

# CMS Masterclasses 2023

## Sofia class - Data analysis

Елтон Шумка

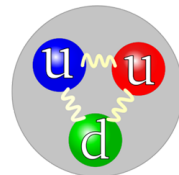
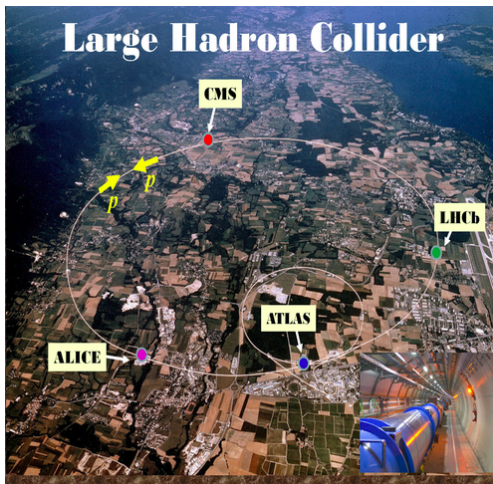
Софийски университет "Св. Климент Охридски"

29 март 2023 г.

# Практическа част - обработка на данни

- Набор на данни в LHC експериментите
- Съдържание на физическите събития
- Дефиниция на задачата
- Уеб приложение за обработка - CIMA
- Уеб приложение за визуализация - iSpy WebGL
- Демонстрация
- Q&A

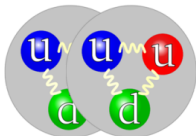
# Ускорителя LHC



ПРОТОН

# Ускоряване на протони

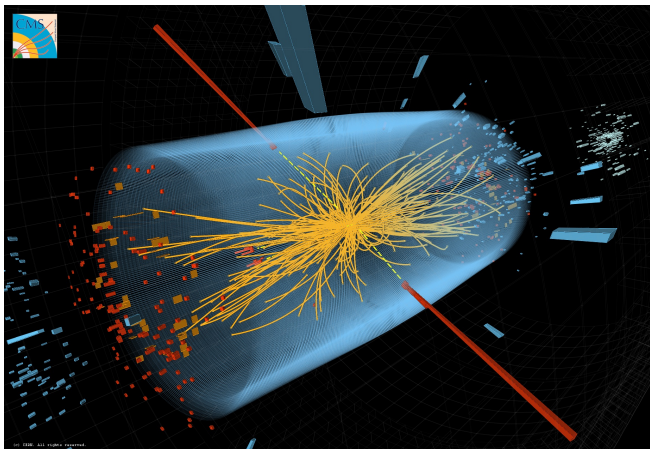
$100,000,000 \times$



$\times 100,000,000$

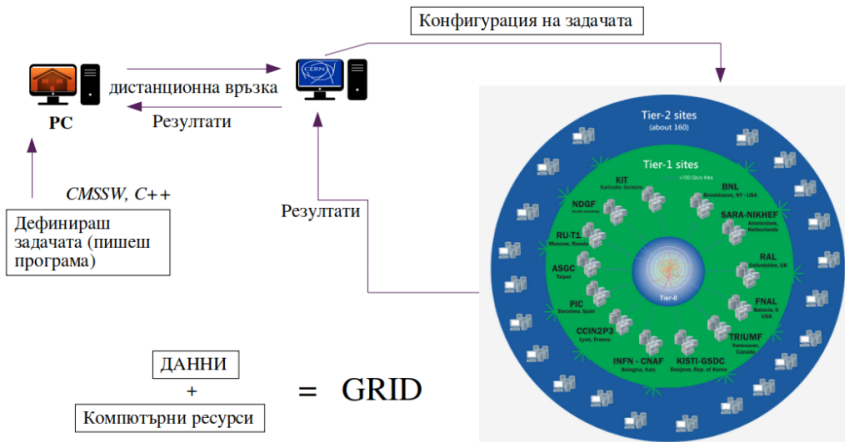
- През една точка на ускорителя, преминава един бънч протони на всеки 25 ns
- Много малка част от протоните взаимодействат при пресичането на сноповете. Това се определя от физическата величина сечение за взаимодействие и се измерва във единици barn.
- Броя на осъществени сблъсъци между протони е  $6 \times 10^8$  събития на секунда

# Събития



Траектории на частици родени при само едно събитие!

# Анализ на данни



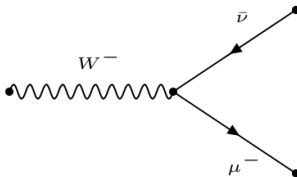
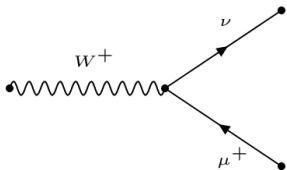
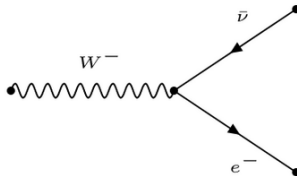
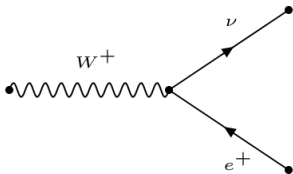
# Дефиниция на задачата

Ще изследваме разпади на частици които имат само лептони в крайното състояние. Това ще са разпади на:

- $W^\pm$  бозони
- $Z_0$  бозон
- $H$  бозон
- Други неутрално заредени частици

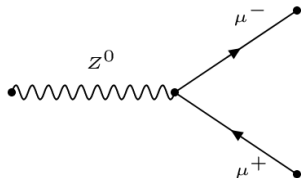
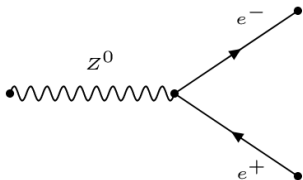
За всяко събитие, целта е да се определи инвариантната маса на разпадналата се частица. След обработването на достатъчно събития, целта е да бъдат идентификувани частиците

# Разпади на $W^\pm$ бозоните - Файнманови диаграми

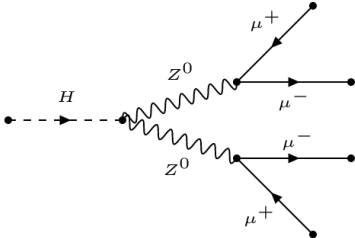
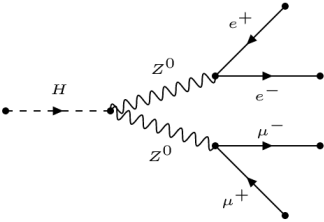
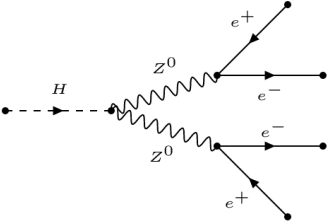




# Разпади на $Z^0$ бозона

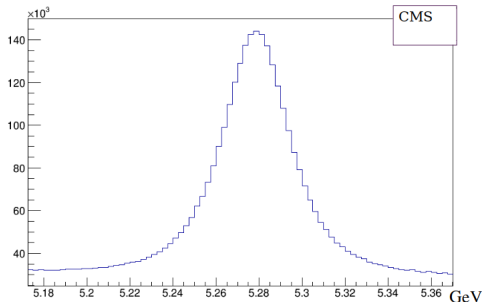


# Разпади на H бозона



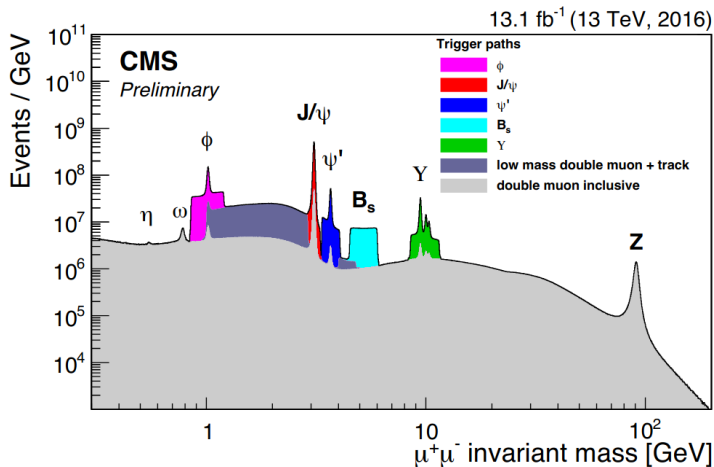
# Записване на резултатите в хистограма

Много измервания, се групират в интервали, наречени бинове




След набирването на достатъчно статистика, разпределението се фитира и се определя средната стойност

# Димюонен спектър







# Уеб приложение CIMA






## CIMA


CMS Instrument for Masterclass Analysis

Choose your Masterclass	Choose your location	Choose your data file
Serbia-5S-2022	VilniusUniversity2023	100.61
Vilnius-02Dec2022	Nicosia2023B	100.62
Milano-22Feb2023	Kaunas2023	100.63
LAMAP-Dec2022	MadridCIEMAT2023	100.64
Sofia-16Jan2023	Sofia2023	100.65
Belgrade-FF-2023	Split2023	100.66
TestEvents-01Jan2022		100.67
SantiagoCampostela_10Feb2023		100.68
CERN-ESADE-14Feb2023		100.69
CERN-ESADE-07Feb2023		100.71
CERN-13Feb2023		100.72
CERN-24Feb2023		100.73
CERN-28Feb2023		100.74
CERN-03Mar2023		100.75
CERN-04Mar2023		100.76
CERN-09Mar2023		100.77
CERN-13Mar2023		100.78
CERN-16Mar2023		100.79
CERN-21Mar2023		100.81
CERN-22Mar2023		100.82
CERN-24Mar2023		100.83
CERN-28Mar2023		100.84

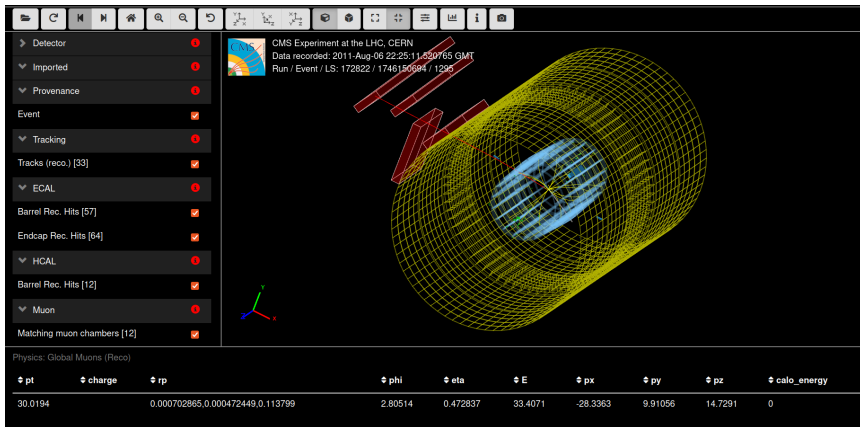
  
  


hands on particle physics

International Particle  
Physics Outreach Group

# Уеб приложение iSpy WebGL



## Контакти:

[elton.shumka@cern.ch](mailto:elton.shumka@cern.ch)

[Bulgarian-MasterClasses-Mentors@cern.ch](mailto:Bulgarian-MasterClasses-Mentors@cern.ch)

## Links:

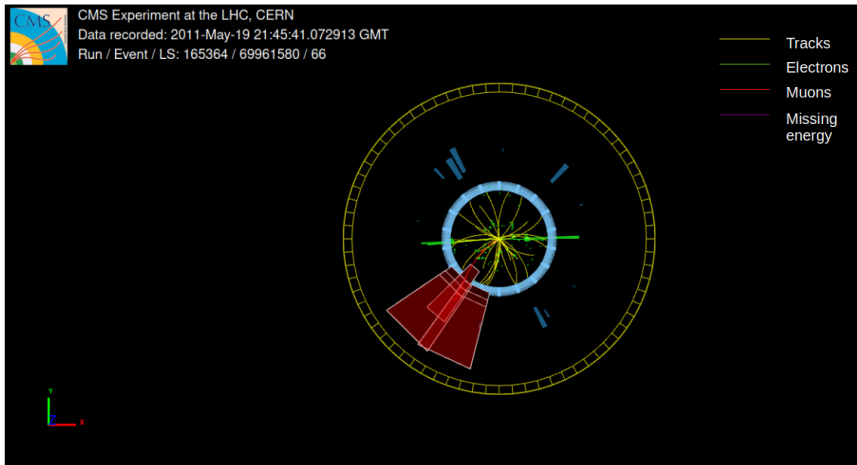
<https://www.i2u2.org/elab/cms/cima-wzh/>

<https://www.i2u2.org/elab/cms/ispy-webgl/>

# Backup slides



# Обозначение



# $Z \rightarrow \mu^+ \mu^-$ пример

The image shows a screenshot of a CMS event viewer interface. At the top left, there are coordinate axes for the detector. Below them, the text reads: "CMS Experiment", "Data recorded: 20...", and "Run / Event / LS: 1...".

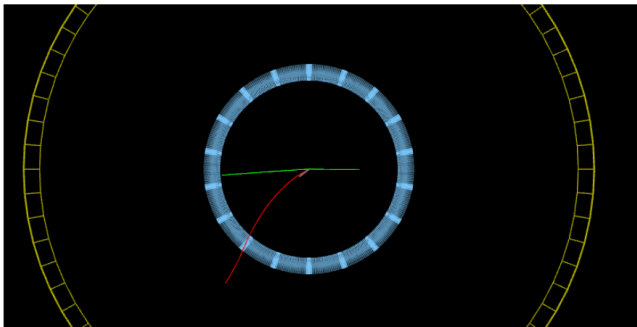
A central dialog box titled "Invariant mass" displays the value "90.33 GeV" and a "Close" button.

The main detector view shows a cross-section of the detector with a blue circle representing the interaction point and two red lines representing the muon tracks. A yellow dashed circle is also visible.

At the bottom, there are three control panels:

- Final State:** Radio buttons for  $e\nu$ ,  $ee$ ,  $4e$ ,  $2e\ 2\mu$ ,  $\mu\nu$ ,  $\mu\mu$  (selected), and  $4\mu$ .
- Primary State:** Radio buttons for Charged Particle ( $W^+$ ,  $W^-$ ,  $W^\pm$ ), Neutral Particle ( $Z, H$ ) (selected), and Zoo.
- Enter Mass:** A text input field containing "90.33" and "GeV/c<sup>2</sup>", with a "Next" button below it.

$$e^+ e^- \mu^- \nu?$$

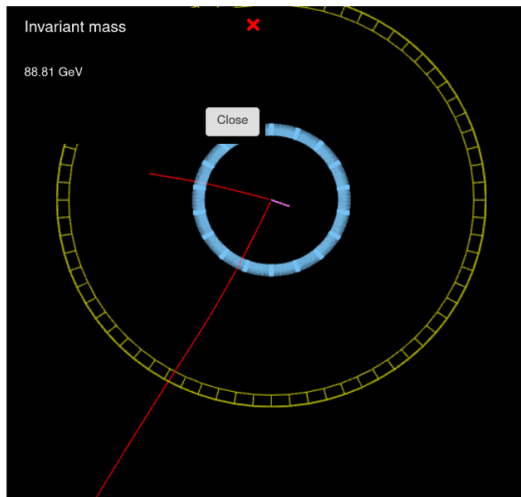


<b>Final State</b> <input type="radio"/> $e \nu$ <input type="radio"/> $e e$ <input type="radio"/> $4e$ <input type="radio"/> $2e 2\mu$ <input checked="" type="radio"/> $\mu \nu$ <input type="radio"/> $\mu \mu$ <input type="radio"/> $4\mu$	<b>Primary State</b> Charged Particle: <input type="radio"/> $W^+$ <input checked="" type="radio"/> $W^-$ <input type="radio"/> $W^z$ <input type="radio"/> Neutral Particle (Z, H) <input type="radio"/> Zoo	<b>Enter Mass</b> <input type="text" value=""/> GeV/c <sup>2</sup> <input type="button" value="Next"/>
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Проверяваме дали електроните са родени в конуса на адронна струя



# $Z \rightarrow \mu^+ \mu^-$ пример 2



**Final State**

e  $\nu$         $\mu \nu$

e e        $\mu \mu$

4e       4 $\mu$

2e 2 $\mu$

**Primary State**

Charged Particle:

W+     W-     W $\pm$

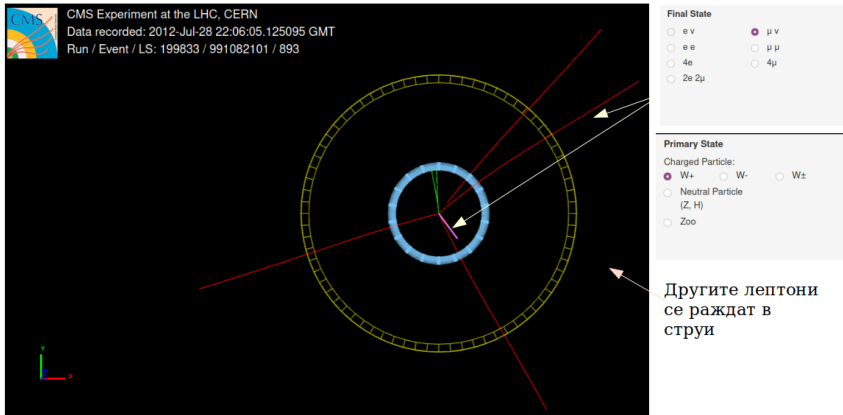
Neutral Particle (Z, H)

Zoo

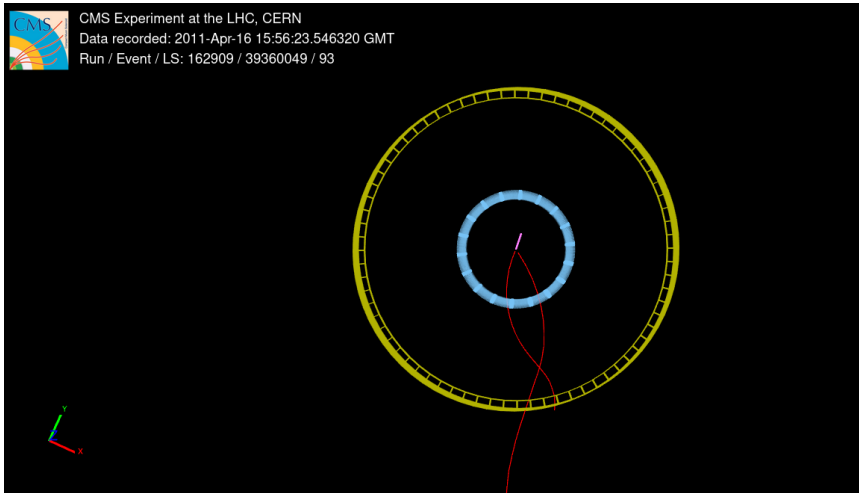
**Enter Mass**

GeV/c<sup>2</sup>

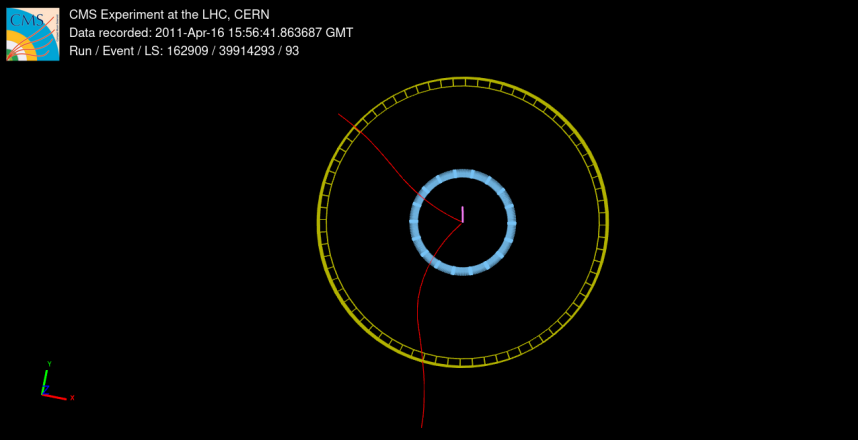
# $4e4\mu?$



# Събитие 66.2



# Събитие 26.29



# Събитие 26.32

