

ATLAS Masterclass

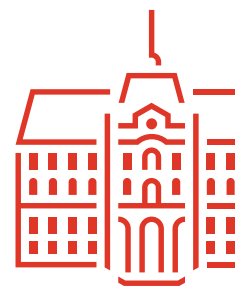
Data Analysis Techniques

Miha Muškinja

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ATLAS Masterclass

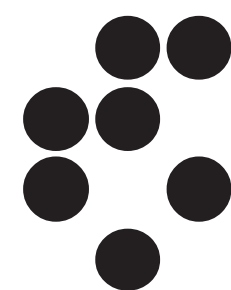
Tuesday, March 5, 2024



UNIVERSITY
OF LJUBLJANA

FMF

Faculty of Mathematics
and Physics



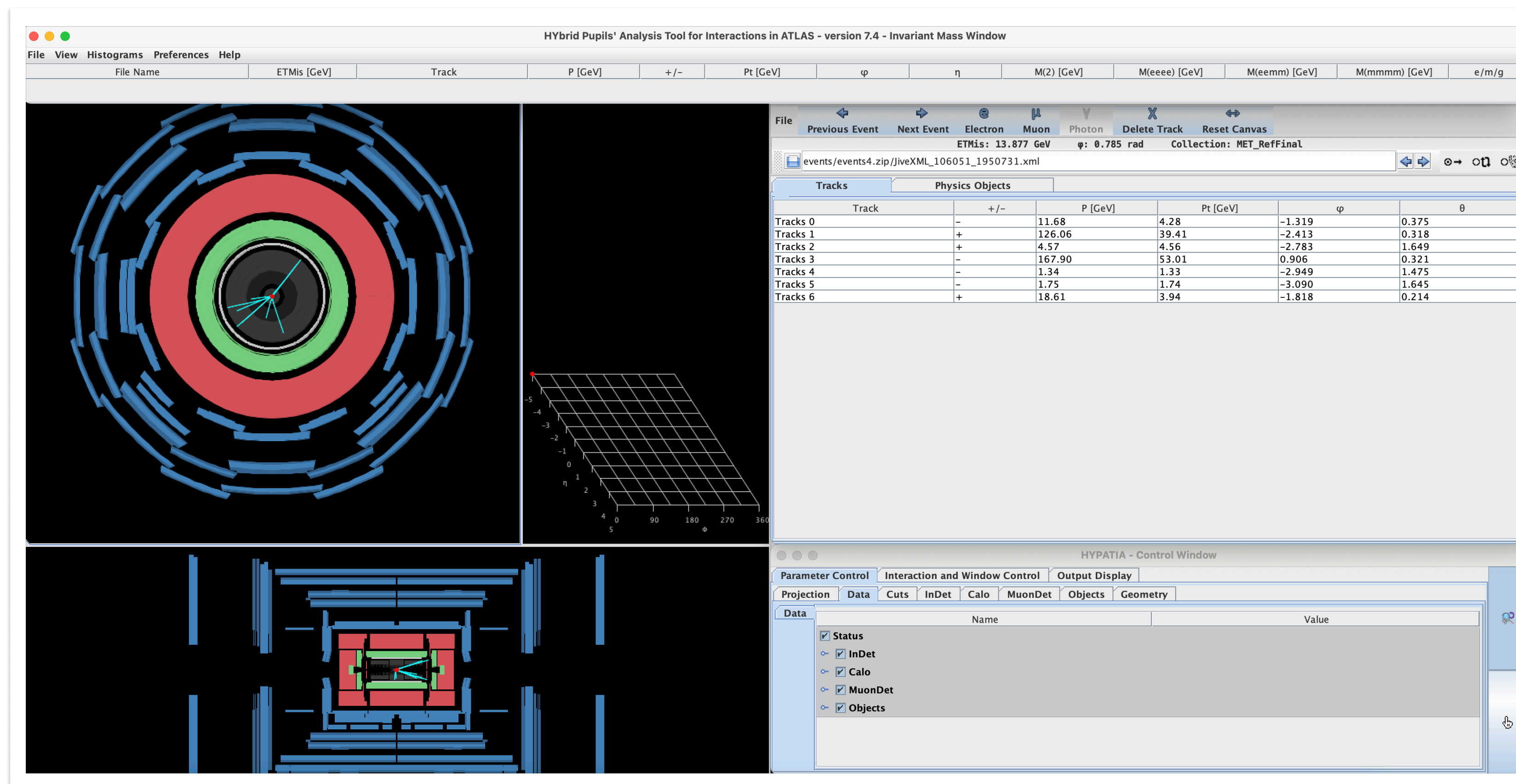
Jožef Stefan Institute, Ljubljana, Slovenia





- **Uporabniško ime:** Tecaj01 - Tecaj15
- **Geslo:** Trikotnik.8642

- Naložite program “Hypathia7” preko enega izmed spodnjih linkov:
 - physicsmasterclasses.org/downloads/Hypatia_7.4_Masterclass.zip
 - www-f9.ijs.si/~miham/imc
- Datoteko razpakirajte (recimo na namizje) in poženite program:
 - Hypatia_7.4_Masterclass.jar



- Navigirajte na spletno stran:
 - <https://cernmasterclass.uio.no/datasets/>

Date	Inst/Datasets								
09.02 (IDWGS)	Valencia IFIC	1	2						
15.02	Lecce	1	2						
16.02	Naples	1	2						
17.02	Konya	1	2						
20.02	Braganca	1	2						
21.02	Nitra	1	2						
23.02	Innsbruck	1	2						
26.02	Nairobi	1	2						
27.02	Linz	1	2						
28.02	Lund	1	2						
29.02	Siegen	1	2						
04.03	Krzeszowice	11	12	13					
05.03	Ljubljana	1	2						

Name	Last modified
Parent Directory	
groupA.zip	Tecaj01
groupB.zip	Tecaj02
groupC.zip	Tecaj03
groupD.zip	Tecaj04
groupE.zip	Tecaj05
groupF.zip	Tecaj06
groupG.zip	Tecaj07
groupH.zip	Tecaj08
groupI.zip	Tecaj09
groupJ.zip	Tecaj10
groupK.zip	Tecaj11
groupL.zip	Tecaj12
groupM.zip	Tecaj13
groupN.zip	Tecaj14
groupO.zip	Tecaj15
groupP.zip	
groupQ.zip	
groupR.zip	
groupS.zip	
groupT.zip	

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, the current event information is displayed: ETMis: 13.877 GeV, φ : 0.785 rad, and Collection: MET_RefFinal. The file path is shown as events/events4.zip/JiveXML_106051_1950731.xml. Below the file path, there is a button labeled "Open local file" and a tab labeled "Physics Objects". 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 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 main window shows a table of track data with columns for Track, +/-, P [GeV], Pt [GeV], ϕ , and θ . A red box highlights the 'Open local file' button, and a red arrow points from it to an 'Open' dialog box. The dialog box shows the 'Downloads' folder containing several files and folders, with 'groupA.zip' selected. The 'File Name' field contains 'groupA.zip' and the 'Files of Type' dropdown is set to '.xml, .zip, .gzip, .gz'. The 'Open' and 'Cancel' buttons are visible at the bottom of the dialog box.

Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 0	-	11.68	4.28	-1.319	0.375
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HTDPU 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
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File: /Users/mihamuskinj/Downloads/groupA.zip/event001.xml

ETMis: 4.167 GeV ϕ : 3.040 rad Collection: MET_RefFinal

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	



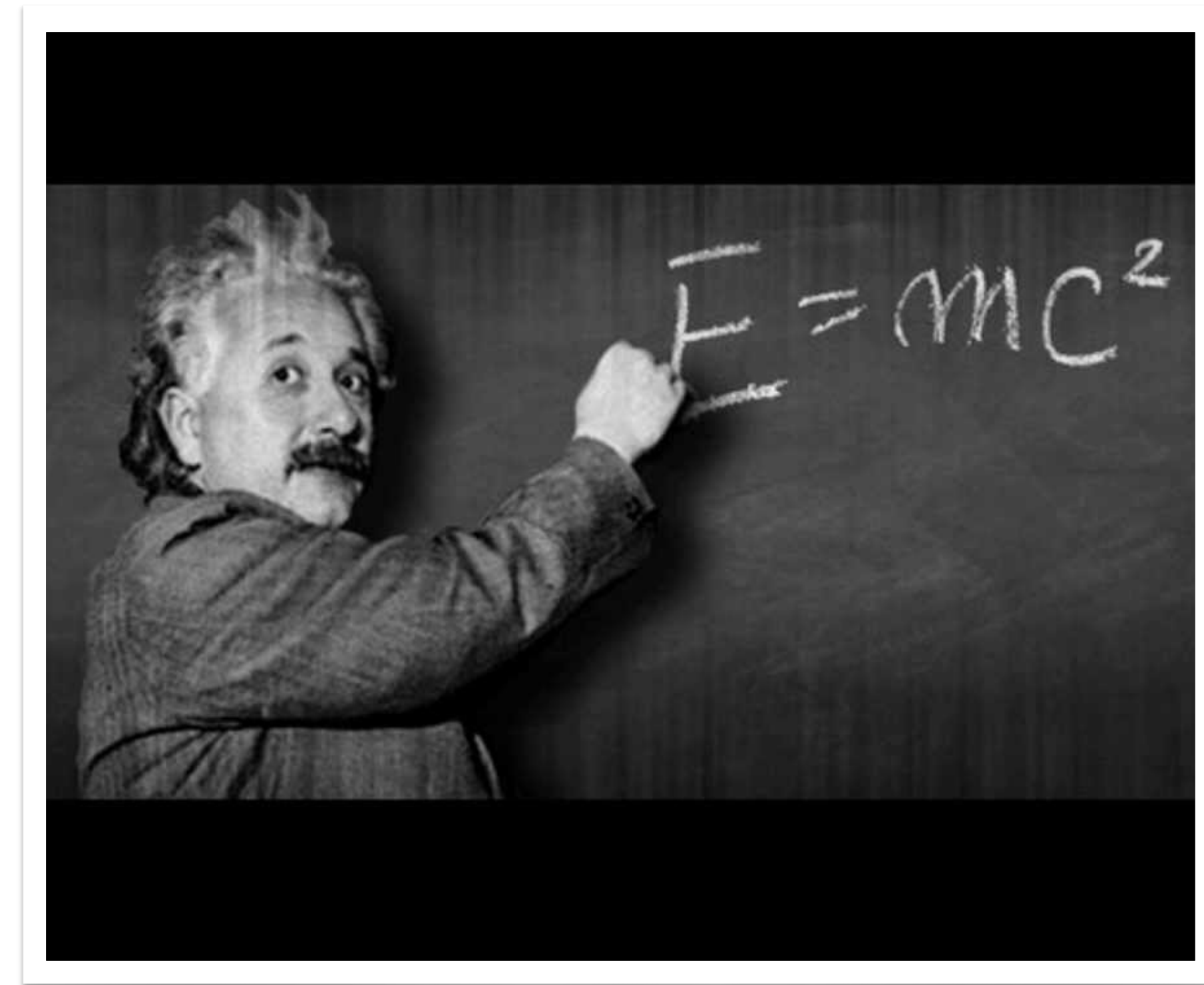
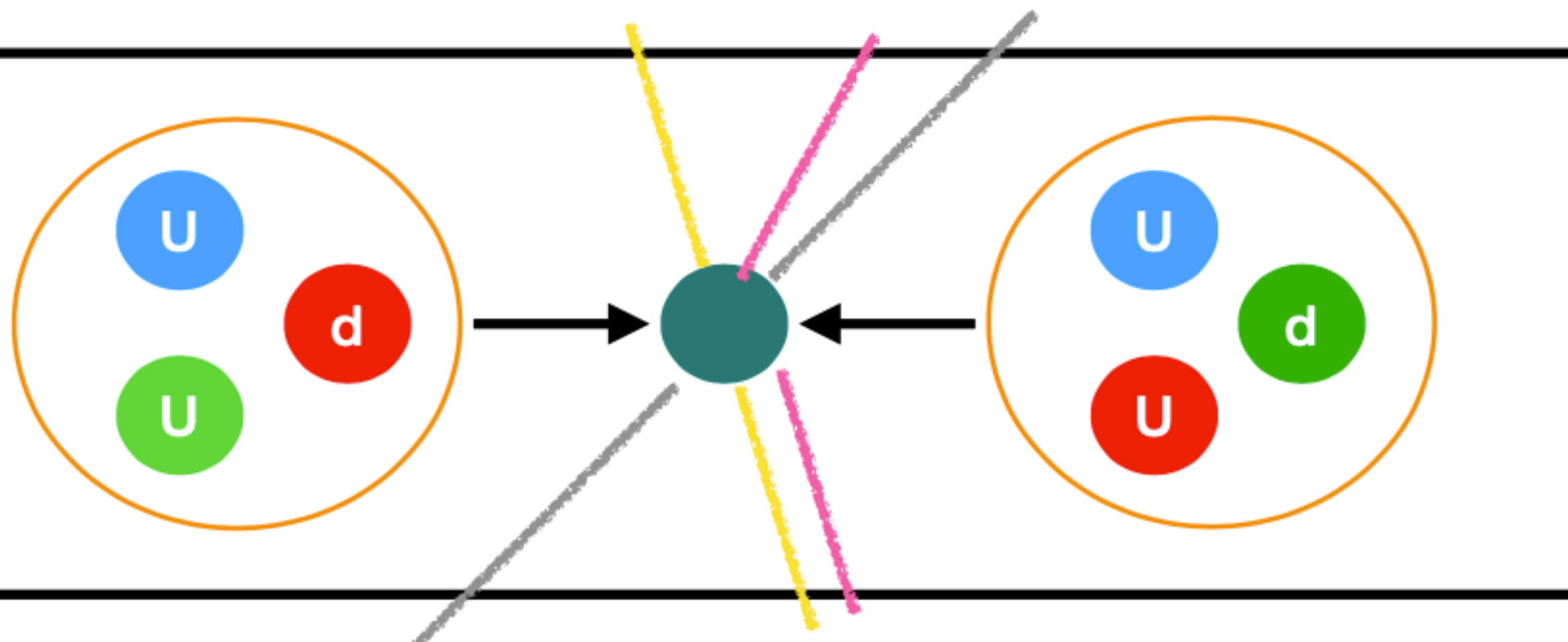
- Preko "indico" strani lahko dostopite vse prosojnice in linke: <https://indico.ijs.si/event/1830>

13:00	Uvod v analizo podatkov, Belle II Marko Bracko	Uvod v analizo podatkov, ATLAS Miha Muskinja	Uvod v delavnico Particle Therapy Andrej Studen
14:00	Delavnica - analiza podatkov z detektorja Belle II Andrej Lozar et al.	Delavnica - analiza podatkov z detektorja ATLAS Miha Muskinja	Delavnica - Particle Therapy Andrej Studen
15:00	Predavalnica, MPŠ Instituta Jožef Stefan 13:30 - 15:45	Predavalnica 3.12, FMF 13:30 - 15:00 Sprehod iz FMF na IJS Ogled laboratorijev na F9 15:05 - 15:45	Predavalnica Triglav, FMF 13:30 - 15:45
Odmor C/0-C084 - F9 seminarska soba, Jamova 15:45 - 16:00			
16:00	Video konferenca Marko Bracko	Video konferenca ATLAS Miha Muskinja	Video konferenca Particle Therapy Andrej Studen
17:00	Predavalnica, MPŠ Instituta Jožef Stefan 16:00 - 17:00	C/0-C084 - F9 seminarska soba, Jamova 16:00 - 17:00	Predavalnica Triglav, FMF 16:00 - 17:00

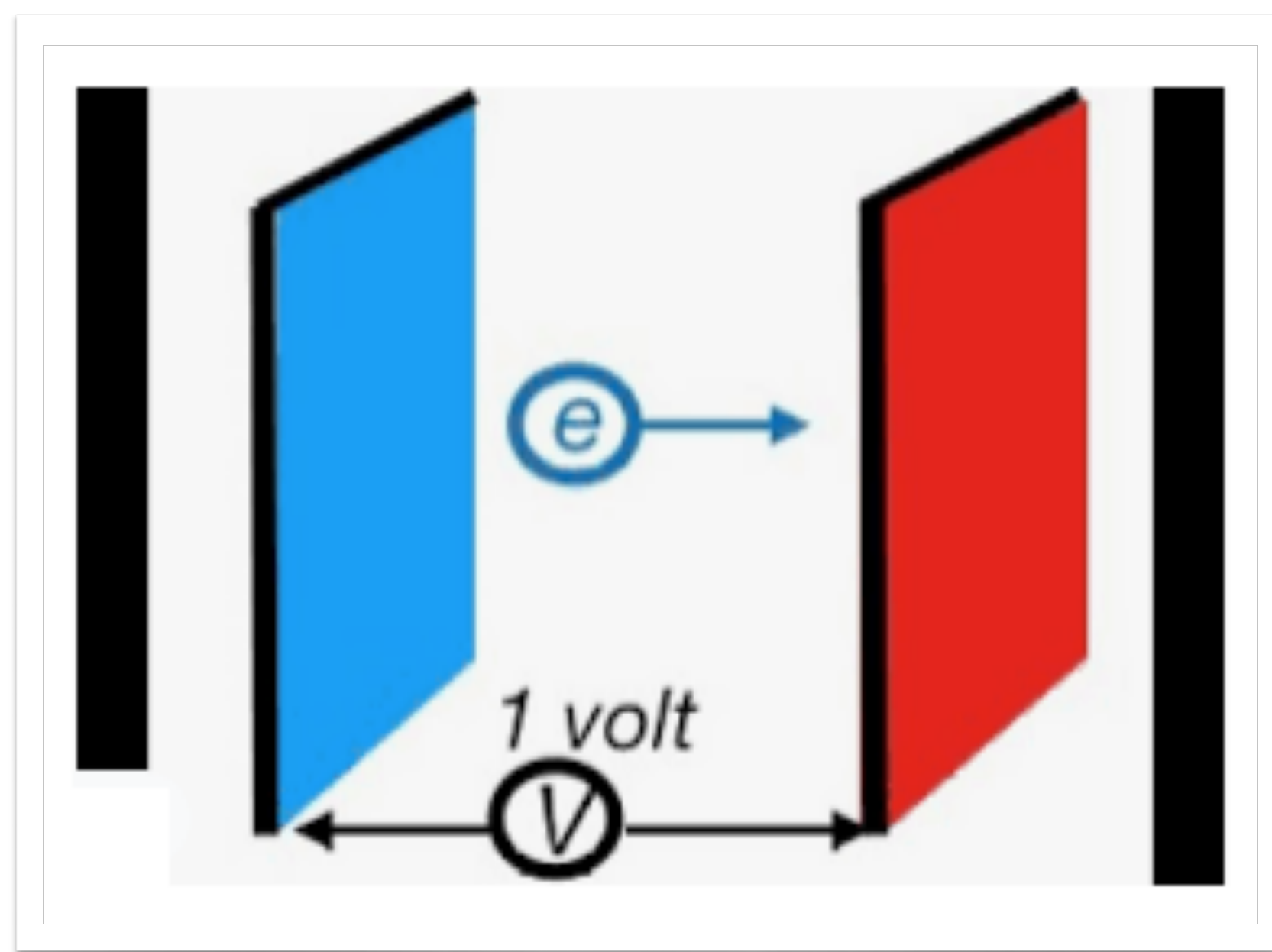
[cheat-sheet](#)
[miham_2024_3_5_Masterclass_DataAnalysis.pdf](#)
[particle-identification](#)

Katere delce bomo iskali?

- **Einstein:** energija in masa sta ekvivalentni!
- Trčenje delcev z visoko energijo proizvaja veliko novih delcev
- Uporabljamo Veliki hadronski trkalnik (LHC), da pospešimo protone na 0,999999999 kratno hitrost svetlobe in jih trčimo (za poznavalce: Lorentz boost $\gamma \approx 7500$)
- Med letoma 2015 in 2018 smo v ATLAS-u proizvedli približno 8.000.000 Higgsovih bozonov



- "0.999999999 kratna hitrost svetlobe" - nepraktično
- Namesto navajanja hitrosti raje govorimo o kinetični energiji
- Energija: 'Jouli'. Vendar raje uporabljamo enoto 'elektronvolt':



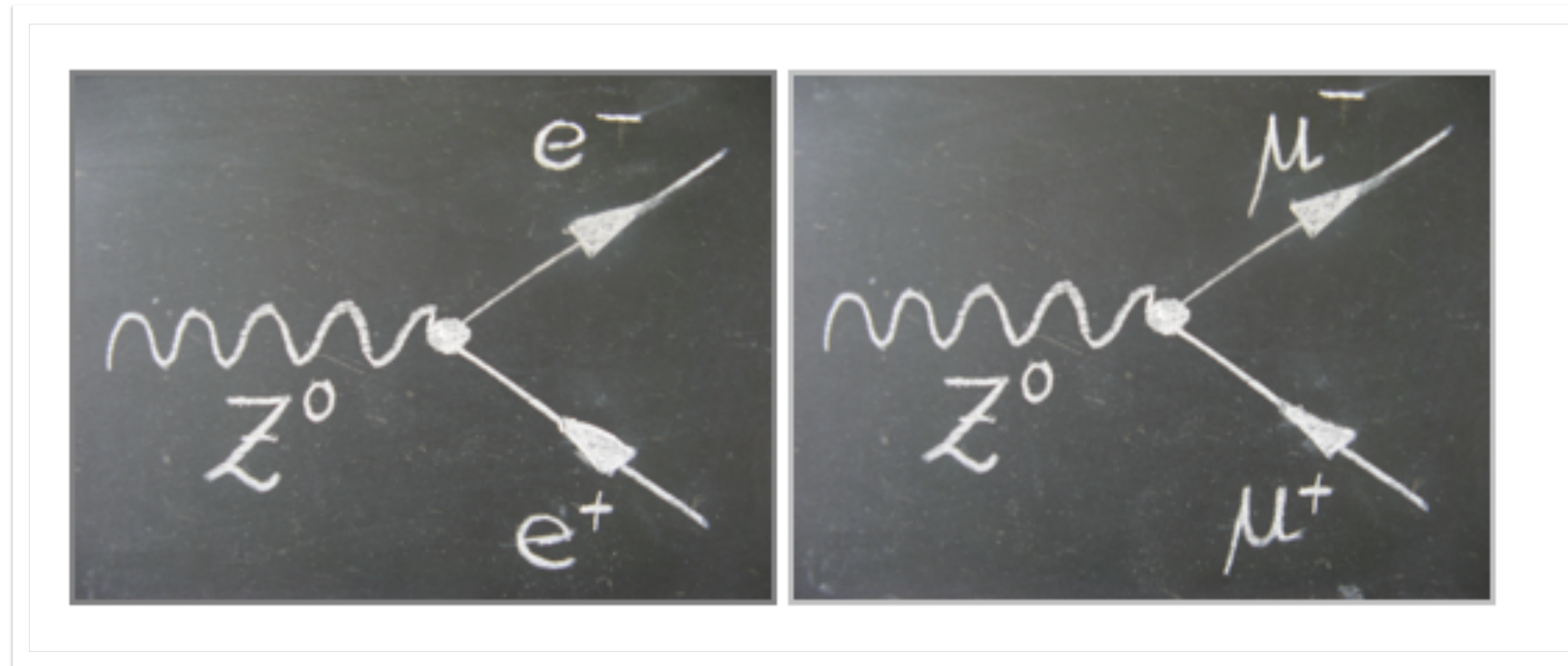
1 'electron Volt' ali 1 eV:

Energija, pridobljena s pospeševanjem elektrona z električnim potencialom enega volta

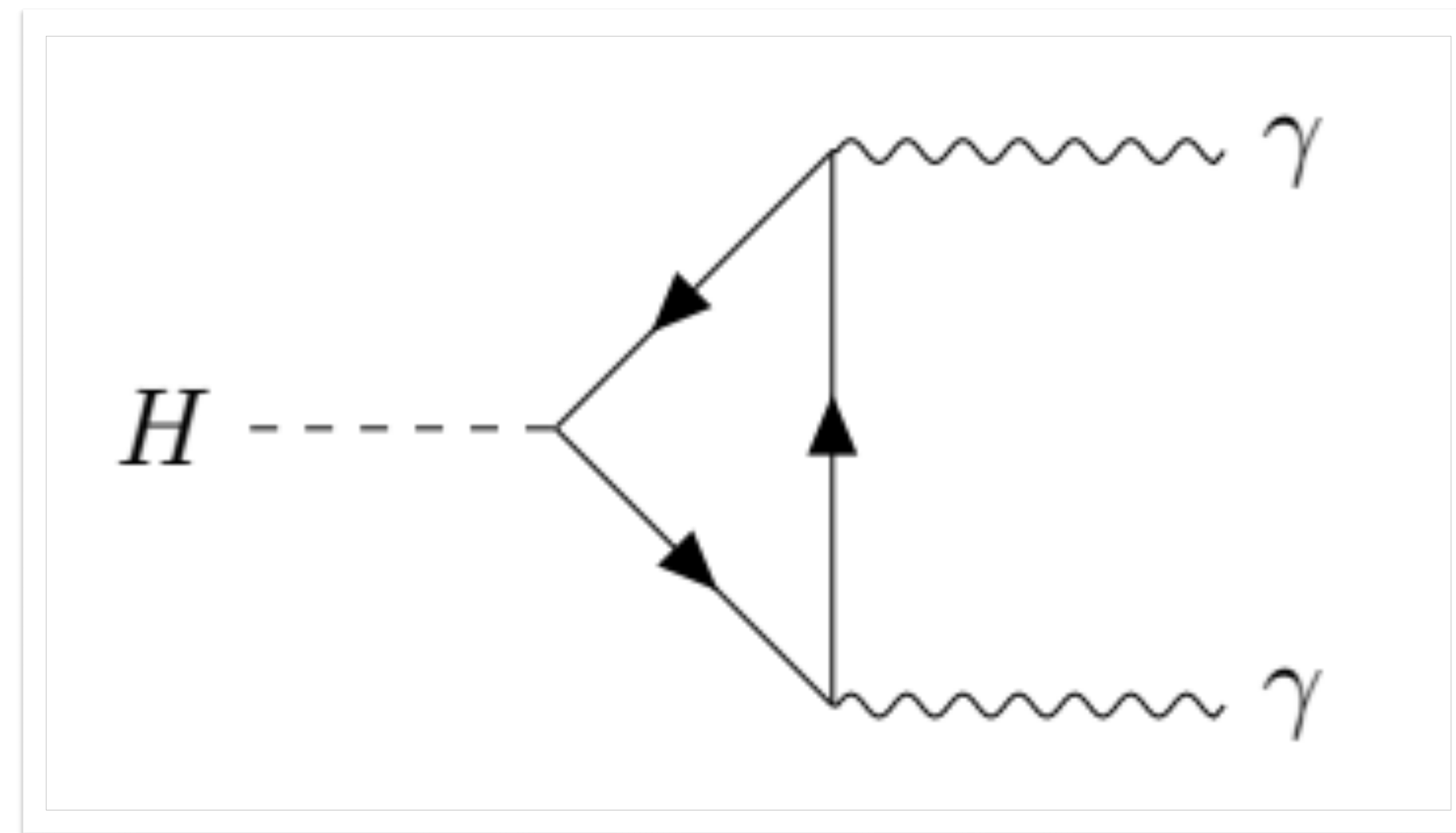
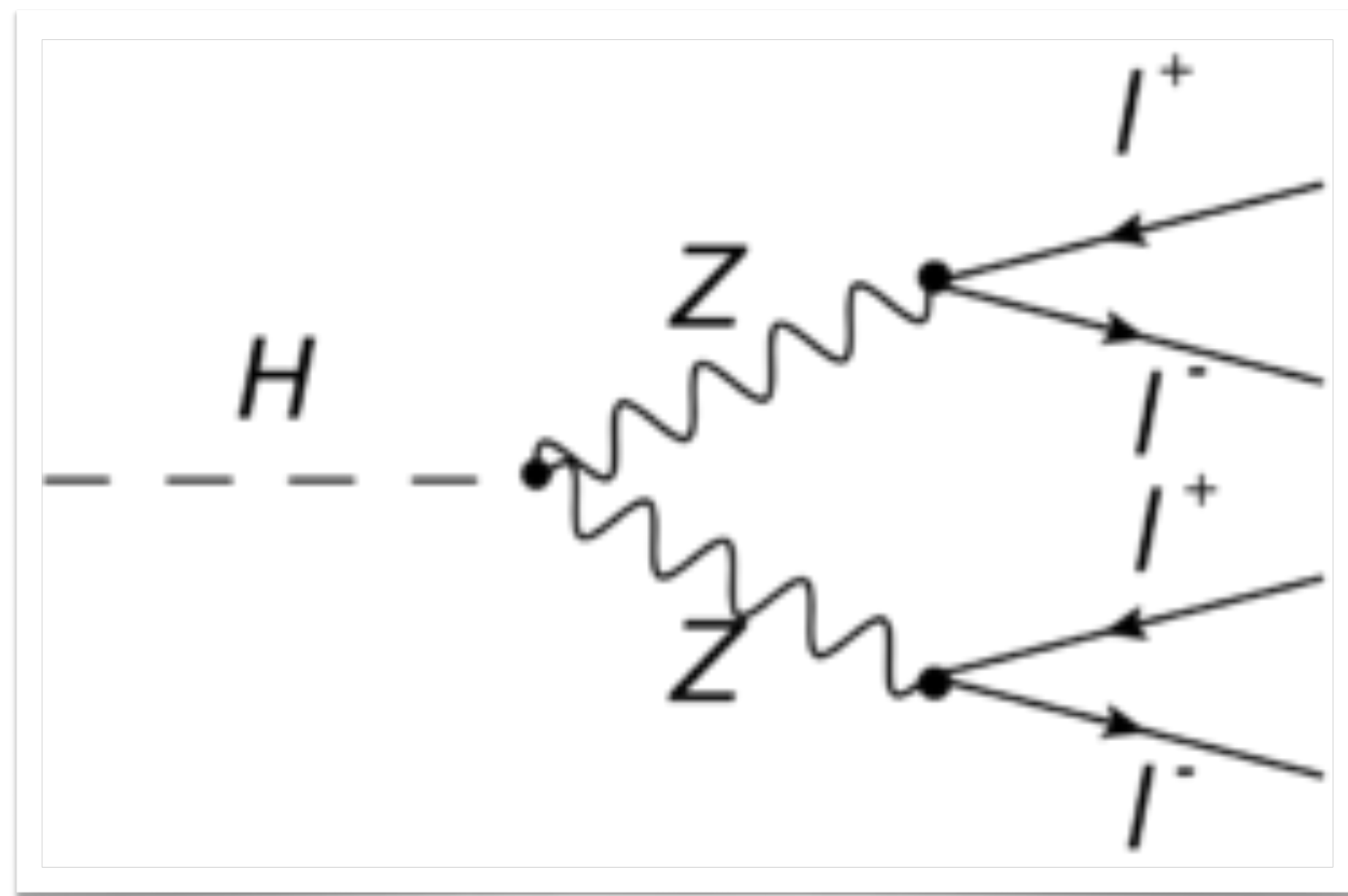
$$1 \text{ eV} = 1.6 \cdot 10^{-19} \text{ J}$$

- Na LHC trčimo protone z energijo $13 \text{ TeV} = 13.000.000.000 \text{ eV}$
- Novi delci, ustvarjeni v teh trkih, običajno imajo energijo okoli **1 do 100 GeV**

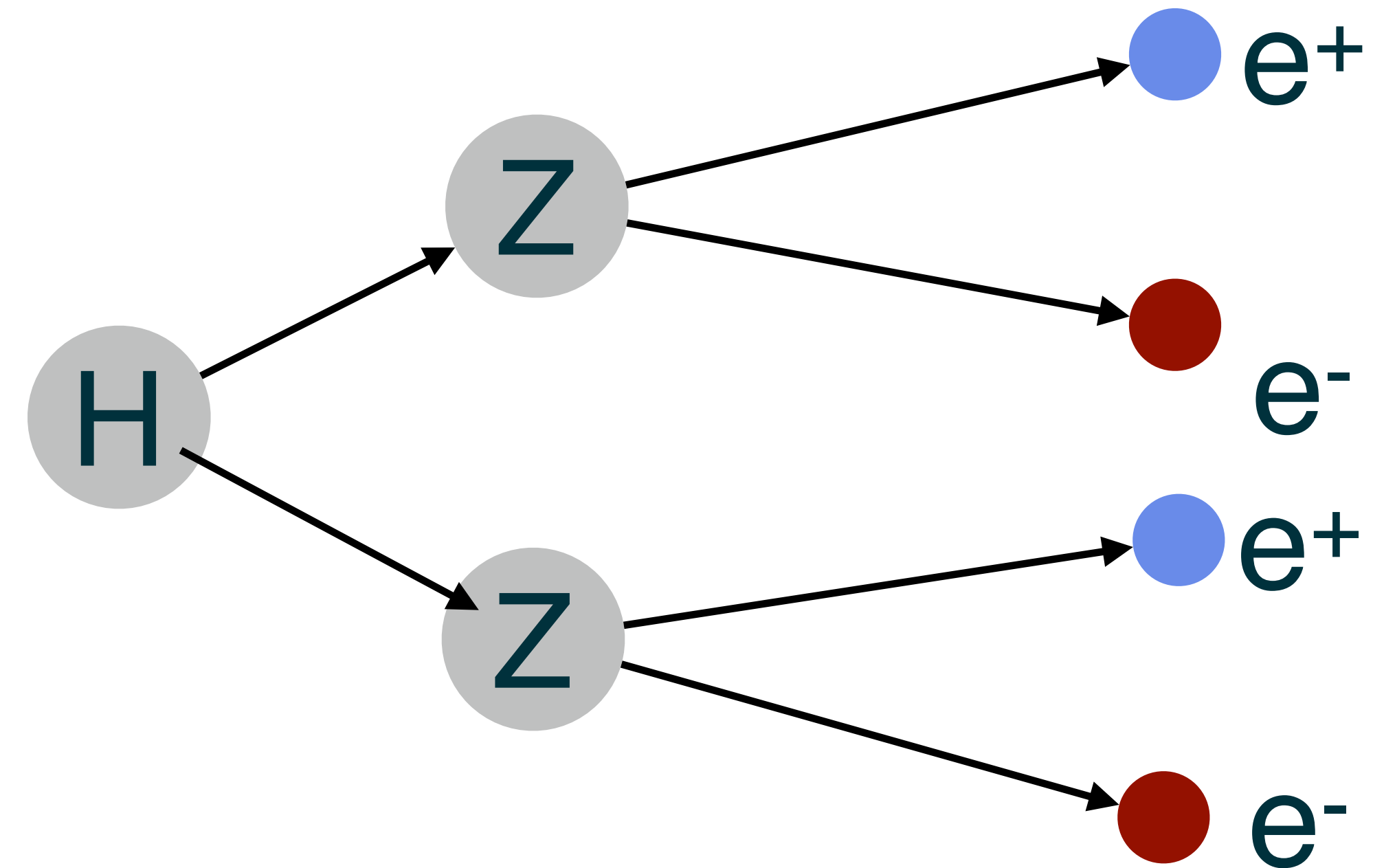
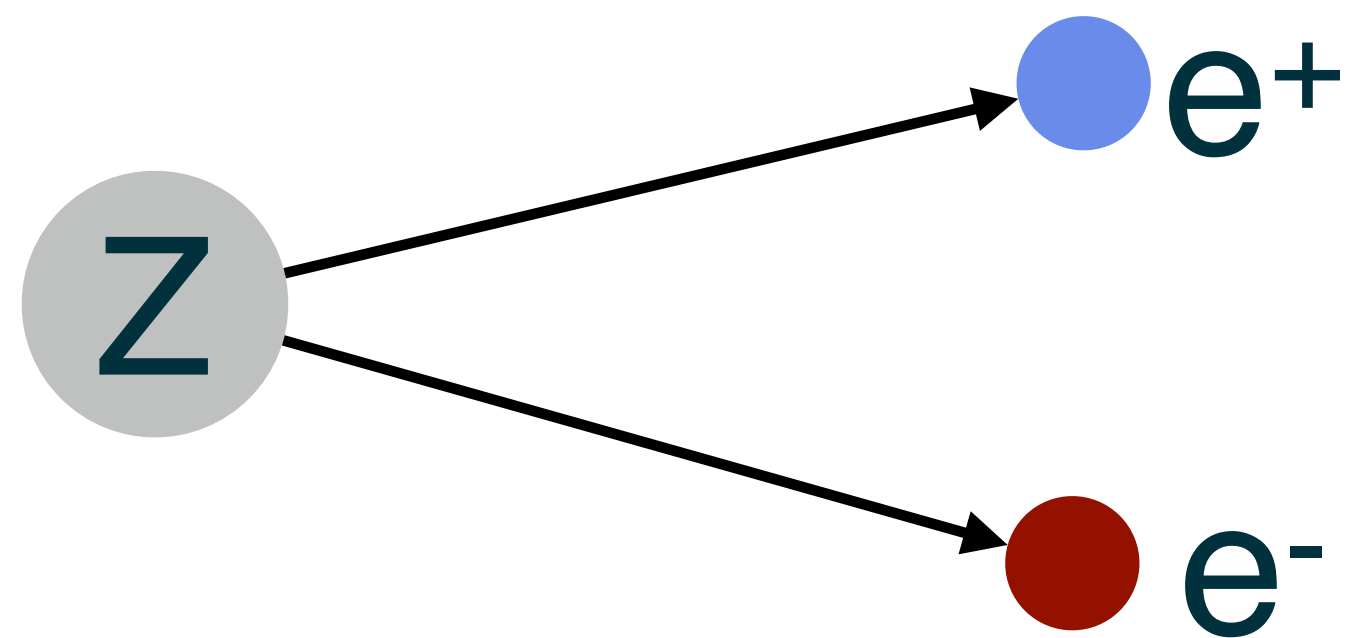
- Danes boste iskali razpade Z bozona:



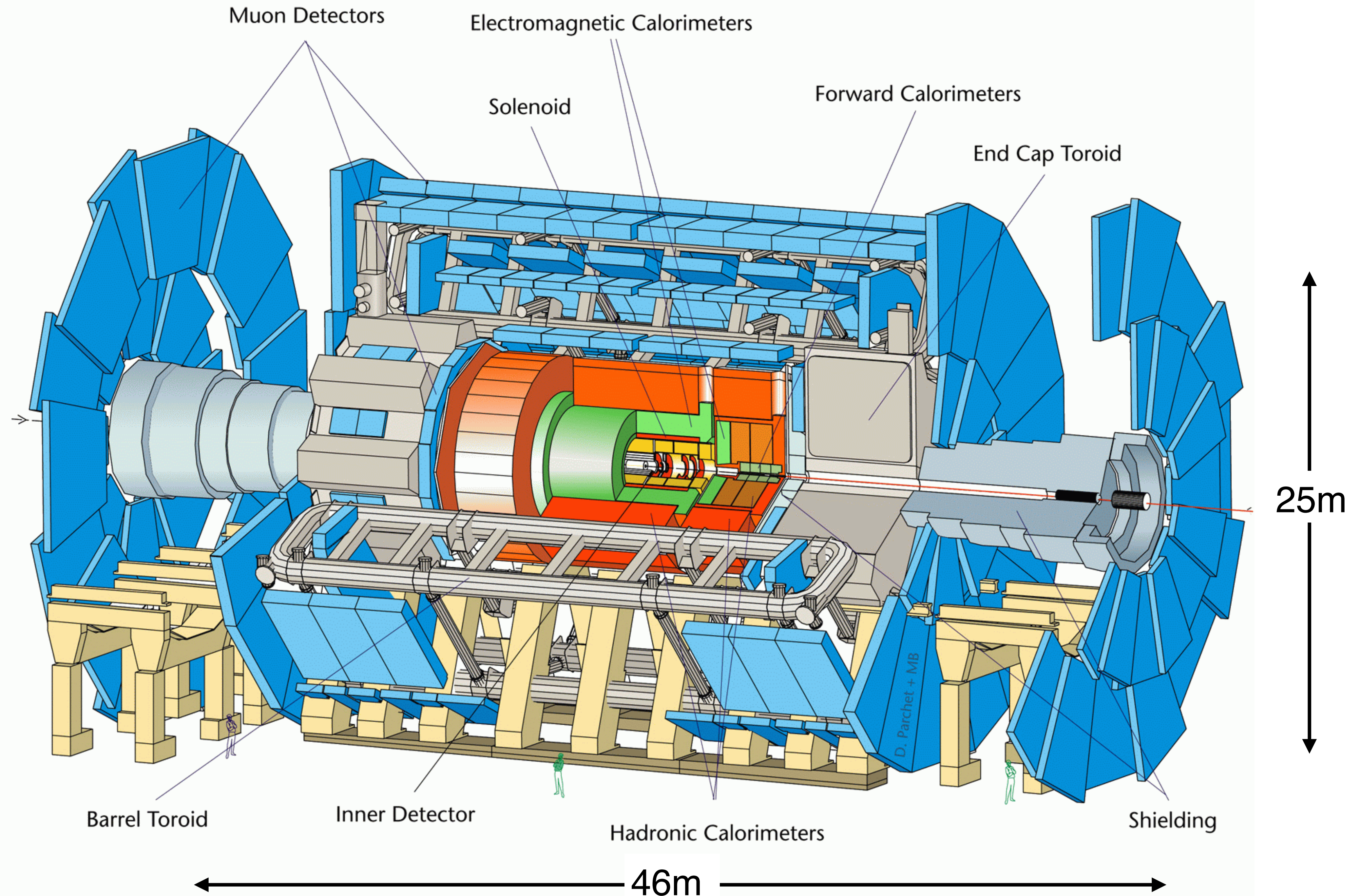
- Z bozon razpade bodisi v dva elektrona bodisi v dva miona
- Z bozon nima naboja
 - Zaradi ohranitve naboja imajo izhodni delci nasprotni naboj: e^- in e^+



- Prav tako boste iskali razpade Higgsovega bozona:
 - $H \rightarrow ZZ \rightarrow 4$ leptoni (elektroni ali mioni)
 - $H \rightarrow \gamma\gamma$ (2 fotona)
- S pravilno identifikacijo Z bozonov boste lahko rekonstruirali Higgsov bozon!

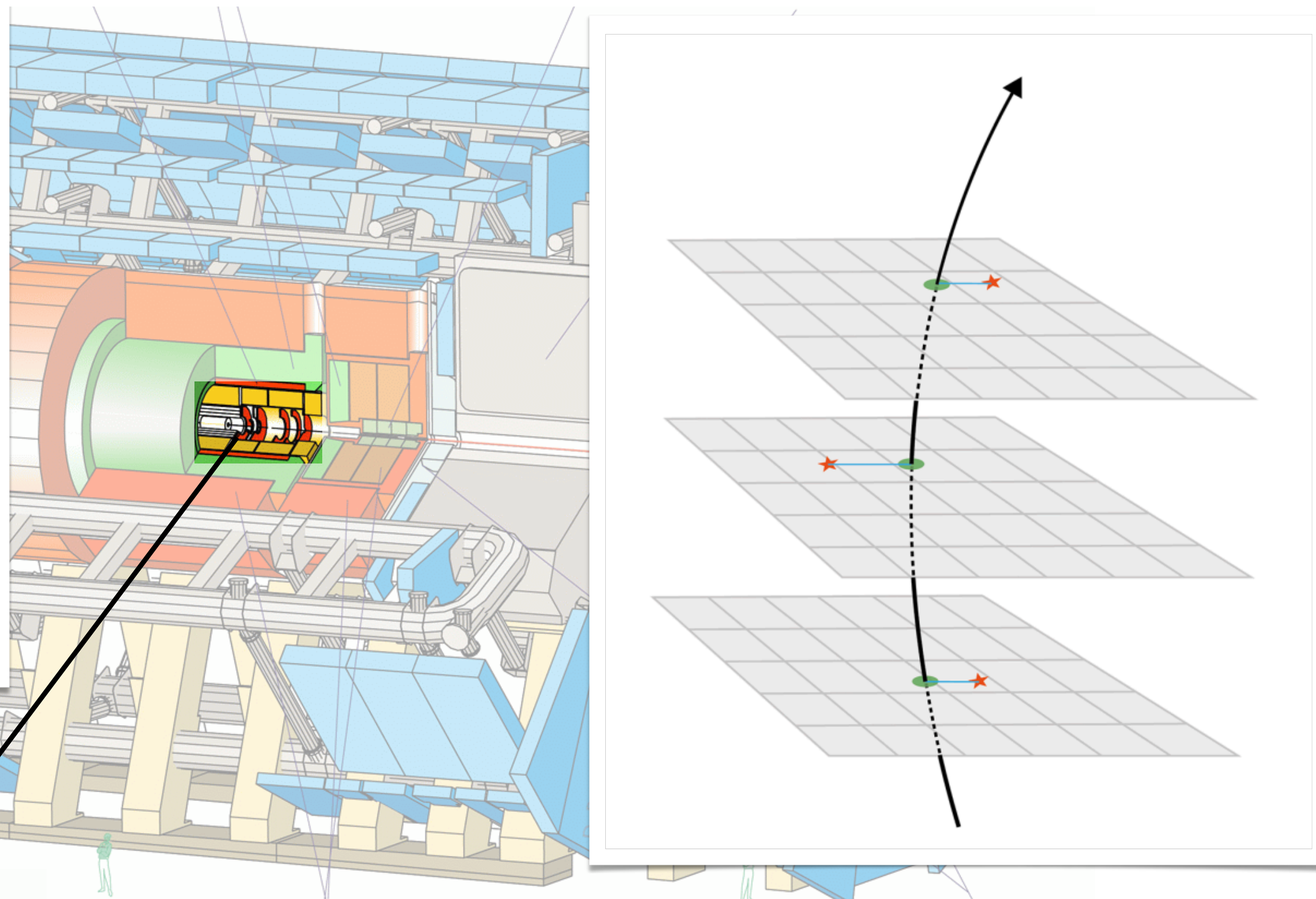
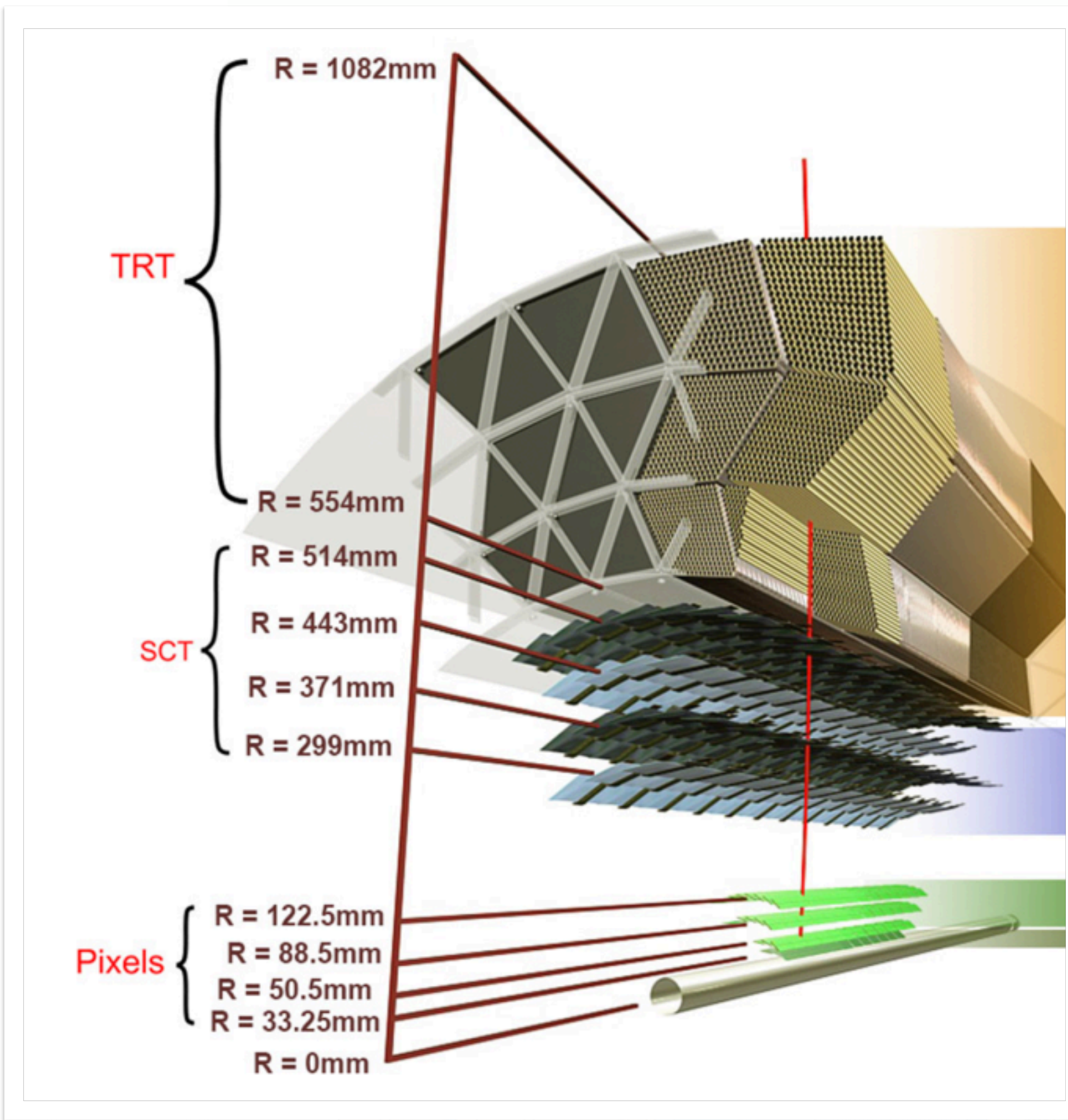


- Detektor ATLAS meri samo gibalno količino končnih delcev (e , μ , γ , ...)
- S temi podatki lahko rekonstruiramo maso začetnega delca (Z bozon ali H bozon)
 - Z bozon: 90 GeV
 - H bozon: 125 GeV
- Vendar pa zaradi merskih napak rekonstruirana masa odstopa od prave mase





Nabiti delci (npr. elektronu) se ukrivijo v močnem magnetnem polju in oddajajo energijo v plasti Notranjega detektorja.



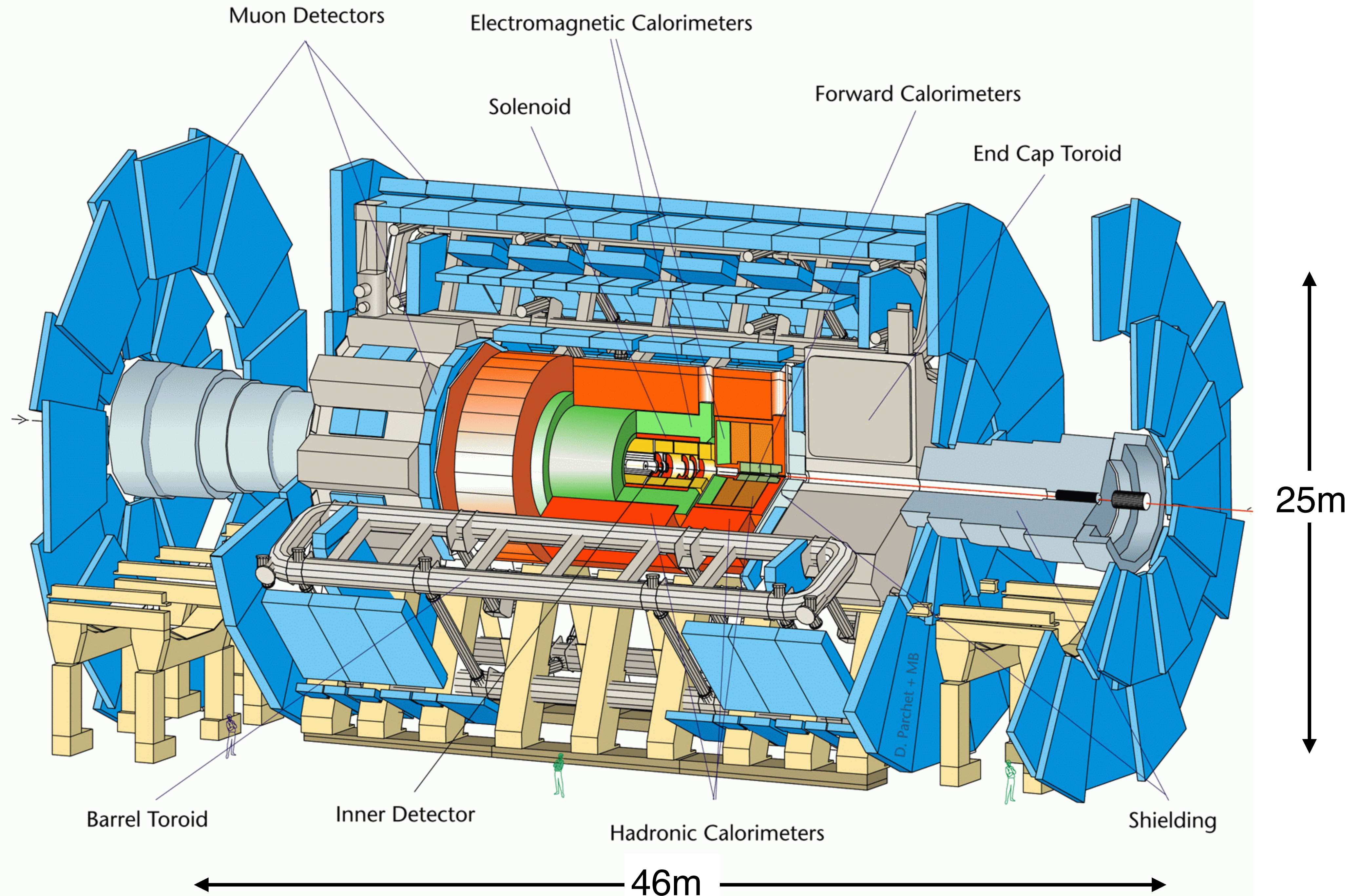
Barrel Toroid

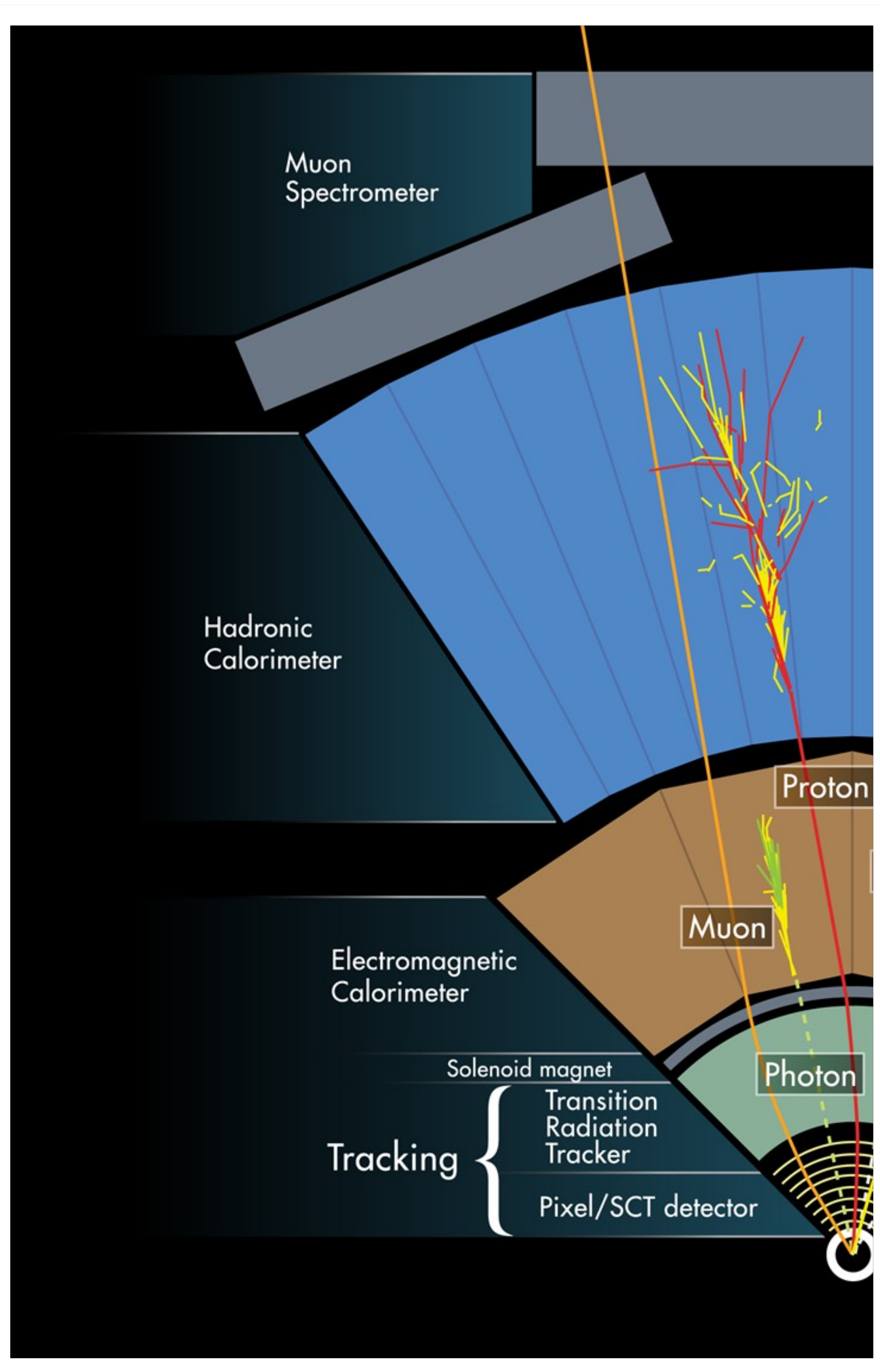
Inner Detector

Hadronic Calorimeters

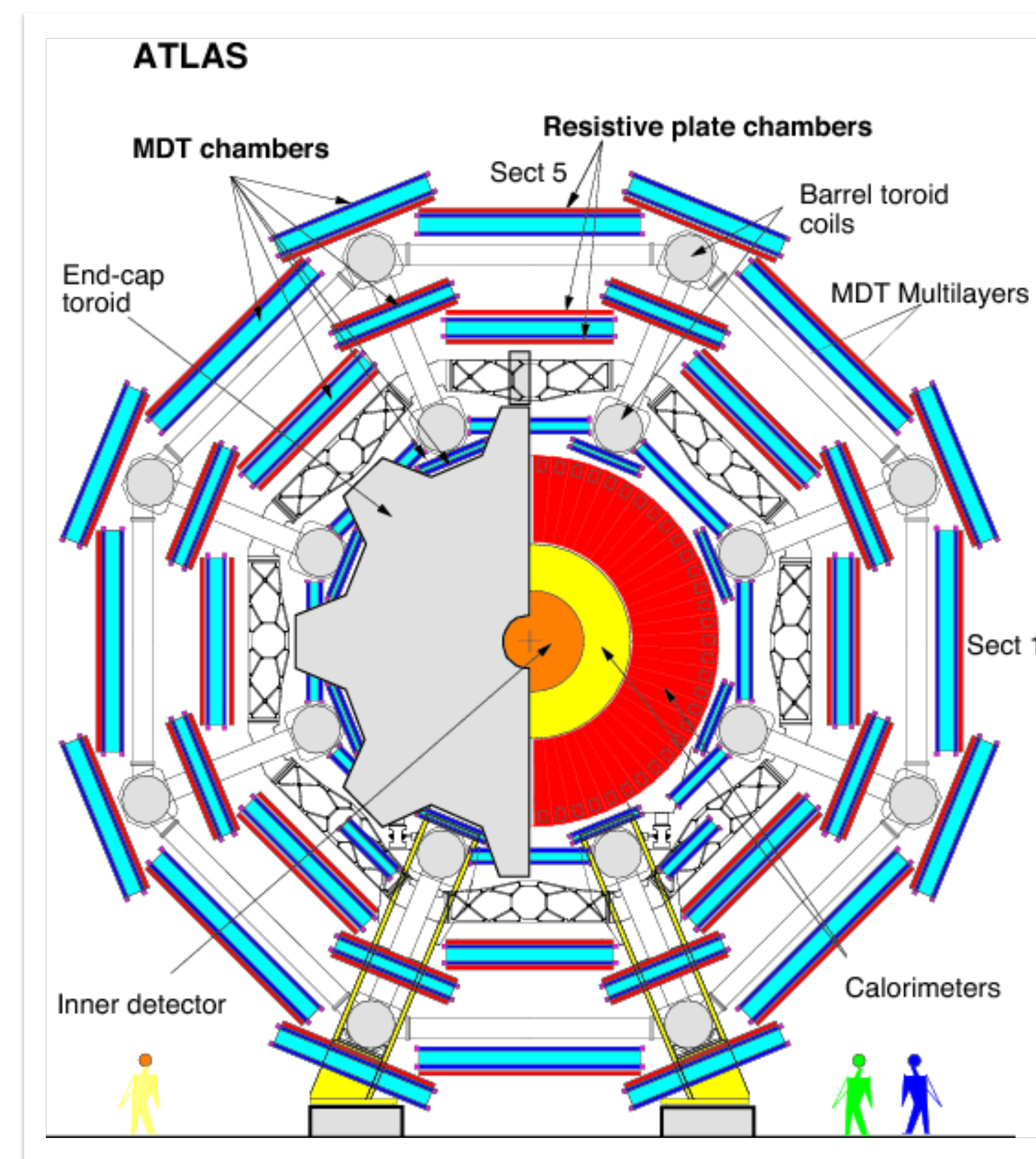
Shielding

46m





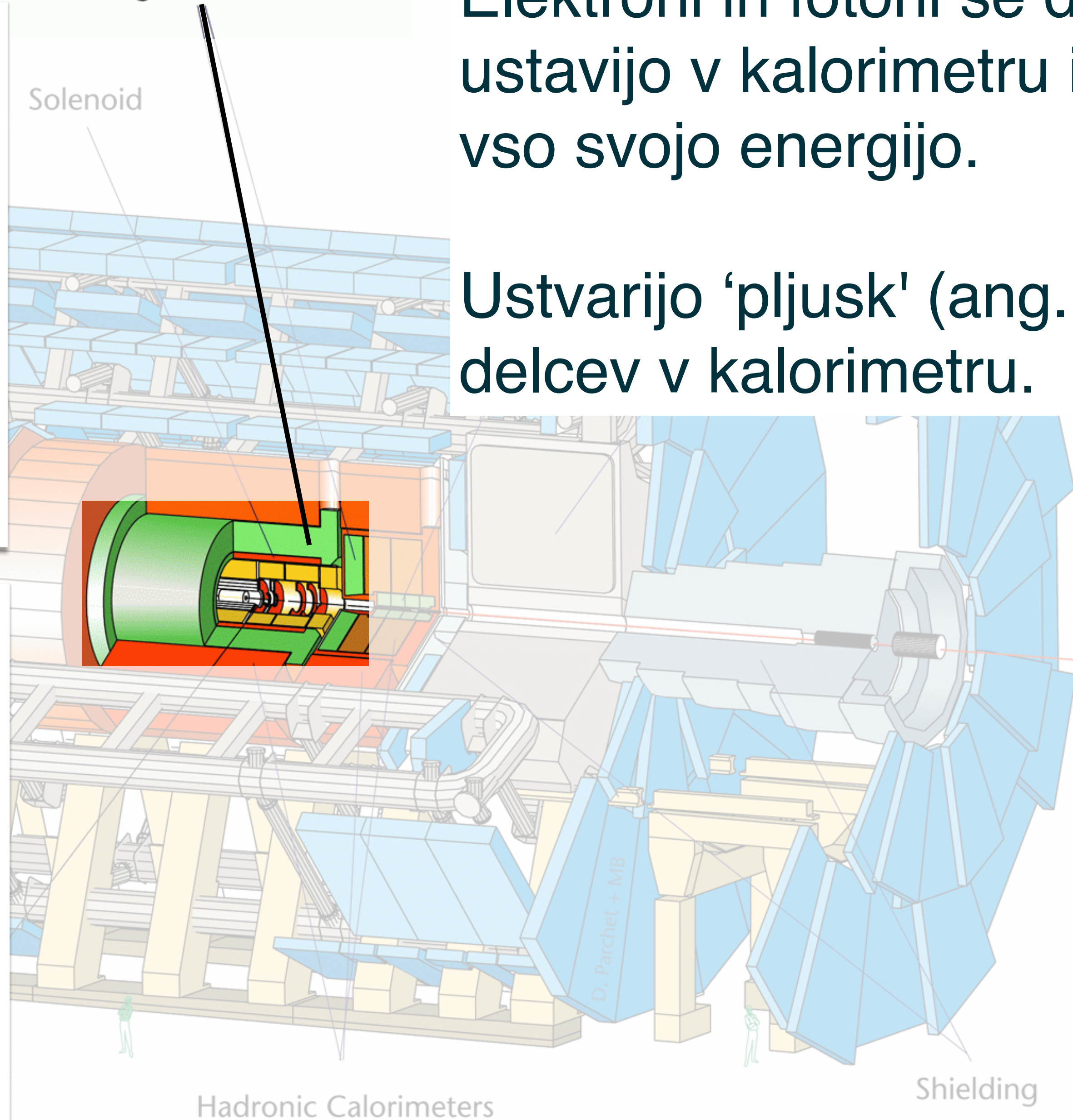
Mioni so težji bratje elektronov. Manj pogosto interagirajo z materialom detektorja in potujejo vse do konca. Ujamejo jih z zunanjimi mionskimi detektorji.



Muon Detectors

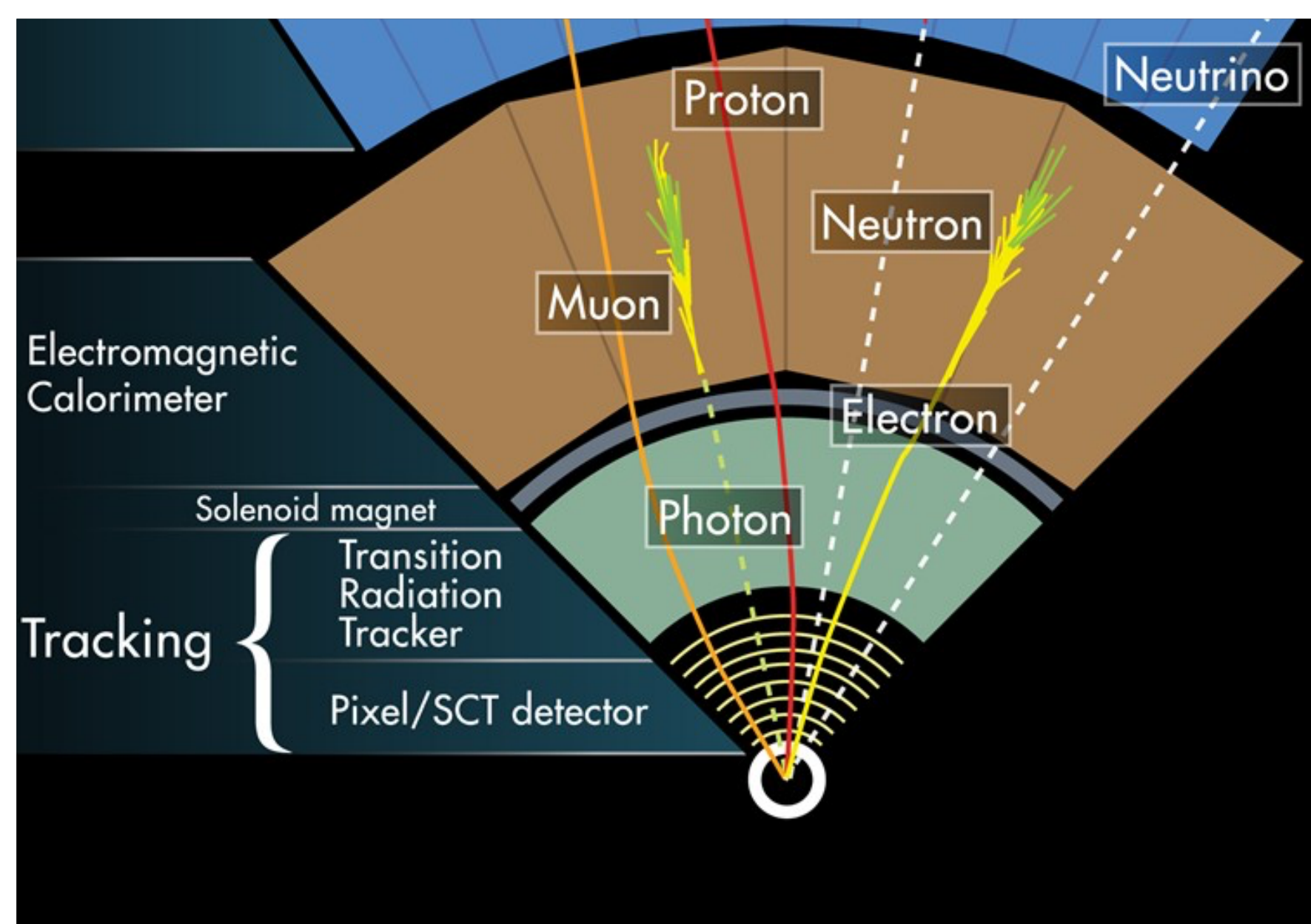


Electromagnetic Calorimeters



Elektroni in fotoni se destruktivno ustavijo v kalorimetru in oddajo vso svojo energijo.

Ustvarijo 'plusk' (ang. 'Jet') delcev v kalorimetru.

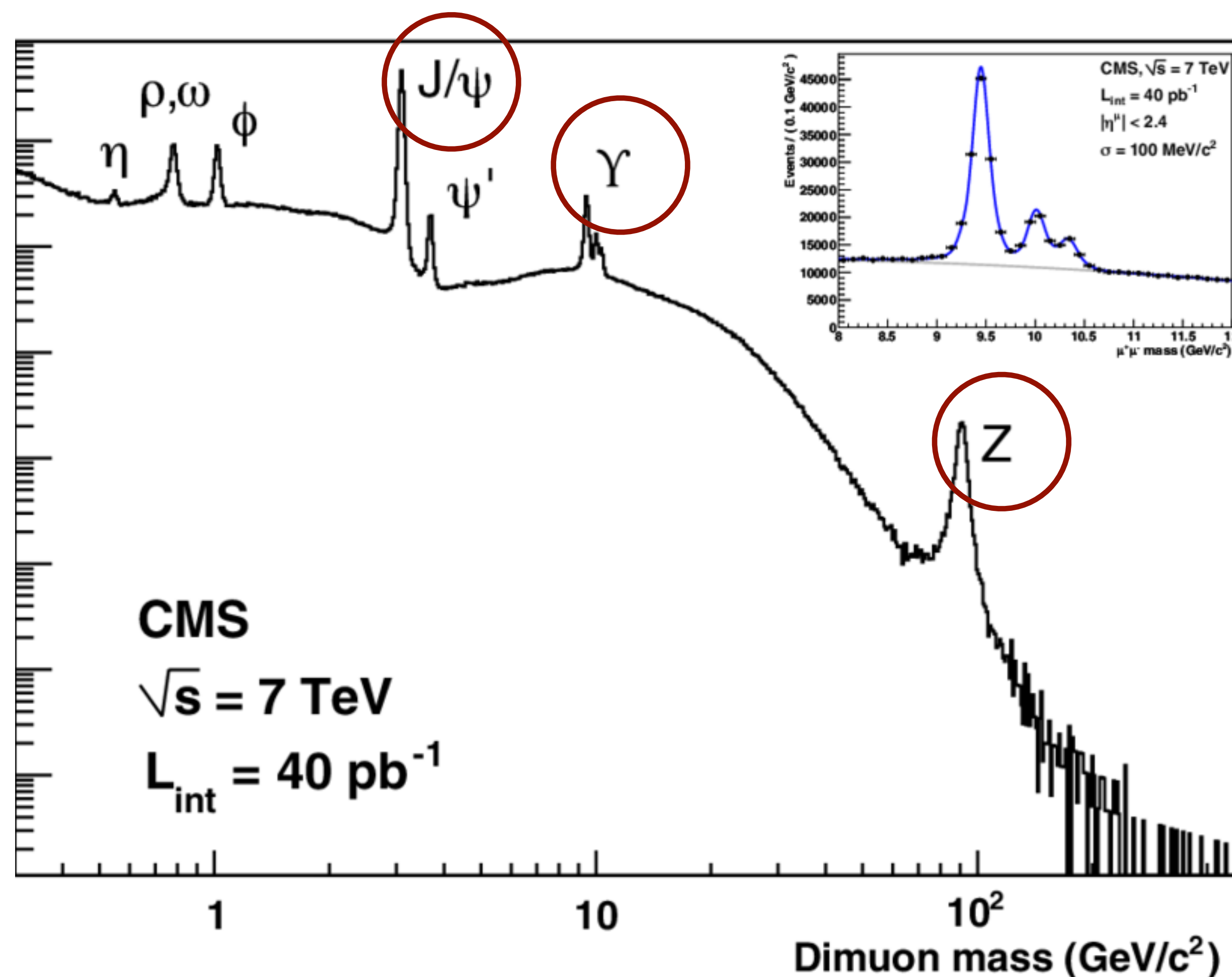


Identifikacija delcev s programom Hypathia

- V nekaterih podatkovnih nizih so skriti tudi dodatni delci:

- $J/\psi \rightarrow \mu^+\mu^-/e^+e^-$ (3.1 GeV)
- $Y \rightarrow \mu^+\mu^-/e^+e^-$ (10.5 GeV)
- $Z' \rightarrow \mu^+\mu^-/e^+e^-$ (>1000 GeV)
- Graviton $\rightarrow \gamma\gamma$ (>> 100 GeV)

Hipotetični delci onkraj Standardnega modela, ki še jih nismo opazili, lahko pa simuliramo, kako bi izgledal njihov “podpis” v detektorju



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

The screenshot displays the 'HYbrid Pupils' Analysis Tool for Interactions in ATLAS - version 7.4 - Invariant Mass Window'. The interface is divided into four main sections:

- Top Left:** A circular event display showing particle tracks in blue, with a central red and green region.
- 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' with tabs for Parameter Control, Interaction and Window Control, and Output Display. The 'Data' tab is active, showing a table with columns for Name and Value, and a list of checked items: Status, InDet, Calo, MuonDet, and Objects.

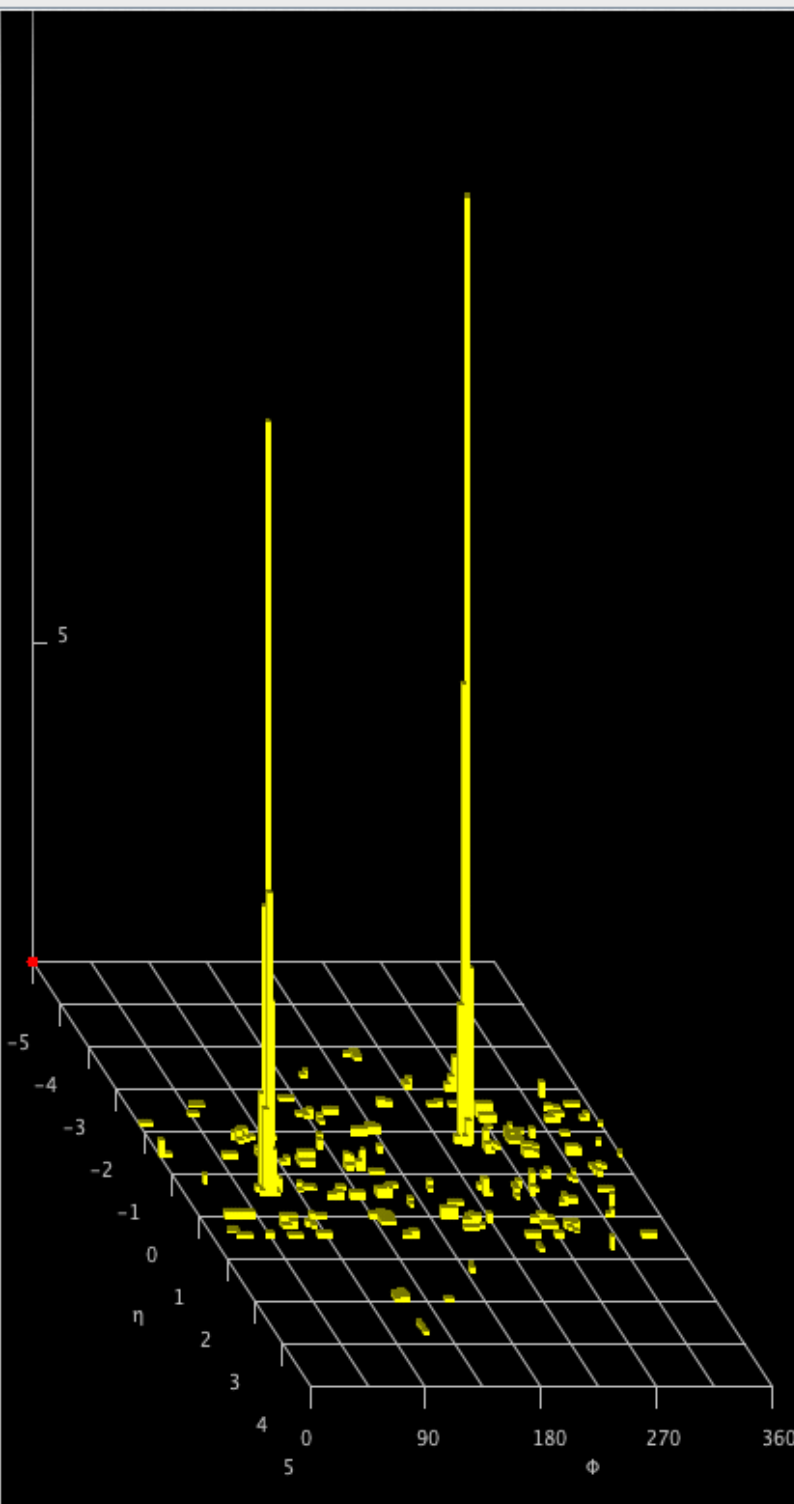
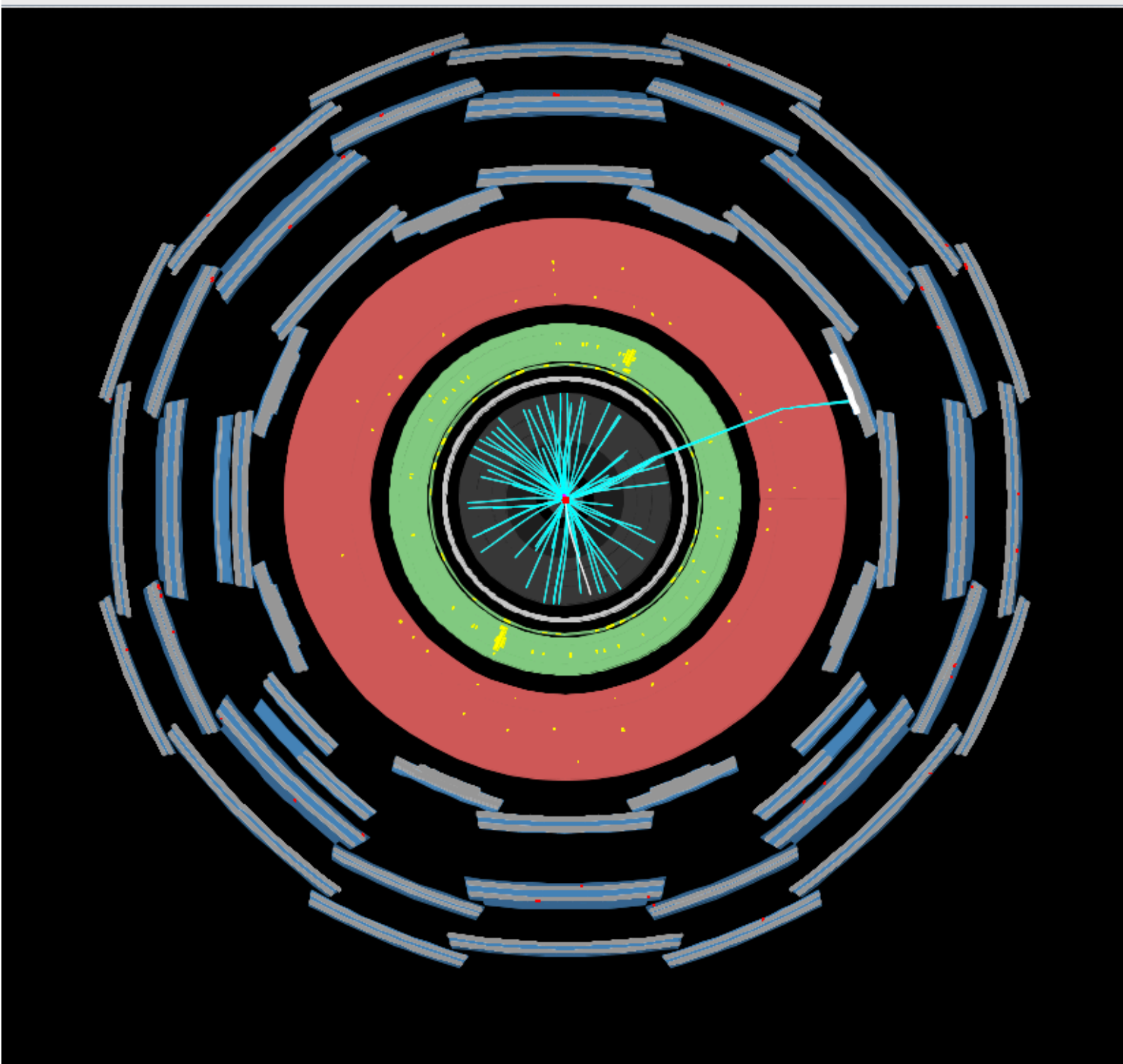
Hypathia navigation: Adding cuts



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
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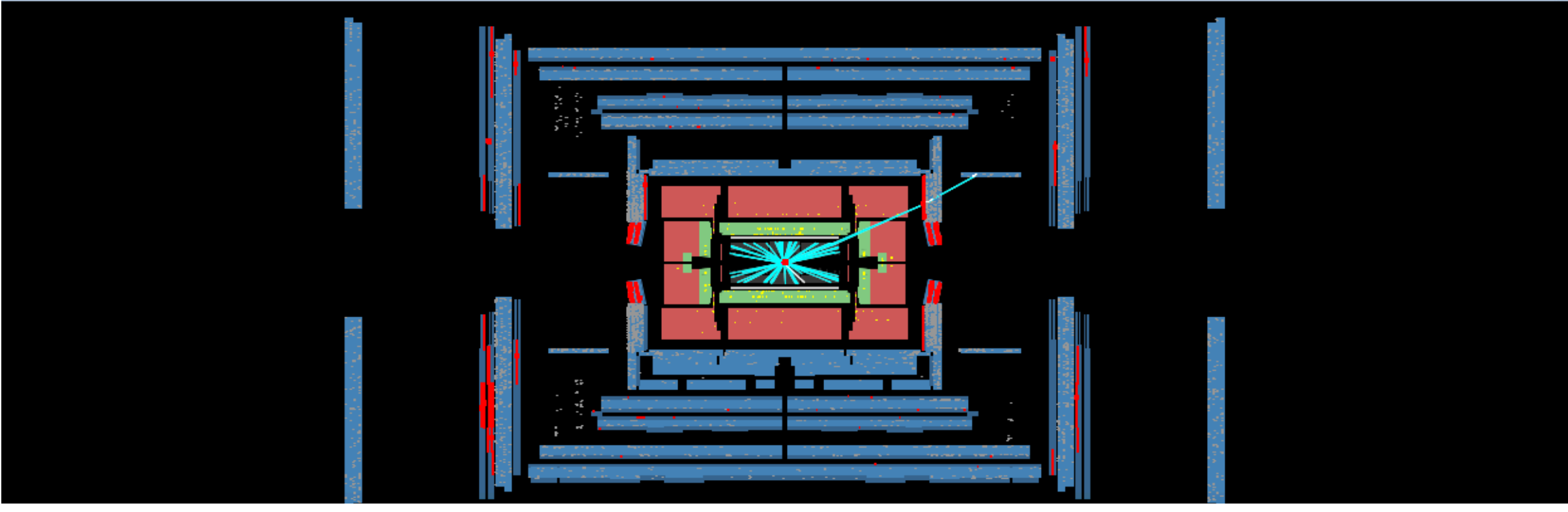


File Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

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
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Tracks 41	-	2.52	1.86	2.745	0.832
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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
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Tracks 91	+	2.07	1.52	-2.857	2.314



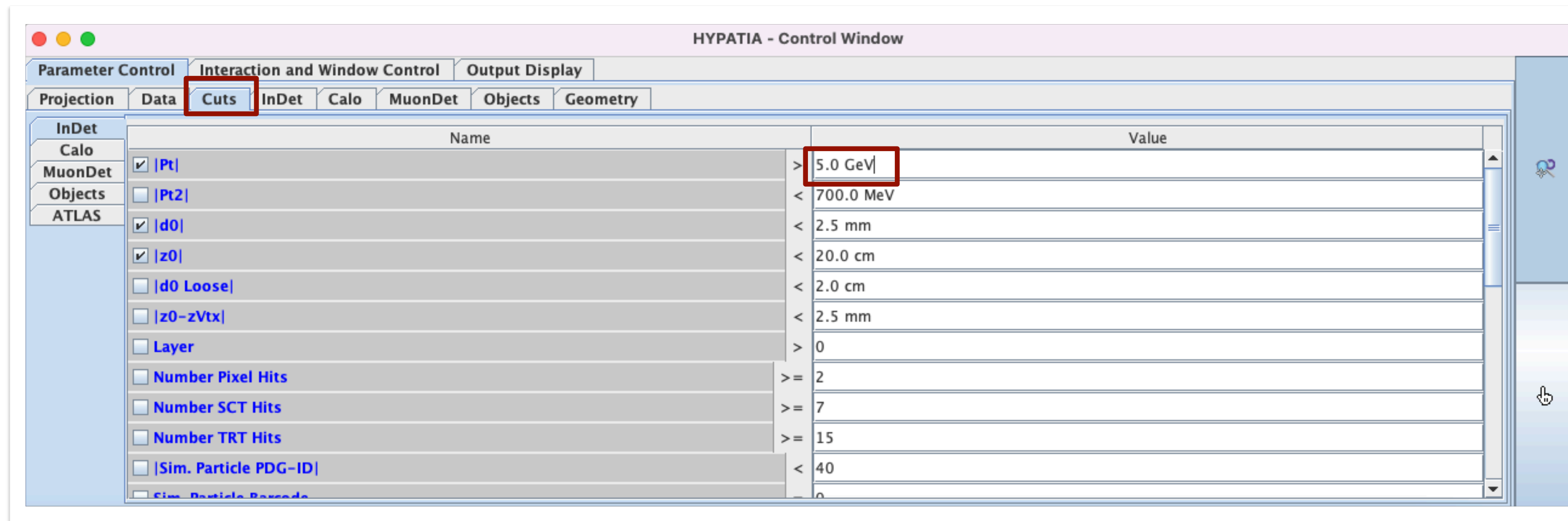
HYPATHIA - Control Window

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]

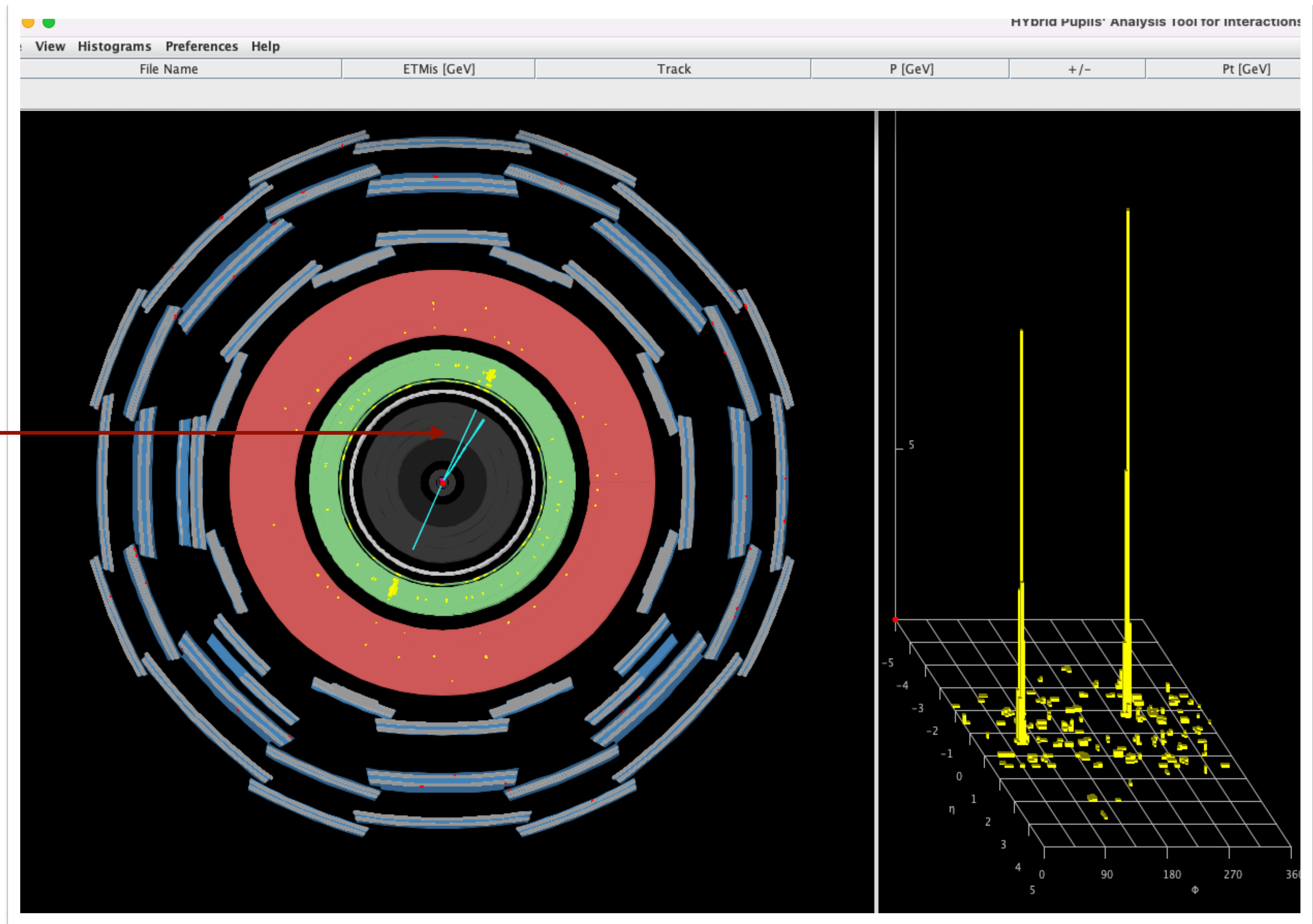
HYPATIA - Control Window

Parameter Control Interaction and Window Control Output Display

Projection Data Cuts InDet Calo MuonDet Objects Geometry

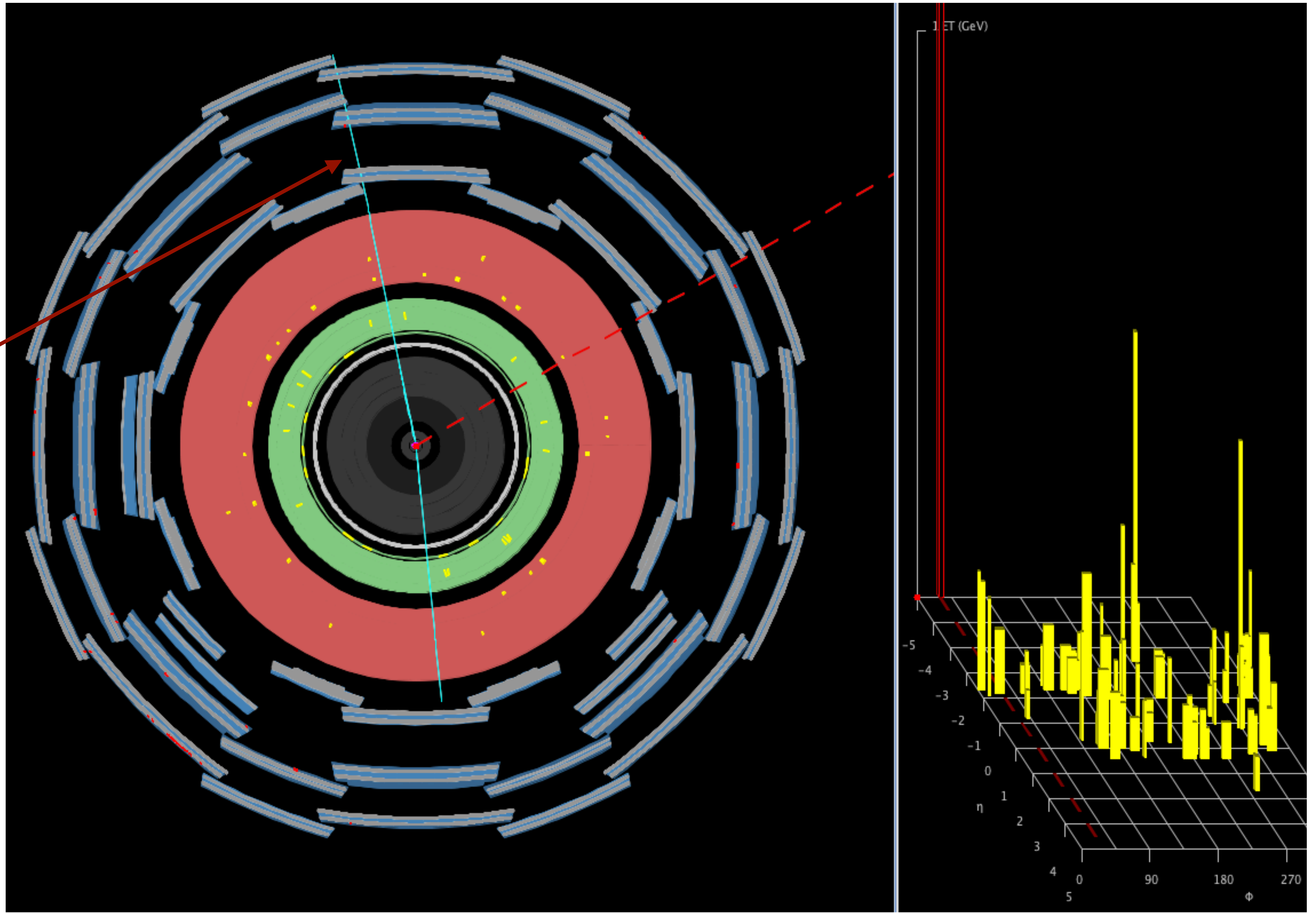
InDet	Name	Value
Calo	<input checked="" type="checkbox"/> Pt	> 5.0 GeV
MuonDet	<input type="checkbox"/> Pt2	< 700.0 MeV
Objects	<input type="checkbox"/> d0	< 2.5 mm
ATLAS	<input checked="" type="checkbox"/> z0	< 20.0 cm
	<input type="checkbox"/> d0 Loose	< 2.0 cm
	<input type="checkbox"/> z0-zVtx	< 2.5 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

Electron:
- ID track
- Calo deposit

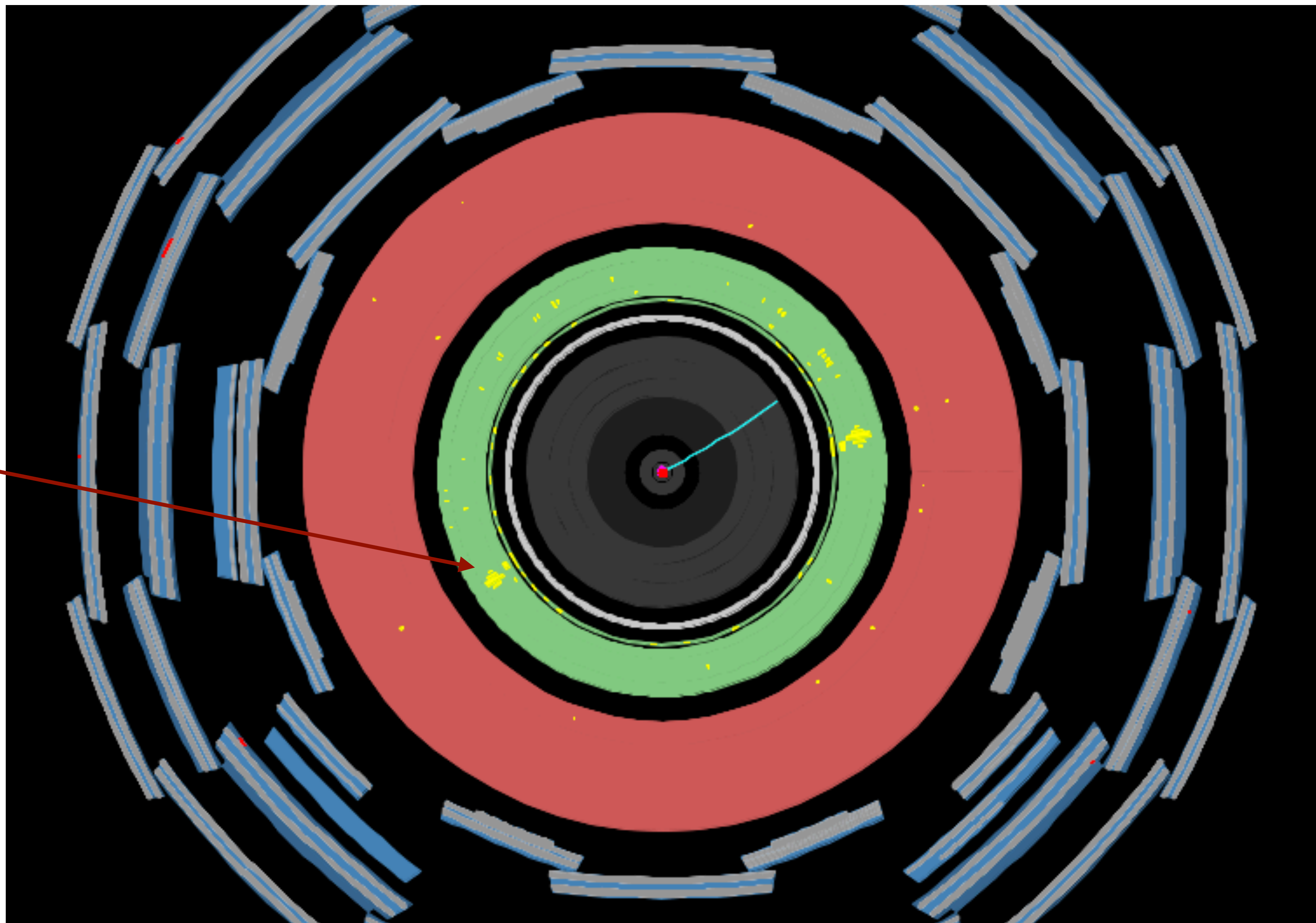


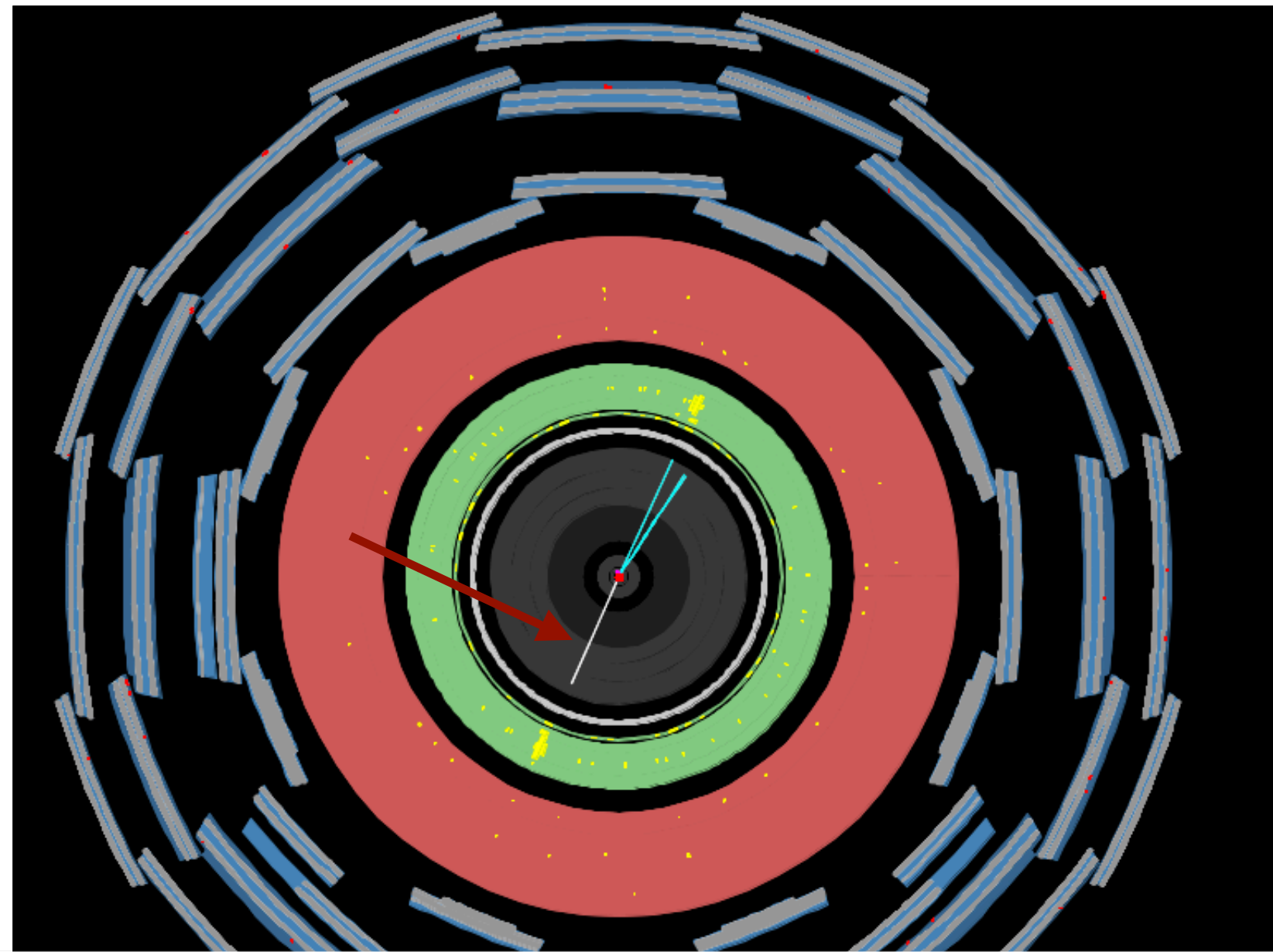


Muon:
- MS track



Photon:
- Calo deposit
- No ID track





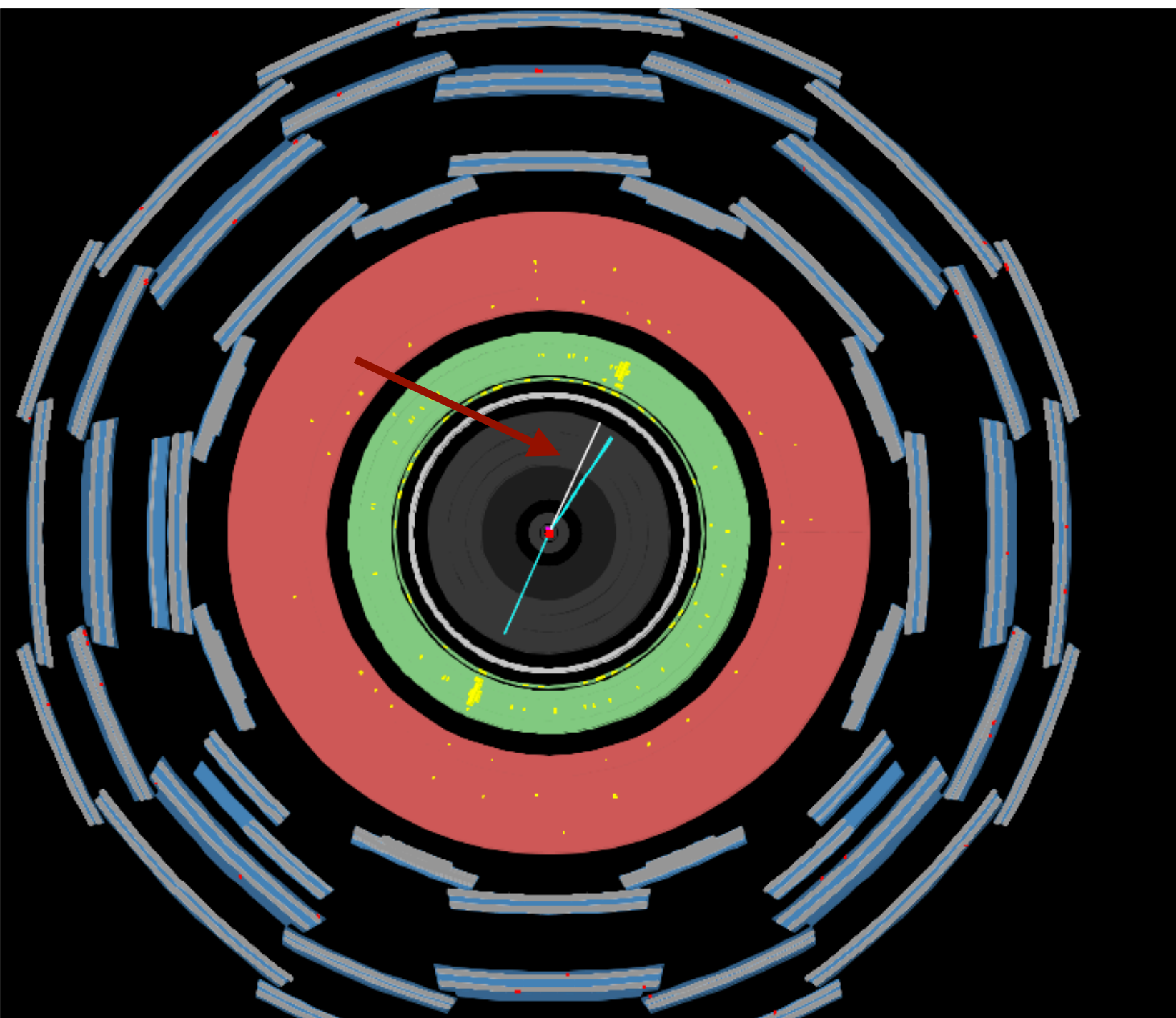
HYPATIA - Track Momenta Window

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



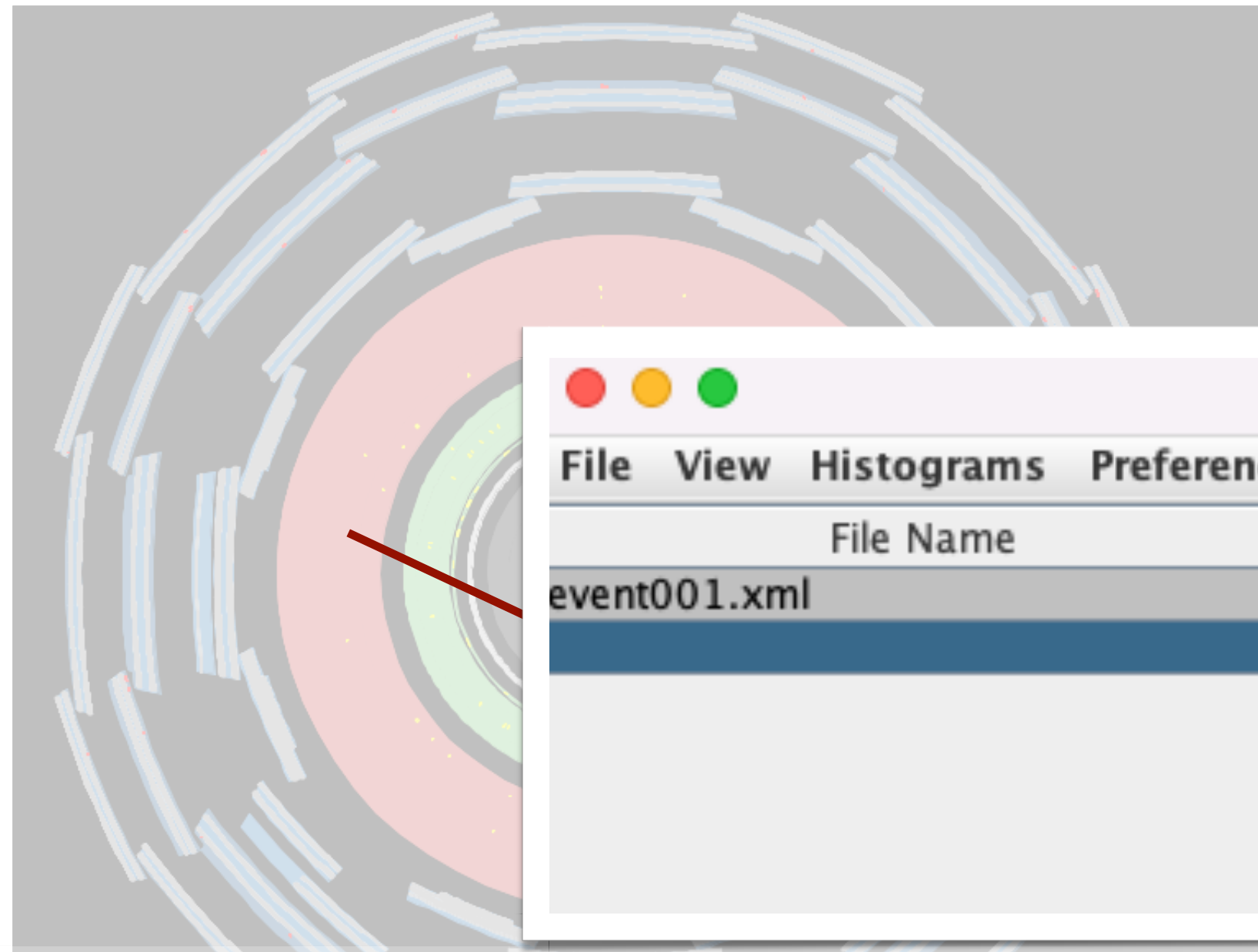
HYPATIA - Track Momenta Window

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

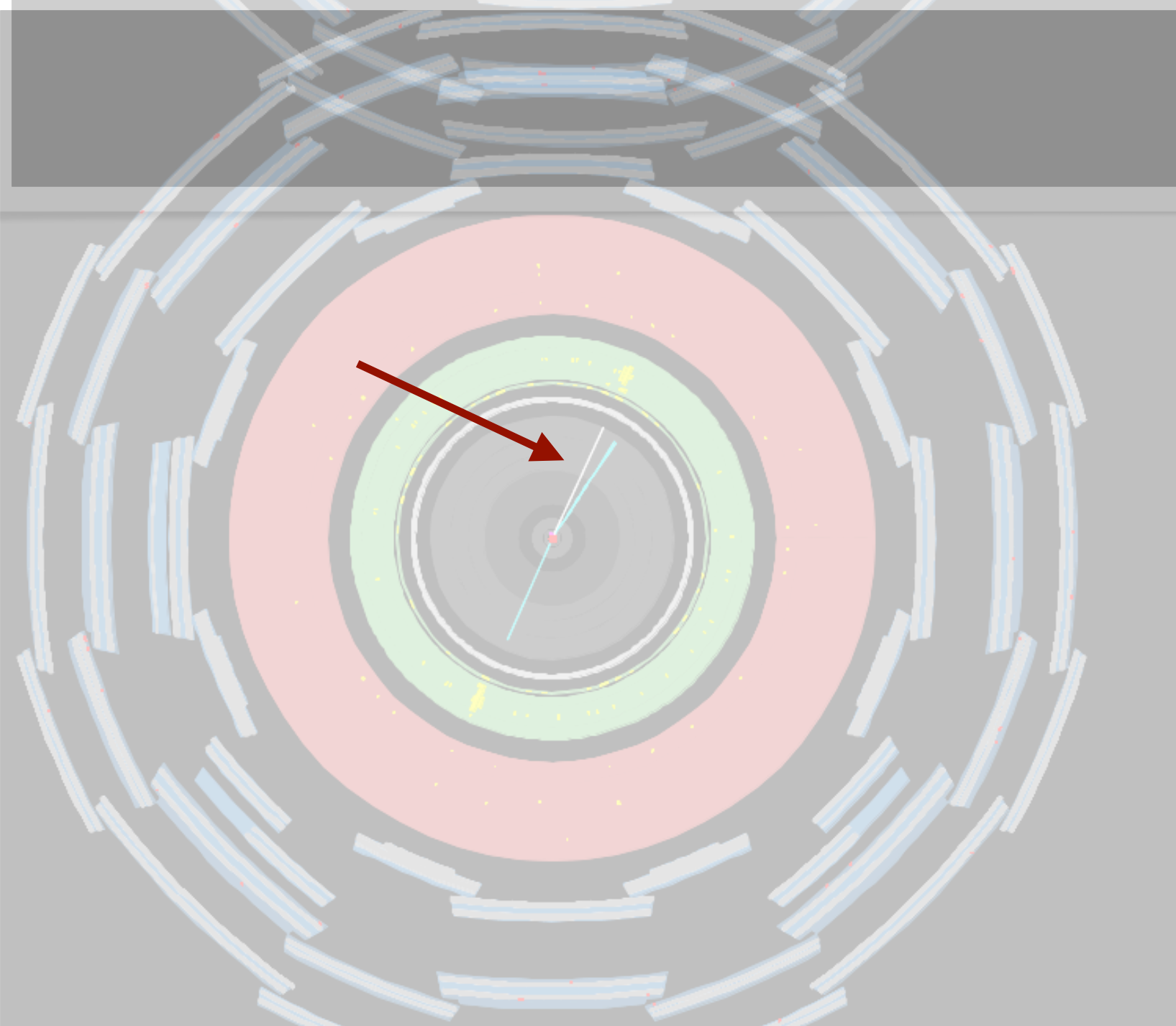
Track	+/-	P [GeV]	Pt [GeV]
Tracks 8	+	47.07	37.95

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

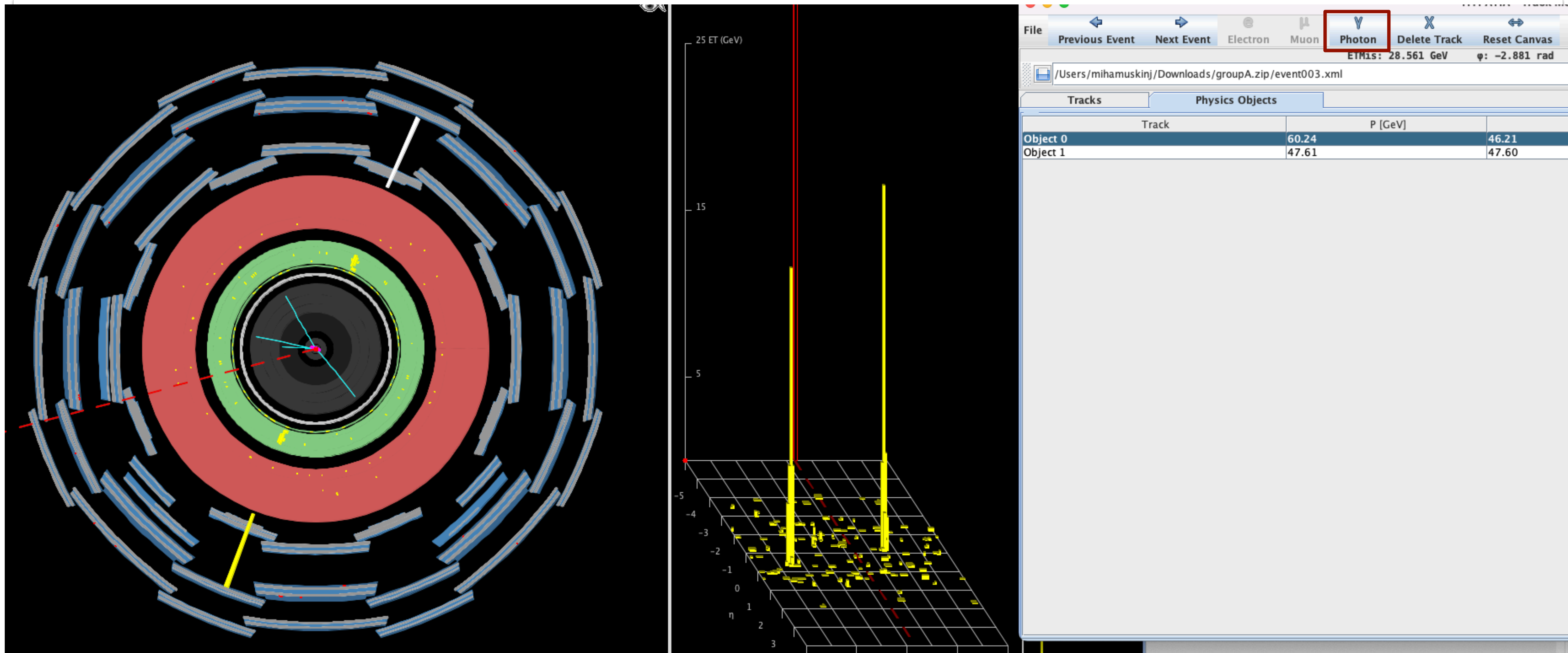
- For photons, need to click on the “**Physics Objects**” tab.

The screenshot displays the Hypathia software interface. On the left is a 2D detector view with concentric rings. The middle panel shows a 3D track visualization with a vertical yellow track and a red track. The right panel shows the 'Physics Objects' tab selected in the 'Tracks' section, with a table of track data.

Track	+/-	P [GeV]
Tracks 380	+	13.76
Tracks 382	+	97.37
Tracks 383	+	19.16
Tracks 389	+	8.22



- 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...

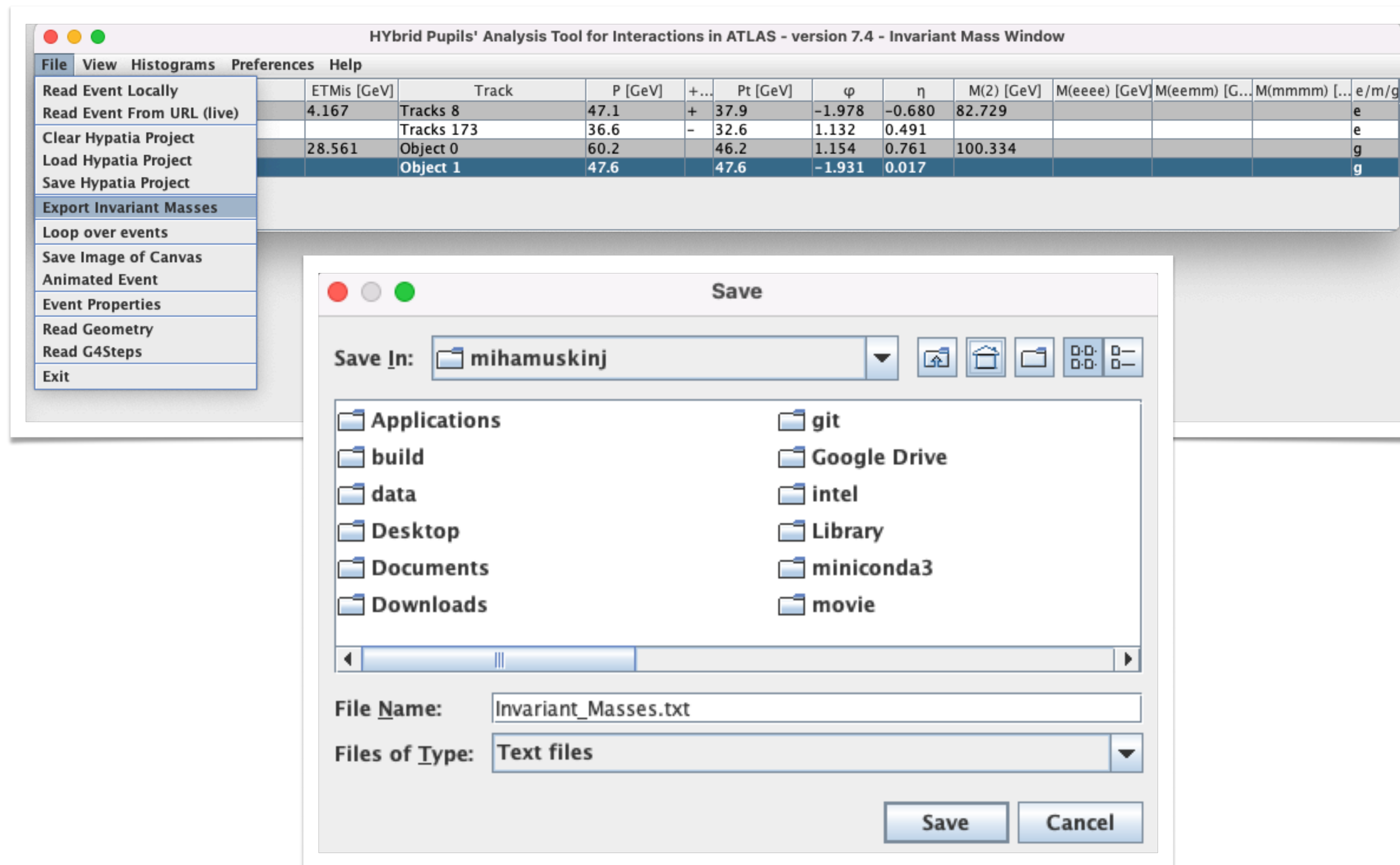
File Name	ETMis [GeV]	Track	P [GeV]	+...	Pt [GeV]	φ	η	M(2) [GeV]
event001.xml	4.167	Tracks 8	47.1	+	37.9	-1.978	-0.680	82.729
event003.xml	28.561	Tracks 173	36.6	-	32.6	1.132	0.491	
		Object 0	60.2		46.2	1.154	0.761	100.334
		Object 1	47.6		47.6	-1.931	0.017	

Probably $H \rightarrow \gamma\gamma$

- 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

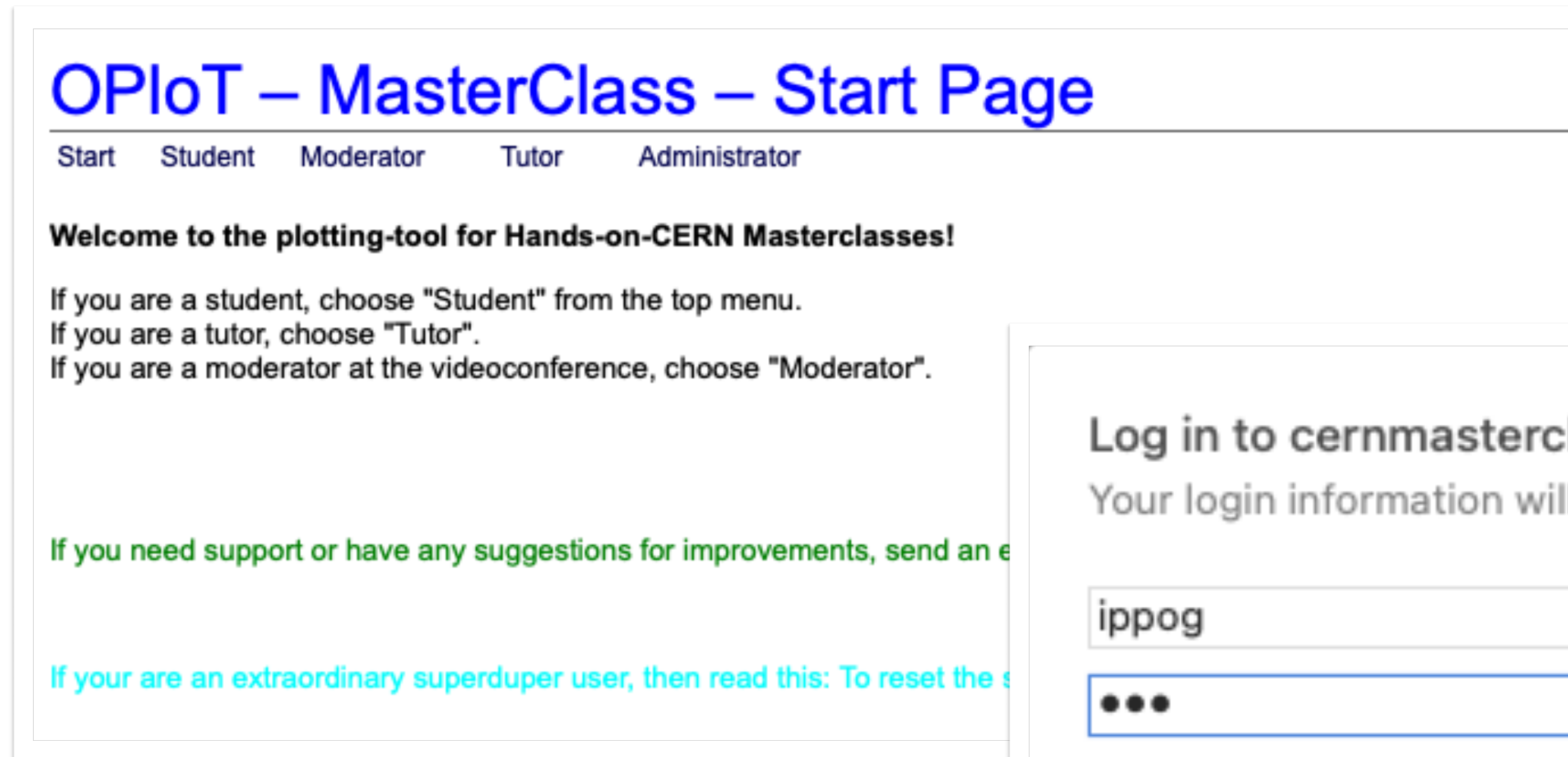
Welcome to the plotting-tool for Hands-on-CERN Masterclasses!

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: cernmasterclass.uio.no/OPIoT-US/OPIoT/index.php
- Upload the data:



OPIoT – MasterClass – Start Page

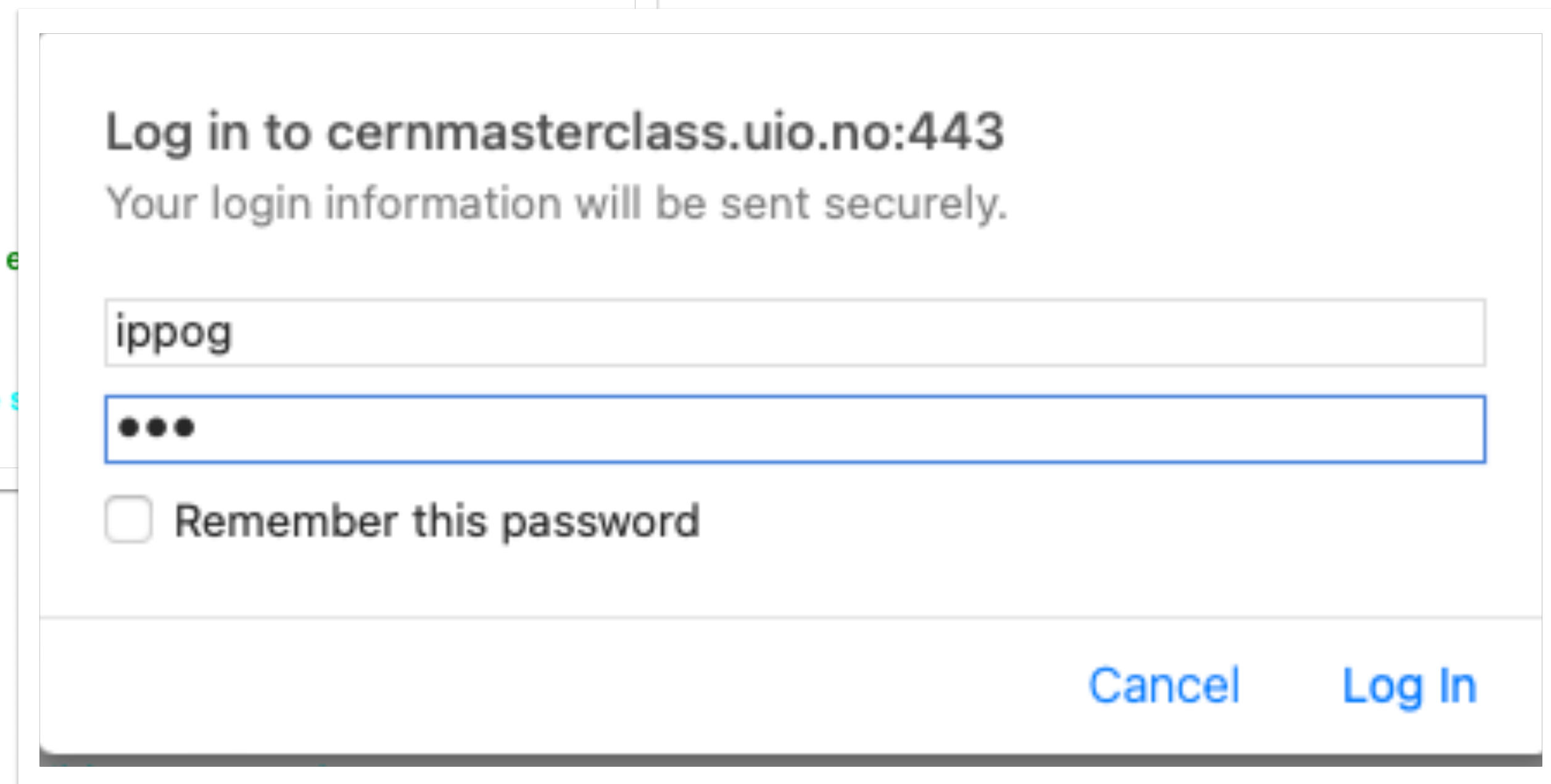
Start Student Moderator Tutor Administrator

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 e-mail to ippog@cern.ch.

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



Log in to cernmasterclass.uio.no:443
Your login information will be sent securely.

ippog

●●●

Remember this password

Cancel Log In

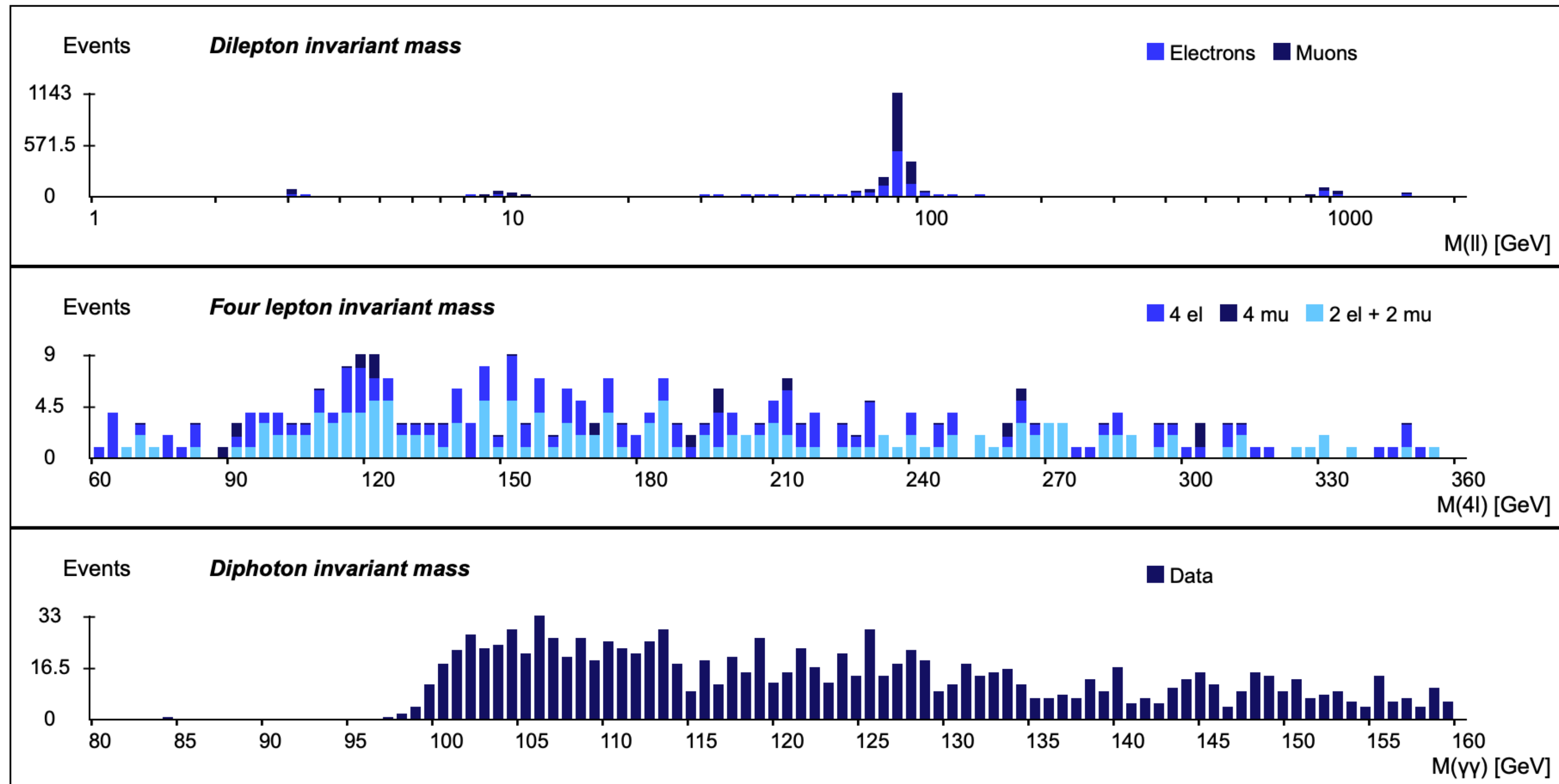
Account: ippog
Password: imc

- Navigate to: <https://zpathweb.hepp.uiocloud.no/OPloT/index.php>
- Upload the data:

The screenshot shows the 'OPloT – MasterClass – Student page'. At the top, there is a navigation menu with links for 'Start', 'Student', 'Moderator', 'Tutor', and 'Administrator'. Below the navigation, the page title is 'OPloT – 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'.

OPlot – MasterClass with CERN – Combination for all institutes on 2023-03-01

Start Student Moderator Tutor Administrator



Plot type:

Dilepton statistics

Region	Electrons			
	R1	R2	R3	R4
Events	93	109	780	104
Mean	3.12	9.47	89.79	997.51
Width	0.49	1.24	3.83	34.30

Region	Muons			
	R1	R2	R3	R4
Events	83	101	964	79
Mean	3.11	9.80	90.66	993.31
Width	0.27	0.73	3.51	53.18

Number of events

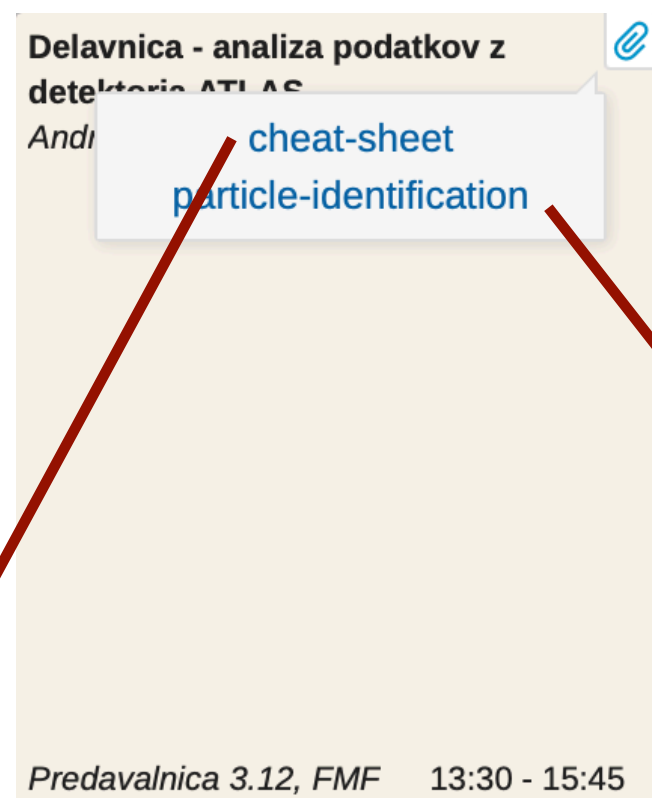
	Student distribution	Expected
ll	3438	3315
4l	425	40
γγ	1184	1530
Sum	5047	4885

Bins:

Update plot

Reset

- For reference:



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)

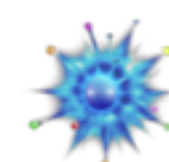
This is:

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

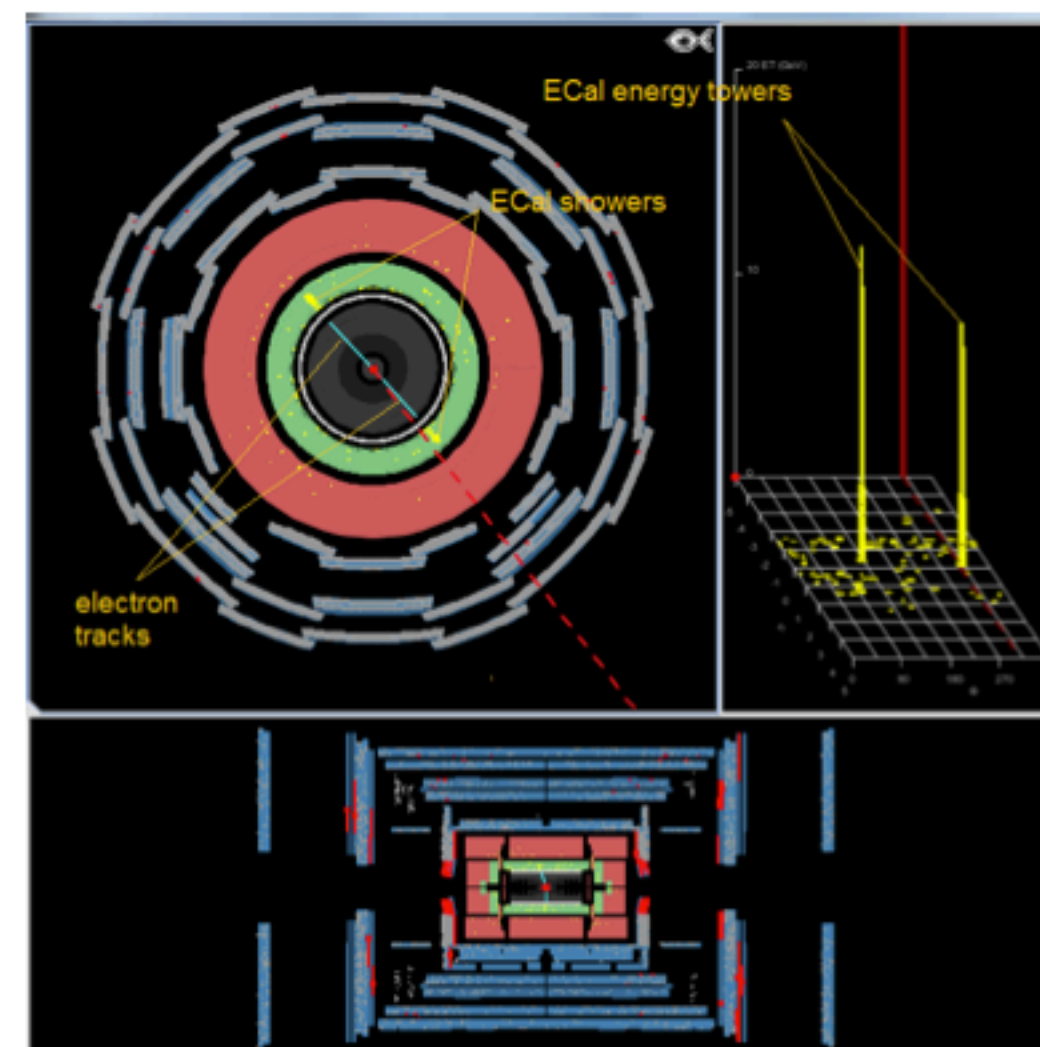
1. Instructions of what to do can be found under the sub-menu items of "Get to work":
 - Get to work→Data samples and tools
 - Get to work→Do it!
 - Get to work→Analyze your result (together with rest of students and tutors)
2. Find and download your data sample - follow instructions found at "Data samples 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



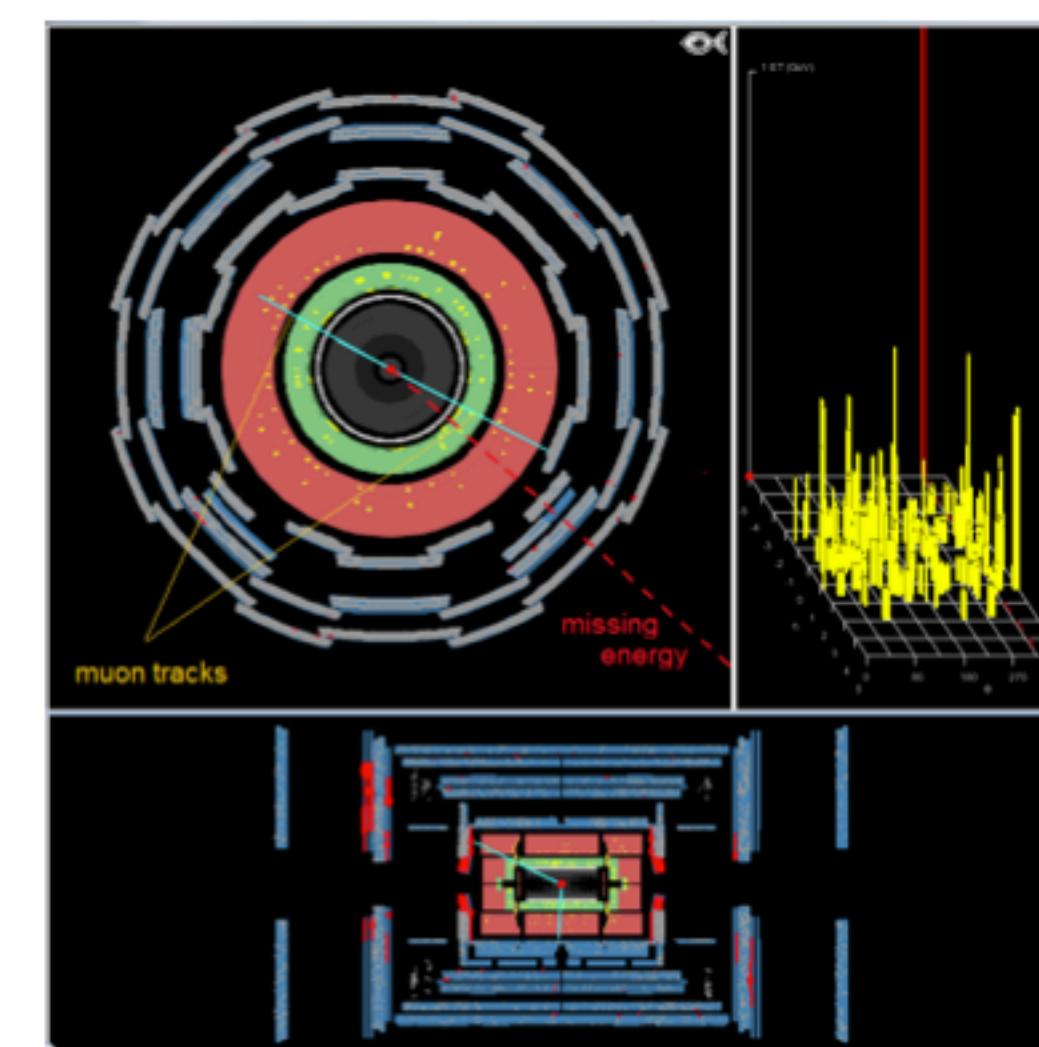
ATLAS Z-path Masterclass "Cheat Sheet"



2-lepton events



Dielectron or e^+e^- event.



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

Backup