Motivación. Ejercicio J/Ψ

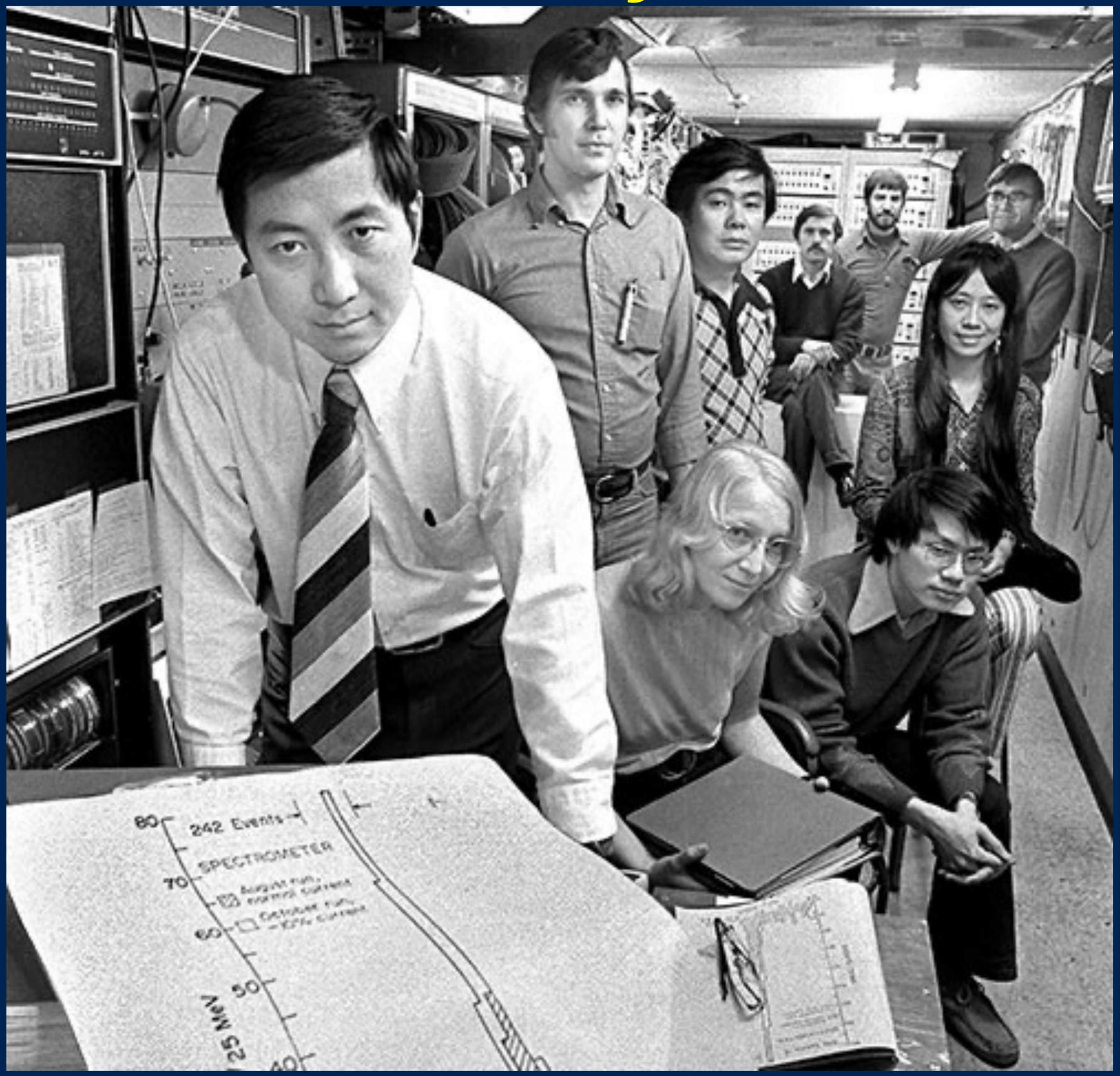
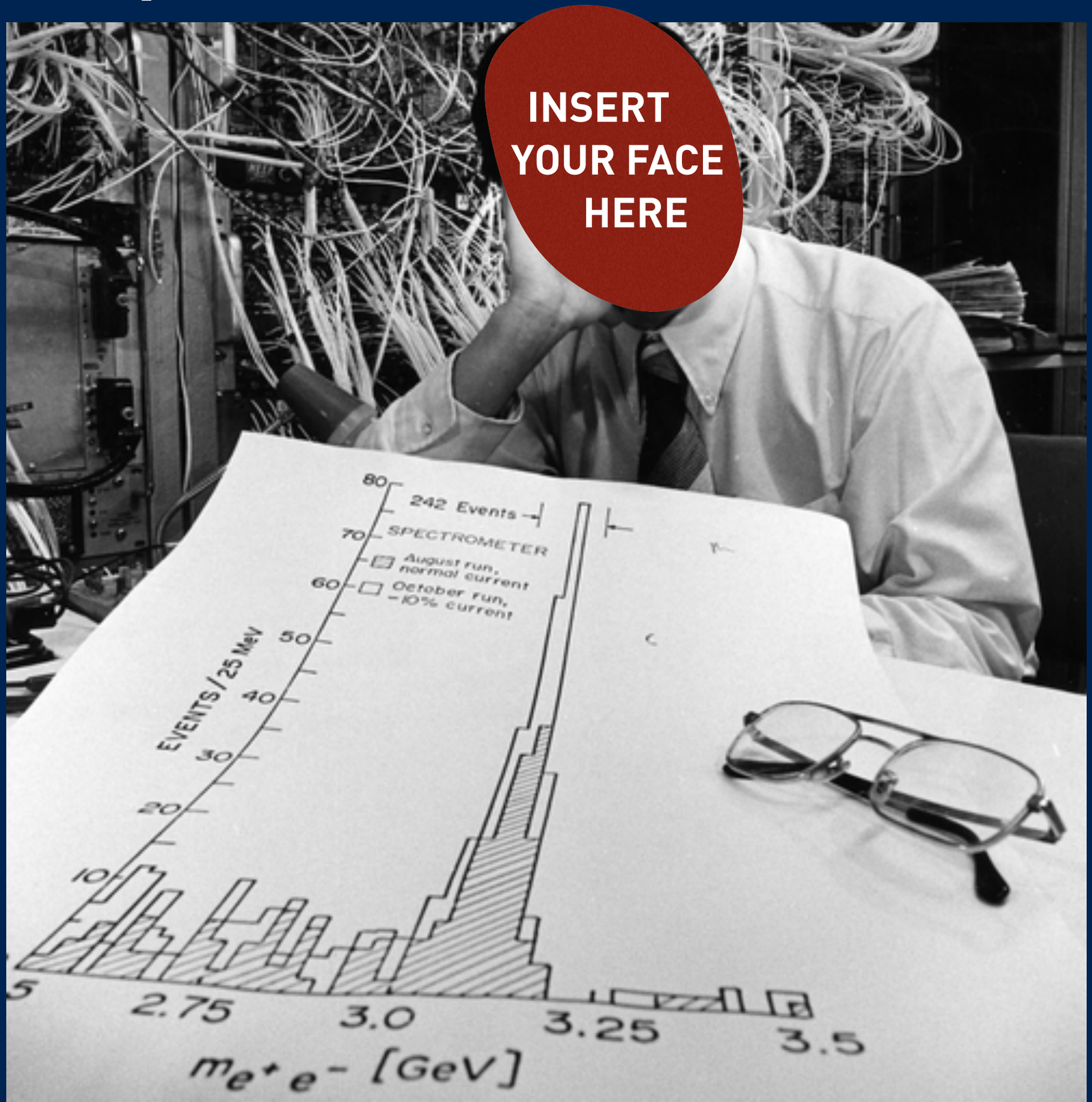


foto BNL

Objetivo


INSERT
YOUR FACE
HERE
242 Events
SPECTROMETER
August run, normal current
October run, ~10% current
EVENTS/25 MeV
80
70
60
50
40
30
20
10
2.75
3.0
3.25
3.5
$m_{e^+e^-}$ [GeV]

Primero conseguir los datos (ya seleccionados y limpios) en formato csv

Events with two muons from 2011 (Primary dataset SingleMu 2011)

http://opendata.cern.ch/record/5202

Z to two muons from 2011

http://opendata.cern.ch/record/5208

J/psi to two muons from 2011

http://opendata.cern.ch/record/5203

Ahora importarlos a una hoja de cálculo (*spreadsheet*) como *LibreOfficeCalc* o *Excel*

En LibreOffice basta abrirlo e indicar que el separador es la coma (,)

En Excel hay que abrir primero el programa y después importar desde

Datos -> Obtener datos externos -> De archivo de texto
el separador es la coma (,)

O usar una herramienta más específica para el análisis de datos y la estadística:

R, Mathematica, Octave, Matlab,Root ;-)

Jpsimumu_Run2011A.csv

Liberation Sans | 10

U1 | = | M

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	Run	Event	Type1	E1	px1	py1	pz1	pt1	eta1	phi1	Q1	Type2	E2	px2	py2	pz2	pt2	eta2	phi2	Q2	M
2	165617	75206813	G	10.1623	0.476262	-8.51642	5.52306	8.52973	0.609133	-1.51493	-1	G	19.7754	2.7508	-13.9871	13.7059	14.255	0.853872	-1.37661	1	3.11319
3	165617	75678475	G	15.8799	15.0618	-1.66581	-4.74643	15.1536	-0.308313	-0.110151	1	G	11.9338	11.9084	-0.767017	-0.0851174	11.933	-0.00713285	-0.0643211	-1	4.11735
4	165617	74428554	G	21.8279	-6.22138	11.0845	17.7447	12.7111	1.13566	2.08225	-1	G	36.6513	-10.6874	15.0692	31.6544	18.4743	1.30761	2.18768	1	3.10098
5	165617	75193169	G	19.4923	2.76125	-5.57686	-18.4719	6.22301	-1.80838	-1.11105	1	G	14.9334	1.55249	-6.12535	-13.5302	6.31902	-1.50505	-1.32257	-1	2.33329
6	165617	74832715	G	8.09718	4.61267	-1.83886	6.39492	4.9657	1.071	-0.379345	-1	T	3.51313	-0.530458	0.68802	3.40238	0.868767	2.07422	2.2276	1	4.56326
7	165617	74981507	G	30.5862	15.5218	5.12931	-25.8509	16.3474	-1.23906	0.31916	1	G	12.4868	7.76402	1.04247	-9.72328	7.83369	-1.04209	0.133471	-1	3.07267
8	165617	75612982	G	7.55441	1.29129	-5.35884	-5.16462	5.51223	-0.836073	-1.33434	-1	T	3.84161	-0.989578	-3.45483	-1.3534	3.59376	-0.36822	-1.84976	1	3.10045
9	165617	74760204	G	24.6376	9.98359	19.1426	-11.8697	21.5896	-0.525296	1.09007	1	G	11.0213	3.37851	7.82724	-6.98411	8.52525	-0.747611	1.16332	-1	3.18964
10	165617	75017052	G	22.5057	5.62963	-9.94966	19.3857	11.4319	1.29867	-1.05589	1	G	30.5709	4.94677	-13.636	26.9102	14.5055	1.37692	-1.22279	-1	2.38114
11	165617	75204668	G	10.7051	-8.46643	-2.23744	-6.15638	8.75709	-0.655136	-2.88323	1	G	55.1896	-45.0429	-16.6152	-27.2205	48.0096	-0.540305	-2.7882	-1	3.07007
12	165617	75056096	G	6.03714	1.16926	-3.40175	-4.84735	3.5971	-1.10713	-1.23972	-1	T	6.20436	0.943712	0.611231	-6.10071	1.12436	-2.39272	0.574748	-1	4.21219
13	165617	75682819	G	22.6067	5.02668	-0.315528	22.0383	5.03658	2.18201	-0.0626883	1	G	17.8797	2.79872	2.05671	17.5388	3.47317	2.32216	0.633751	-1	2.92173
14	165617	75891163	G	11.6778	10.7636	2.25561	-3.92661	10.9974	-0.349867	0.20657	1	G	11.1458	9.00646	3.46981	-5.57321	9.65173	-0.549376	0.367733	-1	2.65228
15	165617	74949022	G	22.4059	1.37594	7.20958	-21.1694	7.3397	-1.78119	1.38222	-1	T	4.78127	-0.56626	0.725542	-4.69067	0.92036	-2.3312	2.23351	1	2.60375
16	165617	75818801	G	25.2596	23.5556	3.19093	8.54321	23.7708	0.352081	0.134644	1	G	11.7166	10.4432	1.12881	5.18956	10.504	0.475887	0.107672	-1	2.01626
17	165617	74875638	G	23.0765	4.47335	7.9045	21.2138	9.08251	1.58441	1.05581	-1	T	25.5421	1.98912	7.72653	24.2637	7.97847	1.83138	1.31883	1	3.07757
18	165617	76187234	G	9.7908	-1.62467	2.06093	9.43195	2.6243	1.99125	2.23837	1	G	11.708	1.32151	1.70919	11.5064	2.16049	2.37441	0.912626	-1	3.07834
19	165617	76650121	G	14.5875	-6.16731	12.5515	-4.14819	13.9849	-0.292434	2.02751	1	G	10.6562	-3.30946	8.62706	-5.30706	9.24006	-0.546709	1.9371	-1	3.08241
20	165617	76624220	G	8.81973	-0.0262702	2.5635	-8.43826	2.56364	-1.90681	1.58104	-1	T	7.49048	-1.27134	-0.627641	-7.35431	1.41782	-2.34848	-2.68301	1	3.34459
21	165617	76796604	G	13.5186	5.42989	7.9615	-9.48005	9.63687	-0.86982	0.972241	1	G	12.9792	7.07465	5.31888	-9.49254	8.85106	-0.931704	0.644667	-1	3.07288
22	165617	76691627	G	4.886	-4.20659	-2.03828	1.41839	4.6744	0.298965	-2.69039	1	T	5.26779	-2.2166	-2.7244	3.92464	3.51222	0.962017	-2.25378	-1	3.25745
23	165617	77405245	G	15.7236	5.88857	-8.86993	-11.5702	10.6466	-0.941403	-0.984725	-1	T	3.5067	1.0852	-1.06305	-3.1588	1.51912	-1.47857	-0.77509	1	2.35866
24	165617	77028337	G	18.8749	4.74788	18.2027	1.53885	18.8118	0.0817115	1.31565	1	G	9.79345	0.45605	9.67412	1.45052	9.68486	0.149218	1.52369	-1	2.95588
25	165617	77061433	G	23.4741	19.8385	-12.2262	-2.82452	23.3033	-0.120912	-0.552309	1	G	22.4032	17.1602	-13.9707	-3.49868	22.1281	-0.157459	-0.683298	-1	3.09333
26	165617	77358505	G	30.75	-7.36353	15.1631	-25.7179	16.8564	-1.20894	2.02288	1	G	5.90232	-2.25754	3.12247	-4.46989	3.85309	-0.990163	2.19679	-1	2.27226
27	165617	76149397	G	20.7971	-14.4118	0.162709	-14.9927	14.4127	-0.909544	3.1303	1	G	14.4089	-10.9596	-1.02027	-9.29794	11.007	-0.767219	-3.04877	-1	2.23231
28	165617	76456028	G	9.54445	-0.356738	8.59924	4.12447	8.60663	0.462549	1.61226	-1	G	8.55543	1.11142	8.28582	1.81496	8.36003	0.215429	1.43746	1	2.57954
29	165617	77284054	G	17.4321	4.465	2.52885	16.6594	5.13141	1.89366	0.515326	1	G	7.26367	3.42745	2.03038	6.07288	3.9837	1.20824	0.534803	-1	3.1697
30	165617	77411254	G	24.318	-14.7649	-13.2682	14.0465	19.8507	0.658889	-2.40954	1	G	11.9776	-5.63516	-7.88985	7.03189	9.69561	0.673242	-2.19101	-1	3.0405
31	165617	76225718	G	136.691	-8.05028	29.9944	-133.116	31.056	-2.16191	1.83301	1	G	13.8132	-1.64543	2.48685	-13.487	2.98192	-2.21431	2.15532	-1	3.1505
32	165617	76306974	G	20.8157	-6.81963	7.37919	18.2297	10.0479	1.35736	2.31681	1	T	7.46953	-3.31196	1.58378	6.50425	3.67117	1.33662	2.69554	1	2.30248

Run	Event
165617	75206813
165617	75678475
165617	74428554
165617	75193169
165617	74832715
165617	74981507
165617	75612982
165617	74760204
165617	75017052

Identificación

Type1	E1	px1	py1	pz1
G	10.1623	0.476262	-8.51642	5.52306
G	15.8799	15.0618	-1.66581	-4.74643
G	21.8279	-6.22138	11.0845	17.7447
G	19.4923	2.76125	-5.57686	-18.4719
G	8.09718	4.61267	-1.83886	6.39492
G	30.5862	15.5218	5.12931	-25.8509
G	7.55441	1.29129	-5.35884	-5.16462
G	24.6376	9.98359	19.1426	-11.8697
G	22.5057	5.62963	-9.94966	19.3857
G	10.7051	-8.46643	-2.23744	-6.15638
G	6.03714	1.16926	-3.40175	-4.84735
G	22.6067	5.02668	-0.315528	22.0383
G	11.6778	10.7636	2.25561	-3.92661
G	22.4059	1.37594	7.20958	-21.1694

Tipo

Parámetros físicos (E, **p**)
(en GeV, GeV/c)

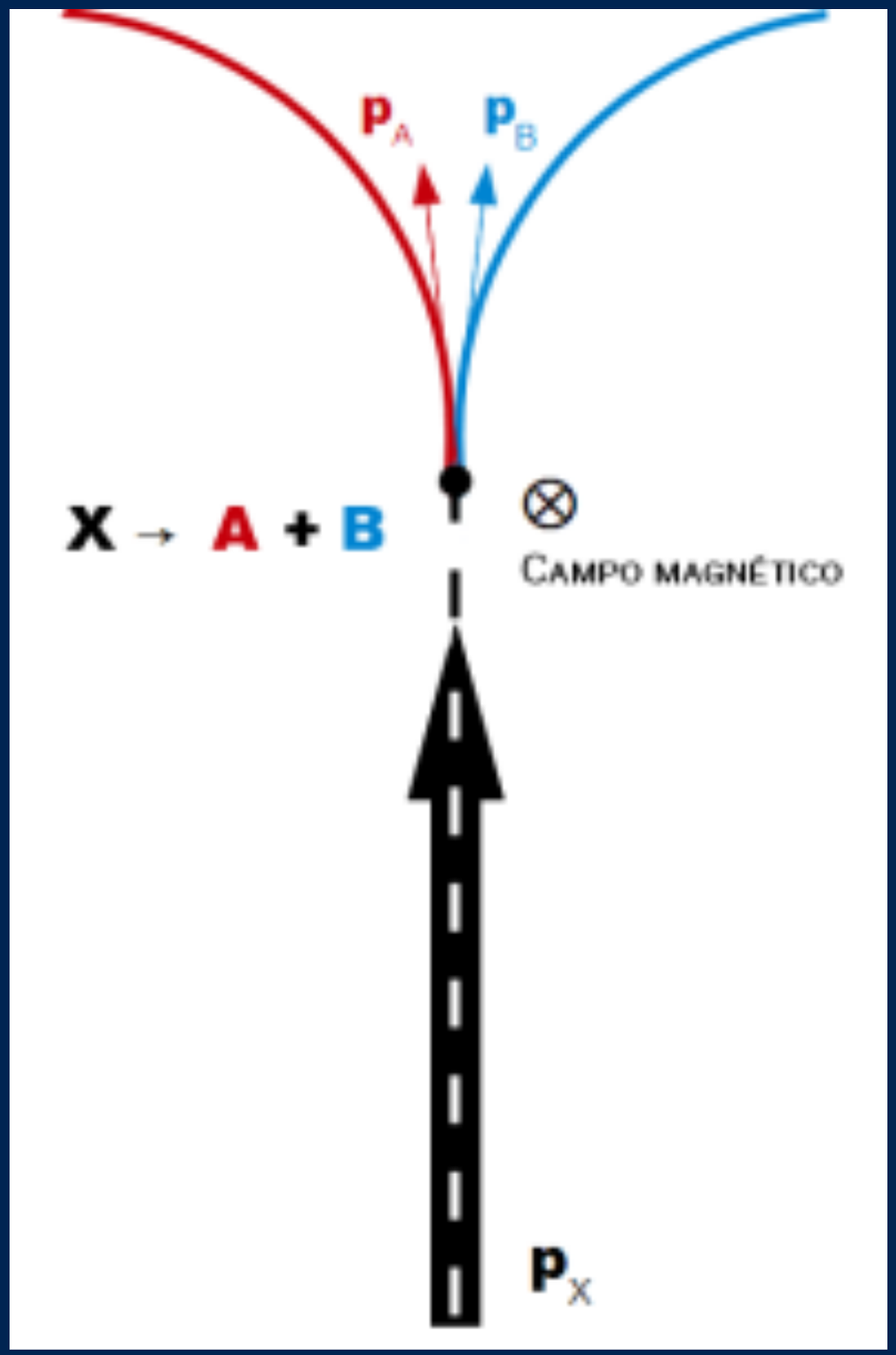
pt1	eta1	phi1
8.52973	0.609133	-1.51493
15.1536	-0.308313	-0.110151
12.7111	1.13566	2.08225
6.22301	-1.80838	-1.11105
4.9657	1.071	-0.379345
16.3474	-1.23906	0.31916
5.51223	-0.836073	-1.33434
21.5896	-0.525296	1.09007

p
en
otras
coordenadas

M
3.11319
4.11735
3.10098
2.33329
4.56326
3.07267
3.10045
3.18964

Masa
invariante
calculada
en GeV/c^2

Nos han dado ya las masas calculadas, pero...



$$X \rightarrow A + B$$

$$\vec{p}_X = \vec{p}_A + \vec{p}_B$$

$$E_X = E_A + E_B$$

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

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

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

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

¡Y ahora los histogramas!

Es decir, calculamos las masas invariantes las agrupamos en "bines" en en eje horizontal y representamos el número de sucesos en el eje vertical.

ATENCIÓN: NO hay una regla sencilla sobre cómo elegir la anchura de los "bines" o "intervalos":
PRUEBEN HASTA QUE SE VEA ESTRUCTURA

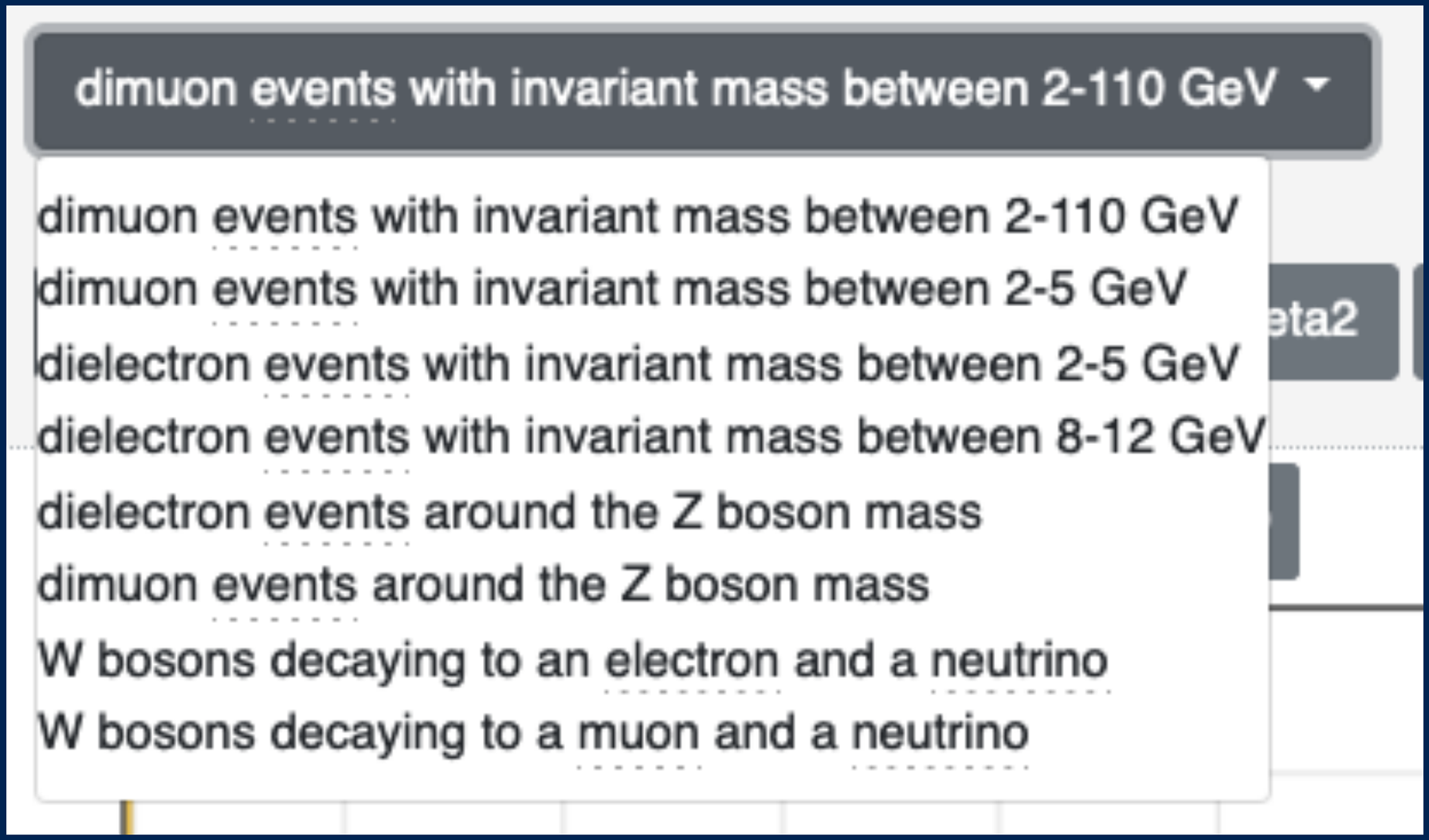
¡Feliz caza!

Y por favor, déjenme sus resultados aquí:

https://cernbox.cern.ch/index.php/s/iPh3SfRoFmmCZ4Z

Si lo anterior les parece excesivo
o simplemente para jugar con los histogramas

http://opendata.cern.ch/visualise/histograms/CMS



opendata CERN

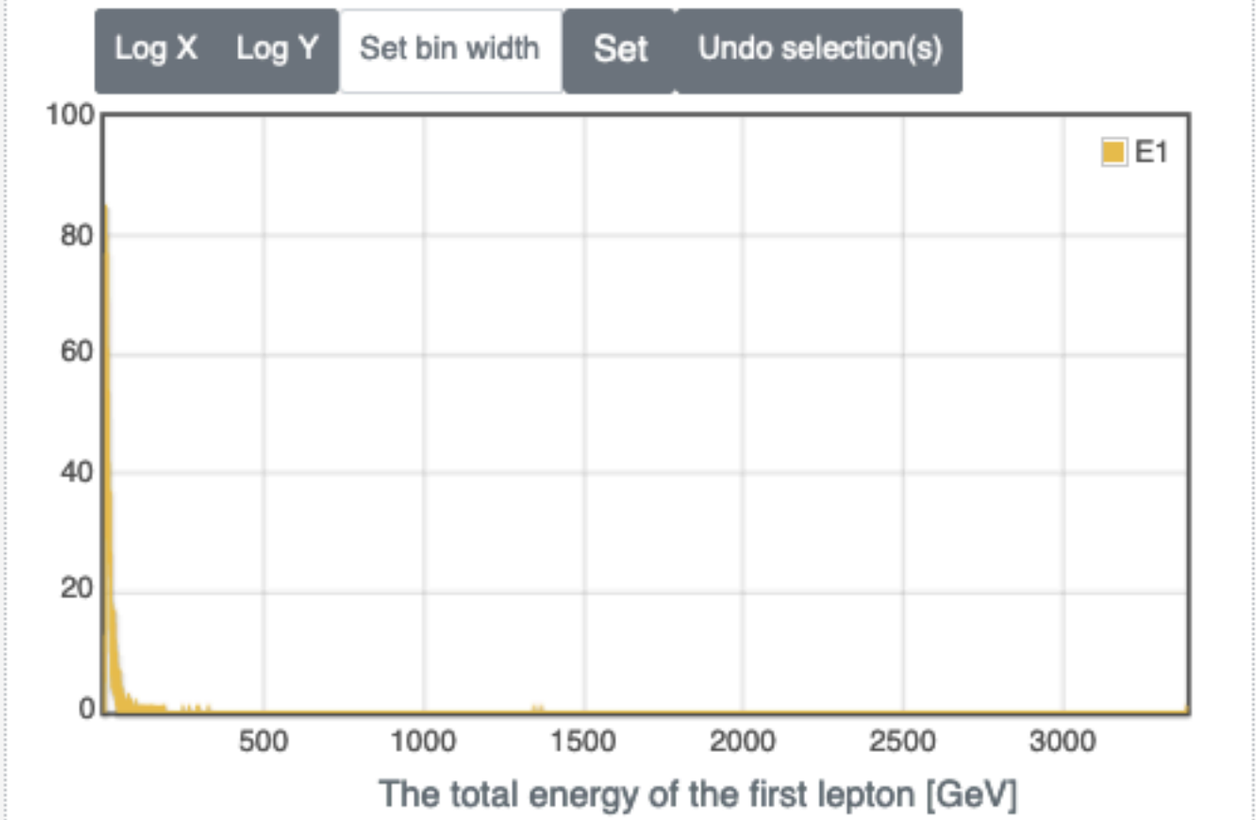
Search

Need HELP?

dimuon events with invariant mass between 2-110 GeV

Select one or more parameters:

E1 pt1 eta1 phi1 Q1 E2 pt2 eta2 phi2 Q2 M



Controls:

Click on the "LogX" and "LogY" buttons to transform the axes by log10

Enter a bin width and click "Set" to change the bin width of the histogram (the default is 0.1)

Click on the histogram and move to select a region along the x axis. Click "Undo selection(s)" to return to the original range.

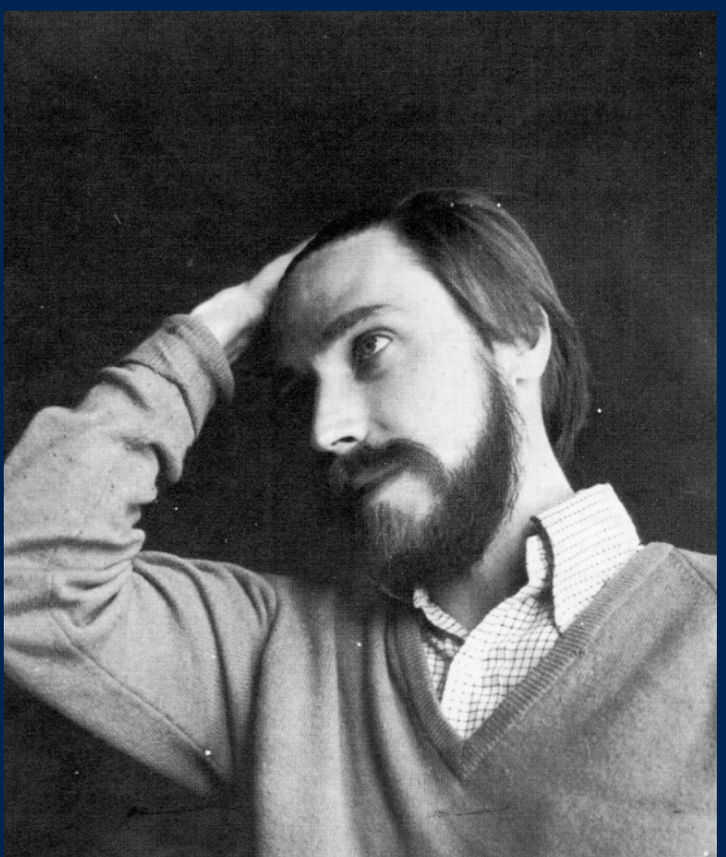
S. Glashow:

In 1969, John Iliopoulos and Luciano Maiani came to Harvard as research fellows. Together, we found the arguments that predicted the existence of charmed hadrons. Much of my later work was done in collaboration with **Alvaro de Rujúla** or Howard Georgi.

In early 1974, we predicted that charm would be discovered in neutrino physics or in $e^+ e^-$ annihilation. So it was.

With the discovery of the J/Psi particle, we realized that many diverse strands of research were converging on a single theory of physics.

https://www.nobelprize.org/prizes/physics/1979/glashow/biographical/



Álvaro de Rújula
AIP Emilio Segrè
Visual Archives

Sheldon Glashow
courtesy AIP Emilio Segrè
Visual Archives