FCC software overview

FCC WEEK, BERLIN 2017

Joschka Lingemann
EP-SFT CERN
on behalf of the software team

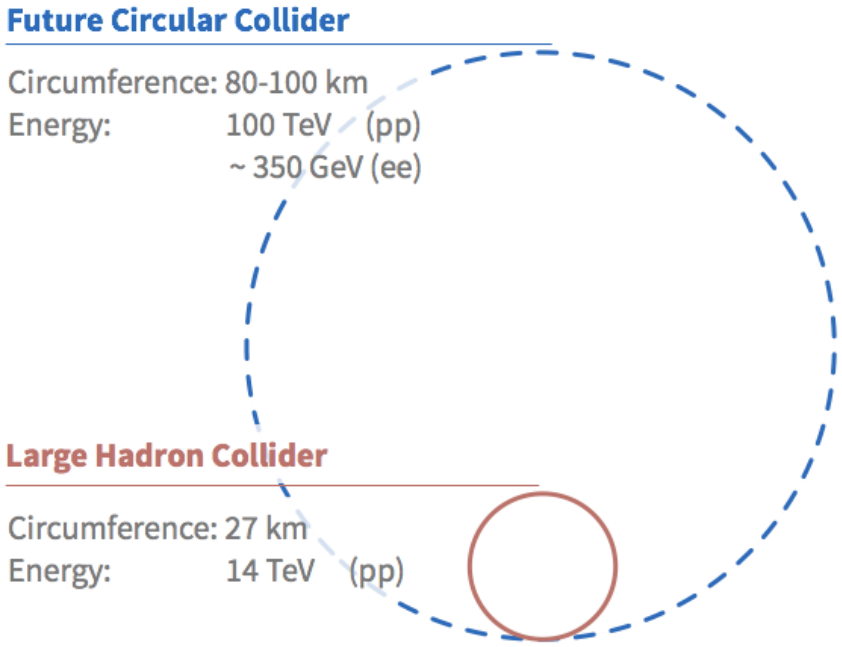
Introduction – What is the FCC-sw?

Support experiments for all colliders: ee, hh & eh

Support physics and detector studies
- Detector concepts: Moving targets
- Both fast and full simulation essential

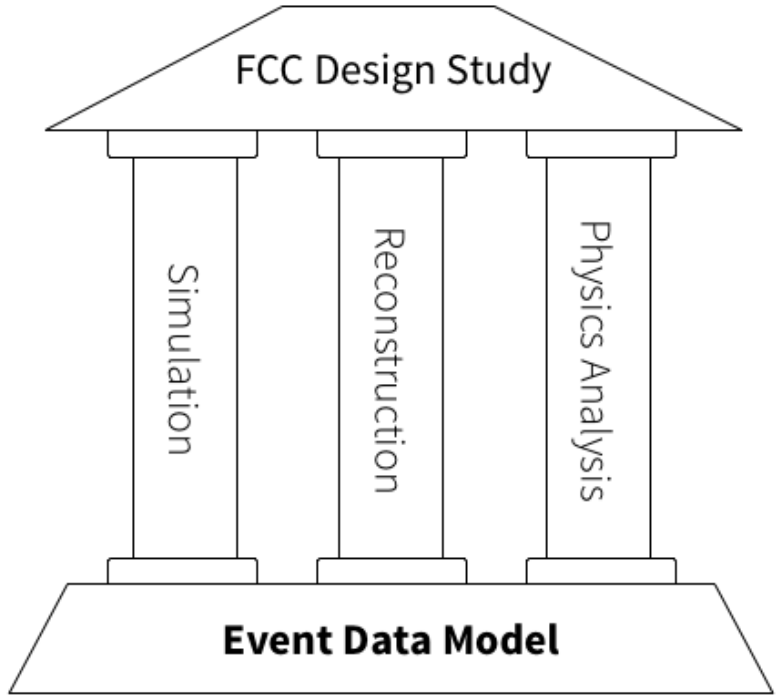
Collaborative approach:
- Extract from the LHC experiments where possible
- Invest to new solutions where necessary

One software stack: Support all experiments from event generation to physics analysis



The Ingredients

- Flexible event data model & detector description
- Simulation
  - Full simulation for detector studies
  - Fast simulation for physics benchmarks
- Reconstruction
  - pp: Extreme pile-up, extrapolation to 100 TeV
  - ee: Achieve the best possible precision
- Physics analysis
  - Allow use outside of framework
  - Python flexibility & C++ performance



Event Data Model

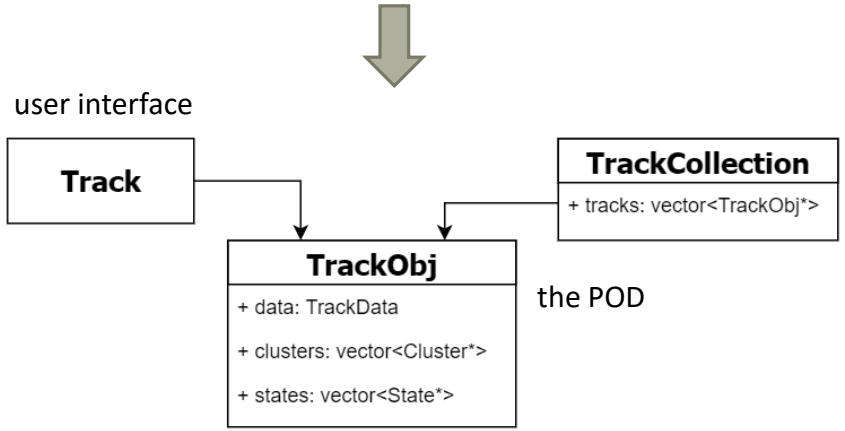
After reviewing existing solutions:

- LHC experiments: Complicated and not extractable
- Linear Collider I/O: Starting point, hard to adapt

Decided to invest: Plain Old Data I/O (PODIO)

- Focus on re-usability and flexibility
- Code fully generated from text files
  - Simply describe your data, PODIO does the rest
  - Easily adapt data model to changing requirements
- Python & C++ supported on the same footing

```
fcc::Track:
  Members:
  - float chi2
  - unsigned ndf
  OneToManyRelations:
  - fcc::TrackCluster clusters
  - fcc::TrackState states
```



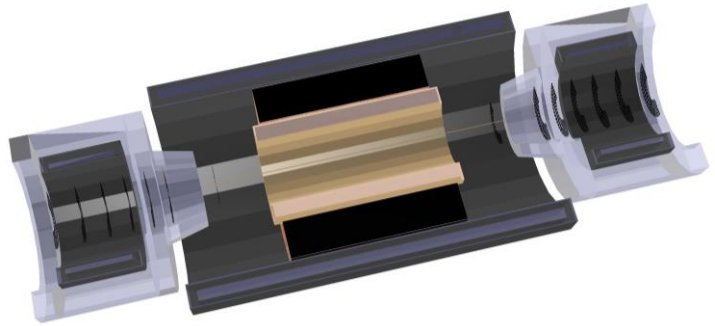
Detector Description

Underlying framework: DD4hep
- Collaborative effort with Linear colliders and LHCb(?)

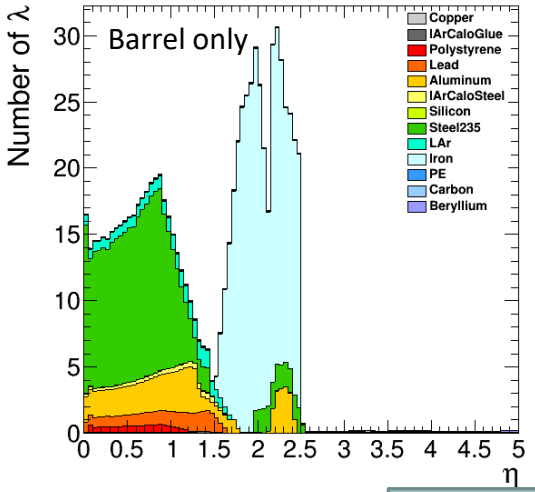
FCC-hh: Baseline concept exists and is stabilizing
- All sub-detectors being mainly developed in FCCSW
  - So far concentrating on non-forward detectors
- First simulation + reconstruction results shown this week

FCC-ee: Starting with geometry based on CLIC concept
- First working implementation integrated in FCCSW
- Material scans + first simulation results

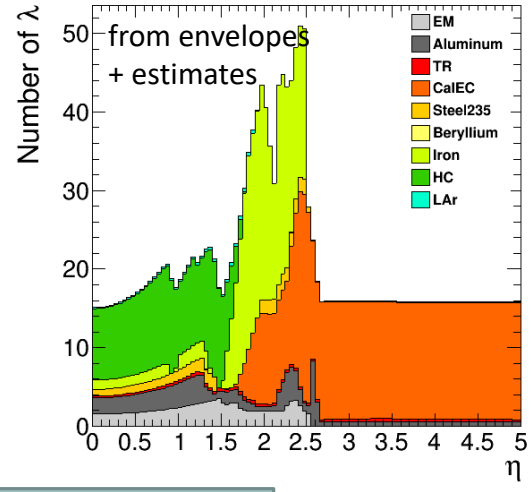
Tutorials on how to add a detector to FCCSW with DD4hep



Geant4 Geometry

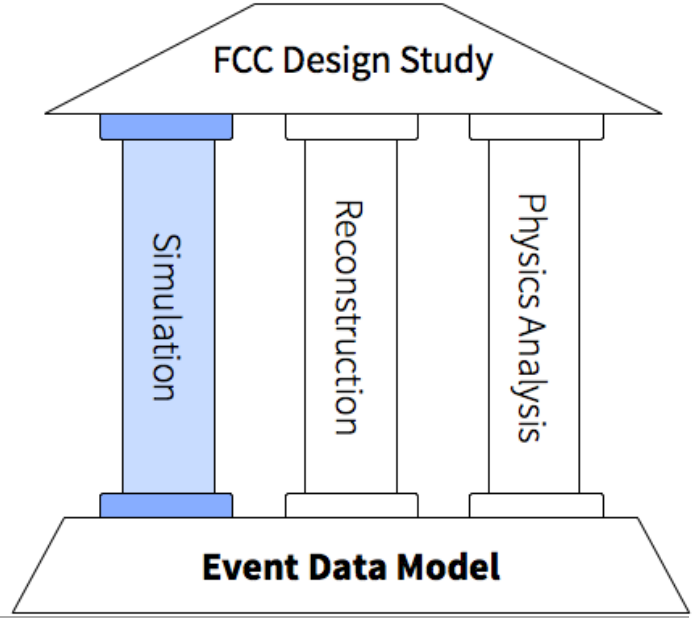


Estimates



Improve plots

SIMULATION

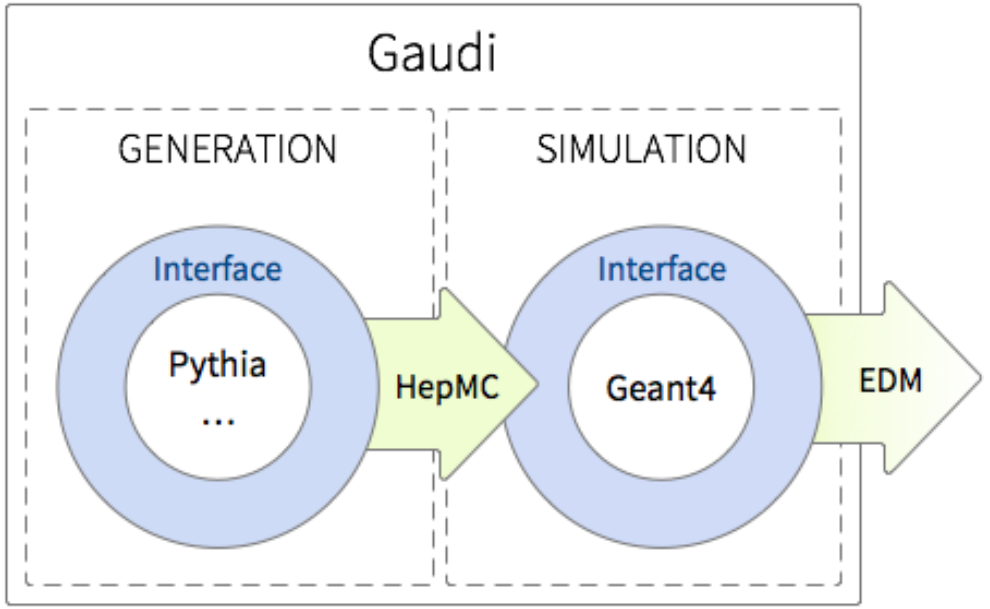

FCC Design Study
Simulation
Reconstruction
Physics Analysis
Event Data Model

Event Generation and Geant4 Simulation

Event Generation
- On the fly: Pythia & Particle gun
- Read LHE files during showering
  - Existing workflow for MadGraph

Simulation with Geant4
- Integrated full & fast simulation
- Feature complete for Design Study
- Existing tutorials and examples

Abstraction: interface based on HepMC



Integrated Fast Simulation

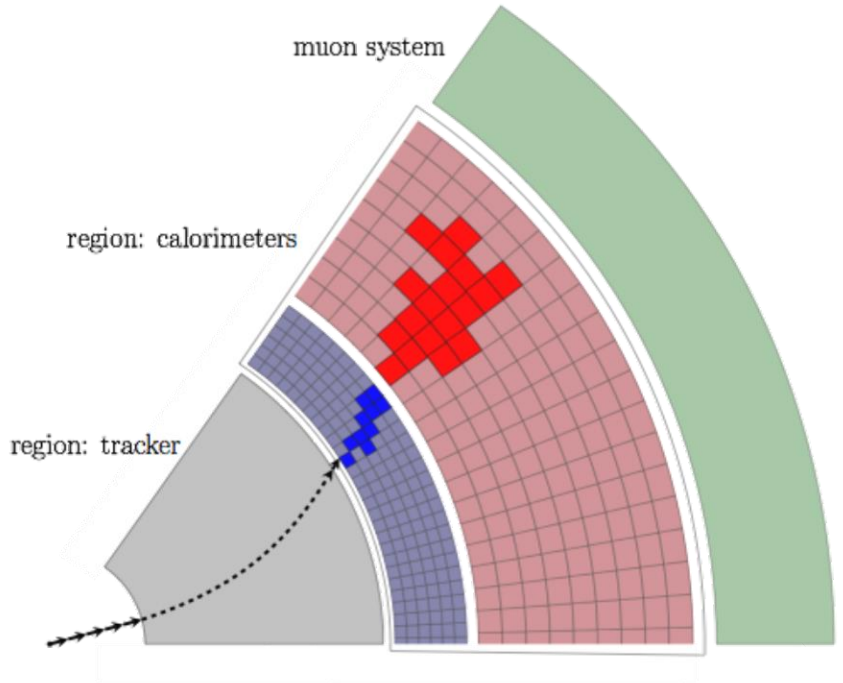
Integrated fast and full simulation:

- Use pre-defined hooks within Geant4
- Mix fast and full simulation in the same event
- Allow to switch based on particle properties, detector region, …

Existing methods:

- Parametric electromagnetic showers
- Particle momentum smearing

Plans to extend these models

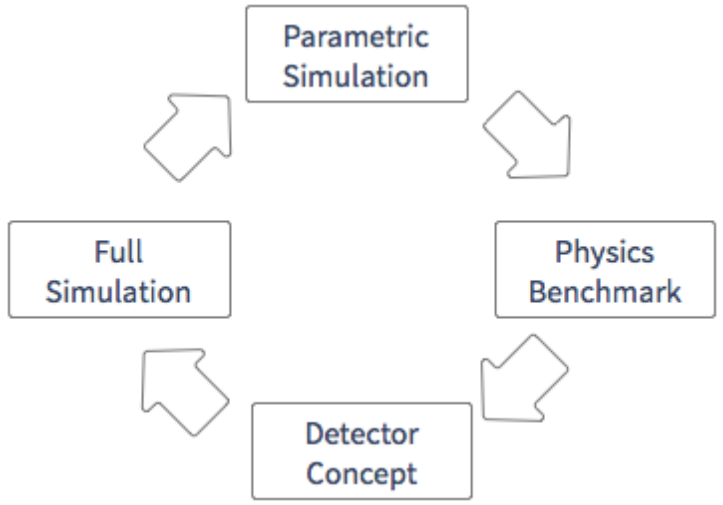


[Tutorials and examples] to get started with Geant4 simulation

Parametric Simulation

Why parametric simulation?

- Define & study physics benchmarks
- Scan detector parameters
- Redo simulation and analyses



Delphes & PAPAS (**Pa**rametrized **Pa**rticle **S**imulation)

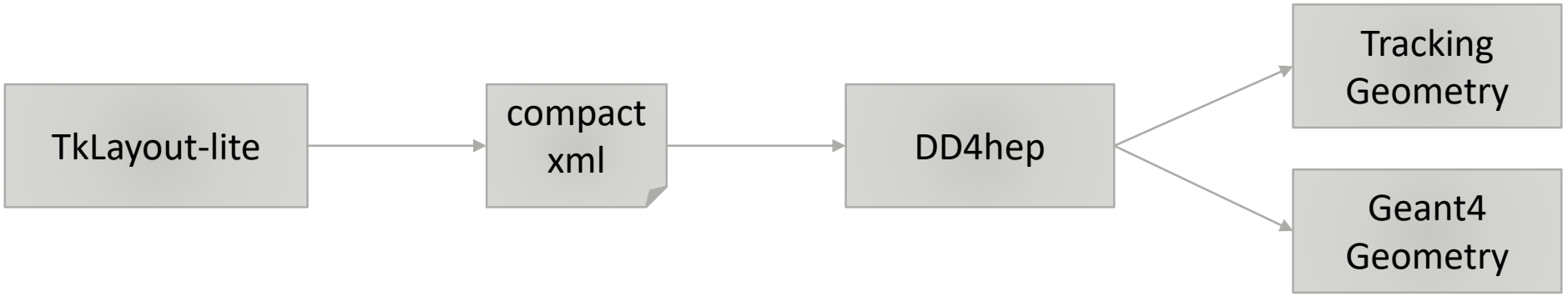
- Both (being) integrated in FCC software (allow cross-checks)
- Tutorials exist to use
  - Delphes (FCC-hh)
  - PAPAS (FCC-ee)
- More details on plans and status of PAPAS later in this session

Special-Purpose Simulation

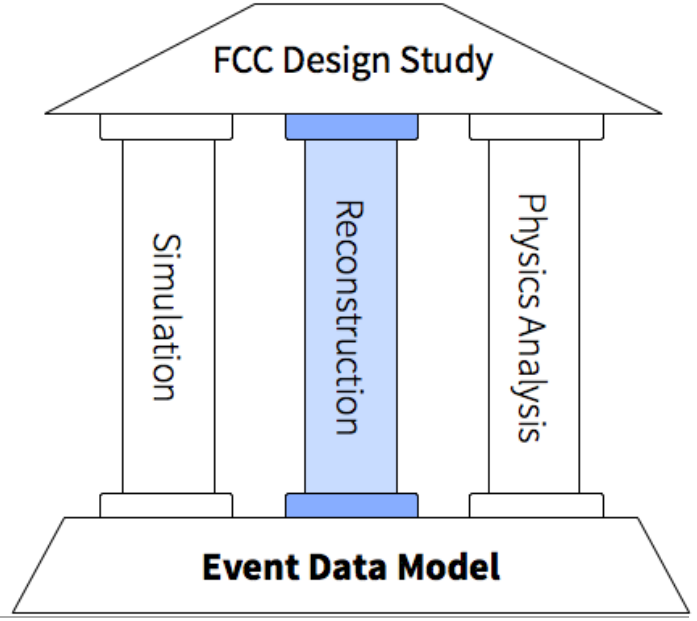
Quick turn-around for initial tracking performance studies: **TkLayout**

- Originally developed for tracking studies in CMS
- Analytical software to study tracker performance
- Invested some work to refactor and ease for external use: TkLayout-lite
  - https://github.com/tkLayout/tkLayout/tree/devLite

Specialised geometry extraction for the FCC ecosystem:



RECONSTRUCTION



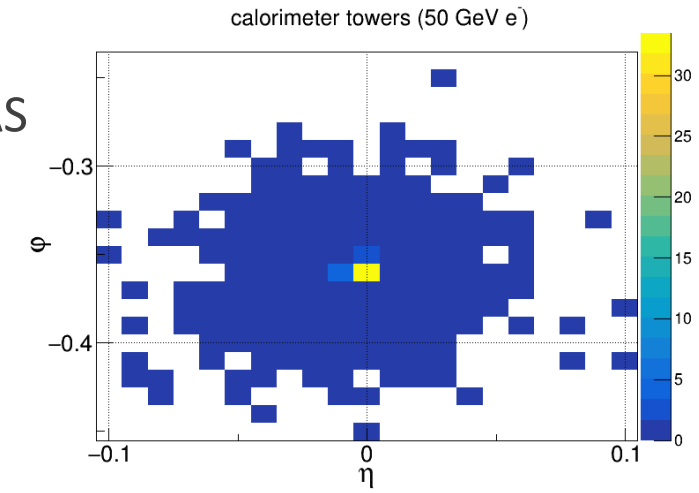
Reconstruction status

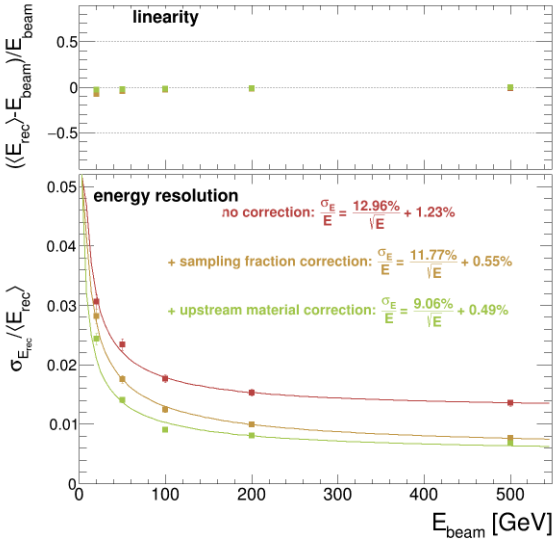
A common tracking software:

- Extraction of the ATLAS tracking code into standalone package
- Geometry automatically converted into optimized geometry via DD4hep
- More information later in this session

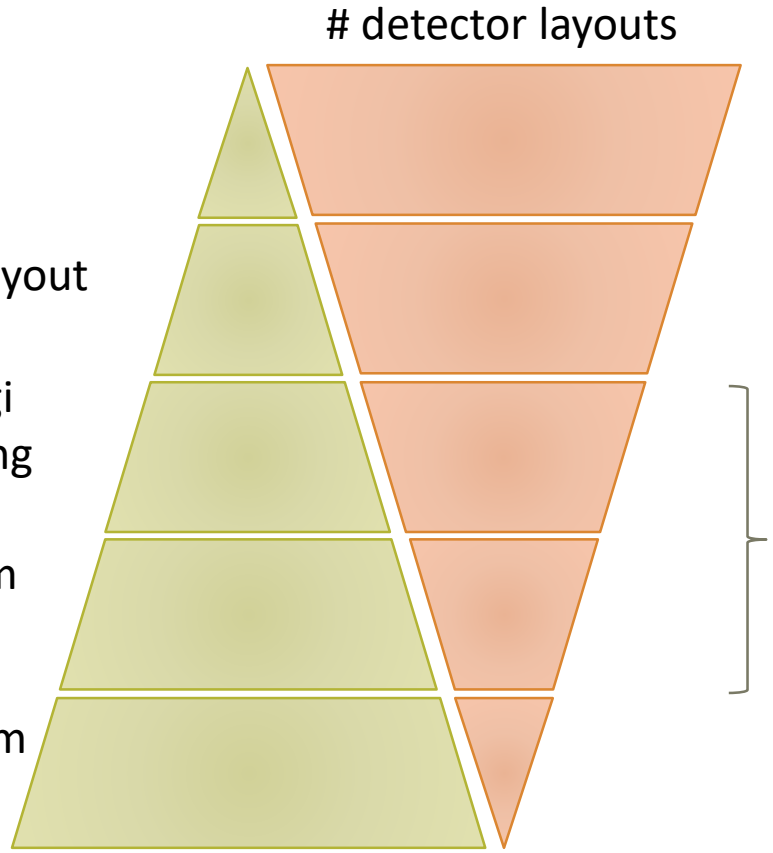
Calorimetry

- Developed within FCCSW, inspired by ATLAS
- Started with dedicated reco for e/gamma
- First results on combined calorimetry
- Will evolve into Particle Flow as the long term goal





The right tools for the right job



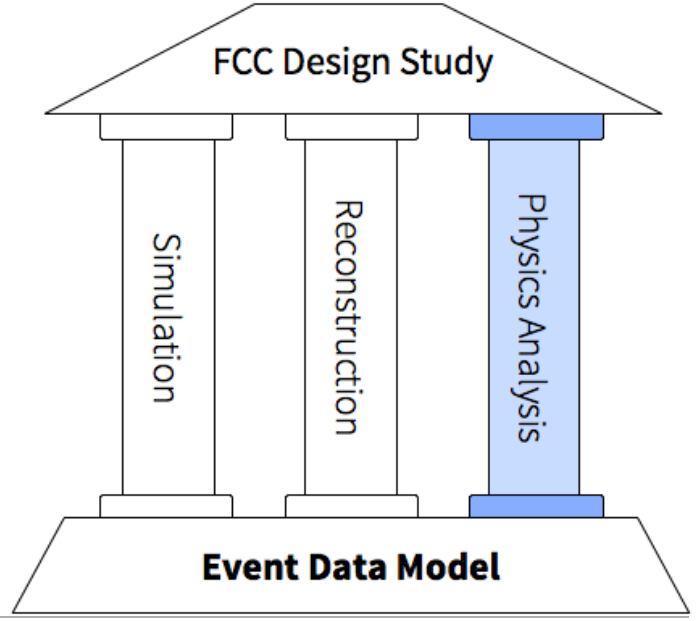
Analysis benchmarks,
high statistics

Reco benchmarks,
detector studies

Detector studies,
full pile-up model

Add some numbers:
Evt / sec
(working on it)

PHYSICS ANALYSIS

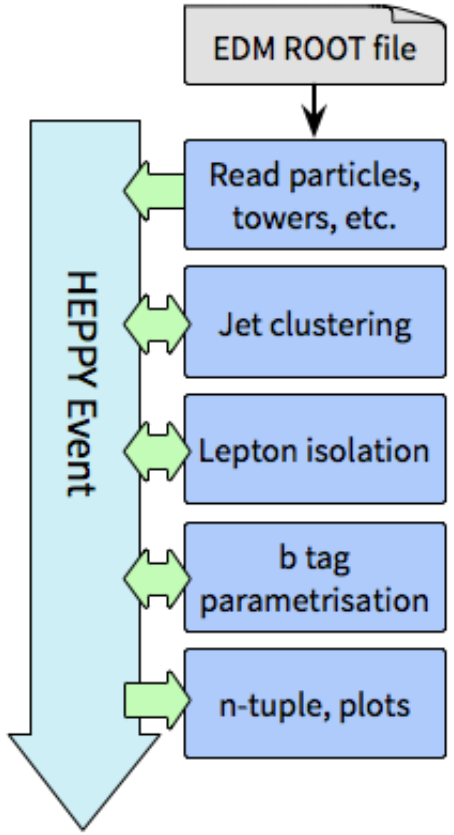


Analysis Front-End

Python based package: HEPPY
- Originally developed in the CERN-CMS group
- Highly configurable, easy to set up
- Includes PAPAS simulation

Long term: Python performance issues?
- Combine strengths of C++ and Python
- Python to allow testing ideas and prototype
- Invest to port performance critical code to C++
  - Use ported Functionality from Python

More information later in this session



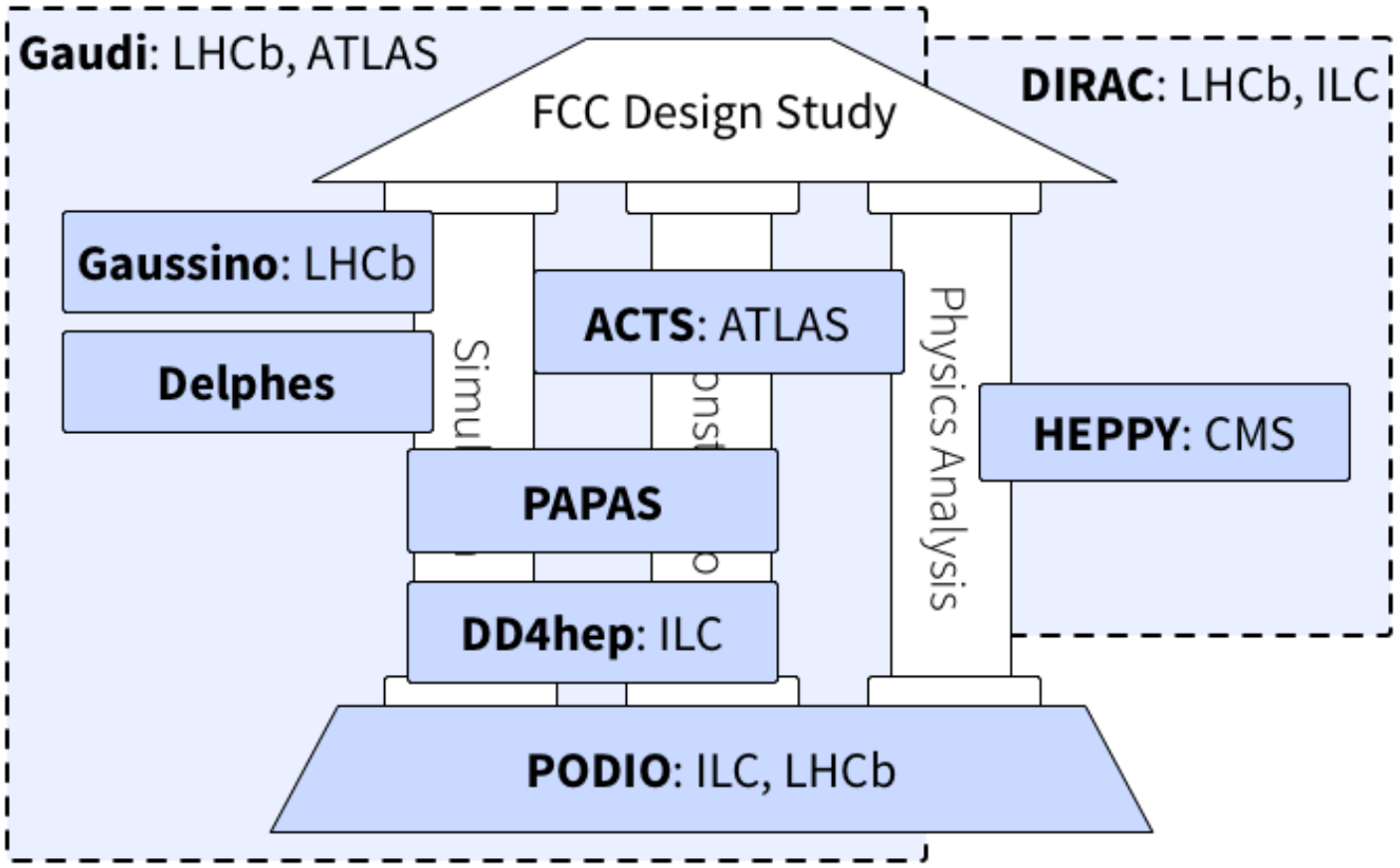
Infrastructure

Ease batch and grid submission: Decided to use DIRAC as a framework

- Effort started by LHCb, now used by several communities, e.g. ILC
- Abstraction layer between users and resources
- First steps done: Integrate FCCSW, currently in review

```
from ILCDIRAC.Interfaces.API.NewInterface.FccJob import FccJob
from ILCDIRAC.Interfaces.API.NewInterface.Applications.Fcc import FccSw

job = FccJob()

fccApp = FccSw(
    fcc_conf_file='my_configuration.py',
    fccsw_path='/cvmfs/fcc.cern.ch/sw/0.8.1/fccsw/0.8.1/x86_64-slc6-gcc62-opt',
    number_of_events=1000)

job.append(fccApp)

jobID = job.submit()
```

Collaborating where we can



Conclusion & Looking forward

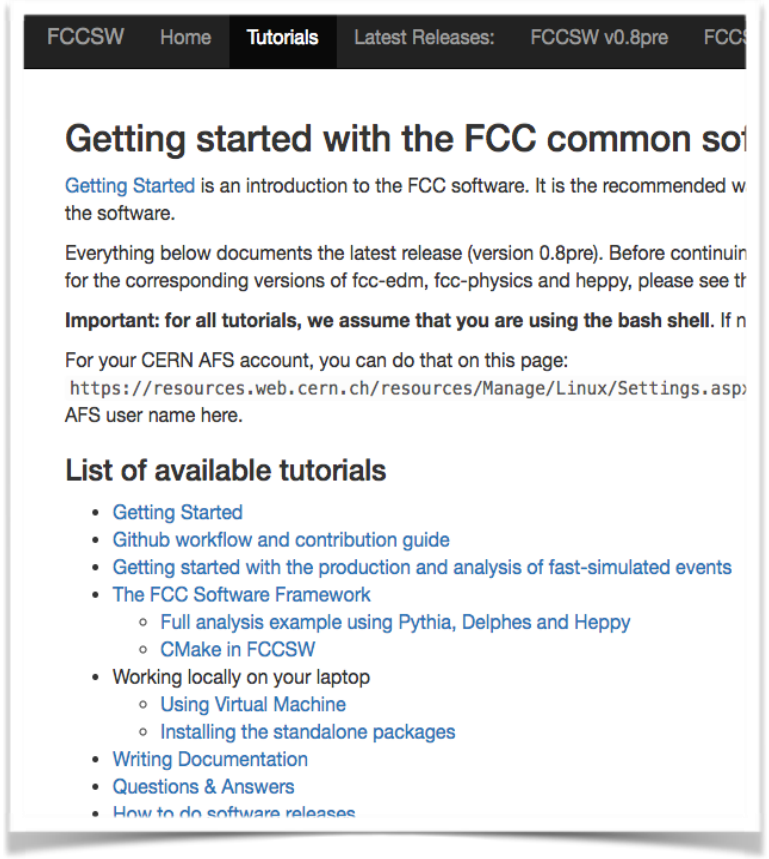
A lot of progress in several areas in the last year

- Ramping up of infrastructure for physics studies and analysis
  - Central simulation production with Delphes
  - Tutorials for Python ecosystem with HEPPY and PAPAS
- Effort to ease contributions from new users
  - Centralized and improved our documentation
  - Continuous integration: Automatic checks of pull-requests & more
- First steps towards a working reconstruction

Still quite a lot of areas to improve and **for you to contribute**:

- Detailed studies of reconstruction / detectors
- Towards the long term aim: Particle flow
- Additional infrastructure: Code skeletons, better event display, …

Where does this leave you?



Web: fccsw.web.cern.ch
- Tutorials and other resources

FCC software e-group
- fcc-experiments-sw-dev
- Ask your questions

FCC software Mattermost
- Chat service provided by CERN
- Join us!

Welcome to our meetings
- Every other Wed 11:00
- https://indico.cern.ch/category/7969/

FCC-ee software workshop

On the agenda:

- Introduction for HEPPY
- Fast simulation with PAPAS & Delphes
- Status of Geant4 geometry for FCC-ee
- Hands-on tutorials!