

# Investigation of the reduced tracker dimensions option

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# Introduction

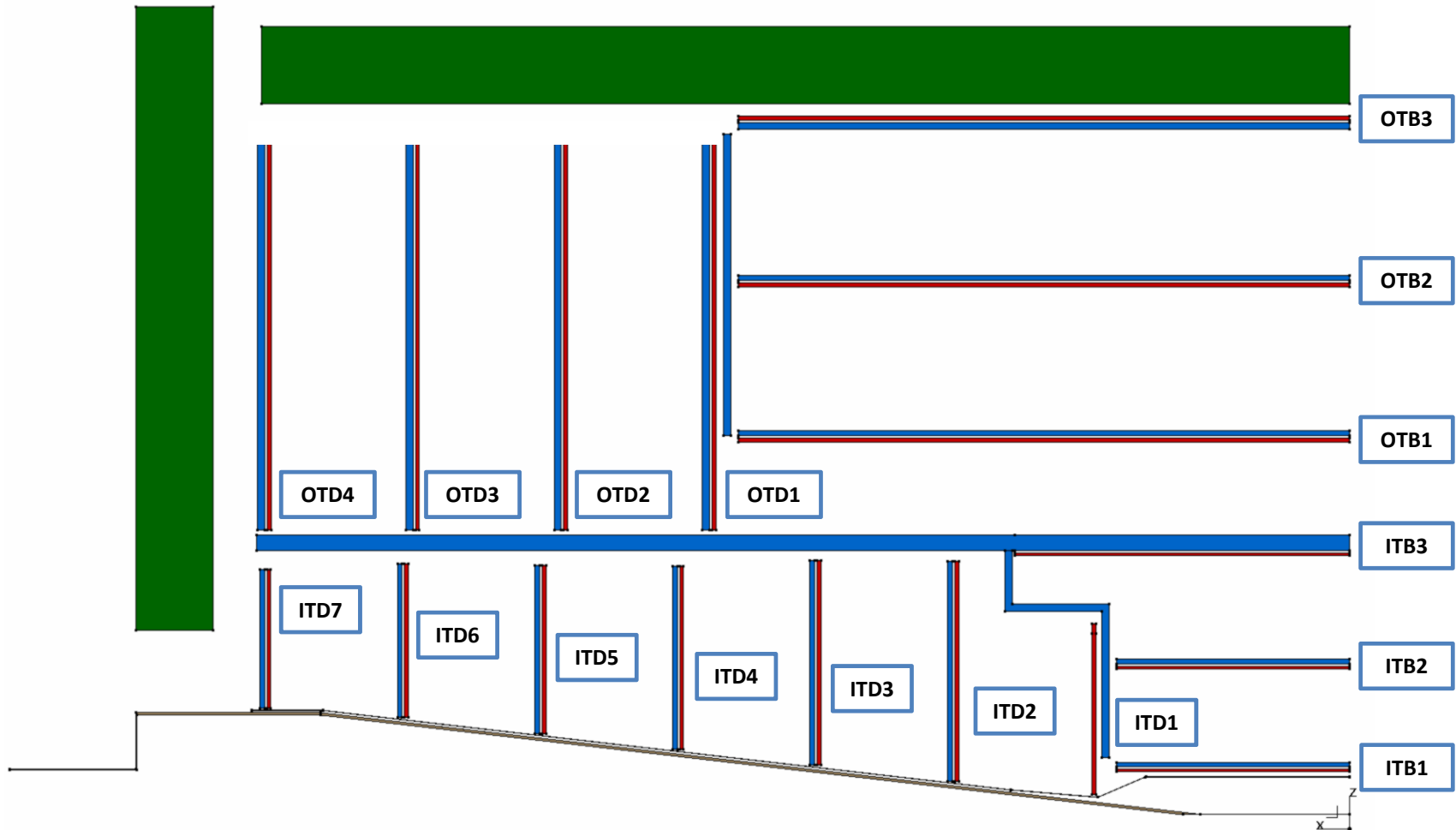
- From the “CLICdp detector optimisation meeting” on Aug 9<sup>th</sup>
  - ❑ Clear preference for the 40L ECAL
  - ❑ 44 mm extra space needed
- 2 options:
  - ❑ Push everything out
  - ❑ Reduce the tracker size ← *investigated, results in this talk*

## ***Fast Simulation, LDT***

- *For the tracker, single point resolution in  $R\phi = 7 \mu\text{m}$*
- *Material budget numbers coherent with full simulation*

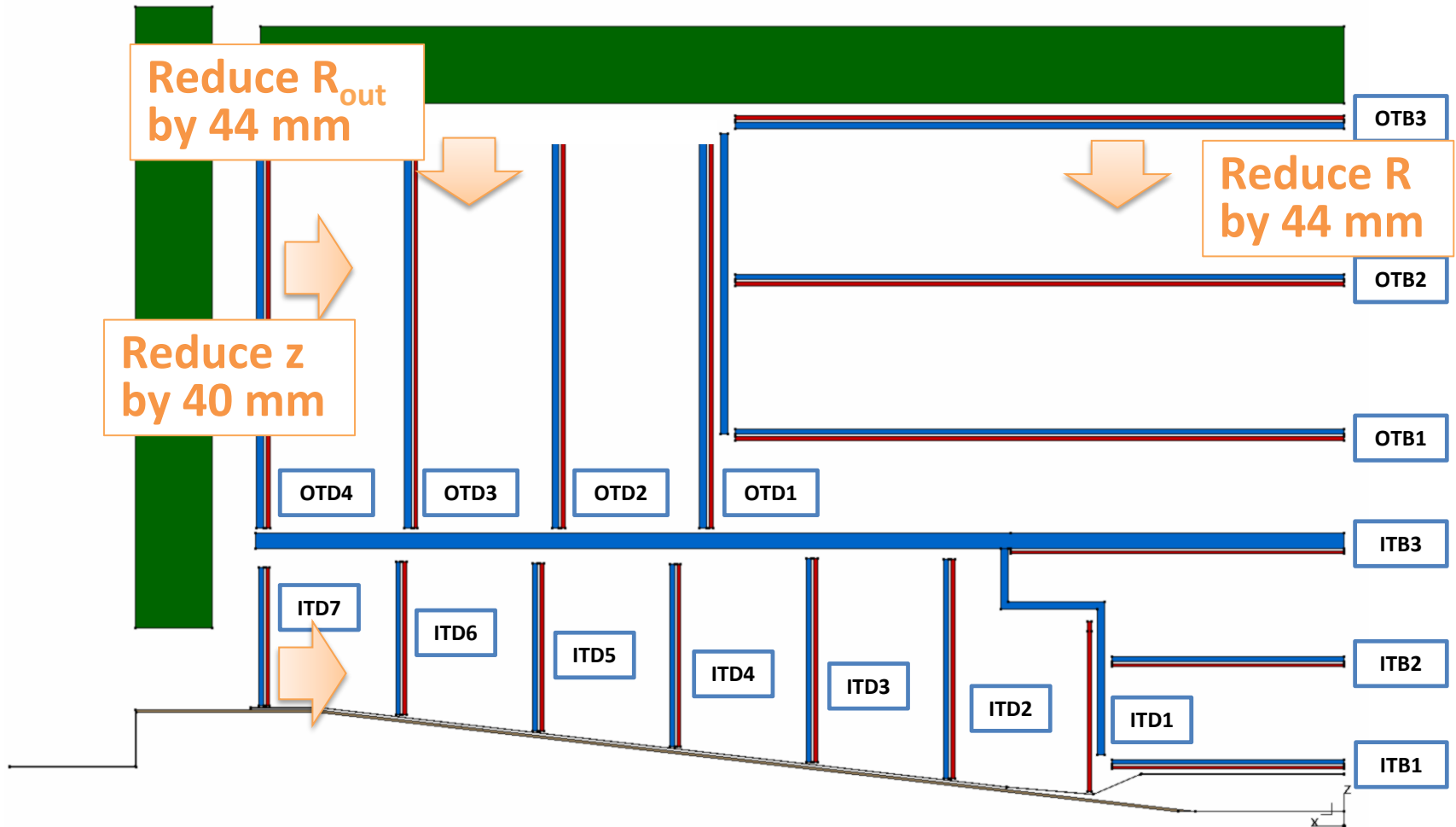
# Current layout

- $R_{\max} = 1486.5 \text{ mm}$ ,  $z_{\max} = 2230.6 \text{ mm}$
- Mostly equispaced layers  $\rightarrow$  layer position optimised to reduce missed hits in gaps (i.e.: due to the support tube)



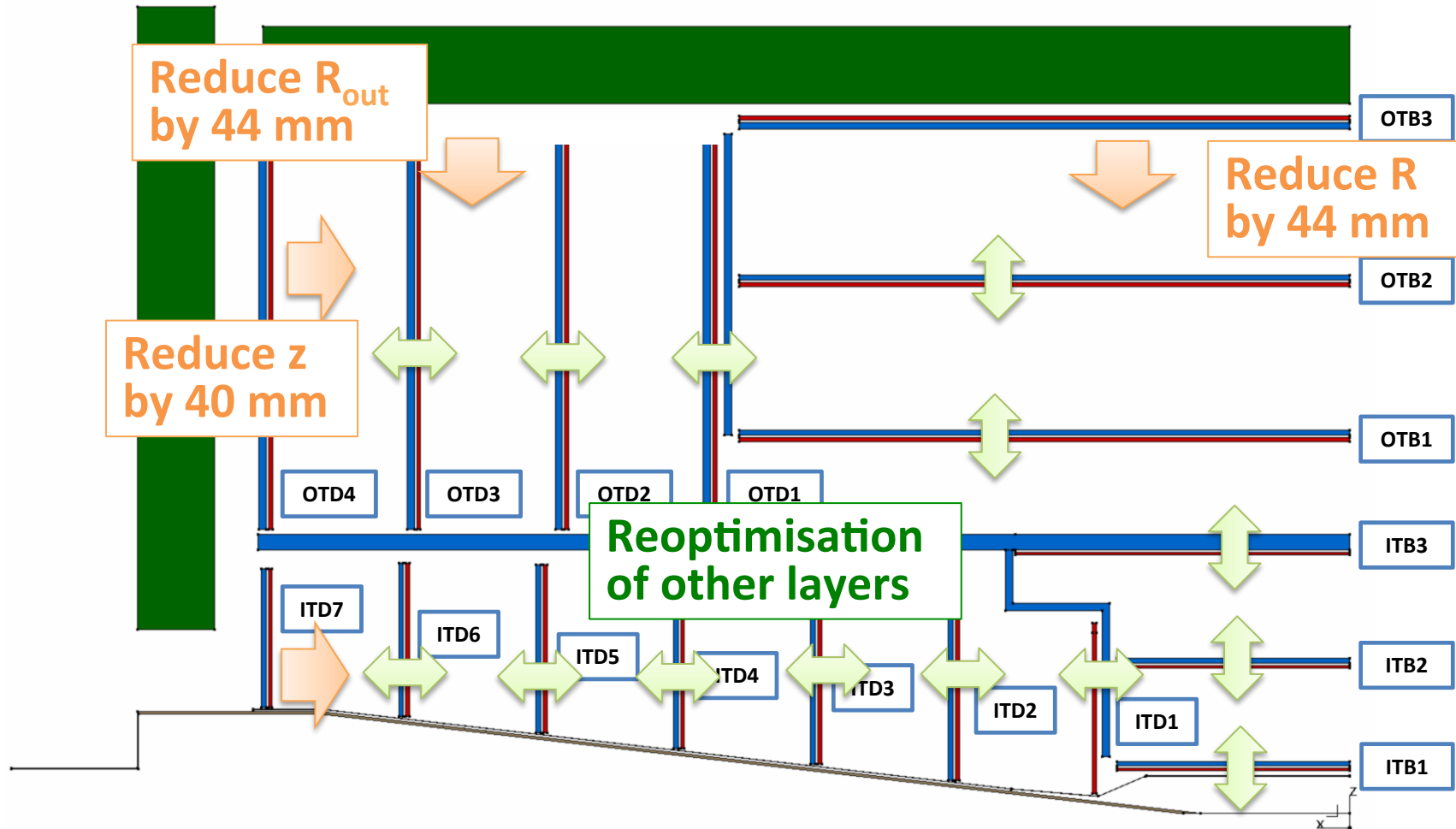
# Reduced tracker layout

- Overall size **reduced**:  $R_{\max} = 1442.6 \text{ mm}$ ,  $z_{\max} = 2190 \text{ mm}$
- Move only “last” layers: OTB3, OTD4, ITD7  
→ layer position not re-optimised



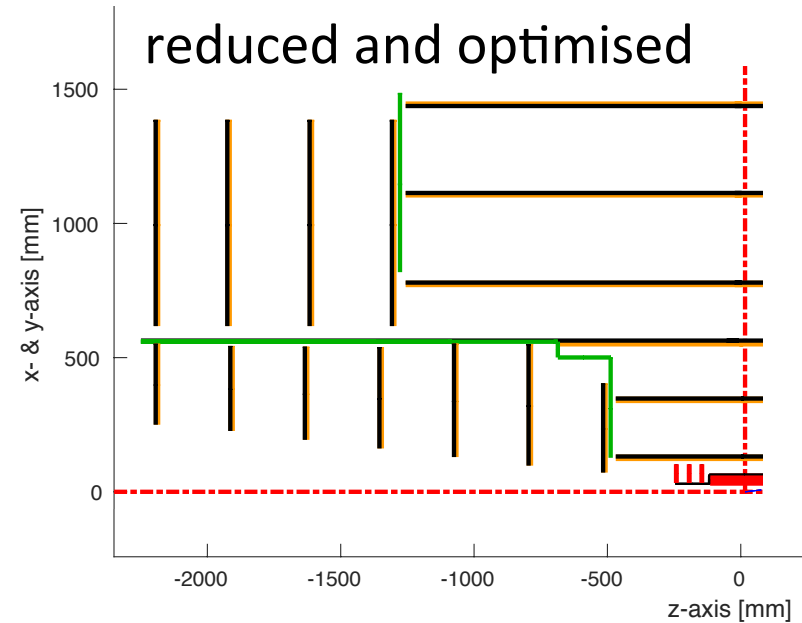
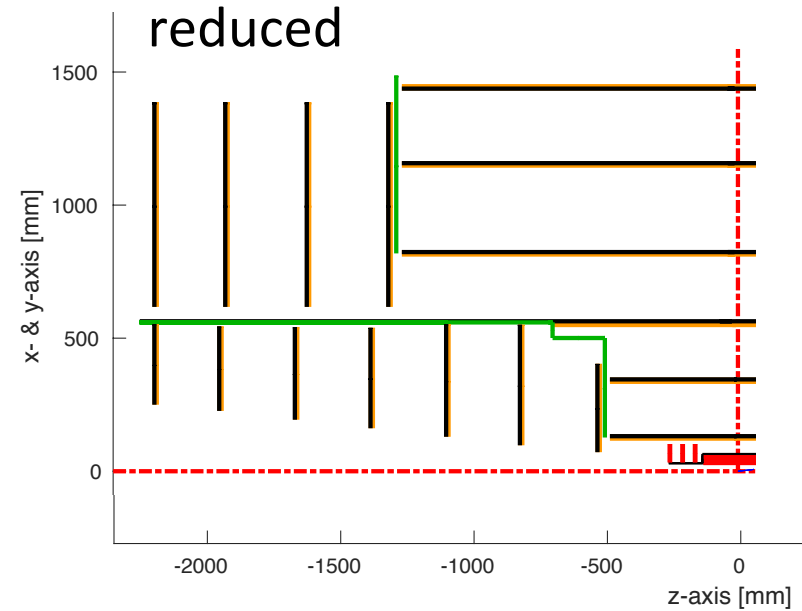
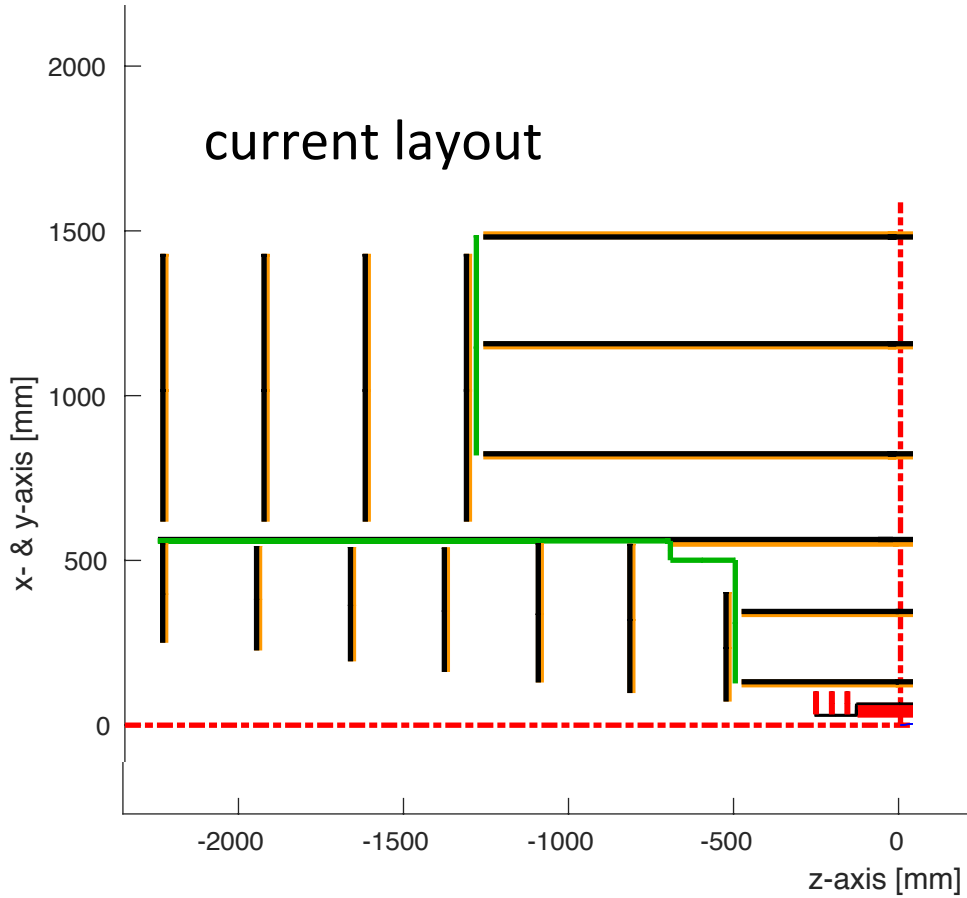
# Reduced and optimised tracker layout

- Overall size **reduced**:  $R_{\max} = 1442.6 \text{ mm}$ ,  $z_{\max} = 2190 \text{ mm}$
- Move only “last” layers: OTB3, OTD4, ITD7  
→ layer position **re-optimised** in order to reduce gaps



# How the models actually look like

- Fast simulation: LDT



# All the numbers – Preliminary

By Szymon and Wolfgang

**Barrel R [mm]**

	<b>current</b>	<b>reduced</b>	<b>reduc + opt</b>
<b>ITB1</b>	126.7	126.7	126.6
<b>ITB2</b>	340.1	340.1	342.6
<b>ITB3</b>	553.5	553.5	553.5
<b>OTB1</b>	818.5	818.5	774.6
<b>OTB2</b>	1152.5	1152.5	1108.6
<b>OTB3</b>	1486.5	1442.6	1442.6

# All the numbers – Preliminary

Disk z [mm],  $R_{in}$  [mm],  $R_{out}$  [mm]

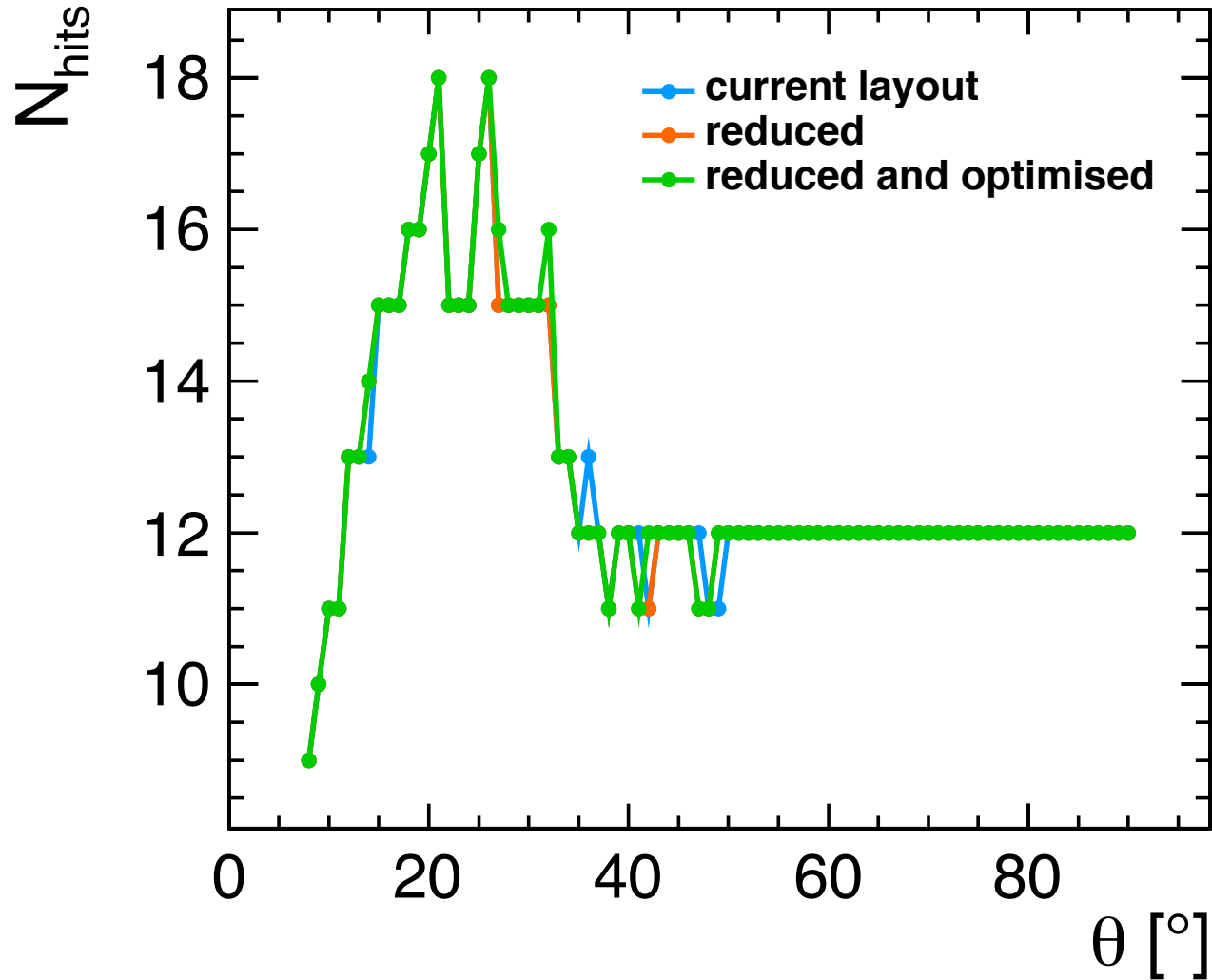
By Szymon and Wolfgang

	Current			Reduced			Reduced + opt		
	z	$R_{in}$	$R_{out}$	z	$R_{in}$	$R_{out}$	z	$R_{in}$	$R_{out}$
<b>ITD1</b>	523.6	71.6	403.5	523.6	71.6	403.5	523.6	71.6	403.5
<b>ITD2</b>	815.1	97.5	550.3	815.1	97.5	550.3	801.3	97.5	550.3
<b>ITD3</b>	1092.6	129.5	552.1	1092.6	129.5	552.1	1079.0	129.5	552.1
<b>ITD4</b>	1377.1	161.5	538.9	1377.1	161.5	538.9	1356.8	161.5	538.9
<b>ITD5</b>	1661.6	193.6	540.7	1661.6	193.6	540.7	1634.5	193.6	540.7
<b>ITD6</b>	1946.1	226.7	543.6	1946.1	226.7	543.6	1912.2	226.7	543.6
<b>ITD7</b>	2230.6	250.0	551.8	2190.0	250.0	551.8	2190.0	250.0	551.8
<b>OTD1</b>	1310.2	617.5	1430.2	1310.2	617.5	1386.2	1310.2	617.5	1386.2
<b>OTD2</b>	1616.8	617.5	1430.2	1616.8	617.5	1386.2	1604.0	617.5	1386.2
<b>OTD3</b>	1923.4	617.5	1430.2	1923.4	617.5	1386.2	1897.0	617.5	1386.2
<b>OTD4</b>	2230.0	617.5	1430.2	2190.0	617.5	1386.2	2190.0	617.5	1386.2



# Number of hits

- Single  $\mu$ ,  $p = 500$  GeV
- Very similar number of hits for all the 3 layouts



# Performance $\Delta p_T/p_T^2$

- Single  $\mu$ , theta = 90 deg, p from 10 GeV to 500 GeV

	10 GeV	20 GeV	50 GeV	100 GeV	200 GeV	500 GeV
<b>current</b>	0.00174	0.00101	0.00043	0.000225	0.000117	0.000051
<b>reduced</b>	0.00176	0.00103	0.00044	0.000231	0.000120	0.000053
<b>reduc + opt</b>	0.00177	0.00104	0.00045	0.000233	0.000122	0.000054
<b>% diff reduc</b>	<b>-1.49</b>	<b>-2.03</b>	<b>-2.34</b>	<b>-2.51</b>	<b>-2.79</b>	<b>-3.36</b>
<b>% diff r+o</b>	<b>-2.02</b>	<b>-2.72</b>	<b>-3.16</b>	<b>-3.47</b>	<b>-4.00</b>	<b>-4.75</b>

- As expected reducing the last barrel layer, worsening of the momentum resolution performance
  - $\Delta R/R \sim 3\%$
- Worsening increases with momentum because tracks are straighter  $\rightarrow$  hit at large R helps in the curvature computation
- Performance with re-optimised layout probably worse because also other layers are at smaller R

# Performance $\Delta p_T/p_T^2$

- Single  $\mu$ ,  $p = 500$  GeV, theta from 30 deg to 90 deg

	30 deg	40 deg	50 deg	60 deg	70 deg	80 deg	90 deg
<b>current</b>	0.001564	0.000184	0.000074	0.000062	0.000056	0.000052	0.000051
<b>reduced</b>	0.001591	0.000184	0.000076	0.000064	0.000058	0.000054	0.000053
<b>red + opt</b>	0.001593	0.000193	0.000077	0.000065	0.000058	0.000055	0.000054
<b>% diff red</b>	<b>-1.77</b>	<b>0.00</b>	<b>-3.06</b>	<b>-3.19</b>	<b>-3.27</b>	<b>-3.33</b>	<b>-3.36</b>
<b>% diff r+o</b>	<b>-1.85</b>	<b>-4.73</b>	<b>-4.47</b>	<b>-4.61</b>	<b>-4.68</b>	<b>-4.73</b>	<b>-4.75</b>

- As expected reducing the overall tracker dimension (R and z), worsening of the momentum resolution performance
  - $\Delta R/R \sim 3\%$ ,  $\Delta z/z \sim 1.7\%$
- Worsening increases in the central region where the R reduction has been larger

# Performance $\Delta p_T/p_T^2$

- Single  $\mu$ ,  $p = 10$  GeV, theta from 30 deg to 90 deg

	30 deg	40 deg	50 deg	60 deg	70 deg	80 deg	90 deg
<b>current</b>	0.003488	0.00269	0.00232	0.00201	0.00185	0.00176	0.00174
<b>reduced</b>	0.003504	0.00269	0.00228	0.00203	0.00188	0.00179	0.00176
<b>red + opt</b>	0.003509	0.00270	0.00229	0.00204	0.00189	0.00180	0.00177
<b>% diff red</b>	<b>-0.45</b>	<b>0.00</b>	<b>1.72</b>	<b>-1.27</b>	<b>-1.39</b>	<b>-1.47</b>	<b>-1.49</b>
<b>% diff r+o</b>	<b>-0.61</b>	<b>-0.08</b>	<b>1.30</b>	<b>-1.75</b>	<b>-1.90</b>	<b>-1.99</b>	<b>-2.02</b>

- General worsening of the momentum resolution performance as expected except for theta = 50 deg
- Same layers (both sensitive and not) crossed at theta = 50 deg and theta = 60 deg  $\rightarrow$  not sure what's going on at theta = 50 deg

# Full simulation - Discussion

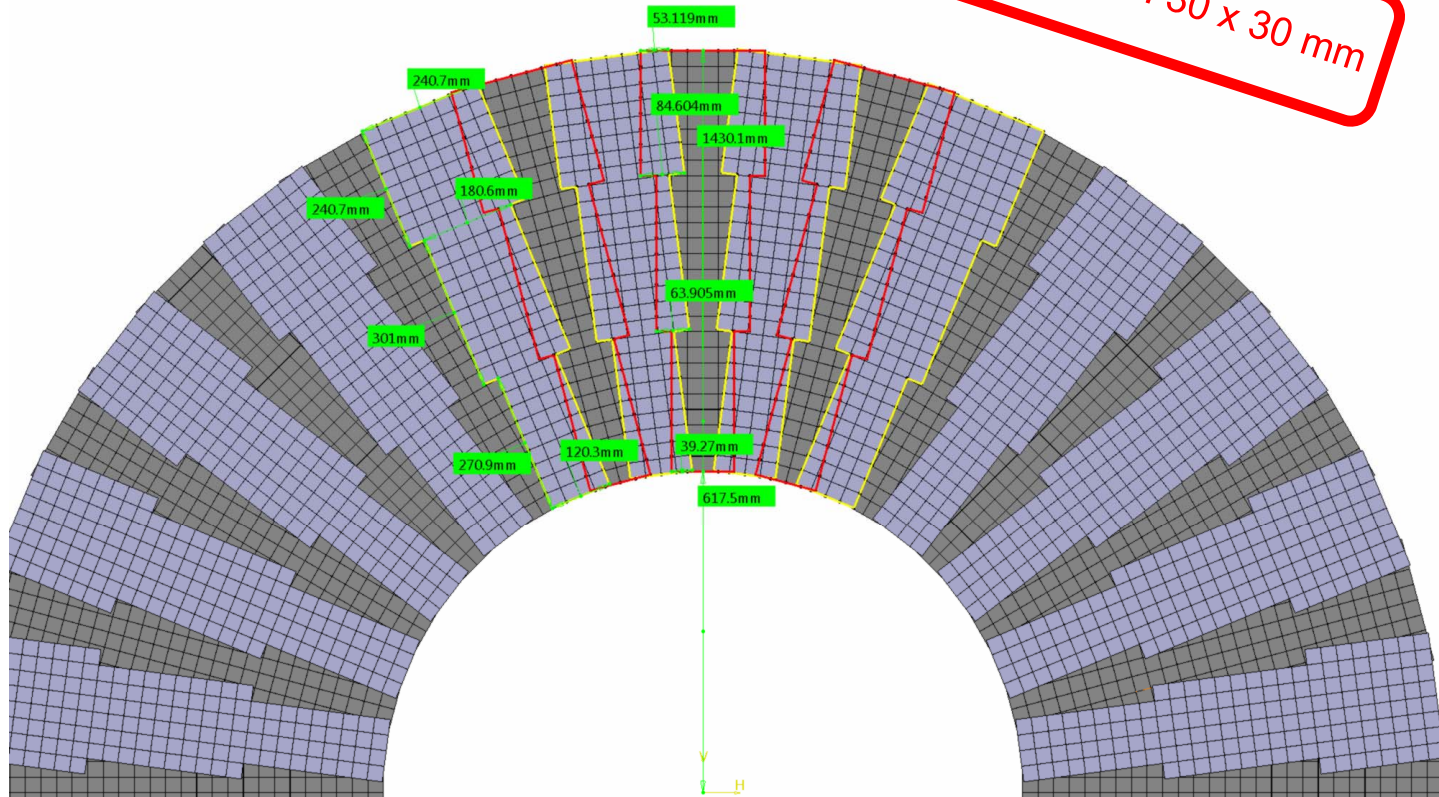
- If we reduce radius of outer tracker disks how the modular structure of the petal would change? (Similar structure for inner tracker disks)

## Outer Tracker Disks

OTD1, OTD2, OTD3, OTD4 - Dimensions



Silicon modules: 30 x 30 mm



# Conclusion

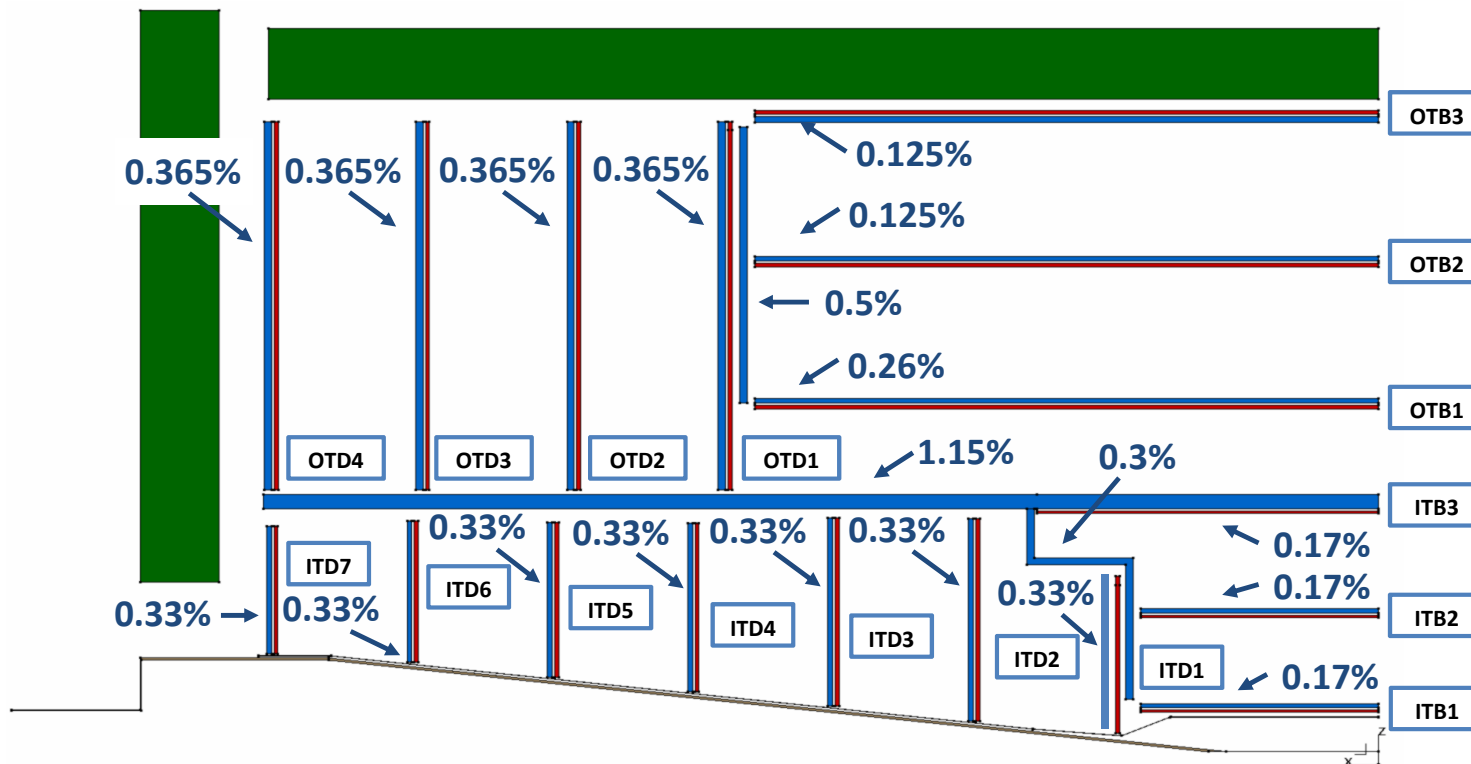
- If we decide to reduce the overall tracker dimensions:  
44 mm in R, 40 mm in z  
there would be a small worsening in the  $p_T$  resolution performance:
  - ▣ Barrel: from  $\sim 2\%$  (low p tracks) to  $\sim 5\%$  (high p tracks)
  - ▣ Disks: from  $\sim 0.5\%$  (low p tracks) to  $\sim 2\%$  (high p tracks)
- The worsening is coherent with the expectations:  
 $\Delta R/R \sim 3\%$ ,  $\Delta z/z \sim 1.7\%$

**BACKUP**

# Material budget

## Preliminary Estimation of Material Budget

### Support Structure



Red - Module + Cold Plate+ Power Bus = 1.02%X0

Dark Blue— Carbon fiber supports

**Work is ongoing**

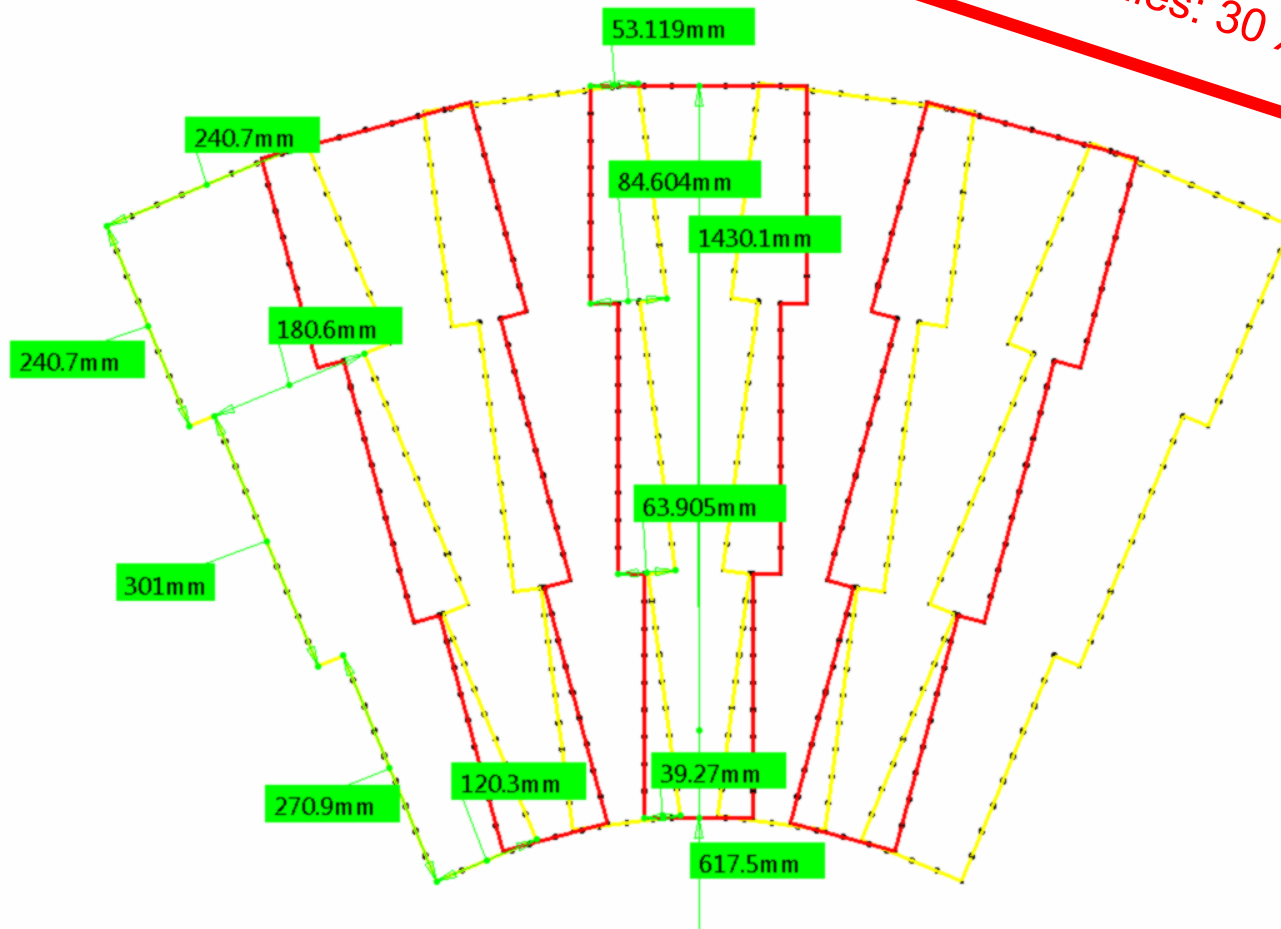


# Modular structure for disk petals

## Outer Tracker Disks

OTD1, OTD2, OTD3, OTD4 - Dimensions

Silicon modules: 30 x 30 mm

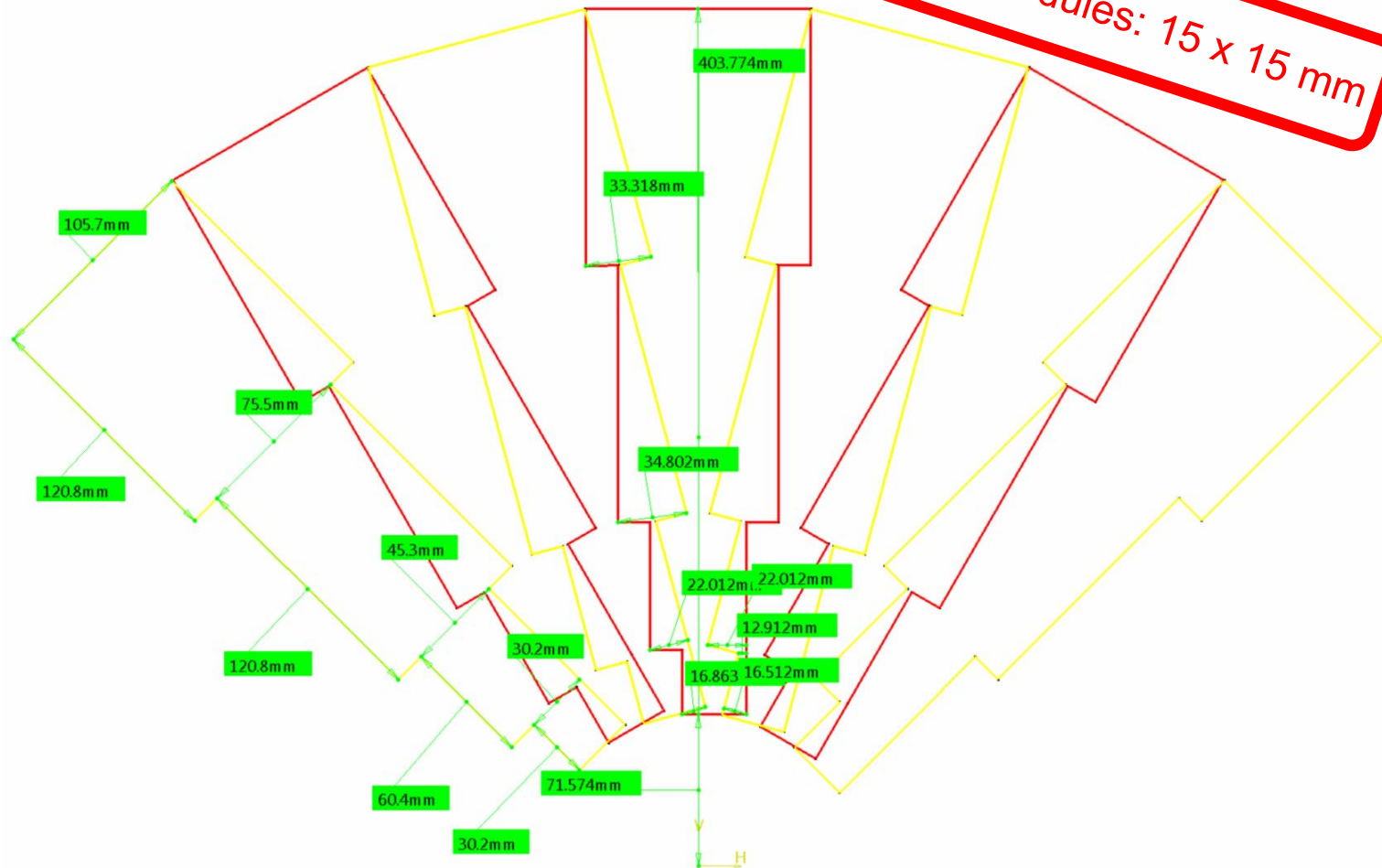


# Modular structure for disk petals

## Inner Tracker Disks

### ITD1- Dimensions

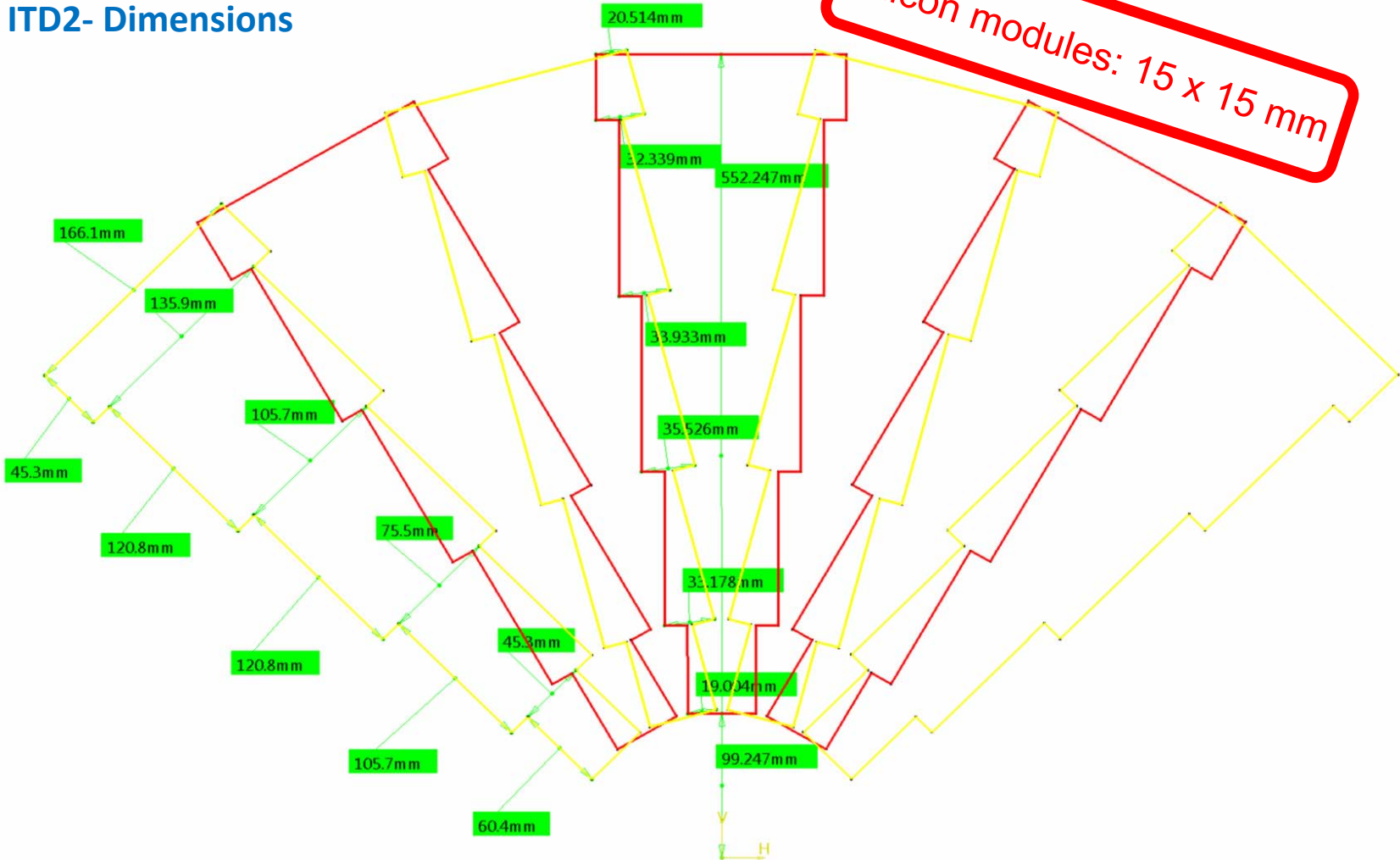
Silicon modules: 15 x 15 mm



# Modular structure for disk petals

## Inner Tracker Disks

### ITD2- Dimensions



# Modular structure for disk petals

## Inner Tracker Disks

### ITD4- Dimensions

