Track seeding and pileup studies
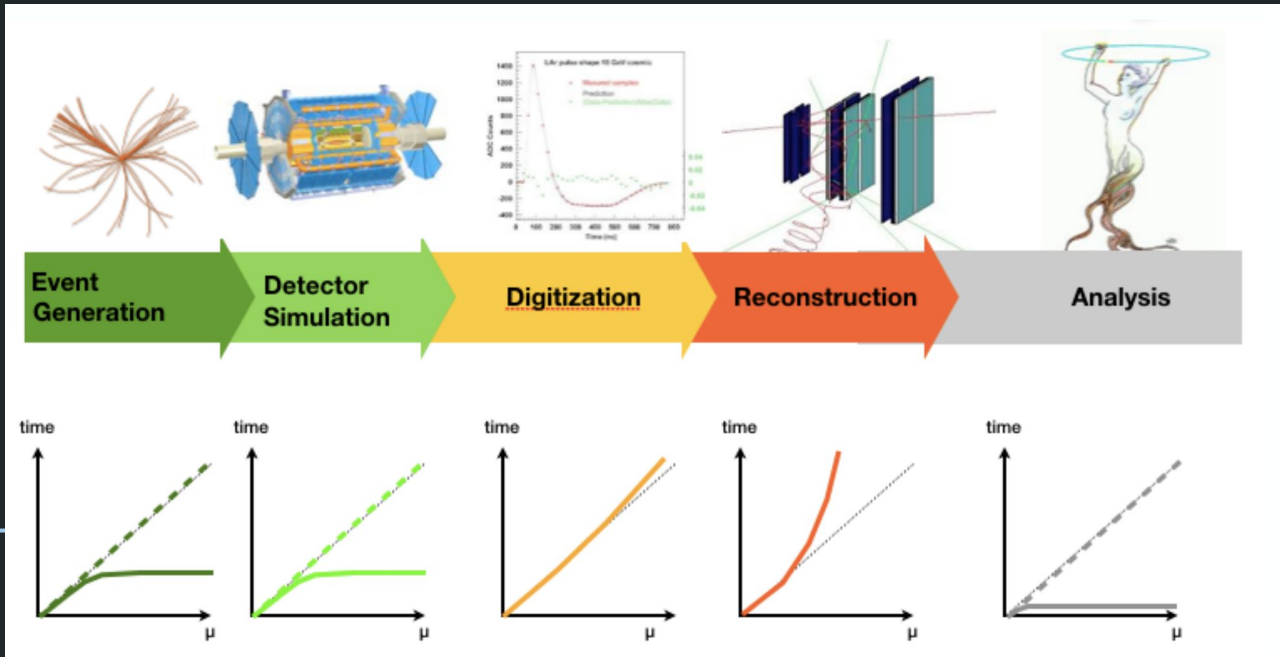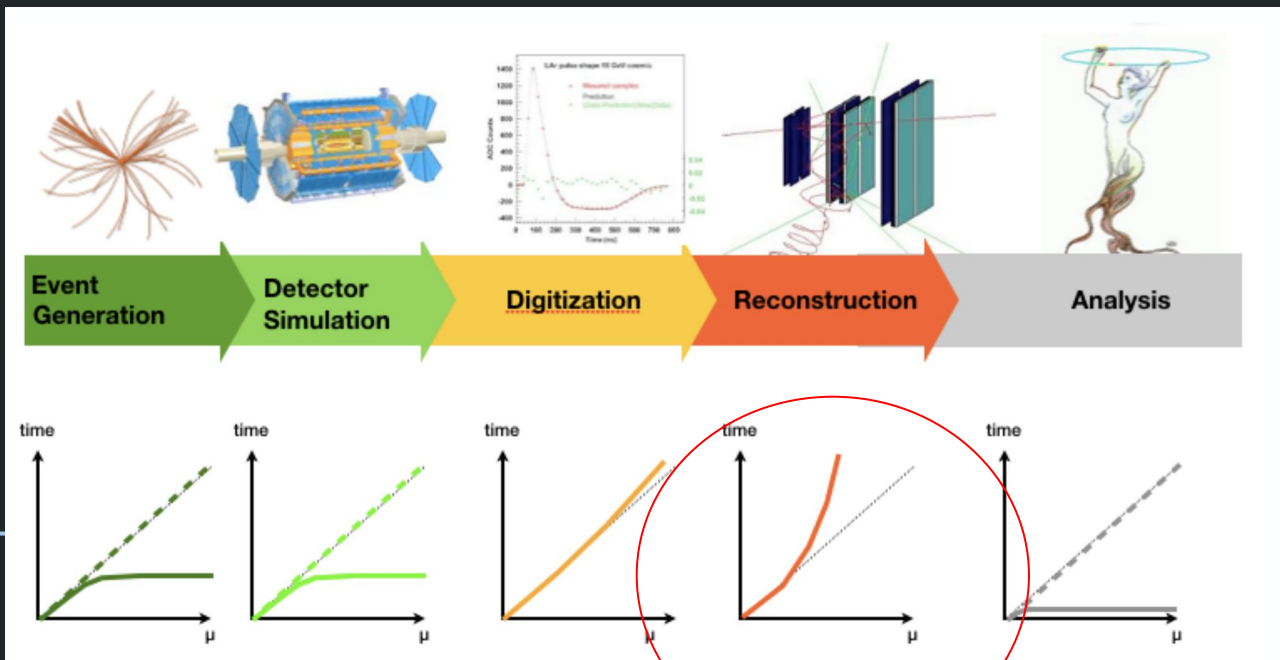
Apr 12, 2018
Valentin Volkl
Univ. Innsbruck / EP-SFT - CERN

**Many Thanks to Felice Pantaleo and the CMS Patatrack-group!**

Event Generation → Detector Simulation → Digitization → Reconstruction → Analysis

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Event Generation → Detector Simulation → Digitization → Reconstruction → Analysis
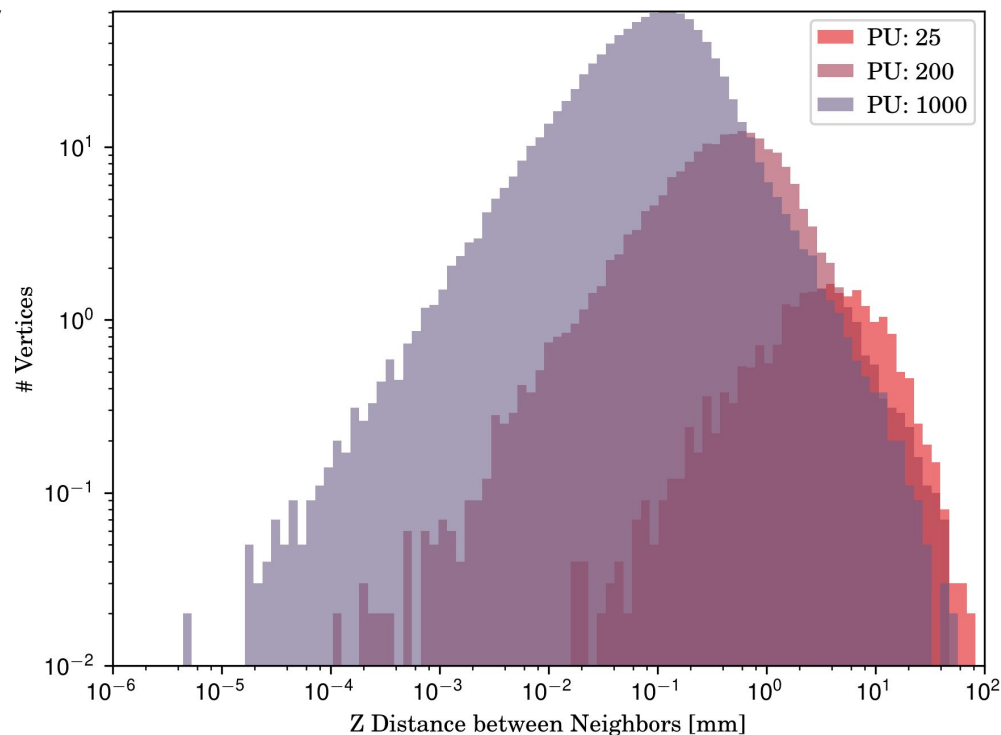
© Andi Salzburger

FCChh Pileup - Generator Level

- Overlay from Min. Bias. Pool <u>supported</u>
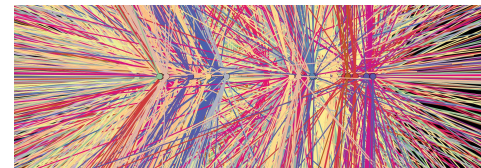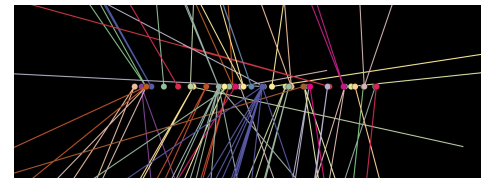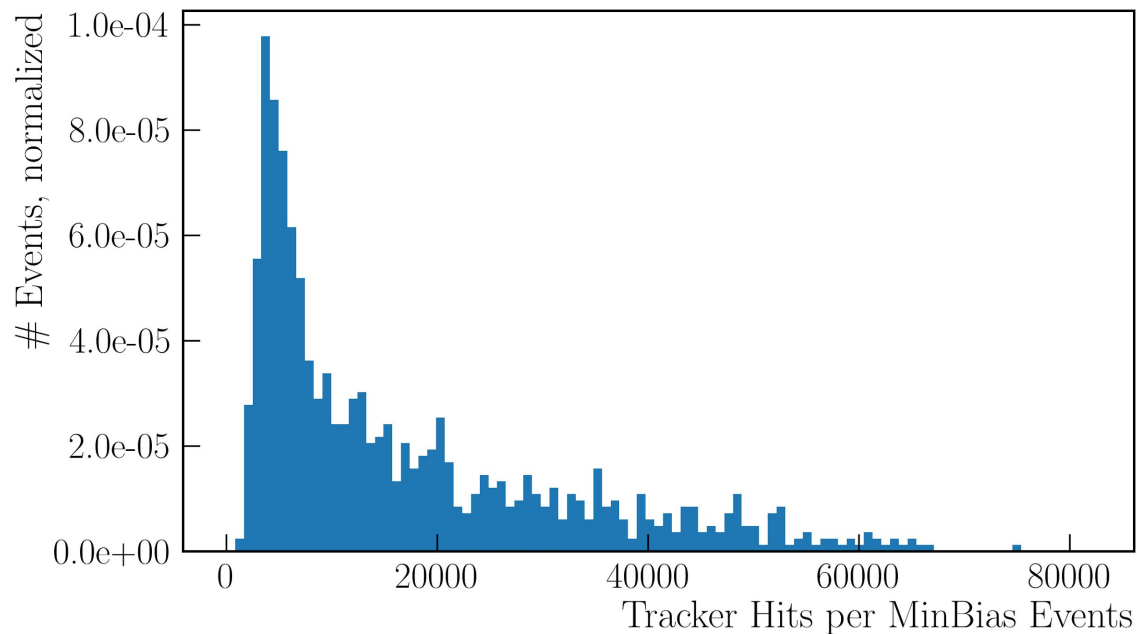- ~ 400 Particles / MinBias Event (280 charged)
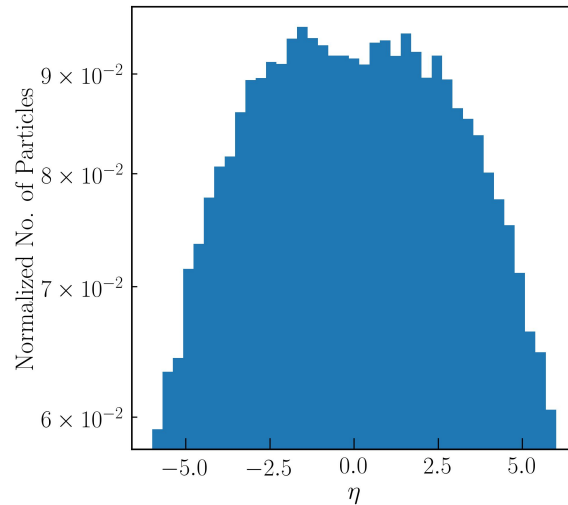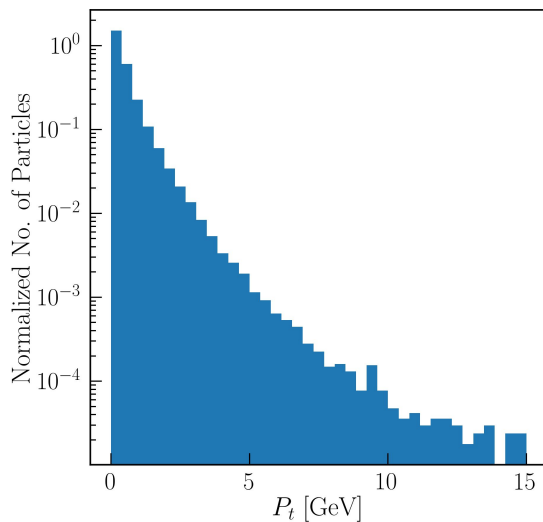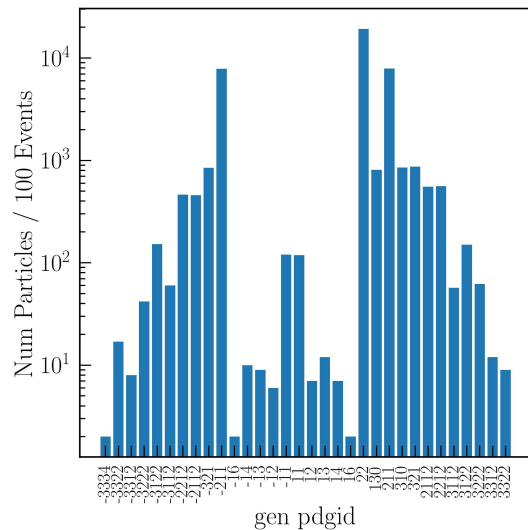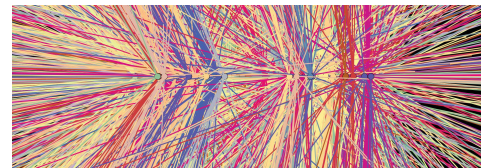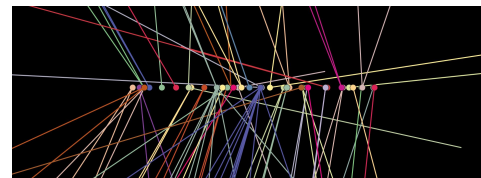
Pileup events at 100 TeV

- Vertices lie extremely dense at 1000 PU
- Time spread of approx. 180 ps similar to HL-LHC
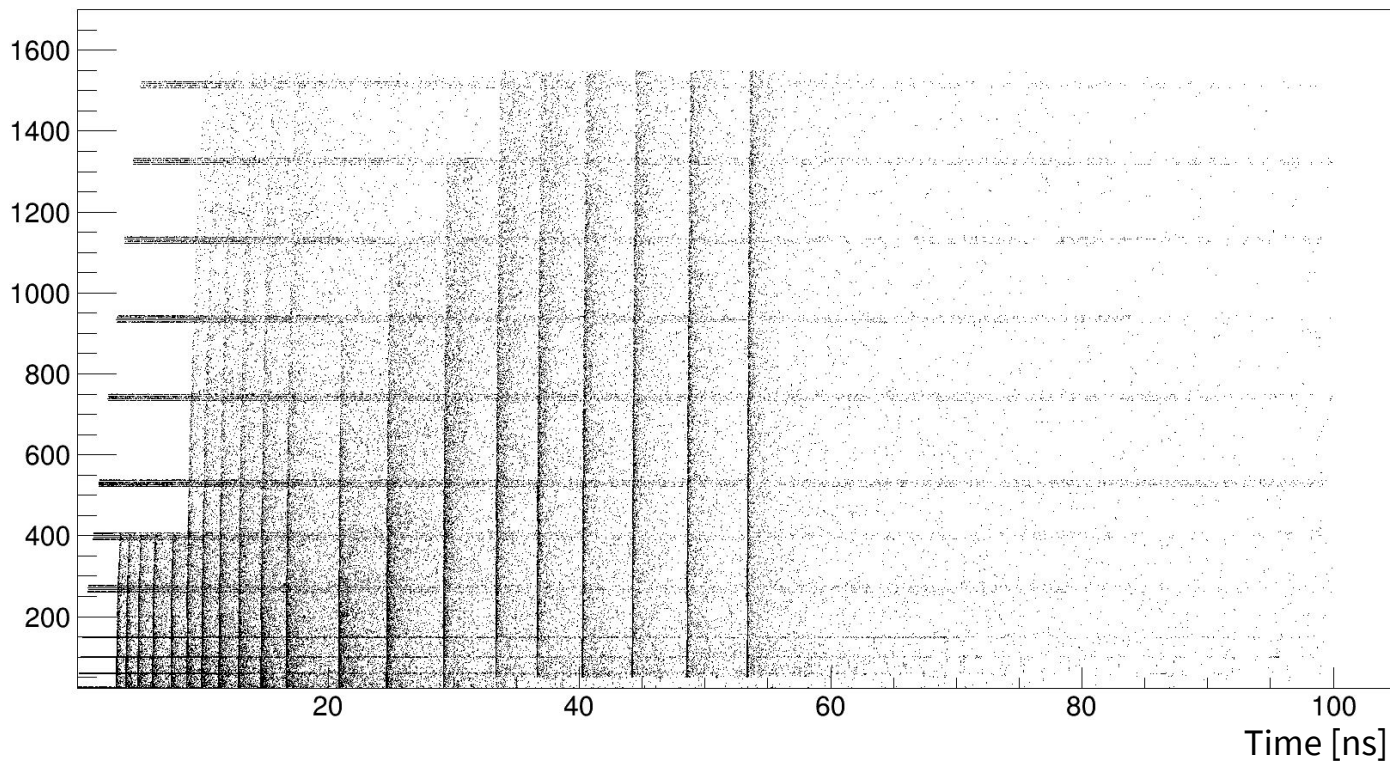
FCChh Pileup - Detector Level

- Note that ideal readout is assumed -
  - See J. Hrdinka's talk for Digitization developments
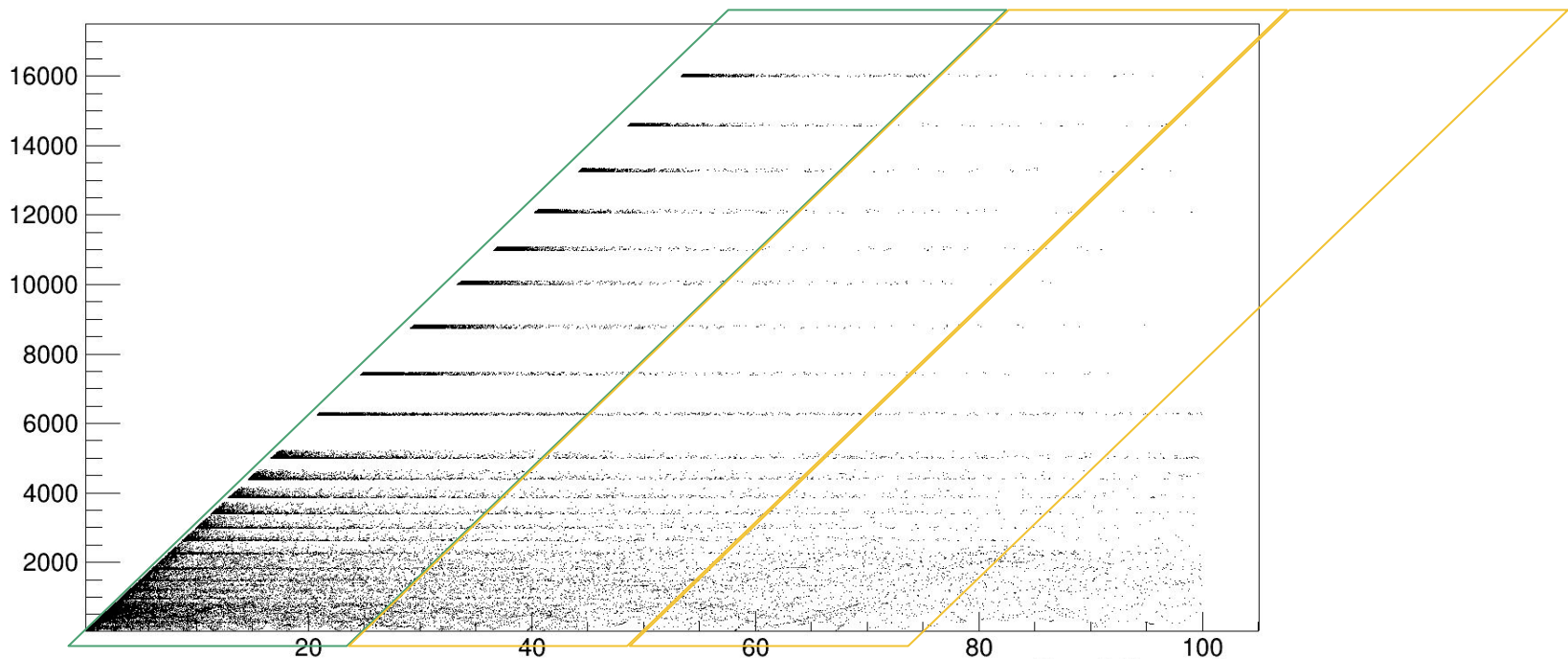
Out of Time Pileup

Radial Distance [mm]

Tracker Hits

Time [ns]

Out of Time Pileup: Structure of a Min. Bias Event

Distance from Origin [mm]

Time [ns]

Track Seeding: `tricktrack::HitChainMaker`

- **3-layer combinatorial seeding available for some time already in FCCSW**
  - Most critical part of track reconstruction , worst scaling with pileup
- **Cellular Automaton based approach performs well in CMS**
  - 3 stage strategy:
    - Hit Doublet Creation (very simple geometrical track candidate rejection)
    - Connecting doublets to CA Cells (simple geometrical track candidate rejection)
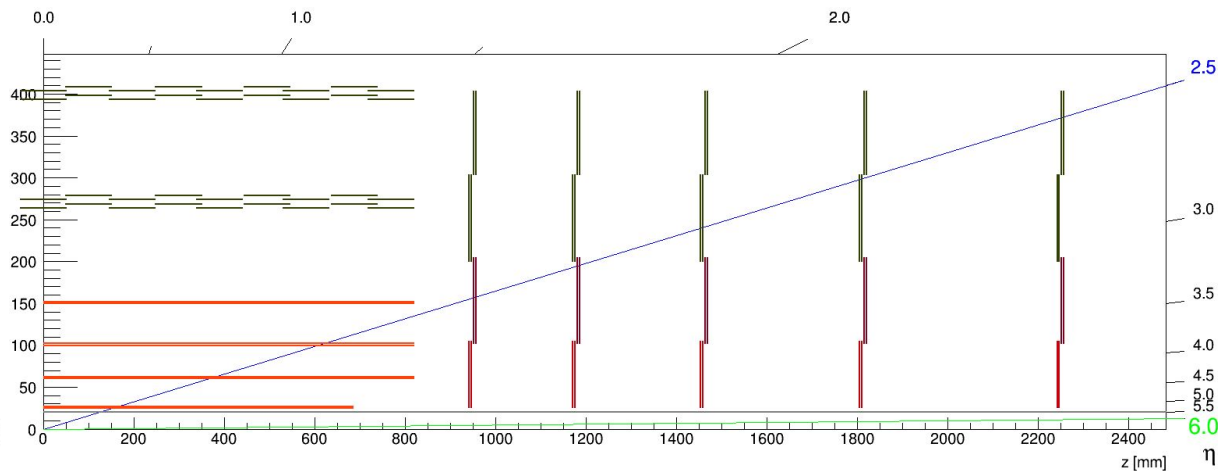   - Evolve cells N times to find N-sized tracklets

- **Allows to add time filters at the Doublet level!**

- hits on barrel layer
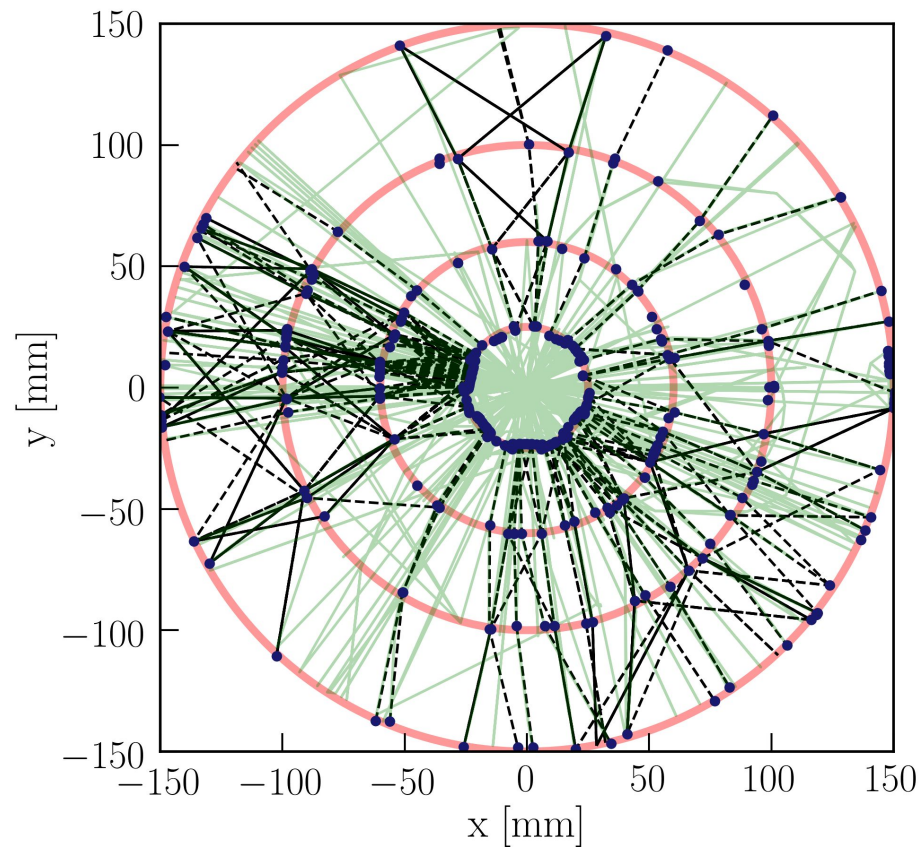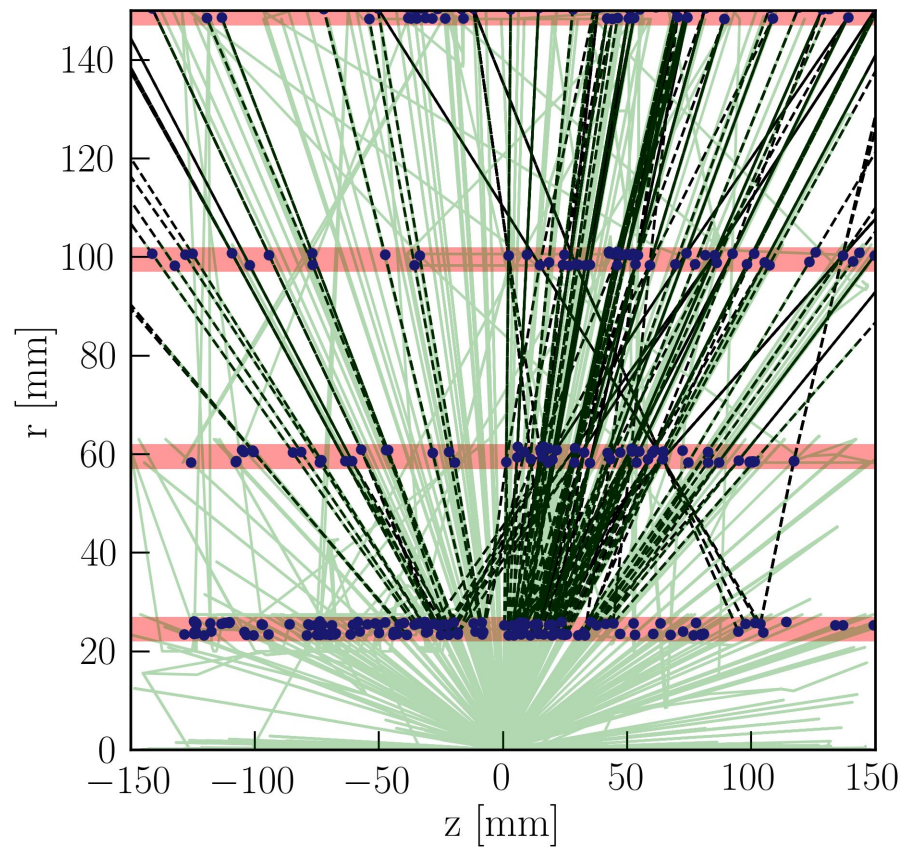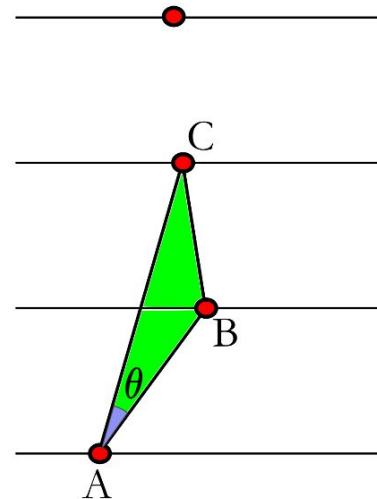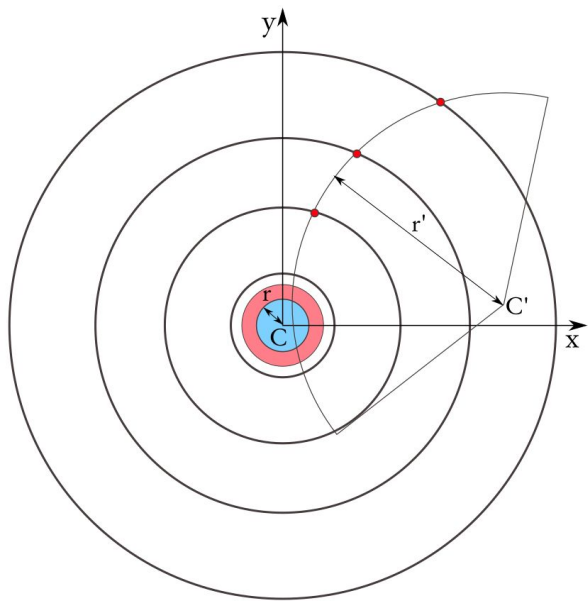- hit doublet
- CA Cell
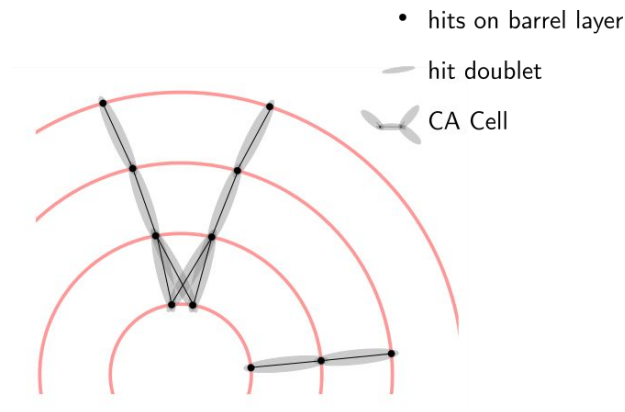
Tracker v3.0.3 Seeding Layers
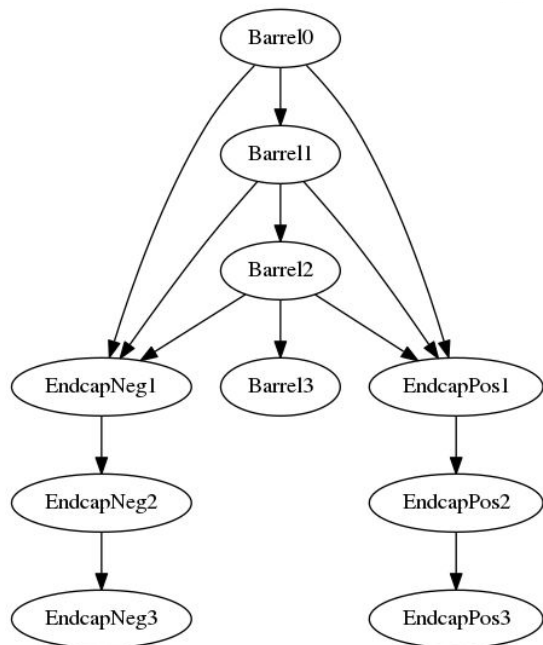
- Longer tracklets (quintuplets, sextuplets) may be studied in the future
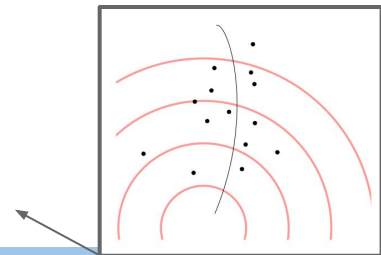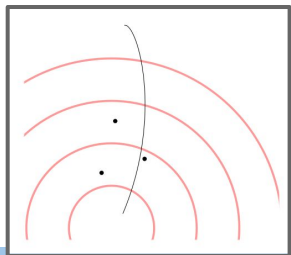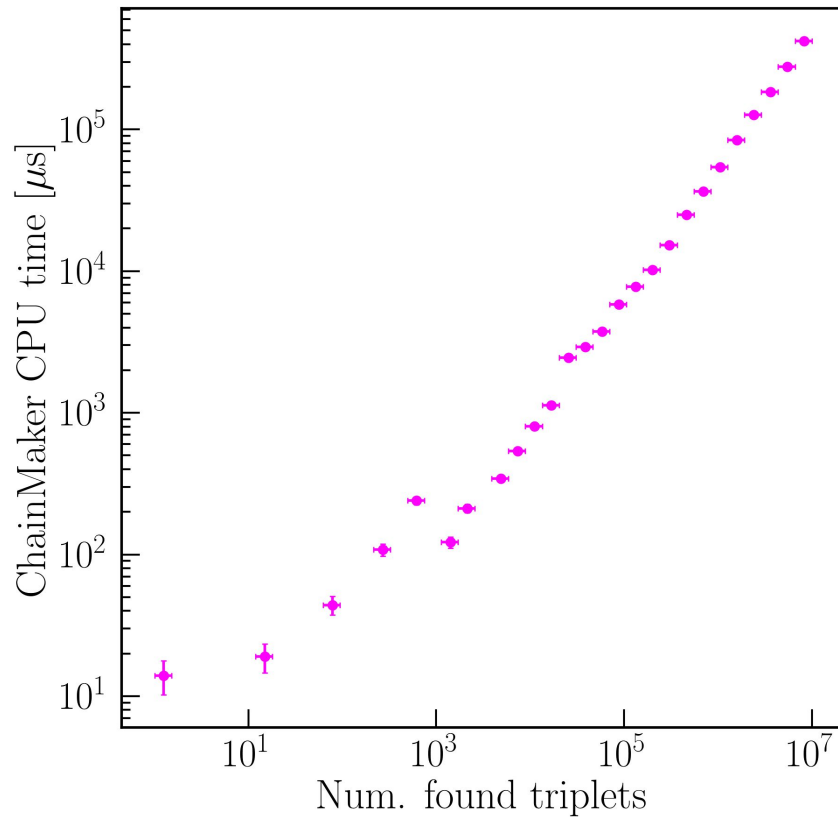
CA Seeding - Min Bias Event Display

Geometrical Filters - Triplet Level

- Track originates from beamspot

- Track is aligned in r-z

HitChainMaker CPU performance
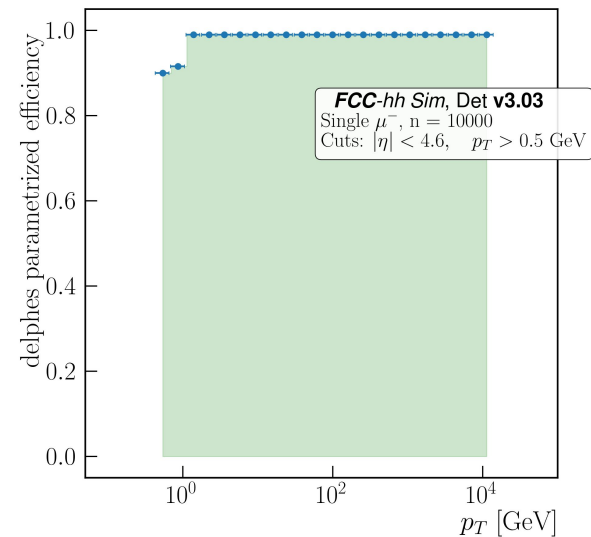
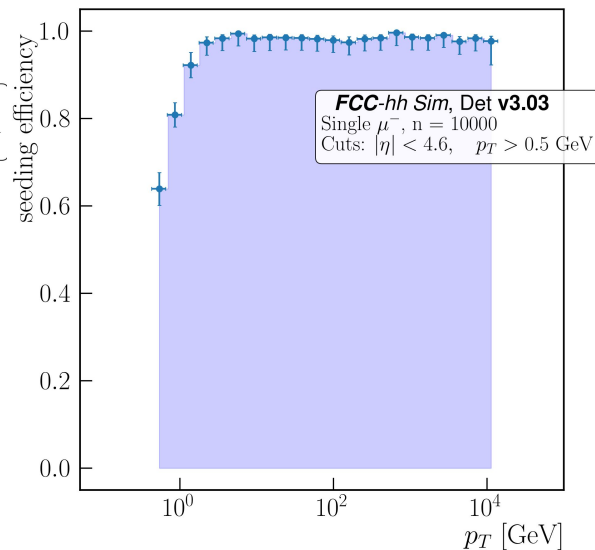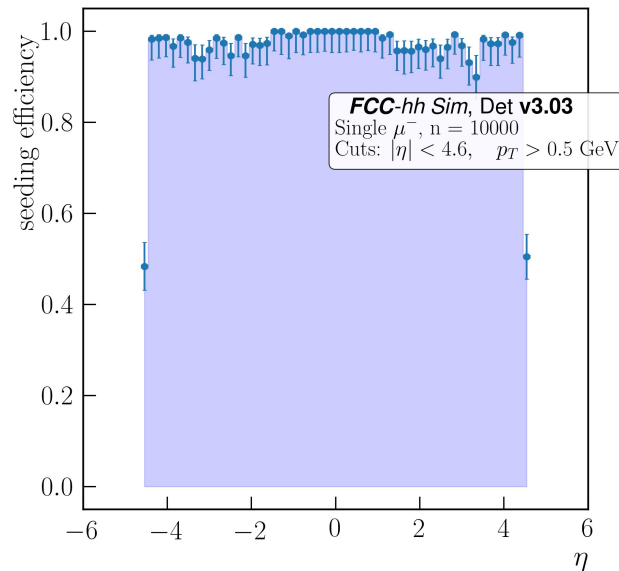# HitChainMaker CPU performance

Computational Complexity

$$\mathcal{O}\left(\text{found tracklets}\right)$$

$$\mathcal{O}\left(\frac{1}{1-\text{fakerate}}\cdot\text{hits}\right)$$
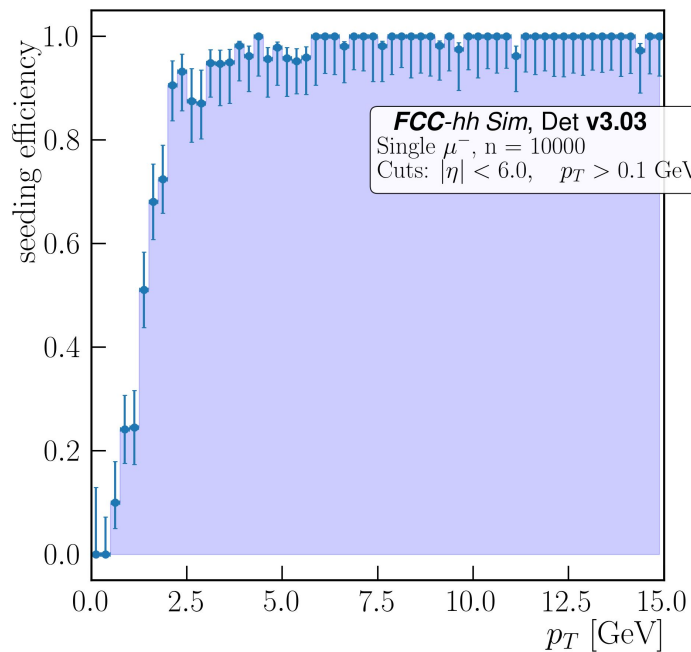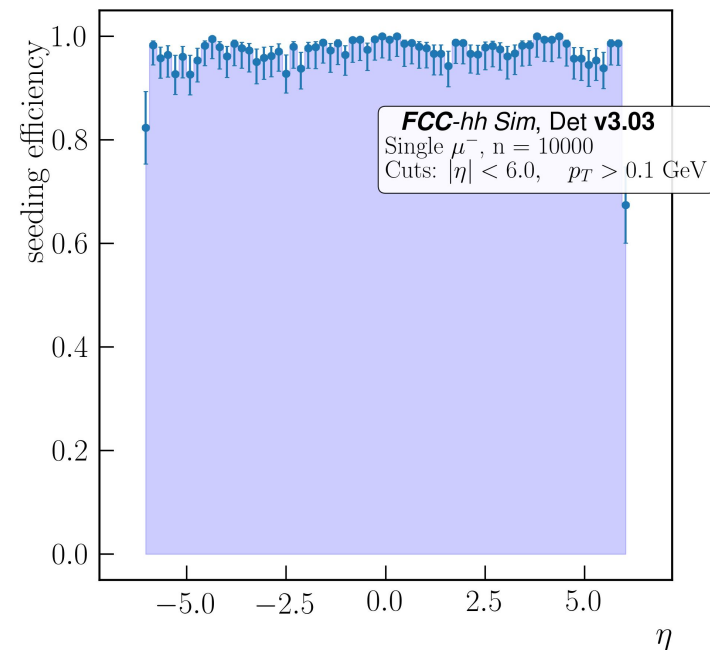

14
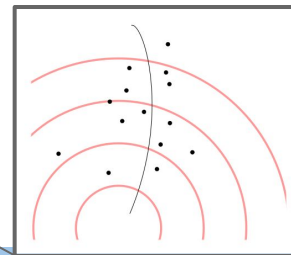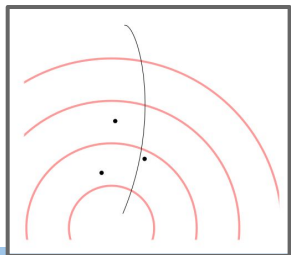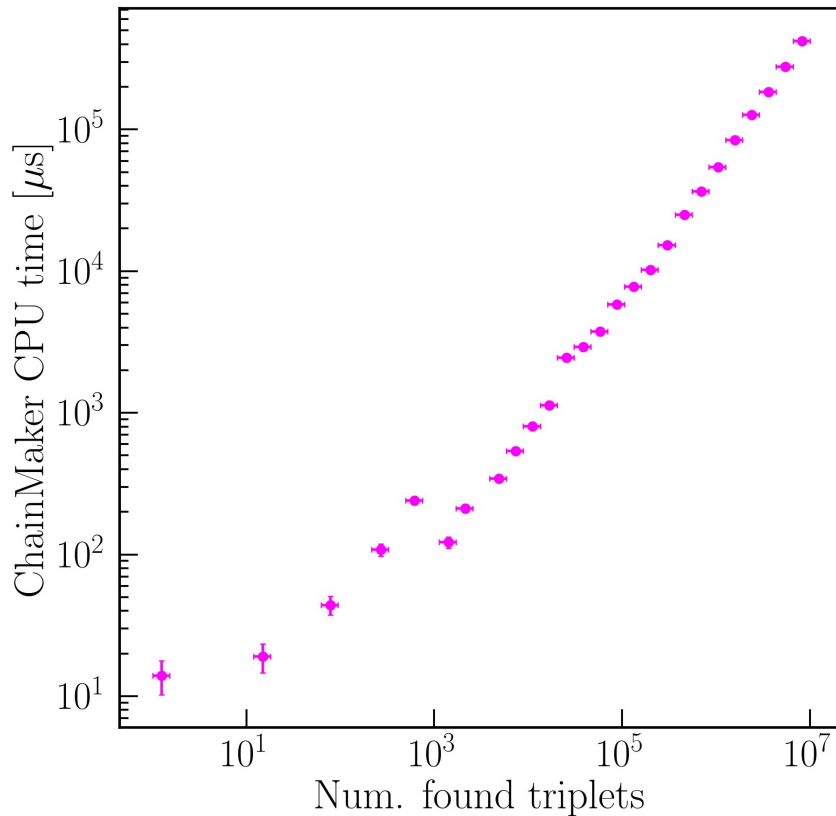
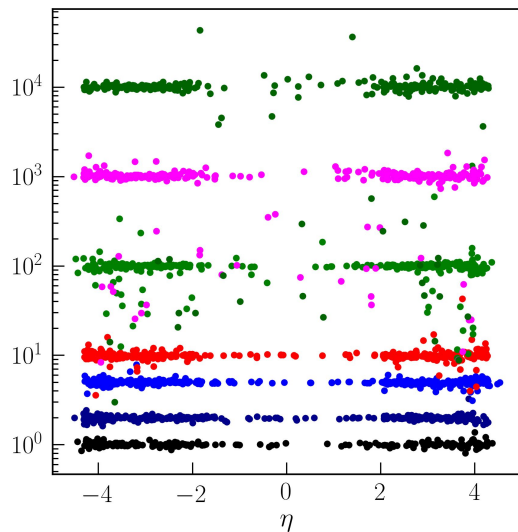# Single Particle Seeding efficiencies

Delphes Parametrisation

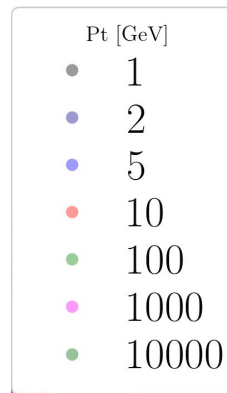# Extending the Seeding up to Eta 6

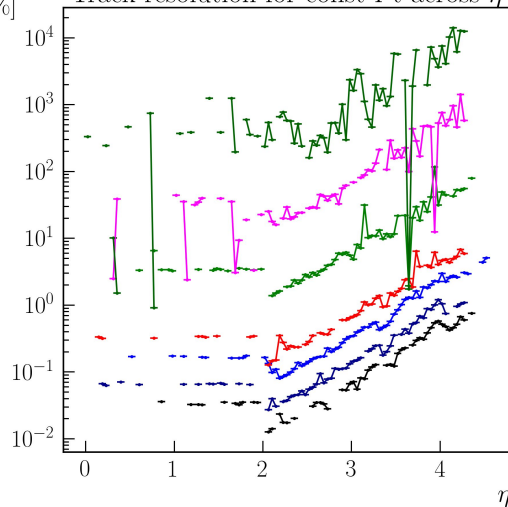Seeding layers need to include **all** forward layers!

Track Parameter Estimation with Riemann Fit

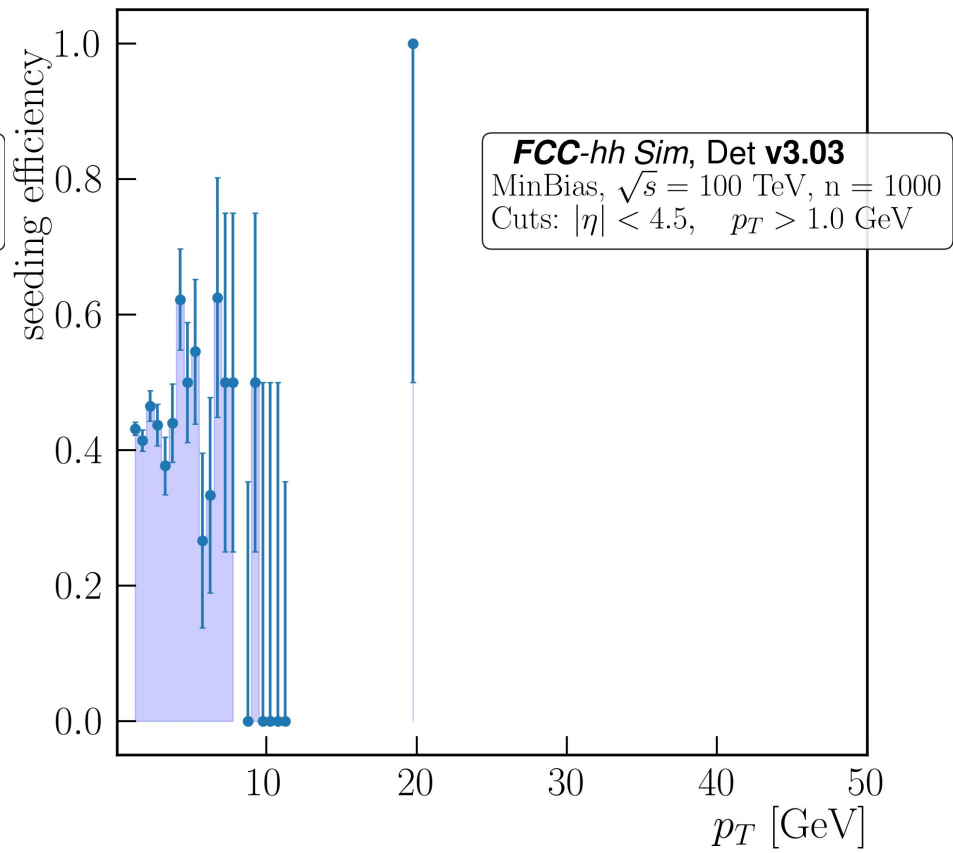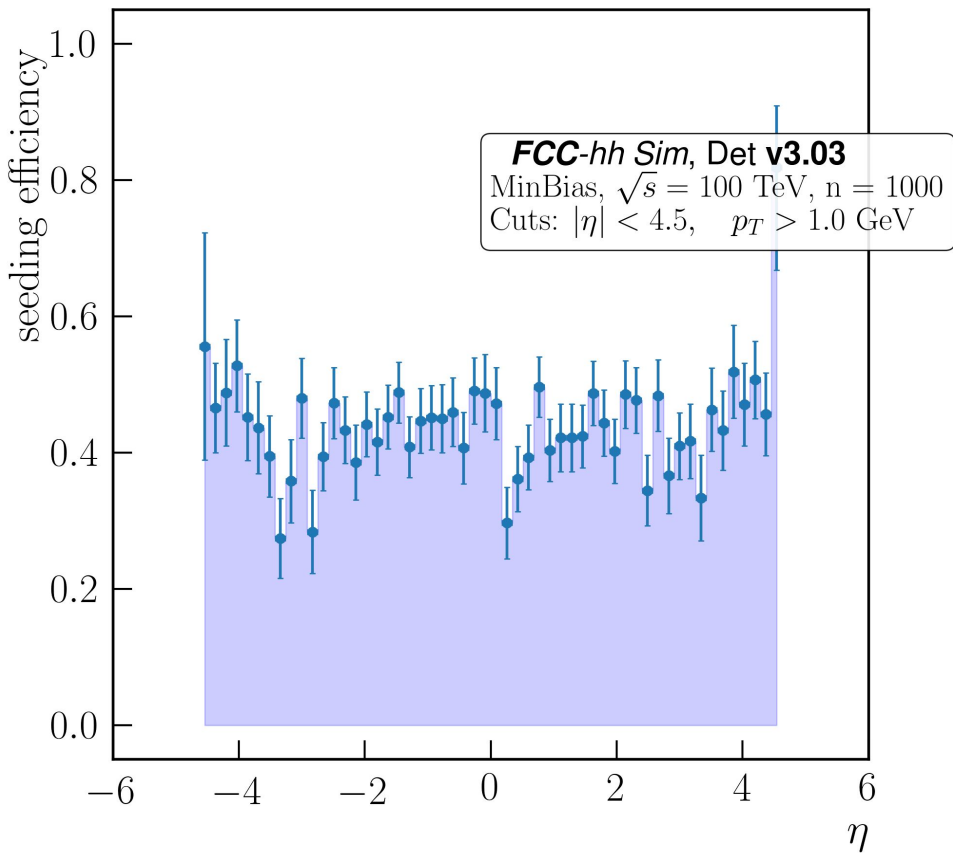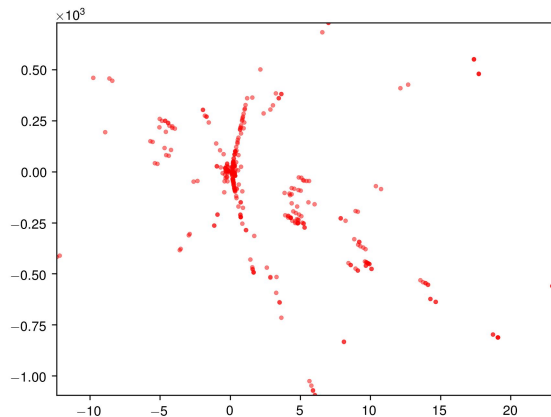- TrickTrack includes an implementation of a Riemann Fit used to estimate track parameters
- Resolution for quadruplets limited, but sufficient to seed Kalman Filter

Min. Bias Seeding Efficiencies

Hit Doublet classifiers

Z [mm]

Phi difference of doublets
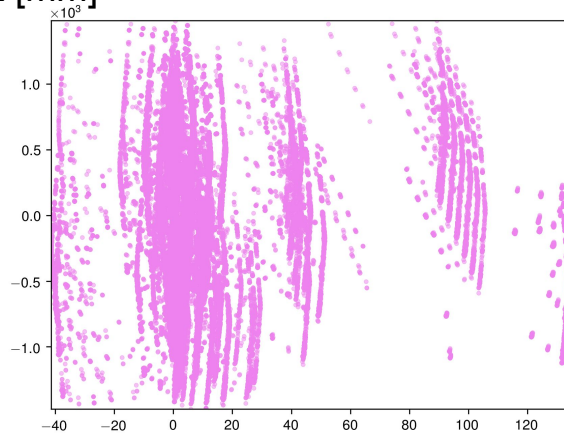
- Hit Pair filtering is hard, but most powerful in reducing combinatorics
- Additional discriminating features - Timing, Cluster shape, can help

Time difference of doublets [ns]

Z difference of doublets [mm]

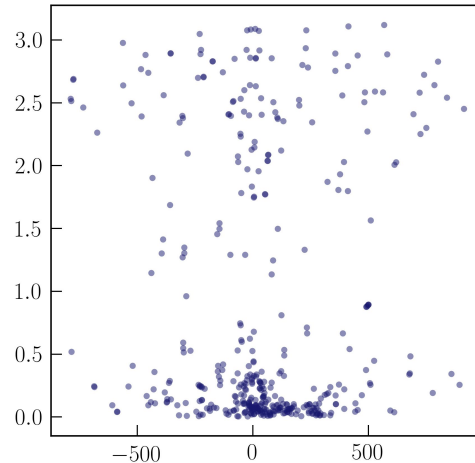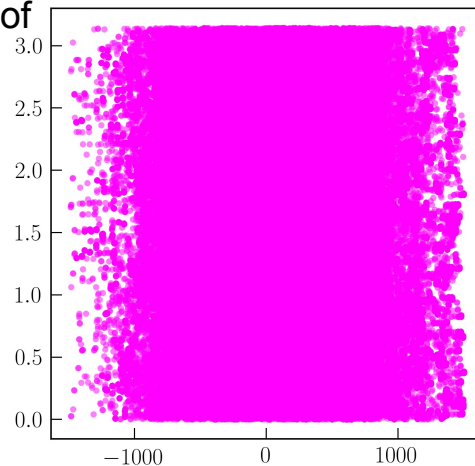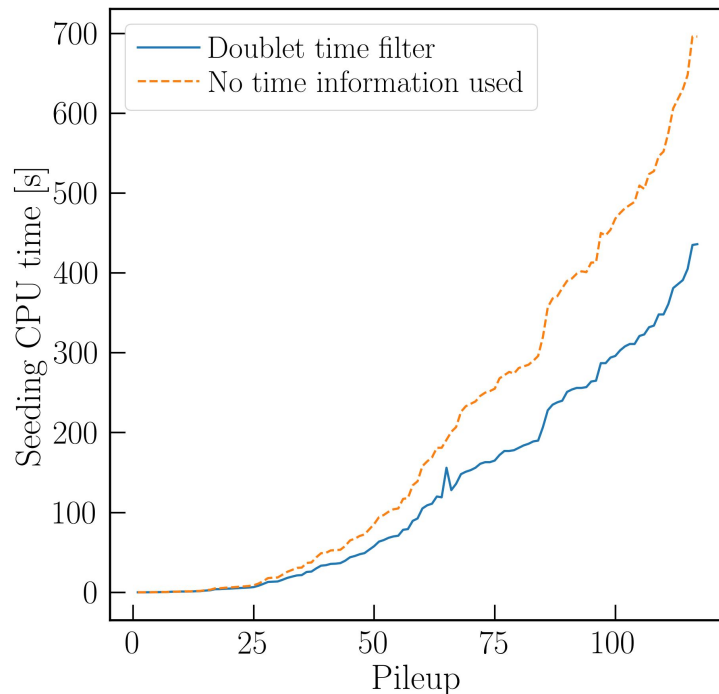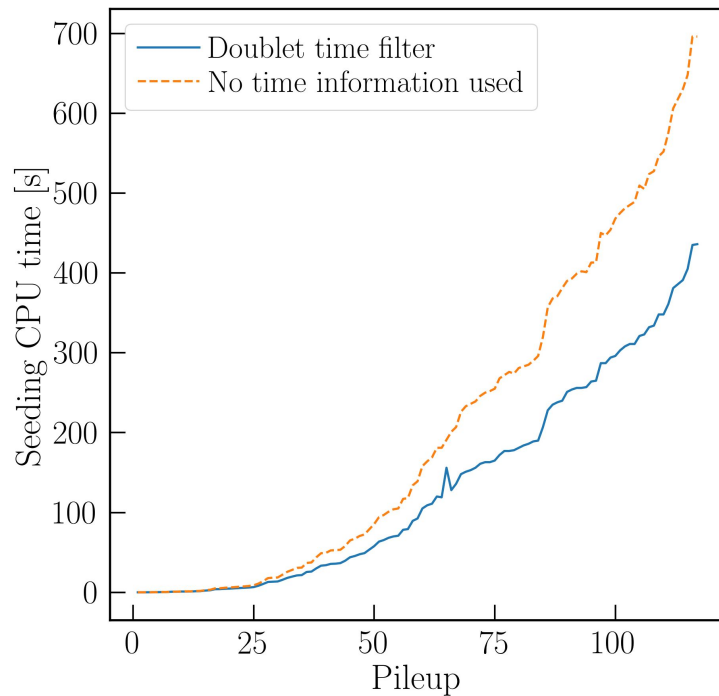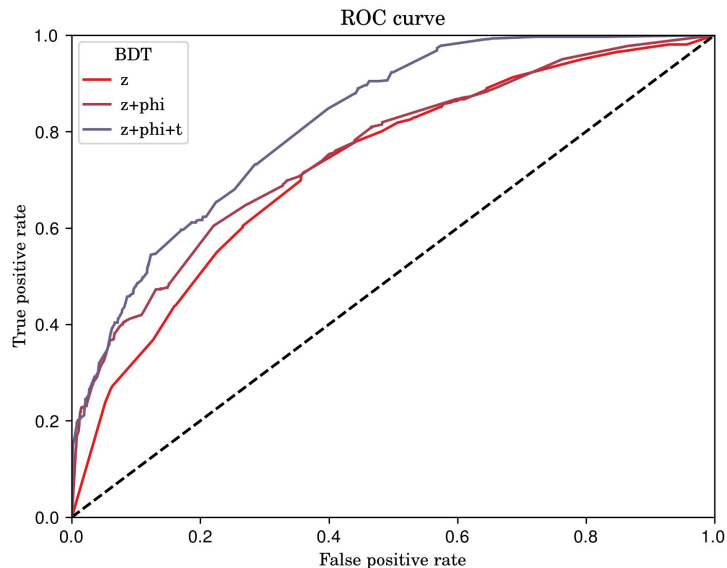# Computing Gains with Time informations

- Full 1000 PU events cannot currently be fully reconstructed
  - Not even with naive time filtering
- More sophisticated metrics or smart reconstruction strategy needed

Computing Gains with Time informations

- Naive BDT classifier to improve metric

Conclusion

- Implemented track seeding and tracking sw infrastructure
    - Cellular Automaton / HitChainMaker
    - RiemannFit
- Validated by use in CMS, good potential for exploiting parallelism
    - Being ported to CUDA/GPUs in CMS
    - https://github.com/HEP-SF/TrickTrack
- Reconstruction with 1000 Pileup extremely complex
    - Additional discriminants such as timing information needed
- Complements ACTS developments