

HepMC Visual

an interactive browser for HepMC events

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Motivation

In current high-energy physics experiments, such as the LHC, HepMC has evolved as a standard event format. At the very high energies, fully simulated events typically have in the order of hundreds of vertices and thousands of particles. The only visual representation that is provided by the HepMC library produces a text-based output of the event.

Therefore a library that allows a graphical interactive representation of HepMC events has been developed.

Goals

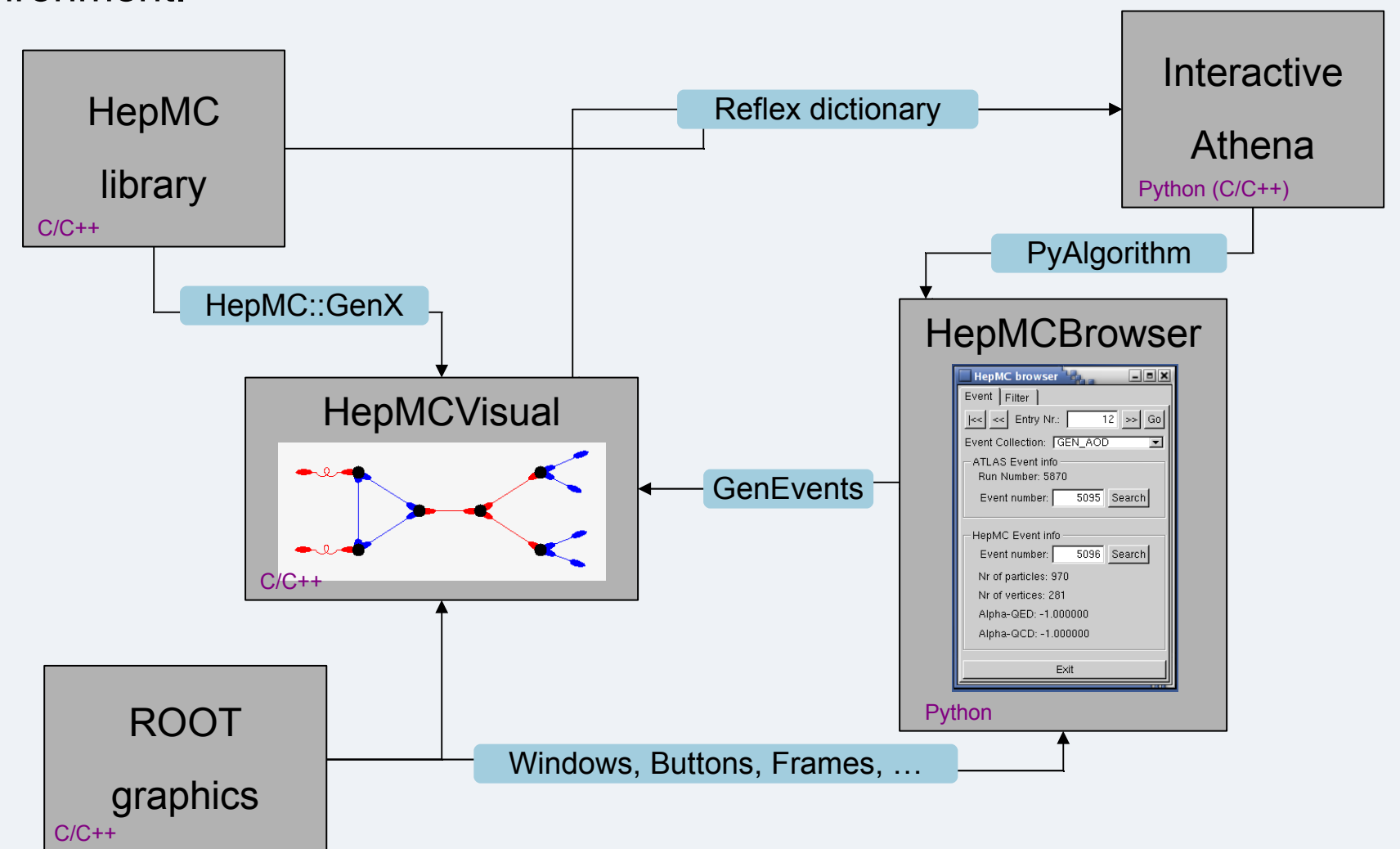
- Interactivity: allow the user to view only the part of the full event he is interested in
- Intuition: make the browsing of the event tree intuitive by following common user interface standards
- Interfaces: provide an easy interface to the user of the library

```

GenEvent: #3230 ID=1820024 SignalProcessVertex Barcode: 0
Entries this event: 343 vertices, 3247 particles.
Beam Particles are not defined.
RndmState(0)=
MgntC3v1: 1.1
EventScale -1 [Energy] alphaQCD=-1 alphaQED=-1
GenParticle Legend
Barcode PDG ID C Px Py Pz E Stat DecayVtx
Vertex: -1 ID: 0 (X,CT)=2.06e-03,+1.30e-03,+8.51e+01,+0.00e+00
I: 1
0:34
1 2212 +0.00e+00,+0.00e+00,+7.00e+06,+7.00e+06 3 -1
21 -3.90e+02,-1.46e+03,+1.68e+05,+1.68e+05 3 -3
26 2 +1.28e+02,+1.94e+02,+0.83e+02,+7.22e+02 2 -16
39 21 -1.19e+02,-3.34e+02,+1.59e+03,+1.63e+03 2 -18
40 21 +1.59e+03,+3.66e+02,+9.05e+02,+1.83e+03 2 -18
41 21 +1.41e+02,+8.39e+02,+1.50e+03,+1.72e+03 2 -18
Vertex: -2 ID: 0 (X,CT)=2.06e-03,+1.30e-03,+8.51e+01,+0.00e+00
I: 1
0:60
2 2212 +0.00e+00,+0.00e+00,-7.00e+06,-7.00e+06 3 -2
4 21 -1.32e+03,-8.39e+02,-3.76e+06,+3.76e+06 3 -4
28 21 -2.24e+03,+3.91e+02,-2.79e+04,+2.80e+04 2 -18
29 21 -1.93e+03,+1.62e+03,-3.81e+04,+3.82e+04 2 -18
30 21 -1.28e+03,+7.17e+02,-9.79e+03,+9.90e+03 2 -18
31 21 +1.00e+02,+1.16e+03,-3.21e+03,+3.41e+03 2 -18
32 21 +4.17e+02,-5.62e+02,-1.40e+04,+1.41e+04 2 -18
33 21 +2.37e+02,+1.88e+02,-6.37e+02,+7.05e+02 2 -18
34 21 +2.25e+01,-8.46e+01,-5.33e+03,+5.33e+03 2 -18
35 21 +1.20e+03,+5.40e+01,-6.14e+03,+6.25e+03 2 -18
36 21 +4.61e+02,-6.54e+02,-9.88e+03,+9.12e+03 2 -18
37 21 -5.46e+02,+4.87e+02,-1.07e+04,+1.07e+04 2 -18
38 21 +2.62e+03,+3.19e+03,-6.68e+04,+6.69e+04 2 -18
Vertex: -3 ID: 0 (X,CT)=2.06e-03,+1.30e-03,+8.51e+01,+0.00e+00
I: 1
3 21 -3.90e+02,-1.46e+03,+1.68e+05,+1.68e+05 3 -3
0: 2
5 4 +1.12e+04,-2.71e+03,+2.62e+04,+2.86e+04 3 -5
25 -4 -1.16e+04,+1.25e+03,+1.39e+05,+1.39e+05 2 -16
Vertex: -4 ID: 0 (X,CT)=2.06e-03,+1.30e-03,+8.51e+01,+0.00e+00
I: 1
0:16
4 21 -1.32e+03,-8.39e+02,-3.76e+06,+3.76e+06 3 -4
6 +4.17e+02,-5.62e+02,-1.40e+04,+1.41e+04 3 -5
27 4 -1.02e+03,-6.84e+02,-2.61e+06,+2.61e+06 2 -18
    
```

Design overview

This sketch shows the dependencies of the library and an implementation with the ATLAS Athena software. The use of ROOT for the graphics and user interface elements allows for a wide range of use cases in the HEP environment.



Implementation

Base classes

- VisualParticle (public GenParticle, public TLine) represents a single particle that connect vertices
- VisualVertex (public GenVertex, public TMarker) owns the particles and knows its position on the screen
- VisualEvent (public GenEvent) owns the vertices

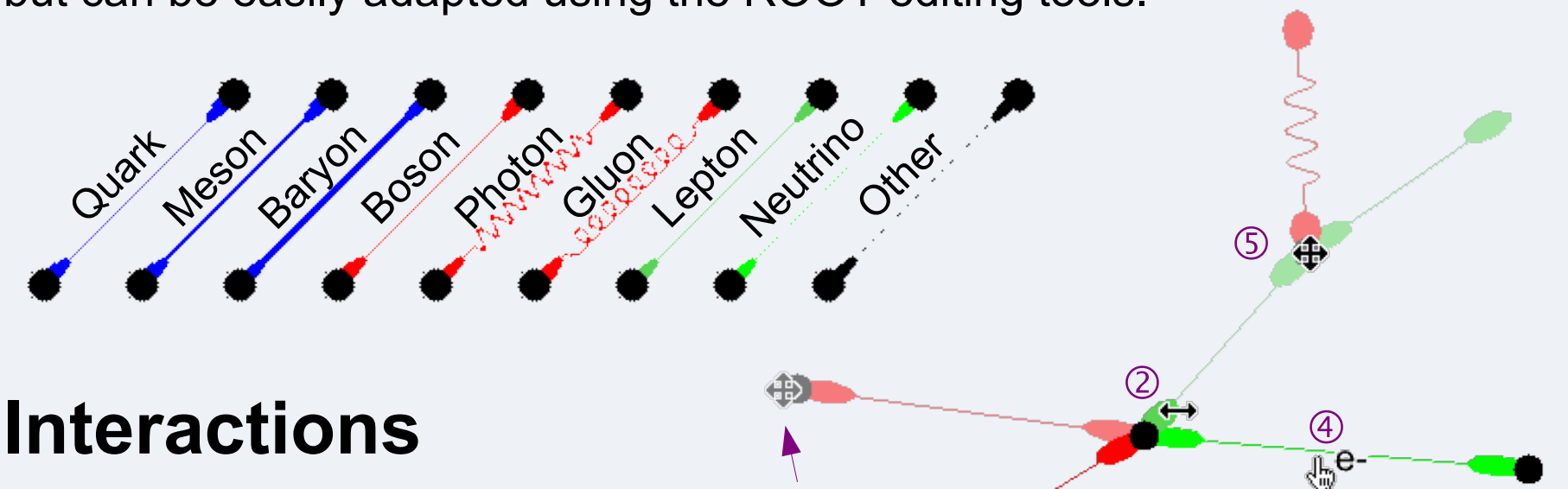
Each of the base classes provides a Draw() function. The one-to-one mapping and run-time type identification allows to start with a single call to Visualize() generating the "visual" partner for any of the HepMC base classes. The vertices – and hence the event – are converted and laid out by the user while browsing.

Filter

Additional filter algorithms have been developed to dynamically remove vertices generated by PYTHIA/Herwig fragmentation or GEANT detector simulation. A search algorithm exists to identify the vertex of interest by in- and outgoing particle IDs.

Particles

Particles are identified by line color, style and thickness. Default values are set, but can be easily adapted using the ROOT editing tools.



Interactions

- 1 Drag vertex to move
- 2 Click particle to expand/collapse branch
- 3 Hold particle to show details
- 4 Double-click particle to attach label
- 5 Double-click vertex

HepMC Info

ID: 23 Barcode: 10001

Status: 0

Energy: 128.96 [GeV]

Momentum: 91.19 [GeV]

Transv. Momentum: 0.00 [GeV]

Calc. Mass: 91187.00 [MeV]

η : -inf ϕ : 0.00 [rad]

PDT Info

Name: Z

Mass: 91187.60 [MeV]

Width: 2495.20 [MeV]

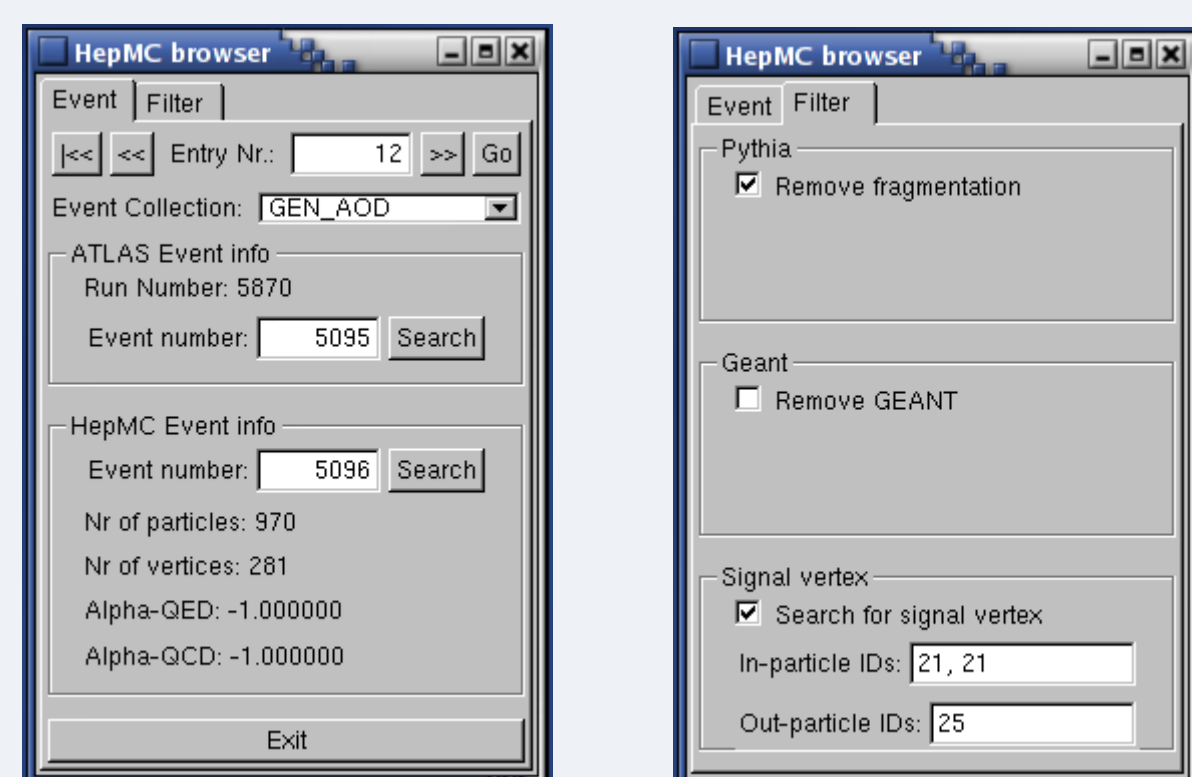
Spin: 0 Charge: 0.00

HepMCBrowser

In the HepMCBrowser application, the library has been interfaced to the Athena software framework used by the ATLAS Collaboration. In the *interactive* mode, Athena provides a user-controlled event loop with Python command line interactions. PyROOT bindings to the Reflex dictionary allow access to the C++ library.

A ROOT graphics library based GUI provides various useful tools such as

- event browsing and seeking
- searching for events by event number
- searching for interesting vertices
- application of the vertex filters



Example

Through the tree-like browsing, the user can quickly restrict the information to the relevant parts and lay them out according to his needs. Use of the ROOT TCanvas allows for easy annotations, labels, formulas, saving in various output formats or combination with histograms.

