Task 12.2 - Turnkey Software

AIDAinnova, 2nd Annual meeting
Valencia

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HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

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AIDA innova

CERN

DESY.

Task 12.2 - Turnkey Software

Overview

- Integrated Turnkey Software Stack, for physics and performance studies
- Simplified data model toolkit for modern hardware platforms
- Digitisation extensions for geometry toolkit
- R&D study on frameworks to manage heterogeneous resources

DESY (lead), CERN,
INFN-PI, (INFN-PD, INFN-BA, INFN-BO - unfunded)
IHEP, SDU - associated

D #	Deliverable Name	Lead beneficiary	Type	Due Date (in months)
D12.1	Turnkey software stack (Key4hep)	12 - DESY	Other	46

MS #	Milestone Name	Lead beneficiary	Due Date (in months)	Means of verification
MS47	LC reconstruction prototype in Key4hep	12 - DESY	21	Reproduce similar detector performance as achieved with the current framework (Task 12.2)

Symbols on coming slides:

✅ Done

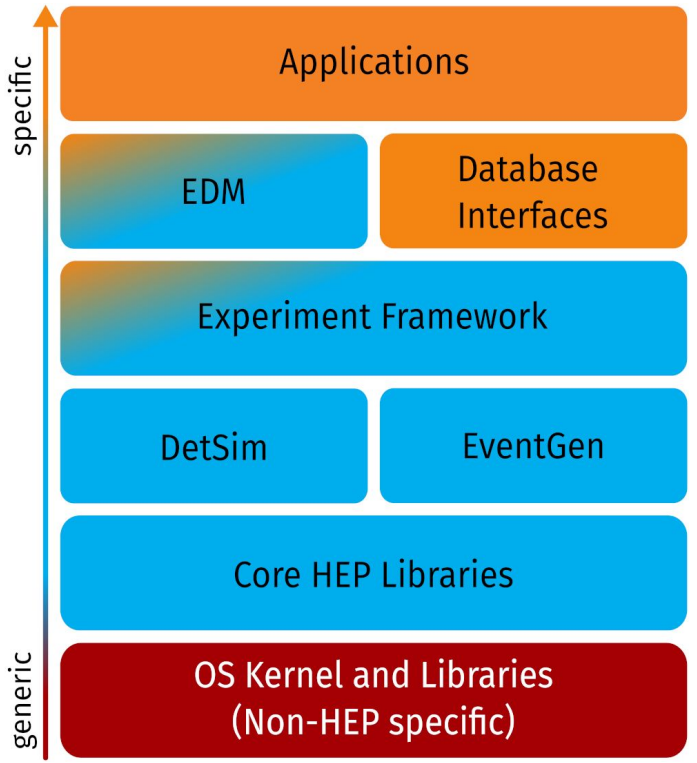
👷 Ongoing or planned

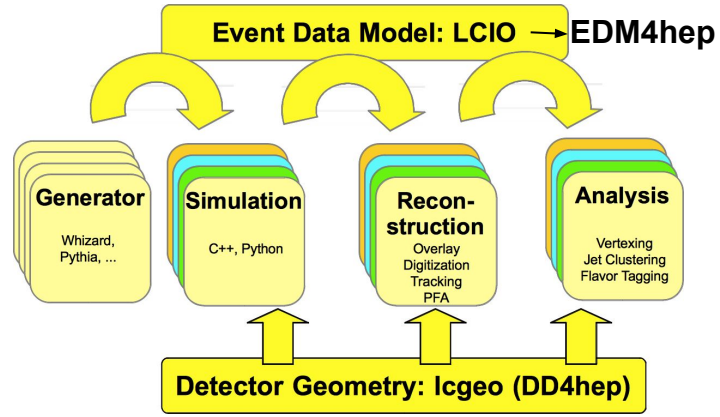
✅

Key4hep

Turnkey software stack for all future collider projects

- Develop a **common turnkey software stack** for future collider studies
- Take existing tools where possible, provide necessary interfaces and contribute to the development
  - A lot of existing software from the shared **iLCSoft** developed by ILC and CLIC for many years
- Develop new tools or libraries where necessary
- All major players involved: CEPC, CLIC, FCC, ILC, EIC, …
- Provide a complete data processing framework
  - Shared components reduce overhead for all users
- Make things as easy to use as possible for everybody (librarians, developers, users)
- Supported by **HSF**, **CERN** and **AIDAinnova**





PODIO

github.com/AIDASoft/podio

The event data model toolkit

- Generate code from simple yaml definition of EDM
- Based on using and storing POD (plain old data) structures
- Make it possible to target different I/O backends

✅ **Frame** class and concept (with accompanying multithreading model)

✅ License change to Apache2

✅ Allow datamodel extensions

✅ Generate code for dumping collections to JSON

✅ Many many changes under the hood

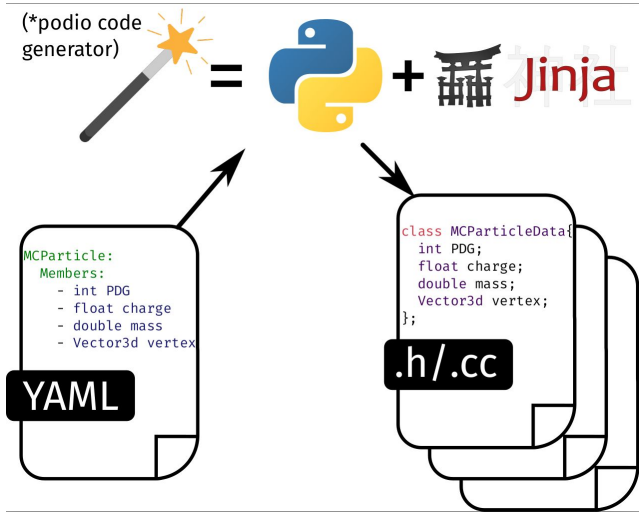
👷 **Schema evolution** of generated EDMs

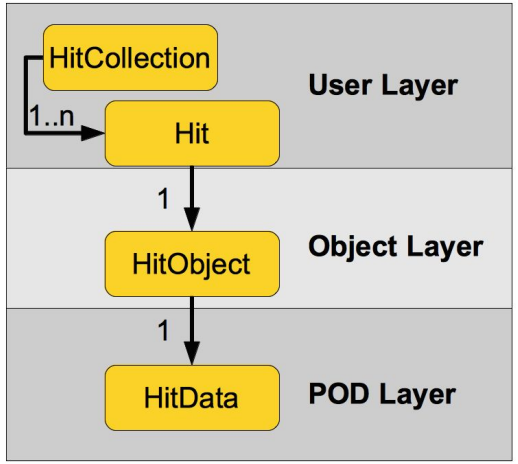
👷 **Version 1.0** (backwards compatibility from then on)

👷 RNTuple based backend (try to merge podio#395 during hackathon)

👷 Some prototyping and testing on heterogeneous resources

👷 Small(-ish) additional features (already a few on the wish list)



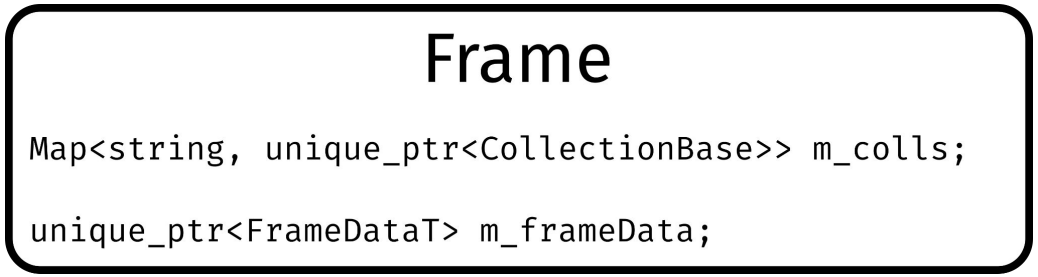


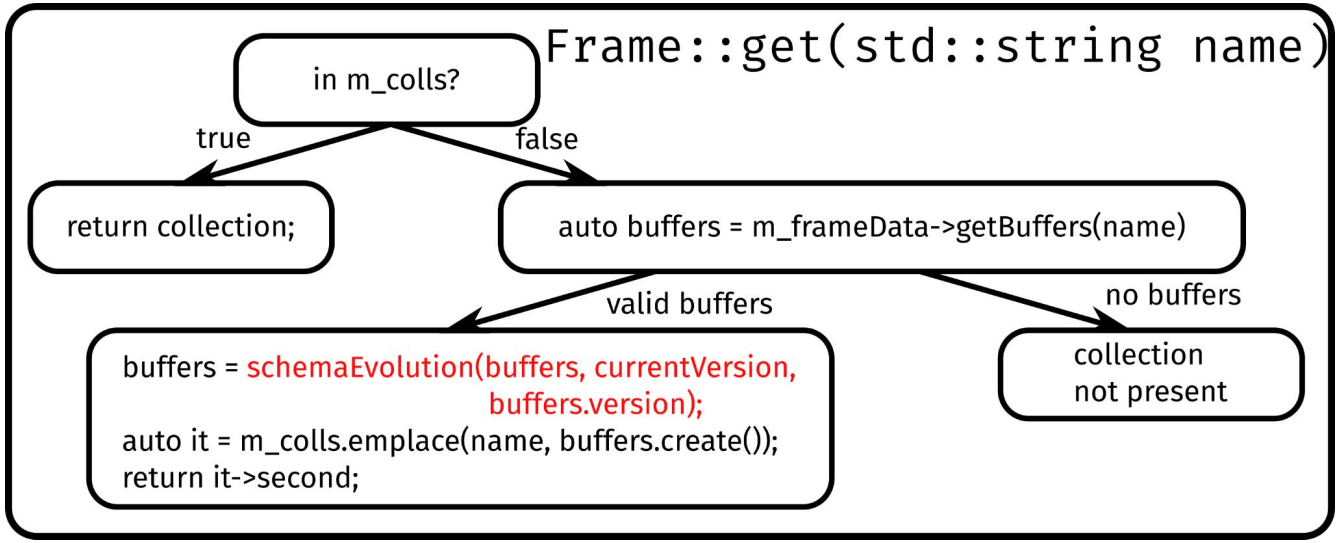
PODIO schema evolution

The feature that keeps on giving

- Biggest missing feature
- Quite large in scope
  - Work with different backends
  - Leverage backend schema evolution if present
  - Support “lazy” unpacking
- Required many under-the-hood changes to podio
- Concept and prototype done
- Currently polishing and refactoring

Conceptual Frame and Frame::get



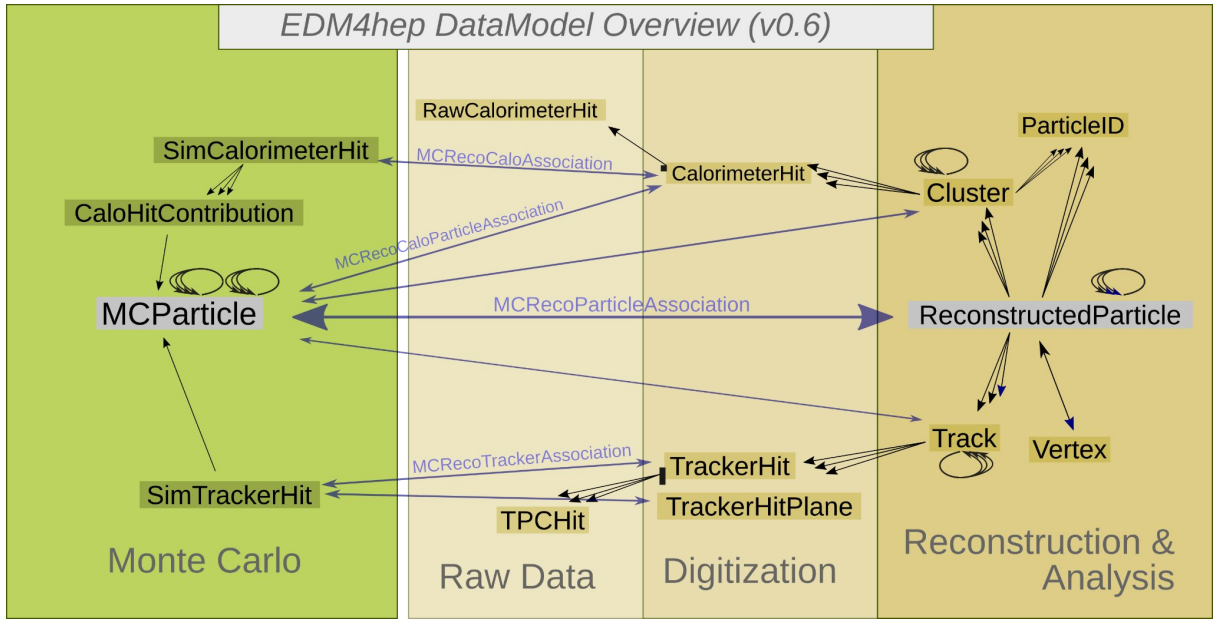


EDM4hep

The common event data model

github.com/key4hep/EDM4hep
edm4hep.web.cern.ch

- EDM4hep defines the common *language* for all Key4hep components to communicate
- Heavily inspired by LCIO that has been successfully shared by ILC and CLIC
  - Additional novel ideas from fcc-edm
- Generated by the PODIO EDM toolkit
  - EDM4hep and EICD main customers of PODIO



✅ Addition of datatypes for drift chamber study

✅ Tool for dumping to JSON for Phoenix event display

✅ Used as “proper” upstream for EICD

👷 **Version 1.0** (backwards compatibility from then on, **needs PODIO schema evolution**)

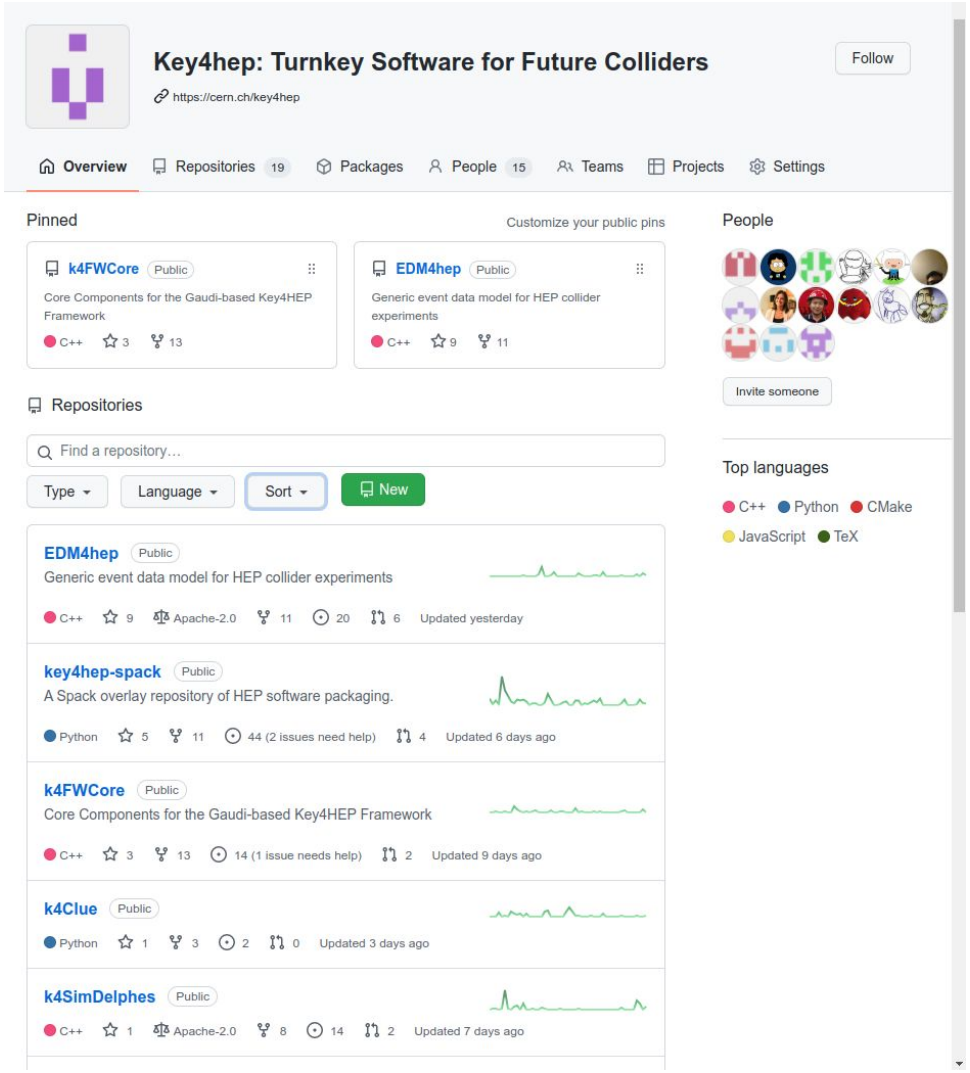
👷 (Standalone) conversion from LCIO

👷 Utility functionality as necessary

Key4hep Framework

github.com/key4hep
key4hep.web.cern.ch

- Gaudi based core framework
  - **k4FWCore** provides I/O for PODIO based EDMs
  - k4SimDelphes for Delphes integration
  - **k4MarlinWrapper** for calling Marlin processors
  - **k4geo** for detector models (rebranded from lcgeo)
  - k4SimGeant4 for Geant4 based simulation
  - k4Gen for generator integration
  - …



✅ **MS47: Comparable performance to iLCSoft via k4MarlinWrapper**

✅ Many small(ish) fixes

👷 Switch FW core to use podio Frames

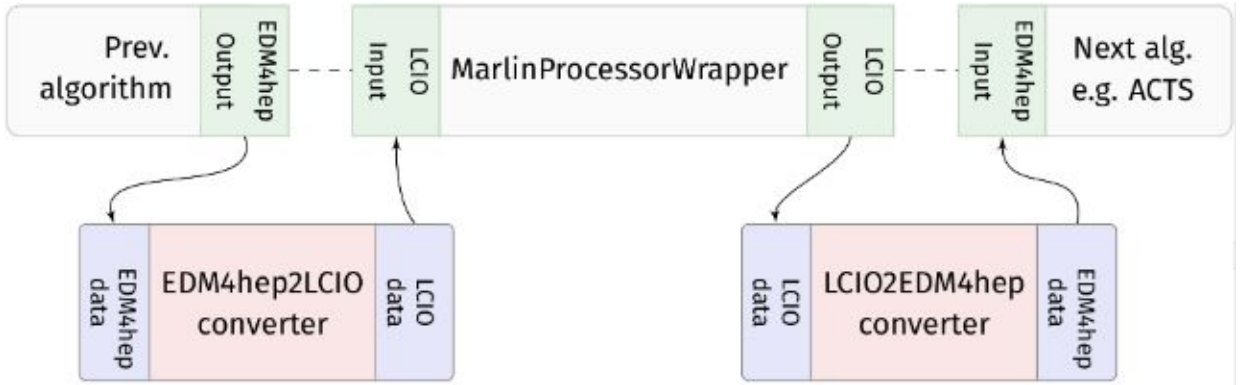
👷 Integration of ACTS, …

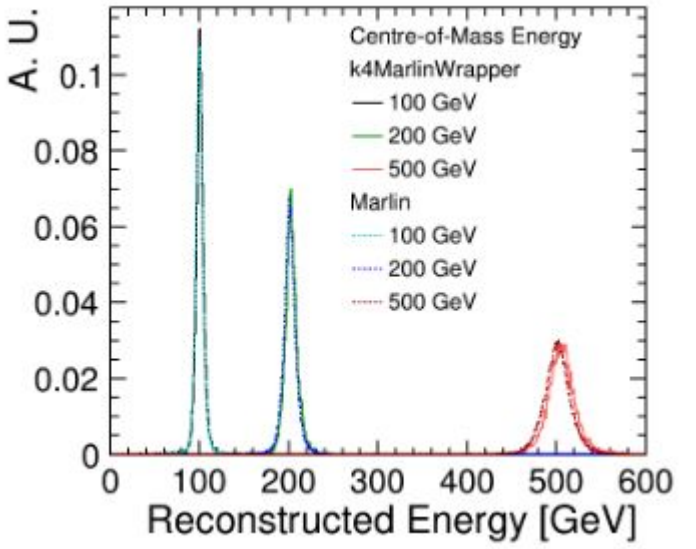
👷 Consolidation of simulation approaches

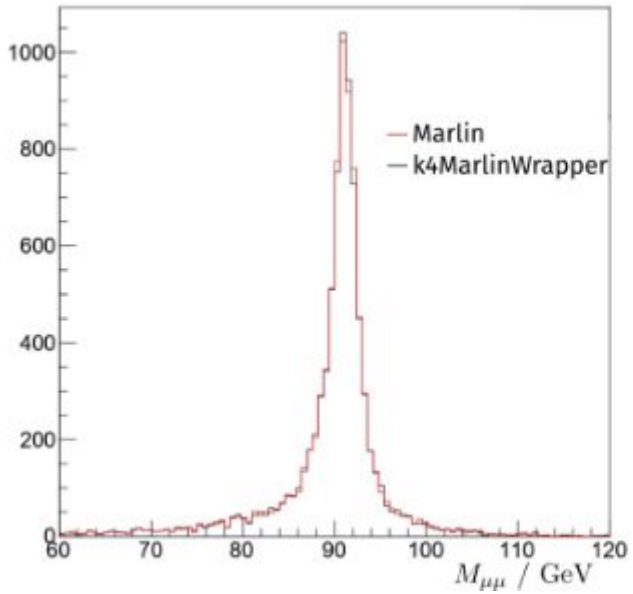
MS47

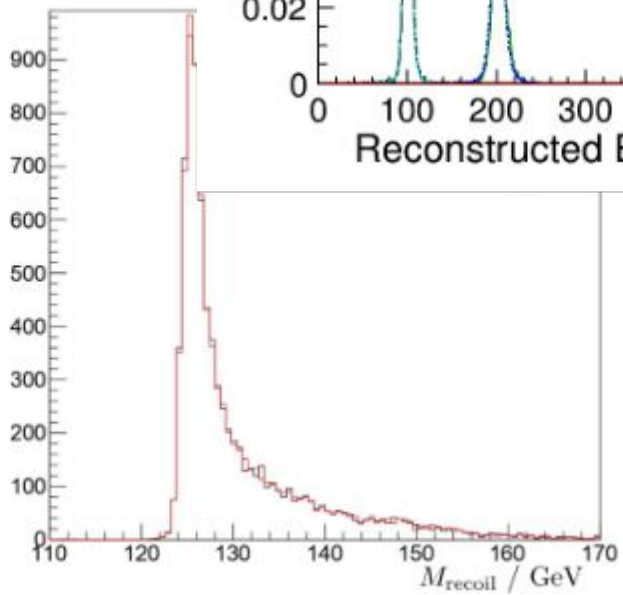
LC reconstruction prototype in Key4hep

- Run unchanged Marlin Processors via Wrapper
- Configurable on-demand conversion between LCIO and EDM4hep (and vice versa)
- Steering file conversion script
- Extended testing uncovered a few smaller issues
- Excellent agreement between Marlin and Gaudi
- CLIC reconstruction run as part of CI for k4MarlinWrapper
- Working horse for k4CLUE studies
- Report online Jan 19, 2023









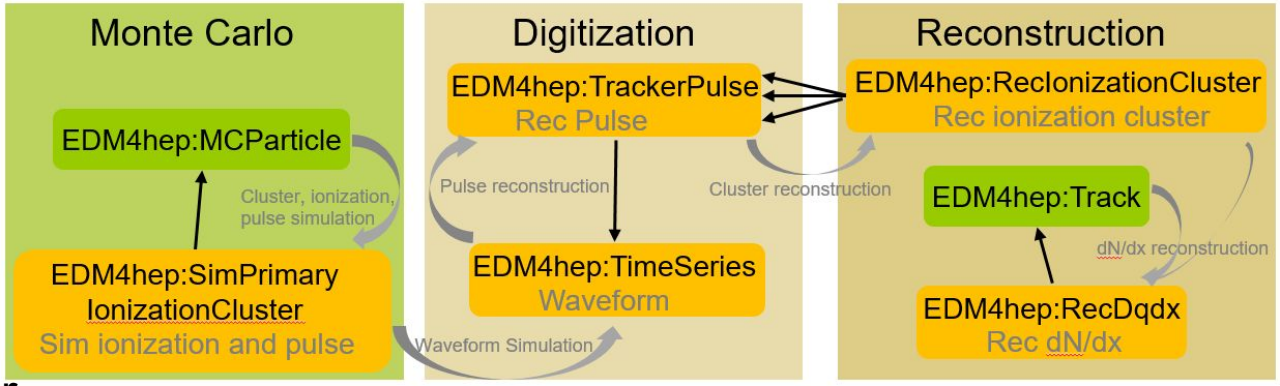
Work at INFN

R&D study on framework to manage heterogeneous resources

- No applicant on second call for dedicated position
  - Despite trying to advertise it as widely as possible
- Competing against numerous other more attractive software/computing positions
  - Both money and career prospects
- Currently figuring out whether a third call is possible
- To be effective would need to be more appealing
  - Funds are rather little

Report from IHEP group

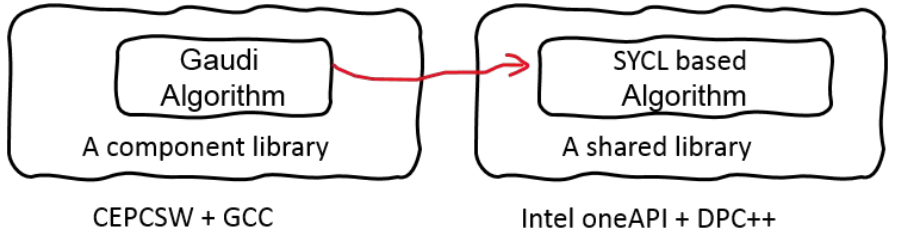
Courtesy Weidong Li



✅ Extending Key4hep to accommodate requirements from simulation of primary ionization in the drift chamber

✅ Integration of ACTS' seeding algorithm (TRACCC) with CEPCS; algorithm using EDM4hep hits as inputs

✅ Prototype for using Gaussino as underlying framework for CEPC detector simulation

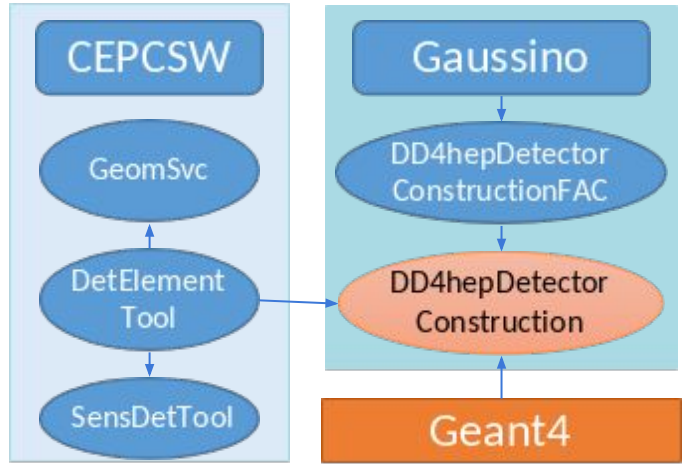


👷 Extend EDM4hep to support ongoing activities in CEPC

- Reconstruction of number of primary ionizations in drift chamber
- Analysis of test beam data for vertex detector prototype

👷 Optimize data flow / communication between CPU and GPU. Investigate possibility of avoiding copies by building a connection between EDM4hep and TRACCCs vecmem

👷 Re-implement CEPC detector simulation with Gaussino

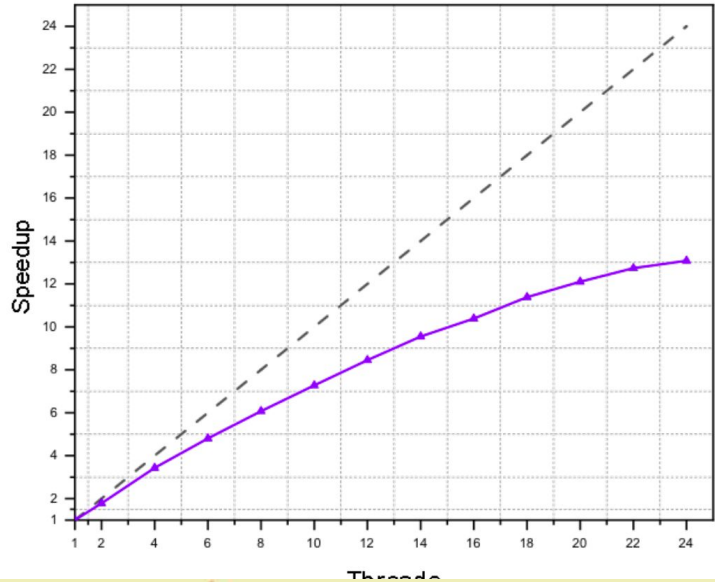


Report from SDU group

Courtesy Xingtao Huang

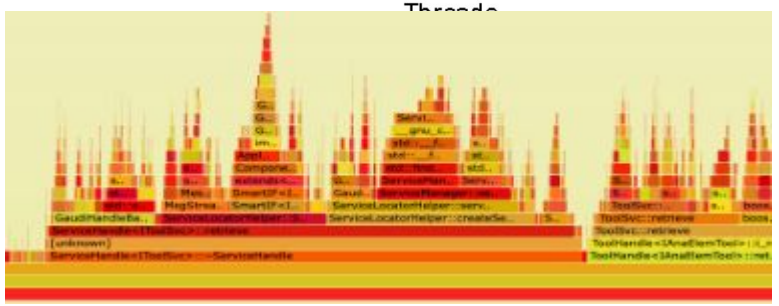
✅ Performance test and development of RDataFrame based Analysis toolkit

- Basic functionality and performance tests using Higgs recoil analysis
- Integration of MarlinKinFit into RDataFrame for CEPC
- Provide example for porting C++ applications to RDataFrame



✅ Developed the Valprod toolkit to support building comprehensive validation jobs

- Integration of Valprod with prmon,
- Enhance Valprod to support disk profiling, drawing on-cpu flame graph,...
- Build basic CI tests for CEPC using Valprod toolkit



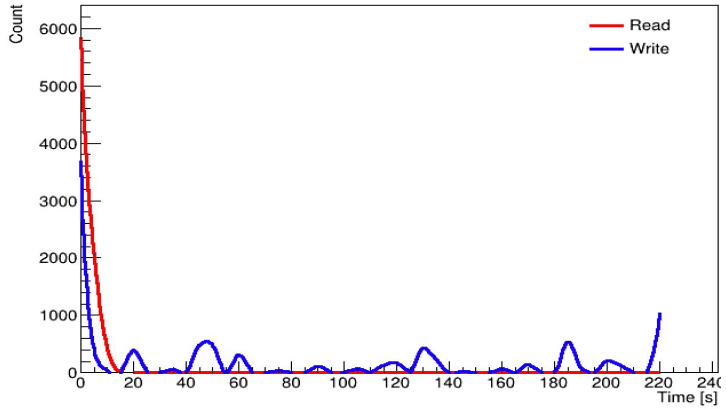
👷 Integrate more missing analysis tools to RDataFrame

👷 Use CEPC beam test data for testing full analysis chain with RDataFrame

👷 Performance tests using multi-threaded RDataFrame and full analysis chain

👷 Continue development of validation system and promote toolkit to other Key4hep components

SimTest IO Operations **CI artifacts**



Summary / Main Goals for the next year

- **Delieverd MS47: LC reconstruction prototype in Key4hep**
- Steady progress in Key4hep
- **First stable releases for PODIO and EDM4hep are in sight**
  - Requires Schema evolution
- First steps on heterogeneous resources with podio generated EDMs
- ACTS integration
- Integration of ML FastSim models into DD4hep
  - Prototype exists
  - Big topic of this years hackathon

Thank you