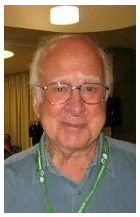
Les XXVI Renconstres de Physique
de la Vallee d'Aoste

Search for the Standard Model Higgs boson at ATLAS



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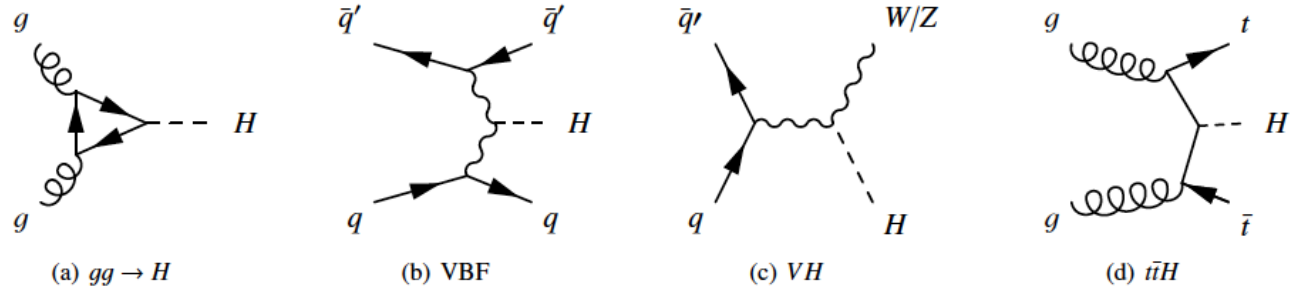
on the behalf of ATLAS collaboration

Content

- Introduction
- Higgs search at ATLAS
  - H->WW->lνlν
  - H->ZZ->llll
  - H->ZZ->llνν
  - H->γγ
- Combination
- Summary and Prospect

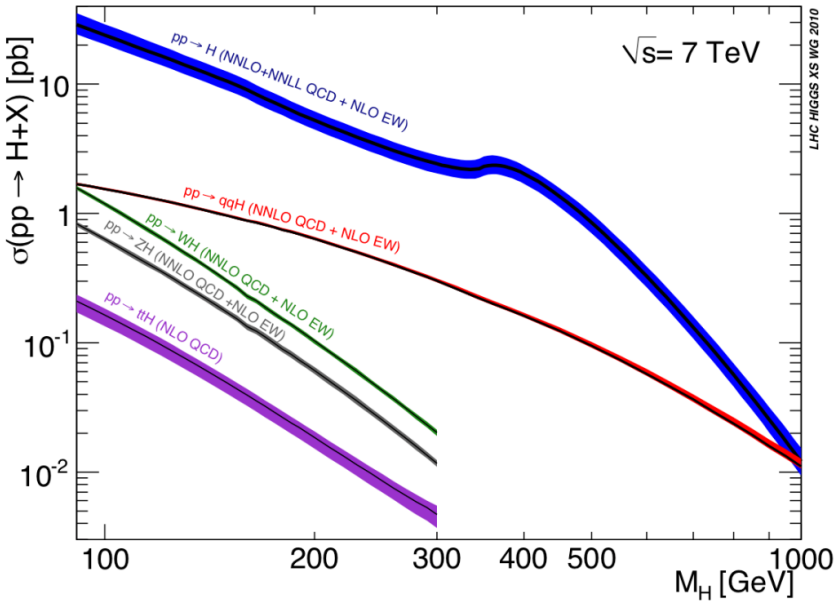
Higgs production and decay at LHC

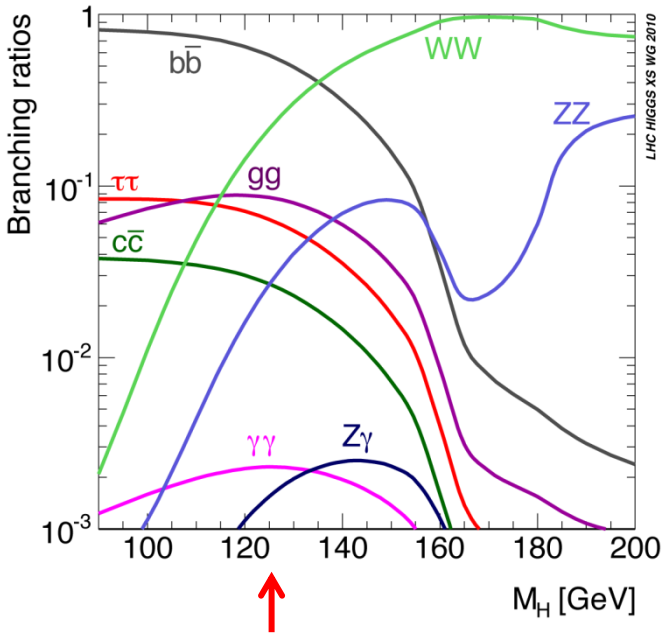


NNLO+NNLL(QCD soft-gluon)+NLO EW

NNLO+NLO EW

NLO



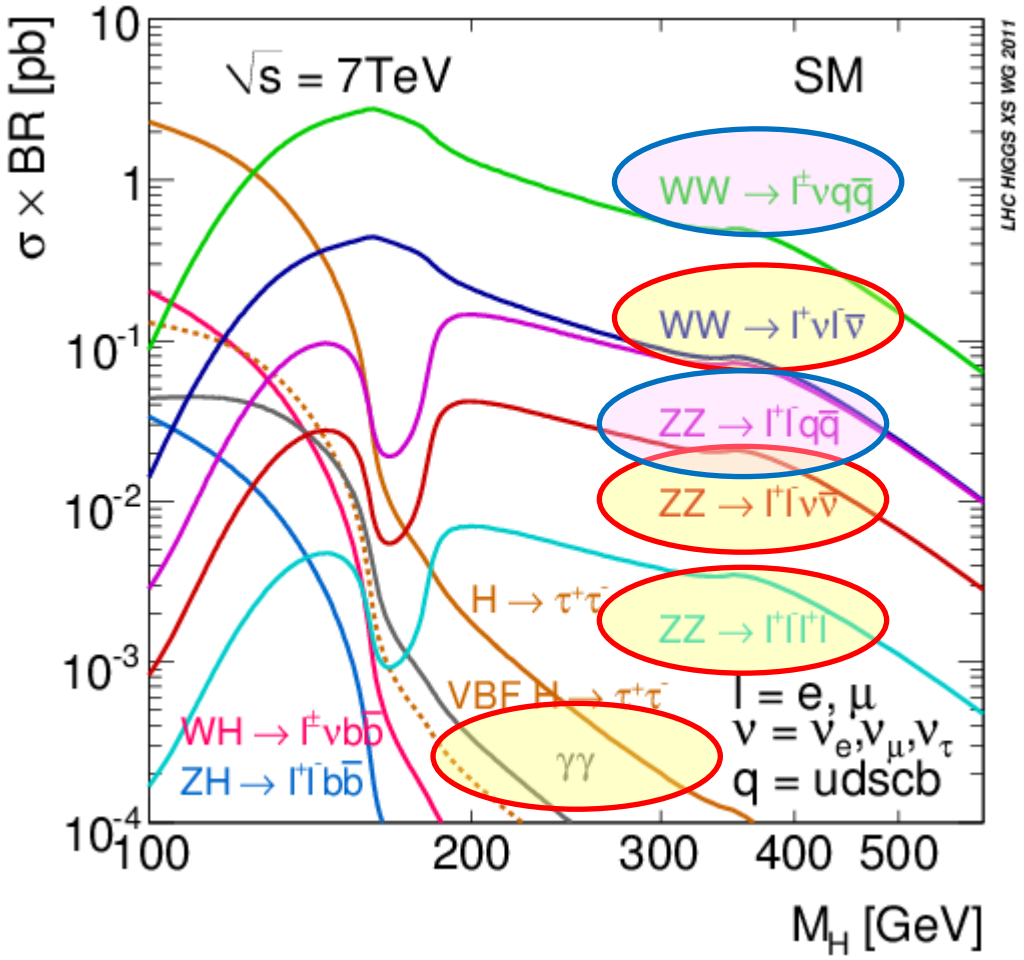


M_H=125GeV: 15.3pb (ggF), 1.2pb(VBF), 0.6pb(WH), 0.3pb(ZH), 0.09pb(ttH)

Yukawa

Today's talk

x-sec x BR for each final state



[Detail of the specific channels]

- H->WW->lνlν with 2.1 fb^{-1}
  - 110-300GeV
- H->ZZ->llll with 4.8 fb^{-1}
  - 110-600GeV
- H->ZZ->llνν with 2.1 fb^{-1}
  - 200-600GeV
- H->γγ with 4.9 fb^{-1}
  - 110-150GeV

[Combination]

Additionally, we use the next;

- H->ZZ->llqq with 2.1 fb^{-1}
  - 200-600GeV
- H->WW->lνqq with 1.0 fb^{-1}
  - 240-600GeV

$H->WW^{*}->l\nu l\nu$

l = electron or muon

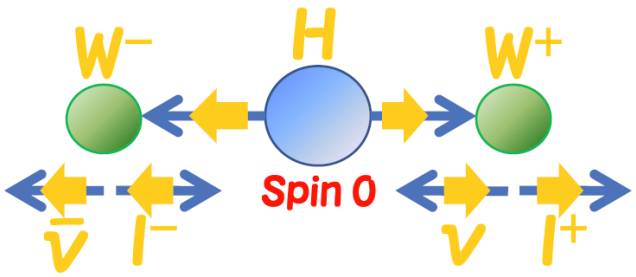
Today talk -> L=2.05 fb^{-1}

(Preliminary) results with ~4.8 fb^{-1} will be shown in Moriond.

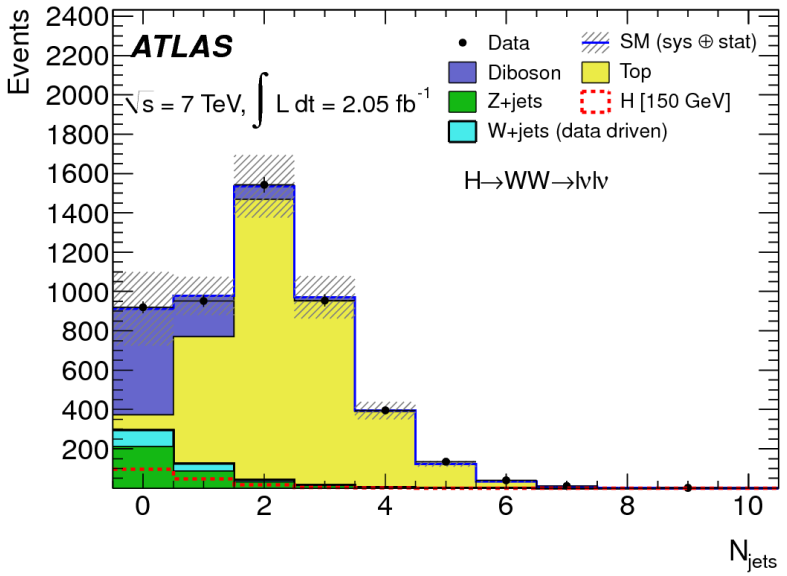
arXiv:1112.2577 (to PRL)

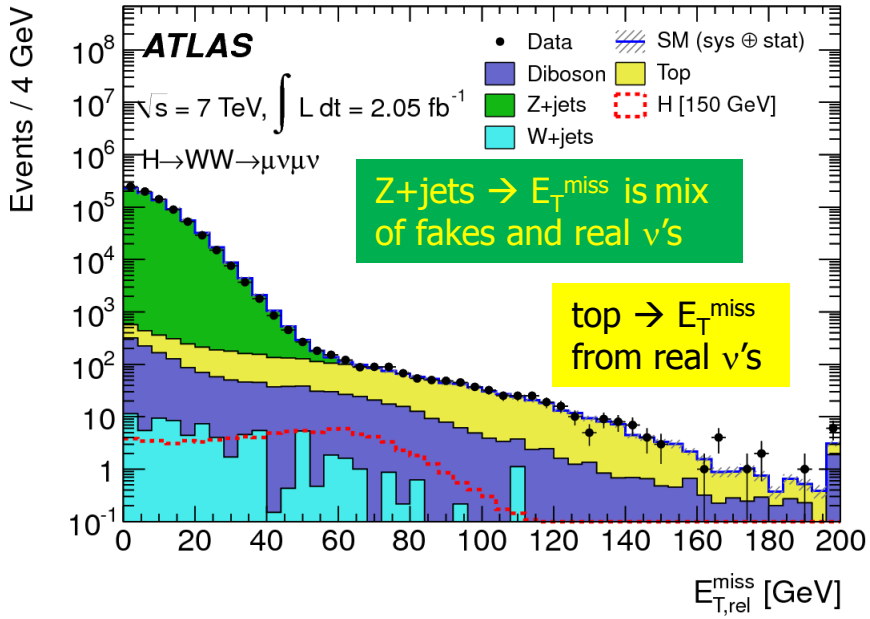
H->WW*->lνlν

L=2.05 fb^{-1}



[1] cannot reconstruct Higgs mass due to 2 neutrinos
[2] "Δϕ(ll)->small" due to spin 0
-> low dilepton inv. mass





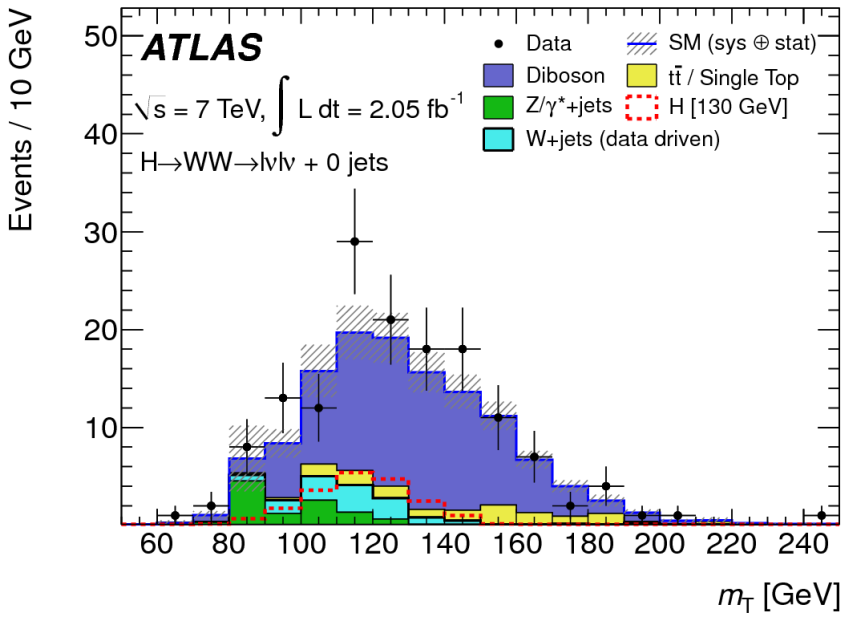
- Event Selection
  - Single lepton trigger
  - 2 isolated leptons
    - 20GeV for elec, 15GeV for muon
    - 25GeV for the leading lepton
  - MET rel ($E_{T,rel}^{miss}$)>40GeV(SF), 25(DF)
  - Jets p_T>25GeV, |eta|<4.5
  - Cuts on Δϕ(ll) and m(ll)

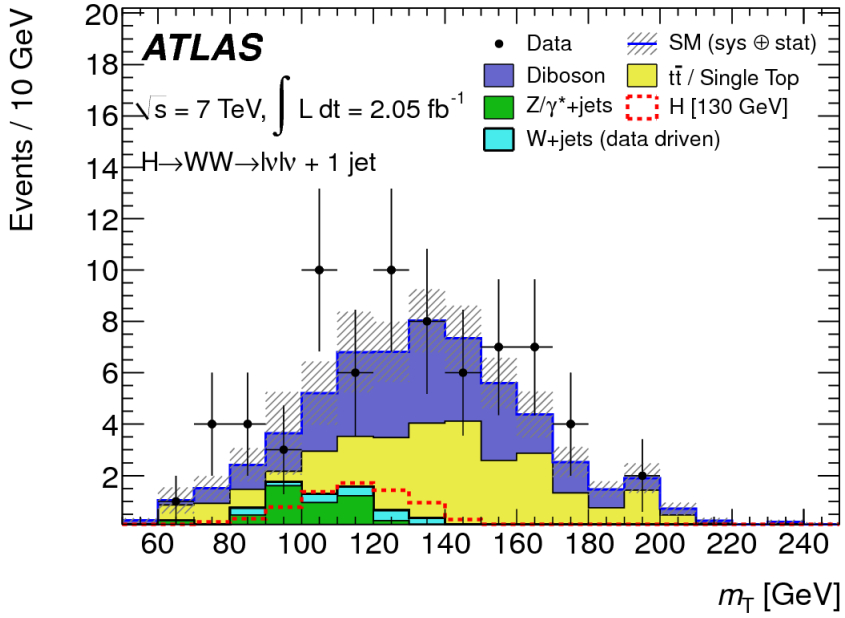
  etc

m_T distribution

$$m_{\mathrm{T}} = \sqrt{(E_{\mathrm{T}}^{\ell\ell} + E_{\mathrm{T}}^{\mathrm{miss}})^2 - (\mathbf{P}_{\mathrm{T}}^{\ell\ell} + \mathbf{P}_{\mathrm{T}}^{\mathrm{miss}})^2}$$

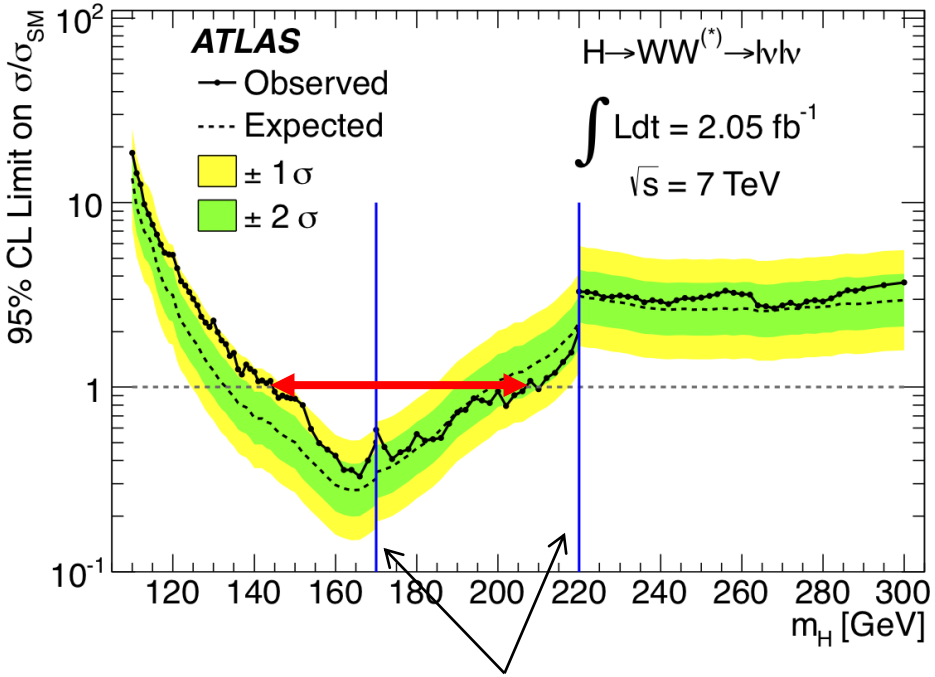
after $\Delta\phi(ll)<1.3$ cut

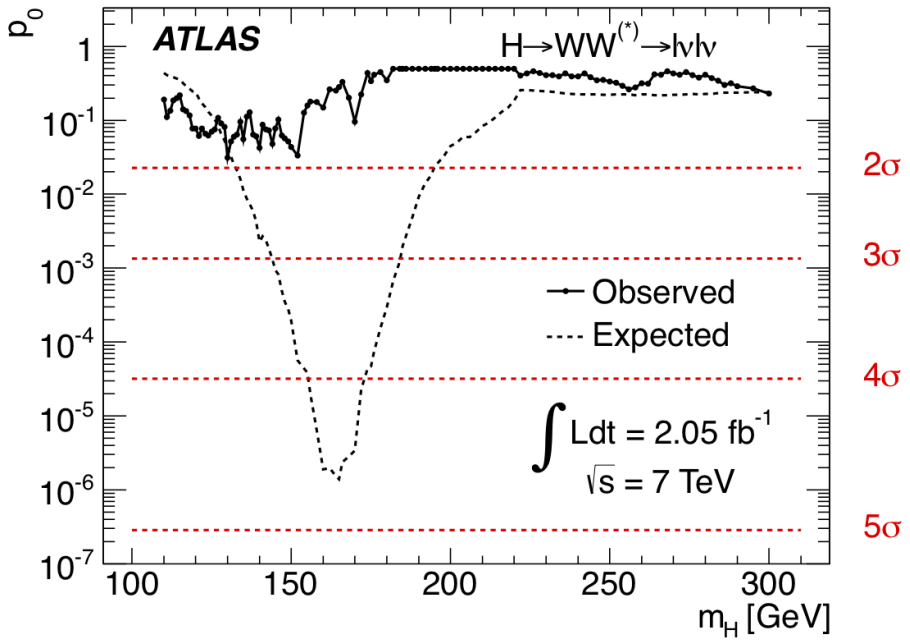




130GeV mass point still survives.

H->WW*->lνlν





Event selection method is changed at 170GeV and 220GeV.

- Observed excluded = 145<m_H<206GeV (expected:134-200GeV)
- Maximum deviation = 1.9σ for m_H~130GeV

H->ZZ*->4l

arXiv:1202.1415 (to PLB)

H->ZZ*->4l

- Clean but rare!

m_H[GeV]	$\sigma \cdot BR \cdot 4.8fb^{-1}$ [events]	Width [GeV]
130	15	0.005
150	22	0.017
200	33	1.4
400	13	29
600	2	120

- Event Selection
  - Single lepton trigger
    - 20-22GeV for elec, 18GeV for muon
  - 4lep p_T>20, 20, 7 and 7GeV
    - Isolated and small impact parameter
  - $|m_Z-m_{12}|$<15GeV
  - m_{34}<115GeV &&

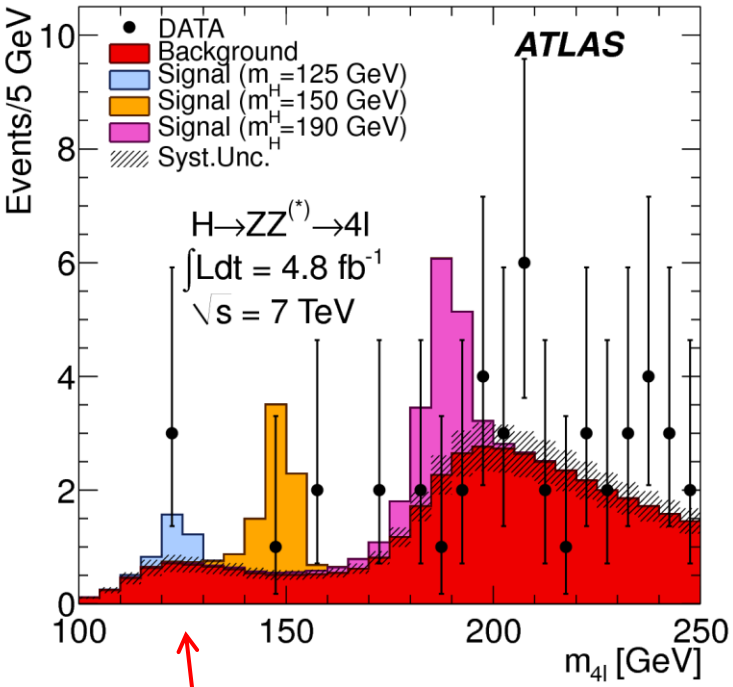
$m_{4\ell}$ (GeV)	≤120	130	140	150	160	165	180	190	≥200
m_{34} threshold (GeV)	15	20	25	30	30	35	40	50	60

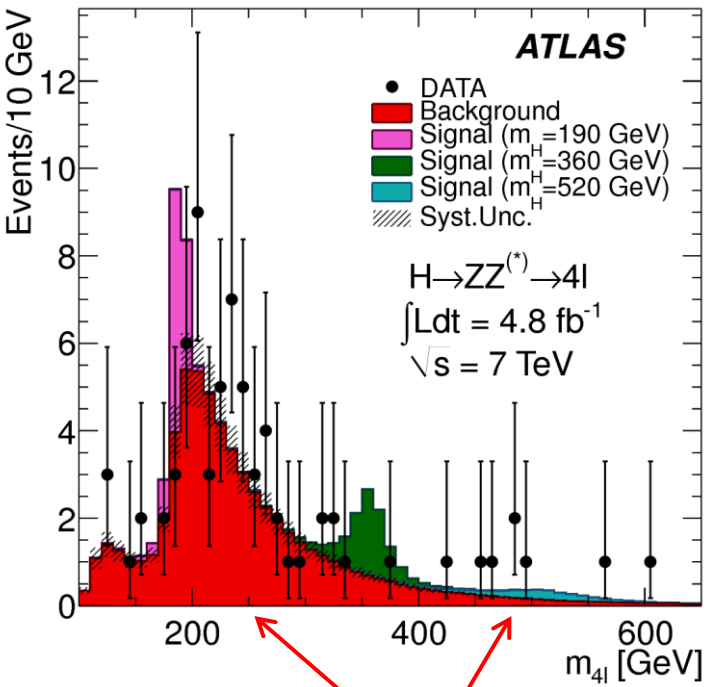
- 4l mass resolution (130GeV)
  - 1.98GeV for 4μ
  - 2.18GeV for 2e2μ
  - 2.53GeV for 4e

Signal acceptance with eff is ~15% for m_H=125GeV. (~48% for m_H=200GeV)

Performance of low p_T lepton gets important for low mass Higgs search.

4lepton inv. mass

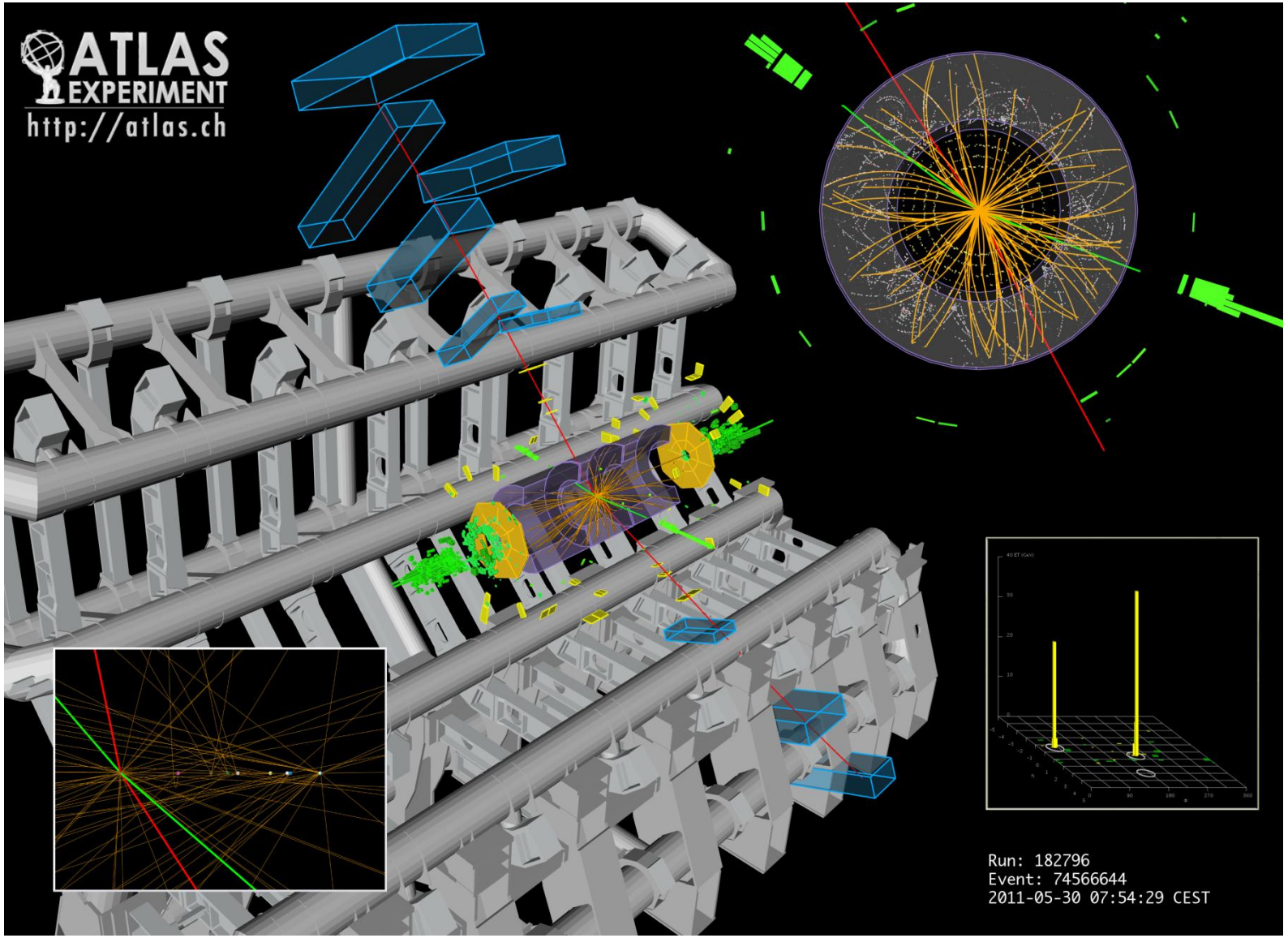




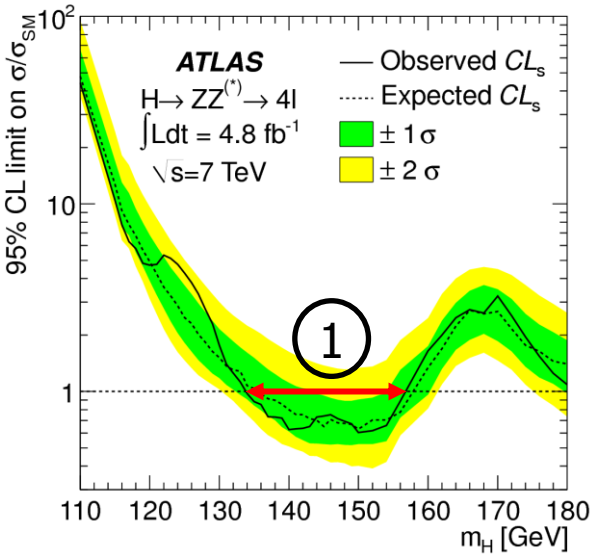
3 events (<140GeV)
124.6(4μ), 124.3(2e2μ), 123.6(2μ2e)

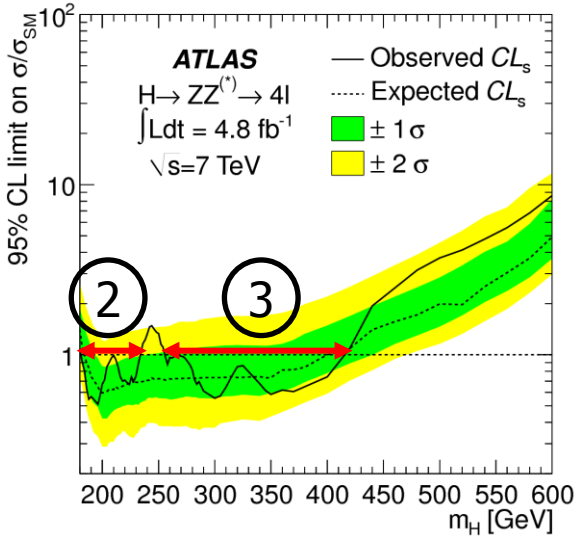
Upward fluctuation ~240GeV and ~500GeV

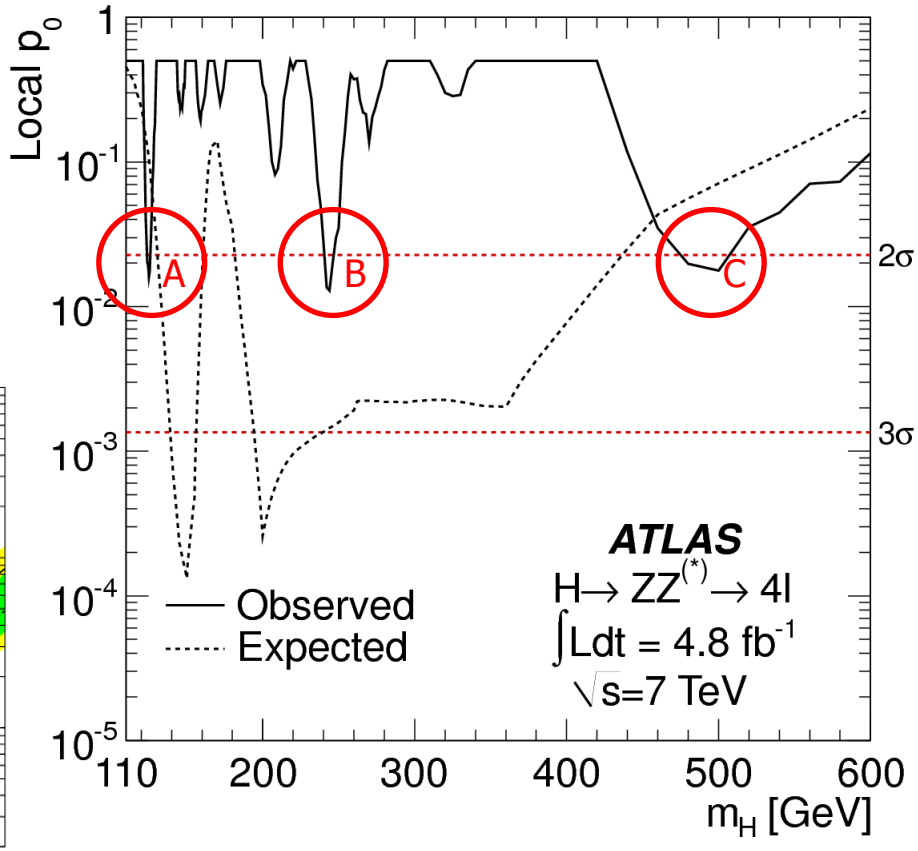
2elec+2muon candidate with m_{4l}=124.3GeV
$m_{12(ee)}$=76.8GeV, $m_{34(\mu\mu)}$=45.7GeV



H->ZZ*->4l







① ~ ③

Excluded four (almost 3) regions at 95% CL:
134-156, 182-233, 256-265, 268-415GeV
(Expected exclusion range 136-157GeV, 184-400GeV)

	m_H(GeV)	Local (global) p_0	Local significance	Expected
A	125	1.6% (~50%)	2.1σ	1.3σ
B	244	1.3% (~50%)	2.2σ	3.0σ
C	500	1.8% (~50%)	2.1σ	1.5σ

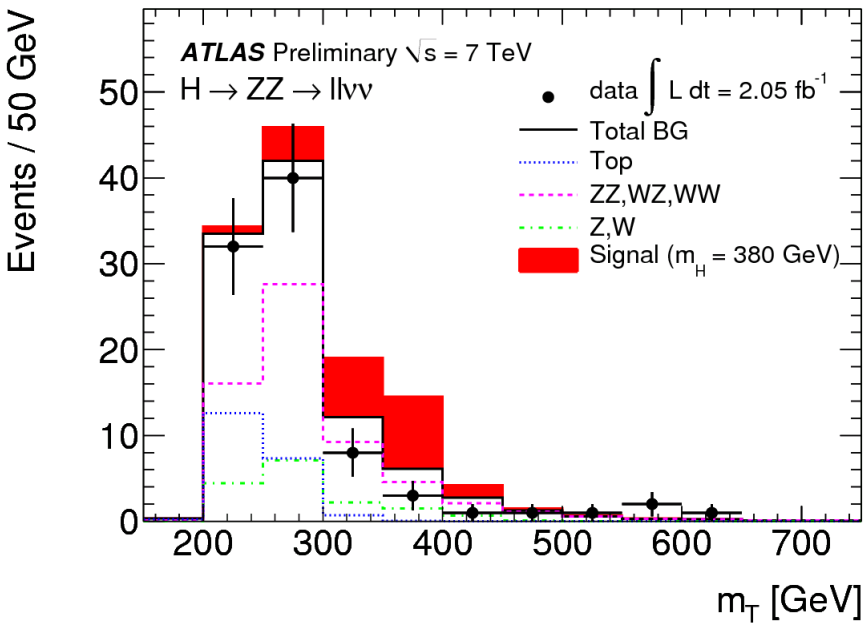
LEE(=look elsewhere effect) estimated over mass range: 110-600GeV

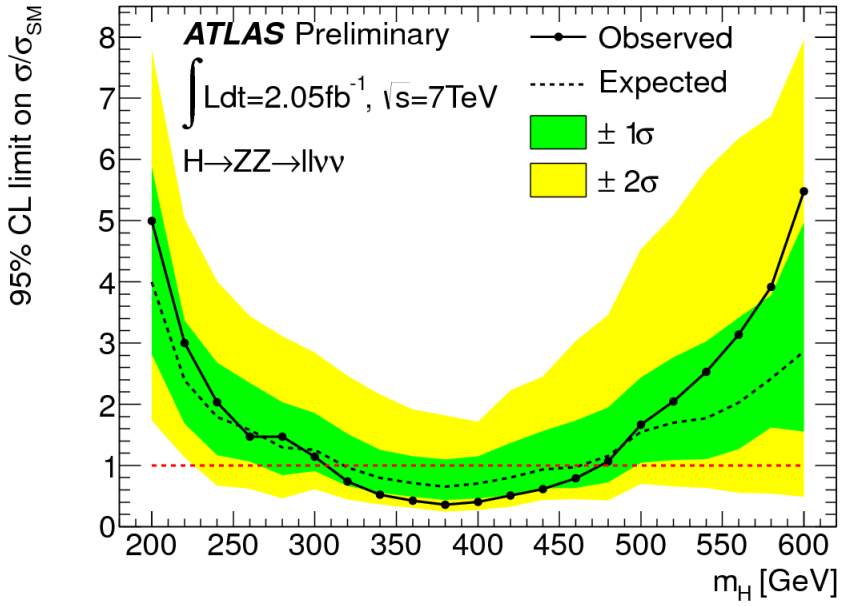
H->ZZ->llνν

ATLAS-CONF-2011-148

H->ZZ->llνν

- Most sensitive channel for m_H > 300GeV
- Signature is Z→ ll + large E_T^{miss}
- Main backgrounds: ZZ (irreducible), top, Z+jets
  - reject with E_T^{miss} cut, b-jet veto and topology
- $m_T(Z,E_T^{miss})$ discriminating variable





Excluded (95%CL): 310 < m_H < 470GeV

H->γγ

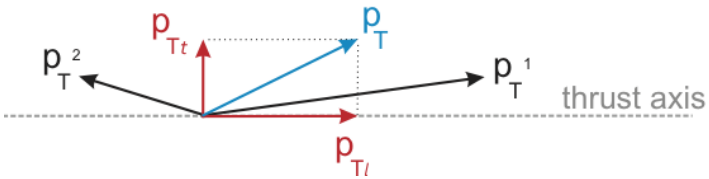
arXiv:1202.1414 (to PRL)

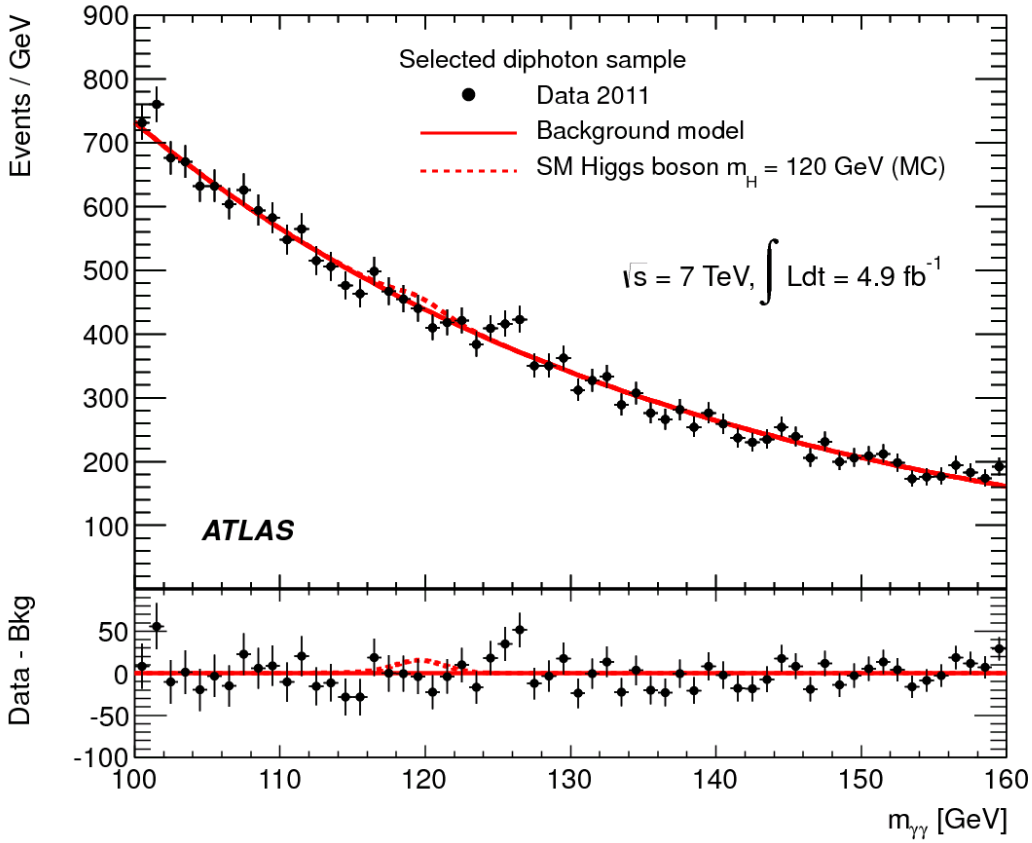
H->γγ

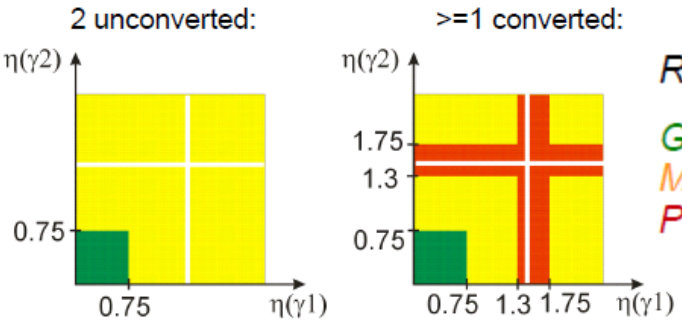
- Event selection
  - Two photon trigger
  - E_T>40GeV and 25GeV
  - Isolated tight photon

-> 22489 events in total (100<$m_{\gamma\gamma}$<160GeV)

- Improve sensitivity by introducing categories.
  -> "9" categories are defined by
  - Conversion status
  - Eta region
  - p_{Tt}=40GeV







Resolution:

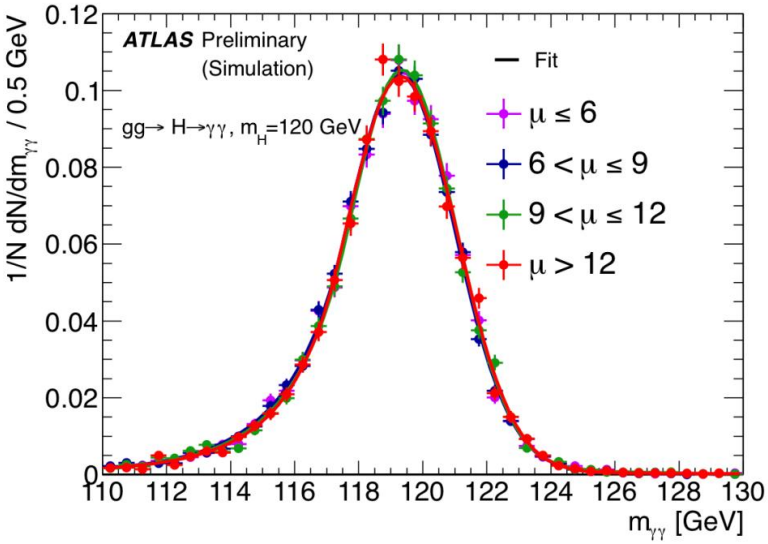
Good
Medium
Poor

-> different S/B

Mass Reconstruction

- Pileup effect on mass resolution is small because
  - Tracks are used for converted photons.
  - Layer structure of LAr EM calorimeter helps us to determine z-position of γγ production vertex.

    (we don't need primary vertex information, which is obtained from independent algorithm, for example, sum of track p_T associated to vertex.)

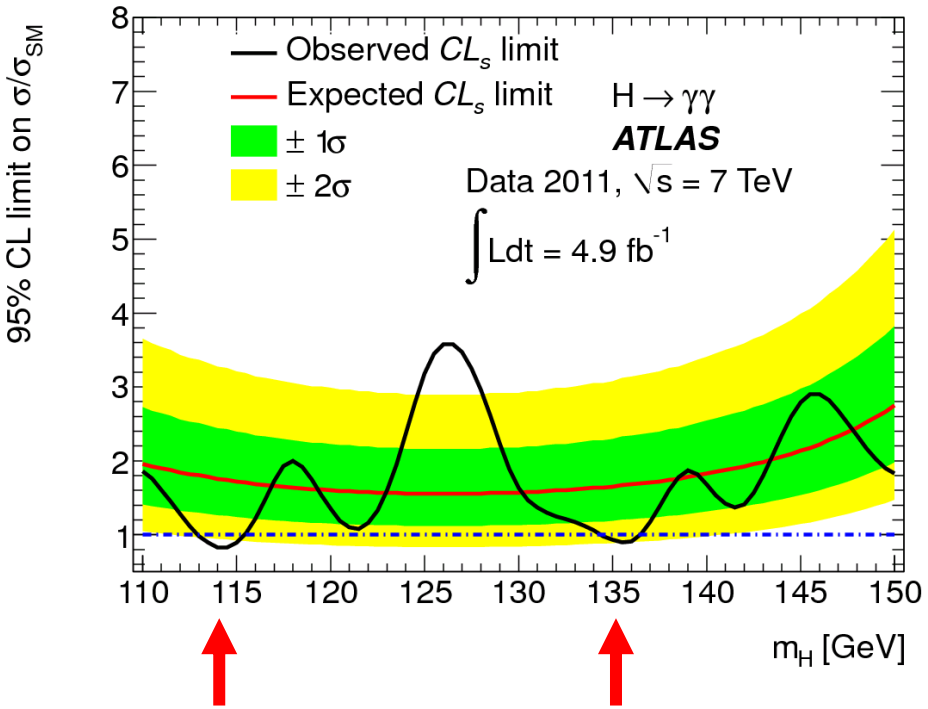


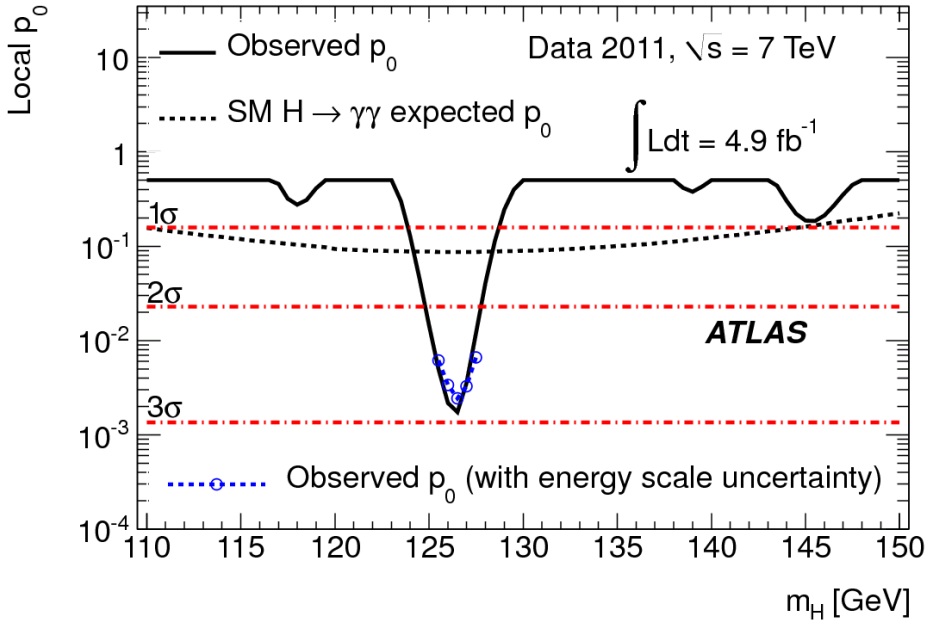
Category	σ_{CB}	FWHM	N_S	N_D	S/B
Unconverted central, low p_{Tt}	1.4	3.4	9.1	1763	0.05
Unconverted central, high p_{Tt}	1.4	3.3	2.6	235	0.11
Unconverted rest, low p_{Tt}	1.7	4.0	17.7	6234	0.02
Unconverted rest, high p_{Tt}	1.6	3.9	4.7	1006	0.04
Converted central, low p_{Tt}	1.6	3.9	6.0	1318	0.03
Converted central, high p_{Tt}	1.5	3.6	1.7	184	0.08
Converted rest, low p_{Tt}	2.0	4.7	17.0	7311	0.01
Converted rest, high p_{Tt}	1.9	4.5	4.8	1072	0.03
Converted transition	2.3	5.9	8.5	3366	0.01
All categories	1.7	4.1	72.1	22489	0.02

σ_{CB} (core width by crystal ball func) is 1.4-2.3GeV depending on categories.

S/B in **high p_{Tt}** is better than **low p_{Tt}**.

H->γγ





- Expected = 1.6-2.7 x SM Higgs
- Excluded = 113-115, 134.5-136GeV

LEP limit (114.4GeV)

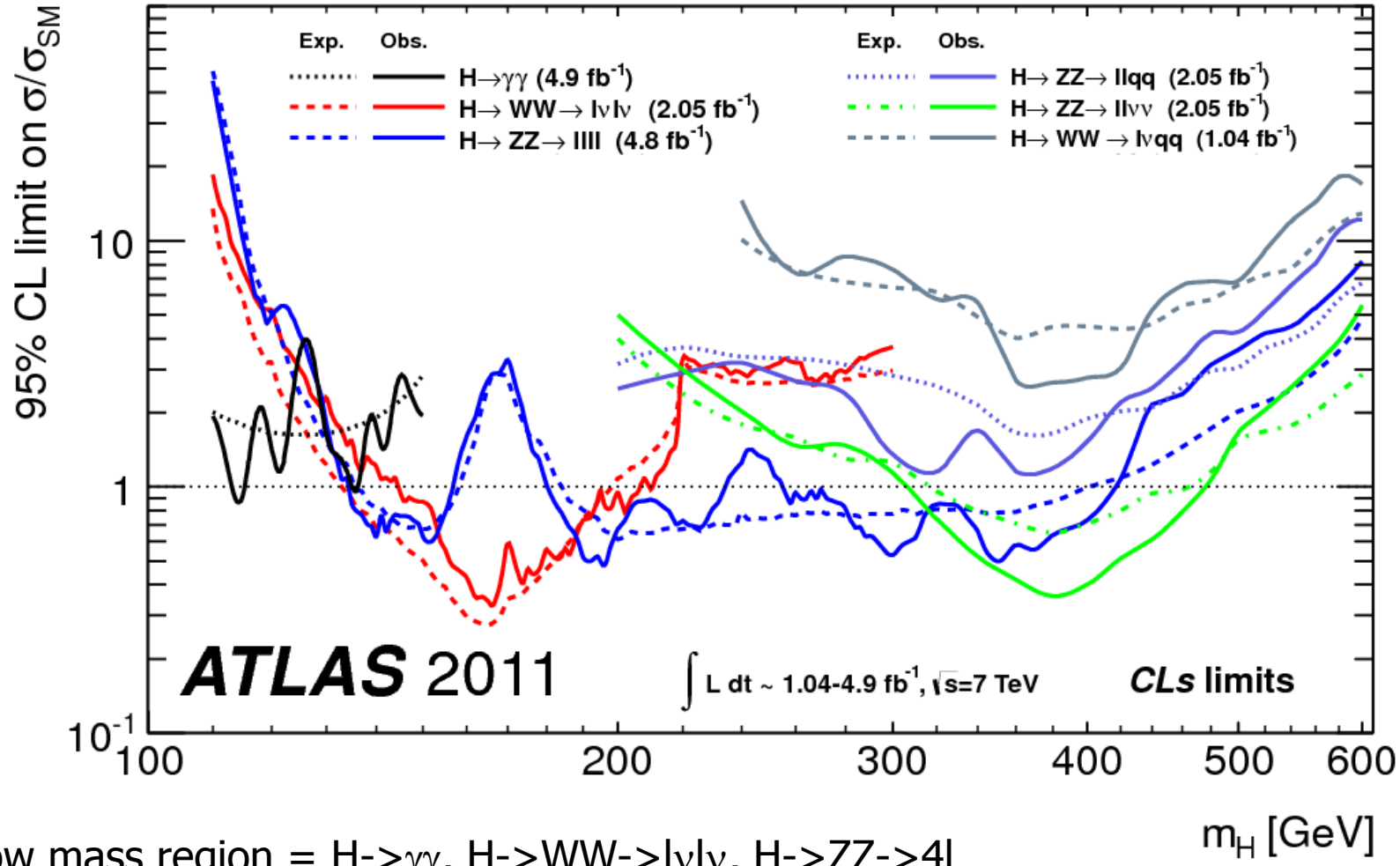
m_H=126.5GeV

- Local p-value = 0.17% -> **2.8σ** (expected 8.7%)
- **1.5σ** (after LEE 110-150GeV)

Combination

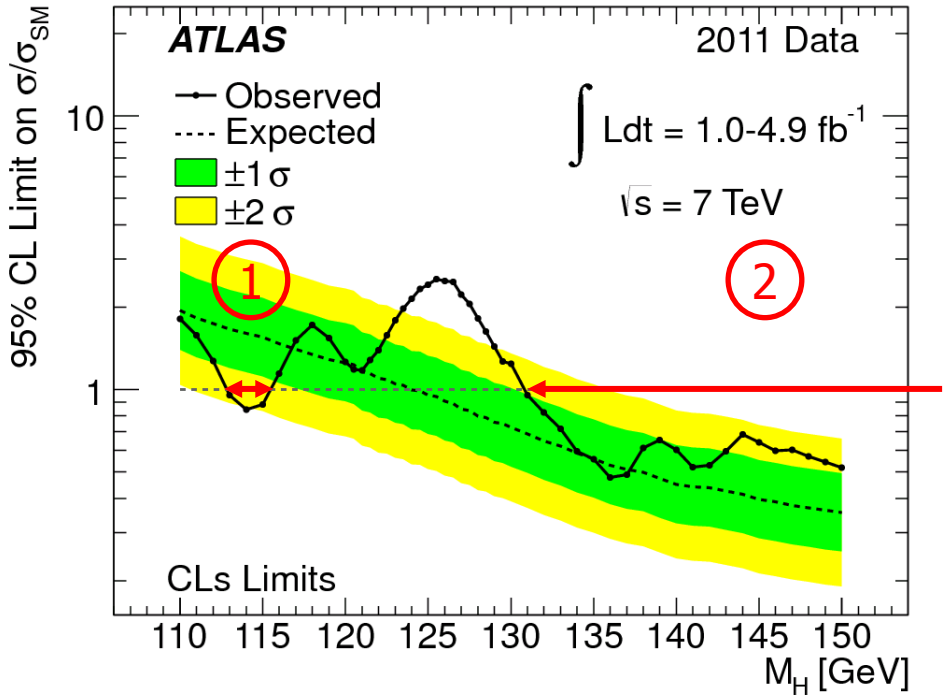
arXiv:1202.1408 (to PLB)

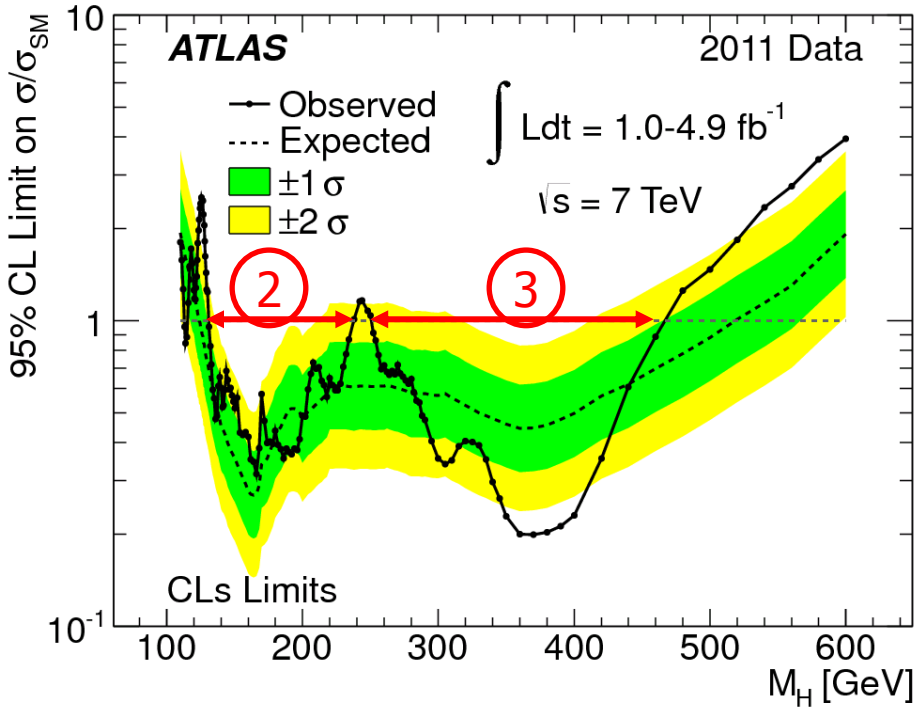
Individual channel



- Low mass region = H->γγ, H->WW->lνlν, H->ZZ->4l
- High mass region = H->ZZ->llνν, H->ZZ->llqq, H->WW->lνqq

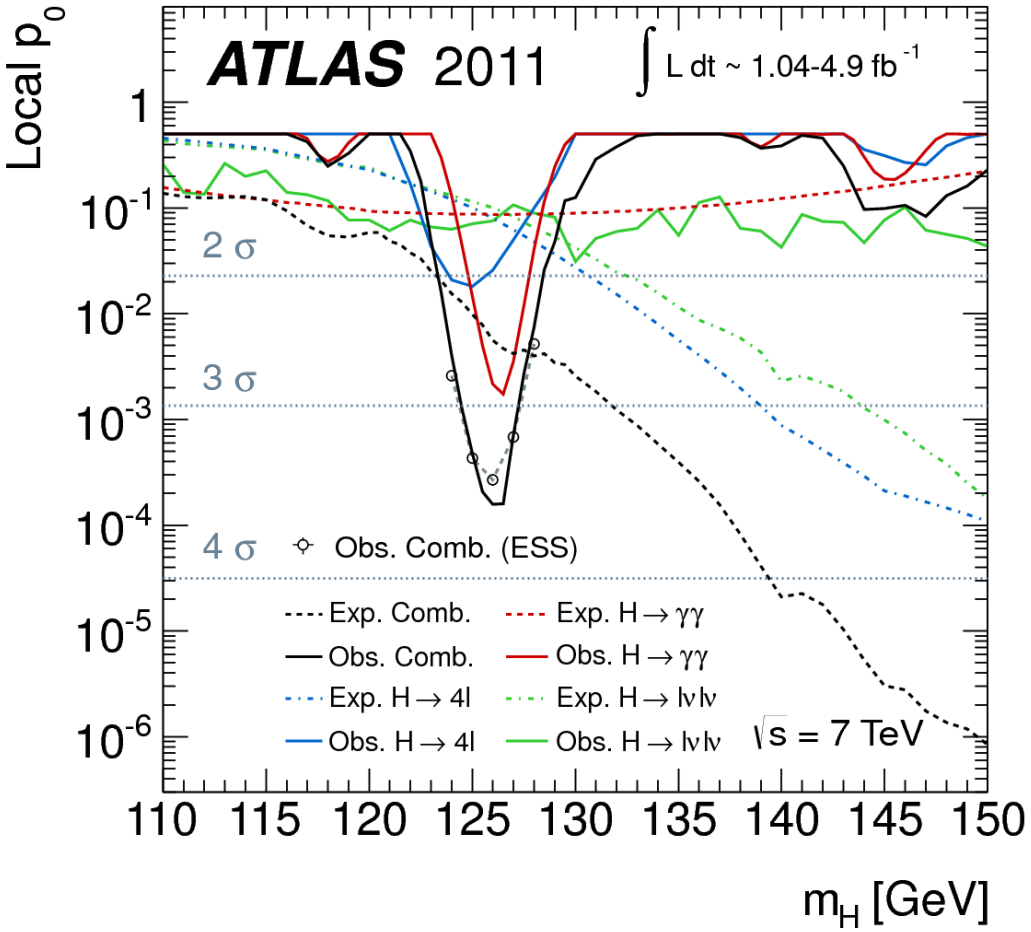
Exclusion Limit





- Expected limit : 124 < m_H < 519GeV
- Observed limit
  - 95%: 112.9 < m_H < 115.5GeV, 131 <m_H < 238GeV , 251 <m_H < 466GeV
  - 99%: 133 < m_H < 230GeV, 260 < m_H < 437GeV

Excess at 126GeV

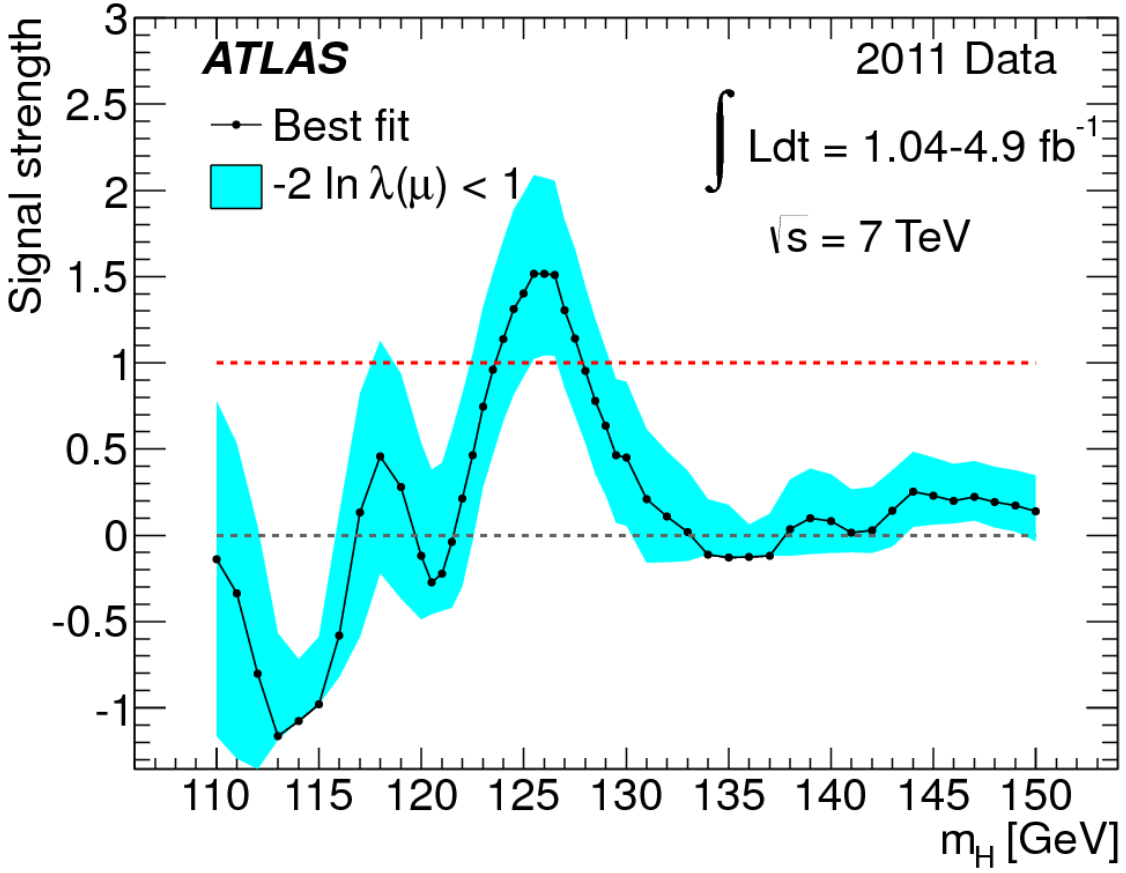


Local p_0-value (126GeV)
- H->γγ 2.8σ
- H->ZZ->4l 2.1σ
- H->WW->lνlν 1.4σ

126GeV Local p_0-value: 0.019% -> **3.5σ** (with energy scale) (expected ~2.5σ)
Global p_0-value: 0.6% -> **2.5σ** with LEE over 114-146GeV
Global p_0-value: 1.4% -> **2.2σ** with LEE over 110-600GeV

Best "μ" for SM Higgs

Consistency with SM Higgs.
(If μ~1, our observed events would be consistent with SM Higgs.)



126GeV, $\mu = 1.5^{+0.6}_{-0.5}$

Summary & Prospect

- **Higgs search at LHC/ATLAS is very exciting now!**
  - ATLAS still have several channels (WW/ττ/bb etc) to be updated.
  -> Wait for new results until Morinod conf.

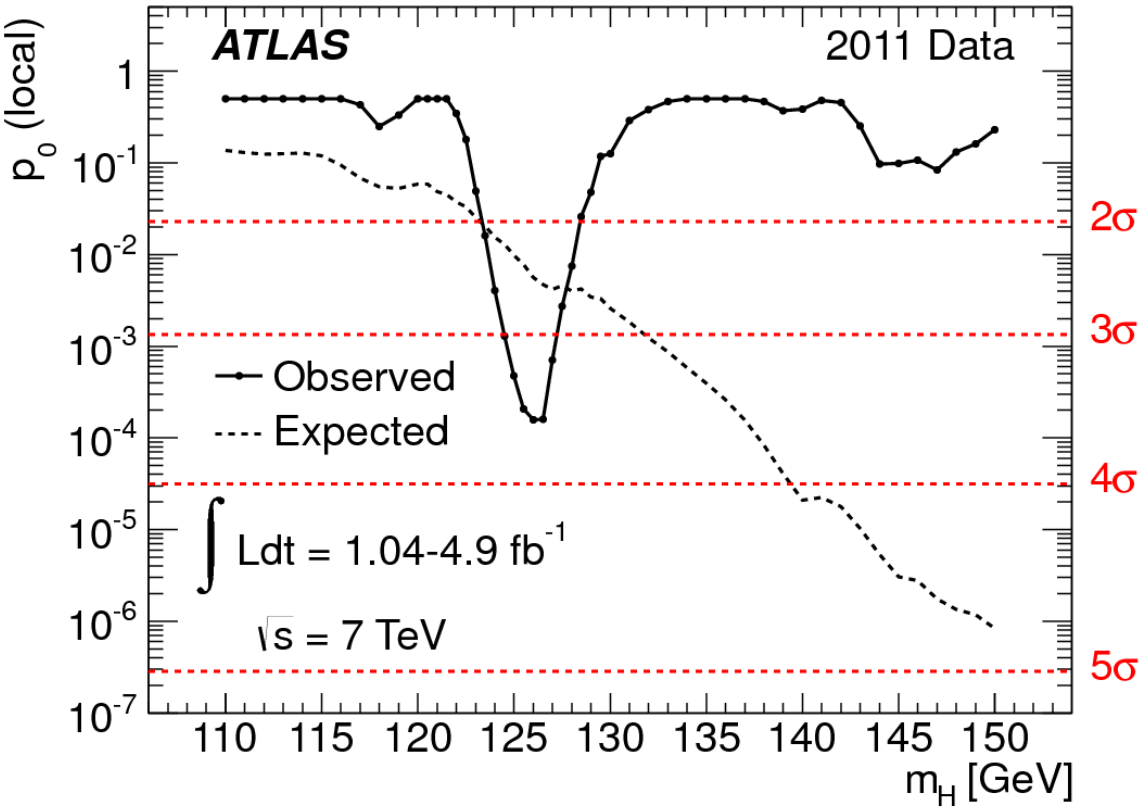
- In the low mass region, we have a small un-excluded mass window of **115.5-131GeV.**

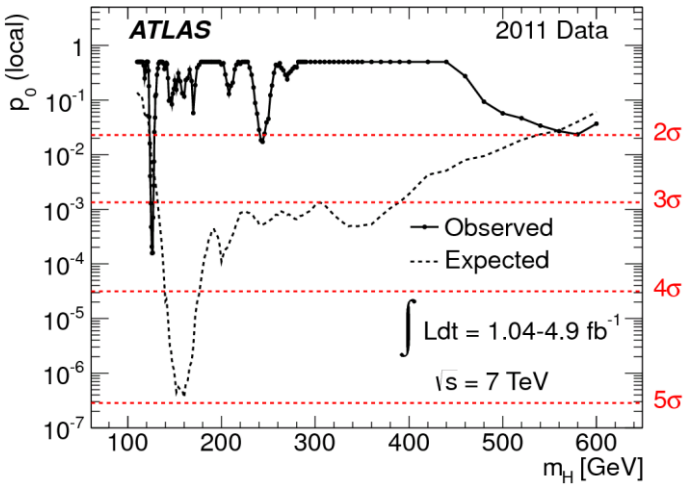
- Small excess around 126GeV is real? -> **No conclusion at the moment**
  -> Still ~2-3 sigma level with the look elsewhere effect.
  -> We need more data in this year.

- **"Additional ~15 fb^{-1}"** with **8TeV** in 2012 per one experiment
  -> **5σ discovery for 120-131GeV!**
  -> **Exclusion of the remaining low mass region (115.5-131GeV)!**

Backup

Excess at 126GeV



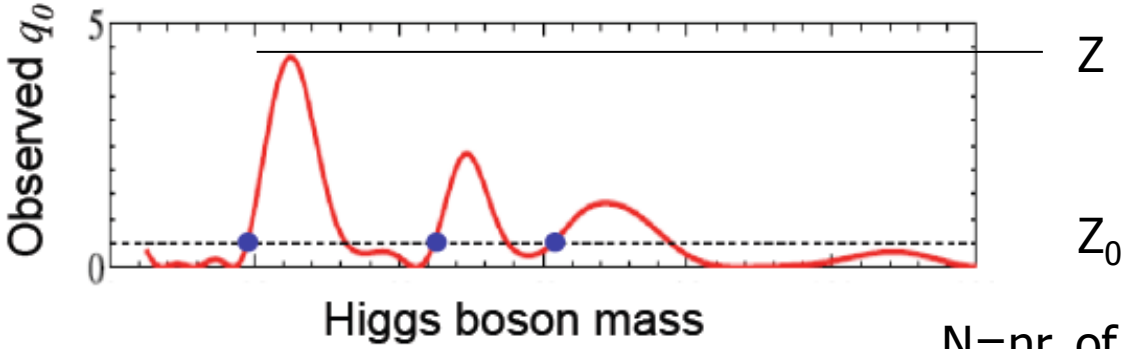


126GeV Local p_0-value: 0.019% -> 3.5σ (with energy scale) (expected ~2.5σ)
Global p_0-value: 0.6% -> 2.5σ with LEE over 114-146GeV
Global p_0-value: 1.4% -> 2.2σ with LEE over 110-600GeV

LEE=look elsewhere effect (important for channels having a good resolution γγ,4l)

Look elsewhere effect

When we search for a new particle ("unknown" mass),
we could have local excesses due to stat. fluctuation in a search mass range.
Such possibility should be taken into account properly to claim the observation.
This effect is important in searches for a narrow resonance in a wide mass range.



N=nr. of up-crossings

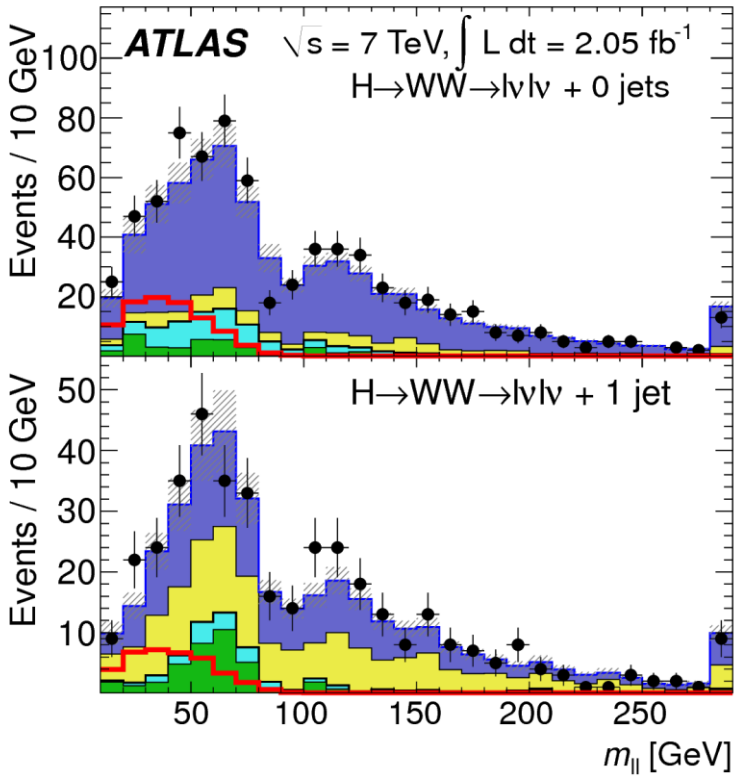
$$p_{global} = p_{local} + Ne^{-(Z^2 - Z_0^2)/2}$$

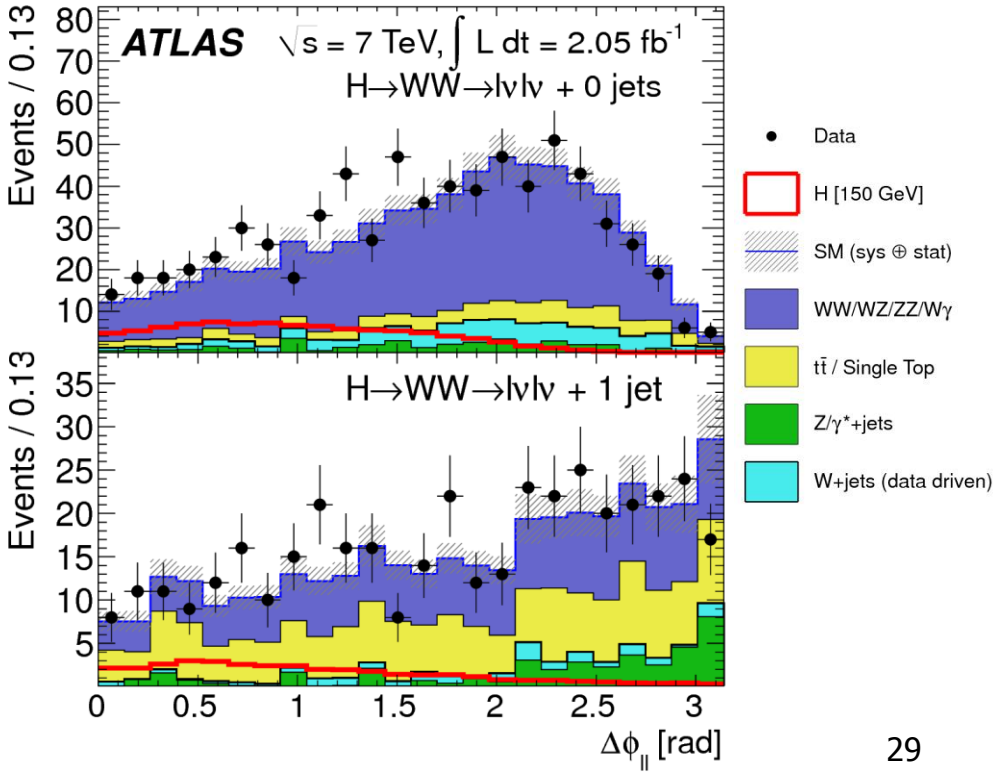
E. Gross and O. Vitells (Eur. Phys. J. C70 525, 2010)

m_H=150GeV

$H+0$-jet Channel	Signal	WW	$W+$jets	Z/γ^*+jets	$t\bar{t}$	$tW/tb/tqb$	$WZ/ZZ/W\gamma$	Total Bkg.	Observed
Jet Veto	99 ± 21	524 ± 52	84 ± 41	174 ± 169	42 ± 14	32 ± 8	15 ± 4	872 ± 182	920
$p_T^{\ell\ell}>30$ GeV	95 ± 20	467 ± 45	69 ± 34	30 ± 12	39 ± 14	29 ± 8	13 ± 4	648 ± 60	700
$m_{\ell\ell}<50$ GeV	68 ± 15	118 ± 15	21 ± 8	13 ± 8	7 ± 4	5.8 ± 1.8	1.9 ± 0.6	166 ± 19	199
$\Delta\phi_{\ell\ell}<1.3$	58 ± 13	91 ± 12	12 ± 5	9 ± 6	6 ± 3	5.8 ± 1.8	1.7 ± 0.6	125 ± 15	149
$0.75\,m_H<m_T<m_H$	40 ± 9	52 ± 7	5 ± 2	2 ± 4	2.4 ± 1.6	1.5 ± 1.0	1.1 ± 0.5	63 ± 9	81
$H+1$-jet Channel	Signal	WW	$W+$jets	Z/γ^*+jets	$t\bar{t}$	$tW/tb/tqb$	$WZ/ZZ/W\gamma$	Total Bkg.	Observed
1 jet	50 ± 9	193 ± 20	38 ± 21	74 ± 65	473 ± 124	174 ± 26	14 ± 2	967 ± 145	952
b-jet veto	48 ± 9	188 ± 19	35 ± 19	73 ± 61	174 ± 49	66 ± 11	14 ± 2	549 ± 83	564
$\lvert\mathbf{p}_T^{tot}\rvert<30$ GeV	39 ± 7	154 ± 16	18 ± 9	38 ± 32	106 ± 30	50 ± 9	9.7 ± 1.5	376 ± 48	405
$Z\to\tau\tau$ veto	39 ± 7	150 ± 17	18 ± 8	34 ± 23	102 ± 23	48 ± 8	9 ± 2	361 ± 38	388
$m_{\ell\ell}<50$ GeV	26 ± 6	33 ± 5	3.3 ± 1.4	8 ± 7	20 ± 7	11 ± 3	1.8 ± 0.5	77 ± 12	90
$\Delta\phi_{\ell\ell}<1.3$	23 ± 5	25 ± 4	2.1 ± 1.0	4 ± 6	17 ± 6	9 ± 3	1.5 ± 0.4	60 ± 10	72
$0.75\,m_H<m_T<m_H$	14 ± 3	12 ± 3	0.9 ± 0.4	1.3 ± 1.9	8 ± 2	4.0 ± 1.6	0.7 ± 0.3	28 ± 4	29

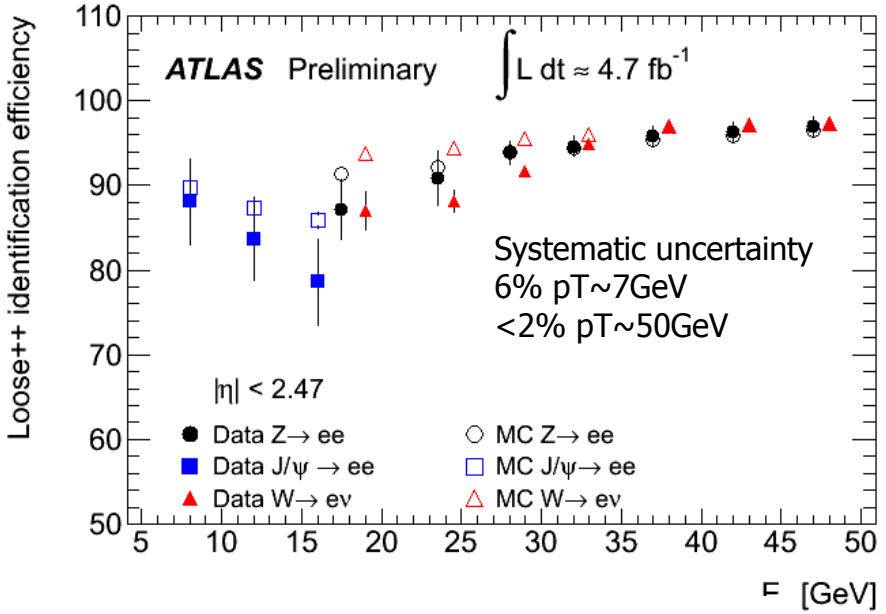
Before mll cut



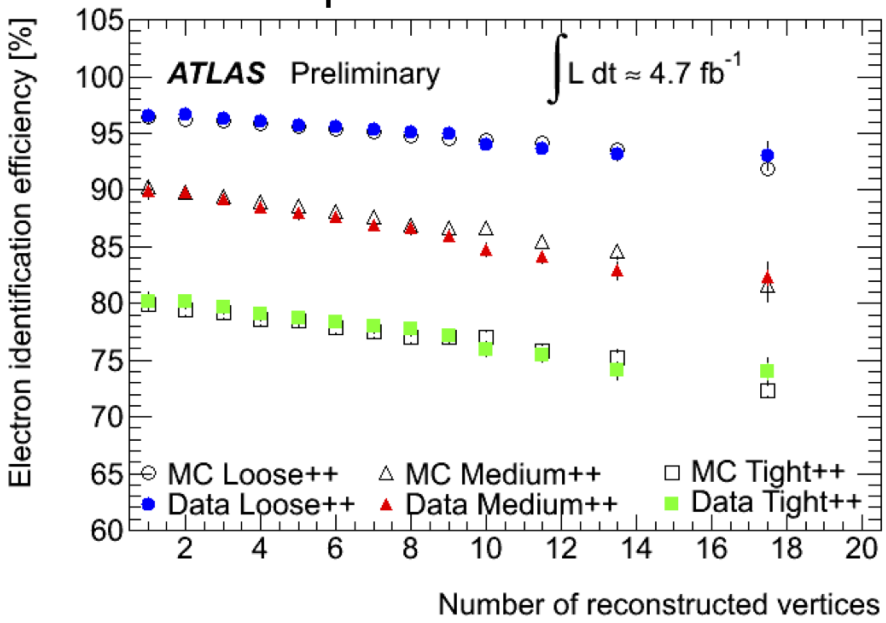


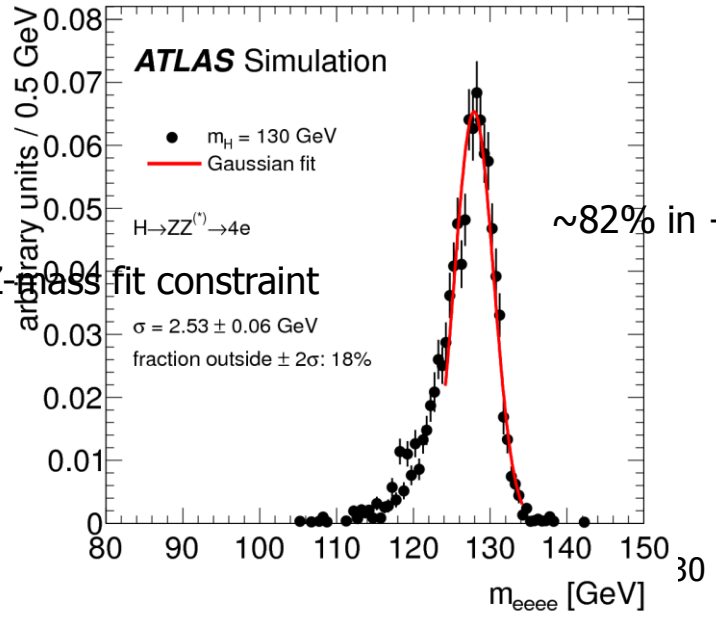
Electron Performance

- J/Ψ->ee, W->eν and Z->ee
  - Challenging->Low pT electrons



Pileup effect with Z->ee



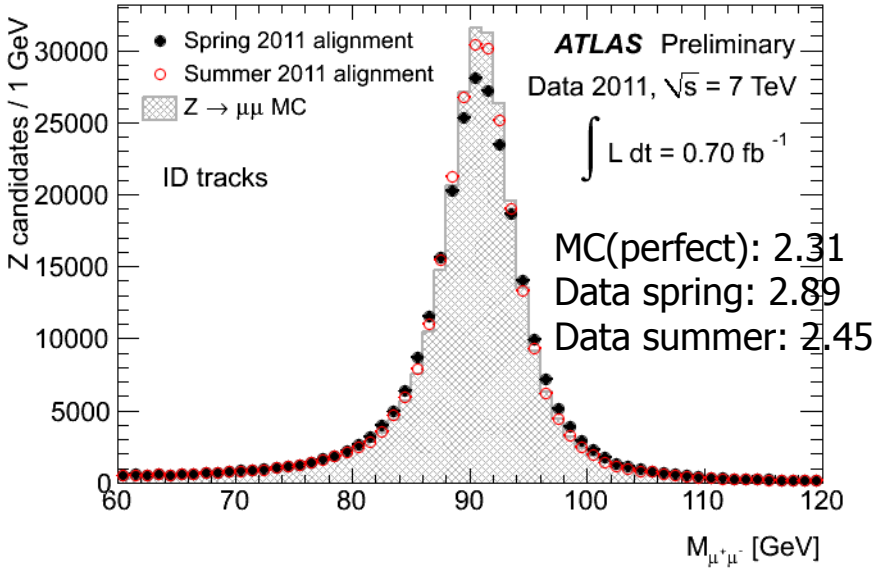


No Z-mass fit constraint

~82% in +-2σ

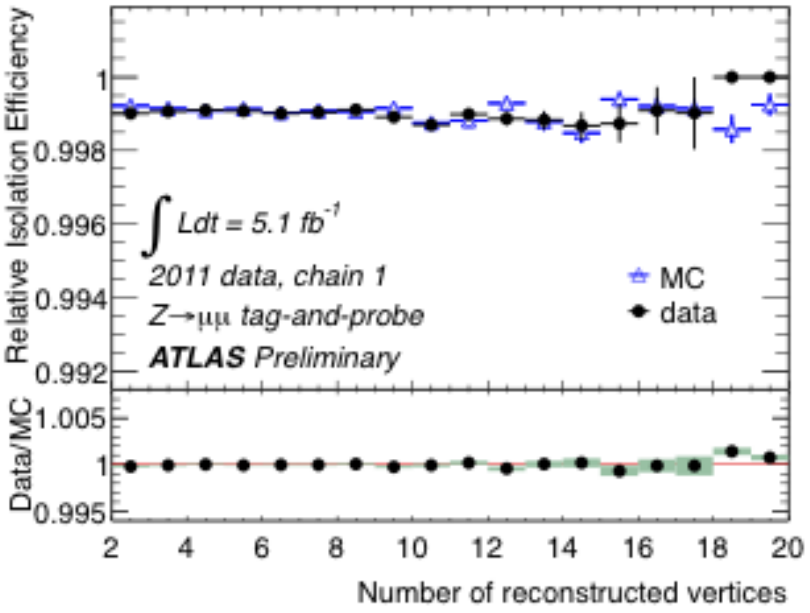
Muon Performance

- Z->μμ
- Muon rec eff > 95% (4<p_T<100GeV)

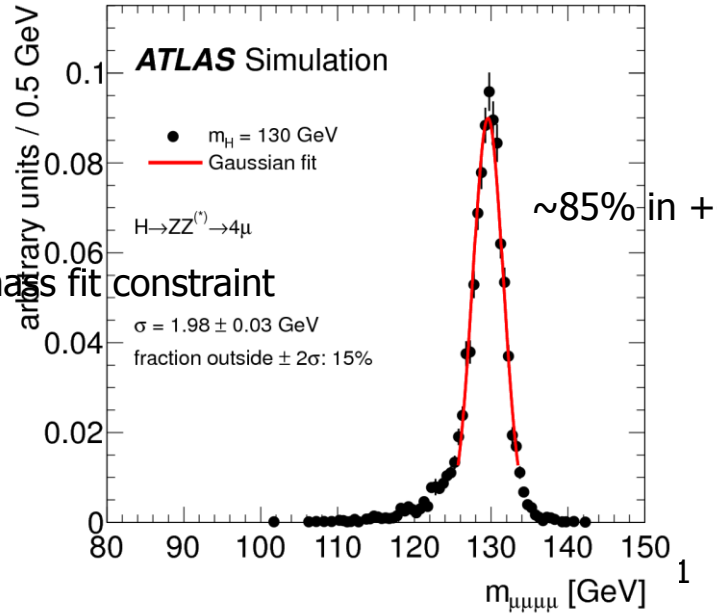


MC(perfect): 2.31
Data spring: 2.89
Data summer: 2.45

Pileup effect with Z->μμ



No Z-mass fit constraint

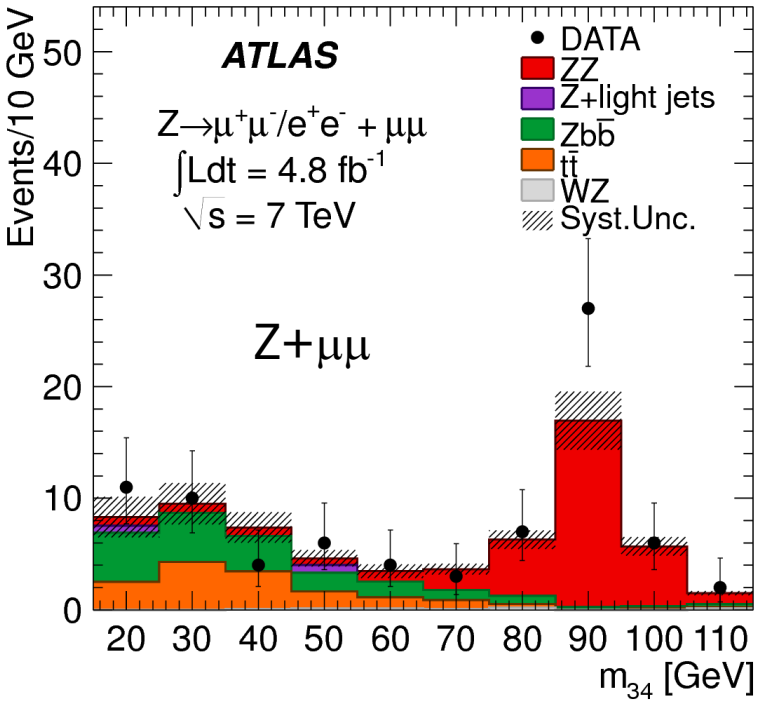


~85% in +-2σ

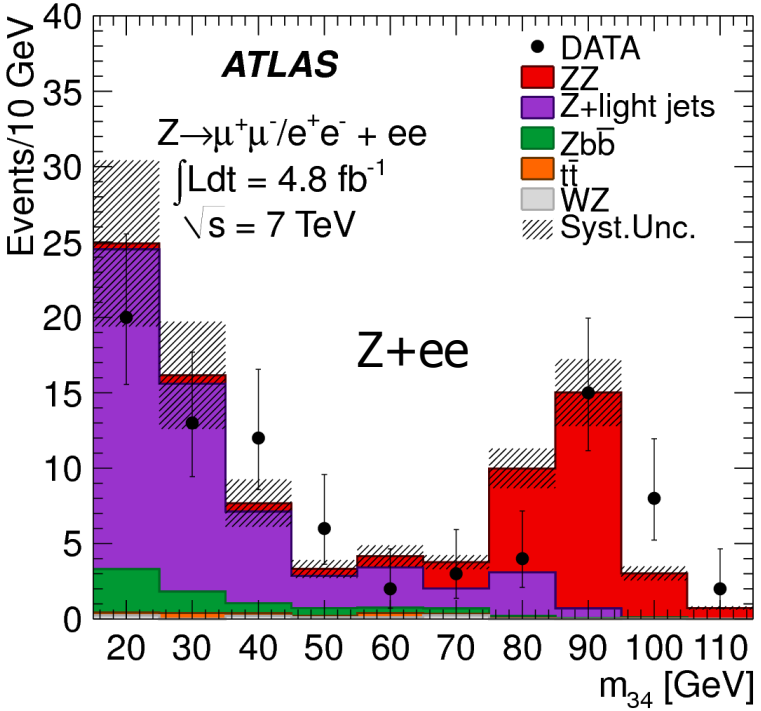
	$\mu^+\mu^-\mu^+\mu^-$		$e^+e^-\mu^+\mu^-$		$e^+e^-e^+e^-$	
	Low-$m_{4\ell}$	High-$m_{4\ell}$	Low-$m_{4\ell}$	High-$m_{4\ell}$	Low-$m_{4\ell}$	High-$m_{4\ell}$(>180GeV)
Int. Luminosity	4.8 fb^{-1}		4.8 fb^{-1}		4.9 fb^{-1}	
$ZZ^{(*)}$	2.1 ± 0.3	16.3 ± 2.4	2.8 ± 0.6	25.2 ± 3.8	1.2 ± 0.3	10.4 ± 1.5
$Z+$ jets and $t\bar{t}$	0.16 ± 0.06	0.02 ± 0.01	1.4 ± 0.5	0.17 ± 0.08	1.6 ± 0.7	0.18 ± 0.08
Total Background	2.2 ± 0.3	16.3 ± 2.4	4.3 ± 0.8	25.4 ± 3.8	2.8 ± 0.8	10.6 ± 1.5
Data	3	21	3	27	2	15
$m_H = 130$ GeV	1.00 ± 0.17		1.22 ± 0.21		0.43 ± 0.08	
$m_H = 150$ GeV	2.1 ± 0.4		2.9 ± 0.4		1.12 ± 0.18	
$m_H = 200$ GeV	4.9 ± 0.7		7.7 ± 1.0		3.1 ± 0.4	
$m_H = 400$ GeV	2.0 ± 0.3		3.3 ± 0.5		1.49 ± 0.21	
$m_H = 600$ GeV	0.34 ± 0.04		0.62 ± 0.10		0.30 ± 0.06	

BG check

Z+jets, where jets fakes leptons.
- 2 OS same-flavor with m_Z+-15GeV
- 2 additional SF leptons passing all cuts except for isolation and impact param.

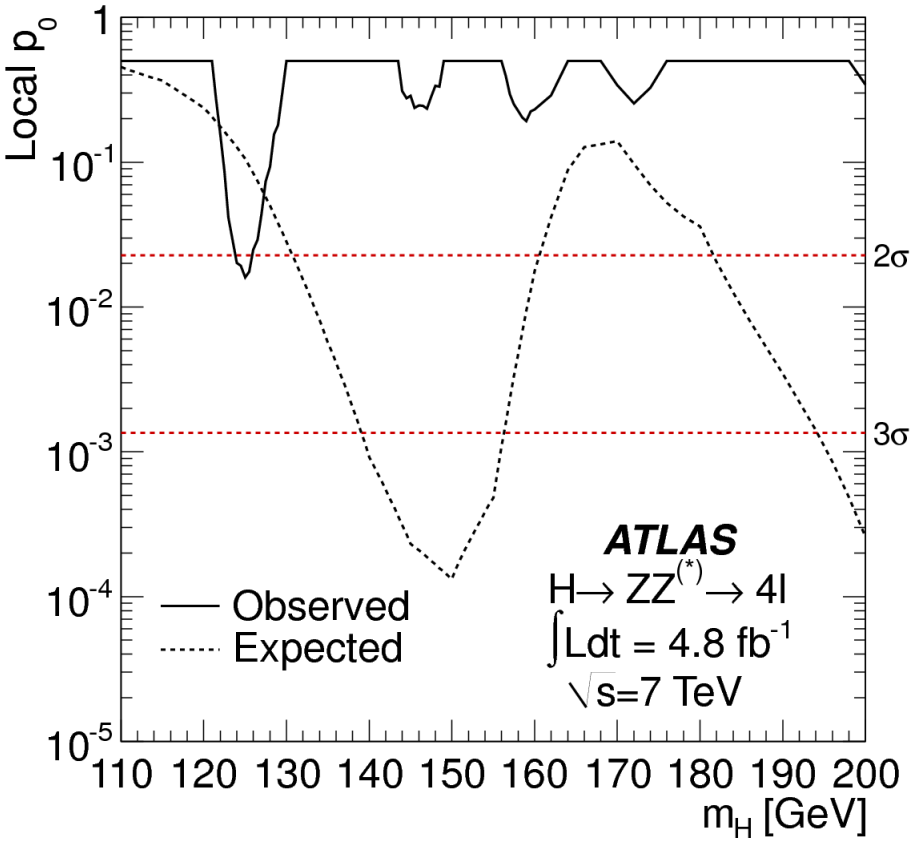


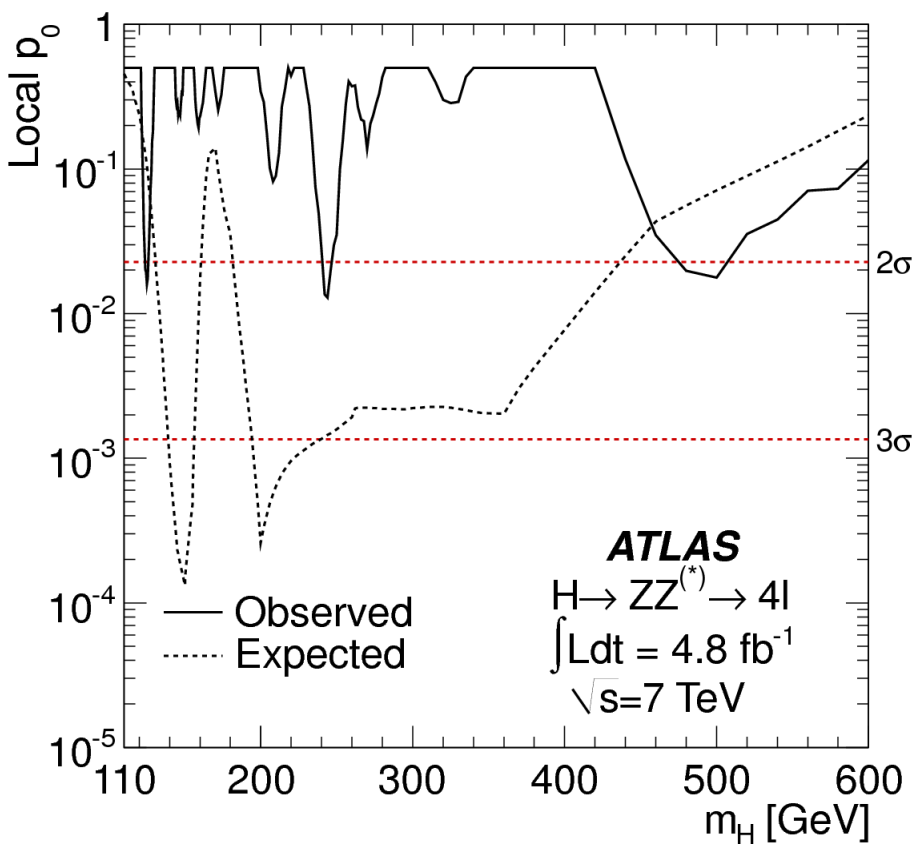
b -> μ



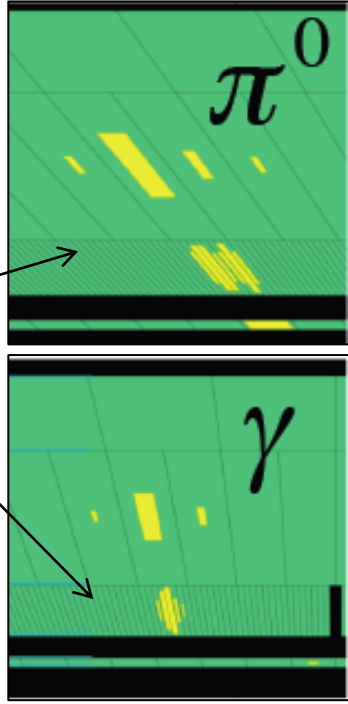
Jet -> e (π^{+-}+π^0)
b -> e

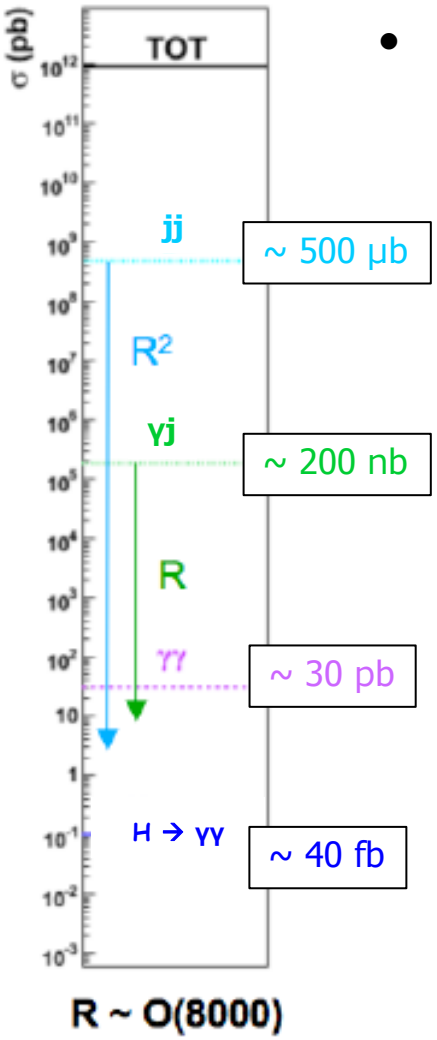
H->ZZ->4l


Local p_0
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
2σ
3σ
Observed
Expected
ATLAS
$H\rightarrow ZZ^{(*)}\rightarrow 4l$
$\int Ldt = 4.8\ fb^{-1}$
$\sqrt{s}$=7 TeV
110 120 130 140 150 160 170 180 190 200
m_H [GeV]

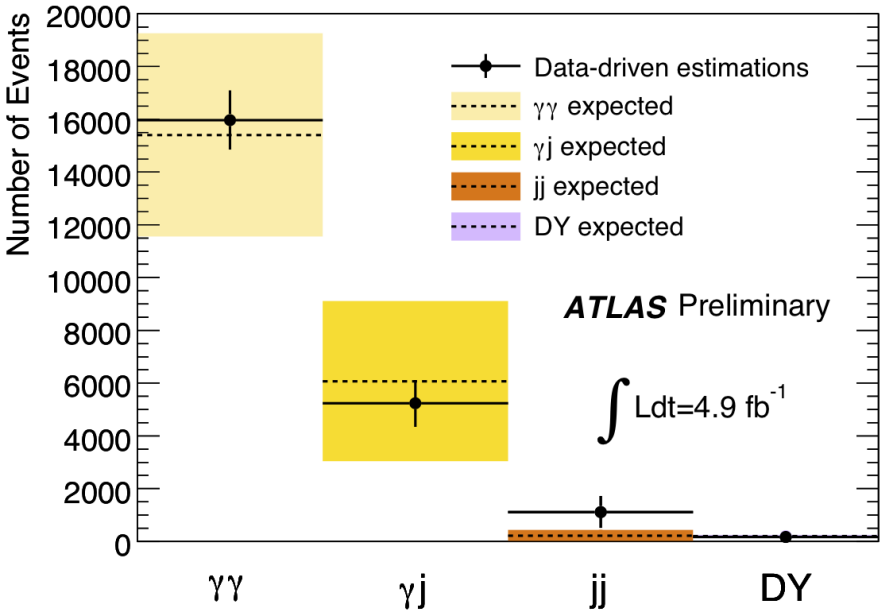

Local p_0
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
2σ
3σ
Observed
Expected
ATLAS
$H\rightarrow ZZ^{(*)}\rightarrow 4l$
$\int Ldt = 4.8\ fb^{-1}$
$\sqrt{s}$=7 TeV
110 200 300 400 500 600
m_H [GeV]

Background



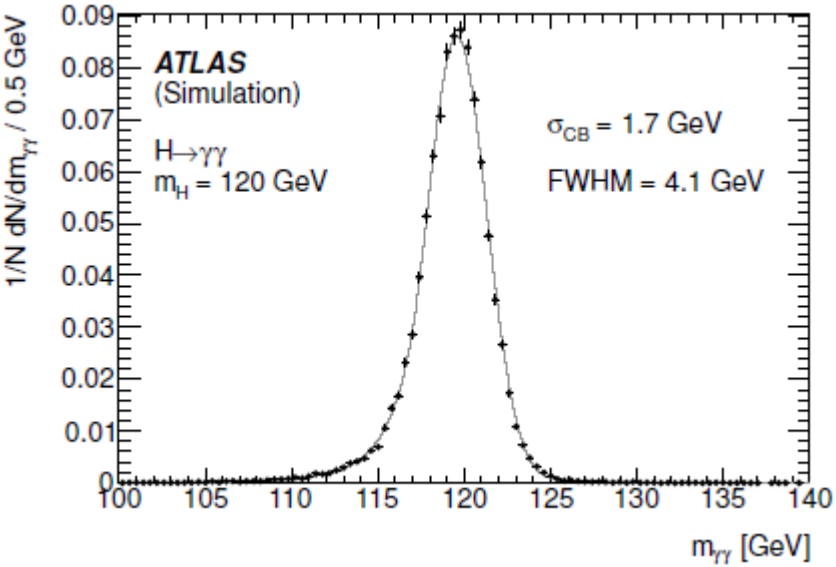


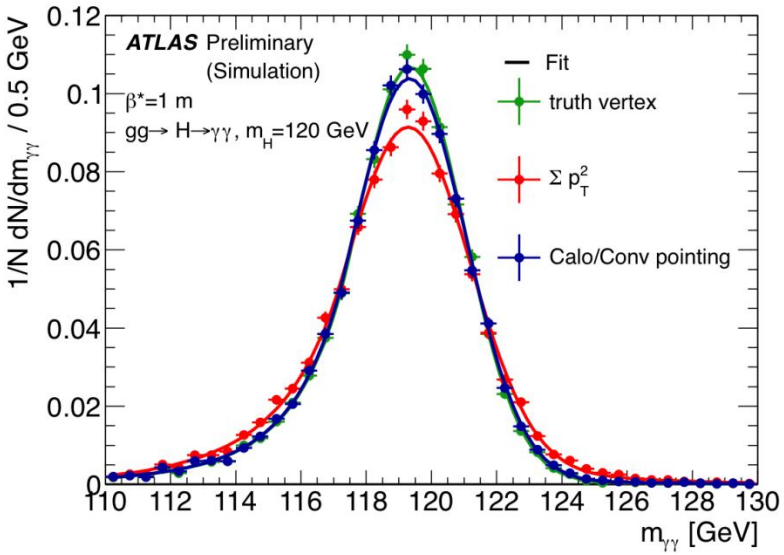
- Processes = γγ, γj and jj
  - Fake photon jet->π^0
    - 1/~10^4 (gluon>quark)(MC)

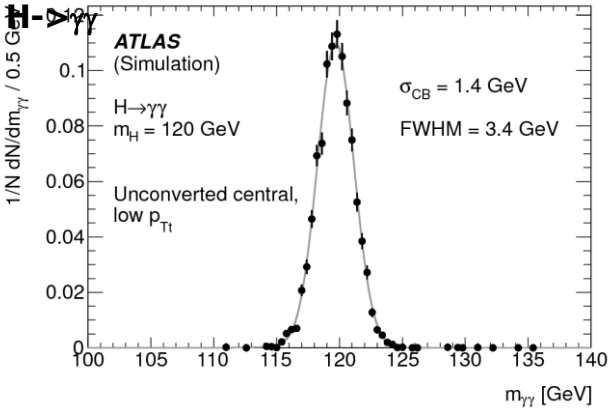


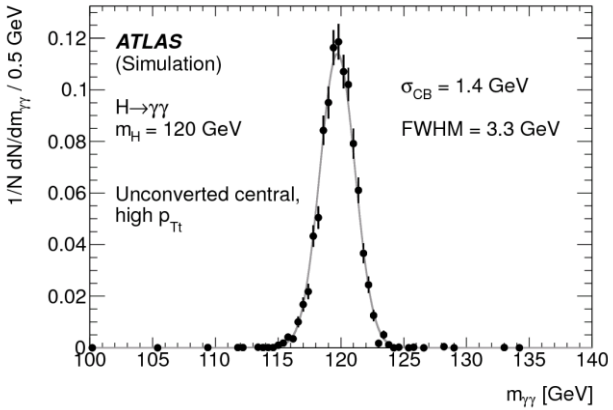
	$\gamma\gamma$	γj	jj	Drell-Yan
Events	16000 ± 1100	5230 ± 890	1130 ± 600	165 ± 8
Fraction	$(71 \pm 5)\,\%$	$(23 \pm 4)\,\%$	$(5 \pm 3)\,\%$	$(0.7 \pm 0.1)\,\%$

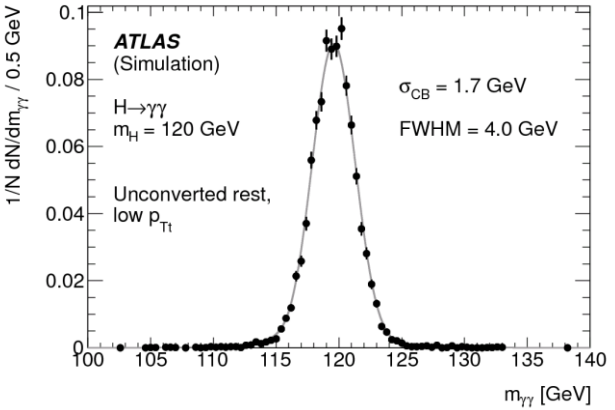
m_H [GeV]	110	115	120	125	130	135	140	145	150
$\sigma \times BR$ [fb]	45	44	43	40	36	32	27	22	16
Signal events	69	72	72	69	65	58	50	41	31
Efficiency [%]	31	33	34	35	37	37	38	38	39

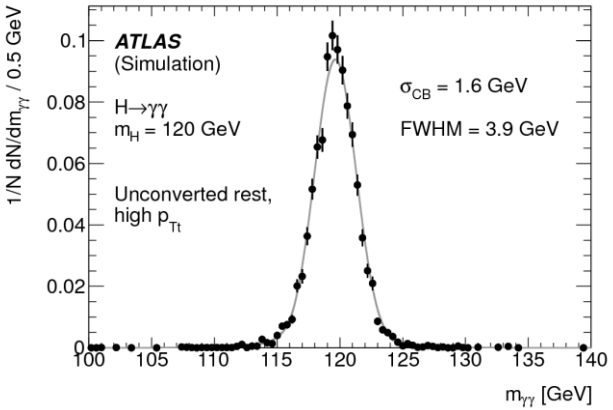


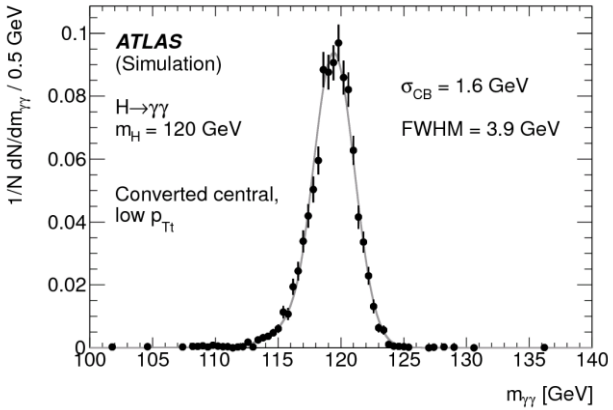


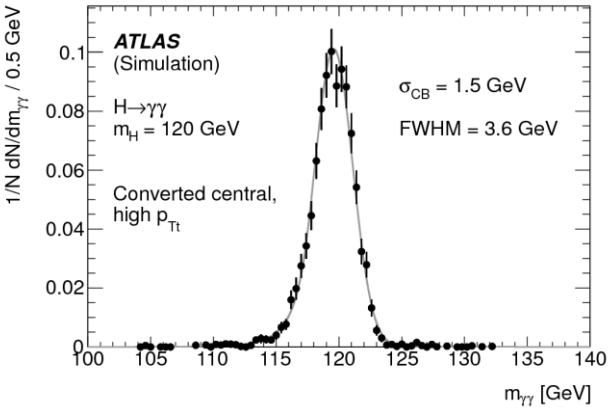

ATLAS
(Simulation)
H→γγ
m_H = 120 GeV
Unconverted central,
low p_Tt
σ_CB = 1.4 GeV
FWHM = 3.4 GeV
1/N dN/dm_γγ / 0.5 GeV
m_γγ [GeV]

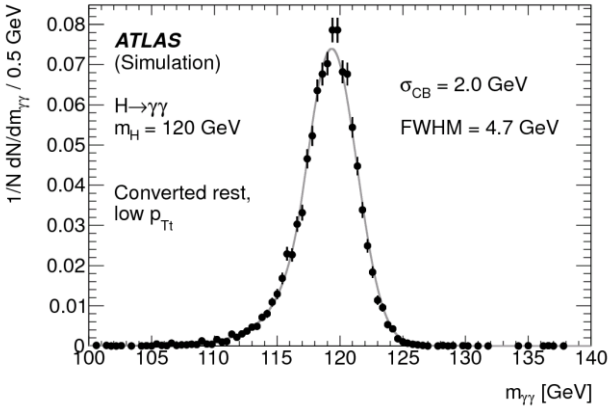

ATLAS
(Simulation)
H→γγ
m_H = 120 GeV
Unconverted central,
high p_Tt
σ_CB = 1.4 GeV
FWHM = 3.3 GeV
1/N dN/dm_γγ / 0.5 GeV
m_γγ [GeV]

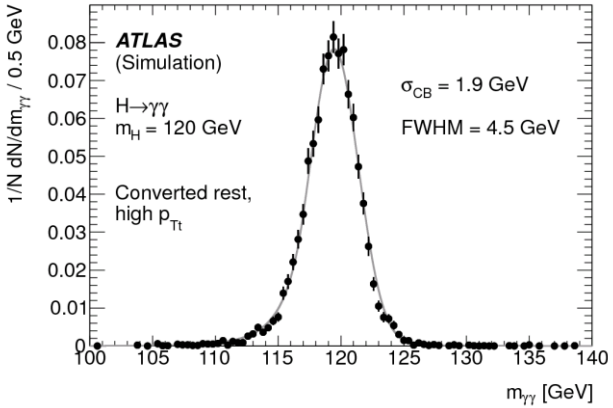

ATLAS
(Simulation)
H→γγ
m_H = 120 GeV
Unconverted rest,
low p_Tt
σ_CB = 1.7 GeV
FWHM = 4.0 GeV
1/N dN/dm_γγ / 0.5 GeV
m_γγ [GeV]

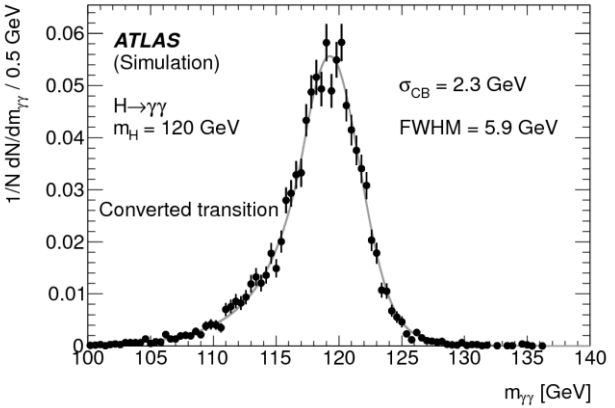

ATLAS
(Simulation)
H→γγ
m_H = 120 GeV
Unconverted rest,
high p_Tt
σ_CB = 1.6 GeV
FWHM = 3.9 GeV
1/N dN/dm_γγ / 0.5 GeV
m_γγ [GeV]


ATLAS
(Simulation)
H→γγ
m_H = 120 GeV
Converted central,
low p_Tt
σ_CB = 1.6 GeV
FWHM = 3.9 GeV
1/N dN/dm_γγ / 0.5 GeV
m_γγ [GeV]


ATLAS
(Simulation)
H→γγ
m_H = 120 GeV
Converted central,
high p_Tt
σ_CB = 1.5 GeV
FWHM = 3.6 GeV
1/N dN/dm_γγ / 0.5 GeV
m_γγ [GeV]

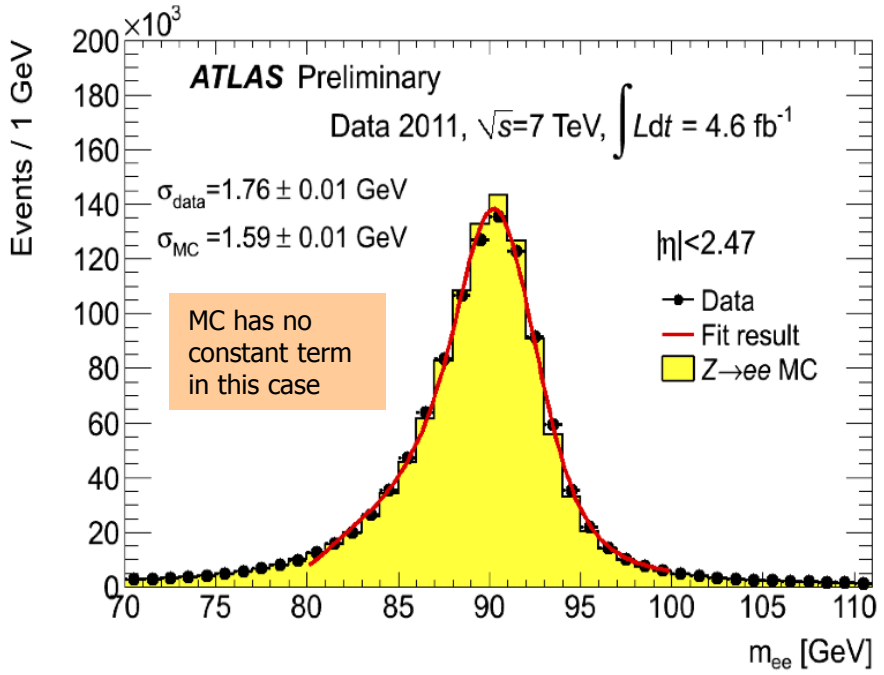

ATLAS
(Simulation)
H→γγ
m_H = 120 GeV
Converted rest,
low p_Tt
σ_CB = 2.0 GeV
FWHM = 4.7 GeV
1/N dN/dm_γγ / 0.5 GeV
m_γγ [GeV]

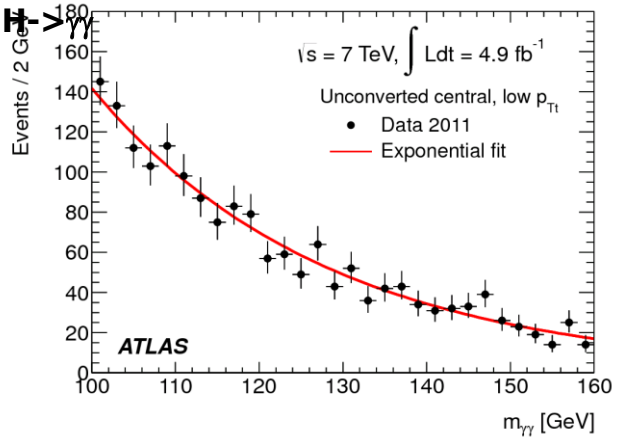

ATLAS
(Simulation)
H→γγ
m_H = 120 GeV
Converted rest,
high p_Tt
σ_CB = 1.9 GeV
FWHM = 4.5 GeV
1/N dN/dm_γγ / 0.5 GeV
m_γγ [GeV]

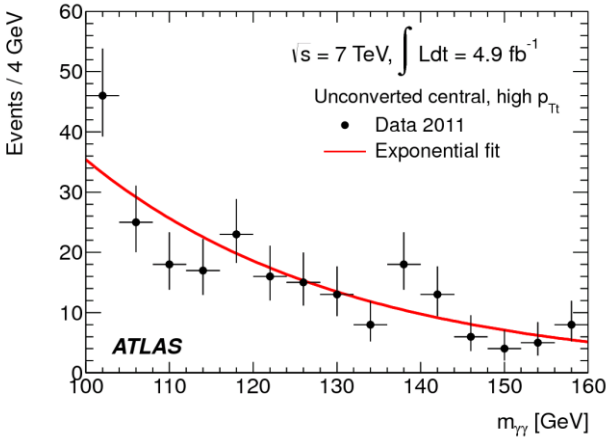

ATLAS
(Simulation)
H→γγ
m_H = 120 GeV
Converted transition
σ_CB = 2.3 GeV
FWHM = 5.9 GeV
1/N dN/dm_γγ / 0.5 GeV
m_γγ [GeV]

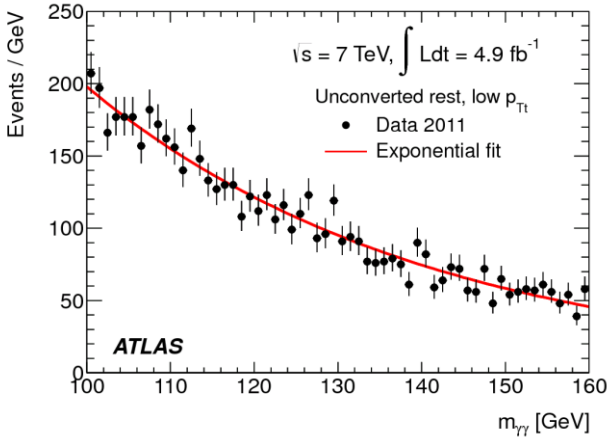
Energy Calibration

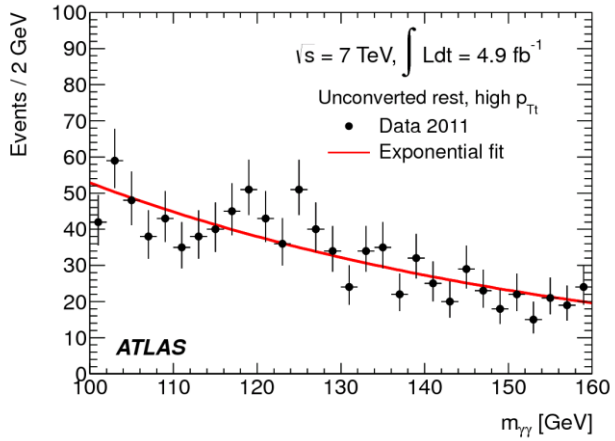
- Z->ee, J/Ψ->ee, W->eν and MC
  - Energy scale at m_Z ~ 0.5%
  - Linearity < 1%
  - Uniformity (constant term) ~1% for barrel and ~1.7% for endcap
- "Electron -> photon" by using MC

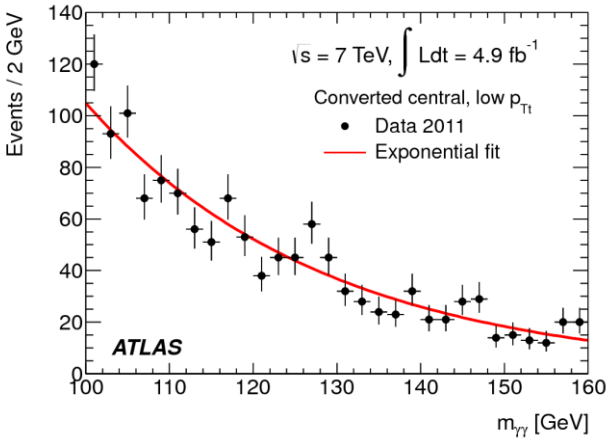


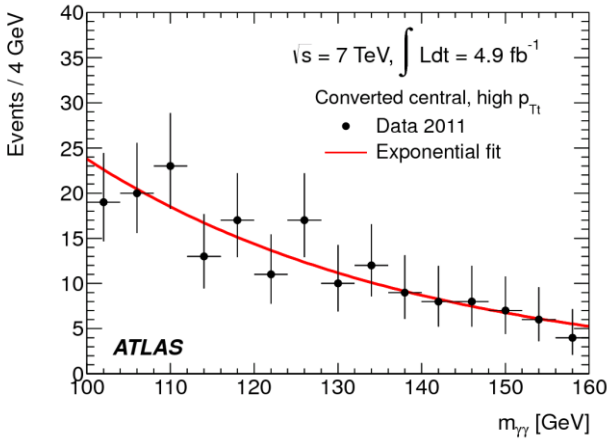

√s = 7 TeV, ∫ Ldt = 4.9 fb-1
Unconverted central, low pTt
Data 2011
Exponential fit
ATLAS
Events / 2 GeV
mγγ [GeV]

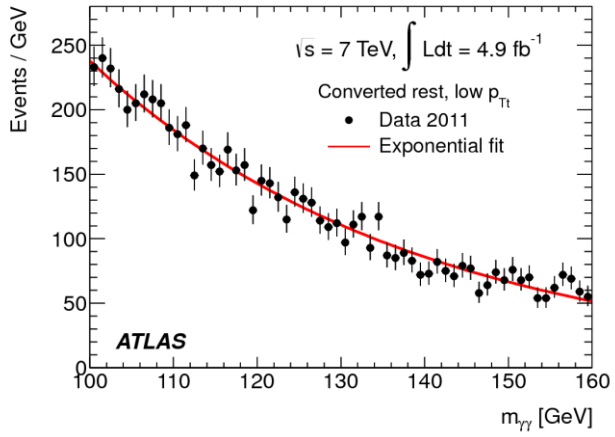

√s = 7 TeV, ∫ Ldt = 4.9 fb-1
Unconverted central, high pTt
Data 2011
Exponential fit
ATLAS
Events / 4 GeV
mγγ [GeV]

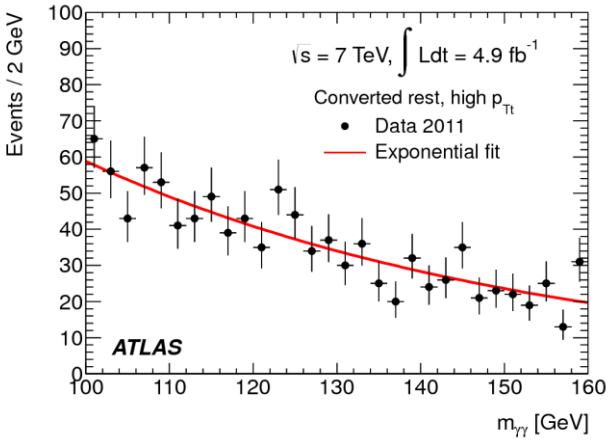

√s = 7 TeV, ∫ Ldt = 4.9 fb-1
Unconverted rest, low pTt
Data 2011
Exponential fit
ATLAS
Events / GeV
mγγ [GeV]

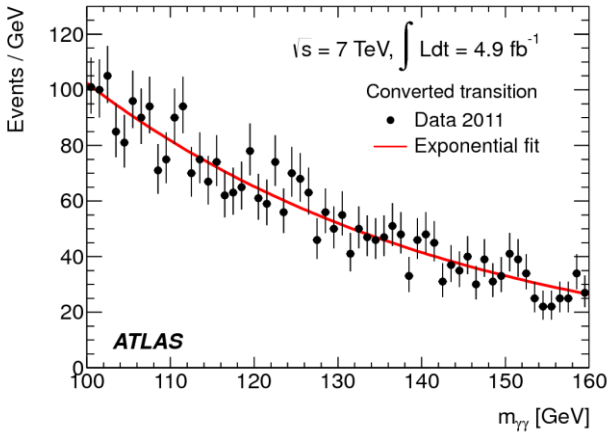

√s = 7 TeV, ∫ Ldt = 4.9 fb-1
Unconverted rest, high pTt
Data 2011
Exponential fit
ATLAS
Events / 2 GeV
mγγ [GeV]


√s = 7 TeV, ∫ Ldt = 4.9 fb-1
Converted central, low pTt
Data 2011
Exponential fit
ATLAS
Events / 2 GeV
mγγ [GeV]


√s = 7 TeV, ∫ Ldt = 4.9 fb-1
Converted central, high pTt
Data 2011
Exponential fit
ATLAS
Events / 4 GeV
mγγ [GeV]


√s = 7 TeV, ∫ Ldt = 4.9 fb-1
Converted rest, low pTt
Data 2011
Exponential fit
ATLAS
Events / GeV
mγγ [GeV]

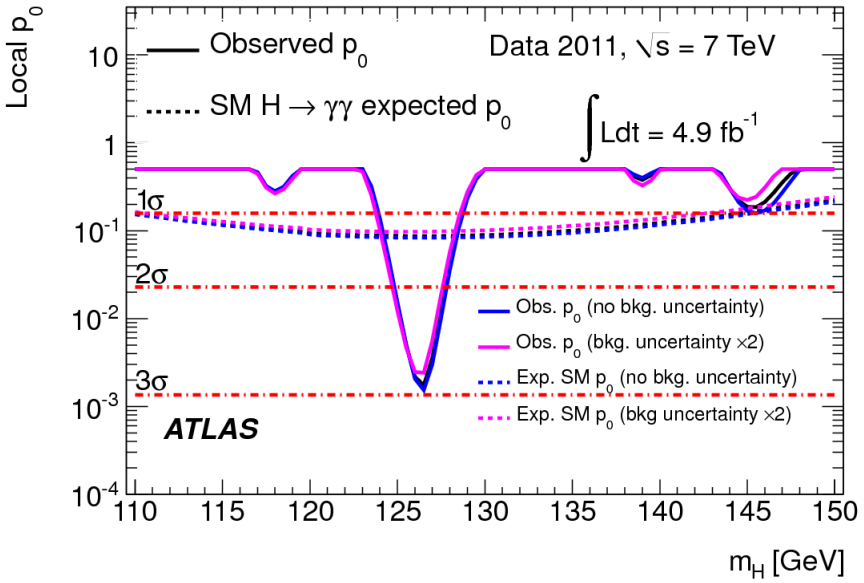

√s = 7 TeV, ∫ Ldt = 4.9 fb-1
Converted rest, high pTt
Data 2011
Exponential fit
ATLAS
Events / 2 GeV
mγγ [GeV]

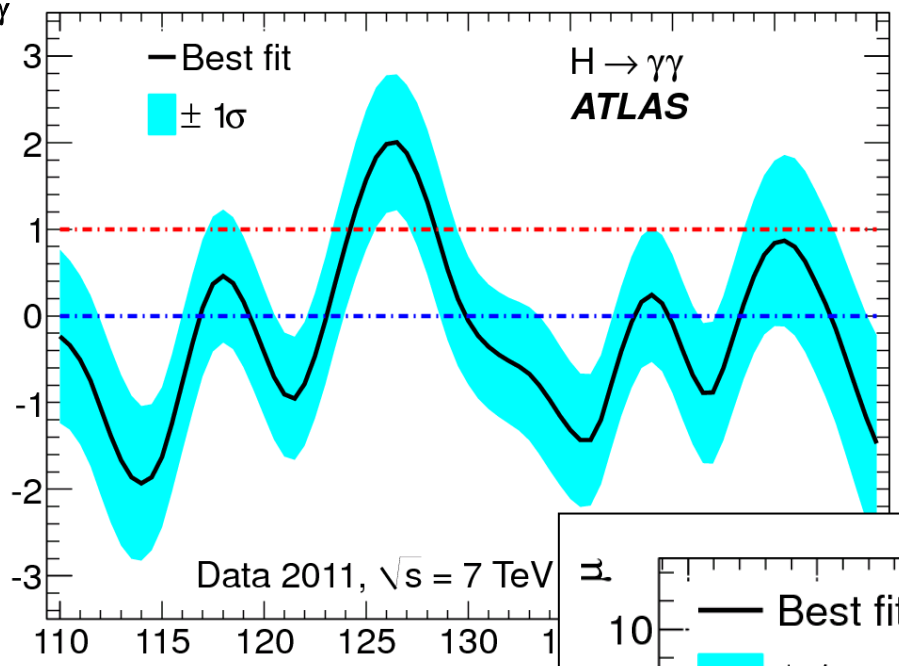

√s = 7 TeV, ∫ Ldt = 4.9 fb-1
Converted transition
Data 2011
Exponential fit
ATLAS
Events / GeV
mγγ [GeV]

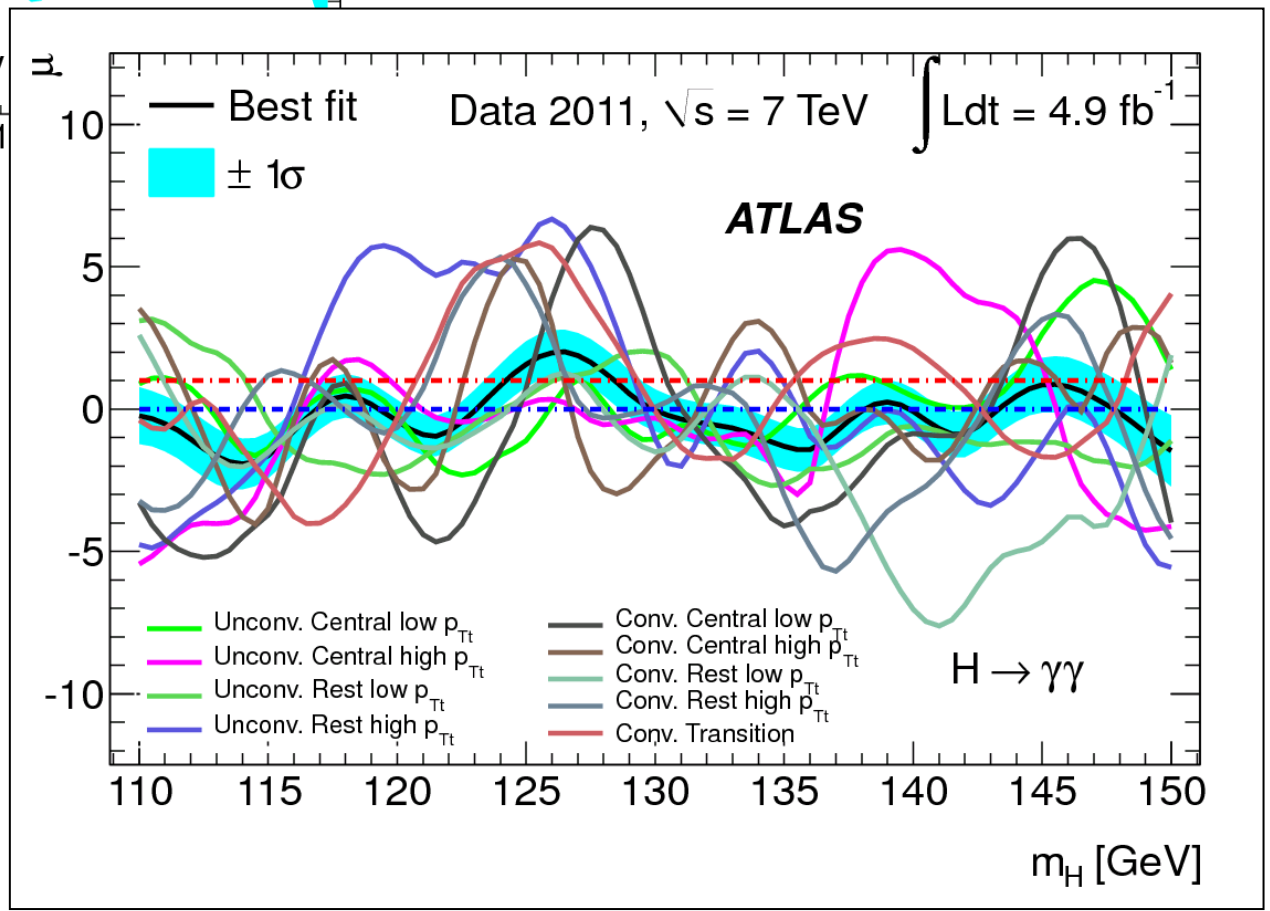
BG modeling

- Single exponential function with mass range of 100-160GeV
  - Limits are obtained for 110-150GeV.
- Assign systematics for the choice of BG modeling

Category	Events
Unconverted central, low p_{Tt}	±2.8
Unconverted central, high p_{Tt}	±0.1
Unconverted rest, low p_{Tt}	±5.9
Unconverted rest, high p_{Tt}	±0.7
Converted central, low p_{Tt}	±1.8
Converted central, high p_{Tt}	±0.1
Converted rest, low p_{Tt}	±7.9
Converted rest, high p_{Tt}	±0.8
Converted transition	±1.7

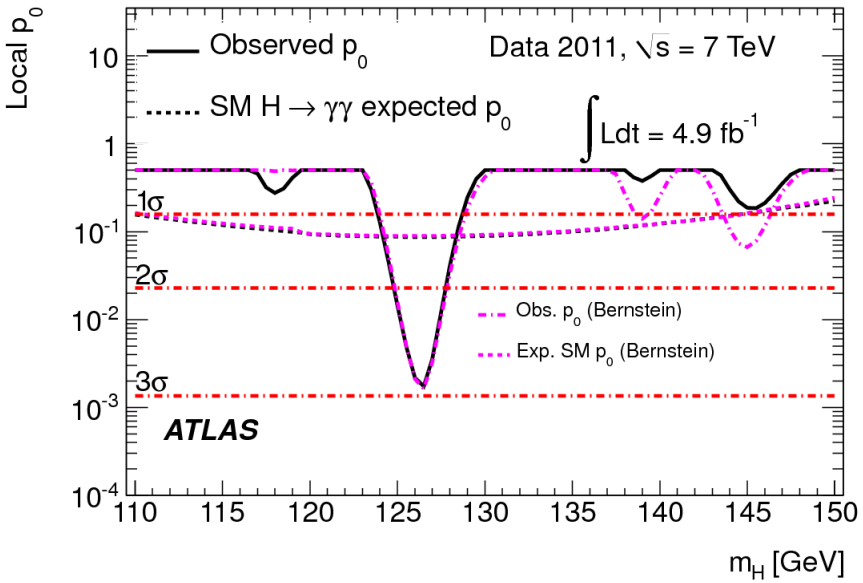



Best fit
± 1σ
H → γγ
ATLAS
Data 2011, √s = 7 TeV
μ
3
2
1
0
-1
-2
-3
110
115
120
125
130


Best fit
± 1σ
Data 2011, √s = 7 TeV
∫Ldt = 4.9 fb-1
ATLAS
μ
10
5
0
-5
-10
Unconv. Central low pTt
Unconv. Central high pTt
Unconv. Rest low pTt
Unconv. Rest high pTt
Conv. Central low pTt
Conv. Central high pTt
Conv. Rest low pTt
Conv. Rest high pTt
Conv. Transition
H → γγ
110
115
120
125
130
135
140
145
150
mH [GeV]

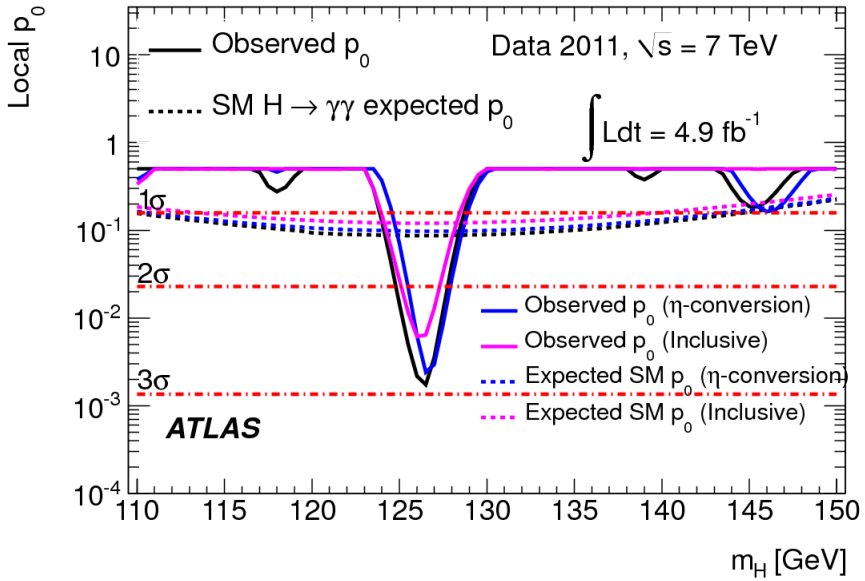
Systematic Uncertainties

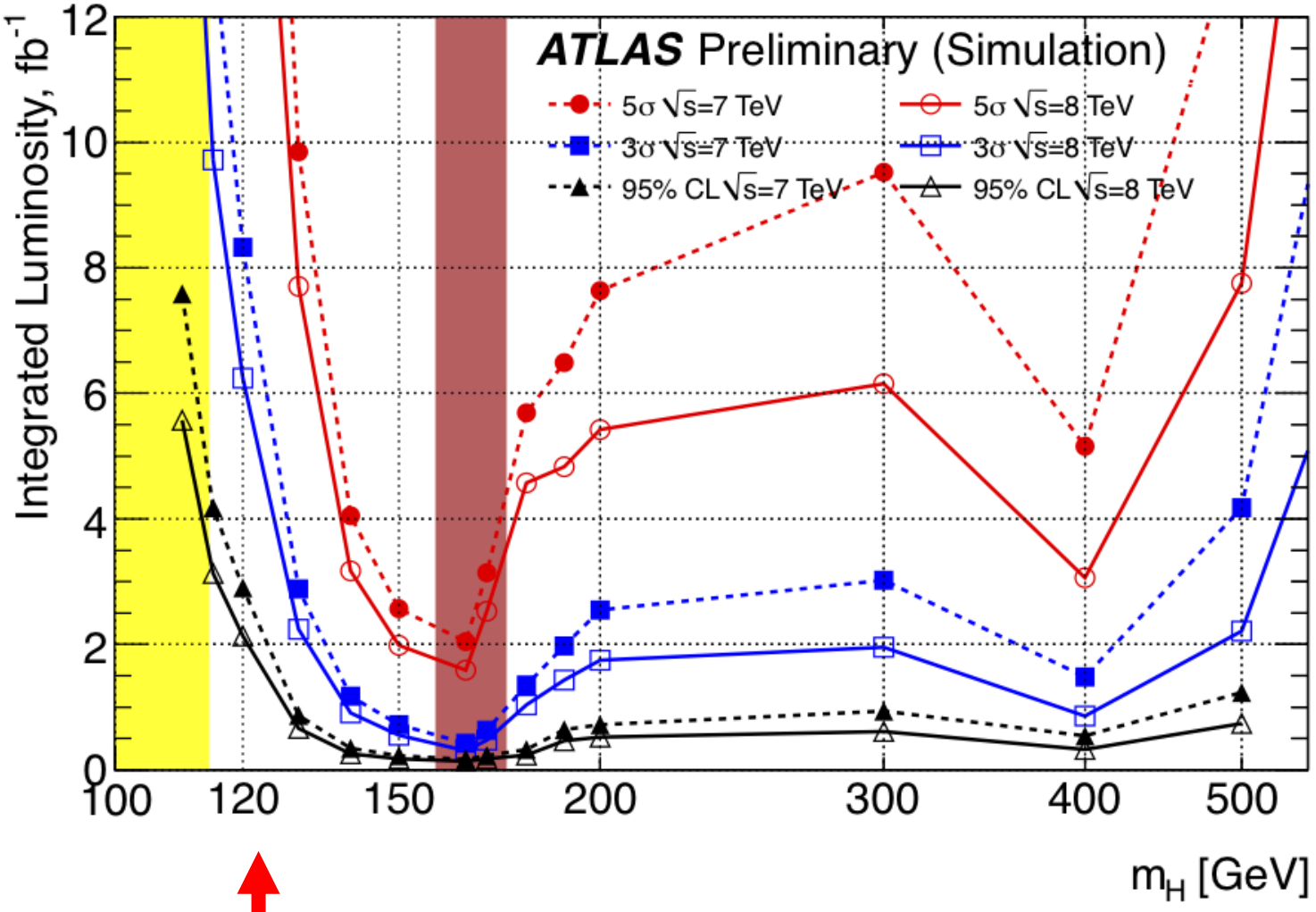
Signal event yield	
Photon reconstruction and identification	$\pm 11\%$
Effect of pileup on photon identification	$\pm 4\%$
Isolation cut efficiency	$\pm 5\%$
Trigger efficiency	$\pm 1\%$
Higgs boson cross section (scales)	$^{+12}_{-8}\%$
Higgs boson cross section (PDF+α_s)	$\pm 8\%$
Higgs boson p_{T} modeling	$\pm 1\%$
Luminosity	$\pm 3.9\%$
Signal mass resolution	
Calorimeter energy resolution	$\pm 12\%$
Photon energy calibration	$\pm 6\%$
Effect of pileup on energy resolution	$\pm 3\%$
Photon angular resolution	$\pm 1\%$
Signal mass position	
Photon energy scale	± 0.7 GeV
Signal category migration	
Higgs boson p_{T} modeling	$\pm 8\%$
Conversion rate	$\pm 4.5\%$
Background model	$\pm\,(0.1 - 7.9)$ events



$$N\left[(1-t)^2 + p_0\, 2t(1-t) + p_1\, t^2\right], \text{ with}$$

$$t = (m_{\gamma\gamma} - 100)/60 \in [0,1].$$





HERE

(Higgs x-sec 7->8TeV ~30% up)