

ATLAS – data for education

[ATLAS W&Z](#)

LHC Masterclasses 2014

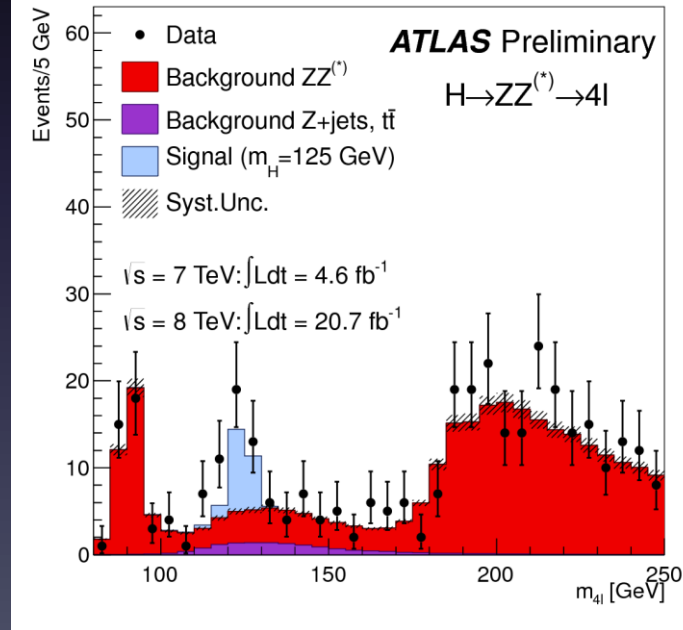
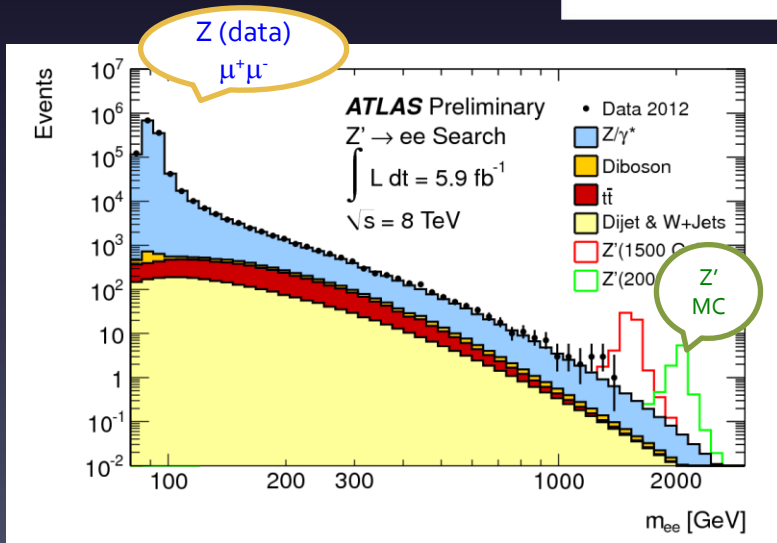
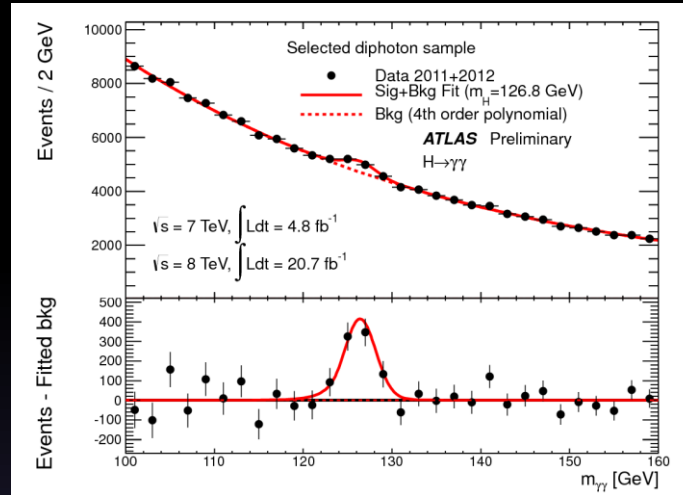
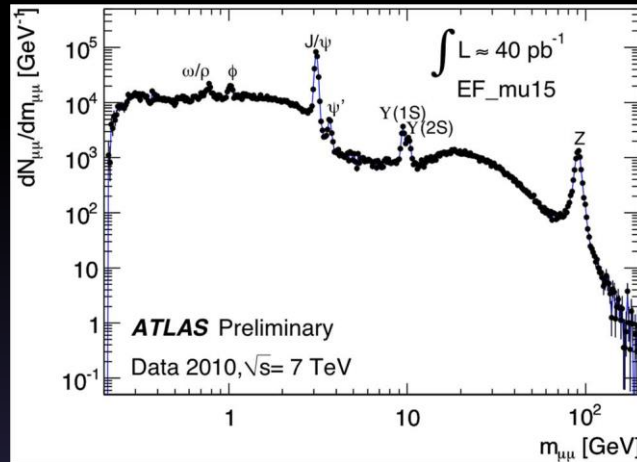
Eirik, Farid, Magnar, Maiken, Vanja

05.05.2014



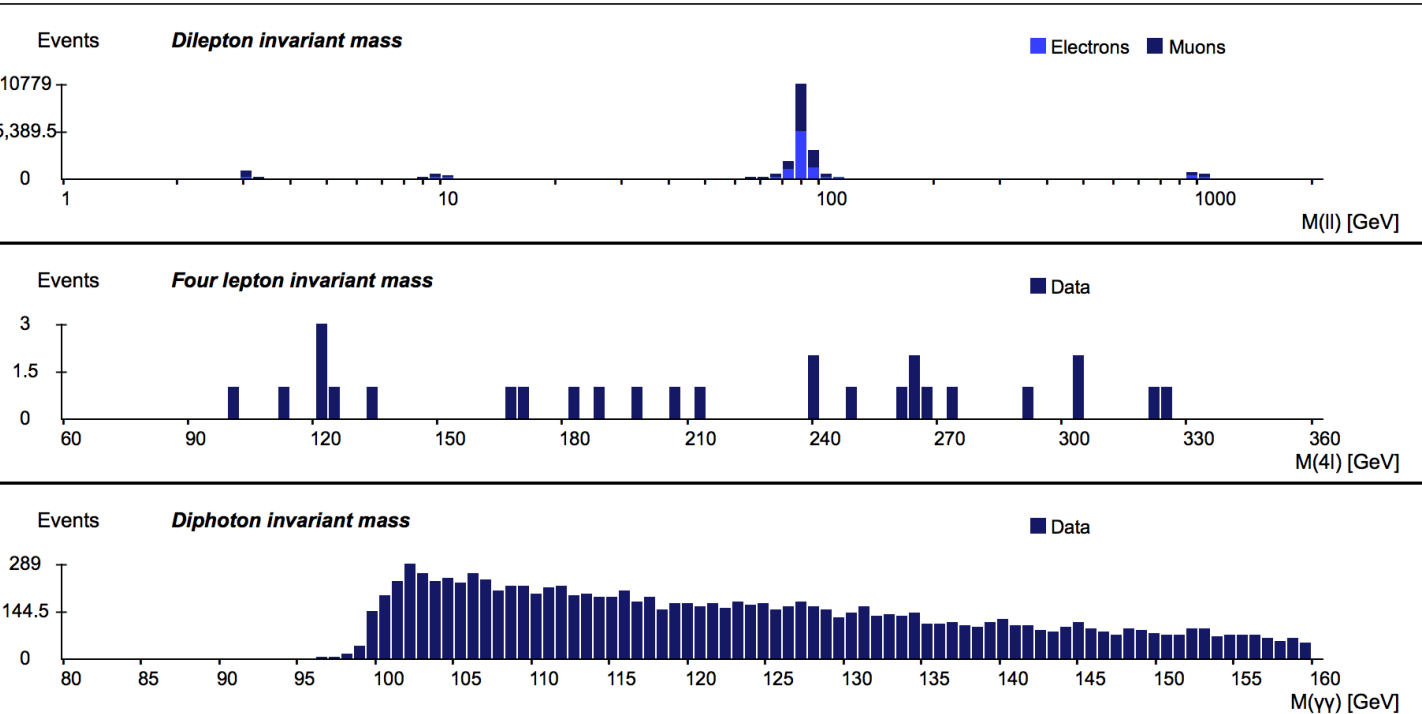
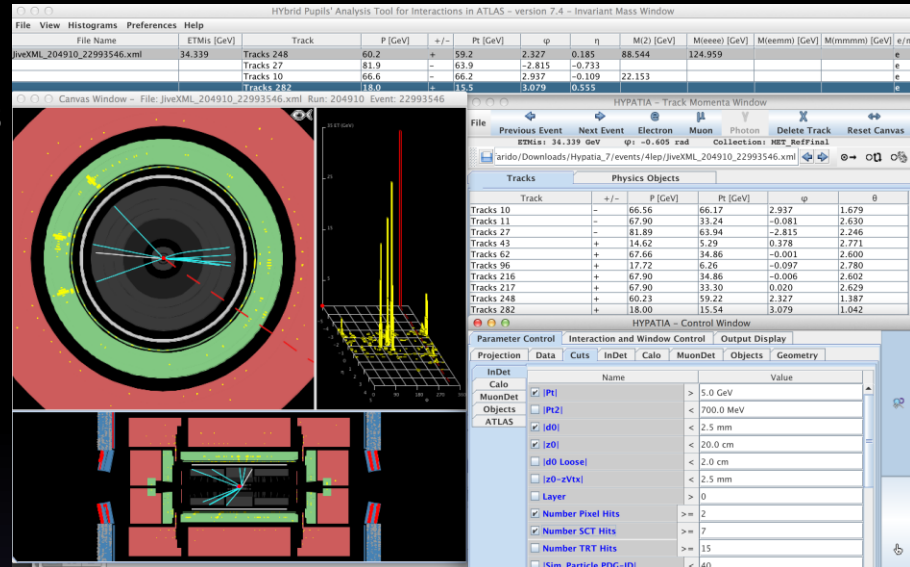
"Z-Path"

- Invariant mass technique
 - Measure mass of short-lived particles
 - Discover new particles
 - Higgs
 - Search for exotic particles – Z' , ...



Z path Measurement, students

- identify ll , $4l$, $\gamma\gamma$ events and calculate invariant masses
- Resulting two-lepton invariant mass distribution is used to measure Z^0 boson and J/ψ and Υ mesons, look for new particles (Z' @ 1 TeV)
- Two photon and four lepton invariant mass distributions are used to provide insight into the process of discovering the Higgs boson at the LHC



Plot type: $ll+4l+\gamma\gamma$ overview

Dilepton statistics

	Electrons			
Region	R1	R2	R3	R4
Events	844	827	7973	895
Mean	3.12	9.68	89.65	994.89
Width	0.37	0.84	3.63	30.73

	Muons			
Region	R1	R2	R3	R4
Events	880	867	8219	686
Mean	3.08	9.86	90.49	995.73
Width	0.26	0.68	3.57	50.73

Number of events

	Student distribution	Expected
ll	24292	130
$4l$	32	10
$\Upsilon\Upsilon$	11163	60
Sum	35487	200

ATLAS Z-path data 2014

- Allowed to use 2/fb for Higgs selections: $\gamma\gamma$, $4l$
 - Sequential run range 204769 - 206971, 2007 /pb, periods B12 – C6, June – July 2012
- Moriond 2013 candidates list following official Higgs selections
 - 40 $H \rightarrow l^+l^-l^+l^-$ candidates with 6 are in the range 120-130 GeV
 - 11 100 $H \rightarrow \gamma\gamma$ candidates (4100 fully unconverted, 5400 mixed, 1800 double conversions)
- Same range as above for di-lepton selection from same run range above
 - 18500 Z , 1850 J/ψ , 1850 Y events (modest fraction, still larger than Higgs)
- MC event displays of Z' events (1850) mixed in real data analyzed by students
 - mc12_8TeV.158020.Pythia8_AU2MSTW2008LO_Zprime_ee_SSM1000.recon.ESD.e1242_s1469_s1470_r3542/
 - mc12_8TeV.158026.Pythia8_AU2MSTW2008LO_Zprime_mumu_SSM1000.recon.ESD.e1242_s1469_s1470_r3542/
- In total 37 000 events

ATLAS Z-path data 2014


- Data distributed as event mixtures in XML format
 - Password protected <http://cernmasterclass.uio.no/datasets/>
 - Accessible from http://atlas.physicsmasterclasses.org/en/zpath_data.htm
 - Read through HYPATIA Event Display
- Di-lepton resonances: $l^+l^- = e^+e^-, \mu^+\mu^-$
 - 50% Z 5% J/ψ 5% Υ 5% Z'
- Higgs
 - 30% $H \rightarrow \gamma\gamma$ (20% unconverted, 10% converted) 5% $H \rightarrow l^+l^-l^+l^-$ (replicated in student datasets)
- 37 directories of 20 (A-T) datasets \rightarrow 50 events analyzed by 2 students
- Some further MC data is used in the online plotting tool [OPloT](#), but only invariant mass distributions are used from these samples

Data samples and Tools

For the measurement, you will need the following:

1. An event display program: HYPATIA- [Download Java 7 version](#) (RECOMMENDED) or [Download Java 6 version](#), if you have not already done so. Start HYPATIA.
2. A Data sample - The data sample of many thousand events is divided into smaller packages with 50 events each. Each group will be assigned one data package.

[Download Data Samples for](#)



INTERNATIONAL
MASTERCLASSES
hands on particle physics

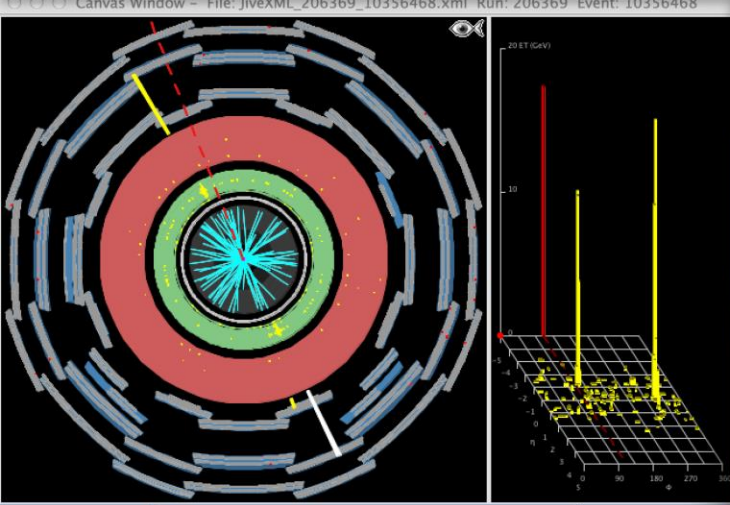
Z-Path

- INTRODUCING THE Z BOSON
- INTRODUCING THE HIGGS BOSON
- IDENTIFYING PARTICLES
- IDENTIFYING EVENTS
- SEARCH AND DISCOVER WITH MASS
- GET TO WORK!
- Data samples and tools**
- Do it!
- ANALYZE YOUR RESULT

Knowledge Center

[ATLAS W&Z](#)

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	ϕ	η	M(2) [GeV]	M(eeee) [GeV]	M(eemm) [GeV]	M(mmmm) [GeV]	e/m
JiveXML_206369_10199519.xml	20.824	Object 0	122.6		74.2	-1.142	1.088	133.676				g
JiveXML_206369_10199519.xml	20.824	Object 1	116.1		59.8	2.108	1.282					g
JiveXML_206369_10356468.xml	17.347	Object 0	55.1		55.0	-1.118	-0.071	124.132				g
JiveXML_206369_10356468.xml	17.347	Object 1	93.7		52.0	2.109	-1.194					g



HYPATIA - Track Momenta Window

File: Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas
 ETMis: 17.347 GeV ϕ : 1.941 rad Collection: MET_RefFinal
 o/Downloads/Hypatia_7/events/gamgam/jiveXML_206369_10356468.xml

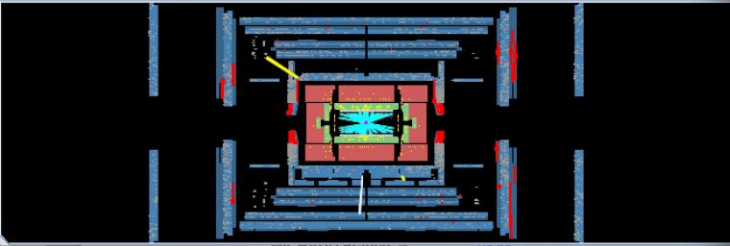
Track	P [GeV]	Pt [GeV]	ϕ	θ
Object 0	55.09	54.95	-1.118	1.642
Object 1	93.69	51.99	2.109	2.553
Object 2	6.97	5.84	-1.243	0.994

HYPATIA - Control Window

Parameter Control Interaction and Window Control Output Display

Projection Data Cuts InDet Calo MuonDet Objects Geometry

InDet	Name	Value
Calo	<input checked="" type="checkbox"/> Pt	> 1.0 GeV
MuonDet	<input type="checkbox"/> Pt2	< 700.0 MeV
Objects	<input checked="" type="checkbox"/> d0	< 2.5 mm
ATLAS	<input checked="" type="checkbox"/> z0	< 20.0 cm
	<input type="checkbox"/> d0 Loose	< 2.0 cm
	<input type="checkbox"/> z0-zVtx	< 2.5 mm
	<input type="checkbox"/> Layer	> 0



File View Histograms Preferences Help

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	ϕ	η	M(2) [GeV]	M(eeee) [GeV]	M(eemm) [GeV]	M(mmmm) [GeV]	e/m
JiveXML_204769_71902630.xml	41.907	Tracks 0	70.3	+	35.7	1.333	1.299	85.865				123.582
		Tracks 19	59.6	-	47.5	-1.658	0.699					m
		Tracks 24	29.4	+	26.4	-2.518	0.470	31.569				m
		Tracks 226	23.3	-	7.2	1.649	1.848					m

Canvas Window - File: JiveXML_204769_71902630.xml Run: 204769 Event: 71902630

HYPATIA - Track Momenta Window

File: Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas
 ETMis: 41.907 GeV ϕ : 0.113 rad Collection: MET_RefFinal
 arido/Downloads/Hypatia_7/events/4lep/JiveXML_204769_71902630.xml

Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 0	+	70.30	35.70	1.333	0.533
Tracks 19	-	59.56	47.49	-1.658	0.923
Tracks 24	+	29.42	26.44	-2.518	1.117
Tracks 226	-	23.32	7.17	1.649	0.312

HYPATIA - Control Window

Parameter Control Interaction and Window Control Output Display

Projection Data Cuts InDet Calo MuonDet Objects Geometry

InDet	Name	Value
Calo	<input checked="" type="checkbox"/> Pt	> 5.0 GeV
MuonDet	<input type="checkbox"/> Pt2	< 700.0 MeV
Objects	<input checked="" type="checkbox"/> d0	< 2.5 mm
ATLAS	<input checked="" type="checkbox"/> z0	< 20.0 cm
	<input type="checkbox"/> d0 Loose	< 2.0 cm
	<input type="checkbox"/> z0-zVtx	< 2.5 mm
	<input type="checkbox"/> Layer	> 0
	<input checked="" type="checkbox"/> Number Pixel Hits	>= 2
	<input checked="" type="checkbox"/> Number SCT Hits	>= 7
	<input checked="" type="checkbox"/> Number TRT Hits	>= 15
	<input type="checkbox"/> Sim. Particle PDG-ID	< 40
	<input type="checkbox"/> Sim. Particle Barcode	= 0
	<input type="checkbox"/> Sim. Particle Type	charged hadron

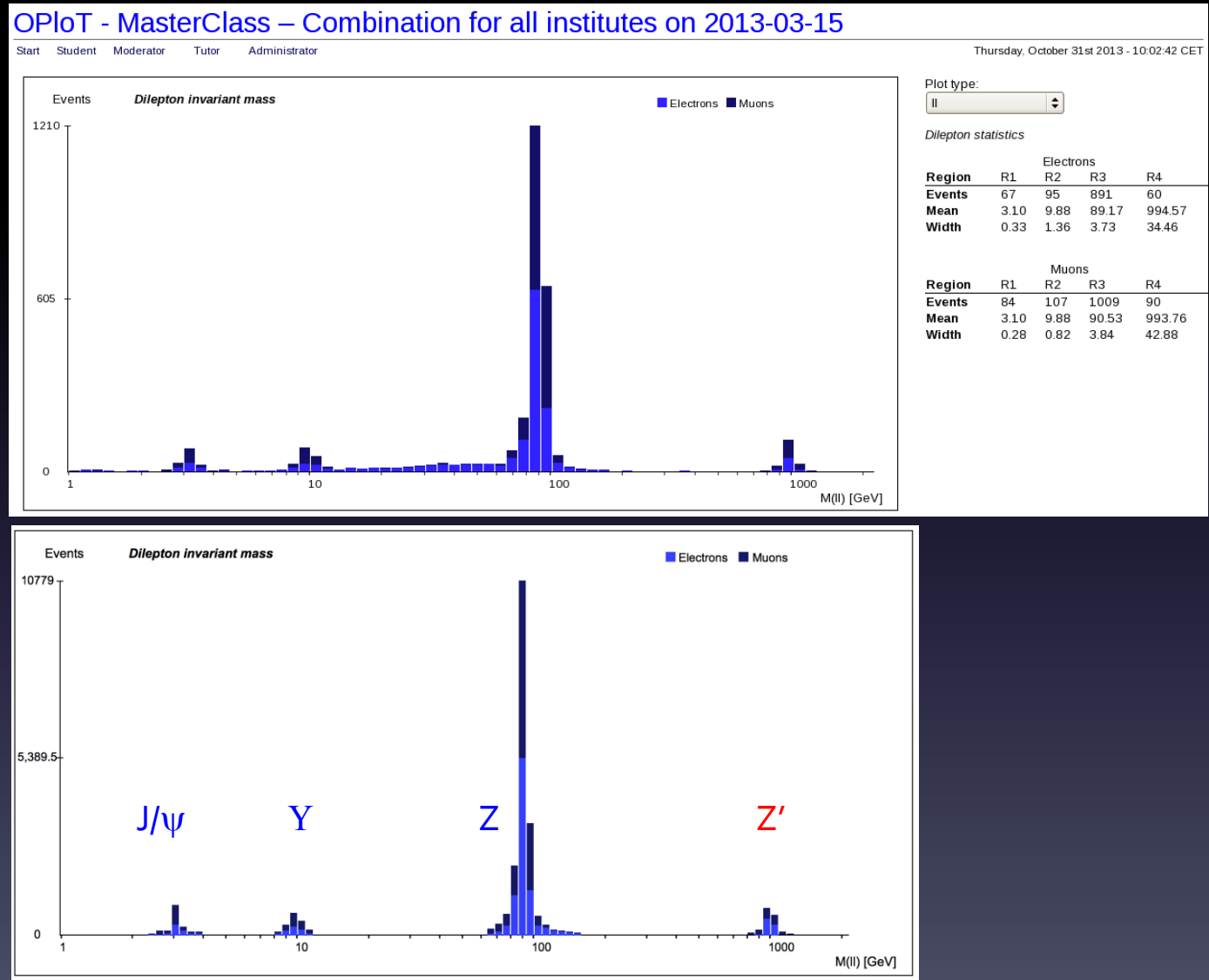
HYPATIA

MC2014 – di-leptons

- Full statistics ~ 24050 events, 8 TeV

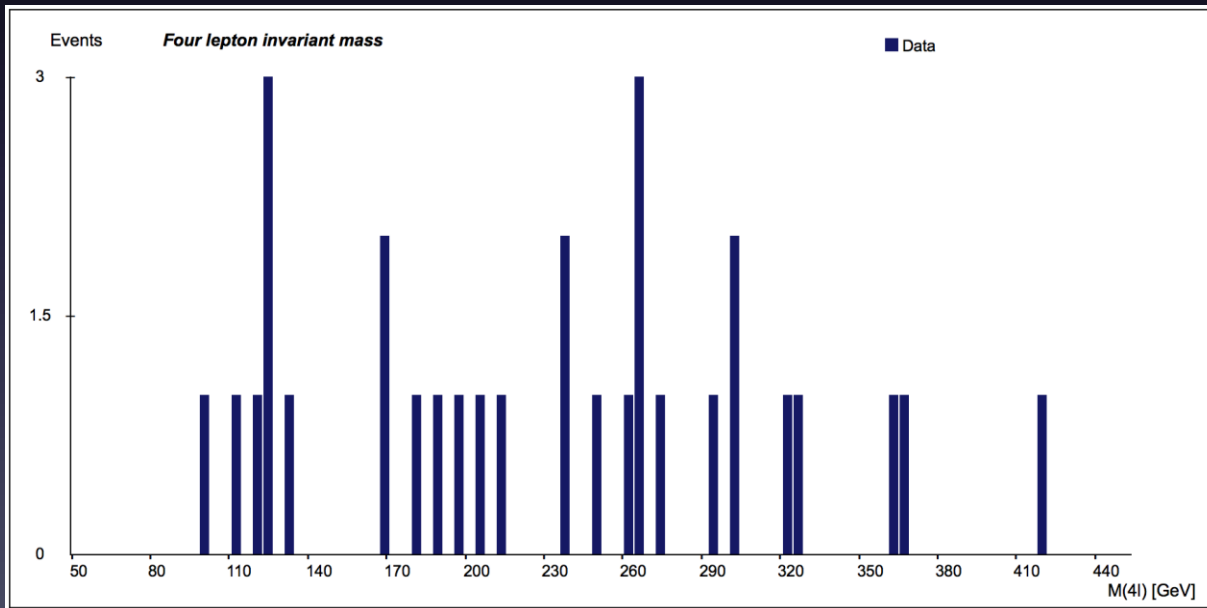
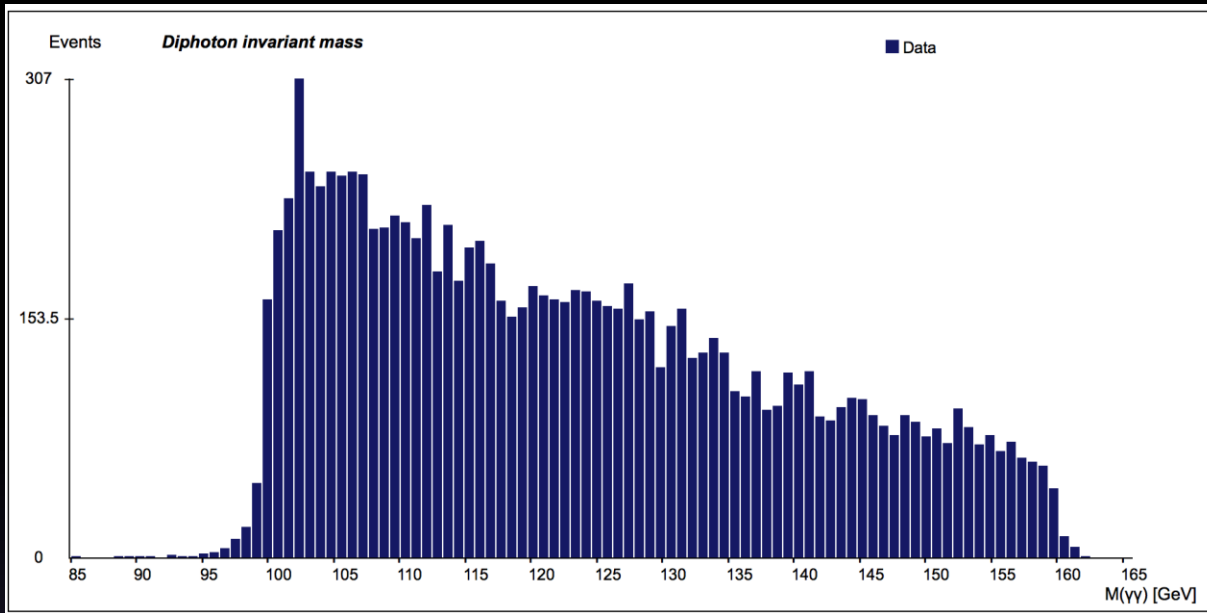
- Measured by students in 2013 (7 TeV, 9000 events) →
- Some misidentified events, especially for electrons
- Otherwise all particles found at right masses, including Z' surprise

- Expected 2014 ~2.5X more statistics →



2 fb^{-1}

$H \rightarrow \gamma\gamma$



$H \rightarrow ZZ^*$
 $\rightarrow 4l$

Future plans

- 2013 (for 2014 the trend continues)
 - ATLAS Z: 70 institutes
 - ATLAS W: 55 institutes
 - CMS: 55 institutes
 - ALICE: 10 institutes
 - LHCb starting in 2014
- Continue developing education material based on ATLAS data & results
 - Zpath: Prepare for possible discoveries (Graviton, SUSY, ...) using similar final states
 - Zpath: Introduce looping over XML events AFTER having studied 50 display events, set-up cuts and plot invariant mass and other variables
- Use of material beyond IPPOG master classes – password protection
 - On-demand events at schools, ...
 - Student Projects at physics institutes, ...