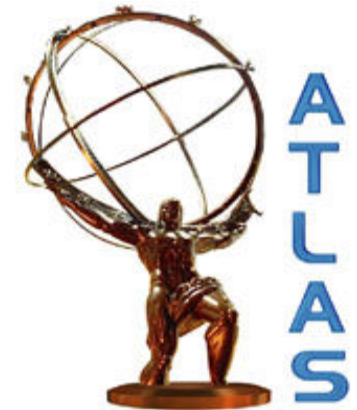
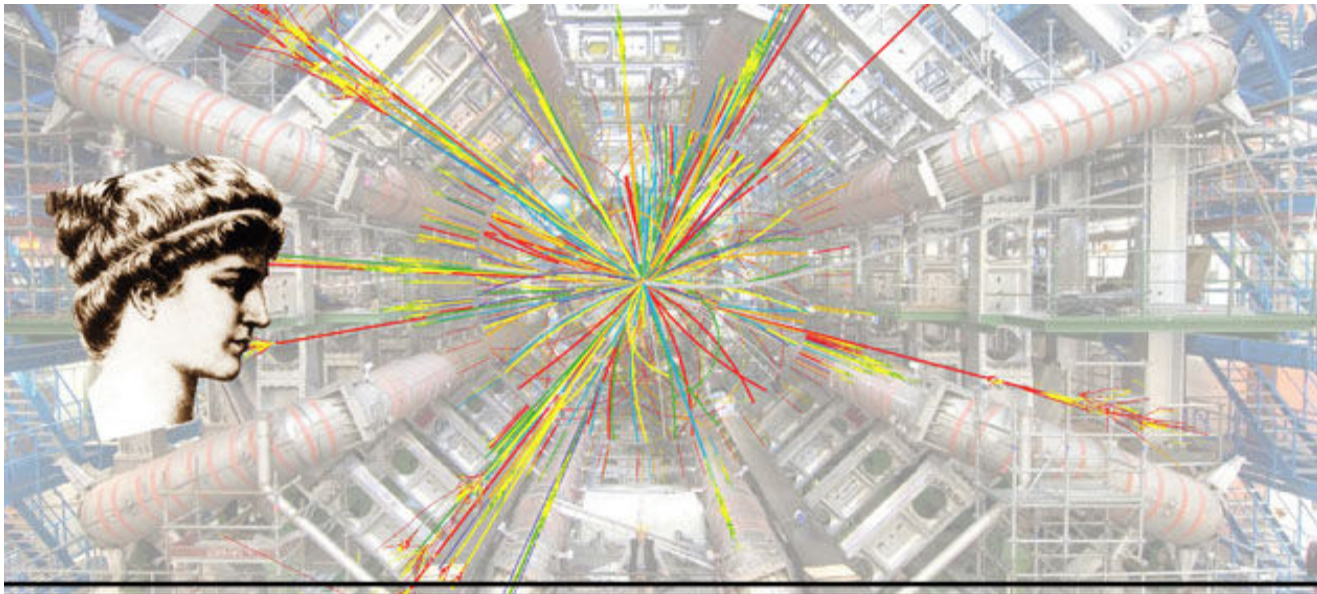


HYbrid Pupil's Analysis Tool for Interactions in ATLAS

<http://hypatia.phy.bg.ac.yu/>

C.Kourkouvelis (UoA)
D.Fassouliotis "
D.Vudragovic (Belgrade)
S.Vourakis (UoA)



H Y P A T I A
HYbrid Pupil's Analysis Tool for Interactions in ATLAS



HYPATIA – Information

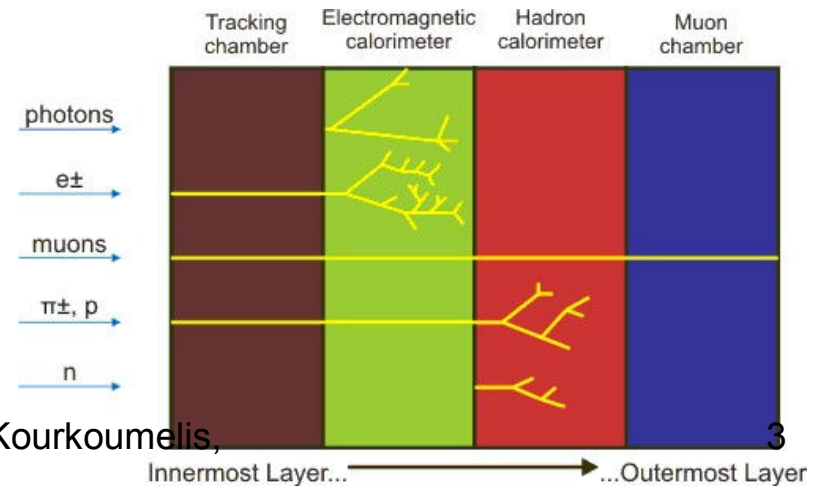
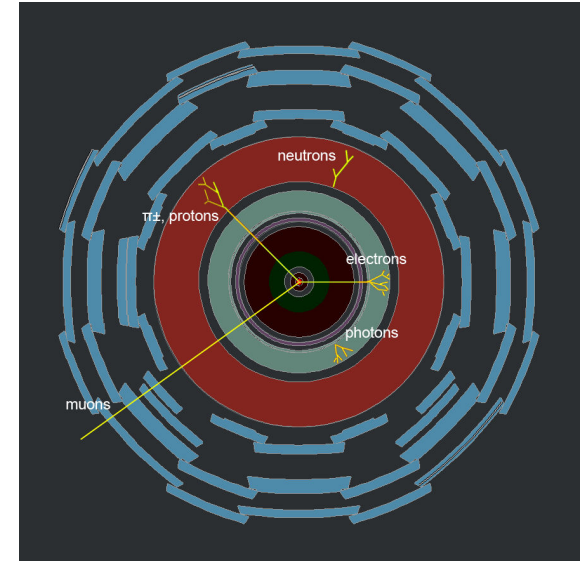
- **Part of the ATLAS Student Event Challenge**, an educational project at the frontier of Particle Physics
- Enables high schools students together with their teachers to study the fundamental particles of matter and their interactions
- Uses real “events” detected by the ATLAS experiment at CERN
- **Full version** for universities/scientific use
- **Simplified version** for educational use

Now all
in one



HYPATIA – Physics

- Particles are shown as tracks on the detectors
- Particle type determines track length
- Detectors :
 - Tracking chamber
 - Electromagnetic calorimeter
 - Hadron calorimeter
 - Muon chamber



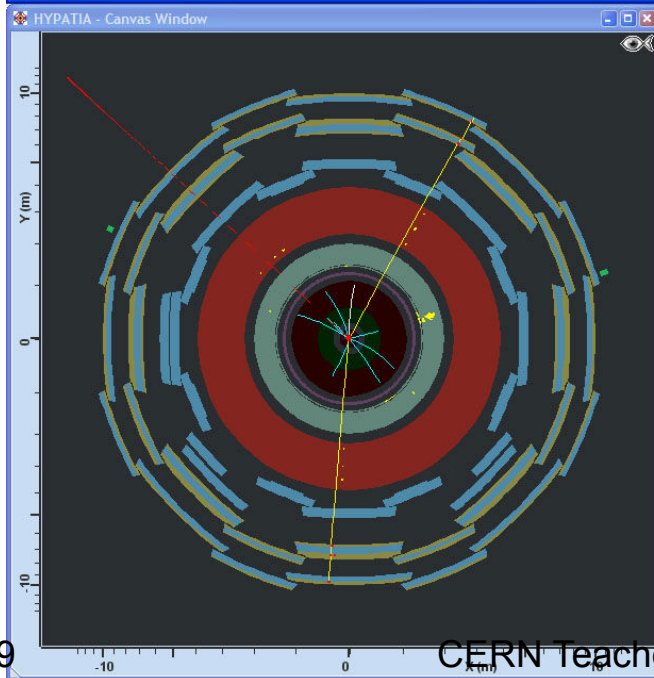


HYPATIA – All Windows

Hybrid pupils' analysis tool for interactions in ATLAS - version 2.0.0-2 - Invariant Mass Window

File View Histograms Preferences Help

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	ψ	η	M(lv) [GeV]	M(2l) [GeV]	M(4l) [GeV]
Event01.xml	91.857	Tracks 0	44.8	+	13.6	3.989	1.860	67.270	198.839	249.756
		Tracks 2	223.7	+	96.3	0.295	-1.486	7.272		
		Tracks 5	81.7	-	45.2	1.245	-1.199	63.293	13.931	
		Tracks 6	13.6	+	10.0	1.796	-0.832	42.920		
Event02.xml	13.451	Tracks 8	58.1	-	41.8	4.611	0.858	42.456	50.698	62.175
		Tracks 10	25.8	-	22.2	0.249	0.564	30.327		
		Tracks 4	18.9	+	8.2	5.358	1.477	20.909	9.090	
		Tracks 15	3.5	+	2.5	1.587	0.862	4.560		
Event03.xml	11.598	Tracks 10	121.6	-	53.4	1.397	-1.464	48.967	15.333	
		Tracks 7	2.5	+	1.1	4.941	-1.408	2.711		
		Tracks 13	1.6	-	1.2	0.427	-0.890	6.988		
		Tracks 5	24.9	-	20.1	0.282	0.675	27.095	50.742	85.173
Event04.xml	9.136	Tracks 9	32.1	+	31.6	2.978	0.177	6.651		
		Tracks 13	2.0	-	2.0	4.294	0.020	3.843	8.251	
		Tracks 16	32.8	+	31.6	5.335	0.274	28.224		
		Tracks 3	10.8	+	3.7	3.491	1.738	5.333	27.460	93.411
Event05.xml	15.681	Tracks 6	33.8	+	32.5	4.276	-0.286	1.562		
		Tracks 10	41.2	-	39.0	1.182	0.331	49.400	28.925	
		Tracks 14	10.9	+	3.6	3.617	1.779	4.344		



HYPATIA - Track Momenta Window

Previous Event Next Event Insert Track Delete Track Enable Color Coding

Event: Event02.xml Run: 6381 Event: 4

SimTracks		DerivativeTrackCollection		JetCollection	
RecTracks		SimTracks		RecMuonTracks	
Track	P [GeV]	+/-	Pt [GeV]	ψ	θ
Tracks 2	1.27	+	1.10	2.512	2.028
Tracks 3	2.32	-	2.23	2.566	2.855
Tracks 4	18.87	+	8.19	5.358	2.020
Tracks 7	4.74	+	1.28	4.442	1.843
Tracks 8	58.14	-	41.79	4.611	2.373
Tracks 9	1.81	+	1.31	5.933	2.380
Tracks 10	25.80	-	22.18	0.249	2.605
Tracks 14	42.87	+	38.89	1.081	0.434
Tracks 15	3.51	+	2.52	1.587	2.370
Tracks 17	1.84	-	1.47	1.841	2.498
Tracks 19	1.42	+	1.39	2.385	2.957

HYPATIA - Control Window

Parameter Control Interaction and Window Control Output Display

Projection Data Cuts InDet Calo MuonDet Objects Geometry

Data

Name	Value
<input checked="" type="checkbox"/> Status	
<input checked="" type="checkbox"/> InDet	
<input checked="" type="checkbox"/> Calo	
<input checked="" type="checkbox"/> MuonDet	
<input checked="" type="checkbox"/> Objects	



HYPATIA – Details

Track Momenta Window

Displays the energies and momenta of all tracks. From here tracks can be picked and inserted for analysis.

Track	P [GeV]	+/-	Pt [GeV]	ϕ	θ
Tracks 2	1.27	+	1.10	2.512	2.628
Tracks 3	2.32	-	2.23	2.566	2.855
Tracks 4	18.87	+	8.19	5.358	2.020
Tracks 7	4.74	+	1.28	4.442	1.843
Tracks 8	58.14	-	41.79	4.611	2.373
Tracks 9	1.81	+	1.31	5.933	2.380
Tracks 10	25.80	-	22.18	0.249	2.605
Tracks 14	42.87	+	38.89	1.081	0.434
Tracks 15	3.51	+	2.52	1.587	2.370
Tracks 17	1.84	-	1.47	1.841	2.498
Tracks 19	1.42	+	1.39	2.385	2.957

Parameter Control Window

Provides functionality for viewing and changing various parameters (data selection, cuts, detector, subdetector systems, projections).

Name	Value
<input checked="" type="checkbox"/> Status	
<input checked="" type="checkbox"/> InDet	
<input checked="" type="checkbox"/> Calo	
<input checked="" type="checkbox"/> MuonDet	
<input checked="" type="checkbox"/> Objects	



HYPATIA – Details

Invariant Mass Window

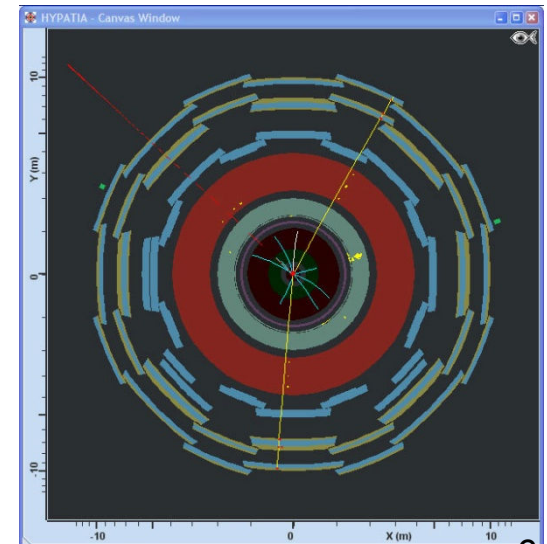
The main analysis window of HYPATIA. Displays the chosen (by user) tracks of each event and values of their main physical quantities (momentum etc.).

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	ϕ	η	M(lv) [GeV]	M(2l) [GeV]	M(4l) [GeV]
Event01.xml	91.857	Tracks 0	44.8	+	13.6	3.989	1.860	67.270	198.839	249.756
		Tracks 2	223.7	+	96.3	0.295	-1.486	7.272		
		Tracks 5	61.7	-	45.2	1.245	-1.199	63.293	13.931	
		Tracks 6	13.6	+	10.0	1.796	-0.922	42.920		
Event02.xml	13.451	Tracks 8	58.1	-	41.8	4.611	0.858	42.456	50.698	62.175
		Tracks 10	25.8	-	22.2	0.249	0.564	30.327		
		Tracks 4	18.9	+	8.2	5.358	1.477	20.909	9.090	
		Tracks 15	3.5	+	2.5	1.587	0.862	4.560		
Event03.xml	11.598	Tracks 10	121.6	-	53.4	1.397	-1.464	48.967	15.333	
		Tracks 7	2.5	+	1.1	4.941	-1.408	2.711		
		Tracks 13	1.6	-	1.2	0.427	-0.990	6.988		
Event04.xml	9.136	Tracks 5	24.9	-	20.1	0.282	0.675	27.095	50.742	85.173
		Tracks 9	32.1	+	31.6	2.978	0.177	6.651		
		Tracks 13	2.0	-	2.0	4.294	0.020	3.843	8.251	
Event05.xml	15.681	Tracks 16	32.8	+	31.6	5.335	0.274	28.224		
		Tracks 3	10.8	+	3.7	3.491	1.738	5.333	27.460	93.411
		Tracks 6	33.8	+	32.5	4.276	-0.206	1.562		
		Tracks 10	41.2	-	39.0	1.192	0.331	48.400	28.925	
		Tracks 14	10.9	+	3.8	3.617	1.779	4.344		

For each event the invariant (or transverse) masses of combinations of chosen particles are automatically calculated and displayed.

Canvas Window

Displays events as tracks through the detectors according to particle type. Has multiple angles and display types.



Full version of Hypatia

"Analyse events, make histos, discover"

Four windows:

- Event display Window (the standard ATLANTIS canvas window)
 - Control Window
 - Track list Window
 - *Invariant Mass determination Window*

Simplified version of Hypatia

"Identify particles in the detector"

Three windows:

- Event display Window (the standard ATLANTIS canvas window)
 - Control Window (simple)
 - Track list Window

**THIS IS THE ONE USED FOR THE
2008 and 2009 MASTERCLASSES**

New Version of Hypatia

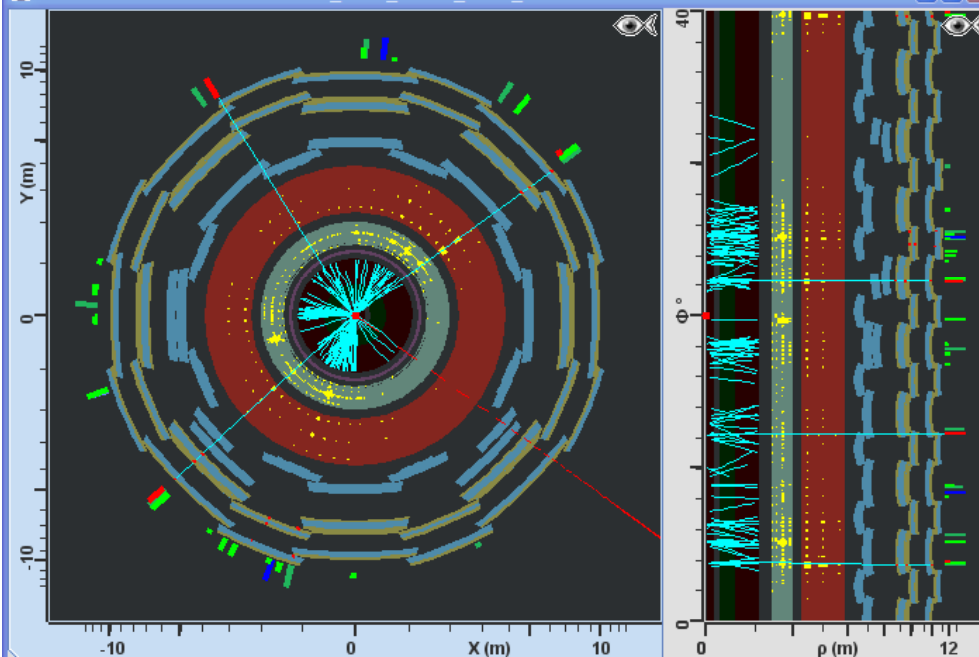
Compatible with updated version of
ATLANTIS

Combines three different versions:

- Demo (free running) one :Installed in ATLAS visitor center
- Simplified one: for Masterclasses and High School Students
- Full one: For Universities and other applications (special projects, science centers, debugging etc)
 - All versions have the following windows
 - Event display Window (the standard ATLANTIS canvas window)
 - Control Window (simple/full)
 - Track list Window (simple/full)
 - Invariant mass window (removable for the simple version)

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	ϕ	η	M(lv) [GeV]	M(2l) [GeV]	M(4l) [GeV]
JiveXML_5640_05500_Black_Holes.xml	311.654	Tracks 6	4.1	+	2.0	0.851	1.314	33.950	10.456	17.003
		Tracks 7	22.3	+	22.2	0.869	-0.118	113.322		
		Tracks 12	3.1	+	3.0	0.680	0.129	37.473	3.845	
		Tracks 18	5.4	-	2.9	1.237	1.254	47.968		
JiveXML_5104_20656.xml	43.752	Tracks 1	6.6	+	3.8	0.601	1.151	4.629	1.041	
		Tracks 3	4.2	-	2.9	0.840	0.945	6.615		
JiveXML_5104_20655.xml	12.780	Tracks 3	3.2	-	1.3	4.441	1.521	3.513	11.351	
JiveXML_5104_20654.xml	12.522	Tracks 2	13.1	+	12.2	0.279	-0.368	24.958		
		Tracks 7	4.5	-	1.3	5.670	1.957	0.243	8.417	45.240
		Tracks 19	76.2	-	14.5	3.039	2.344	26.259		
		Tracks 28	4.3	+	1.4	1.971	1.785	8.004	9.960	
JiveXML_5104_20653.xml	34.341	Tracks 29	6.5	-	3.5	3.280	-1.246	12.417		
		Tracks 6	2.1	+	2.0	2.933	-0.255	16.096	1.647	
		Tracks 12	2.2	-	1.2	3.141	-1.271	12.458		

Canvas Window - Event: JiveXML_5640_05500_Black_Holes... Run: 5640 Event: 5500



HYPATIA - Track Momenta Window

File Previous Event Next Event Insert Track Delete Track Reset Canvas View

Hide Invariant Mass Window Hide Simulated Demo Mode

ETMis: 311.654 GeV ϕ : 5.653 rad Enable Color Coding

Reconstructed Simulated Physics Objects

Track	P [GeV]	+/-	Pt [GeV]	ϕ	θ
Tracks 2	3.03	-	3.01	2.057	0.118
Tracks 3	6.65	+	6.06	3.170	0.426
Tracks 4	55.55	+	44.38	3.904	0.645
Tracks 5	17.74	-	17.62	4.119	3.030
Tracks 6	4.05	+	2.03	0.851	2.096
Tracks 7	22.34	+	22.19	0.869	0.118
Tracks 8	1.40	+	1.08	2.272	2.457
Tracks 9	3.97	+	3.90	4.429	2.964
Tracks 11	3.29	+	2.95	4.307	2.685
Tracks 12	3.06	+	3.03	0.680	3.013
Tracks 13	1.51	+	1.37	0.910	0.438
Tracks 14	1.91	+	1.80	1.056	0.331
Tracks 16	35.75	-	33.45	1.099	0.360
Tracks 17	28.85	-	27.44	1.125	0.315
Tracks 18	5.41	-	2.86	1.237	2.127
Tracks 20	6.56	+	6.55	2.070	0.062
Tracks 21	2.14	+	2.14	2.161	0.070
Tracks 22	388.09	+	230.89	2.134	2.208
Tracks 24	6.37	+	6.32	2.238	0.117
Tracks 25	2.61	-	2.61	2.237	0.029


HYPATIA - Control Window

Parameter Control Interaction and Window Control Output Display

Projection Data Cuts InDet Calo MuonDet Objects Geometry

Data

Name	Value
<input checked="" type="checkbox"/> Status	
<input checked="" type="checkbox"/> InDet	
<input checked="" type="checkbox"/> Calo	
<input checked="" type="checkbox"/> MuonDet	
<input checked="" type="checkbox"/> Objects	

 **HYPATIA - Track Momenta Window**

File Previous Event Next Event Insert Track Delete Track Reset Canvas View

Hide Invariant Mass Window Hide Simulated Demo Mode

ETMis: 311.654 GeV φ : 5.653 rad Enable Color Coding

Reconstructed Simulated Physics Objects

HY.P.A.T.I.A - Installed at the ATLAS Visitor Room

The screenshot displays the HYPATIA software interface, which is used for analyzing ATLAS simulated events. The main window is titled "Hybrid pupils' analysis tool for interactions in ATLAS - version 2.3.1 - University of Athens - Invariant Mass Window".

Data Table:

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	ϕ	η	M(lv) [GeV]	M(2l) [GeV]	M(4l) [GeV]
JiveXML_6381_00006.xml	11.775	Tracks 7	2.5	+	1.1	4.941	-1.408	2.708	15.333	23.820
		Tracks 10	121.6	-	53.4	1.397	-1.464	49.371		
		Tracks 13	1.6	-	1.2	0.427	-0.890	7.034	1.883	
JiveXML_6381_00007.xml	9.081	Tracks 24	3.2	+	1.3	5.199	-1.560	3.806		
		Tracks 9	32.1	+	31.6	2.978	0.177	6.928	9.907	29.992
		Tracks 13	2.0	-	2.0	4.294	0.020	3.763		
JiveXML_6381_00008.xml	14.607	Tracks 23	9.9	+	2.4	5.619	2.099	8.350	5.366	
		Tracks 29	1.1	-	1.0	1.445	-0.242	5.103		
		Tracks 3	10.8	+	3.7	3.491	1.738	4.715	27.460	101.249
JiveXML_6381_00001.xml	2.096							2.865		
								47.568	40.491	
								10.227		
								23.214	16.303	
								2.835		

Control Panel (HYPATIA - University of Athens - Demo Control):

This is the demonstration mode of "HYPATIA" which displays ATLAS simulated events. After the beam collisions start up, it will also display real data.

The user can:

- Display selected types of events
- Define the delay before next event display
- Stop display (**untick demo tab**) Demo Mode and further interact/analyze the events
- Zoom in & out
- Choose detector view
- Pick tracks
- Calculate invariant masses
- Display simulated tracks (with color coding according to particle type)

For further information go to <http://hypatia.phys.bg.ac.yu>

Event Type: H → 4ℓ

Delay between events (sec): tt-bar → ℓ + X, W → ev, W → μν, Z → e++ e-, Z → μ++ μ-

Display events in random order:

Start: H → 4ℓ, Mini Black Holes, Find The Higgs

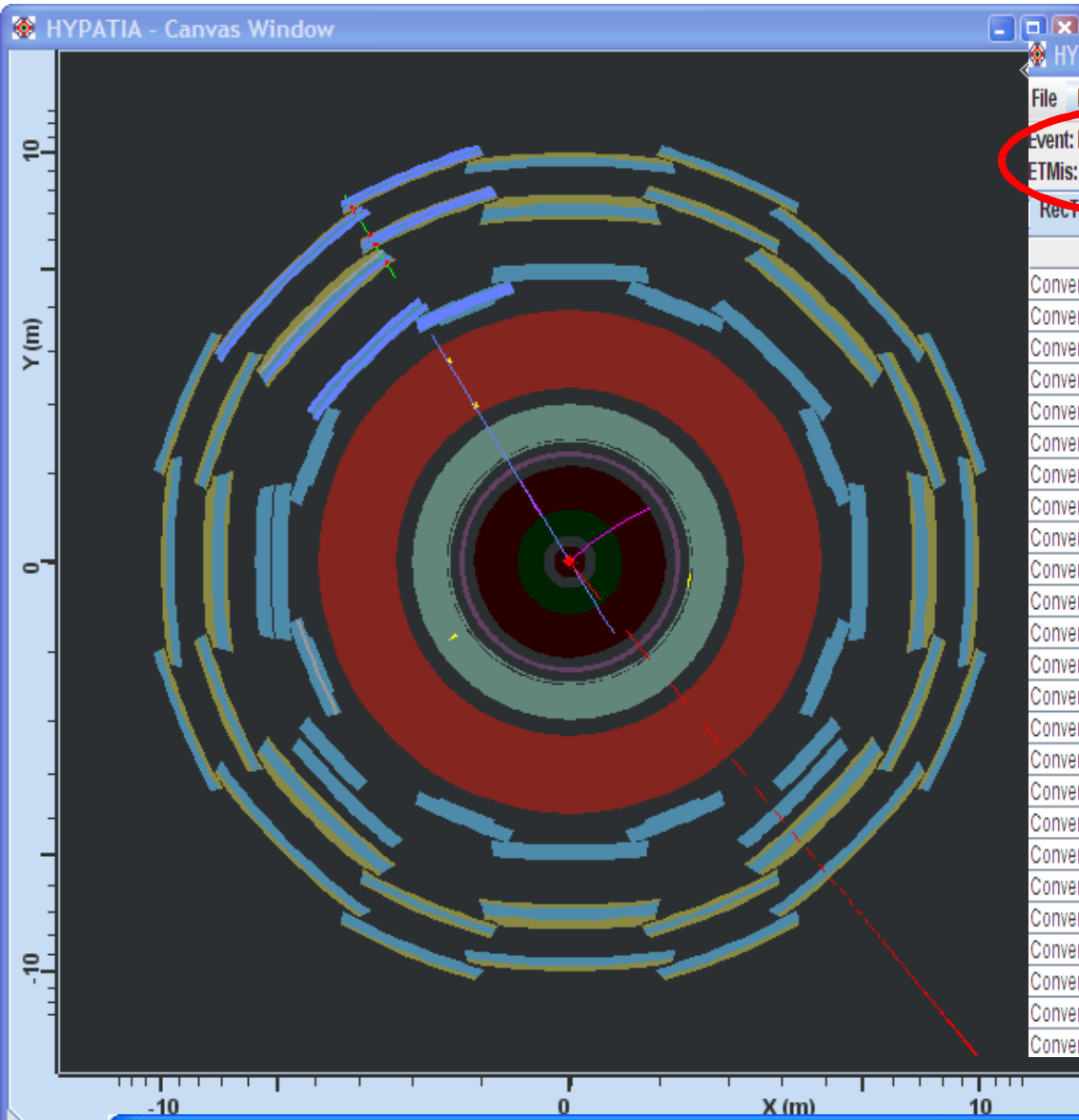
Detector View: Calo, MuonDet, Objects

Output Display: Calo, MuonDet, Objects, Geometry

Value:

An exampleSimplified version used in the Masterclasses (2008 and 2009)

- students at the end of LEP exercise had to look at a mixture of $Z \rightarrow ee$, $Z \rightarrow \mu\mu$, $t\bar{t} \rightarrow \text{lepton}(s)$
- decide which decay mode they saw
- apply simple criteria to distinguish signal from background
- $E_{\text{miss}} < 10 \text{ GeV}$
- $E(\text{lepton1}) + E(\text{lepton2}) > 91 \text{ GeV}$
- count events types
- compare the BR of $Z \rightarrow ee$ and $Z \rightarrow \mu\mu$
- compare with results of LEP exercise



HYPATIA - Track Momenta Window

File Previous Event Next Event Show Simulated

Event: Event_00004.xml Run: 5144 Event: 3

ETMis: 12.955 GeV ϕ : 4.352 rad

RecTracks

Track	P [GeV]	\pm	Pt [GeV]	ϕ	θ
ConvertedIPatTracks 0	22.60	-	5.00	1.201	0.223
ConvertedIPatTracks 1	6.58	+	3.48	1.099	-0.556
ConvertedIPatTracks 2	2.96	-	2.91	1.747	1.388
ConvertedIPatTracks 3	3.26	+	3.03	0.196	1.191
ConvertedIPatTracks 4	3.06	-	2.99	1.976	-1.368
ConvertedIPatTracks 5	4.65	-	2.76	2.228	0.636
ConvertedIPatTracks 6	2.74	-	2.63	1.744	1.289
ConvertedIPatTracks 7	2.84	-	2.50	0.255	-1.076
ConvertedIPatTracks 8	5.50	+	2.44	4.301	0.461
ConvertedIPatTracks 9	2.15	+	1.99	1.693	1.185
ConvertedIPatTracks 10	2.01	-	1.96	6.176	-1.344
ConvertedIPatTracks 11	1.92	+	1.91	2.894	1.467
ConvertedIPatTracks 12	1.99	+	1.82	4.836	-1.157
ConvertedIPatTracks 13	3.16	-	1.79	4.705	-0.599
ConvertedIPatTracks 14	2.80	+	1.70	1.524	-0.652
ConvertedIPatTracks 15	5.17	+	1.61	3.751	0.316
ConvertedIPatTracks 16	1.75	-	1.63	1.951	1.201
ConvertedIPatTracks 17	9.54	-	1.60	0.900	-0.169
ConvertedIPatTracks 18	9.81	+	1.60	1.632	0.164
ConvertedIPatTracks 19	1.66	+	1.59	1.734	1.288
ConvertedIPatTracks 20	1.62	+	1.42	3.113	1.072
ConvertedIPatTracks 21	1.49	+	1.47	3.051	-1.383
ConvertedIPatTracks 22	2.82	-	1.39	4.769	-0.516
ConvertedIPatTracks 23	1.33	+	1.32	2.189	-1.459
ConvertedIPatTracks 24	1.37	-	1.35	1.726	-1.414

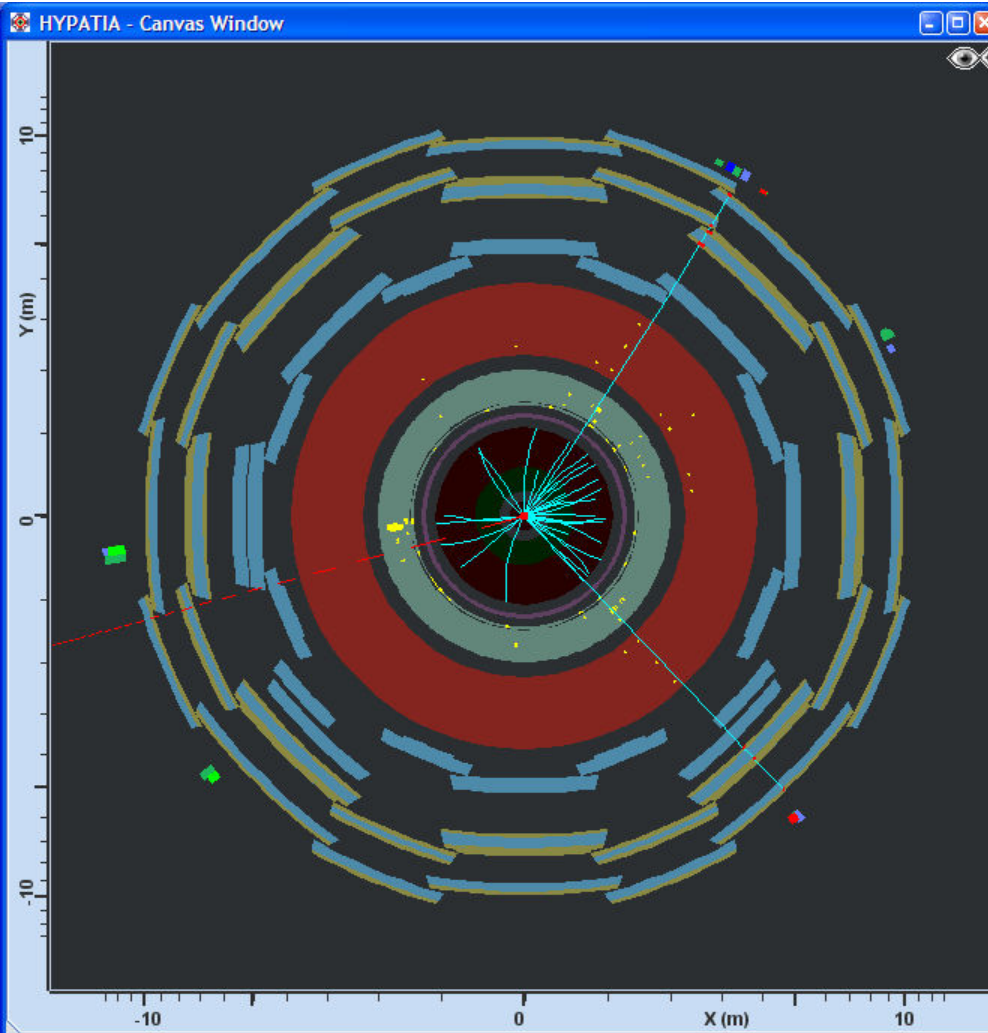
HYPATIA - Control Window

Projection: End-View Side-View

Interaction: Zoom Pick

Cut: |Pt| > 1.0 GeV

$Z \rightarrow \mu\mu$



HYPATIA - Track Momenta Window

Event: Event004.xml Run: 5211 Event: 24084
FTMis: 6.444 GeV ϕ : 3.409 rad (Collection : MET_Final)

Track	E [GeV]	+/-	Pt [GeV]	ϕ	θ
Tracks 1	3.64	-	3.54	5.444	2.917
Tracks 2	19.53	+	3.82	0.535	1.767
Tracks 4	1.81	+	1.68	0.963	0.383
Tracks 5	54.46	-	44.71	3.227	0.608
Tracks 6	3.23	-	1.13	5.764	1.213
Tracks 8	2.64	-	1.18	5.990	1.237
Tracks 9	47.05	+	20.30	3.840	2.017
Tracks 11	15.15	-	9.31	0.428	0.911
Tracks 14	11.31	+	10.92	1.055	0.264
Tracks 17	1.16	+	1.16	4.228	0.019
Tracks 20	1.38	+	1.36	5.793	2.980
Tracks 23	3.10	+	1.30	0.413	1.139
Tracks 25	2.10	-	2.09	5.612	3.047
Tracks 26	2.55	-	1.47	0.137	0.956
Tracks 27	1.41	+	1.04	6.209	2.398
Tracks 28	2.98	+	1.00	3.405	1.228
Tracks 32	2.80	+	1.53	0.887	0.993
Tracks 34	1.32	+	1.22	3.744	0.403
Tracks 37	10.10	-	10.00	0.934	0.140
Tracks 38	5.58	+	1.36	0.874	1.817
Tracks 40	22.10	-	20.50	5.441	2.759
Tracks 45	3.12	-	2.56	2.078	2.535
Tracks 47	5.86	+	1.68	0.129	1.279
Tracks 49	6.11	+	1.31	6.244	1.787
Tracks 53	4.95	+	4.67	5.515	2.807
Tracks 54	3.68	+	3.18	0.725	0.526
Tracks 55	7.65	-	1.48	1.177	1.766
Tracks 57	36.96	-	6.52	0.344	1.748
Tracks 63	1.54	+	1.54	1.644	3.132
Tracks 69	2.81	-	1.23	6.026	2.025
Tracks 71	1.54	+	1.02	2.451	0.851

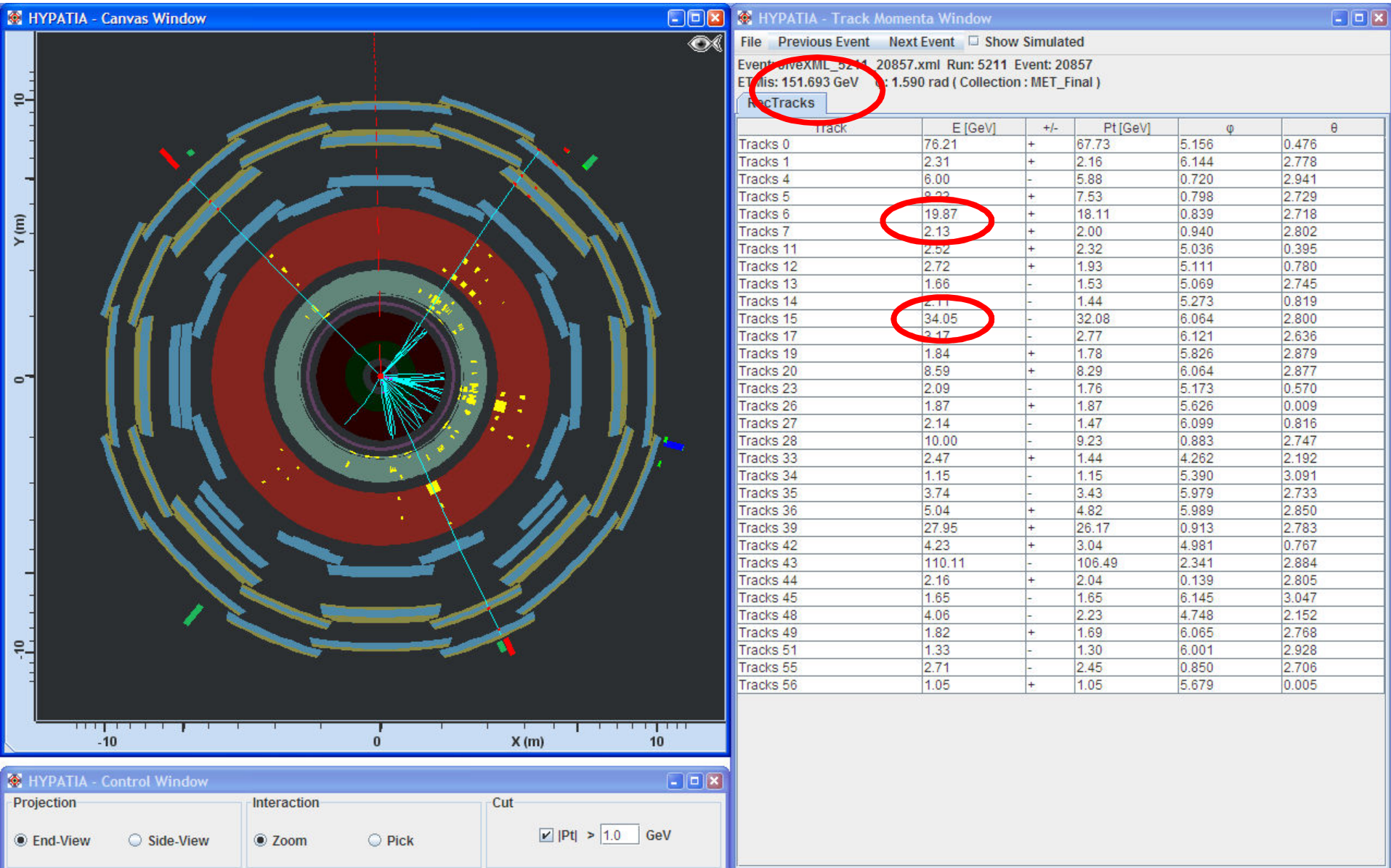
HYPATIA - Control Window

Projection: End-View Side-View

Interaction: Zoom Pick

Cut: |Pt| > 1.0 GeV

Background $t\bar{t} \rightarrow \text{leptons} + X$



Learning with ATLAS @ CERN

Consortium

- National and Kapodistrian University of Athens
- University of Stockholm
- Austrian Ministry of Education
- University of Birmingham
- Ellinogermaniki Agogi
- HEUREKA
- House of Science
- University of Bayreuth
- European Physical Society
- CERN
- LBNL



Workpackages

1. Management and Scientific Coordination (UoA)
2. Pedagogical Design and LA@CERN Missions Development (UoBirmingham)
3. LA@CERN Education and Outreach Portal (UoA)
4. Implementation & Validation (EA-GR)
5. Evaluation & Quality Assurance (Bayreuth)
6. Dissemination (UoStockholm)
7. Exploitation (Austrian Ministry of Edu)

2 years started 1/12/2009

Go ahead and play with HYPATIA!!
You can download program and event files from:

<http://hypatia.phy.bg.ac.yu/>

The web page of the Learning with ATLAS @ CERN EU project is at

<http://www.ea.gr/ep/lacern/>

Please help by thinking about pedagogical scenaria