



# CMS Masterclass 2017 for Moderators



## CMS DETECTOR

Total weight : 14,000 tonnes  
 Overall diameter : 15.0 m  
 Overall length : 28.7 m  
 Magnetic field : 3.8 T

STEEL RETURN YOKE  
 12,500 tonnes

SILICON TRACKERS  
 Pixel (100x150  $\mu\text{m}$ )  $\sim 16\text{m}^2 \sim 66\text{M}$  channels  
 Microstrips (80x180  $\mu\text{m}$ )  $\sim 200\text{m}^2 \sim 9.6\text{M}$  channels

SUPERCONDUCTING SOLENOID  
 Niobium titanium coil carrying  $\sim 18,000\text{A}$

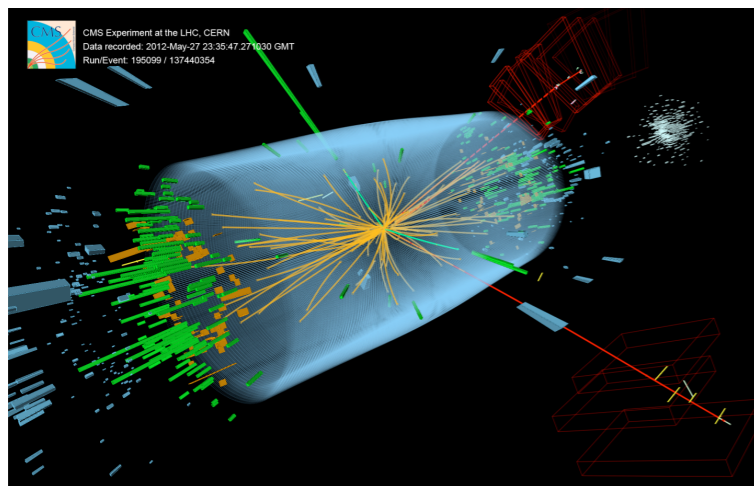
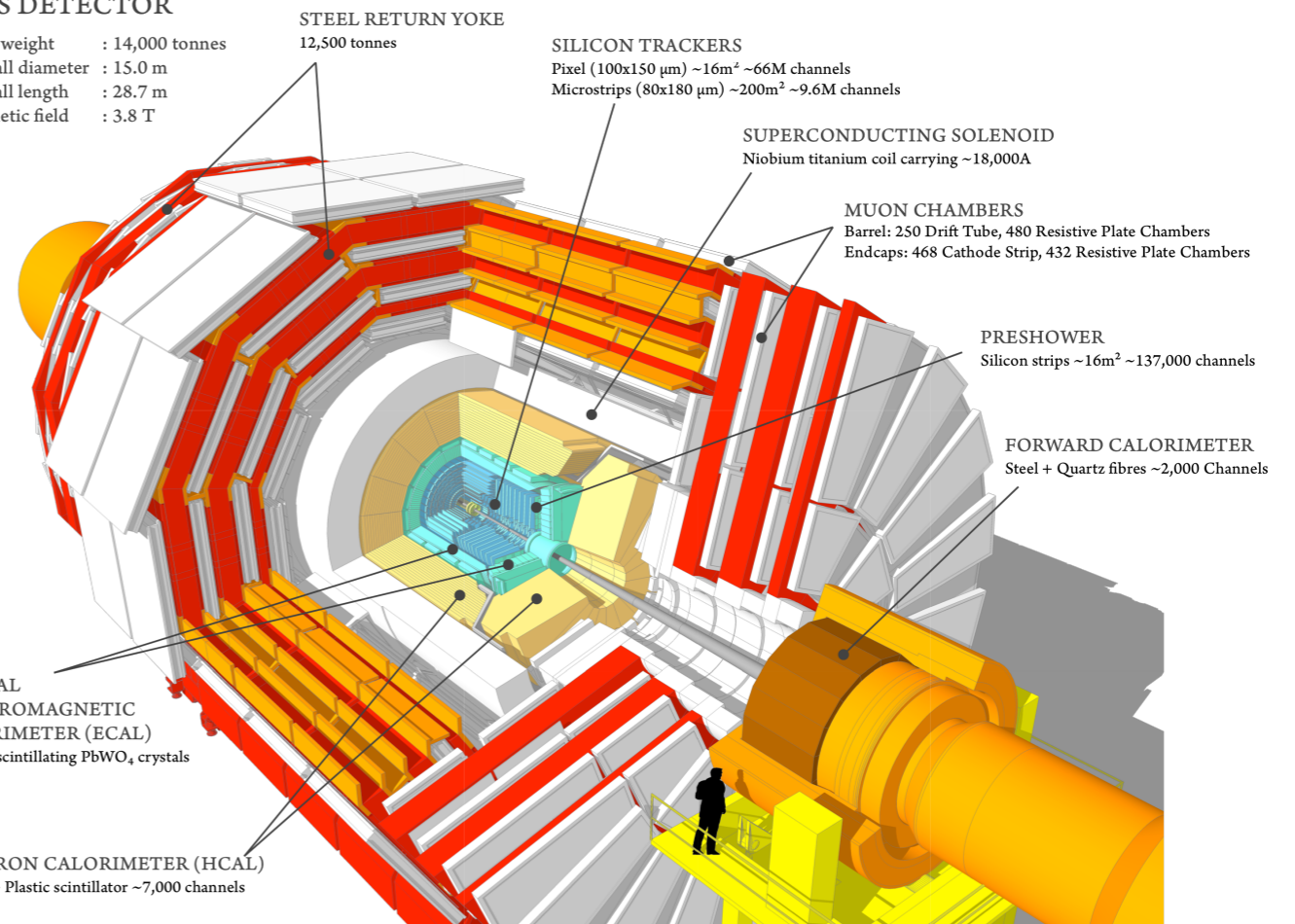
MUON CHAMBERS  
 Barrel: 250 Drift Tube, 480 Resistive Plate Chambers  
 Endcaps: 468 Cathode Strip, 432 Resistive Plate Chambers

PRESHOWER  
 Silicon strips  $\sim 16\text{m}^2 \sim 137,000$  channels

FORWARD CALORIMETER  
 Steel + Quartz fibres  $\sim 2,000$  Channels

CRYSTAL ELECTROMAGNETIC CALORIMETER (ECAL)  
 $\sim 76,000$  scintillating PbWO<sub>4</sub> crystals

HADRON CALORIMETER (HCAL)  
 Brass + Plastic scintillator  $\sim 7,000$  channels





## CMS masterclass features

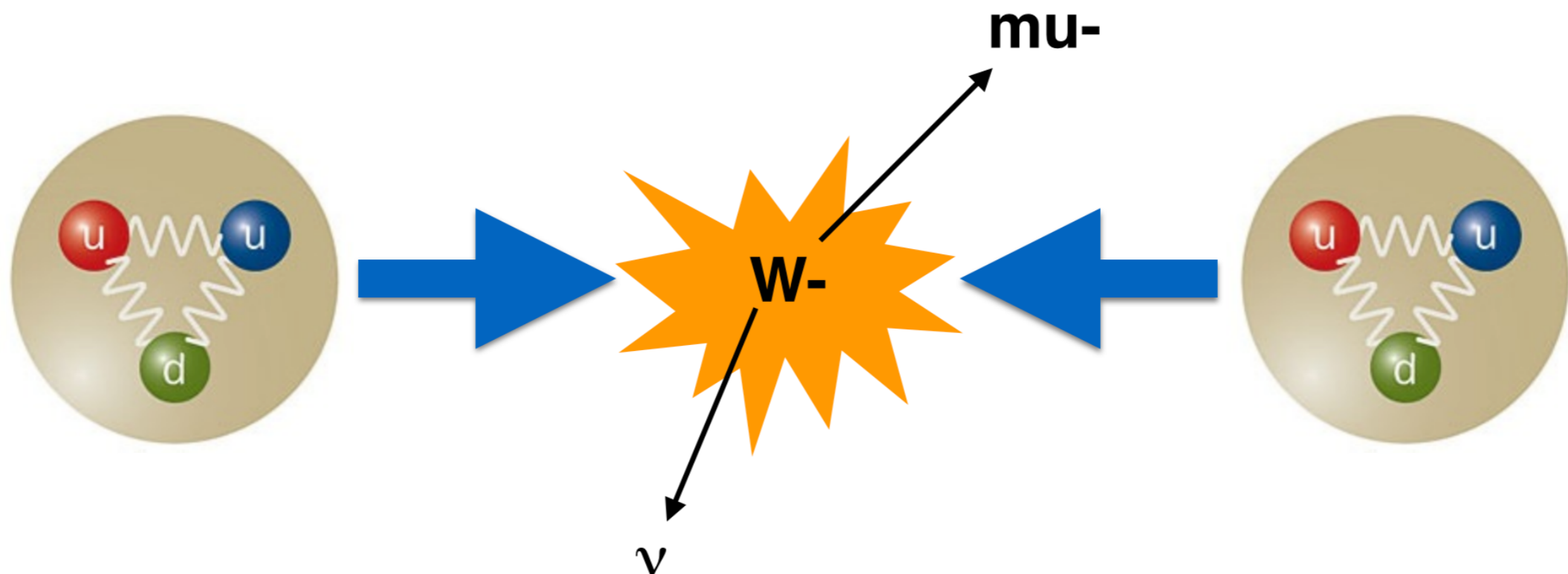
- 10 000 events (divided into 100 datasets):
  - $W$
  - $Z, J/\Psi, \Upsilon$
  - $H \rightarrow \gamma\gamma$ , a few, repeated
  - $H \rightarrow ZZ$ , a few, repeated
- Event display: iSpy-WebGL
- CIMA: CMS Instrument for Masterclass Analysis
- Updated documentation at <http://tiny.cc/doc17cms>.

Students find  $e:\mu$  and  $W^+:W^-$ ; create dilepton mass plot.



## About collisions

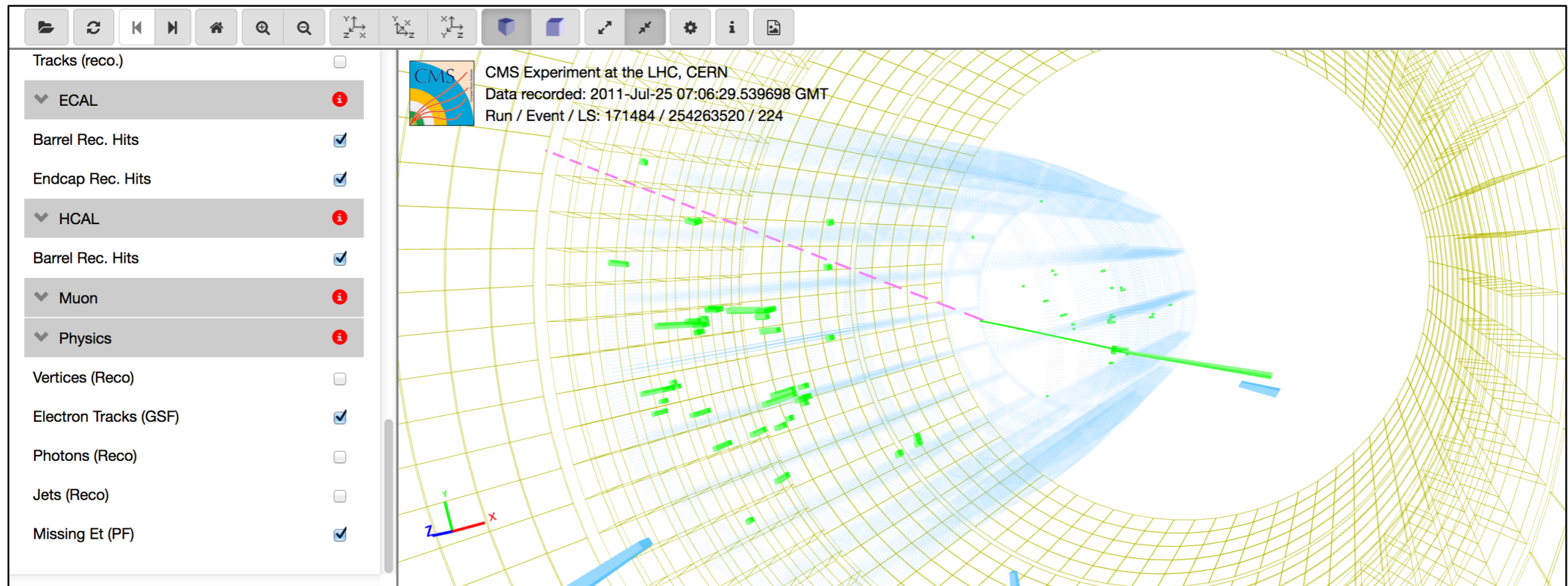
- Protons as “bags of partons”
- Parton-parton collisions
- Each parton shares only a portion of proton momentum
- $W^+ : W^-$  as probe of proton structure







# iSpy-WebGL



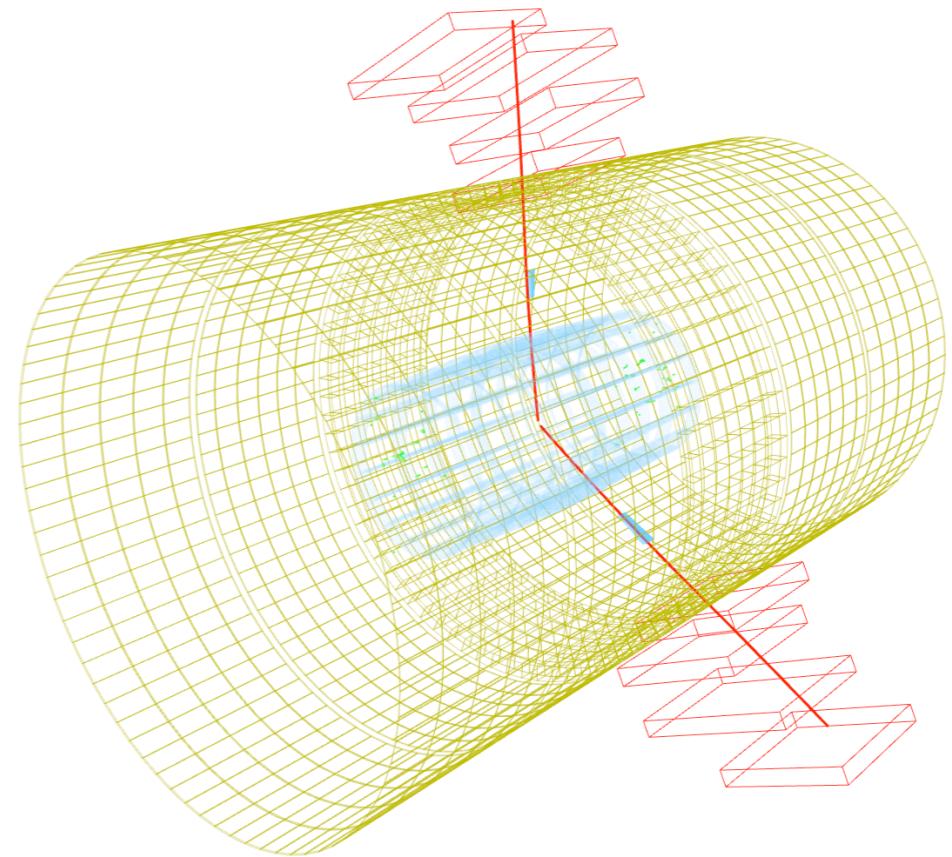
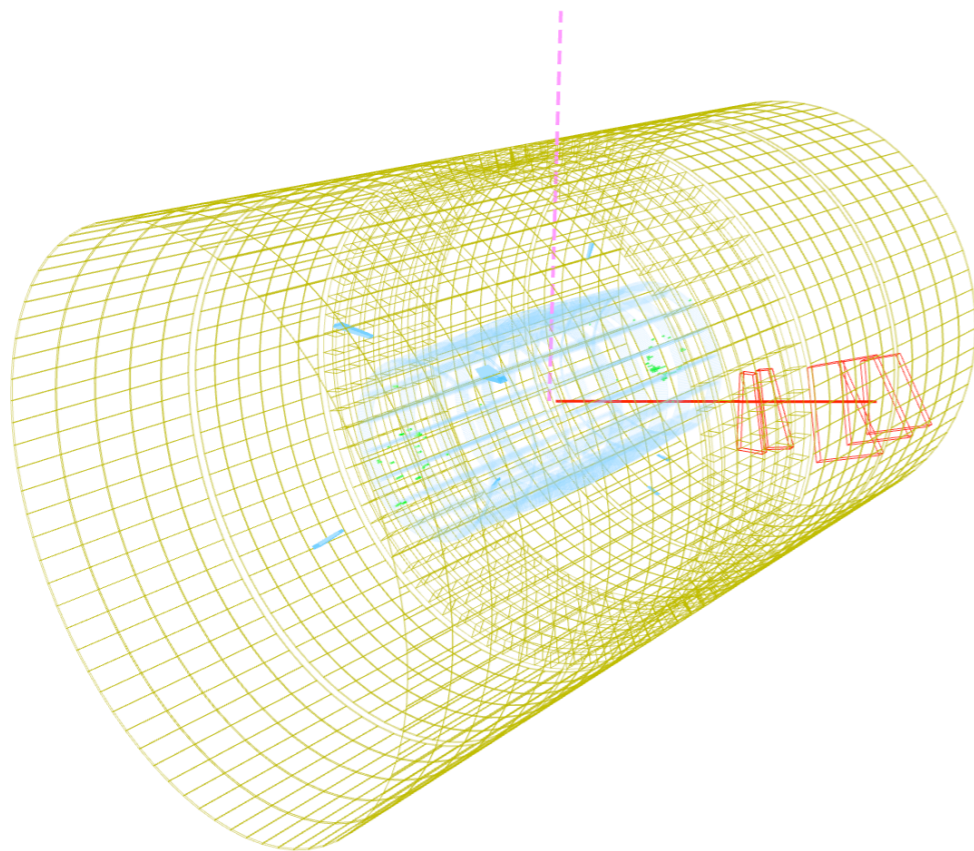
<https://www.i2u2.org/elab/cms/ispy-webgl>  
<http://cern.ch/ispy-webgl-masterclass>



## Student tasks

Students must distinguish W from Z candidates.

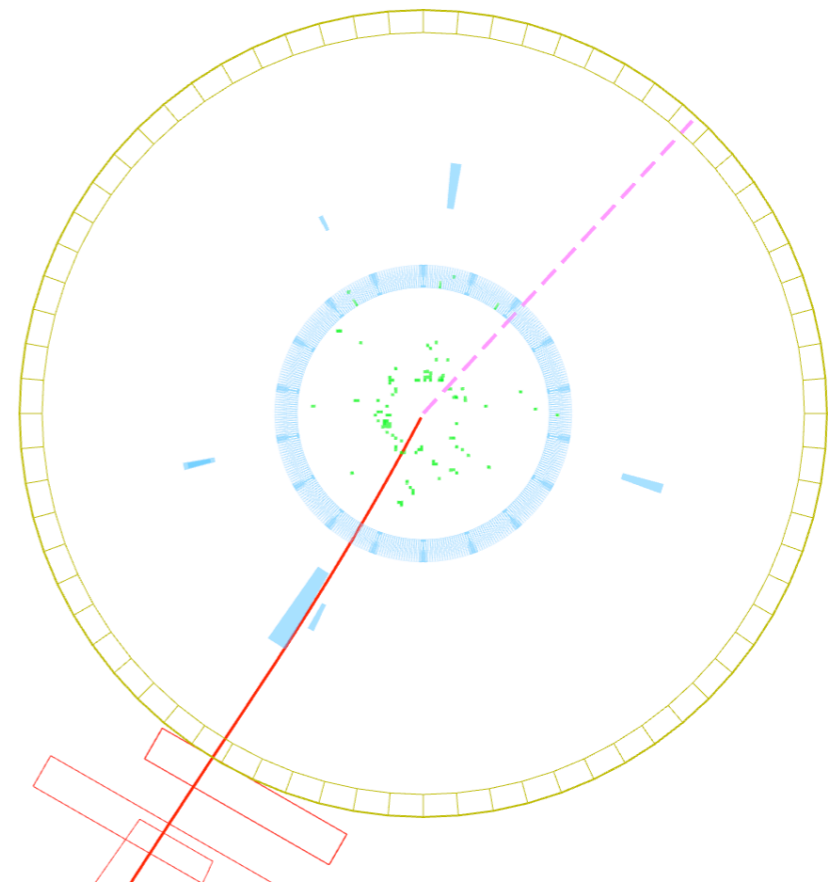
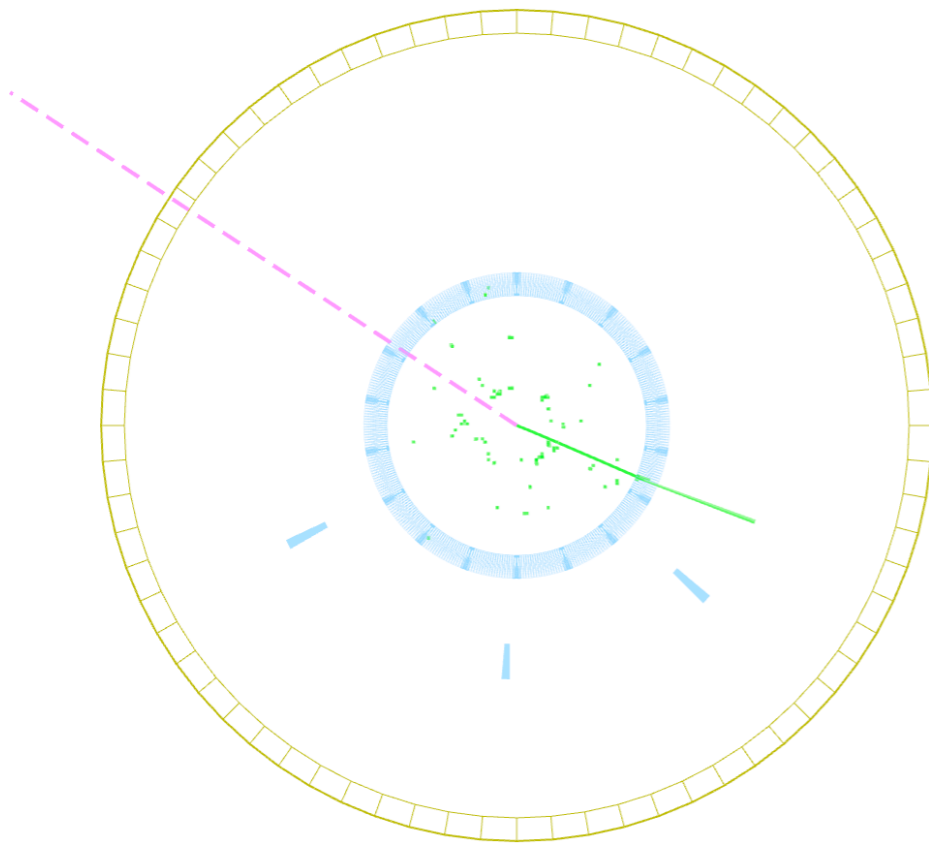
*Typical questions are about 2nd or 3rd lepton track  
(check pt)*





## Student tasks

Students distinguish electron *events* from muon *events*.

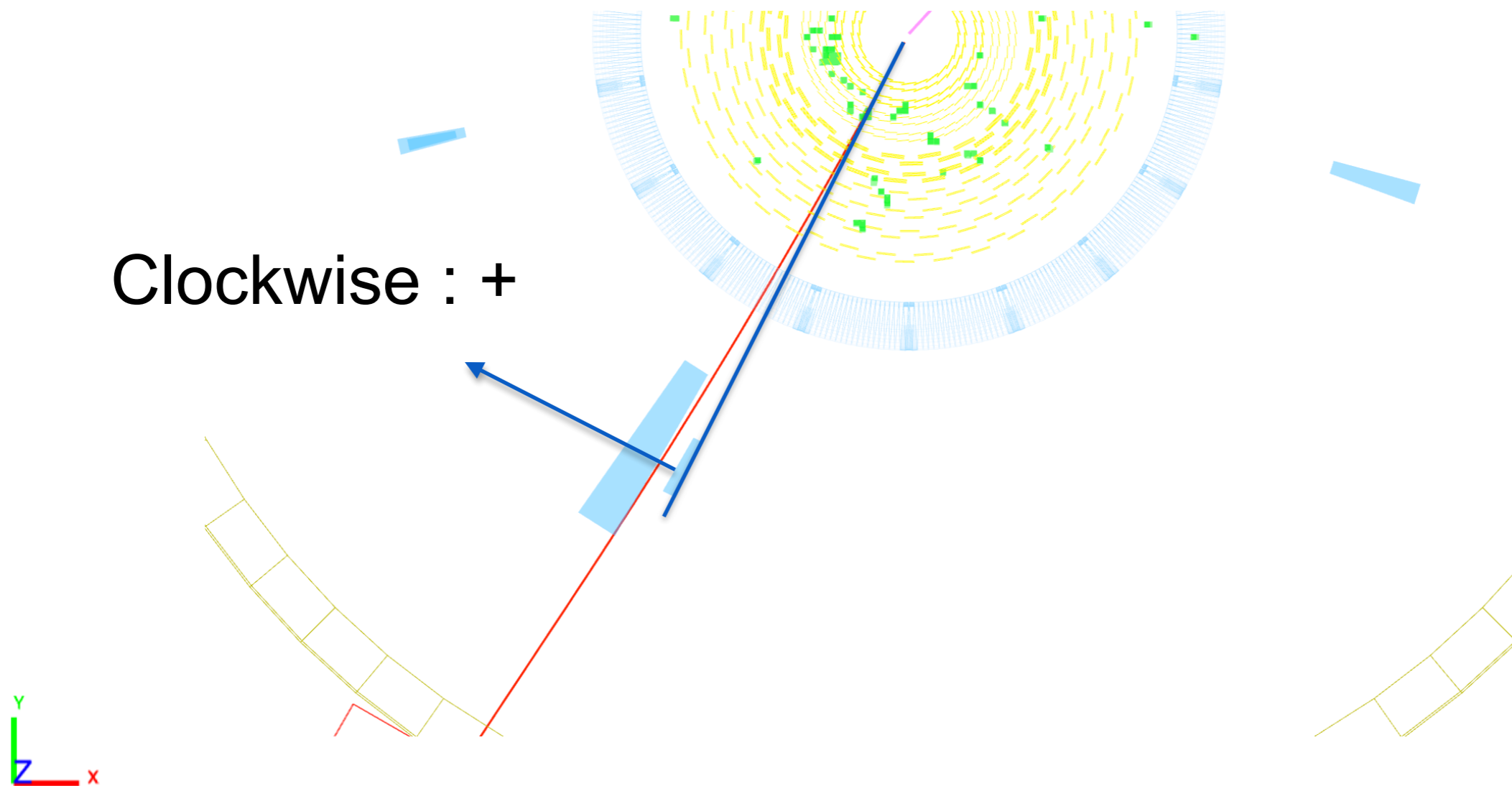






# Student Tasks

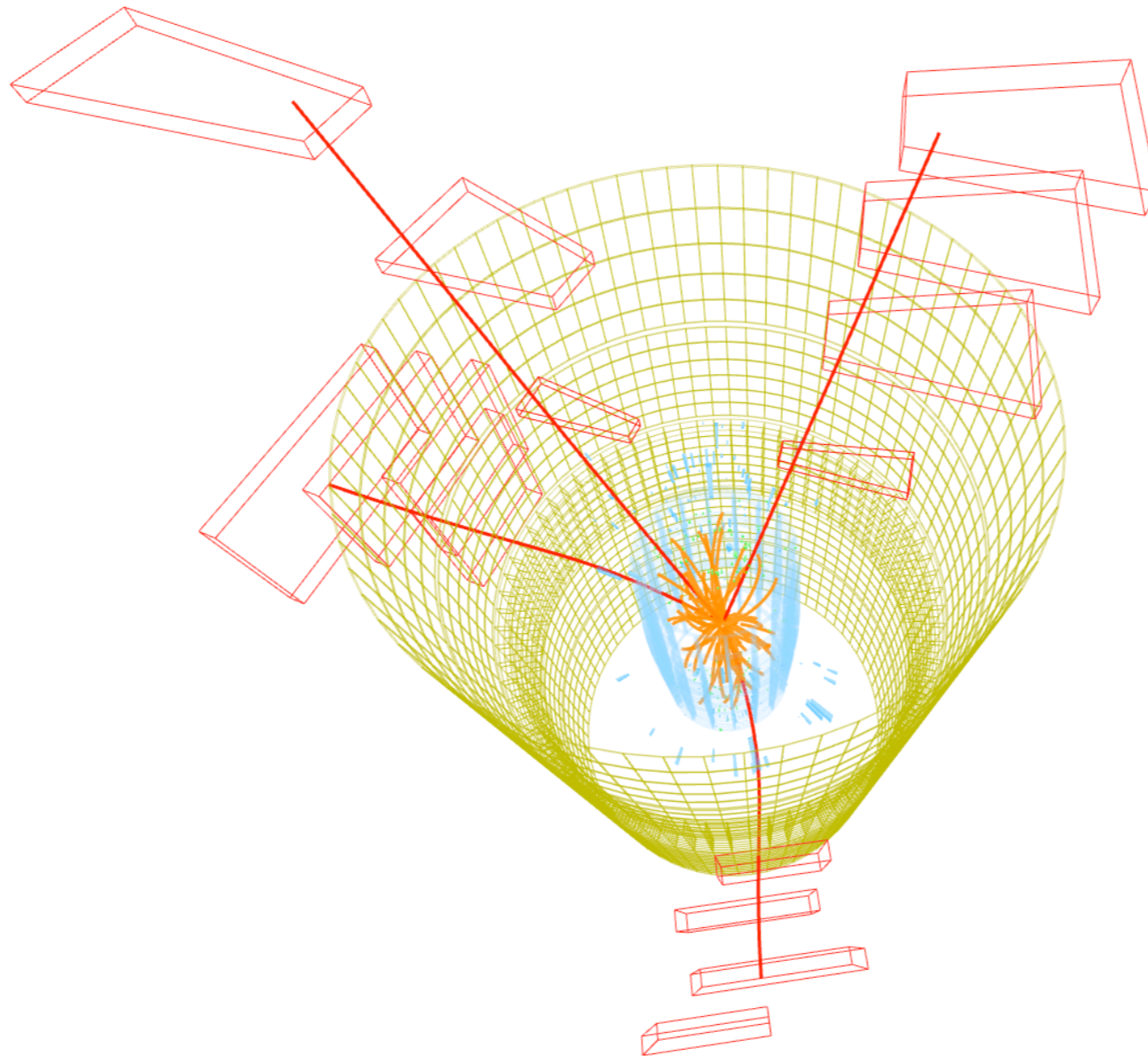
Students distinguish  $W^+$  from  $W^-$  using track curvature.





## Student tasks

Students look for  $H \rightarrow ZZ$  and  $H \rightarrow \gamma\gamma$  candidate events.








# Recording event data

Find your dataset.

Record parent particles and decay modes.



**CIMA**  
CMS Instrument for Masterclass Analysis

Choose your Masterclass

test  
Test2  
**31Jan2015**

Choose your location

Buffalo  
**MexicoCity**  
Quito

Choose your group

6  
**7**  
8  
9  
10

Choose the *date* of your masterclass, the *institute*, and your *dataset*.

Back
Events Table (Group 1)
Mass Histogram (TT1)
Results (TT1)
➔ Event Display

Masterclass: TestTables-Feb2017

location: TT1

Group: 1

Instructions (also available as [screencast](#)):

- For each event, identify the final state and select a primary state candidate.
  - For Higgs or Zoo candidate, no final state is chosen
  - If you cannot decide between W<sup>+</sup> and W<sup>-</sup>, choose W instead
- If you think the final state is a neutral particle (like a Z), but you don't know its exact type, select NP for "neutral particle." Find its mass from the Event Display and enter it.
- Once you have selected everything, click "Submit".

In case of an error, double clicking the data line will reload it; you can then try it again.

<b>Select Event</b>	<b>final state</b>	<b>primary state candidate</b>	<b>NP Mass:</b> <input type="text" value="4.55"/> <small>GeV/c<sup>2</sup></small>
Event index: <input type="text" value="10"/>	<input type="checkbox"/> Electron	<input type="checkbox"/> W <sup>-</sup> <input checked="" type="checkbox"/> NP	<input type="button" value="Submit"/>
Event number: 1-10	<input checked="" type="checkbox"/> Muon ( $\mu$ )	<input type="checkbox"/> W <sup>+</sup> <input type="checkbox"/> W	
		<input type="checkbox"/> Higgs	
		<input type="checkbox"/> Zoo	

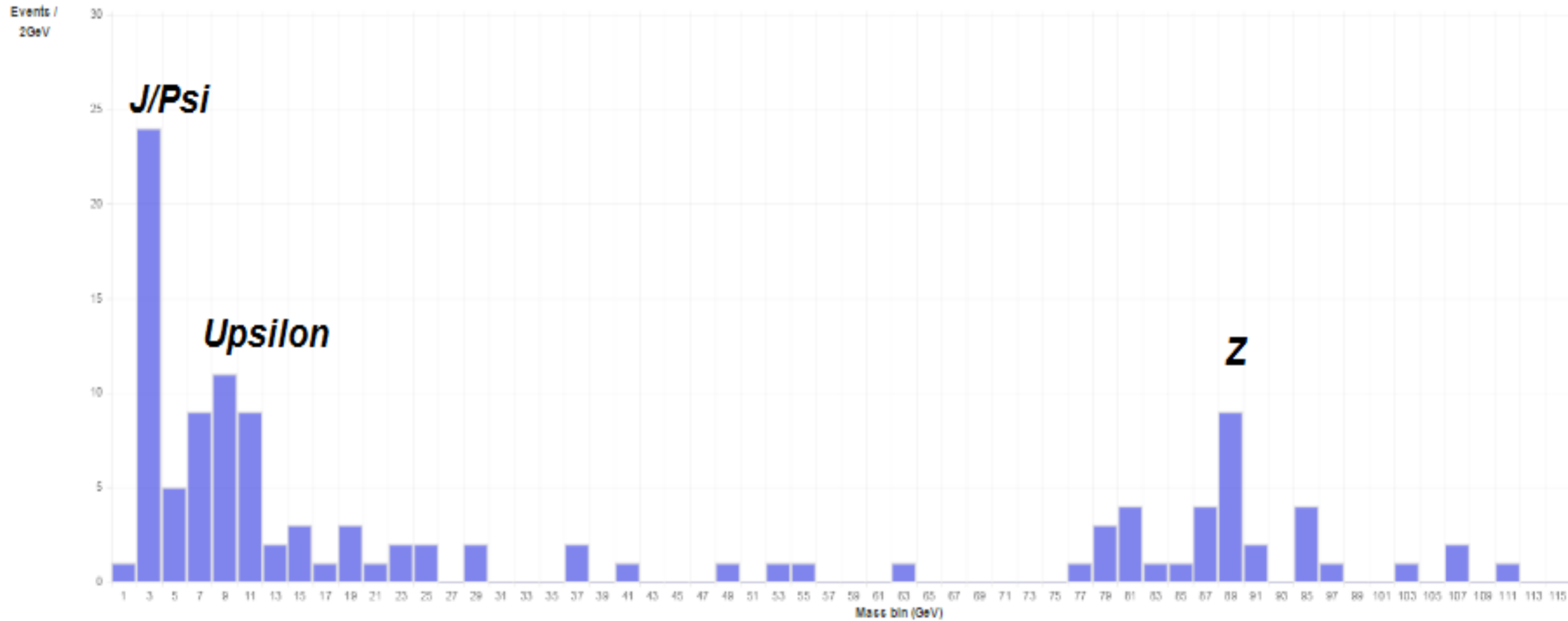
Event index	Event number	Chosen Values	Mass
9	1-9	Z, $\mu$	mu
8	1-8	e, W <sup>+</sup>	
7	1-7	$\mu$ , Z	95
6	1-6	$\mu$ , Z	NaN
5	1-5	e, Z	NaN
4	1-4	$\mu$ , W <sup>+</sup>	
3	1-3	$\mu$ , W <sup>+</sup>	
2	1-2	e, W <sup>-</sup>	
1	1-1	e, W <sup>+</sup>	



# What you see

Back Events Table **Mass Histogram** Results

Masterclass: 29Jan2015-NIMC-Winfeltorgym.  
Location: Dueren



Tip: Remove data from the histogram by holding the ctrl key  
(the command key for mac users)



# What you see

Back Events Table Mass Histogram Results

Masterclass: 28Jan2015-NMC-Witelltoqym.  
Location: Dueren

Group	Muon	Electron	W	W-	W+	Z	Higgs	Zoo	Total
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	19	22	6	6	10	19	0	18	59
4	23	15	0	9	16	13	1	13	52
5	18	21	10	9	9	11	0	8	47
6	8	8	1	6	4	5	0	11	27
7	0	0	0	0	0	0	0	0	0
8	16	15	2	7	10	12	1	14	46
9	21	13	2	11	10	11	0	14	48
10	0	0	0	0	0	0	0	0	0
11	26	24	0	14	19	17	0	1	51
12	15	19	0	7	13	14	3	10	47
13	15	22	0	11	16	10	1	6	44
14	24	15	0	7	17	15	0	8	47
15	0	0	0	0	0	0	0	0	0

↓

Total:

Muon	Electron	W	W-	W+	Z	Higgs	Zoo	Sum	e/mu	W+/W-
185	174	21	87	124	127	6	103	468	0.94	1.43





# Additional step with CIMA

<https://www.i2u2.org/elab/cms/cima/auth.php>

username  
Admin

password  
\*\*\*\*\*

Go!

MasterClass



# Additional step with CIMA

The screenshot illustrates the workflow for accessing the CIMA interface. It shows two browser windows. The left window, titled `https://www.i2u2.org/elab/cms/cima/auth.php`, contains a login form with fields for `username` (containing 'Admin') and `password` (masked with dots). A red arrow points from the password field to the text 'MasterClass'. A large blue arrow points from this window to the right window.

The right window, titled `https://www.i2u2.org/elab/cms/cima/Classes.php`, displays the 'Create new Masterclass Event' page. It includes a 'Create Event' button, an 'Edit Event' button, and a 'Manage Tables' section. The 'Manage Tables' section contains two tables:

Masterclasses	status
Test2	(active)
31Jan2015	(active)
10Feb2015	(active)
01Jan2015(orientations)	(active)
<b>04Mar2015</b>	(active)
09Feb2015	(active)
Femilab-06Mar2015	(active)
Femilab-07Mar2015-14C	(active)
Femilab-07Mar2015-15C	(active)
Femilab-12Mar2015	(active)

Tables	# of Groups
RiyadhTeam1	15
RiyadhTeam2	15
RiyadhTeam3	15
RiyadhTeam4	15

Red annotations highlight the '04Mar2015' entry in the Masterclasses table and the 'Results' button in the Tables section. Red text instructions state: 'Choose: - Date - Results button - Nothing else on this page!'.



# Combined results







## Q&A

*Students might ask:*

- About individual (collision) events
- Life at CERN or Fermilab
- Popular doomsdays

You might ask or comment on:

- How students decided on specific candidate events
- No. of events needed for “good” results
- How their day went

Questions? Ken Cecire: [kcecire@nd.edu](mailto:kcecire@nd.edu)

(also, CMS Question Time, later today...see Uta.)