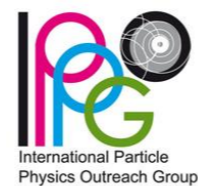


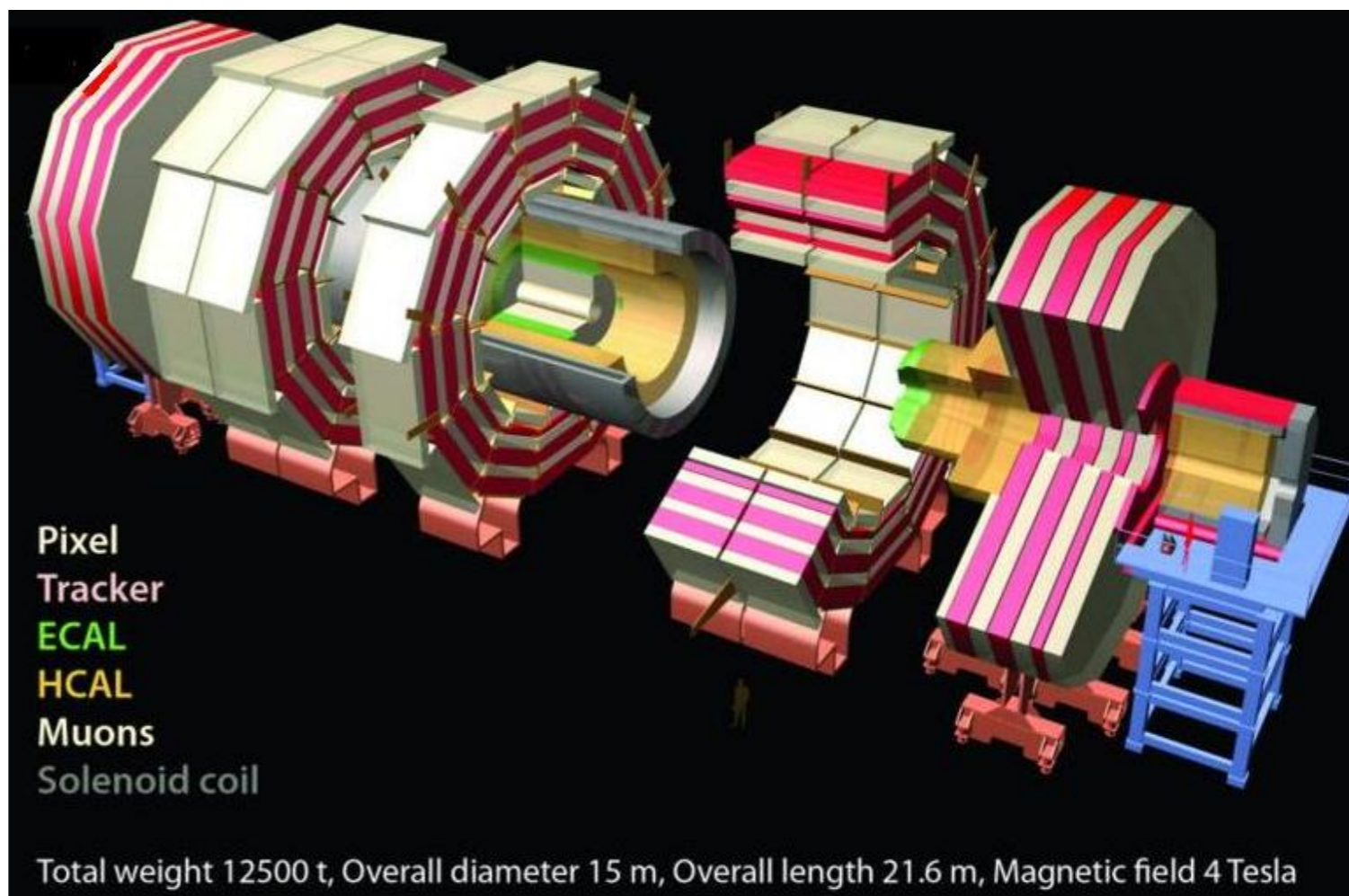
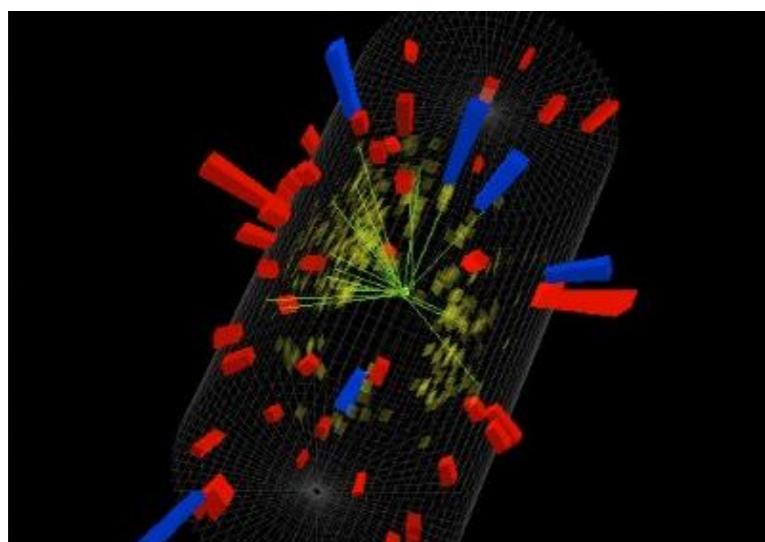
INTERNATIONAL MASTERCLASSES

hands on particle physics

QuarkNet



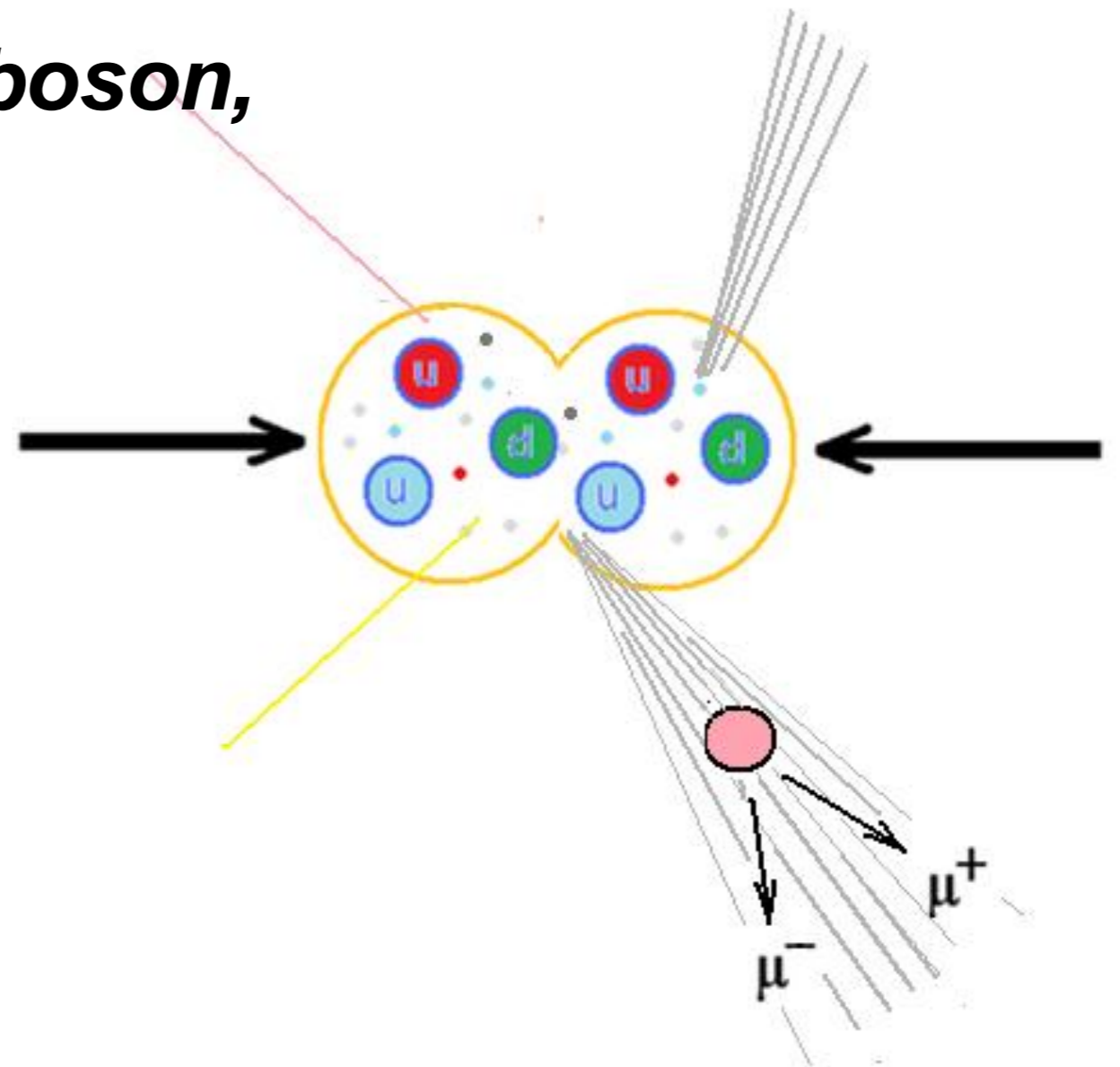
CMS Masterclass 2012



W and Z Particles

Looking for the mediators of the *weak interaction*:

- electrically charged W^+ boson,
- the negative W^- boson,
- the neutral Z boson.

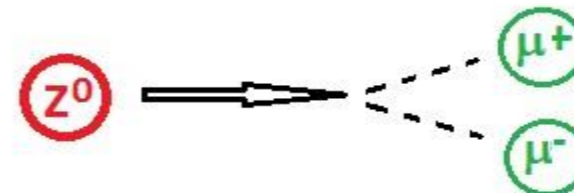
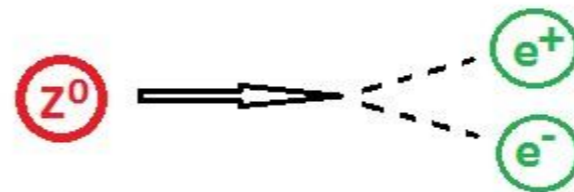


W and Z Decays

W and Z travel only a tiny distance before decaying, so CMS does not “see” W or Z bosons directly.

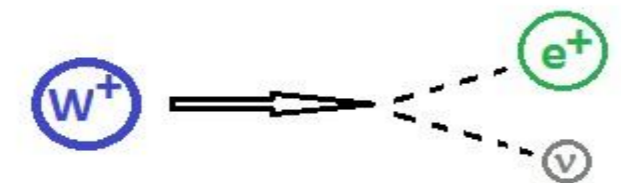
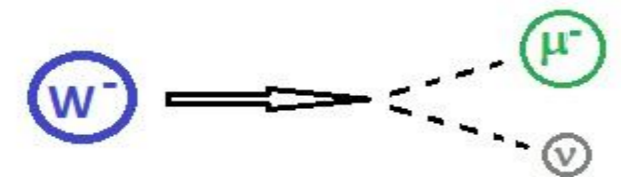
CMS can detect

- electrons
- muons



CMS can infer

- neutrinos from “missing energy”



iSpy-online

The image displays the iSpy-online interface, which is used for visualizing particle detector events. On the left, there is a control panel with several sections:

- Detector Model:** A list of detector components with checkboxes. The checked items are ECAL Barrel, HCAL Outer, and HCAL Forward.
- Tracking:** A list of tracking-related components, all of which are currently unchecked.
- ECAL:** A list of ECAL components, with 'Barrel Rec. Hits' and 'Endcap Rec. Hits' checked.
- HCAL:** A list of HCAL components, with 'Barrel Rec. Hits' and 'Endcap Rec. Hits' checked.
- Controls:** A section with three mouse control icons: 'rotate', 'Ctrl + pan x/y', and 'Shift + pan z'.

At the top of the interface is a toolbar with icons for file operations, navigation, and help. The main 3D view shows a wireframe model of the detector. Key features are labeled with arrows:

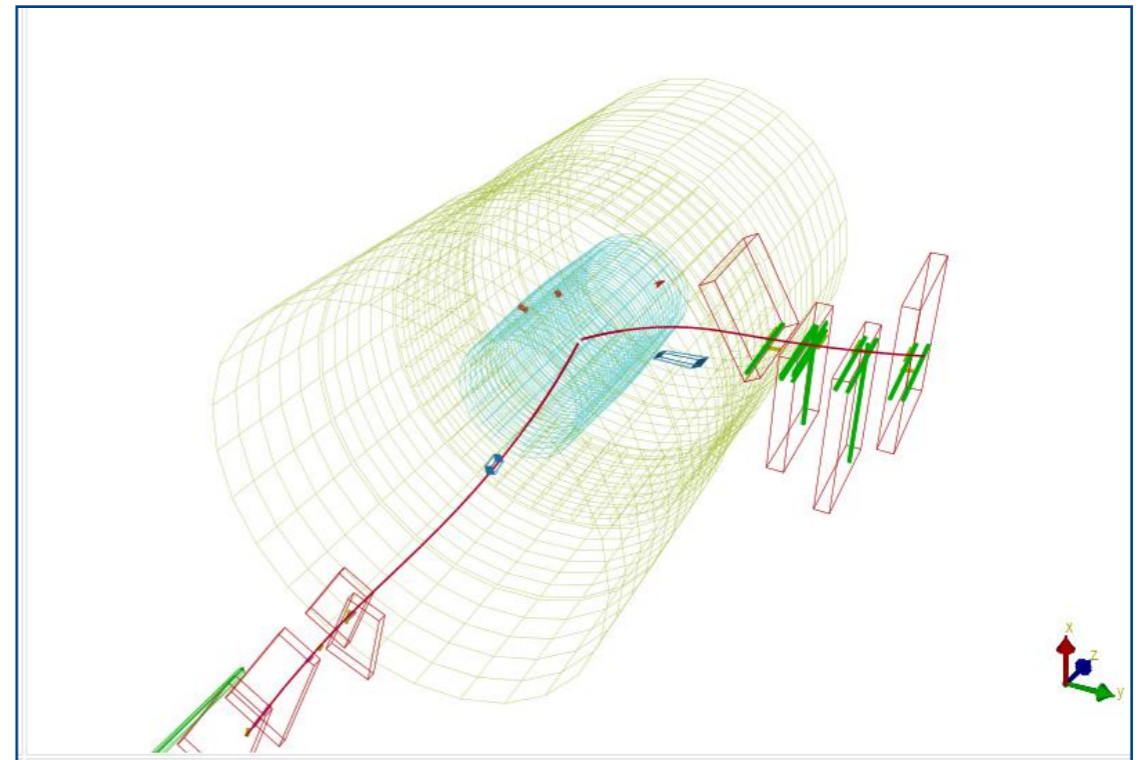
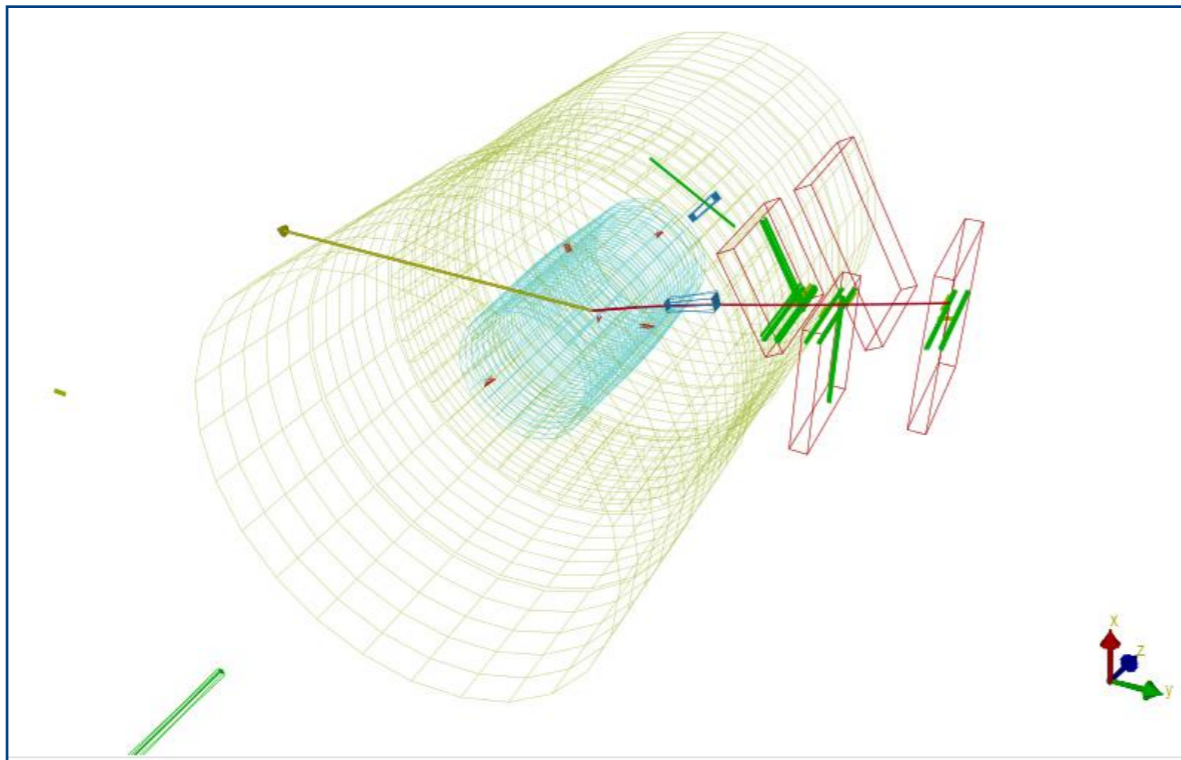
- event display controls:** Points to the toolbar at the top.
- event vertex (near collision):** Points to the central point where the collision occurs.
- beamline:** Points to the central axis of the detector.
- inner detector (tracker):** Points to the inner cylindrical region of the detector.
- electron track:** Points to a track originating from the vertex and moving towards the ECAL.
- energy deposit:** Points to a cluster of hits in the ECAL barrel.
- missing energy:** Points to a green arrow indicating energy that is not accounted for by the visible tracks.

A 3D coordinate system (x, y, z) is visible in the bottom right corner of the 3D view.

The Task

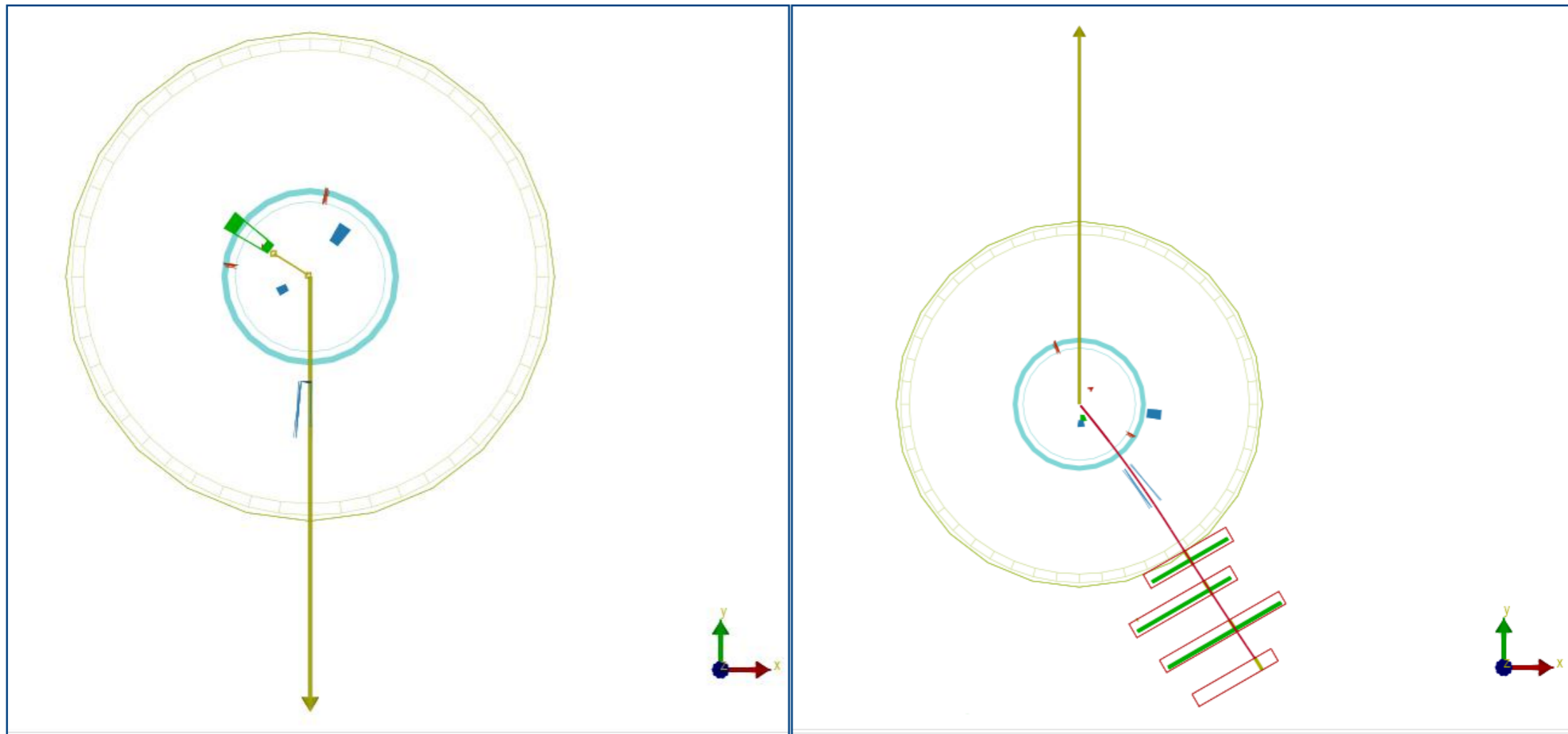
Use new data from the LHC in iSpy to test CMS performance.

Can we distinguish W from Z candidates?



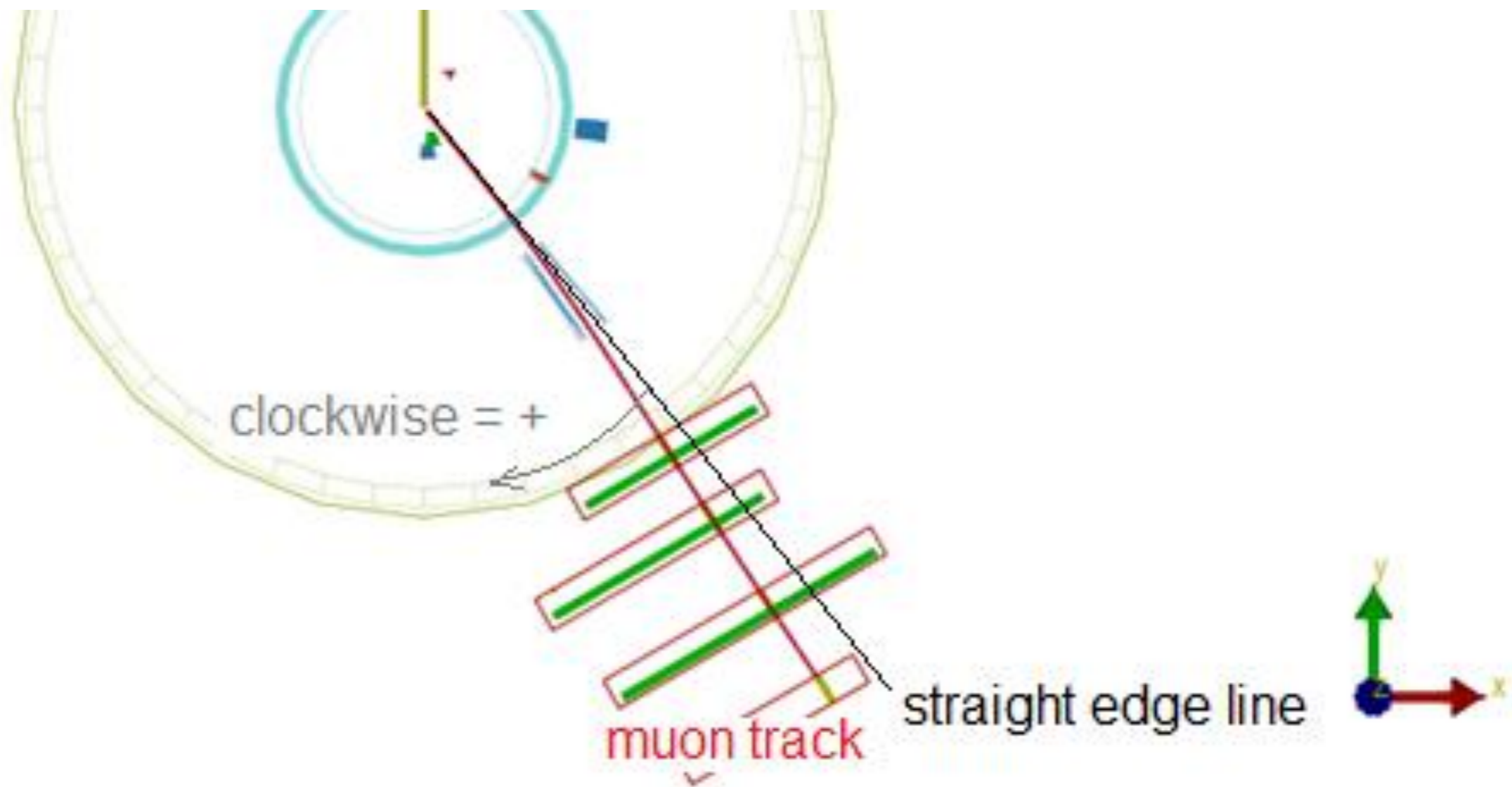
The Task

Can we calculate the e/μ ratio?



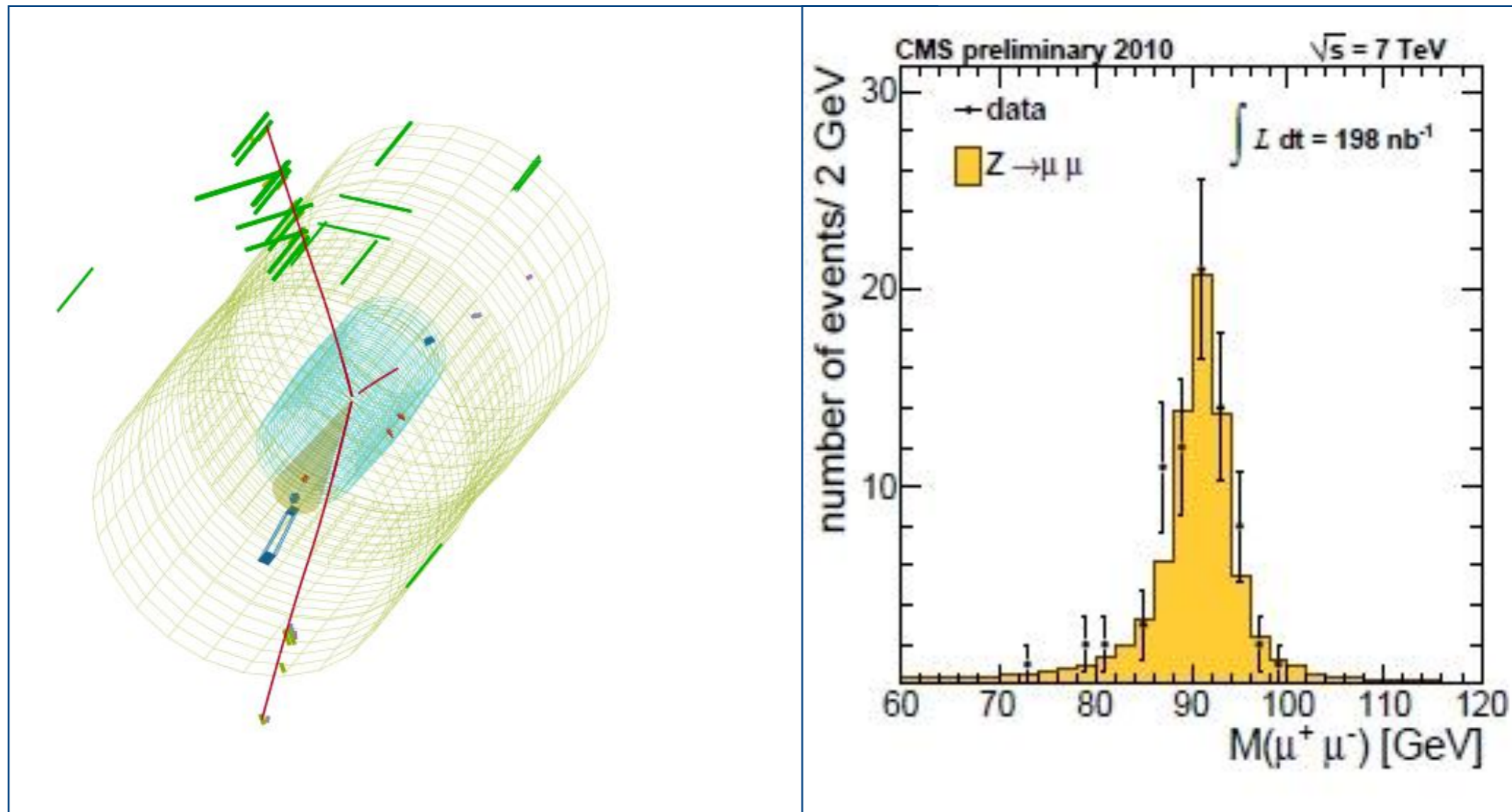
The Task

Can we calculate a W^+/W^- ratio for CMS?



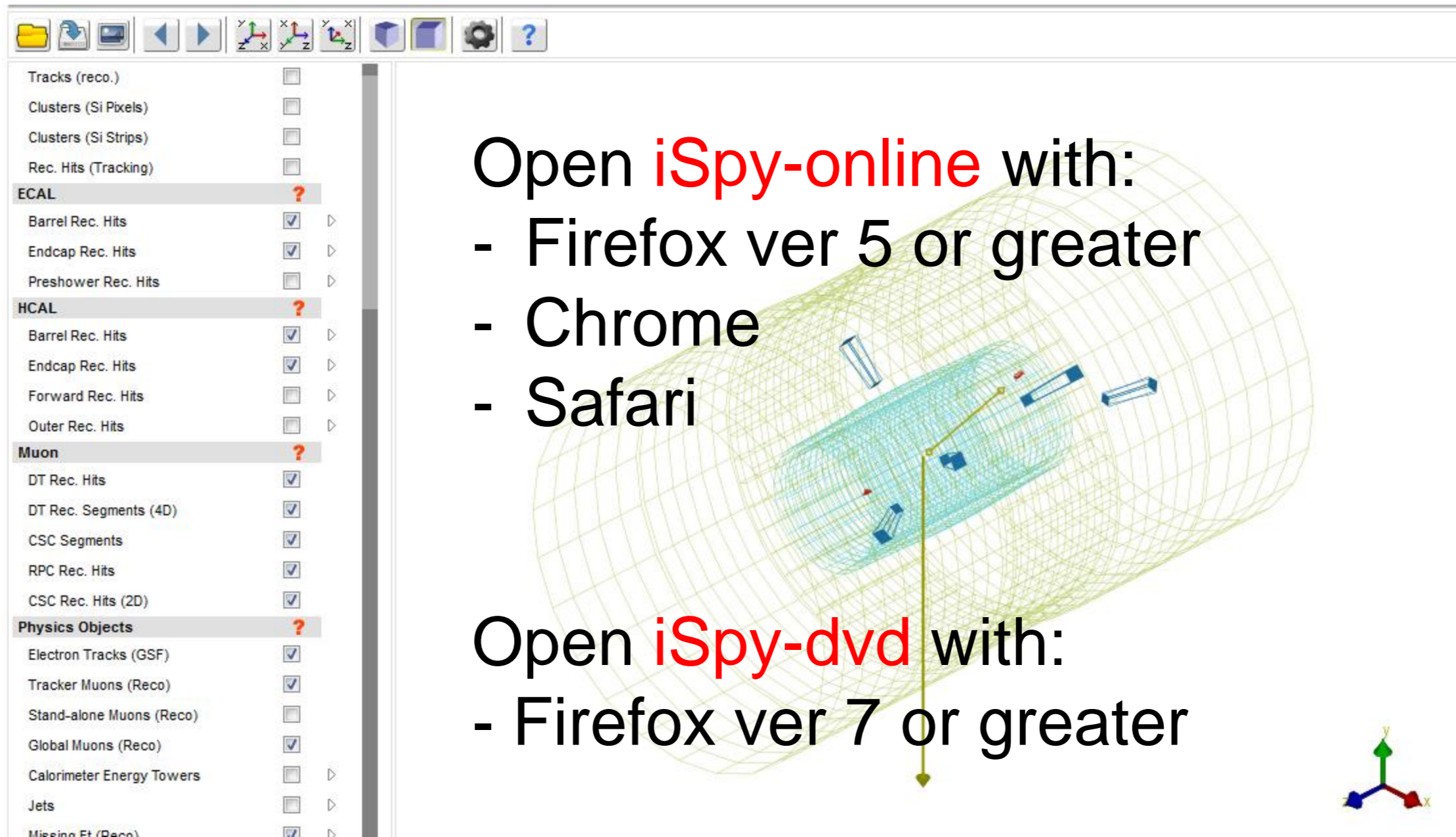
The Task

Can we make mass plot of Z candidates?



EvNo	E1	px1	py1	pz1	pt1	eta1	phi1	Q1	E2	px2	py2	pz2	pt2	eta2	phi2	Q2	M
128943239	72.89895	13.36098	-26.087	66.74727	29.3095	1.5612	-1.09746	1	37.6277	-10.9181	35.80517	-3.82334	37.3966	-0.10197	1.86677	-1	90.31227

Try Real Events



The screenshot shows the iSpy-online interface. On the left is a list of data layers with checkboxes and expand/collapse icons. The main area displays a 3D visualization of a particle detector, likely the ATLAS detector, with a green wireframe grid and various colored components. A yellow line with a downward arrow points from the text below to the detector visualization.

Layer Name	Checked	Expand
Tracks (reco.)	<input type="checkbox"/>	
Clusters (Si Pixels)	<input type="checkbox"/>	
Clusters (Si Strips)	<input type="checkbox"/>	
Rec. Hits (Tracking)	<input type="checkbox"/>	
ECAL	<input type="checkbox"/>	<input type="checkbox"/>
Barrel Rec. Hits	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Endcap Rec. Hits	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Preshower Rec. Hits	<input type="checkbox"/>	<input type="checkbox"/>
HCAL	<input type="checkbox"/>	<input type="checkbox"/>
Barrel Rec. Hits	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Endcap Rec. Hits	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Forward Rec. Hits	<input type="checkbox"/>	<input type="checkbox"/>
Outer Rec. Hits	<input type="checkbox"/>	<input type="checkbox"/>
Muon	<input type="checkbox"/>	<input type="checkbox"/>
DT Rec. Hits	<input checked="" type="checkbox"/>	
DT Rec. Segments (4D)	<input checked="" type="checkbox"/>	
CSC Segments	<input checked="" type="checkbox"/>	
RPC Rec. Hits	<input checked="" type="checkbox"/>	
CSC Rec. Hits (2D)	<input checked="" type="checkbox"/>	
Physics Objects	<input type="checkbox"/>	<input type="checkbox"/>
Electron Tracks (GSF)	<input checked="" type="checkbox"/>	
Tracker Muons (Reco)	<input checked="" type="checkbox"/>	
Stand-alone Muons (Reco)	<input type="checkbox"/>	
Global Muons (Reco)	<input checked="" type="checkbox"/>	
Calorimeter Energy Towers	<input type="checkbox"/>	<input type="checkbox"/>
Jets	<input type="checkbox"/>	<input type="checkbox"/>
Missing Et (Deno)	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Open **iSpy-online** with:

- Firefox ver 5 or greater
- Chrome
- Safari

Open **iSpy-dvd** with:

- Firefox ver 7 or greater

Recording Event Data

https://www.editgrid.com/qn-nd/qnmasterclasses/CMS_WZ_cohoes

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Arial 11 pt B I U S

MC No	Ev No	electron	muon	W+ cand	W- cand	W cand	Z cand	"zoo"	Z mass	Zmass list
201	110239978			1	1					
202	112324546	1					1			
203	112536826	1						1	23.44	23.44
204	115180352			1		1				86.23
205	118510854			1		1				86.56
206	120218778	1						1	86.23	29.41
207	120706369	1					1			9.42
208	127095686	1			1					9.08
209	130593477	1				1				10.33
210	130601256		1	1						5.85
211	139591470	1		1						24.03
212	139984297	1				1				24.57
213	140664090	1		1						2.97
214	141933955	1				1				63.88
215	142471053	1				1				49.58
216	142715334	1				1				85.97
217	147313218	1				1				68.3
218	15395536	1						1	86.56	90.39
219	156900355	1		1						70.37
220	164518991		1	1						86.75
221	173183638		1	1						64.67
222	188499351	1		1						
223	207058976	1		1						
296	658338706		1					1	64.67	
297	664543623		1	1						
298	667373800		1			1				
299	96499840	1		1						
300	96771000	1				1				
Sums -->		41	53	43	28	2	19	8	46.94 <--Averages	
Ratios -->		e/mu	W+/W-							
		0.773584905	1.53571428571429							

Recording Event Data

https://www.editgrid.com/qn-nd/qnmasterclasses/CMS_WZ_cohoes

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A1	mc_no.	electron	muon	W+ cand	W- cand	W cand	Z cand	"zoo"					
1	mc_no.	electron	muon	W+ cand	W- cand	W cand	Z cand	"zoo"					
2	1	49	49	40	45	0	8	6					
3	2	56	57	39	35	7	13	5					
4	3	41	53	43	28	2	19	8					
5	4	0	0	34	17	0	11	3					
6	5	59	45	48	41	0	10	0					
7	6												
8	7												
9	8												
10	9												
11	10												
12	11												
13	12												
14	13												
15	14												
16	15												
17	16												
18	17												
19	18												
20	19												
21		205	204	204	166	9	61	22	← Institute Totals				
22													
23													
24	Z cand masses	← make one contiguous list below A24											
25	3.03												
26	11.18												
27	8.25												
28	11.1												
29	17.01												
30	94.57												

W+/W- = 1.2289156626506

e/m = 1.00490196078431

mc_7 / mc_8 / mc_9 / mc_10 / mc_11 / mc_12 / mc_13 / mc_14 / mc_15 / mc_16 / mc_17 / mc_18 / mc_19 Result

Upload Institute Results

quarknet.us/library/index.php/CMS_Combination_of_Results_2012#Moderator_Level

5. Find your data upload spreadsheet for:
 1. [CERN-moderated video conferences](#)
 2. [Fermilab-moderated video conferences](#) (or use Indico page)
6. Send the following to moderators at least 30 minutes prior to video conference:
 1. final tally of e, mu, W+, W-, Z, and zoo
 2. list of all Z candidate masses (including events which are not near Z mass)
7. Share mass plot on Vidyo and/or transmit to moderators (U.S. Masterclass can upload to Indico page)

Moderator Level

[edit]

Find your data upload spreadsheet for

- [CERN-moderated video conferences](#)
- [Fermilab-moderated video conferences](#) (or use Indico page)

Moderators should show and discuss the following results with students:

- e/ μ ratio
- W+/W- ratio
- Z candidate mass plot (including "surprises") for all Institutes that day.

Optional:

The second and third tabs of the data upload spreadsheet each have moment measurement. Moderators may use this to create a unique plot of their own (

quarknet.us/library/index.php/Spreadsheets_2012#CERN

CERN

Date (2012)	Time (CET)	Results upload	Data analysis spreadsheets
Tue 28 Feb	16:00	CERN 1	Roma Sapienzia - Notre Dame 1 - Cohoes
Thu 08 Mar	16:00	CERN 2	Paliaseau 1 - Notre Dame 2 - Zagreb
Fri 09 Mar	16:00	CERN 3	Santander - Perugia - Wien HEPHY
Sat 10 Mar	16:00	CERN 4	Antwerp - Warszawa - Ghent
Mon 12 Mar	16:00	CERN 5	Padova 1 - Split - Trieste - Łódz - Genève CERN
Tue 13 Mar	16:00	CERN 6	Padova 2 - Obuda - Debrecen
Wed 14 Mar	16:00	CERN 7	Padova 3 - Jerusalem - Mons - Athena, Demokritos
Thu 15 Mar	16:00	CERN 8	Palaiseau 2 - Lyons - Rio de Janeiro
Thu 22 Mar	16:00	CERN 9	Strasbourg 1 - Palaiseau 3 - Madrid CIEMAT - Budapest KFKI - Bragança
Fri 23 Mar	16:00	CERN 10	Strasbourg 2 - Torino

Combination of Results pages
linked from
<http://physicsmasterclasses.org>

Upload Institute Results

Browser address: https://www.editgrid.com/qn-nd/qnmasterclasses/CMS_WZ_Combined_28_Feb2012_CERN

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Spreadsheet / qnmasterclasses / CMS WZ Combined 28 Feb2012 CERN

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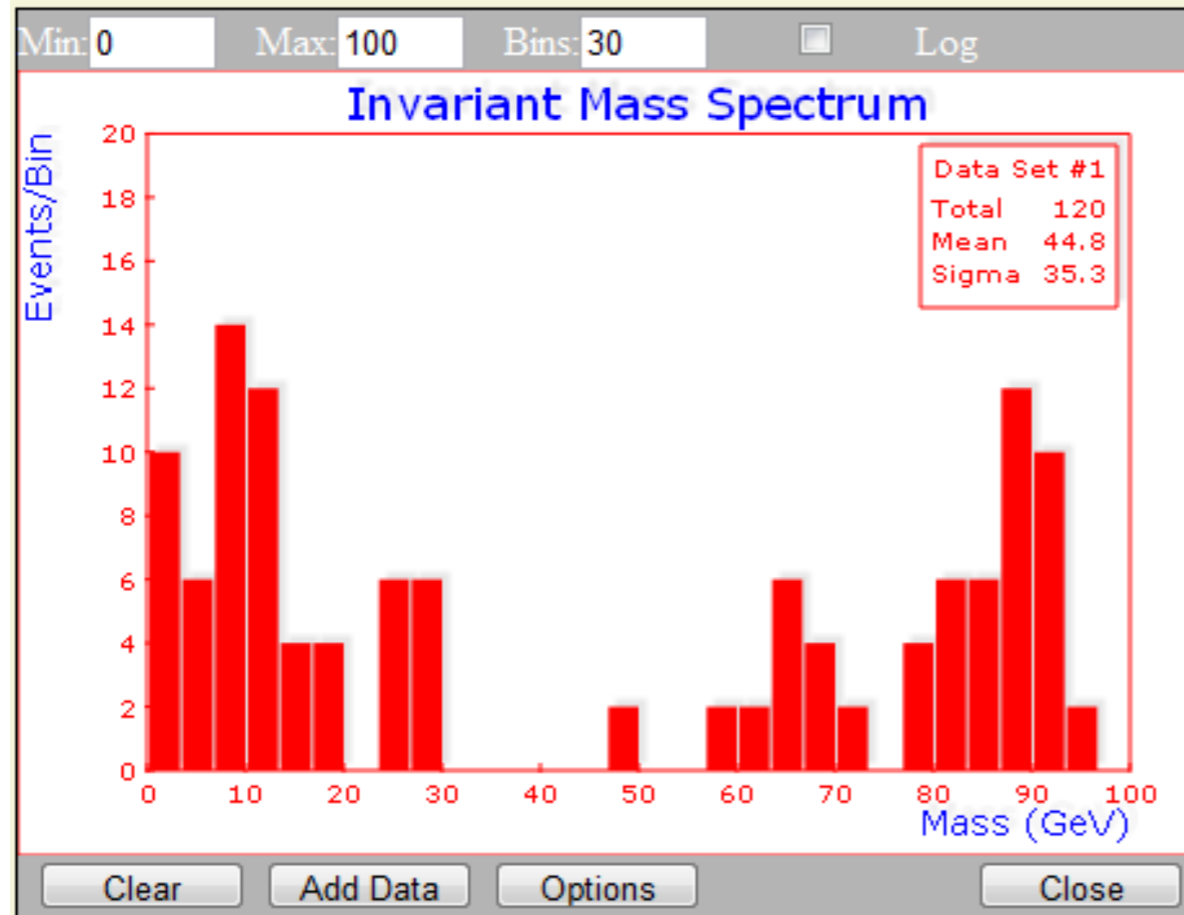
Auto Saved Close

	A	B	C	D	E	F	G	H	I	J
1	CMS W/Z Measurement Results				Date:					
2										
3	Institute	electron	muon	W+ cand	W- cand	W cand	Z cand	"zoo"	e/mu	W+/W-
4	Roma Sapienza									
5	Notre Dame									
6	Cohoes	205	204	204	166	9	61	22		
7										
8										
9		205	204	204	166	9	61	22	1.0049019	1.228915
10										
11										
12	Z cand masses									
13	3.03	<-- make one contiguous list below A10								
14	11.18									
15	8.25									
16	11.1									
17	17.01									
18	94.57									
19	89.96									
20	90.21									
21	23.44									
22	86.23									

Results | Inu_ext_data | ll_ext_data

Masterclass Results

Make mass plot for all Institutes



Optional scatter plot (example):

