ATLAS search for the decay H→WW

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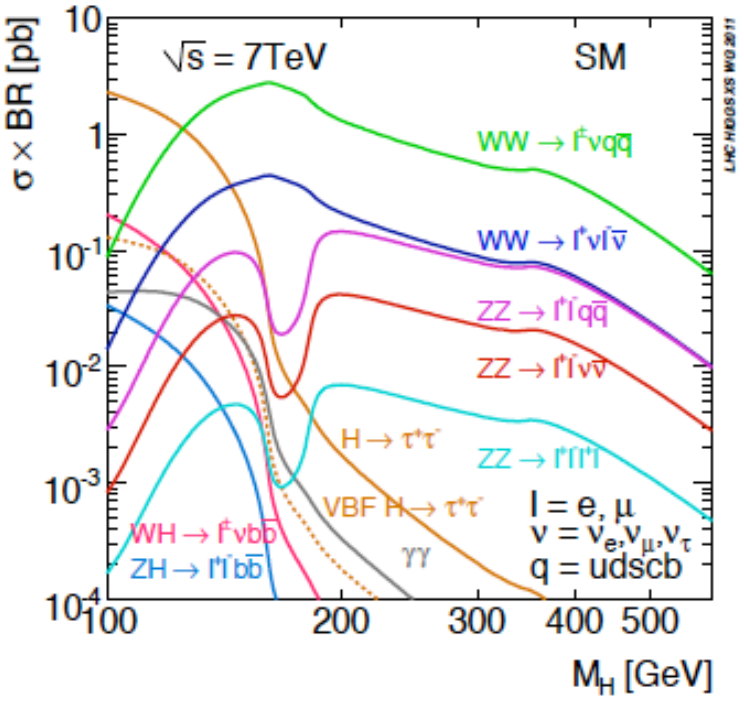
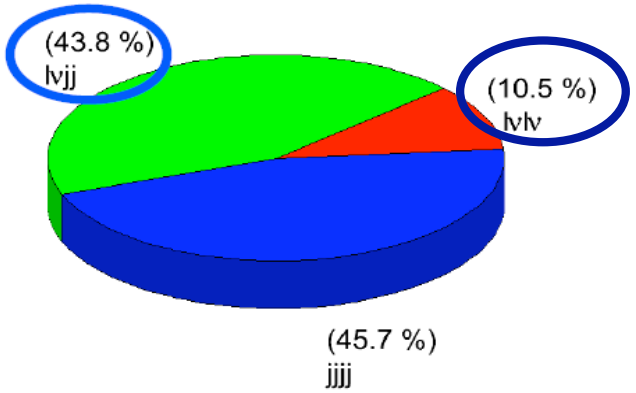
Higgs Boson Decays

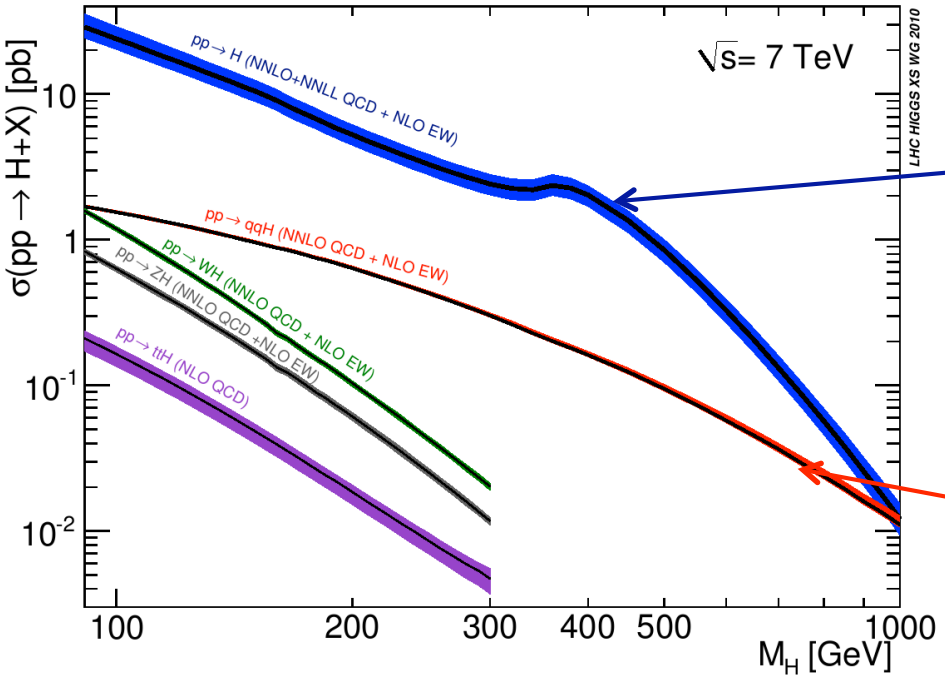
- H→WW→lνlν
  - m_H = 100-500 GeV
  - 9 sub-channels :
    - (ee, μμ, eμ) x (0,1,2 Jets)
  - m_T shape for the limit setting
  - Ref: ATLAS-CONF-2012-012



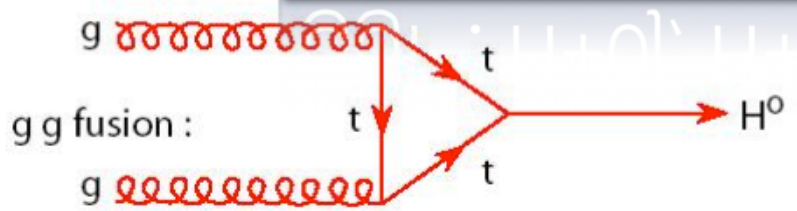
- H→WW→lνjj
  - m_H=300-600 GeV
  - 6 sub-channels :
    - (e,μ) x (0,1,2 Jets)
  - $m_{lνjj}$ for the limit setting
  - Ref : ATLAS-CONF-2012-018

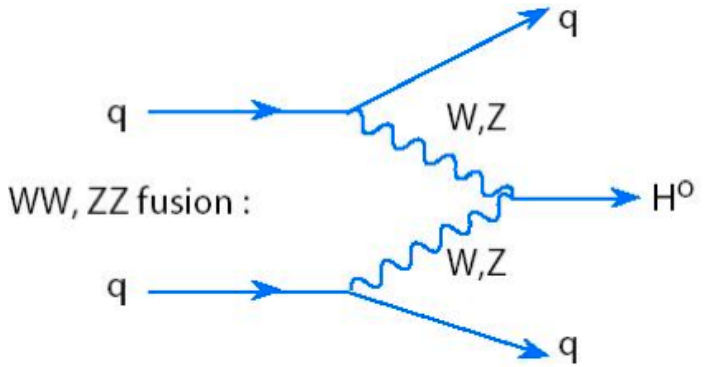


Higgs Boson Production @ LHC



ggF : H+0j, H+1j



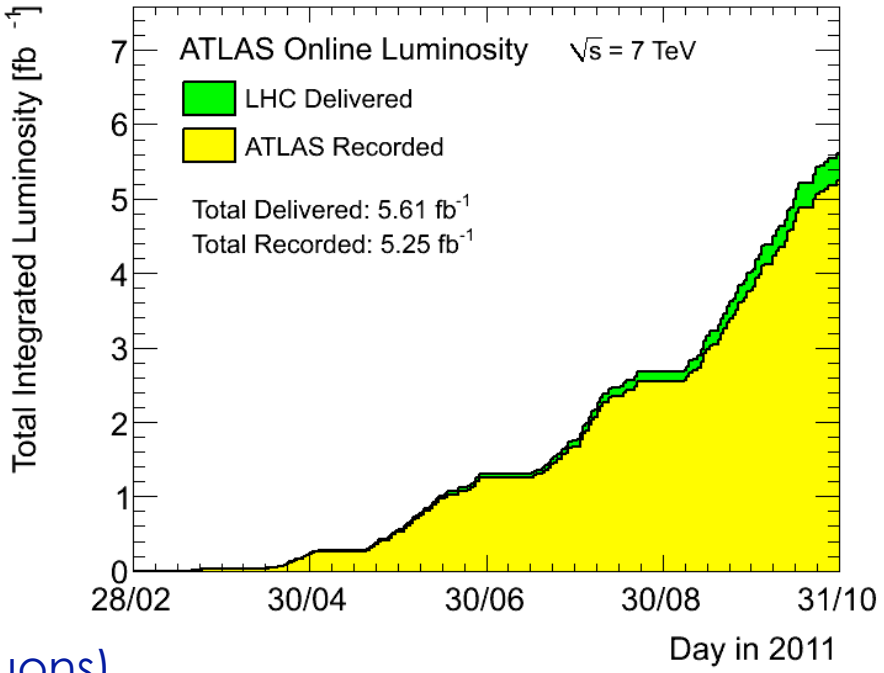


VBF : H+2j

LHC Higgs Cross Section Working Group: arXiv:1101.0593 arXiv:1201.3084

Ingredients

- Int. L = 4.7 fb^{-1} (ATLAS 2011, $\sqrt{s}$=7TeV)
- Trigger based on inclusive single lepton selection
  - $p_T(\mu)$>18GeV, $\varepsilon\approx$95% wrt offline
  - $p_T(e)$>20-22 GeV, $\varepsilon\approx$100% wrt offline



- High p_T isolated leptons (electrons or muons)
  - electron from EM cluster + tracks, $|\eta|$<2.47
  - muons from inner detector + muon spectrometer, $|\eta|$<2.4
- jets from anti-kt topological clusters, b-tag for veto
- E_T^{miss} from calibrated jets, leptons, photons and soft calorimeters term

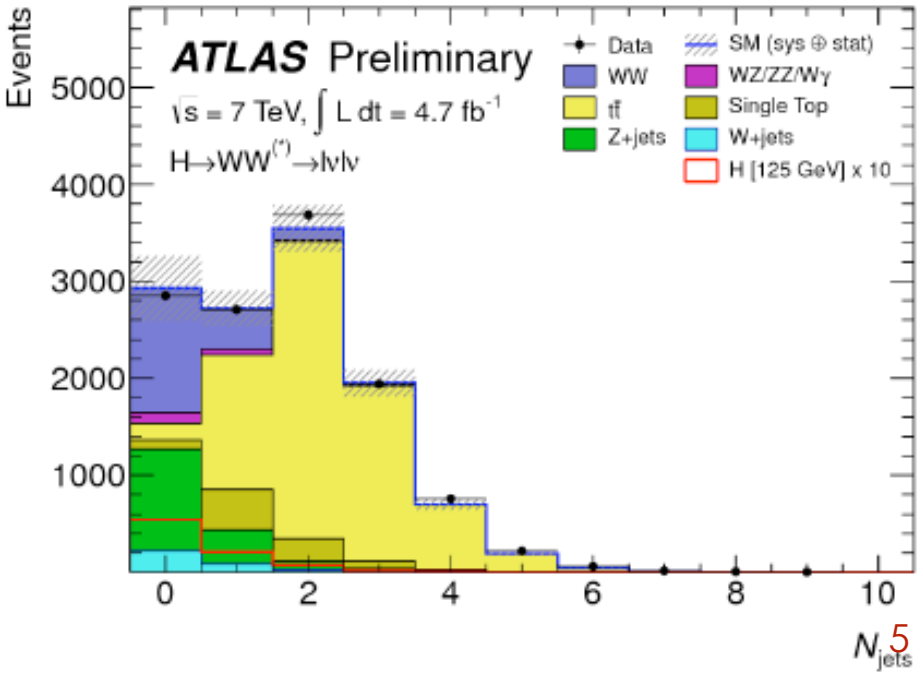
H→WW→lvlv : Pre-Selection

- Two isolated opposite-sign leptons (p_T > 25,15 GeV)
- Z veto in the same flavor channel
- Large missing transverse energy (E^{miss}_T >45 (25) GeV for ee, μμ(eμ))
- Further selection and

background estimation

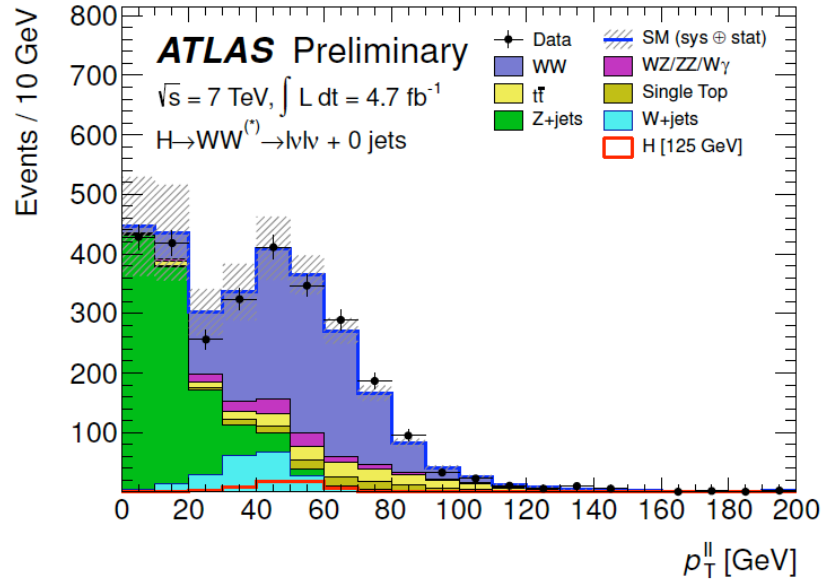
based on jet (pT>25-30 GeV,

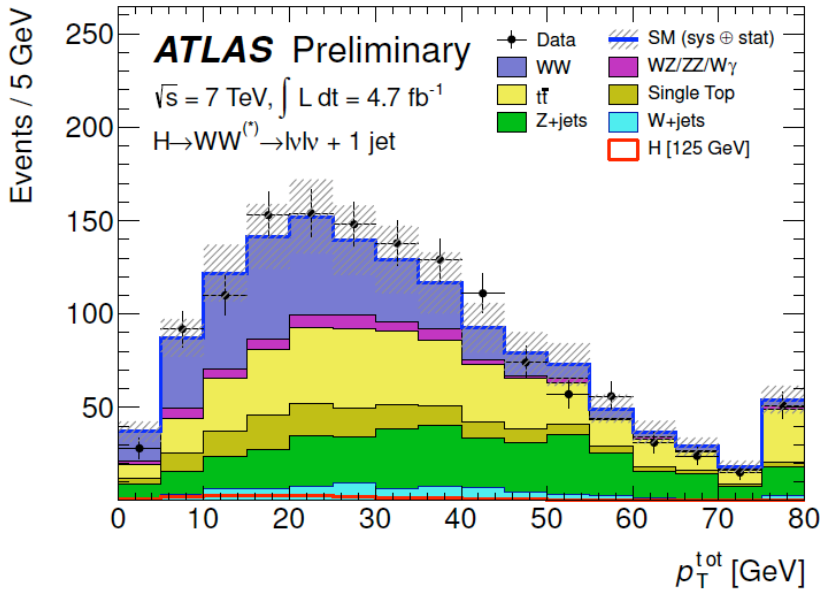
|η|<4.5) multiplicity



H→WW→lνlν : Selection

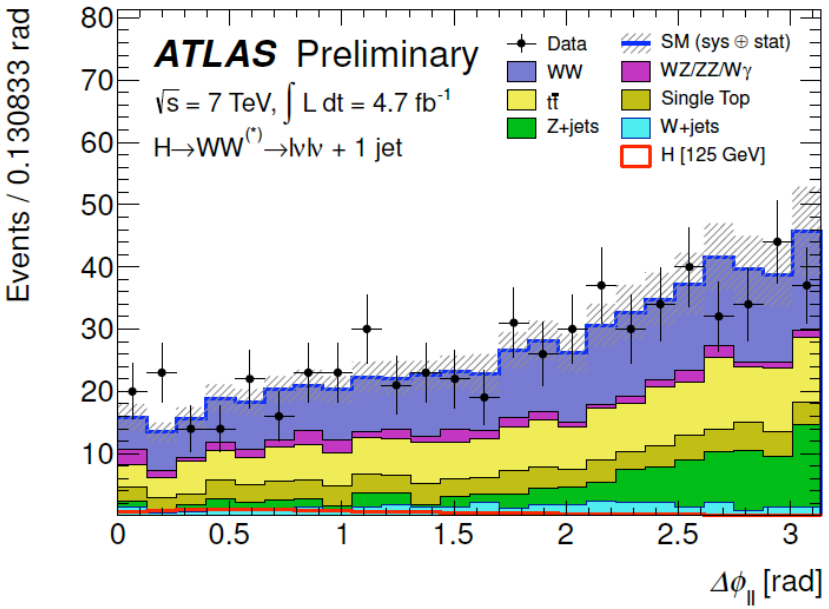
- H+0jet:
  - p_T^{ll}>45 (30) GeV for μμ,ee (eμ) → DY rejection
- H+1jet:
  - b-tag veto → top rejection
  - p_T(tot) < 30 GeV → soft jets rejection
  - Z→ττ veto
- H+2jet (contributions from VBF) as H+1jet plus:
  - jets in opposite hemispheres
  - m_{jj} > 500 GeV
  - central jet veto

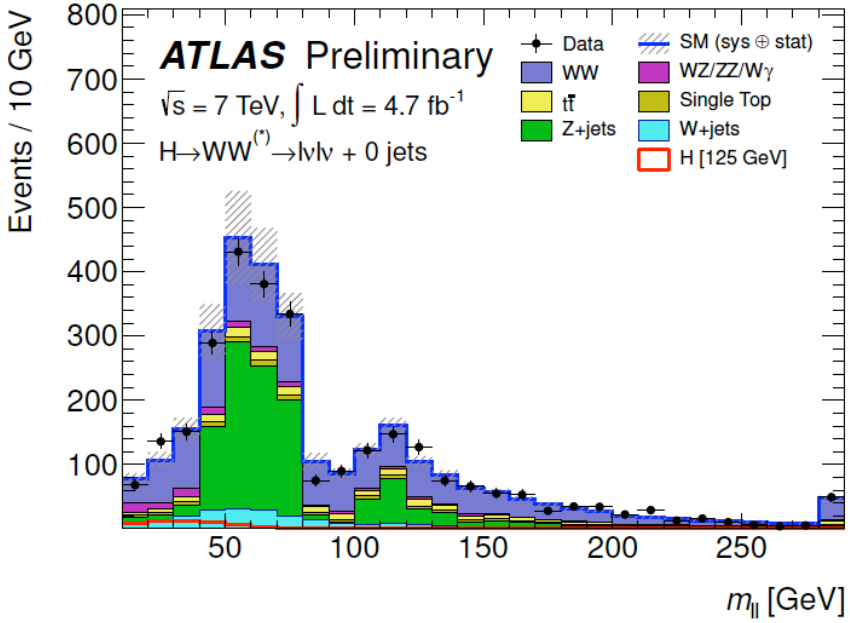




H→WW→lνlν : Common Topological Cuts

- (Low mass Higgs) Spin correlation in the WW* system → leptons tend to emerge in the same direction
  - Require small $\Delta\phi_{ll}$ (<1.8 for m_H<200 GeV) and small m_{ll} (<50 GeV for m_H<300GeV)





H→WW→lνlν : Background Estimation

Use data-driven estimates for main backgrounds

- SM WW
  - control sample (no $\delta\phi_{ll}$ cut, high m_{ll} region)
  - For m_H >300 GeV only from MC
- top
  - control regions:
    - H+0j : from the dilepton sample with large E_T^{miss} + probability to pass the jet veto
    - H+1j : reversing the b-jet veto and removing $\Delta\phi_{ll}$ and m_{ll} cuts
- DY/Z+jets
  - ABCD method in the E_T^{miss}–m_{ll} plane
- W+jets
  - control sample with one inverted lepton ID passing loose criteria + estimation of fake factors

Remaining backgrounds from Di-Bosons are estimated using MC

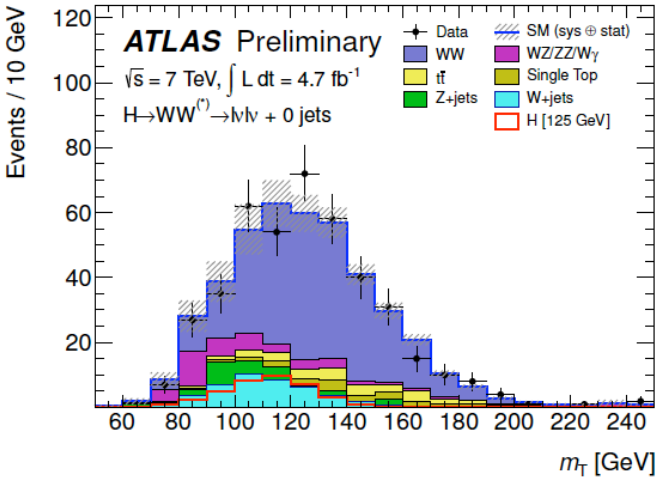
H→WW→lνlν : Yields and M_T Distributions

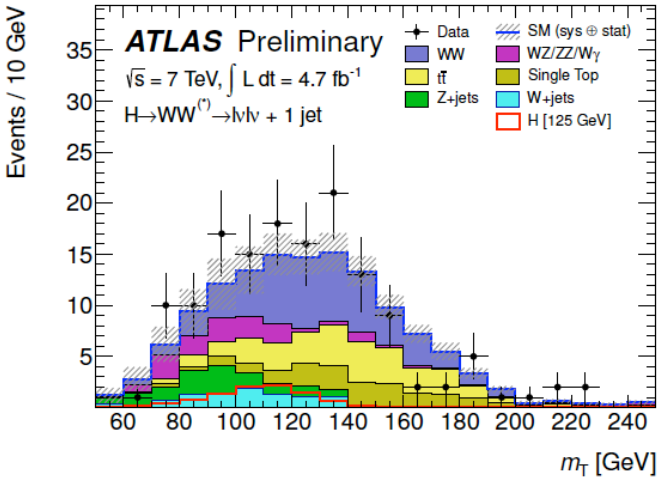
Lepton Channels	0-jet ee	0-jet $\mu\mu$	0-jet $e\mu$	1-jet ee	1-jet $\mu\mu$	1-jet $e\mu$
Total bkg.	58 ± 5	114 ± 10	257 ± 13	21 ± 3	37 ± 5	76 ± 6
Signal	3.8 ± 0.1	9.0 ± 0.1	25 ± 0.2	1.1 ± 0.1	2.3 ± 0.1	6.0 ± 0.1
Observed	52	138	237	19	36	90

H+2j:
Obs = 1
Tot Bkg = 1.8
Signal = 0.8

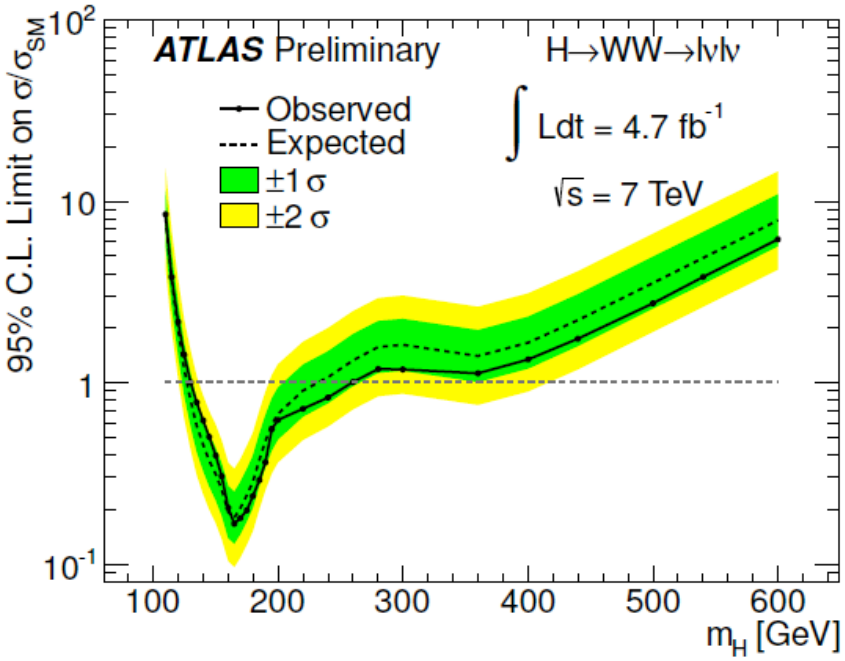
No mass reconstruction possible due to 2ν → fit M_T shape

$$m_T = \sqrt{\left(E_T^{\ell\ell} + E_T^{miss}\right)^2 - \left|\vec{p}_T^{\,\ell\ell} + \vec{p}_T^{\,miss}\right|^2}$$

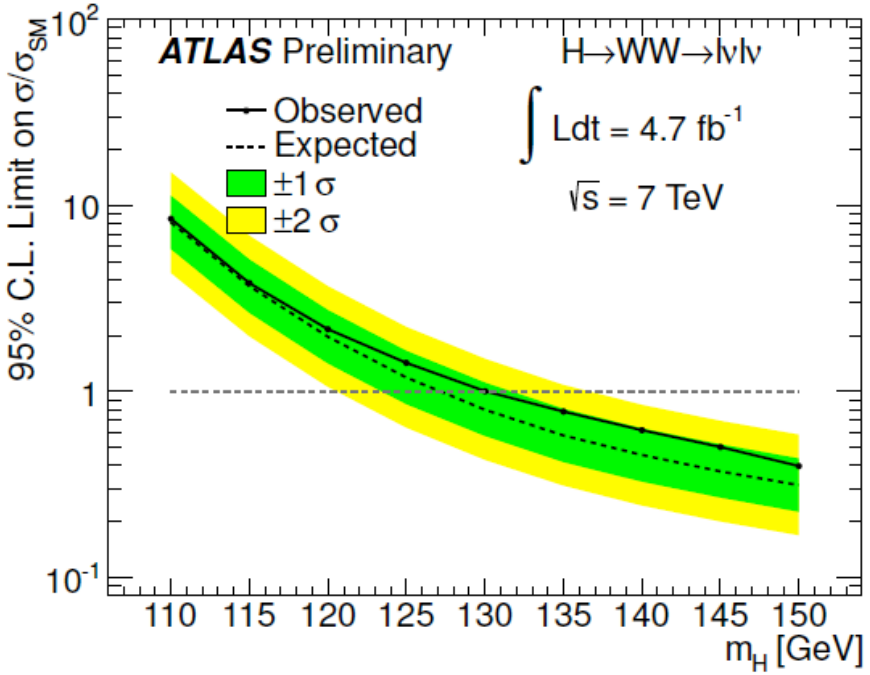




Exclusion Limit from WW→lνlν



low-mass region



➪ Higgs mass in the range from 130 GeV to 260 GeV is excluded at 95% CL

➪ expected exclusion range is 127 GeV ≤ m_H ≤ 234 GeV.

HWW→lνjj

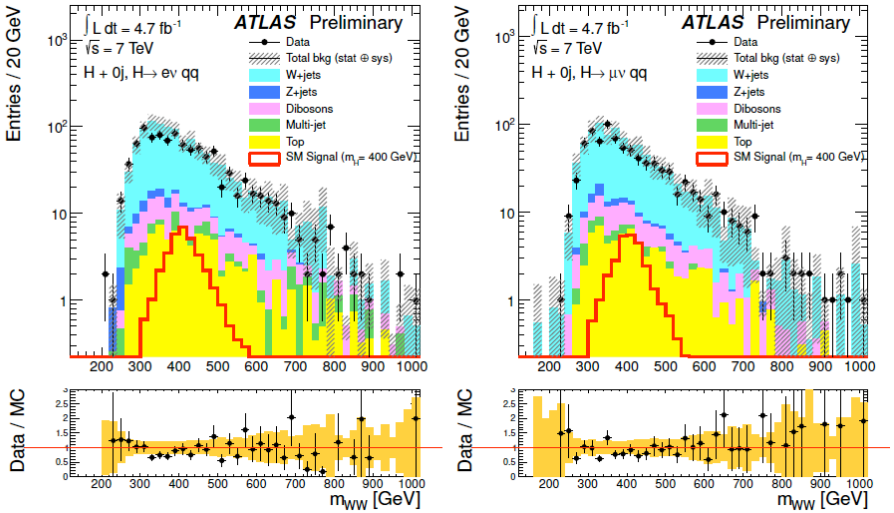
- Sensitive for $m_H > 300$GeV since the jets from W+jets are less energetic then those from Higgs
  - dominant background (W+jets) falls off rapidly with increasing $M_{l\nu jj}$
- Possibility of fully reconstruct the Higgs boson mass ($M_{l\,\nu\,jj}$)
  - Imposing $M_{l\,\nu}=M_W$ and $M_{jj}=M_W$
- Analysis splitted into 0,1 and 2 (VBF) jets
  - in addition to the 2 jets from Higgs

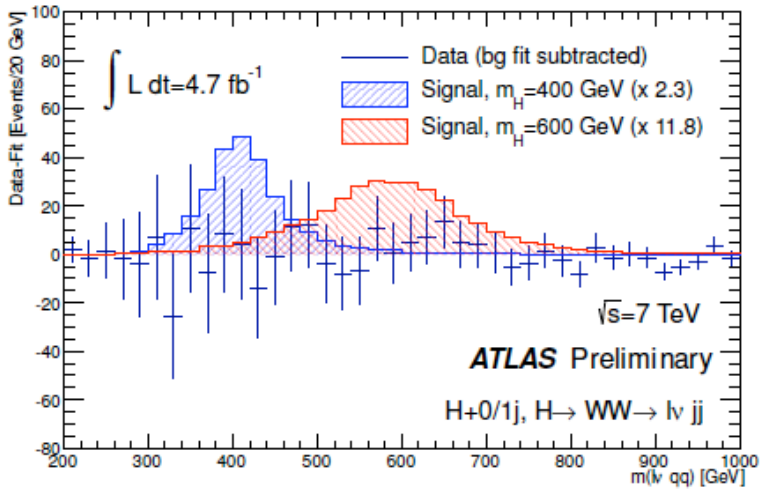
HWW→lνjj : Selection

- H+0j, H+1j:
  - 1 isolated lepton (electron or muon) with pT> 40 GeV
  - exactly 2 or 3 jets with p_T>40 GeV and $|\eta|$<4.5
  - jets from W decay
    - p_T(j1)>60 GeV
    - required to be in $|\eta|$<2.8, ΔR_{jj}<1.3 and not b-tagged
  - E_T^{miss} >40 GeV
- VBF:
  - 1 isolated lepton (electron or muon) with pT> 30 GeV
  - at least 4 jets with p_T>25 GeV and $|\eta|$<4.5, two jets with $M_{jj}=M_W$
  - E_T^{miss} >30 GeV
  - Forward jet tagging for VBF , m_{jj}>600GeV
  - no b-tagged jets

H→WW→lνjj : Mass Distribution and Bkg Modeling

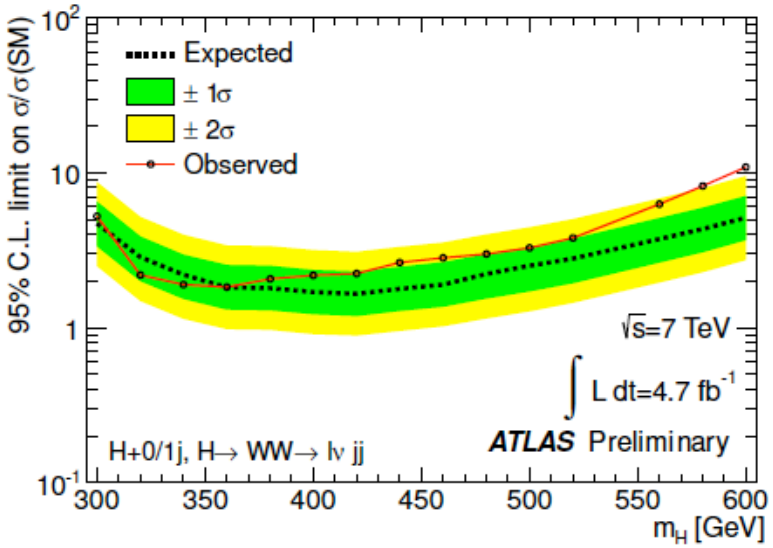
- Background modeled directly from the fit to the $m_{l\nu jj}$ mass spectrum
  - functional form by MC studies and tested with events in m_{jj} sidebands
- Major systematic uncertainties from
  - jet energy scale and resolution (10%-20%)
  - E_T^{miss} resolution due to pile-up (10%-15%).

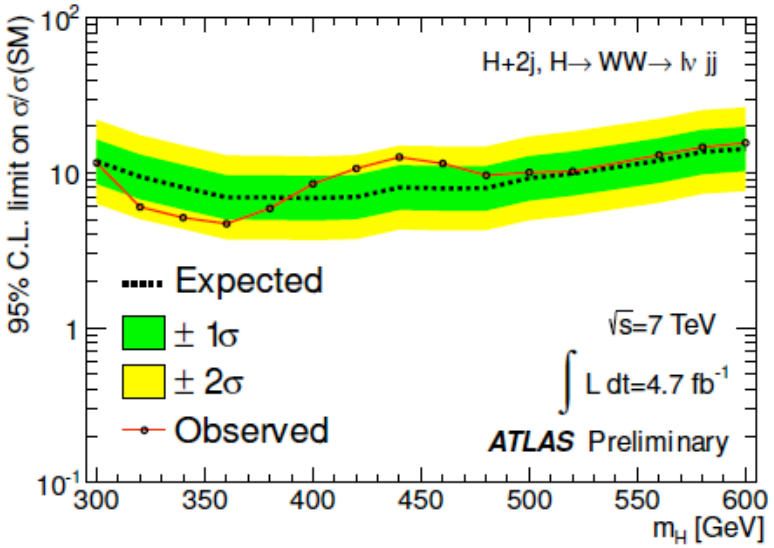




H→WW→lνjj : Exclusion limits

- Limits are set fitting the shape of the $m_{l\nu jj}$ distribution
- Best sensitivity for m_H=400GeV



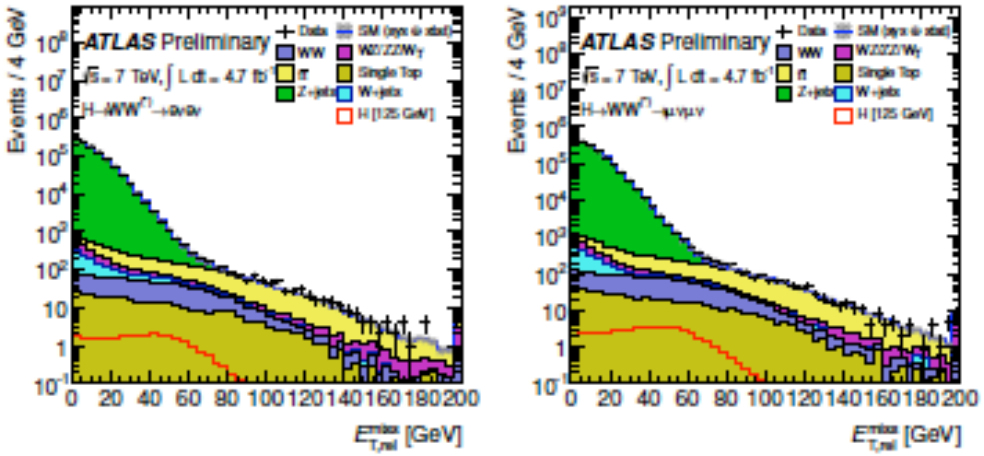


Conclusions

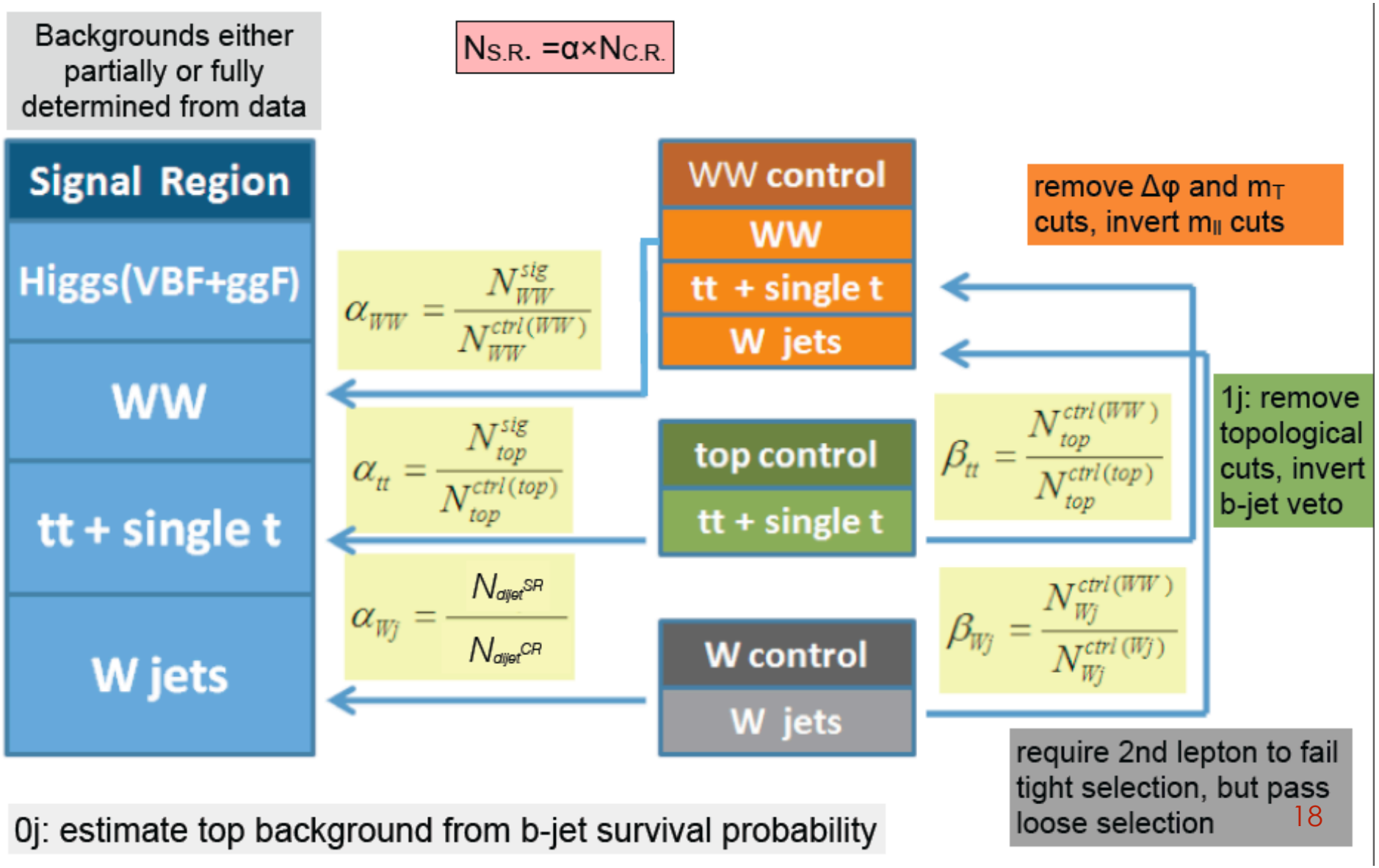
- Latest results on the search for the SM Higgs boson in the H→WW channel from ATLAS presented
- No evidence for the Higgs boson with 4.7 fb^{-1}
- Higgs mass in the range from 130 GeV to 260 GeV is excluded at 95% CL
  - expected exclusion range is 127 GeV ≤ m_H ≤ 234 GeV.
- Allowed Scalar Boson mass has been squeezed from ATLAS into a tiny region (see A. Messina talk): 117.5-118.5 GeV, 122.5-129 GeV
  - SM Higgs excluded from 129 < mH < 539 GeV at 95% CL
- H→WW is expected to play an important role in 2012 analysis!
  - Many improvements possible
    - Better pileup suppression, associated production, multivariate techniques. low-p_T leptons
    - More data!

Backup

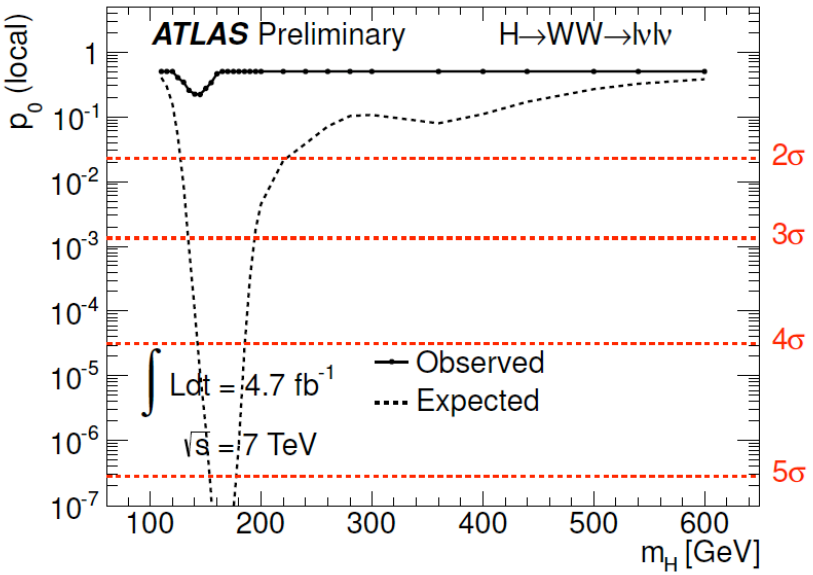
E_T^{miss} Distribution in di-lepton Events

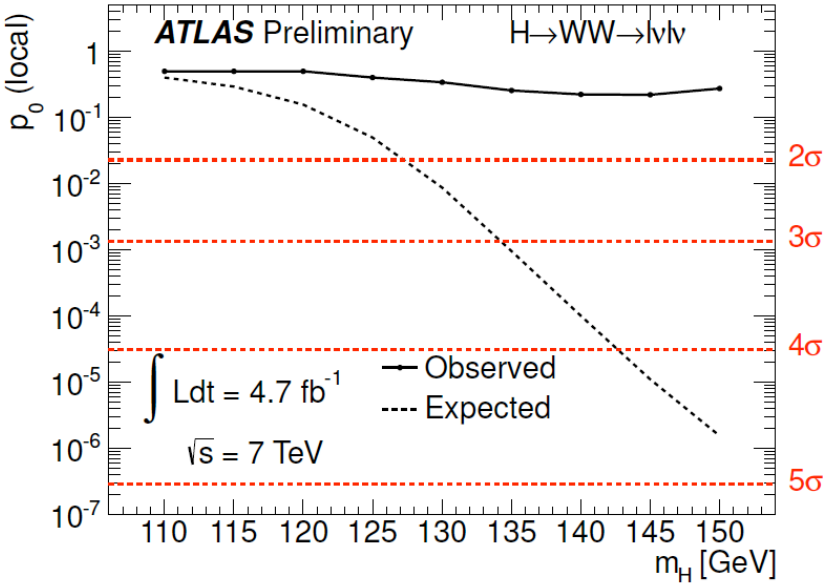


H→WW→lnln / Background Estimation



HWW→lνlν : Background compatibility





Probability that the excess is caused by a background fluctuation