Uso de datos públicos del CERN en el aula

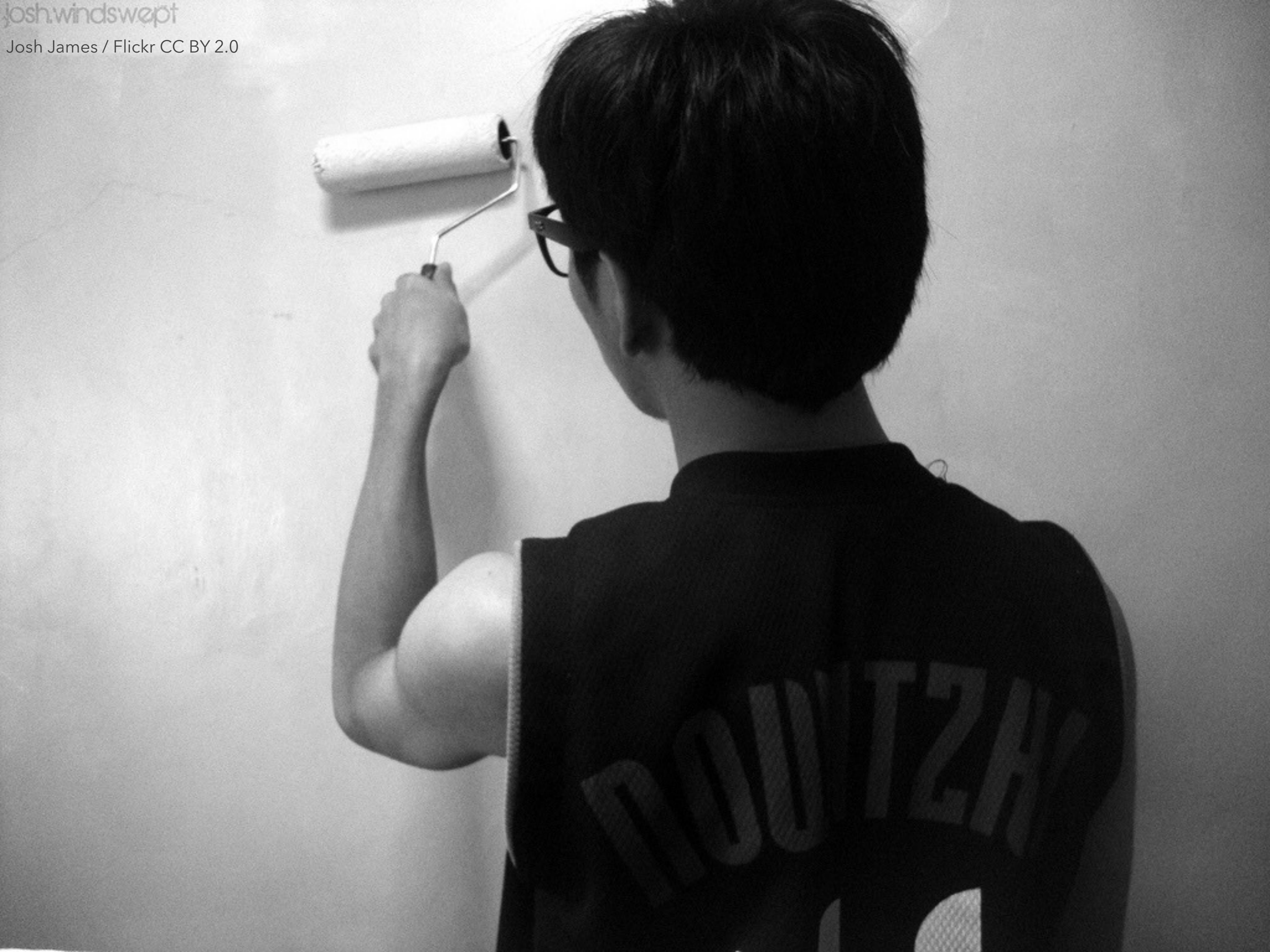
Una invitación y una microguía

Motivación:

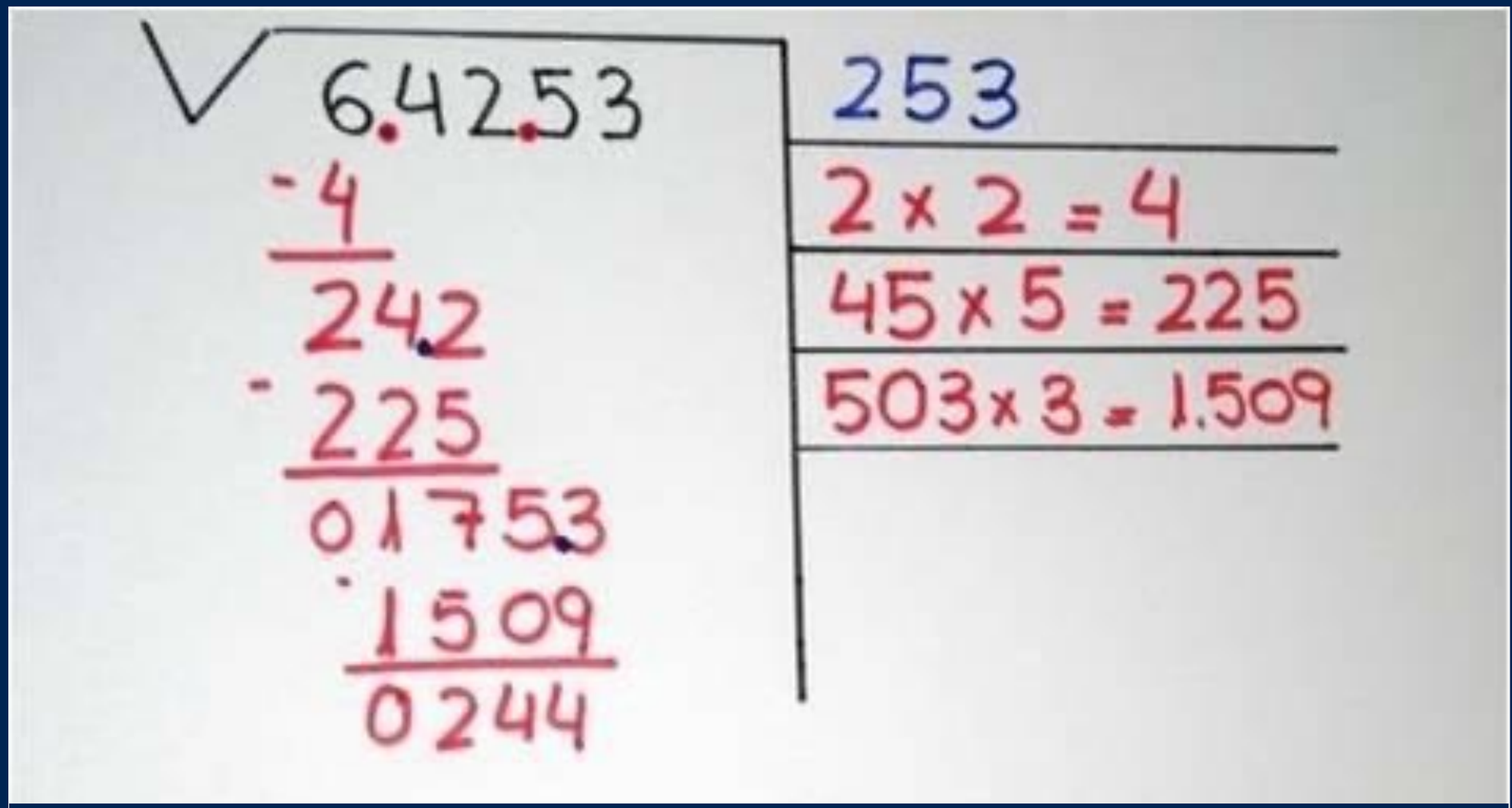
Imaginemos que vais a una clase de pintura y os encontráis esto:

josh.windswept

Josh James / Flickr CC BY 2.0



o que en clase de
matemáticas
no hay nada más que cosas
como esta:



o en física…

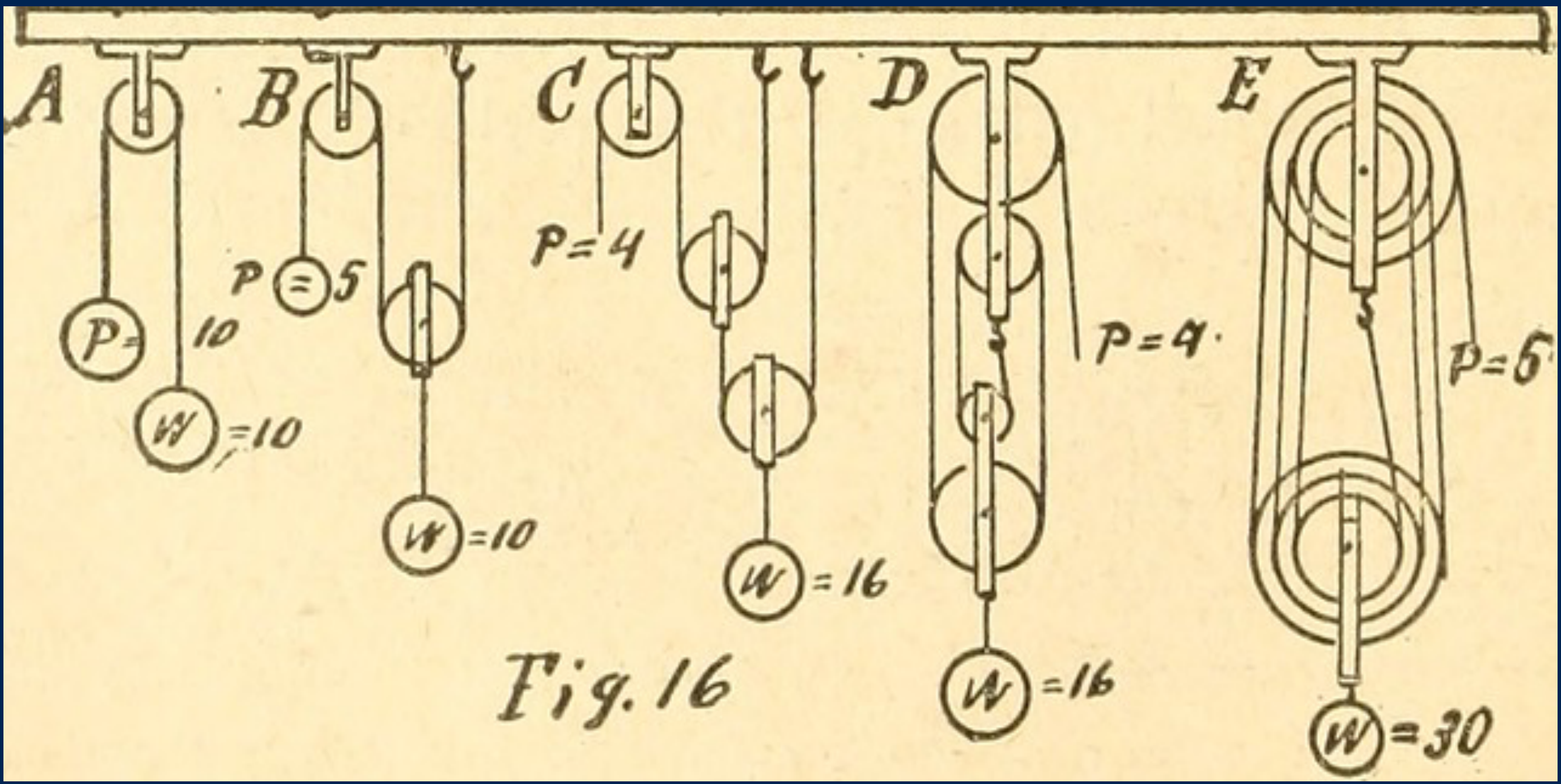


Fig. 16

Image from page 45 of "Elementary lessons in the physics of agriculture" (1894)

Hay alternativas...

Adam Jones / Flickr CC BY-SA 2.0

Diana González Yuste
The October Press, Alicante

Begoña V.

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Motivación

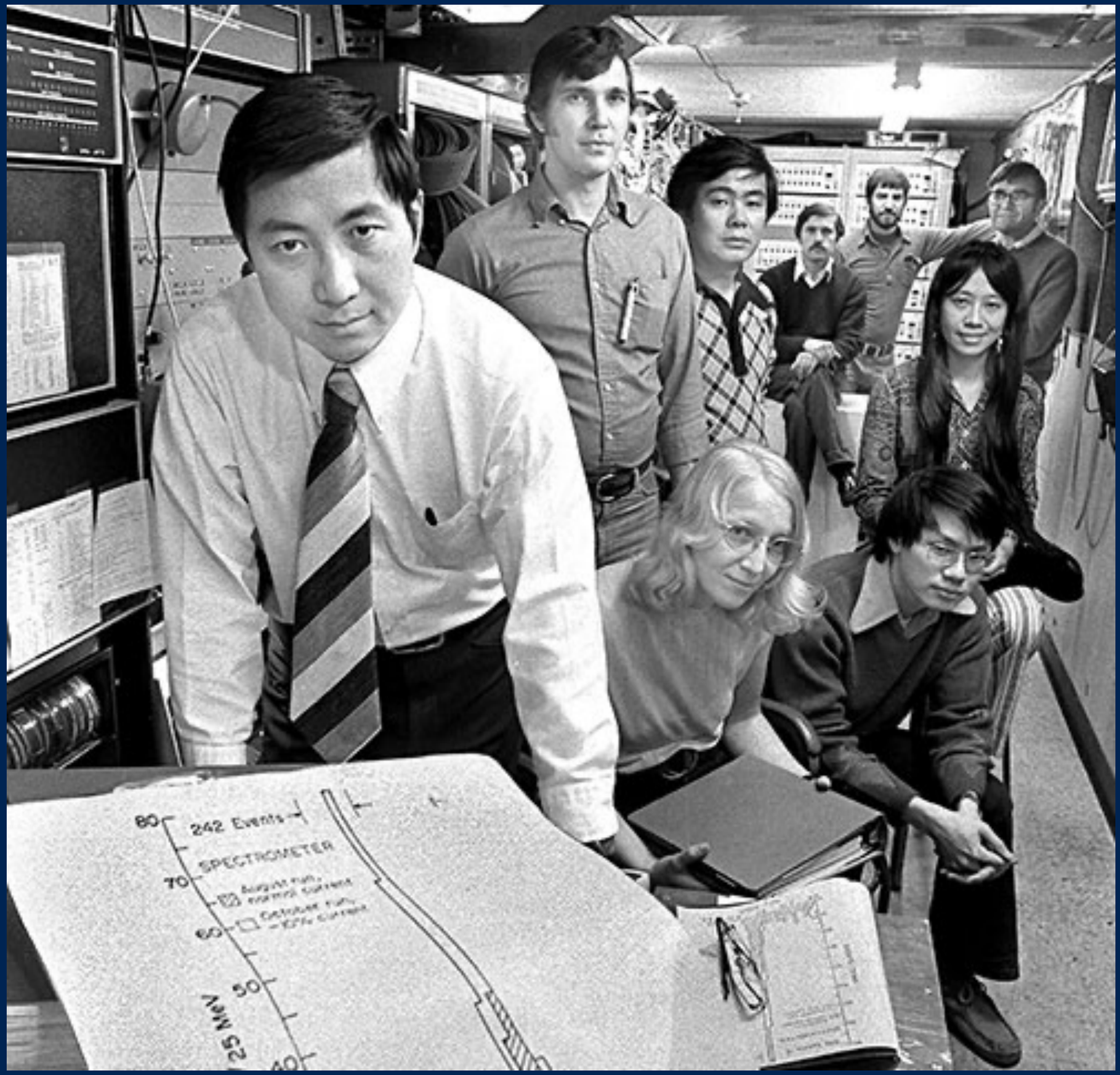
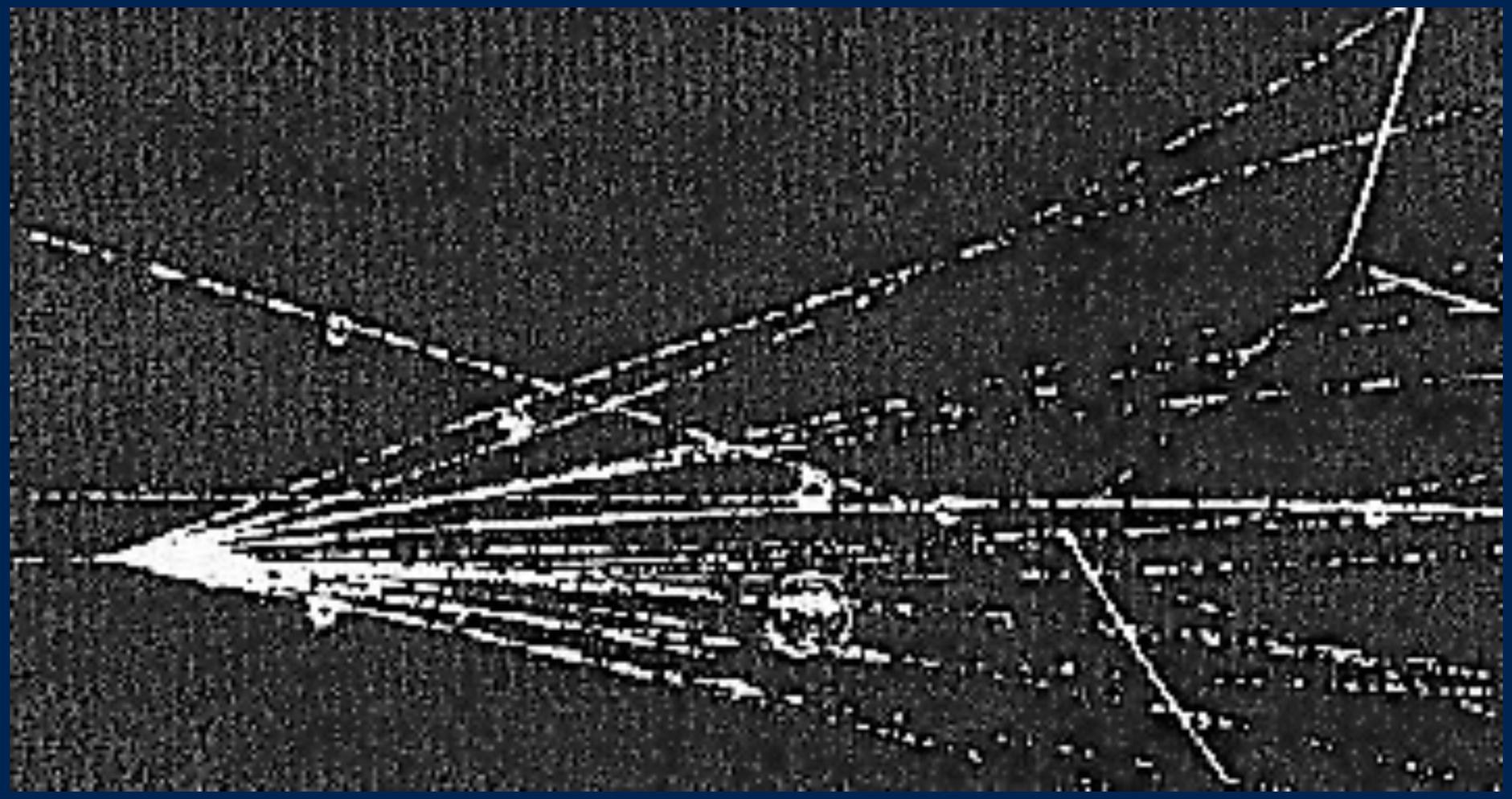


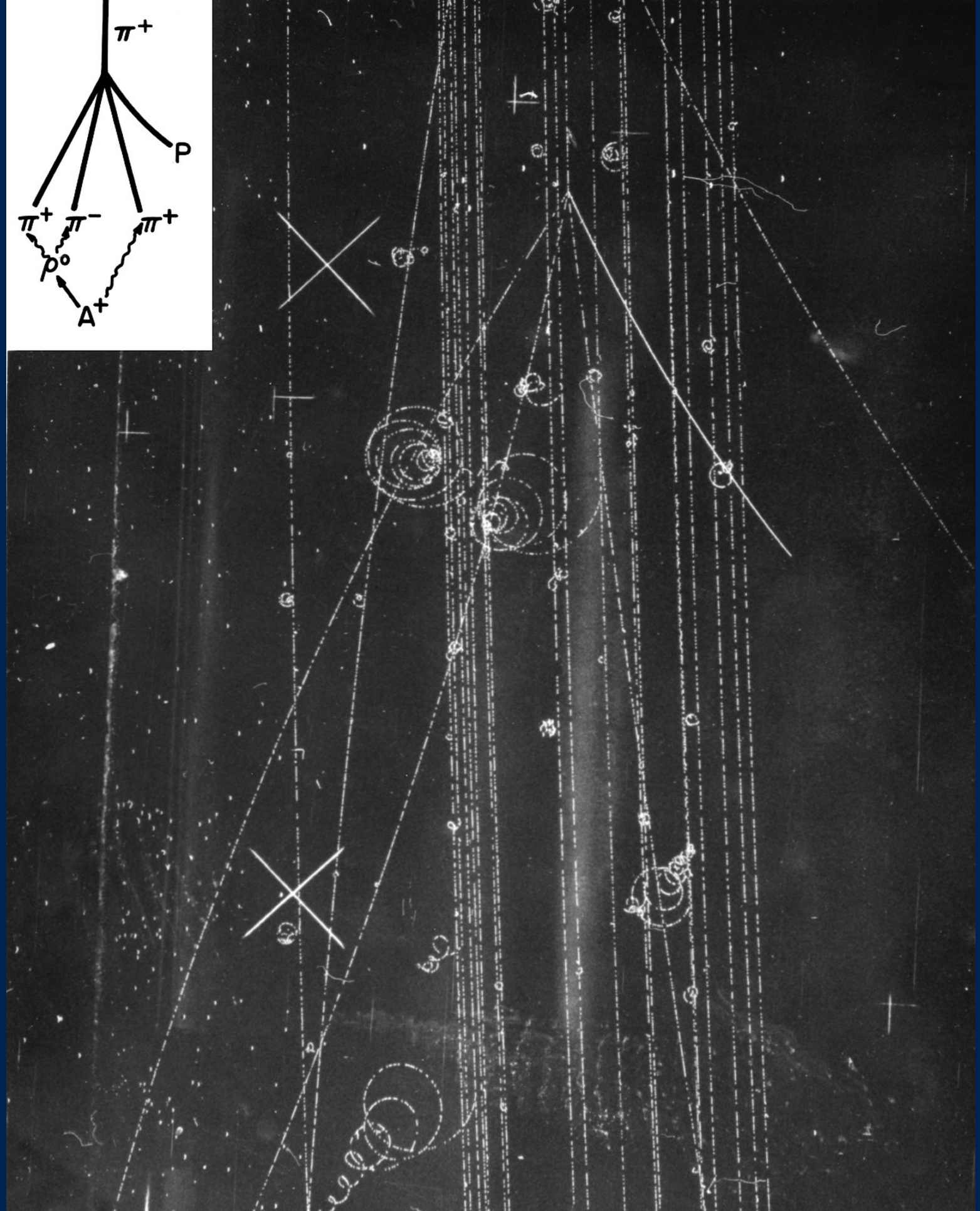
foto BNL

Estas colisiones no son como las de los coches…



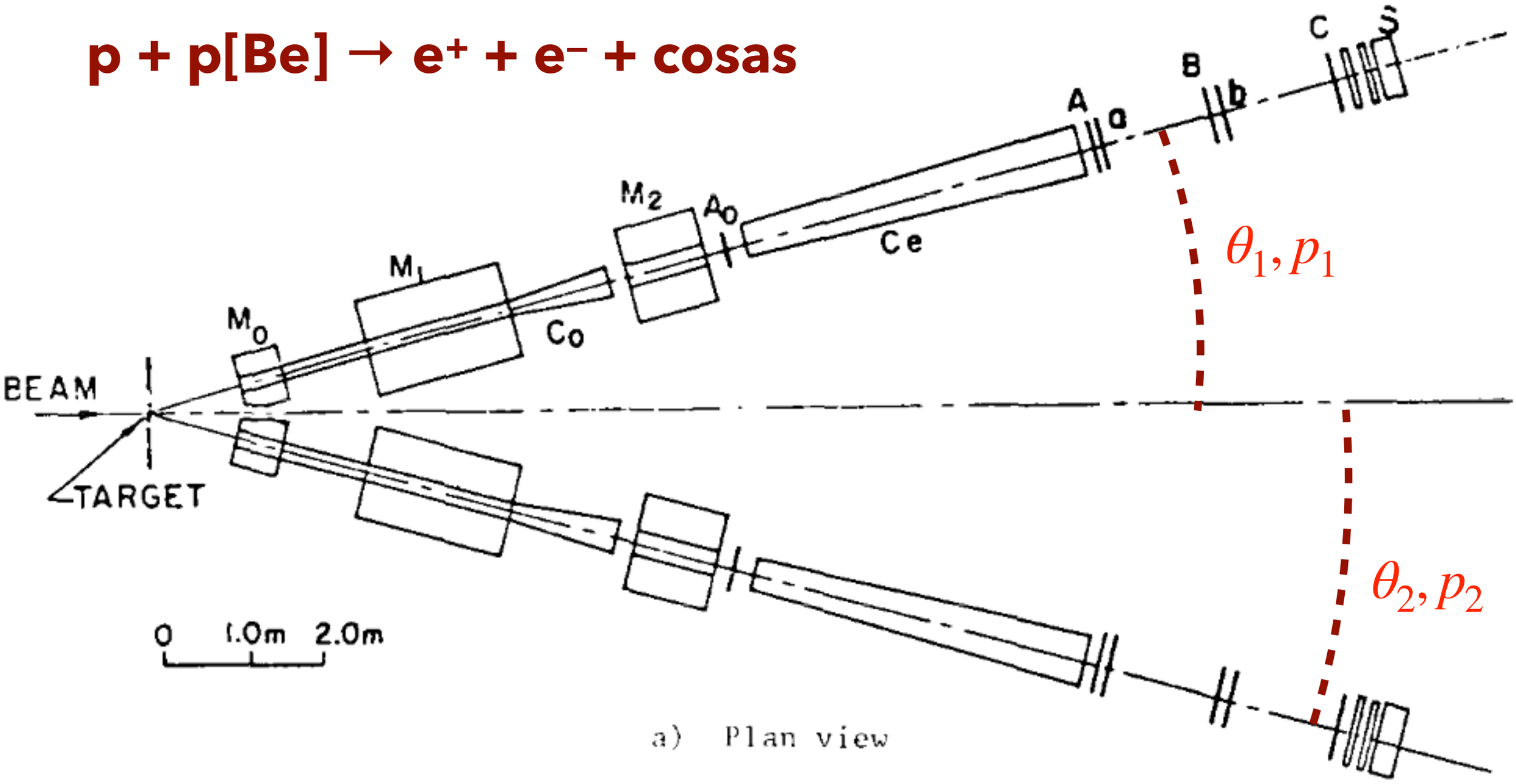
An 18-prong event produced by a 16 GeV/c negative pion beam in the 2 m bubble chamber in 1967.
Foto CERN

$$\pi^- p \rightarrow p\pi^+\pi^+\pi^+\pi^+\pi^+\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-\pi^-\pi^-\pi^-\pi^-\pi^-$$



Bubble chamber event. Inset diagram indicating form of A-plus production in peripheral collision (performed at Brookhaven National Laboratory). Photograph taken January 31, 1964. Bubble Chamber-1348

p + p[Be] → e⁺ + e⁻ + cosas



a) Plan view

https://www.nobelprize.org/uploads/2018/06/ting-lecture.pdf

Si resulta que **p + p → X → e⁺ + e⁻** la masa m de X será:

$$m^2 = m_1^2 + m_2^2 + 2[E_1 E_2 - p_1 p_2 \cos(\theta_1 + \theta_2)]$$

VOLUME 33, NUMBER 23 PHYSICAL REVIEW LETTERS 2 DECEMBER 1974

Experimental Observation of a Heavy Particle J†

J. J. Aubert, U. Becker, P. J. Biggs, J. Burger, M. Chen, G. Everhart, P. Goldhagen, J. Leong, T. McCorriston, T. G. Rhoades, M. Rohde, Samuel C. C. Ting, and Sau Lan Wu
Laboratory for Nuclear Science and Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

and

Y. Y. Lee
Brookhaven National Laboratory, Upton, New York 11973
(Received 12 November 1974)

We report the observation of a heavy particle J, with mass $m = 3.1$ GeV and width approximately zero. The observation was made from the reaction $p + \mathrm{Be} \rightarrow e^+ + e^- + x$ by measuring the e^+e^- mass spectrum with a precise pair spectrometer at the Brookhaven National Laboratory's 30-GeV alternating-gradient synchrotron.

This experiment is part of a large program to study the behavior of timelike photons in $p + p \rightarrow e^+ + e^- + x$ reactions[1] and to search for new particles which decay into e^+e^- and $\mu^+\mu^-$ pairs.

daily with a thin Al foil. The beam spot size is 3×6 mm^2, and is monitored with closed-circuit television. Figure 1(a) shows the simplified side view of one arm of the spectrometer. The two

J. J. Aubert, U. Becker, P. J. Biggs, J. Burger, M. Chen, G. Everhart, P. Goldhagen, J. Leong, T. McCorriston, T. G. Rhoades, M. Rohde, Samuel C. C. Ting, Sau Lan Wu, and Y. Y. Lee

Phys. Rev. Lett. 33, 1404 – Published 2 December 1974

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The observation was made from the reaction p+Be→e++e−+x by measuring the e+e− mass spectrum with a precise pair spectrometer at the Brookhaven National Laboratory's 30-GeV alternating-gradient synchrotron.

Received 12 November 1974

Discovery of a Narrow Resonance in e^+e^- Annihilation

J. -E. Augustin *et al.*
Phys. Rev. Lett. **33**, 1406 – Published 2 December 1974

Physics See Focus story: *Landmarks*—The Charming Debut of a New Quark

An article within the collection: Letters from the Past - A PRL Retrospective

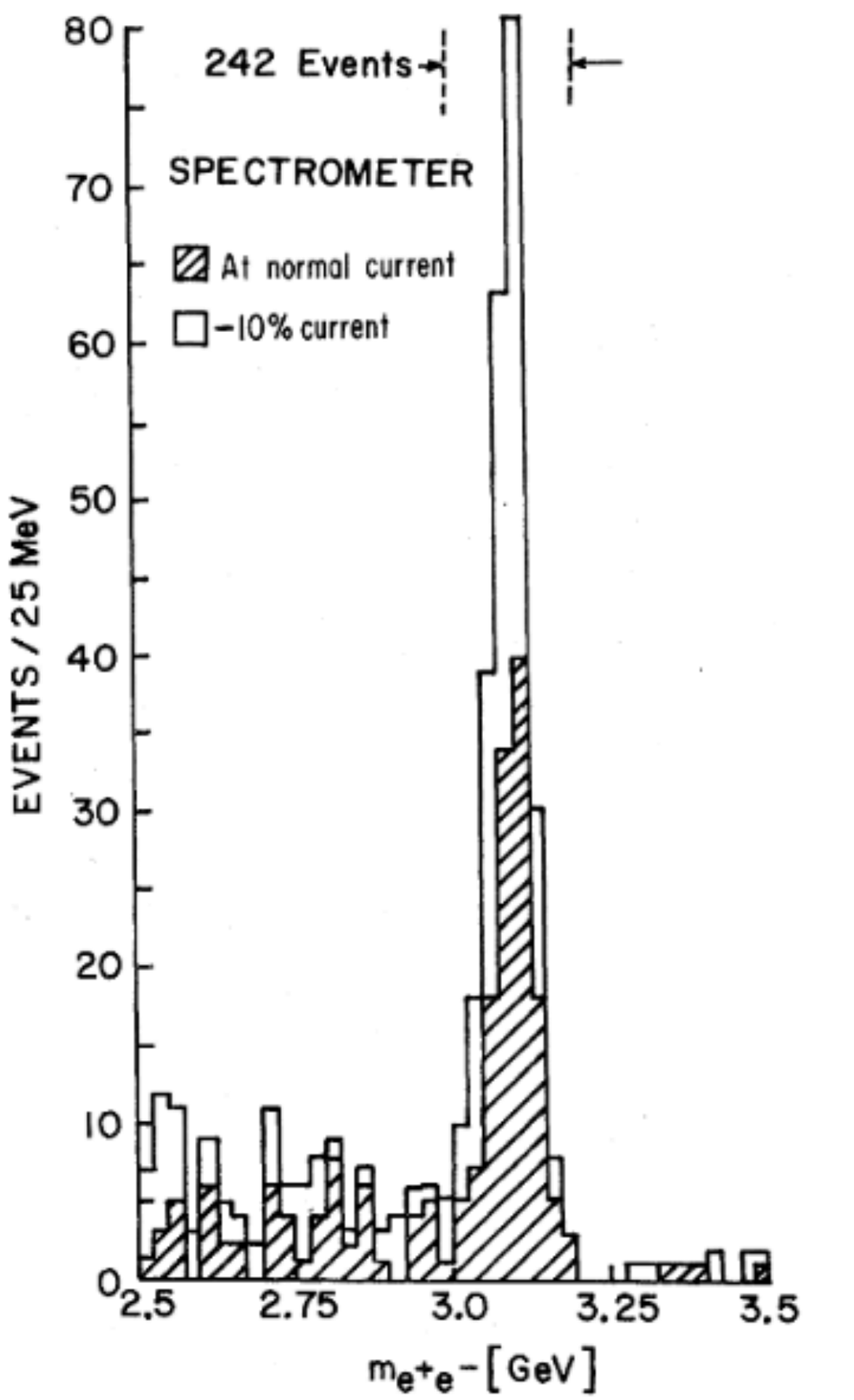


FIG. 2. Mass spectrum showing the existence of J. Results from two spectrometer settings are plotted showing that the peak is independent of spectrometer currents. The run at reduced current was taken two months later than the normal run.

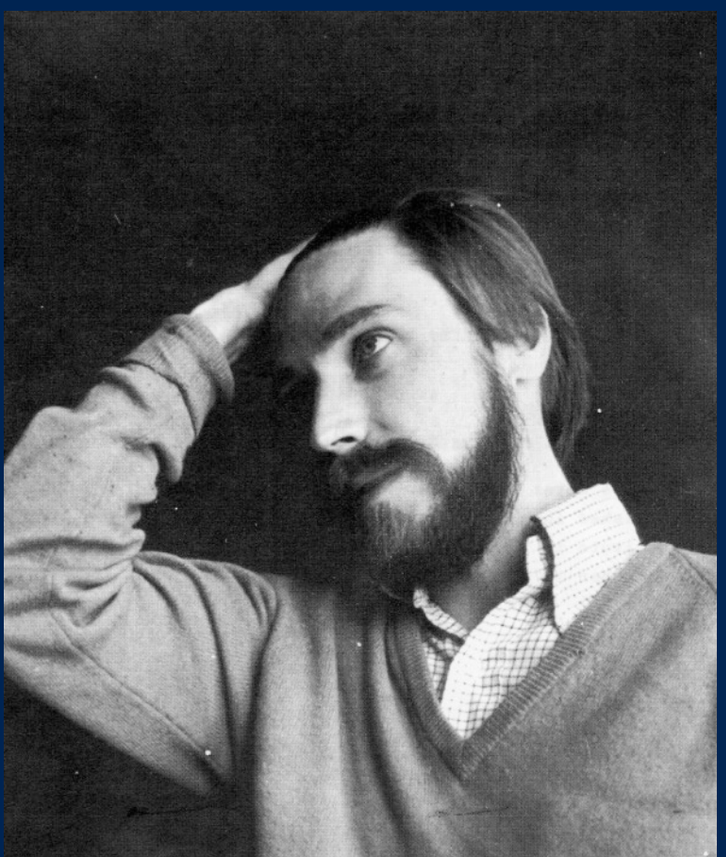
S. Glashow:

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

VOLUME 34, NUMBER 1 PHYSICAL REVIEW LETTERS 6 JANUARY 1975

Is Bound Charm Found?*

A. De Rújula
Lyman Laboratory of Physics, Harvard University, Cambridge, Massachusetts 02138

and

S. L. Glashow†
Center for Theoretical Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

(Received 27 November 1974)

We argue that the newly discovered narrow resonance at 3.1 GeV is a $^3S_1$ bound state of charmed quarks and we show the consistency of this interpretation with known meson systematics. The crucial test of this notion is the existence of charmed hadrons near 2 GeV.

A surprisingly narrow resonance at $M = 3.1$ GeV was discovered in $p + \mathrm{Be} \to e^+ + e^- + \ldots$[1] and in e^+e^- annihilation.[2] Estimates[3] of its decay

variant. It contributes to the singlet mass. We suggest that the remaining term is just the sum of the quark masses plus a common additive con-

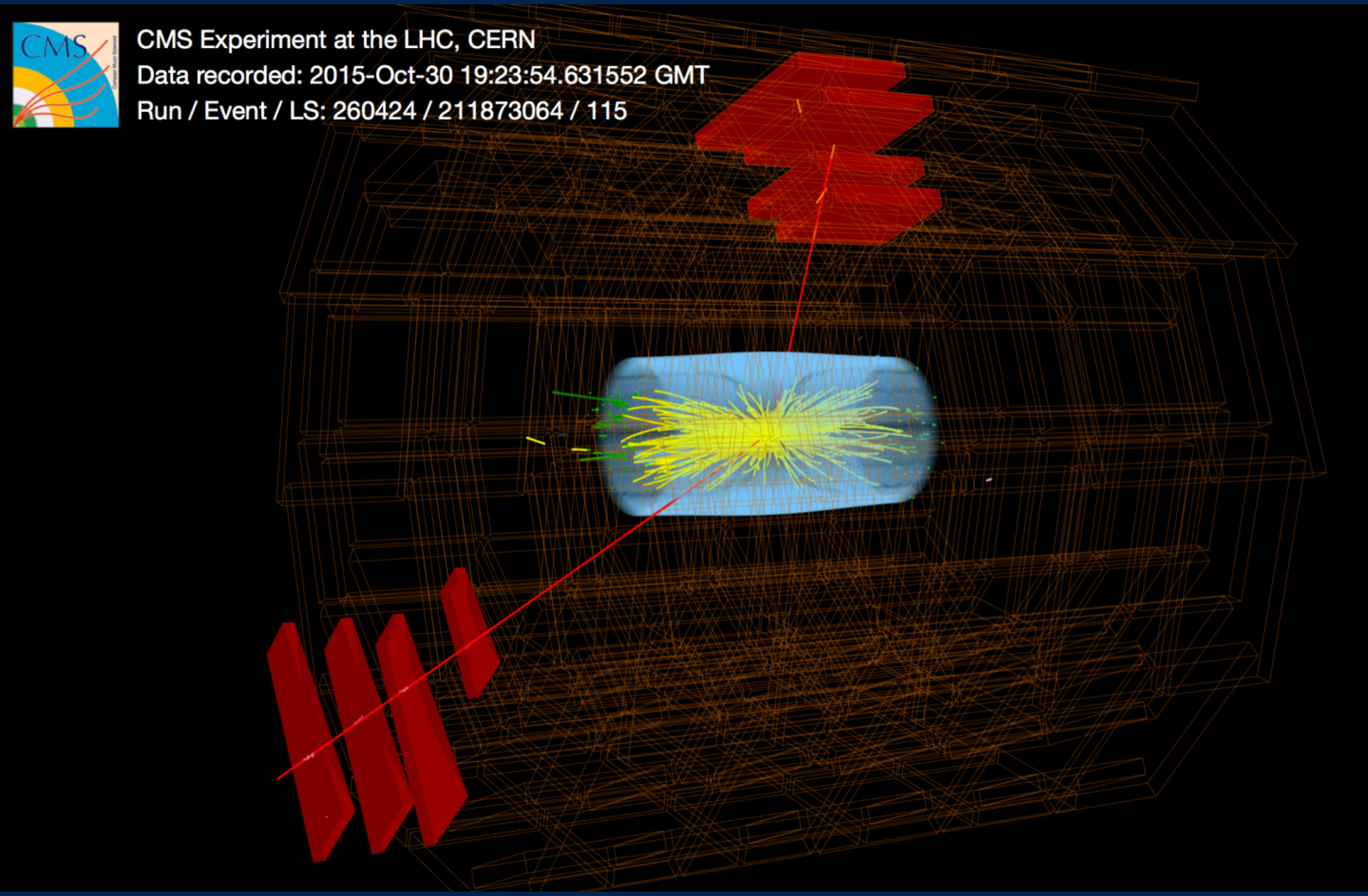
Ahora nos toca a nosotros

Gracias a CMS que nos cede sus parejas de muones o electrones, usados, pero muy bien seleccionados y limpios…

CMS Experiment at the LHC, CERN

Data recorded: 2015-Oct-30 19:23:54.631552 GMT

Run / Event / LS: 260424 / 211873064 / 115



CMS Experiment at the LHC, CERN
Data recorded: 2015-Oct-30 19:23:54.631552 GMT
Run / Event / LS: 260424 / 211873064 / 115

μ^+

p

p

μ^-

CMS Experiment at the LHC, CERN
Data recorded: 2015-Oct-30 19:23:54.631552 GMT
Run / Event / LS: 260424 / 211873064 / 115

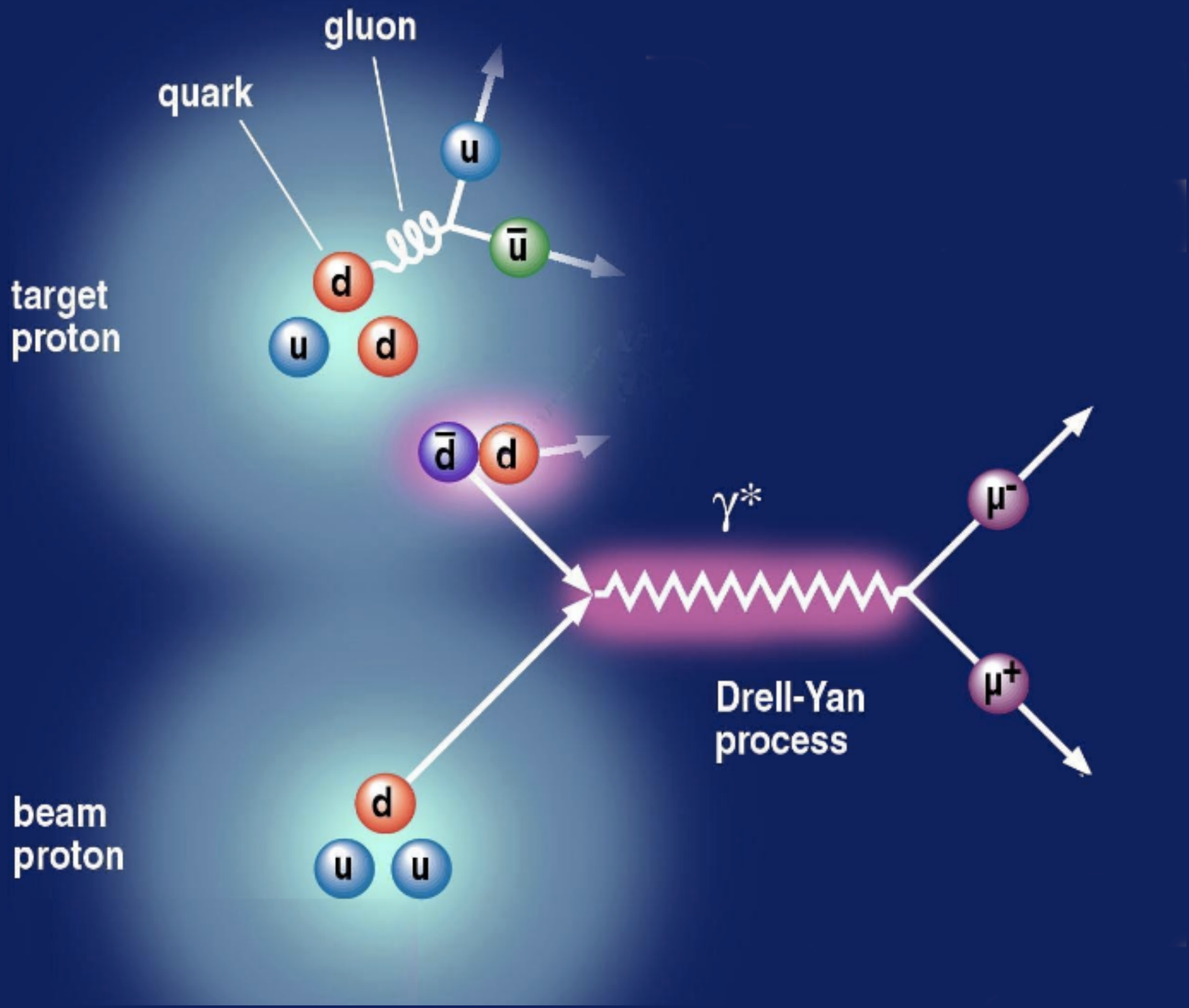
μ^+

p

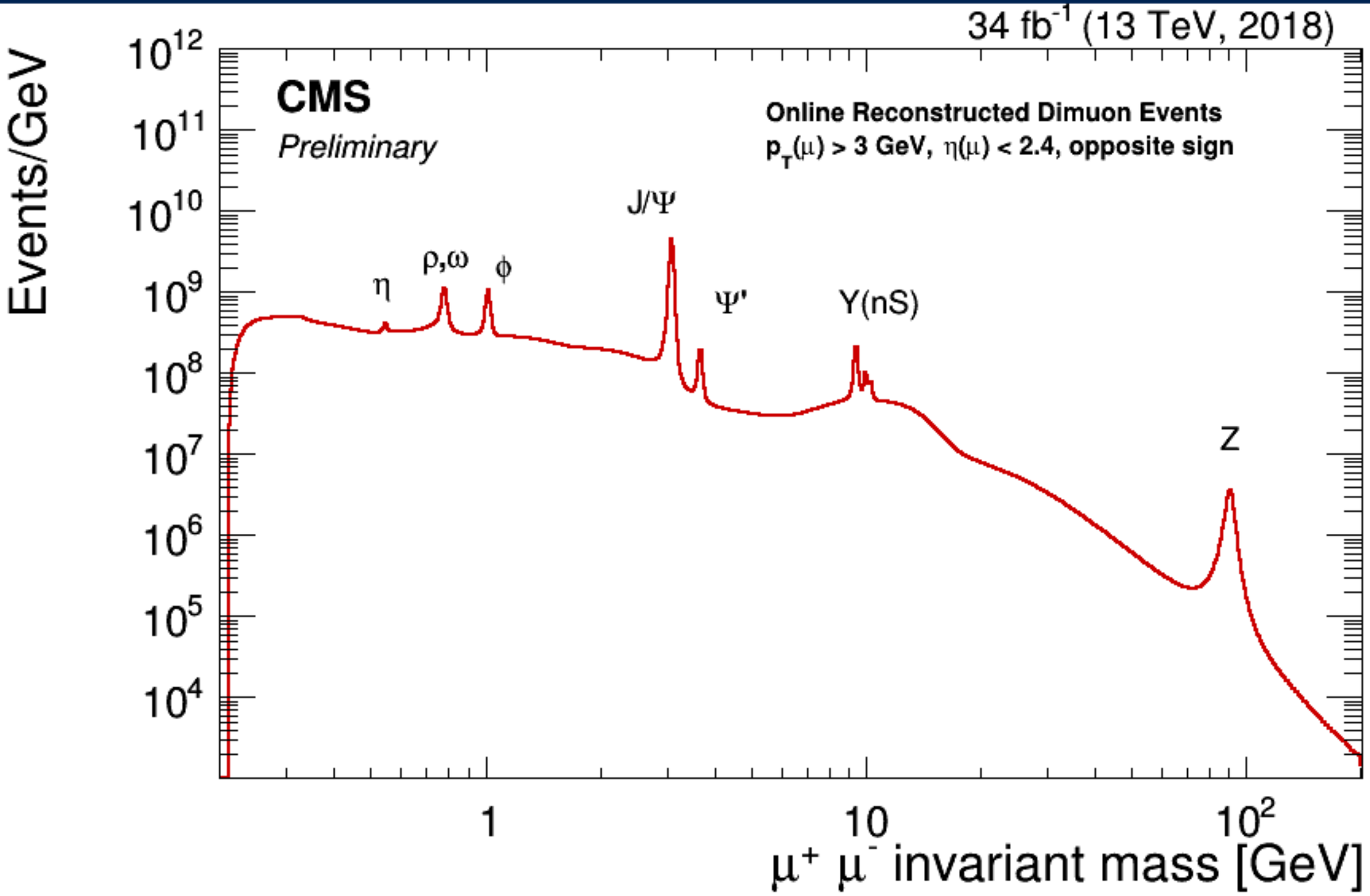
p

$p + p \rightarrow X \rightarrow \mu^+ + \mu^-$

μ^-



otras maneras
de obtener $\mu^+ + \mu^-$


34 fb-1 (13 TeV, 2018)
CMS
Preliminary
Online Reconstructed Dimuon Events
pT(μ) > 3 GeV, η(μ) < 2.4, opposite sign
Events/GeV
η
ρ,ω
ϕ
J/Ψ
Ψ'
Y(nS)
Z
μ+ μ- invariant mass [GeV]

Otras posibilidades:

Z, Higgs


THE FORCES IN NATURE
TYPE
INTENSITY OF FORCES (DECREASING ORDER)
BINDING PARTICLE (FIELD QUANTUM)
OCCURS IN
STRONG NUCLEAR FORCE
GLUONS (NO MASS)
ATOMIC NUCLEUS
ELECTRO-MAGNETIC FORCE
PHOTON (NO MASS)
ATOMIC SHELL ELECTROTECHNIQUE
WEAK NUCLEAR FORCE
RADIOACTIVE BETA DISINTEGRATION
GRAVITATION
GRAVITON ?
HEAVENLY BODIES
THE EXCHANGE OF PARTICLES IS RESPONSIBLE FOR THE FORCES
Dr. Carlo RUBBIA.
Groupe UA-1
Pr. Herwig SCHOPPER
Directeur General CERN


LEP
W±
Z°
STOCHASTIC ! COOLING !

The New York Times

Founded in 1851

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ARTHUR HAYS SULZBERGER, *Publisher 1935-1961*
ORVIL E. DRYFOOS, *Publisher 1961-1963*

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Europe 3, U.S. Not Even Z-Zero

A team of 126 scientists at the CERN accelerator in Geneva reports proof of an important new subatomic particle, the Z-zero. The discovery carries two messages. The good news is that it confirms a major theory about the fundamental forces of nature. The bad news is that Europeans have taken the lead in the race to discover the ultimate building blocks of matter.

Spurred by an esthetic faith that nature's laws are at root elegantly simple, physicists have long tried to embrace the four basic forces of nature within a unified framework. A theory that unites two of the forces, electromagnetism and the "weak" nuclear force seen in radioactivity, predicts three new particles known as intermediate vector bosons. Dubbed the W+, the W- and the Z-zero, the bosons would mediate the weak force just as the photon mediates the force of electromagnetism.

Looking for the bosons was to be a prime task of the $500 million accelerator being constructed at Brookhaven on Long Island. But while the Brookhaven machine fell behind schedule, the Geneva accelerator was cunningly upgraded to the energy range at which bosons might be created.

CERN announced discovery of the two W bosons last January and has now found the Z-zero. With that and the previous discovery of "gluons" at a German machine, European accelerators have established a better record of success than any of the three American laboratories.

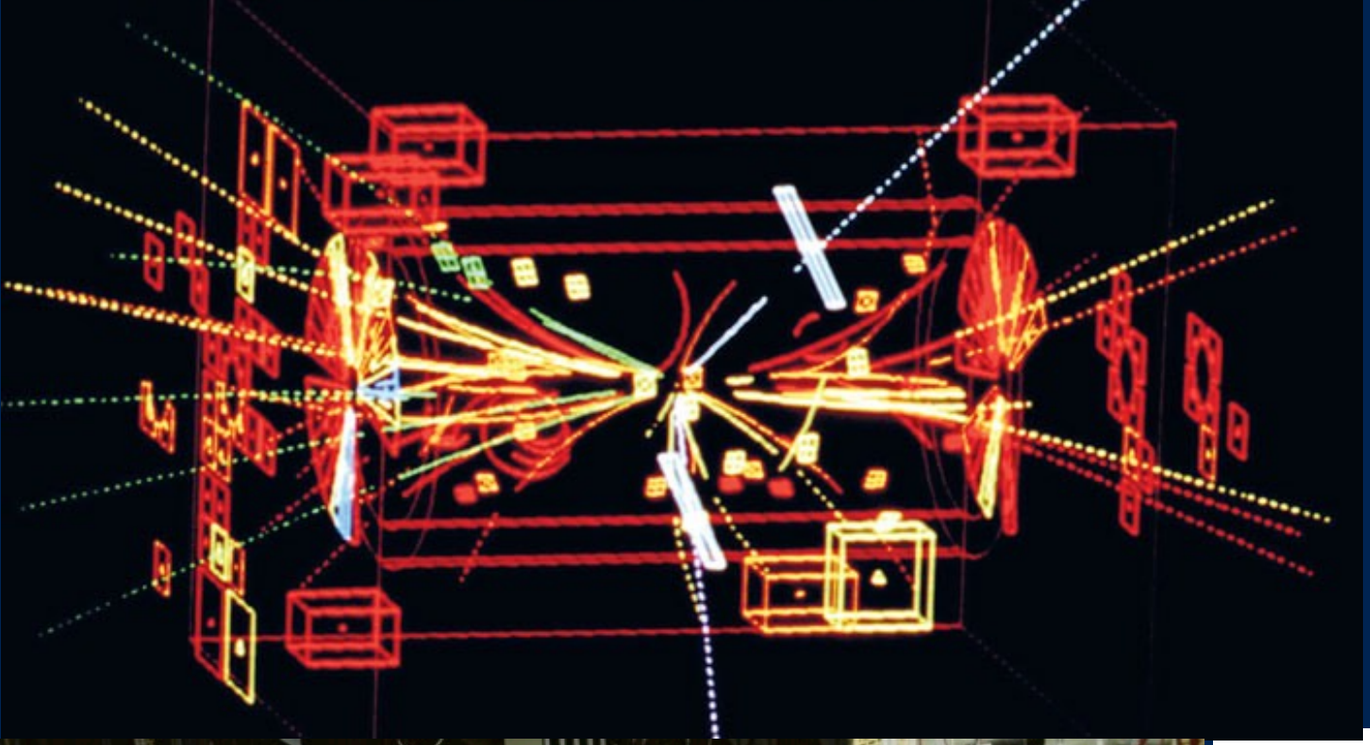
American physicists blame lack of Federal support. But some observers, like the President's science adviser, George Keyworth, blame the physicists for routinely spreading funds among the three major American research centers. "Our world leadership in high energy physics has been dissipated," he has said. "In the years American physicists squandered on a pork barrel squabble, the Europeans moved boldly ahead."

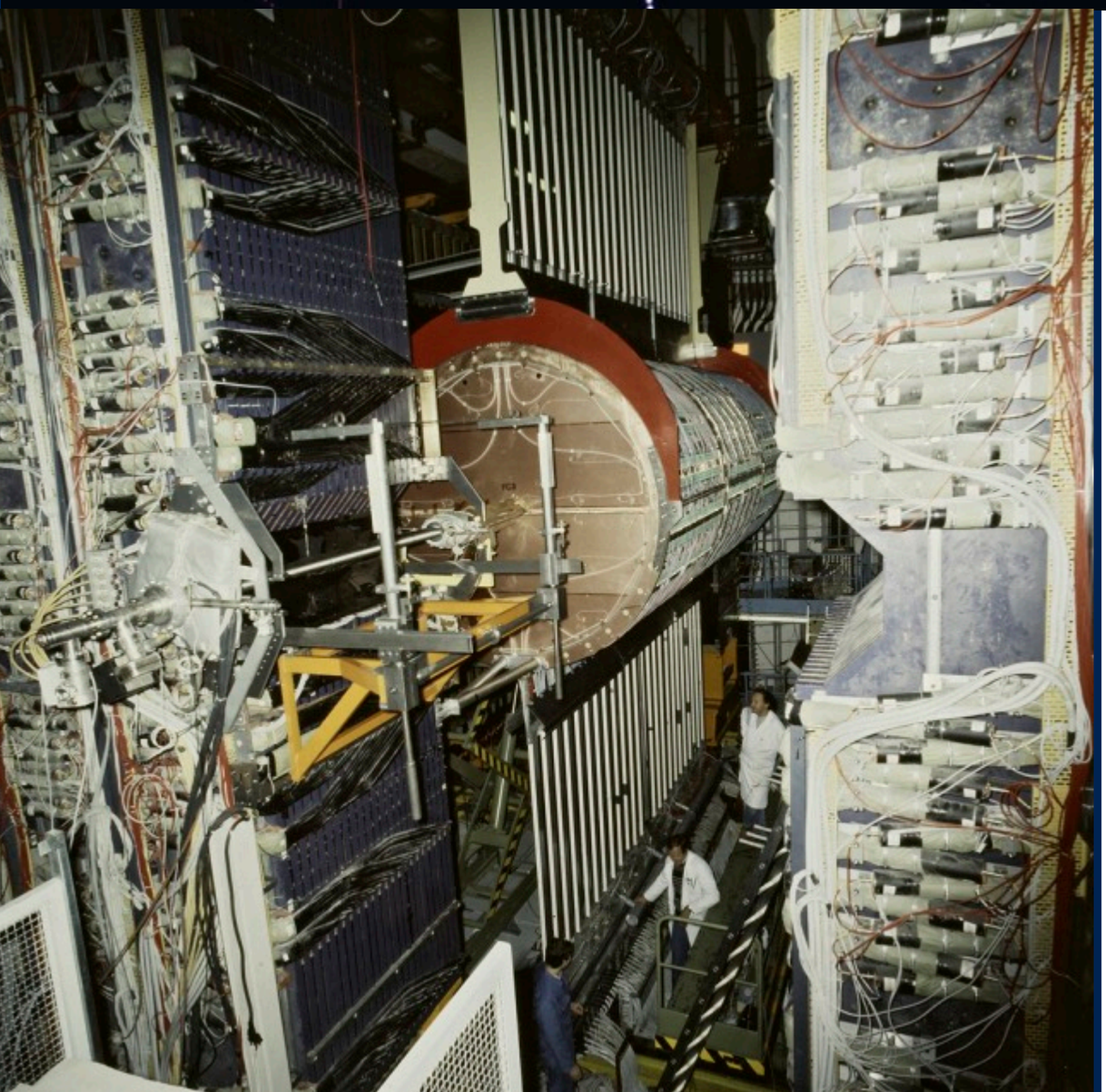
•

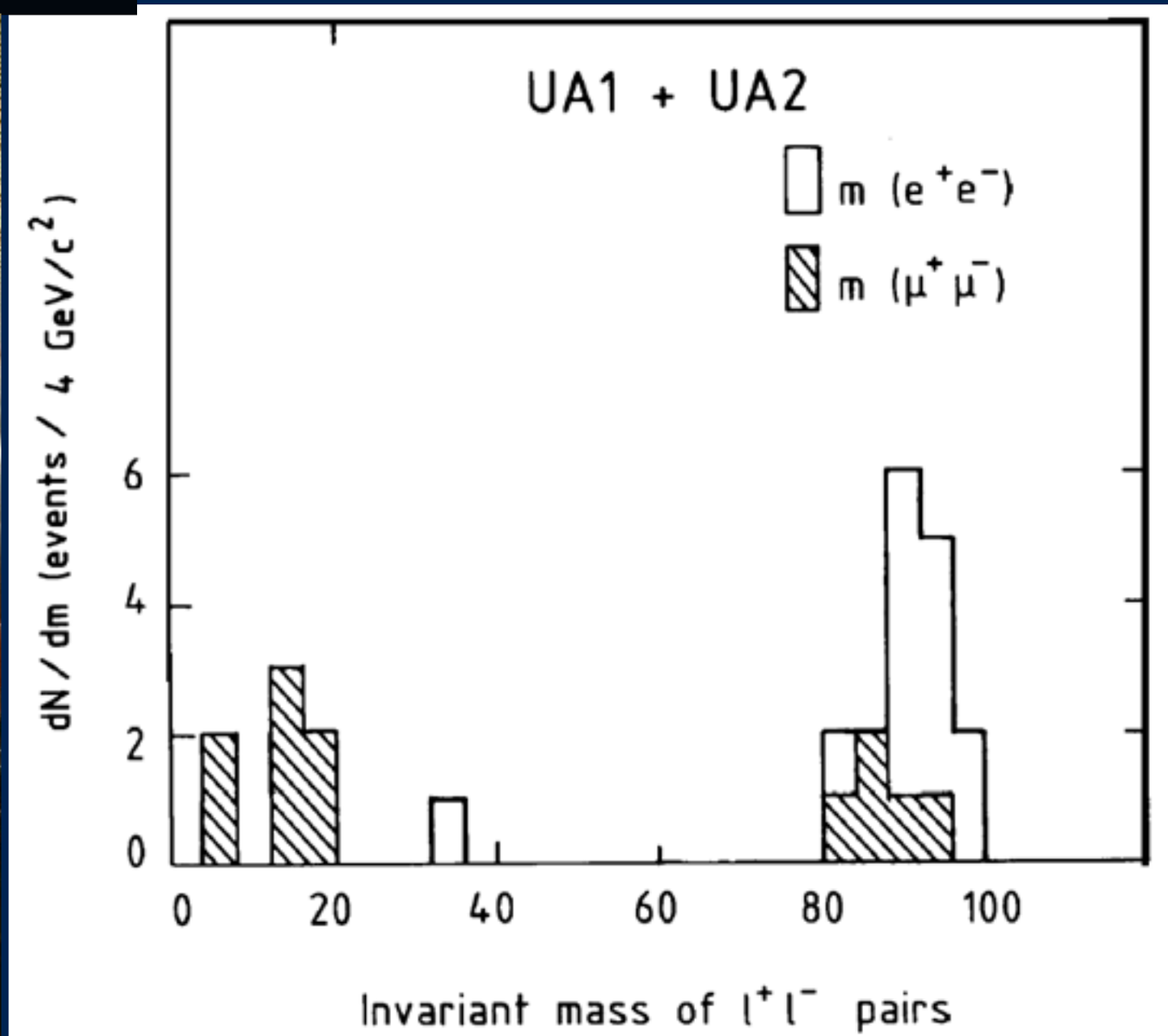
Narrow national comparisons have little meaning in physics. Several of the "European" successes were due to American physicists working at European machines. But competition is a useful spur, and American accelerators should be designed to win or not be built at all. The string of European successes underscores the strengths of cautious design, consolidated effort and plans and budgets that allow machines to come in on time.

A panel of American physicists is meeting this week at Woods Hole to decide the fate of the limping Brookhaven accelerator and to plan a new machine for the future. The tougher the competition they can arrange for their European colleagues, the faster will be the advance of knowledge.

The 3-0 loss in the boson race cries out for earnest revenge. The physics team needs to try harder, and coach Keyworth should reward any sensible new strategy with management's full support.

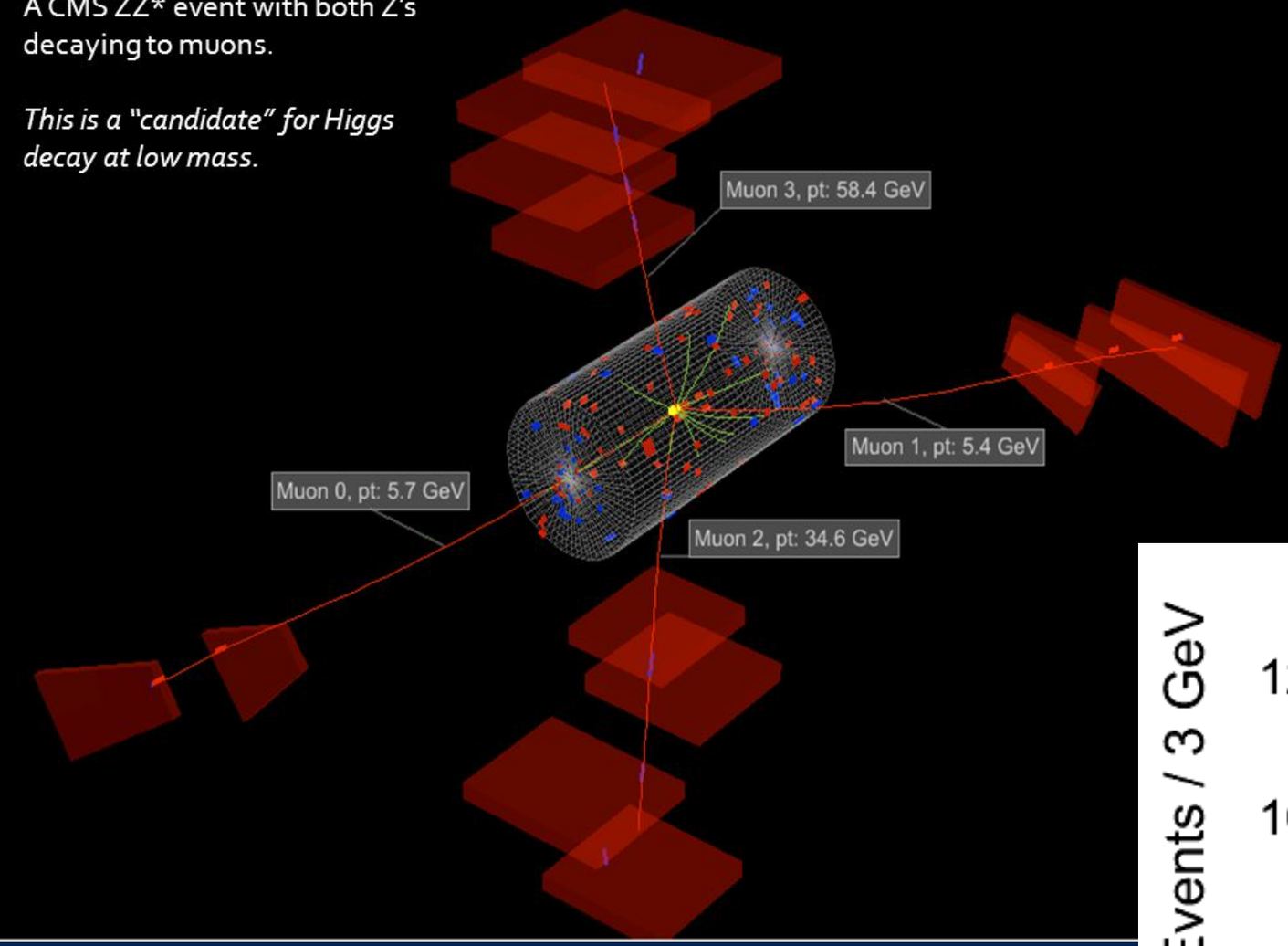


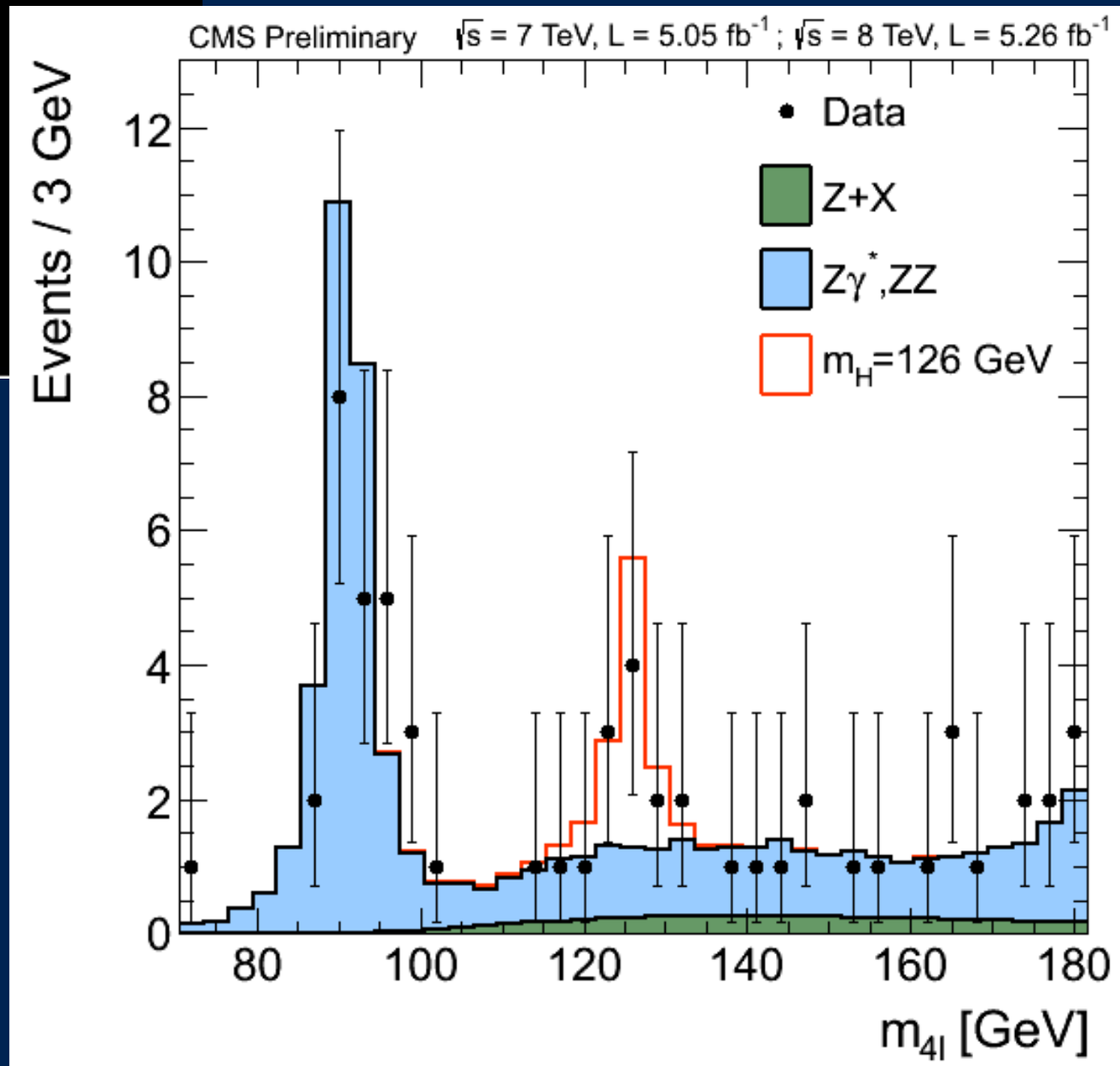



UA1 + UA2
m (e+e−)
m (μ+μ−)
dN / dm (events / 4 GeV/c2)
0
2
4
6
0
20
40
60
80
100
Invariant mass of l+l− pairs

A CMS ZZ* event with both Z's decaying to muons.

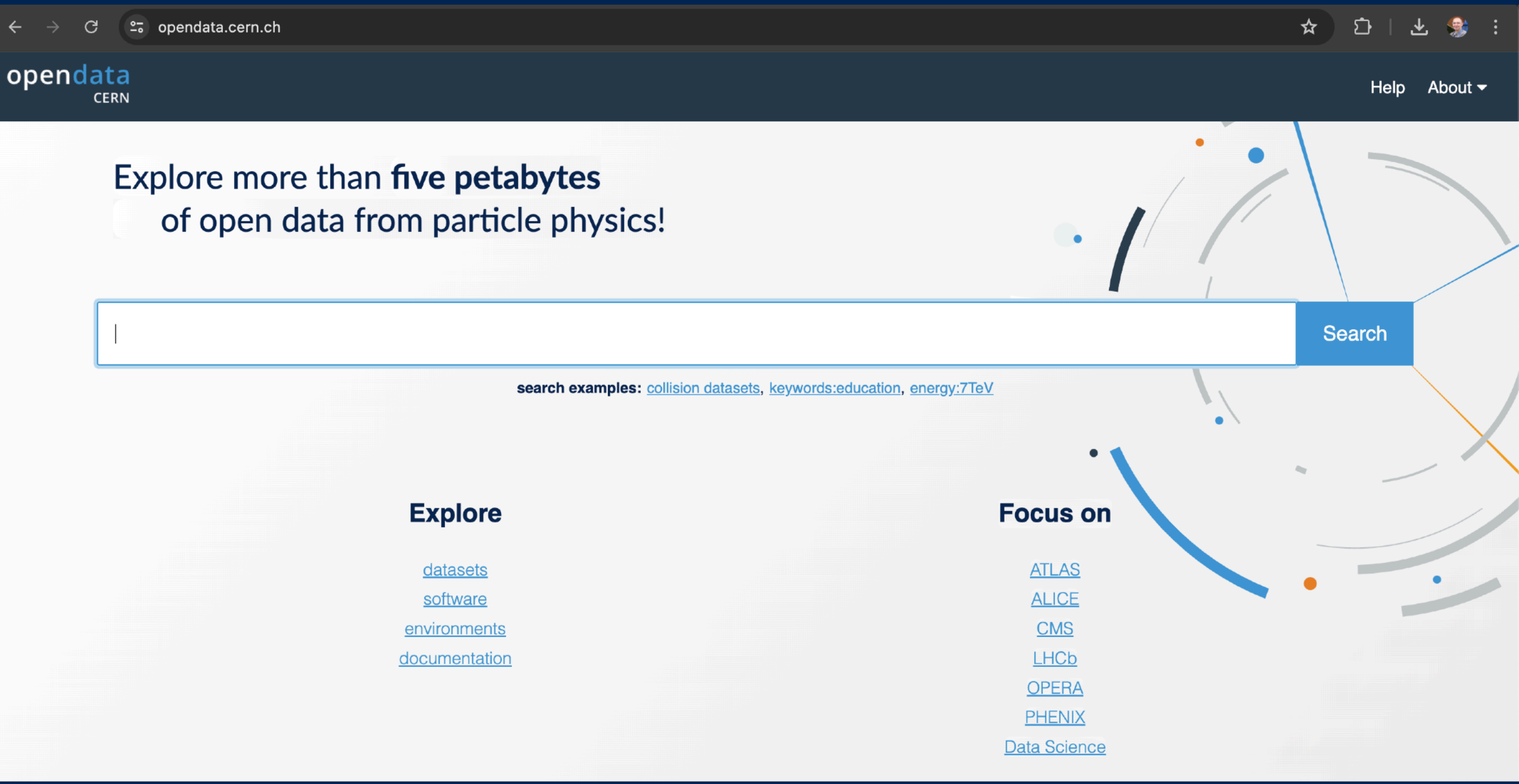
This is a "candidate" for Higgs decay at low mass.





Dónde encontrar material apropiado y cómo usarlo

opendata.cern.ch



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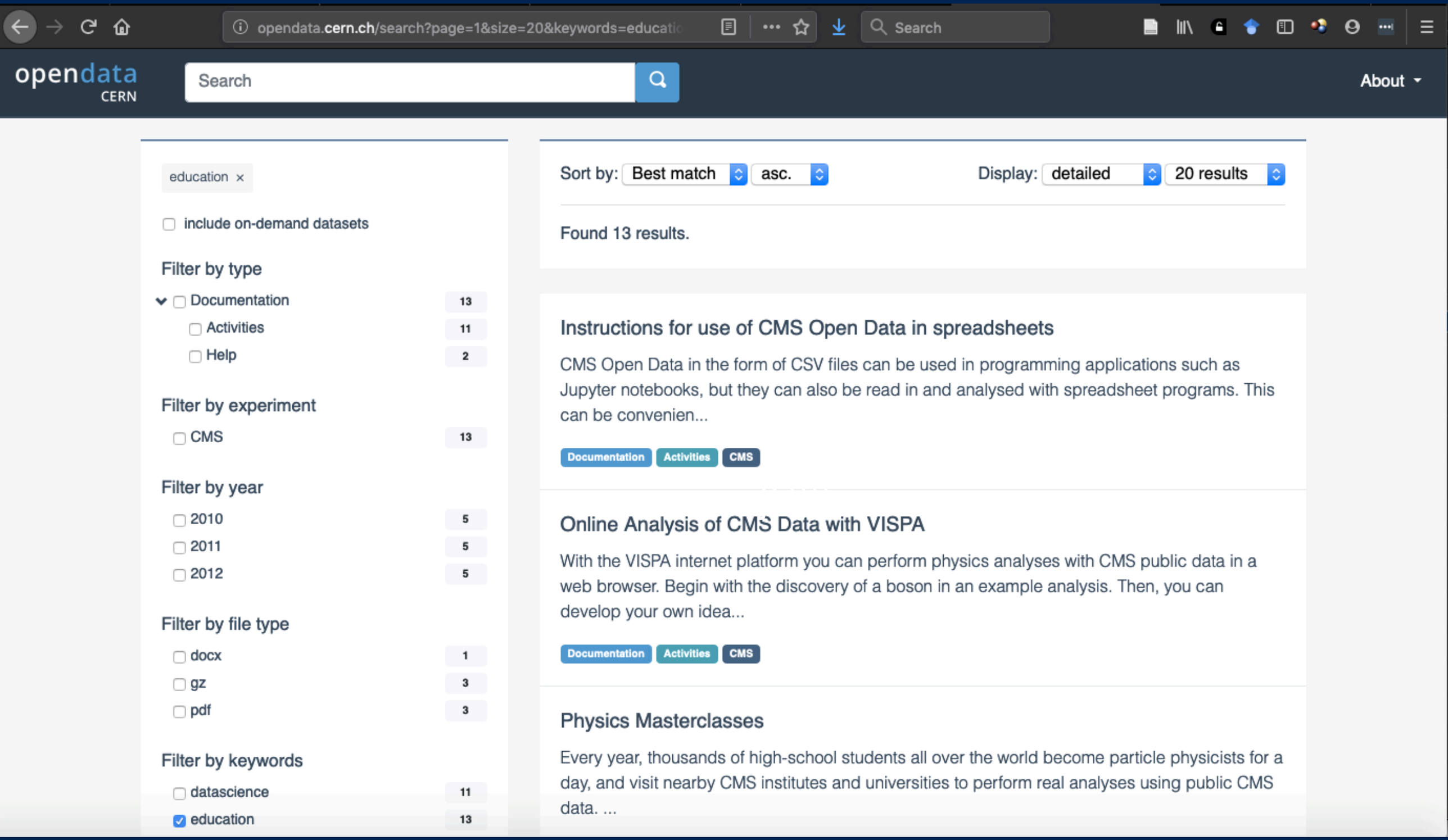

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Jupyter notebooks using CMS Open Data

CMS Open Data in the form of CSV files can be used in programming applications such as Jupyter notebooks. These example notebooks have been prepared as a tutorial to introduce Jupyter and CMS Open...

Documentation Activities CMS

Worksheets and instructions for schools prepared during the High School Teacher Programme 2016

During the High School Teacher Programme in 2016 at CERN, a working group prepared worksheets and instructions on the use of open data in schools. Different aspects of open data were addressed: vi...

Documentation Activities CMS

Instructions for use of CMS Open Data in R

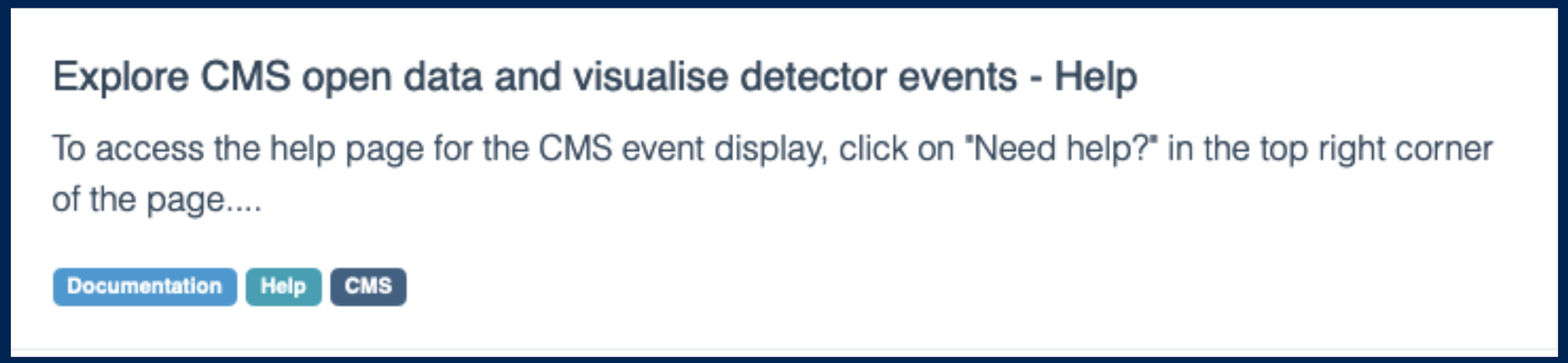
CMS Open Data in the form of CSV files can be used in programming applications such as Jupyter notebooks or R. A tutorial is provided to introduce R and CMS Open Data. You can access the repositor...

Documentation Activities CMS

Instructions for use of CMS Open Data in spreadsheets

CMS Open Data in the form of CSV files can be used in programming applications such as Jupyter notebooks, but they can also be read in and analysed with spreadsheet programs. This can be convenien...

Documentation Activities CMS



http://opendata.cern.ch/record/5103

http://opendata.cern.ch/visualise/events/cms

Una posibilidad sencilla: usar una muestra *limpia* de *dimuones* para redescubrir la partícula J/Ψ o el bosón Z

The events in this derived dataset were 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.

opendata CERN

dimuon

include on-demand datasets

Filter by type

- Dataset 12
  - Collision 7
  - Derived 5
- Documentation 1
  - Guide 1
- Software 6
  - Analysis 3
  - Tool 1
  - Validation 2

Sort by: Best match asc. Display: detailed 20 results

Found 19 results.

Dimuon events with invariant mass range 2-5 GeV for public education and outreach

The collaboration approved 2000 dimuon events around the J/psi for use in education and outreach. This record contains the necessary files for these use-cases.

These data were selected for u...

Dataset Derived CMS

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. Files with an underscore contain 10k...

Dataset Derived CMS

Dimuon events for use in outreach and education

The CMS collaboration has approved the release of 100k dimuon events in the invariant mass range 2-110 GeV for use in outreach and education. This document contains the files for this release.

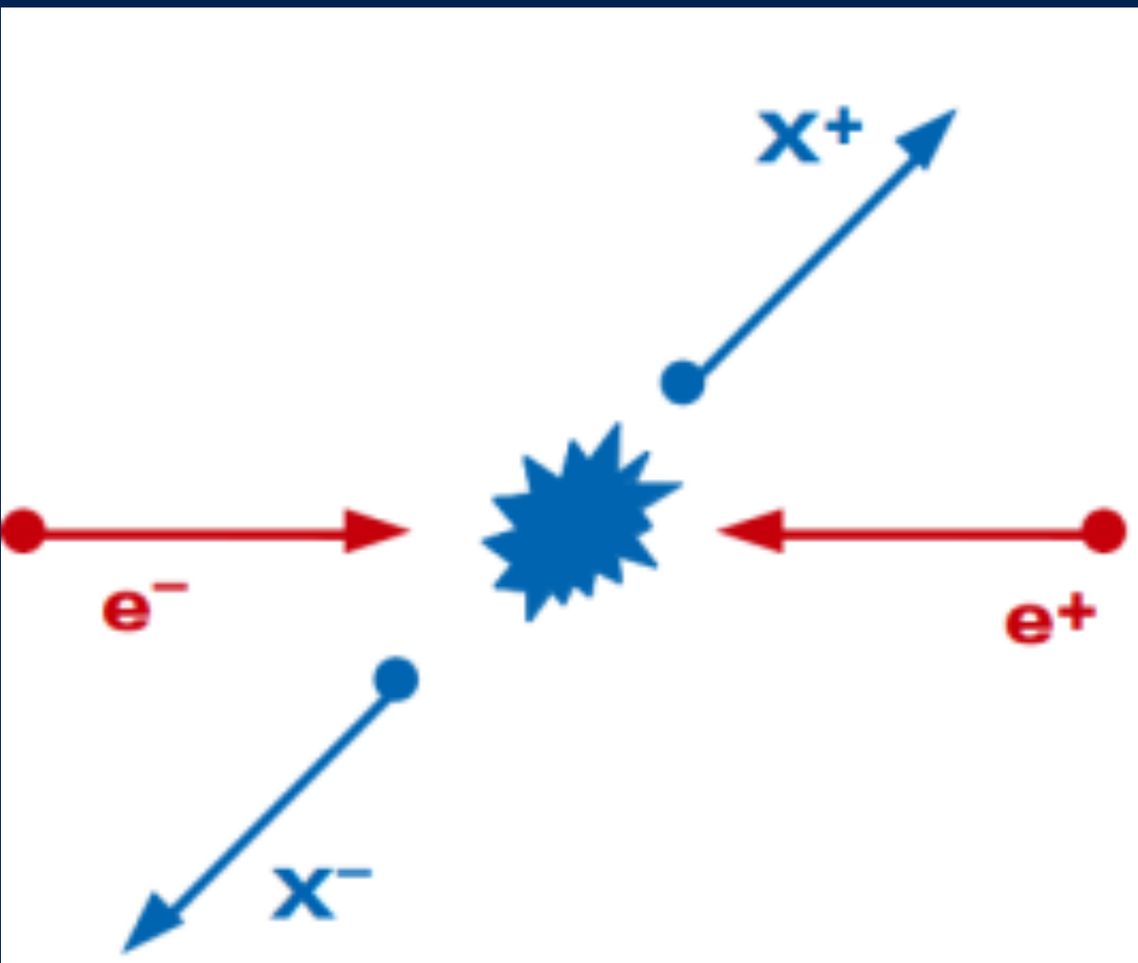
Herramientas necesarias:

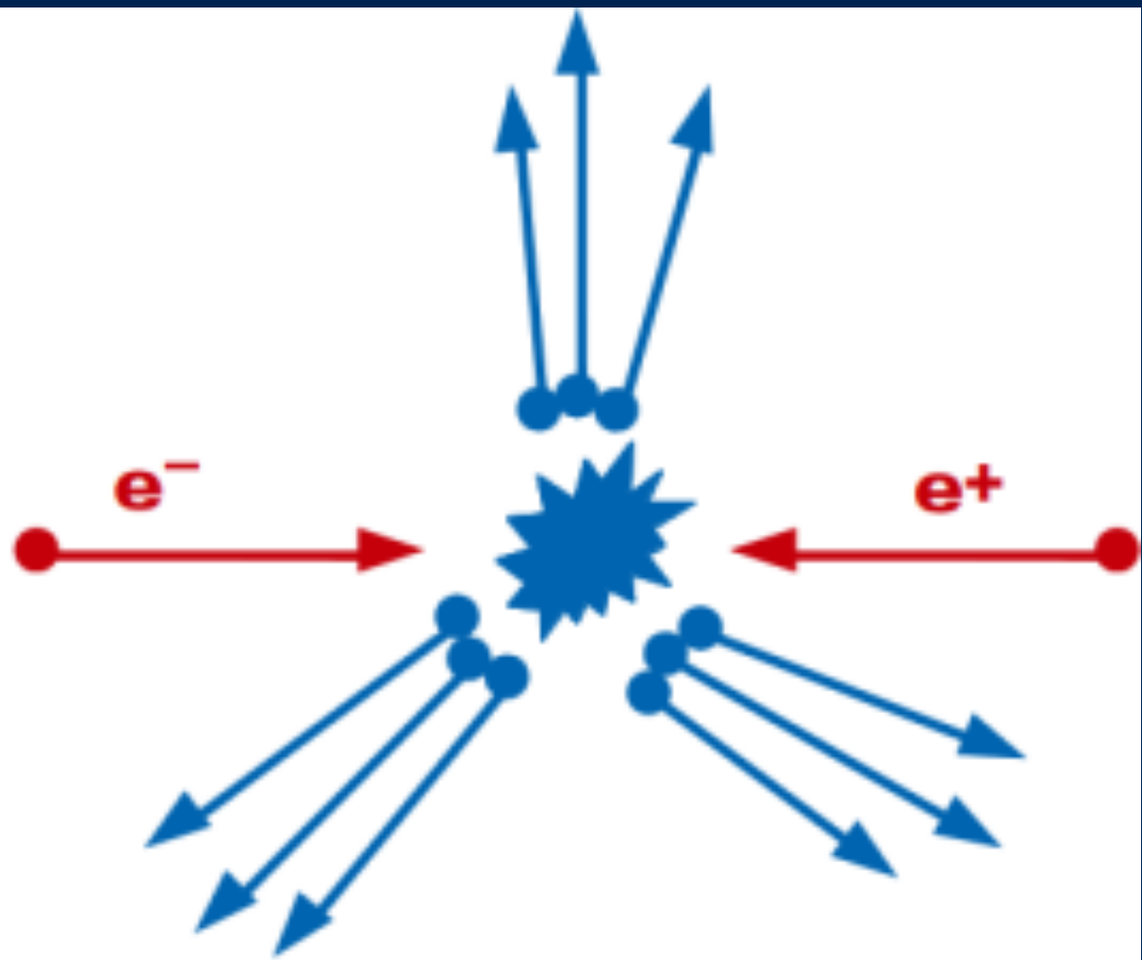
1. Entendimiento básico del funcionamiento de un detector
2. Ley de conservación de la energía y el momento $(E, \vec{p})$
3. Expresión relativista de la energía de una partícula:

$$E^2 = (pc)^2 + \left(mc^2\right)^2$$

Aquí están los detalles:

https://fbarradass.wordpress.com/2011/05/13/%C2%BFcomo-saber-si-se-ha-descubierto-una-particula-1/

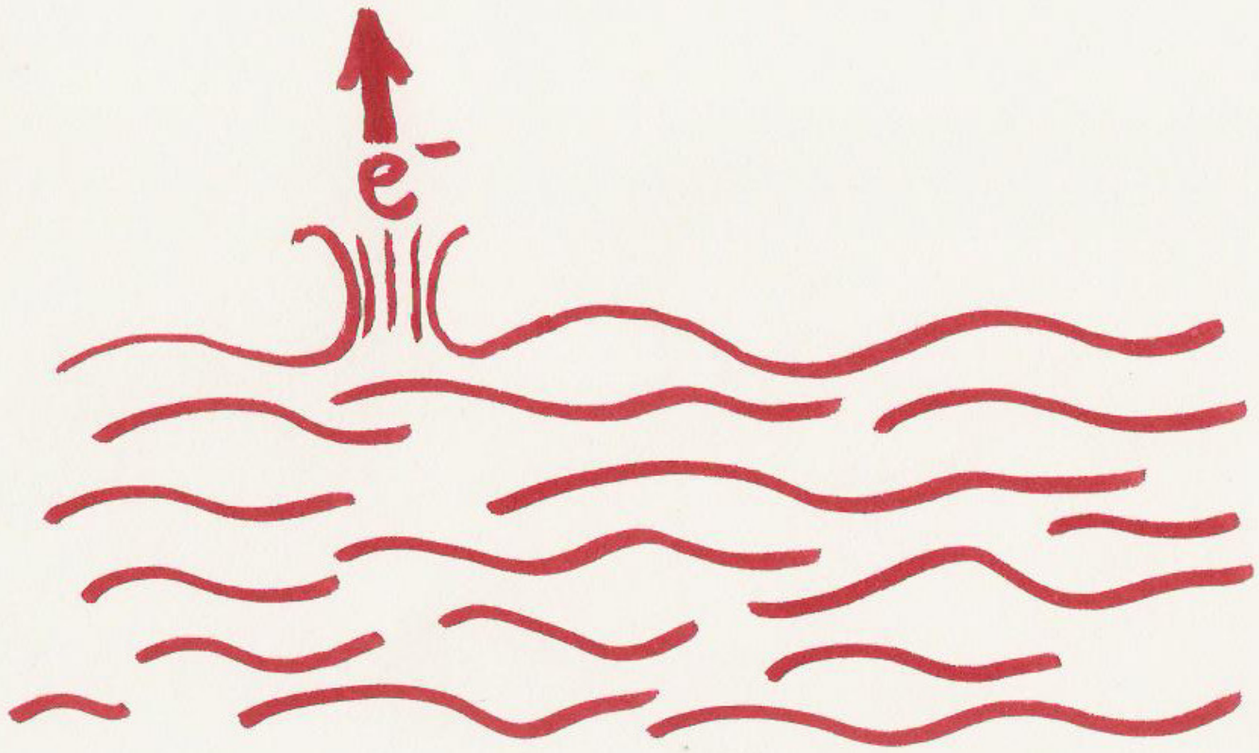




Cuando chocan un electrón y un positrón a altas energías hay muchas posibilidades distintas; en primer lugar podrían "rebotar" sin más (colisión elástica), pero más comúnmente se aniquilan y como resultado ***final*** aparecen nuevas partículas como

- parejas partícula / antipartícula (e^+/e^-, μ^+/μ^-...)
- hadrones (particulas compuestas por quarks)...


ALUMETAL Rte S.E.D.E.
CATU PARIS



UN ELECTRÓN LIBRE NO ES UNA BOLITA CARGADA, ES MÁS BIEN UNA EXCITACIÓN ESPECIAL DEL

CAMPO ELECTRÓNICO

PARA LA QUE SE CUMPLE

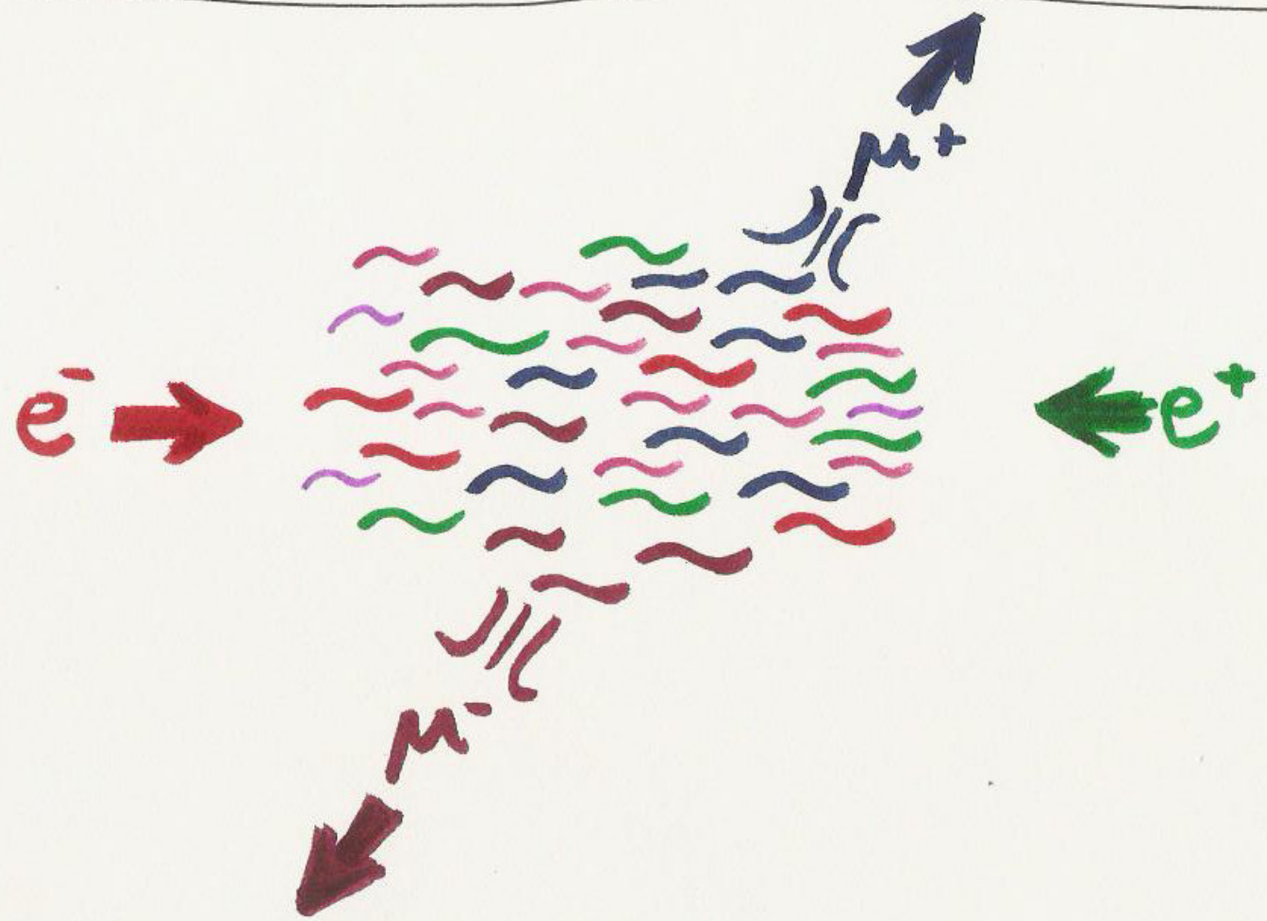
$$E^2 = (pc)^2 + (m_e c^2)^2$$

EN UNA COLISIÓN, POR EJEMPLO

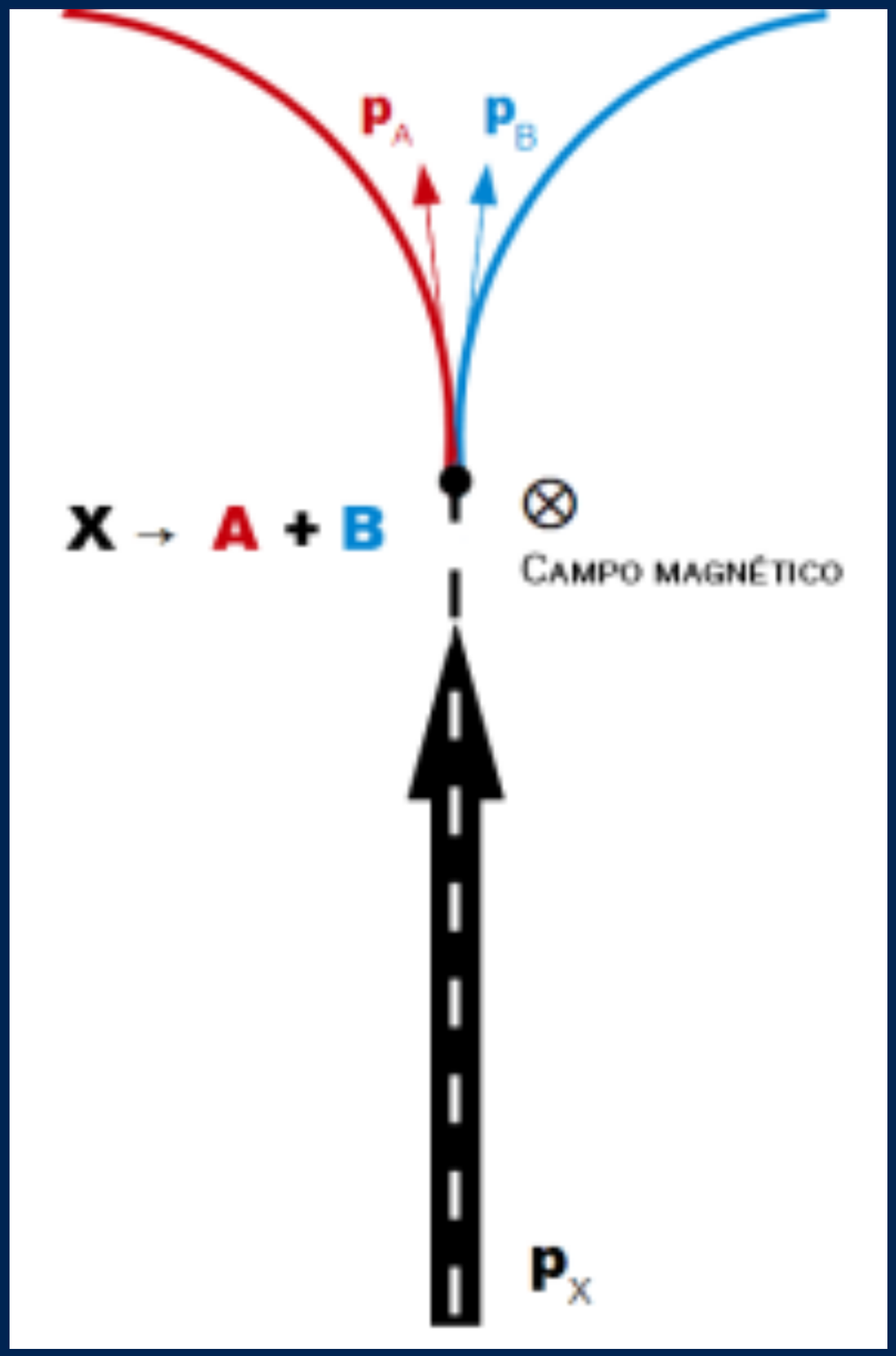
e^+ e^-

LA ENERGÍA DE LOS CAMPOS QUE "LLENAN" EL ESPACIO SE PUEDE REDISTRIBUIR DANDO LUGAR A NUEVAS EXCITACIONES TIPO PARTÍCULA, EN ESTE CASO **DOS MUONES**

μ^+ μ^-



MinutePhysics / Henry Reich
Theory of Everything: What is Matter?
https://youtu.be/Fxeb3Pc4PA4



$$X \rightarrow A + B$$

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

$$E_X = E_A + E_B$$

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

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

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

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

http://opendata.cern.ch/search?cc=CMS-Derived-Datasets&ln=en&jrec=51

Showing records 51 to 59 out of 59 results.

Example CSV output file for SUSYBSMAnalysis-RazorFilter

This file contains events from the MultiJet primary dataset from the CMS open data release, and computes the razor variables MR and Rsq, used in supersymmetric particle searches. More details on the razor variables can be found in Phys. Rev

Collection CMS-Derived-Datasets | DOI 10.7483/OPENDATA.CMS.GACK.GEJA | Author Duarte, Javier

Parent Dataset /MultiJet/Run2010B-Apr21ReReco-v1/AOD

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 | Author McCauley, Thomas

DOI 10.7483/OPENDATA.CMS.CB8H.MFFA | Parent Dataset /Mu/Run-2010B-Apr21ReReco-v1/AOD

Muons a… Reco-v1/AOD primary …

Preprocess…

Dimuon events for use in outreach and education

The CMS collaboration has approved the release of 100k dimuon events in the invariant mass range 2-110 GeV for use in outreach and education. This document contains the files for this release.

Collection CMS-Derived-Datasets | Author McCauley, Thomas

DOI 10.7483/OPENDATA.CMS.4M97.3SQ9

http://opendata.cern.ch/record/303

vuestros dimuones: parejas de muones de cargas opuestas $\mu^+\mu^-$ "de buena calidad"

Dimuon events for use in outreach and education

McCauley, Thomas

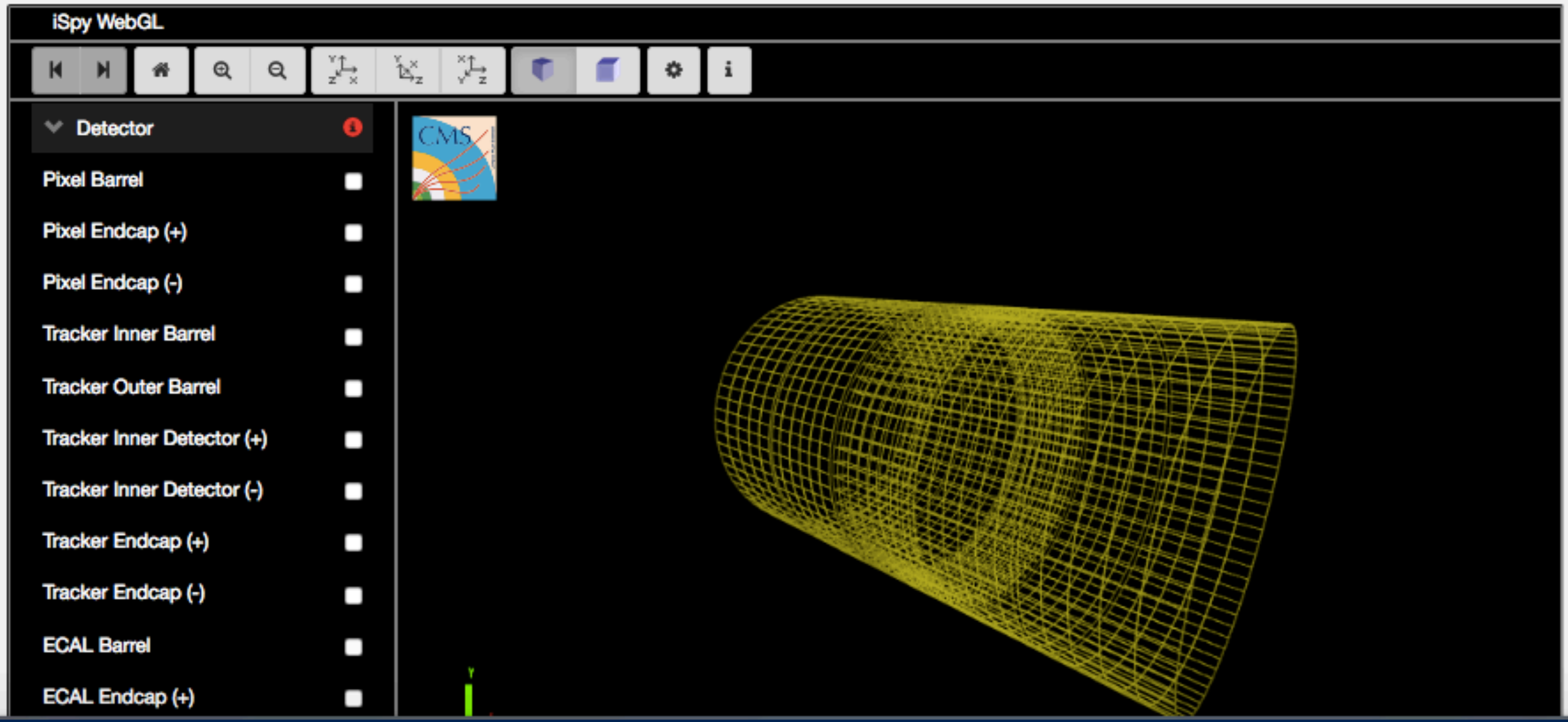
Cite as: McCauley, T. (2014). Dimuon events for use in outreach and education. CERN Open Data Portal. DOI: 10.7483/OPENDATA.CMS.4M97.3SQ9

Collection: CMS Derived Datasets | Accelerator: CERN-LHC | Experiment: CMS

Description

The CMS collaboration has approved the release of 100k dimuon events in the invariant mass range 2-110 GeV for use in outreach and education. This document contains the files for this release.

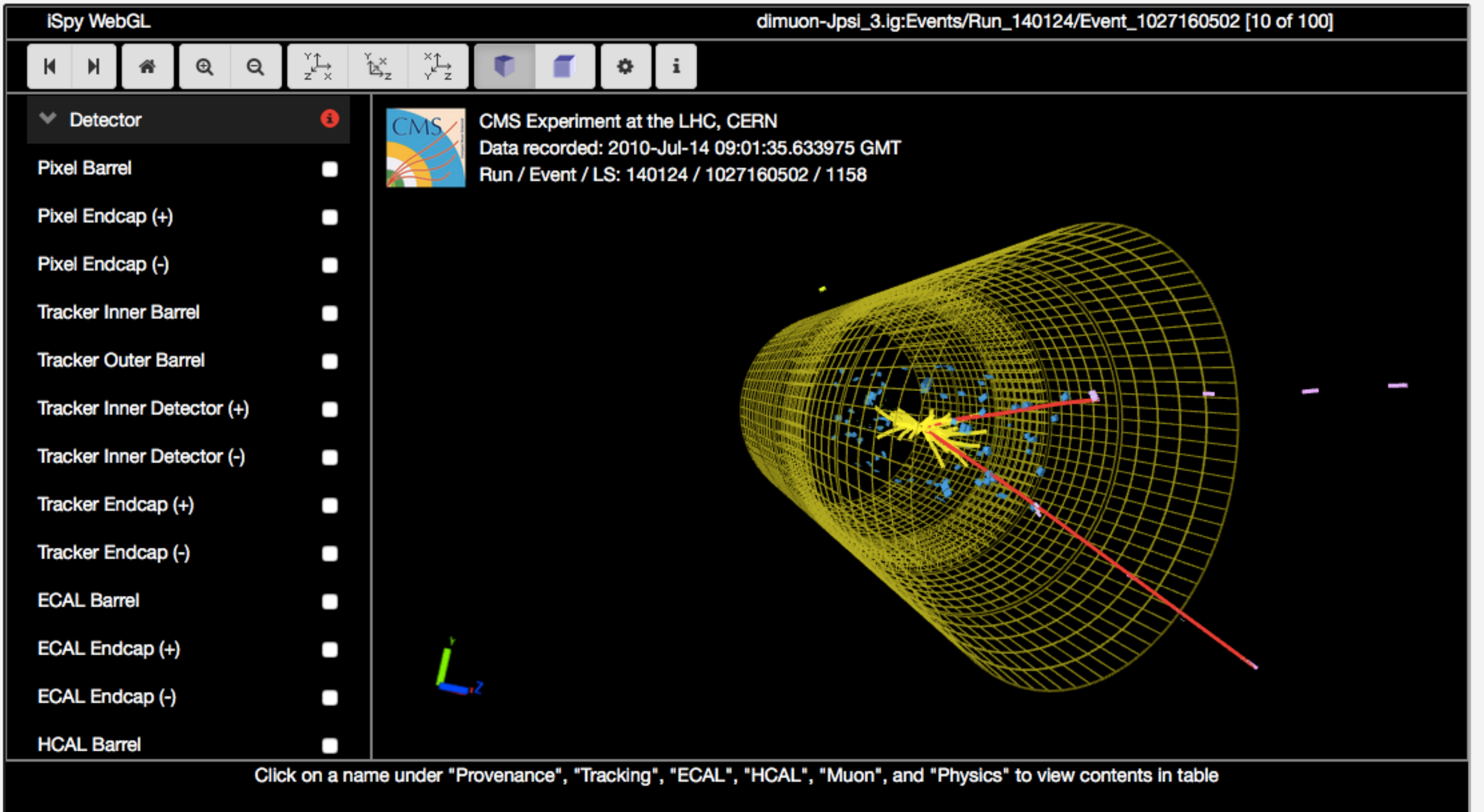
Preview

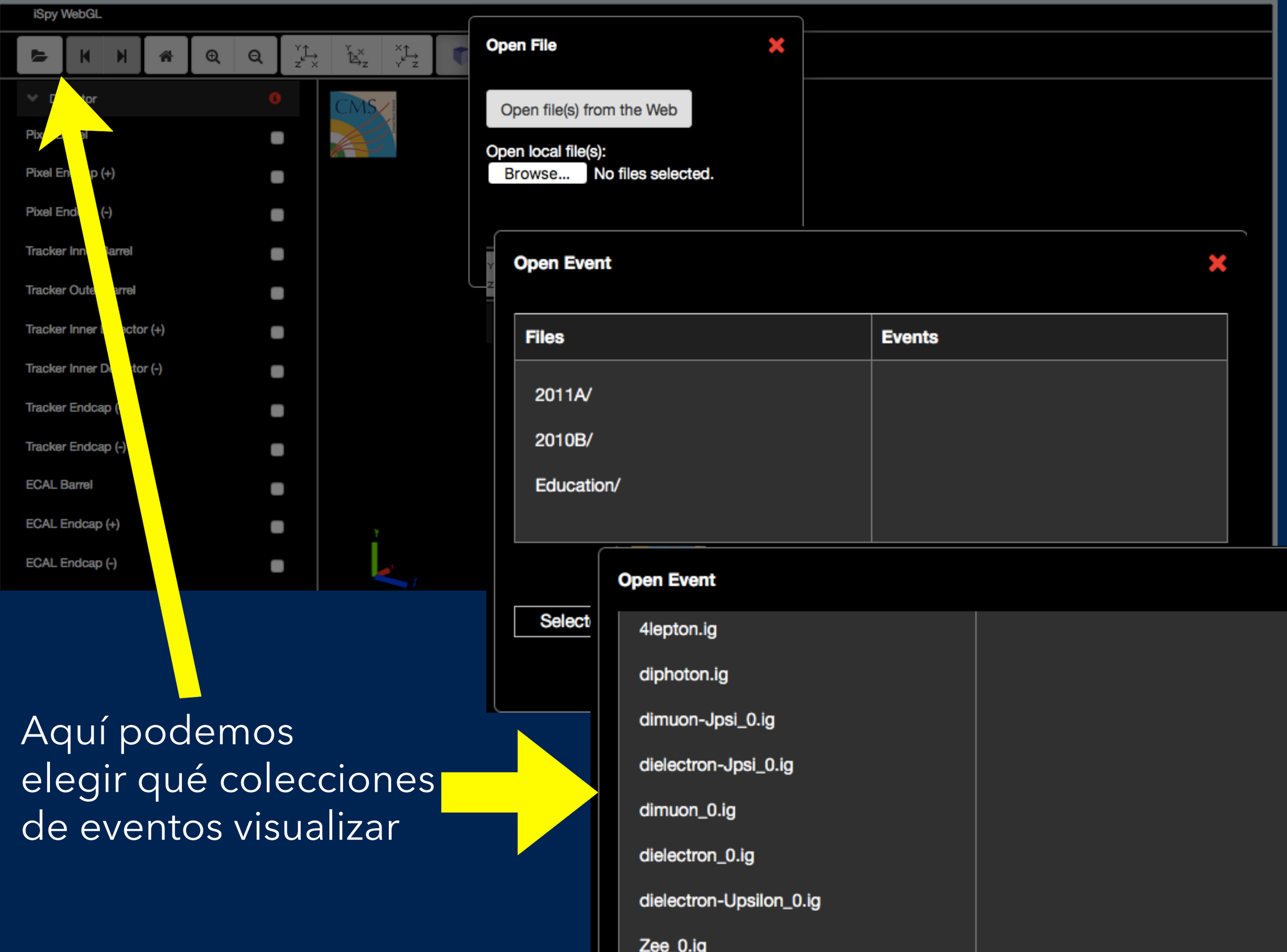


Liberation Sans | 10

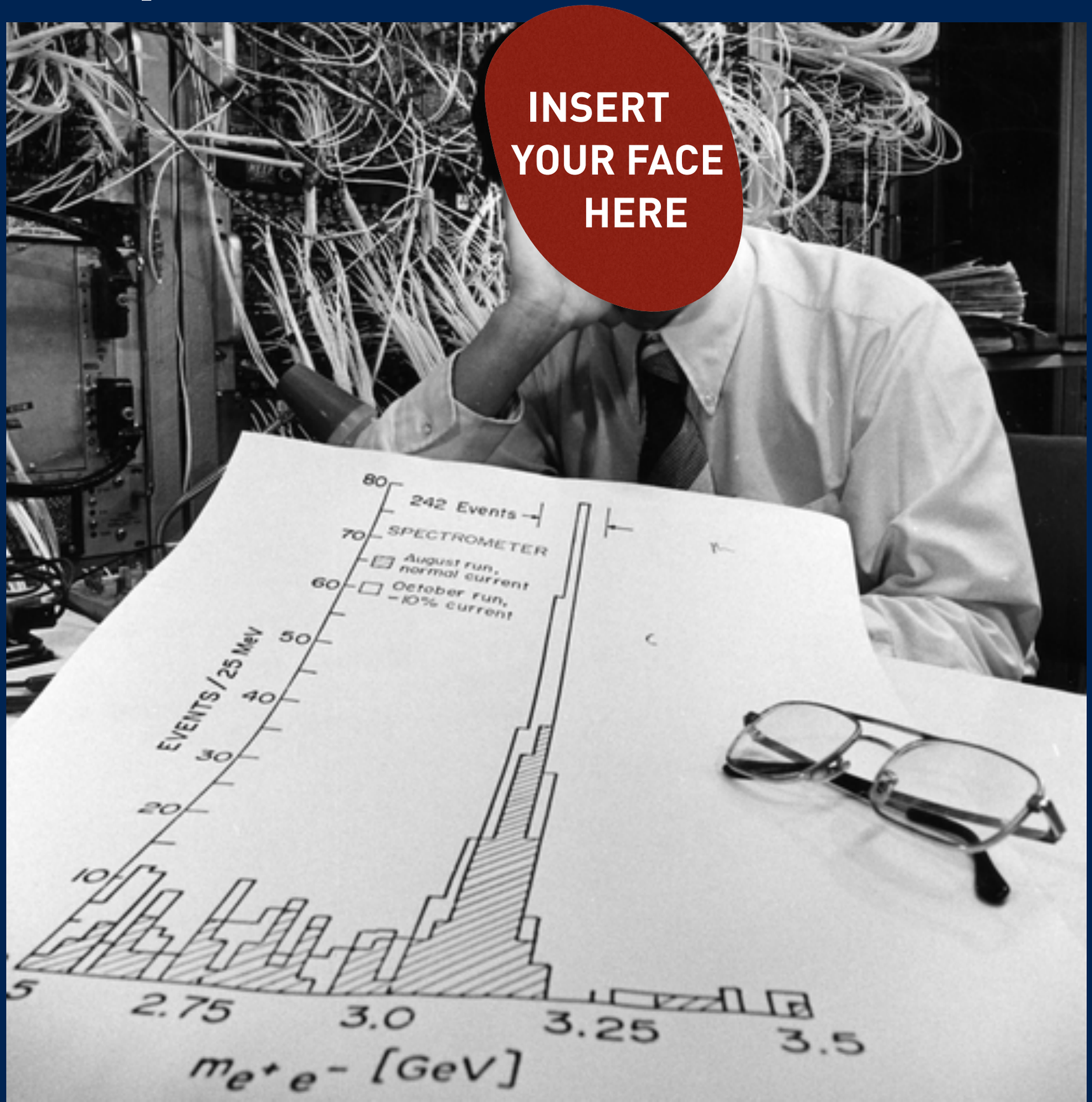
A1 | Type

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Type	Run	Event	E1	px1	py1	pz1	pt1	eta1	phi1	Q1	E2	px2
2	GT	140124	1007912007	13.7061	4.88649	-2.5086	12.5569	5.4928006044	1.564708153	-0.4742899747	1	3.67389	-0.68
3	GT	140124	1007957044	9.09052	-2.16135	-2.96392	-8.31686	3.6682769237	-1.5571370107	-2.2008651123	-1	3.80945	0.787
4	GG	140124	1008000431	6.81754	5.76035	3.23987	-1.67015	6.6089628339	-0.2500945607	0.5123463528	1	19.1486	12.8
5	GT	140124	1008032300	31.8853	-5.85709	2.78331	-31.2188	6.48477585	-2.2753268595	2.6979782463	1	4.26886	-1.50
6	GT	140124	1008075983	13.5527	1.18694	-2.35966	-13.2924	2.641367426	-2.3187715021	-1.1047411075	1	4.36207	1.19




iSpy WebGL
Open File
Open file(s) from the Web
Open local file(s):
Browse...
No files selected.
Open Event
Files
Events
2011A/
2010B/
Education/
Select
Open Event
4lepton.ig
diphoton.ig
dimuon-Jpsi_0.ig
dielectron-Jpsi_0.ig
dimuon_0.ig
dielectron_0.ig
dielectron-Upsilon_0.ig
Zee_0.ig
Pixel Endcap (+)
Pixel Endcap (-)
Tracker Endcap (+)
Tracker Endcap (-)
ECAL Barrel
ECAL Endcap (+)
ECAL Endcap (-)
Aquí podemos
elegir qué colecciones
de eventos visualizar

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

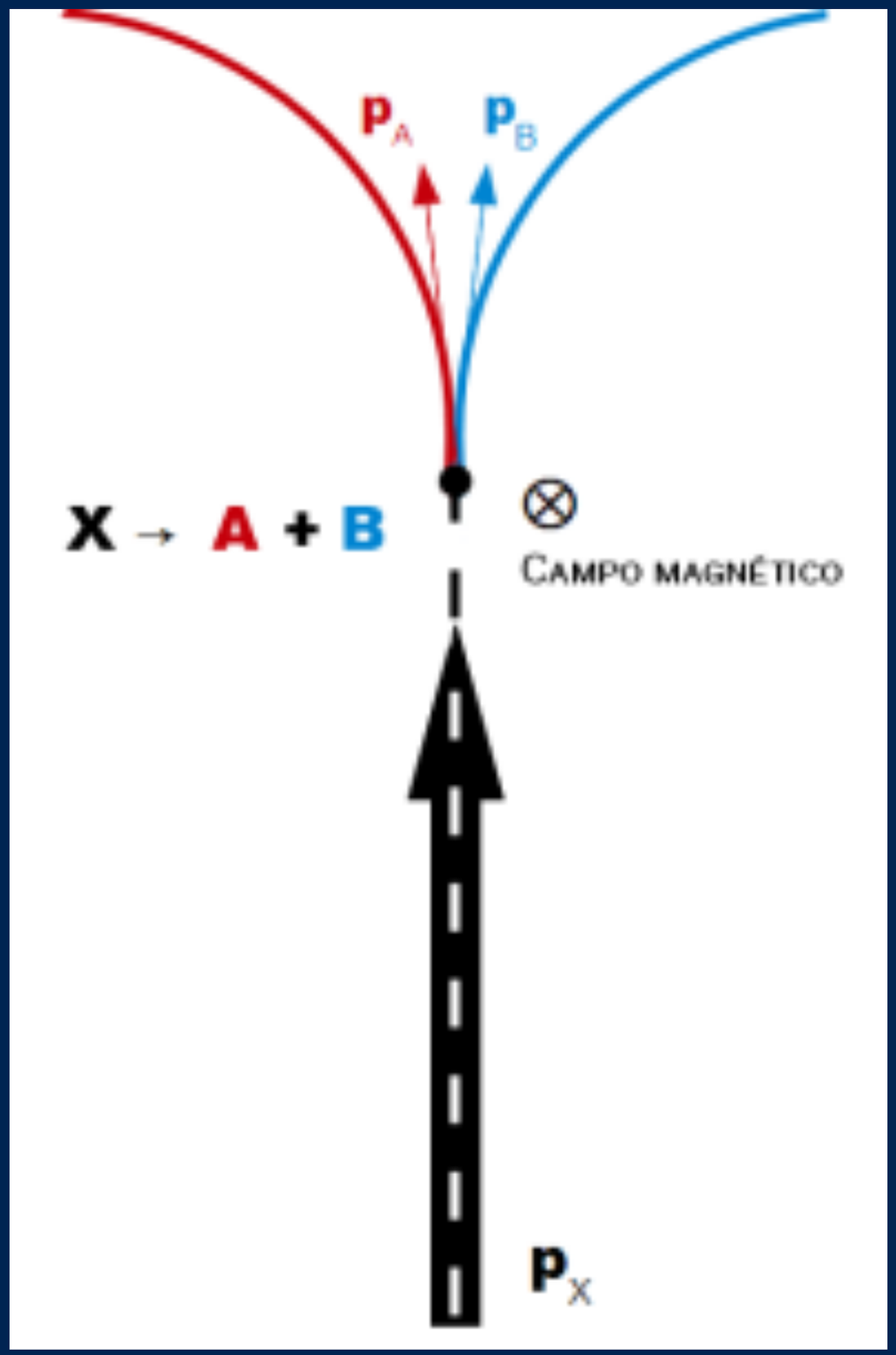
Masa
invariante
calculada
en GeV/c^2

Herramientas necesarias:

1. Entendimiento básico del funcionamiento de un detector
2. Ley de conservación de la energía y el momento $(E, \vec{p})$
3. Expresión relativista de la energía de una partícula:

$$E^2 = (pc)^2 + (mc^2)^2$$

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



$$X \rightarrow A + B$$

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

$$E_X = E_A + E_B$$

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

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

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

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

	Type	Run	Event	E1	px1	py1	pz1	pt1
1	GT	140124	1007912007	13.70610	4.88649000	-2.5086000	12.556900	5.492801
2	GT	140124	1007957044	9.09052	-2.16135000	-2.9639200	-8.316860	3.668277
3	GG	140124	1008000431	6.81754	5.76035000	3.2398700	-1.670150	6.608963

Q1	E2	px2	py2	pz2	pt2	e
1	3.67389	-0.6832500	0.529614000	3.56917	0.8644776	
-1	3.80945	0.7874280	-0.775826000	-3.64400	1.1054179	-
1	19.14860	12.8875000	12.388700000	-6.86217	17.8764522	-

En los archivos .csv con los datos la última columna contiene ya las masas invariantes calculadas, pero puede ser una buena idea que las calculemos nosotros mismos a partir de las energías y momentos.

$$M_X = \frac{1}{c^2}\left[\left(E_1 + E_2\right)^2 - c^2\left(\vec{p}_1 + \vec{p}_2\right)^2\right]^{\frac{1}{2}}$$

¿pero no habéis visto las unidades de los físicos, criaturas terrenales?

	Type	Run	Event	E1	px1	py1	pz1	pt1
1	GT	140124	1007912007	13.70610	4.88649000	-2.5086000	12.556900	5.492801
2	GT	140124	1007957044	9.09052	-2.16135000	-2.9639200	-8.316860	3.668277
3	GG	140124	1008000431	6.81754	5.76035000	3.2398700	-1.670150	6.608963

Q1	E2	px2	py2	pz2	pt2	e
1	3.67389	-0.6832500	0.529614000	3.56917	0.8644776	
-1	3.80945	0.7874280	-0.775826000	-3.64400	1.1054179	-
1	19.14860	12.8875000	12.388700000	-6.86217	17.8764522	-

En los archivos .csv con los datos la última columna contiene ya las masas invariantes calculadas, pero puede ser una buena idea que las calculemos nosotros mismos a partir de las energías y momentos.

$$M_X = \left[\left(E_1 + E_2 \right)^2 - \left(\vec{p}_1 + \vec{p}_2 \right)^2 \right]^{\frac{1}{2}}$$

Herramientas necesarias:

1. Entendimiento básico del funcionamiento de un detector
2. Ley de conservación de la energía y el momento $(E, \vec{p})$
3. Expresión relativista de la energía de una partícula:

$$E^2 = p^2 + m^2$$

¡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":
Probad HASTA QUE SE VEA ESTRUCTURA ;-)

¡Feliz caza!

Y por favor, dejad vuestros resultados aquí:

https://cernbox.cern.ch/s/ZYvX61kgwZGK0sA

Y ahora...
manos a la obra

Herramientas:
Por el momento sólo histogramas de M

- Hoja de cálculo: *Excel* sí, *LibreOffice Calc* no tan fácil
- o algo más potente, como python (o *R*)
- O una herramienta *online* como *Plotly*

O lo más sencillo (herramienta de CMS)

Filter by type

- Dataset 4
  - Derived 4

Filter by experiment

- [x] CMS 4
- [ ] OPERA 831

Filter by file type

- [ ] aod 2
- [ ] aodsim 17
- [ ] cc 4
- [x] csv 4
- [ ] gz 2
- [ ] h5 2
- [ ] ig 3
- [ ] json 2
- [ ] m4v 1
- [ ] pdf 1
- [ ] png 2
- [ ] py 20
- [ ] raw 1
- [ ] root 24
- [ ] txt 1
- [ ] xls 1
- [ ] xml 3
- [ ] zip 1

Z to ee candidate events for public use

500 Z ee candidate events from real data (2010, 7 TeV) approved for public outreach and education usage at Dec 2010 Collaboration Board meeting.

These data were selected for use in education...

Dataset Derived CMS

Z to mu mu candidate events for public use

500 Z mu mu candidate events from real data (2010, 7 TeV) approved for public outreach and education usage at Dec 2010 Collaboration Board meeting.

These data were selected for use in educat...

Dataset Derived CMS

Datasets derived from the Run2011A SingleElectron, SingleMu, DoubleElectron, and DoubleMu primary datasets

These data were selected from the primary datasets in order to obtain candidate J/psi and Y events, candidate W and Z boson events, and general di-electron and dimuon spectra.

These data wer...

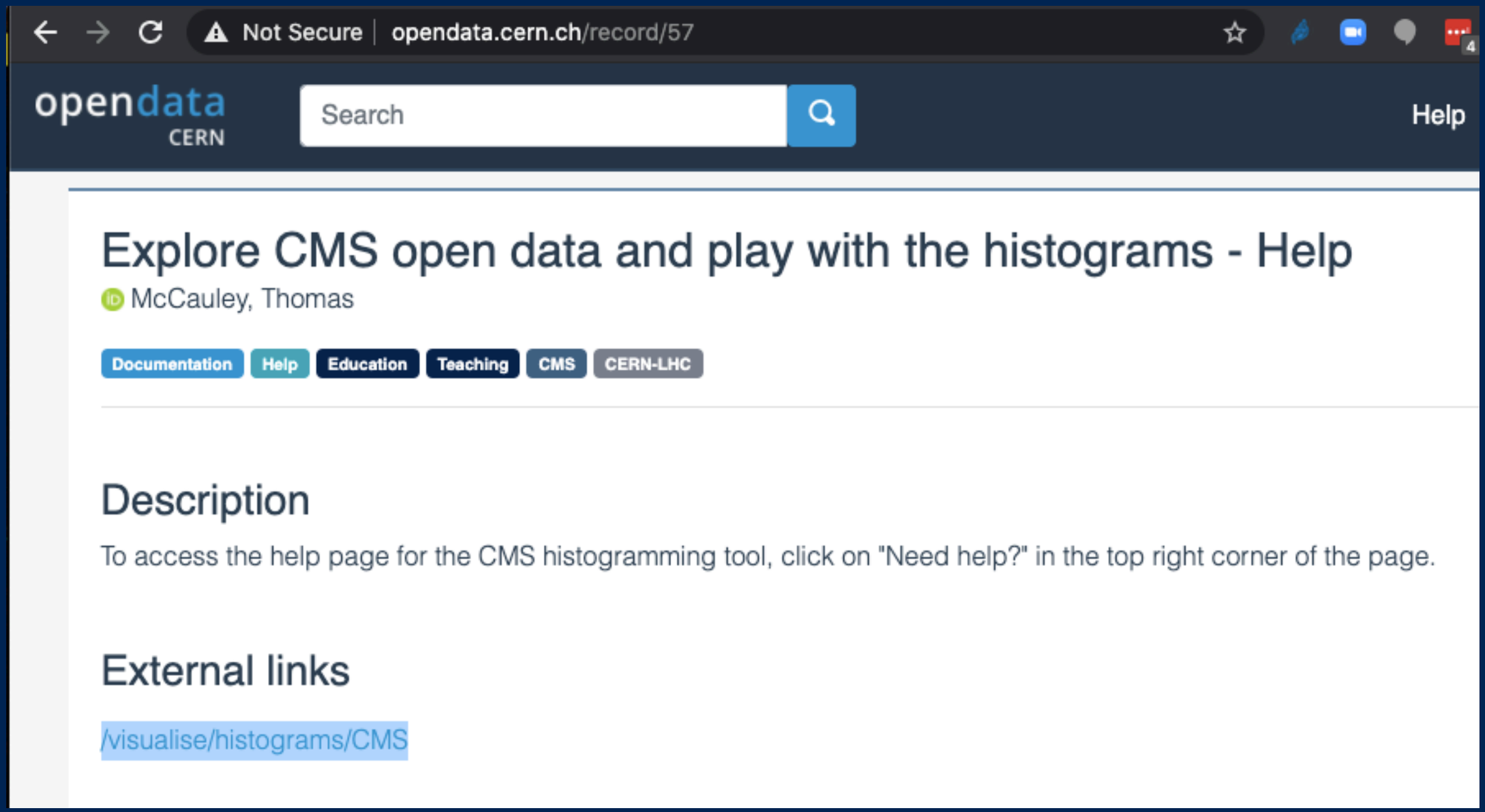
Dataset Derived CMS

Event files for CMS masterclass exercise 2014

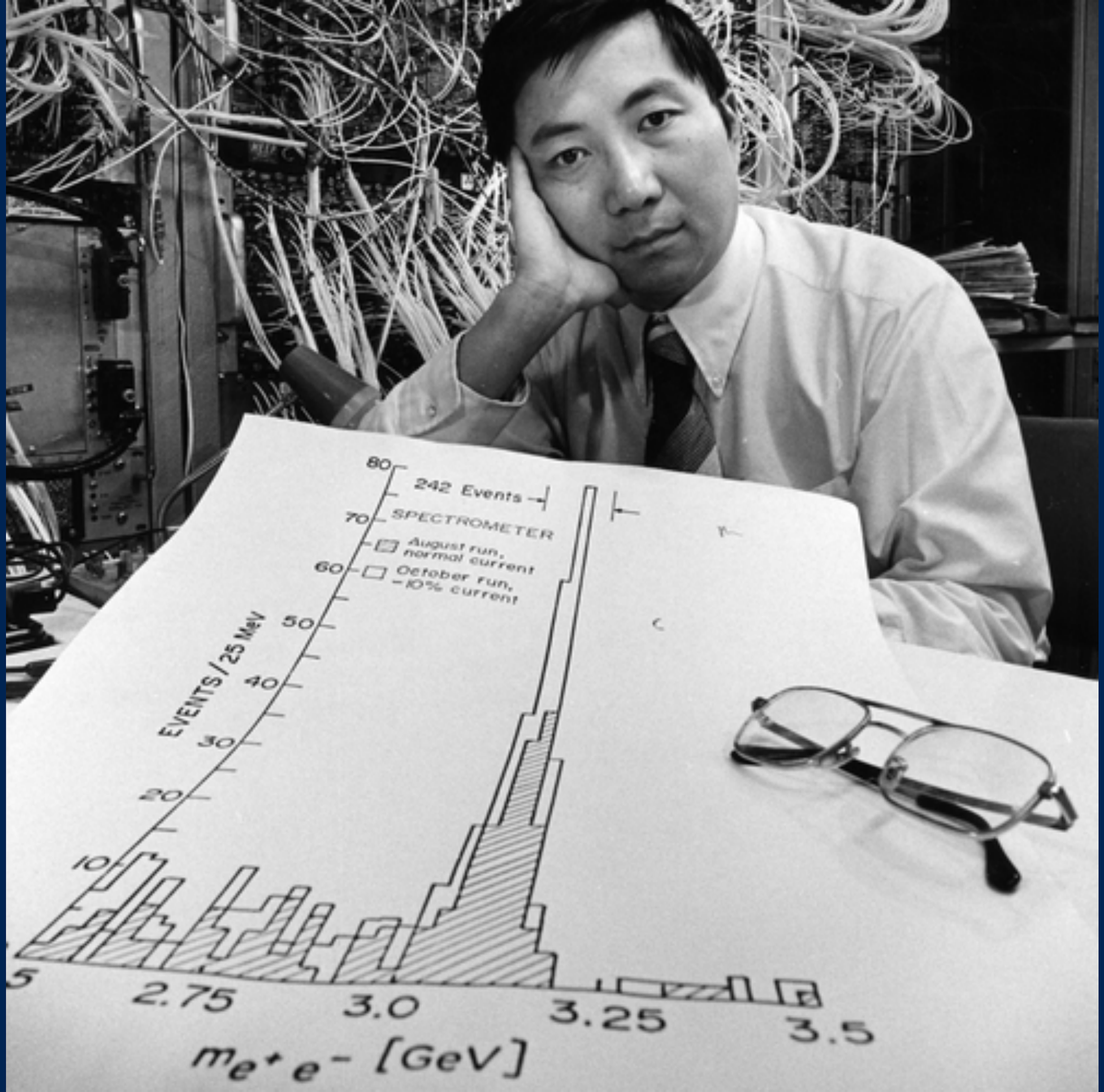
This document collects event information for use in the 2014 CMS masterclass exercise. It contains previously-released data: 800 events each of W to munu and enu, 75 events each of Z to ee and mumu...

Dataset Derived CMS

Alternativa sencilla



http://opendata.cern.ch/record/57


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]