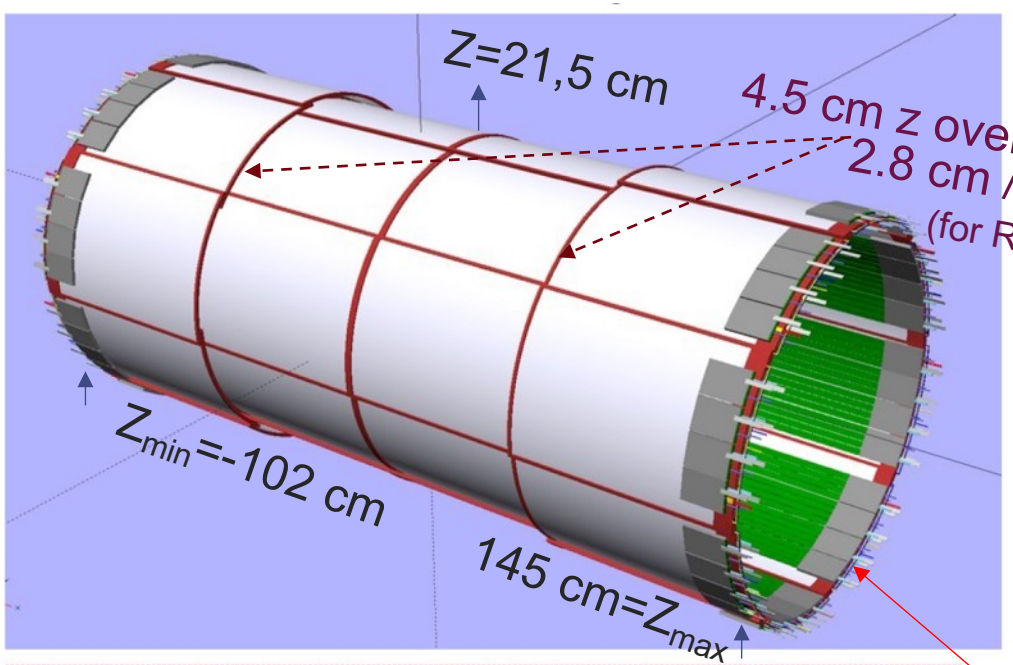
Services (readout electronics not included)

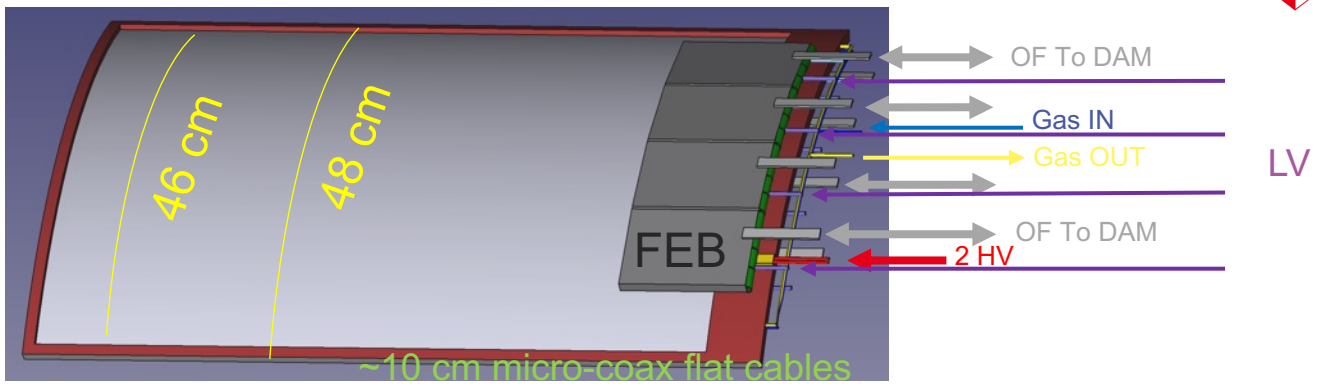
- 2xHV lines : 1 for the resistive anode (<500V), the other for the e- drift cathode <1.5 kV)
- Gas IN/OUT (through inlets in “external” hoop, barrel tiles probably in series)
- No heat dissipation (nA currents)
- Tile PCB and FEB Grounds connected together and to global grounding

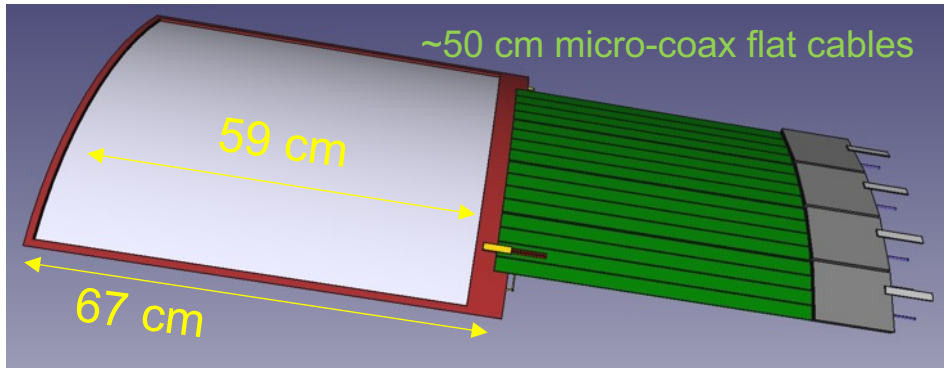
Current status & mid-term plans

- **Flat, small size prototypes to fix the detector 2D readout structure**
  Test beam foreseen week 47-48 @ CERN
- Design & test on dedicated prototypes of the mechanicals (hoops, longerons) needed for 55-60 cm cylindrical shape
- Desing of a scale 1 tile PCB (just started)

The current baseline design of the CyMBaL barrel

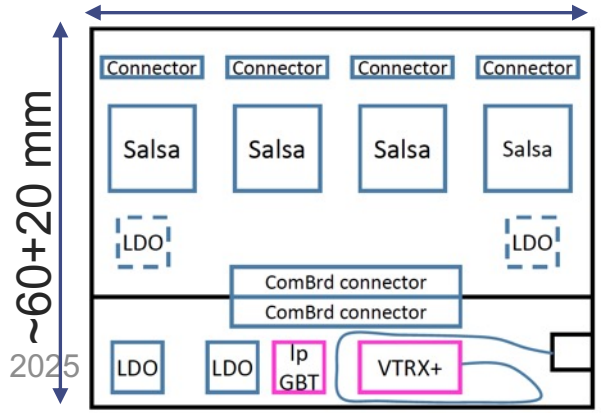






- 32 module: 8 modules in ϕ times 4 modules in z
- Overlaps in ϕ and in z for hermeticity
- 1024 readout channels/module
- 32K readout channels
- 128 FEBs (2x32 on each side - 4/tile)

FEB+cooling plate (15 mm thick ?)



weight estimates

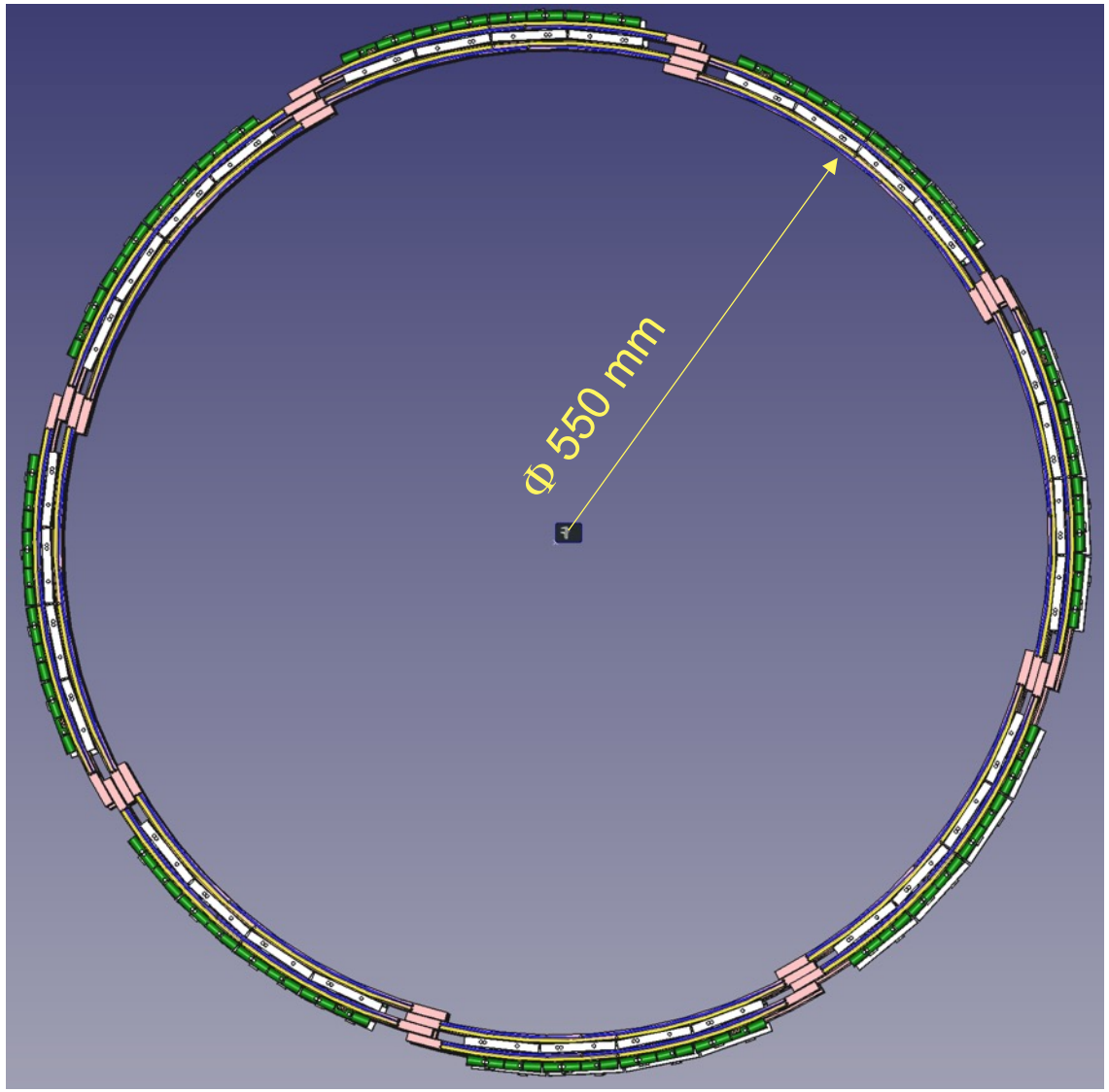
- Raw tile	~1 kg
- FEB PCB	~0.3 kg
- Cooling plate+fluid tube	~0.3 kg

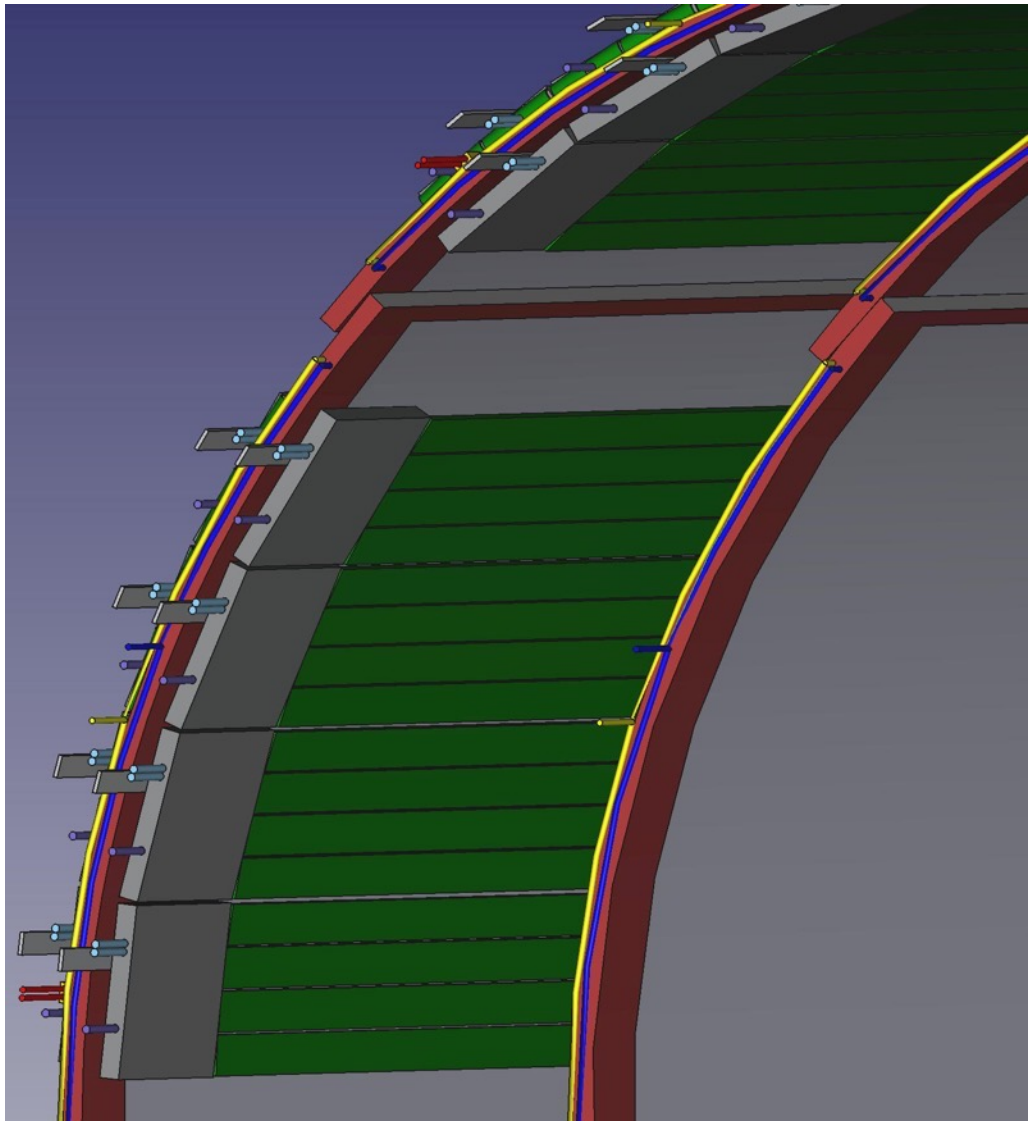
(*rough estimate for 3 mm Al cooling plate + copper tubes, thermal simulations to be done*)

On each side of the barrel	**~40 kg**
Cymbal	**~110 kg**

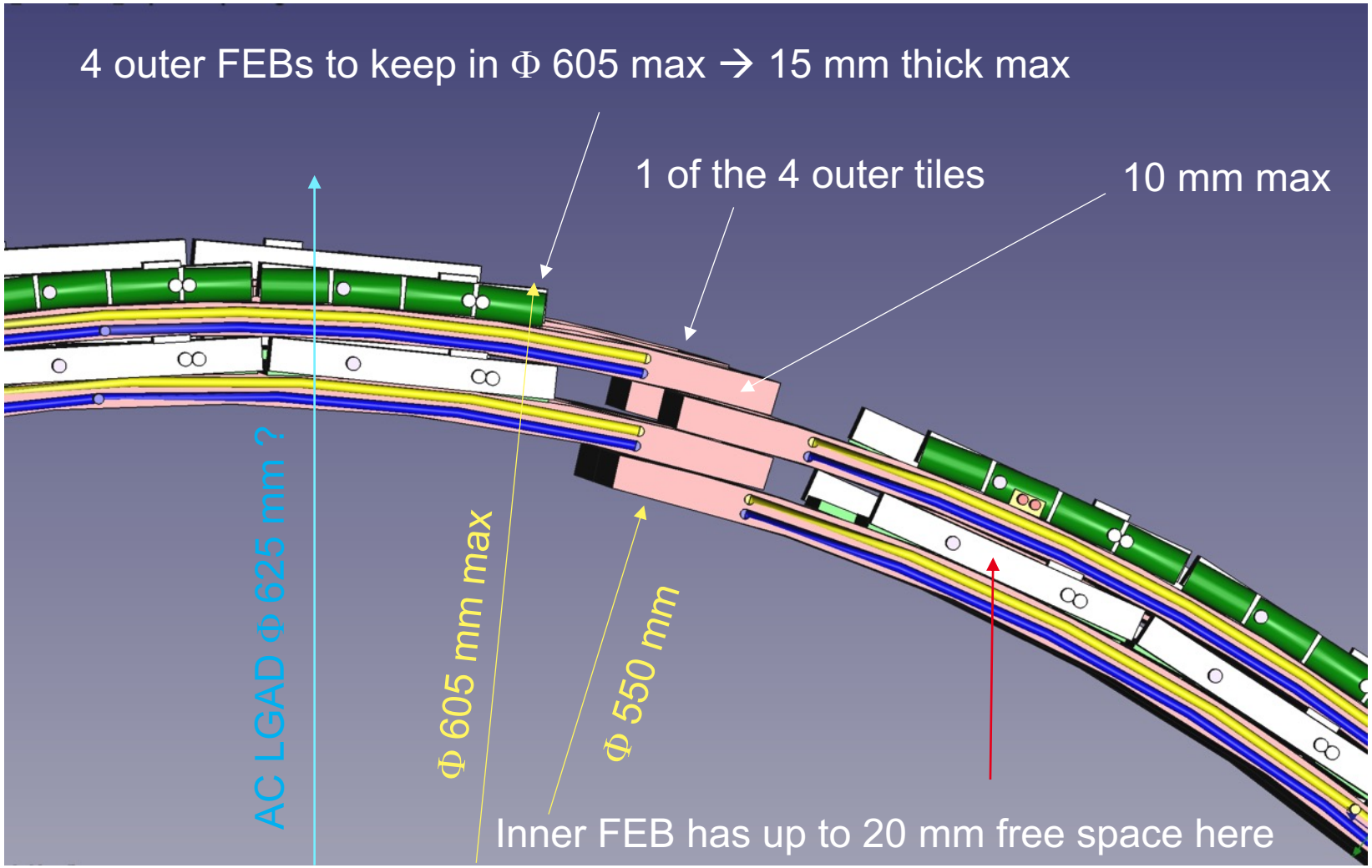
« Outer FEBs » location

On each side of the barrel, room (up to 20 mm) for the 16 FEBs reading « inner » tiles.





FEBs integration in CyMBaL envelop



Current thicknesses assuptions

- Micromegas PCB + drift: ~3.5 mm
- With longerons & Hoops : < 5 mm ?
- **Tile assembly, fixation & cylindrical shape tolerance/ margin : few mm ?**

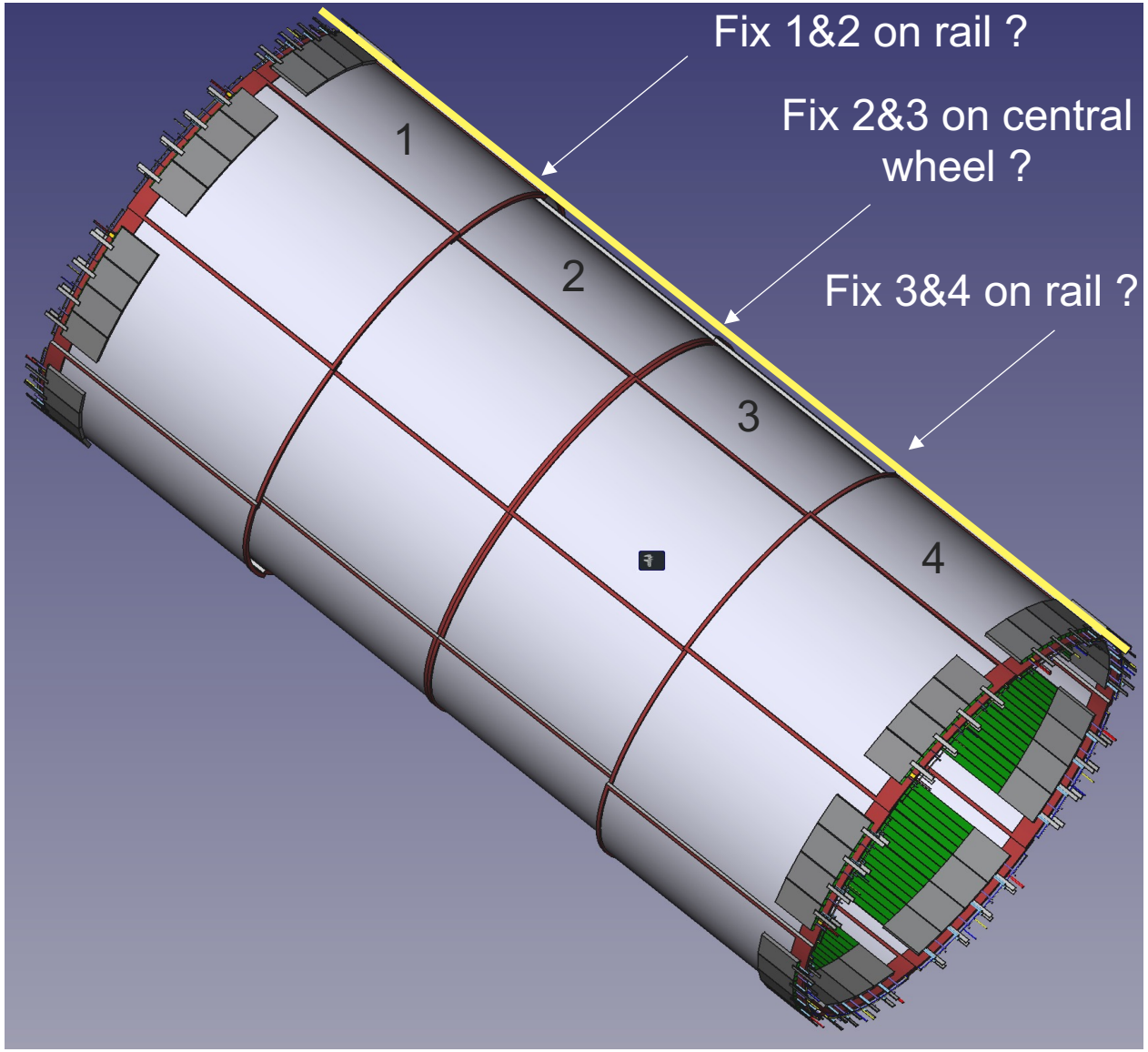
→ 10 mm thick max assumption

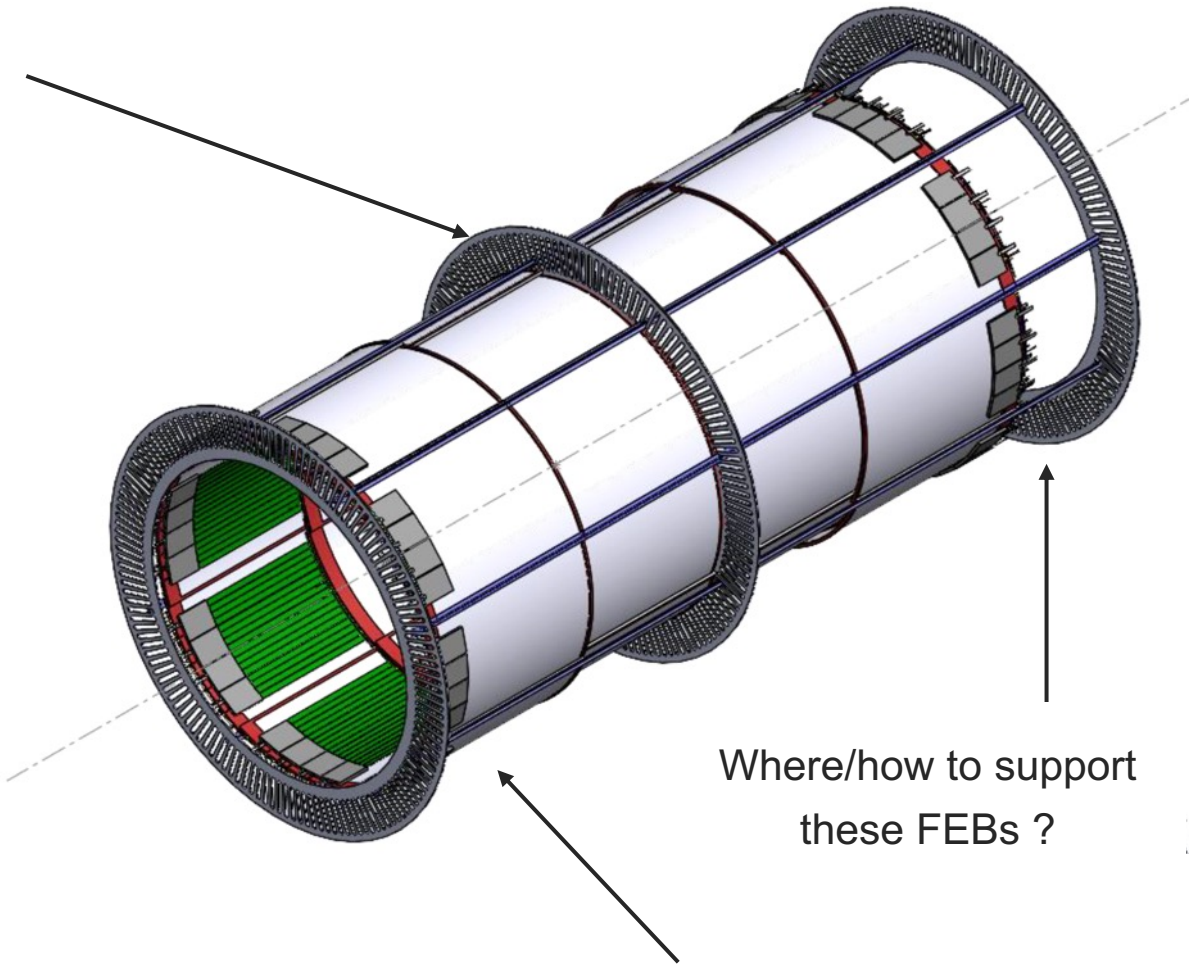
- FEB + cooling plate thickness should be < 15 mm (fixed by “outer FEBs Vs Φ605 mm max)

  → May be difficult (see next slide, depending on thermal simulations)

- Margin from tile thickness <10 mm
- 20 mm clearance before AC LGAD ?

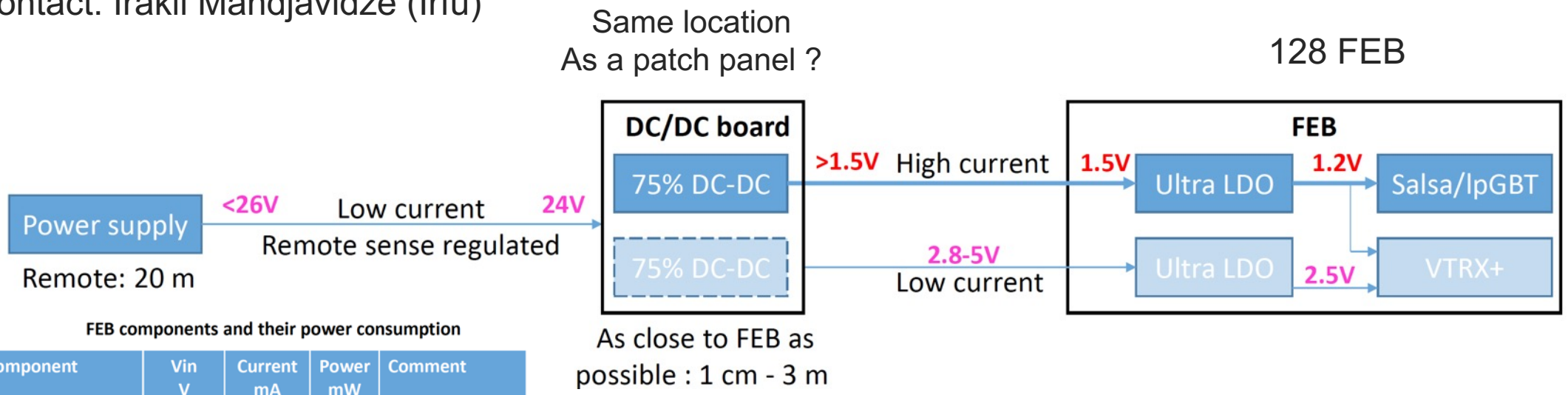
GST Rails & wheels Vs the CyMBaL barrel + FEBs





LV powering the Front-End readout electronics

Contact: Irakli Mandjavidze (Irfu)



FEB components and their power consumption

Component	Vin V	Current mA	Power mW	Comment
Salsa 1	1.2	1 000	1 200	15 mW/ch
Salsa 2				
Salsa 3				
Salsa 4				
lpGBT	1.2	420	500	Overestimated
VTRX+	1.2	20	25	
	2.5	70	175	
LDO Salsa 1-2	1.5	2 000	600	LDO / Salsa to avoid hotspots ?
LDO Salsa 3-4				
LDO lpGBT/VTRX+	1.5	440	130	
LDO VTRX+	2.8	70	20	

Total ~6.8 W (8.5 W with 25% safety margin)

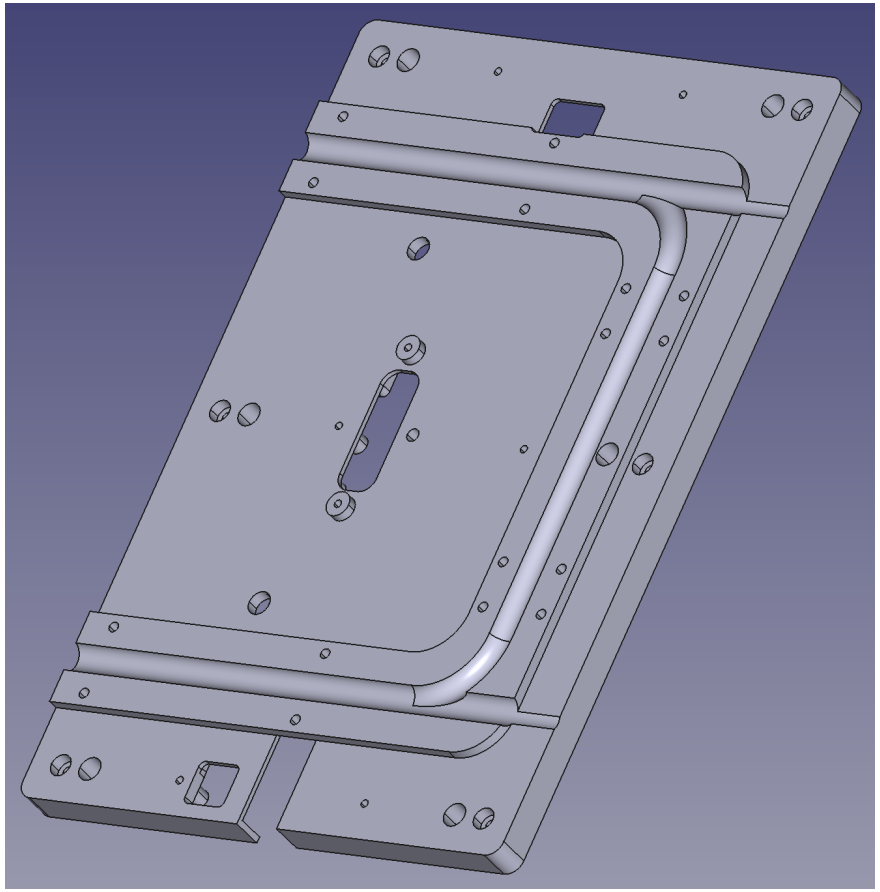
→ CyMBaL Barrel total power of **~1.1 kW** (+ extra from DC/DC)

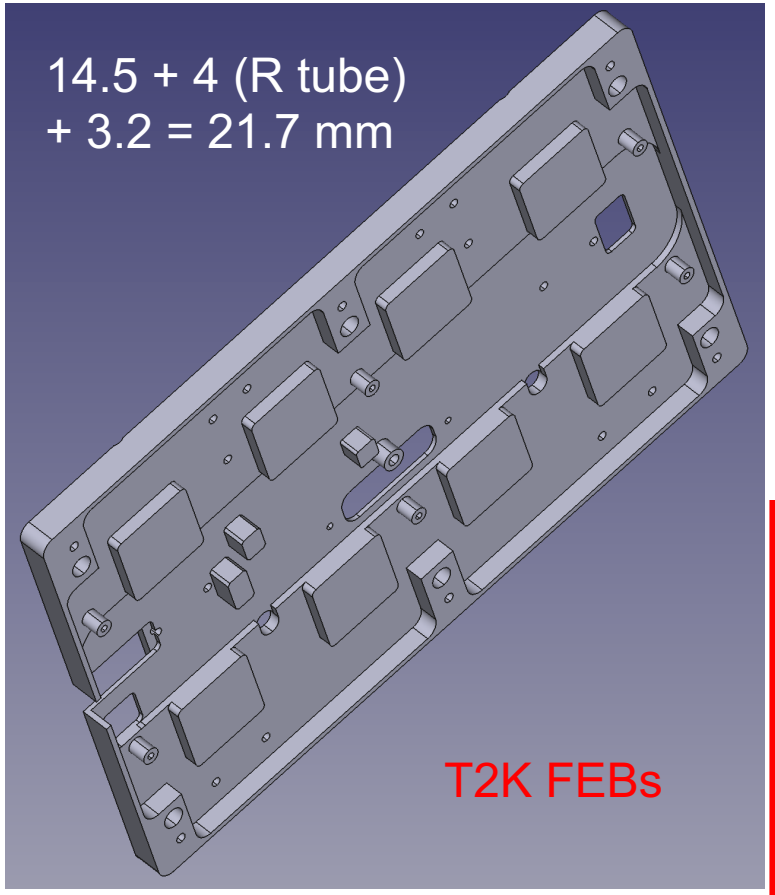
Tim Camarda & Gerard Visser

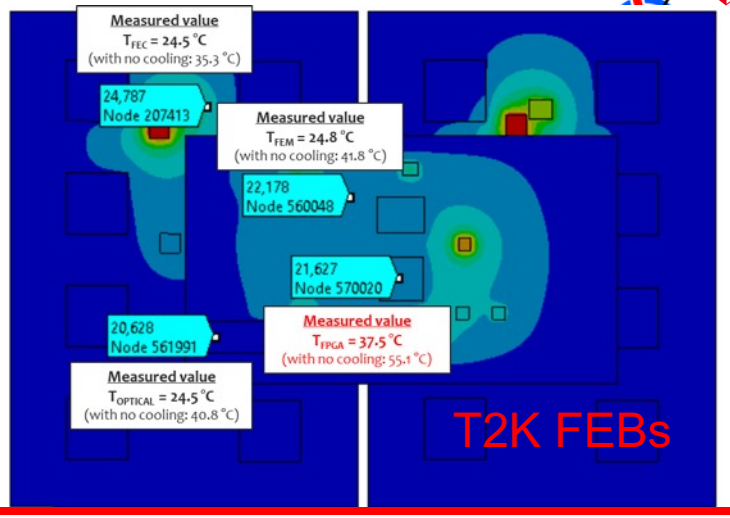
50-70% Power efficiency of DC/DC converters

Circuit	V_{IN}	I_{IN}	Reg	V_{OUT}	I_{OUT}	P_{OUT}	P_{LOSS}	P_{EFF}
SALSA ASIC	3.0	2A	LT3033 (1)	1.2V	2A	2.4W	3.6W	50%
SALSA ASIC	3.0	2A	LT3033 (2)	1.2V	2A	2.4W	3.6W	50%
LpGBT	3.0	700mA	LT3033 (3)	1.2V	700mA	850mW	1.3W	53%
VTRX	3.0	50mA	LT3033 (3)	1.2V	50mA	60mW	90mW	50%
VTRX	3.0	105mA	LT3042 (4)	2.5V	105mA	275mW	60mW	78%
Input Reg	24V	870mA	bPOL48V	3.0V	4.86A	14.6W	4.38W	70%

From T2K/HA-TPC readout FEBs cooling to CyMBaL







- Negative pressure water cooling system
- 7 W/FEB (**8.5 for CyMBaL**), cooled at ~25°C +/- 0.2 °C with ~3 l/minute 18°C water flow in 6 ID/8 OD copper tubes
- Confirmed with complete thermal simulations (heat dissipation, steady state temperatures, pressure drops, water flow, …)

More compact design for CyMBaL

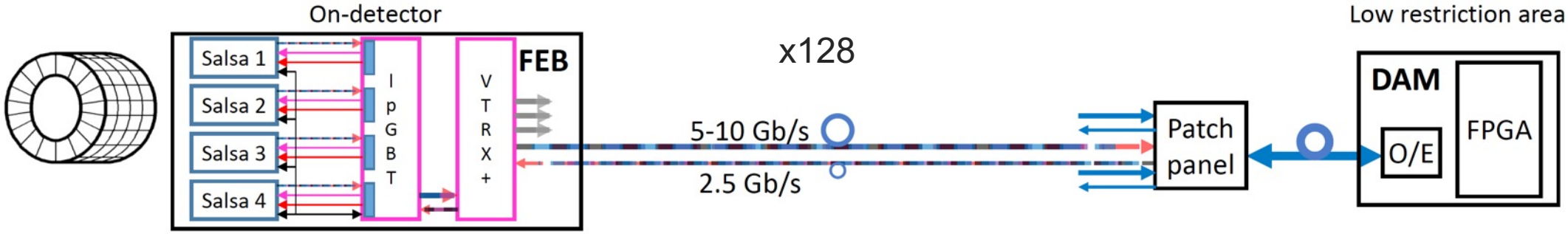
<u>Minimal</u> figures (?) to be confirmed for / by simulations **(mm)**

- FEB PCB : 3.2
- Component height : 3
- Compressed thermal foam : 1
- Plain cooling plate : 3
- Pipe outer radius (enough flow ?) : 3

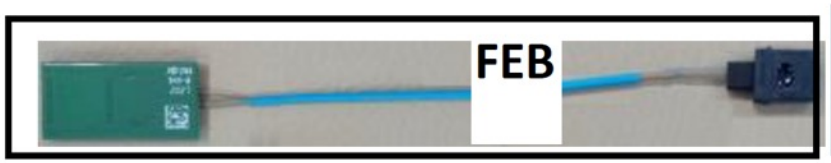
minimal FEB+cooling plate thickness 13.2 mm ?

The detector readout electronics

Contact: Irakli Mandjavidze

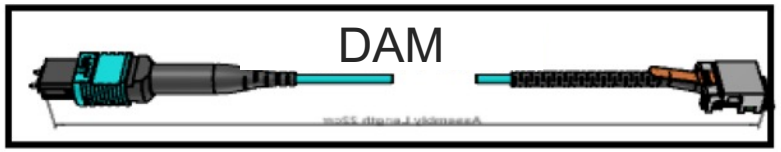


MT MPO low profile adapter from Senko : 7P5 SM 1
→ **8.6 mm height**



Short pigtail / on board

Fibers of adapted length between patch panels



Short pigtail / on board

The High-voltage cabling (one possible option)

On Cymbal tile

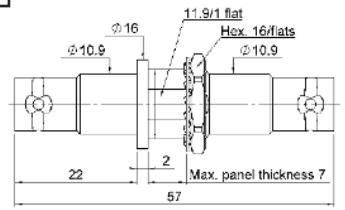
x64

Patch panel

x64

HV PS

HTC-50-1-1 (CEH50) coax cable (CERN)



SHV connector
(ex: radiall R317.072.000)

Services / cabling (new update – no more RDO)

https://brookhavenlab.sharepoint.com/:x:/s/EICPublicSharingDocs/EdH38QZE9HpJrl039jn2-q4BbPvrMv7dTFiLV8--atclKw?rtime=du5DNOZX3Ug
https://brookhavenlab.sharepoint.com/:x:/s/EICPublicSharingDocs/EbyvmR-fBZ5Eo2V6NI7eMcgBqtR1I7isGIvRyRK-nE-uJQ?rtime=Le_8RP9p3Ug

Update 3/10/2025

Barrel Inner MPGDs Services

Person to contact F. Jeanneau / F. Bossu

Cables, Fibers, etc.

Item	Description	Quantity	Diameter	Estimated Length	Notes	Assumptions
FEE data	VTRX+ MPO parallel optical fiber	128	connector 10mm	To DAM	https://suddendocs.samtec.com/catalog_english/ecue.pdf	
~~RDO data~~	~~FEE optical fibers~~	~~64~~	~~3.2mm~~	~~TBD~~	~~hypothesis: 2 FEB for 1 RDO; **TBD;** MTP® 12 (Male) to MTP® 12 (Female) OM4 Multimode Elite Trunk Cable, 12 Fibers, Type B, Plenum (OFNP), Magenta~~	
HV cables	HV cables to patch panel	96	3.2mm	to patch panel	HTC-50-1-1, 0.5Lz/1.5, CEH50 Dakra; to patch panel	
HV cables	HV cables from patch panel to Rack	TBD (example. ten 9-channel HV cables)	TBD	TBD	possibly high density cables if compactness is needed	1 drift + 2 resistive
LV cables	**From DC/DC** to FEB	128	0 / 4 to 5.5 mm	0/ 0.3 to 1 m	Alpha Wire 3464C (<0,3m), 6328 (0,3-0,5m), 2414C (upt to 1m)	
LV cables	From LV PS **to DC/DC**	128	6 mm	TBD	Alpha Wire 2424C	
Gas tubing	inlet and outlet each 2 modules in serie	16 IN / 16 out	4mm	TBD	https://www.mcmaster.com/5384K524/	2 tiles in series
Flat cables	flat cables from modules to FEEs	512+512	1mmx20mm	10cm / 50 cm	within the CYMBAL envelop	

Cooling, etc.

Item	Description	Quantity	Diameter	Estimated Length	Notes	Assumptions
Cooling tubing	Cooling tubes to FEEs, N FEE in series TBD	32x(2 per FEB)/N	6.25mm ?	TBD	https://www.mcmaster.com/5648K74/	To be confirmed by simulations

Summary of open questions to discuss

CyMBaL interfaces with GST (Irfu/Purdue)

- How to use the GST longitudinal beams (up to 8 ?) and the 3 engagement rings to fix the tiles, the 2 halves ?
- How to support / fix the ~0.6 kg FEB cards on each sides of the barrel ? Can not be done on the CyMBaL barrel (not self supporting) → Via the engagement rings with brackets ?
- Define where these GST/CyMBal interfaces are ?
- Integration sequence in GST ? In 2 halves via the longitudinal beams ? Toolings ?

Scale 1 CyMBaL tile mechanical design and prototyping

- Refine tile area VS areas for FEB connection and for fixation in GST (started with sensor PCB design)
- Shaping the tile in cylindrical shape with hoops and logerons (protyping with 150 μm thick Kapton + 150 μm FR4)
- Mechanical assembly between tiles before assembly in halves ?

Thermal power dissipation and cooling simulations for design of the FEB + cooling plate

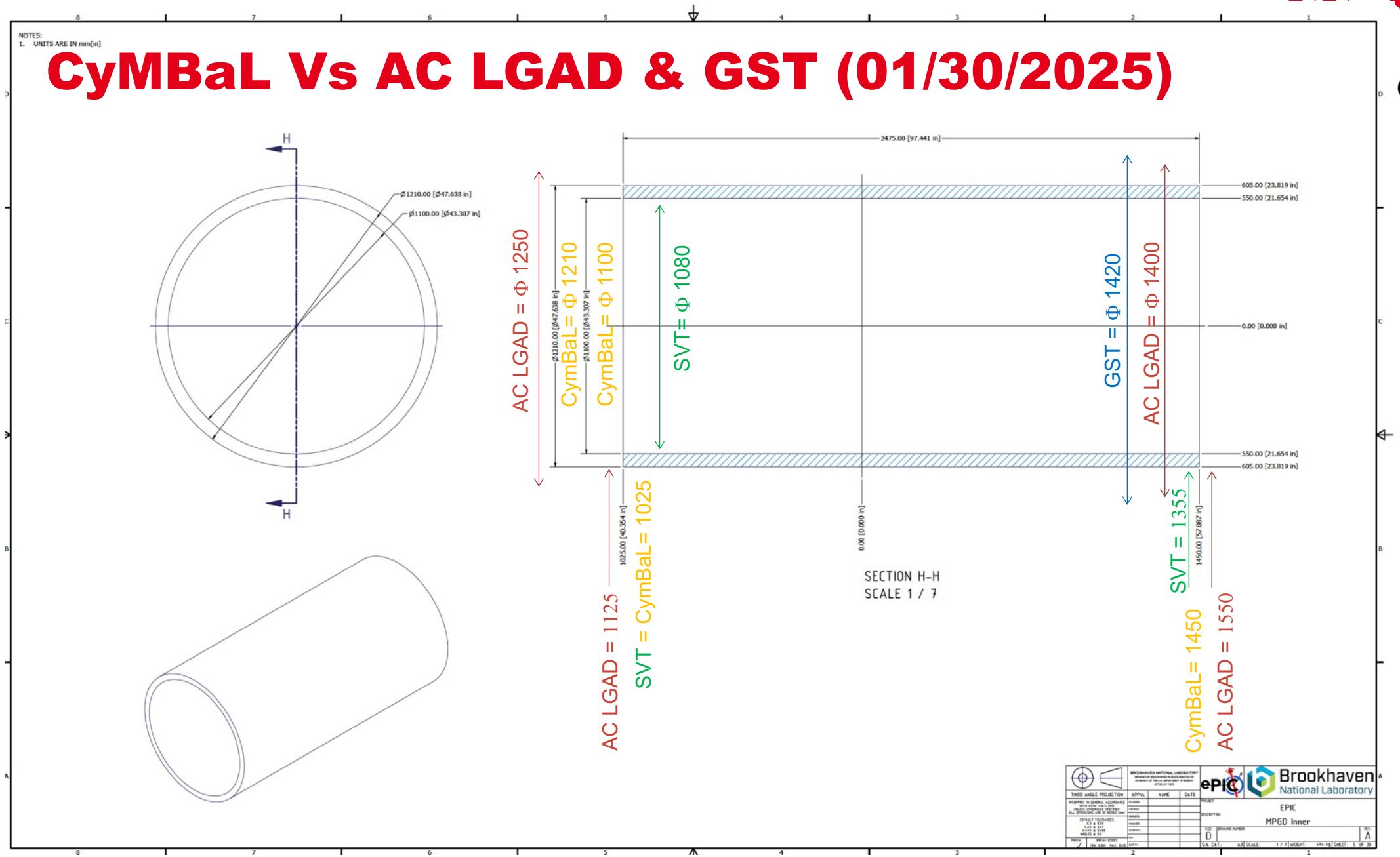
- Can 18°C / 3 l/mn water cooling be an option ?
- Start with a FEB + cooling plate upper thickness of 15 mm

Define location of the patch panel(s) and the DC/DC converter cards

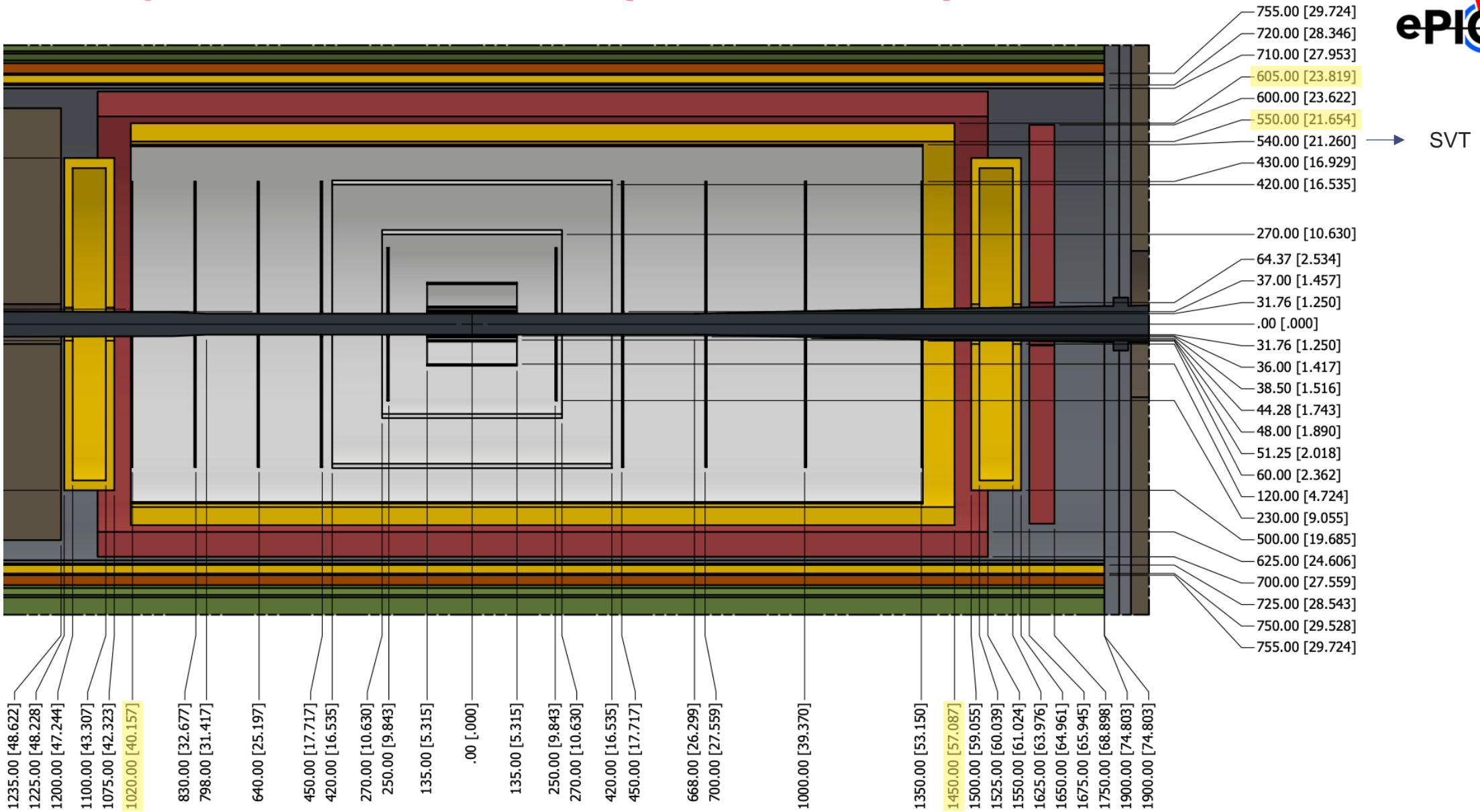
Update of CyMBal CAD “conceptual” model with GST interfaces can be done by Alain with help of a SolidEdge designer. A mechanical engineer (identified) should join the team **in June** for detail design and thermal simulations

Backup

CyMBaL Vs AC LGAD & GST (01/30/2025)



The CyMBaL envelops (01/30/2025)



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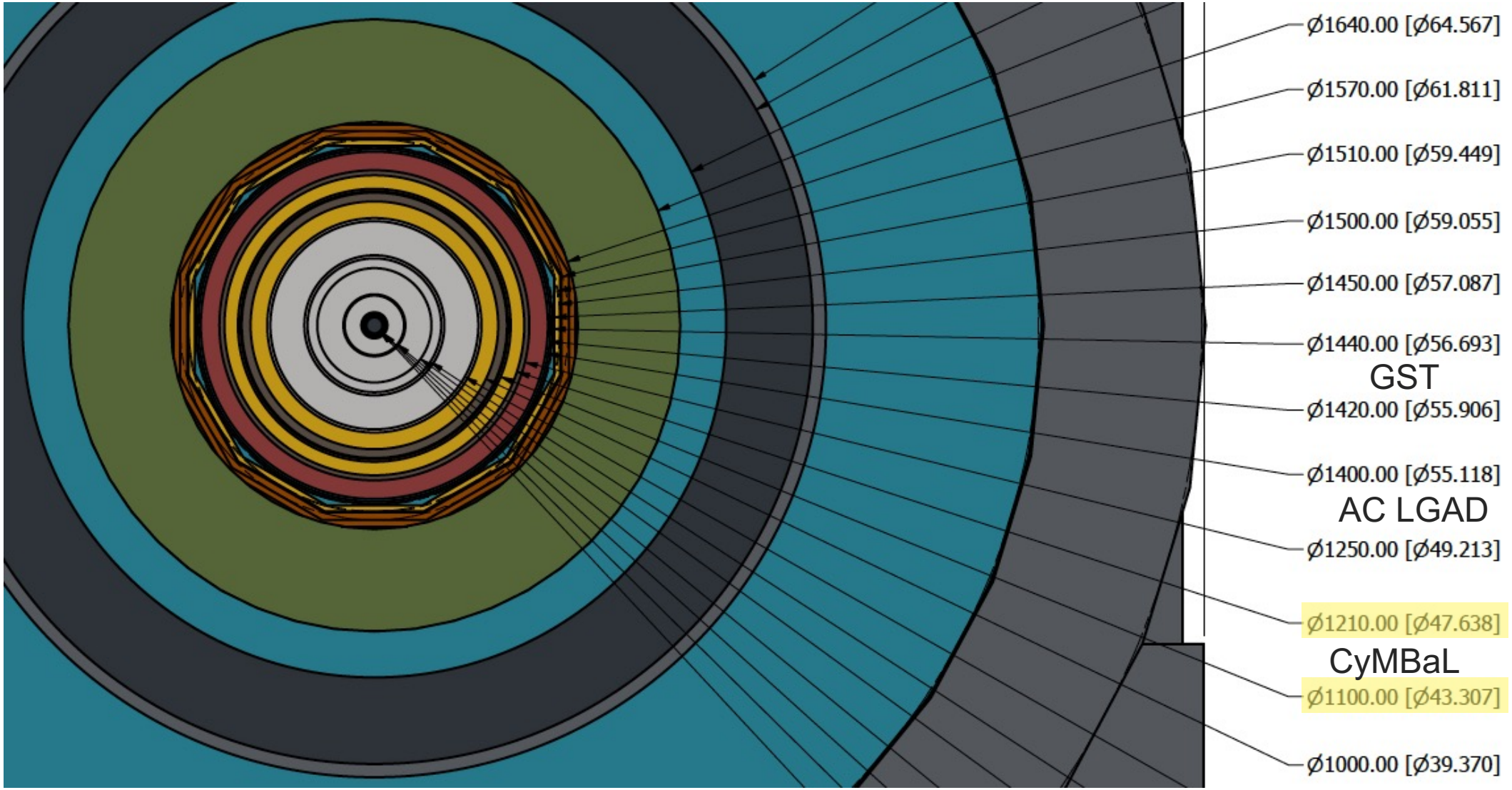
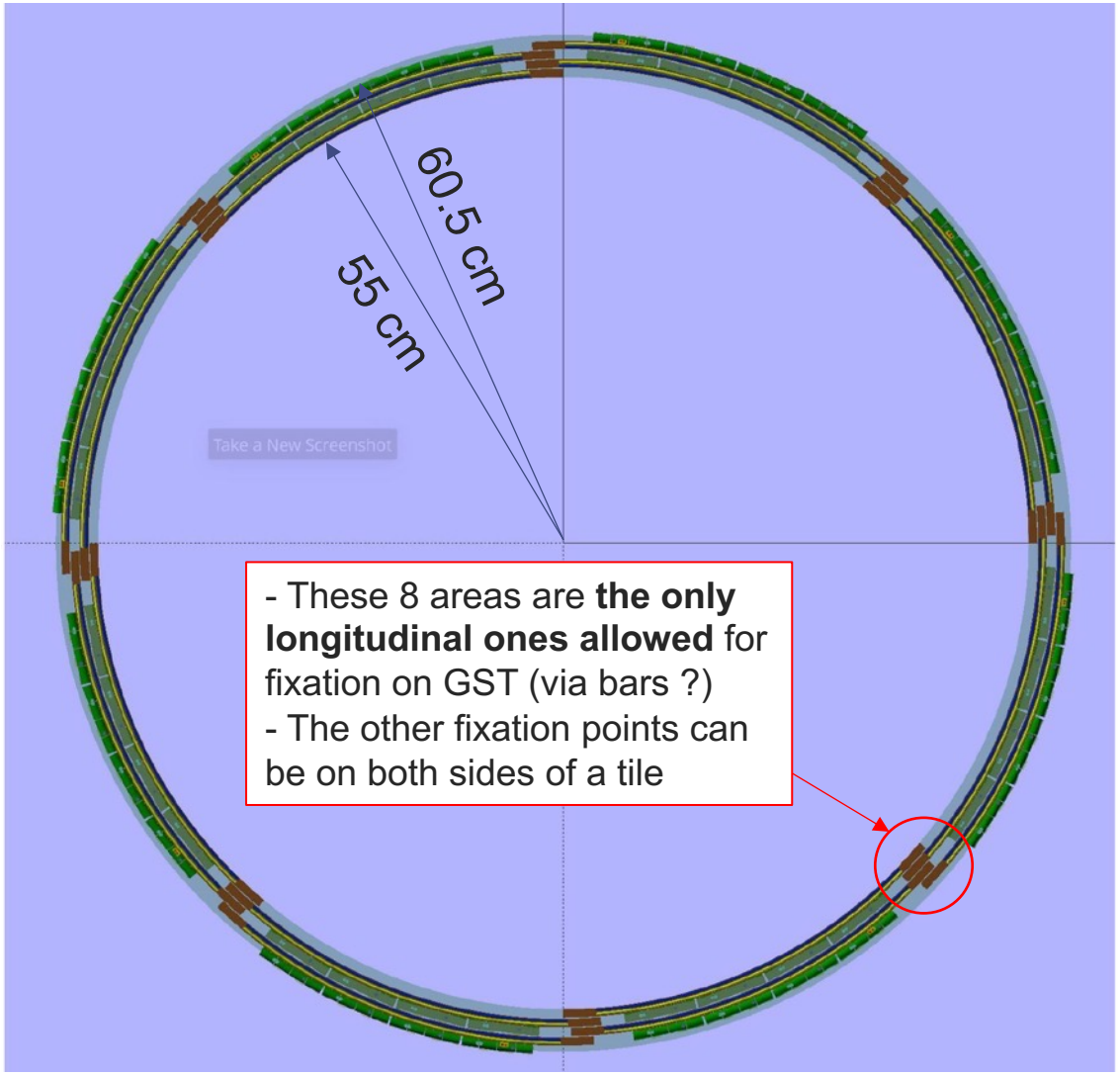
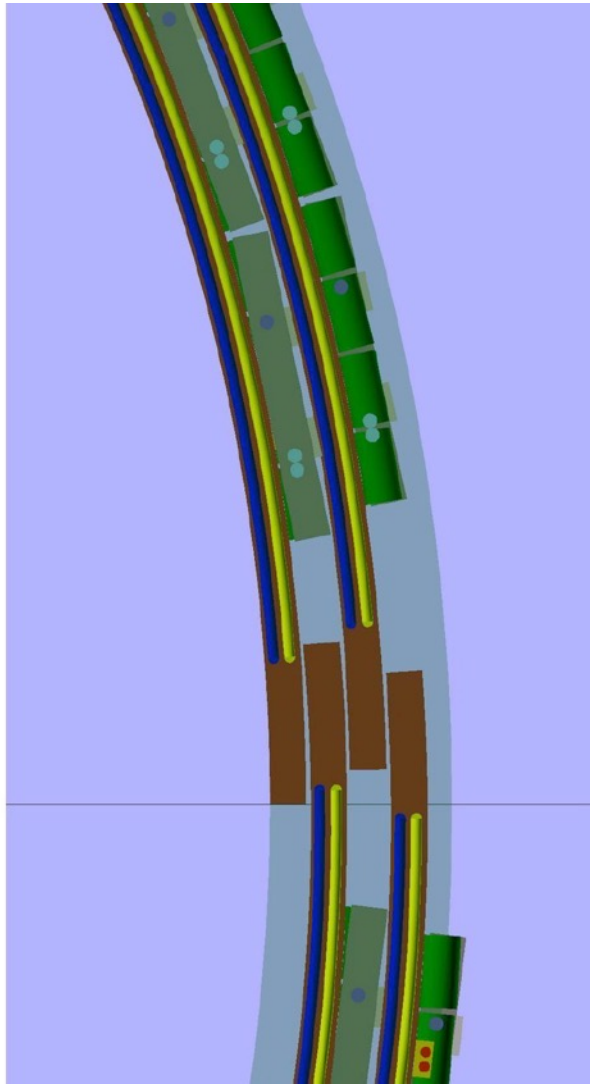


The current baseline design of the CyMBaL barrel

Contact: future mechanical engineer & Alain Delbart





- Detailed engineering design Siemens NX & SolidEdge) will start as soon as a mechanical engineer is available at IRFU …
- … in close contact with the tile PCB design team …
- … and close contact with GST team (Andy/Sushrut)
- To produce a first scale 1 prototype (not yet a Module0)