

SOFIA UNIVERSITY
ST. KLIMENT OHRIDSKI

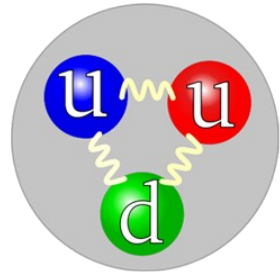


CMS MASTERCLASSES 2024 SOFIA CLASS



Анализ на данни

Какви събития ще изследваме?



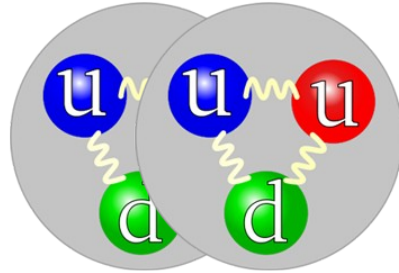
ПРОТОН



Анализ на данни

Какви събития ще изследваме?

100,000,000 ×

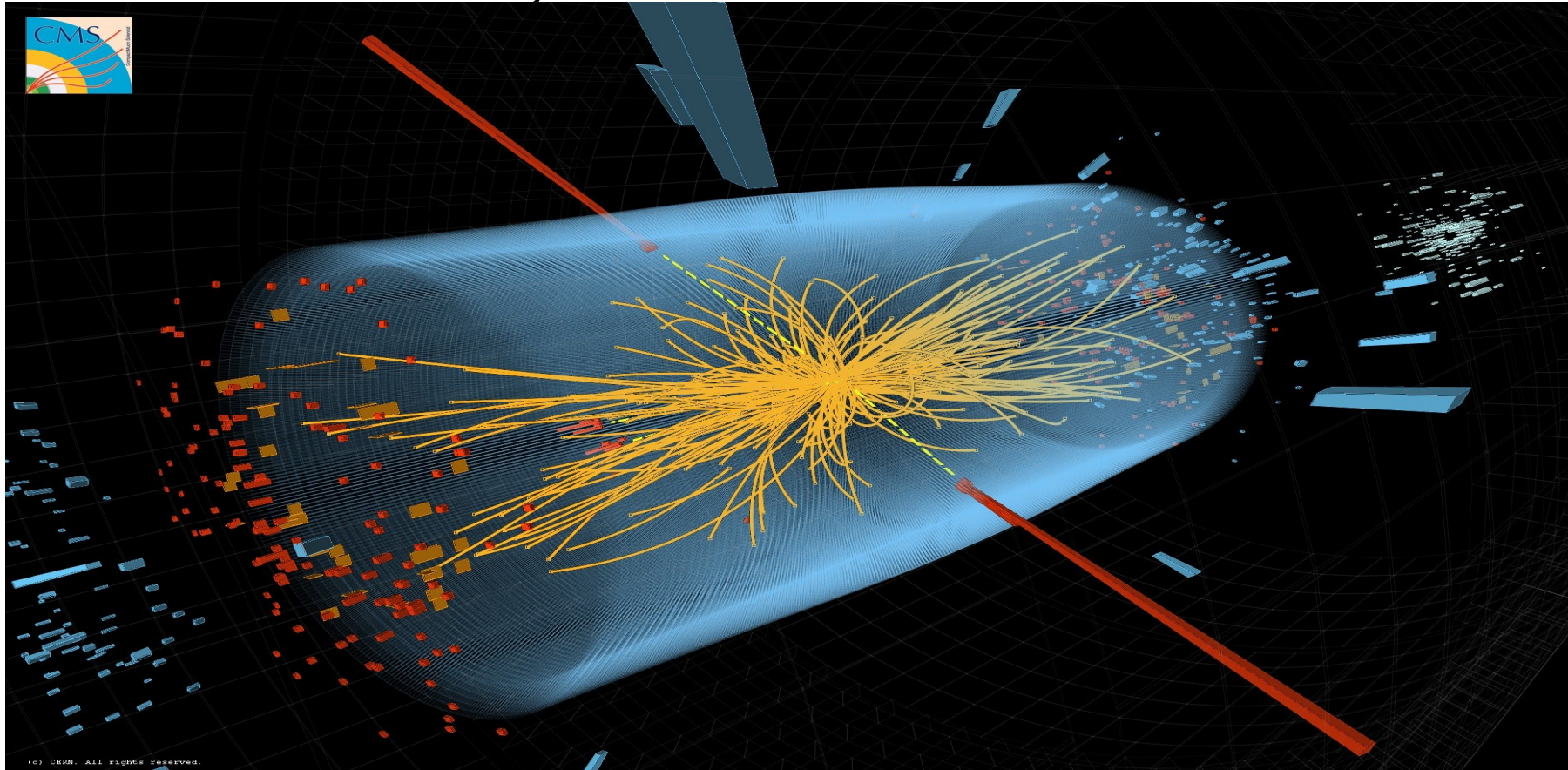


× 100,000,000

25 ns расстояние между бърч-овете → $\sim 6 \cdot 10^8$ събития за секунда

Анализ на данни

Какви събития ще изследваме?



Траектории на частици родени при само едно събитие!

Анализ на данни

How do They do it?

Конфигурация на задачата



PC

remote връзка

Резултати



Резултати

CMSSW, C++

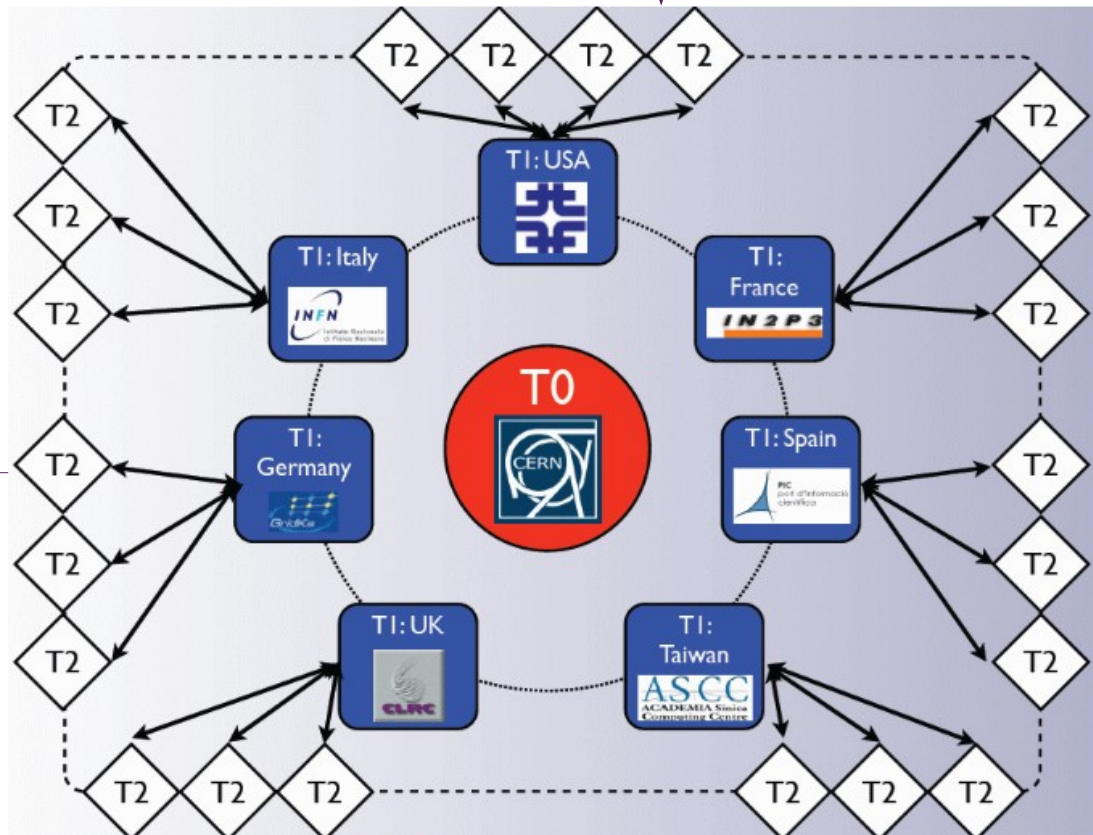
Дефинираш
задачата (пишеш
програма)

ДАНИИ

+

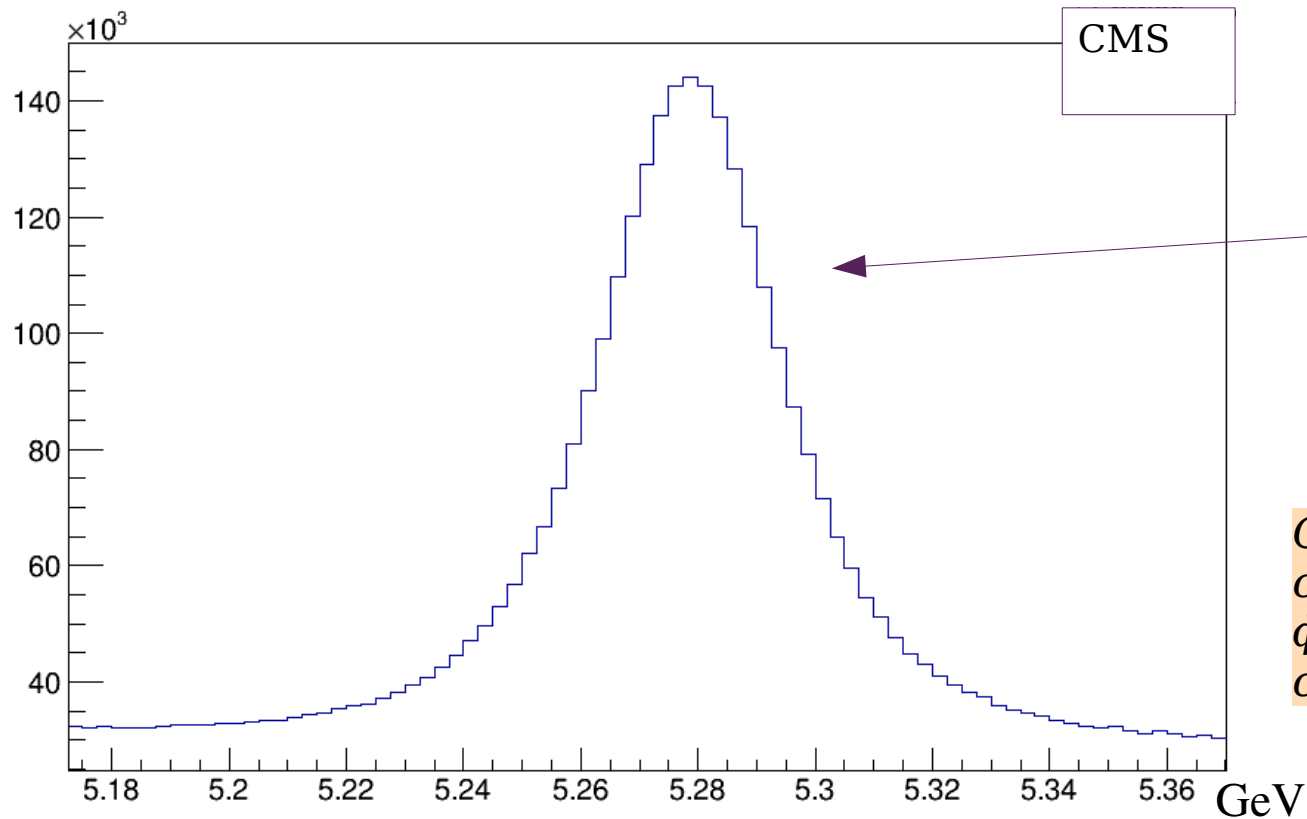
Компютърни ресурси

= GRID



Записване на резултатите в хистограма

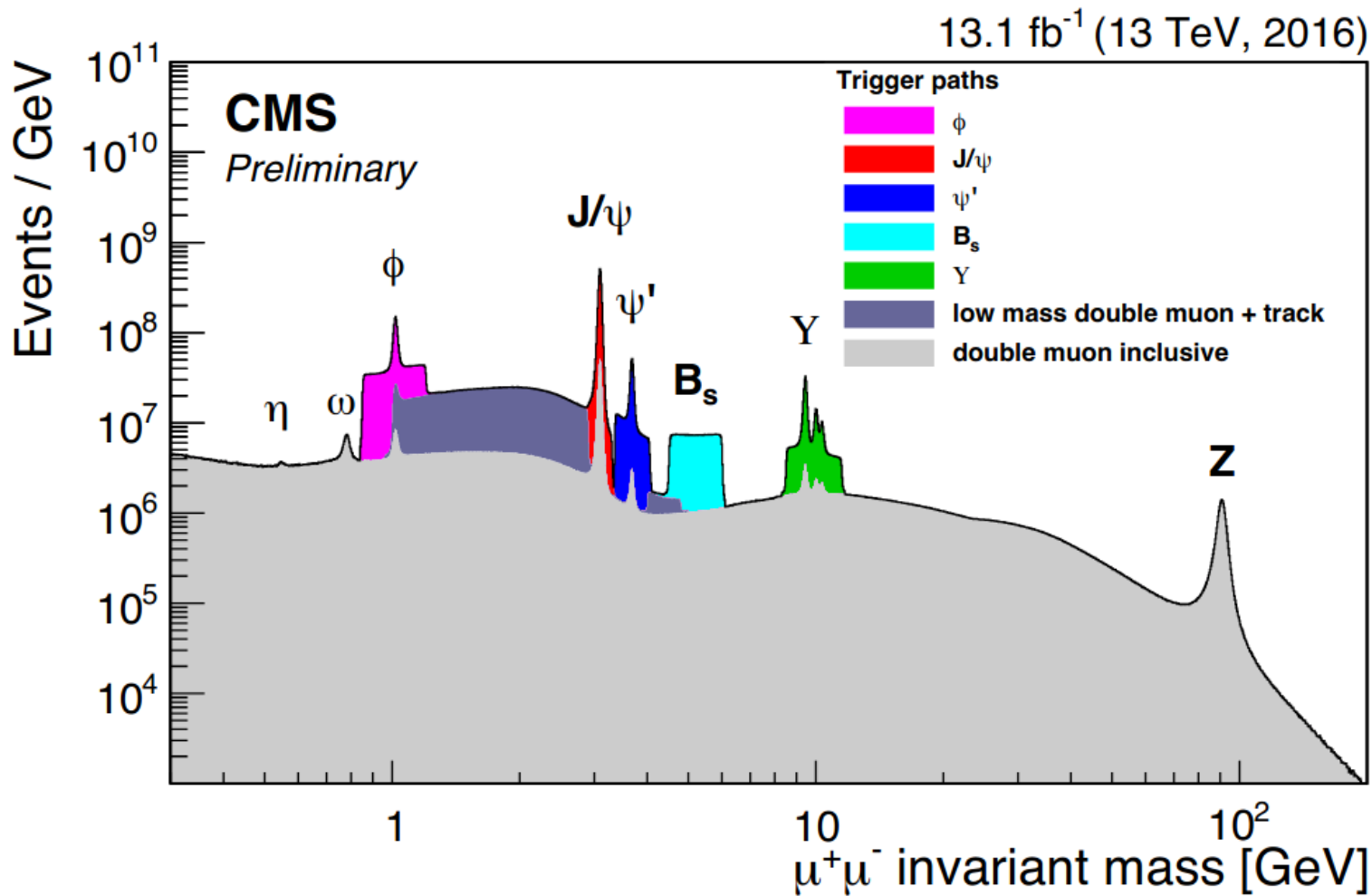
Много измервания, се групират в интервали, наречени бинове



Разпределение на измерванията на масата

След набирание на достатъчно статистика, разпр. се фитира и се определя средната стойност

Записване на резултатите в хистограма



ДИМЮОНЕН
СПЕКТЪР

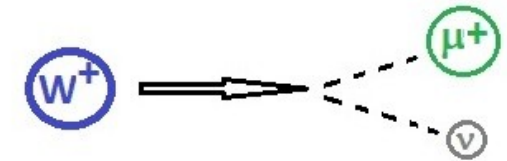
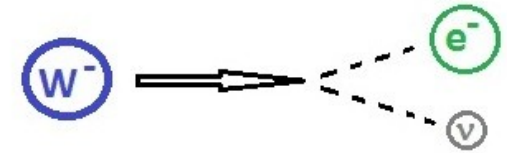
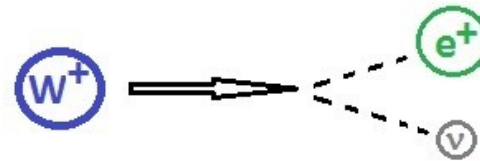
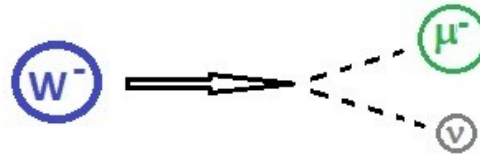
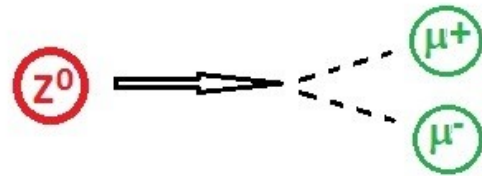
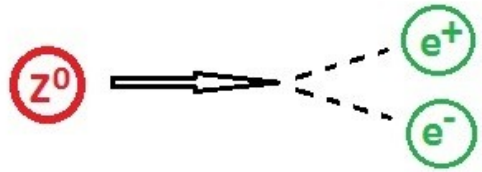
Веб приложенията за анализ



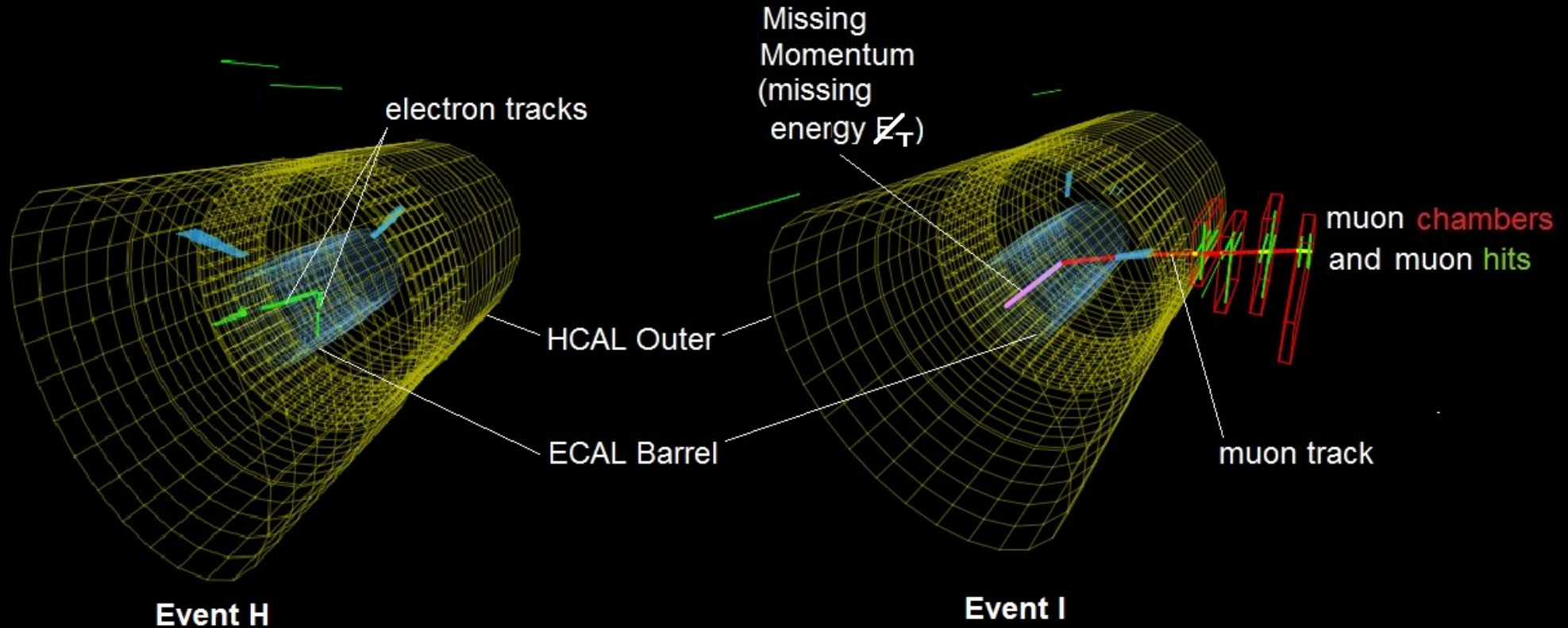
Choose your Masterclass	Choose your location	Choose your data file
TestEvents-01Jan2022	Debrecen2024	100.51
Santander-13May2024	IstanbulYTU2024-B	100.52
CERN-27Nov2023	Firenze2024-B	100.53
Salo-07Dec2023	SofiaUni2024	100.54
Sofia-13Dec2023	Zagreb2024	100.55
CERN-LAMAP-08Dec2023		100.56
MP-15Jan2024		100.57
Cakovec-24Jan2024		100.58
Bristol-27Mar2024		100.59
CERN-09Feb2024		100.61
Sandbox-31Dec2023		100.62
CERN-20Feb2024		100.63
CERN-26Feb2024		100.64
CERN-29Feb2024		100.65
CERN-22Feb2024		100.66
CERN-01Mar2024		100.67
CERN-04Mar2024		100.68
CERN-06Mar2024		100.69
CERN-08Mar2024		100.71
CERN-11Mar2024		100.72
CERN-13Mar2024		100.73
CERN-19Mar2024		100.74
CERN-22Mar2024		100.75
CERN-27Mar2024		100.76
FNAL-01Mar2024		100.77
FNAL-08Mar2024		100.78
FNAL-09Mar2024		100.79
FNAL-13Mar2024		5.1
FNAL-14Mar2024		5.2
FNAL-15Mar2024		5.3
FNAL-16Mar2024		5.4



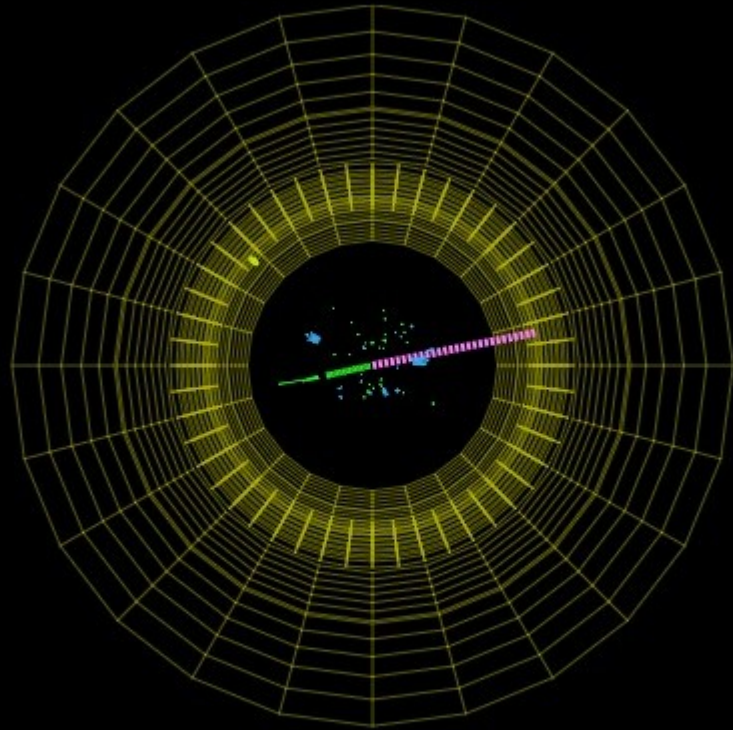
Анализ на данни



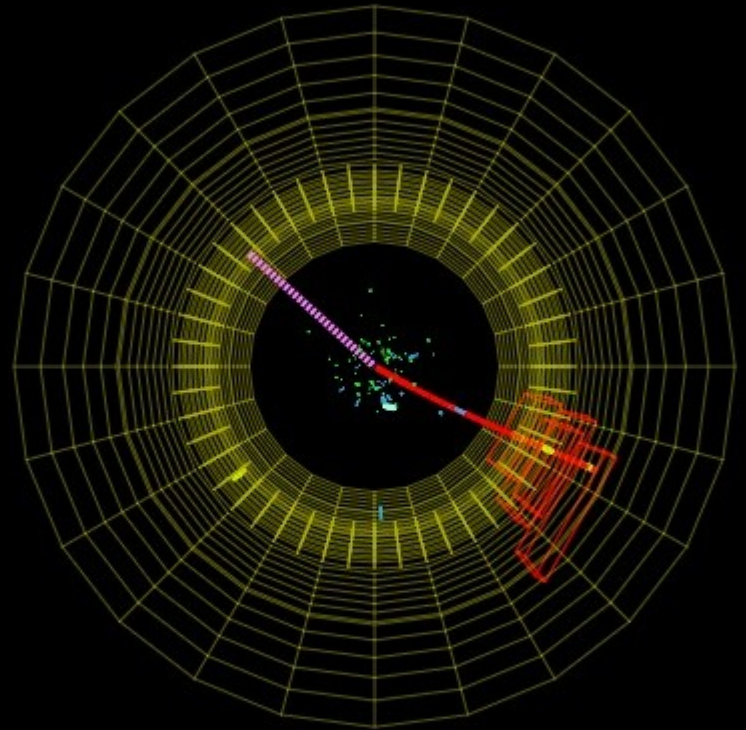
Анализ на данни



clockwise for positive charge and anticlockwise for negative



Event A



Event B

Допълнителни слайдове - iSpy примери

iSpy WebGL примери

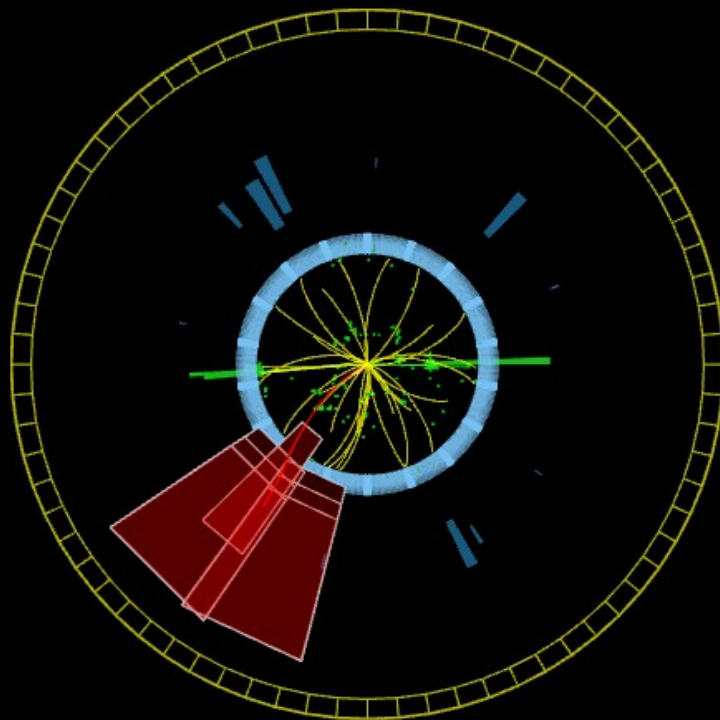


CMS Experiment at the LHC, CERN

Data recorded: 2011-May-19 21:45:41.072913 GMT

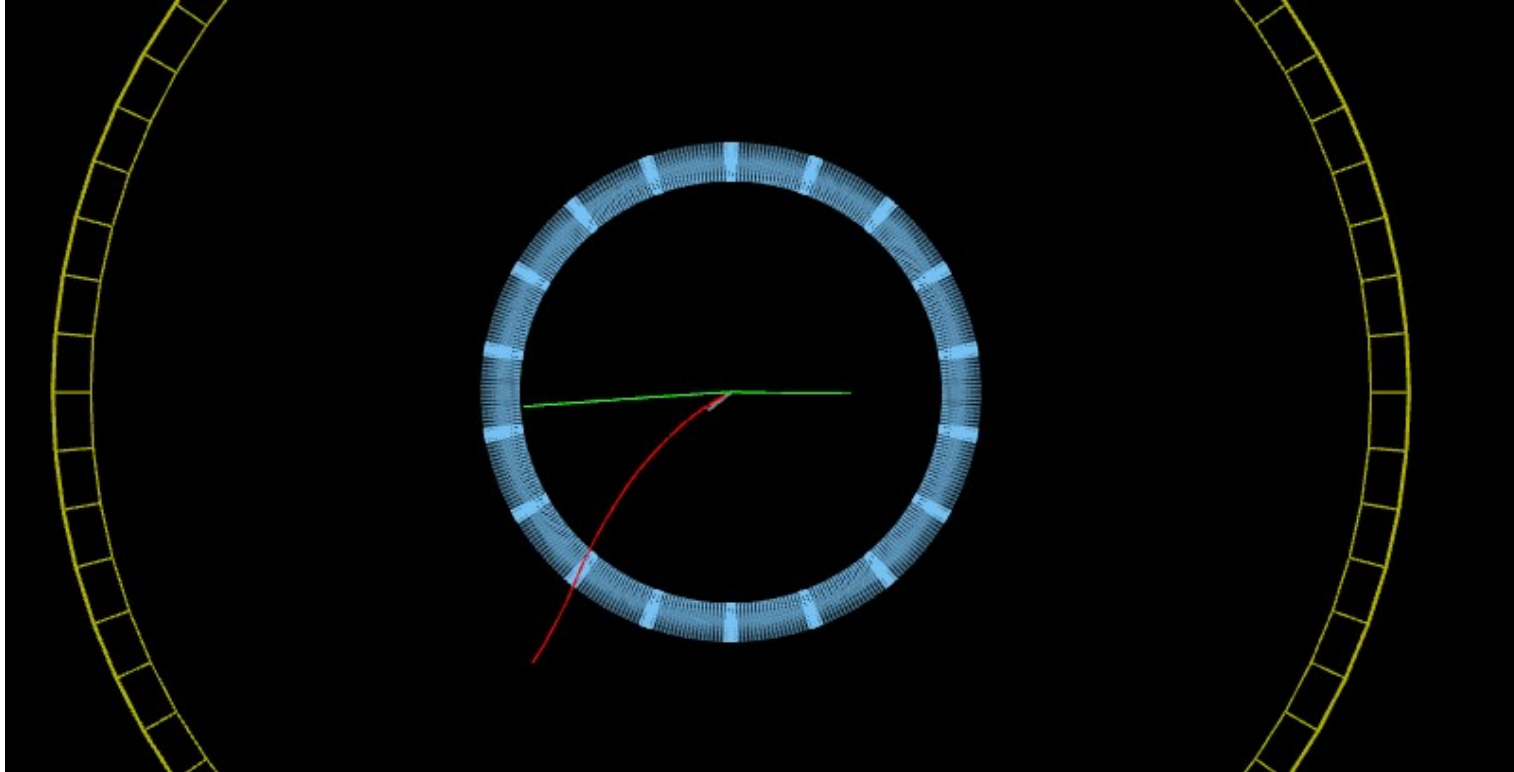
Run / Event / LS: 165364 / 69961580 / 66

- Tracks
- Electrons
- Muons
- Missing energy



$2e+\mu+\nu$?

Проверяваме дали електроните се раждат в конуса на адронна струя!



Final State <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"/> 4μ	Primary State Charged Particle: <input type="radio"/> W^+ <input checked="" type="radio"/> W^- <input type="radio"/> W^\pm <input type="radio"/> Neutral Particle (Z, H) <input type="radio"/> Zoo	Enter Mass <input type="text"/> GeV/c ² <input type="button" value="Next"/>
----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------

Invariant mass

88.81 GeV



Close

Final State

- e ν
- e e
- 4e
- 2e 2 μ
- $\mu \nu$
- $\mu \mu$
- 4 μ

Primary State

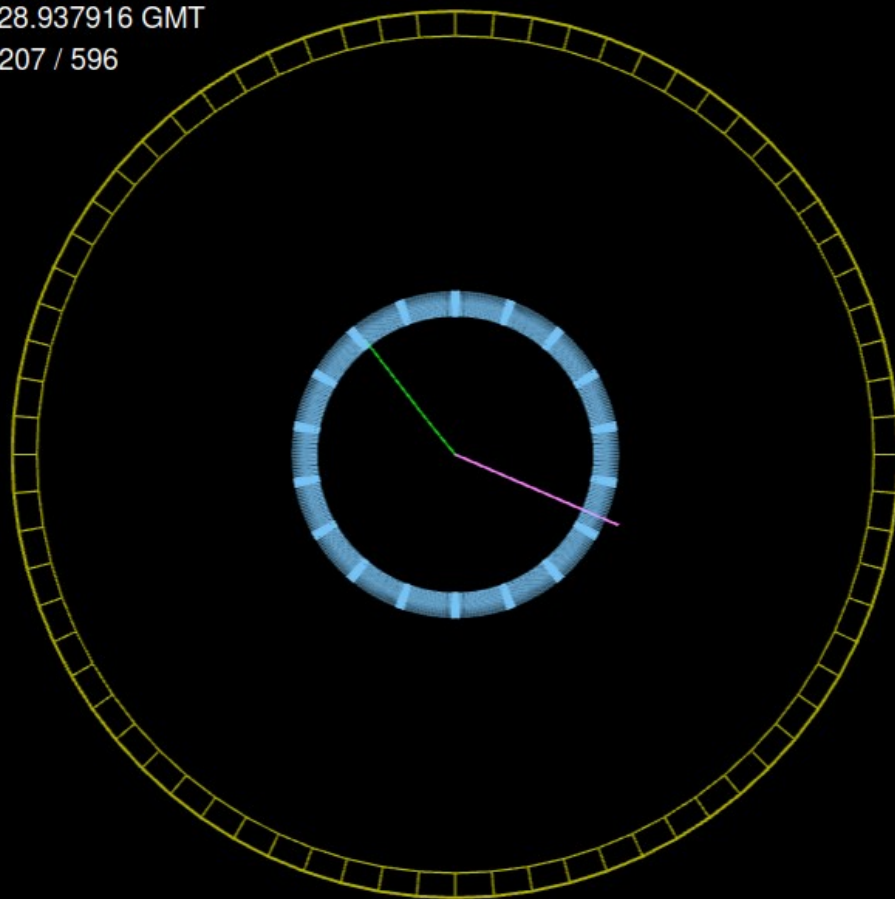
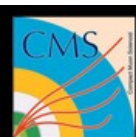
Charged Particle:

- W⁺
- W⁻
- W \pm
- Neutral Particle (Z, H)
- Zoo

Enter Mass

88.81 GeV/c²

Next



Final State

- e ν
- e e
- 4e
- 2e 2 μ
- $\mu \nu$
- $\mu \mu$
- 4 μ

Primary State

Charged Particle:

- W⁺
- W⁻
- W \pm
- Neutral Particle (Z, H)
- Zoo



Ако не сме сигурни за посоката на отклонение на трека



Не се смята масата!

$4\mu+4e$ +Missing energy?

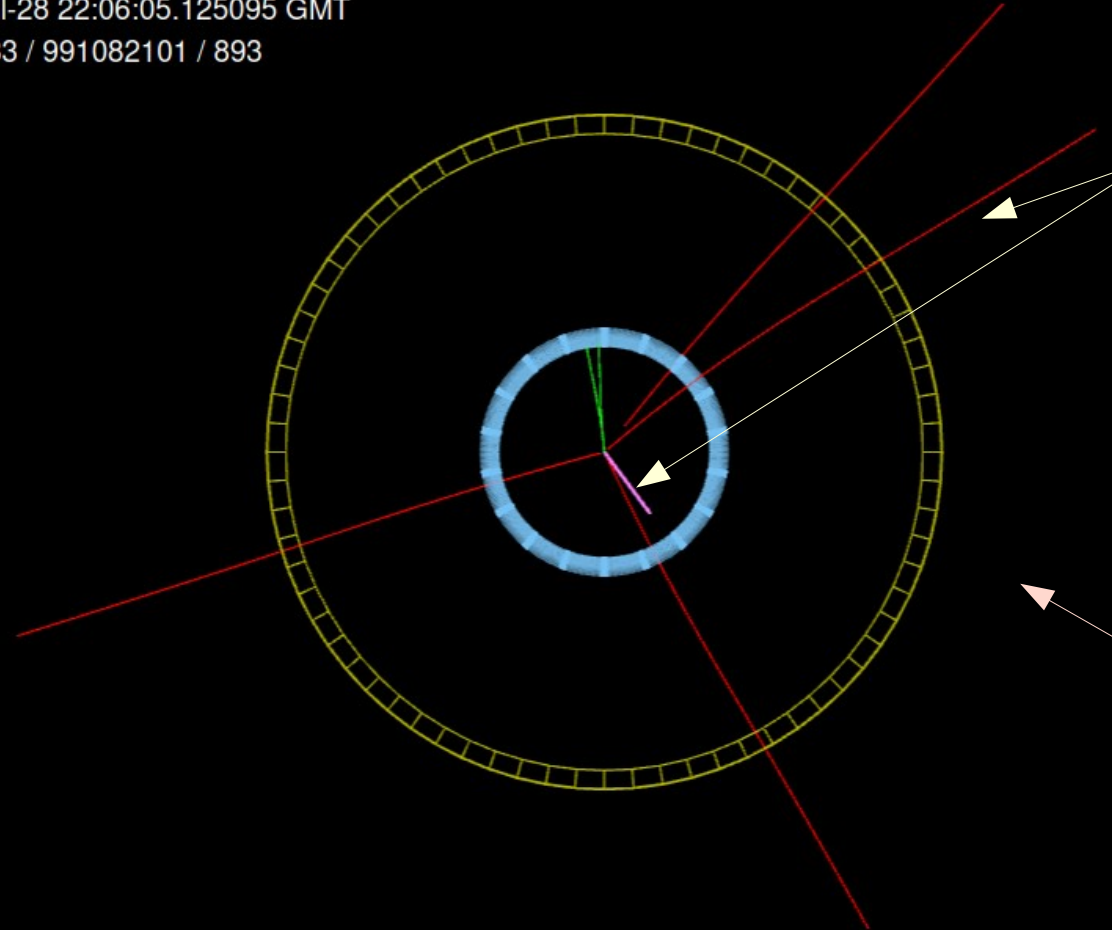
4μ ?



CMS Experiment at the LHC, CERN

Data recorded: 2012-Jul-28 22:06:05.125095 GMT

Run / Event / LS: 199833 / 991082101 / 893



Final State

<input type="radio"/> $e \nu$	<input checked="" type="radio"/> $\mu \nu$
<input type="radio"/> $e e$	<input type="radio"/> $\mu \mu$
<input type="radio"/> $4e$	<input type="radio"/> 4μ
<input type="radio"/> $2e 2\mu$	

Primary State

Charged Particle:

<input checked="" type="radio"/> W^+	<input type="radio"/> W^-	<input type="radio"/> W^\pm
<input type="radio"/> Neutral Particle (Z, H)		
<input type="radio"/> Zoo		

Другите лептони се раждат в струи

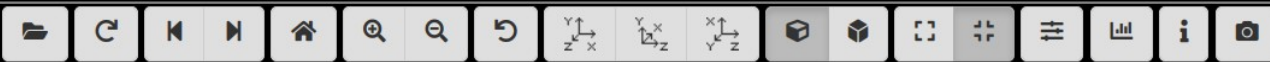
Links:

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

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

- <https://web.quarknet.org/mc/cms/imc2021/pages/cmswz.html>
-

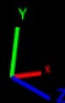
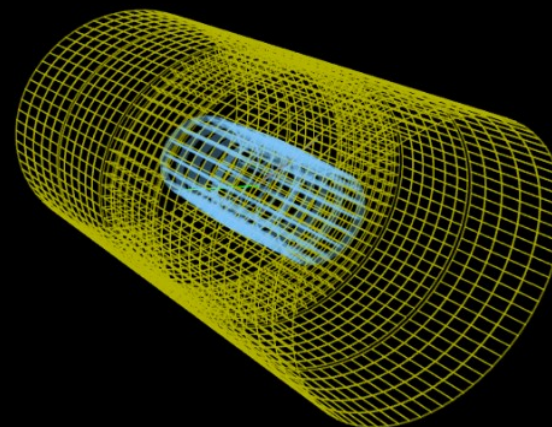
Уеб приложенията за анализ



- Drift Tubes
- Cathode Strip Chambers
- Resistive Plate Chambers (barrel)
- Resistive Plate Chambers (+)
- Resistive Plate Chambers (-)
- Imported ⓘ
- Provenance ⓘ
- Event
- Tracking ⓘ
- Tracks (reco.) [41]
- ECAL ⓘ
- Barrel Rec. Hits [165]



CMS Experiment at the LHC, CERN
Data recorded: 2011-Jul-25 01:45:09.442492 GMT
Run / Event / LS: 171446 / 759187428 / 592



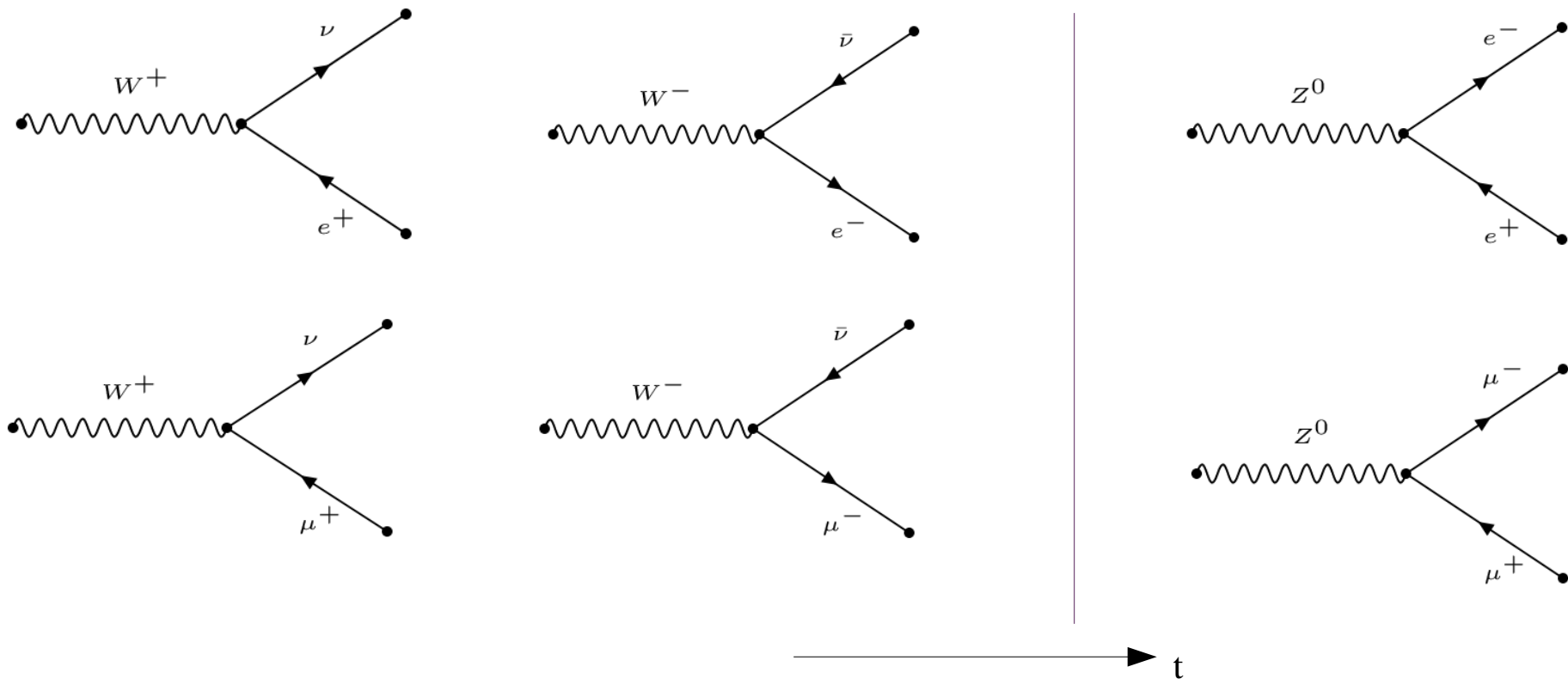
Physics: Electron Tracks (GSF)

◆ pt	◆ eta	◆ phi	◆ charge	◆ E	◆ px	◆ py	◆ pz
30.6103	-1.23306	-2.57323		56.9825	-25.7978	-16.4761	-48.0627

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Какви събития ще изследваме?

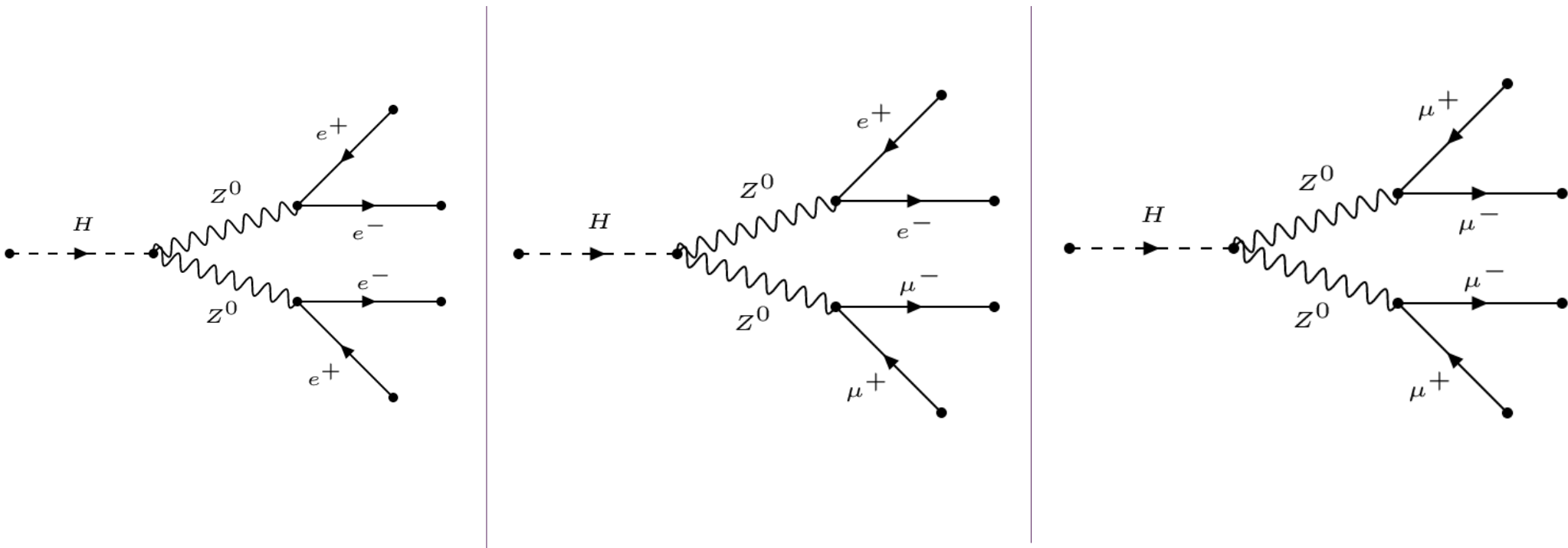
Събития с 1,2 или 4 лептона в крайното състояние



Анализ на данни

Какви събития ще изследваме?

Събития с 1,2 или 4 лептона в крайното състояние



Цел на реконструкцията: измерване на масата