Higgs Hunting in ATLAS

Nansi Andari

On Behalf of the ATLAS collaboration

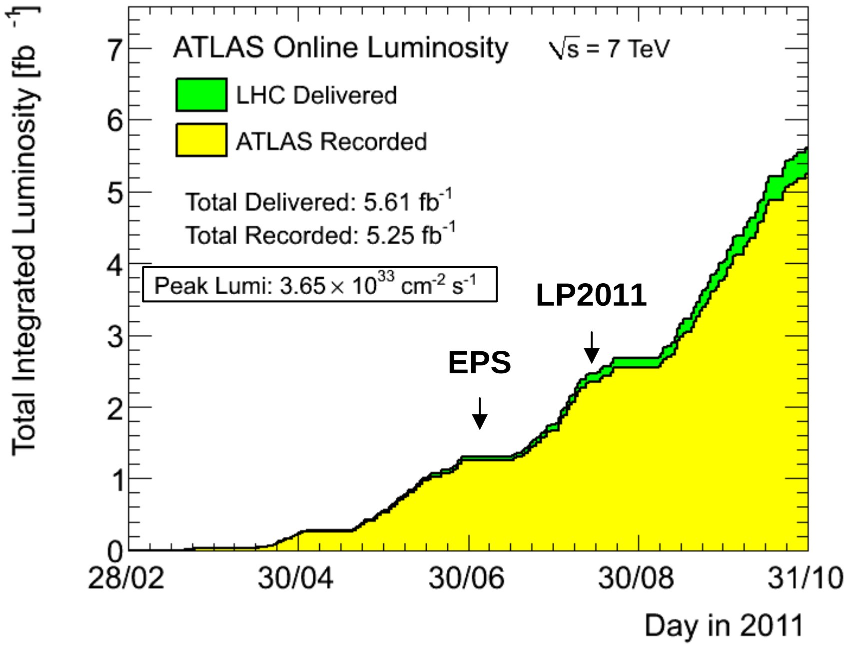
Laboratoire de l'Accélérateur Linéaire
IN2P3, CNRS - France

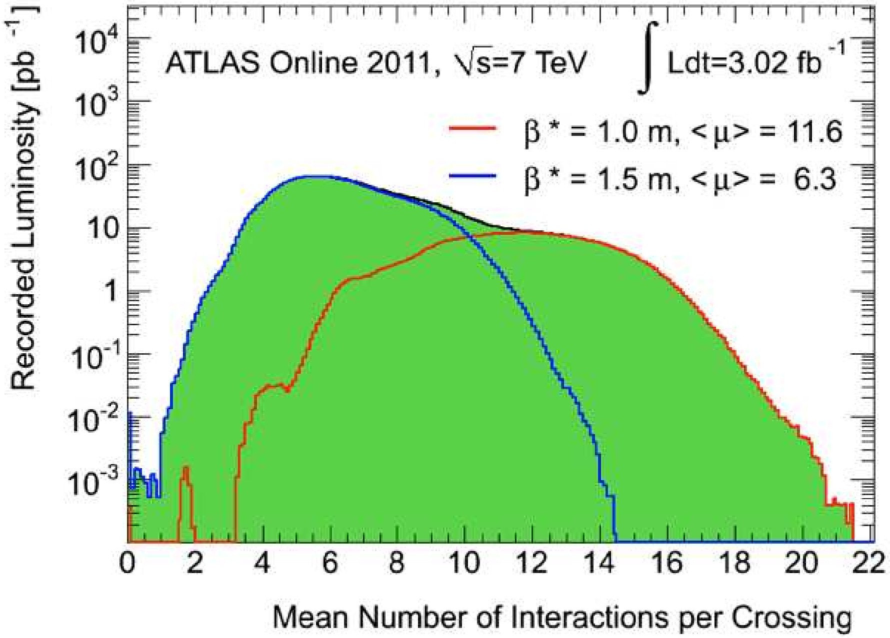
Outline

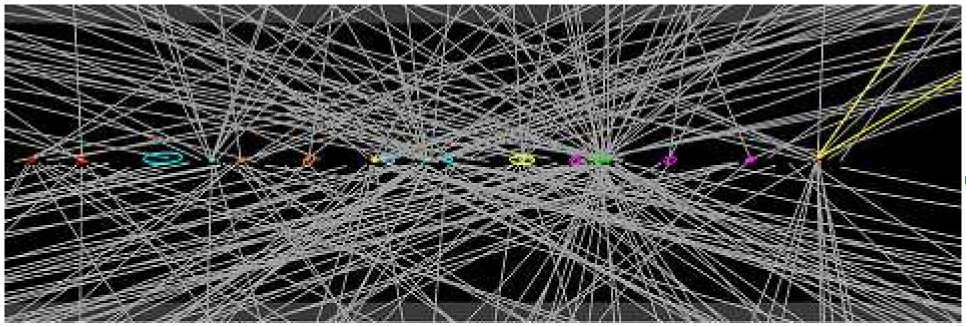
- **ATLAS data taking in 2011**
- **Standard Model (SM) Higgs production and decay**
- **Recent Results for SM Higgs searches:**
  - $H \rightarrow WW^{(*)} \rightarrow l\nu l\nu$
  - $H \rightarrow ZZ^{(*)} \rightarrow llll$
  - $H \rightarrow ZZ \rightarrow ll\nu\nu$
  - $H \rightarrow ZZ \rightarrow llqq$
  - $H \rightarrow WW \rightarrow l\nu jj$
  - $H \rightarrow \gamma\gamma$
  - $H \rightarrow \tau\tau$
  - Associated ($W \rightarrow l\nu$, $Z \rightarrow ll$) production $H \rightarrow$ bb-bar
- **SM Higgs combination**
- **MSSM Higgs searches**

For future analysis use

ATLAS DATA TAKING





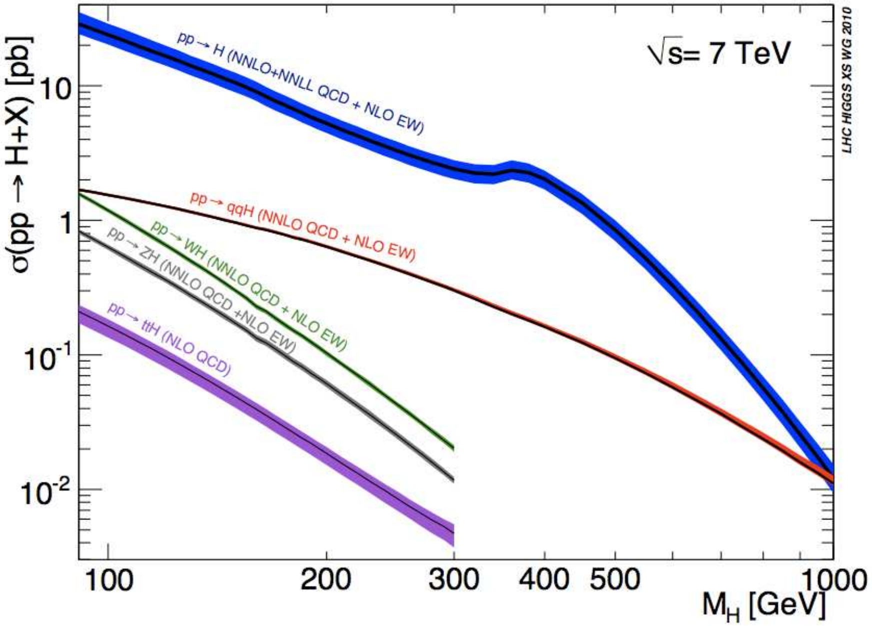


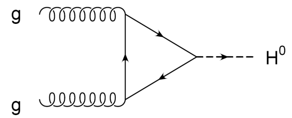
Pile-Up Challenge

Candidate Z→μμ event with 20 reconstructed vertices

SM Higgs production at the LHC

Compiled by the LHC Higgs XS WG 2010

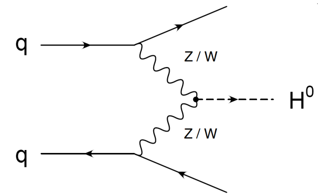




Gluon Fusion

Dominant process at the LHC known at NNLO+NNLL

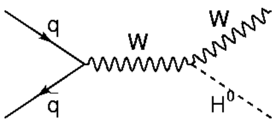
However large theoretical uncertainty O(15%)



Vector Boson Fusion

Process known at ~NNLO, theoretical uncertainty O(5%)

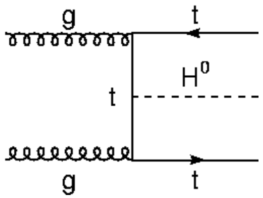
Two forward jets and a rapidity gap



Associated W,Z production

Process known at NNLO

Theoretical uncertainty O(5%)

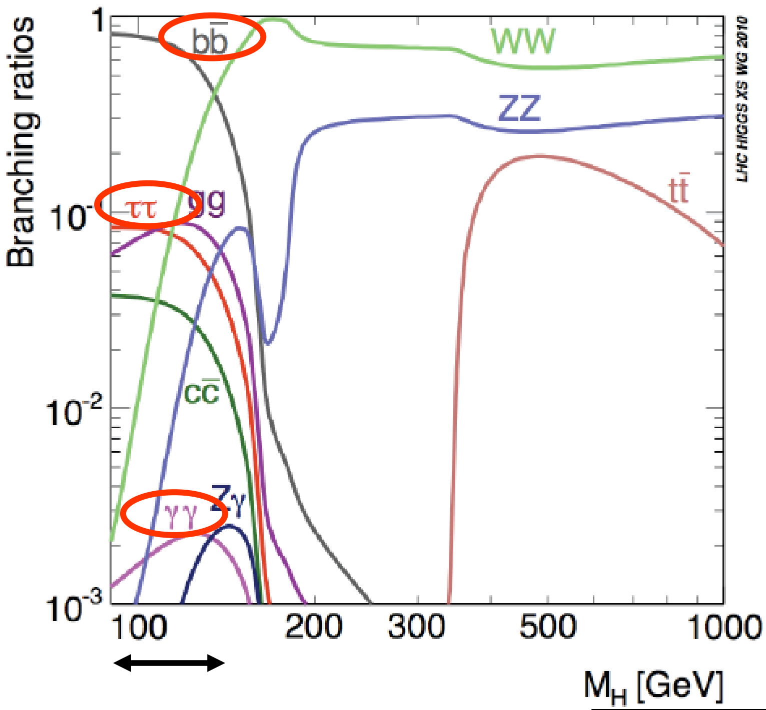


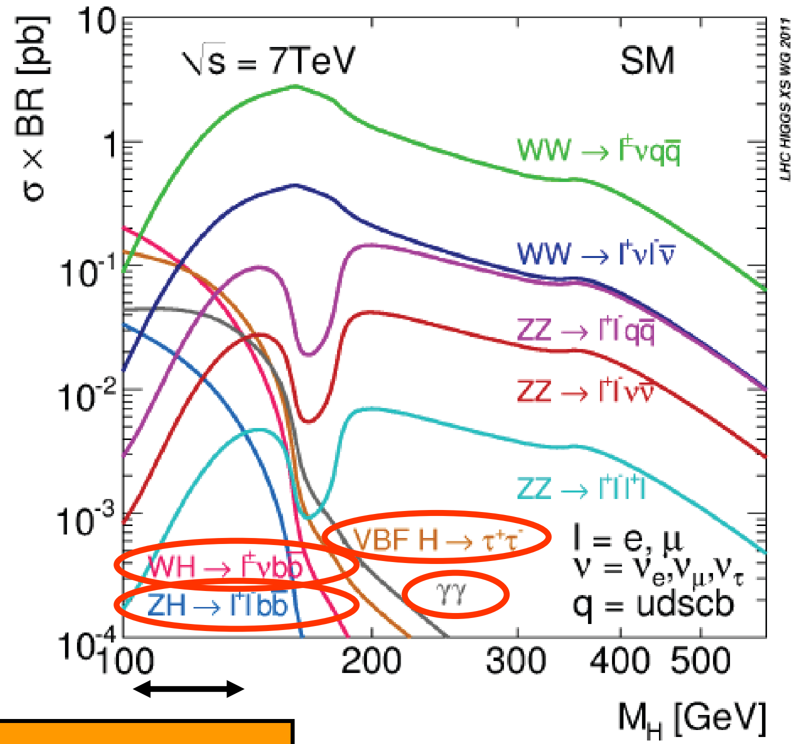
Associated tt-bar production

Process known at NLO

Theoretical uncertainty O(15%)

SM Higgs cross sections at the LHC

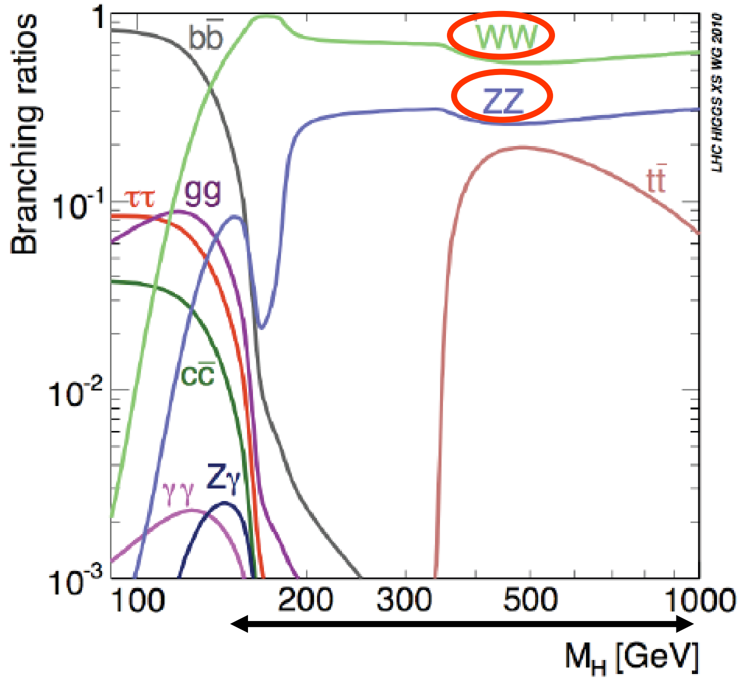


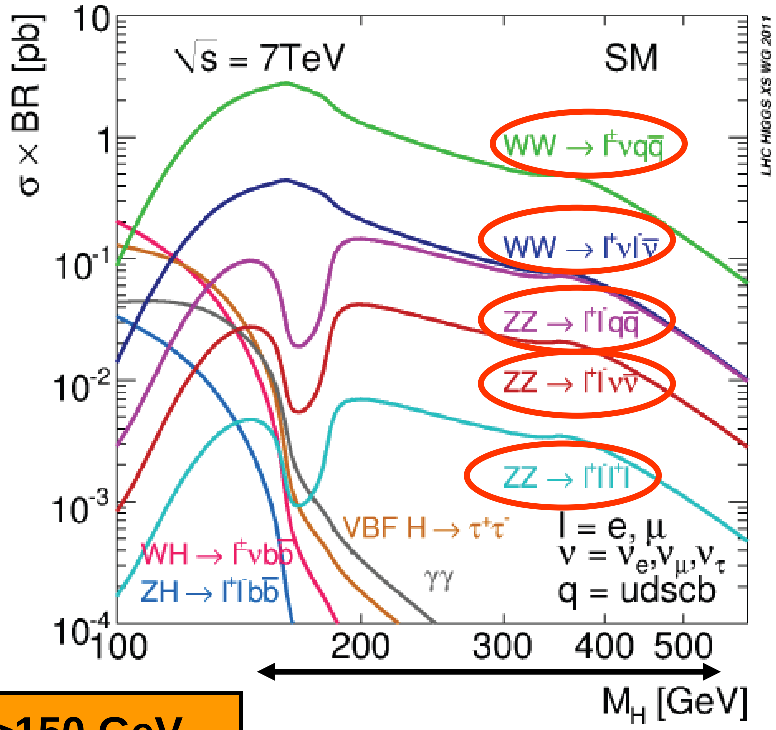


Low Mass Range m_H<150 GeV

- **H→γγ** *the best channel in this region: small BR but clean signature*
- **H→bb-bar** *dominant BR: huge background (therefore reduce it by asking W and Z associated production , with leptonic decays of W and Z), but important for H to quark couplings*
- **H→ττ** *good S/B, enhanced VBF*

SM Higgs cross sections at the LHC





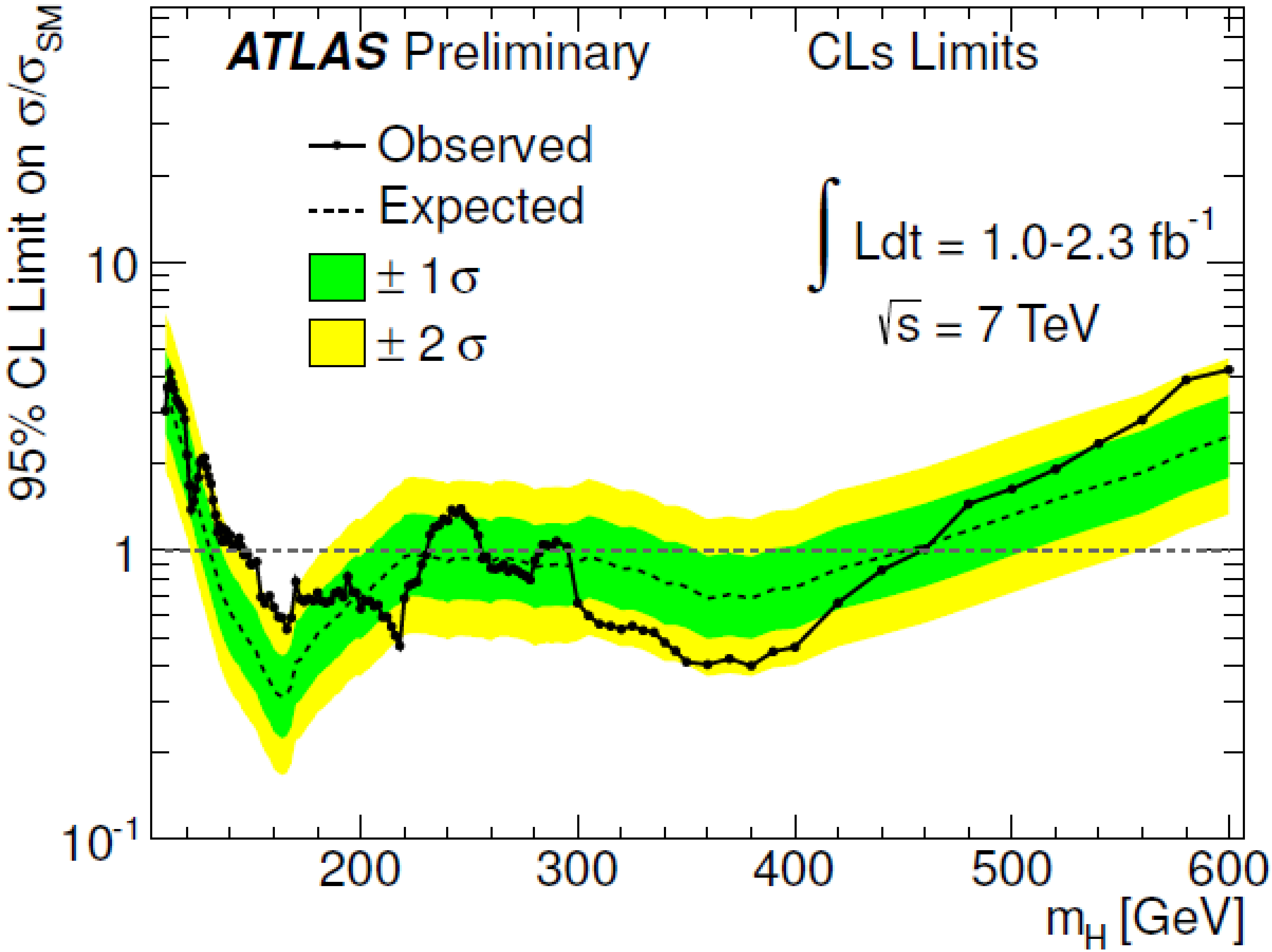
High Mass Range m_H>150 GeV

- **$H \rightarrow WW^{(*)}$:** - *$l\nu l\nu$ very important in the intermediate mass (also important for masses >120 GeV)*
  - *$l\nu qq$: highest rate important at high mass*
- **$H \rightarrow ZZ^{(*)}$:** - *4l golden channel large S/B (also important for masses >130 GeV)*
  - *$ll\nu\nu$ dominant channel at high mass*
  - *llqq important for high mass but has also much larger background*

Status of the Higgs searches in ATLAS

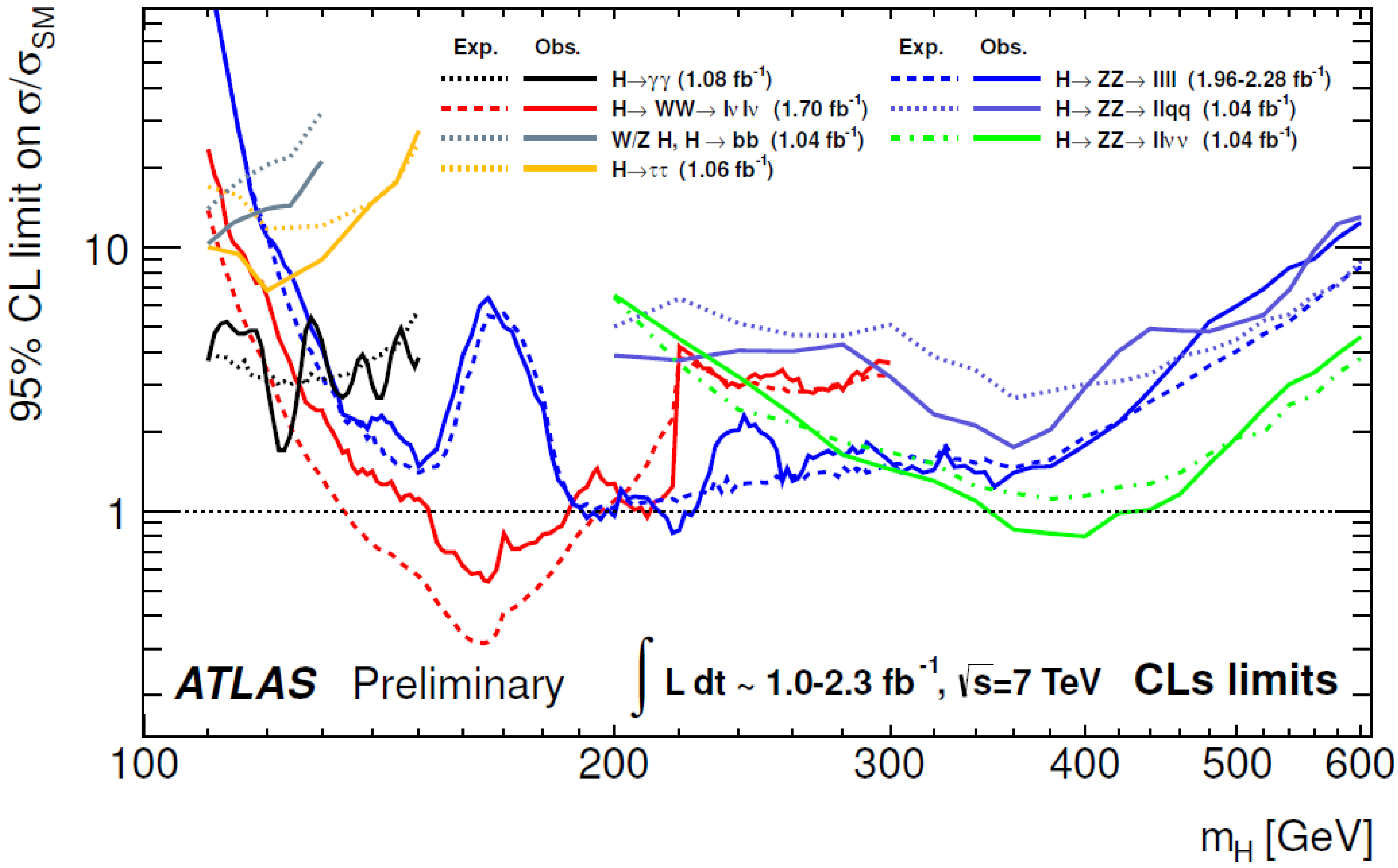
Combined channels: SM Higgs exclusion limits

ATLAS-CONF-2011-135



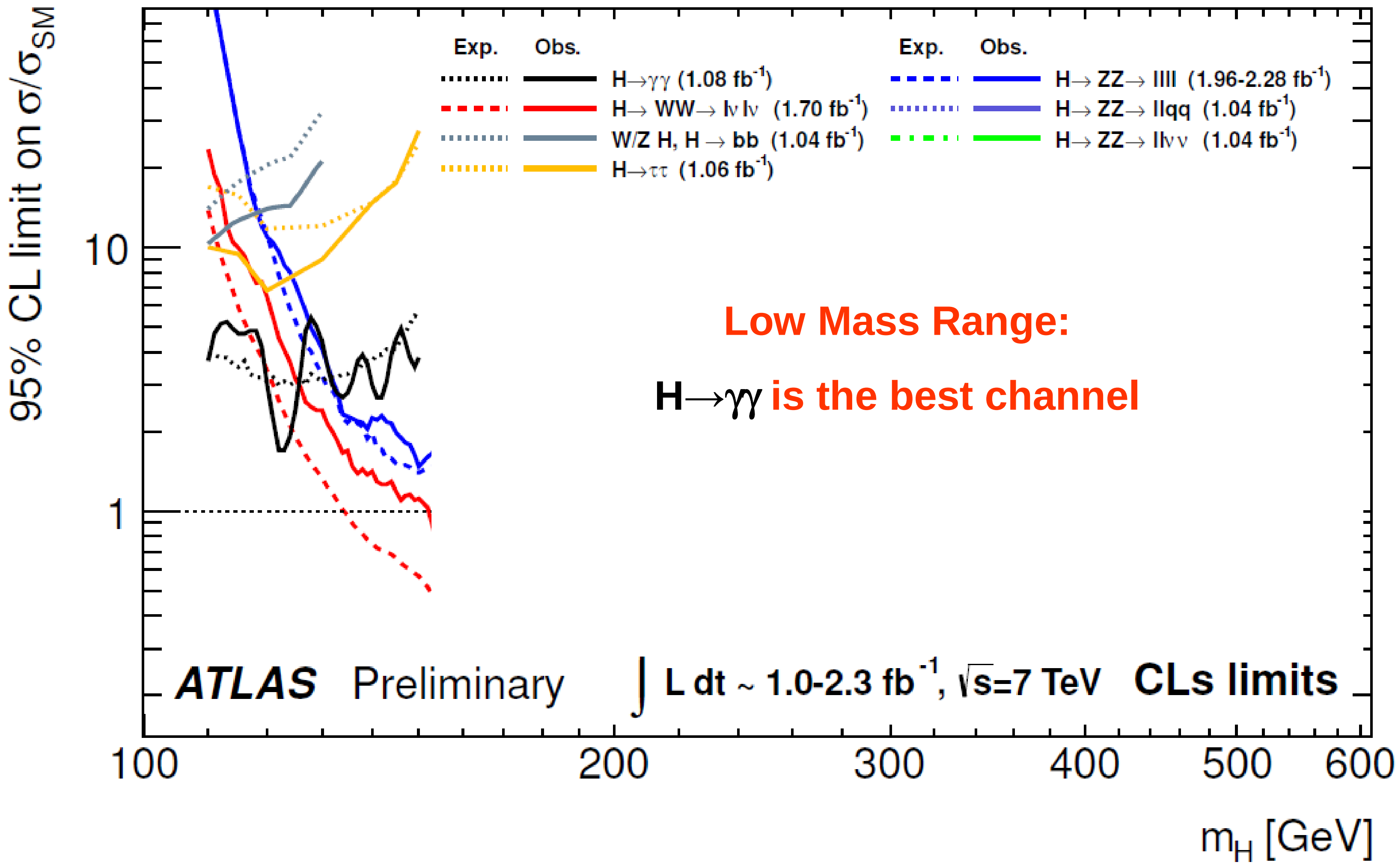
Individual channels contributions

ATLAS-CONF-2011-135



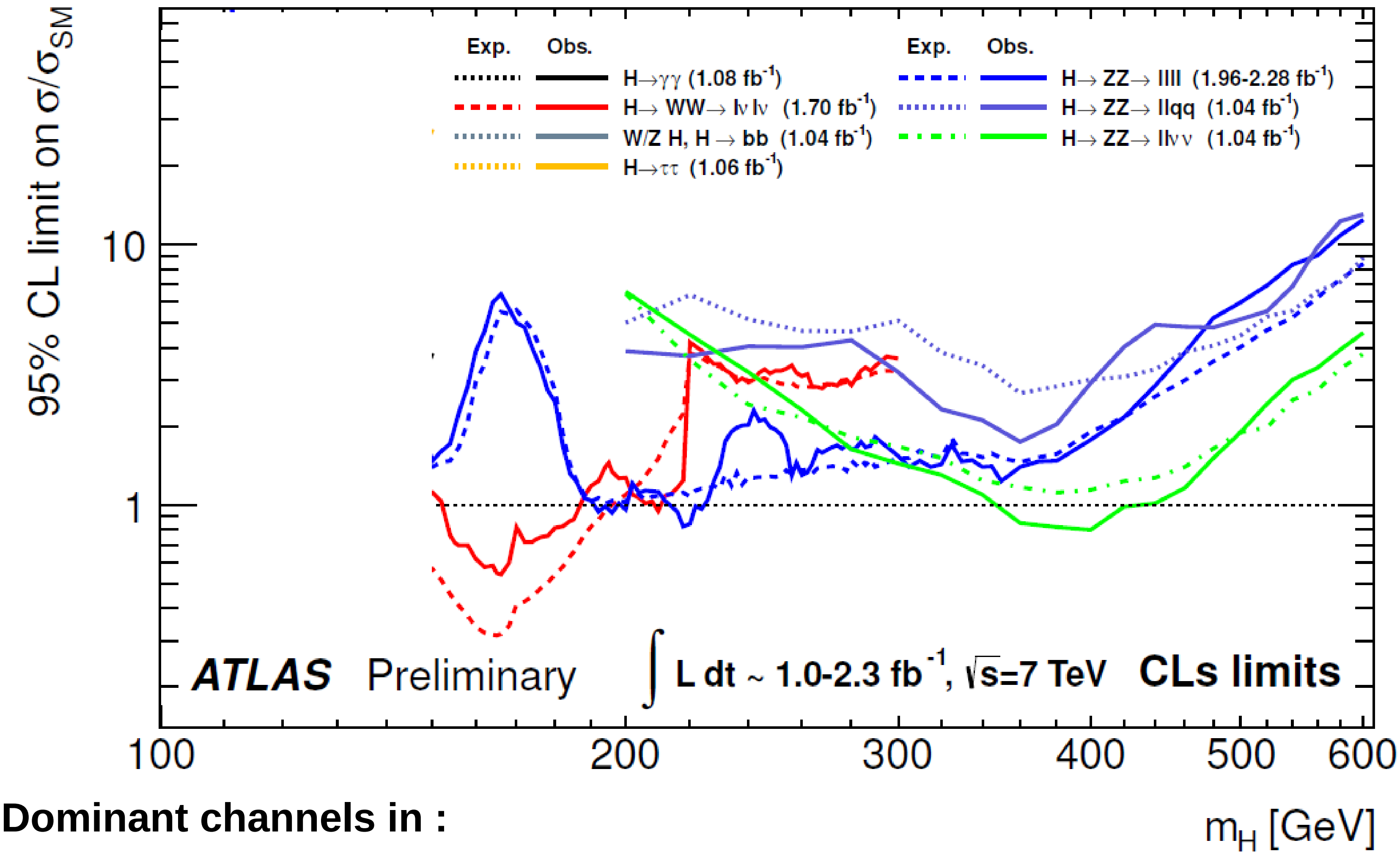
Individual channels contributions

ATLAS-CONF-2011-135



Individual channels contributions

ATLAS-CONF-2011-135



Dominant channels in :

- **Intermediate Mass Range: $H\rightarrow WW\rightarrow l\nu l\nu$, $H\rightarrow ZZ\rightarrow 4l$**
- **Very High Mass Range: $H\rightarrow ZZ\rightarrow ll\nu\nu$**

In the following, only the 4 dominant channels will be discussed in details:

- **$H \rightarrow WW \rightarrow l\nu l\nu$**
- **$H \rightarrow ZZ \rightarrow llll$**
- **$H \rightarrow \gamma\gamma$**
- **$H \rightarrow ZZ \rightarrow ll\nu\nu$**

For the other channels, the selection cuts will not be described (but are written)

High Mass Higgs Searches

$WW^{(*)} \to l\nu l\nu$

ATLAS-CONF-2011-134

Selection cuts

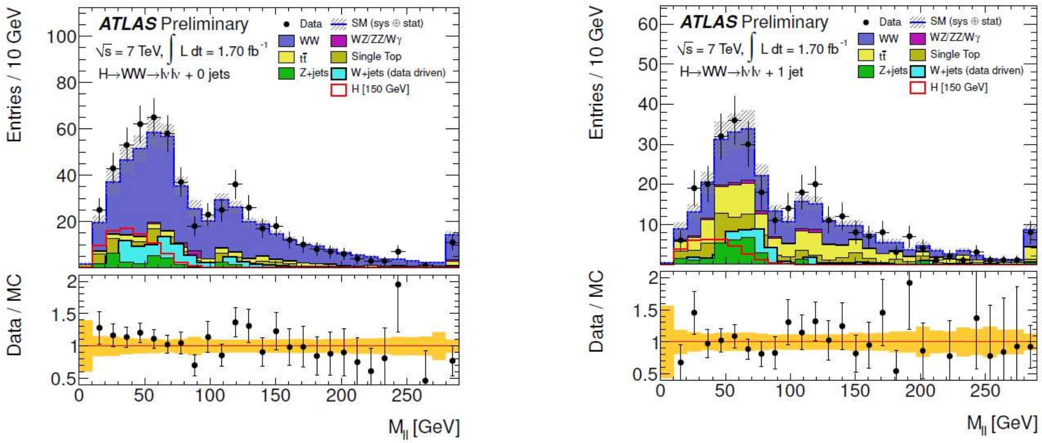
- 2 opposite-sign leptons (e/μ) with leading pT>25 GeV and subleading pT>20(15)GeV for e(μ).
- 2 leptons DF (different flavour) → m_{ll}>10 GeV
- 2 leptons SF (same flavour) → m_{ll}>15 GeV (to suppress bkg from Υ,γ^*) and $|m_{ll}-m_Z|$>15 GeV (to suppress background from Z)
- $E_{T,rel}^{miss}$ >40 (25) GeV if SF (DF) 2 leptons (to suppress bkg from QCD multijets and Drell-Yan)
- **2 categories (H+0jet) and (H+1jet)**
- (H+0jet) : pT(ll)>30 GeV (to suppress background from Z+jets and WW)
- (H+1jet) : bjet veto (to suppress top background), pT(tot)<30 GeV and $Z \to \tau\tau$ veto
- **Upper bound on m_{ll} is applied depending on m_H (to suppress top and WW background)**
- **Change of the selection at 220 GeV.**

$WW^{(*)} \rightarrow l\nu l\nu$

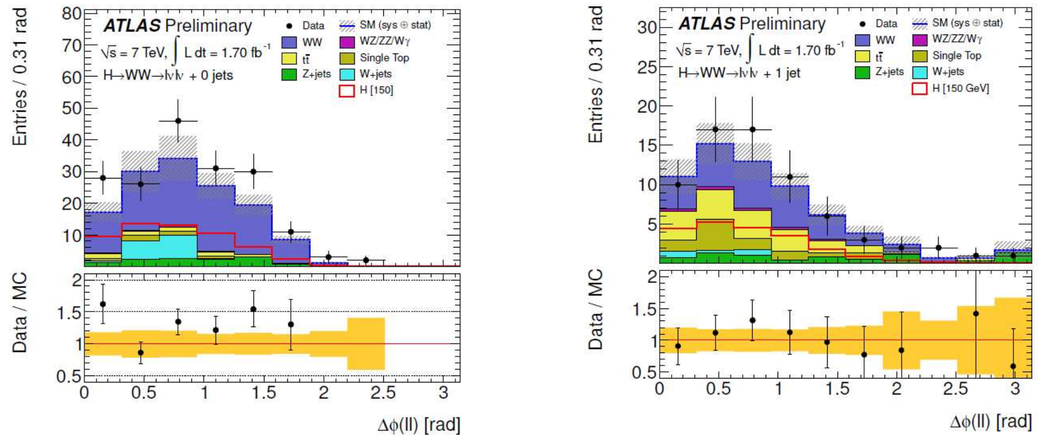
Main Backgrounds

• **WW, tt-bar, single top, Z/γ*+jets, diboson (WZ,ZZ,Wγ):** ***from MC corrected by scale factors derived from control samples***

•**W+jets:** ***from data using loosened identification and isolation criteria***



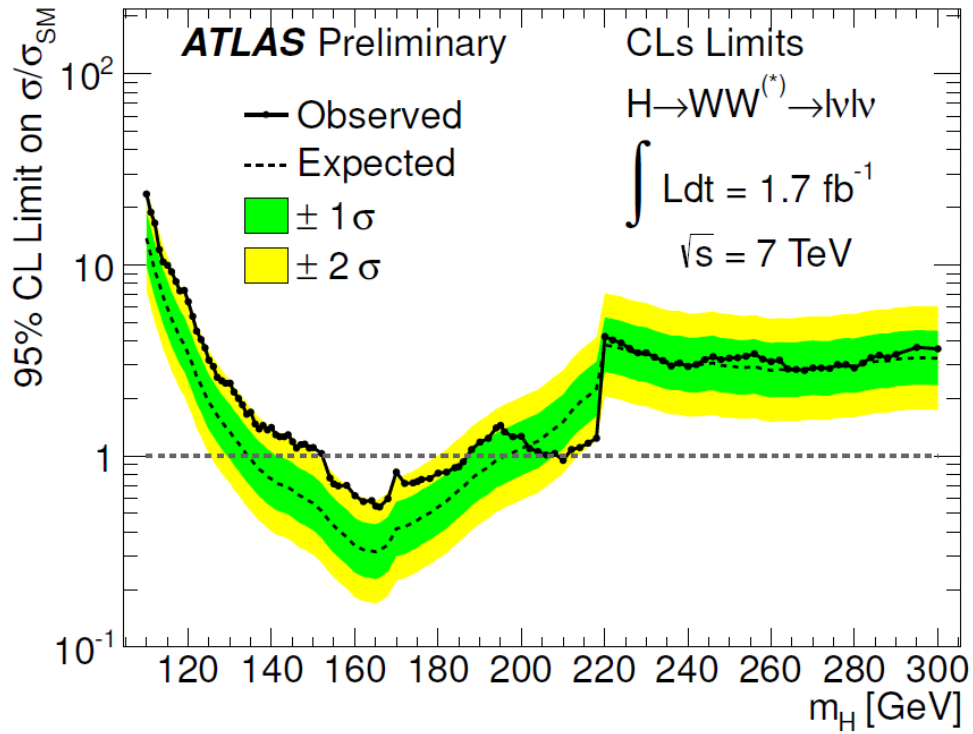
M_{ll} for H→WW→lνlν + 0/1 jet



$\Delta\varphi_{ll}$ for H→WW→lνlν + 0/1 jet

$WW^{(*)} \rightarrow l\nu l\nu$

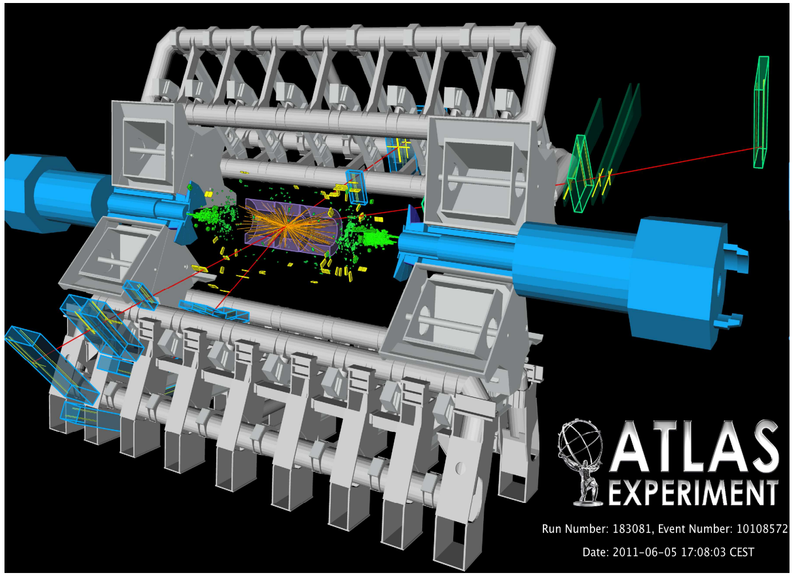
Dominant systematic uncertainties: JES, E_T^{miss} measurement (on signal ±6.1%)



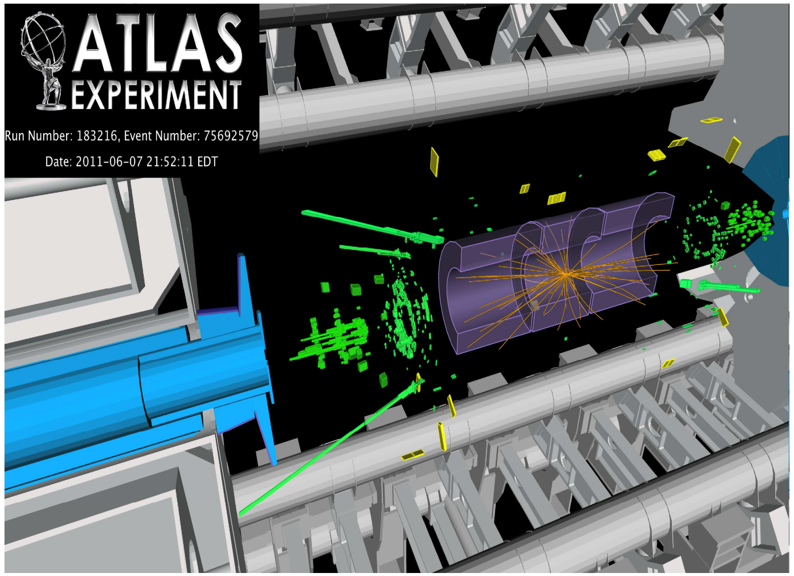
SM Higgs boson excluded at 95%CL between 154-186 GeV.

No significant excess is observed, the largest observed deviation from the expected background is 2σ

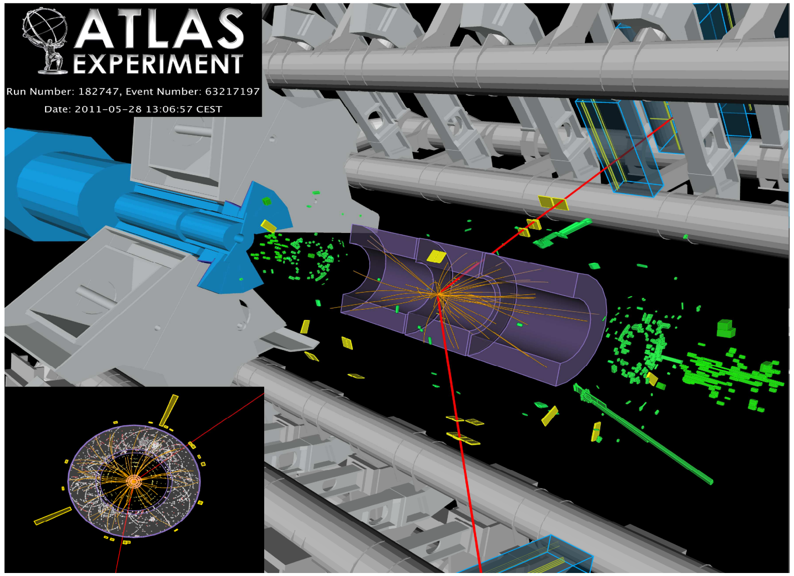
ZZ$^{(*)}$→4l event displays



4μ candidate m=143.5GeV



4e candidate m=270.1GeV



2μ2e candidate m=209.7GeV

« Golden Channel »

$ZZ^{(*)} \to 4l$ (4e, 4μ, 2e2μ)

arXiv:1109.5945v1 [hep-ex]

Search for a narrow resonance over a continuum. Analysis performed between 110-600 GeV

Selection cuts

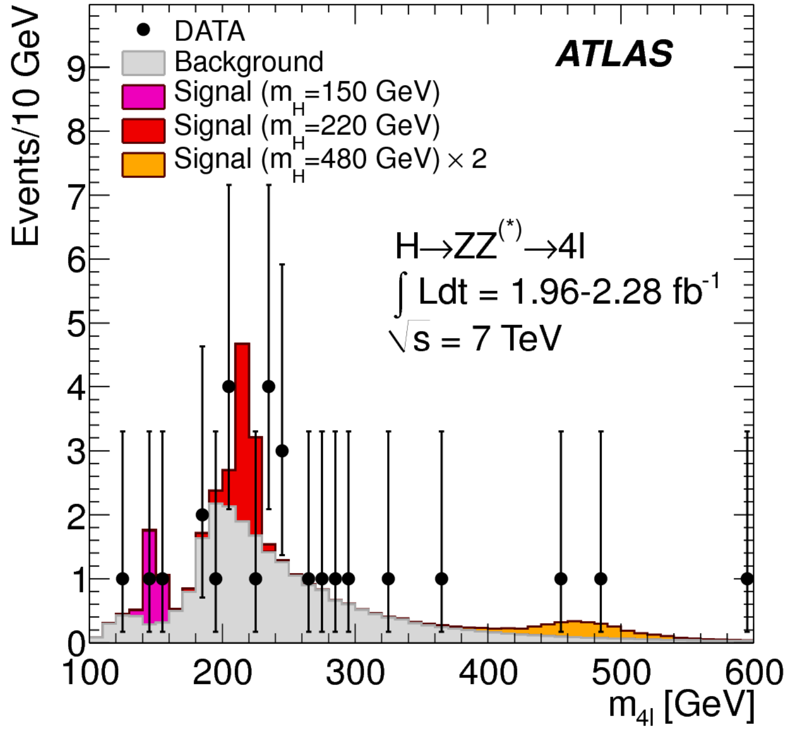
Trigger: e (pT>20-22GeV) / μ (pT>18GeV)

2 SF opposite sign isolated lepton pairs with pT>7GeV. At least 2 leptons with pT>20GeV. Lepton pair mass cut: $|m_{12}-m_Z|<15$GeV, $m_{Threshold}(m_{4l})<m_{34}<115$GeV

Requirements on impact parameter for $m_{4l}<190$GeV (rejects Zbb-bar and tt-bar)

Main Backgrounds

- ***ZZ(*):** from MC theoretical uncertainty (15%)*
- ***tt-bar:** from MC theory normalization uncertainty (10%), test on data with opposite sign e/μ pairs.*
- ***Z+jets:** normalized using data (control sample regions) uncertainties 20-40%*



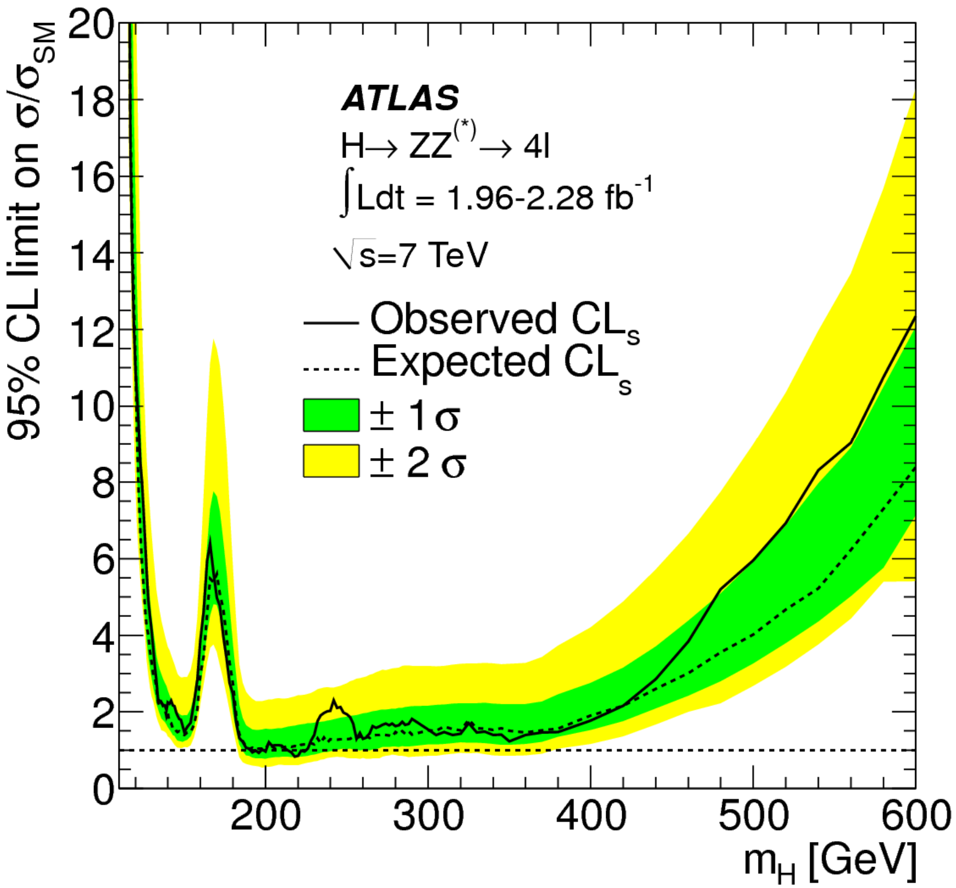
27 observed candidates

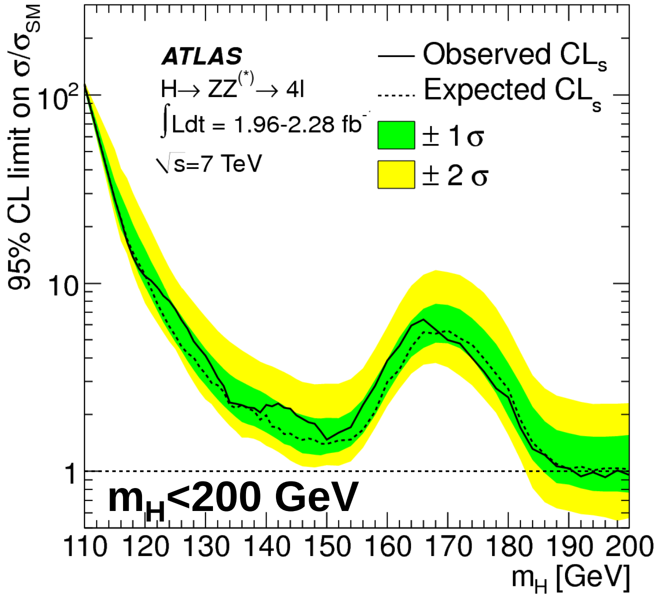
24±4 expected candidates

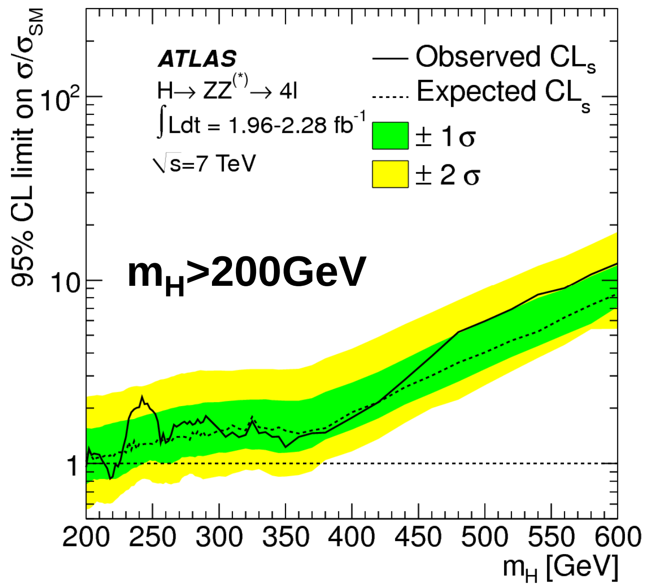
FWHM (full width at half maximum) for m_H=130GeV~4.5(4μ) to 6.5(4e) GeV

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

arXiv:1109.5945v1 [hep-ex]







SM Higgs boson excluded at 95%CL in the mass ranges 191-197, 199-200 and 214-224 GeV. Upward statistical (?) fluctuations observed.

Selection cuts

ZZ→llνν

ATLAS-CONF-2011-148

New!

- **Best channel at high mass (analysis includes contribution from H→WW→lνlν)**
- **Identify Z→ll:**

Trigger: e (pT>22GeV) / μ (pT>18GeV)

2 SF opposite sign isolated leptons (e/μ) with $|m_{ll}-m_Z|<15$GeV

- **Identify Z→νν if m_H>200 GeV:**

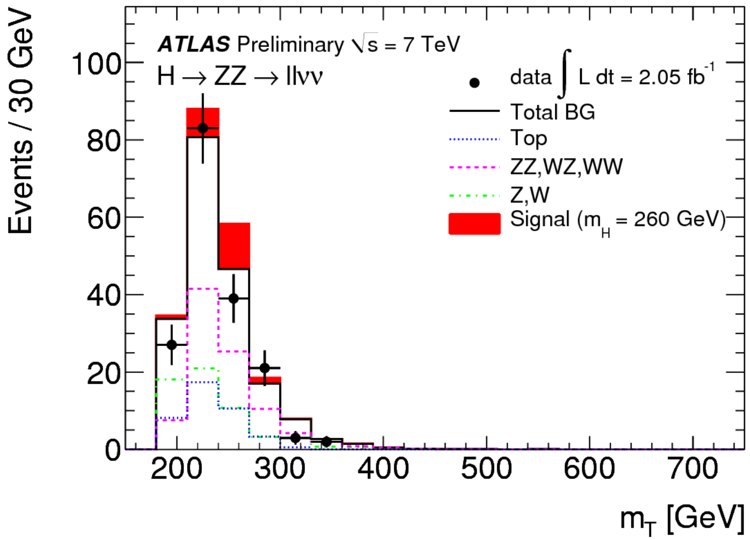
Reject event with $\Delta\varphi(pT^{miss},pT^{jet})<0.3$ to reduce bkg with fake E_T^{miss} → mismeasured jets

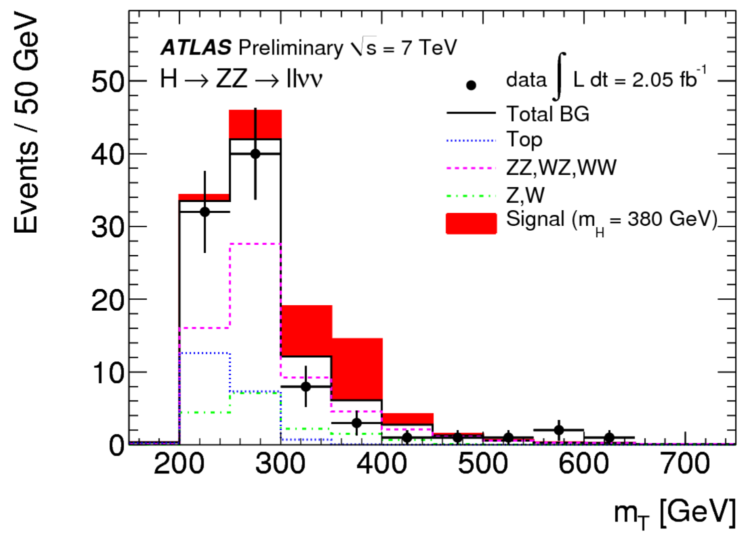
E_T^{miss}>66 (82)GeV in low (high) mass region

- **Events with one or more b-tagged jets are rejected (to reduce top bkg)**

Main Backgrounds

- **Diboson, Z, tt-bar:** ***from MC***
- W : *normalization obtained data/MC of like-sign lepton pair events with high ETmiss*
- QCD multijet: *using data sample with loosened electron selection (μ-channel negligible)*



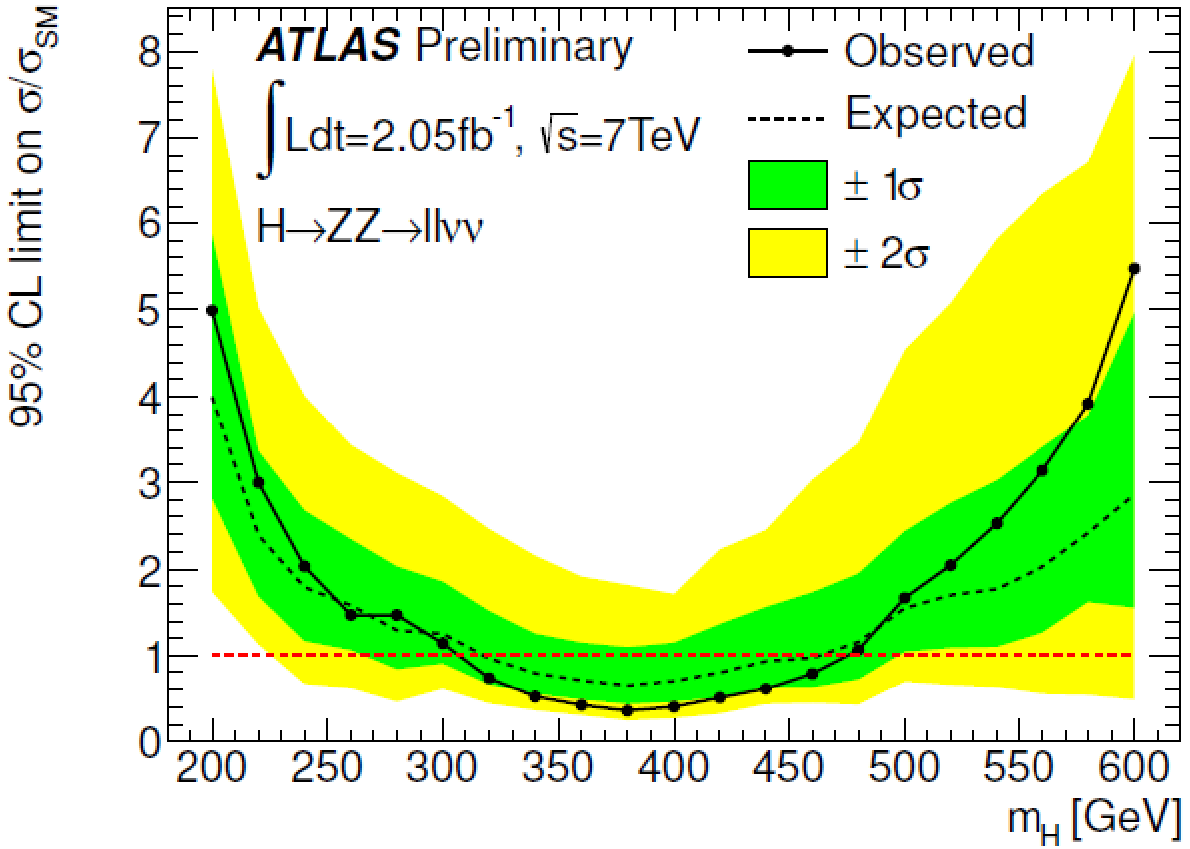


$$m_T^2 \equiv \left[\sqrt{m_Z^2+|\vec{p}_T^{\,\ell\ell}|^2}+\sqrt{m_Z^2+|\vec{p}_T^{\,miss}|^2}\right]^2-\left[\vec{p}_T^{\,\ell\ell}+\vec{p}_T^{\,miss}\right]^2$$

ZZ→llνν

New!

Dominant systematic uncertainties: JES (+5.9-4.0% on expected signal) , b-tagging efficiency.



No excess is observed! A SM Higgs boson is excluded at 95%CL in the mass range 310- 470 GeV.

ATLAS-CONF-2011-150

ZZ→llqq

New!

Selection cuts

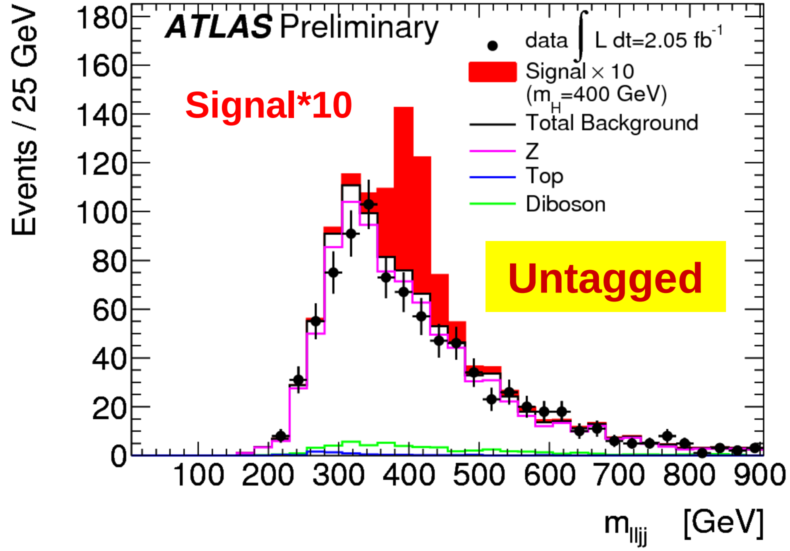
- **2 on-shell Z's (if $m_H>2m_Z$)**

- isolated leptons pT>20 GeV with $|m_{ll}-m_Z|<15$GeV

-2 jets pT>25 GeV with 70 <m_{jj}<105 GeV and m_{jj} constrained to Z mass

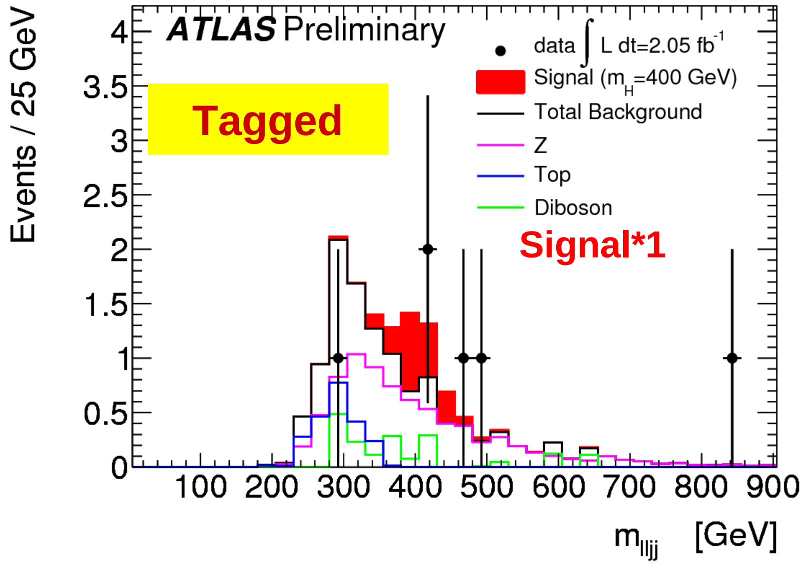
- For mH>300 GeV: $\Delta\varphi_{ll,jj}<90°$ & 2 jets pT>45 GeV

- **E_T^{miss} <50GeV (to reduce bkg from tt-bar)**
- **Categories: 2b-tagged jets and untagged jets (less than 2b tags)**



Main Backgrounds

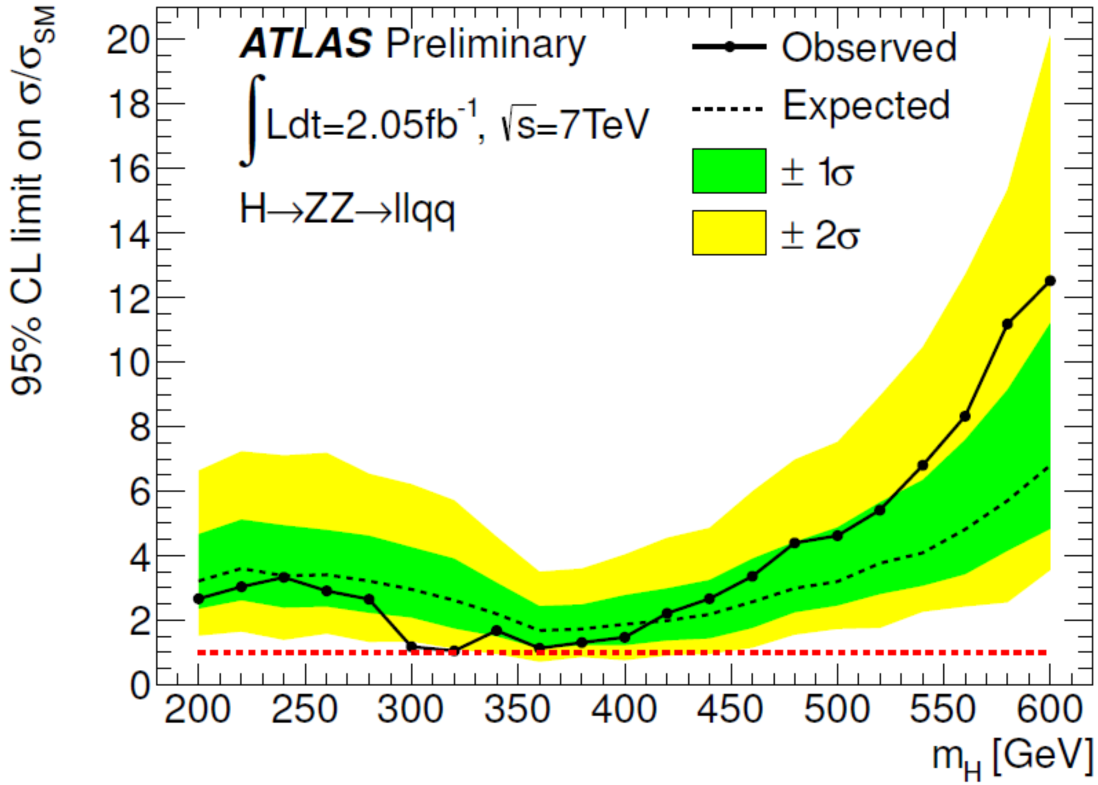
- ***Z+jets:** shape from MC and normalization from data using sidebands* **40<m_{jj}<70 GeV or 105 <m_{jj}<150 GeV**
- ***top:** shape from MC and normalization from data using sidebands* **60<m_{ll}<76 GeV or 106<m_{ll}<150 GeV**
- **ZZ, WZ, W+jets:** *from MC*
- ***QCD multijet:** using data sample with loosened electron selection (μ-channel negligible)*



ZZ→llqq

New!

Dominant systematic uncertainties: JES (+3.7-10.4% on expected signal), b-tagging efficiency, Z+jets normalization



Observed limit, SM-like Higgs boson with a production rate of 1.2 to 12 SM cross section is excluded at 95%CL. Expected limit 1.7 to 6.7 SM cross section.

Selection cuts

WW→lνjj

arXiv:1109.3615v1 [hep-ex]

- **Largest σ*BR**
- **2 on-shell W's (if $m_H > 2m_W$)**

Trigger: e (pT>20GeV) / μ (pT>18GeV)

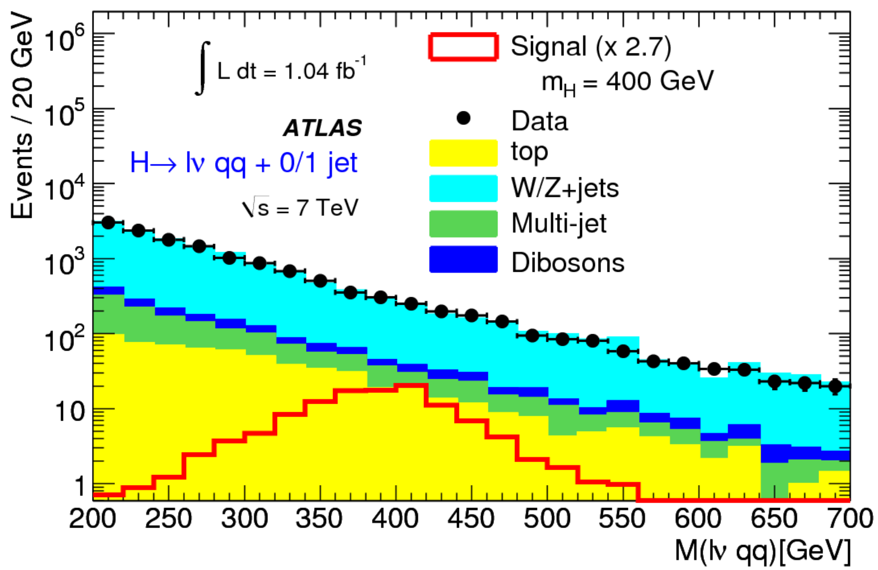
Exactly one reconstructed isolated lepton (e/μ) with pT>30 GeV

E_T^{miss} >30 GeV

Exactly 2 jets (H+0jet) or 3 jets (H+1jet) with pT> 25 GeV and the closest mass to W of the jet pair has to satistfy $71 < m_{jj} < 91$ GeV

m(lν)=m(W)

- **Events with one or more b-tagged jets are rejected (to reduce top bkg)**



Main Backgrounds

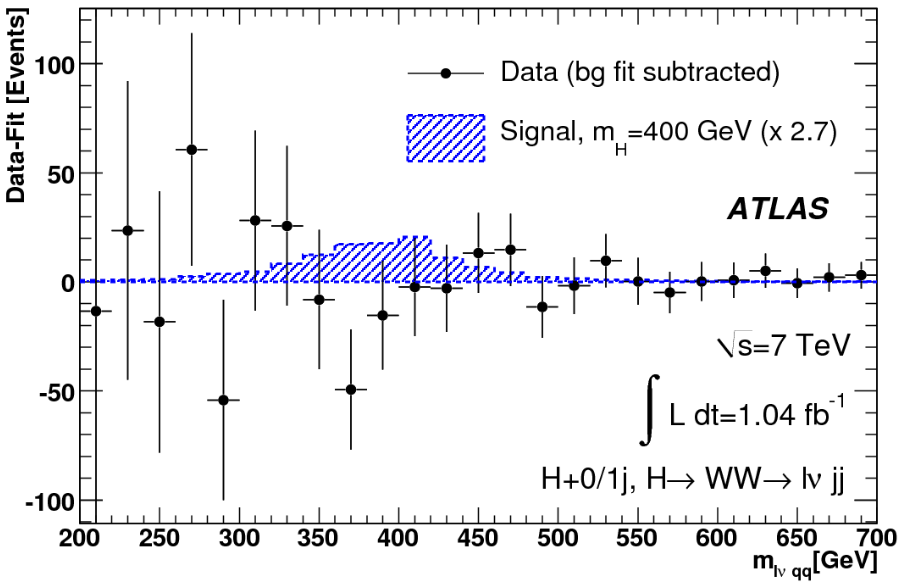
- **W+jets:** *from MC*
- **Z+jets, tt-bar, diboson:** *from MC*
- **QCD multijet:** *using data sample with loosened electron selection (μ-channel negligible)*

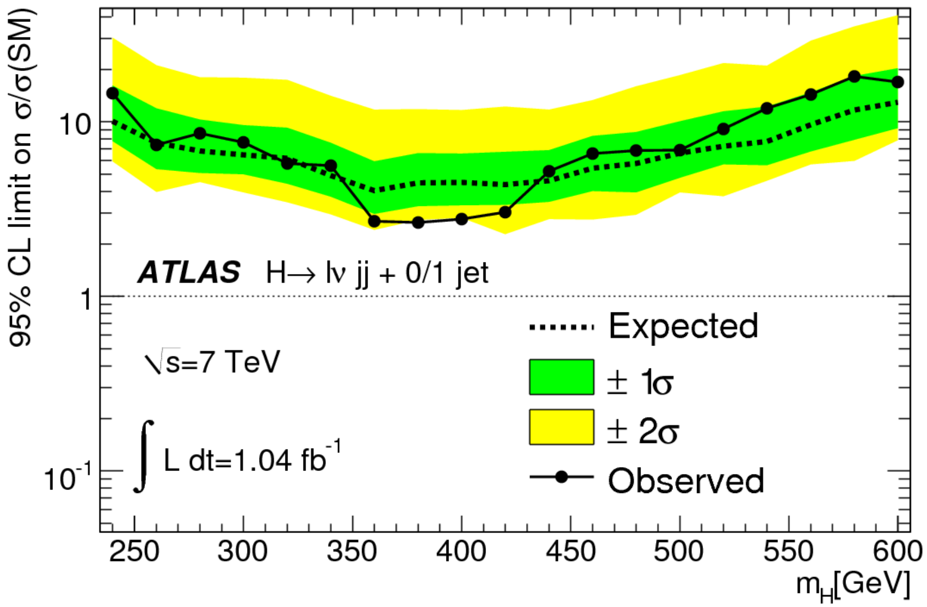
Observed	**41687**
Expected Bkg	**42600±1200**
Expected Sig (mH=400GeV)	**58±15**

WW→lνjj

A double exponential is used to fit the data (background model).

Dominant systematic uncertainties: JES (17% on expected signal), theory (19.4%), jet energy resolution (8.6% on signal)





The difference between the mass distribution in data and the fitted bkg → no indication of any significant excess

The upper limit at mH=400GeV is 2.7 SM cross section. The expected limit for this mass is around 5 SM cross section.

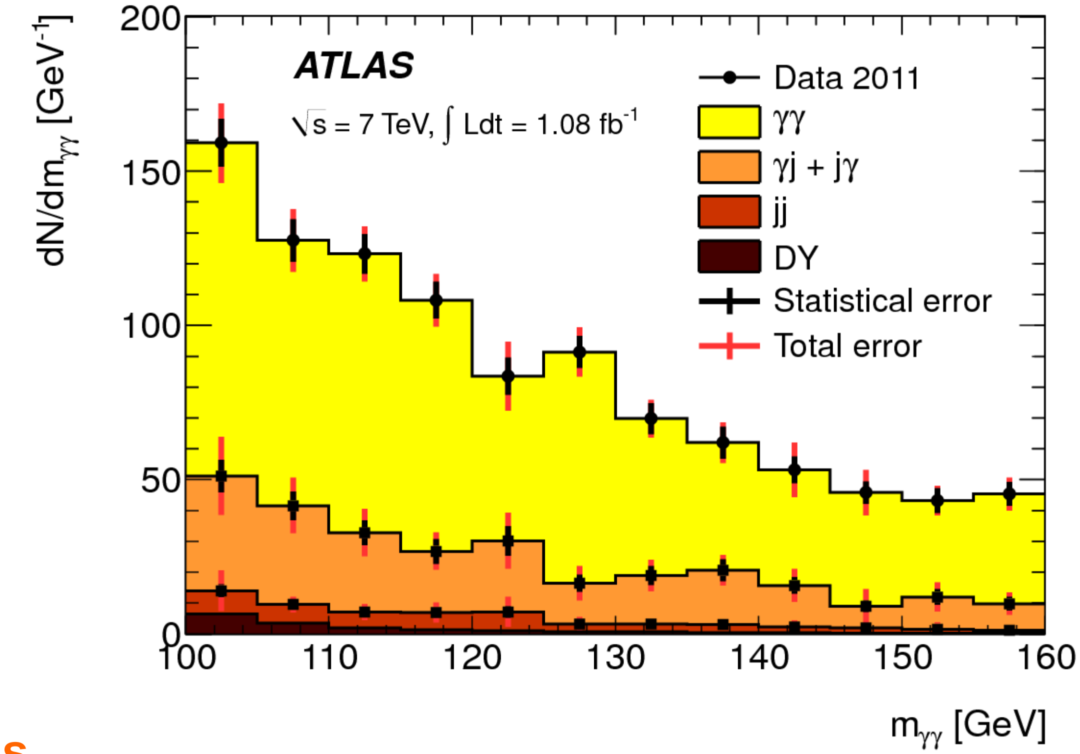
Low Mass Higgs Searches

H→γγ

arXiv:1108.5895v1 [hep-ex]

Selection cuts

- Trigger: 2γ (pT>20GeV)
- $pT(\gamma_1)$>40 GeV & $pT(\gamma_2)$>25 GeV
- |η|<1.37 & 1.52<|η|<2.37
- 2 tight isolated photons required
- 5 categories (η bins and converted/unconverted)



Main Backgrounds

- irreducible bkg γγ
- reducible:

- one or more jets misidentified as photons

- Drell-Yan: electrons misidentified as photons

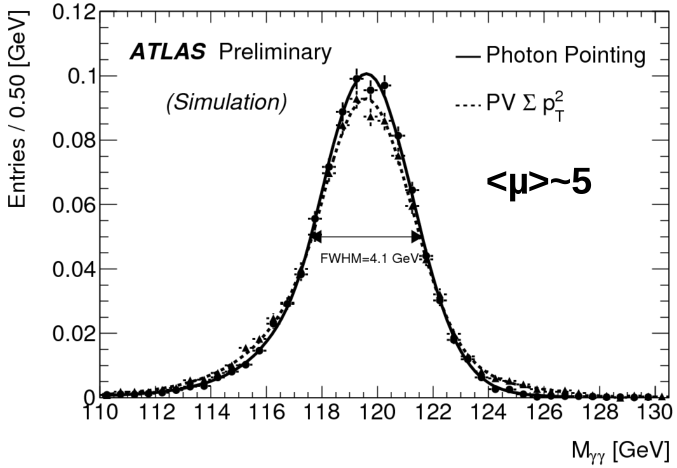
The purity is about 72%

H→γγ

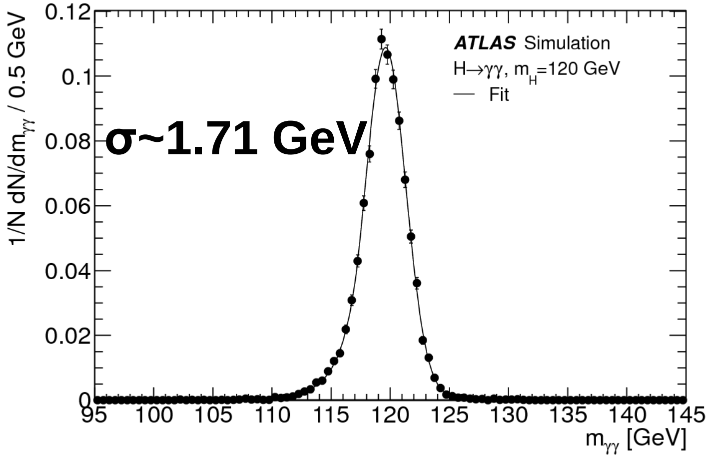
Mass Reconstruction:

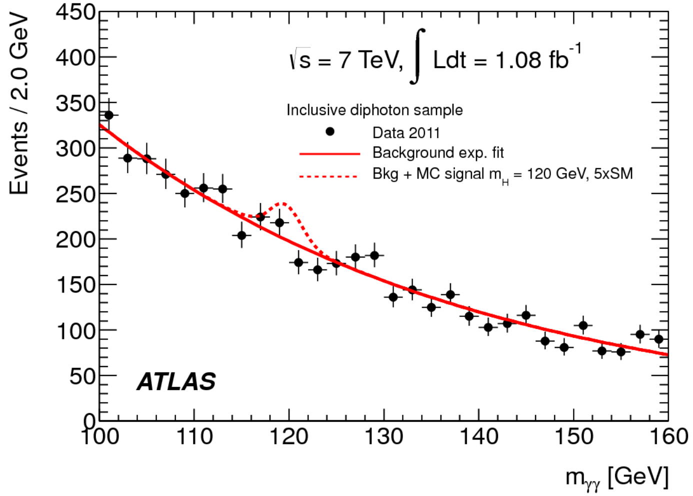
$$m_{\gamma\gamma}^2 = 2E_1^{\gamma}E_2^{\gamma}(1-\cos\alpha_{12})$$

A pointing method (using the first two samplings of the LAr calorimeter , or the first sampling and the conversion point for converted photons) is used to determine the vertex position → Its resolution is ~1.6 cm (unconverted photons)



Less tail with pointing (robust with pile-up increasing) improvement of ~10%



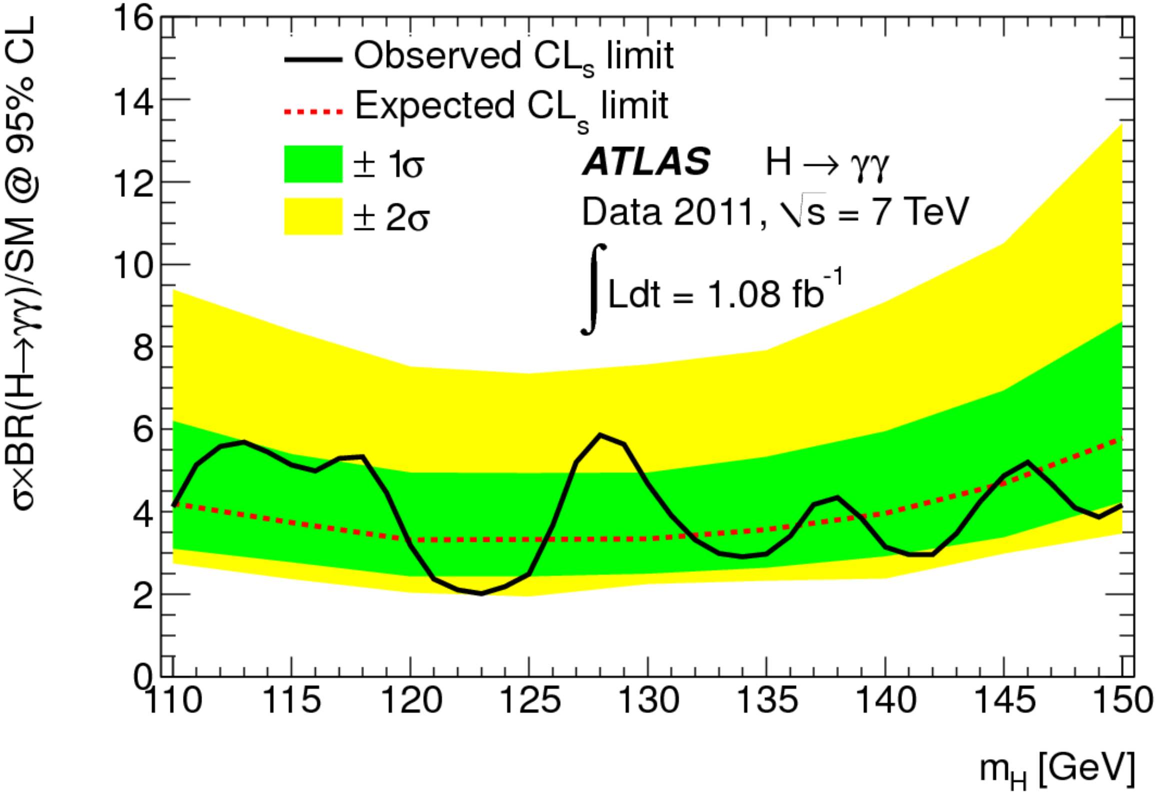


Signal Model : Crystal-Ball + gaussian from MC sample

Background Model: fit of the data with an exponential

$H \rightarrow \gamma\gamma$

Dominant Systematic uncertainties: energy resolution (12%) and photon ID efficiency(10%)



No significant excess observed.

Observed exclusion at 95%CL between 2 and 5.8 SM cross section.

The variation of the observed limit around the expected limit is consistent with the expected statistical fluctuations.

$H\to\tau\tau$

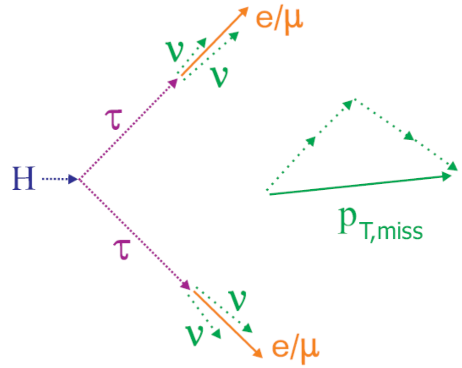
$H\to\tau\tau\to ll+4\nu$

ATLAS-CONF-2011-133

$H\to\tau\tau\to l\tau_{had}+3\nu$

ATLAS-CONF-2011-135

Main challenge: $\tau\tau$ mass reconstruction technique



- **ll analysis: collinear approximation assumes a strict collinearity of the visible and invisible τ decay products.**

$$x_{1,2} = \frac{p_{vis1,2}}{(p_{vis1,2} + p_{mis1,2})} \qquad m_{\tau\tau} = \frac{m_{vis}}{\sqrt{x_1 x_2}}$$

- **lh: MMC (missing mass calculator) new mass reconstruction technique**

A more sophisticated version of the collinear approximation (described in details in ATLAS-CONF-2011-132).

A gain in acceptance (also in resolution) is reached with this new method.

$H\rightarrow\tau\tau\rightarrow ll+4\nu$

ATLAS-CONF-2011-133

Selection cuts

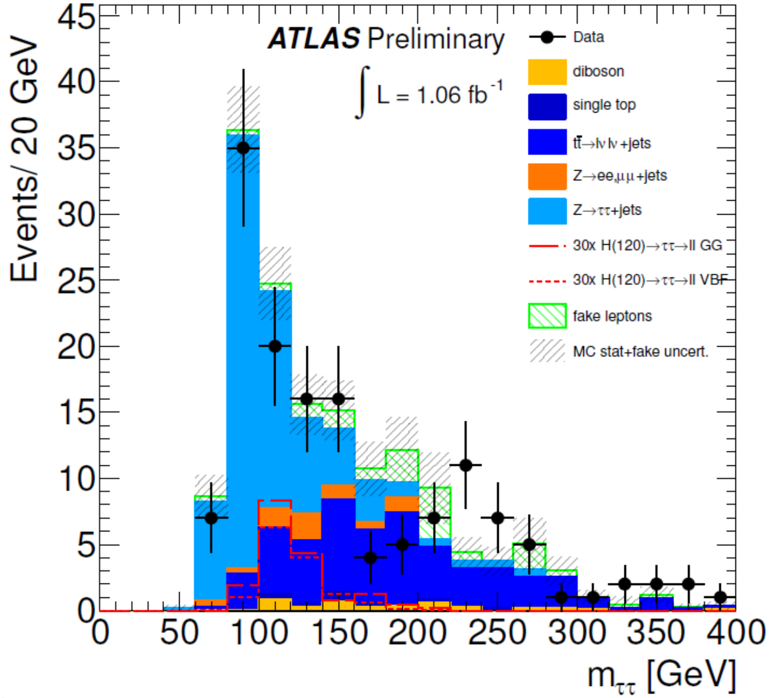
Trigger: 2e (pT>12GeV)/ 1μ (pT>18GeV)/eμ (1e pT^{e}>20GeV)

2 isolated leptons with $30<m_{ll}<75$GeV for same flavour (SF) (to reduce $Z\rightarrow ll$) and $30<m_{ll}<100$GeV for different flavour (DF)

At least one jet with pT>40GeV (enhances VBF and useful for collinear approximation)

E_T^{miss} >30GeV for SF and E_T^{miss}>20GeV for DF

Mass reconstructed with **collinear approximation**



	ee + μμ + eμ
$Z/\gamma^* \rightarrow \tau^+\tau^-$	25.4 ± 2.7
$Z/\gamma^* \rightarrow \ell^+\ell^-$ (ℓ=e,μ)	3.7 ± 1.2
$t\bar{t}$	13.2 ± 2.2
Single-t	1.2 ± 0.5
Di-boson	1.6 ± 0.6
Backgrounds with fake Leptons	2.2 ± 0.9
Total Background expectation	47.4 ± 3.9
Observed data	46

SM signal	$gg\rightarrow H$	VBF
m_H = 110 GeV	0.39 ± 0.06	0.35 ± 0.02
m_H = 115 GeV	0.39 ± 0.06	0.35 ± 0.02
m_H = 120 GeV	0.44 ± 0.05	0.38 ± 0.02
m_H = 130 GeV	0.40 ± 0.04	0.33 ± 0.01
m_H = 140 GeV	0.21 ± 0.02	0.19 ± 0.01

Expected 47.4±3.9

Observed 46

Signal 120GeV 0.82

Main Backgrounds

- **$Z/\gamma^*(\rightarrow l^+l^-)$+jets** *estimated with the τ-embedding method from $Z\rightarrow\mu^+\mu^-$ data*
- **tt-bar, single t, $Z\rightarrow l^+l^-$ and EW diboson:** *from MC*
- **fake leptons:** *normalisation and shape from a data-driven template method*

$H \rightarrow \tau\tau \rightarrow l\tau_{had} + 3\nu$

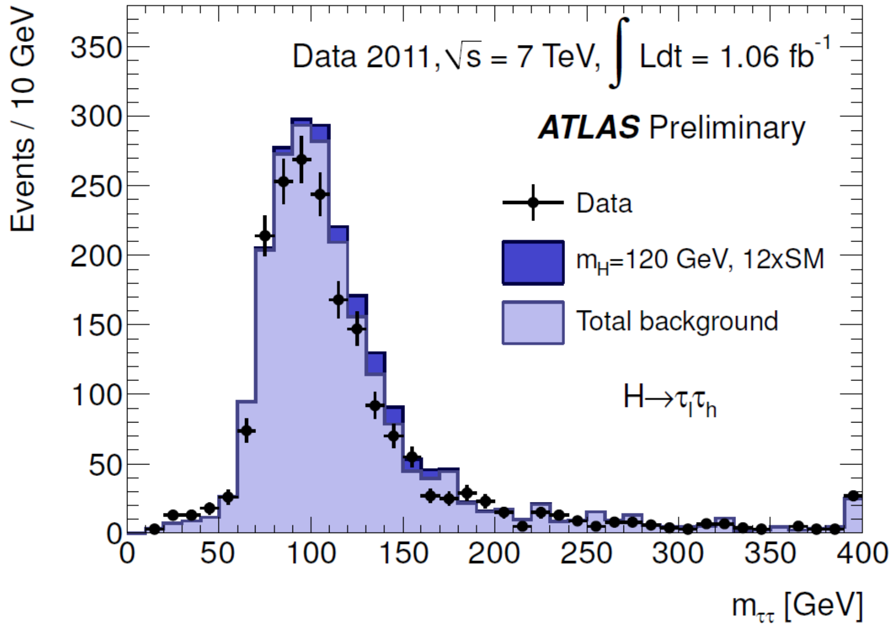
ATLAS-CONF-2011-135

Selection cuts

One electron (muon) pT>25(20) GeV and one τ_{had} pT>20 GeV and E_T^{miss} >20 GeV

The transverse mass of the lepton and missing energy of the system is required to be smaller than 30 GeV (suppresses W(→lν)+jet)

Mass reconstructed with **MMC**



Main Backgrounds

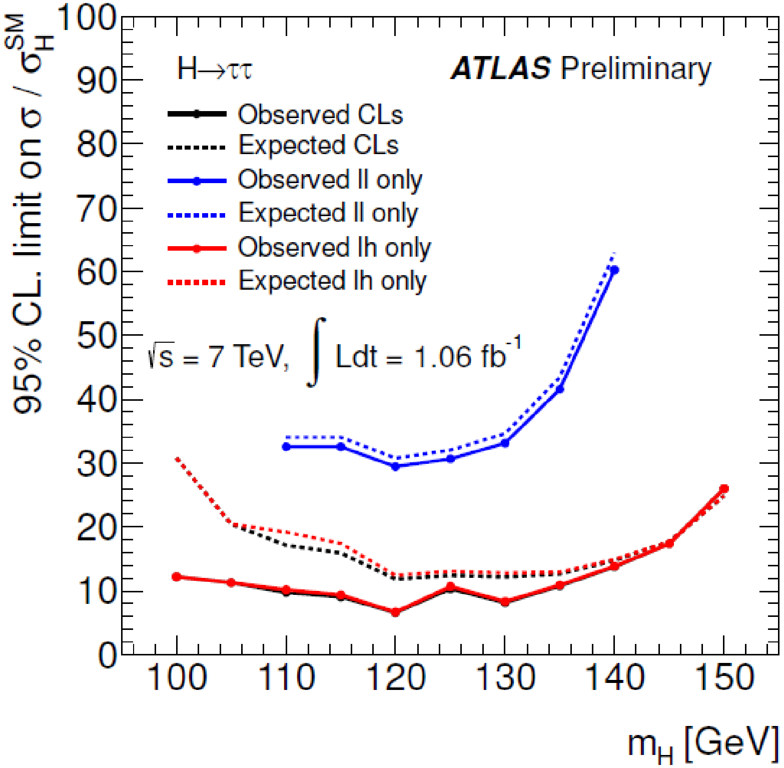
• ***Z/γ*→τ⁺τ⁻:*** *estimated with the τ-embedding method from Z->μ⁺μ⁻ data*

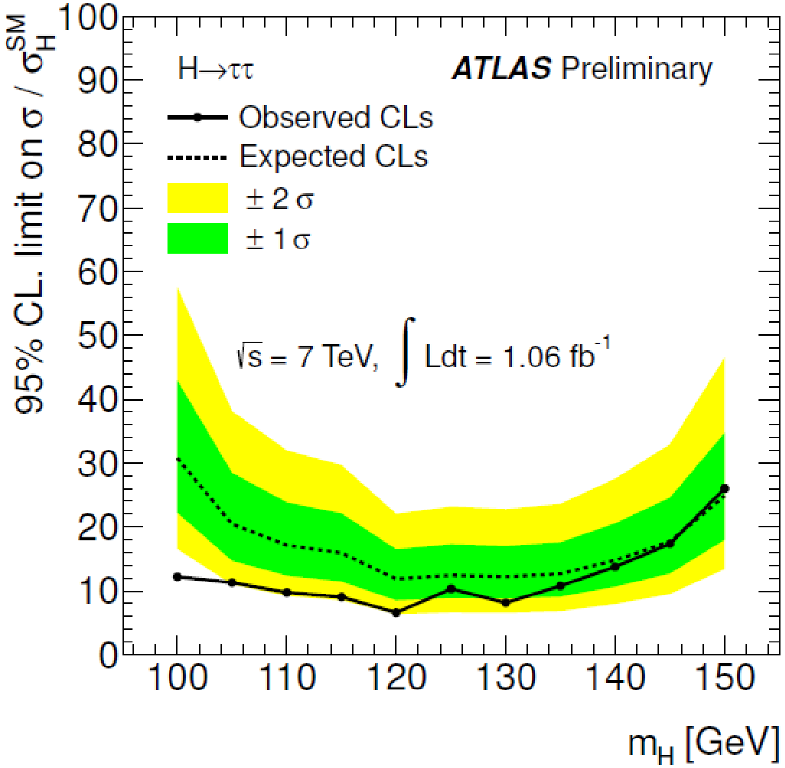
• ***Other :*** *estimated using same sign events and in part using the MC for the difference between the number of opposite signe and same sign events.*

H→ττ

ATLAS-CONF-2011-135

Main Systematic Uncertainties: JES, E_T^{miss} Reconstruction (uncertainty on signal +19-16%) and theory.





No excess is seen. Combined exclusion limits of the order of 10 to 20 times the SM cross section. $H \rightarrow \tau\tau \rightarrow l\tau_{had}+3\nu$ is significantly more sensitive than the $H \rightarrow \tau\tau \rightarrow ll+4\nu$.

Selection cuts

ZH→llbb-bar

ATLAS-CONF-2011-103

- **Identify Z:**

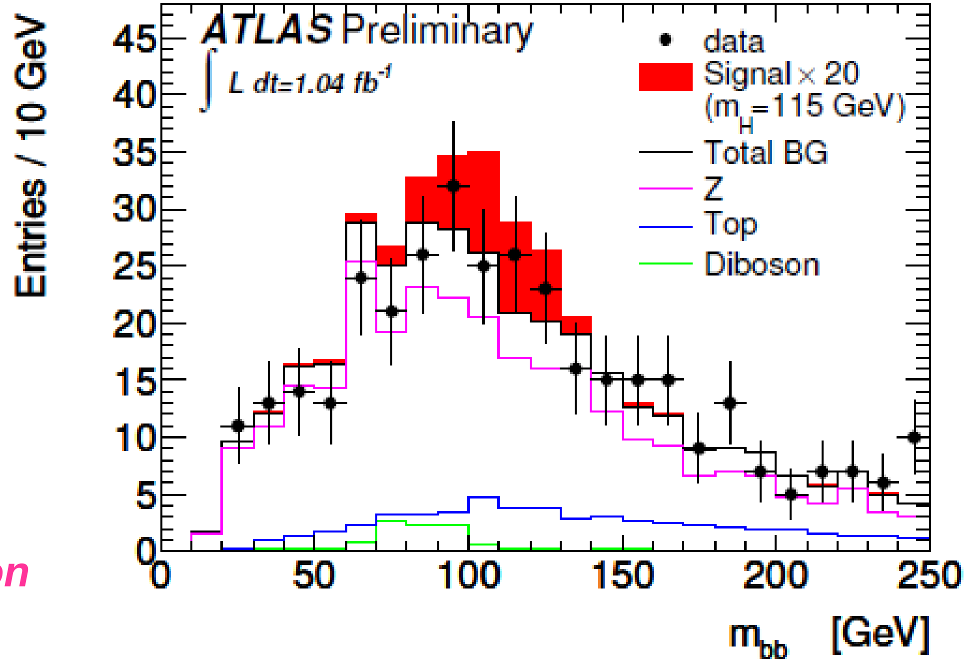
Trigger: - e (pT>20GeV)/ μ (pT>18GeV)

- 2e/2μ pT>12GeV

2 leptons pT>25GeV

76<mll<106GeV

- **2 b-tagged leading jets (reject Z+jets)**
- **E_T^{miss}<50GeV (reject tt-bar)**
- **Search range 110-130 GeV**



Main Backgrounds

•**Z+jets:** *Shape from MC and normalization from sideband (m_{bb}<80GeV and 140<m_{bb}<250GeV)*

•**Diboson ZZ,WZ:** *from MC*

•**Top quark:** *from MC*

•**QCD multijet:** *e-channel from data by reverting electron quality cuts and μ-channel neglected*

Source	expected events		(stat.)		(sys.)
Z+jets	261.0	±	7.8	±	24.6
Top-quark	52.0	±	1.3	±	10.6
Multijet	1.4	±	0.4	±	1.4
ZZ	9.2	±	1.1	±	2.3
WZ	1.1	±	0.3	±	0.3
Total background	324.7	±	8.0	±	27.9
Data	329				
Signal m_H = 110 GeV	2.22	±	0.09	±	0.43
Signal m_H = 115 GeV	1.91	±	0.07	±	0.38
Signal m_H = 120 GeV	1.58	±	0.06	±	0.32
Signal m_H = 125 GeV	1.44	±	0.05	±	0.28
Signal m_H = 130 GeV	1.02	±	0.04	±	0.20

Selection cuts

WH→lνbb-bar

ATLAS-CONF-2011-103

- **Identify W:**

Trigger: e (p_T>20GeV)/ μ (p_T>18GeV)

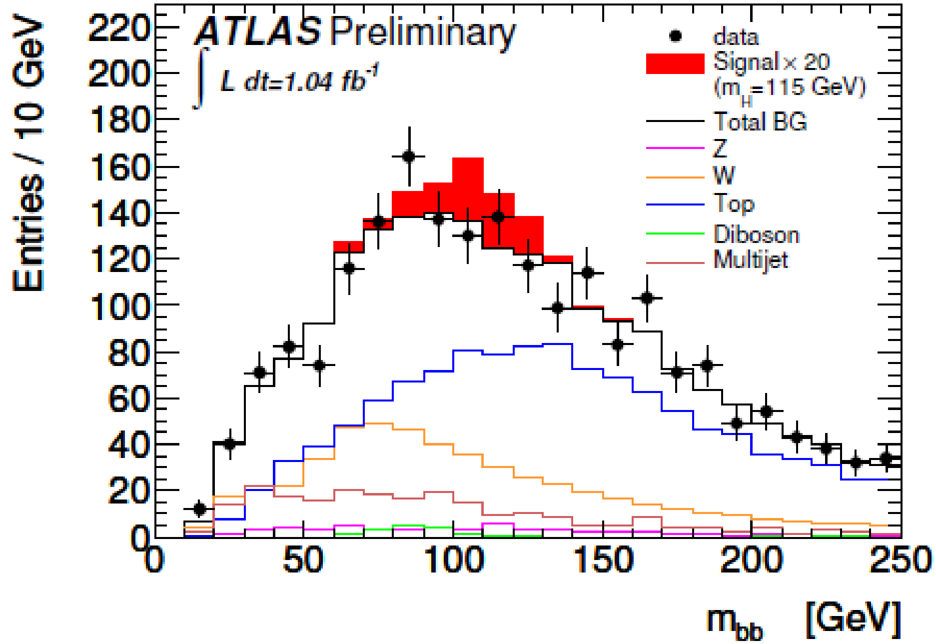
1 lepton p_T>25GeV

M_T>40GeV

E_T^{miss}>25GeV

- **Exactly 2 jets (to reduce top background from tt-bar→bW(→lν) b-barW(→qq))**

- **These jets have to be b-tagged (to reduce W+jets)**



Main Backgrounds

- ***Top quark:* *Shape from MC and normalization from sideband ($40<m_{bb}<80$GeV and $140<m_{bb}<250$GeV)***

- ***W+jets:* *Shape from untagged m_{jj} in data and normalization from sideband (same as top)***

- ***Z+jets:* *Shape from MC and normalization like ZH analysis***

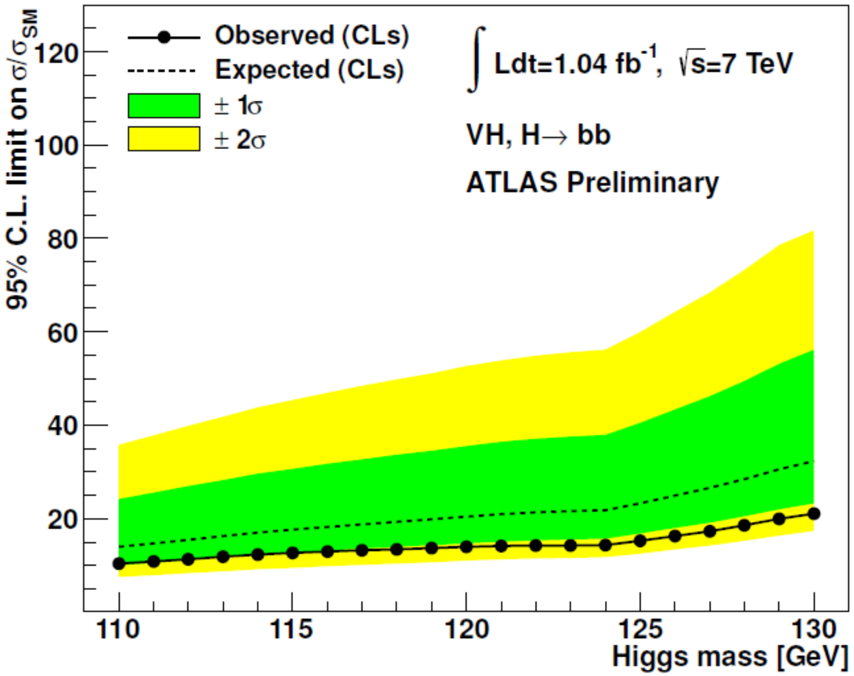
- ***Diboson WW,WZ:* *from MC***

- ***QCD multijet:* *from data by reverting isolation cuts***

Source	expected events		(stat.)		(sys.)
Z+jets	54.4	±	3.9	±	12.3
W+jets	466.7	±	1.4	±	66.5
Top-quark	1141.8	±	8.8	±	78.0
Multijet	193.0	±	9.4	±	96.5
WZ	16.1	±	2.2	±	3.4
WW	4.8	±	1.1	±	1.4
Total background	1876.8	±	13.7	±	147.2
Data	1888				
Signal m_H = 110 GeV	6.72	±	0.31	±	1.20
Signal m_H = 115 GeV	5.25	±	0.30	±	0.97
Signal m_H = 120 GeV	4.54	±	0.25	±	0.83
Signal m_H = 125 GeV	4.08	±	0.21	±	0.77
Signal m_H = 130 GeV	3.28	±	0.17	±	0.62

H→bb-bar

ATLAS-CONF-2011-103



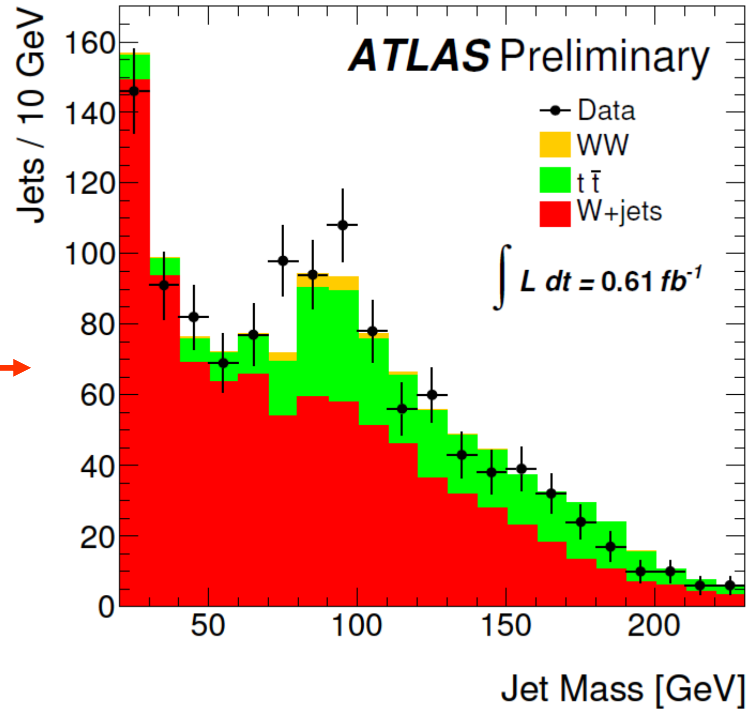
Dominant Systematic uncertainties: b-tagging efficiency (on signal efficiency +37-33%) and jet energy scale (on signal efficiency +21-17%)

The combined (WH+ZH) exclusion ranges between 10 to 20 times the SM cross section

→ No Excess is observed

Possible improvements of bb-bar analysis using boosted jet pairs and jet substructure technique

First results are encouraging: observation of W→qq from tt→bW(→lν)bW(→qq)

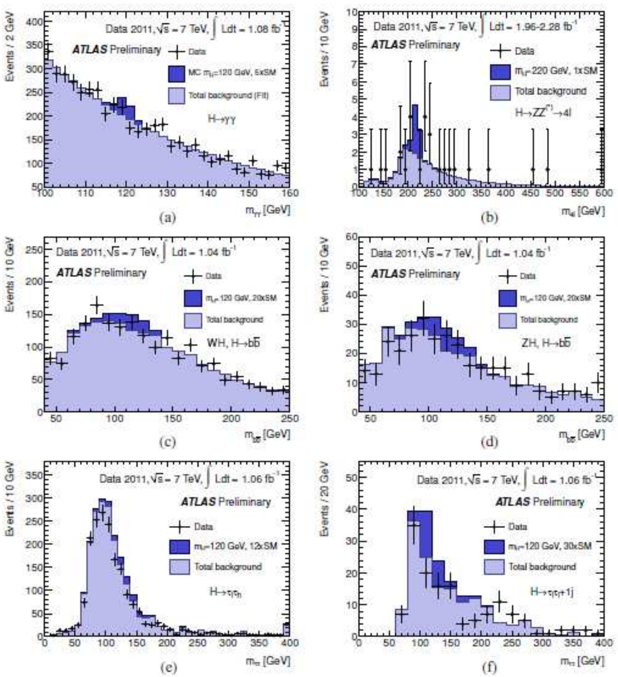


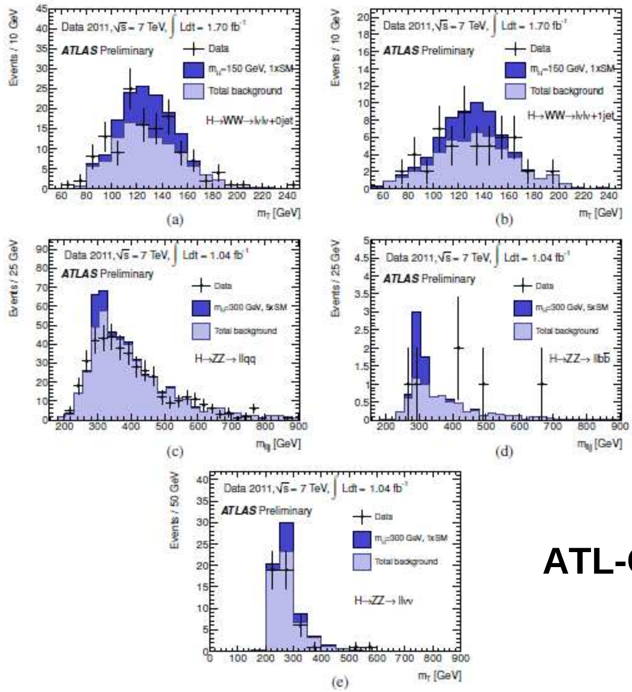
ATLAS SM Higgs Combination

ATLAS SM Higgs Combination

	$H \to \tau^+\tau^-$		$H \to \gamma\gamma$	$H \to b\bar{b}$	$H \to WW^{(*)}$	$H \to ZZ^{(*)}$		
	$\tau_\ell \tau_{had}$	$\tau_\ell \tau_\ell + jet$			$\ell\nu\ell\nu$ 0-jet 1-jet	$\ell\ell\ell\ell$	$\ell\ell\nu\nu$	$\ell\ell qq$
$\mathscr{L}$ (fb^{-1}) Old	-	-	1.08	1.04	1.04	1.04-1.21	1.04	1.04
$\mathscr{L}$ (fb^{-1}) New	1.06	1.06	1.08	1.04	1.70	1.96-2.28	1.04	1.04
Analysis Opt.	No	No	No	No	Yes	No	No	No

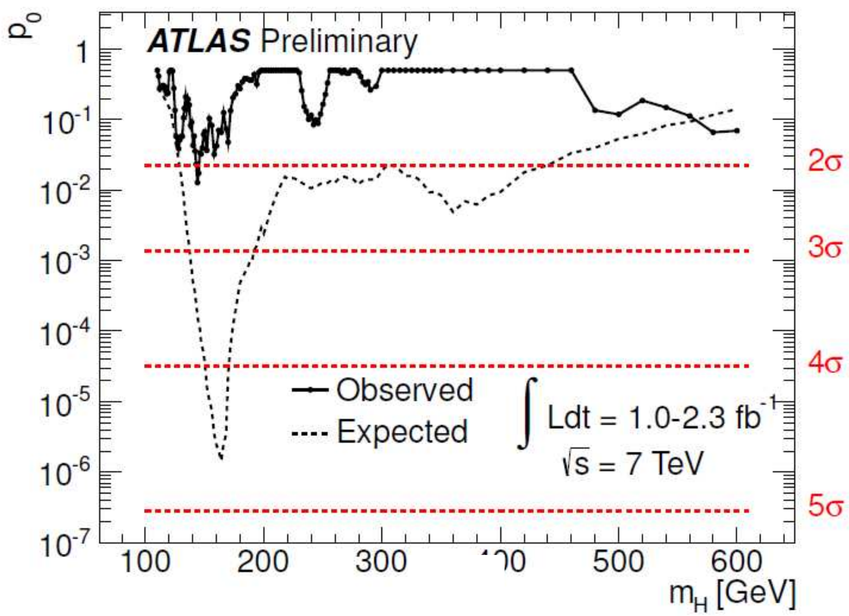
Most of the signal-related systematic uncertainties are correlated. The background-related systematic uncertainties are typically uncorrelated (in particular when estimated from data control samples)





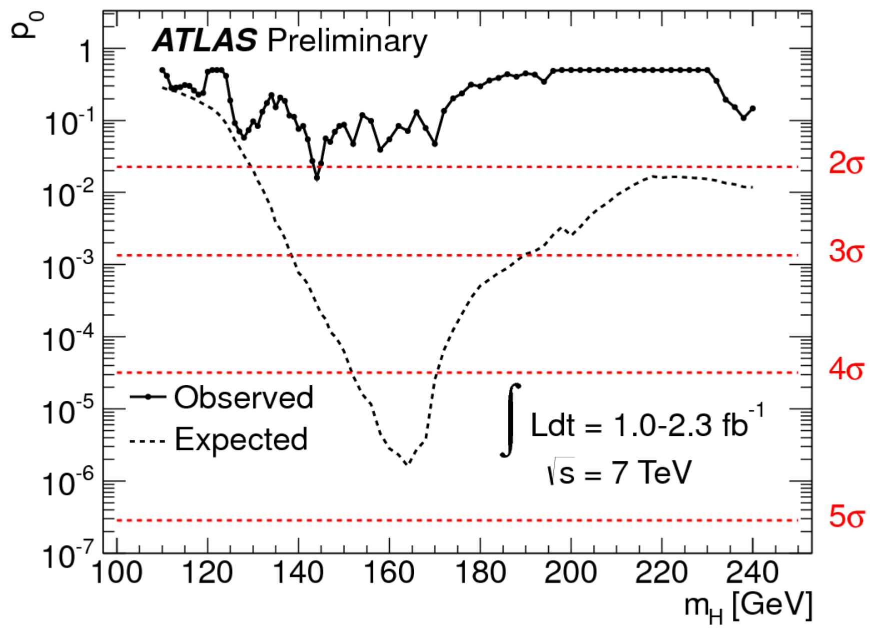
ATL-CONF-2011-135

ATLAS SM Higgs Combination

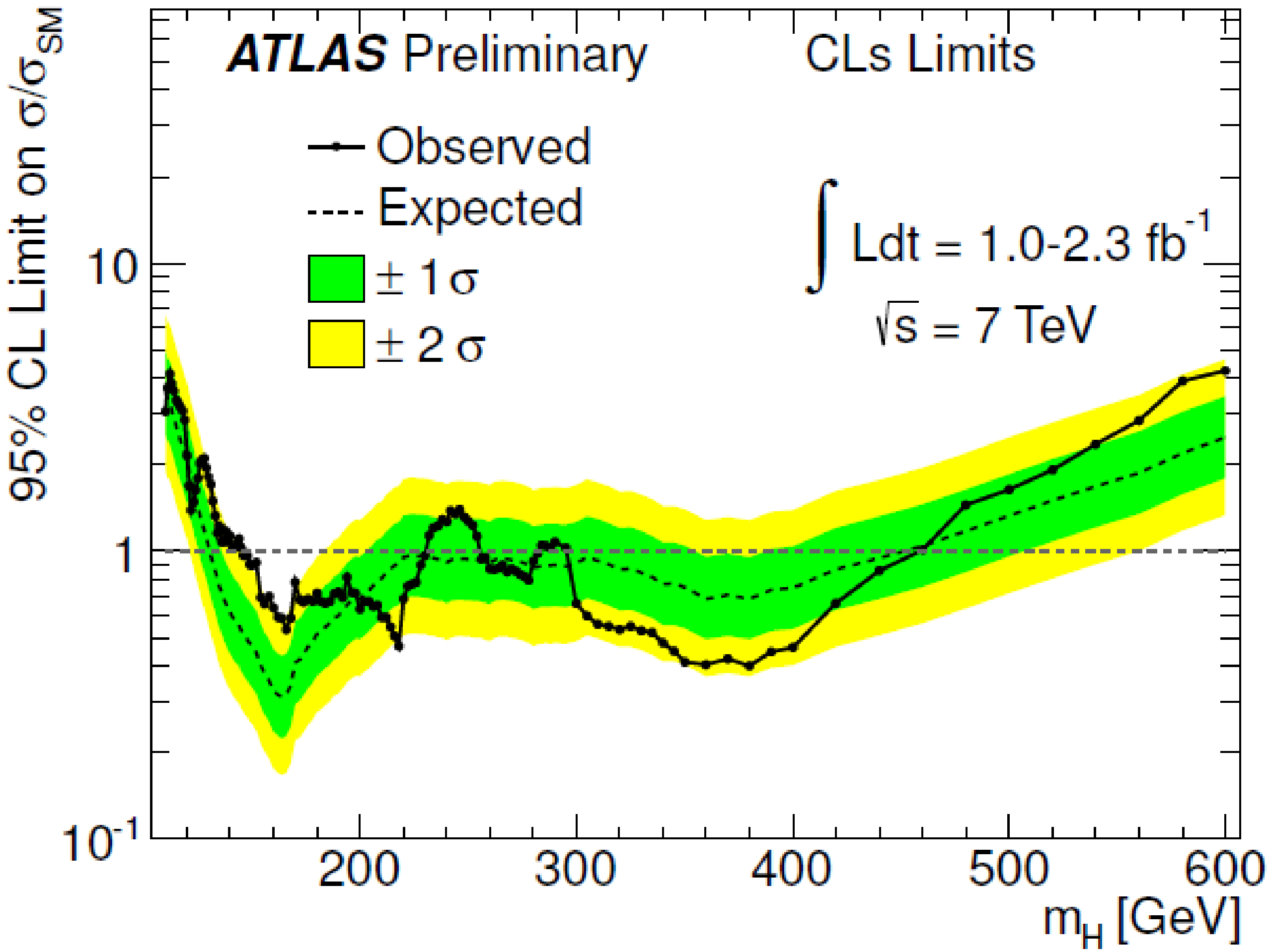


p0: probability that a bakground only experiment is more signal-like than the observed one.

The most extreme value of the p0 which is observed at 144 GeV (due to the small excess in the WW→lνlν channel and one event observed in the ZZ*→ 4l analysis) has a significance of 2σ



ATLAS SM Higgs Combination: Combined channels



Excluded at 95% CL mass regions

146 to 232, 256 to 282 and 296 to 466 GeV

MSSM Higgs Searches

MSSM H/A/h→ττ

ATL-CONF-2011-132

- **One of the most promising channel**
- **Production: gg→A/H/h and associated bbA/H/h**

Event selection and mass reconstruction:

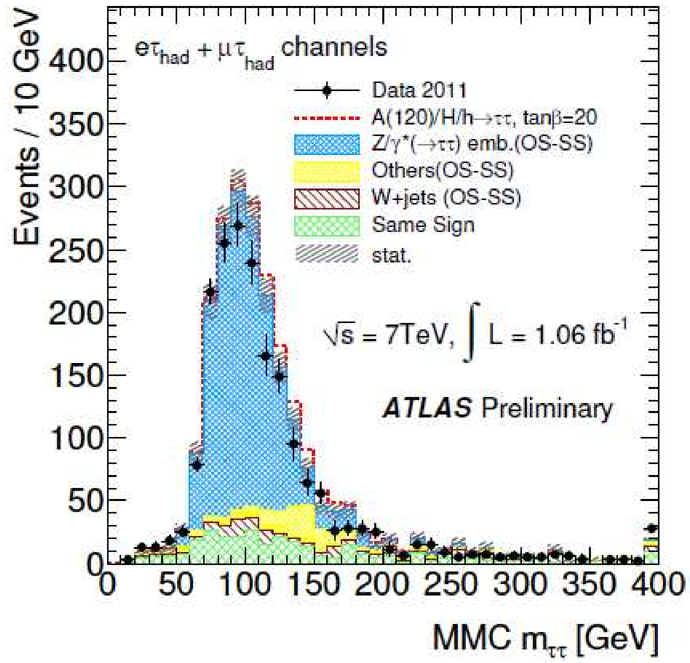
- eμ4ν: one isolated electron pT>22 GeV(15), muon pT>10 GeV(20) if event triggered by the e (μ) trigger and E_T^{miss}. Mass reconstruction $m_{\tau\tau}$ effective.

- e/μτ_{had}3ν: Exactly one isolated e(μ) with pT>25(20)GeV and one oppositely-charged τ_{had} candidate pT>20 GeV and E_T^{miss} >20GeV. Veto on Z→ll with loose lepton ID cuts. Missing Mass Calculator (MMC) $m_{\tau\tau}$.

- $\tau_{had}\tau_{had}$2ν: Exactly 2 oppositely charged τ_{had} (pT>45,30GeV) and E_T^{miss} >25GeV. Mass reconstruction $m_{\tau\tau}$ visible.

Main Backgrounds:

Z/γ*, W+jets, top quark, EW diboson are dominant bkg for eμ and lτ_{had}. QCD jet processes are dominant bkg in the $\tau_{had}\tau_{had}$ final state.

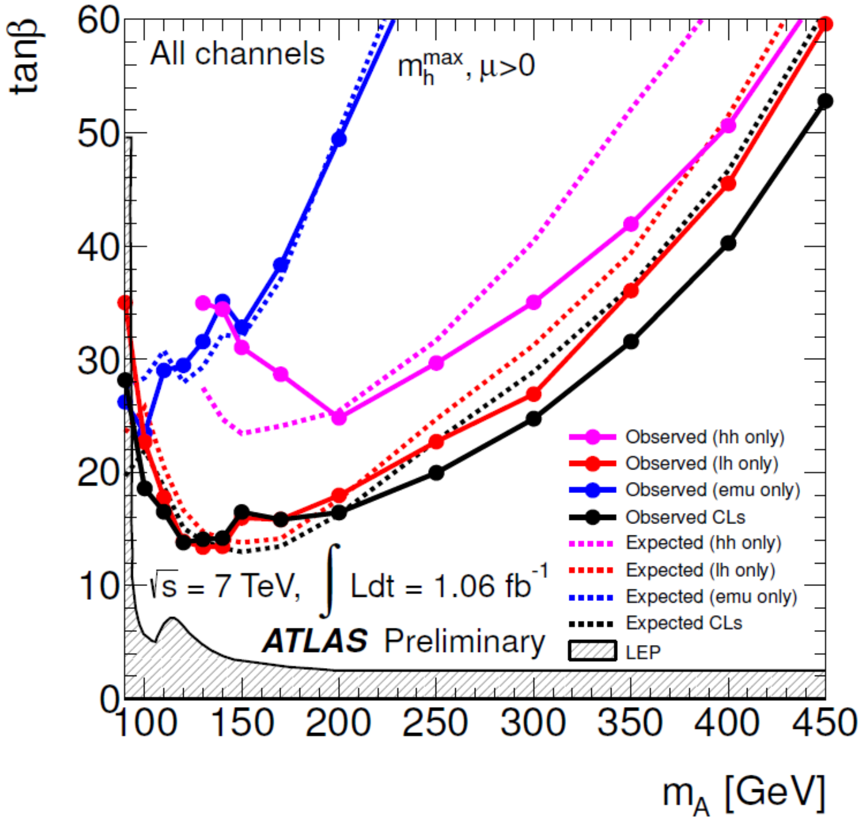


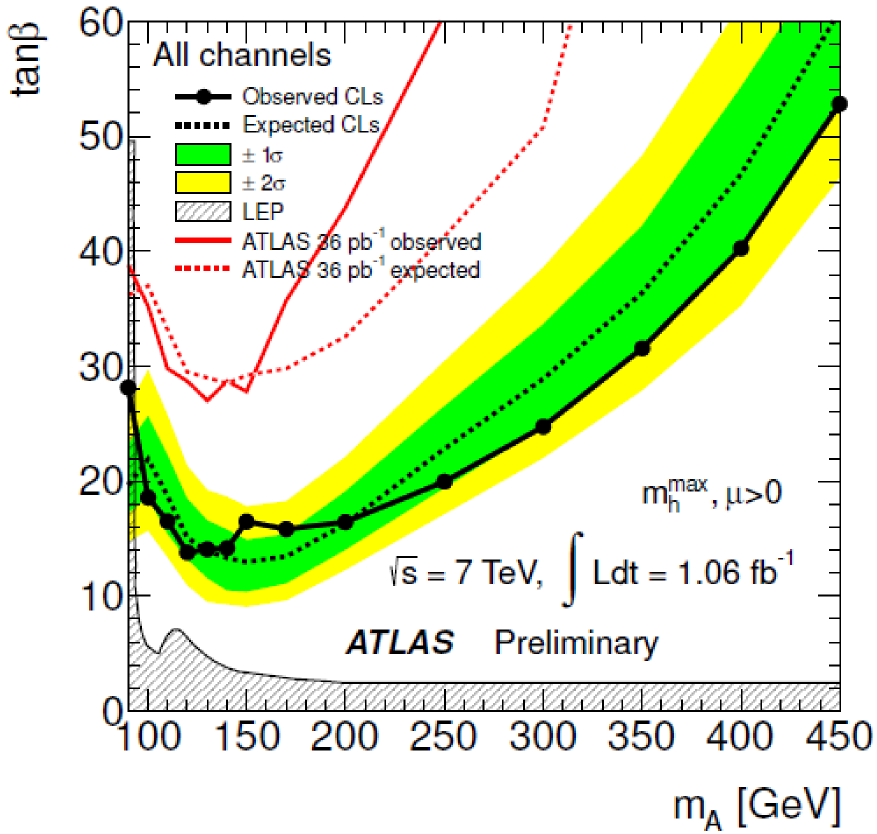
Final state	Exp. Background	Data
$e\mu$	$(2.6 \pm 0.2) \times 10^3$	2472
$\ell\tau_{had}$	$(2.1 \pm 0.4) \times 10^3$	1913
$\tau_{had}\tau_{had}$	$233\ ^{+44}_{-28}$	245
Sum	$(4.9 \pm 0.6) \times 10^3$	4630

Systematic uncerntainties included

MSSM H/A/h→ττ

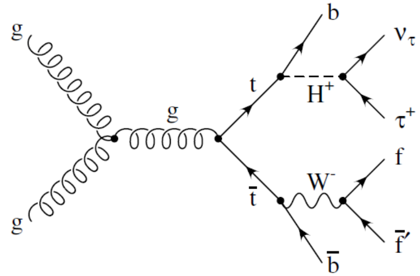
Dominant systematic uncertainties: energy scales and resolution (1/+30-23/+9-8% for eμ/lτ_{had}/$\tau_{had}\tau_{had}$)





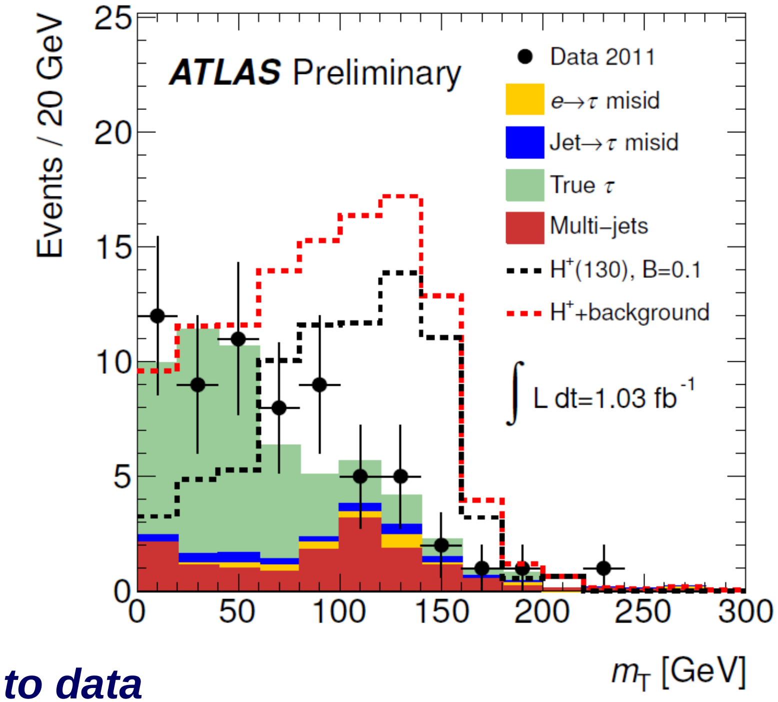
The lτ_{had} final state provides the most stringent limit. The eμ and $\tau_{had}\tau_{had}$ final states lead to improvements of the exclusion limits for small and high Higgs boson masses resp.

No significant excess is observed in any of the final states.



$H^+ \rightarrow \tau_{had}^+ + \nu$

ATLAS-CONF-2011-138



Selection cuts

- τ jet with pT>35 GeV. Events with a second identified τ jet pT>20GeV, an electron pT>20 GeV or a muon pT>10GeV are vetoed
- E_T^{miss} >40 GeV. Events with large E_T^{miss} due to the limited resolution of the energy measurement are reject with the cut: $E_T^{miss} / (0.5\sqrt{\Sigma E_T}) > 8\ GeV^{1/2}$
- At least one b-tagged jet required

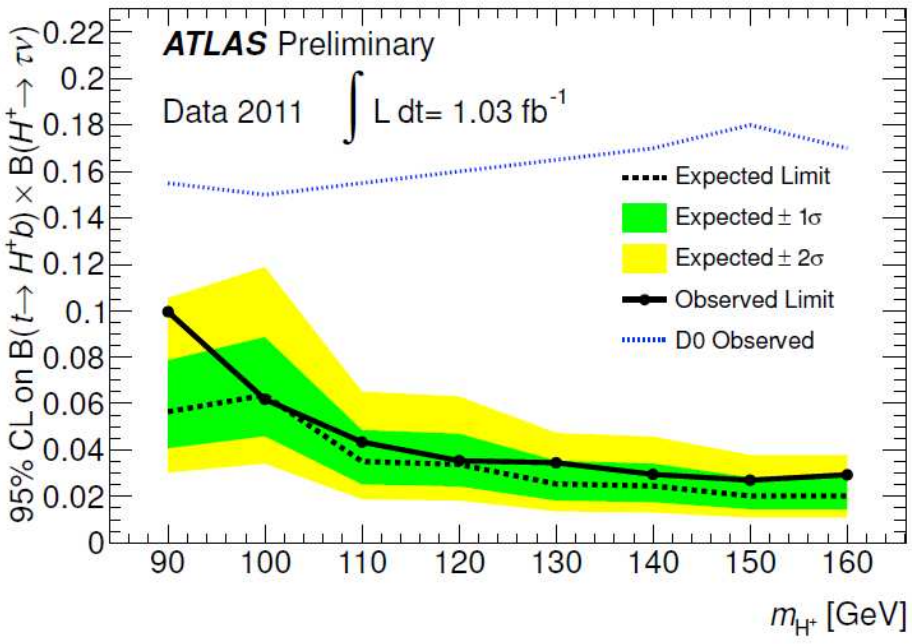
Main Backgrounds

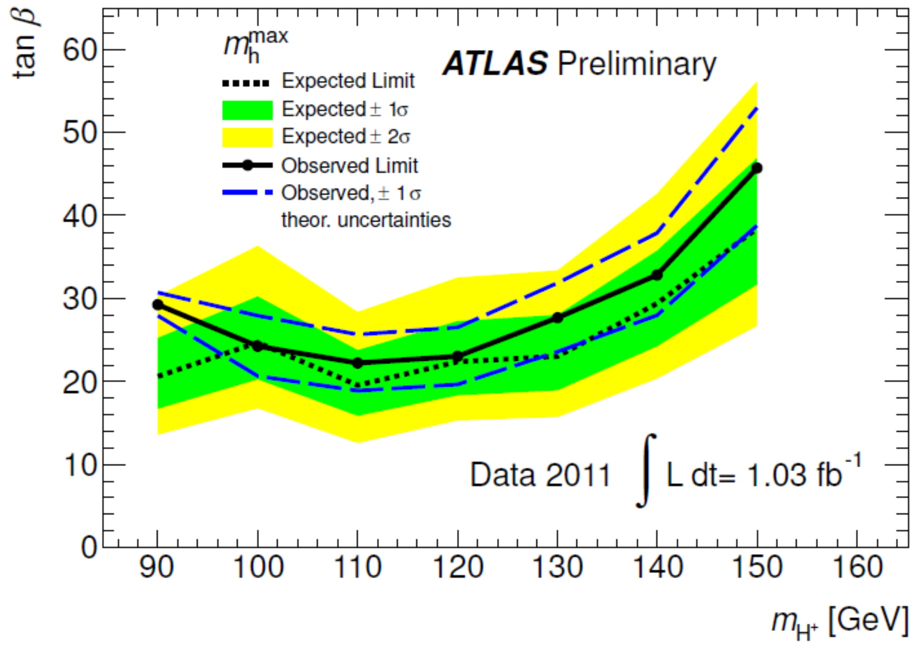
- **true τ jets:** *embedding method (from $Z \rightarrow \mu^+\mu^-$ data)*
- **multi-jet:** *shape from sideband region and fitting it to data*
- **jet→τ misidentification:** *with intrinsic E_T^{miss} and with γ+jets control samples*
- **e→τ misidentification:** *from Z/γ*→ee control samples*

	Events with/from					
	true τ jets	jet → τ mis-id	e → τ mis-id	multi-jet	expected (sum)	data
m_T > 40 GeV	21 ± 5	2.4 ± 0.7	1.9 ± 0.2	12 ± 5	37 ± 7	43

$H^+ \to \tau_{had}^+ + \nu$

Dominant systematic uncertainties: jet energy scale (2.5-14%) and resolution (10-30%)





Values of $BR(t \to bH^+) * BR(H^+ \to \tau_{had}^+ + \nu)$ larger than 0.03-0.10 are excluded in the H^+ mass range 90-160 GeV.

In the context of m_h^{max}, values of $\tan\beta$ above 22-30 are excluded in the H^+ mass range 90-140 GeV.

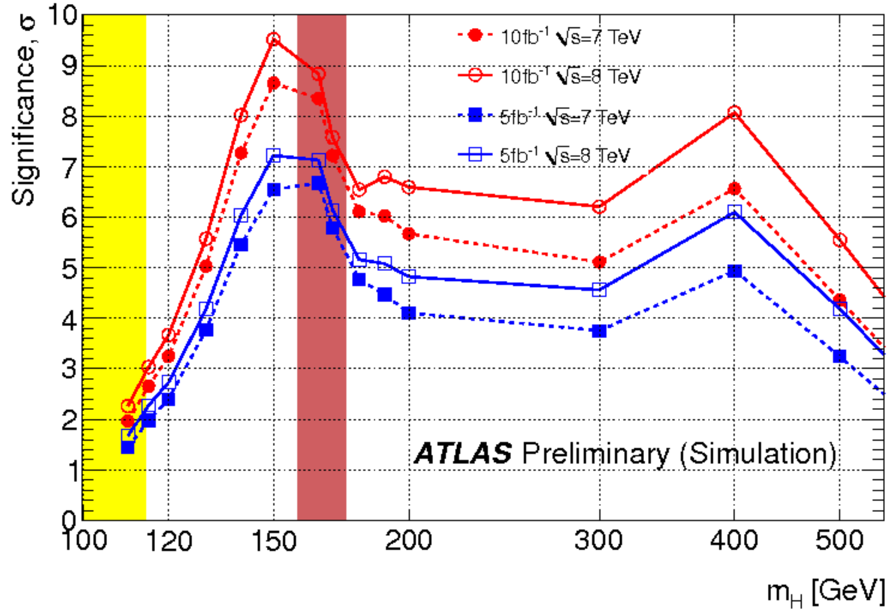
Conclusions and Perspectives

• No significant excess was observed in ATLAS for the mass range 110-600 GeV.

• Mass excluded for SM Higgs boson: 146 to 232, 256 to 282 and 296 to 466 GeV

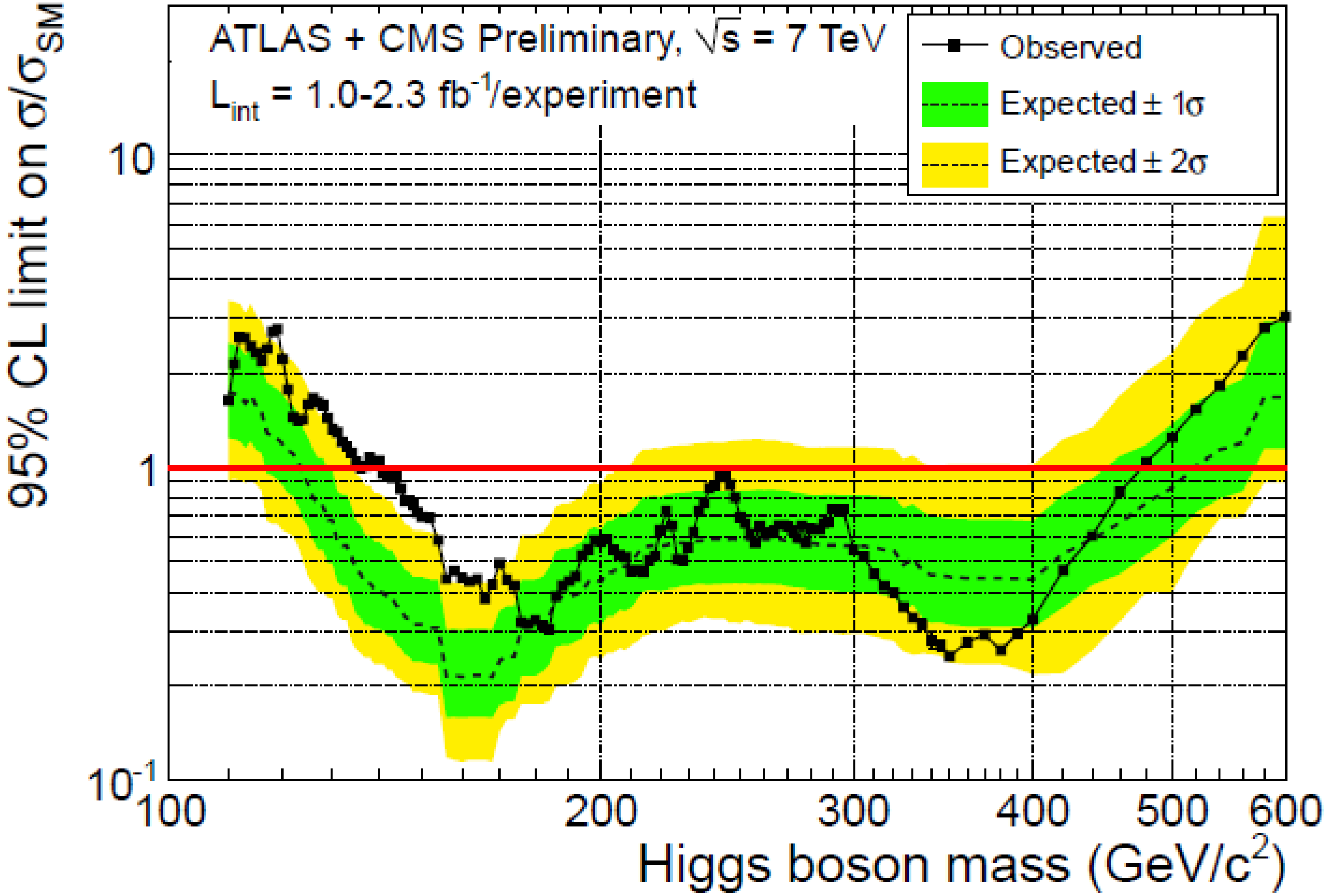
• A 95% CL exclusion for the whole mass range could be achieved by combining ATLAS-CMS results for an integrated luminosity of about 4-5 fb^{-1}.

2012 (with hopefully additional 15 to 20 fb^{-1}) should hopefully bring more answers!



Combination ATLAS+CMS

New!

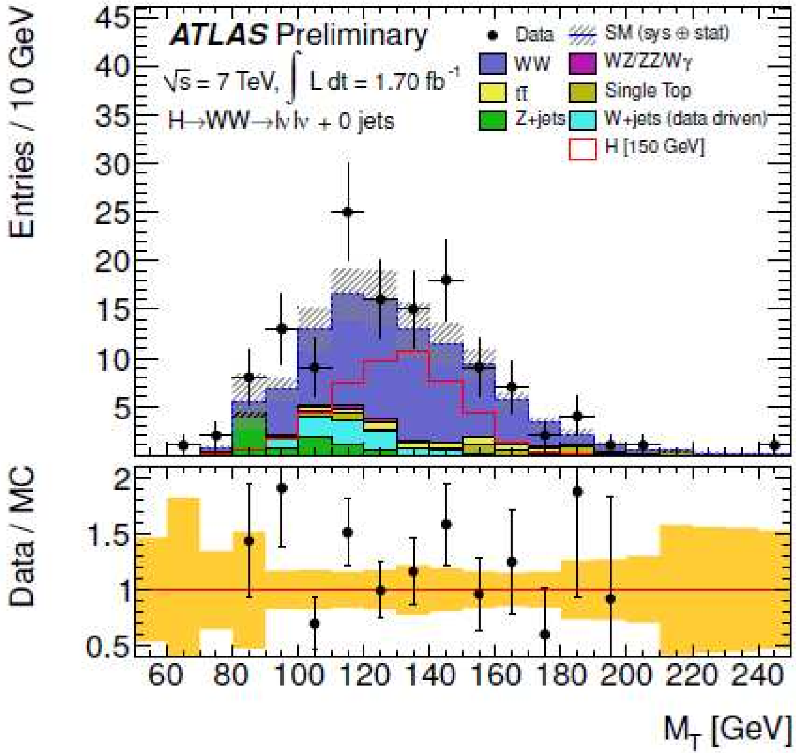


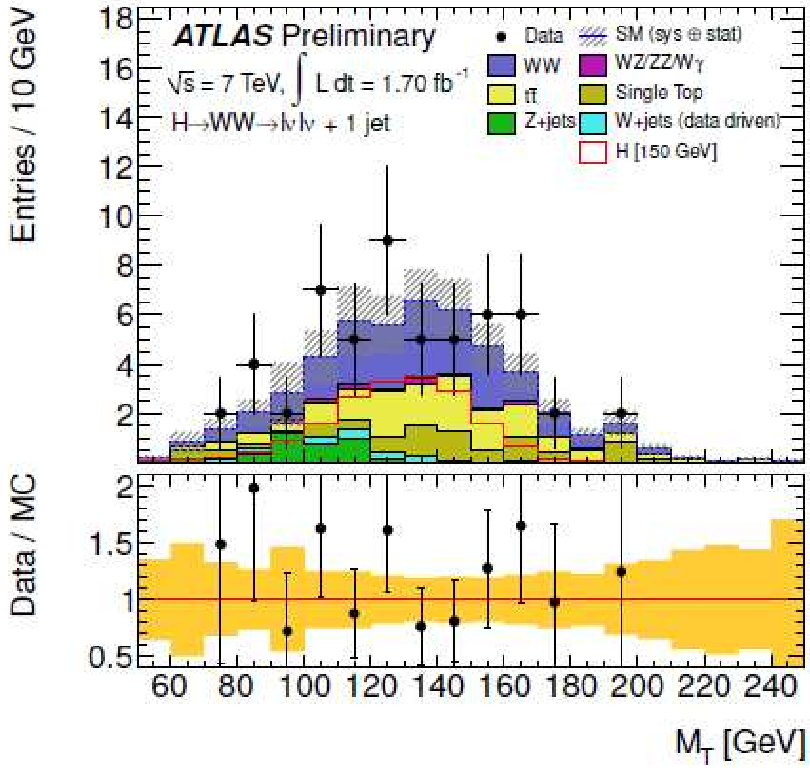
Observed data are compatible with the background-only hypothesis
SM Higgs boson is excluded at 95%CL or higher in the mass range 141- 476 GeV.
The region from 146 to 443 GeV is excluded at 99%CL, except three small regions between 220 and 320 GeV

Thank you for your attention!

Backup Slides

WW(*)→lνlν





M_T for H→WW→lνlν + 0/1 jet

Collinear Approximation

$$\not{E}_X = P_{\nu 1} \cdot \cos(\theta_1) \cdot \cos(\varphi_1) + P_{\nu 2} \cdot \cos(\theta_2) \cdot \cos(\varphi_2)$$
$$\not{E}_Y = P_{\nu 1} \cdot \cos(\theta_1) \cdot \sin(\varphi_1) + P_{\nu 2} \cdot \cos(\theta_2) \cdot \sin(\varphi_2)$$

MMC

$$\not{E}_{\mathrm{T}x} = p_{\mathrm{mis}_1} \sin\theta_{\mathrm{mis}_1} \cos\phi_{\mathrm{mis}_1} + p_{\mathrm{mis}_2} \sin\theta_{\mathrm{mis}_2} \cos\phi_{\mathrm{mis}_2}$$
$$\not{E}_{\mathrm{T}y} = p_{\mathrm{mis}_1} \sin\theta_{\mathrm{mis}_1} \sin\phi_{\mathrm{mis}_1} + p_{\mathrm{mis}_2} \sin\theta_{\mathrm{mis}_2} \sin\phi_{\mathrm{mis}_2}$$
$$M_{\tau_1}^2 = m_{\mathrm{mis}_1}^2 + m_{\mathrm{vis}_1}^2 + 2\sqrt{p_{\mathrm{vis}_1}^2 + m_{\mathrm{vis}_1}^2}\sqrt{p_{\mathrm{mis}_1}^2 + m_{\mathrm{mis}_1}^2} - 2 p_{\mathrm{vis}_1} p_{\mathrm{mis}_1} \cos\Delta\theta_{vm_1}$$
$$M_{\tau_2}^2 = m_{\mathrm{mis}_2}^2 + m_{\mathrm{vis}_2}^2 + 2\sqrt{p_{\mathrm{vis}_2}^2 + m_{\mathrm{vis}_2}^2}\sqrt{p_{\mathrm{mis}_2}^2 + m_{\mathrm{mis}_2}^2} - 2 p_{\mathrm{vis}_2} p_{\mathrm{mis}_2} \cos\Delta\theta_{vm_2}$$