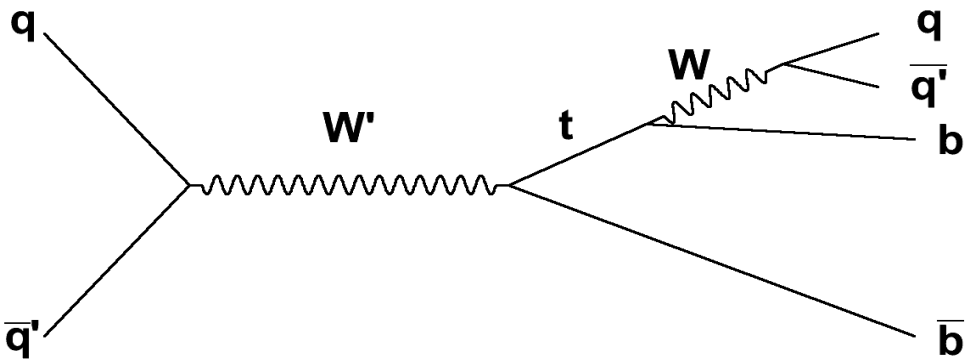
THE UNIVERSITY OF CHICAGO

Search for W' → tb → qqbb Decays with the ATLAS detector



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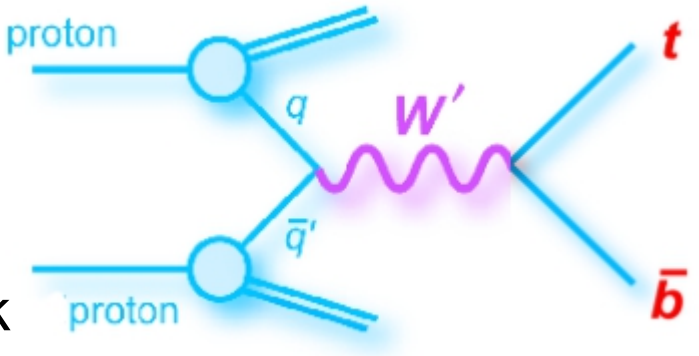
Introduction

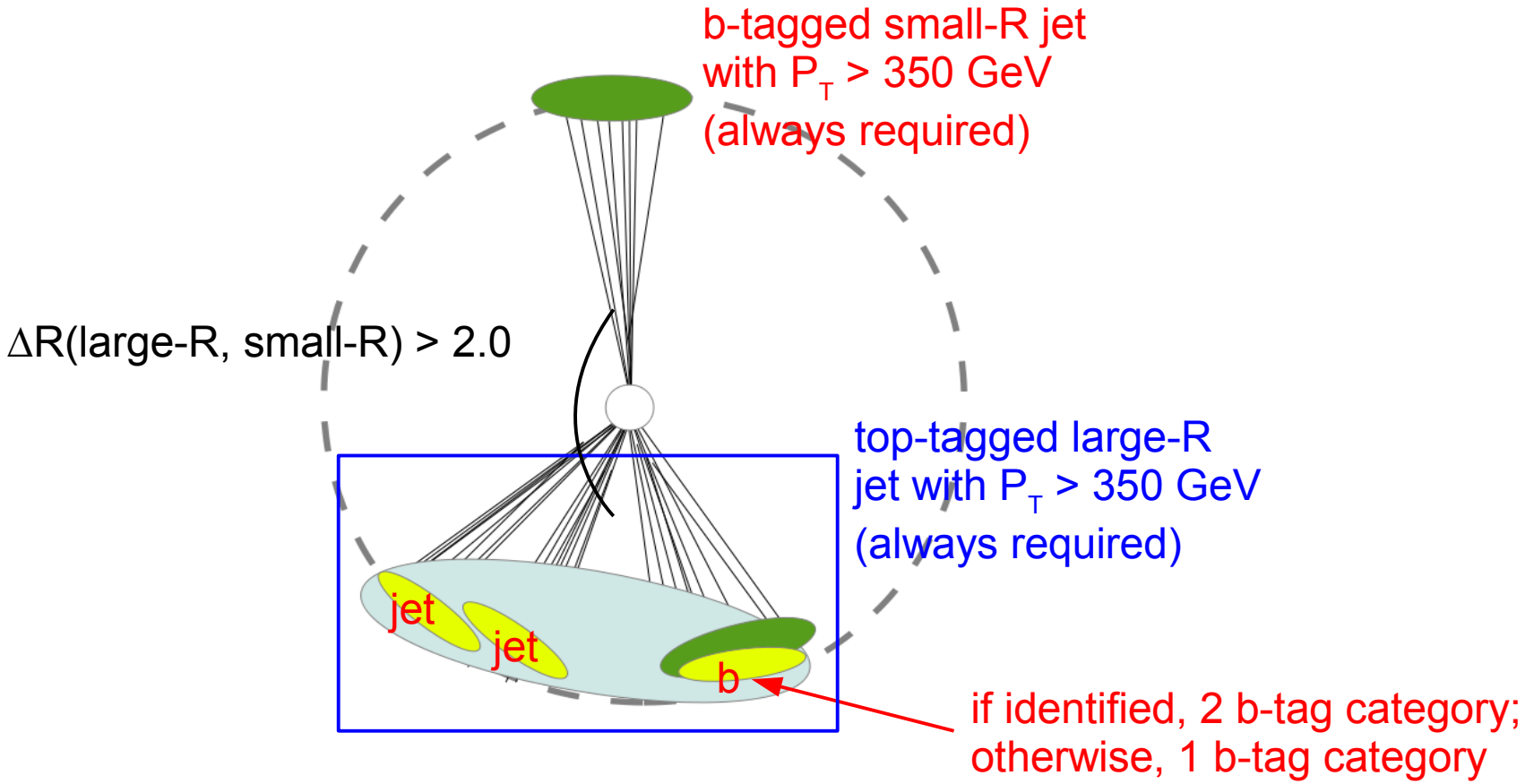
- What is W'?
  - A heavy, Standard-Model-like W gauge boson (same charge, spin)
  - Consequence of physics beyond the Standard Model
    - Extra Dimension model, a new gauge sector, composite boson
  - Possible search channels: $W' \rightarrow l\nu$ (l = e, μ), $W' \rightarrow WZ$, $W' \rightarrow tb$
    - $W' \rightarrow tb$: search for new physics in the 3rd generation

- $W' \rightarrow tb$ channel
  - Before August 2014, only $W' \rightarrow tb \rightarrow l\nu bb$ published
    - ATLAS limits (20.3 fb^{-1}): 1.70 TeV (W'_L) and 1.92 TeV (W'_R)
    - CMS: http://arxiv.org/abs/1402.2176
  - First result on $W' \rightarrow tb \rightarrow qqbb$
    - Available on http://arxiv.org/abs/1408.0886
    - Advantages
      - $Br(t \rightarrow qqb) \sim 3 \times Br(t \rightarrow l\nu b)$
      - Able to reconstruct a sharp W' mass peak
      - Sensitivity maintained for high $m_{W'}$
    - Disadvantage
      - Enormous QCD background



Search strategy for W' → tb → qqbb

- Looking for tagged dijet events



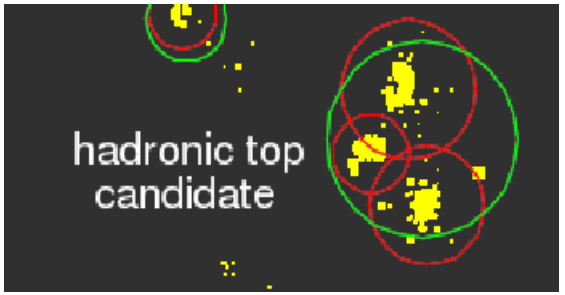
- Electron and muon veto applied
- Search for a bump in m_{tb} spectrum
  - Start the search at W' mass > 1.5 TeV

Hadronic top reconstruction

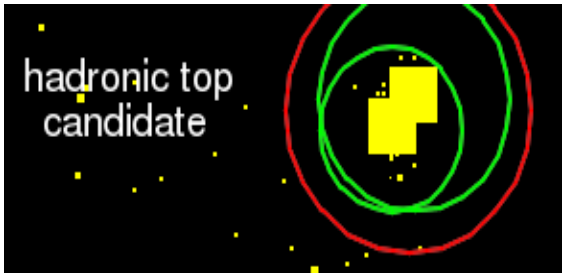
- Want to differentiate jets from hadronic top decays from QCD
  - Top jet: high mass (173 GeV) and contains 3 showers (q, q, b)

- Search for W' with mass greater than 1.5 TeV
  - Top has high P_T → decay products tend to merge
  - Reconstruct top decay products by large-R (radius para. R=1.0) jets
    - ATLAS standard jets have radius parameter R=0.4
  - Use jet substructure information to distinguish top jets from light jets

low P_T top
e.g. 100 GeV

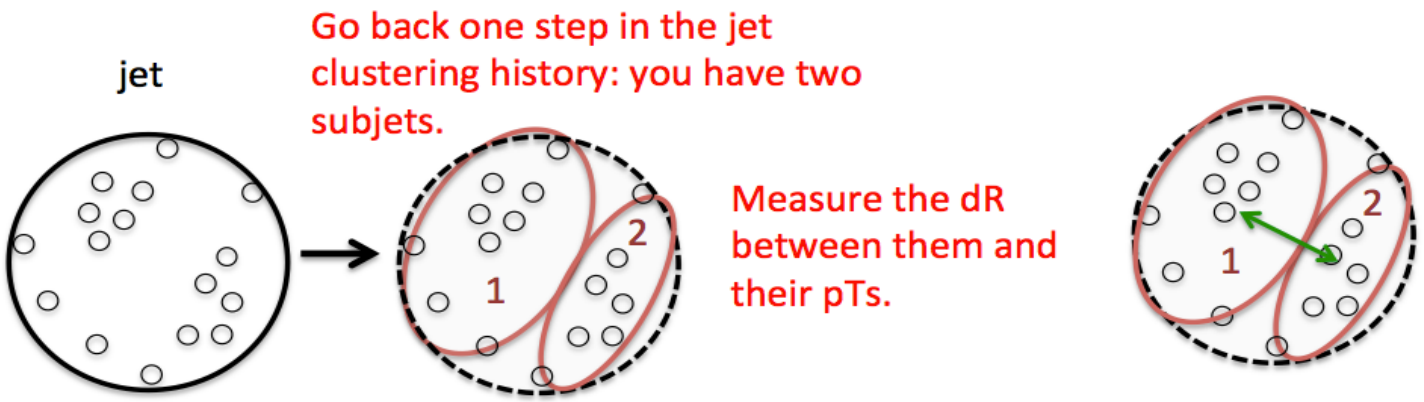


high P_T top
e.g. 800 GeV

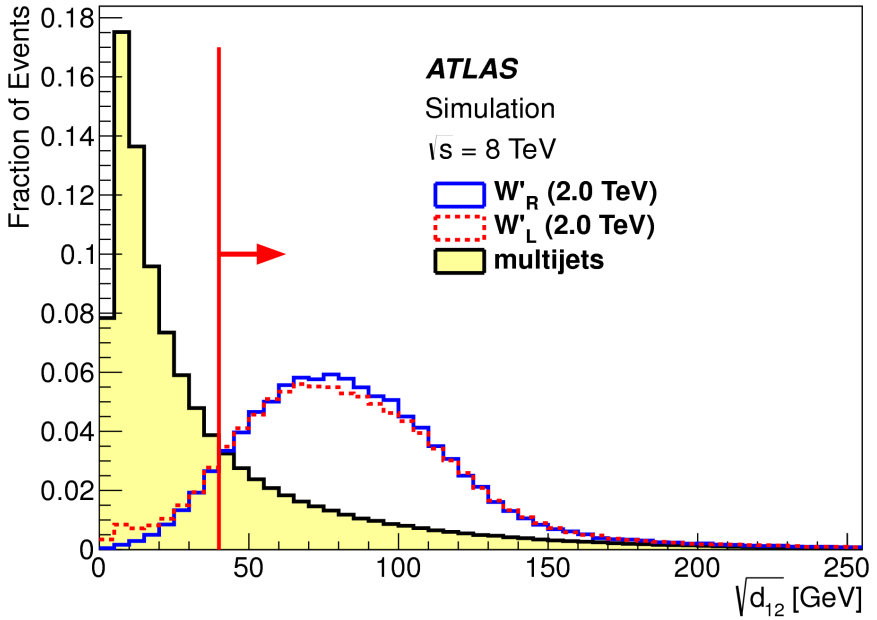


Jet substructure variables for top-tagging

- Splitting scale $\sqrt{d_{12}}$, ratios of n-subjettiness τ_{21} and τ_{32} are used to distinguish top jets and light jets
  - Splitting scale $\sqrt{d_{12}}$

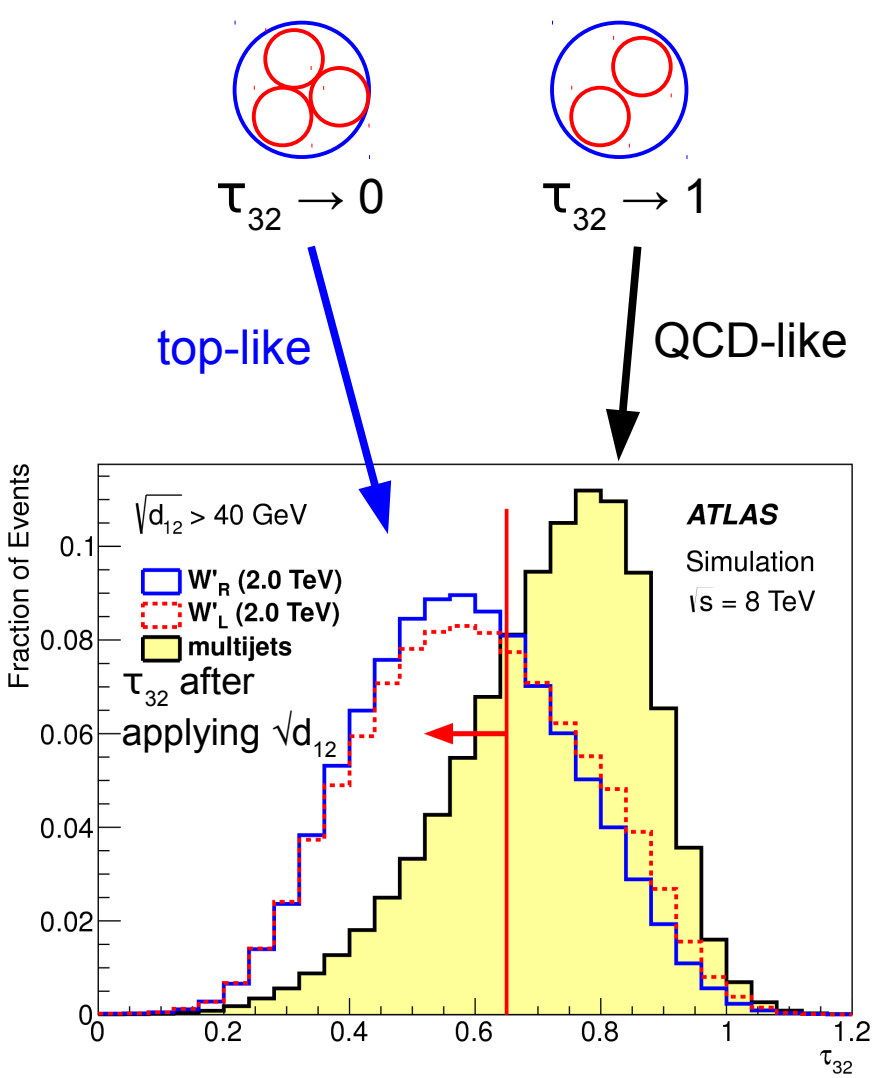


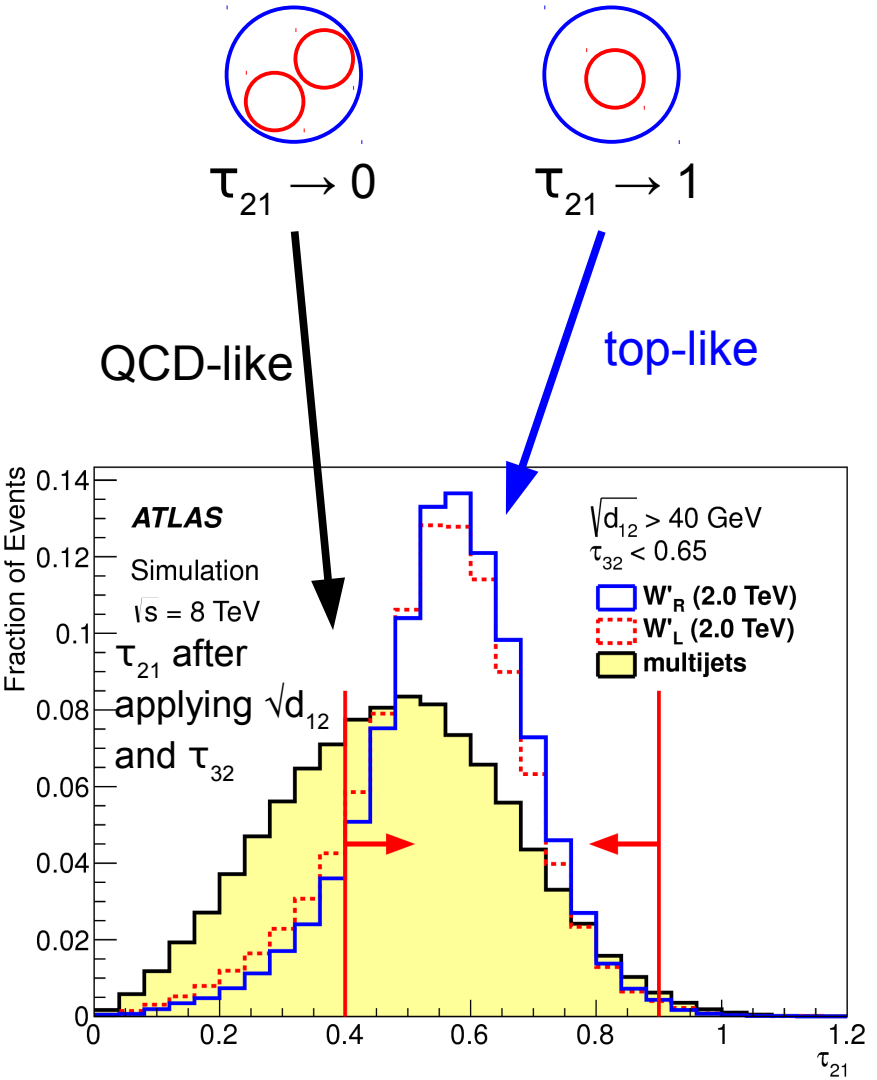
$\sqrt{d_{12}} = \min(P_T(1), P_T(2)) \times \Delta R(1,2)$



Jet substructure variables for top-tagging

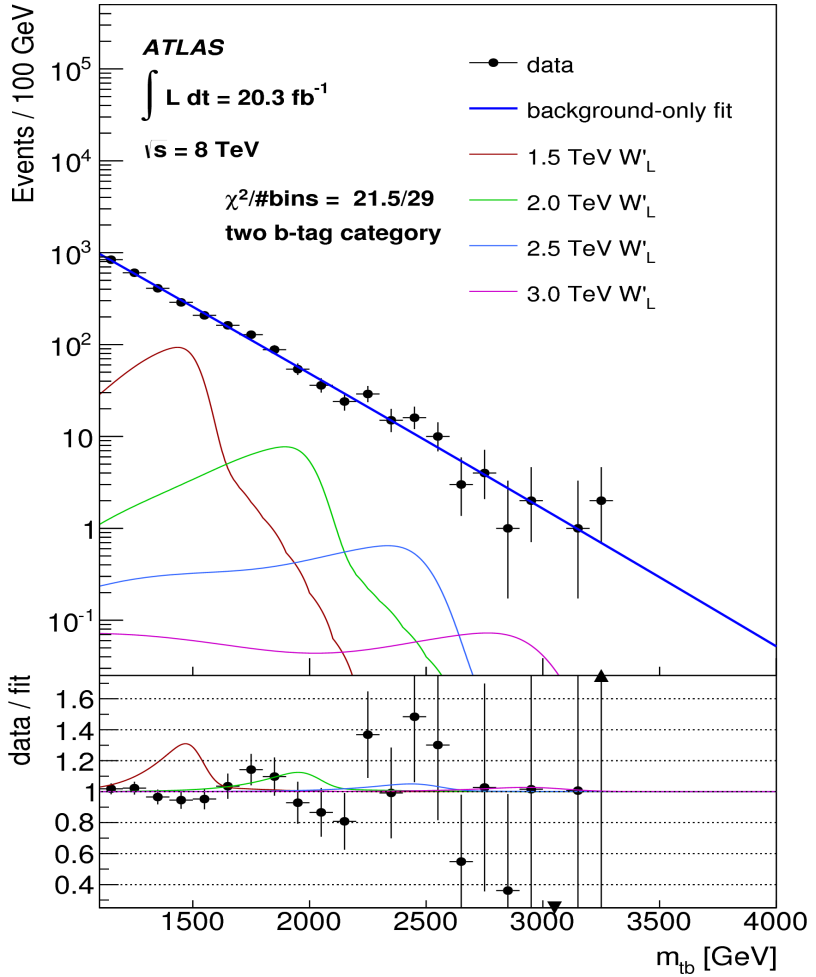
- Ratio of n-subjettiness τ_{32} and τ_{21}
  - Ratio related to number of showers inside the jet



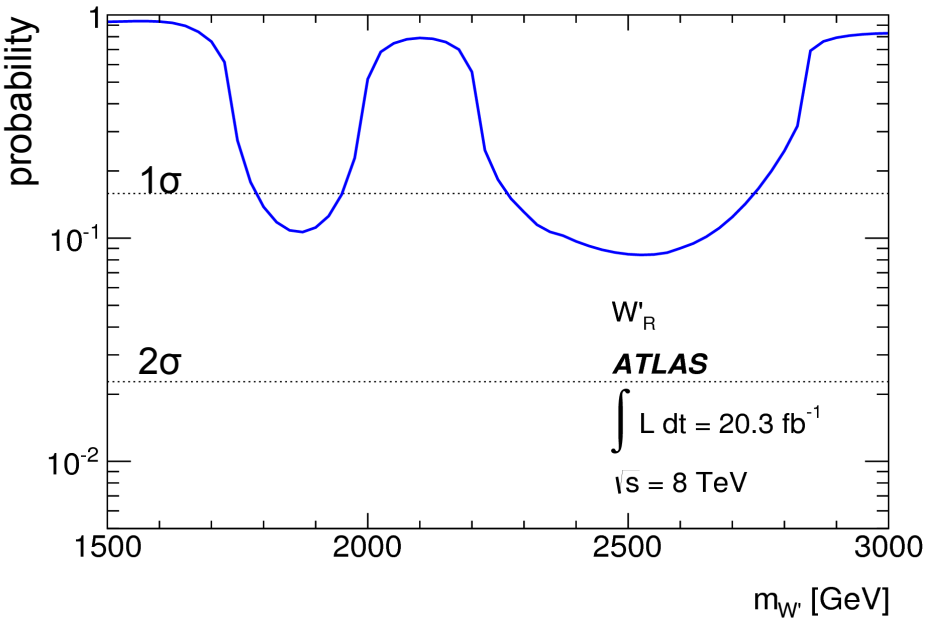


Statistical strategy

- Signal parametrized by analytic functions
- Background obtained from fitting data with analytic functions
  - Functions tested on data-driven background sample before unblinding
- Unbinned likelihood fit to m_{tb} distribution
  - Determine excess from probability for signal+background hypothesis
  - If no excess, set 95% Confidence Level limits



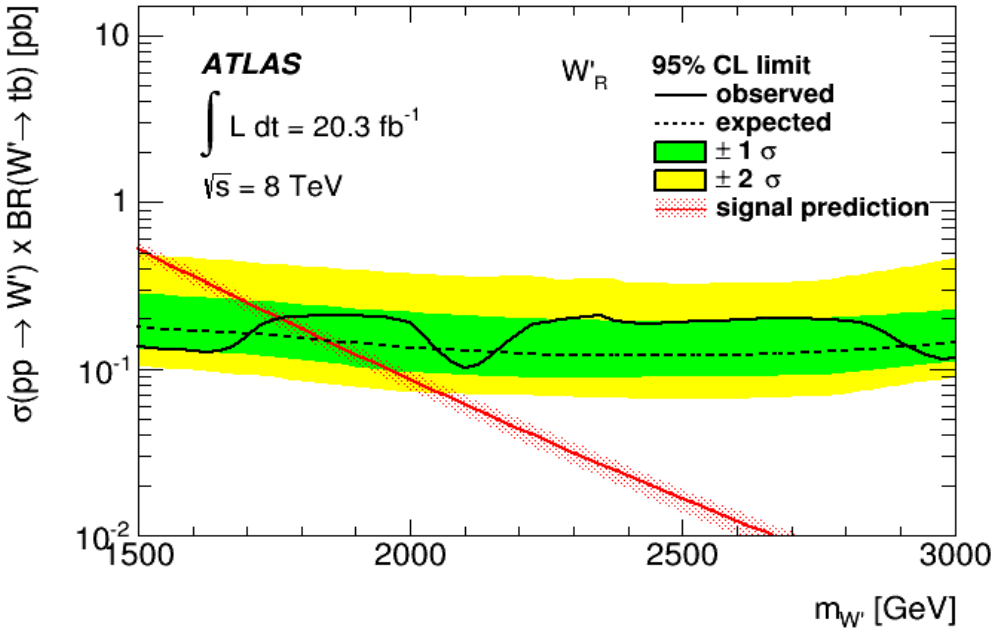
Data consistent with the Standard Model

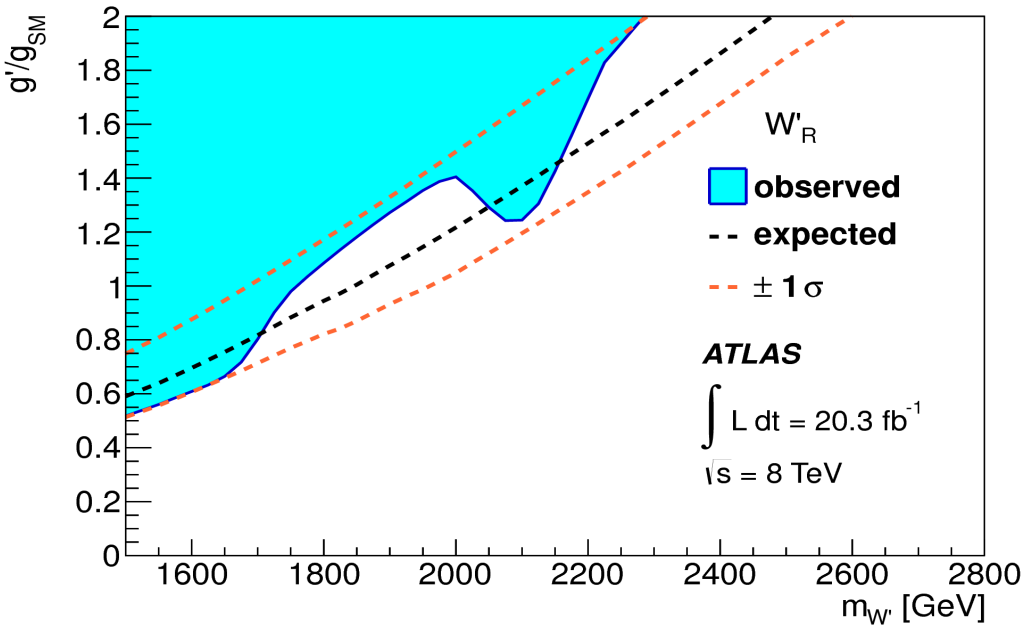


Results: W'_R

- Observed (expected) limits on cross section x Br assuming g_{SM}
  - Mass of W'_R > 1.76 (1.85) TeV

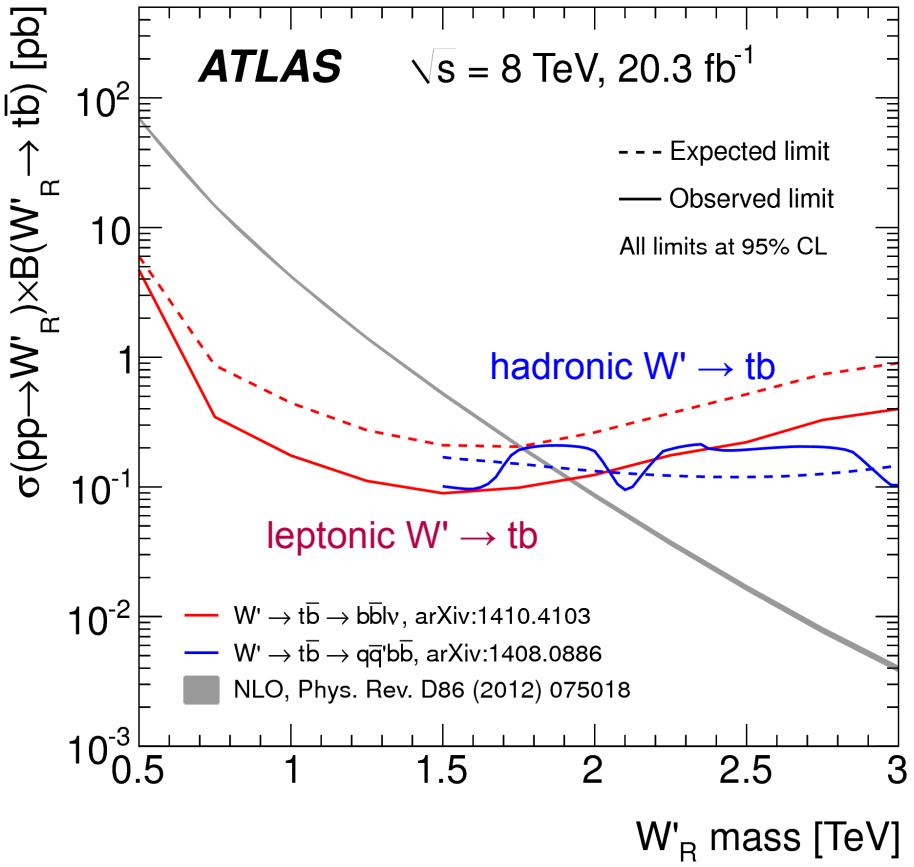
- Set limits on g'/g_{SM} up to 2 as a function of $m_{W'}$
  - At g'/g_{SM} = 2, mass limit is 2.29
  - At $m_{W'}$ = 1.5 TeV, g'/g_{SM} < 0.55





Leptonic and hadronic $W'_R \rightarrow tb$

- Currently, comparable expected limits
- Hadronic: flat sensitivity up to $m_{W'} \sim 3$ TeV



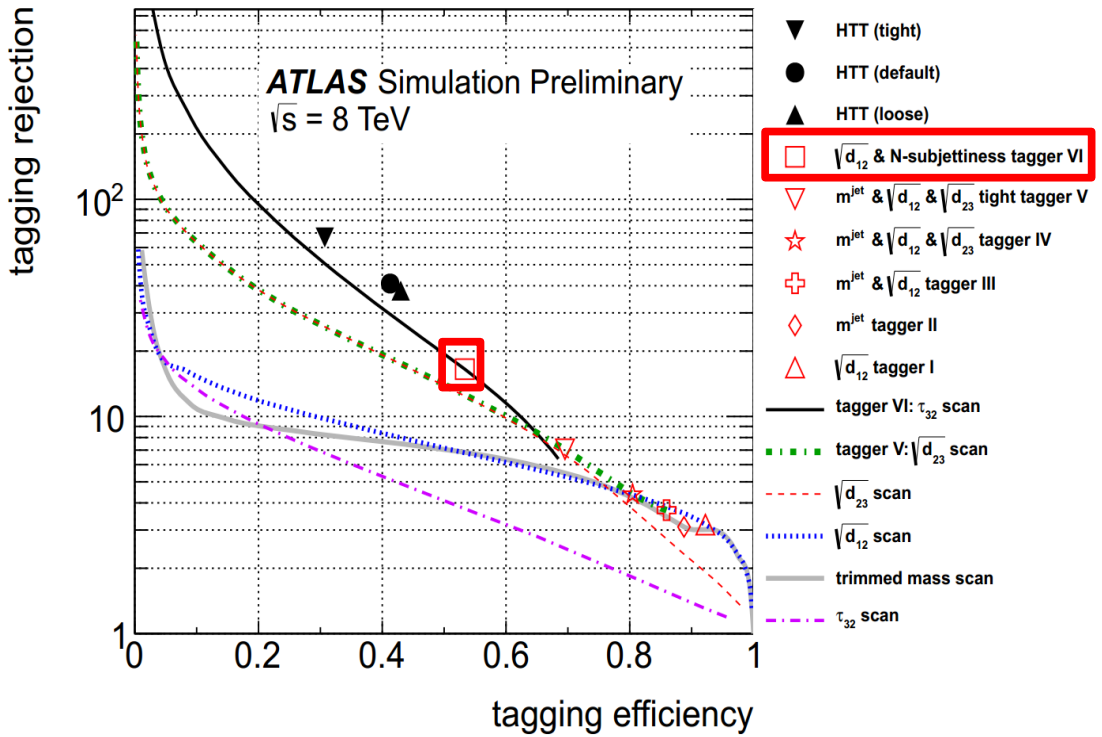
Summary and outlook

- First result on W' → tb in the decay channel of t → qqb
  - Dijets events with one jet top-tagged and the other one b-tagged
- Developed new and simple top-tagger with high performance
- Limits on cross section x Br ($g' = g_{SM}$)
  - Mass of W'_R > 1.76 TeV
- Limits on g'/g_{SM} as a function of $m_{W'}$
  - At $g'/g_{SM} = 2$, mass limit is 2.29
- Outlook
  - Sensitivity up to W' mass ~ 3 TeV
  - More important as LHC increases to 13 - 14 TeV for Run II (2015 – 2018)
- Thank you!

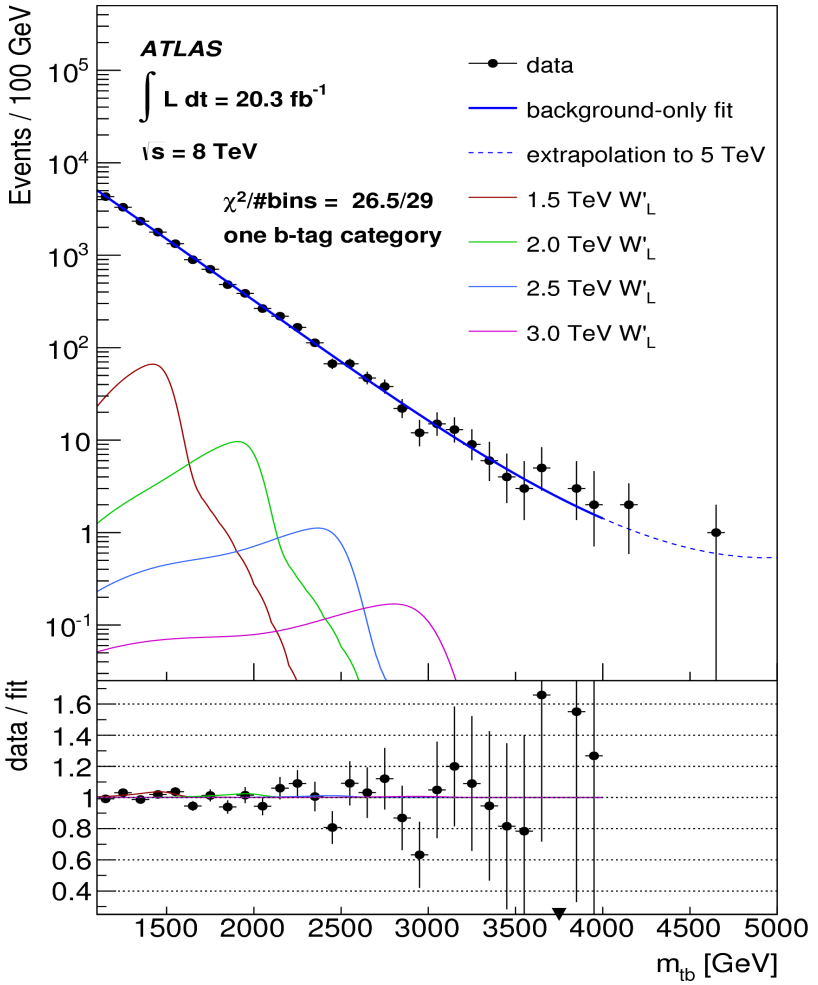
backup

W' top-tagger performance

- Shown compatible performance in ATLAS top tagger performance note

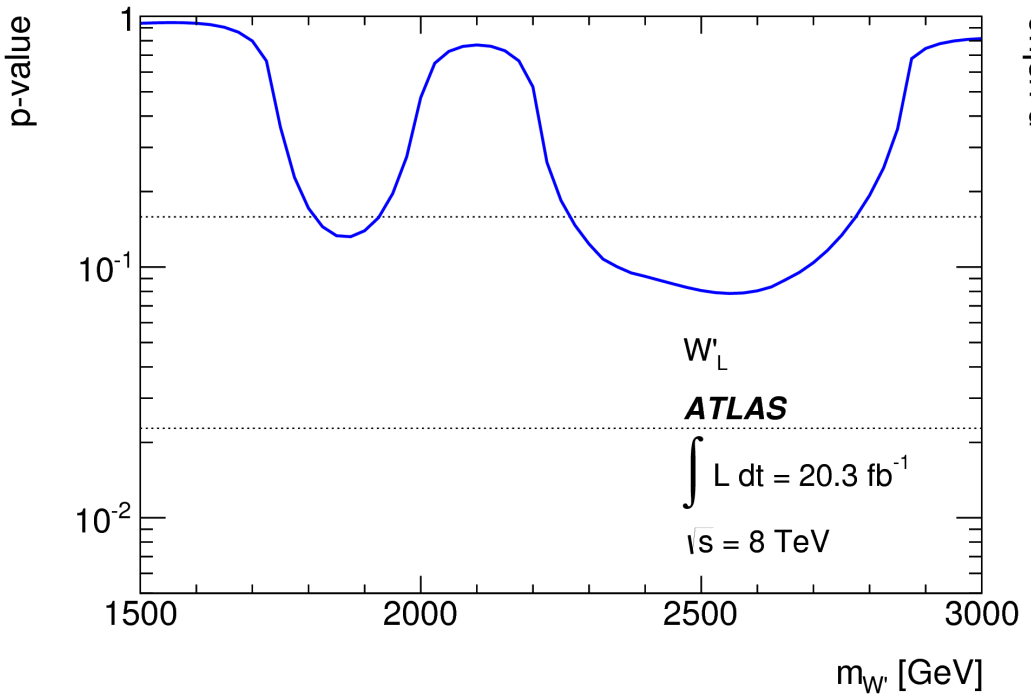


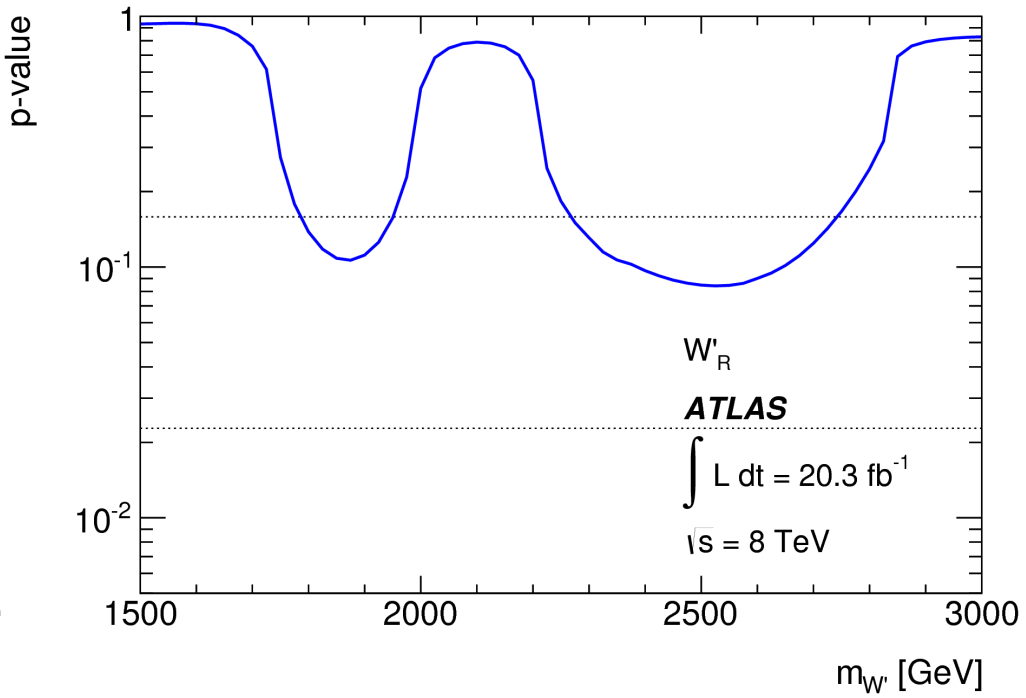
Fit to data – one b-tag category



Probability of signal region fits

- Consistent with SM





Results: W'_L

- Observed (expected) limits on cross section x Br assuming g_{SM}
  - Mass of W'_L > 1.68 (1.63) TeV
- Set limits on g'/g_{SM} up to 2 as a function of $m_{W'}$
  - At g'/g_{SM} = 2, mass limit is 2.18
  - At $m_{W'}$ = 1.5 TeV, g'/g_{SM} < 0.70