

Fireworks:

A Physics Event Display for CMS

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Overview



Requirements

Building Blocks

Interface

Views

Filtering

Requirements



When Viewing Data Only for Physics Content

Easy to use

First time users can easily be put off

Concentrate on only what you care about

Show only the data types requested

Show only the data items of interest

Pixel accurate representation may hamper physics

Distortion of space can be used to better use screen space

Placing objects in logical layers rather than exact x,y can aid comparison

Simple geometry avoids need for alignment info

Airplane test

Physicists want to be able to look at their data even away from a network

Building Block: EDM

CMS's New Event Data Model

Began in 2005 and now fully utilized

Strict separation of algorithm and data

Code that is used to create data is in separate libraries from the data

Data objects serialized directly by ROOT

Tiered analysis strategies

Full framework: can access all conditions information and use on grid

Lite framework: helper classes and dictionaries for use in ROOT

Bare ROOT: quickly look at simple data quantities

Fireworks is Built on the Lite Framework

Building Block: Eve



Eve is a New Package in ROOT

Used for constructing event displays

Originally developed for ALICE

Features

Optimized OpenGL rendering

3D, 2D and lego views

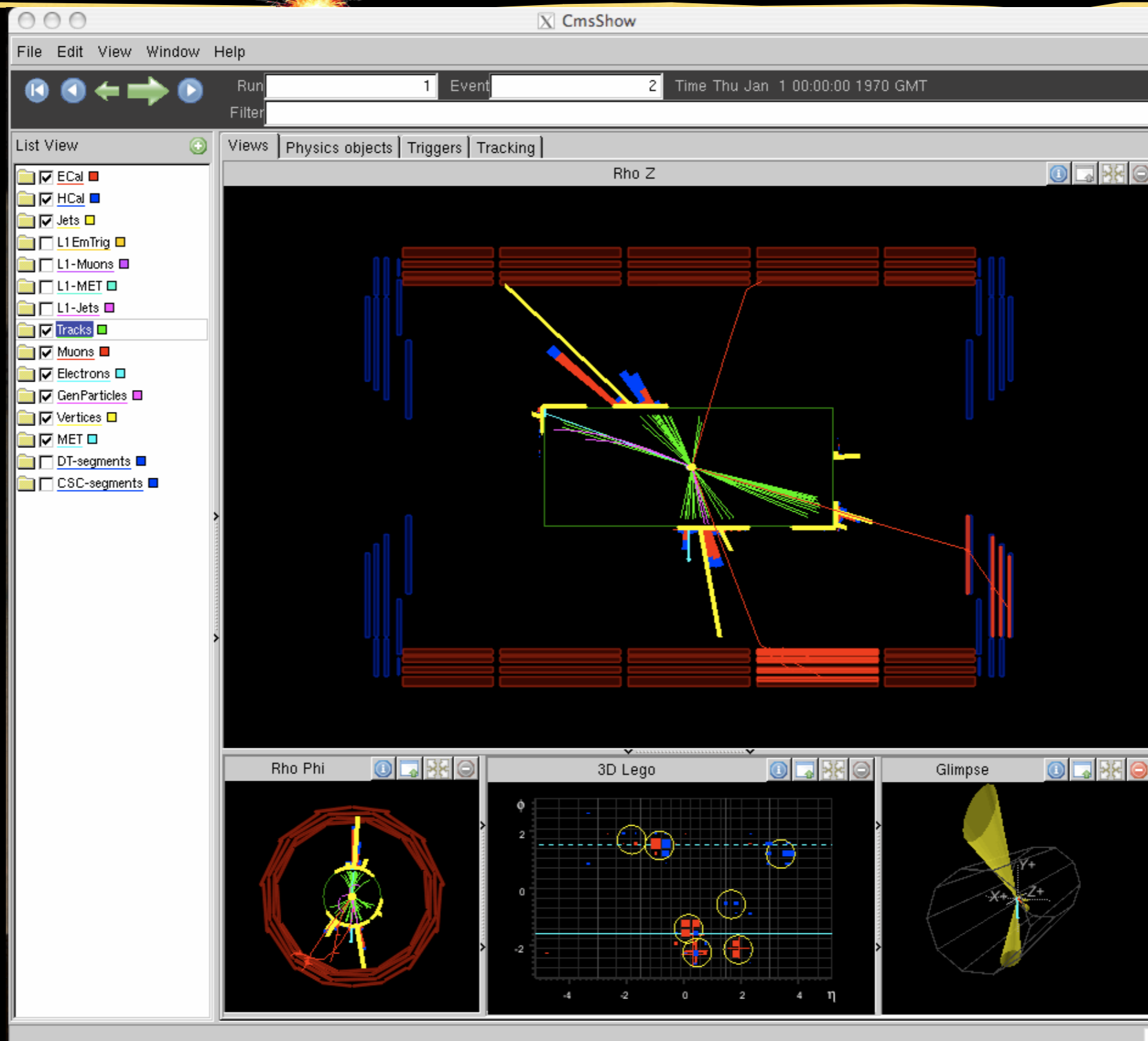
Real-time spatial distortions

E.g., fish-eye

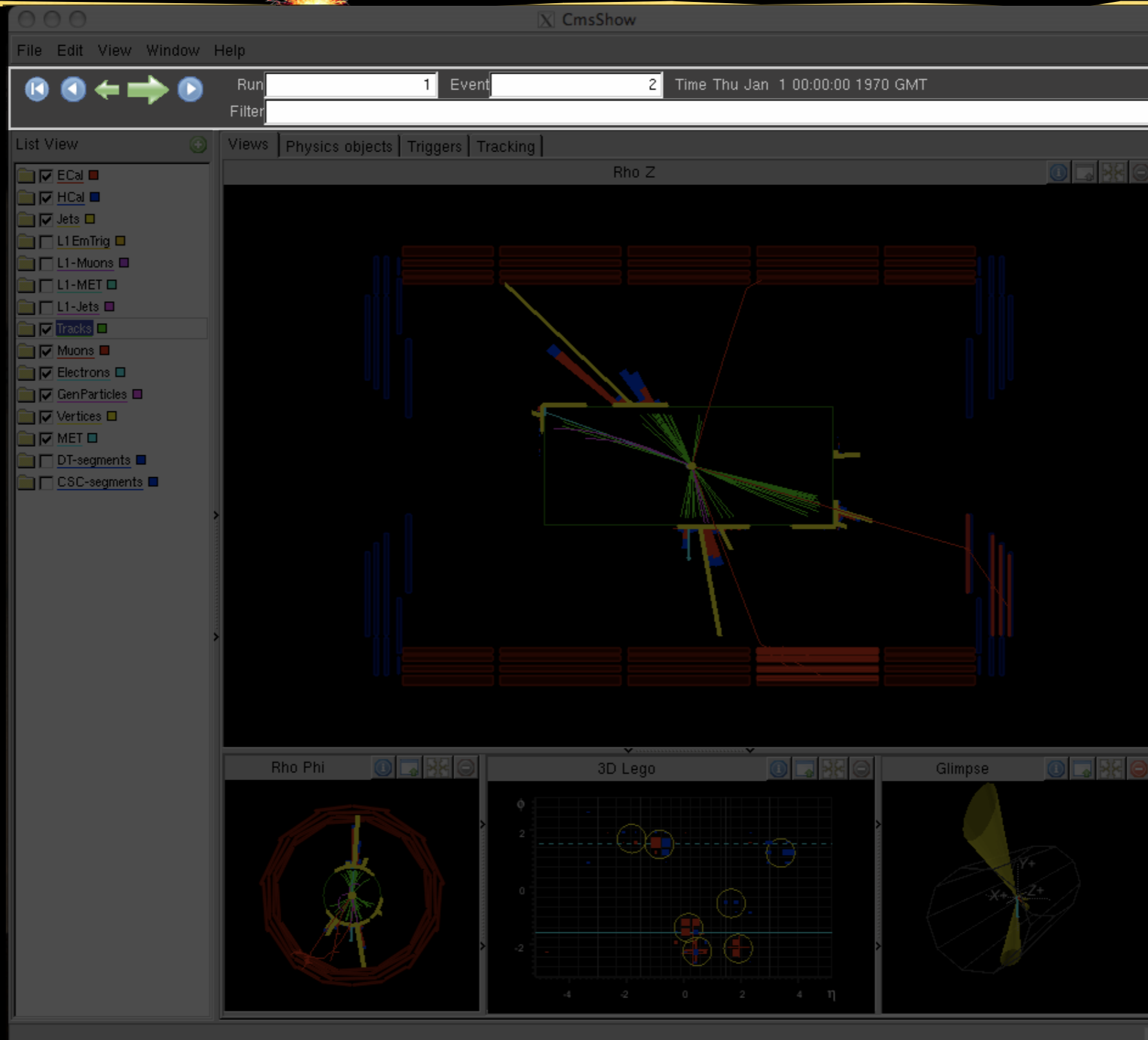
Individual object selection and highlighting

Eve Developers are Fireworks Members

Interface



Interface



Interface

Event Controls



Easy access for most common actions

Single step forward and back

Play forward and back

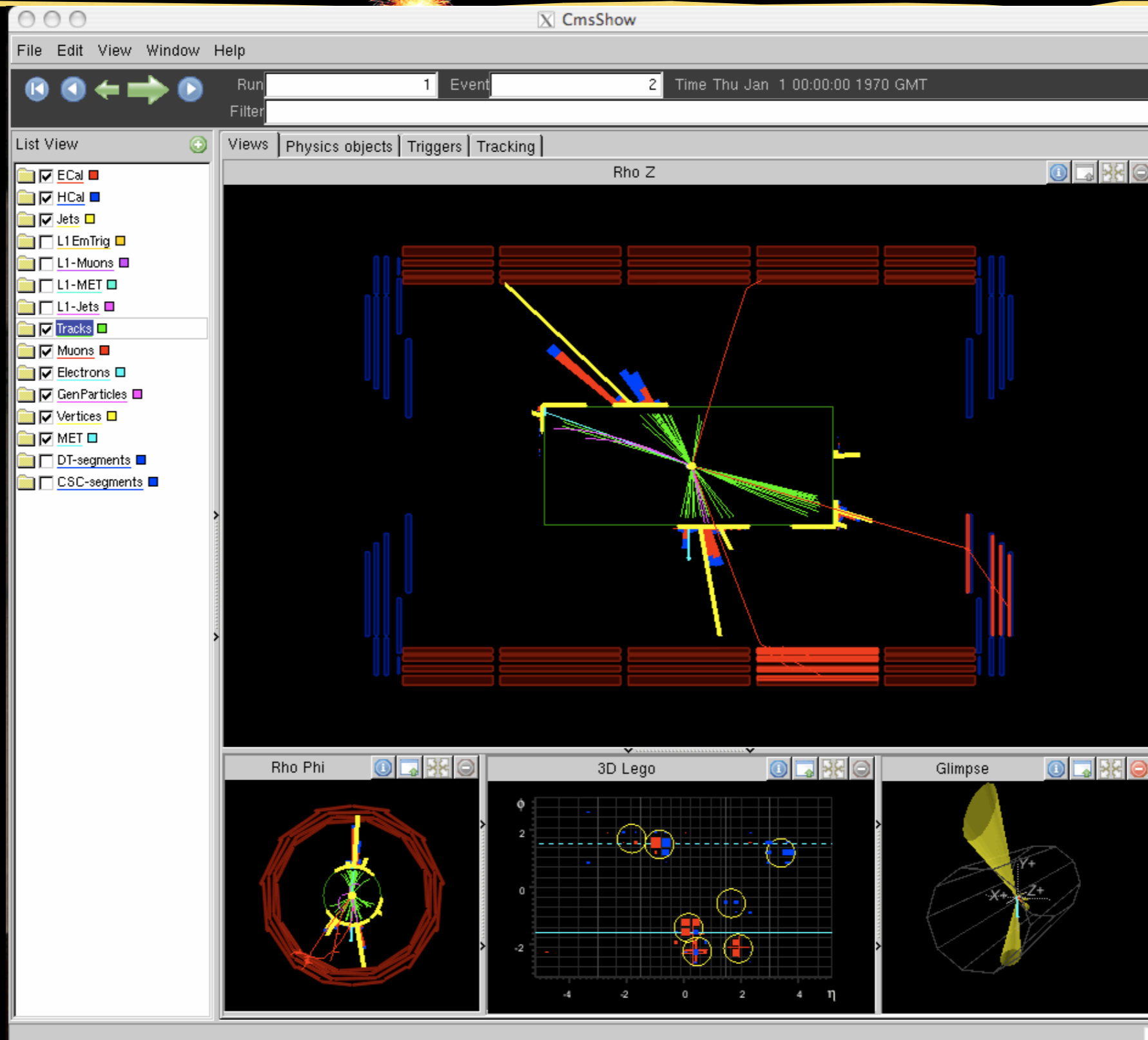
Go to first event

Jump to Run/Event

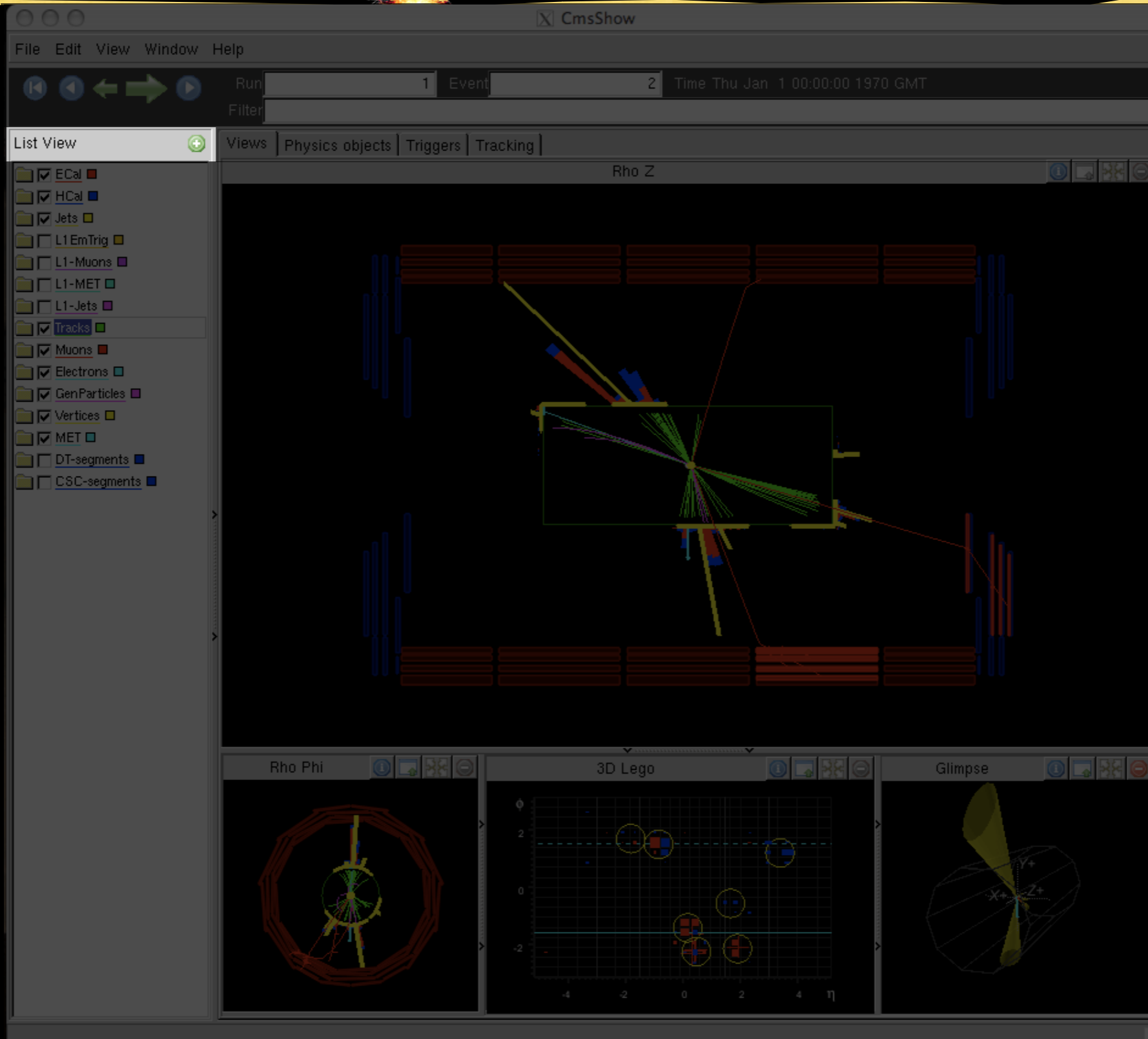
Filter events



Interface



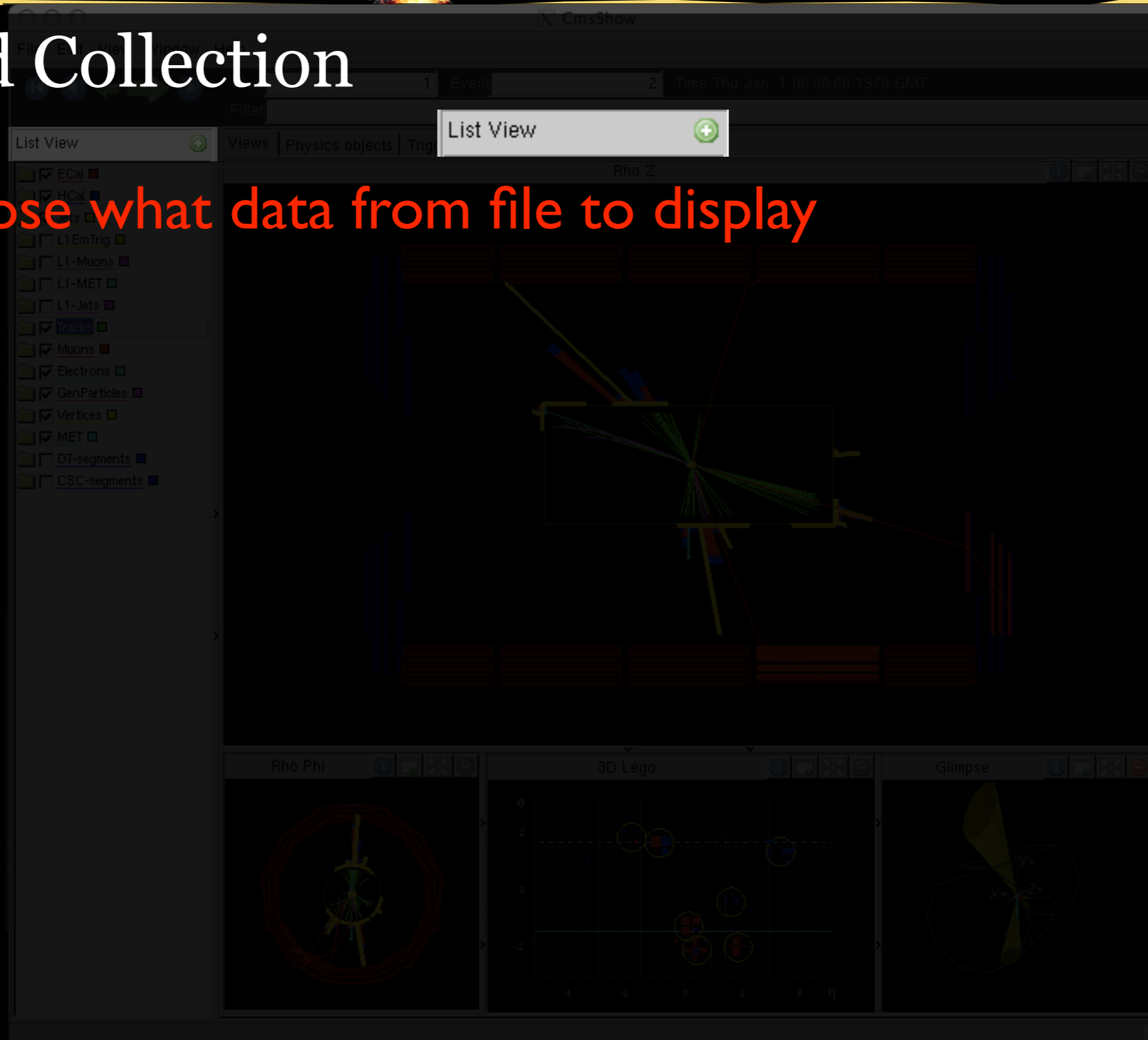
Interface



Interface

Add Collection

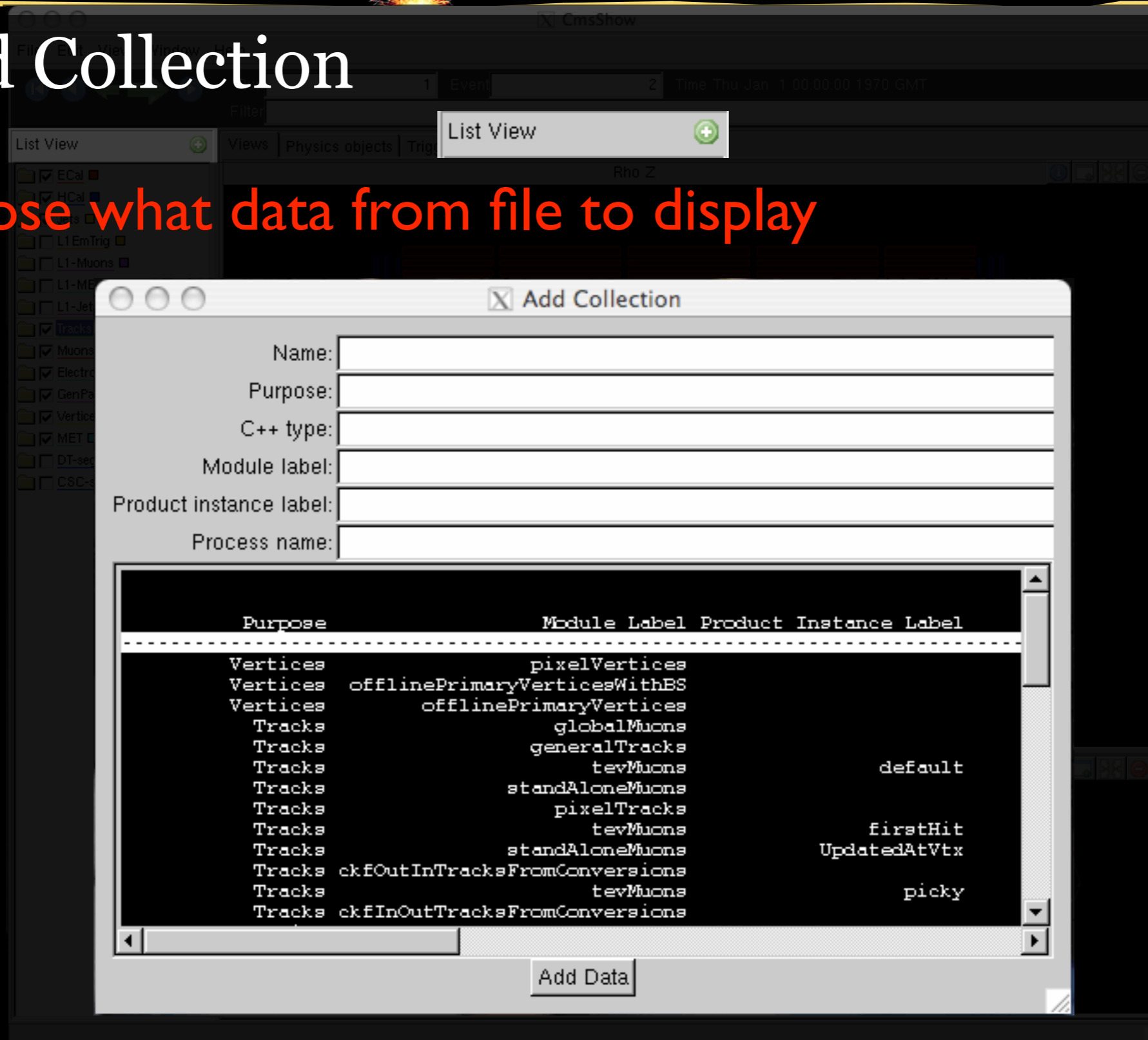
Choose what data from file to display



Interface

Add Collection

Choose what data from file to display



Interface

Add Collection

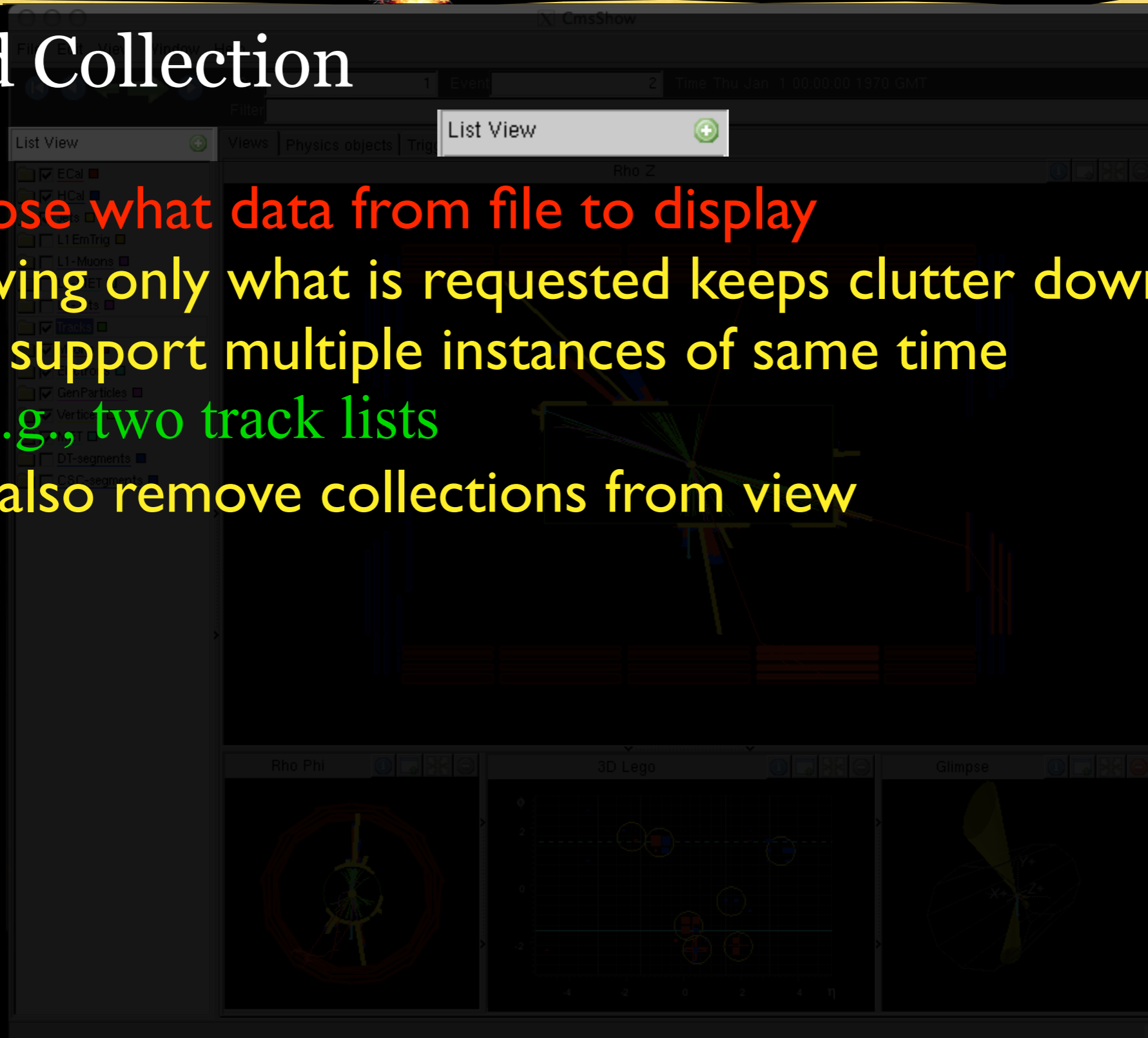
Choose what data from file to display

Showing only what is requested keeps clutter down

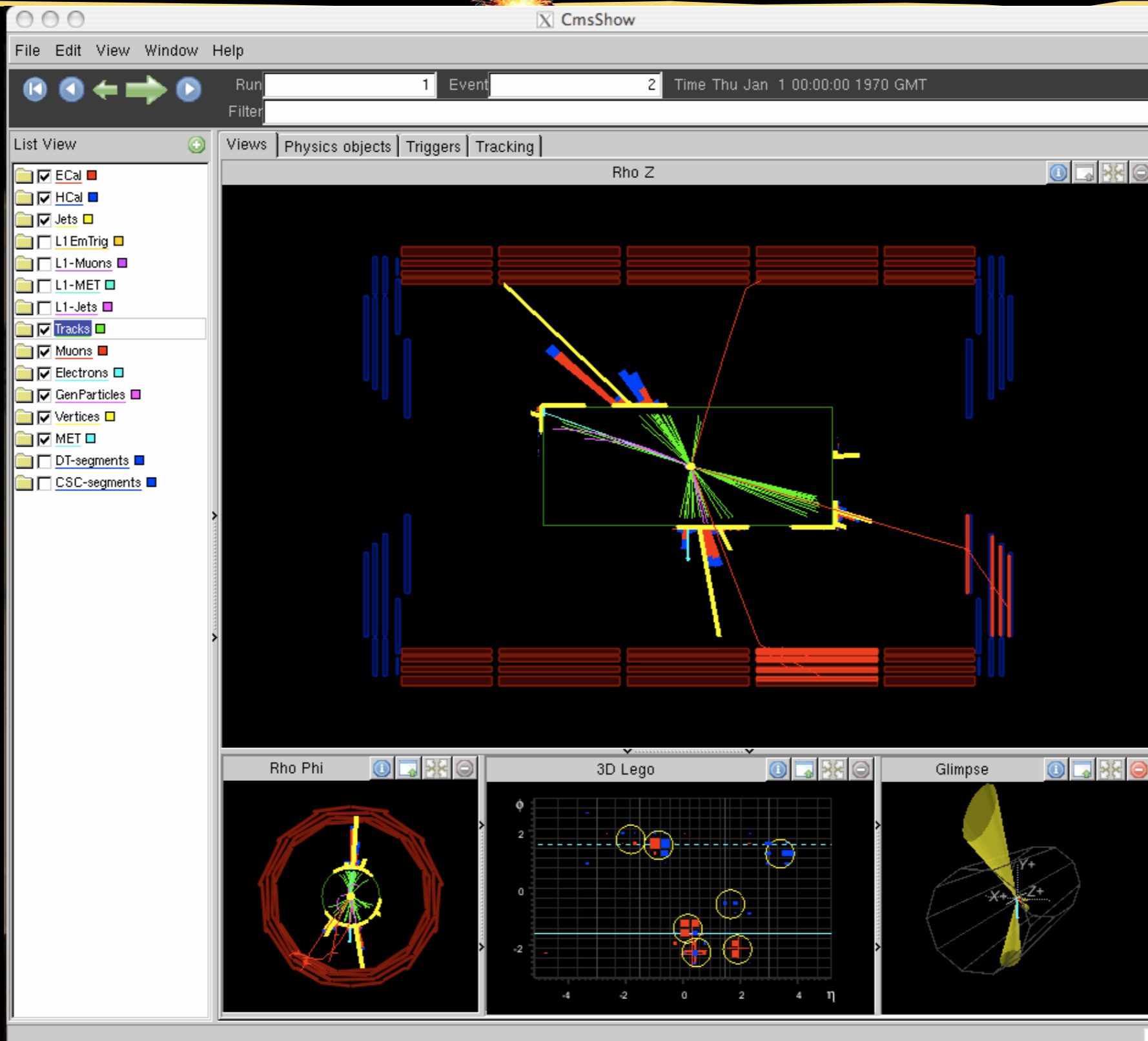
Also support multiple instances of same time

e.g., two track lists

Can also remove collections from view



Views



Views

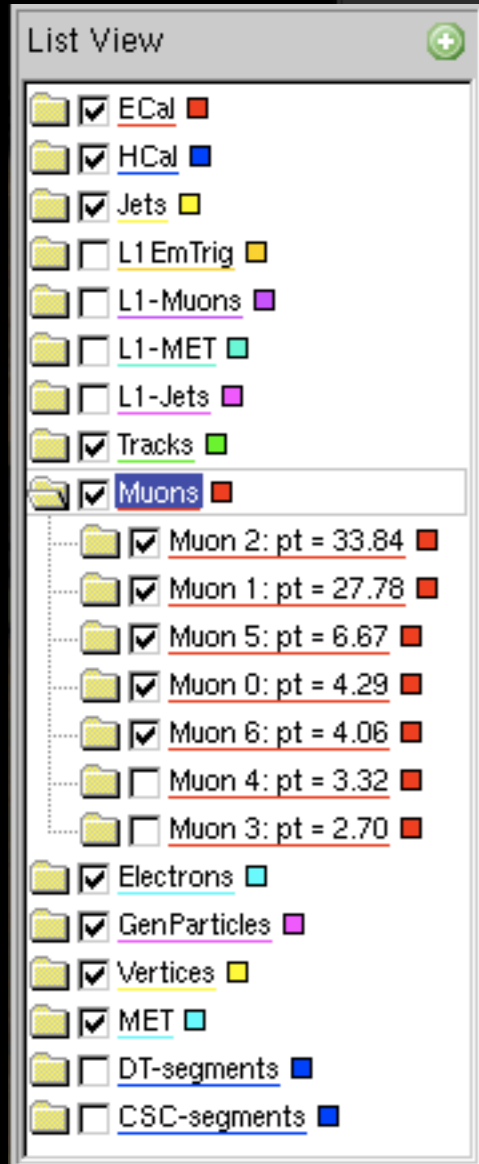


The screenshot displays the CmsShow application window. At the top, there is a menu bar (File, Edit, View, Window, Help) and a toolbar with navigation buttons. Below the toolbar, the 'Run' section shows 'Event 2' and 'Time Thu Jan 1 00:00:00 1970 GMT'. The main interface is divided into several panels:

- List View:** A sidebar on the left containing a tree view of physics objects with checkboxes and color-coded icons. Objects include ECal, HCal, Jets, L1 EmTrig, L1-Muons, L1-MET, L1-Jets, Tracks, Muons, Electrons, GenParticles, Vertices, MET, DT-segments, and CSC-segments.
- Rho Z:** A large central plot showing a top-down view of the detector's calorimeter structure (brown bars) with particle tracks (colored lines) originating from a central vertex (green box).
- Rho Phi:** A smaller plot below Rho Z showing a top-down view of the detector structure with tracks.
- 3D Lego:** A plot showing a 2D projection of the detector structure with tracks, overlaid on a grid.
- Glimpse:** A 3D visualization of the detector structure with a yellow cone representing a particle's path.

Views

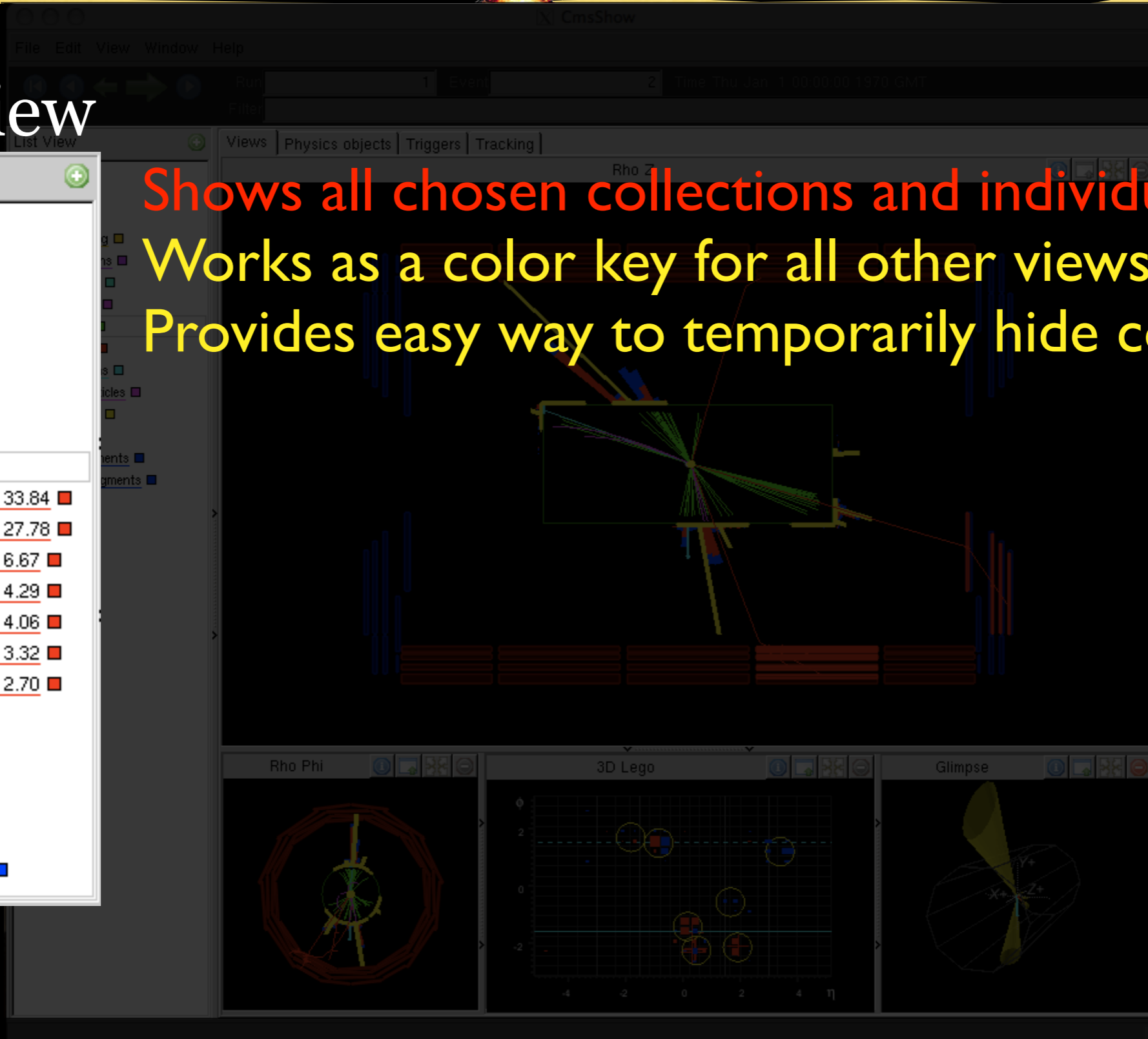
List View



List View

- ECal
- HCal
- Jets
- L1 EmTrig
- L1-Muons
- L1-MET
- L1-Jets
- Tracks
- Muons
 - Muon 2: pt = 33.84
 - Muon 1: pt = 27.78
 - Muon 5: pt = 6.67
 - Muon 0: pt = 4.29
 - Muon 6: pt = 4.06
 - Muon 4: pt = 3.32
 - Muon 3: pt = 2.70
- Electrons
- GenParticles
- Vertices
- MET
- DT-segments
- CSC-segments

Shows all chosen collections and individual items
Works as a color key for all other views
Provides easy way to temporarily hide collections



Views



The screenshot displays the CmsShow application window. At the top, the title bar reads "CmsShow". Below it is a menu bar with "File", "Edit", "View", "Window", and "Help". A status bar shows "Run 1", "Event 2", and "Time Thu Jan 1 00:00:00 1970 GMT".

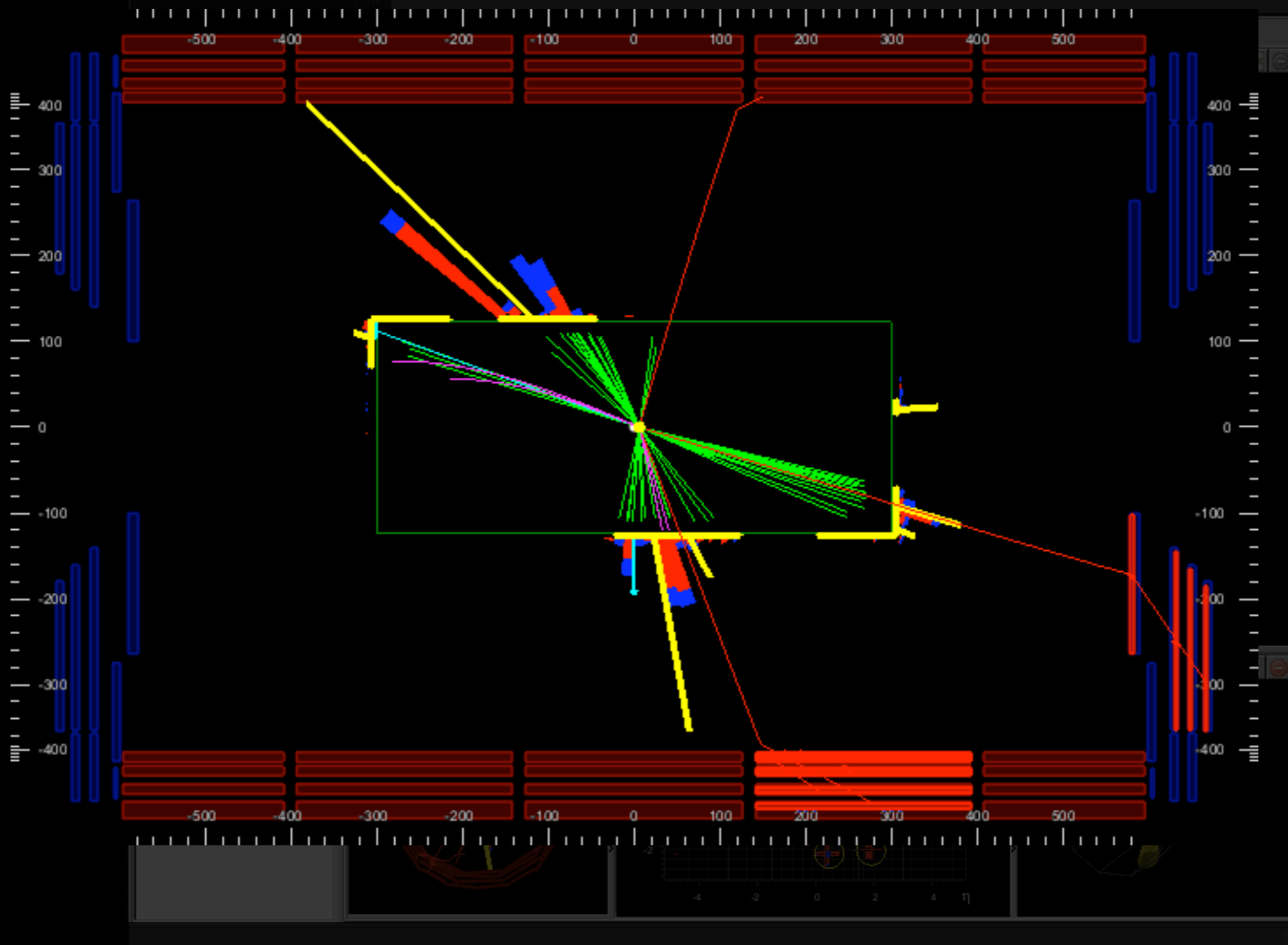
The main interface is divided into several panels:

- List View:** A sidebar on the left containing a tree of physics objects with checkboxes and color-coded icons. Objects include ECal, HCal, Jets, L1 EmTrig, L1-Muons, L1-MET, L1-Jets, Tracks, Muons, Electrons, GenParticles, Vertices, MET, DT-segments, and CSC-segments.
- Rho Z:** The largest central panel showing a top-down view of the detector's calorimeter structure (brown bars) with particle tracks (colored lines) originating from a central vertex (green box).
- Rho Phi:** A smaller panel at the bottom left showing a circular view of the detector with tracks.
- 3D Lego:** A panel at the bottom middle showing a 2D plot of particle positions on a grid, with axes labeled η and ϕ .
- Glimpse:** A panel at the bottom right showing a 3D view of the detector geometry with a yellow cone representing a particle's path.

Views



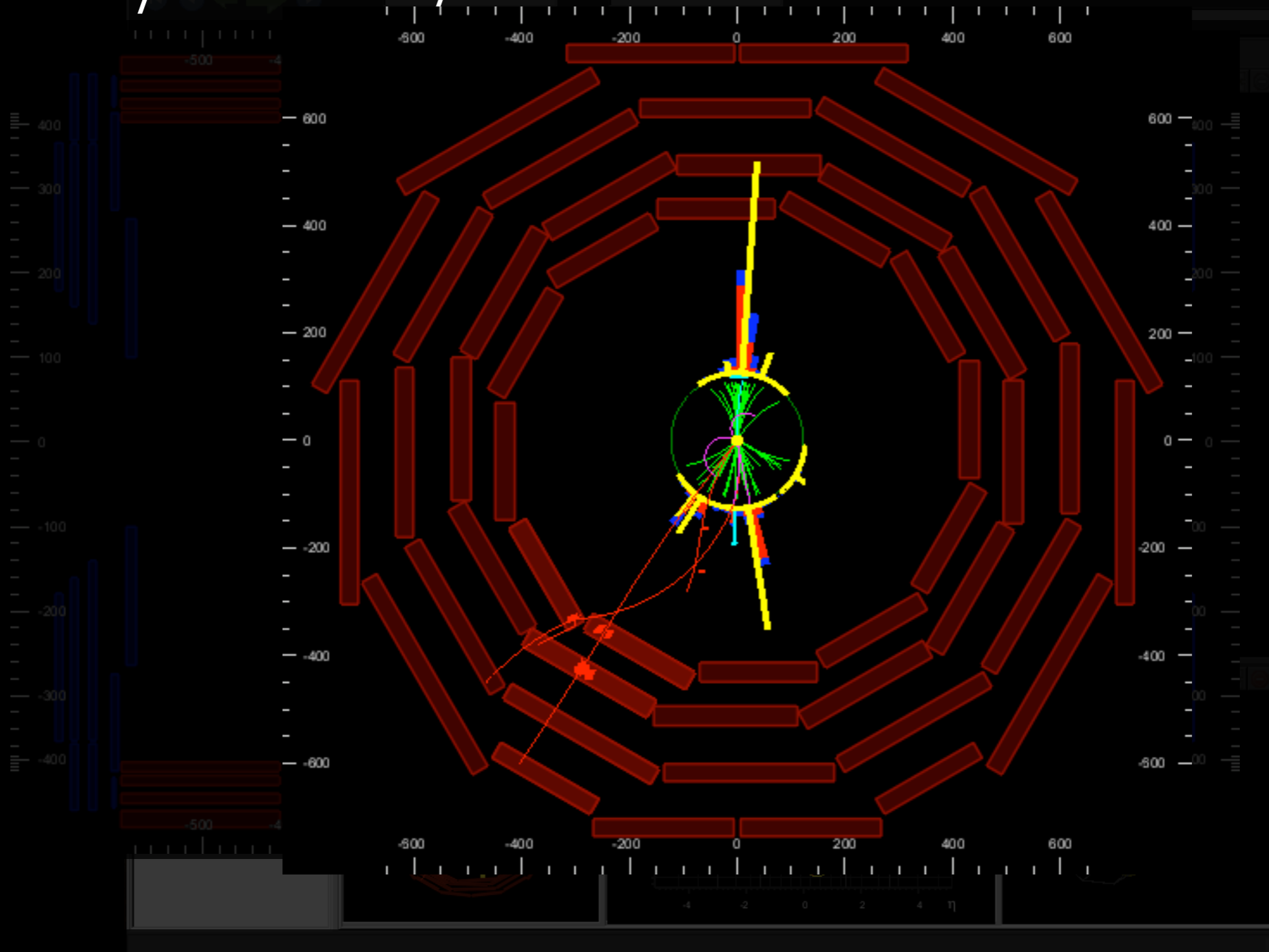
Rho/Z & Rho/Phi Views



Views



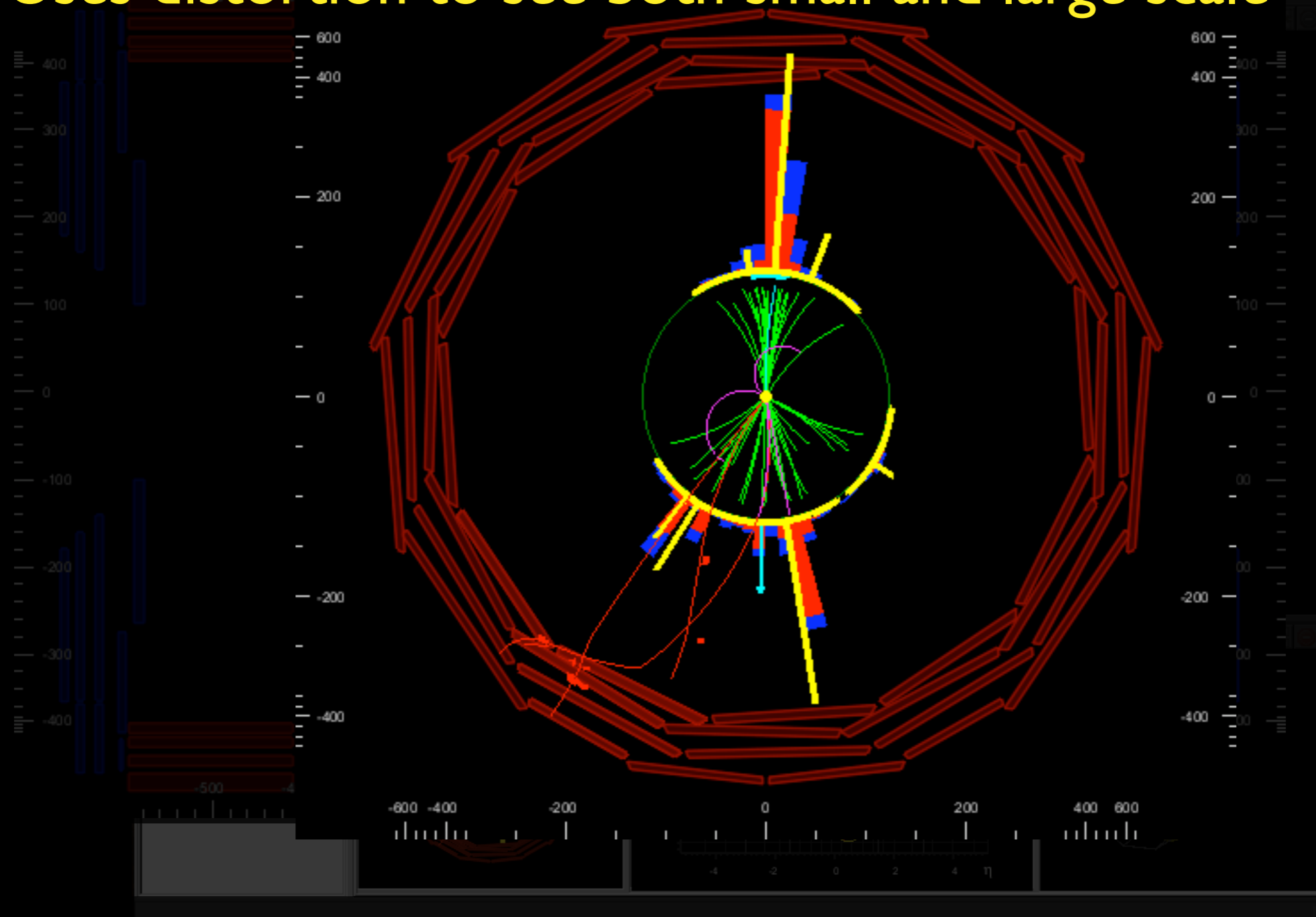
Rho/Z & Rho/Phi Views



Views

Rho/Z & Rho/Phi Views

Uses distortion to see both small and large scale



Views



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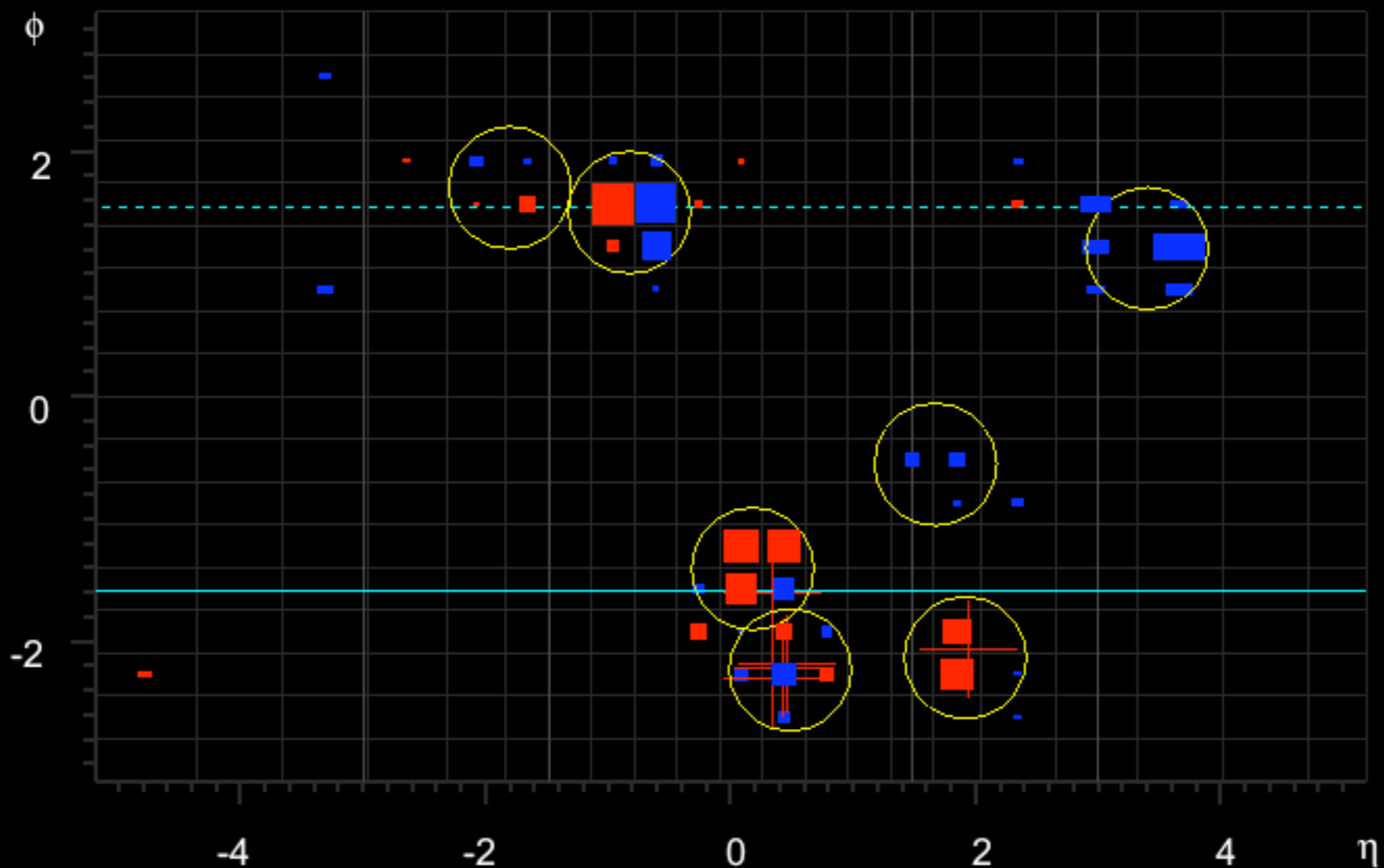
- List View:** A sidebar on the left containing a tree of physics objects with checkboxes. Checked items include ECal, HCal, Tracks, Muons, Electrons, GenParticles, Vertices, and MET. Unchecked items include Jets, L1 EmTrig, L1-Muons, L1-MET, L1-Jets, DT-segments, and CSC-segments.
- Rho Z:** The largest central panel showing a top-down view of the detector's calorimeter structure (brown bars) with particle tracks (colored lines) originating from a central vertex (green box).
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Views



Lego View

From top shows 2D

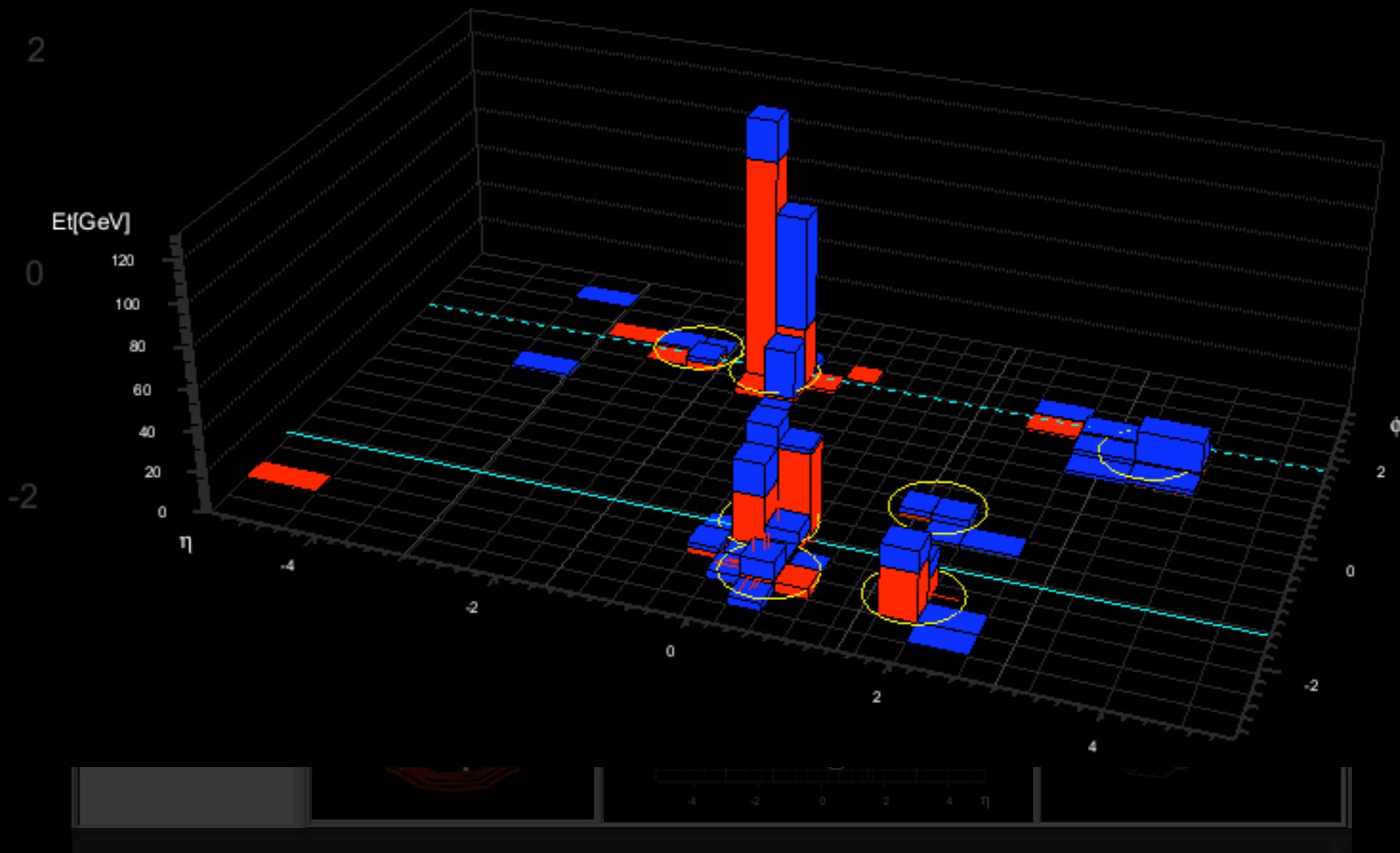


Views

Lego View

From top shows 2D

Rotation will show 3D



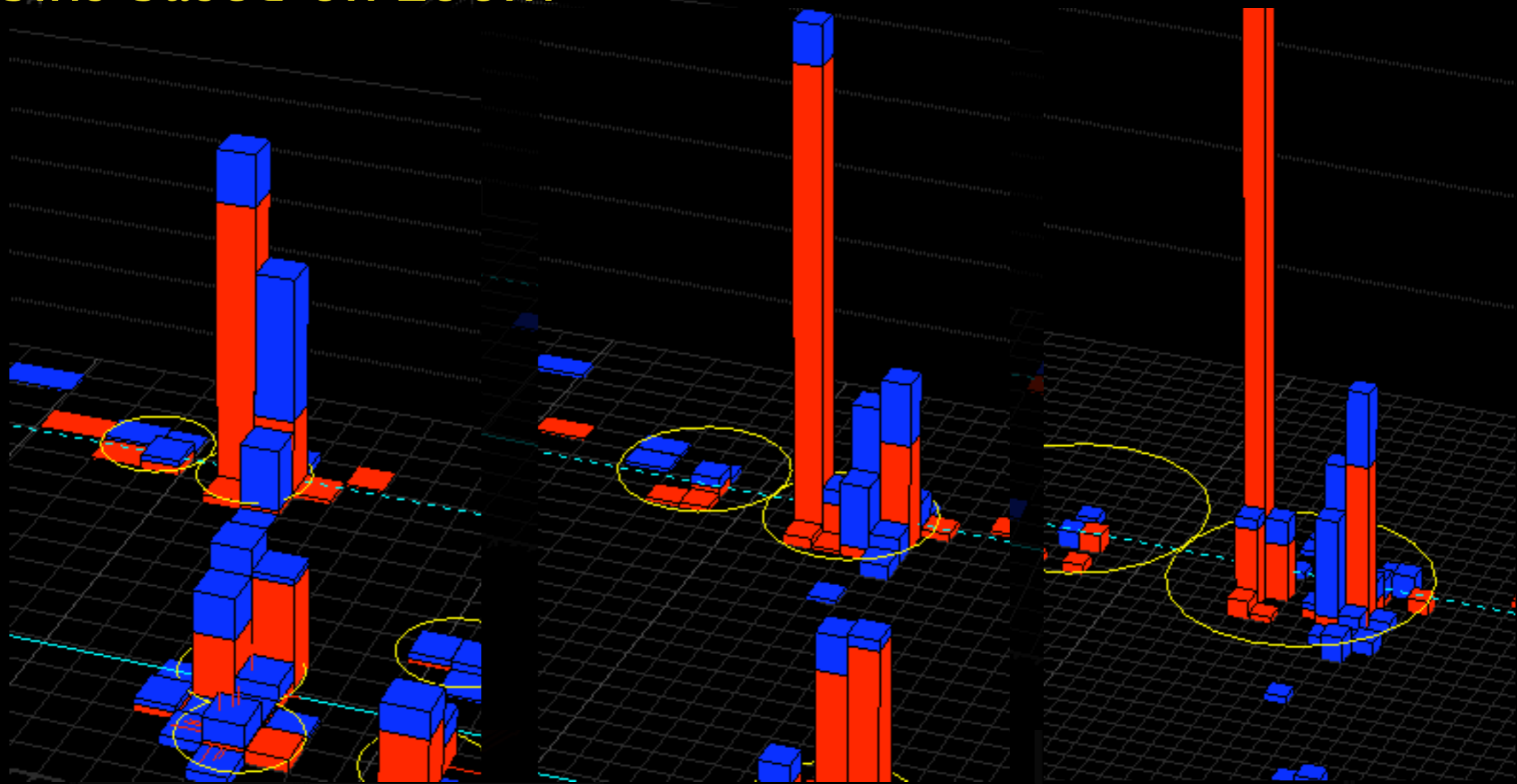
Views

Lego View

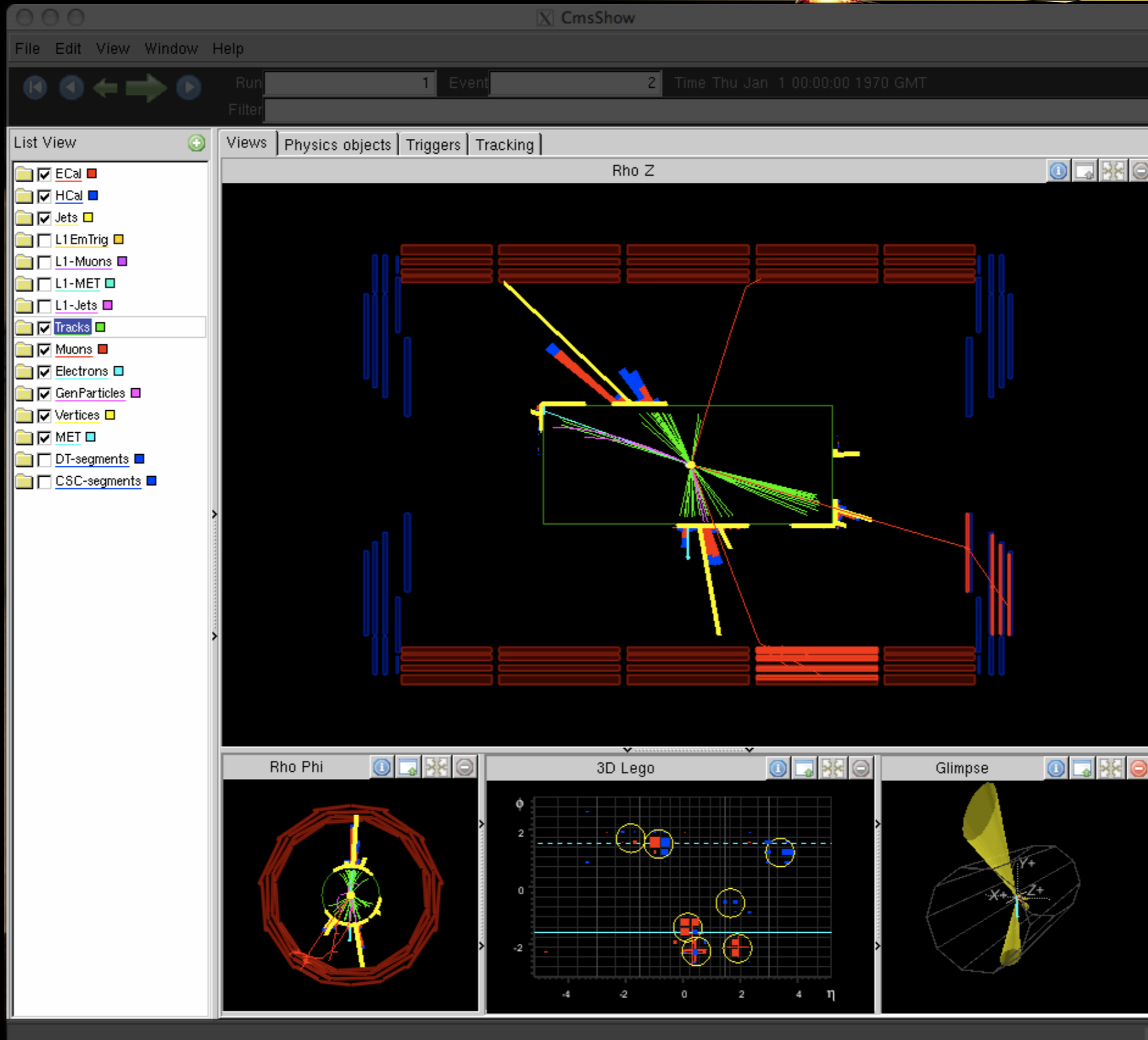
From top shows 2D

Rotation will show 3D

Rebins based on zoom



Views

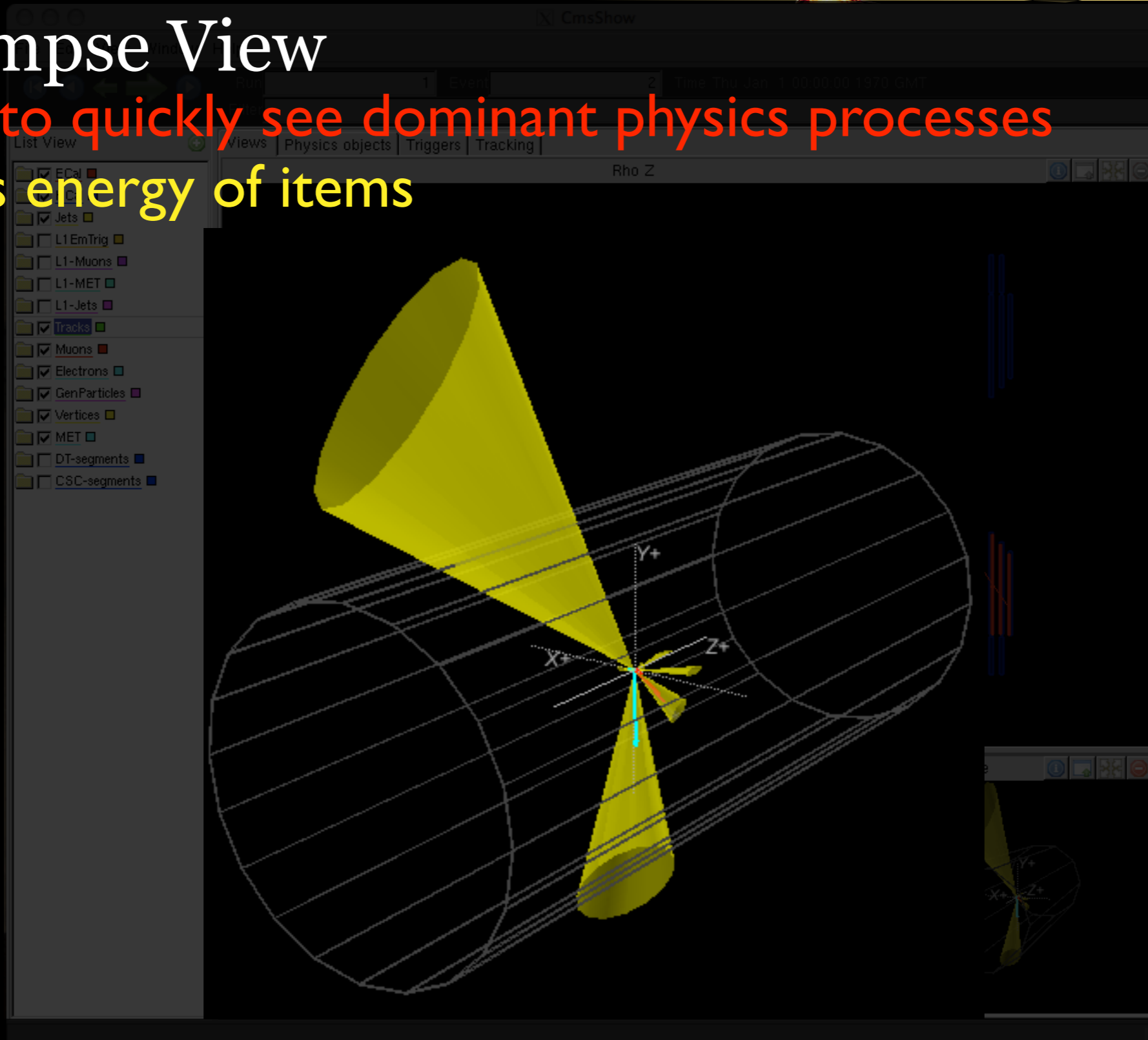


Views

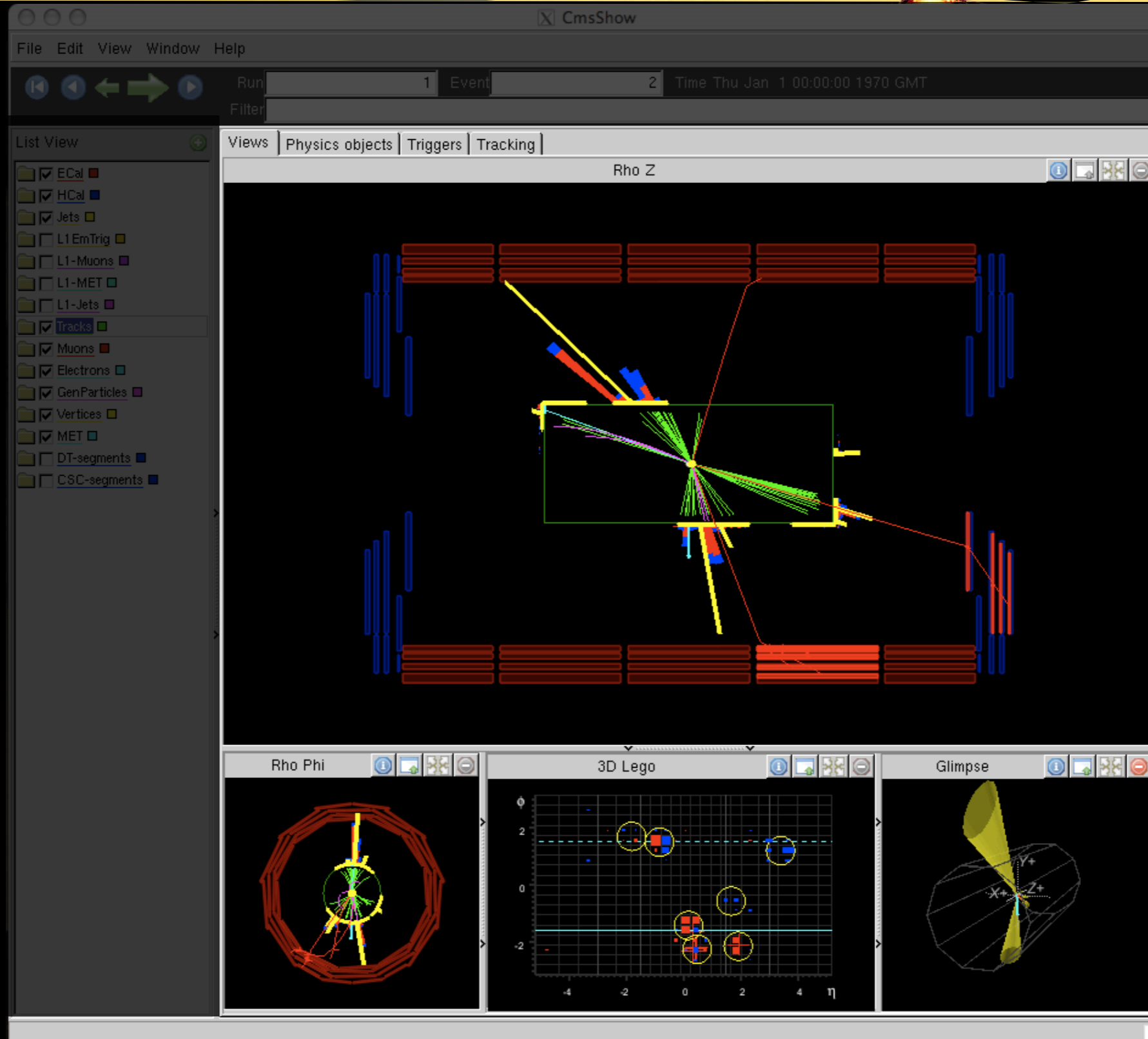
Glimpse View

Use to quickly see dominant physics processes

Plots energy of items



Views



Views



CmsShow

File Edit View Window Help

Run 1 Event 2 Time Thu Jan 1 00:00:00 1970 GMT

Filter

Views Physics objects Triggers Tracking

Dump to file event_dump.txt append to file Dump to terminal Dump to printer `enscript -r -f Courier7`

Run 1 MET 62.1 GeV Event 2 MET phi -1.599 Sum ET 723.4 GeV MET significance 2.31 (GeV)^{1/2}

idx	Et	eta	Jets phi	ECAL	HCAL	emf
0	345.8	-0.825	1.500	292.3	178.2	0.621
1	204.3	0.181	-1.410	143.7	64.0	0.692
2	69.4	1.917	-2.136	150.3	91.0	0.623
3	47.9	0.487	-2.236	29.6	24.1	0.551
4	43.5	3.402	1.205	184.5	469.3	0.282
5	21.7	1.674	-0.556	16.9	42.9	0.282
6	20.0	-1.803	1.703	29.9	32.4	0.480
7	8.5	2.747	1.509	27.3	39.3	0.410
8	6.9	-0.161	-1.846	3.9	3.1	0.552
9	4.6	-0.104	1.872	4.6	0.0	1.000
10	4.2	2.066	-0.975	2.4	14.6	0.138
11	3.0	-3.498	0.859	15.1	34.6	0.304

idx	Et	eta	phi	E/p	H/E	fbrem	dei	dpi
1	9.7	-1.728	1.609	1.882	0.000	-0.010	-0.016	0.101
0	5.6	0.559	-2.150	0.556	0.054	0.013	0.003	-0.004

idx	pt	global	tk	SA	calo	tr pt	eta	phi	d0	sig(d0)
2	33.8	yes	yes	yes	no	32.986	0.374	-2.246	-0.026	-26.483
1	27.8	yes	yes	yes	no	3.804	0.532	-2.190	-0.131	-50.495
5	6.7	no	no	yes	no	-1.000	0.537	-2.818	-1.000	-1.000
0	4.3	yes	yes	yes	no	4.246	1.913	-2.176	-0.039	-8.264
6	4.1	no	no	yes	no	-1.000	0.295	-1.495	-1.000	-1.000
4	3.3	no	yes	no	no	3.322	2.042	-2.193	-0.029	-4.622
3	2.7	no	yes	no	no	2.696	2.010	-1.237	-0.029	-3.679

Views



Text View

Tabular display of values for each item

Sorted based on selected column

idx	Et	eta	Jeta phi	ECAL	HCAL	emf
0	345.8	-0.825	1.500	292.3	178.2	0.621
1	204.3	0.181	-1.410	143.7	64.0	0.692
2	69.4	1.917	-2.136	150.3	91.0	0.623
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11	3.0	-3.498	0.859	15.1	34.6	0.304

View Integration



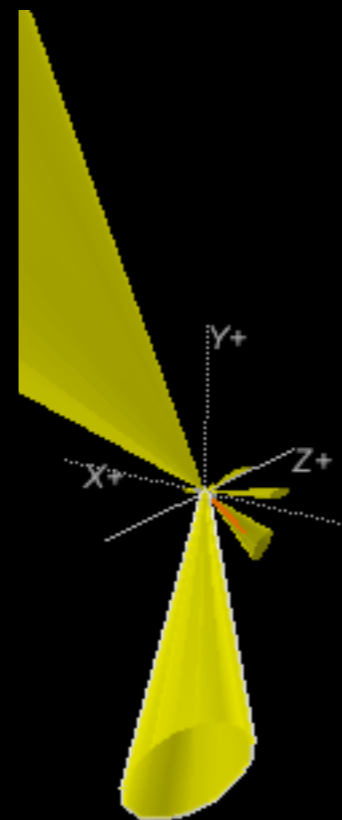
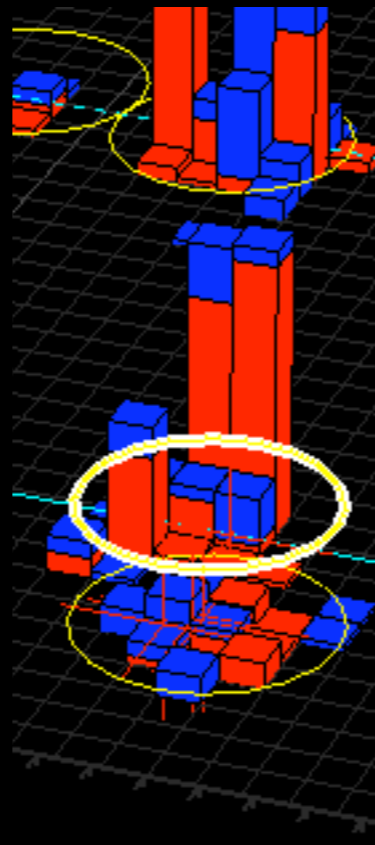
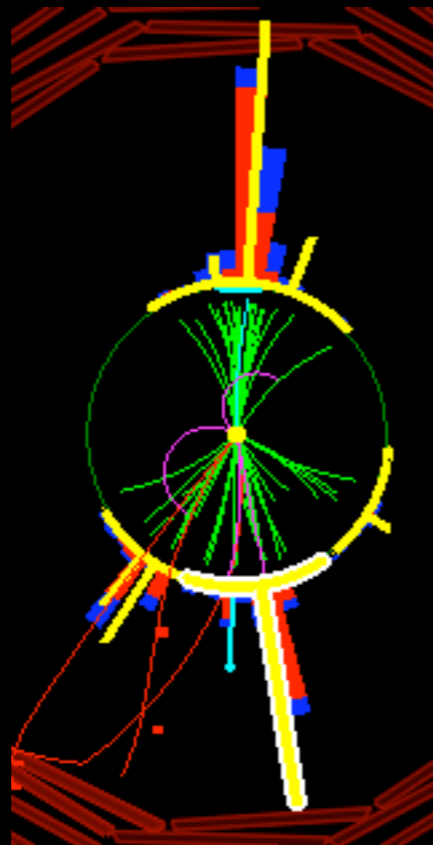
All Views

Use same object colors

Allow individual object selections

Highlight selected objects

<input checked="" type="checkbox"/>	ECal	<input type="checkbox"/>
<input checked="" type="checkbox"/>	HCal	<input type="checkbox"/>
<input checked="" type="checkbox"/>	Jets	<input type="checkbox"/>
<input checked="" type="checkbox"/>	Jet 0: pt = 341.04	<input type="checkbox"/>
<input checked="" type="checkbox"/>	Jet 1: pt = 200.45	<input type="checkbox"/>
<input checked="" type="checkbox"/>	Jet 2: pt = 69.38	<input type="checkbox"/>
<input checked="" type="checkbox"/>	Jet 3: pt = 47.03	<input type="checkbox"/>
<input checked="" type="checkbox"/>	Jet 4: pt = 43.50	<input type="checkbox"/>
<input checked="" type="checkbox"/>	Jet 5: pt = 21.62	<input type="checkbox"/>
<input checked="" type="checkbox"/>	Jet 6: pt = 19.94	<input type="checkbox"/>
<input type="checkbox"/>	Jet 7: pt = 8.50	<input type="checkbox"/>
<input type="checkbox"/>	Jet 8: pt = 6.92	<input type="checkbox"/>
<input type="checkbox"/>	Jet 9: pt = 4.47	<input type="checkbox"/>
<input type="checkbox"/>	Jet 10: pt = 4.24	<input type="checkbox"/>
<input type="checkbox"/>	Jet 11: pt = 3.01	<input type="checkbox"/>
<input type="checkbox"/>	Jet 12: pt = 2.17	<input type="checkbox"/>
<input type="checkbox"/>	Jet 13: pt = 1.39	<input type="checkbox"/>



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7	8.5	2.747	1.509	27.3
8	6.9	-0.161	-1.846	3.9
9	4.6	-0.104	1.872	4.6
10	4.2	2.066	-0.975	2.4
11	3.0	-3.498	0.859	15.1
12	2.2	-4.379	-2.261	86.6
13	1.4	-2.934	2.007	11.3
14	1.3	-0.652	0.829	0.0
15	1.1	2.416	2.007	0.0

Filtering



Event Filtering

Uses ROOT's TEventList

E.g., Show events with at least one 10 GeV muon

```
$Muons.pt() > 10
```

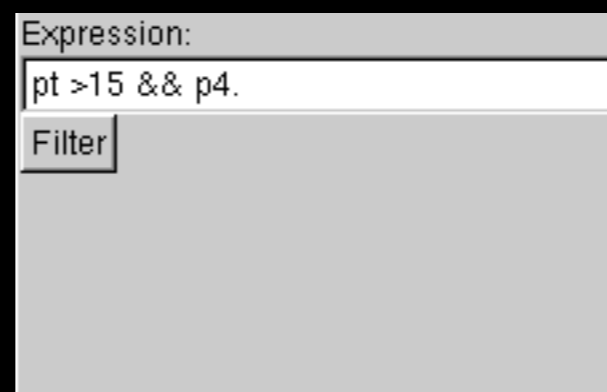
Item Filtering

Uses custom parser

Uses ROOT Reflex dictionaries

More than 50 times faster than CINT

Provide tab completion of member functions



Filtering



Event Filtering

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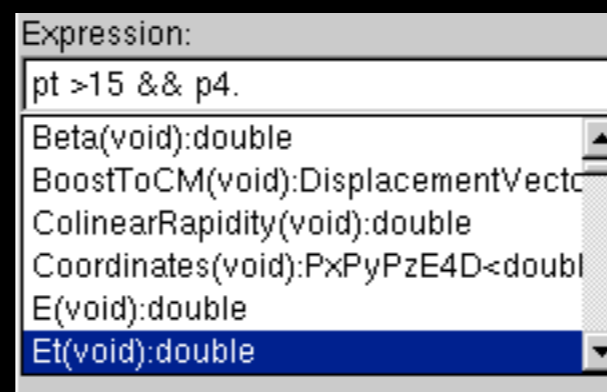
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Conclusion

User Response

Very positive

Like being able to install on laptops using tar

Presently support Linux and Mac OS X

Steady request for new objects to display

Future Plans

Simplify how data are converted to graphics objects

Pick graphics object based on data object base classes

Improvements to user interface

Complete Windows port