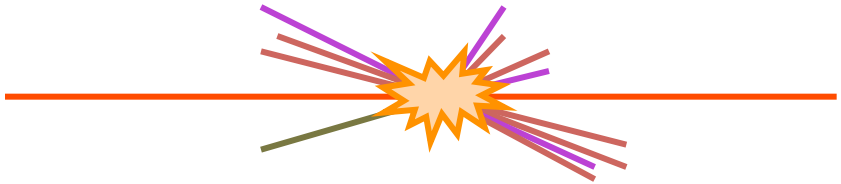
Measurements of single top quark production at ATLAS

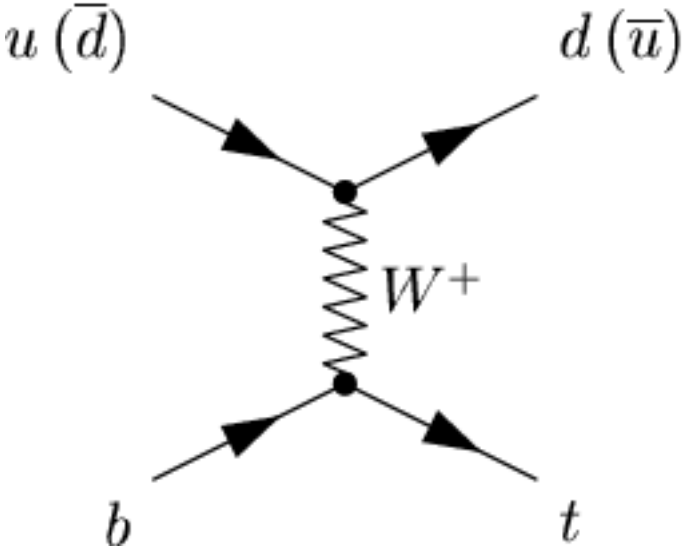


W. H. Bell

Université de Genève

On behalf of the ATLAS collaboration

Single top production



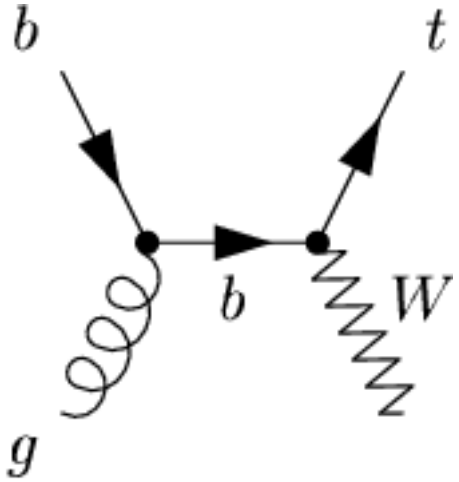
t-channel single top-quark production

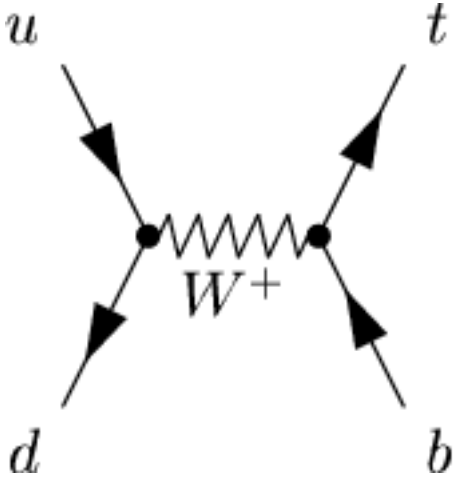
NLO with NNLO resummation

Sample	Cross-section (pb)
t-channel	$64.6^{+3.3}_{-2.6}$
Wt	$15.7^{+1.3}_{-1.4}$
s-channel	4.6 ± 0.3

N. Kinodakis , arXiv 1103.2792, 1005.4451, 1001.5034

Wt single top-quark production



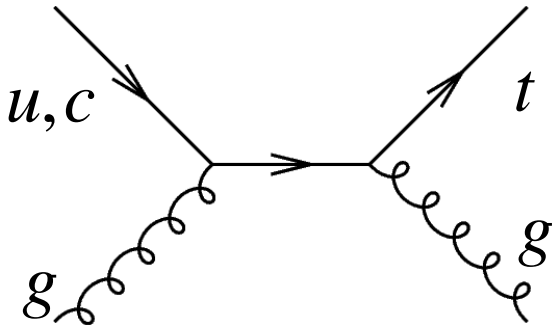


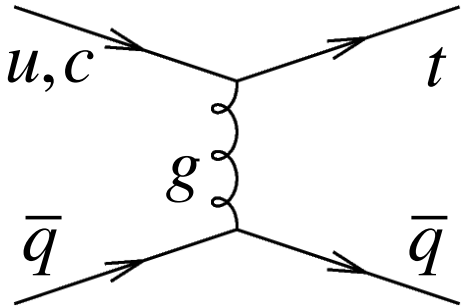
s-channel single top-quark production

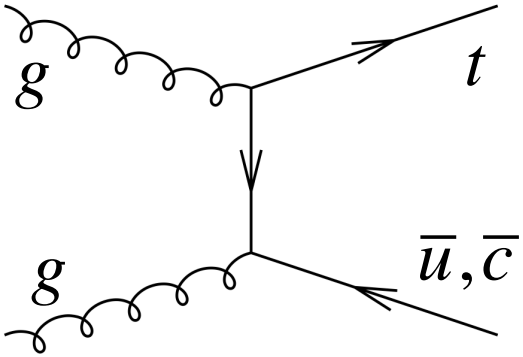
Flavour changing neutral-current

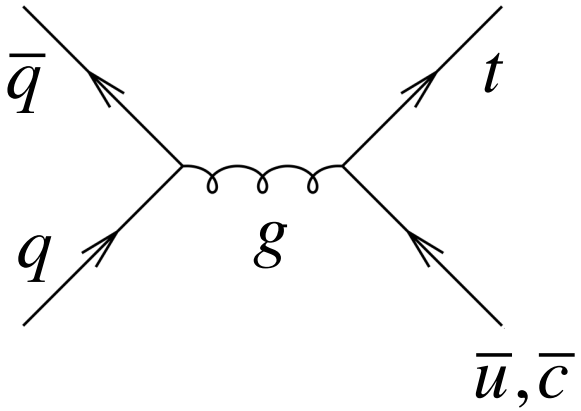
Forbidden at tree level and suppressed at higher orders (Glashow-Iliopoulos-Maiani)

Leading order FCNC processes



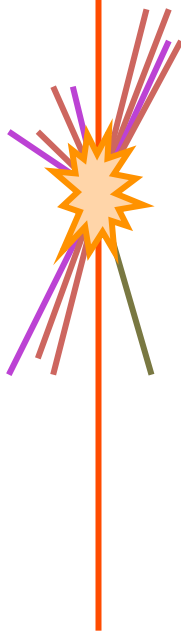






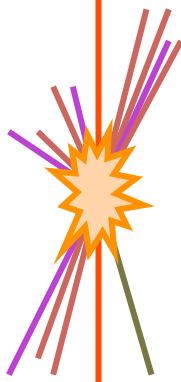
Beyond the standard model theories (exotic quarks, new scalars, supersymmetry, and technicolour) predict higher FCNC rates

Motivation



- Standard model (SM) tests
  - Measure V_{tb}
  - Examine Wtb vertex, for anomalous couplings
  - t and Wt channels contain b-quarks in the initial state.
    - Sensitive to b-quark PDF component.
- Physics beyond the SM
  - Search for FCNC
  - W', MSSM charged Higgs.

Event selection

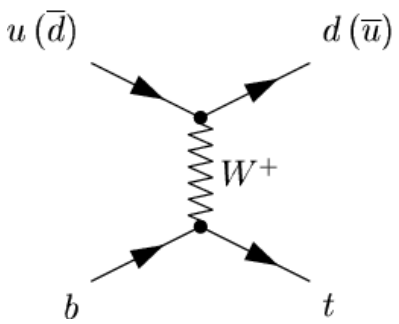


- Single lepton high p_T trigger.
- Selected lepton p_T>25GeV, |η|<2.5, and isolation.
- Missing transverse energy
  - E_T^{miss}>25GeV (t/s-channel), E_T^{miss}>50GeV(Wt-channel)
  - Triangular requirement m_T(W)+E_T^{miss}> 60GeV
- Jets
  - Anti-k_t, radius parameter 0.4.
  - p_T>25GeV (t/s-channel), p_T>25GeV (Wt-channel)
  - |η| <4.5 (t-channel),|η|<2.5 (s/Wt-channel)
  - b-tag: |η|<2.5, 57% efficiency

- QCD multijet background sample selected from single jet trigger and the requirement of enhanced EM fraction.

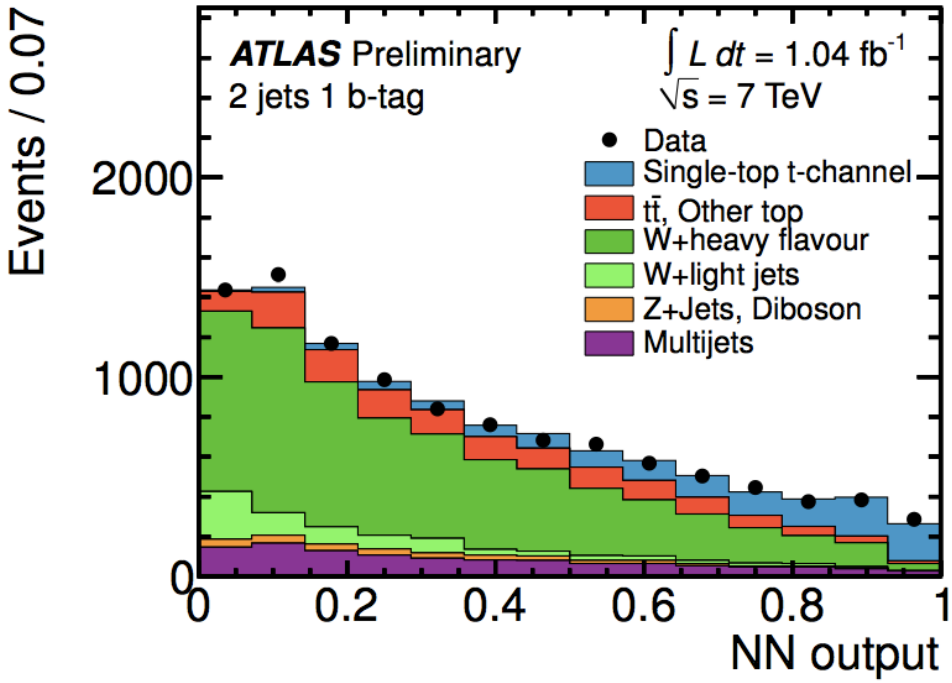
Background processes

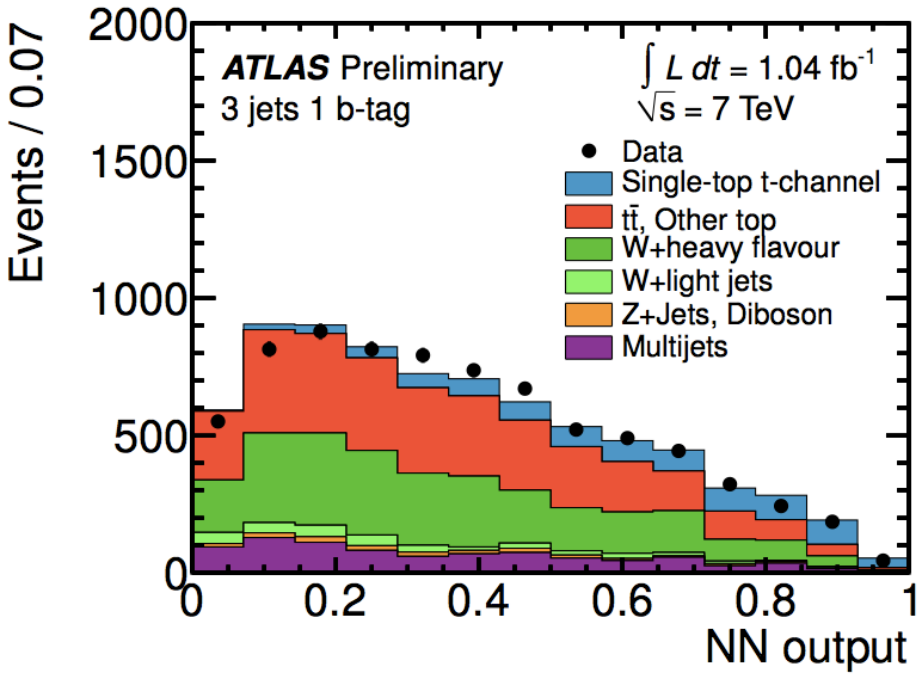
- Several sources of background,
  - Top anti-top pair production
  - W+ccbar, W+bbbar, W+light jets
  - Z+jets
  - QCD-multijets
  - Diboson production (significant in Wt-channel)
- Normalisations from data or from Monte Carlo simulation scaled to the theoretical cross-section predictions.
  - W+jets samples from Alpgen LO+LL.
    - Heavy flavour components scaled to agree with experimental measurements.
    - Light flavour scaled by a simultaneous fit (NN) or fit in control regions (cut based) OR assumed to be remaining background in each bin.
  - QCD-multijets from estimation from data
    - jet-electron model (jet with high EM fraction.)
    - Matrix method (used for Wt-channel.)



t-channel: neural network

12 (18) variables used for the 2 (3) jet bins.
NeuroBayes applied to use all of the input information





NN output distribution normalised to the result of the maximum likelihood fit for the 2-jet and 3-jet *b*-tagged samples, respectively.

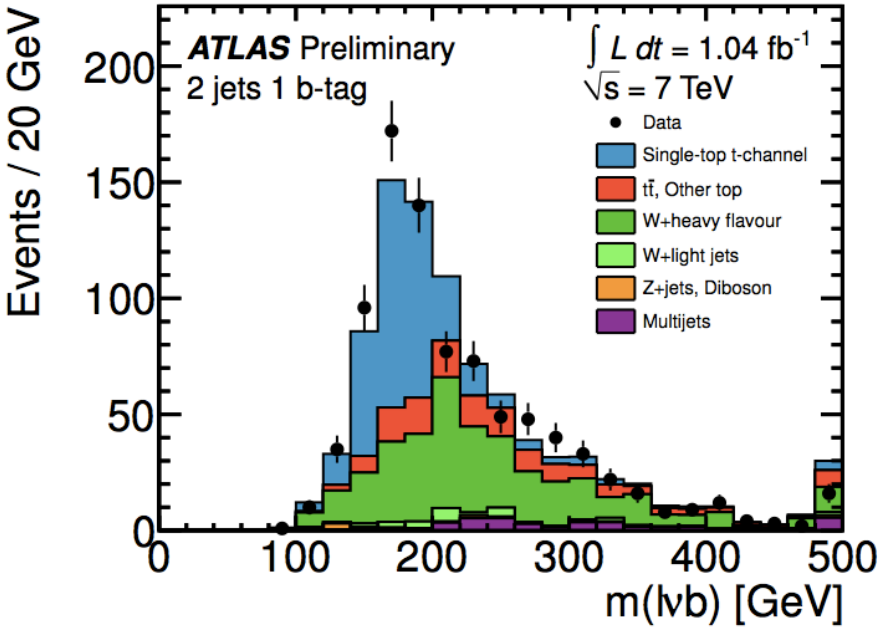
Electron and muon samples are combined in each distribution.

Paper close to submission (ATLAS-CONF-2011-101 + updates)

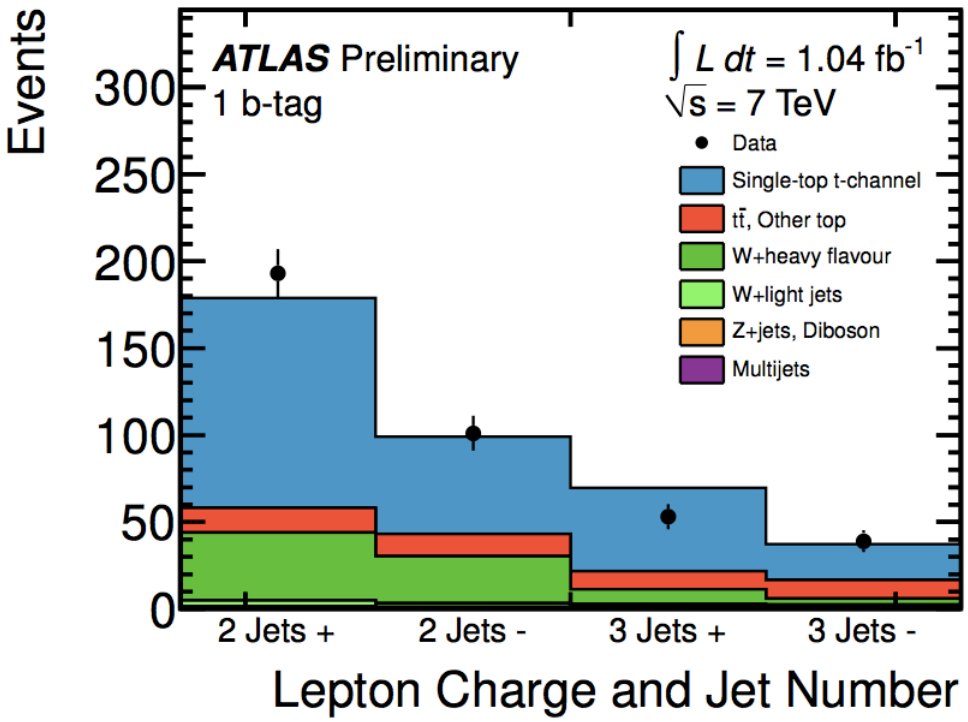
t-channel: cut-based analysis

Cross-check analysis, providing charge information.
Five of the best neutral network variables used to further enrich the sample.

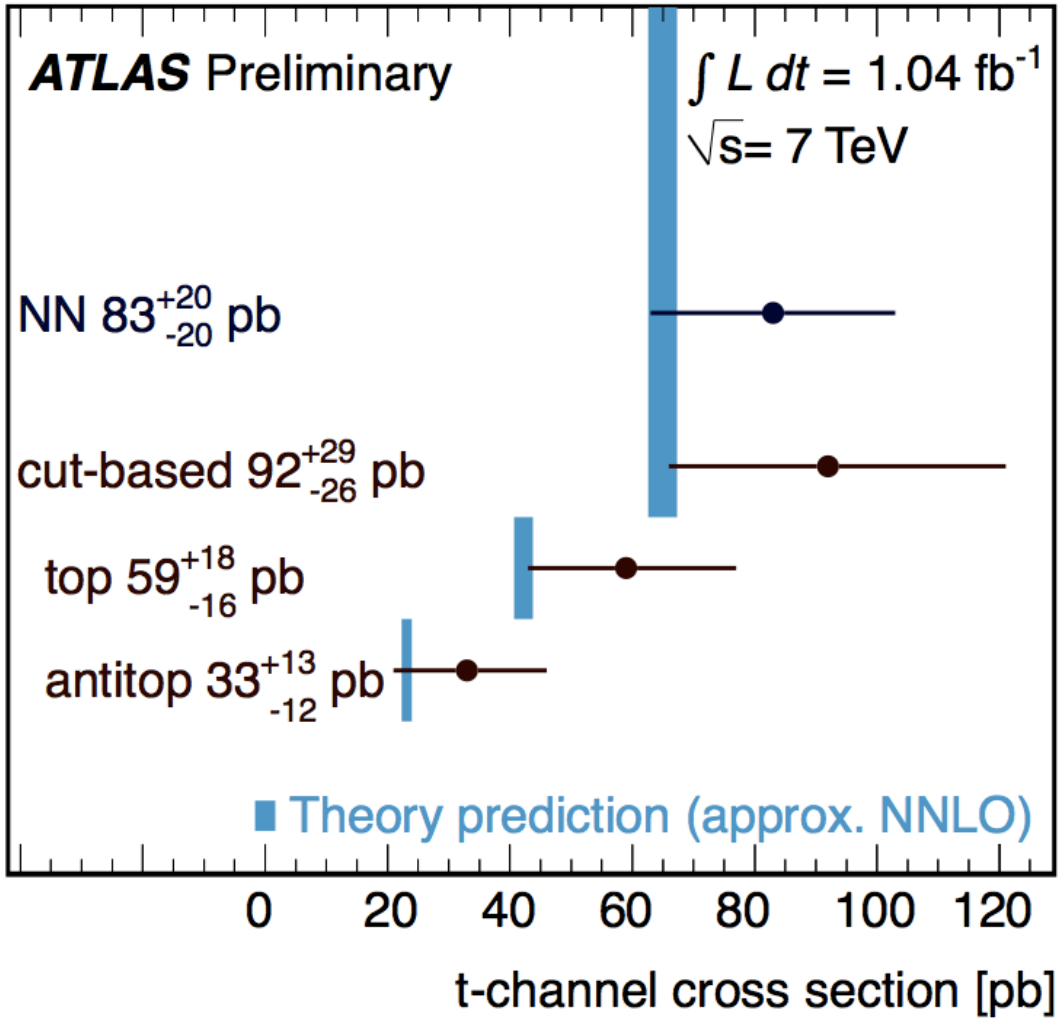
Full event selection, except for *m*(lvb) requirement



After full event selection



t-channel cross-section summary

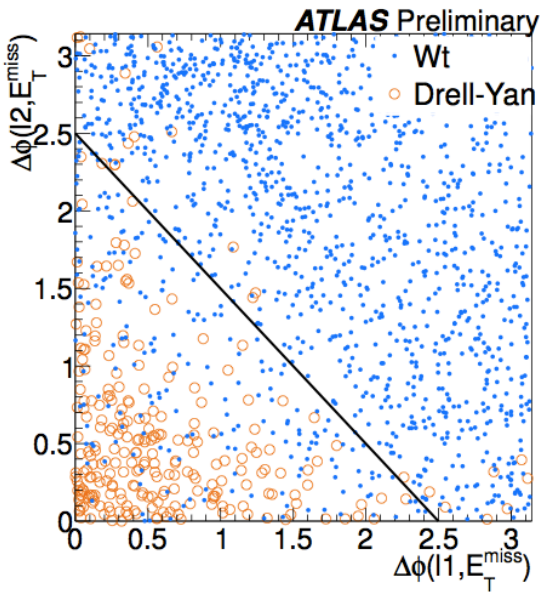


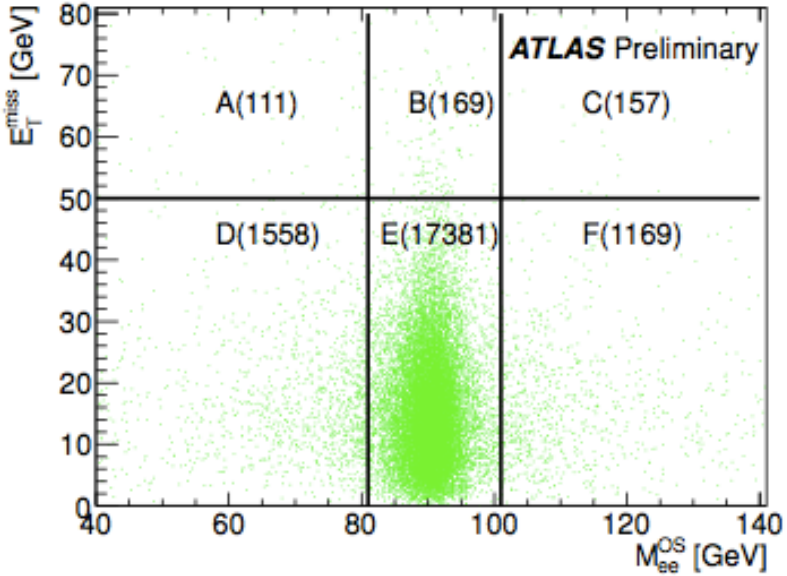
$|V_{tb}|^2$ extracted by dividing the observed combined single top-quark *t*-channel cross-section by SM expectation

Restricting $|V_{tb}|$ to be within zero and one, $|V_{tb}|>0.75$ (95% C.L.)

Wt (dilepton): backgrounds

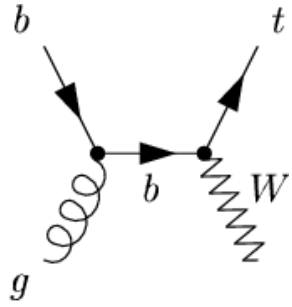
- Additional selection for di-electron and di-muon
  - ($81 < m_{ll} < 101$ GeV) and triangular cut.
- $\Delta\phi(l, E_T^{miss})$ requirement to reduce ZZ→tau+tau
- QCD-multijet and W+jets background from matrix method.
  - Real efficiency from Z→ll
  - Fake efficiency from control regions.
- Drell-Yann normalisation from ABCDEF method.
  - Orthogonal cuts on two variables to define a set of signal and background enriched regions.
  - Combine information for estimate in signal region.

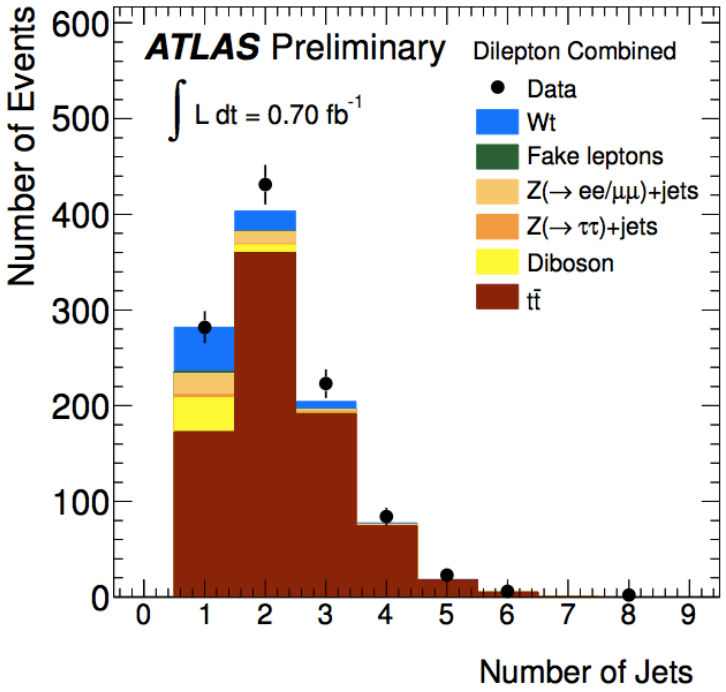




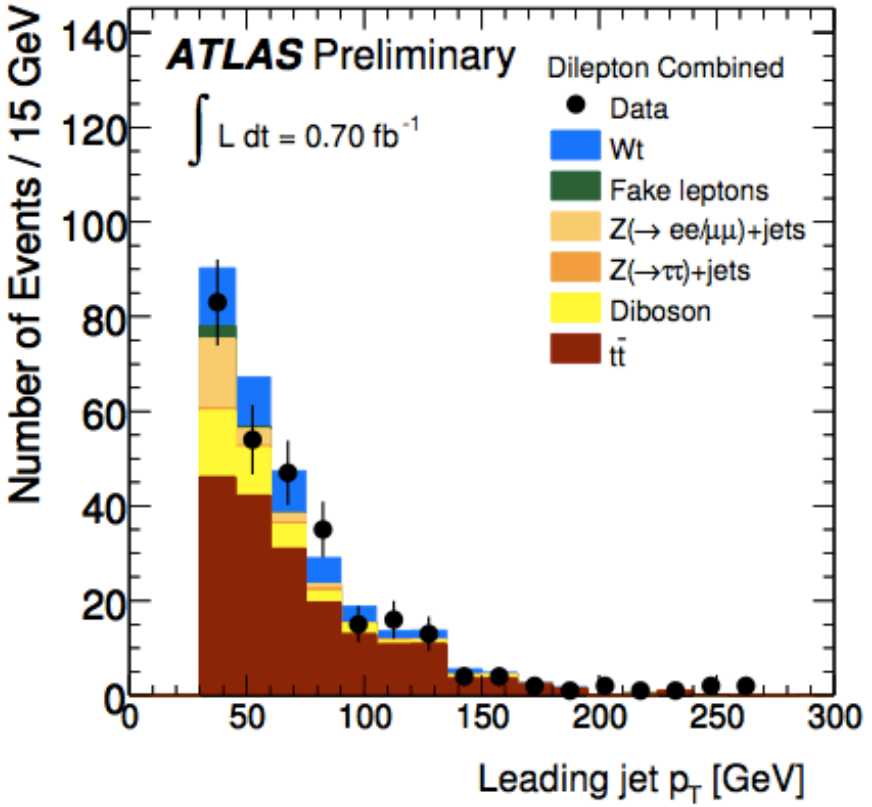
ATLAS-CONF-2011-104

Wt associated production



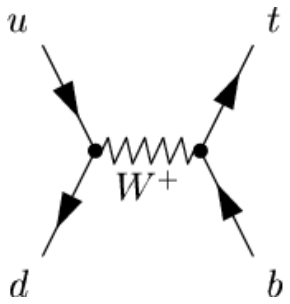


$\sigma(pp \rightarrow Wt + X) < 39\ (41)$ pb



At least two jets above 30GeV is used to define ttbar enriched sample.

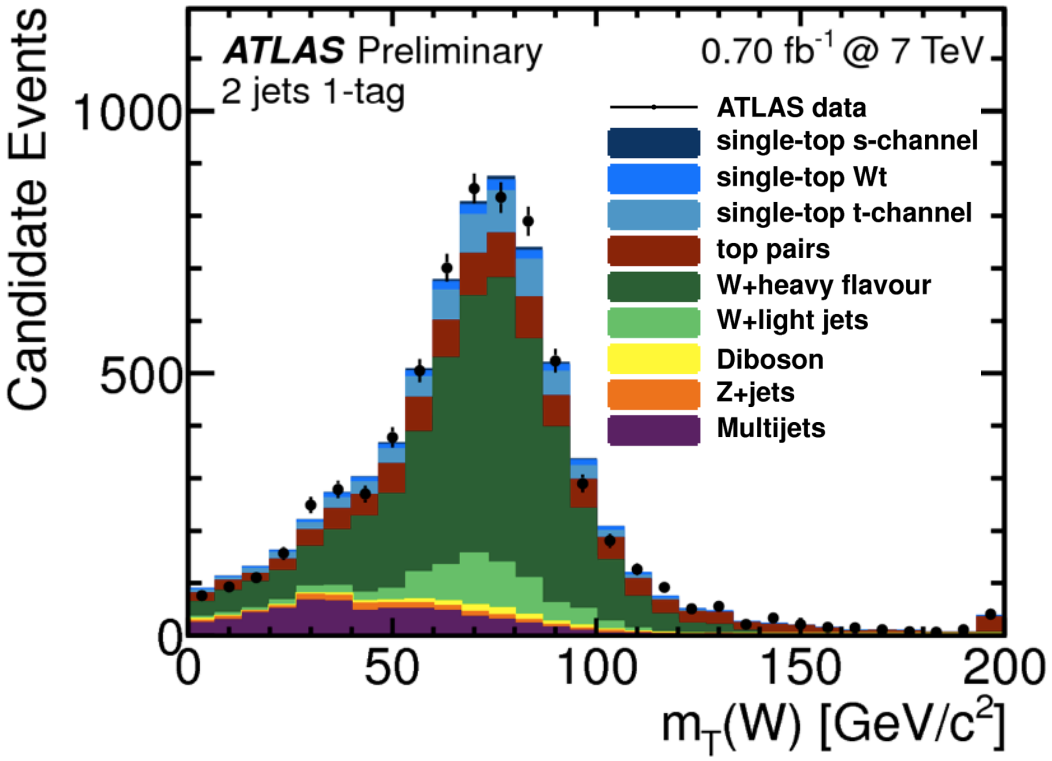
MC shape then used to extrapolate into the one jet bin.



s-channel

Discriminating variables: Two b-tagged jets, $m_T(W)$, $m_{top,b-jet1}$, $m_{top,\ jet2}$, p_T(jet1, jet2), ΔR (jet1, jet2), and ΔR(jet1,lepton)

- Event selection: one lepton, missing transverse energy and two jets (b-tagged).
  - Sample without b-tagging requirement is used to evaluate data-driven background estimates.
- QCD-multijet using jet-electron.
- W+jets using data for heavy flavour and overall normalisation from remaining data after subtraction.
- Tight kinematic constraints to select enriched s-channel region.



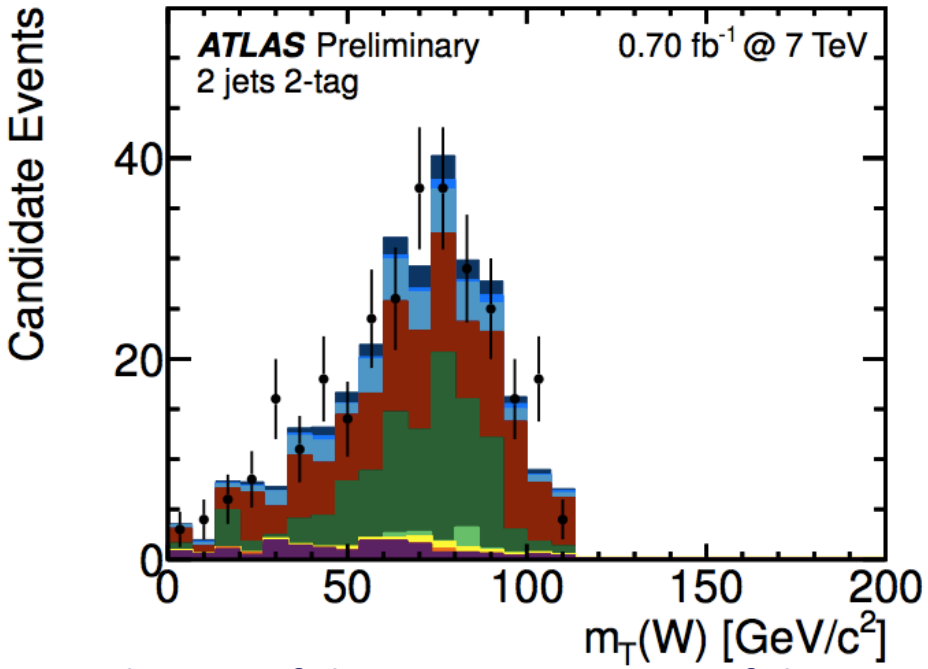
Distribution of the transverse mass of the reconstructed W-boson for electron and muon two-jets 1-tag events.

ATLAS-CONF-2011-118

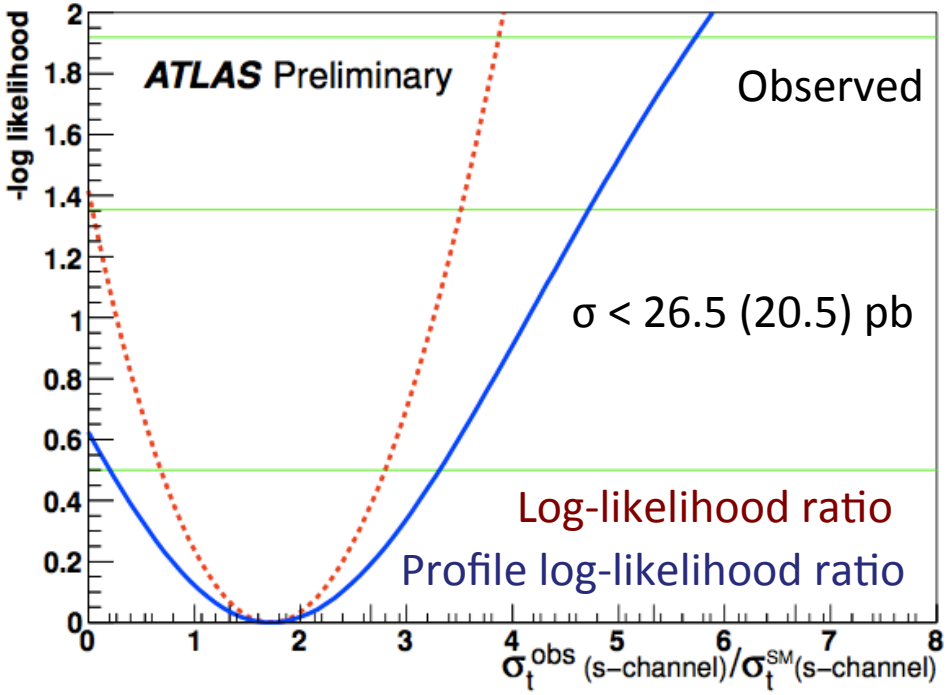
s-channel likelihood distributions

Likelihood function constructed including statistical and systematic uncertainties.
Cross-section obtained by maximum likelihood estimate fit.

The effect of statistical and systematic uncertainties was inferred from the shapes of the likelihood ratio and profile likelihood ratio, respectively.

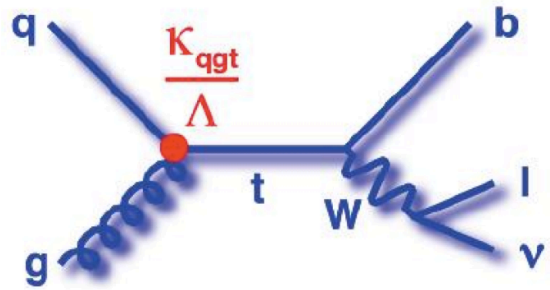


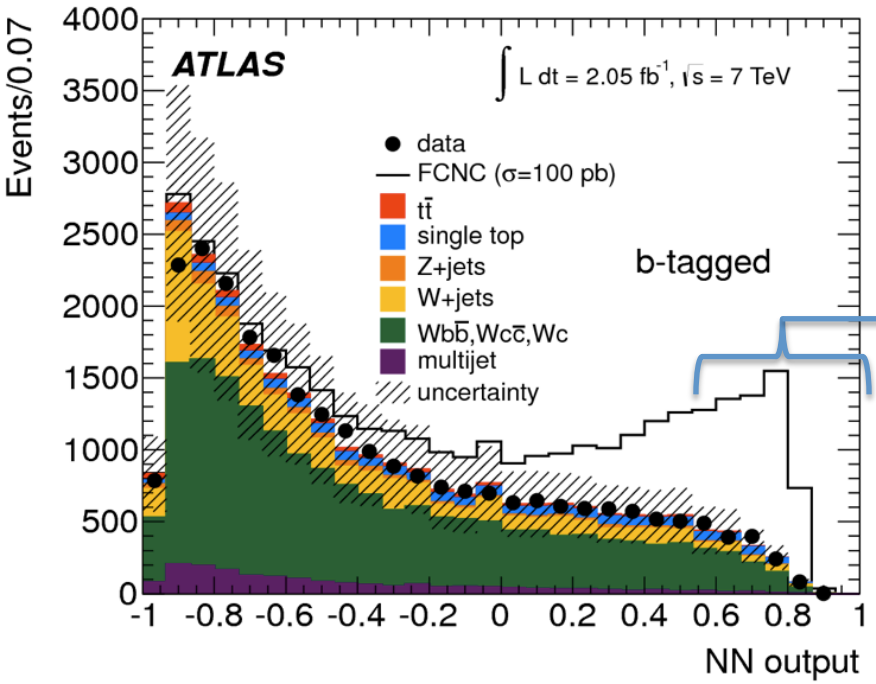
Distribution of the transverse mass of the reconstructed W-boson for electron and muon and full event selection



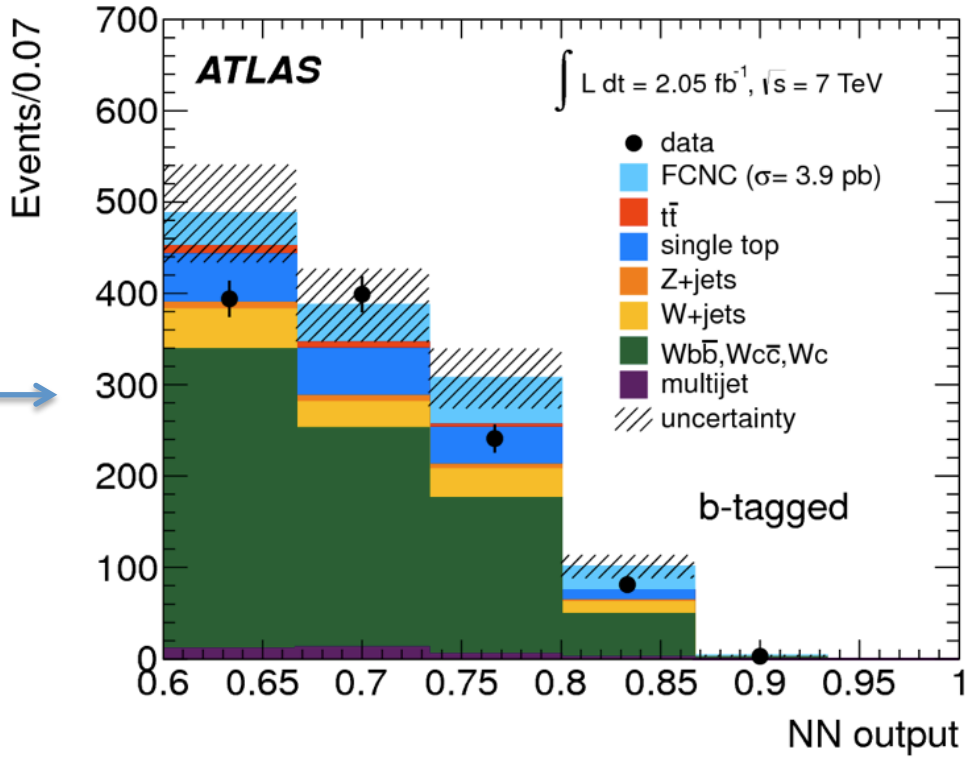
The horizontal bands: 68%, 90% and 95% CL.

FCNC single top-quark





Distribution of the neural network output for observed signal and simulated background. Signal normalisation corresponding to 100pb.

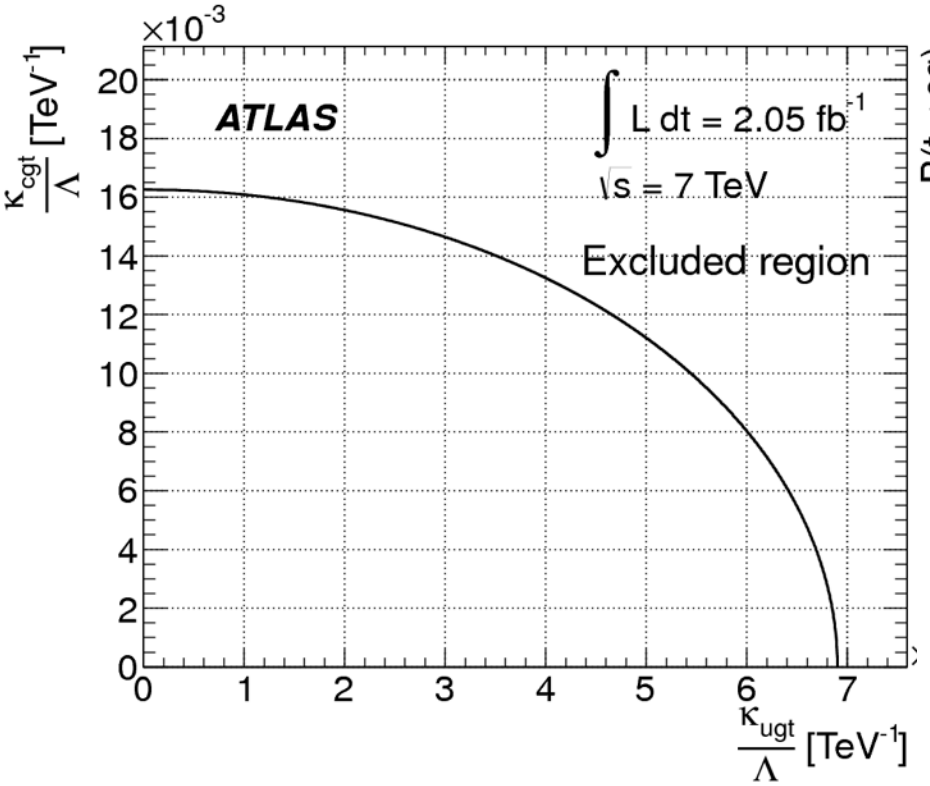


Distribution of the neural network output for observed signal and simulated background. Signal normalisation corresponding to observed limit of 3.9 pb

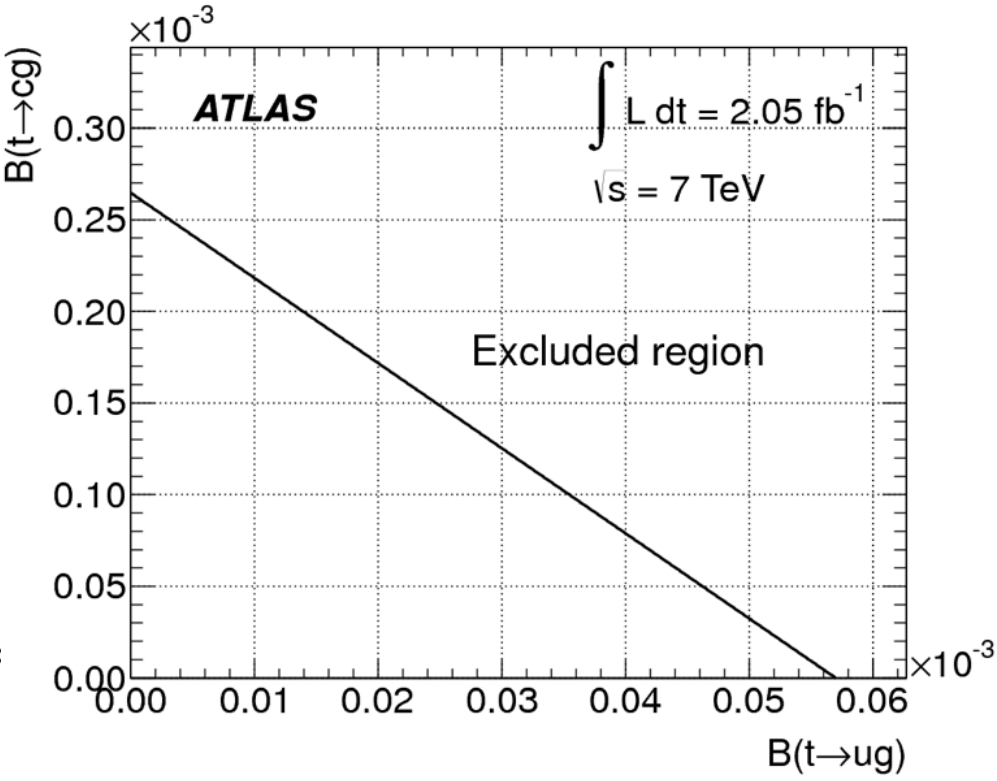
arXiv:1203.0529v1 [hep-ex]

FCNC single top-quark limits

NLO calculation is used to convert the cross-section limit into limit on kappa and BR



The upper limit on the coupling constants κ_{ugt}/Λ and κ_{cgt}/Λ.

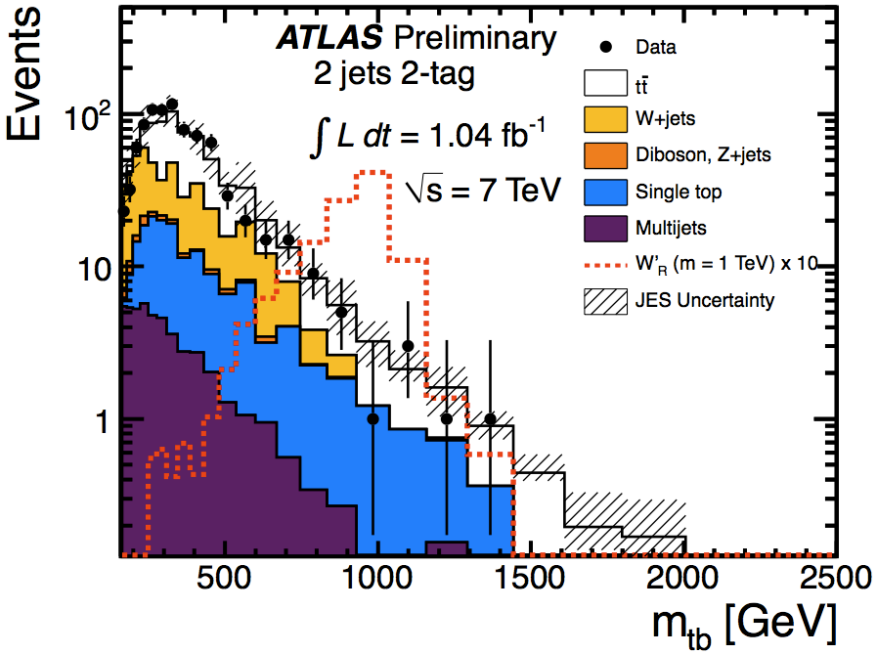


The upper limit on the branching fractions t→ ug and t→ cg

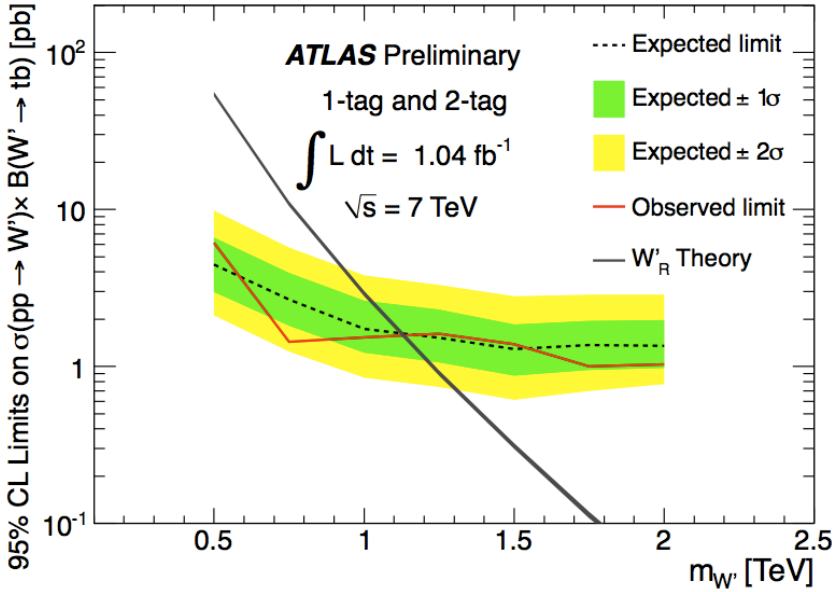
$$\sigma_{qg\to t} \times Br(t \to Wb) < 3.9 \text{ pb} \quad \text{at 95\% CL}$$

W'→tb limit

The distribution of m_{tb} for double-tagged two-jet events in data compared to Standard Model expectations.



95% CL limit on the cross section, $\sigma(pp \rightarrow W'_R)$, times branching ratio for $W'_R \rightarrow tb$ as a function of the W' boson mass.



Observed (expected) limits for $\sigma(pp \rightarrow W_R') \times Br(W_R' \rightarrow tb)$ found to be within the range 6.1(4.5) - 1.0 (1.4) pb for W_R' masses ranging from 0.5 to 2 TeV at the 95% CL.

Converted to $m(W_R)' < 1.13$ (1.13) TeV using intersection between W_R' theory and limits.

Paper close to submission

Conclusions

- ATLAS has performed a complete set of single top analyses
- Measured the t-channel production cross-section
- 95% CL on the *Wt* associated production cross-section : $\sigma(pp \rightarrow Wt + X) < 39\ (41)$ pb
- 95% CL on the s-channel single top-quark production cross section of $\sigma_t < 26.5\ (20.5)$ pb
- Presented the most powerful limits on FCNC single top-quark production ($qg \rightarrow t$).
- Most stringent limit on right handed W'

$$m_{W'_R} < 1.13\,\text{TeV}$$