

# Summary of Software Workshop

Towards a common Turnkey Software Stack

Frank Gaede, DESY  
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# Mini-Workshop

## Requirements of Software for e<sup>+</sup>e<sup>-</sup> Colliders

- one day workshop
- with software experts from all four e<sup>+</sup>e<sup>-</sup> Collider Projects: CEPC, CLIC, FCC and ILC
- follow-up on the **Future Collider Software Workshop** held in June 2019 in Bologna
- were the first steps towards a **common software stack for all four e<sup>+</sup>e<sup>-</sup> colliders** were taken

Introduction: Towards a Common Software for Future HEP Projects

[\[Slides\]](#)

**Paolo GIACOMELLI**

*National Institute for Nuclear Physics (INFN, Bologna)*

The Turnkey Software Stack: Where Are We and Where We Want to Go?

[\[Slides\]](#)

**Gerri GANIS**

*CERN*

EDM4hep: A Common Event Data Model [\[Slides\]](#)

**Frank GAEDE**

*DESY*

Coffee Break (Venue: Open Area, 1/F)

DD4hep and Shareable Detector Geometry Description [\[Slides\]](#)

**Andre SAILER**

*CERN*

CEPC Software Prototype [\[Slides\]](#)

**Jiaheng ZOU**

*Institute of High Energy Physics, Chinese Academy of Sciences*

CEPC Simulation [\[Slides\]](#)

**Tao LIN**

*Institute of High Energy Physics, Chinese Academy of Sciences*

A Worldwide Software Collaboration? [\[Slides\]](#)

**David LANGE**

*Princeton University*

Coffee Break (Venue: Open Area, 1/F)

Future Software Implementations [\[Slides\]](#)

**Gerri GANIS, Xingtao HUANG and All**

Wrap Up and Next Goals [\[Slides\]](#)

**Paolo GIACOMELLI and All**

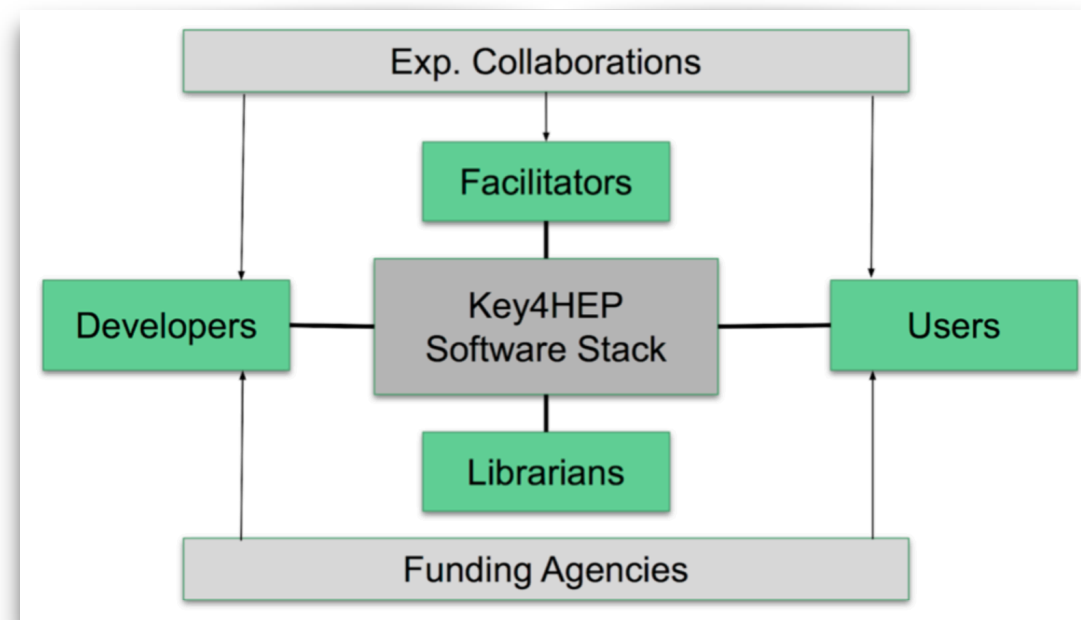
# Introduction

## Outcome of the Bologna Meeting

- many software experts from future collider collaboration and working groups: ILC, CLIC, FCC, CEPC, SCTF,...
- at the end of the workshop there was the overall agreement that we should try and work towards a common turnkey software stack: **Key4hep**
- based on:
  - standard HEP and external libraries like ROOT, Geant4, HepMC, VecGeom, boost, Eigen,...
  - **DD4hep, PODIO, ACTS, PandoraPFA,...**
  - new common Event Data Model: **EDM4hep**
  - use the primarily the **Gaudi** framework

note that this is a **quite remarkable** outcome and at the same time a rather **ambitious** goal

P.Giacomelli



## Purpose of today's workshop

- Keep the **same collaborative spirit** shown at the meeting in Bologna!
- Continue in the footsteps of the first workshop
- Show the development done since Bologna's workshop
- Illustrate and detail the next steps of the development of the common software
- Describe the action items

# The Turnkey Software Stack

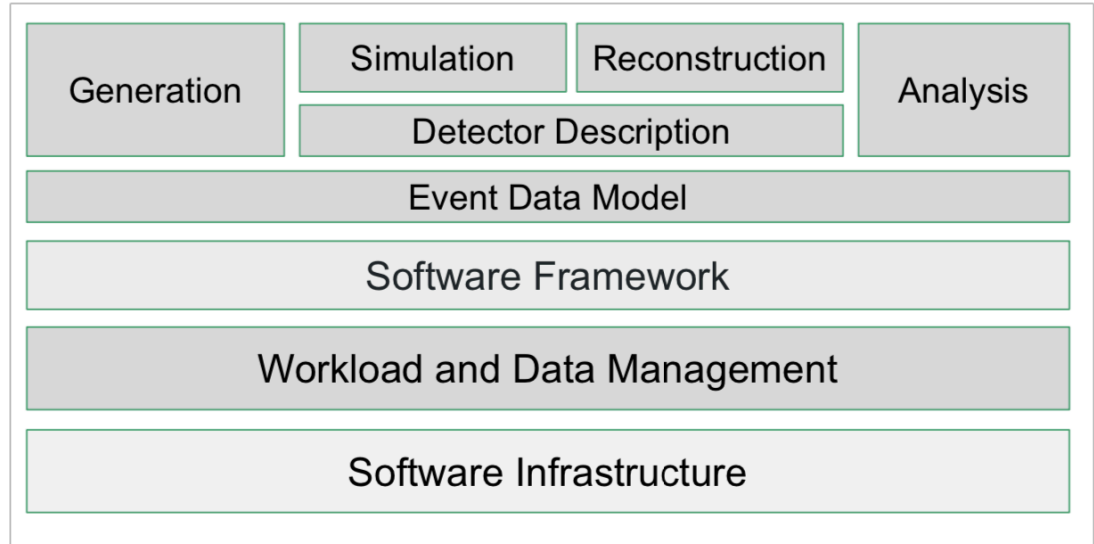
G.Ganis

work on Key4hep has started - mostly at CERN:

- **Manpower *quest***
  - **AIDA++** software submissions included Key4hep as R&D line
  - **EP software R&D** working package got concrete
    - A fellow hired, started Jan 2020 ( V Volkl)
  - Second CERN fellow hired on **CREMLIN PLUS** funds
    - starting in March 2020
- **Dissemination of the idea**
  - Collaboration meetings: FCC, CLIC, ...
  - Talk at CHEP 2019

important to have dedicated manpower assigned to the overall integration of Key4hep

A generic Software Stack in HEP:



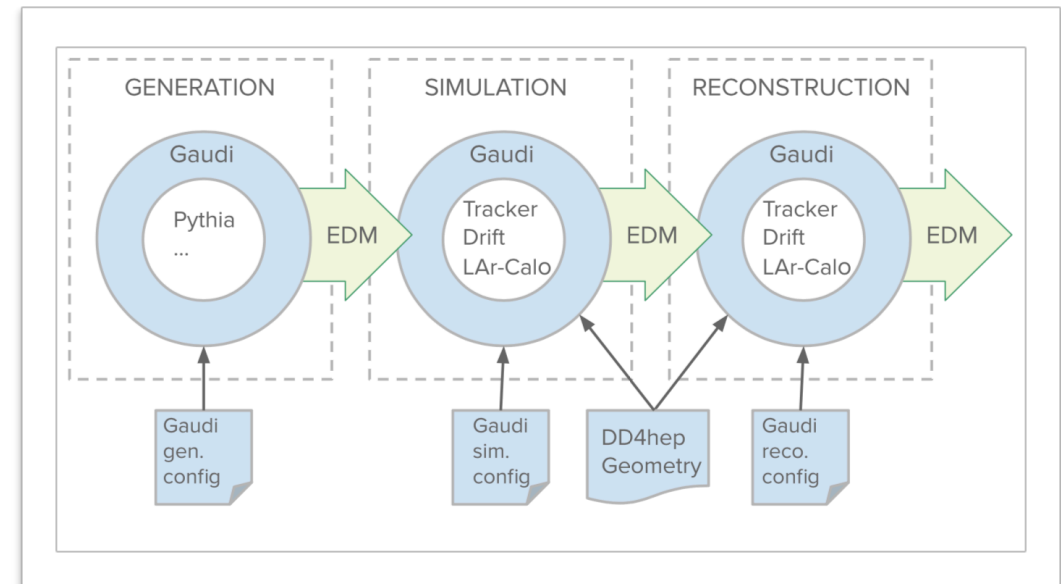
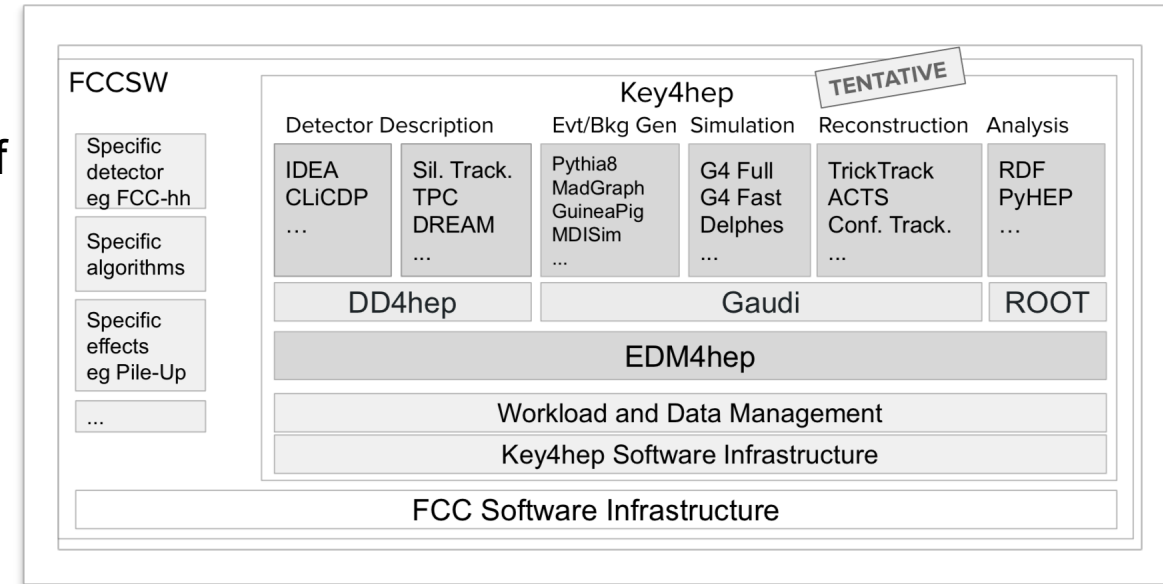
this needs to be filled with life using the agreed upon components

# The FCC Software Framework

G.Ganis

- FCC already has setup a software framework with most of the core components envisaged for **Key4hep**
- yet missing are **reconstruction tools**:
  - tracking tools
  - PandoraPFA
  - HLR tools: flavour tagging, jet finding, PID,...
- > **all of this is already available in the LC Marlin world**
- and **EDM4hep** is not yet used (available)

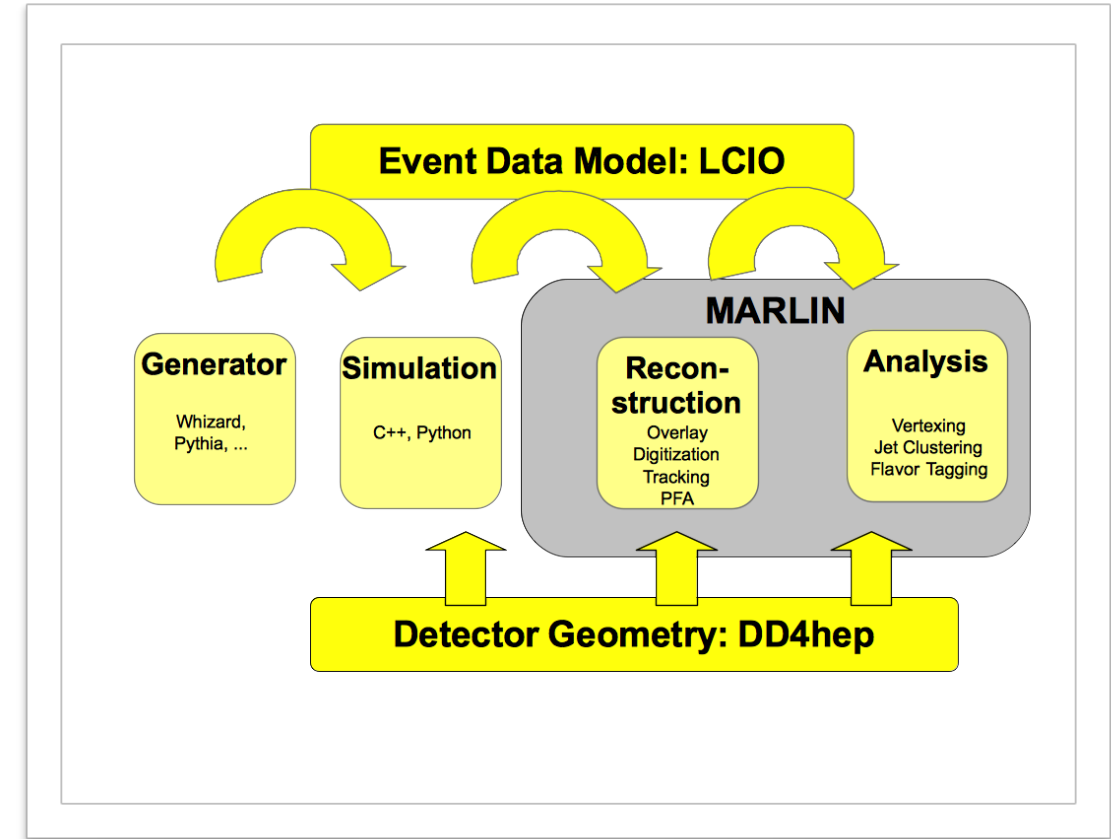
open question:  
should generator and simulation be run in Gaudi or standalone ?  
-> **should be flexible and allow both approaches in Key4hep**



# The ILC software framework



- the ILC community has started with common software tools already in 2003 with the development of the common event data model **LCIO**
  - four different experiments with four different frameworks at the time
- this has developed into **iLCSoft** which is now used by ILC, CLICdp, CEPC, partly FCC-ee, Calice, LCTPC, HPS,...
- it uses the **Marlin** framework and **DD4hep** for the geometry description (and Geant4 simulation)
- **a complete suite of digitisation, tracking, PFA and HLR tools exist**
- these have been battle proven in several **large Monte Carlo campaigns**

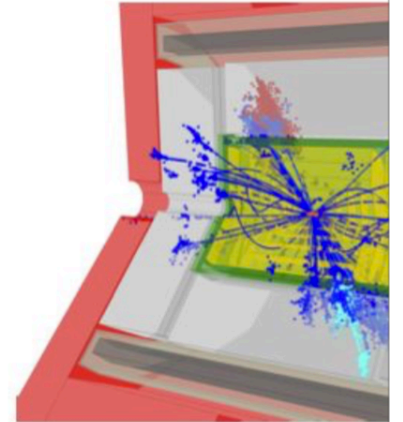


it is important for the ILC community to preserve all the existing functionality when moving to Key4hep

- CLICdp uses also the iLCSoft framework
- mostly the same algorithms as used for ILC, tuned and optimised for the CLIC detector
- also some specific algorithms for CLIC, e.g.
- ConformalTracking: pattern recognition algorithm based on **conformal mapping** and **cellular automata**
  - rather geometry agnostic -> could easily be adapted to other (Si-tracking) detectors
- developed a programme based on **adiabatic changes** to move from iLCSoft to Key4hep
  - based on **Gaudi-Marlin wrapper**

## CLIC Reco Evolution: Adiabatic Changes

- Full CLIC reconstruction implemented in iLCSoft
- While transitioning to KEY4HEP, need to be able to keep running the CLIC reconstruction
- Switch components one by one, validate changes
  - Geometry provided by DD4HEP, no changes needed
  - Move framework from Marlin to Gaudi: wrap existing processors
  - Move from LCIO to EDM4HEP
  - Replace wrapped processors with native Gaudi algorithms
- Incidentally will make iLCSoft functionality available to other users of the stack



also CLICdp community needs to preserve all the existing functionality when moving to Key4hep



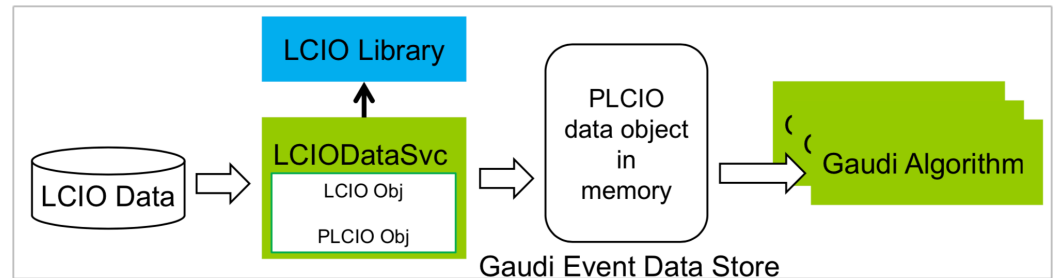
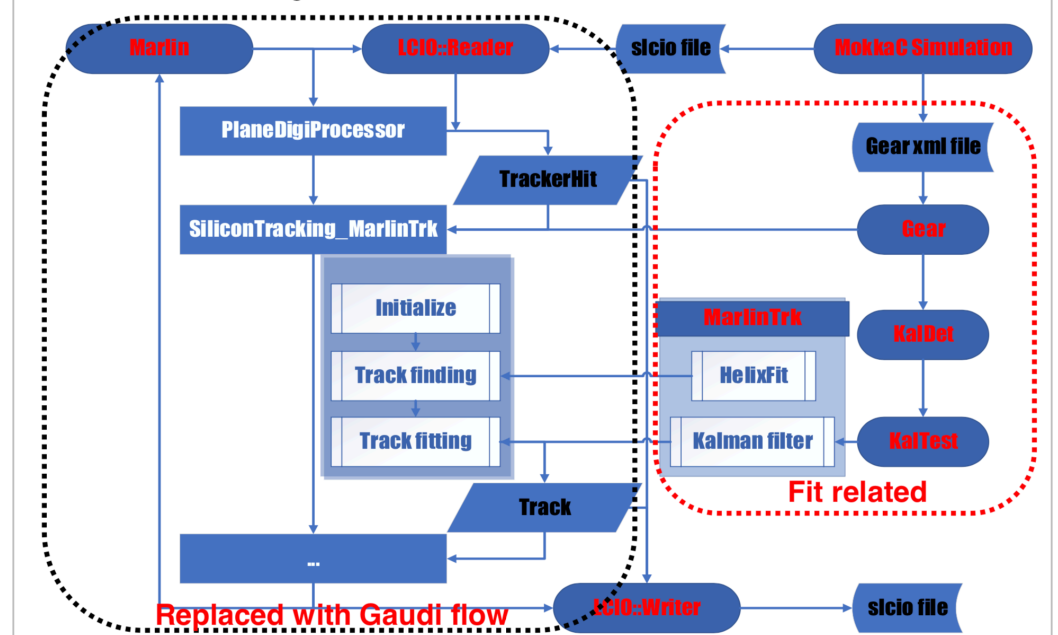
# The CEPC software framework

J.Zou

- started out from using **iLCSoft** (and ILD detector)
  - used for CDR (2018)
- now planning to use Key4hep eventually
  - started with using **pLCIO** and porting algorithms from Marlin to Gaudi
  - developed **LCIODataSVC** -> **pLCIO** object in memory
- ported **SiliconTracking** from **MarlinTrk** into Gaudi
- also ported **DDPlanarDigi** to DDPlanarSrv

very useful alternative route for the transition from **iLCSoft** to **Key4hep**  
need to make sure that we soon integrate the different transition solutions from FCC, CLIC and CEPC

As a first step, the SiliconTracking algorithm is ported from iLCSoft to CEPSCSW  
The results are intelligible same as Marlin's.

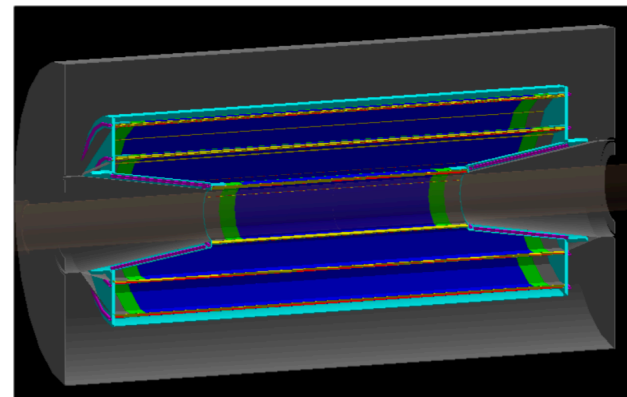
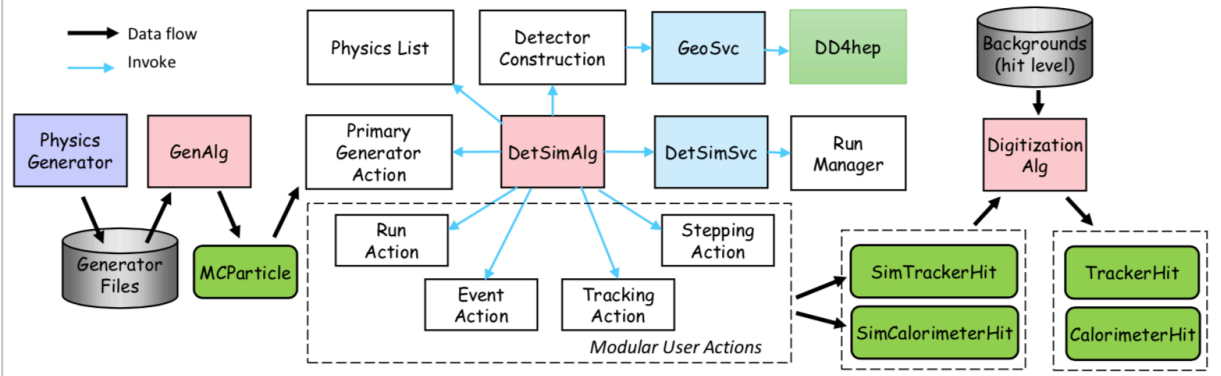




- started to port the detector simulation model from the (old) iLCSoft Mokka simulation tool to DD4hep
- run the Geant4 simulation within the Gaudi framework
- developed a number of **GenTools** for reading generator information, conversion to *MCParticle*, a particle gun, etc
- Note: most of this and more plugins for MCTruth linking etc. are already available in DD4hep/DDG4 and used by ILC/CLIC <-> need to understand differences
- CEPC also working on parallelising the simulation with MT and MPI (for HPC resources)
  - interesting for Key4hep

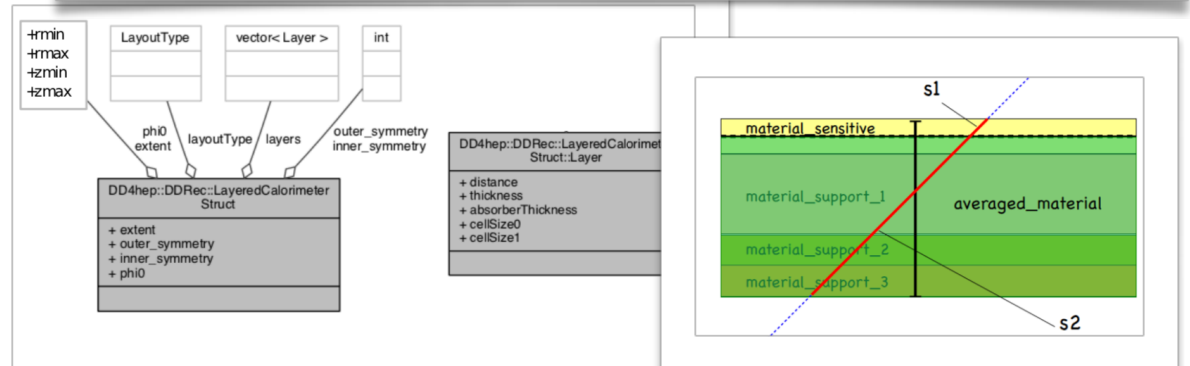
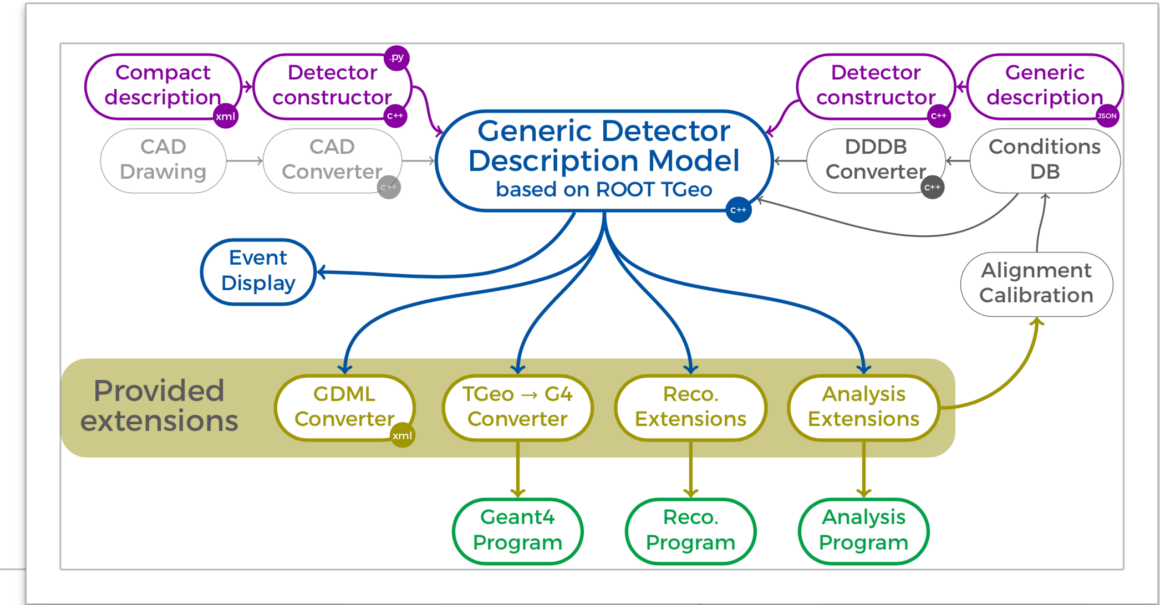
## Design of simulation framework

- Based on Gaudi and DD4hep.
  - Reuse part of interfaces defined in FCCSW.
- In the current prototype, “Tracker” is setup.



VXD detector  
implemented  
in DD4hep

- DD4hep originally developed in context of ILC/CLIC
- provides complete solution for **detector description, simulation, interface to reconstruction**, conditions and alignment
- large palette of **sub-detector drivers** exist - generic and CLICdp, ILD specific
  - to be extended as needed, e.g.
  - **drift chamber** and **dual readout calorimeter**
- DDPec: interface to geometry as needed for reconstruction
  - surfaces and generic detector classes
  - to be extended in a generic way



| Data Structure         | Detector Type            |
|------------------------|--------------------------|
| ConicalSupportData     | Cones and Tubes          |
| FixedPadSizeTPCData    | Cylindrical TPC          |
| LayeredCalorimeterData | Sandwich Calorimeters    |
| ZPlanarData            | Planar Silicon Trackers  |
| ZDiskPetalsData        | Forward Silicon Trackers |

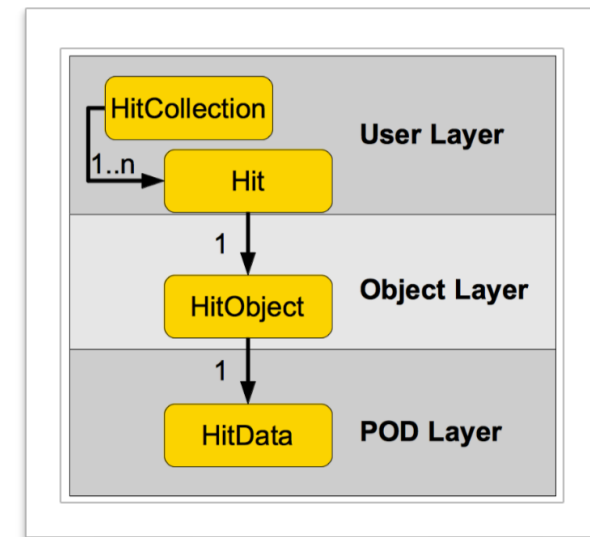
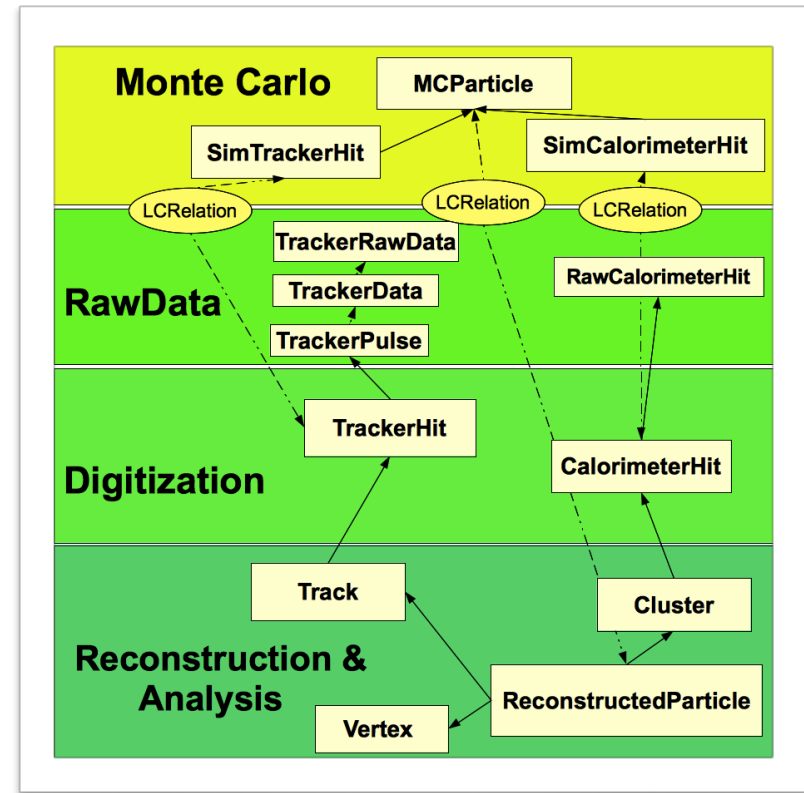
ddrec::Surface geometry for track reconstruction

# EDM4hep

## The common Event Data Model for HEP

- the LCIO EDM has been a great success for the common software framework iLCSoft of the linear collider community
- it provided the basis for collaboration for more than 15 years
- EDM4hep** should be a successor with **modernised EDM and better I/O performance**
  - based on LCIO and the fcc-edm
  - implemented using **PODIO**
- PODIO: EDM tool based on storing PODs with ROOT I/O
  - already used in the FCCSW and by pLCIO
  - pLCIO: almost complete re-implementation of LCIO in PODIO
- started with Simulation model: *MCParticle* *SimTrackerHit*, *SimCalorimeterHit* - next: **tracking classes**

involve experts from **all four colliders** in defining the EDM  
try to be **close to LCIO** to preserve all the existing code base



# A worldwide Software Collaboration ?

D.Lange

## The LHC perspective on Key4hep

- LHC started with idea of having a common software stack - in the end only few common tools remained
- new common solutions arose with time, e.g: DD4hep
- HL-LHC is facing tremendous computing challenges
- HSF created to provide a platform addressing these challenges in a collaborative way - first outcome:
  - CWP process: “A Roadmap for HEP Software and Computing R&D”
- have started iris-HEP fellows programme in the US to address common HEP computing issues
  - could contribute to future collider community

Key4hep not targeted at HL-LHC - but we should of course stay close to LHC developments, even though our requirements are quite different



The HEP Software Foundation facilitates cooperation and **common efforts** in High Energy Physics software and computing internationally.

- The HSF (<http://hepsoftwarefoundation.org>) was created in early 2015 as a means for organizing our community to address the software challenges of future projects such as the HL-LHC. The HSF has the following objectives:
  - Catalyze new common projects
  - Promote commonality and collaboration in new developments to make the most of limited resources
  - Provide a framework for attracting effort and support to S&C common projects (new resources!)
  - Provide a structure to set priorities and goals for the work

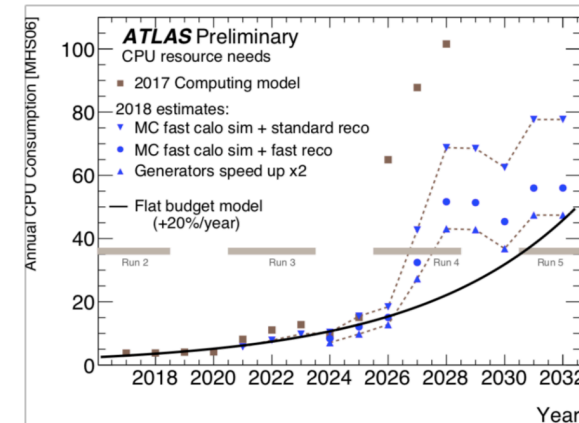
## Community White Paper

Now published in “Computing and Software for Big Science”  
<https://link.springer.com/article/10.1007/s41781-018-001>

### A Roadmap for HEP Software and Computing R&D for the 2020s

HEP Software Foundation<sup>1</sup>

ABSTRACT: Particle physics has an ambitious and broad experimental programme for the coming decades. This programme requires large investments in detector hardware, either to build new facilities and experiments, or to upgrade existing ones. Similarly, it requires commensurate investment in the R&D of software to acquire, manage, process, and analyse the sheer amounts of data to be recorded. In planning for the HL-LHC in particular, it is critical that all of the collaborating stakeholders agree on the software goals and priorities, and that the efforts complement each other. In this spirit, this white paper describes the R&D activities required to prepare for this software upgrade.



# Conclusion

## Summary of discussion at the end of the workshop

- workshop showed **quite some progress** in all four collider communities since Bologna meeting
- also many **open questions identified**, e.g. how to exactly go about the transition from iLCSoft/ Marlin to the new Gaudi based world
  - have seen quite different approaches
  - need to be flexible for quite some time
- however: general **agreement to continue the collaboration** and work towards a common Key4hep framework
- started to put together a long list of To-Do items in order to make progress fast
- some immediate To-Do items:
  - **goal: get a first version of Key4hep with core component and a data service based on EDM4hep**
    - setup Hey4hep mailing list
    - call for regular phone meetings
    - setup **Git project Key4hep** and add new packages there, e.g.
      - FWCore component, space installation scripts, experiment specific configurations
  - organise a dedicated software workshop in a few months from now

**overall a very useful software workshop - but the real work is now ahead of us ...**