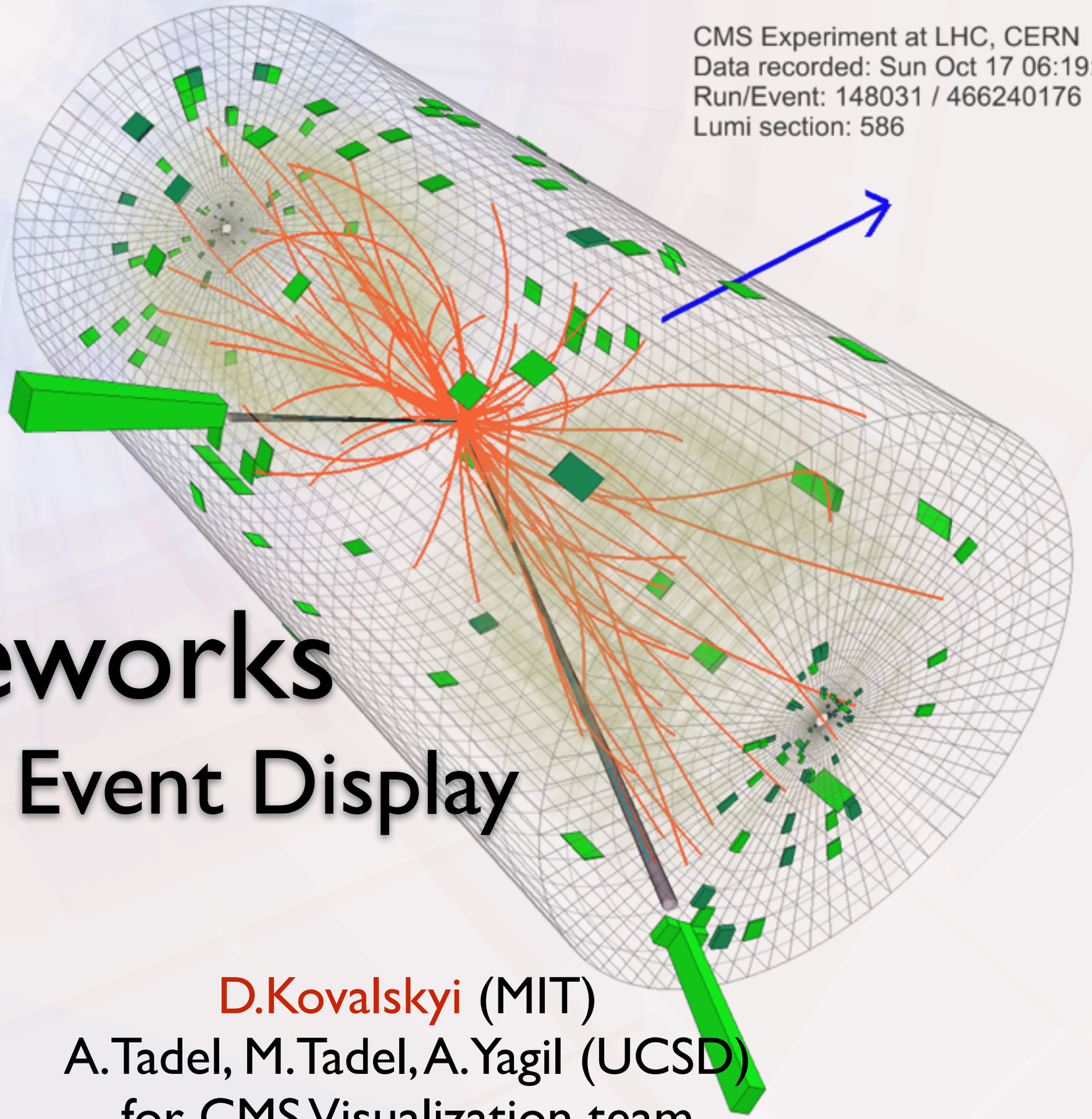

Fireworks
The CMS Event Display

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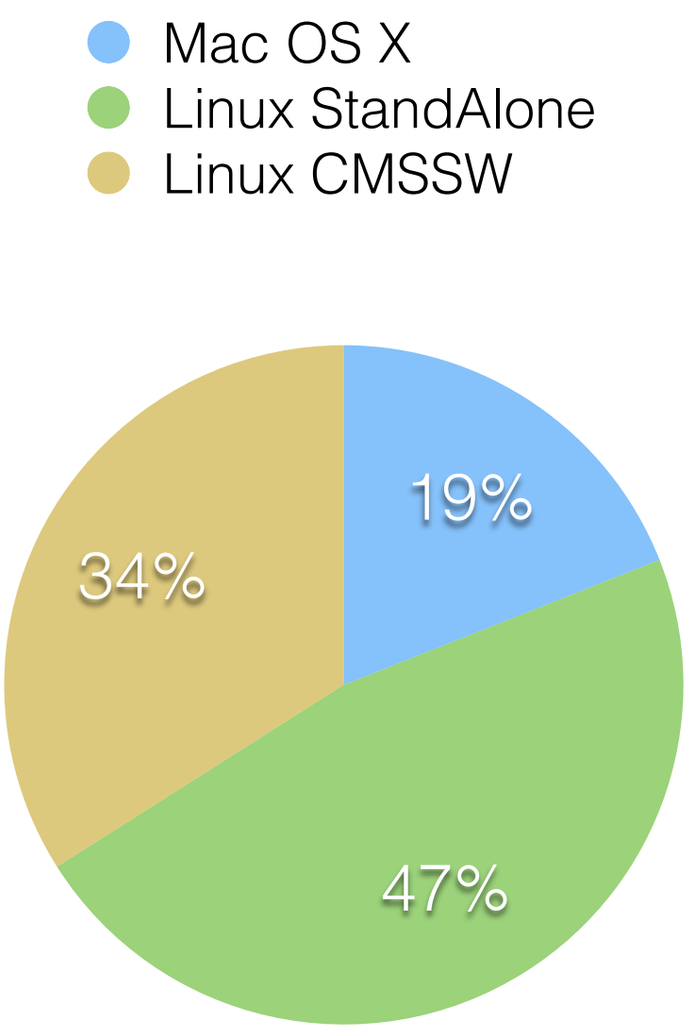
A.Tadel, M.Tadel, A.Yagil (UCSD)
for CMS Visualization team

Introduction

- Fireworks - CMS data exploration tool
  - graphical and tabulated information presentation
- Based on ROOT - can be reused in other experiments
  - Data stored in ROOT format
  - All core elements are TEve objects
- Physics Analysis oriented
  - Simplified information presentation is favored over exact 3D presentation for primary users
    - Low level details are accessible for experts in a full CMSSW framework implementation

Distribution Model

1. "Tarball" - stand alone application for Mac OS X and Linux
   - Input: data in ROOT EDM format (local files, xrootd etc)
2. Full framework - expert option
   - All CMSSW reconstruction algorithms are available
3. Online data visualization at P5@CERN
   - Dedicated setup with prompt data reconstruction and live data visualization
4. Web-based visualization
   - Under development



Primary Users

- Physics Analyzers
  - identify a subset of events that needs to be understood using user ntuples, extract the events in EDM format and explore
- "MET scanners"
  - a group of physicists looking at events with anomalous large missing energy and develop filtering strategy for new physics searches
- Particle Flow algorithm developers
  - core of CMS global event view approach
- New detector geometry developers
- Debugging of low level reconstruction issues
- Live low latency data monitoring at P5

cmsShow: data.root [1/1], event [1/10]

File Edit View Window Help

FIREWORKS

Delay 3.0s

Run 1 Lumi 43 Event 2101 Thu Jan 1 01:00:00 1970 CET

Filtering is OFF.

CMS

Summary View

Add Collection

- ECal
- HCal
- Jets
- Tracks
- Muons
- Electrons
- Vertices
- BeamSpot
- DT-segments
- CSC-segments
- Photons
- MET
- Conversions

Rho Phi

Lego

Rho Z

3D Tower

Table

Collection Jets

	pT	eta	phi	electronEnergyFraction	muonEr
0	95.8	-0.835	2.953	0.000	
1	82.1	-0.388	2.820	0.000	
2	78.9	1.669	1.026	0.896	
3	63.3	-0.687	-0.617	0.000	
4	56.9	0.554	-0.797	0.407	
5	31.8	-0.869	-1.903	0.000	
6	31.4	0.714	0.410	0.000	
7	26.5	3.328	-3.046	0.000	
8	18.5	-3.148	1.372	0.000	
9	13.5	-0.749	-1.188	0.000	
10	13.1	-3.626	-1.454	0.000	

L1 Table

Algorithm Name

- L1_ZeroBias
- L1_AlwaysTrue
- L1_SingleEG2_BptxAND
- L1_SingleJet16
- L1_Mu16er_TauJet40erORCenJet72er
- L1_Mu12_EG10
- L1_Mu5_EG15
- L1_DoubleTauJet40er
- L1_IsoEG20er_TauJet20er_NotWdEta0
- L1_Mu16er_TauJet20er
- L1_QuadJetC84
- L1_DoubleJetC72
- L1_DoubleJetC120
- L1_SingleJet52
- L1_SingleJet68
- L1_SingleJet92

Summary View
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pT eta phi electronEnergyFraction muonEr
0 95.8 -0.835 2.953 0.000
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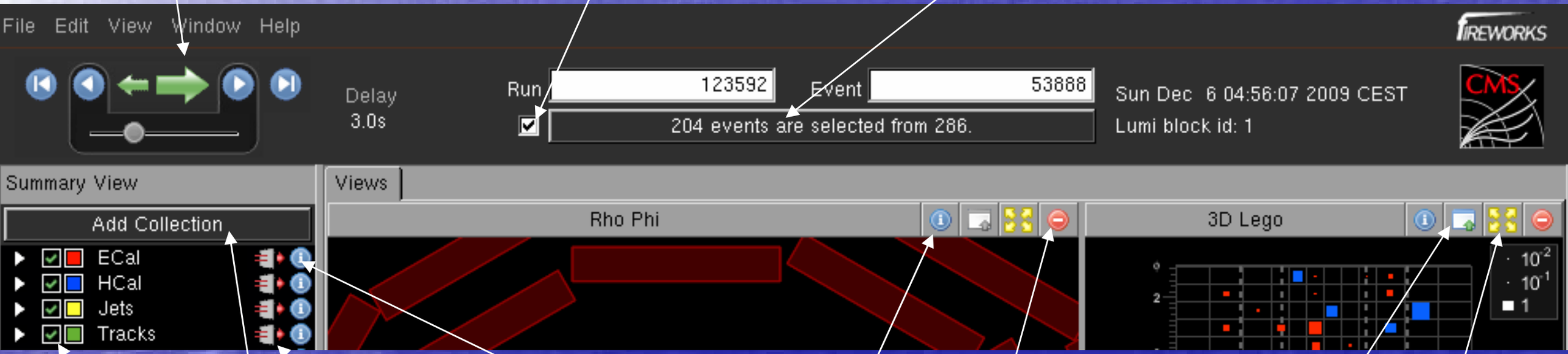
L1_Mu12_EG10
L1_Mu5_EG15
L1_DoubleTauJet40er
L1_IsoEG20er_TauJet20er_NotWdEta0
L1_Mu16er_TauJet20er
L1_QuadJetC84
L1_DoubleJetC72
L1_DoubleJetC120
L1_SingleJet52
L1_SingleJet68
L1_SingleJet92

Controls



Event Navigation

Event Filtering ON/OFF

Edit Event Filters

Show/Hide

Add New Data

Object Filtering Flag

Parameters

Remove View

Swap with the main view

Put in a separate floating window

Add New Collection

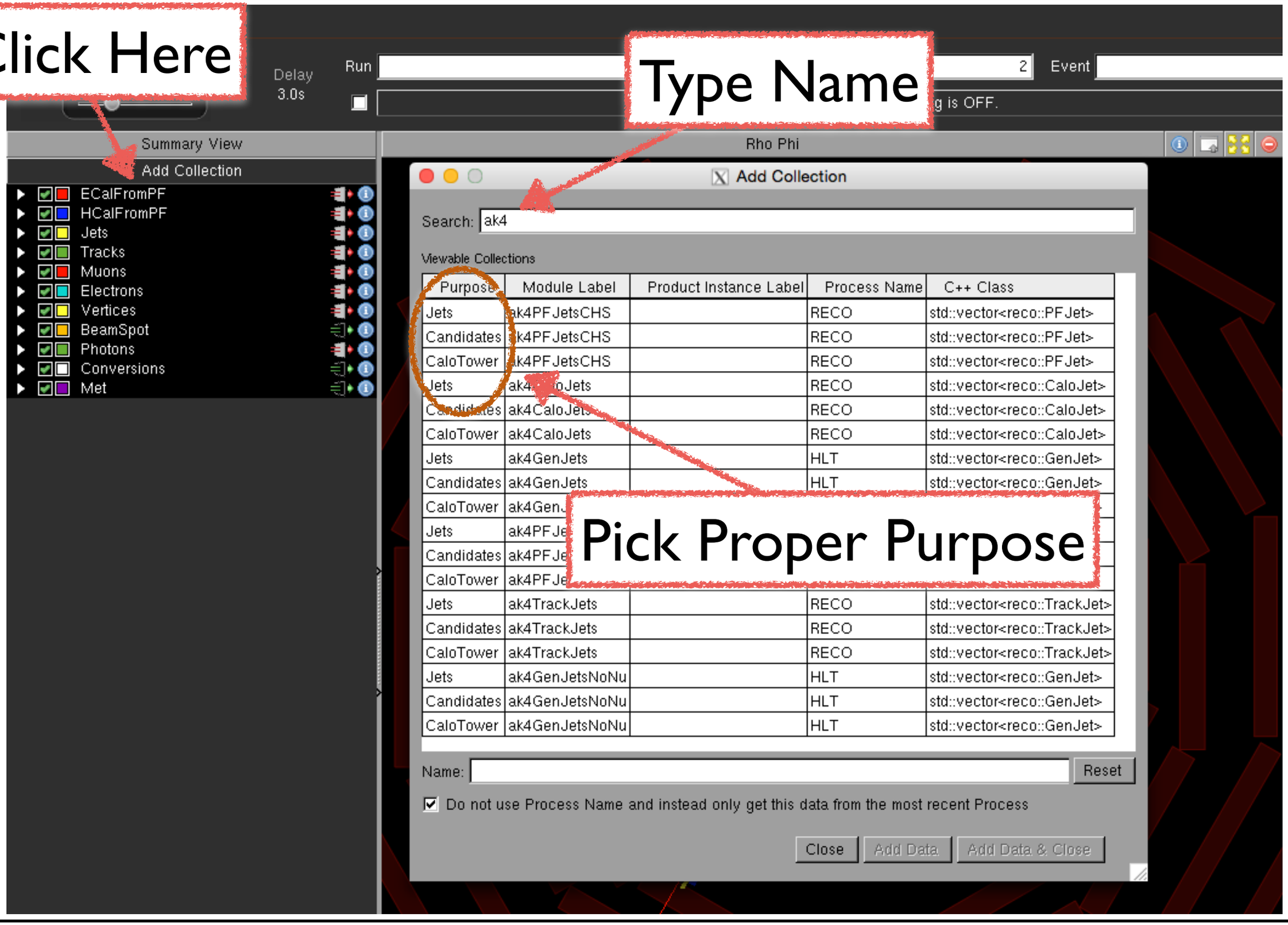


Table View

Expression is a method of the class - use tab completion to see what is available

Table

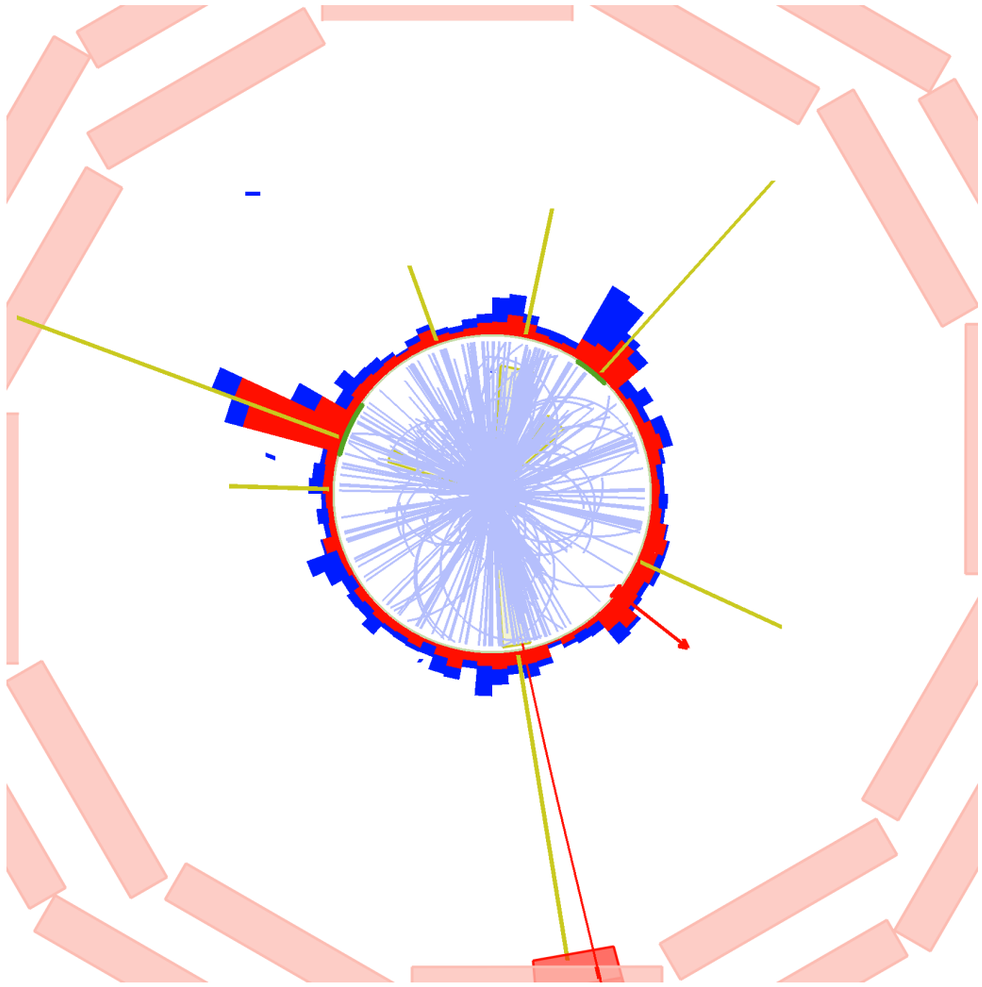
Collection: Muons

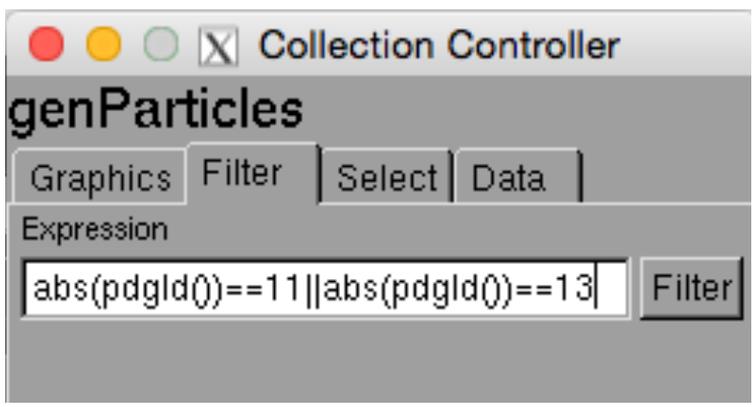
Column editor

Title: tracker | Expression: isTrackerMuon | Precision: -2 | Add | Delete | Modify

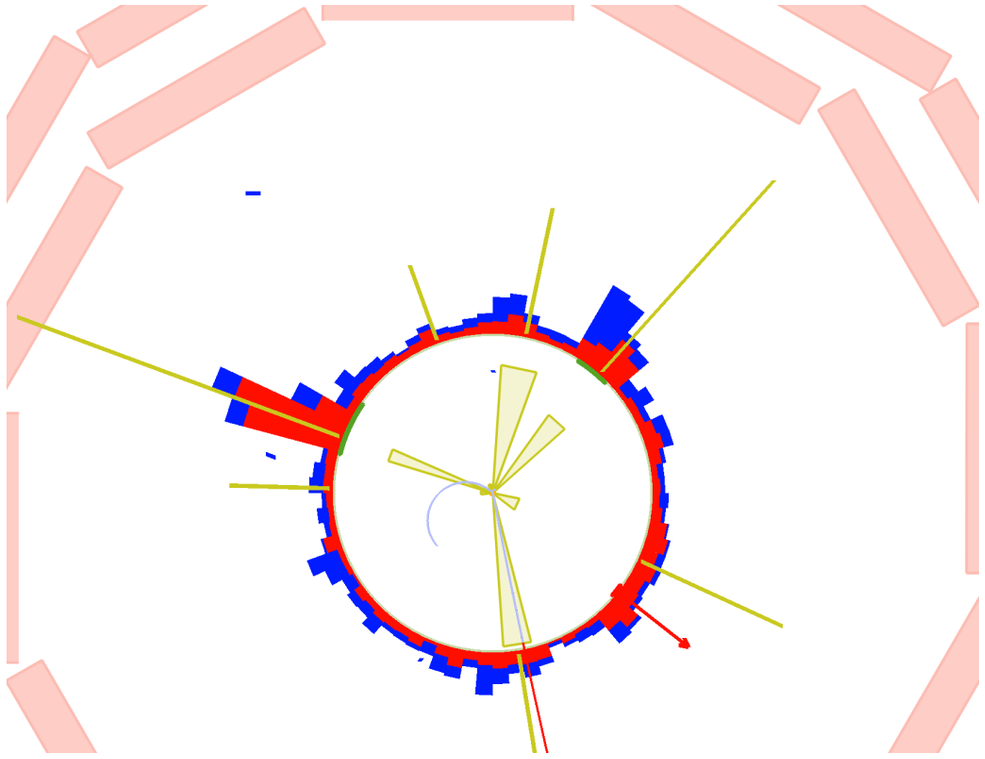
	pT	global	▽tracker	SA	calo	tr pt	eta	phi	matches	d0	d0 / d0Err	charge
1	13.1	true	true	true	false	13.1	-0.392	1.049	1	0.034	14.787	1
3	8.8	false	true	false	false	8.8	0.384	-1.677	1	-0.028	-13.355	1
4	25.5	false	true	false	false	25.5	1.963	0.594	1	0.021	16.186	1
5	11.3	false	true	false	false	11.3	-0.374	0.989	1	0.027	14.508	1
6	12.9	false	true	false	false	12.9	-0.323	1.021	1	0.029	15.167	1
7	15.6	false	true	false	false	15.6	-0.302	0.987	1	0.028	17.197	1
8	8.5	false	true	false	false	8.5	-0.307	1.070	1	0.030	14.305	1
9	35.2	false	true	false	false	35.2	1.940	0.573	1	0.017	11.269	-1
10	18.0	false	true	false	false	18.0	1.965	0.615	1	0.021	17.079	-1
0	5.1	true	false	true	false	5.1	-0.114	1.409	0	0.038	12.369	-1
2	6.8	true	false	true	false	6.8	-0.373	1.029	0	-0.038	-1.971	-1

Object Filtering

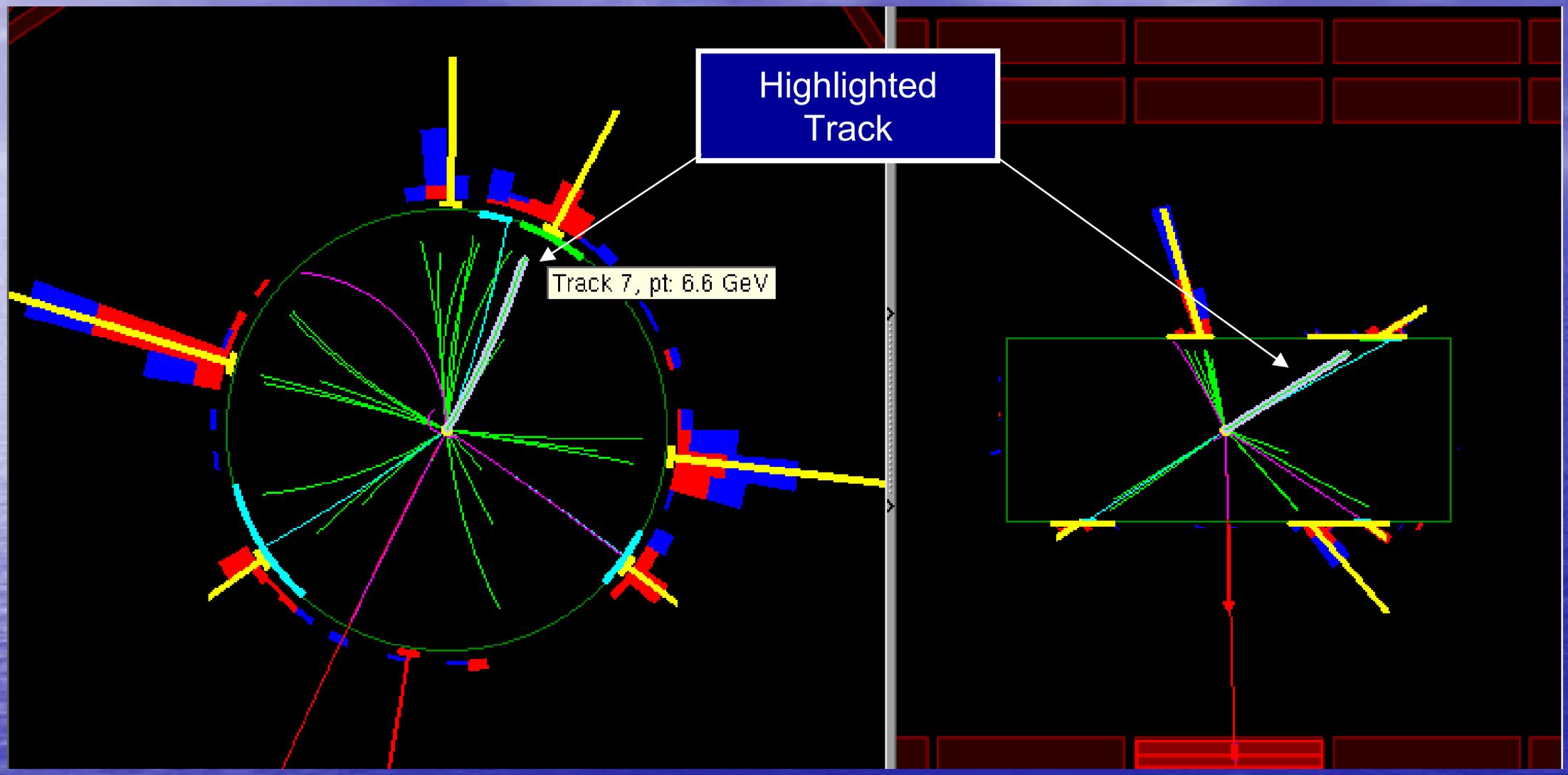




- Filtering can be applied to each collection independently
- User can build a complex expression using methods of the object class
- Filters are stored as a part of custom configuration to be re-used
- Tab-completion helps to explore methods of the object class for improved usability

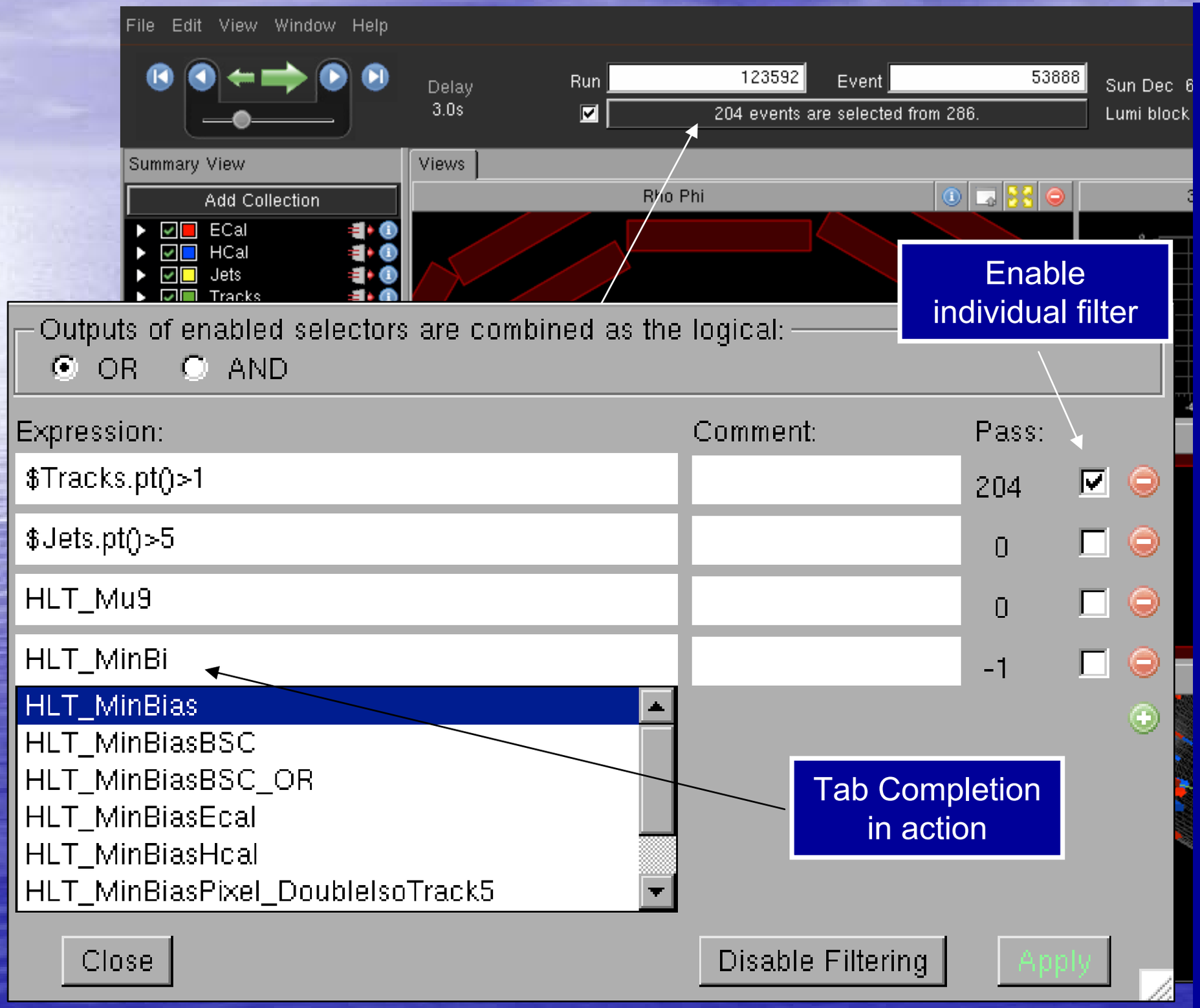


Object Selection



- All projections of an object in different views are logically connected
- Selection and highlight are automatically propagated to all views making it simple to visualize where the object is in 3D
- Mouse over event trigger Hint PopUp, which displays information about the object. In the example we see 7th track in the Tracks collection and its Pt is 6.6 GeV

Event Filtering



- Event filtering allows to select interesting events based on a complex selection – anything that you can use as selection in a Draw command in FWLite/ROOT will work
- You may also filter on HLT triggers
- When filter is in use, all event navigation is limited to events that passed the selection.

Summary

- Fireworks Event Display is a powerful tool that allows to explore data in a graphical and numerical forms
- Developed for physics analyzers as primary users
  - Detector, online and offline needs are taken into account
- Primary distribution model
  - A tarball for Linux and Mac OS X
    - Full framework implementation is available for experts
- We are looking to retain the functionalities that our community uses and expects
  - if possible we would like to add to them, but not at a cost of compromising or losing any