Higgs Boson Searches in ATLAS

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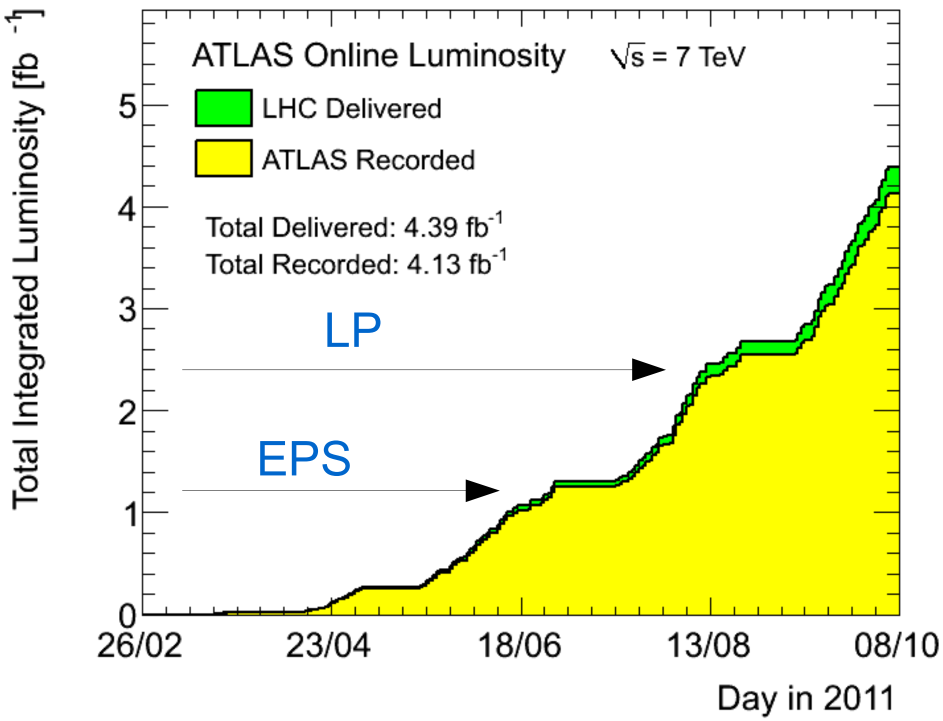
ATLAS Data Taking in 2011



Results presented based on EPS or Lepton-Photon Conference Papers and Letters (~1-2 /fb) @ 7 TeV

Data taken with 50 ns bunch spacing
(very small fraction with 75 ns)

On average 6 interactions per bunch crossing

Between 96% and 100% of all channels operational
(depending on detector subsystem)

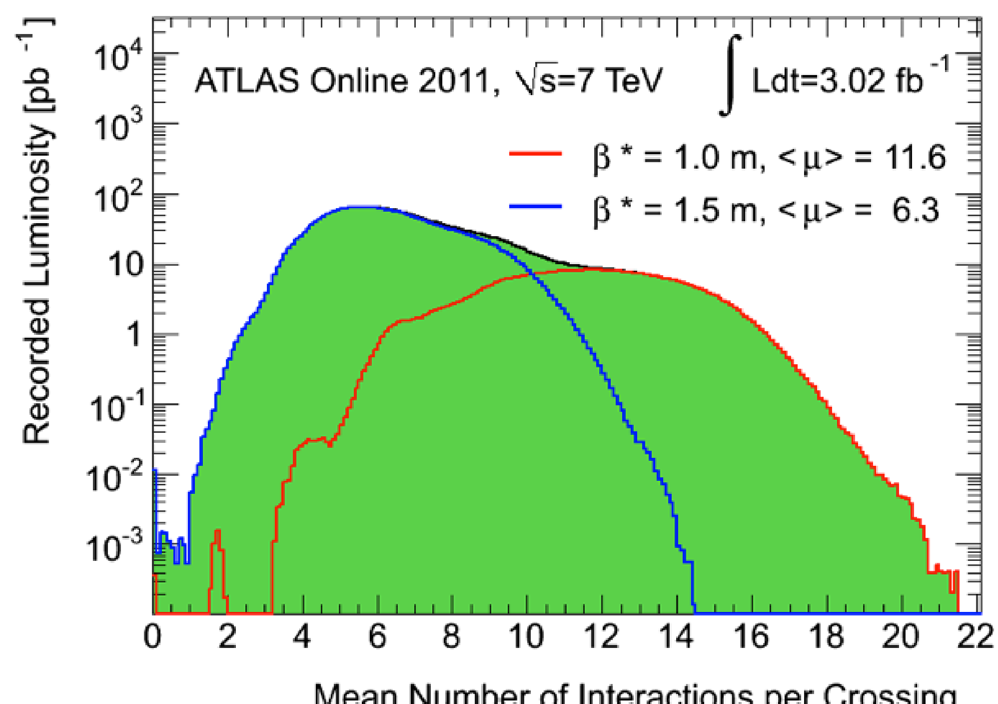
Current status:

ATLAS data on tape: 4.2 /fb,
Peak luminosity: 3.3 x 10^{33} /cm^2/s

New data with 12 interactions per crossing
(half of the value expected at design lumi)

Collect ~5 /fb by end of 2011

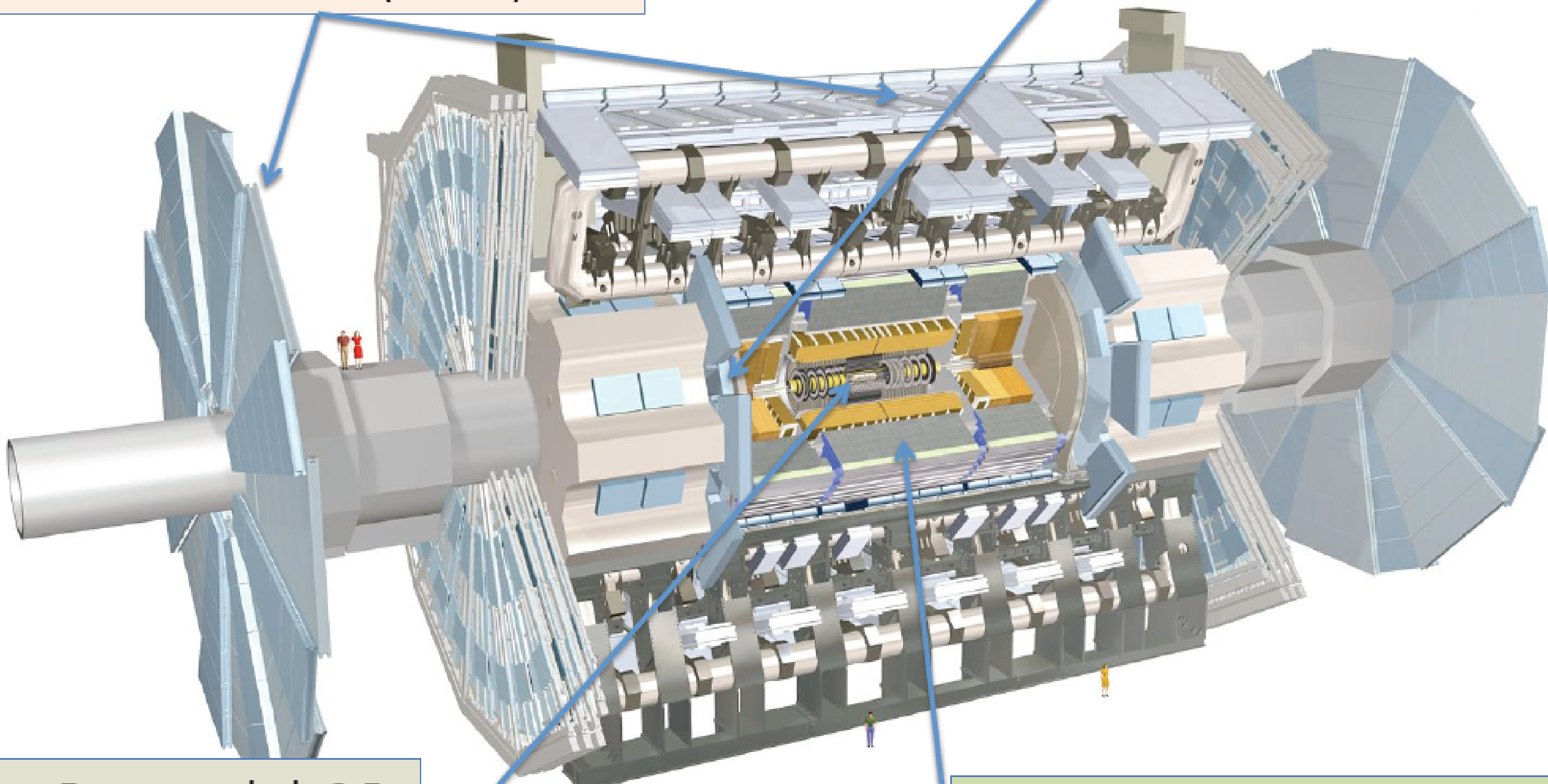
Collect ~15-20 /fb by end of 2012



ATLAS Detector

Muon Spectrometer: $|\eta|<2.7$
Air-core toroids and gas-based muon chambers σ/p_T = 2% @ 50 GeV to 10% @ 1TeV (ID+MS)

EM Calorimeter: $|\eta|<3.2$
Pb-LAr Accordion $\sigma/E=10\%\sqrt{E}\oplus0.7\%$

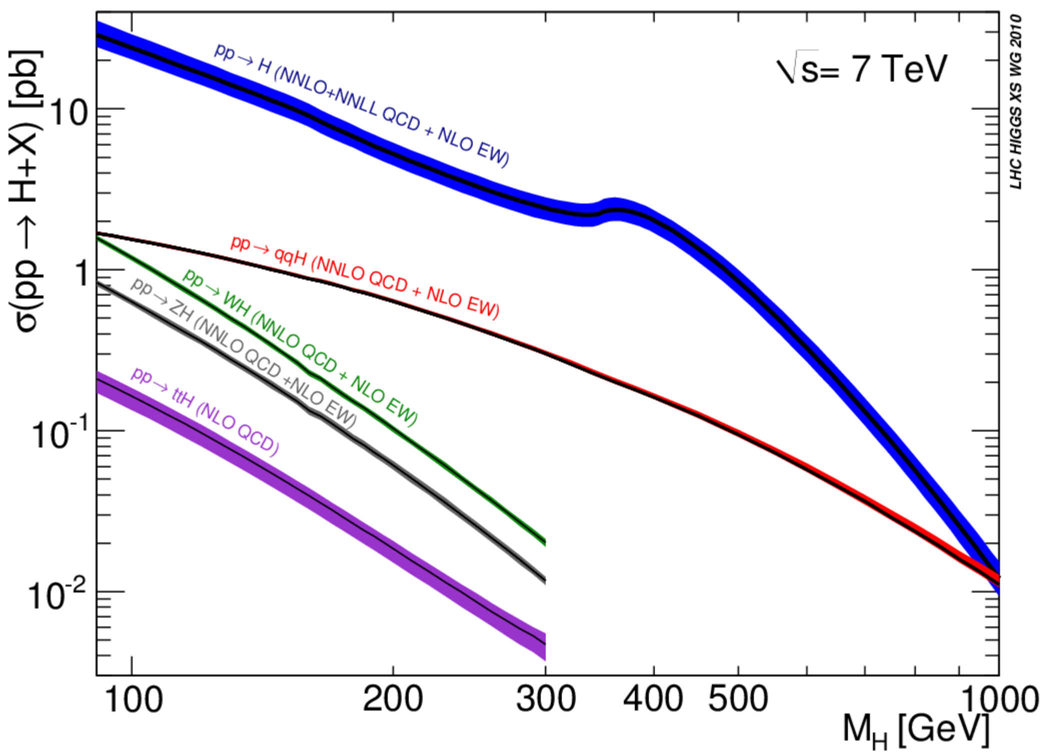


Inner Detector: $|\eta|<2.5$, B=2T, Si pixels/strips and Trans. Rad. Det.; σ/pT = 0.05% pT (GeV) $\oplus$ 1%

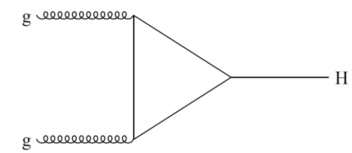
Hadronic calorimeter: $|\eta|<1.7$ Fe/scintillator $1.3<|\eta|<4.9$ Cu/W-LAr; σ/E_{jet}= 50%/$\sqrt{E}$ $\oplus$ 3%

SM Higgs Boson Production at the LHC

LHC cross-section working group arXiv:1101.0593v3

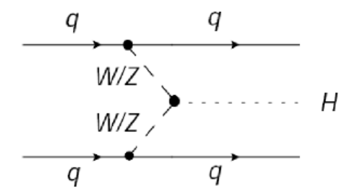


- Gluon fusion (ggF)



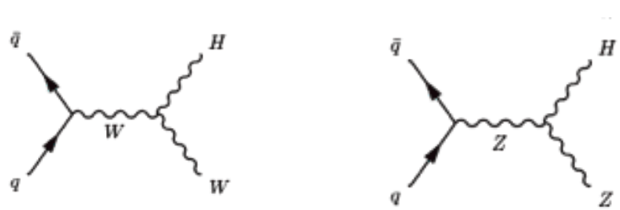
dominant process at LHC
10x higher rate than at Tevatron
known to NNLO + NNLL + NLO EW
15-20% theory uncertainty

- Vector boson fusion (VBF)



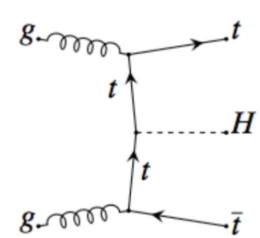
known at NLO, ~5% theory uncertainty
distinctive experimental signature
becomes more important at high mass

- Associated production with W or Z



known at NNLO, ~5% theory uncertainty
Leptonic signature useful for study of $H \rightarrow b\bar{b}$

- Associated production with ttbar

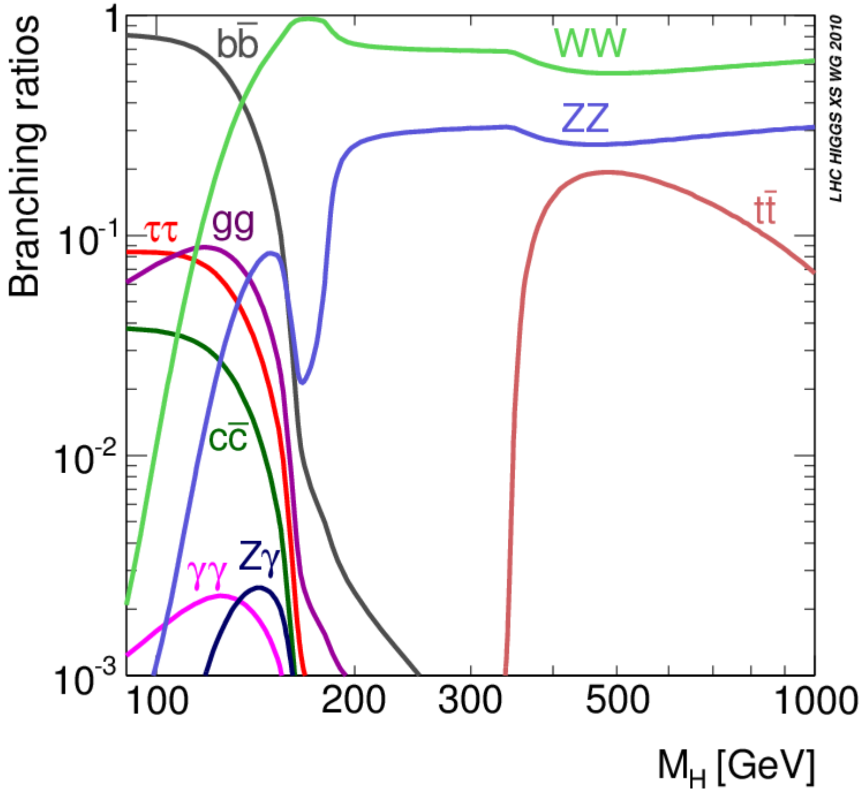


known at NLO, ~5% theory uncertainty
Provides little additional sensitivity

Theory uncertainty mostly from scale variations and PDFs

SM Higgs Boson Decay

(MSSM and Exotic Higgs in Backup)



$H \rightarrow \gamma\gamma$
$H \rightarrow bb$
$H \rightarrow \tau\tau$

Low mass (m_H < 140 GeV)

$H \rightarrow WW \rightarrow l\nu l\nu$
$H \rightarrow ZZ \rightarrow 4l$

Intermediate, wide mass range (130 – 600 GeV)

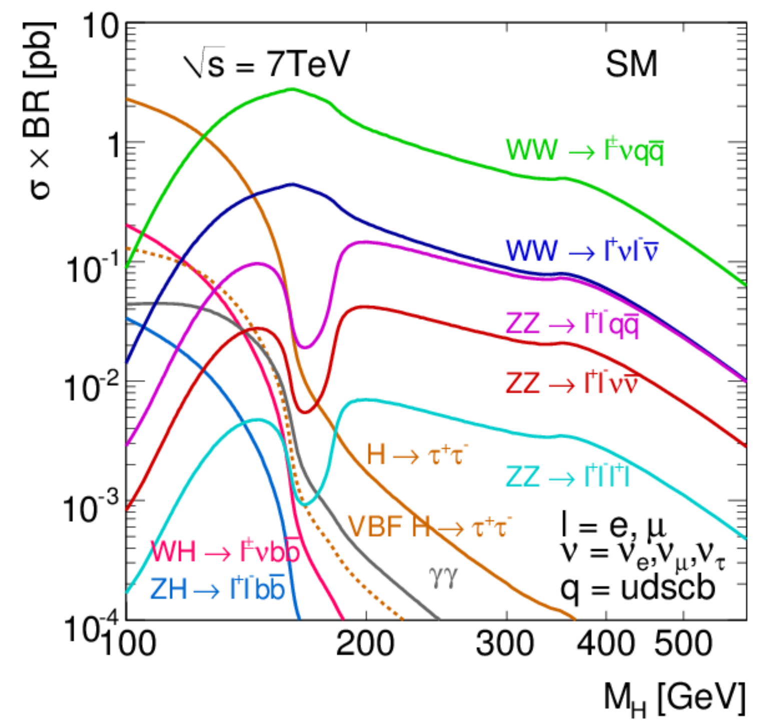
$H \rightarrow ZZ \rightarrow ll\nu\nu$
$H \rightarrow ZZ \rightarrow llqq$
$H \rightarrow WW \rightarrow l\nu qq$

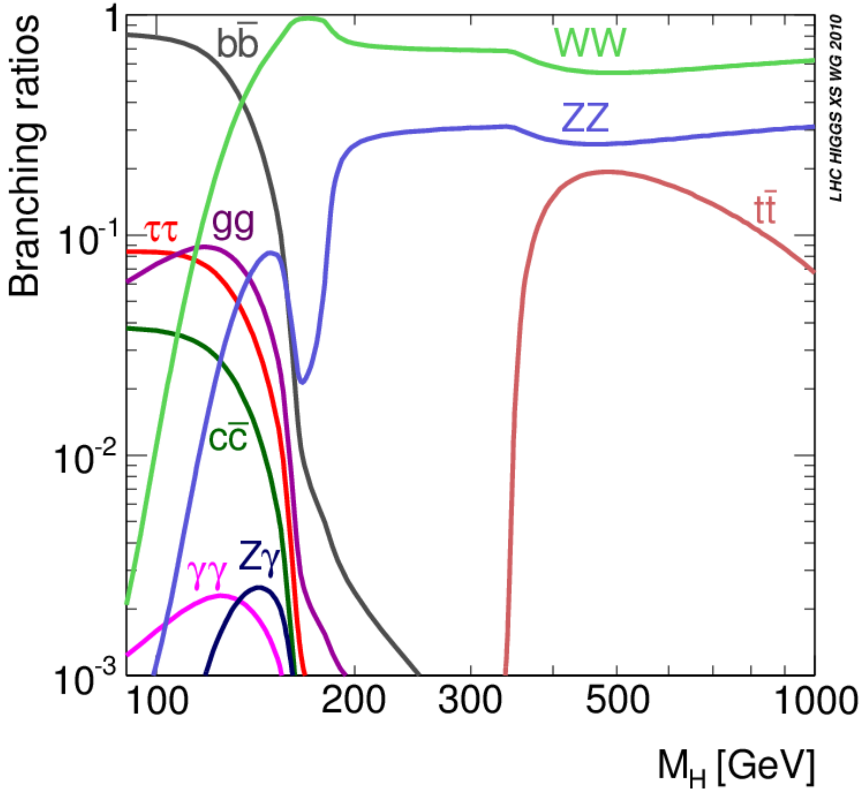
Predominantly at high mass

Events expected to be produced with L=1 fb^{-1}

m_H, GeV	WW→lνlν	ZZ→4l	γγ
120	127	1.5	43
150	390	4.6	16
300	89	3.8	0.04

(before selection)





m_H = 200 GeV – 600 GeV

$H \rightarrow WW \rightarrow l\nu qq$

$H \rightarrow ZZ \rightarrow llqq$

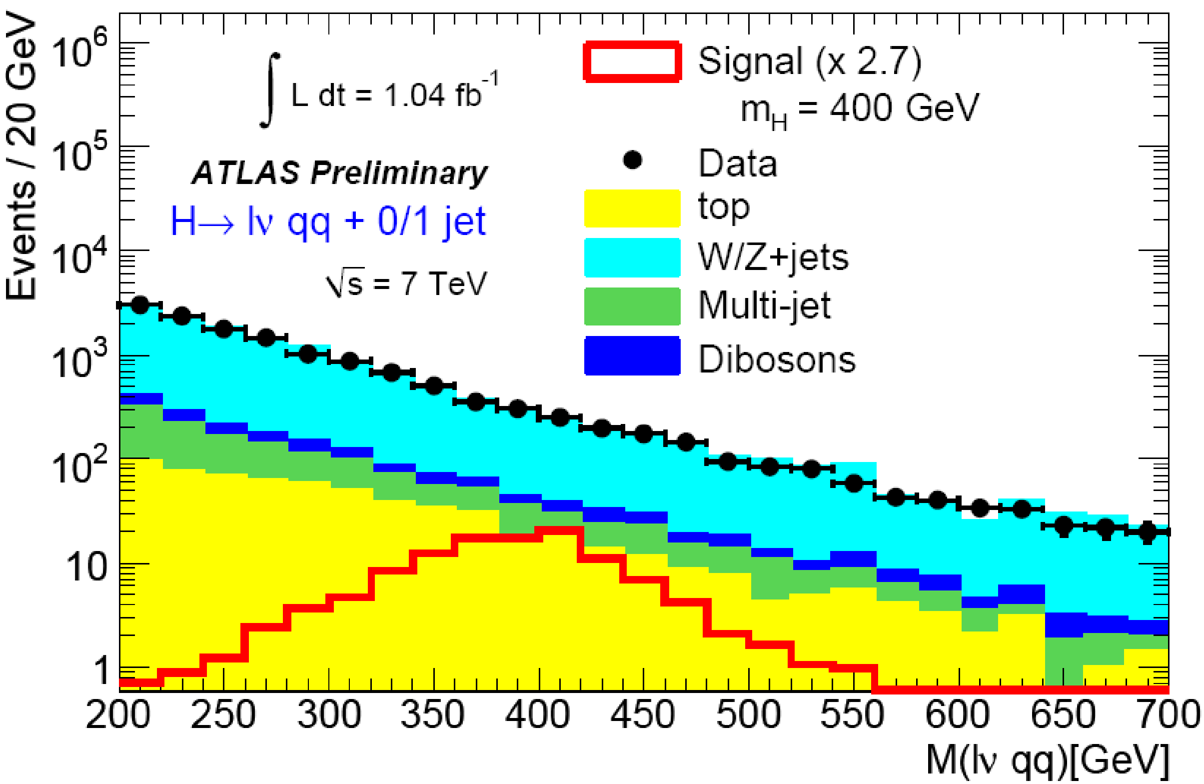
$H \rightarrow ZZ \rightarrow ll\nu\nu$

arXiv:1109.3615v1

Full mass reconstruction possible, in contrary to $l\nu l\nu$ channel.

Event selection:

- Isolated e or μ with p_T > 30 GeV
- Veto events with 2nd lepton (to ensure independence from $ZZ \rightarrow ll\nu\nu$)
- Exactly 2 jets OR 3 jets with p_T > 25 GeV (**0 and 1 jet analyses**)
- MET > 30 GeV
- $|m_{jj} - m_W| < 10$ GeV
- Reject events with b-jets (reduces top)



Sample composition understood using MC and data (Multijet and W/Z data-driven)

Mass reconstruction:

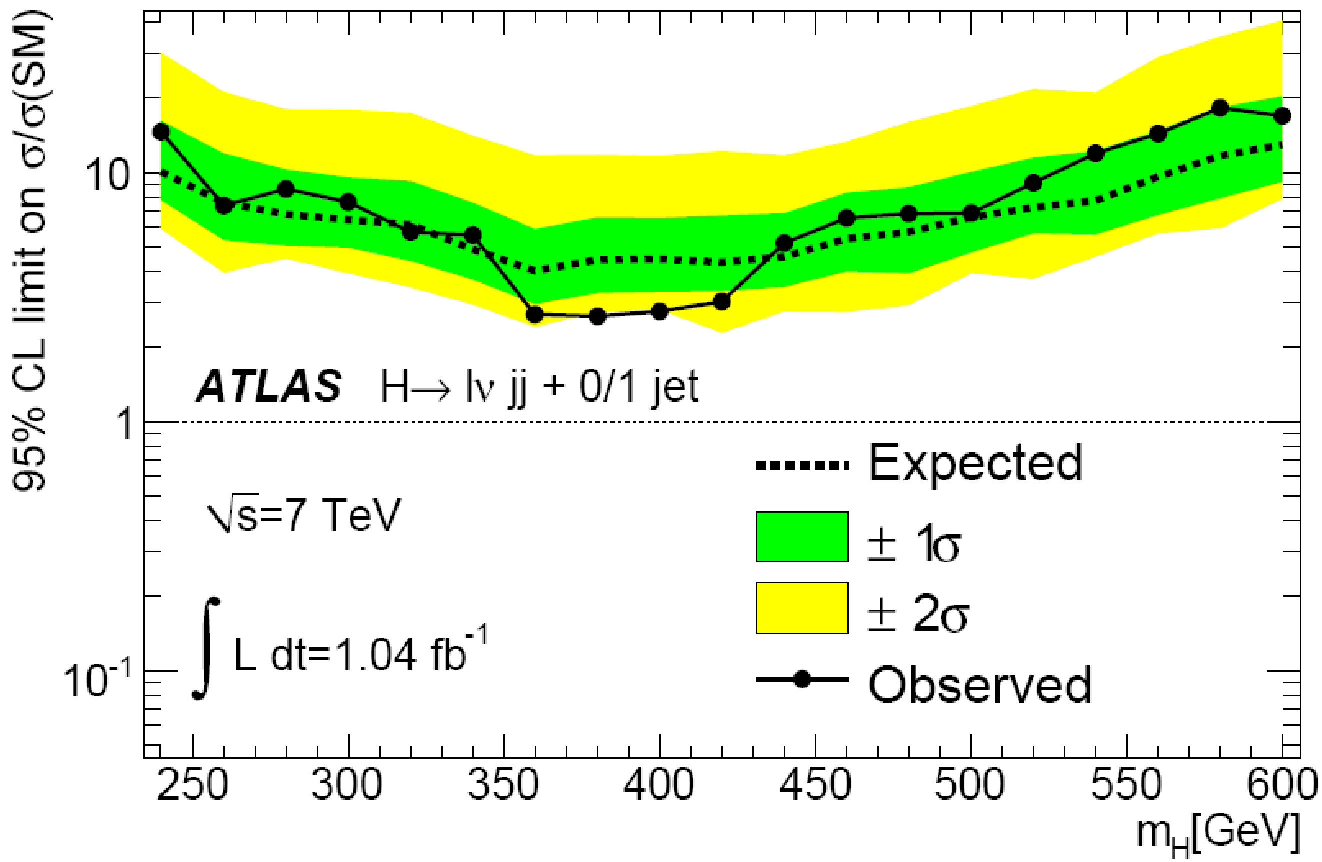
Constraint: $m(l\nu) = m(W)$

Rejects 45% of BG and 36% of signal

Systematic uncertainties:

Lepton and jet reconstruction, dominant are jet energy scale and resolution.

Results:



Data	Total BG	mH=400 GeV
41 687	42 600 ± 1 200	58 ± 15

No counting experiment. Limits obtained by fit with double exponential.

$H \to ZZ \to llqq$ 200 GeV < m_H < 600 GeV 1.04 /fb

arXiv:1108.5064v1

Event selection:

- Two same flavor leptons (e/μ)
- $|m_{ll}-m_{Z}|$ < 15 GeV
- Two jets, p_T > 25 GeV in $|\eta|$ < 2.5
- MET < 50 GeV

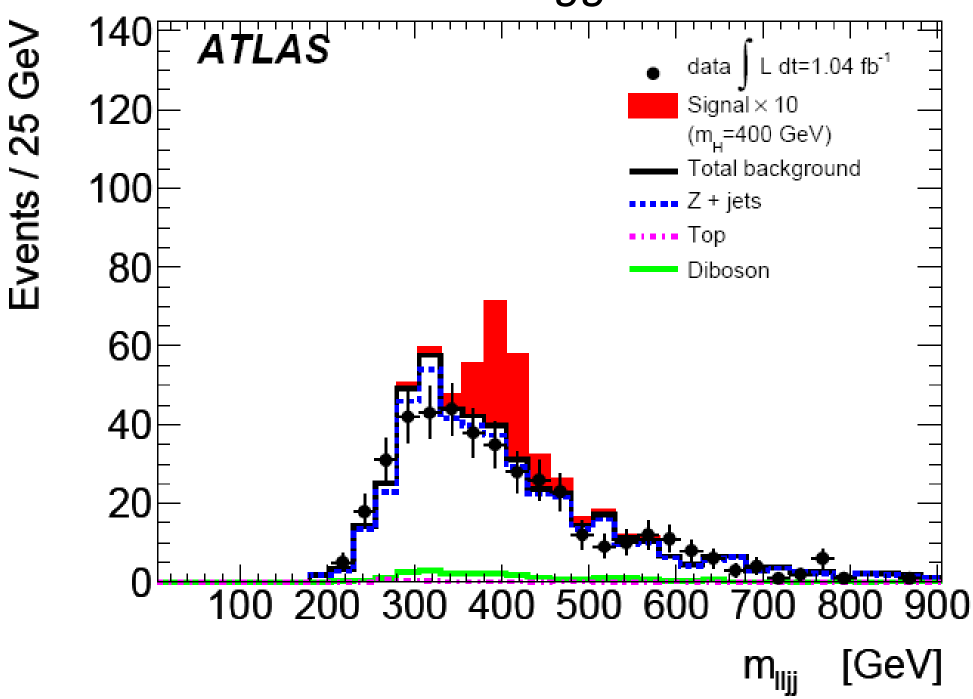
Special high mass cuts:
Jet p_T > 45 GeV, $\Delta\Phi$(l,l) < 1.6, $\Delta\Phi$(j,j) < 1.6

Background control:

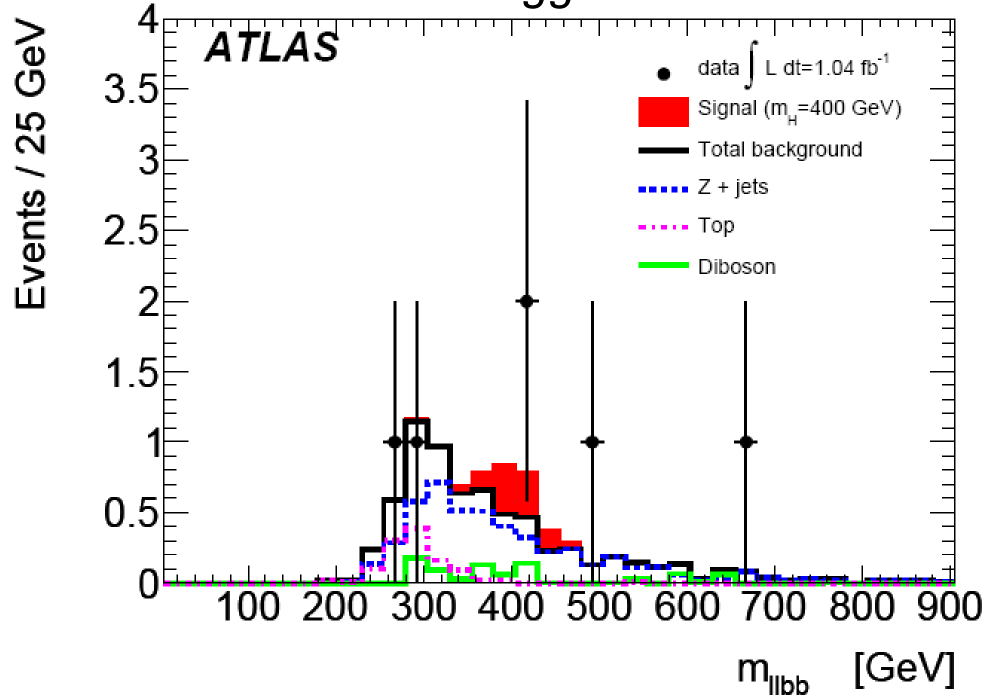
- Z+jets: shape from MC, scaling from m_{jj} sidebands
- Top: shape from MC, norm. from m_{ll} sidebands
- Dibosons from MC
- QCD from loose data sample

Treat $llb\bar{b}$ subsample (~21 % of signal) independently to increase sensitivity.

Untagged

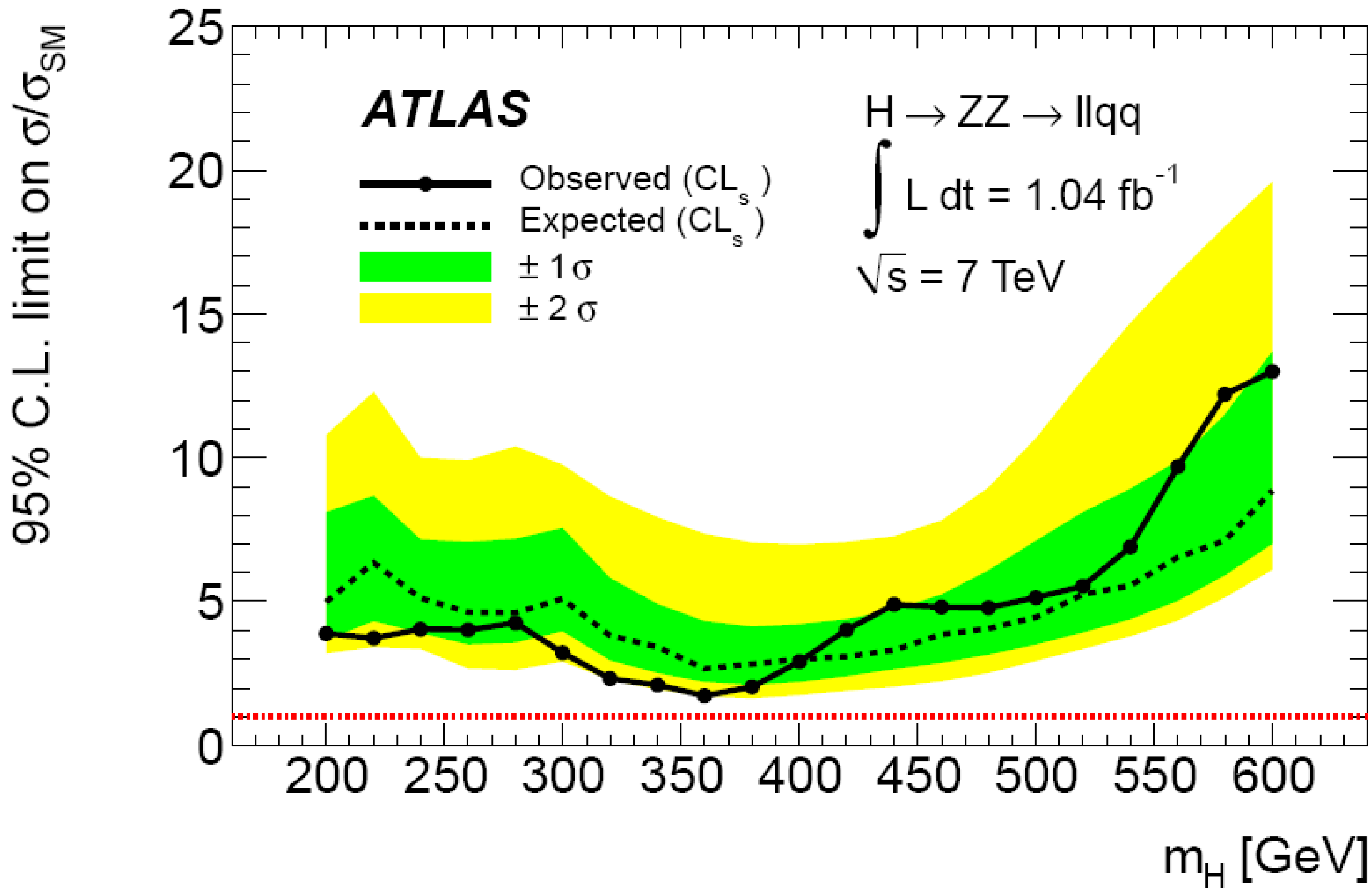


Tagged



Results:

	Data	Total BG	mH=400 GeV
untagged	419	450±13±30	9.8±0.3±1.8
tagged	6	6.9±0.4±1.2	1.1±0.1±0.3



Combined Limit

Dominant systematic uncertainties:

Jet energy scale
b-taggging efficiency in tagged analysis

$H \rightarrow ZZ \rightarrow ll\nu\nu$ 200 GeV < m_H < 600 GeV 1.04 /fb

Strong at high mass, good background separation.

arXiv: 1109.3357v1

Event selection:

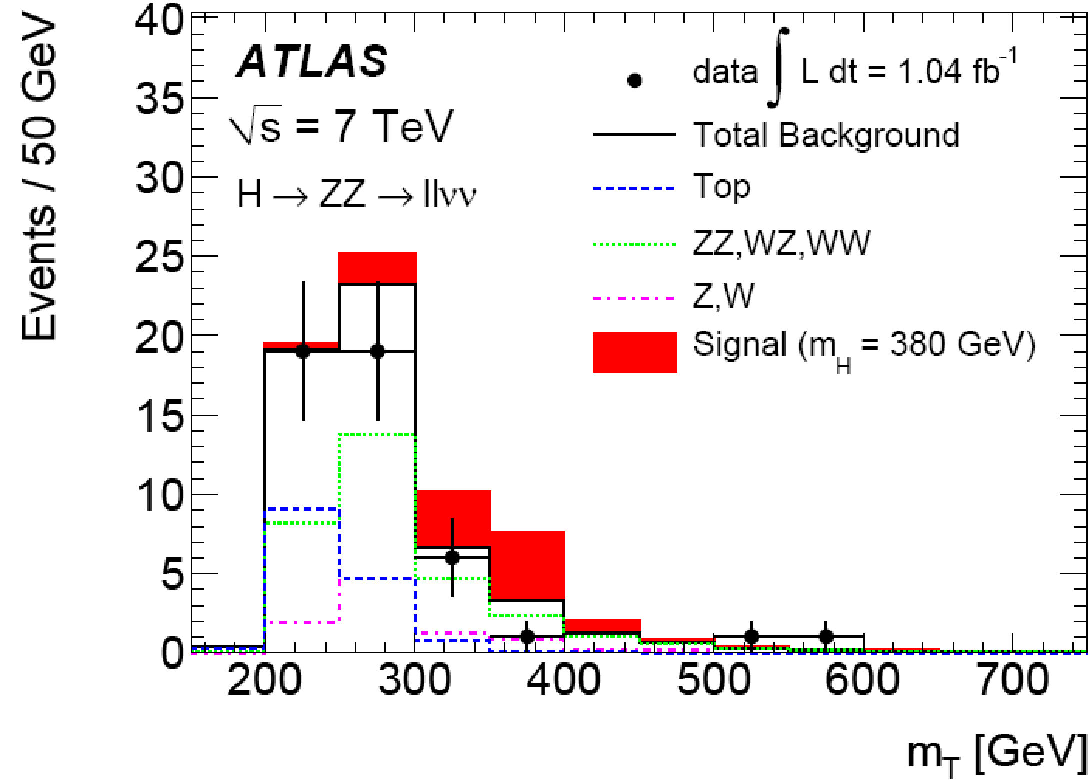
- Pair of same flavor OS leptons
- Veto events with b-tags
- $|m_Z - m_{ll}|$ < 15 GeV
- $\Delta\Phi$(MET,p_T leading jet) < 0.3

Low mass analysis (m_H < 280 GeV):

- MET > 66 GeV
- 1 < $\Delta\Phi$(l,l) < 2.64

High mass analysis (m_H > 280 GeV):

- MET > 82 GeV
- $\Delta\Phi$(l,l) < 2.25 (larger boost)
- $\Delta\Phi$(MET,p_T^{ll}) < 1



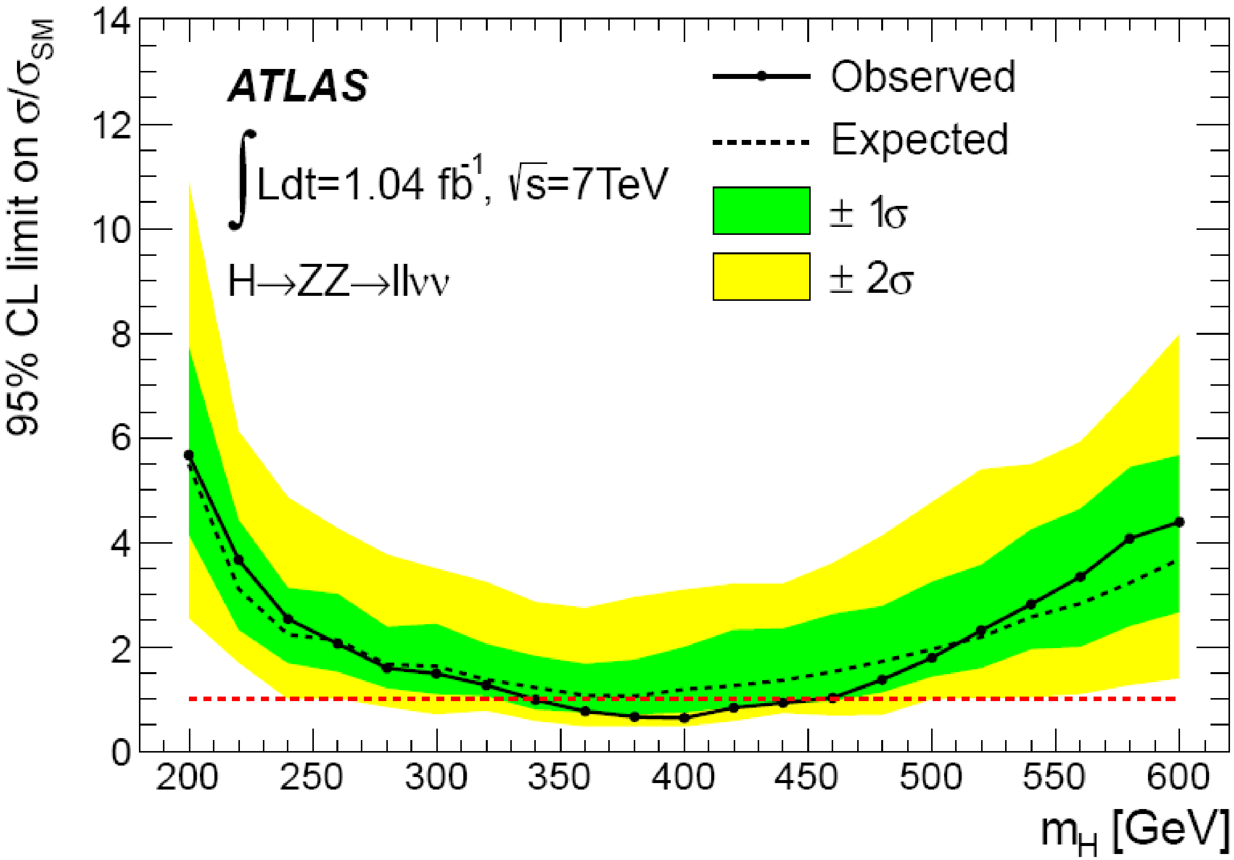
$$m_T^2 \equiv \left[\sqrt{m_Z^2 + |\vec{p}_T^{\,\ell\ell}|^2} + \sqrt{m_Z^2 + |\vec{p}_T^{\,\mathrm{miss}}|^2}\right]^2 - \left[\vec{p}_T^{\,\ell\ell} + \vec{p}_T^{\,\mathrm{miss}}\right]^2$$

Background control:

- ZZ continuum from MC (~10% uncertainty)
- Z+jets from MC, cross checked with looser selection
- Top: from MC, but cross checked with two control samples (eμ and b-tagged sample)
- W+jets: from same sign lepton pairs
- QCD: From loose selection. Negligible contribution.

Dominant systematic uncertainties:

MET and b-tagging efficiency



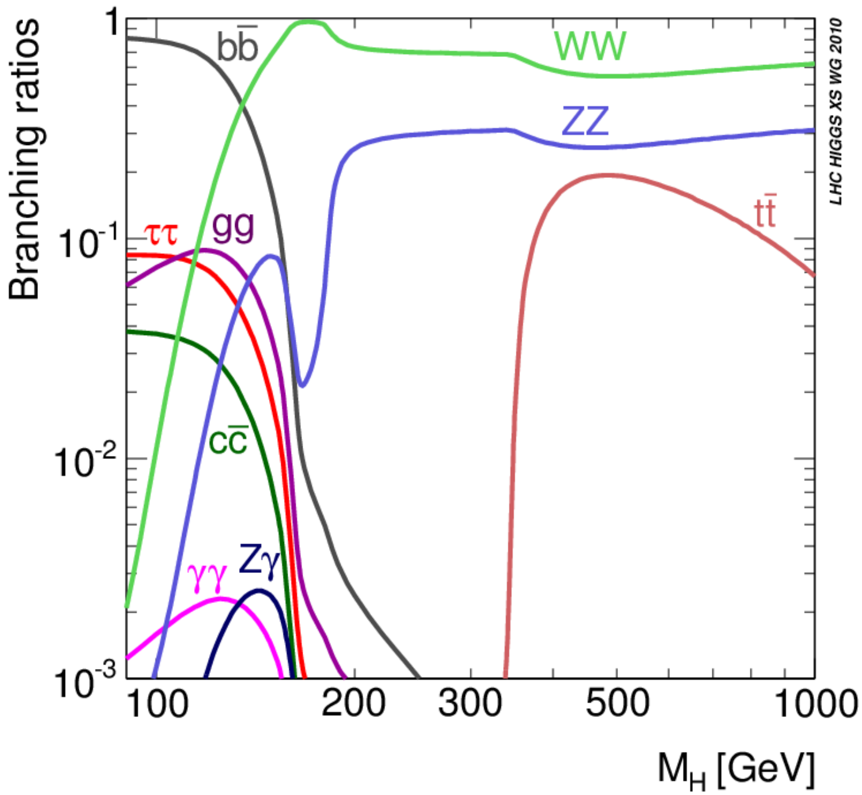
Exclusion @ 95% CL:

340 GeV < mH < 450 GeV

Data	Total BG	mH=400 GeV
47	55.3±2.0±7.8	10.0±0.2±1.7

Signal includes contributions from $ZZ \rightarrow 4l$ and $WW \rightarrow l\nu l\nu$.
Independent channel due to selection criteria

Intermediate and Wide Mass Higgs Searches



m_H = 110 GeV – 600 GeV

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

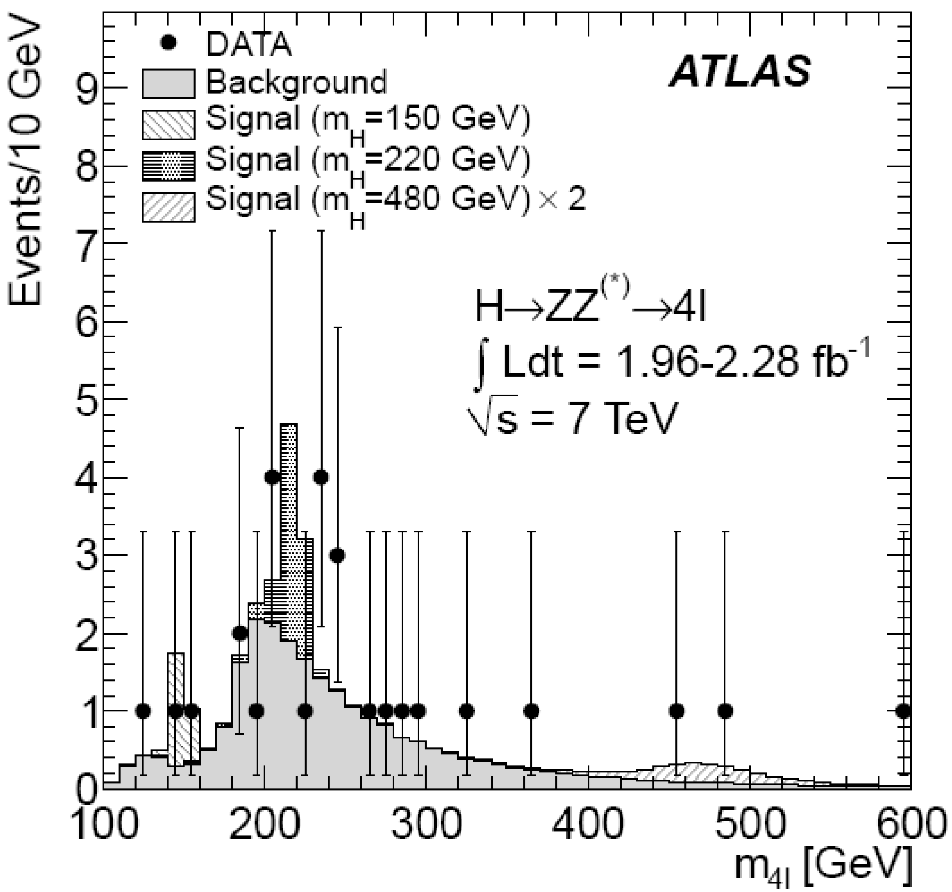
$H \to ZZ^{(*)} \to 4\ l$

arXiv:1109.5945v1

Clean but very rare channel.

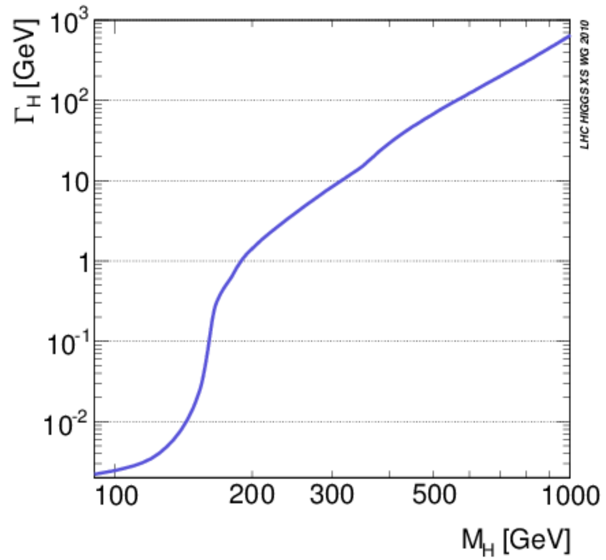
Event selection:

- Two same-flavor OS lepton pairs
- Track and calo-based lepton isolation
- $|m_{12}-m_Z| < 15$ GeV
- $m_{4l} < m_{34} < 115$ GeV, mass dependent low threshold



Mass resolution FWHM:

- m_H=130 GeV: 4.5 – 6.5 GeV
- m_H=400 GeV: 35 GeV



At low mass detector resolution dominant
At high mass natural width relevant

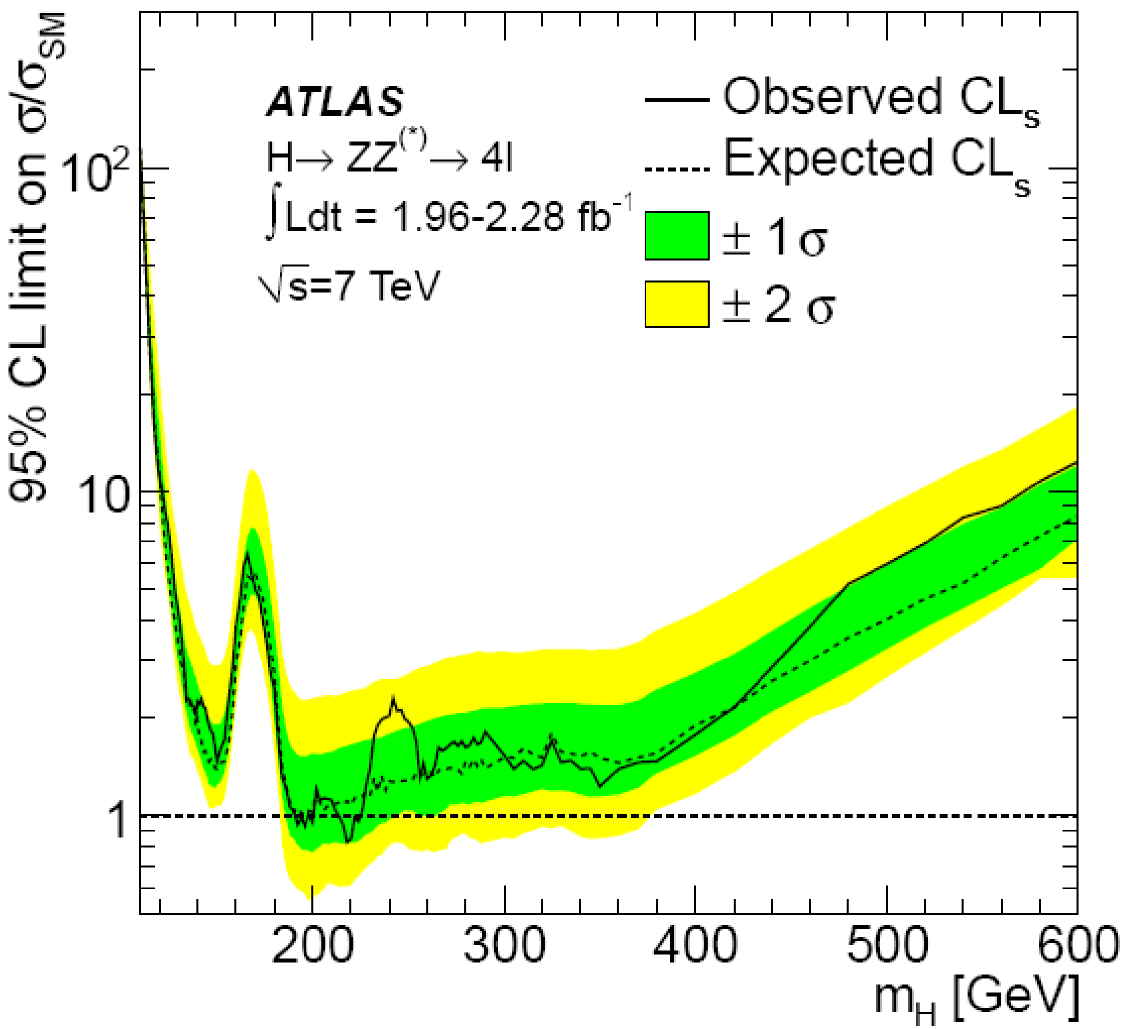
Background control:

- Dominant ZZ(*) from MC (~15% uncertainty)
- ttbar: MC shape and eμ data control sample
- Z+jets: Yield extrapolated from control region

$H \rightarrow ZZ^{(*)} \rightarrow 4l$ 110 GeV < m_H < 600 GeV 2.1 /fb

Results:

	Data	Total BG	m_H=200 GeV
4e	5	3.7±0.5	1.0±0.1
4μ	11	7.7±1.2	2.3±0.3
2e2μ	8	9.8±1.4	2.6±0.4



Systematic uncertainties:

Lepton-related uncertainties determined from W, Z and J/Ψ:

→ Impact of μ efficiency uncertainty: 1.7% (4μ), 1.2 % (2e2μ)

→ Impact of e efficiency uncertainty: 3%-15% (4e), 2%-6% (2e2μ)

Exclusion @ 95%CL:

191 GeV -197 GeV
199 GeV -200 GeV
214 GeV -224 GeV

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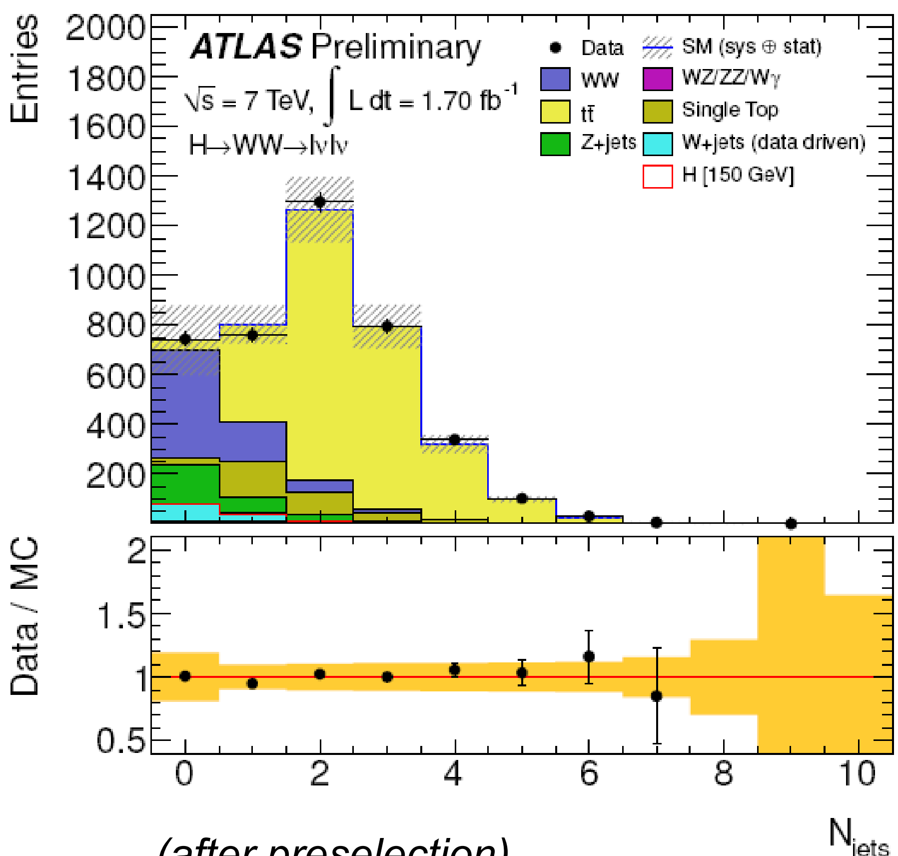
Most sensitive channel in intermediate mass range.

Event Selection:

- Exactly two isolated leptons with pT > 15 GeV
- ee/μμ: $|m_{ll}-m_Z|$ >15 GeV, m_{ll}> 15 GeV, MET_{rel} > 40 GeV
  eμ: m_{ll}> 10 GeV, MET_{rel} > 25 GeV

$$E_{T,rel}^{miss} = \begin{cases} E_T^{miss} & \text{if } \Delta\phi \geq \pi/2 \\ E_T^{miss} \cdot \sin\Delta\phi & \text{if } \Delta\phi < \pi/2 \end{cases}$$

ΔΦ=min(ΔΦ(MET,lep) , ΔΦ(MET,jet))



(after preselection)

Further cuts on p_T^{ll}, m_{ll}, $\Delta\phi_{ll}$, m_T
Optimized for three different mass ranges.

H+0jet selection:

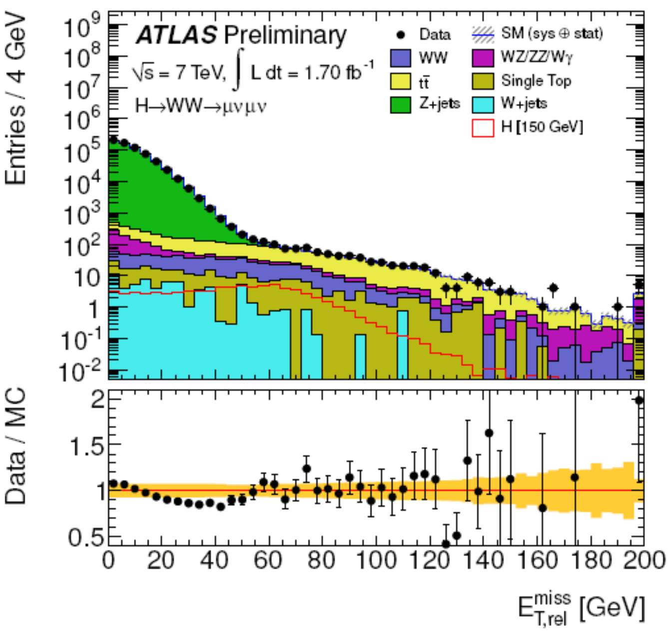
Exactly zero jets with pT > 25 GeV
→ WW background dominant

H+1jet selection:

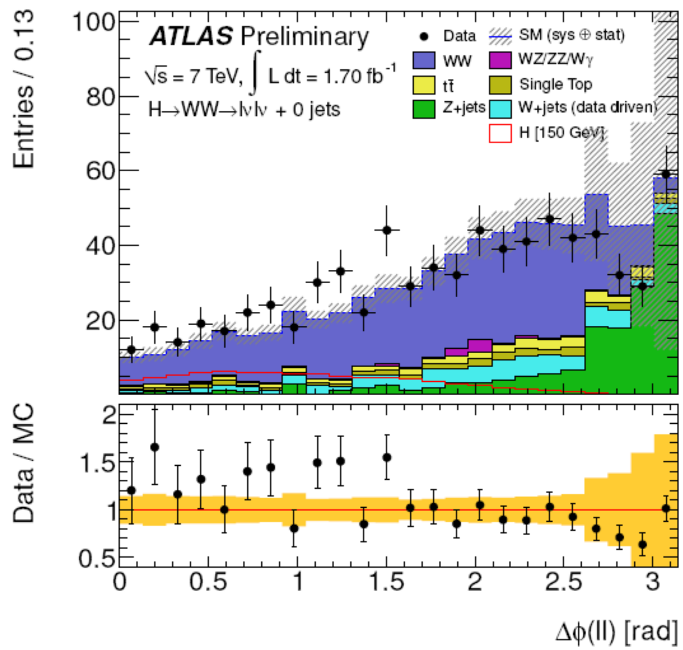
- Exactly one jet but no b-tag
- Z→ττ veto by $|m_{\tau\tau}-m_Z|$ > 25 GeV
- Total pT < 30 GeV (MET + leptons +jet) (rejects top)

→ Large tt̄ background

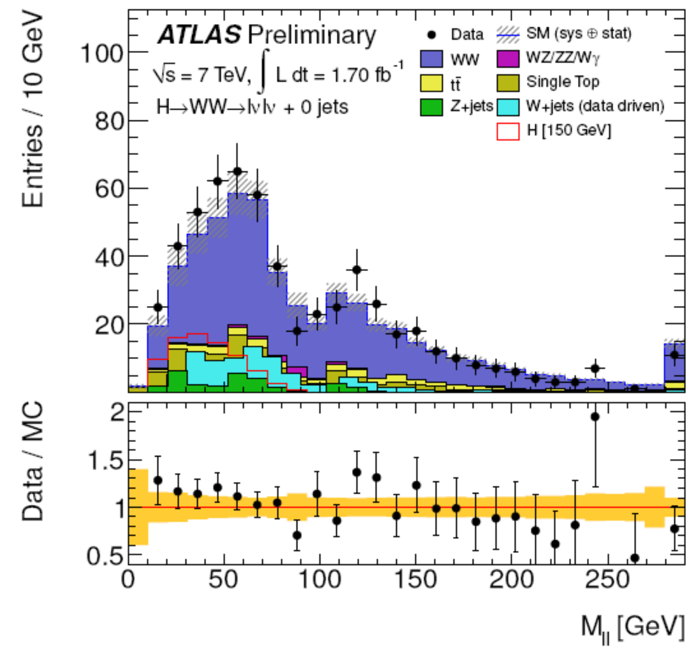
Kinematic distributions in μμ channel: *(no shape uncertainties shown)*



(minimal pT and m_{ll} cuts applied)



(0 jet analysis after jet veto cut)



(0 jet analysis after p_T^{ll} cut)

Background control:

- WW normalization from control region
- Z+jets rescaled with mismodelling factor obtained from control region
- Top normalization from control region
- W+jets fake factor from control region

Systematic uncertainties:

- e/μ E scale, resolution, efficiency 0.3-5%
- Jet energy resolution 14%, JES 3-9 %
- B-tagging: 5-15 %, Mistagging: 21 %
- MET: ~13 %, Lumi 3.7%

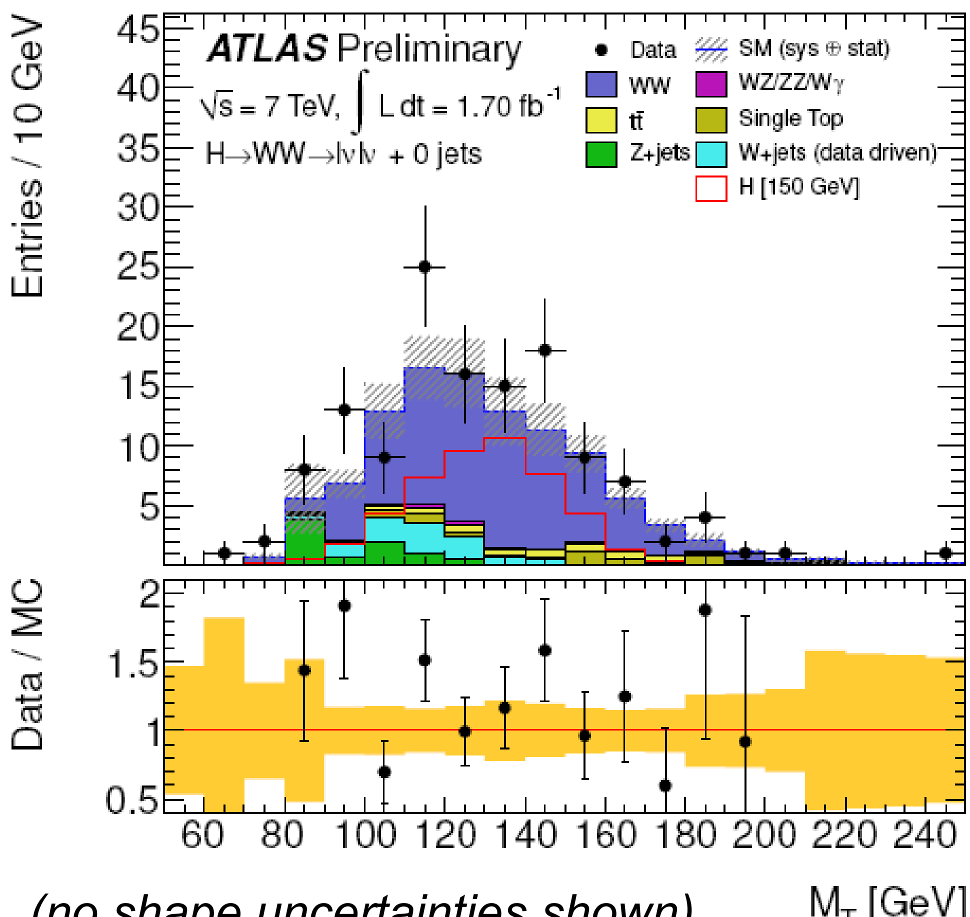
Results

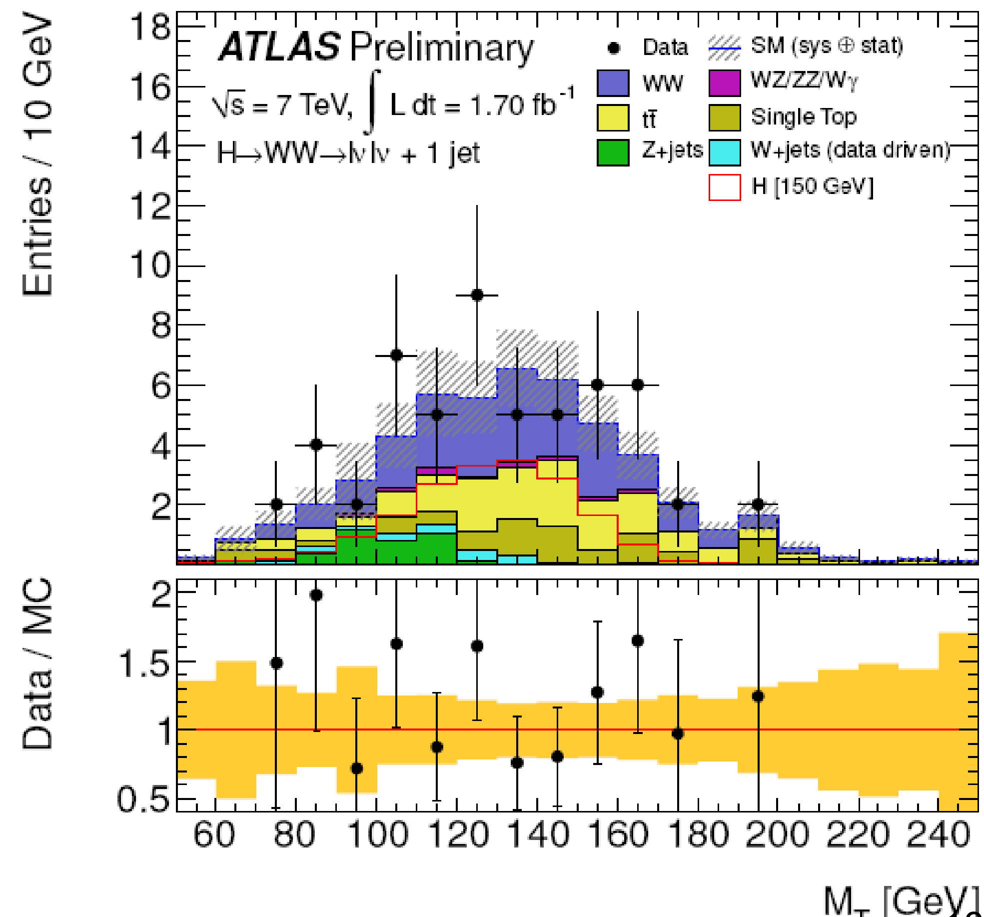
H+0jet

	Data	Total BG	mH=150 GeV
ee	9	8.2 ± 1.7	5.2 ± 1.2
eμ	32	27 ± 4	17 ± 4
μμ	**29**	**18 ± 5**	**11 ± 2**

H+1jet

	Data	Total BG	mH=150 GeV
ee	5	2.8 ± 0.7	1.7 ± 0.4
eμ	11	13 ± 3	6.3 ± 1.5
μμ	7	8 ± 2	3.9 ± 0.9





(no shape uncertainties shown)

Results

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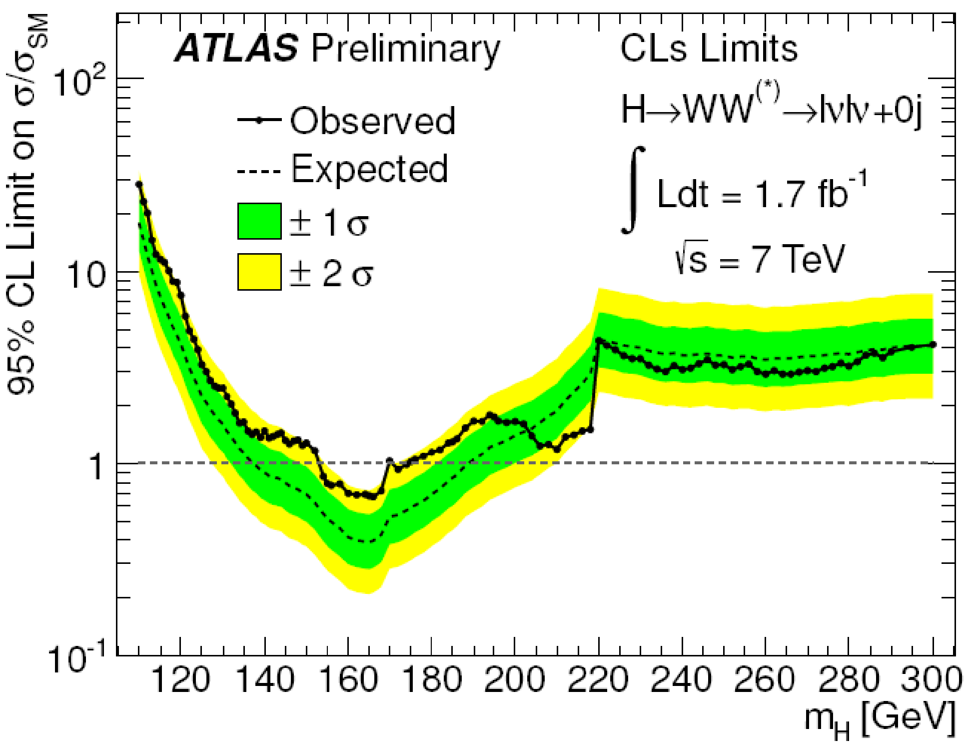
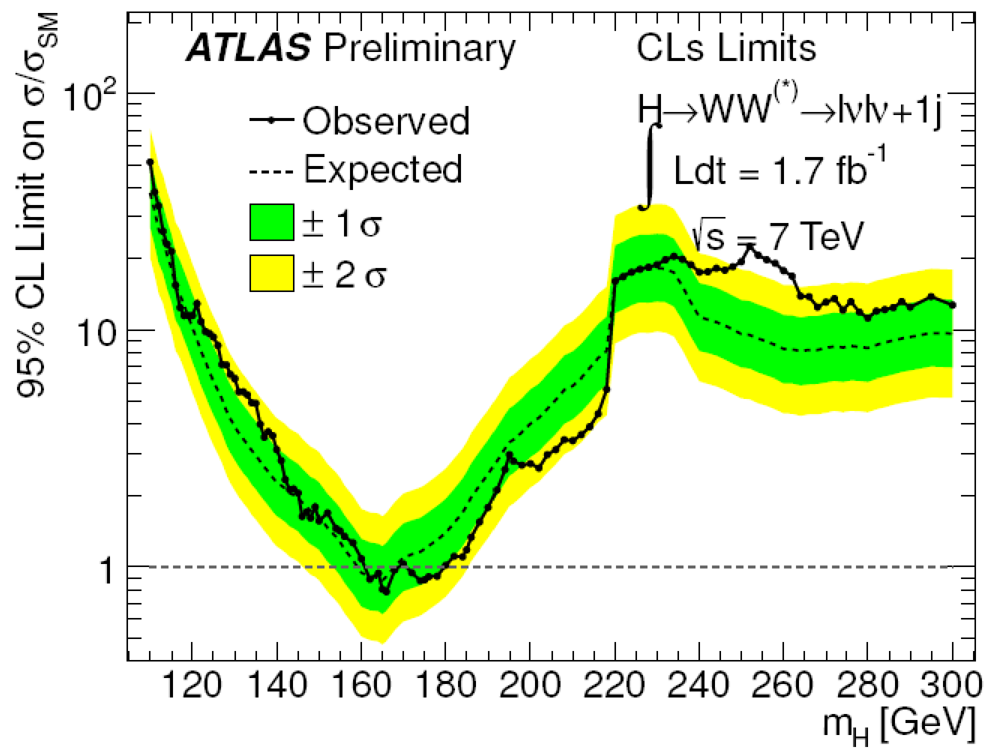




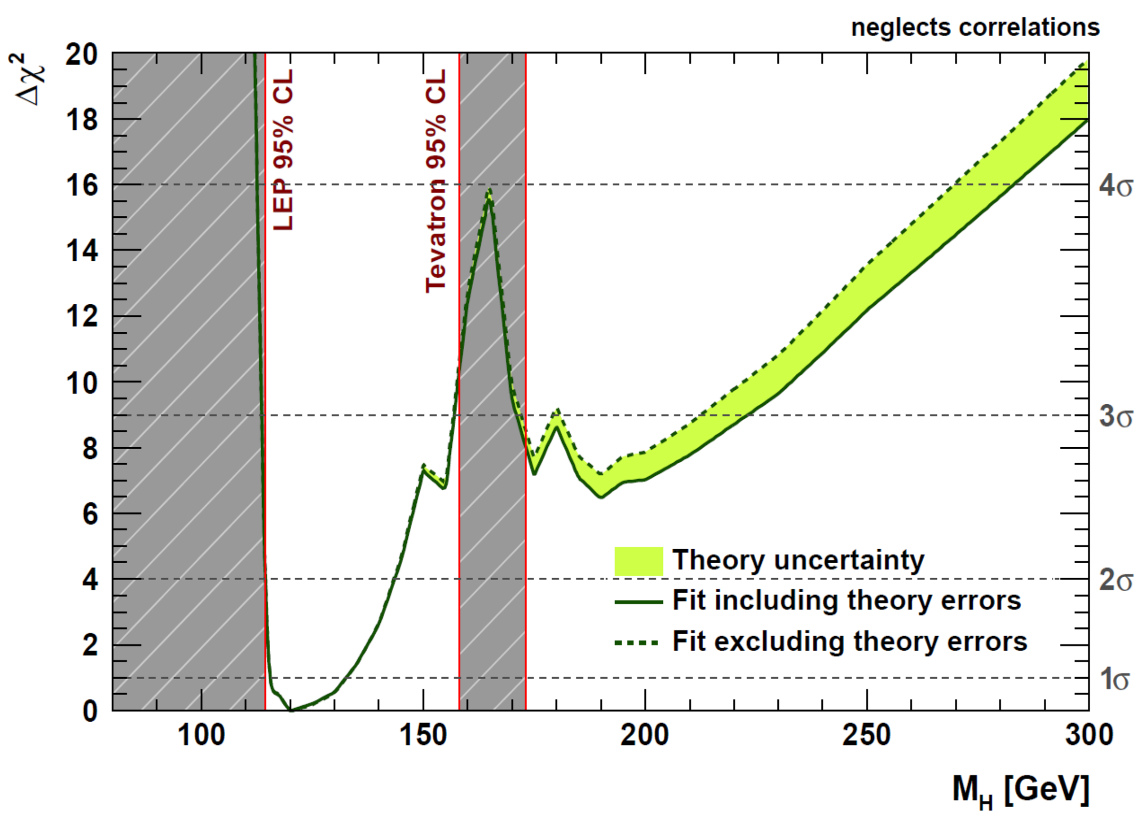
Combined exclusion: Expected 135 GeV < m_H < 196 GeV

Observed 154 GeV < m_H < 186 GeV

Low Mass Higgs Searches

- $H \rightarrow \tau\tau$
- $H \rightarrow b\bar{b}$
- $H \rightarrow \gamma\gamma$

Fit to EW precision data suggests a light Higgs boson:



The Gfitter group
arXiv:1107.0975v1

(incl. measurements from
LEP, Tevatron and LHC 2010 data)

Most probable value: $m_H = 120^{+12}_{-5}$ GeV

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

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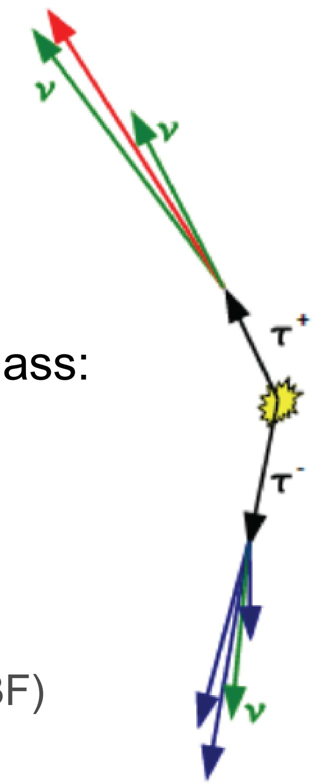
- Two isolated OS leptons
- Require a high p_T jet to boost the system
- Cuts on $\Delta\Phi(ll)$, $m_{\tau\tau j}$, m_{ll}
- Collinear approximation to reconstruct $\tau\tau$ mass:

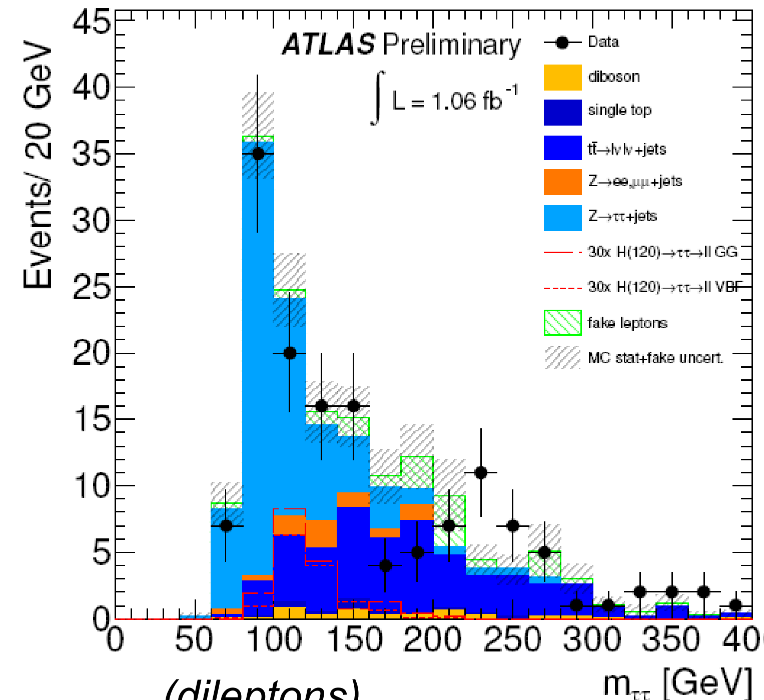
$$m_{\tau\tau} = \frac{m_{vis}}{\sqrt{x_1 x_2}}$$

x is momentum fraction
of visible decay products

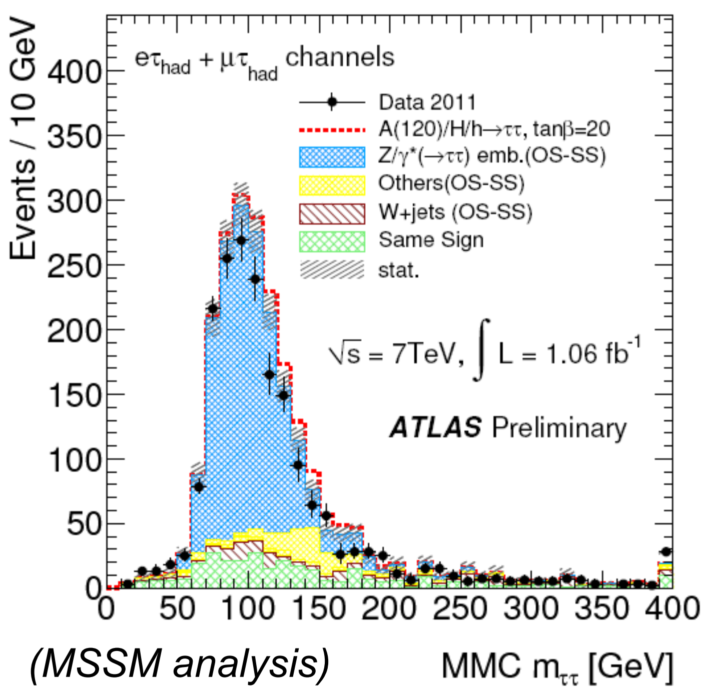
- Mass resolution m_H=120 GeV $\sim$ 24 GeV

(bit less for VBF)





(dileptons)



(MSSM analysis)

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

- More background (from fake τ): W, QCD
- τ pT: 20 GeV, neural net based τ ID
- MET > 20 GeV, m_T < 30 GeV
- Stronger at higher masses

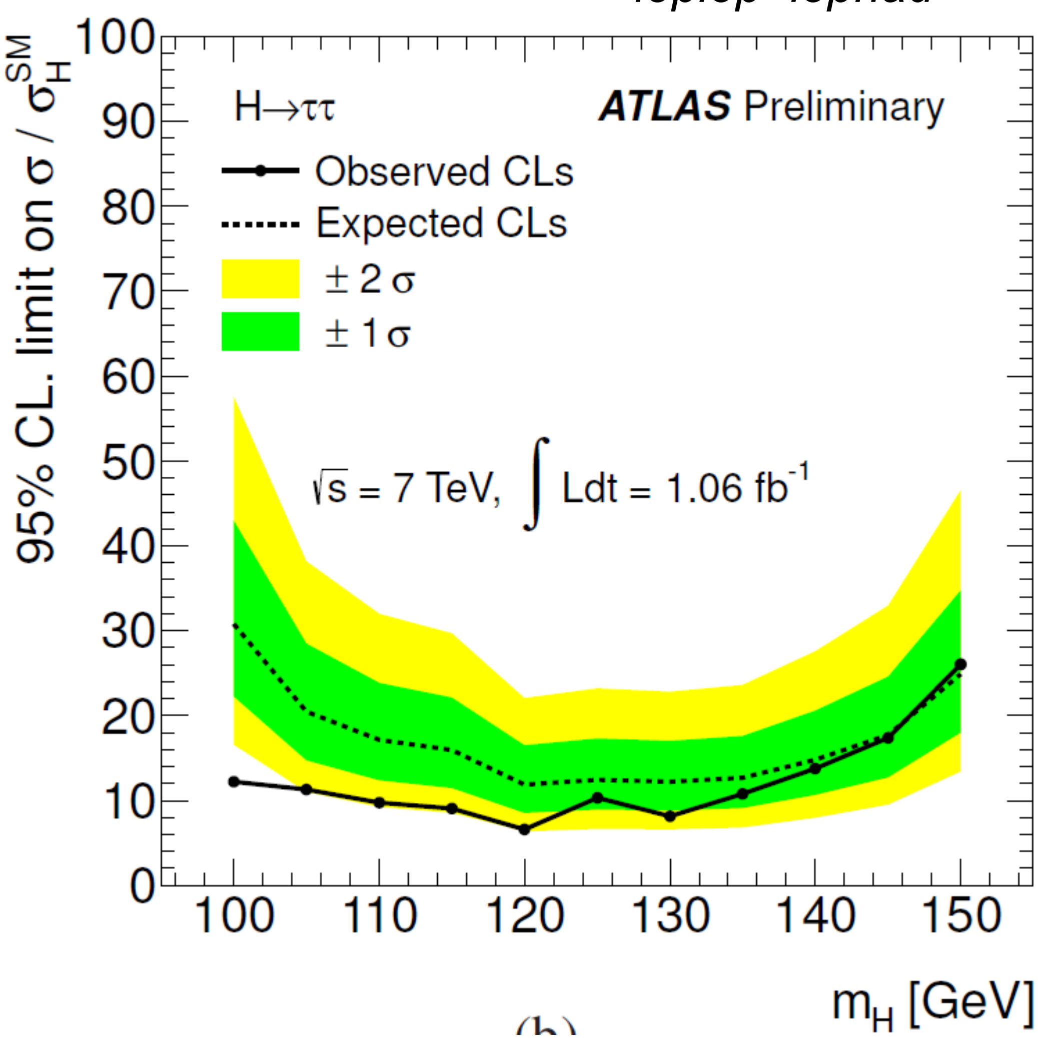
Missing Mass Calculator arXiv: 0901.0512

Background control:

- Irreducible $Z \rightarrow \tau\tau$ shape from τ embedding into $Z \rightarrow \mu\mu$ data events arXiv: 1107.5003v1
- Fake lepton backgrounds from control sample

Results:

leplep+lephad



Dilepton channel:

Data	Total BG	m_H=120 GeV
46	47.4±4.9	0.8

(ggF and VBF)

Dominant systematic uncertainties:

Jet and τ energy scale, τ ID and MET

Results of MSSM h/A/H $\rightarrow \tau\tau$ in backup slides.

Future: Dedicated VBF analysis.

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W/Z associated. Largest branching fraction at low mass, but huge backgrounds.

Event Selection:

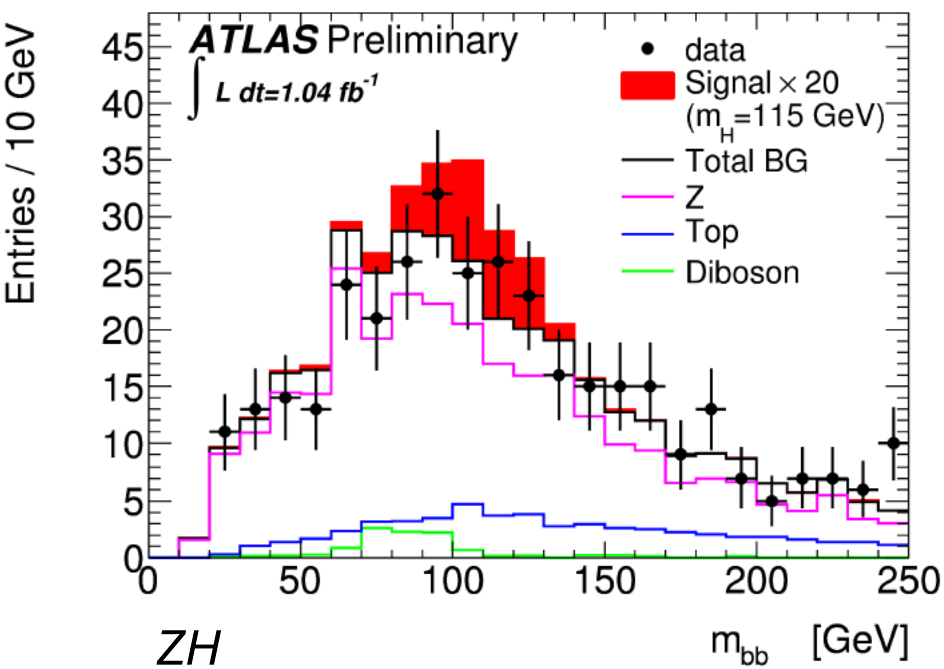
- Single lepton triggers: μ18, e20
- At least two jets with p_T > 25 GeV within |η|<2.5, two highes p_T jets b-tagged

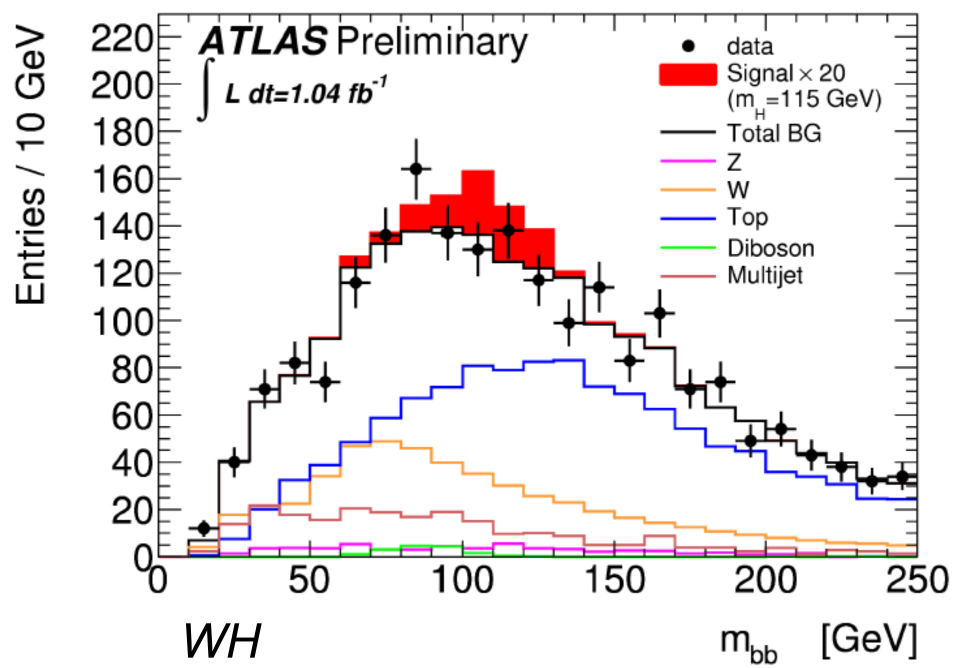
ZH → llbb

- Two isolated leptons (e/μ), p_T>20 GeV
- MET < 50 GeV (rejects top)
- $|m_{ll}-m_z|$ < 15 GeV

WH → lνbb

- One isolated lepton (e/μ) p_T > 25 GeV
- MET > 25 GeV
- m_T > 40 GeV $m_T = \sqrt{2p_T^{\ell}p_T^{\nu}(1-cos(\phi^{\ell}-\phi^{\nu}))}$



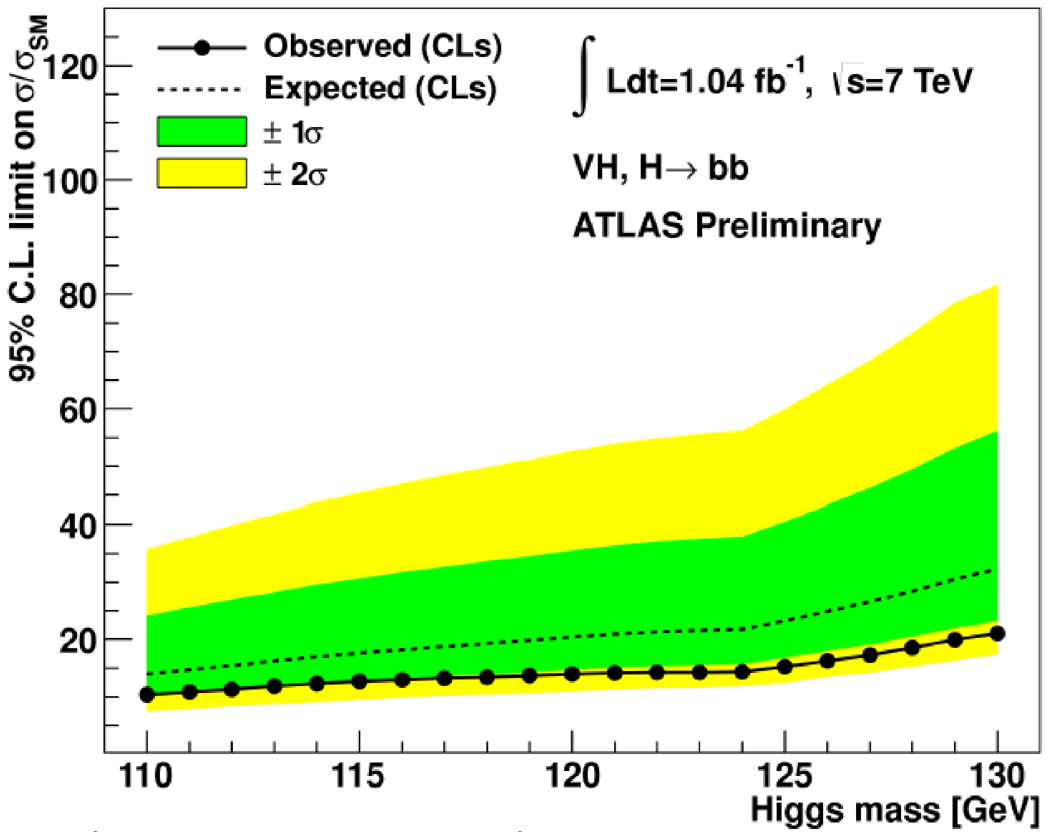


Background Control:

All background checked on data using control samples.

Typically: Shape from MC, normalization from a sideband. $W_{b\bar{b}}$ and QCD shape from data.

Results:



(WH and ZH combined)

	Data	Total BG	mH=120 GeV
ZH	329	325±8±28	1.6
WH	1 888	1 877±14±147	4.5

Dominant systematic uncertainties:

Jet energy scale: 2-7 %
Jet energy resolution: 5-12 %
B-tagging efficiency: 5-14 %
Mistagging rate: 8-12 %

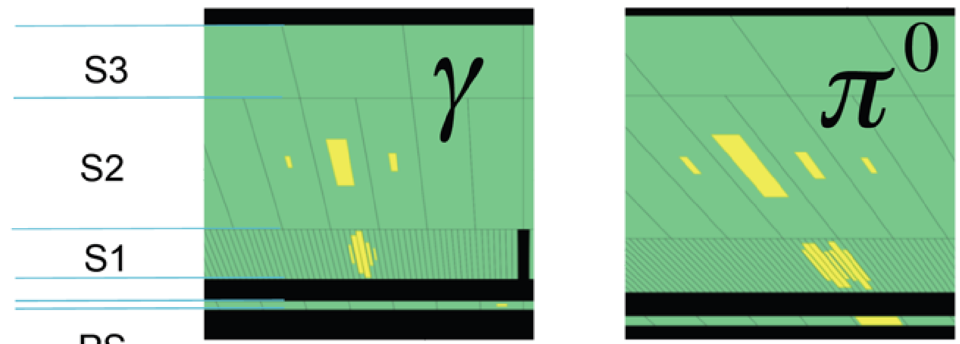
Future: Boosted Higgs at high pT, use jet substructure

arXiv:1108.5895v1

Best mass resolution, large event yield, simple analysis.

- Photons seeded by clusters in elmag. calorimeter (E_T>2.5 GeV)
- Unconverted, single and double track conversions
- Fine granularity of 1st (strip) sampling allows rejection of neutral mesons (π^0)

γ–π^0 separation



(2010 data event)

- E resolution:

$\sigma(E)/E = 10\%/\sqrt{E} \oplus 0.3\text{GeV}/E \oplus (1.1\text{-}1.8)\%$

with E calibration correction from $Z \rightarrow ee$ data)

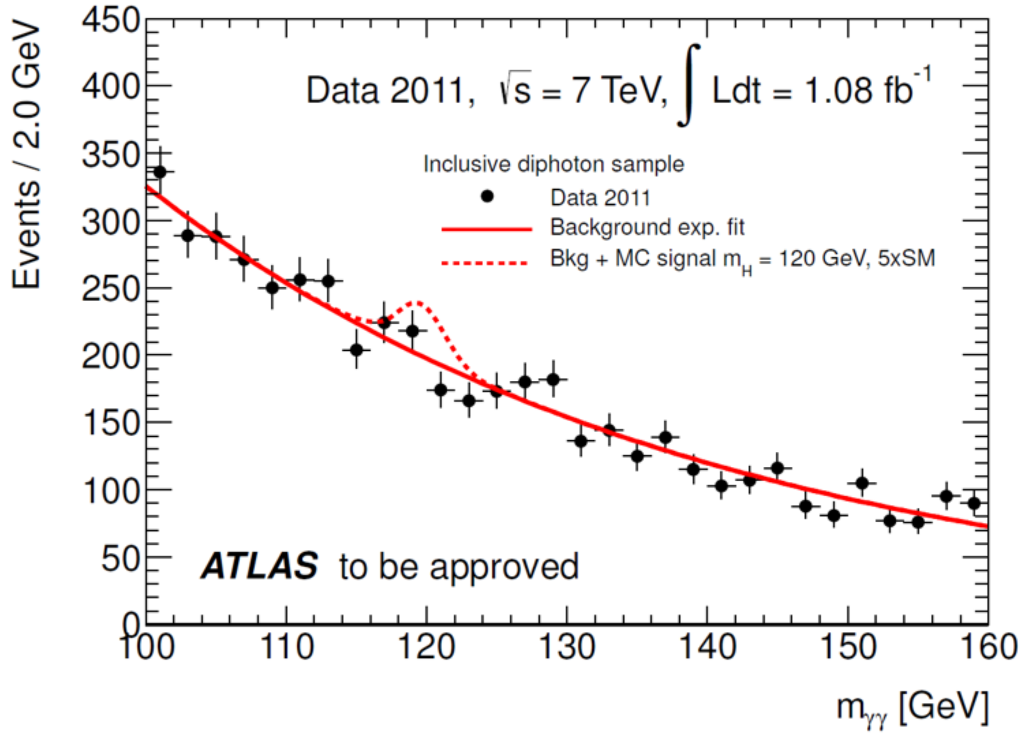
Inclusive event selection:

- Trigger: Two γ with p_T>20 GeV
- p_T > 40 / 25 GeV, Tight identification cuts
- Calo-based isolation < 5 GeV
  (corrected for Pile-Up and out-of-cone leakages)

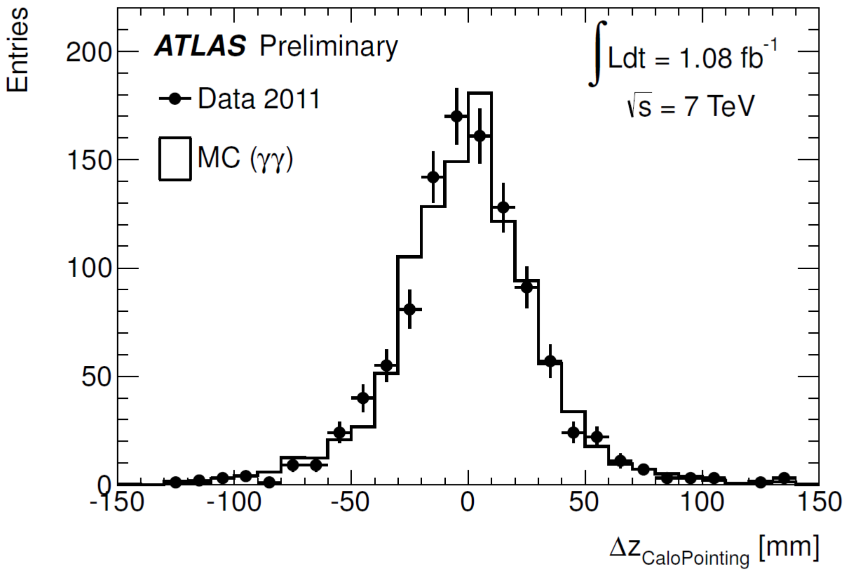
Data	*mH=120 GeV
5 063	17.6

*sum of ggH, VBF, Z/WH, $t\bar{t}H$

Fit to data with single exponential:



Unconverted photons in Barrel compared with $\gamma\gamma$ MC:



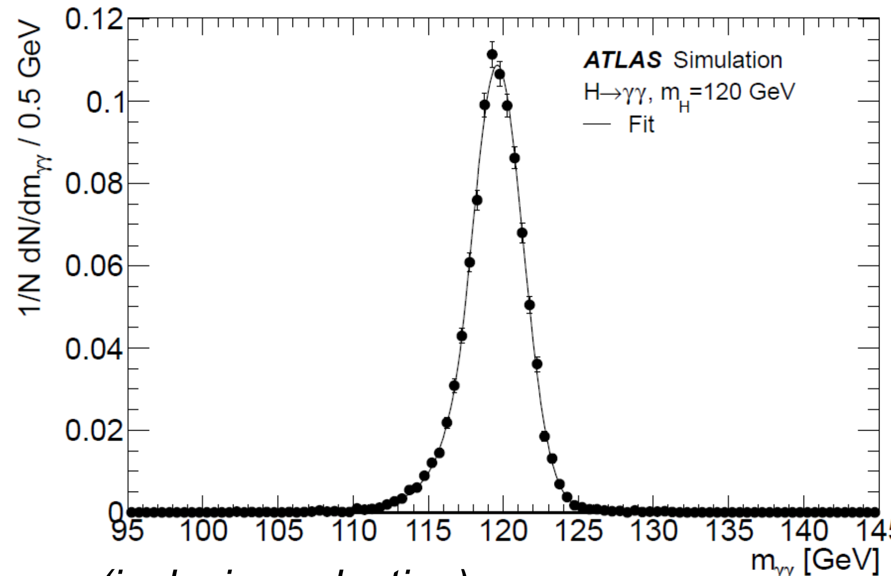
Calorimeter pointing:

Combine front and middle layer of ECAL to deduce photon direction and z coordinate, combined with tracker if photon is converted

$\rightarrow$ Δz = 1.5 cm (unconverted, Barrel)

Mass resolution: 1.7 GeV (FWHM 4.15 GeV)

Could improve by 15% with nominal constant term of 0.8%



(inclusive selection)

Categorized analysis:

Divide sample into 5 categories: Conversion status $\oplus$ position in the calorimeter exploiting different S/B ratios and resolutions to increase sensitivity.

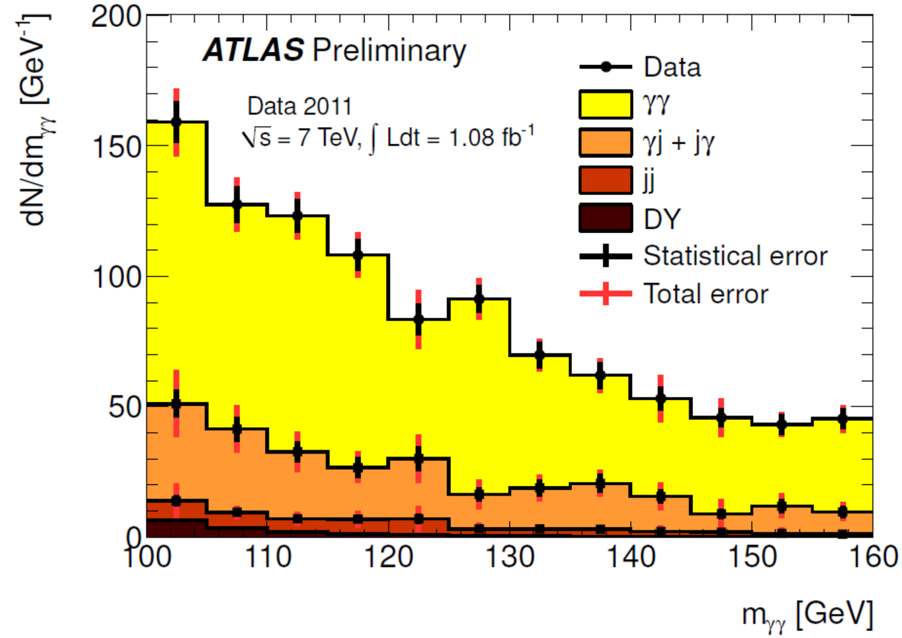
Background processes:

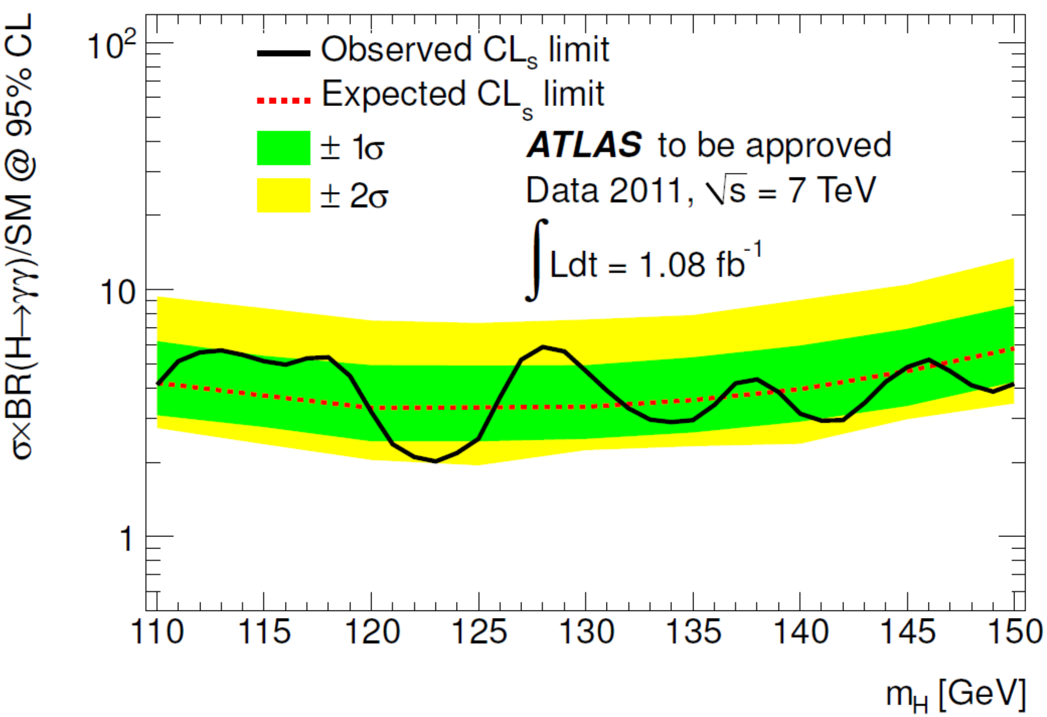
- Irreducible diphotons, gamma-jet and jet-jet
- Electron induced ($Z \rightarrow ee$)

Data sample decomposed using 2D sidebands (identification vs. isolation), cross checked with 2D fit of isolation templates:

→ $\gamma\gamma$ purity: 72 %

Data-driven methods in diphoton cross section measurement arXiv:1107.0581v1 [hep-ex]





Systematic uncertainties:

Signal yield 12 % (γ efficiency, Lumi, $p_T^{\gamma\gamma}$)
Signal resolution: 14 % (E calibration, Δz)
BG shape model: ±(3 - 5) events

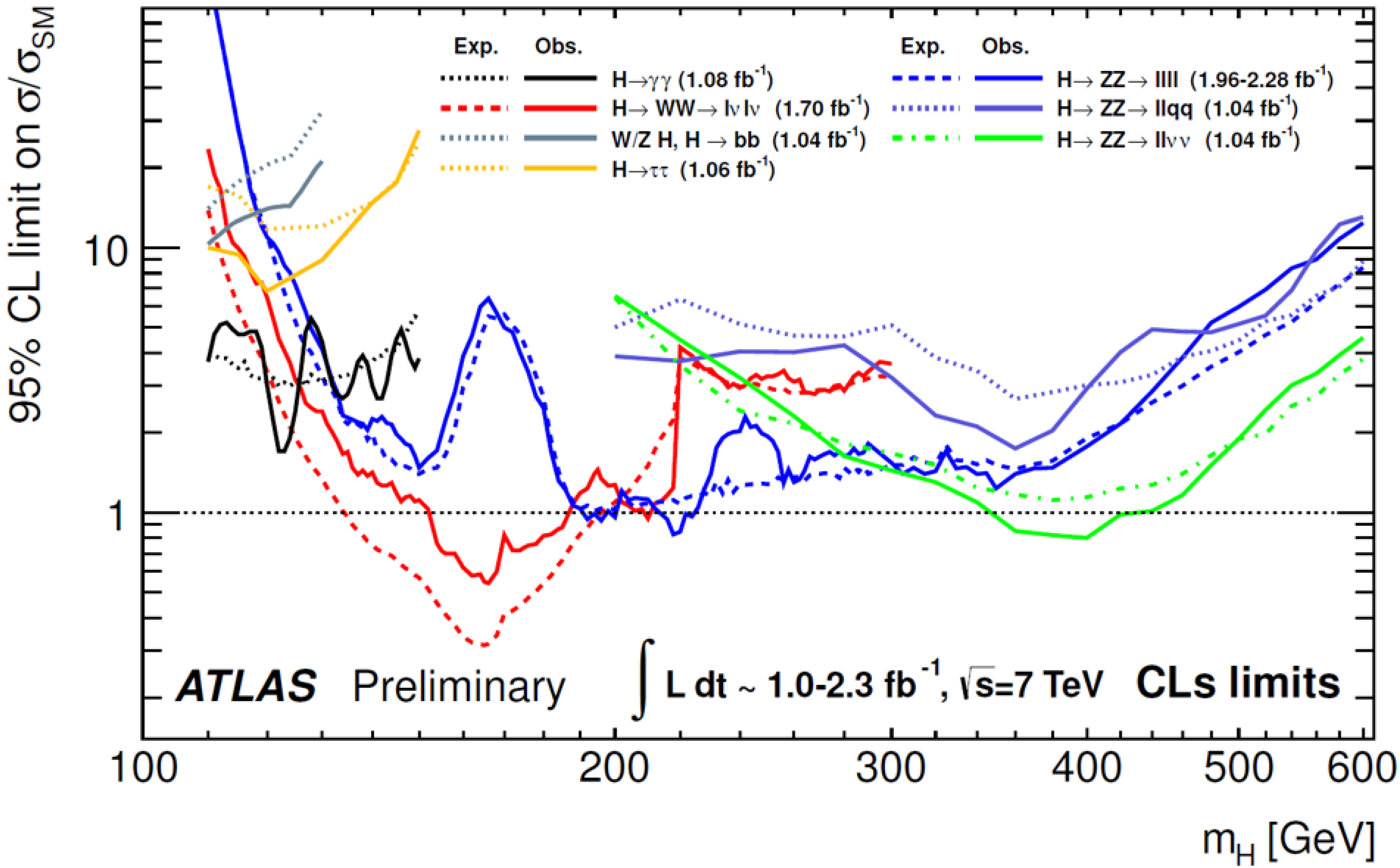
Expected exclusion: 4 x SM

observed: 2-6 x SM

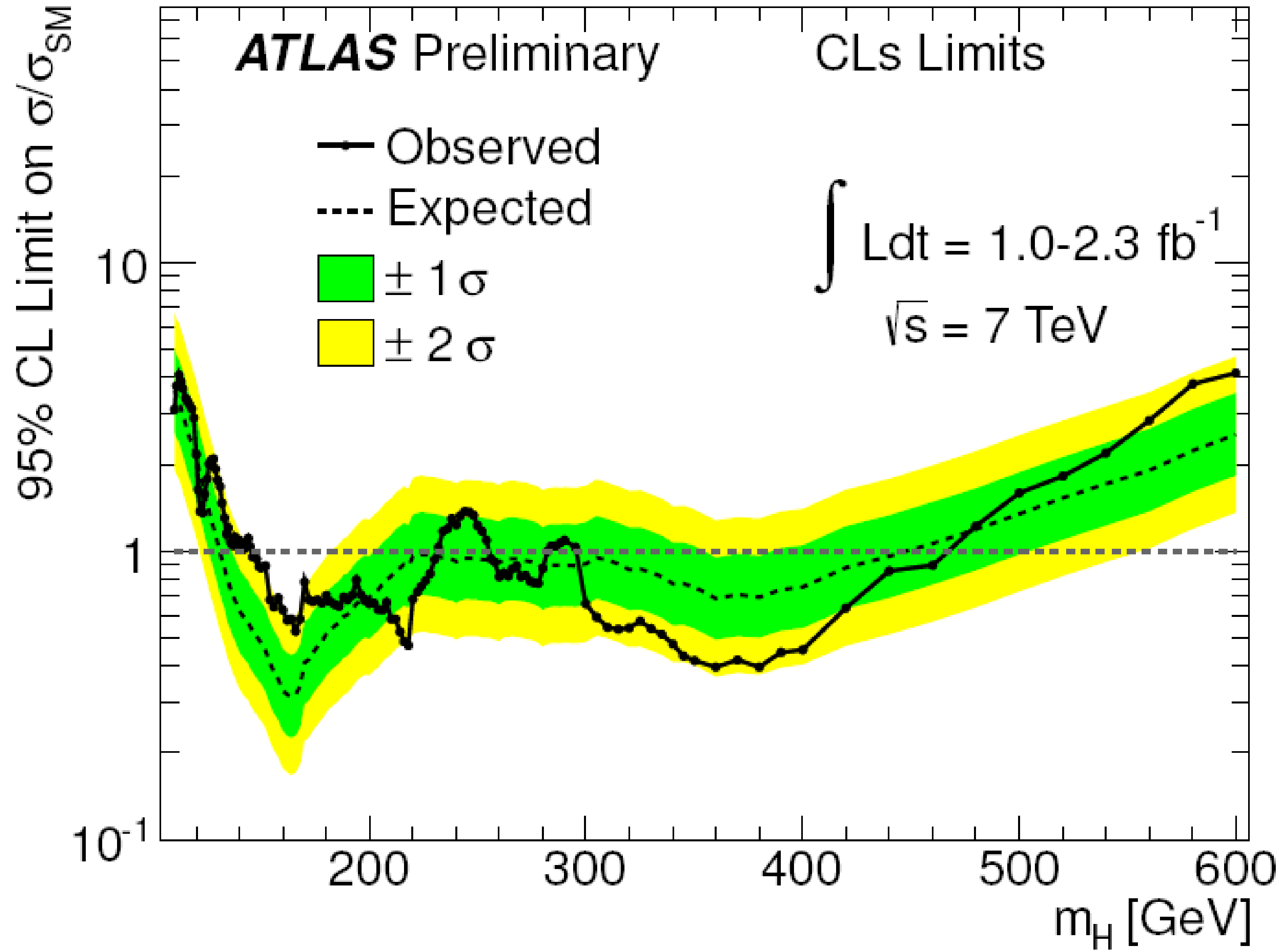
Future: Improve performance, use jet categories and exclusive analyses

Summary SM Higgs Searches

ATL-CONF-2011-135



ATL-CONF-2011-135

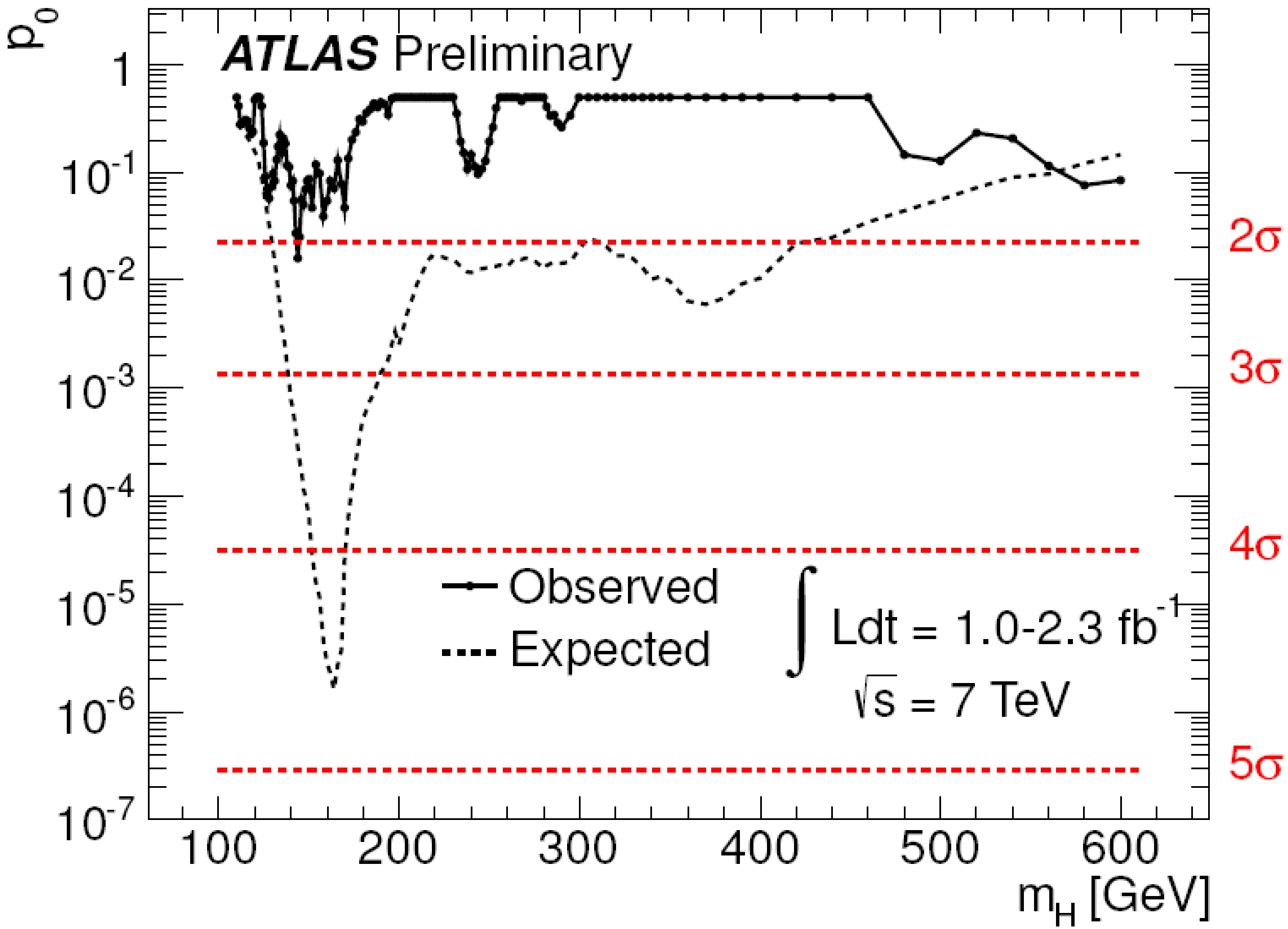


Expected exclusion: 131– 450 GeV

Observed exclusion: 146 – 232 GeV, 256 – 282 GeV, 296 – 466 GeV

SM Higgs Combination

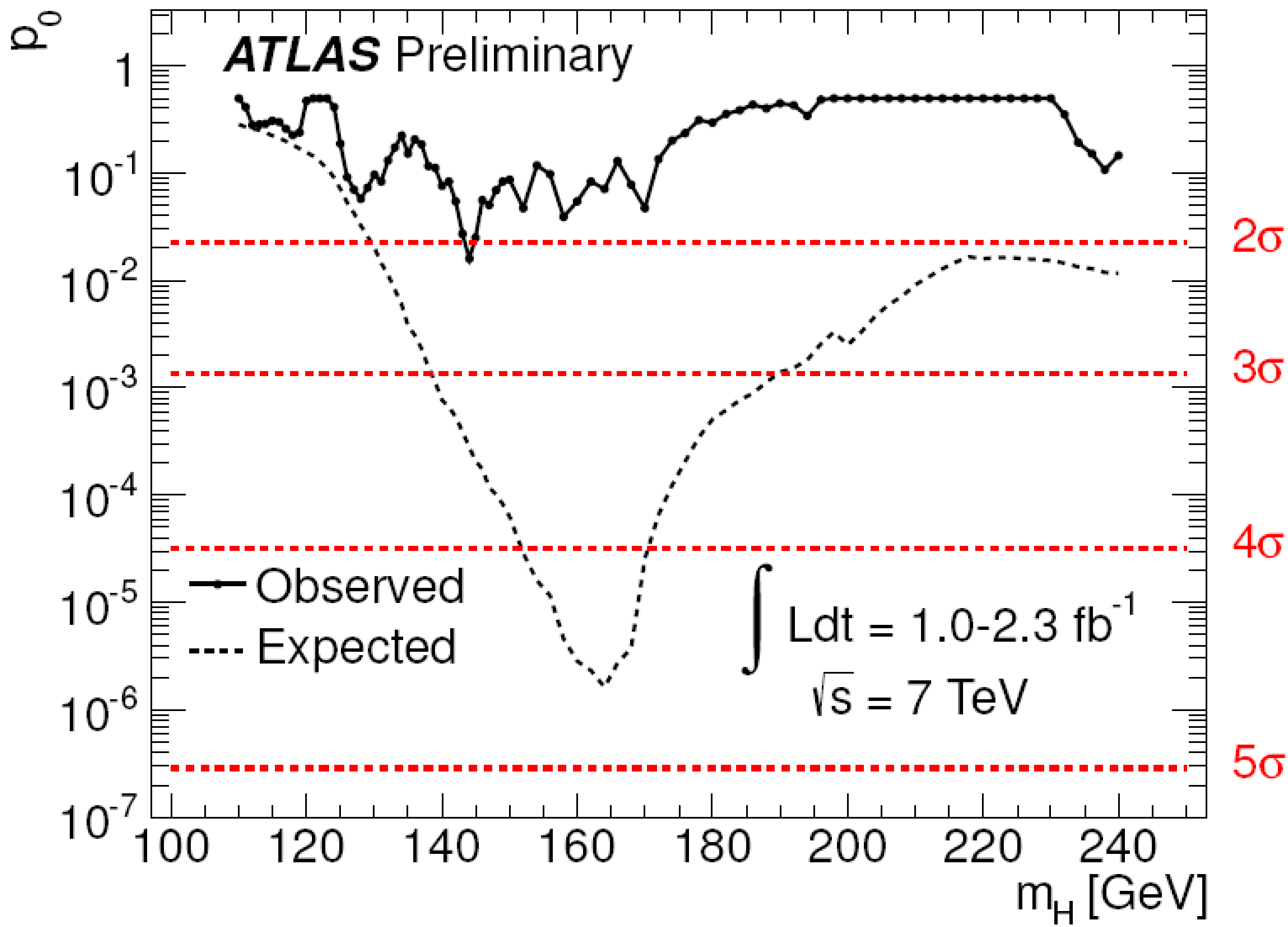
Consistency with Background-Only Hypothesis



Dashed line gives location of the median p-value in case a Higgs signal would be present
Solid line is observed combined p-value.
Small p-value means little agreement with background-only hypothesis.

SM Higgs Combination

Consistency with Background-Only Hypothesis (Low Mass)



Dashed line gives location of the median p-value in case a Higgs signal would be present
Solid line is observed combined p-value.
Small p-value means little agreement with background-only hypothesis.

Conclusions

- **No significant excess seen**
- **ATLAS excludes SM Higgs with at least 95% CL. for**

  146 GeV – 232 GeV
  256 GeV – 282 GeV
  296 GeV – 466 GeV

- **ATLAS and CMS combination at m_H=115 GeV:**

  Possible exclusion at Moriond 2012 (~5 /fb)

  With ~20 /fb by end of 2012 4σ observation possible

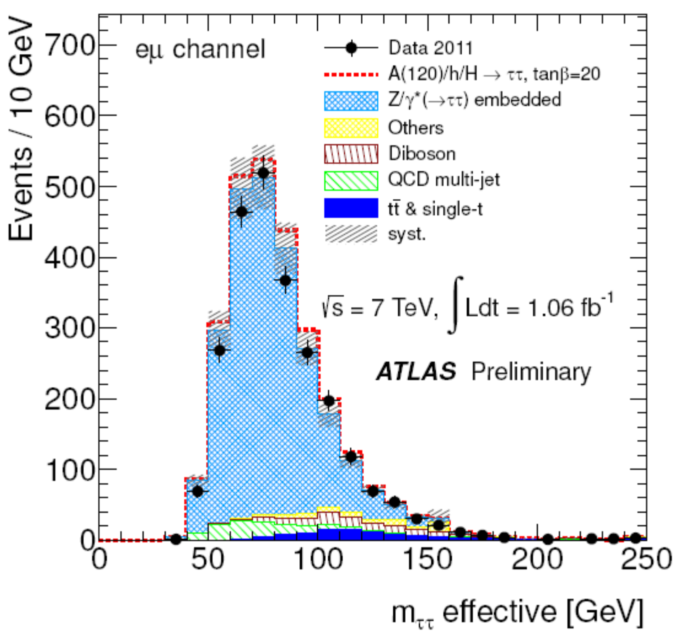
Additional Slides

ATL-CONF-2011-132

In SUSY coupling to vector bosons supressed/absent.
Enhanced coupling to down-type fermions, ~tanβ

Considered final states: eμ, $e\tau_h$, $\mu\tau_h$, $\tau_h\tau_h$

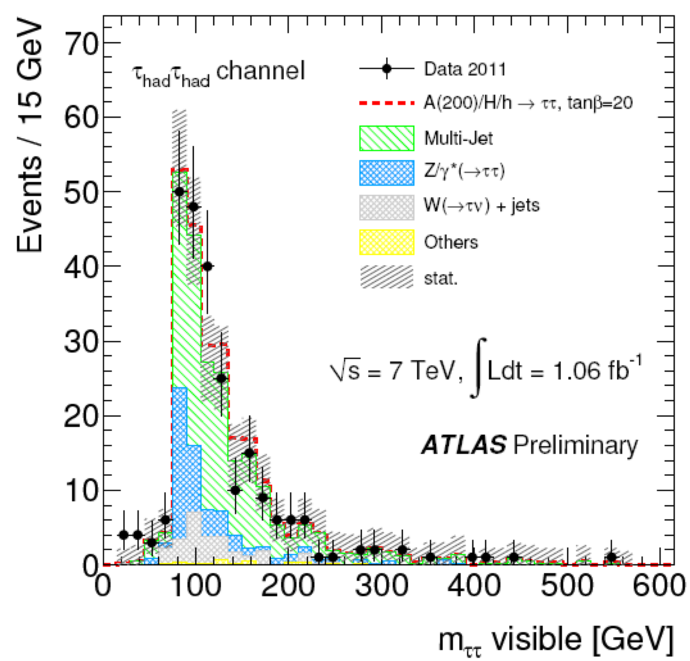
Leplep channel:



$$m_{\tau\tau}^{\text{effective}} = \sqrt{(p_{\tau^+} + p_{\tau^-} + p_{\text{miss}})^2}$$

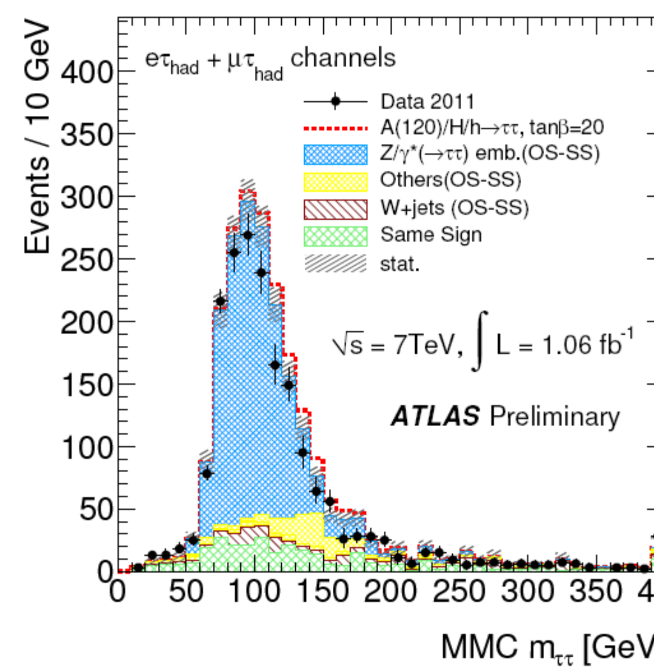
- Lepton pT cut trigger dependent: e (μ): 22 (10) GeV or 15 (20) GeV
- Sum lepton pT + MET < 120 GeV
- ΔΦ(eμ) > 2.0

Fully hadronic channel:



- Two-τ trigger
- Cut based τ ID
  τ pT > 45 (30) GeV
- MET > 25 GeV
- Veto events with high-pT leptons

Lephad channel



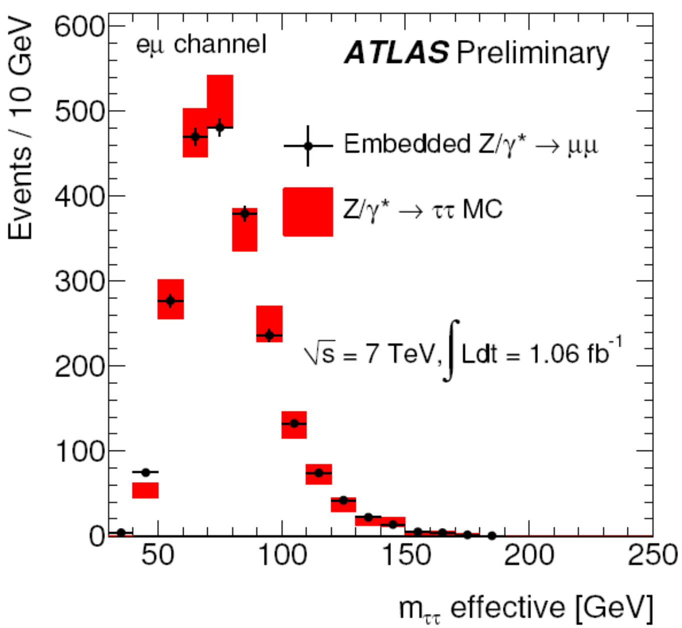
- Lepton pT: e (μ) 25 (20) GeV when more leptons in the event: e (μ) 15 (10) GeV
- τ pT: 20 GeV, τ ID NN based
- MET > 20 GeV, mT < 30 GeV

Missing Mass Calculator
arXiv: 0901.0512

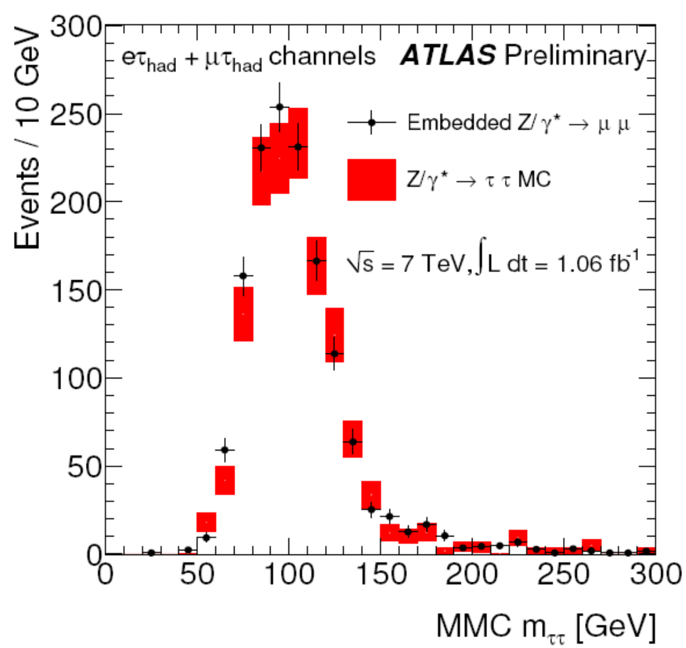
Background control:

- **Z→ ττ from τ embedding into Z→ μμ data events**
- W+jets and QCD from SS mass shape in lephad channel
- QCD in fully hadronic channel from ABCD method (τ ID vs. charge product)

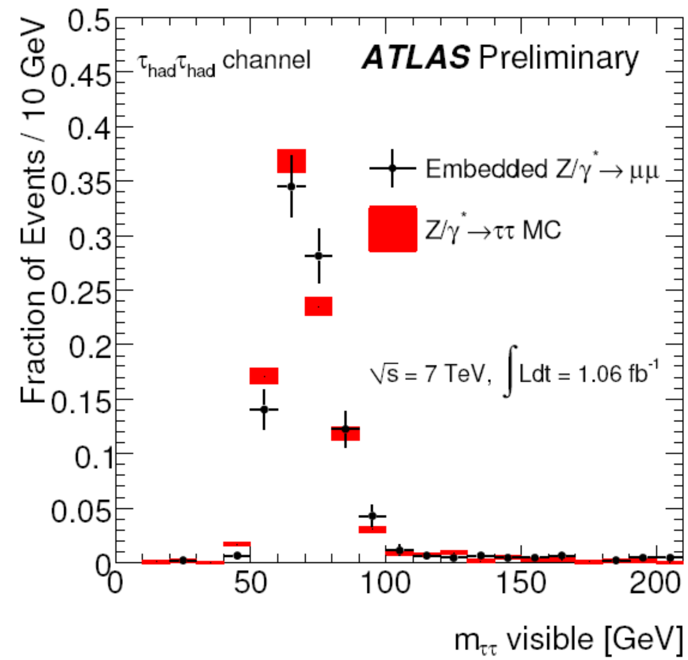
Leplep channel:



Fully hadronic channel:



Lephad channel



Systematic uncertainties:

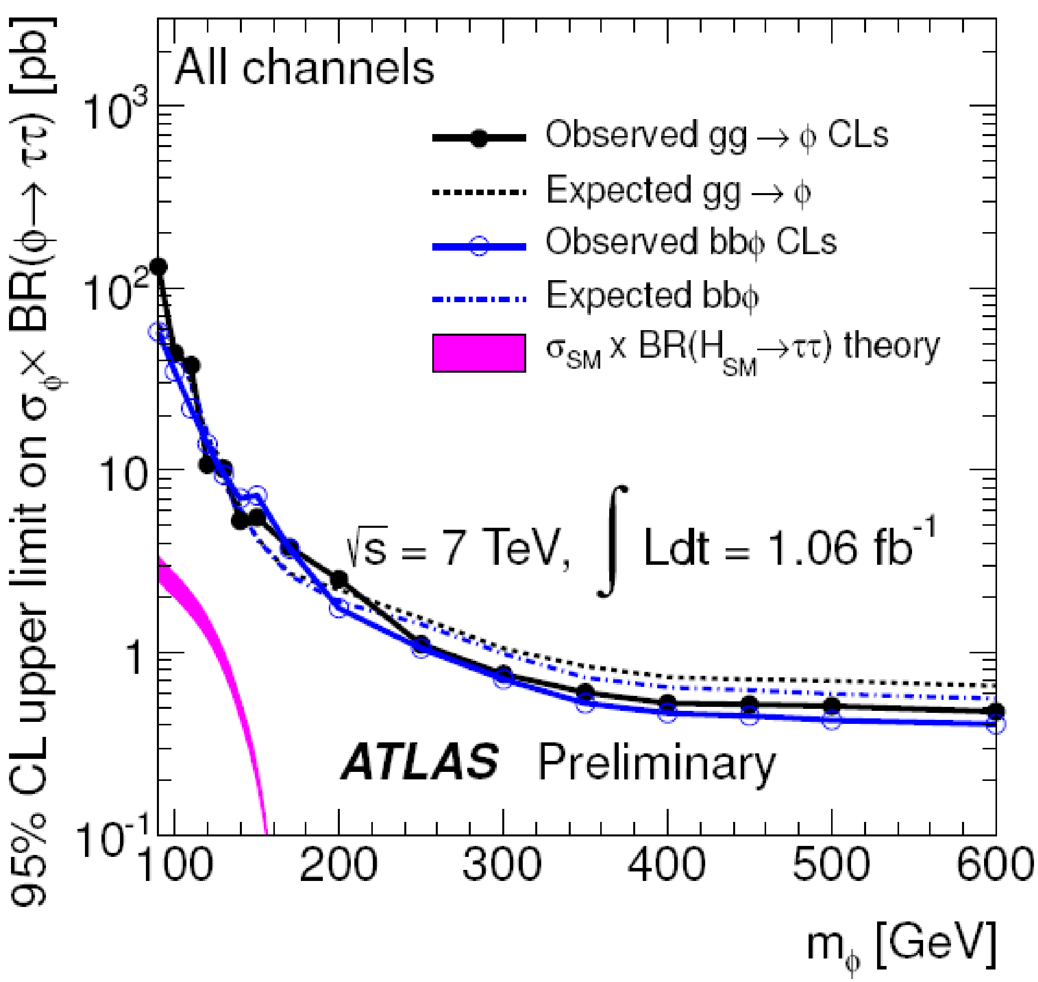
- Dominant τ_h ID efficiency & fake rate uncertainty: 10 %
- Also important: τ and jet energy scales and resolutions

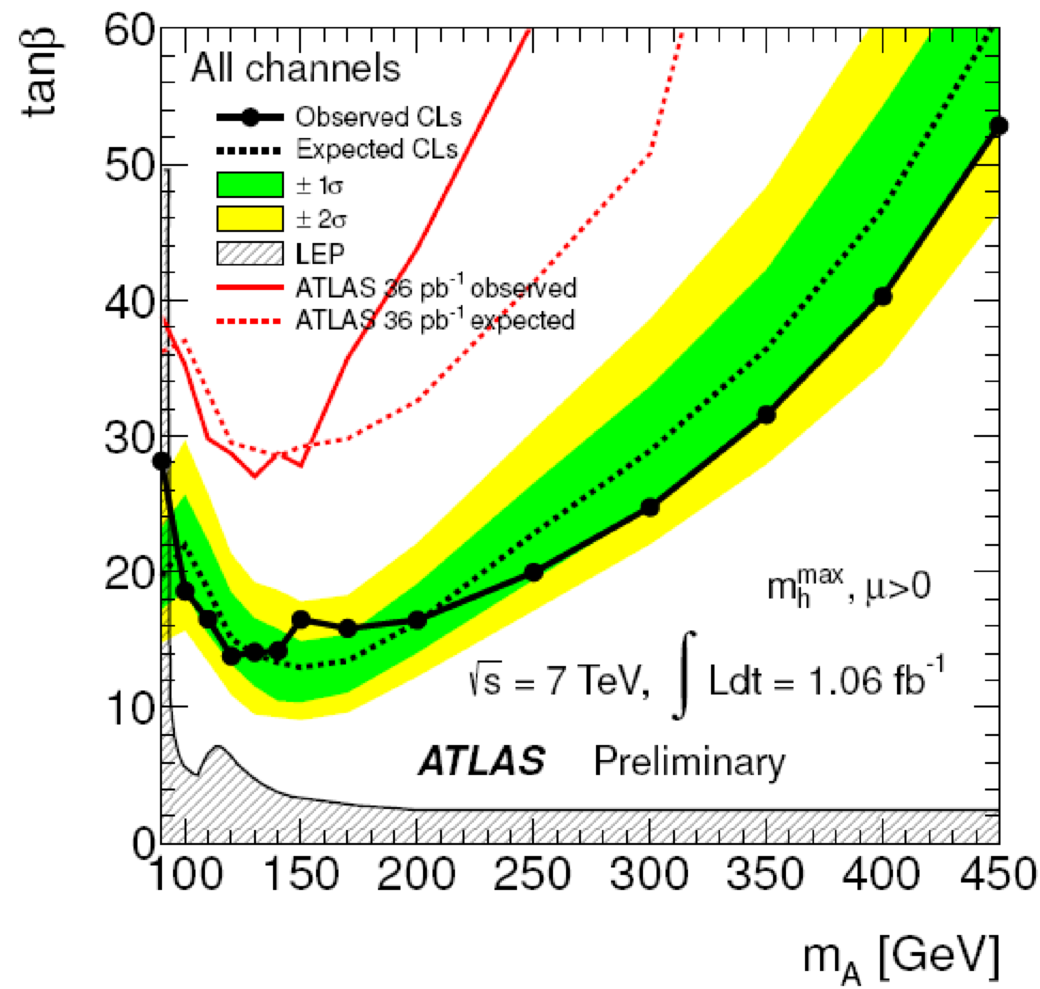
MSSM h/A/H → ττ   100 GeV < mA < 600 GeV   1.06 /fb

Results:

**ggF and b-associated production*

	Data	Total BG	Signal* tanβ=20
leplep	2 472	2 600 ± 200	mH=120 GeV:155±6
lephad	1 913	2 100 ± 400	mH=120 GeV:116±9
hadhad	245	233 +44 -28	mH=200 GeV:19±1





MSSM $H^+ \rightarrow \tau\nu$ — 90 GeV < m_{H^+} < 160 GeV — 1.03 /fb

ATLAS-CONF-2011-138

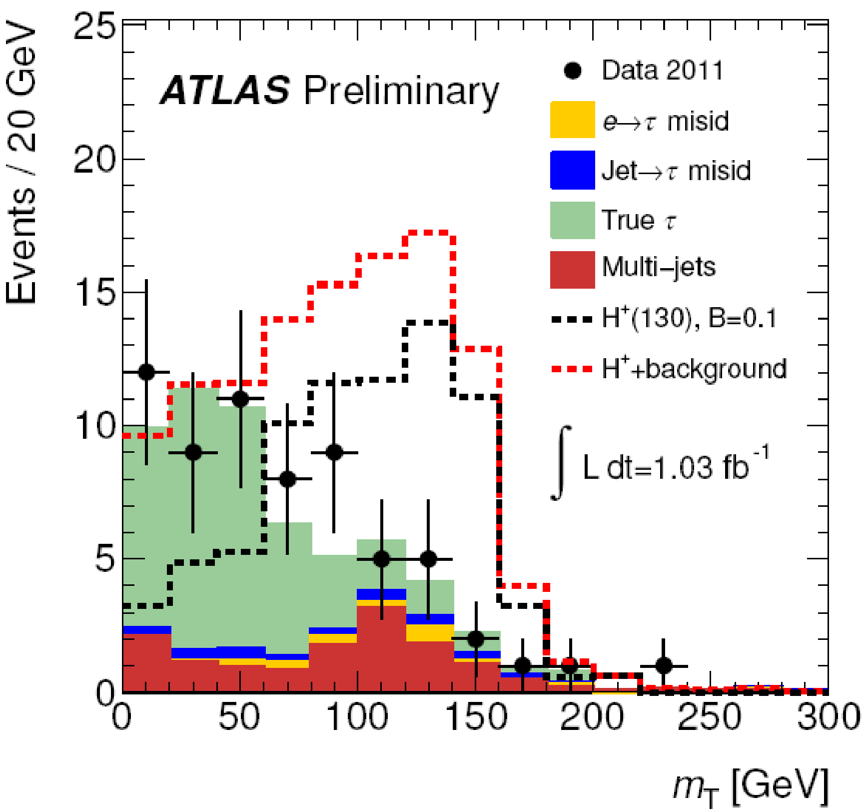
Search channel: $t\bar{t} \rightarrow H^+b + W^-b \rightarrow \tau\nu b + qq'\,b$

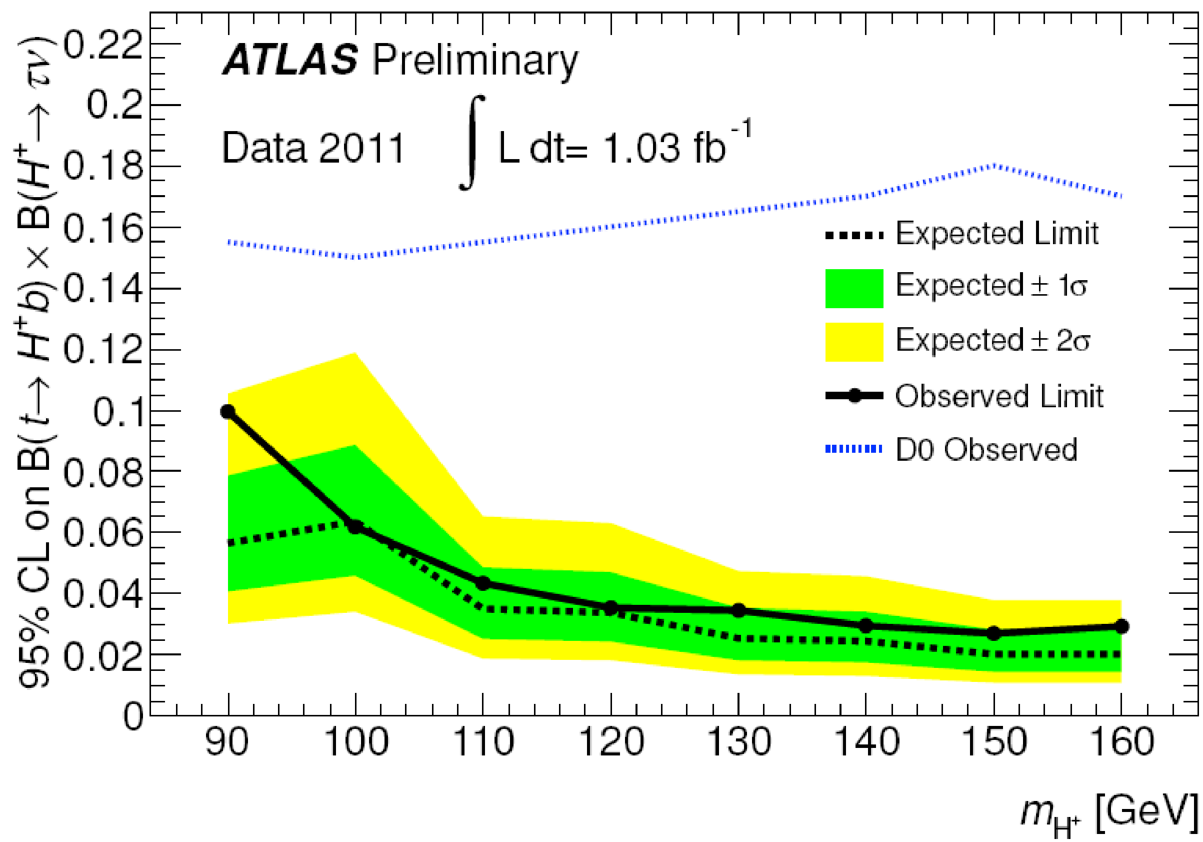
Event selection:

- MET + τ trigger
- MET > 50 GeV
- Hadronic t with pT > 35 GeV
- At least one b-tagged jet
- Two additional jets + b-jet
- Final discriminant: mT

Data	Total BG	m_{H^+}=130 GeV, BR ($t\rightarrow bH^+$)=0.1
43	37±7	70

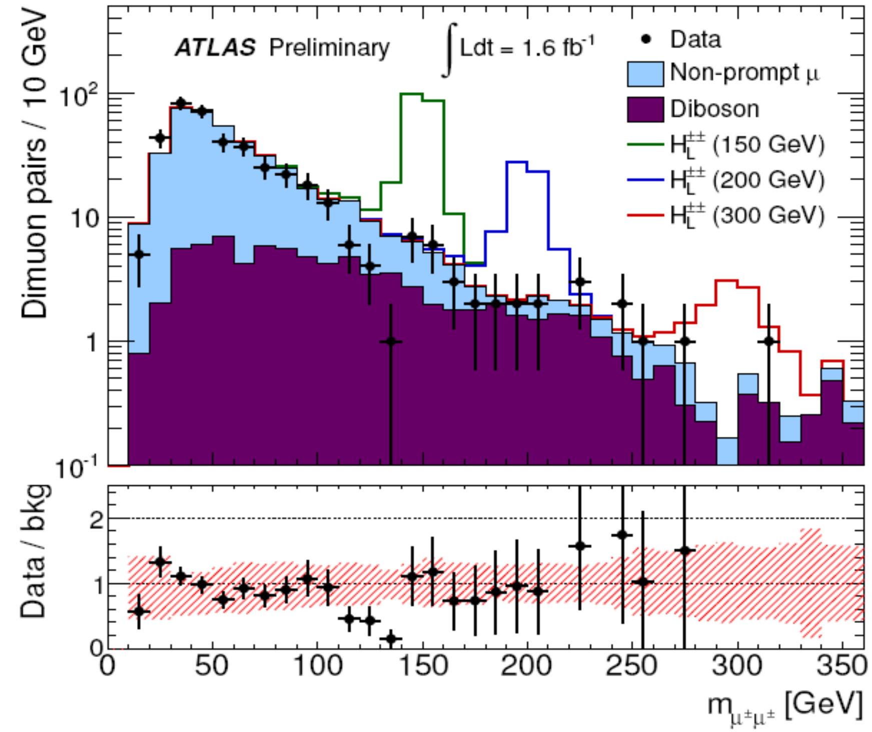
- Jet and τ related systematics dominant
- True τ background via τ embedding into μ+jets data sample





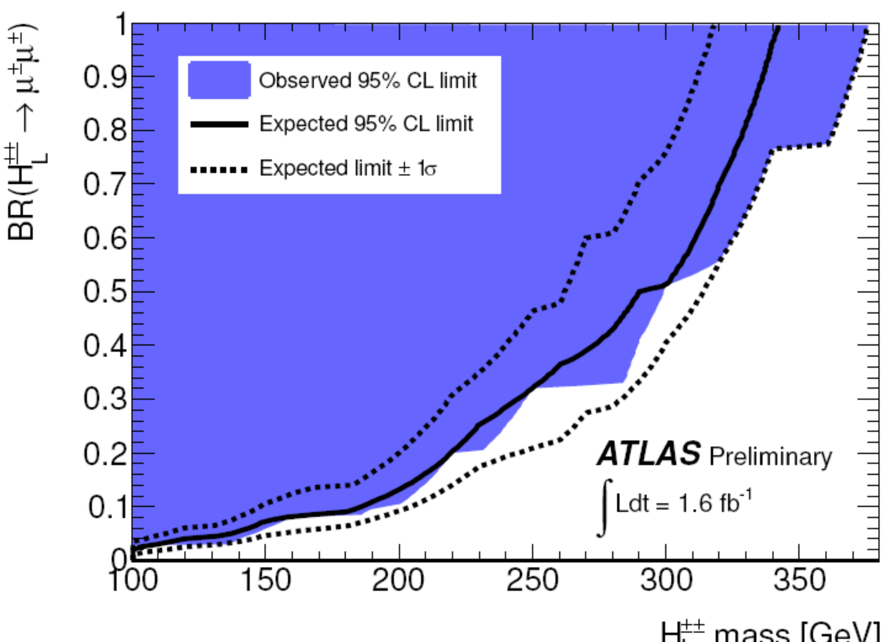
$H^{\pm\pm} \rightarrow \mu\mu$ 100 GeV < $m_{H^{\pm\pm}}$ < 400 GeV 1.6 /fb

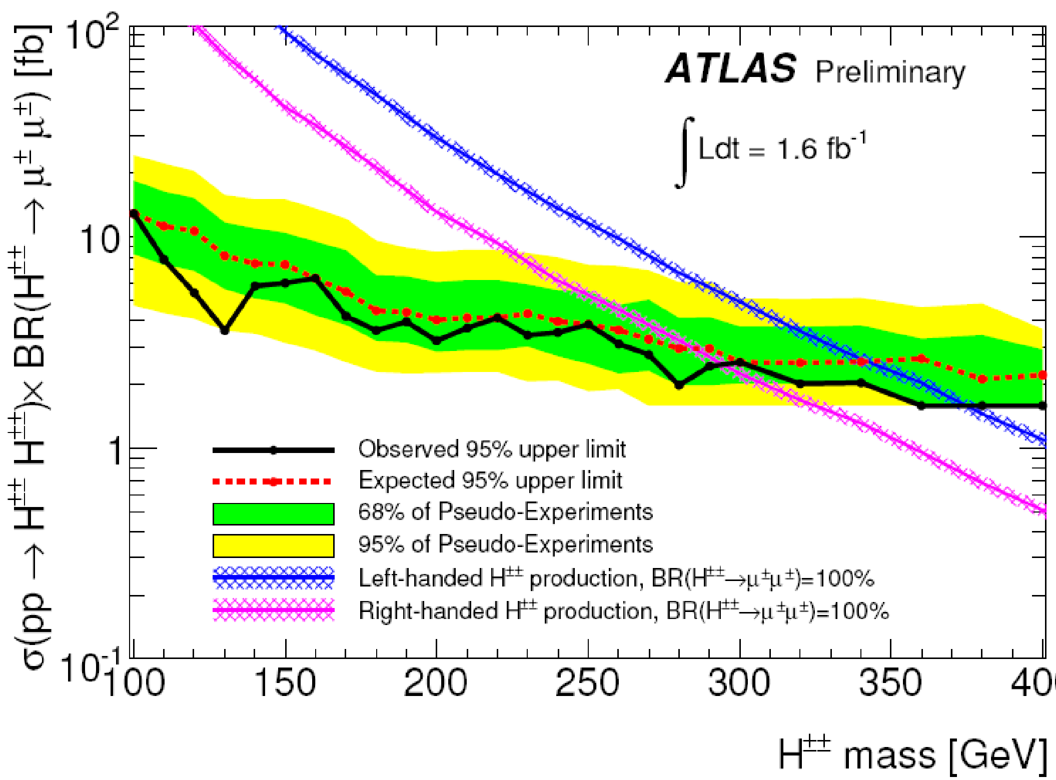
ATL-CONF-2011-127



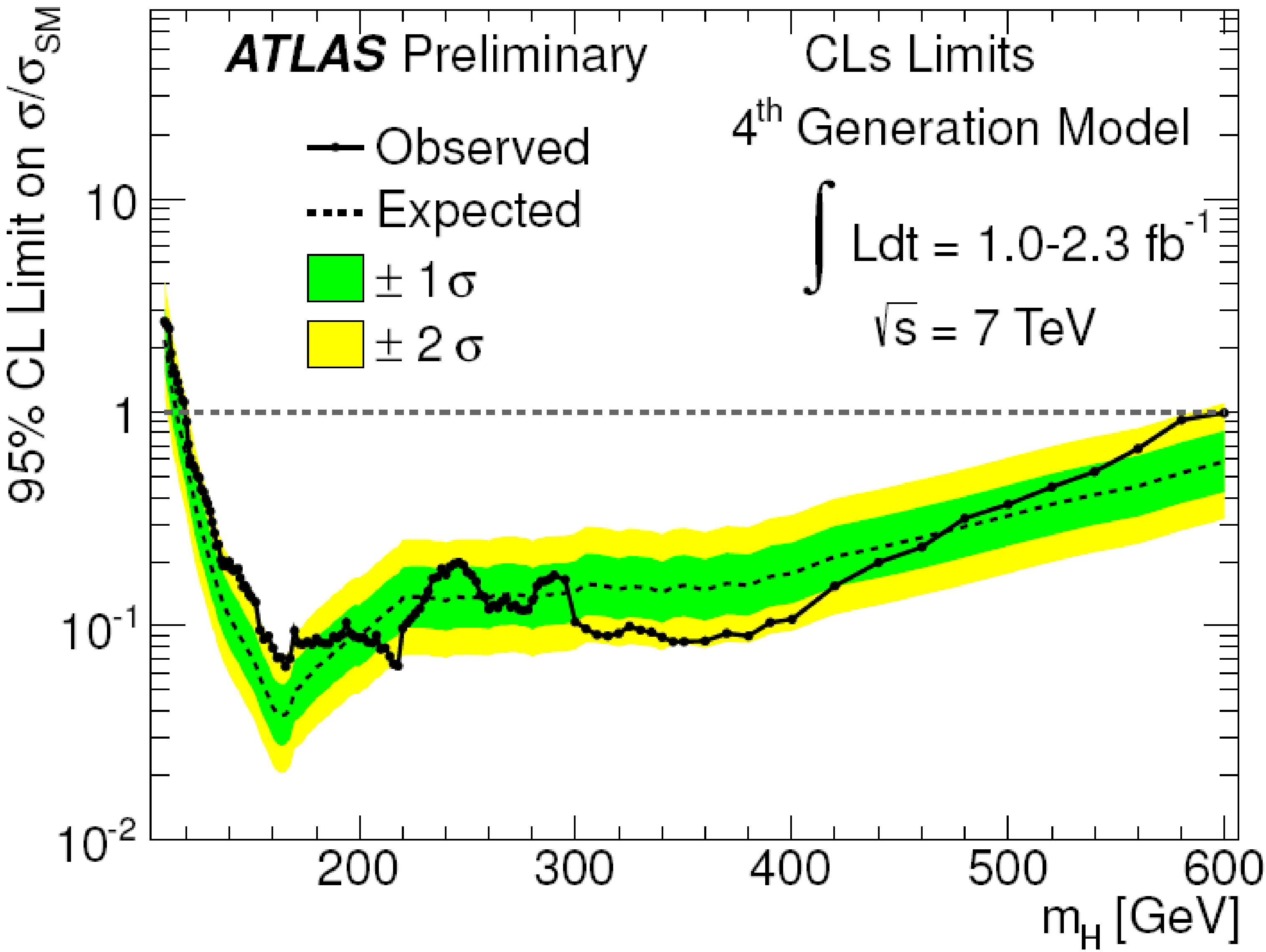
- Relevant models eg. Little Higgs, Higgs triplets
- Select events with 2 high pT same sign muons
- Production in DY process $q\bar{q} \rightarrow Z/\gamma^* \rightarrow H^{++}H^{--}$
- If BR=1, left-handed $H^{\pm\pm}$ excluded for m_H < 375 GeV, right-handed $H^{\pm\pm}$ excluded for m_H < 295 GeV

Data	Total BG
401	437+96 -186



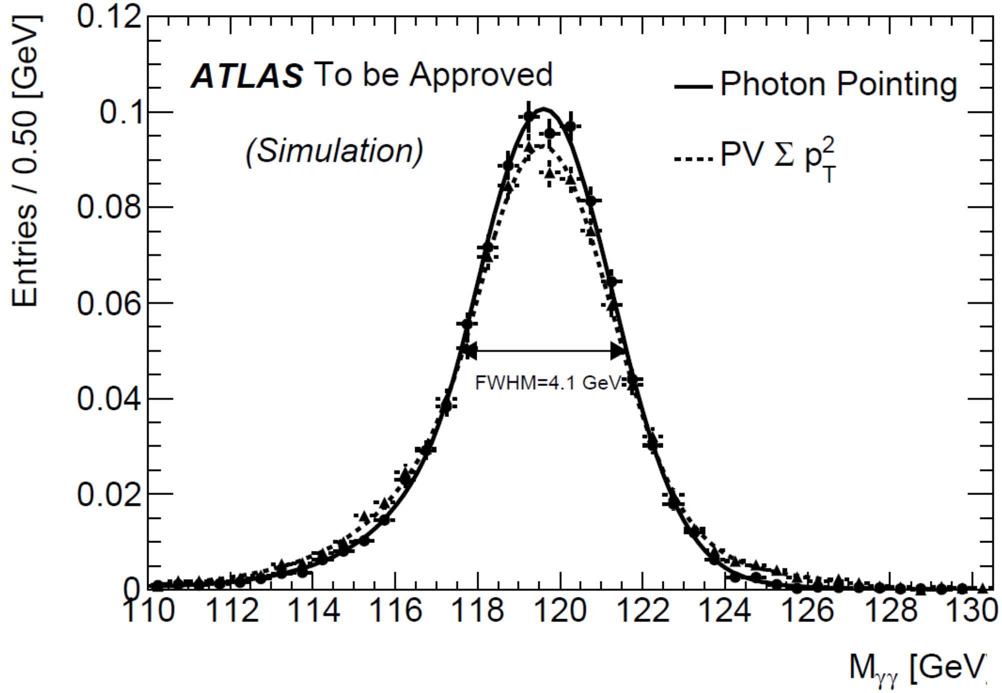


4^{th} Generation



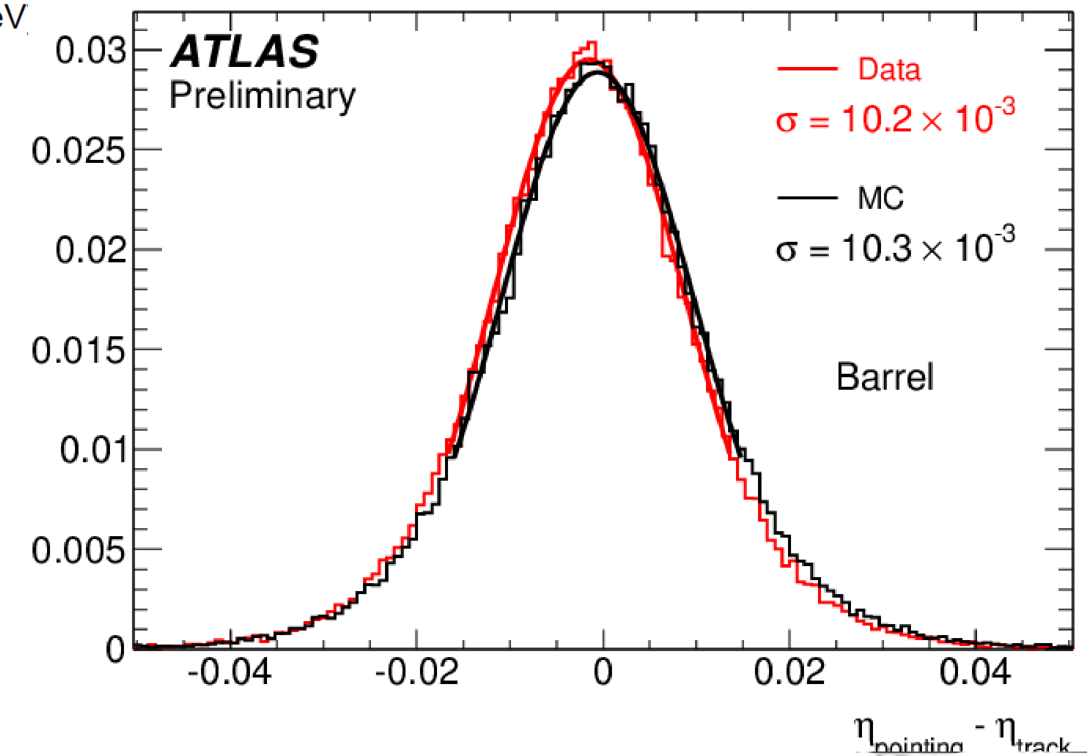
- Heavy 4^{th} generation: m = 600 GeV
- Exclusion: 120 GeV – 600 GeV

$H \rightarrow \gamma\gamma$

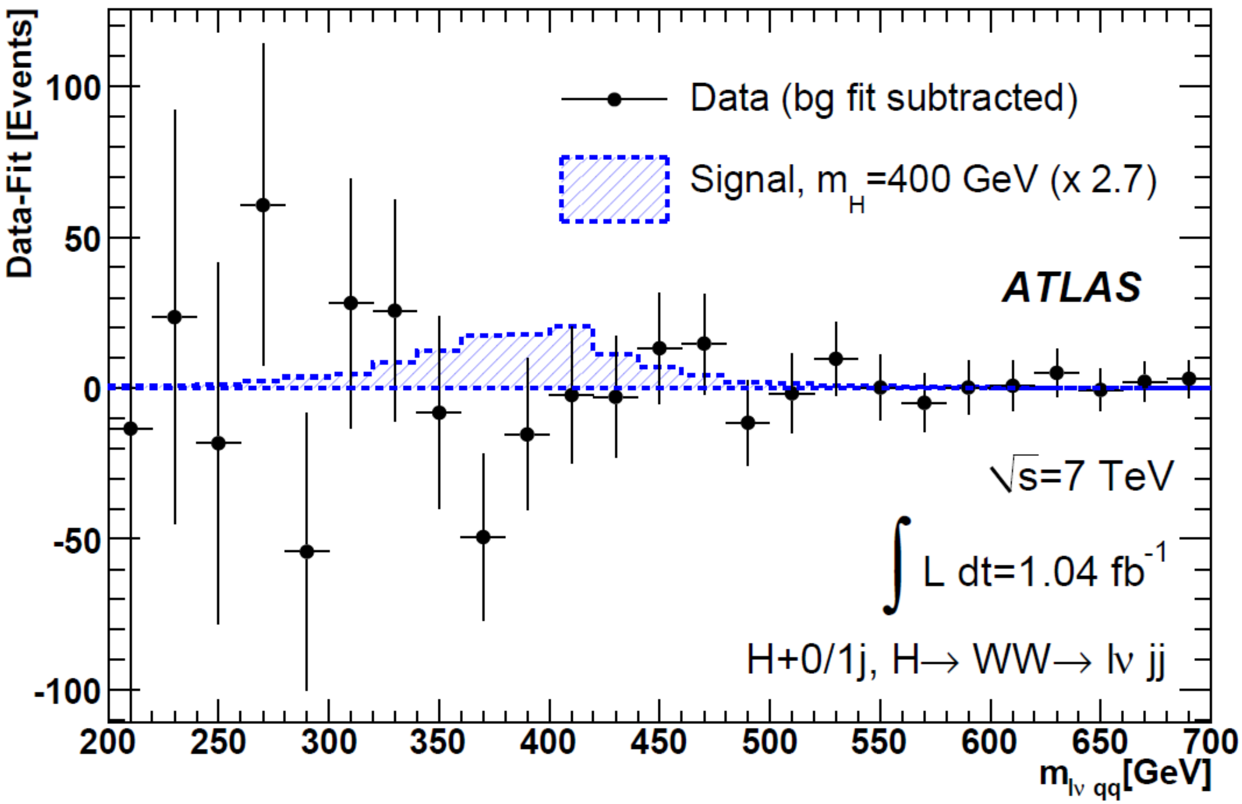


Improvement of mass resolution using photon pointing instead of Sum p_T^2 to deduce PV.

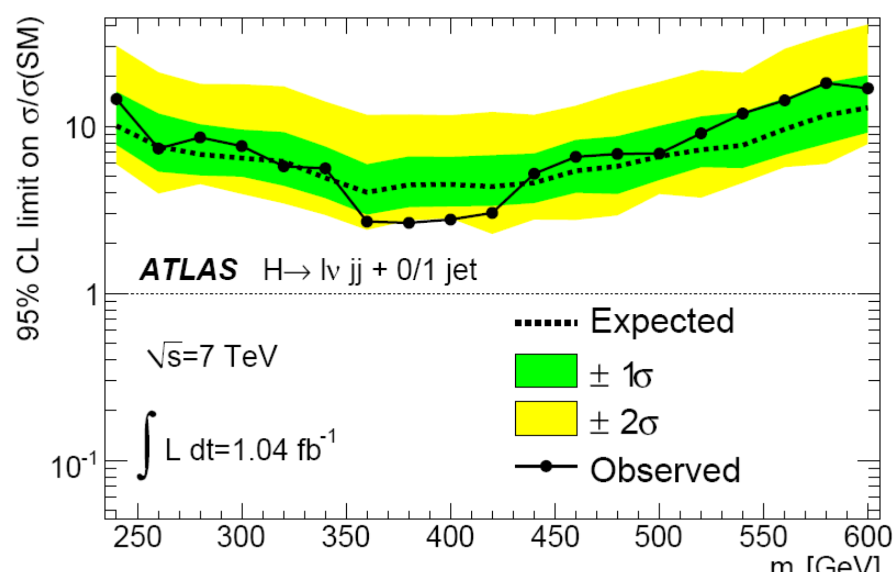
Comparison of eta deduced by calo pointing to the track direction obtained from $Z \rightarrow ee$.



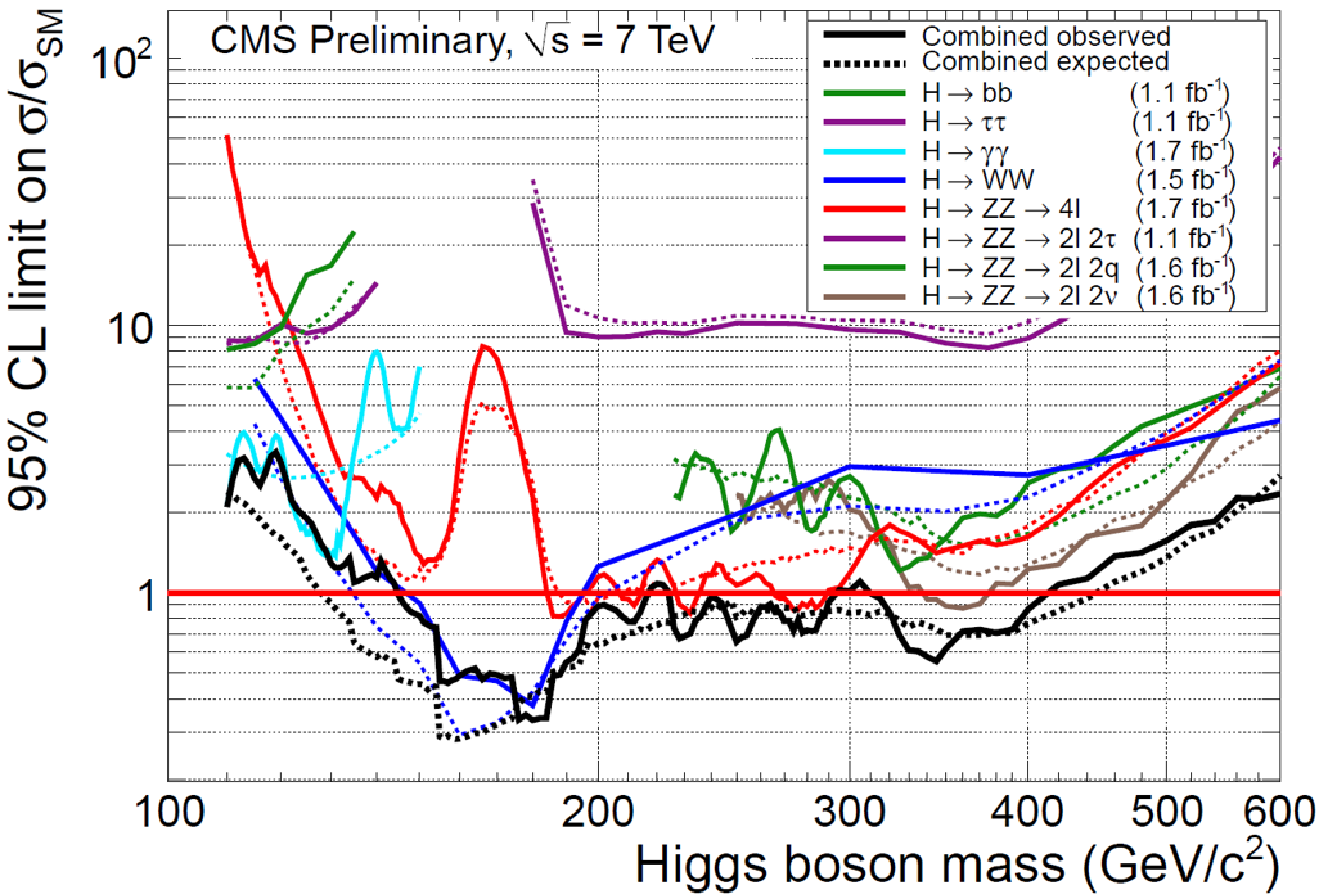
H → W W → lνqq



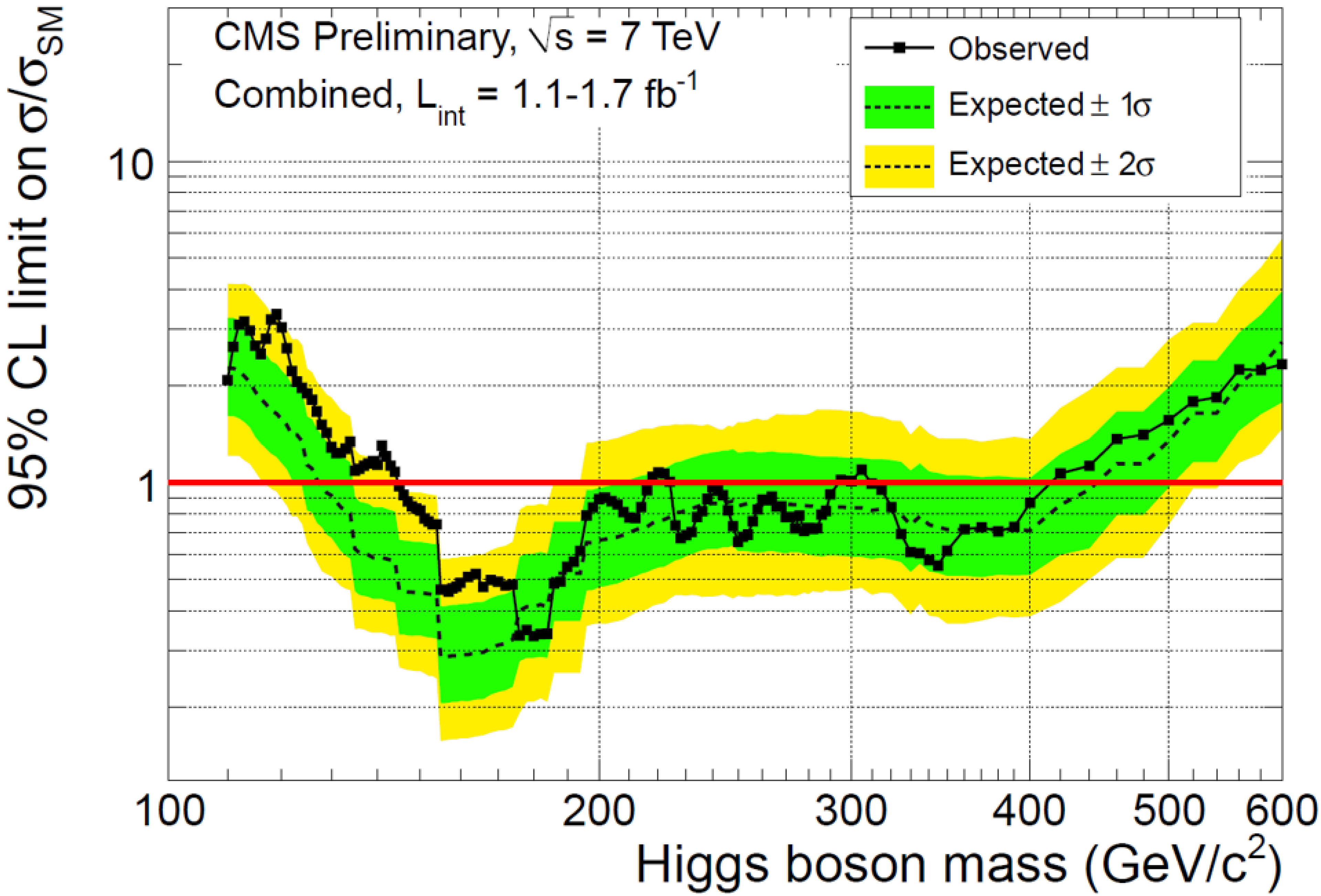
Deficit observed in the data for 350 GeV – 400 GeV.



CMS Higgs Results Summary



CMS Higgs Results Combination



Summary SM Higgs Searches

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}	200-600	Z+jets (from MC) and top (from MC)

* CMS only / ** ATLAS only