The FCC software
how to keep SW experiment independent

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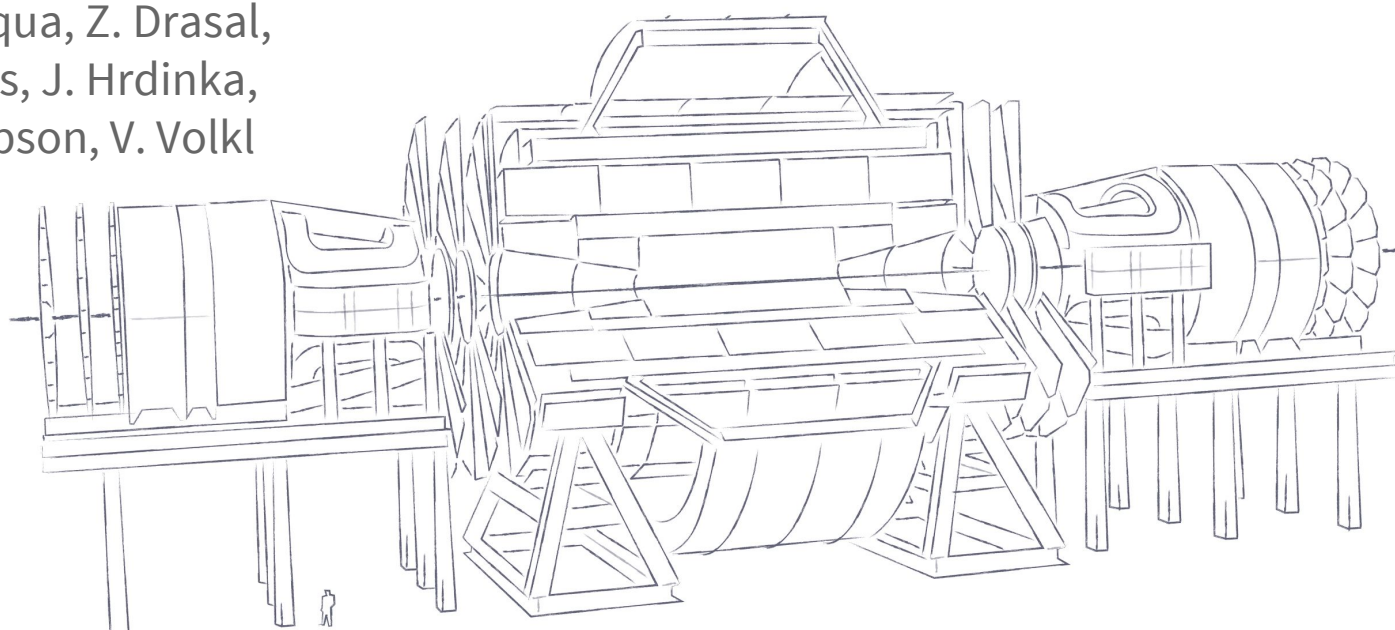


The FCC design study

A conceptual design for accelerators and detectors

- Different requirements ee vs pp
- Support physics and detector studies
  - Detector concepts: Moving targets
  - Both fast and full simulation essential
- Challenging backgrounds (computing and physics-wise):
  - Pile-up for pp: 1000 events
  - Beam-background for ee

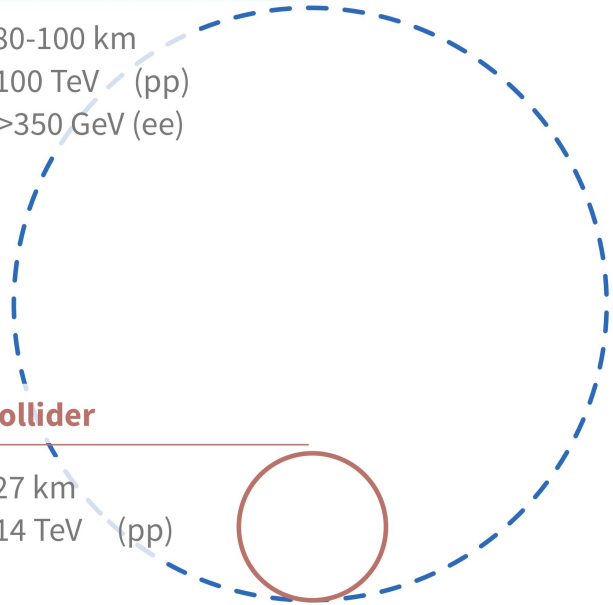
One software stack to support them all

Future Circular Collider

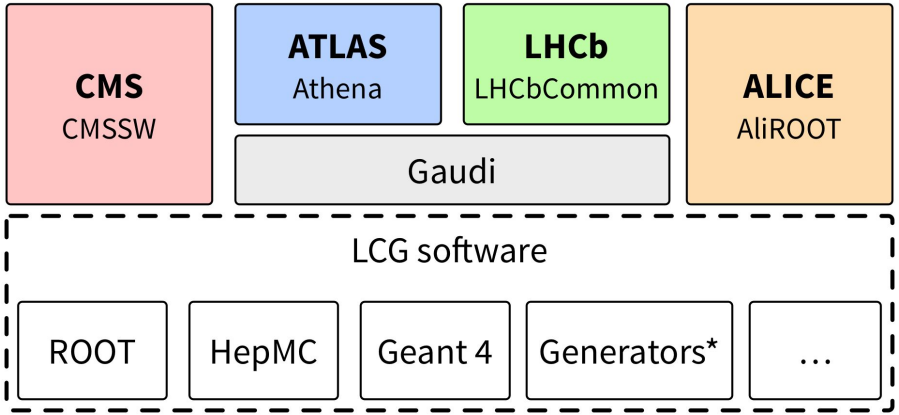
Circumference: 80-100 km
Energy: 100 TeV (pp)
>350 GeV (ee)

Large Hadron Collider

Circumference: 27 km
Energy: 14 TeV (pp)



Contrasting with the LHC experiment approach



Each experiment has dedicated software:

- Effort duplication
- LHCb and ATLAS started to collaborate
  - Gaudi as underlying framework
  - Also used in FCC software

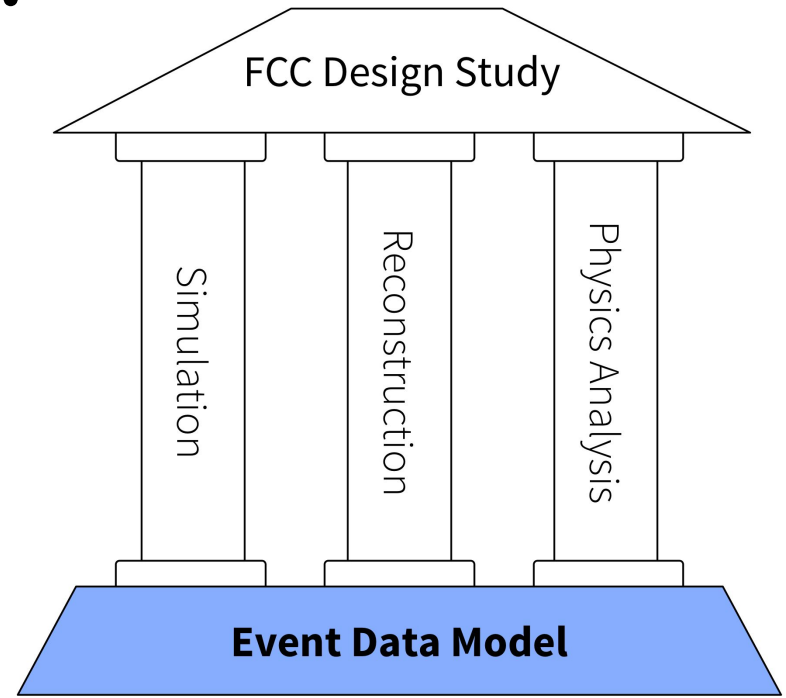
Is there a fundamental reason not to collaborate and share?

We decided to try!

*too many to list them all

What are the ingredients?

- Flexible event data model
- Flexible detector description
  - Detector concepts are moving targets



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- Flexible event data model
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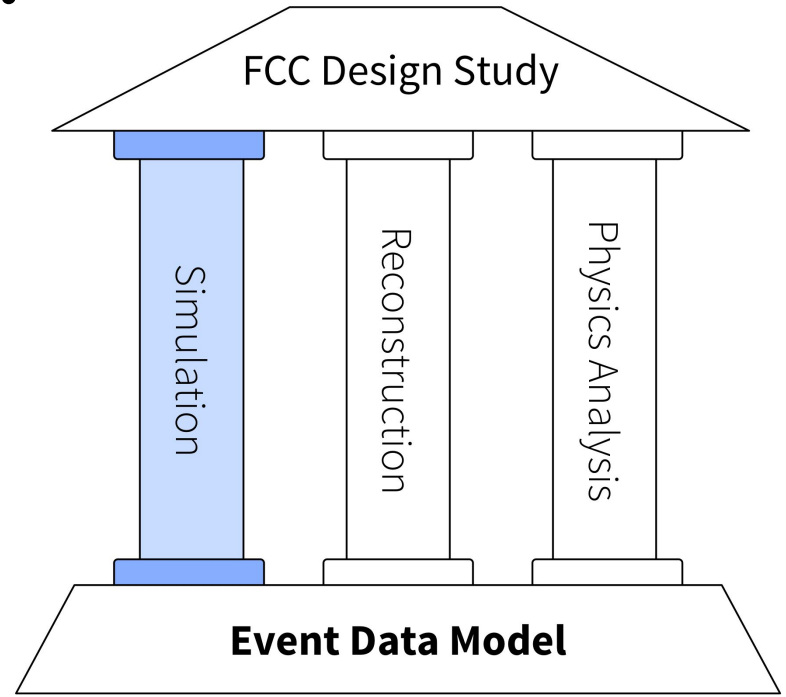
- Simulation
  - Full simulation for detector studies
  - Fast simulation for physics studies



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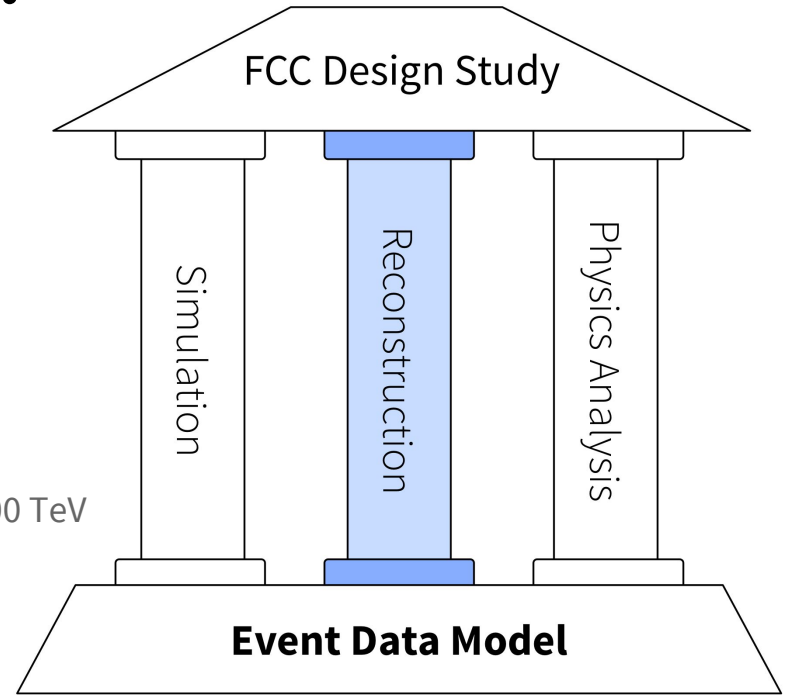
- Reconstruction:
  - FCC-hh: Extreme pile-up, extrapolation to 100 TeV
  - FCC-ee: Achieve the best possible precision



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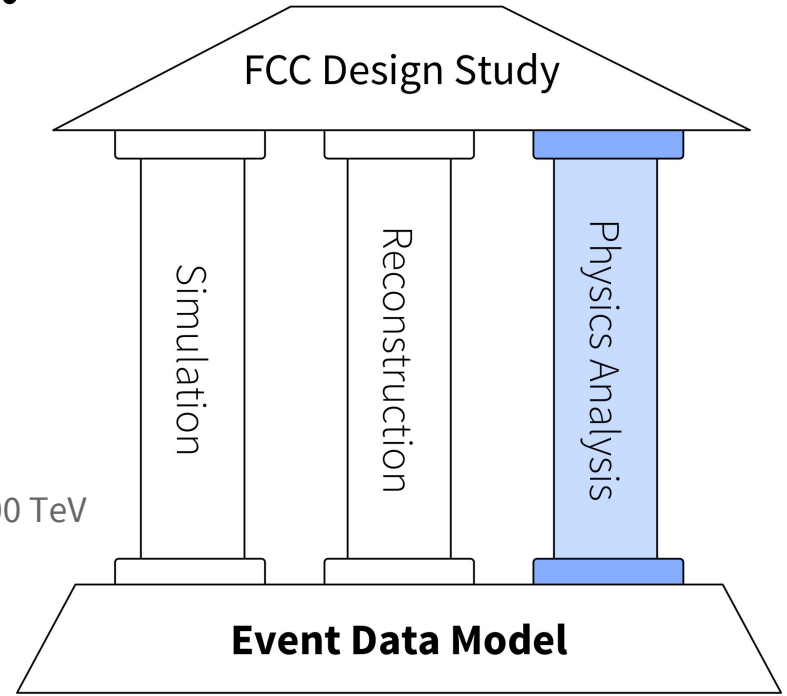
  - FCC-ee: Achieve the best possible precision
- Physics analysis
  - Allow use outside of framework
  - Python flexibility & C++ performance



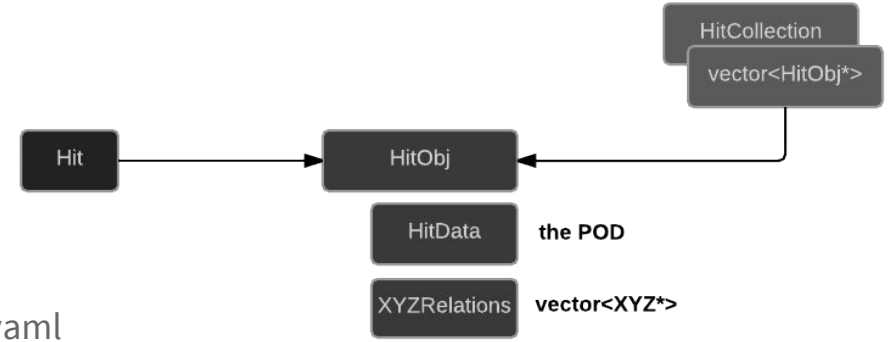
Event data model

Reviewing existing experiment solutions:

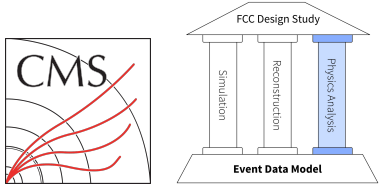
- Most: Complex inheritance and polymorphism
  - Problematic: data layout becomes more important
- Users: Not comfortable using them
  - Final analysis: Uses ntuples (and python)

Decided to invest here:
Plain **O**ld **D**ata **I**nput **O**utput (PODIO)

- Focus on reusability
  - All code generated: Data types described in yaml
  - Interest expressed by LHCb and ILC
- Designed with parallelism in mind
- Python and C++ supporting EDM on equal footing

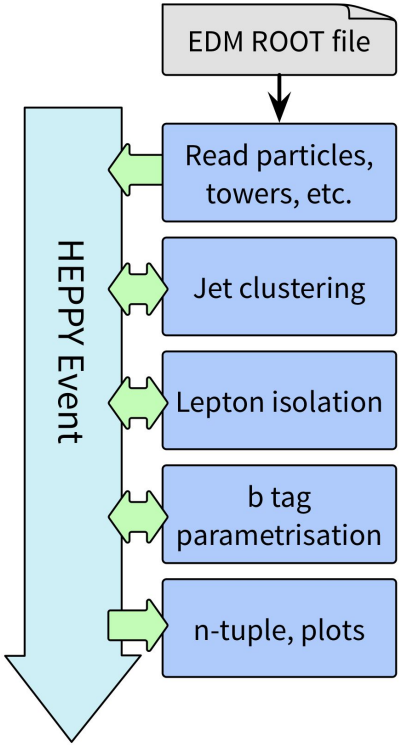


The Analysis Front-End



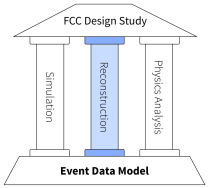
Python-based analysis: **HEPPY**

- Highly configurable, encourages code reuse
- Includes PAPAS simulation
  - Parametric simulation + particle flow reco (used in FCC-ee)
- Python: Testing ideas and prototyping algorithms
- Gradual port of code from Python to C++
  - Ported functionality still available via ROOT-based bindings



Balancing development agility vs. code performance

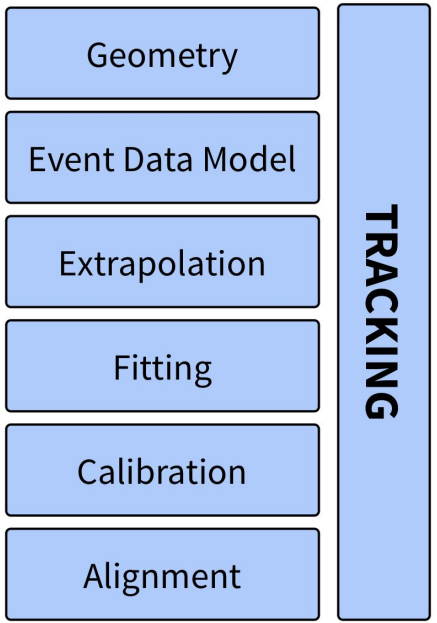
A Common Tracking Software



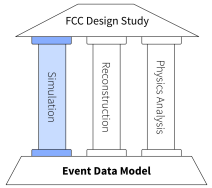
Extracting ATLAS tracking software into a standalone toolkit:

- Simplified geometry description optimised for tracking
  - Plugins available for ATLAS, DD4hep and TGeo
- Internally use simple EDM
- All necessary tools included
- Addon: Alternative fast simulation of inner detector
- Completely independent of experiment software

Solution that offers all functionality that is needed.



Generation and Simulation

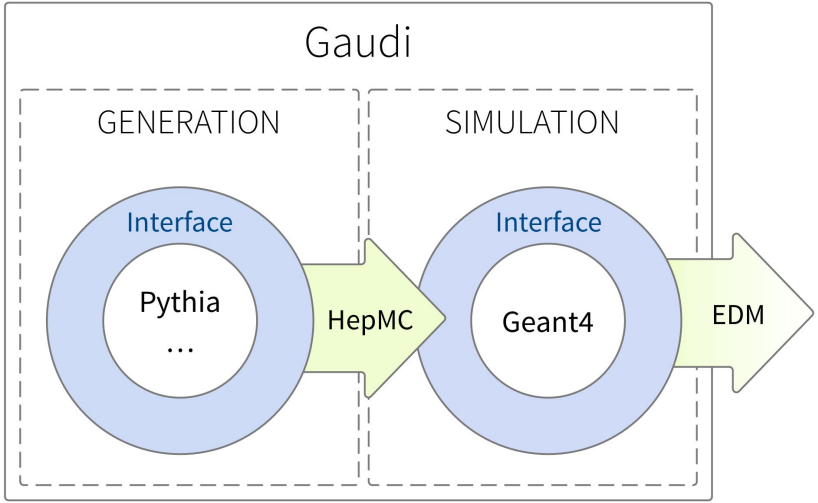


Based on LHCb's Gauss package:

- Event generation and simulation
- Based on Gaudi for event processing
- Independent of EDM: Uses HepMC

Extract the core: **Gaussino**

- Generation infrastructure: ~taken as is
- Simulation: decided to re-design
  - Take the opportunity to simplify (also needed for multi-threading)
  - Integrated fast and full simulation with Geant 4



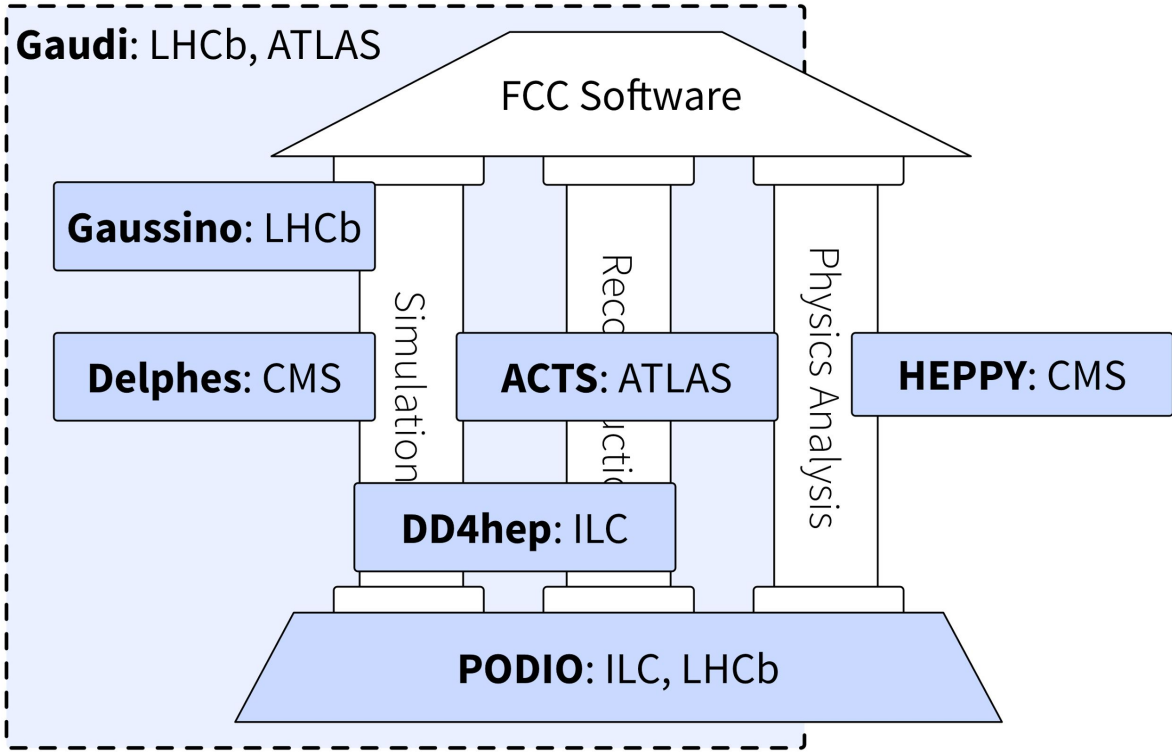
The Solutions

Collaborating where possible

- LHC experiments
- Linear collider community

Synergies

- Share the effort
- **Don’t re-invent the wheel**
- **Improve** existing solutions



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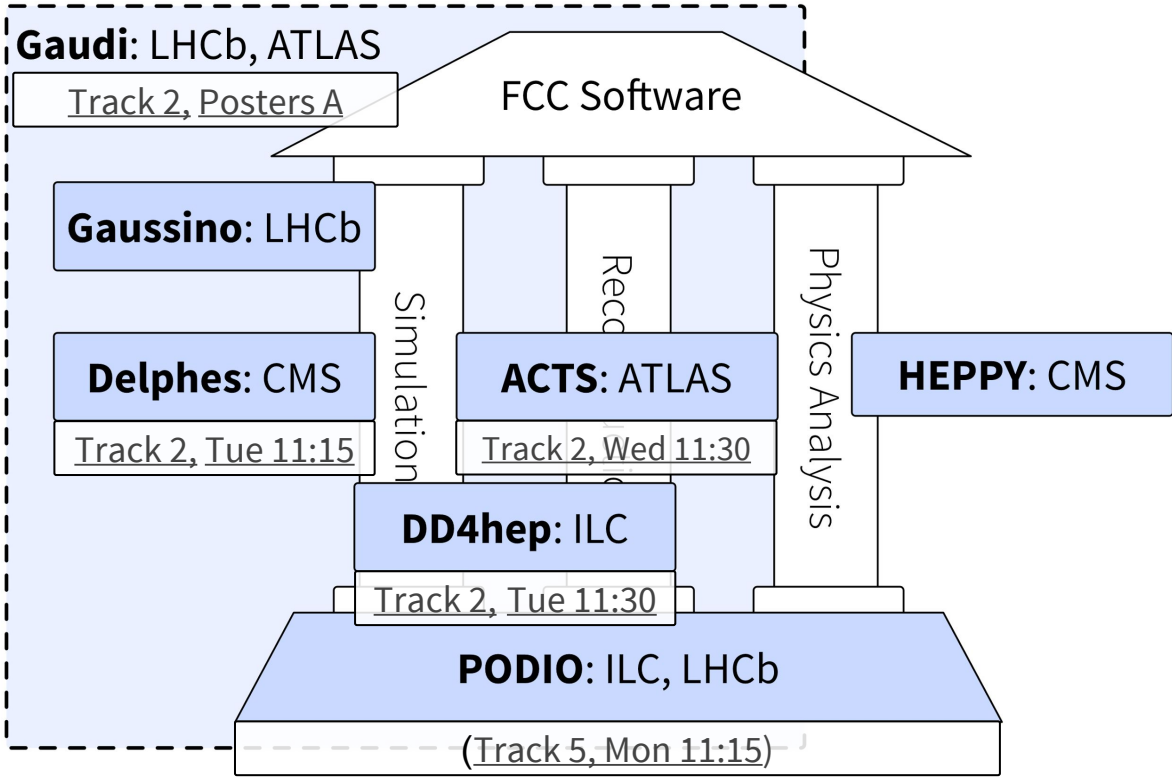


Conclusion

Is it possible to keep software experiment independent? **Yes**

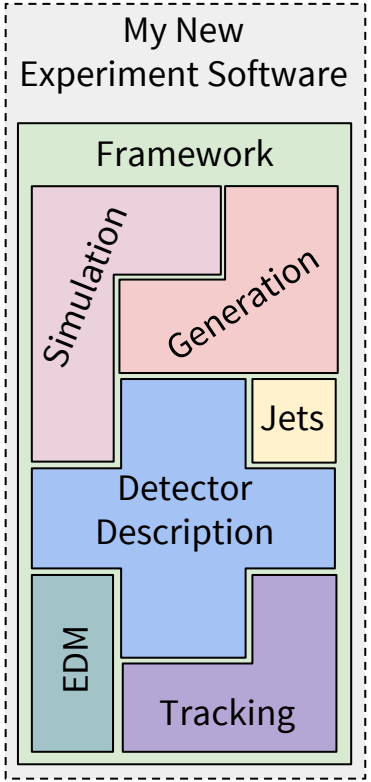
- Met with enthusiasm from the community
  - Developers are happy if their code is reused
- Only a small additional step needed to achieve it

Many good solutions out there

- Cherry pick solutions that fit

Identify areas without obvious candidates

- Invest and give back: Event data model, HEPPY



Thank You

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