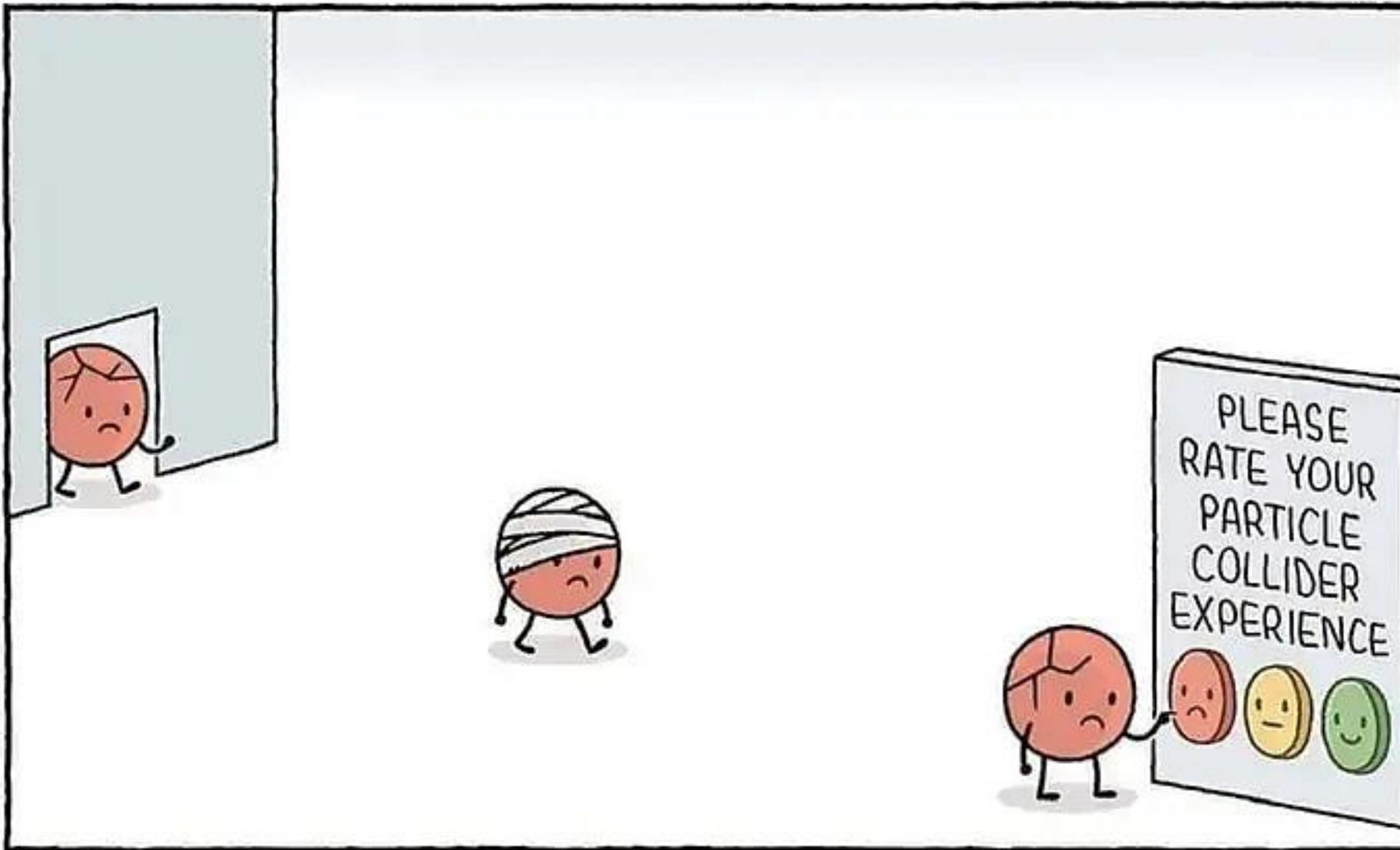
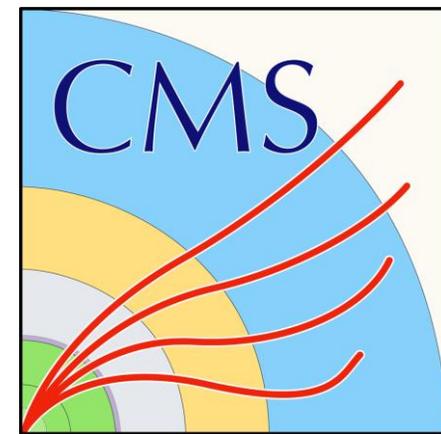
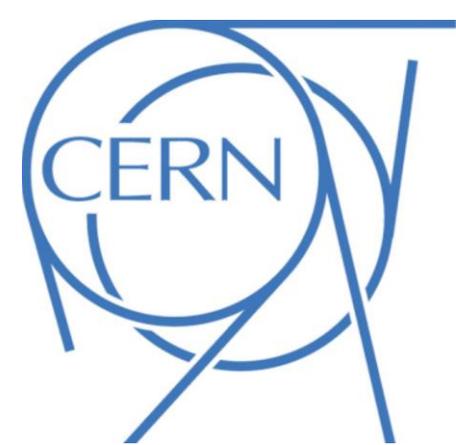


# Compilare il questionario!





# Discussione dei Risultati

01/03/2024

A. Lapertosa

Uni  
ct

FISICA E ASTRONOMIA  
"ETTORE MAJORANA"

INFN  
CATANIA



# Risultati: numeri e frequenze

- Domande:
  - Quanti elettroni? Quanti muoni?
    - Rapporto tra elettroni/muoni: 0.98

Total:

Group	e	$\mu$	W+	W-	W $\pm$	Neutral	Zoo	Total
All	774	788	308	244	340	570	143	1605

# Risultati: numeri e frequenze

- Domande:

- Quanti elettroni? Quanti muoni?
  - Rapporto tra elettroni/muoni: 0.98
  - Previsione: 1 (Universalità leptonica)

- $W \rightarrow e \nu_e$
- $W \rightarrow \mu \nu_\mu$
- $W \rightarrow \tau \nu_\tau$
- $Z \rightarrow e e$
- $Z \rightarrow \mu \mu$
- $Z \rightarrow \tau \tau$
- $Z \rightarrow \nu_e \nu_e$
- $Z \rightarrow \nu_\mu \nu_\mu$
- $Z \rightarrow \nu_\tau \nu_\tau$

## Leptoni

<b>e</b> elettrone	<b>μ</b> muone	<b>τ</b> tau
<b>ν<sub>e</sub></b> neutrino	<b>ν<sub>μ</sub></b> neutrino	<b>ν<sub>τ</sub></b> neutrino

### Total:

Group	e	μ	W+	W-	W±	Neutral	Zoo	Total
All	774	788	308	244	340	570	143	1605



# Risultati: numeri e frequenze

- Domande:
  - Quanti  $W^+$ ? Quanti  $W^-$ ?
    - Rapporto tra  $W^+/W^-$ : 1.3

Total:

Group	e	$\mu$	$W^+$	$W^-$	$W^\pm$	Neutral	Zoo	Total
All	774	788	308	244	340	570	143	1605

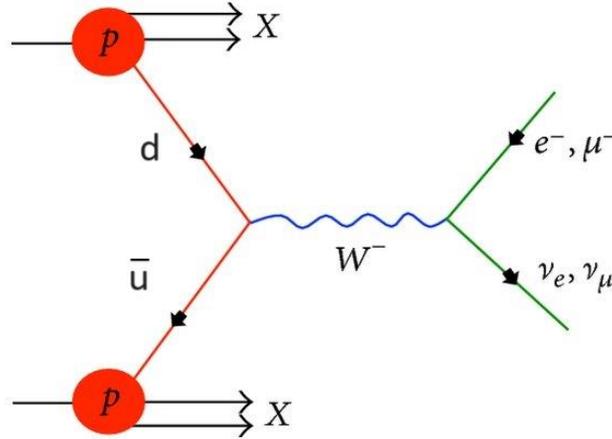
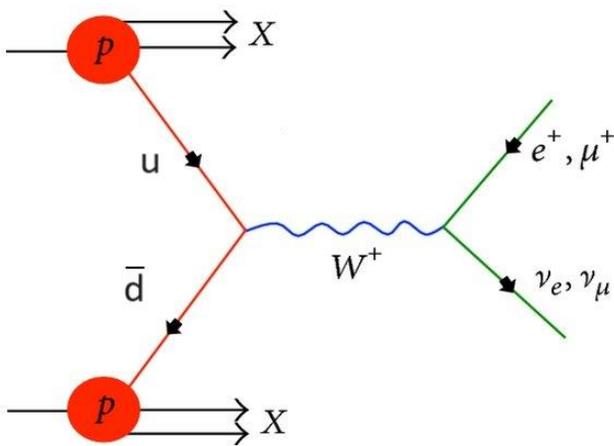
# Risultati: numeri e frequenze

- Domande:

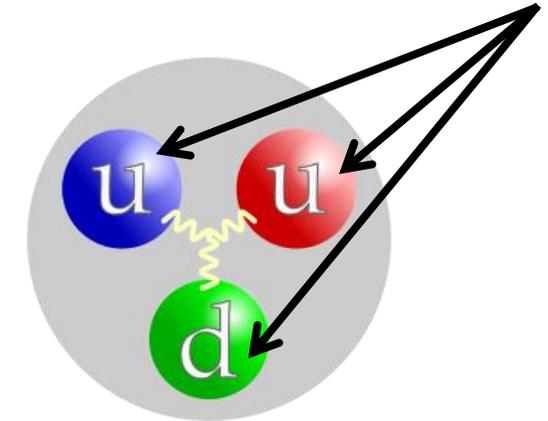
- Quanti  $W^+$ ? Quanti  $W^-$ ?

- Rapporto tra  $W^+/W^-$ : 1.3

- Previsione: 1.4 (Rapporto quark up/down nel protone)



## Protone Quark

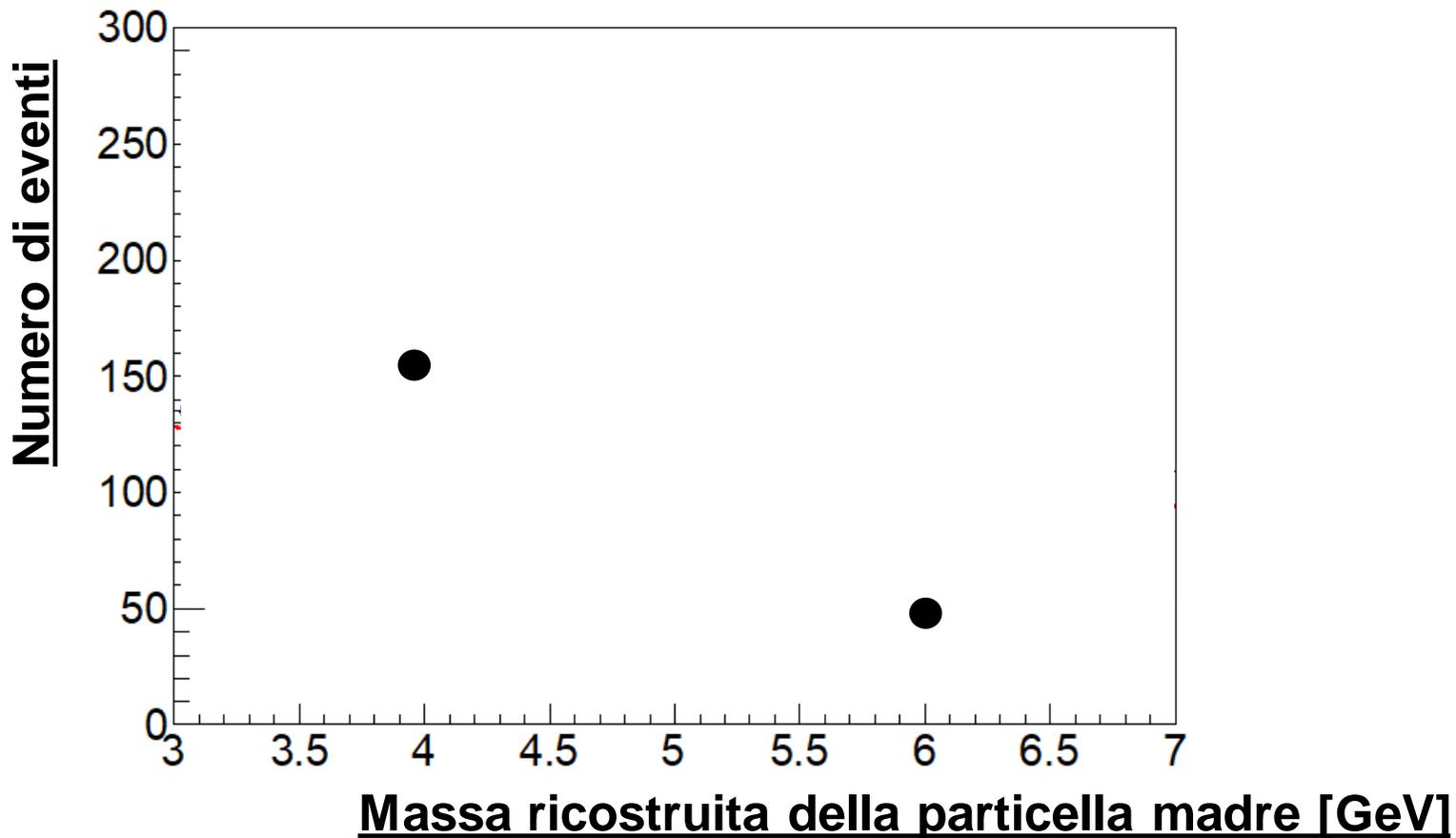


### Total:

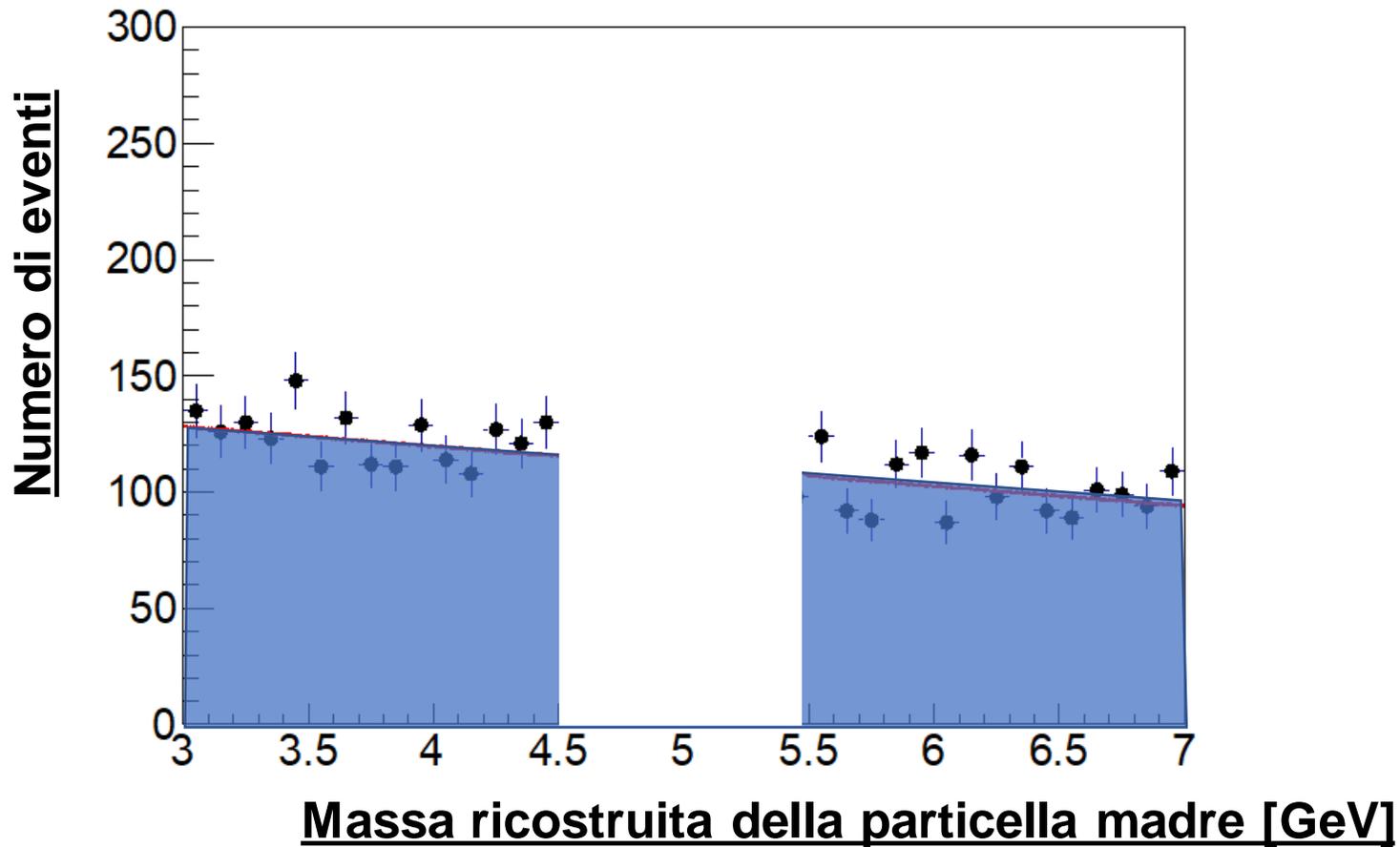
Group	e	$\mu$	<b>W+</b>	<b>W-</b>	$W^\pm$	Neutral	Zoo	Total
All	774	788	308	244	340	570	143	1605

# Istogramma di massa

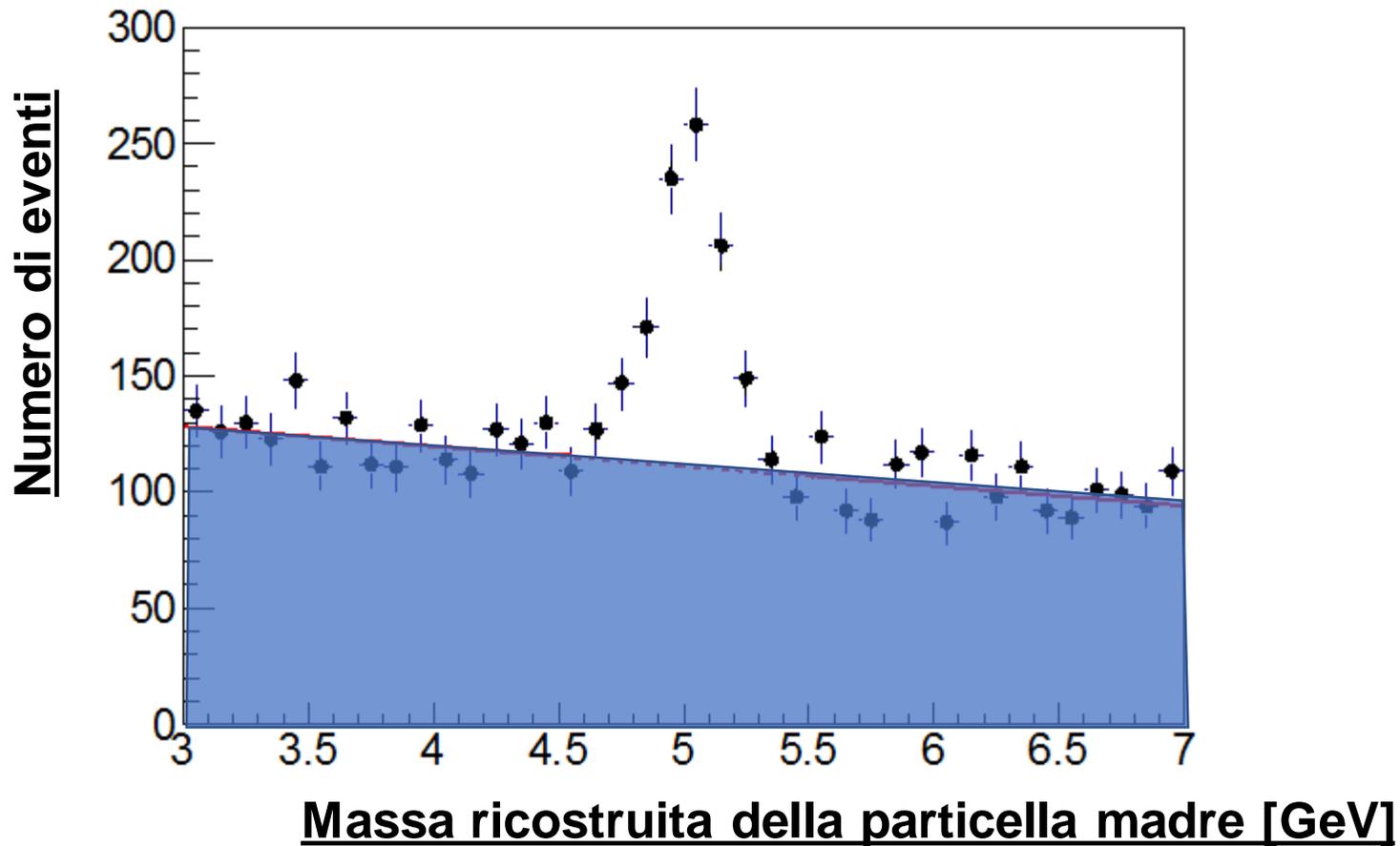
- Dopo aver identificato i segnali e classificato gli eventi
  - I dati vengono analizzati statisticamente
  - Le informazioni delle collisioni vengono sintetizzate in **istogrammi**



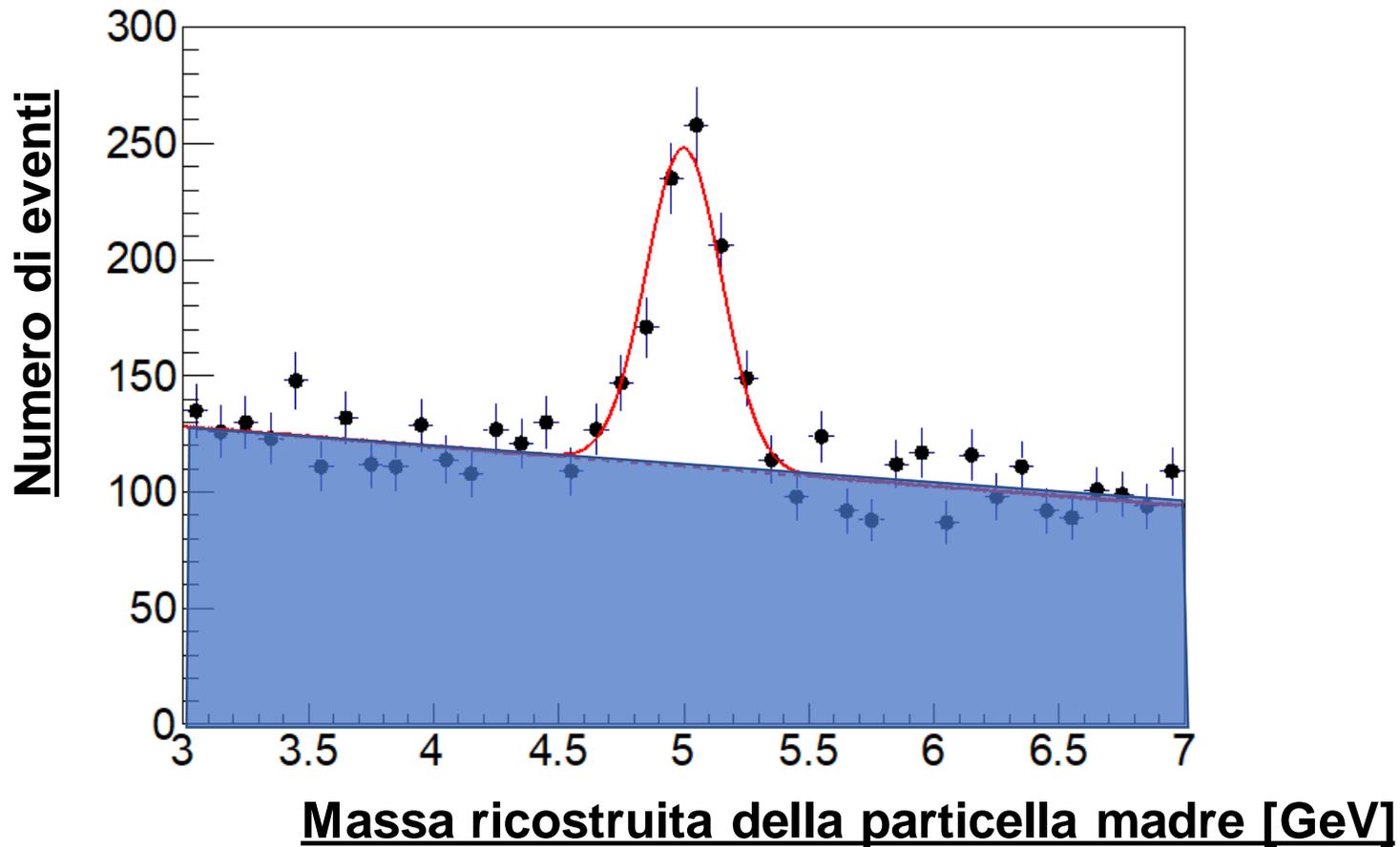
# Eventi casuali distribuiti casualmente



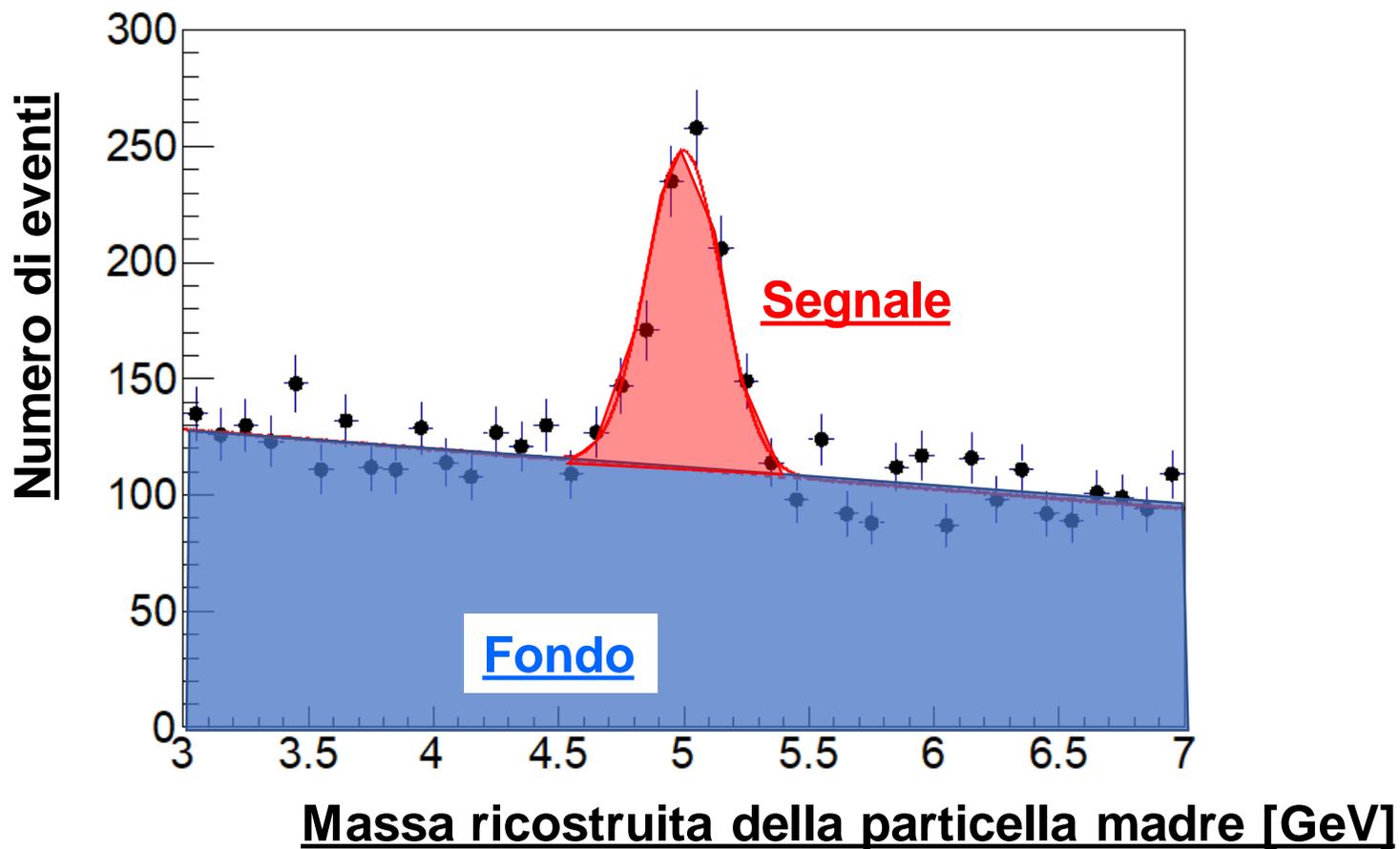
# C'è qualcosa in più del previsto



# Scoperta di una particella!

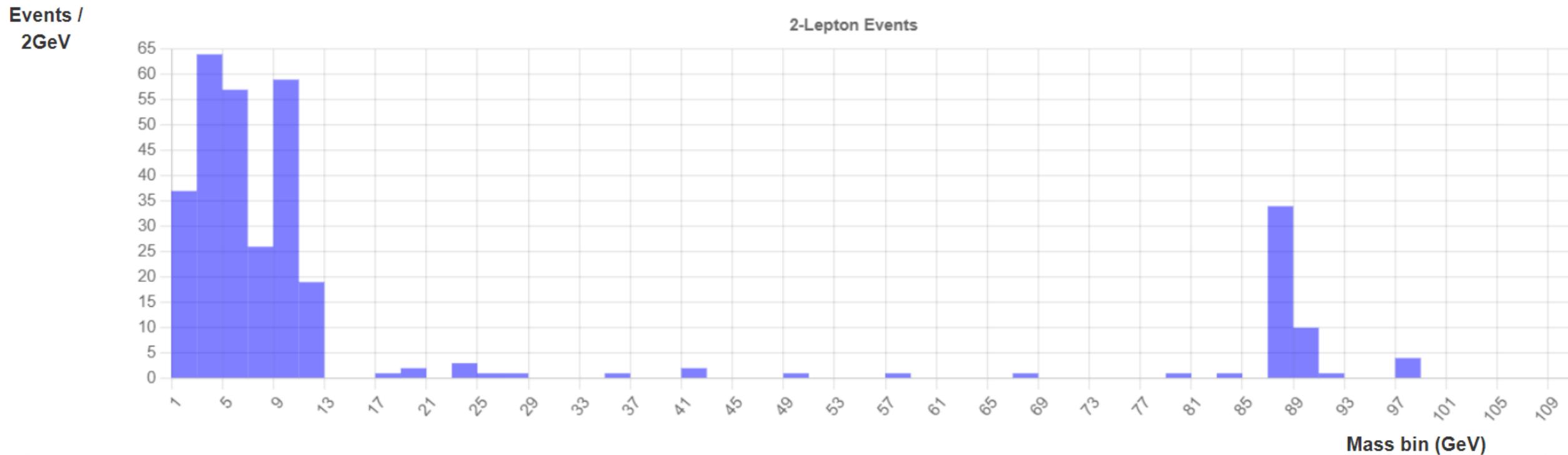


# Fondo + Segnale



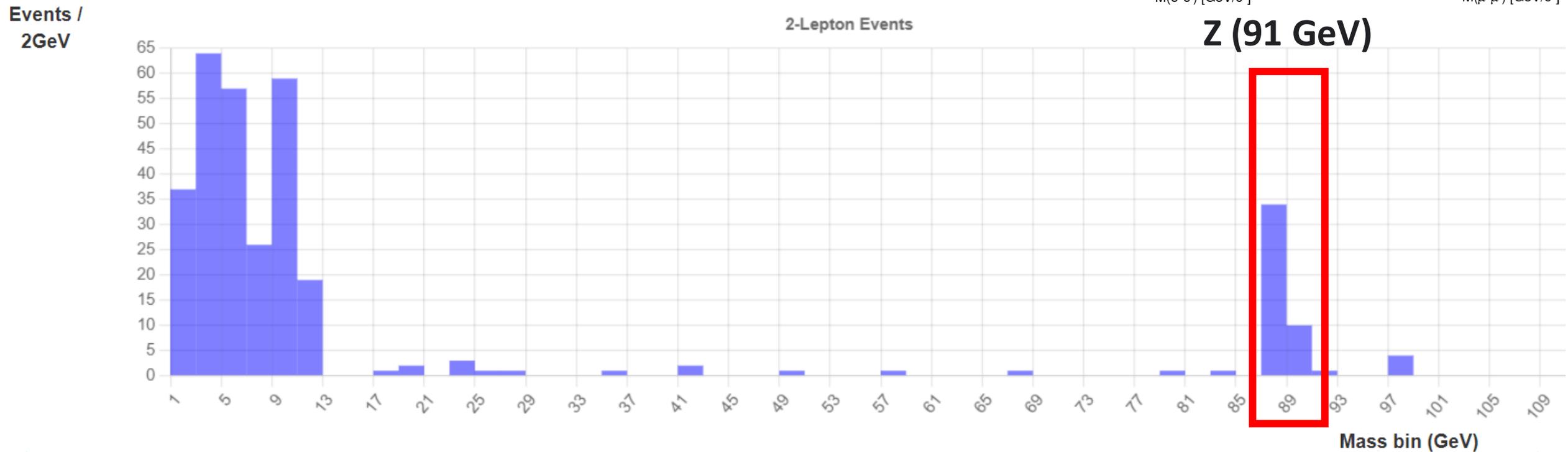
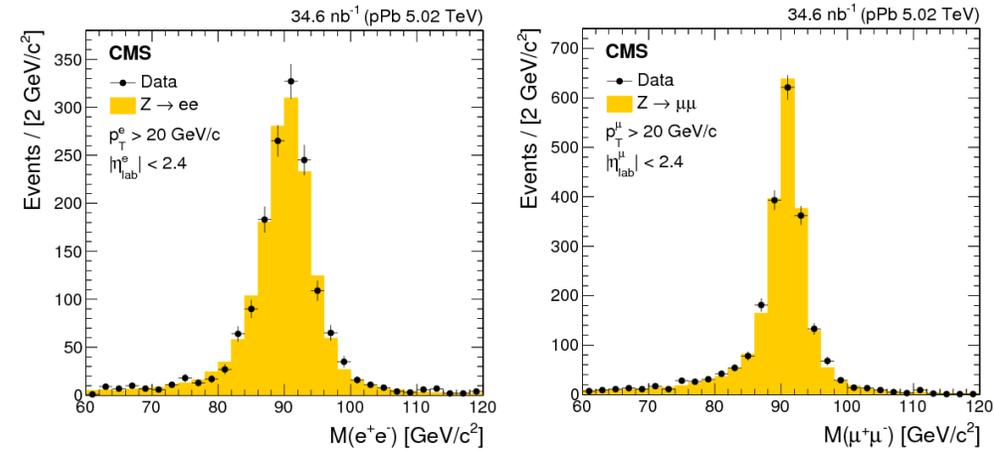
# Risultati: istogramma di massa ( $Z \rightarrow ee/\mu\mu$ )

- Domande:
  - Cosa si vede?
  - C'è un picco?
    - Quale massa [GeV]?
    - A quale particella corrisponde?



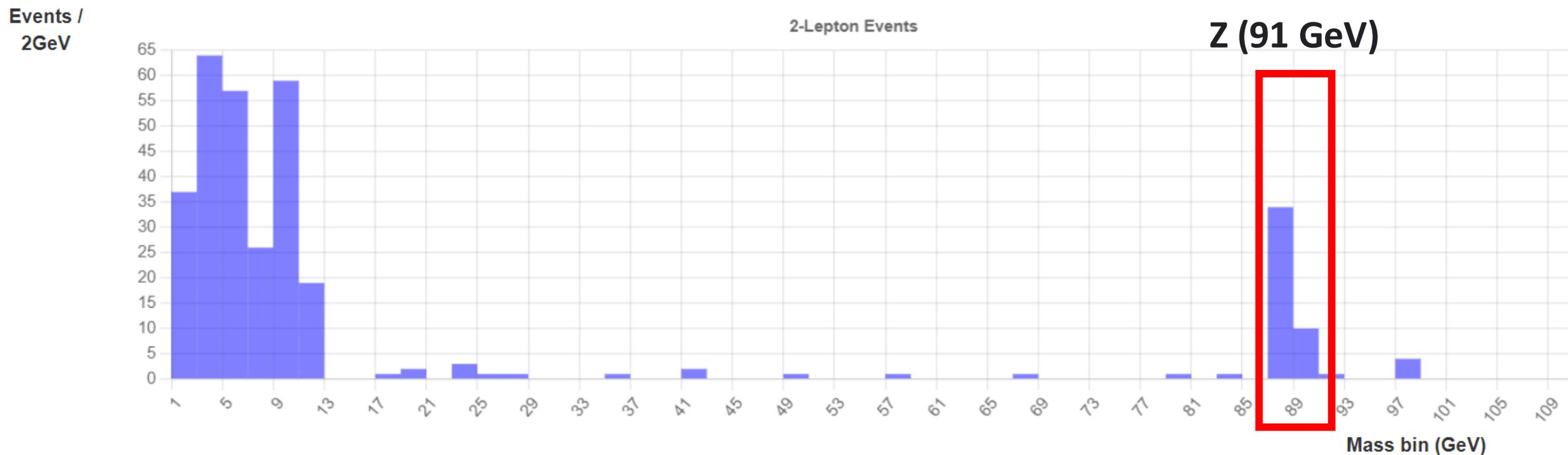
# Risultati: istogramma di massa ( $Z \rightarrow ee/\mu\mu$ )

- Domande:
  - Cosa si vede?
  - C'è un picco?
    - Quale massa [GeV]?
    - A quale particella corrisponde?



# Risultati: istogramma di massa ( $Z \rightarrow ee/\mu\mu$ )

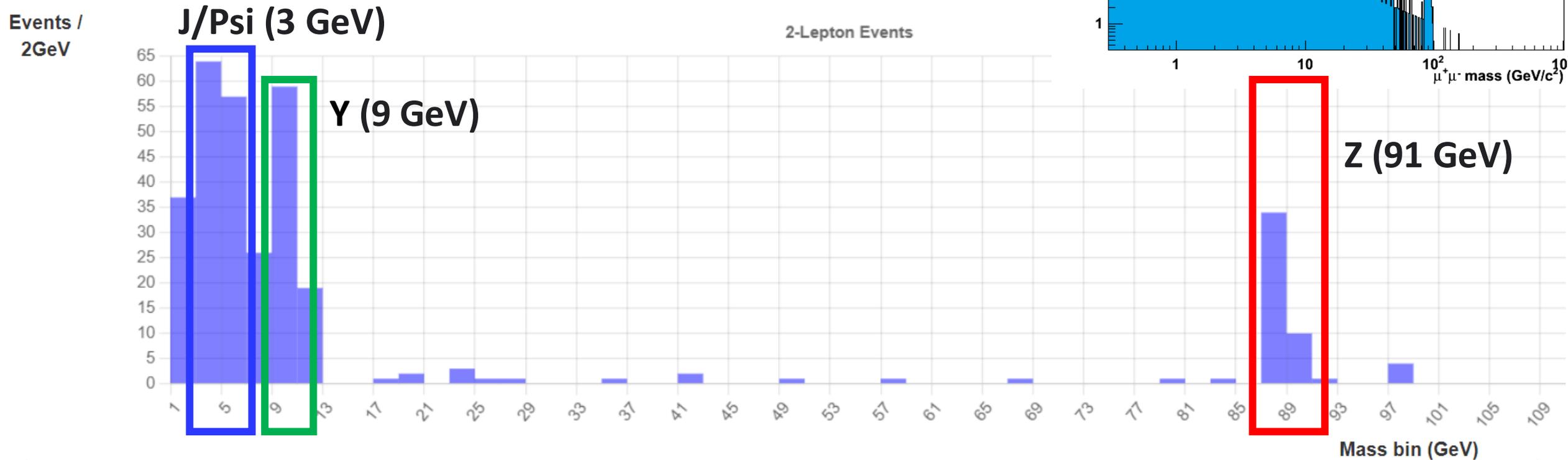
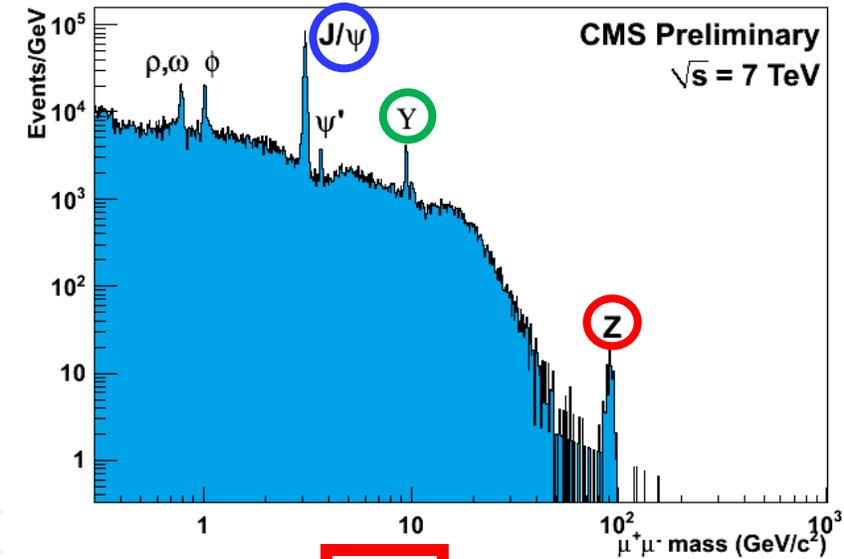
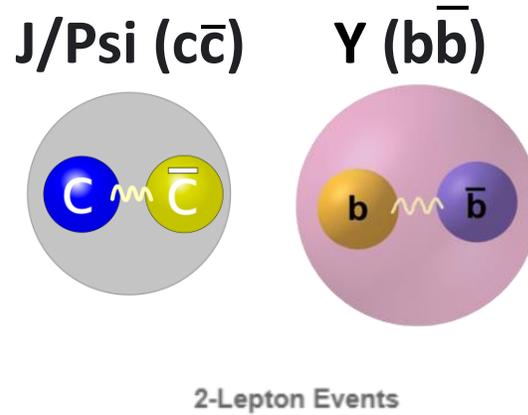
- Domande:
  - Cosa si vede?
  - C'è un picco?
    - Quale massa [GeV]?
    - A quale particella corrisponde?
  - Ci sono altri picchi?



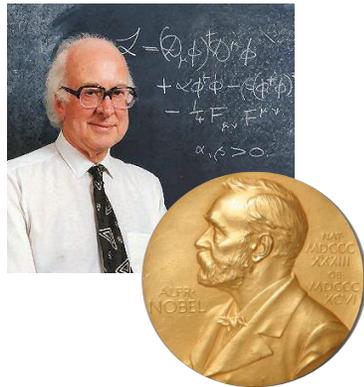
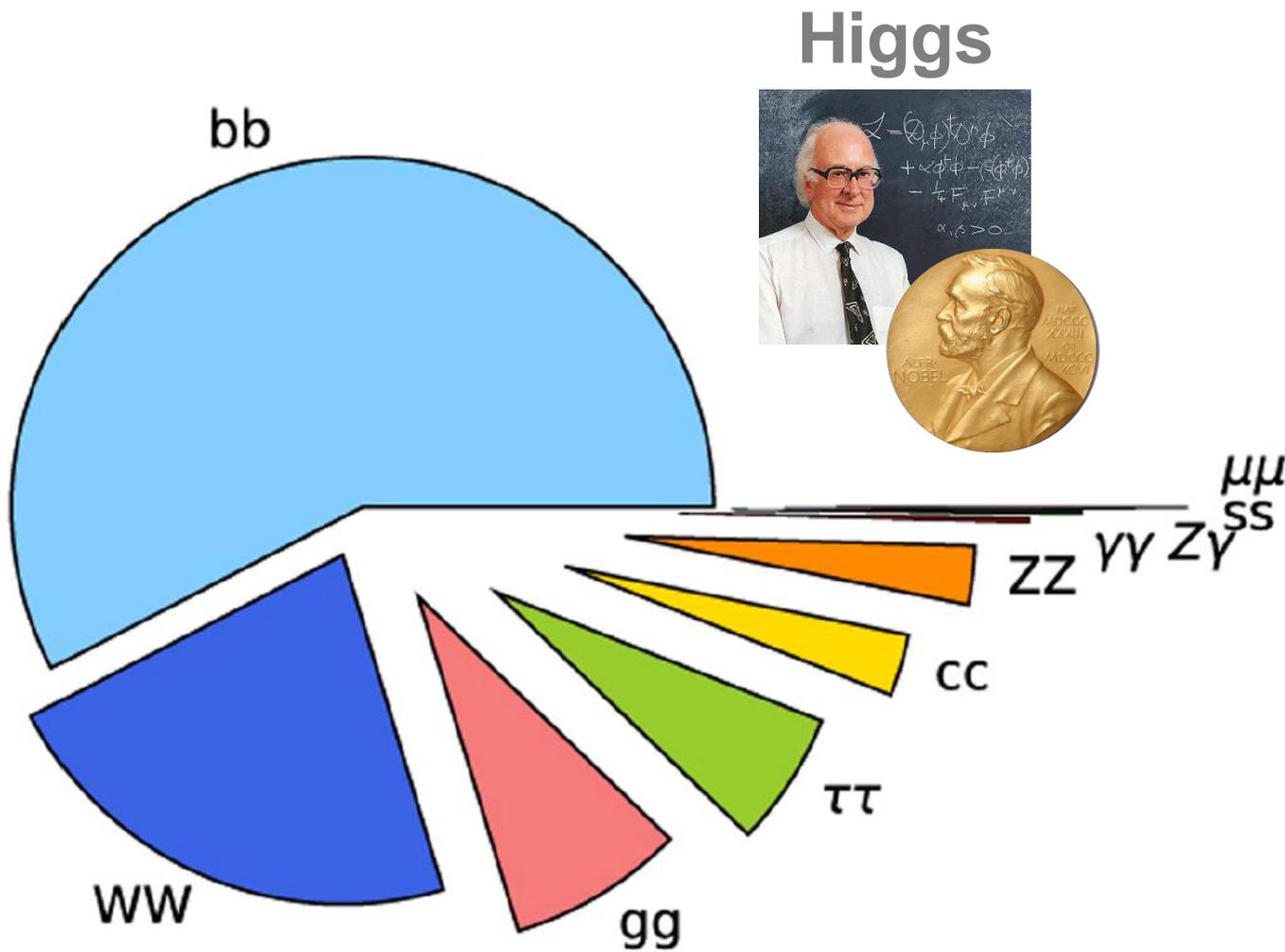
# Risultati: istogramma di massa ( $Z \rightarrow ee/\mu\mu$ )

• Domande:

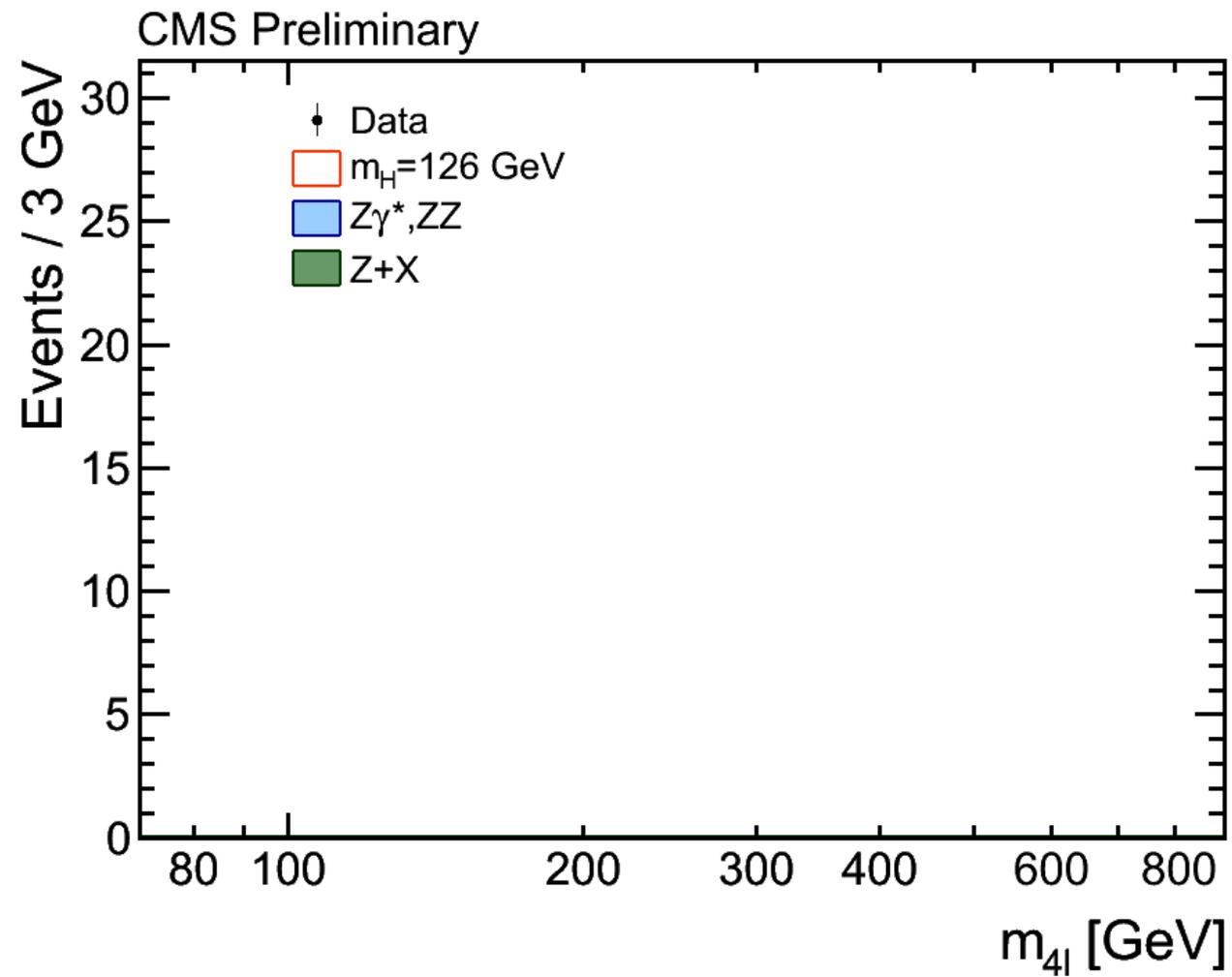
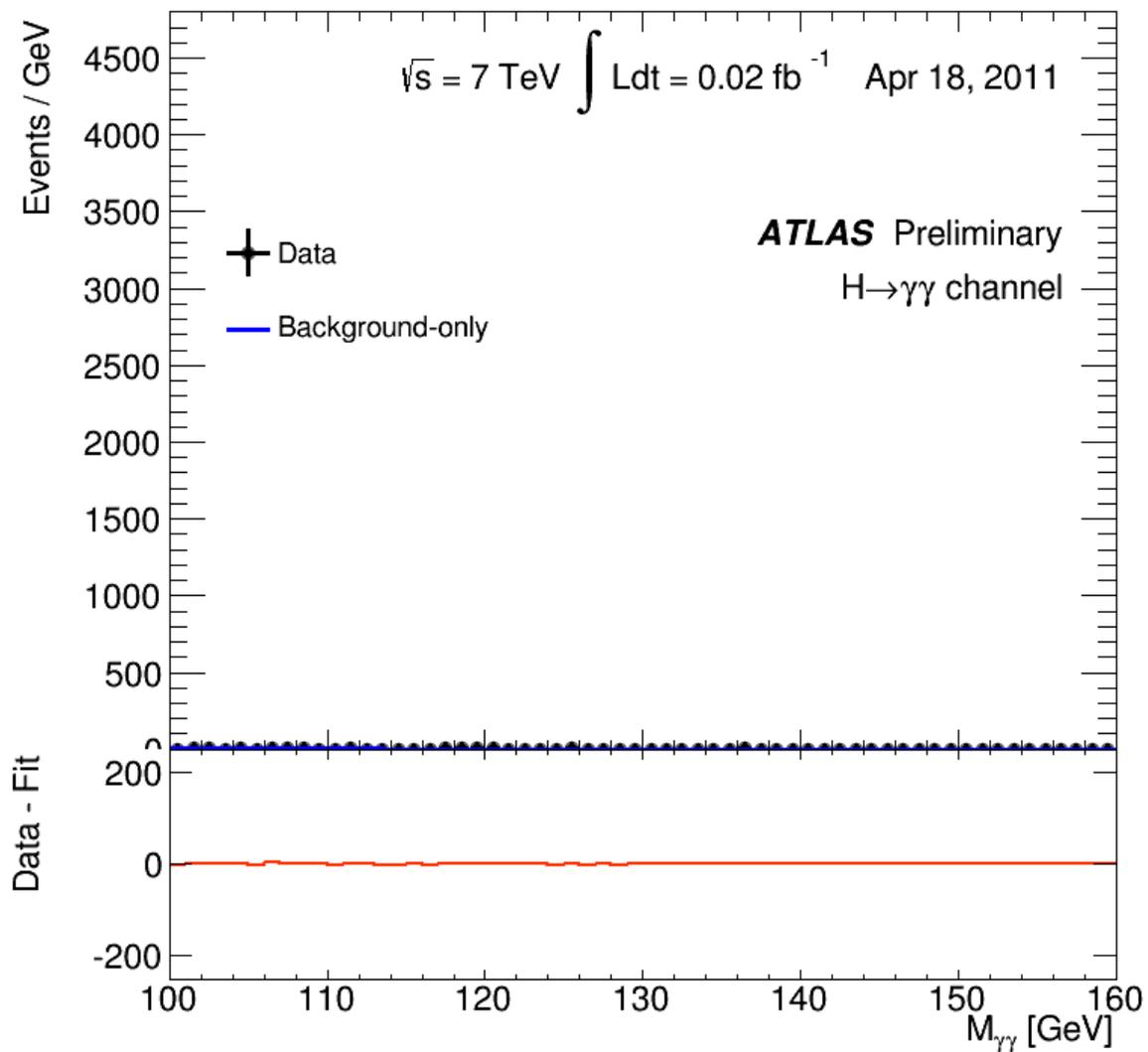
- Cosa si vede?
- C'è un picco?
  - Quale massa [GeV]?
  - A quale particella corrisponde?
- Ci sono altri picchi?



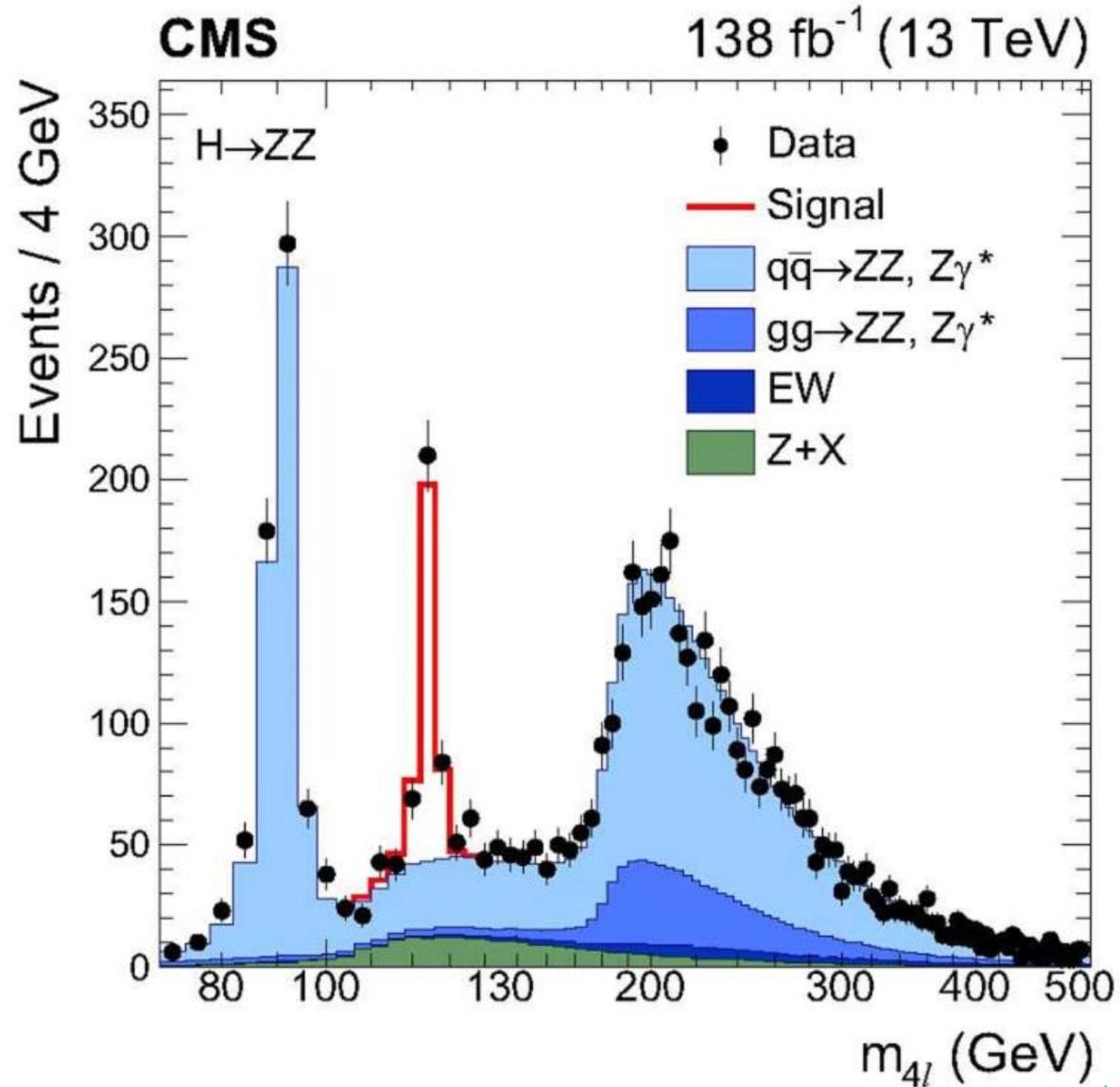
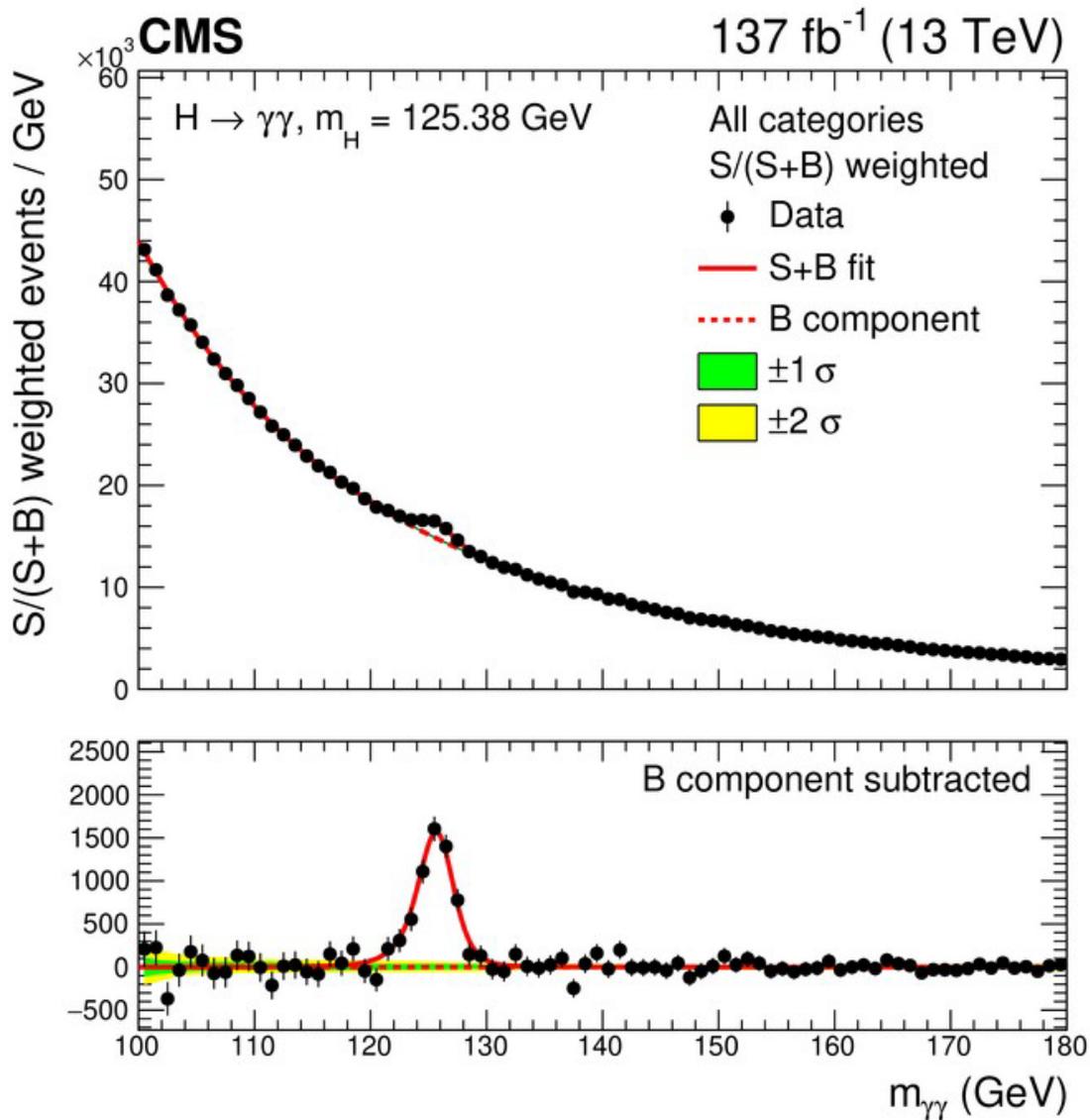
# Canali di Decadimento del Bosone di Higgs



Decadimento	Probabilità [%]
$H \rightarrow b\bar{b}$	$57.5 \pm 1.9$
$H \rightarrow WW$	$21.6 \pm 0.9$
$H \rightarrow gg$	$8.56 \pm 0.86$
$H \rightarrow \tau\tau$	$6.30 \pm 0.36$
$H \rightarrow c\bar{c}$	$2.90 \pm 0.35$
$H \rightarrow ZZ$	$2.67 \pm 0.11$
$H \rightarrow \gamma\gamma$	$0.228 \pm 0.011$
$H \rightarrow Z\gamma$	$0.155 \pm 0.014$
$H \rightarrow \mu\mu$	$0.022 \pm 0.001$

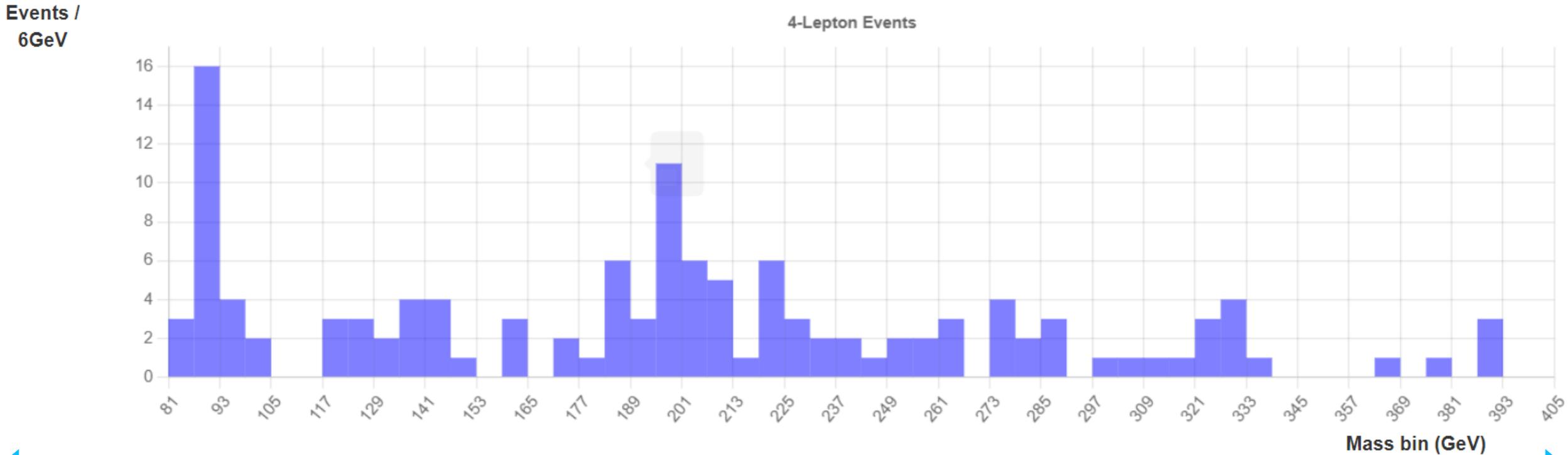


# Dati 2015-2018: $H \rightarrow \gamma\gamma \dots H \rightarrow ZZ$



# Risultati: istogramma di massa ( $H \rightarrow ZZ$ )

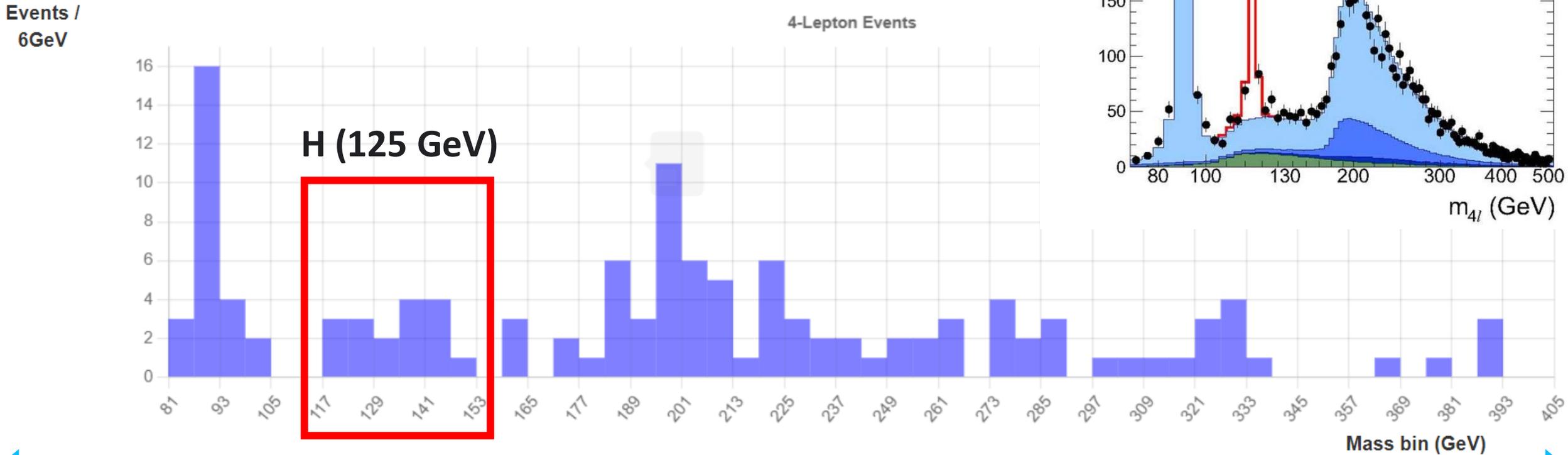
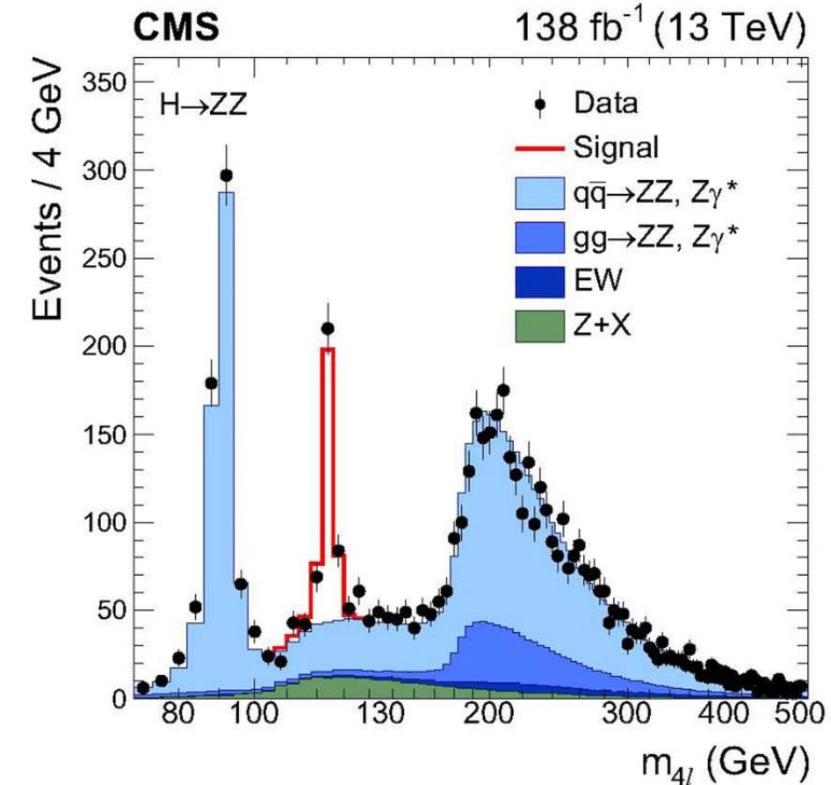
- Domande:
  - Cosa si vede?
  - C'è un picco?
    - Quale massa [GeV]?
    - A quale particella corrisponde?
  - Ci sono altri picchi?



# Risultati: istogramma di massa ( $H \rightarrow ZZ$ )

• Domande:

- Cosa si vede?
- C'è un picco?
  - Quale massa [GeV]?
  - A quale particella corrisponde?
- Ci sono altri picchi?



# Fisica: Modello Standard

Quark

<b>u</b> up	<b>c</b> charm	<b>t</b> top
<b>d</b> down	<b>s</b> strange	<b>b</b> beauty

Leptoni

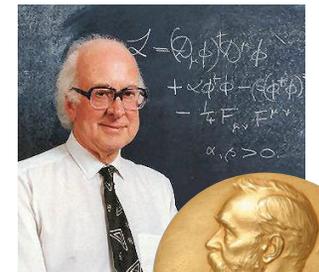
<b>e</b> elettrone	<b><math>\mu</math></b> muone	<b><math>\tau</math></b> tau
<b><math>\nu_e</math></b> neutrino	<b><math>\nu_\mu</math></b> neutrino	<b><math>\nu_\tau</math></b> neutrino

Bosoni

<b>W</b>
<b>Z</b>
<b>g</b> gluone
<b><math>\gamma</math></b> fotone



Higgs





# Video conferenza ore 16:00

- Ci collegheremo con il CERN!
- Ci saranno 2 moderatori:
  - Andrea Massironi (Milano, Italia)
  - Roumyana Hadjiiska (Sofia, Bulgaria)
- Parteciperanno anche altri 4 istituti!
  - [Constantine \(Algeria\)](#)
  - [Kharkiv \(Ucraina\)](#)
  - [Helsinki \(Finlandia\)](#)
  - [Santiago de Compostela \(Spagna\)](#)



# Risultati: numeri e frequenze

- Domande:

- Quanti elettroni? Quanti muoni?
  - Rapporto tra elettroni/muoni: 0.98
  - Previsione: 1 (Universalità leptonica)

- $W \rightarrow e \nu_e$
- $W \rightarrow \mu \nu_\mu$
- $W \rightarrow \tau \nu_\tau$
- $Z \rightarrow e e$
- $Z \rightarrow \mu \mu$
- $Z \rightarrow \tau \tau$
- $Z \rightarrow \nu_e \nu_e$
- $Z \rightarrow \nu_\mu \nu_\mu$
- $Z \rightarrow \nu_\tau \nu_\tau$

## Leptoni

<b>e</b> elettrone	<b><math>\mu</math></b> muone	<b><math>\tau</math></b> tau
<b><math>\nu_e</math></b> neutrino	<b><math>\nu_\mu</math></b> neutrino	<b><math>\nu_\tau</math></b> neutrino

### Total:

Group	e	$\mu$	W+	W-	W $\pm$	Neutral	Zoo	Total
All	774	788	308	244	340	570	143	1605

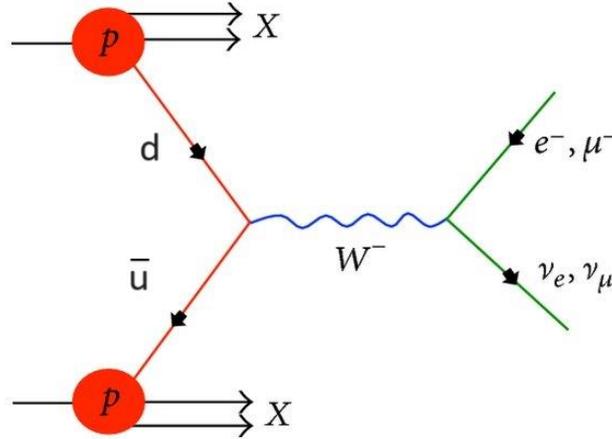
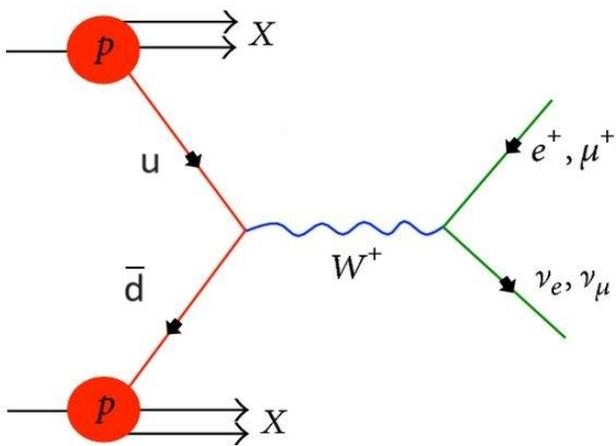
# Risultati: numeri e frequenze

- Domande:

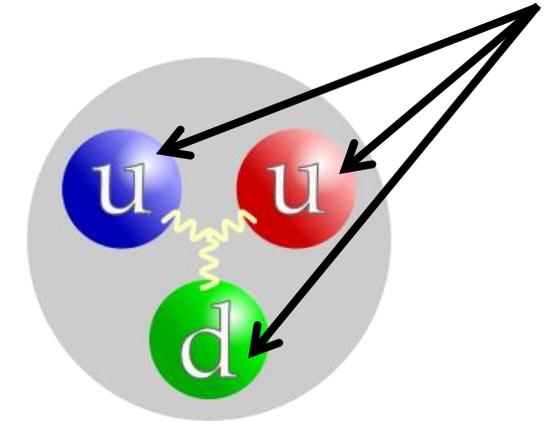
- Quanti  $W^+$ ? Quanti  $W^-$ ?

- Rapporto tra  $W^+/W^-$ : 1.3

- Previsione: 1.4 (Rapporto quark up/down nel protone)



## Protone Quark



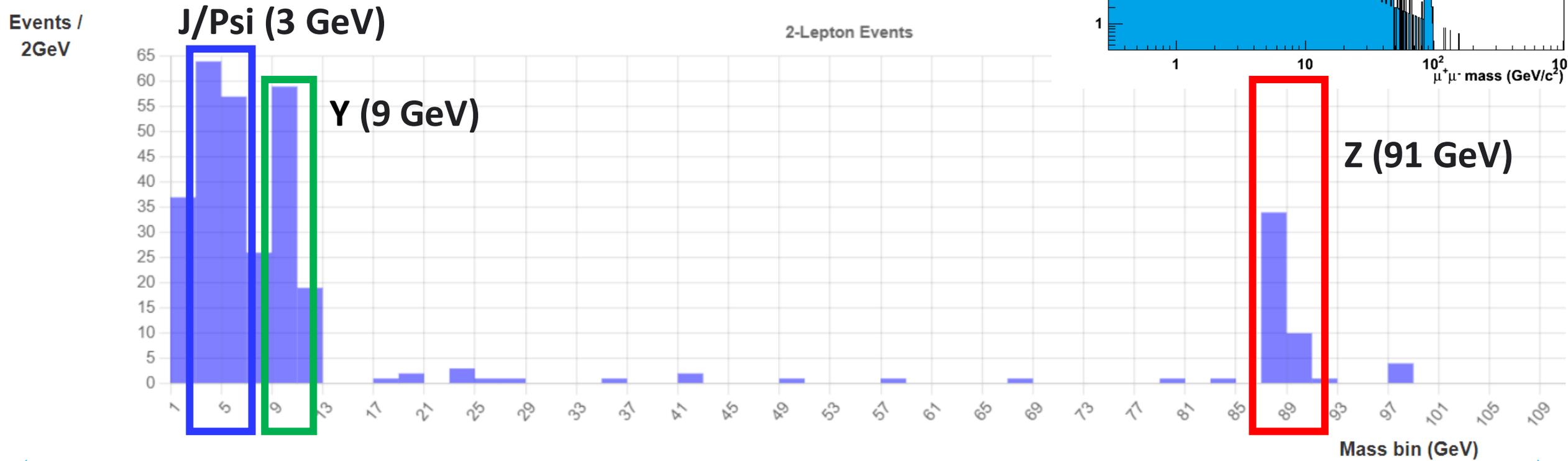
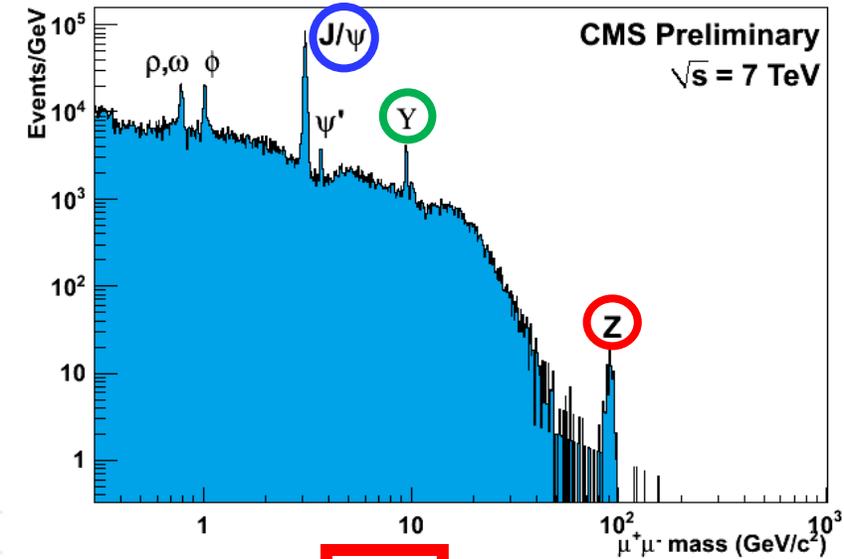
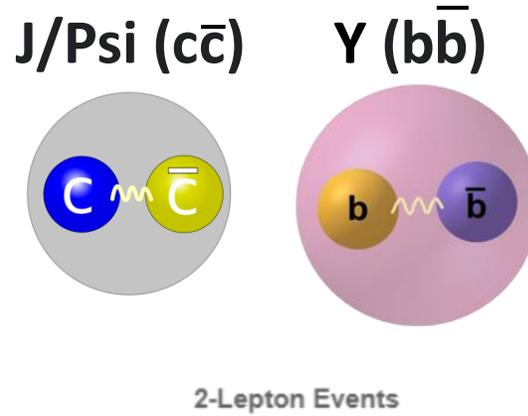
### Total:

Group	e	$\mu$	<b>W+</b>	<b>W-</b>	$W^\pm$	Neutral	Zoo	Total
All	774	788	308	244	340	570	143	1605

# Risultati: istogramma di massa ( $Z \rightarrow ee/\mu\mu$ )

• Domande:

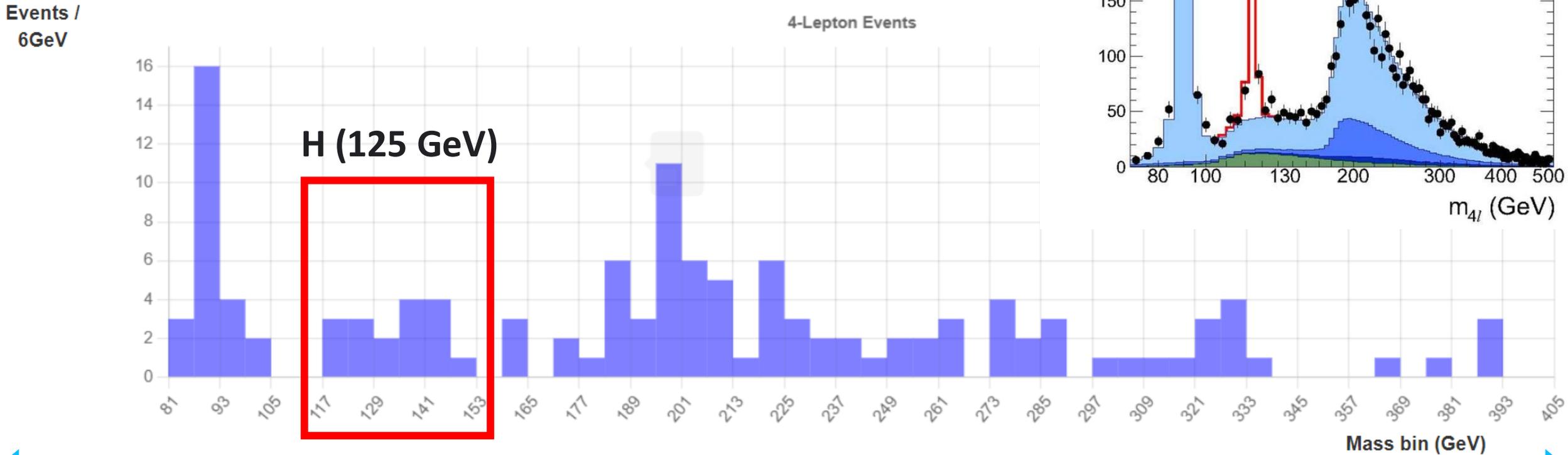
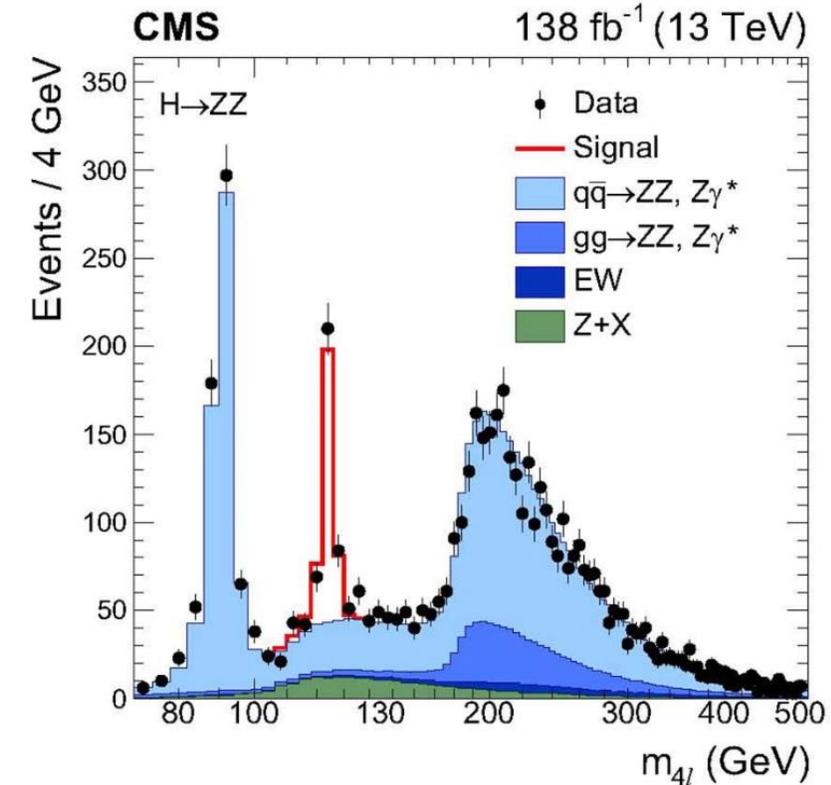
- Cosa si vede?
- C'è un picco?
  - Quale massa [GeV]?
  - A quale particella corrisponde?
- Ci sono altri picchi?



# Risultati: istogramma di massa ( $H \rightarrow ZZ$ )

- Domande:

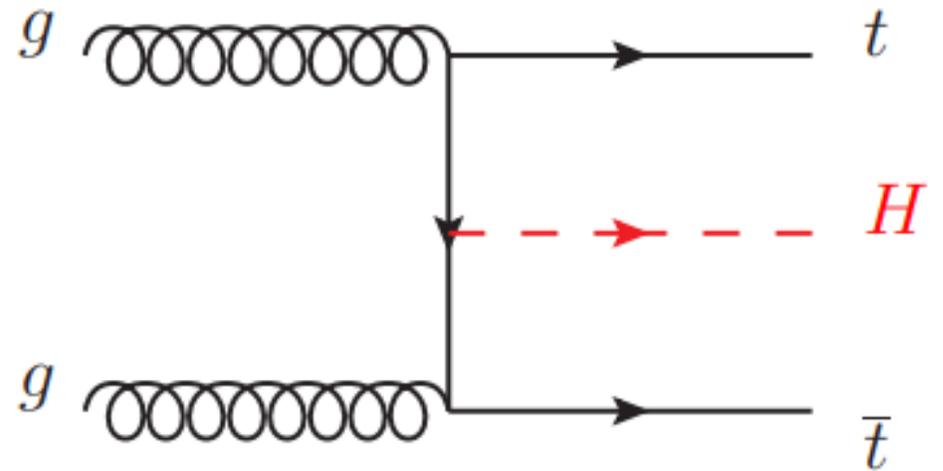
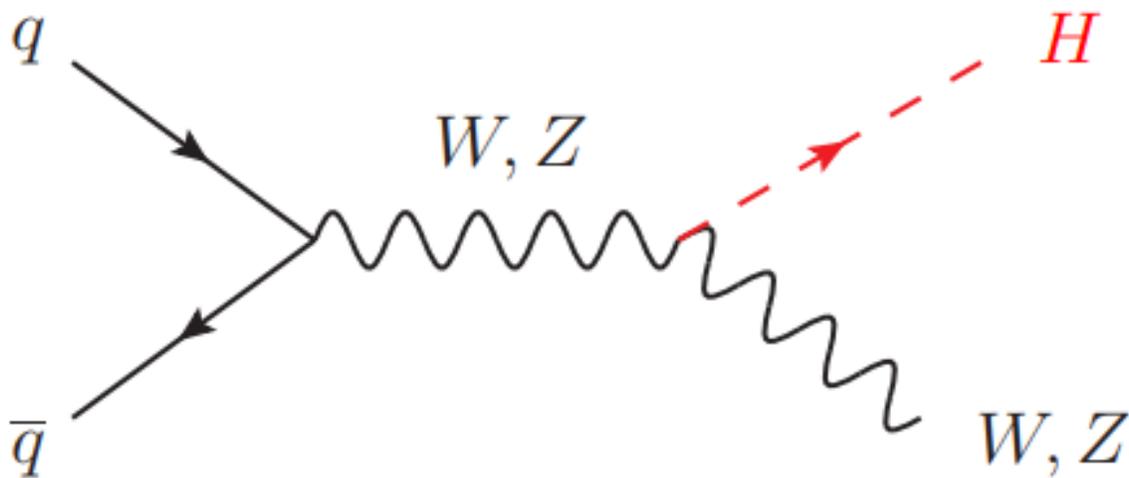
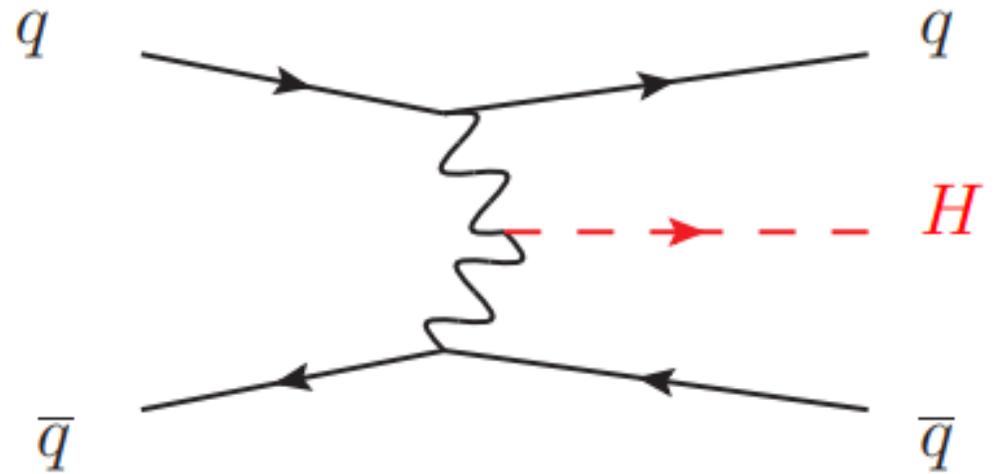
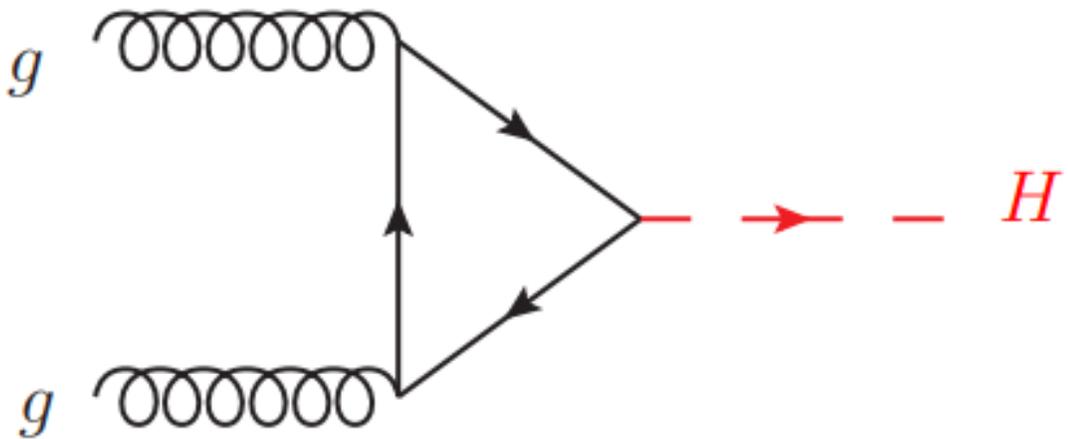
- Cosa si vede?
- C'è un picco?
  - Quale massa [GeV]?
  - A quale particella corrisponde?
- Ci sono altri picchi?



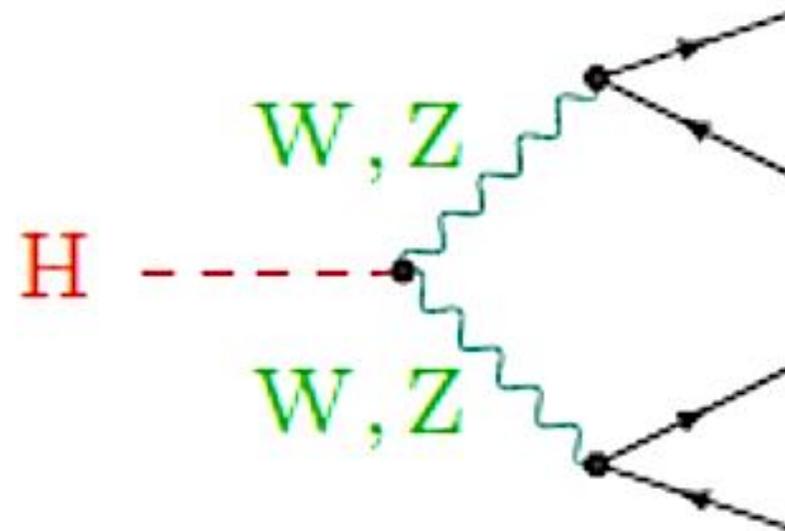
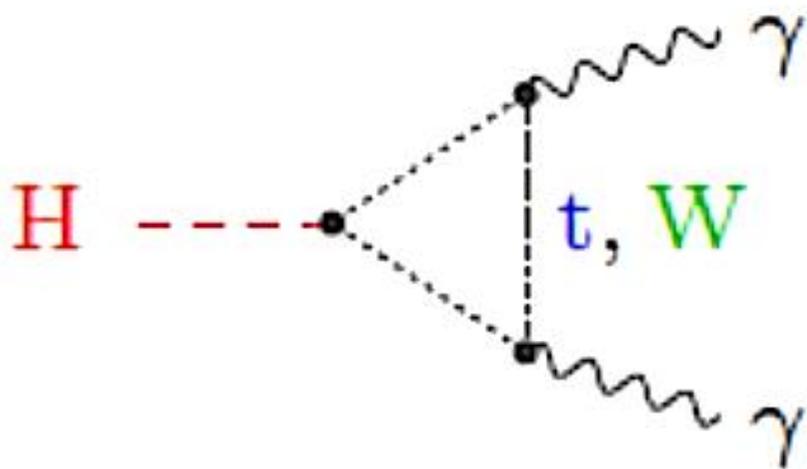
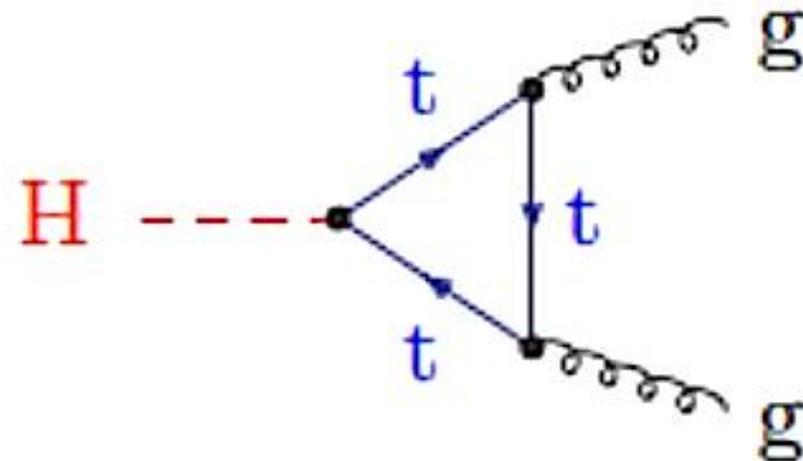
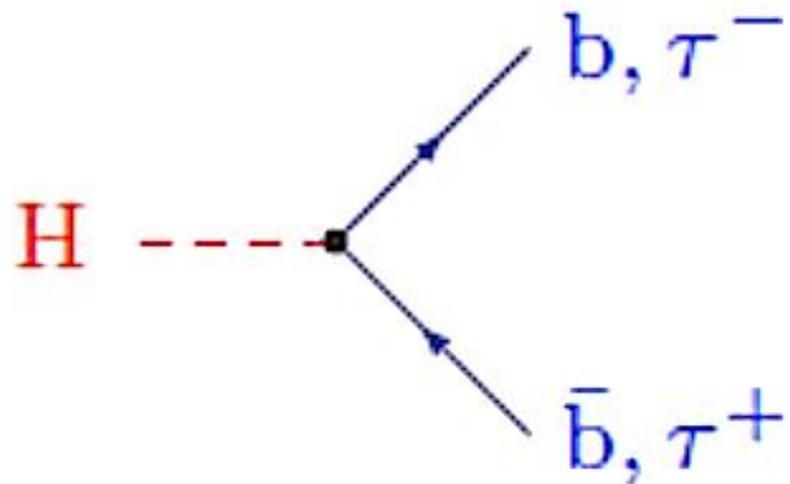


# Backup

# Processi di produzione del Bosone di Higgs



# Canali di Decadimento del Bosone di Higgs



# Meccanismo di Higgs: la massa

- Interazione con bosone di Higgs proporzionale alla massa!

- $t$ : 173 GeV
- $Z$ : 90 GeV
- $W$ : 80 GeV
- $b$ : 4 GeV
- $\tau$ : 2 GeV
- $\mu$ : 0.1 GeV

35.9-137 fb<sup>-1</sup> (13 TeV)

