

# 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)
    - ❖ e.g. strongly forward-boosted

# ILC vs FCCee

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



From Daniel Jeans

# Starting Point

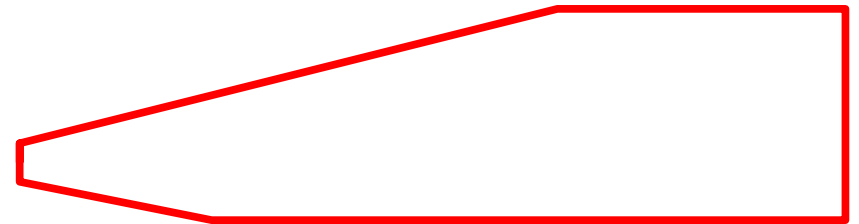
## **ILD** (for ILC)

- ❖ ILC MDI
- ❖ Hybrid tracking layout

TPC

## **CLD** (CLIC-like Detector)

- ❖ FCCee MDI
- ❖ All-silicon tracking



FCCee MDI

# Starting Point

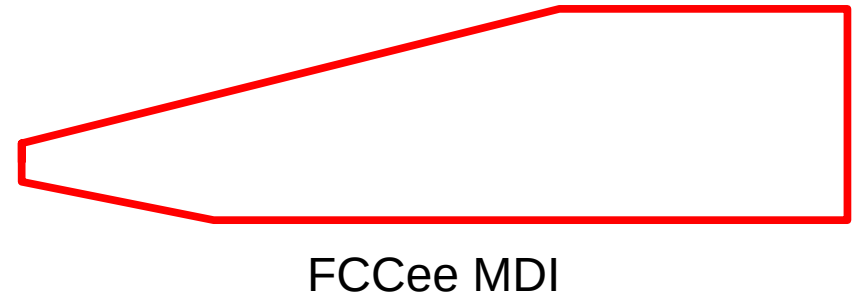
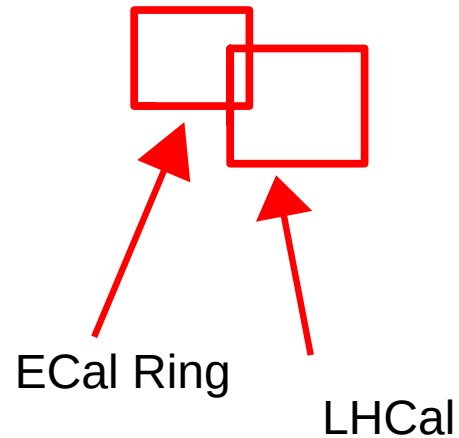
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## CLD (CLIC-like Detector)

- ❖ FCCee MDI
- ❖ All-silicon tracking

TPC



# Ansatz

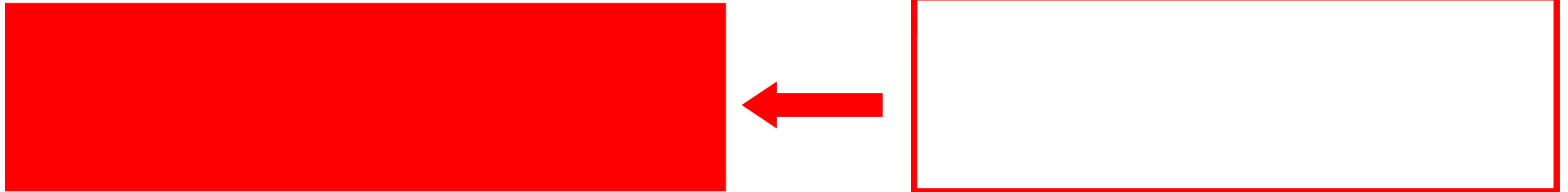
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- ❖ All-silicon tracking

TPC



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

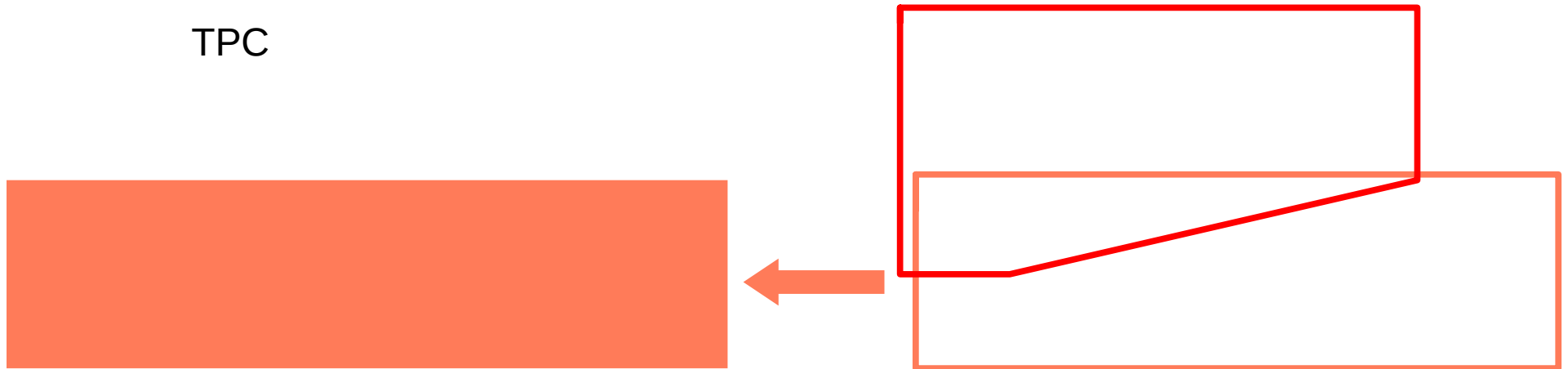
# Ansatz

## ILD (for ILC)

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- ❖ Hybrid tracking layout

## CLD (CLIC-like Detector)

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

# 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



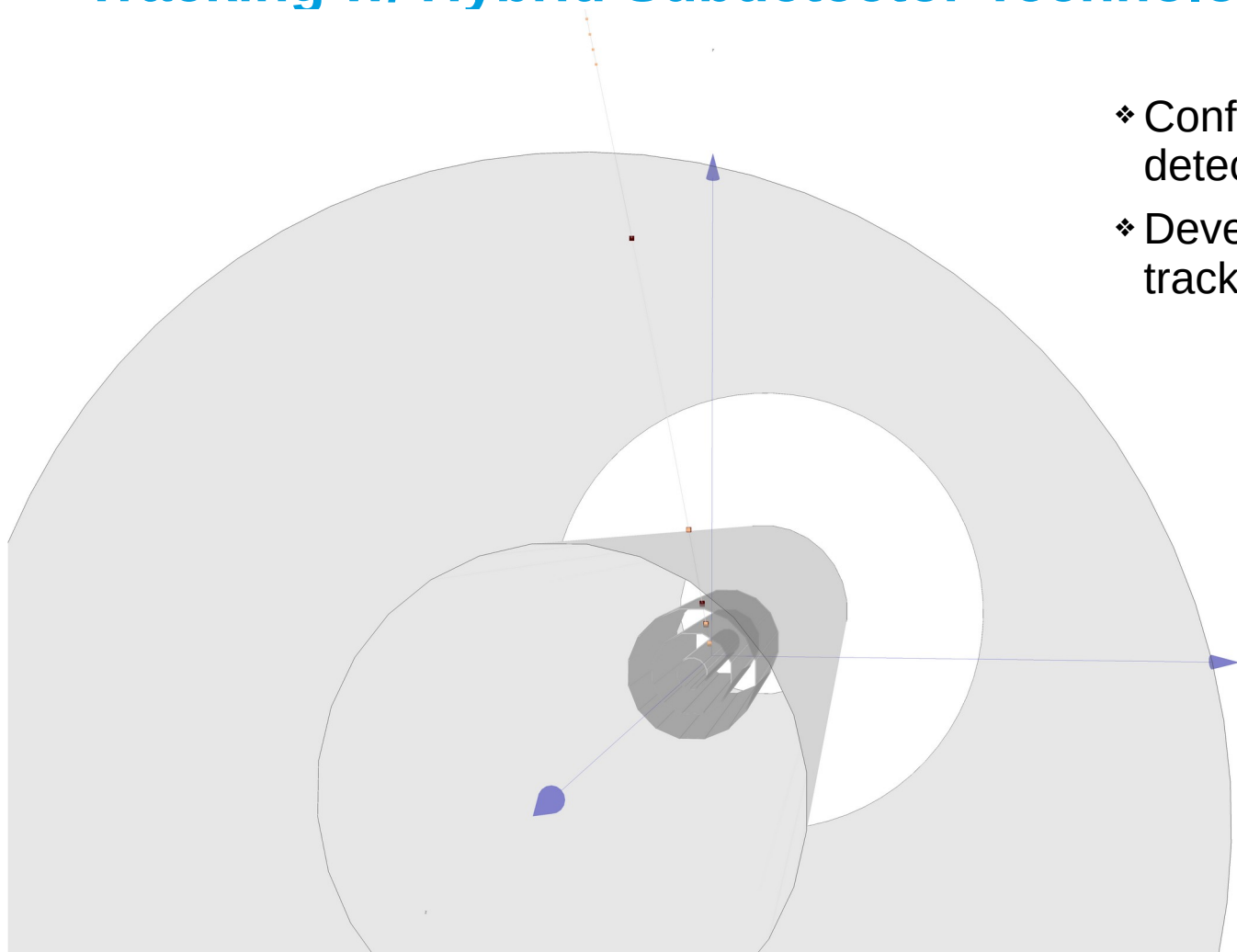
\*Common MDI\_o1\_v00

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



# Tracking for Hybrid Layouts

# Tracking w/ Hybrid Subdetector Technologies



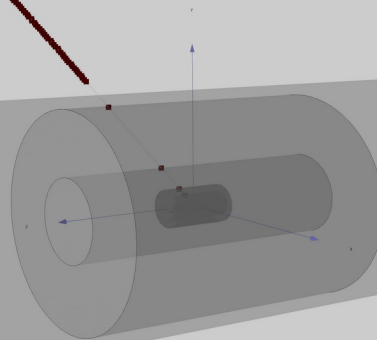
- ❖ Conformal Tracking used for silicon detectors
- ❖ Developed for CLIC (full-silicon tracking)

\*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

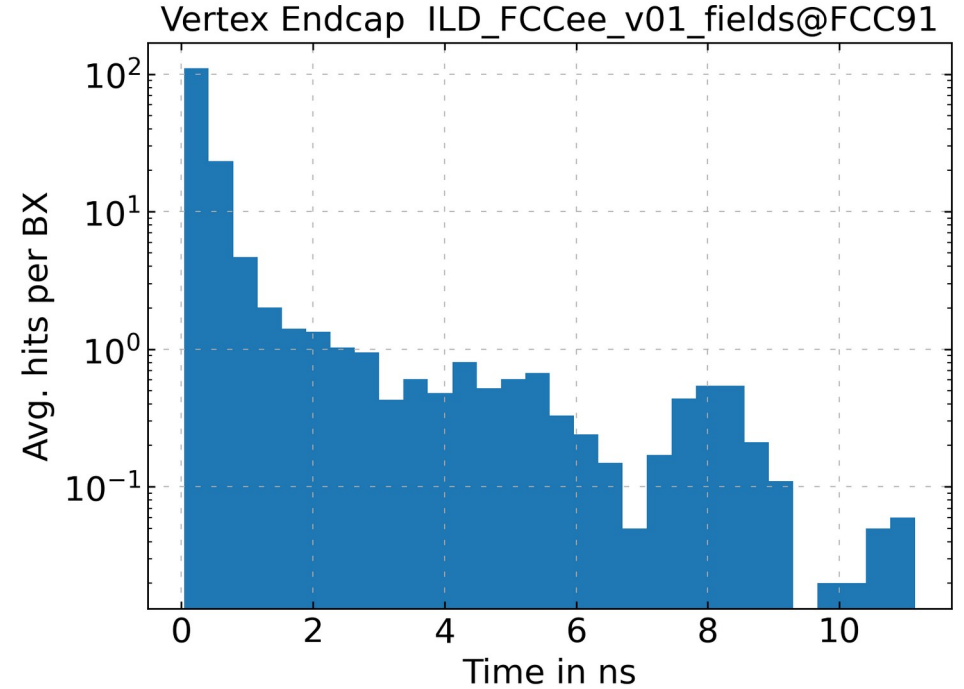
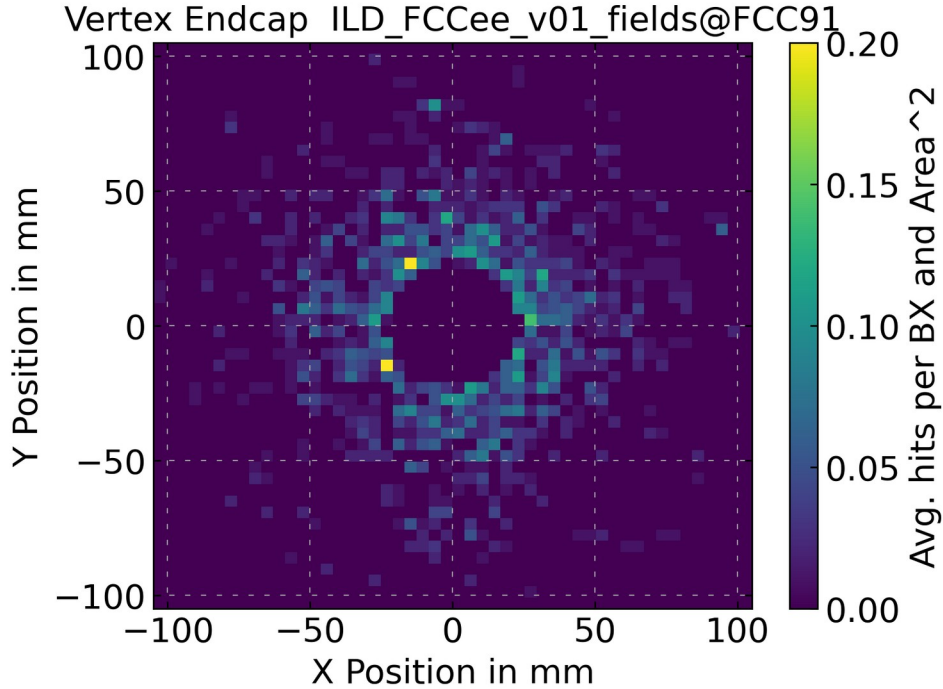


# Beamstrahlung

# Magnetic Field Map of ILD\_FCCee\_01

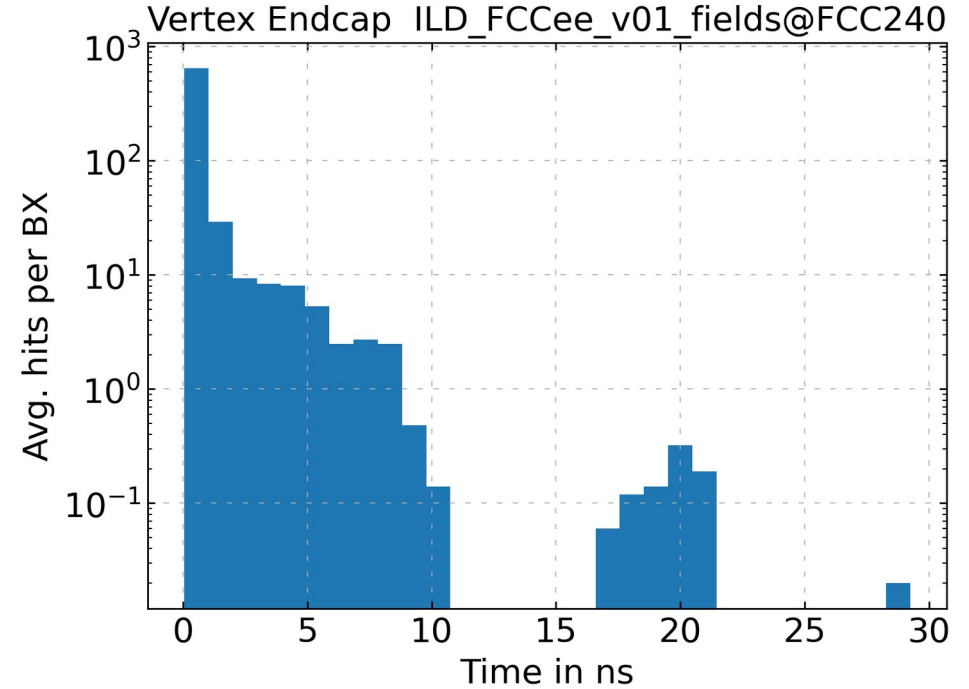
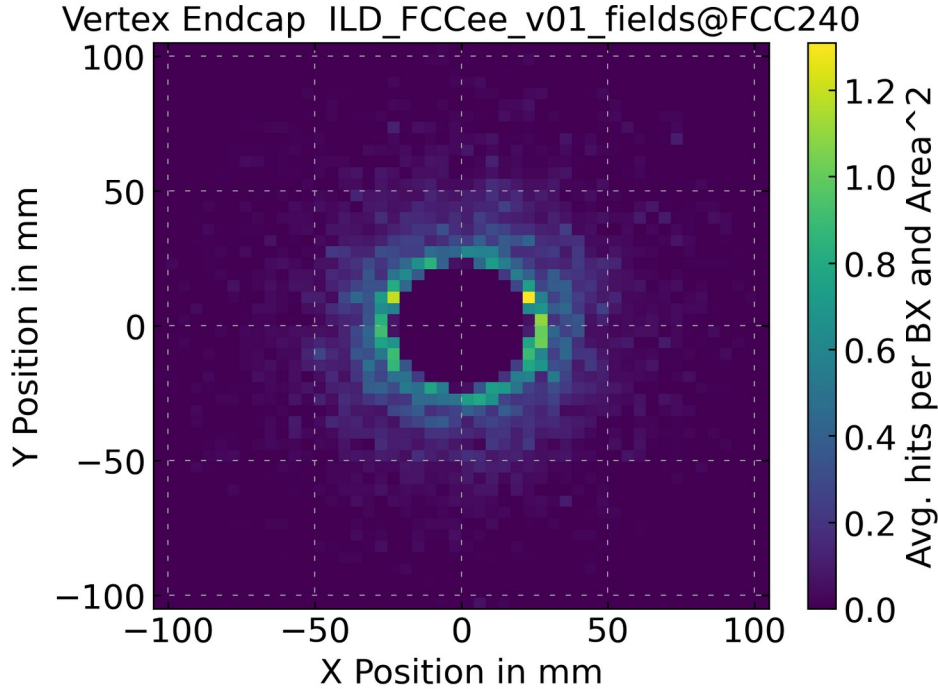
- ❖ Beamstrahlung simulation by Andrea Ciarna w/ guineaPig
- ❖ Only Vertex Detector considered, TPC results in detector parallel session by Daniel Jeans

# Vertex Endcap @ FCC91



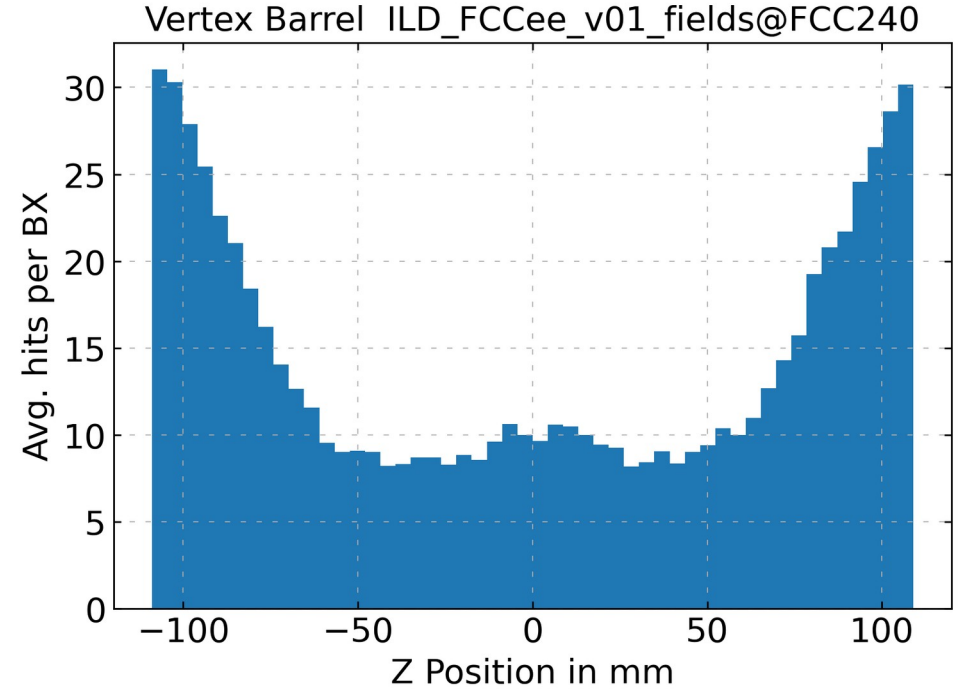
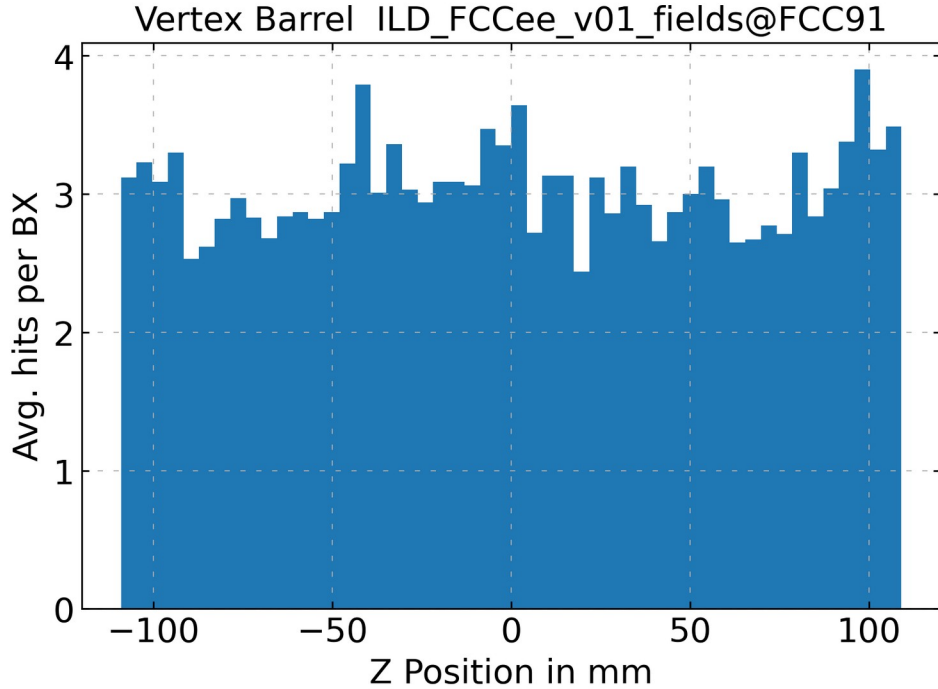
- ❖ Mostly prompt hits, some back-scattering
- ❖ Decreasing with radius

# 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



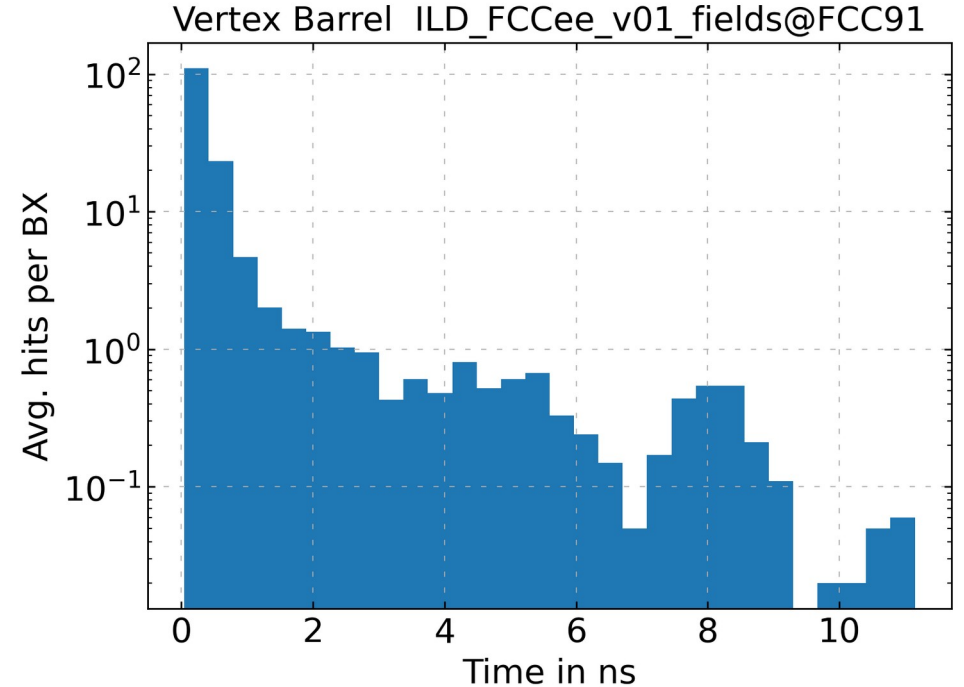
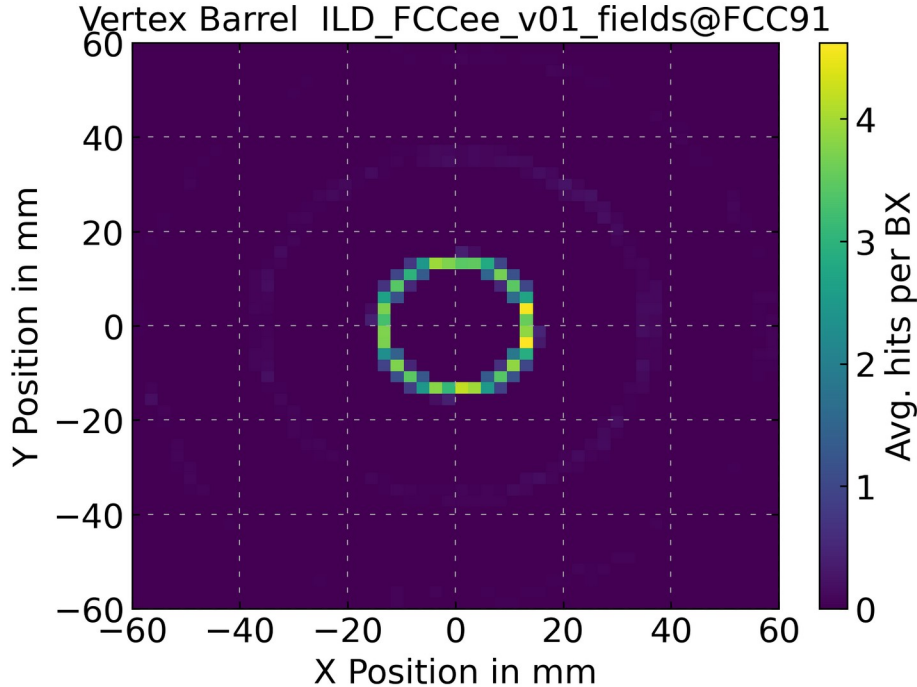
# Outlook (this slide will not make it into the final presi)

- ❖ Overlay gun muons with background data
- ❖ Study effect on tracking efficiency

# Back-Up

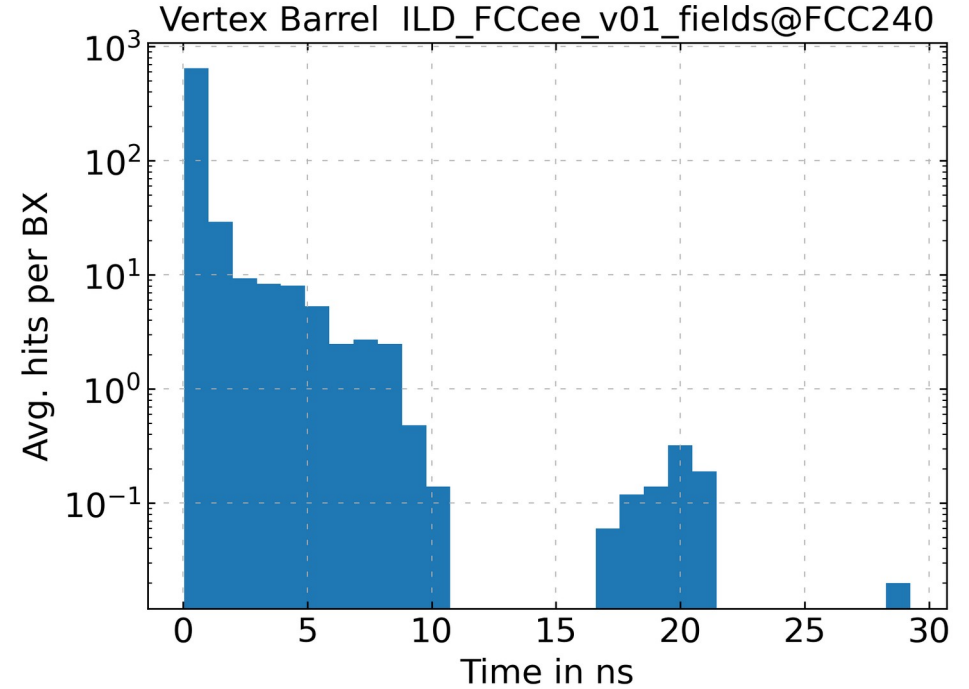
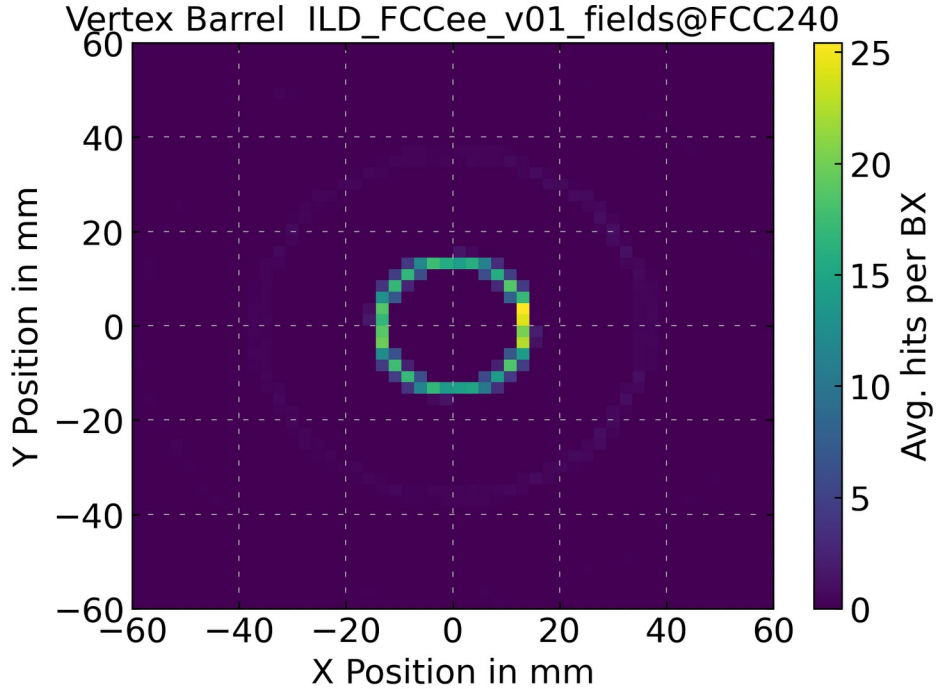
# Template BS Comparison

# 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



FCC1

FCC2



v11

CLD

# Overview of ILD Models



FCC1

FCC2



v11

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



ILD



CLD



# 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>