

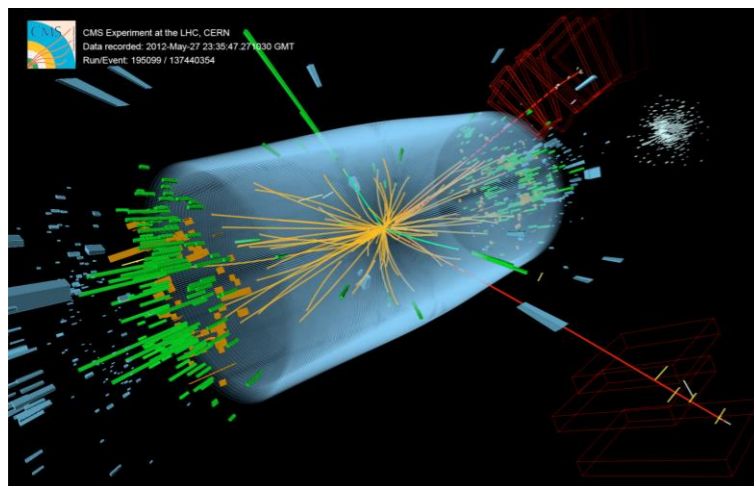
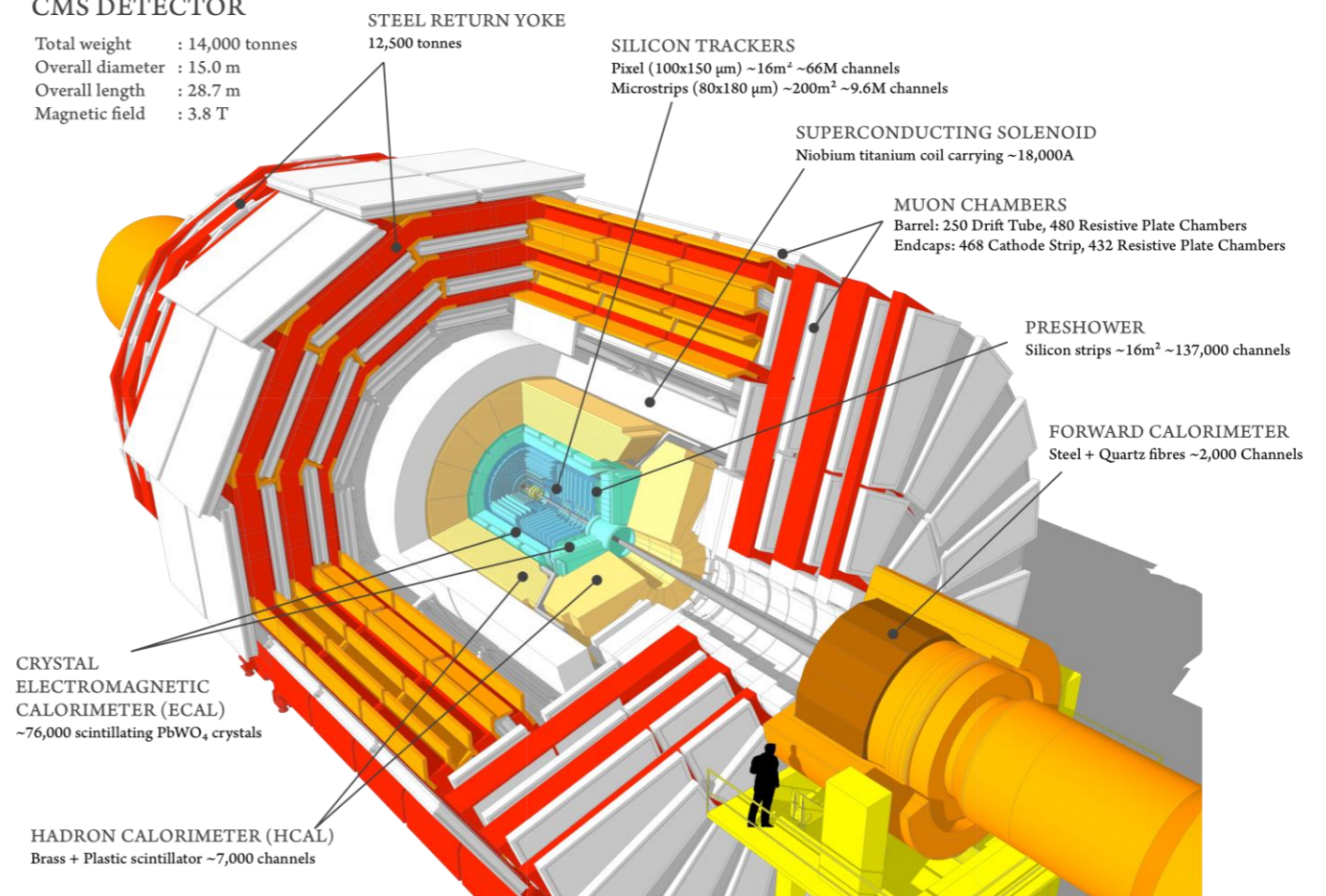


CMS Masterclass 2019 for Moderators



CMS DETECTOR

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





CMS masterclass features

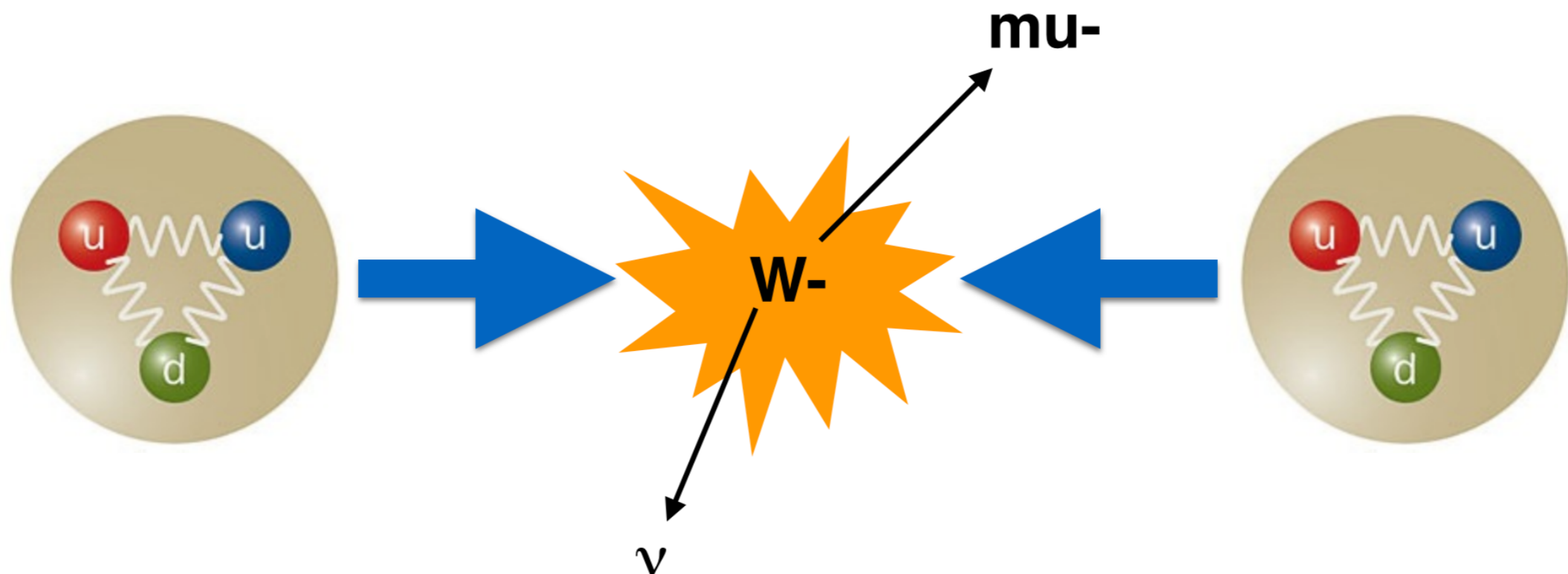
- *10 000 events (divided into 100 datasets):*
 - ***W***
 - ***Z, J/Psi, Upsilon***
 - *H* → 2 photons, *few, repeated*
 - *H* → *ZZ*, *few, repeated*
- *Event display: iSpy-WebGL*
- *CIMA – CMS Instrument for Masterclass Analysis*
- *Updated documentation at <http://tiny.cc/cms-doc-imc19>.*

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



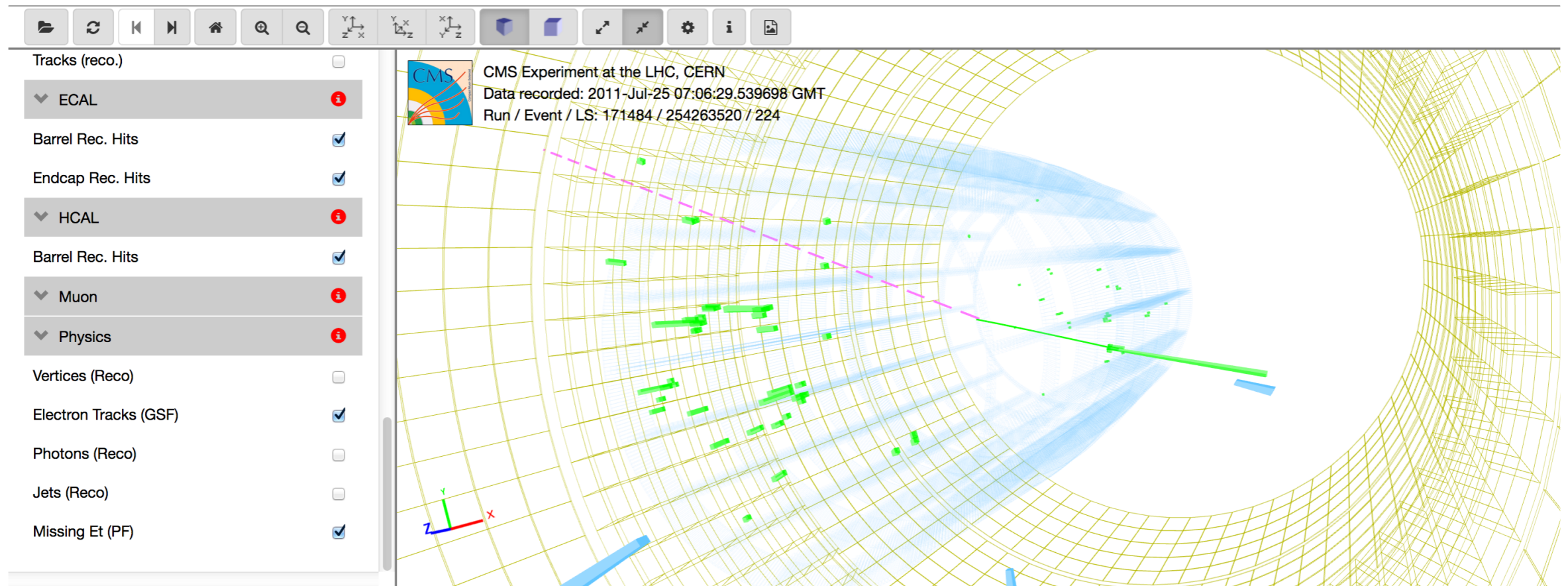
About collisions

- 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

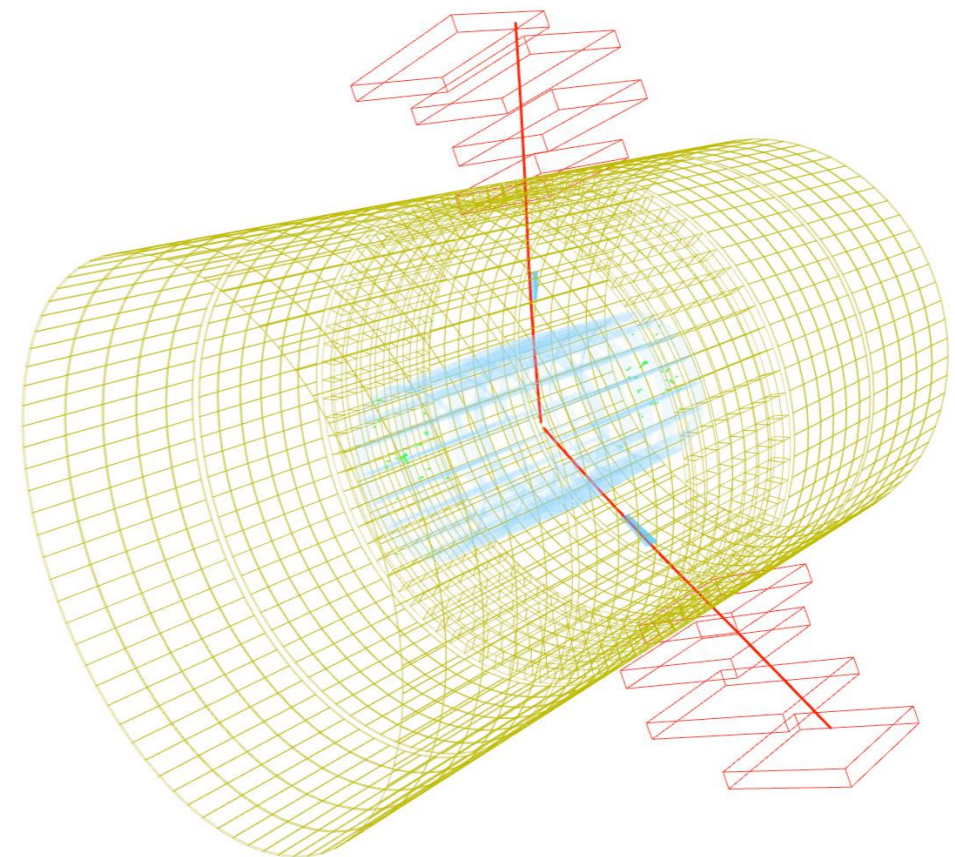
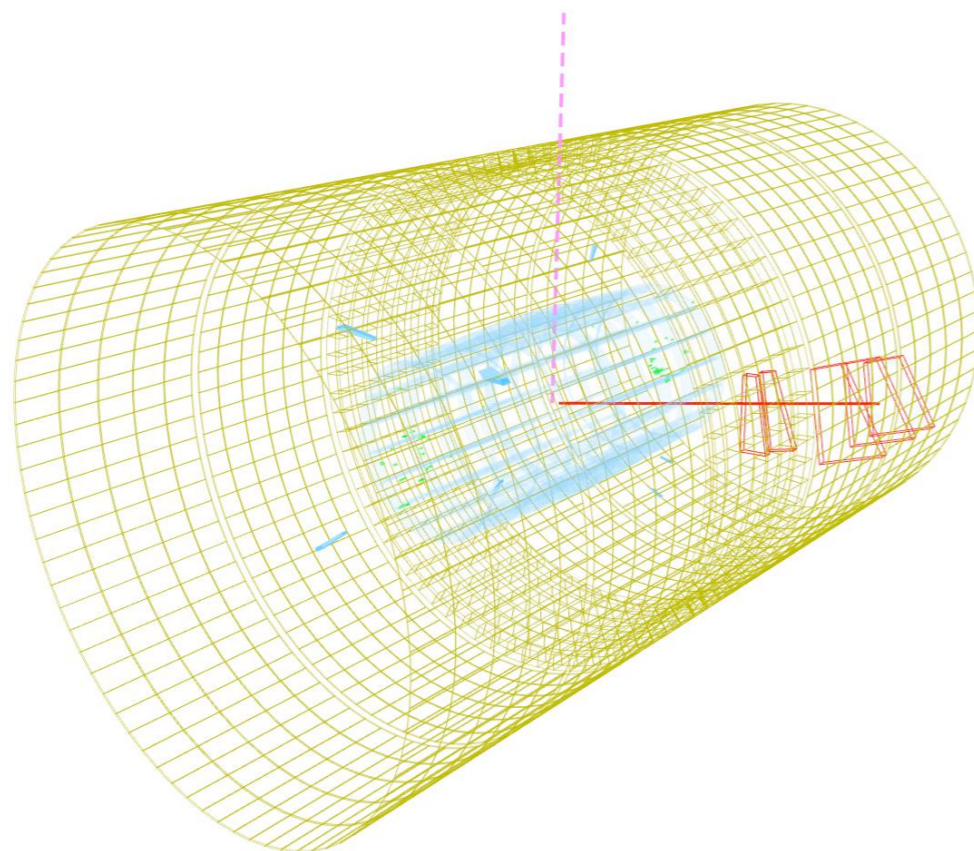




Student tasks

Students must distinguish W from Z candidates.

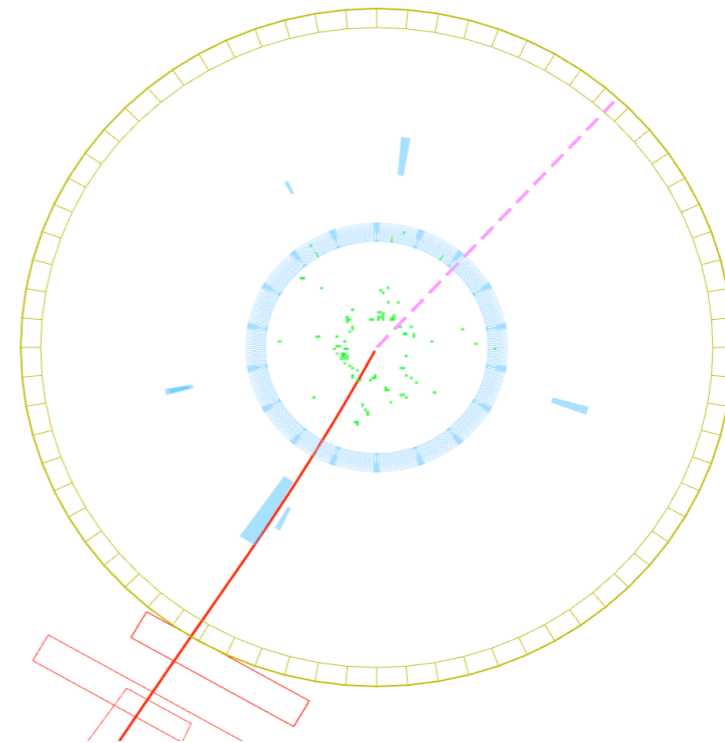
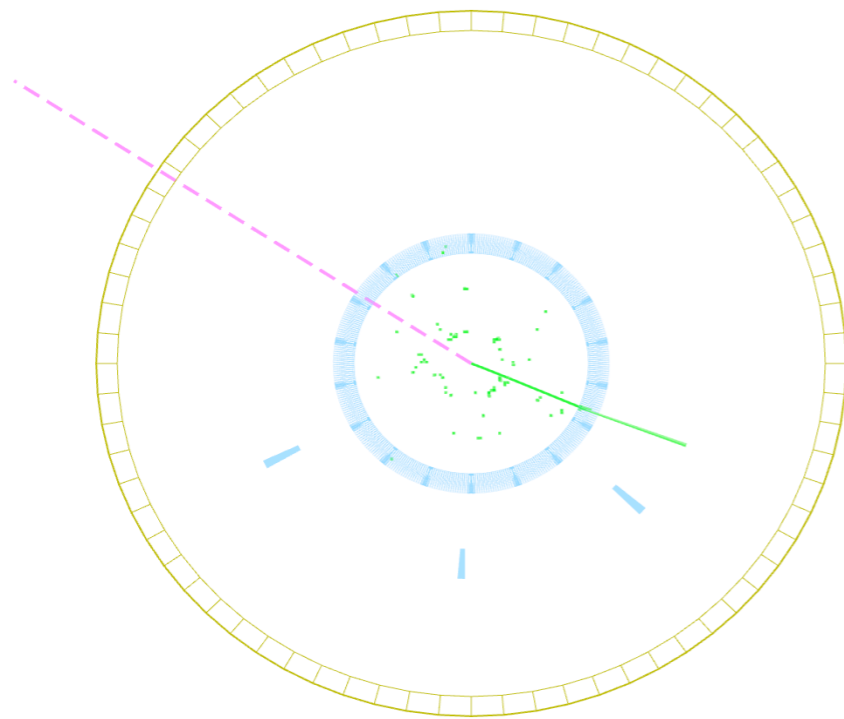
*Typical questions are about 2nd or 3rd lepton track
(check pt)*





Student tasks

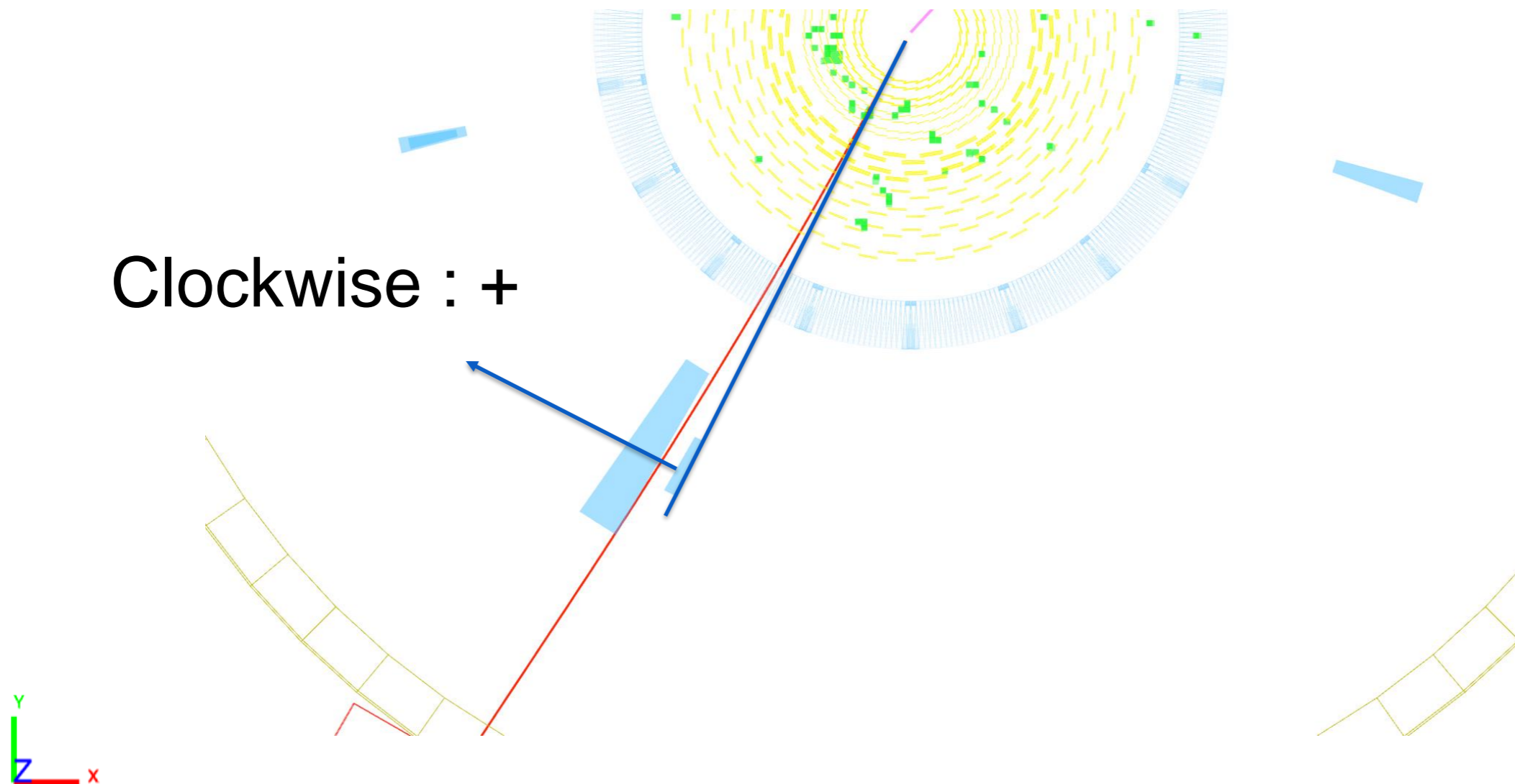
Students distinguish electron *events* from muon *events*.





Student Tasks

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

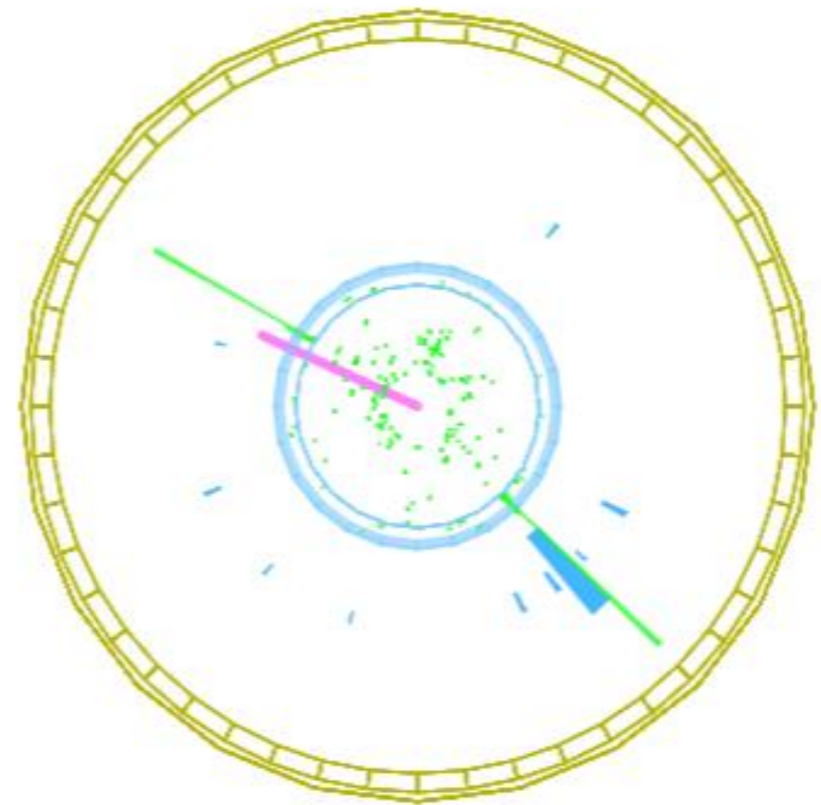
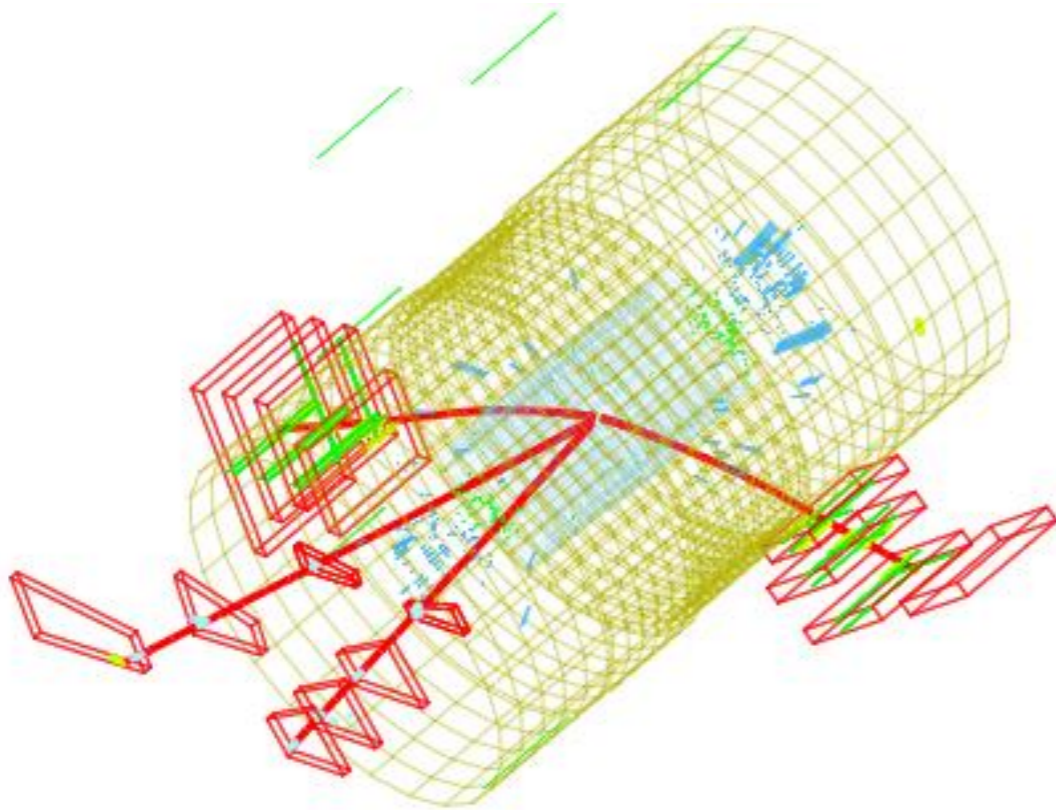




Student tasks

Students look for $H \rightarrow ZZ$ and $H \rightarrow \text{diphoton}$ events.

Occasionally, students “find” too many Higgs candidates.





Recording event data



Find your dataset.

Record parent particles and decay modes.

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^+ and W^- , 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.

Select Event	final state	primary state candidate	NP Mass: 4.55 <small>GeV/c²</small>
Event index: 10 Event number: 1-10	<input type="checkbox"/> Electron <input checked="" type="checkbox"/> Muon (μ)	<input type="checkbox"/> W^- <input type="checkbox"/> W^+ <input checked="" type="checkbox"/> NP <input type="checkbox"/> W	<input type="checkbox"/> Higgs <input type="checkbox"/> Zoo

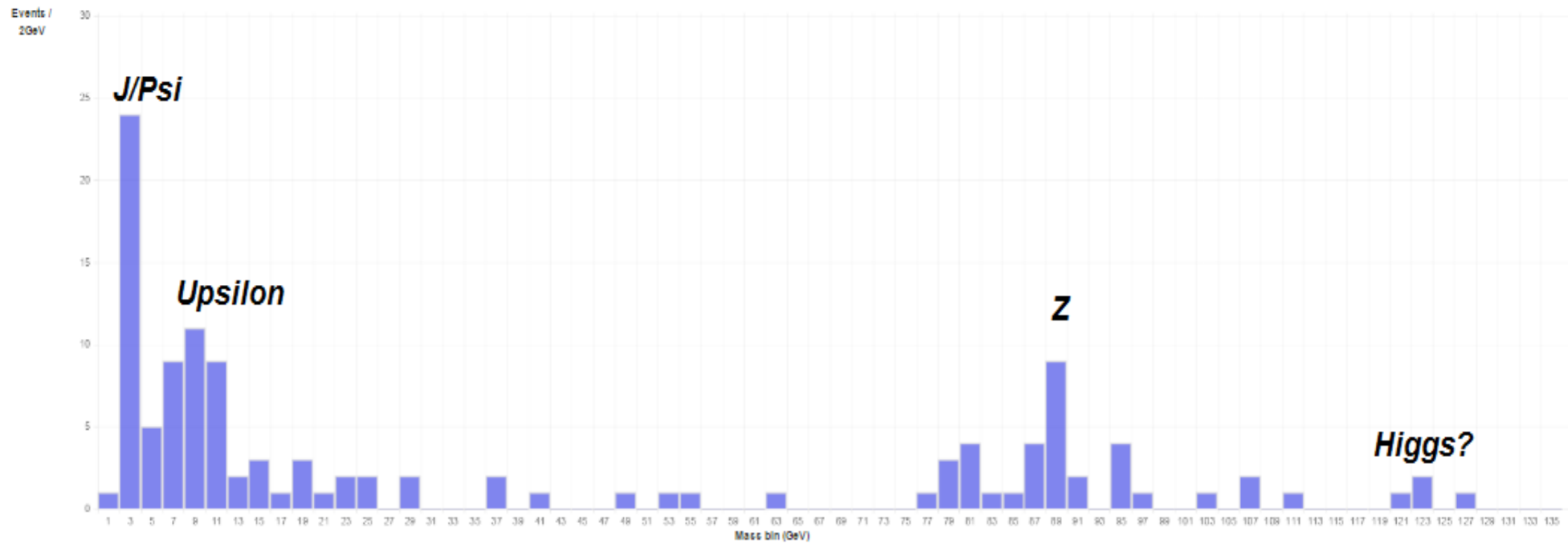
Event index	Event number	Chosen Values	Mass
9	1-9	Z, μ	mu
8	1-8	e, W^+	
7	1-7	μ , Z	95
6	1-6	μ , Z	NaN
5	1-5	e, Z	NaN
4	1-4	μ , W^+	
3	1-3	μ , W^+	
2	1-2	e, W^-	
1	1-1	e, W^+	



What you see

Back Events Table **Mass Histogram** Results [Event Display](#)

Masterclass: 28Jan2015-NMC-Wirteltogym.
location: Dueren



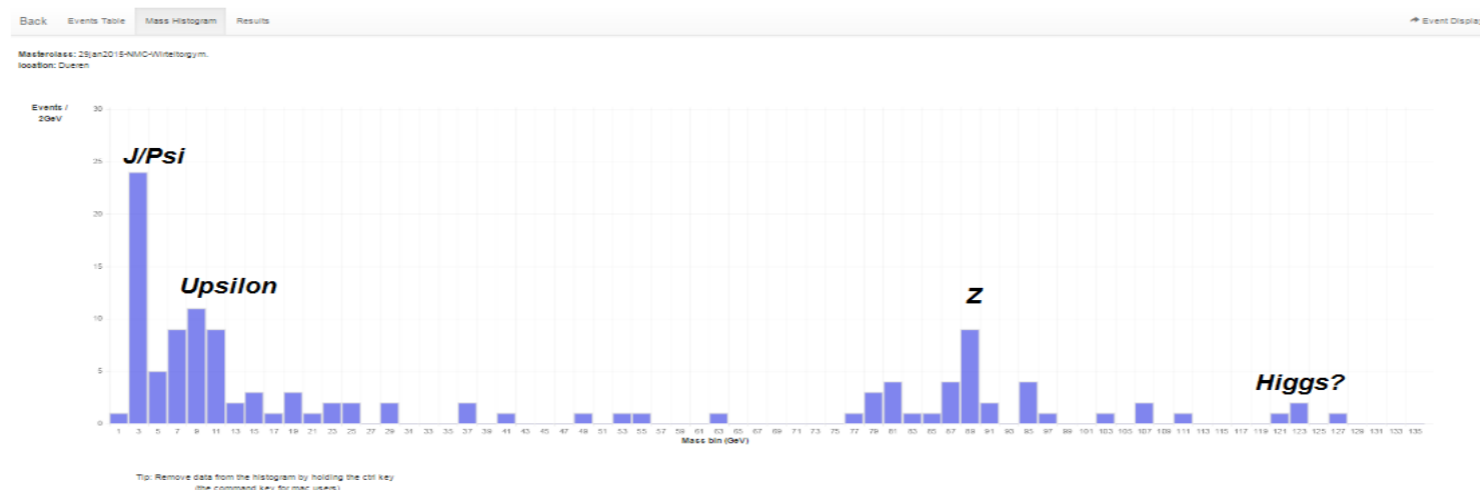
Tip: Remove data from the histogram by holding the ctrl key
(the command key for mac users)



Questions you can ask

Ask the students:

- Where are the peaks in the Mass Histogram? What do they represent?
- Where is Z boson in the plot? What are the other peaks, then?
- Do you have possible Higgs events in the plot? Where? Can we claim discovery?





What you see

Back Events Table Mass Histogram Results

Masterclass: 29Jan2015-NMC-Winfeltogym.
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



Questions you can ask

Ask the students:

- What do you expect the ratio of electron events to muon events to be? Is your result consistent with this?
- What is the ratio of W^+ to W^- bosons? What does this ratio tell us about protons?

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	elmu	W+/W-
185	174	21	87	124	127	6	103	488	0.94	1.43



Additional step with CIMA

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

username

password

Go!

Get login and password from IMC Central Coordination!



Additional step with CIMA

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

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

username

password

Go!

Create new Masterclass Event

Enter name of new event:
 Event name **Create Event**

Edit Event

Select event:
 Test2 **Edit Event**

Manage Tables:

change active status delete

Masterclasses	status	Tables	# of Groups
Test2	(active)	RiyadhTeam1	15
31Jan2015	(active)	RiyadhTeam2	15
10Feb2015	(active)	RiyadhTeam3	15
01Jan2015(orientations)	(active)	RiyadhTeam4	15
04Mar2015	(active)		
09Feb2015	(active)		
Femilab-06Mar2015	(active)		
Femilab-07Mar2015-14C	(active)		
Femilab-07Mar2015-15C	(active)		
Femilab-12Mar2015	(active)		
	(active)		
	(active)		
	(active)		
	(active)		
	(active)		
	(active)		
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	(active)		
	(active)		
	(active)		
	(active)		

Results

Choose:

- Date
- Results button
- Nothing else on this page!

Get login and password from IMC Central Coordination!



Q&A

Students might ask:

- *About individual events → try to keep it general*
- *About double events, like $W+W^-$ or WZ (nope)*
- *Life at CERN or Fermilab*
- *Seemingly “weird” physics*
- *Why we do research; how do we justify it.*

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 for Ken: kcecire@nd.edu