CEPC Silicon Tracker Progress Report (6)

Qi Yan *on behalf of the Silicon Tracker Group*

Sep 3, 2024, IHEP

Latest Progress on CEPC ITK Mechanical Design

- Quan JI is the new ITK mechanical lead, and his deputy, Yujie LI (a Ph.D. student) has also joined the ITK mechanical design team.

- The progress on the ITK mechanical design has accelerated rapidly:

1) Since last week, we have organized 3 rounds of mechanical meetings to discuss the details of the ITK mechanical design. There is strong cooperation between the detector design team (Qi YAN, Yihan ZHANG, Shoudong LUO, …) and the mechanical design team (Quan JI, Yujie LI, Shang XIA, …).

2) The dimensions of the ITK detector has been adjusted to fully fit within the TPC and can be seamlessly installed around the beam pipe.

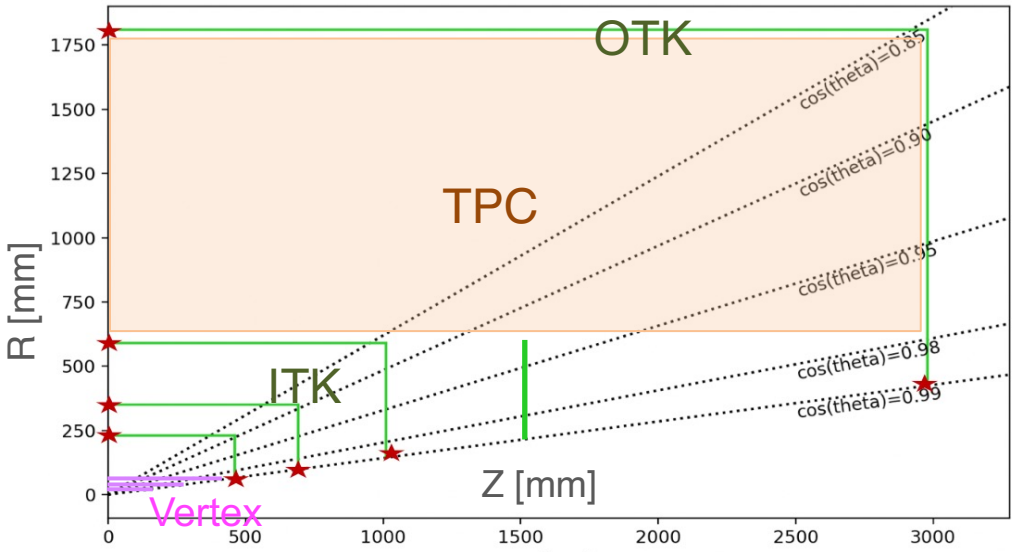
3) Thanks to Quan JI and his team's innovative design, the full ITK installation procedure has now been established.

Adjustment of ITK Detector Dimensions

Barrel	ITKB1	ITKB2	ITKB3
R [mm]	240	350	~~600~~ 564
Half-Z [mm]	500.5	715	1001

Gang Li, Qi YAN, and Quan JI

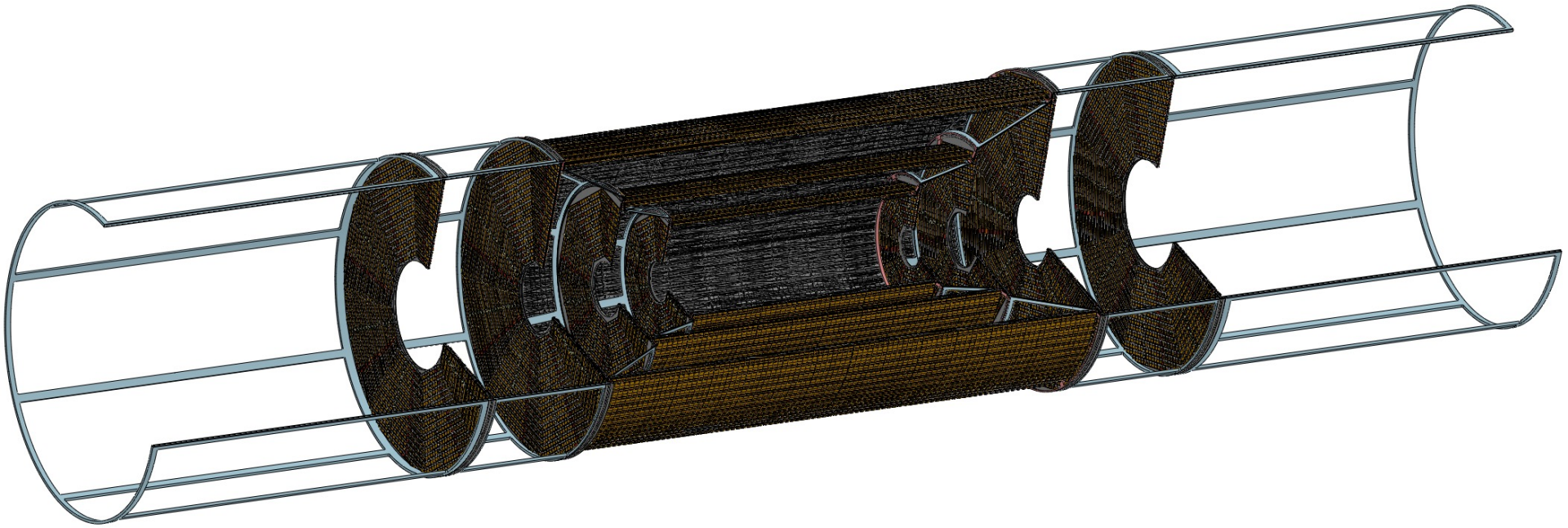
See details in Quan JI's talk



Endcap	ITKE1	ITKE2	ITKE3	ITKE4
|Z|[mm]	500.5	715	1001	1500
R-I [mm]	~~75~~ 78.8	~~101.9~~ 114.4	~~142.6~~ 150	~~214~~ 219
R-O[mm] (detector)	~~257.3~~ 240	~~377.1~~ 350	~~586~~ 564	~~586~~ 564
R-O[mm] (mechanics)	257.3	377.1	586	586

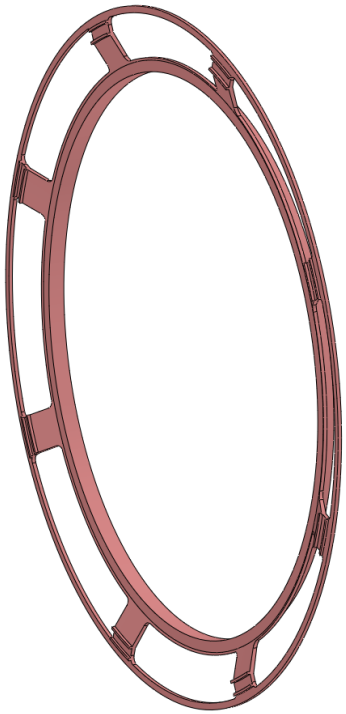
ITK Installation Step Design

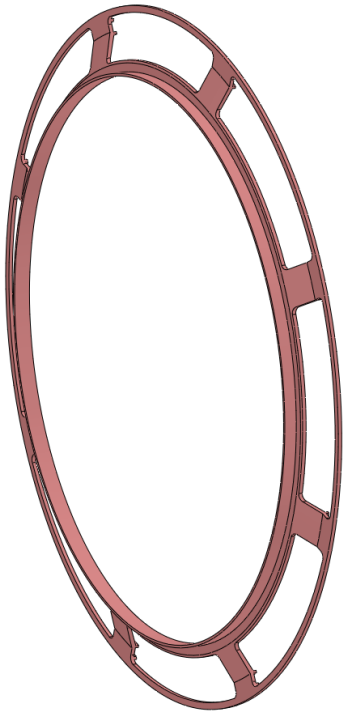
Quan JI



ITK Installation Step 1

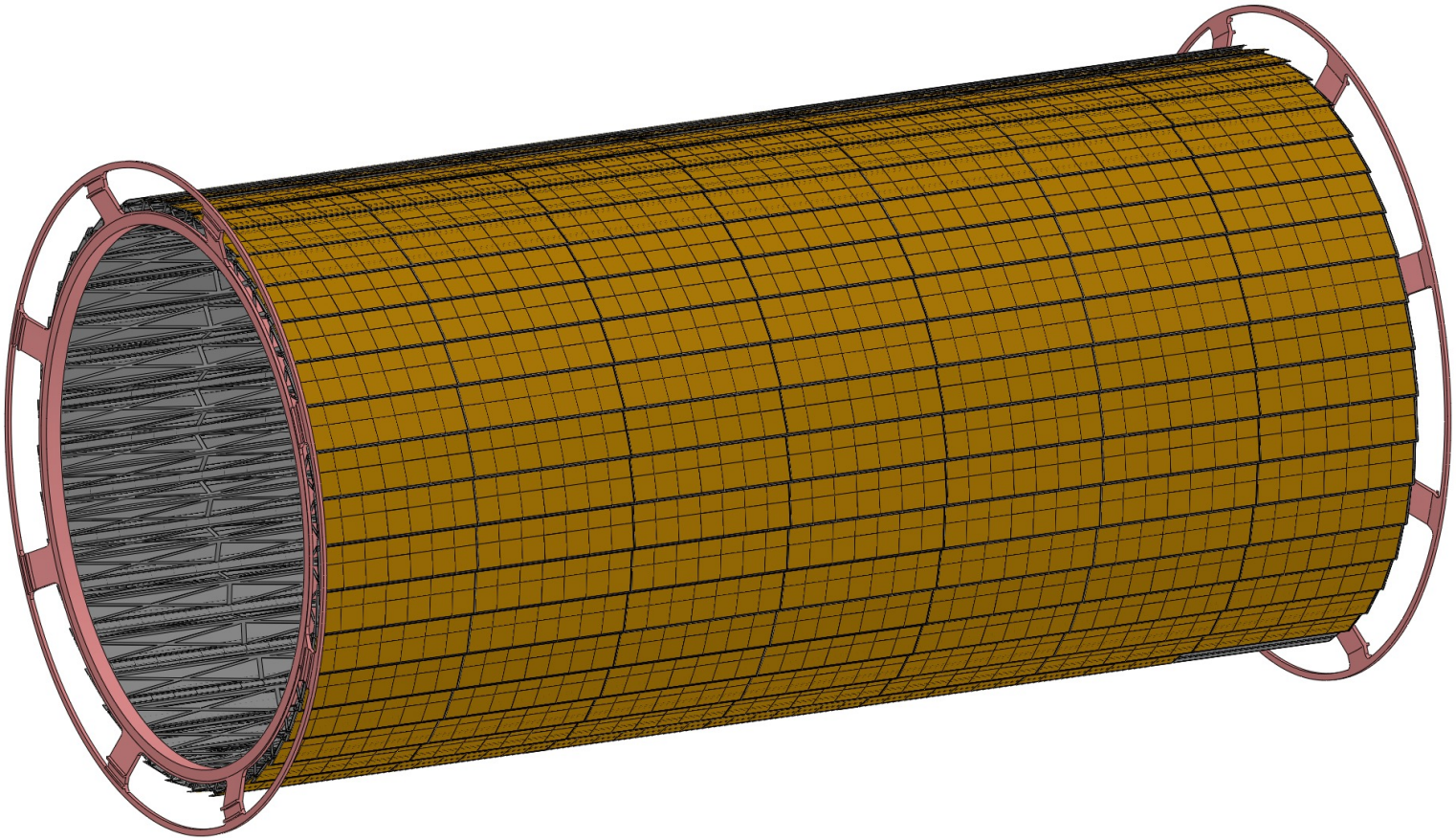
Two Supporting Rings for the 1st ITK Barrel:





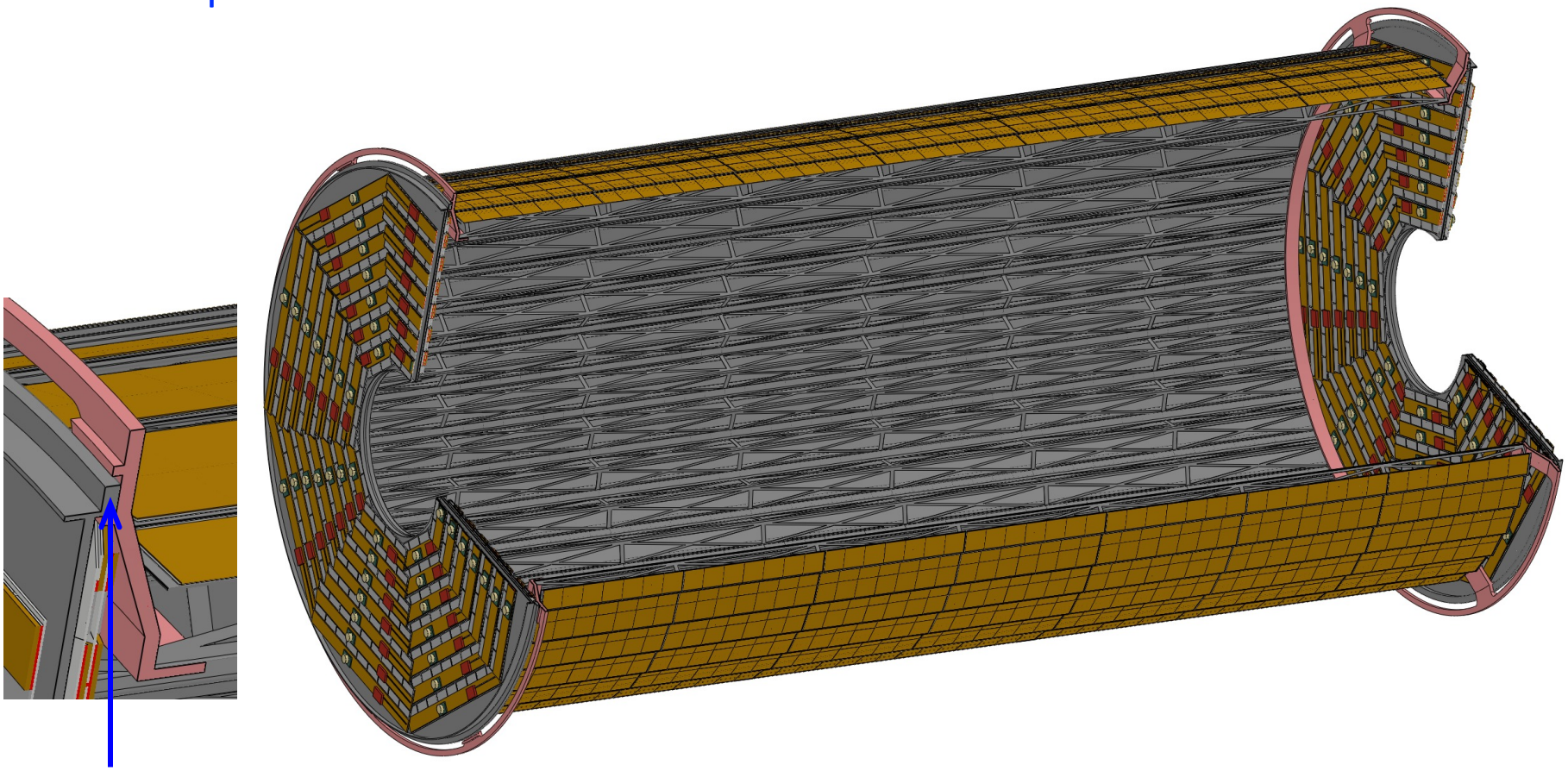
ITK Installation Step 2

Stave installation for the 1st ITK Barrel:



ITK Installation Step 3

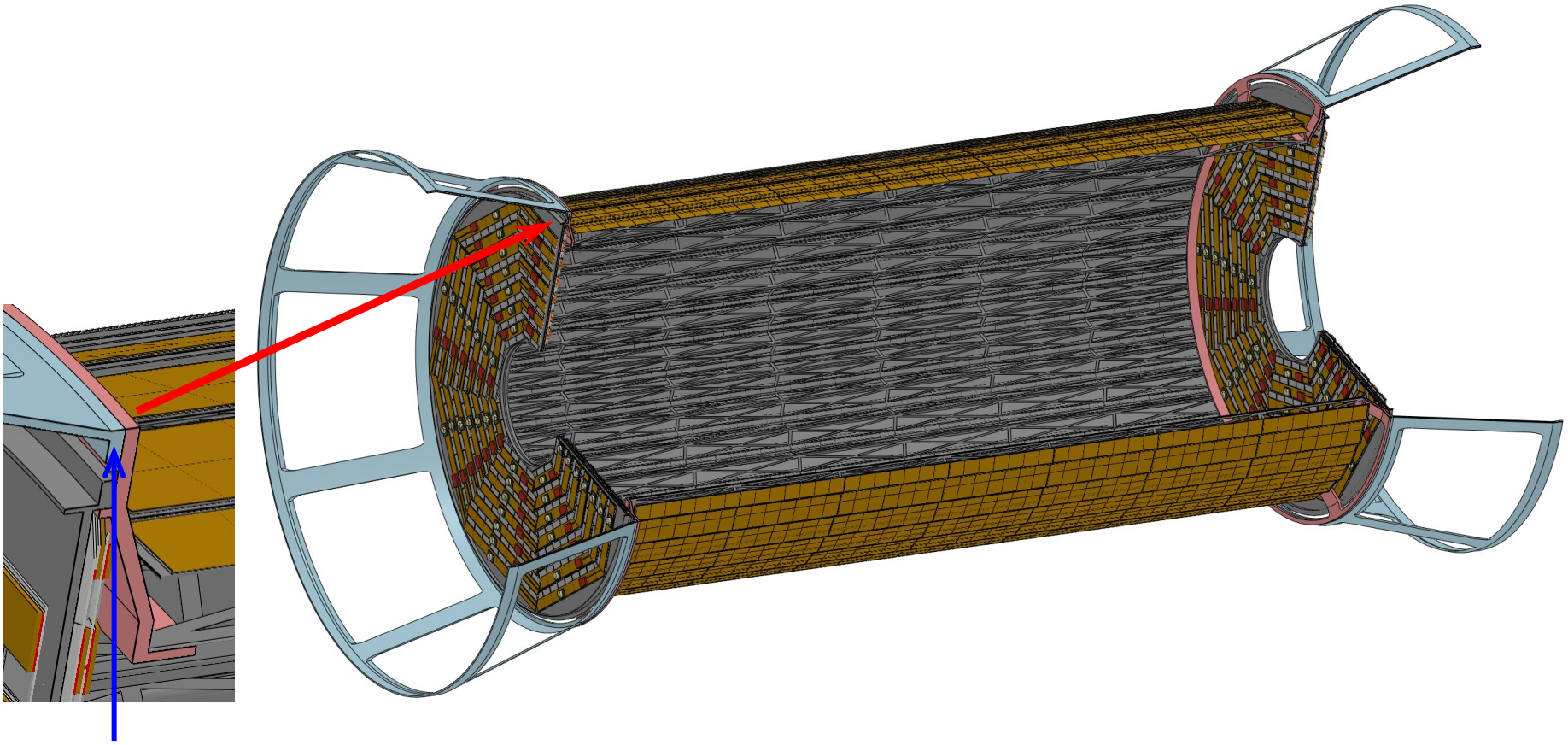
1st Endcap installation:



Endcap Disk and Supporting Ring docking latches

ITK Installation Step 4

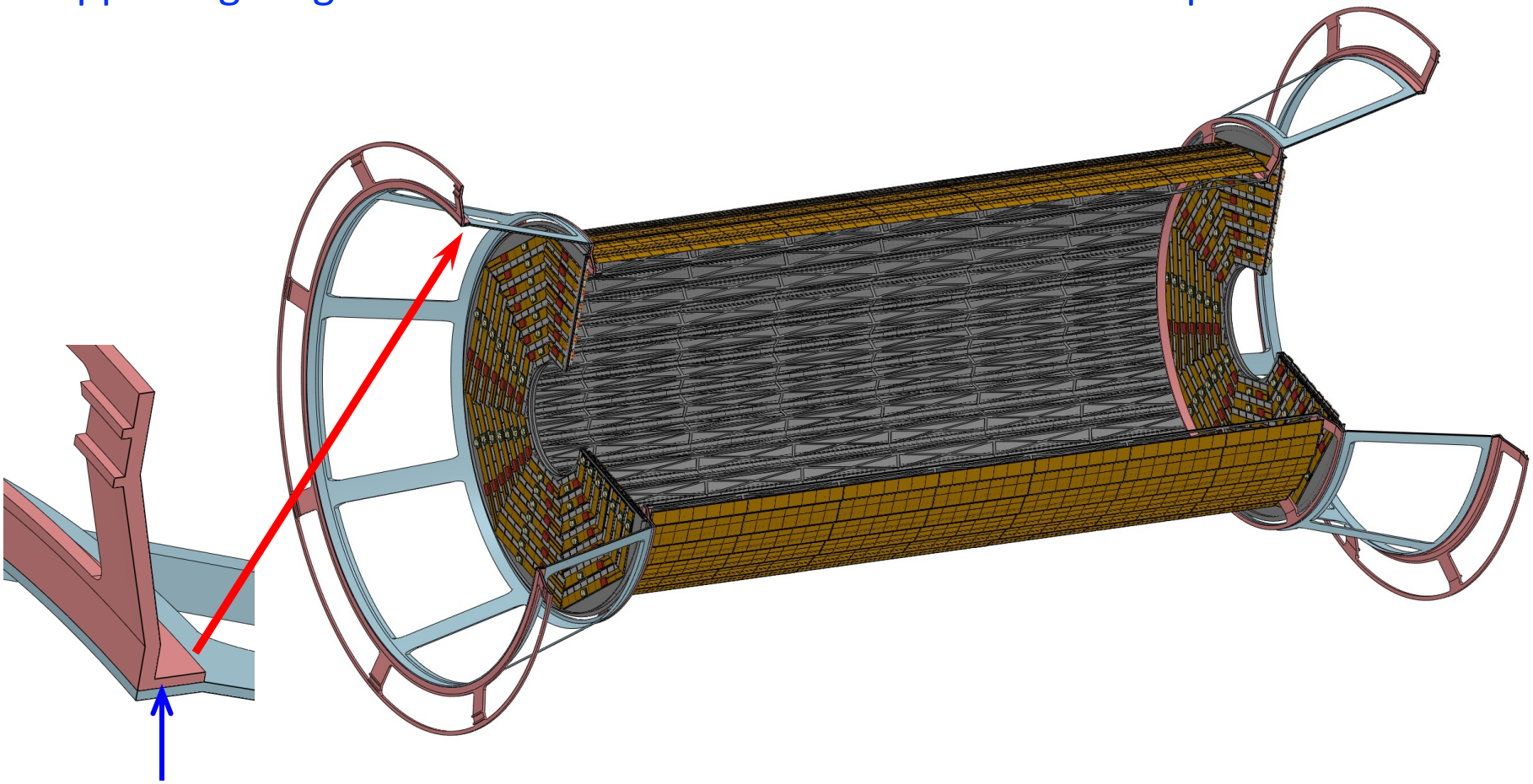
Flange installation for the 2nd ITK Barrel and Endcaps:



Flange and Supporting Ring docking latches

ITK Installation Step 5

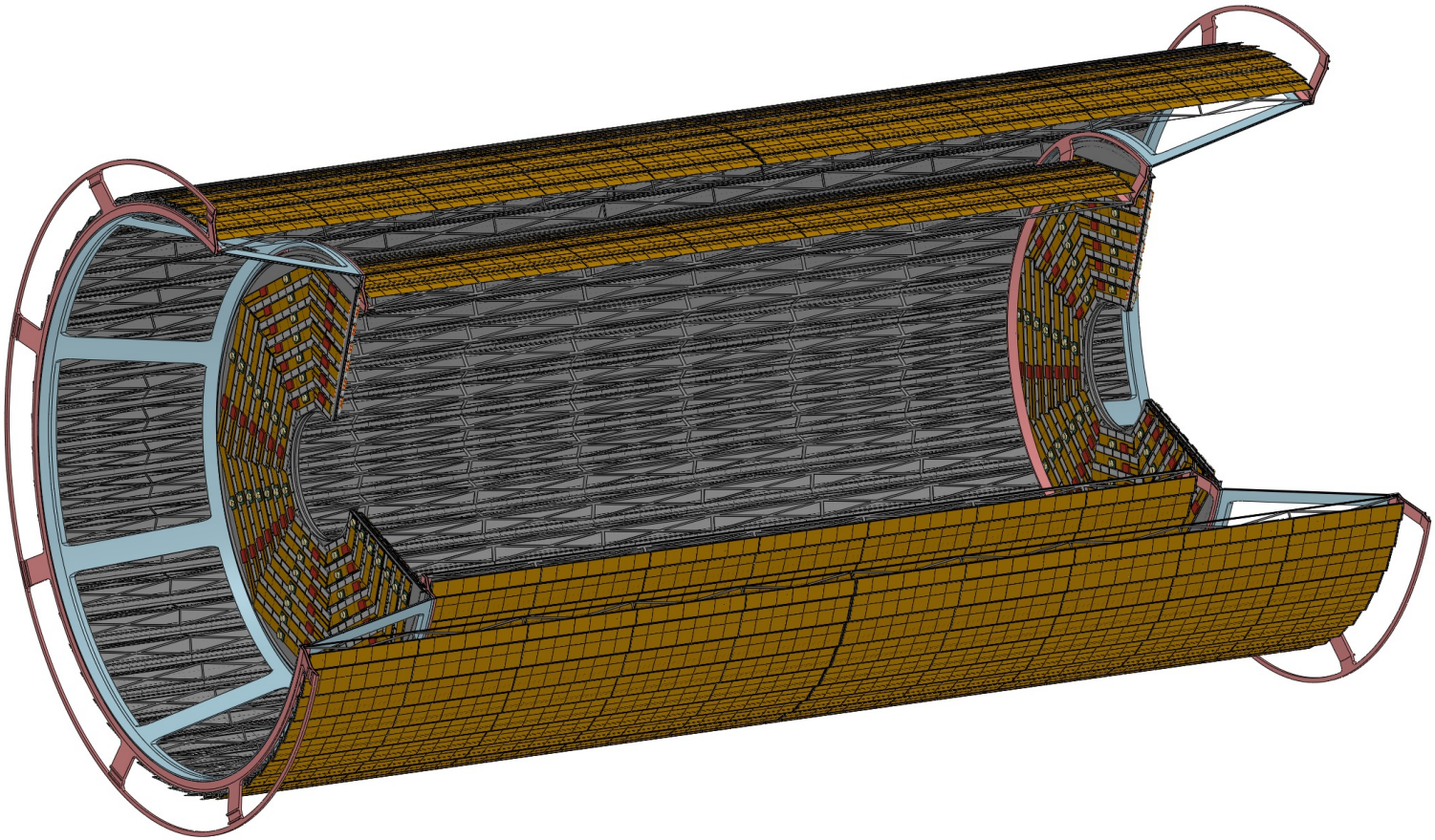
Supporting Ring installation for the 2nd ITK Barrel and Endcaps:



Supporting Ring and Flange docking latches

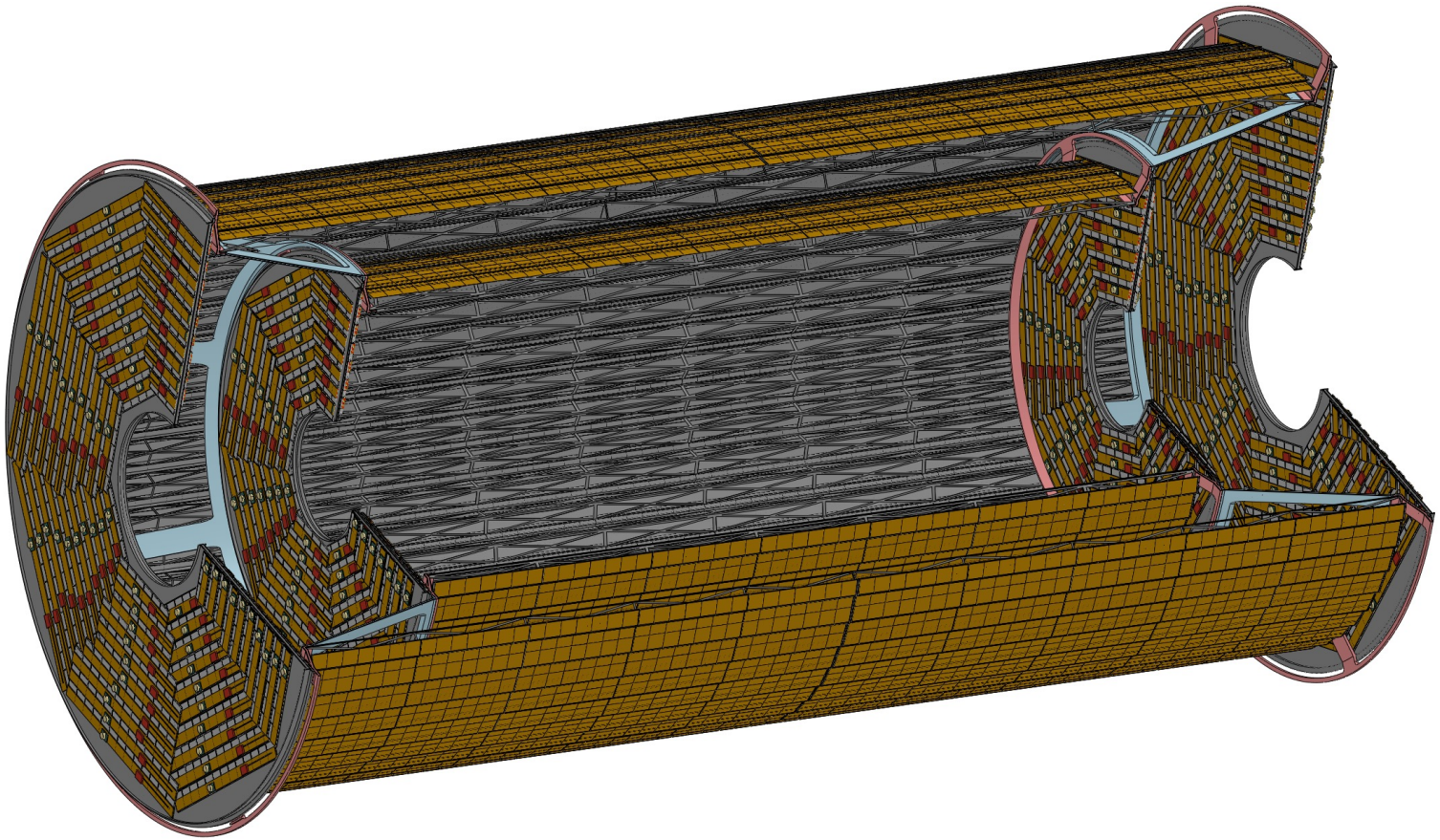
ITK Installation Step 6

Stave installation for the 2nd ITK Barrel:



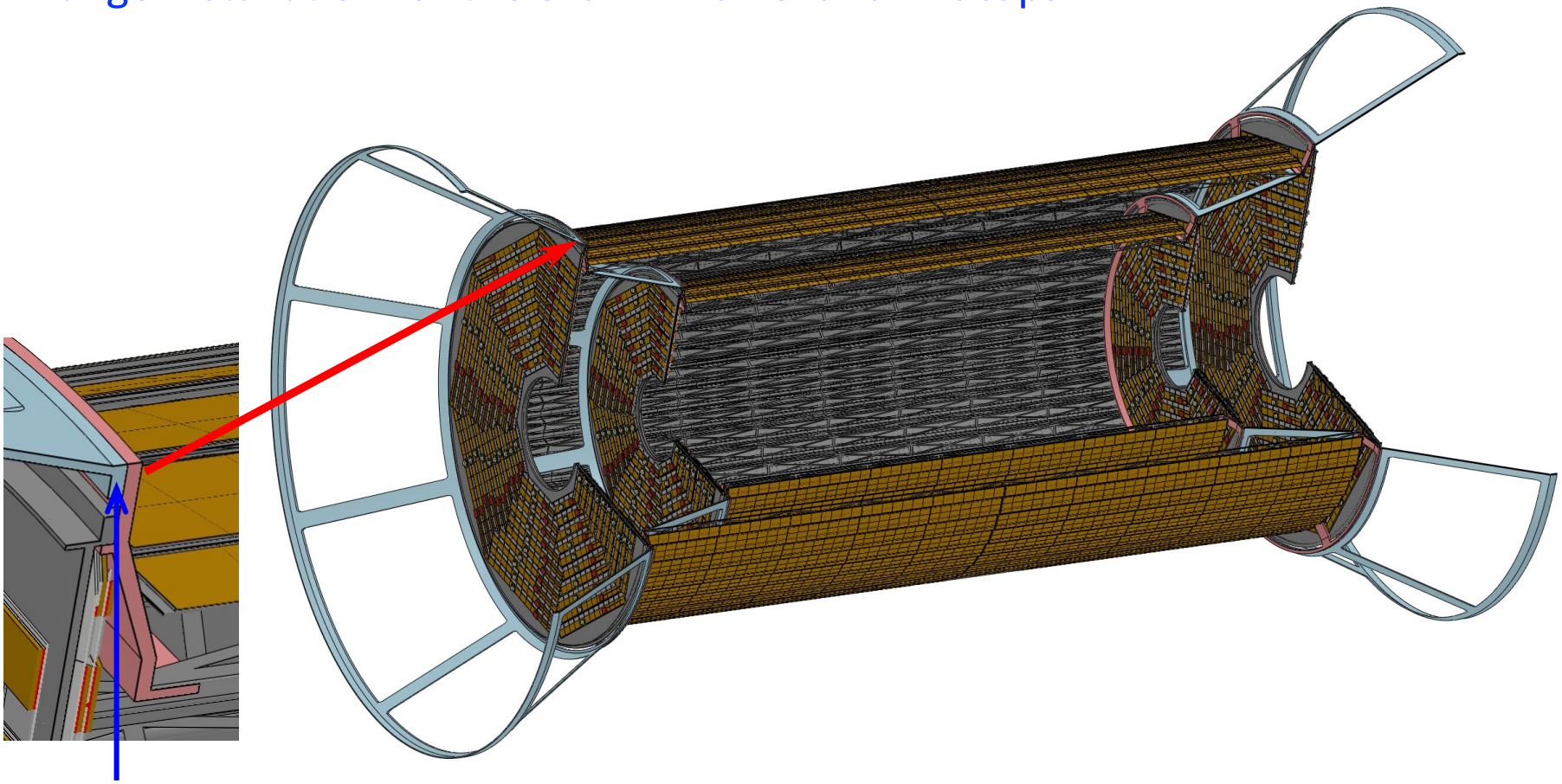
ITK Installation Step 7

2nd Endcap installation:



ITK Installation Step 8

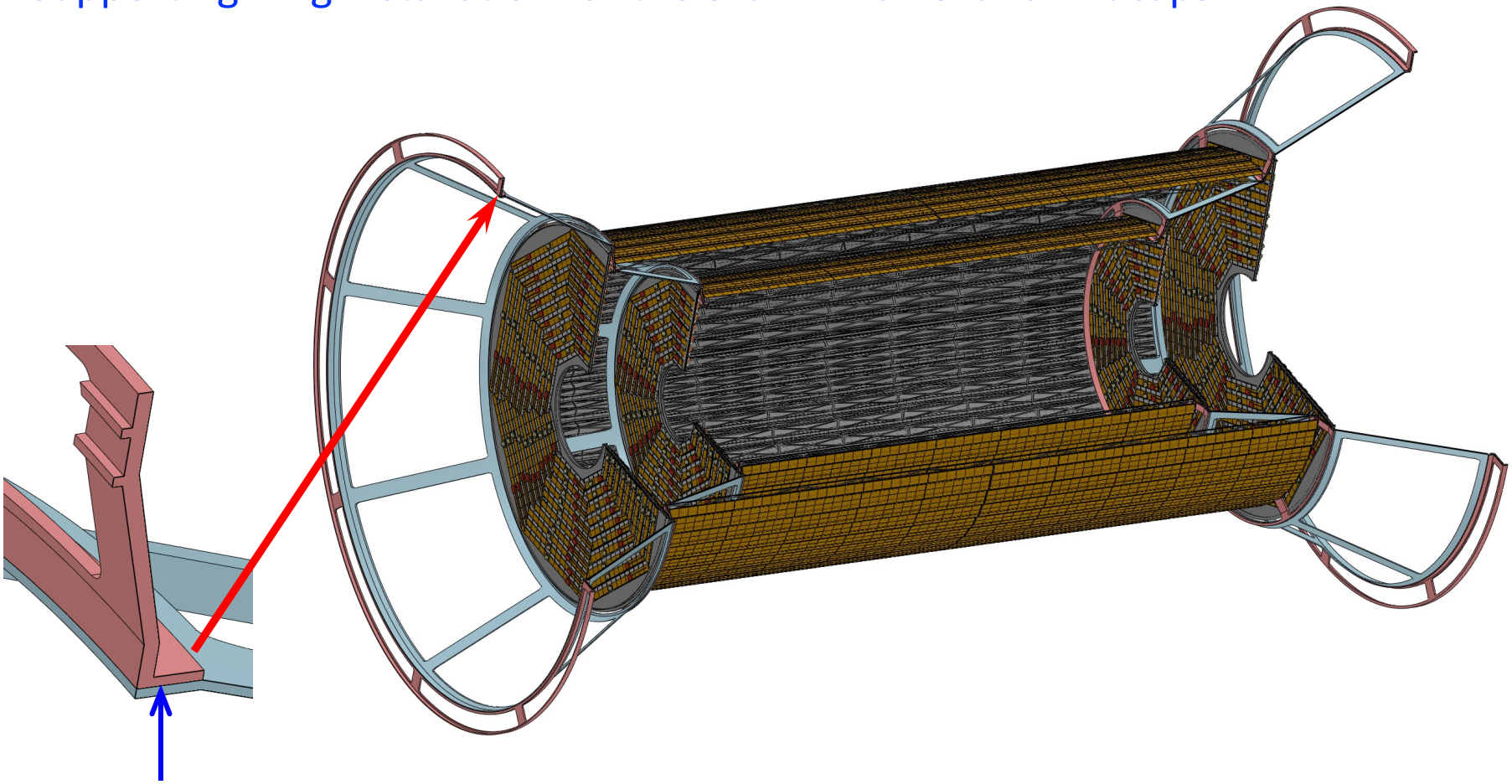
Flange installation for the 3rd ITK Barrel and Endcaps:



Flange and Supporting Ring docking latches

ITK Installation Step 9

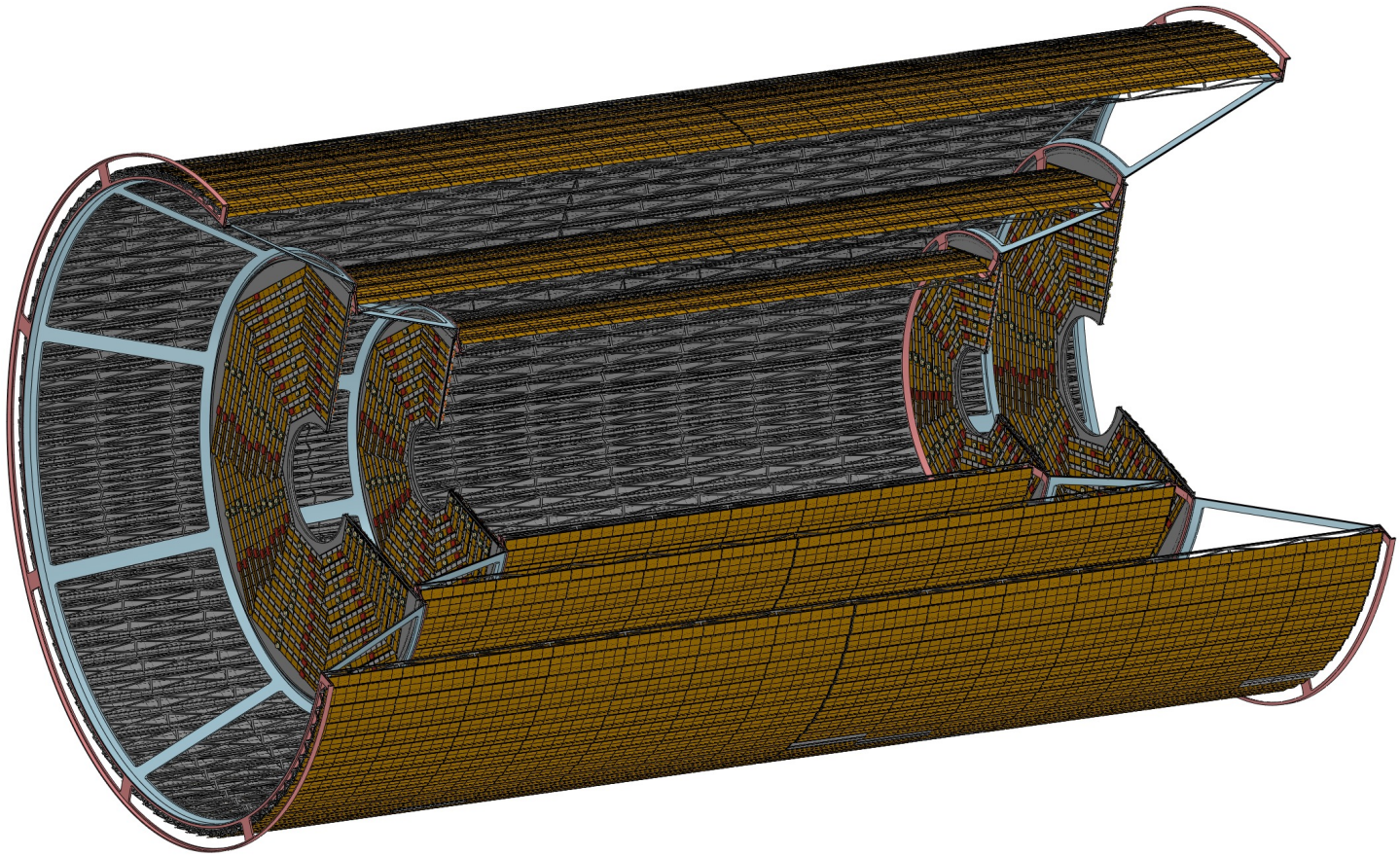
Supporting Ring installation for the 3rd ITK Barrel and Endcaps:



Supporting Ring and Flange docking latches

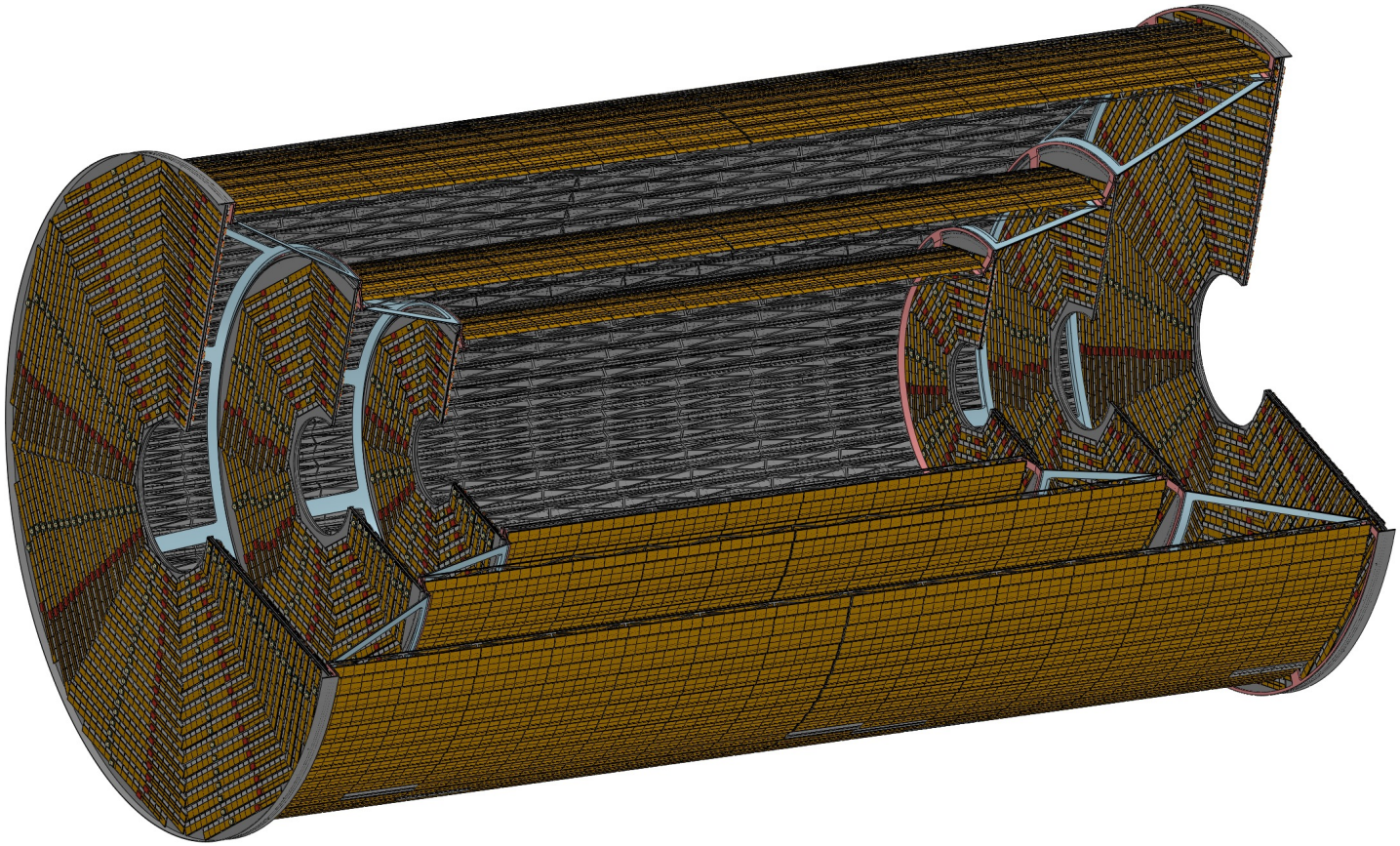
ITK Installation Step 10

Stave installation for the 3rd ITK Barrel:



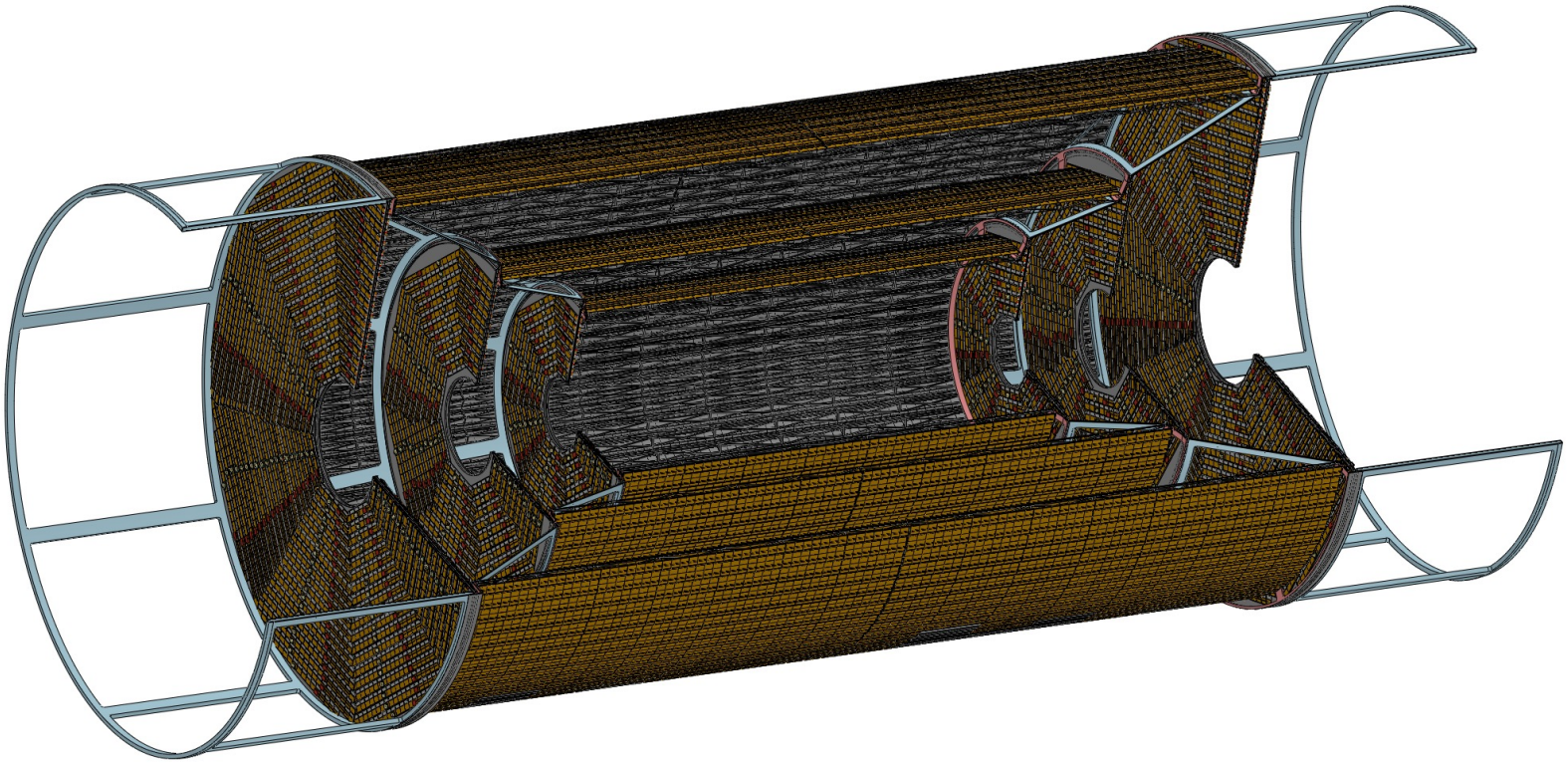
ITK Installation Step 11

3rd Endcap installation:



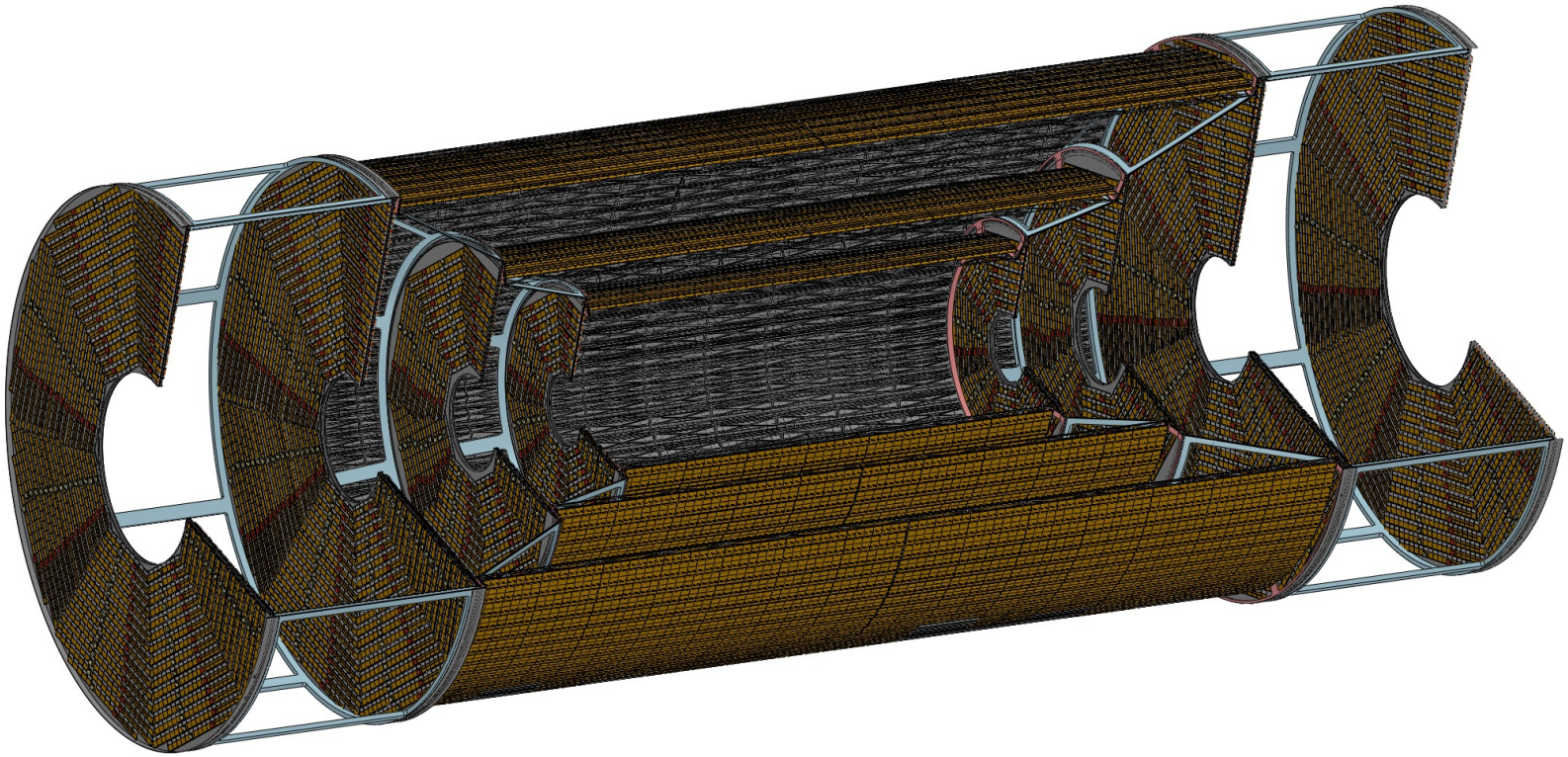
ITK Installation Step 12

Flange installation for the 4th ITK Endcaps:



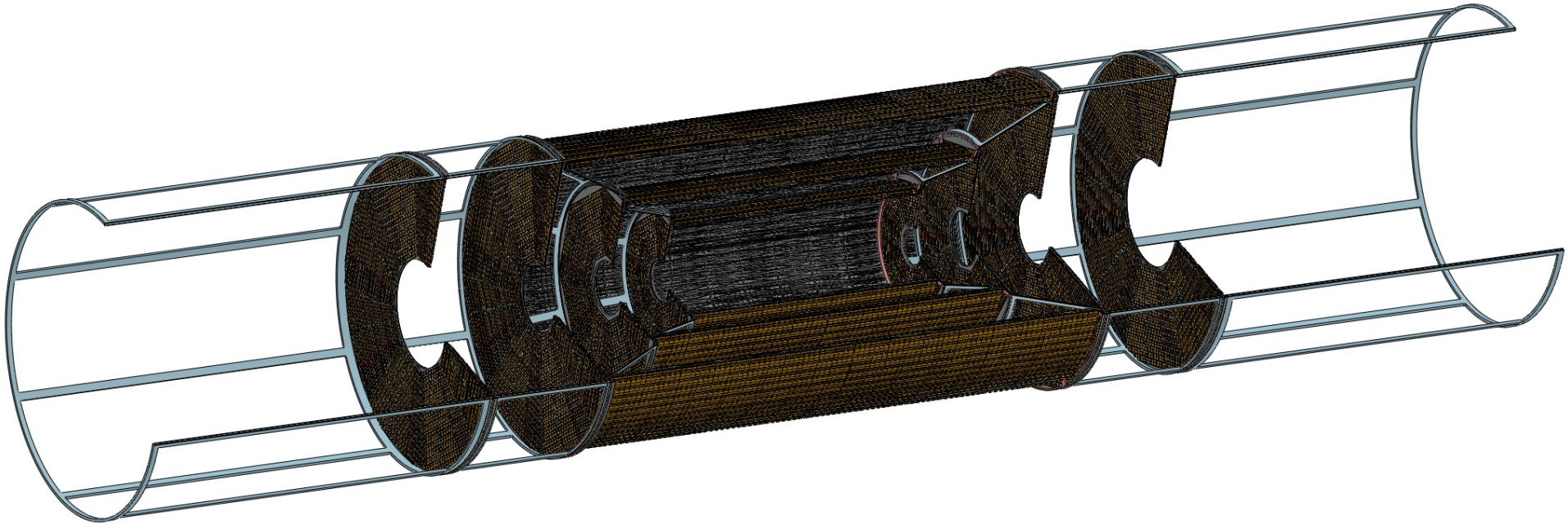
ITK Installation Step 13

4th Endcap installation:



ITK Installation Step 14

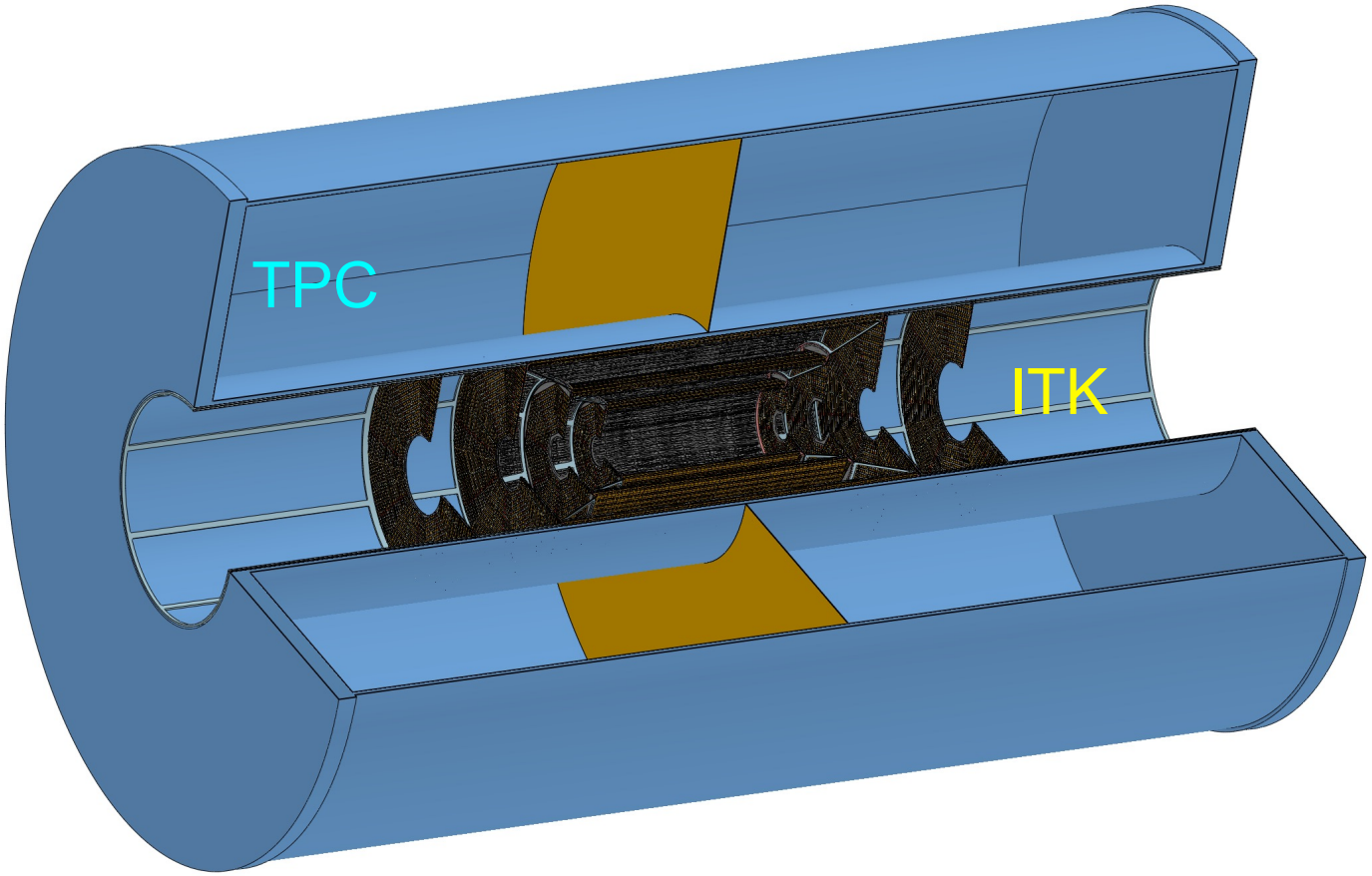
Installation of the Connection Ring with TPC:



ITK Installation Step 15

Installation of the ITK to TPC:

Quan JI



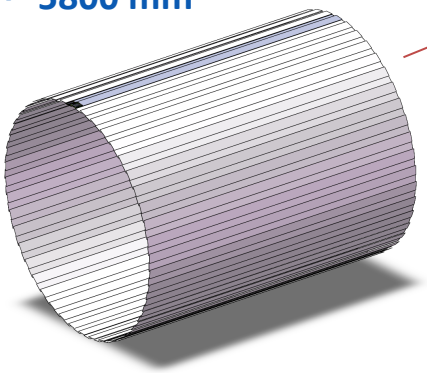
Current OTK Barrel Design

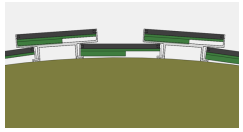
Yunyun FAN

Layout design (total area: 70 m^2):

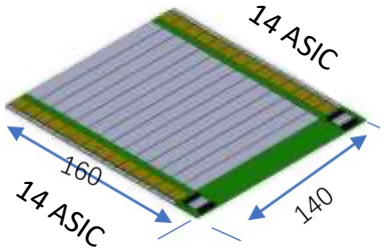
- 90 ladders (staves)
- Each ladder (stave) has 42 modules
- Each module has 28 ASICs
- Each ASIC has 128 channels

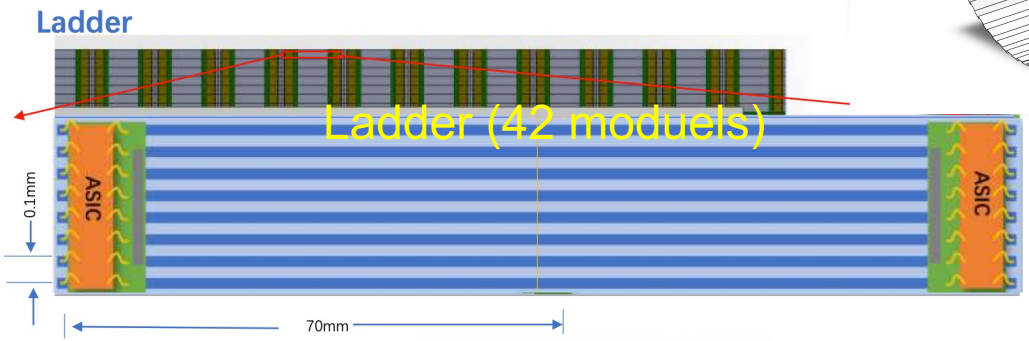
OTK barrel:
R= 1800 mm
H ~ 5800 mm

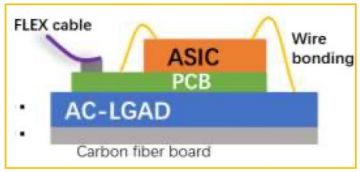




Module:
140 mm x 160 mm







High time precision ASIC (naive power consumption estimation):

- 20 mW/channel
- 2.56 W/ASIC
- 1.71 W/cm^2

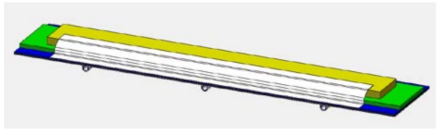
ASIC is the primary component contributing to power consumption in OTK!

OTK Thermal Design Progress

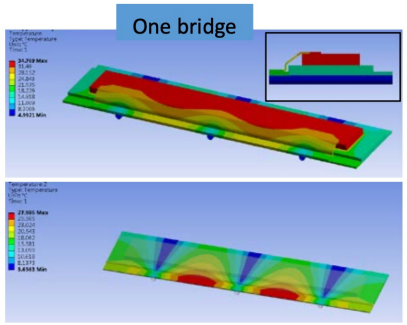
From Jinyu Fu

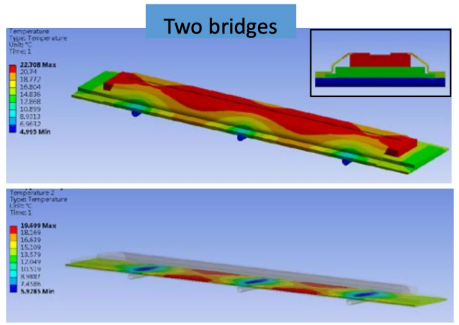
If heat can be transferred from the surface of the ASIC to the AC-LGAD, preliminary simulations indicate that the temperature of the OTK ladder can remain below 23 ℃.

New optimized cooling scheme: add a thermal conductive bridge over the PCB to connect the ASIC and LGAD



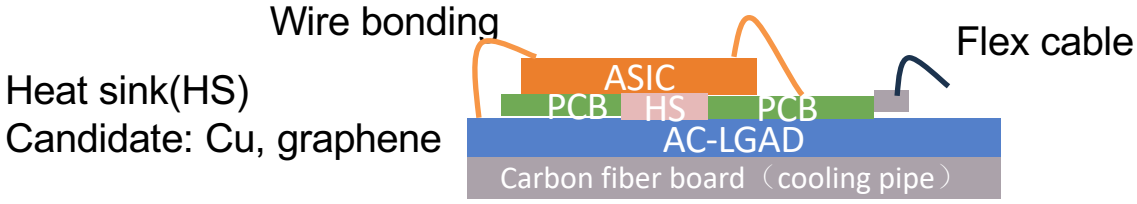
One bridge, 0.5mm Cu: ASIC~ 35 ℃, LGAD ~ 28 ℃
Two bridges, 0.5mm Cu: ASIC~ 23℃, LGAD ~ 20 ℃

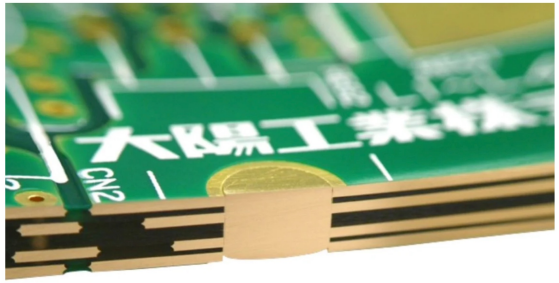




Add a heat sink (HS) to the PCB to enhance thermal conduction, enabling more efficient heat transfer from the ASIC. A heat sink has been applied in JUNO.

Yunyun FAN

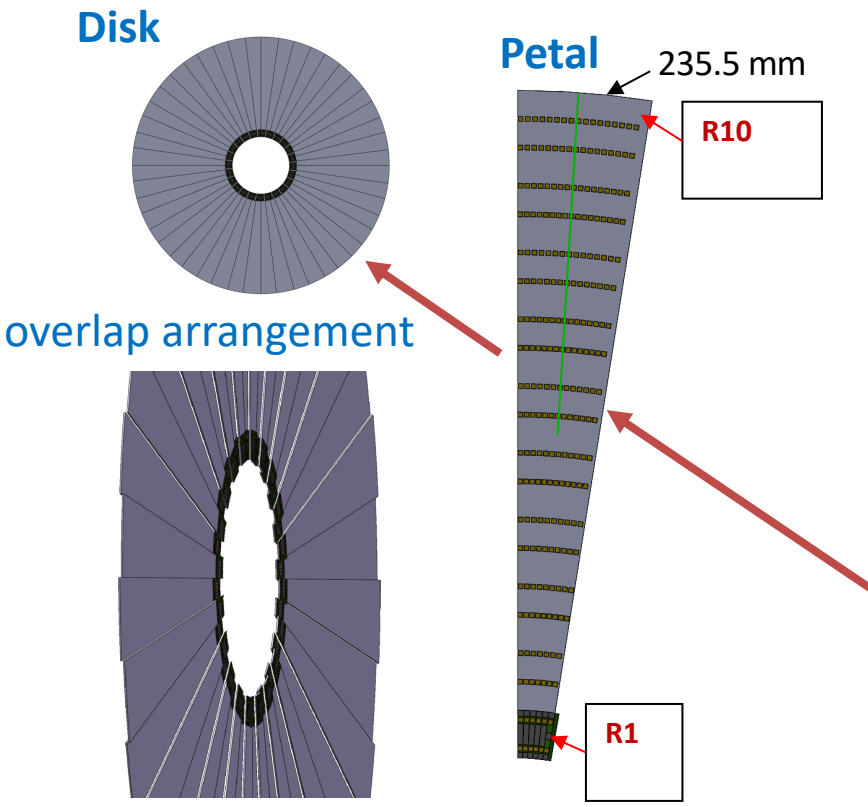




The detailed thermal simulation is ongoing with the heat sink included.

Current OTK Endcap Design (Sector Sensor)

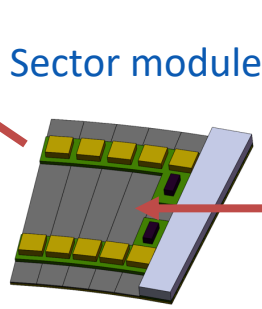
Yunyun FAN

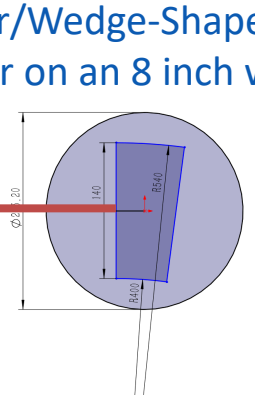


R1: 52.36 mm-70.69 mm

Layout design (total area: 19.4 m^2)

- 48 petals: neighboring petals overlap to reduce dead area
- Each petal contains 10 rows of sector modules:
  - top 5 rows: 2 sector modules each
  - bottom 5 rows: 1 sector module each

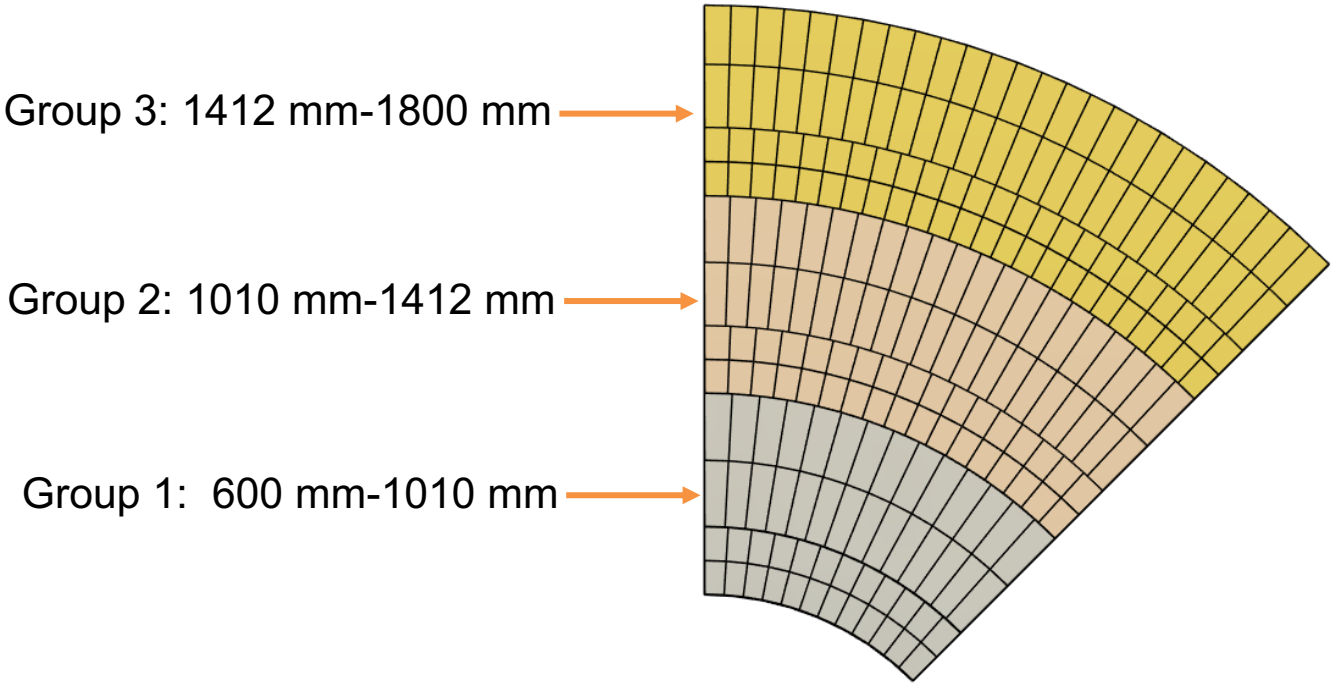




New OTK Endcap Design with Trapezoid Sensor

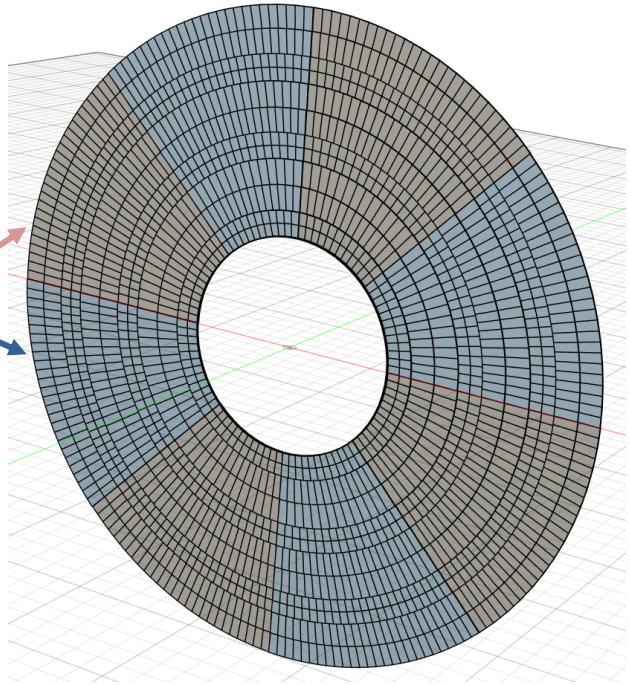
Qi YAN, Yihan ZHANG, *and* Shoudong LUO

- 12 rings, each 4 rings is a group.
- Each group contains 4 types of trapezoid sensors, which can be fitted to one silicon wafer.
- Each group of sensors can be aligned to a 1/8 sector.

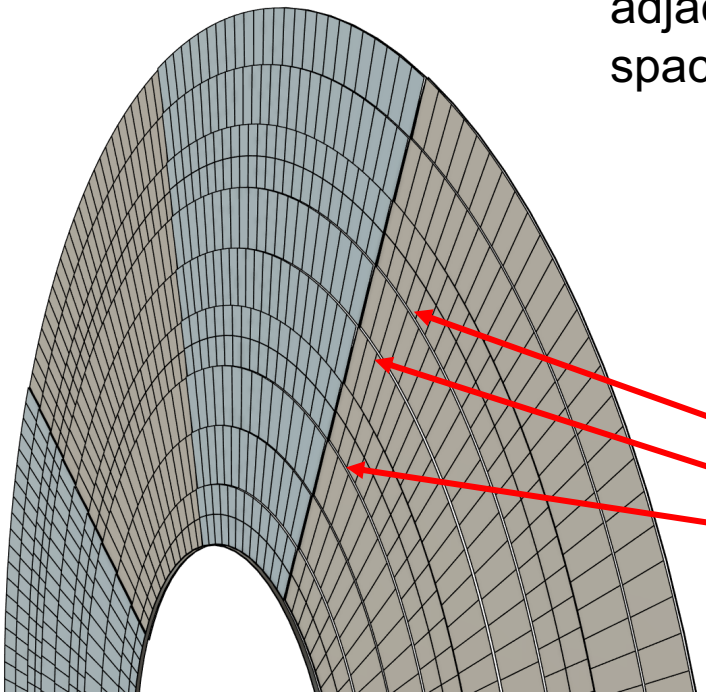


Overlapping Region

Qi YAN, Yihan ZHANG, *and* Shoudong LUO



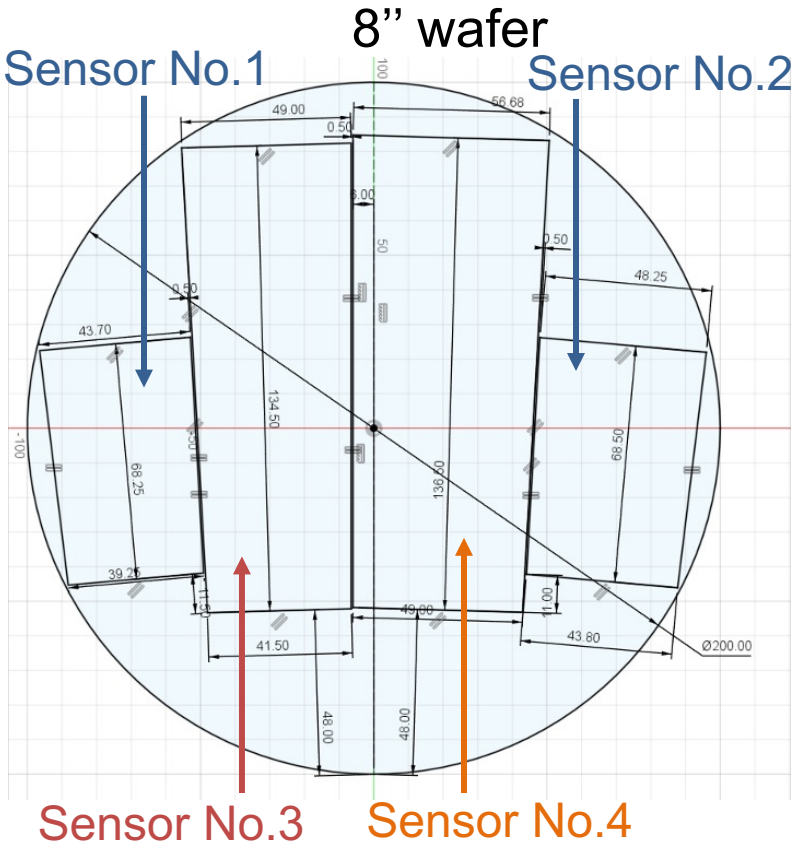
To simplify installation, adjacent sectors are spaced 5mm apart.

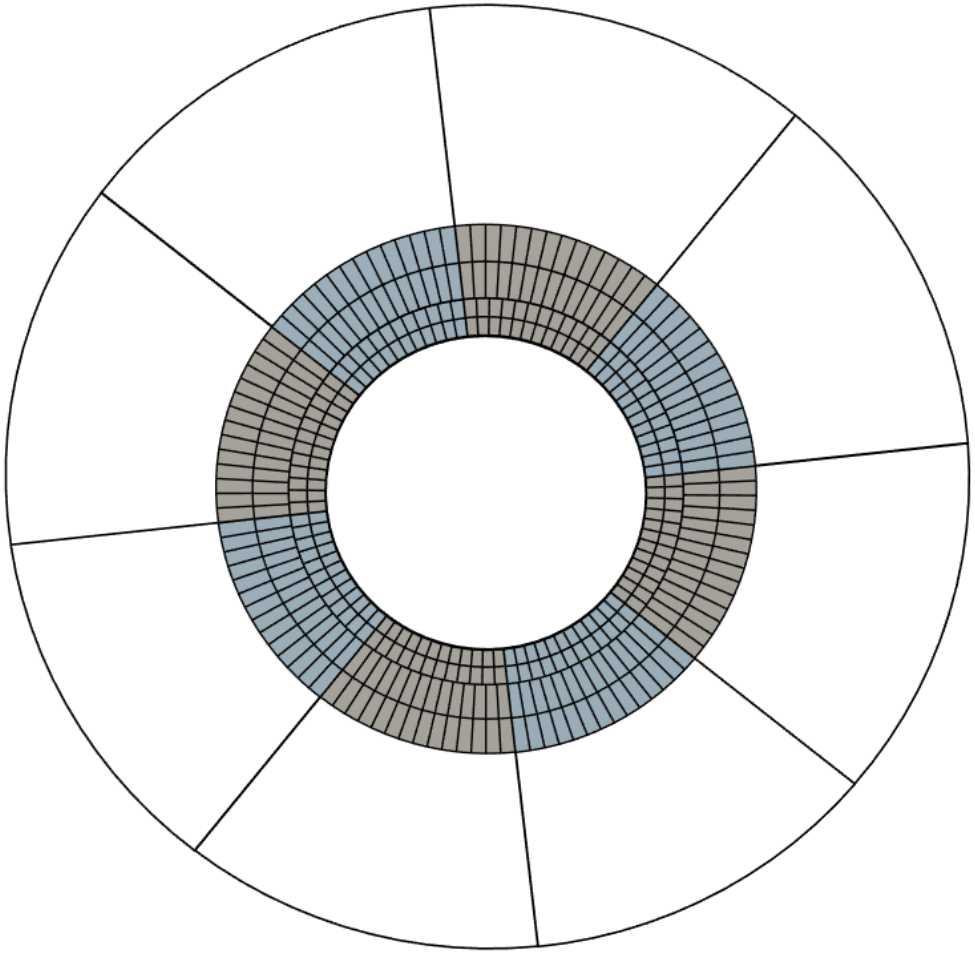


Slight tilt (2 to 4 deg) from inner ring to outer ring to cover full area.

R: 600mm-1010mm (Group 1)

Qi YAN, Yihan ZHANG, *and* Shoudong LUO

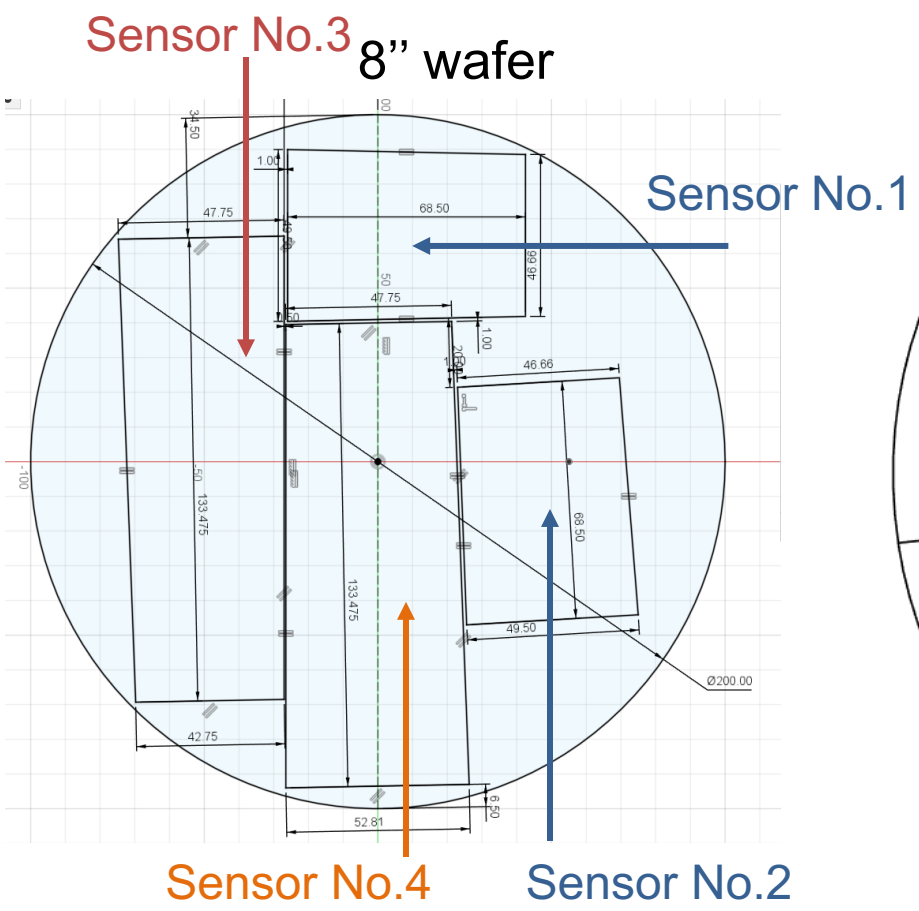


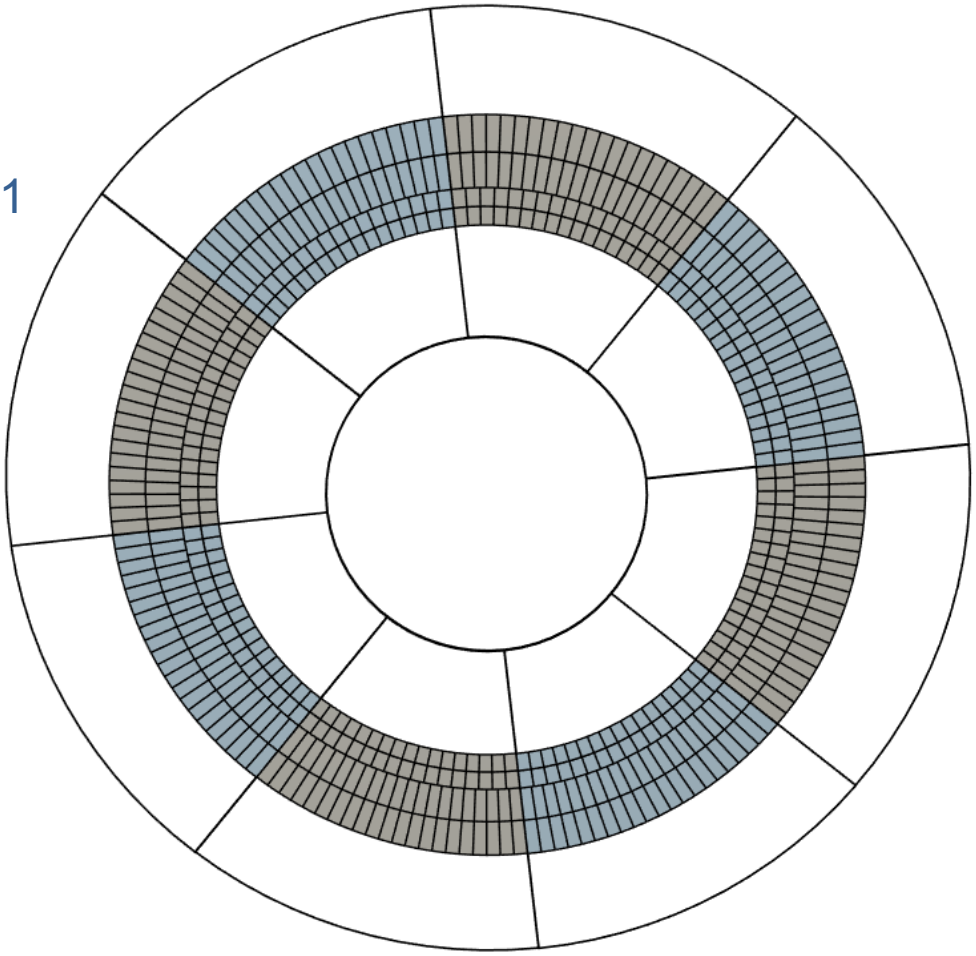


Type of sensors	1	2	3	4		
Number of sensors	96	96	112	112	112	Wafers

R: 1010 mm-1412 mm (Group 2)

Qi YAN, Yihan ZHANG, *and* Shoudong LUO

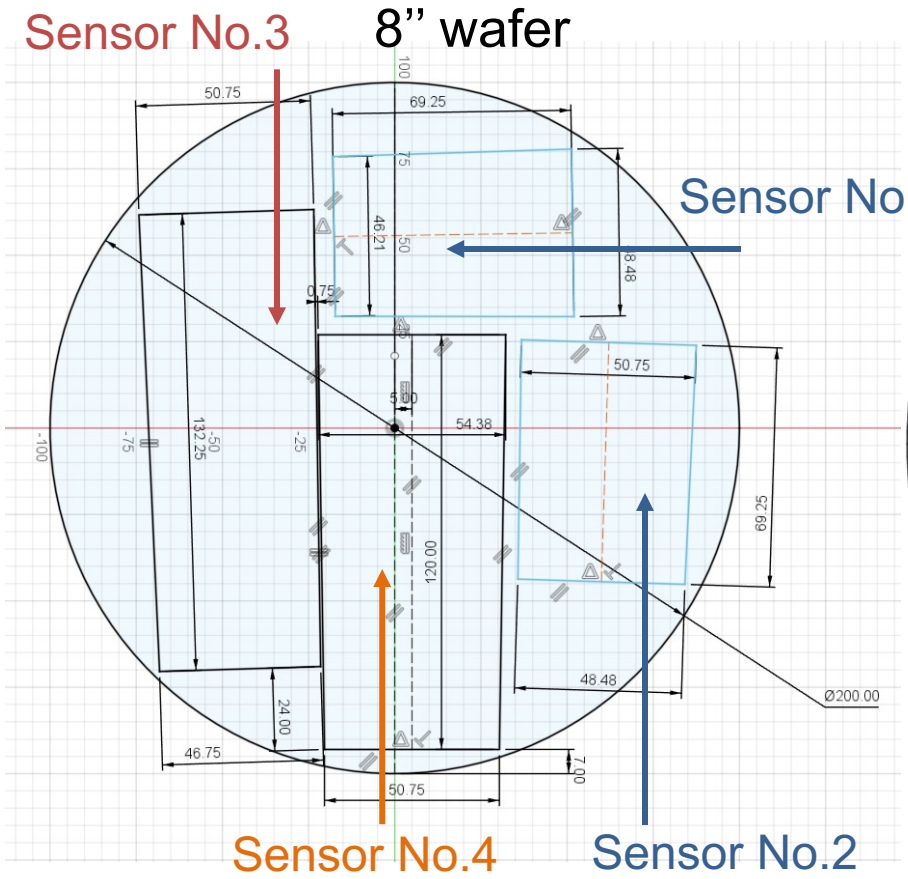


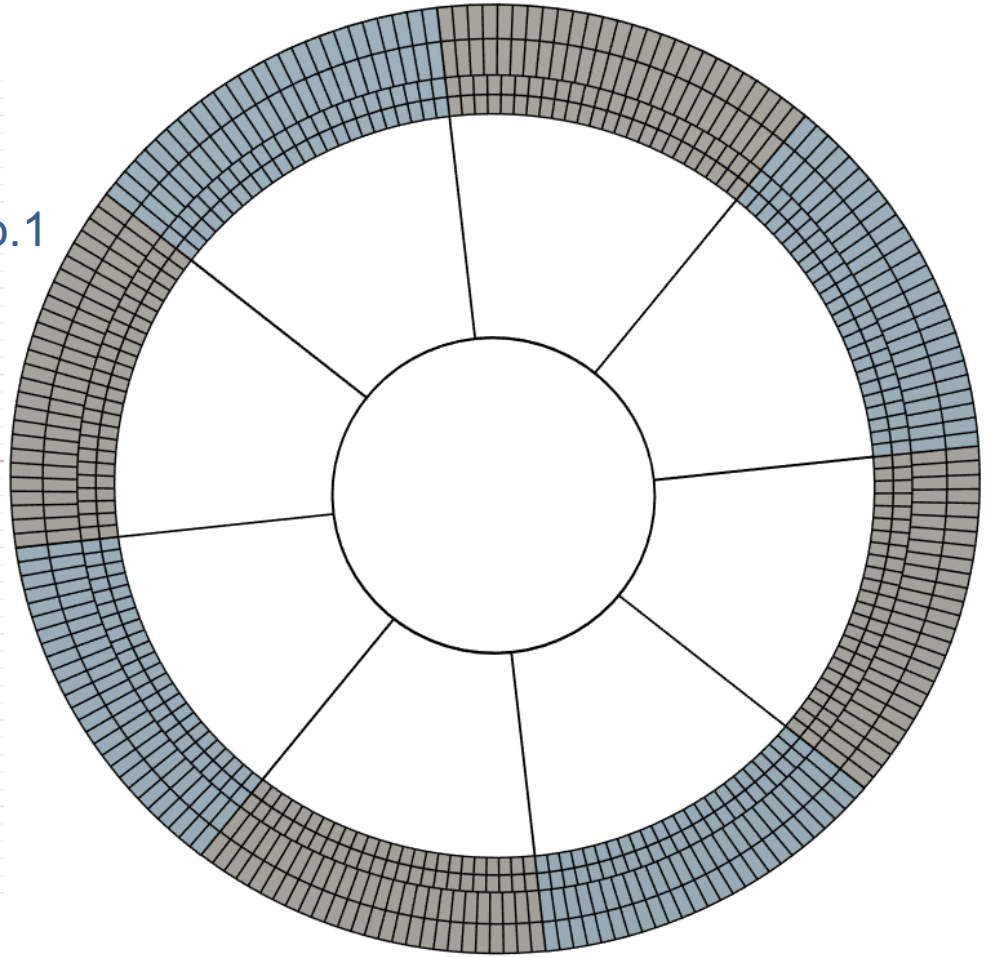


Type of sensors	1	2	3	4		
Number of sensors	136	136	168	168	168	Wafers

R: 1412 mm-1800 mm (Group 3)

Qi YAN, Yihan ZHANG, *and* Shoudong LUO





Type of sensors	1	2	3	4		
Number of sensors	192	192	208	208	208	Wafers

Other Features of the New OTK Endcap Design

Qi YAN, Yihan ZHANG, *and* Shoudong LUO

1) The widths of all trapezoid sensors are ~5 cm, and the corresponding number of readout channels is ~512 channels, which allows for the use of the same number of ASICs for all sensors.

2) The total length of 2 small neighboring sensors is ~13 cm, which is similar to the length of all long sensors. These neighboring small sensors can be connected through wire bonding to share a common readout.