

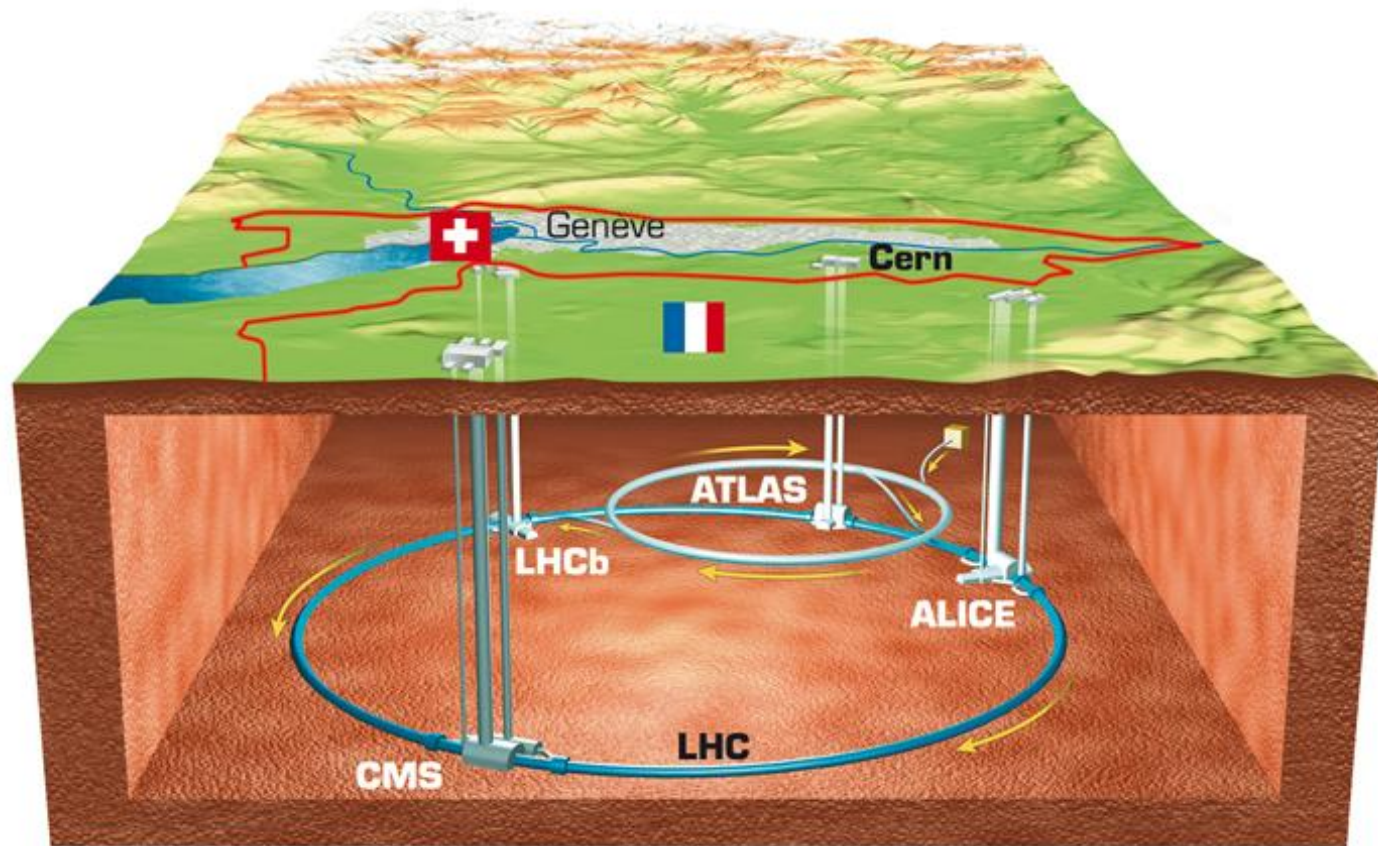
Analisi dei dati con HYPATIA

Masterclass Pisa 2018

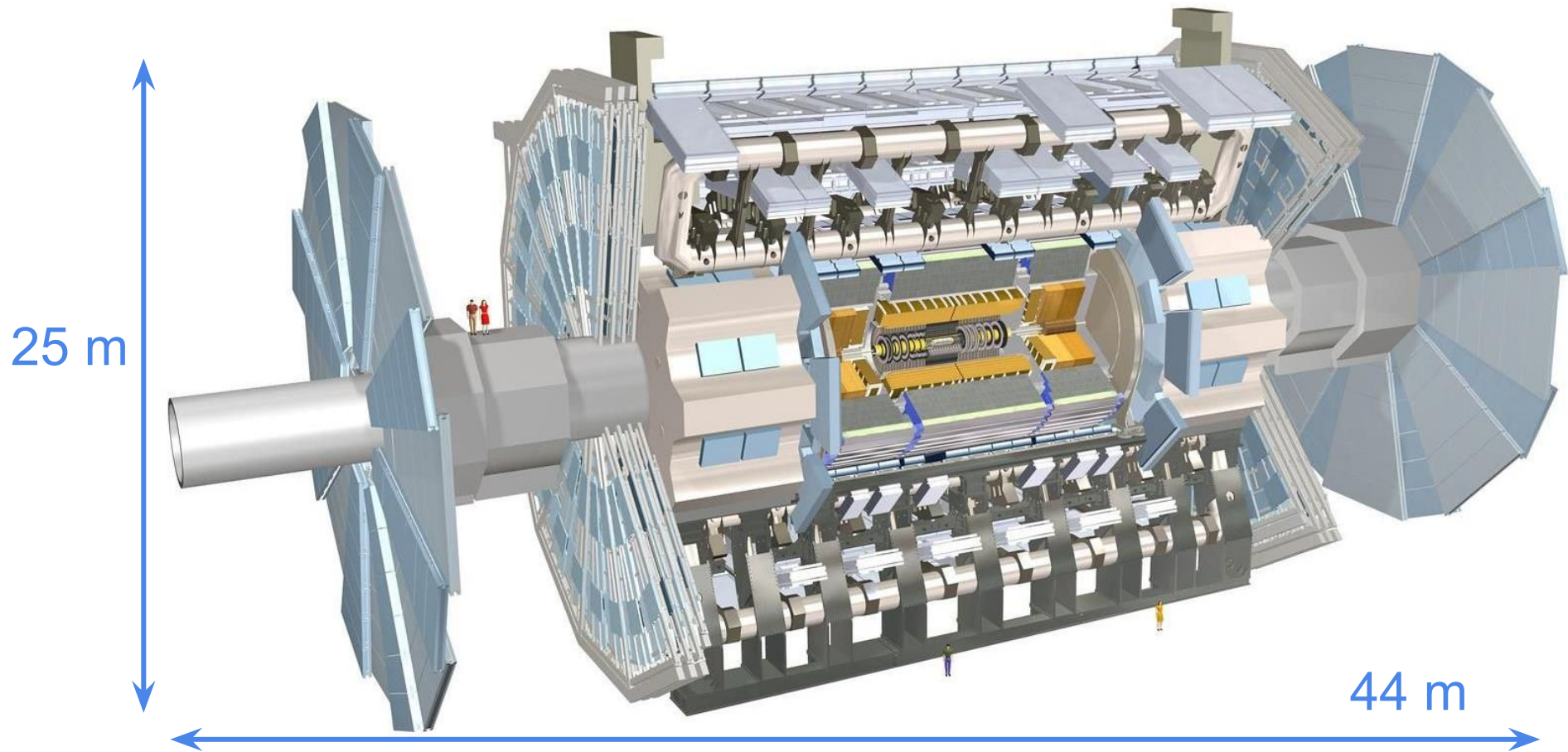
Milène Calvetti e Giulia Di Gregorio

INFN e Università di Pisa

milene.calvetti@cern.ch giulia.di.gregorio@cern.ch

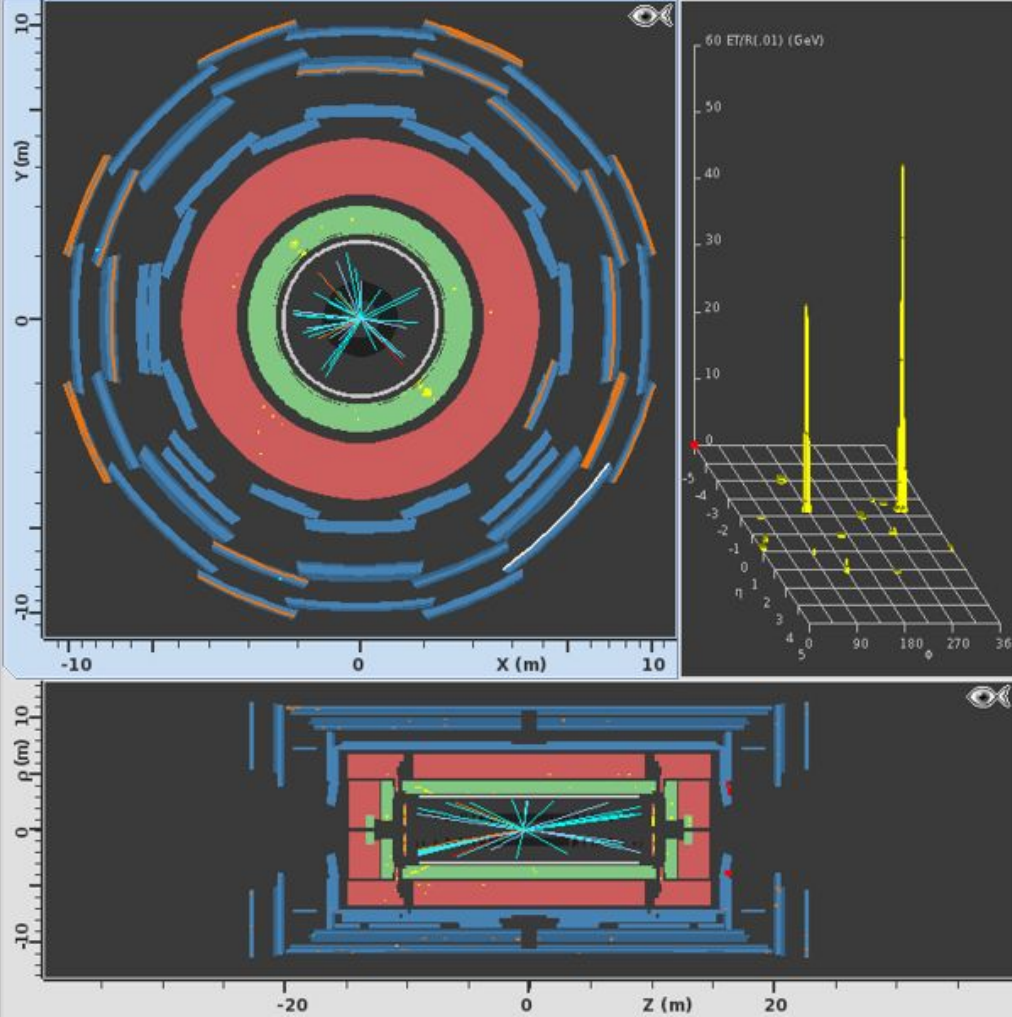
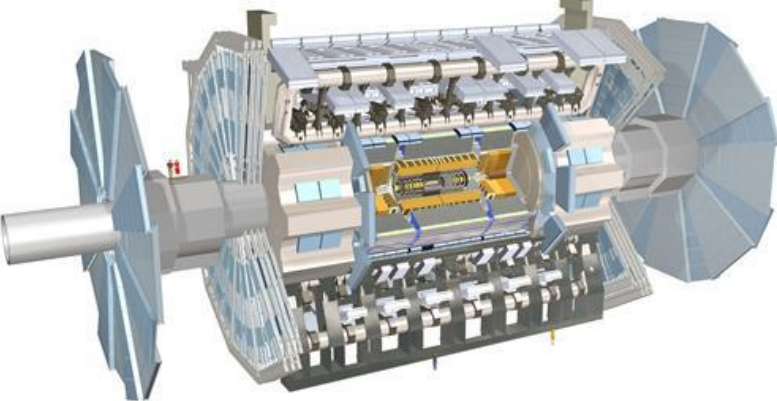


Rivelatore ATLAS

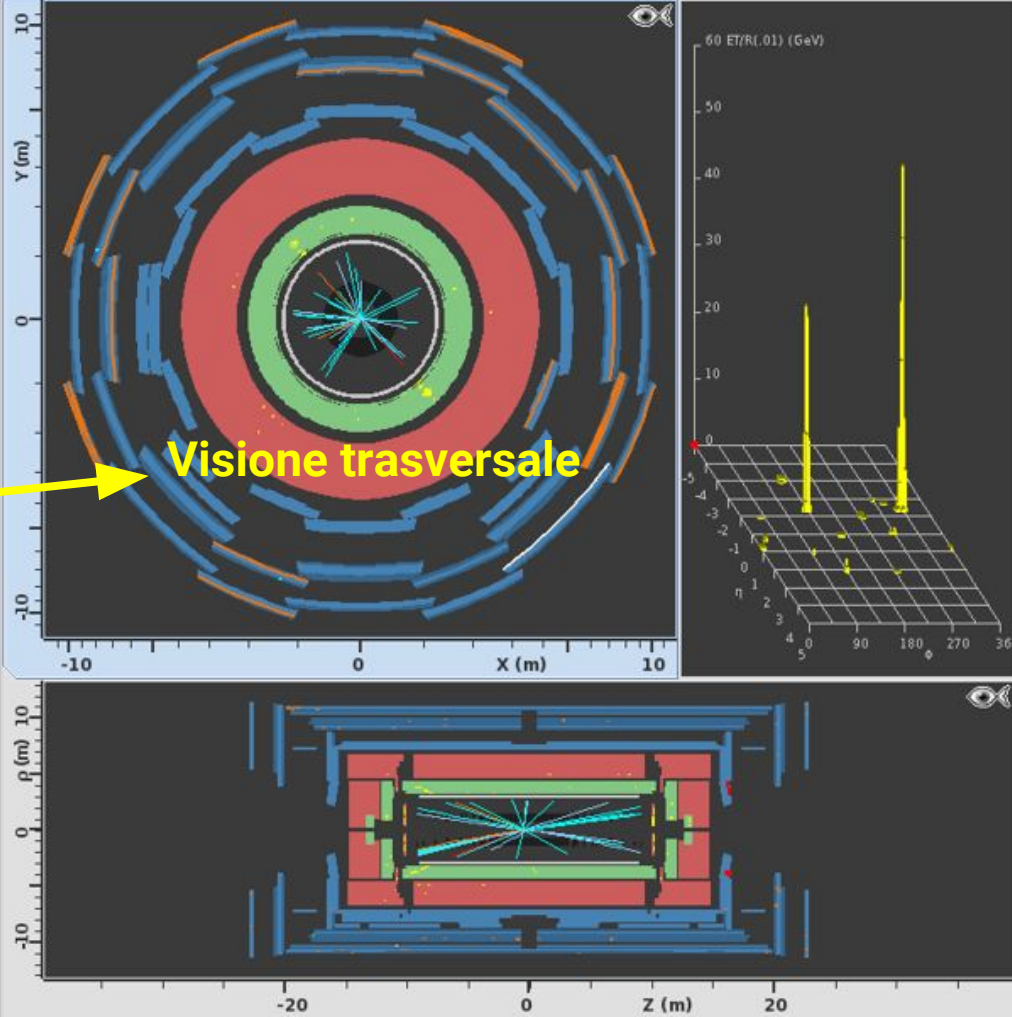
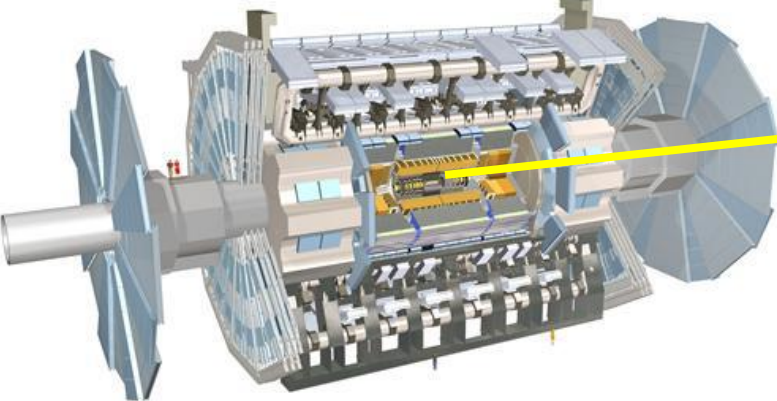




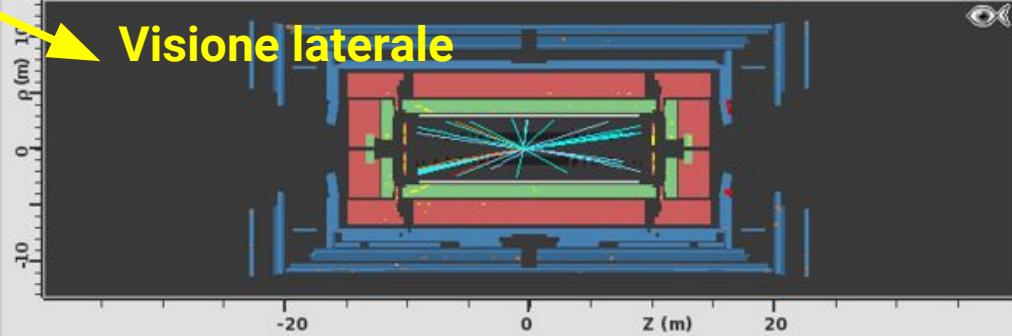
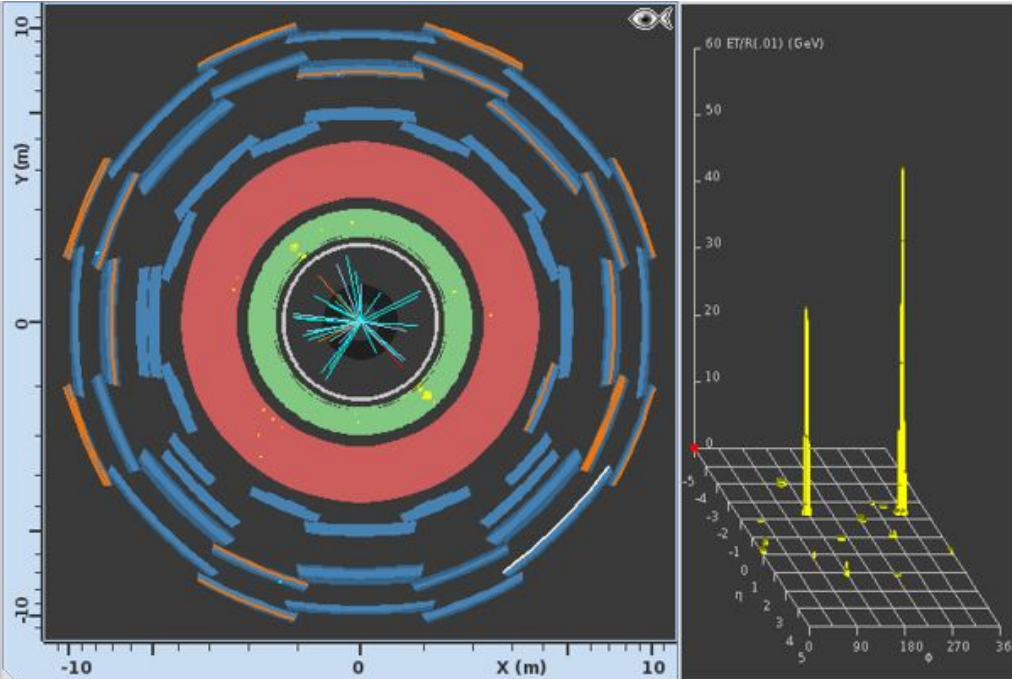
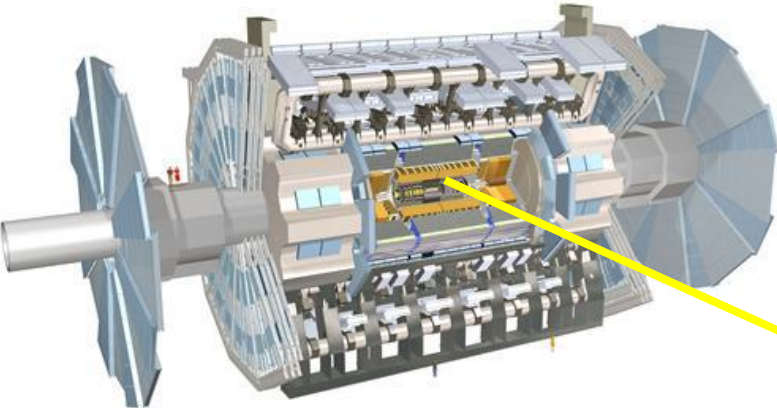
Rappresentare gli eventi



Rappresentare gli eventi



Rappresentare gli eventi



Visione laterale

HYPATIA (Hybrid Pupil's Analysis Tool for Interactions in Atlas)



Ipàzia
(Ὑπατία, Alessandria d'Egitto,
355/370 - 415)

The screenshot displays the HYPATIA software interface with several key components:

- Top Left:** Event information: ATLAS 2010-09-24 07:01:05 CEST source:jiveXML_165632_82716614 HYPATIA
- Top Right:** Navigation and event details. Previous Event: ETMIs: 7.384 GeV, ϕ : 2.227 rad, Collection: MET RefFinal. File path: masterClass/zpath/Els/jiveXML_165632_82716614.xml
- Center Left:** 2D view of the ATLAS detector cross-section with tracks overlaid. The vertical axis is labeled "ETR(.01) (GeV)" with values from 0 to 60.
- Center Right:** 3D view of the detector cross-section with tracks overlaid.
- Bottom Left:** Longitudinal view of the detector with tracks overlaid. The horizontal axis is labeled "Z (m)" with values from -20 to 20.
- Bottom Right:** "Reconstructed Tracks" table and "HYPATIA - Control Window".

Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 15	+	1.32	119	0.728	1.126
Tracks 23	+	1.81	181	-3.046	1.513
Tracks 24	+	1.64	163	-1.903	1.695
Tracks 26	+	5.08	153	-0.616	2.835
Tracks 30	+	2.19	127	-2.001	2.526
Tracks 31	+	6.86	121	2.569	0.177
Tracks 32	+	1.58	155	1.978	1.766
Tracks 34	-	5.41	181	-3.037	2.801
Tracks 36	-	10.23	205	1.480	2.940
Tracks 40	+	4.73	145	-2.665	2.830
Tracks 54	-	60.96	33.55	2.296	2.559

HYPATIA - Control Window

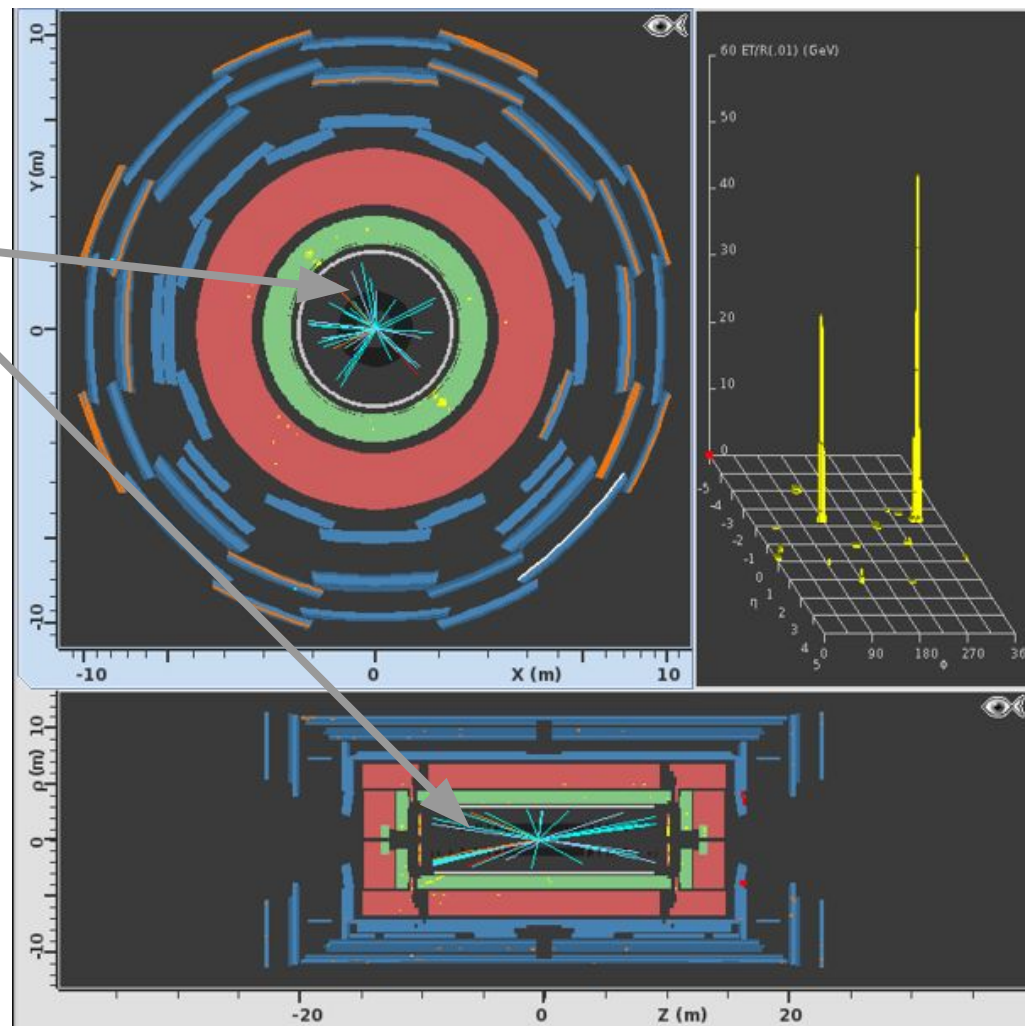
Interaction and Window Control | Output Display

Parameter Control

InDet	Calo	MuonDet	Objects	Geometry
			<input checked="" type="checkbox"/> Pt	> 1.0 GeV
			<input checked="" type="checkbox"/> d0	< 6.5 mm
			<input checked="" type="checkbox"/> z0	< 25.0 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	>= 30
			<input type="checkbox"/> Sim. Particle PDG-ID	< 40
			<input type="checkbox"/> Sim. Particle Barcode	= 0
			<input type="checkbox"/> Sim. Particle Type	charged hadron

Event display

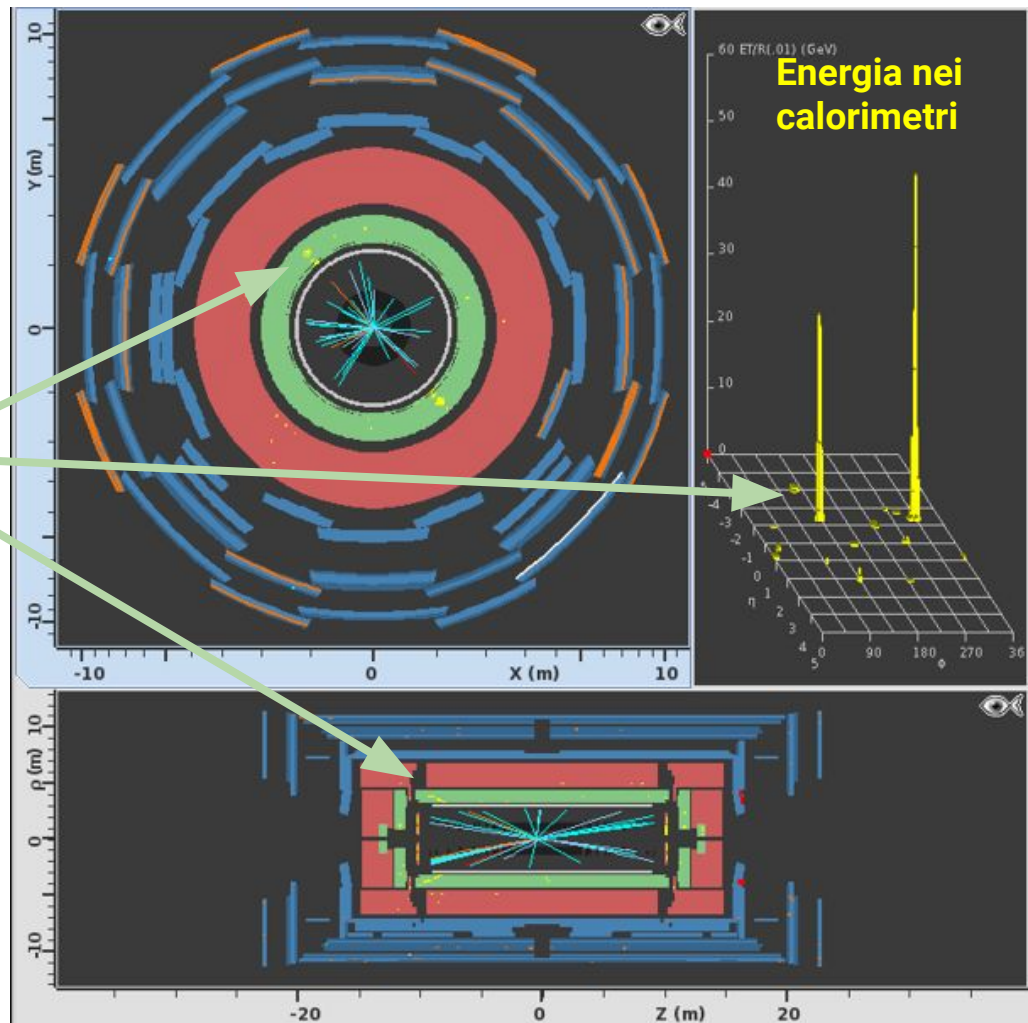
Tracciatore:
particelle cariche



Event display

Tracciatore:
particelle cariche

Calorimetro elettromagnetico:
elettroni (e^-), positroni (e^+) e
fotoni.

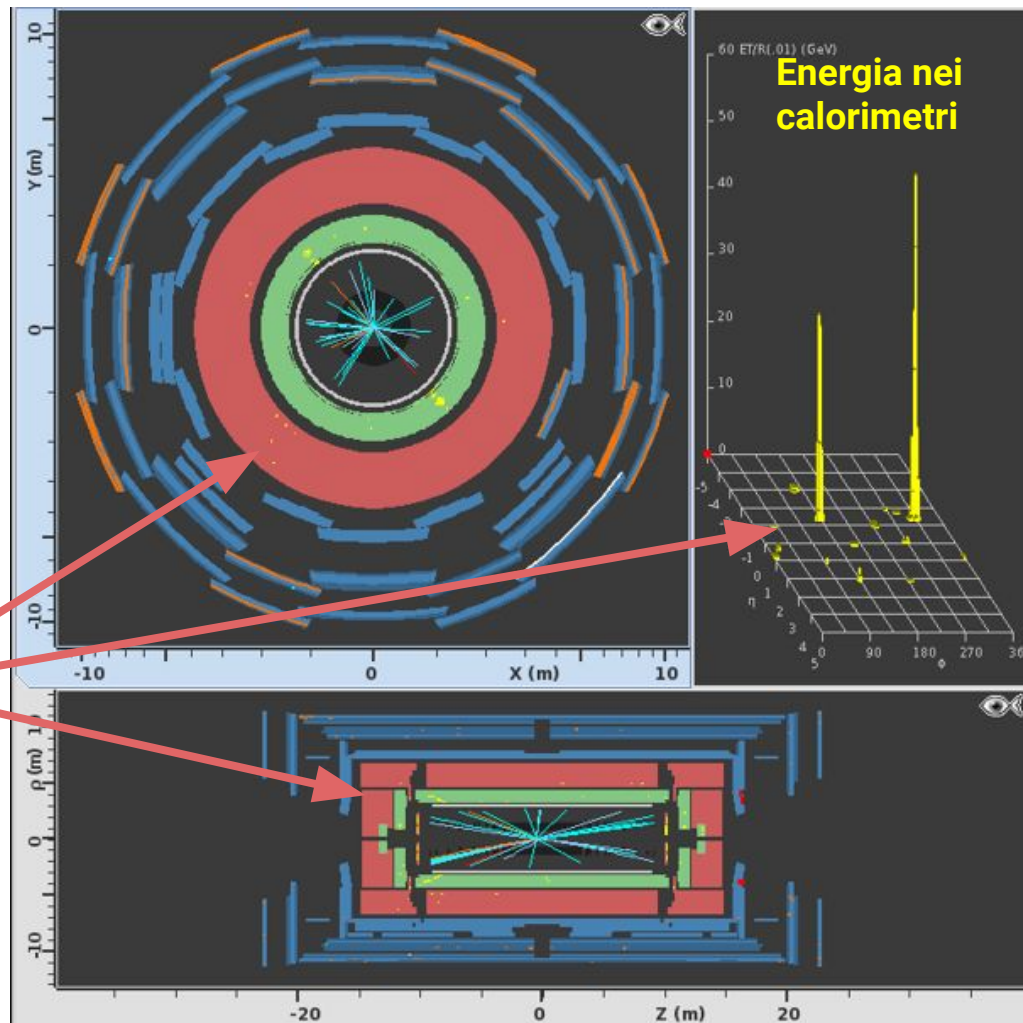


Event display

**Tracciatore:
particelle cariche**

**Calorimetro elettromagnetico:
elettroni (e^-), positroni (e^+) e
fotoni.**

**Calorimetro adronico: adroni
(es: protoni, neutroni)**



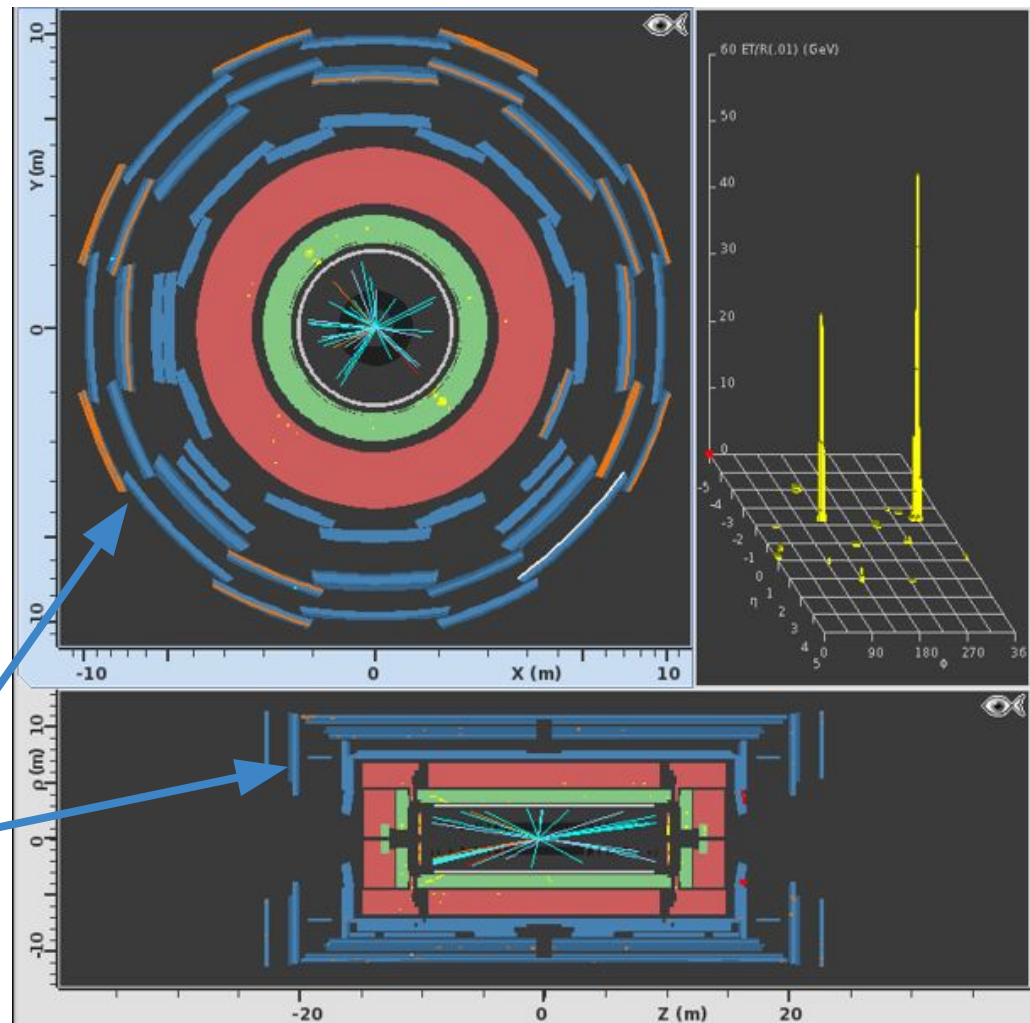
Event display

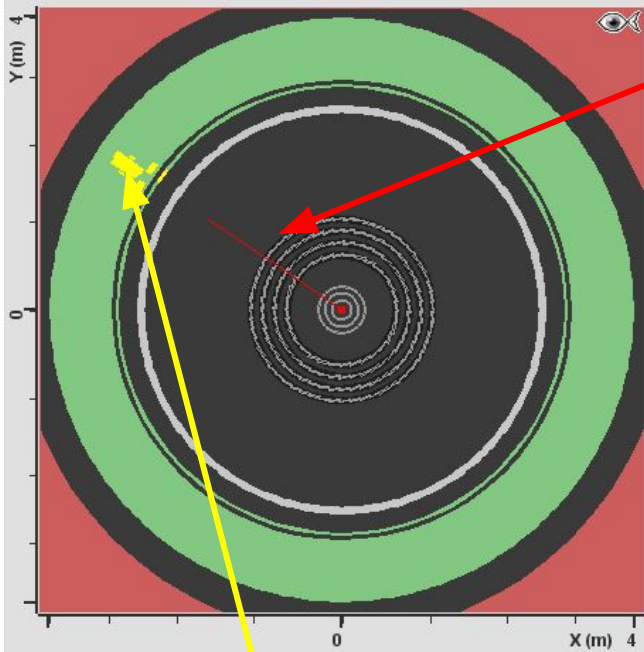
**Tracciatore:
particelle cariche**

**Calorimetro elettromagnetico:
elettroni (e^-), positroni (e^+) e
fotoni.**

**Calorimetro adronico: adroni
(es: protoni, neutroni)**

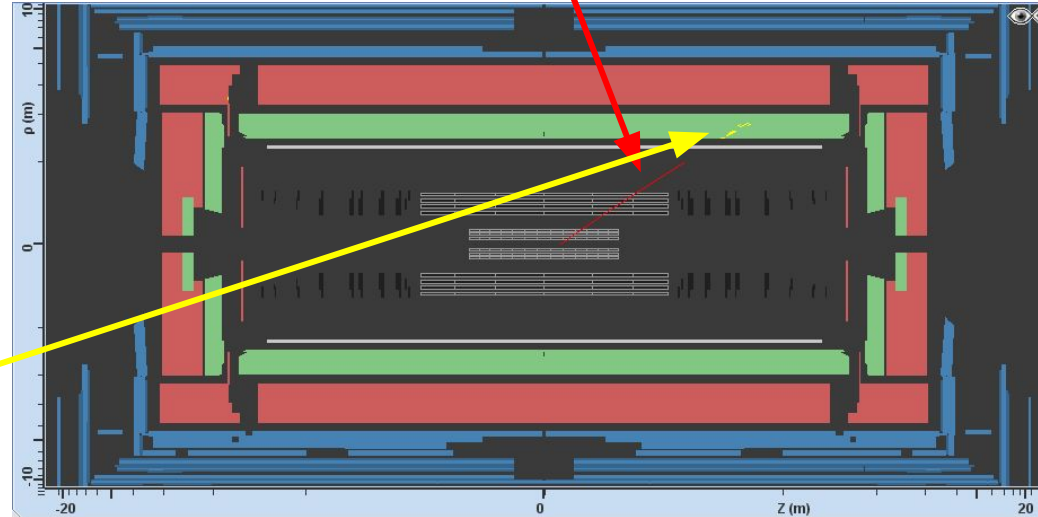
Rivelatori muoni



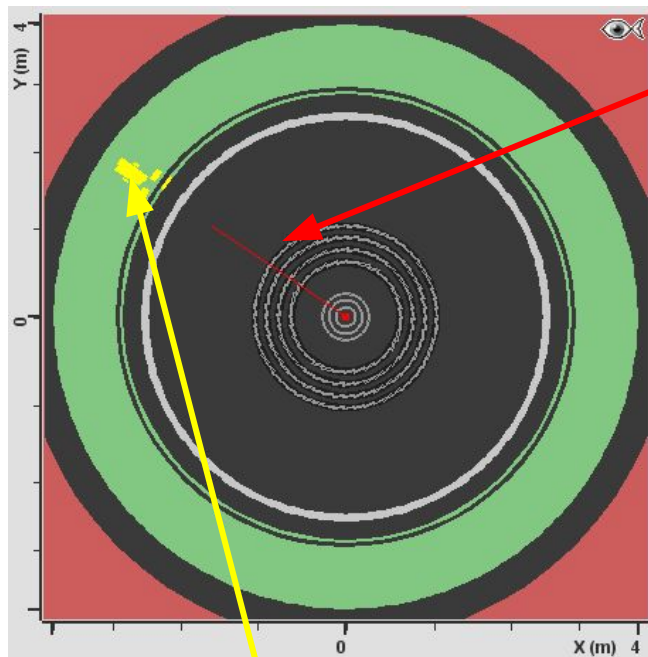


Traccia nel **tracciatore interno**

Energia nel **calorimetro elettromagnetico**

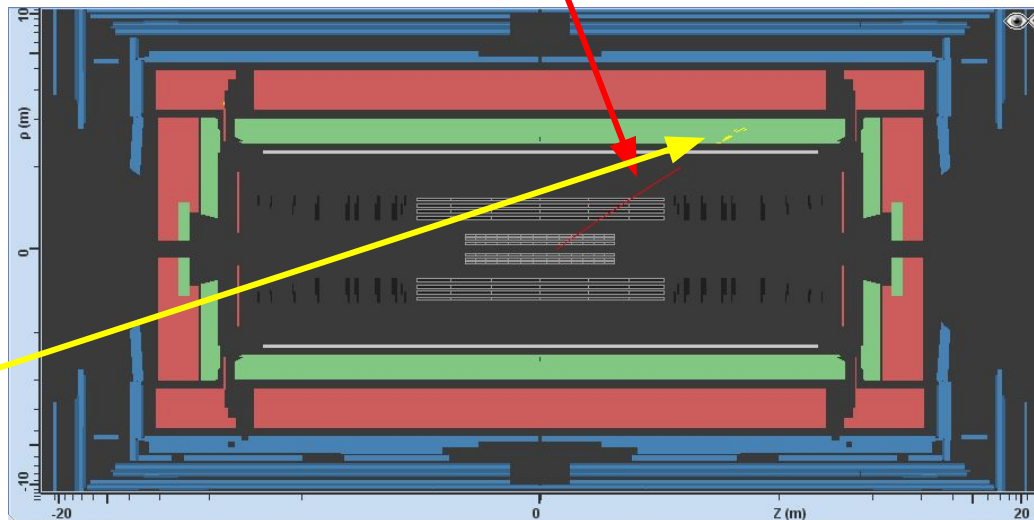


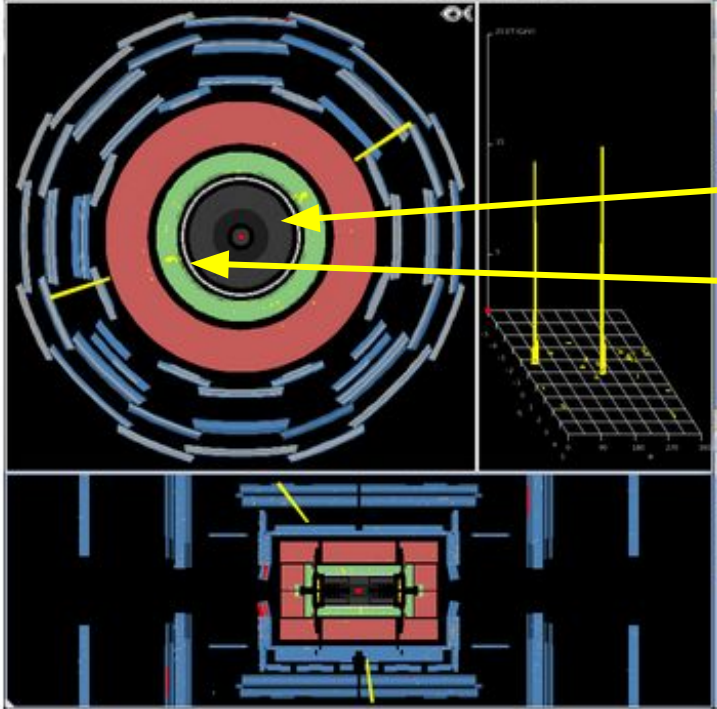
Identificazione elettroni (e^-) e positroni (e^+)



Traccia nel **tracciatore interno**

Energia nel **calorimetro elettromagnetico**

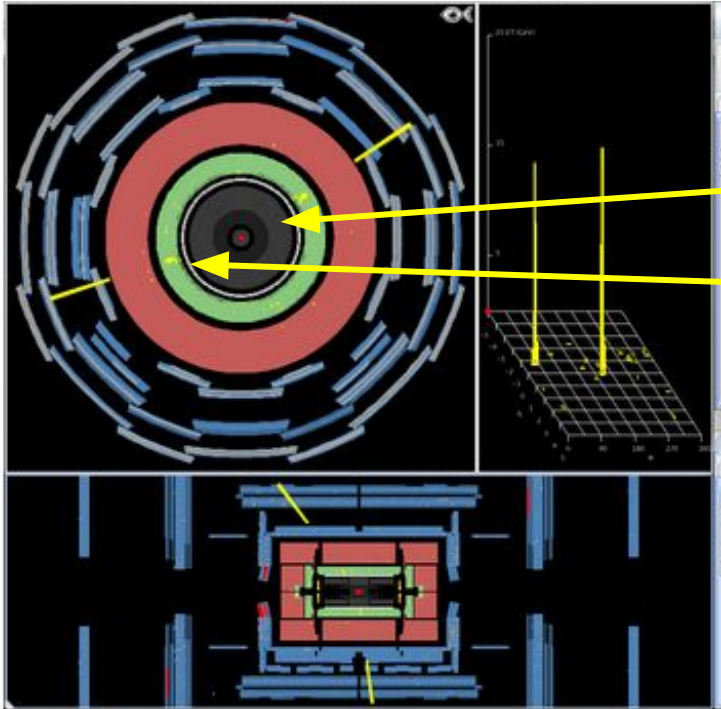




Neutri → non lasciano tracce nel **tracciatore**

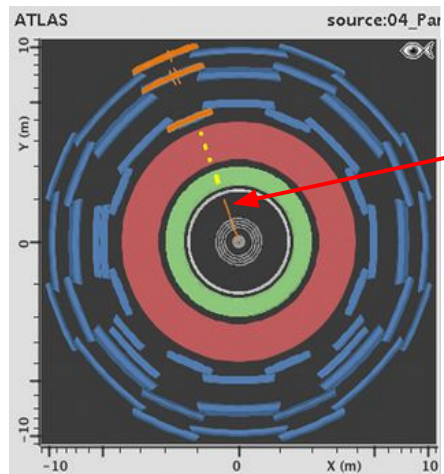
Solo nel **calorimetro elettromagnetico**

Identificazione fotoni

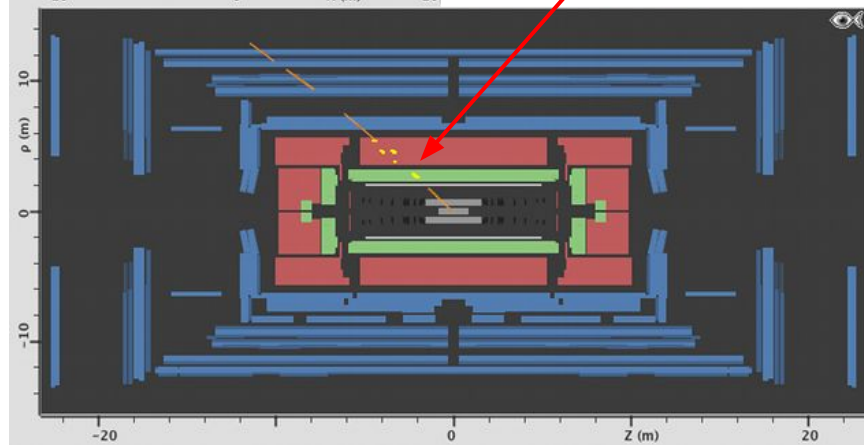


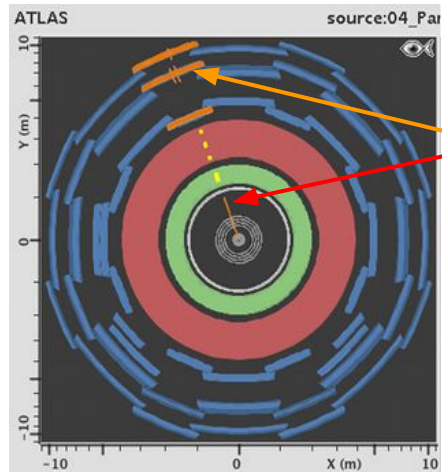
Neutri → non lasciano tracce nel **tracciatore**

Solo nel **calorimetro elettromagnetico**



Traccia nel **tracciatore interno**

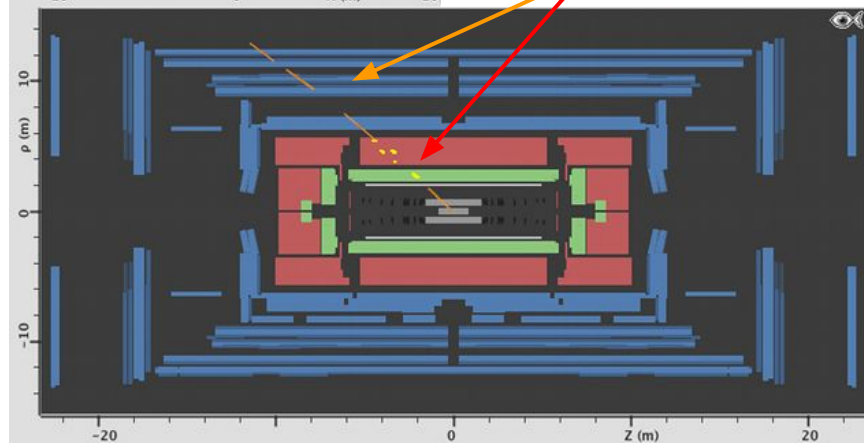




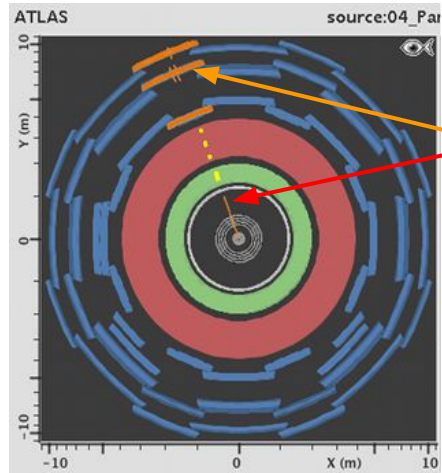
Traccia nel **tracciatore interno**

Traccia nel **rivelatore di muoni**

Poca attività nel **calorimetro
elettromagnetico e adronico**

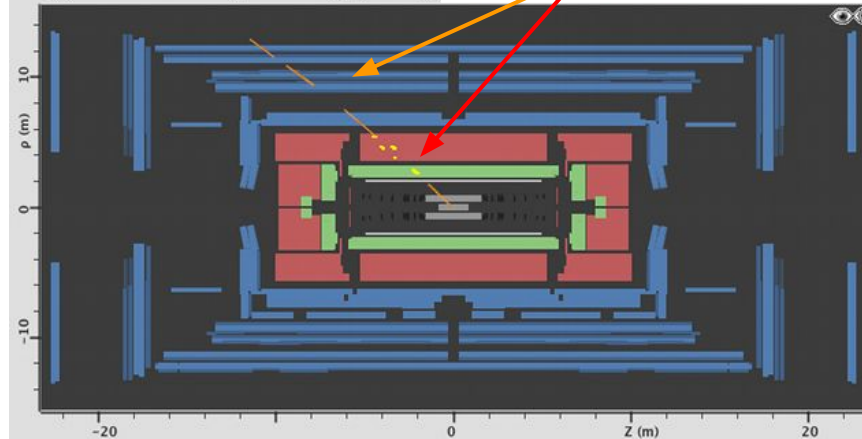


Identificazione muoni (μ^-) e antimuoni (μ^+)



Traccia nel **tracciatore interno**

Traccia nel **rivelatore di muoni**

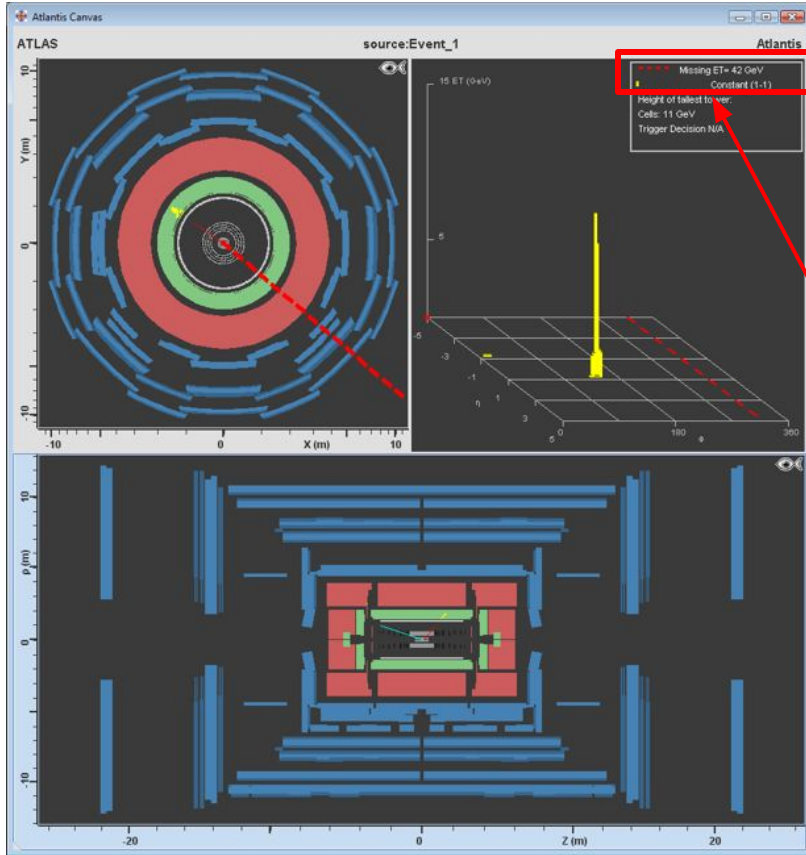


Poca attività nel **calorimetro
elettromagnetico** e **adronico**

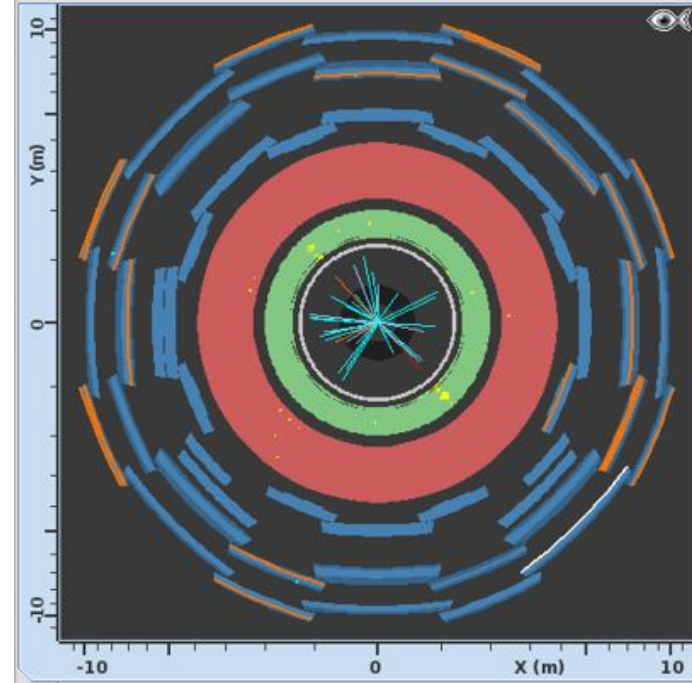
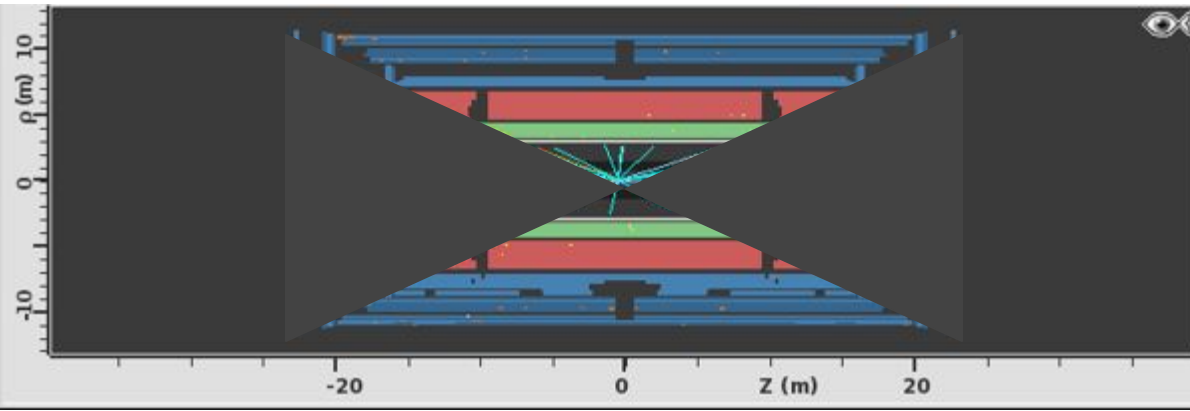
Identificazione neutrini

Trovati dal calcolo dell' **“impulso mancante”** sul piano trasverso

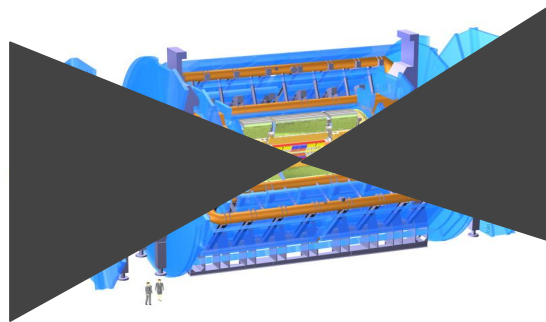
Valore dell'impulso del neutrino (Missing ET)



Event display



Solo le particelle ricostruite nella regione centrale sono visibili nella visione trasversale



HYPATIA - Track Momenta Window

Previous Event Next Event Insert Electron Insert Muon Delete

ETHis: 7.384 GeV ϕ : 2.227 rad Collection: MET ReFFinal

masterClass/zpath/Els/jiveXML_165632_82716614.xml

Reconstructed Tracks

Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 15	+	1.32	1.19	0.728	1.126
Tracks 23	+	1.81	1.81	-3.046	1.513
Tracks 24	+	1.64	1.63	-1.903	1.695
Tracks 26	+	5.08	1.53	-0.616	2.835
Tracks 30	+	2.19	1.27	-2.001	2.526
Tracks 31	+	6.86	1.21	2.569	0.177
Tracks 32	+	1.58	1.55	1.978	1.766
Tracks 34	-	5.41	1.81	-3.037	2.801
Tracks 36	-	10.23	2.05	1.480	2.940
Tracks 40	+	4.73	1.45	-2.665	2.830
Tracks 54	-	60.96	33.55	2.296	2.559

Particelle selezionate



Interaction and Window Control Output Display

Parameter Control

InDet Calo MuonDet Objects Geometry

Projection Data Cuts

	Name	Value
<input checked="" type="checkbox"/>	Pt	> 1.0 GeV
<input checked="" type="checkbox"/>	d0	< 6.5 mm
<input checked="" type="checkbox"/>	z0	< 25.0 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	>= 30
<input type="checkbox"/>	Sim. Particle PDG-ID	< 40
<input type="checkbox"/>	Sim. Particle Barcode	= 0
<input type="checkbox"/>	Sim. Particle Type	skipped hadron

Tagli sull'impulso



Selezione degli eventi

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

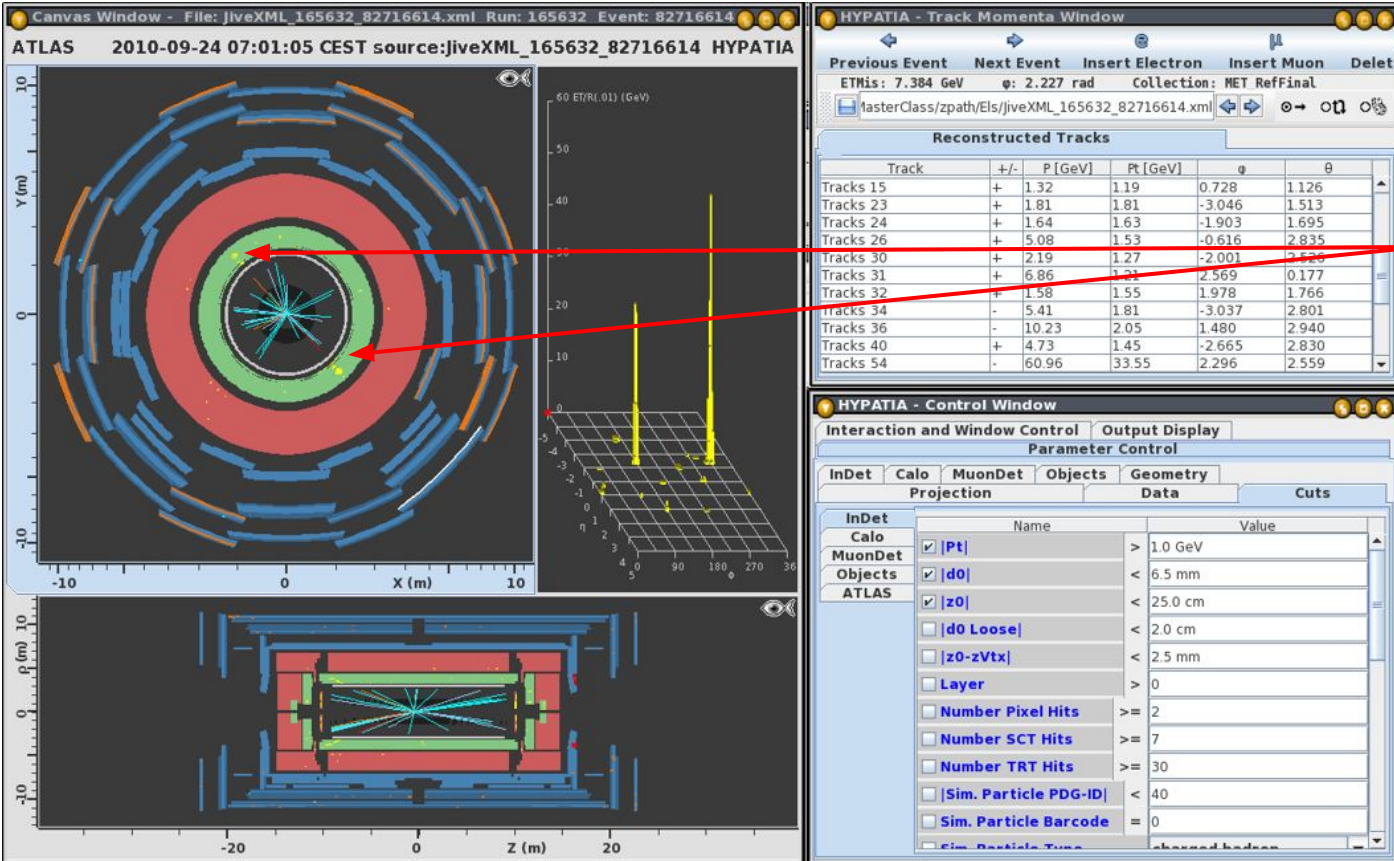
Tagli: criteri di selezione degli eventi

Zoom/Move/Rotate

Mostra informazioni per l'oggetto selezionato

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

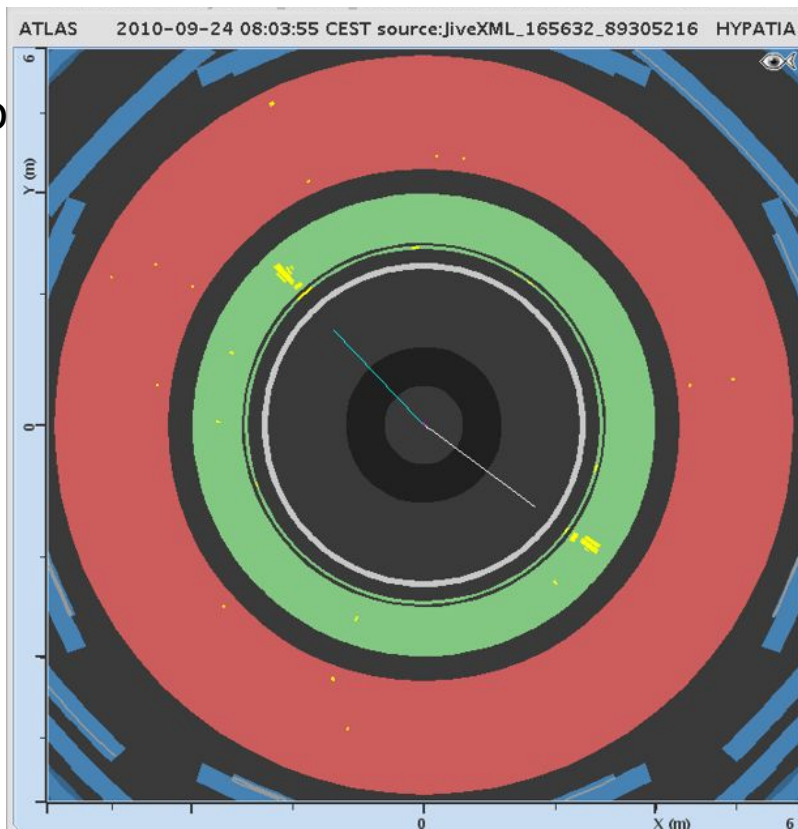
Il bosone Z è **neutro**.



Elettrone e positrone

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

Taglio sull'impulso
 $p_T > 25 \text{ GeV}$



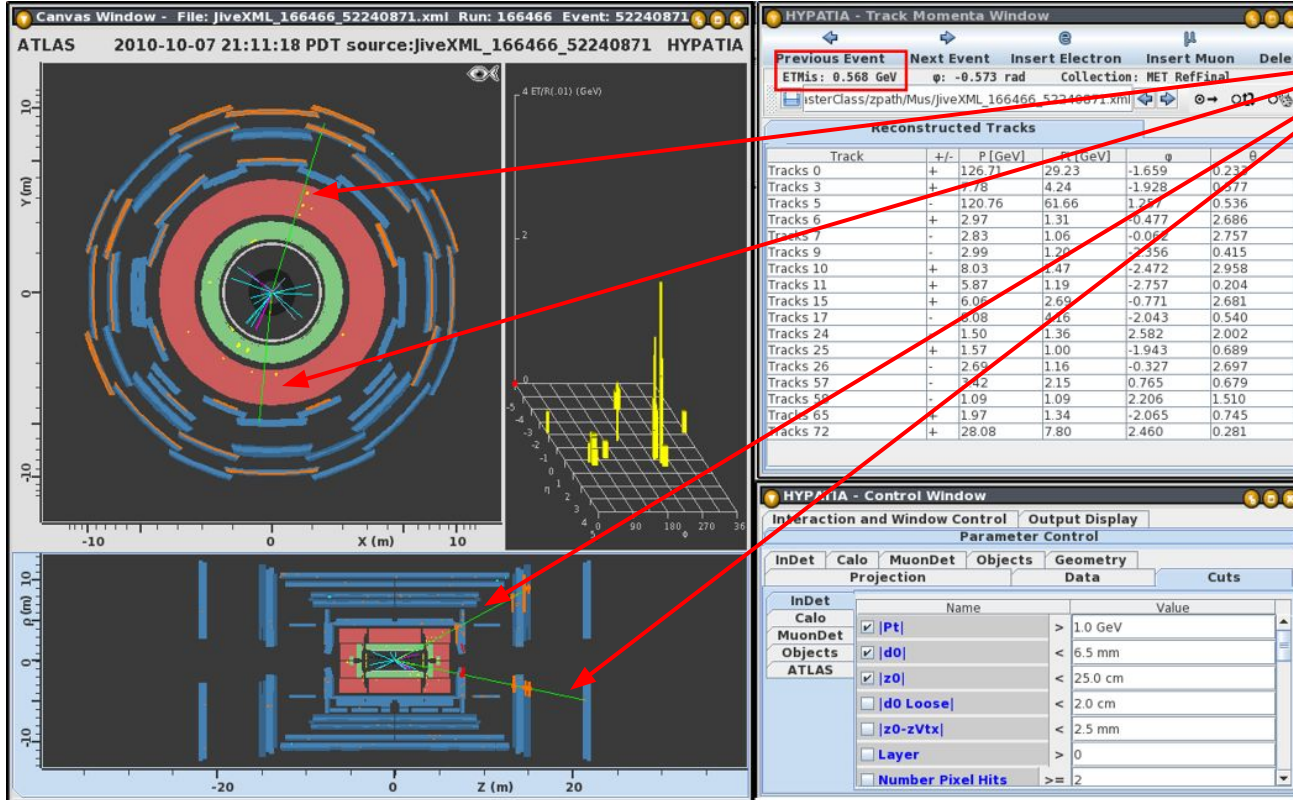
Previous Event Next Event Insert Electron Insert Muon Delete Track Reset Can
BTMIs: 0.663 GeV ϕ : -0.317 rad Collection: MET_RefFinal
/dns/xml/user.maikenp.Zpath.Els/jiveXML_165632_89305216.xml

Reconstructed Tracks						
Track	+/-	P [GeV]	Pt [GeV]	ψ	θ	
Tracks 1	+	51.94	46.66	2.336	2.288	
Tracks 72	-	33.25	31.18	-0.642	1.216	

Carica positiva: positrone

Carica negativa: elettrone

$$Z \rightarrow \mu^- \mu^+$$



Muone e anti-muone

Cosa fare

Se pensi di aver visto una delle particelle sopra elencate, click sulla particella corrispondente

HYPATIA - Track Momenta Window

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

ETMis: 13.877 GeV ϕ : 0.785 rad Collection: MET_RefFinal

events\events4.zip\JiveXML_106051_1950731.xml

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

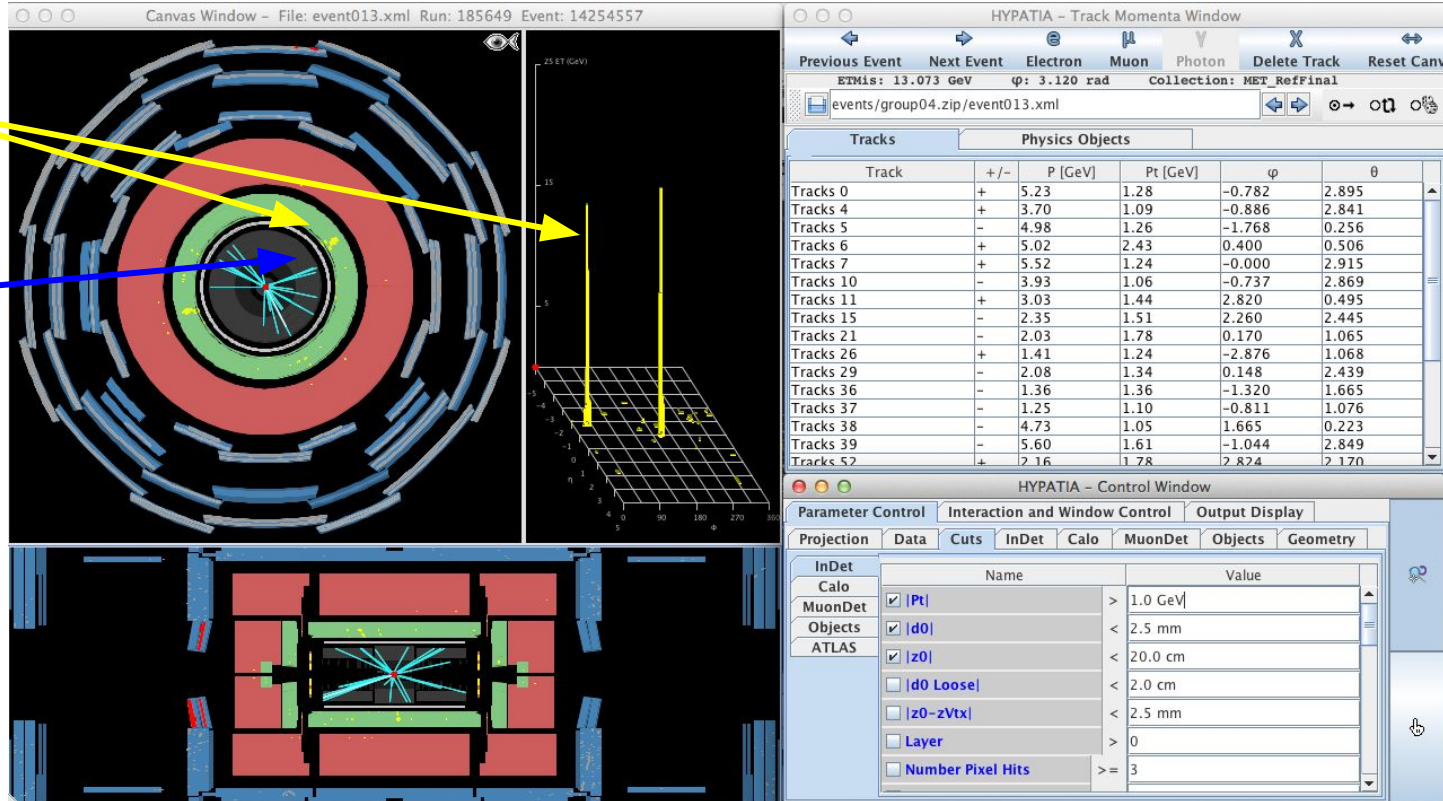
Hybrid Pupils' Analysis Tool for Interactions in ATLAS - version 7.4 - Invariant Mass Window

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	ϕ	η	M(2) [GeV]	M(eeee) [GeV]	M(eemm) [GeV]	M(mmmm) [GeV]	e/m/g
JiveXML_106051_1950731.xml	13.877	Tracks 1	126.1	+	39.4	-2.413	1.830					m

Higgs \rightarrow fotone - fotone

Energia nel
calorimetro
elettromagnetico

No tracce vicino ai
depositi \rightarrow non
sono elettroni



Higgs → fotone - fotone

Applicando un taglio $p_T > 5$ GeV non vedo più le tracce nel tracciatore

I fotoni sono fra i "Physics Objects"

The image displays the HYPATIA software interface, which is used for particle physics simulation and analysis. It is divided into several windows:

- Canvas Window:** Shows a top-down view of the ATLAS detector simulation. The central region is highlighted in red and green. Two yellow arrows point to the inner detector layers. A 3D plot on the right shows the detector geometry with two vertical yellow lines representing photon paths.
- HYPATIA - Track Momenta Window:** Displays a table of physics objects. The "Physics Objects" tab is selected and highlighted with a red box. The table contains the following data:

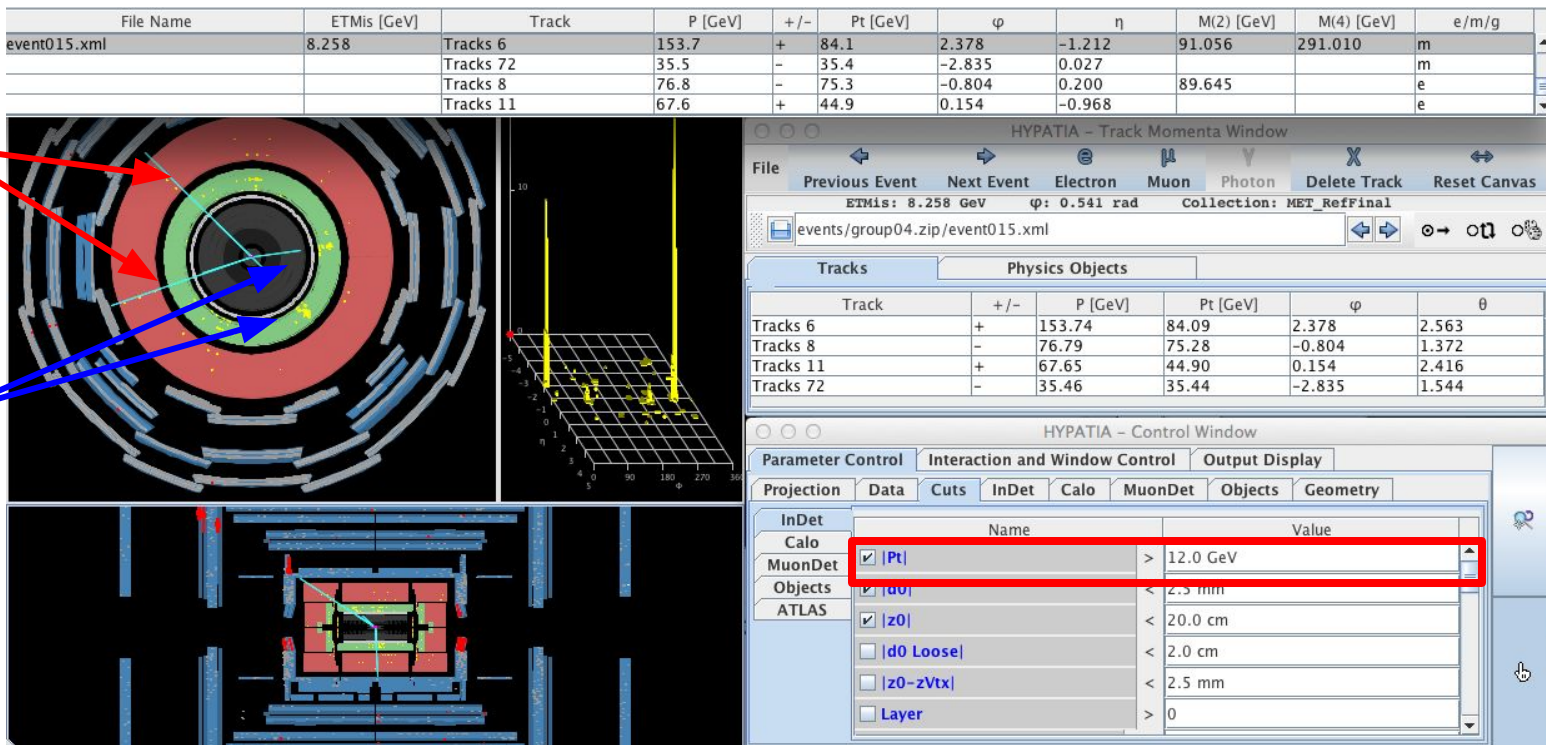
Track	P [GeV]	Pt [GeV]	φ	θ
Object 0	49.03	48.71	-2.834	1.456
Object 1	67.27	54.15	0.588	2.206

- HYPATIA - Control Window:** Shows the "Parameter Control" section with various detector components and their associated parameters. The "Objects" section is expanded, showing the following parameters:

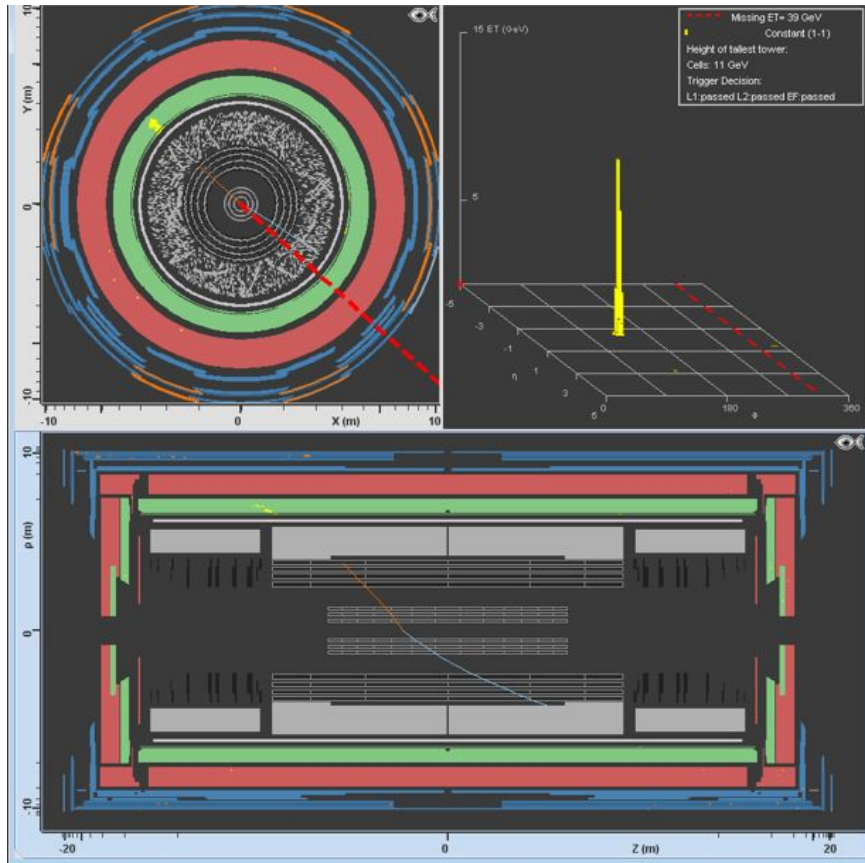
Component	Name	Value
Calo		
MuonDet	<input checked="" type="checkbox"/> Pt	> 5.0 GeV
Objects	<input checked="" type="checkbox"/> d0	< 2.5 mm
ATLAS	<input checked="" type="checkbox"/> z0	< 20.0 cm
	<input type="checkbox"/> d0 Loose	< 2.0 cm
	<input type="checkbox"/> z0-zVtx	< 2.5 mm
	<input type="checkbox"/> Layer	> 0
	<input type="checkbox"/> Number Pixel Hits	>= 3

Higgs \rightarrow 4 particelle cariche (es: $H \rightarrow e^+ e^- \mu^+ \mu^-$)

Il bosone H è **neutro**.



Fondo: $W \rightarrow e\nu$



Riconoscere $W \rightarrow e\nu$ (o $W \rightarrow \mu\nu$)

- Grande impulso trasverso mancante
- Una sola traccia carica

Scopo dell'esercizio

Obiettivo: Misurare la massa del **bosone Z** e di **eventuali altre particelle** presenti nel campione di dati (compreso il **bosone di Higgs**).

Identificare eventi con Z (**da salvare**) nei decadimenti:

- Elettrone (e^-) -positrone (e^+)
- Muone (μ^-)-antimuone (μ^+)

Identificare eventi con Higgs (**da salvare**) nei decadimenti:

- Due coppie di particelle cariche ($e^+e^-e^+e^-$, $e^+e^- \mu^+\mu^-$, $\mu^+\mu^- \mu^+\mu^-$)
- fotone - fotone

Identificare eventi dovuti ad altri processi (**da ignorare**):

- Jets
- Decadimenti di W (particella carica + neutrino)

Analisi dati

Ogni gruppo analizza un campione di **50 eventi** identificato con una lettera, indicata sul foglio

Lettera del campione

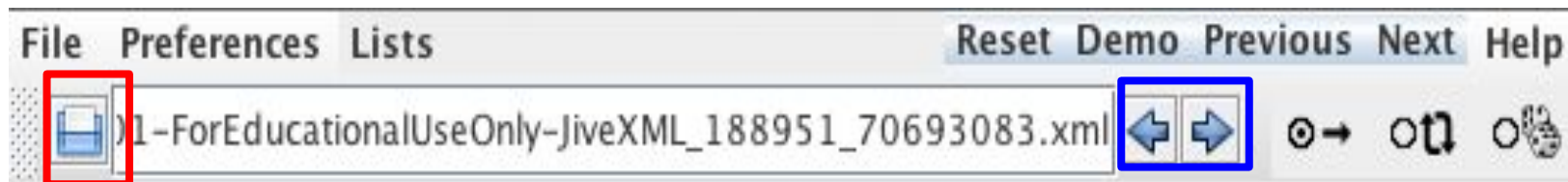
DATASET 3 A			
EVENT TYPE	EVENT NUMBERS	TALLY MARKS	SUM
Zilko etc			
Zilko etc	Somme		
Higg=llie 4L			
Higg=llie 77			
GRAND TOTAL			

Tipo di eventi

Aprire HYPATIA

1. Aprire 'This PC'
2. Selezionare disco 'share'
3. Selezionare 'leone infn'
4. Selezionare 'distribuzione'
5. Selezionare 'ATLAS'
6. Selezionare 'esercizio'
7. Doppio click su Hypatia_7.4_Masterclass Executable Jar File

Caricare gli eventi



Click sul **dischetto** e selezionare i dati che vi sono stati assegnati

Frecce blu → scorrere gli eventi

Cosa fare

- **Ignora** gli eventi di fondo:
 - Jets
 - Decadimenti di W (particella carica + neutrino)
 - Ricorda di **selezionare** coppie coerenti:
 - elettrone (e^-) -positrone (e^+)
 - muone (μ^-)-antimuone (μ^+) } Z
 - $e^+e^- e^+e^-$
 - $e^+e^- \mu^+\mu^-$
 - $\mu^+\mu^- \mu^+\mu^-$
 - fotone - fotone
- } Higgs
- Dopo aver analizzato tutti gli eventi, **esporta** i risultati:
 - File → Export Invariant Masses.
 - Save in: leone infn → risultati → ATLAS
 - Il nome da dare al file è Invariant_Masses_3X.txt con X corrispondente alla propria 'lettera'