

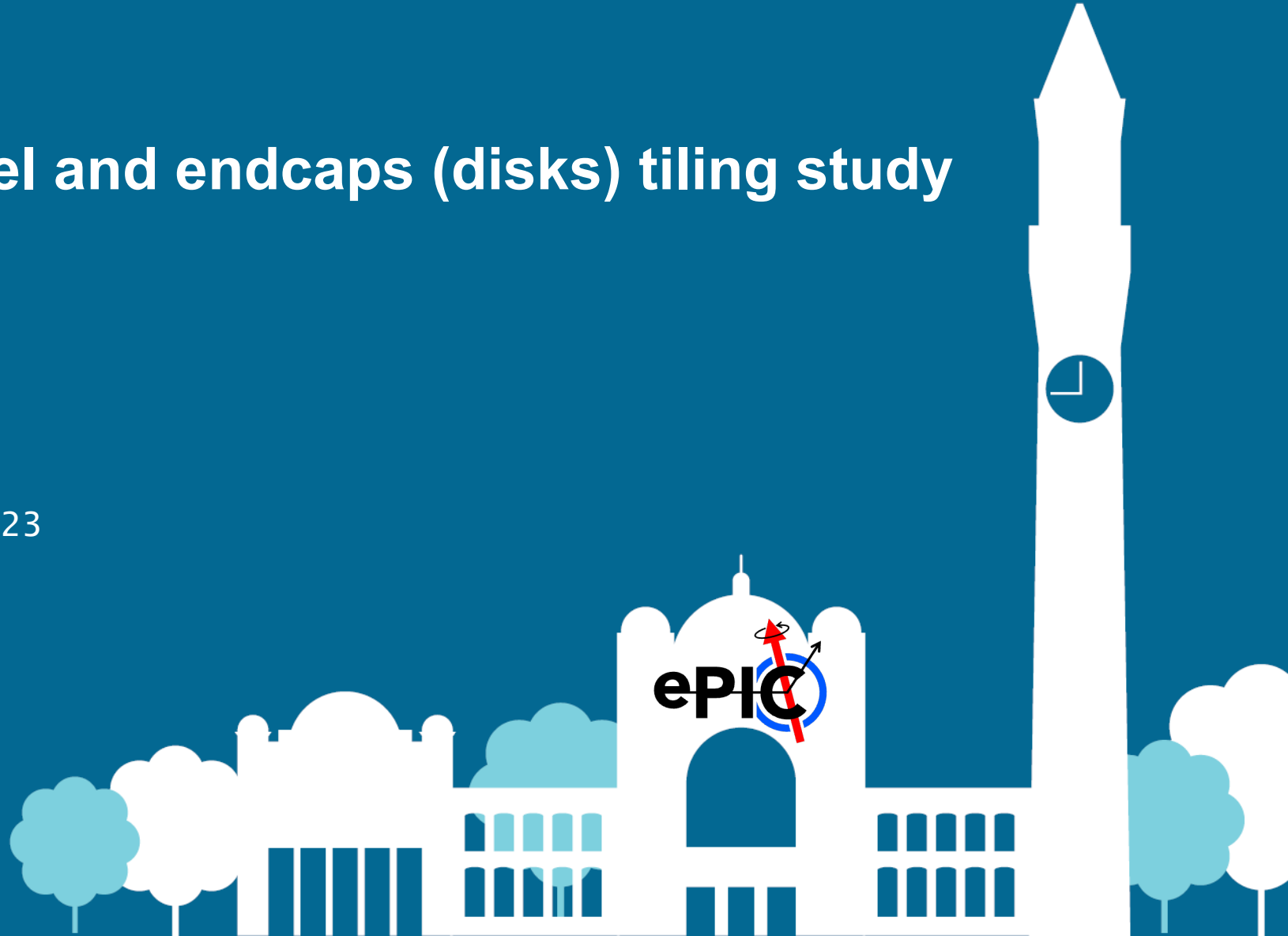


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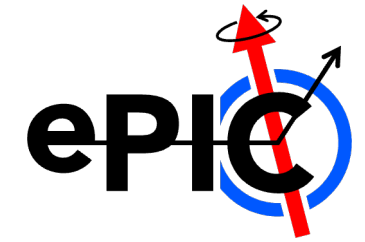
# Update on outer barrel and endcaps (disks) tiling study

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ePIC SVT DSC Meeting 8<sup>th</sup> August 2023



# ITS3 – Stitched Sensor



## Updated sensor specifications

Lol: RSU =  $18.85 \times 30 \text{ mm}^2$ , 9 RSUs per segment, active length = 270 mm

ER1: RSU =  $14 \times 25.5 \text{ mm}^2$ , 10 RSUs per segment, active length = 255 mm

ER2: RSU =  $19.564 \times 21.666 \text{ mm}^2$ , 12 RSUs per segment, active length = 260 mm

## ER2 Stitched Sensor

ER2 Sensor aims to meet the ITS3 requirements

Layer 0: 12 x 3 repeated units+endcaps

Layer 1: 12 x 4 repeated units+endcaps

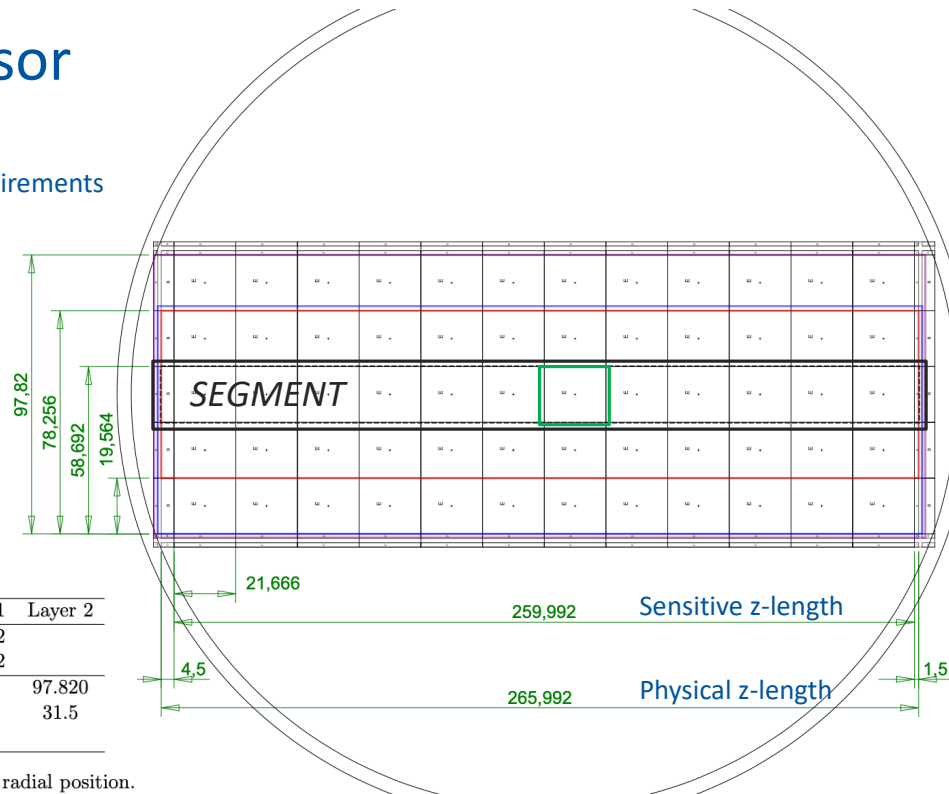
Layer 2: 12 x 5 repeated units+endcaps

 Repeated (Stitched) Sensing Unit

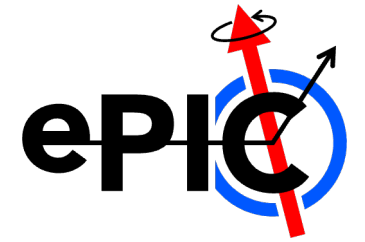
### AZIMUTHAL WIDTH UPDATED

| IB Layer Parameters         | Layer 0 | Layer 1 | Layer 2 |
|-----------------------------|---------|---------|---------|
| Sensor length [mm]          |         | 265.992 |         |
| Sensitive length [mm]       |         | 259.992 |         |
| Sensor azimuthal width [mm] | 58.692  | 78.256  | 97.820  |
| Radial position [mm]        | 19.0    | 25.2    | 31.5    |
| Equatorial gap [mm]         |         | 1.0     |         |

Table 3.2: Design dimensions of the sensor dies and radial position.



# ITS3 – Stitched Sensor

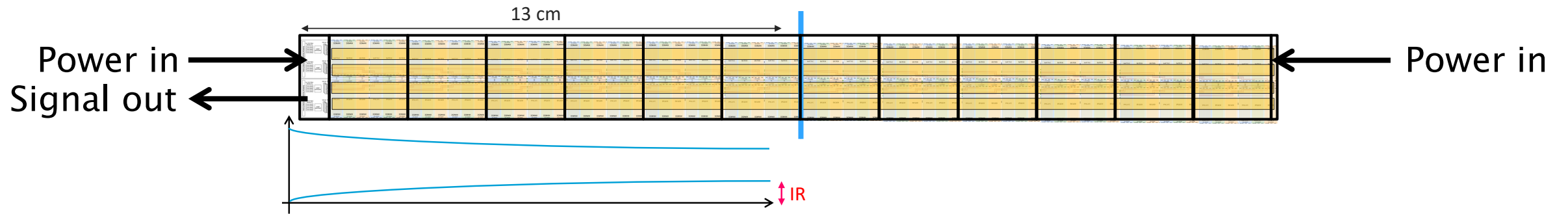


- Sensor length considerations for Outer Barrel and Endcaps

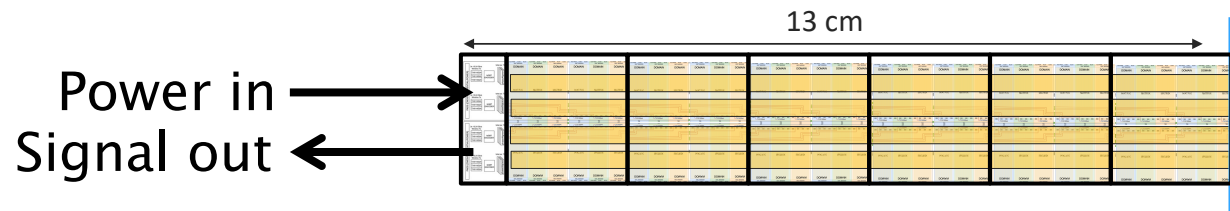
Concern over IR drop over the length of the stitched sensor

Mitigation is to supply power from both ends of the sensor; readout at one end

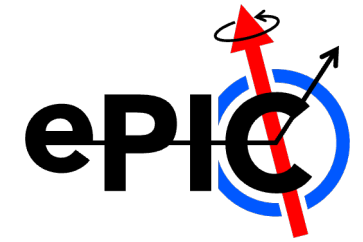
Need to allow for endcaps (periphery) at both ends (4.5 mm and 1.5 mm, respectively)



If we restrict the EIC LAS to a maximum of 6 RSUs, it should be possible to power from one end only



# ePIC – SVT Barrel Layers



## ▪ Sensor length considerations

### Current conceptual design based on ITS3 Lol

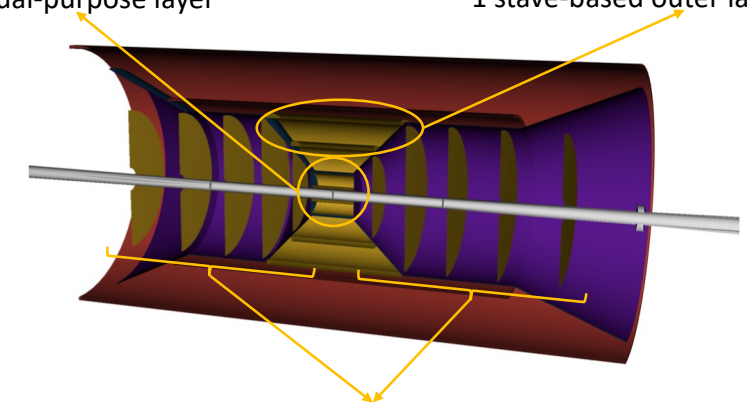
|    | Layer | r (mm) | l (mm) | X/X <sub>0</sub> (%) | Area (m <sup>2</sup> ) | theta (deg) | eta  |
|----|-------|--------|--------|----------------------|------------------------|-------------|------|
| IB | L0    | 36.0   | 270    | 0.05                 | 0.06                   | 14.93       | 2.03 |
|    | L1    | 48.0   | 270    | 0.05                 | 0.08                   | 19.57       | 1.76 |
|    | L2    | 120.0  | 270    | 0.05                 | 0.20                   | 41.63       | 0.97 |
| OB | L3    | 270    | 540    | 0.25                 | 0.92                   | 45.00       | 0.88 |
|    | L4    | 420    | 840    | 0.55                 | 2.22                   | 45.00       | 0.88 |

#### Inner Barrel (IB)

- 2 curved silicon vertex layers
- 1 curved dual-purpose layer

#### Outer Barrel (OB)

- 1 stave-based sagitta layer
- 1 stave-based outer layer

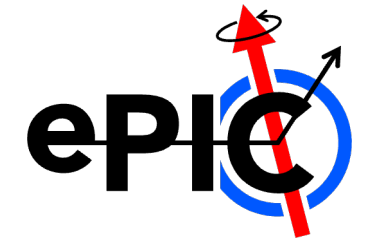


#### Electron/Hadron Endcaps (EE, HE)

- 5 disks on either side of the IP

### Proposed new layout based on ITS3 ER2 sensor

|          | Layer | r (mm) | l (mm) | X/X <sub>0</sub> (%) | Area (m <sup>2</sup> ) | theta (deg) | eta  | n <sub>rsu</sub> | T6 | T5 |
|----------|-------|--------|--------|----------------------|------------------------|-------------|------|------------------|----|----|
| IB       | L0    | 37.4   | 260    | 0.05                 | 0.06                   | 16.04       | 1.96 |                  |    |    |
|          | L1    | 49.8   | 260    | 0.05                 | 0.08                   | 20.97       | 1.69 |                  |    |    |
|          | L2    | 124.5  | 260    | 0.05                 | 0.20                   | 43.77       | 0.91 |                  |    |    |
| OB Opt 1 | L3    | 260    | 520    | 0.25                 | 0.85                   | 45.00       | 0.88 | 24               | 4  |    |
|          | L4    | 390    | 780    | 0.55                 | 1.91                   | 45.00       | 0.88 | 36               | 6  |    |
| OB Opt 2 | L3    | 270    | 520    | 0.25                 | 0.88                   | 46.08       | 0.85 | 24               | 4  |    |
|          | L4    | 420    | 780    | 0.55                 | 2.06                   | 47.12       | 0.83 | 36               | 6  |    |
| OB Opt 3 | L3    | 271    | 542    | 0.25                 | 0.92                   | 45.00       | 0.88 | 25               |    | 5  |
|          | L4    | 422    | 845    | 0.55                 | 2.24                   | 45.00       | 0.88 | 39               | 4  | 3  |



## ▪ Sensor length considerations

Current conceptual design based on ITS3 Lol

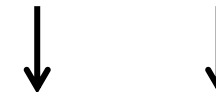
|    | Layer | r (mm) | l (mm) | X/X_0 (%) | Area (m <sup>2</sup> ) | theta (deg) | eta  |
|----|-------|--------|--------|-----------|------------------------|-------------|------|
| IB | L0    | 36.0   | 270    | 0.05      | 0.06                   | 14.93       | 2.03 |
|    | L1    | 48.0   | 270    | 0.05      | 0.08                   | 19.57       | 1.76 |
|    | L2    | 120.0  | 270    | 0.05      | 0.20                   | 41.63       | 0.97 |
| OB | L3    | 270    | 540    | 0.25      | 0.92                   | 45.00       | 0.88 |
|    | L4    | 420    | 840    | 0.55      | 2.22                   | 45.00       | 0.88 |

## Comments

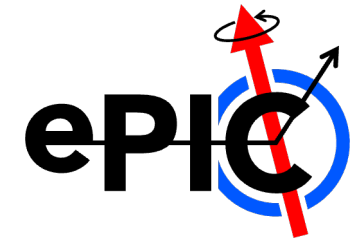
- Beam pipe radius = 31.76 mm
- New L0 radius is +5.64 mm
- New (and old) IB radii assume no overlap
- IB length is fixed by maximum 12 RSUs
- Note that lengths are active lengths - do not include the endcaps (4.5 mm and 1.5 mm)
- OB Opt 1: smaller radii to keep same eta coverage
- OB Opt 2: original radii with reduced eta coverage
- OB Opt 3: original radii and eta coverage by adding an additional sensor per layer
- T6 = 1x6 RSUs, T5 = 1x5 RSUs

Proposed new layout based on ITS3 ER2 sensor

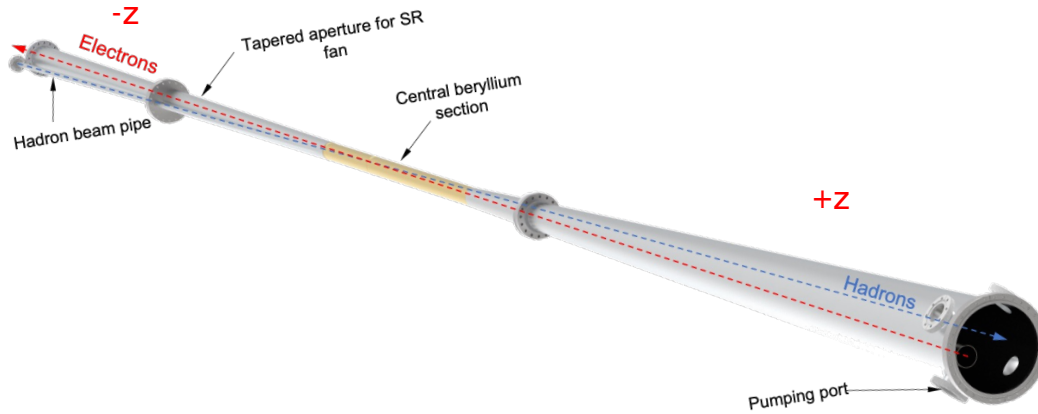
|          | Layer | r (mm) | l (mm) | X/X_0 (%) | Area (m <sup>2</sup> ) | theta (deg) | eta  | n_rsu | T6 | T5 |
|----------|-------|--------|--------|-----------|------------------------|-------------|------|-------|----|----|
| IB       | L0    | 37.4   | 260    | 0.05      | 0.06                   | 16.04       | 1.96 |       |    |    |
|          | L1    | 49.8   | 260    | 0.05      | 0.08                   | 20.97       | 1.69 |       |    |    |
|          | L2    | 124.5  | 260    | 0.05      | 0.20                   | 43.77       | 0.91 |       |    |    |
| OB Opt 1 | L3    | 260    | 520    | 0.25      | 0.85                   | 45.00       | 0.88 | 24    | 4  |    |
|          | L4    | 390    | 780    | 0.55      | 1.91                   | 45.00       | 0.88 | 36    | 6  |    |
| OB Opt 2 | L3    | 270    | 520    | 0.25      | 0.88                   | 46.08       | 0.85 | 24    | 4  |    |
|          | L4    | 420    | 780    | 0.55      | 2.06                   | 47.12       | 0.83 | 36    | 6  |    |
| OB Opt 3 | L3    | 271    | 542    | 0.25      | 0.92                   | 45.00       | 0.88 | 25    |    | 5  |
|          | L4    | 422    | 845    | 0.55      | 2.24                   | 45.00       | 0.88 | 39    | 4  | 3  |



# ePIC – Optimised disk layout

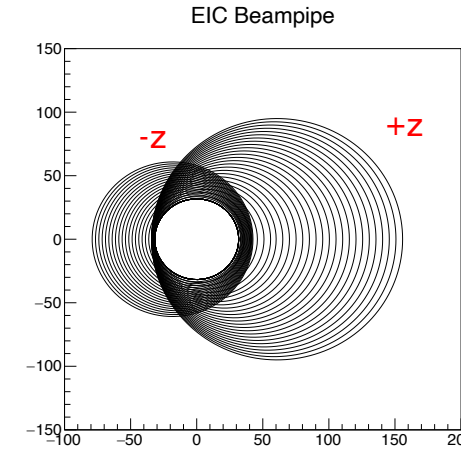


## Updated size specifications



Original study

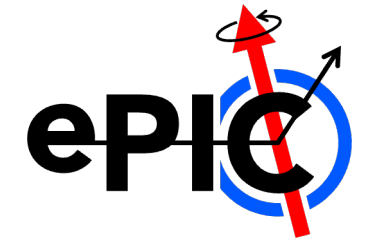
|    | Z - ePIC | R_bpipe | x_offset | R_inner | R_outer |
|----|----------|---------|----------|---------|---------|
| 5n | -1350    | 41.08   | -5.30    | 46.1    | 430     |
| 4n | -1000    | 35.76   | -1.81    | 40.8    | 430     |
| 3n | -700     | 31.76   | 0.00     | 36.8    | 430     |
| 2n | -450     | 31.76   | 0.00     | 36.8    | 430     |
| 1n | -250     | 31.76   | 0.00     | 36.8    | 230     |
| 1p | 250      | 31.76   | 0.00     | 36.8    | 230     |
| 2p | 450      | 31.76   | 0.00     | 36.8    | 430     |
| 3p | 700      | 32.86   | 0.56     | 37.9    | 430     |
| 4p | 1000     | 40.58   | 7.85     | 45.6    | 430     |
| 5p | 1350     | 49.12   | 16.02    | 54.2    | 430     |



Updated geometry

| Disk | Z - ePIC | R_bpipe | x_offset | R_inner | R_outer |
|------|----------|---------|----------|---------|---------|
| ED4  | -1050    | 36.52   | -2.31    | 41.52   | 421.4   |
| ED3  | -850     | 33.48   | -0.32    | 38.48   | 421.4   |
| ED2  | -650     | 31.76   | 0.00     | 36.76   | 421.4   |
| ED1  | -450     | 31.76   | 0.00     | 36.76   | 415     |
| ED0  | -250     | 31.76   | 0.00     | 36.76   | 240     |
| HD0  | 250      | 31.76   | 0.00     | 36.76   | 240     |
| HD1  | 450      | 31.76   | 0.00     | 36.76   | 415     |
| HD2  | 700      | 32.86   | 0.56     | 37.86   | 421.4   |
| HD3  | 1000     | 40.58   | 7.85     | 45.58   | 421.4   |
| HD4  | 1350     | 49.12   | 16.02    | 54.12   | 421.4   |

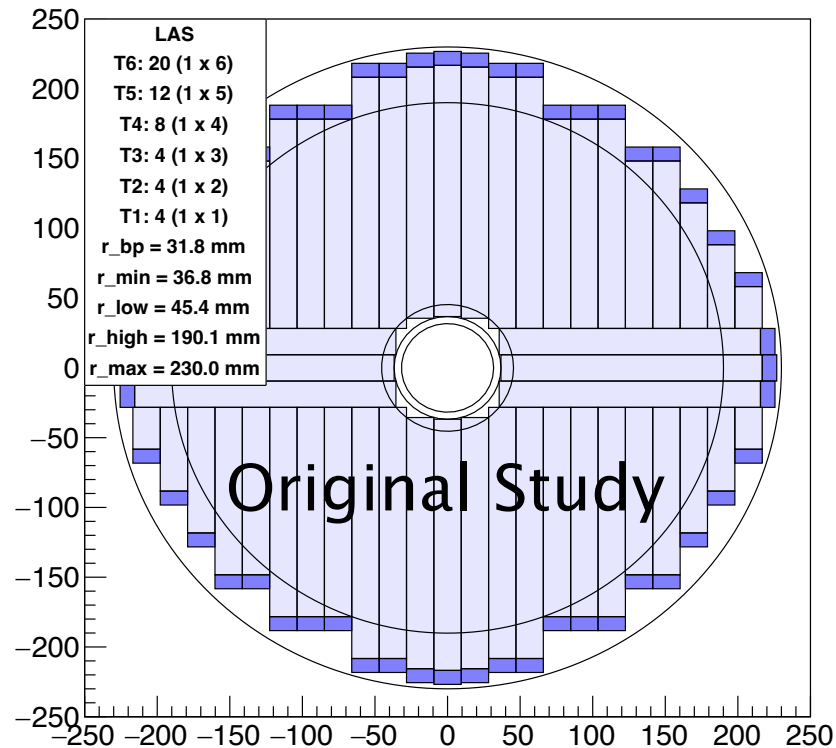
# ePIC Disk Layout Studies – Disk 0 (ED0/HD0)



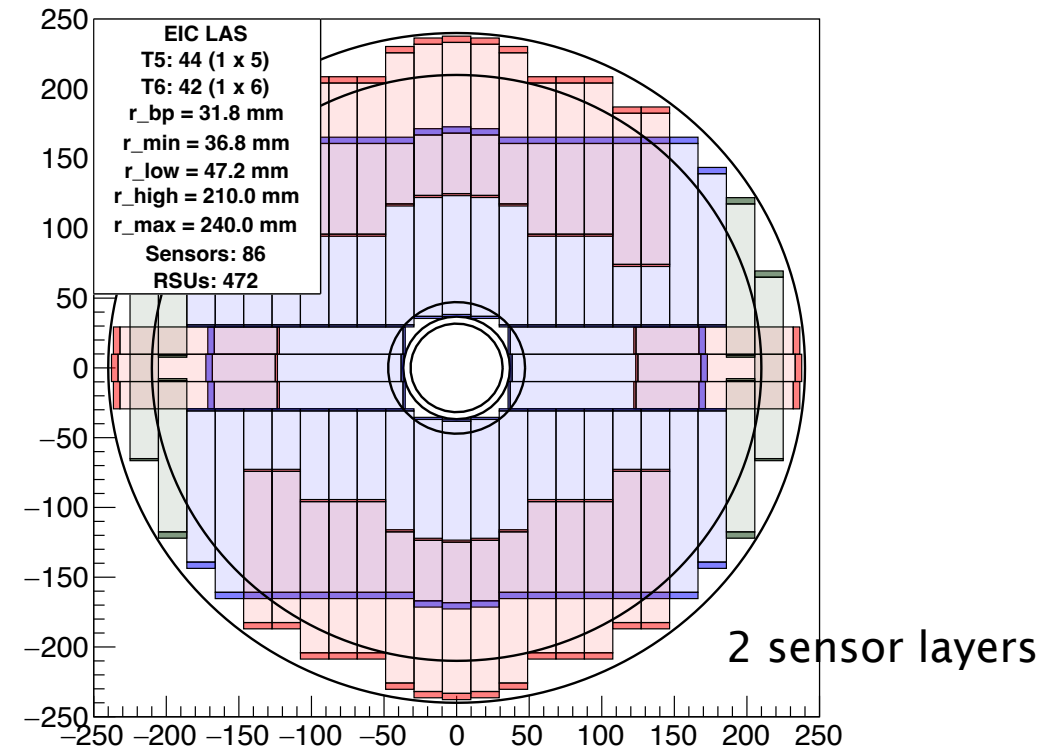
- Updated for new sensor size specification

First look: two different lengths (foundry rule/limitation) 1x6 RSUs and 1x5 RSUs

EIC-SVT Disk-1 Tile

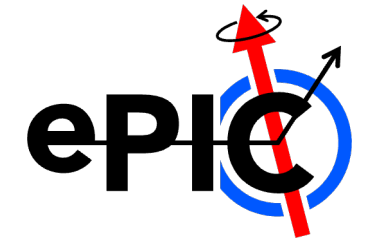


ePIC-SVT ED0/HD0 z=-/+250 cm



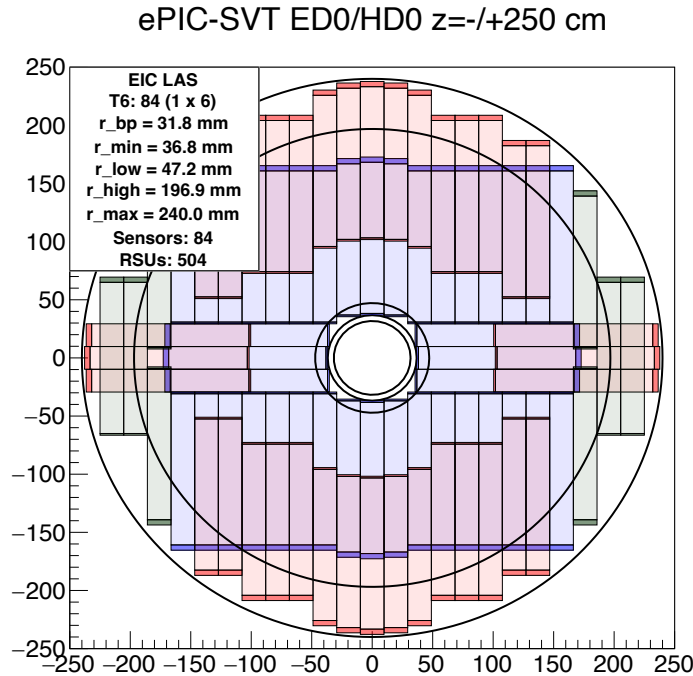
Max. required length = 9 RSU  
Shorter second sensor would lead to less overlap

# ePIC Disk Layout Studies – Disk 0 (ED0/HD0)

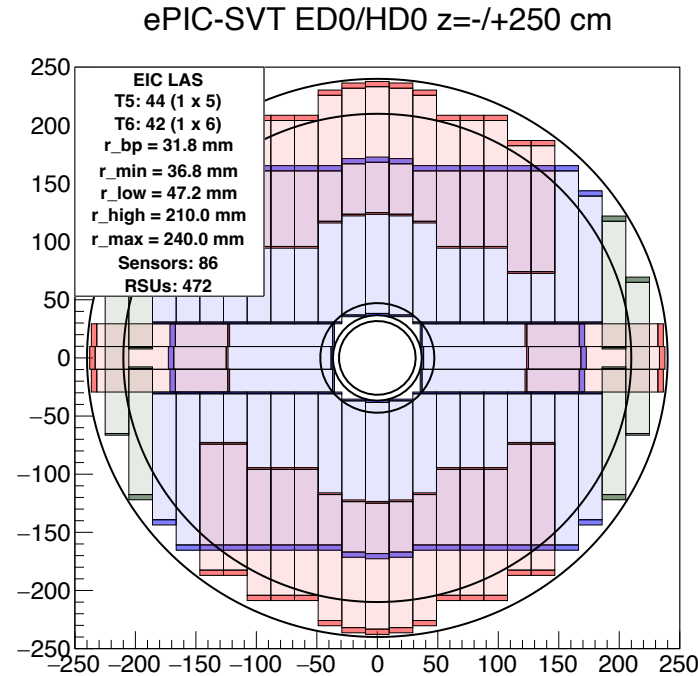


- Tiling first disk with different sensor variants

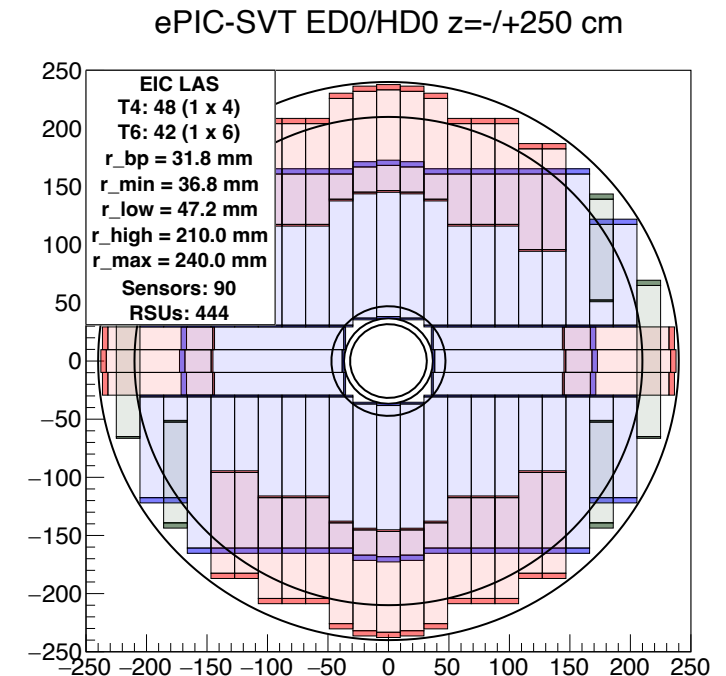
Strategy #1 – use long sensors first to keep services to outer part of the disk



84 1x6 sensors  
 504 RSUs  
 r\_high = 196.9 mm



42 1x6 sensors  
 45 1x5 sensors  
 472 RSUs  
 r\_high = 210.0 mm

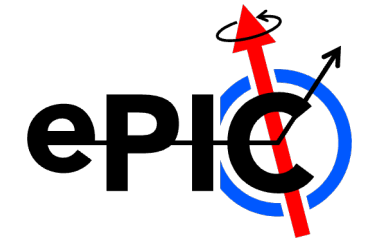


42 1x6 sensors  
 48 1x4 sensors  
 444 RSUs  
 r\_high = 210.0 mm

r\_high = largest radius with full azimuthal acceptance

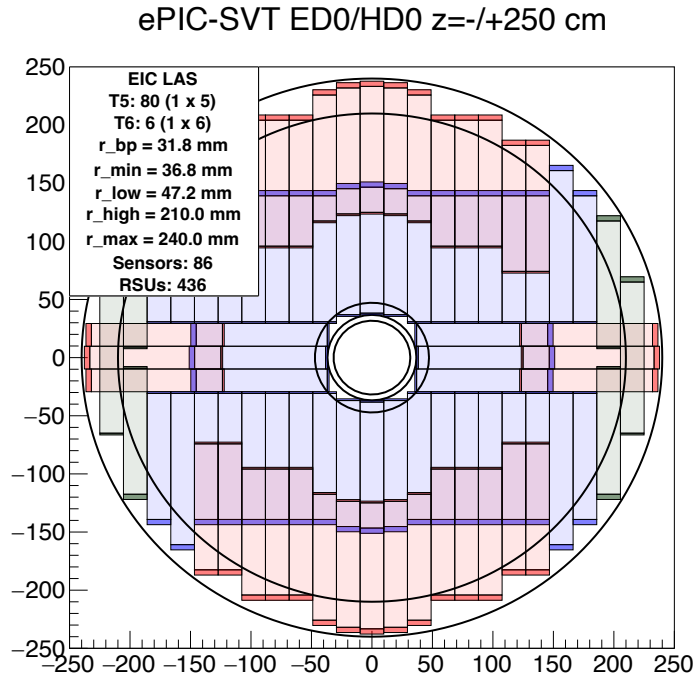


# ePIC Disk Layout Studies – Disk 0 (ED0/HD0)

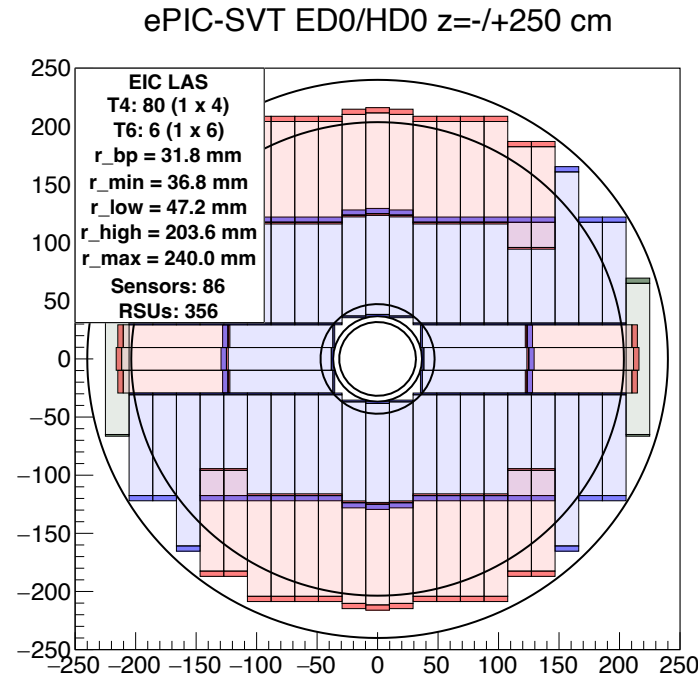


- Tiling first disk with different sensor variants

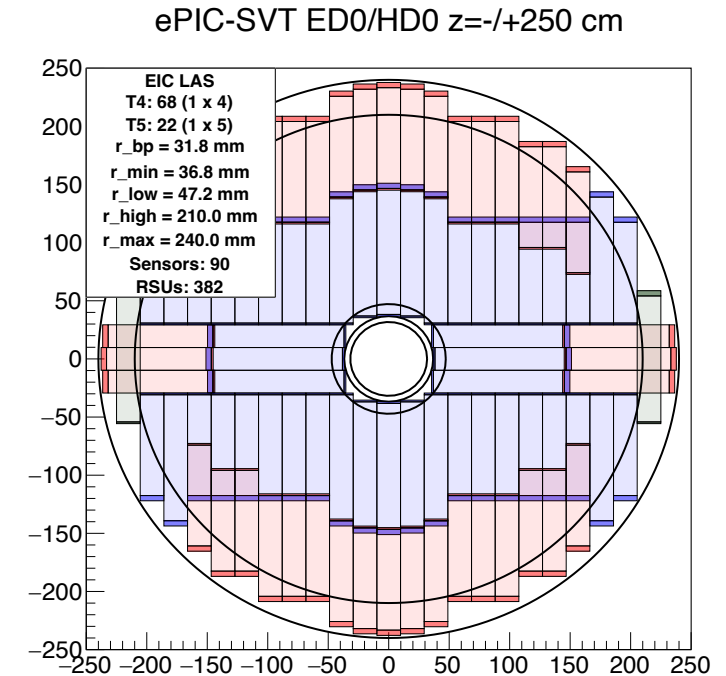
Strategy #2 – use sensors in combinations that minimise overlap



Minimise overlap  
6 1x6 sensors  
80 1x5 sensors  
436 RSUs  
r\_high = 210.0 mm

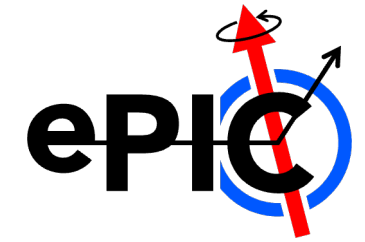


Minimise overlap  
6 1x6 sensors  
80 1x4 sensors  
356 RSUs  
r\_high = 203.6 mm



Minimise overlap  
22 1x5 sensors  
68 1x4 sensors  
382 RSUs  
r\_high = 210.0 mm

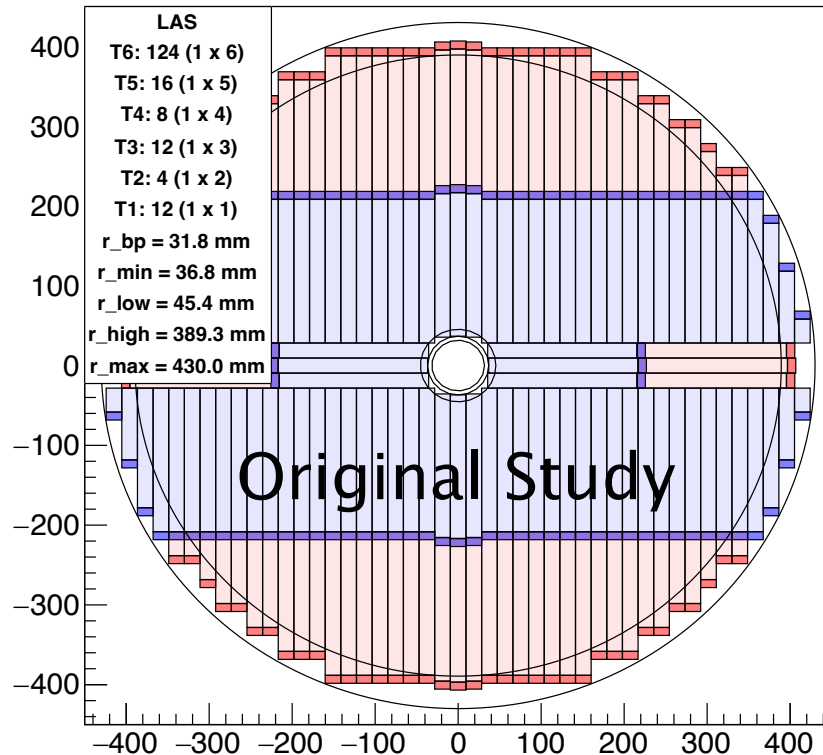
# ePIC Disk Layout Studies – Disk 1 (ED1/HD1)



- Updated for new sensor size specification

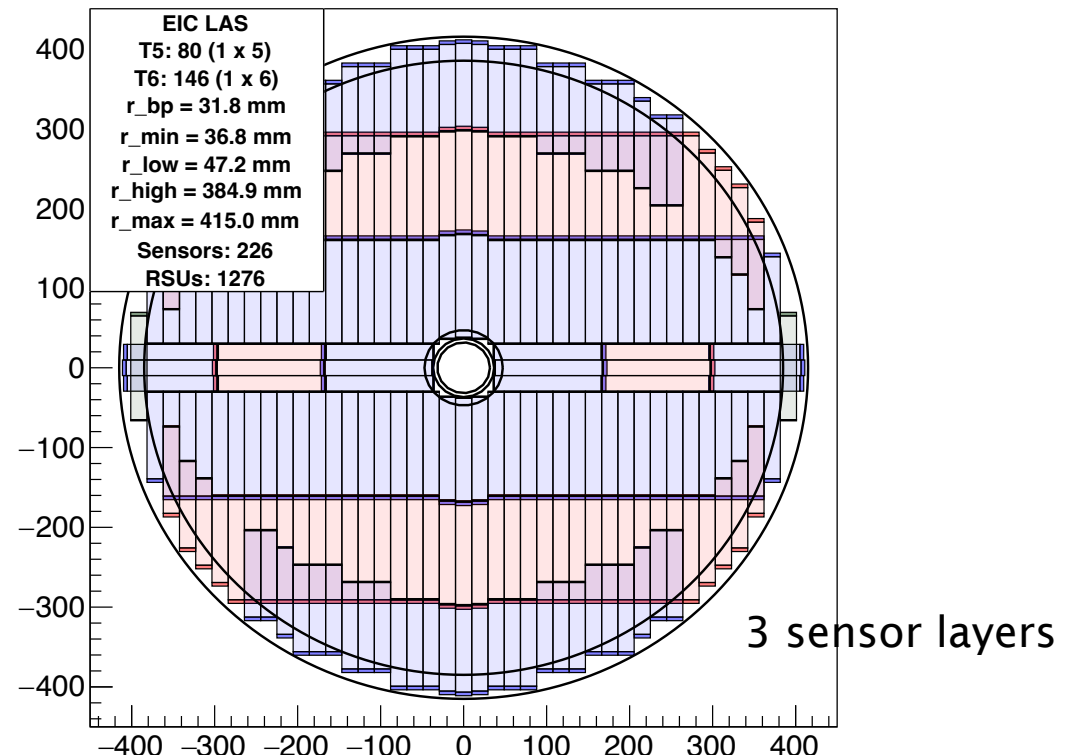
First look: two different lengths 1x6 RSUs and 1x5 RSUs

EIC-SVT Disk-2/3n Tile



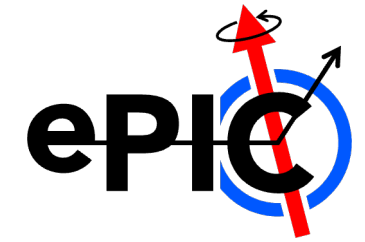
Max. sensor length = 6 RSUs = 180 mm

EIC-SVT ED1/HD1 z=-/+450 cm



Max. required length = 17 RSUs  
 Max. sensor length = 6 RSUs = 130 mm

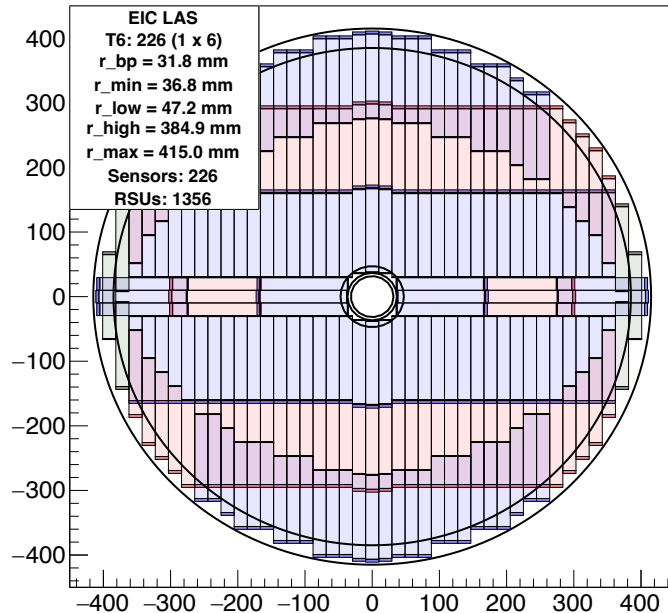
# ePIC Disk Layout Studies – Disk 1 (ED1/HD1)



- Tiling first disk with different sensor variants

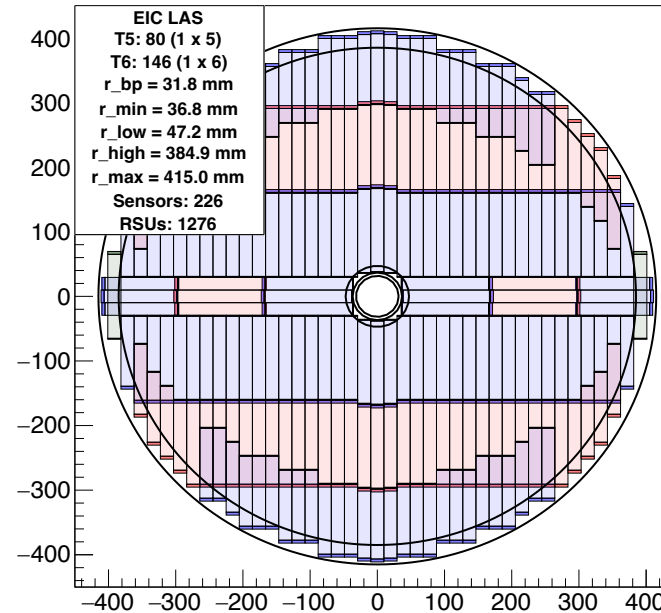
Strategy #1 – use long sensors first to keep services to outer part of the disk

EIC-SVT ED1/HD1 z=-/+450 cm



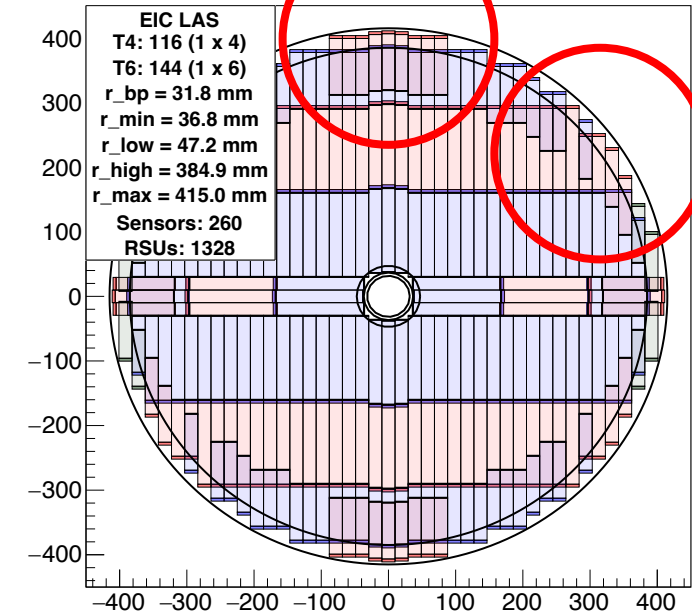
226 1x6 sensors  
 226 sensors  
**1356** RSUs  
 r\_high = 384.9 mm

EIC-SVT ED1/HD1 z=-/+450 cm



146 1x6 sensors  
 80 1x5 sensors  
 226 sensors  
**1276** RSUs  
 r\_high = 384.9 mm

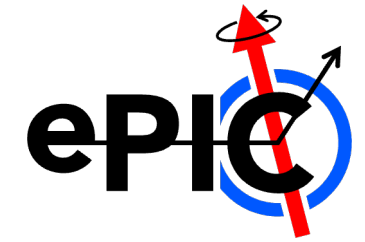
EIC-SVT ED1/HD1 z=-/+450 cm



144 1x6 sensors  
 116 1x4 sensors  
 260 sensors  
**1328** RSUs  
 r\_high = 384.9 mm

Note large number of 1x1 sensors

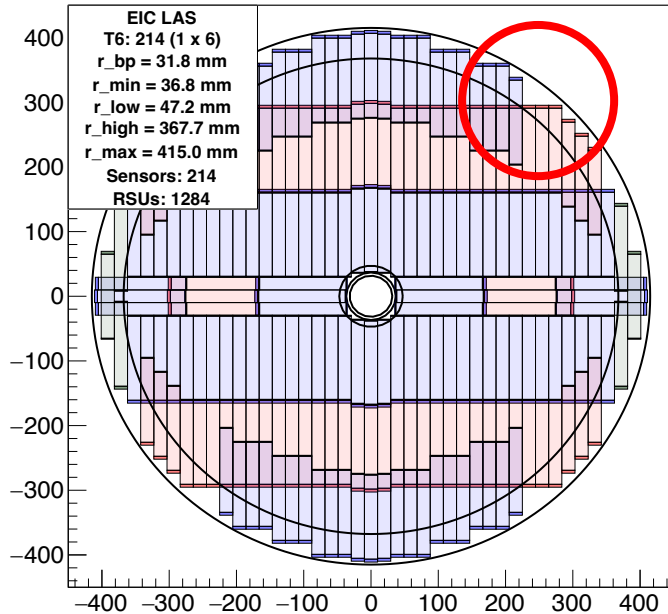
# ePIC Disk Layout Studies – Disk 1 (ED1/HD1)



- Tiling first disk with different sensor variants

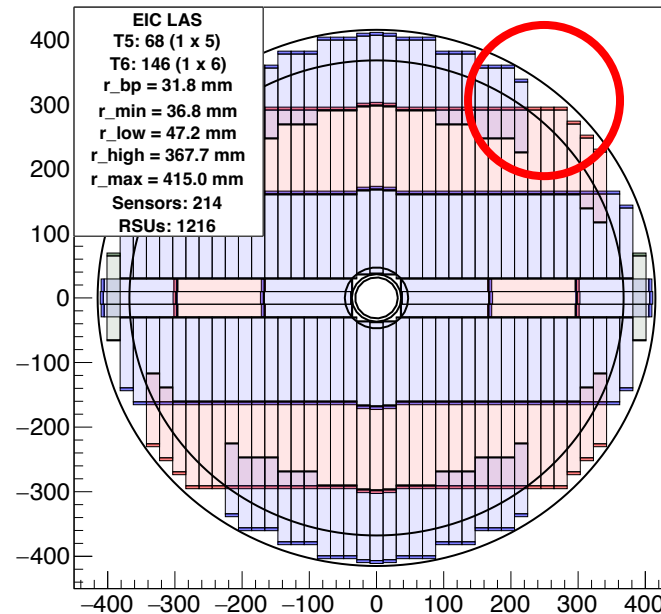
Strategy #1b – use long sensors first to keep services to outer part of the disk (and exclude 1x1 sensors)

ePIC-SVT ED1/HD1 z=-/+450 cm



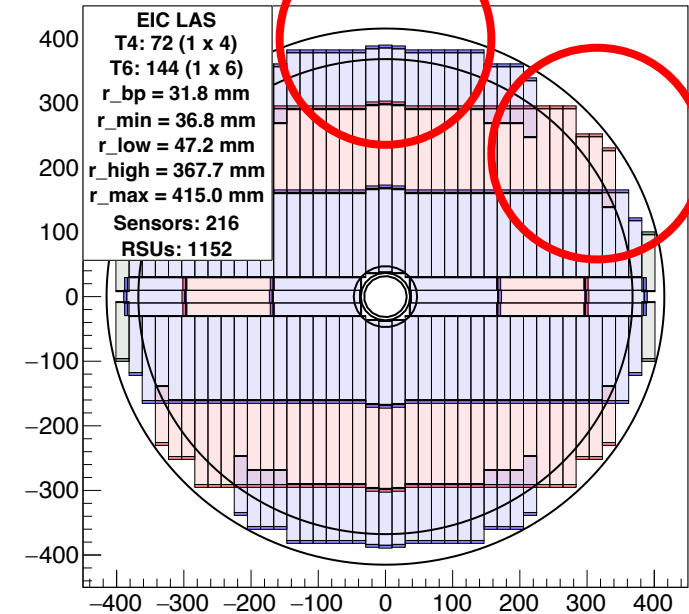
214 1x6 sensors  
 214 sensors  
 1289 RSUs  
 r\_high = 367.7 mm

ePIC-SVT ED1/HD1 z=-/+450 cm



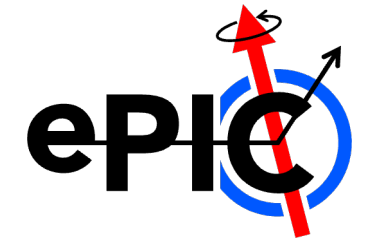
146 1x6 sensors  
 68 1x5 sensors  
 214 sensors  
 1216 RSUs  
 r\_high = 367.7 mm

ePIC-SVT ED1/HD1 z=-/+450 cm



144 1x6 sensors  
 72 1x4 sensors  
 216 sensors  
 1152 RSUs  
 r\_high = 367.7 mm

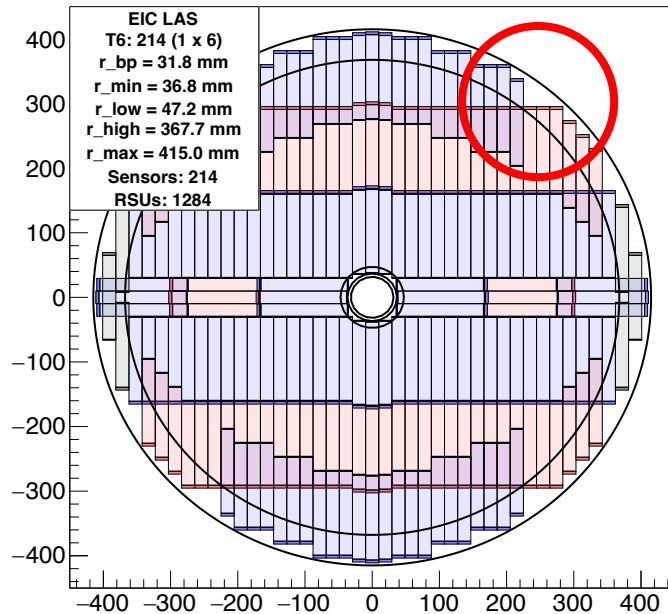
# ePIC Disk Layout Studies – Disk 1 (ED1/HD1)



## ■ Tiling first disk with different sensor variants

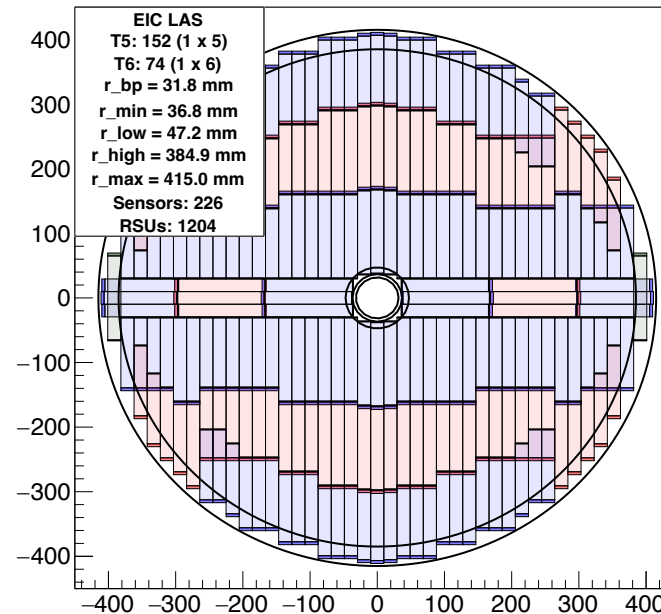
Strategy #2b – use sensors in combinations that minimise overlap (and exclude 1x1 sensors)

ePIC-SVT ED1/HD1 z=-/+450 cm



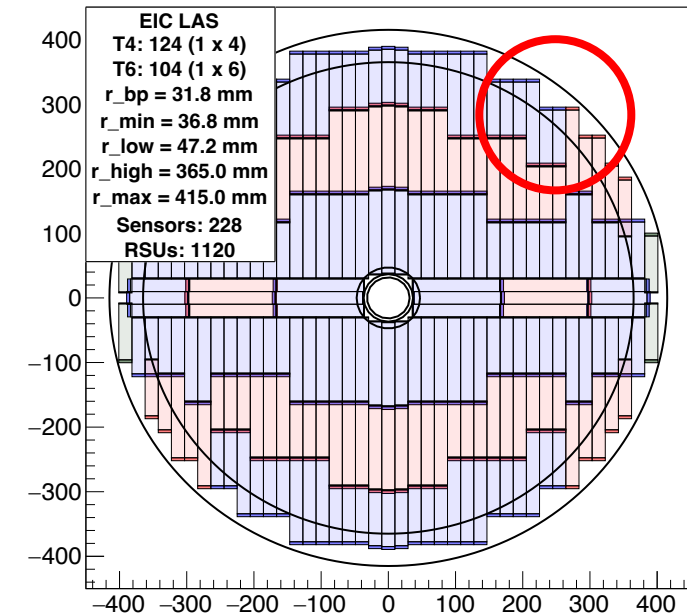
214 1x6 sensors  
214 sensors  
**1284** RSUs  
r\_high = 367.7 mm

ePIC-SVT ED1/HD1 z=-/+450 cm



74 1x6 sensors  
152 1x5 sensors  
226 sensors  
**1204** RSUs  
r\_high = 384.9 mm  
Maximum acceptance

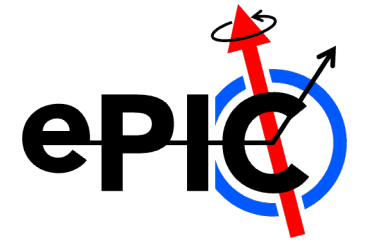
ePIC-SVT ED1/HD1 z=-/+450 cm



104 1x6 sensors  
124 1x4 sensors  
228 sensors  
**1120** RSUs  
r\_high = 365.0 mm  
No overlap but smaller acceptance

# Summary

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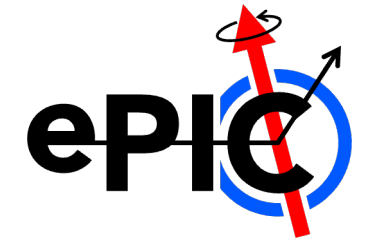
## ▪ Barrel layers

- ITS3 ER2 wafer-scale sensor has larger width and smaller active length than suggest in the Lol
- Means that the inner barrel (IB) radii are slightly larger, eta acceptance is smaller
- Outer barrel (OB) layers can be accommodated most easily with 4 (L3) and 6 (L4) 1x6 RSU sensors
- Smaller radii to keep eta acceptance, or smaller eta acceptance to keep current radial positions
- Can keep both current radial positions and eta acceptance using combination of 1x6 and 1x5 RSU sensors

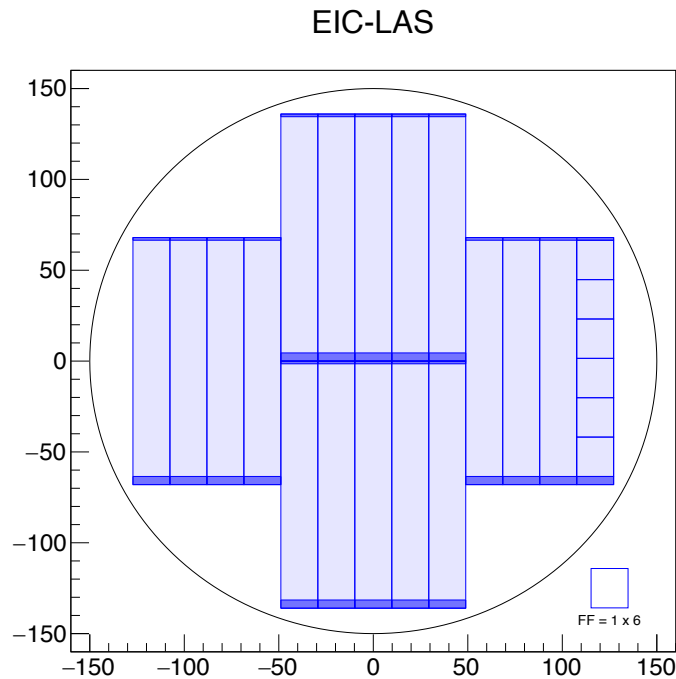
## ▪ Endcaps

- An additional sensor layer is needed for each disk if we limit ourselves to maximum 1x6 RSU sensors
- Investigating optimum choice of sensor variants (1x6 plus one other)
- Two tiling strategies studied:
  1. Use long sensor first to keep services to outer part of the disk – introduces more sensor overlap
  2. Use sensors in combinations that minimise sensor overlap – favours shorter sensors
- Eliminating 1x1 sensors helps to reduce overlap but tends to reduce azimuthal acceptance
- Based on experience with ITS3 ER1 wafers 1x1 sensors may come for free, so could be added if needed

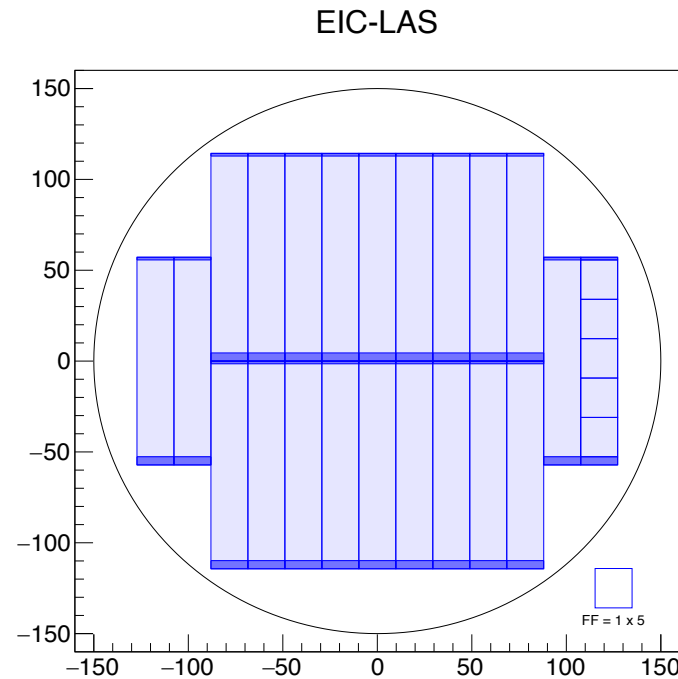
# EIC-LAS Sensor Variants



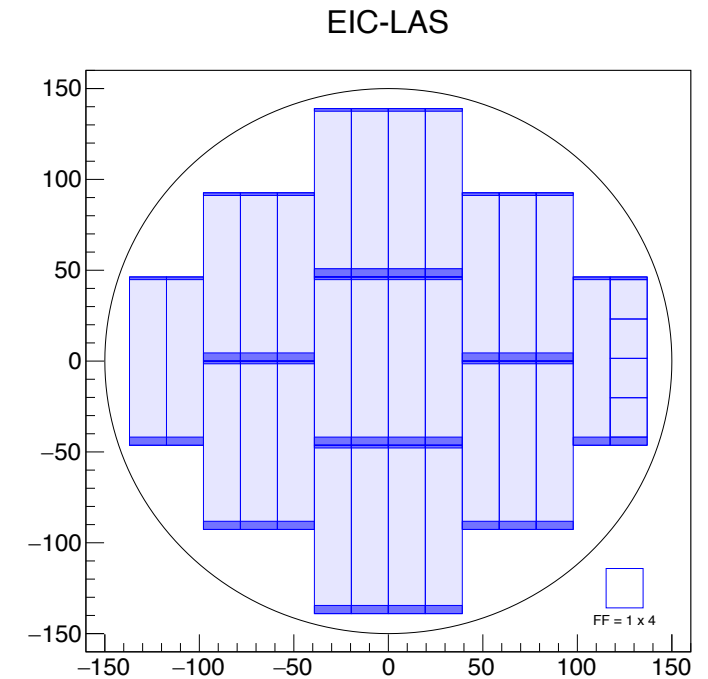
- Sensor layout on wafer (one sensor variant per wafer)



1x6 LAS  
18 sensors  
108 RSUs



1x5 LAS  
22 sensors  
110 RSUs



1x4 LAS  
28 sensors  
112 RSUs