

# Tracking for the Modified ILD Detector Concept at the FCCee

**3<sup>rd</sup> 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

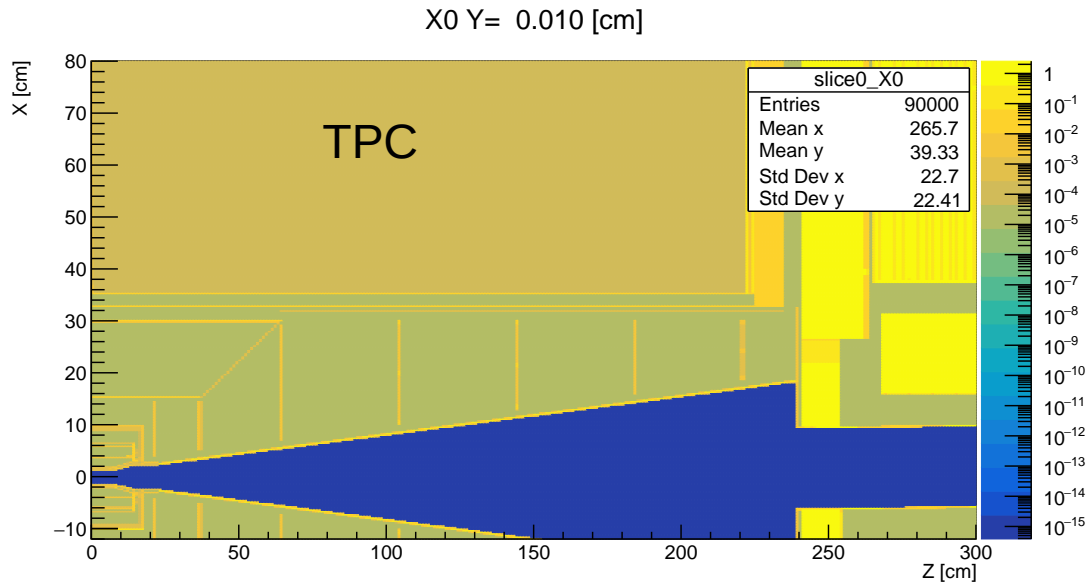
	ILC	FCCee
crossing angle	14 mrad	30 mrad
$L^*$ [distance from IP to last accel focusing quadupole magnet]	4.1 m	2.0 m
detector solenoid	3.5 T	2.0 T
additional B-fields	anti-DID (?)	- compensating - screening

From Daniel Jeans

# Starting Point

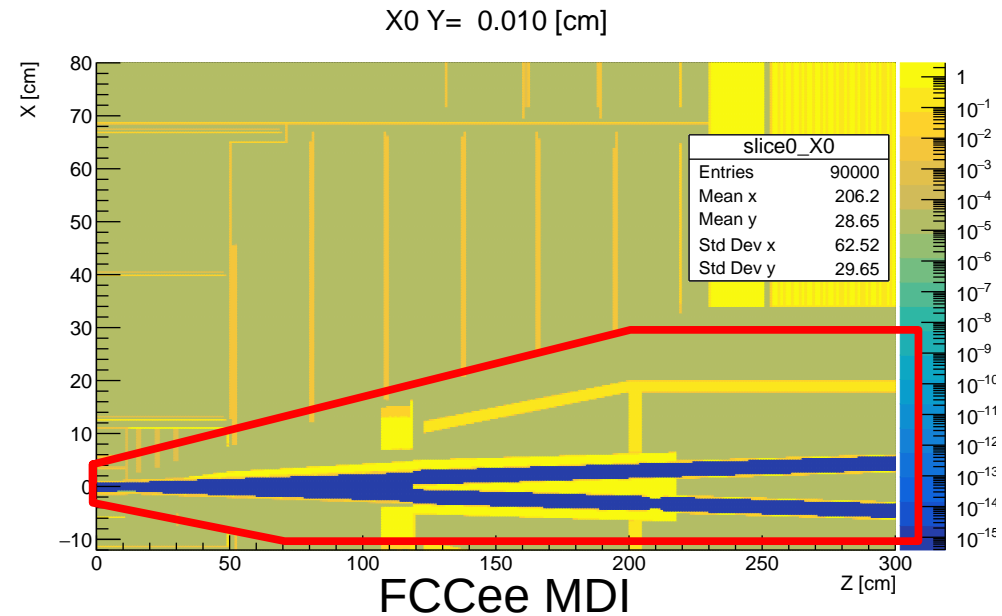
## ILD (for ILC)

- ❖ ILC MDI
- ❖ Hybrid tracking layout



## CLD (CLIC-like Detector)

- ❖ FCCee MDI
- ❖ All-silicon tracking



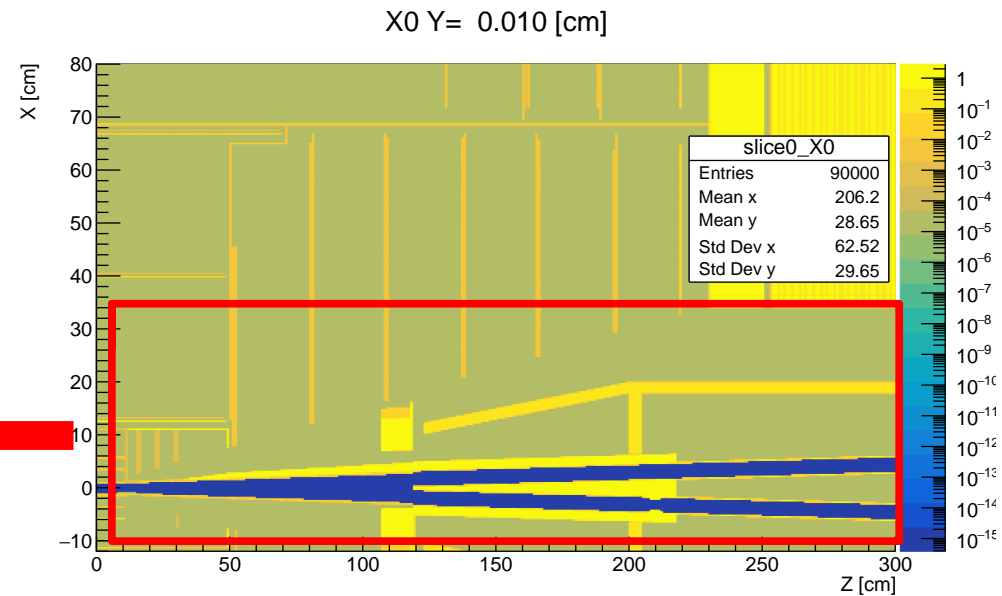
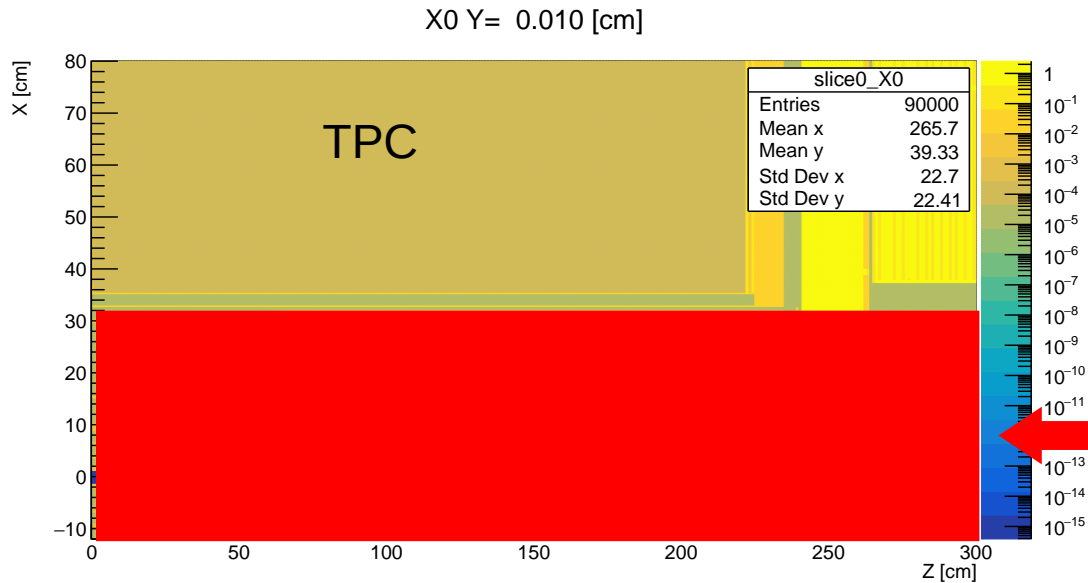
# Ansatz

## 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

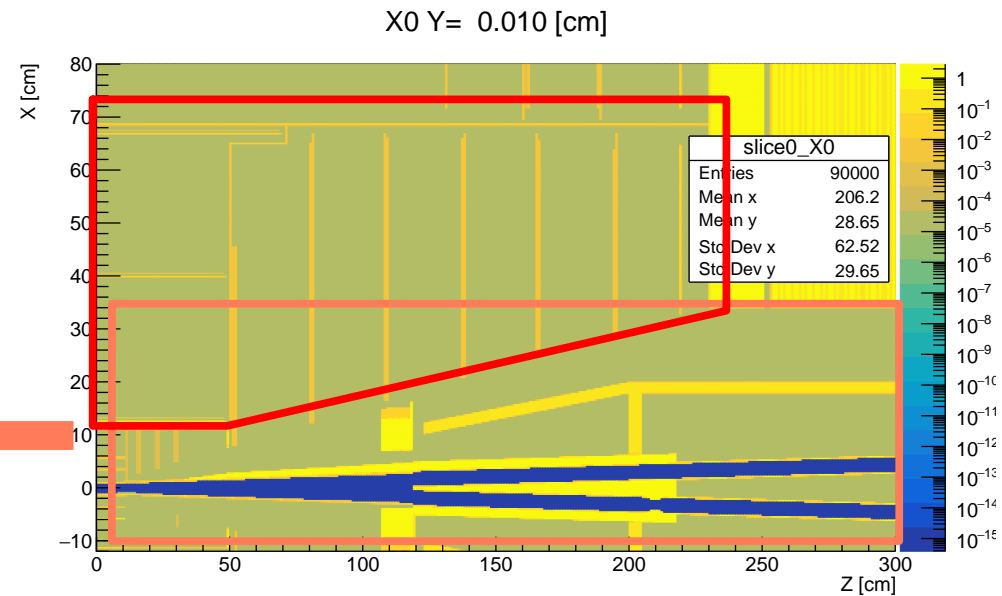
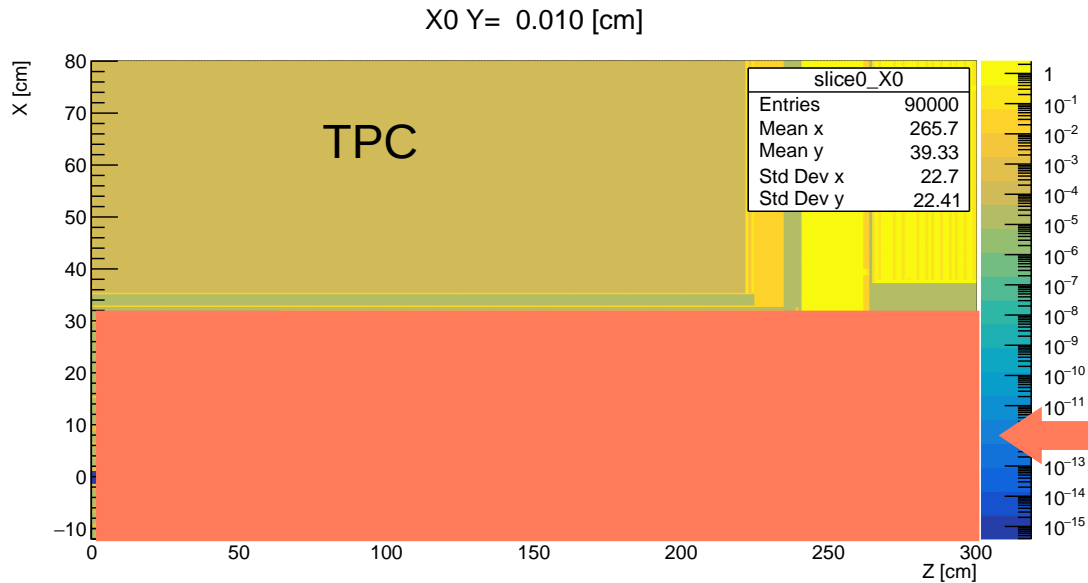
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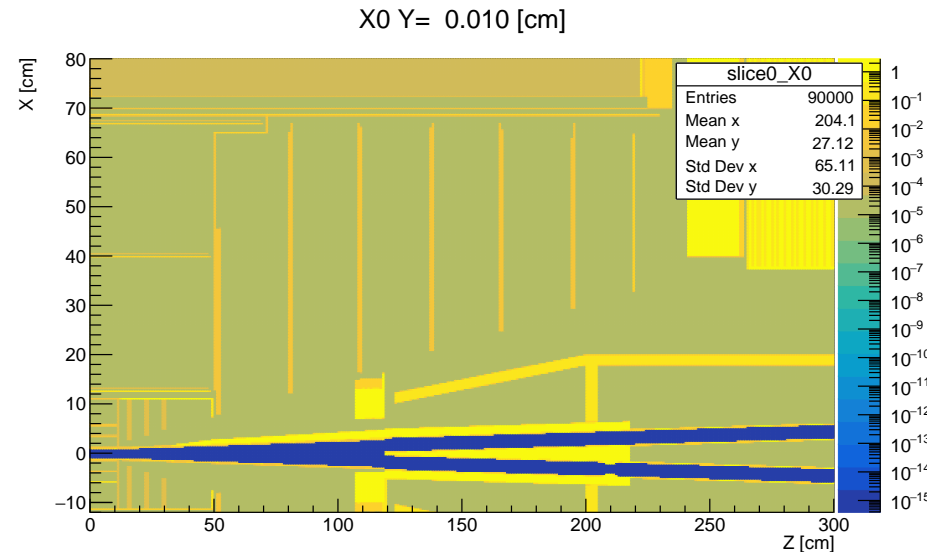
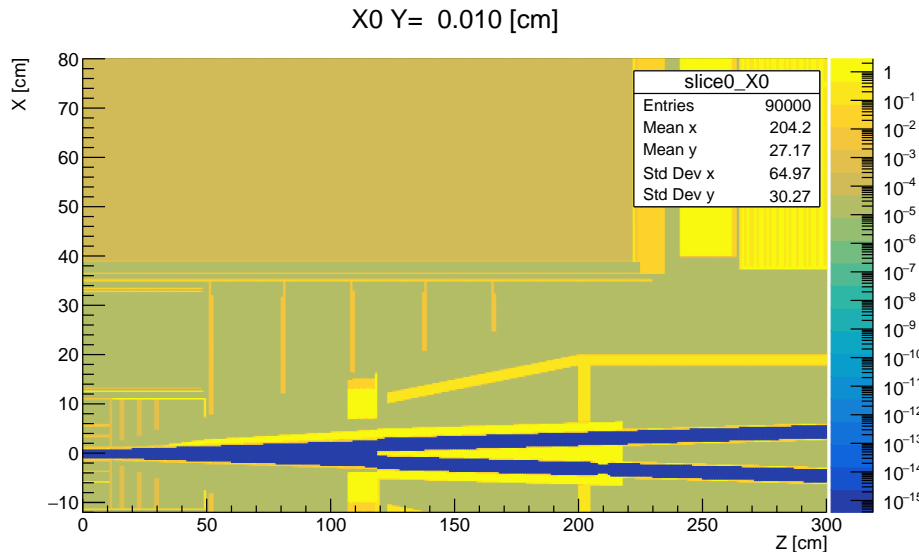
# New Models or 2 Merging Strategies

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

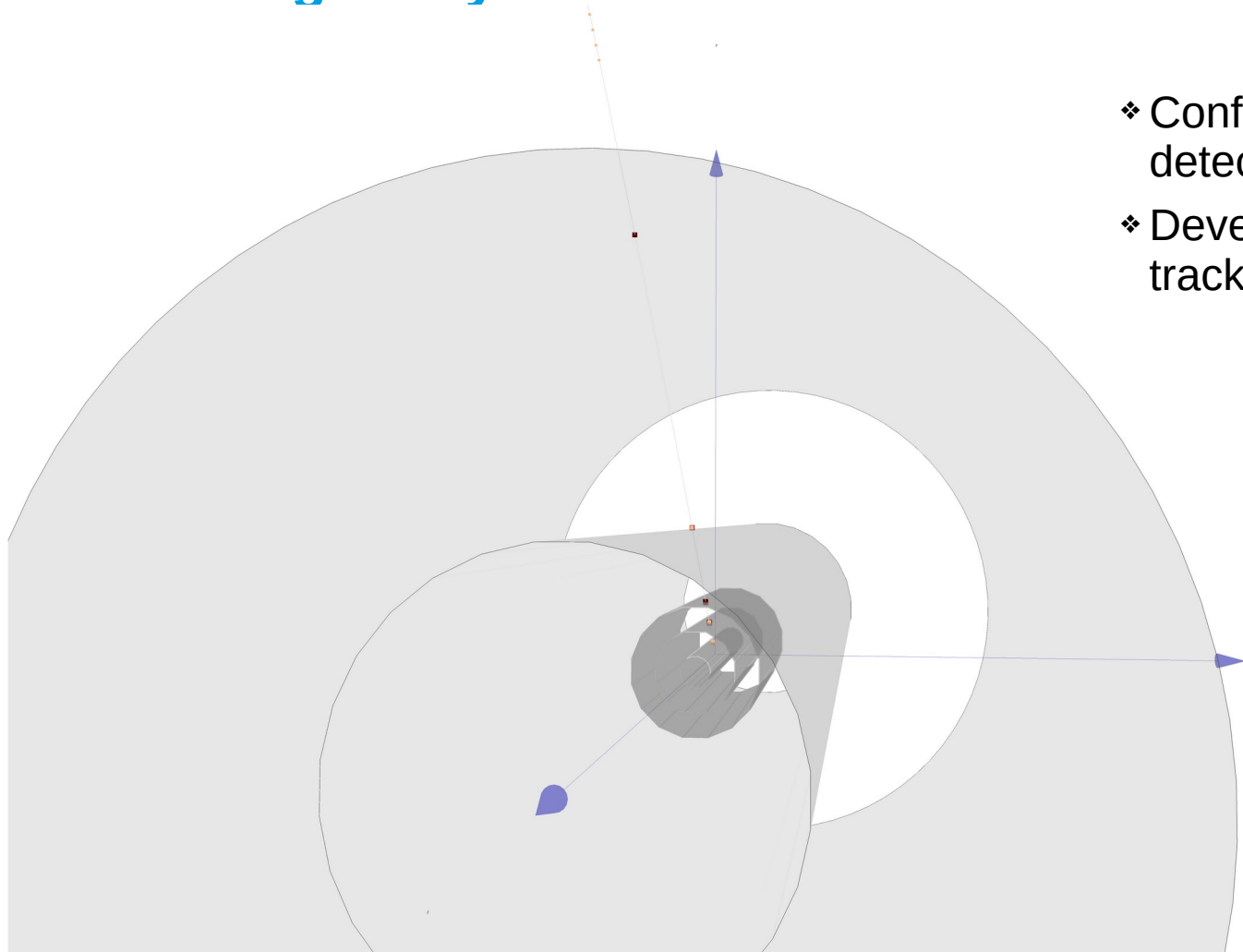
\*Calorimeter and solenoid volumes were left unchanged, except for removed ECal Ring and LHCAL

[model description source](#)

# Tracking for Hybrid Layouts



# Tracking w/ Hybrid Subdetector Technologies



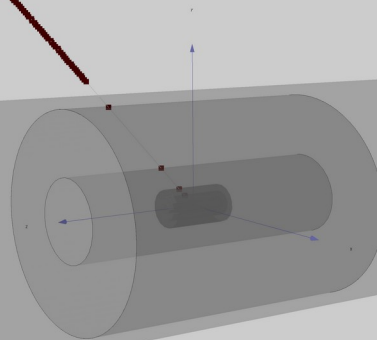
- ❖ Conformal Tracking used for silicon detectors
- ❖ Developed for CLIC (full-silicon tracking)

\*ILD\_FCce\_v01

# Tracking w/ Hybrid Subdetector Technologies

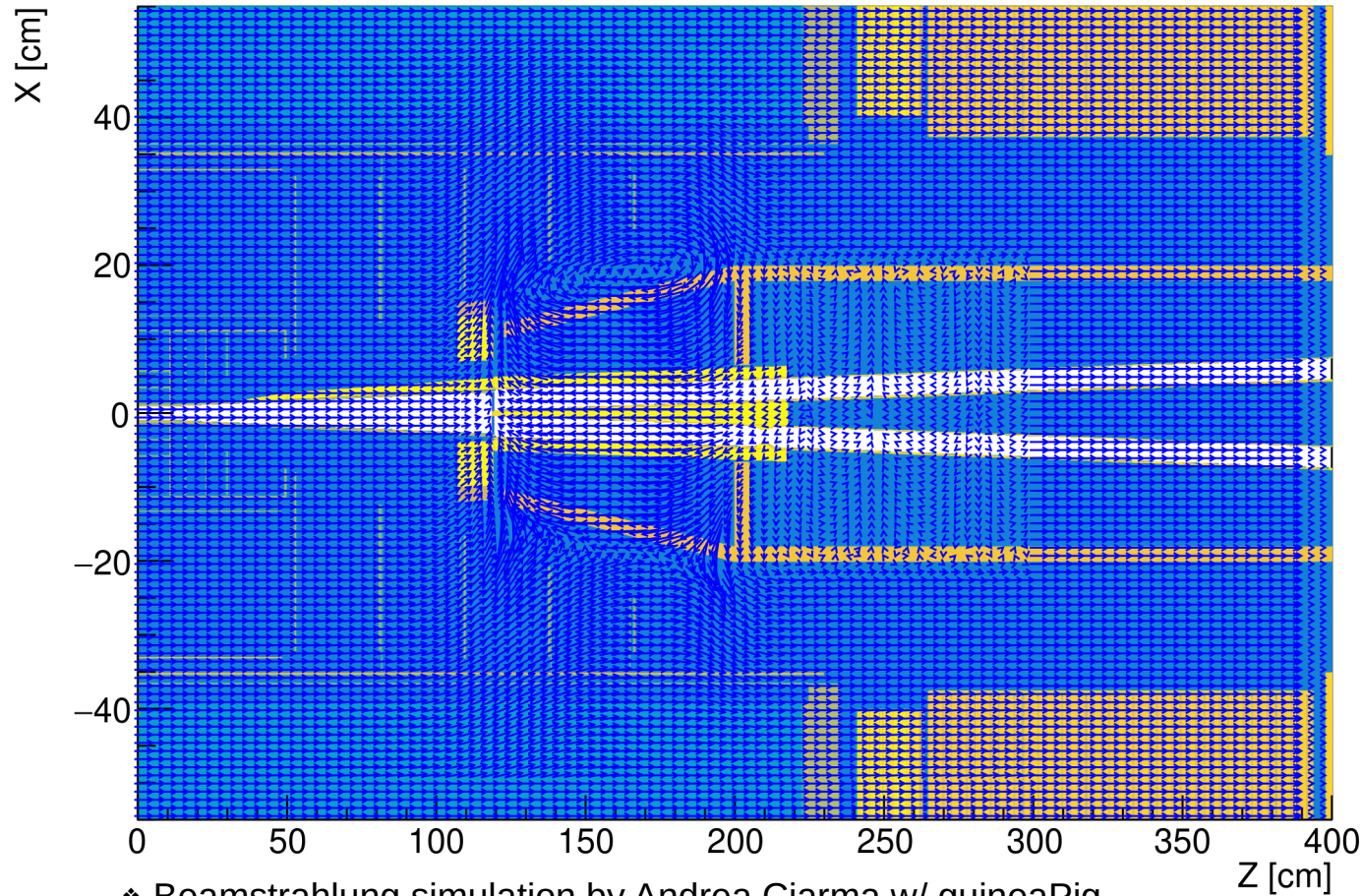
❖ Clupatra Tracking used for TPC

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



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

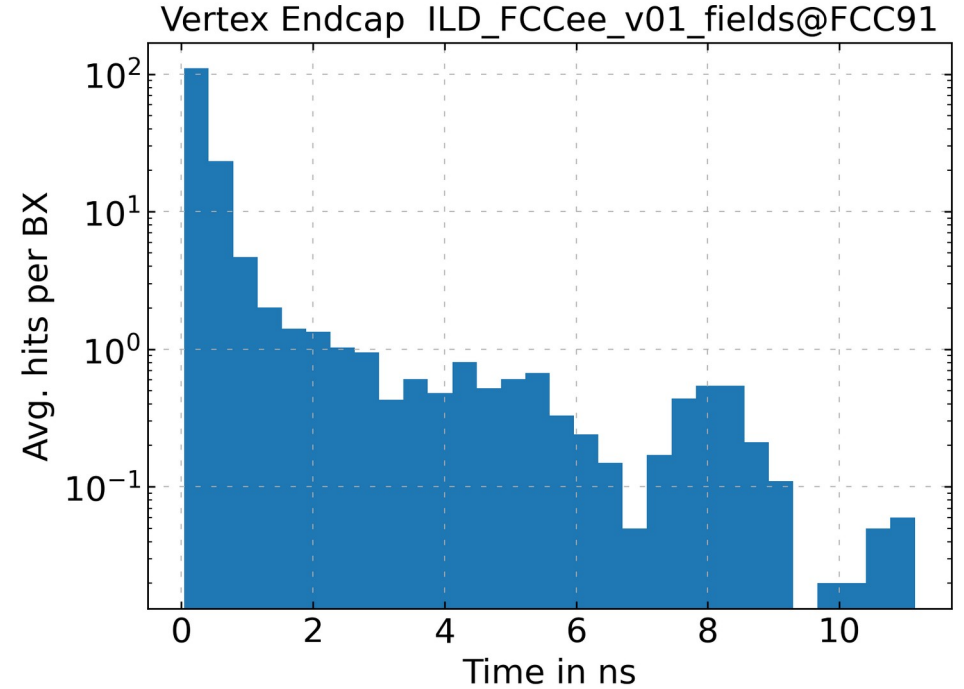
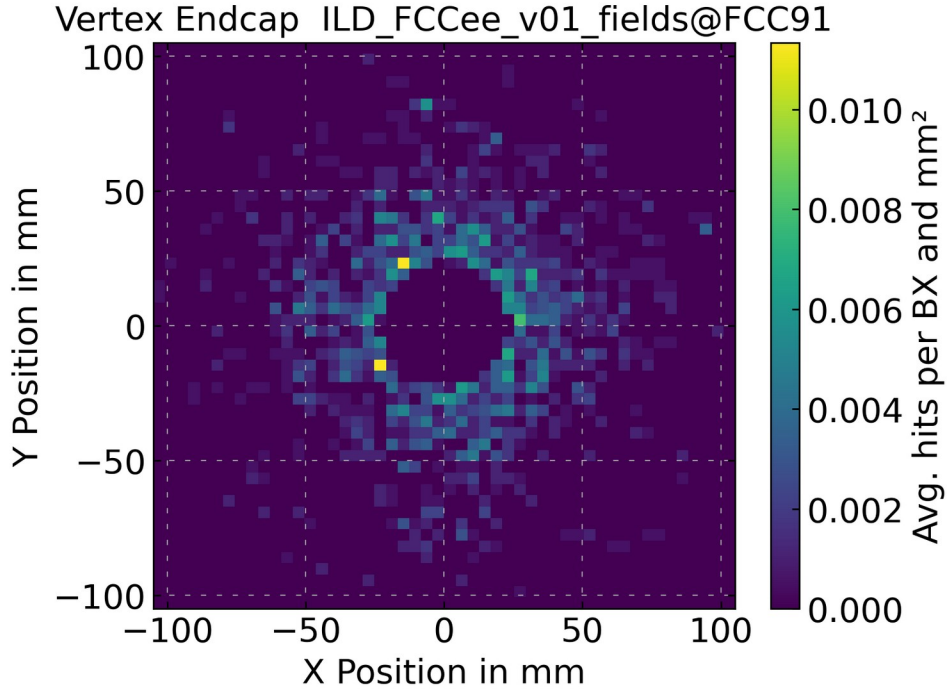
# Magnetic Field Map of ILD\_FCc\_01



❖ Beamstrahlung simulation by Andrea Ciarma w/ guineaPig

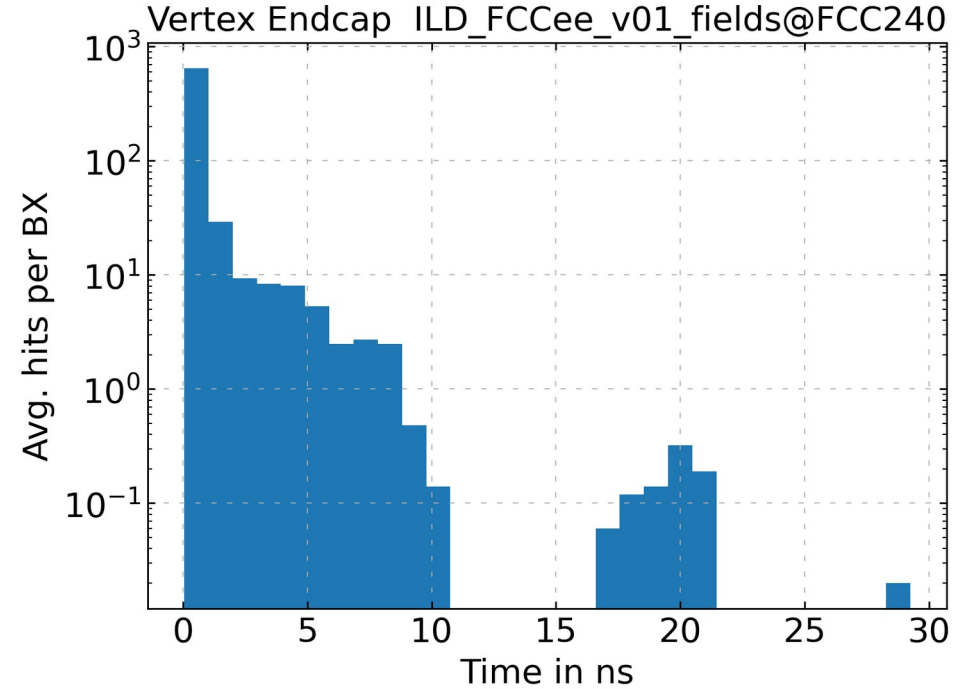
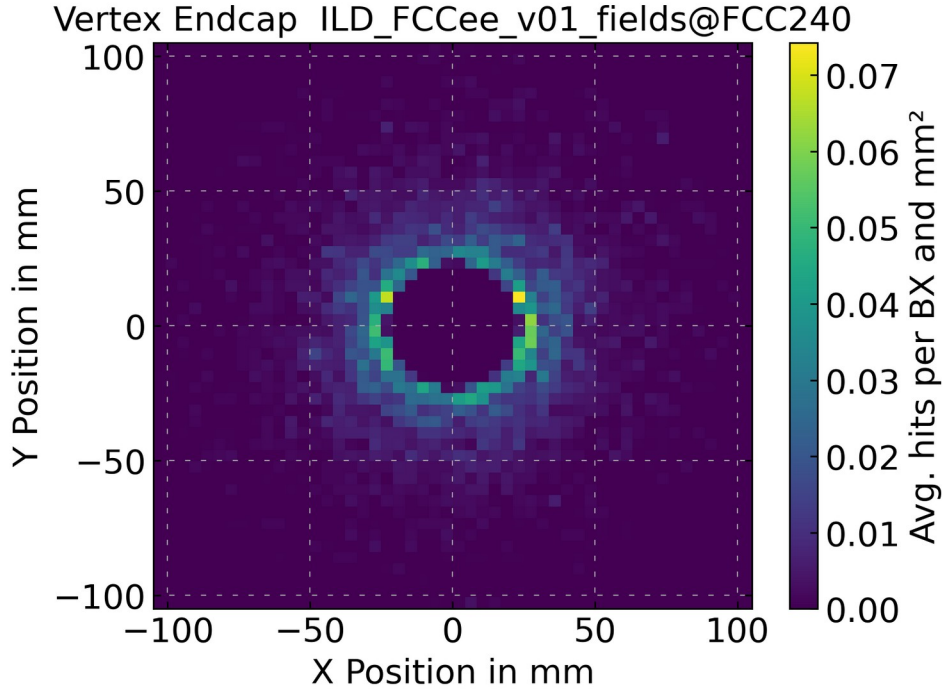
❖ Only Vertex Detector considered, TPC results in detector parallel session by Daniel Jeans

# Vertex Endcap @ FCC91



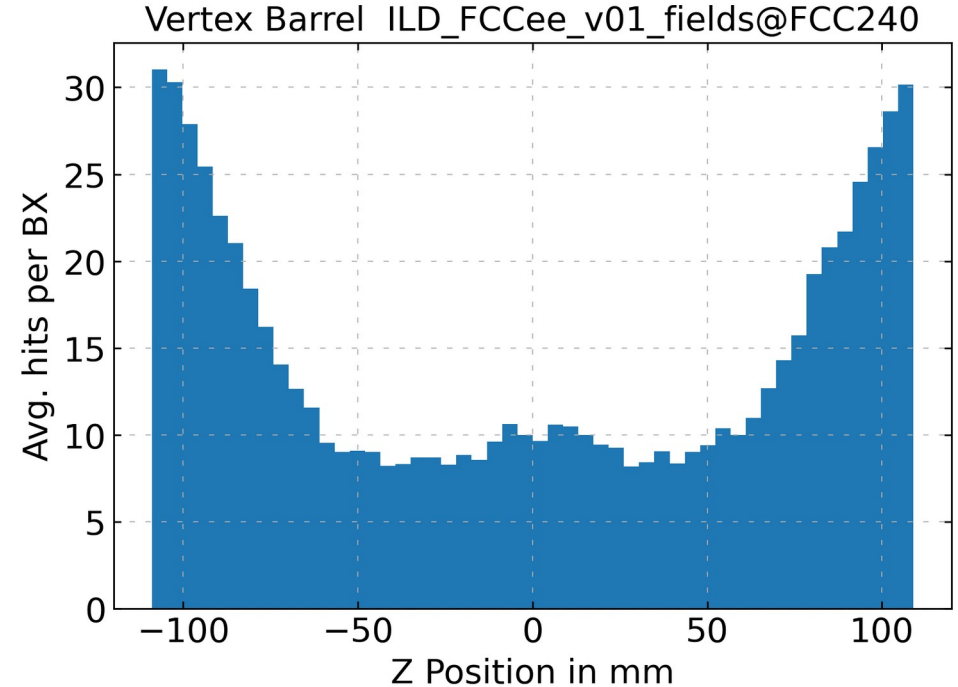
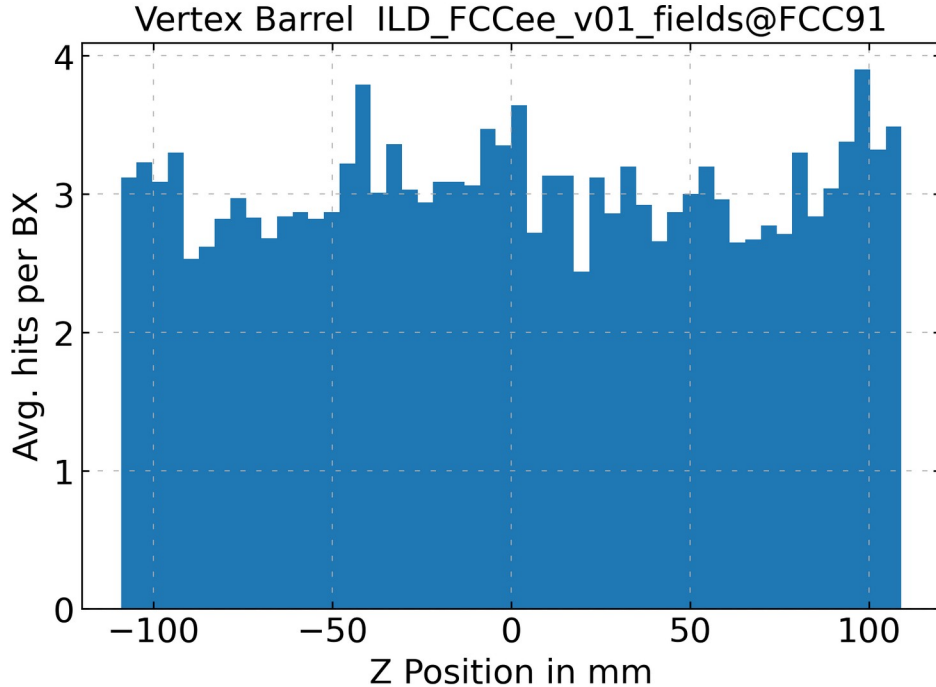
- ❖ Mostly prompt hits, some back-scattering
- ❖ Decreasing with radius

# Vertex Endcap @ FCC240



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

# Vertex Barrel Occupancy @ FCC91 vs FCC240



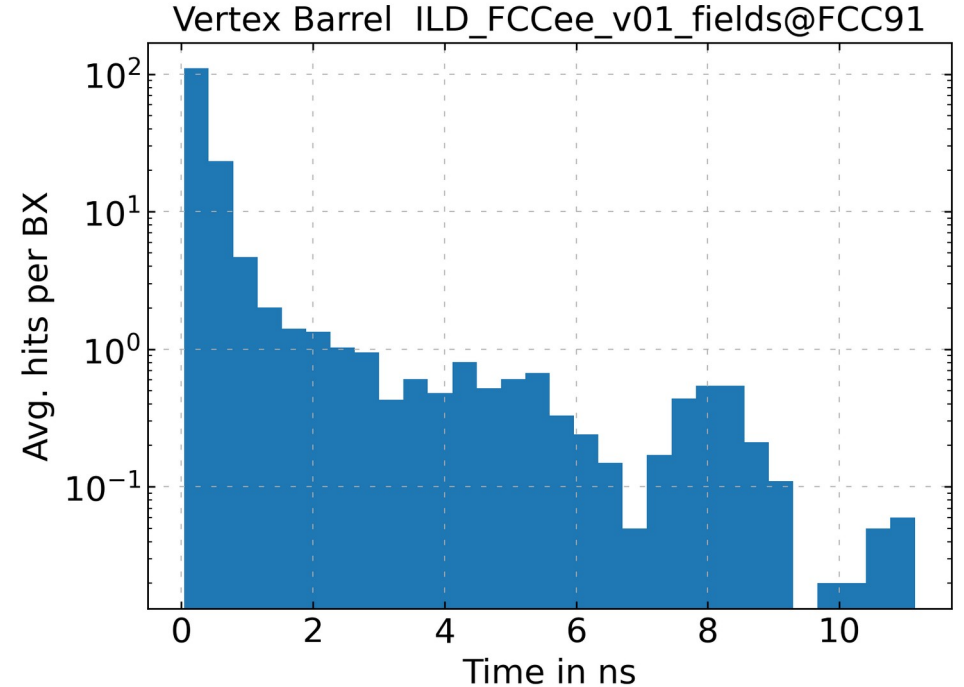
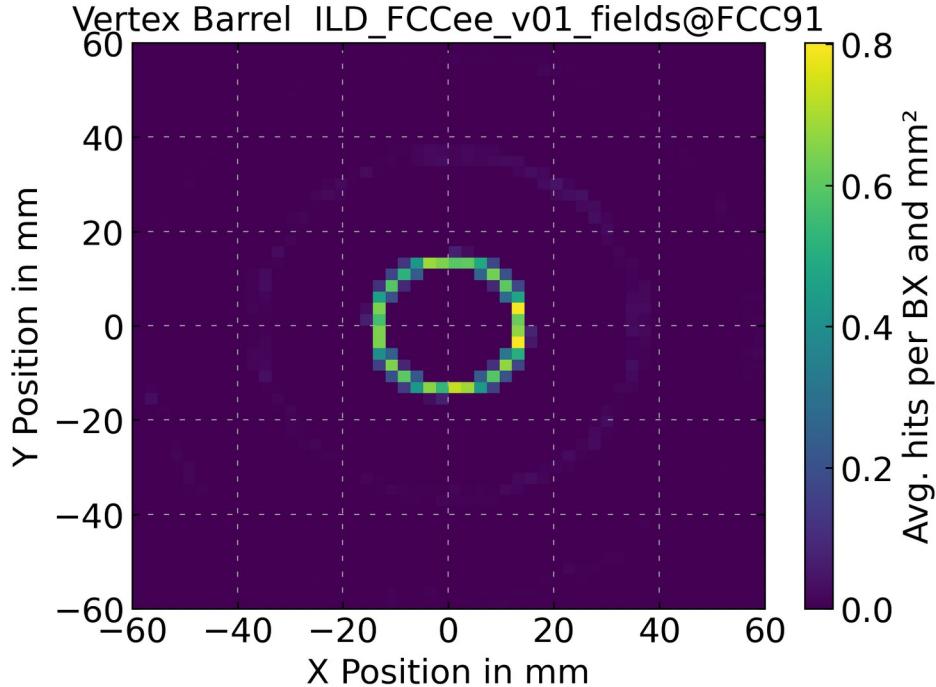
- ❖ Intensity increases with beam energy
- ❖ Beamstrahlung more boosted → hits shifted away from center
- ❖ Effect on tracking efficiencies to be studied

**Thanks for your attention!**



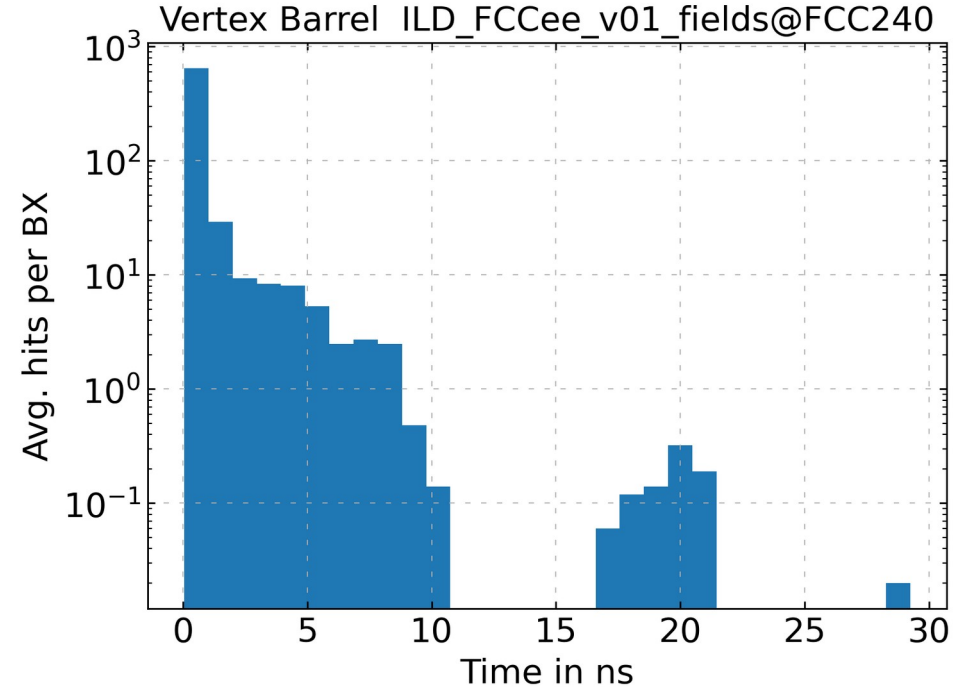
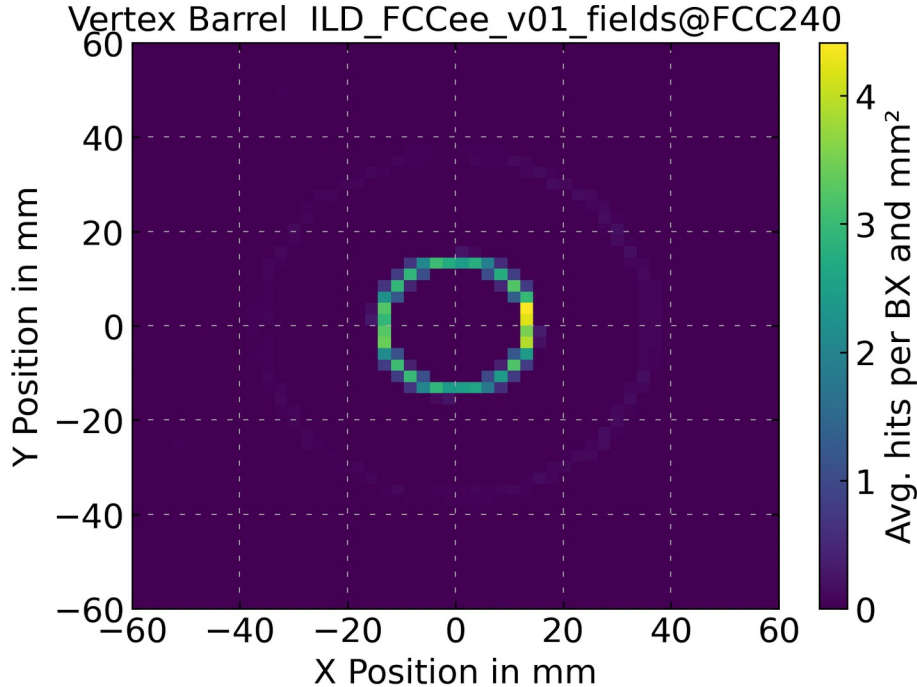
# Back-Up

# Vertex Barrel @ FCC91



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

# Vertex Barrel @ FCC240

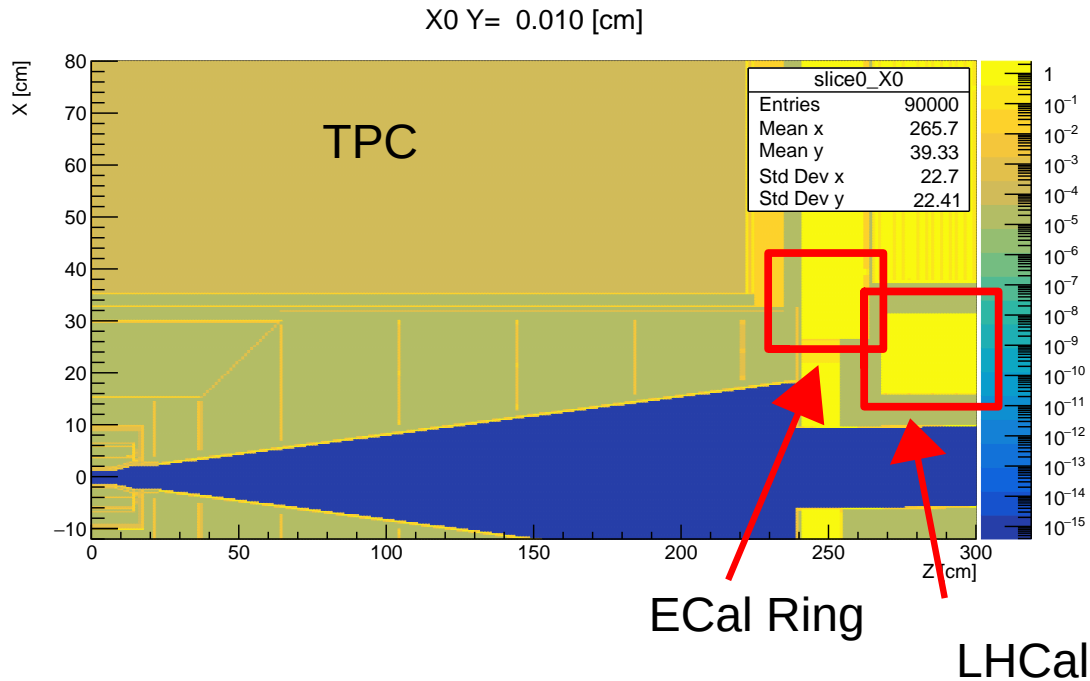


- ❖ Intensity increased
- ❖ Mostly prompt hits

# Starting Point

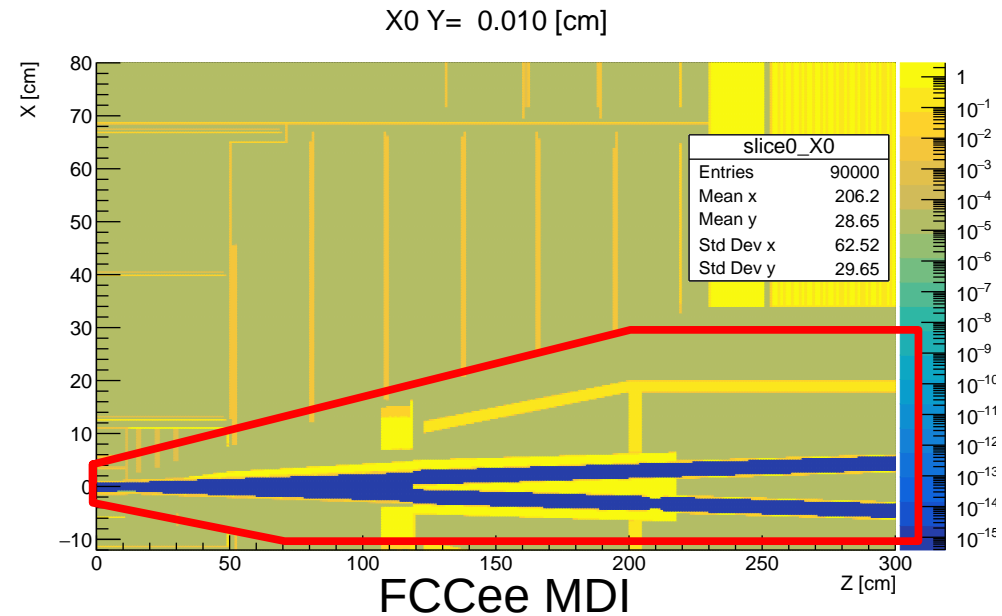
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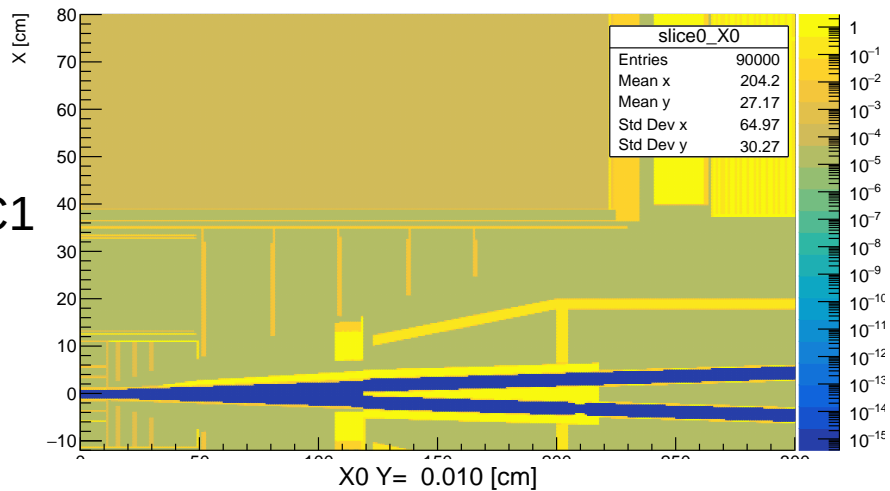
- ❖ FCCee MDI
- ❖ All-silicon tracking



# Overview of FCCee Models

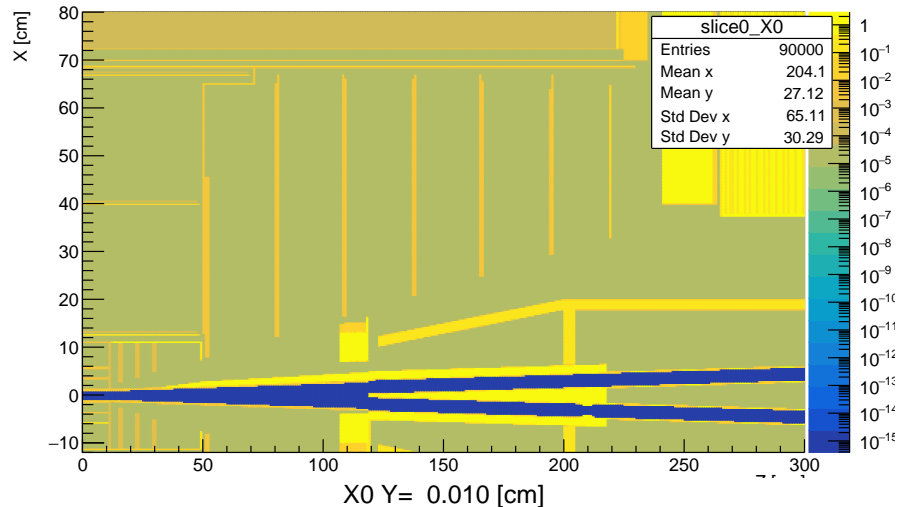
X0 Y= 0.010 [cm]

FCC1



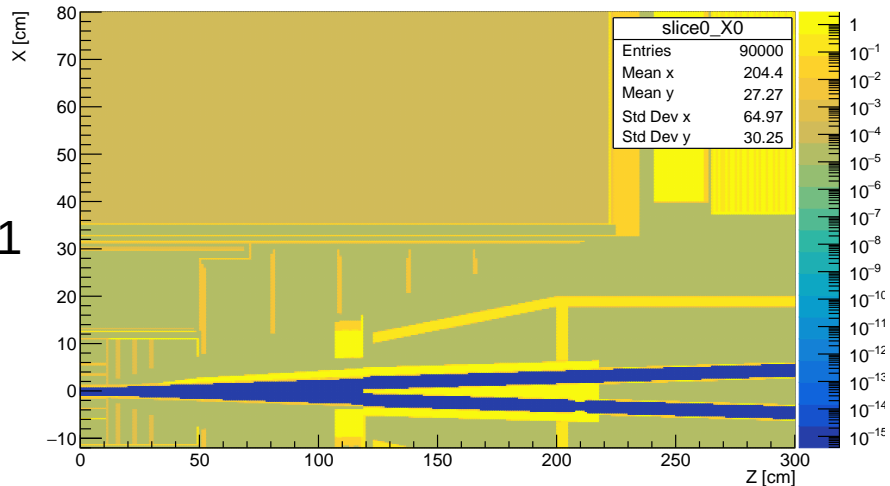
X0 Y= 0.010 [cm]

FCC2



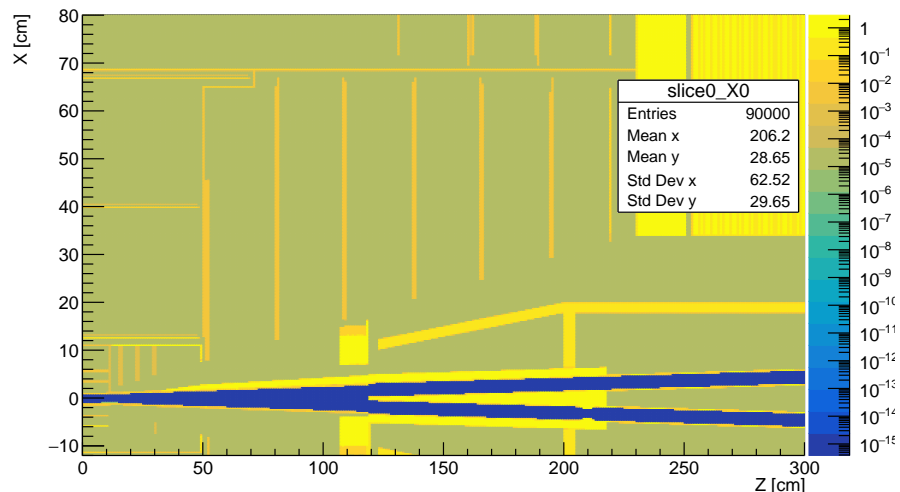
X0 Y= 0.010 [cm]

v11



X0 Y= 0.010 [cm]

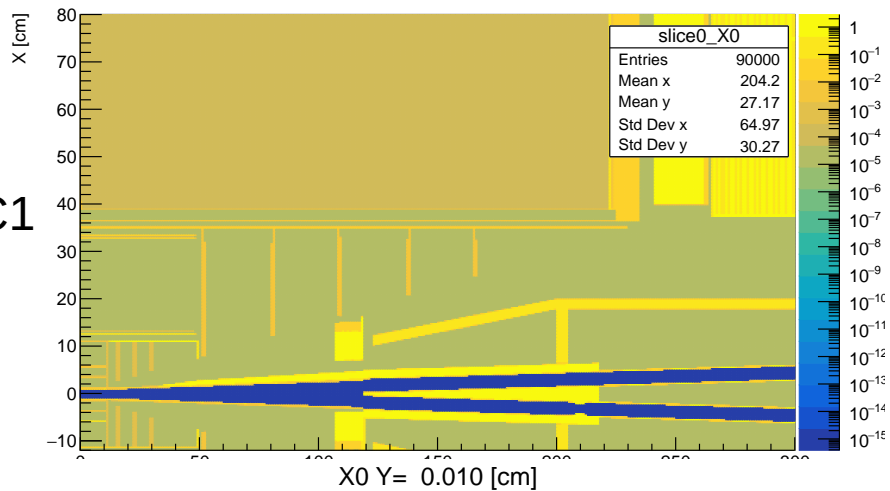
CLD



# Overview of ILD Models

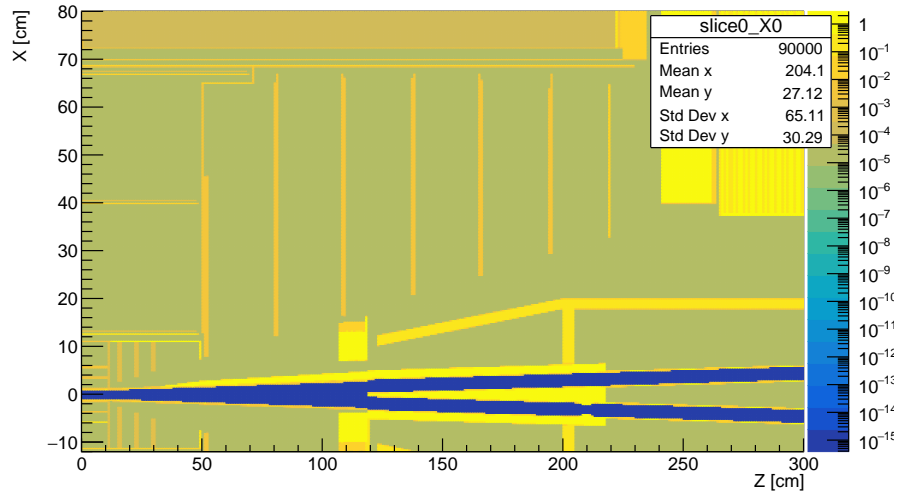
X0 Y= 0.010 [cm]

FCC1



X0 Y= 0.010 [cm]

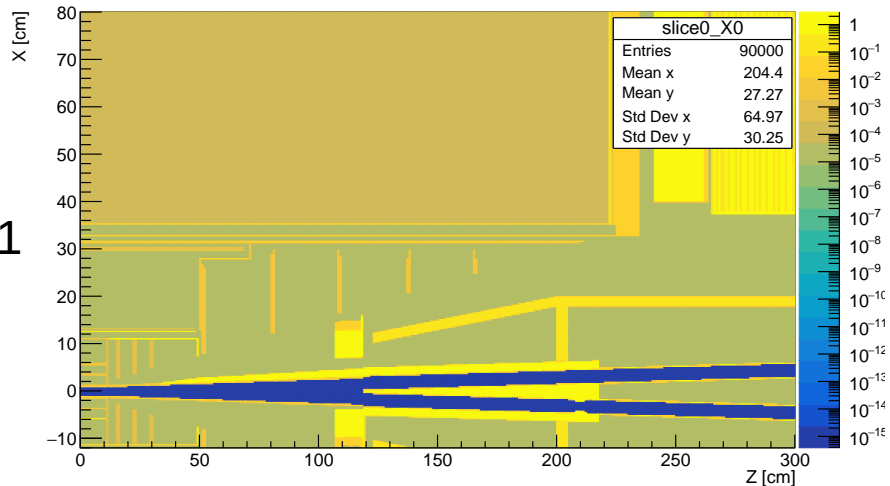
X [cm]



FCC2

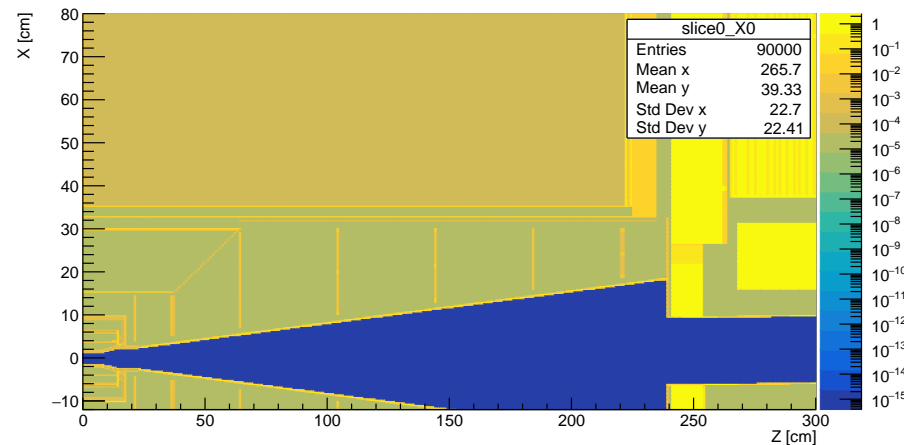
X0 Y= 0.010 [cm]

v11



X0 Y= 0.010 [cm]

X [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

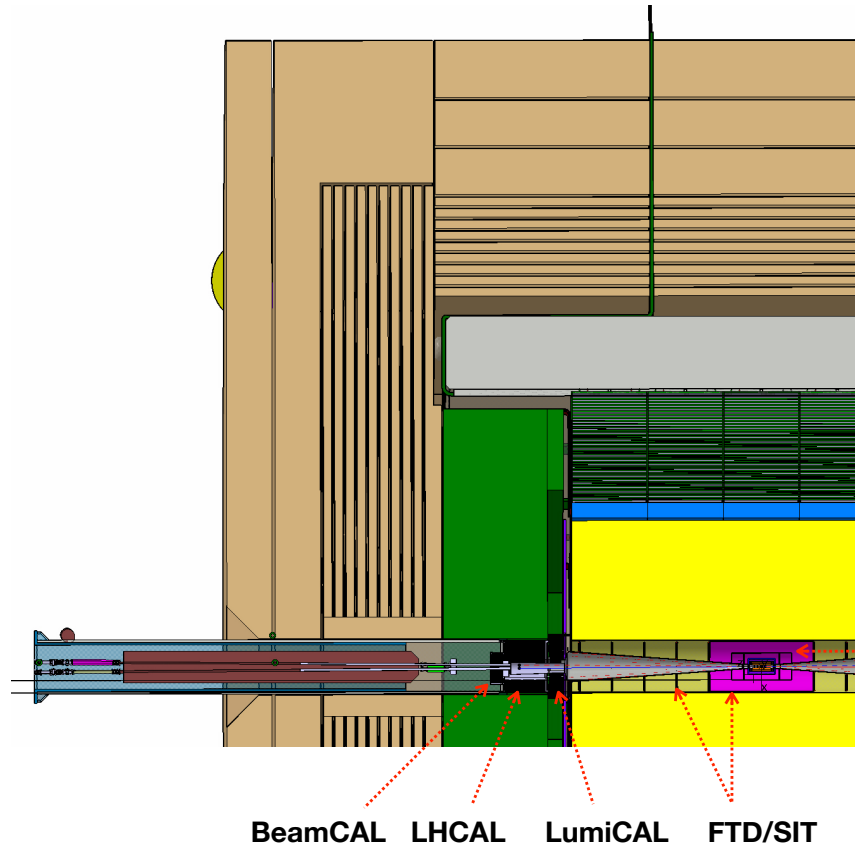
### **ILD disc/endcap tracker:**

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

## CLD

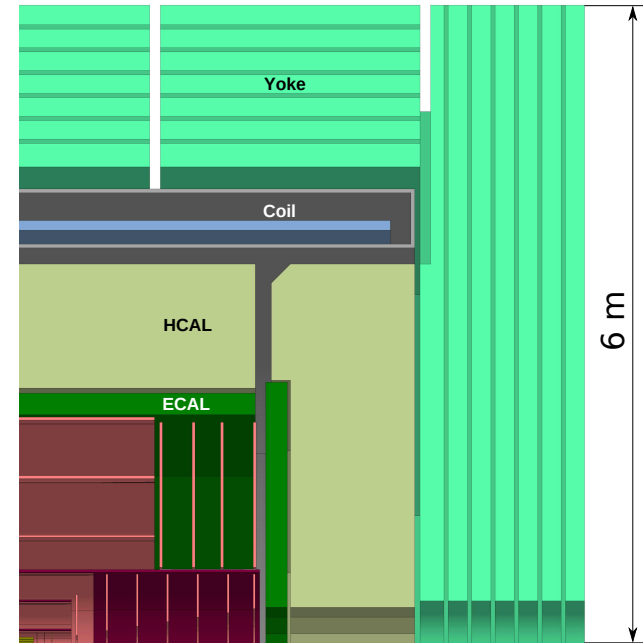
- ❖ All-silicon tracker
- ❖ All subdetectors: barrel + discs/endcaps
- ❖ **Vertex Detector:**
  - ❖ Three double layers + three double-discs on both sides
- ❖ **Inner Tracker:**
  - ❖ Three barrel layers + seven discs
- ❖ **Outer Tracker:**
  - ❖ Three barrel layers + four discs (enclosing the Inner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

# ILD vs CLD



- ← Yoke/Muon
- ← Coil
- ← HCAL
- ← ECAL
- ← TPC
- ← Vertex

ILD

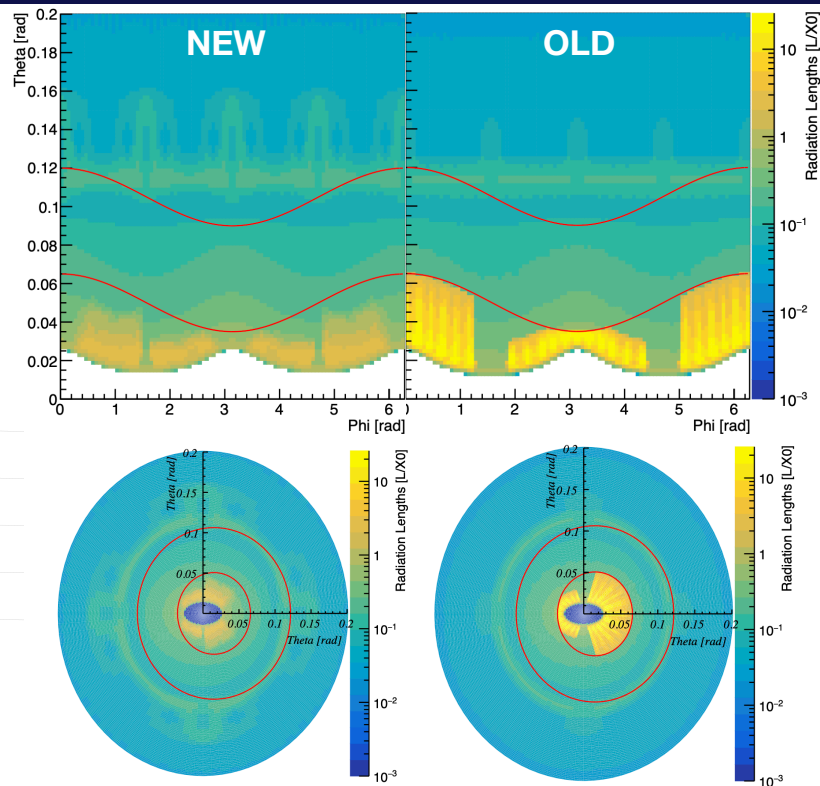
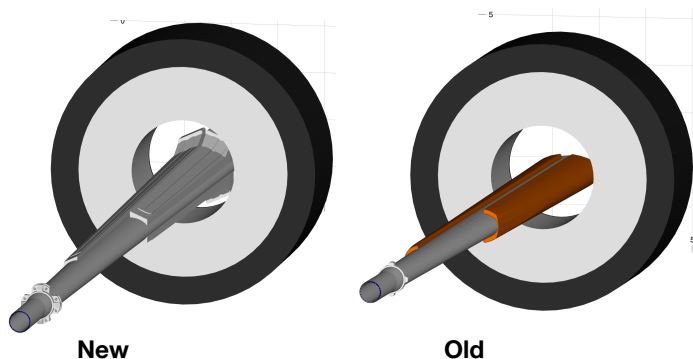


CLD



# 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>