# Taller práctico: *Masterclass* CMS

# Discusión resultados

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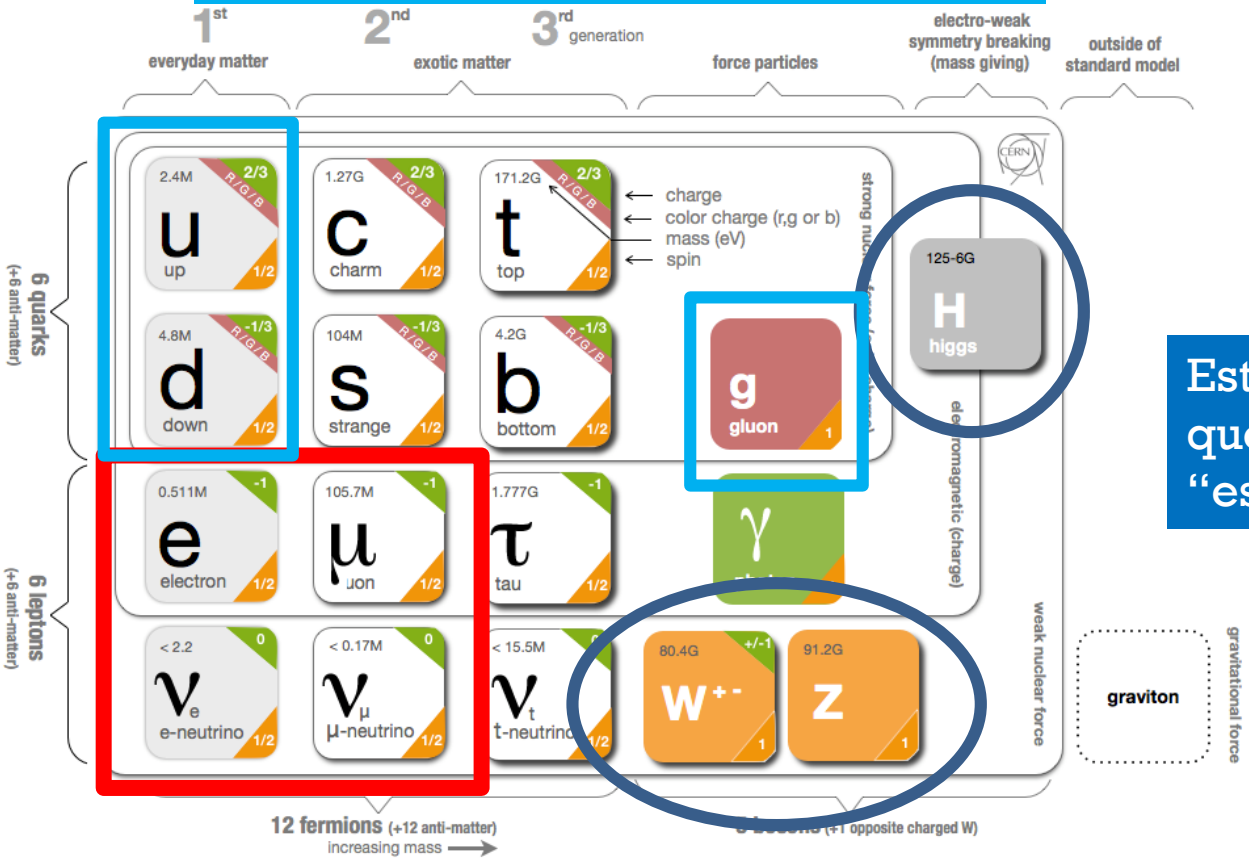
**CIEMAT-FP**


Programa español para profesores – CERN – Junio 2018

# El Modelo Estándar (ME)

Estas son las que van a interaccionar



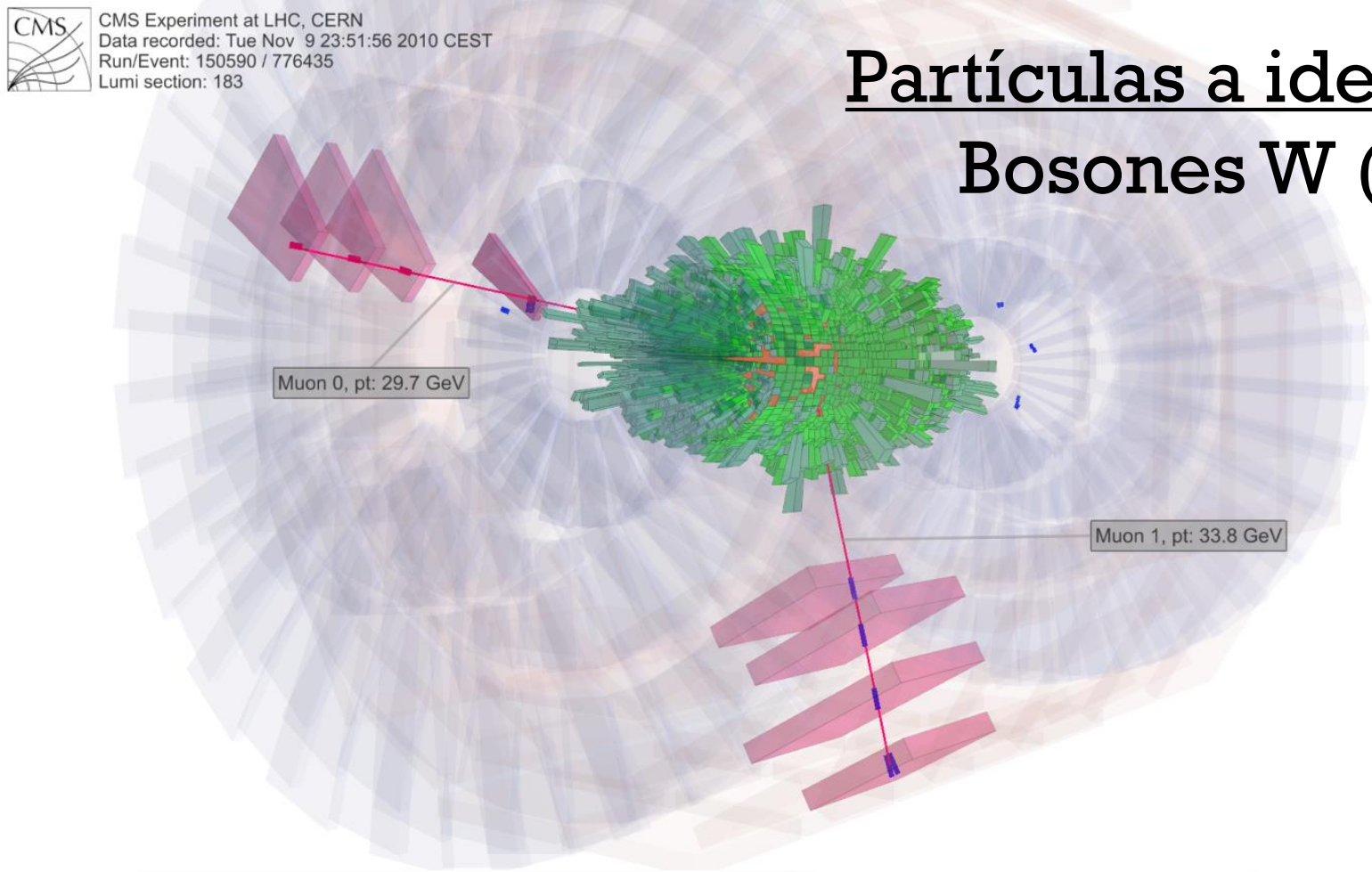

Estas son las que vais a "ver"

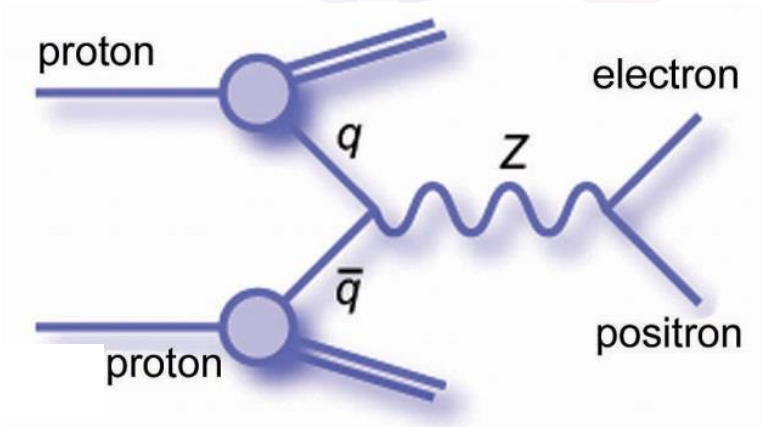
Estas son las que vais a "estudiar"

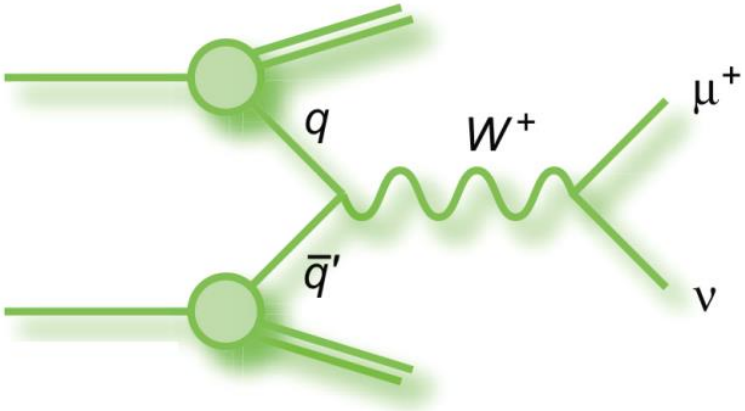
¡Y sus antipartículas también! (μ+, anti-u, anti-d, e+…)

# Partículas a identificar:

# Bosones W (+/-) y Z

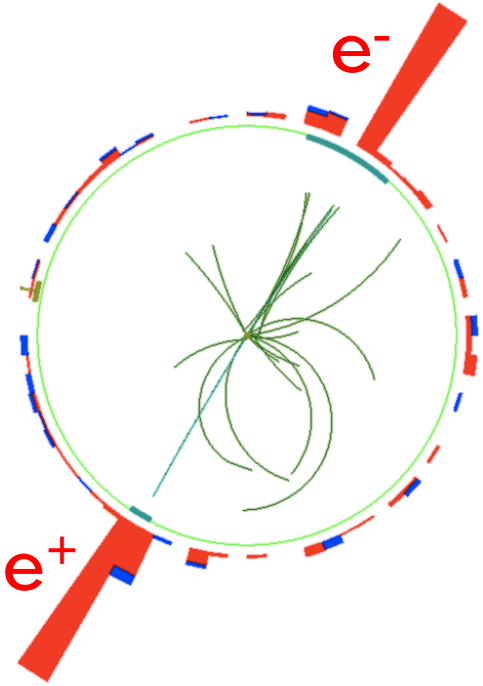


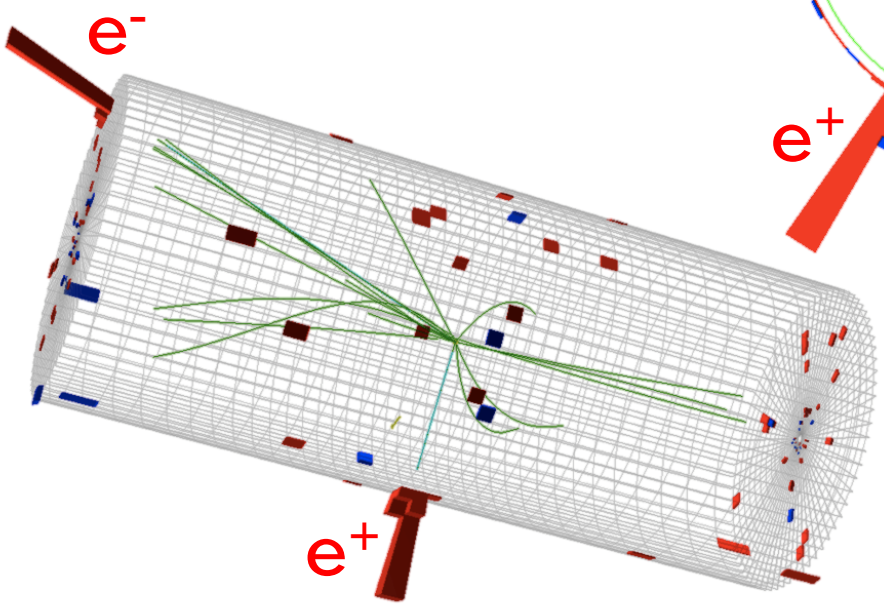



CMS Experiment at LHC, CERN
Run 133877, Event 28405693
Lumi section: 387
Sat Apr 24 2010, 14:00:54 CEST

Electrons $p_T$ = 34.0, 31.9 GeV/c
Inv. mass = 91.2 GeV/$c^2$

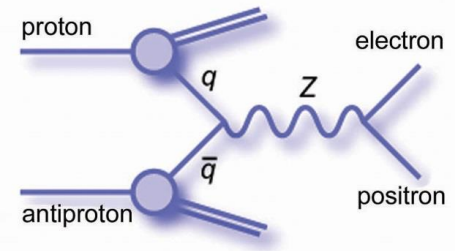


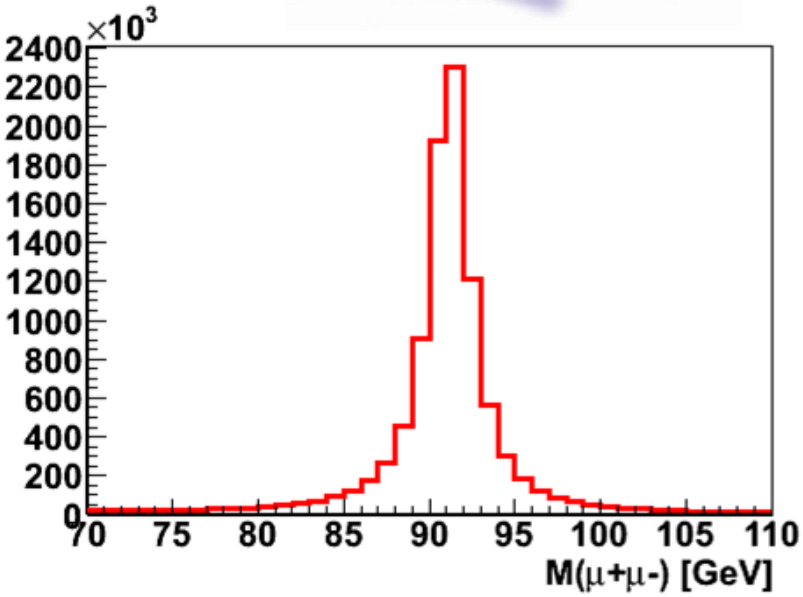




**Candidato a Z:**

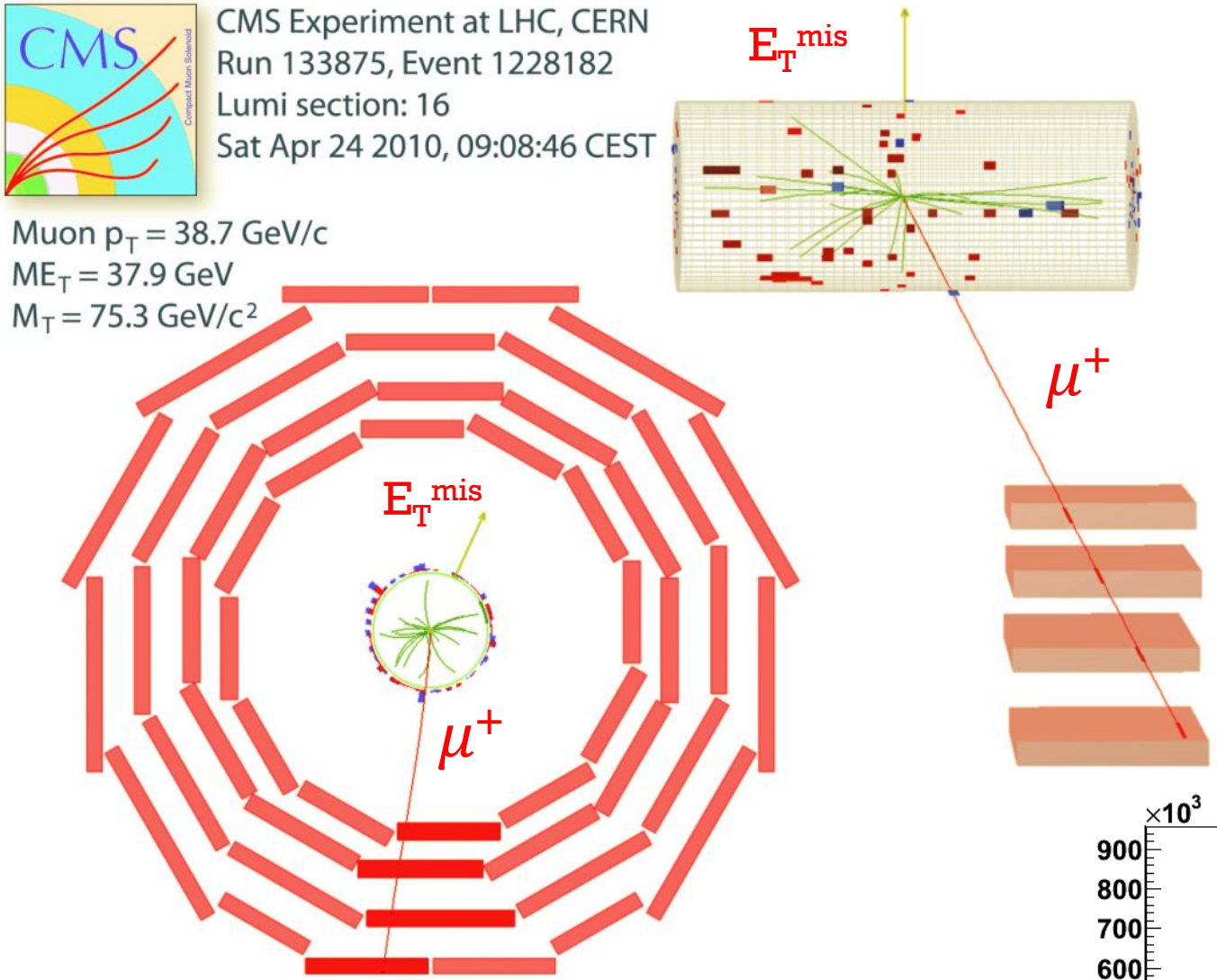
2 *leptones cargados* del mismo sabor (e, μ) y carga opuesta.

Balanceados en el plano transverso.



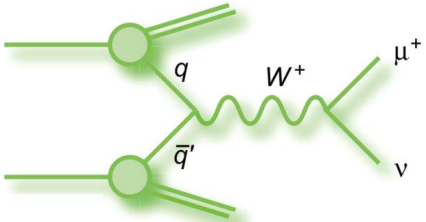

$$pp \rightarrow Z+X \rightarrow e^+e^- + X$$

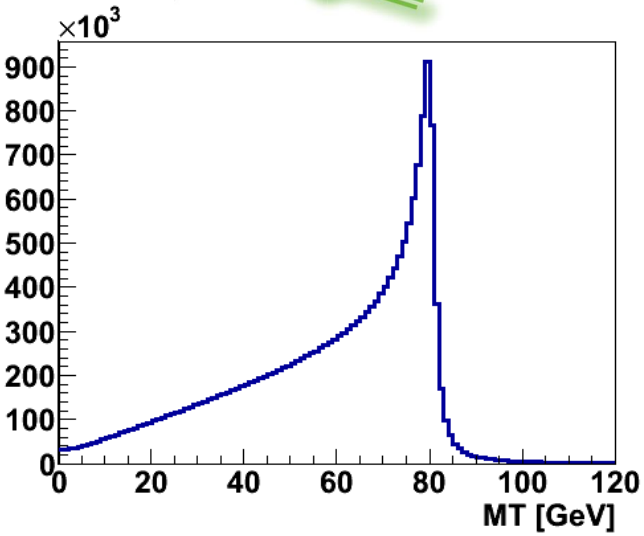



**Candidato a W:**

1 *leptón cargado* (e, μ) y un **neutrino** ($E_T^{mis}$).

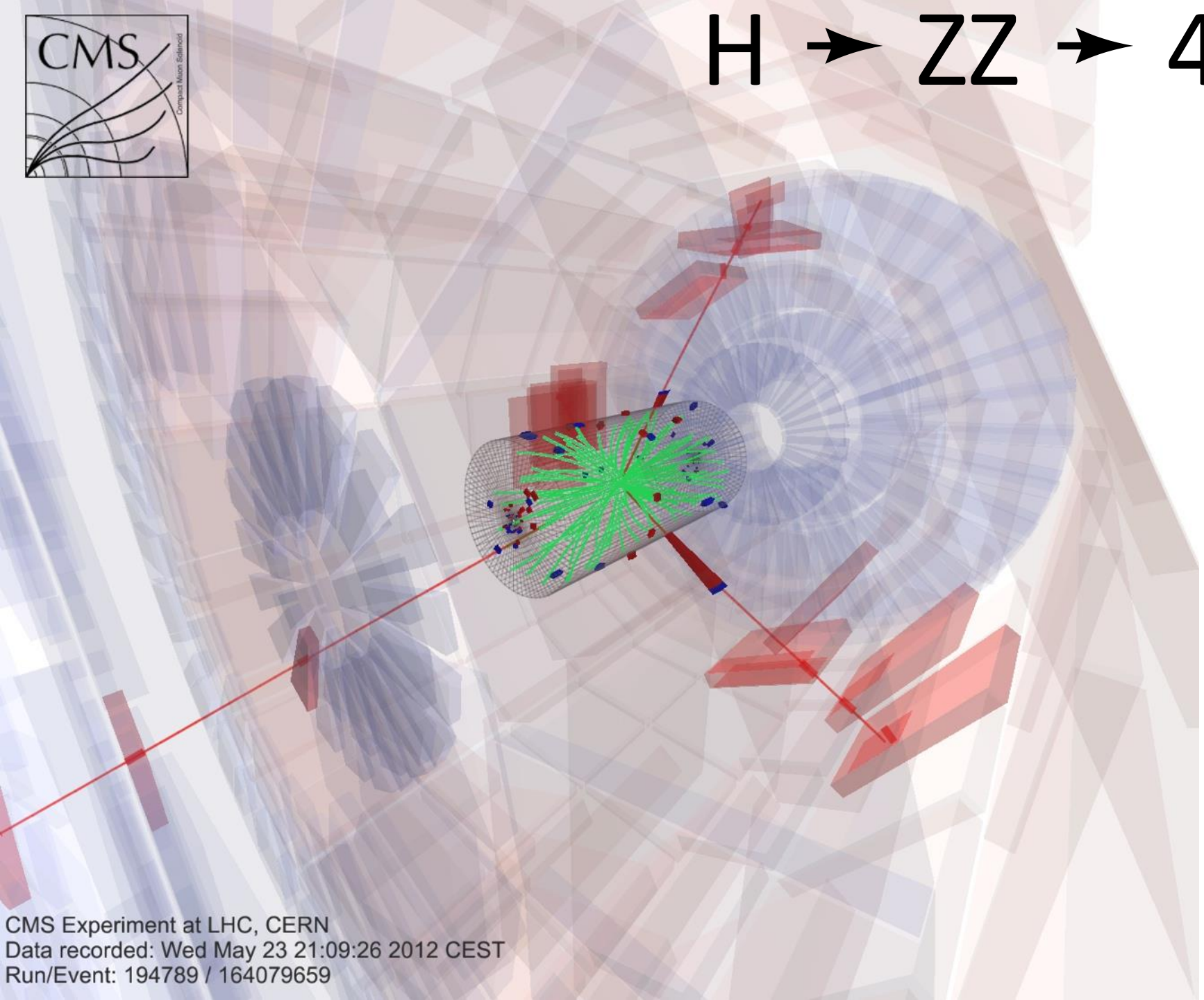
El neutrino se manifiesta por la *falta aparente* de conservación de energía-momento.



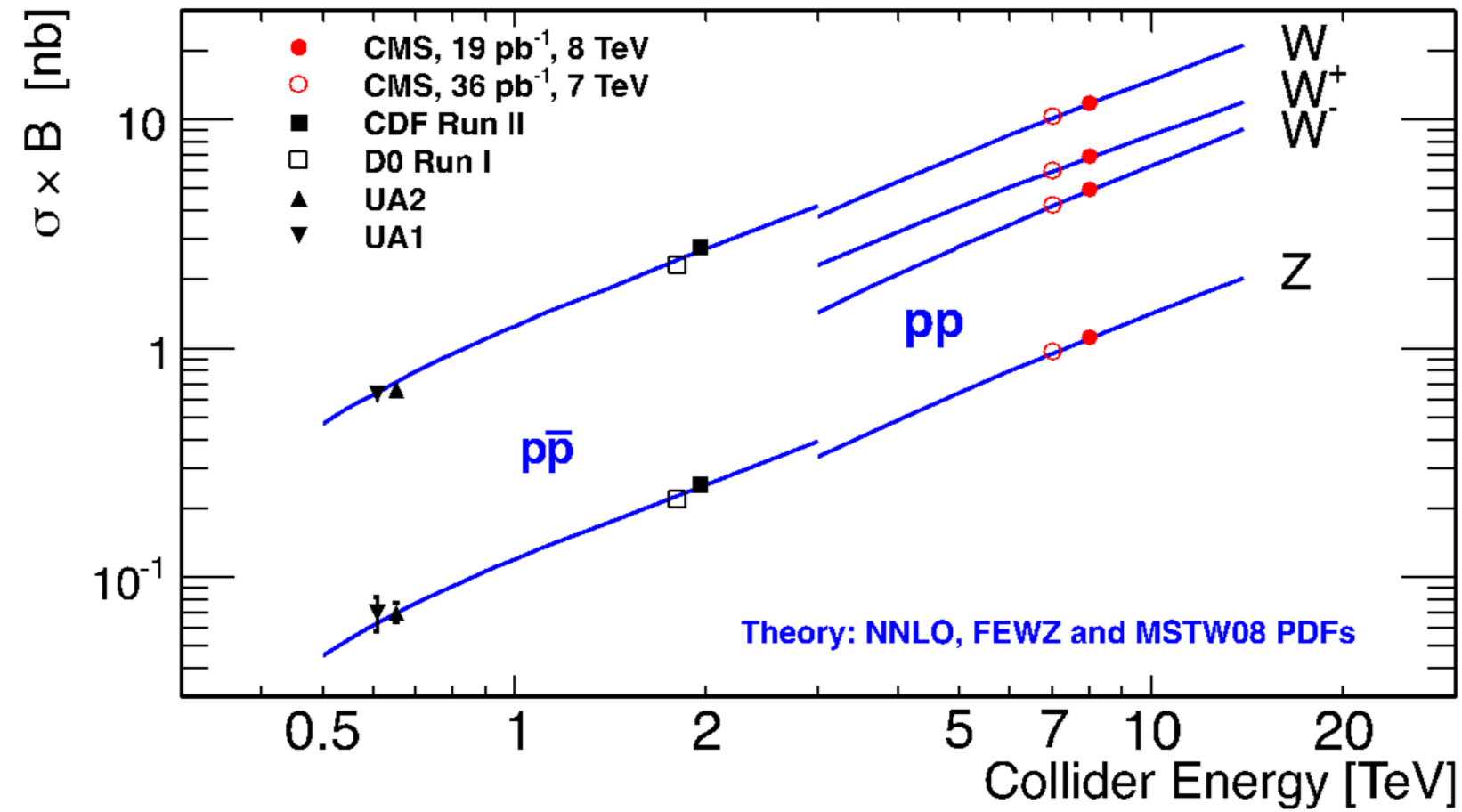




$$pp \rightarrow W+X \rightarrow \mu^+\nu+X$$

# $H \rightarrow ZZ \rightarrow 4\ell$



# Secciones eficaces de producción de W y Z




Las predicciones teóricas de la *evolución de la sección eficaz* con la energía están de acuerdo con las medidas experimentales.

Los cocientes $W^+/W^-$ y $W/Z$ se miden con *mayor precisión*.

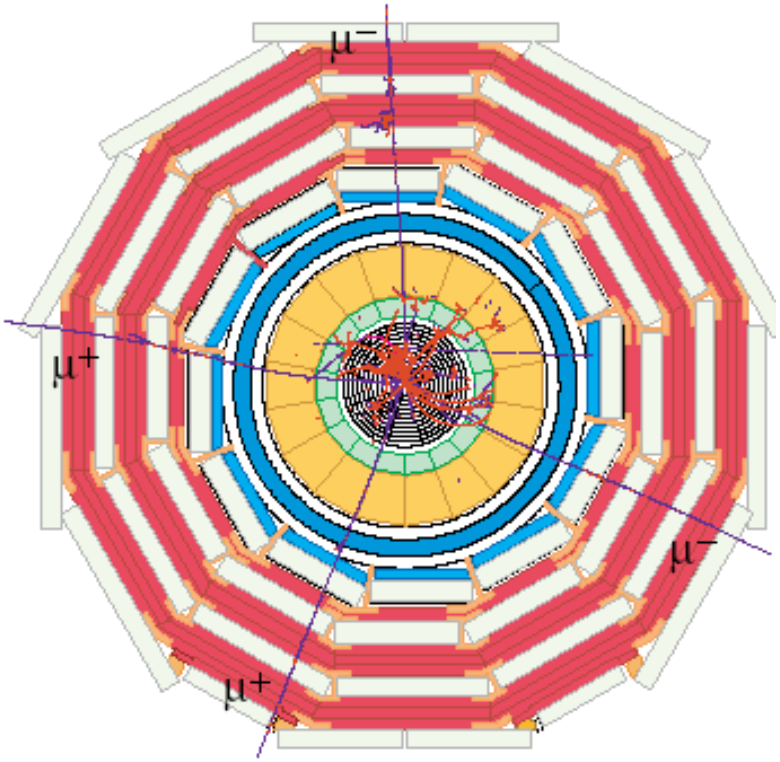
# Higgs -> 4 leptones

Otro modo de desintegración del Higgs es su desintegración en 2 bosones Z que a su vez se desintegran en pares de leptones.

Seleccionando sucesos con al menos 4 muones de alto momento se reconstruye la masa de la posible partícula que se desintegró en esos 4 cuerpos

$$M_H^2 = (p_1 + p_2 + p_3 + p_4)^2$$

.

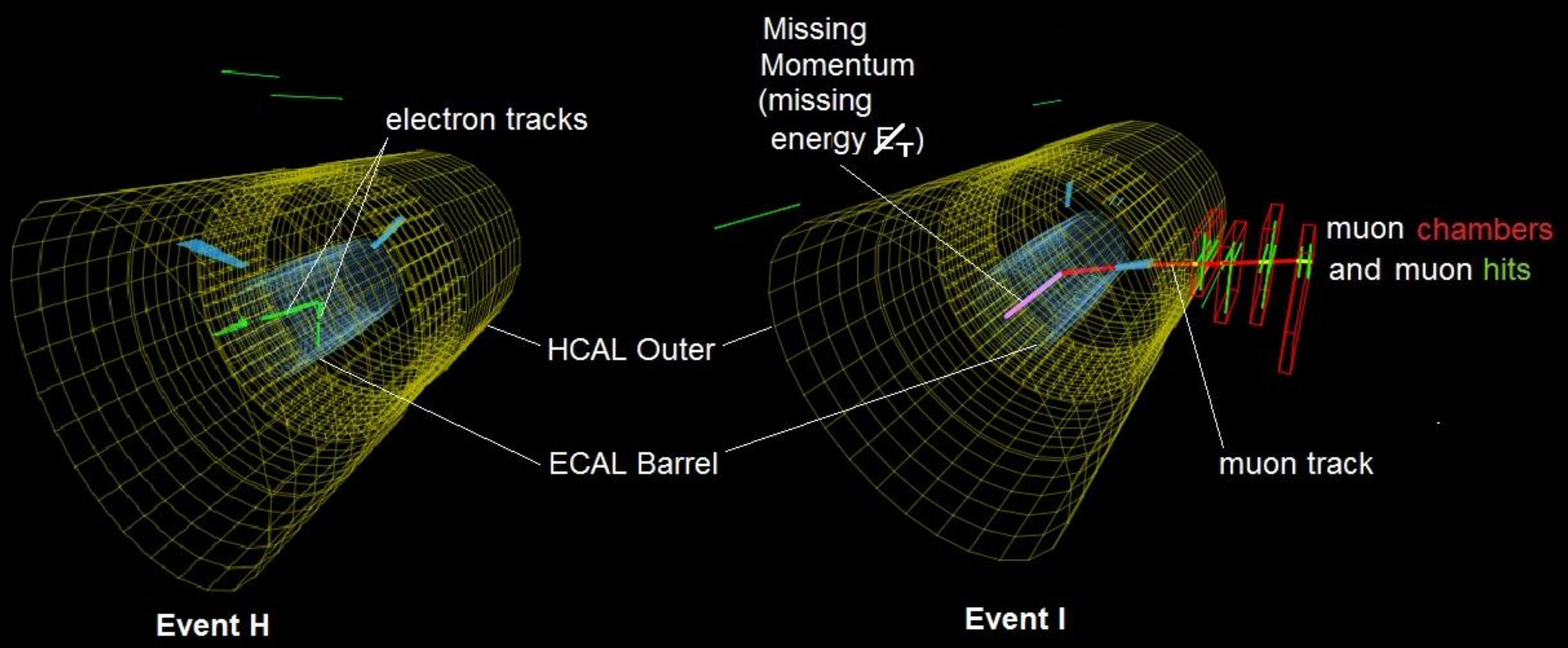



Al ser M(H) alta (125 Gev), los momentos de las partículas hijas serán altos

→ Trayectorias "casi" rectas

$p = 0.3 \cdot B \cdot R$

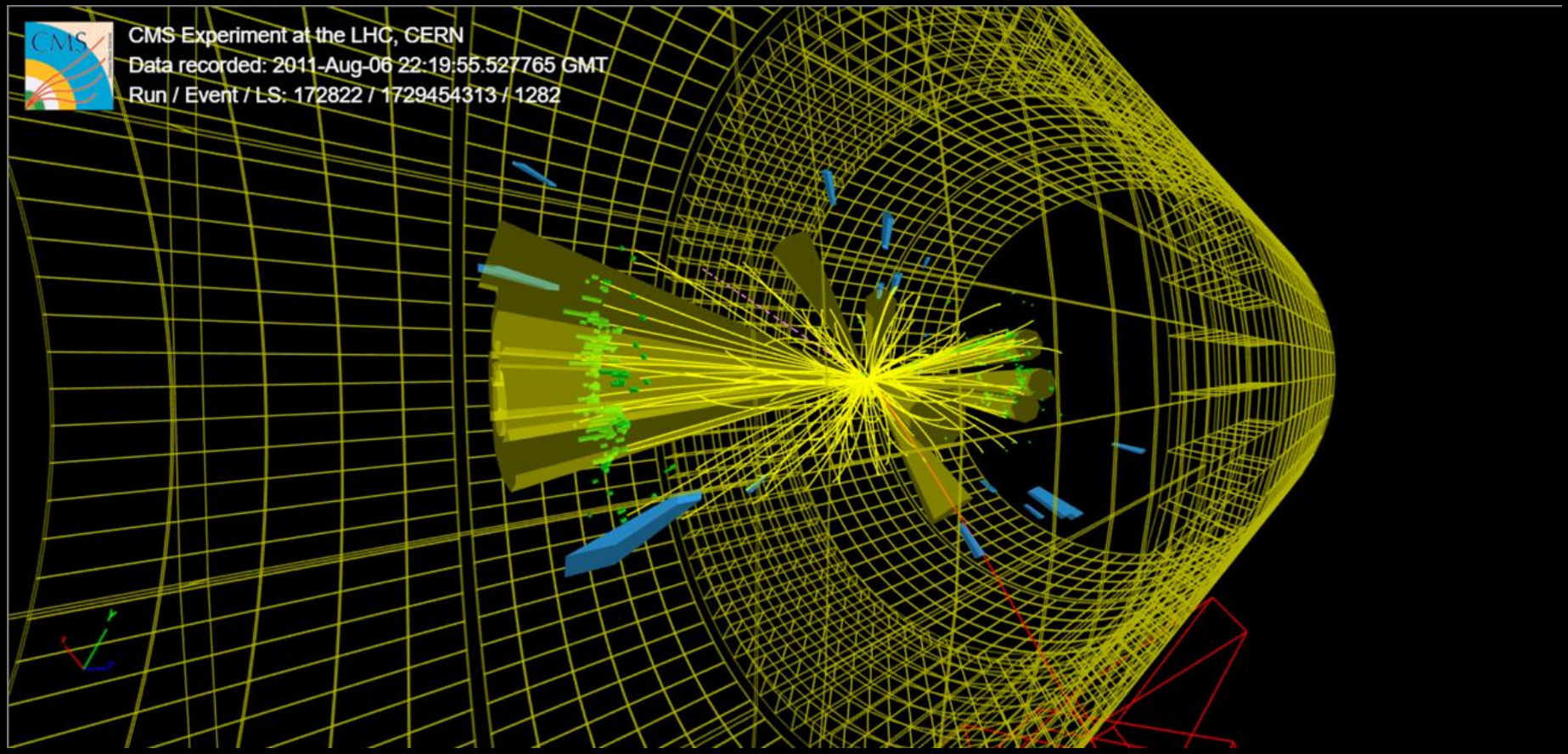
# 1) Identificación de sucesos




¿Problemas?

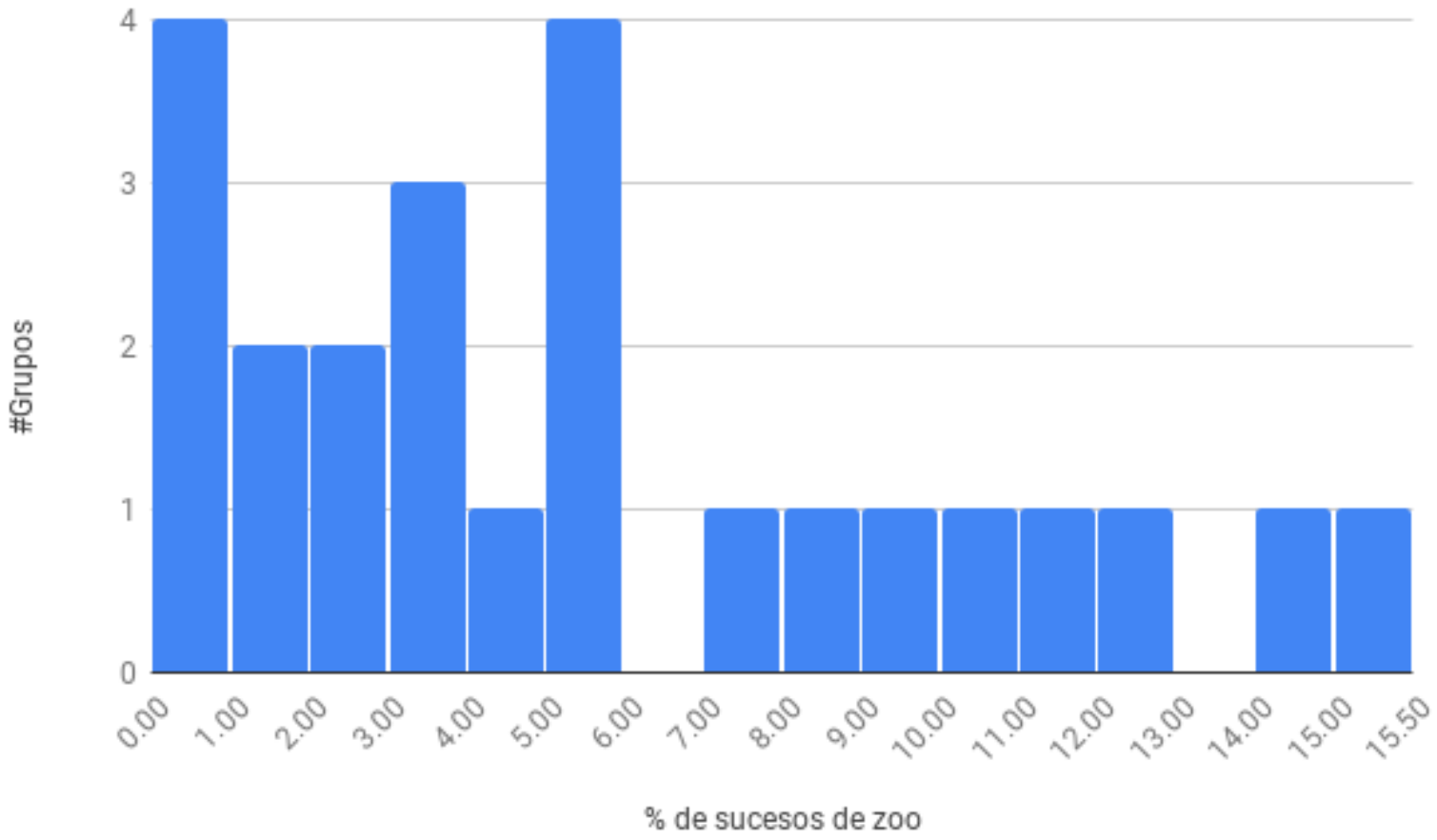
1. Manejo del visualizador
2. Identificar estados finales
3. ¿Por qué había eventos “zoo”?
4. ¿Por qué había otras partículas?

Requiere práctica…



# Índice de pereza

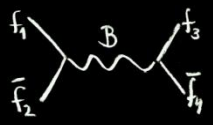
# Coeficiente de perrez



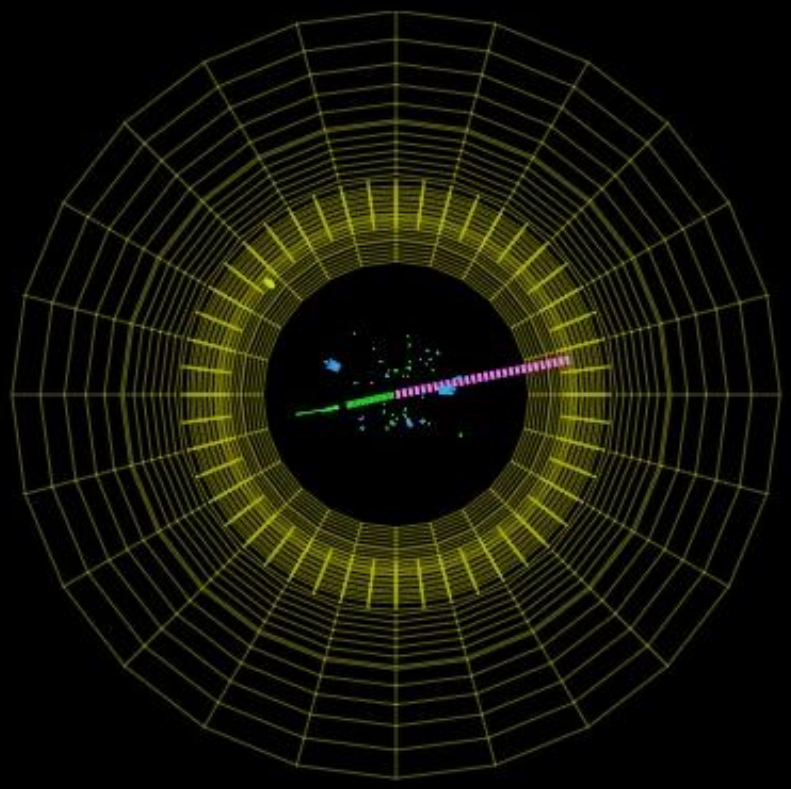
# 2) Resultados

| TOTAL | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Suma** | **μ** | **e** | **W** | **W-** | **W+** | **NP** | **H** | **Zoo** | **e/μ** | **W+/W-** |
| 1751 | 814 | 808 | 185 | 448 | 608 | 380 | 22 | 108 | 0.99 | 1.36 |

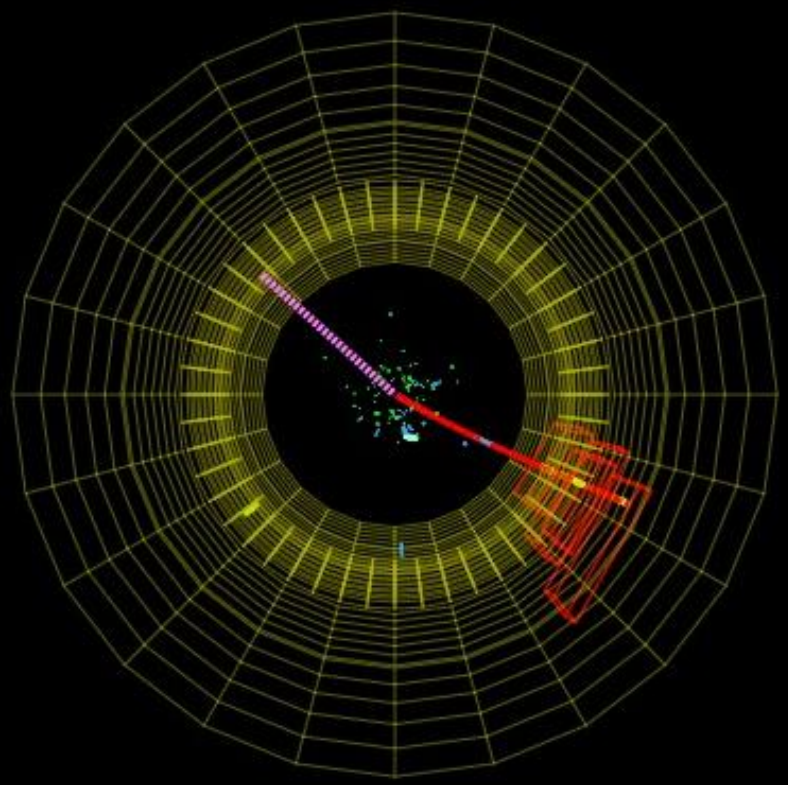
73% de eventos analizados




# 3) Los bosones W



Event A

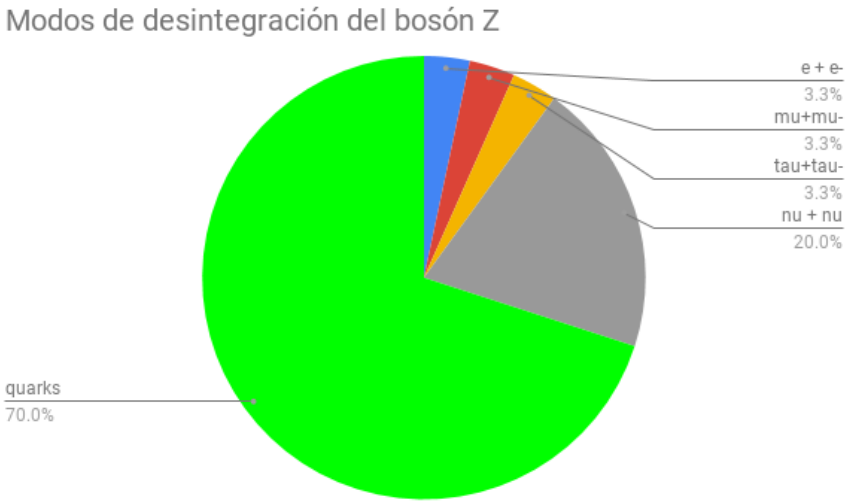


Event B

¿Problemas?

# 2) Los bosones W

## ¿Podemos calcular la razón e/m en estados finales de W (igual para Z)?

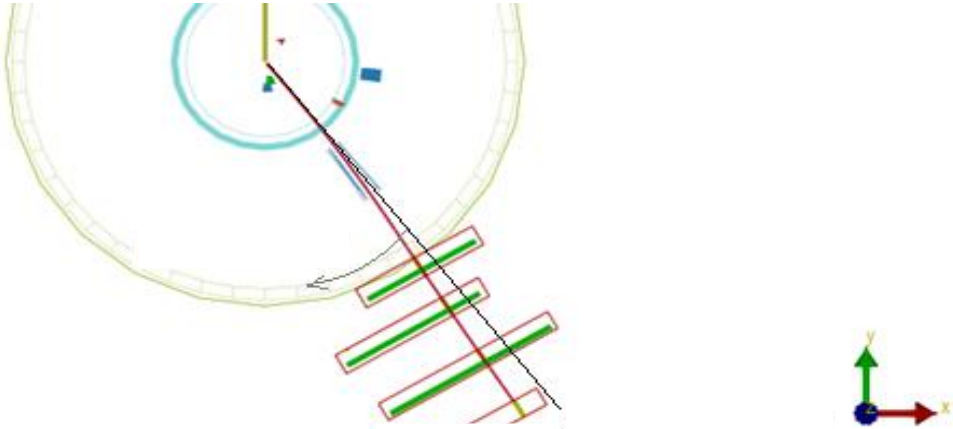


| TOTAL | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Suma** | **μ** | **e** | **W** | **W-** | **W+** | **e/μ** | **W+/W-** |
| 1751 | 814 | 808 | 185 | 448 | 608 | 0.99 | 1.36 |

Teoría / medido en CMS : e/$\mu$ = 1

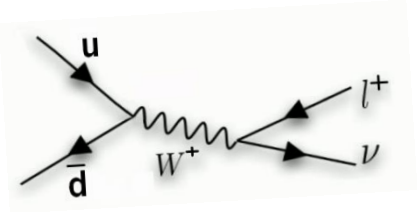
# 2) Los bosones W

## ¿Podemos calcular la razón $W^+/W^-$ para CMS?



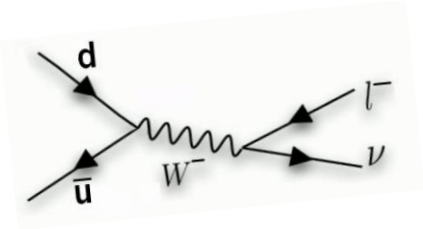
**traza de muón**

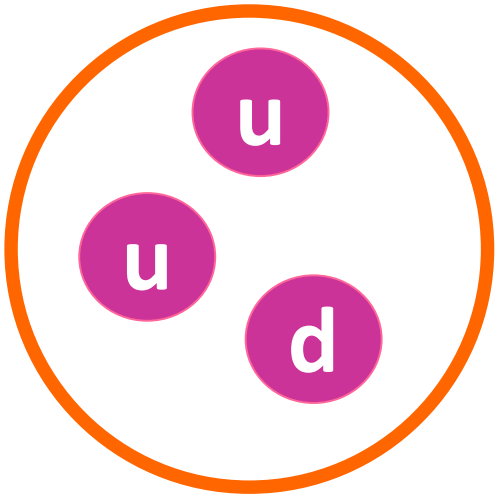
# Asimetría en la producción de W

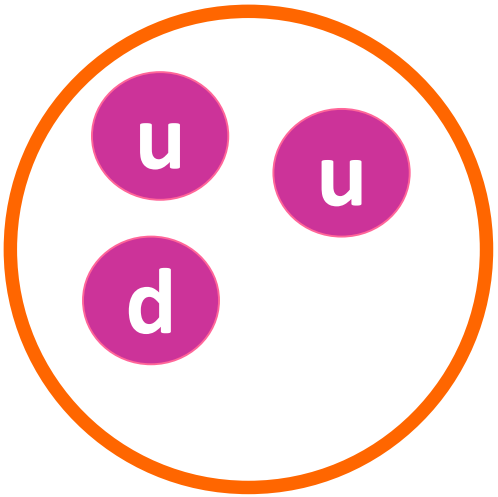



$$u\bar{d} \rightarrow W^+$$

$$\bar{u}d \rightarrow W^-$$



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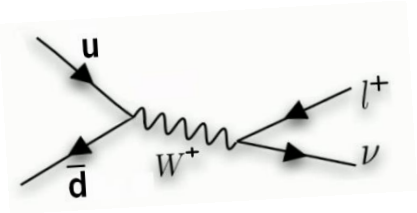
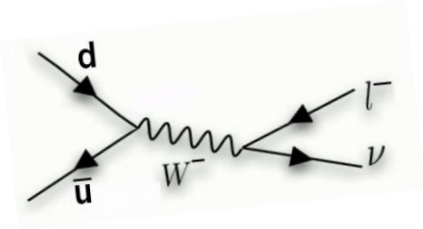
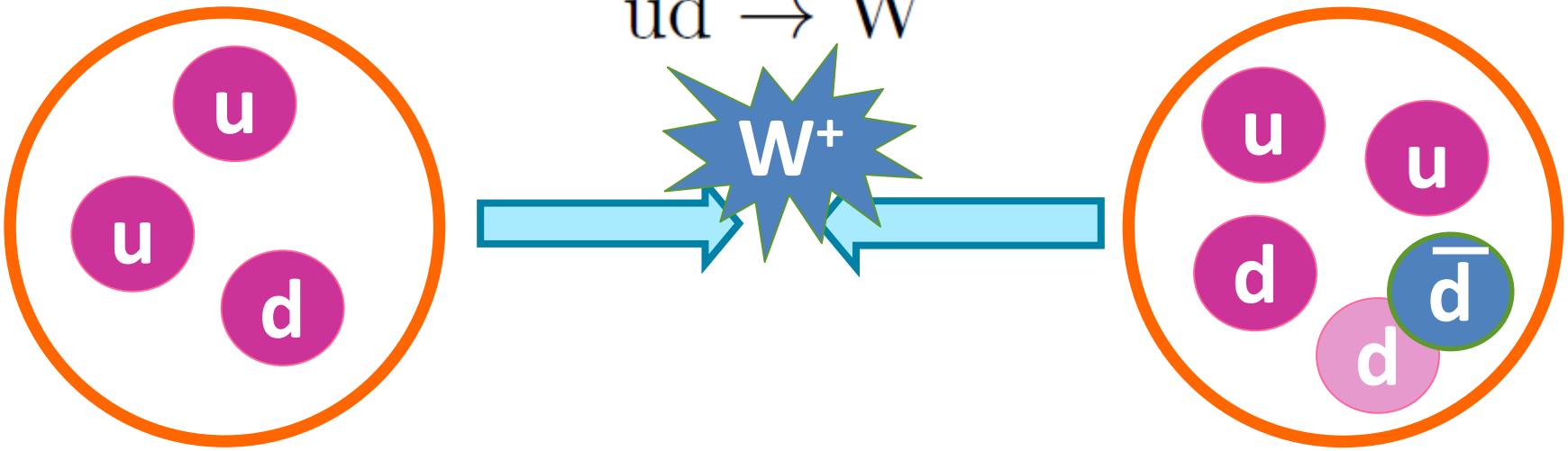


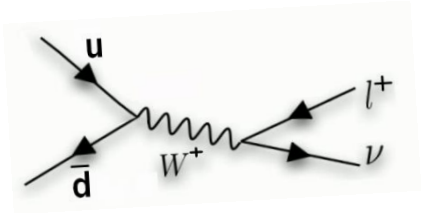

$$u\bar{d} \rightarrow W^+$$

$$\bar{u}d \rightarrow W^-$$



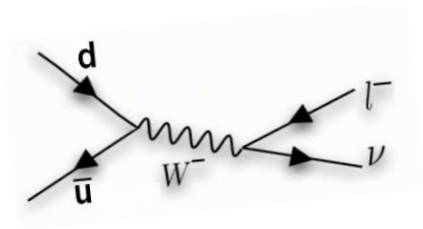



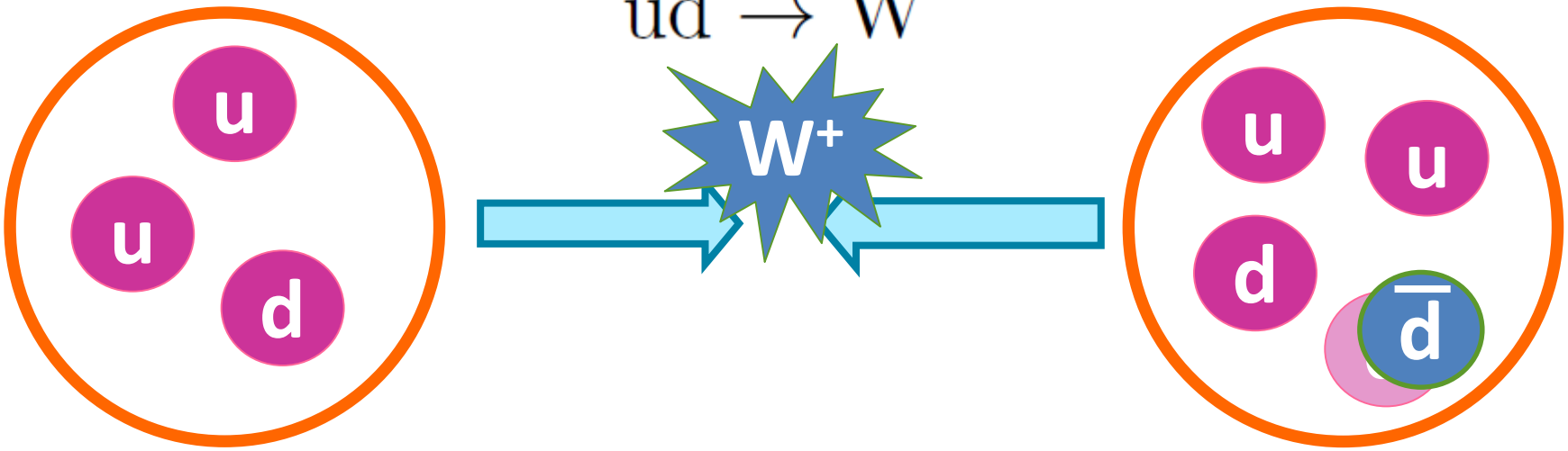
# Asimetría en la producción de W

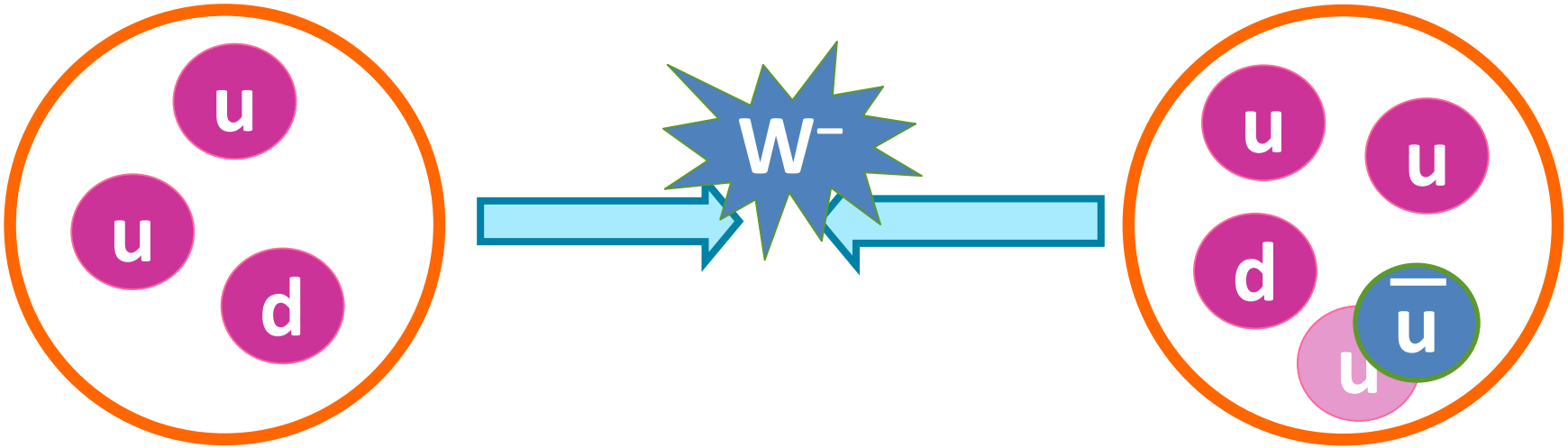



$$u\bar{d} \rightarrow W^+$$

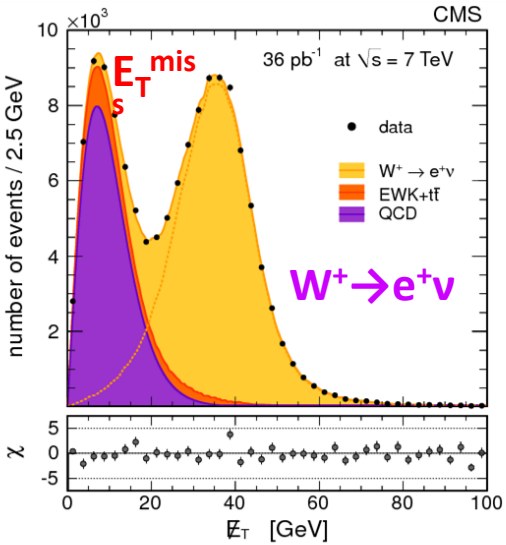
$$\bar{u}d \rightarrow W^-$$

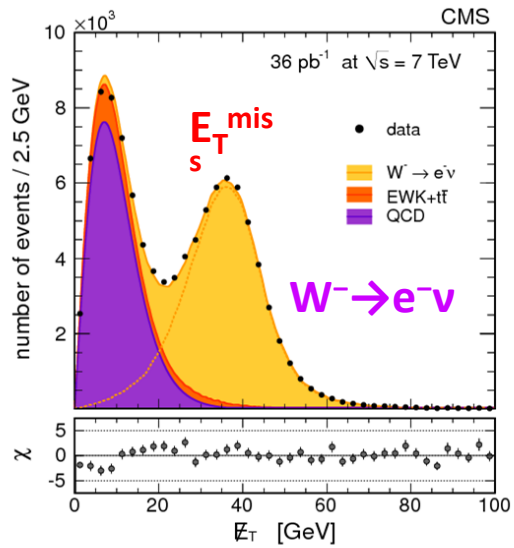


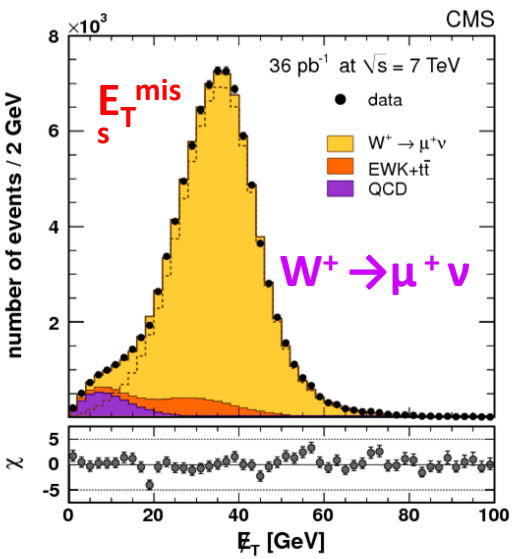



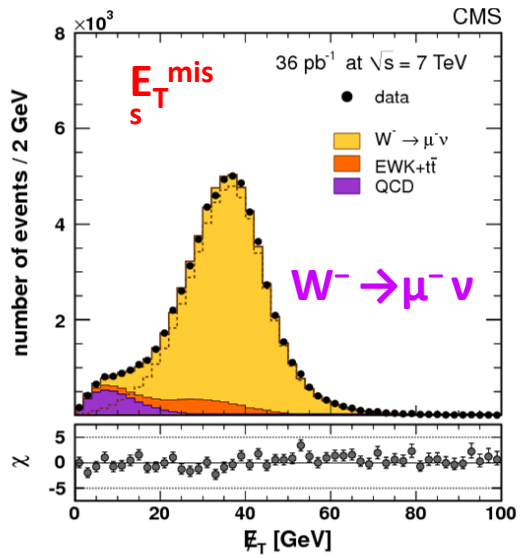
# Asimetría en la producción de W

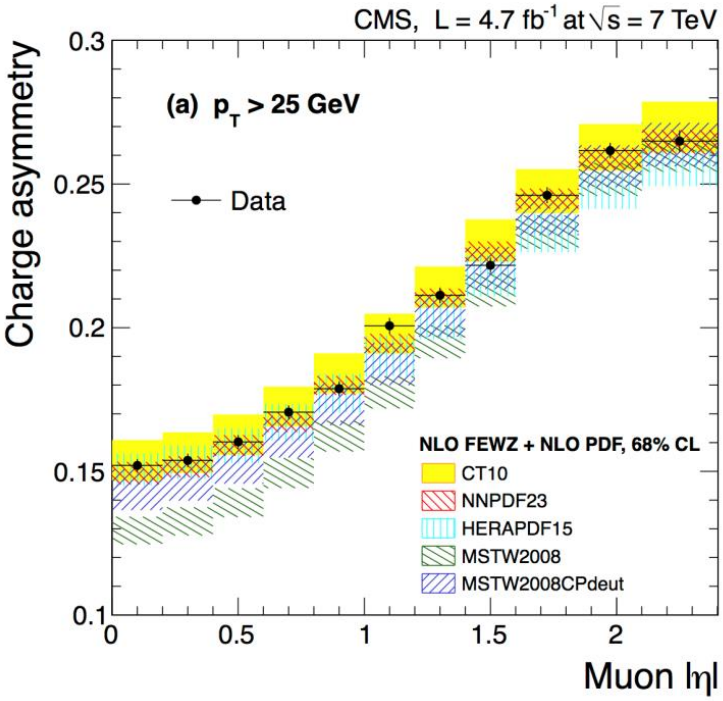


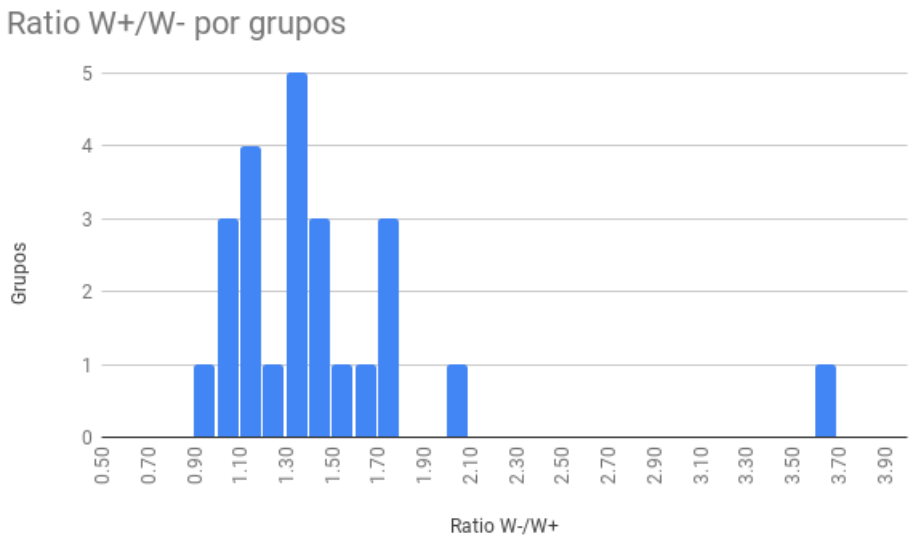

La asimetría depende de las PDFs de los quarks en el protón.



## ¿Podemos calcular la razón $W^+/W^-$ para CMS?



| TOTAL | | | | | | | |
|---|---|---|---|---|---|---|---|
| Suma | Mu | e | ~~W~~ | W- | W+ | e/mu | W+/W- |
| 1751 | 814 | 808 | ~~185~~ | 448 | 608 | 0.99 | 1.36 |

CMS: $W^+/W^- \approx 1.60$

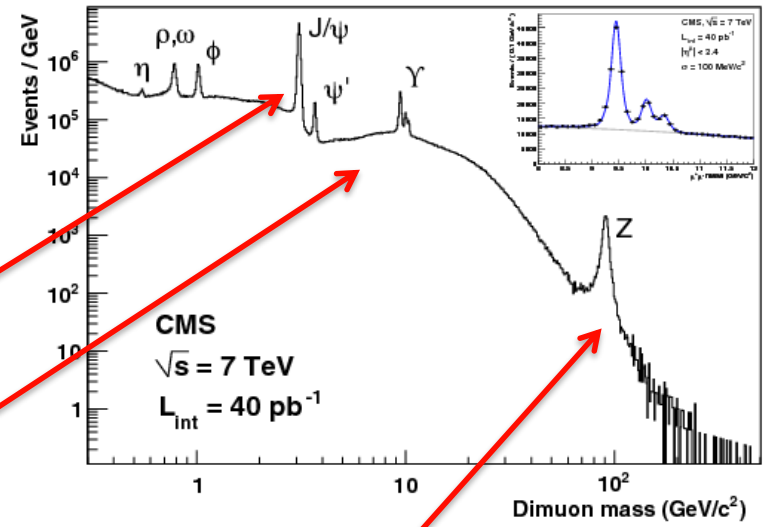
~15% (compatible con errores)

Estimar la curvatura “a ojo” no es fiable…

# 3) Histograma de masas de partículas neutras

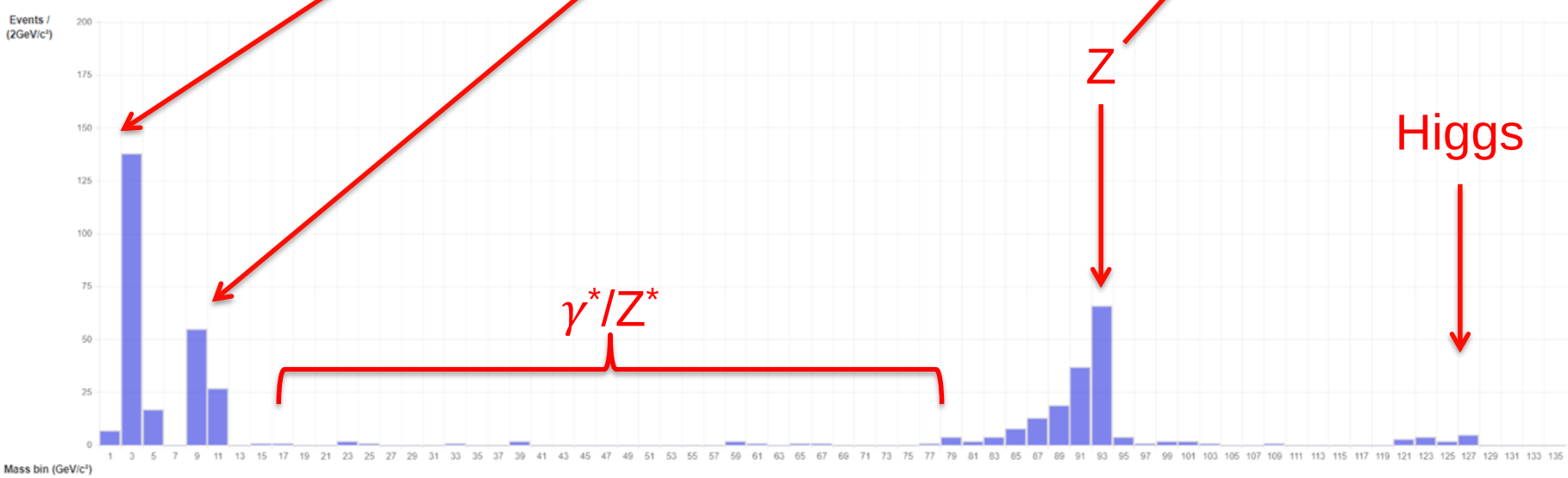
# 3) Histograma masas

**Masa J/ψ ~ 3 GeV**
**Masa ϒ ~ 9.4 GeV**



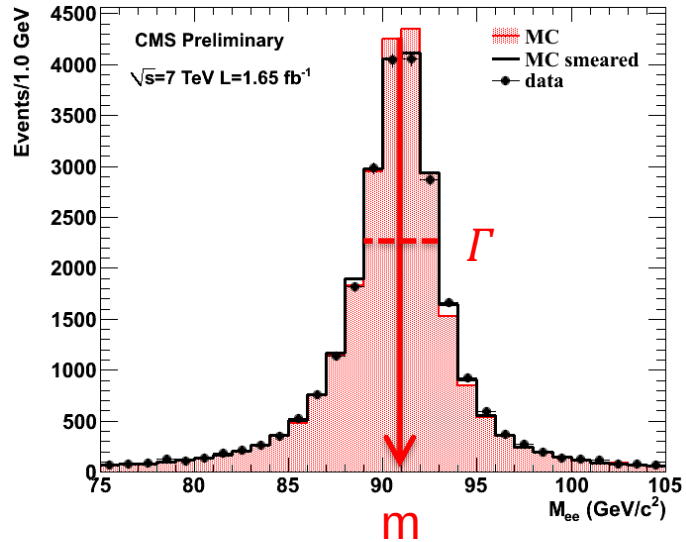

J/ψ (cc̲)

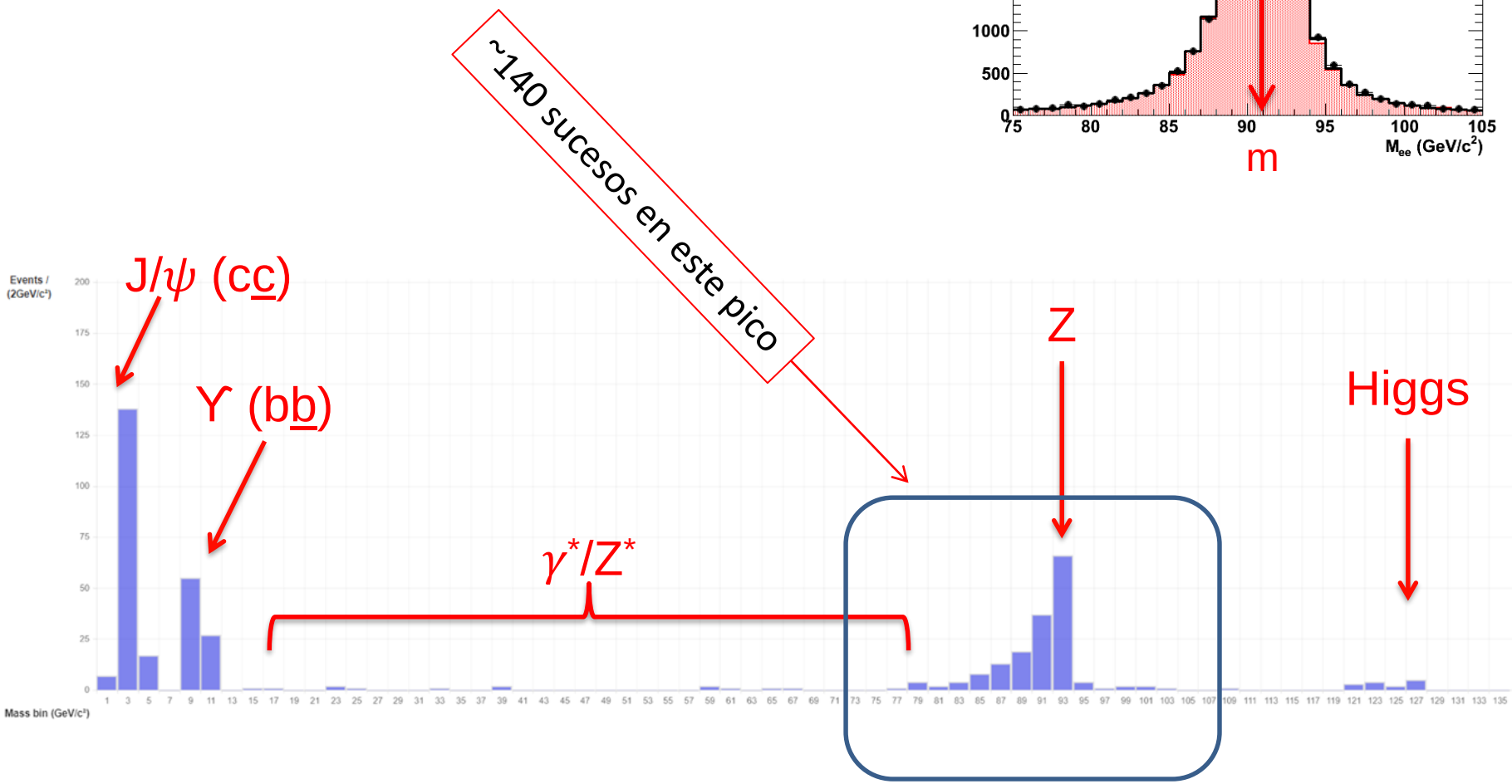
ϒ (bb̲)



# 3) Histograma masas

**Masa Z ~ 91 GeV**



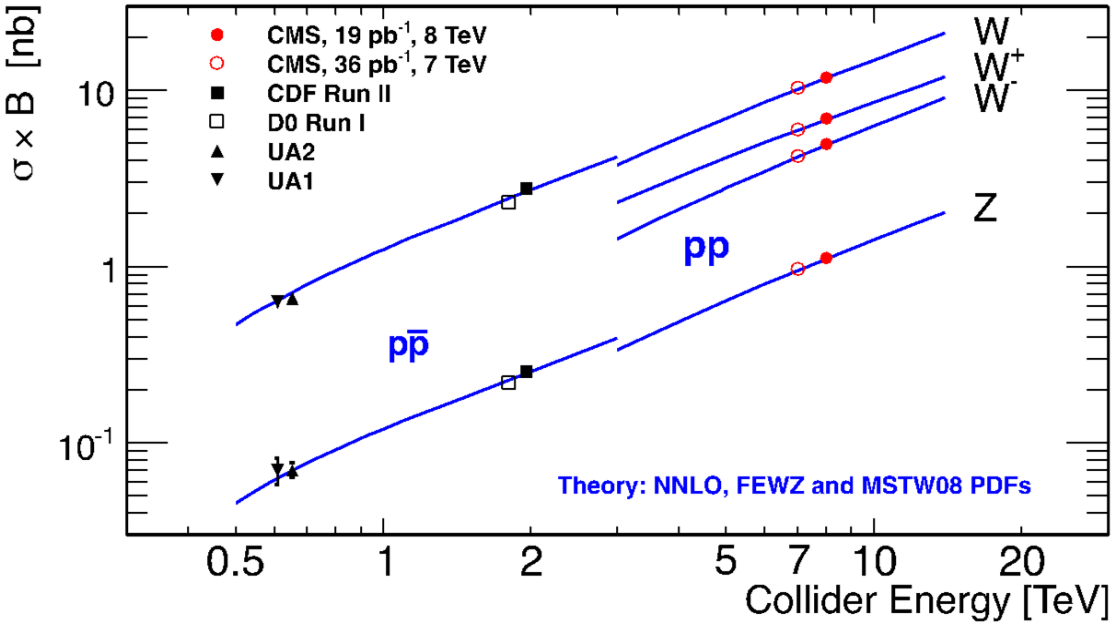



# 4) ¿Hay más W o Z?

1241 sucesos W

| TOTAL | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Suma** | **Mu** | **e** | **W** | **W-** | **W+** | **NP** | **H** | **Zoo** | **e/mu** | **W+/W-** |
| 1751 | 814 | 808 | 185 | 448 | 608 | 380 | 22 | 108 | 0.99 | 1.36 |

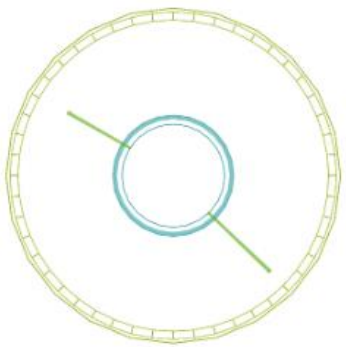
140 sucesos de Z entre estos

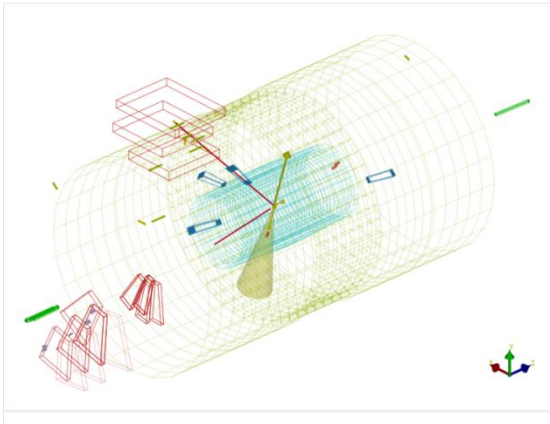


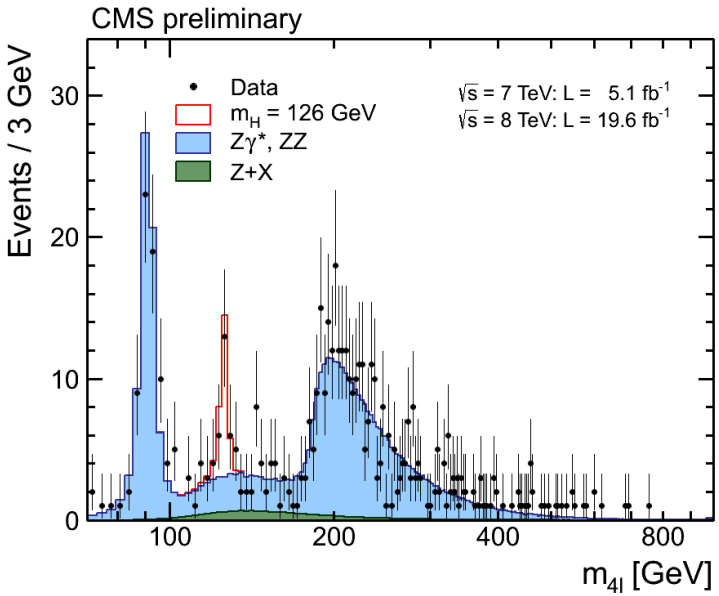

**Medido: W/Z ~ 8.9**

**CMS: W/Z ≈ 12**

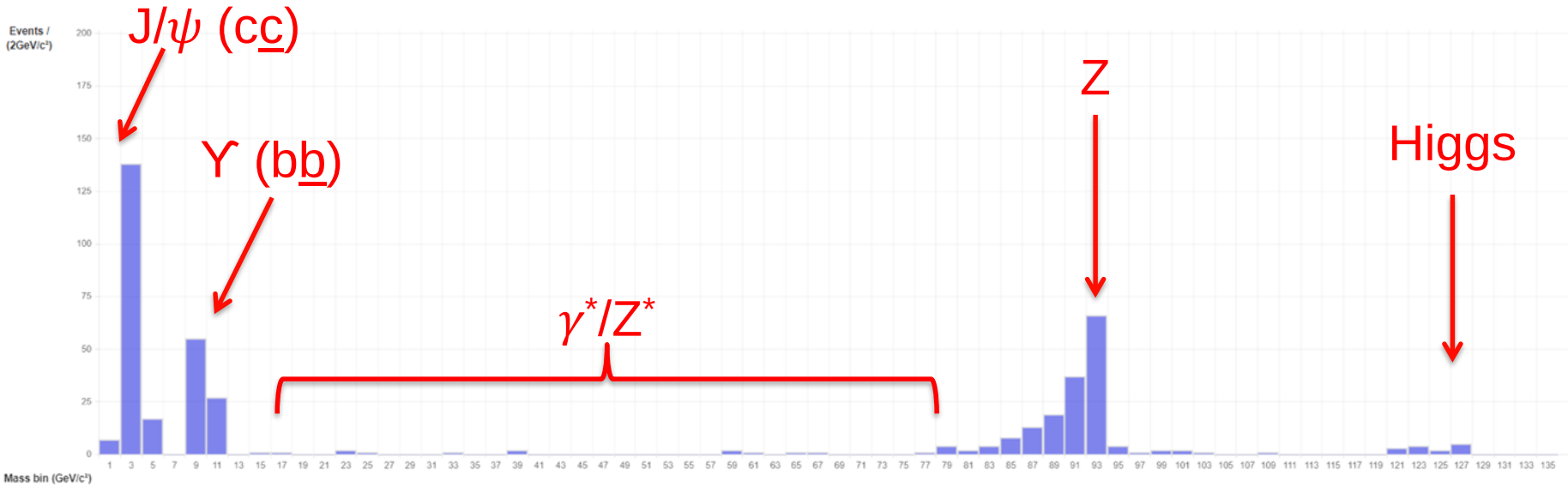
# 5) ¿Bosones de Higgs?

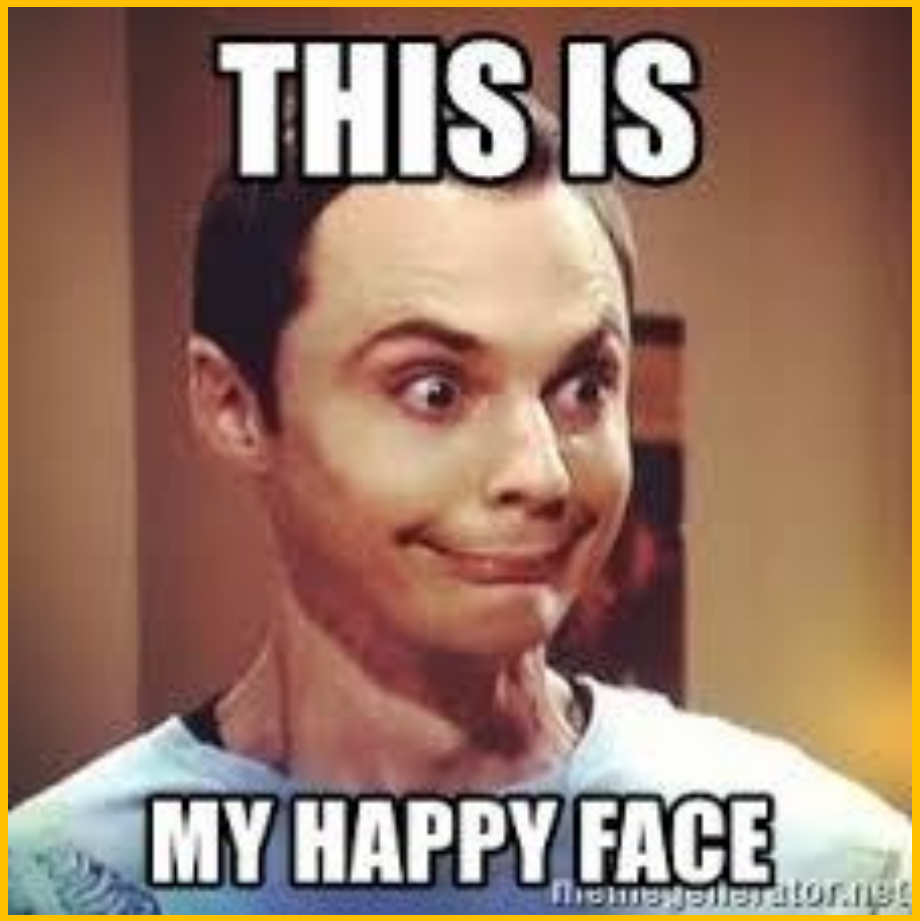







**Masa H ~ 125 GeV**






# ¡¡¡BUEN TRABAJO!!!

cfp

CIEMAT

física de partículas