



# PROGRAMA DEL CERN PARA PROFESORES EN LENGUA ESPAÑOLA SLTP 2015

**TALLER**

**USO DE**

**DATOS PÚBLICOS DEL CERN**

**EN LA ENSEÑANZA**

## Education

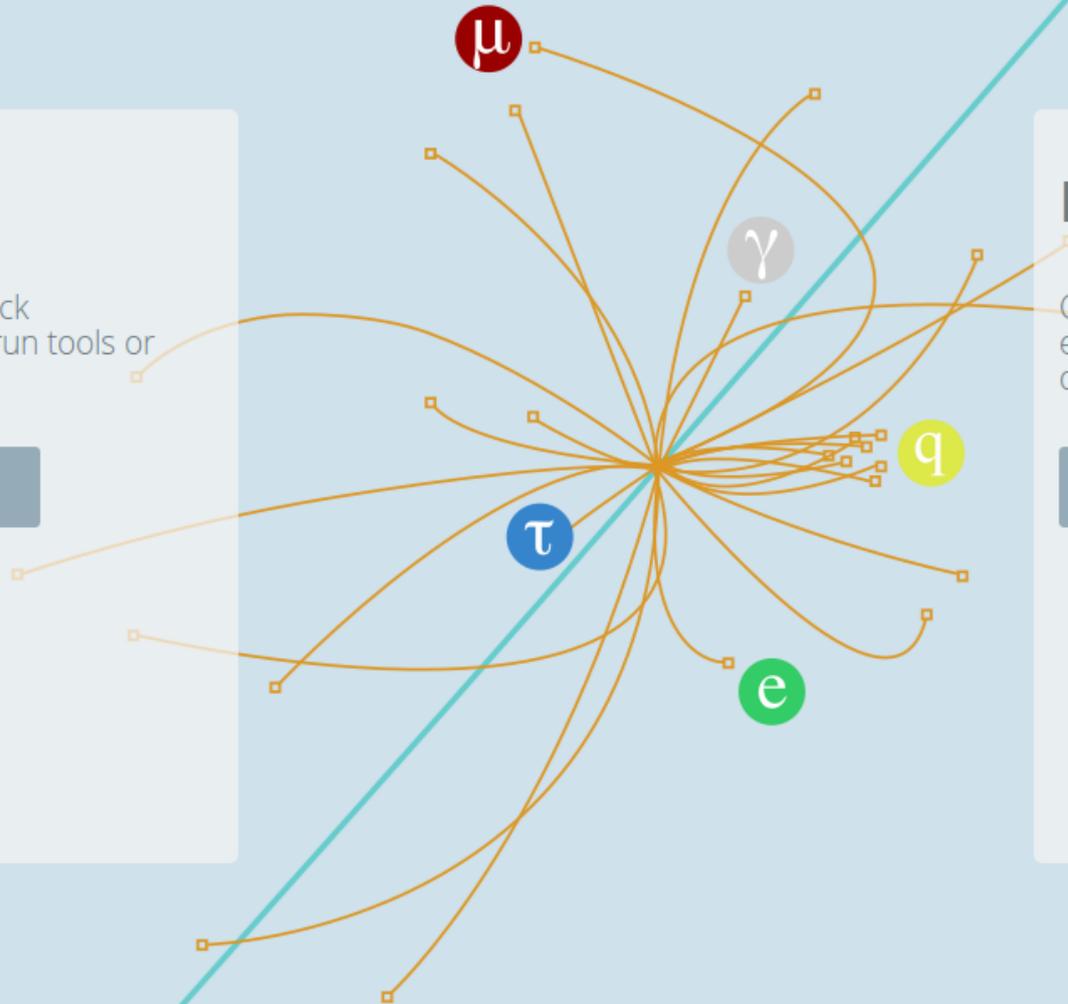
Visualise events, check reconstructed data, run tools or build your own!

Start learning

## Research

Get the genuine working environments, virtual machines and datasets to start your research

Start analysing



De todo esto, ¿qué se puede utilizar? (sin que implique usar software raro -para nosotros- como ROOT)



[HOMEPAGE](#)

[D<sup>0</sup> LIFETIME](#)

[SCHEDULE](#)

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[EVENTS](#)

**LHCb@InternationalMasterclasses**  
**Measuring the D<sup>0</sup> lifetime at the LHCb**

**Introductory slides**

[PDF](#), [PPT](#), [KEY](#)

Más complicada que la de CMS

# También están las masterclasses de ATLAS

atlas.physicsmasterclasses.org/en/index.htm



[HOMEPAGE](#)

[W-Path](#)

[Z-Path](#)

# Y CMS... Además de las masterclasses

opendata.cern.ch/collection/CMS-Derived-Datasets

opendata  
CERN

ABOUT SEARCH EDUCATION RESEARCH

Search

↑ CMS > CMS Derived Datasets

## CMS Derived Datasets

This collection includes data that have been derived from the CMS primary datasets. The data may be reduced in the sense that (a) only part of the information is kept or (b) only part of the events are selected. Datasets include those which may be accessed using the VM image of the CMS environment or those which are adapted for other tools and applications. The tools and instructions to access and use these data are linked to each record.

### Dimuon event information derived from the Run2010B public Mu dataset

This document contains 100k dimuon events selected from the Mu dataset from Run2010B. Each line corresponds to an event. The main file contains all 100k events

Collection CMS-Derived-Datasets DOI 10.7483/OPENDATA.CMS.CB8H.MFFA Author McCauley, Thomas

Parent Dataset AOD/Mu/Run-2010B-Apr21ReReco-v1/

# Abrid los archivos .csv

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Run	Event	Type1	E1	px1	py1	pz1	pt1	eta1	phi1	Q1	Type2	E2	px2	py2	pz2	pt2	eta2
2	148864	313172902	G	5.80834	1.30378	2.6809	-4.98383	2.98112	-1.28643	1.11815	1 G	6.26854	-1.77239	2.43657	-5.49592	3.01301	-1.36207	
3	148864	313184070	G	8.25068	2.56204	1.64825	-7.66693	3.04643	-1.65341	0.571676	1 G	8.9897	-0.300947	-6.47197	-6.2311	6.47897	-0.854061	
4	148864	313270206	G	78.8653	20.0124	6.24233	-76.0281	20.9634	-1.99996	0.302359	1 T	5.34244	1.25496	1.0041	-5.09386	1.60721	-1.87069	
5	148864	313482374	G	11.6694	-3.41138	-0.357351	11.1534	3.43005	1.89516	-3.03722	1 T	15.681	-2.94366	1.15315	15.3586	3.16147	2.28422	
6	148864	313486094	G	12.6982	8.43604	3.15775	-8.94963	9.00767	-0.87681	0.358171	-1 T	4.87194	2.11957	0.177451	-4.38185	2.12699	-1.4702	
7	148864	313541854	G	6.78291	1.90901	-4.11136	-5.04472	4.53295	-0.958996	-1.13609	1 T	7.25492	2.39322	-2.28819	-6.45441	3.31109	-1.42074	
8	148864	313560670	G	18.7438	-5.06358	0.636482	18.0353	5.10342	1.97501	3.01655	-1 G	6.86628	-2.87873	1.66187	6.00714	3.32399	1.35394	
9	148864	313654910	G	41.3267	5.67917	37.1685	17.1503	37.5999	0.44163	1.41917	-1 T	4.32885	0.0528257	1.4326	-4.08321	1.43357	-1.76934	
10	148864	313706014	G	36.167	7.39656	-12.2918	33.2001	14.3457	1.57596	-1.02909	1 G	14.9408	-7.20046	-8.26595	10.151	10.9623	0.828062	
11	148864	313719502	G	20.4762	4.5801	-4.83287	-19.3631	6.65837	-1.78897	-0.812245	-1 T	7.18884	2.50581	-0.120497	-6.73607	2.50871	-1.71386	
12	148864	313749846	G	27.6516	1.67831	8.95026	26.1089	9.10625	1.77557	1.38543	1 T	30.1773	0.963388	6.76773	29.3927	6.83596	2.16495	
13	148864	313796470	G	9.43786	1.84491	-2.55758	-8.89478	3.15355	-1.76012	-0.945884	-1 G	16.3741	2.3166	2.93921	15.9403	3.7424	2.15578	
14	148864	313811550	G	13.9886	-5.89747	-8.62514	-9.30029	10.4486	-0.80149	-2.17054	-1 T	5.16872	-0.0475243	-1.31786	-4.99655	1.31872	-2.04221	
15	148864	313810390	G	52.9973	5.12972	-13.9022	50.8834	14.8184	1.94737	-1.21731	1 T	25.8159	3.46936	-8.78166	24.027	9.44214	1.66369	
16	148864	313861606	G	52.5403	5.77954	-7.54675	51.6732	9.5056	2.39456	-0.917239	1 T	4.03962	1.02197	-0.0911695	3.90572	1.02603	2.04671	
17	148864	313898622	G	10.1113	2.89844	3.88844	8.87162	4.84984	1.36456	0.930247	-1 G	6.3431	-0.2962	2.98513	5.58794	2.99979	1.38053	
18	148864	313897782	G	11.5056	2.4245	-5.22149	-9.96126	5.75692	-1.31609	-1.13609	1 G	14.0152	4.49225	-2.69846	-12.9981	5.24042	-1.63991	
19	148864	313944942	G	5.59929	-0.390942	4.13825	3.75006	4.15668	0.810484	1.66499	-1 G	13.4368	-2.25367	-7.67436	10.7963	7.99842	1.10846	
20	148864	313980158	G	6.28197	0.18885	-4.92332	3.8958	4.92694	0.725401	-1.53246	-1 G	5.79427	5.76065	-0.542447	0.288213	5.78613	0.0497905	
21	148864	313990902	G	9.80145	2.2347	-4.10441	8.61494	4.67334	1.37134	-1.07222	-1 T	13.3506	4.83134	-2.51594	12.1884	5.44718	1.54509	
22	148864	313991334	G	6.85601	0.935787	-3.02294	6.08111	3.16447	1.40805	-1.27059	-1 G	7.67116	5.39026	3.10668	4.48655	6.22145	0.669902	
23	148864	314031310	G	14.7898	1.56464	-4.50612	-13.9991	4.77003	-1.79762	-1.23659	1 G	12.0112	2.05543	-5.67596	-10.3835	6.03666	-1.31095	
24	148864	314033486	G	39.4555	7.0011	-7.13782	38.1675	9.99819	2.04946	-0.795067	1 T	10.1869	0.667561	-1.89114	9.98696	2.00551	2.30846	
25	148864	314045614	G	25.3754	-4.56805	-1.58746	24.9101	4.83602	2.34162	-2.80713	-1 G	8.02099	4.26224	-3.35954	5.90524	5.42708	0.942323	
26	148864	314064494	G	9.43483	1.04631	-4.25973	-8.35253	4.38635	-1.39996	-1.32994	-1 G	6.16472	1.7924	-4.0195	-4.3155	4.40104	-0.867563	
27	148864	314092046	G	15.127	-9.33257	-11.5629	2.83145	14.8592	0.189417	-2.24986	1 T	19.6533	-12.6765	-14.9606	1.31562	19.609	0.0670425	
28	148864	314093174	G	8.17241	-0.484994	4.60528	6.733	4.63074	1.16896	1.67572	-1 G	5.84518	-5.80242	0.178591	0.6746	5.80516	0.115947	
29	148864	314103158	G	13.928	0.209515	4.4006	13.3269	4.04602	1.90748	1.51899	1 G	9.8235	1.00008	-4.89478	8.4576	4.9959	1.29722	
30	148864	314114254	G	5.47265	-1.33841	-4.97392	1.84595	5.15084	0.351119	-1.83366	1 G	6.75646	0.614449	6.32337	-2.29696	6.35315	-0.3541	
31	148864	314135422	G	7.99809	3.17797	-4.63727	-5.68811	5.62173	-0.889698	-0.969997	-1 G	13.7511	2.48205	-5.27973	12.4517	5.83405	1.50214	

# Y jugad con los datos...

Con vuestros propios medios o con los suyos

The screenshot shows a web browser window with the URL `opendata.cern.ch/visualise/histograms/CMS`. The page header includes the "opendata CERN" logo and navigation links for "ABOUT", "SEARCH", "EDUCATION", and "RESEARCH". A breadcrumb trail indicates the current location: "Education > Visualise Histograms > CMS". The main heading reads "Explore CMS open data and play with the histograms". A "Need HELP?" link is visible on the right. The main content area features a search bar with the text "dimuon events with invariant mass between 2-110 GeV" and a dropdown arrow. Below this, a section titled "Select one or more parameters:" contains a row of ten buttons: "E1", "pt1", "eta1", "phi1", "Q1", "E2", "pt2", "eta2", "phi2", "Q2", and "M".

## Cálculo de la masa invariante de una partícula que se desintegra en otras dos según

$$X \rightarrow A + B$$

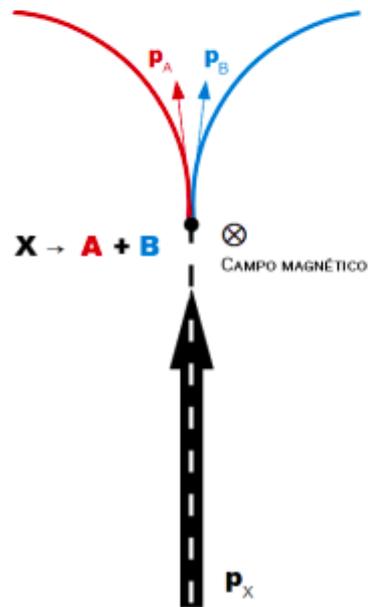
<http://opendata.cern.ch/record/70>

Afortunadamente la energía y el momento lineal (y también la carga eléctrica) se conservan, así que debe cumplir

$$\vec{p}_X = \vec{p}_A + \vec{p}_B \quad [1]$$

$$E_X = E_A + E_B \quad [2]$$

(y también  $Q_X = Q_A + Q_B$ , lo que nos dice que si X es una partícula neutra, A y B deben tener cargas opuestas)



Pero en mecánica relativista, la relación entre energía y momento NO es  $E = \vec{p}^2/2m$  [nuestra amiga la energía cinética de una partícula libre disfrazada,  $E = mv^2/2$ ] sino más bien

$$E = (\vec{p}^2 c^2 + m^2 c^4)^{\frac{1}{2}} (*)$$

Ahora vamos a despejar la masa (invariante) de X, que es lo que andamos buscando:

$$E_X^2 = \vec{p}_X^2 c^2 + M_X^2 c^4$$

$$M_X = \frac{1}{c^2} (E_X^2 - \vec{p}_X^2 c^2)^{\frac{1}{2}}$$

y si ahora sustituimos [1] y [2] llegamos finalmente a la expresión que nos da  $M_X$  en función de las energías y momentos de las partículas detectadas, A y B:

$$M_X = \frac{1}{c^2} \left[ (E_A + E_B)^2 - c^2 (\vec{p}_A + \vec{p}_B)^2 \right]^{\frac{1}{2}}$$

## Un ejemplo:

100000 dimuon events selected from the Mu dataset from Run2010B. Selected because of the presence of precisely two muons with invariant mass between 2-110 GeV, one of which is a high-quality "global" muon

<https://fbarradass.wordpress.com/2011/05/20/%C2%BFcomo-saber-si-se-ha-descubierto-una-particula-apendice-4-1/>

frecuencia

3700

450

2

3.1

3.7

9.5

masa( $\mu\mu$ ) / GeV

$J/\Psi$

$\Psi(2s)$

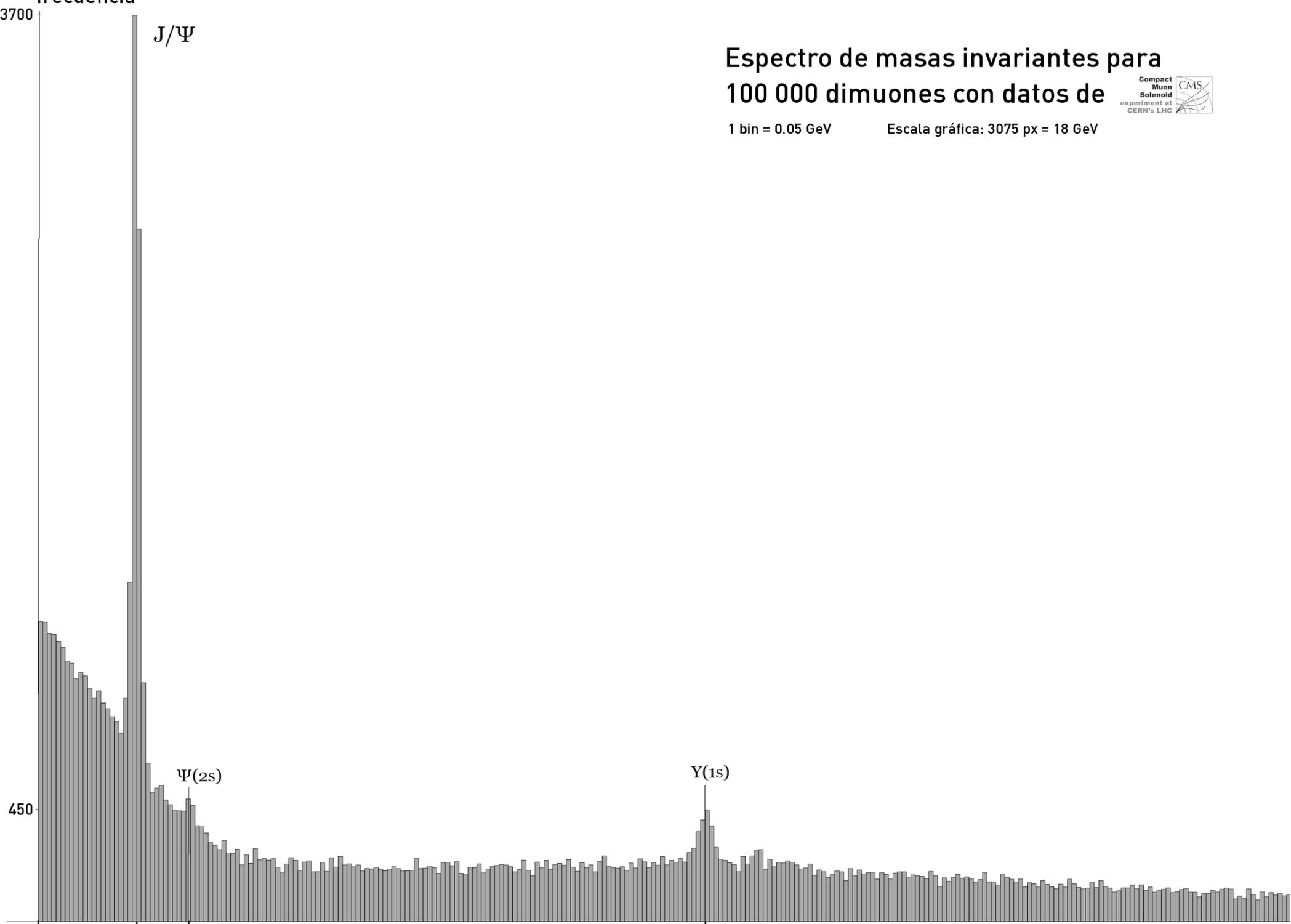
$Y(1s)$

# Espectro de masas invariantes para 100 000 dimuones con datos de



1 bin = 0.05 GeV

Escala gráfica: 3075 px = 18 GeV



Si queréis hacer vuestros propios histogramas con barras de error, etc. hay cosas mejores que las hojas de cálculo, por ejemplo:

R (y RStudio, para que sea más sencillo):

<http://cran.r-project.org/>

<http://www.rstudio.com/>

Plotly (una herramienta *online*)

<https://plot.ly/feed/>

**Todas las imágenes que no son propias son cortesía del CERN**