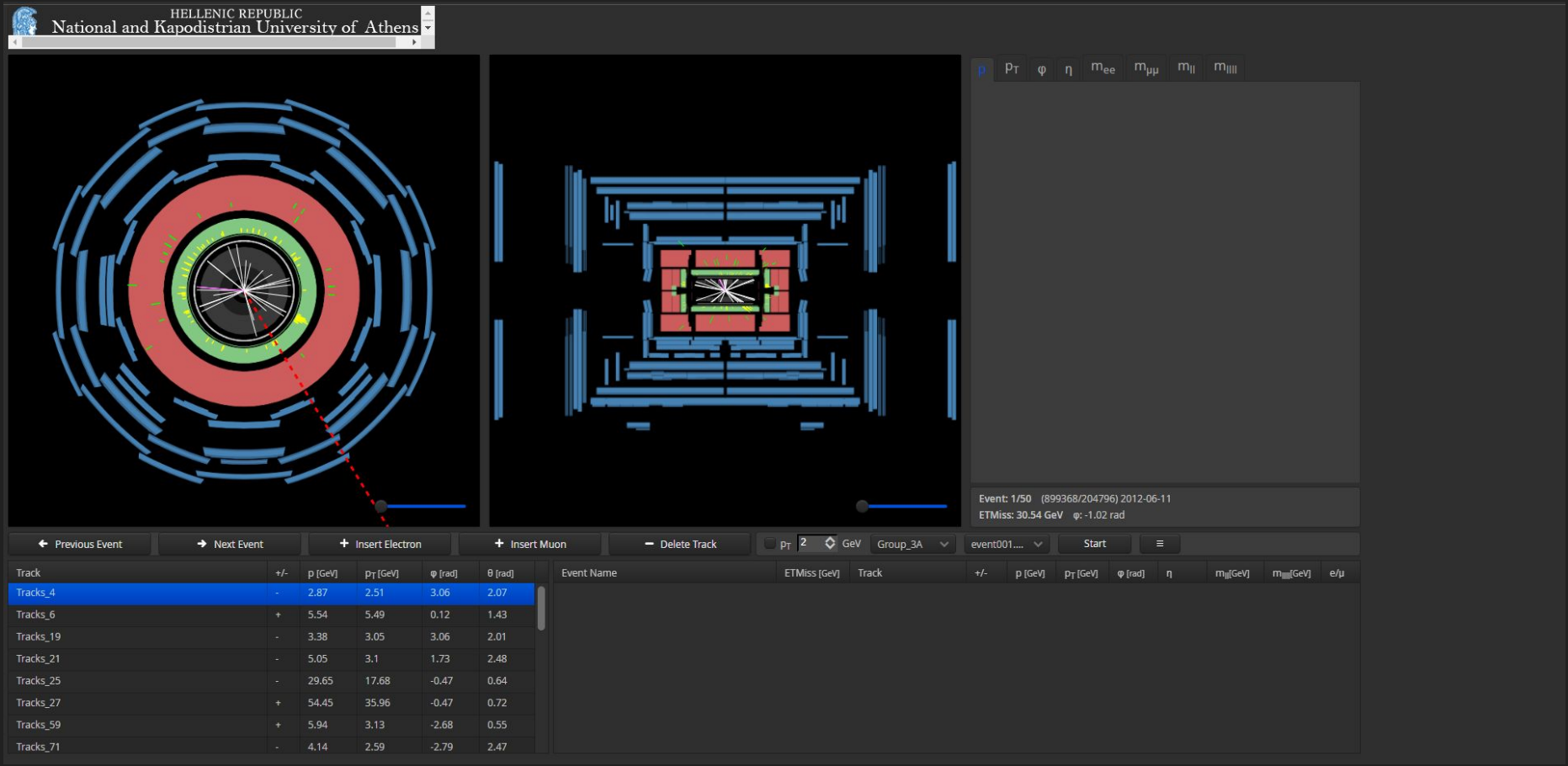
HYPATIA Guide for BAMA

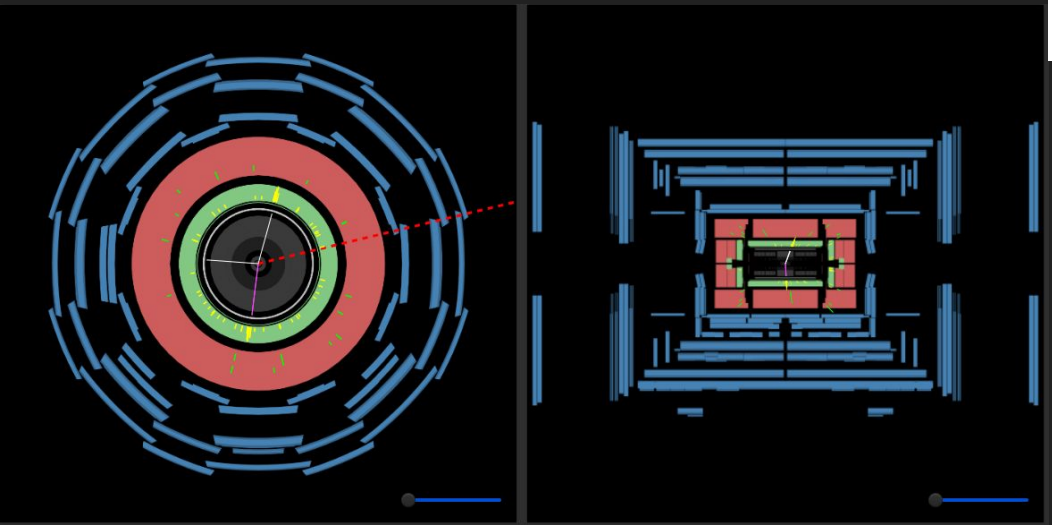
Big Analysis of Muons in ATLAS

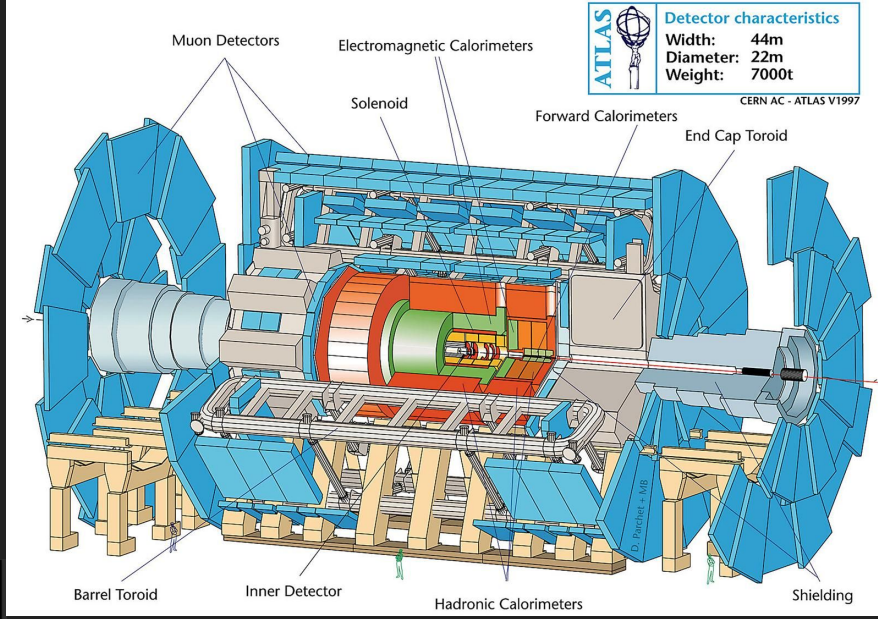
05/02/22 SVHS

Open the HYPATIA 4 site:



Briefly, let's try to understand what we are looking at here. The HYPATIA site shows a representation of two different views of the ATLAS detector (below). The view on the left is a cross-section of the collider facing along the axis of the cylinder, i.e. along the path of the protons. On the right is a cross section as viewed perpendicular to the axis of the cylinder, more similar in angle to the drawing to the right.





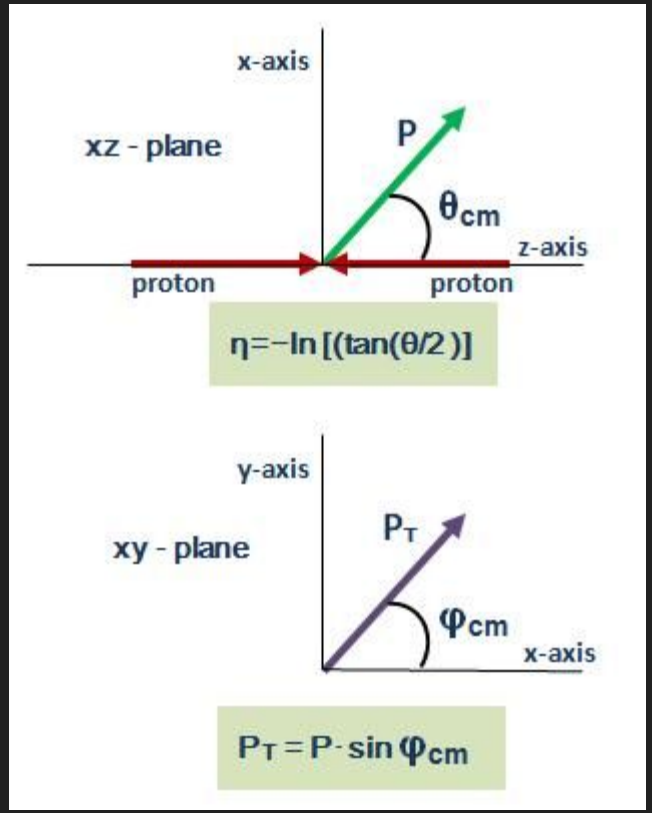
The values we want to extract are the m_{ll} values of muon pairs we find, that is, the invariant mass of the two-lepton system. These masses should correspond to the masses of the particles that decay to produce the muon pairs.

In our case, m_{ll} is calculated automatically for us in all our HYPATIA events. Here is a simple overview of some of the measurements used to calculate the m_{ll}:

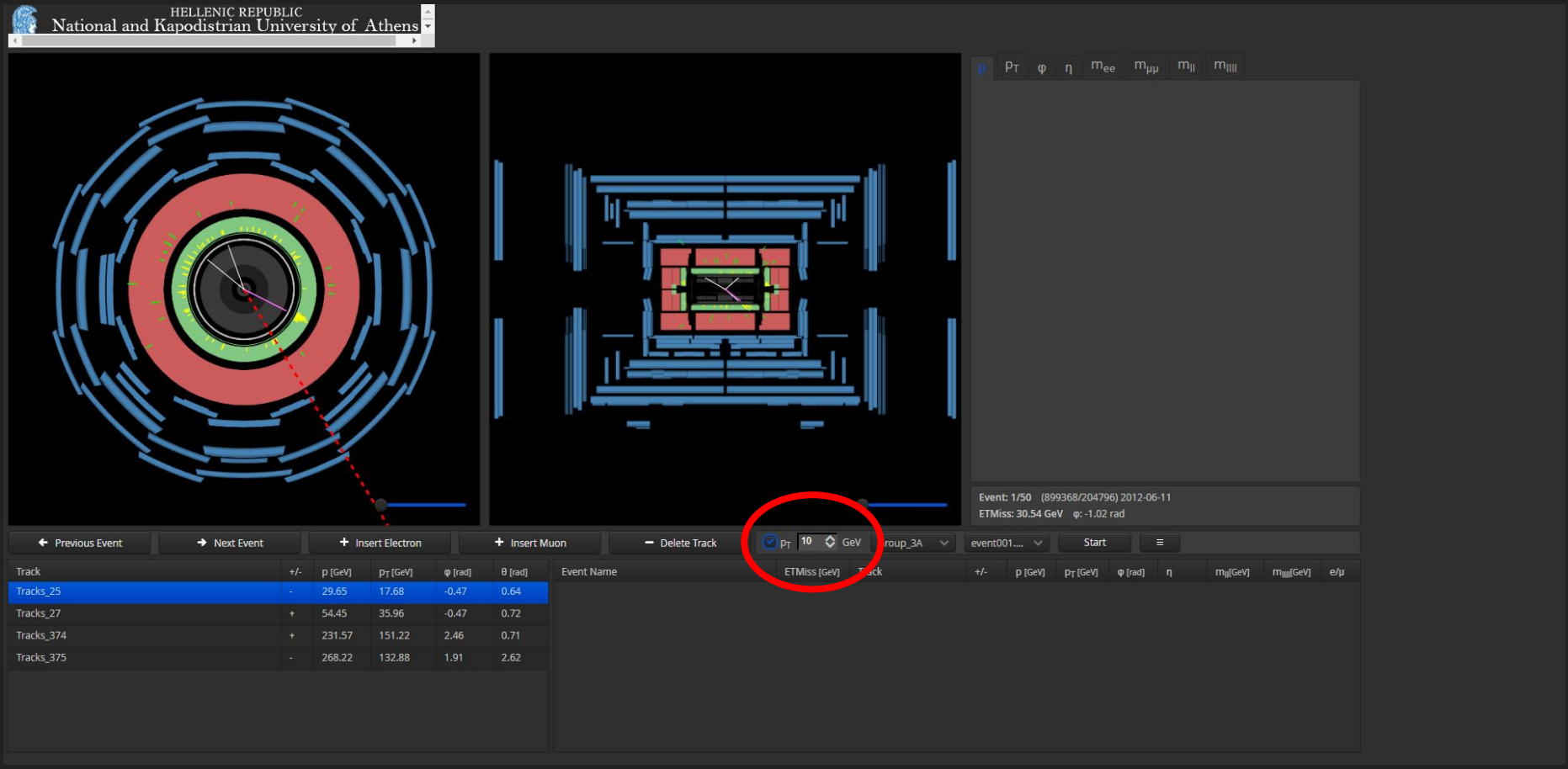
The ***pseudorapidity*** **η** is a function of the polar angle of a given particle's momentum; it is thus a measure of the angle of the particle relative to the beam axis (z-axis).

The ***transverse momentum*** $\mathbf{P_T}$ is the component of momentum perpendicular to the beam axis (z-axis), with an ***azimuthal angle*** **φ .**

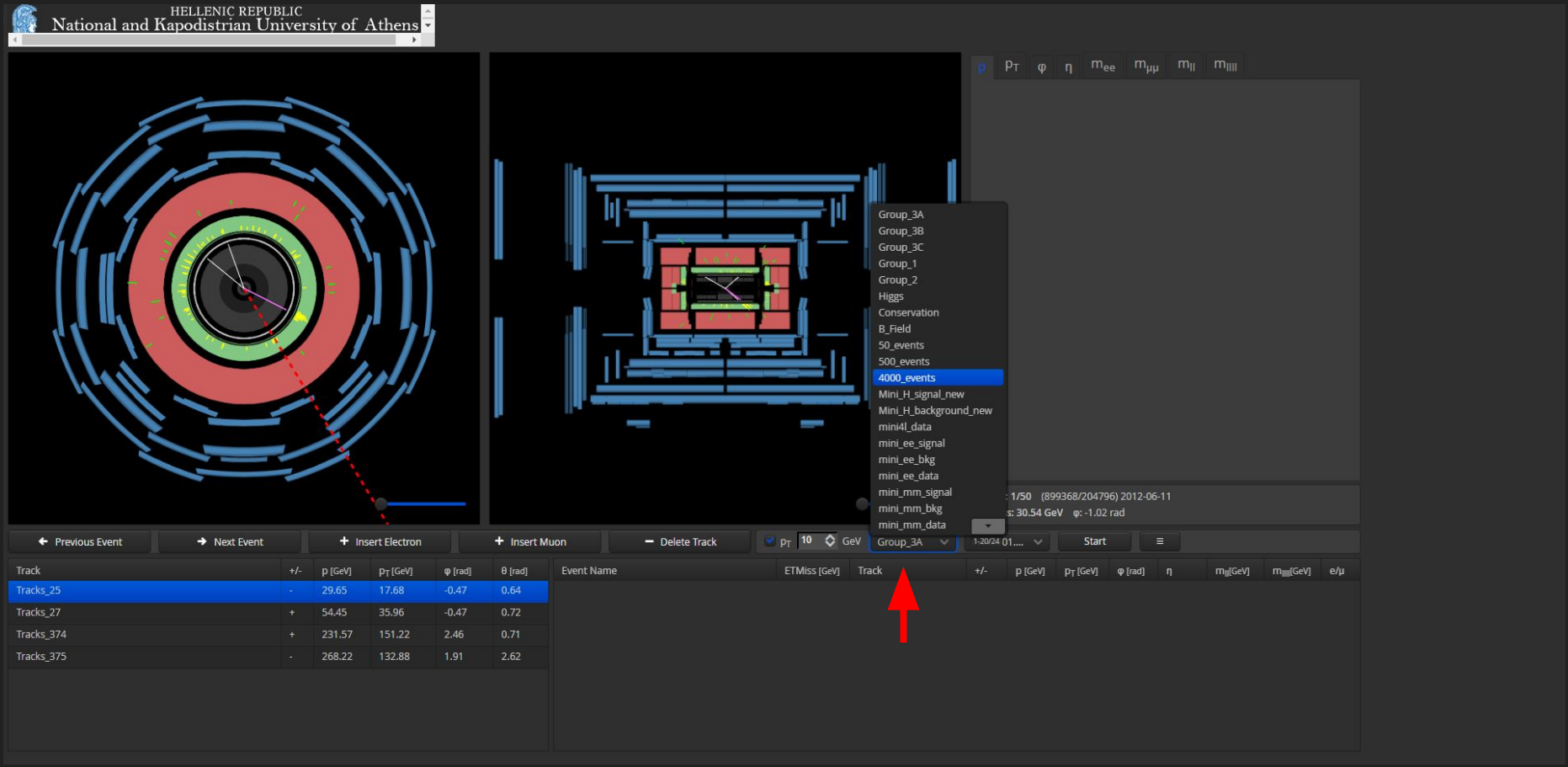
The measurements of these values from each lepton in a pair are used to calculate the dilepton invariant mass.



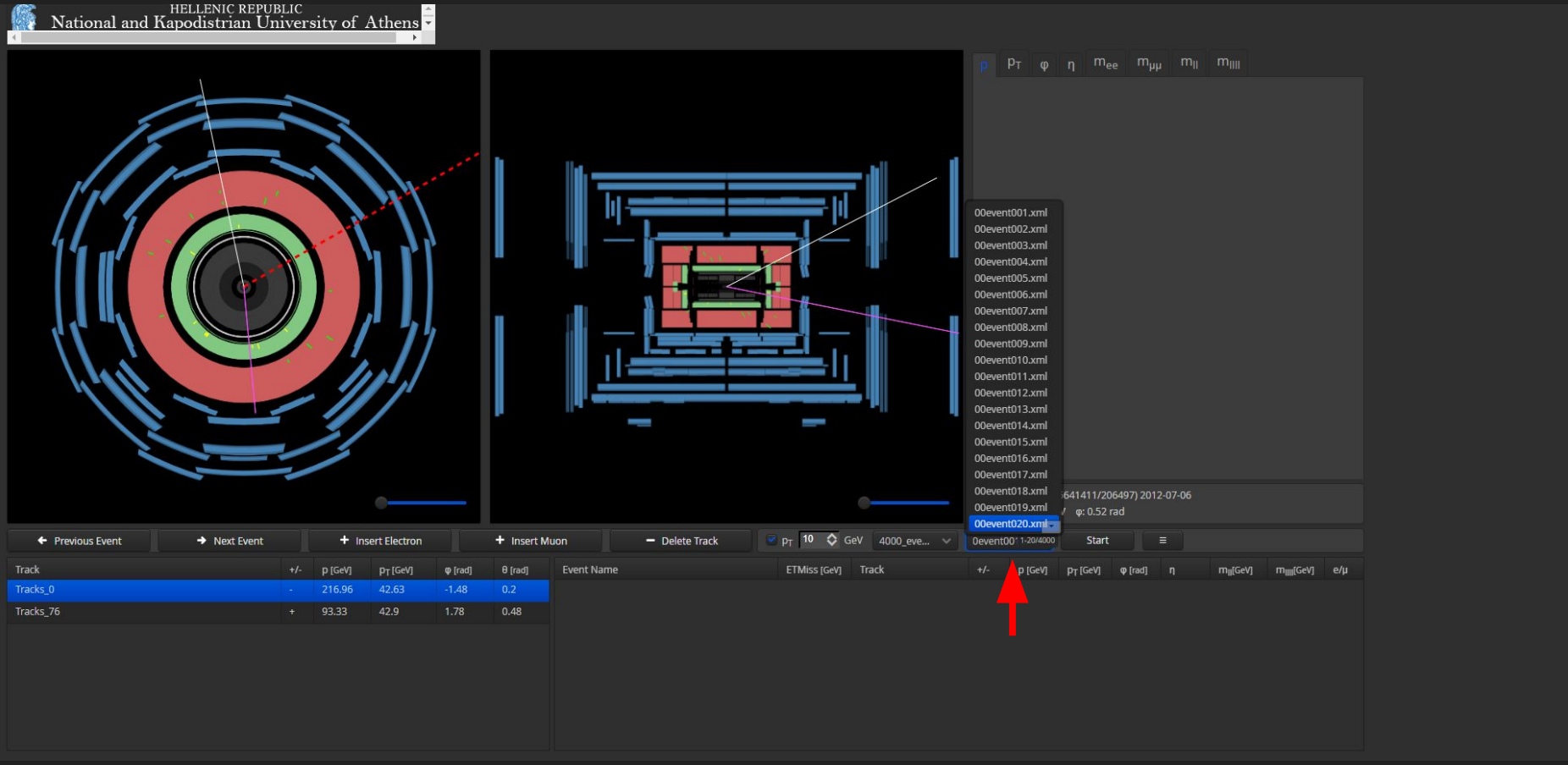
First, in the bar below the graphics, set check p_T and set the value to 10 GeV to filter out low-momentum particle tracks (they won't be relevant for our analysis).



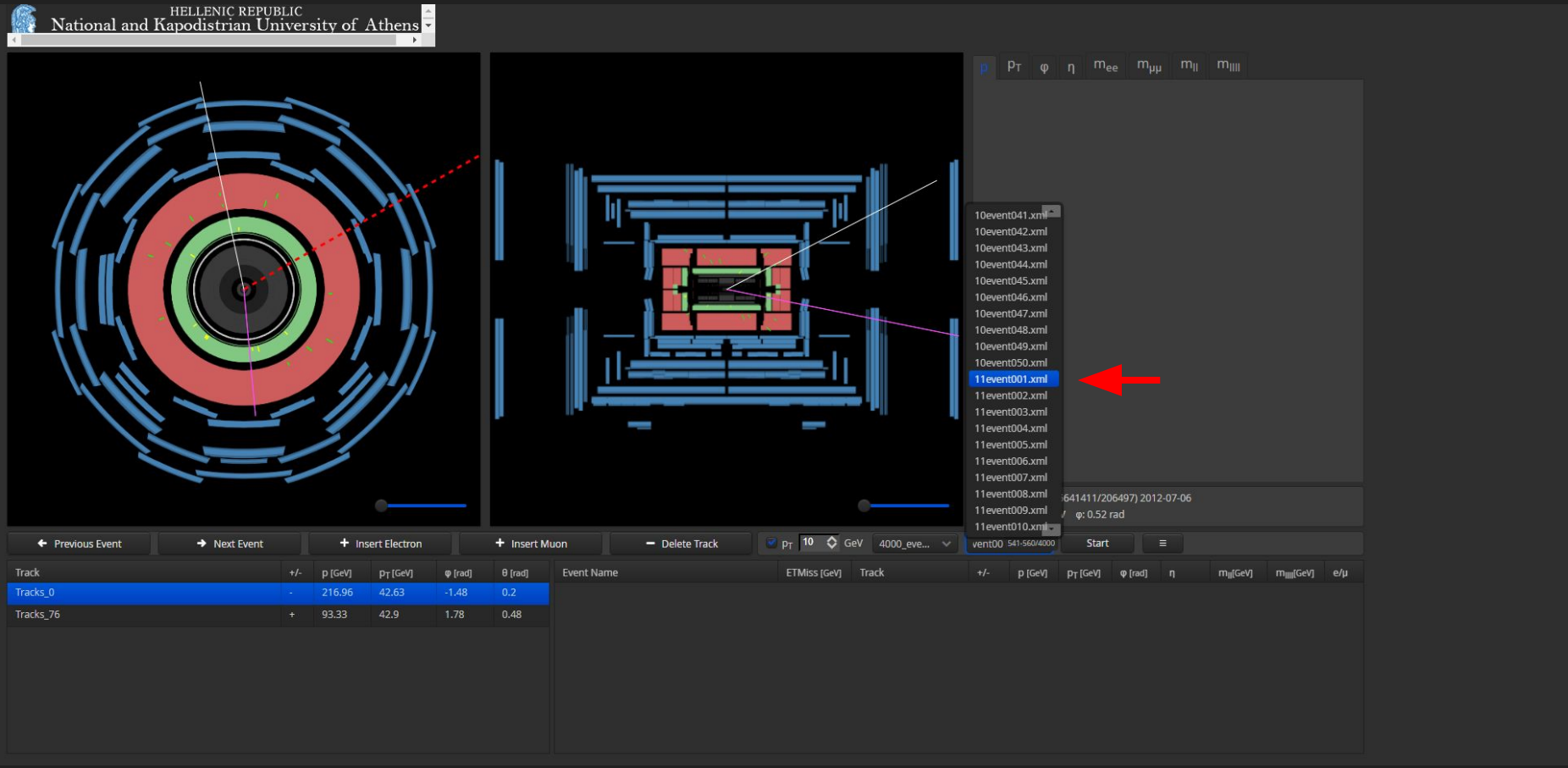
On the button to the right, click to open the menu and select the folder “4000 events.”



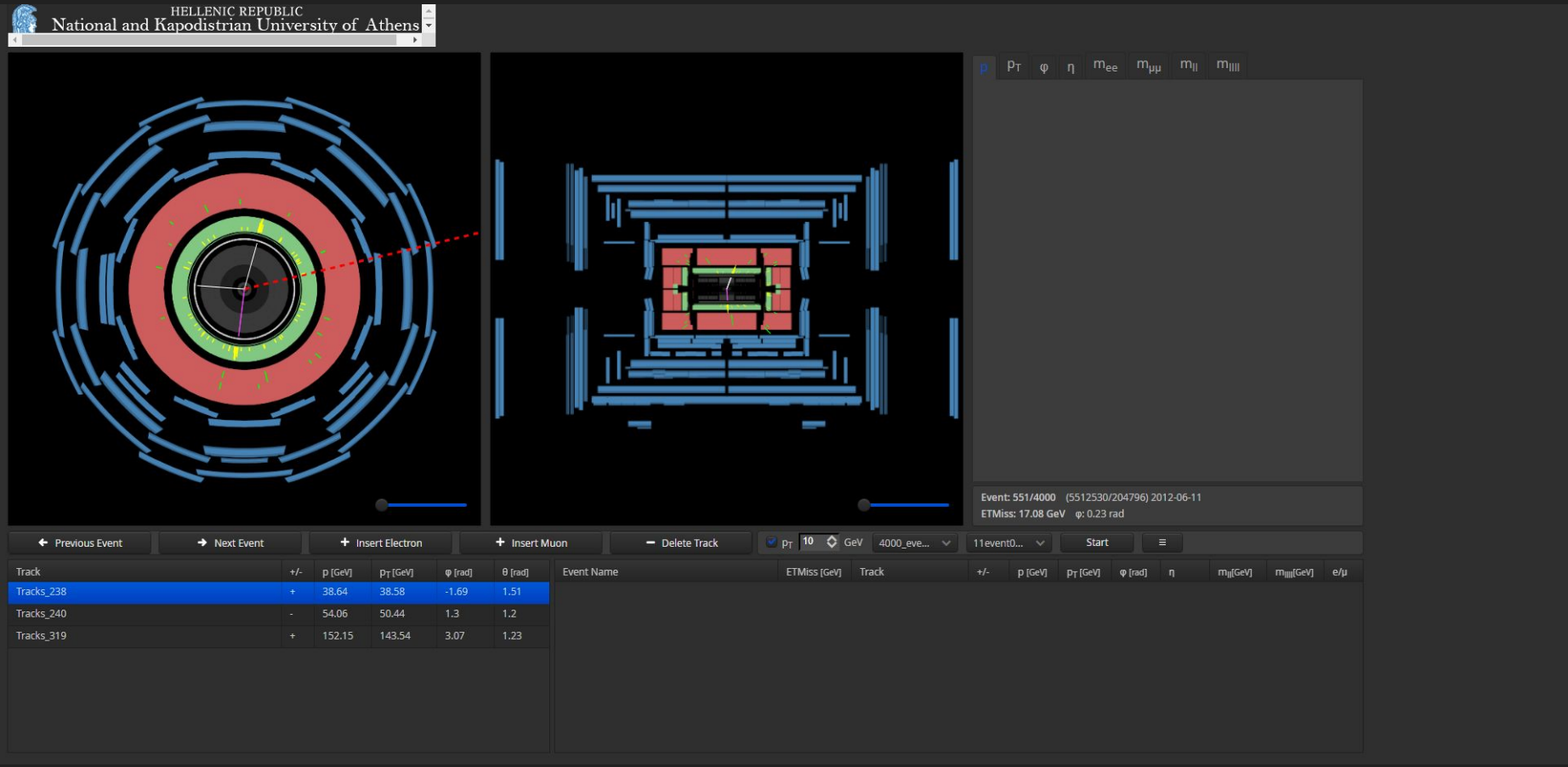
Even further right, open this menu to select your starting event - scroll or click arrows to find events with the first two digits (##) as the number you've been assigned



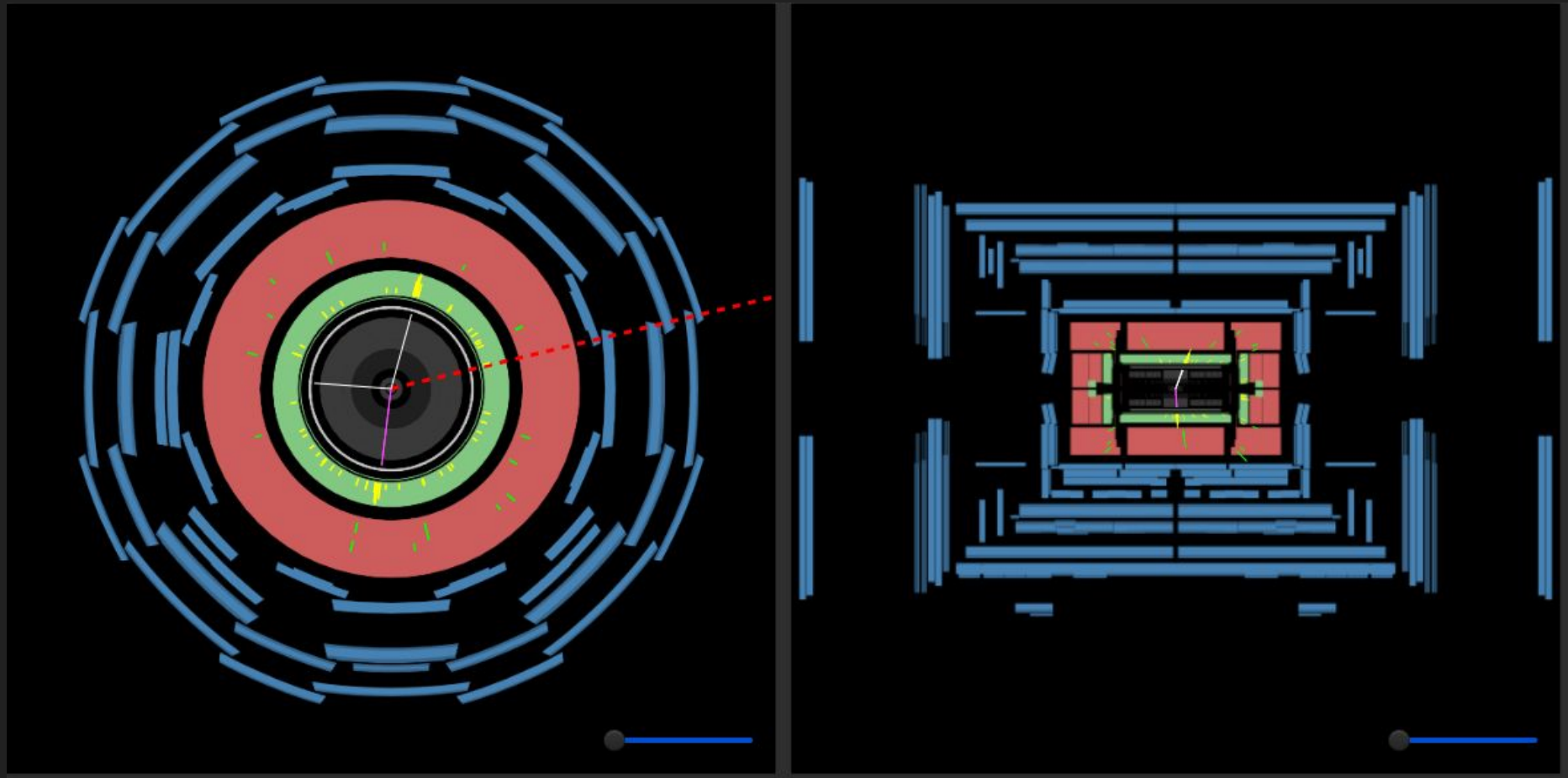
Example: I've been assigned subset 11, so I scrolled and clicked 11event001.



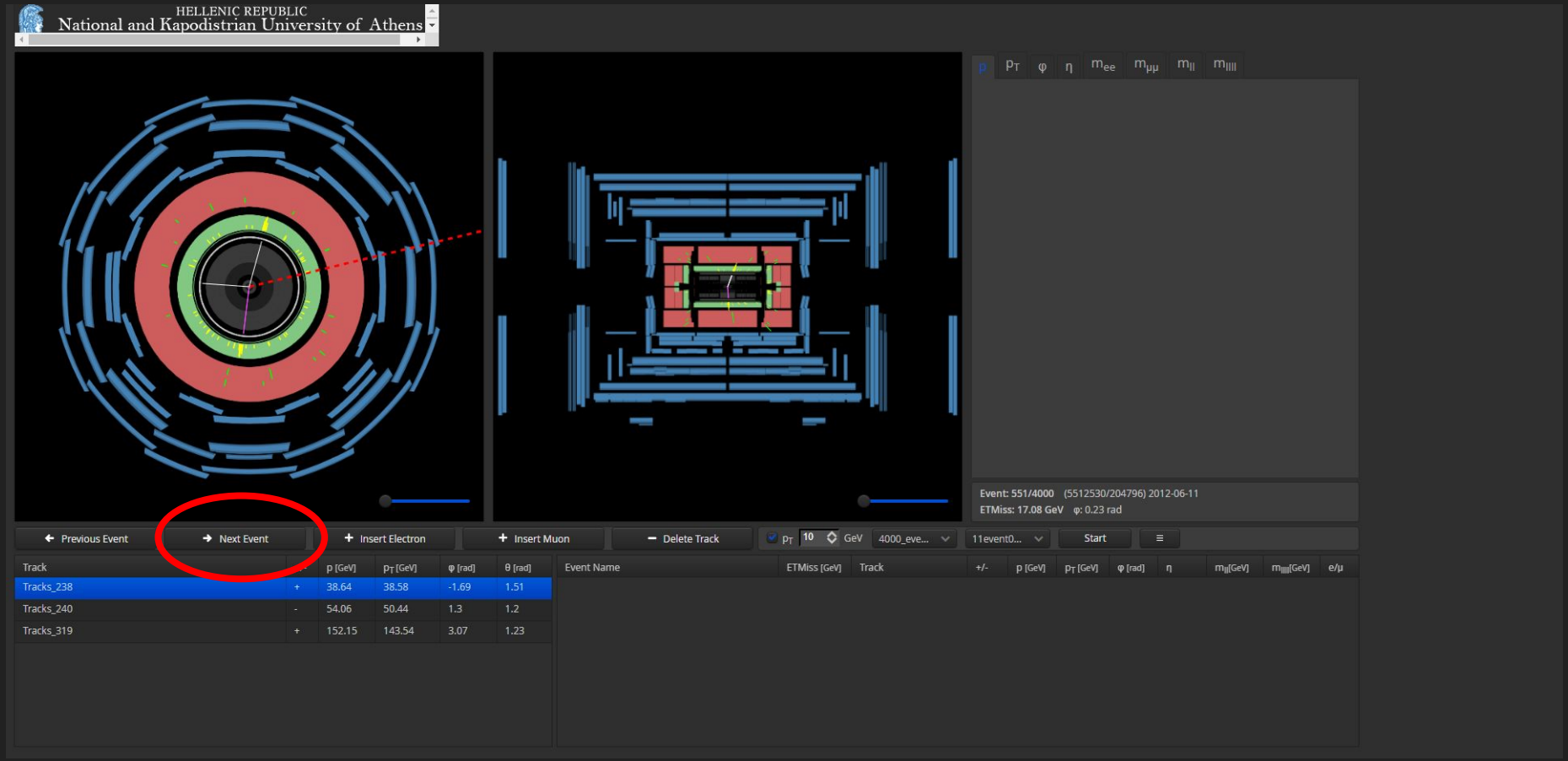
Now we can begin going through the events.



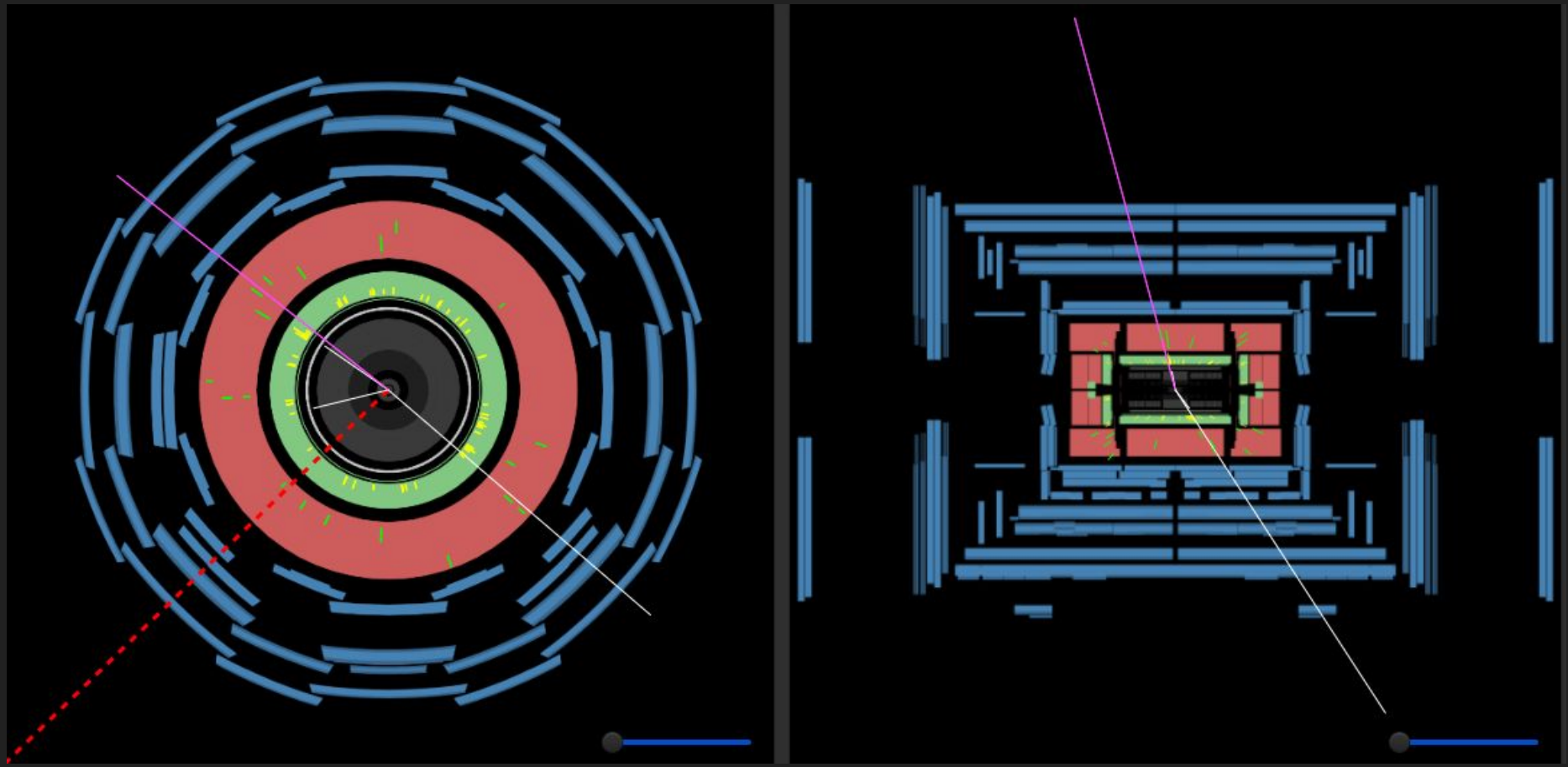
The tracks (white/purple lines) we are looking for will penetrate the electromagnetic calorimeter (green section) of the detector. This event, for example, has no such tracks:



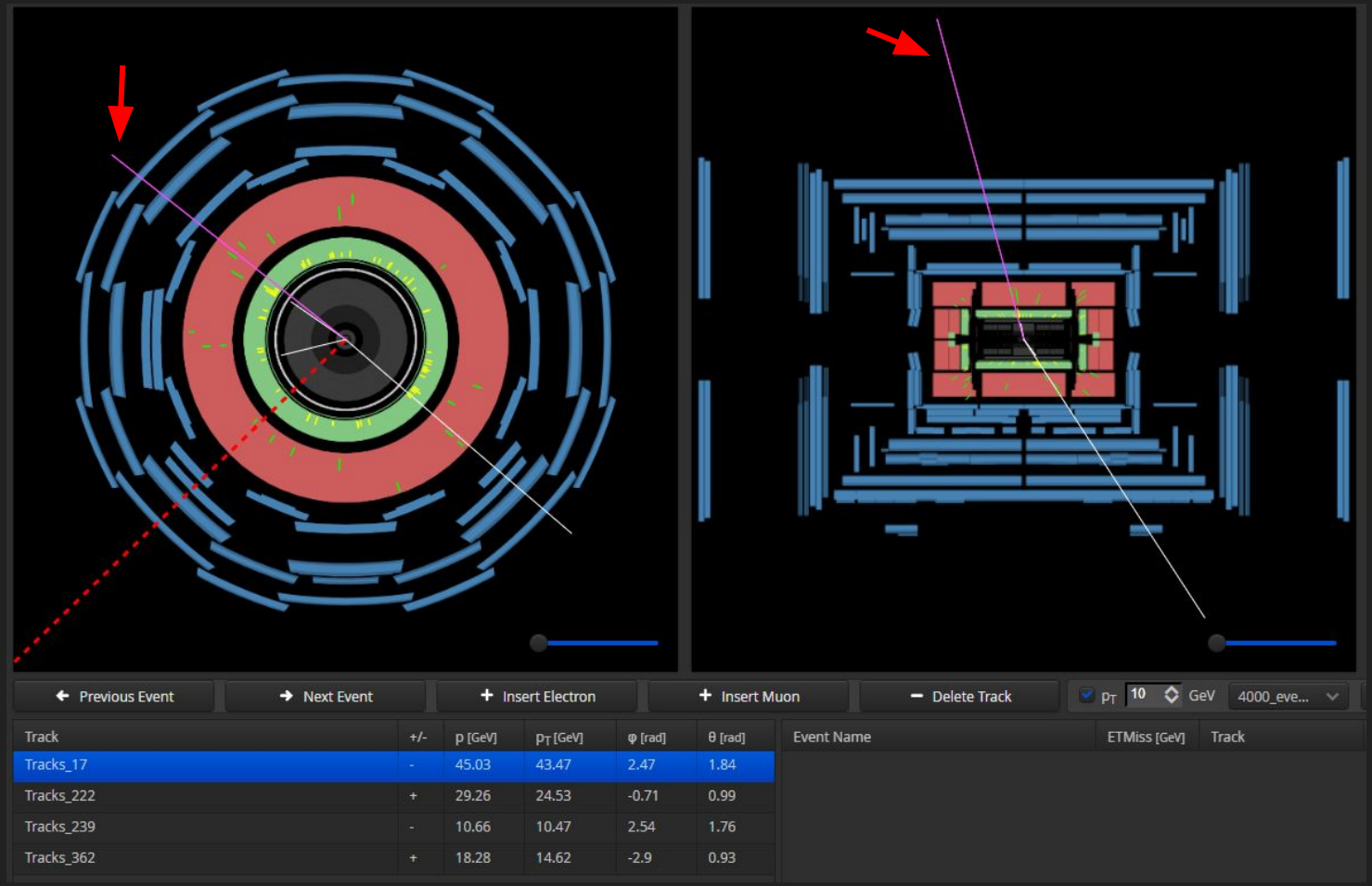
We go on to the next event by clicking “next event.”



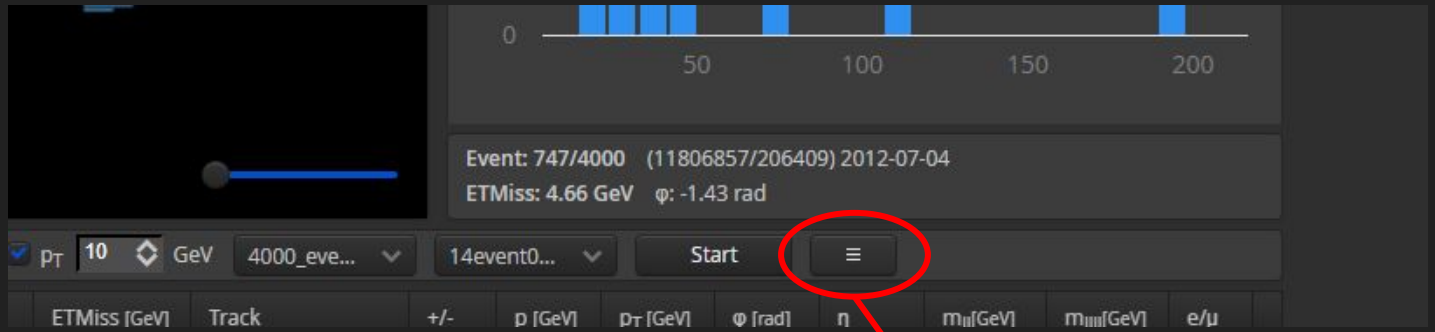
This event does have two trails penetrating through, and thus is of interest to us.

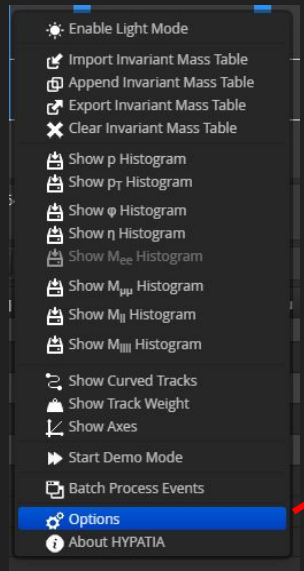


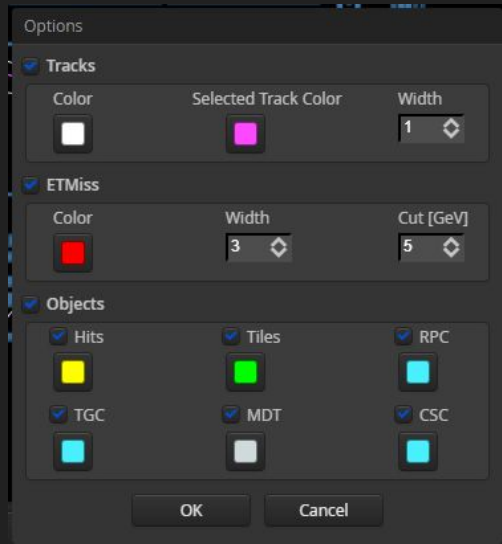
Note that the track highlighted in the lower left window will be purple in the upper display.



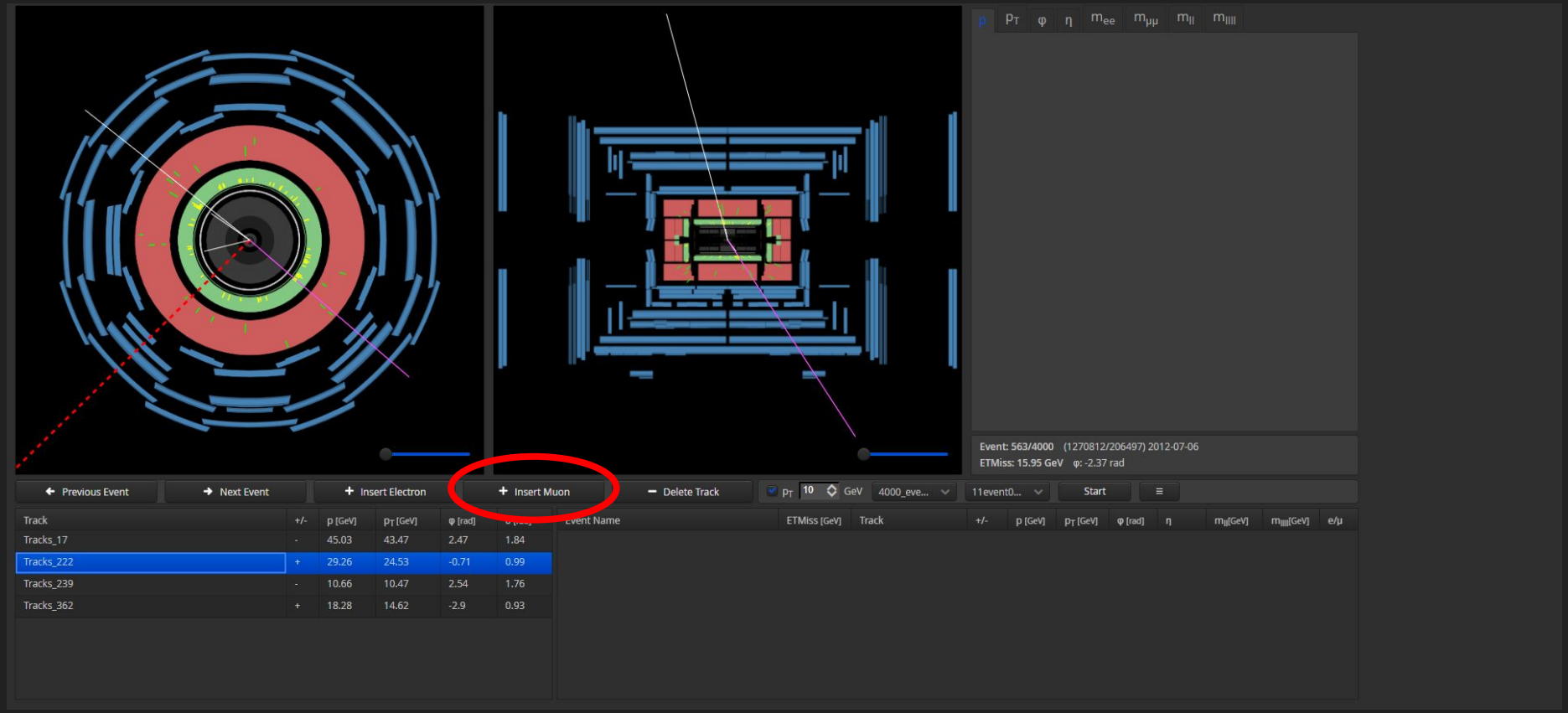
Side note: The red dashed line and smaller colored lines on the displays aren't of concern to us in this exercise, so if they are distracting they can be turned off in the options menu:



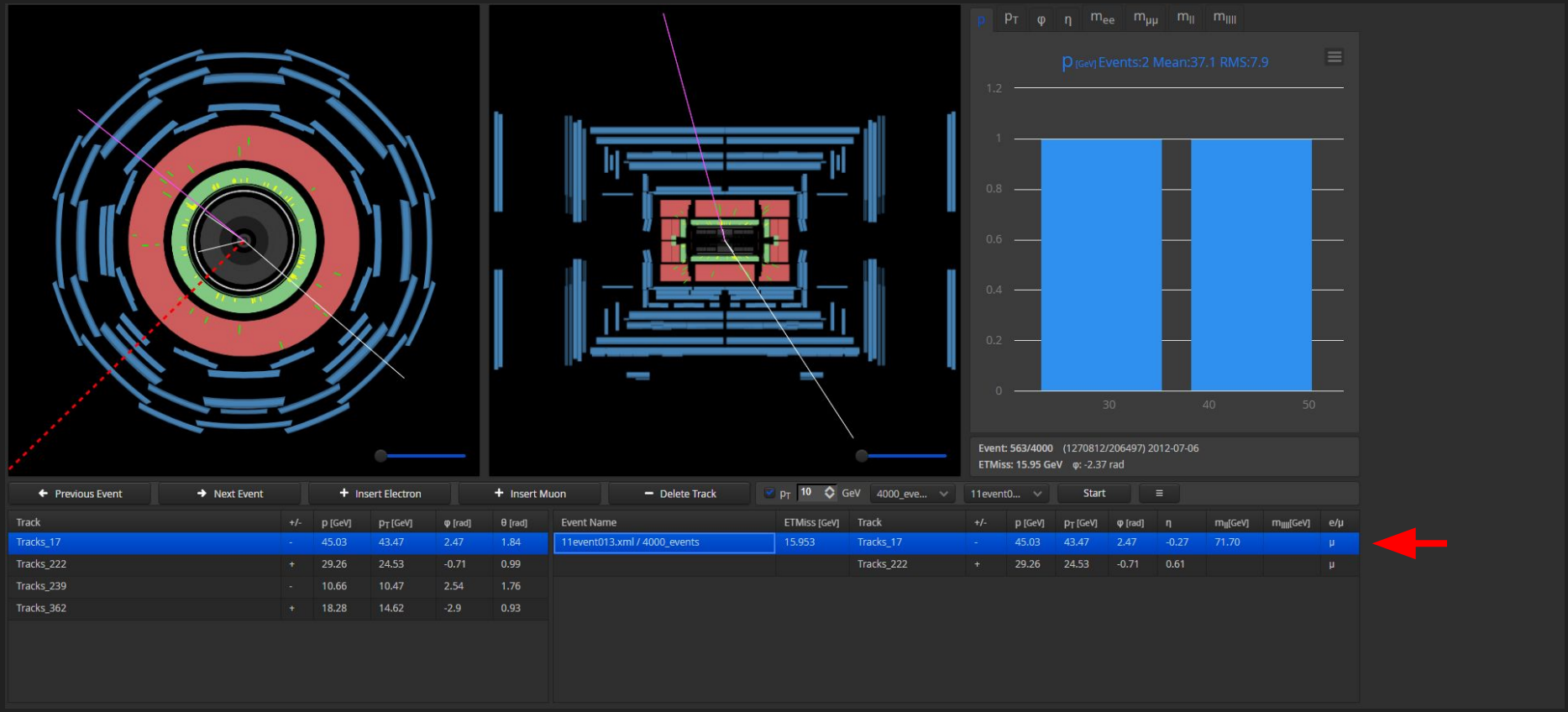




Once we identify a pair, for each we want to: select the track in the lower left window, check the purple line above to be sure that it is the correct track, and then click “insert muon.”



Each track “inserted” will be added to the lower-right table.



Track	+/-	p [GeV]	pT [GeV]	φ [rad]	θ [rad]
Tracks_17	-	45.03	43.47	2.47	1.84
Tracks_222	+	29.26	24.53	-0.71	0.99
Tracks_239	-	10.66	10.47	2.54	1.76
Tracks_362	+	18.28	14.62	-2.9	0.93

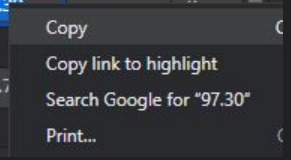
Event Name	ETMiss [GeV]	Track	+/-	p [GeV]	pT [GeV]	φ [rad]	η	mll[GeV]	mllll[GeV]	e/μ
11event013.xml / 4000_events	15.953	Tracks_17	-	45.03	43.47	2.47	-0.27	71.70		μ
		Tracks_222	+	29.26	24.53	-0.71	0.61			μ

Looking at the lower-right table, we can see that an m_{ll} (dilepton mass) value is calculated for each muon pair. These are the values we will record.

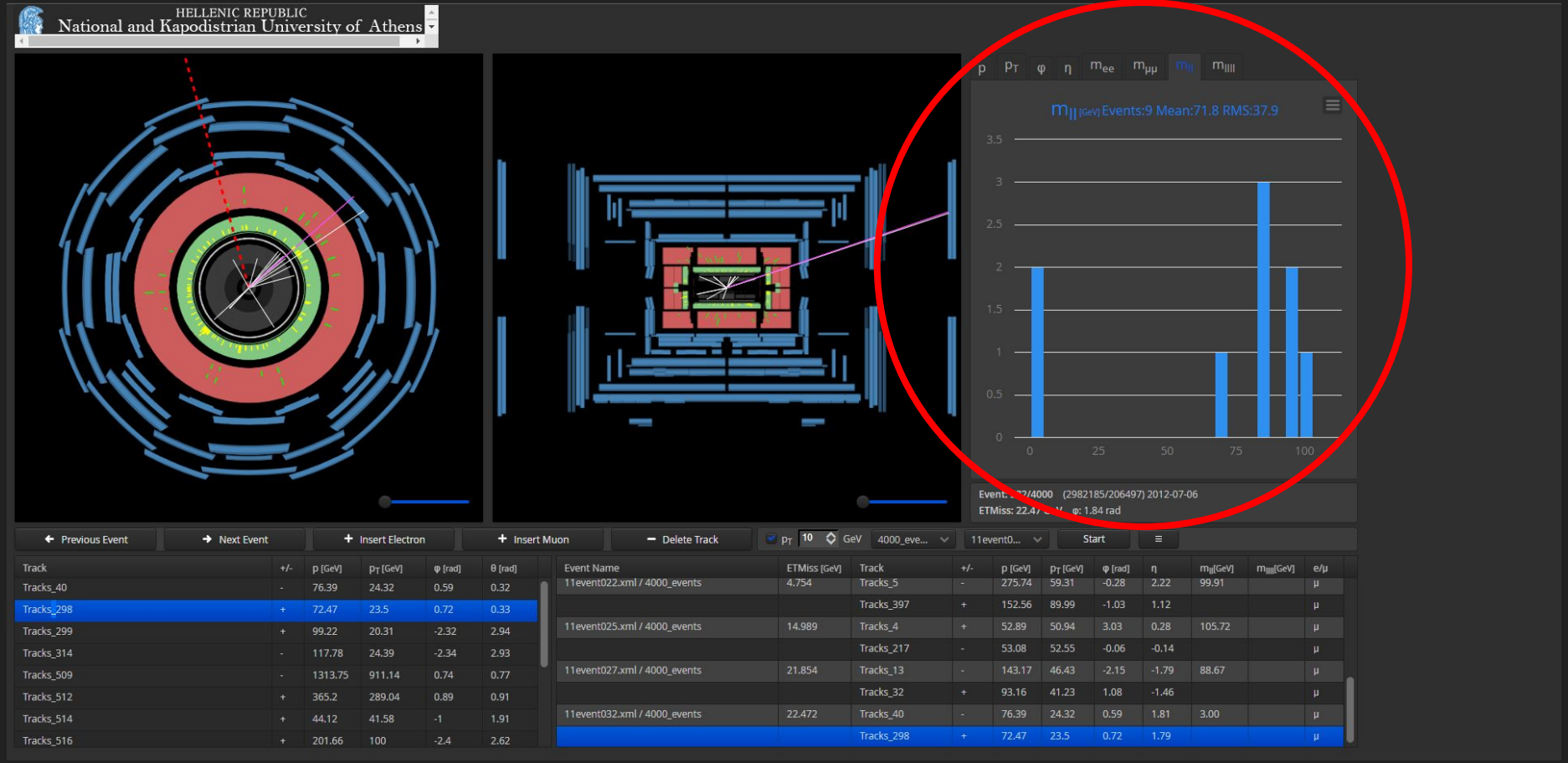
Event Name	ETMiss [GeV]	Track	+/-	p [GeV]	p_T [GeV]	φ [rad]	η	m_{ll}[GeV]	m_{llll}[GeV]	e/μ
11event013.xml / 4000_events	15.953	Tracks_17	-	45.03	43.47	2.47	-0.27	71.70		μ
		Tracks_222	+	29.26	24.53	-0.71	0.61			μ
11event014.xml / 4000_events	17.703	Tracks_16	-	79.65	38.92	-1.45	1.34	97.30		μ
		Tracks_19	+	38.82	38.75	1.47	-0.06			μ
11event017.xml / 4000_events	13.572	Tracks_14	-	43.54	43.41	-2.62	0.08	87.70		μ
		Tracks_142	+	46.98	42.92	0.53	0.43			μ

The m_{ll} values can be copied from this table and pasted into your spreadsheet sections.

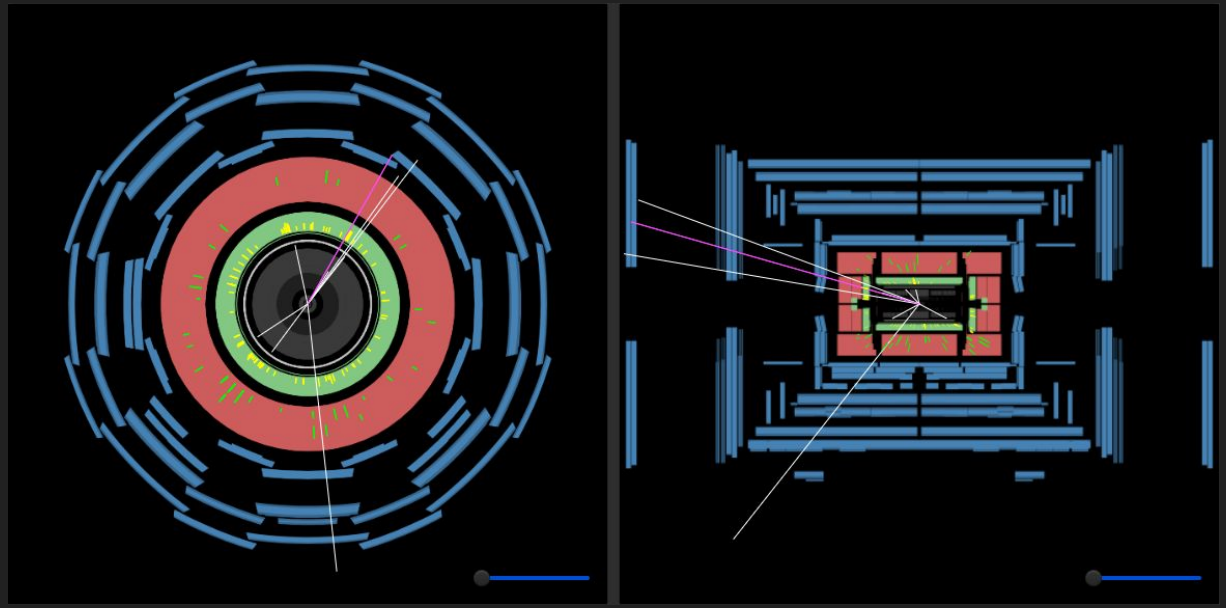
Event Name	ETMiss [GeV]	Track	+/-	p [GeV]	p_T [GeV]	φ [rad]	η	m_{ll}[GeV]	m_{llll}[GeV]	e/μ
		Tracks_331	+	151.97	47.1	1.1	-1.84			μ
11event013.xml / 4000_events	15.953	Tracks_17	-	45.03	43.47	2.47	-0.27	71.70		μ
		Tracks_222	+	29.26	24.53	-0.71	0.61			μ
11event014.xml / 4000_events	17.703	Tracks_16	-	79.65	38.92	-1.45	1.34	97.3		
		Tracks_19	+	38.82	38.75	1.47	-0.06			
11event017.xml / 4000_events	13.572	Tracks_14	-	43.54	43.41	-2.62	0.08	87.7		
		Tracks_142	+	46.98	42.92	0.53	0.43			



On the right, you can click the “m_{ll}” tab to view a histogram of your tabulated m_{ll} values.



Very few events in the dataset will feature 4 muon tracks - in this case, add both pairs and record the m_{ll} masses as usual, but also record the m_{llll} mass of the entire quad-lepton system.



								m_{ll}	m_{llll}	
14event047.xml / 4000_events	4.655	Tracks_10	-	202.75	55.49	1.05	-1.97	8.49	88.31	μ
		Tracks_11	+	46	15.96	0.92	-1.72			μ
		Tracks_36	+	18.14	14.22	-1.46	-0.73	44.63		μ
		Tracks_47	-	112.87	18.9	0.95	-2.47			μ

Once you see the event selection reach the next double digit number (i.e. 11 -> 12), you have gone through the 50 events in your subset.