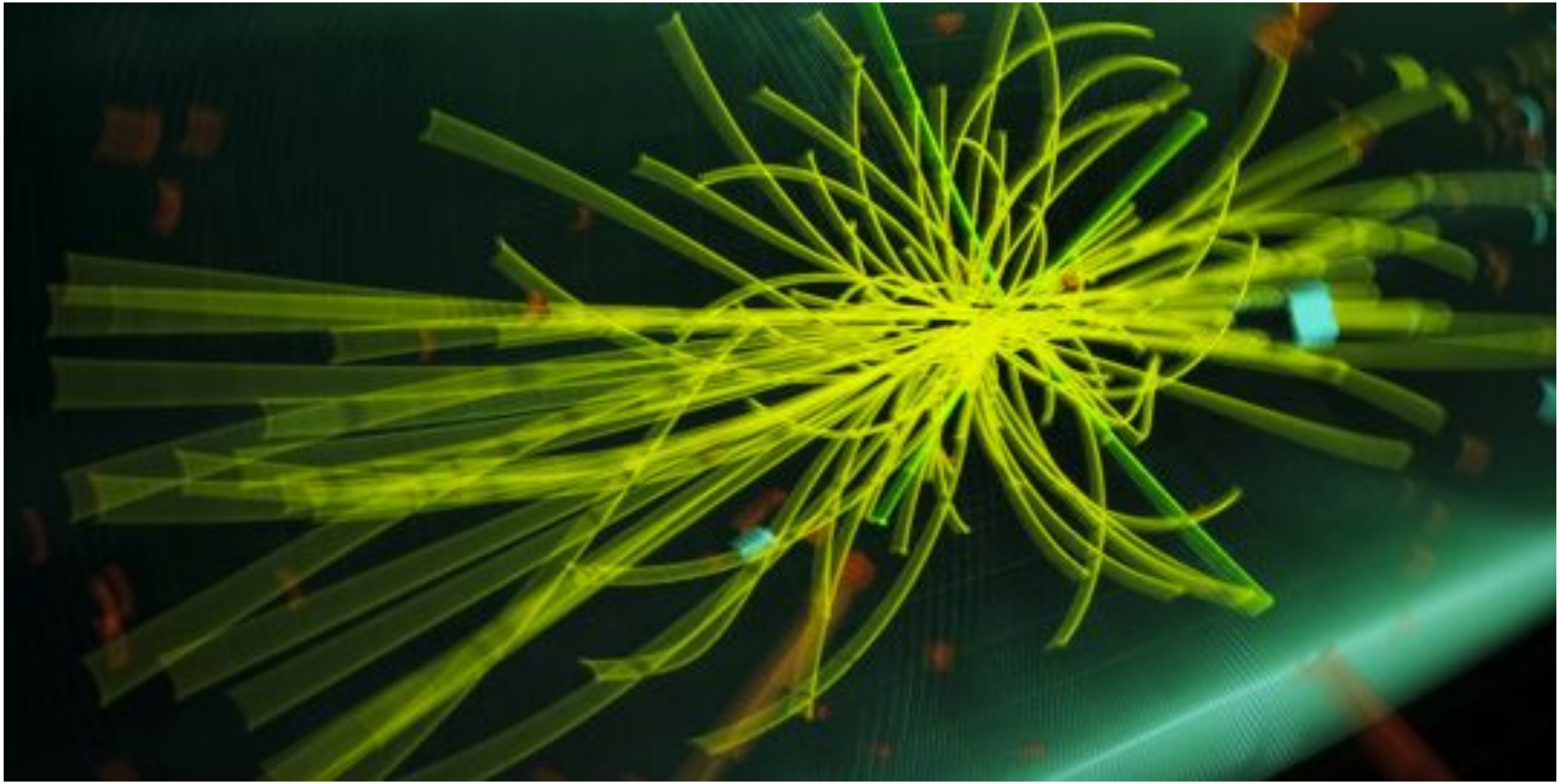
Le Monde

13/12/11

La Chasse au Boson de Higgs touche presque a sa fin…



Marumi Kado

Laboratoire de l'Accélérateur Linéaire (LAL)
IN2P3, CNRS

In the News December 2011…

Le Cern aurait capté des "signaux" du boson de Higgs.

Le Monde

Science: les physiciens pensent avoir approché le mystérieux boson de Higgs.

Libération

Data Hints at Elusive Particle, but the Wait Continues

The New York Times

Higgs boson hunters scent their elusive quarry at the LHC.

theguardian

… in the CERN Press Release

Excerpts

Taken individually, none of these excesses is any more statistically significant than rolling a die and coming up with two sixes in a row (~3%).

What is interesting is that there are multiple independent measurements pointing to the region of 124 to 126 GeV.

It's far too early to say whether ATLAS and CMS have discovered the Higgs boson, but these updated results are generating a lot of interest in the particle physics community.

1976

A PHENOMENOLOGICAL PROFILE OF THE HIGGS BOSON

John Ellis, Mary K. Gaillard *) and D.V. Nanopoulos +)
CERN -- Geneva

The situation with regard to Higgs bosons is unsatisfactory. First it should be stressed that they may well not exist.

We should perhaps finish with an apology and a caution. We apologize to experimentalists for having no idea what is the mass of the Higgs boson, unlike the case with charm [3),4)] and for not being sure of its couplings to other particles, except that they are probably all very small. For these reasons we do not want to encourage big experimental searches for the Higgs boson, but we do feel that people performing experiments vulnerable to the Higgs boson should know how it may turn up.

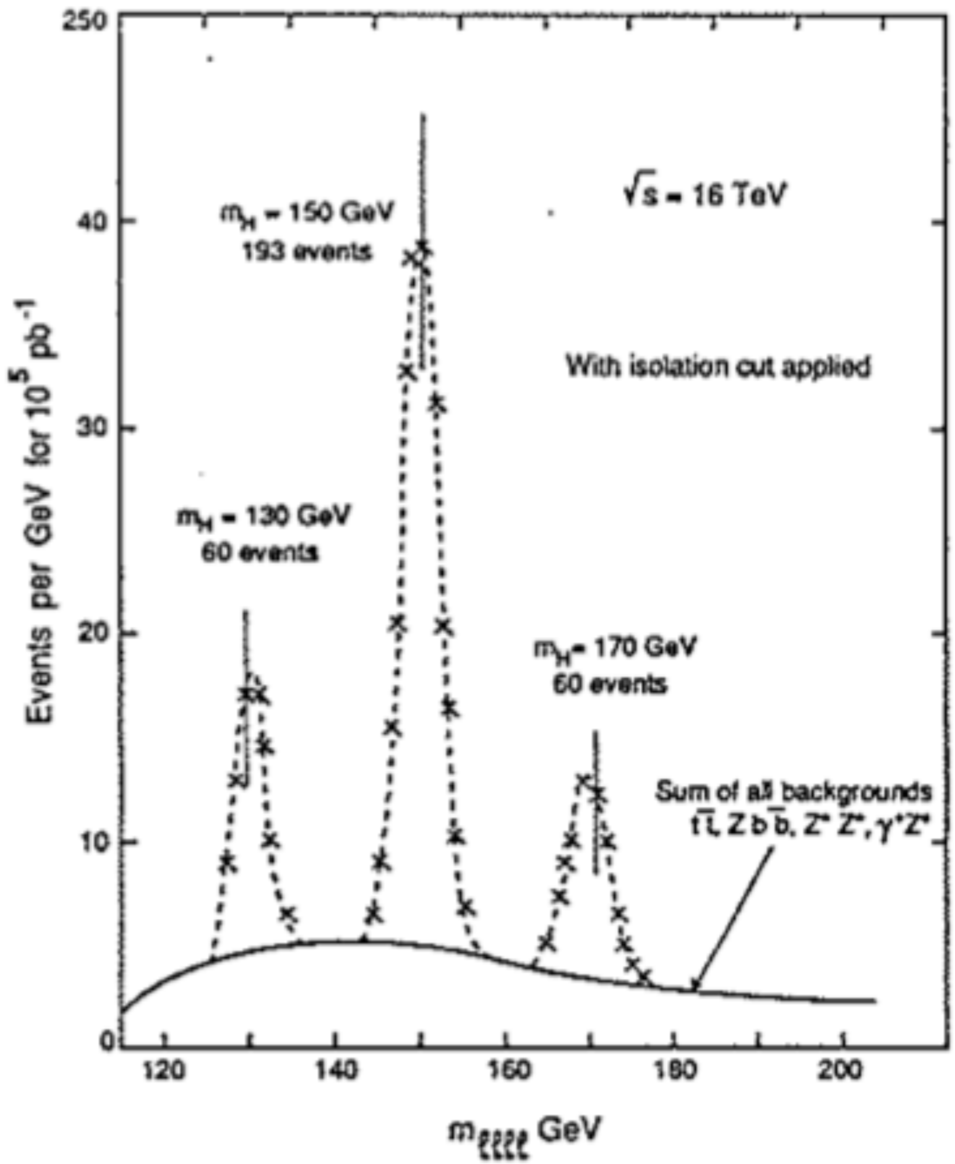
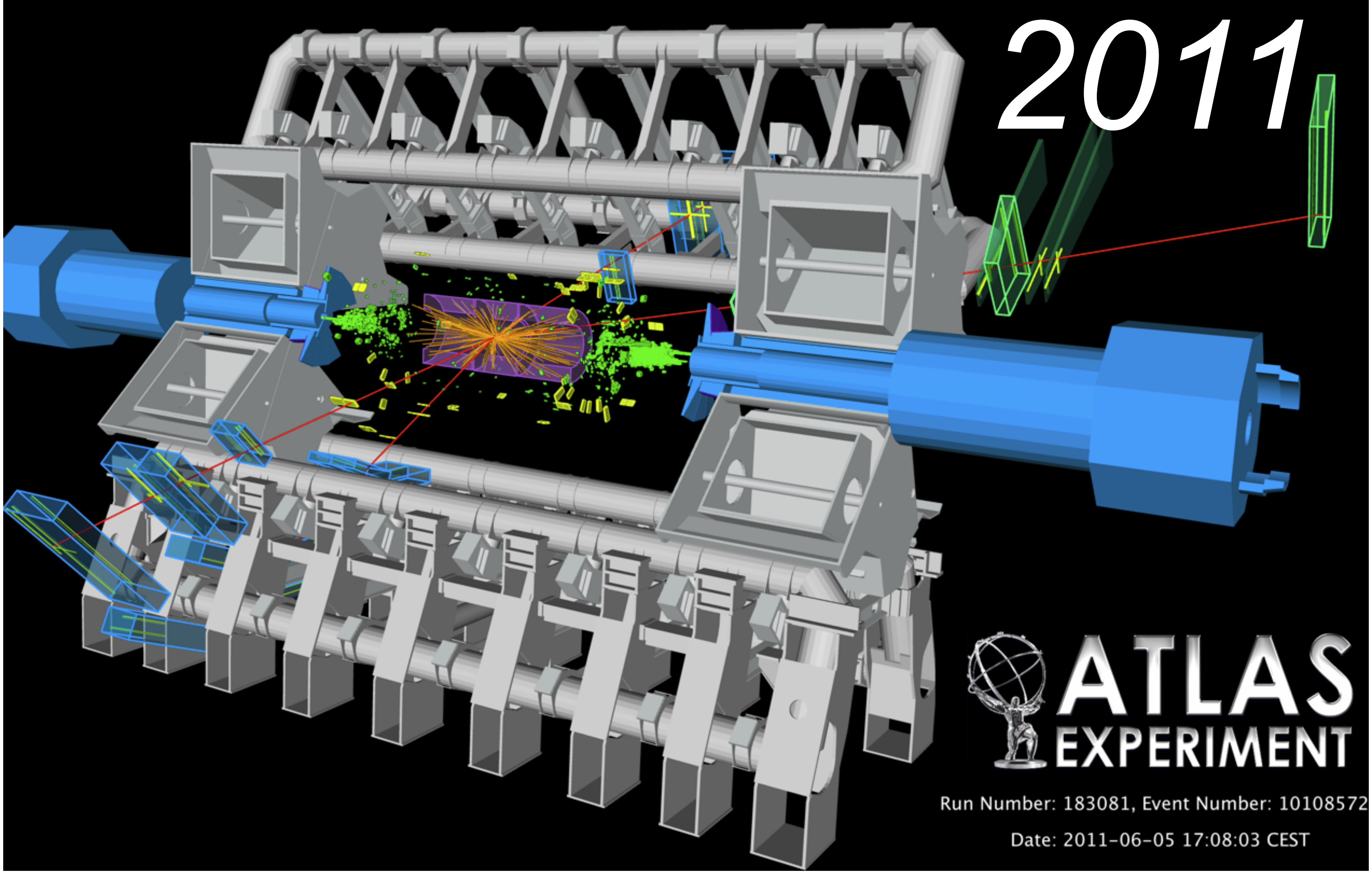


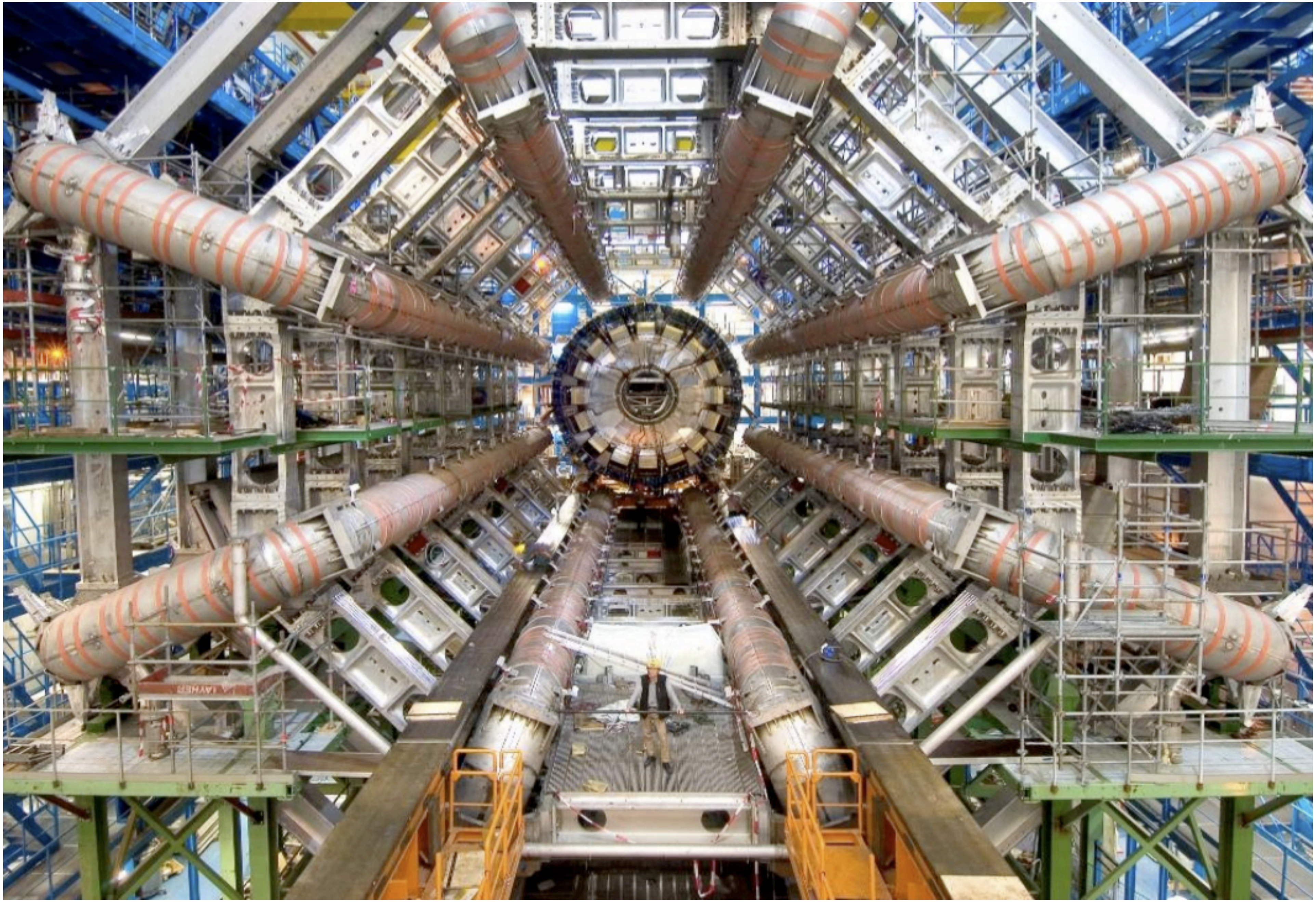
Fig. 10

1990

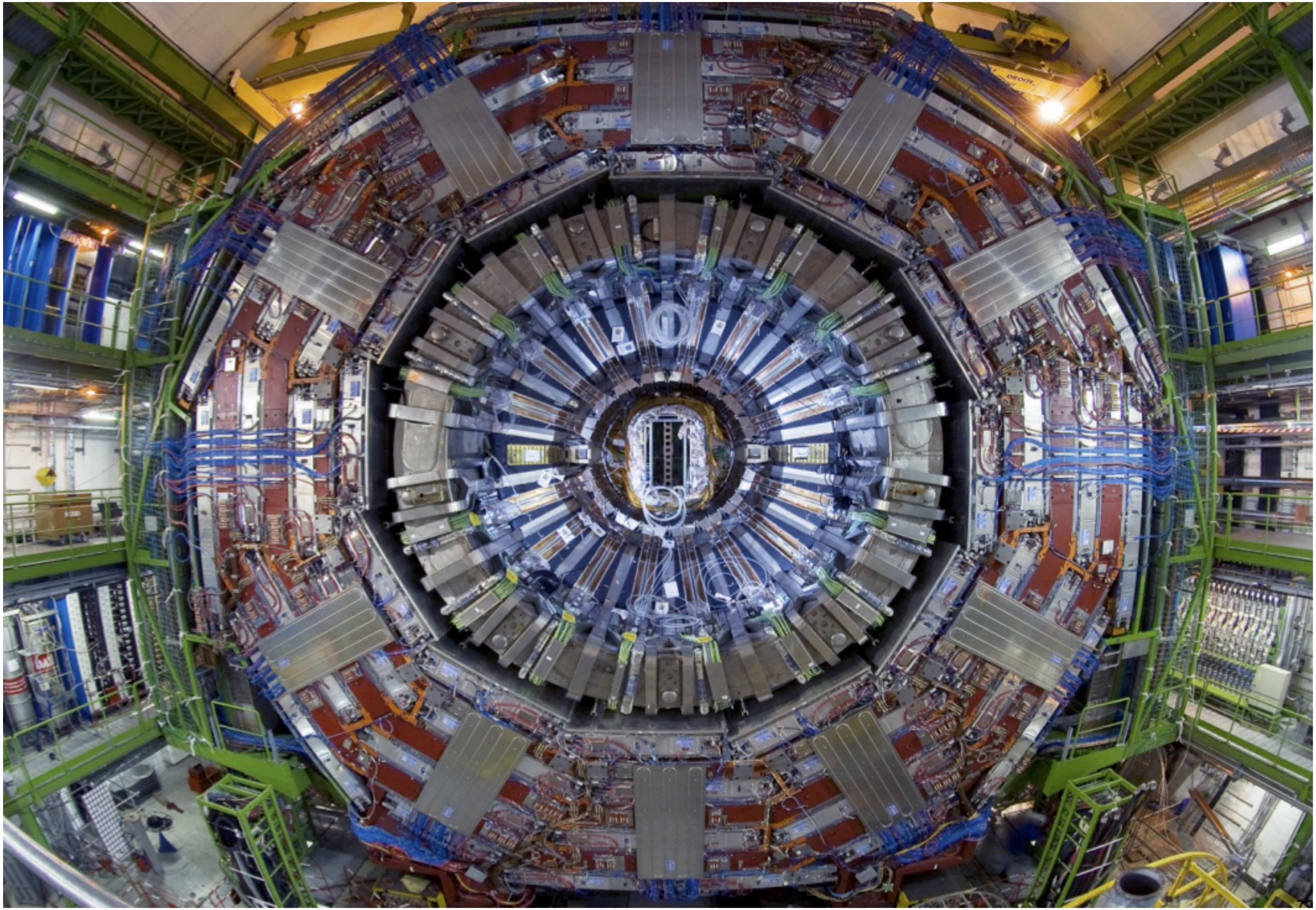
Proceedings of LHC Workshop (Aachen, 1990): $\sqrt{s}$ = 16 TeV, 100 fb^{-1}

4 μ event … *Standard EW only or Higgs?*

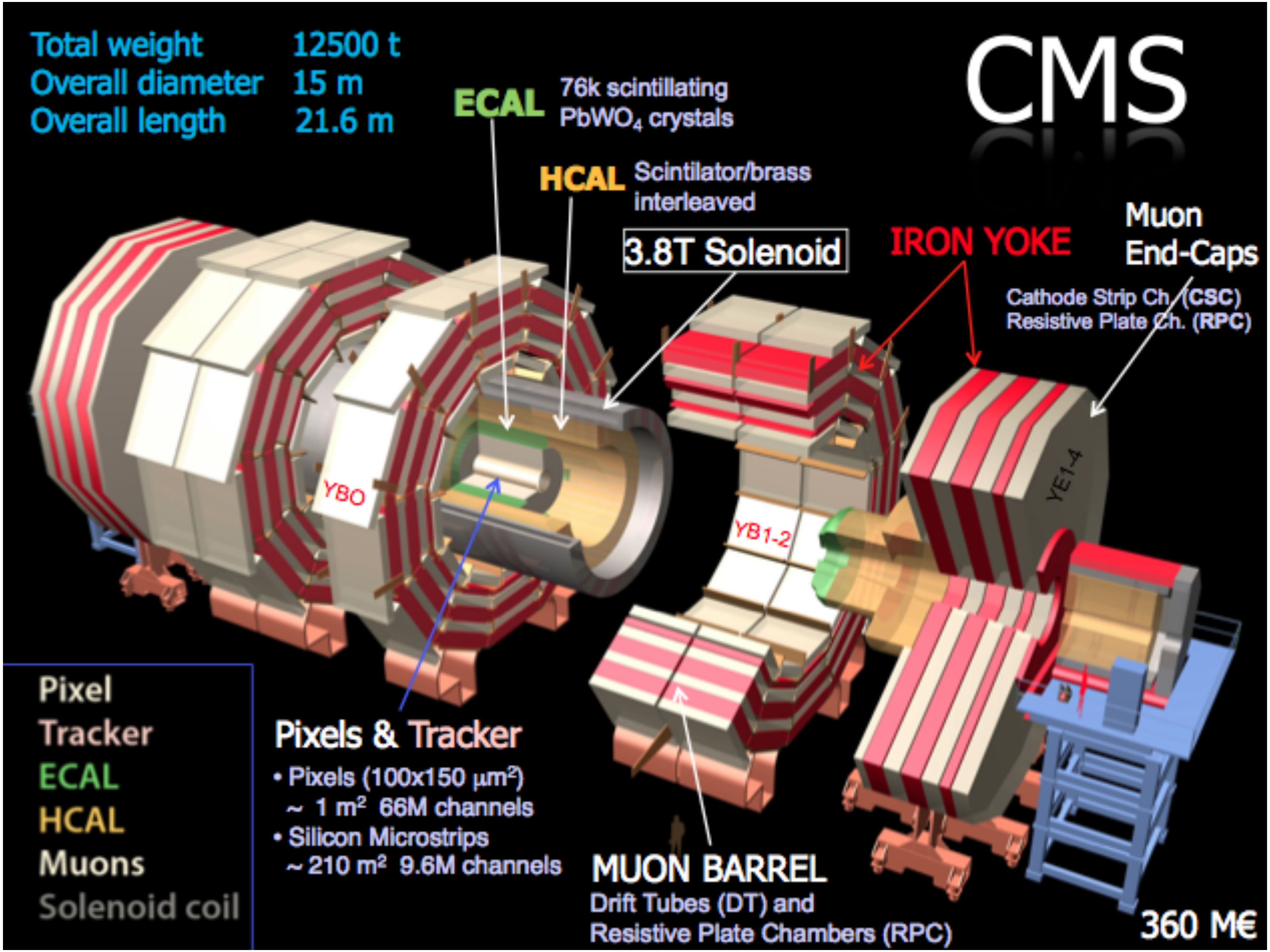


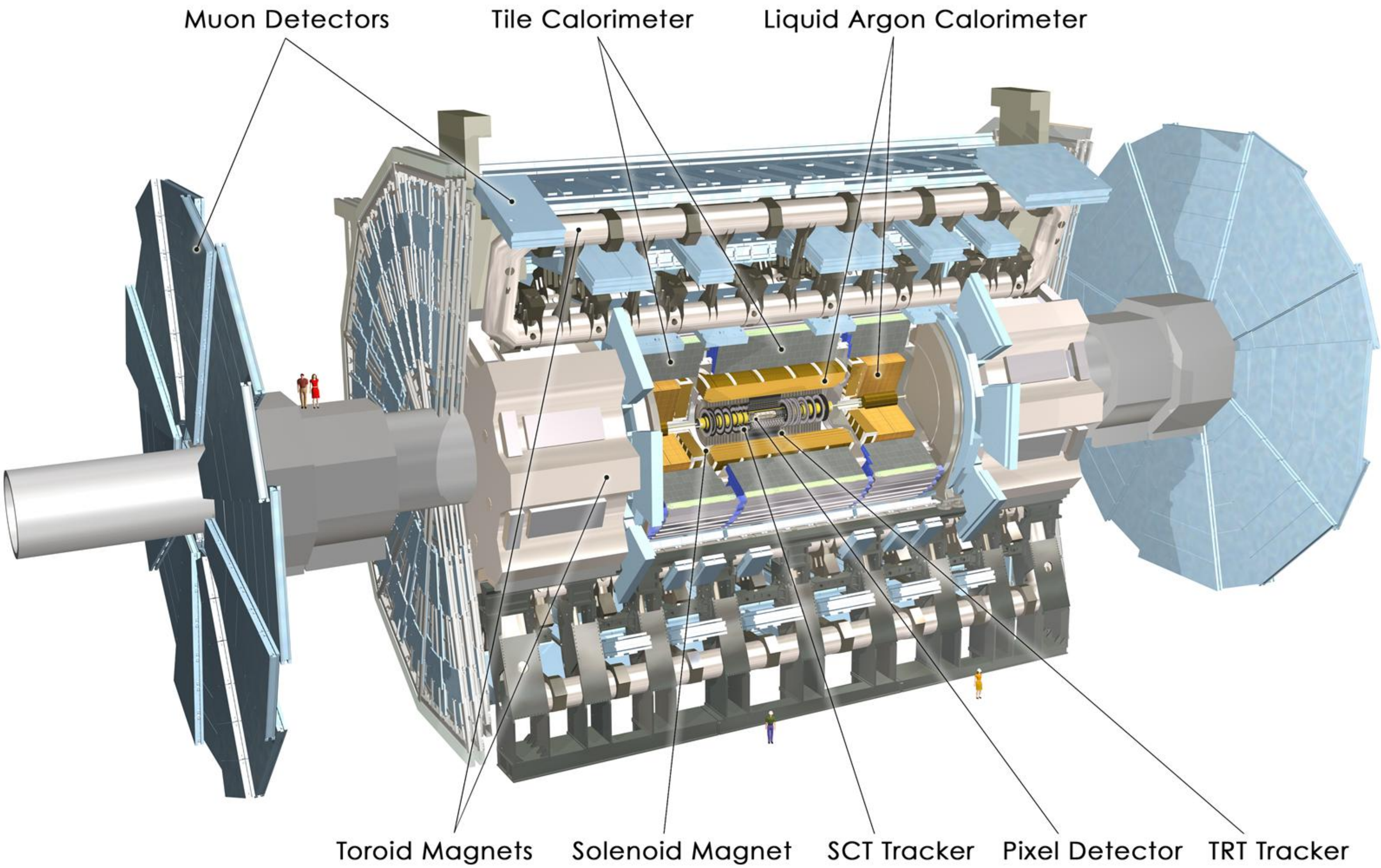


ATLAS



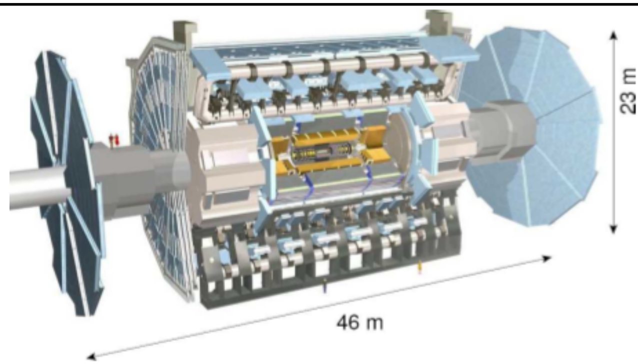
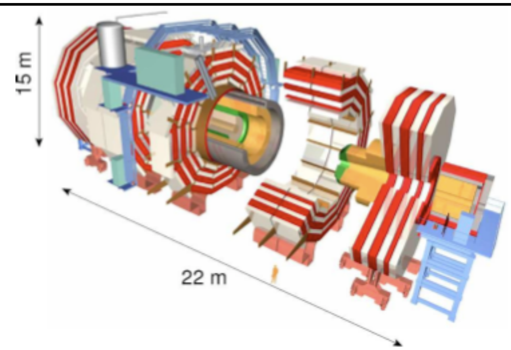
CMS


Total weight 12500 t
Overall diameter 15 m
Overall length 21.6 m
CMS
ECAL
76k scintillating
PbWO4 crystals
HCAL
Scintilator/brass
interleaved
3.8T Solenoid
IRON YOKE
Muon
End-Caps
Cathode Strip Ch. (CSC)
Resistive Plate Ch. (RPC)
YB0
YB1-2
YE1-4
Pixel
Tracker
ECAL
HCAL
Muons
Solenoid coil
Pixels & Tracker
• Pixels (100x150 μm2)
~ 1 m2 66M channels
• Silicon Microstrips
~ 210 m2 9.6M channels
MUON BARREL
Drift Tubes (DT) and
Resistive Plate Chambers (RPC)
360 M€


Muon Detectors
Tile Calorimeter
Liquid Argon Calorimeter
Toroid Magnets
Solenoid Magnet
SCT Tracker
Pixel Detector
TRT Tracker

ATLAS

The ATLAS and CMS Detectors In a Nutshell

Sub System	ATLAS	CMS
Design		
Magnet(s)	Solenoid (within EM Calo) 2T 3 Air-core Toroids	Solenoid 3.8T Calorimeters Inside
Inner Tracking	Pixels, Si-strips, TRT PID w/ TRT and dE/dx $\sigma_{p_T}/p_T \sim 5\times10^{-4}p_T \oplus 0.01$	Pixels and Si-strips PID w/ dE/dx $\sigma_{p_T}/p_T \sim 1.5\times10^{-4}p_T \oplus 0.005$
EM Calorimeter	Lead-Larg Sampling w/ longitudinal segmentation $\sigma_E/E \sim 10\%/\sqrt{E} \oplus 0.007$	Lead-Tungstate Crys. Homogeneous w/o longitudinal segmentation $\sigma_E/E \sim 3\%/\sqrt{E} \oplus 0.5\%$
Hadronic Calorimeter	Fe-Scint. & Cu-Larg (fwd) $\gtrsim 11\lambda_0$ $\sigma_E/E \sim 50\%/\sqrt{E} \oplus 0.03$	Brass-scint. $\gtrsim 7\lambda_0$ Tail Catcher $\sigma_E/E \sim 100\%/\sqrt{E} \oplus 0.05$
Muon Spectrometer System Acc. ATLAS 2.7 & CMS 2.4	Instrumented Air Core (std. alone) $\sigma_{p_T}/p_T \sim 4\,\%$ (at 50 GeV) $\sim 11\,\%$ (at 1 TeV)	Instrumented Iron return yoke $\sigma_{p_T}/p_T \sim 1\%$ (at 50 GeV) $\sim 10\%$ (at 1 TeV)


14 TeV
13 TeV
7 or 8 TeV ?

Luminosity and Beam cross section

$$\mathcal{L} = \frac{N_p^2 k_b f_{rev} \gamma}{4\pi \beta^* \epsilon_n} F$$

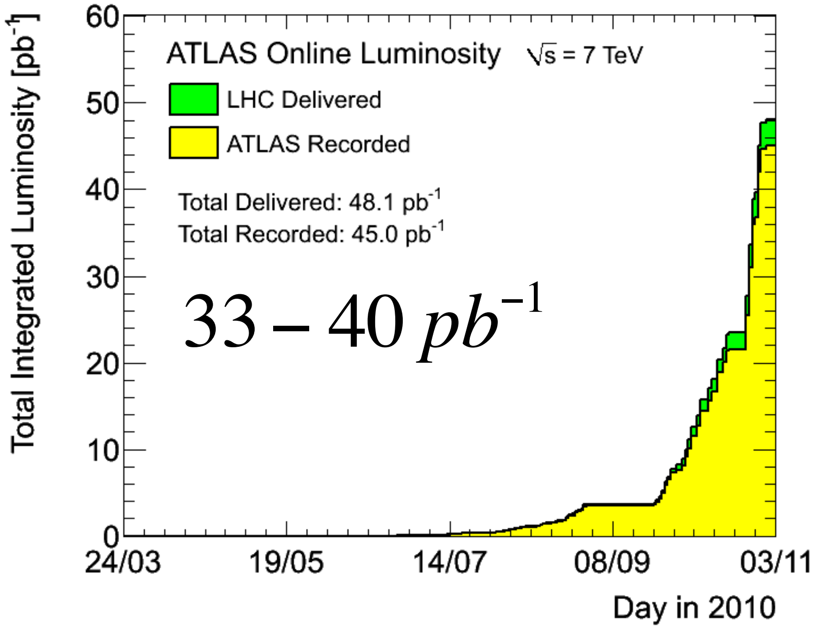
Reduction factor W/ Beam crossing angle O(0.9)

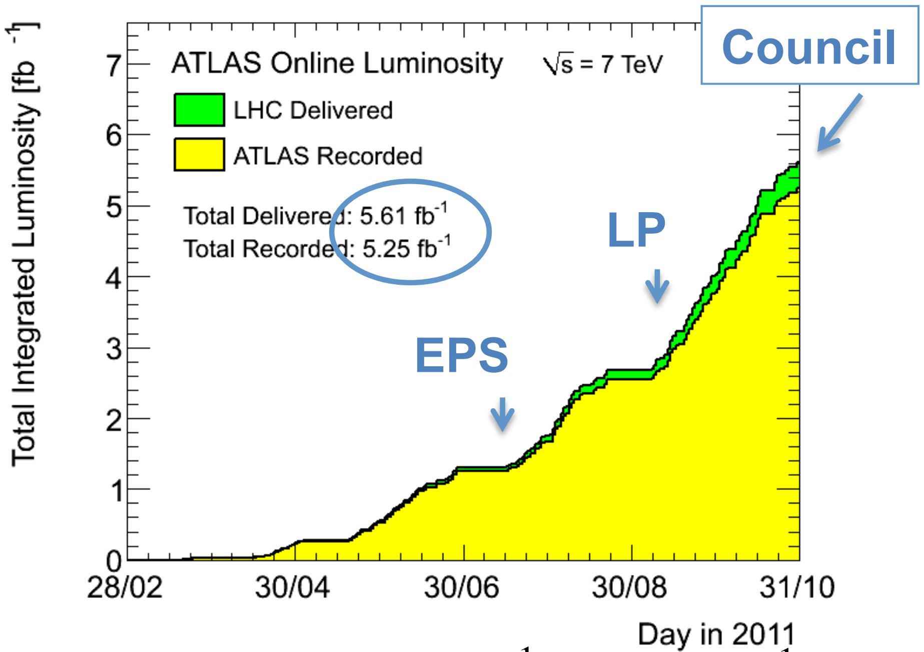
Parameter	2010	2011	Nominal
N (10^{11} p/bunch)	**1.2**	**1.35**	1.15
k (no. bunches)	368	1380	2808
Bunch spacing	150	50	25
ε (μm rad)	**2.4-4**	**1.9-2.3**	3.75
β* (m)	3.5	1.5 → 1	0.55
L ($cm^{-2}s^{-1}$)	**2×10^{32}**	**3.3×10^{33}**	10^{34}

Two Years of Remarkable LHC operations

Glimpse at the Luminosity

2010	*2011*
Re-discovery of the SM at LHC	Closing in on the Higgs search





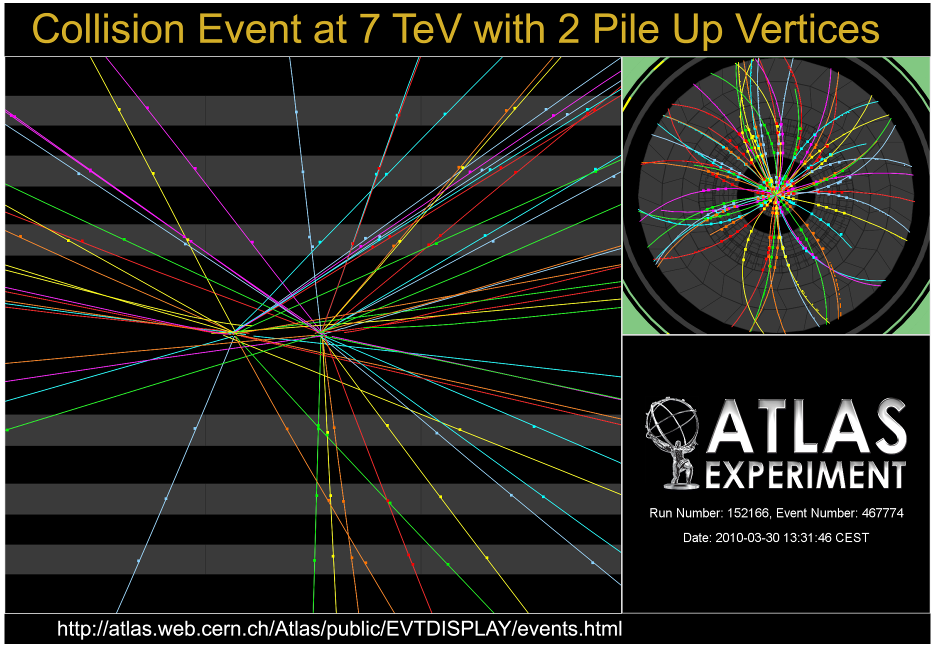
$1.0-1.2\ fb^{-1}$ $2.2\ fb^{-1}$

Measurement of rather detailed properties of the W and Z boson production	Measurement of di-boson production and Higgs searches

Two Years of Remarkable LHC operations

The Pile-up (PU) evolution

2010	*2011*
O(2) Pile-up events (per bunch crossing)	O(6) Pile-up events (per bunch crossing)
150 ns inter-bunch spacing	50 ns inter-bunch spacing



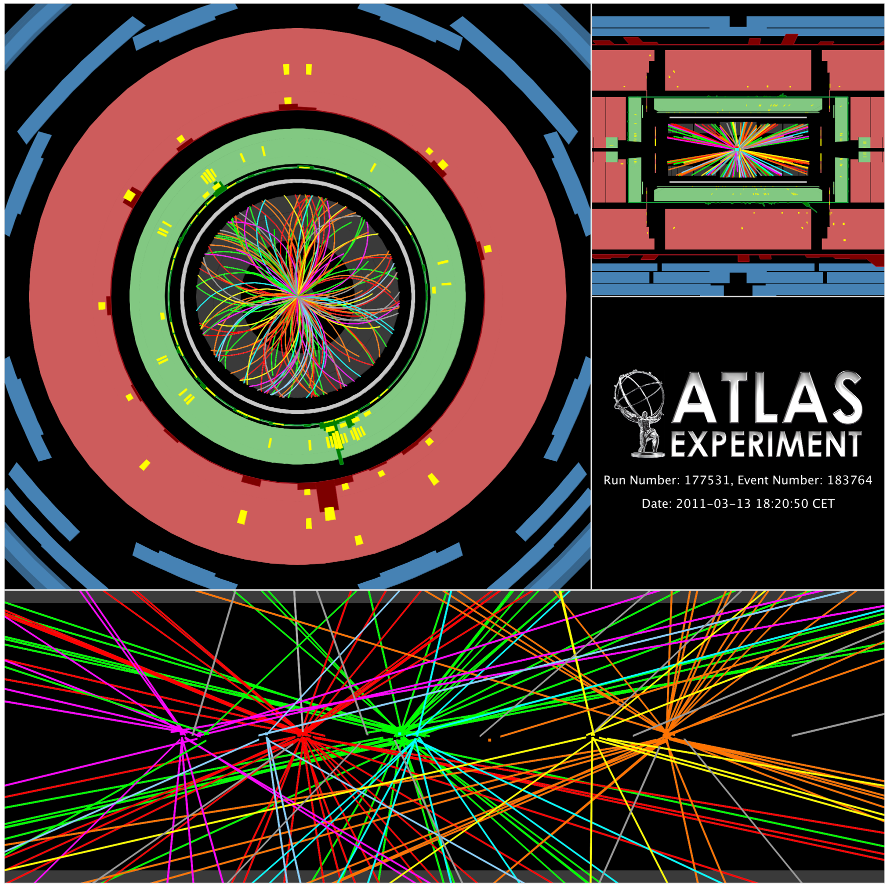
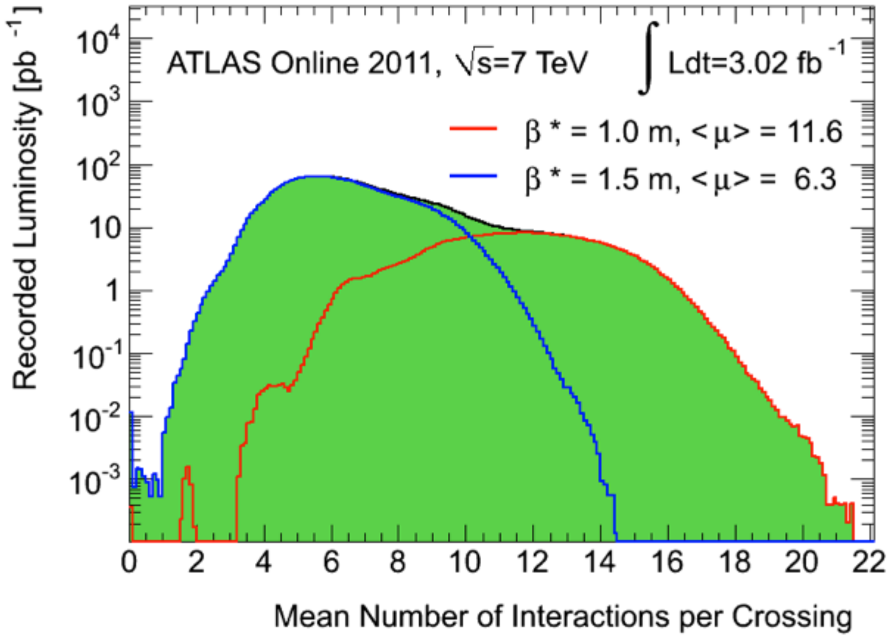


Illustration of events taken at random (filled) bunch crossings

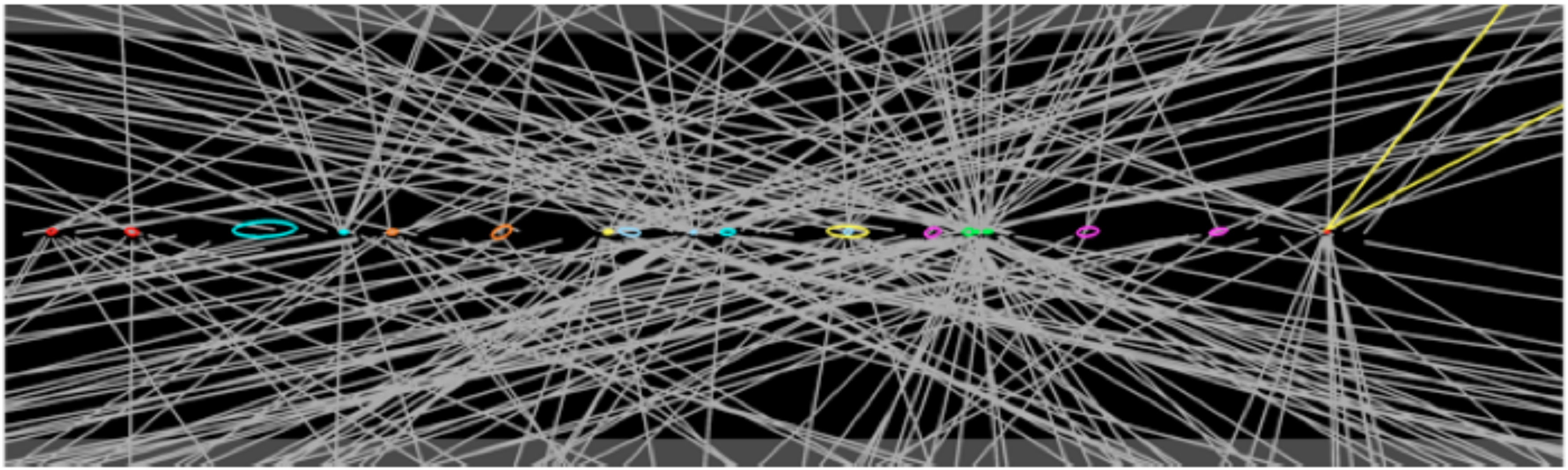
The 2011 Dataset

$$\sim 5\,fb^{-1}$$



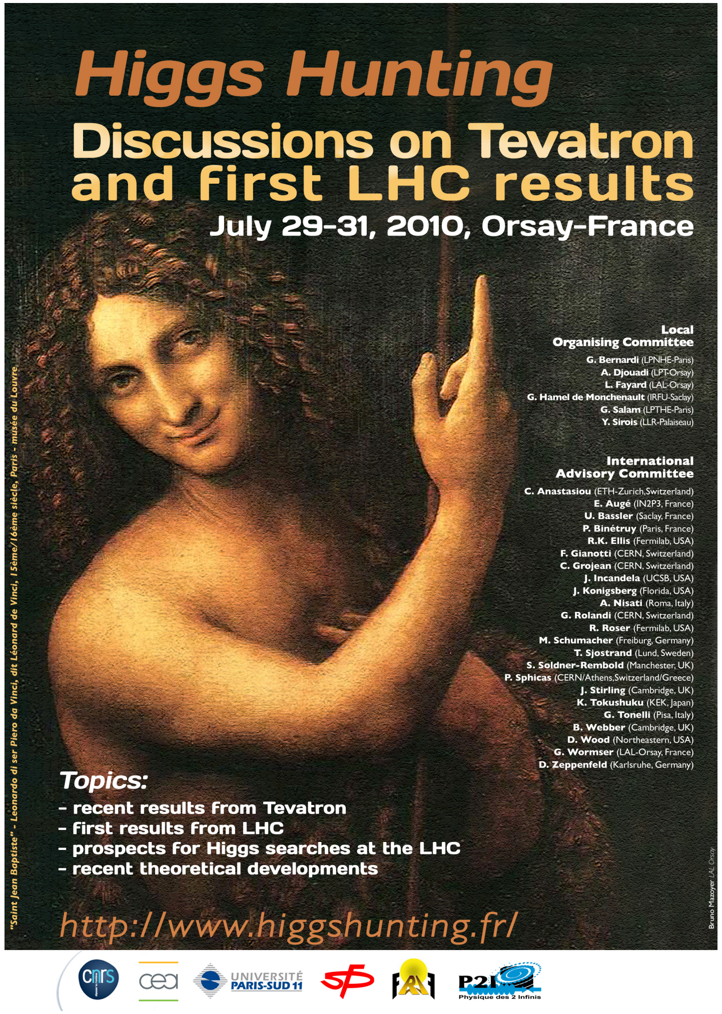
- New runs at higher luminosity…
- Much higher PU!

Recent event with 15 Vertices



The Higgs Hunt in the LHC Era…

2010



2011

Preamble : Breakthroughs in Phenomenolgy

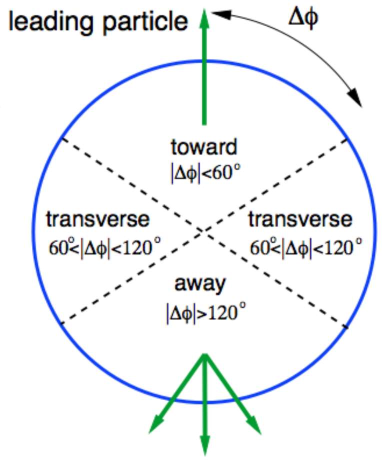
Several breakthroughs in the past decade have drastically changed the theory prospective to the hadron collider processes.

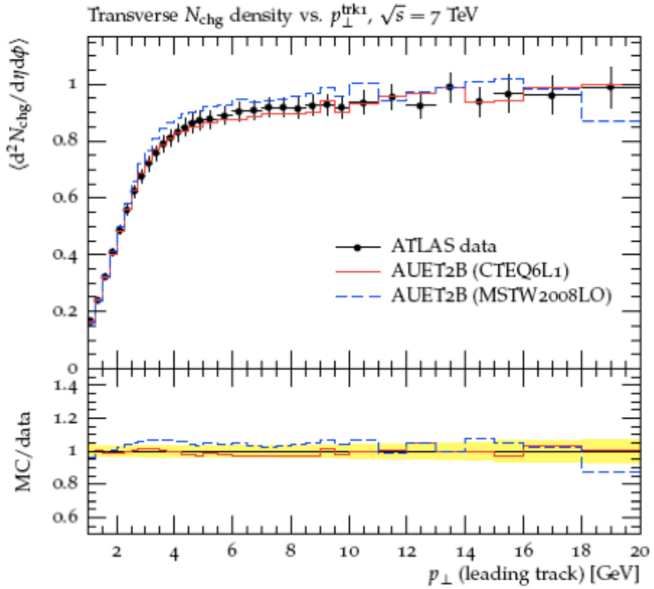
- The "Next-to…" revolution :
  - Breakthrough ideas in computation of loops (sewing together tree level amplitudes).
  - NLO generators, blackhat, NLOjet++, Phox, MCFM, etc…
  - NLO generators w/ PS, MC@NLO and POWHEG.
  - NLO+NLL or NNLL, CAESAR, ResBos, HqT
  - NNLO, FEHIP, FEWZ, HNNLO, DYNNLO
  - …
- NNLO PDFs sets
- Parton Shower (and Matrix Element matching) improvements :

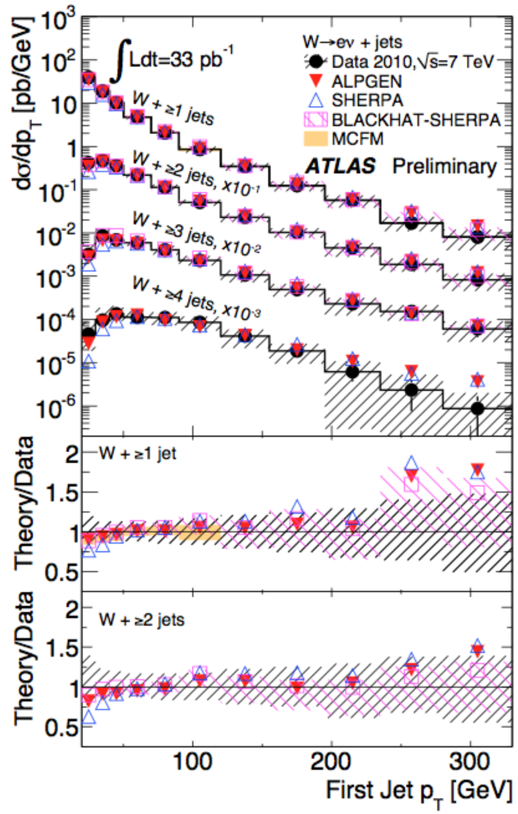
  Pythia (8.1), Herwig++, Sherpa and CKKW (1.3) and MadGraph (5.0) performing very well (Including description of the Pile Up and the underlying event).

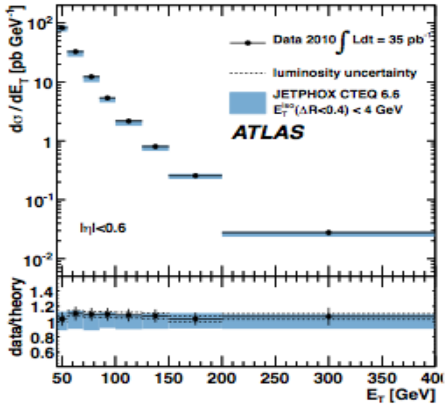
- The Jet revolution (Fast Jet) : Allowing to compute in reasonable time infra-red safe k_T jets.

QCD

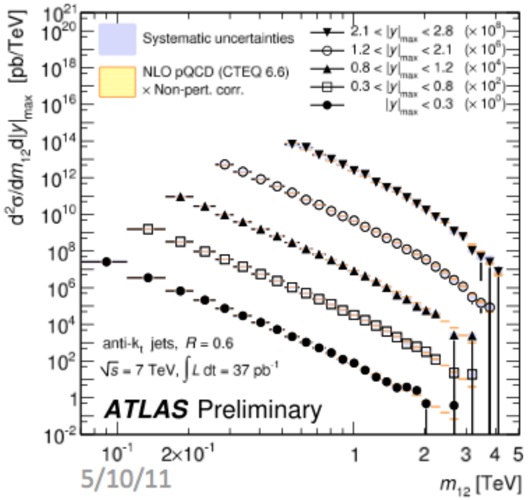


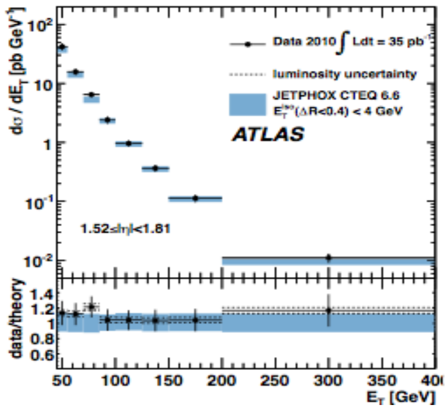


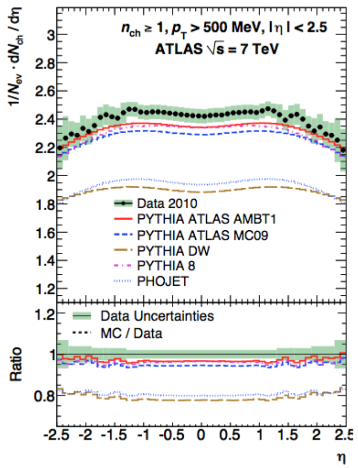


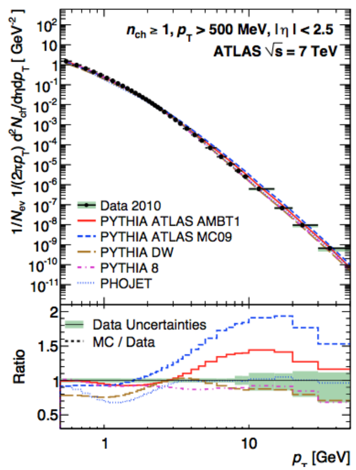


10^2 10^3 p_T [GeV]



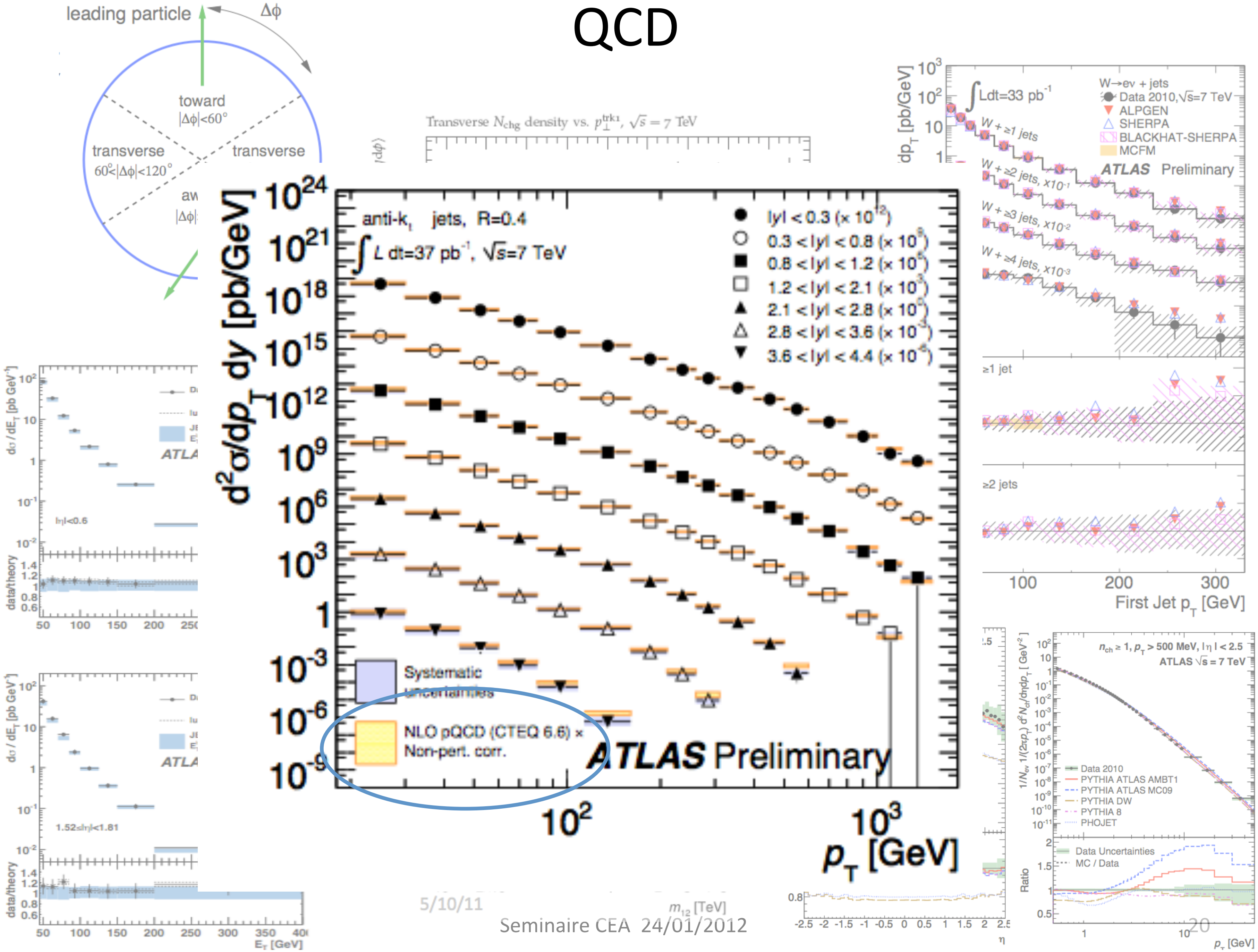






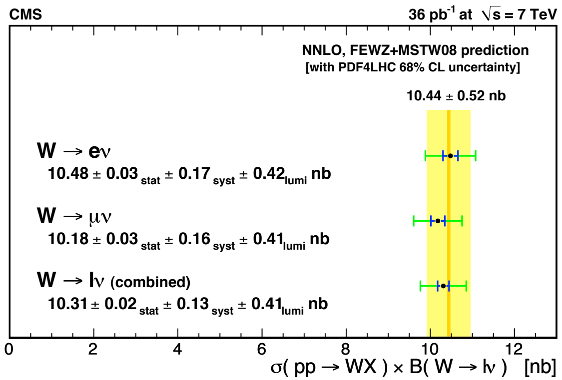
5/10/11

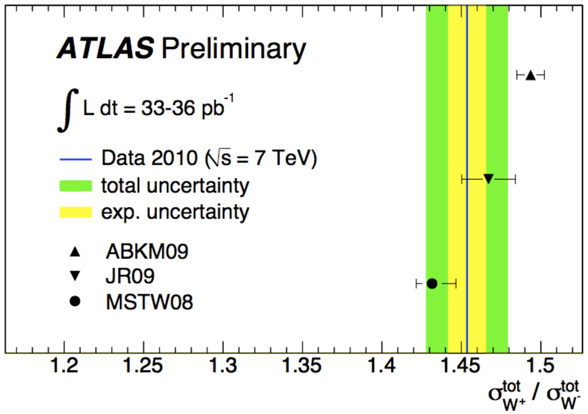
QCD

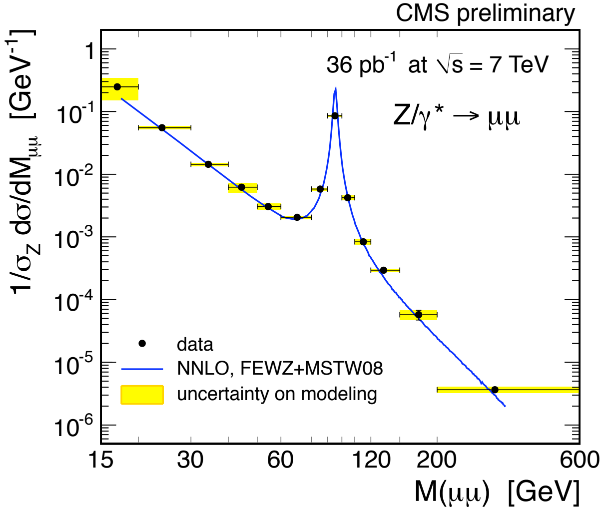


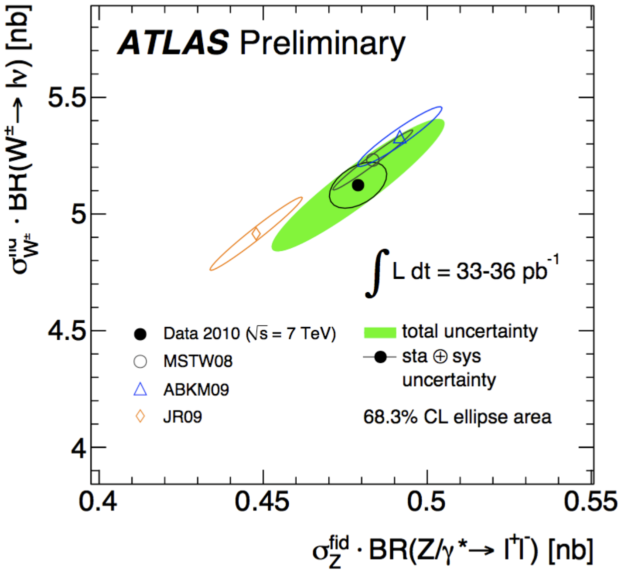
anti-k$_t$ jets, R=0.4
$\int L\,dt$=37 pb^{-1}, $\sqrt{s}$=7 TeV
|y| < 0.3 (× 10^{12})
0.3 < |y| < 0.8 (× 10^{9})
0.8 < |y| < 1.2 (× 10^{6})
1.2 < |y| < 2.1 (× 10^{3})
2.1 < |y| < 2.8 (× 10^{0})
2.8 < |y| < 3.6 (× 10^{-3})
3.6 < |y| < 4.4 (× 10^{-6})
Systematic uncertainties
NLO pQCD (CTEQ 6.6) × Non-pert. corr.
ATLAS Preliminary
$d^2\sigma/dp_T dy$ [pb/GeV]
p_T [GeV]
leading particle
Δϕ
toward
|Δϕ|<60°
transverse
60°<|Δϕ|<120°
transverse
W→eν + jets
Data 2010,$\sqrt{s}$=7 TeV
ALPGEN
SHERPA
BLACKHAT-SHERPA
MCFM
$\int$Ldt=33 pb^{-1}
First Jet p$_T$ [GeV]
Data 2010
PYTHIA ATLAS AMBT1
PYTHIA ATLAS MC09
PYTHIA DW
PYTHIA 8
PHOJET
Data Uncertainties
MC / Data

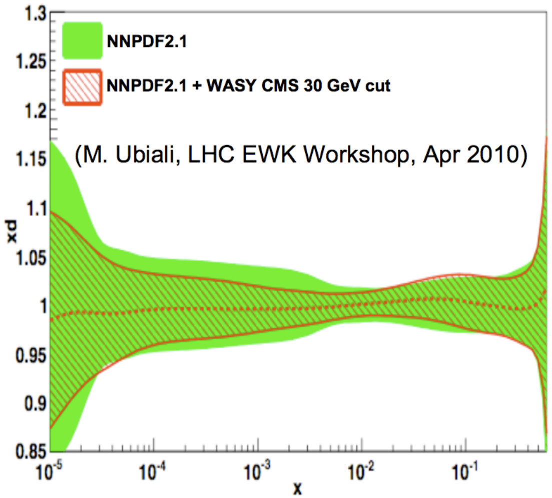
EW

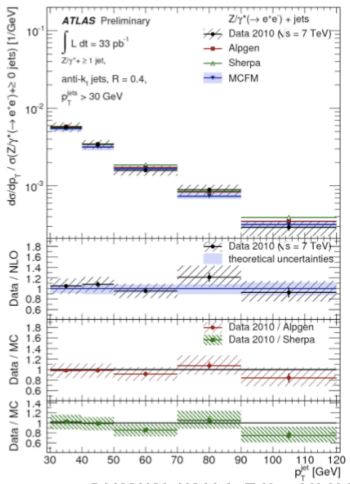

CMS
36 pb^{-1} at $\sqrt{s}$ = 7 TeV
NNLO, FEWZ+MSTW08 prediction
[with PDF4LHC 68% CL uncertainty]
10.44 ± 0.52 nb
W → eν
10.48 ± 0.03 stat ± 0.17 syst ± 0.42 lumi nb
W → μν
10.18 ± 0.03 stat ± 0.16 syst ± 0.41 lumi nb
W → lν (combined)
10.31 ± 0.02 stat ± 0.13 syst ± 0.41 lumi nb
σ(pp → WX) × B(W → lν) [nb]

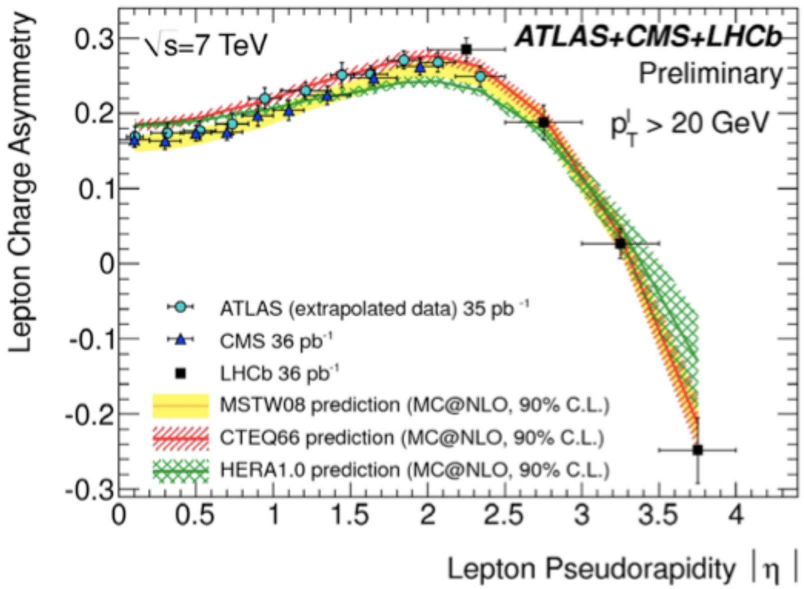

ATLAS Preliminary
∫ L dt = 33-36 pb^{-1}
Data 2010 ($\sqrt{s}$ = 7 TeV)
total uncertainty
exp. uncertainty
ABKM09
JR09
MSTW08
$\sigma^{tot}_{W^+} / \sigma^{tot}_{W^-}$


CMS preliminary
36 pb^{-1} at $\sqrt{s}$ = 7 TeV
Z/γ* → μμ
data
NNLO, FEWZ+MSTW08
uncertainty on modeling
$1/\sigma_Z\, d\sigma/dM_{\mu\mu}$ [GeV^{-1}]
M(μμ) [GeV]

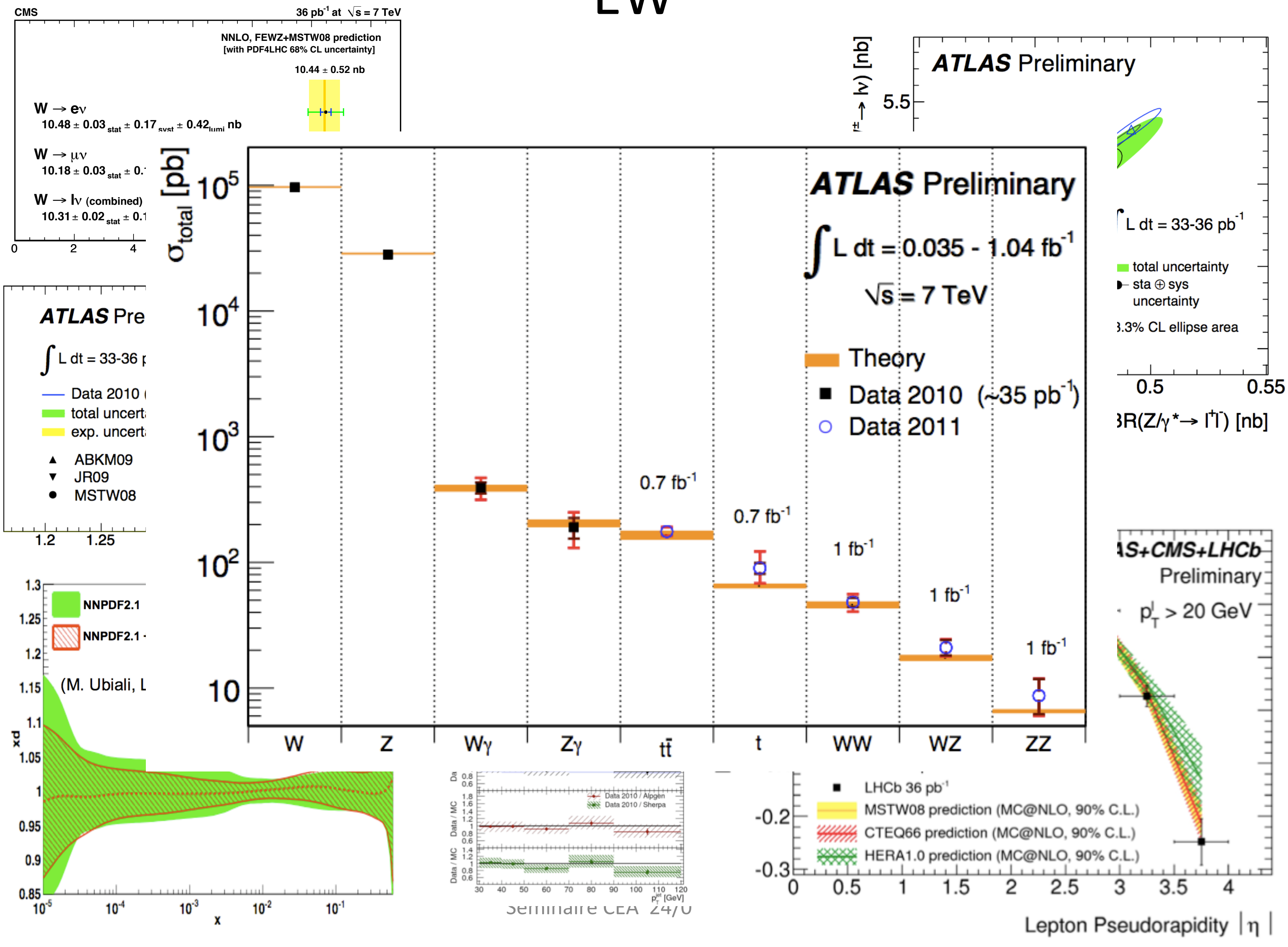

ATLAS Preliminary
∫ L dt = 33-36 pb^{-1}
Data 2010 ($\sqrt{s}$ = 7 TeV)
MSTW08
ABKM09
JR09
total uncertainty
sta ⊕ sys uncertainty
68.3% CL ellipse area
$\sigma^{fid}_{W^\pm} \cdot$ BR($W^\pm \to l\nu$) [nb]
$\sigma^{fid}_{Z} \cdot$ BR($Z/\gamma^* \to l^+l^-$) [nb]


NNPDF2.1
NNPDF2.1 + WASY CMS 30 GeV cut
(M. Ubiali, LHC EWK Workshop, Apr 2010)
xd
x


ATLAS Preliminary
Z/γ*(→ e⁺e⁻) + jets
Data 2010 ($\sqrt{s}$ = 7 TeV)
Alpgen
Sherpa
MCFM
anti-k_t jets, R = 0.4,
Data / NLO
Data / MC
Data 2010 / Alpgen
Data 2010 / Sherpa

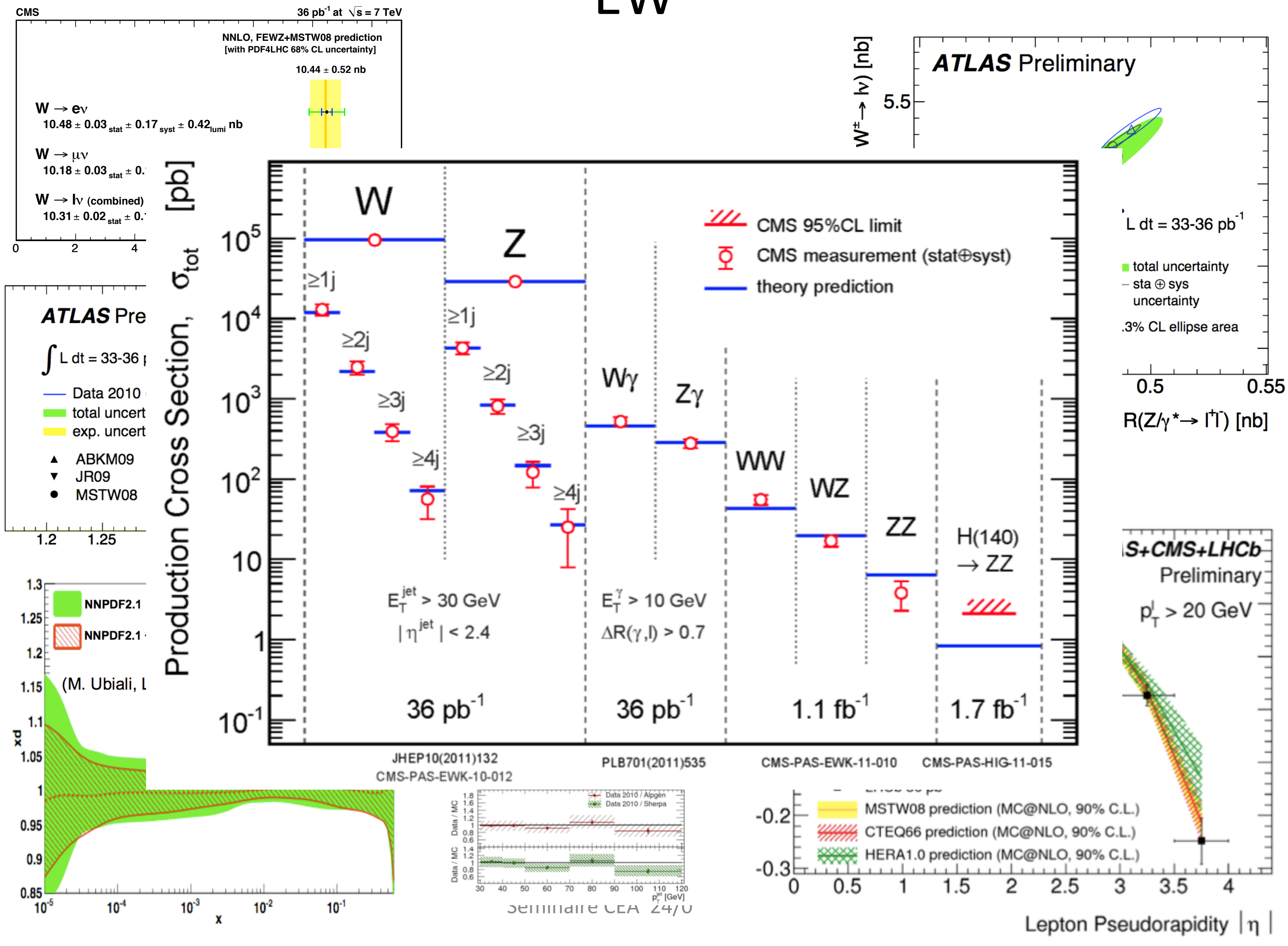

$\sqrt{s}$=7 TeV
ATLAS+CMS+LHCb
Preliminary
p^l_T > 20 GeV
ATLAS (extrapolated data) 35 pb^{-1}
CMS 36 pb^{-1}
LHCb 36 pb^{-1}
MSTW08 prediction (MC@NLO, 90% C.L.)
CTEQ66 prediction (MC@NLO, 90% C.L.)
HERA1.0 prediction (MC@NLO, 90% C.L.)
Lepton Charge Asymmetry
Lepton Pseudorapidity |η|

EW



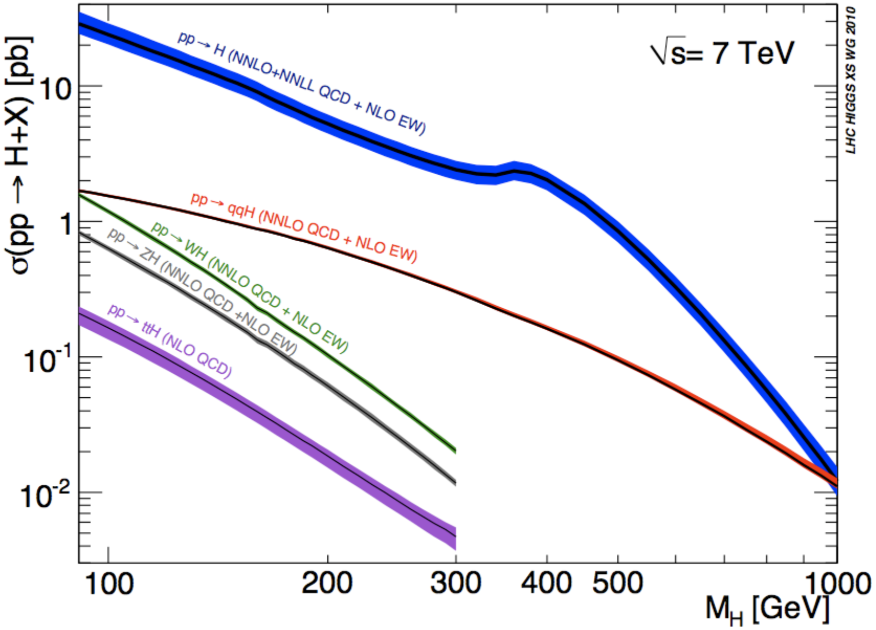
ATLAS Preliminary
∫L dt = 0.035 - 1.04 fb⁻¹
√s = 7 TeV
Theory
Data 2010 (~35 pb⁻¹)
Data 2011
σ_total [pb]
0.7 fb⁻¹
0.7 fb⁻¹
1 fb⁻¹
1 fb⁻¹
1 fb⁻¹
W
Z
Wγ
Zγ
tt̄
t
WW
WZ
ZZ
CMS
36 pb⁻¹ at √s = 7 TeV
NNLO, FEWZ+MSTW08 prediction
[with PDF4LHC 68% CL uncertainty]
10.44 ± 0.52 nb
W → eν
10.48 ± 0.03 stat ± 0.17 syst ± 0.42 lumi nb
W → μν
W → lν (combined)
ATLAS Preliminary
∫L dt = 33-36 pb⁻¹
total uncertainty
uncertainty
ABKM09
JR09
MSTW08
NNPDF2.1
(M. Ubiali, L
LHCb 36 pb⁻¹
MSTW08 prediction (MC@NLO, 90% C.L.)
CTEQ66 prediction (MC@NLO, 90% C.L.)
HERA1.0 prediction (MC@NLO, 90% C.L.)
Preliminary
Lepton Pseudorapidity |η|

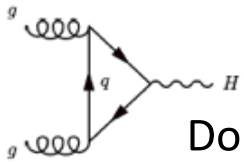
EW


CMS
36 pb-1 at √s = 7 TeV
NNLO, FEWZ+MSTW08 prediction
[with PDF4LHC 68% CL uncertainty]
10.44 ± 0.52 nb
W → eν
10.48 ± 0.03 stat ± 0.17 syst ± 0.42 lumi nb
W → μν
W → lν (combined)
ATLAS Preliminary
Data 2010
total uncert
exp. uncert
ABKM09
JR09
MSTW08
NNPDF2.1
(M. Ubiali,
W
Z
Production Cross Section, σtot [pb]
CMS 95%CL limit
CMS measurement (stat⊕syst)
theory prediction
Wγ
Zγ
WW
WZ
ZZ
H(140) → ZZ
36 pb-1
1.1 fb-1
1.7 fb-1
JHEP10(2011)132
CMS-PAS-EWK-10-012
PLB701(2011)535
CMS-PAS-EWK-11-010
CMS-PAS-HIG-11-015
MSTW08 prediction (MC@NLO, 90% C.L.)
CTEQ66 prediction (MC@NLO, 90% C.L.)
HERA1.0 prediction (MC@NLO, 90% C.L.)
Lepton Pseudorapidity |η|
Preliminary
total uncertainty
R(Z/γ*→ l+l-) [nb]

The Main Production Modes

Data driven background estimates legitimate use of NNLO cross sections!





- Gluon fusion process :

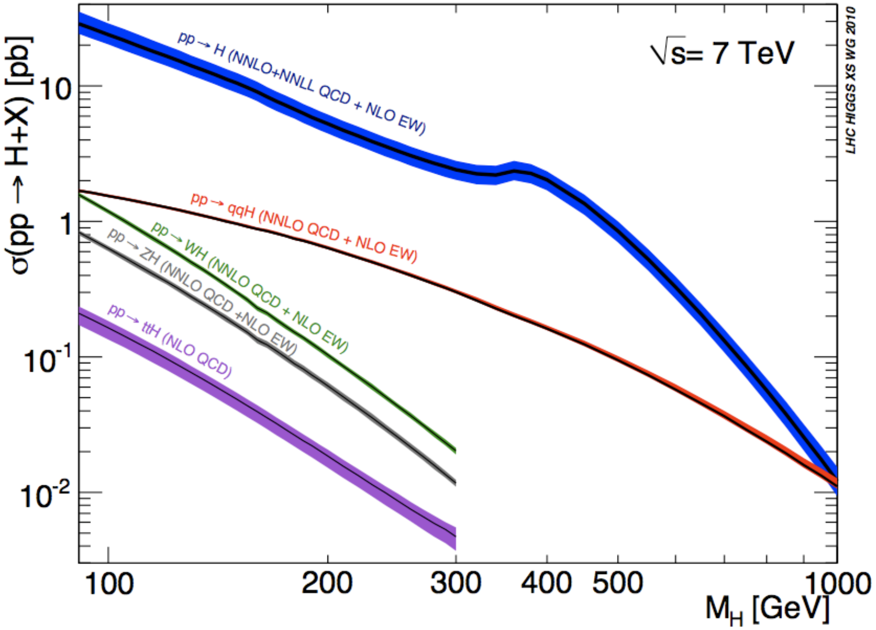
Dominant process known at NNnLO

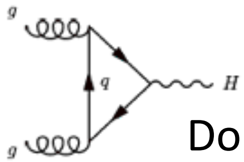
However rather large TH uncertainty* ~O(15%) due to the large corrections for gluon initiated process

* TH uncertainty mostly from scale variation and PDFs, $\delta\sigma_{PDF-\alpha s}$~8-10% and $\delta\sigma_{Scale}$~ 7-8%

The Main Production Modes

Data driven background estimates legitimate use of NNLO cross sections!





- Gluon fusion process :

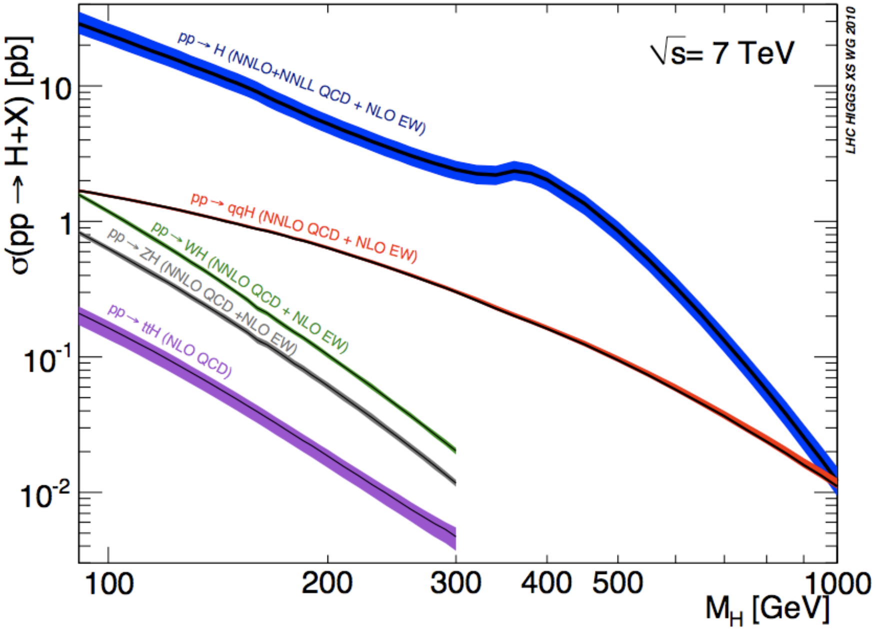
Dominant process known at NNnLO

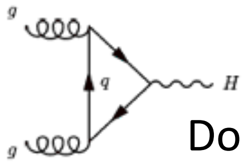
~100 kEvts produced at 120 GeV

* TH uncertainty mostly from scale variation and PDFs, $\delta\sigma_{PDF\text{-}\alpha s}$~8-10% and $\delta\sigma_{Scale}$~ 7-8%

The Main Production Modes

Data driven background estimates legitimate use of NNLO cross sections!

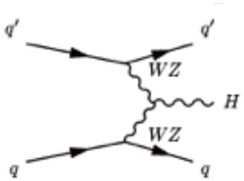




- Gluon fusion process :

Dominant process known at NNnLO

~100 kEvts produced at 120 GeV



- Vector Boson Fusion :

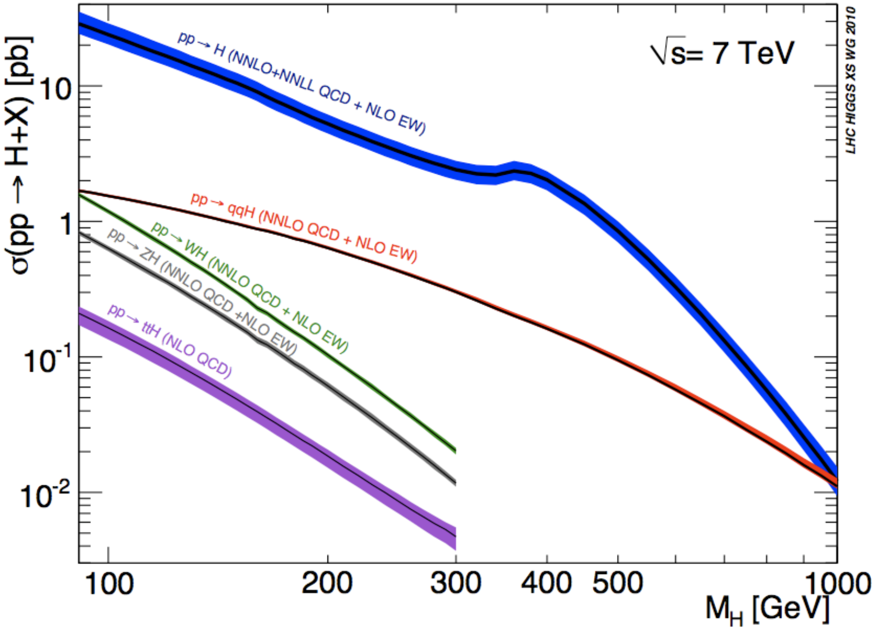
known at NLO TH uncertainty ~O(5%)

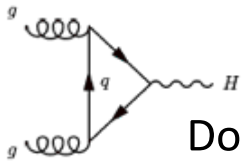
Rather distinctive features w/ two conspicuous forward jets and a rapidity gap

* TH uncertainty mostly from scale variation and PDFs, $\delta\sigma_{PDF-\alpha s}$~8-10% and $\delta\sigma_{Scale\sim}$ 7-8%

The Main Production Modes

Data driven background estimates legitimate use of NNLO cross sections!





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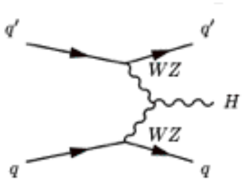

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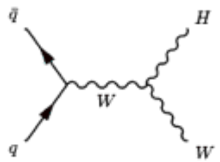
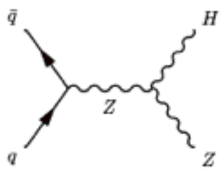
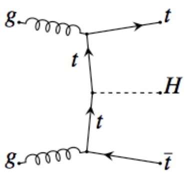




- Associated Production with W and Z :

known at NNLO TH uncertainty ~O(5%)

Very distinctive feature with a Z or W decaying leptonically



- Associated Production with top pair :

known at NLO TH uncertainty ~O(15%)

Quite distinctive but also quite crowded

* TH uncertainty mostly from scale variation and PDFs, $\delta\sigma_{PDF-\alpha s}$~8-10% and $\delta\sigma_{Scale\sim}$ 7-8%

Decay Modes

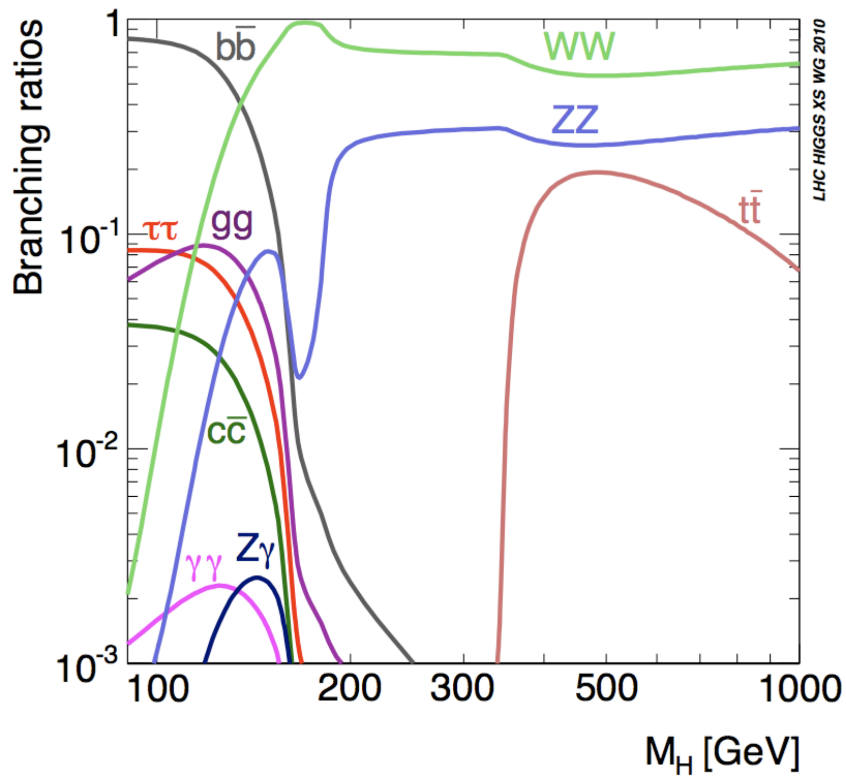
Pure Branching Fractions

- The dominant b-decay channel

Huge backgrounds, needs distinctive features at production level and beyond… Associate production W,Z H and Boost!

- The $\tau\tau$ channel

Also needs distinctive production features, typically VBF. Can also be done inclusively, especially since the NEW MASS RECOSTRUCTION techniques

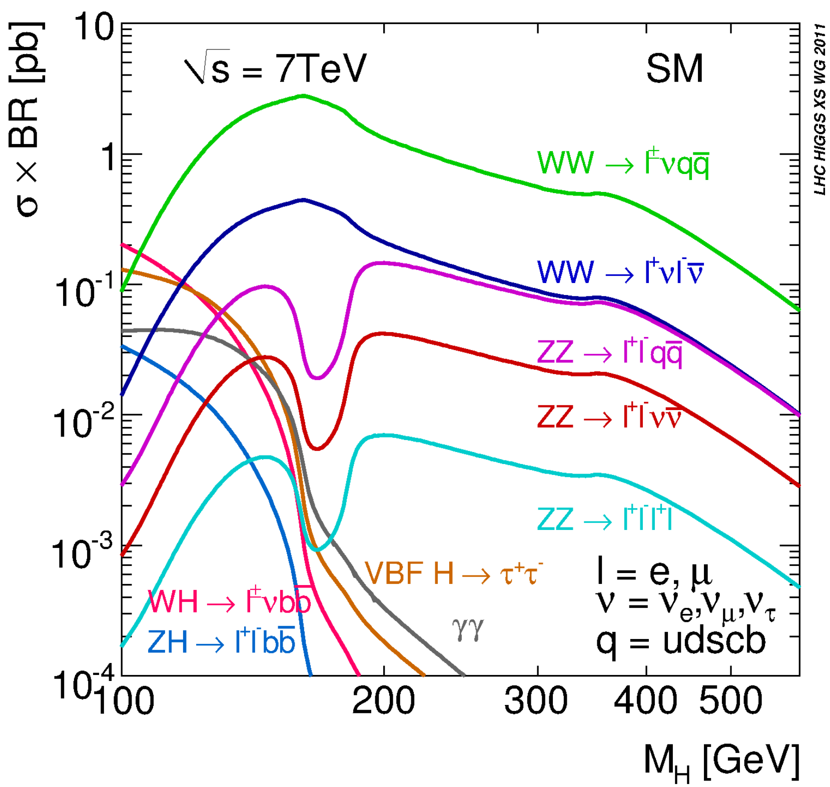


Decay Modes

Exclusive Modes Cross Sections

- The dominant b-decay channel

Huge backgrounds, needs distinctive features at production level and beyond… Associate production W,Z H and Boost!



- The ττ channel

Also needs distinctive production features, typically VBF. Can also be done inclusively, especially since the NEW MASS RECOSTRUCTION techniques

- The γγ channel

Dominant Channel in the very low mass range. Small branching but sizable yield. Very distinctive signature on its own.

- The WW Channels

- Dilepton (lnln) channel is dominant in the low mass (very poor mass resolution, essentially counting experiment)
- Semi leptonic (lnqq) largest event yield effective at large mass where the background is smaller.

- The ZZ Channels

- 4-leptons : "Golden mode" smallest event yield but large s/b ratio
- semi-leptonic (llqq) larger event yield but also much larger background (make use of the large branching Z in bb)
- 2-leptons 2-neutrinos (llnn) : Best compromise yield/purity. Dominant channel at high mass

Production Modes and Decay Channels

Channel		ggF	VBF	W,Z H	ttH
γγ		✓	✓	✓	✓
ττ		✓	✓		
W,Z H (bb)				✓	
ZZ (llll)		✓	✓		
WW (lνlν)	0-jet	✓			
	1-jet	✓	✓		
	VBF	✓	✓		
WW (lνqq)	0-jet	✓	✓		
	1-jet	✓	✓		
ZZ (llνν)		✓	✓		
ZZ (llττ)		✓	✓		
ZZ (llqq)		✓	✓		

Low Mass :
Challenging Range
110 -150 GeV/c^2

Intermediate :
Wide Range
110 - 600 GeV/c^2

High Mass : Larger contribution from VBF
200 - 600 GeV/c^2

Not theory difficulties above 500 GeV/c^2

Take home message : - Mostly ggF analyses
- VBF important at High Mass (caution with the Higgs width)

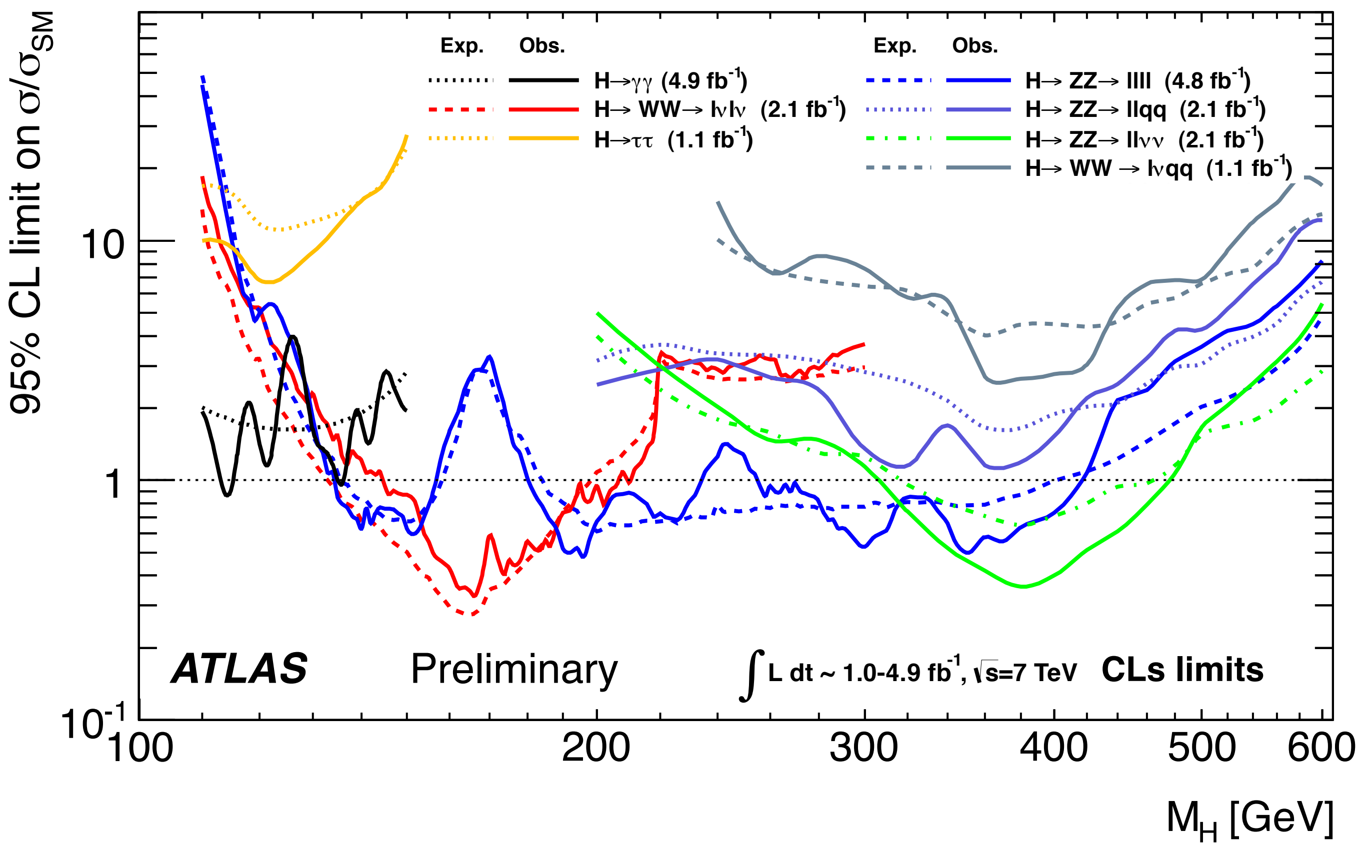
Channels nano Review

Channel		btag (veto)	Jets	MET (GeV)	Shape	Mass Range (GeV/c^2)	Main backgrounds
$\gamma\gamma$					$M_{\gamma\gamma}$	110-150	$\gamma\gamma$ (from sidebands)
$\tau\tau$		✓	✓		$M_{\tau\tau}$	110-140	Z from data driven methods
WH		✓	2		M_{bb}	110-130	Top (3j - high M_{bb}) and W+jets (low M_{bb})
ZH		✓	2		M_{bb}	110-130	Z+jets (low M_{bb})
WW ($l\nu l\nu$)	0-jet		0	>30		110-600	WW (control region M_{ll})
	1-jet	veto	1	>30		110-600	Top (from reverse btag) and WW (M_{ll} CR)
	VBF*	veto	2	>30		110-600	Top from CS
WW** ($l\nu qq$)	0-jet		0	>30	M_{WW}	200-600	W+jets (sidebands)
	1-jet	veto	1	>30	M_{WW}	200-600	W+jets (sidebands)
ZZ (llll)		IP			M_{4l}	110-600	ZZ (from MC), Z+jets and top (CR)
ZZ ($ll\tau\tau$)*					$M_{2l2\tau}$	200-600	ZZ (From Z - data)
ZZ ($ll\nu\nu$)		✓		>30	M_T	200-600	VV(from MC) and top (MC and checks)
ZZ (llqq)		✓	2	<50	M_{llqq}	130*-600	Z+jets (from MC) and top (from MC)

* CMS only / ** ATLAS only

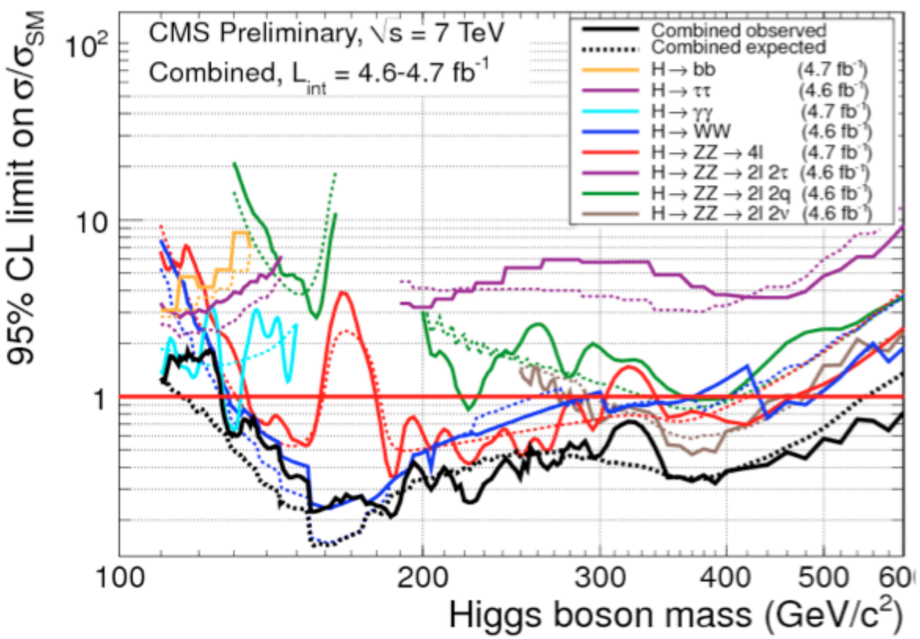
Channels Overview

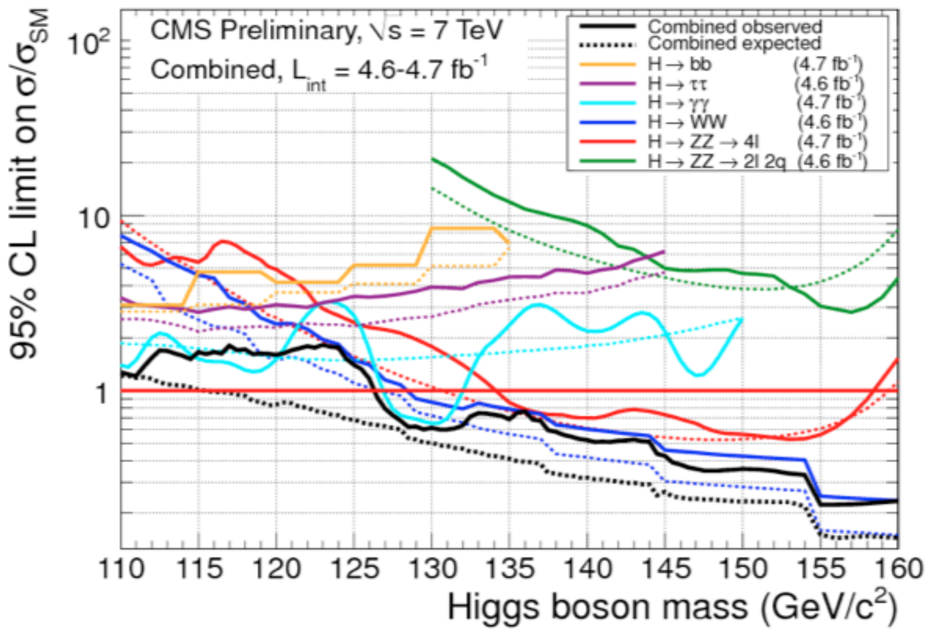
The Complete ATLAS Picture



Channels Overview

The Complete CMS Picture

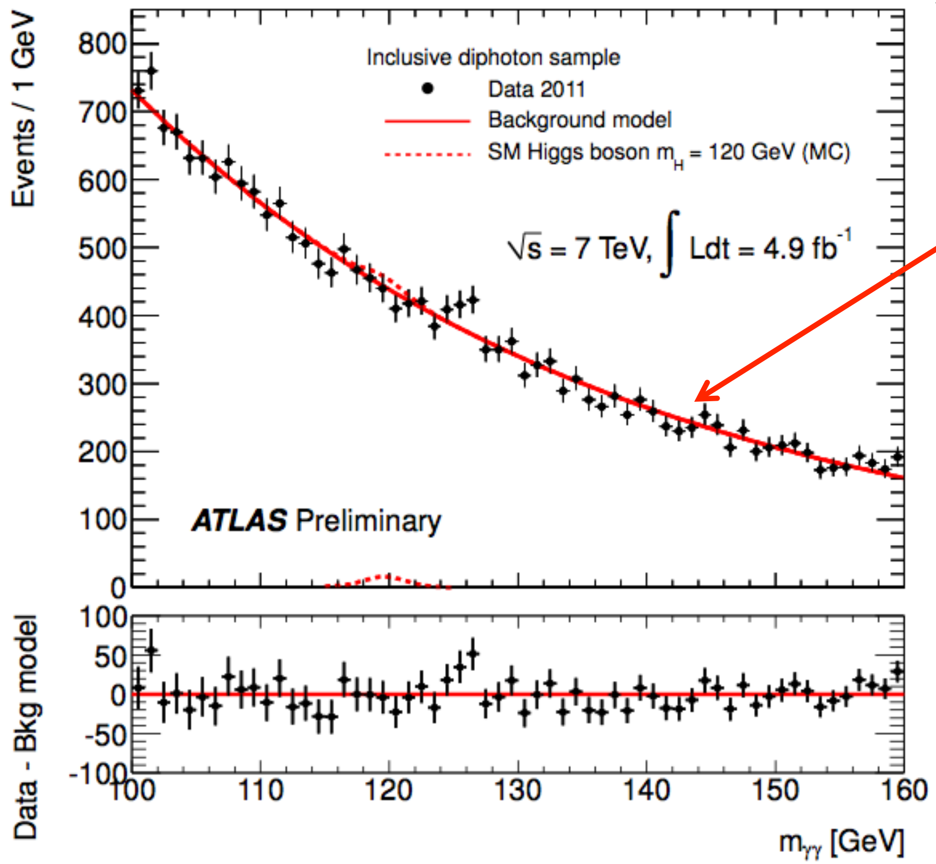




Statistical Interpretation

How to read Higgs Search Plots

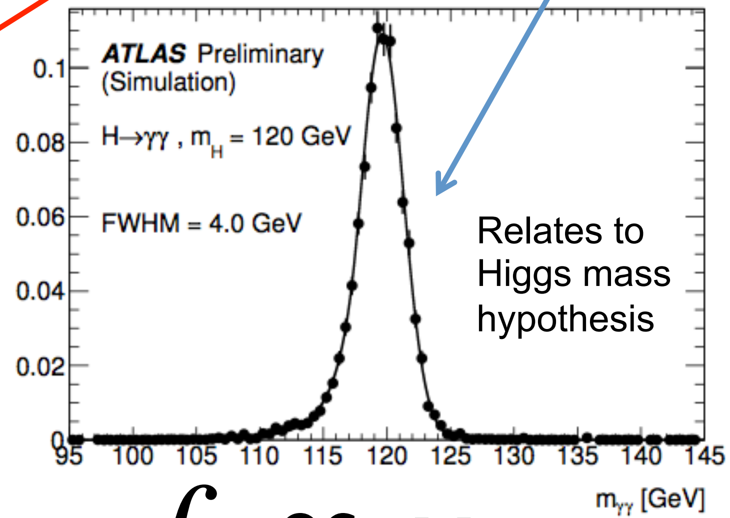
Hypothesis testing using the Profile likelihood ratio…



Likelihood Definition:

Simplified

$$L(\mu,\theta) = f_b \psi_b(M_{\gamma\gamma}) + f_s \psi_s(M_{\gamma\gamma})$$



Relates to Higgs mass hypothesis

$$f_s \propto \mu$$

Global coherent factor

$$n_s = \mu \sigma Br L \varepsilon$$

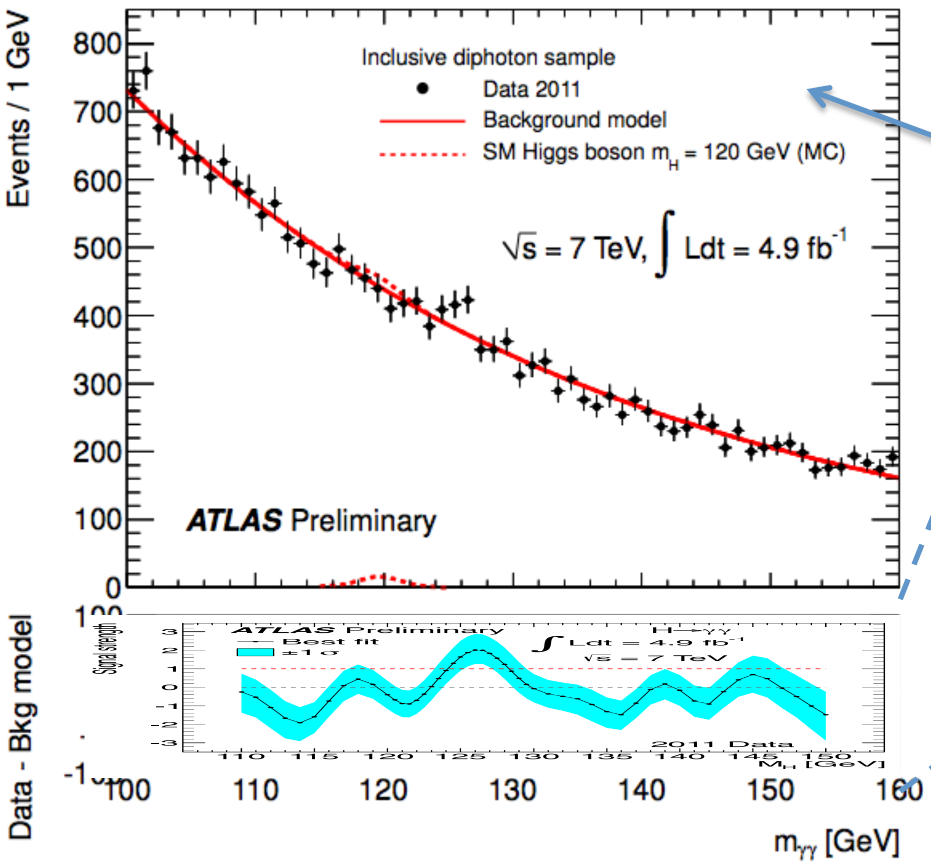
Statistical Interpretation

How to read Higgs Search Plots

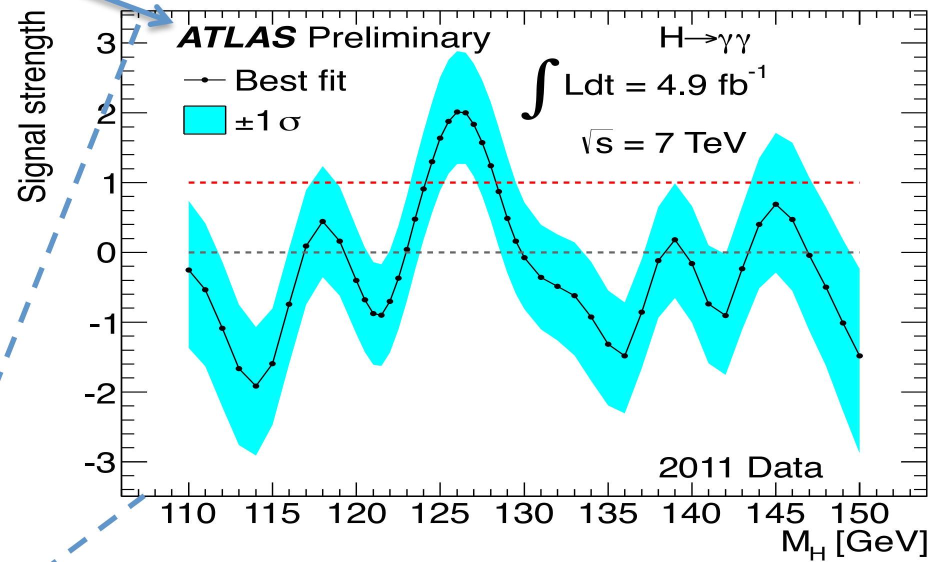
Hypothesis testing using the

Profile likelihood ratio…

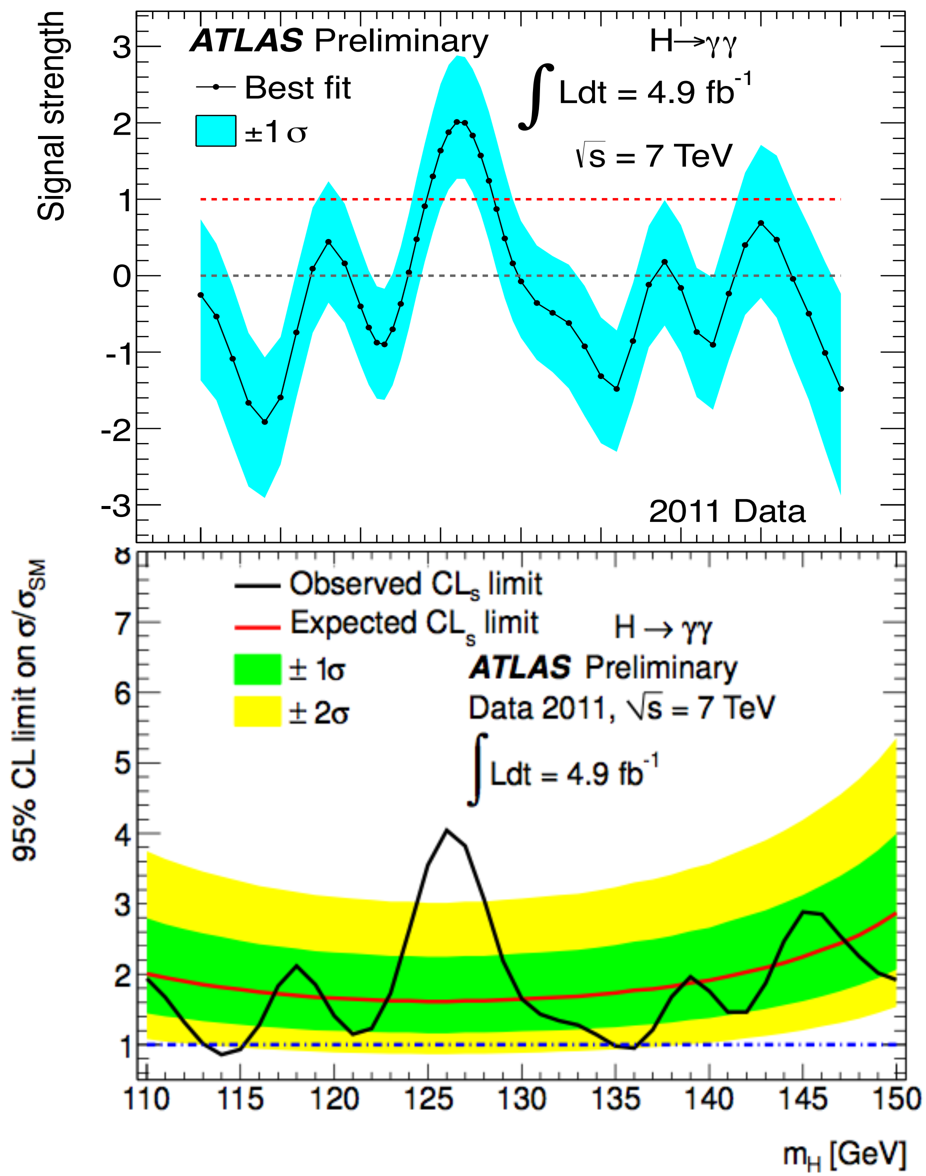
$\hat{\mu}$



Relate to Higgs mass hypothesis



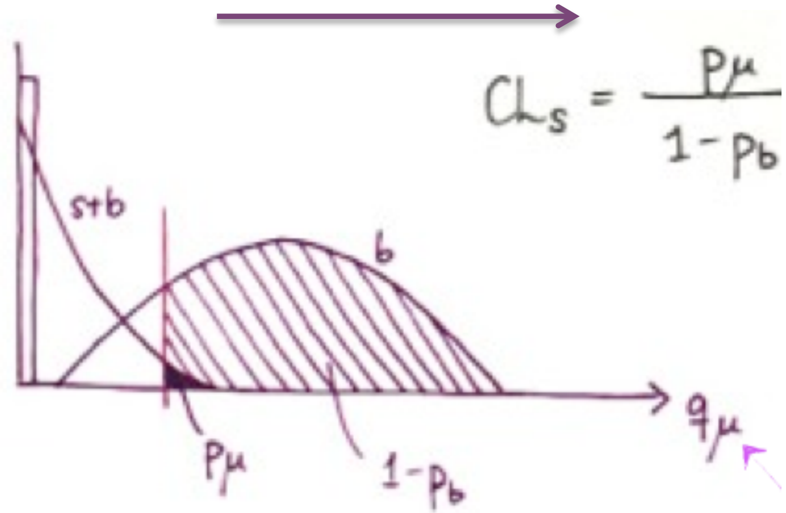
How to Read Higgs Exclusion Limits Plots



$$\lambda_\mu = \lambda(\mu,\theta) = \frac{L(\mu,\hat{\hat{\theta}}(\mu))}{L(\hat{\mu},\hat{\theta})}$$

$$q_\mu = -2\ln\lambda_\mu$$

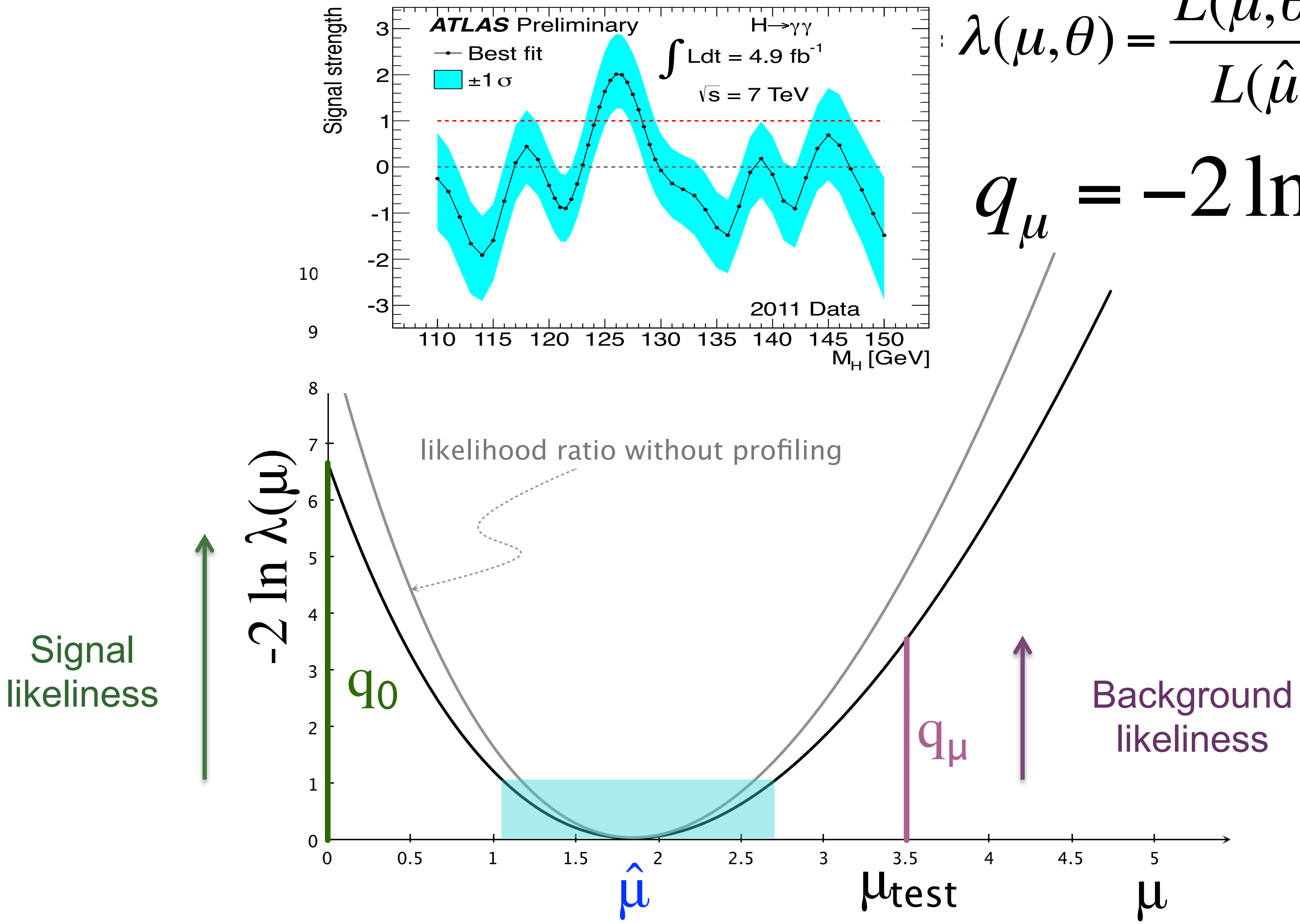
Background likeliness



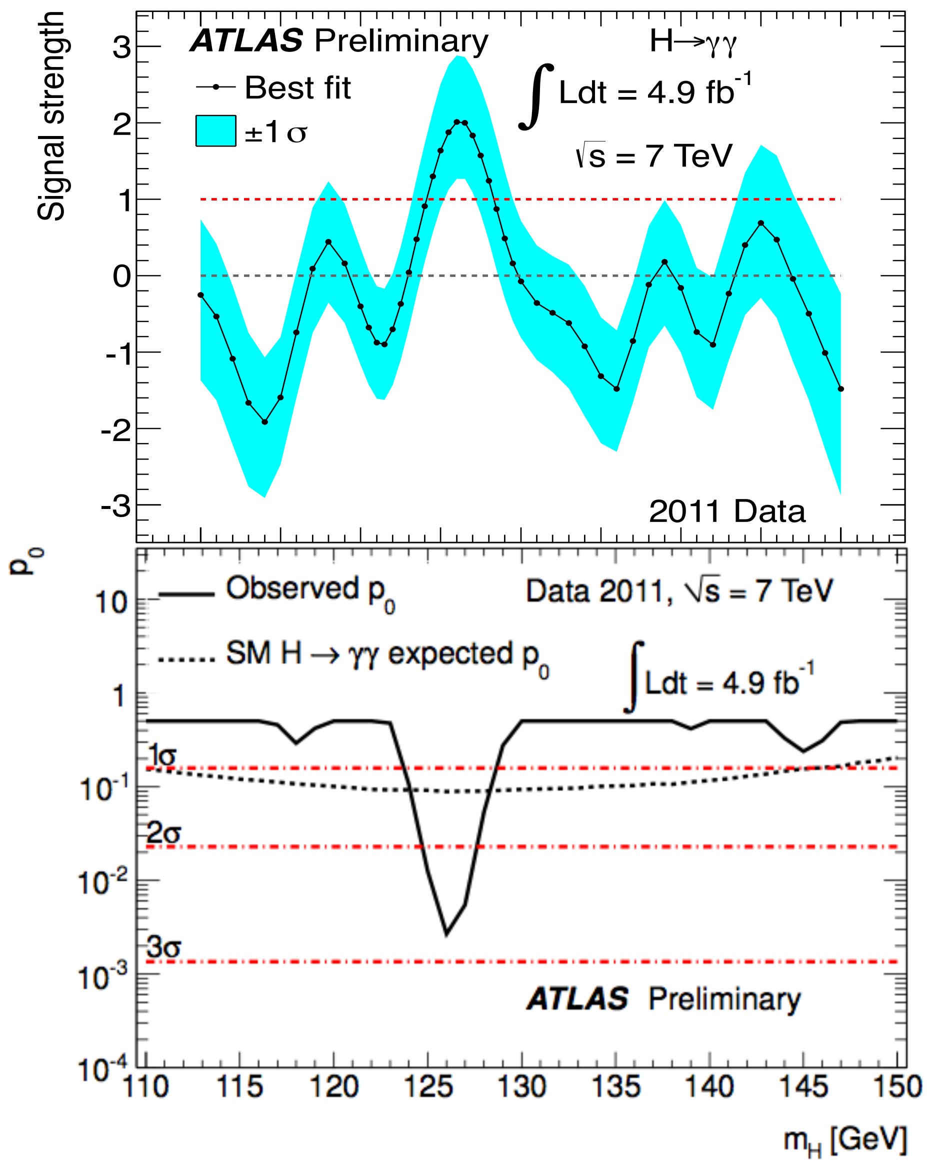
How to Read Higgs Exclusion Limits Plots

$$\lambda(\mu,\theta) = \frac{L(\mu,\hat{\hat{\theta}}(\mu))}{L(\hat{\mu},\hat{\theta})}$$

$$q_\mu = -2\ln\lambda_\mu$$

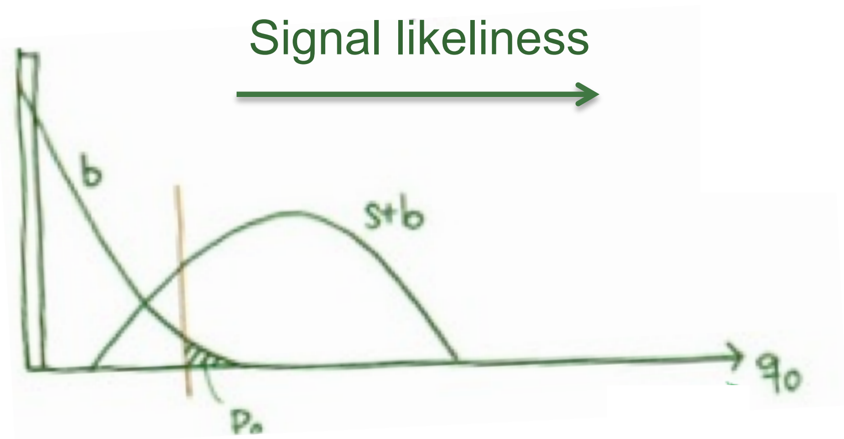


How to Read Higgs Observation Estimates



$$\lambda_0 = \lambda(0,\theta) = \frac{L(0,\hat{\hat{\theta}}(0))}{L(\hat{\mu},\hat{\theta})}$$

$$q_0 = -2\ln\lambda_0$$

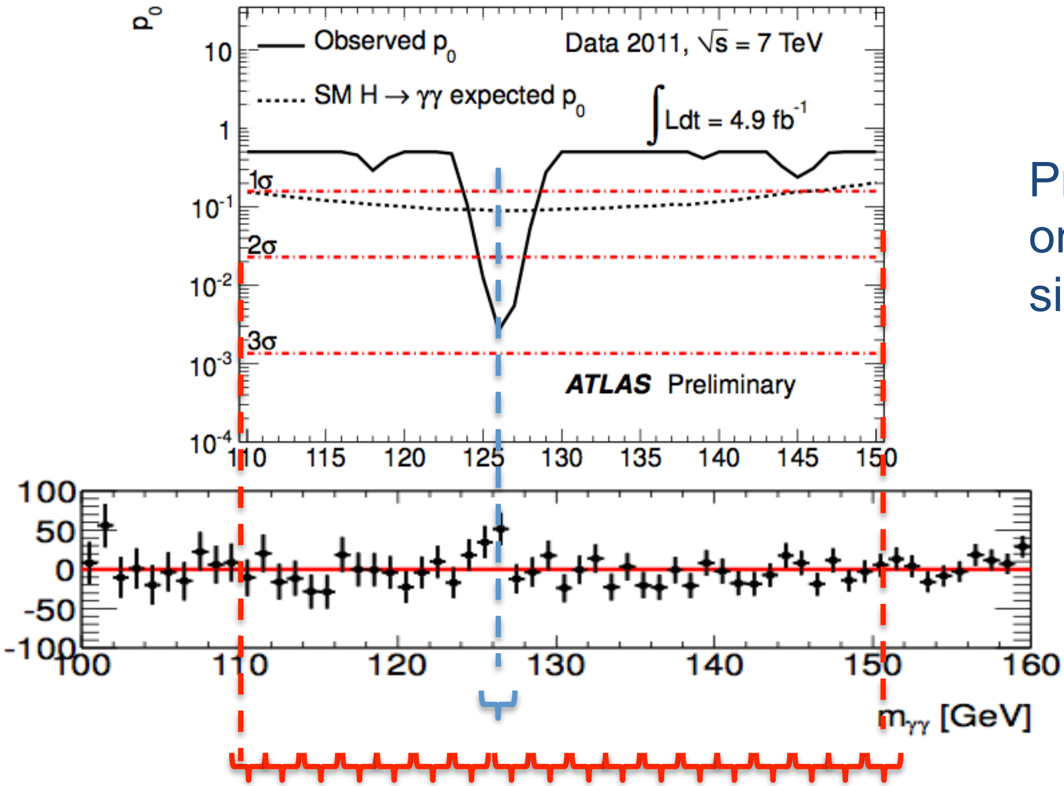


p_0 Probability that a background only experiment be more signal like than observed

Local vs. Global Probability

Look Elswhere Effect

(over)Simplified View



Probability of observing an excess at one specific mass (in absence of signal)…

What is the probability of observing an excess at least as large as observed within a mass range ?

Trial factor ~ Number of possible independent outcomes within a mass range…

For a typical channel

$$L(\mu,\theta) = Poisson(n_s + n_b, N_{SR}) \times Poisson(b, N_{bkg}) \times G(\theta_{JES}(\mu) | \hat{\hat{\theta}}(\mu), \sigma_{JES})$$

(1) Signal Region

(2) Control Region

(3) Auxiliary Measurement

$$n_b = \alpha \times \hat{\hat{b}}(\mu) \quad \xleftarrow{\ \alpha\ } \quad \hat{\hat{b}}(\mu)$$

$$n_s = \mu\sigma BrL \times \varepsilon \times (1+\theta_\varepsilon) \quad \longleftarrow \quad \hat{\hat{\theta}}_\varepsilon(\mu)$$

What we do :

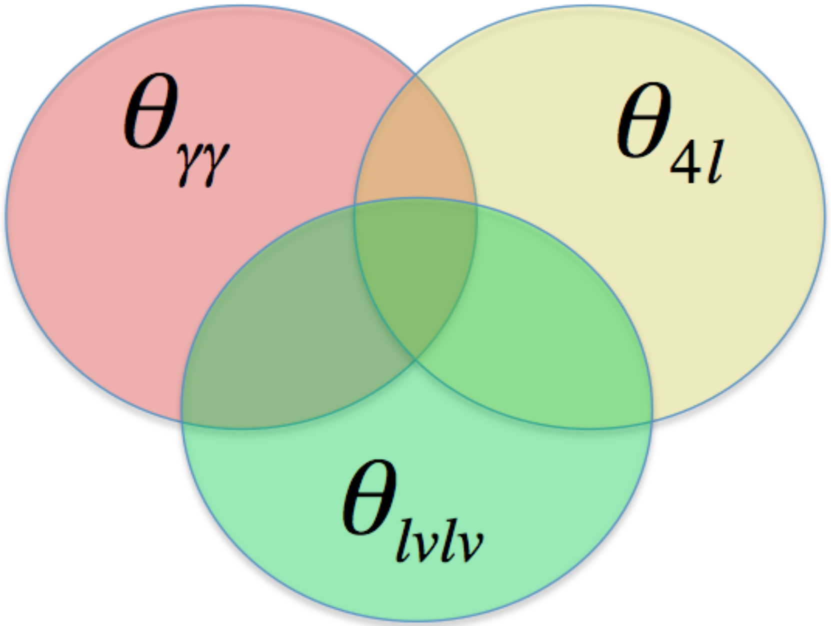
1.- Test hypotheses of signal

2.- Measure background in control regions (CR)

3.- Taking into account syst. Using auxiliary measurements (e.g. Perf. Groups)

Combination : Use Correlations with Caution

$$L_{Combined}(\mu,\theta) = L_{\gamma\gamma}(\mu,\theta_{\gamma\gamma}) \times L_{4l}(\mu,\theta_{4l}) \times L_{l\nu l\nu}(\mu,\theta_{l\nu l\nu}) \times L_{\tau\tau}(\mu,\theta_{\tau\tau})$$

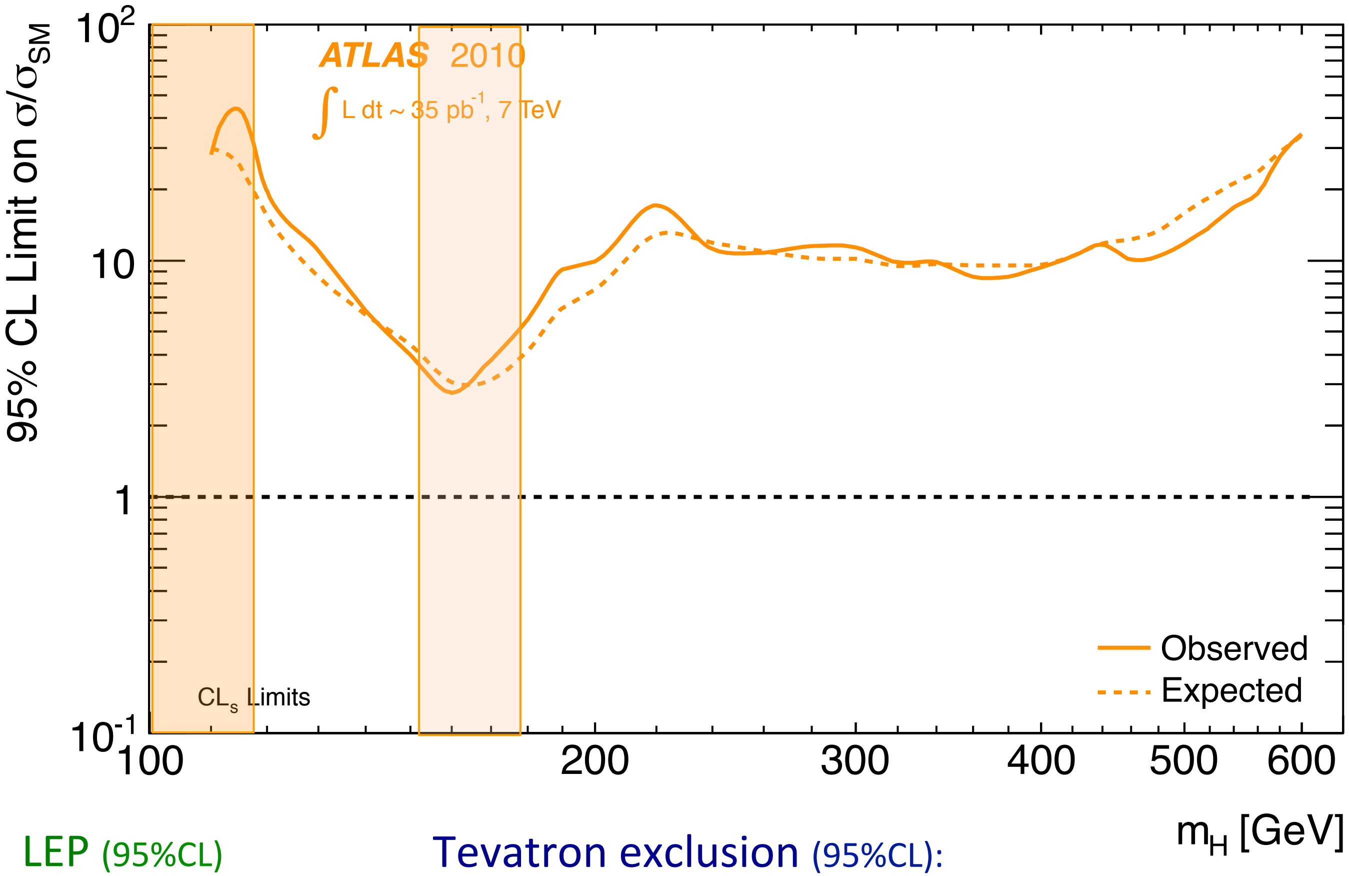


Need to very carefully check the interplay between correlated systematics…

Fast Forward Evolution Since Moriond 2011

…in ATLAS…

Moriond 2011 (2010 Data)



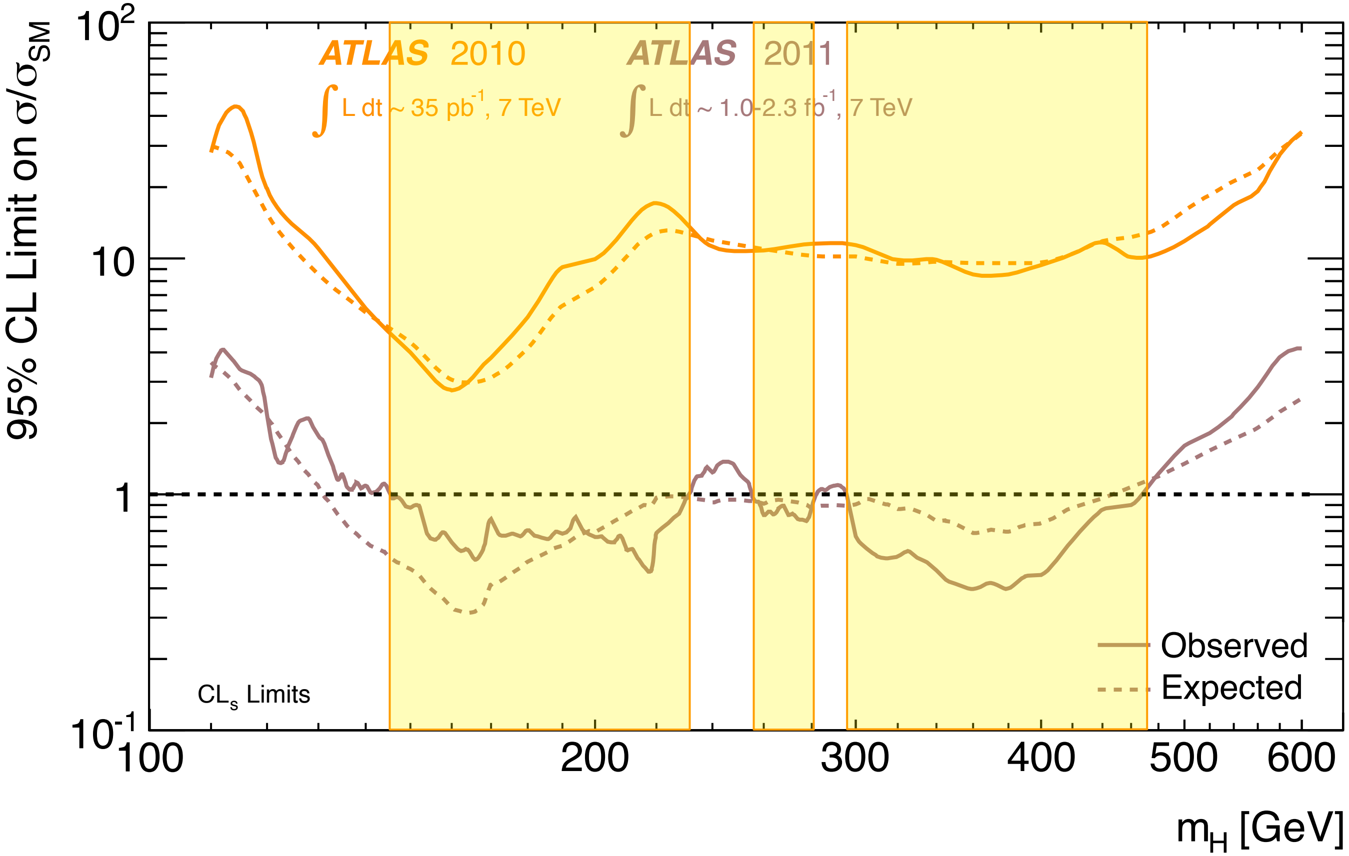
LEP (95%CL)
m_H > 114 GeV

Tevatron exclusion (95%CL):
100 < m_H < 109 GeV
156 < m_H < 177 GeV

Fast Forward Evolution Since Moriond 2011

…in ATLAS…

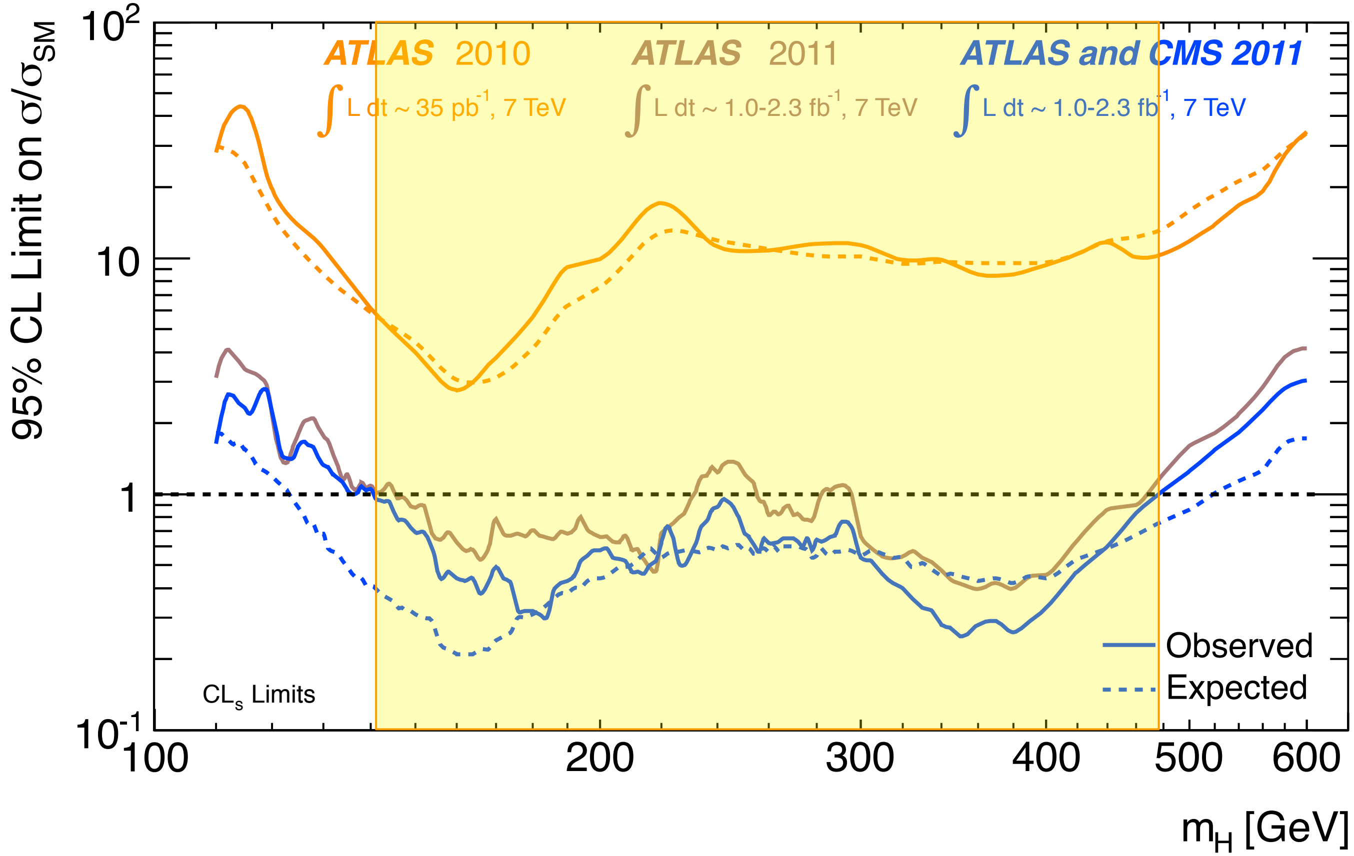
EPS 2011



Fast Forward Evolution Since Moriond 2011

…in ATLAS…

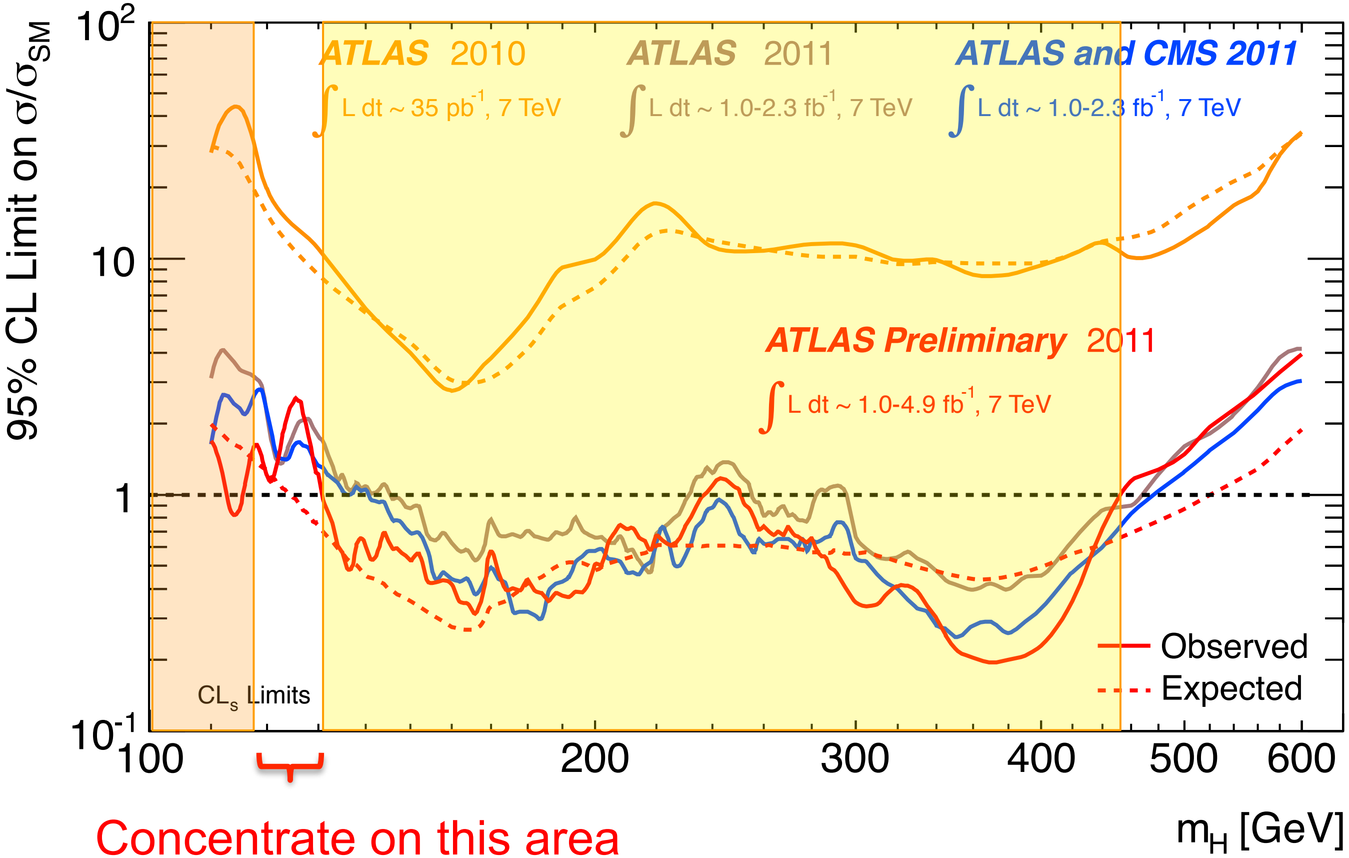
Combination HCP 2011



Fast Forward Evolution Since Moriond 2011

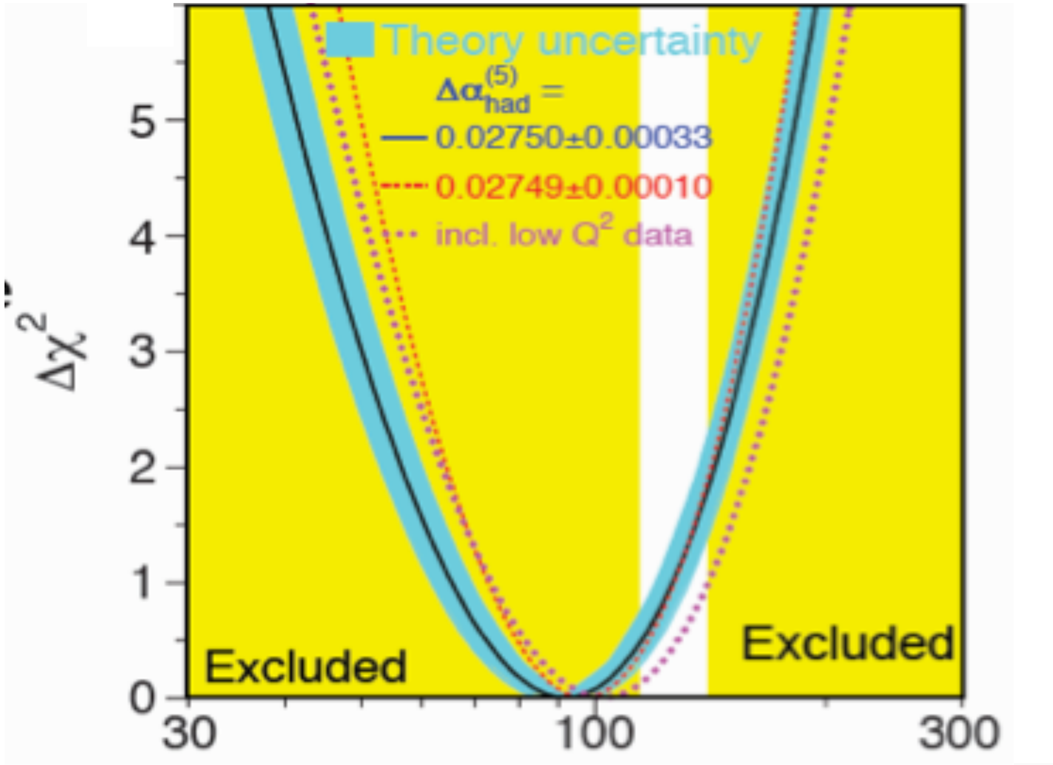
…in ATLAS…

Council 2011



Concentrate on this area

The Low Higgs Mass Domain



Will Concentrate on low mass SM Higgs boson searches

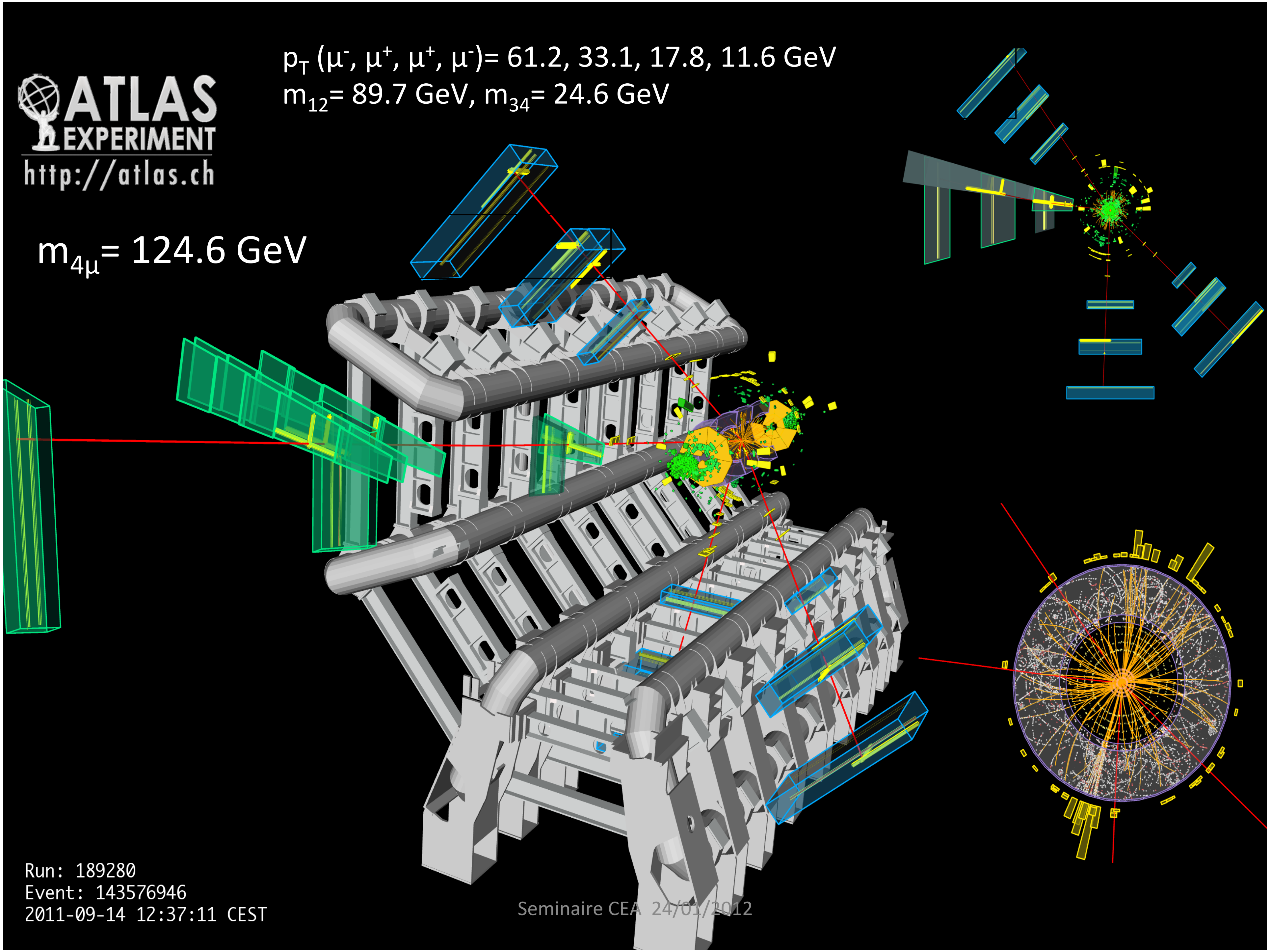
Apologies for the uncovered general Higgs searches sujects
(material in backup)

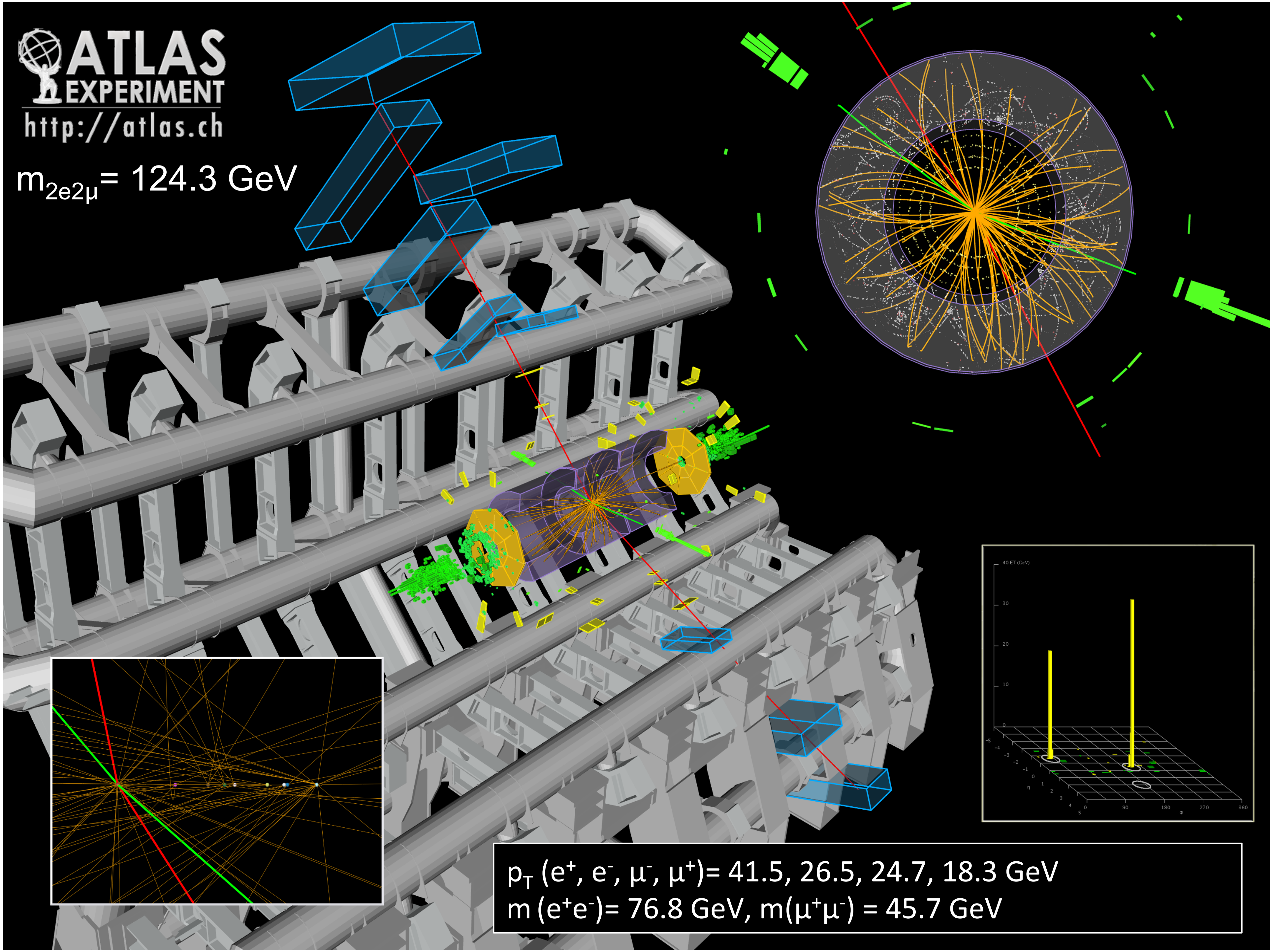
$$H \rightarrow ZZ \rightarrow \ell\ell\ell\ell$$

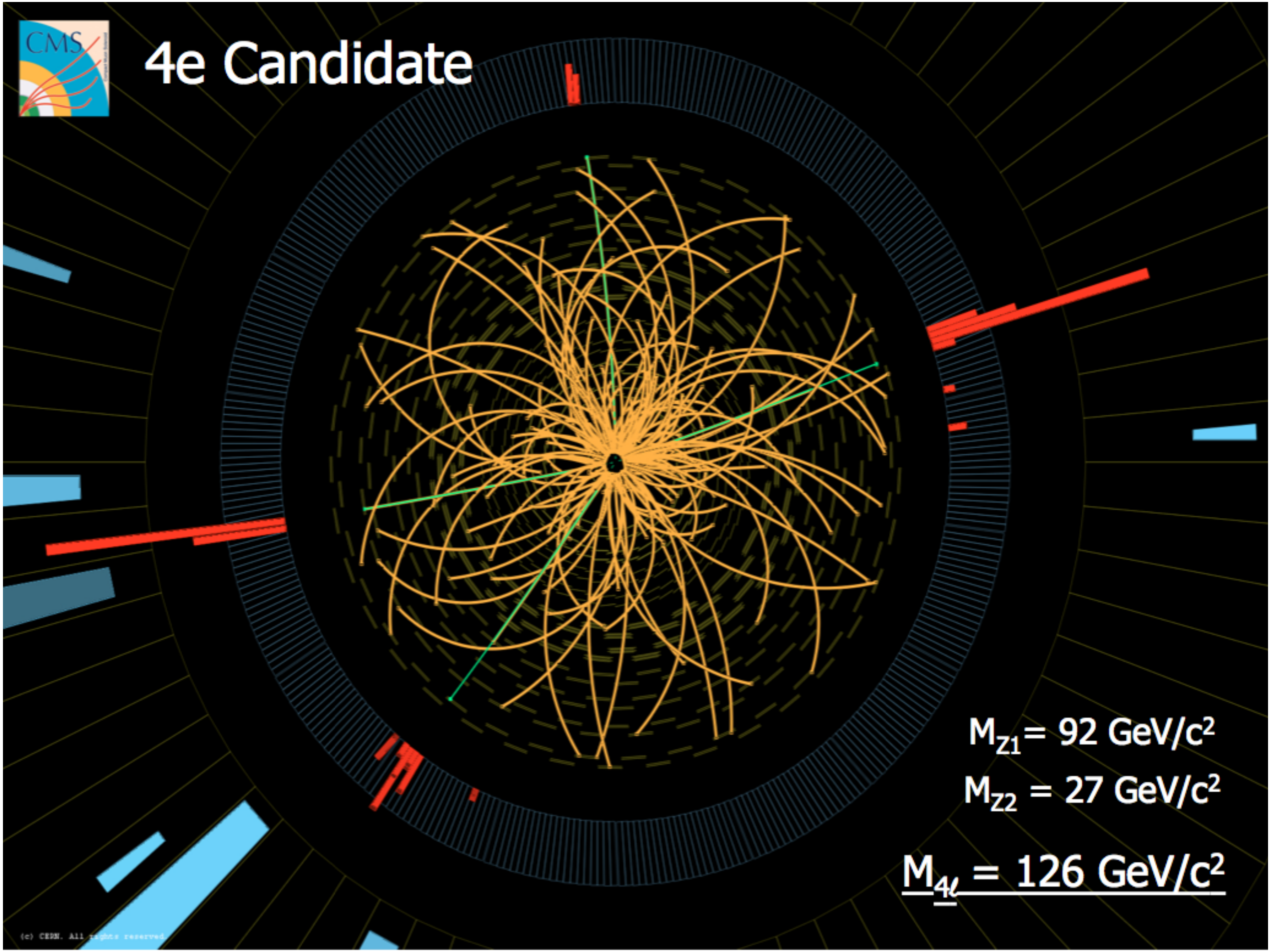
Most sensitive Channel in [180-250] GeV Mass range

ATLAS 4.9 fb^{-1}

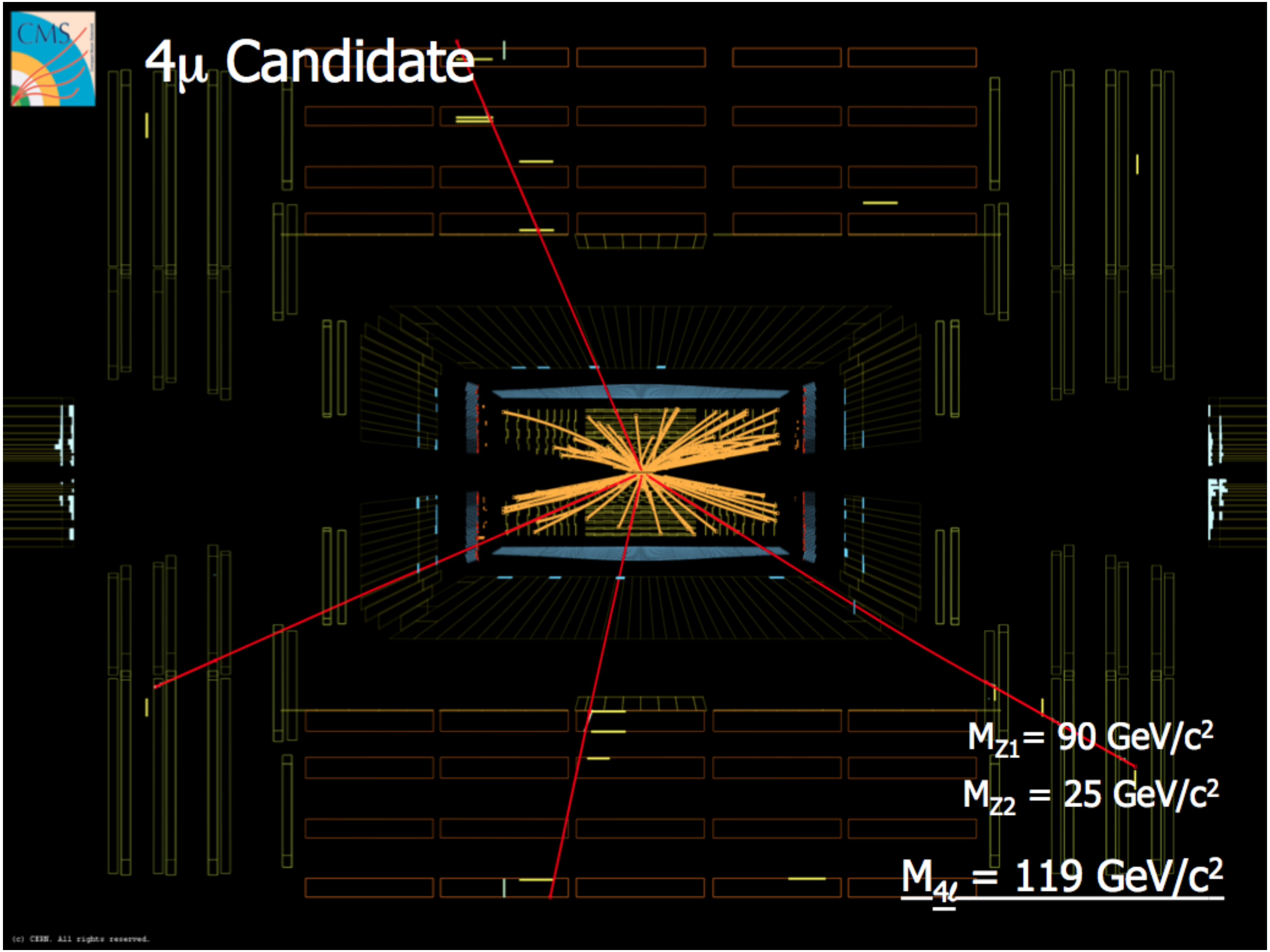
CMS 4.6 fb^{-1}


p_T (μ^-, μ^+, μ^+, μ^-)= 61.2, 33.1, 17.8, 11.6 GeV
m_{12}= 89.7 GeV, m_{34}= 24.6 GeV
ATLAS EXPERIMENT
http://atlas.ch
$m_{4\mu}$= 124.6 GeV
Run: 189280
Event: 143576946
2011-09-14 12:37:11 CEST
Seminaire CEA 24/01/2012


ATLAS EXPERIMENT
http://atlas.ch
$m_{2e2\mu}$ = 124.3 GeV
p_T (e^+, e^-, μ^-, μ^+) = 41.5, 26.5, 24.7, 18.3 GeV
m (e^+e^-) = 76.8 GeV, m($\mu^+\mu^-$) = 45.7 GeV


CMS
4e Candidate
M_{Z1}= 92 GeV/c^2
M_{Z2} = 27 GeV/c^2
M_{4ℓ} = 126 GeV/c^2
(c) CERN. All rights reserved

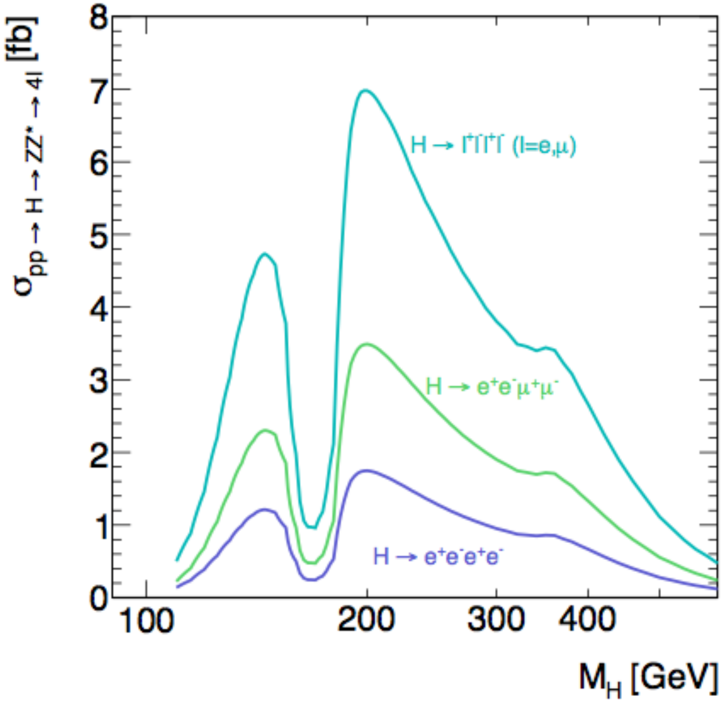
4μ Candidate



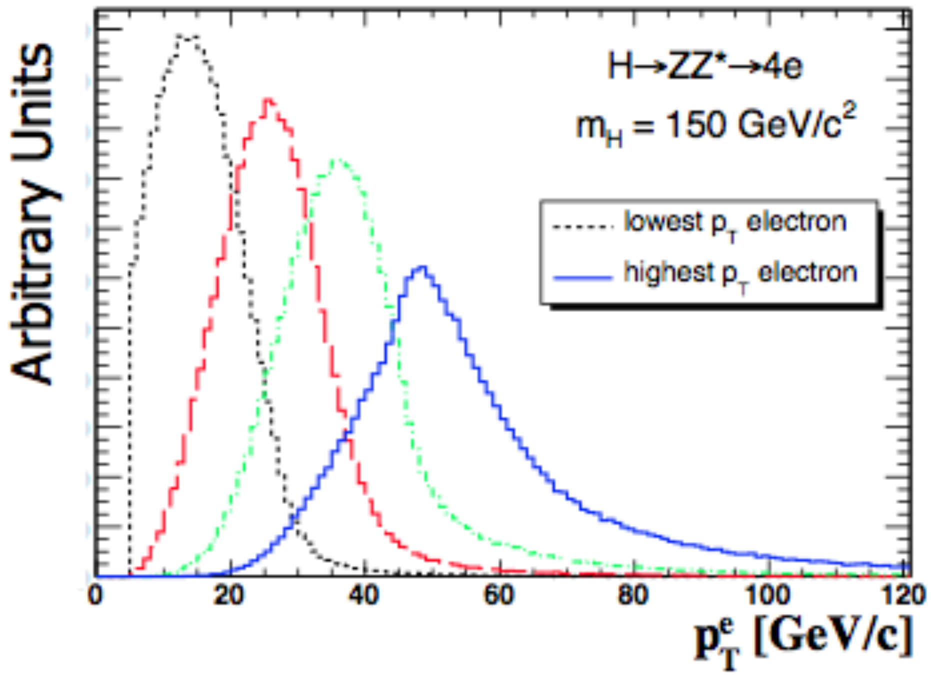
Higgs Boson Search in the $ZZ^{(*)} \rightarrow 4l$

"Golden Channel"

- One Z allowed to be off-mass shell (m_H < 180 GeV)
- p_T thresholds important for lower mass reach
- Invariant mass selections also important to optimize low mass selection
- Main Background ZZ from Monte Carlo (ATLAS) and derived from Z (CMS)
- Other backgrounds (Zbb and top) data driven (but small)



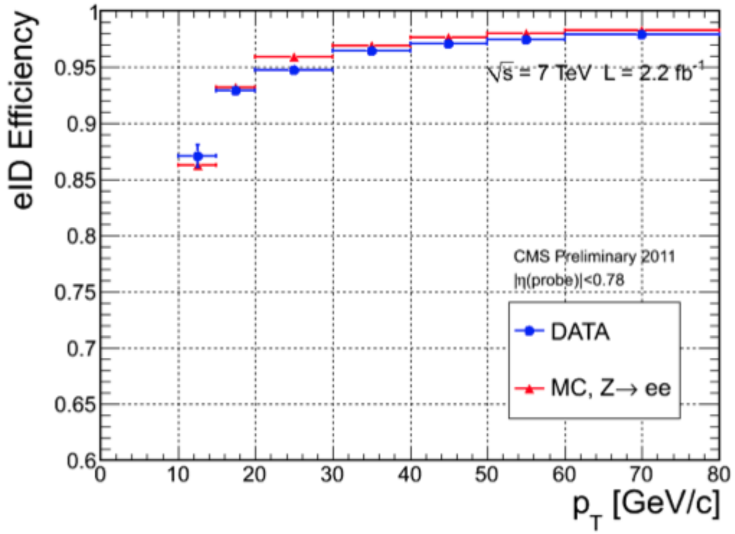
Yield after cuts (low mass) ~1 /fb^{-1}

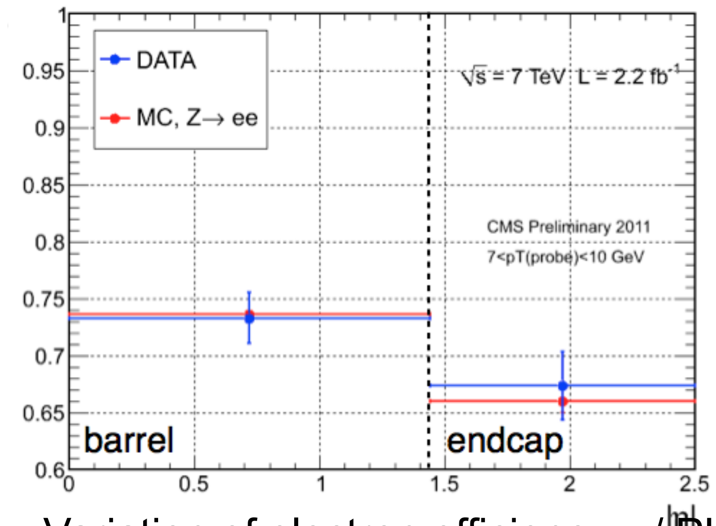


Delicate Question of Electron (esp. low p_T) Efficiencies

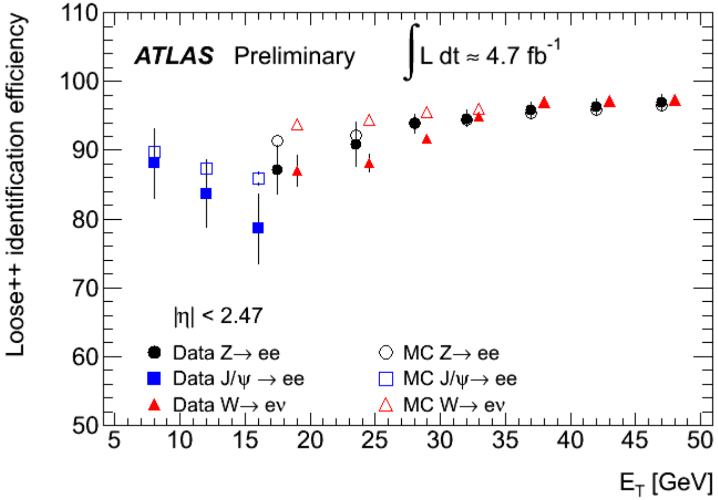
Internal Brem. Treatment important at low p_T

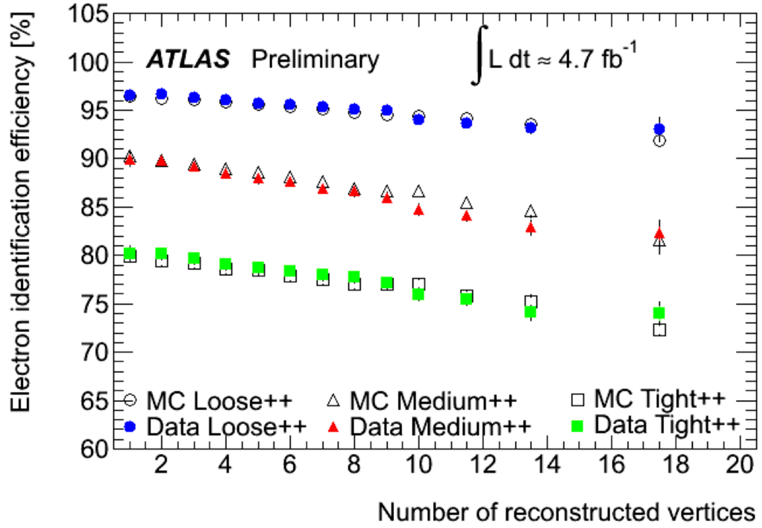
CMS able to cover down to 7 GeV with Z



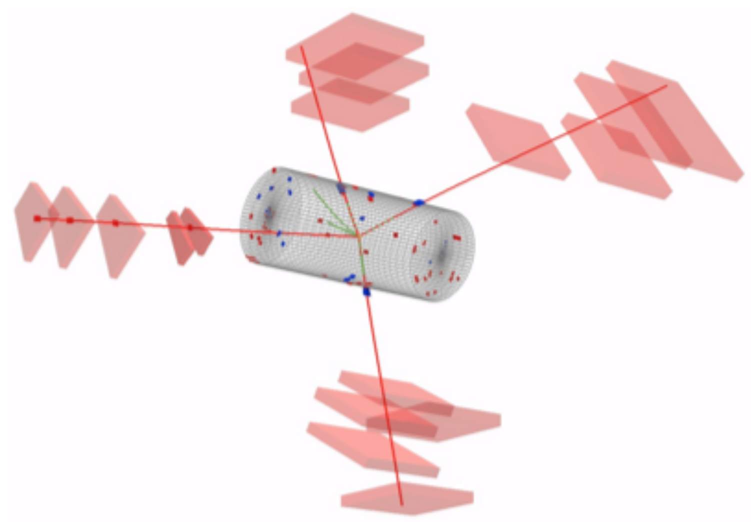


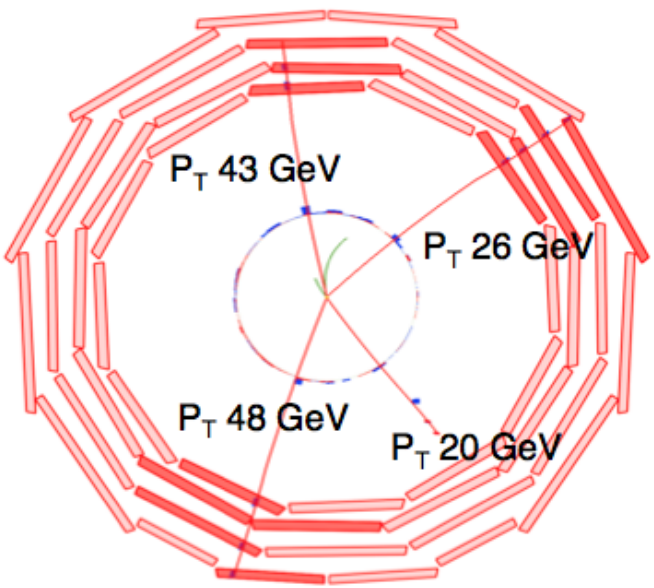
Variation of electron efficiency w/ PU





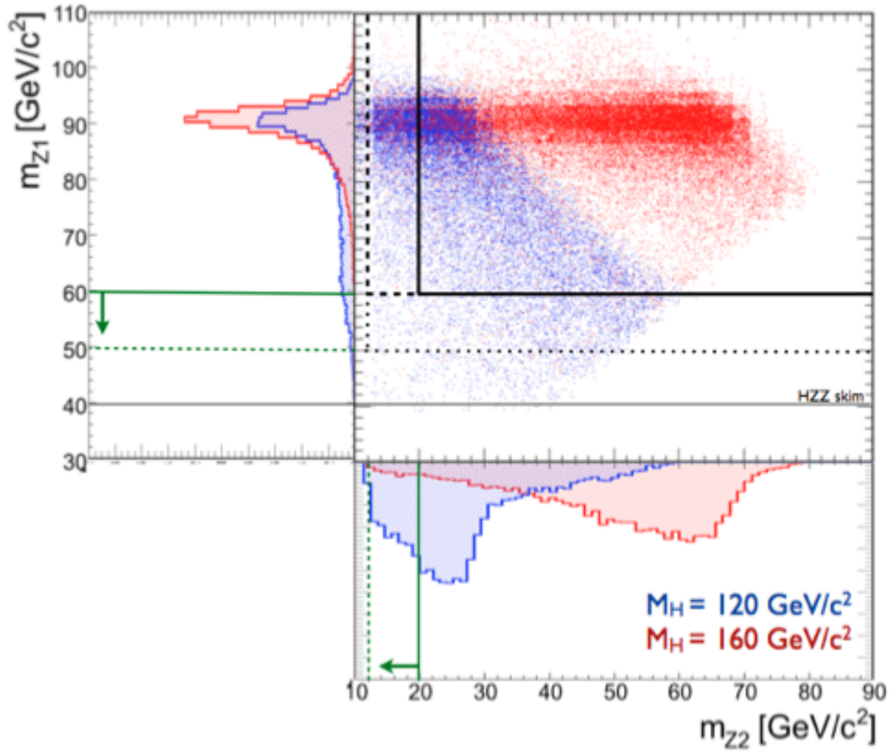
Reaching Lower Mass Sensitivity





Improved sensitivity at low Higgs masses

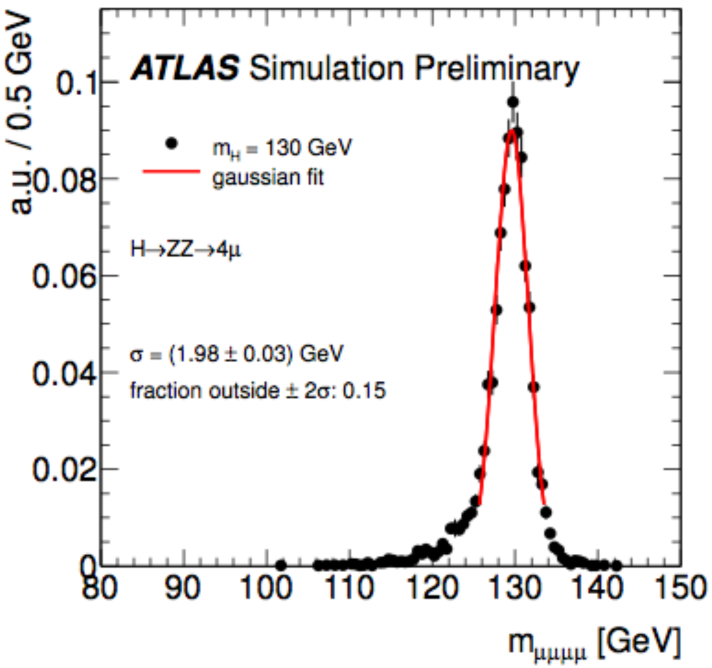
- Reduce MZ_1 cut from 60 → 50GeV
- Reduce MZ_2 cut from 20 → 12GeV



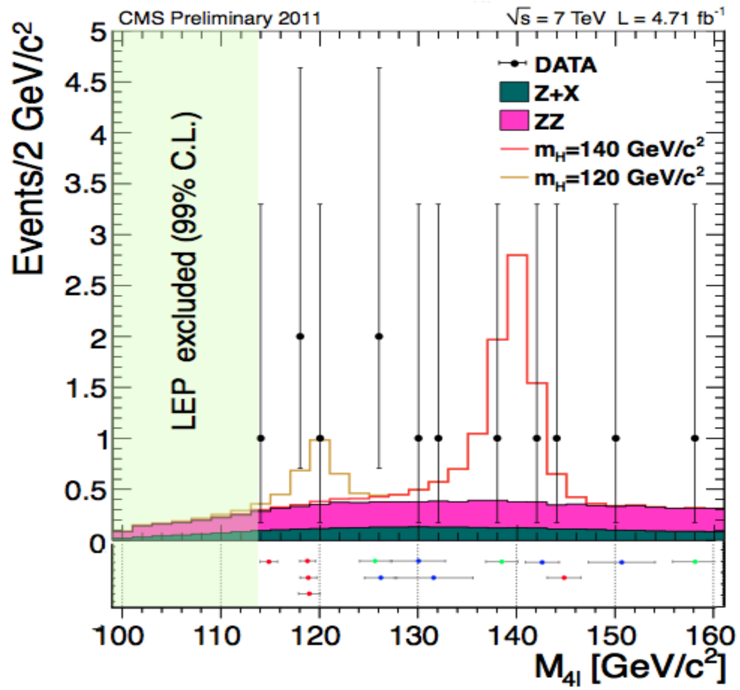
Comparative Cut Flow and Resolutions

Selection CUT	ATLAS Value	CMS Value
Lowest P_T (e/m)	7 / 7 GeV/c	7 / 5 GeV/c
h Range (e/m)	2.47 / 2.7	2.4 / 2.5
Highest P_T (e/m)	20 GeV/c	20 GeV/c
M_{Z1}	~[75, 105] GeV/c^2	[50, 120] GeV/c^2
M_{Z2}	[15-60*, 115] GeV/c^2	[12, 120] GeV/c^2

FWHM@130 GeV 4 (4μ) and 6 (4e)



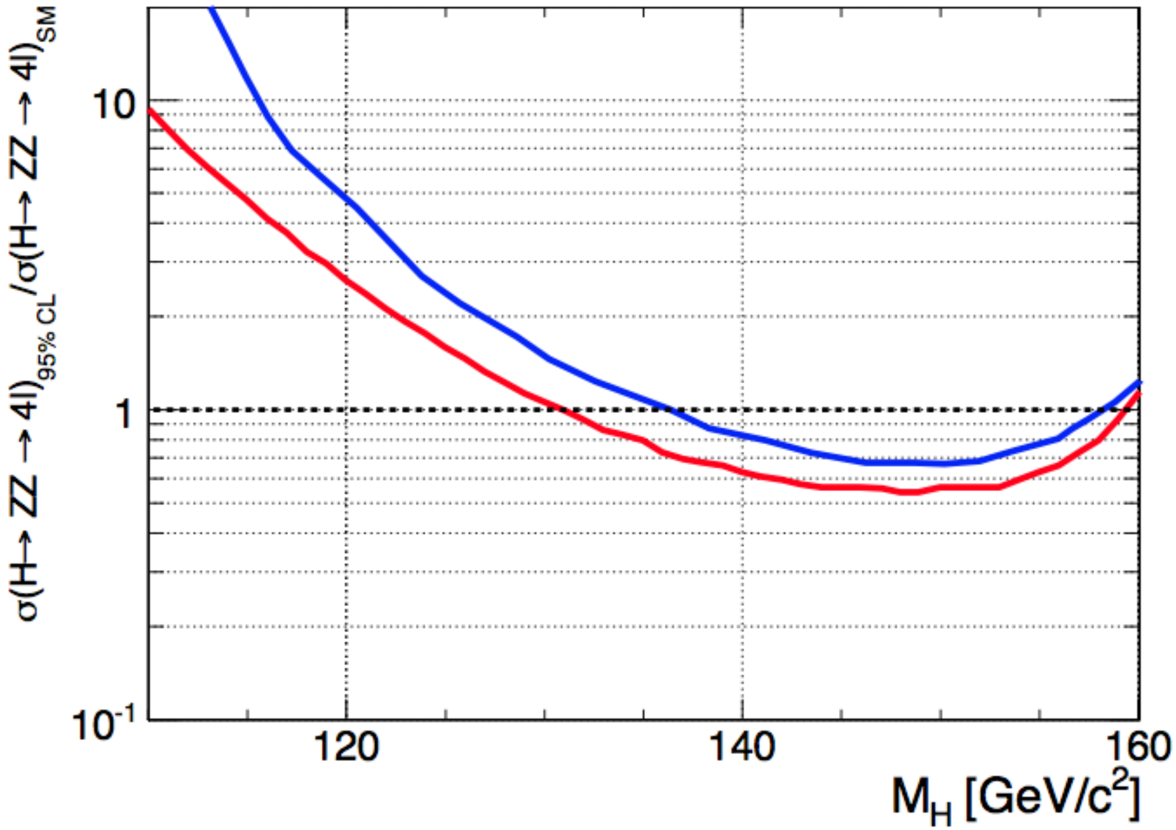
FWHM@150 GeV 3.8 (4μ) and 6.3 (4e)



*cut dependent on the 4l invariant mass 120-200 GeV

ATLAS vs. CMS comparison

Difference mostly in the low mass range (sizable)



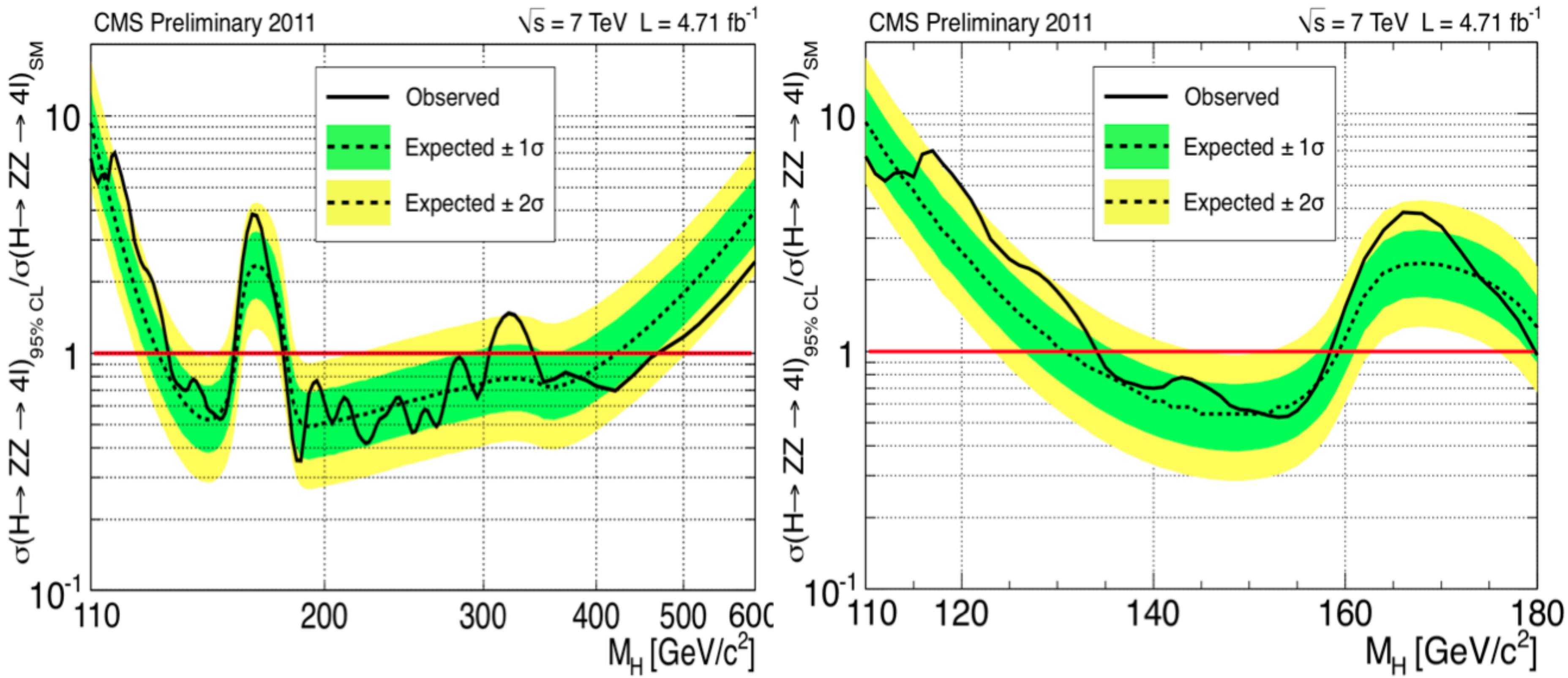
ATLAS : - ID optimization (electrons) at low p_T

- Extending p_T cut
- Mass cut otimization

CMS…

CMS

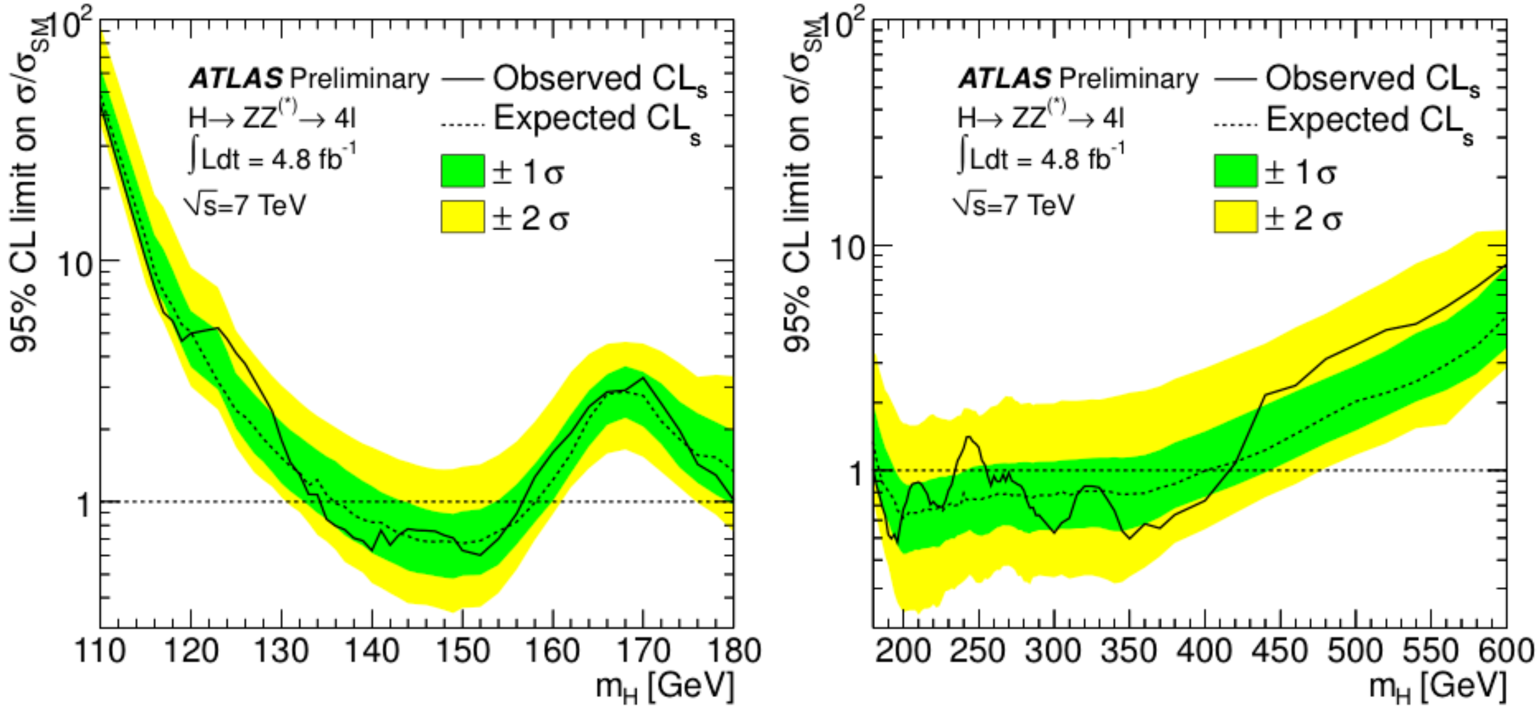
Higgs Boson Search in the $ZZ^{(*)} \rightarrow 4l$



Expected range: $130 < M_H < 160$ GeV; $182 < M_H < 420$ GeV
Observed range: $134 < M_H < 158$ GeV; $180 < M_H < 305$ GeV; $340 < M_H < 460$ GeV

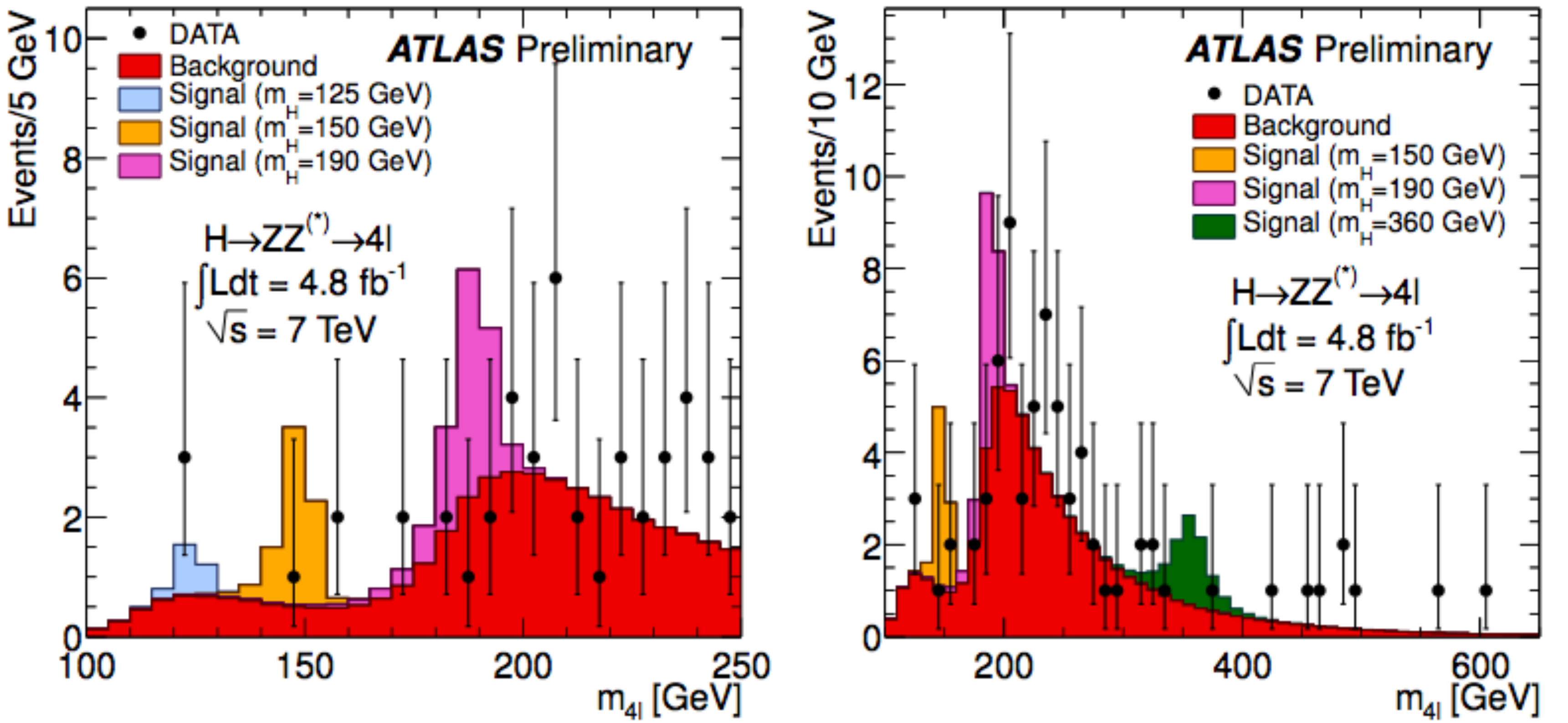
ATLAS

Higgs Boson Search in the $ZZ^{(*)} \rightarrow 4l$



Excluded (95% CL): 135 < m_H < 156 GeV and 181 < m_H < 415 GeV (except 234-255 GeV)
Expected (95% CL): 137 < m_H < 158 GeV and 185 < m_H < 400 GeV

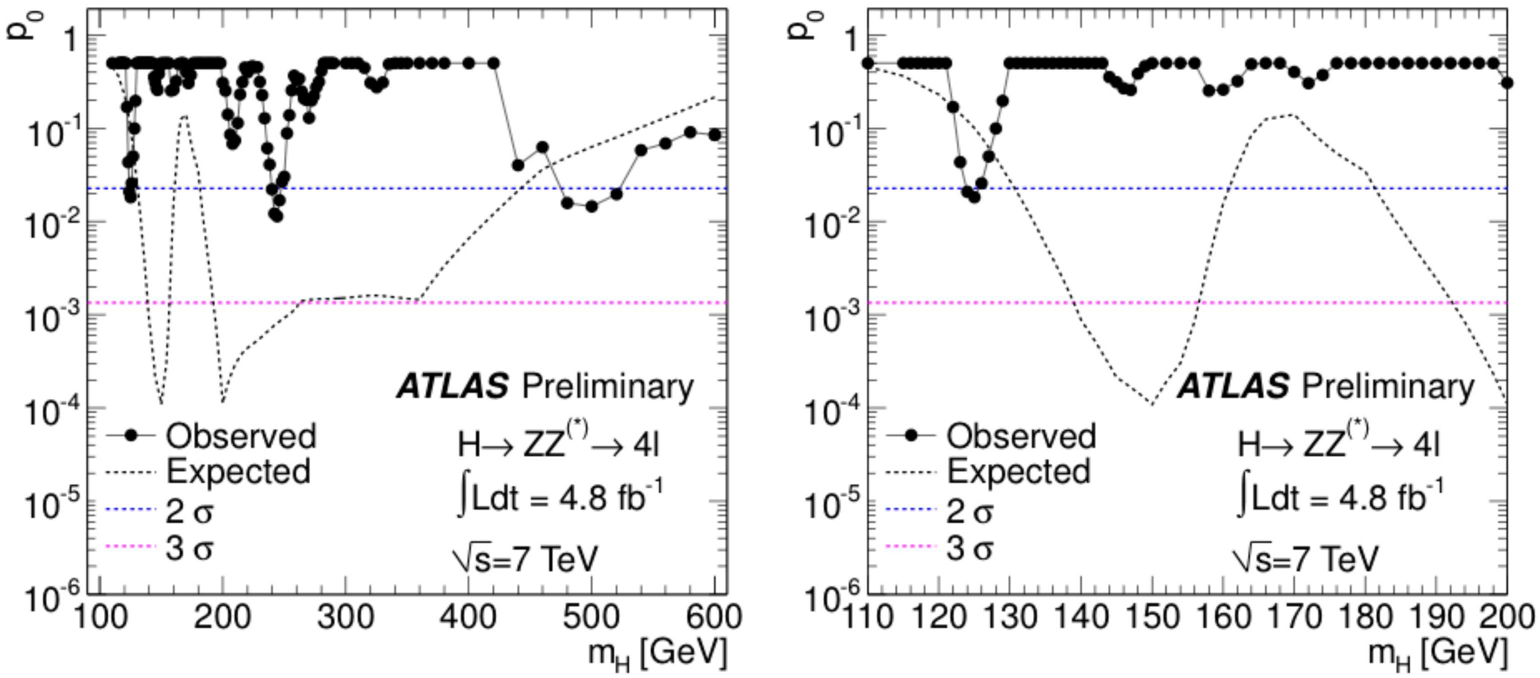
ATLAS $ZZ^{(*)}\rightarrow 4l$ Discussion



Excluded at 95% C.L. by ATLAS+CMS combination →

m_H (GeV)	Local (global) p_0	Local significance	Expected from SM Higgs
125	1.8% (~50%)	2.1 σ	1.4σ
244	1.1% (~50%)	2.3 σ	3.2σ
500	1.4% (~50%)	2.2 σ	1.5σ

ATLAS $ZZ^{(*)} \rightarrow 4l$ Discussion



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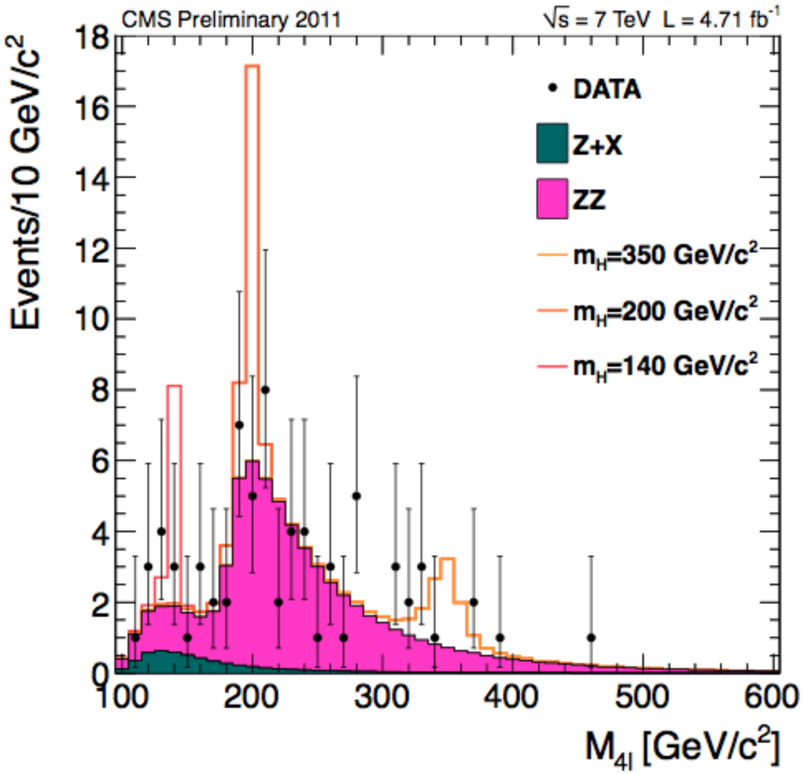
Excluded at 95% C.L. by ATLAS+CMS combination → 244

CMS $ZZ^{(*)} \rightarrow 4l$ Discussion (Full Mass Range)



Baseline Selection

$50 < M_{Z1} < 120$ GeV/c²

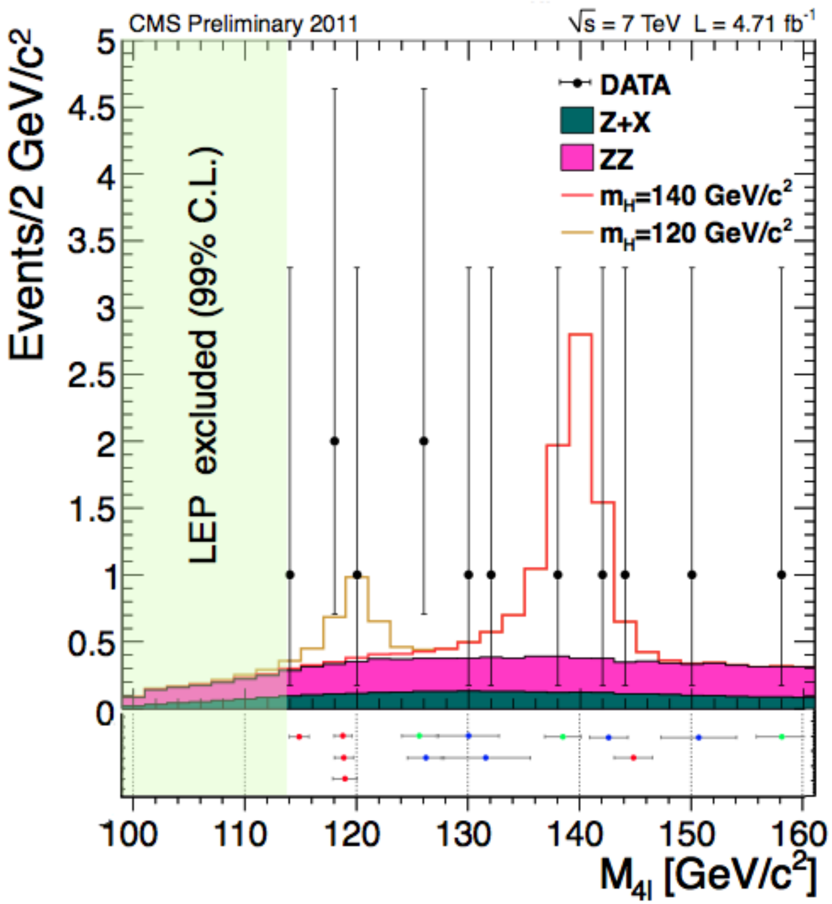
$12 < M_{Z2} < 120$ GeV/c²

Event Yields:

Baseline	$4e$	4μ	$2e2\mu$
ZZ	12.27 ± 1.16	19.11 ± 1.75	30.25 ± 2.78
Z+X	1.67 ± 0.55	1.13 ± 0.55	2.71 ± 0.96
All background	13.94 ± 1.28	20.24 ± 1.83	32.96 ± 2.94
$m_H = 120\,\mathrm{GeV}/c^2$	0.25	0.62	0.68
$m_H = 140\,\mathrm{GeV}/c^2$	1.32	2.48	3.37
$m_H = 350\,\mathrm{GeV}/c^2$	1.95	2.61	4.64
Observed	12	23	37

$M_{4\ell} > 100$ GeV/c² Observed: 72 Expected: 67.1 ± 6.0 events

CMS ZZ$^{(*)}$→4l Discussion (Low Mass)



Baseline Selection

$50 < M_{Z1} < 120$ GeV/c^2

$12 < M_{Z2} < 120$ GeV/c^2

$\varepsilon(M_H \sim 120) \sim 20\%$ (4e), 40% (4μ), 25% (2e2μ)

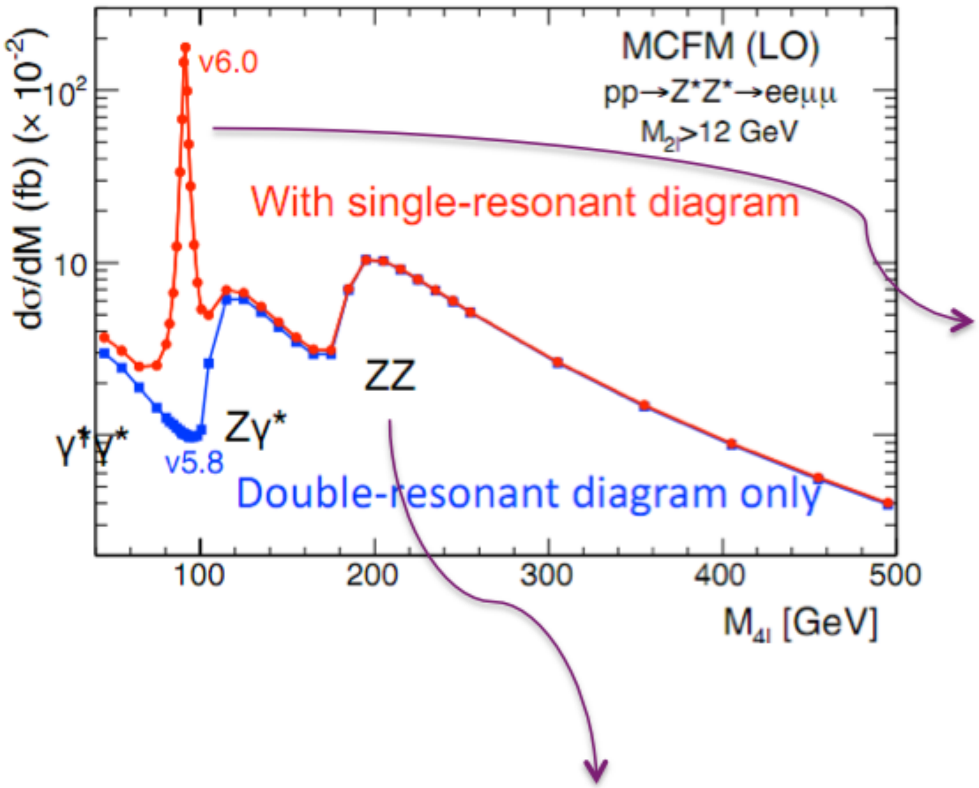
$\varepsilon(M_H \sim 160) \sim 42\%$ (4e), 75% (4μ), 55% (2e2μ)

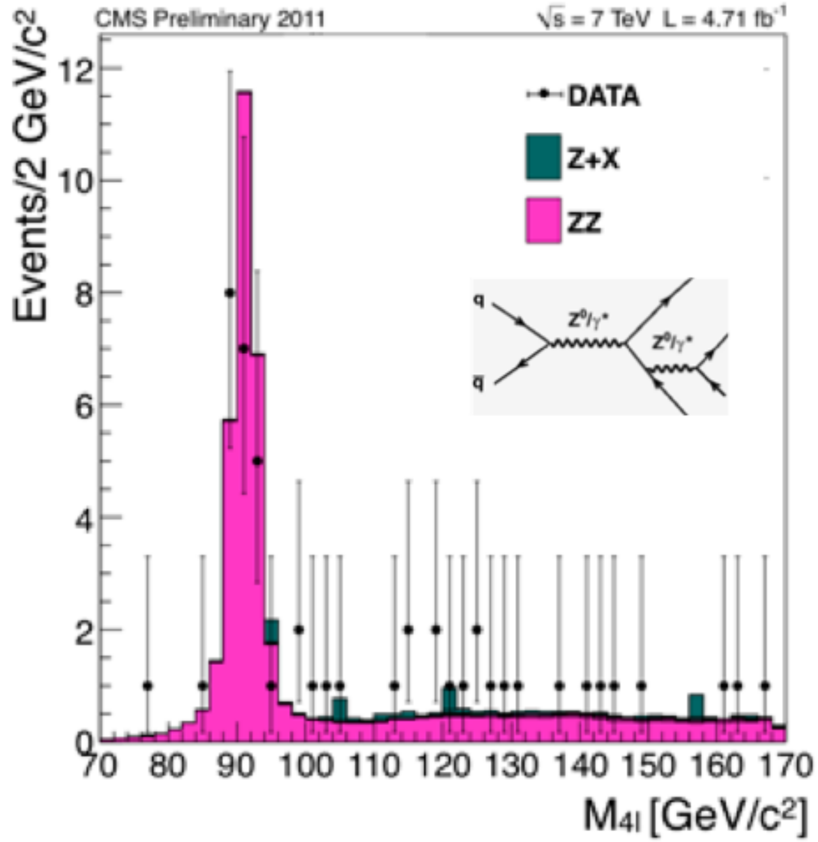
Event Yields:

Final state:	4e	4μ	2e2μ
Obs. events:	3	5	5
Exp. events:	1.7	3.3	4.5

$100 < M_{4\ell} < 160$ GeV/c^2 Observed: 13 Expected: 9.5 ± 1.3 events

Interesting Control Measurement





Measurement of the ZZ cross section with both Z on shell (60<MZ<120):

$$\sigma(pp \to ZZ + X) \times \mathcal{B}(ZZ \to 4\ell) = 28.1^{+4.6}_{-4.0}(\text{stat.}) \pm 1.2(\text{syst.}) \pm 1.3(\text{lumi.})\ \text{fb}$$

To be compared with the SM XS = 27.9 +- 1.9 fb

$$H \rightarrow \gamma\gamma$$

Most sensitive Channel in [115-125] GeV Mass range

ATLAS 4.9 fb^{-1}

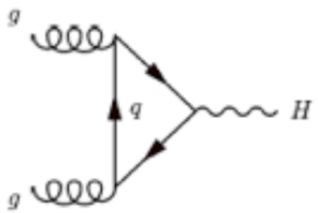
CMS 4.8 fb^{-1}

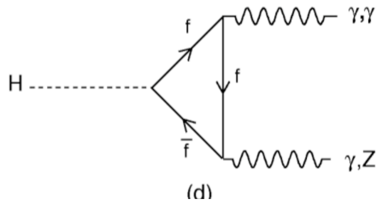
DiPhoton Channel

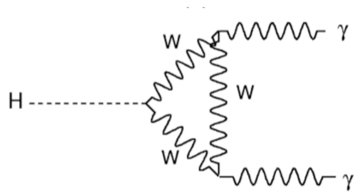
Common Misconceptions and Basic Facts

- Small branching… but amongst largest yields (Dominant Channel in the very low mass range 110-125 GeV)

- Main production and decay processes occur through loops :







A priori potentially large enhancement… *… Not so obviously enhanced (e.g. SUSY, SM4)*

*Still e.g. NMMSSM (U. Ellwanger Phys.Lett. **B 698**, 293-296,2011) up to x6 at low masses, Fermiophobia…*

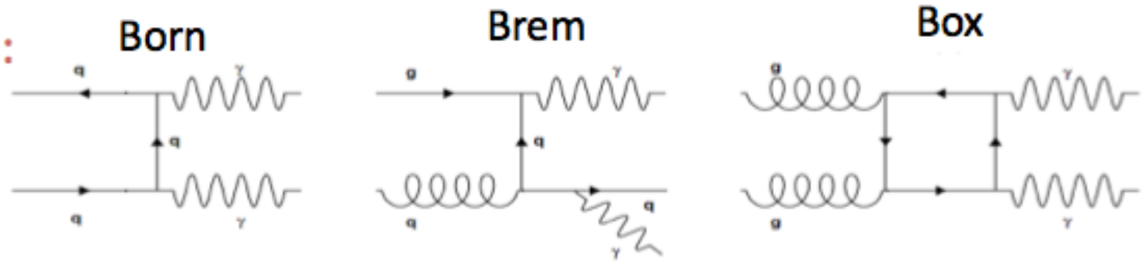
- If observed implies that it does not originate from spin 1 : Landau-Yang theorem

L. Landau, Dokl. Akad. Nauk. , USSR **60**, 207 (1948) and C. N. Yang, Phys. Rev. **77**, 242 (1950).

- Extremely simple event selection : two photons 25/40 GeV (ATLAS) and 30/40 GeV (CMS)

Main Backgrounds

Irreducible backgrounds :



- Born and box Best estimate by parton-level resummed NLO ResBos

- The brem is in principle reducible in practice not, and it is a process difficult to simulate

Best estimate by parton-level NLO fixed order Diphox (T. Binoth,J.Ph. Guillet et al.)

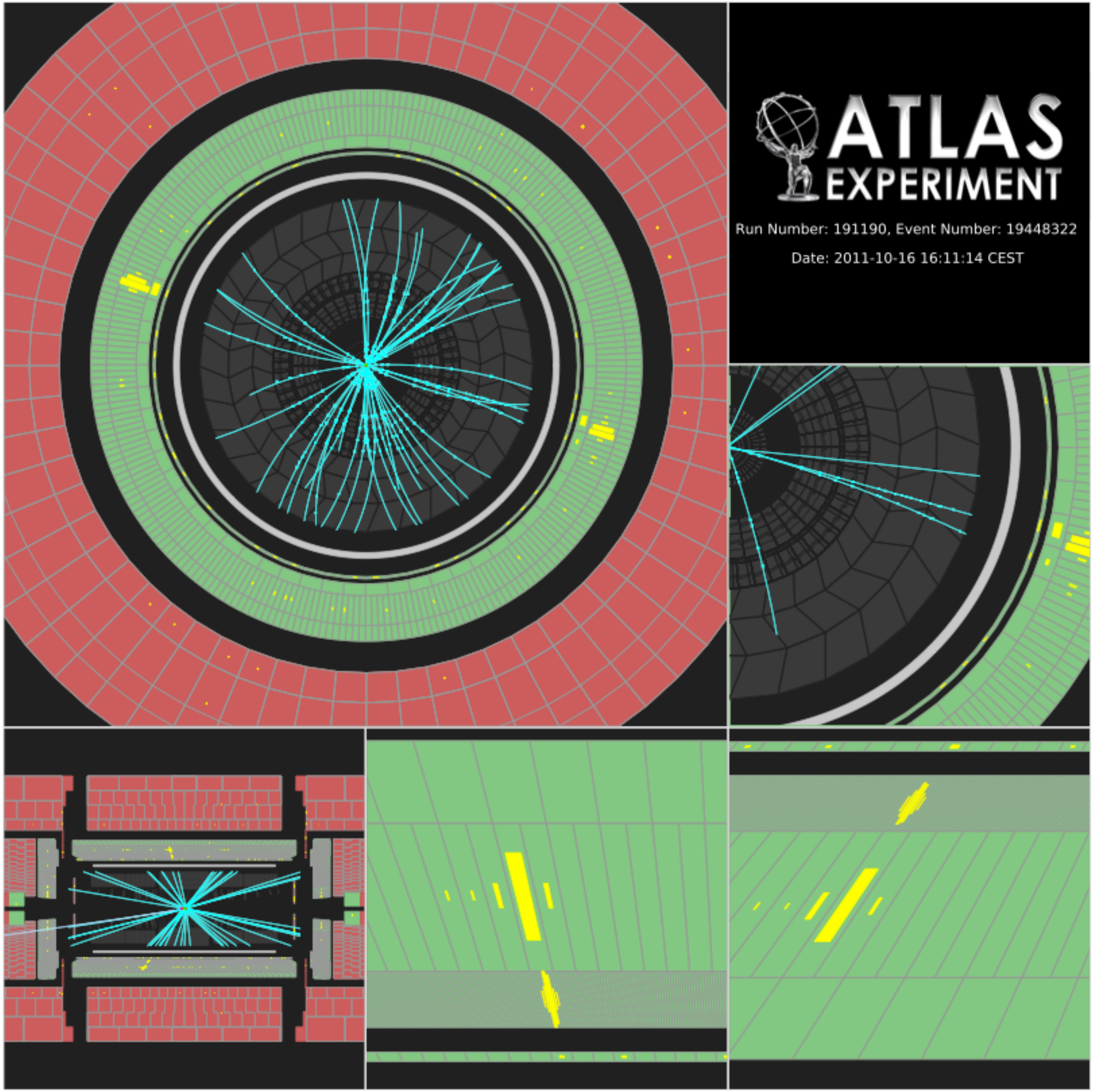
Now SHERPA (Gleisberg, Hoeche et al.)

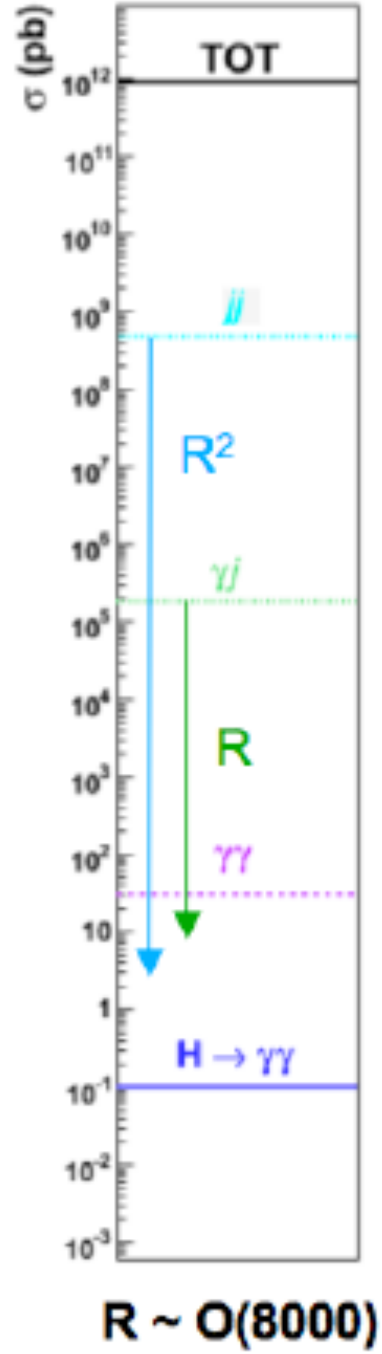
The Reducible backgrounds : Critical to reach jet rejections O(5000)

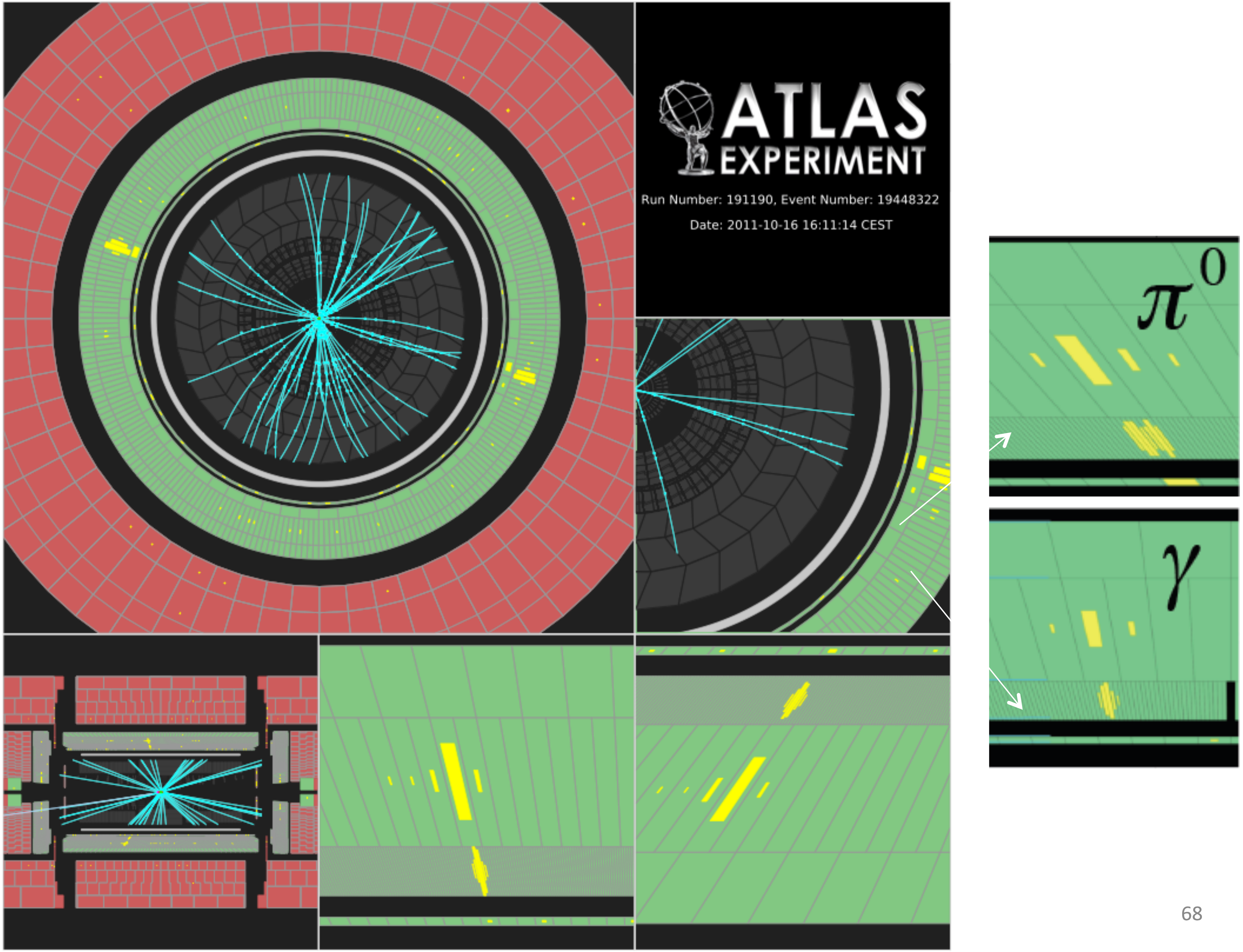
Final state parton(s) fragments into a leading π^0

Best estimate by parton-level fixed order NLO JetPhox (S. Catani, M. Fontannaz et al.)

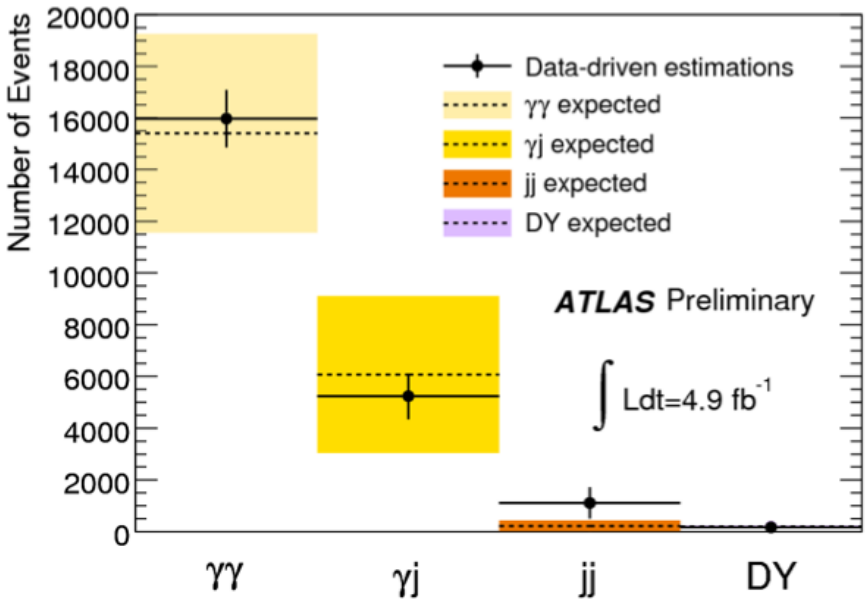
Also note : large difference Pythia vs. Herwig in the leading $\pi 0$ fragmentation

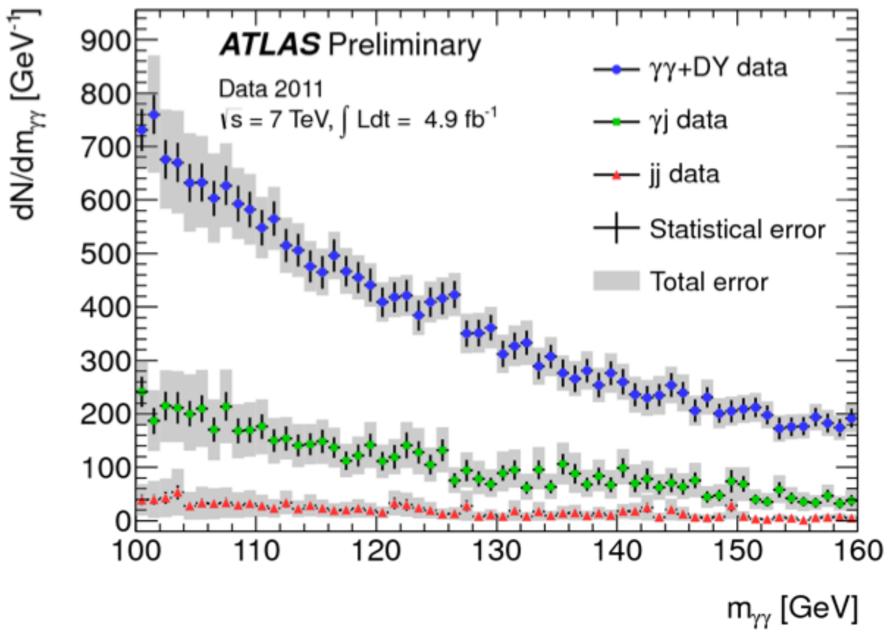

ATLAS
EXPERIMENT
Run Number: 191190, Event Number: 19448322
Date: 2011-10-16 16:11:14 CEST


σ (pb)
TOT
jj
R²
γj
R
γγ
H → γγ
R ~ O(8000)


ATLAS
EXPERIMENT
Run Number: 191190, Event Number: 19448322
Date: 2011-10-16 16:11:14 CEST
π^0
γ

Estimation du Bruit de Fond





γj + jj << γγ irreducible (purity ~ 70%)

Photon identification efficiency: ~ 85±5% from MC, cross-checked with data (Z→ ee, Z→ eeγ, μμγ)

Performances similaires dans CMS…

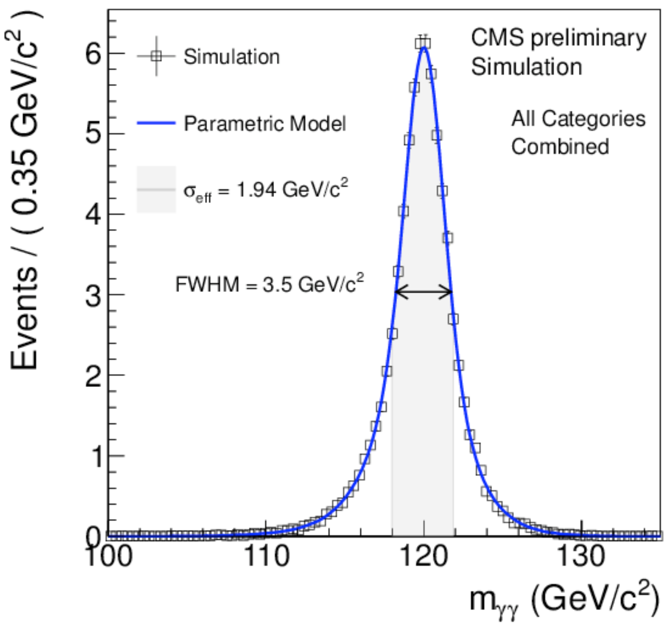
-Key features :

-Invariant mass resolution

- Energy response carateristics of EM-Calorimeters
- Energy calibration
- Interaction vertex position (IP spread of 5.6 cm, assuming (0,0,0) adds ~1.4 GeV in mass resolution equiv. to the calo. $M_{\gamma\gamma}$ resolution itself).

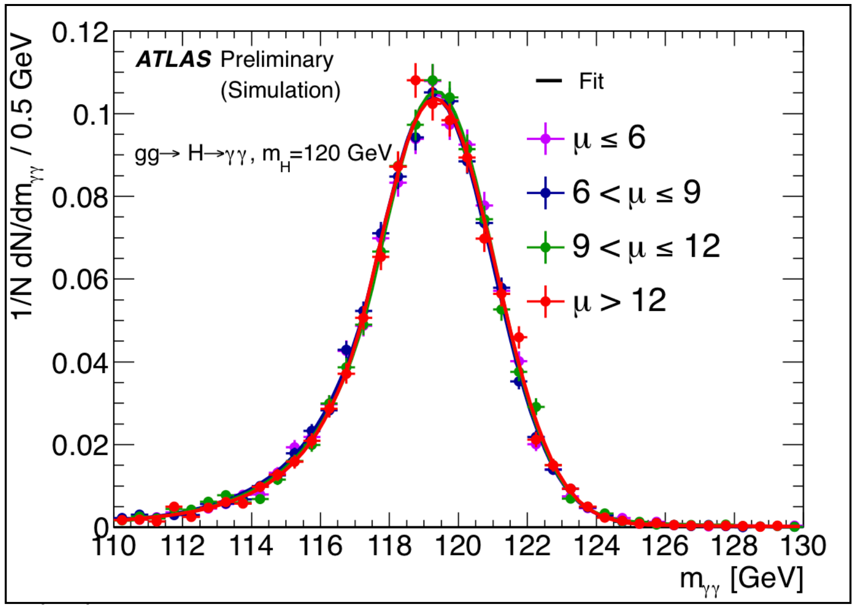
Transparence Calibration Crucial

$$FWHM \sim 3.5 \text{ GeV}$$



Calibration for Material Upstream important

$$FWHM \sim 4.0 \text{ GeV}$$



re CEA

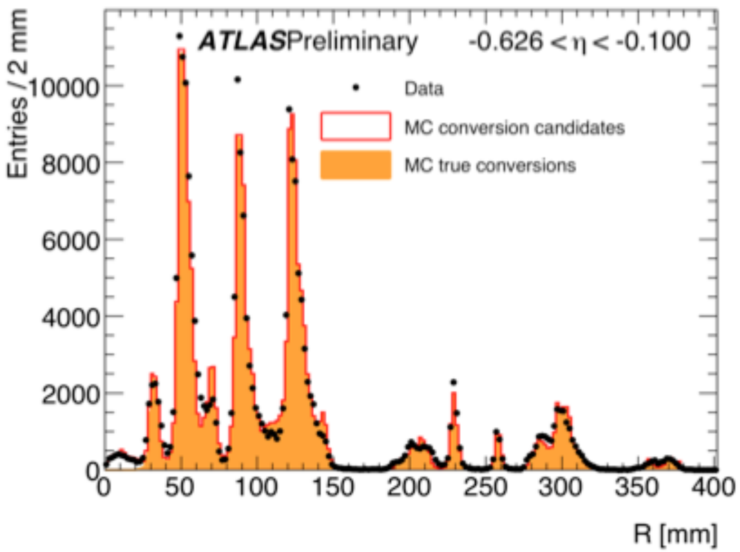
Photon Energy Calibration

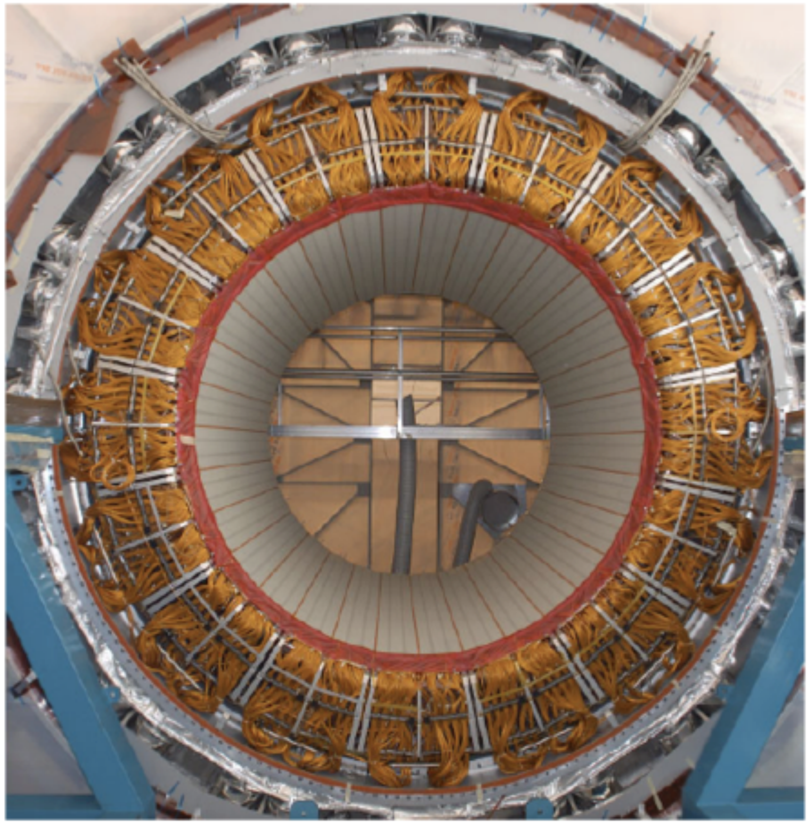
The Electromagnetic Calorimeter Uniform by Construction

- Crack-less Accordion geometry

SA constant term : ~0.5% (per TB module)

- γ Calibration : MC based calibration (EM Calorimeter full simulation tuned in Test Beam) and accurate material description upstream (Verified with in situ measurements).





(Conversions, e^- shower shapes, energy flow, E/p distributions, etc...)

Energy scale calibration from Z decays to electrons

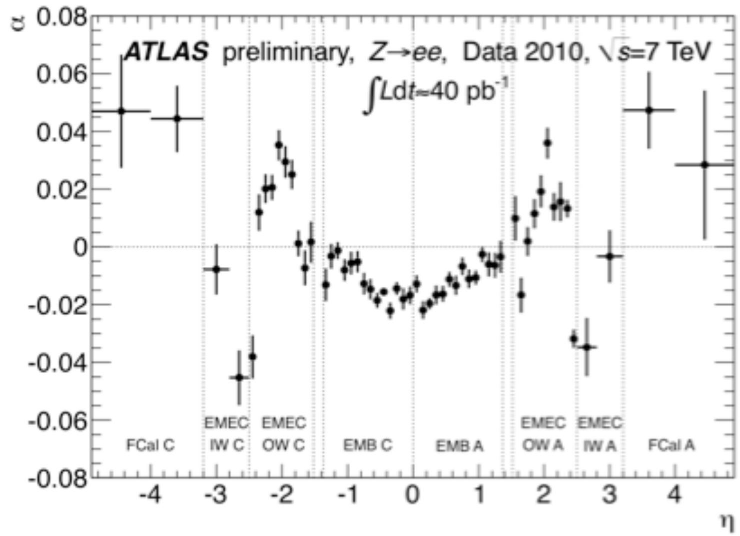
… In absence of a significant γ calibration signal*

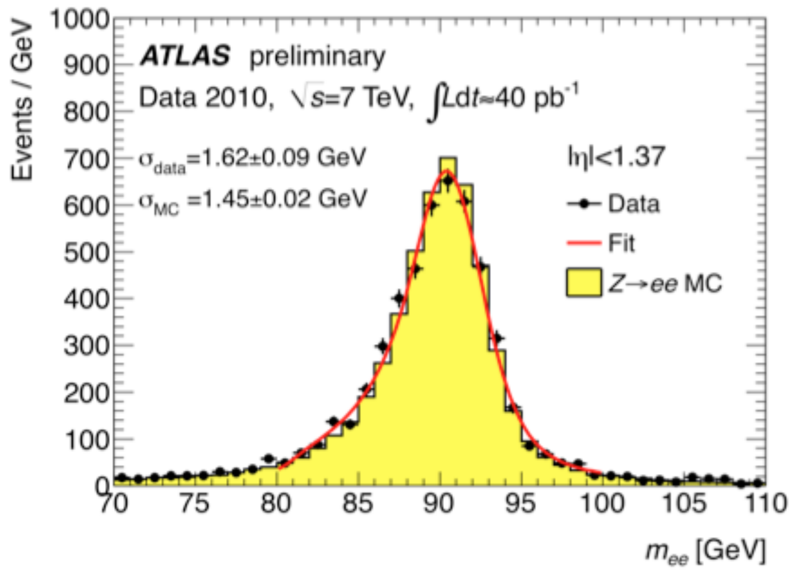
- After MC based calibration, apply electron energy scale corrections from a global fit to the 2010 data (Z to e^+e^-) .

- Coarse corrections averaged in ϕ

- Resolution correction derived from a comparison of the MC to the data in electrons.

- Energy scale and resolution corrections do not necessarily apply to photon : taken into account in material effect systematic uncertainty.



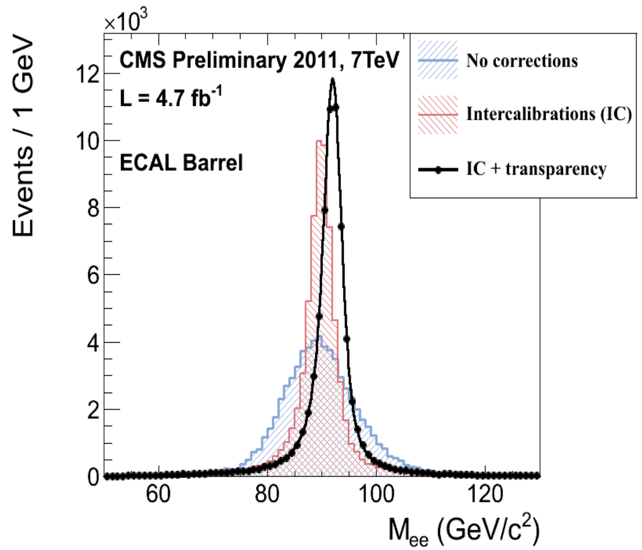


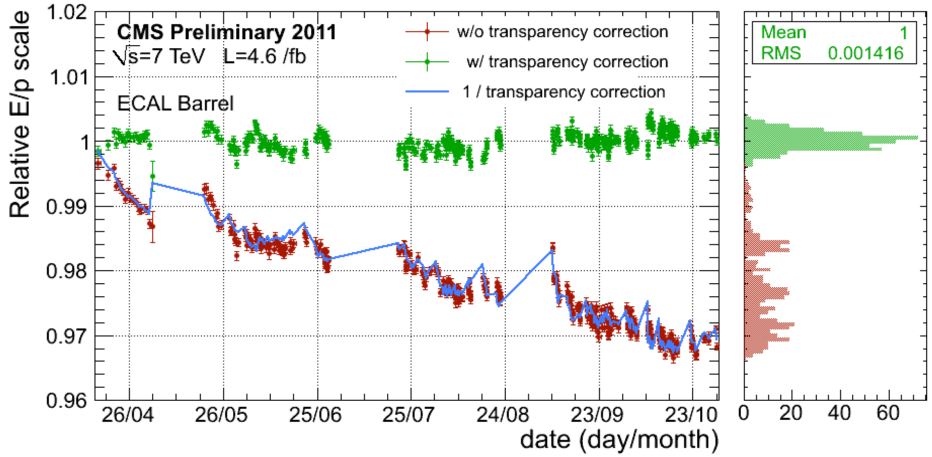
*Zγ not (yet) used for calibration

Photon Energy Reconstruction (CMS)

- **Comprehensive energy resolution studies made with Z →ee, W →eν and E/p, π^o intercalibrations and laser signals for transparency corrections**

Effect of new laser corrections and intercalibration on barrel-barrel Z→ee
Resolution in data improves typically by 10%, EB, |η|>1, R9>0.94
Instrumental contribution to the mass resolution in the best EB category is 0.99 ±0.01 GeV





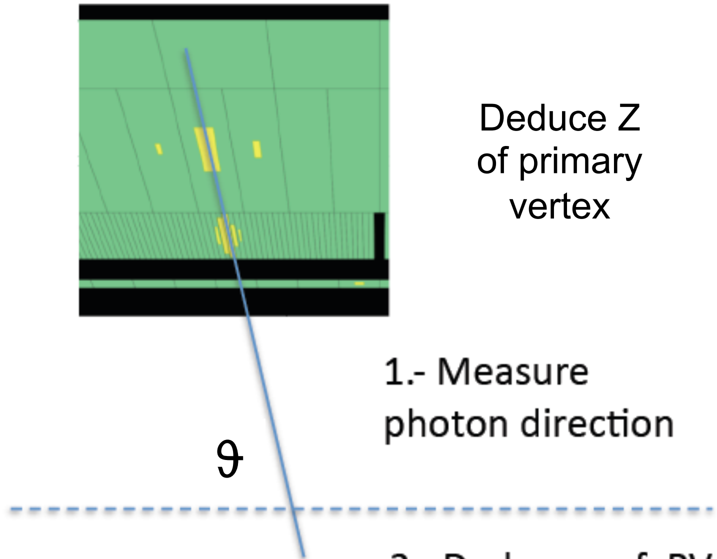
Energy scale for W→eν and Z→ee stable throughout 2011 at the level of 0.1 GeV.

EB inter-calibration and transparency correction fully understood for EB for the entire 2011 data set.

Primary Vertex Reconstruction (ATLAS)

$m^2_{\gamma\gamma} = 2\, E_1\, E_2\, (1\text{-}\cos\alpha)$

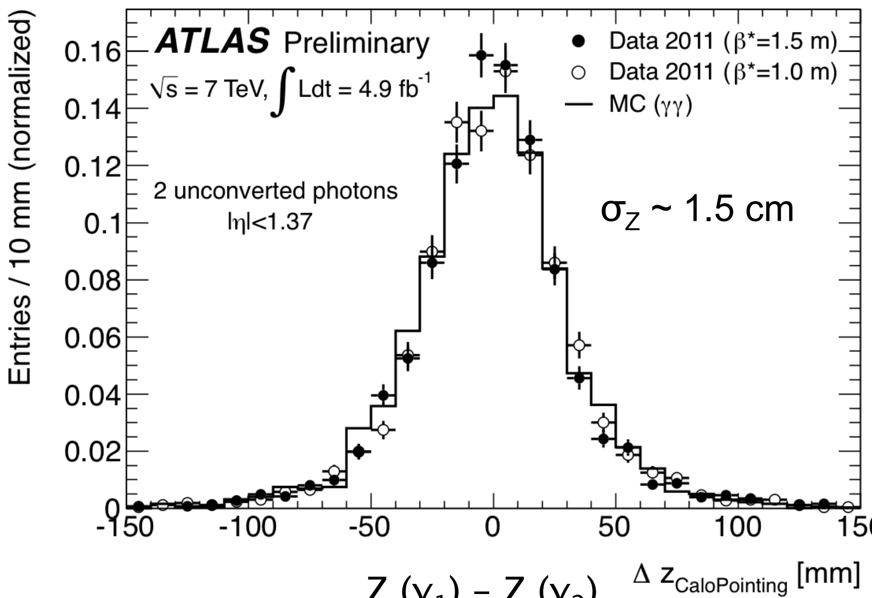
α=opening angle of the two photons



Use longitudinal (and lateral) segmentation of EM calorimeter

crucial at high pile-up

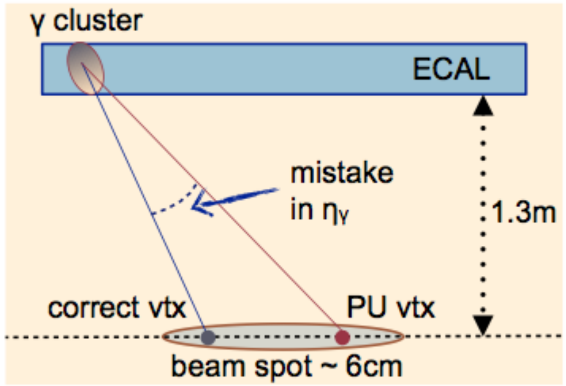
Δz in γγ events



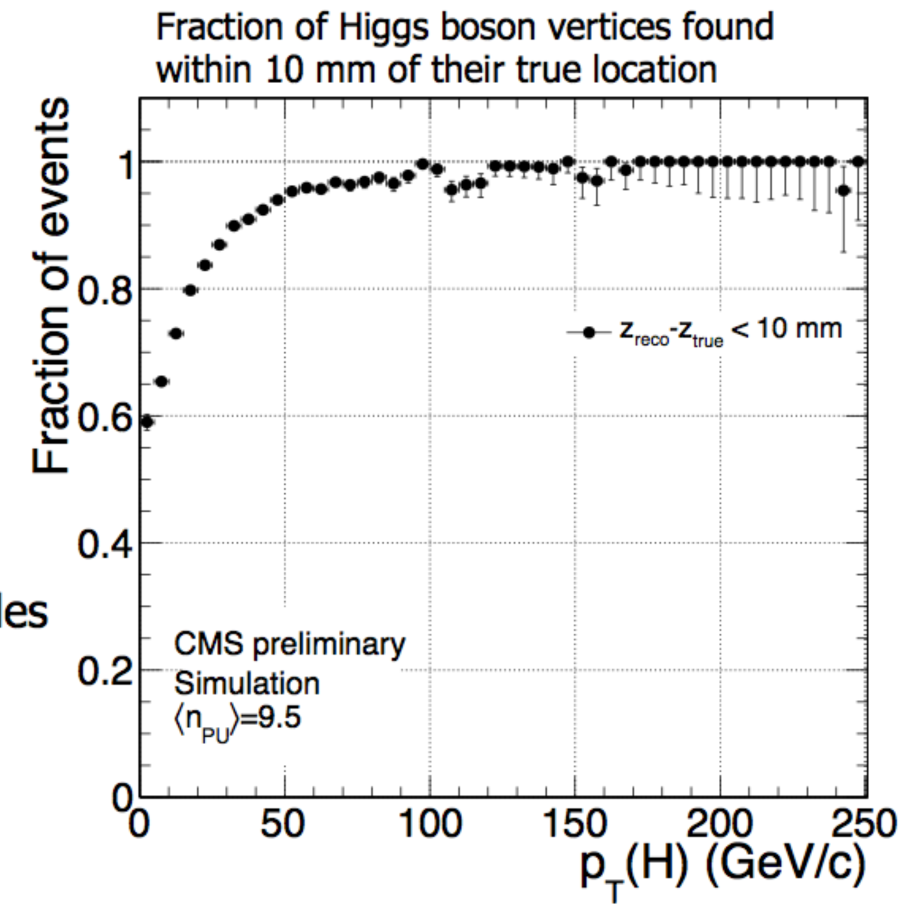
$Z(\gamma_1) - Z(\gamma_2)$

- Calorimeter pointing resolution ~ 5.6 cm (LHC beam spot) to ~ 1.5 cm
→ Contribution to mass resolution from angular term is negligible with calo pointing (γ →ee vertex also used)
- Robust against pile-up

Primary Vertex Reconstruction (CMS)



Vertex:
BDT Trained using input variables computed from track momenta (tracks recoiling against the γγ and/or converted γ's) and photon kinematics



2011A	2011B	2011
$86.3\% \pm 0.2\% \pm 0.4\%$	$79.8\% \pm 0.2\% \pm 0.5\%$	$83.0\% \pm 0.2\% \pm 0.4\%$

Selection and Categories (ATLAS and CMS)

ATLAS :
- $|\eta|<2.5$
- Crack removed (1.37-1.52)
- $E_1>40$ GeV and $E_2>25$ GeV
- Isolation (Calorimeter only)

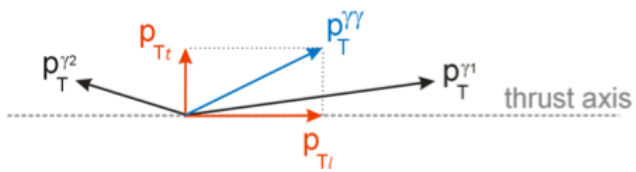
$$\varepsilon \sim 35\%$$

CMS :
- $|\eta|<2.5$
- Crack removed (1.4442-1.566)
- $E_1>m_{\gamma\gamma}/3$ and $E_2>m_{\gamma\gamma}/4$
- Isolation (Calorimeter and tracks)

$$\varepsilon \sim 40\%$$

ATLAS (9 Categories) :

- Pseudo-rapidity
- Conversion status (tracks)
- Transverse momentum w.r.t. thrust axis



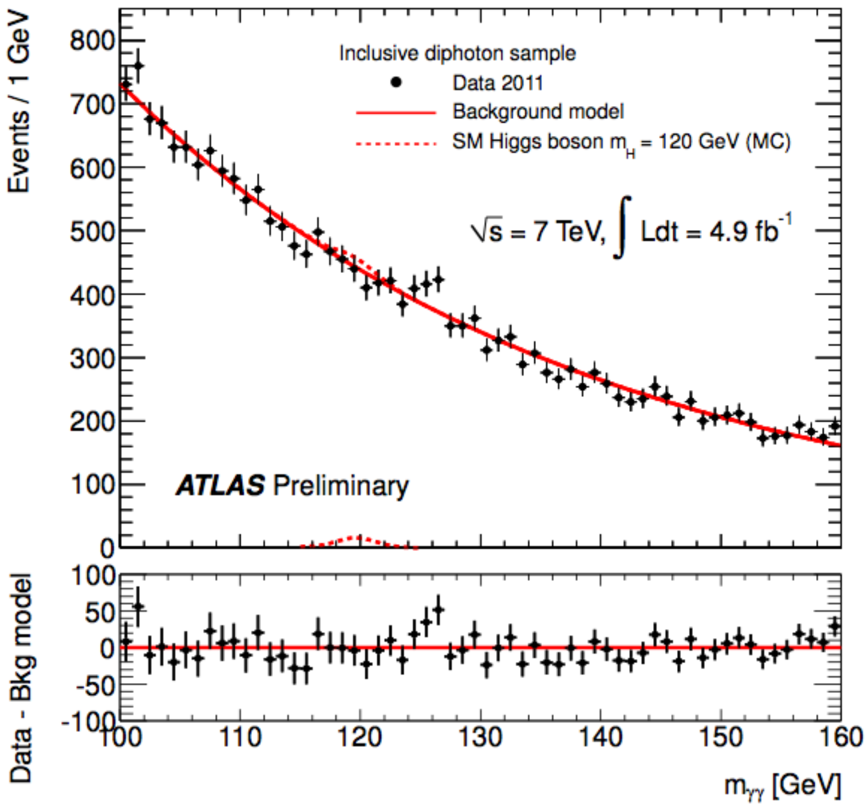
CMS (4 Categories) :

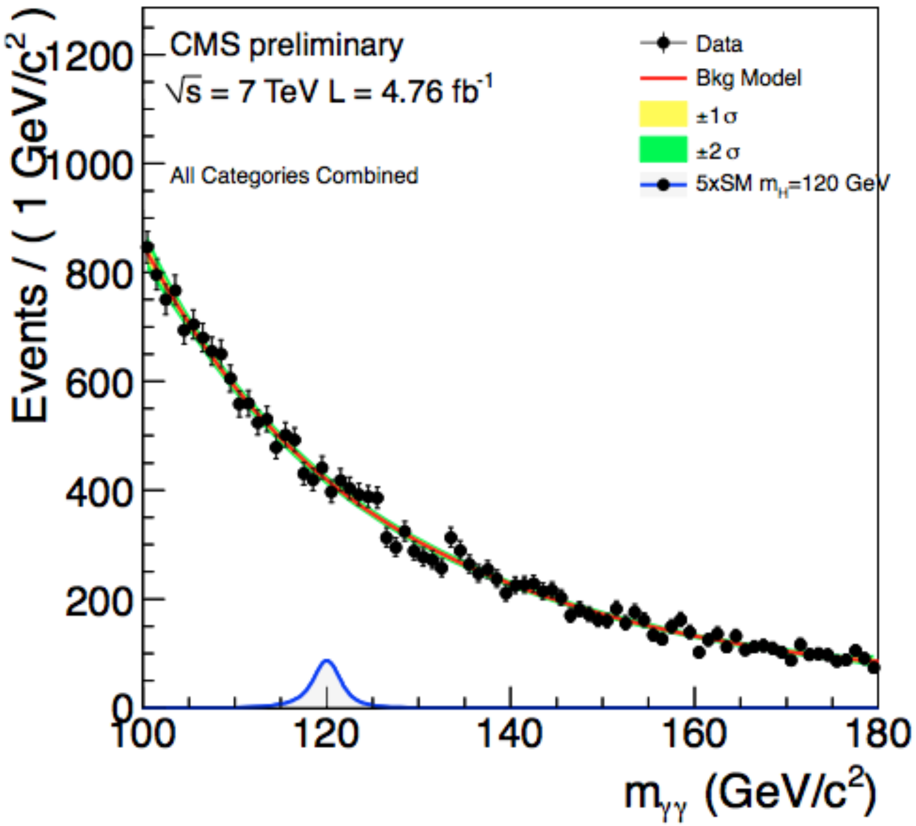
- Pseudo-rapidity
- Conversion status (R9)

R9 : 3x3/Super Cluster

Yield after cuts ~O(15) /fb^{-1}

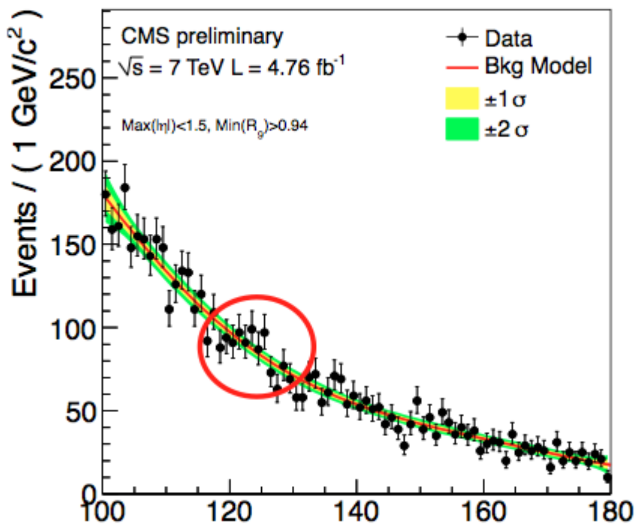
Inclusive Mass Spectra



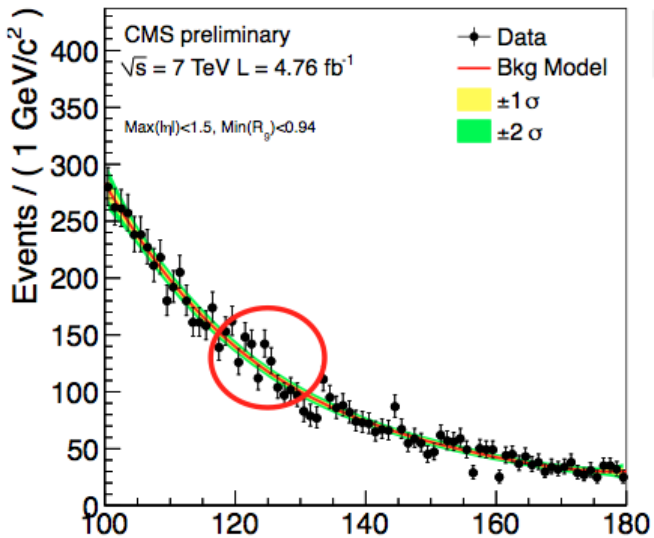


Steeper slope du to the
sliding thresholds

CMS



CMS preliminary
√s = 7 TeV L = 4.76 fb-1
Max(|η|)<1.5, Min(R9)>0.94
Data
Bkg Model
±1 σ
±2 σ
Events / (1 GeV/c2)



CMS preliminary
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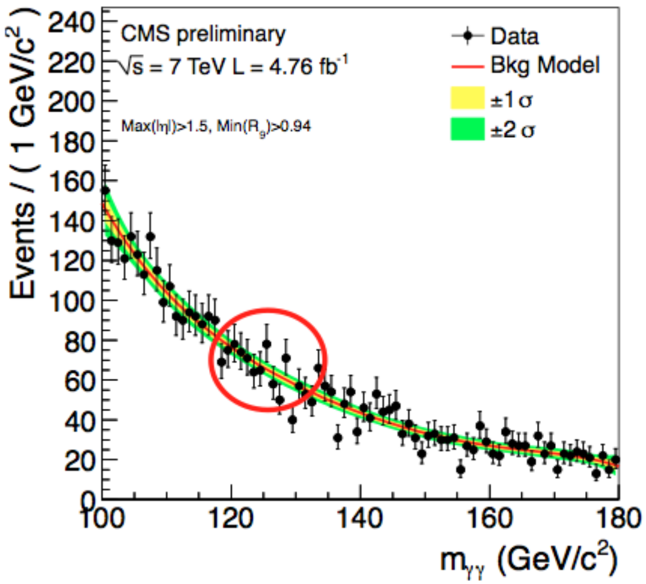
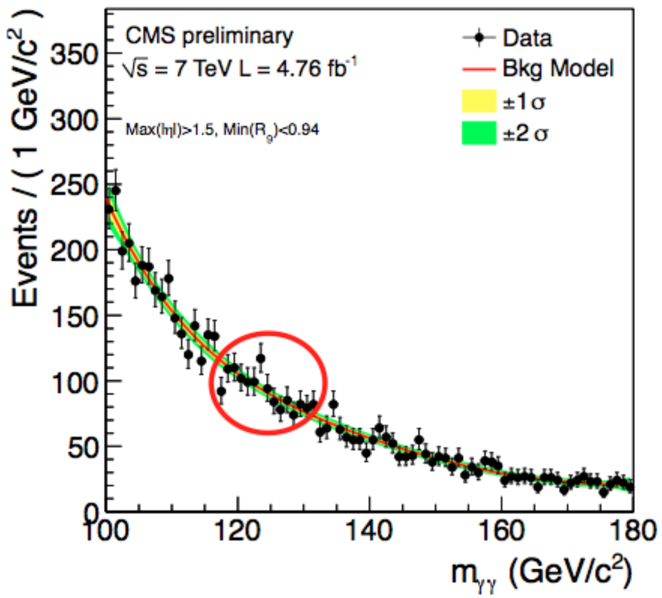
Max(|η|)<1.5, Min(R9)<0.94
Data
Bkg Model
±1 σ
±2 σ
Events / (1 GeV/c2)

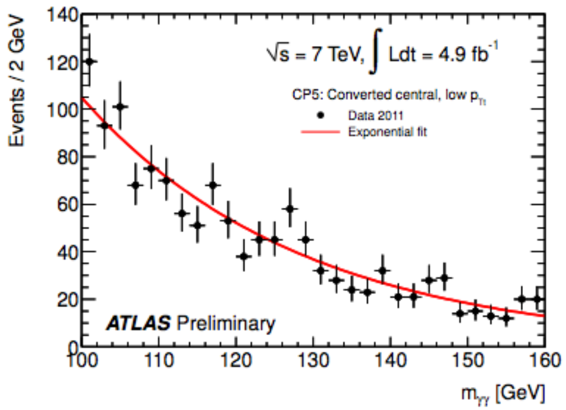


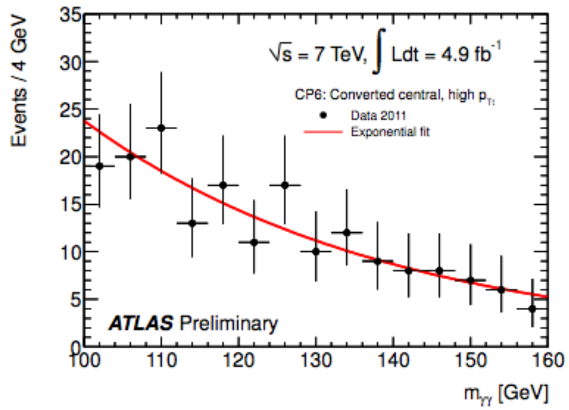
CMS preliminary
√s = 7 TeV L = 4.76 fb-1
Max(|η|)>1.5, Min(R9)>0.94
Data
Bkg Model
±1 σ
±2 σ
Events / (1 GeV/c2)
mγγ (GeV/c2)

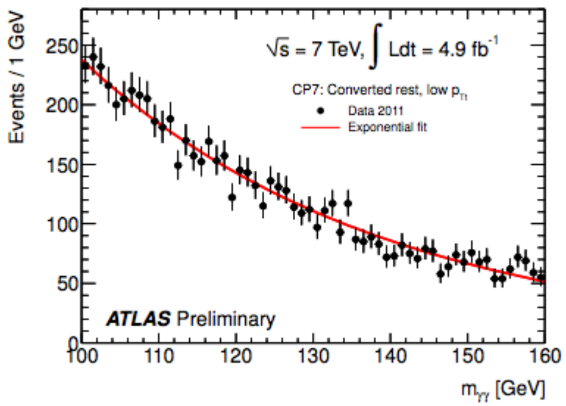


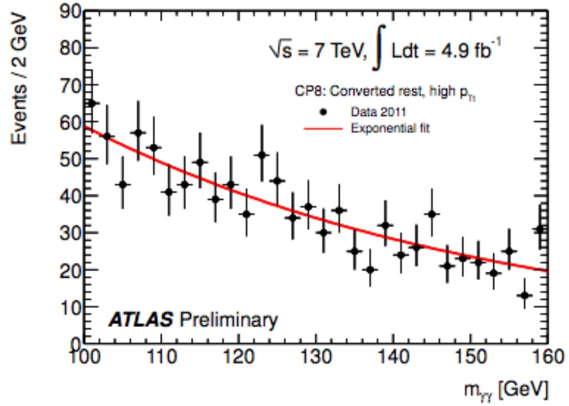
CMS preliminary
√s = 7 TeV L = 4.76 fb-1
Max(|η|)>1.5, Min(R9)<0.94
Data
Bkg Model
±1 σ
±2 σ
Events / (1 GeV/c2)
mγγ (GeV/c2)

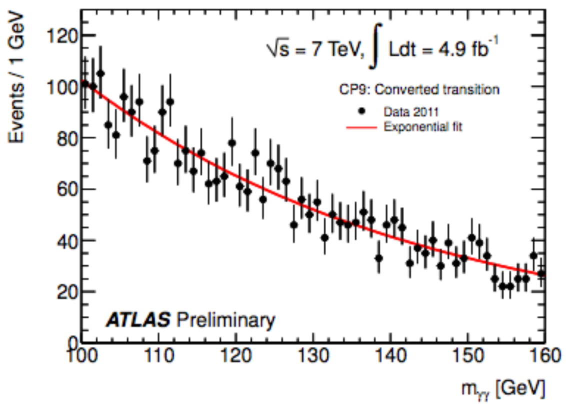
ATLAS


Events / 2 GeV
$\sqrt{s}$ = 7 TeV, $\int$ Ldt = 4.9 fb^{-1}
CP5: Converted central, low p_{Tt}
Data 2011
Exponential fit
ATLAS Preliminary
$m_{\gamma\gamma}$ [GeV]

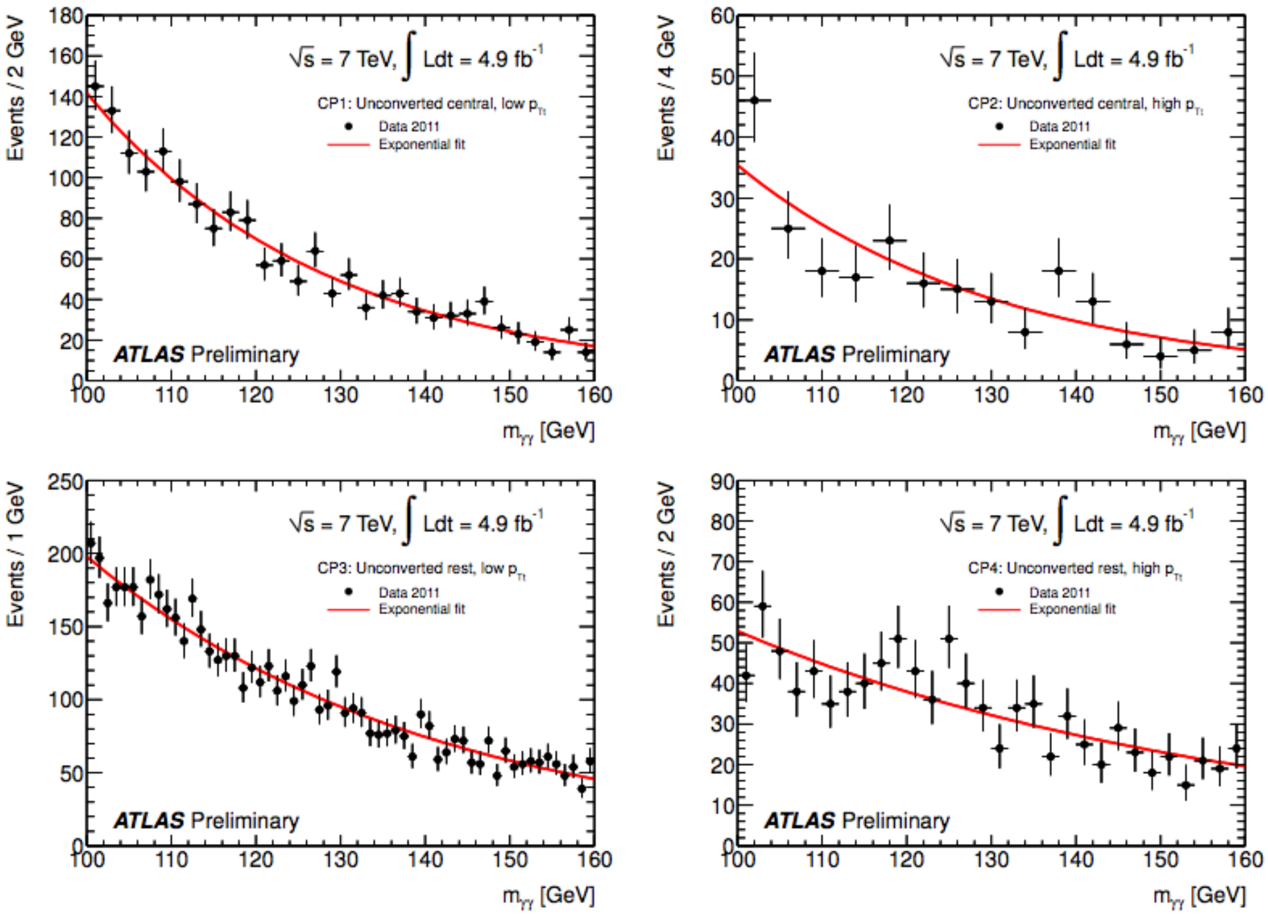

Events / 4 GeV
$\sqrt{s}$ = 7 TeV, $\int$ Ldt = 4.9 fb^{-1}
CP6: Converted central, high p_{Tt}
Data 2011
Exponential fit
ATLAS Preliminary
$m_{\gamma\gamma}$ [GeV]


Events / 1 GeV
$\sqrt{s}$ = 7 TeV, $\int$ Ldt = 4.9 fb^{-1}
CP7: Converted rest, low p_{Tt}
Data 2011
Exponential fit
ATLAS Preliminary
$m_{\gamma\gamma}$ [GeV]


Events / 2 GeV
$\sqrt{s}$ = 7 TeV, $\int$ Ldt = 4.9 fb^{-1}
CP8: Converted rest, high p_{Tt}
Data 2011
Exponential fit
ATLAS Preliminary
$m_{\gamma\gamma}$ [GeV]


Events / 1 GeV
$\sqrt{s}$ = 7 TeV, $\int$ Ldt = 4.9 fb^{-1}
CP9: Converted transition
Data 2011
Exponential fit
ATLAS Preliminary
$m_{\gamma\gamma}$ [GeV]

ATLAS



√s = 7 TeV, ∫ Ldt = 4.9 fb⁻¹
CP1: Unconverted central, low p_Tt
Data 2011
Exponential fit
ATLAS Preliminary
Events / 2 GeV
m_γγ [GeV]
CP2: Unconverted central, high p_Tt
Events / 4 GeV
CP3: Unconverted rest, low p_Tt
Events / 1 GeV
CP4: Unconverted rest, high p_Tt

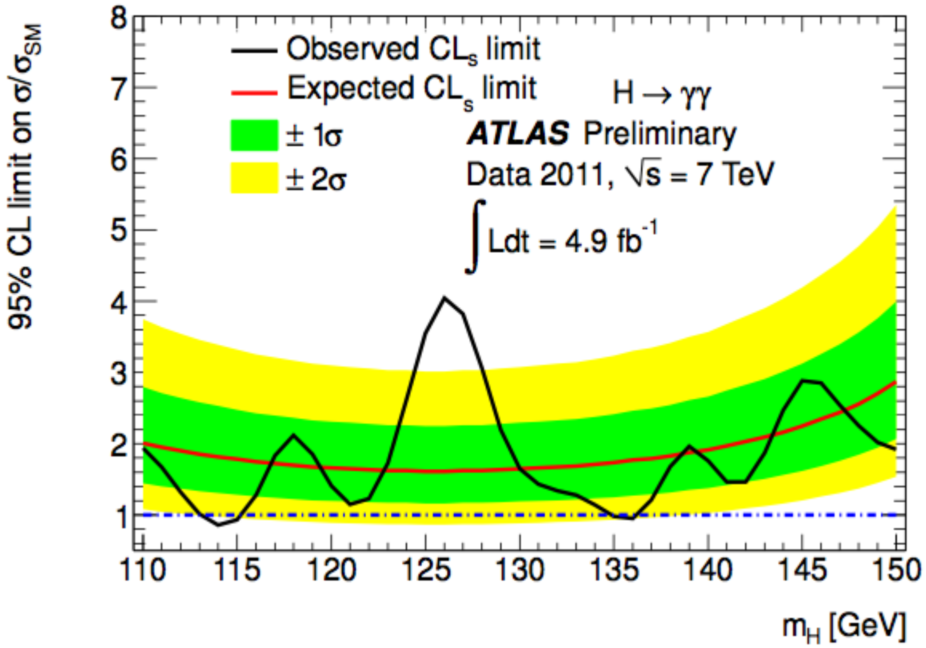
Systematic Uncertainties (ATLAS)

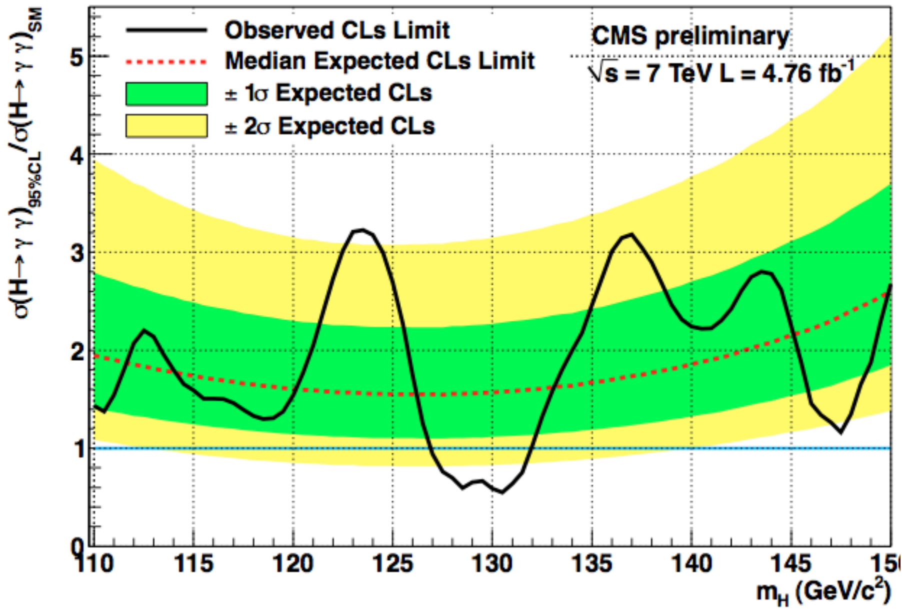
Type and source	Uncertainty
Event yield	
Photon reconstruction and identification	±11%
Effect of pileup on photon identification	±4%
Isolation cut efficiency	±5%
Trigger efficiency	±1%
Higgs boson cross section	+15%/ − 11%
Higgs boson p_T modeling	±1%
Luminosity	±3.9%
Mass resolution	
Calorimeter energy resolution	±12%
Photon energy calibration	±6%
Effect of pileup on energy resolution	±3%
Photon angular resolution	±1%
Migration	
Higgs boson p_T modeling	±8%
Conversion reconstruction	±4.5%

Systematic Uncertainties (CMS)

Source		Uncertainty	
Photon identification efficiency:	barrel	1.0%	
	endcap	2.6%	
R_9 >0.94 efficiency	barrel	4%	
(results in class migration)	endcap	6.5%	
		$R_9 > 0.94$	$R_9 < 0.94$
Energy resolution ($\Delta\sigma/E_{MC}$):	barrel low η, high η	0.22%, 0.61%	0.24%, 0.59%
	endcap low η, high η	0.91%, 0.34%	0.30%, 0.53%
Energy scale ($(E_{data} - E_{MC})/E_{MC}$)	barrel low η, high η	0.19%, 0.71%	0.13%, 0.51%
	endcap low η, high η	0.88%, 0.19%	0.18%, 0.28%
Integrated luminosity		4.5%	
Trigger efficiency: One or more photons $R_9 < 0.94$ in endcap		0.4%	
	Other events	0.1%	
Vertex finding efficiency		0.4%	
gluon fusion process cross section (scale)		+12.5% -8.2%	
gluon fusion process cross section (PDF)		+7.9% -7.7%	
Vector boson fusion process cross section (scale)		+0.5% -0.3%	
Vector boson fusion process cross section (PDF)		+2.7% -2.1%	
Associated production with W/Z cross section (scale)		+1.8% -1.8%	
Associated production with W/Z cross section (PDF)		+4.2% -4.2%	
Associated production with $t\bar{t}$ cross section (scale)		+3.6% -9.5%	
Associated production with $t\bar{t}$ cross section (PDF)		+8.5% -8.5%	

Effect on mass ?





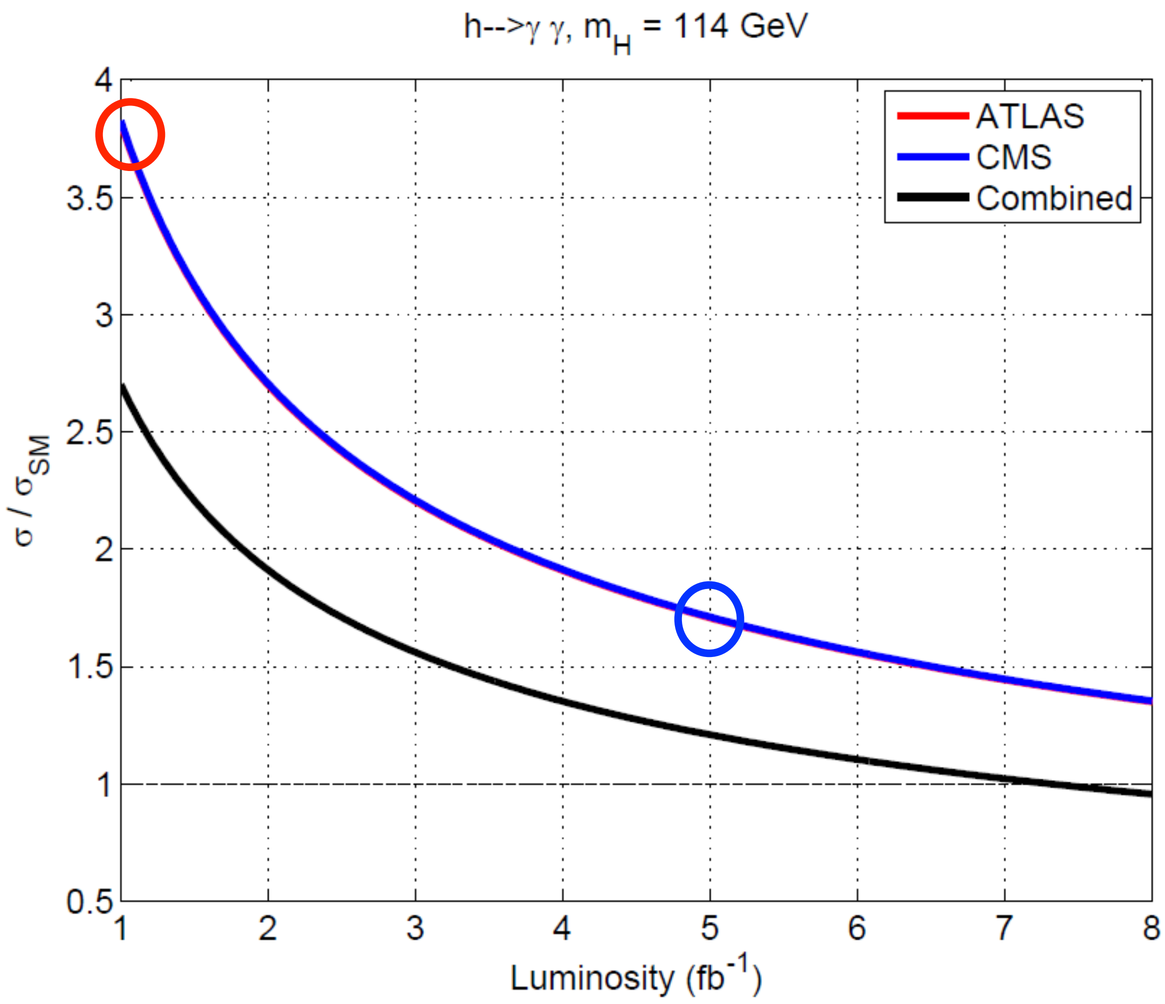
- ATLAS and CMS very similar performance

- Main differences between ATLAS and CMS :

    - Use of $P_T^{\gamma\gamma}$ categories
    - Photon pointing capabilities
    - Photon energy resolution

H → γγ projection: 114GeV

- Extrapolate current results using 1/√L
  - Neglects improvements
  - Also neglects pileup degradations...
- ATLAS & CMS identical
  - Curves overlap
- 8fb^{-1} for SM exclusion



$$H \rightarrow W^{+}W^{-} \rightarrow \ell\upsilon\ell\upsilon$$

Most sensitive Channel in [125-180] GeV Mass range

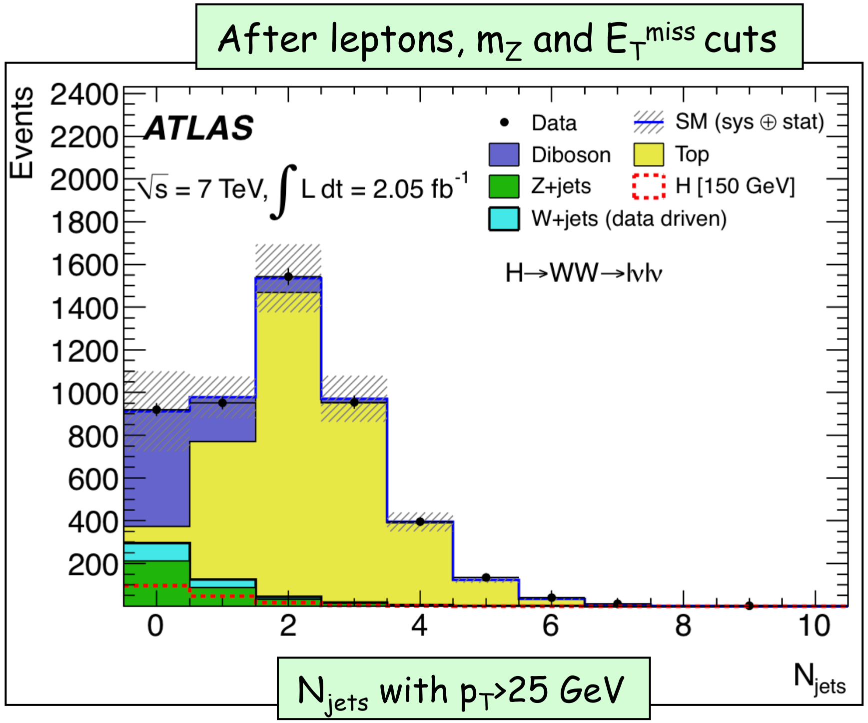
ATLAS 2.3 fb^{-1}

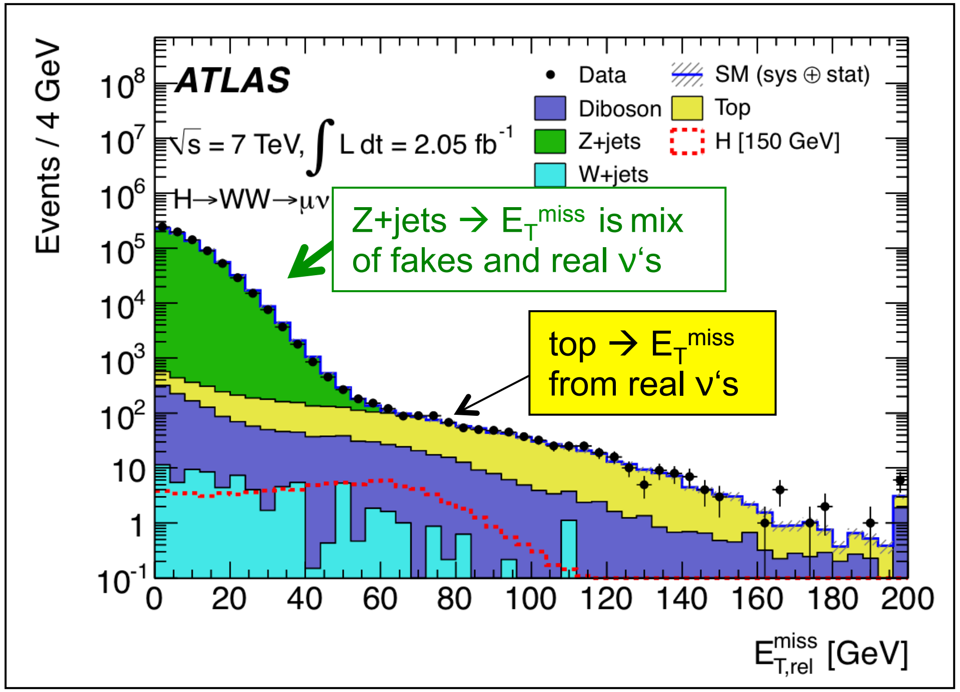
CMS 4.6 fb^{-1}

Higgs Boson Search in the WW→lνlν

Key features :

- Not a search for a mass peak : Counting experiment only!
- Search carried out in 0 and 1 bins (VBF for CMS) in numbers of jets
- ATLAS cut based only / CMS cut based and MVA (EPS only)
- Good control of the WW and top backgrounds is essential!



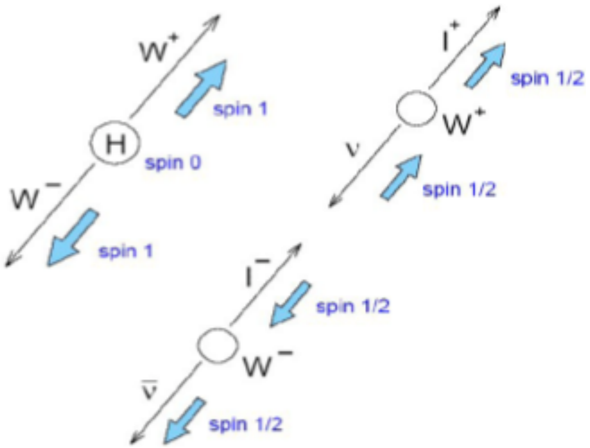


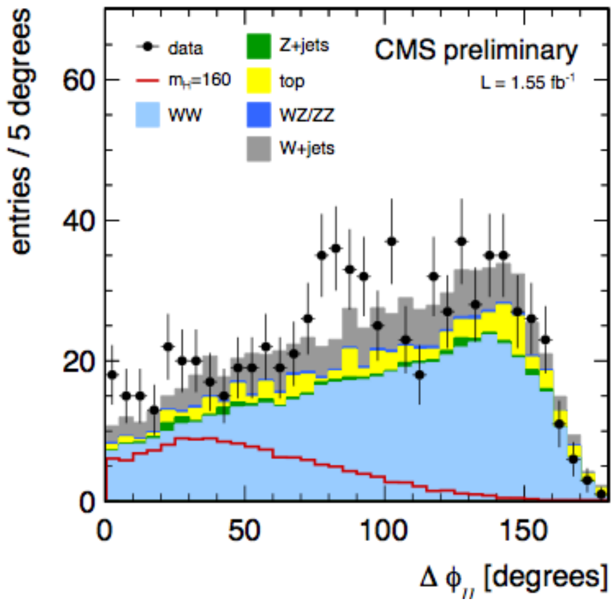
ATLAS MET distribution (not as easy as in the 2010 data!)

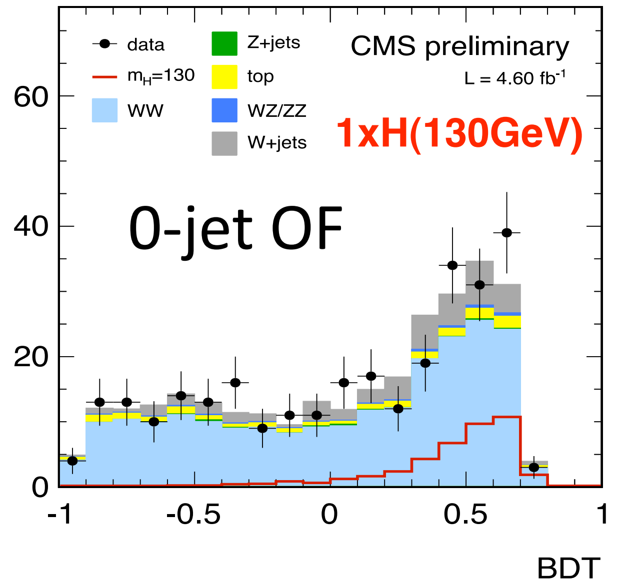
Higgs Boson Search in the WW→lνlν

Key features :

- Not a search for a mass peak : Counting experiment only!
- Search carried out in 0 and 1 bins (VBF for CMS) in numbers of jets
- ATLAS cut based only / CMS cut based and MVA (EPS only)
- Good control of the WW and top backgrounds is essential!
- Use of spin correlations is essential for the analysis and to define control regions… CMS also use a BDT (kinematic variables)



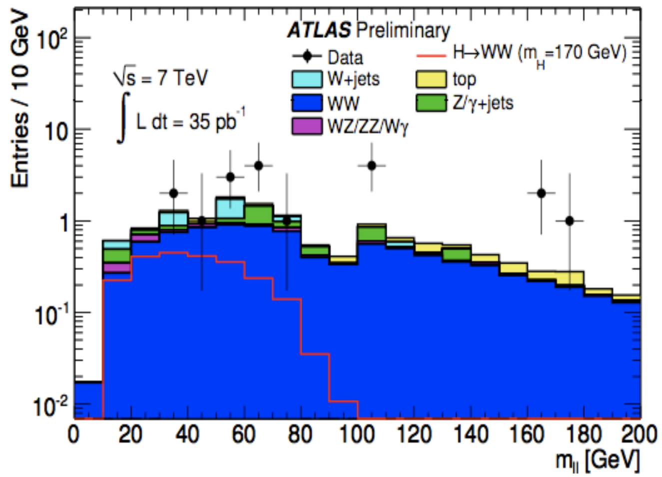




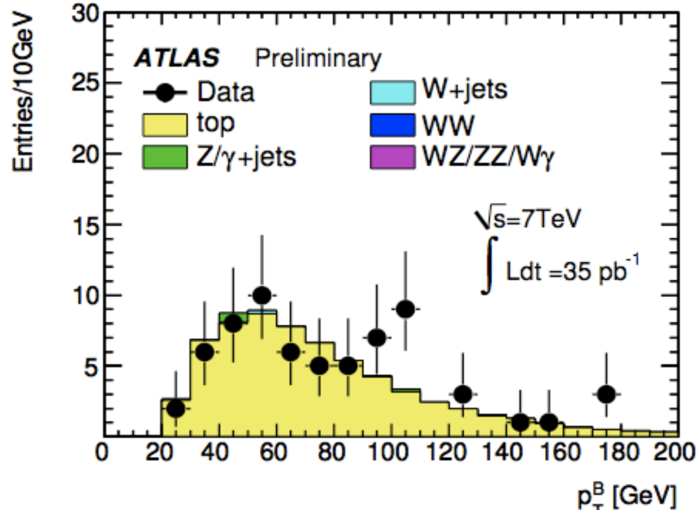
A Word on Control Regions

$$N^{S.R.}_{data} = \alpha \times N^{C.R.}_{data}, \qquad \alpha = \frac{N^{S.R.}_{MC}}{N^{C.R.}_{MC}}$$

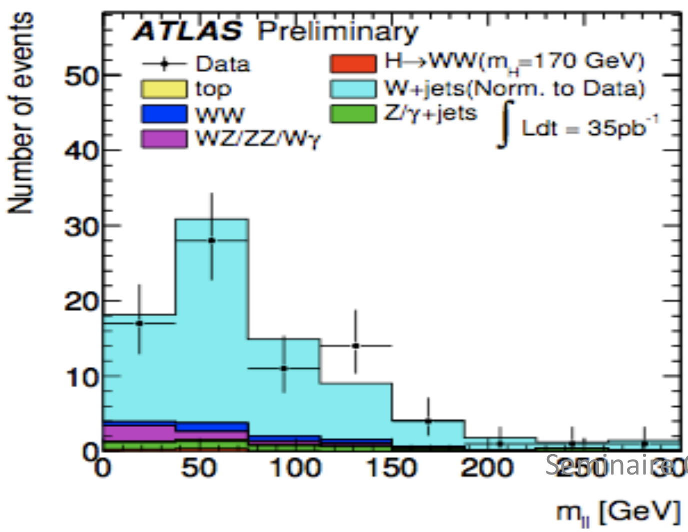
- WW : From side bands in M_{ll}



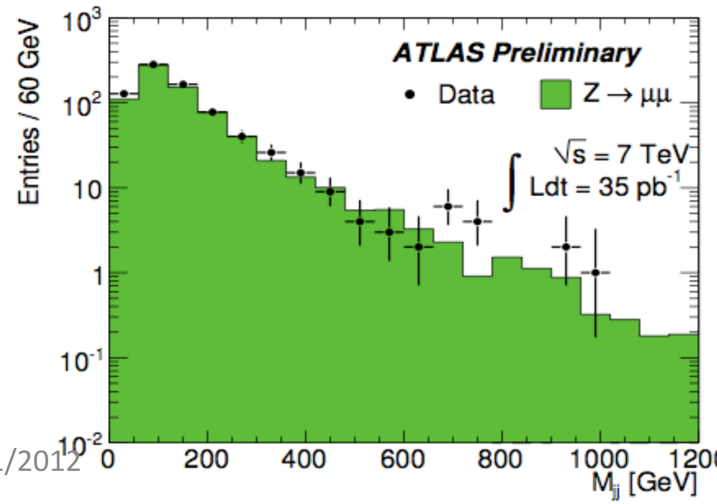
- Top : b-tagging CS (MC for CMS)



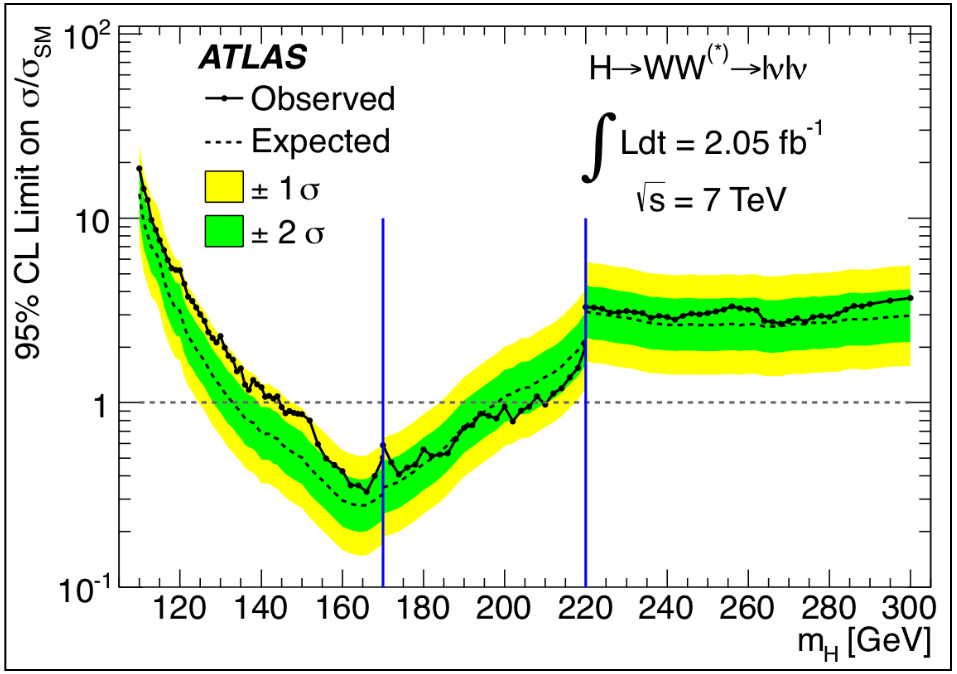
- W+jets : Loose ID on second lepton

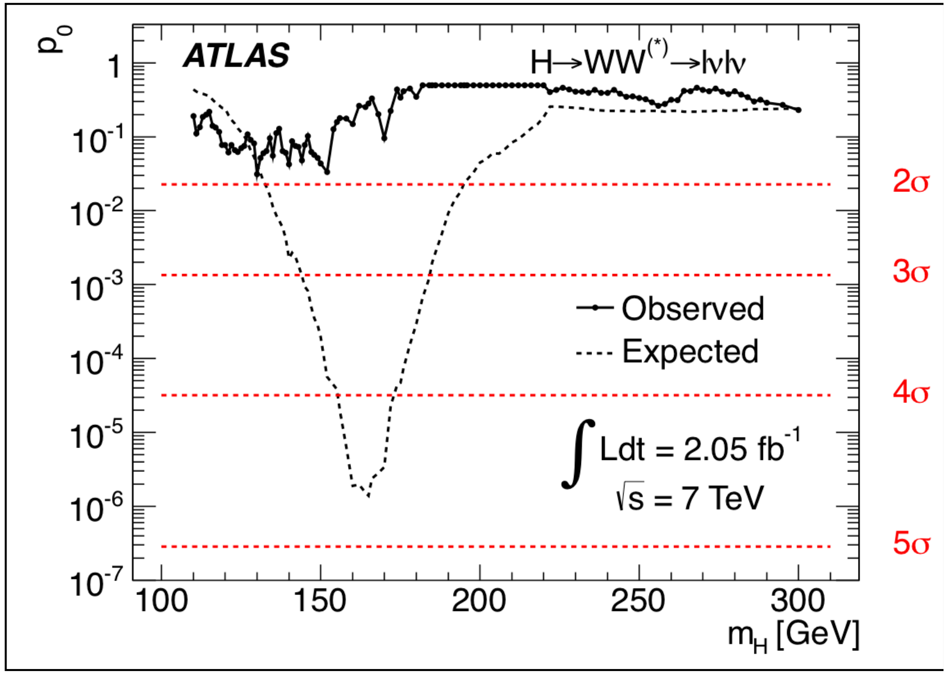


- Z+jets : ABCD method in M_{ll} MET plane



Higgs Boson Search in the WW→lνlν

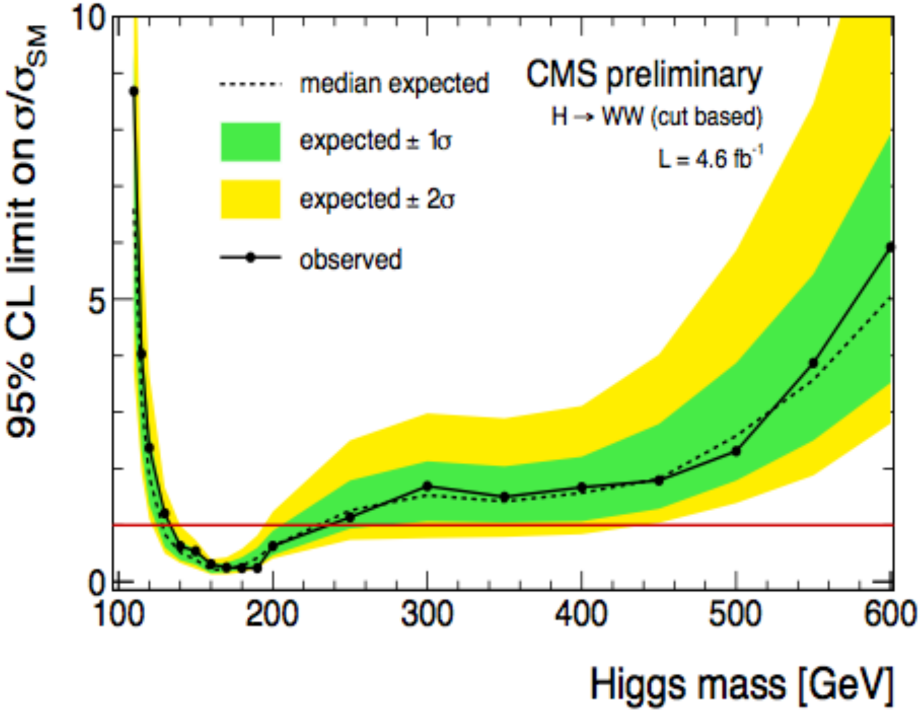


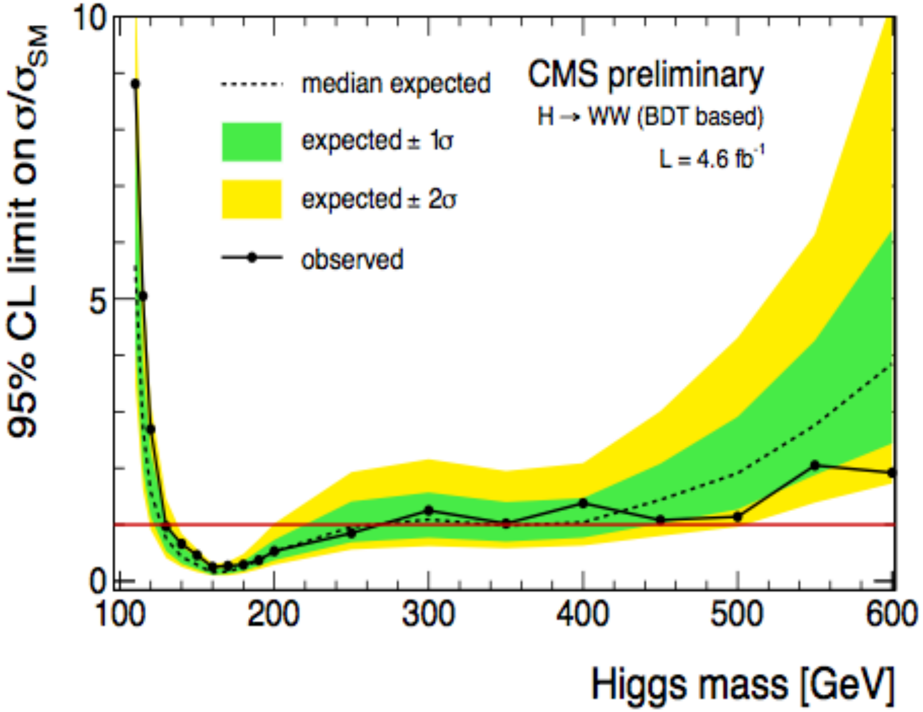


Excluded (95% CL):
145 < m_H < 206 GeV
(expected: 134-200 GeV)

Slight excess (at 125 GeV 1.4σ observed and expected in presence of signal…)

Higgs Boson Search in the WW→lνlν





Very slight excess…

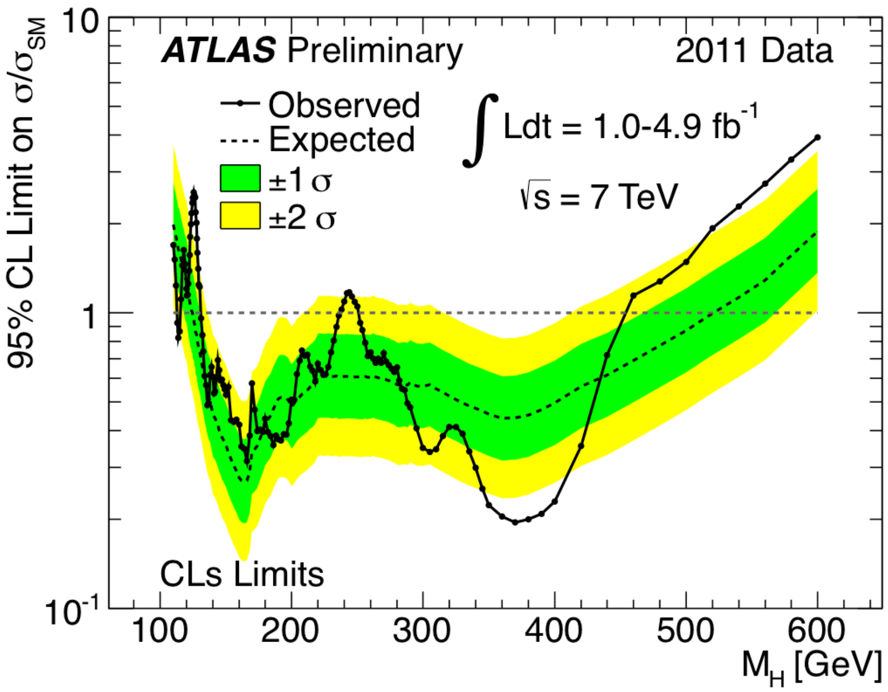
Main differences between ATLAS and CMS :

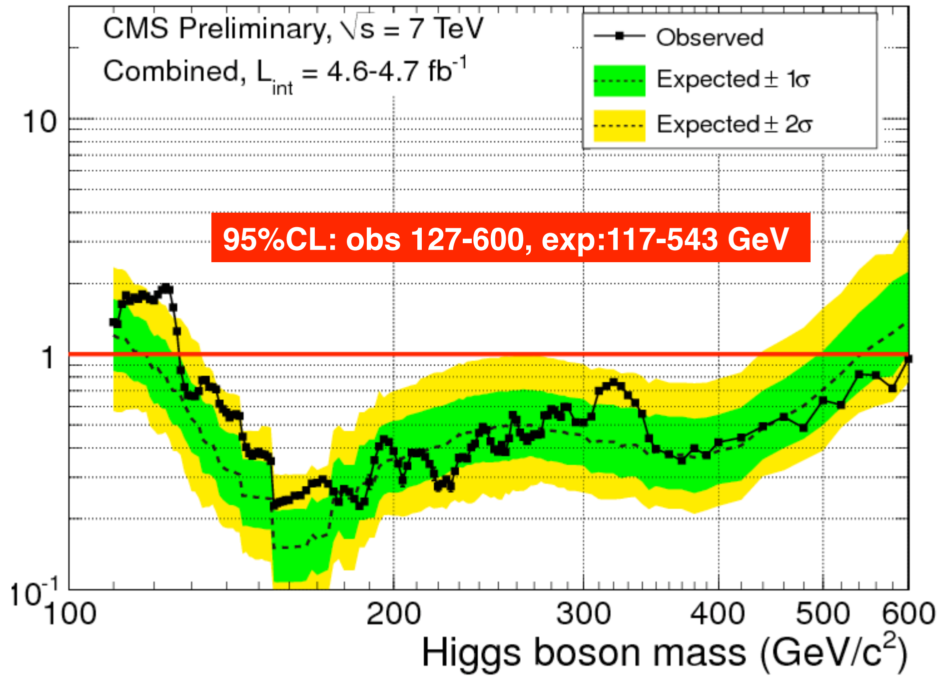
- Use of BDT
- Luminosity

Combination

Combination of All Channels

The ATLAS and CMS Combinations

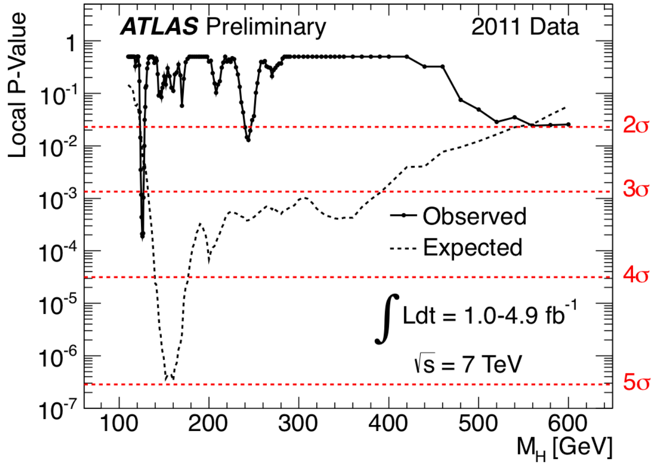




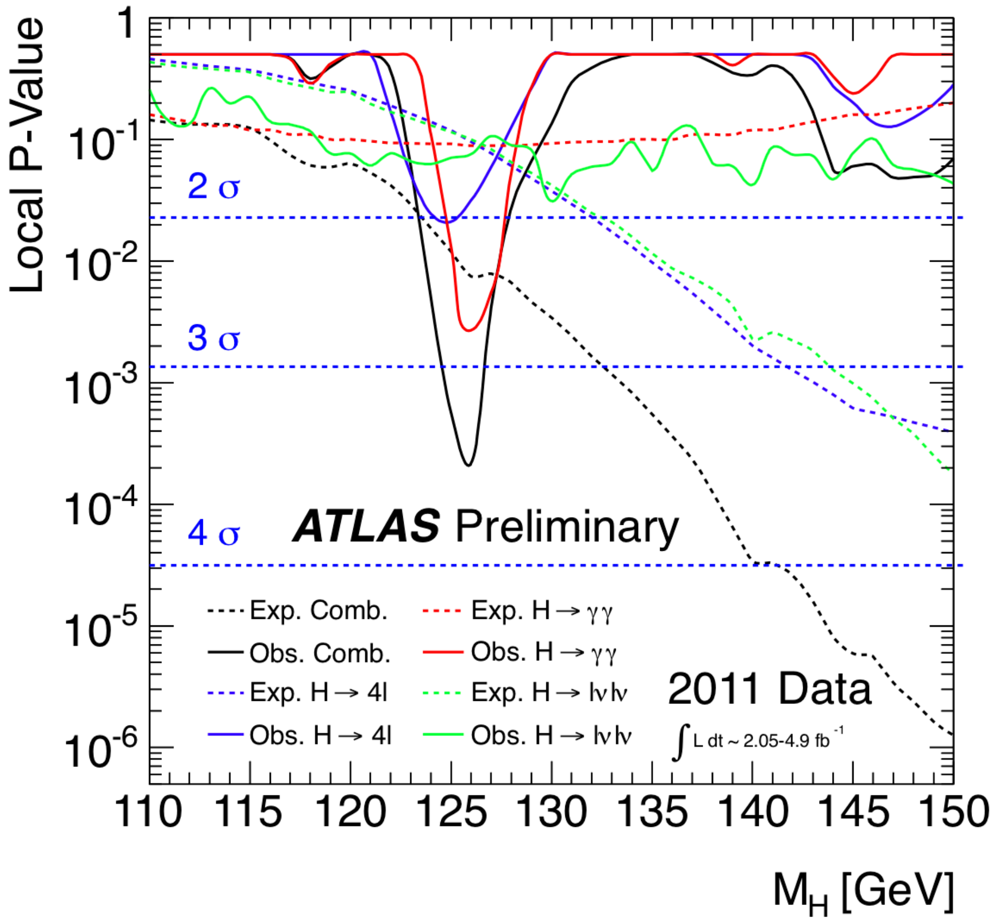
Expected : 125 – 520 GeV
Observed : 113-116, 131-237, 251-453 GeV

Expected : 117 – 543 GeV
Observed : 127 - 600 GeV

Observation of an Excess in ATLAS



3 visible excesses … but one in particular



Local p_0-value: 1.9 10^{-4}

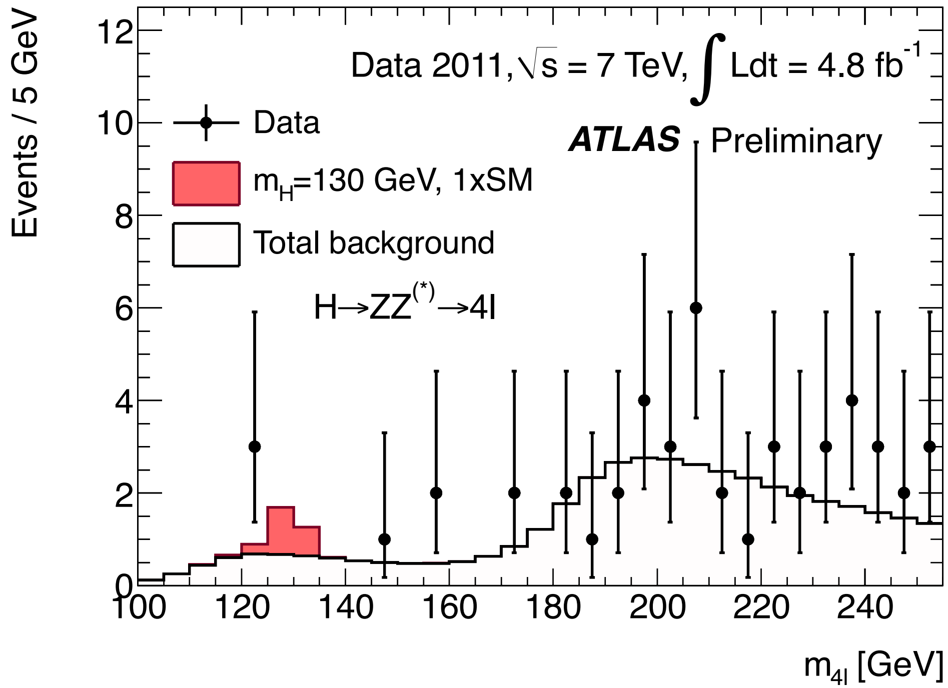
→ local significance of the excess: 3.6σ

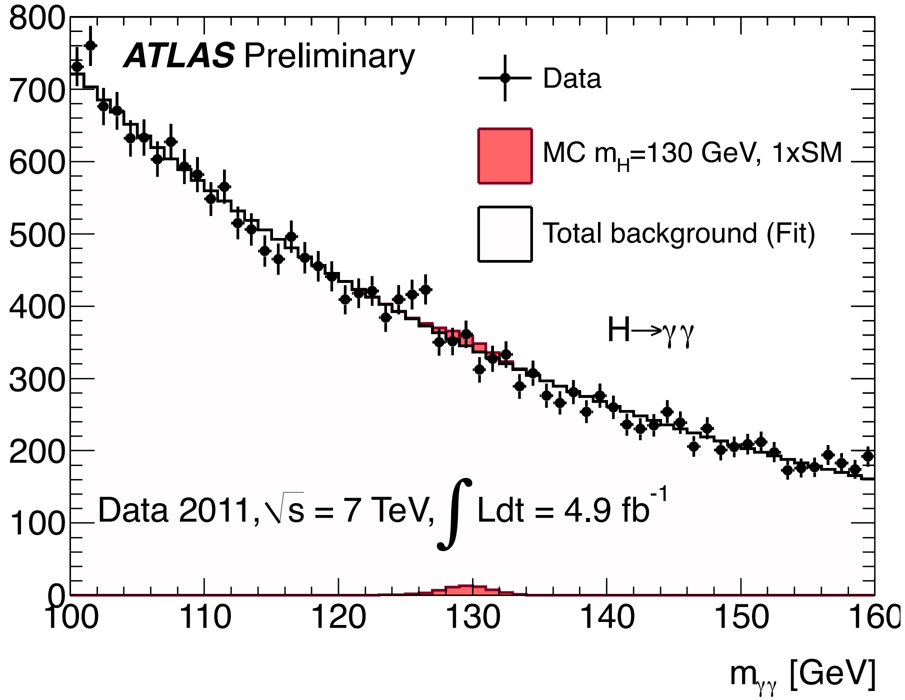
~ 2.8σ H→ γγ, 2.1σ H→ 4l, 1.4σ H→ lνlν

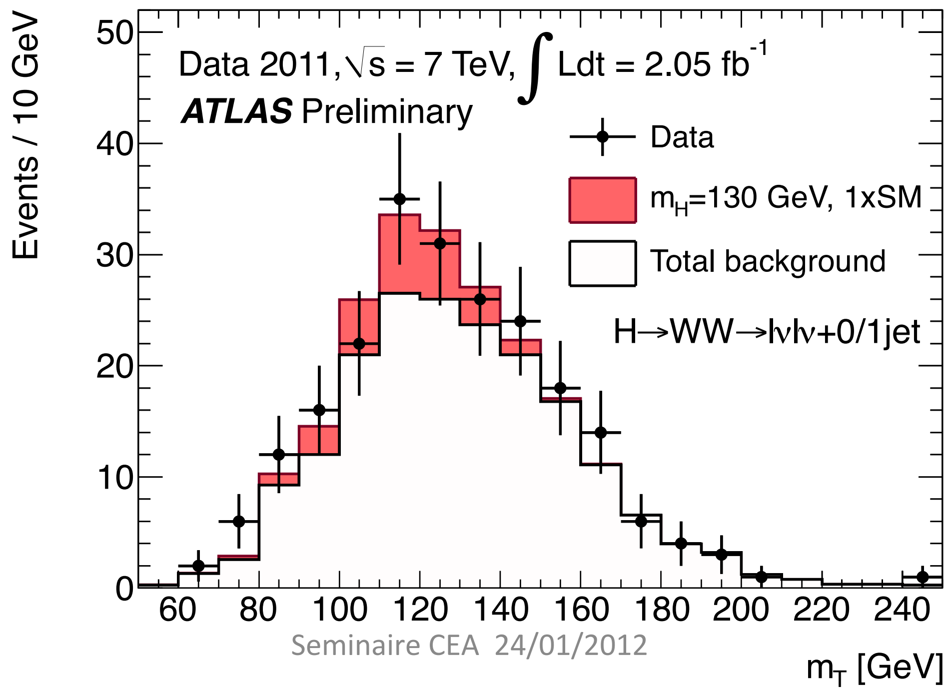
Expected from SM Higgs: ~2.4σ local (~1.4σ per channel)

Global p_0-value : 0.6% →2.5σ LEE over 110-146 GeV

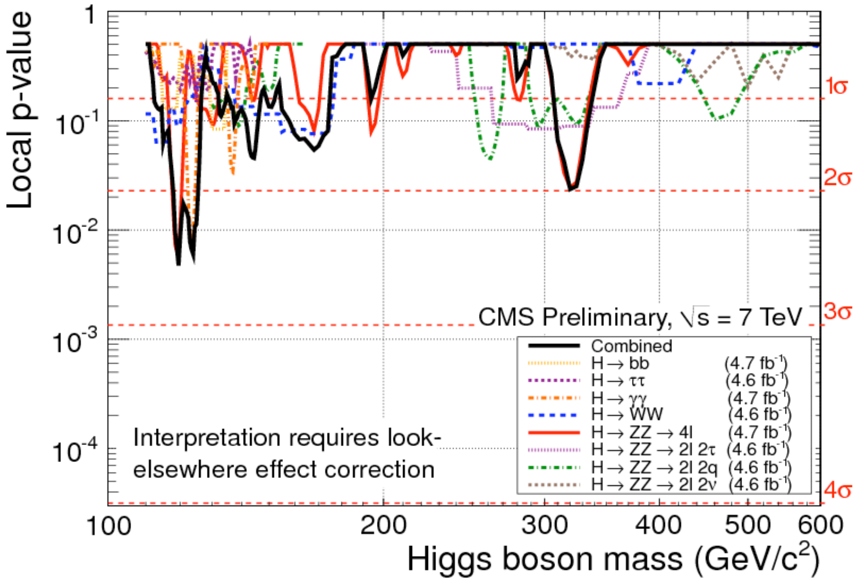
Global p_0-value : 1.4% →2.2σ LEE over 110-600 GeV

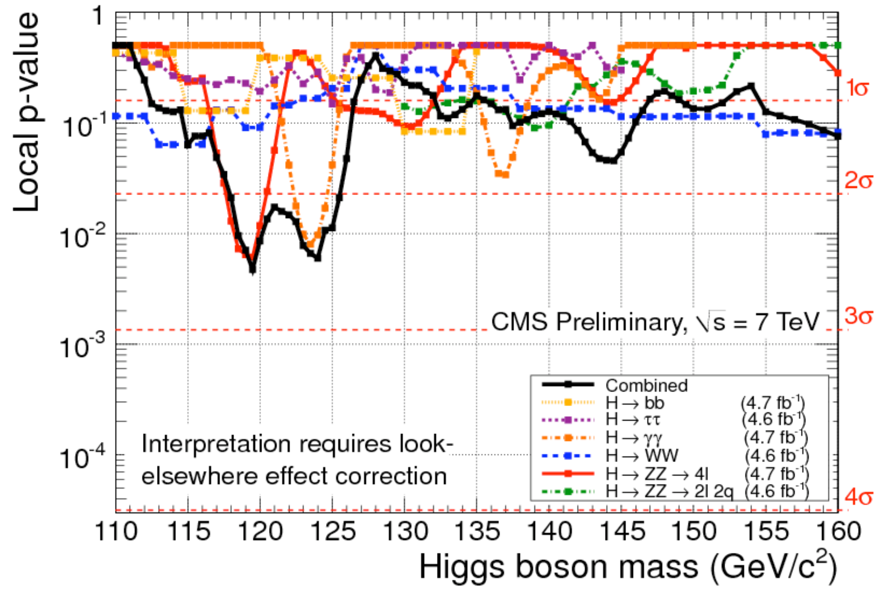

Data 2011, √s = 7 TeV, ∫ Ldt = 4.8 fb⁻¹
ATLAS Preliminary
Data
m_H=130 GeV, 1xSM
Total background
H→ZZ(*)→4l
Events / 5 GeV
m_4l [GeV]
0
2
4
6
8
10
12
100
120
140
160
180
200
220
240


ATLAS Preliminary
Data
MC m_H=130 GeV, 1xSM
Total background (Fit)
H→γγ
Data 2011, √s = 7 TeV, ∫ Ldt = 4.9 fb⁻¹
m_γγ [GeV]
0
100
200
300
400
500
600
700
800
100
110
120
130
140
150
160


Data 2011, √s = 7 TeV, ∫ Ldt = 2.05 fb⁻¹
ATLAS Preliminary
Data
m_H=130 GeV, 1xSM
Total background
H→WW→lνlν+0/1jet
Events / 10 GeV
m_T [GeV]
0
10
20
30
40
50
60
80
100
120
140
160
180
200
220
240

Anatomy of an excess: local and global p-values





Maximum local significance **2.6σ.**

LEE-corrected significance (full mass range: 110-600GeV)= **0.6σ**

LEE-corrected significance (low mass range: 110-145GeV)= **1.9σ**

The excess we see in the low mass region has a modest statistical significance and could be reasonably a fluctuation of the background.

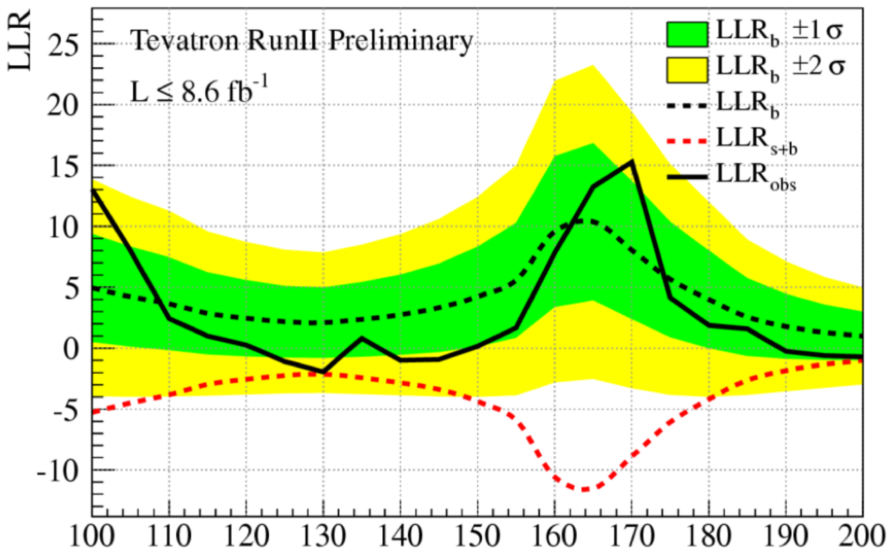
Conclusions and Outlook

Tantalizing Hints around 125 GeV…

- Significant excess in ATLAS
- Multiple excesses in CMS

  Energy scale compatibility?

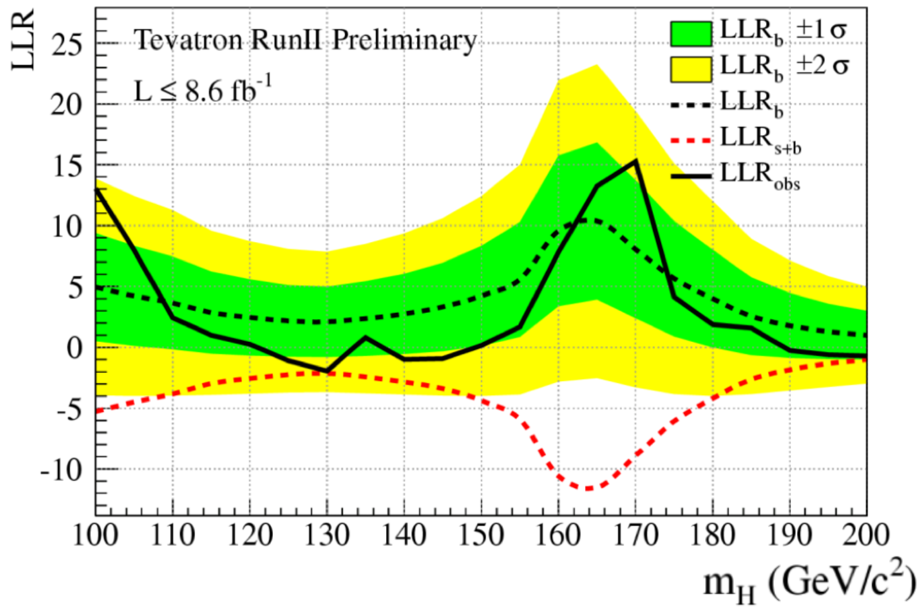
- Excess also in TeVatron



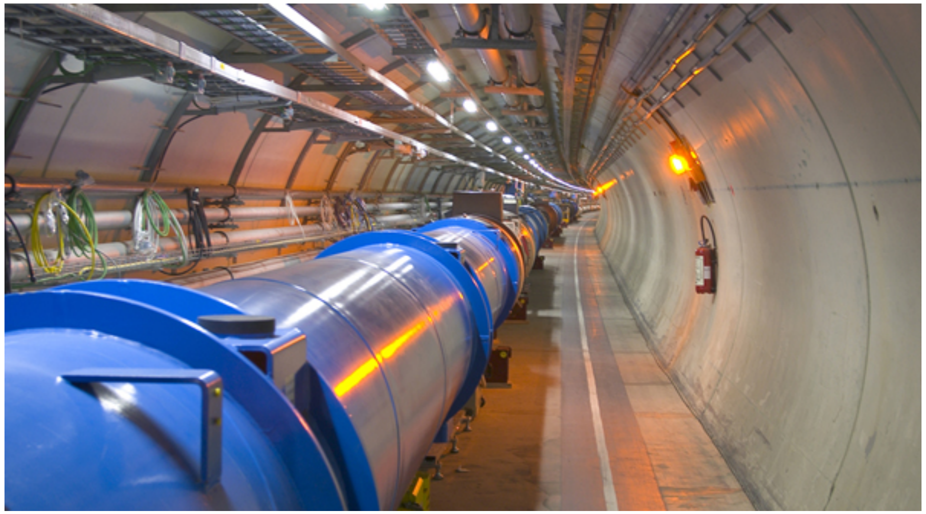
- Lucky if we have a SM signal
- Unlucky if there is only background
- Need ~20 fb^{-1} to :
  - Confirm (5σ sensitivity)
  - Infirm (exclude at 95% CL with such a large excess)

What Next?

The Tevatron, the world's highest-energy proton-antiproton collider, has shut down on Sept. 30, 2011.



Year	Lumi	Total	c.o.m. Energy
2011	5	5	7 TeV
2012	10-15	15-20	7-8 TeV
2013	LS1	15-20	LS1
2014	LS1	15-20	LS1
2015	>10	>25	>12 TeV



The Higgs Hunt in 2012…

- Preferred option 8 TeV / 25 ns ?

- To reach optimal analyses will require

    - More work on performances
      (at all levels of the analyses)
    - Analysis improvements/optimization

- Carefully prepare 2012 for a robust independent check

- The Higgs boson will not be unveiled easily…

The Higgs Hunt in 2012…

- Preferred option 8 TeV / 25 ns ?

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  - More work on performances
    (at all levels of the analyses)
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Luminosity and Beam cross section

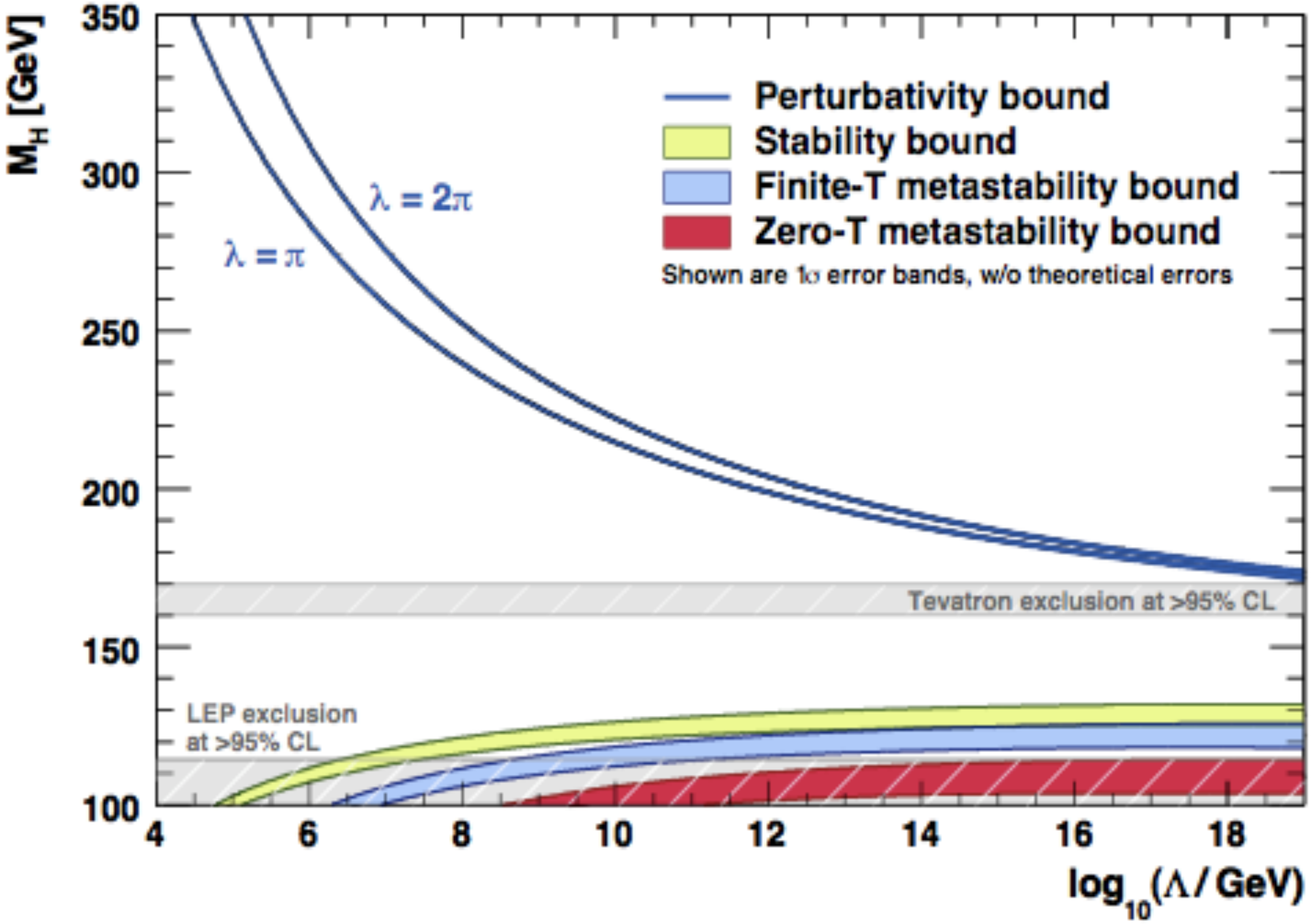
$$\mathcal{L} = \frac{N_p^2 k_b f_{rev} \gamma}{4\pi \beta^* \epsilon_n} F$$

Reduction factor W/ Beam crossing angle O(0.95)

LHC beam parameters (SPS extraction)

Spacing	N	ε [μrad]
150 ns	1.1×10^{11}	1.6
75 ns	1.2×10^{11}	2.0
50 ns	1.6×10^{11}	1.8
50 ns	$1.2\text{-}1.35 \times 10^{11}$	1.3-1.5
25 ns	1.2×10^{11}	2.7

What do we learn?



What do we learn?