



INTERNATIONAL  
**MASTERCLASSES**

hands on particle physics



Pavia, 3 Marzo 2023

# Masterclass di Fisica:3.3.2023

Fri, Mar 03

VC 1: ATLAS Z

Hassnae

David R.

Genoa



Freiburg



Pavia



Braga



Rome, Tor Vergata



Hassnae El  
Jarrari  
(ATLAS)



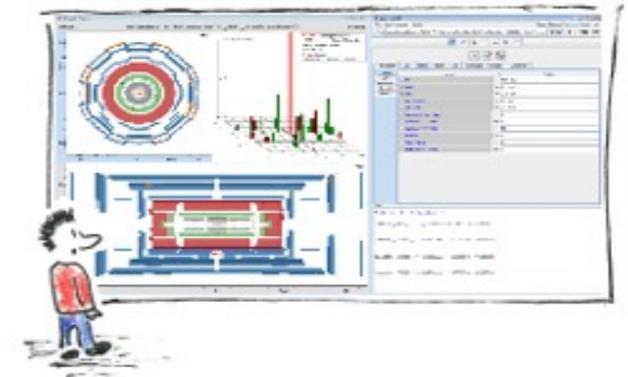
David  
Rouso  
(ATLAS)



Oggi pomeriggio:  
13:00 inizio attività in laboratorio  
16:00 videoconferenza

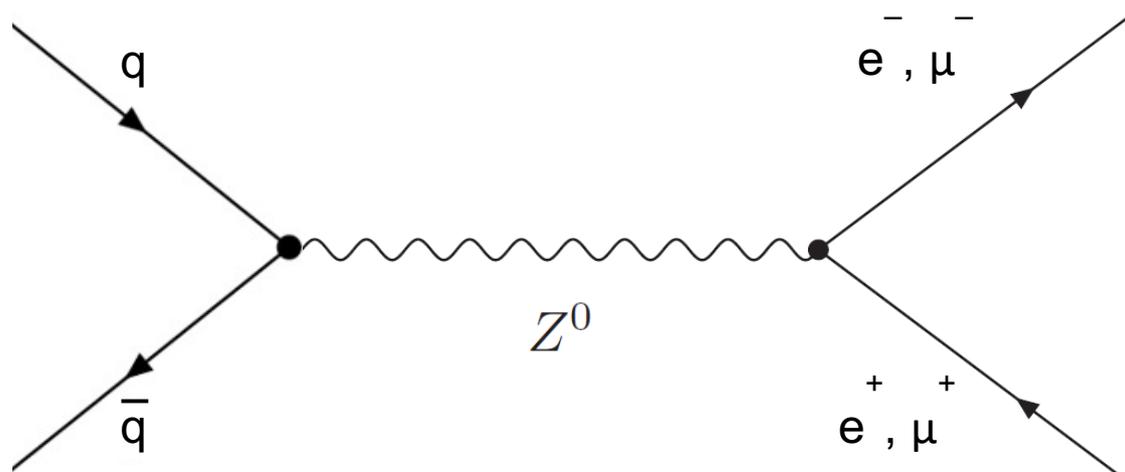
# Analisi

- ◆ Analizzare un insieme di dati raccolti dall'esperimento ATLAS ad LHC
  - Utilizzando un event display
  - 50 eventi ogni persona
- ◆ Selezionare campione di eventi con le caratteristiche di potenziali **candidati**
  - Bosone vettore Z e altre "risonanze" di-leptoniche
  - Bosone di Higgs
- ◆ Analizzare statisticamente il campione per distinguere il segnale dal fondo
  - Cioè, costruzione di un istogramma



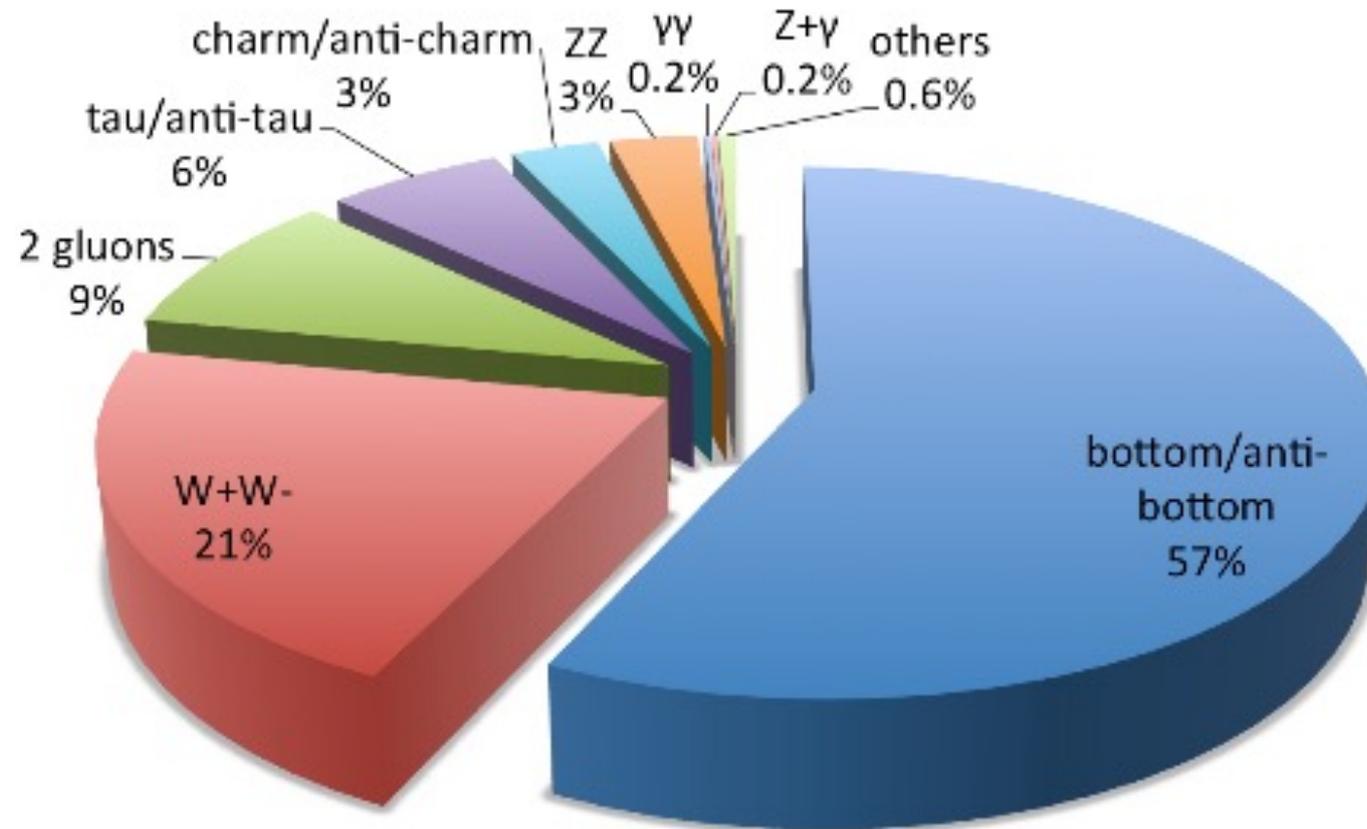
# Bosone Z

- Molti possibili canali di decadimento
  - Cercheremo il decadimento in coppie di leptoni dello stesso tipo (o elettroni o muoni) di segno opposto



# Bosone di Higgs

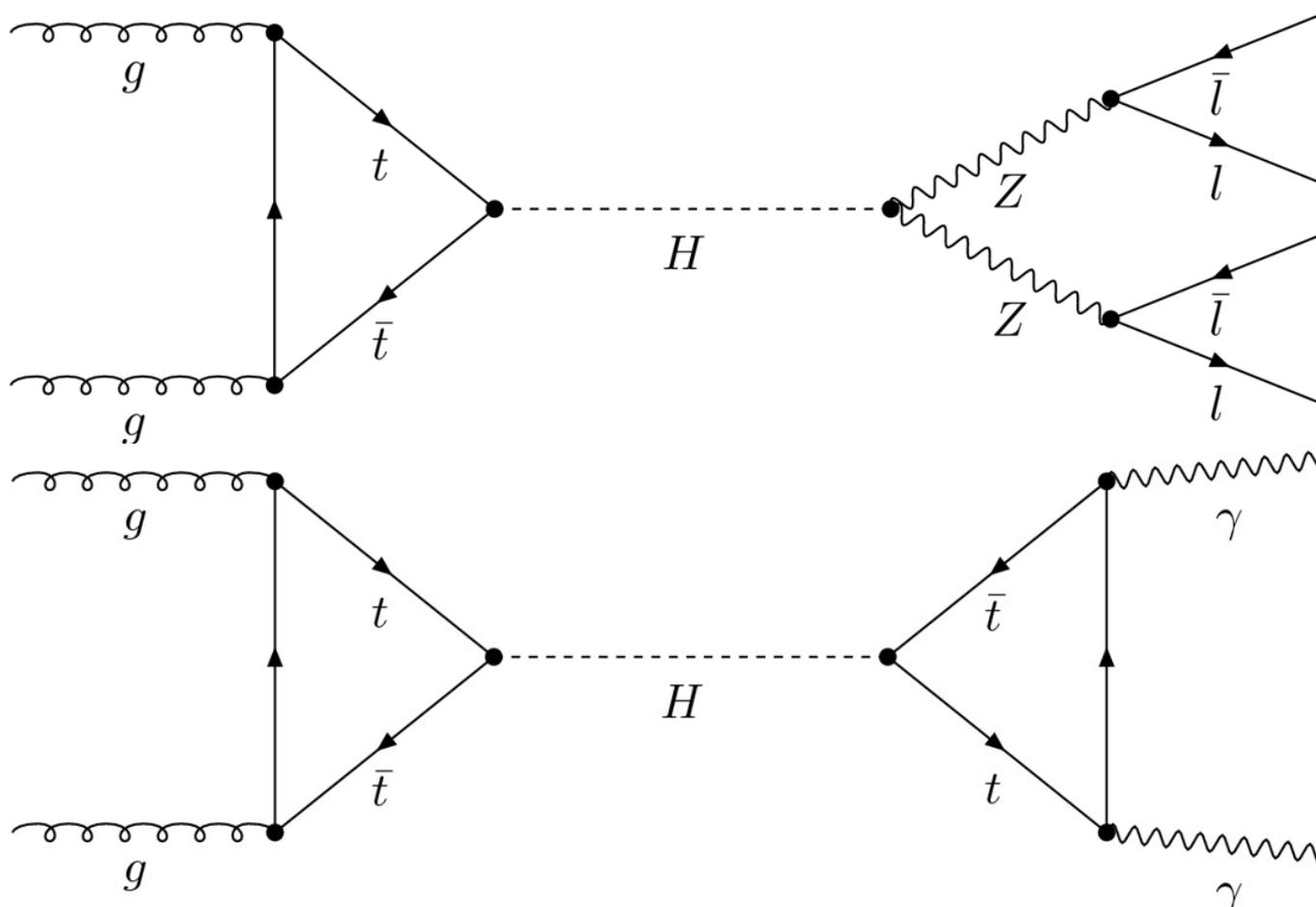
Quale canale di decadimento sceglieresti?



- A. Bottom/antibottom
- B. ZZ
- C.  $\gamma\gamma$
- D. WW

# Bosone di Higgs

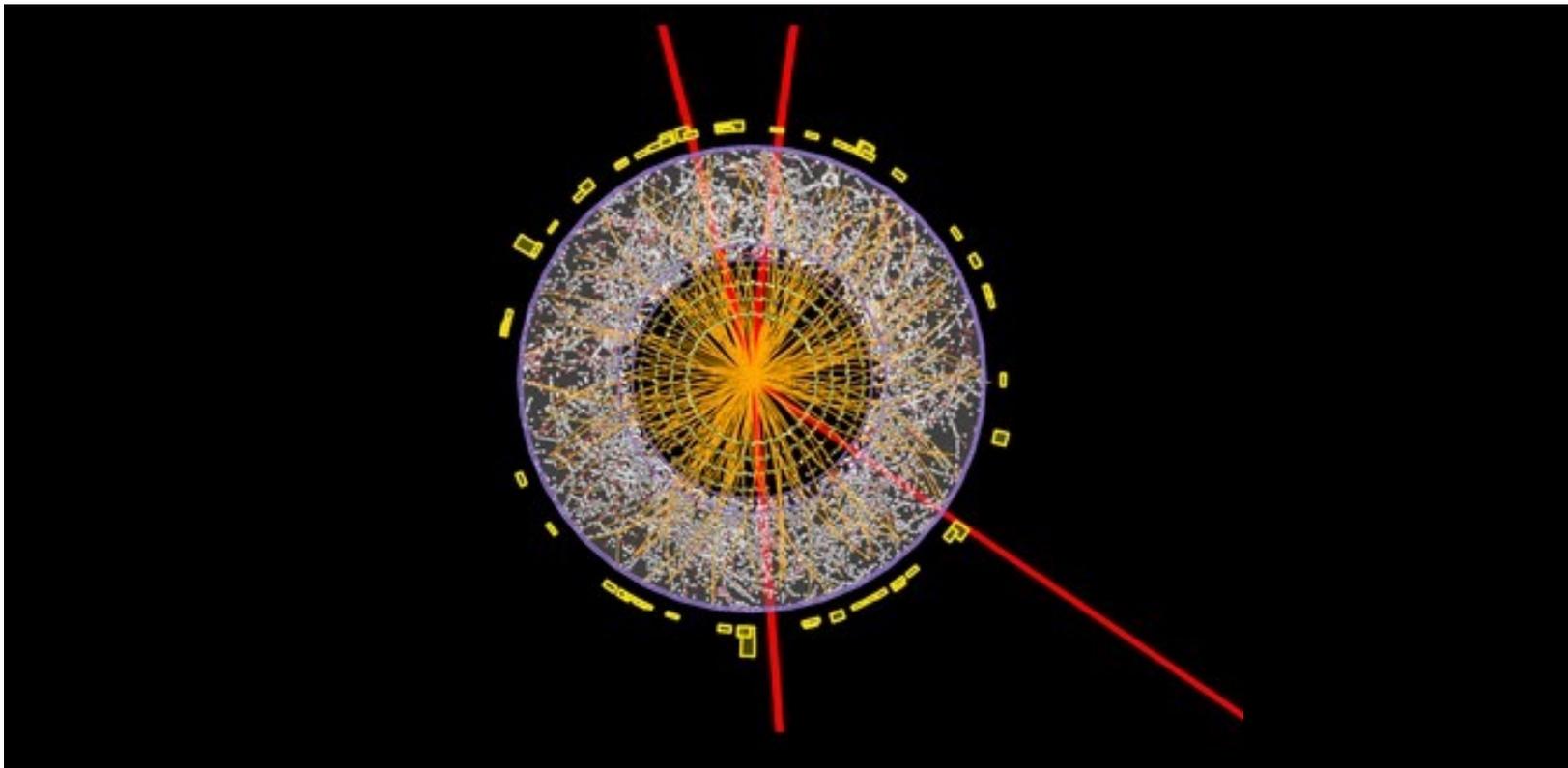
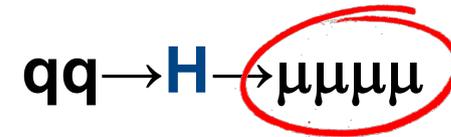
- Cercheremo i canali di decadimento in
  - 4 leptoni (attraverso una coppia di Z)
  - 2 fotoni



# Eventi candidati

Impossibile catalogare univocamente una data collisione (**evento**)

Il **fondo** può avere stessa segnatura del **segnale**



Come le distinguiamo?

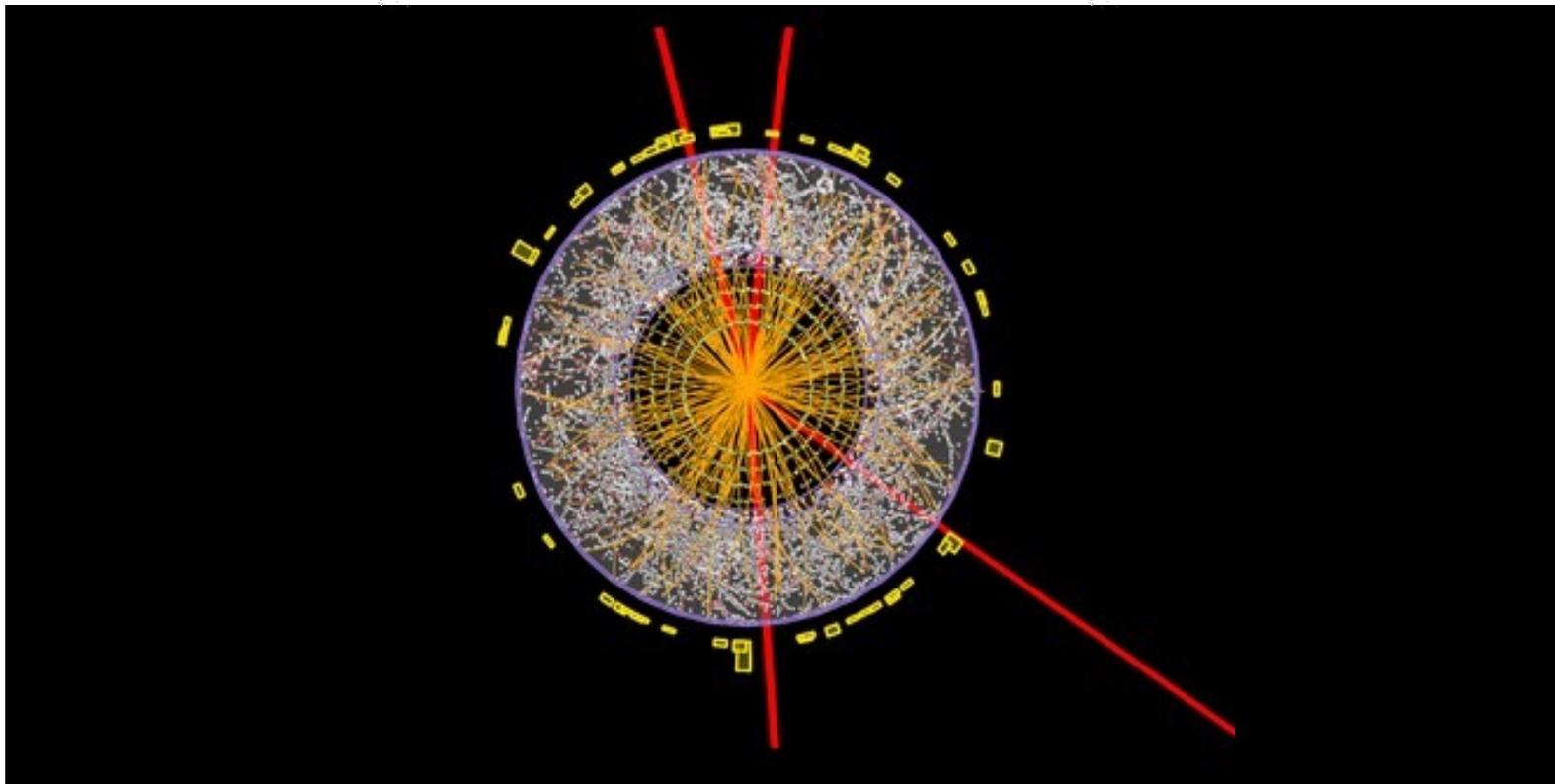
# Eventi candidati

Impossibile catalogare univocamente una data collisione (**evento**)

- Il **fondo** può avere stessa segnatura del **segnale**

$qq \rightarrow ZZ \rightarrow \mu\mu\mu\mu$

$qq \rightarrow H \rightarrow \mu\mu\mu\mu$



Come le distinguiamo?

- Non le distinguiamo. Necessario approccio statistico

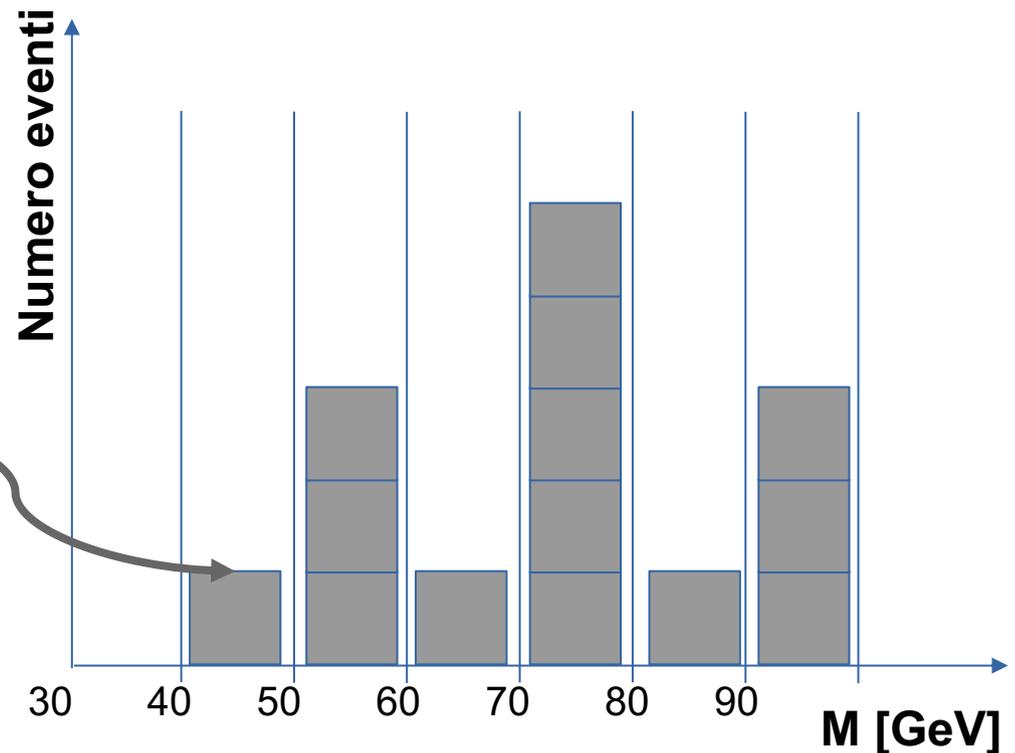
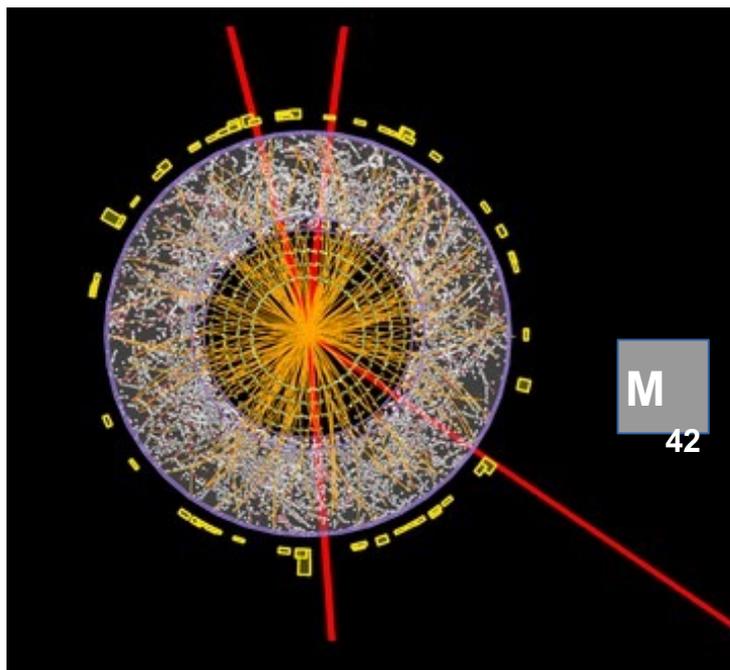
# Approccio Statistico

**Istogramma:** per ogni evento

- calcolo la **massa invariante** del sistema finale  $M_i$

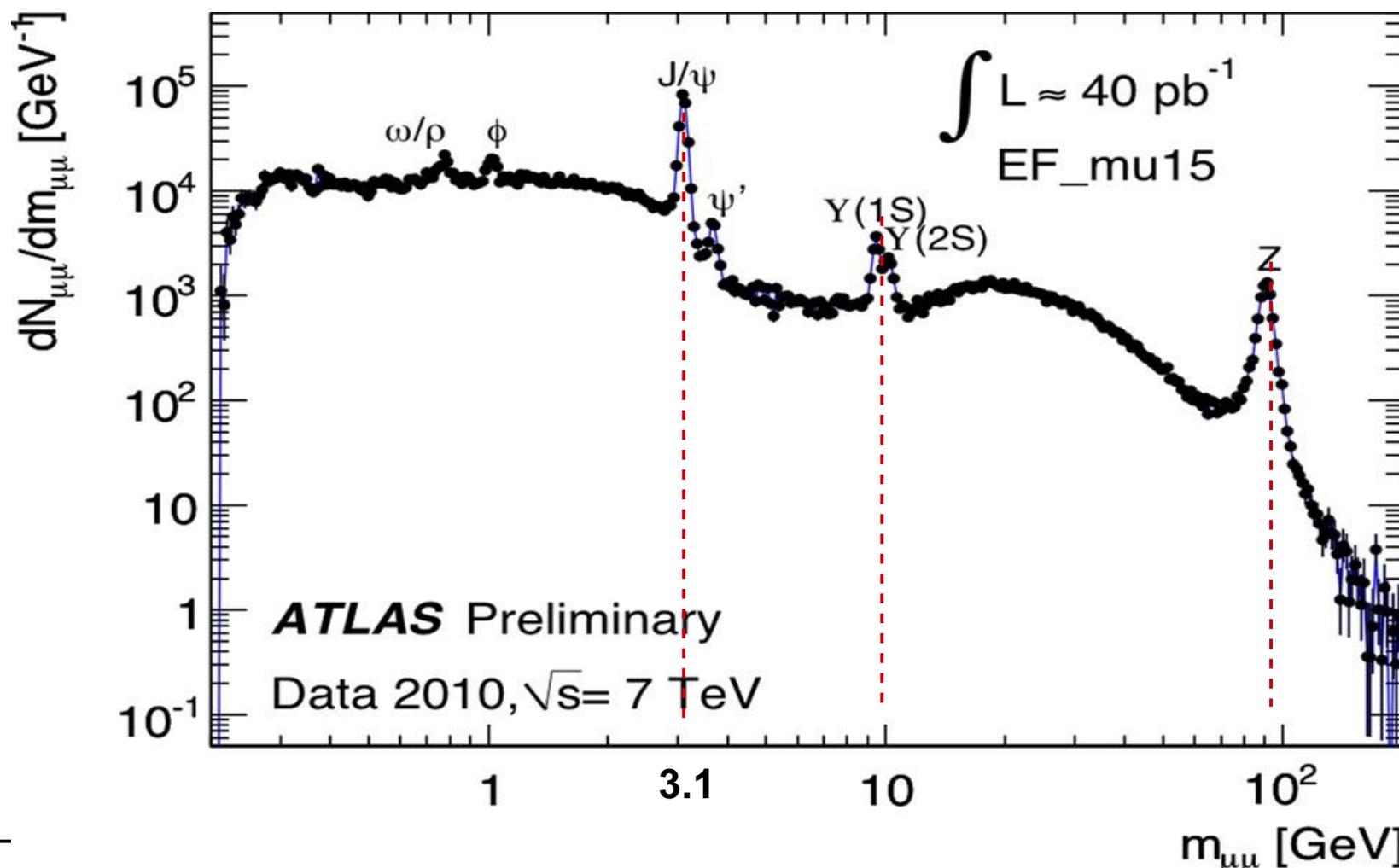
$$m_0^{(z)} = \sqrt{\left(\frac{(E_{e^-} + E_{e^+})}{c^2}\right)^2 - \left(\frac{\vec{p}_{e^-} + \vec{p}_{e^+}}{c}\right)^2}$$

- Aggiungo un conteggio al canale dell'istogramma corrispondente ad  $M_i$

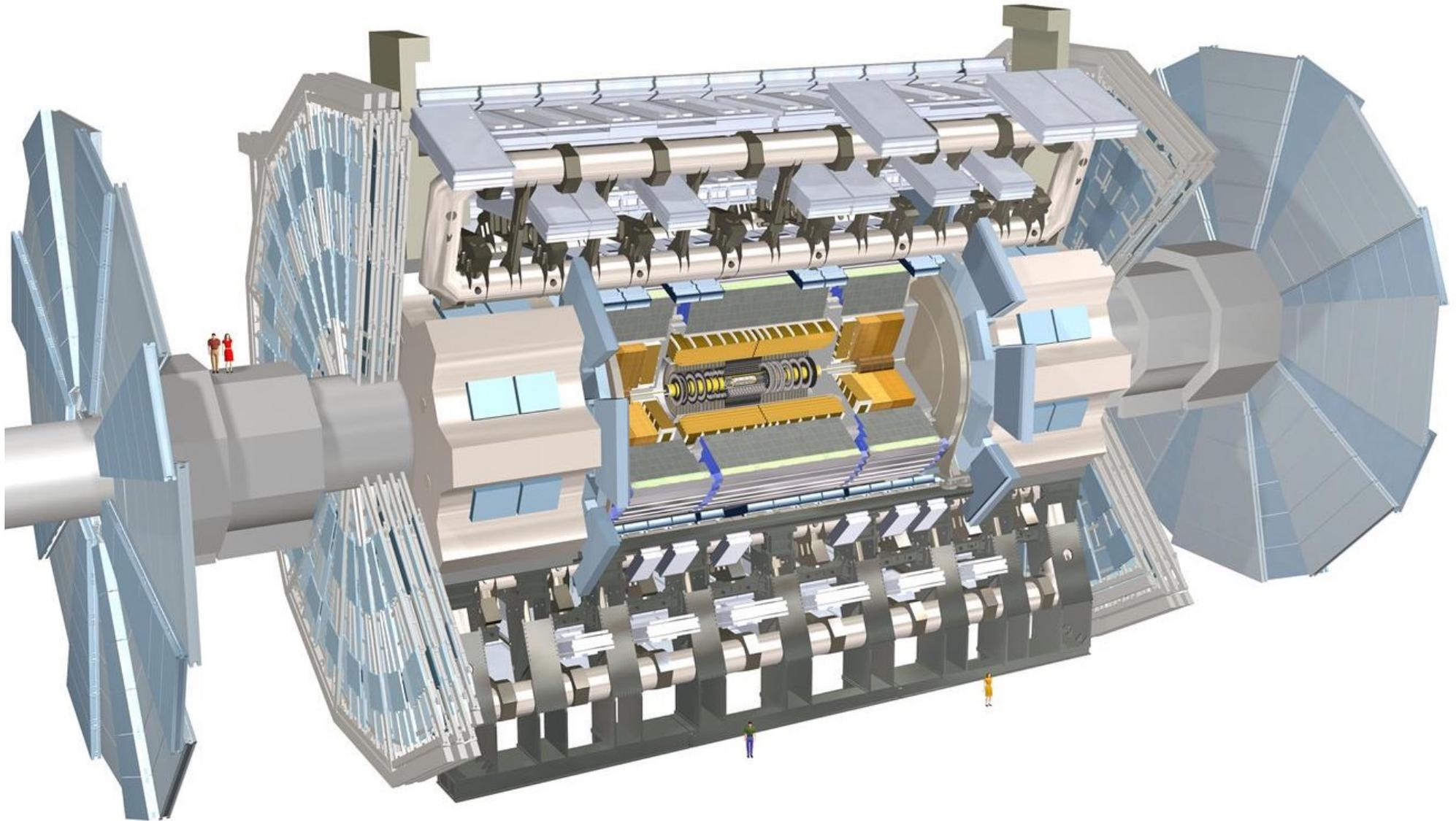


# Istogramma

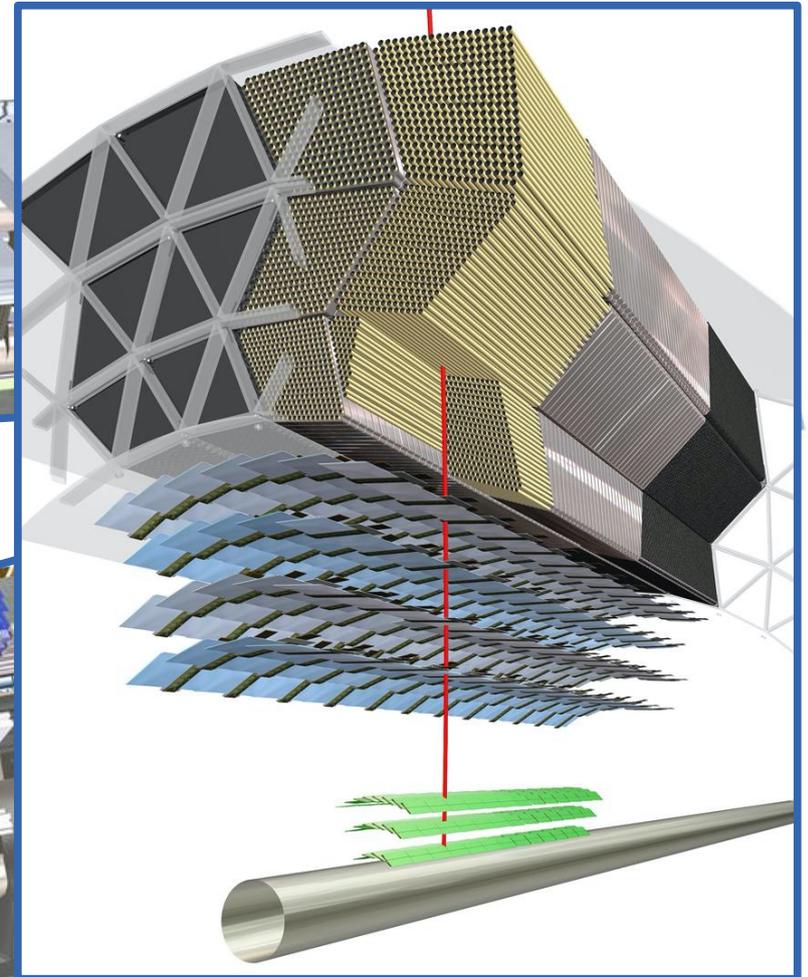
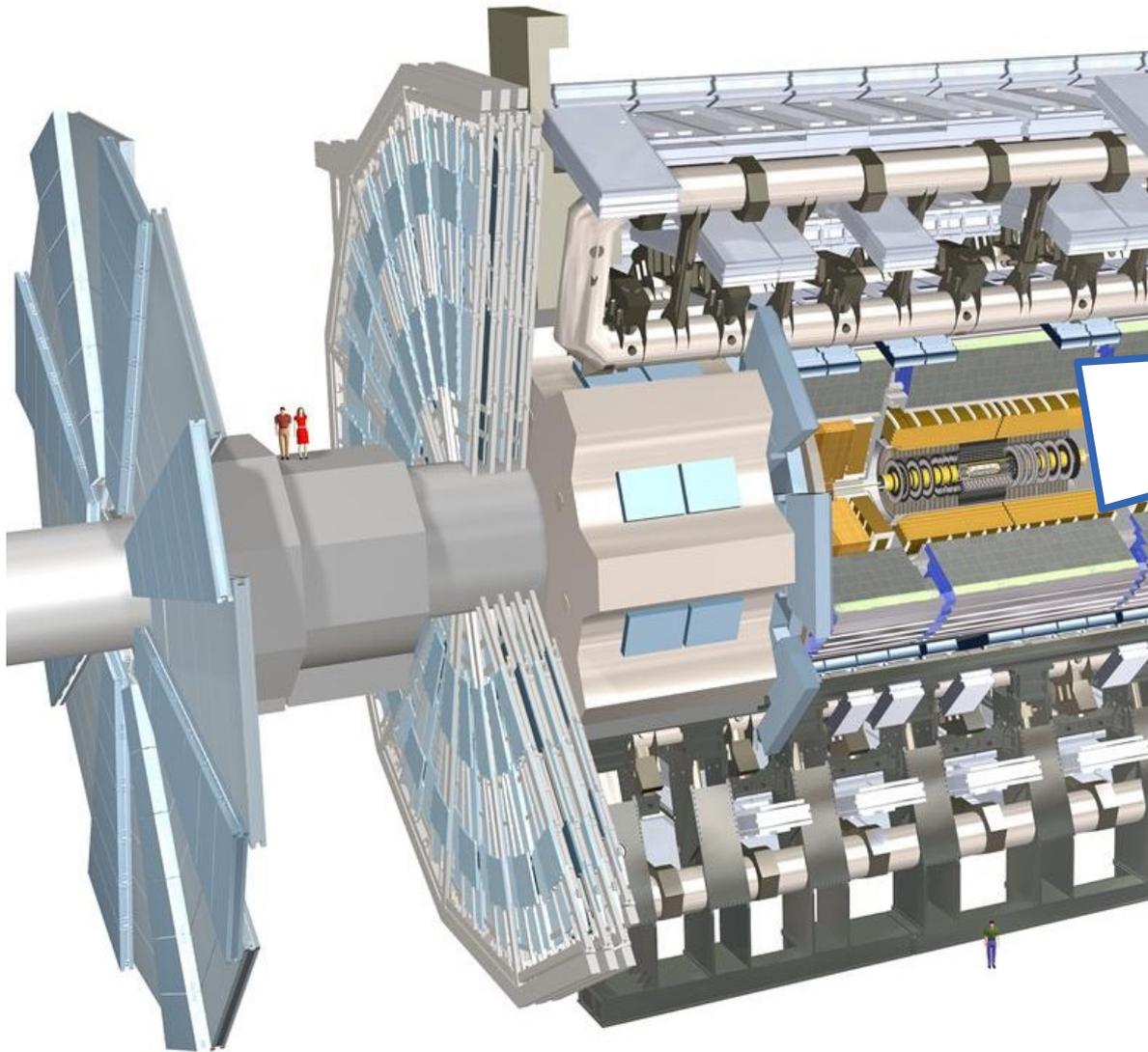
- Massa invariante del sistema dei due leptoni
  - La massa del “potenziale” progenitore



# ATLAS

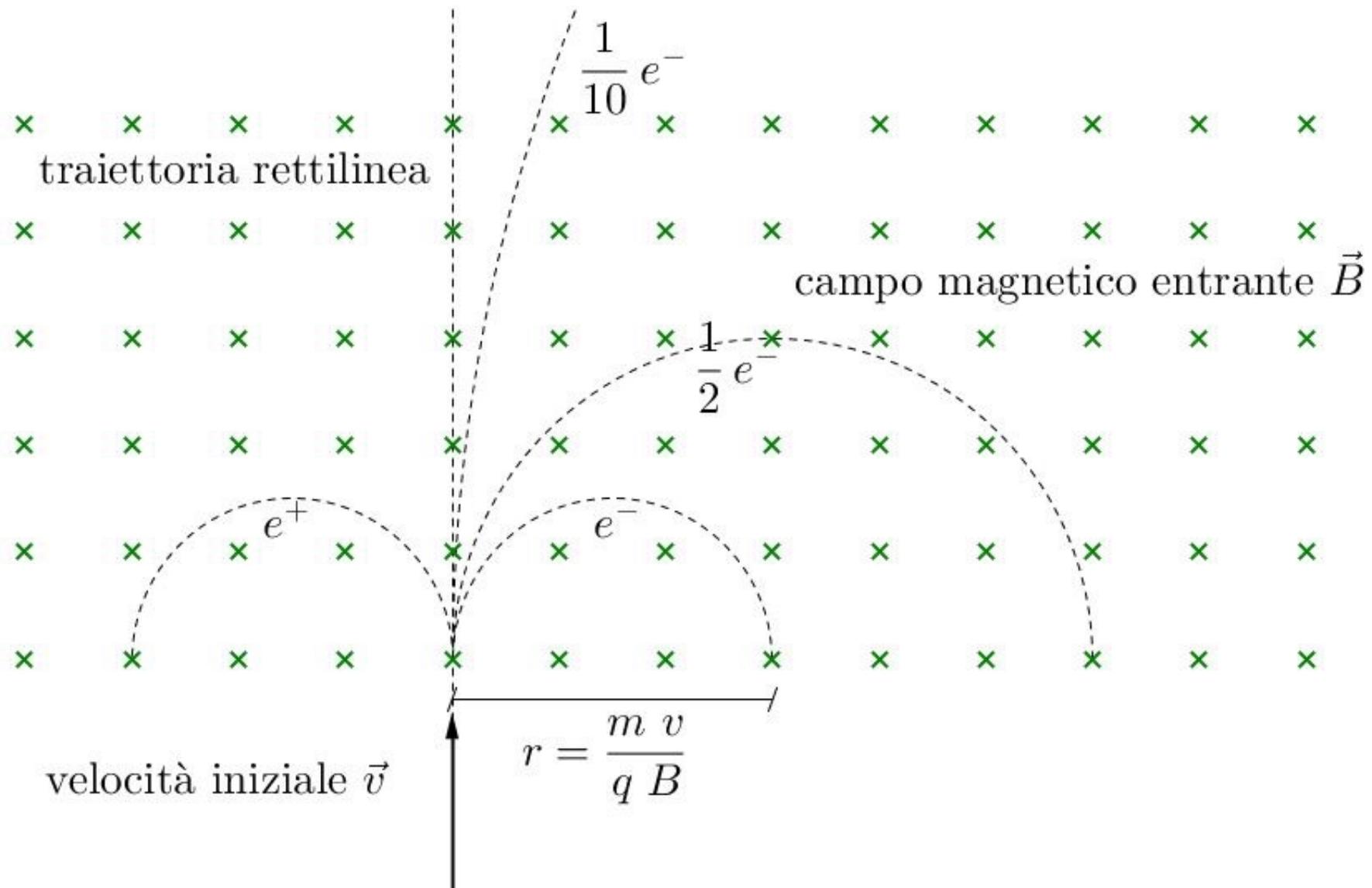


# Tracciatore interno

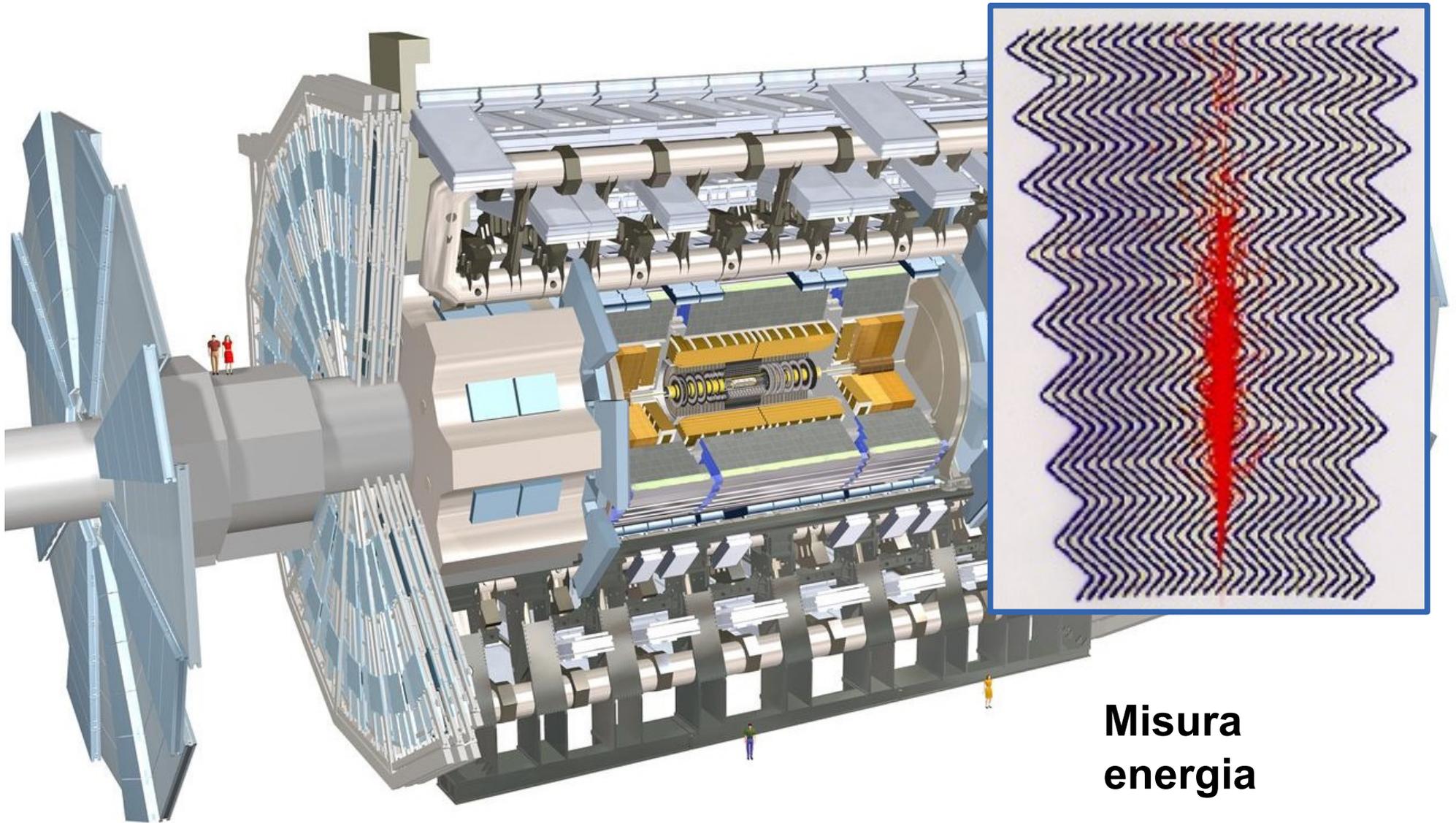


**Misura di posizione  
in campo magnetico  
(→momento)**

# Misura del momento di una particella

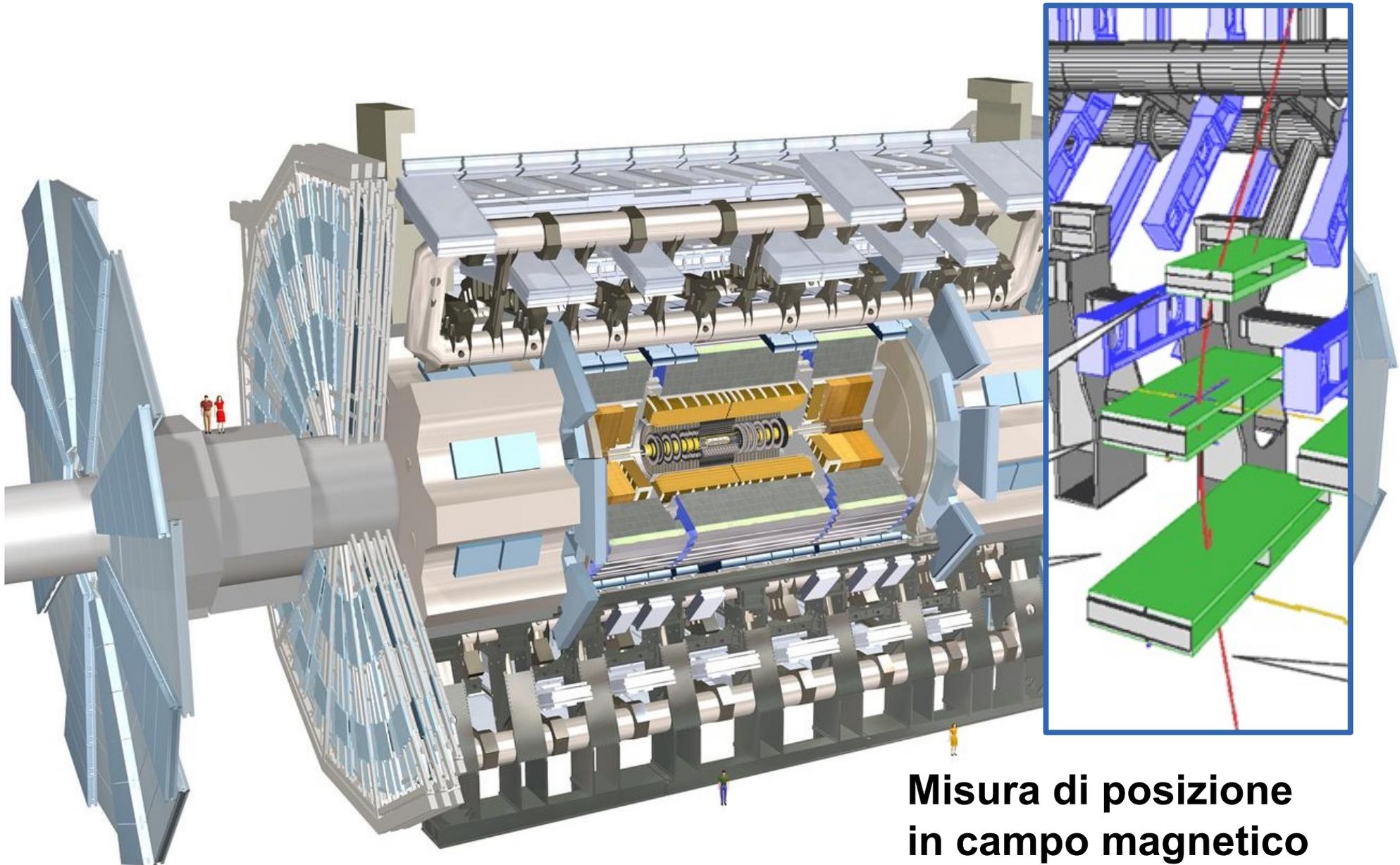


# Sistema di calorimetria



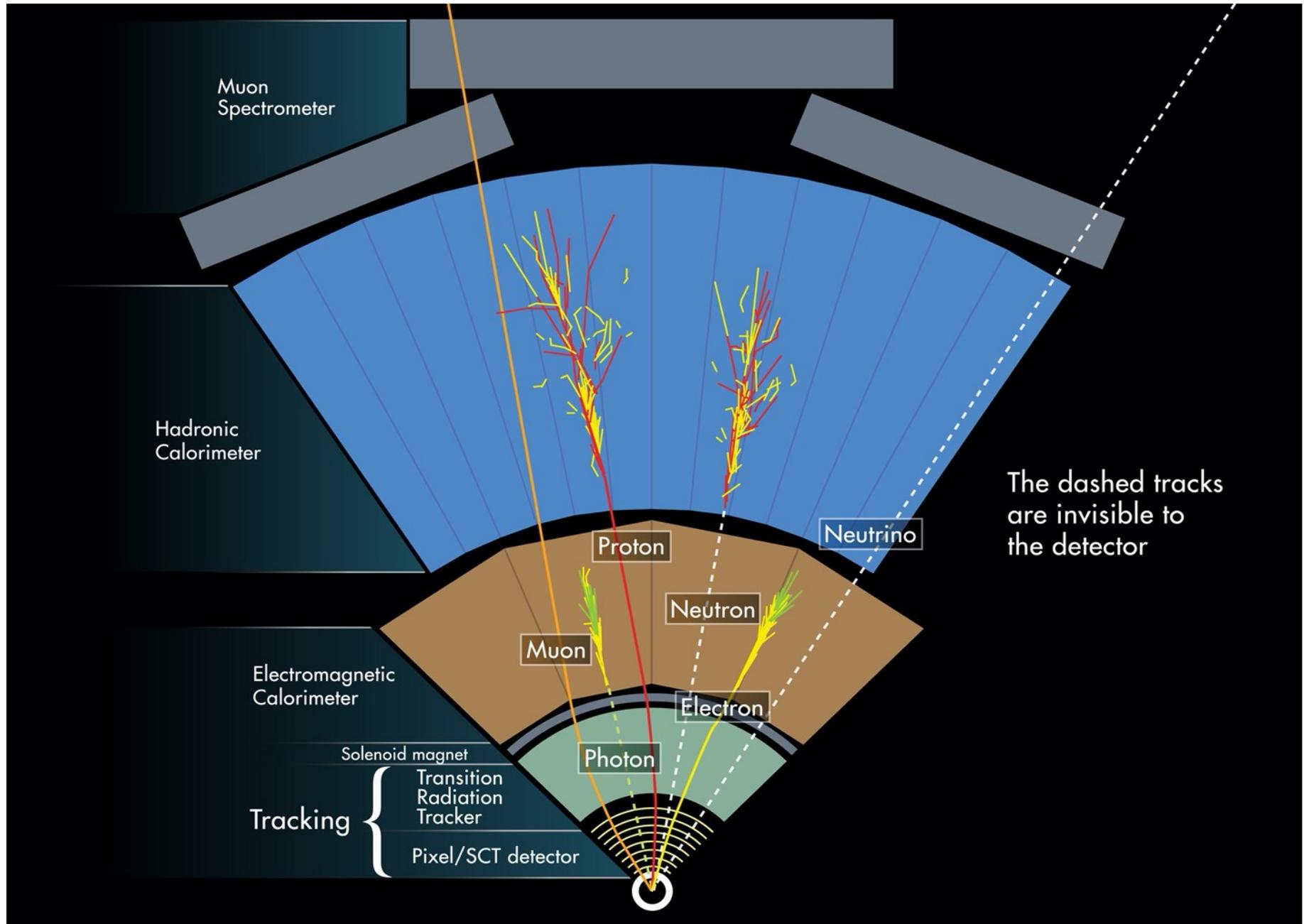
**Misura  
energia**

# Spettrometro muonico



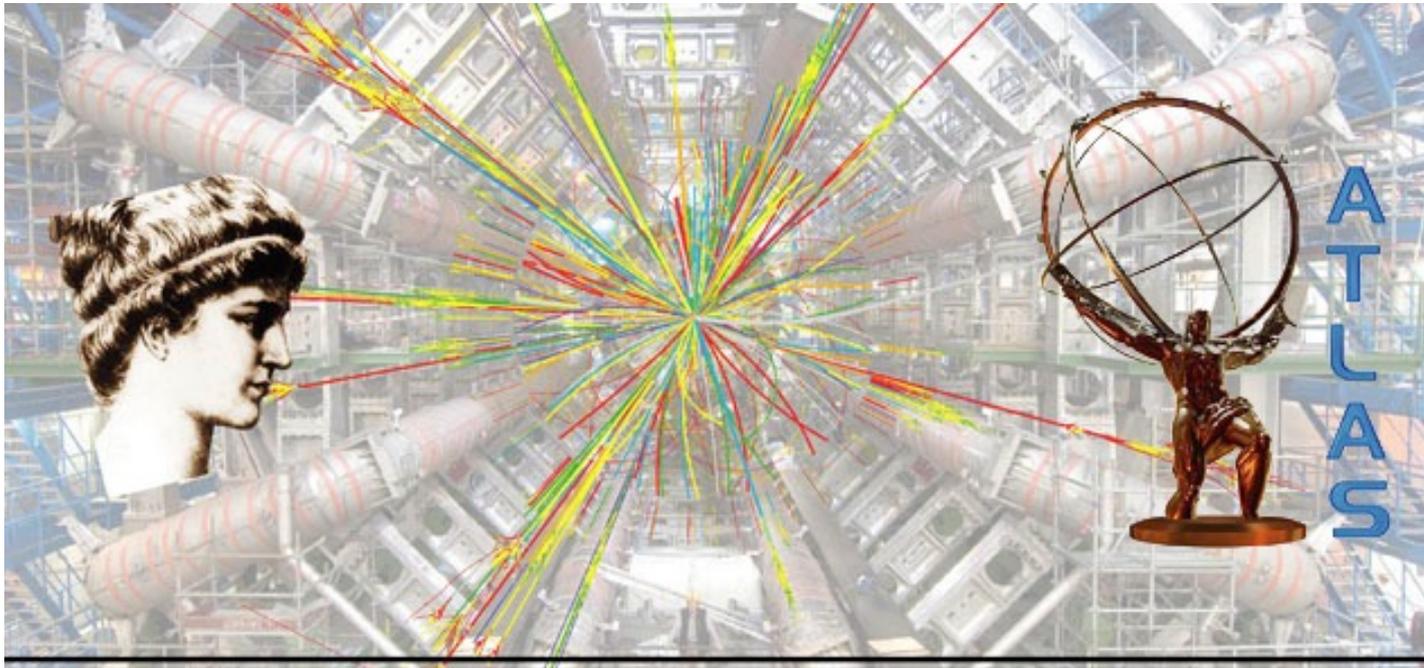
**Misura di posizione  
in campo magnetico  
(→momento)**

# Identificazione delle particelle



- Muoni, antimuoni
    - Tracce sia nel rivelatore interno che nello spettrometro
  - Elettroni, positroni
    - Tracce nel rivelatore interno che puntano a depositi di energia nel calorimetro elettromagnetico
  - Fotoni
    - Depositi di energia nel calorimetro senza tracce associate
  - Jet (decadimenti di quark e gluoni)
    - “Fascio” di tracce che puntano a depositi di energia in entrambi i tipi di calorimetri
  - Neutrini
    - Energia mancante nel piano trasverso rispetto al fascio
-

# Hypatia Event Viewer



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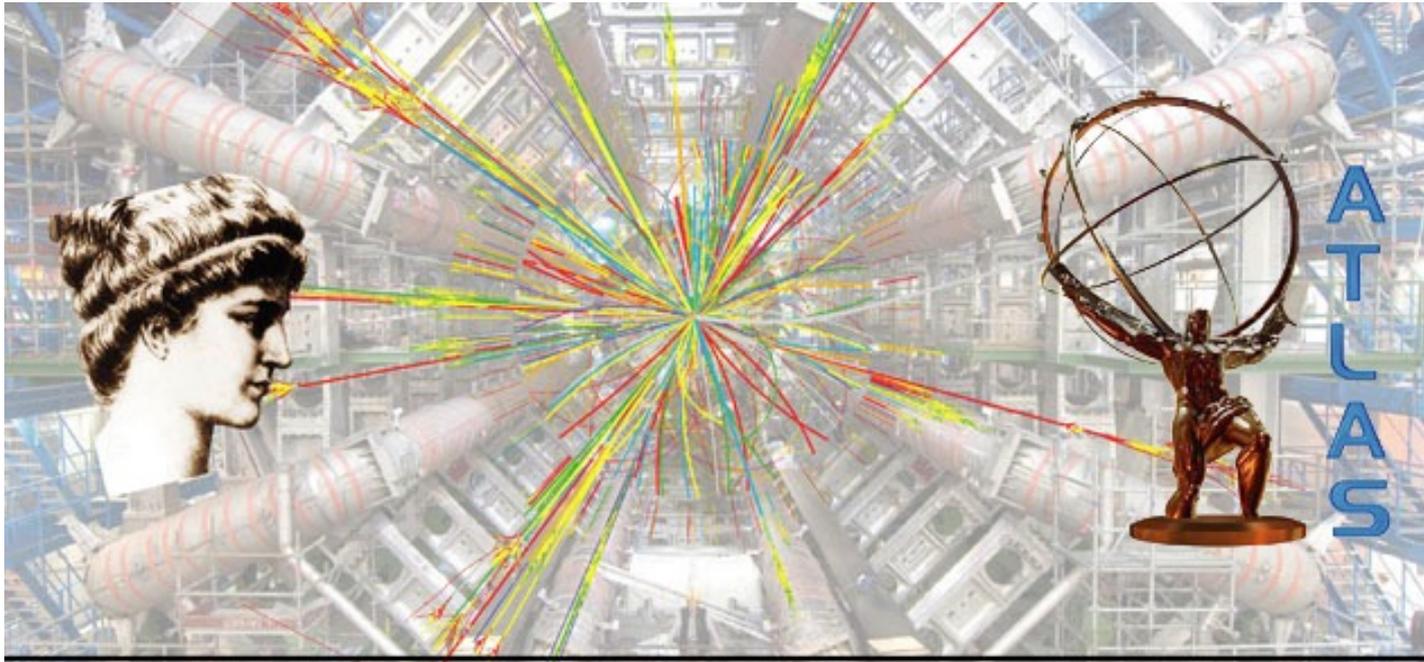


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H Y P A T I A

HYbrid Pupil's Analysis Tool for Interactions in ATLAS

# Hypatia Event Viewer



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BELGRADE

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

java -jar Hypatia\_7.4\_Masterclass.jar

# Hypatia Event Viewer



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] | $\phi$ | $\eta$ | M(2) [GeV] | M(eeee) [GeV] | M(eemm) [GeV] | M(mmmm) [GeV] | e/m/g |
|--------------|-------------|------------|---------|-----|----------|--------|--------|------------|---------------|---------------|---------------|-------|
| event002.xml | 23.199      | Tracks 0   | 217.0   | -   | 42.6     | -1.479 | 2.310  | 94.165     |               |               |               | e     |
|              |             | Tracks 76  | 93.3    | +   | 42.9     | 1.779  | 1.413  |            |               |               |               | e     |
| event003.xml | 22.805      | Tracks 184 | 449.7   | +   | 423.3    | -1.090 | -0.352 | 994.430    |               |               |               | e     |
|              |             | Tracks 247 | 567.5   | -   | 434.3    | 2.080  | 0.764  |            |               |               |               | e     |

Canvas Window - File: event003.xml Run: 110158020 Event: 3101

HYPATIA - Track Momenta Window

Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

ETHis: 22.805 GeV  $\phi$ : -1.466 rad Collection: MET\_RefFinal

/home/negri/MasterClasses/groupA.zip/event003.xml

| Track      | +/- | P [GeV] | Pt [GeV] | $\phi$ | $\theta$ |
|------------|-----|---------|----------|--------|----------|
| Tracks 4   | -   | 9.77    | 9.42     | -0.195 | 1.302    |
| Tracks 184 | +   | 449.71  | 423.28   | -1.090 | 1.915    |
| Tracks 218 | -   | 28.13   | 5.75     | 2.487  | 2.936    |
| Tracks 247 | -   | 567.48  | 434.30   | 2.080  | 0.872    |

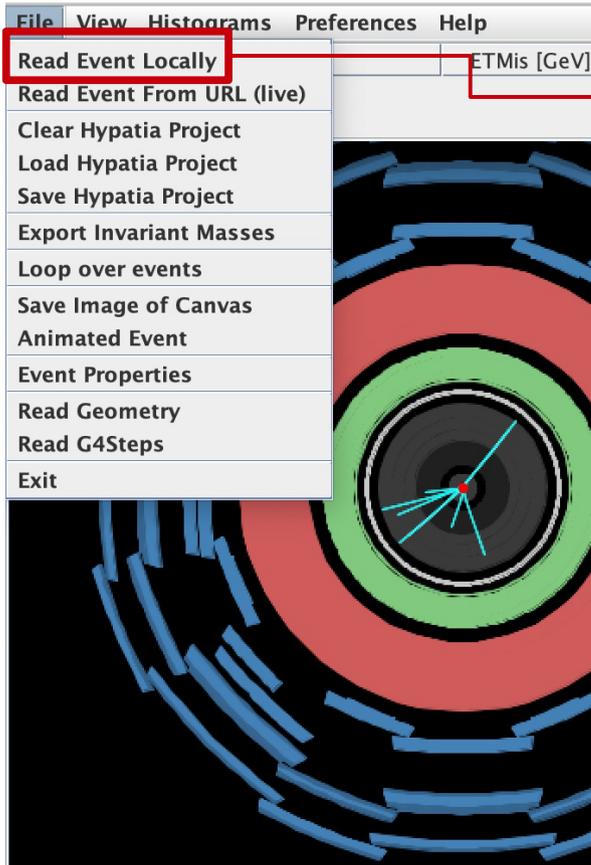
HYPATIA - Control Window

Parameter Control Interaction and Window Control Output Display

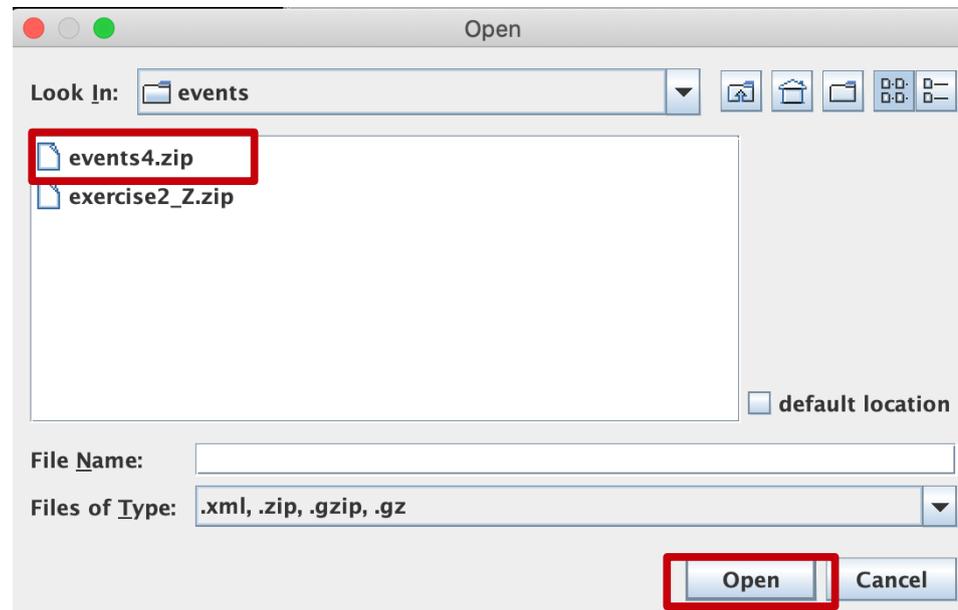
Projection Data Cuts InDet Calo MuonDet Objects Geometry

| InDet   | Name                                       | Value       |
|---------|--|-------------|
| Calo    | <input checked="" type="checkbox"/>  Pt    | > 5.0 GeV   |
| MuonDet | <input type="checkbox"/>  Pt2              | < 700.0 MeV |
| Objects | <input 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 | >= 2        |

# Data Files



Per selezionare il file di dati scaricato



[groupA.zip](#)  
[groupB.zip](#)  
[groupC.zip](#)  
[groupD.zip](#)  
[groupE.zip](#)  
[groupF.zip](#)  
[groupG.zip](#)  
[groupH.zip](#)  
[groupI.zip](#)  
[groupJ.zip](#)  
[groupK.zip](#)  
[groupL.zip](#)  
[groupM.zip](#)  
[groupN.zip](#)  
[groupO.zip](#)  
[groupP.zip](#)  
[groupQ.zip](#)  
[groupR.zip](#)  
[groupS.zip](#)  
[groupT.zip](#)

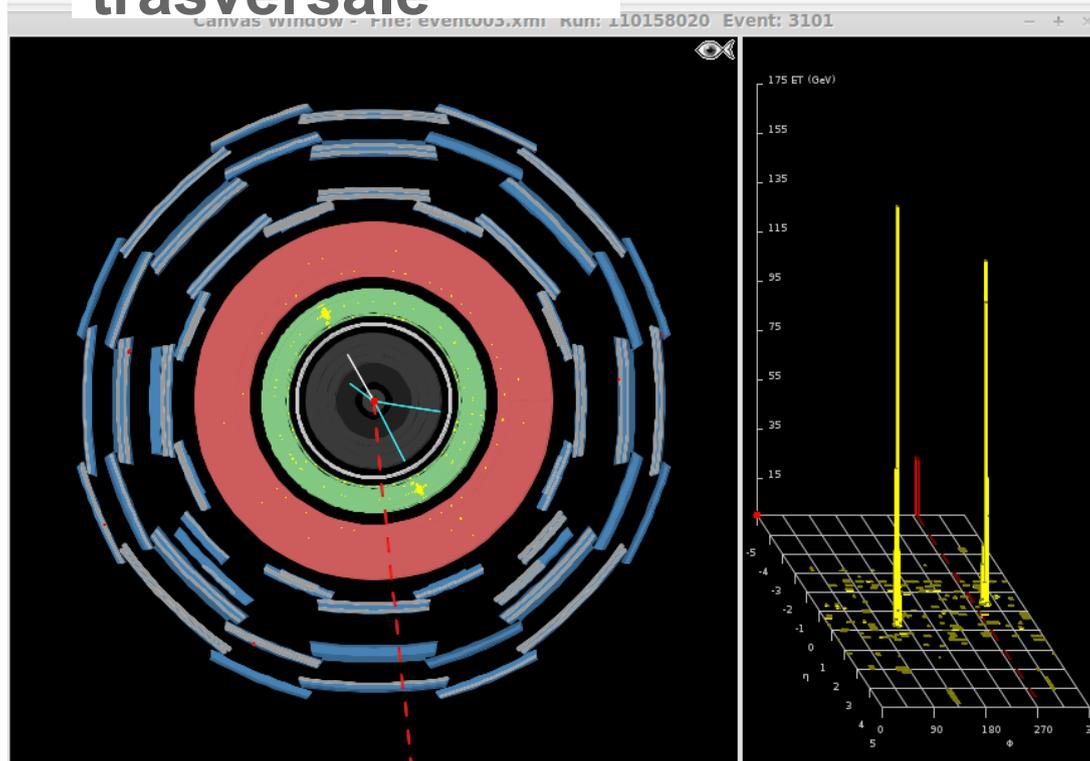
# Finestra grafica

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

File View Histograms Preferences Help

|         | P [GeV] | +/- | Pt [GeV] | $\phi$ | $\eta$ | M(2) [GeV] | M(eeee) [GeV] | M(eemm) [GeV] | M(mmmm) [GeV] | e/m/g |
|---------|---------|-----|----------|--------|--------|------------|---------------|---------------|---------------|-------|
| event00 | 217.0   | -   | 42.6     | -1.479 | 2.310  | 94.165     |               |               |               | e     |
|         | 93.3    | +   | 42.9     | 1.779  | 1.413  |            |               |               |               | e     |
| event00 | 449.7   | +   | 423.3    | -1.090 | -0.352 | 994.430    |               |               |               | e     |
|         | 567.5   | -   | 434.3    | 2.080  | 0.764  |            |               |               |               | e     |

Vista trasversale



HYPATIA - Track Momenta Window

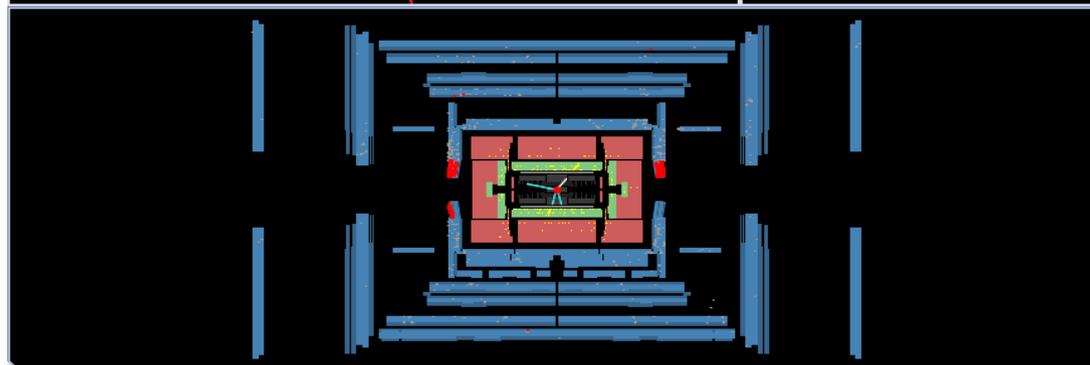
Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

ETHis: 22.805 GeV  $\phi$ : -1.466 rad Collection: MET\_Reffinal

/home/negri/MasterClasses/groupA.zip/event003.xml

| Track      | +/- | P [GeV] | Pt [GeV] | $\phi$ | $\theta$ |
|------------|-----|---------|----------|--------|----------|
| Tracks 4   | -   | 9.77    | 9.42     | -0.195 | 1.302    |
| Tracks 184 | +   | 449.71  | 423.28   | -1.090 | 1.915    |
| Tracks 218 | -   | 28.13   | 5.75     | 2.487  | 2.936    |
| Tracks 247 | -   | 567.48  | 434.30   | 2.080  | 0.872    |

Sviluppo sul piano del sistema di calorimetria



HYPATIA - Control Window

Parameter Control Interaction and Window Control Output Display

Projection Data Cuts InDet Calo MuonDet Objects Geometry

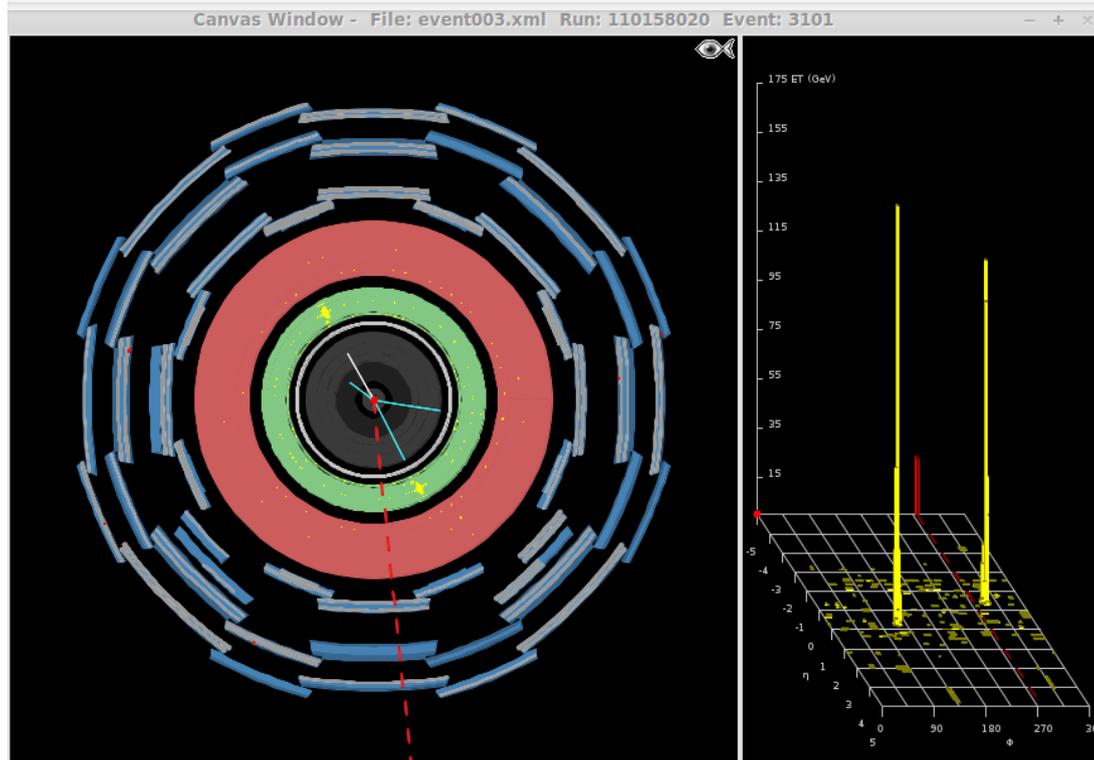
| InDet   | Name                                       | Value     |
|---------|--|-----------|
| Calo    |  |           |
| MuonDet | <input checked="" type="checkbox"/>  Pt    | > 5.0 GeV |
|         | <input type="checkbox"/>  d0 Loose         | < 2.0 cm  |
|         | <input type="checkbox"/>  z0-zVtx          | < 2.5 mm  |
|         | <input type="checkbox"/> Layer             | > 0       |
|         | <input type="checkbox"/> Number Pixel Hits | >= 2      |

Vista longitudinale

# Finestra grafica

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

| File Name    | ETMis [GeV] | Track      | P [GeV] | +/- | Pt [GeV] | $\phi$ | $\eta$ | M(2) [GeV] | M(eeee) [GeV] | M(eemm) [GeV] | M(mmmm) [GeV] | e/m/g |
|--------------|-------------|------------|---------|-----|----------|--------|--------|------------|---------------|---------------|---------------|-------|
| event002.xml | 23.199      | Tracks 0   | 217.0   | -   | 42.6     | -1.479 | 2.310  | 94.165     |               |               |               | e     |
|              |             | Tracks 76  | 93.3    | +   | 42.9     | 1.779  | 1.413  |            |               |               |               | e     |
| event003.xml | 22.805      | Tracks 184 | 449.7   | +   | 423.3    | -1.090 | -0.352 | 994.430    |               |               |               | e     |
|              |             | Tracks 247 | 567.5   | -   | 434.3    | 2.080  | 0.764  |            |               |               |               | e     |



HYPATIA - Track Momenta Window

Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

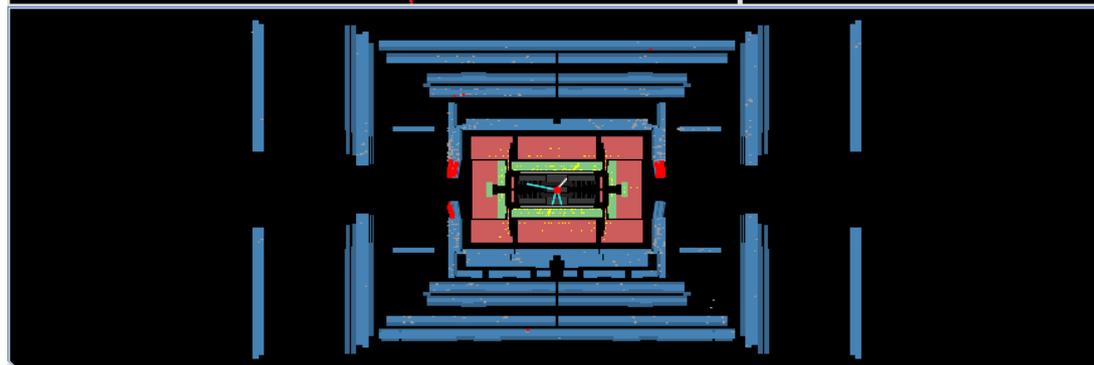
ETHis: 22.805 GeV  $\phi$ : -1.466 rad Collection: MET\_Reffinal

/home/negri/MasterClasses/groupA.zip/event003.xml

| Track      | +/- | P [GeV] | Pt [GeV] | $\phi$ | $\theta$ |
|------------|-----|---------|----------|--------|----------|
| Tracks 4   | -   | 9.77    | 9.42     | -0.195 | 1.302    |
| Tracks 184 | +   | 449.71  | 423.28   | -1.090 | 1.915    |
| Tracks 218 | -   | 28.13   | 5.75     | 2.487  | 2.936    |
| Tracks 247 | -   | 567.48  | 434.30   | 2.080  | 0.872    |

**Col mouse è possibile**

- selezionare una traccia
- fare lo zoom



HYPATIA - Control Window

Parameter Control Interaction and Window Control

Projection Data Cuts InDet Calo MuonDet

| InDet   | Name                                       | Value     |
|---------|--|-----------|
| Calo    | <input type="checkbox"/>  PT               | > 5.0 GeV |
| MuonDet | <input type="checkbox"/>  PT2              | < 700.0 V |
| 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 | >= 2      |

**Tasto per modalità zoom**

**Tasto per modalità selezione**

# Finestra di controllo

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] | +/- |       |        |     |        |  |  |
|--------------|-------------|------------|---------|-----|-------|--------|-----|--------|--|--|
| event002.xml | 23.199      | Tracks 0   | 217.0   | -   | 42.6  |        |     |        |  |  |
|              |             | Tracks 76  | 93.3    | +   | 42.9  |        |     |        |  |  |
| event003.xml | 22.805      | Tracks 184 | 449.7   | +   | 423.3 | -1.090 | 352 | 994.30 |  |  |
|              |             | Tracks 247 | 567.5   | -   | 434.3 | 2.080  | 764 |        |  |  |

## Avanzamento eventi

numero evento

Canvas Window - File: event003.xml Run: 110158020 Event: 3101

YPATIA - Track Momenta Window

Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

ETHis: 22.805 GeV  $\phi$ : -1.466 rad Collection: MET\_RefFinal

/home/negri/MasterClasses/groupA.../event003.xml

| Track      | +/- | P [GeV] | Pt [GeV] | $\phi$ | $\theta$ |
|------------|-----|---------|----------|--------|----------|
| Tracks 4   | -   | 9.77    | 9.42     | -0.195 | 1.302    |
| Tracks 184 | +   | 449.71  | 423.28   | -1.090 | 1.915    |
| Tracks 218 | -   | 28.13   | 5.75     | 2.487  | 2.936    |
| Tracks 247 | -   | 567.48  | 434.30   | 2.080  | 0.872    |

**Analisi tracce:**  
selezionando una riga la corrispondente traccia nella finestra grafica viene colorata di bianco

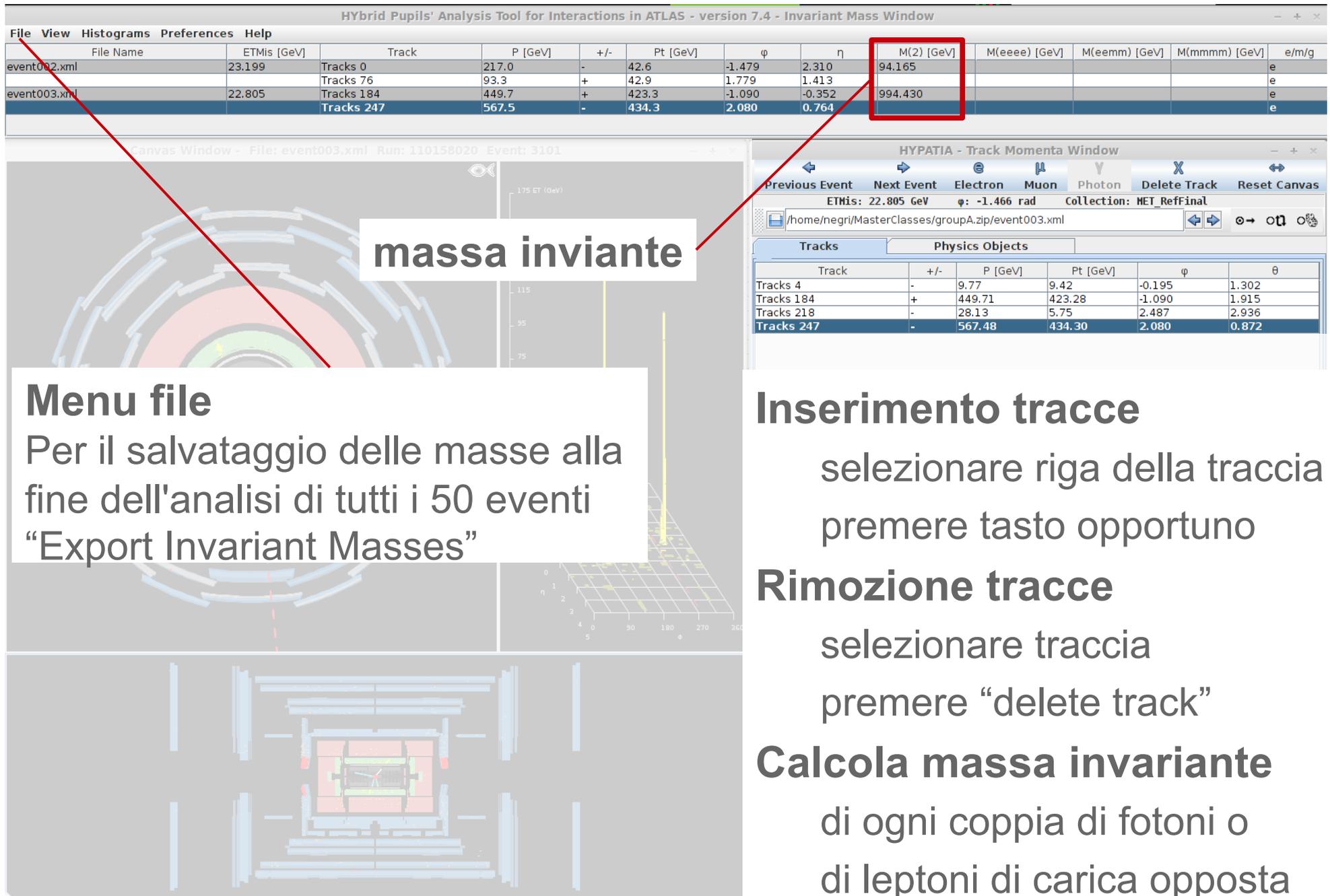
HYPATIA - Control Window

Parameter Control Interaction and Window Control Output Display

Projection Data Cuts InDet Calo MuonDet Objects Geometry

| InDet   | Name                                       | Value       |
|---------|--|-------------|
| Calo    |  |             |
| MuonDet | <input checked="" type="checkbox"/>  Pt    | > 5.0 GeV   |
| Objects | <input type="checkbox"/>  Pt2              | < 700.0 MeV |
| ATLAS   | <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        |

# Finestra massa invariante



**massa invariante**

**Menu file**  
Per il salvataggio delle masse alla fine dell'analisi di tutti i 50 eventi  
“Export Invariant Masses”

**Inserimento tracce**  
selezionare riga della traccia  
premere tasto opportuno

**Rimozione tracce**  
selezionare traccia  
premere “delete track”

**Calcola massa invariante**  
di ogni coppia di fotoni o  
di leptoni di carica opposta

| File Name    | ETMis [GeV] | Track      | P [GeV] | +/- | Pt [GeV] | $\phi$ | $\eta$ | M(2) [GeV] | M(eeee) [GeV] | M(eemm) [GeV] | M(mmmm) [GeV] | e/m/g |
|--------------|-------------|------------|---------|-----|----------|--------|--------|------------|---------------|---------------|---------------|-------|
| event002.xml | 23.199      | Tracks 0   | 217.0   | -   | 42.6     | -1.479 | 2.310  | 94.165     |               |               |               | e     |
|              |             | Tracks 76  | 93.3    | +   | 42.9     | 1.779  | 1.413  |            |               |               |               | e     |
| event003.xml | 22.805      | Tracks 184 | 449.7   | +   | 423.3    | -1.090 | -0.352 | 994.430    |               |               |               | e     |
|              |             | Tracks 247 | 567.5   | -   | 434.3    | 2.080  | 0.764  |            |               |               |               | e     |

| Track      | +/- | P [GeV] | Pt [GeV] | $\phi$ | $\theta$ |
|------------|-----|---------|----------|--------|----------|
| Tracks 4   | -   | 9.77    | 9.42     | -0.195 | 1.302    |
| Tracks 184 | +   | 449.71  | 423.28   | -1.090 | 1.915    |
| Tracks 218 | -   | 28.13   | 5.75     | 2.487  | 2.936    |
| Tracks 247 | -   | 567.48  | 434.30   | 2.080  | 0.872    |

# Finestra strumenti

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] | $\phi$ | $\eta$ | M(2) [GeV] | M(eeee) [GeV] | M(eemm) [GeV] | M(mmmm) [GeV] | e/m/g |
|--------------|-------------|------------|---------|-----|----------|--------|--------|------------|---------------|---------------|---------------|-------|
| event002.xml | 23.199      | Tracks 0   | 217.0   | -   | 42.6     | -1.479 | 2.310  | 94.165     |               |               |               | e     |
|              |             | Tracks 76  | 93.3    | +   | 42.9     | 1.779  | 1.413  |            |               |               |               | e     |
| event003.xml | 22.805      | Tracks 184 | 449.7   | +   | 423.3    | -1.090 | -0.352 | 994.430    |               |               |               | e     |
|              |             | Tracks 247 | 567.5   | -   | 434.3    | 2.080  | 0.764  |            |               |               |               | e     |

Canvas Window - File: event003.xml Run: 110158020 Event: 3101

HYPATIA - Track Momenta Window

Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

ETHis: 22.805 GeV  $\phi$ : -1.466 rad Collection: MET\_RefFinal

/home/negri/MasterClasses/groupA.zip/event003.xml

| Track      | +/- | P [GeV] | Pt [GeV] | $\phi$ | $\theta$ |
|------------|-----|---------|----------|--------|----------|
| Tracks 4   | -   | 9.77    | 9.42     | -0.195 | 1.302    |
| Tracks 184 | +   | 449.71  | 423.28   | -1.090 | 1.915    |
| Tracks 247 | -   | 567.5   | 434.3    | 2.080  | 0.764    |

## Taglio sulle tracce

Visualizzazione delle sole tracce con momento superiore ad una certa soglia  
Partire sempre da 5 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 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 | >= 2        |

# Hypatia Event Viewer

Hybrid Pupils' Analysis Tool for Intermediate Energy Particle Physics

File View Histograms Preferences Help

| File Name    | ETMis [GeV] | Track      | P [GeV] | M(2) [GeV] | M(eeee) [GeV] |
|--------------|-------------|------------|---------|------------|---------------|
| event002.xml | 23.199      | Tracks 0   | 217.0   | 94.165     |               |
|              |             | Tracks 76  | 93.3    |            |               |
| event003.xml | 22.805      | Tracks 184 | 449.7   | 994.430    |               |
|              |             | Tracks 247 | 567.5   |            |               |

**Masse invarianti**

**Inserimento tracce per calcolo masse**

Canvas Window - File: event003.xml Run: 11

**Vista trasversale (dalla linea del fascio)**

**Sviluppo piano celle calorimetro**

**Avanzamento eventi**

Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

ETMis: 22.805 GeV  $\phi$ : -1.466 rad Collection: MET\_RefFinal

/home/negri/MasterClasses/groupA.zip/event003.xml

| Track      | +/- | P [GeV] | Pt [GeV] | $\phi$ | $\theta$ |
|------------|-----|---------|----------|--------|----------|
| Tracks 4   | -   | 9.77    | 9.42     | -0.195 | 1.302    |
| Tracks 184 | +   | 449.71  | 423.28   | -1.090 | 1.915    |
| Tracks 218 | -   | 28.13   | 5.75     | 2.487  | 2.936    |
| Tracks 247 | -   | 567.48  | 434.30   | 2.080  | 0.872    |

**Scheda oggetti: fotoni**

**Scheda tracce: elettroni e muoni**

**Tasti cambio modalità: zoom / selezione**

HYPATIA - Control Window

Parameter Control Interaction and Window Control Output Display

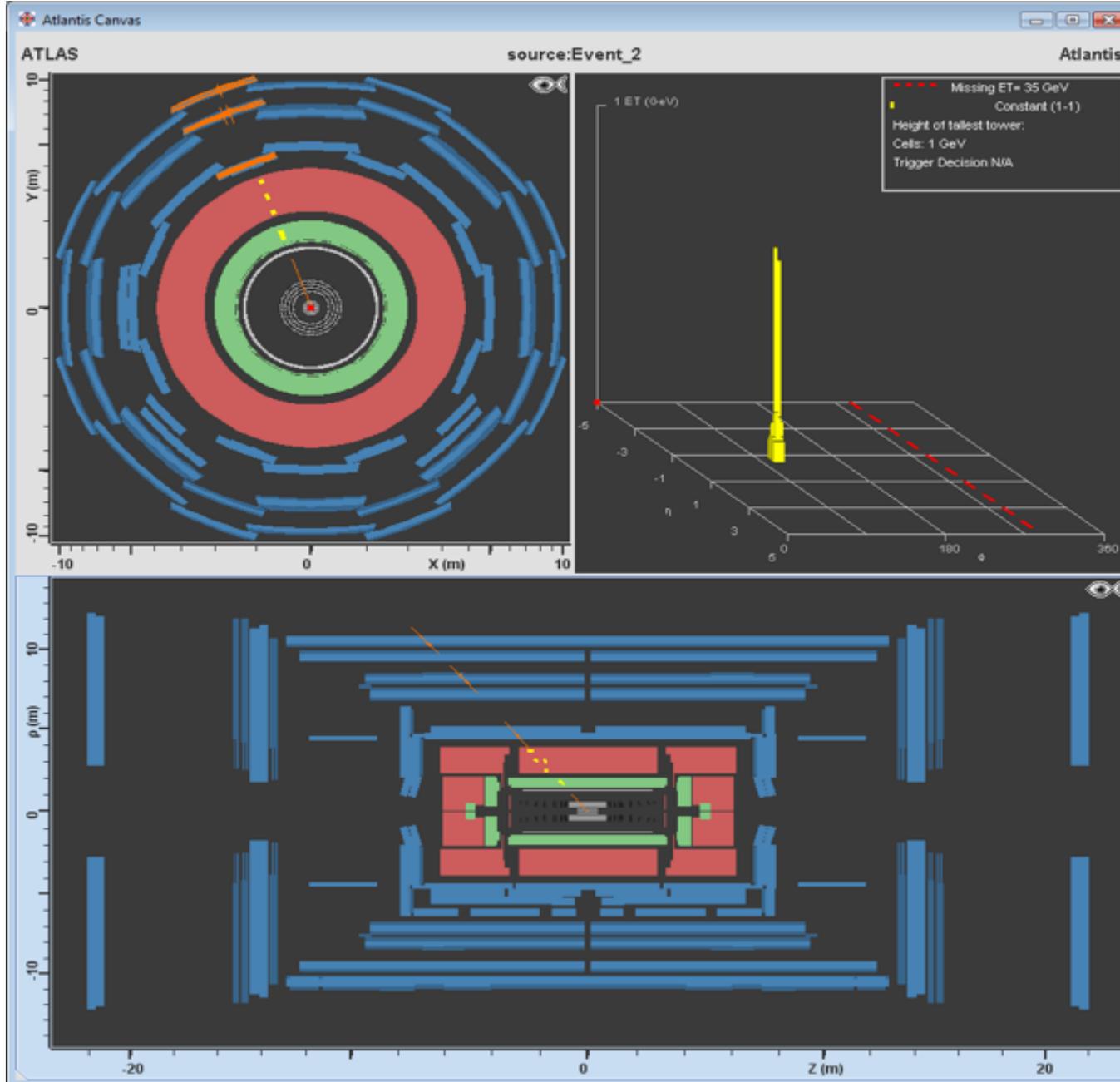
Projection Data Cuts InDet Calo MuonDet Objects Geometry

| Category | Name                                       | Value       |
|----------|--|-------------|
| InDet    |  |             |
| Calo     |  |             |
| MuonDet  | <input checked="" type="checkbox"/>  Pt    | > 5.0 GeV   |
| Objects  | <input type="checkbox"/>  Pt2              | < 700.0 MeV |
| ATLAS    | <input checked="" type="checkbox"/>  d0    | < 2.5 mm    |
|          | <input checked="" type="checkbox"/>  z0    | < 20.0 cm   |
|          | <input type="checkbox"/> Layer             | > 0         |
|          | <input type="checkbox"/> Number Pixel Hits | >= 2        |

**Taglio momento tracce**

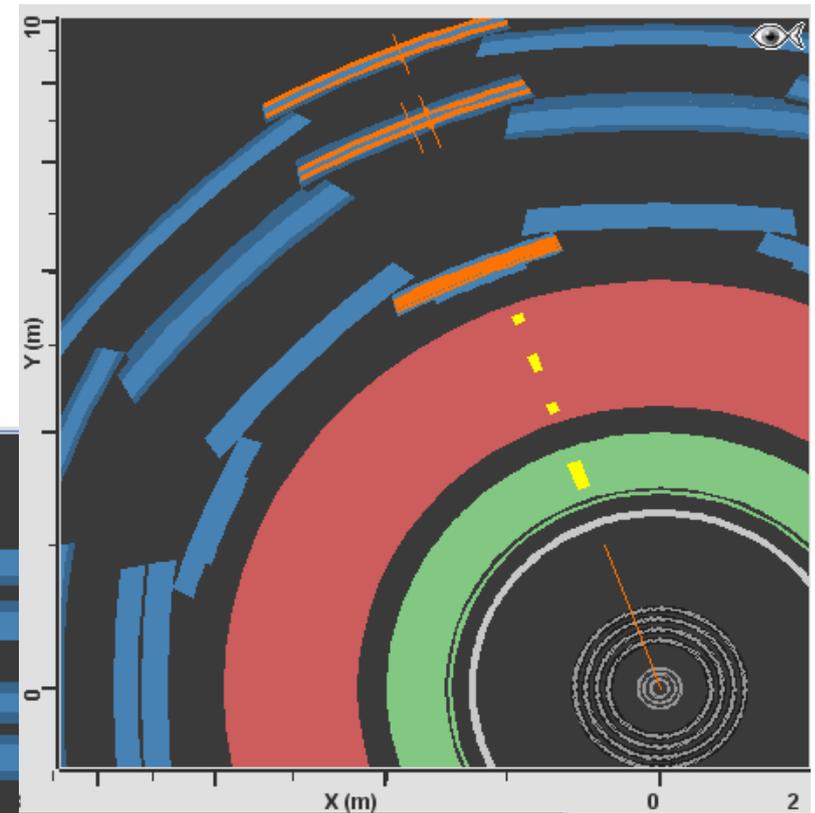
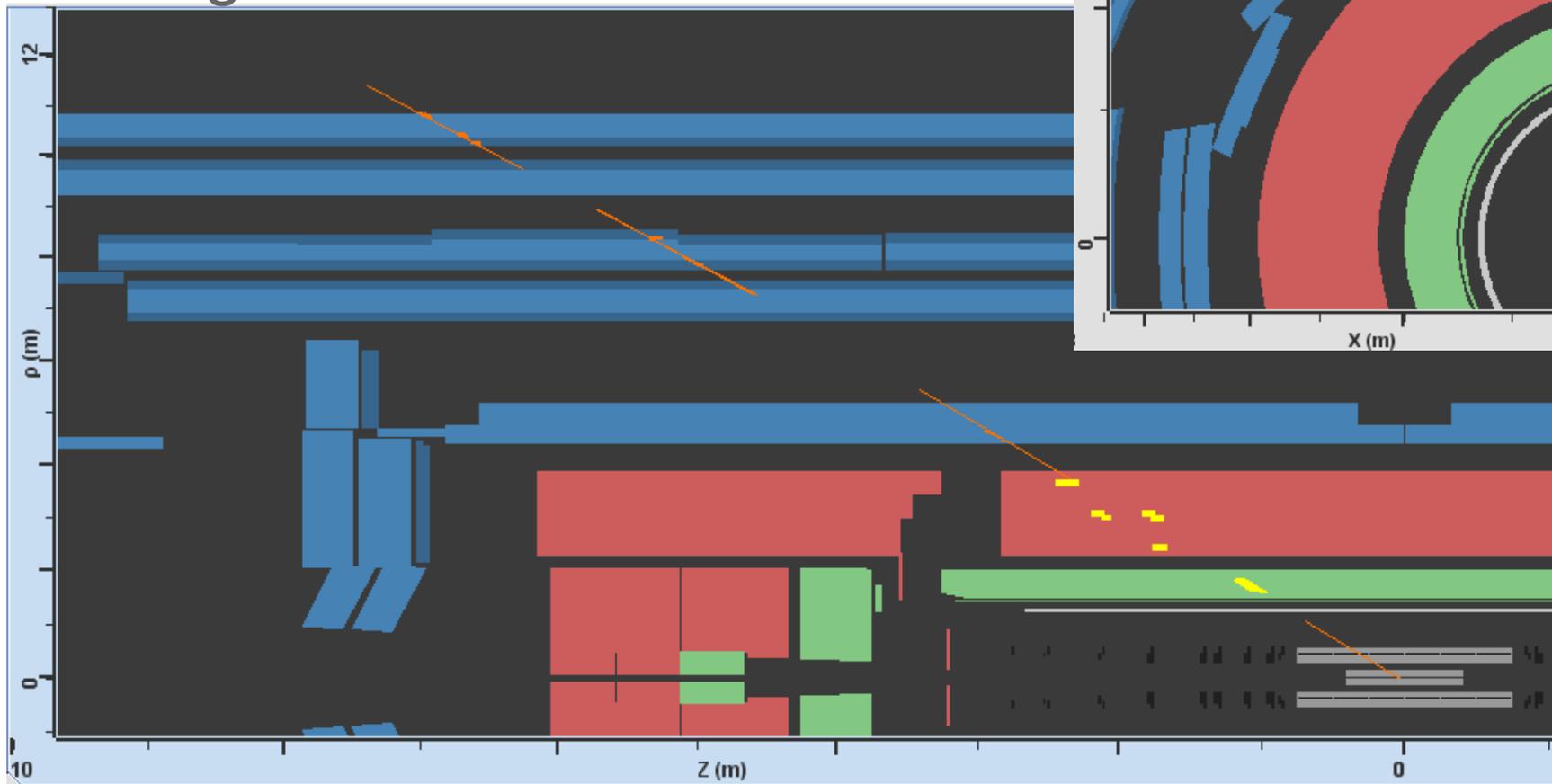
**Vista longitudinale**

# Identikit: (anti)muoni

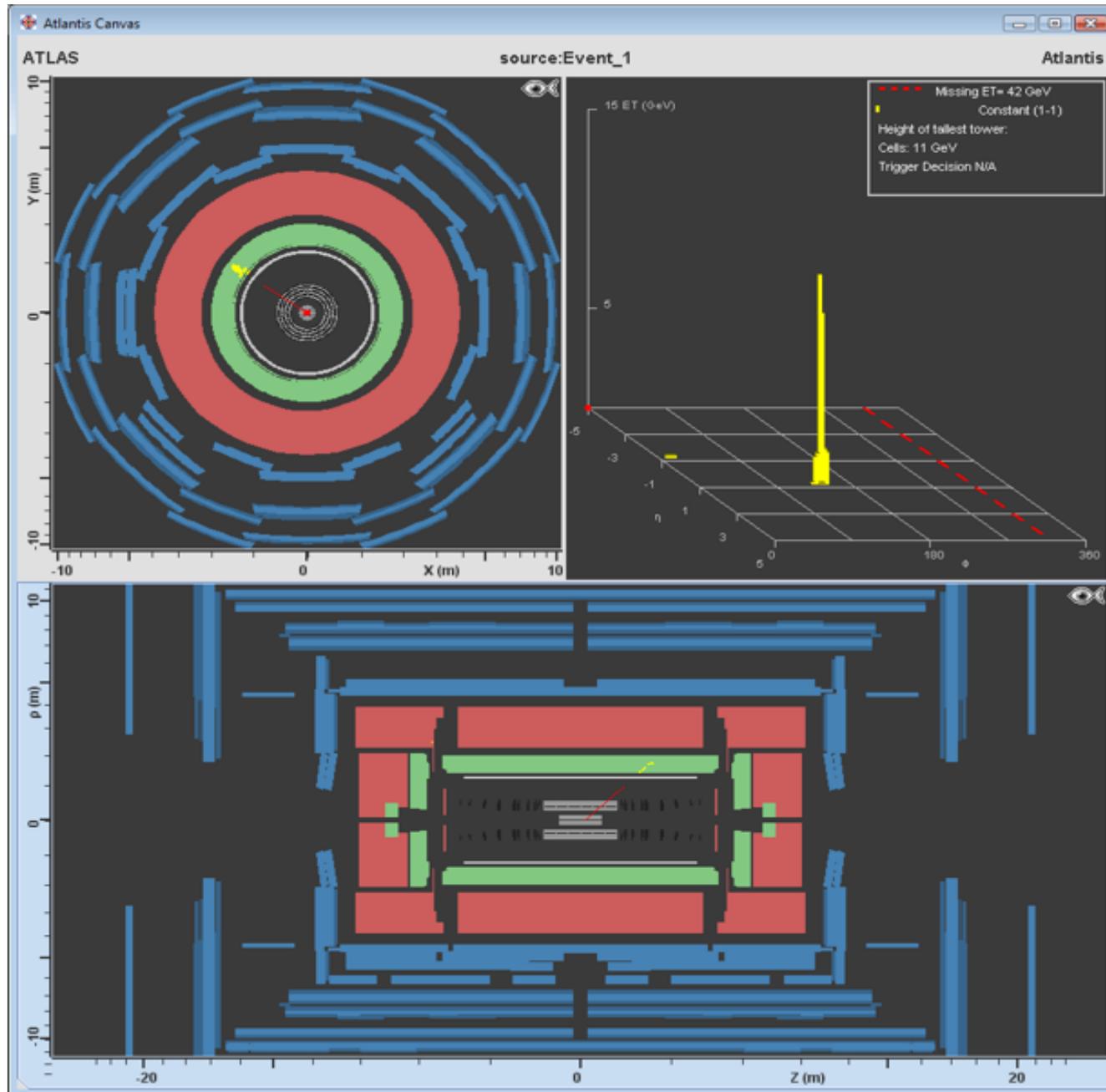


# Identikit: (anti)muoni

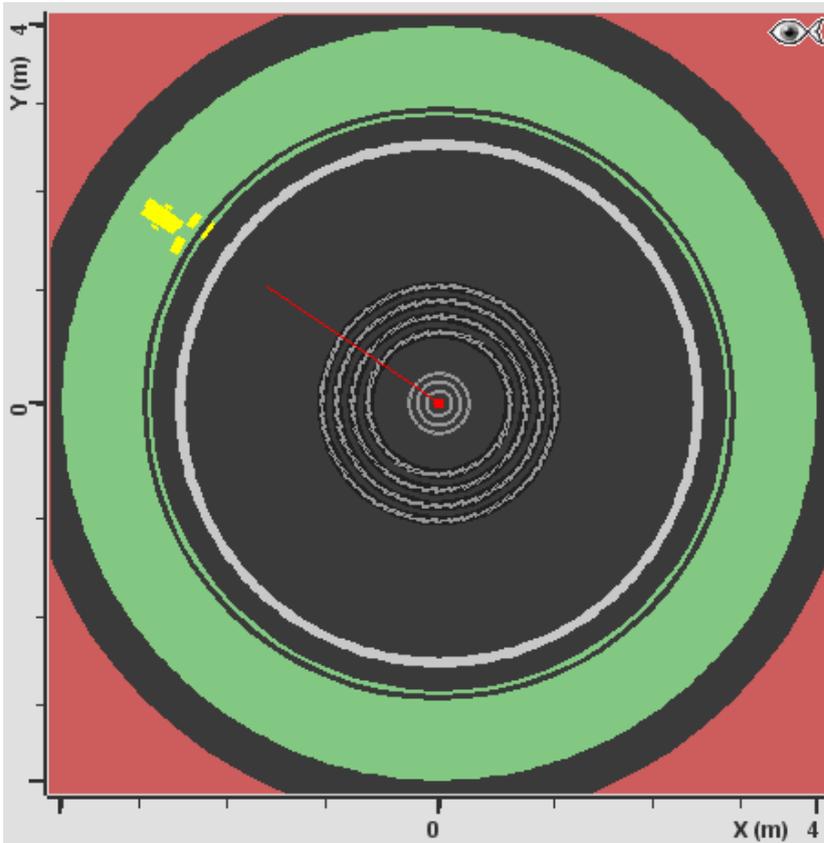
Traccia nel rivelatore interno  
e nello spettrometro senza  
significativi depositi di  
energia nei calorimetri



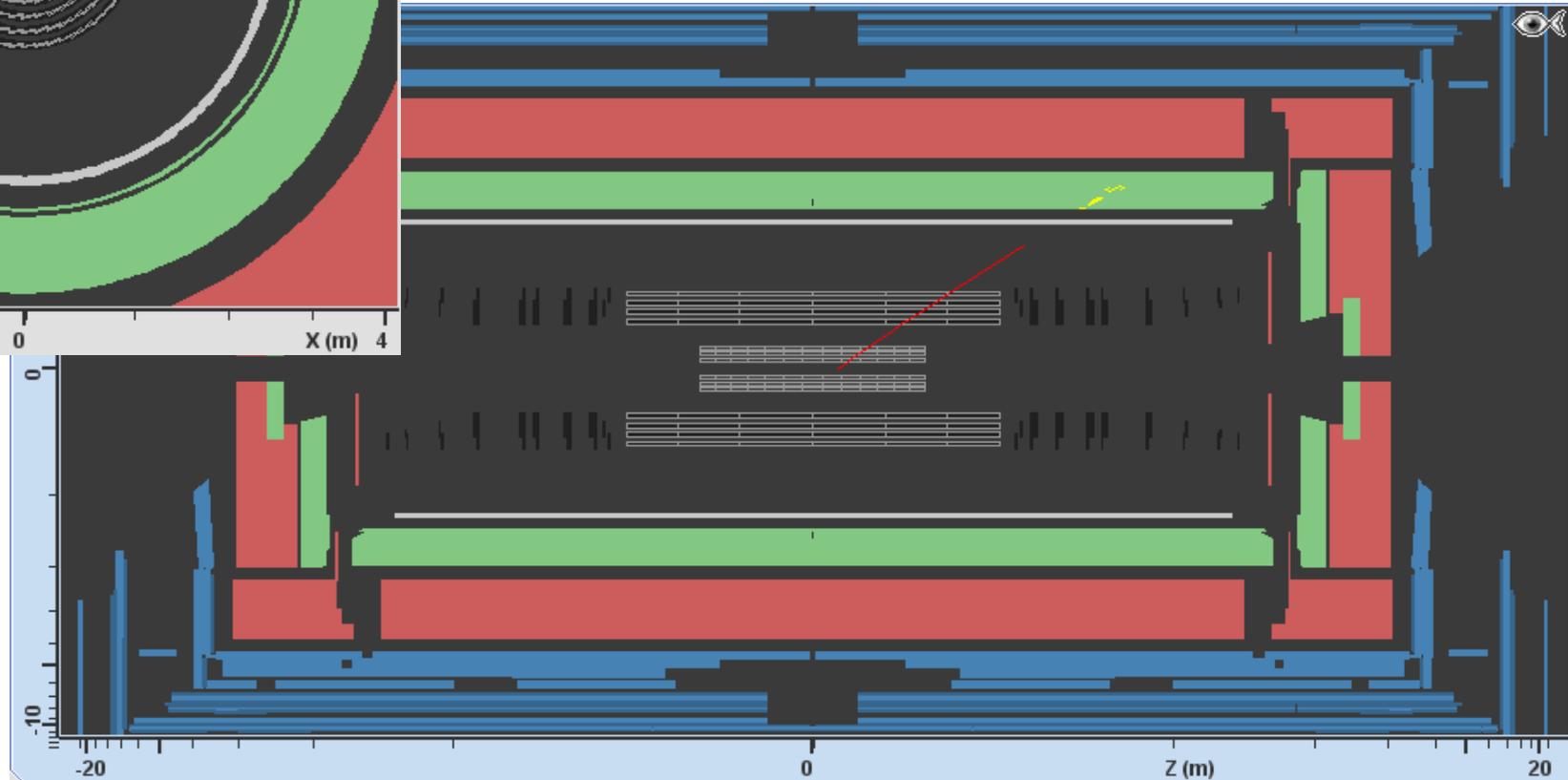
# Identikit: elettroni/positroni



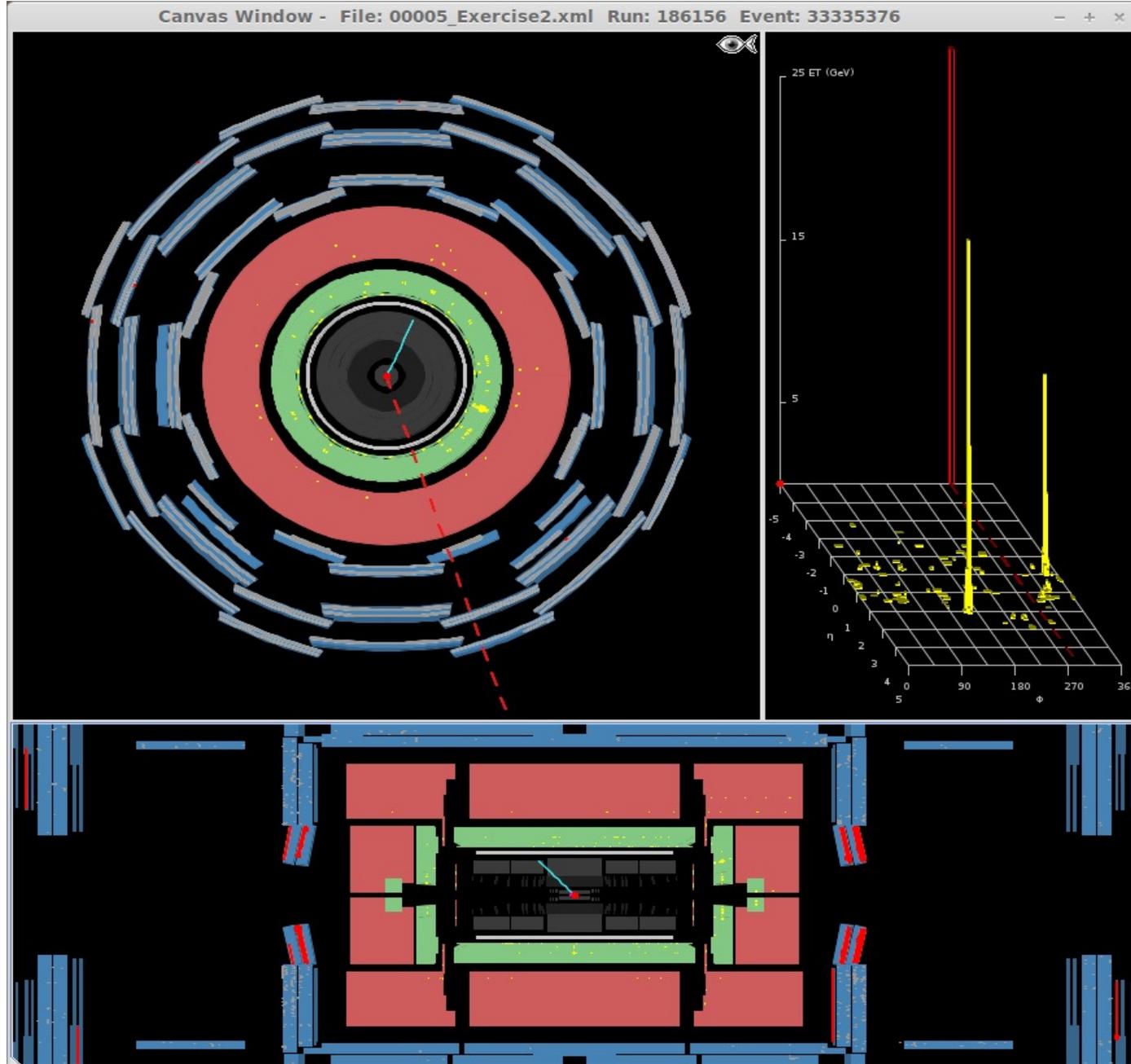
# Identikit: elettroni/positroni



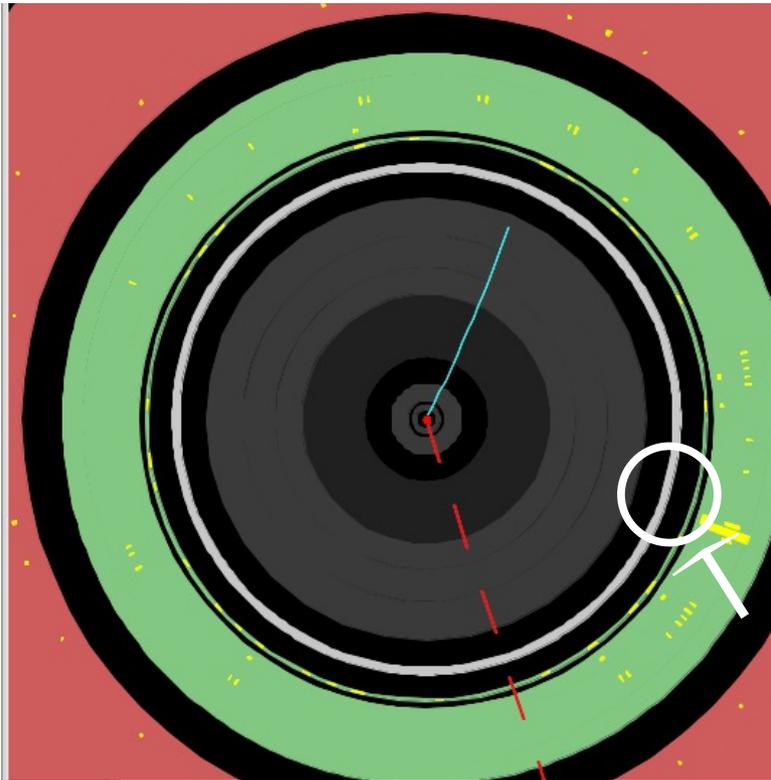
Tracce nel rivelatore interno  
che puntano a depositi di  
energia nel calorimetro  
elettromagnetico



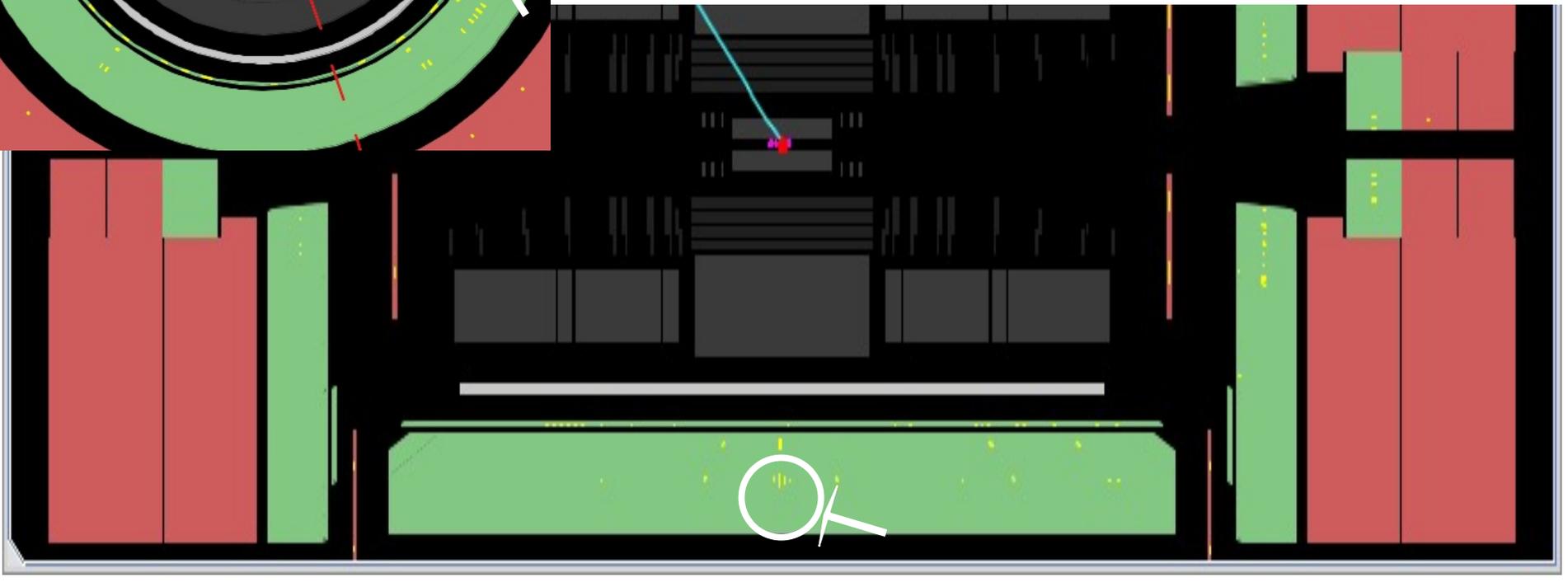
# Identikit: fotoni



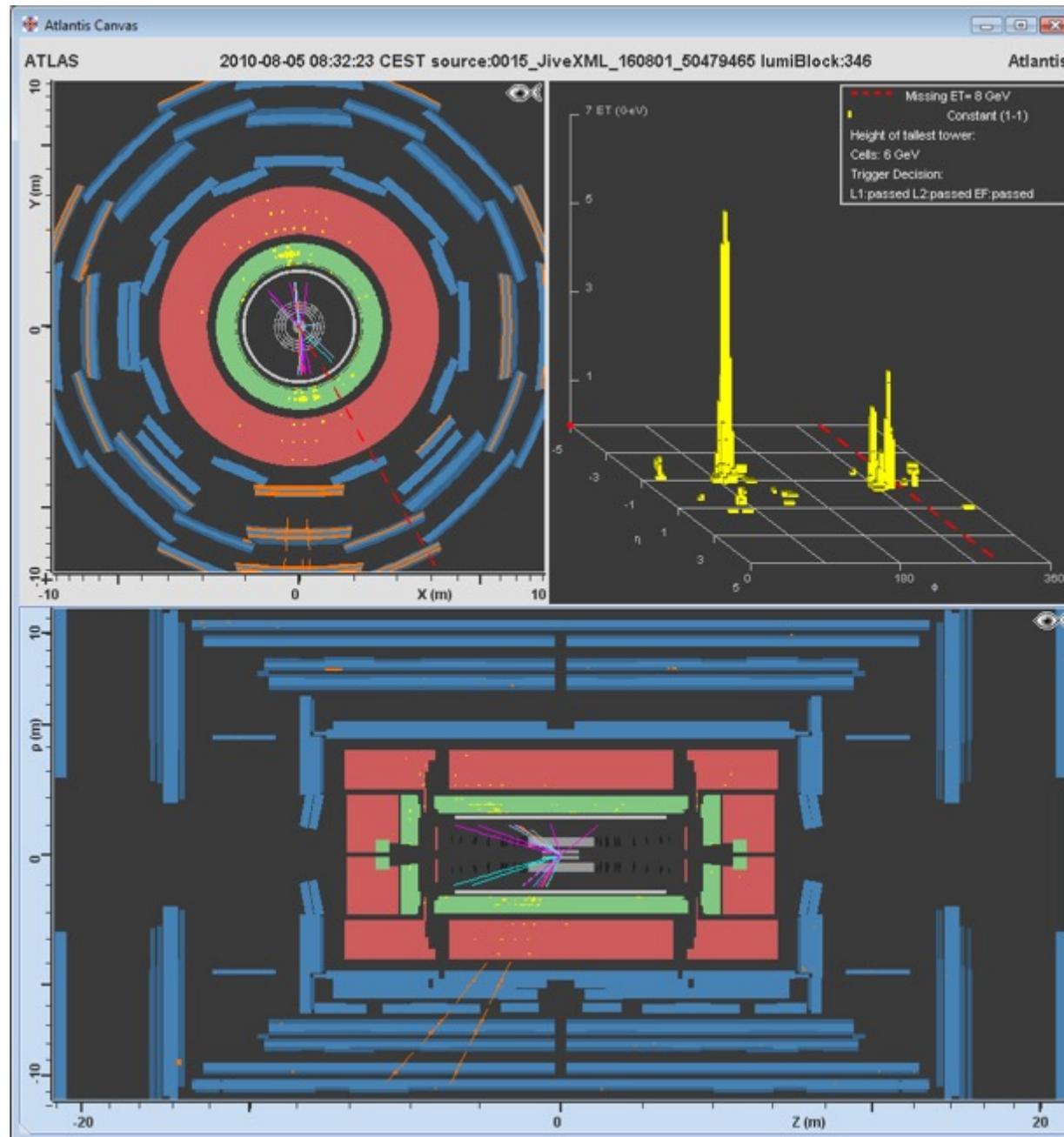
# Identikit: fotoni



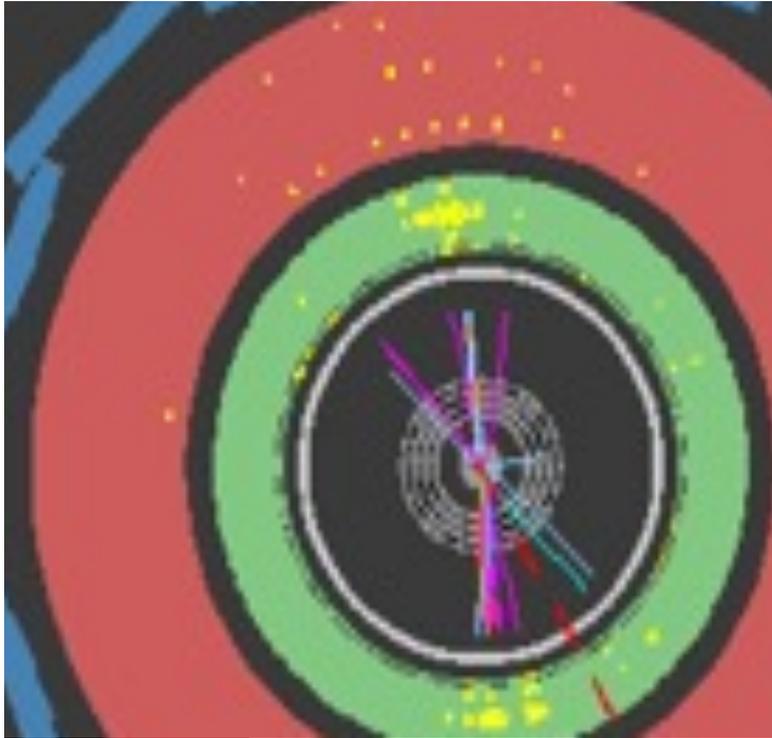
Depositi di energia nel calorimetro elettromagnetico senza tracce associate



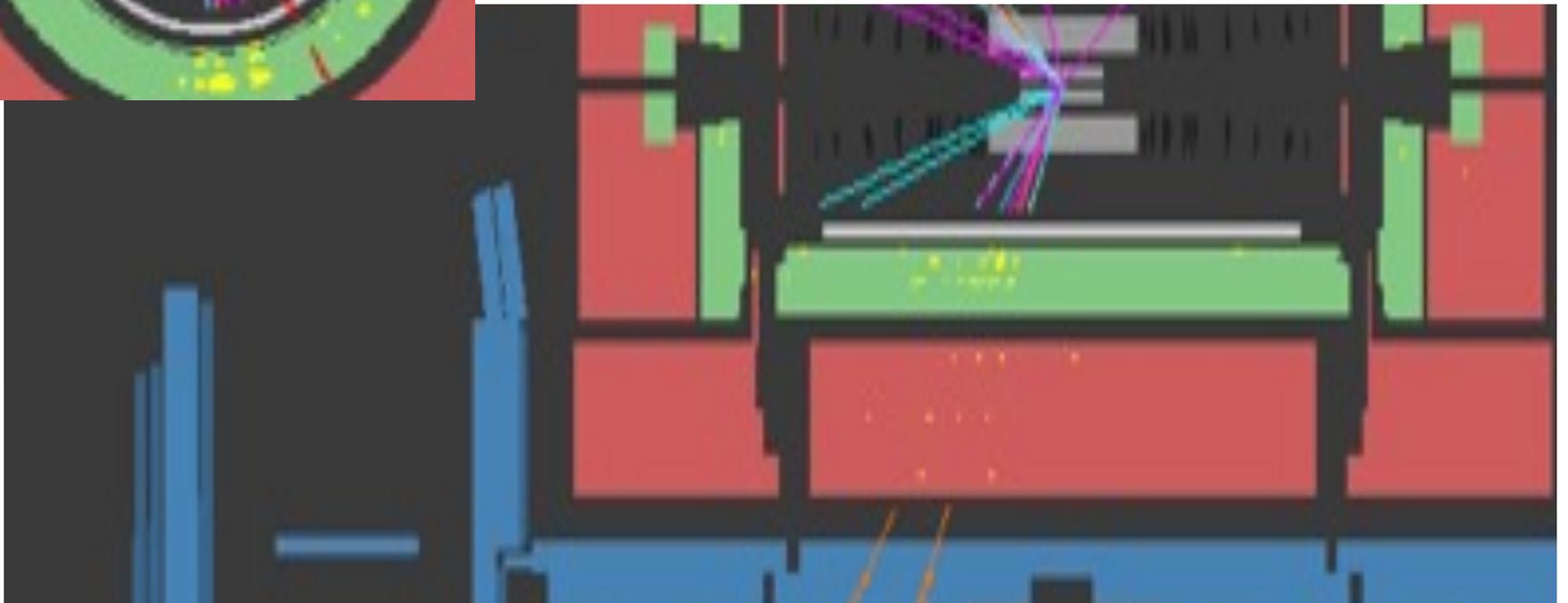
# Identikit: jets



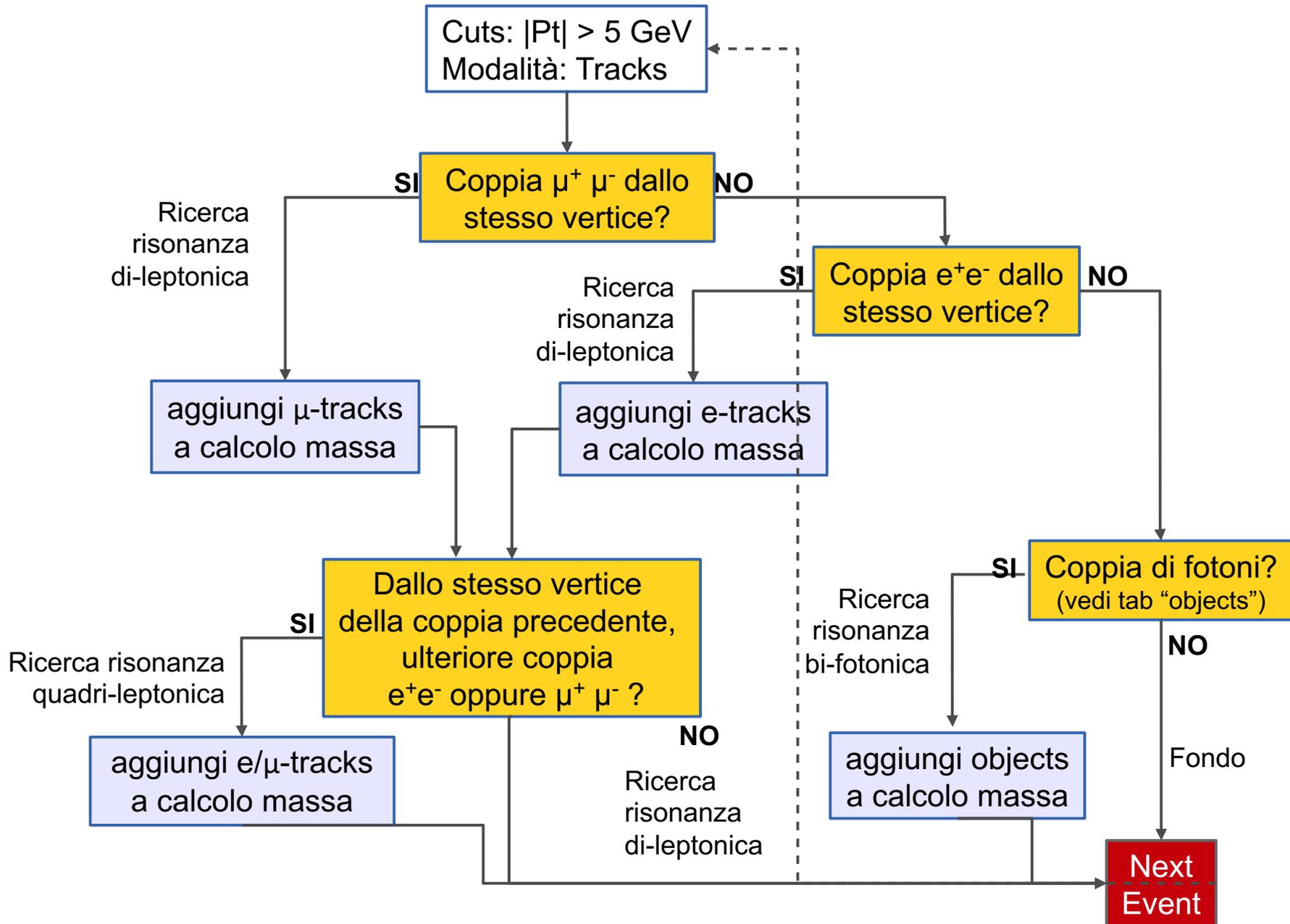
# Identikit: jets



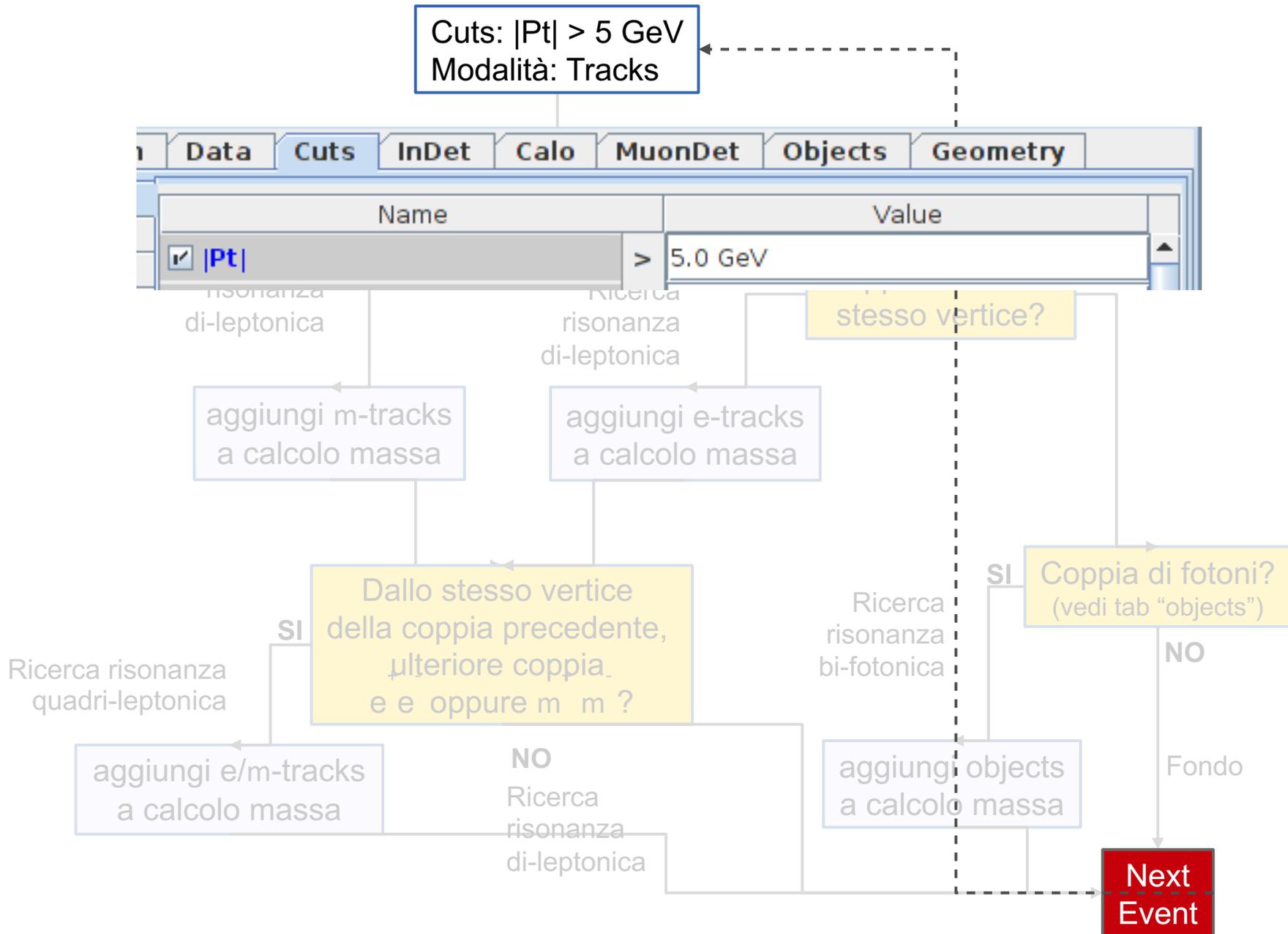
“Fascio” di tracce che puntano a depositi di energia in entrambi i tipi di calorimetri



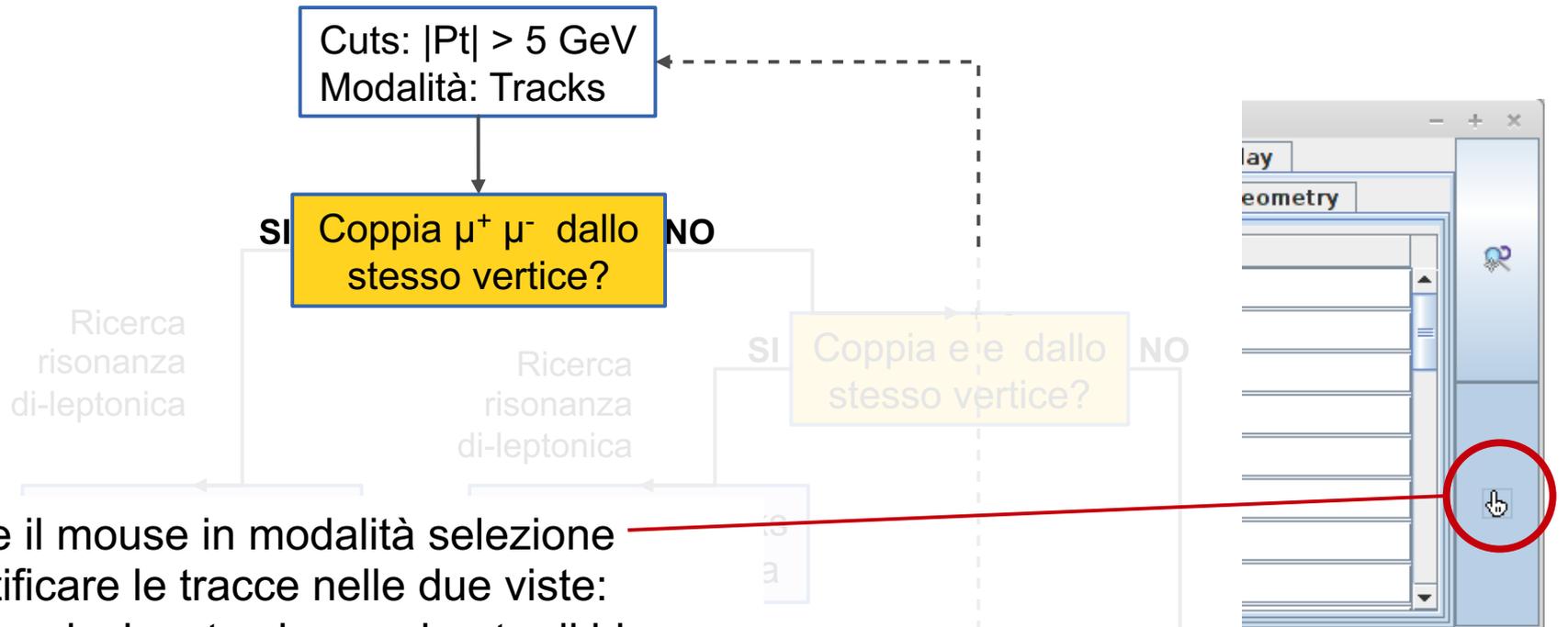
# Piano di lavoro: flow chart



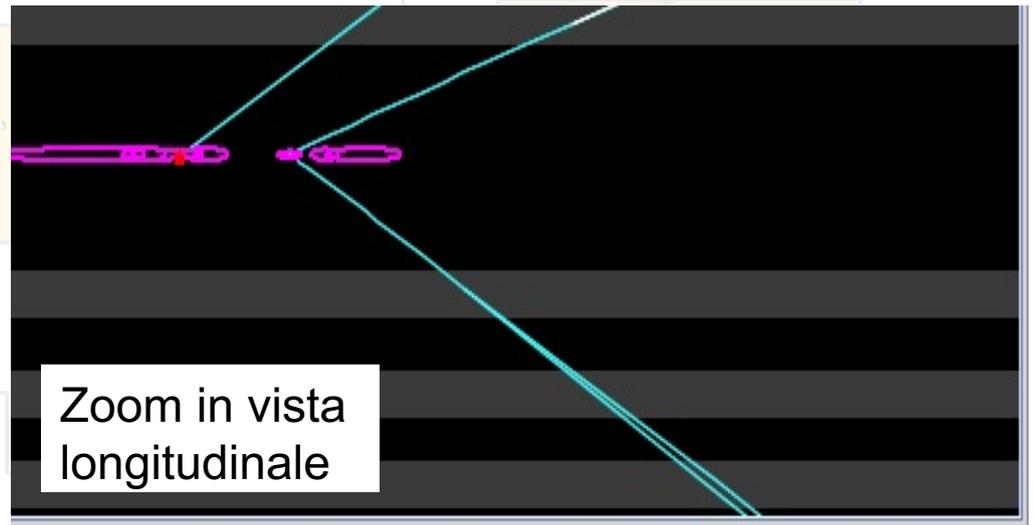
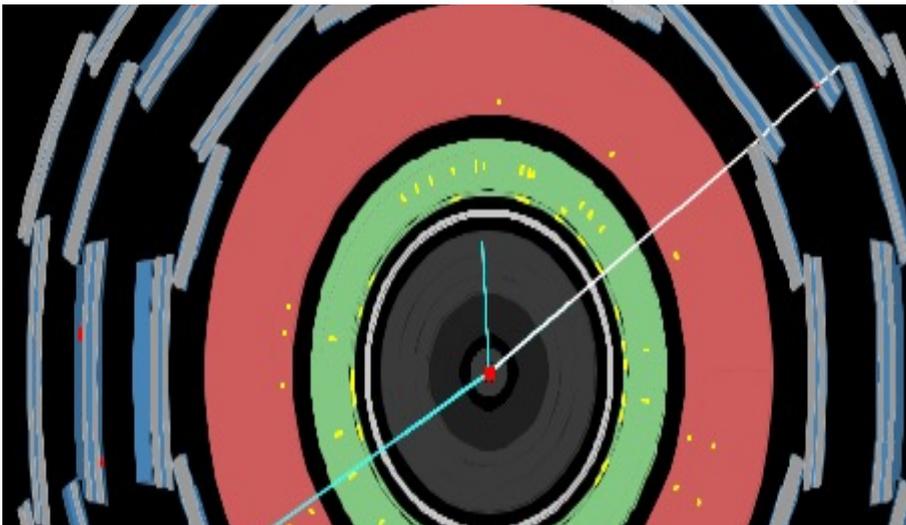
# Piano di lavoro: flow chart



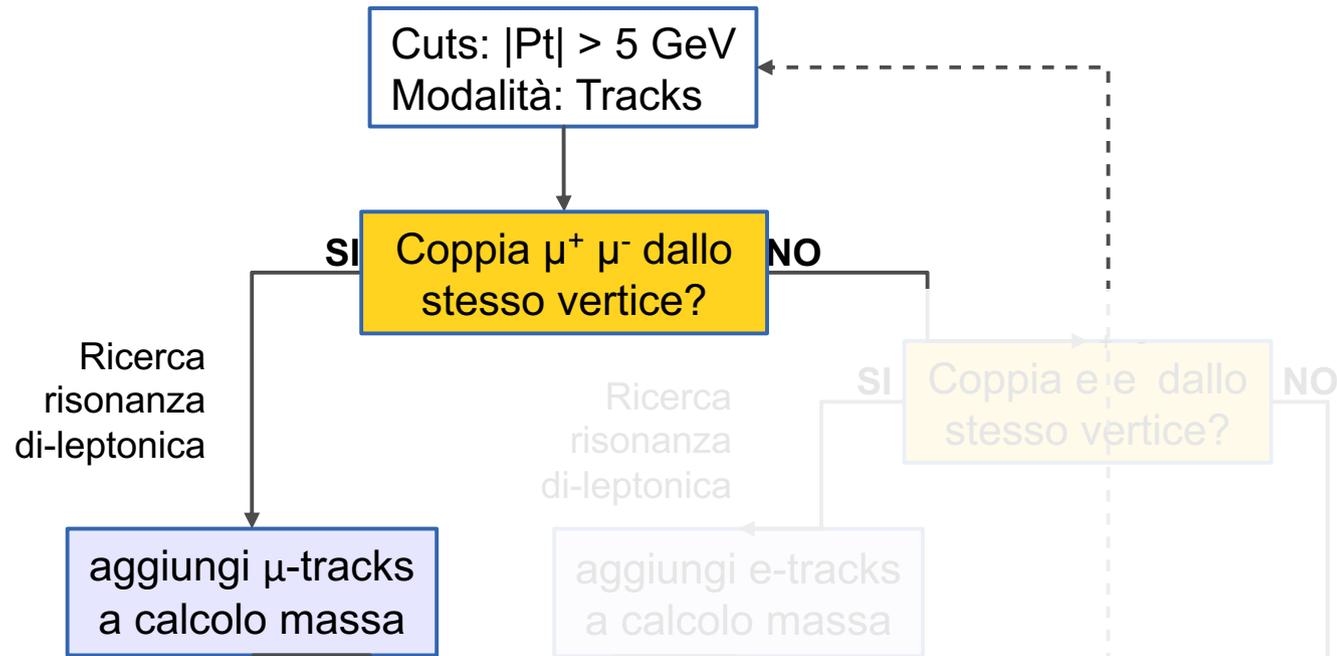
# Piano di lavoro: flow chart



Utilizzare il mouse in modalità selezione per identificare le tracce nelle due viste: la traccia selezionata viene colorata di bianco



# Piano di lavoro: flow chart



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

| File Name           | ETMis [GeV] | Track      | P [GeV] | +/- | Pt [GeV] | $\phi$ | $\eta$ | MC     |
|---------------------|-------------|------------|---------|-----|----------|--------|--------|--------|
| event003.xml        | 22.805      | Tracks 184 | 449.7   | +   | 423.3    | -1.090 | -0.352 | 994.43 |
|                     |             | Tracks 247 | 567.5   | -   | 434.3    | 2.080  | 0.764  |        |
| 00007_Exercise2.xml | 7.369       | Tracks 22  | 139.5   | -   | 47.7     | 0.576  | 1.736  | 86.854 |
|                     |             | Tracks 139 | 73.7    | +   | 37.7     | -2.627 | 1.291  |        |

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

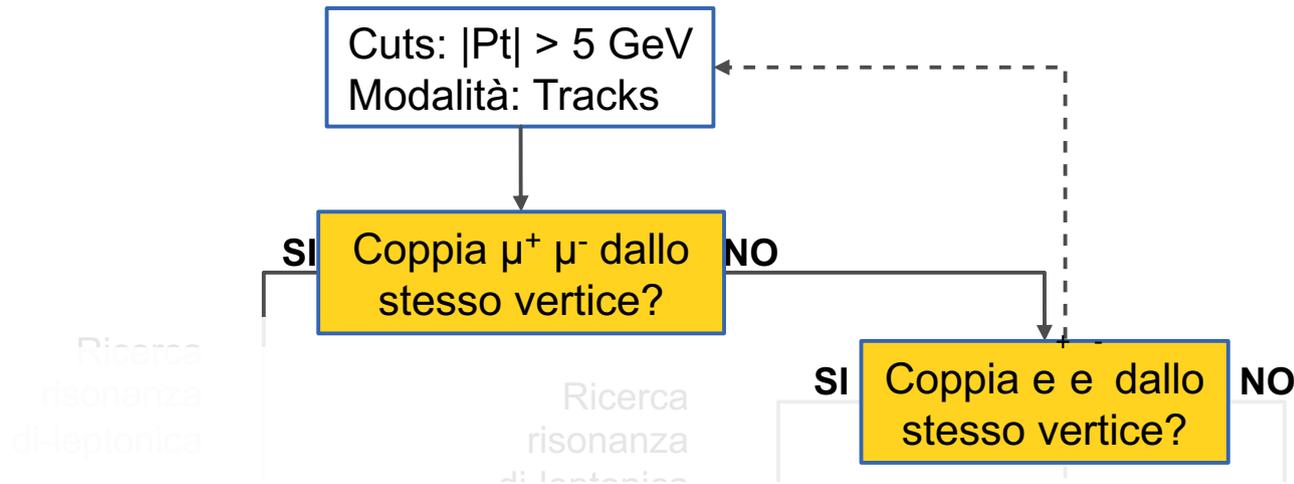
ETMis: 7.369 GeV    $\phi$ : 2.796 rad   Collection: MET\_RefFinal

/home/negri/MasterClasses/exercise2\_Z.zip/00007\_Exercise2.xml

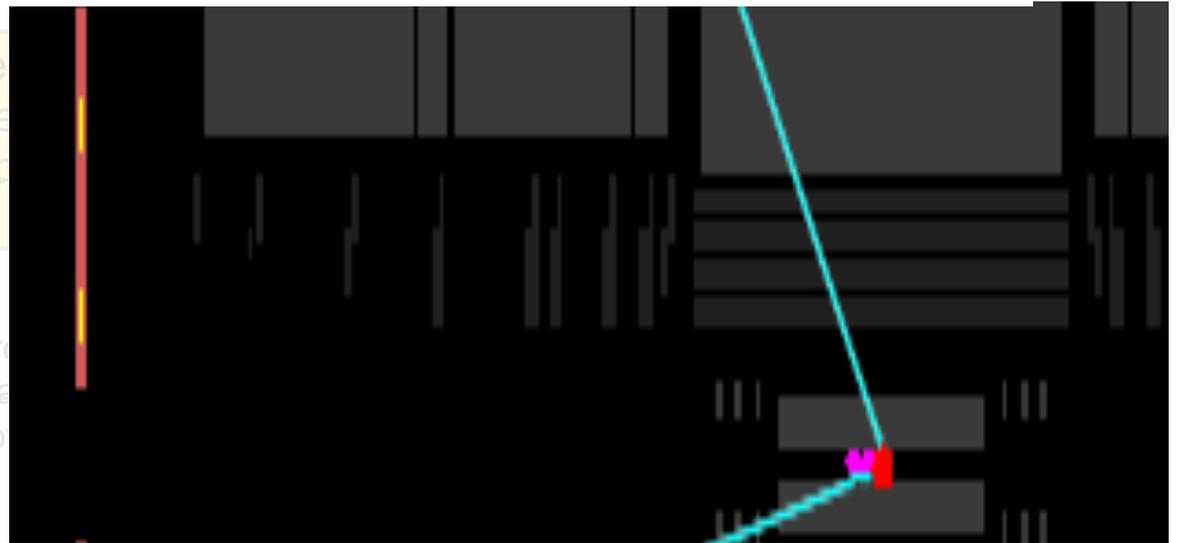
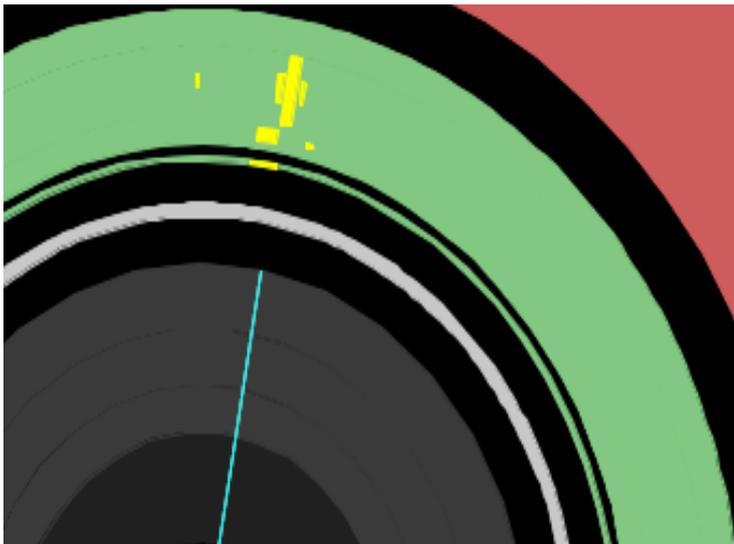
Tracks   Physics Objects

| Track | +/- | P [GeV] | Pt [GeV] | $\phi$ | $\theta$ |
|-------|-----|---------|----------|--------|----------|
|-------|-----|---------|----------|--------|----------|

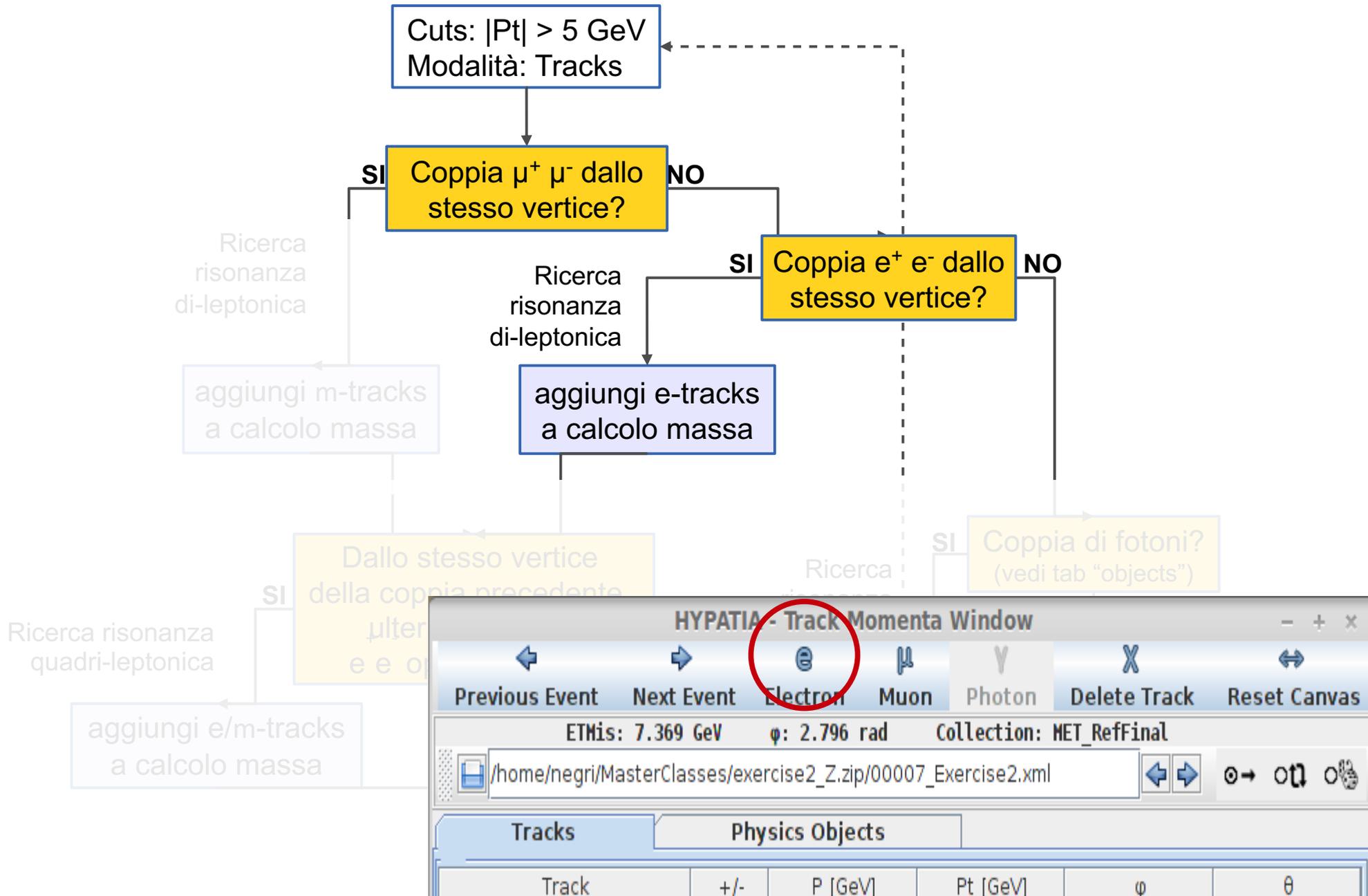
# Piano di lavoro: flow chart



- Cercare depositi di energia nel calorimetro
- Verificare la presenza di tracce che puntano ai depositi
- Verificare che puntino allo stesso vertice primario



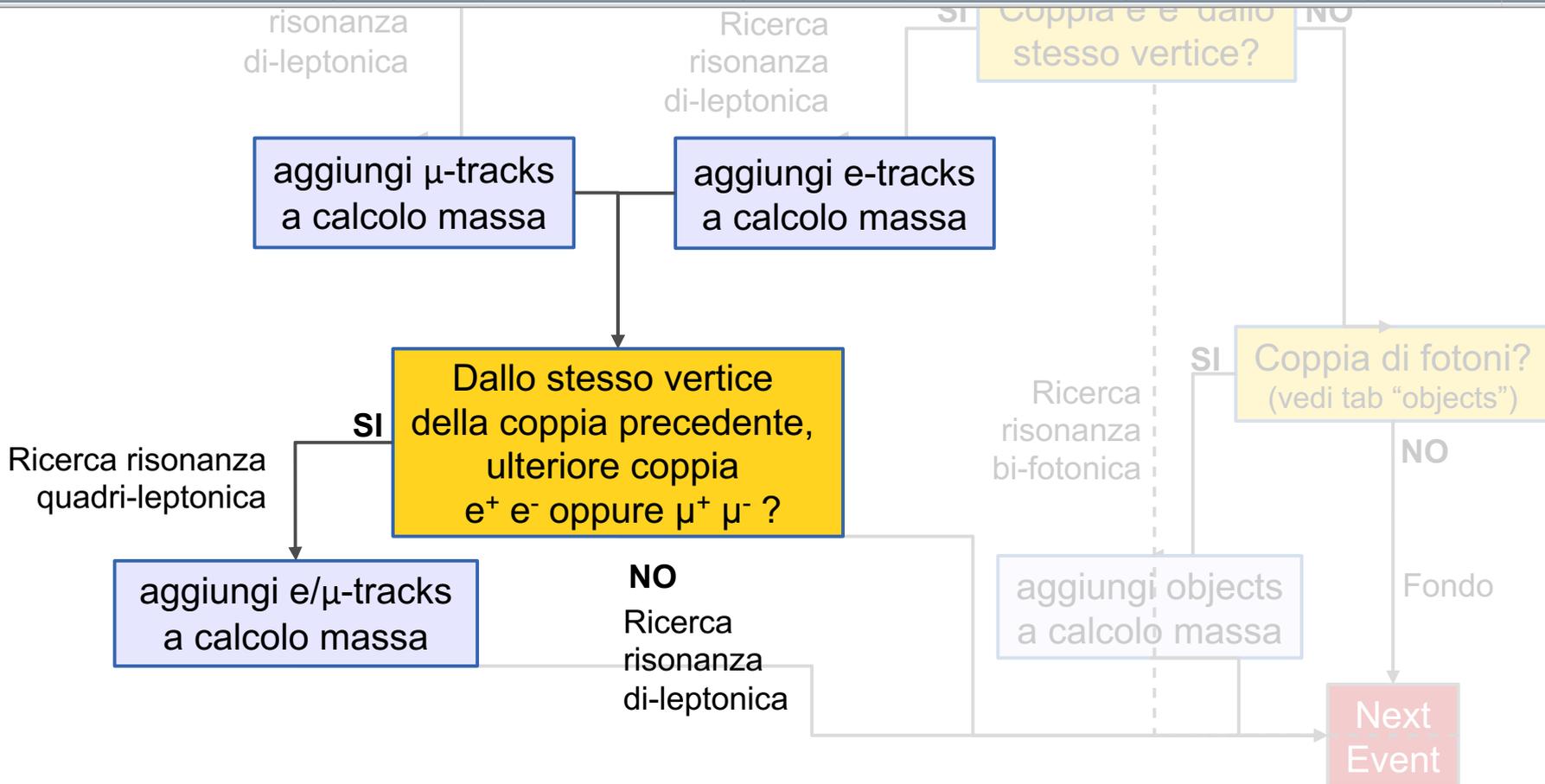
# Piano di lavoro: flow chart



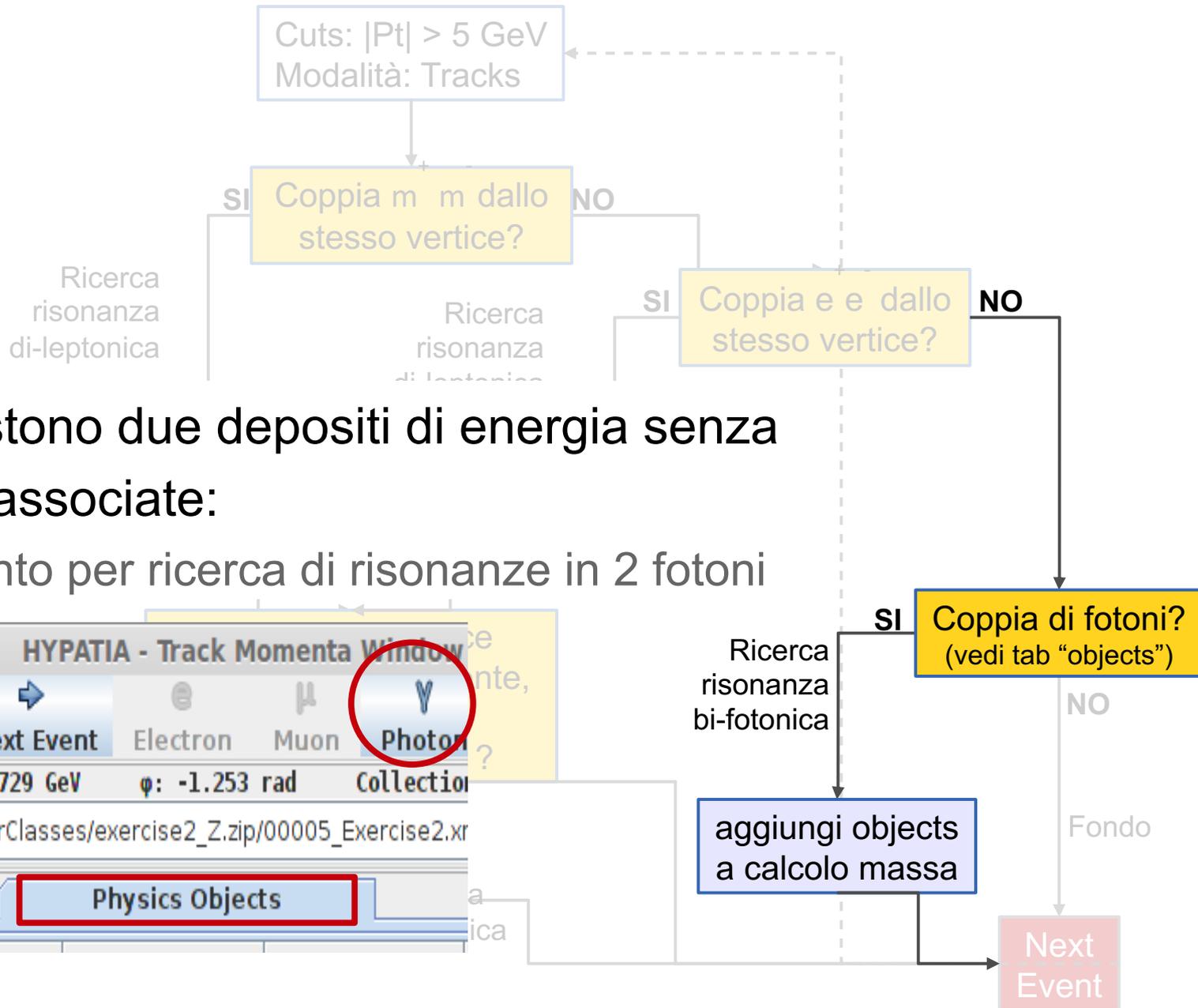
# Piano di lavoro: flow chart

Cuts:  $|Pt| > 5$  GeV  
Modalità: Tracks

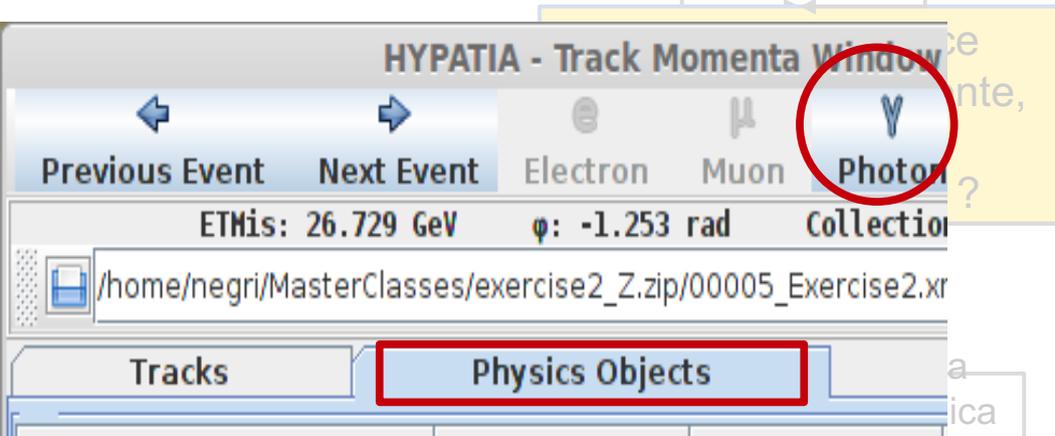
| HYbrid Pupils' Analysis Tool for Interactions in ATLAS - version 7.4 - Invariant Mass Window |             |           |         |     |          |           |        |            |  |
|--|-------------|-----------|---------|-----|----------|-----------|--------|------------|--|
| File Name  | ETMis [GeV] | Track     | P [GeV] | +/- | Pt [GeV] | $\varphi$ | $\eta$ | M(2) [GeV] |  |
| event046.xml   | 37.975      | Tracks 2  | 108.7   | -   | 58.0     | 1.525     | 1.242  | 90.333     |  |
|  |             | Tracks 21 | 43.4    | +   | 41.7     | 2.277     | -0.289 |            |  |
|  |             | Tracks 4  | 98.8    | +   | 61.2     | -2.171    | -1.058 | 91.492     |  |
|  |             | Tracks 10 | 136.9   | -   | 39.2     | -0.248    | -1.922 |            |  |



# Piano di lavoro: flow chart



- Se esistono due depositi di energia senza tracce associate:
  - evento per ricerca di risonanze in 2 fotoni





# Alla fine dei 50 eventi



Aprire il link:

<https://cernmasterclass.uio.no/OPloT/index.php>

Selezionare “Student” (Username/Password: ippog/imc)

## OPloT – MasterClass – Student page

Start Student Moderator Tutor Administrator

### Student Tasks

Please select items from the drop-down boxes to submit your results!

2023 ▾ March ▾ 03 ▾ Pavia ▾ 5 ▾ A ▾

5 o 6

A-T

# Alla fine dei 50 eventi



Caricare il file “Invariant\_masses.txt”  
Choose file → Submit

OPlOT – MasterClass – Plot for Pavia Group 5B on 2023-03-03

[Start](#) [Student](#) [Moderator](#) [Tutor](#) [Administrator](#)

Thursday, March 2nd 2023 - 19:57:01 UTC

The image shows a file upload interface. At the top, there are three light blue buttons stacked vertically: 'Change date', 'Change institute', and 'Change group'. Below these is the text 'Upload your file:'. Underneath, there is a 'Choose file' button, the text 'No file chosen', and a 'Submit' button. A red oval is drawn around the 'Choose file' and 'Submit' buttons.