H→WW→lνlν analysis with ATLAS detector at LHC

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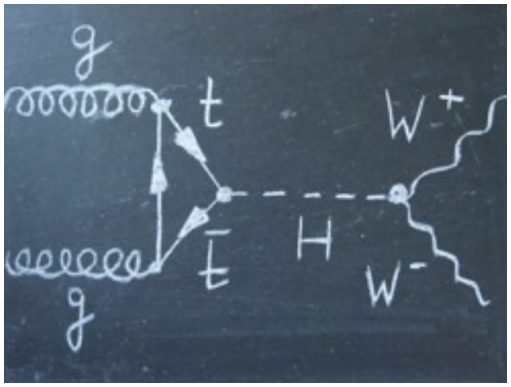
New results. Outline

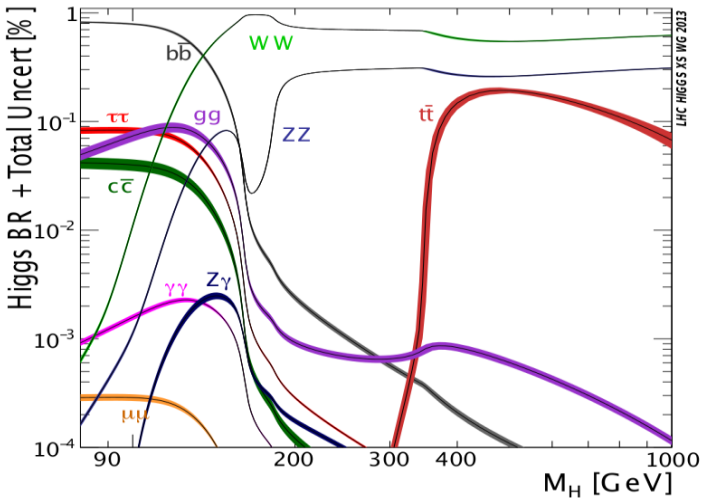
- Update to the full LHC 2012 dataset (20.7/fb)
- Improved 0/1-jet ggF analyses:
  - Previous results (13/fb) systematic limited
  - Changes address sources of systematic uncertainties
- First VBF results
- Extension of results to ee/μμ channels
  - New analysis technique to estimate Z/γ* background

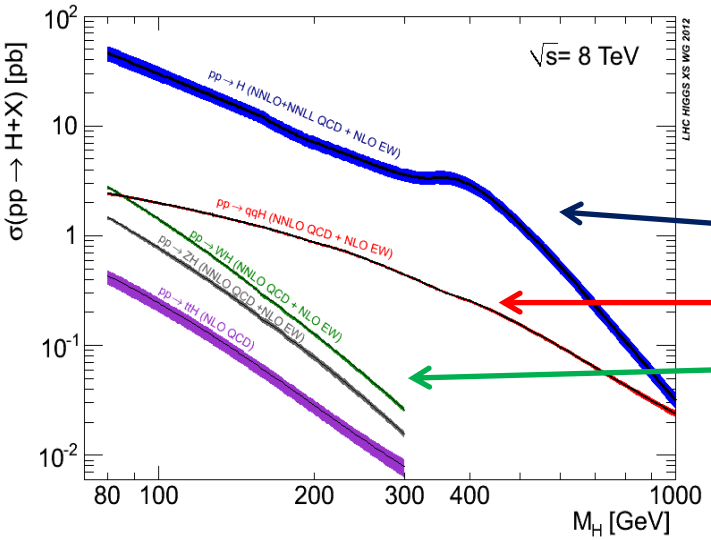
- Motivation / Analysis strategy
- Event selection
  - eμ 0-jet channel
  - VBF channel
- Including Same Flavour Lepton Channel
- Results



https://cds.cern.ch/record/1527126/files/ATLAS-CONF-2013-030.pdf

Motivation





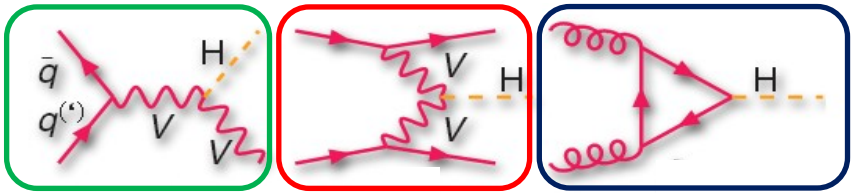
→ **Large Higgs boson production cross section over wide and relevant range of M_H**

- ee/eμ/μμ + missing E_T signature
- Sensitive SM Higgs search channel

The challenges,

- Many background (both irreducible and reducible)

- Poor mass resolution (due to 2 escaping ν)



Different signal production mechanisms:

gluon fusion

VBF

associated production

lead to different kinematic signatures and jet multiplicities

Figures from https://twiki.cern.ch/twiki/bin/view/LHCPhysics/CrossSections

Event selection

→ Event signature

di-lepton (e / μ) with missing E_T signature

P_T > 25 GeV / 15 GeV (single-lepton triggers)

mll > 10 GeV

→ Analysis performed in 4-channels

Different Flavour (eμ / μe)

Same Flavour (ee / μμ)

High pile-up → degraded MET resolution

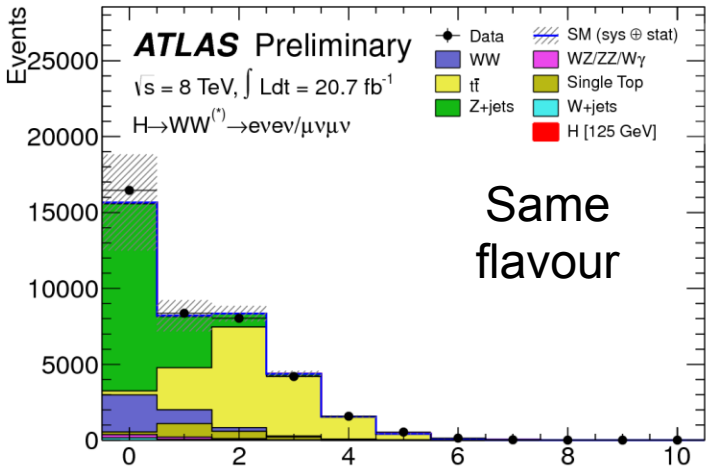
→ Split by Jet-multiplicity

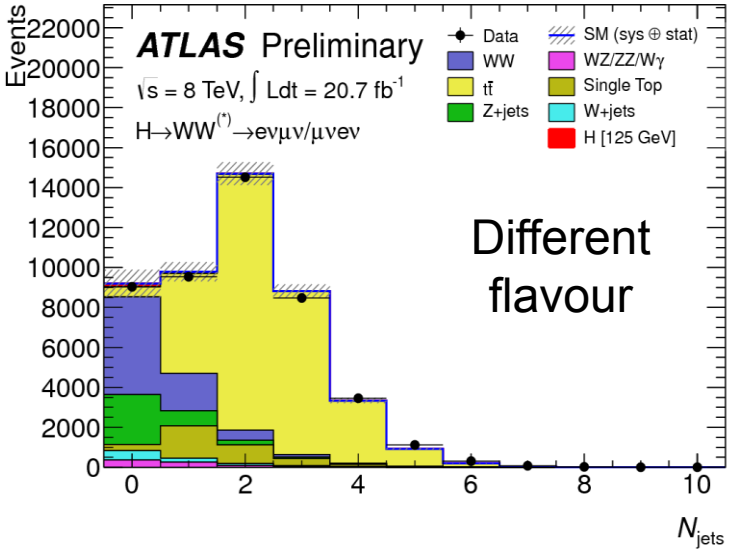
0 : Dominated by **WW** and **Z/γ*+jets**

1 : Dominated by **WW** and **top**

>= 2 : Dominated by **top**

ggF sensitivity driven by 0-jet eμ
VBF sensitiviy driven by 2-jet eμ
Focus talk on these results





H→WW→lνlν Analysis Strategy

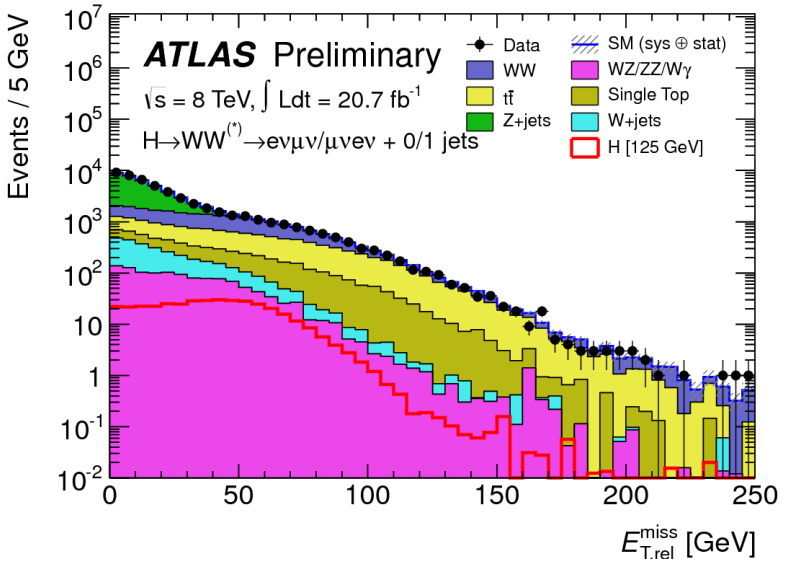
Challenge: many backgrounds

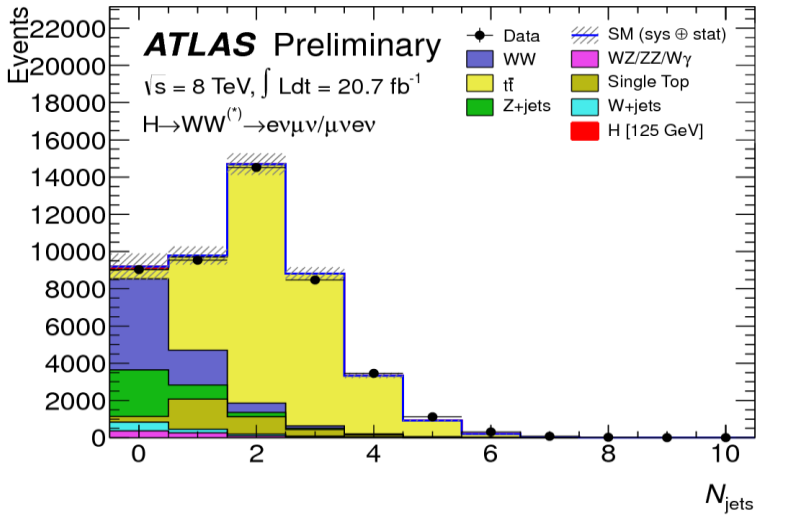
Z+jets: lepton pair + fake MET
- Require Large MET
- Reject events consistents with Z mass peak

Top: WW produced with 2 b-jets
- Jet Veto

W+Jets: lepton with MET + fake lepton
- Isolation / lepton identification

Other Diboson: WZ, ZZ, Wγ
- Remove events with > 2leptons





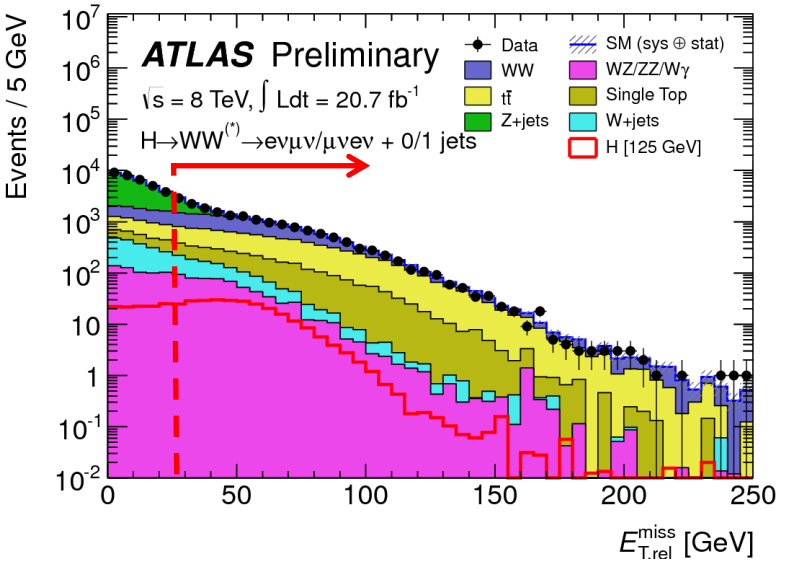
H→WW→lνlν Analysis Strategy

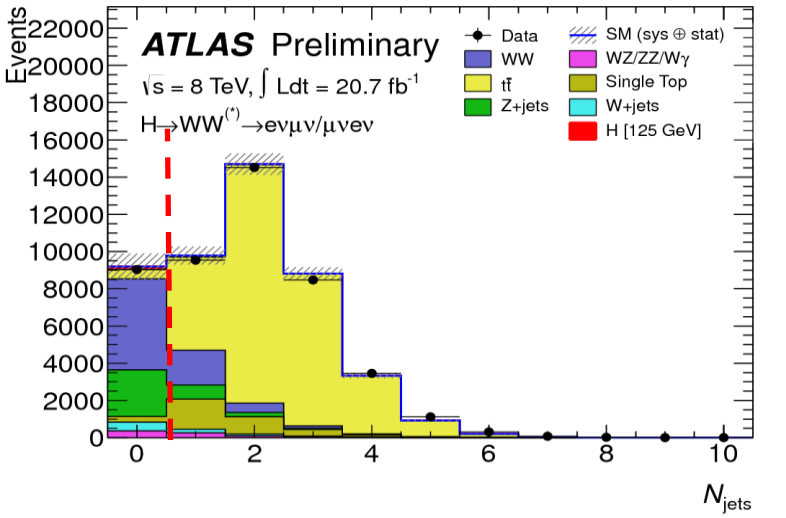
Challenge: many backgrounds

Z+jets: lepton pair + fake MET
- Require Large MET
- Reject events consistents with Z mass peak

Top: WW produced with 2 b-jets
- Jet Veto

- Large backgrounds but reduced with Event Selection
- Modeled by MC
- Corrected to Data in CRs





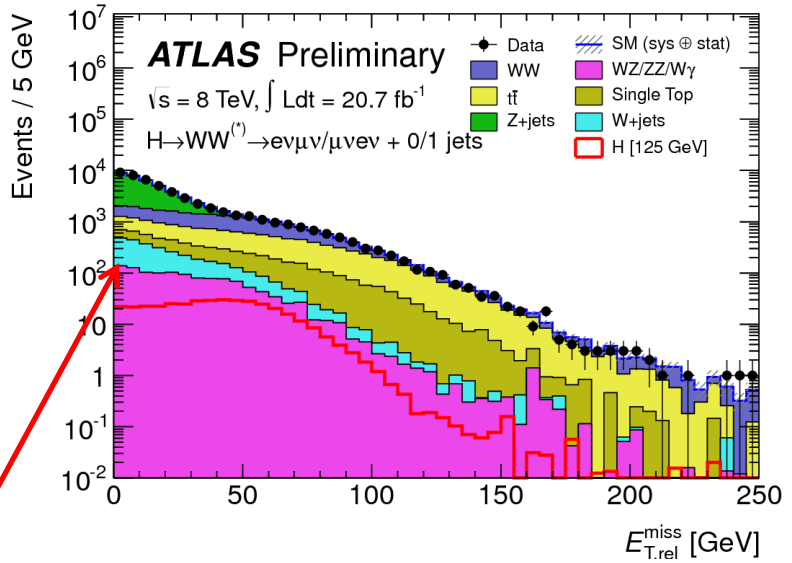
H→WW→lνlν Analysis Strategy

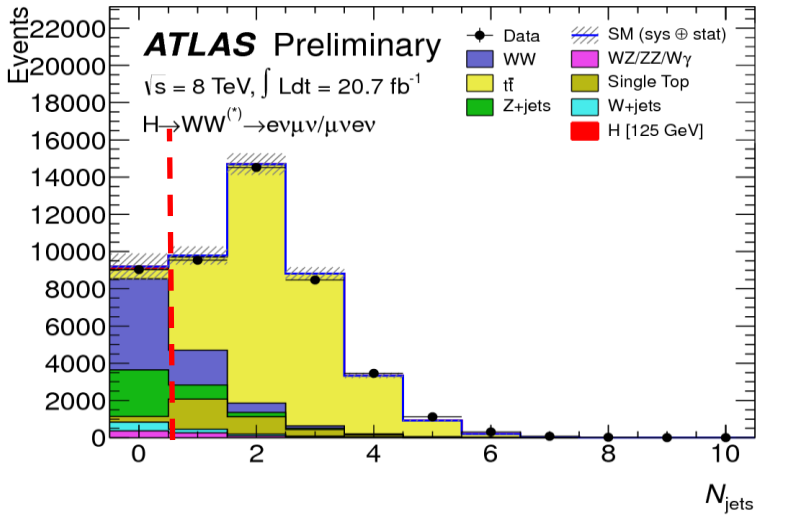
Challenge: many backgrounds

- Important → shape is signal like after event selection
- Small, but not suppressed with Event Selection
- Difficult to model lepton fake rate in MC
- Use Data-Driven method

W+Jets: lepton with MET + fake lepton
• Isolation / lepton identification

Other Diboson: WZ, ZZ, Wγ
• Remove events with > 2leptons





H→WW→lνlν Analysis Strategy

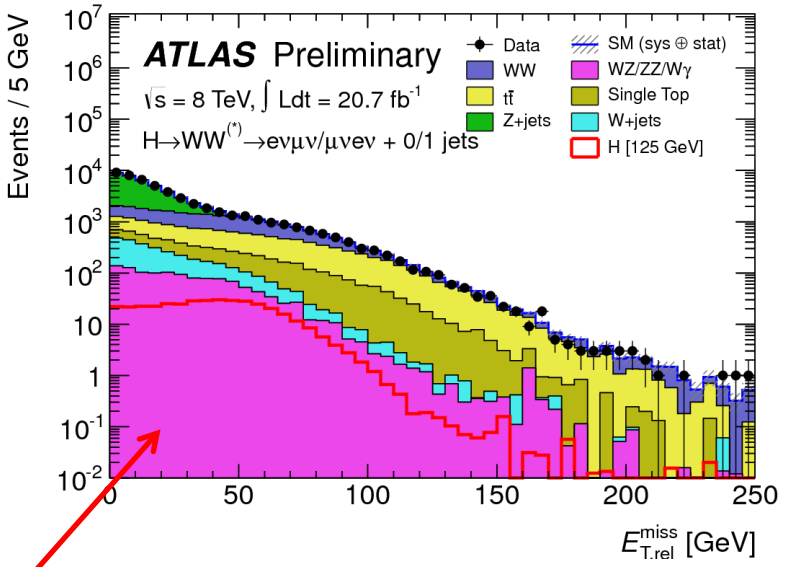
Challenge: many backgrounds

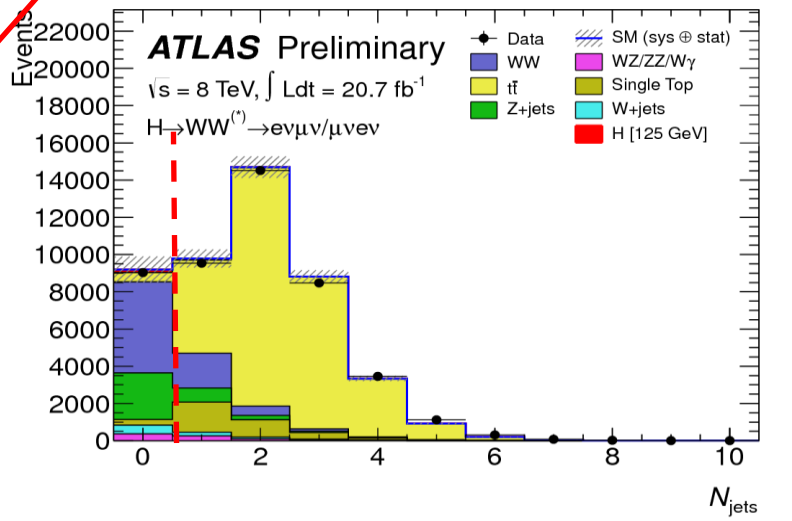
Z+jets: lepton pair + fake MET
- Require Large MET
- Reject events consistents with Z mass peak

Top: WW produced with 2 b-jets

-Small and suppressed with Event Selection
- Modeled by MC

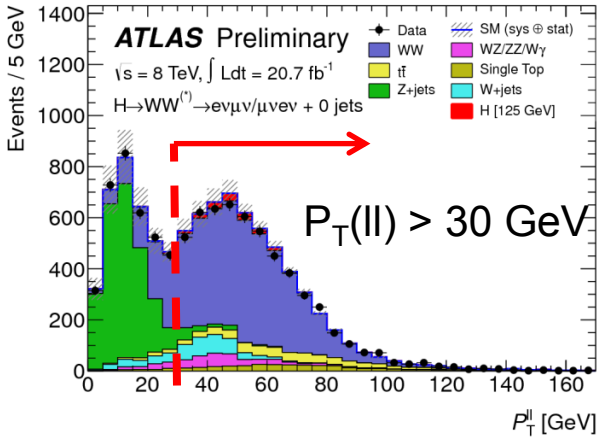
Other Diboson: WZ, ZZ, Wγ
- Remove events with > 2leptons

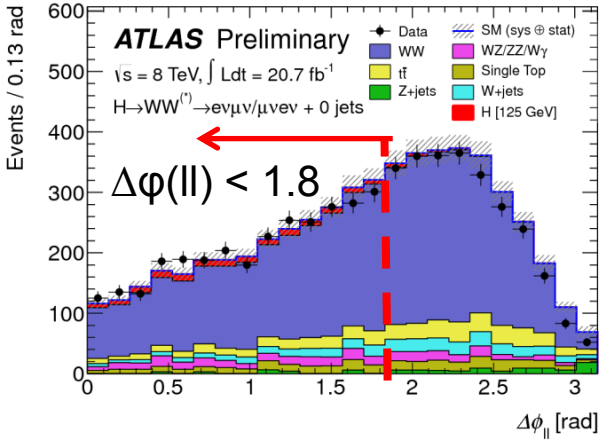


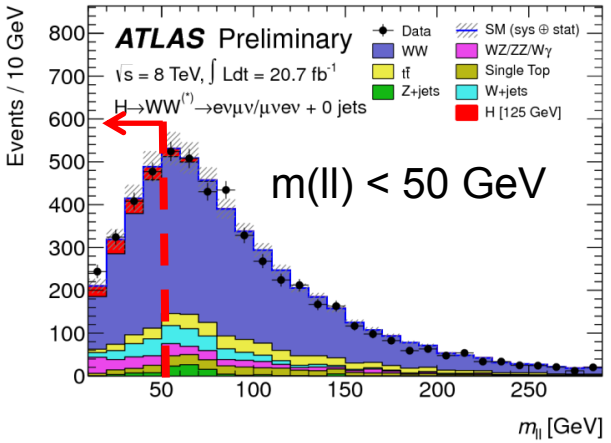


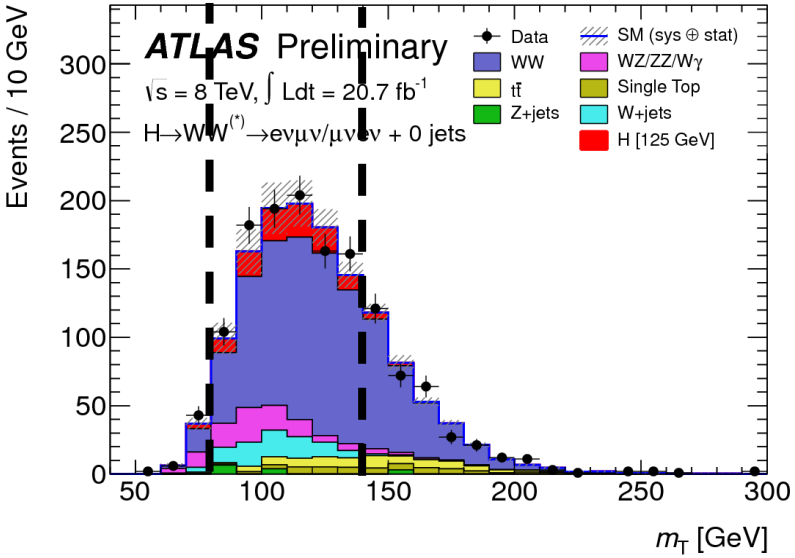
H→WW→lνlν Analysis Strategy

Kinematic selection exploits Spin 0 Nature of Higgs boson:









WW
Other
Diboson
Zjets
Wjets
Top
Signal

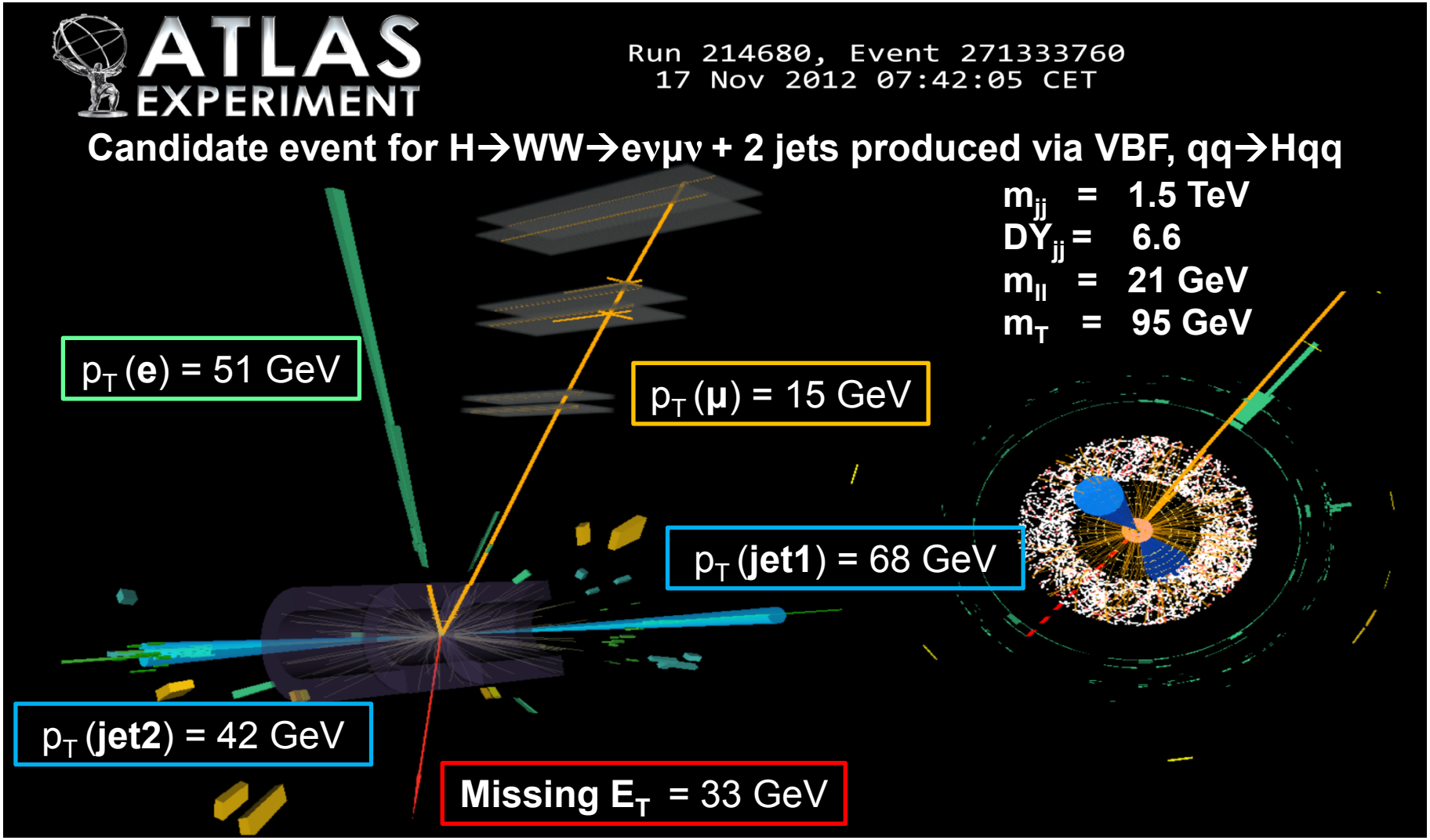
Separate H→WW from non-resonant WW production

Final results obtained from binned likelihood fits to M_T distribution

$$m_T^2 = \left(\sqrt{m_{ll}^2 + \left|\vec{p}_{T_{ll}}\right|^2} + E_T^{miss} \right)^2 - \left(\vec{p}_{T_{ll}} + \vec{E}_T^{miss} \right)^2$$

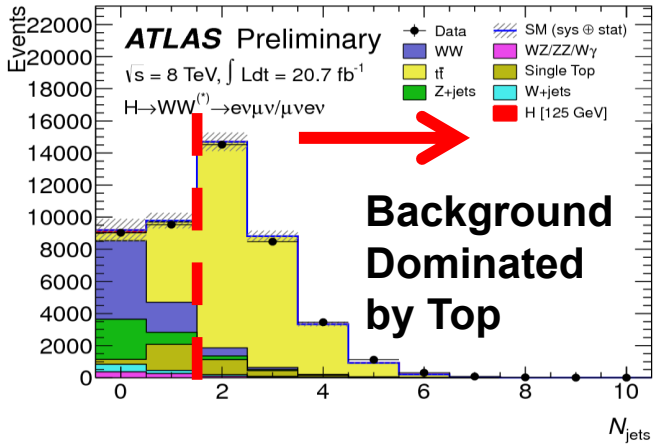
5 (3) bins for 0-jet (1-jet)

VBF Event Selection



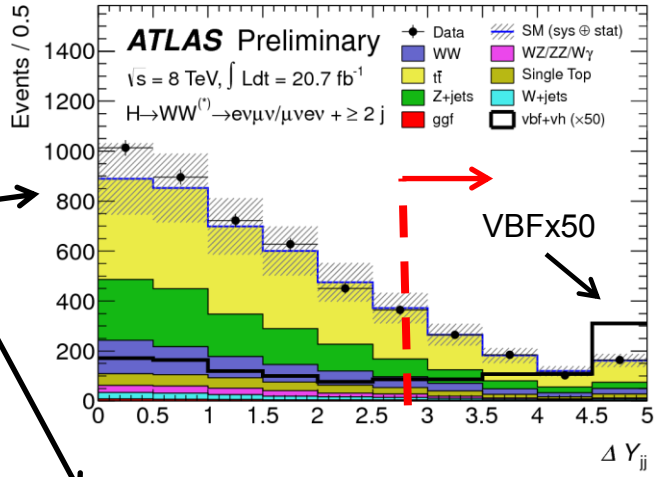
VBF Event Selection

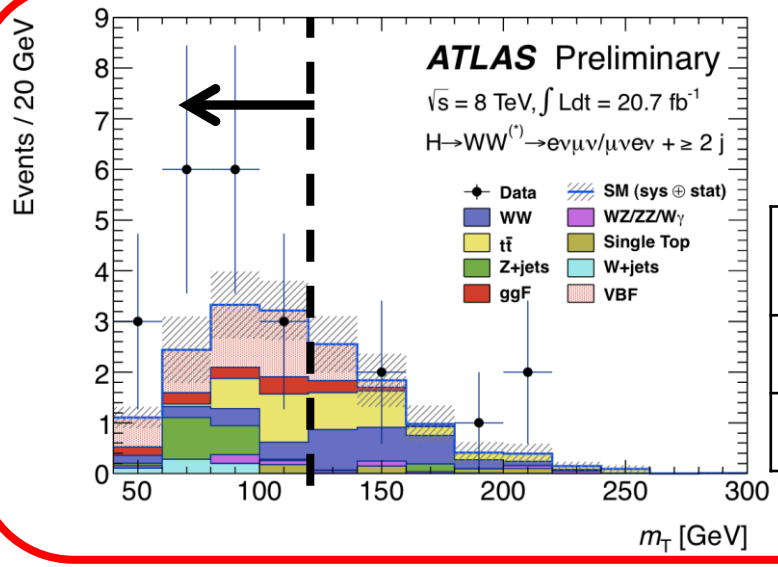
VBF signature: WW + 2 forward jets



Additional Event Selection

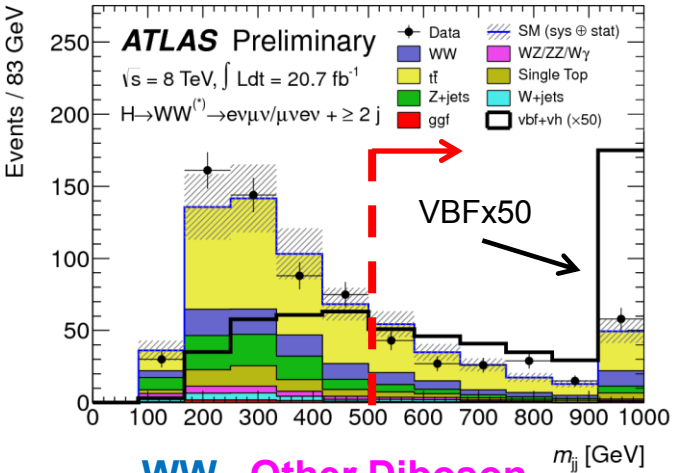
- b-tag veto
- P_T(tot) < 45 GeV
- ΔYjj > 2.8
- Mjj > 500 GeV
- No additional central jets
- Require central leptons





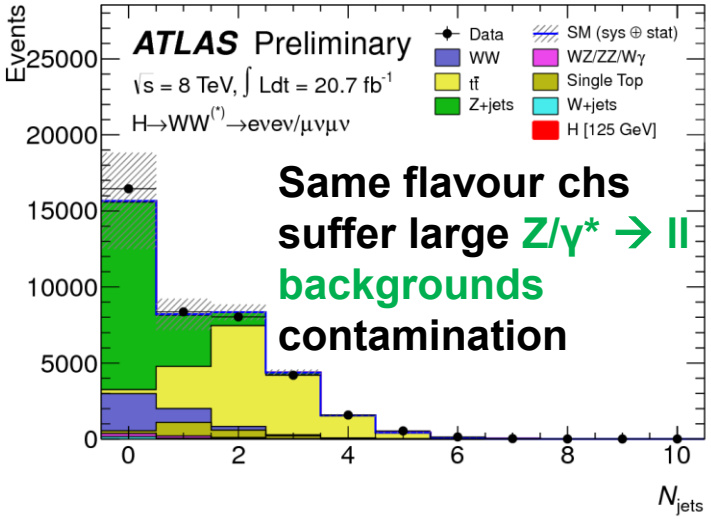
m_T after VBF signal selection

Exp Signal	5.0 ± 0.1
Total Bkg	10 ± 1
Observed	**20**

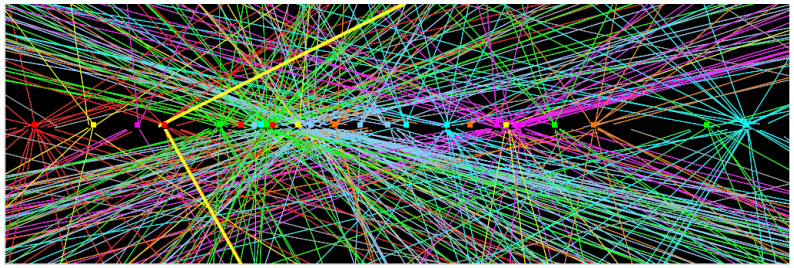


WW **Other Diboson**
Zjets **Wjets** **Top**

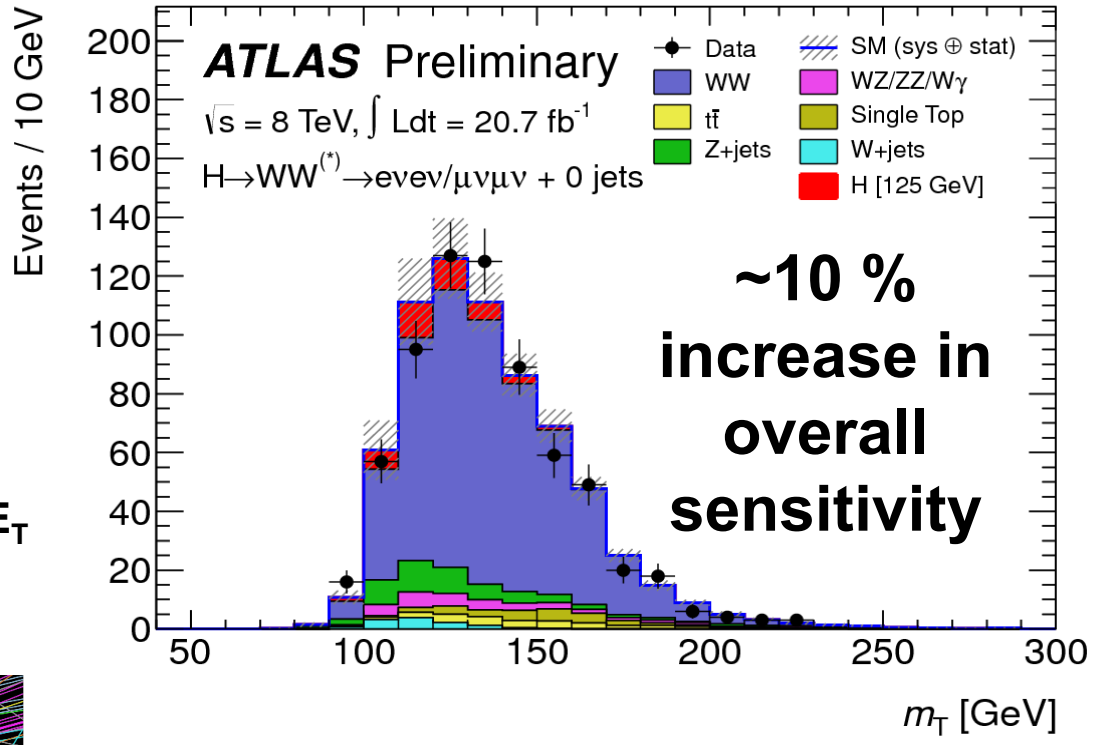
Same Flavour channels



- **Primarily suppressed with Missing E_T**
- **Large Pile-up degrades Missing E_T resolution…**



A candidate Z boson event in the dimuon decay with 25 reconstructed vertices

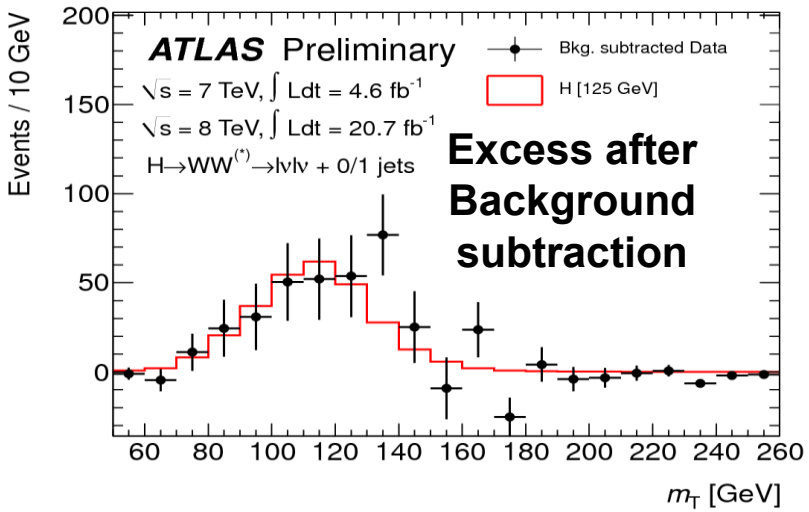


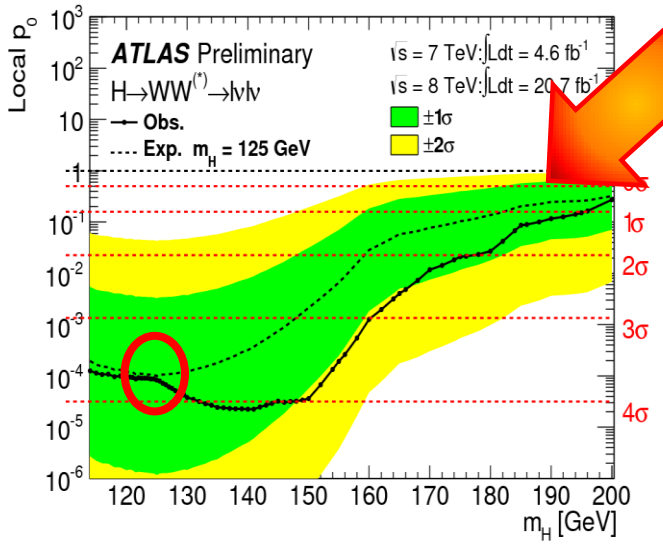
- Adopt harder Missing E_T selection
  30% acceptance relative to OF ch
- Dedicated data-driven method to understand residual **Z/γ* → ll bkgs**

2012+2011 Combined Results

		Signal expectation	Total Bkg	Data
8TeV	0 jet	97 ± 20	739 ± 39	831
	1jet	40 ± 13	261 ± 28	309
	2 jet	10.6 ± 1.4	36 ± 4	55
7TeV	0 jet	25 ± 5	161 ± 11	154
	1jet	7 ± 2	47 ± 6	62
	2 jet	1.4 ± 0.2	4.6 ± 0.8	2

Numbers quoted for 0.75 m_H < m_T < m_H with m_H =125 GeV (m_T < 1.2 m_H for 2-jet)



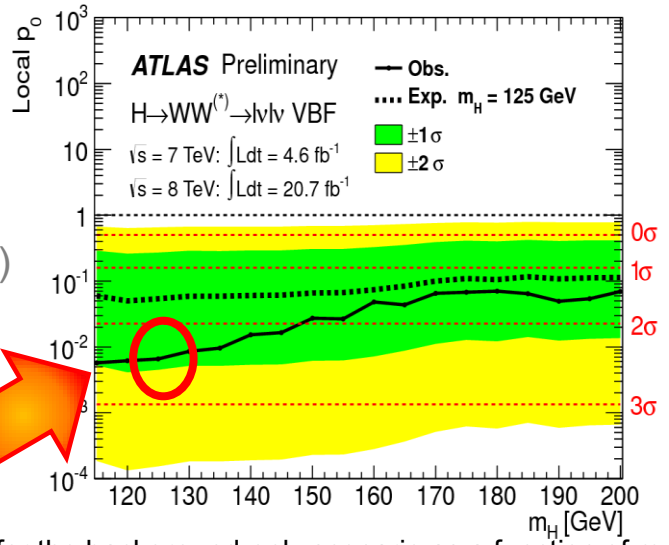


0/1jet→The excess is observed in m_H<150 GeV with a significance of 3.8σ at m_H=125 GeV

(expected significance is 3.7σ)

VBF→ the significance of the excess is 2.5σ at m_H=125GeV

(the expected value is 1.6)

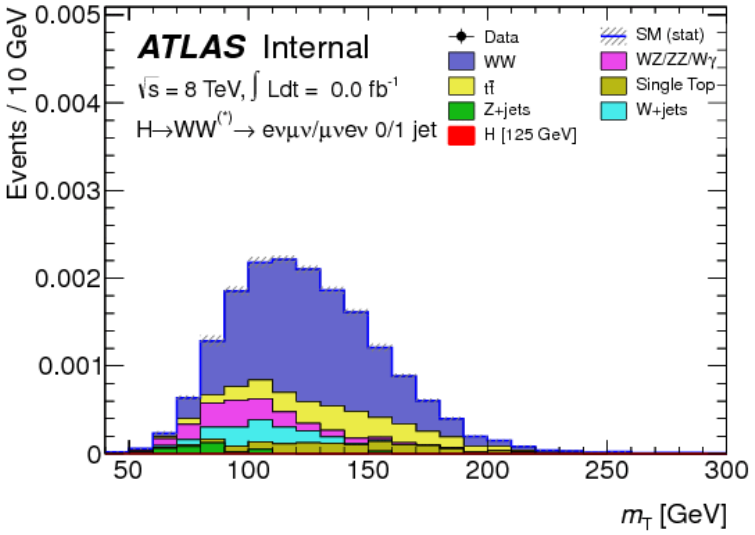


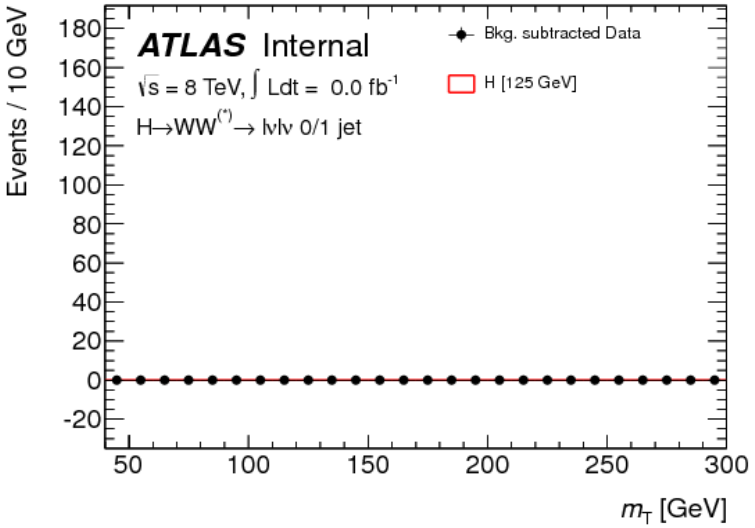
The p_0 is the given probability for the background-only scenario as a function of m_H

Conclusions

- Presentation of H→WW→lνlν results with full Run I data set
  - 20.7/fb at √s = 8TeV in 2012 and 4.6/fb at 7TeV in 2011 collected with the ATLAS detector at the LHC
- Updated Results (included Same Flavour channels)
  - The signal significance at m_H = 125 GeV is 3.8σ.
  - The best fit signal strength at that mass is μ = 1.01±0.31
- VBF analysis added
  - observe excess with 2.5σ significance
- Next steps
  - Work ongoing to improve the signal efficiency for this channel… Expect to improve the signal significance up to 5σ.

THANK YOU!!

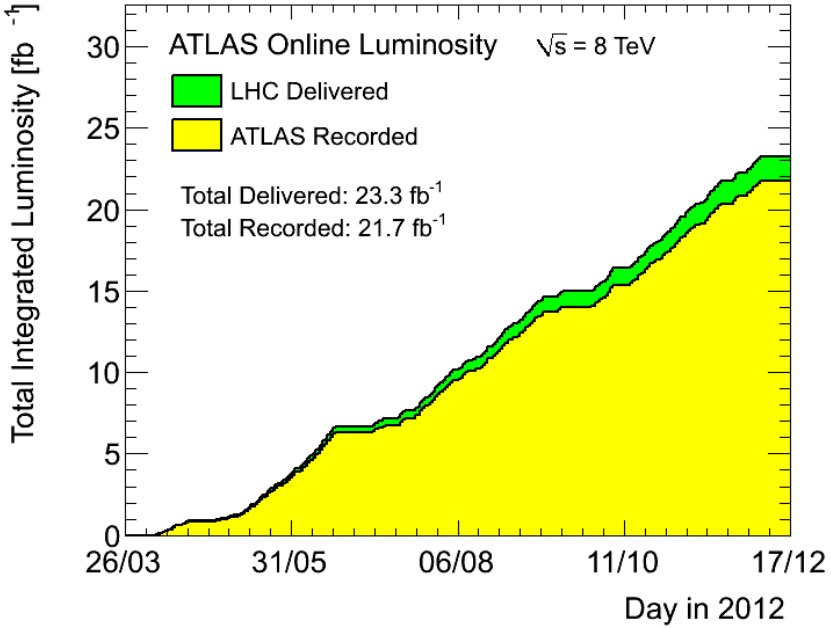


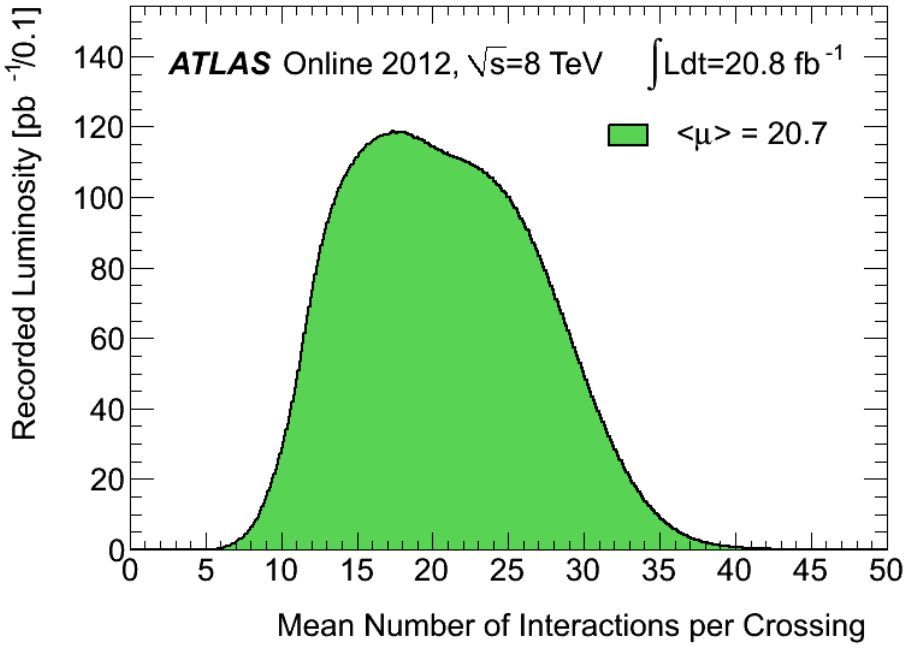


Backup slides

2012 pp Collisions in ATLAS

22 fb^{-1} of data at ~$7x10^{33}$ peak luminosity with higher pile-up



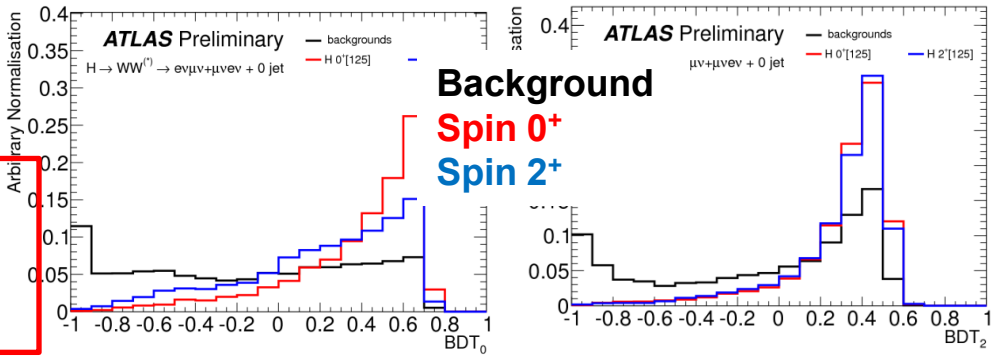


Spin analysis

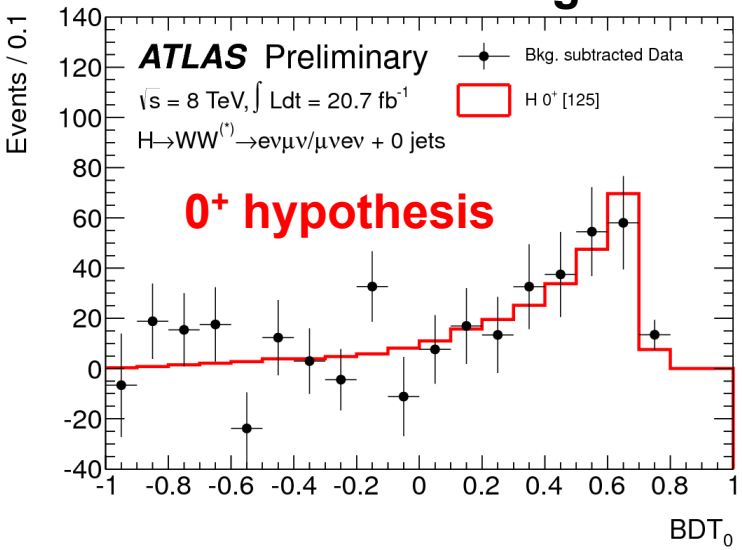
BDT trained for 0^+ and 2^+ hypothesis using 4-input variables:

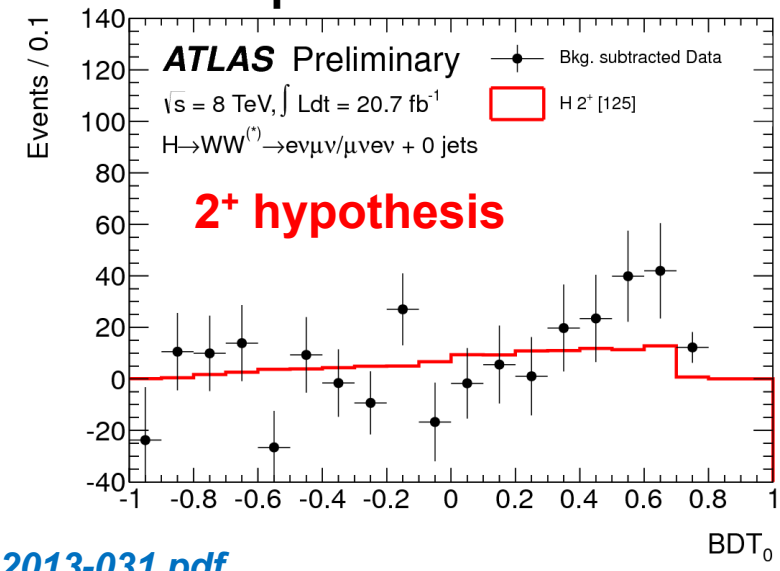
- m_T, $\Delta\Phi_{ll}$, m_{ll}, $P_T(ll)$
- Use output to test 0^+ vs 2^+

- **Data compatible with 0+ hypothesis**
- 2+ (graviton-like) scenario excluded at: 99%CL if qq production / 95% if gg



Background substracted BDT output





http://cds.cern.ch/record/1527127/files/ATLAS-CONF-2013-031.pdf