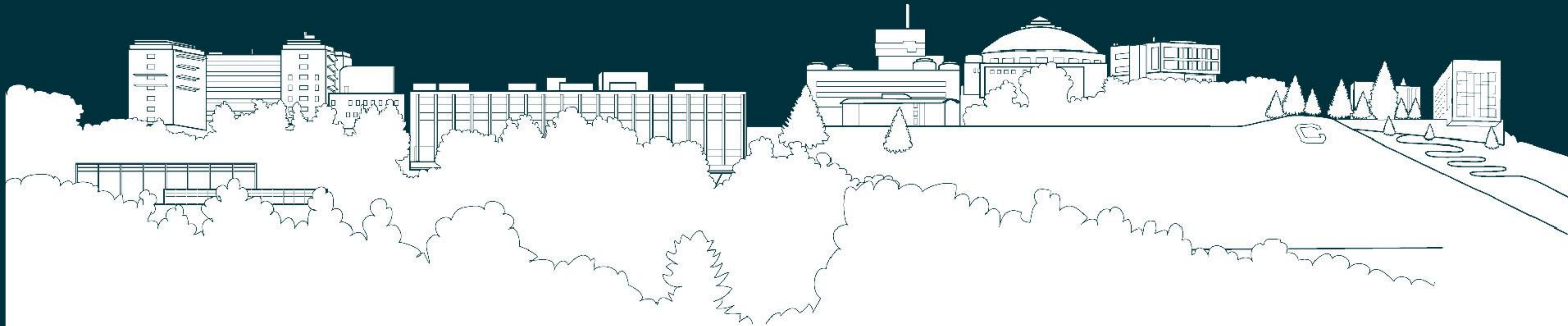


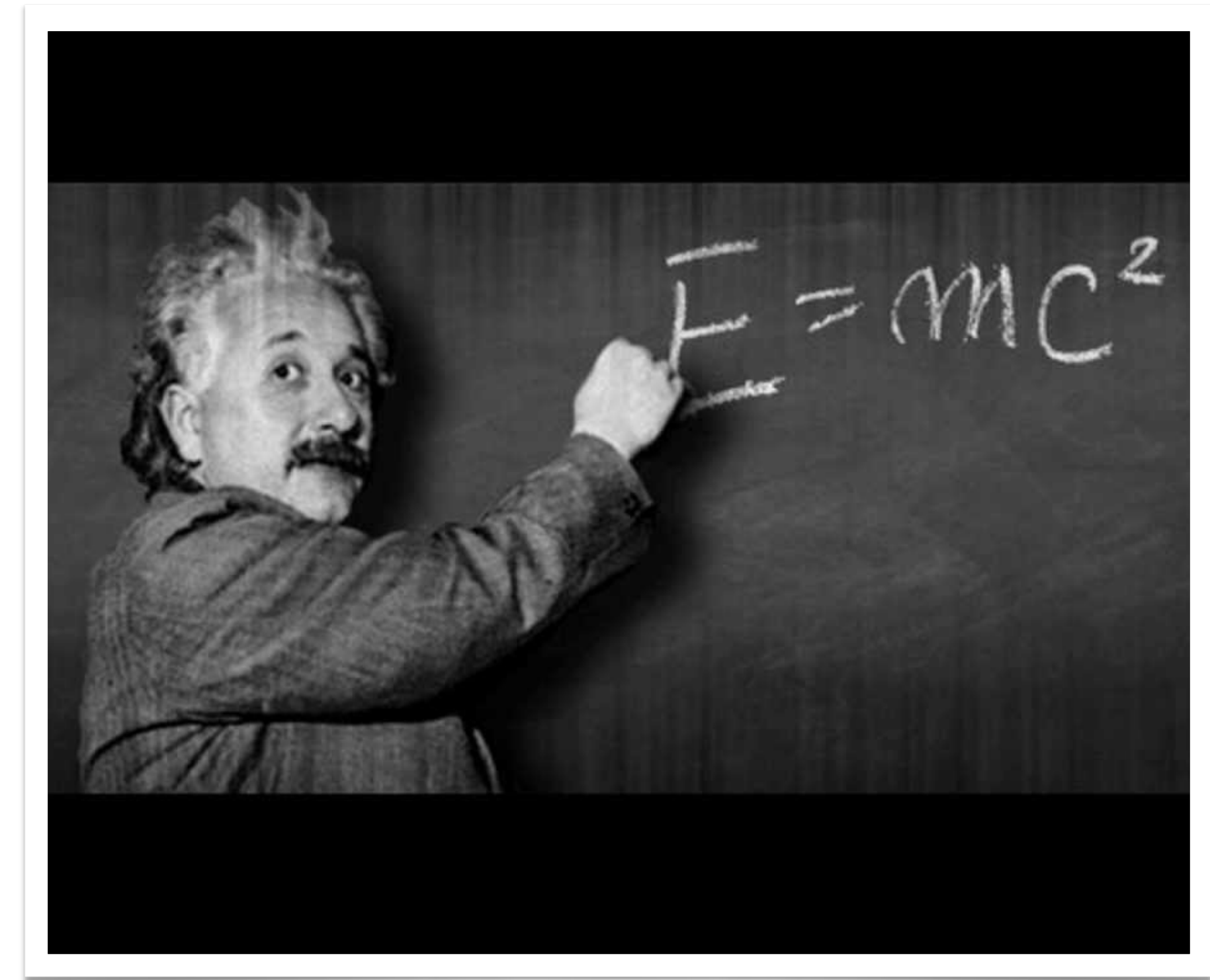
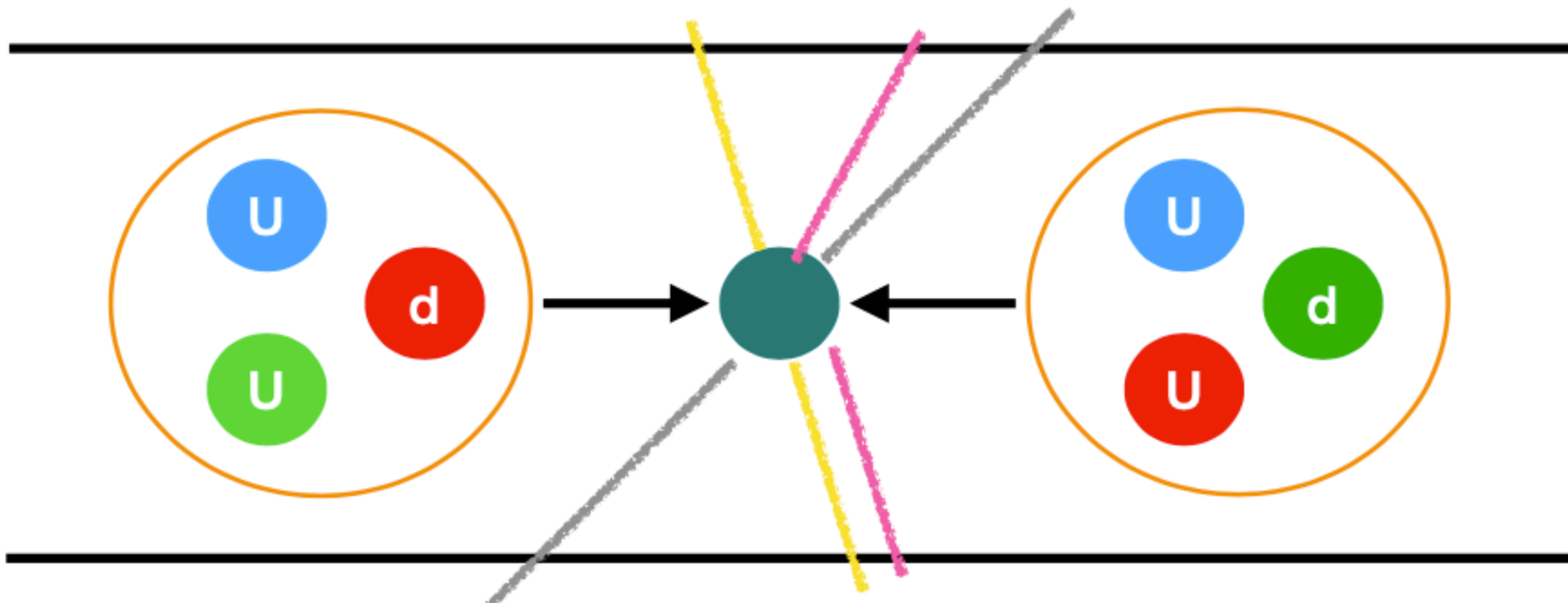
ATLAS Masterclass

Data Analysis Techniques

Miha Muškinja

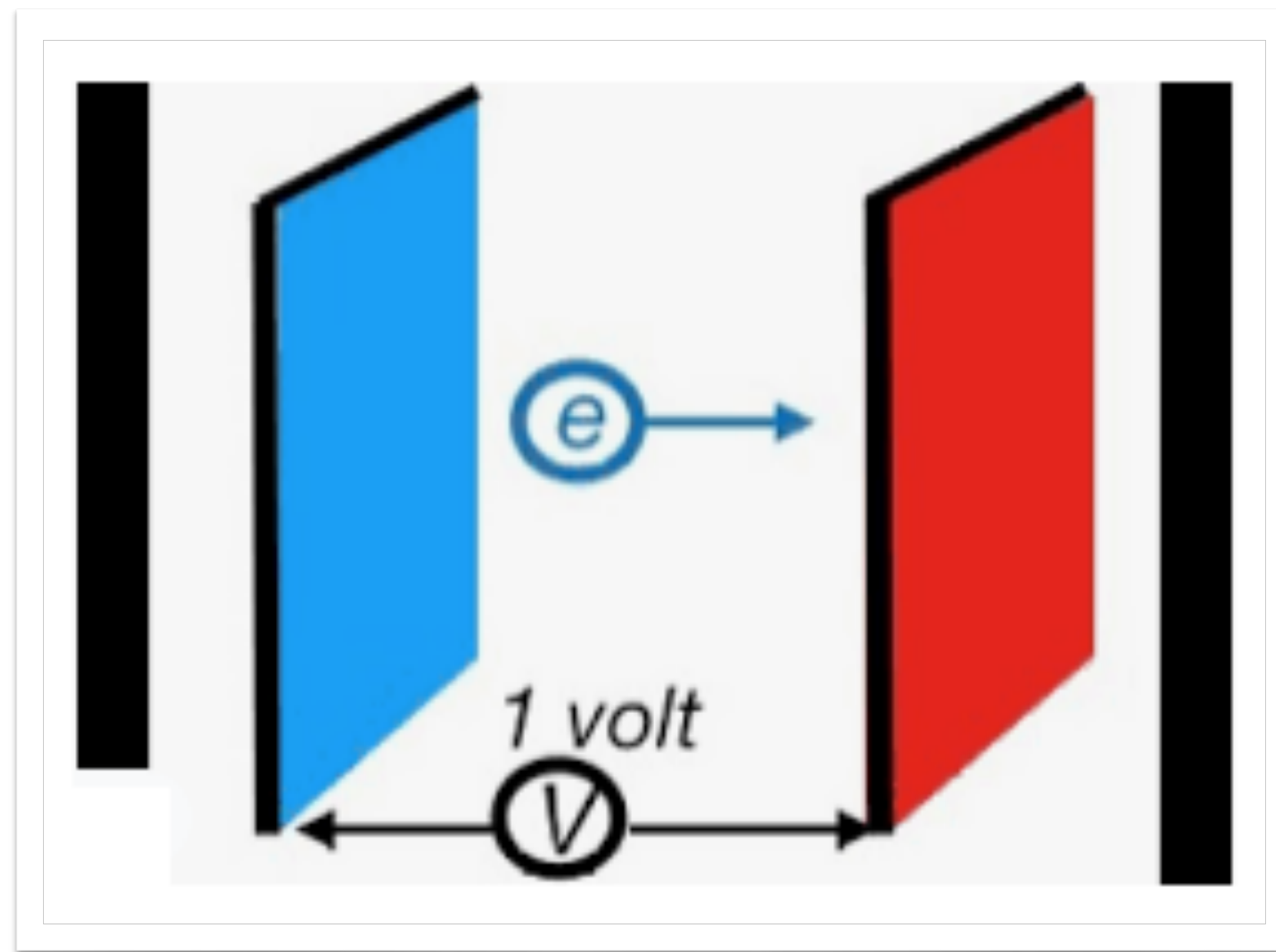
ATLAS Masterclass
Saturday, April 22, 2023





- Einstein: energy and mass are equivalent!
- Colliding particles with high energy produces many new particles,
- We use the Large Hadron Collider (LHC) to accelerate protons to 0.999999999 times the speed of light and collide them,
 - Between 2015 and 2018, we produced about 8,000,000 Higgs bosons in ATLAS.

- “0.999999999 times the speed of light”— inconvenient,
 - Instead of quoting the speed, we rather talk about the kinetic energy,
- Energy: 'Joules'. However we rather use the 'electron Volt' unit:



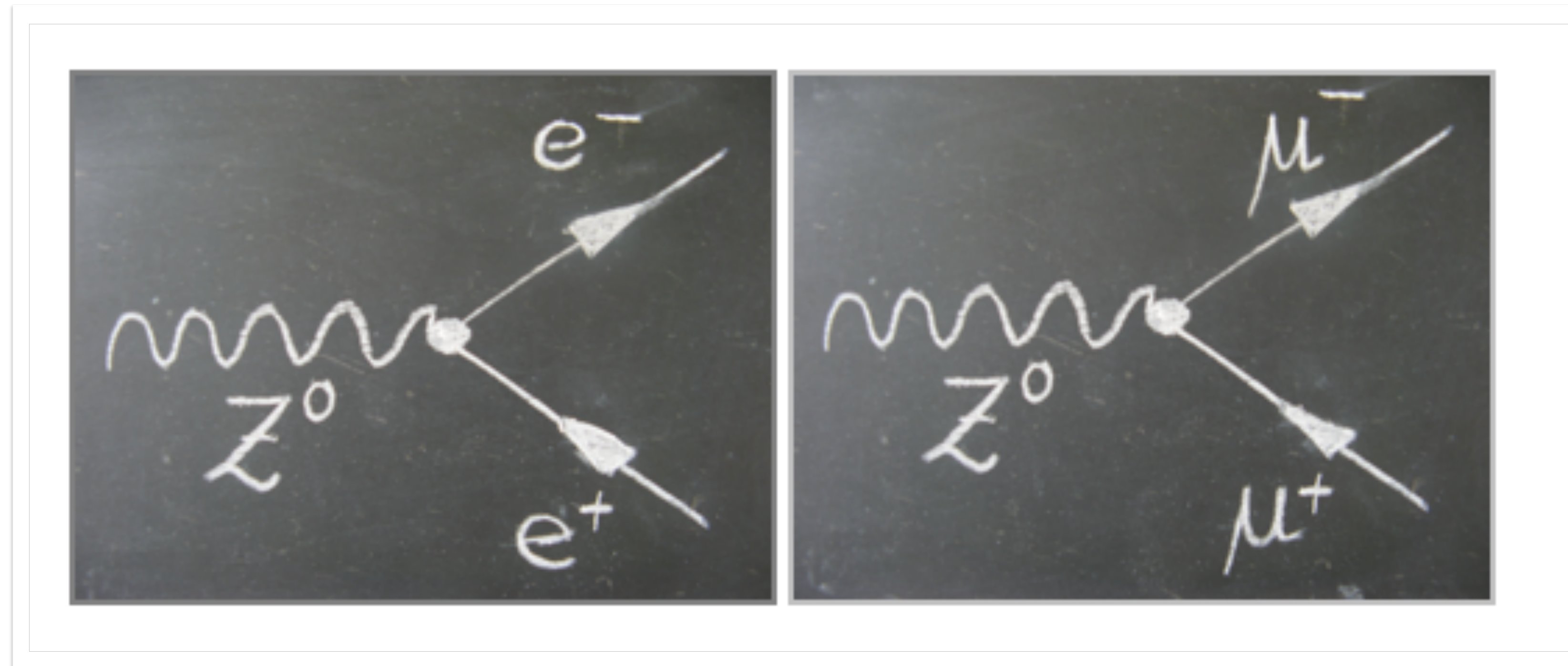
1 'electron Volt' or 1 eV:

Energy gained by an electron accelerated by an electrical potential of one Volt.

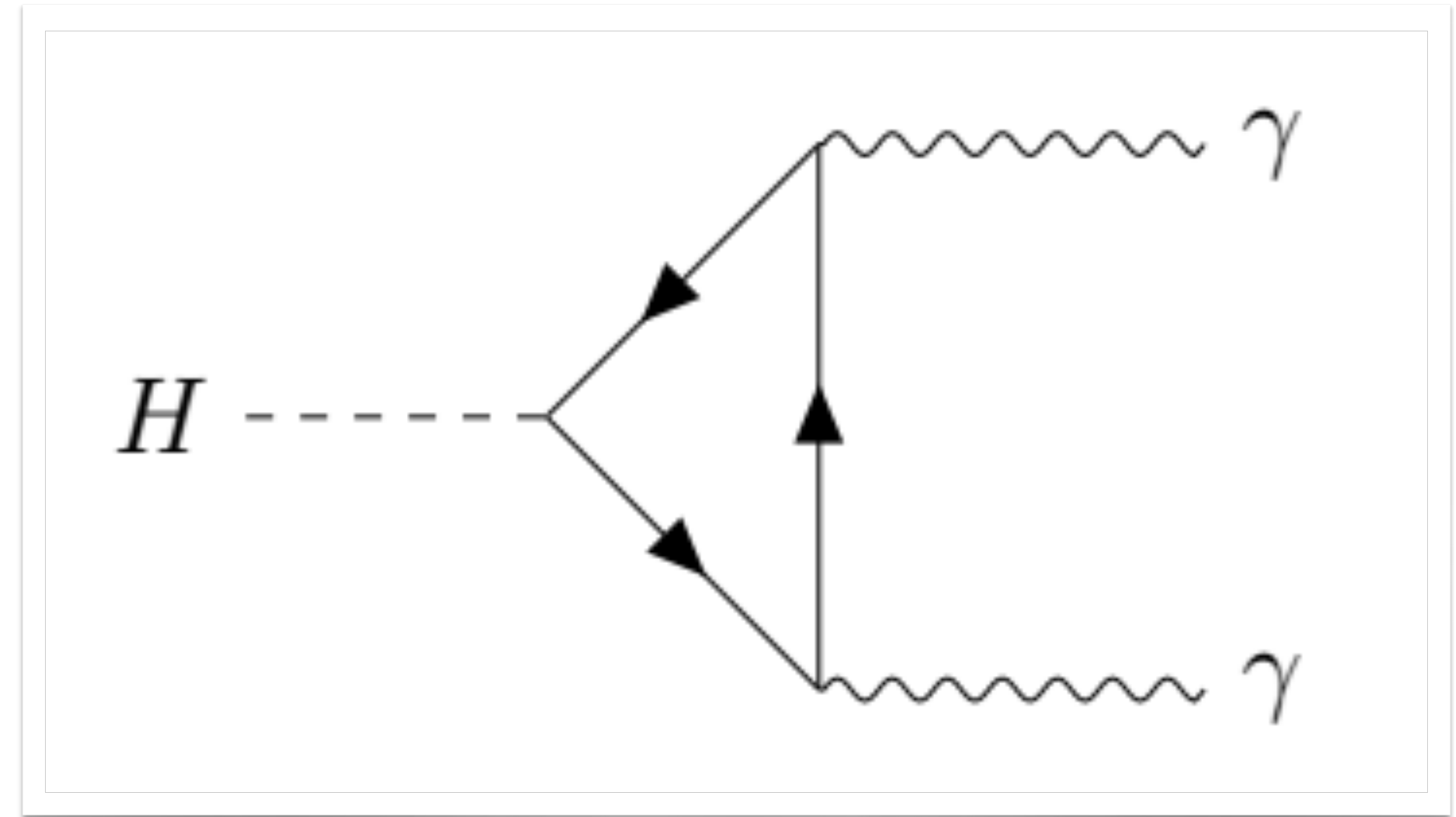
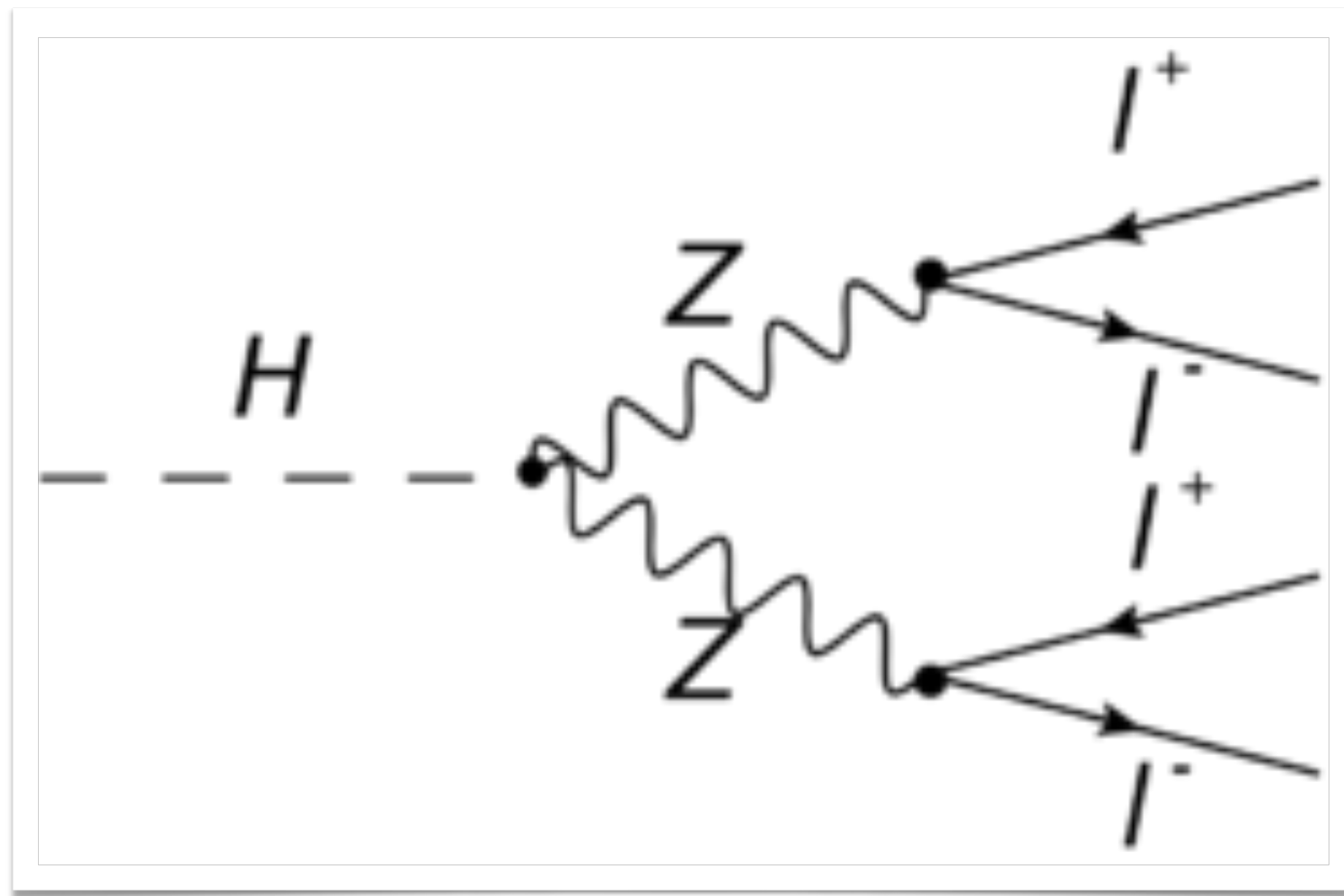
$$1 \text{ eV} = 1.6 \cdot 10^{-19} \text{ J}$$

- At the LHC, we collide protons with the energy of 13 TeV = 13,000,000,000 eV,
- New particles created in these collisions typically have energy around 1—100 GeV.

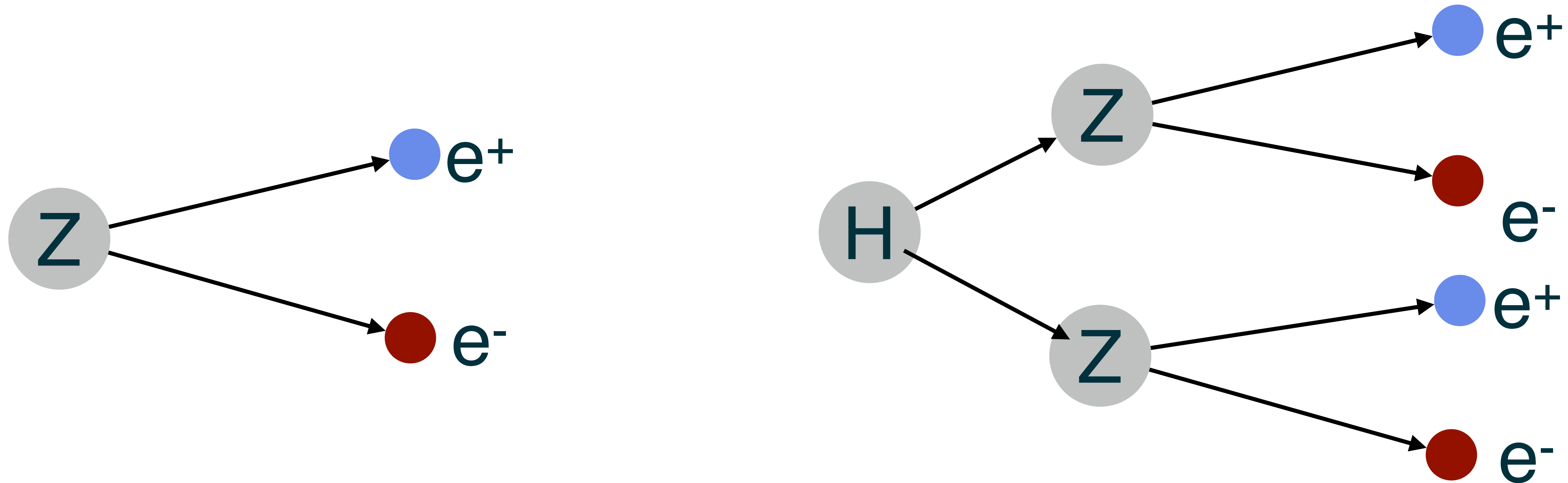
- Today, you will be searching for the Z boson decays:



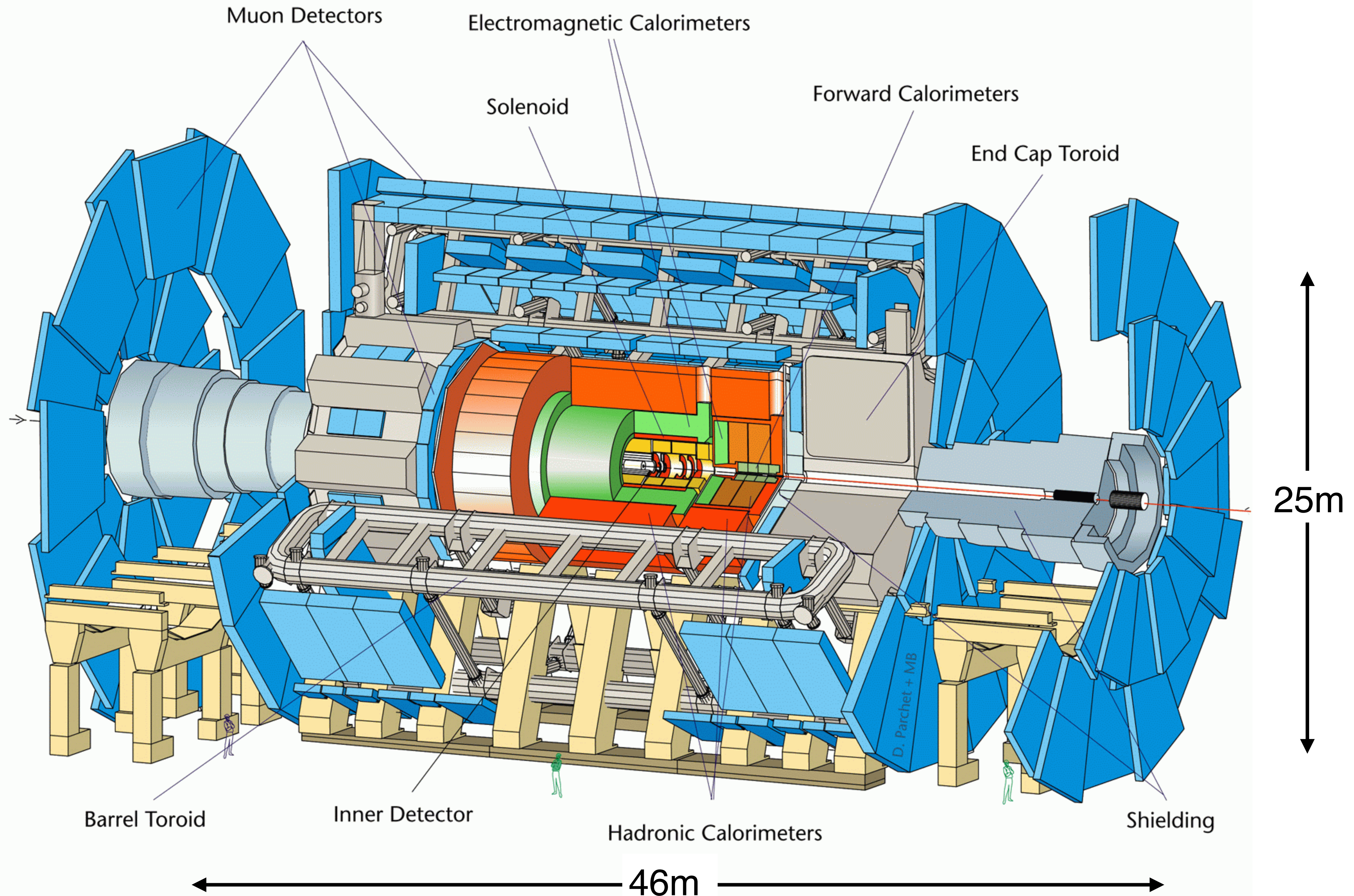
- The Z boson decays either into two electrons or two muons,
- The Z boson has no charge. Due to charge conservation, outgoing particles have the opposite charge: e^- and e^+ .



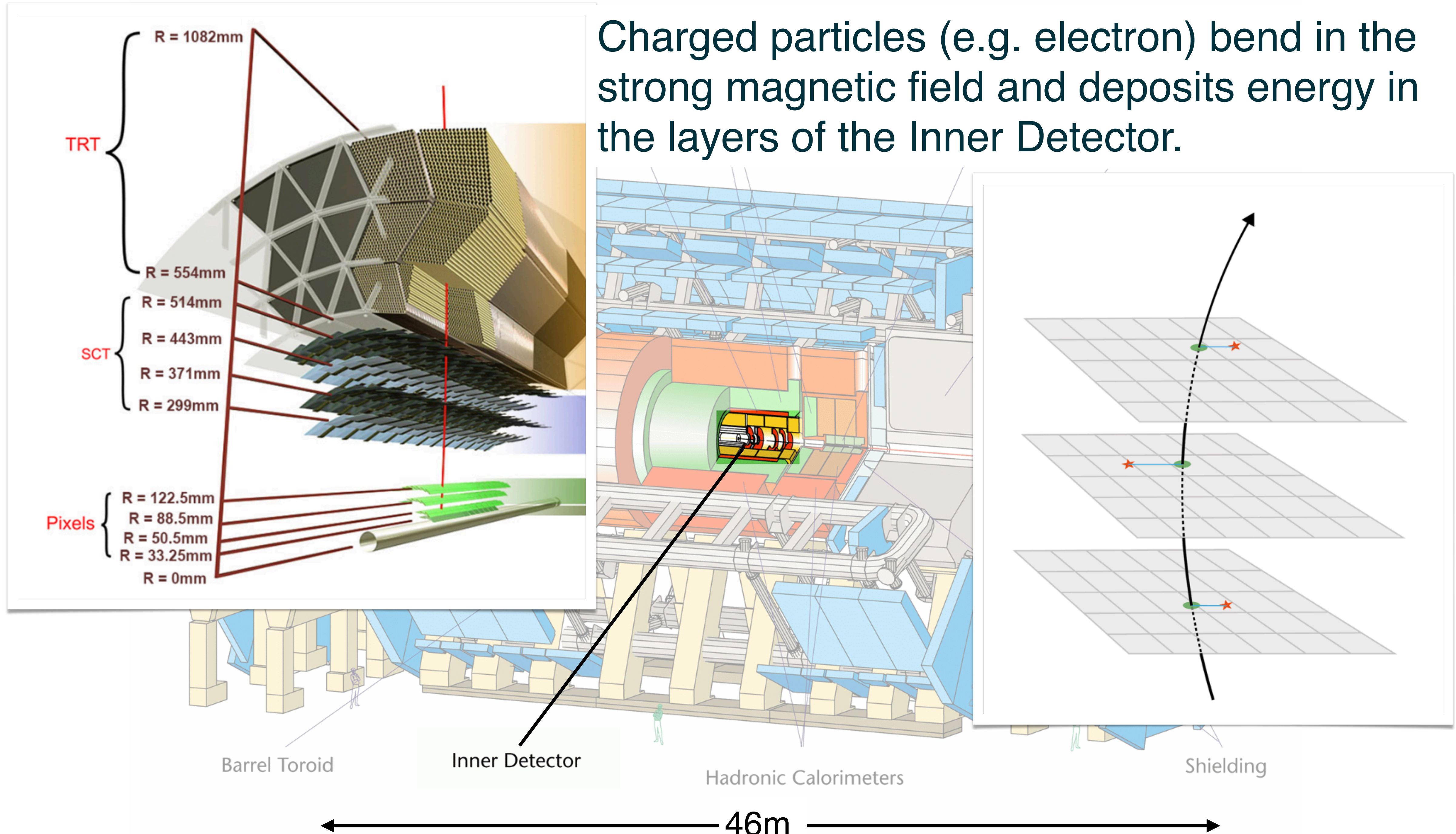
- You will also be searching for Higgs boson decays:
 - $H \rightarrow ZZ \rightarrow 4$ leptons (electrons or muons),
 - $H \rightarrow \gamma\gamma$ (2 photons),
- By correctly identifying the Z bosons, you will be able to reconstruct the Higgs boson!

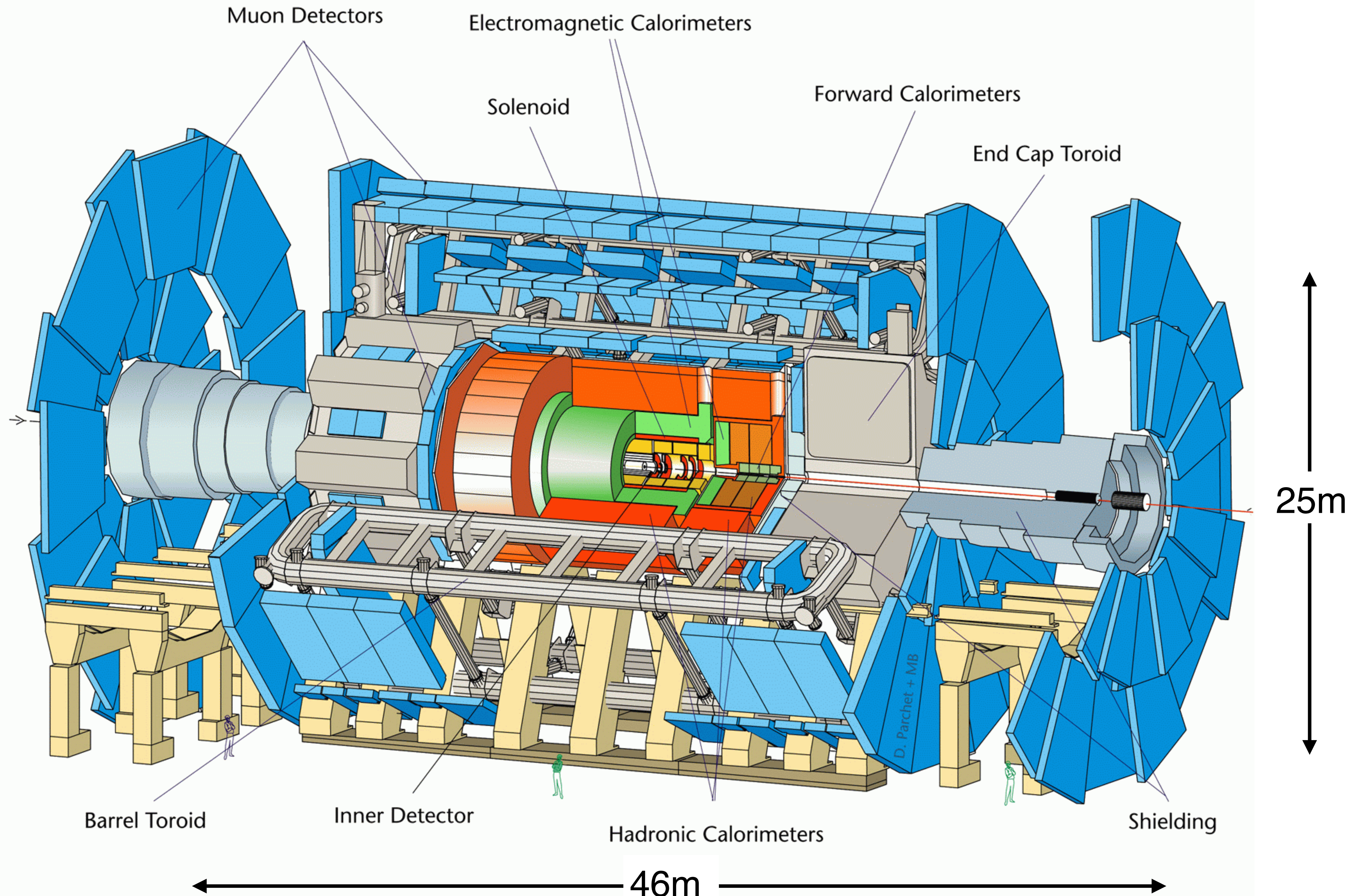


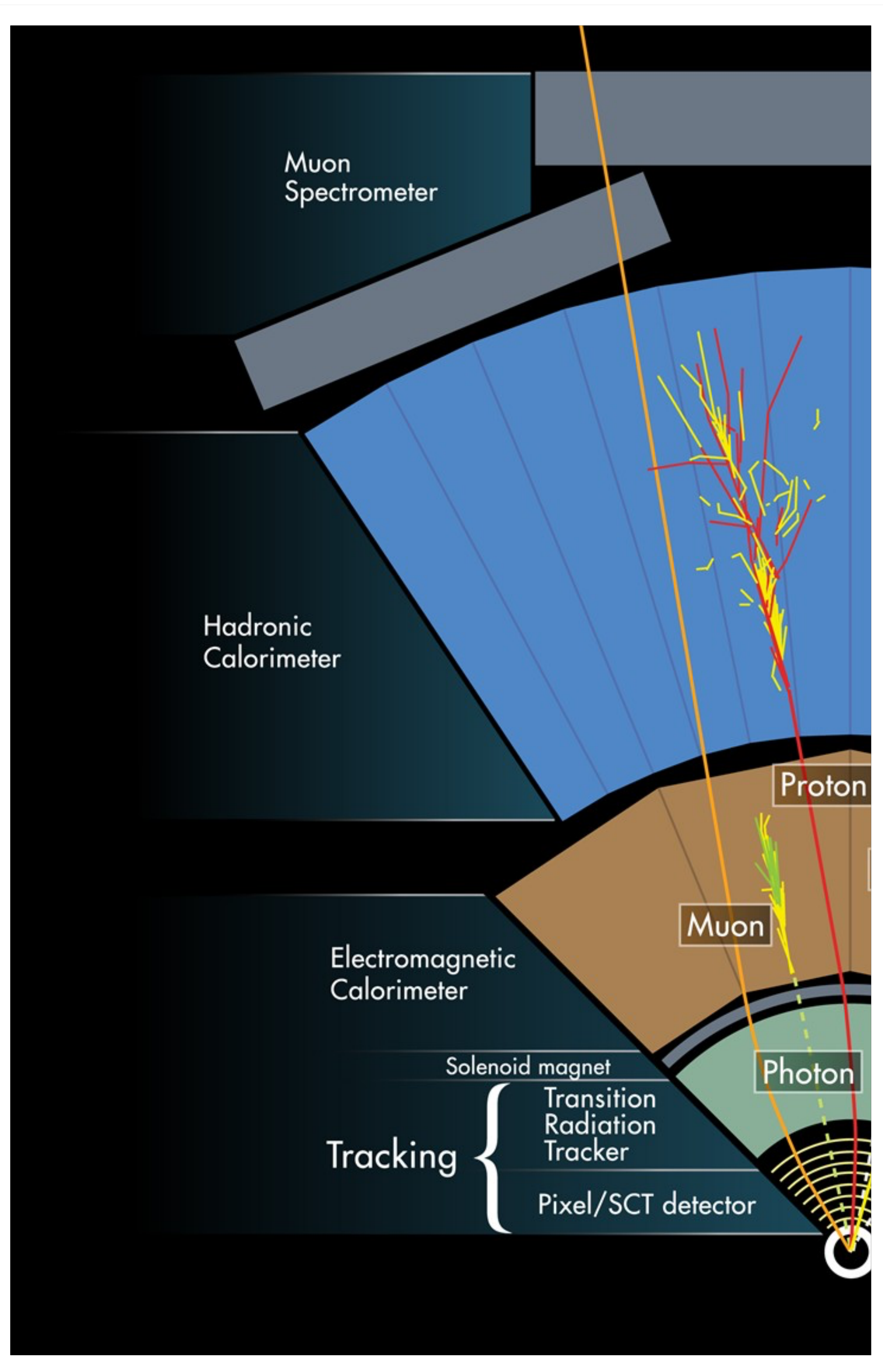
- The ATLAS detector measures the momentum of final particles only (e , μ , γ , ...),
- With these we can reconstruct the **mass** of the initial particle (Z boson or H boson),
 - Z boson: 90 GeV,
 - H boson: 125 GeV,
- However, because the detector has some measurement error, the reconstructed mass will be scattered around the true mass.



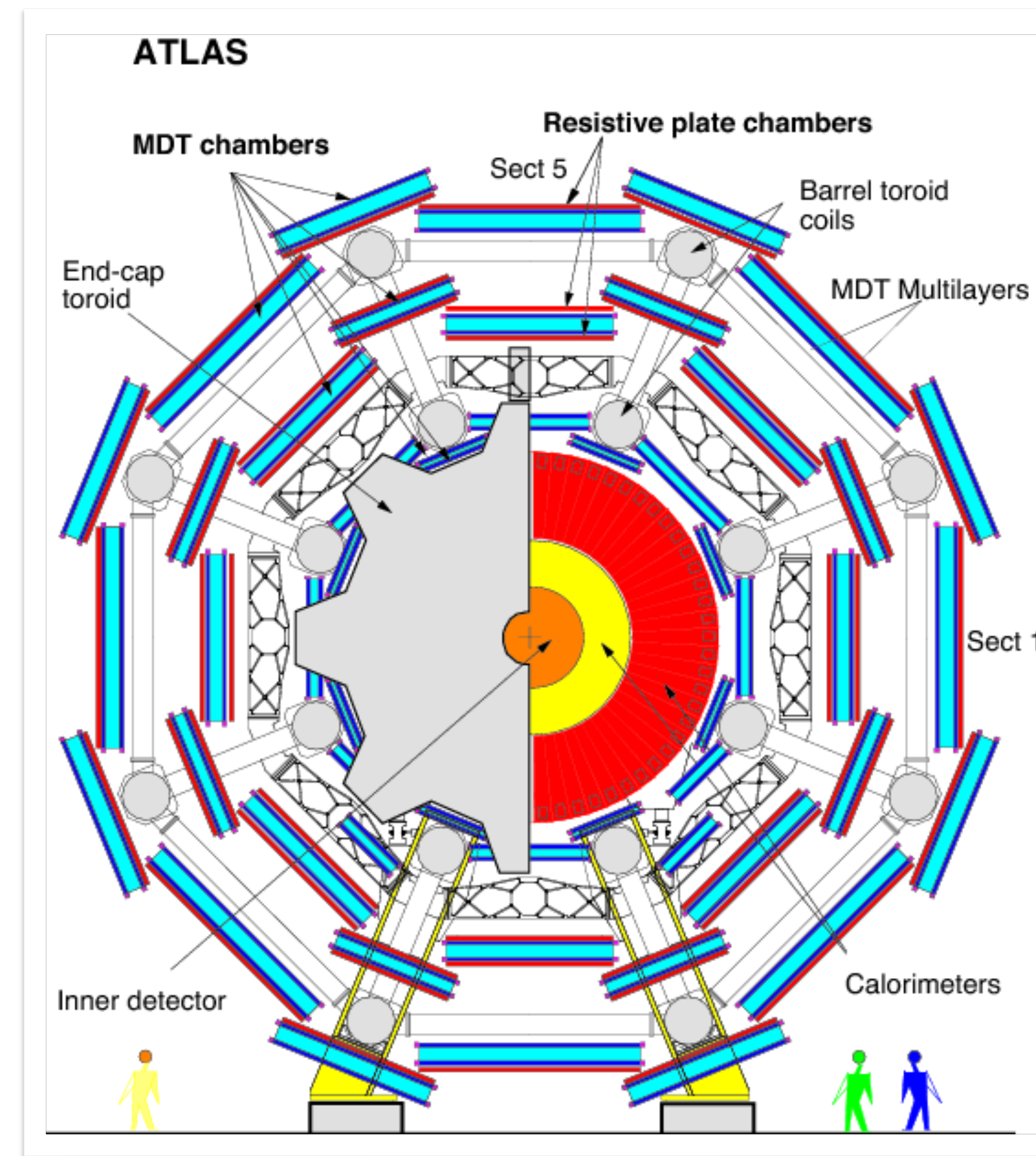
Charged particles (e.g. electron) bend in the strong magnetic field and deposits energy in the layers of the Inner Detector.







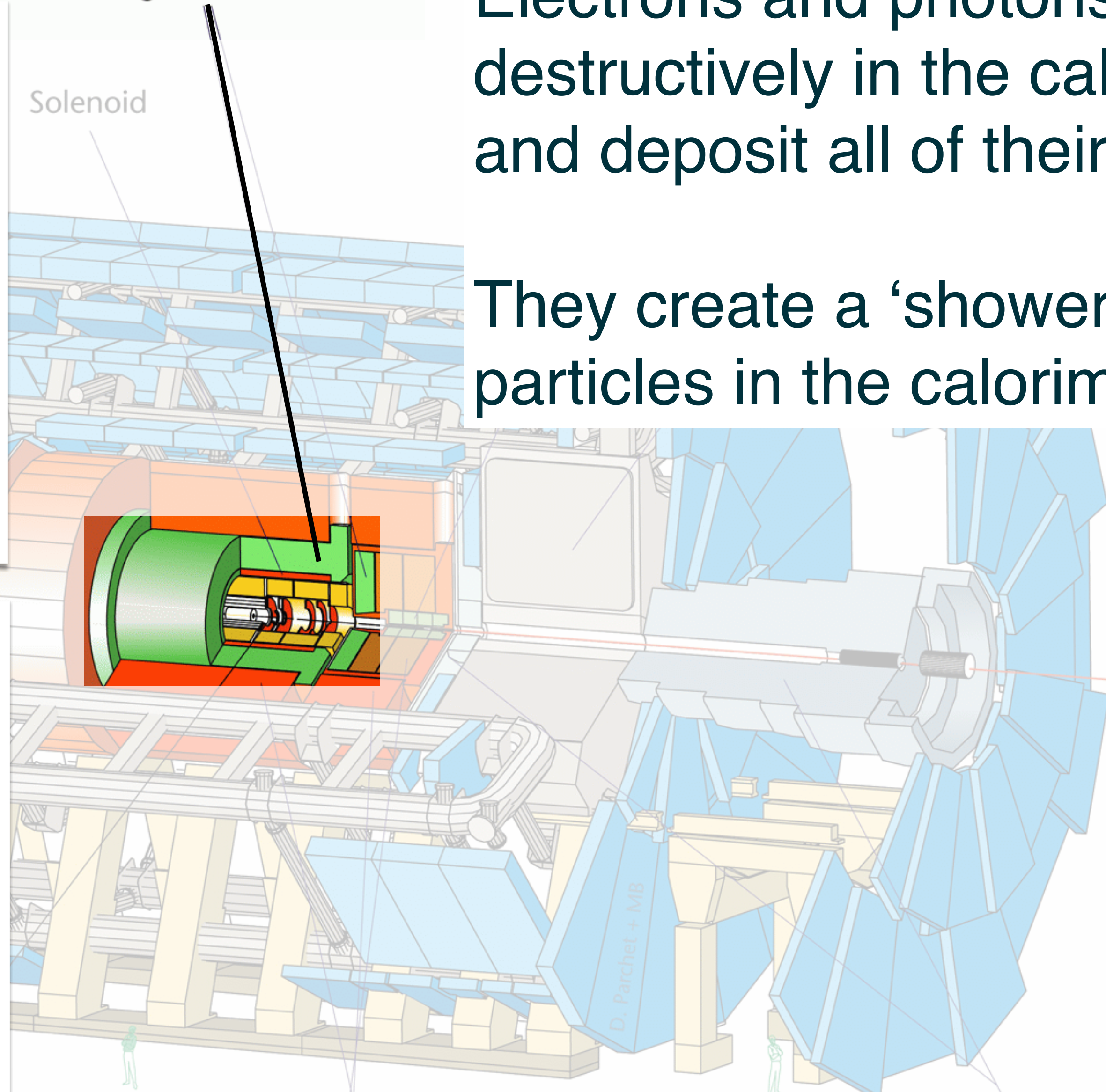
Muons are the heavier siblings of electrons. They interact with the detector material less frequently and travel all the way through. We catch them with the outer Muon Detectors.



Muon Detectors

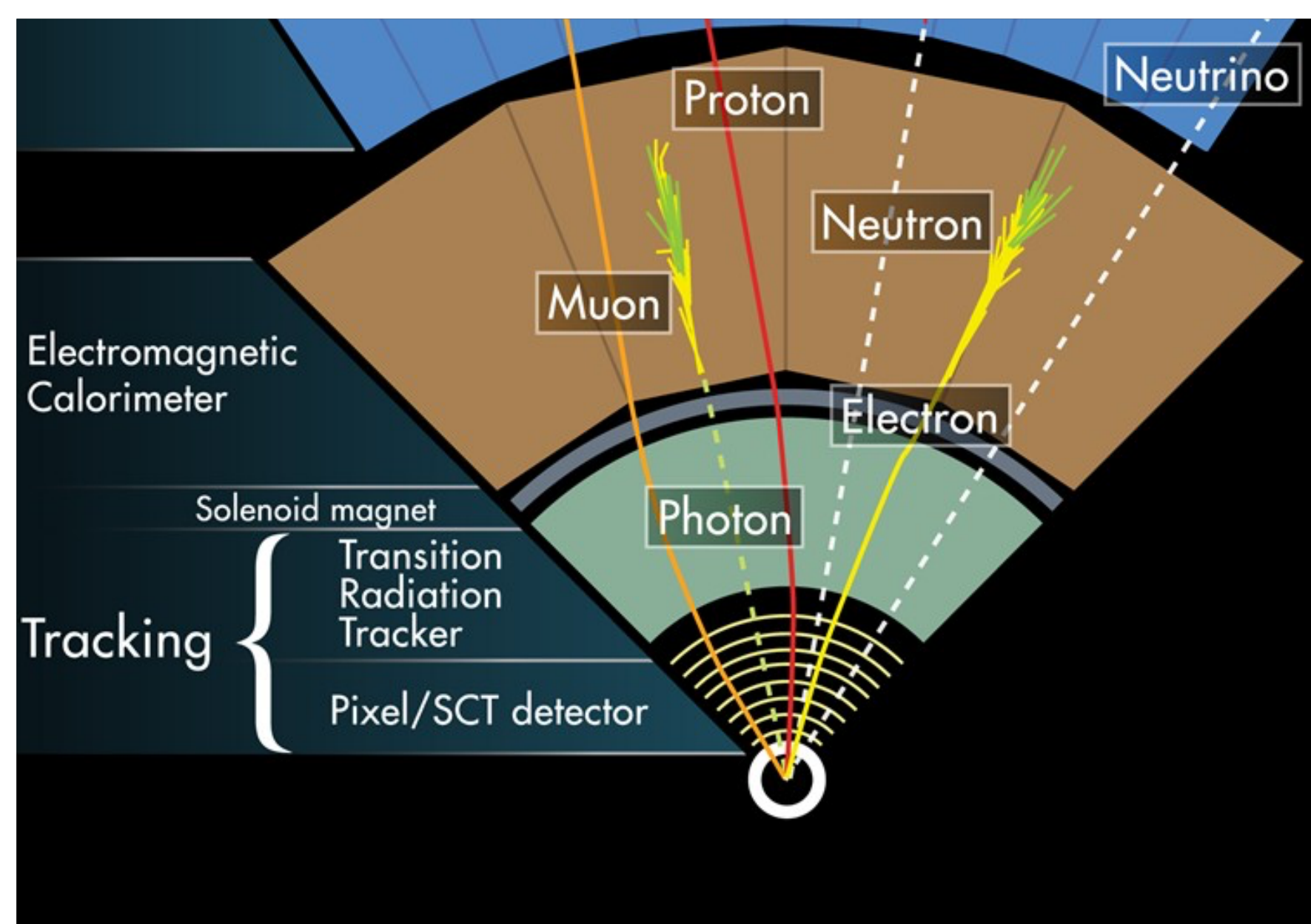


Electromagnetic Calorimeters



Electrons and photons stop destructively in the calorimeter and deposit all of their energy.

They create a 'shower' of particles in the calorimeter.



Hadronic Calorimeters

Shielding

Hypathia software

- Four screens— ‘invariant mass’ window, event display, control panels.

The screenshot displays the HYPATHIA software interface, titled "HYbrid Pupils' Analysis Tool for Interactions in ATLAS - version 7.4 - Invariant Mass Window". The interface is divided into four main panels:

- Top Left:** A circular event display showing particle tracks in blue, with a central red and green region representing the interaction point.
- Top Right:** A table of track parameters. The table has columns for Track, +/-, P [GeV], Pt [GeV], φ , and θ . The data is as follows:

Track	+/-	P [GeV]	Pt [GeV]	φ	θ
Tracks 0	-	11.68	4.28	-1.319	0.375
Tracks 1	+	126.06	39.41	-2.413	0.318
Tracks 2	+	4.57	4.56	-2.783	1.649
Tracks 3	-	167.90	53.01	0.906	0.321
Tracks 4	-	1.34	1.33	-2.949	1.475
Tracks 5	-	1.75	1.74	-3.090	1.645
Tracks 6	+	18.61	3.94	-1.818	0.214
- Bottom Left:** A 3D detector geometry view showing the ATLAS detector structure with tracks overlaid.
- Bottom Right:** The "HYPATHIA - Control Window" containing parameter control and data display sections. The "Data" section shows a table with columns for Name and Value, and a list of checked items: Status, InDet, Calo, MuonDet, and Objects.



Name	Dataset	Name	Dataset
Jia Mohan	12-A	Carlos Fernandez	12-M
Talon Joe	12-B	Claire Palmer	12-N
Adrian Womack	12-C	Andrea Torres	12-O
Zachary Capote	12-D	Jocelin Ramos	12-P
Elsie Scott	12-E	Abhiraj Jalagekar	12-Q
Ryan Tonkovich	12-F	Miya Takeuchi	12-R
Benite Bazinga	12-G	Rigby Shaw	12-S
Xenia Gomez Iñiguez	12-H	Jaden Patel	12-T
Hagan Sum	12-I	Jadin Mom	13-A
Vincent Vazquez	12-J	Isaac Wong	13-B
Nora Weltman	12-K	karina pablo calmo	13-C
Michael Lac	12-L		

- <https://quarknet.org/content/atlas-z-path-measurement>

Data assignments for CERN masterclass institutes

Table of data assignments for Fermilab 2023 masterclass institutes.

Date	Institute, data groups	Institute, data groups	Institute, data groups
Sat 25 Feb	LisboaUni, 1 and 2		
Fri 03 Mar	Stillwater A, 1 and 2	Ruston, 3 and 4	
Sat 04 Mar	Santa Cruz, 5 and 6		
Thu 09 Mar	Dallas, 7 and 8		
Tue 14 Mar	DeKalb, 10 and 11		
Fri 24 Mar	Stillwater B, 13 and 14		
Sat 25 Mar AM	LisboaLIP, 1 , 2 , and 3	Coimbra, 4 , 5 , 10 , and 11	Evora, 6 and 7
Sat 25 Mar PM	Stillwater C, 8 and 9		
Fri 31 Mar	Stillwater D, 10 and 11		
Thu 06 Apr	Accra, 1 and 2		
Sat 22 Apr	Berkeley, 12 and 14		

E-mail for data login and password

The screenshot displays the Hypathia software interface. At the top, there is a menu bar with options: File, Previous Event, Next Event, Electron, Muon, Photon, Delete Track, and Reset Canvas. Below the menu bar, the current event information is shown: ETMis: 13.877 GeV, φ : 0.785 rad, and Collection: MET_RefFinal. The file path is `events/events4.zip/JiveXML_106051_1950731.xml`. A red box highlights the file path and the 'Open local file' button. Below the file path, there is a 'Physics Objects' tab. The main area of the interface contains a table with the following data:

Track	+/-	P [GeV]	Pt [GeV]	φ	θ
Tracks 0	-	11.68	4.28	-1.319	0.375
Tracks 1	+	126.06	39.41	-2.413	0.318
Tracks 2	+	4.57	4.56	-2.783	1.649
Tracks 3	-	167.90	53.01	0.906	0.321
Tracks 4	-	1.34	1.33	-2.949	1.475
Tracks 5	-	1.75	1.74	-3.090	1.645
Tracks 6	+	18.61	3.94	-1.818	0.214

The screenshot shows the Hypathia software interface. At the top, there is a menu bar with options: File, Previous Event, Next Event, Electron, Muon, Photon, Delete Track, and Reset Canvas. Below the menu bar, there is a status bar displaying "ETMis: 13.877 GeV", " ϕ : 0.785 rad", and "Collection: MET_RefFinal". The main window displays a table of tracks with columns: Track, +/-, P [GeV], Pt [GeV], ϕ , and θ . A red box highlights the "Open local file" button in the top left corner. A red arrow points from this button to an "Open" dialog box that is open in the foreground. The dialog box shows the "Look In:" field set to "Downloads" and a list of files and folders. The file "groupA.zip" is selected. The "File Name:" field contains "groupA.zip" and the "Files of Type:" dropdown is set to ".xml, .zip, .gzip, .gz".

Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 0	-	11.68	4.28	-1.319	0.375
Tracks 1	+	126.06	39.41	-2.413	0.318
Tracks 2	+	4.57	4.56	-2.783	1.649
Tracks 3	-	167.90	53.01	0.906	0.321
Tracks 4	-	1.34	1.33	-2.949	1.475
Tracks 5	-	1.75	1.74	-3.090	1.645
Tracks 6	+	18.61	3.94	-1.818	0.214

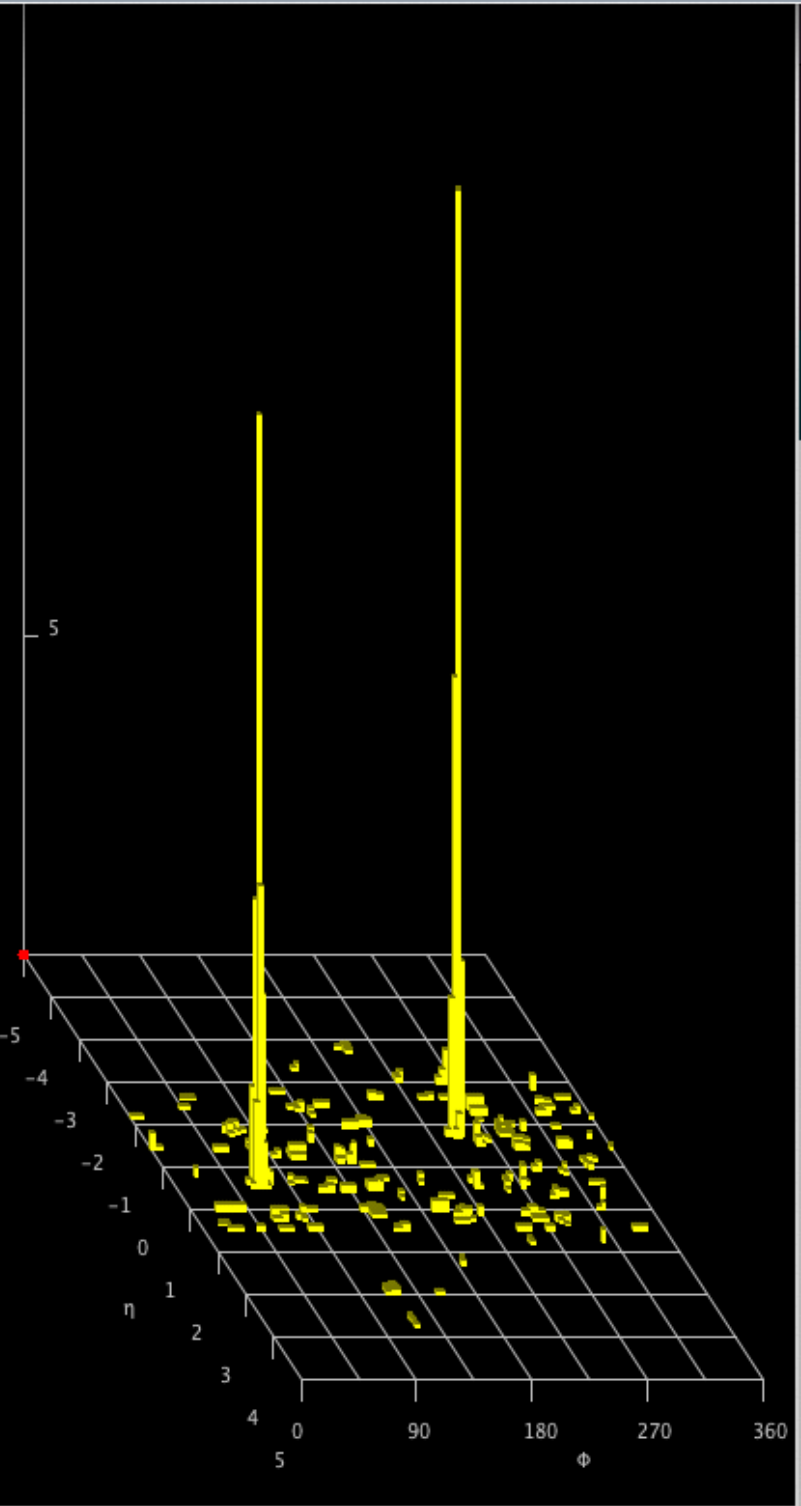
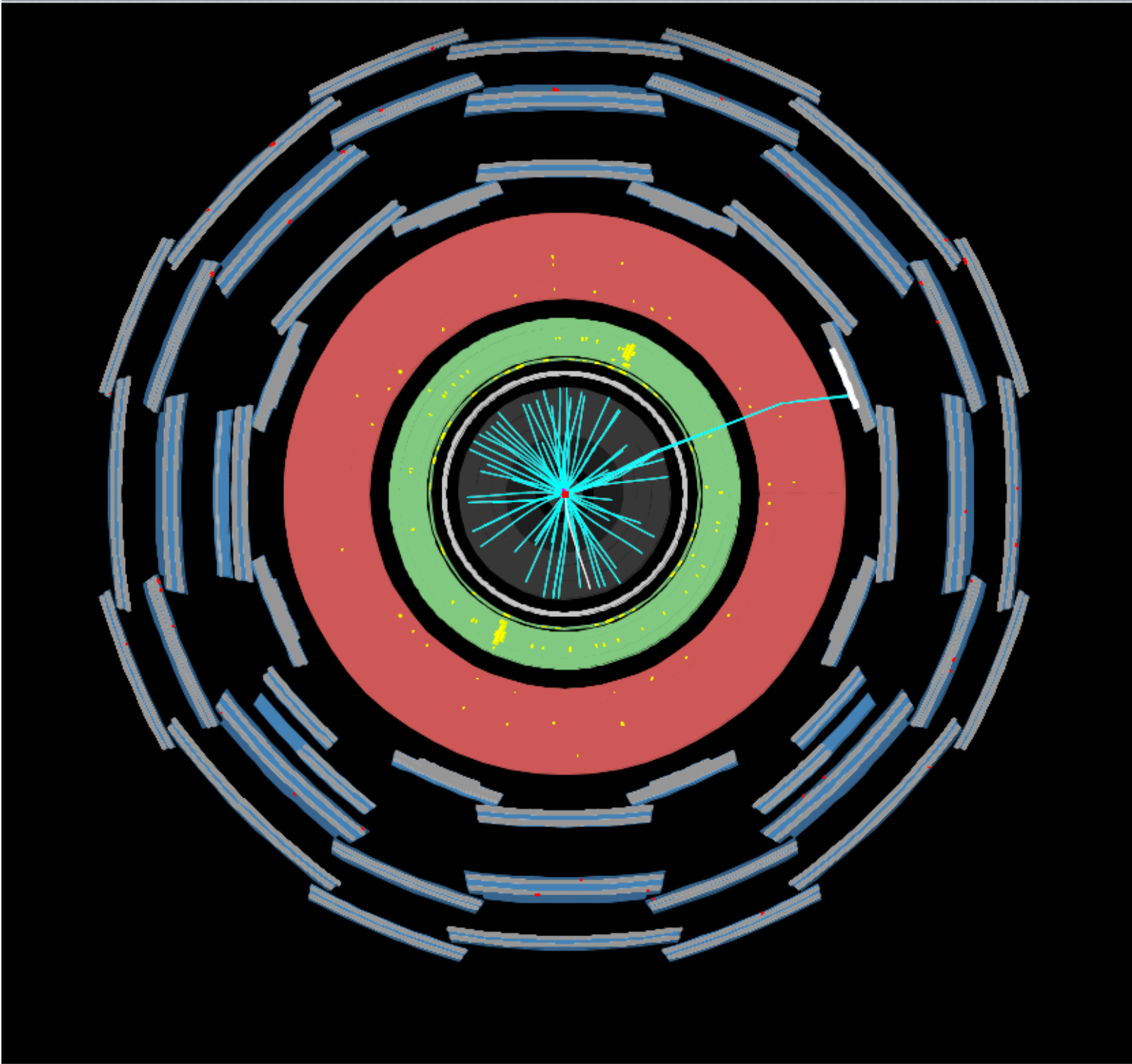
Hypathia navigation: Loading the data



HYPATIA Pupils Analysis tool for interactions in ATLAS - version 7.4 - Invariant mass window

e View Histograms Preferences Help

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	ϕ	η	M(2) [GeV]	M(eeee) [GeV]	M(eemm) [GeV]	M(mmmm) [GeV]	e/m/g
-----------	-------------	-------	---------	-----	----------	--------	--------	------------	---------------	---------------	---------------	-------

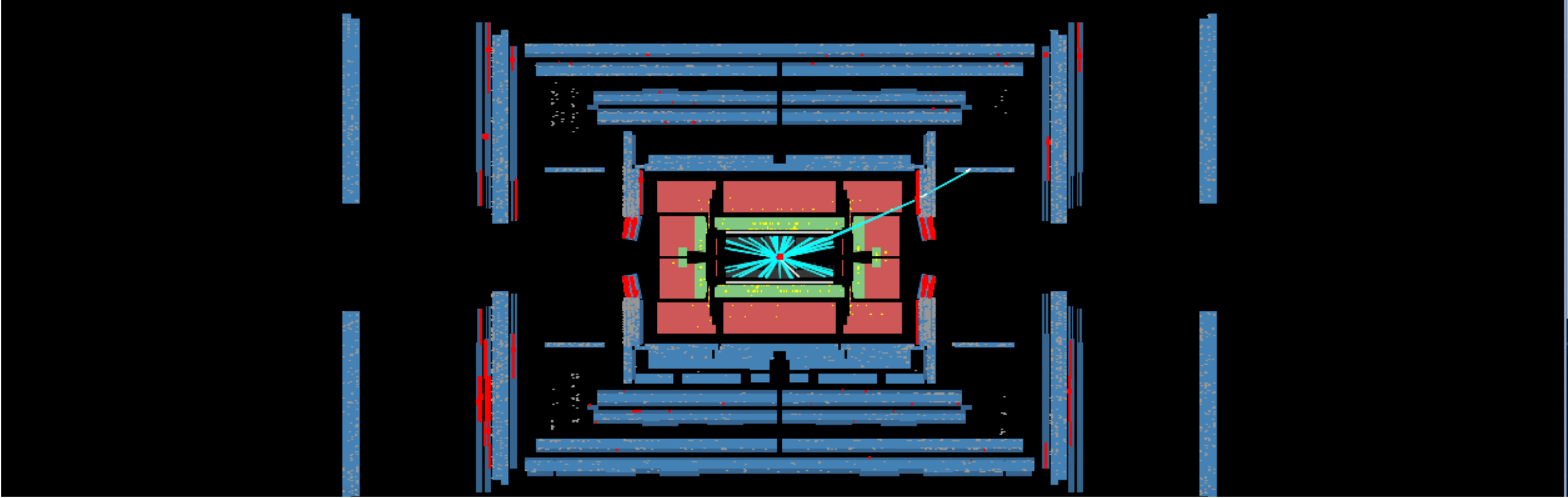


File Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

ETMis: 4.167 GeV ϕ : 3.040 rad Collection: MET_RefFinal

/Users/mihamuskinj/Downloads/groupA.zip/event001.xml

Tracks	Physics Objects				
Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 4	-	5.83	1.43	0.509	0.248
Tracks 7	-	3.40	1.06	-2.977	0.316
Tracks 8	+	47.07	37.95	-1.978	2.204
Tracks 10	-	2.34	1.28	2.093	0.580
Tracks 11	-	5.42	1.44	0.516	0.269
Tracks 12	-	2.96	1.20	-2.802	2.724
Tracks 13	-	8.30	1.47	2.483	2.964
Tracks 14	-	6.58	2.03	-1.081	0.313
Tracks 15	+	7.59	1.50	-1.220	2.943
Tracks 17	-	2.00	1.12	2.214	2.546
Tracks 21	+	2.65	1.91	-0.290	2.338
Tracks 25	+	6.27	1.30	2.975	0.209
Tracks 27	-	4.12	1.43	0.256	0.355
Tracks 28	-	1.92	1.65	2.064	1.039
Tracks 31	-	1.58	1.54	-1.098	1.367
Tracks 33	-	3.08	1.21	-1.953	0.406
Tracks 35	-	2.88	1.13	-2.993	0.404
Tracks 36	+	2.09	1.86	-1.513	1.094
Tracks 41	-	2.52	1.86	2.745	0.832
Tracks 42	+	1.29	1.22	1.668	1.247
Tracks 44	+	3.95	1.00	-2.840	0.256
Tracks 48	+	3.90	1.10	2.977	0.286
Tracks 49	-	2.86	1.09	0.165	0.391
Tracks 58	+	1.95	1.95	2.874	1.561
Tracks 63	-	8.03	1.87	-0.613	2.906
Tracks 67	-	1.02	1.01	-2.092	1.491
Tracks 68	+	1.68	1.64	1.815	1.768
Tracks 69	+	10.96	2.05	2.045	0.188
Tracks 75	+	1.84	1.55	-1.469	1.003
Tracks 77	+	6.43	1.99	1.824	2.828
Tracks 80	+	2.38	1.24	1.732	2.594
Tracks 81	+	2.45	2.24	0.300	1.996
Tracks 82	-	2.20	1.51	-1.508	0.758
Tracks 84	-	2.35	1.08	-0.928	2.664
Tracks 85	-	1.54	1.16	1.708	2.293
Tracks 87	+	2.42	1.62	-2.037	0.733
Tracks 88	-	4.49	2.01	3.045	2.678
Tracks 89	-	1.97	1.70	-1.199	1.037
Tracks 91	+	2.07	1.52	-2.857	2.314



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	

Adding cuts

Hypathia navigation: Adding cuts



HTD10 Pupils Analysis tool for interactions in ATLAS - version 7.4 - invariant mass window

e View Histograms Preferences Help

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	ϕ	η	M(2) [GeV]	M(eeee) [GeV]	M(eemm) [GeV]	M(mmmm) [GeV]	e/m/g
-----------	-------------	-------	---------	-----	----------	--------	--------	------------	---------------	---------------	---------------	-------

File Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

ETMis: 4.167 GeV ϕ : 3.040 rad Collection: MET_RefFinal

/Users/mihamuskinj/Downloads/groupA.zip/event001.xml

Tracks	Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 4	-	5.83	1.43	0.509	0.248	
Tracks 7	-	3.40	1.06	-2.977	0.316	
Tracks 8	+	47.07	37.95	-1.978	2.204	
Tracks 10	-	2.34	1.28	2.093	0.580	
Tracks 11	-	5.42	1.44	0.516	0.269	
Tracks 12	-	2.96	1.20	-2.802	2.724	
Tracks 13	-	8.30	1.47	2.483	2.964	
Tracks 14	-	6.58	2.03	-1.081	0.313	
Tracks 15	+	7.59	1.50	-1.220	2.943	
Tracks 17	-	2.00	1.12	2.214	2.546	
Tracks 21	+	2.65	1.91	-0.290	2.338	
Tracks 25	+	6.27	1.30	2.975	0.209	
Tracks 27	-	4.12	1.43	0.256	0.355	
Tracks 28	-	1.92	1.65	2.064	1.039	
Tracks 31	-	1.58	1.54	-1.098	1.367	
Tracks 33	-	3.08	1.21	-1.953	0.406	
Tracks 35	-	2.88	1.13	-2.993	0.404	
Tracks 36	+	2.09	1.86	-1.513	1.094	
Tracks 41	-	2.52	1.86	2.745	0.832	
Tracks 42	+	1.29	1.22	1.668	1.247	
Tracks 44	+	3.95	1.00	-2.840	0.256	
Tracks 48	+	3.90	1.10	2.977	0.286	
Tracks 49	-	2.86	1.09	0.165	0.391	
Tracks 58	+	1.95	1.95	2.874	1.561	
Tracks 63	-	8.03	1.87	-0.613	2.906	
Tracks 67	-	1.02	1.01	-2.092	1.491	
Tracks 68	+	1.68	1.64	1.815	1.768	
Tracks 69	+	10.96	2.05	2.045	0.188	
Tracks 75	+	1.84	1.55	-1.469	1.003	
Tracks 77	+	6.43	1.99	1.824	2.828	
Tracks 80	+	2.38	1.24	1.732	2.594	
Tracks 81	+	2.45	2.24	0.300	1.996	
Tracks 82	-	2.20	1.51	-1.508	0.758	
Tracks 84	-	2.35	1.08	-0.928	2.664	
Tracks 85	-	1.54	1.16	1.708	2.293	
Tracks 87	+	2.42	1.62	-2.037	0.733	
Tracks 88	-	4.49	2.01	3.045	2.678	
Tracks 89	-	1.97	1.70	-1.199	1.037	
Tracks 91	+	2.07	1.52	-2.857	2.314	

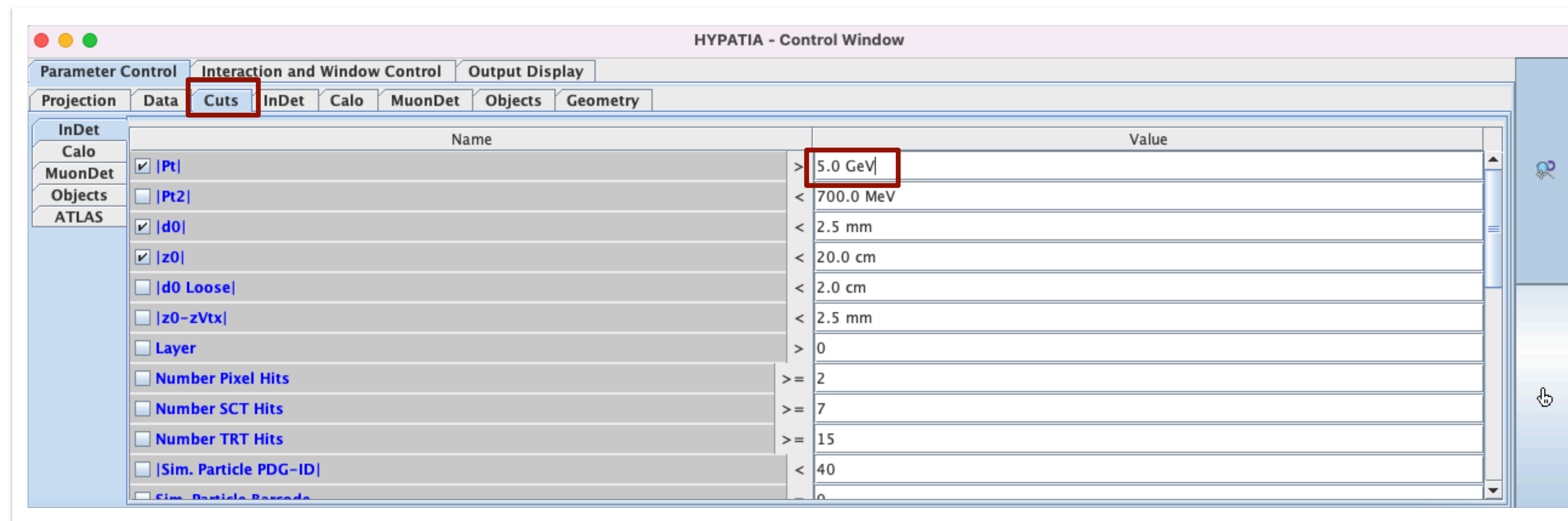
HYPATHIA - Control Window

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	

- Change the track p_T cut to 10 GeV to remove fake tracks...



Hypathia navigation: Adding cuts



HYBRID Pupils' Analysis tool for interactions in ATLAS - version 7.4 - invariant mass window

View Histograms Preferences Help

File Name ETMis [GeV] Track P [GeV] +/- Pt [GeV] φ η M(2) [GeV] M(eeee) [GeV] M(eemm) [GeV] M(mmmm) [GeV] e/m/g

File Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

ETMis: 4.167 GeV φ : 3.040 rad Collection: MET_RefFinal

/Users/mihamuskinj/Downloads/groupA.zip/event001.xml

Track	+/-	P [GeV]	Pt [GeV]	φ	θ
Tracks 8	+	47.07	37.95	-1.978	2.204
Tracks 173	-	36.59	32.59	1.132	1.098
Tracks 239	+	827.36	311.58	0.983	0.386
Tracks 243	+	37.38	20.42	1.010	0.578

charge p_T [GeV]

HYPATIA - Control Window

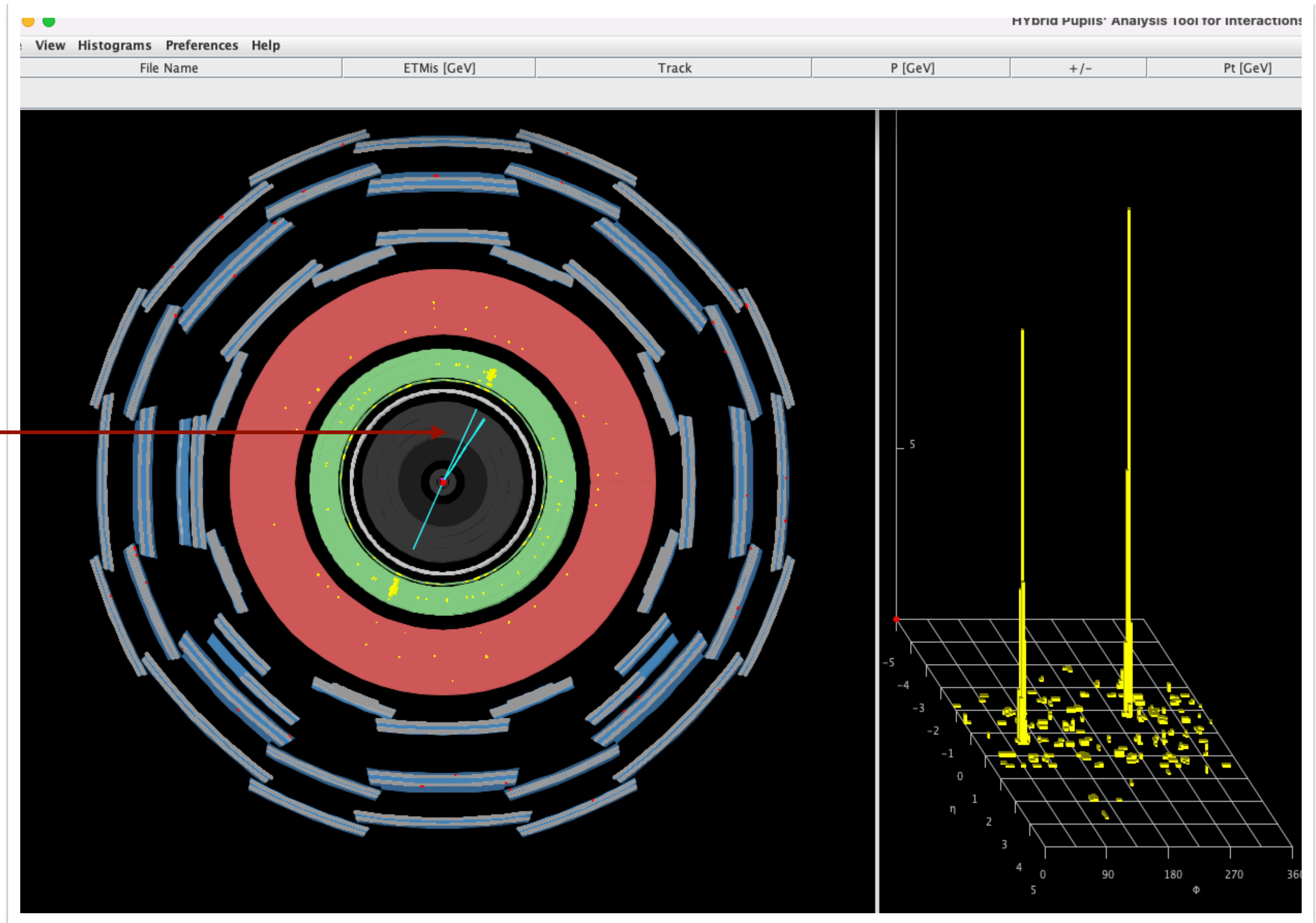
Parameter Control Interaction and Window Control Output Display

Projection Data Cuts InDet Calo MuonDet Objects Geometry

Name	Value
<input checked="" type="checkbox"/> Pt	> 5.0 GeV
<input type="checkbox"/> Pt2	< 700.0 MeV
<input checked="" type="checkbox"/> d0	< 2.5 mm
<input checked="" type="checkbox"/> z0	< 20.0 cm
<input type="checkbox"/> d0 Loose	< 2.0 cm
<input type="checkbox"/> z0-zVtx	< 2.5 mm
<input type="checkbox"/> Layer	> 0
<input type="checkbox"/> Number Pixel Hits	>= 2
<input type="checkbox"/> Number SCT Hits	>= 7
<input type="checkbox"/> Number TRT Hits	>= 15
<input type="checkbox"/> Sim. Particle PDG-ID	< 40
<input type="checkbox"/> Sim. Particle Name	< 0

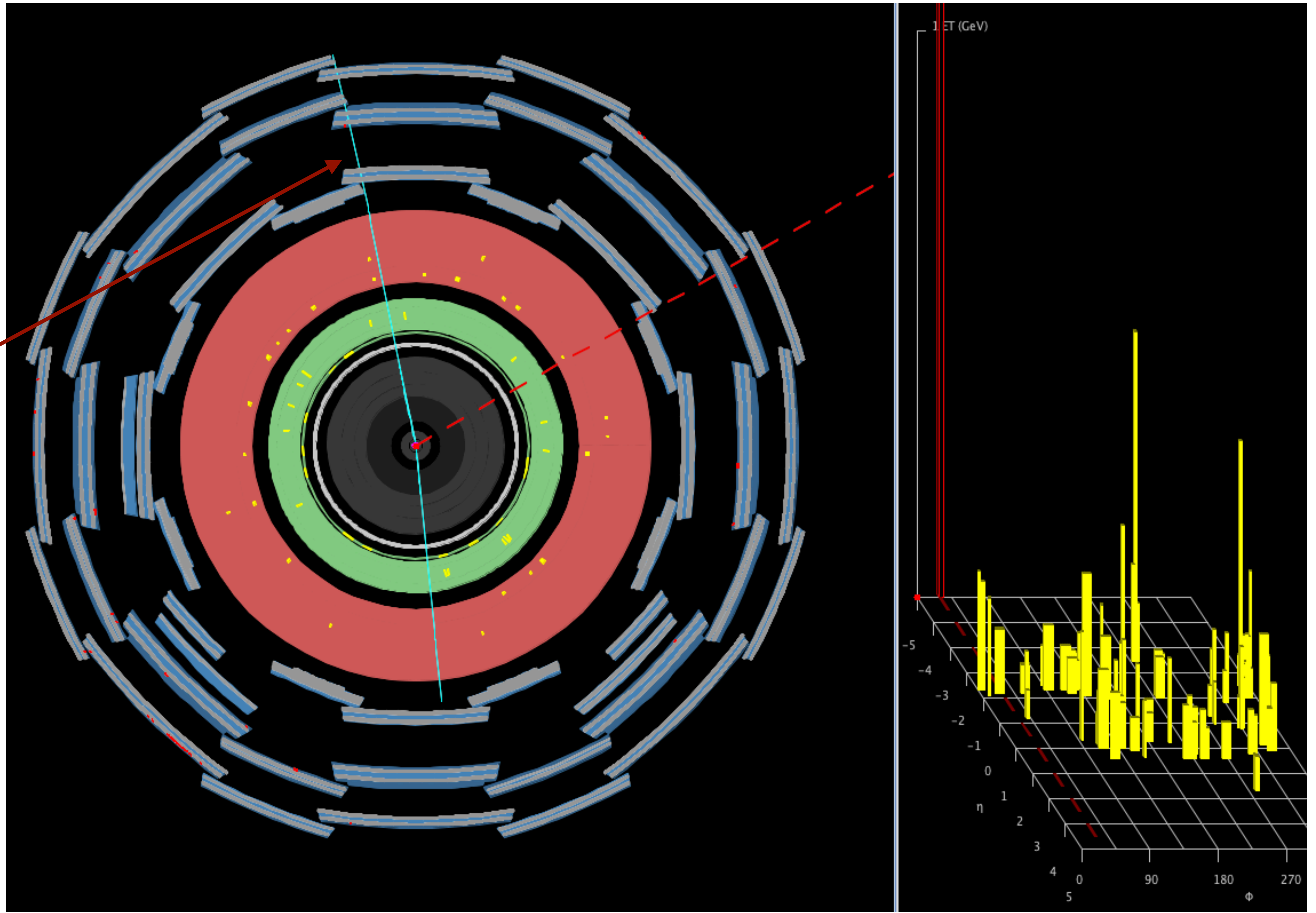
Particle identification

Electron:
- ID track
- Calo deposit

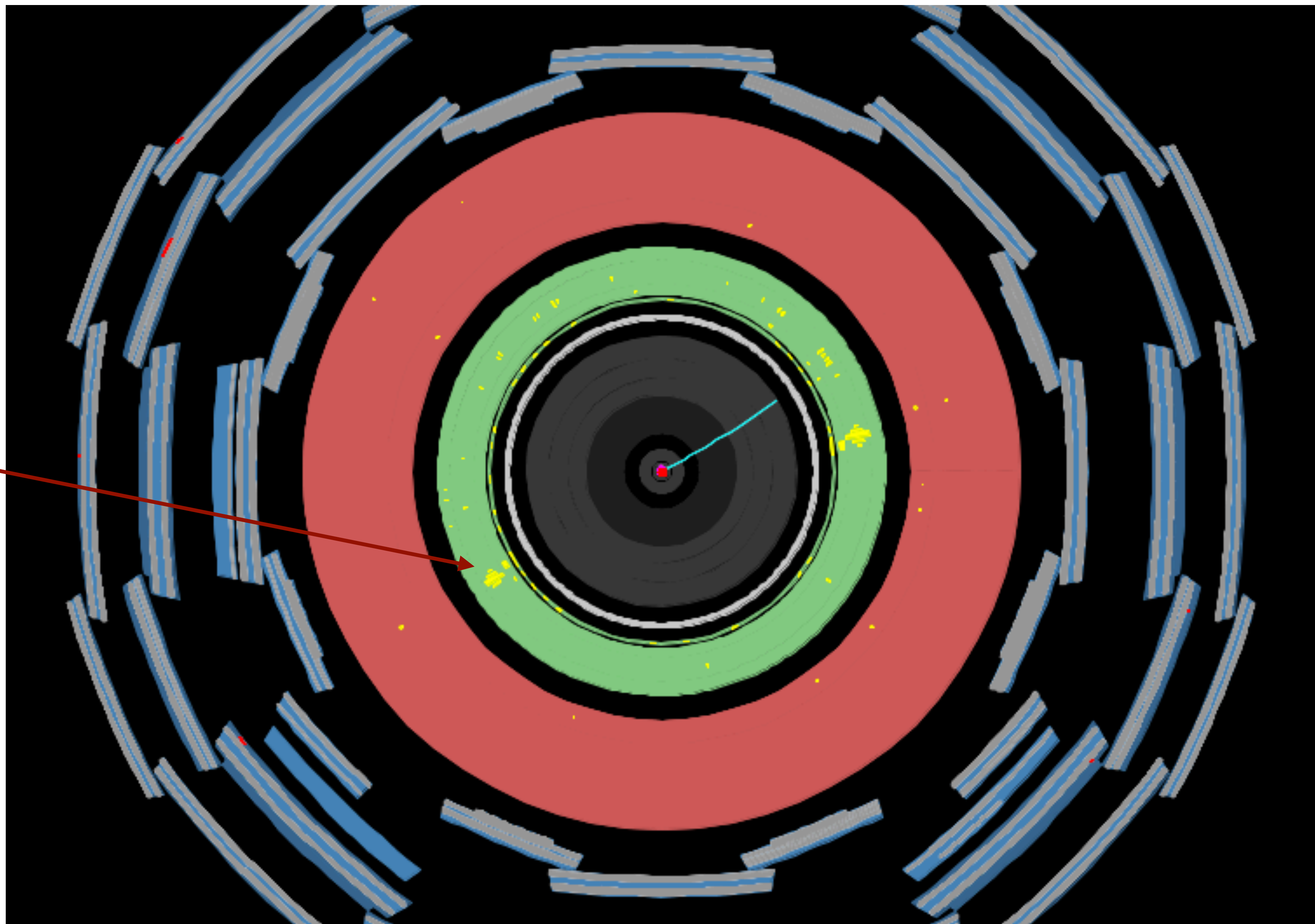


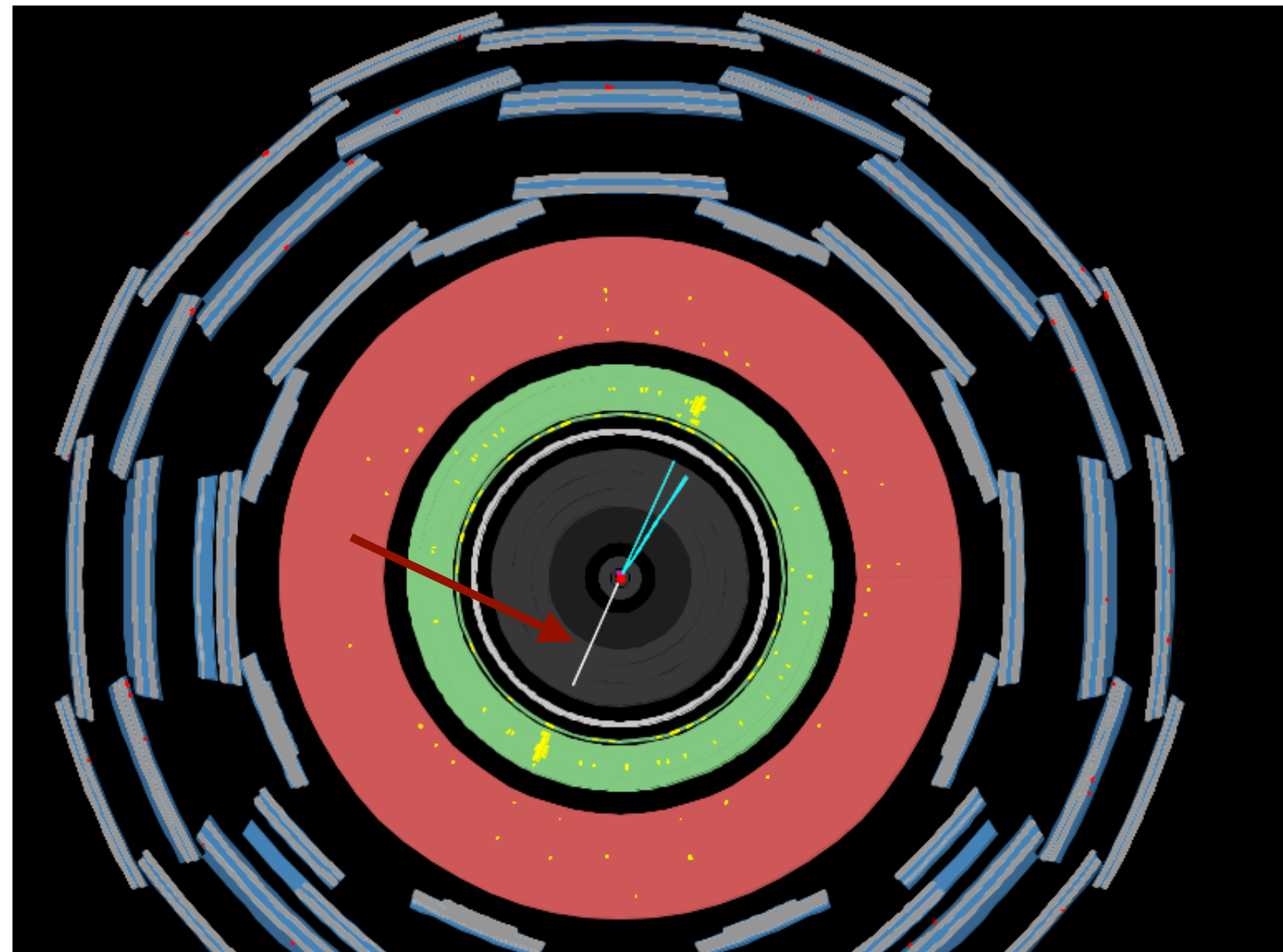


Muon:
- MS track



Photon:
- Calo deposit
- No ID track





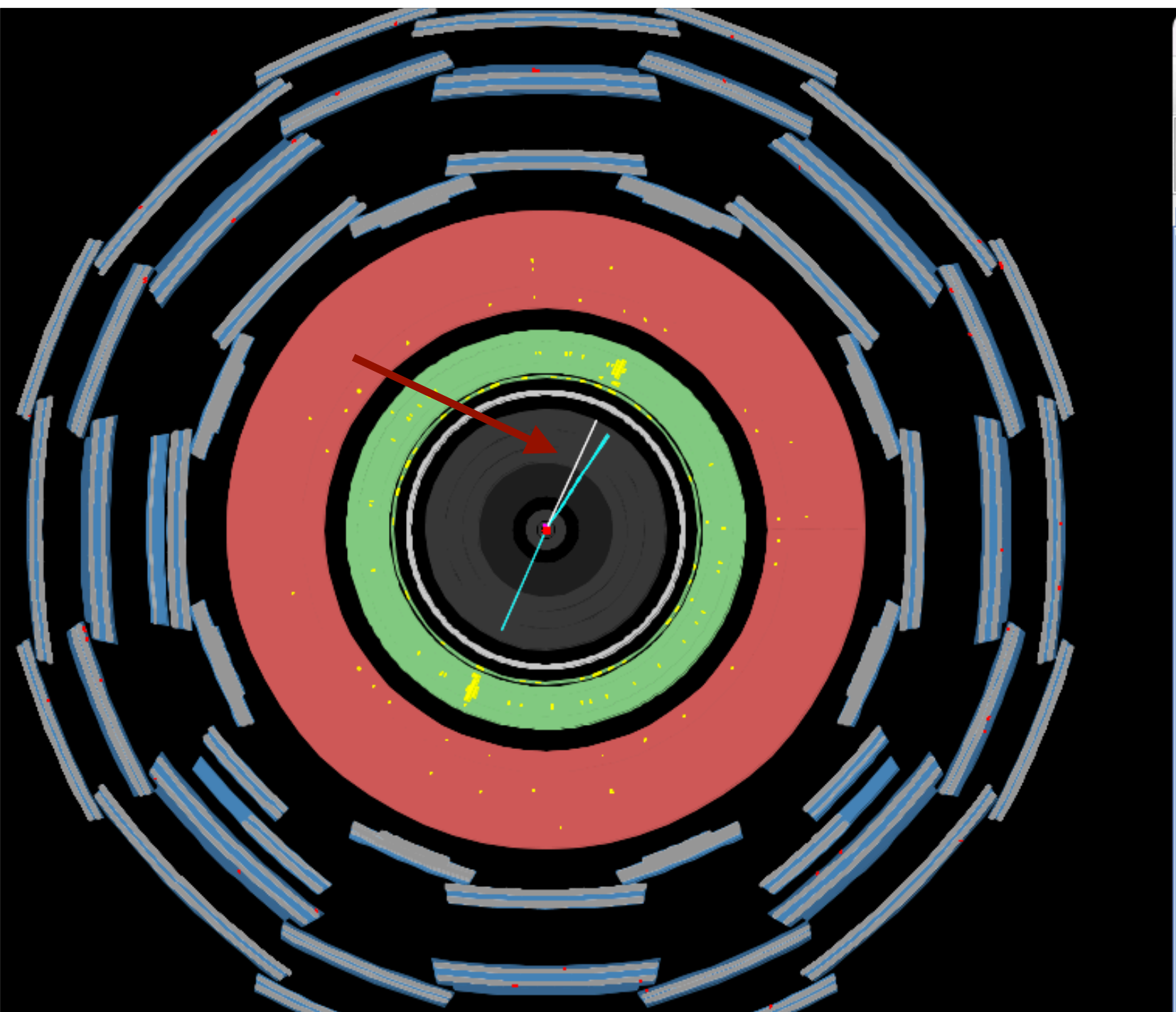
HYPATIA - Track Momenta Window

File Previous Event Next Event **Electron** Muon Photon Delete Track Reset Canvas

ETMis: 4.167 GeV φ : 3.040 rad Collection: MET_Reffinal

/Users/mihamuskinj/Downloads/groupA.zip/event001.xml

Track	+/-	P [GeV]	Pt [GeV]
Tracks 8	+	47.07	37.95
Tracks 173	-	36.59	32.59
Tracks 239	+	827.36	311.58
Tracks 243	+	37.38	20.42



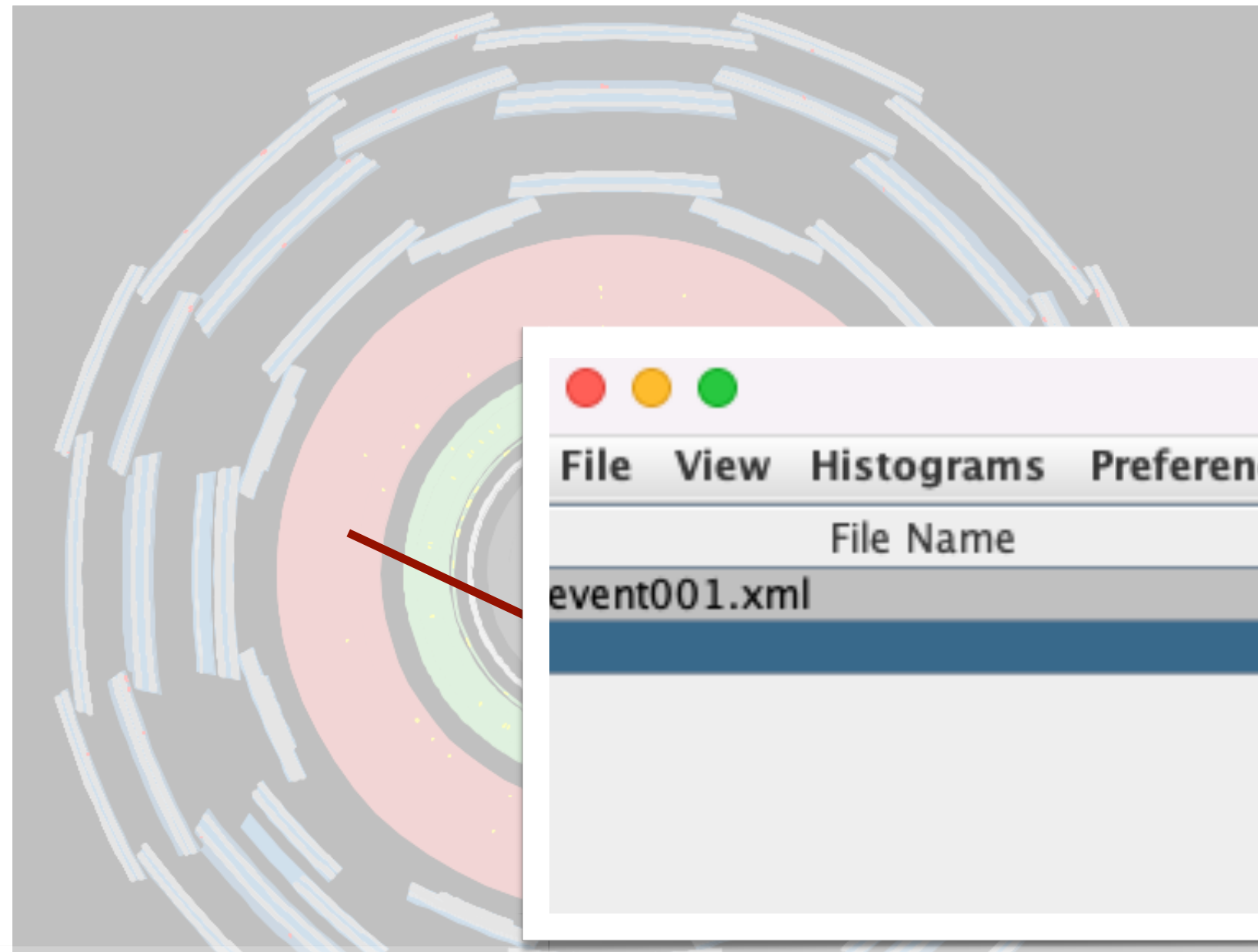
HYPATIA - Track Momenta Window

File Previous Event Next Event **Electron** Muon Photon Delete Track Reset Canvas

ETMis: 4.167 GeV φ : 3.040 rad Collection: MET_Reffinal

/Users/mihamuskinj/Downloads/groupA.zip/event001.xml

Track	+/-	P [GeV]	Pt [GeV]
Tracks 8	+	47.07	37.95
Tracks 173	-	36.59	32.59
Tracks 239	+	827.36	311.58
Tracks 243	+	37.38	20.42



HYPATIA - Track Momenta Window

File Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

ETMis: 4.167 GeV φ : 3.040 rad Collection: MET_RefFinal

/Users/mihamuskinj/Downloads/groupA.zip/event001.xml

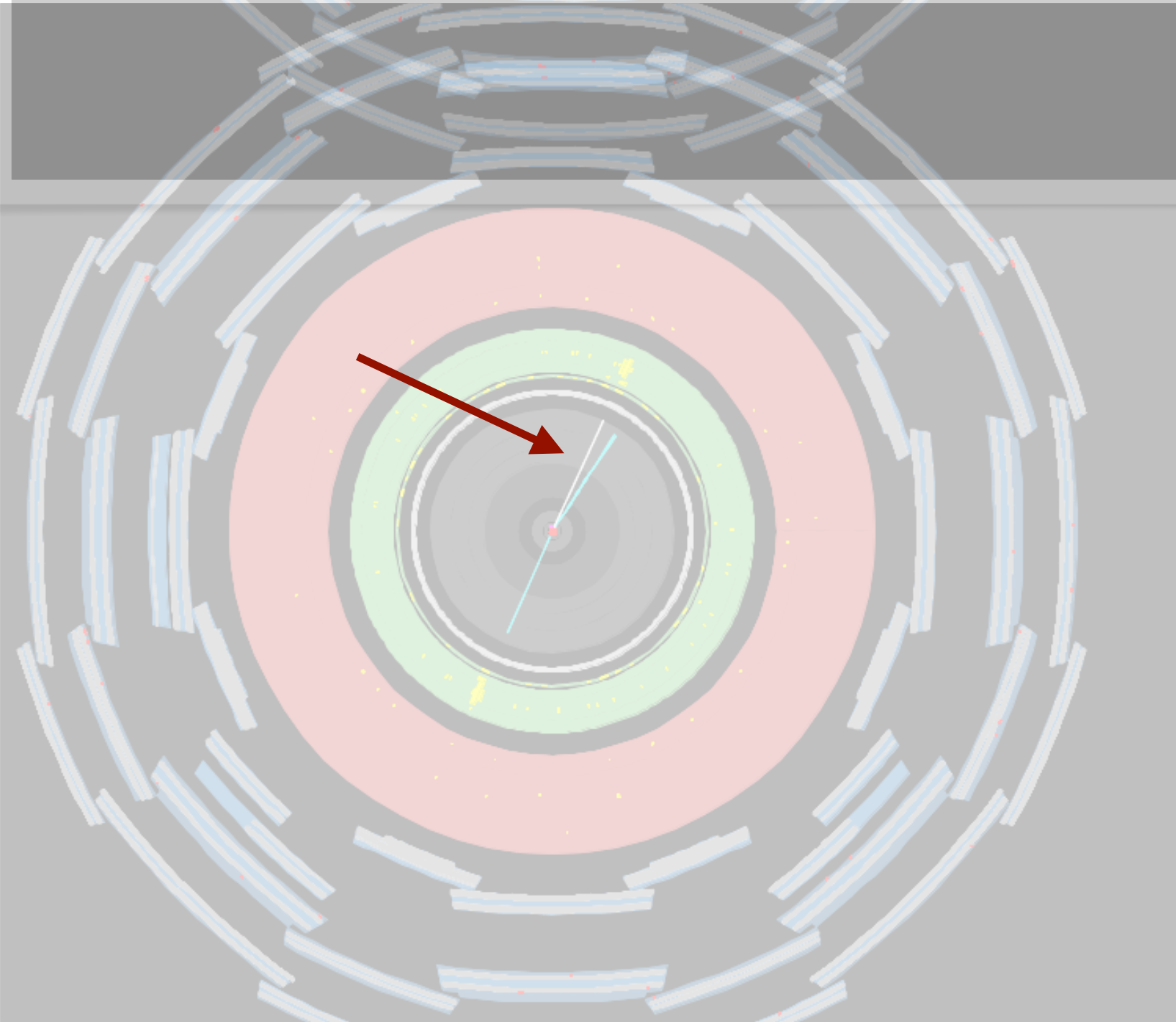
Track	+/-	P [GeV]	Pt [GeV]
Tracks 8	+	47.07	37.95

HYbrid Pupils' Analysis Tool for Interactions in ATLAS - version 7.4 - Invariant Mass Window

File View Histograms Preferences Help

File Name	ETMis [GeV]	Track	P [GeV]	+...	Pt [GeV]	φ	η	M(2) [GeV]
event001.xml	4.167	Tracks 8	47.1	+	37.9	-1.978	-0.680	82.729
		Tracks 173	36.6	-	32.6	1.132	0.491	

Probably $Z \rightarrow e^+ e^-$



HYPATIA - Track Momenta Window

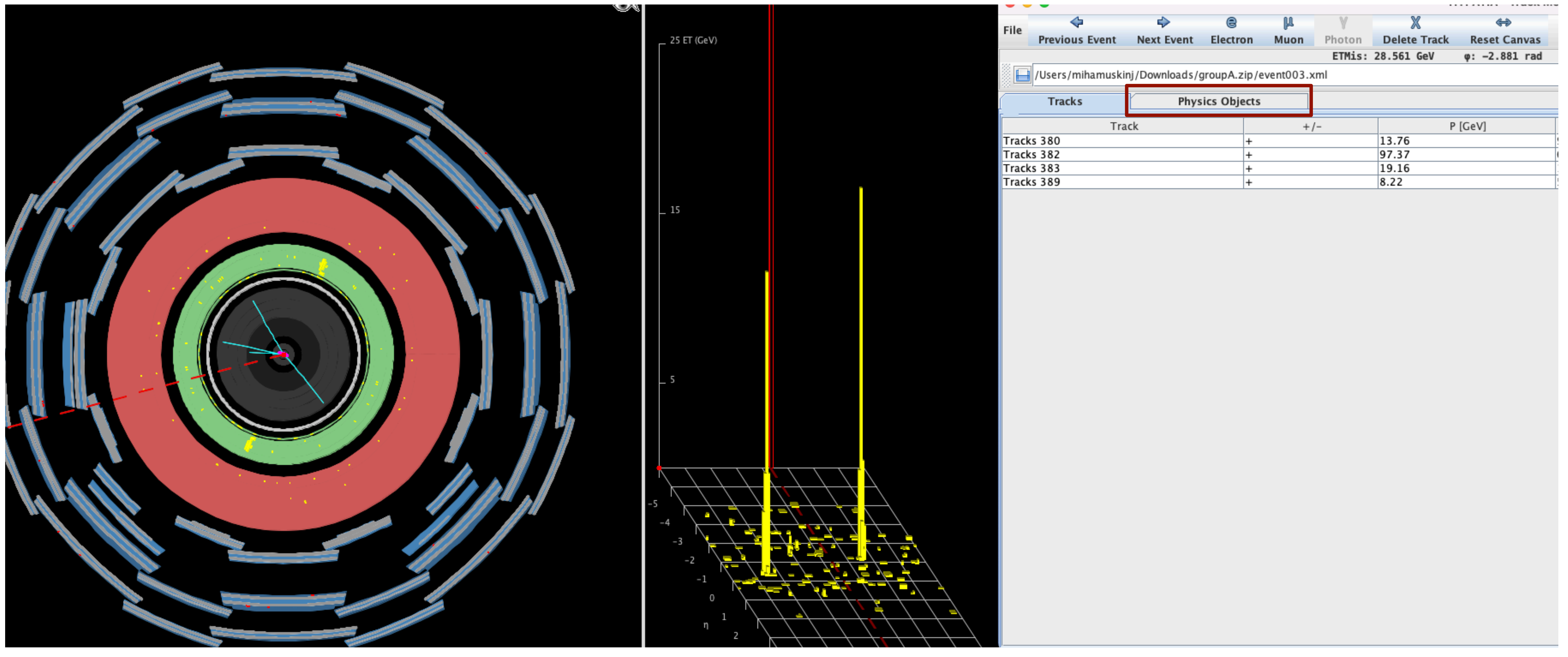
File Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

ETMis: 4.167 GeV φ : 3.040 rad Collection: MET_RefFinal

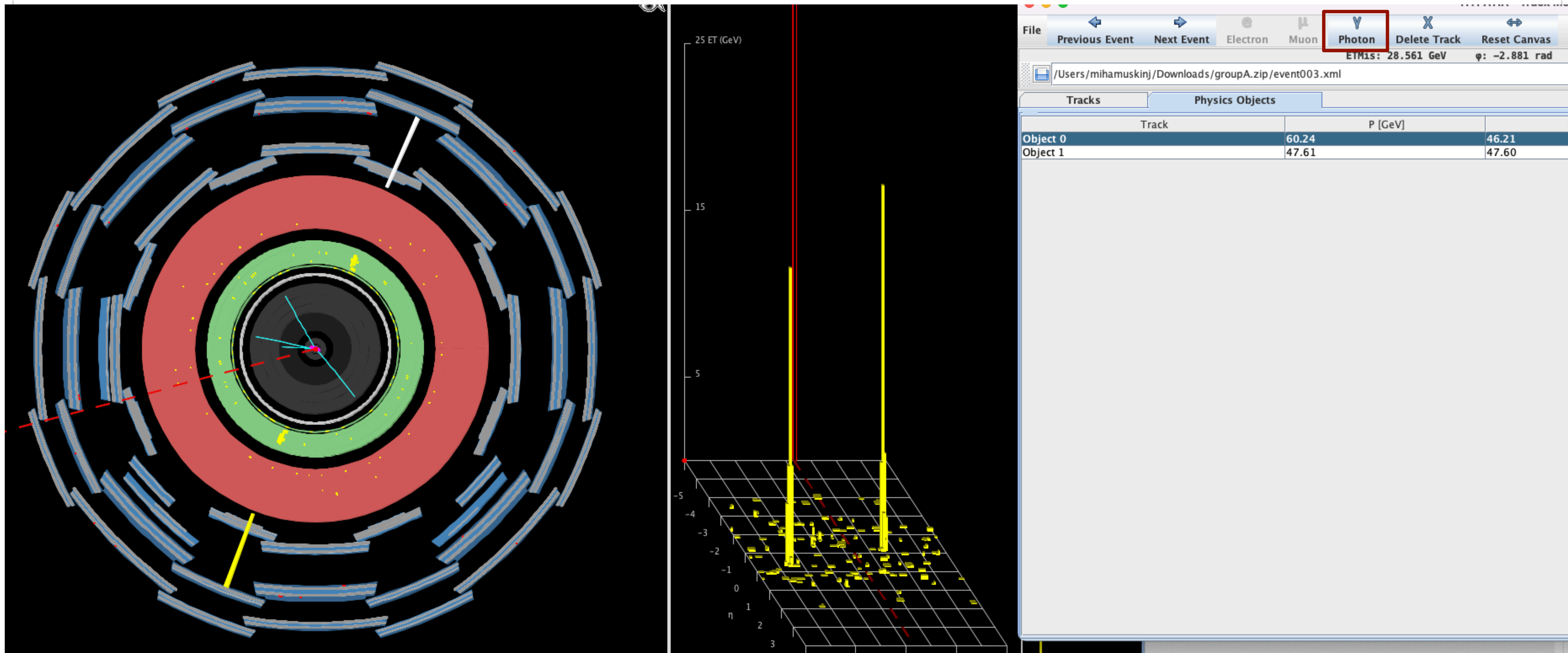
/Users/mihamuskinj/Downloads/groupA.zip/event001.xml

Track	+/-	P [GeV]	Pt [GeV]
Tracks 8	+	47.07	37.95
Tracks 173	-	36.59	32.59
Tracks 239	+	827.36	311.58
Tracks 243	+	37.38	20.42

- For photons, need to click on the “**Physics Objects**” tab.



- For photons, need to click on the “**Physics Objects**” tab,
- Now select them...



- For photons, need to click on the “**Physics Objects**” tab,
- Now select them...

HYbrid Pupils' Analysis Tool for Interactions in ATLAS - version 7.4 - Invariant Mass Window

File Name	ETMis [GeV]	Track	P [GeV]	+...	Pt [GeV]	φ	η	M(2) [GeV]
event001.xml	4.167	Tracks 8	47.1	+	37.9	-1.978	-0.680	82.729
		Tracks 173	36.6	-	32.6	1.132	0.491	
event003.xml	28.561	Object 0	60.2		46.2	1.154	0.761	100.334
		Object 1	47.6		47.6	-1.931	0.017	

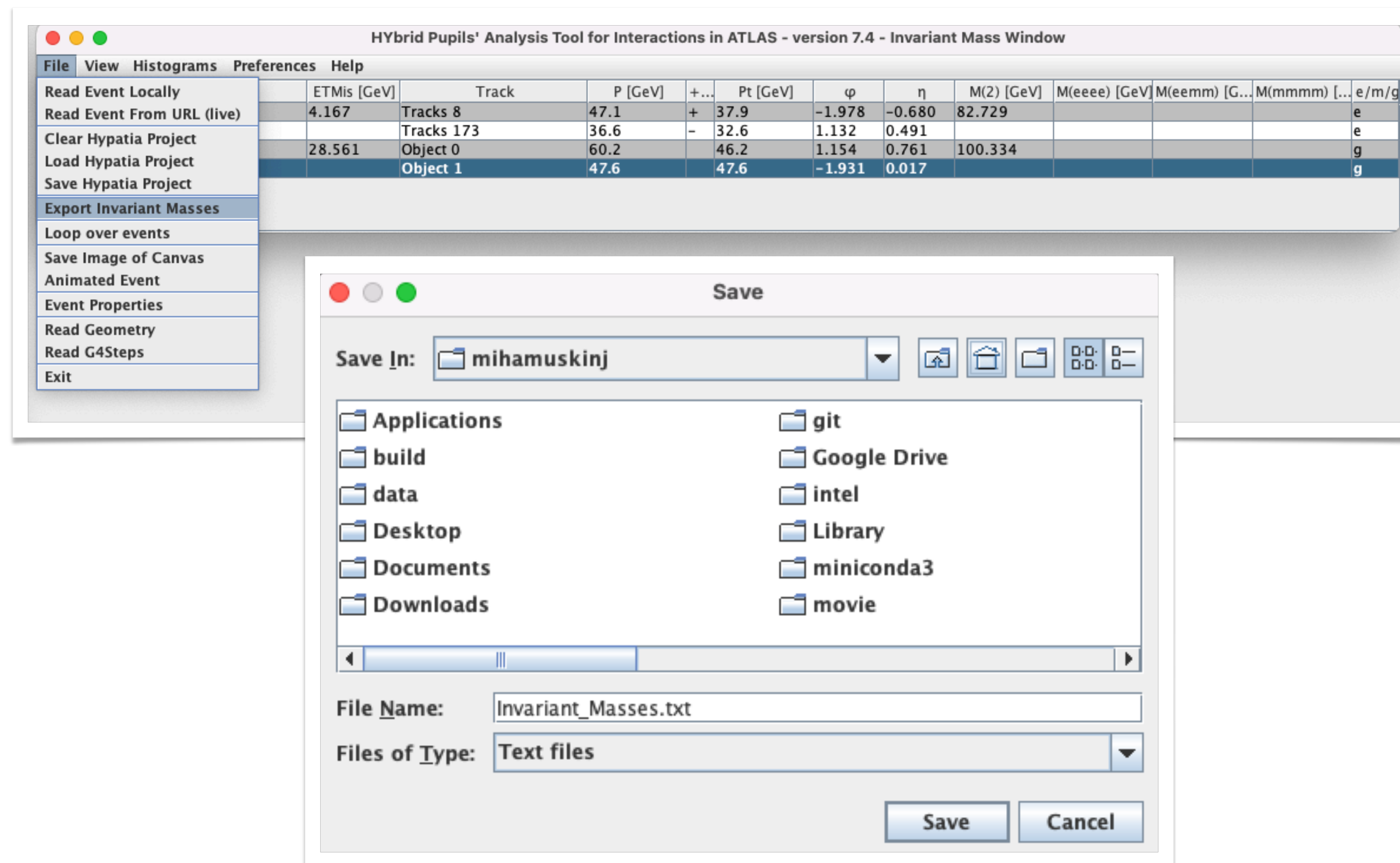
Probably $H \rightarrow \gamma\gamma$

Exporting data

- The data will be uploaded to a webpage and merged with the data from other students,
- Invariant mass plots will be created automatically,
- Later merged also with other groups doing the event at the same time.

	ETMis [GeV]	Track	P [GeV]	+...	Pt [GeV]	ϕ	η	M(2) [GeV]	M(eeee) [GeV]	M(eemm) [GeV]	M(mmmm) [GeV]	e/m/g
Read Event Locally	4.167	Tracks 8	47.1	+	37.9	-1.978	-0.680	82.729				e
Read Event From URL (live)		Tracks 173	36.6	-	32.6	1.132	0.491					e
Clear Hypatia Project	28.561	Object 0	60.2		46.2	1.154	0.761	100.334				g
Load Hypatia Project		Object 1	47.6		47.6	-1.931	0.017					g
Save Hypatia Project												
Export Invariant Masses												
Loop over events												
Save Image of Canvas												
Animated Event												
Event Properties												
Read Geometry												
Read G4Steps												
Exit												

- The data will be uploaded to a webpage and merged with the data from other students,
- Invariant mass plots will be created automatically,
- Later merged also with other groups doing the event at the same time.




- Navigate to: <https://cernmasterclass.uio.no/OPlot-US/OPlot/index.php>,
- Upload the data:

OPlot – MasterClass – Start Page

Start **Student** Moderator Tutor Administrator

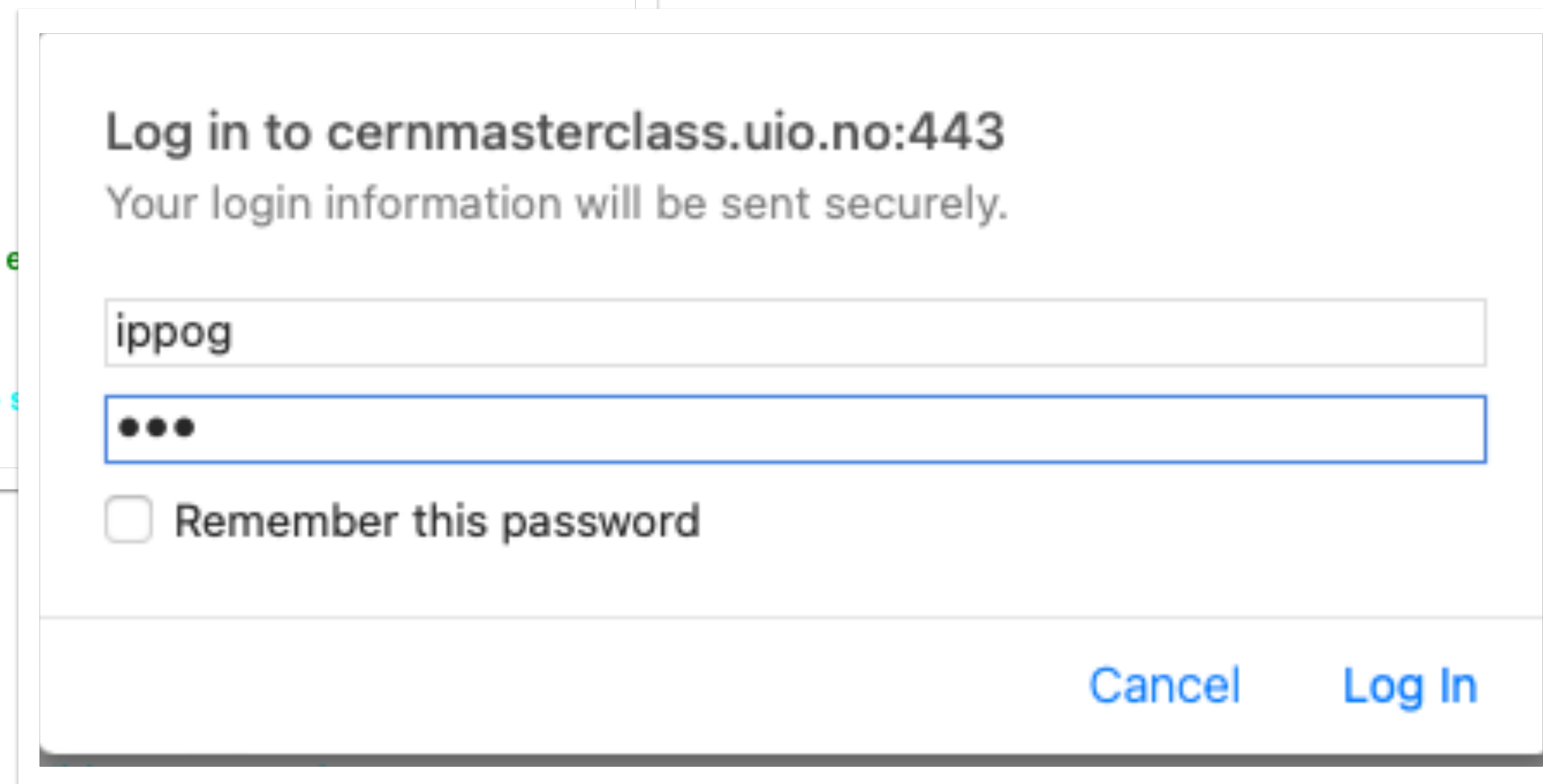
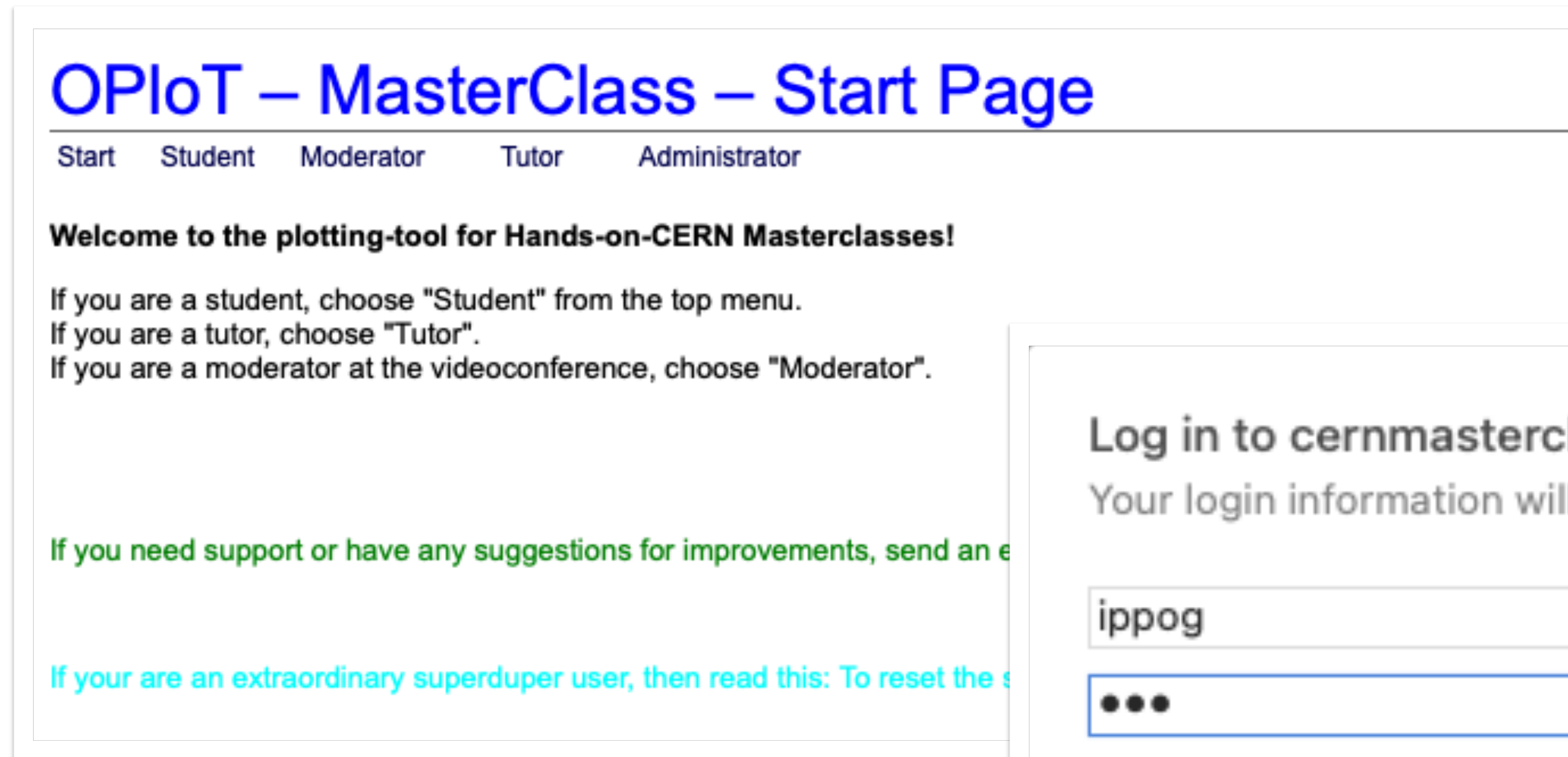
Welcome to the plotting-tool for Hands-on-CERN Masterclasses!

If you are a student, choose "Student" from the top menu.
If you are a tutor, choose "Tutor".
If you are a moderator at the videoconference, choose "Moderator".

If you need support or have any suggestions for improvements, send an email to [epf-mc\(at\)fys.uio.no](mailto:epf-mc(at)fys.uio.no) 

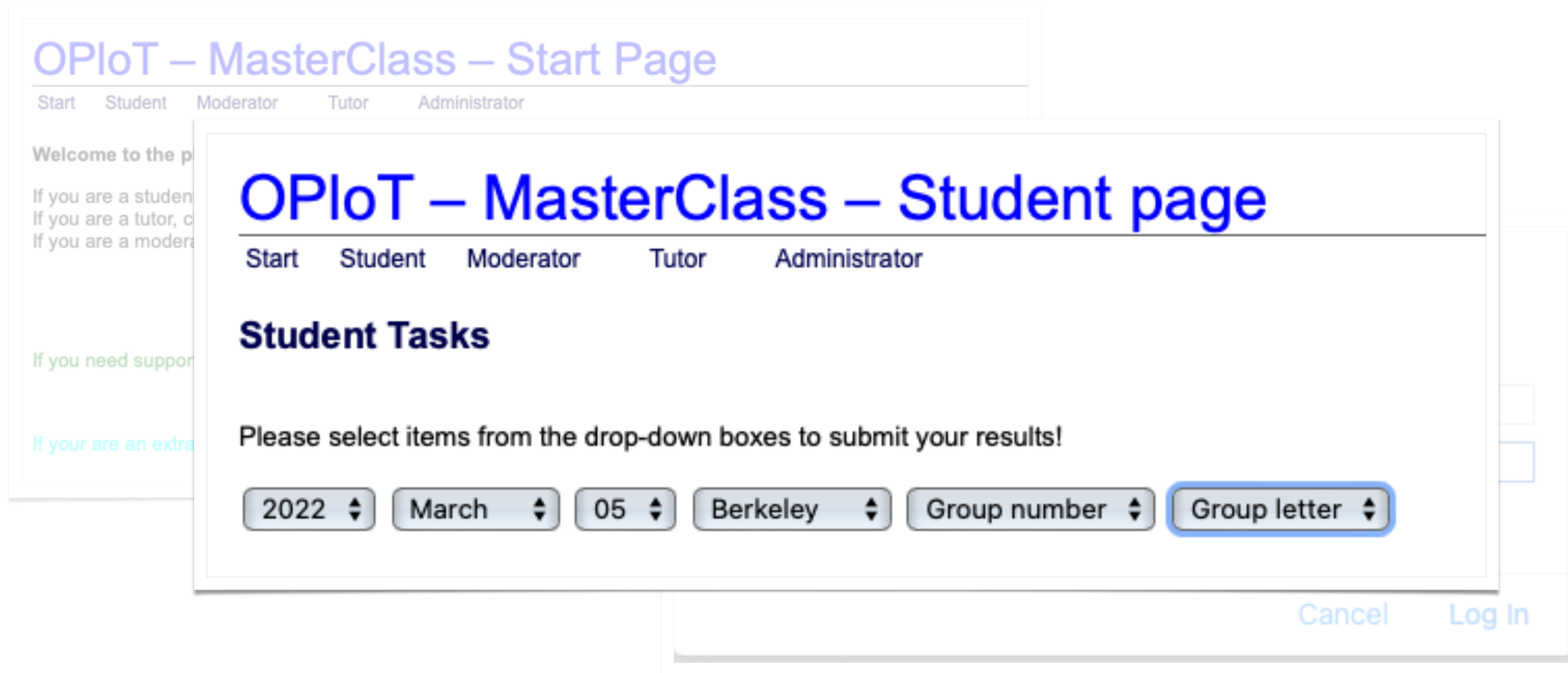
If you are an extraordinary superduper user, then read this: [To reset the session, visit this page again.](#)

- Navigate to: <https://cernmasterclass.uio.no/OPIoT-US/OPIoT/index.php>,
- Upload the data:



Account: ippog
Password: imc

- Navigate to: <https://cernmasterclass.uio.no/OPIoT-US/OPIoT/index.php>,
- Upload the data:



The screenshot shows the 'OPIoT – MasterClass – Student page'. At the top, there is a navigation menu with links for 'Start', 'Student', 'Moderator', 'Tutor', and 'Administrator'. Below the menu, the page title is 'OPIoT – MasterClass – Student page'. Underneath, there is a section titled 'Student Tasks' with the instruction: 'Please select items from the drop-down boxes to submit your results!'. The form contains five drop-down menus: '2022', 'March', '05', 'Berkeley', and 'Group number'. The 'Group letter' drop-down menu is highlighted with a blue border. At the bottom right of the form, there are two buttons: 'Cancel' and 'Log In'.

- For reference:

11:00 → 12:00 **Hands-on part: Data Analysis** 🕒 1h ✎

You and your group, along with your mentors, will solve a task using LHC data

[🔗 Cheat Sheet](#) [🔗 Particle Identificati...](#)

GET STARTED ON THE WEB WITH HYPATIA AND OPlOT

You will now analyze up to 50 particle collisions (events) by using the visualization application HYPATIA.

From these collisions, you shall try to find the footprints from heavy neutral particles, like for instance the Z-boson or the Higgs boson.

All you need can be found at

http://atlas.physicsmasterclasses.org/en/zpath_measurement.htm (replace /en/ with your language)

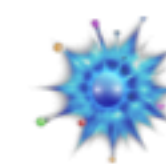
This is:

1. The HYPATIA application and instructions
2. Your unique dataset - ask your tutor if you need help
3. The web plotting tool OPlOT: <http://cernmasterclass.uio.no/OPlOT/>
 - username: ippog
 - password: imc

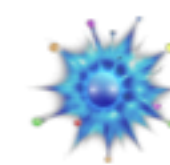
Do the following:

Go to the Z-Path: http://atlas.physicsmasterclasses.org/en/zpath_measurement.htm

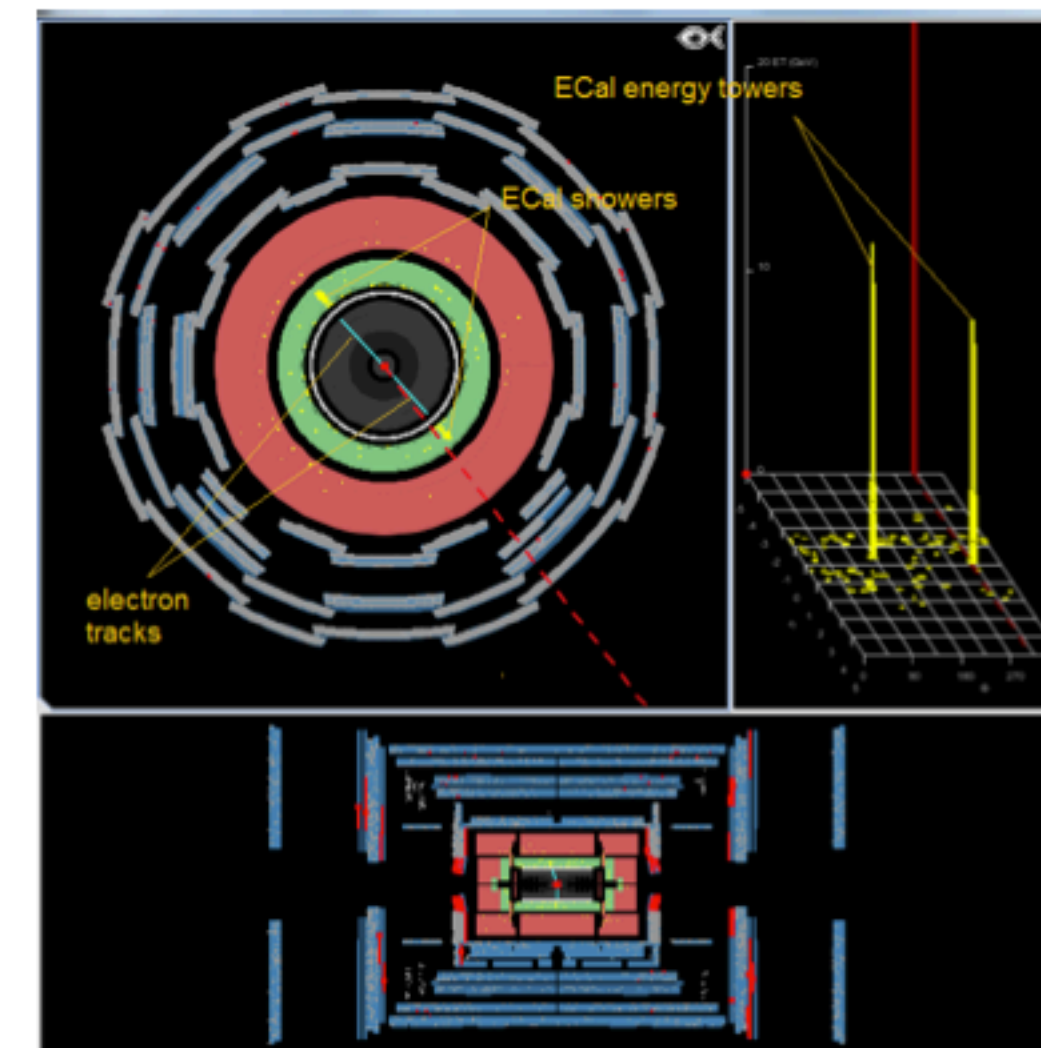
1. Instructions of what to do can be found under the sub-menu items of "Get to work":
 - Get to work→Data samples and tools
 - Get to work→Do it!
 - Get to work→Analyze your result (together with rest of students and tutors)
2. Find and download your data sample - follow instructions found at "Data samples and tools".
 - To start HYPATIA
 - On a Windows or Mac:
 - Double-click the file Hypatia_7.4_Masterclass.jar
 - On Linux:
 - Right-click the file: HYPATIA_for_Linux.sh
 - Change the permissions to make it executable
 - Double-click the HYPATIA_for_Linux.sh file
 - Unzip data sample
 - Load events in HYPATIA with File→Read Events Locally - Navigate to your downloaded and unzipped data sample



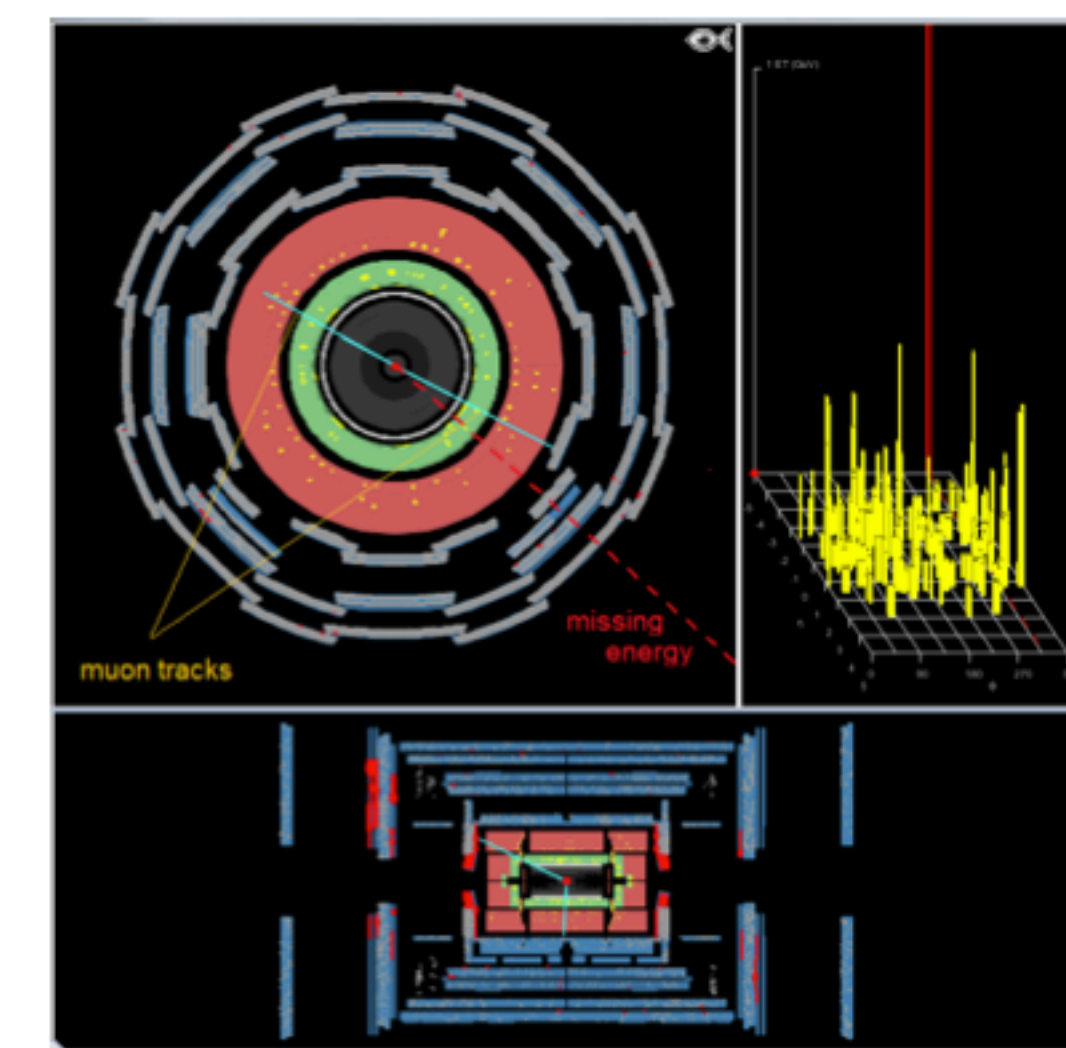
ATLAS Z-path Masterclass "Cheat Sheet"



2-lepton events



Dielectron or e^+e^- event.



Dimuon or $\mu^+\mu^-$ event.

Backup

