Future Particle Colliders Software tutorial

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Who are we?

Patrick Koppenburg

- Staff on LHCb
- You've seen my timeline before
- With Clara and Wouter, trying to get Nikhef to think more about the future beyond the LHC

Armin Ilg

- Postdoc at University of Zürich
- PhD on ATLAS ITk and SUSY
- Working 100% on FCC-ee
- Vertex detector simulation
- Monolithic sensor development towards FCC-ee vertex
- Flavour tagging and case study (to be started)

Birgit Stapf

- Postdoc at University Hamburg/DESY
- PhD on ATLAS BSM Higgs - at Nikhef! 😊
- Now working on ATLAS SM Higgs + Higgs self-coupling projections for FCC-hh

Key4hep

Huge ecosystem of software packages adopted by all future collider projects

- Complete workflow from generator to analysis
- Event data model: EDM4hep for exchange among framework components
  - Podio as underlying tool
  - Including truth information
- Data processing framework: Gaudi
- Geometry description: DD4hep
- Package manager: Spack:
  source /cvmfs/sw.hsf.org/Key4hep/setup.sh

EDM4HEP format
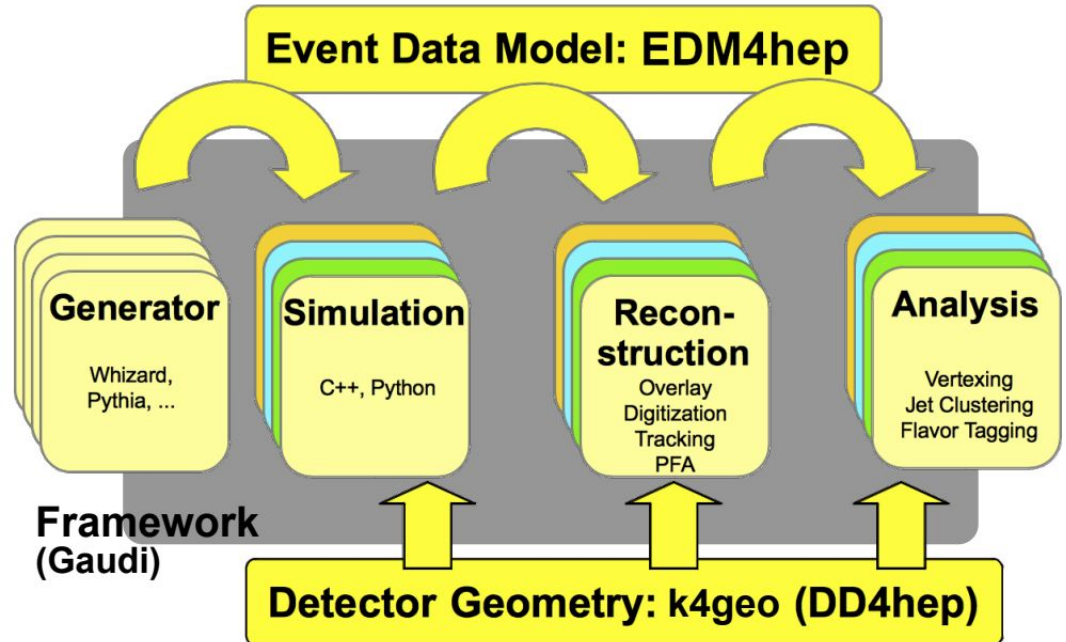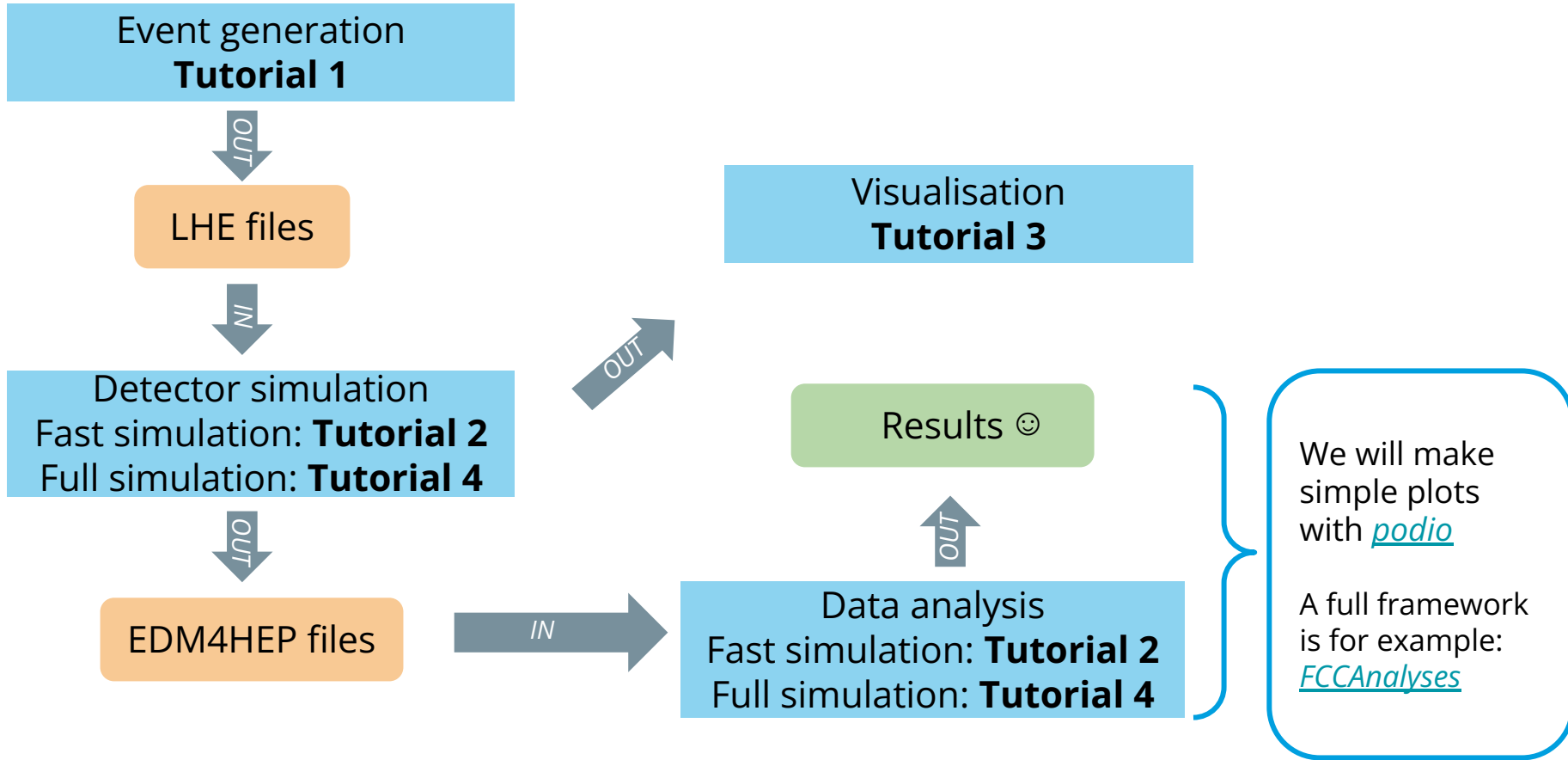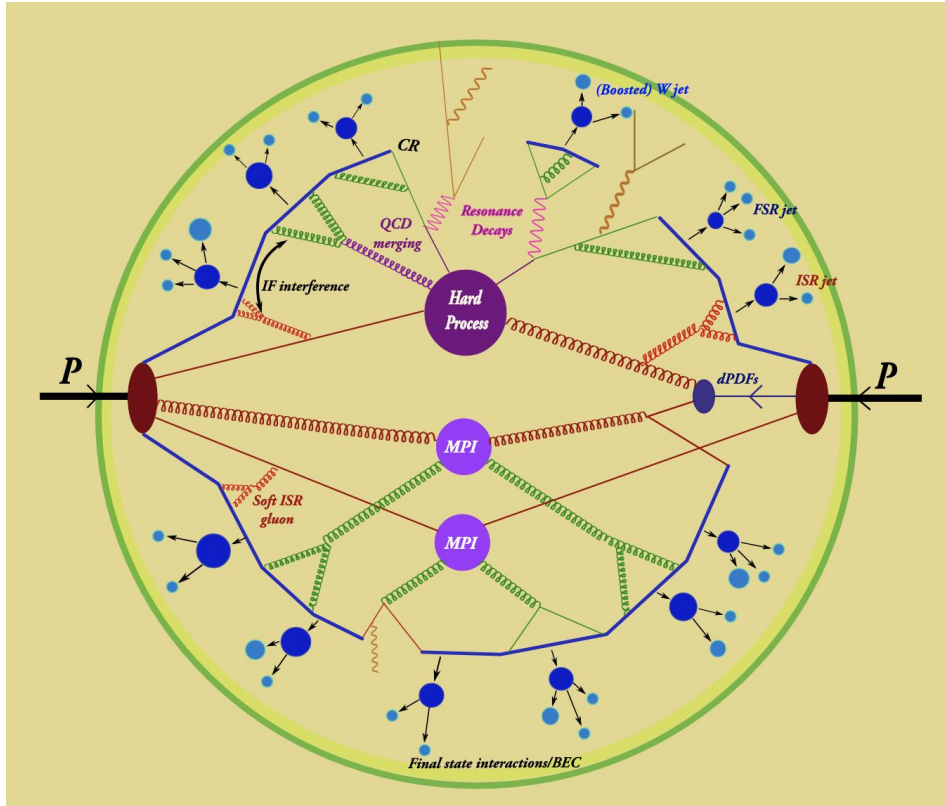

EDM4hep DataModel Overview (v0.6)
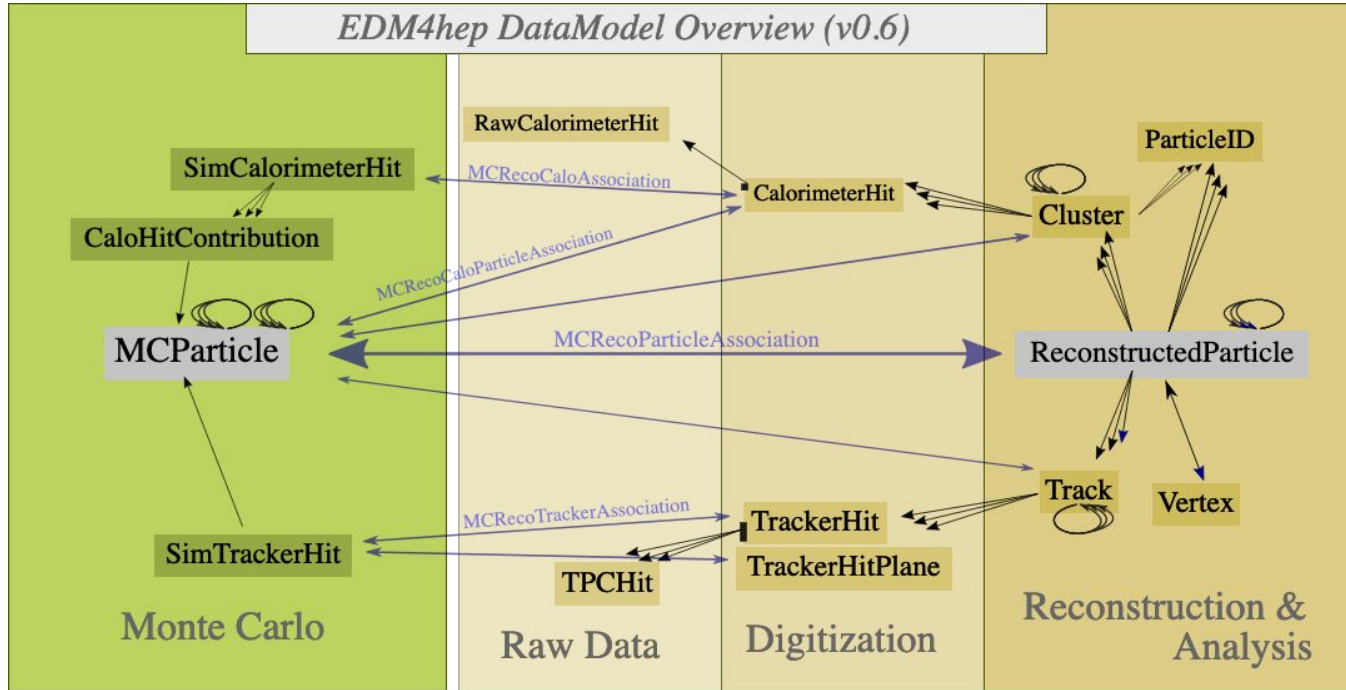
"A generic event data model for future HEP collider experiments"

But how do we analyse it? Could read directly, but existing FW FCCAnalyses handles it for us
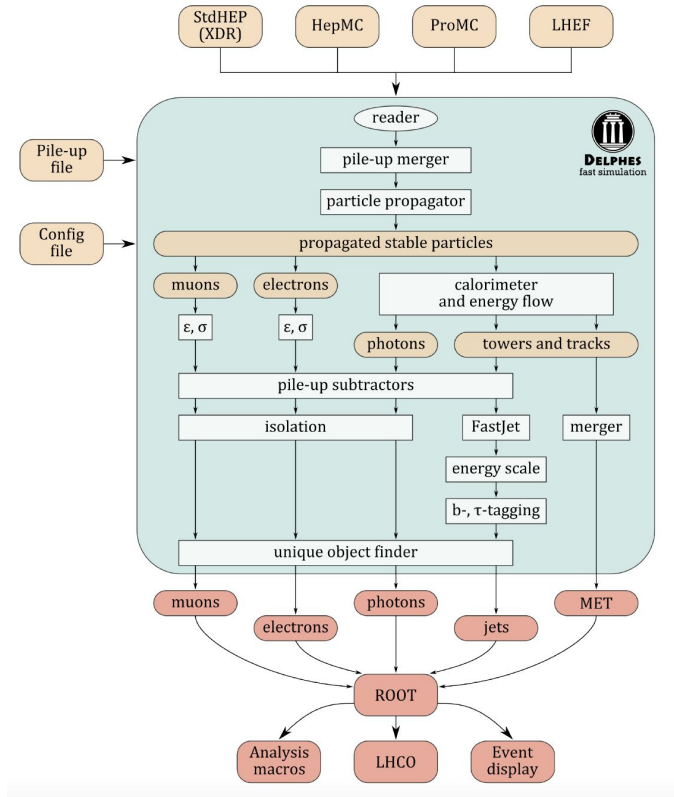
# Overview

Tutorial 1: Generators

- Learn how to configure and run MC generator and how to check the output files in different formats
  - I.e. edm4hep, LHEf, HEPMc
- Produce $e^+e^- \rightarrow Z \rightarrow \tau^+\tau^-$ events with Pythia, Whizard and KKMCee

Tutorial 2: Fast simulation using DELPHES

- Learn how to run the fast, parameterized simulation provided by DELPHES
  - Within the key4hep framework
  - Understand the configuration ("Delphes card")
- Look inside the produced edm4hep, and make simple plots with podio
- Using pp → HH → bbyy events @ 100 TeV, with the FCC-hh baseline detector scenario
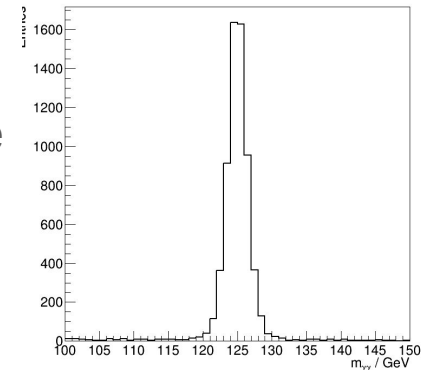
# Tutorial 3: Detector geometry and visualisation

- Learn how to visualise detector geometries in various ways
- How to adapt existing detector geometries
- How to produce event displays
- In CLIC and FCC-ee
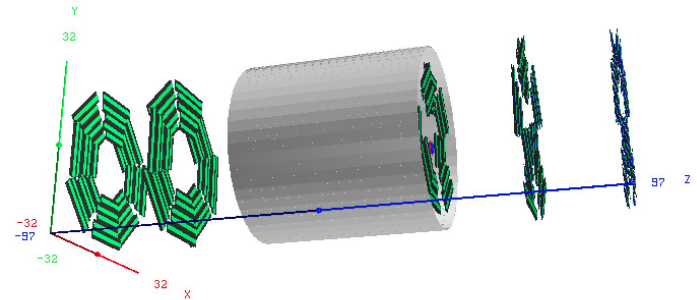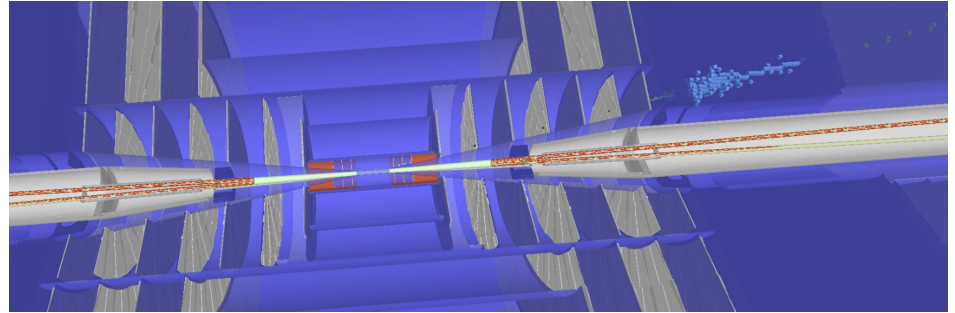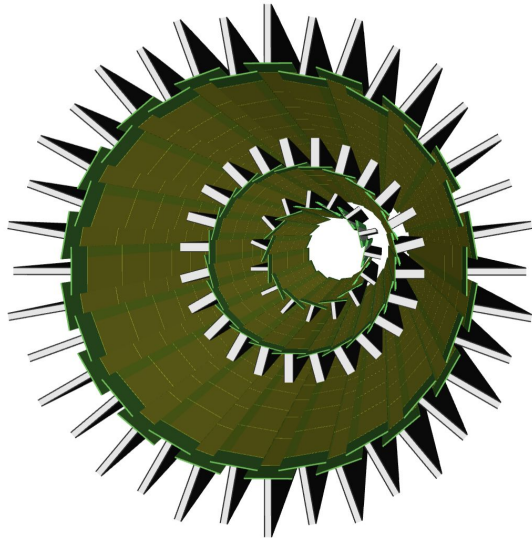
Tutorial 4: Analysis and full simulation reconstruction

- Learn how to do full simulation reconstruction
  - Using K4MarlinWrapper we can use all iLCSoft tools developed in the last decades!
- Analyse $e^+e^- \rightarrow Z^* \rightarrow ZH \rightarrow HZ$ ($Z \rightarrow \mu^+\mu^-$)
  - Z recoils against H. This is the channel for Higgs studies at ILC and FCC-ee
- Using the ILD detector at ILC
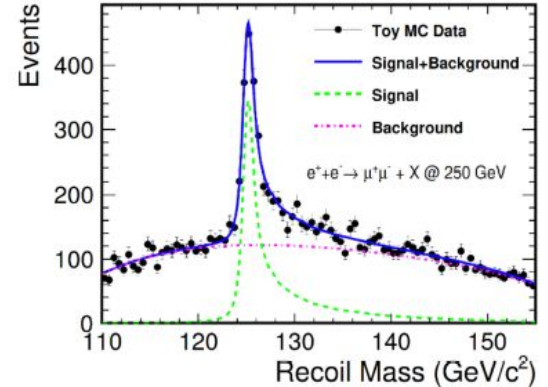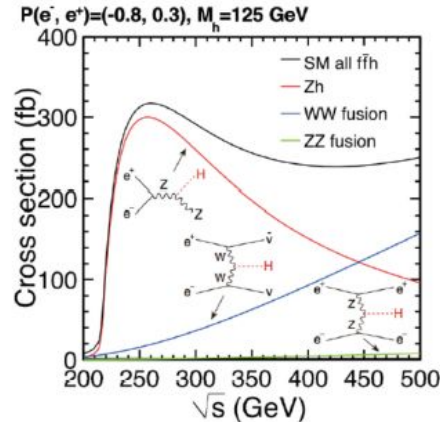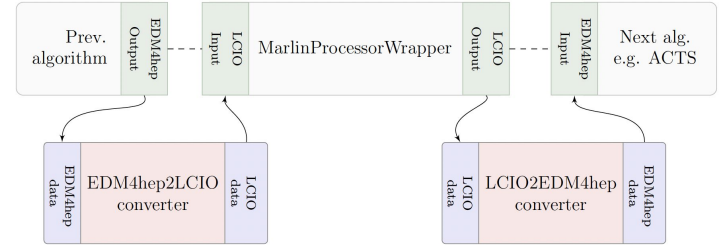
Future colliders software tutorial: Key messages

- A lot of software is out there, building on advances from LHC experiments and past developments for ILC and CLIC
- **Cross-experimental:** All future colliders initiatives use Key4hep and Co.
  - ILC, CLIC, FCC-ee, FCC-hh, CEPC, Muon colliders, EIC, …
- **Portable**: *Let me insert the ILD time-projection chamber tracker into CLD and see what happens*
- **Open to innovation**: Let's make future software better than present one
- **Open to new people**: Mostly ECRs that develop the software for future colliders. With 20% of your time, you can already achieve a lot (and get recognition for it!)