Status of EDM4hep

Towards a first stable release

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ILD group meeting

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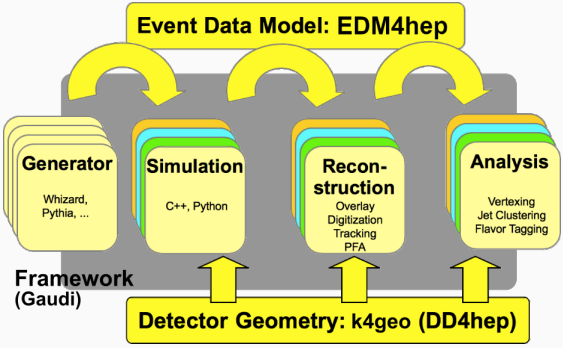
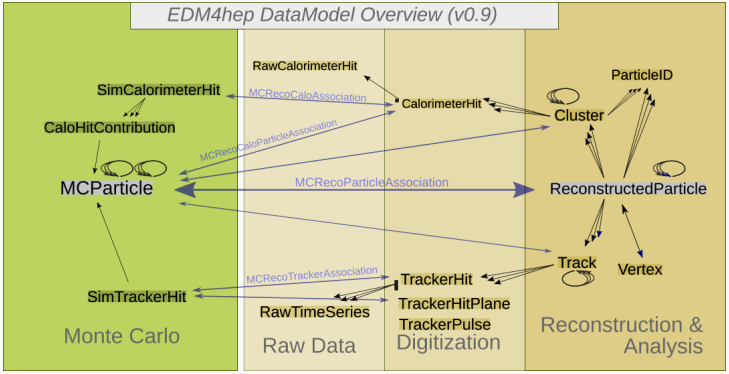
The EDM at the core of HEP software



- Different components of 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

EDM4hep - The common EDM for Key4hep



key4hep/EDM4hep

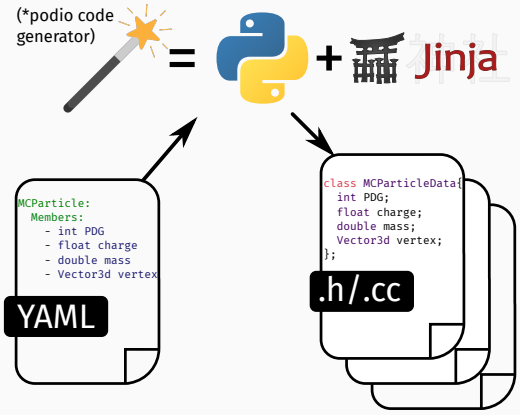
edm4hep.web.cern.ch

AIDASoft/podio

- Based on `LCIO` and `FCC-edm`
  - Focus on usability in analysis
- Quite stable over the last two years
  - **Some breaking changes recently for v1.0!**
- Can easily be extended
  - Used by EDM4eic
  - Prototyping!
- Generated via `podio`

The podio EDM toolkit

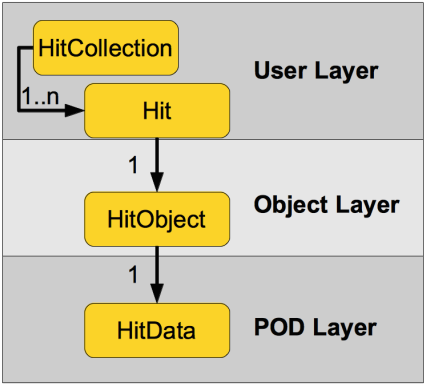
- Implementing a performant event data model (EDM) is non-trivial
- Use `podio` to generate code starting from a high level description
- Provide an easy to use interface to the users
- Main customers and feature drivers
  - key4hep/EDM4hep
  - eic/EDM4eic



AIDASoft/podio

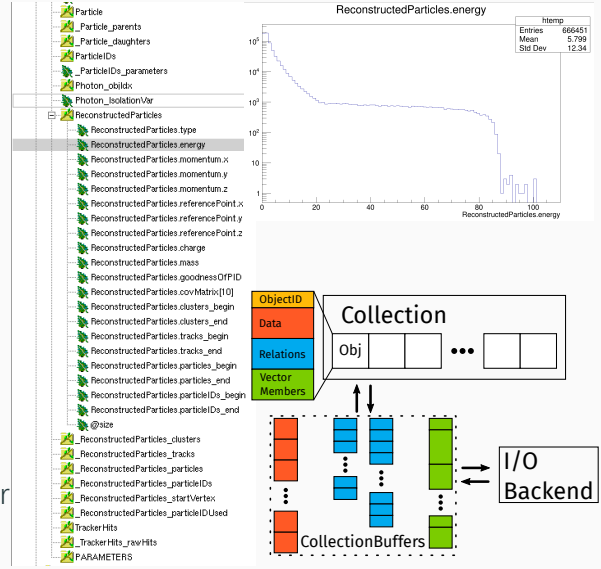
The three layers of podio

- 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 supports different I/O backends

- Default **ROOT** backend
  - Effectively flat ntuples (`TTree` / `RNTuple`)
  - Files can be interpreted **without EDM library**(!)
  - Can be used in `RDataFrame` (**FCCAnalyses**) or with `uproot`
  - Also with Julia
- Adding more I/O backends is possible
  - Alternative SIO backend exists
  - Working on `RDataSource` for better RDataFrame integration

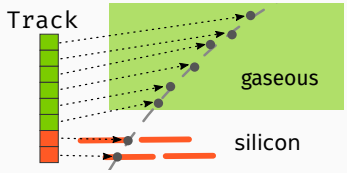


Schema evolution


```
Comparing datamodel versions v2 and v1

Found 3 schema changes:
 - 'ex2::NamespaceStruct' has an addded member 'y'
 - 'ex2::NamespaceStruct' has a dropped member 'y_old'
 - 'ExampleStruct.x' changed type from 'int' to 'double'

Warnings:
 - Definition 'ex2::NamespaceStruct' has a potential [...]

ERRORS:
 - Forbidden schema change in 'ExampleStruct' for 'x' [...]
```

- Allow to read old versions of an EDM from file and convert “on-the-fly”
- Hard problem with many considerations
  - Leverage backend if possible
  - Allow user defined evolution
- **Evolution always directly to current version**
- Detect potential problems at code generation
  - Expand available automatic evolutions as necessary
- **Machinery in place**; “whatever ROOT can do” for now

Interface types and their use in EDM4hep



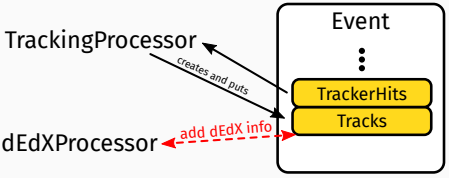

```yaml
interfaces:
  edm4hep::TrackerHit:
    Types: [edm4hep::TrackerHit3D, edm4hep::TrackerHitPlane]
    Members:
      - edm4hep::Vector3f position [mm] // hit position

datatypes:
  edm4hep::Track:
    OneToManyRelations:
      - edm4hep::TrackerHit trackerHits // hits of this track
```

```cpp
auto track = edm4hep::Track{};
track.addHit(edm4hep::TrackerHit3D{});
track.addHit(edm4hep::TrackerHitPlane{});

const auto hits = track.getHits();
hits[0].isA<edm4hep::TrackerHit3D>();       // <-- true
hits[0].getValue<edm4hep::TrackerHit3D>(); // <-- "cast back"
hits[1].isA<edm4hep::TrackerHit3D>();       // <-- false
hits[1].getValue<edm4hep::TrackerHit3D>(); // <-- exception!
```

- General interface can be useful to "gloss over some details"
- Value semantics prevent inheritance based approach
  - Pointers in interfaces break consistency
  - No base class to inherit from
- Introduce *interfaces* as new category in YAML definition
  - Define desired functionality
  - **No collections!**
  - Use like normal *datatypes*
  - "Casting back" is possible

Consistent mutability concept

- Some inconsistencies inherited from LCIO
  - Stricter multithreading concept in EDM4hep
- *Things can only be mutated during creation*
  - Trivial thread safety
  - Improved provenance
- Opportunity to “clean up” some things
- Some workflows cannot be directly ported

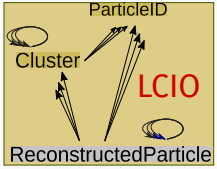


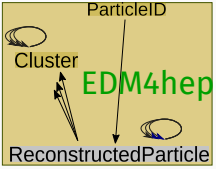

```
edm4hep::RecDqdx:
  Description: "dE/dx or dN/dx"
  Members:
    - edm4hep::Quantity dQdx  // value + error
  OneToOneRelations:
    - edm4hep::Track track    // computed from here
```

ParticleID handling EDM4hep vs LCIO

- Remove `ParticleID` relation from `Cluster`
  - Found no usage in ILD / CLIC reconstruction
- Make `ParticleID` have a one-to-one relation to `ReconstructedParticle`
  - Also remove `particleIDUsed`
- `ParticleID` has been (ab)used in LCIO as *transient parameter (values) store*
  - Will require change of pattern for EDM4hep
- Simple use cases become simpler with EDM4hep
- Tooling keeps the rest at the same level
- Some usability isses still to be addressed
  - keyhep/EDM4hep#298

key4hep/EDM4hep#268





ParticleID related utilities

- `edm4hep::utils::PIDHandler` similar to `UTIL::PIDHandler`
  - Get related `ParticleID`s from a `ReconstructedParticle`
  - Retrieve some PID metadata
  - Slightly more modern interface for EDM4hep
- Handling of necessary metadata very different
  - LCIO: *collection parameters* - tight coupling
  - EDM4hep: *file level metadata* - looser coupling
  - Gory details here and here
- See the documentation for more usage examples
- **Feedback very much appreciated!**

ParticleID handling comparison

Getting the dE/dx distance wrt an electron for all particles

```cpp
using namespace EVENT;
using namespace UTIL;

auto recos = event->getCollection("PandoraPFOs");
auto pidHandler = PIDHandler(recos);

const auto dEdxId = pidHandler.getAlgorithmID(_dEdxname);
const auto dEdx_e_Id = pidHandler.getAlgorithmID(dEdxId,
                                                 "e_dEdx_dist");

for (int i = 0; i < recos->getNumberOfElements(); ++i) {
  auto p = static_cast<ReconstructedParticle*>(
             recos->getElementAt(i));

  if (p->getCharge() == 0.0) {
    continue; // only charged particles have tracks
  }

  const auto& dEdxParams = pidHandler.getParticleID(p, dEdxId);
  const auto dEdx_e_dist = dEdxParams[dEdx_e_Id];

  // do something with the particle and the dEdx distance
}
```

LCIO

```cpp
using namespace edm4hep;
using namespace edm4hep::utils;

const auto dEdx = event.get<ParticleIDCollection>("dEdx");


const auto dEdxMeta = PIDHandler::getAlgoInfo(metadata, "dEdx");
const auto dEdx_e_Id = getParamIndex(dEdxMeta, "e_dEdx_dist");


for (const auto pid : dEdx) {

  const auto p = pid.getParticle();
  const auto dEdx_e_dist = dEdx.getParameters()[dEdx_e_Id];

  // do something with the particle and the dEdx distance
}
```

EDM4hep

Summary & Outlook

- EDM4hep is currently undergoing the final developments before v1.0
- podio as generating tool has accomodated the necessary feature requests
- Addressed some conceptual issues inherited from LCIO
  - `ParticleID`s & handling with largest differences
  - First version of corresponding utilities in place
- Transparent migrations and backwards compatibility after v1.0
- **Now is the best* time to test and request changes!**
  - Current version of EDM4hep available via the Key4hep nightlies
    `/cvmfs/sw-nightlies.hsf.org/key4hep/setup.sh`

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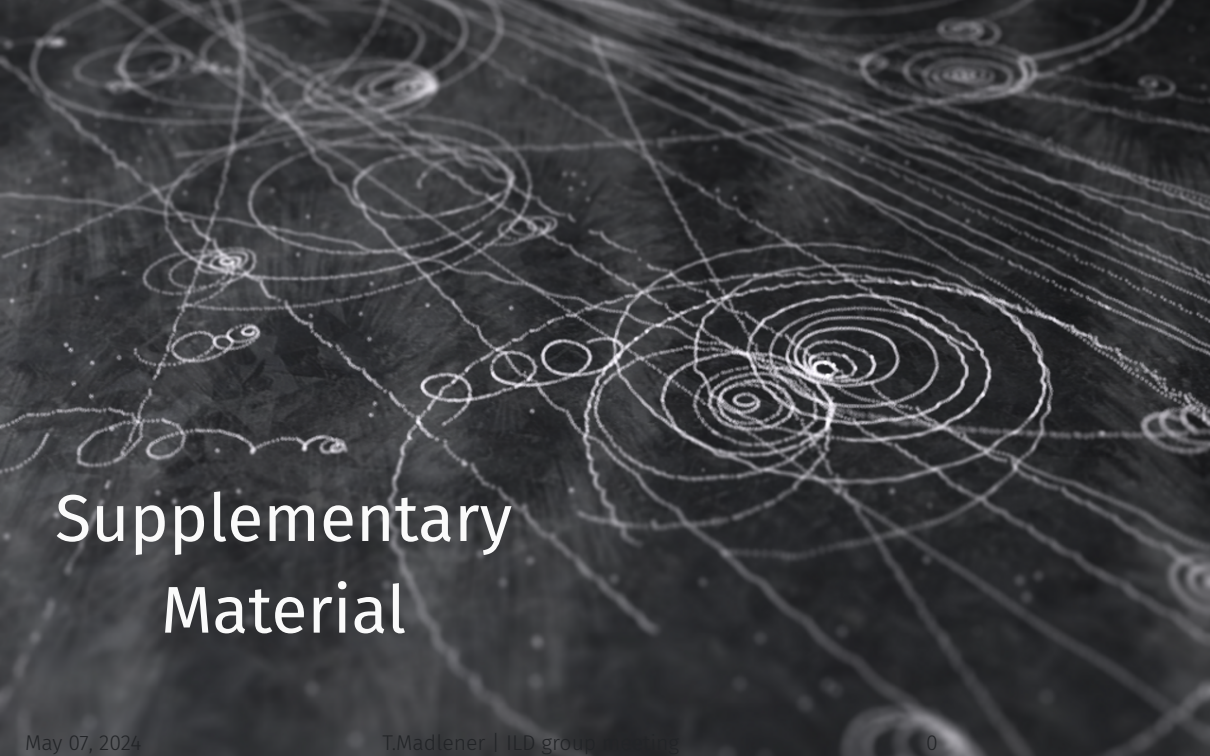
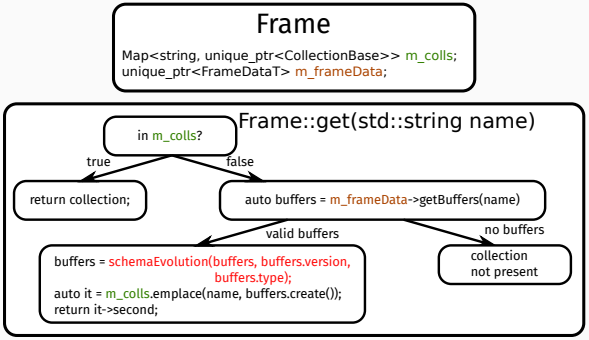
*last chance ;)



Supplementary Material

Schema evolution - Technical details

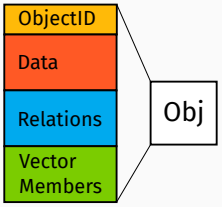
- Called as early as possible and as late as necessary
  - Earliest point where we have collection buffers from all backends is in Frame
- Schema evolution functions available from `SchemaEvolution` singleton
  - Populated during shared library loading
- Schema evolution can be a no-op



More recent transparent(-ish) changes

- Stable collection IDs
  - Initially: Insertion order into Frame
  - Now: Hash of collection name
  - 32 bits for transparent migration
- RNTuple based backend
- Storing datamodel definition in *metadata Frame*
  - Always possible to regenerate datamodel from datafile
  - Retrievable programmatically
  - Dumping via `podio-dump`
  - String literal embedded into binary

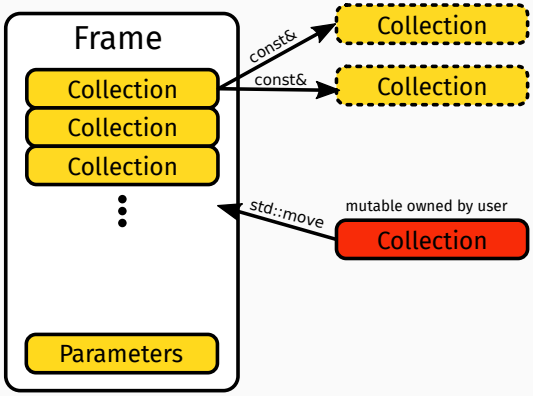
```
struct ObjectID {
  int index;
  uint32_t collectionID;
};
```




```
readelf -p .rodata libedm4hep.so | grep options
  [   368]  {"options": {<...>},
"schema_version": 1, "components": {<...>},
"datatypes": {<...>}}
```

The `Frame` - A generalized (event) data container

- *Type erased* container aggregating all relevant data
- Defines an *interval of validity* / category for contained data
  - Event, Run, readout frame, ...
- Easy to use and thread safe interface for data access
  - Immutable read access only
  - Ownership model reflected in API
- Decouples I/O from operating on the data
- Old `EventStore` has been removed!




```
template<typename CollT>
const CollT& get(const std::string& name) const;

template<typename CollT, /*enable_if*/>
const CollT& put(CollT&& collection,
                 const std::string& name);
```