

Tracking for the Modified ILD Detector Concept at the FCCee

**3rd ECFA Workshop on e+e- Higgs,
Top & ElectroWeak Factories**

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HELMHOLTZ



CLUSTER OF EXCELLENCE
QUANTUM UNIVERSE



My PhD Project in a Nutshell

- ❖ Modified ILD model...
 - ❖ ... compatible with FCC requirements
 - ❖ ... that mitigates backgrounds and other machine-related effects
 - ❖ ... that can be assembled and maintained
- ❖ Carry out a physics study with this detector model
 - ❖ Sensitive to differences in machine-detector-interface (MDI)
 - strongly forward-boosted

ILC vs FCCee

- ❖ Different machine interface
- ❖ Different backgrounds
 - ❖ ILC: mainly beamstrahlung
 - ❖ FCC: synchrotron radiation, scattering and beam-gas interaction more relevant

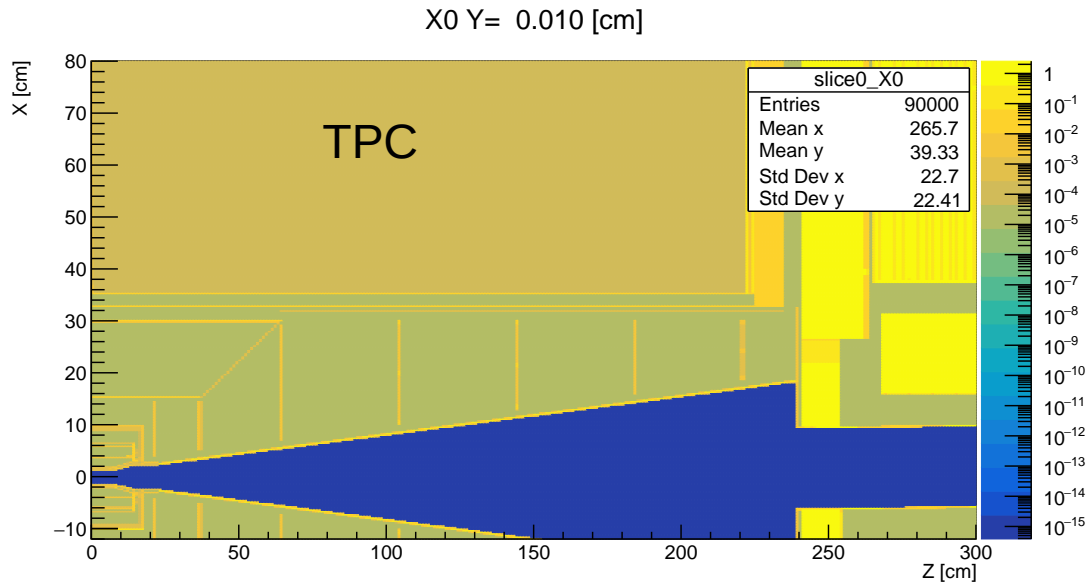
| | ILC | FCCee |
|--|--------------|-------------------------------|
| crossing angle | 14 mrad | 30 mrad |
| L^* [distance from IP to last accel focusing quadupole magnet] | 4.1 m | 2.0 m |
| detector solenoid | 3.5 T | 2.0 T |
| additional B-fields | anti-DID (?) | - compensating - screening |

From Daniel Jeans

Starting Point

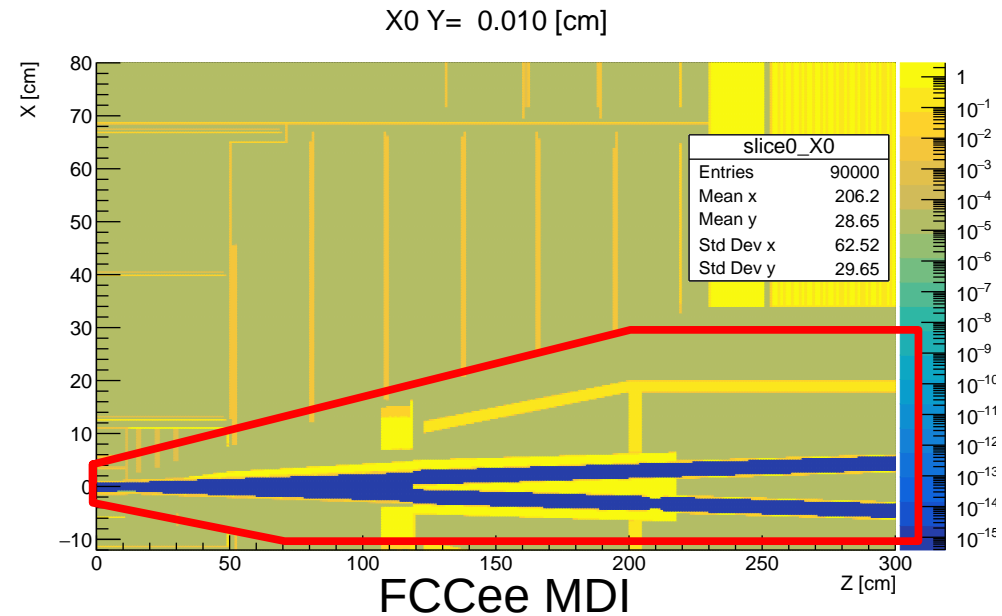
ILD (for ILC)

- ❖ ILC MDI
- ❖ Hybrid tracking layout



CLD (CLIC-like Detector)

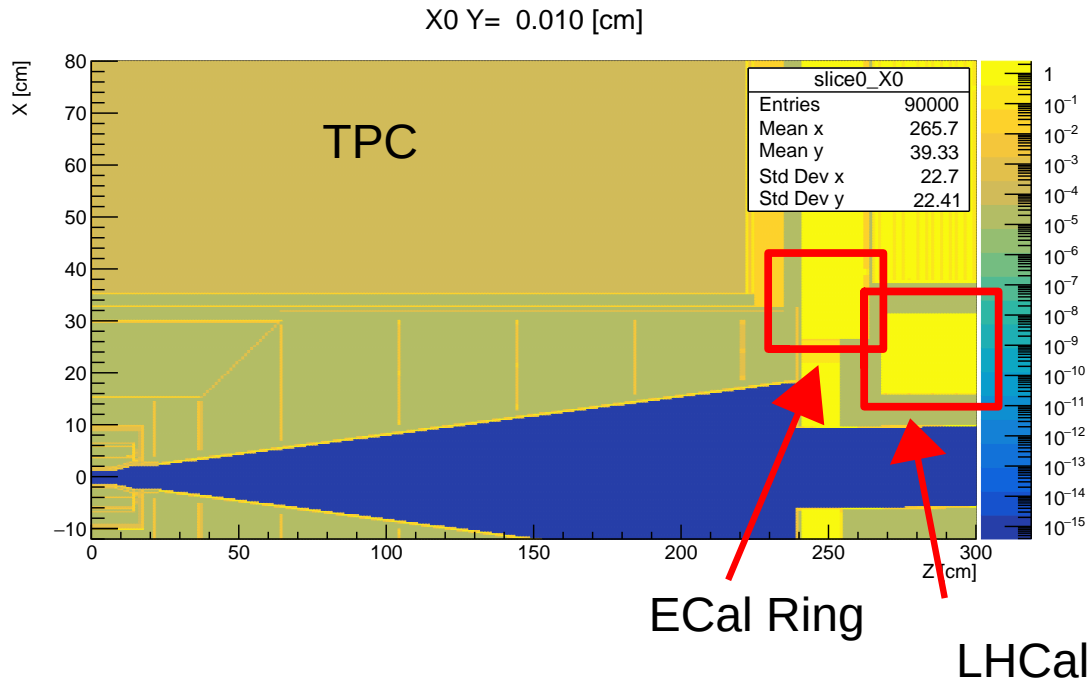
- ❖ FCCee MDI
- ❖ All-silicon tracking



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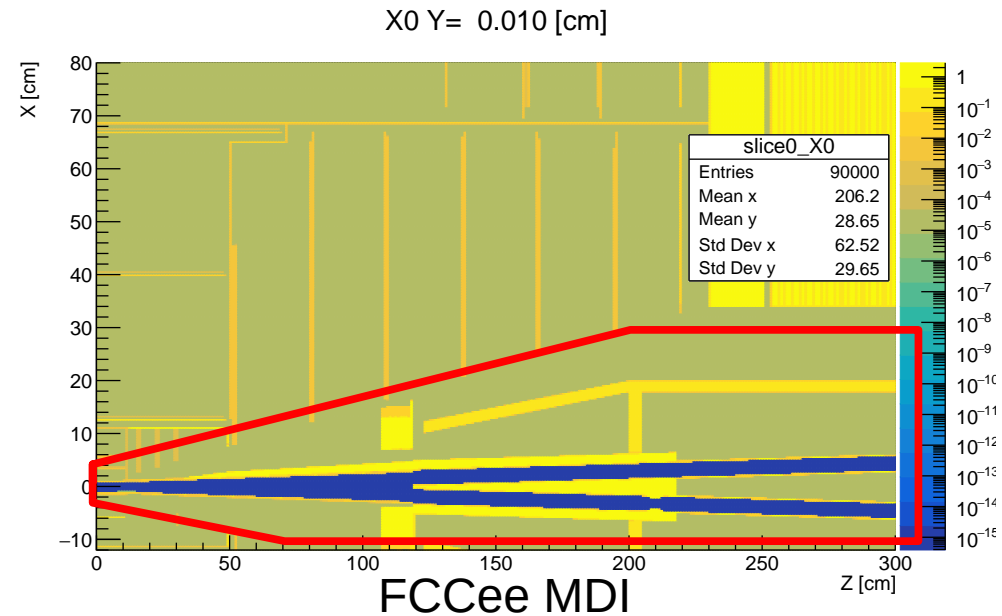
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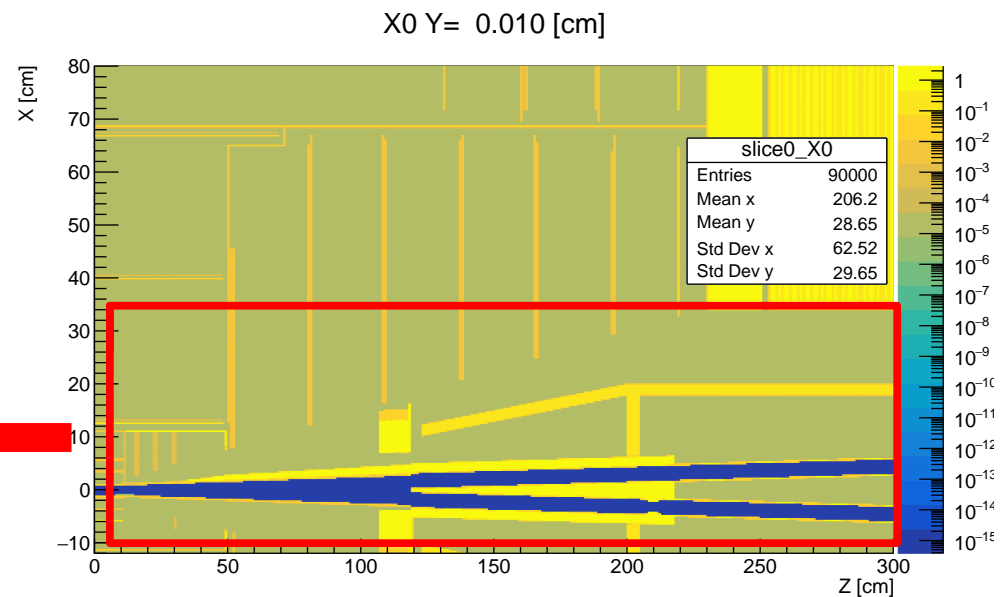
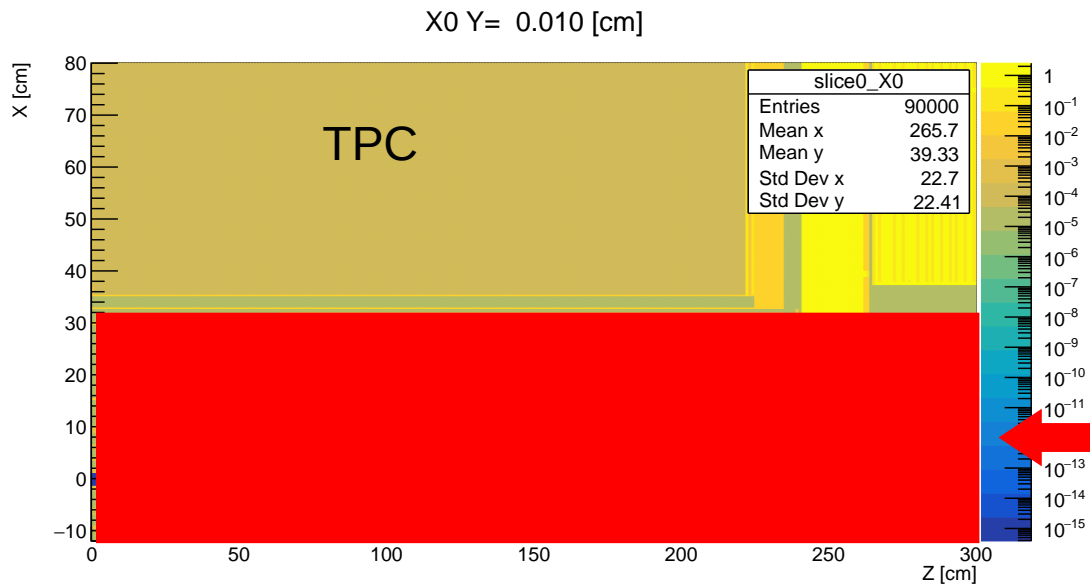
Ansatz

ILD (for ILC)

- ❖ ILC MDI
- ❖ Hybrid tracking layout

CLD (CLIC-like Detector)

- ❖ FCCee MDI
- ❖ All-silicon tracking



- Ansatz:**
- 1) Remove everything inside of the TPC from ILD
 - 2) Replace with CLD subdetectors

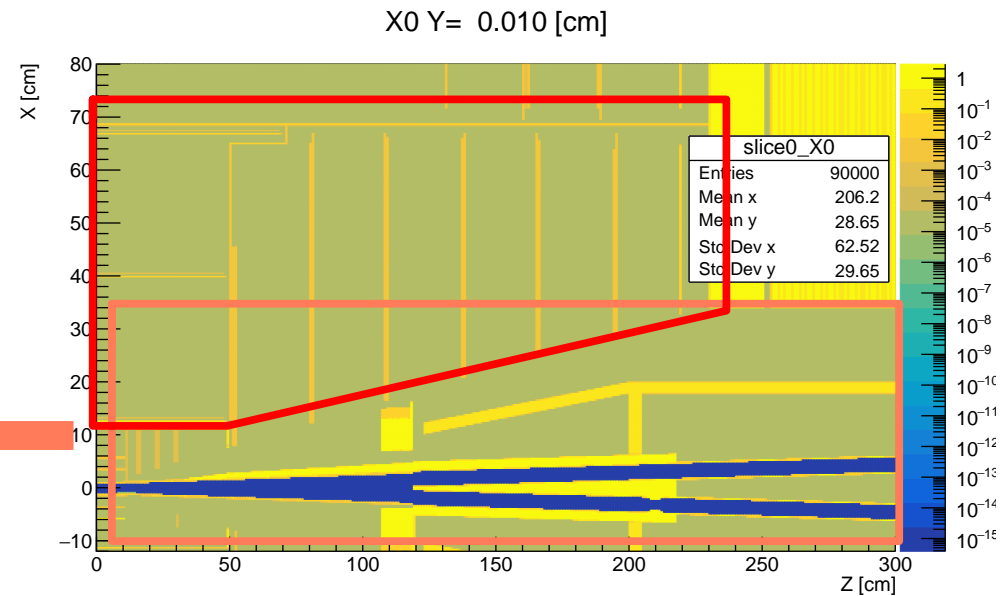
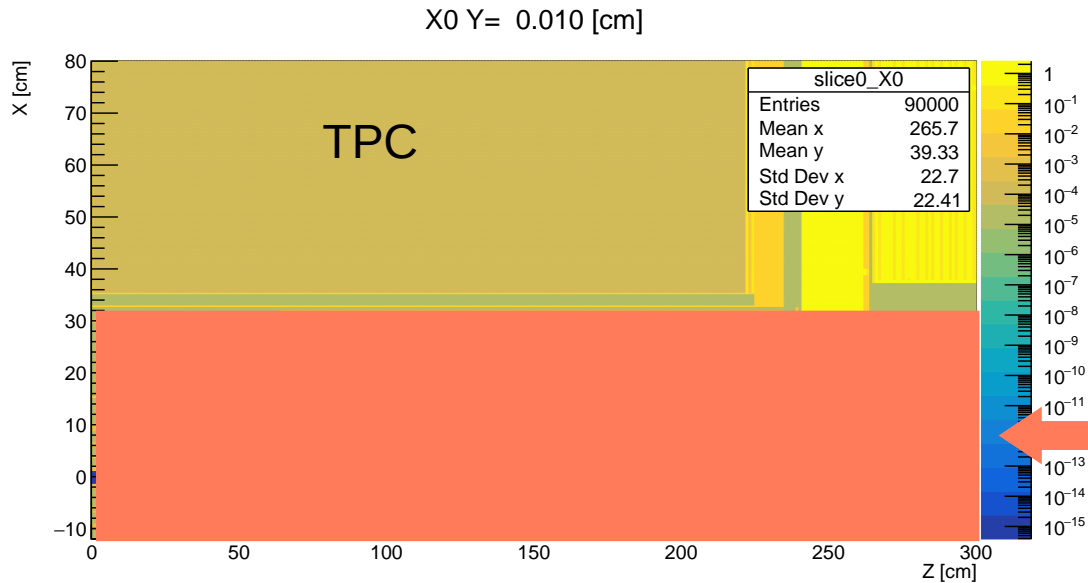
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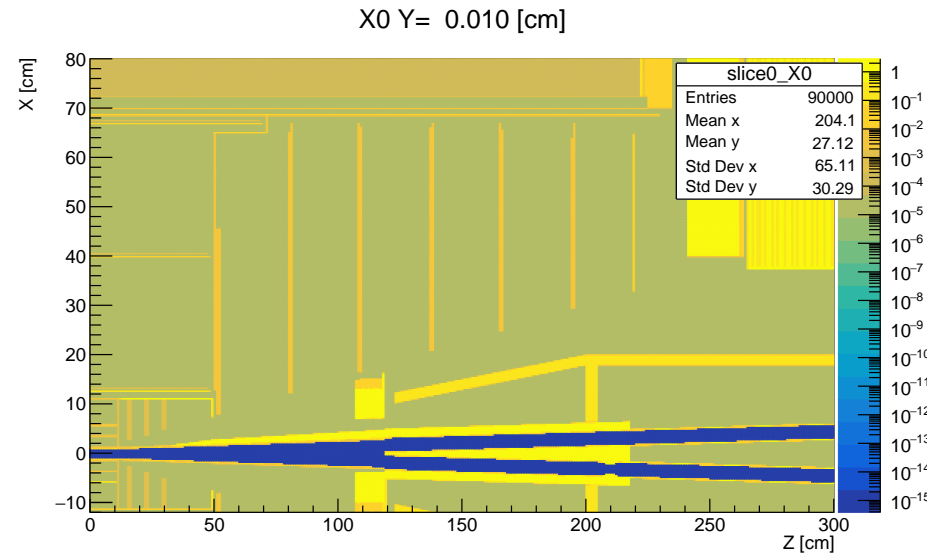
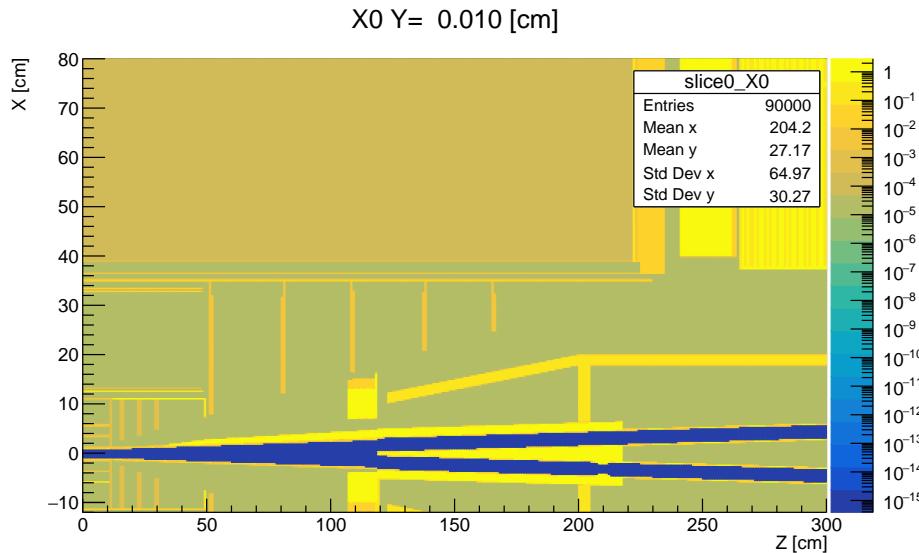
New Models or 2 Merging Strategies

ILD for FCCee **v01** – large TPC:

- ❖ Leave TPC as large as possible
- ❖ Squeeze Inner Tracker in between TPC and Vertex Detector

ILD for FCCee **v02** – small TPC:

- ❖ Copy Inner Tracker from CLD
- ❖ Shrink TPC to accommodate the IT



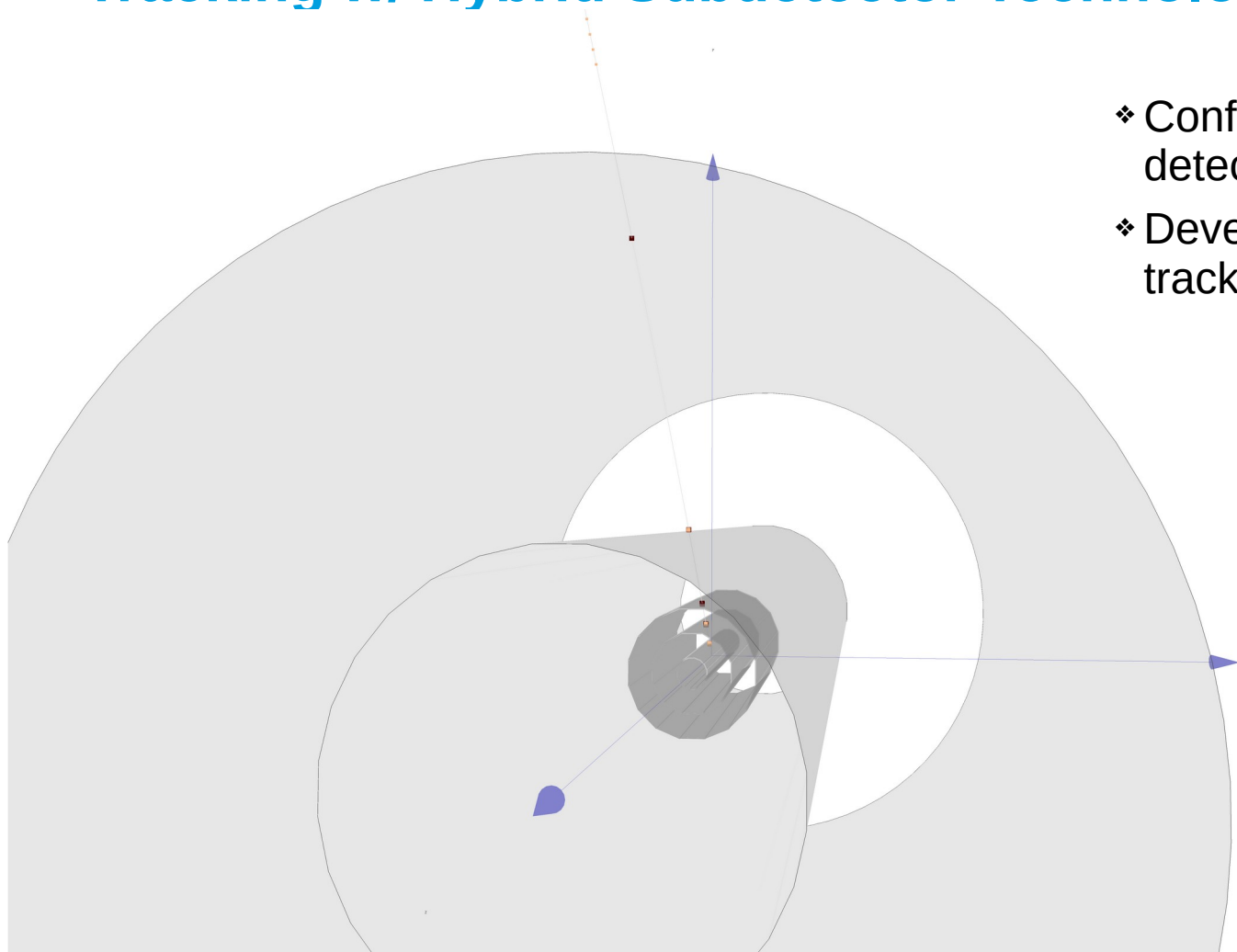
*Common MDI_o1_v00

*Calorimeter and solenoid volumes were left unchanged, except for removed ECal Ring and LHCal

[model description source](#)

Tracking for Hybrid Layouts

Tracking w/ Hybrid Subdetector Technologies



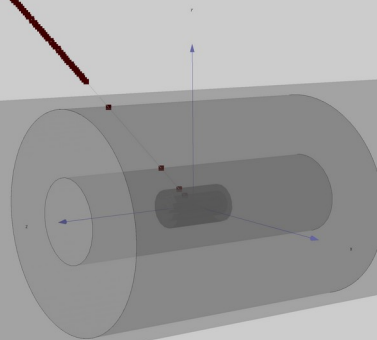
- ❖ Conformal Tracking used for silicon detectors
- ❖ Developed for CLIC (full-silicon tracking)

*ILD_FCce_v01

Tracking w/ Hybrid Subdetector Technologies

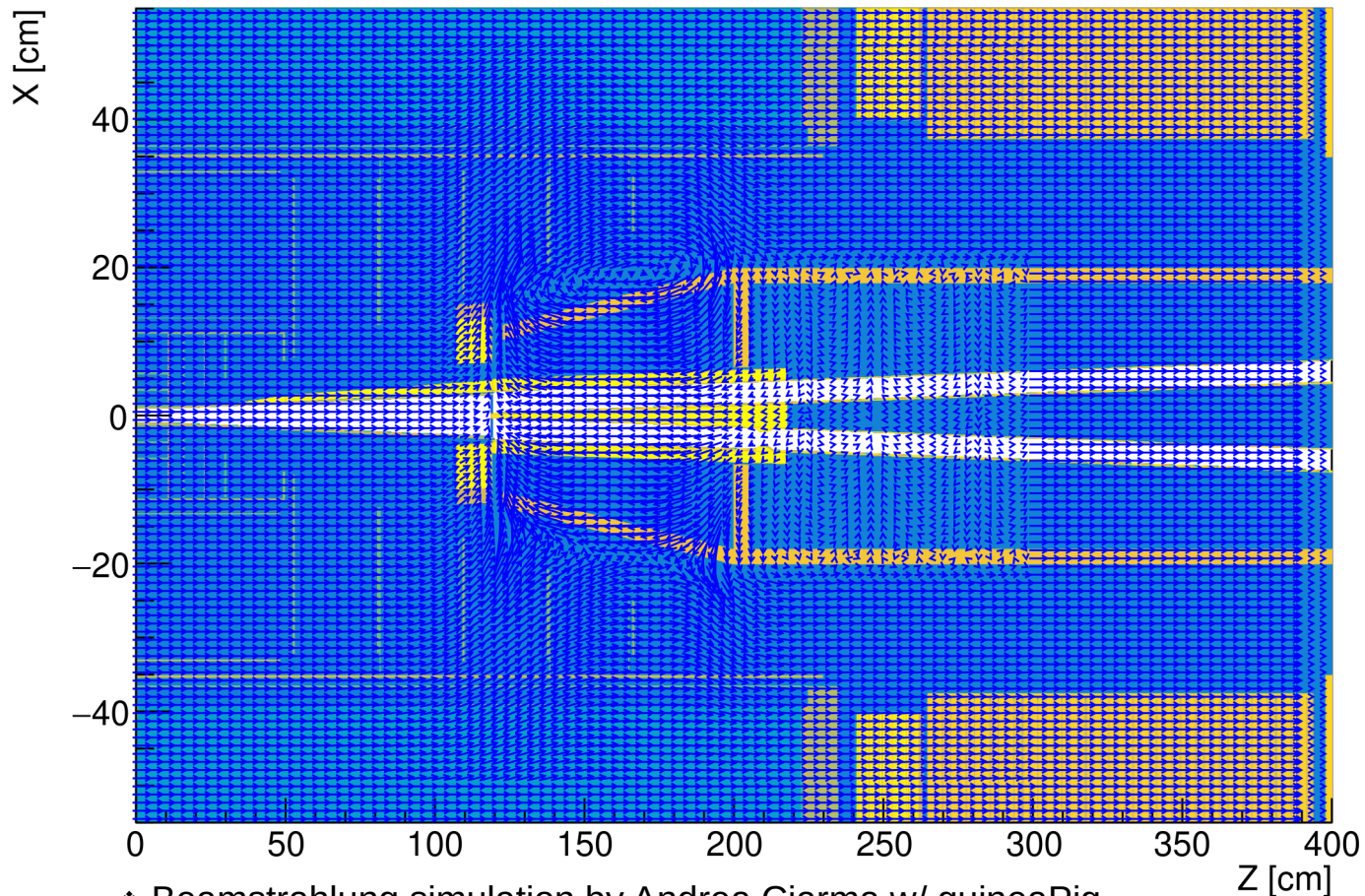
❖ Clupatra Tracking used for TPC

❖ Generalized merging of TPC tracks and silicon tracks is work-in-progress



Can tracking work reliably with the prevailing background conditions at the FCC?

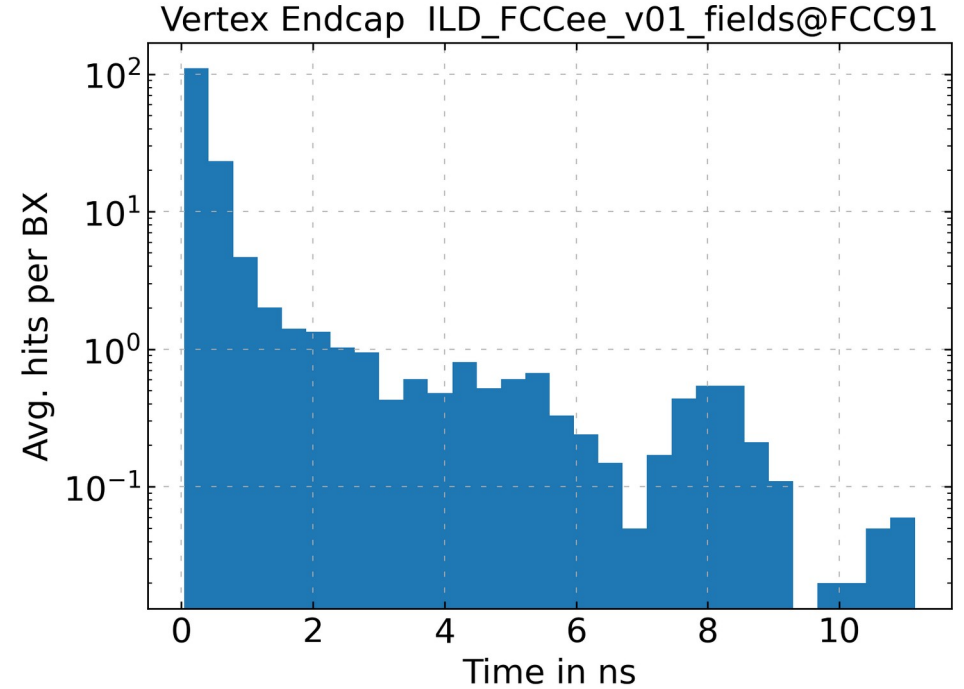
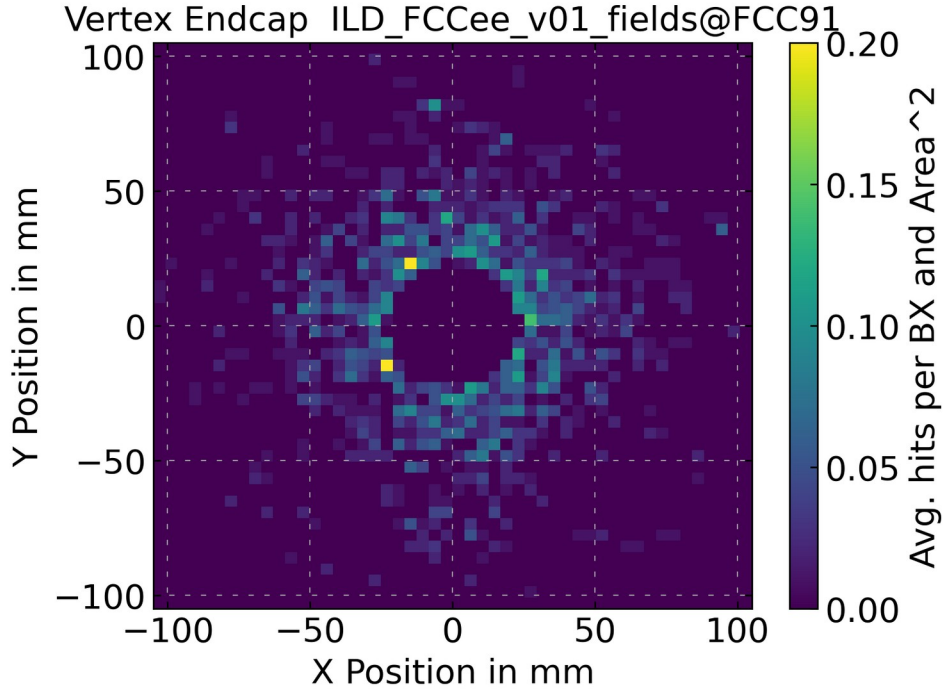
Magnetic Field Map of ILD_FCce_01



❖ Beamstrahlung simulation by Andrea Ciarma w/ guineaPig

❖ Only Vertex Detector considered, TPC results in detector parallel session by Daniel Jeans

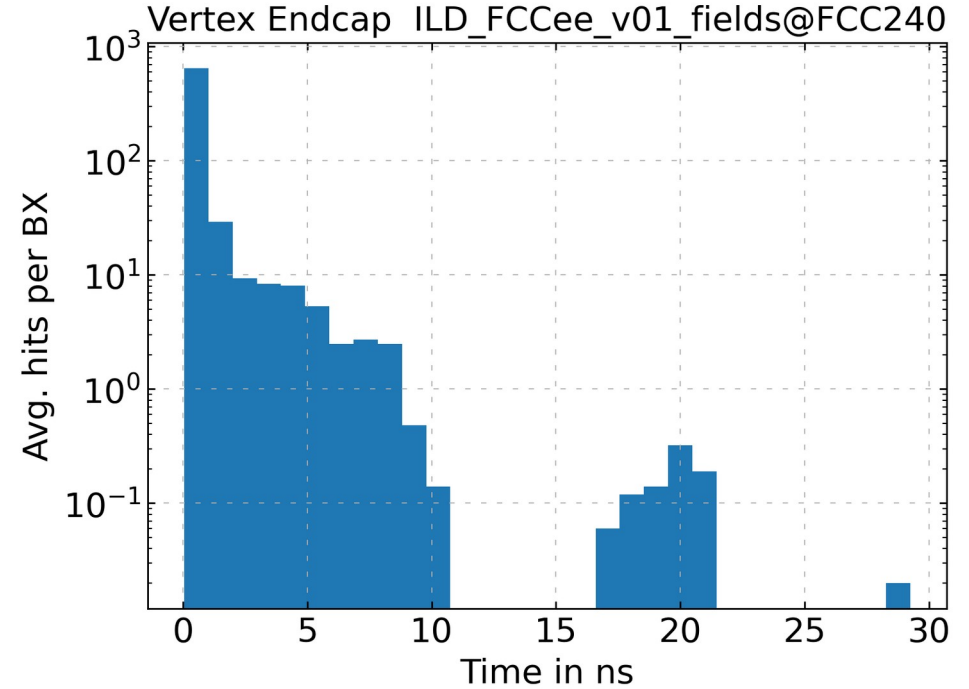
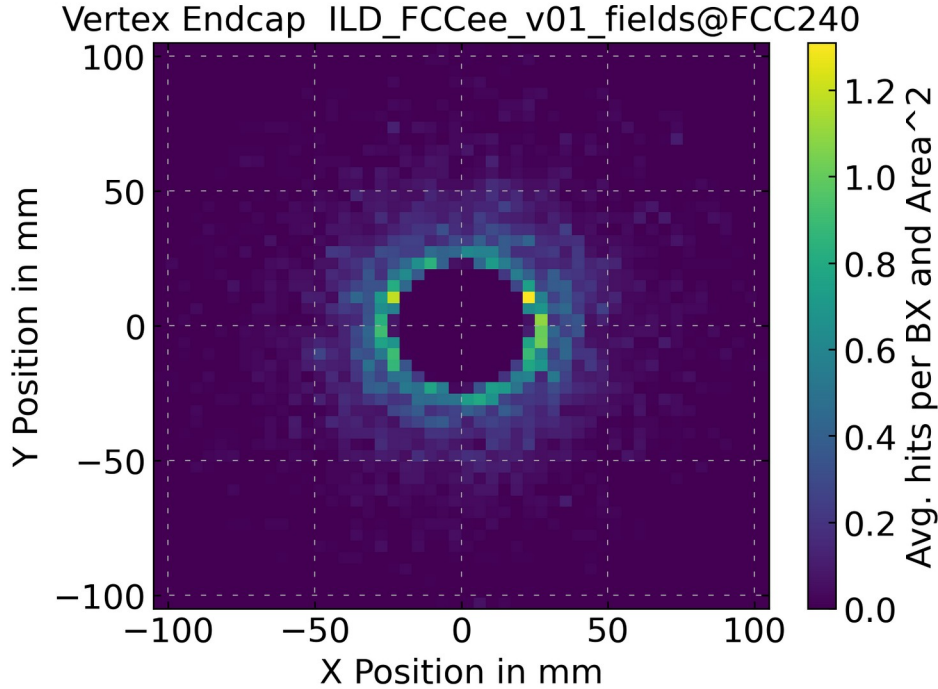
Vertex Endcap @ FCC91



- ❖ Mostly prompt hits, some back-scattering
- ❖ Decreasing with radius

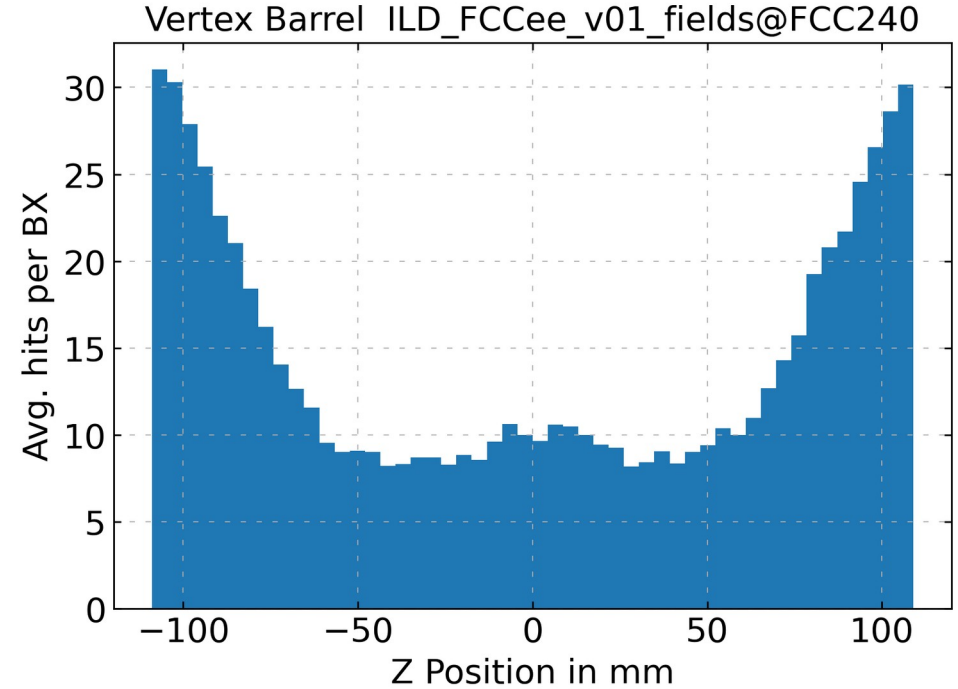
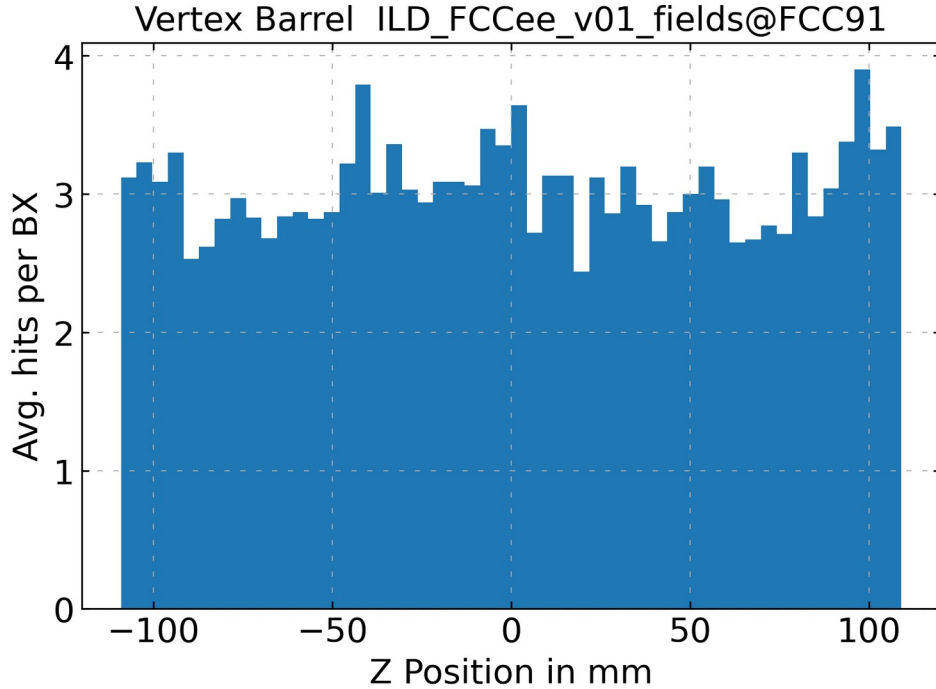
*averaged over 100 BXs

Vertex Endcap @ FCC240



- ❖ Mostly prompt hits
- ❖ Increased intensity
- ❖ Slightly more boosted

Vertex Barrel Occupancy @ FCC91 vs FCC240

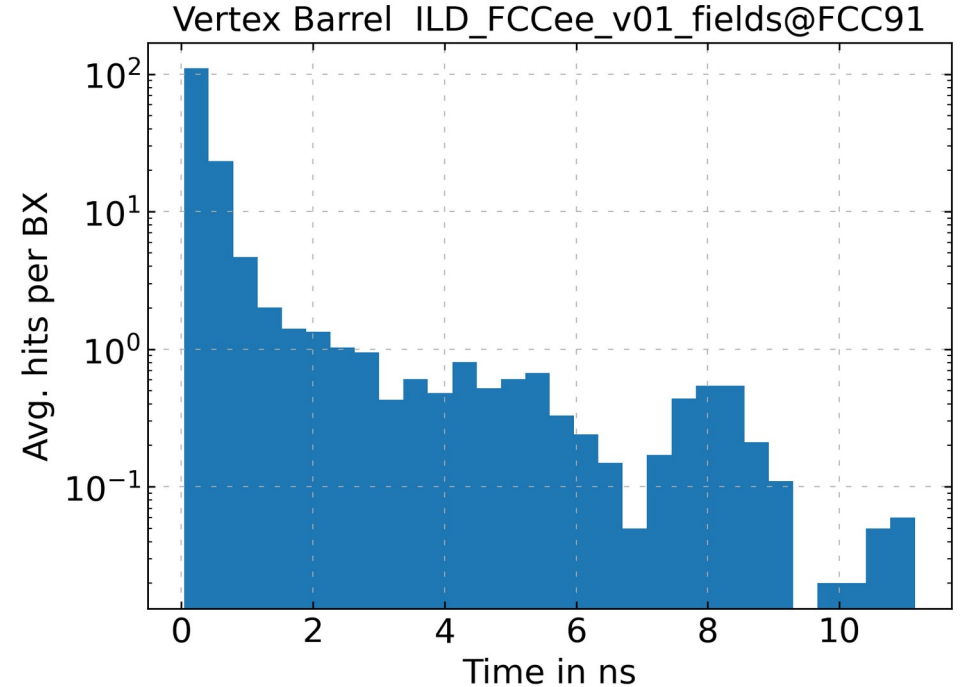
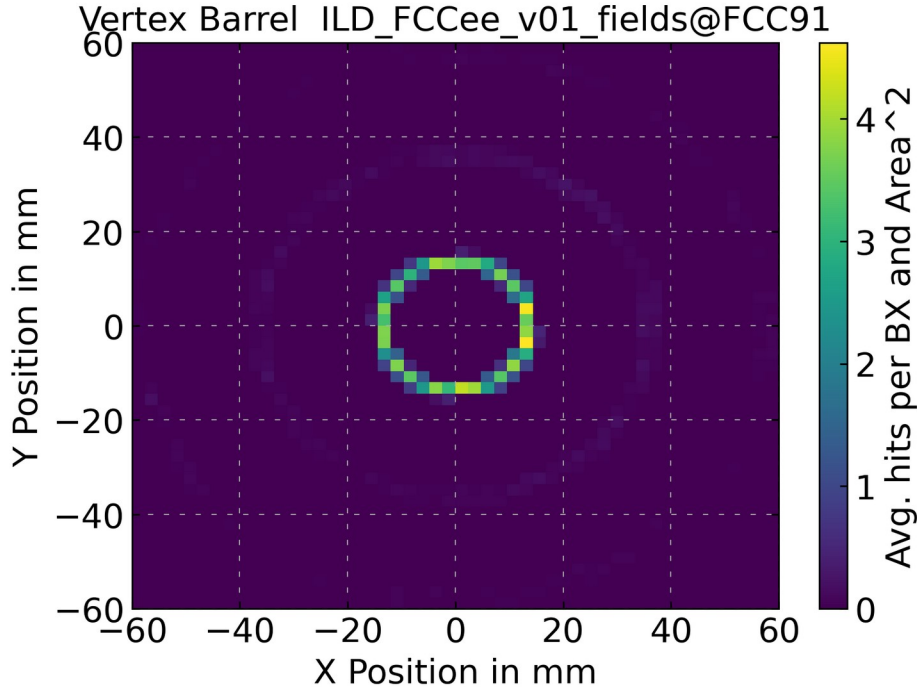


- ❖ Intensity increases with beam energy
- ❖ Beamstrahlung more boosted → hits shifted away from center
- ❖ Effect on tracking efficiencies to be studied

Thanks for your attention!

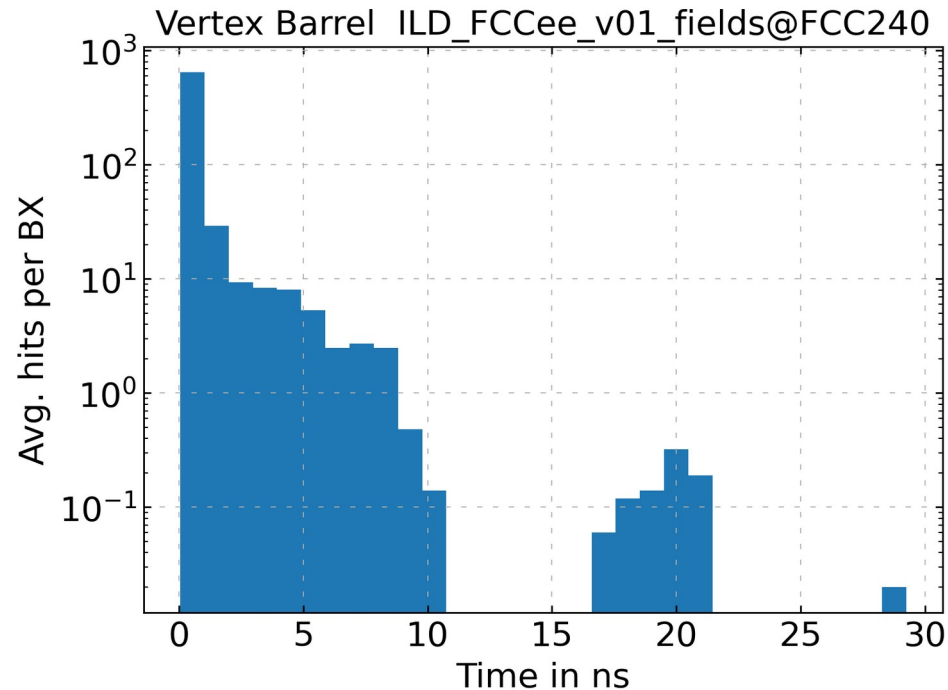
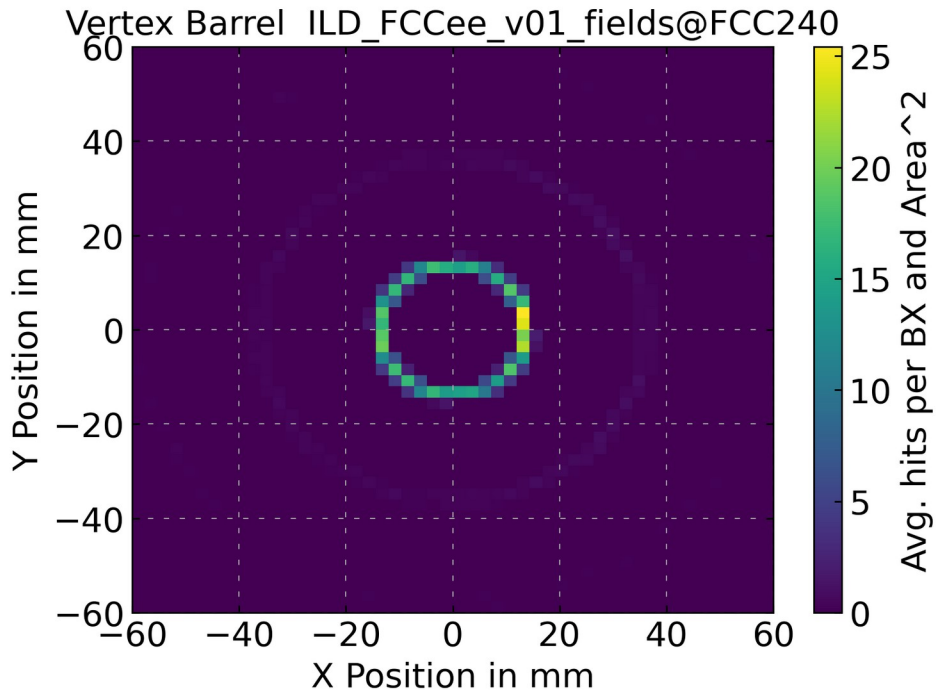
Back-Up

Vertex Barrel @ FCC91



- ❖ Mostly prompt hits, some back-scattering
- ❖ Intensity decreases with radius

Vertex Barrel @ FCC240

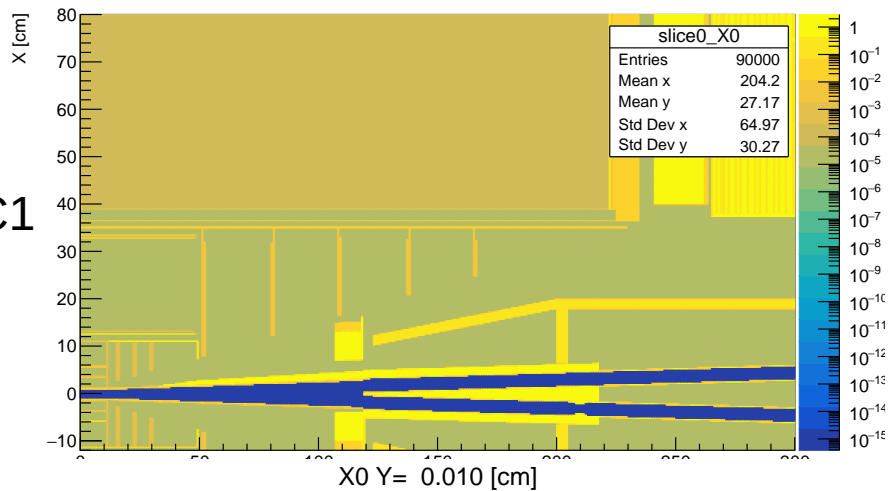


- ❖ Intensity increased
- ❖ Mostly prompt hits

Overview of FCCee Models

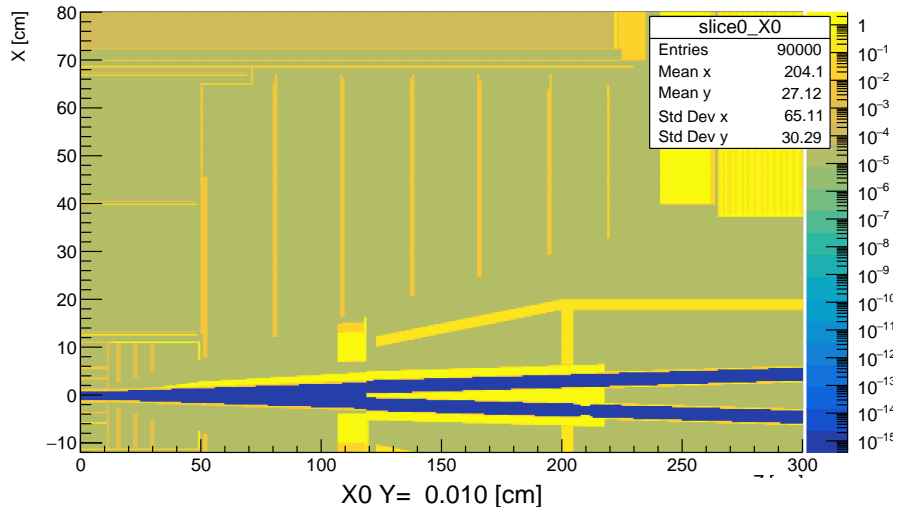
X0 Y= 0.010 [cm]

FCC1



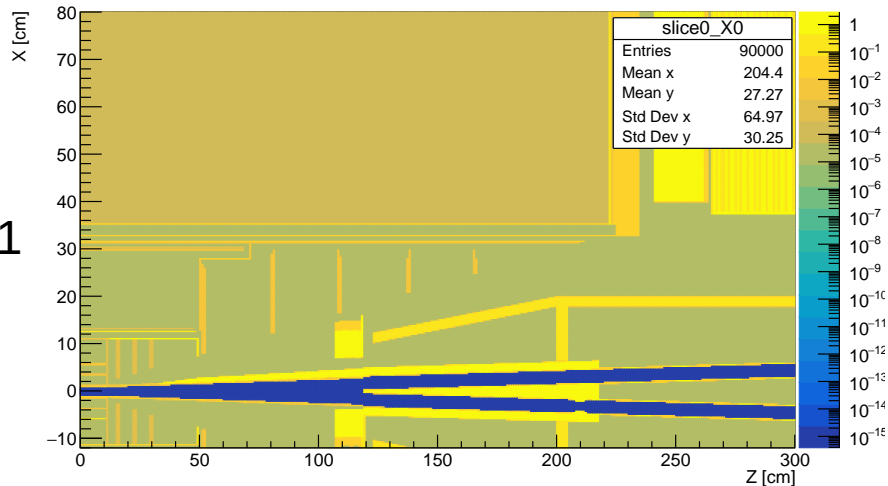
X0 Y= 0.010 [cm]

FCC2



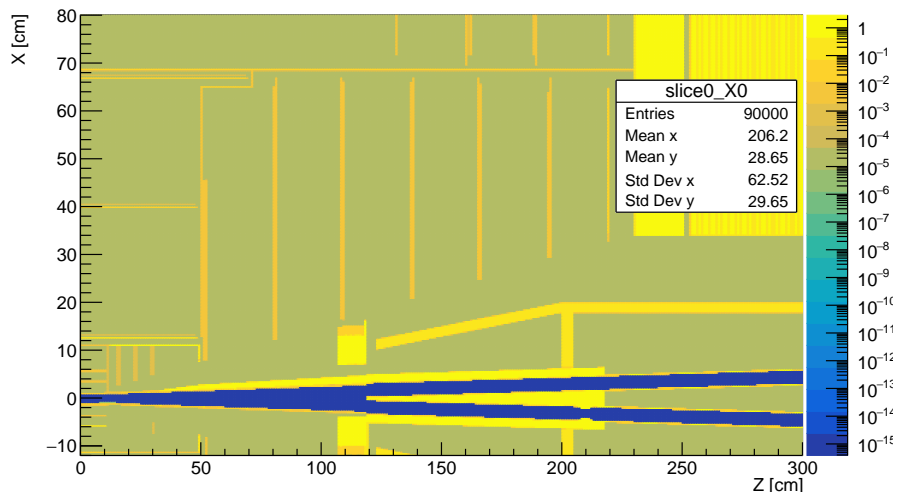
X0 Y= 0.010 [cm]

v11



X0 Y= 0.010 [cm]

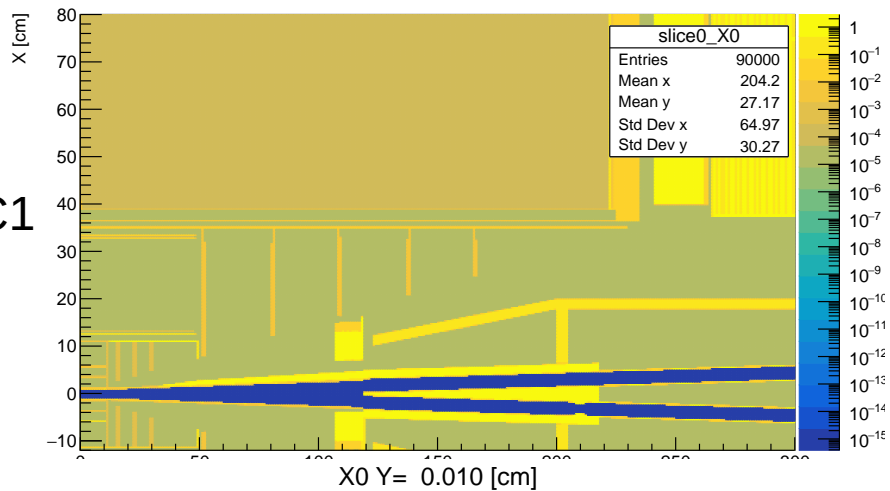
CLD



Overview of ILD Models

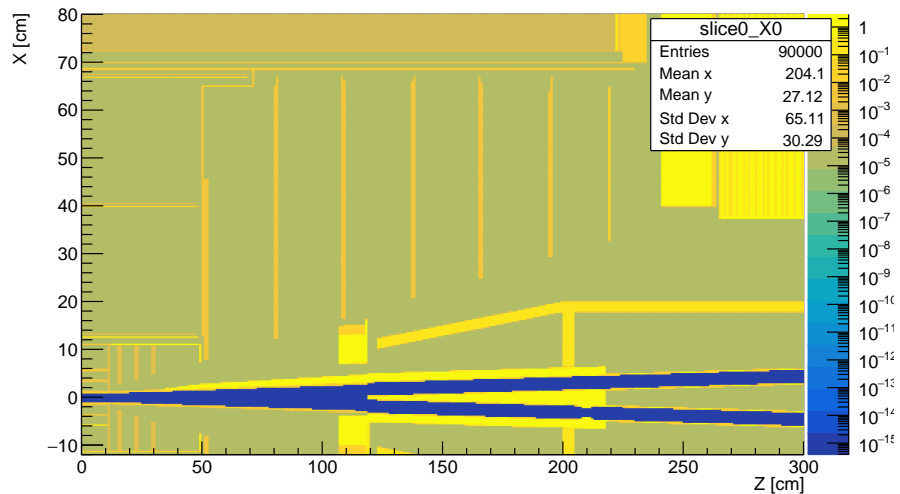
X0 Y= 0.010 [cm]

FCC1



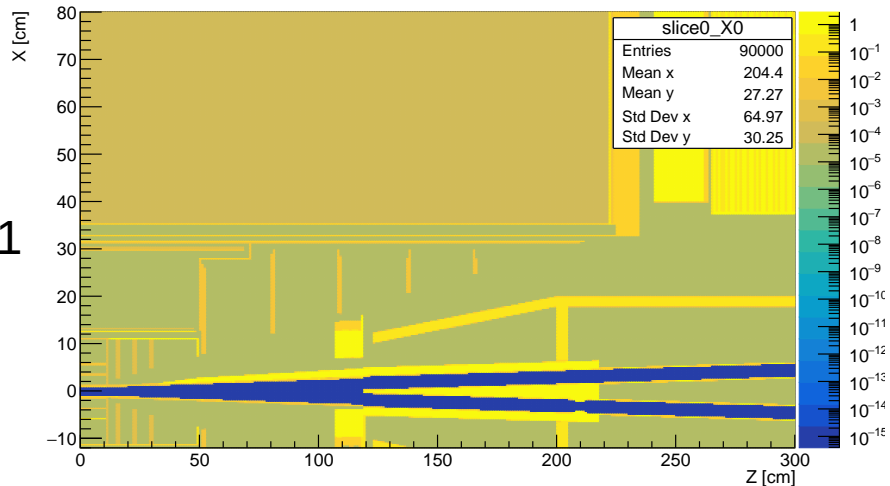
X0 Y= 0.010 [cm]

FCC2



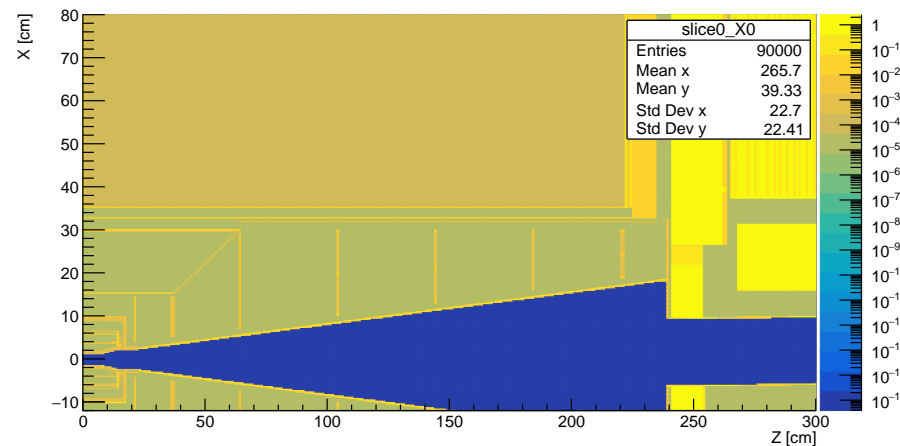
X0 Y= 0.010 [cm]

v11



X0 Y= 0.010 [cm]

v02



Tracking Subdetector Systems ILD vs CLD

ILD

- ❖ Hybrid tracking layout

ILD barrel trackers:

- ❖ VerTeX detector (VTX)
- ❖ Silicon Internal Tracker (SIT)
 - ❖ Two layers
- ❖ Time Projection Chamber (TPC)
- ❖ Silicon External Tracker (SET)
 - ❖ One layer

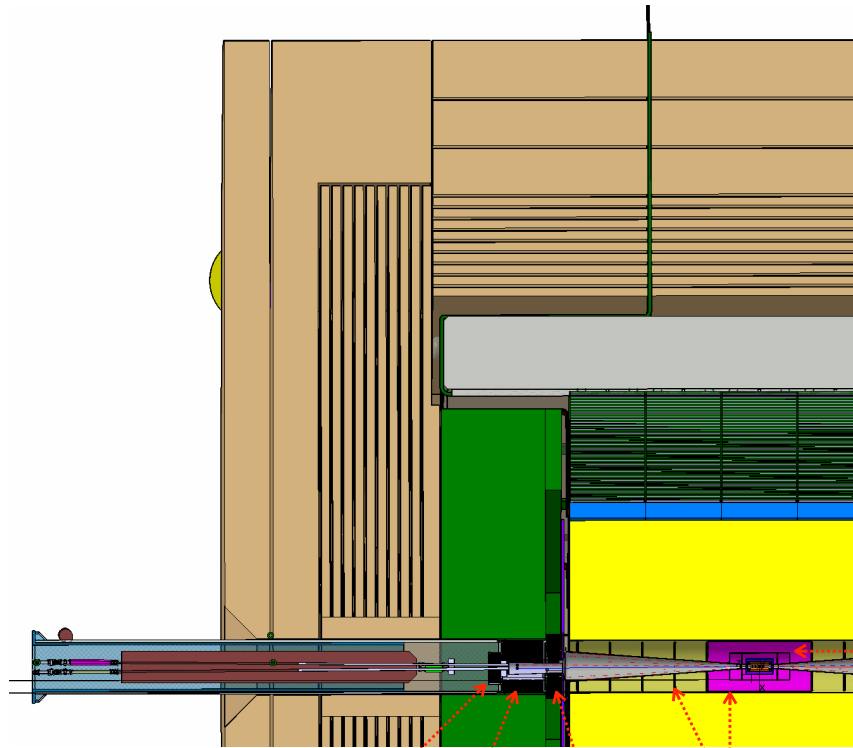
ILD disc/endcap tracker:

- ❖ Forward Tracking Detector (FTD)
 - ❖ 2 + 5 discs
 - ❖ Endcap for VTX and SIT

CLD

- ❖ All-silicon tracker
- ❖ All subdetectors: barrel + discs/endcaps
- ❖ **Vertex Detector:**
 - ❖ Three double layers + three double-discs on both sides
- ❖ **Inner Tracker:**
 - ❖ Three barrel layers + seven discs
- ❖ **Outer Tracker:**
 - ❖ Three barrel layers + four discs (enclosing the Inner Tracker discs)

ILD vs CLD



BeamCAL LHCAL LumiCAL FTD/SIT

← Yoke/Muon

← Coil

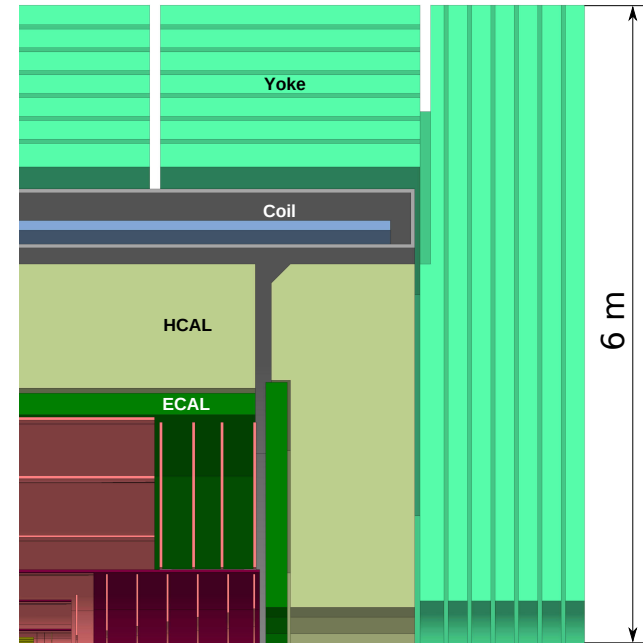
← HCAL

← ECAL

← TPC

← Vertex

ILD



Yoke

Coil

HCAL

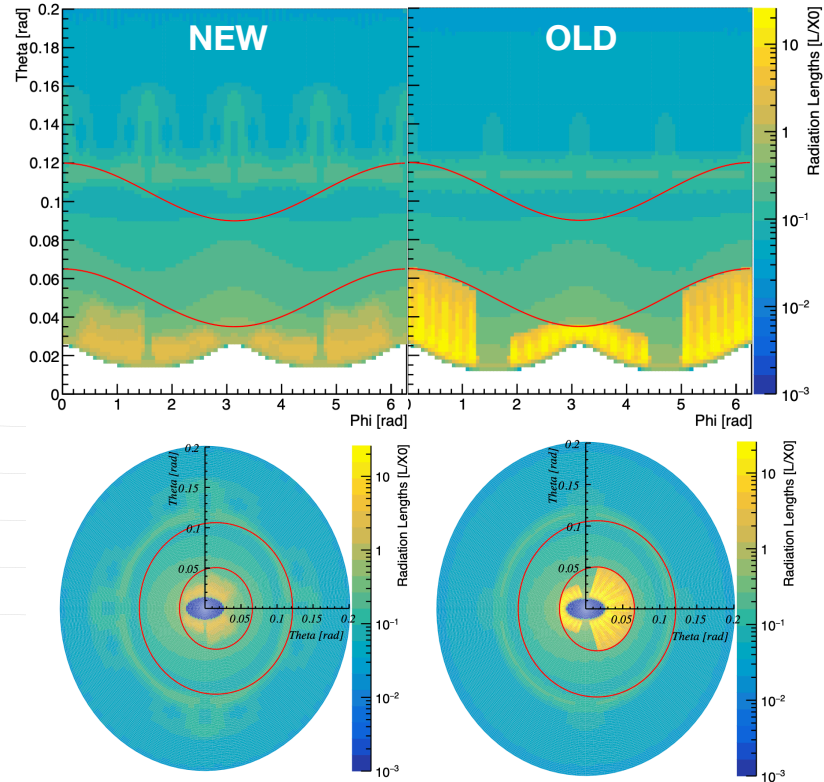
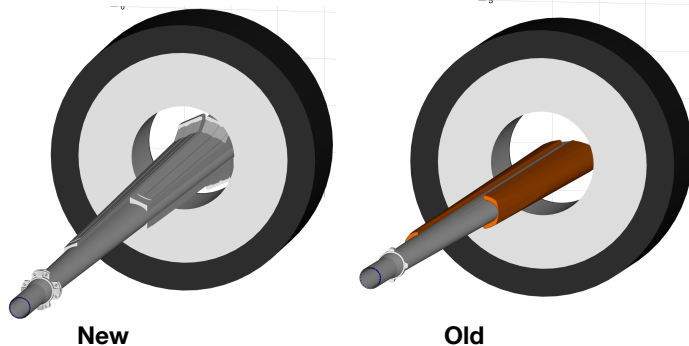
ECAL

6 m

CLD

New beam pipe and cooling

After this feedback, a new solution for the trapezoidal chamber cooling was found. Cooling manifolds are now **all in AlBeMet162** and are placed at **safety margin from the LumiCal acceptance**.



k4DetPerformance

- ❖ Framework designed to study tracking performance within full simulation environments
 - ❖ Requires complete simulation and reconstruction setup
 - ❖ Matches reconstructed tracks to simulated particles
 - ❖ Various plotting options: superimpose plots and ratios for comparative analyses
- ❖ Initially developed for CLD at FCCee by Gaelle Sadowski
- ❖ Now integrated into Key4HEP
- ❖ Leonhard Reichenbach, Gaelle and me are looking into extending its applicability to other detectors

<https://github.com/key4hep/k4DetPerformance>