CEPC Silicon Tracker Progress Report (7)

Qi Yan *on behalf of the Silicon Tracker Group*

Sep 10, 2024, IHEP

Remaining Tasks of Silicon Tracker

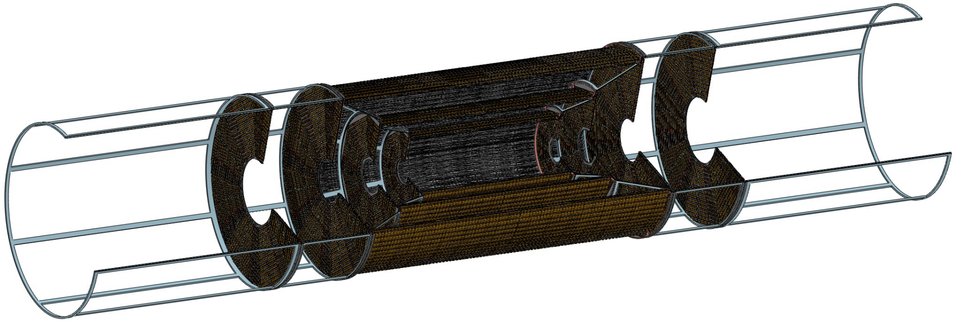
- ITK

1) ITK detailed mechanical analysis and cooling study. (Progress report today)
2) ITK endcap PID using dE/dx measurements. (Study on going and will be reported in near future)
3) Layout optimization study. (Study on going and will be reported in near future)

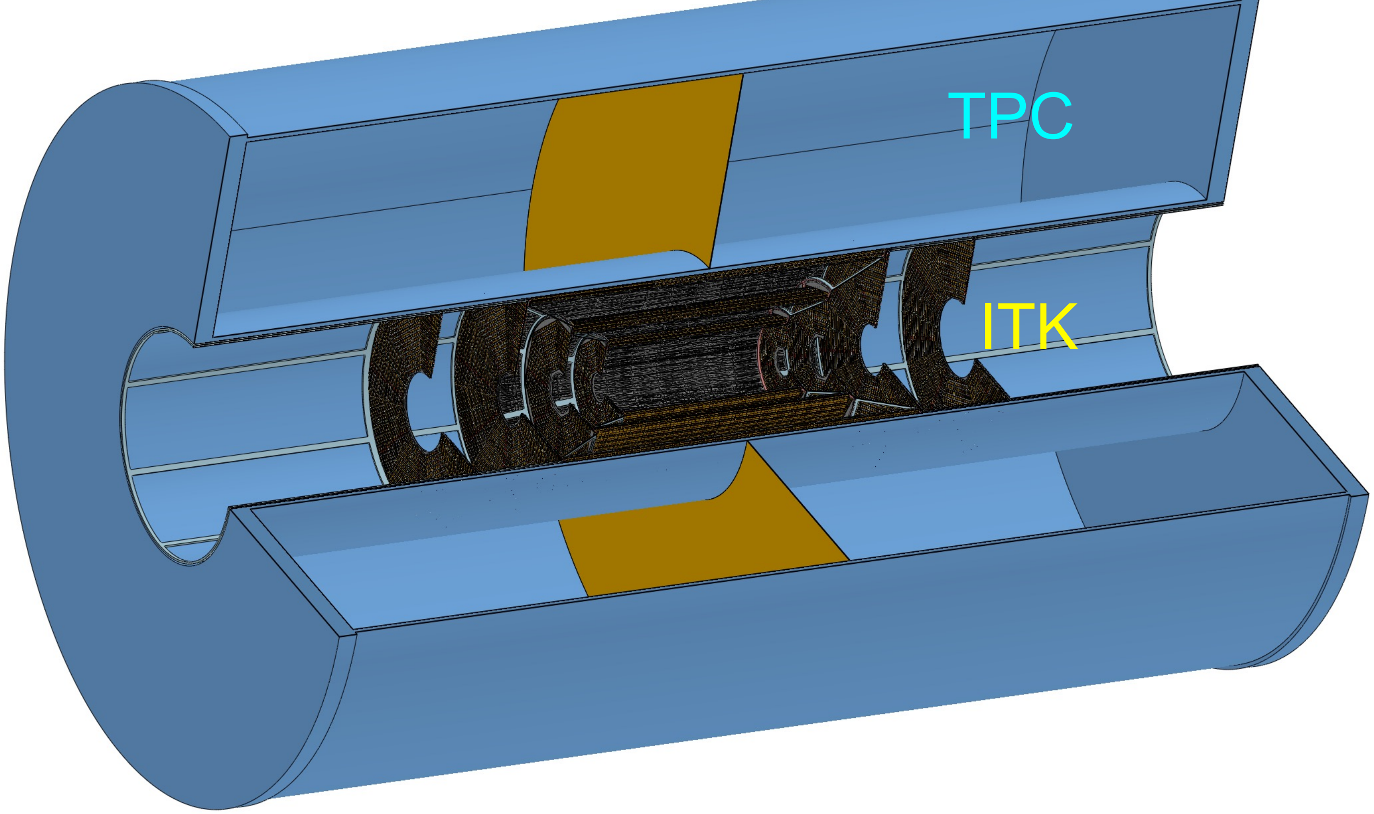
- OTK

1) Study of OTK ASIC cooling with Heat Sink. (Progress report today)
2) Update of OTK endcap design with trapezoid sensors. (Report today)
3) OTK mechanical design (endcap) and optimization (barrel), incorporating into the CEPC overall mechanical drawing.
4) OTK detailed mechanical analysis and cooling study, including the overall cooling strategy.

ITK Supporting Mechanics and Installation



CEPC detector meeting on Sep 3
(Quan JI)

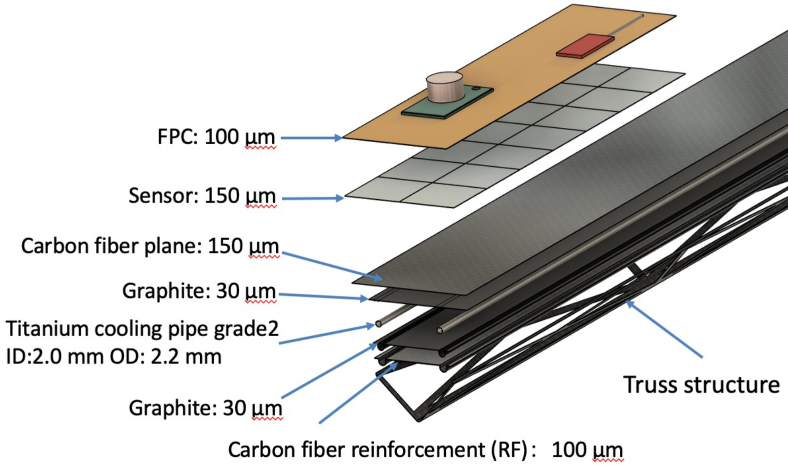


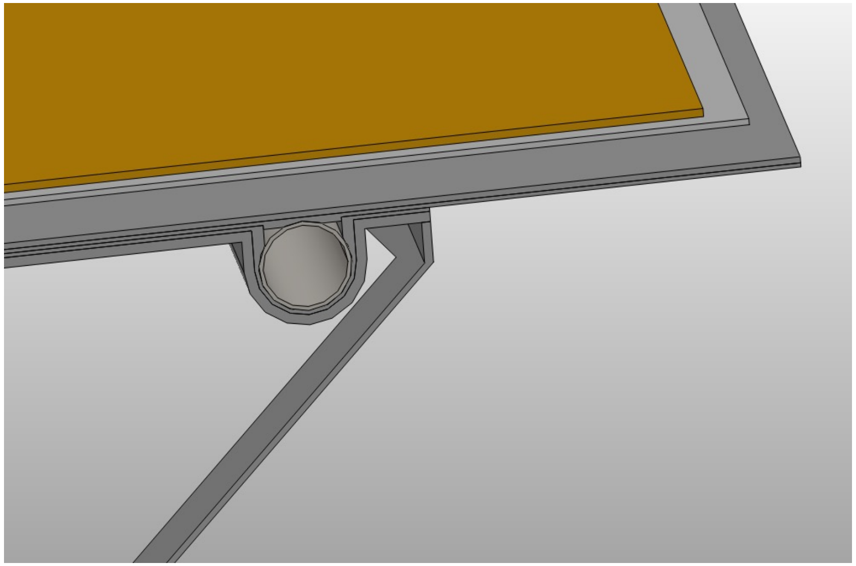
ITK Mechanical Analysis

Mechanical strength calculation with simplified model:

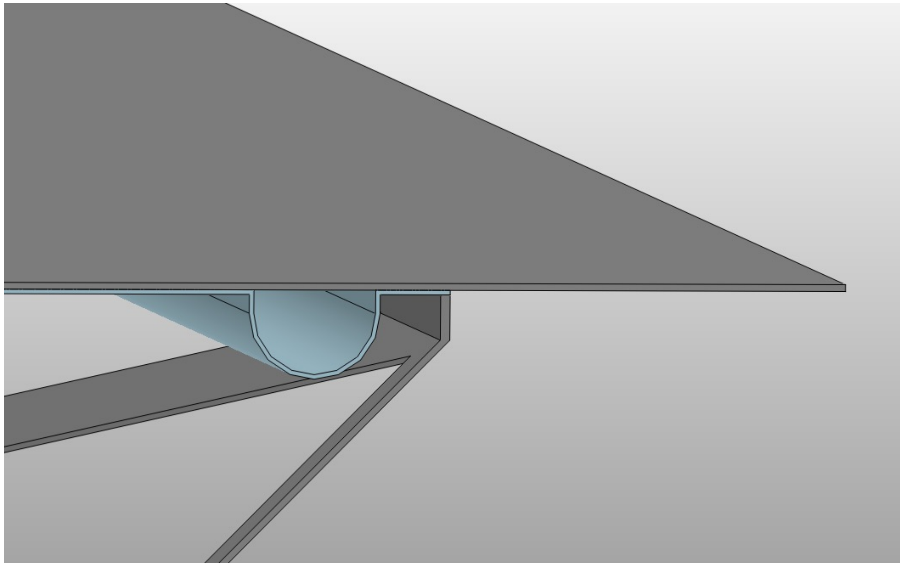
Remove the sensor, graphite layer, and Ti pipe, keeping the carbon plate and support (Ti pipe strength not considered).

Yujie LI *and* Quan JI





Original

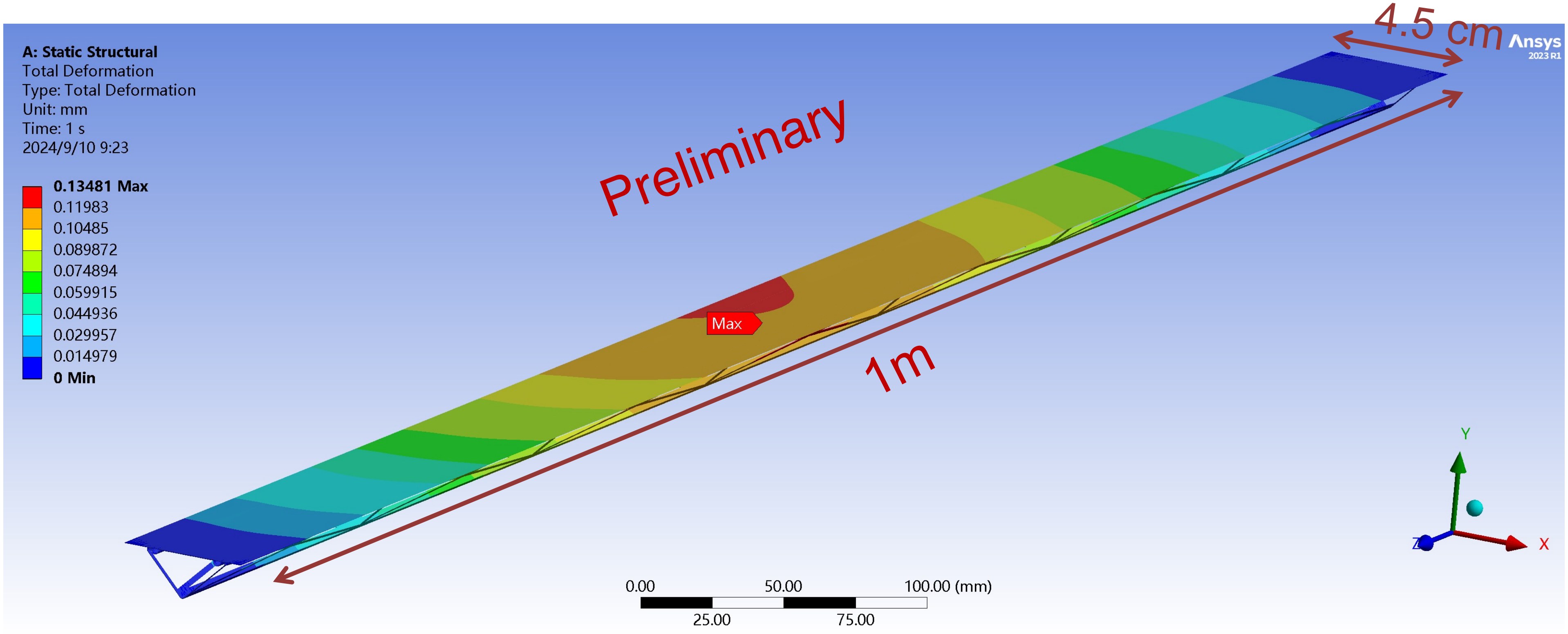


Simplified

Apply the removed components as a pressure load:

FPC+SENSOR, Graphite, Ti tube, …
S (carbon plate) = 0.045 m²
P = mg/S

Yujie LI *and* Quan JI



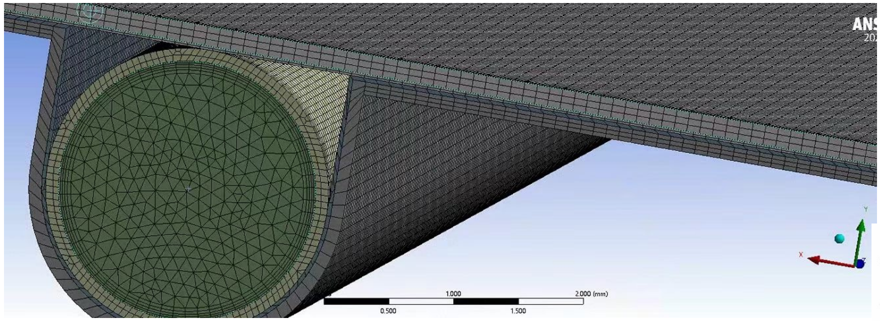
A: Static Structural
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1 s
2024/9/10 9:23

ITK Thermal Analysis

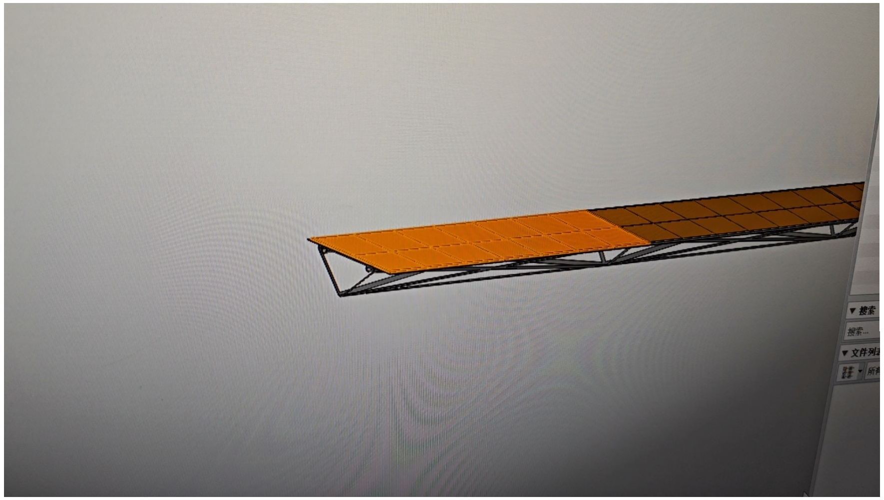
Thermal calculation model:

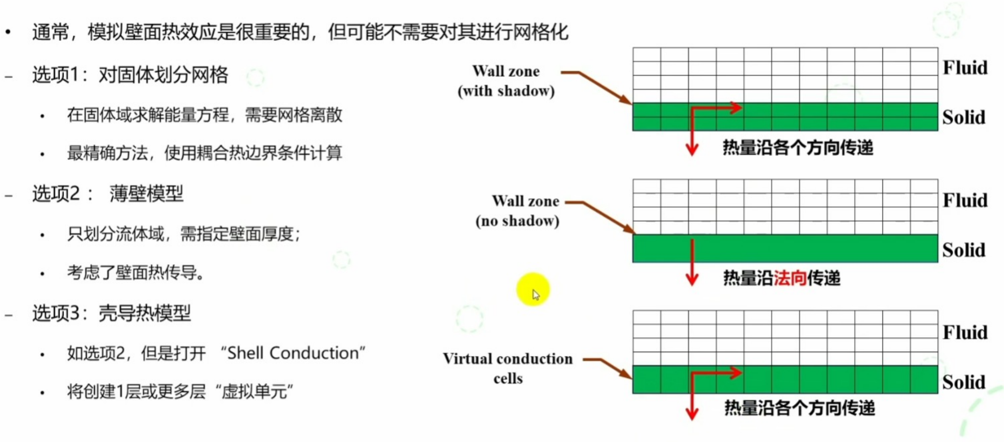
Even with a symmetric model and given the poor mesh quality of the graphite layer, a single stave in the thermal analysis has over forty million elements.

Plan: Probe the relationship between thickness and thermal conductivity based on a single module to provide a simplification for the whole stave calculation.



Yujie LI *and* Quan JI





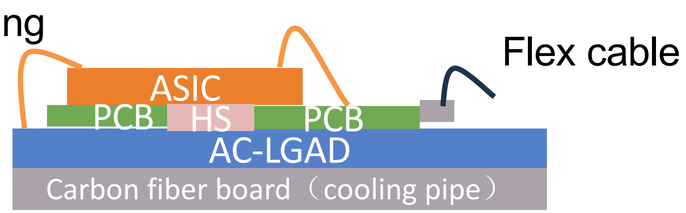
- 通常，模拟壁面热效应是很重要的，但可能不需要对其进行网格化
  - 选项1：对固体划分网格
    - 在固体域求解能量方程，需要网格离散
    - 最精确方法，使用耦合热边界条件计算
  - 选项2： 薄壁模型
    - 只划分流体域，需指定壁面厚度；
    - 考虑了壁面热传导。
  - 选项3：壳导热模型
    - 如选项2，但是打开 “Shell Conduction”
    - 将创建1层或更多层 “虚拟单元”

ITK thermal analysis is ongoing.

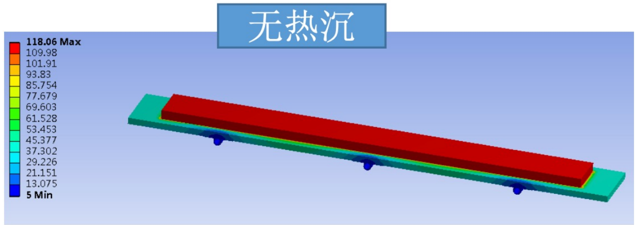
Study of OTK ASIC Cooling with Heat Sink

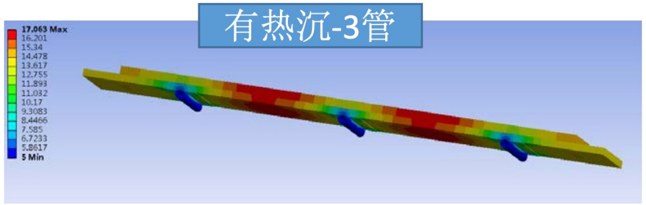
The sensor heating dissipation (20 mW/channel, strip 0.01 cm*7 cm) is ~300 mW/cm^2, mainly contributed by the ASIC. Adding a heat sink (HS) to the PCB can enhance thermal conduction, enabling more efficient heat transfer from the ASIC. This is a reasonable proposal, and the choice of HS materials is currently under study.

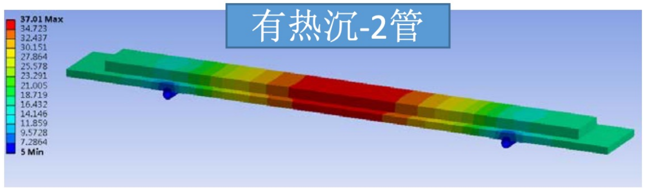
Yunyun FAN



Heat sink(HS)
Candidate: Cu, Al, graphene







ASIC Power: 35.84W (15x140x3 mm)
PCB t=1.6mm
LGAD t= 0.5mm

Jingyu FU

冷管温度5℃

当前初始尺寸方案已有初步结果：

显示热沉效果比较好。

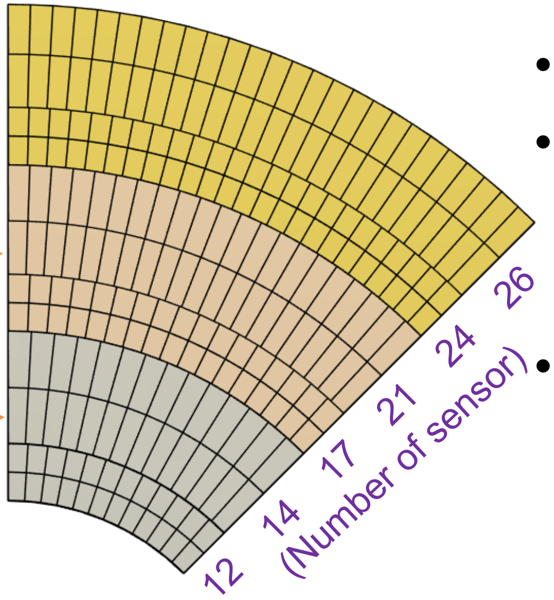
之前提供的发热量计算有误。后续按更新发热量，分析对比其他配置，优化方案。

The thermal simulation study with heat sink is still ongoing.
The overall cooling strategy for OTK (~300 kW) will need to be considered.

Update of OTK Endcap Design with Trapezoid Sensors

CEPC detector meeting on Sep 3:

Qi YAN, Yihan ZHANG, *and* Shoudong LUO



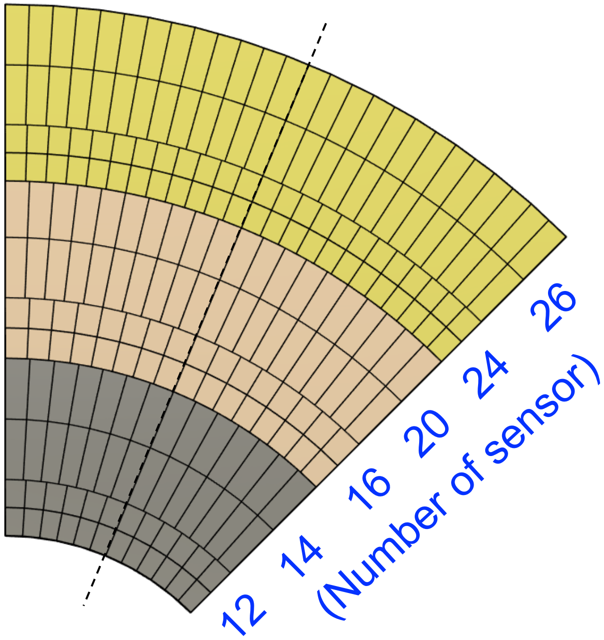
Group 3: 1412 mm-1800 mm

Group 2: 1010 mm-1412 mm

Group 1: 600 mm-1010 mm

- 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 or 1/16 sector.

New updated design:



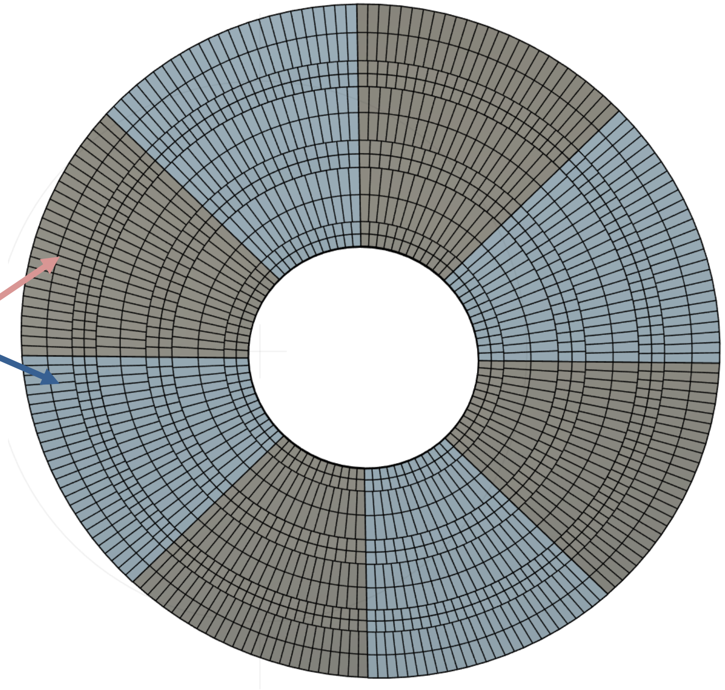
Group 3: 1412 mm-1816 mm

Group 2: 1006 mm-1412 mm

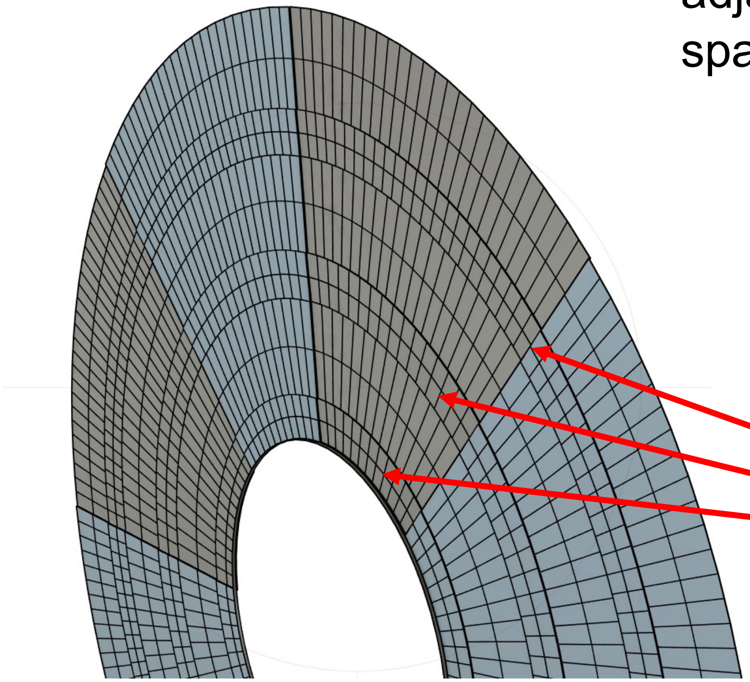
Group 1: 600 mm-1006 mm

Overlapping Region

Qi YAN, Yihan ZHANG, *and* Shoudong LUO

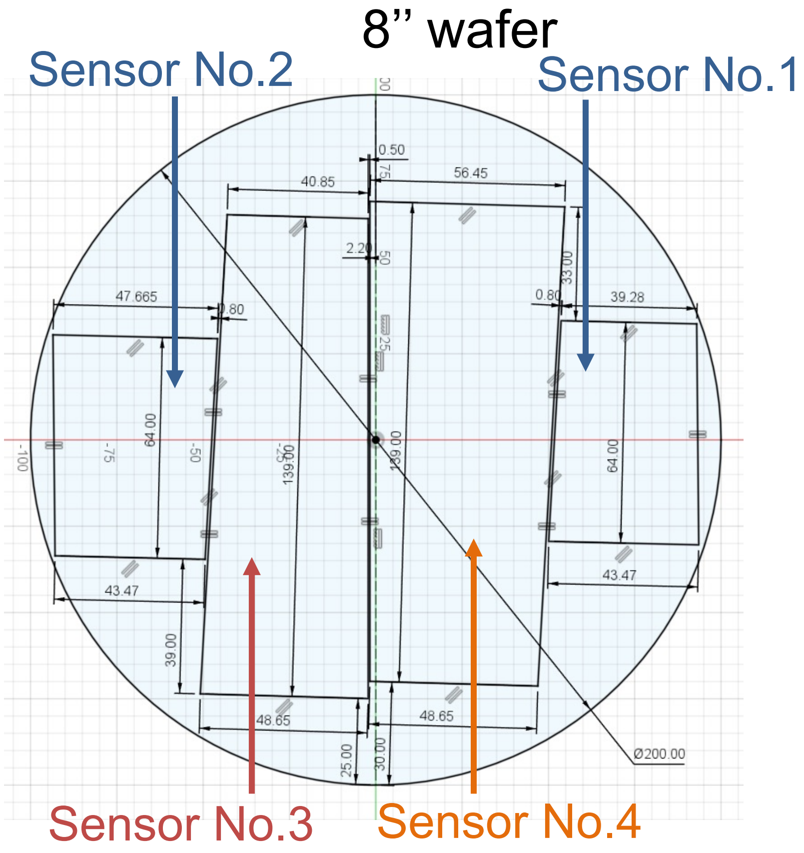


To simplify installation, adjacent sectors are spaced 5 mm apart.



Slight tilt (2 to 4 deg) on 3 small rings to cover the full area. No dead area in the layout. Each sensor has ~3% inactive area, assuming a 300 μm guard ring.

R: 600mm-1006mm (Group 1)



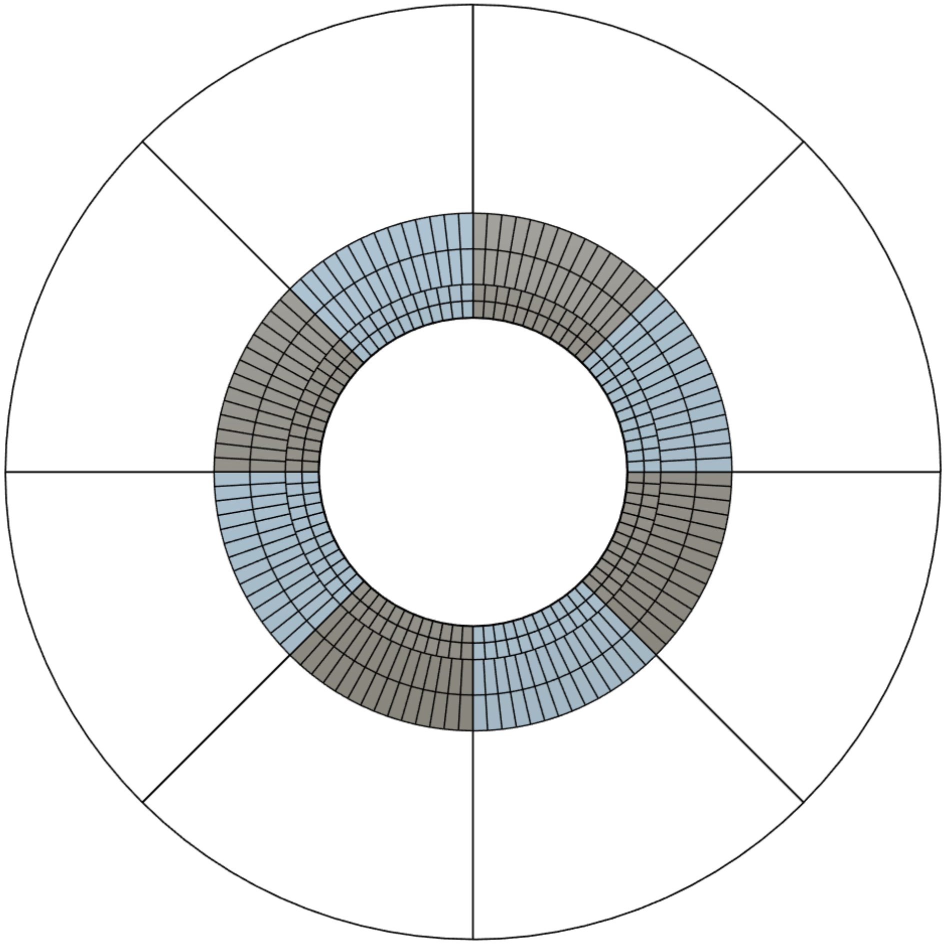
8'' wafer

Sensor No.2

Sensor No.1

Sensor No.3

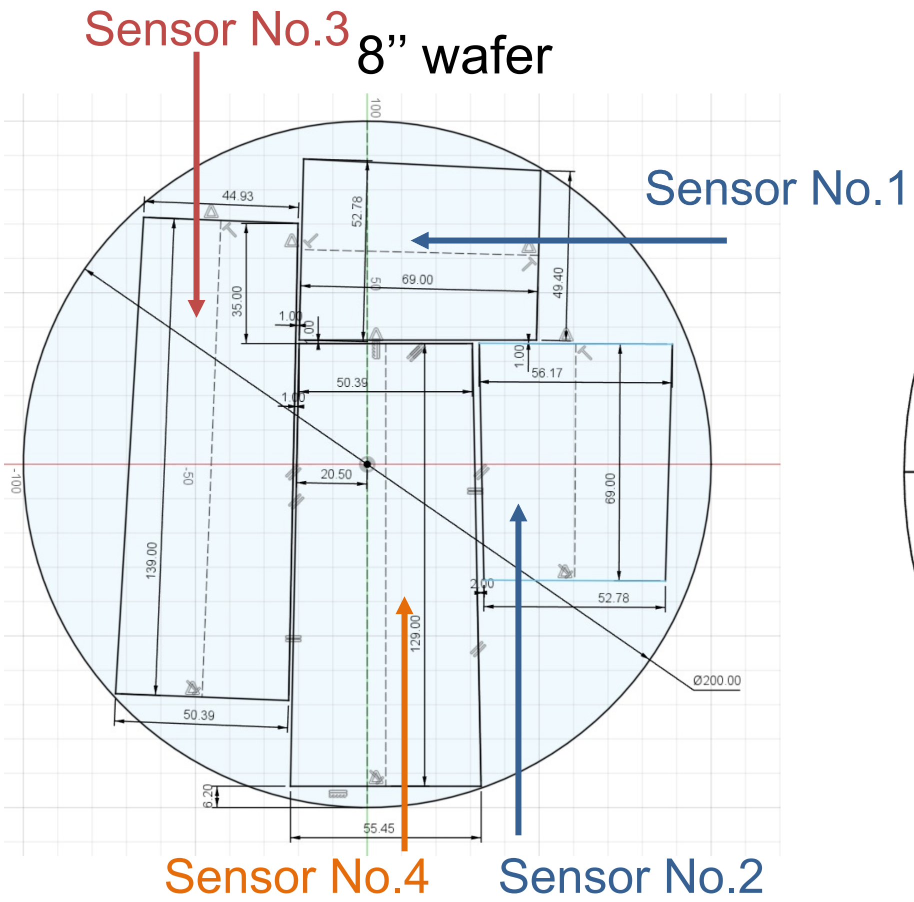
Sensor No.4



Type of sensors	1	2	3	4		
N sensors (Sep 3)	96	96	112	112	112	N wafers
N sensors (New)	96	96	112	112	112	N wafers

R: 1006 mm-1412 mm (Group 2)

8'' wafer

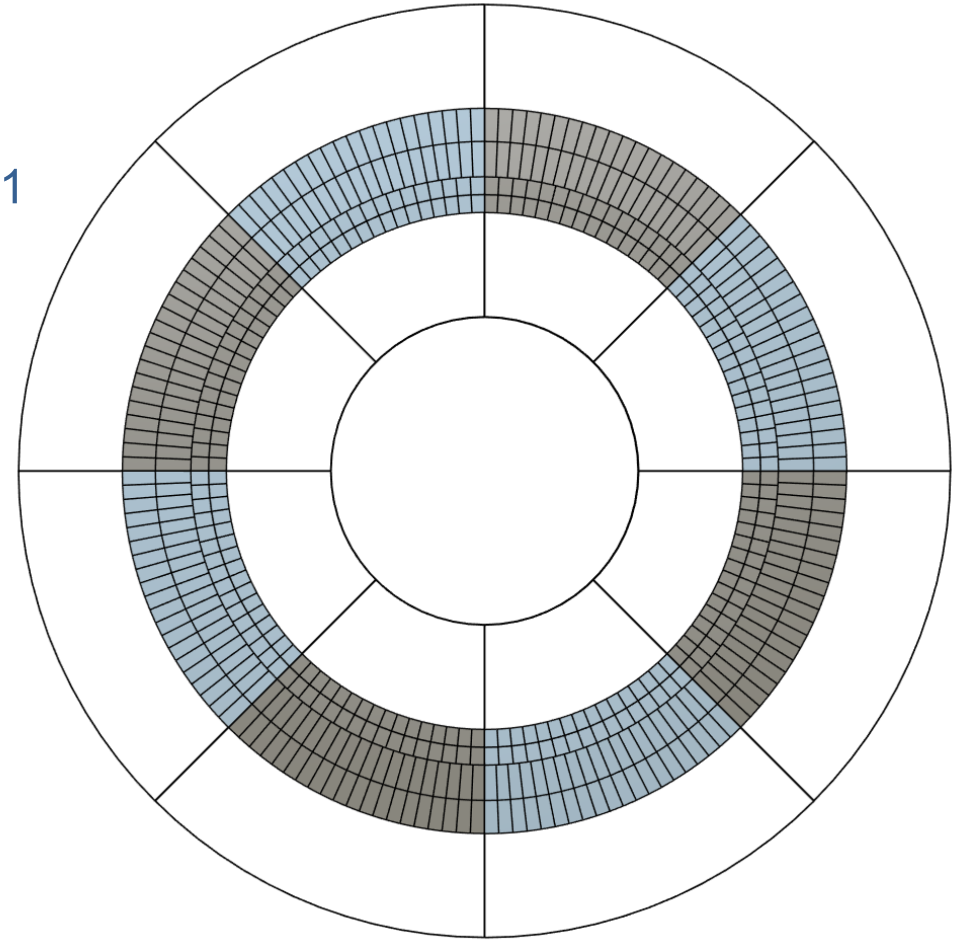


Sensor No.3

Sensor No.1

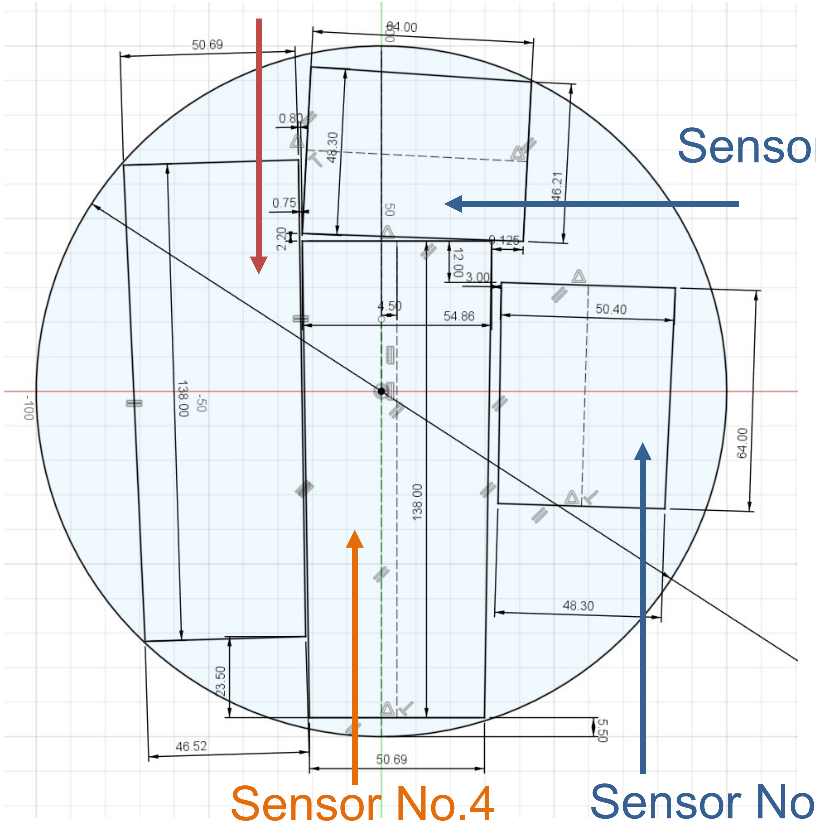
Sensor No.4

Sensor No.2



Type of sensors	1	2	3	4		
N sensors (Sep 3)	136	136	168	168	168	N wafers
N sensors (New)	128	128	160	160	160	N wafers

R: 1412 mm-1816 mm (Group 3)



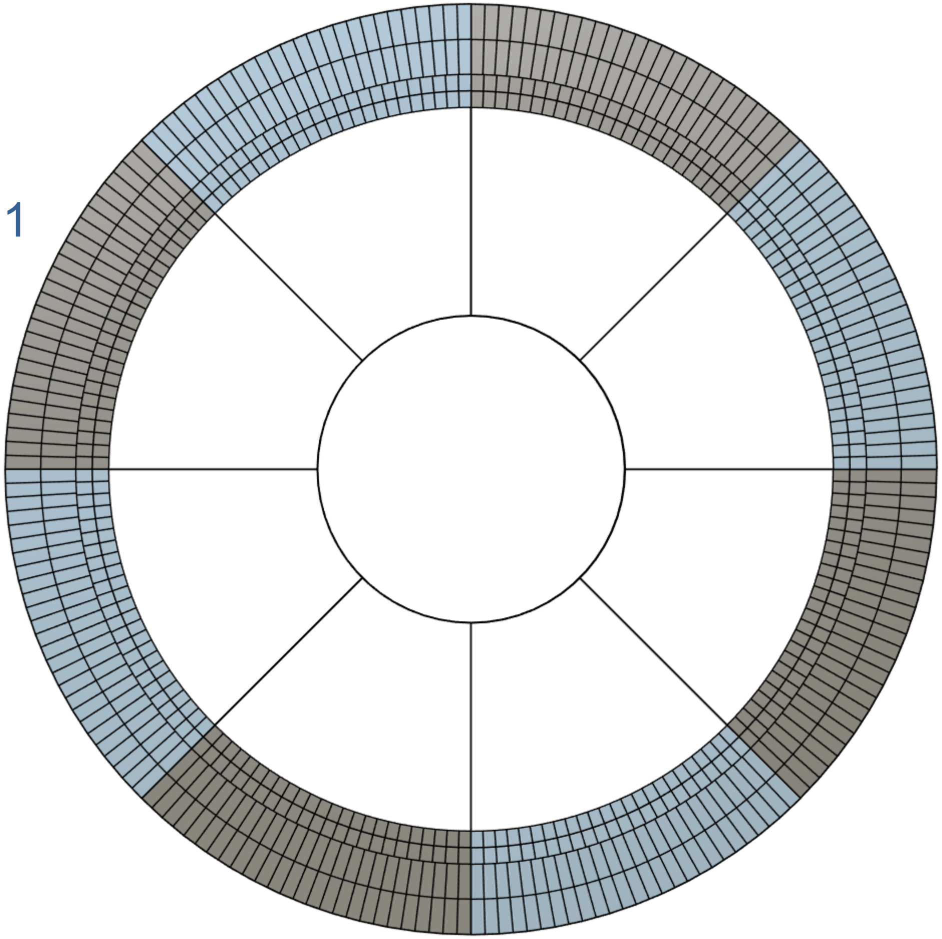
Sensor No.3

8'' wafer

Sensor No.1

Sensor No.4

Sensor No.2



Type of sensors	1	2	3	4		
N sensors (Sep 3)	192	192	208	208	208	N wafers
N sensors (New)	192	192	208	208	208	N wafers

Other Features of the New OTK Endcap Design

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.