

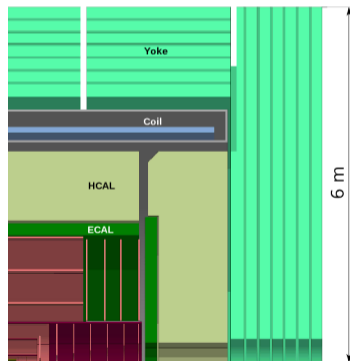
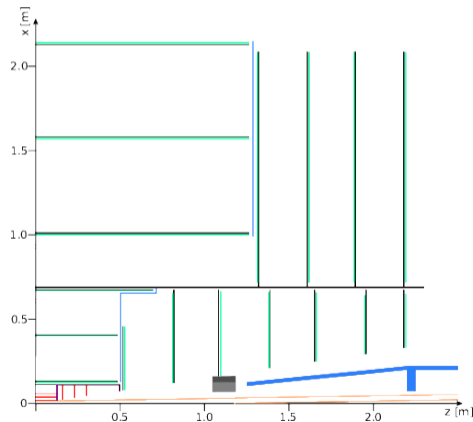
Heavy Neutral Lepton studies with CLD Full Simulation

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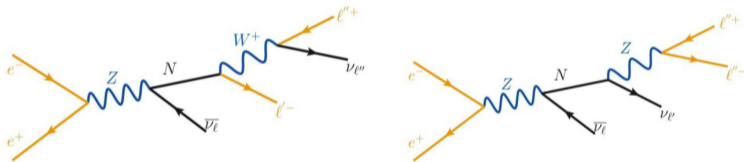
Goals

- Full Simulation study, with CLD detector
- First attempt for physics analysis with HNL
 - ▶ With CLD_01_v04 geometry: BeamPipe material 100 % Be, BeamPipe radius = 15 mm



HNL study

- Generation of Long Lived Particle within the Heavy Neutral Lepton model
- Inherits from FCCee paper (Alimena&al [arXiv:2203.05502v4](https://arxiv.org/abs/2203.05502v4))

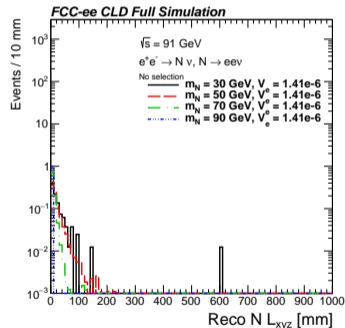
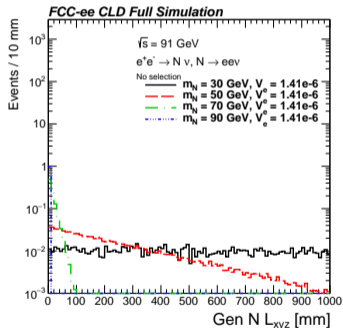
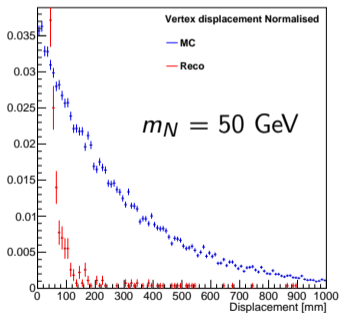


- Full Simulation with ddsim
- Reconstruction with Marlin (key4hep)

HNL study

Last presented result

- No reconstructed tracks for >10 cm displacement

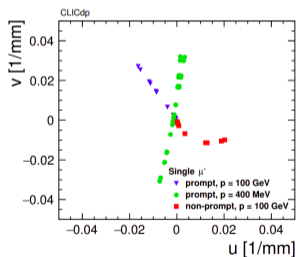
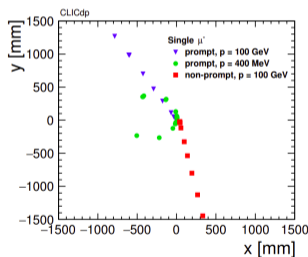


HNL study

Conformal Tracking*

- **Conformal mapping:** coordinates (x, y) in Euclidean space are converted to coordinates (u, v) in conformal space, circles passing through the origin are transformed into straight lines

$$u = \frac{x}{x^2 + y^2}, \quad v = \frac{y}{x^2 + y^2}$$



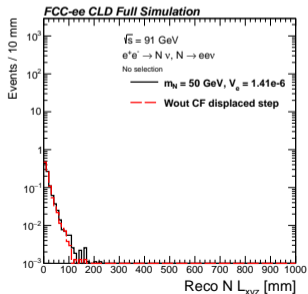
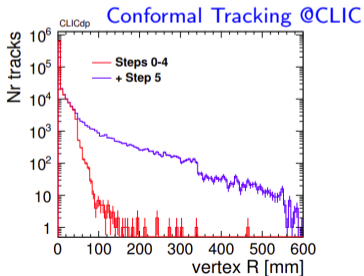
- **Cellular Automaton Track Finding:** for pattern recognition

*Conformal Tracking @CLIC

HNL study

Investigation in conformal tracking

- ▶ **VXDBarrel**: build track seeds in the vertex barrel
- ▶ **VXDEndcap**: extend track seed through the vertex endcaps
- ▶ **LowerCellAngle1**: build track candidates with tight cuts for high- p_T tracks
- ▶ **LowerCellAngle2**: build track candidates with looser cuts to reconstruct low- p_T tracks
- ▶ **Tracker**: extends all existing partial tracks through the tracker
- ▶ **Displaced (step5)**: build additional tracks with optimised cuts for displaced tracks from all the leftover hits



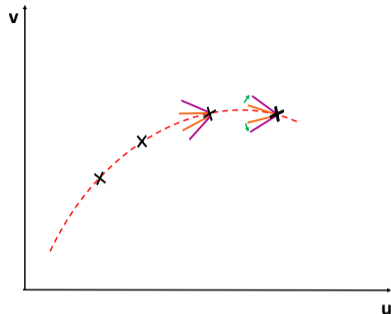
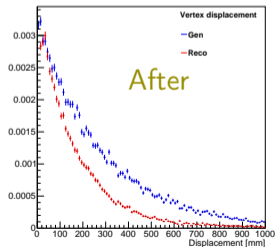
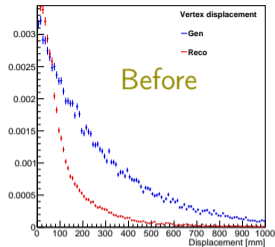
⇒ Step 5 is not working as it should

HNL study

Investigation in conformal tracking

Parameters in step 5:

- ▶ MaxCellAngle: 0.1 → 0.5
- ▶ MaxCellAngleRZ: 0.1 → 0.5
- ▶ Chi2Cut
- ▶ MinClustersOnTrack
- ▶ MaxDistance
- ▶ SlopeZRange
- ▶ HighPTCut



×2 vertices, window for extension to next hit was too small for the displaced step in conformal tracking^a

^aThe choice of the 0.5 value was somewhat arbitrary, and further optimisation is required. see [bug report](#)

HNL study

Electron reconstruction efficiency

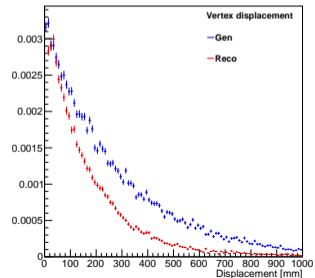
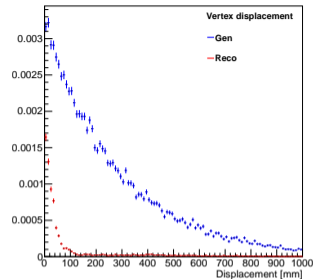
- Issue with electron reconstruction

- ▶ Electrons reconstruction efficiency

- top plot → HNL vertex with **reconstructed electron tracks**

- bottom plot → HNL vertex with **all reconstructed tracks**

- ⇒ e^- are not reconstructed properly



HNL study

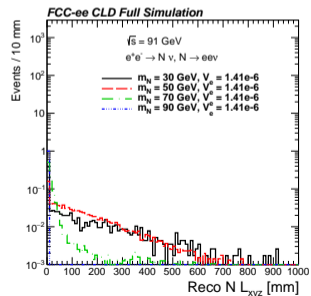
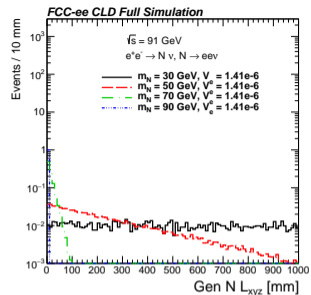
Results (considering all reconstructed tracks)

- **Object selection:**
- Gen HNL vertex $r < 1500$ and $|z| < 2000$, to match tracker acceptance
- Considering all reconstructed particles matched with Gen electrons ($\Delta R < 0.4$)
- Reco particles momentum > 5 GeV
- **Event selection:**
 - ▶ Exactly 2 reco particles with sum charge $== 0$
 - ▶ Invariant mass incompatible with a Z boson : $m > 96 \ \&\& \ < 86$ GeV
- Vertex reconstruction with reconstructed tracks

HNL study

Results (considering all reconstructed tracks)

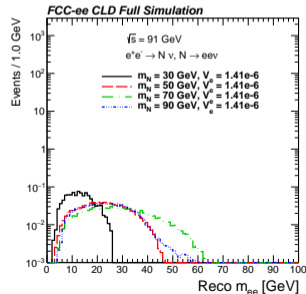
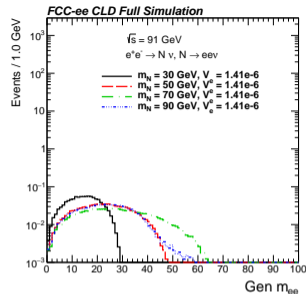
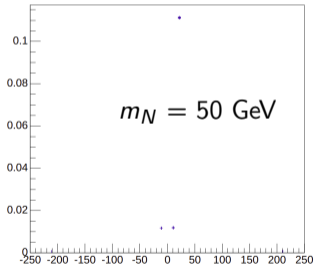
- Reconstructed vertices up to 600 mm displacement, as expected from Conformal Tracking paper



HNL study

Results (considering all reconstructed tracks)

- Invariant "di-lepton" mass match Gen level
- PDG ID of reco particles are mainly photons



HNL study

Conclusion

- Displaced tracks are now correctly reconstructed
- Electrons are not reconstructed properly, need to investigate