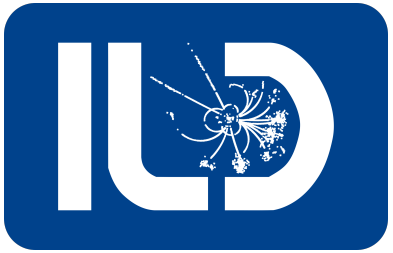
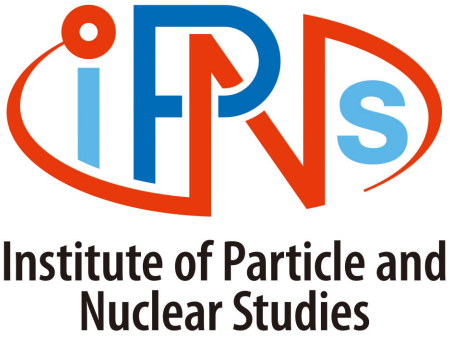


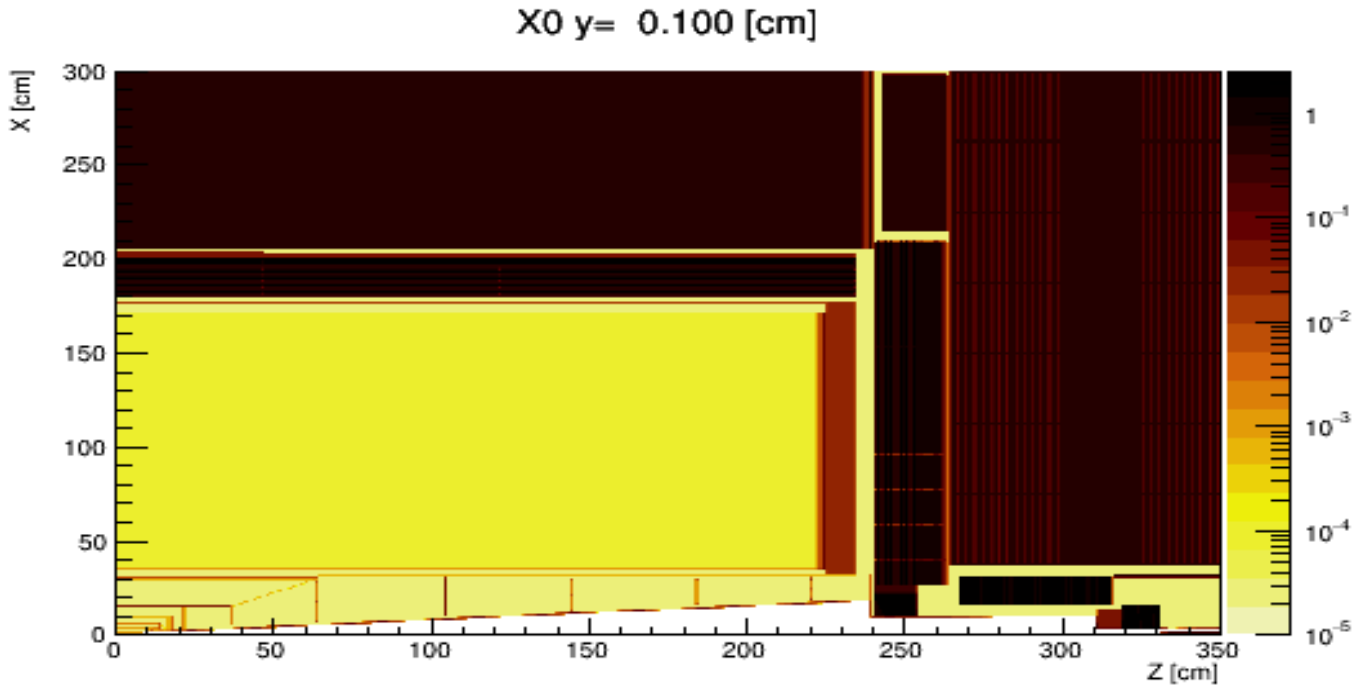
# a silicon tracker for ILD ?

## replacing ILD's TPC with a CLIC-like silicon tracker (in simulation)

Daniel Jeans, KEK/IPNS

ILC detector meeting, 2022/3/9





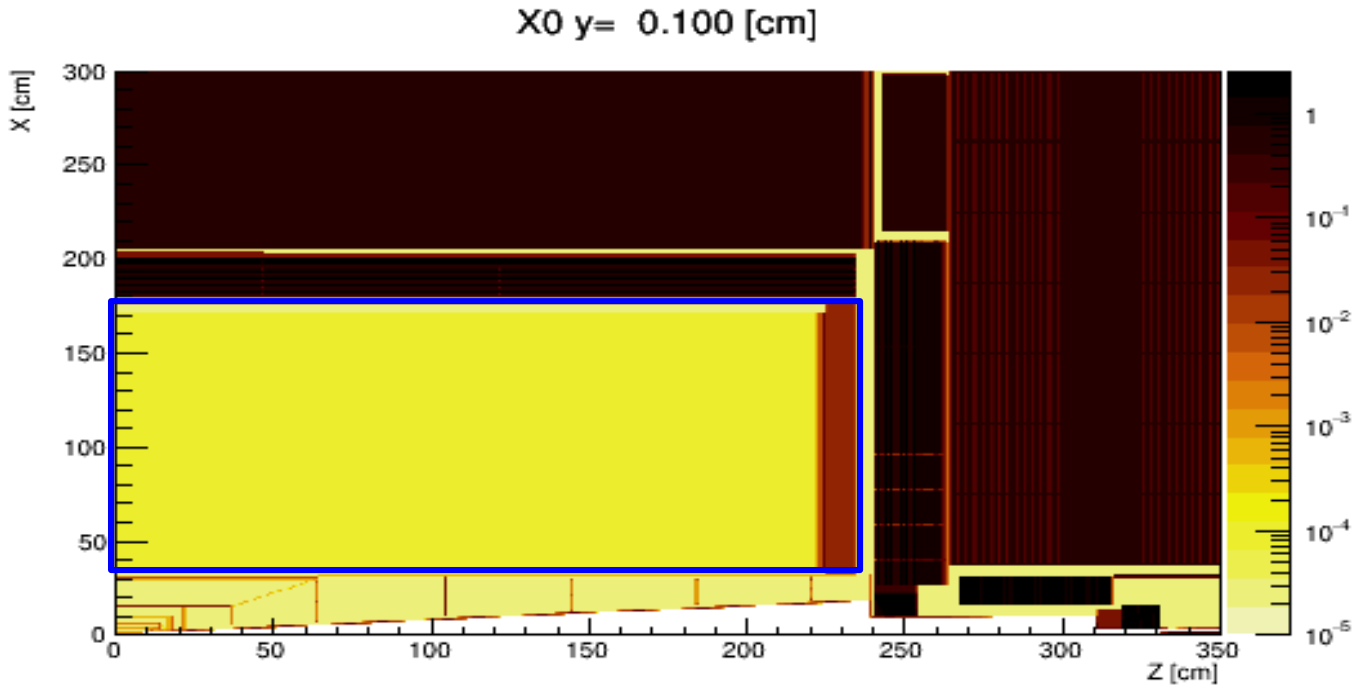

ILD's simulation model is designed to make it easy to compare technologies

e.g. * "hybrid calorimeters" → simultaneous simulation of silicon/scintillator ECAL
scintillator/RPC HCAL

* Large and Small versions of ILD

These can help us to decide which technology is better
change just one detector part; most of detector is identical
same events
same reconstruction algorithms (or possibly some adaptation)

→ detector optimisation



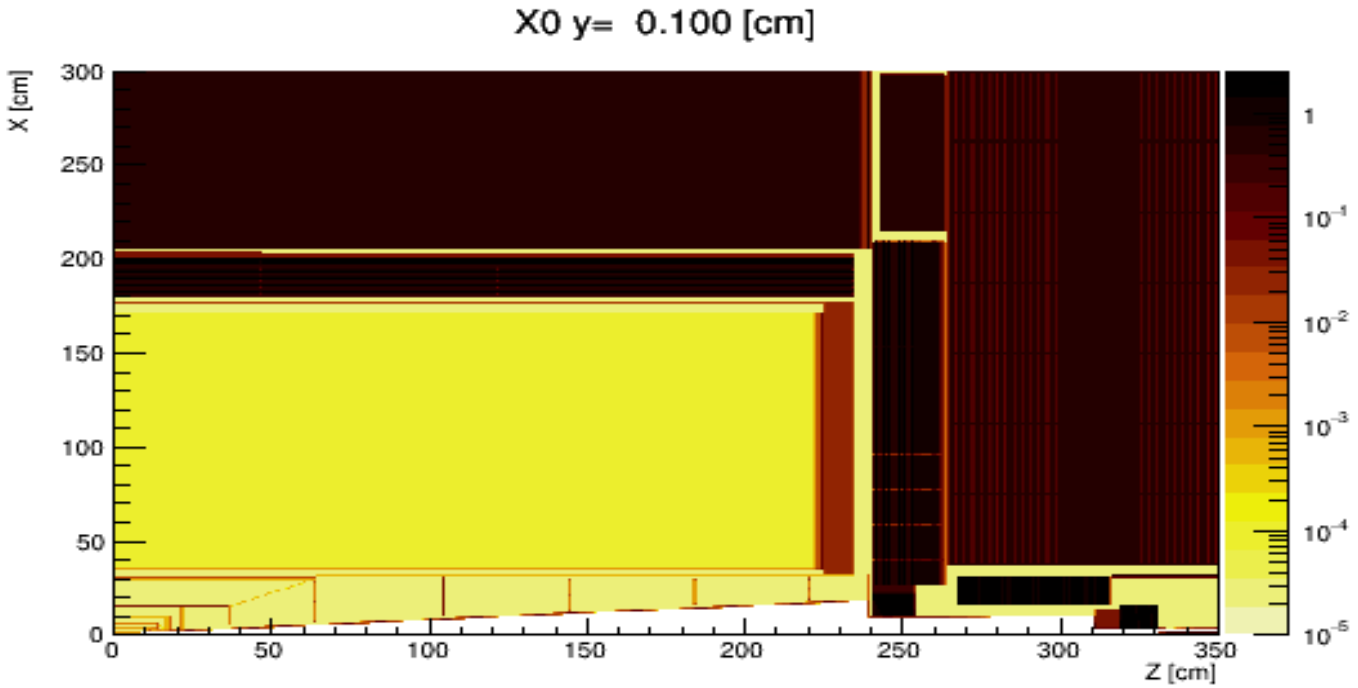

in this talk, I'll describe a new model which replaces the TPC (and SET)
with an all-silicon tracker

when is TPC better ?

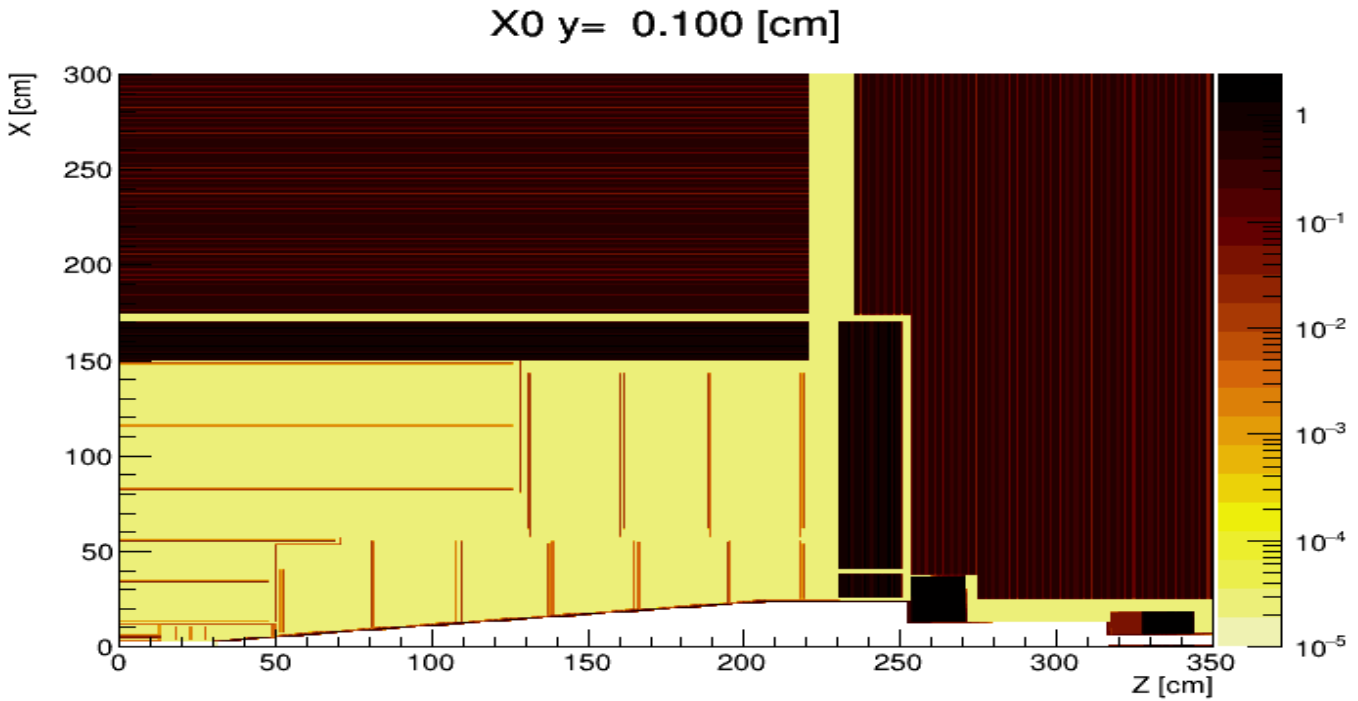
does all-silicon tracker have any advantages?

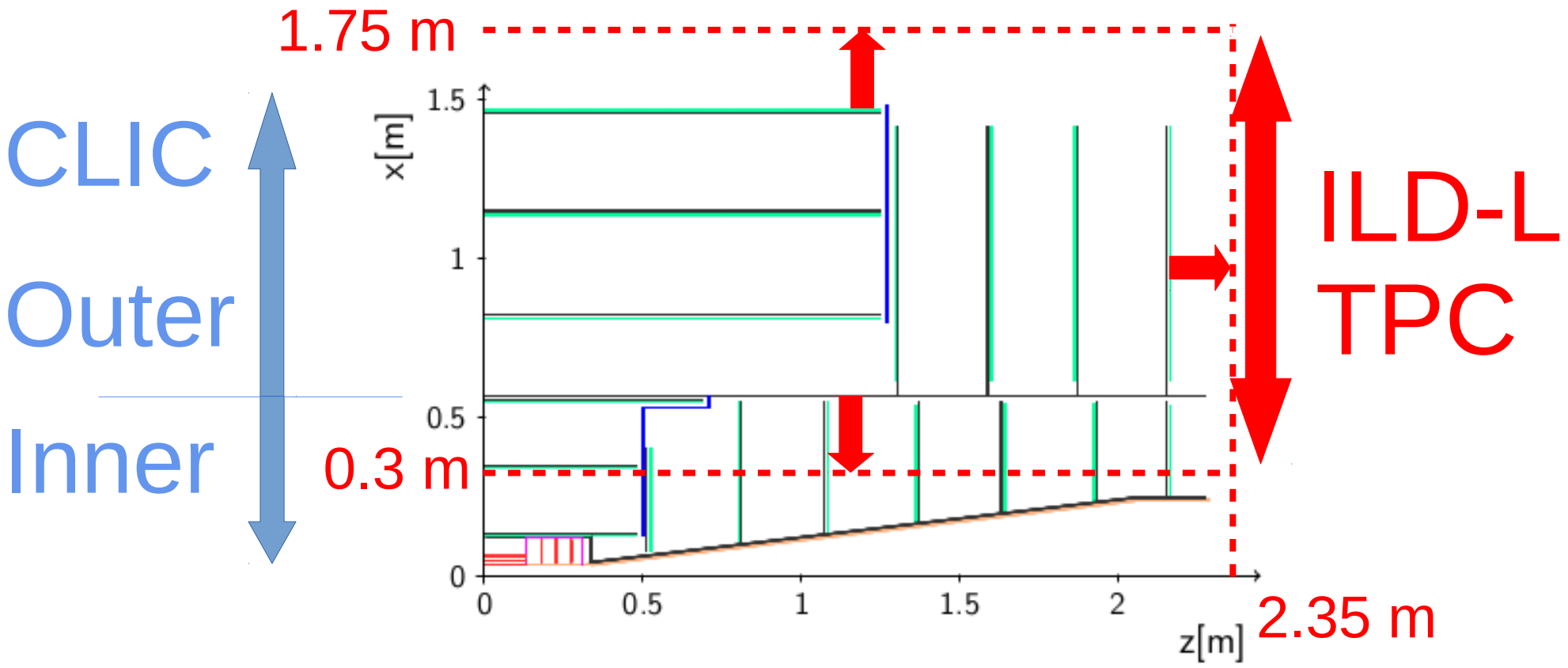
how about at other Higgs factories ?

ILD_l5_v02




CLIC_o3_v14





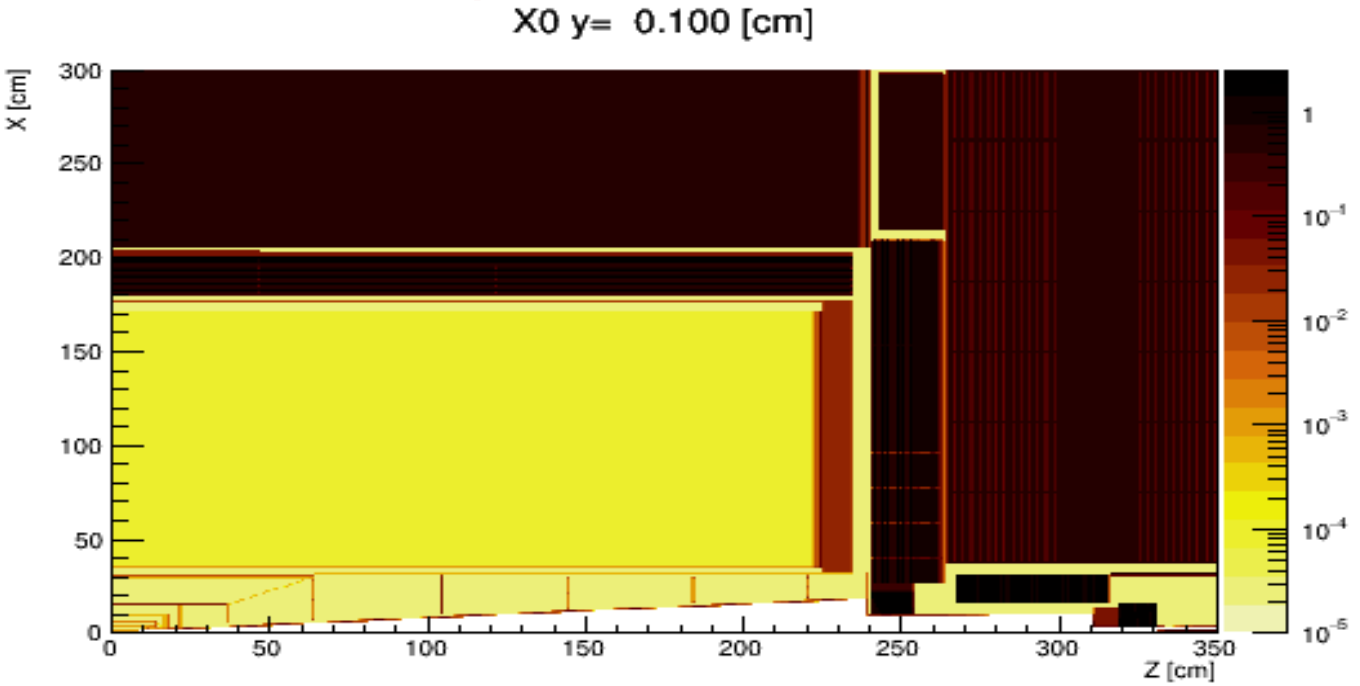

replace ILD-L's TPC+SET with CLIC-like outer silicon tracker

* radial size significantly larger: 1 additional barrel layer wrt CLIC
* length similar:
  same tracker barrel → endcap disk transition position ~ 1.25m
  slightly more separated endcap disks

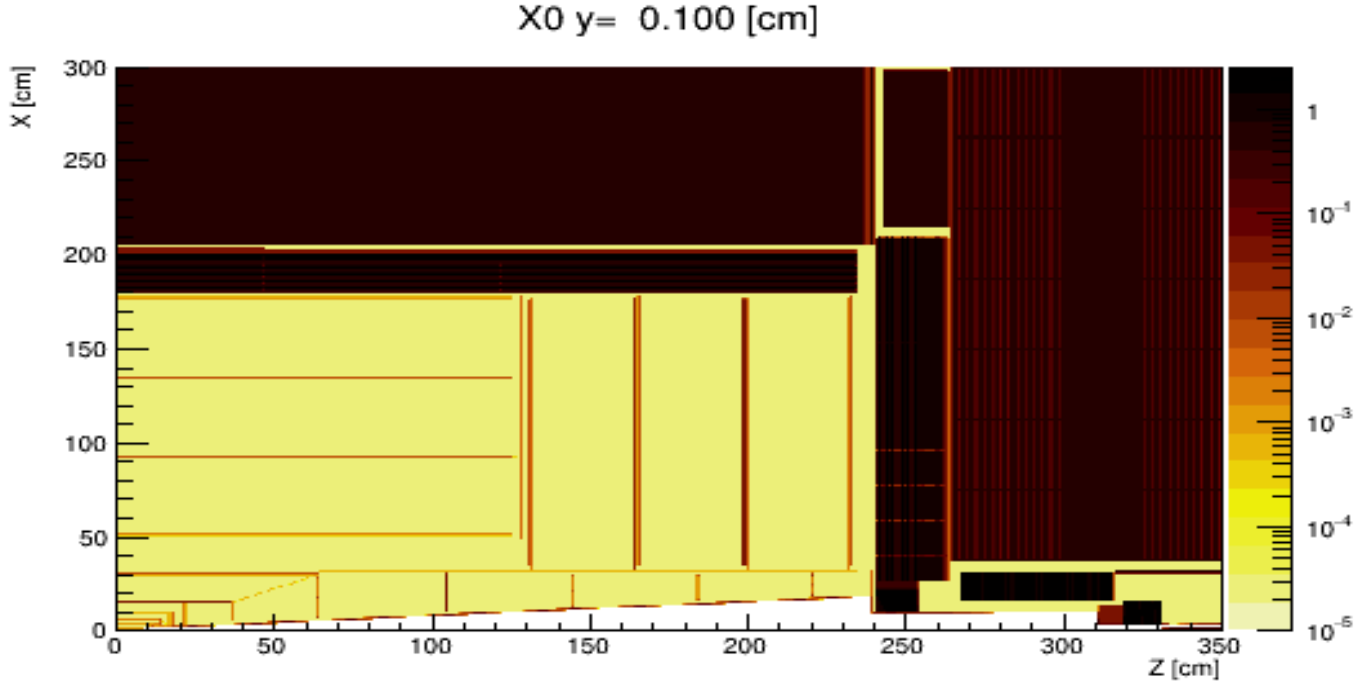
[ I am not a tracking expert, so this is probably not optimal
  → very happy to receive suggestions! ]

# geometry implemented in DD4hep

ILD_l5_v02

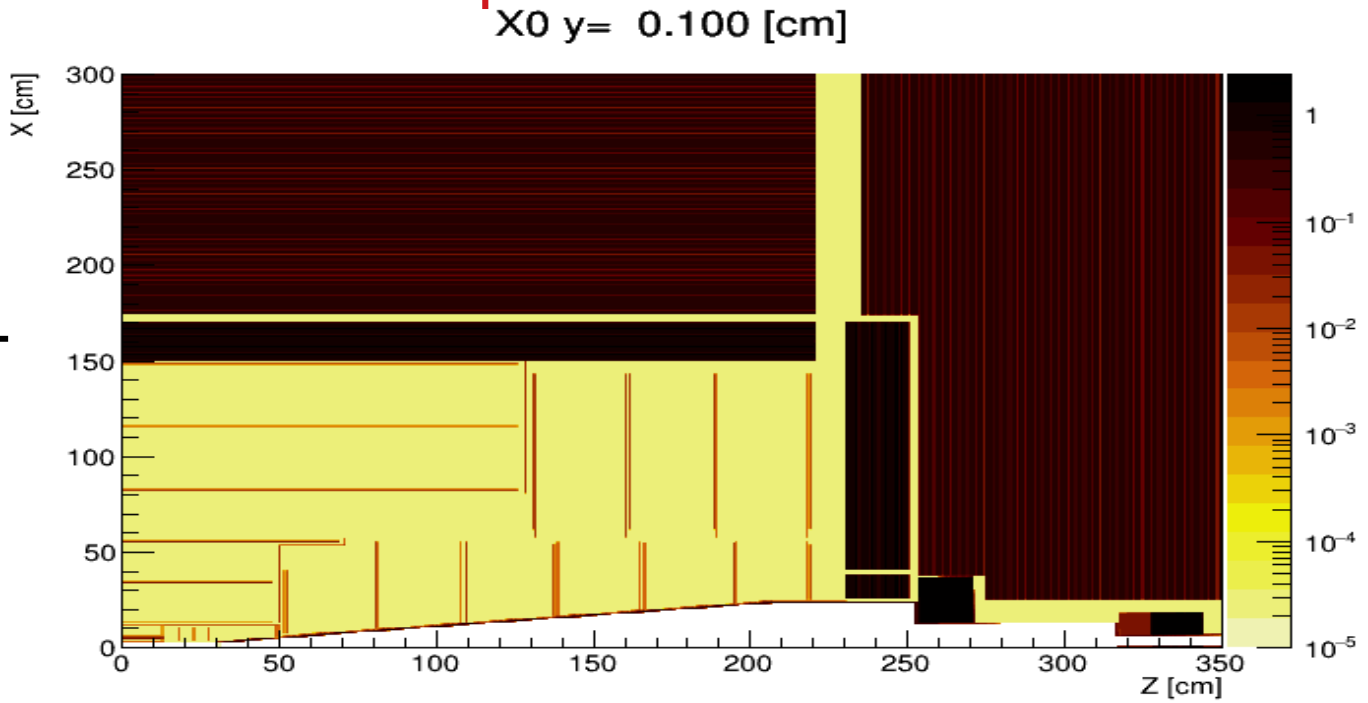



ILD_l5_v09

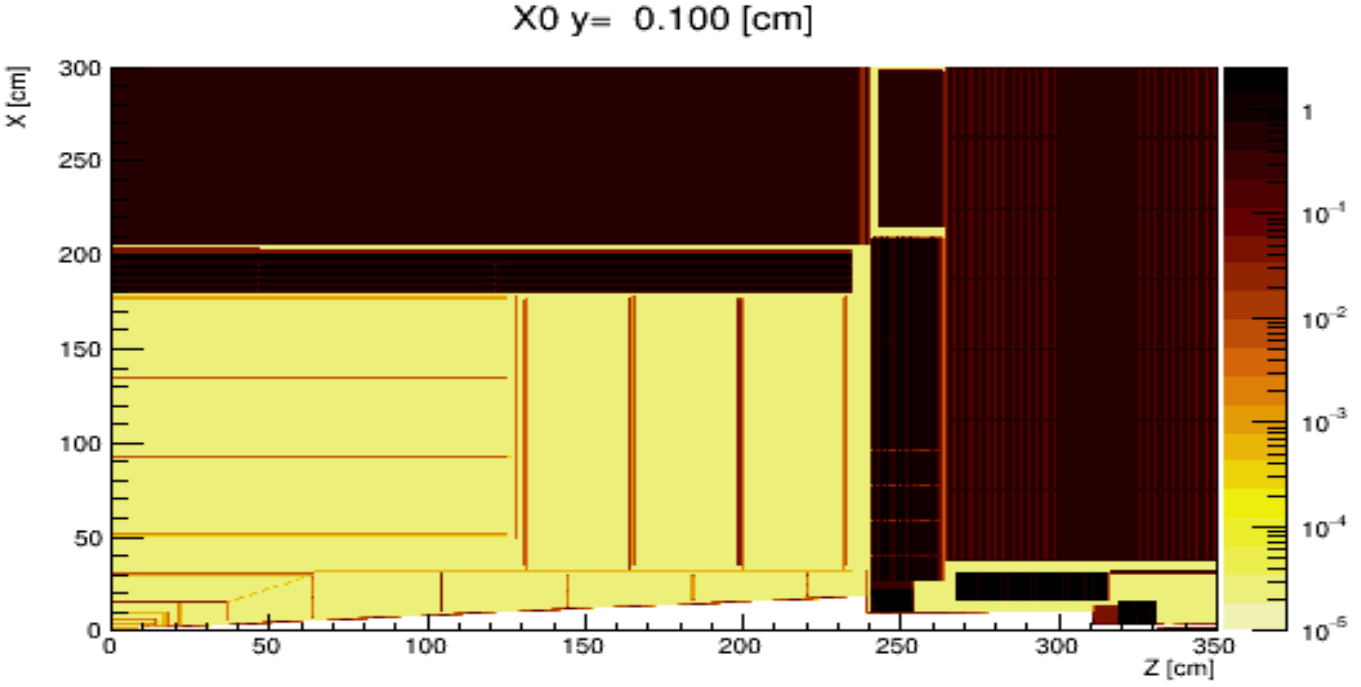


# geometry implemented in DD4hep

CLIC_o3_v14



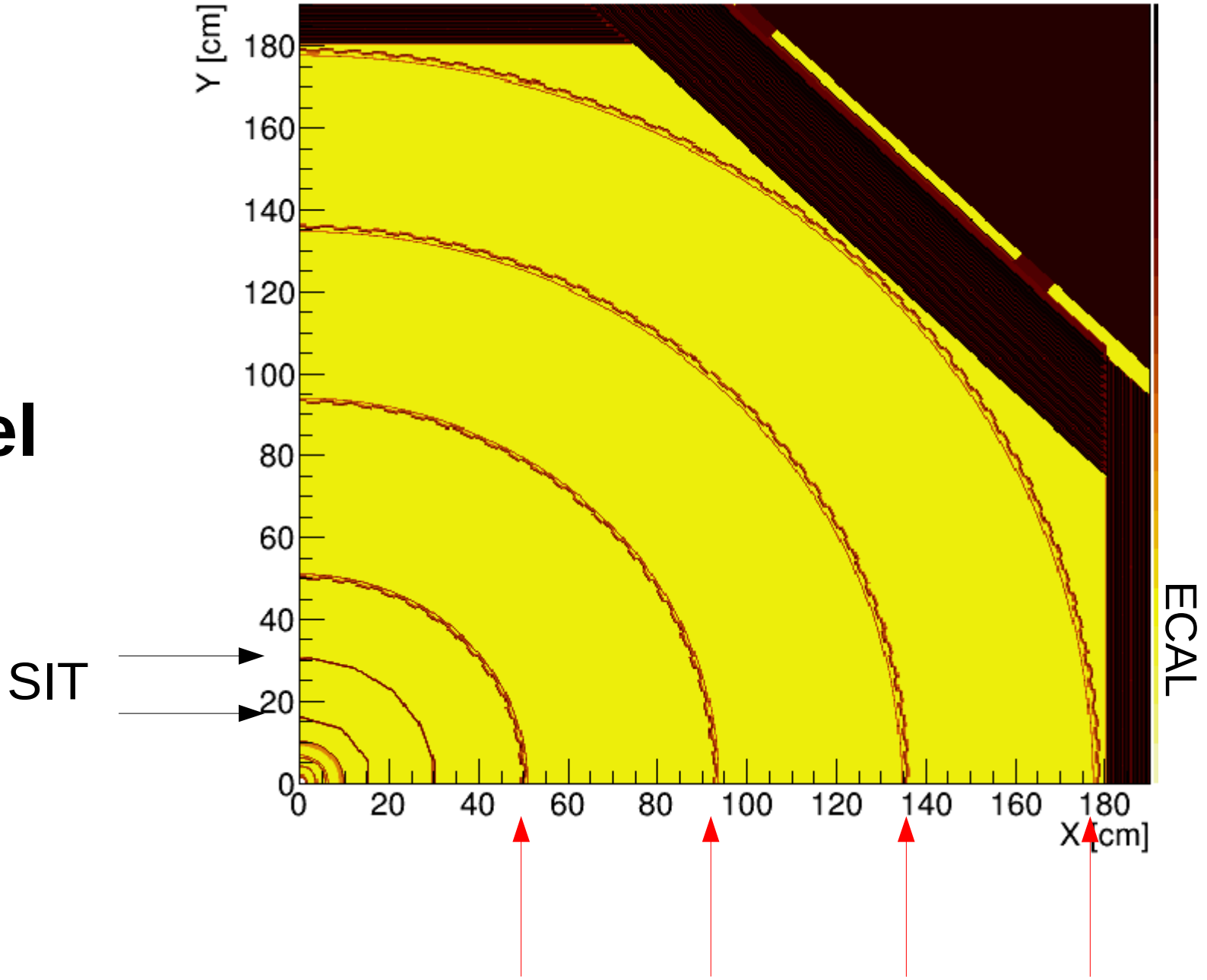

ILD_l5_v09



# tracker design rather detailed

ILD_l5_v09

**barrel**

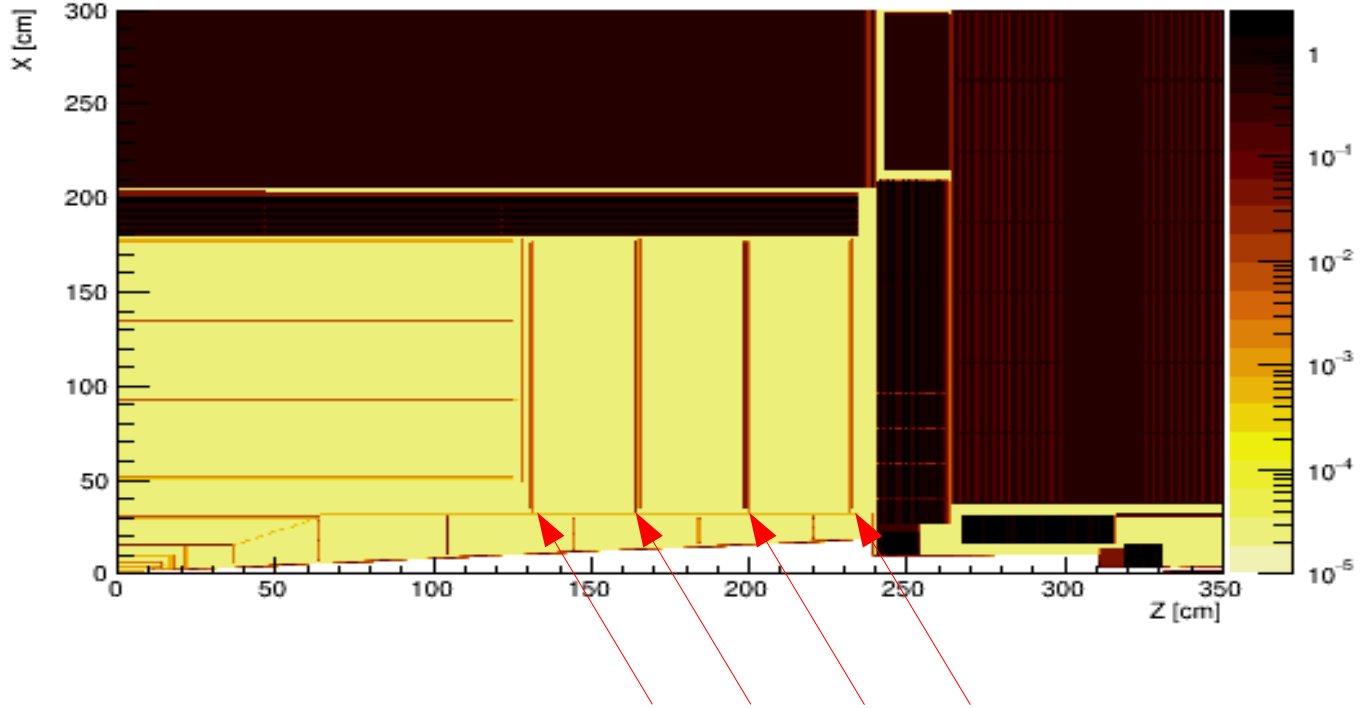



4 barrel layers, made up of small sensors

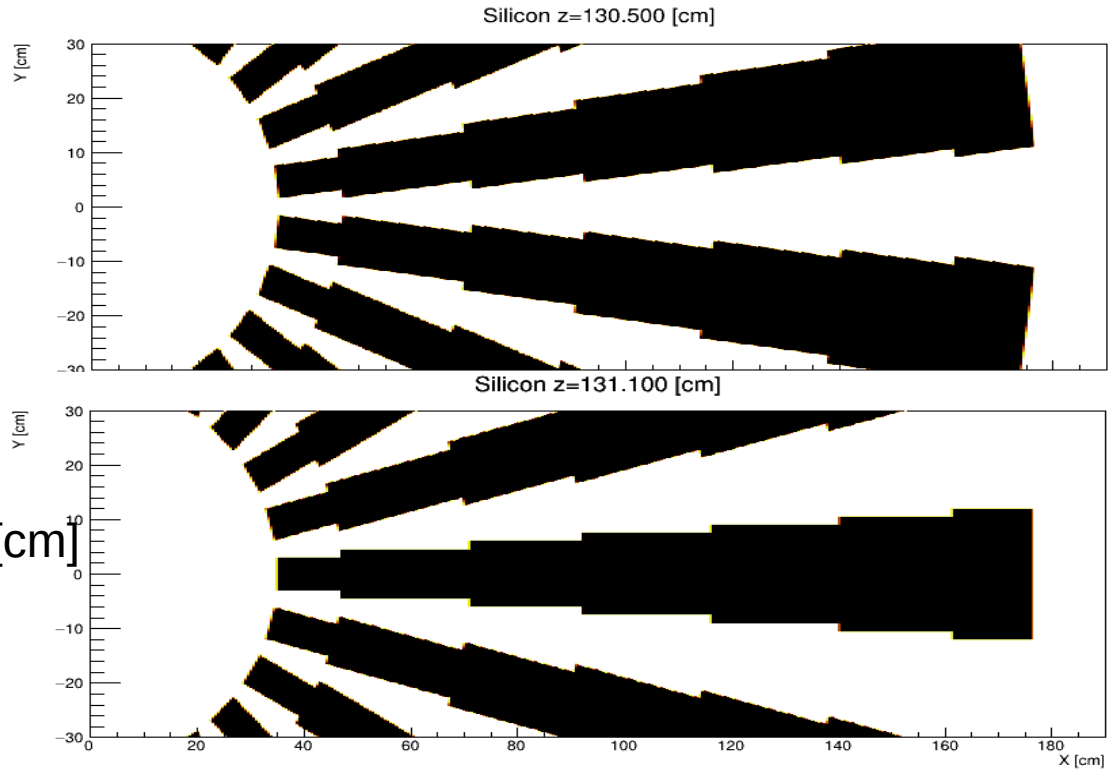
# ILD_l5_v09

## endcap

pairs of endcap disks,
48 petals per disk
disks offset in phi to completely cover




4 endcap disk pairs




disk 1

disk 2

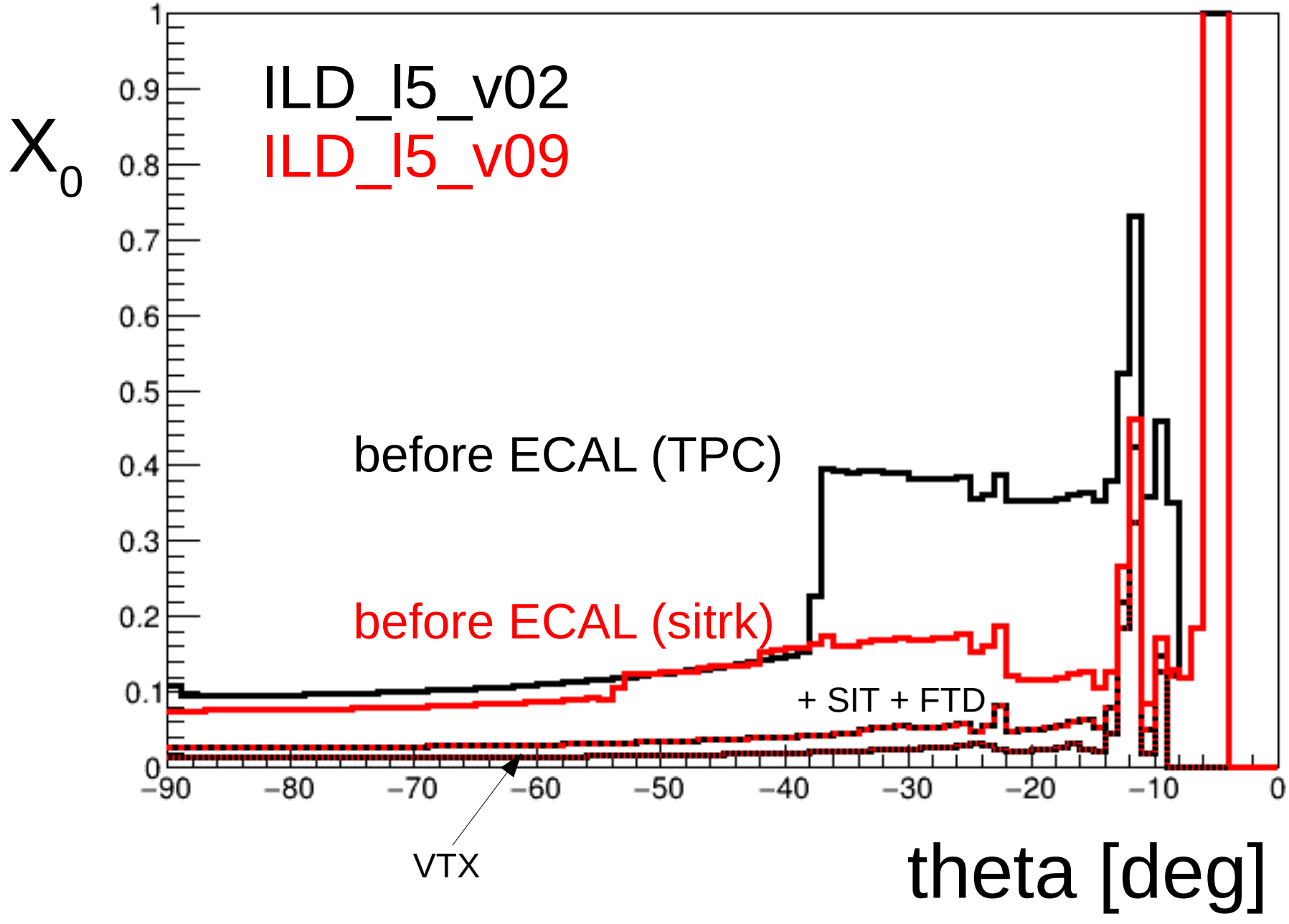
each petal is a mosaic of 30x30 mm$^2$ sensors; just enough to cover

Y [cm]

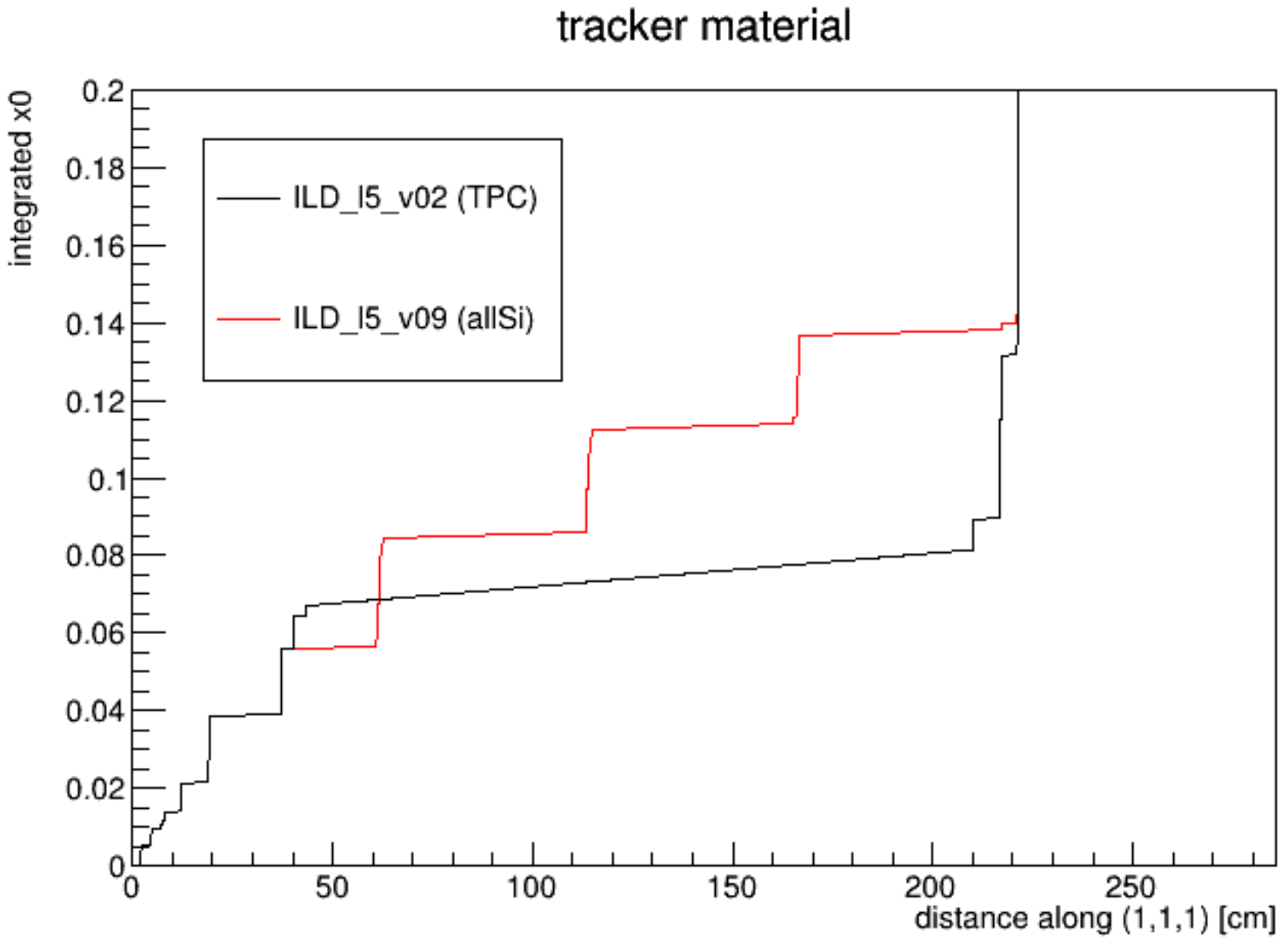
X [cm]

180 cm

# compare material budget (along y=0)

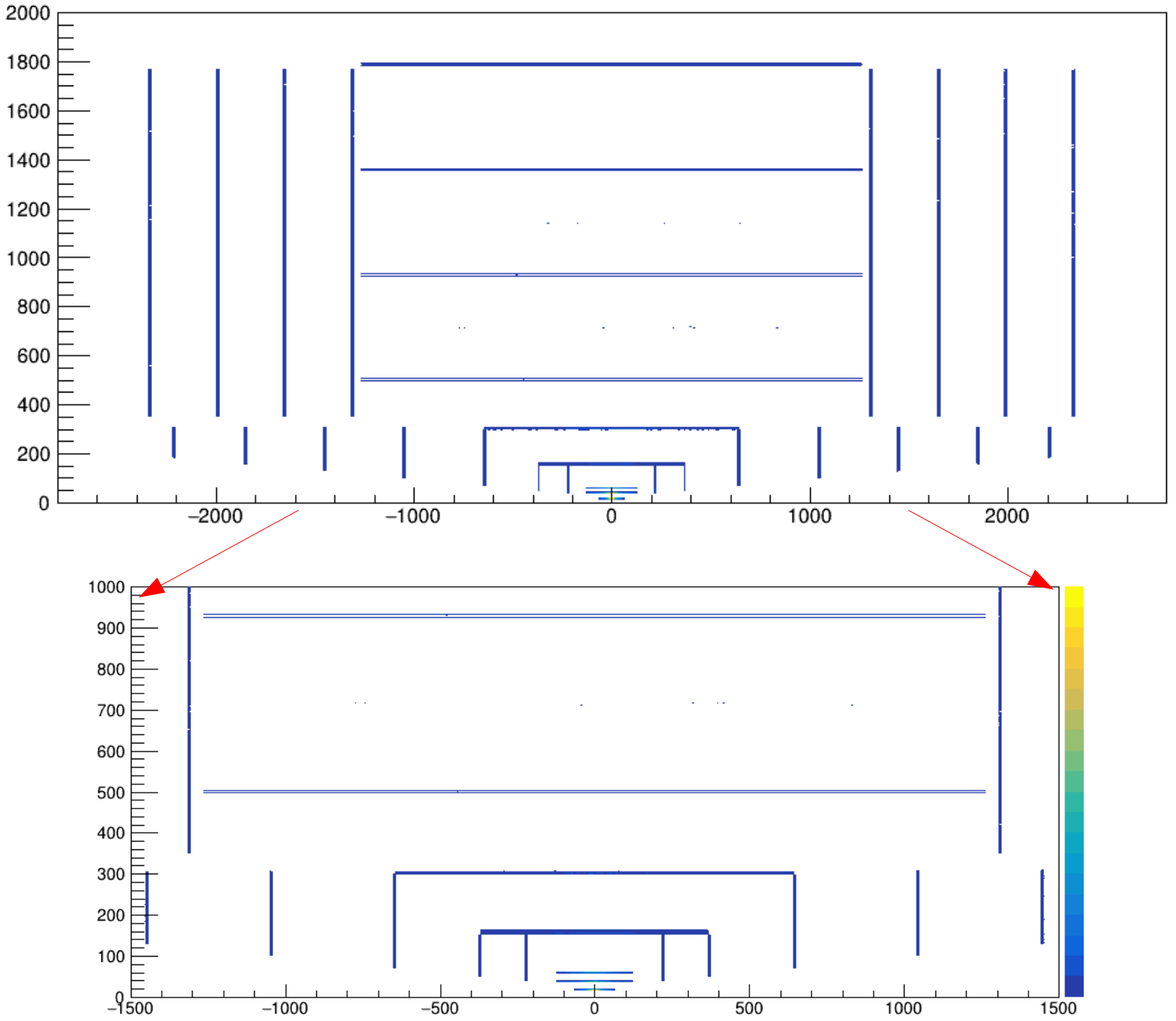


# compare material budget (along x=y=z)



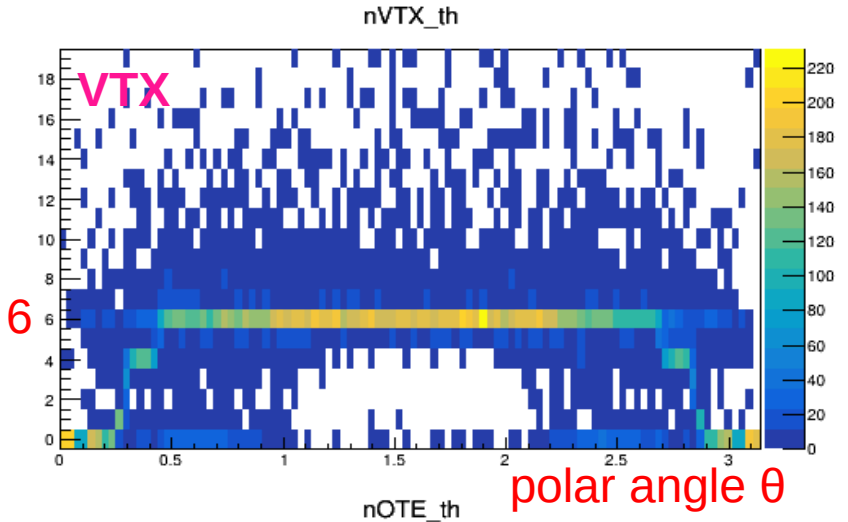
# tracker hit map

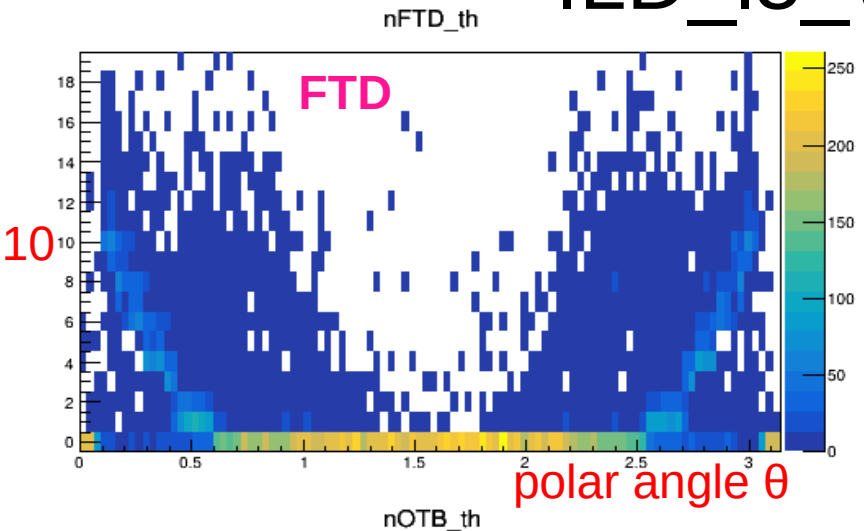
ILD_l5_v09

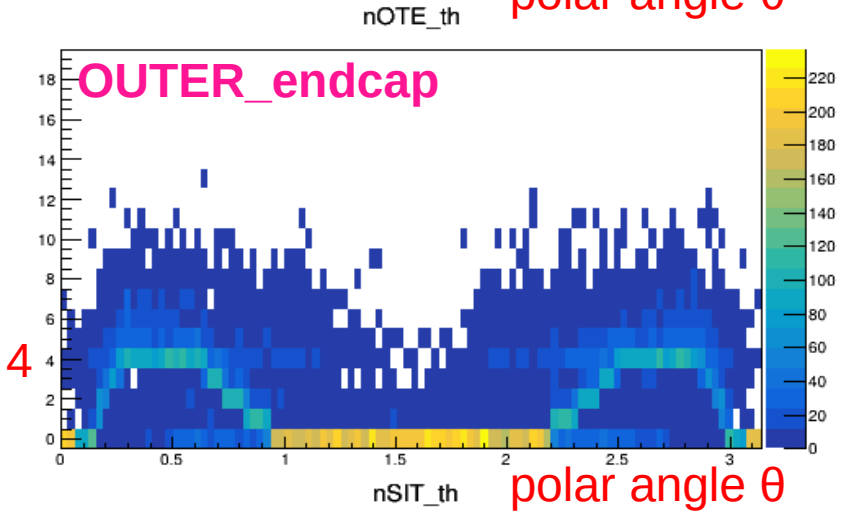


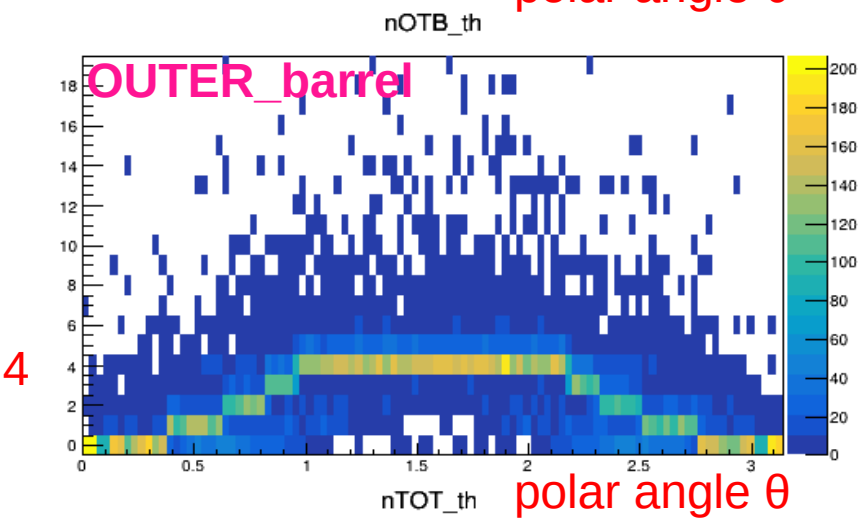
# # tracker hits [ 20k 50GeV mu-, flat in theta & phi ]

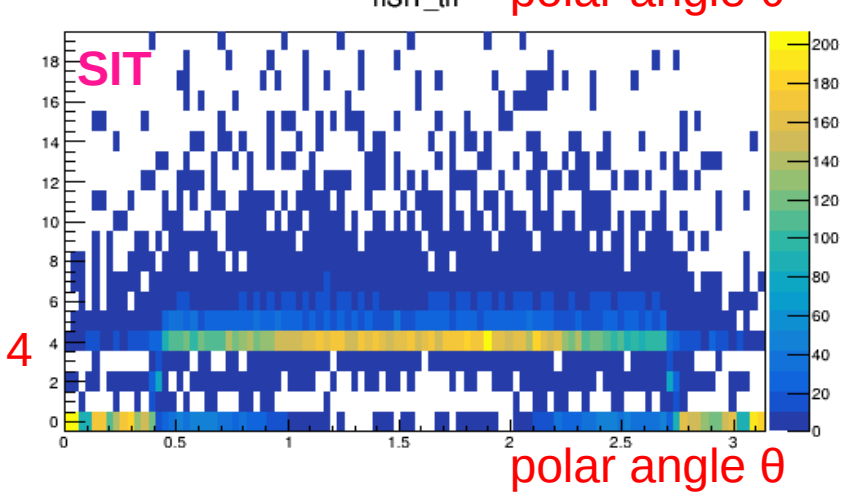
ILD_l5_v09

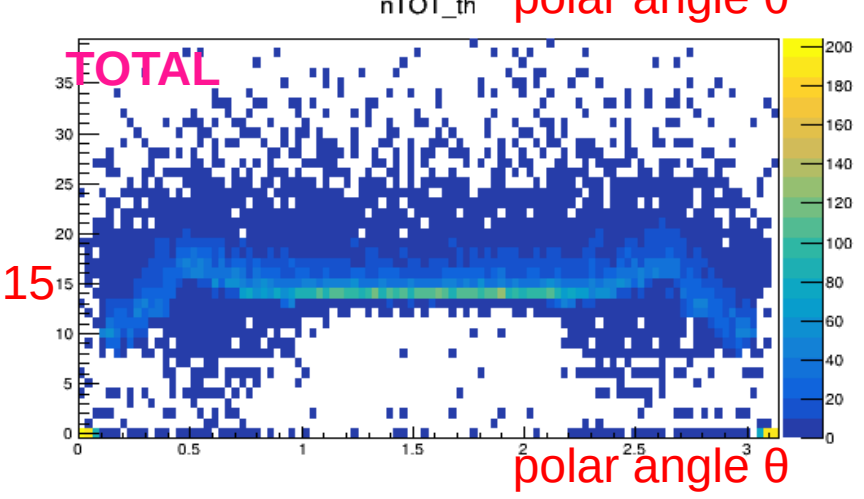


# summary

ILD model with si-only tracker
    outer tracker adapted from CLICdp design

comments on design very welcome
    (especially from tracking experts)

simulation technically works ; pull request to lcgeo pending

if people are interested:
    - adjust model according to your suggestions
    - reconstruction (conformal tracking as at CLIC?)
    - comparison @ single particle, physics analysis

backup

based on OuterTracker_o2_v06_01.xml (used in e.g. CLIC_o3_v14)

which uses TrackerBarrel_o1_v05
TrackerEndcap_o2_v06
TrackerBarrelSupport_o1_v01
TrackerEndcapSupport_o1_v01

some of the parameters:

```
<constant name="OuterTracker_Barrel_radius_0" value="500*mm"/>
<constant name="OuterTracker_Barrel_radius_MAX" value="TPC_outer_radius+Ecal_Tpc_gap-20*mm"/>
<constant name="OuterTracker_Barrel_radius_GAP" value="(1./3.)*(OuterTracker_Barrel_radius_MAX -
                                                        OuterTracker_Barrel_radius_0)"/>


<constant name="OuterTracker_Barrel_radius_1" value="OuterTracker_Barrel_radius_0 +
                                                     OuterTracker_Barrel_radius_GAP"/>
<constant name="OuterTracker_Barrel_radius_2" value="OuterTracker_Barrel_radius_1 +
                                                     OuterTracker_Barrel_radius_GAP"/>
<constant name="OuterTracker_Barrel_radius_3" value="OuterTracker_Barrel_radius_MAX"/>

<constant name="OuterTracker_Barrel_half_length" value="1264.2*mm"/>

<constant name="OuterTracker_Endcap_outer_radius" value="OuterTracker_Barrel_radius_MAX"/>
<constant name="OuterTracker_Endcap_inner_radius" value="350*mm"/>

<constant name="OuterTracker_Endcap_z_0" value="1310*mm"/>
<constant name="OuterTracker_Endcap_z_1" value="1650*mm"/>
<constant name="OuterTracker_Endcap_z_2" value="1990*mm"/>
<constant name="OuterTracker_Endcap_z_3" value="2330*mm"/>
```

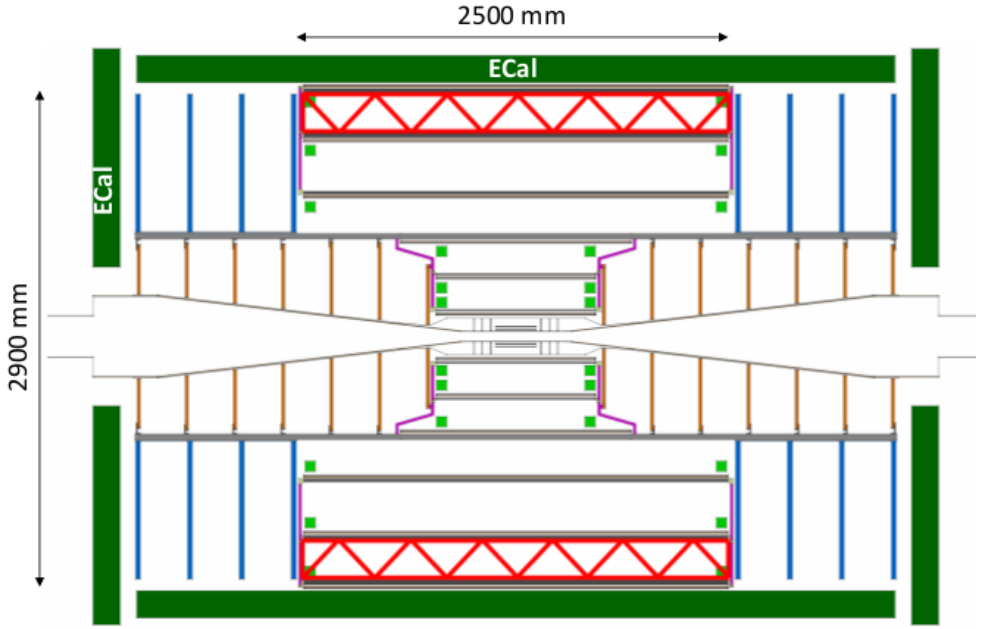
# si tracker module:

| | |
|---|---|
| 0.100*mm Kapton | Power bus: Insulating layer |
| 0.200*mm Aluminium | Power bus: Conductor |
| 0.100*mm Kapton | Power bus: Insulating layer |
| 0.100*mm Epoxy | Glue: Eccobond |
| 0.050*mm Kapton | Module: FPC insulating layer |
| 0.050*mm Aluminium | Module: FPC metal layer |
| 0.050*mm Kapton | Module: FPC insulating layer |
| 0.100*mm Silicon | Module: r/o ASIC |
| 0.100*mm Silicon | Module: Sensor |
| 0.100*mm Epoxy | Glue: Eccobond |
| 0.150*mm CarbonFiber | Structure and cooling: CF Skins |
| 0.025*mm CarbonFiber | Structure and cooling: Interface |
| 0.100*mm Epoxy | Structure and cooling: Glue layer |
| 0.235*mm Water | Structure and cooling: Cooling fluid |
| 0.068*mm Kapton | Structure and cooling: Cooling Pipe |
| 0.700*mm Allcomp_K9 | Structure and cooling: Carbon Foam |
| 2.800*mm Rohacell_IG51 | Structure and cooling: Core |
| 0.100*mm Epoxy | Structure and cooling: Glue layer |
| 0.025*mm CarbonFiber | Structure and cooling: Interface |
| 0.150*mm CarbonFiber | Structure and cooling: CF Skins |

```
+-------------------------------------------------------------------
+ Material scan between: x_0 = (  40.00,   0.00, 131.00) [cm]
                     and  x_1 = (  40.00,   0.00, 135.00) [cm] :
+-----------------------------------------------
|     \   Material                  Integrated
| Num. \  Name            Thickness      X0
| Layer \                     [cm]      [cm]
+-----------------------------------------------
|     1 Air                   0.035    0.000001
|     2 Kapton                0.010    0.000354  ← module start
|     3 Aluminium             0.020    0.002602
|     4 Kapton                0.010    0.002954
|     5 Epoxy                 0.010    0.003271
|     6 Kapton                0.005    0.003447
|     7 Aluminium             0.005    0.004009
|     8 Kapton                0.005    0.004185
|     9 Silicon               0.010    0.005253
|    10 Silicon               0.010    0.006320
|    11 Epoxy                 0.010    0.006637
|    12 CarbonFiber           0.015    0.007161
|    13 CarbonFiber           0.003    0.007249
|    14 Epoxy                 0.010    0.007565
|    15 Water                 0.024    0.008217
|    16 Kapton                0.007    0.008456
|    17 Allcomp_K9            0.070    0.008823
|    18 Rohacell_IG51         0.280    0.009168
|    19 Epoxy                 0.010    0.009484
|    20 CarbonFiber           0.003    0.009572
|    21 CarbonFiber           0.015    0.010096  ← module end: 1% X0
|    22 Air                   0.384    0.010109
|    23 Air                   0.051    0.010110
|    24 CarbonFiber           0.102    0.013659  ← CF support
|    25 Air                   0.051    0.013660
|    26 Air                   2.848    0.013754
+-----------------------------------------------
|     0 Average Material      4.000    0.013754
+-----------------------------------------------
```

https://indico.cern.ch/event/569246/#2-overview-of-the-tracker-oute [F. Ramos]

## Tracker layout

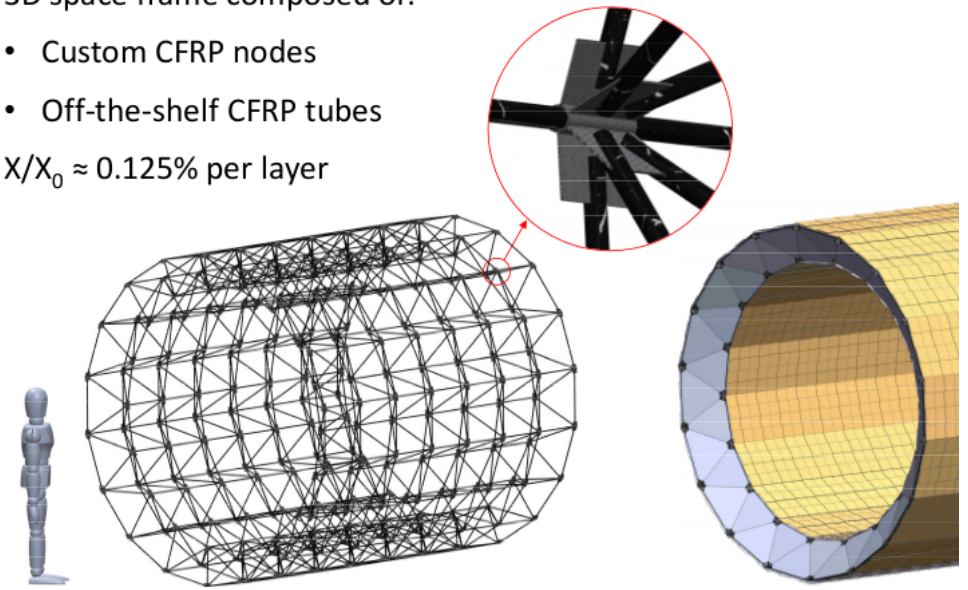


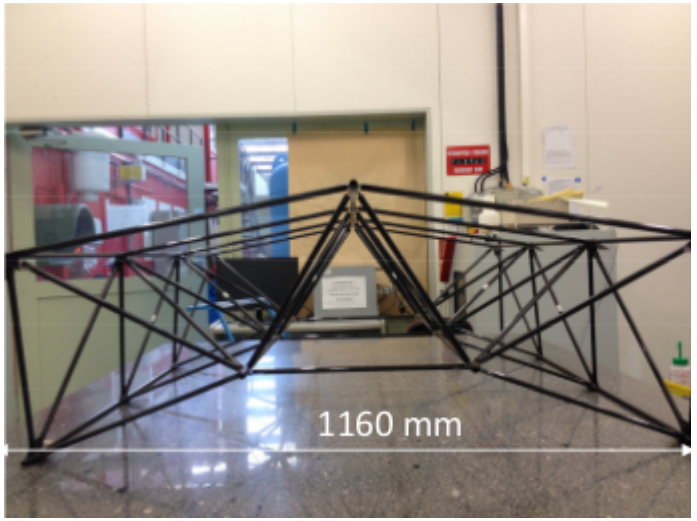

## Outer barrel support structure concept

3D space frame composed of:

- Custom CFRP nodes
- Off-the-shelf CFRP tubes

$X/X_0 \approx 0.125\%$ per layer



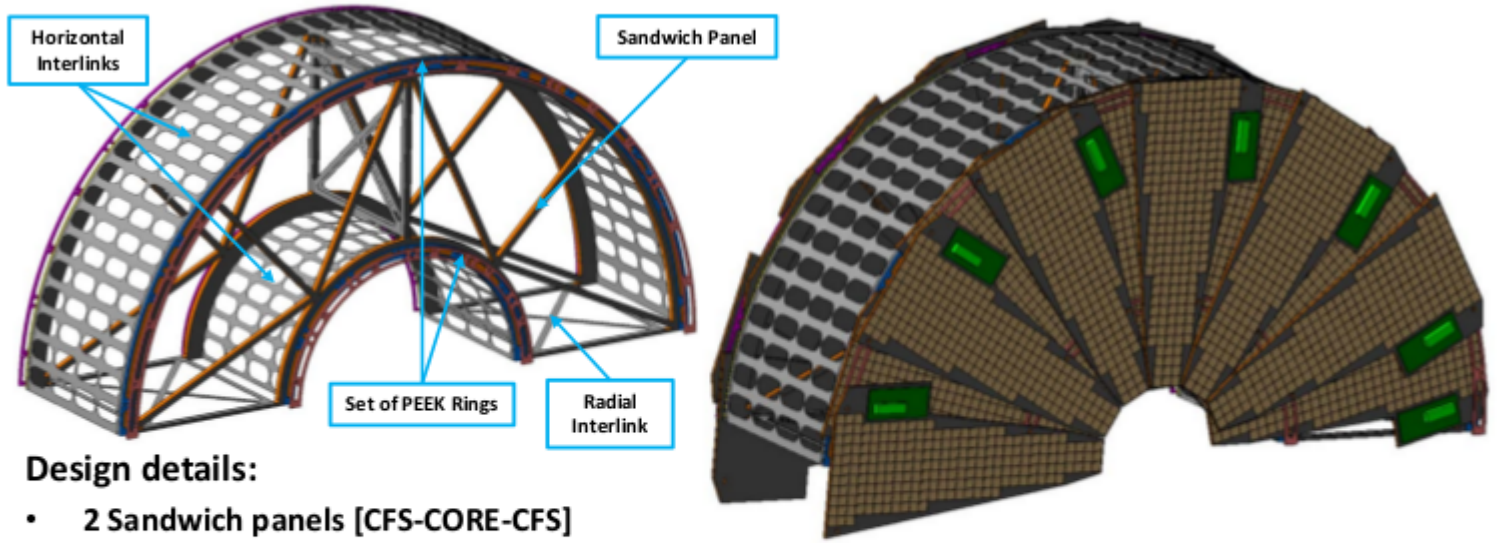


https://indico.cern.ch/event/569246/#1-design-concept-of-the-itds-s

Szymon Sroka, Fernando Duarte Ramos

this is for inner tracker disks; probably similar for outer tracker disks (?)

# Technical Details




**Design details:**

- **2 Sandwich panels [CFS-CORE-CFS]**
  - CFS RINGS: 0.48 mm → Woven Fabric, Ultra High Modulus Fibers M55JB 6K
  - CFS SPOKES: 0.48 mm → Carbon Fiber Laminate, Toray M55J
  - Core: 10mm → Rohacell IG51
- **2 Sets of rings on each side (in total 8 rings)**
  - Peek Rings: 4 mm
- **Horizontal Interlinks – Inner & Outer CF Shell**
  - CF SHELLS: 0.48 mm → Woven Fabric, Ultra High Modulus Fibers M55JB 6K
- **Radial Interlinks – CF Plates**
  - CF Plates: 0.8 mm → Carbon Fiber Laminate, Toray M55J