

# Tracker and tracking status

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with material from S. Sroka and D. Hynds

Tracker size revised

# TRACKER STATUS

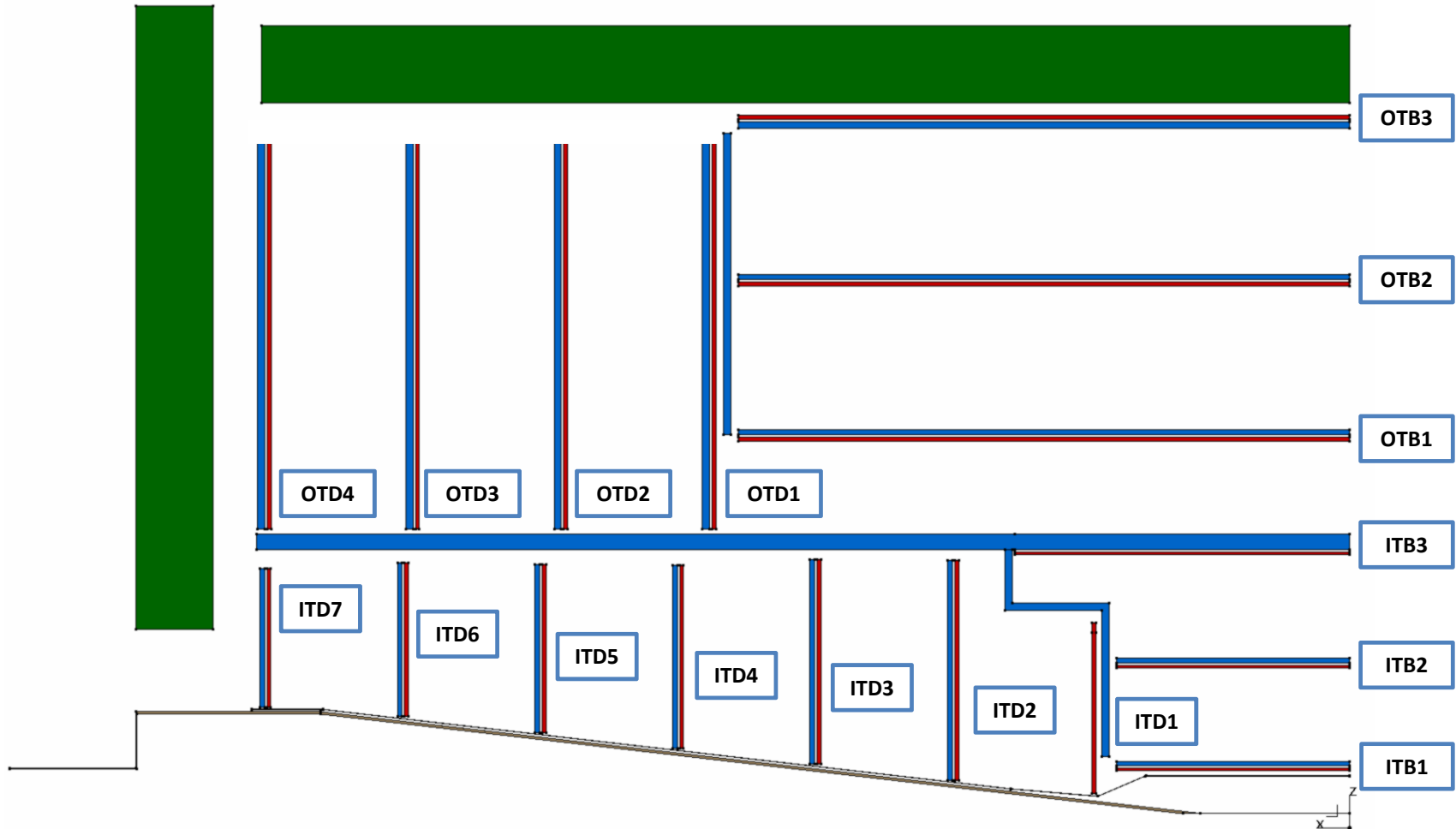
# Introduction

- 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

- *Quick study in LDT fast simulation*
- *Validation of the “chosen” model in full simulation*

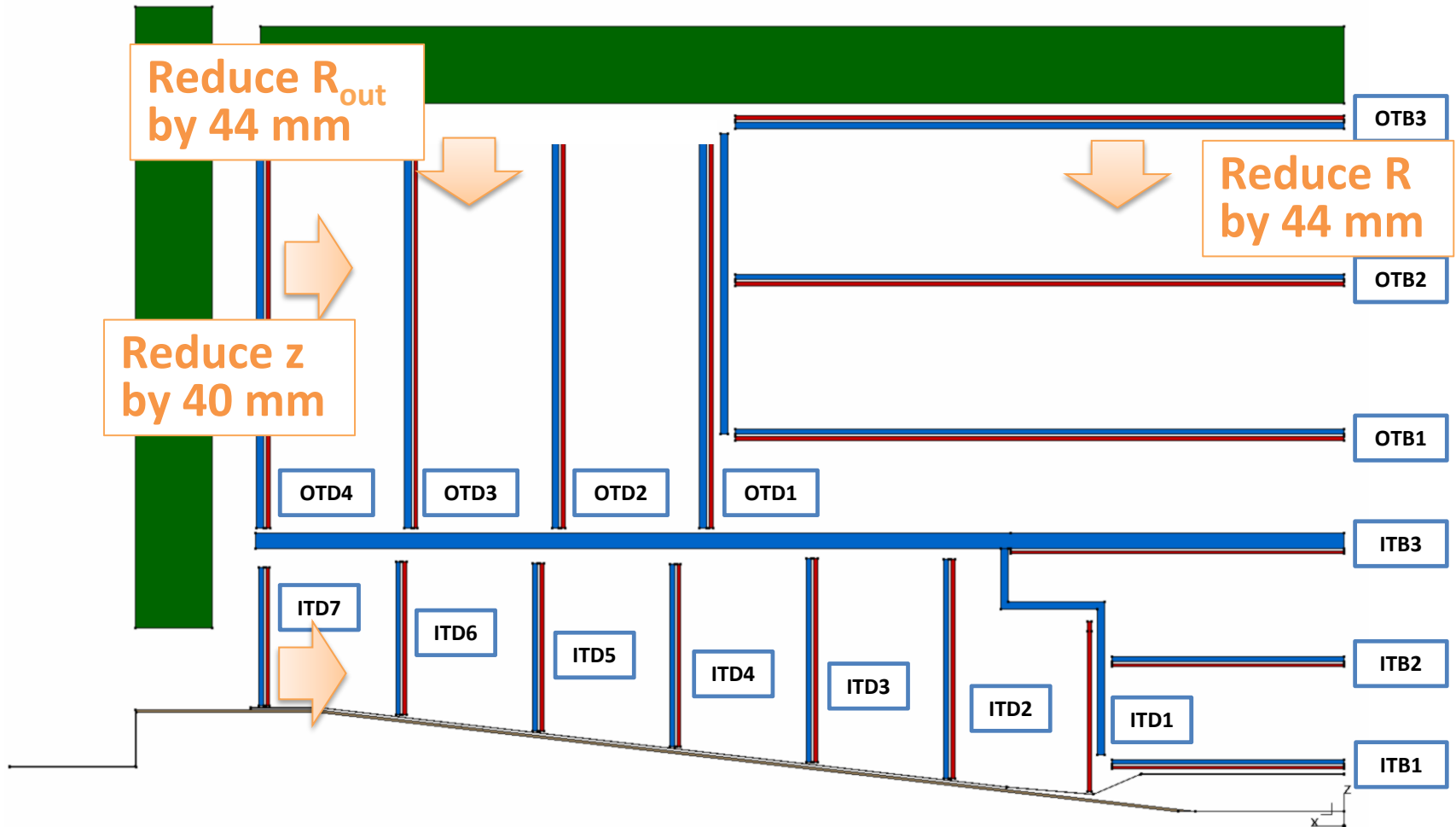
# Current layout

- $R_{\max} = 1486.5 \text{ mm}$ ,  $z_{\max} = 2230.6 \text{ mm}$
- Mostly equispaced layers



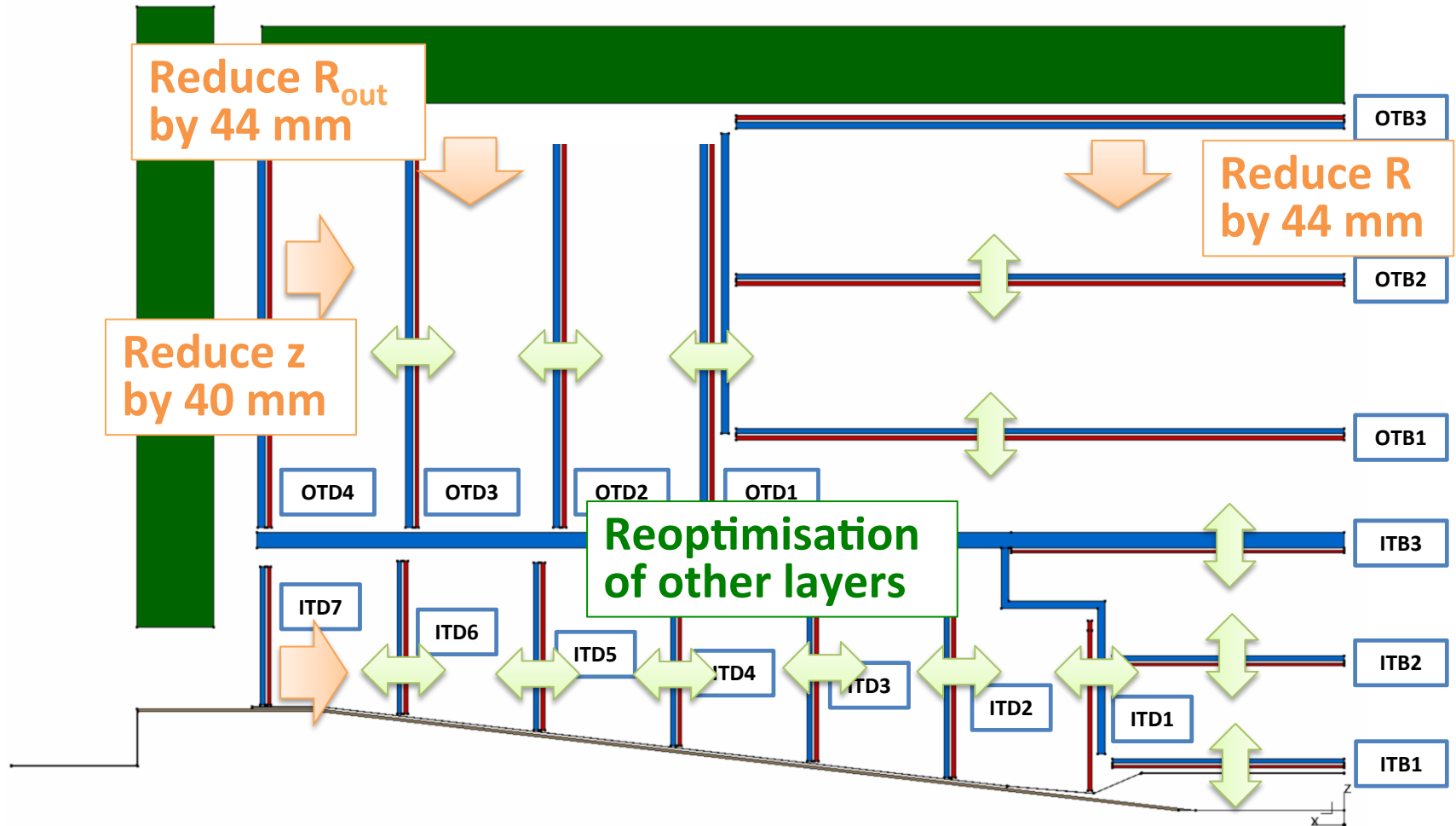
# Reduced tracker layout

- Overall size **reduced**:  $R_{\max}$  by 44 mm,  $z_{\max}$  by 40 mm (4 mm from services)
- Move only “last” layers: OTB3, OTD4, ITD7



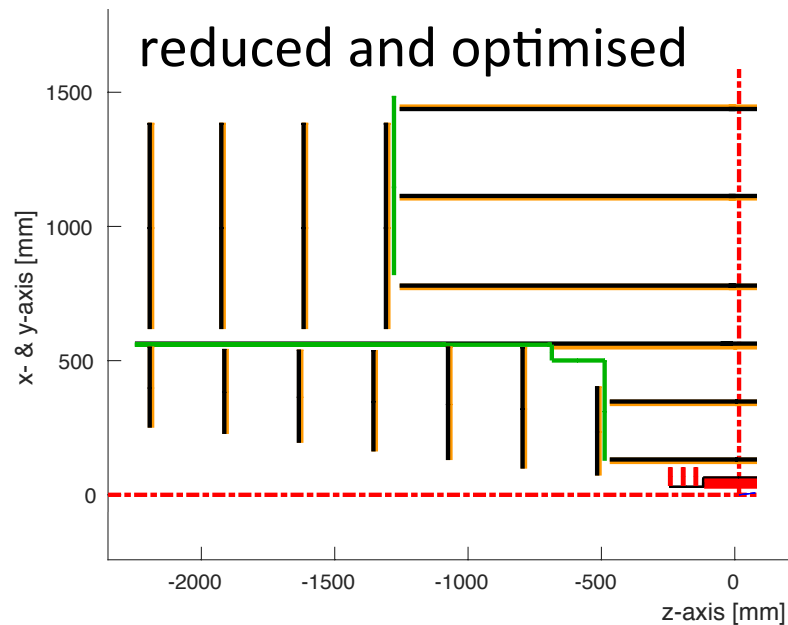
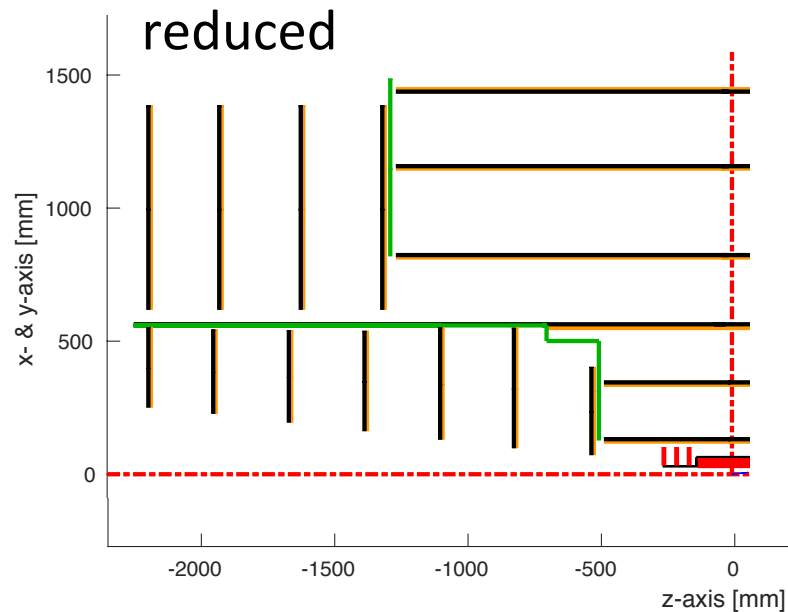
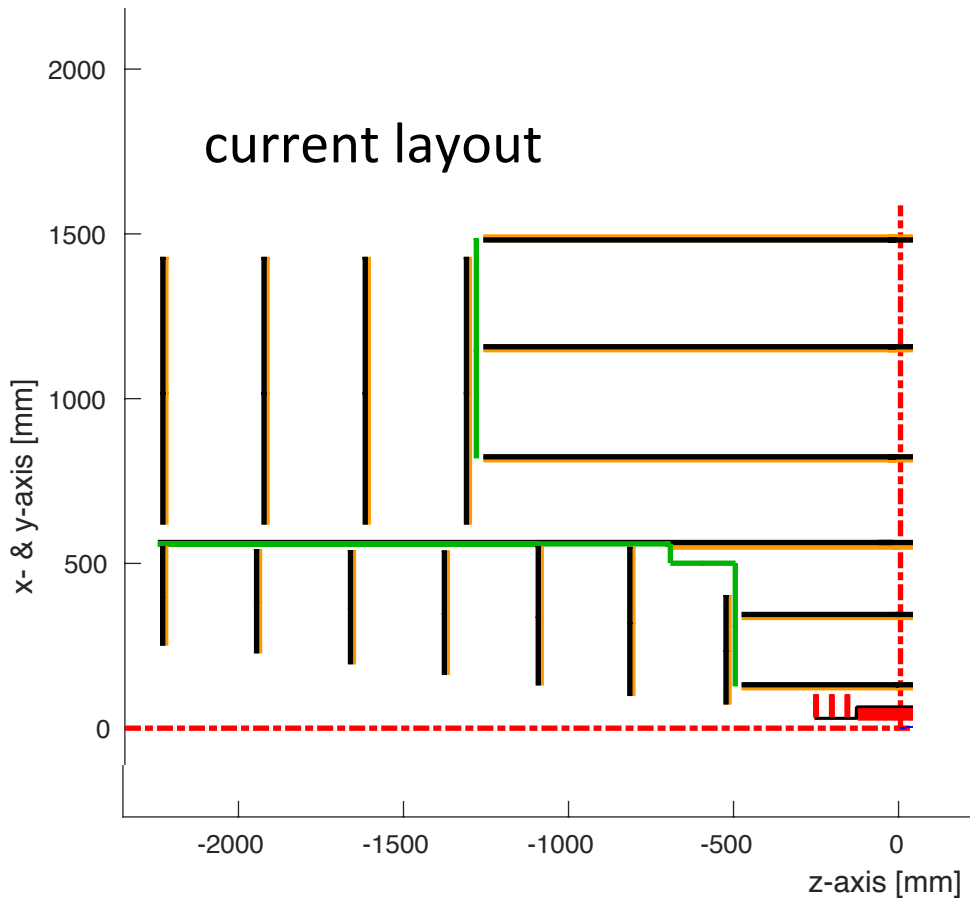
# Reduced and optimised tracker layout

- Overall size **reduced**:  $R_{\max}$  by 44 mm,  $z_{\max}$  by 40 mm
- **Re-optimised** position of all layers



# How the models actually look like

Fast simulation: LDT



# 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
current	0.00174	0.00101	0.00043	0.000225	0.000117	0.000051
reduced	0.00176	0.00103	0.00044	0.000231	0.000120	0.000053
reduc + opt	0.00177	0.00104	0.00045	0.000233	0.000122	0.000054
% diff reduc	-1.49	-2.03	-2.34	-2.51	-2.79	-3.36
% diff r+o	-2.02	-2.72	-3.16	-3.47	-4.00	-4.75

- 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 $\Delta p_T/p_T^2$

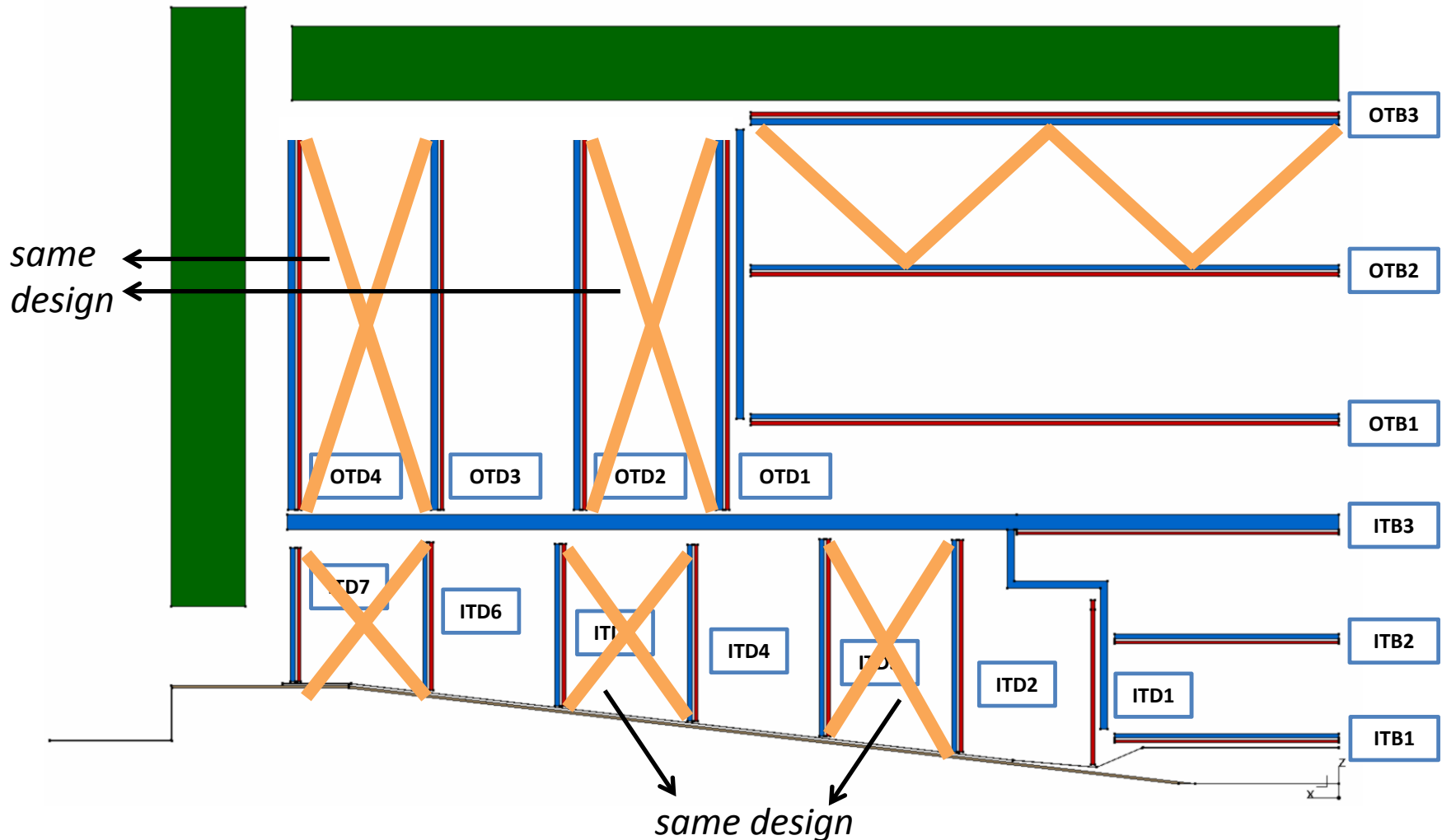
- Single  $\mu$ ,  $p = 500$  GeV, theta from 30 deg to 90 deg

	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

# Constrains from support structures

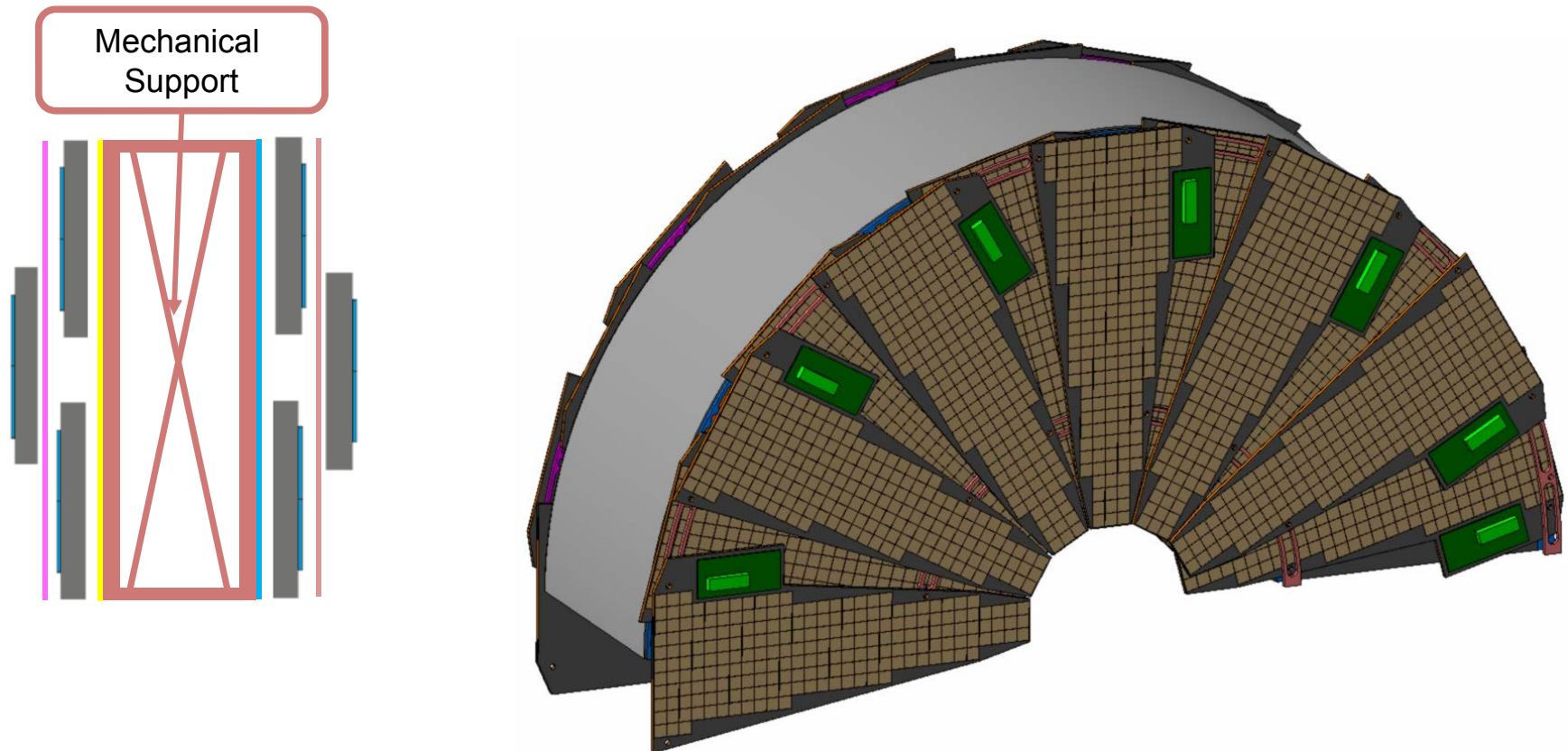
- Common mechanical structures supporting 2 pairs of layers
  - Either move in z a pair of layers or reoptimise the supports
- But conical support tube, if move disk in z inner radius changes



# Support and petal structures

*S. Sroka's talk at:*

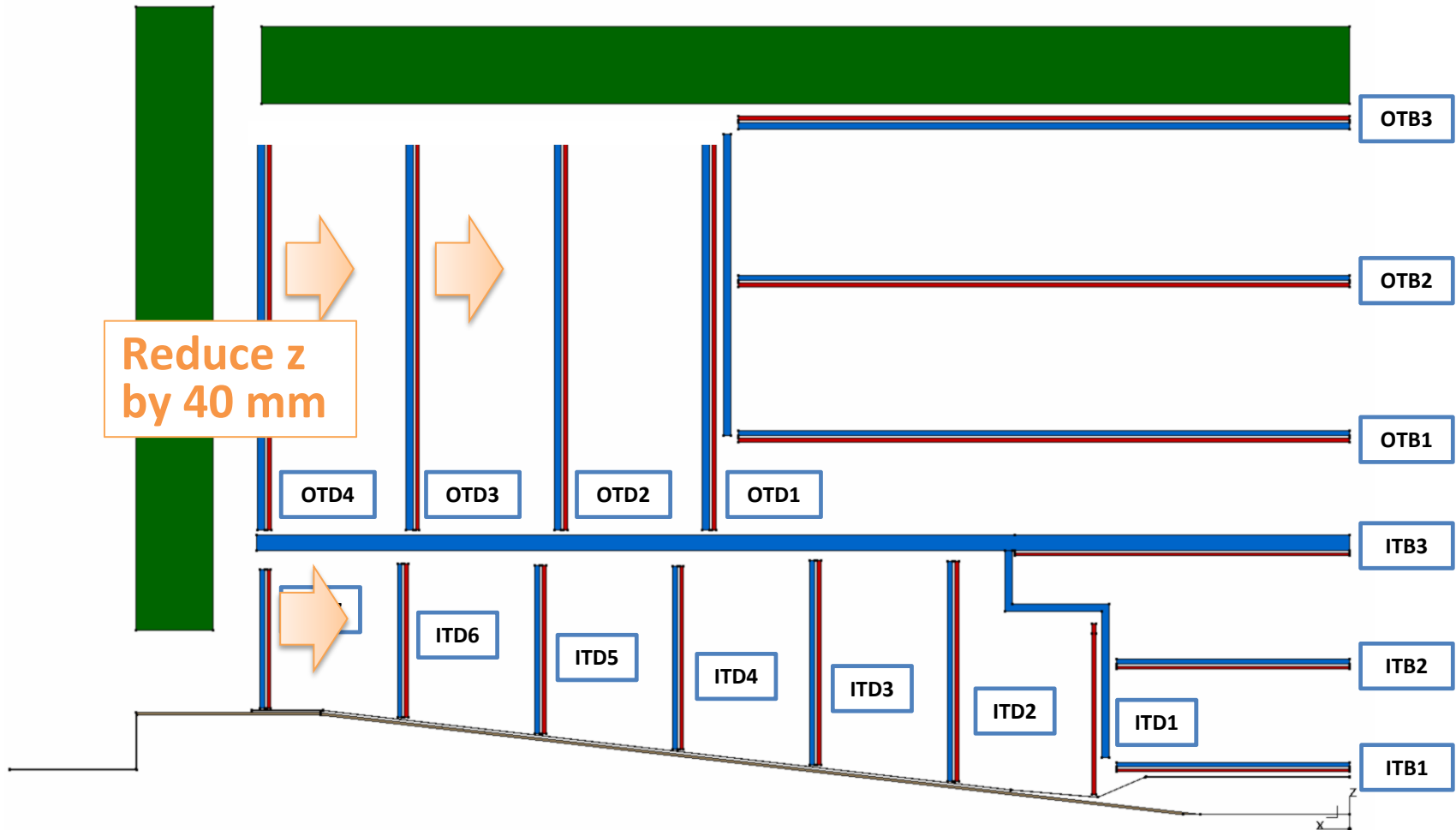
<http://indico.cern.ch/event/561842/>



- Undesired changing the petal structure for the engineer design and the full simulation implementation

# What we are proposing

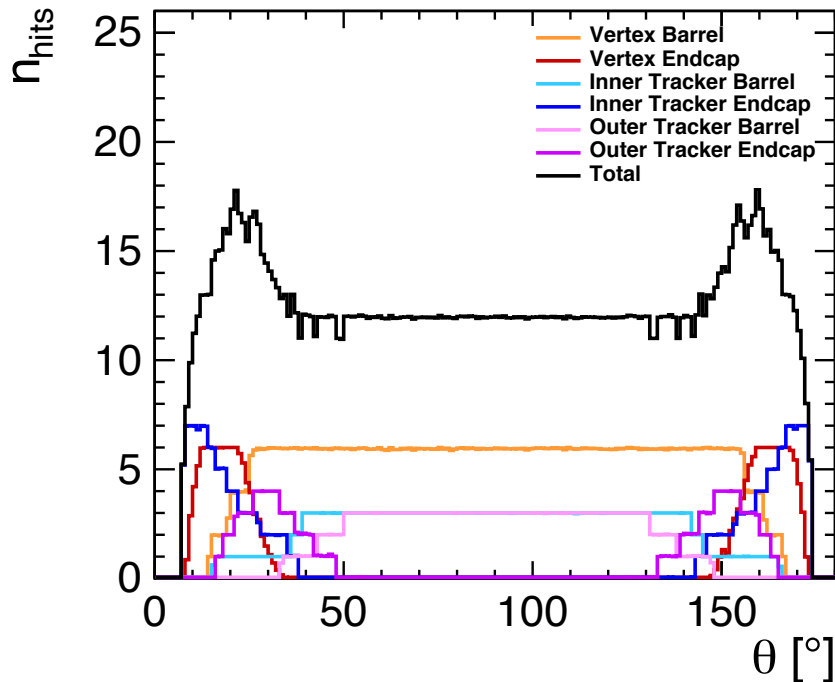
- $Z$  reduced by 40 mm for OTD4-OTD3, ITD7,  $R$  unchanged
- Keep same support design for: OTD3-OTD4 and OTD1-OTD2
- Revise support design for ITD6-ITD6



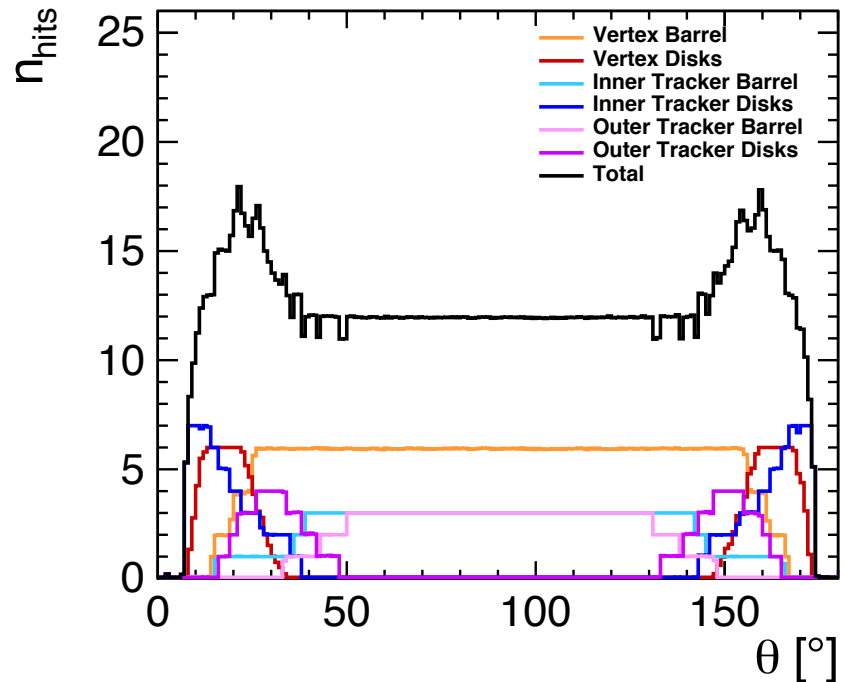
# Validation in full simulation – nhits

- Implementation (*M. Petric*) in full simulation (ECAL to be revised)
- Single  $\mu$ ,  $p = 500$  GeV
- Basically no differences in the number of hits

CLIC\_o3\_v5

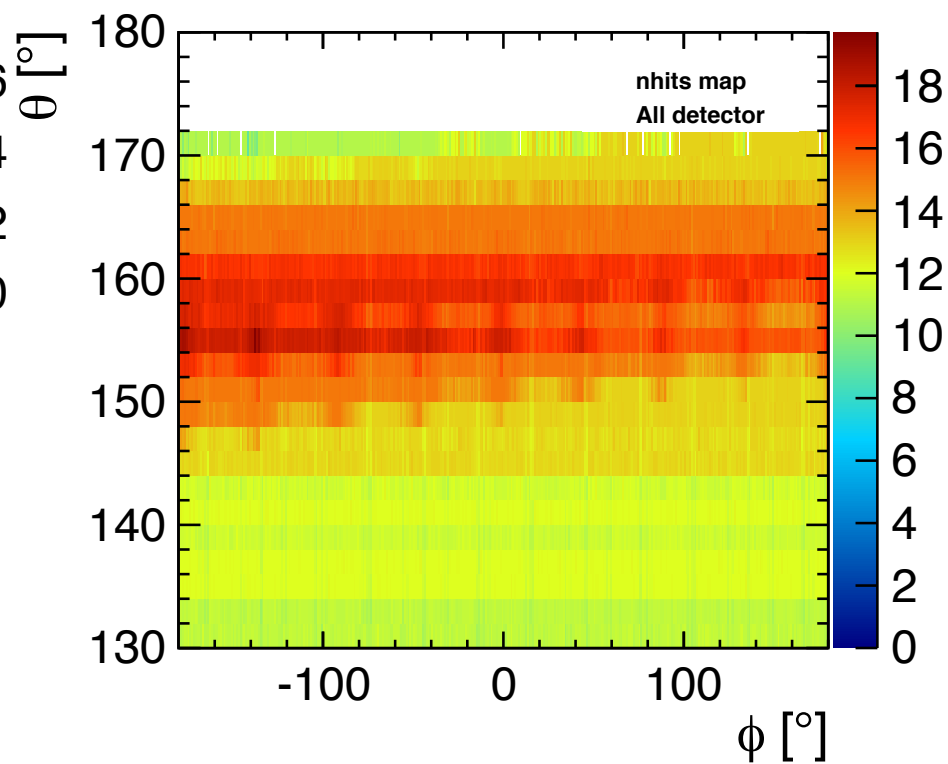
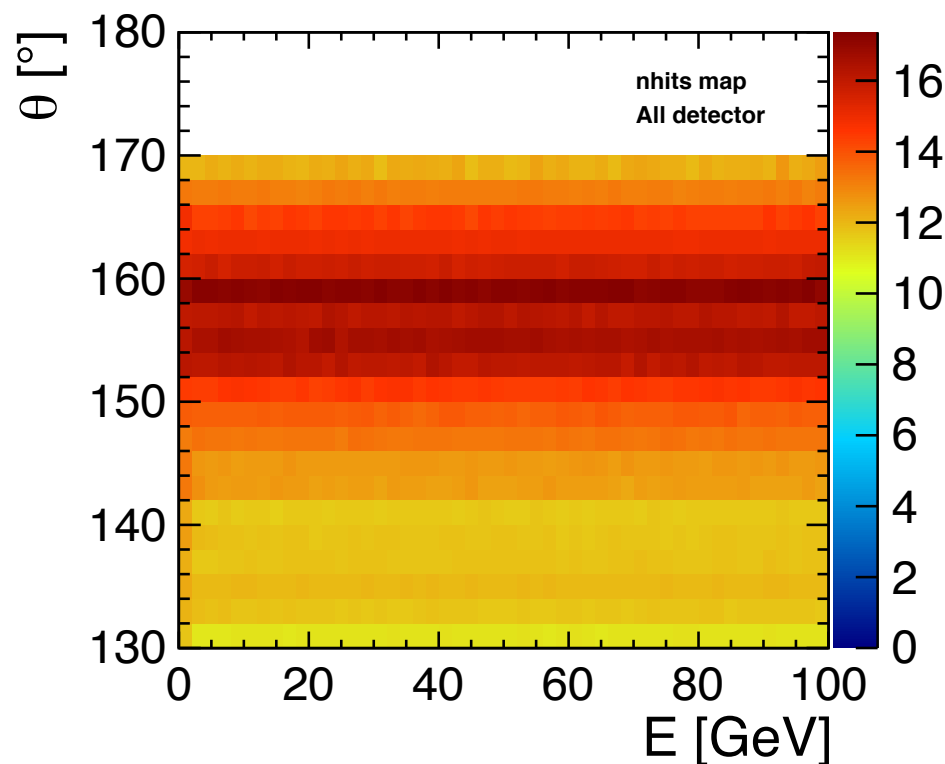


z reduced by 40 mm



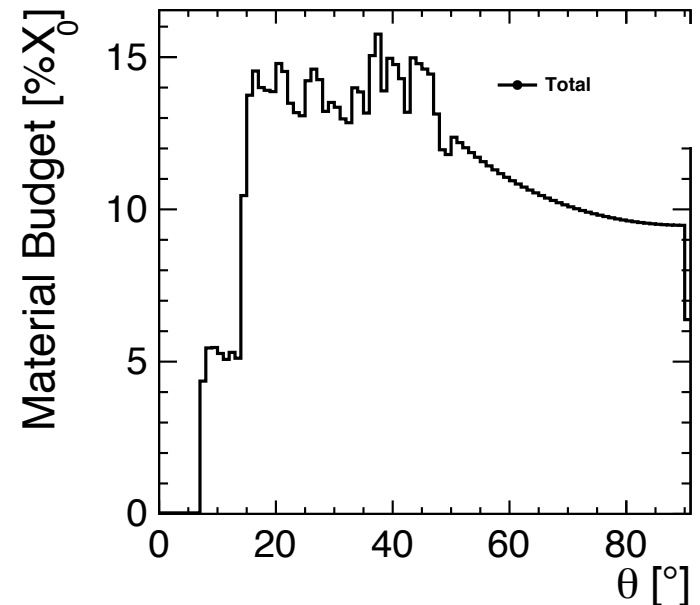
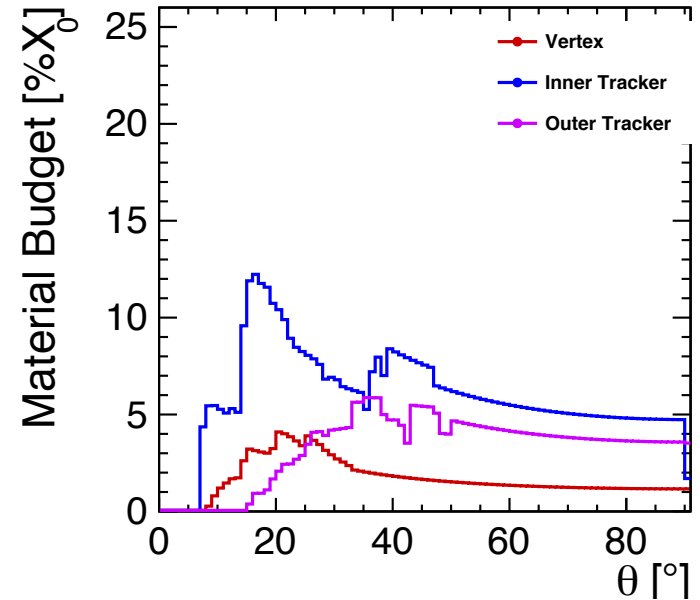
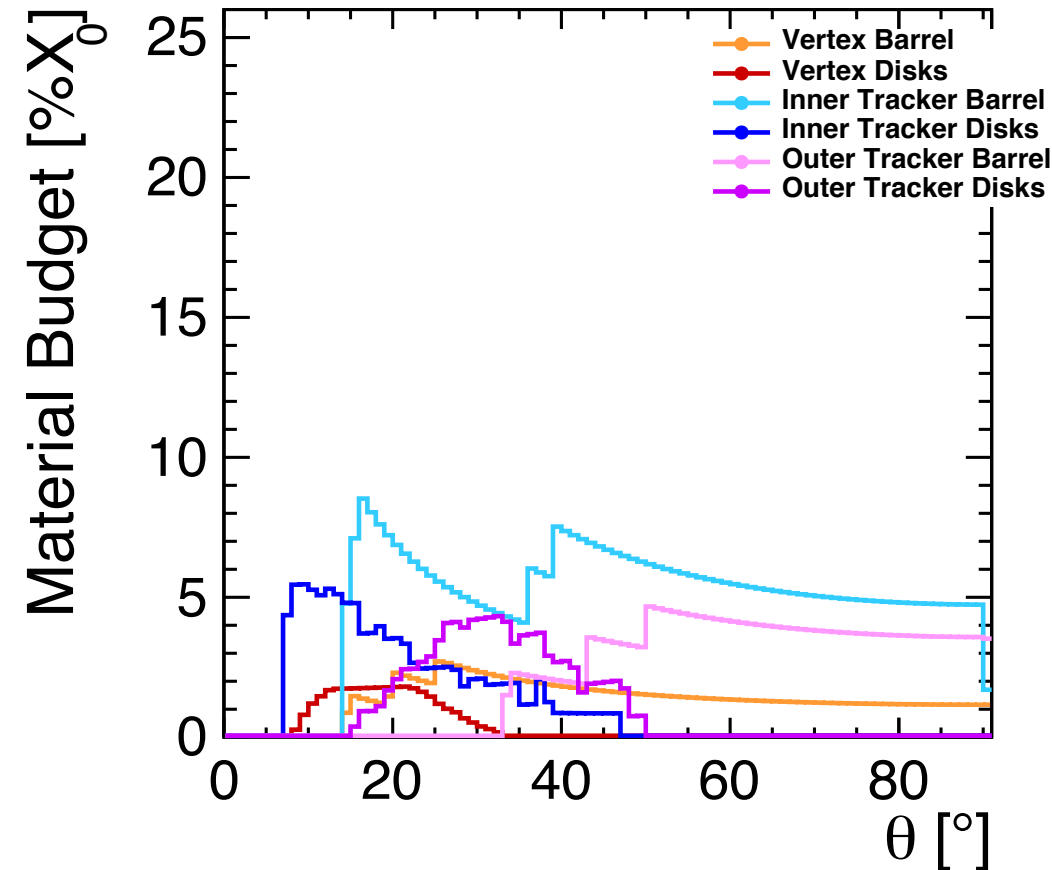
# Hit map

- N of hits investigated as a function of particle energy (in case at low momentum the particle “curls” into holes)
  - To be study also as a function of pT
- Dependence on phi due to spiral vertex geometry in the disks

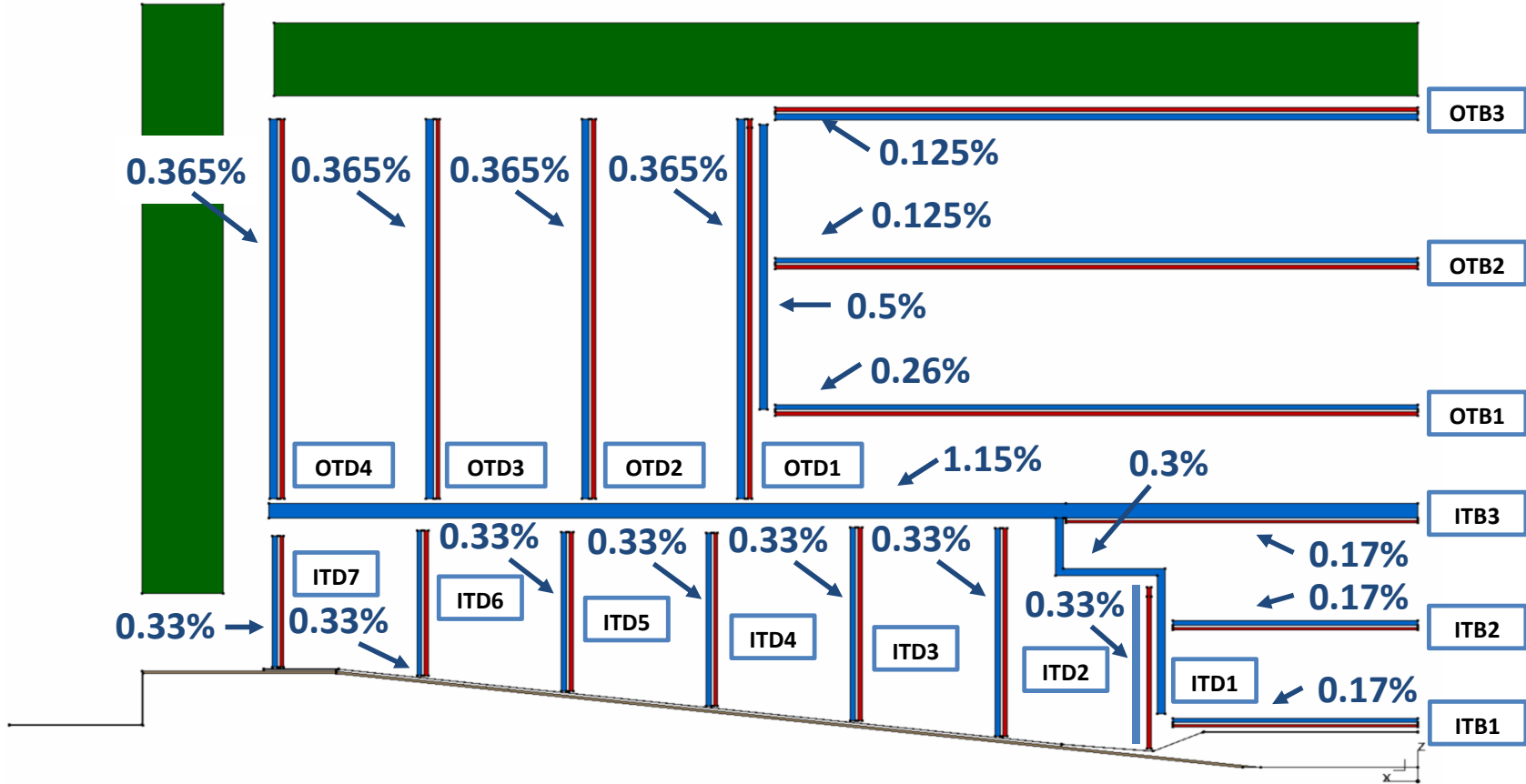


# Material budget

- Coherent with expectation
- Inner Tracker Barrel also include the support tube
- Next: add Beampipe contribution



# We are light



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

Dark Blue- Carbon fiber supports

**Work is ongoing**



Pattern recognition methods

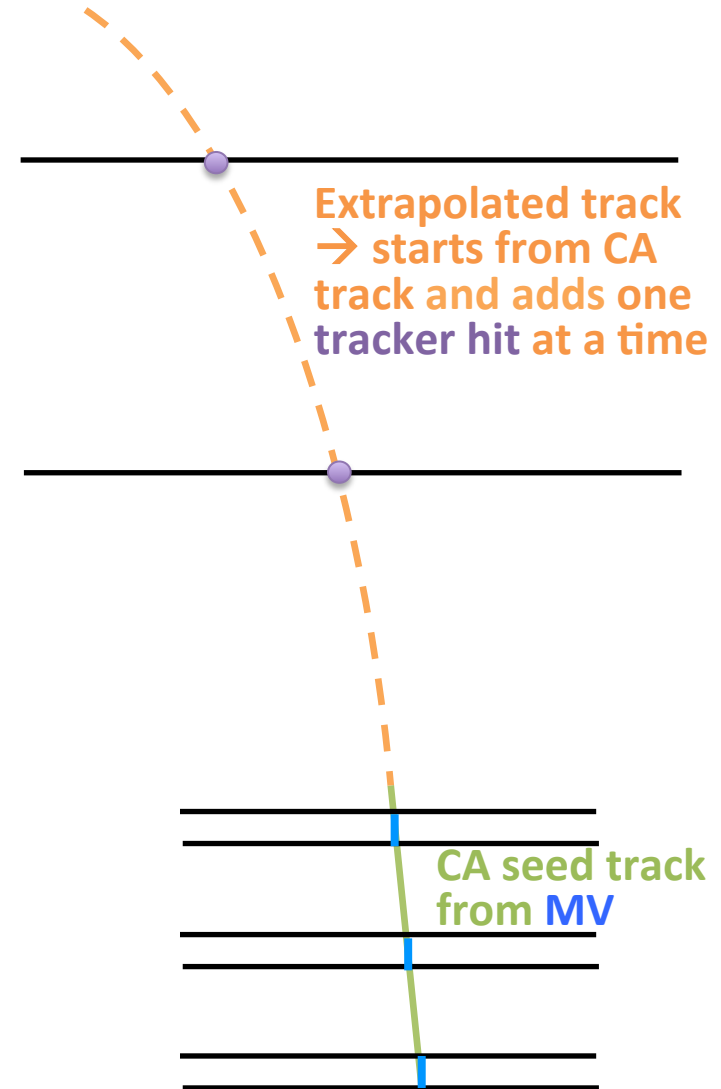
# **TRACKING STATUS**

# Pattern recognition I – Reminder

- For tracks traversing the vertex barrel
  1. Compute *mini vectors* (MV) exploiting the double layer structure of the vertex barrel
  2. Run *Cellular Automaton on MV* → obtain vertex tracks
  3. Use vertex tracks as seed for track *extrapolation* to Inner and Outer Tracker in Barrel and Disks
- To be combined with *independent Cellular Automaton in the forward*

## Mini Vectors:

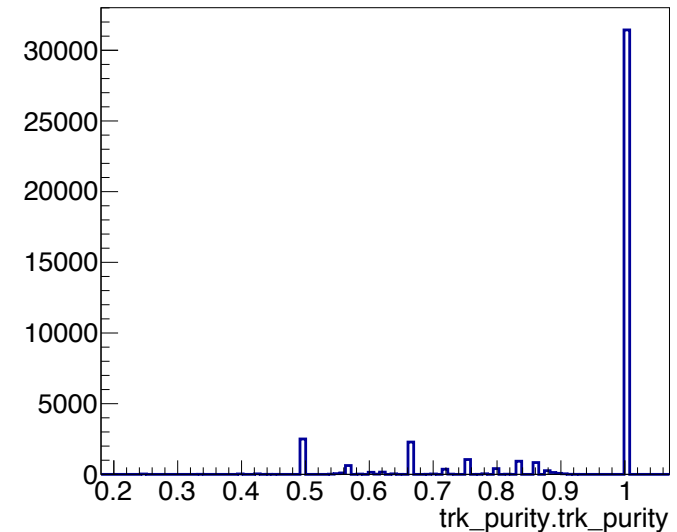
Create a mini vector out of 2 hits on adjacent layers ( $d < 5$  mm) with  $\delta\theta < 1^\circ$



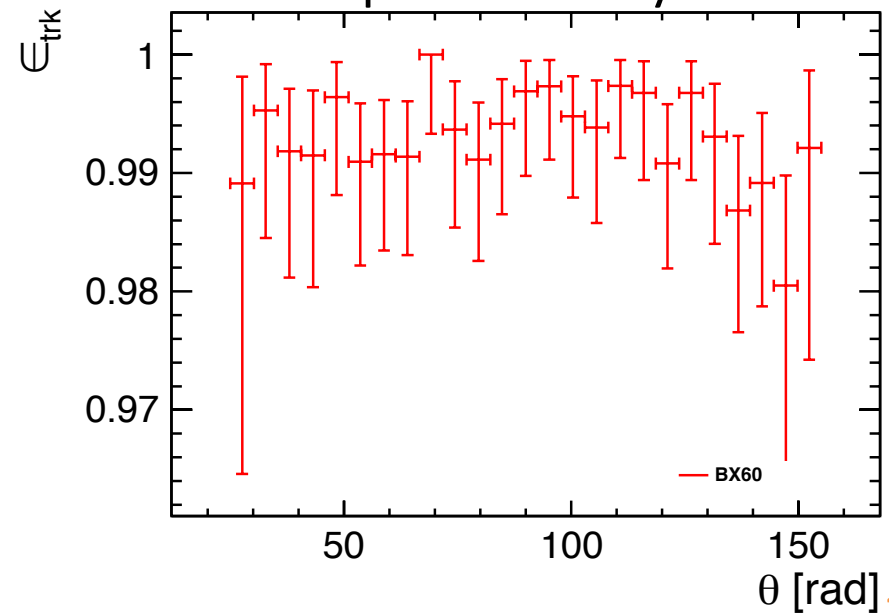
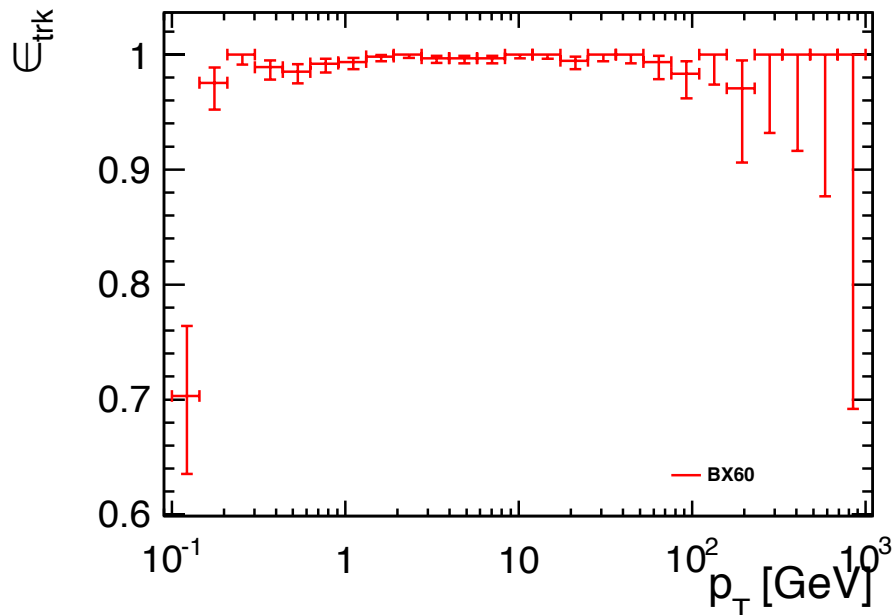
# Pattern recognition I – Results

- 3 TeV ttbar sample with 60BX overlaid
  - For new samples: 30BX vs the 60BX?
- Reoptimisation necessary
- Purity ok but room for improvement
- Not run any profiler yet to optimise timing (anyway no longer of current tracking)
  - Optimised loop in hits
  - Extrapolation procedure takes time

trk\_purity.trk\_purity



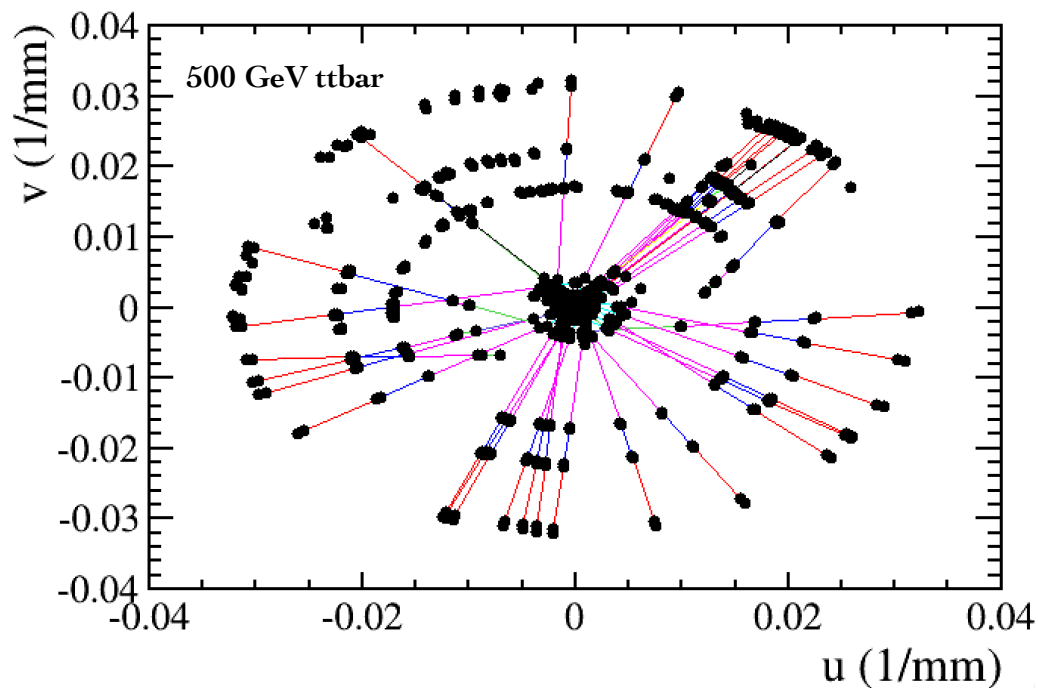
Mini Vector + Cellular Automaton + Extrapolation only



# Pattern recognition II – Reminder

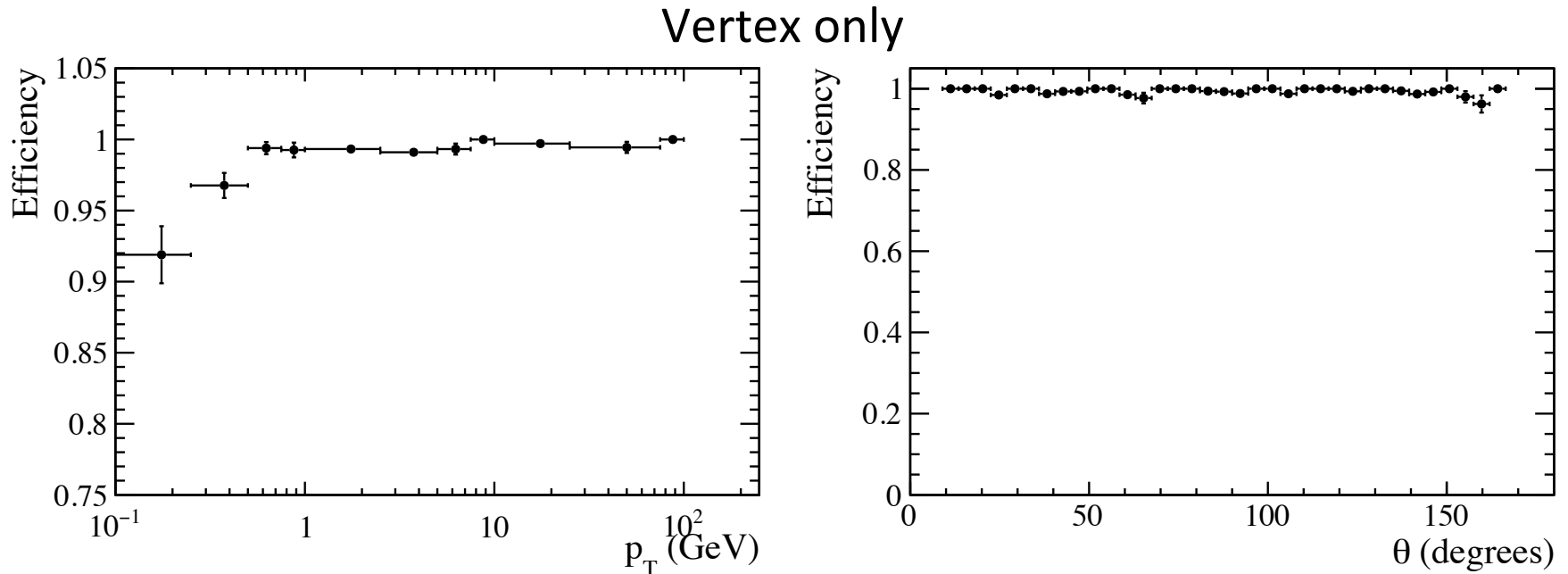
- *Conformal mapping*: coordinate transformation that preserves local angles
  - (x,y)-plane in the (u,v)-plane
  - Tracks are straight lines
- *Run CA sequentially on all hit collections*
  - same approach in the full tracker system
  - no sub-track combination needed
- Track ambiguity resolved with linear fit

$$\begin{cases} u = x/(x^2 + y^2) \\ v = y/(x^2 + y^2) \end{cases}$$



# Pattern recognition II – Results

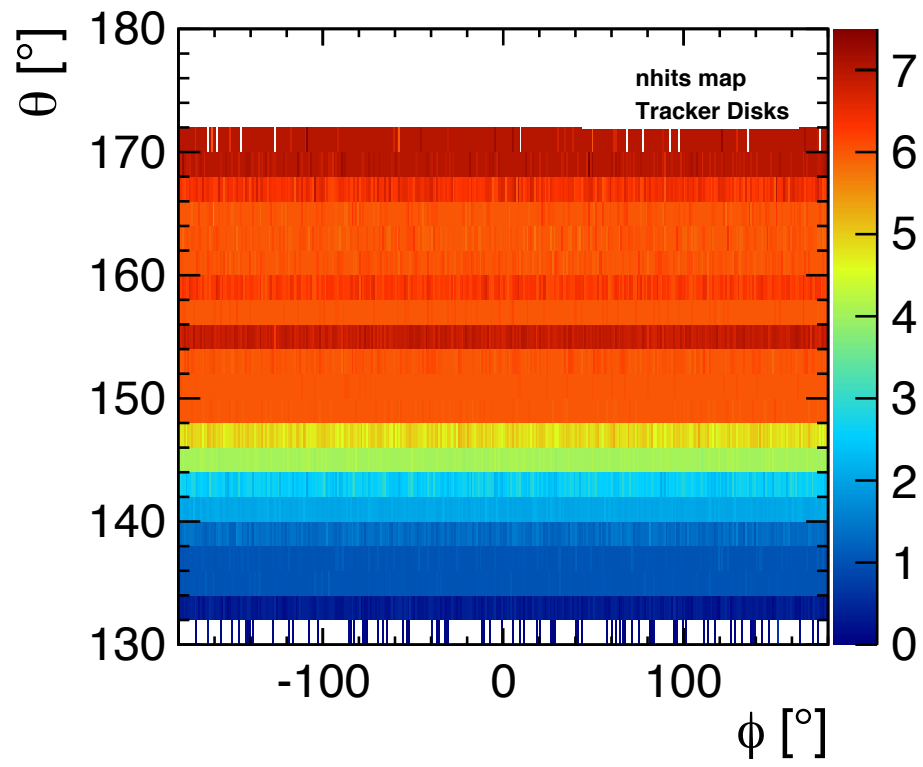
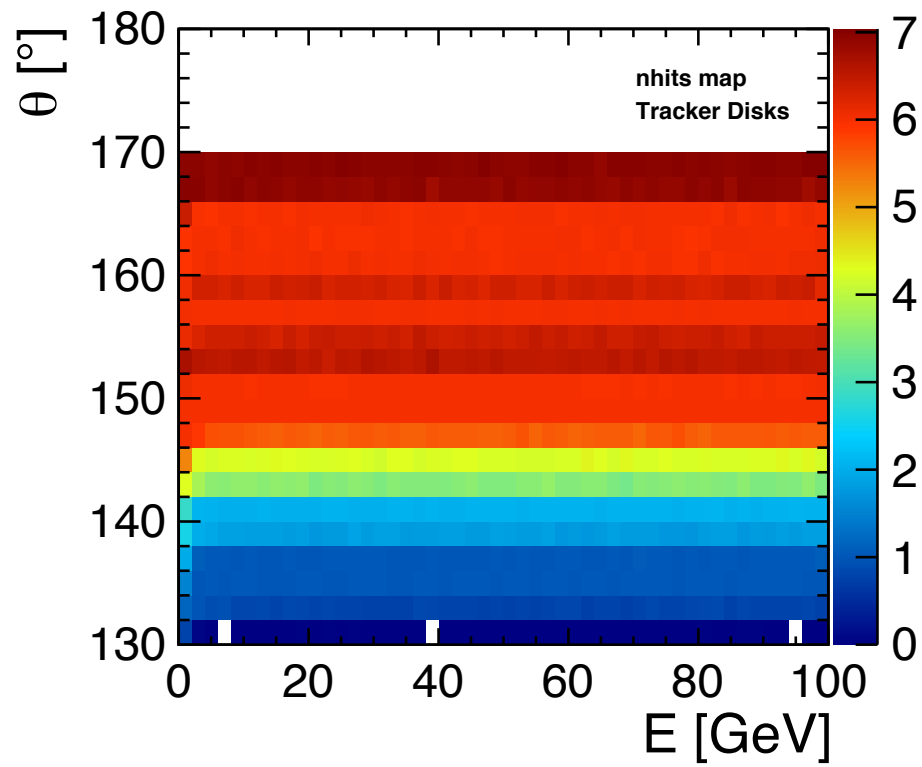
- 3 TeV  $t\bar{t}$  sample without overlay
- Cell following logic revised, keep more tracks candidate till the end
- Added fit in sz-fit to gain 3D-info
- Timing improved  $\rightarrow$  0.3 s/event (no Marlin track fit)
  - Linear regression implemented instead of chi2 for fit
  - Code profiled to find hotspot
- Good purity, numbers to be computed



# Conclusions

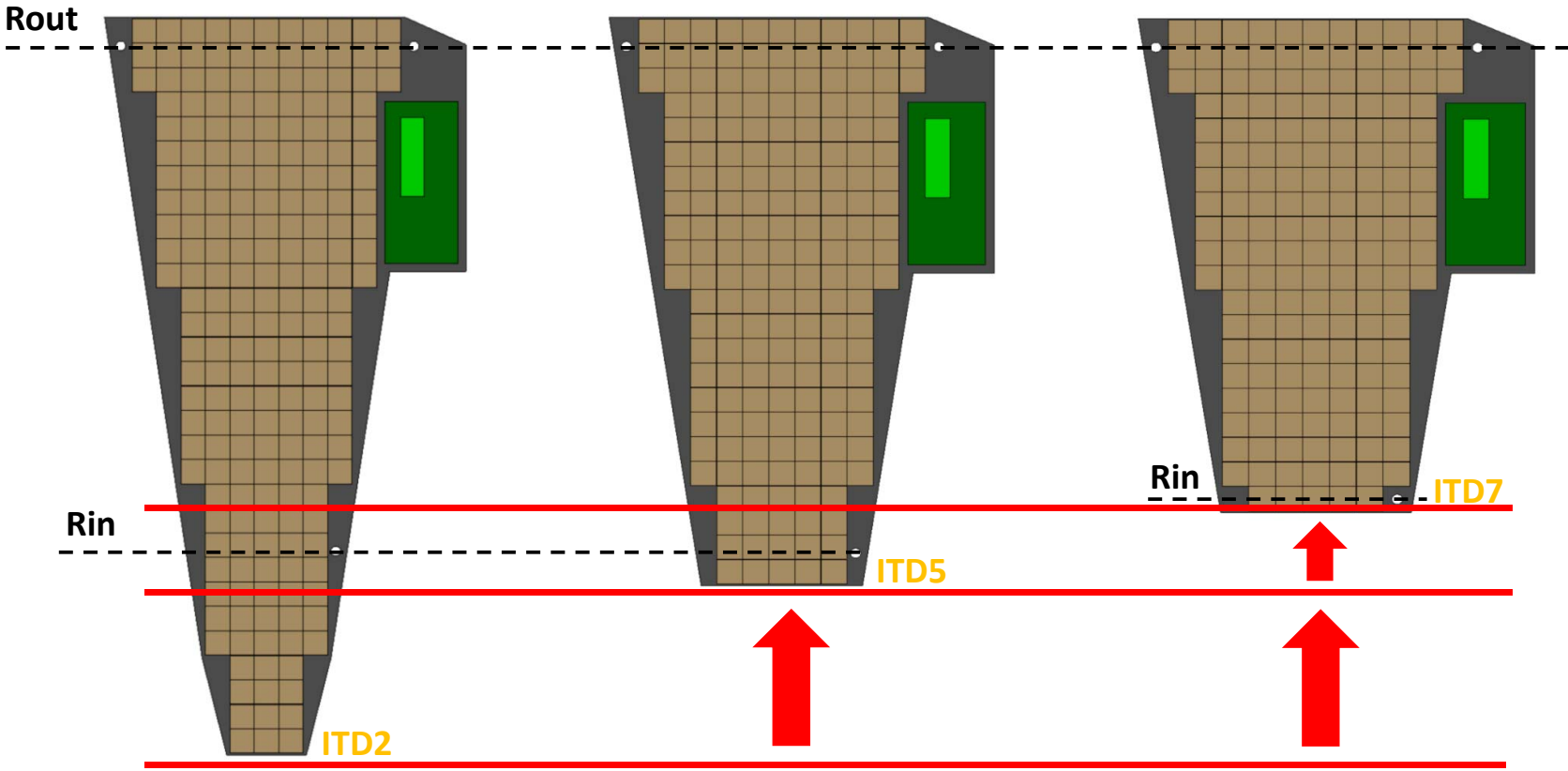
- **Tracker size** has been revised to allow space for the ECAL
  - ❑ Reduce  $z$  by 40 mm → it allows to not change the complex forward design of the other system
  - ❑  $R$  kept unchanged → ECAL will push all the rest out
  - Validation of implementation in full simulation looks ok
- **Tracking** is coming together
  - ❑ Moving to 3 TeV w/wo BX has required work and optimisation
  - ❑ Very good efficiency reached
  - ❑ Work on going to check/improve fake rate

**BACK-UP**

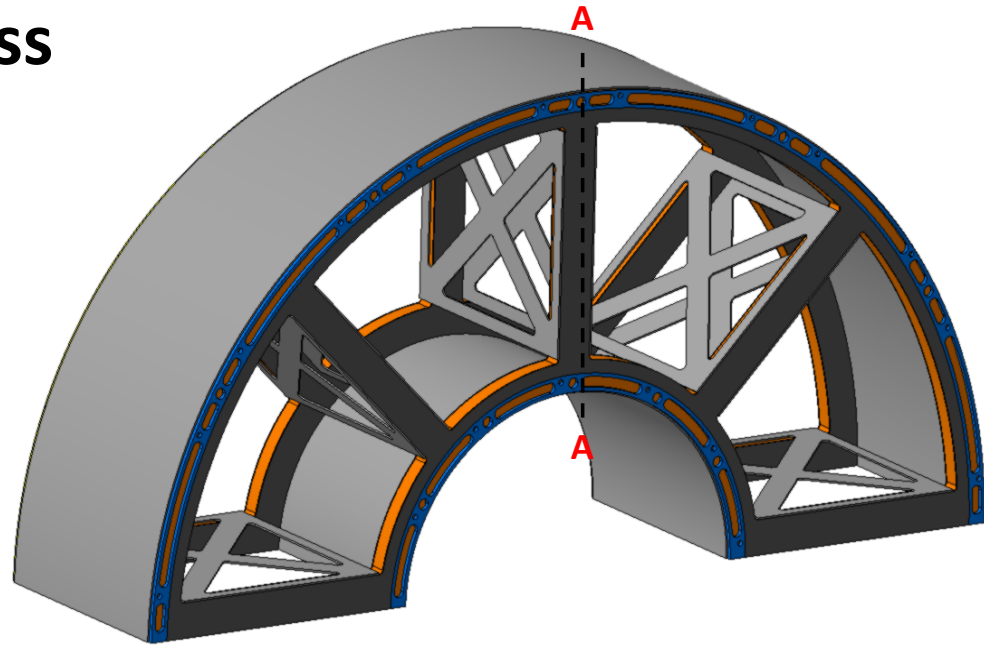
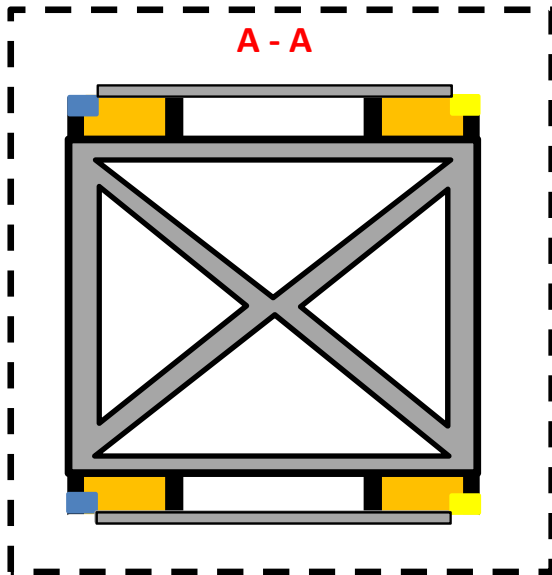




# Design of Petals



# Introduction to Design and the Concept Development Process



## Design details:

- 2 Sandwich faces [CFS-CORE-CFS]
- 2 Rings on each side (in total 4) e.g. made of PEEK
- Horizontal Interlinks – Inner & Outer CF Shell
- Radial Interlinks – CF Plates