



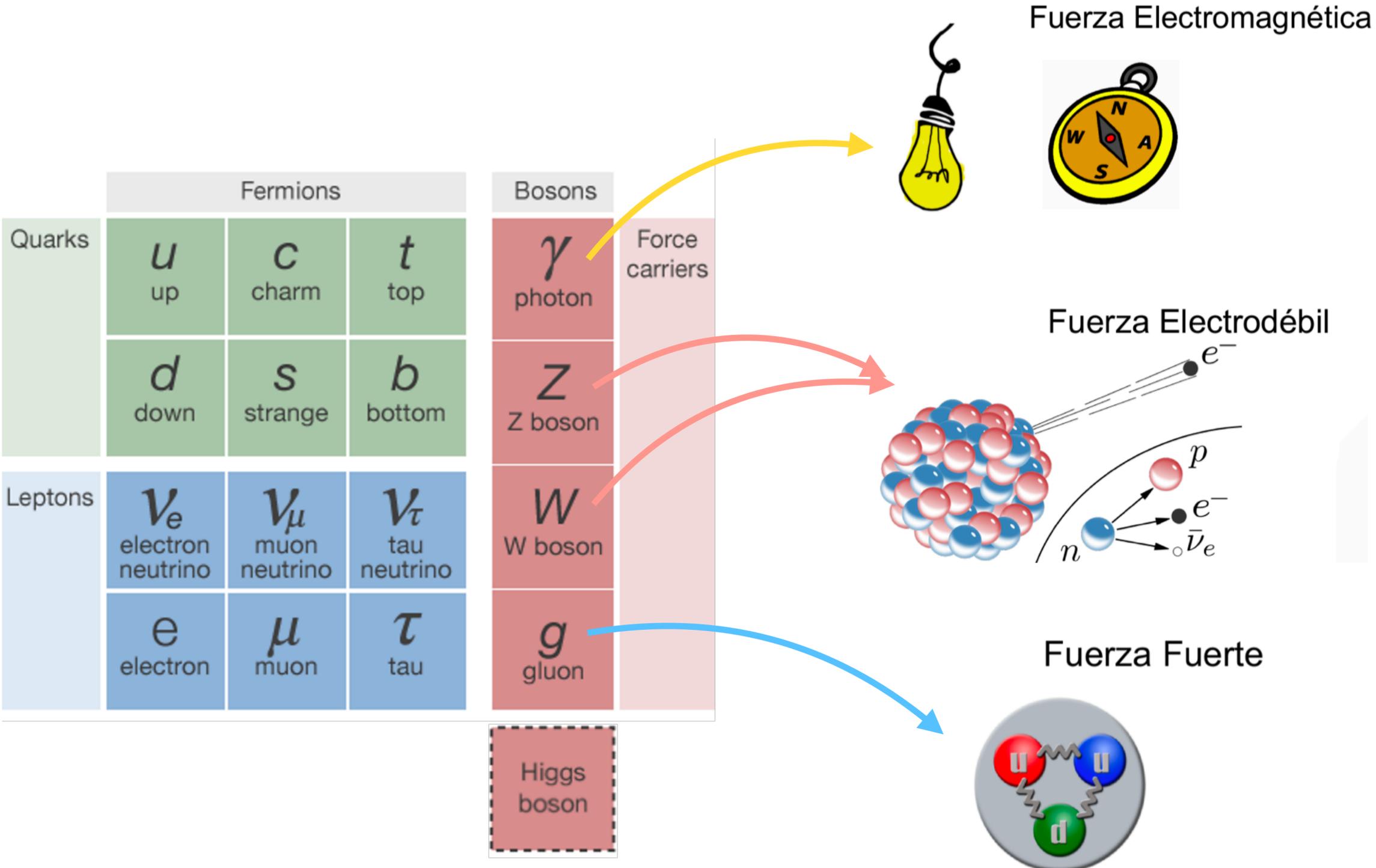
El recorrido del Z

Master Class IFIC

11 febrero 2022

Basado en transparencias de Clara Remón y Clara Murgui

El Modelo Estándar

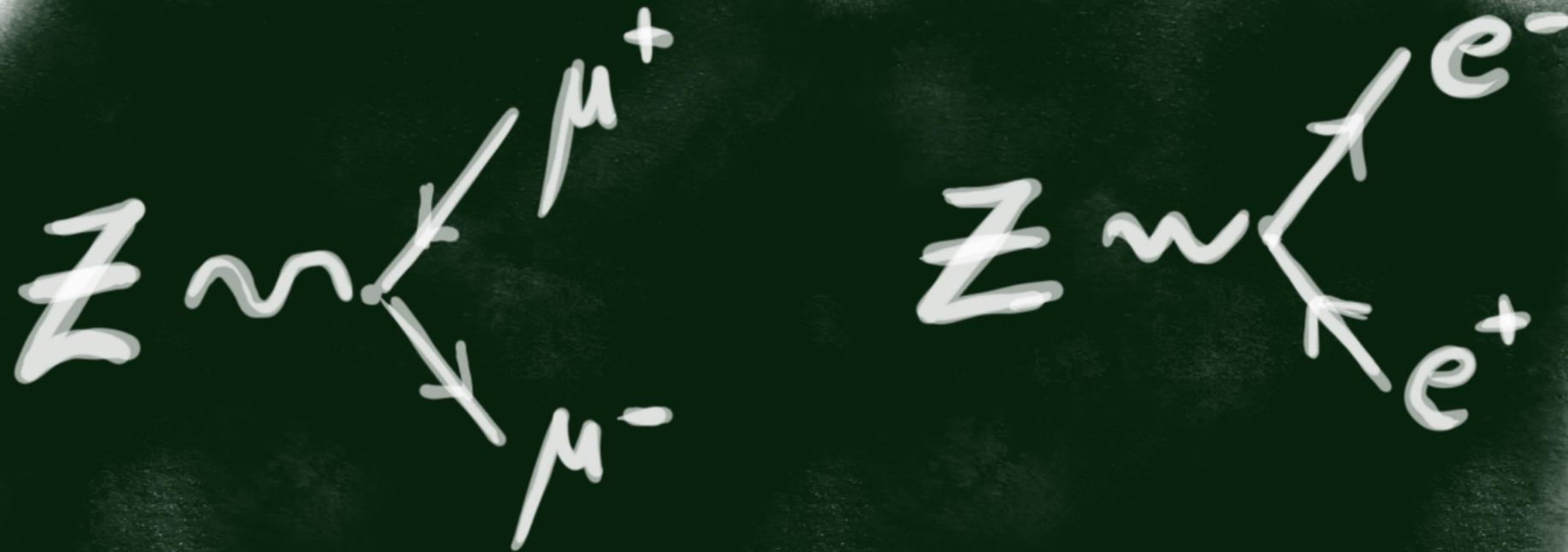


Nuestro Objetivo!

1. Re-descubrir el bosón Z

El bosón Z es una partículas inestable

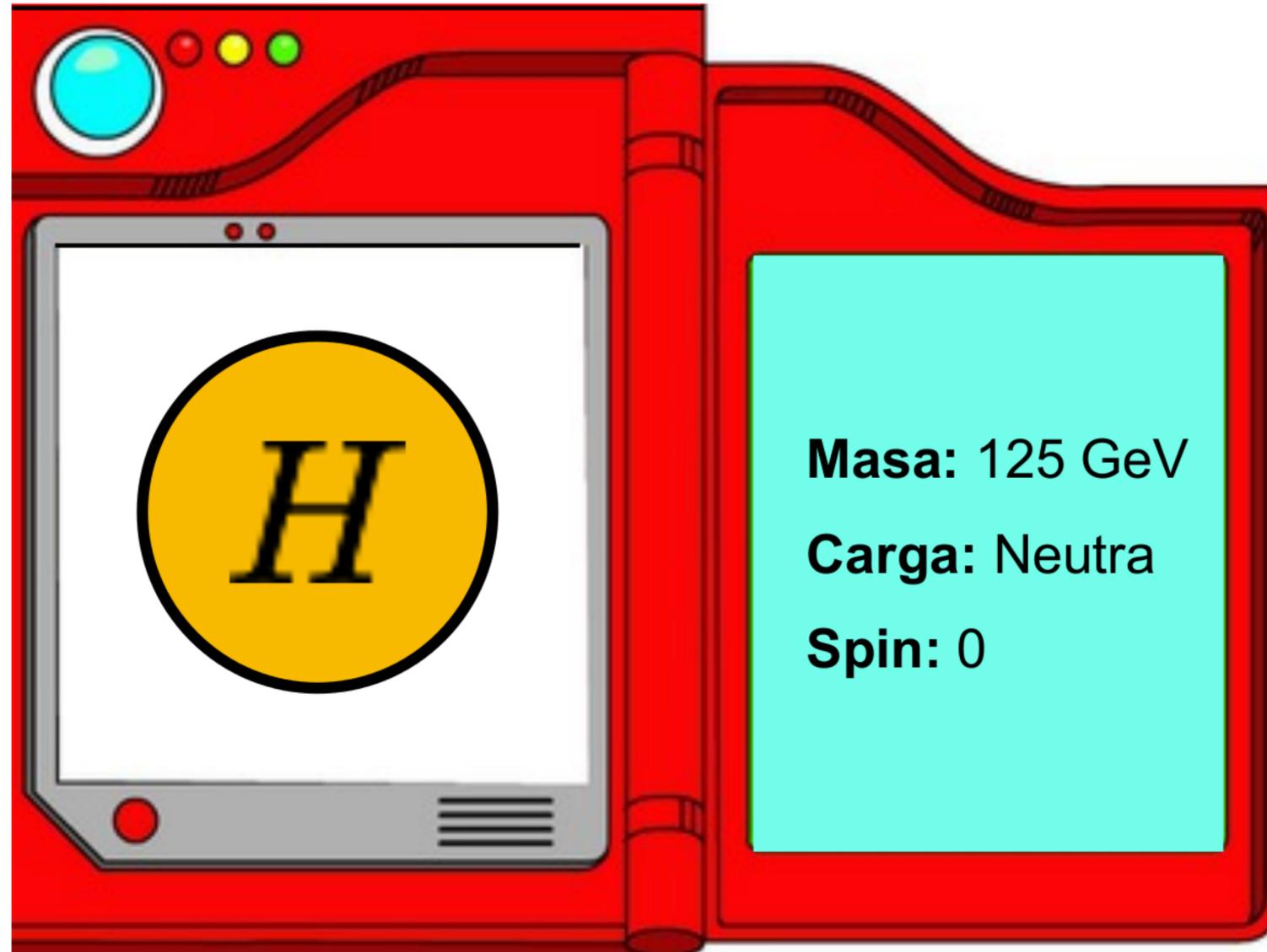
Detectamos sus productos de desintegración



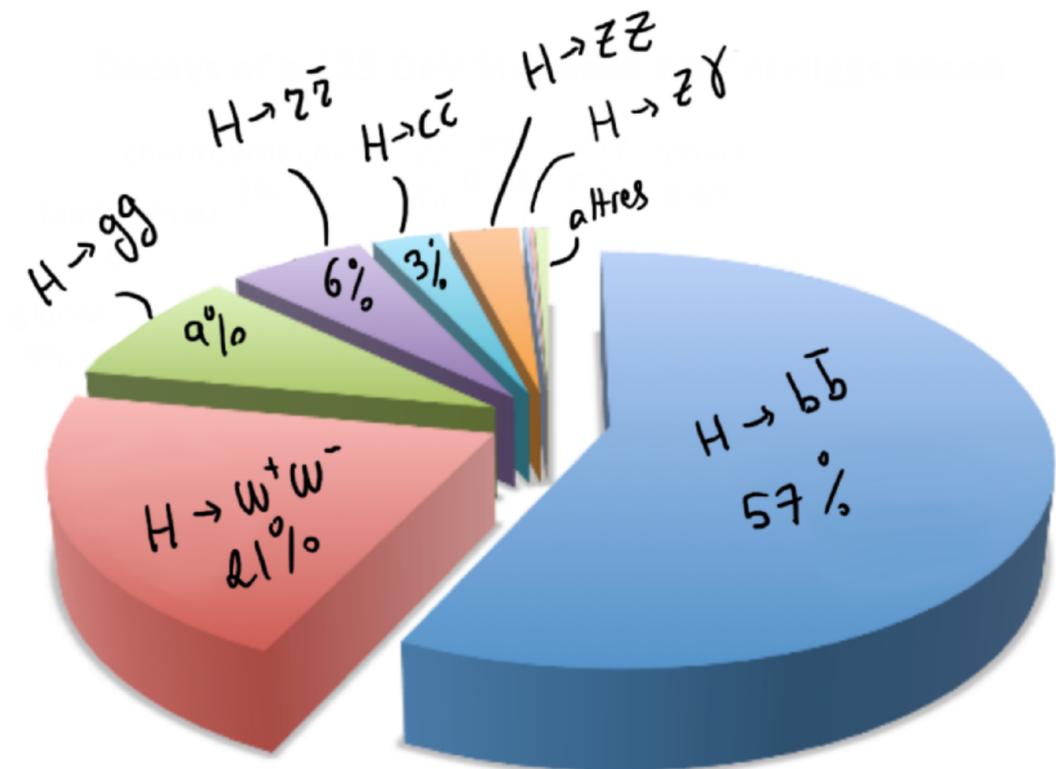
Nuestro Objetivo!

1. Re-descubrir el bosón Z
2. Buscar el boson de Higgs

El Bosón de Higgs

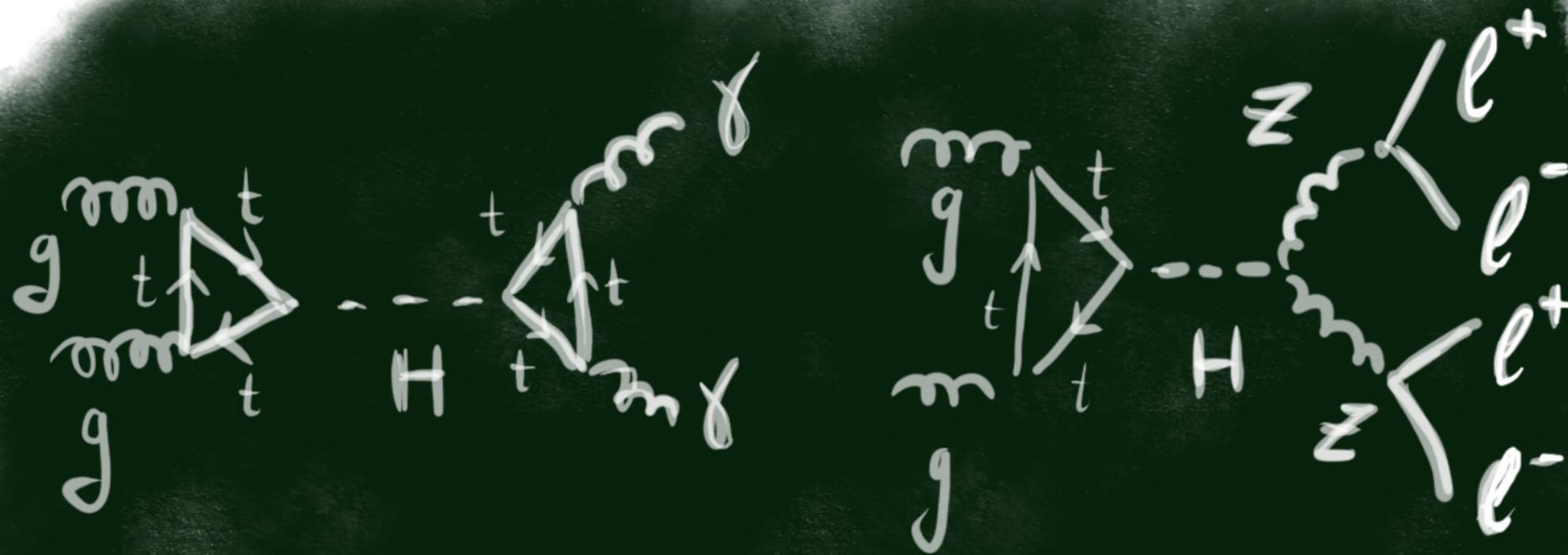


La partícula más joven
(y más esperada!)
4 Julio 2012



El bosón H también es una partículas inestable

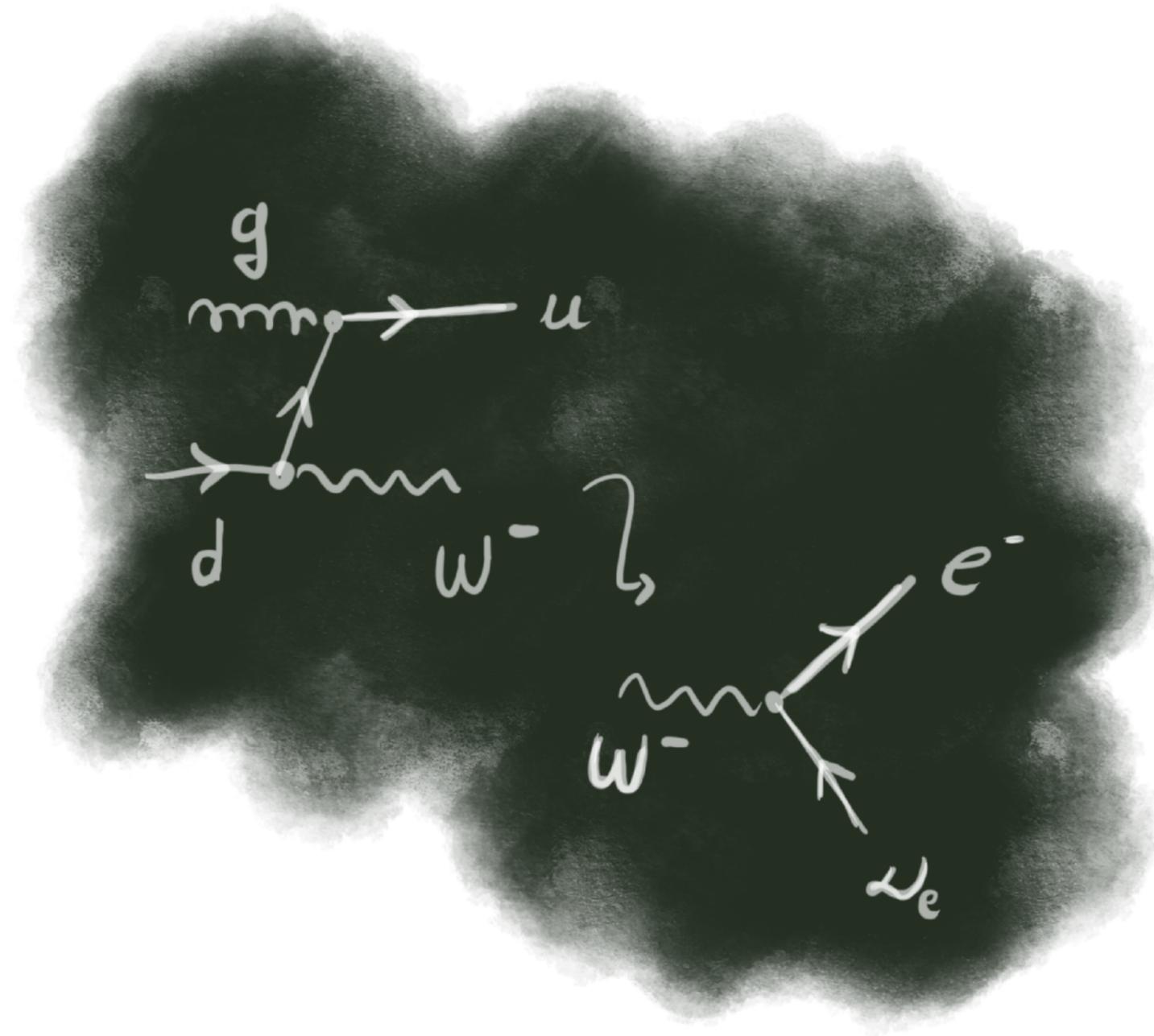
Detectamos sus productos de desintegración



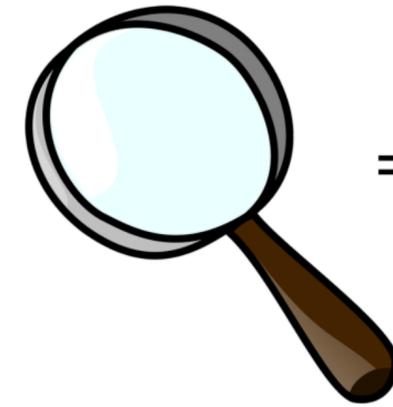
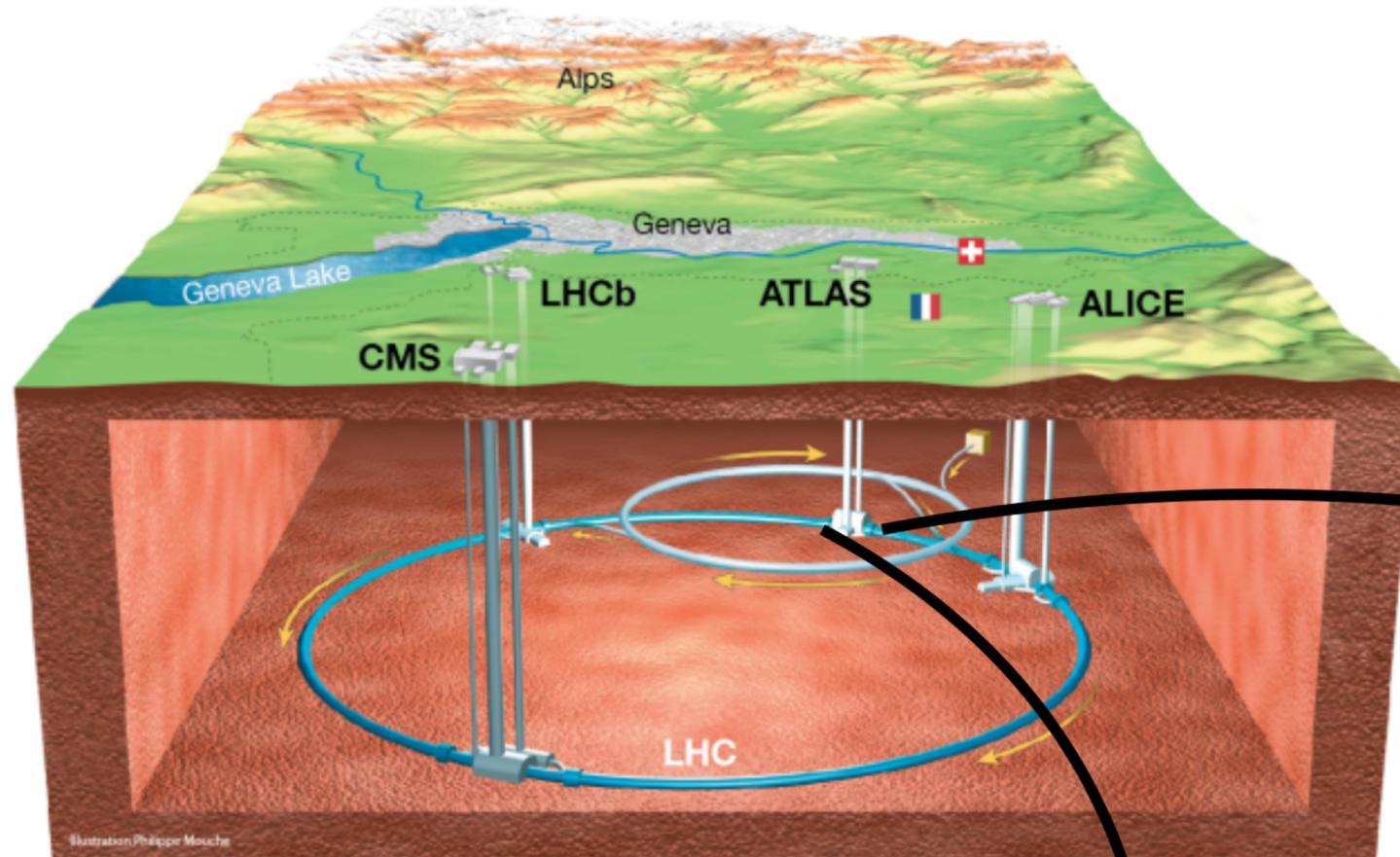
¿Qué más nos podemos encontrar?

“Background”

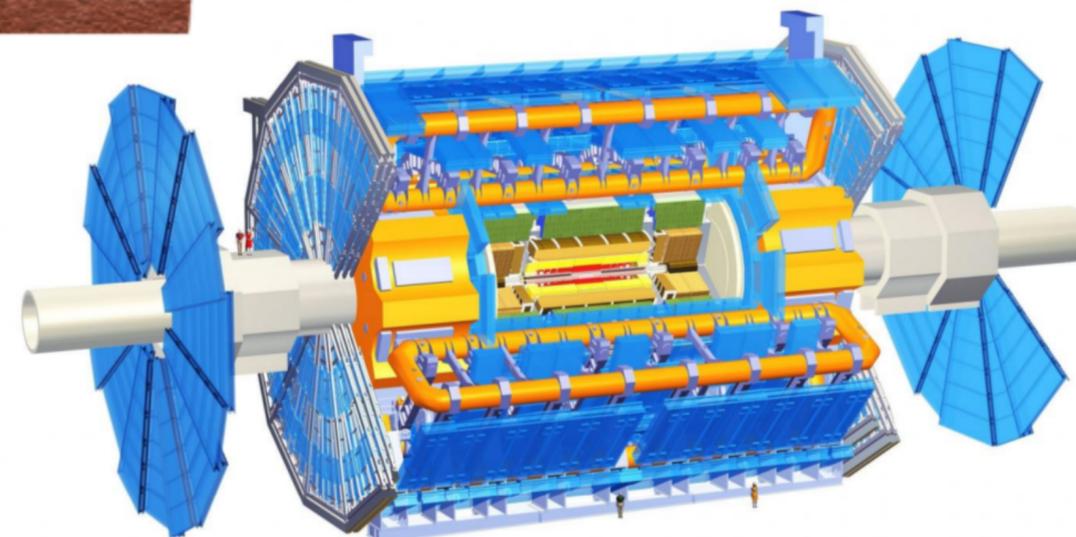
A parte de las partículas que queremos observar (Z y H),
otras partículas pueden aparecer en la colisión!



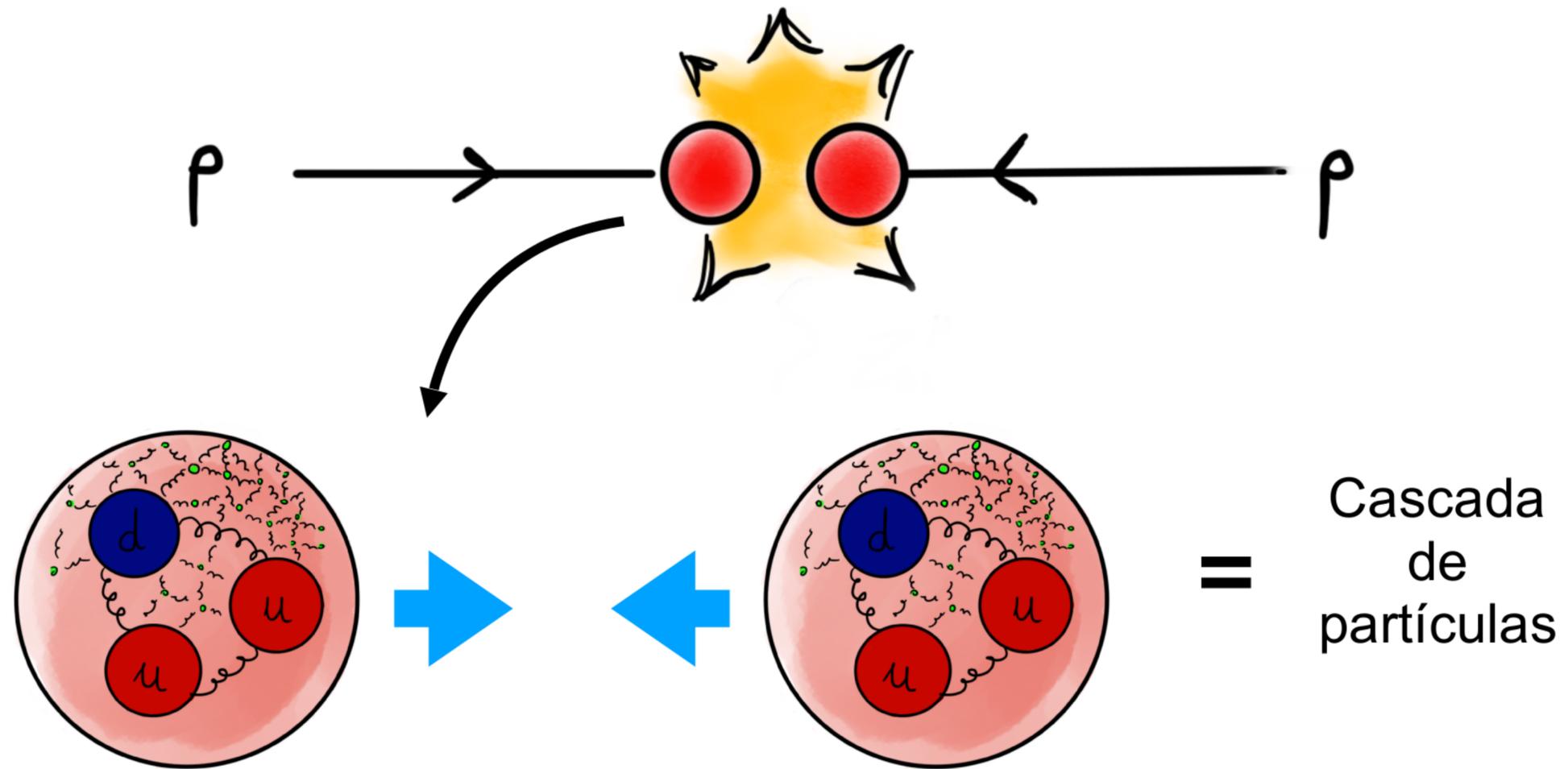
Cómo “ver”? Detectores



= Energía



Cómo “ver”? Detectores

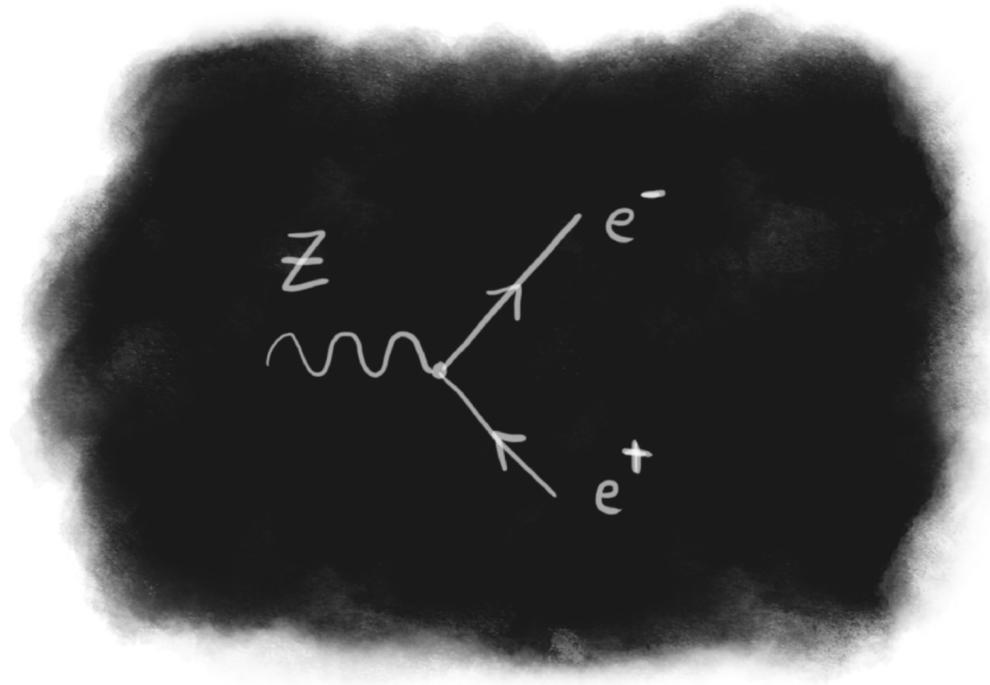
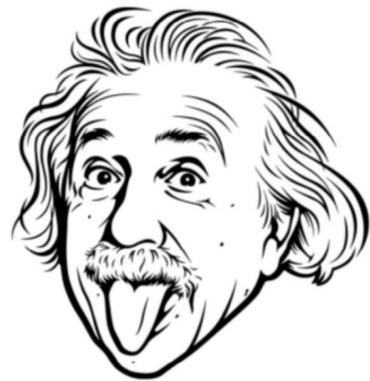


Energia inicial = Energia final

Masa Invariante

Energia inicial = Energia final

$$E = mc^2$$

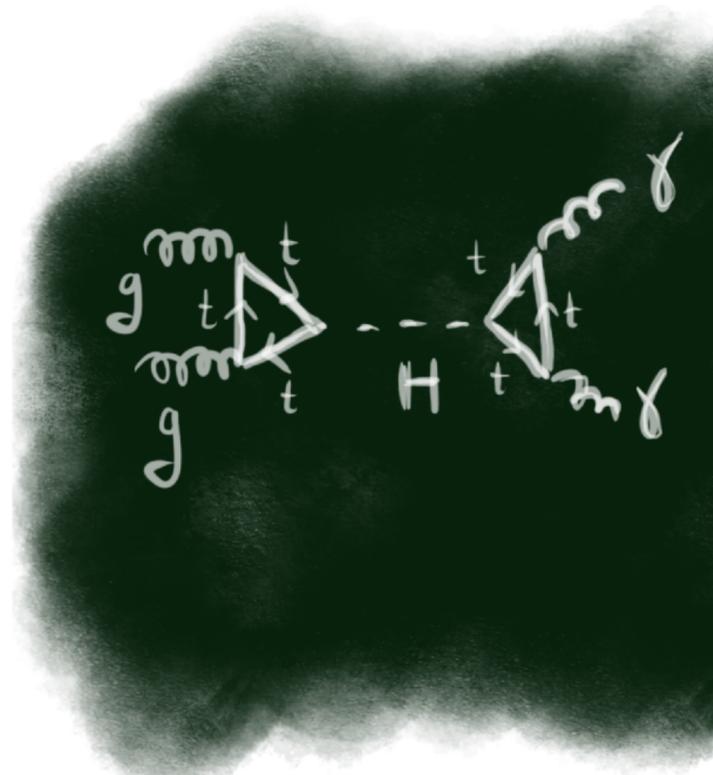
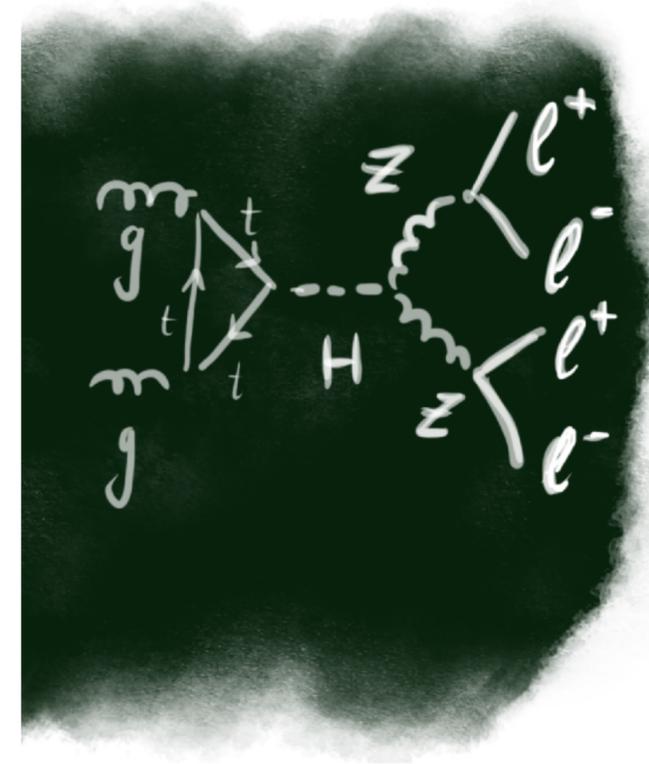


$$M_0^{(Z)} = \sqrt{\left(\frac{E_{e^-} + E_{e^+}}{c^2}\right)^2 - \left(\frac{p_{e^-}^{\vec{}} + p_{e^+}^{\vec{}}}{c}\right)^2}$$

Masa Invariante

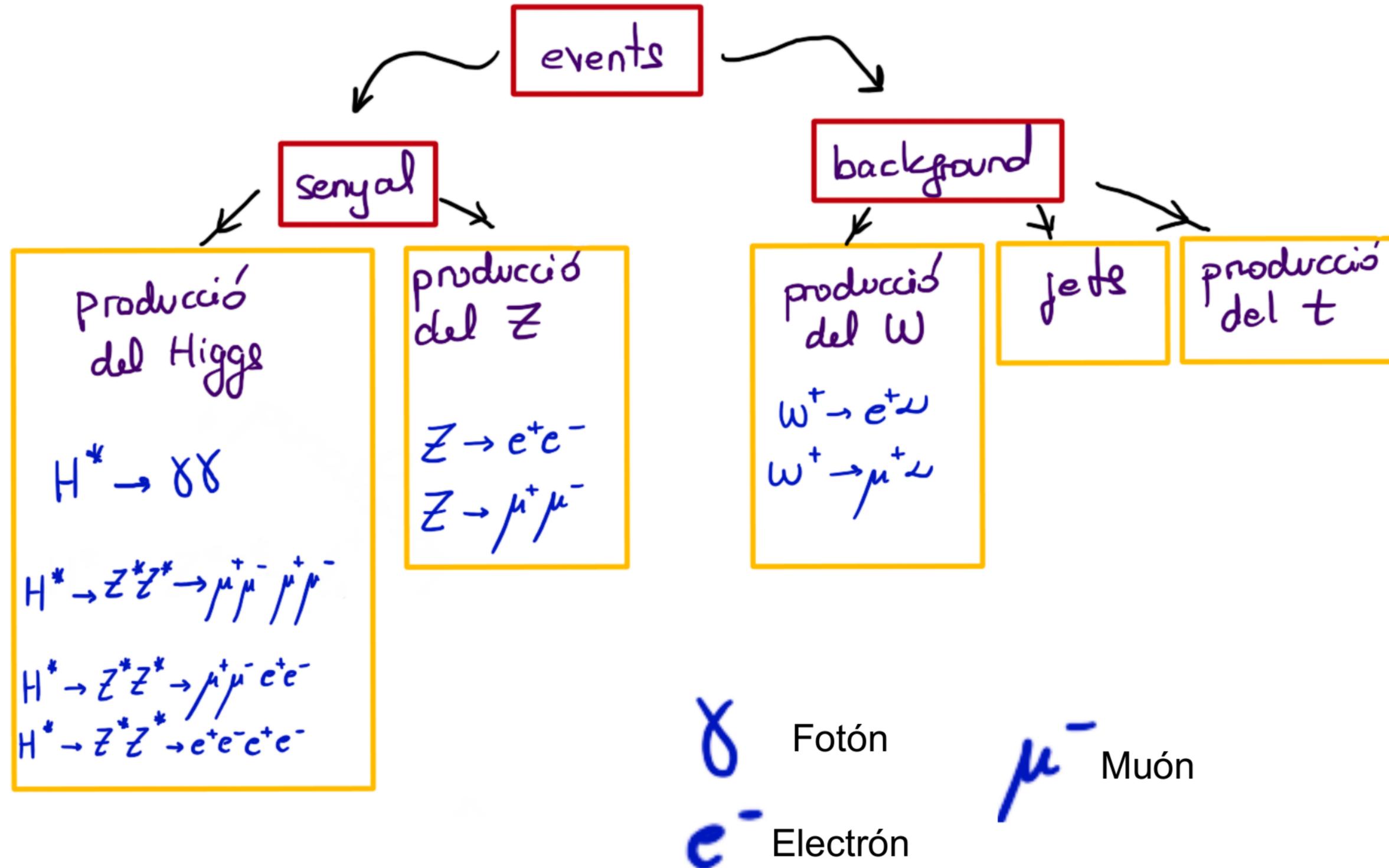
Energia inicial = Energia final

$$M_0^{(H)} = \sqrt{\left(\frac{E_\gamma + E_\gamma}{c^2}\right)^2 - \left(\frac{\vec{p}_\gamma + \vec{p}_\gamma}{c}\right)^2}$$

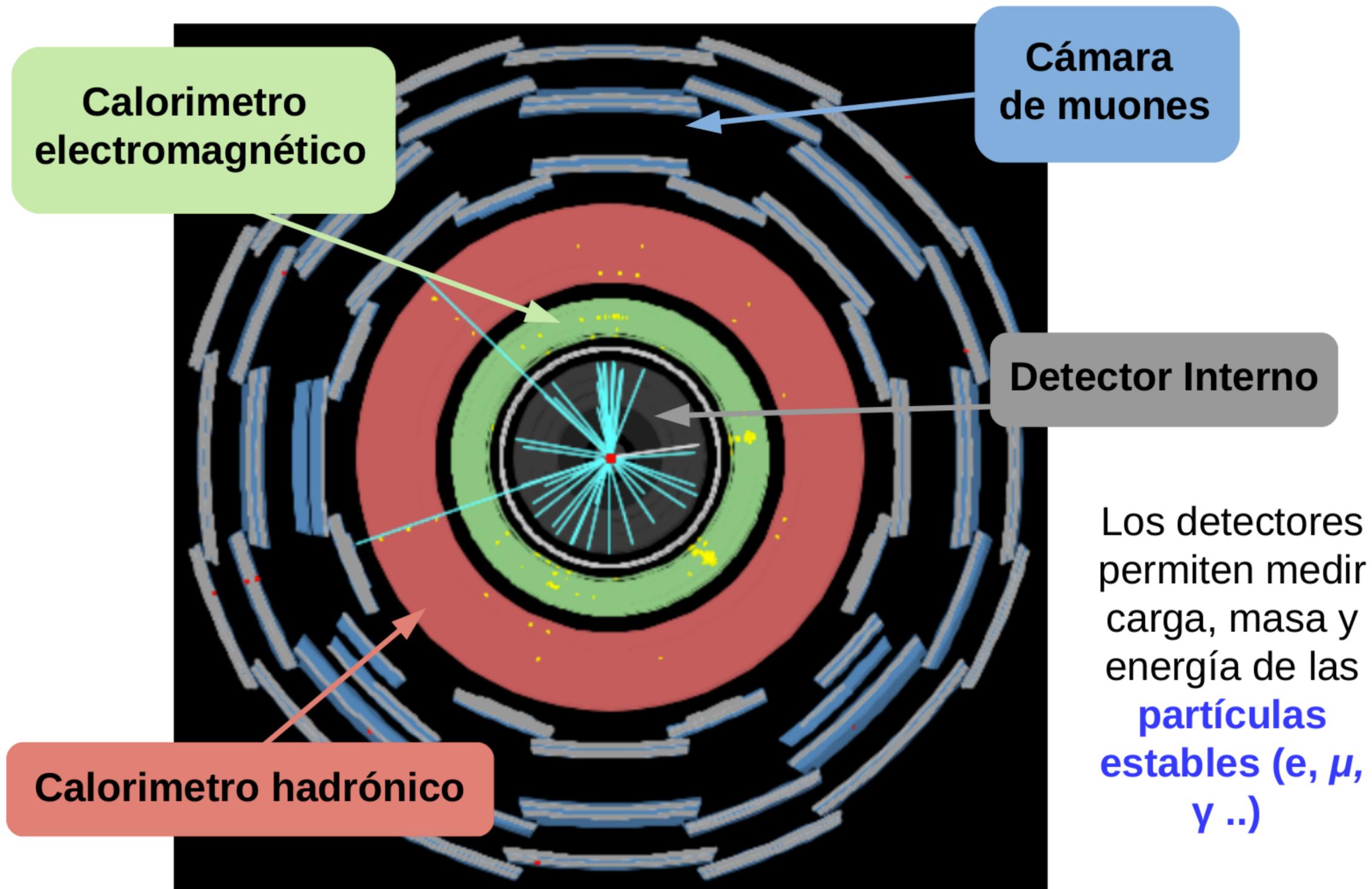


$$M_0^{(H)} = \sqrt{\left(\frac{E_{e_1^+} + E_{e_1^-} + E_{e_2^+} + E_{e_2^-}}{c^2}\right)^2 - \left(\frac{p_{e_1^+}^{\vec{}} + p_{e_1^-}^{\vec{}} + p_{e_2^+}^{\vec{}} + p_{e_2^-}^{\vec{}}}{c}\right)^2}$$

Clasificación de Eventos



Visualización en Hypatia del detector ATLAS

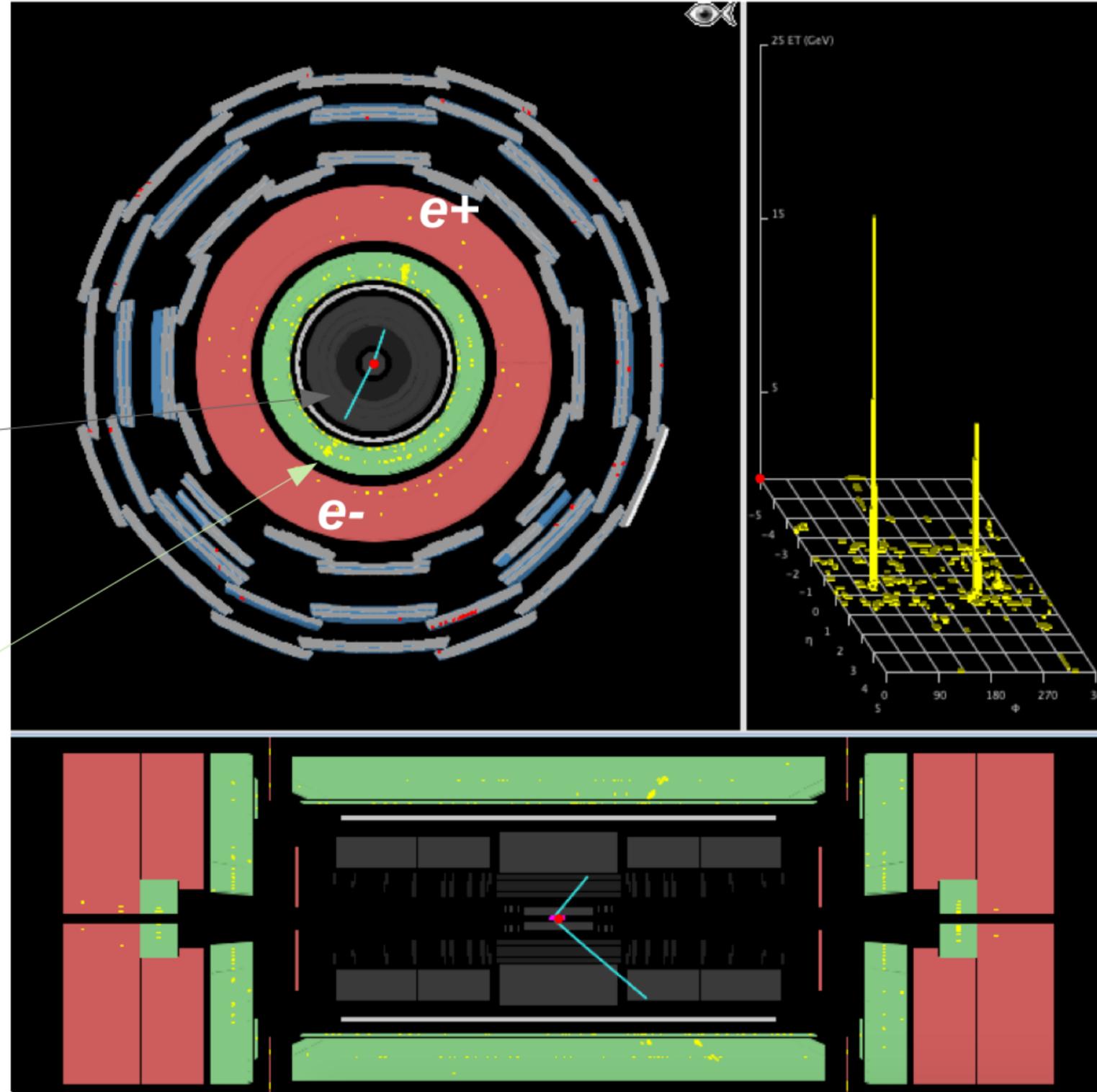


Identificando partículas: electrón e^-

El electrón es una partícula **ligera** y **cargada** que deja señal en:

Detector Interno

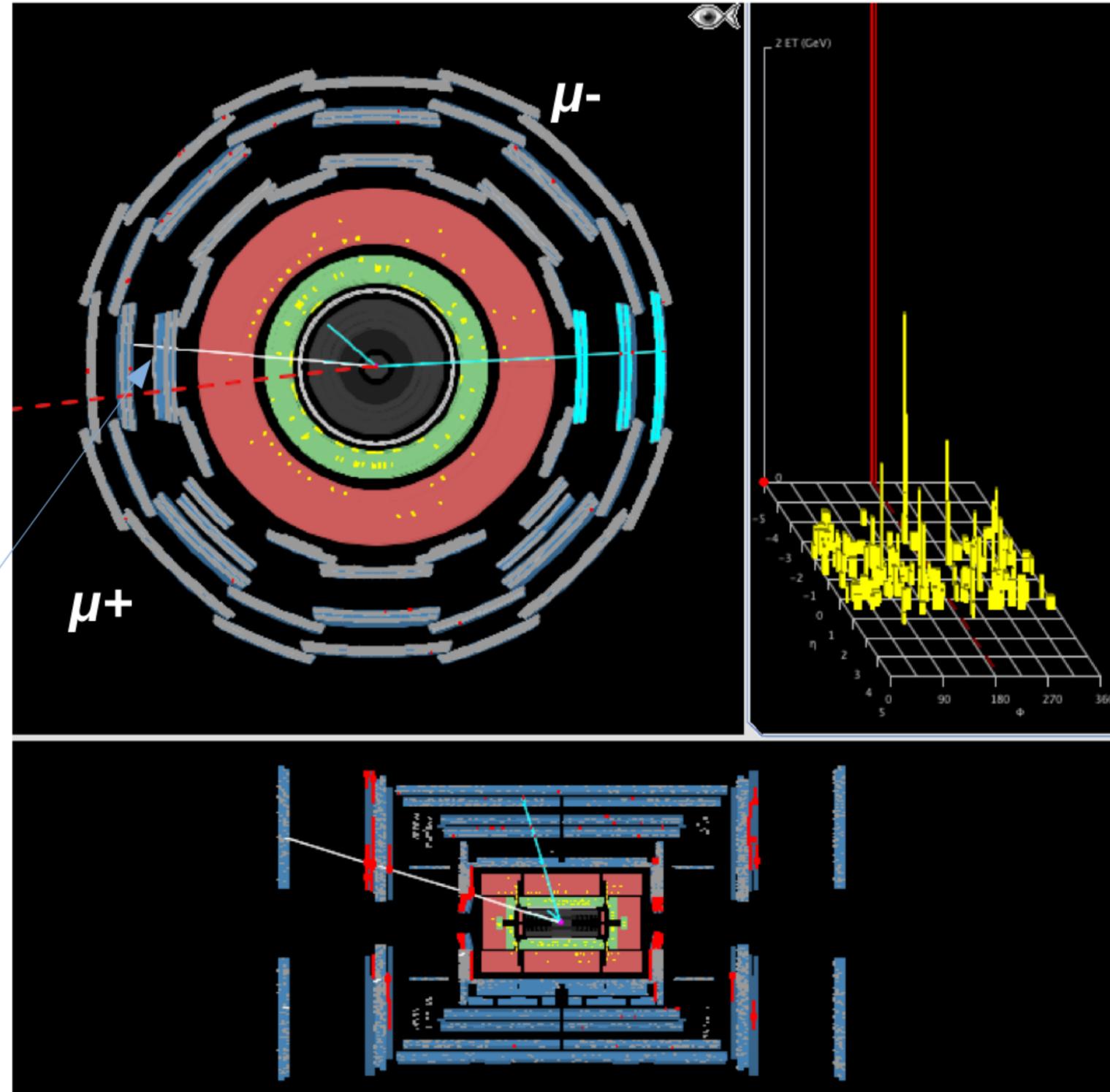
Cal. Electromagnético



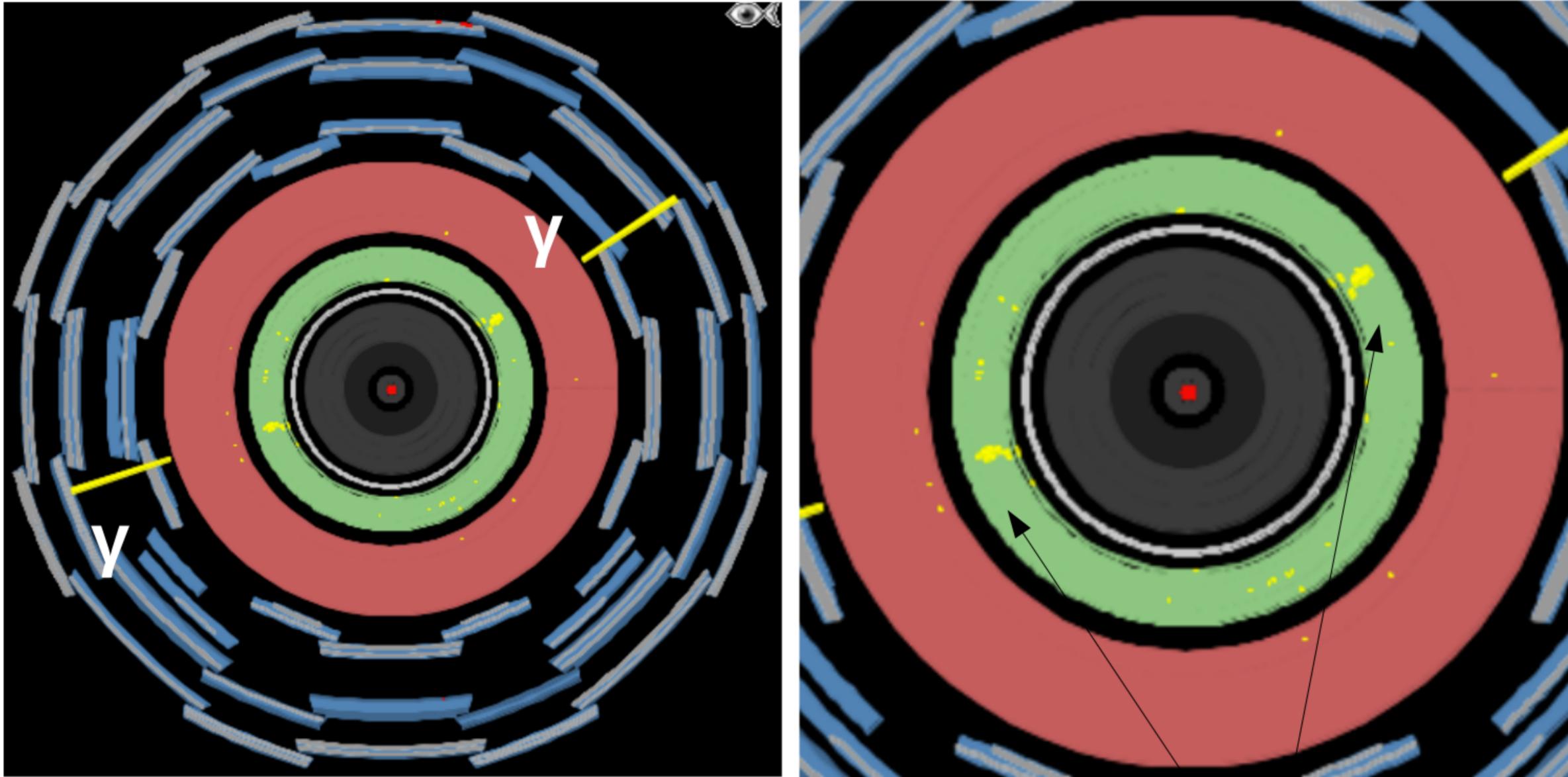
Identificando partículas: muón μ^-

Señal característica de un muón \rightarrow traza que recorre todo el detector dejando señal las cámaras de muones

Cámaras de muones



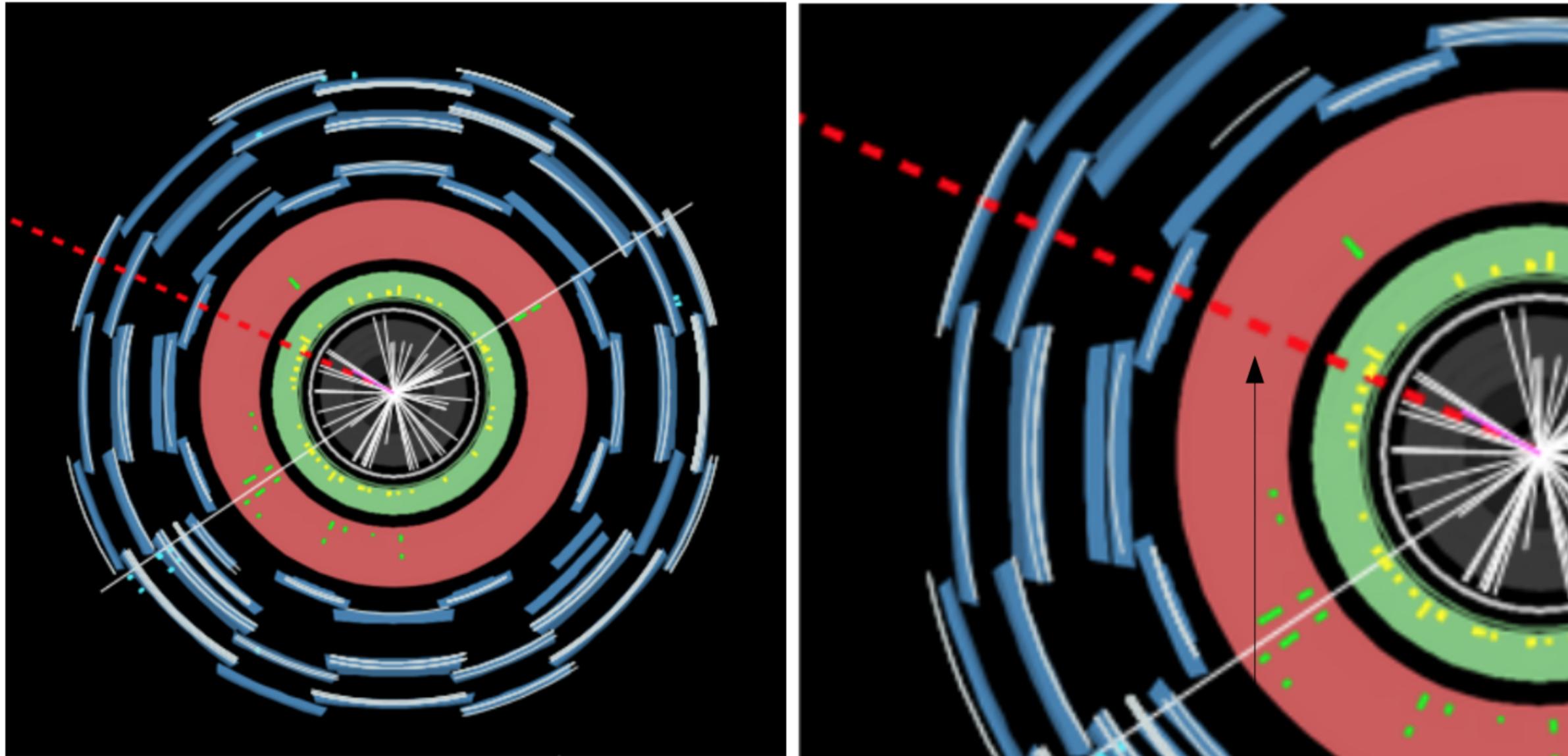
Identificando partículas: **fotón γ**



El fotón es una partícula **neutra** que no deja señal en el detector interno pero sí en:

Calorimetro Electromagnético

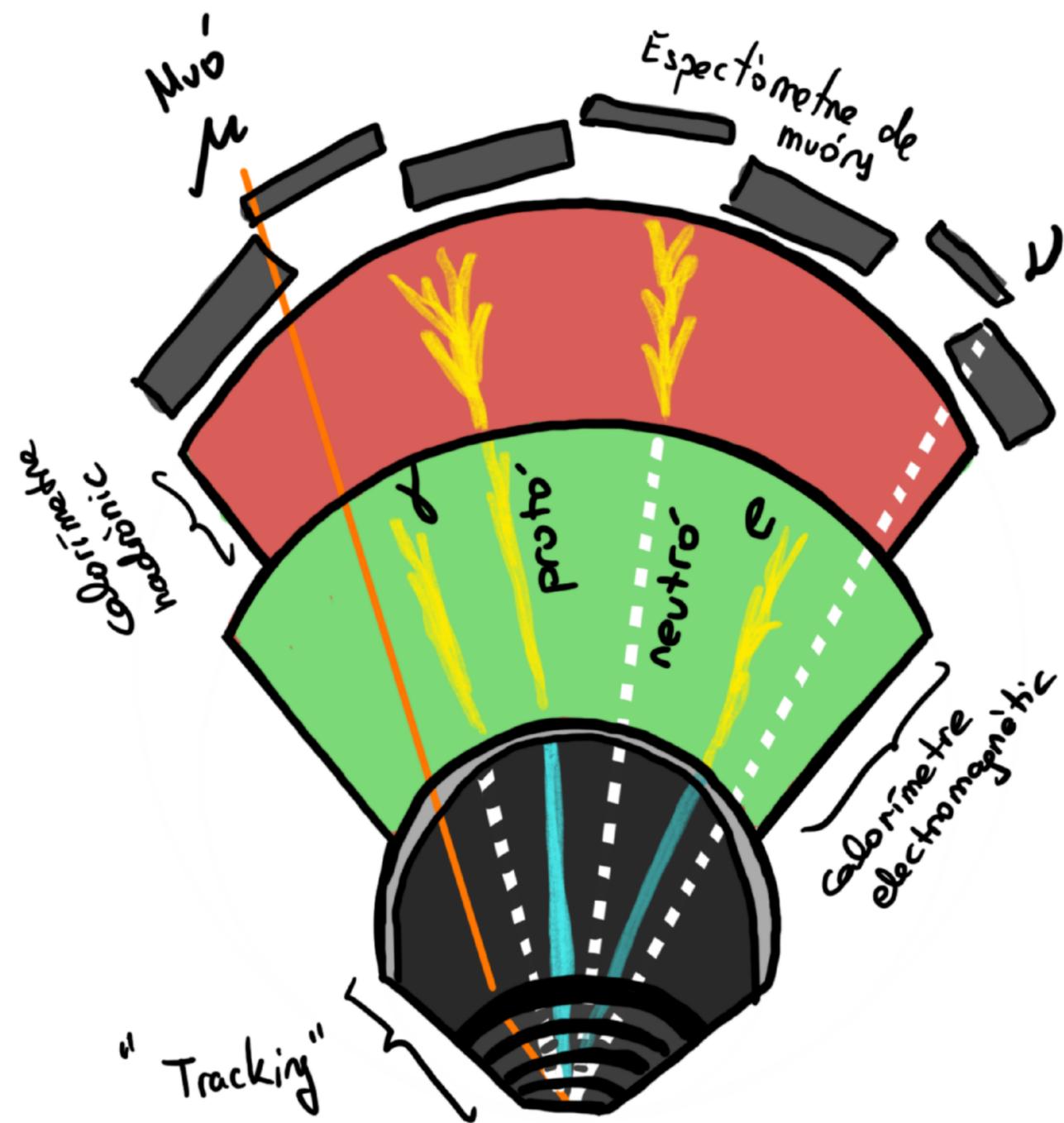
Identificando partículas: neutrino ν



El neutrino es una partícula **neutra** y sin masa que no deja señal en el detector:

Energia Faltante

Señales en el detector



Encontrando los eventos $Z^0 \rightarrow e^- e^+$, $Z^0 \rightarrow \mu^- \mu^+$ y
 $H \rightarrow Z^0 Z^0$, $H \rightarrow \gamma \gamma$

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

- Top Table:** A table listing event files and their parameters.

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	ϕ	η	M(2) [GeV]	M(eeee) [GeV]	M(eemm) [GeV]	M(mmmm) [...]	e/m/g
groupB/event035.xml	70,331	Tracks 4	65,2	+	45,7	-2,086	0,894					m
		Object 0	44,6		40,2	-1,482	0,464	135,619				g
		Object 1	162,9		29,3							g
groupB/event009.xml	30,821	Tracks 2	155,8	+	37,9	0						e
- Physics Objects Table:** A table showing track details for two tracks.

Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 29	-	5,04	33,41	-2,067	0,714
Tracks 330	+	6,06	54,32	1,250	0,905
- Parameter Control Panel:** A panel with tabs for 'Projection', 'Data', 'Cuts', 'InDet', 'Calo', 'MuonDet', 'Objects', and 'Geometry'. Under the 'Cuts' tab, a table shows cut values:

Name	Value
Pt	20.0 GeV
Pt2	< 700.0 MeV
d0	< 2.5 mm
z0	< 20.0 cm

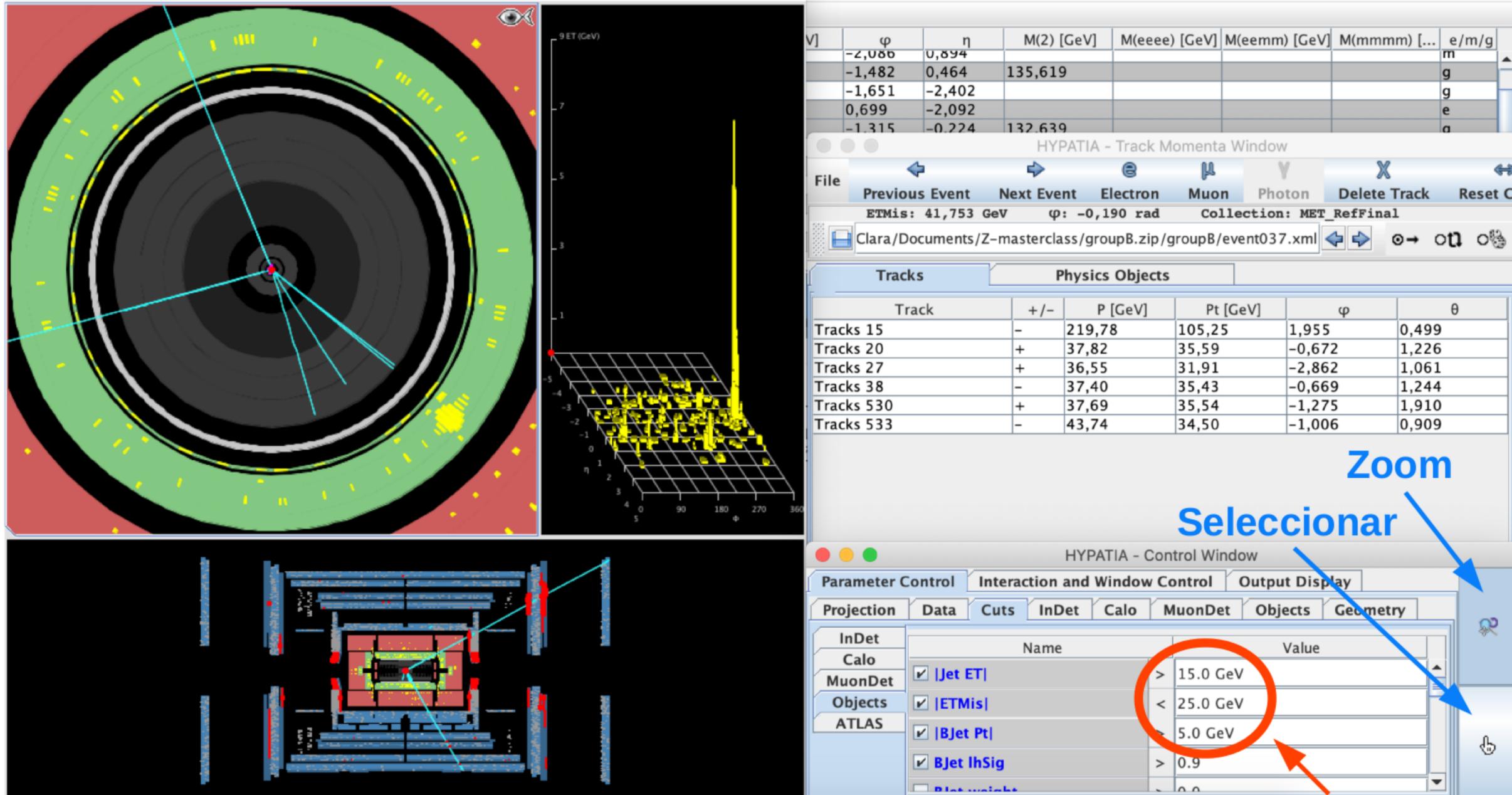
2l con cargas opuestas

Configuración inicial poner: > 10 GeV

Cortes en momento (Pt)

Encontrando los eventos $Z^0 \rightarrow e^- e^+$, $Z^0 \rightarrow \mu^- \mu^+$ y

$H \rightarrow Z^0 Z^0$, $H \rightarrow \gamma \gamma$



Cortes en energia faltante (ETmis)

Seleccionar los eventos $Z^0 \rightarrow e^- e^+$, $Z^0 \rightarrow \mu^- \mu^+$ y
 $H \rightarrow Z^0 Z^0$, $H \rightarrow \gamma \gamma$

Siguiente evento

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	φ	η	M(2) [GeV]	M(eeee) [GeV]	M(eemm) [GeV]	M(mmmm) [...]	e/m/g
groupB/event008.xml	20,271	Object 0	45,8		44,7	-1,315	-0,224	132,639				g
		Object 1	125,6		41,2	1,823	1,780					g
groupB/event036.xml	12,159	Tracks 29	51,0	-	33,4	-2,067	0,987	85,634				e
		Tracks 330	69,1	+	54,3	1,250	0,721					e

Guardar las partículas

Track	+/-	P [GeV]	Pt [GeV]	φ	θ
Tracks 29	-	51,04	33,41	-2,067	0,714
Tracks 330	+	69,06	54,32	1,250	0,905

Projection	Name	Value
InDet		
Calo		
MuonDet	<input checked="" type="checkbox"/> Pt	> 20.0 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	< 2.0 mm

Seleccionar los eventos $Z^0 \rightarrow e^- e^+$, $Z^0 \rightarrow \mu^- \mu^+$ y

$H \rightarrow Z^0 Z^0$, $H \rightarrow \gamma \gamma$

The screenshot displays the HYPATIA software interface with several windows:

- Canvas Window:** Shows a top-down view of the ATLAS detector with tracks and energy deposits. A yellow track is highlighted.
- 3D Plot:** A 3D plot of energy deposits (yellow points) with two vertical yellow lines indicating track positions.
- Invariant Mass Window:** A table showing invariant masses for different particle combinations.
- Track Momenta Window:** A window for selecting physical objects, with an arrow pointing to the 'Physics Objects' tab.
- Projection Window:** A window for setting cuts on various detector components.

Invariant Mass Window Table:

V	φ	η	M(2) [GeV]	M(eeee) [GeV]	M(eemm) [GeV]	M(mmmm) [...]	e/m/g
-2,067	0,987		85,634				e
1,250	0,721						e
0,077	-0,300		85,444				m
3,042	-1,846						m

Track Momenta Window Table:

Track	P [GeV]	Pt [GeV]	φ	θ
Object 0	59,63	57,06	-1,360	1,865
Object 1	61,25	50,19	2,140	0,960

Projection Window Cuts:

Component	Name	Value
InDet		
Calo		
MuonDet	<input checked="" type="checkbox"/> Pt	> 10.0 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 level	< 2.0 mm

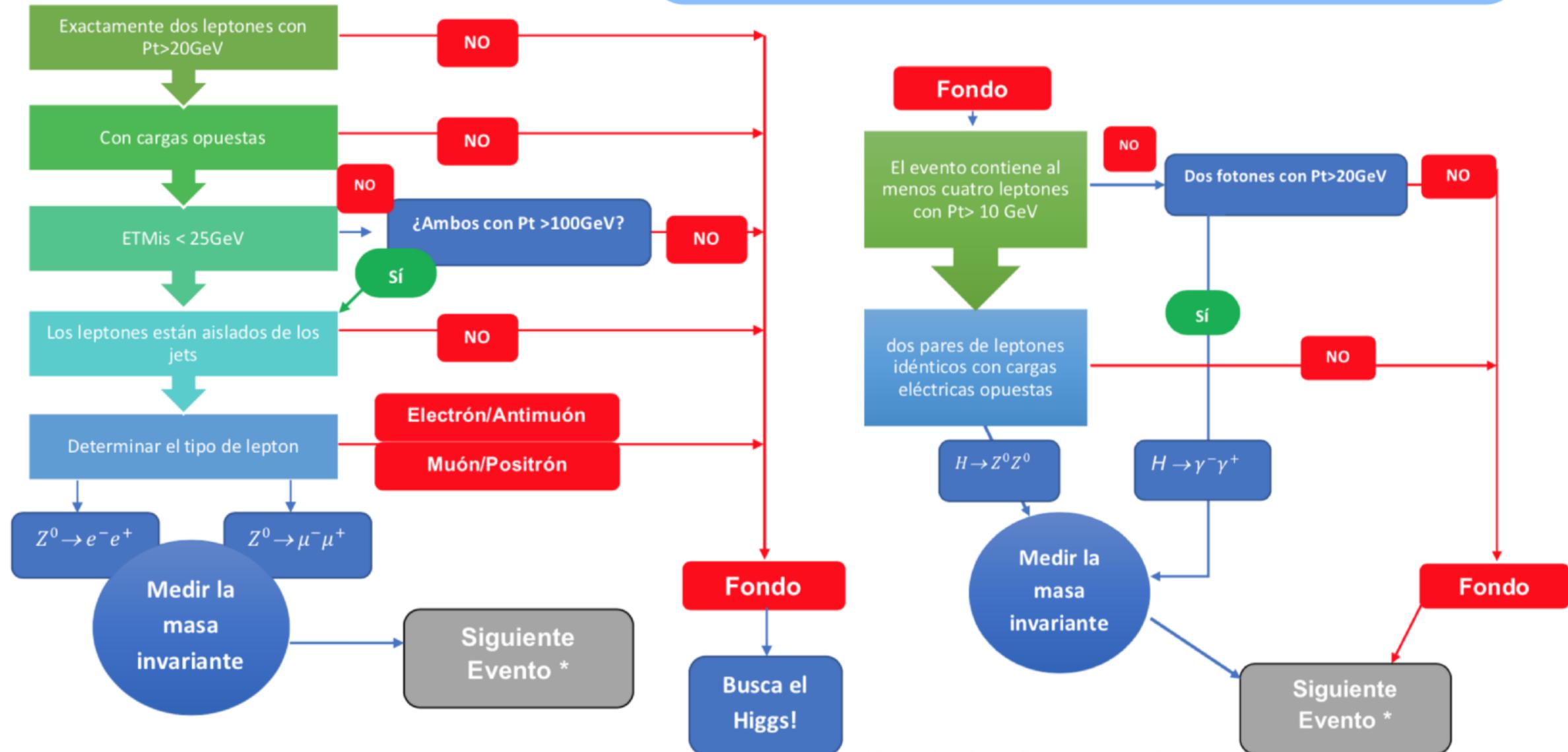
Text Overlay: Visualizar los fotones: click Physical Objects !!

A buscar Z^0 y Higgs! $Z^0 \rightarrow e^- e^+$, $Z^0 \rightarrow \mu^- \mu^+$,

$$H \rightarrow \gamma\gamma \quad y \quad H \rightarrow Z^0 Z^0$$

Con datos REALES de ATLAS!!

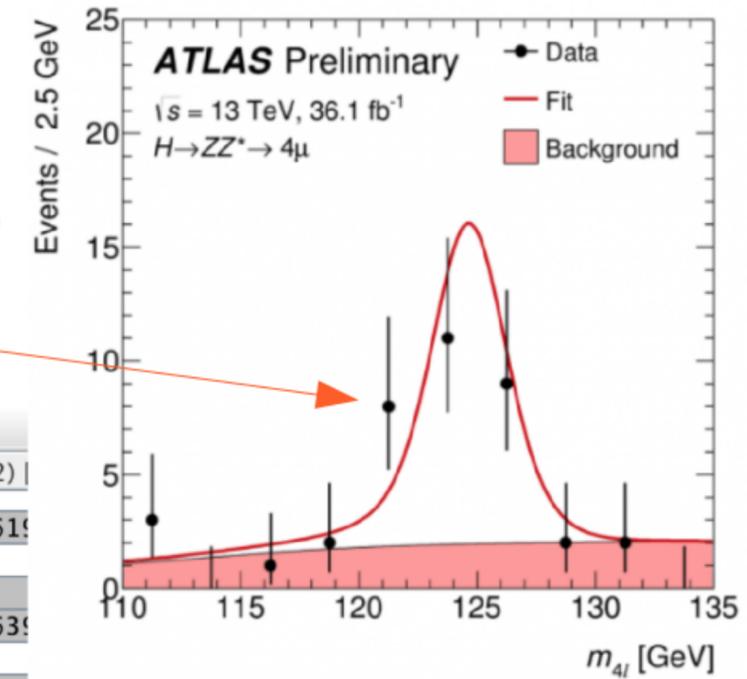
- 1º Pt > 10 GeV
- 2º Cuantos leptones (e, μ) podemos observar?
- 3º Hay 2 leptones: posible Z (seguir camino 1)
- 4º Hay 4 leptones: posible H (seguir camino 2)
- 5º Si no hay leptones: Hay 2 fotones? **Physics Objects**
- 6º Si hay dos fotones tienes un H. Si no es fondo!



* Recuerde volver aplicar los cortes en Pt.

Histograma de masa invariante

El detector no es perfecto, cada desintegración que observamos no tiene exactamente la misma masa : *distribución de masa*



File View Histograms Preferences Help

- M(1) Histogram
- M(2) Histogram
- M(III) Histogram
- M(ee) Histogram
- M(mm) Histogram
- M(gg) Histogram
- M(eeee) Histogram
- M(eemm) Histogram
- M(mmmm) Histogram
- ETMis Histogram
- P Histogram
- Pt Histogram
- ϕ Histogram
- $\cot \theta$ Histogram
- η Histogram

ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	ϕ	η	M(2)
70,331	Tracks 4	65,2	+	45,7	-2,086	0,894	
	Object 0	44,6		40,2	-1,482	0,464	135,619
	Object 1	162,9		29,3	-1,651	-2,402	
30,821	Tracks 2	155,8	+	37,9	0,699	-2,092	
20,271	Object 0	45,8		44,7	-1,315	-0,224	132,639
	Object 1	125,6		41,2	1,823	1,780	
12,159	Tracks 29	51,0	-	33,4	-2,067	0,987	85,634
	Tracks 330	69,1	+	54,3	1,250	0,721	
25,033	Tracks 34	36,1	+	34,5	0,077	-0,300	85,441
	Tracks 1	99,8	-	30,8	3,042	-1,846	
29,281	Object 0	59,6		57,1	-1,360	-0,299	117,830
	Object 1	61,3		50,2	2,140	0,652	

Track	P [GeV]	Pt [GeV]	ϕ	θ
Object 0	59,63	57,06	-1,360	1,865
	61,25	50,19	2,140	0,960

HYPATIA - Histogram

M(gg) [GeV]

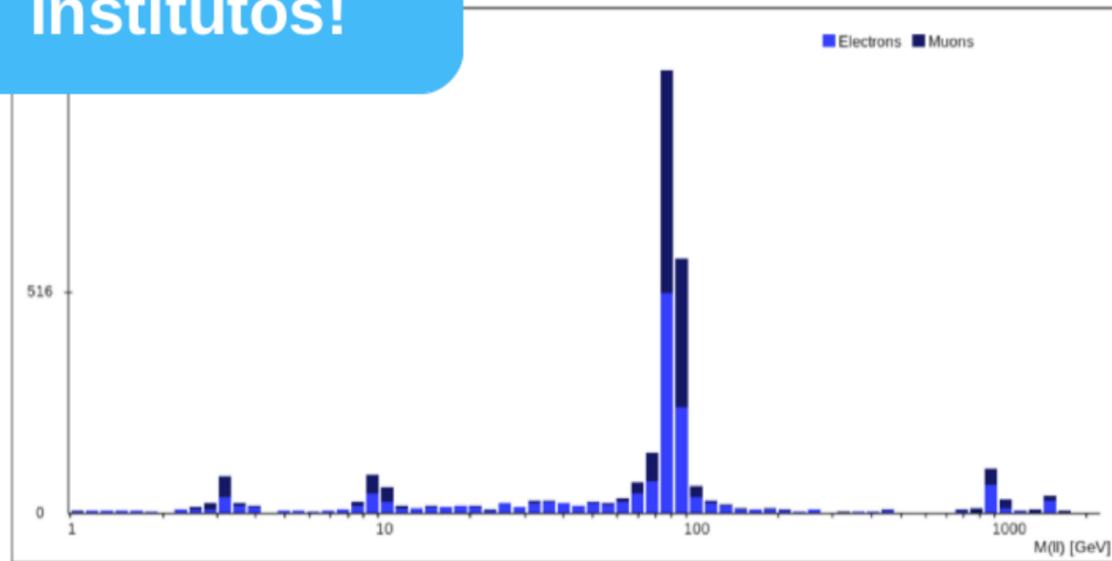
Entries : 3
Mean : 128.69
Rms : 7.7792

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 > 2.5 mm	> 2.5 mm

Descubriendo el H y Z^0 (necesitamos más estadística!)

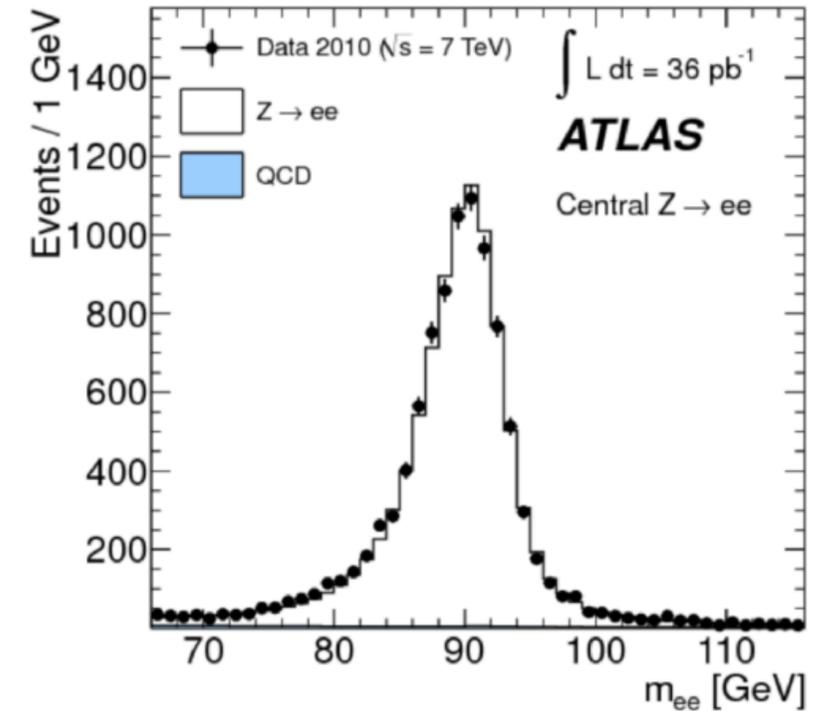
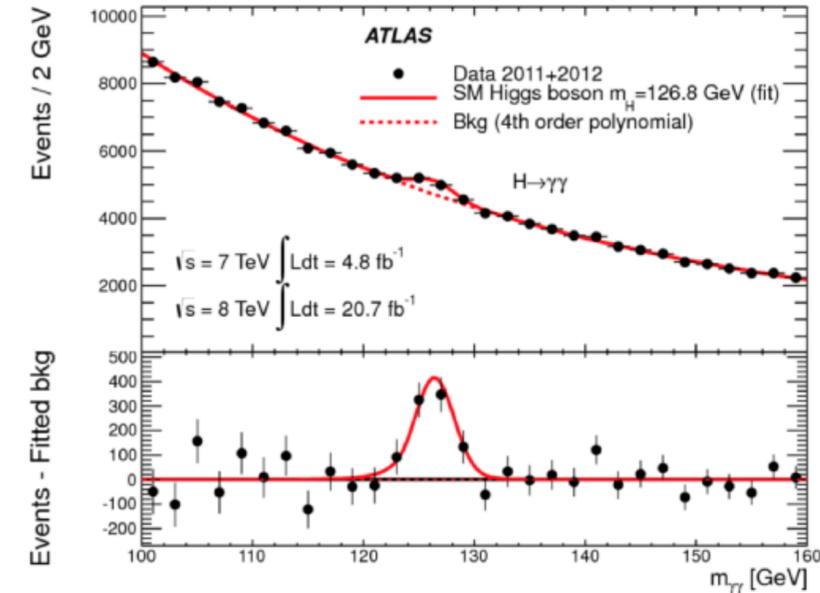
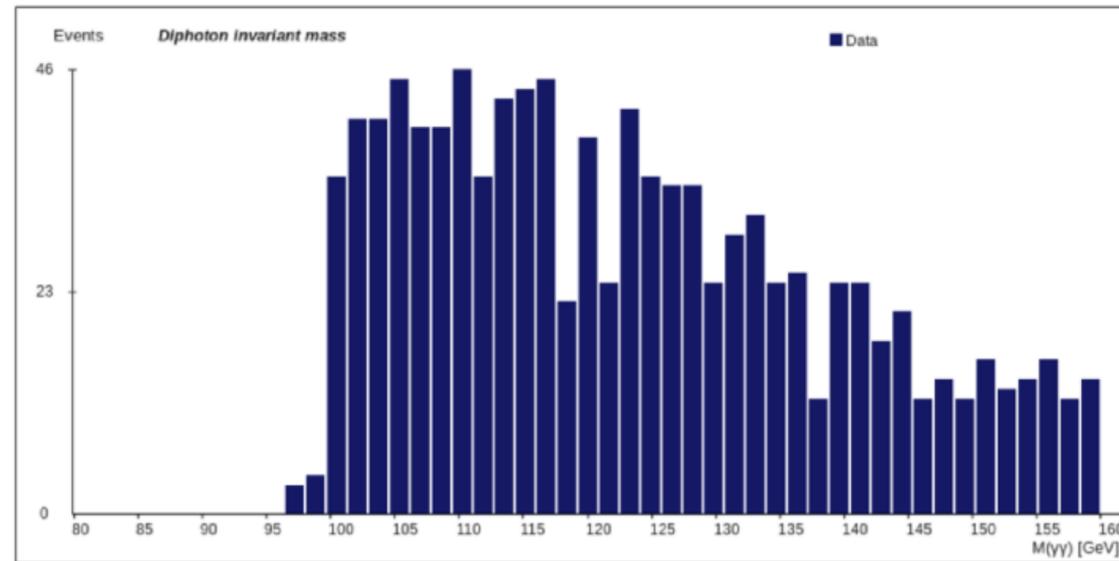
Combinamos todos los institutos!

Combination for all institutes on 2016-03-09



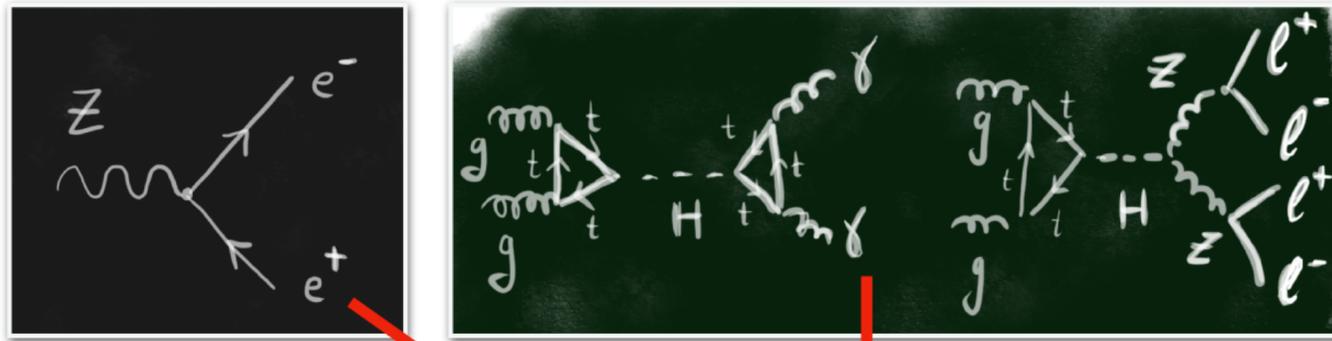
OPlot – MasterClass – Combination for all institutes on 2016-03-09

Start Student Moderator Tutor Administrator



Resumen

Con **Hypatia** clasificamos el evento:

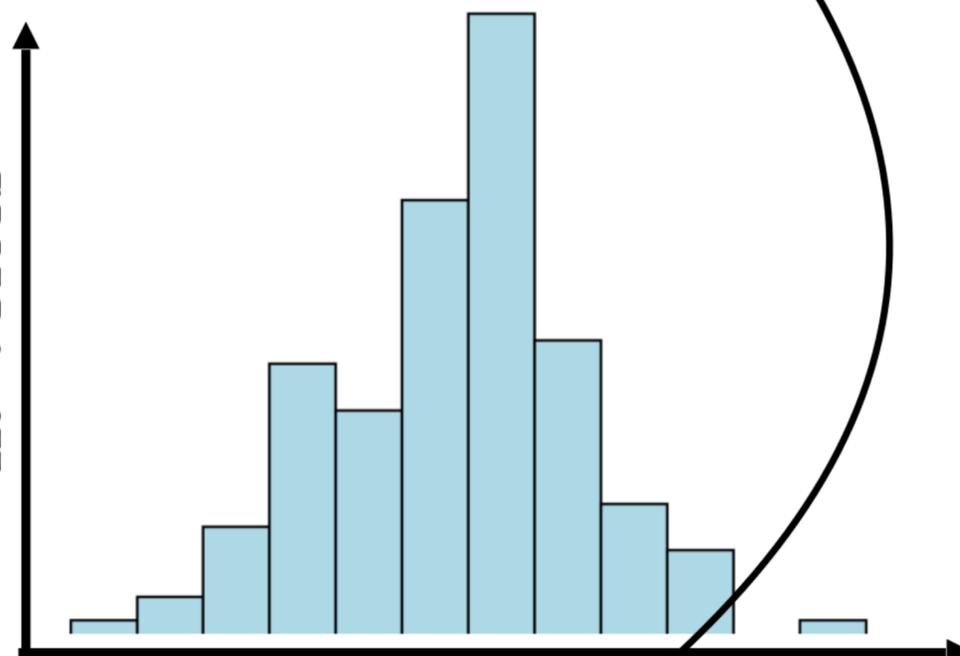


Qué partícula
será la que descubramos? :)



OPIoT

n. voltes

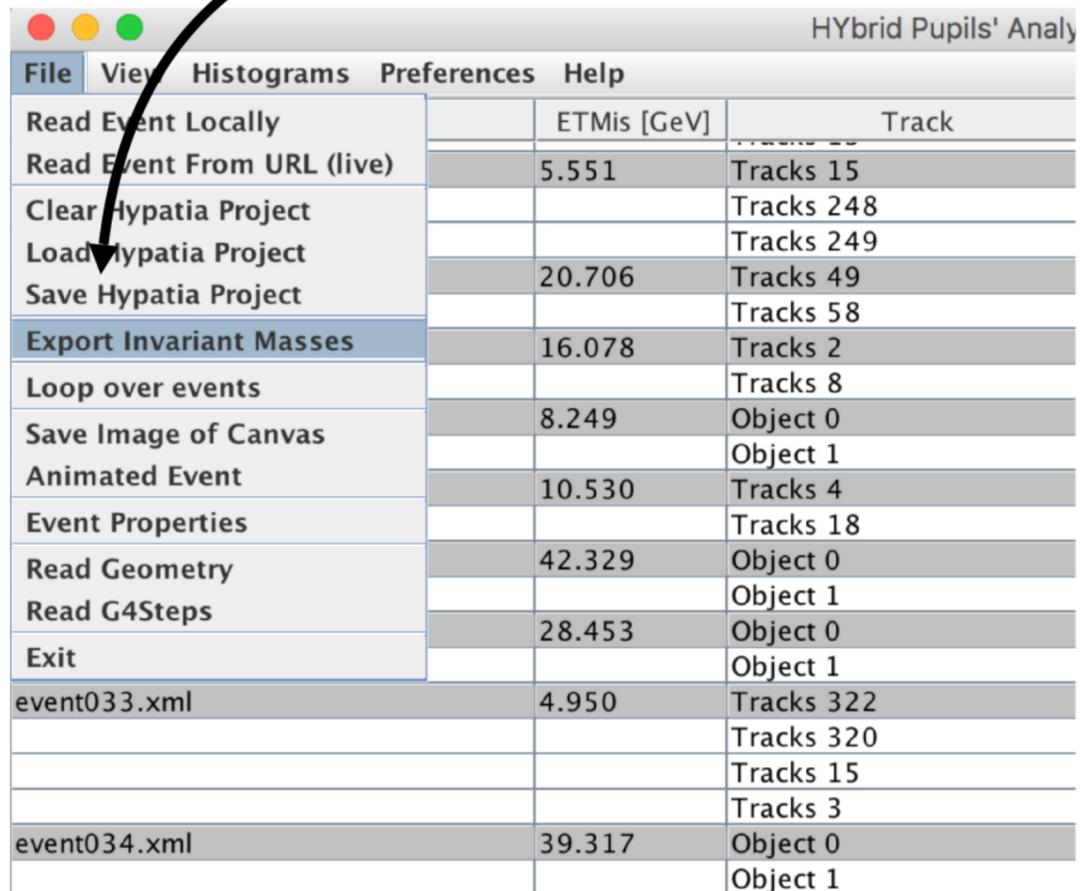


Exportamos los datos,
los **subimos** a la plataforma
y crearemos un **histograma** con ellos!

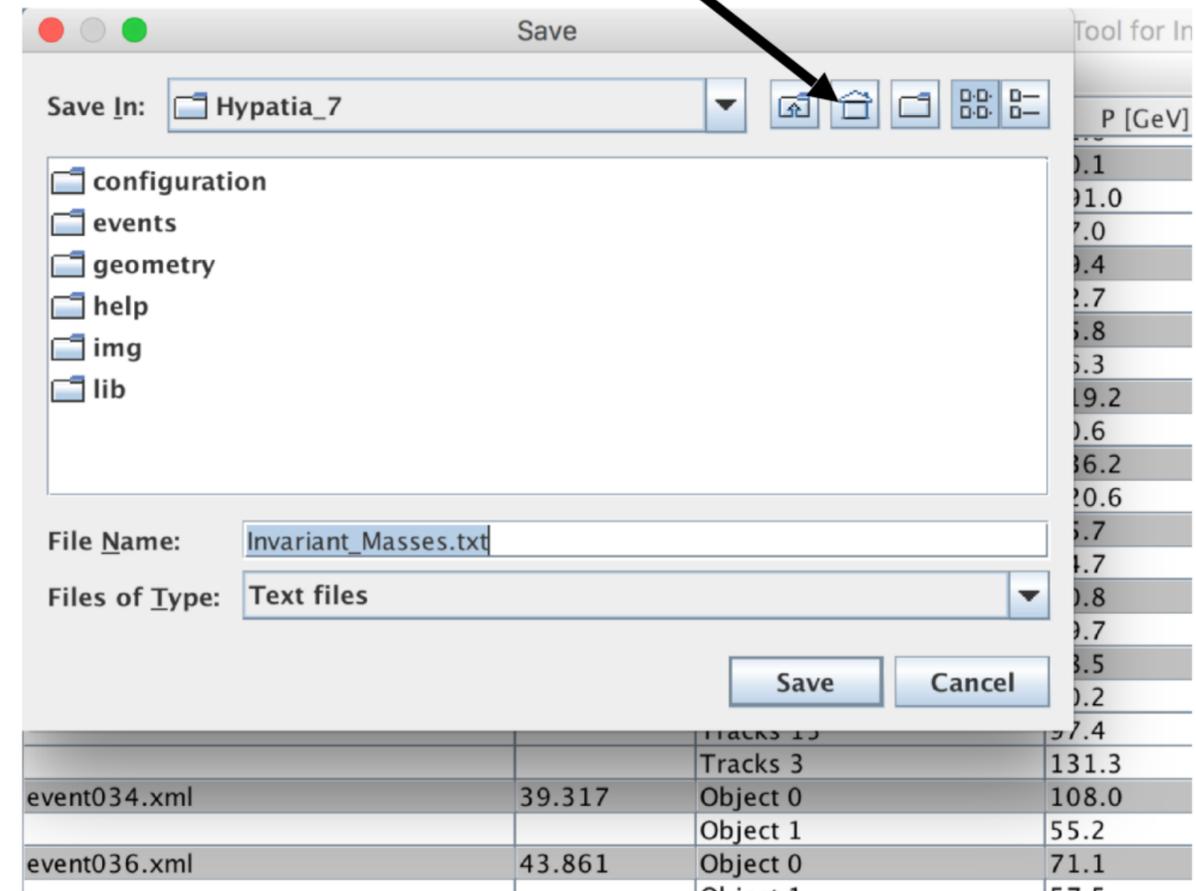
Histograma: Exportar

<http://cernmasterclass.uio.no>

Exportad los datos del histograma



Guardadlo en el Escritorio



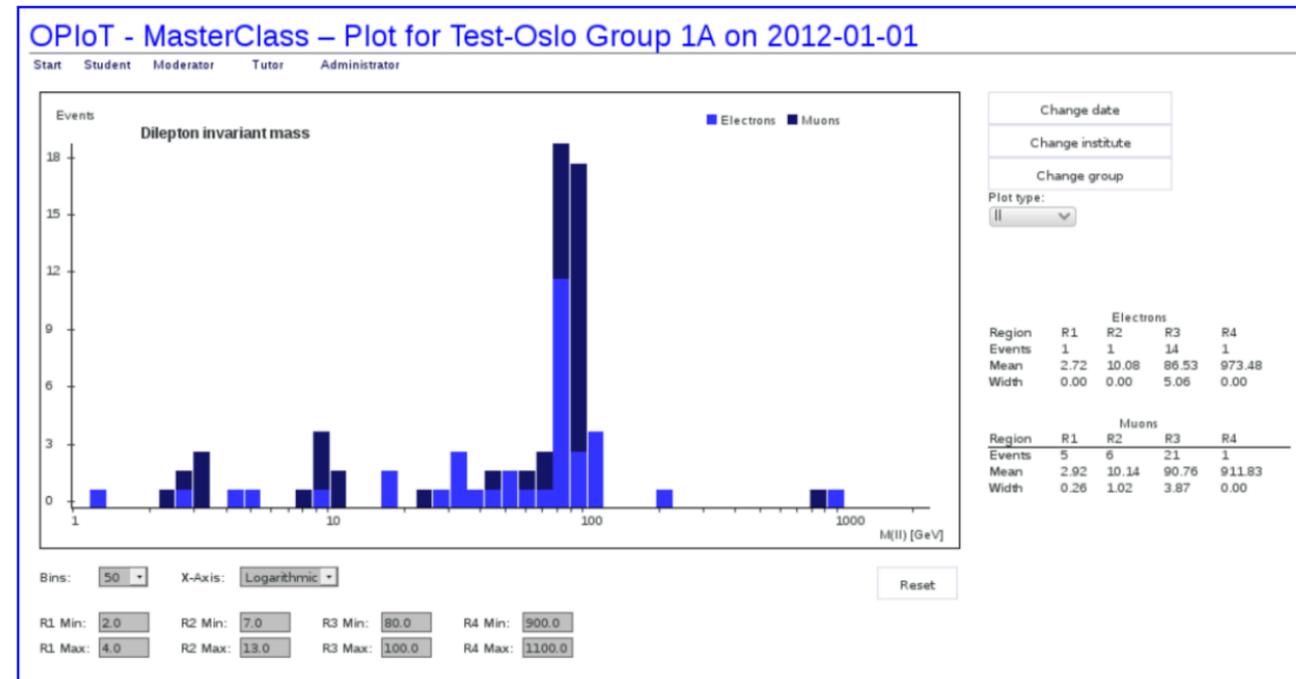
Histograma: Subir

OPlot - the introduction

[Introduction](#) [OPlot test](#) [OPlot](#)

You have now gone through a lot of events in HYPATIA (or the program of your choice), carefully classifying each. OPlot is the tool that will display the fruits of your labor for you - you upload the files with the invariant masses of the events, and up comes a histogram displaying the distribution.

An example of how OPlot can be used, is shown below (to test the plot, go to "OPlot test" in the menu above). Here you can manually input invariant masses of dileptons or dimuons, and the tool plots them for you. You can adjust the number of bins and choose between logarithmic and linear x-axis. The four regions are also adjustable. The mean value and width of the four regions are shown in the table to the far right, for dielectrons and dimuons separately.



Password: **imc**

Username: **ippog**

Log in to cernmasterclass.uio.no:80
Your password will be sent unencrypted.

ippog

...

Remember this password

Cancel Log In

Vuestro número de grupo (**3 o 4**) y la **letra!**

OPIoT – MasterClass – Student page

Start Student Moderator Tutor Administrator

Student Tasks

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

February 11 Valencia IFIC Group number Group letter

Selecciona el fichero:
“Invariant_Masses.txt”

Change date
Change institute
Change group

Upload your file:
Choose File no file selected

Bins: 50 X-Axis: Linear Lower: 0 Upper: 2000 Update plot Reset

R1 Min: 2.0 R2 Min: 7.0 R3 Min: 80.0 R4 Min: 900.0 R5 Min: 1400.0
R1 Max: 4.0 R2 Max: 13.0 R3 Max: 100.0 R4 Max: 1100.0 R5 Max: 1600.0

Una vez cargado,
haz click en el botón de
“submit”

Change date
Change institute
Change group

Upload your file.
Choose File Invariant_Masses.txt Submit