EDM4hep and podio - The event data model of the Key4hep project and its implementation

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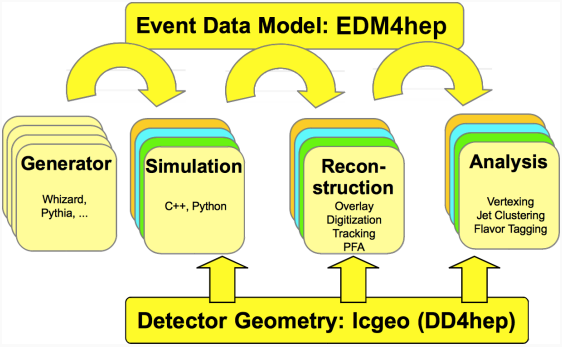
The EDM at the core of HEP software



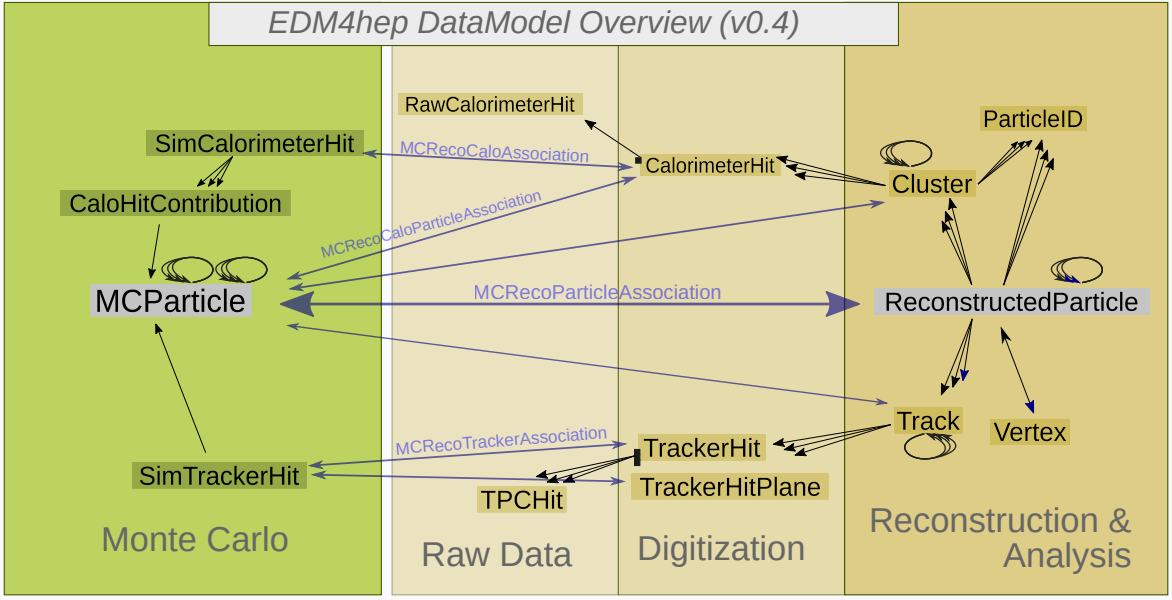
- Different components of HEP experiment software have to talk to each other
- The event data model defines the language for this communication
- Users express their ideas in the same language

Goals for EDM4hep

key4hep/EDM4hep

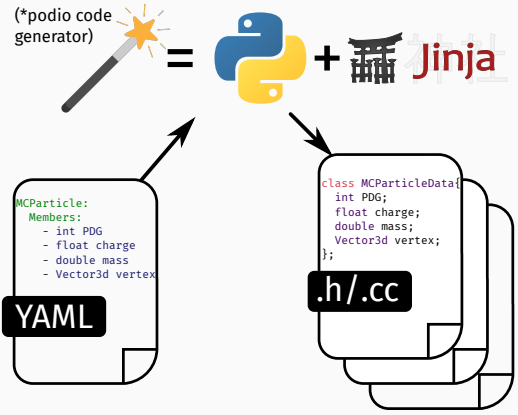
- The Key4hep project aims to define a **common software stack for all future collider projects**
- EDM4hep is the common EDM that can be used by all communities in the Key4Hep project
  - **ILC, CLIC, FCC-ee & FCC-hh, CEPC, EIC, ...**
- Efficiently implemented, support multi-threading and potentially heterogeneous computing

EDM4hep schema



podio as generator for EDM4hep

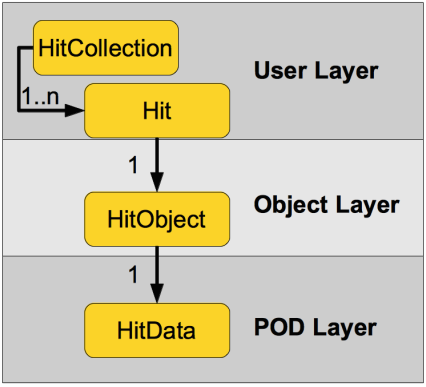
- Traditionally HEP c++ EDMs are heavily Object Oriented
- Use `podio` to generate thread safe code starting from a high level description
- Provide an easy to use interface to the users



AIDASoft/podio

The three layers of podio

- podio favors **composition over inheritance** and uses **plain-old-data (POD)** types wherever possible
- Layered design allows for efficient memory layout and performant I/O implementation



podio - features of generated code

- c++17 code with “value semantics”

```cpp
auto particles = MCParticleCollection();
// ... fill ...

for (auto mc : particles) {
  auto mass = mc.getMass();
  for (auto p : mc.getParents()) {
    auto pid = p.getPDG();
  }
}
```

- Python bindings via PyROOT

```python
particles = MCParticleCollection()
# ... fill ...

for mc in particles:
  mass = mc.getMass()
  for p in mc.getParents():
    pid = p.getPDG()
```

- Easy to read ROOT files

```python
d = ROOT.RDataFrame('events', 'events.root')
h = (d.Define('abs_pdg', 'abs(Particle.PDG)')
      .Define('mu_sel', 'abs_pdg == 13')
      .Define('mu_px',
              'Particle.momentum.x[mu_sel]')
      .Histo1D('mu_px'))
h.DrawCopy()
```

Summary & Outlook

Summary

- EDM4hep is the common EDM for all future collider projects
- It is generated via podio from a high level description

Next steps / TODO list

- Schema evolution for EDMs
- `podio::Frame` - a generalied “event”
- Support for usage on heterogenous resources
- ...


Backup

podio - datamodel definition

```yaml
components:
  edm4hep::Vector3f:
    Members: [float x, float y, float z]

datatypes:
  edm4hep::ReconstructedParticle:
    Description: "Reconstructed Particle"
    Author : "F.Gaede, DESY"
    Members:
      - edm4hep::Vector3f     momentum   // [GeV] particle momentum
      - std::array<float, 10> covMatrix  // energy-momentum covariance
    OneToOneRelations:
      - edm4hep::Vertex startVertex // start vertex associated to this particle
    OneToManyRelations:
      - edm4hep::Cluster clusters  // clusters that have been used for this particle
      - edm4hep::ReconstructedParticle particles // associated particles
    ExtraCode:
      declaration: "bool isCompund() const { return particles_size() > 0; }\n"

  edm4hep::ParticleID:
    VectorMembers:
      - float parameters // hypothesis params
```

*extracted from edm4hep.yaml

- Reusable components
- Fixed sized arrays as members
- *VectorMembers* for variable sized array members
- 1 – 1 and 1 – N relations
- Additional user-provided code

CMake interface for projects using podio

```cmake
find_package(PODIO)

# generate the c++ code from the yaml definition
PODIO_GENERATE_DATAMODEL(edm4hep edm4hep.yaml headers sources IO_BACKEND_HANDLERS "ROOT;SIO")
# compile the core data model shared library (no I/O)
PODIO_ADD_DATAMODEL_CORE_LIB(edm4hep "${headers}" "${sources}")
# generate and compile the ROOT I/O dictionary
PODIO_ADD_ROOT_IO_DICT(edm4hepDict edm4hep "${headers}" src/selection.xml)
# compile the SIOBlocks shared library for the SIO backend
PODIO_ADD_SIO_IO_BLOCKS(edm4hep "${headers}" "${sources}")

# Install the created targets
install(TARGETS edm4hep edm4hepDict edm4hepSioBlocks)
```

- Easy to use functions for integrating a podio generated EDM into a project
- Split into core EDM library and I/O handling for different backends
  - Pick what you need
  - I/O handling parts dynamically loaded by podio on startup (searching `LD_LIBRARY_PATH`)

The I/O in podio

- I/O operations are based on collections
- Concatenate the different parts into arrays of PODs
- I/O backends only have to be able to read / write arrays of PODs. The rest is handled by podio