FCC software strategies and challenges

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CERN-BINP workshop

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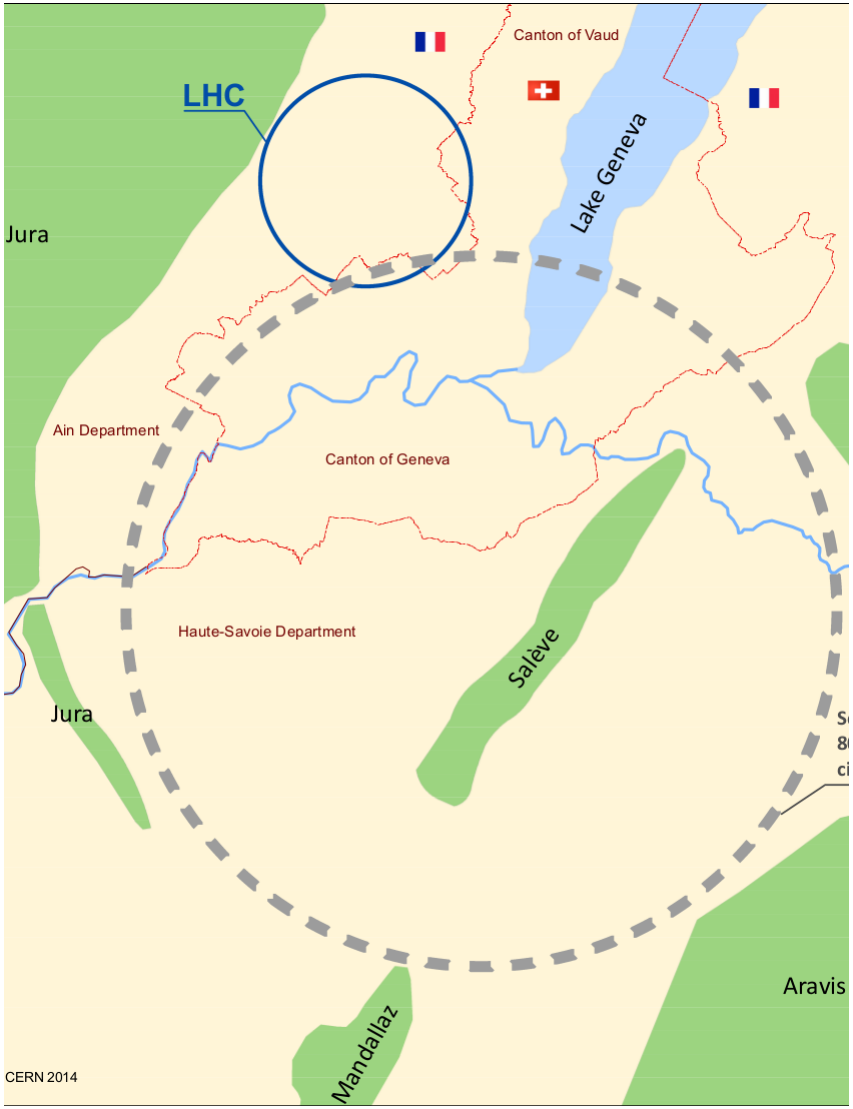
Outline

- Motivation
  - Pileup at FCC-hh / Beam Background at FCC-ee
- Common Software Framework for FCC-ee / FCC-hh
- Software performance and pileup merging strategies
- Summary

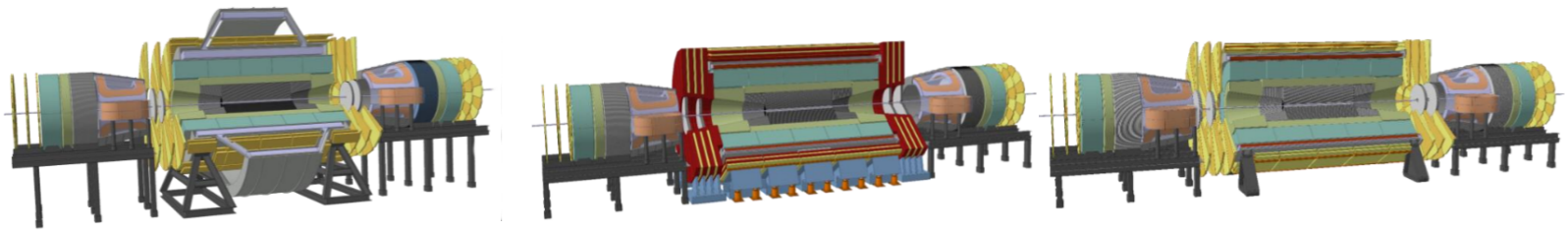
The Future Circular Collider

- Goal: Conceptual Design Report for the next European Strategy Update (2019)
  - pp-collider (FCC-hh)
  - 16 T -> 100 TeV pp in 100 km
  - 80-100 km tunnel infrastructure in Geneva area
  - e^+e^- collider (FCC-ee) as a potential first step
  - pe (FCC-he) option



Detector R&D

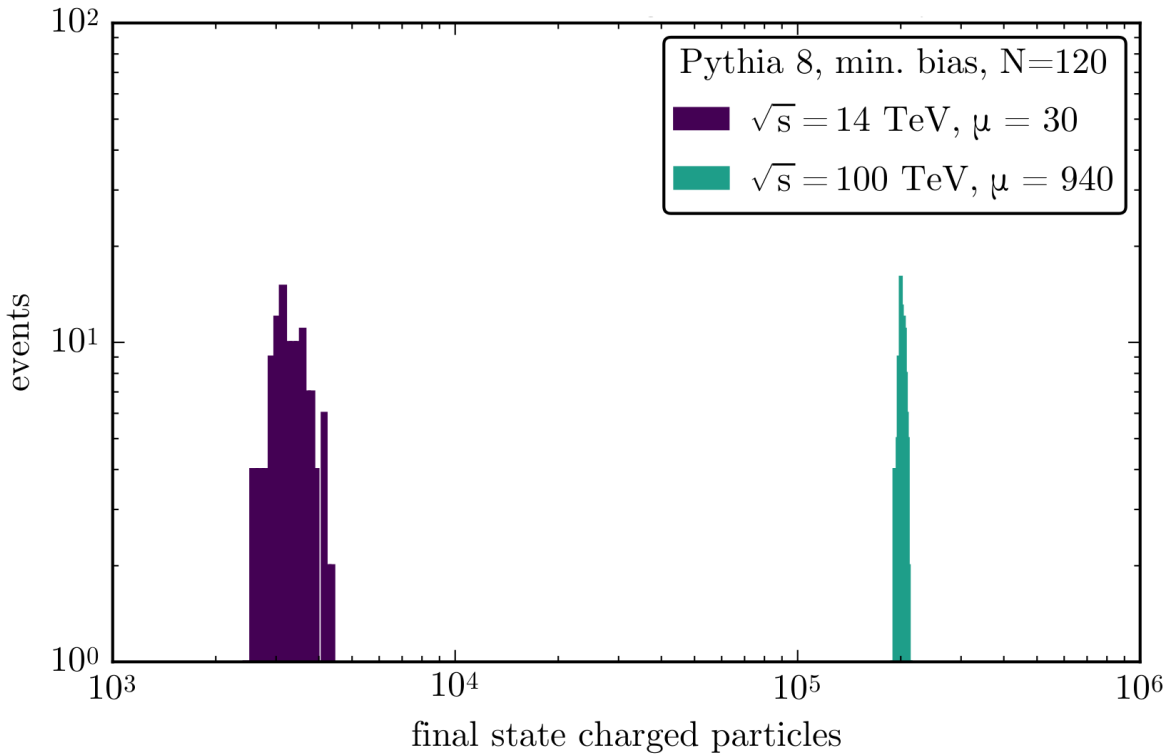
- Challenge: provide credible detector design for conceptual design report
  - Possibly many changes and iterations on design



- Parametrised simulation and back-of the-envelope calculations where possible, but full simulation studies needed in the end

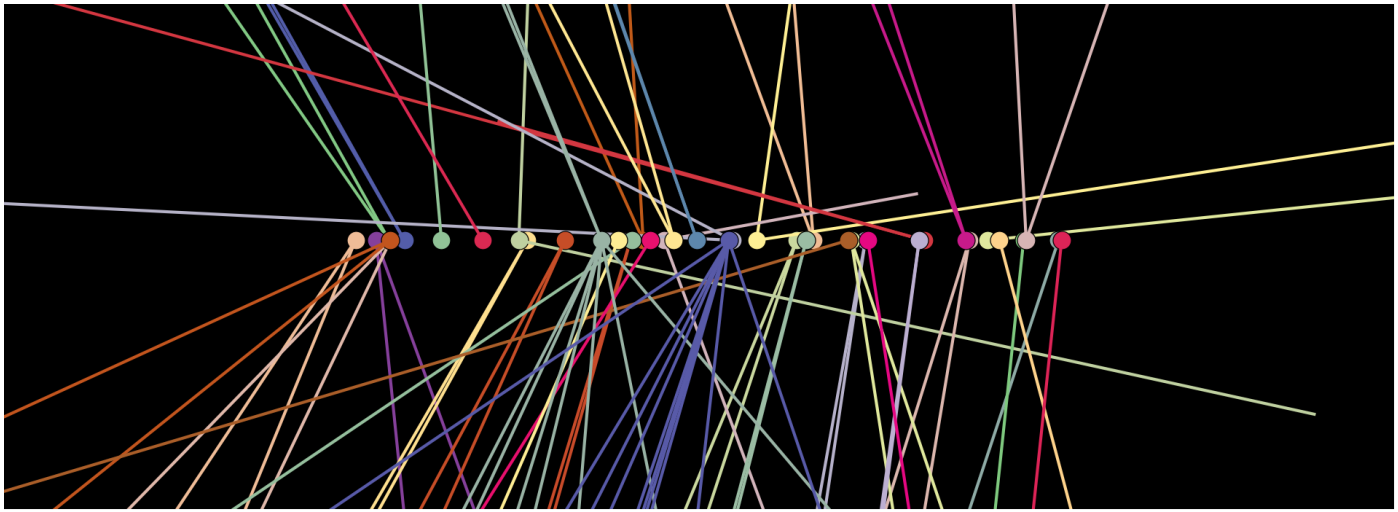
Pileup at FCC-hh

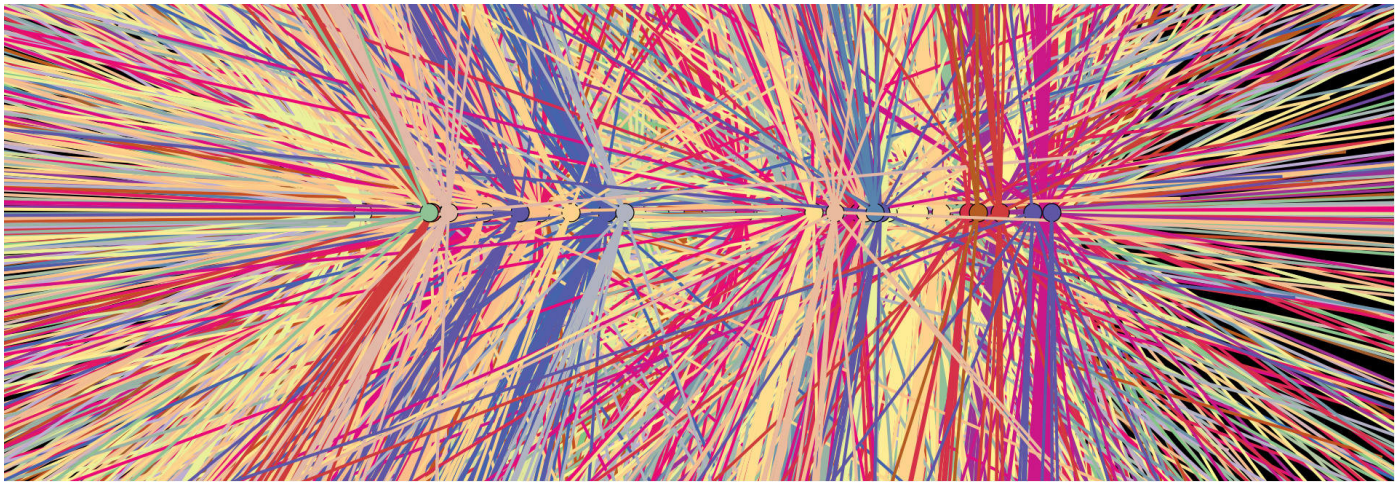
- Up to 1020 additional interaction per bunch crossing
- Option with shorter bunch spacing (25 $\longrightarrow$ 5 ns)
- LHC-like conditions vs. FCC-like conditions



Pileup at FCC-hh

- Charged tracks and vertices
  - LHC-like conditions ($\mu = 25$) vs. FCC-like conditions ($\mu = 1020$)

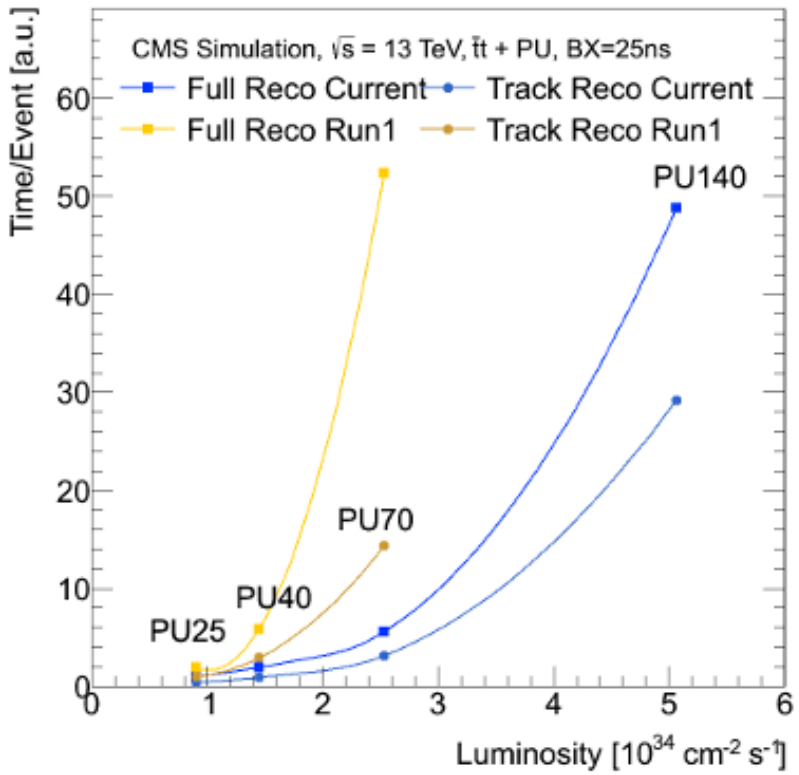




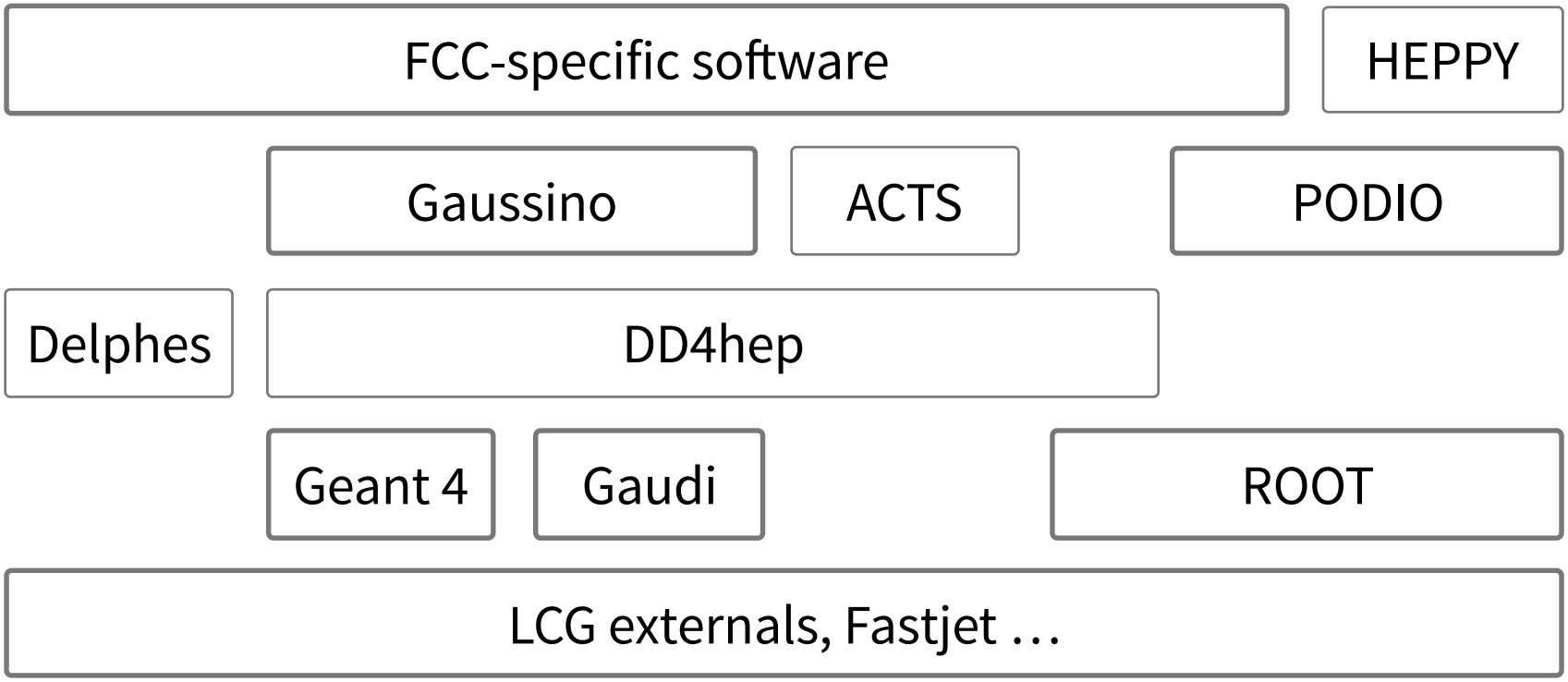
Software performance

- Pileup already a problem for LHC experiments
- Simulation time effectively linear
- Reconstruction will consume larger part of resources as pileup grows

Current CMS software performance plot



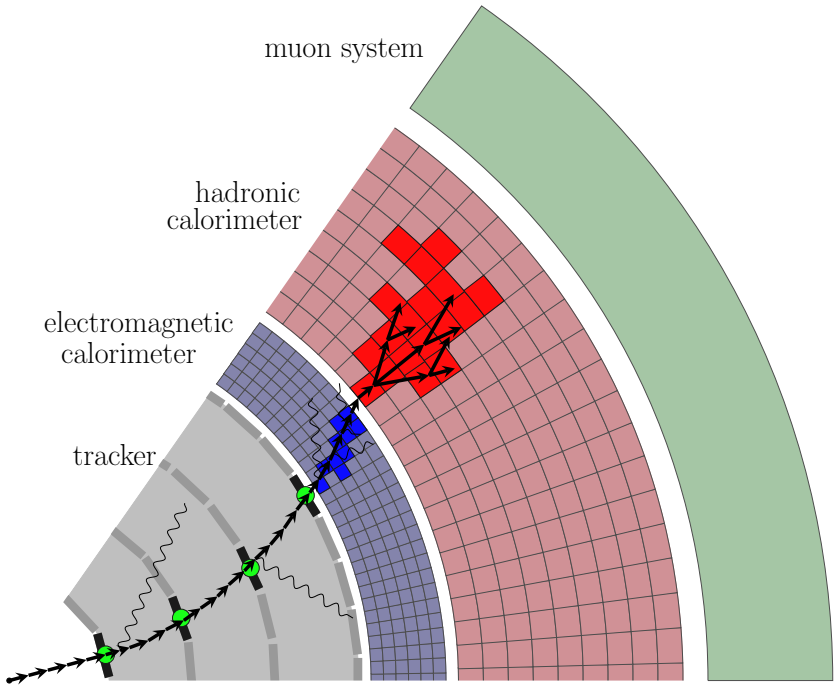
FCC Software overview



- Emphasis on re-use of generic HEP - software
- Single entry point for FCCSW docs:
  - `http://fccsw.web.cern.ch/fccsw/`

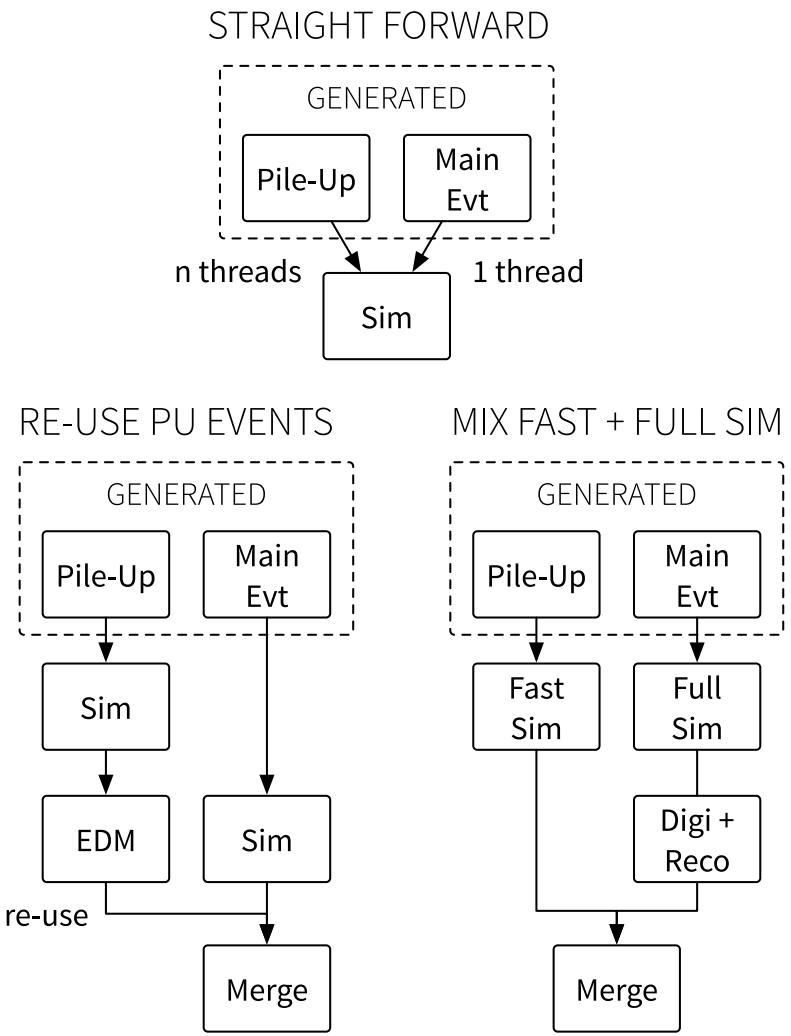
Software Details

- Detector Description: DD4hep
  - Toolkit for full detector description
  - used currently only for the pure geometry description
- Geant4 toolkit used for full and parametrised simulation
  - fast simulation fully integrated
  - mixing full and fast simulation possible
    - for different volumes
    - for different particles



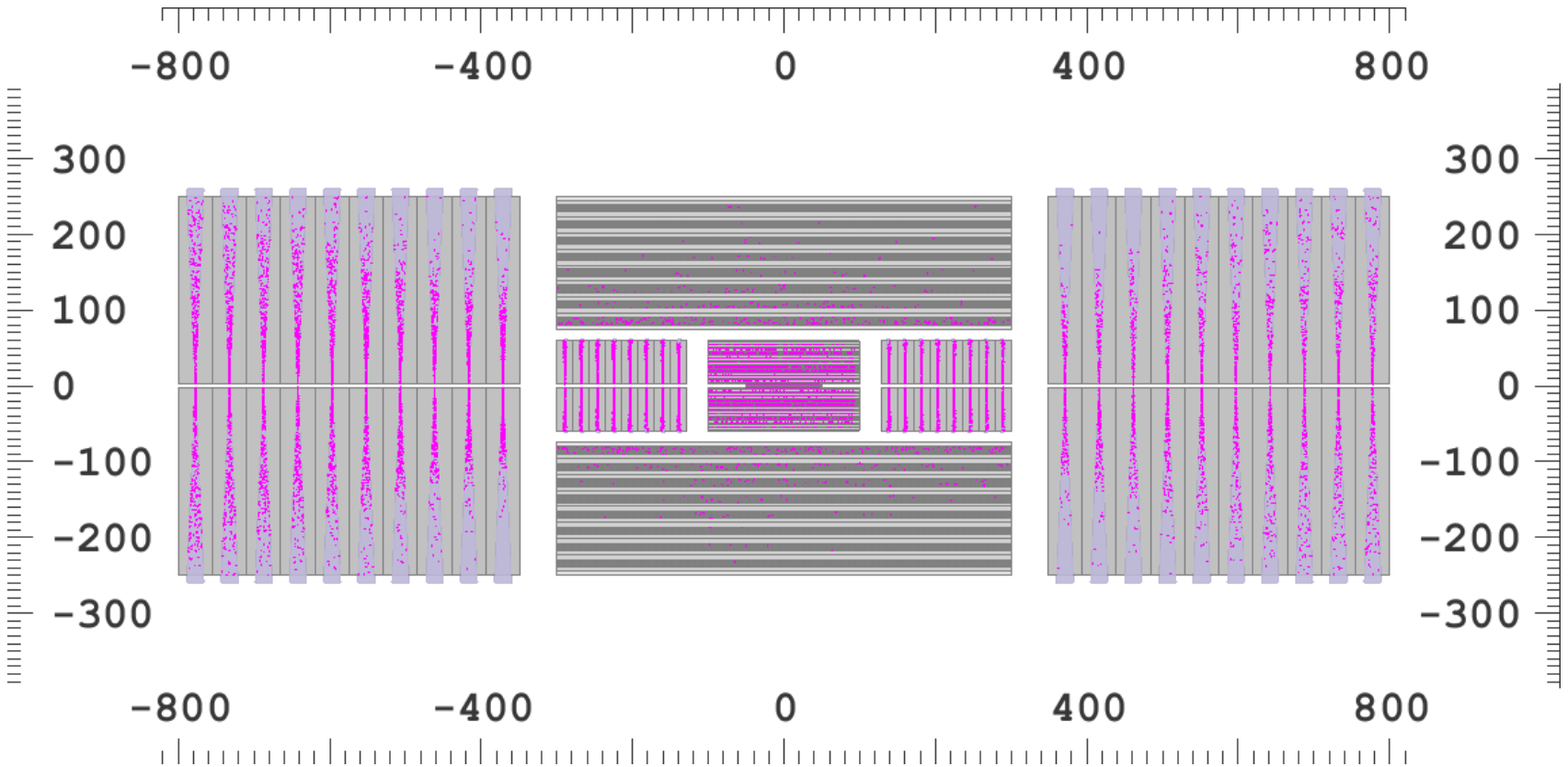
Pileup merging strategies

- Full simulation of pileup extremely expensive
- Timing structure of events needed for out-of time pileup



Simulation Results: peak pileup vs. **no pileup**

- full sim study of *preliminary* tracker layout and parameters
- event display, Z-Rho projection [mm]



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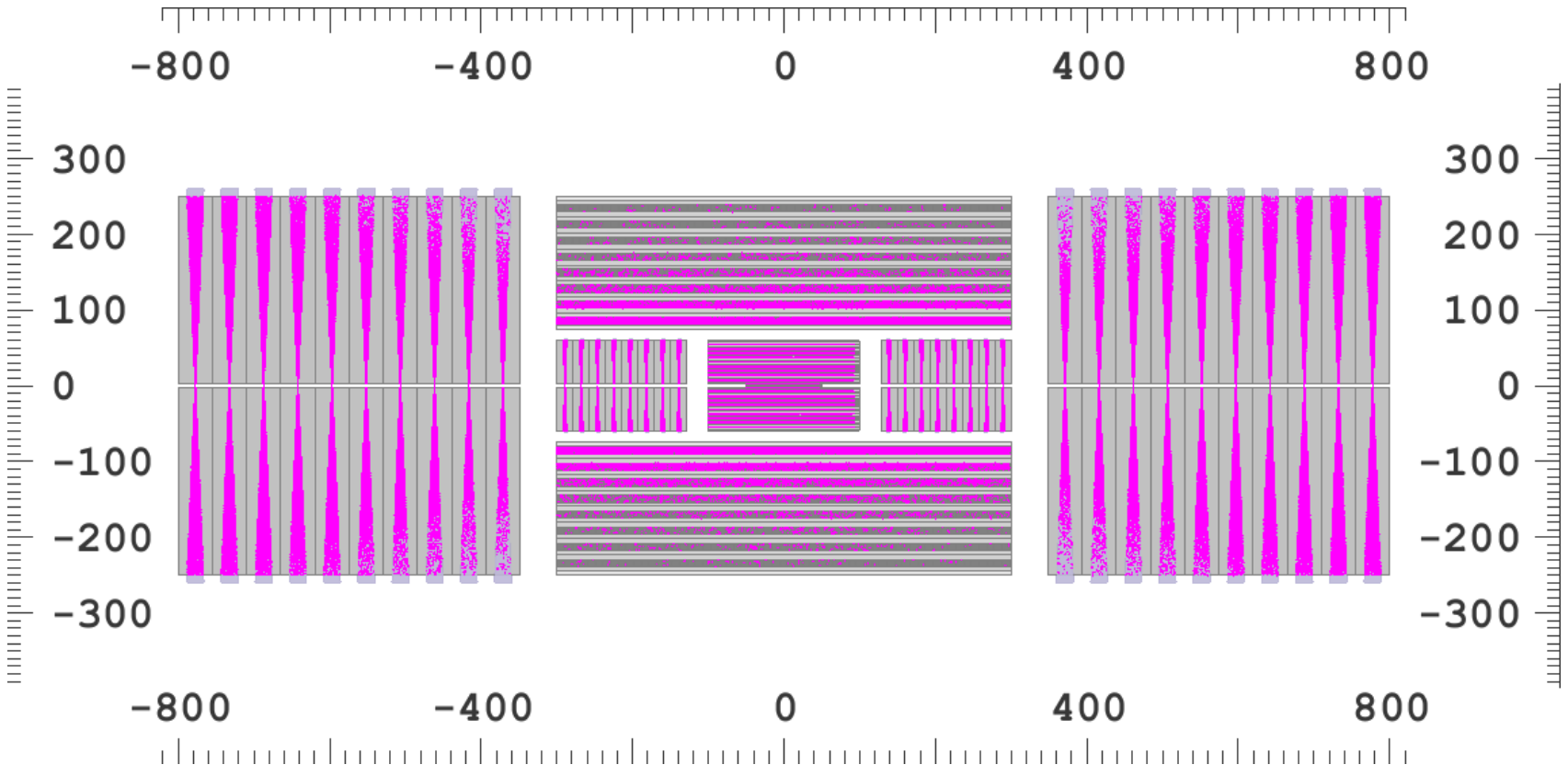
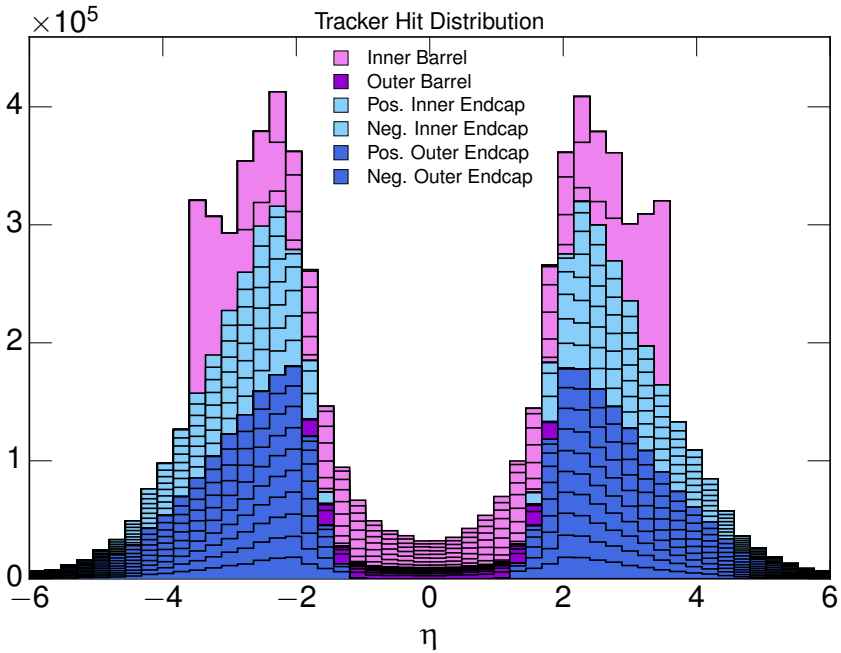
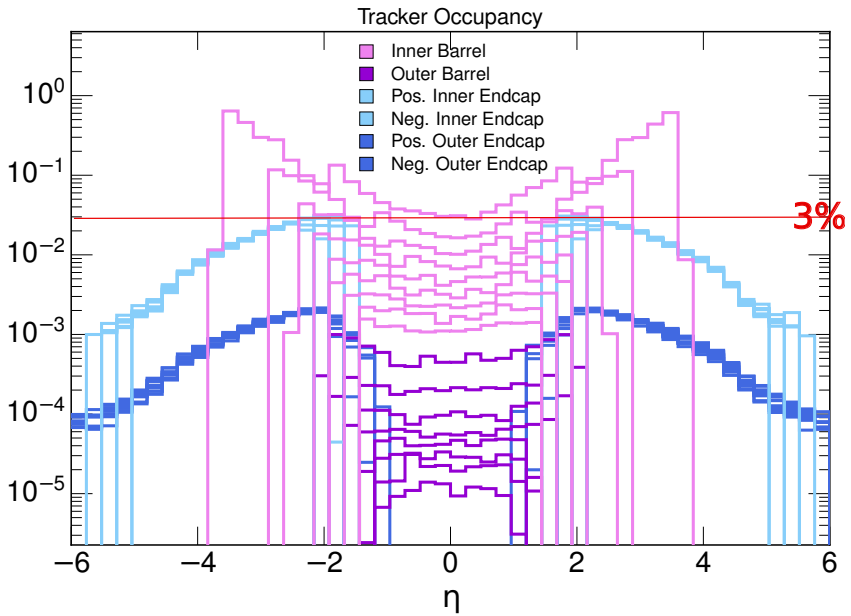


Simulation Results: More quantitatively

- full sim study of *preliminary* tracker layout and parameters
- assume 50 microns pixel width (compare CLIC)

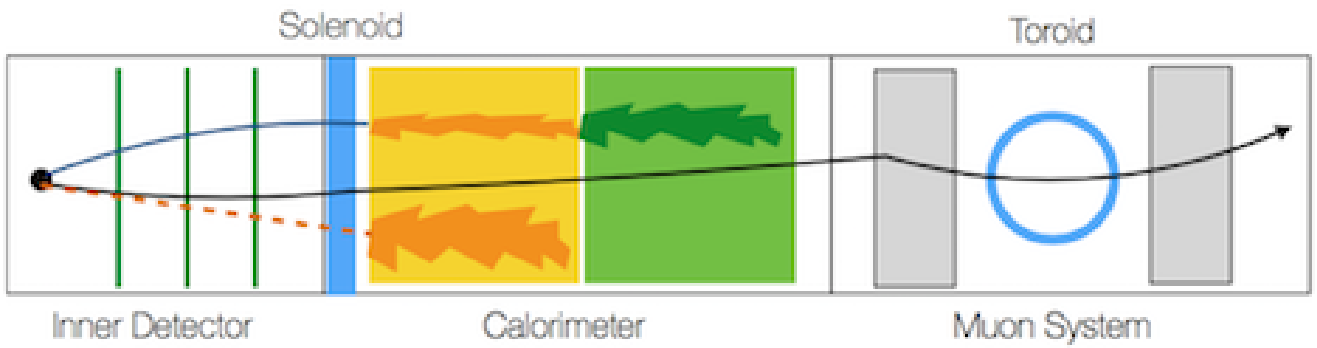


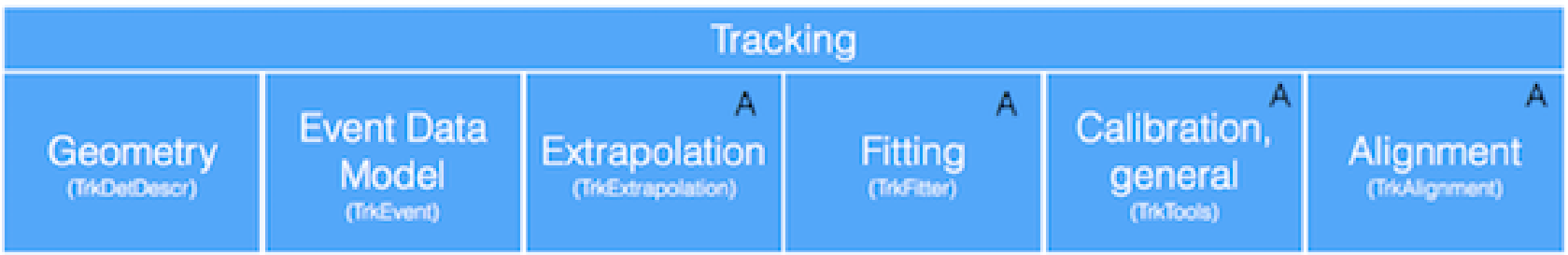


- occupancy in inner layer orders of magnitude too high
- pileup mitigation techniques needed

ACTS

- **A C**ommon **T**racking **S**oftware: ATLAS tracking code
- Decoupled from Athena (ATLAS software framework), standalone library
- First alpha release in June, recently prototype of last missing feature (Kalman-Fitter) finished





PODIO

- centered on the concept of using **P**lain **O**ld **D**ata in the data-model
  - simple, C-like structures
- one of the many components in the FCC software stack aiming at more general usability in HEP (see *presentation*)
- ROOT as I/O backend
- generates relevant code from a plain-text description of the data-model

PODIO - Code Generation

- Code Generation
  - data model described in `.yaml` file
  - separate repository for FCC event data model
  - low level details and memory management completely handles by PODIO
  - user interaction only with high level objects

- Example definition in yaml:

```
  ExampleCluster :
Description : "Cluster"
Members:
  - double energy // cluster energy
OneToManyRelations:
 // hits contained in the cluster
 - ExampleHit Hits
 // sub clusters used to create this cluster
 - ExampleCluster Clusters
```

Summary

- The FCC Design Study plans for a post-LHC Circular Collider
- Formidable computing/physics challenges
  - support detector design studies
  - extreme pileup in phase 2
- Detector background is a serious computing issue
- Common Software to support FCC-hh, -ee, and -eh
  - synergies with current experiments
  - borrow and use generic HEP-software (ACTS …)
  - PODIO developed by FCC

Thank you!

Backup

	FCC Phase 1	FCC Phase 2
bunch spacing [ns]	25	25 (5)
Peak luminosity [$\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$]	$5 \cdot 10^{-34}$	$30 \cdot 10^{-34}$
Total luminosity [ab^{-1}]	2.5 (10 years)	15 (15 years)
Peak pileup	170	1020 (204)
Peak pileup line density m^{-1}	≤ 3200	≤ 17000
rms bunch length [cm]	8	8
...		

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