EDM4hep & DD4hep for LUXE

Some first steps

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with a lot of help from Sasha

LUXE SAS meeting

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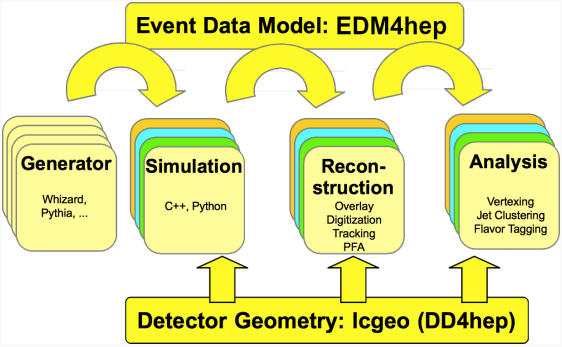
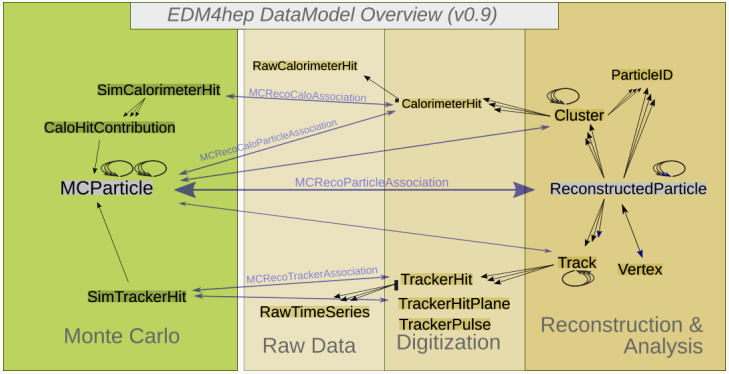
The EDM at the core of HEP software



- 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

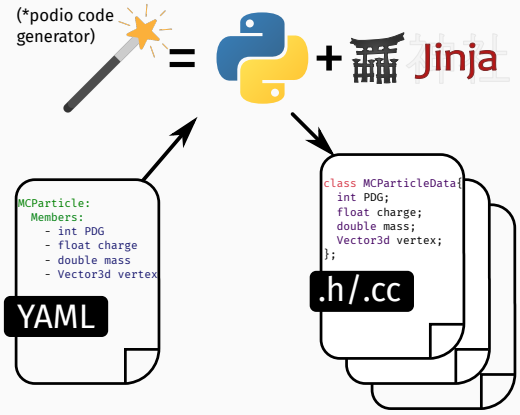
edm4hep.web.cern.ch

AIDASoft/podio

- Based on experience from LC and FCC
  - Focus on usability in analysis
- Works well for current Future Collider studies
- Quite stable over the last two years
- Generated via `podio`
- **Can be extended for LUXE specific use cases**

The podio EDM toolkit

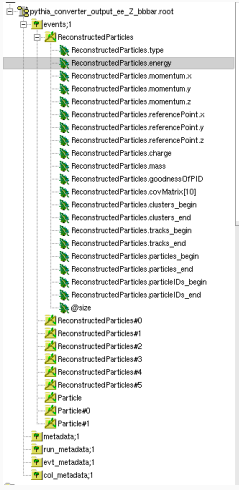
- Implementing a performant event data model (EDM) is non-trivial
- Use `podio` to generate code starting from a high level description
- Provide an easy to use interface to the users
- Main customers
  - key4hep/EDM4hep
  - eic/EDM4eic
- **Finishing schema evolution for v1.0**

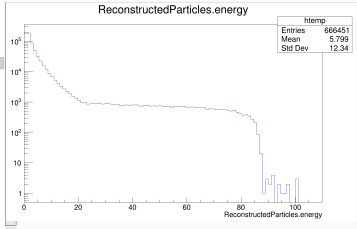


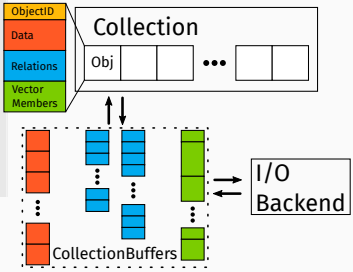
AIDASoft/podio

podio supports different I/O backends

- Default **ROOT** backend
  - POD buffers are stored as branches in a `TTree`
  - Files can be interpreted **without EDM library**(!)
  - Can be used in `RDataFrame` or with `uproot`
- Alternative **SIO** backend
  - Persistency library used in `LCIO`
  - Complete events are stored as binary records
- Adding more I/O backends is possible



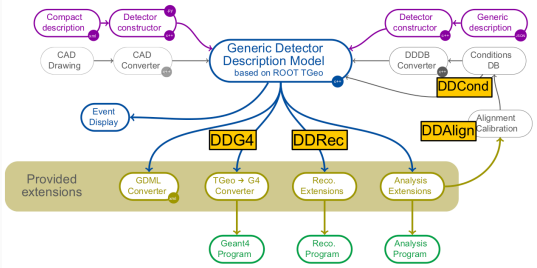


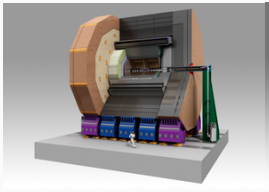


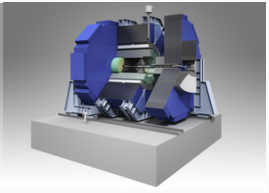
DD4hep - Detector description

dd4hep.web.cern.ch

- Complete detector description
  - Geometry, materials, visualization, readout, alignment, calibration, ...
- From a **single source of information**
  - Simulation, reconstruction, analysis
- Comes with a powerful plug-in mechanism that allows customization
- More or less “industry standard” now
  - ILC, CLIC, FCC, CEPC, EIC, LHCb, CMS, ...
- **`ddsim` - standalone simulation executable**







`lxsim` vs `ddsim`/DD4hep (at a very high level)

	`lxsim`	`ddsim`
detector description	C++	XML & C++ (detector constructors)
executable	compiled C++	python script (`ddsim`)
simulation config	`.mac` files	python (+ command line)
output	custom ROOT & HDF5 format	EDM4hep, ...

- Conceptually and (simulation) functionality wise quite similar
- Major differences:
  - `ddsim` (DD4hep) detector also encodes sensitive detectors (and their readouts) in geometry (XML)
  - `lxsim` can dump to GDML (only volumes, no info on sensitive detectors)
- DD4hep geometry can directly be used in reconstruction & analysis

Using GDML geometry with DD4hep

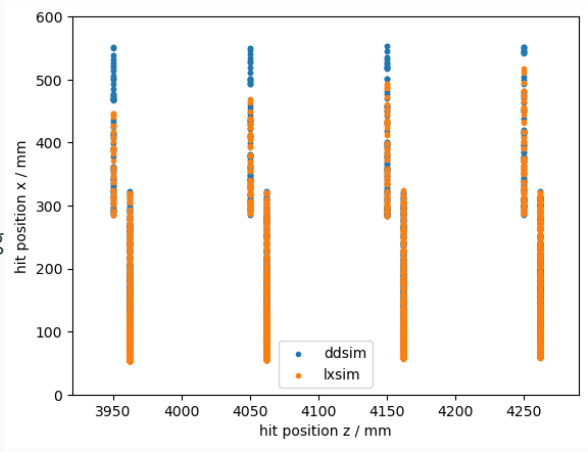
```
<detectors>
  <detector id="1" name="LUXE_GDML" type="DD4hep_GdmlDetector" vis="InvisibleWithChildren">
    <gdmlFile ref="lxgeomdump.gdml"/>
    <parent name="/world"/>
  </detector>
</detectors>

<plugins>
  <plugin name="DD4hep_PlacedVolumeProcessor">
    <arg value="-recursive"/>
    <arg value="-processor"/>
    <arg value="DD4hep_DetElementCreator"/>
    <arg value="-detector"/>
    <arg value="Tracker"/>
    <arg value="-print"/>
    <arg value="DEBUG"/>
    <arg value="-level"/>
    <arg value="4"/>
    <arg value="-material"/>
    <arg value="Silicon"/>
    <arg value="-match"/>
    <arg value="OPPPTracker"/>
    <arg value="-veto"/>
    <arg value="Support"/>
    <arg value="-type"/>
    <arg value="tracker"/>
  </plugin>
</plugins>

<fields>
  <field name="MagnetFields_Dipole" type="MultipoleMagnet" Z="0.*tesla">
    <position x="0*cm" y="0*cm" z="205.3*cm"/>
    <coefficient coefficient="-0.95*tesla" skew="0.*tesla"/>
    <shape type="Box" dx="16.5*cm" dy="3*cm" dz="61.9*cm"/>
  </field>
</fields>
```

← Almost complete DD4hep XML

- Read GDML geometry
  - (from `lxsim`)
- Need to add sensitive detectors based on heuristics
  - E.g. material, name, ...
- Magnetic field also needs to be added in XML

First steps and early results

- Particle gun at IP $(0, 0, 0)$, direction along beam axis, uniform energy range
- Silicon tracker only
- **This is more or less a technical demonstration**
  - Verify that loading GDML and using a plugin to place sensitive detectors works
  - Establish the potential of a migration in steps
  - Produce some first outputs in EDM4hep format



Next steps

Immediate

- More detailed analysis of first steps
  - Tracker hit position and energy correlations
- Make the calorimeter sensitive and repeat exercise for calorimeter hits

Workshop (goal)

- Implement “proper” tracker geometry and use that with rest in GDML
- Load tracker geometry from DD4hep to ACTS and reconstruct some tracks

Midterm

- Implement more detectors in DD4hep and replace GDML parts “one-by-one”
- Define datatypes to store hits from all detectors (new ones of necessary)

Summary

- Need a well defined EDM to facilitate reconstruction & analysis workflows
- Use EDM4hep where possible, extend as needed for LUXE
- Started to explore migration path to DD4hep
- Very first results based on GDML geometry dumped from `lxsim`
- The “real” work is yet to start and will take quite some time
  - Need to prioritize what to do first