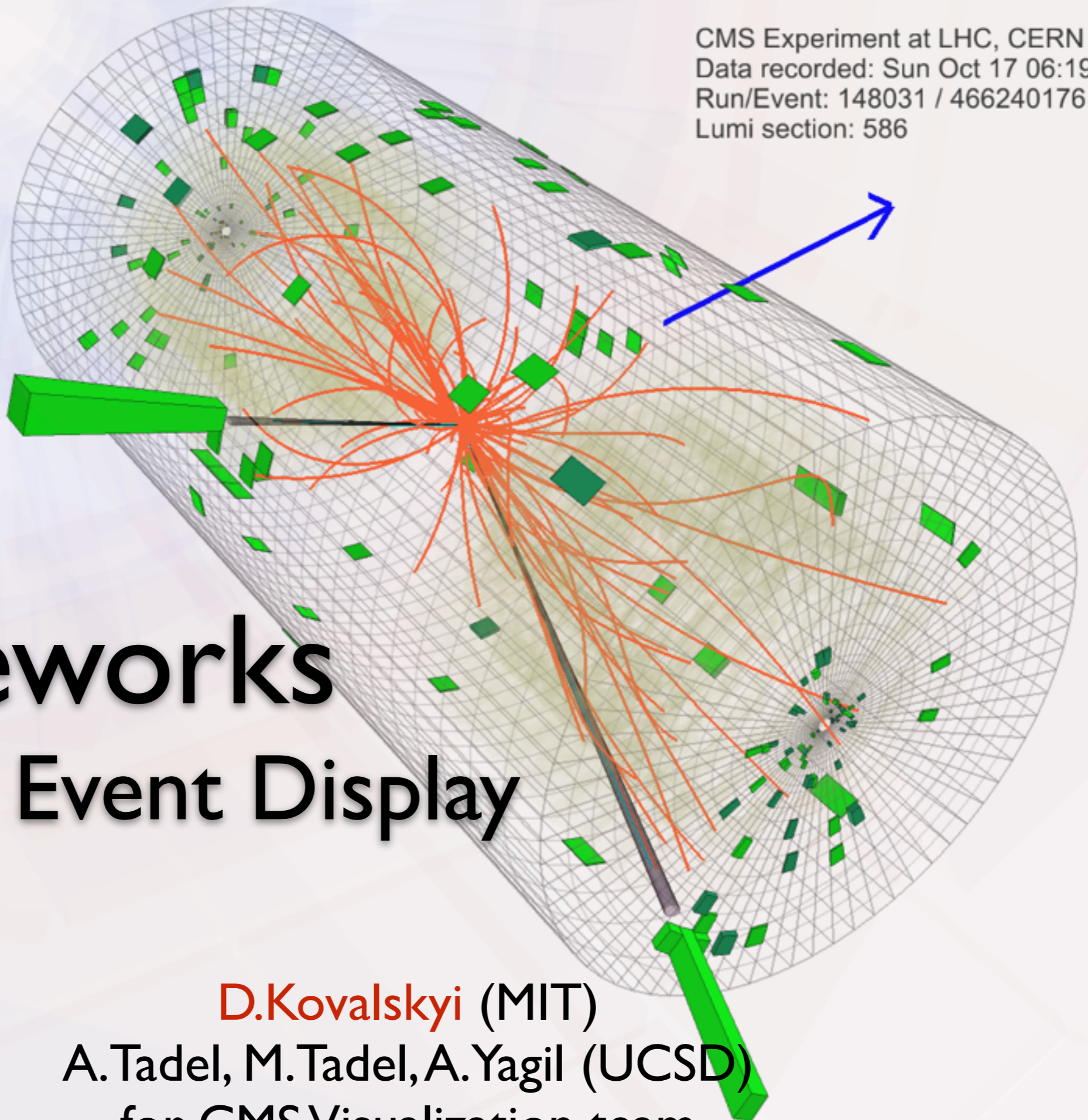




CMS Experiment at LHC, CERN
Data recorded: Sun Oct 17 06:19:04 2010
Run/Event: 148031 / 466240176
Lumi section: 586



Fireworks

The CMS Event Display

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



- ▶ **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

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

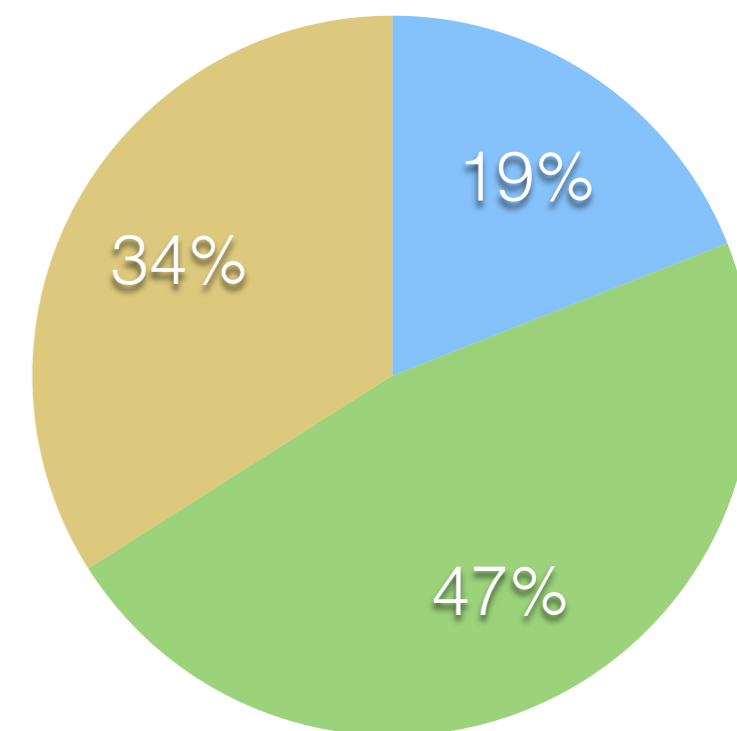
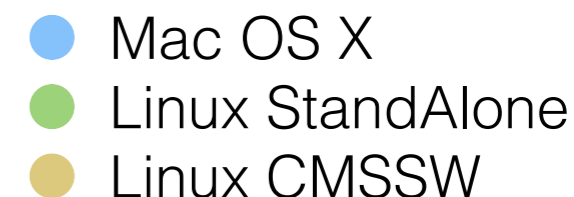
- ▶ All CMSSW reconstruction algorithms are available

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

Delay 3.0s Run 1 Lumi 43 Event 2101 Thu Jan 1 01:00:00 1970 CET

Filtering is OFF.

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	
11		13.0	0.878	-2.385	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

Add Collection

- ECal
- HCal
- Jets
- Tracks
- Muons
- Electrons
- Vertices
- BeamSpot
- DT-segments
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3D Tower

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- 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

File Edit View Window Help

IREWORKS



Delay
3.0s

Run

123592

Event

53888

204 events are selected from 286.

Sun Dec 6 04:56:07 2009 CEST
Lumi block id: 1



Summary View

Views

Add Collection

Rho Phi

3D Lego

- ECal
- HCal
- Jets
- Tracks

Show/Hide

Object
Filtering
Flag

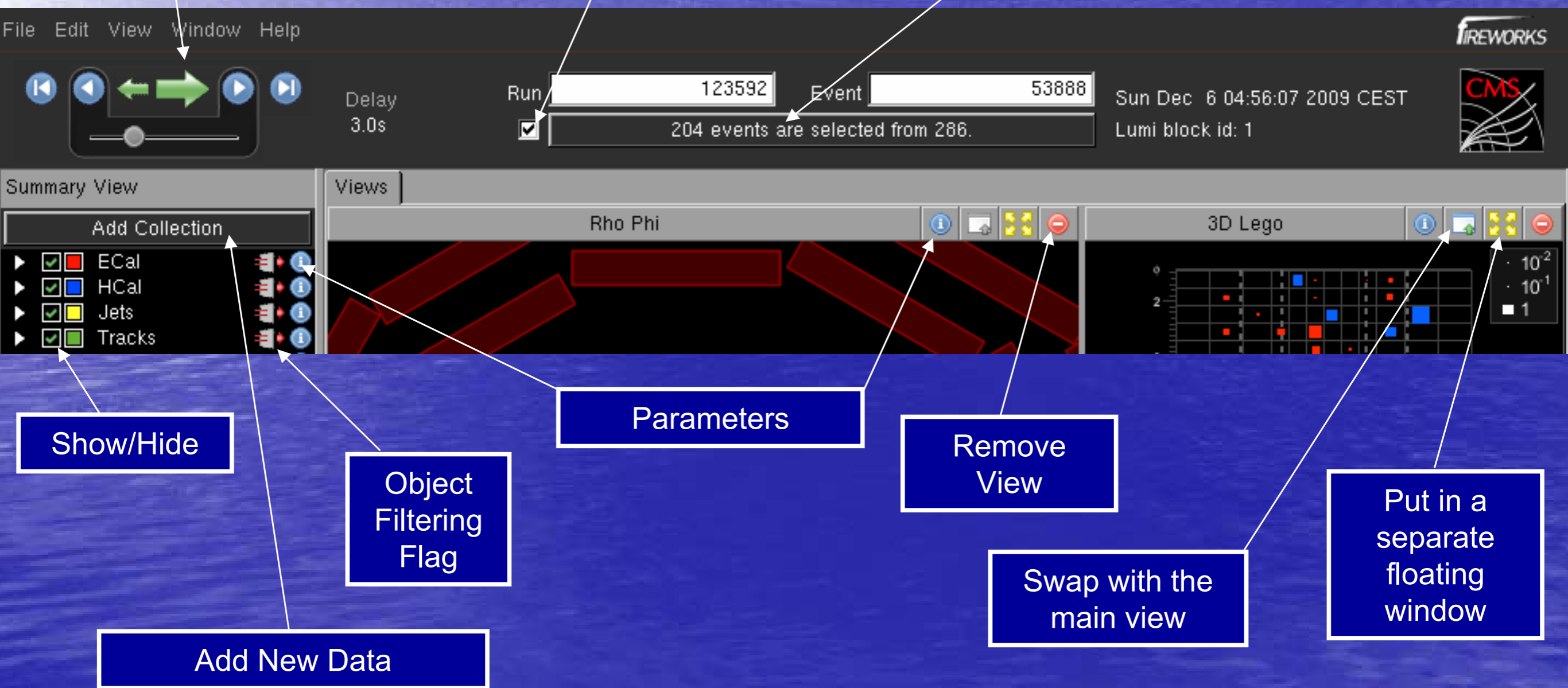
Parameters

Remove
View

Swap with the
main view

Put in a
separate
floating
window

Add New Data



Add New Collection

Click Here

Type Name

- Summary View
- Add Collection
- ECalFromPF
 - HCalFromPF
 - Jets
 - Tracks
 - Muons
 - Electrons
 - Vertices
 - BeamSpot
 - Photons
 - Conversions
 - Met

Rho Phi

g is OFF.

Delay 3.0s

Run

2

Event

Add Collection

Search: ak4

Viewable Collections

Purpose	Module Label	Product Instance Label	Process Name	C++ Class
Jets	ak4PFJetsCHS		RECO	std::vector<reco::PFJet>
Candidates	ak4PFJetsCHS		RECO	std::vector<reco::PFJet>
CaloTower	ak4PFJetsCHS		RECO	std::vector<reco::PFJet>
Jets	ak4CaloJets		RECO	std::vector<reco::CaloJet>
Candidates	ak4CaloJets		RECO	std::vector<reco::CaloJet>
CaloTower	ak4CaloJets		RECO	std::vector<reco::CaloJet>
Jets	ak4GenJets		HLT	std::vector<reco::GenJet>
Candidates	ak4GenJets		HLT	std::vector<reco::GenJet>
CaloTower	ak4GenJets		HLT	std::vector<reco::GenJet>
Jets	ak4PFJets			
Candidates	ak4PFJets			
CaloTower	ak4PFJets			
Jets	ak4TrackJets		RECO	std::vector<reco::TrackJet>
Candidates	ak4TrackJets		RECO	std::vector<reco::TrackJet>
CaloTower	ak4TrackJets		RECO	std::vector<reco::TrackJet>
Jets	ak4GenJetsNoNu		HLT	std::vector<reco::GenJet>
Candidates	ak4GenJetsNoNu		HLT	std::vector<reco::GenJet>
CaloTower	ak4GenJetsNoNu		HLT	std::vector<reco::GenJet>

Name: Reset

Do not use Process Name and instead only get this data from the most recent Process

Close Add Data Add Data & Close

Pick Proper Purpose

Table View



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

Table

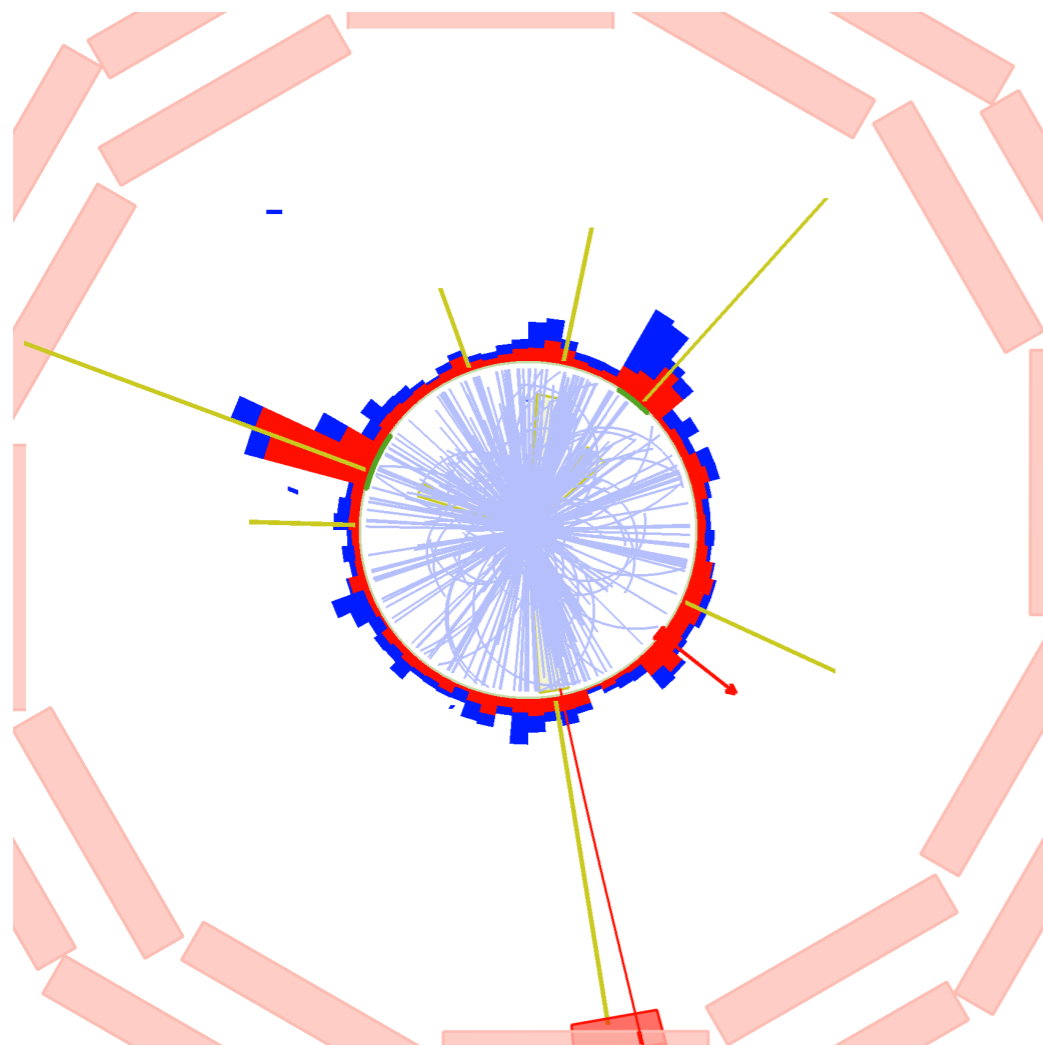
Collection: Muons

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

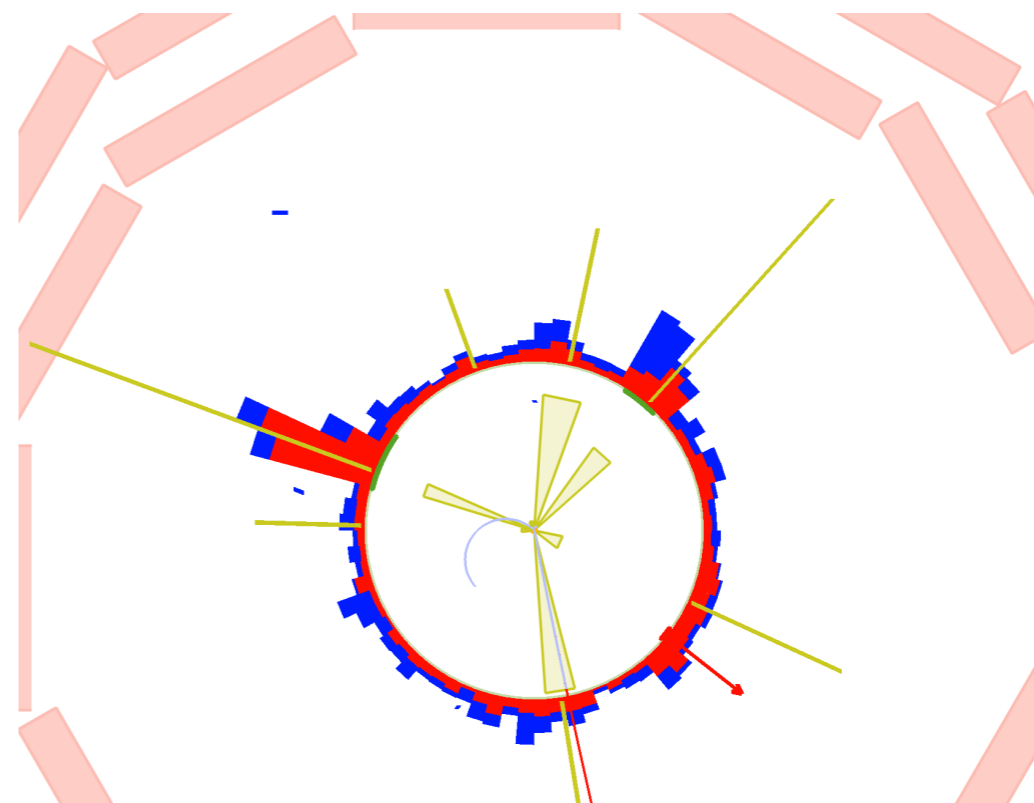
● ● ● X
Collection Controller

genParticles

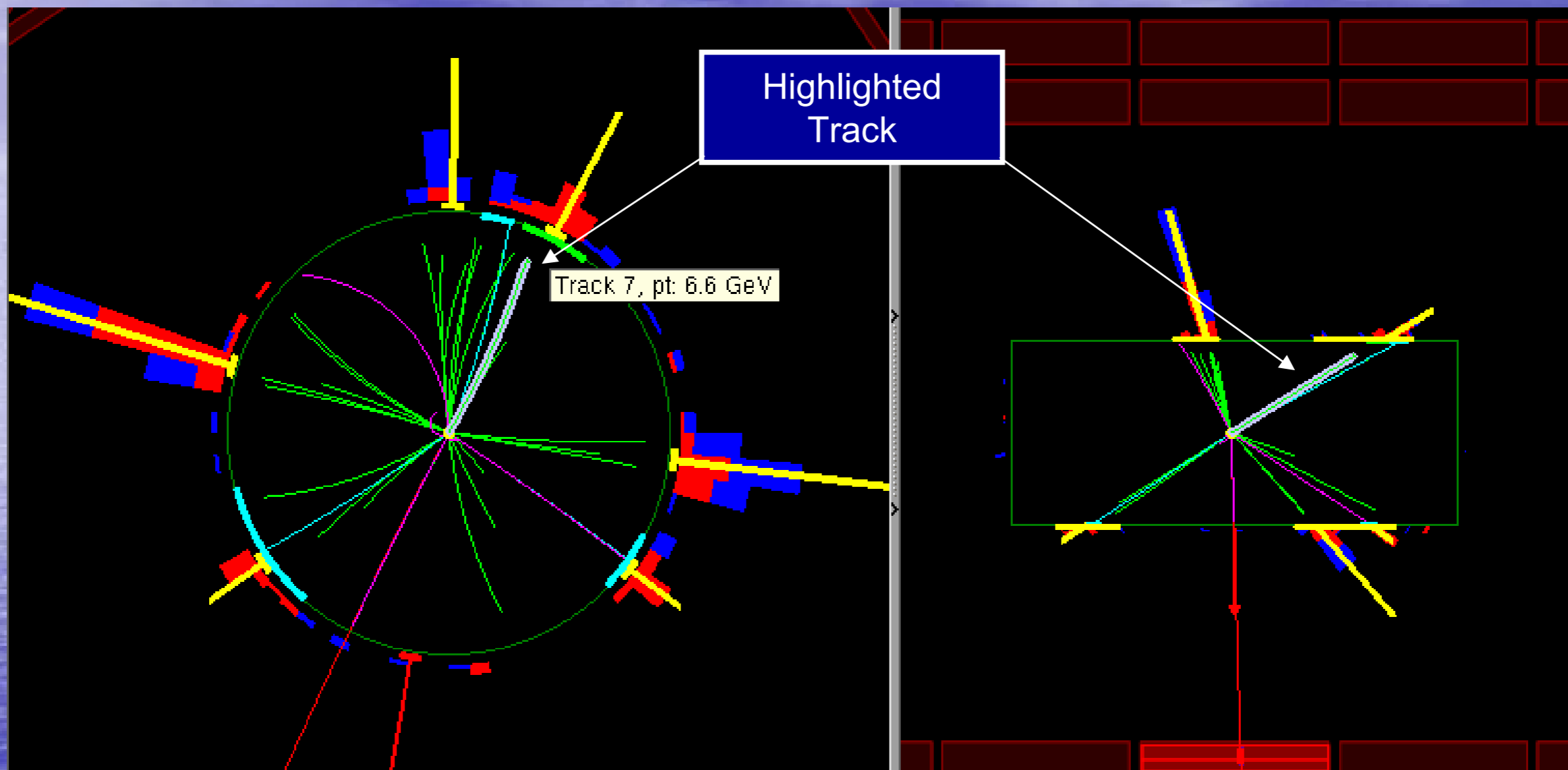
Graphics
Filter
Select
Data

Expression

Filter



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

File Edit View Window Help

Delay 3.0s Run 123592 Event 53888 Sun Dec 6
204 events are selected from 286. Lumi block

Summary View Views

Add Collection

- ECal
- HCal
- Jets
- Tracks

Rho Phi

Enable individual filter

Outputs of enabled selectors are combined as the logical:
 OR AND

Expression:	Comment:	Pass:
<code>\$Tracks.pt()>1</code>		204 <input checked="" type="checkbox"/>
<code>\$Jets.pt()>5</code>		0 <input type="checkbox"/>
HLT_Mu9		0 <input type="checkbox"/>
HLT_MinBi		-1 <input type="checkbox"/>
HLT_MinBias		<input type="checkbox"/> +
HLT_MinBiasBSC		
HLT_MinBiasBSC_OR		
HLT_MinBiasEcal		
HLT_MinBiasHcal		
HLT_MinBiasPixel_DoubleIsoTrack5		

Close Disable Filtering Apply

Tab Completion in action

- 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.

- ▶ 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