Exploring server/web-client event display for CMS

Alja Mrak Tadel, Avi Yagil, Matevz Tadel – UCSD
Dymtro Kovalskyi – MIT
Sergey Linev – GSI

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Content

• Review of functionality of current CMS event display, Fireworks, and ROOT EVE
• Motivation to “change”
• Preliminary exploration with JSROOT and Fireworks
• EVE modernization
• Future work plan
CMS event display

• Fireworks application – CMS data exploration tool
• Based on ROOT
  – Data stored in ROOT format (CMS EDM)
  – All 2D/3D graphics is done with ROOT EVE + GL
• Physics Analysis oriented
  – Primary users
    • Physics analysers, MET scanners, Particle Flow algorithm developers, new detector geometry developers
  – Simplified information presentation is favored over exact 3D presentation for primary users
Essential Features

Fireworks only:
- Ability to access and interact with data collections, physics objects and experiment data model
  - Event filtering
  - Collection selection, item filtering
  - Table view where column value can be an arbitrary expression

Used from EVE:
- Primitives & Algorithms for Physics oriented event Display:
  - Multi-view / multi-scene support
  - Geometry access and drawing
  - Flexible track propagator accepting trajectory guides; magnetic field representation
  - Automatic non-linear (fish-eye) and scaling transformations
- Object selection and highlighting across multiple views
Fireworks screenshot
Motivations for change

1. Long term maintainability
   - GUI and GL components are becoming really old
     - Increasing number of issues with system level support for GL and remote GL
     - OpenGL being deprecated in general and on OSX in particular

2. On client side, support as many platforms as possible
   - Windows and future versions of OSX
   - Allow access from phones and tablets
   - Easier client side customization with usage of standard libraries

3. ROOT is moving to web based interface in version 7
Preliminary exploration with JSROOT

• Embed THttpServer into Fireworks
  – Wrote a simple client based on JSROOT / OpenUI-5 / THREE.js
  – Client commands get translated into Fireworks signals to initiate change:
    • Event navigation, rebuild table view content, EVE scenes, …
  – Draw / display what was relatively easy to stream:
    • Table view, simple shapes, tracks, and hits
  – Did not do:
    • Streaming and client rendering for more advanced EVE classes (jets, calos)
    • Interaction with EVE elements
    • Projections

• **Goal:** learn about new technologies, evaluate existing code in view of what should be done a true web-based display.
First test – simple Fireworks client:
Screenshot of web browser window

Summary

- slimmedJets [19]
- slimmedMuons [5]
- offlineSlimmedPrimaryVertices [28]
Second Step: the Web Entanglement

• The first step – declare success!
  – Technology available and easy to use.
  – Staying with ROOT / close to ROOT makes the most sense.

• The problem – what to do next?
  – We did not know enough to estimate the exact needed time (rough guess 4 FTE).

• The solution:
  • Minimal refactoring of EVE for server – web-client operation.
  • Forego any changes on Fireworks side – but think how some of its features could be transplanted into EVE.
  
  – This effort was supported by the ROOT team:
    • Considered as prototype of ROOT-7 EVE ➔ EVE-7 or FireEve
  
  – This phase has actually just concluded (Jun 2018).
EVE ↔ EVE-7 prototype

- Strip away all GUI / GL functionality
- Implement:
  - Object identification
  - Serialization for Eve classes (JSON for meta-data, binary for tesselations/points)
  - Mechanism to execute client commands as object function calls through interpreter
  - Subscription scheme so clients can receive only parts of the available content
    - This is a multi-clinet event display where different clients have different view types
- Reuse:
  - RhoPhi / RhoZ projection and Track Propagator code
  - Scene & Object change / update protocol
- Port only a subset of EVE classes (skip calorimeters, digit classes, etc).
Eve-7 client in Chrome browser
Physics collections in EVE-7

• Old EVE had no support for management & display of experiment specific physics collections
  – EVE objects were always just visual representations of physics objects.
• Concepts of Physics Collections and Event Items are essential to Fireworks data management and display.
• We realized the Physics Collection concept can be implemented in EVE-7! Benefits:
  • Provide filtering of physics objects on the level of physics collection.
  • Support Table views with arbitrary expressions for each column.
  – Use CLING and lambdas for compilation of filtering and column expressions.
TParticle collection in EVE-7

Table: Tracks Collection
Class: TParticle

<table>
<thead>
<tr>
<th>Name</th>
<th>Rnr</th>
<th>pt</th>
<th>phi</th>
<th>eta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle 1</td>
<td>*</td>
<td>8.80</td>
<td>0.667</td>
<td>0.734</td>
</tr>
<tr>
<td>Particle 2</td>
<td></td>
<td>2.89</td>
<td>4.049</td>
<td>1.518</td>
</tr>
<tr>
<td>Particle 3</td>
<td></td>
<td>5.17</td>
<td>1.125</td>
<td>2.385</td>
</tr>
<tr>
<td>Particle 4</td>
<td>*</td>
<td>7.70</td>
<td>5.927</td>
<td>0.965</td>
</tr>
<tr>
<td>Particle 5</td>
<td></td>
<td>7.70</td>
<td>0.637</td>
<td>-2.072</td>
</tr>
<tr>
<td>Particle 6</td>
<td>*</td>
<td>2.98</td>
<td>4.224</td>
<td>0.739</td>
</tr>
<tr>
<td>Particle 7</td>
<td></td>
<td>3.08</td>
<td>0.303</td>
<td>-2.100</td>
</tr>
<tr>
<td>Particle 8</td>
<td></td>
<td>6.38</td>
<td>6.045</td>
<td>1.970</td>
</tr>
<tr>
<td>Particle 9</td>
<td></td>
<td>1.50</td>
<td>2.317</td>
<td>-1.220</td>
</tr>
<tr>
<td>Particle 10</td>
<td></td>
<td>3.20</td>
<td>4.821</td>
<td>1.118</td>
</tr>
<tr>
<td>Particle 11</td>
<td>*</td>
<td>3.61</td>
<td>4.320</td>
<td>-0.267</td>
</tr>
<tr>
<td>Particle 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particle 13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particle 14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Filter: pT > 1 && std::abs(i.Eta()) < 1
Conclusion

• Web based event display is attainable solution for the next decade.
• CMS is committed to support development of EVE-7 and modernization of Fireworks.
  – Chosen solution for Physics oriented event display from Run 3 onwards.
• Expected workplan:
  – Evolve EVE-7 to contain basic features
  – Port Fireworks to EVE-7
  – Work on advanced features of Fireworks and EVE-7
• BoF session today from 2 to 4pm