

# Introduzione alla sessione di analisi

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# OBIETTIVO ANALISI

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

1. **Identificare eventi con Z** nei decadimenti:
  - a. Elettrone ( $e^-$ )-positrone ( $e^+$ )
  - b. Muone ( $\mu^-$ )-antimuone ( $\mu^+$ )
2. **Identificare eventi con Higgs** nei decadimenti:
  - a. Due coppie di particelle cariche ( $e^+e^- e^+e^-$ ,  $e^+e^- \mu^+\mu^-$ ,  $\mu^+\mu^- \mu^+\mu^-$ )
  - b. fotone - fotone



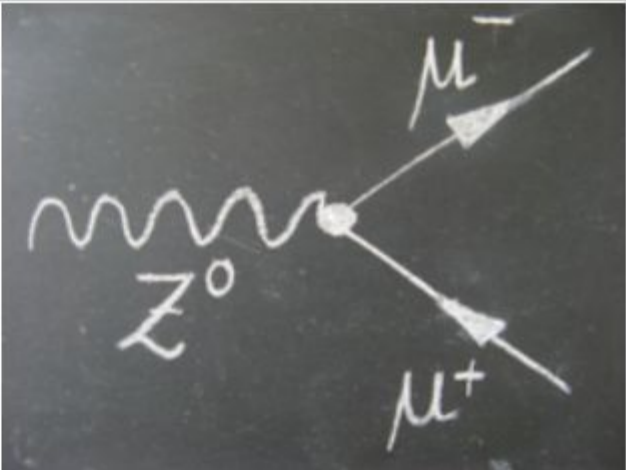
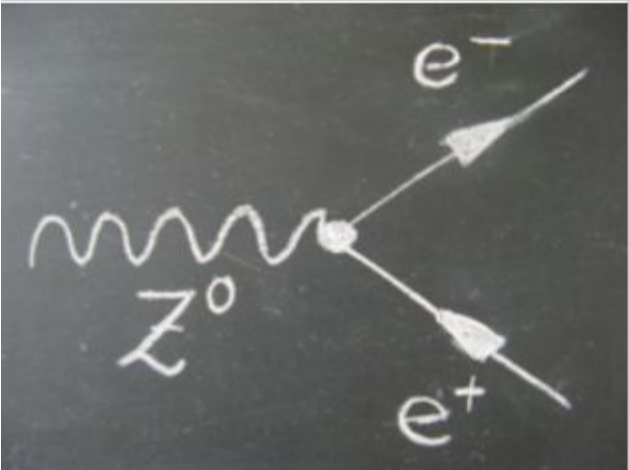
# Obiettivo #1

## bosone Z

mass  
charge  
spin

$\approx 91.19 \text{ GeV}/c^2$   
0  
1  
**Z**  
**Z boson**

COPPIA  
LEPTONE-ANTILEPTONE



# Obiettivo #2

## bosone di Higgs

mass  
charge  
spin

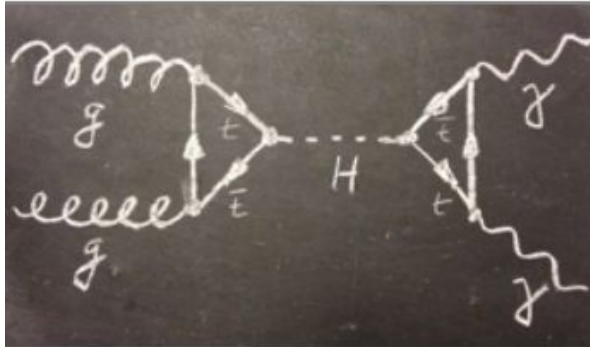
$\approx 124.97 \text{ GeV}/c^2$

0  
0

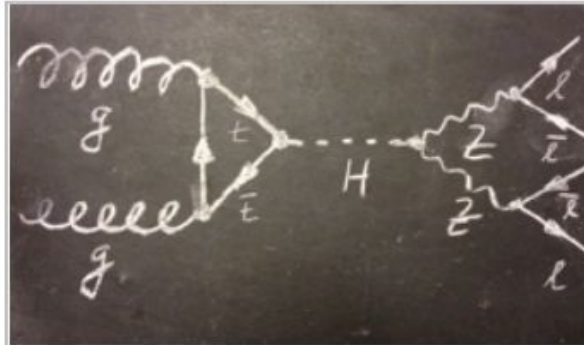
H

higgs

COPPIA FOTONE-FOTONE



COPPIA BOSONI Z<sup>0</sup>

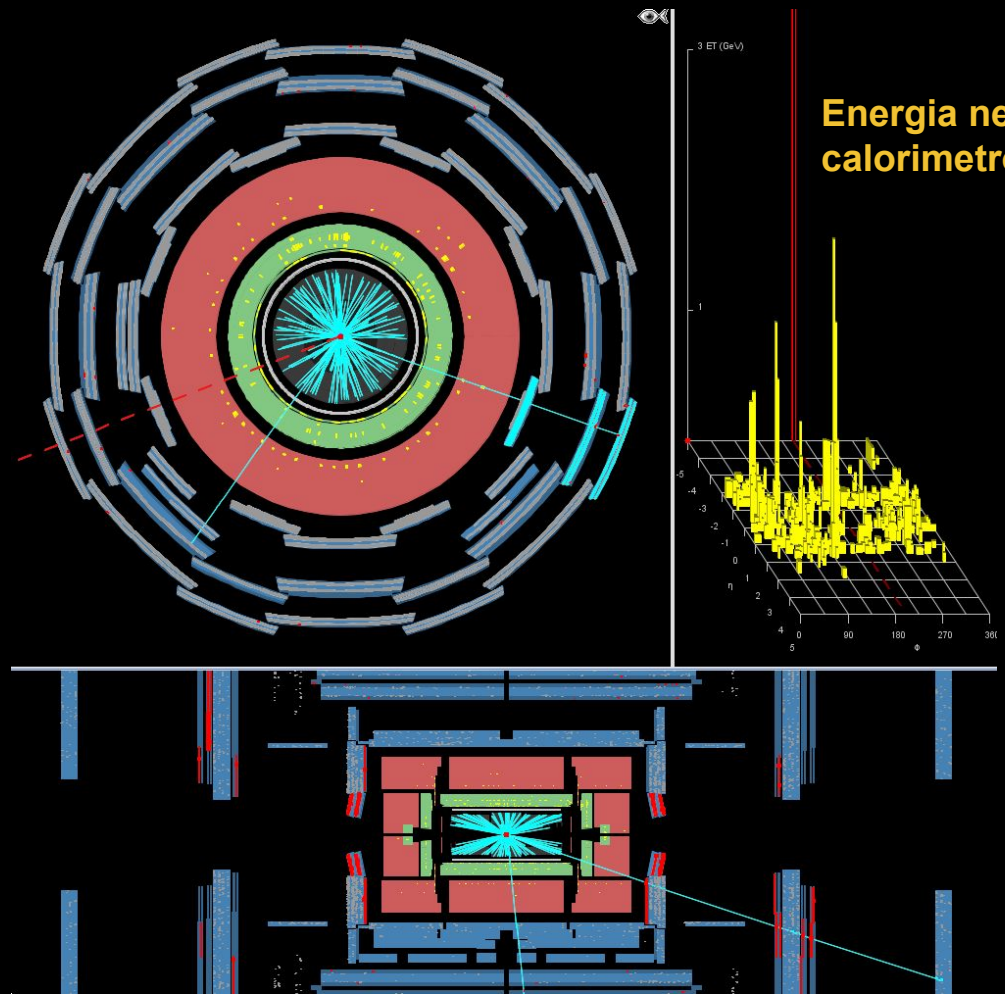


**Tracciatore**  
particelle cariche

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

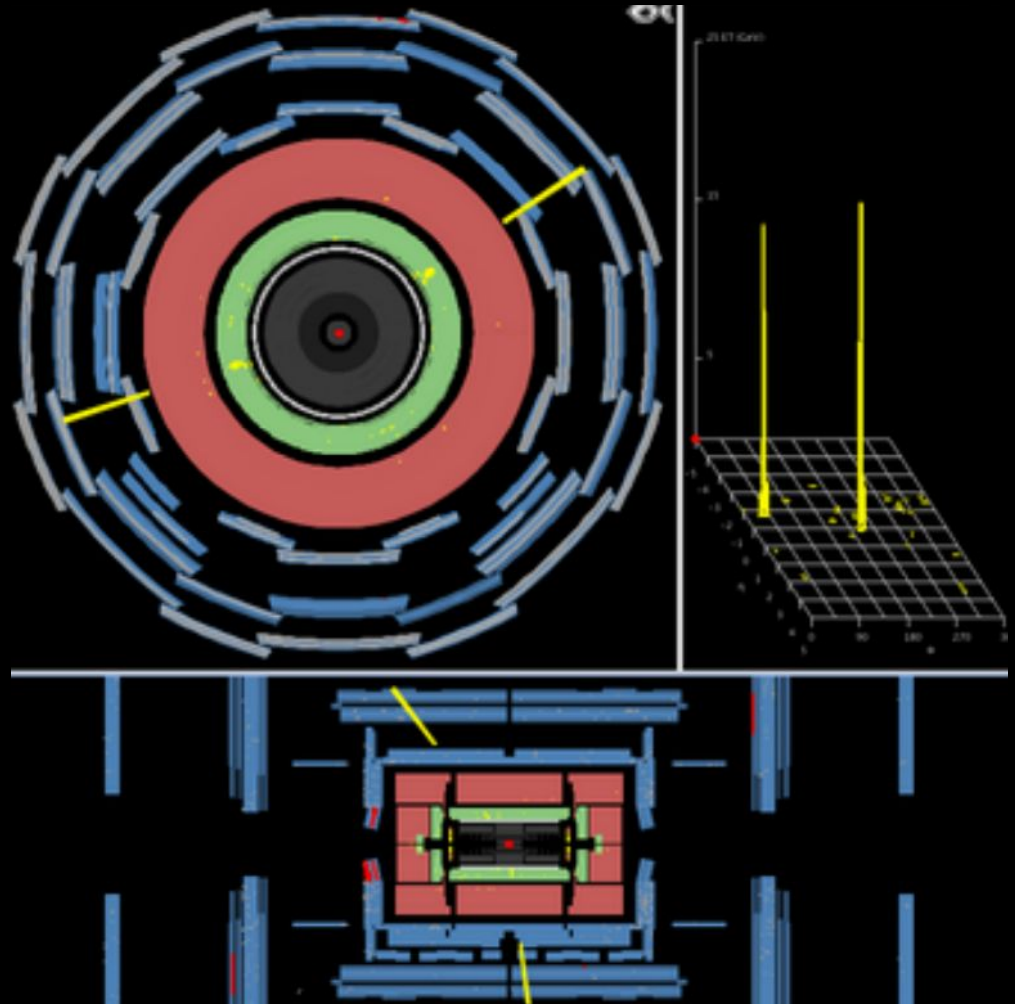
**Calorimetro adronico**  
adroni (es: protoni, neutroni)

**Rivelatori muoni**



# Fotone

mass  
0  
charge  
0  
spin  
1



**Non lascia traccia** nel rivelatore interno.

Deposita tutta la sua energia nel Calorimetro Elettromagnetico.

# Elettrone

mass  
charge  
spin

$\approx 0.511 \text{ MeV}/c^2$

-1

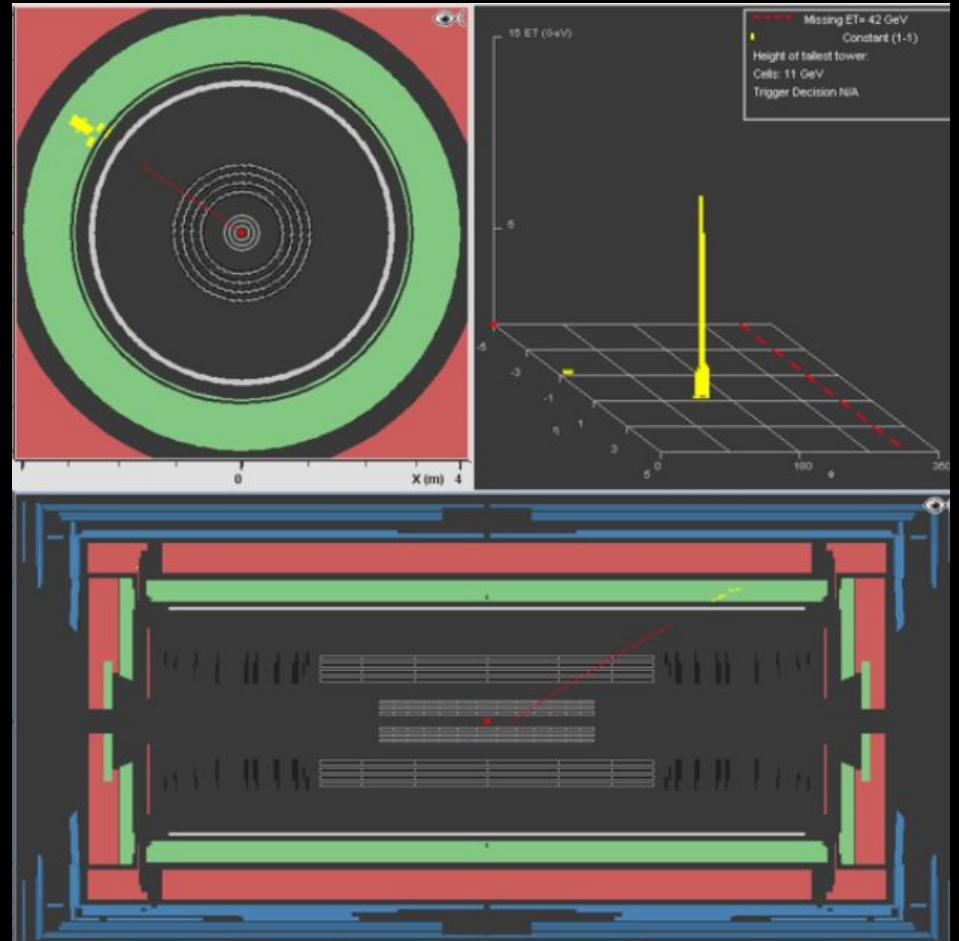
$\frac{1}{2}$



electron

Lascia una traccia nel rivelatore interno

Deposita tutta la sua energia nel Calorimetro Elettromagnetico



# Muone

mass  
charge  
spin

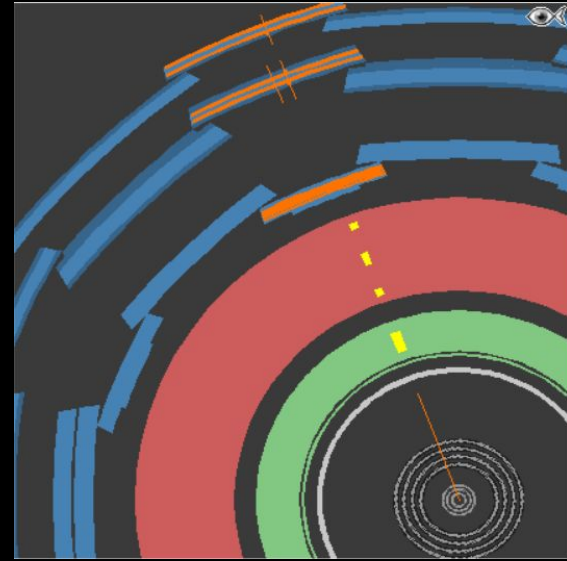
$\approx 105.66 \text{ MeV}/c^2$

-1

$\frac{1}{2}$



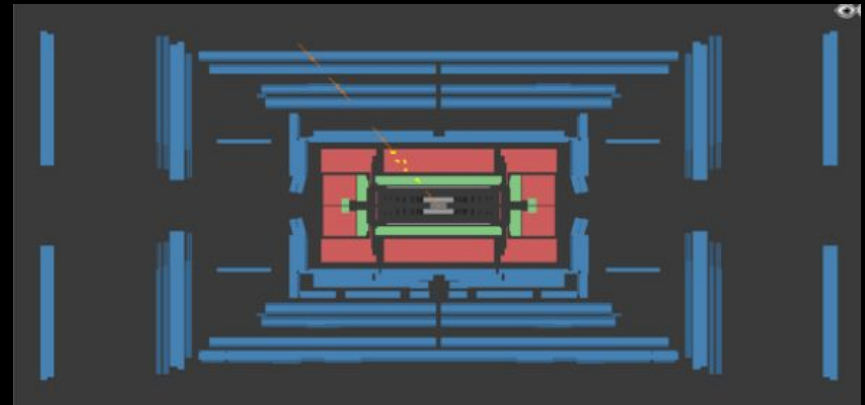
muon



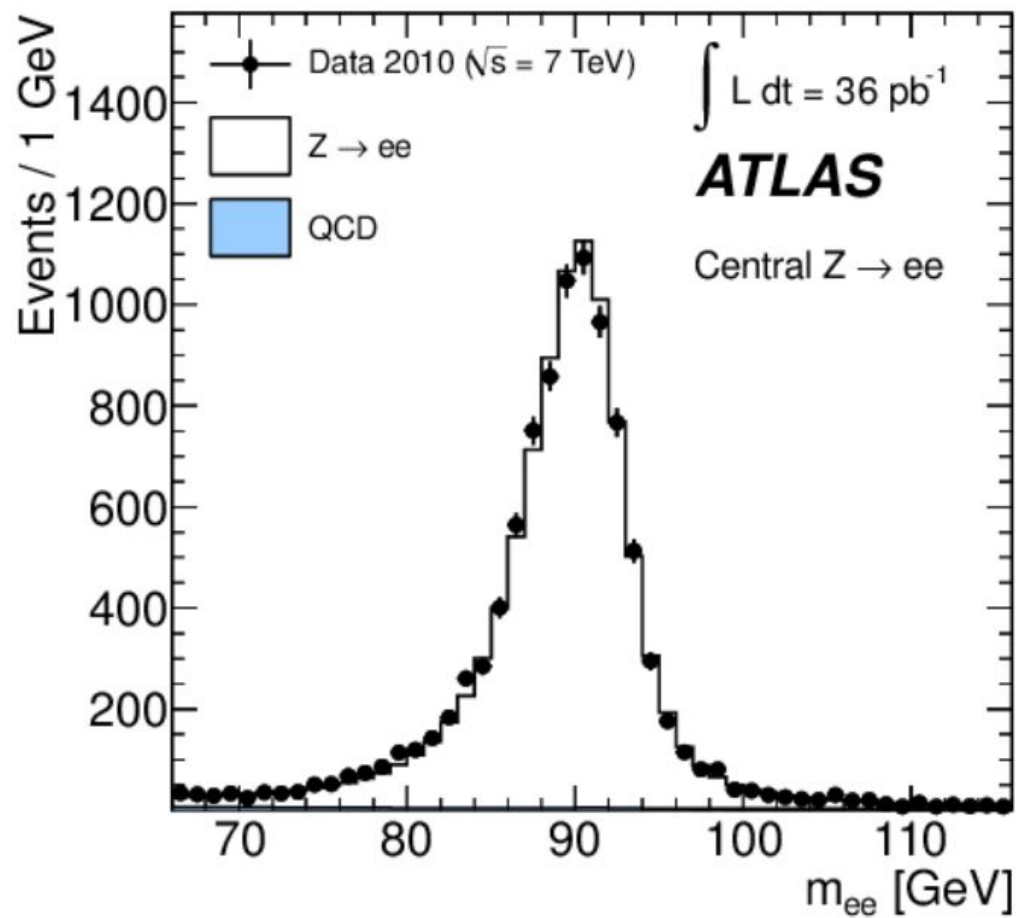
Lascia traccia nel rivelatore interno

Pochissima energia nei Calorimetri

**Raggiunge il rivelatore più esterno**

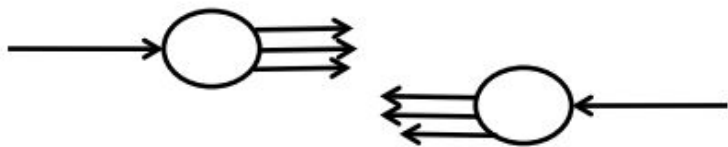






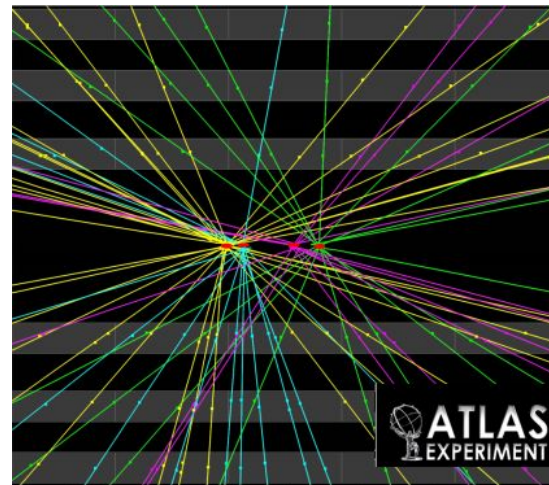
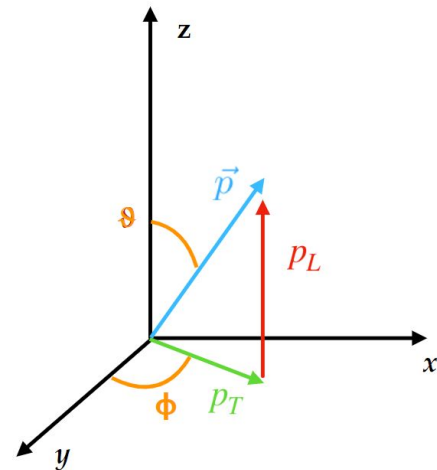
# Taglia sul $p_T$ !

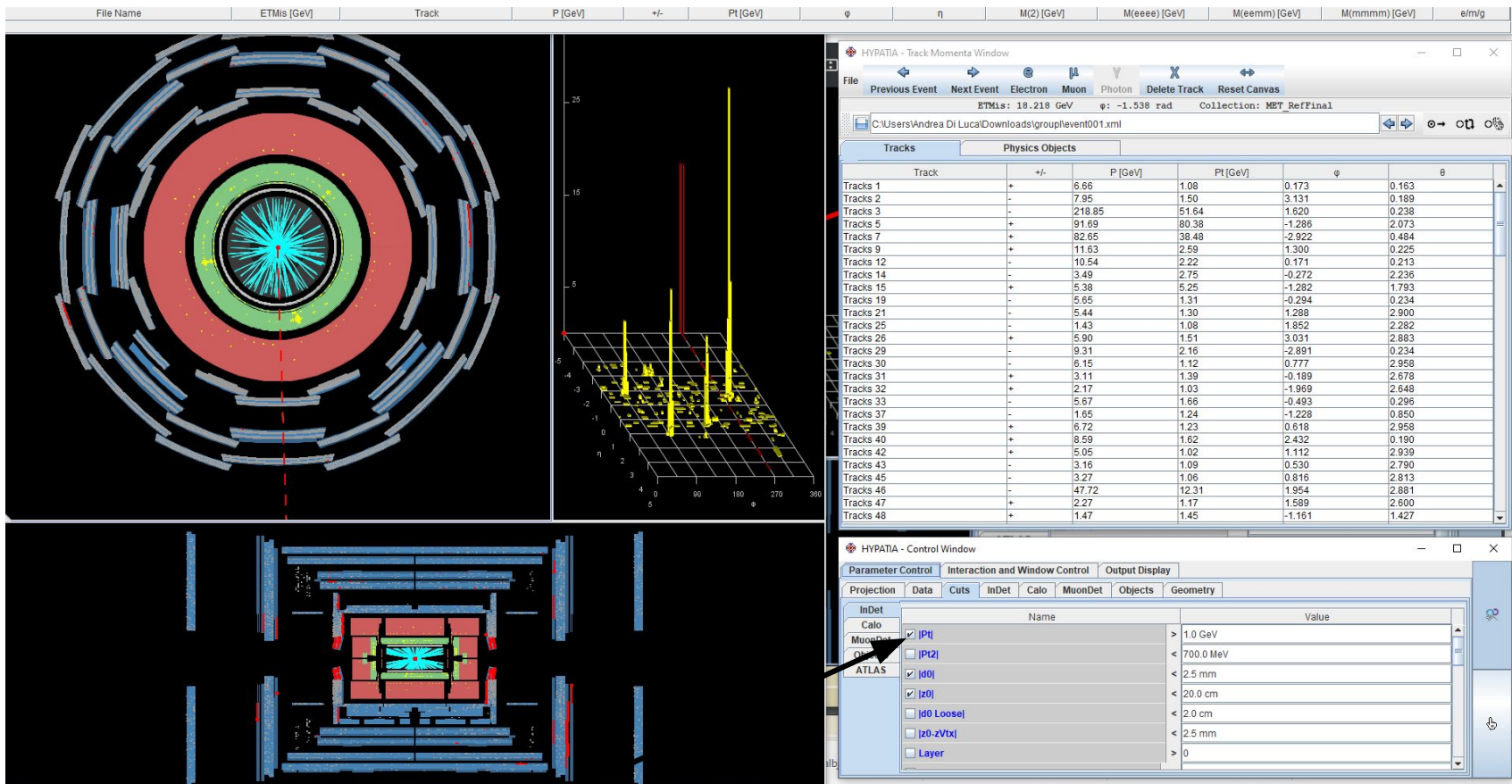
Eventi interessanti se il protone si frammenta:  
**hard scattering**



La maggior parte delle interazioni avvengono a grande distanza tra i protoni e con piccolo scambio di momento:  
**soft interaction**

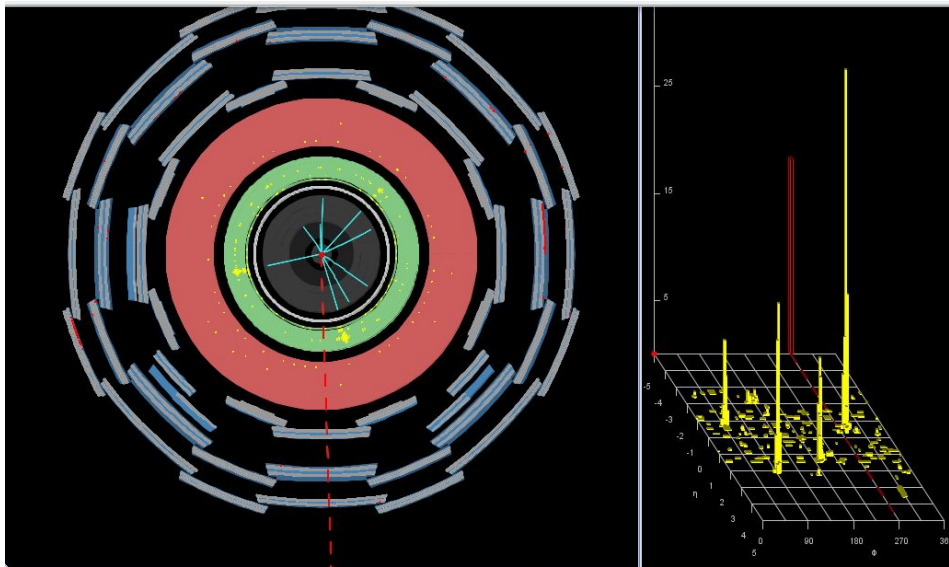
**Le particelle nello stato finale hanno  $p_T$  basso.**





$P_T > 5 \text{ GeV}/c$

Abbiamo più di 50 tracce nell'evento..



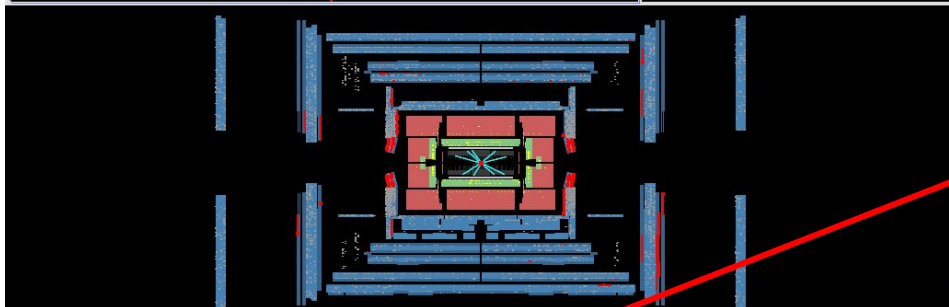
HYPATIA - Track Momenta Window

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

ETMIs: 18.218 GeV  $\phi$ : -1.538 rad Collection: MET\_RefFinal

C:\Users\Andrea Di Luca\Downloads\group1event001.xml

Track	+/-	P [GeV]	Pt [GeV]	1.620	$\phi$	$\theta$
Tracks 3	-	218.85	51.64	1.620	0.238	
Tracks 5	+	91.69	80.38	-1.296	2.073	
Tracks 7	+	82.65	38.48	-2.922	0.484	
Tracks 46	-	47.72	12.31	1.954	2.881	
Tracks 64	-	35.22	28.96	0.817	2.176	
Tracks 500	+	1749.34	1181.03	-1.050	0.741	
Tracks 501	+	119.01	76.12	0.452	0.694	
Tracks 508	+	37.66	20.69	-0.597	2.560	
Tracks 517	-	24.91	16.77	1.536	2.403	



HYPATIA - Control Window

Parameter Control Interaction and Window Control Output Display

Projection Data Cuts InDet Calo MuonDet Objects Geometry

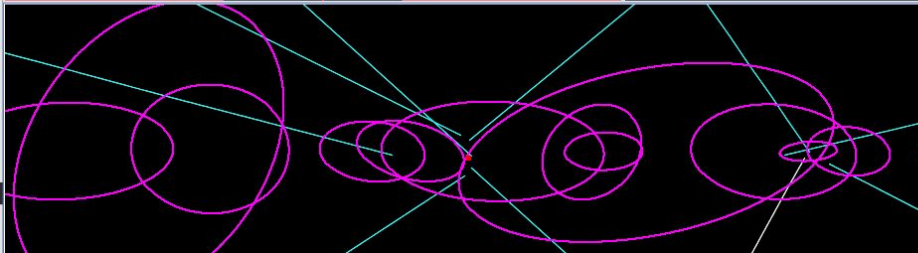
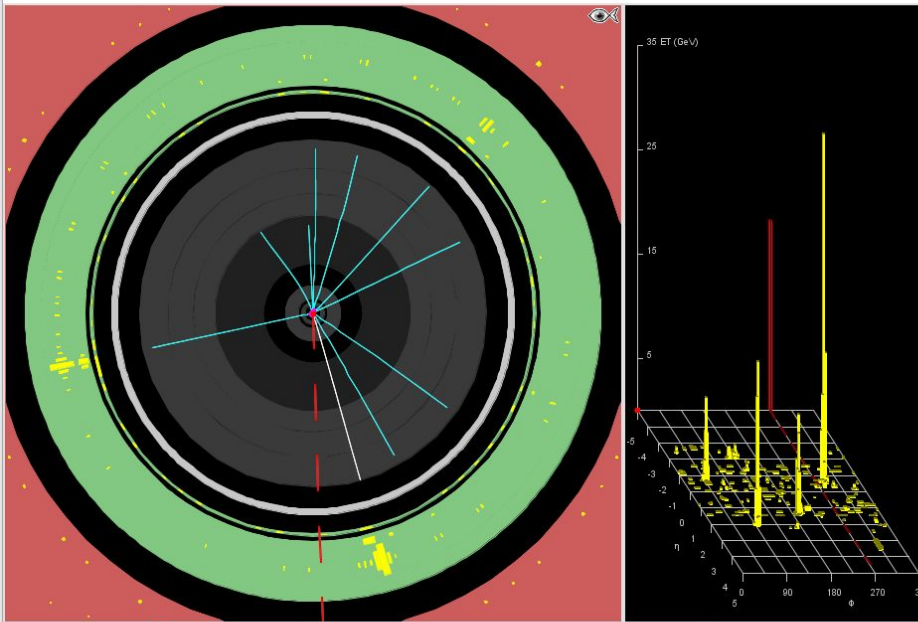
InDet	Name	Value
Calo	<input type="checkbox"/>  P	> 12.0 GeV
MuonDet	<input type="checkbox"/>  P 2	< 700.0 MeV
Calo	<input type="checkbox"/>  d0	< 2.5 mm
ATLAS	<input checked="" type="checkbox"/>  d0	< 20.0 cm
	<input type="checkbox"/>  d0 Loose	< 2.0 cm
	<input type="checkbox"/>  z0-zVtx	< 2.5 mm
	<input type="checkbox"/> Layer	>

$P_T > 12 \text{ GeV}/c$

Dopo il taglio abbiamo 9 tracce

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	$\phi$	$\eta$	M(2) [GeV]	M(eeee) [GeV]	M(eemm) [GeV]	M(mmmm) [GeV]
event001.xml	18.218	Tracks 5 Tracks 64	91.7 35.2	+ -	80.4 29.0	-1.286 0.817	-0.524 -0.646	83.979			

Canvas Window - File: event001.xml Run: 204954 Event: 19454464



HYPATIA - Track Momenta Window

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

ETMis: 18.218 GeV  $\phi$ : -1.538 rad Collection: MET\_RefFinal

C:\Users\Andrea Di Luca\Downloads\group\event001.xml

Track	+/-	P [GeV]	Pt [GeV]	$\phi$	$\theta$
Tracks 3	-	218.85	51.64	1.620	0.238
Tracks 5	+	91.69	80.38	-1.286	2.073
Tracks 7	+	82.65	38.48	-2.922	0.484
Tracks 46	-	47.72	12.31	1.954	2.881
Tracks 64	-	35.22	28.96	0.817	2.176
Tracks 500	+	1749.34	1181.03	-1.050	0.741
Tracks 501	+	119.01	76.12	0.452	0.694
Tracks 508	+	37.66	20.69	-0.597	2.560
Tracks 517	-	24.91	16.77	1.536	2.403
Tracks 522	-	22.39	10.03	1.264	2.677

HYPATIA - Control Window

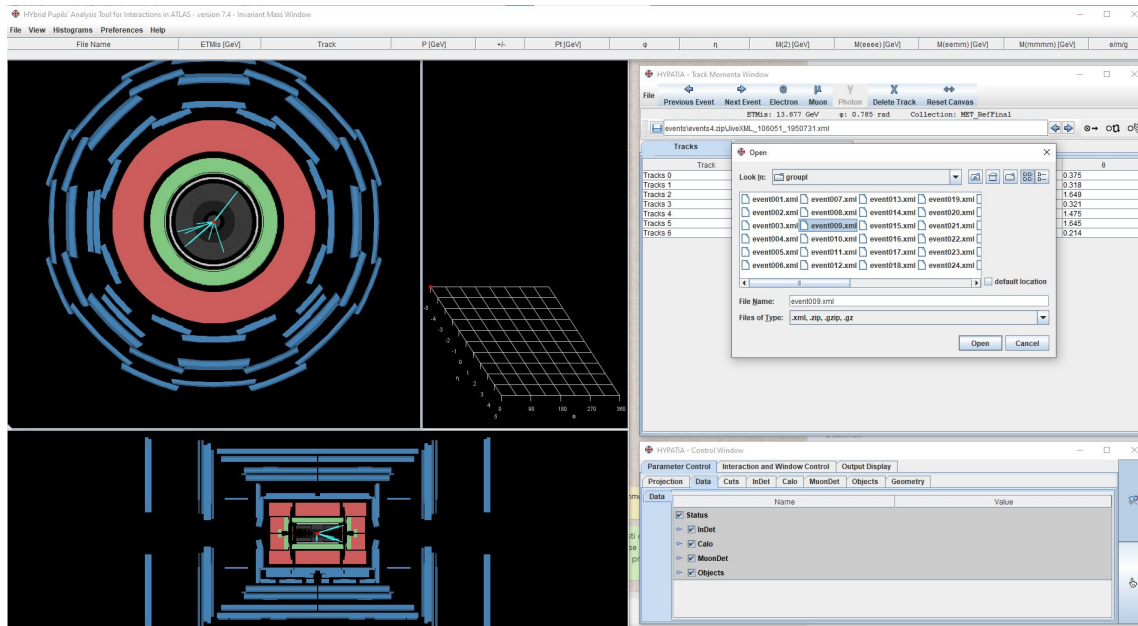
Parameter Control Interaction and Window Control Output Display

Projection Data Cuts InDet Calo MuonDet Objects Geometry

InDet	Calo	MuonDet	Objects	ATLAS	Name	Value
		<input checked="" type="checkbox"/>			Pt	> 10.0 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

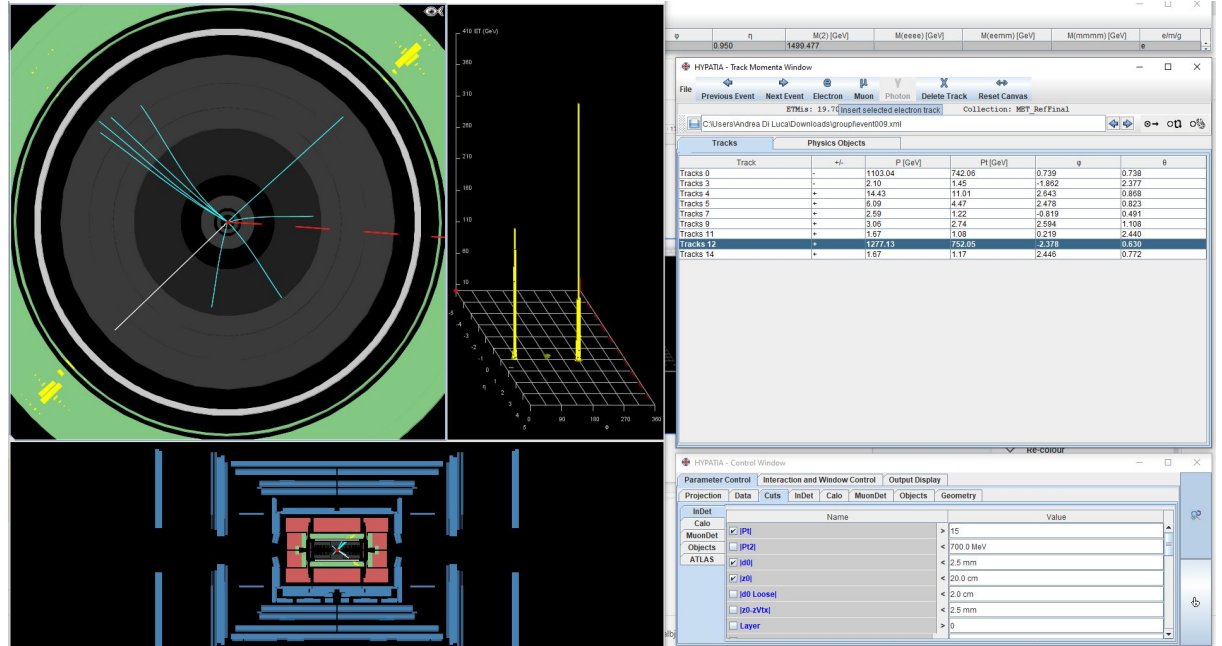
# Apriamo Hypatia e selezioniamo un set di eventi

1. Clicca su *File*
2. Clicca *Read Event Locally*
3. Seleziona la cartella contenente gli eventi



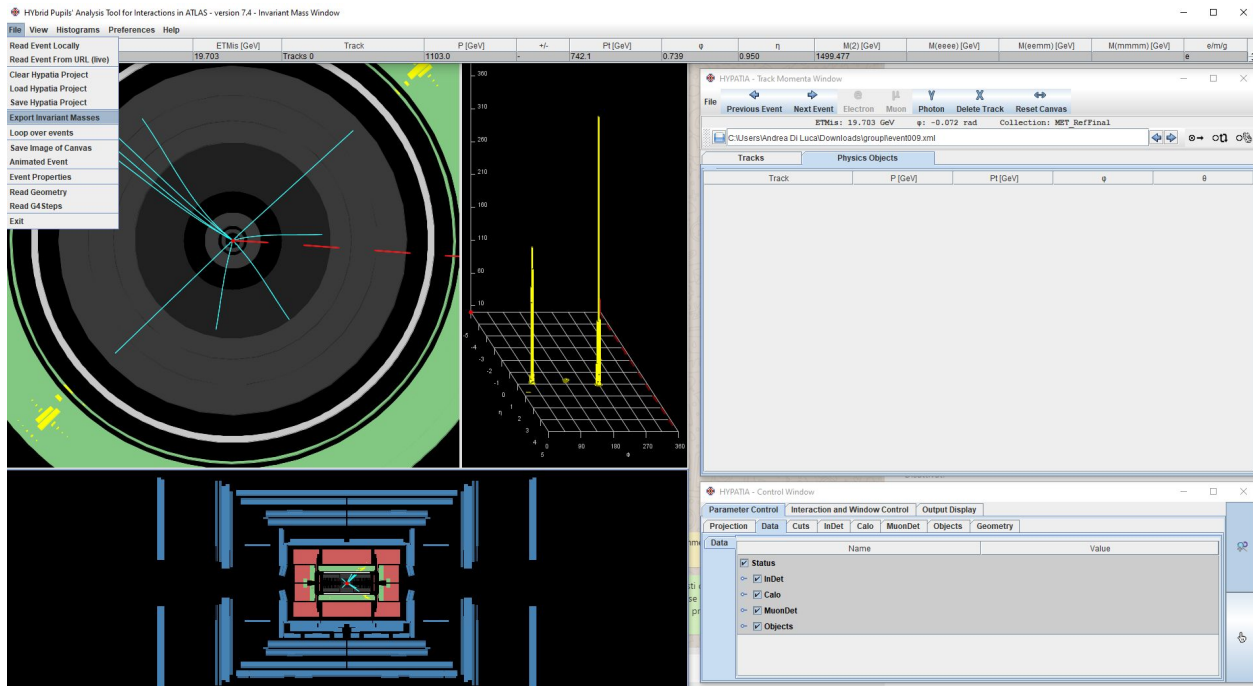
# Analizza l'evento

1. Applica le selezioni che ritieni utili per classificare il tuo evento
2. Seleziona le tracce in Tracks ed assegna il tipo di particella

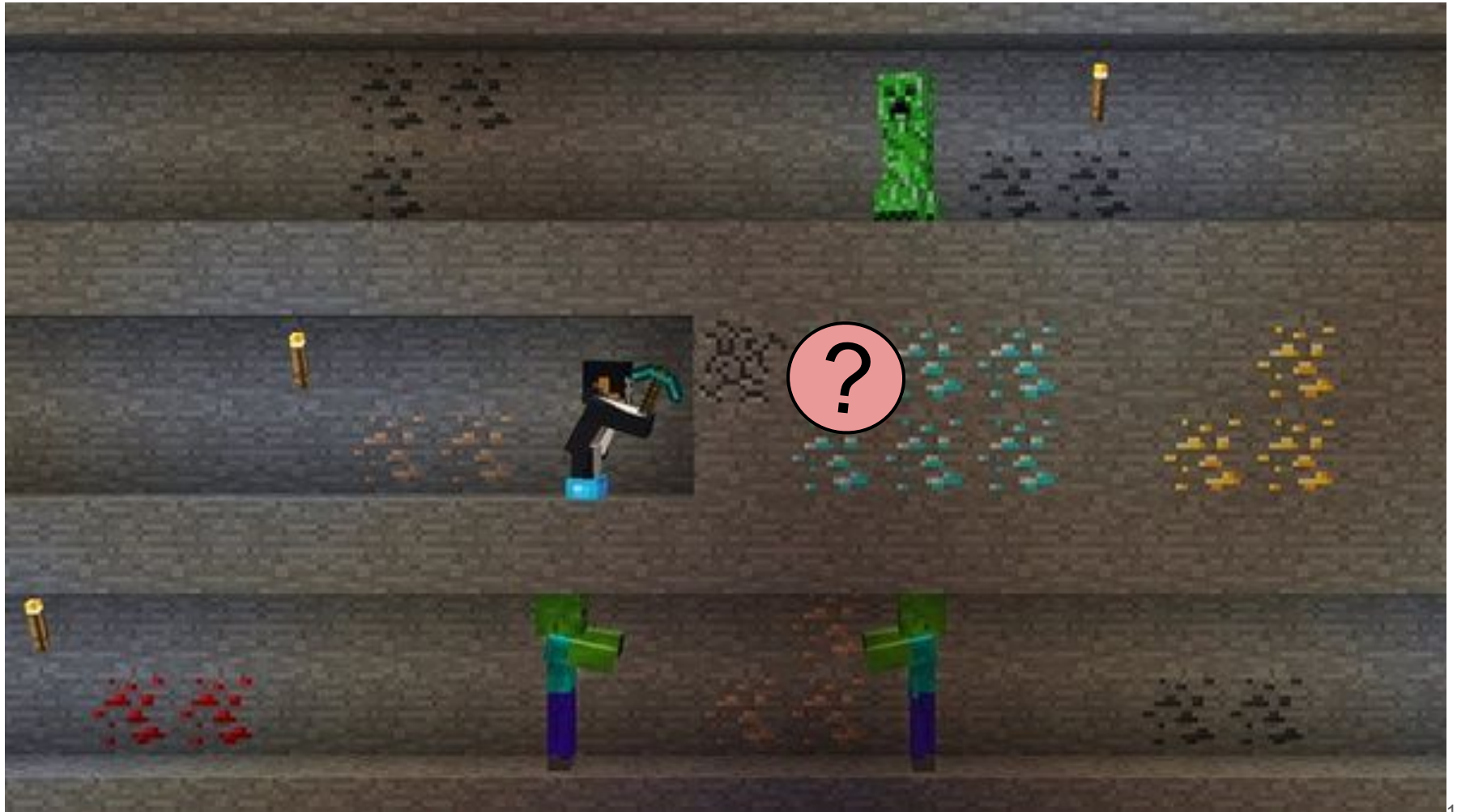


# Esporta i risultati della tua analisi

1. Una volta terminato, clicca su *File*, poi su *Export invariant masses*
2. Salva il file che poi potrai sottomettere.



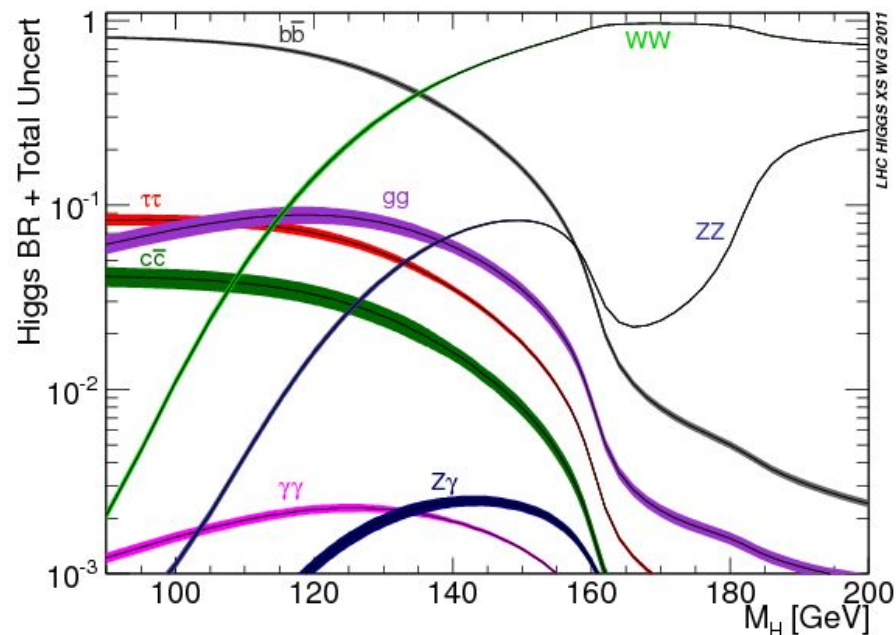


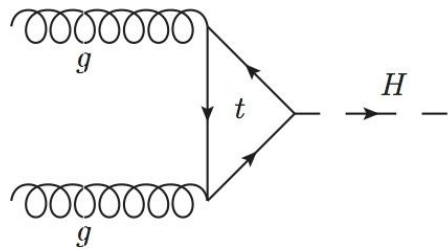


# Backup

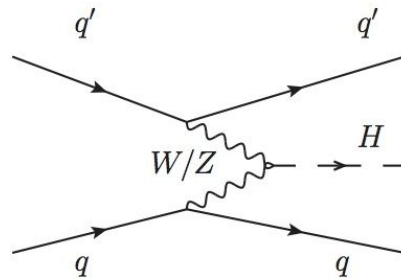
# Come decade il bosone di Higgs?

Decay channel	Branching ratio	Rel. uncertainty
$H \rightarrow \gamma\gamma$	$2.28 \times 10^{-3}$	+5.0% -4.9%
$H \rightarrow ZZ$	$2.64 \times 10^{-2}$	+4.3% -4.1%
$H \rightarrow W^+W^-$	$2.15 \times 10^{-1}$	+4.3% -4.2%
$H \rightarrow \tau^+\tau^-$	$6.32 \times 10^{-2}$	+5.7% -5.7%
$H \rightarrow b\bar{b}$	$5.77 \times 10^{-1}$	+3.2% -3.3%
$H \rightarrow Z\gamma$	$1.54 \times 10^{-3}$	+9.0% -8.9%
$H \rightarrow \mu^+\mu^-$	$2.19 \times 10^{-4}$	+6.0% -5.9%

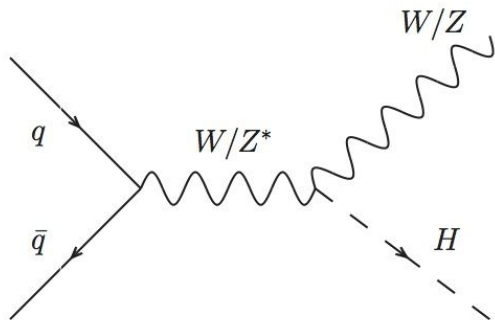




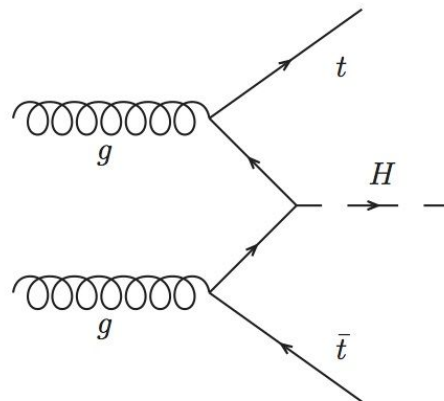
a)



b)



c)



d)