Search for a New Heavy Charged Gauge Boson with ATLAS

UNIVERSITY OF LIVERPOOL

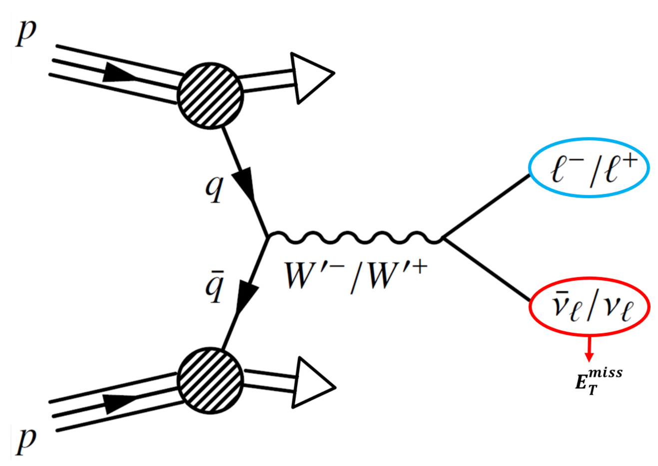
Ellis Kay

Supervisors: Uta Klein & Carl Gwilliam

ATLAS EXPERIMENT

1 Introduction

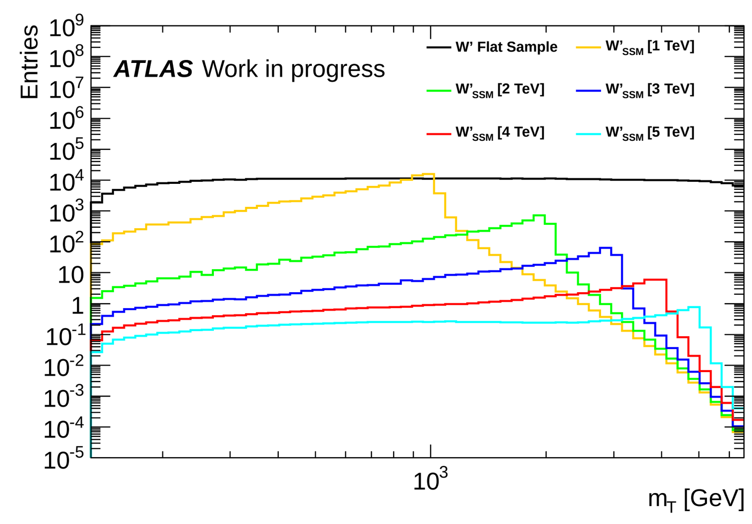
- The W' is a new gauge boson arising from extensions of electroweak symmetry.
- Predicted in a wealth of BSM theories:
  - Little Higgs (hierarchy problem)
  - Left-Right Symmetric (GUT)
  - 331 Models (3 quark families)



- We consider spin-1 s-channel W' resonances in the context of the Sequential Standard Model (SSM) [1].
  - Same couplings to fermions as the SM W, TeV scale mass.
- Identify events with one high-p_T lepton and large E_T^{miss}
- Search for deviations from SM in $m_T = \sqrt{2 p_T E_T^{miss}(1 - \cos\phi_{\ell\nu})}$
- For the electron channel $\rightarrow$ e: p_T > 65 GeV, E_T^{miss} > 65 GeV, m_T > 130 GeV

2 Samples

- Using the full 36.1 fb^{-1} of 2015+2016 ATLAS data.
- "Flat" W' signal samples (PYTHIA) are reweighted to the desired pole mass.



- SM backgrounds estimated with Monte Carlo include:
  - Charged Current Drell-Yan (CCDY) $W \rightarrow e\nu$ ⋆ (mass-binned)
  - Neutral Current Drell-Yan (NCDY) $Z \rightarrow \ell\ell$ ⋆ (mass-binned)
  - Top ($t\bar{t}$ & single top) ⋆ (inclusive)
  - Diboson † (inclusive)

  ⋆ - Powheg & Pythia8, † - Sherpa.
- 'Multijet' background is estimated using data-driven methods.

3 "Fake" Lepton Background

- SM Background due to misidentified leptons in multijet processes ("fake" leptons) are poorly described by MC
- Use a data-driven Matrix Method:
  - Exploits the different probabilities for "real" and "fake" leptons to pass from "loose" to "tight" cuts
  - Using measurable quantities to calculate truth quantities

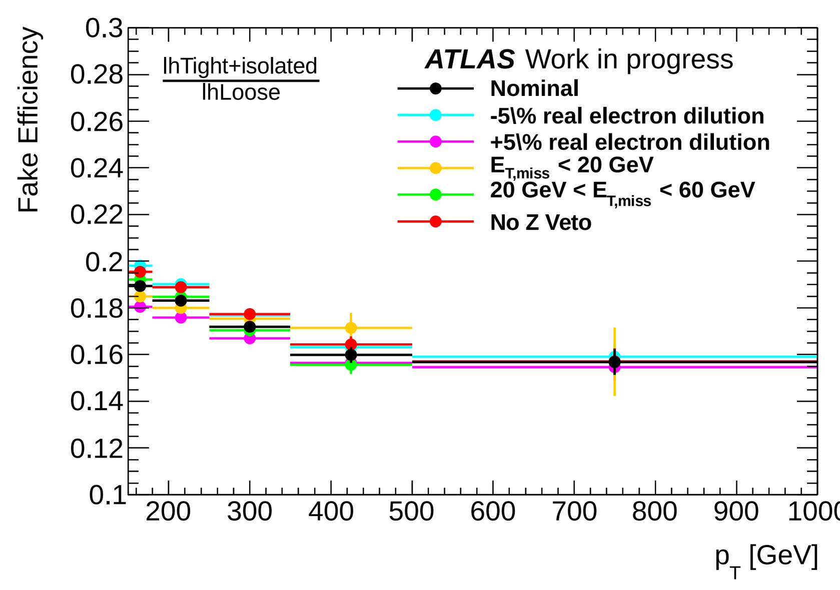
$$\begin{pmatrix} N_T \\ N_L \end{pmatrix} = \begin{pmatrix} \epsilon_R & \epsilon_F \\ 1-\epsilon_R & 1-\epsilon_F \end{pmatrix} \begin{pmatrix} N_R \\ N_F \end{pmatrix} \qquad \epsilon_F = \frac{N^{fake}_{tight}}{N^{fake}_{loose}}, \quad \epsilon_R = \frac{N^{real}_{tight}}{N^{real}_{loose}}$$

- From the first line: $\underbrace{N_T}_{\text{signal selection}} = \underbrace{\epsilon_R N_R}_{\text{contribution from real electrons}} + \underbrace{\epsilon_F N_F}_{\text{contribution from fake electrons}}$
- Inverting matrix yields "fake" component in data (tight selection):

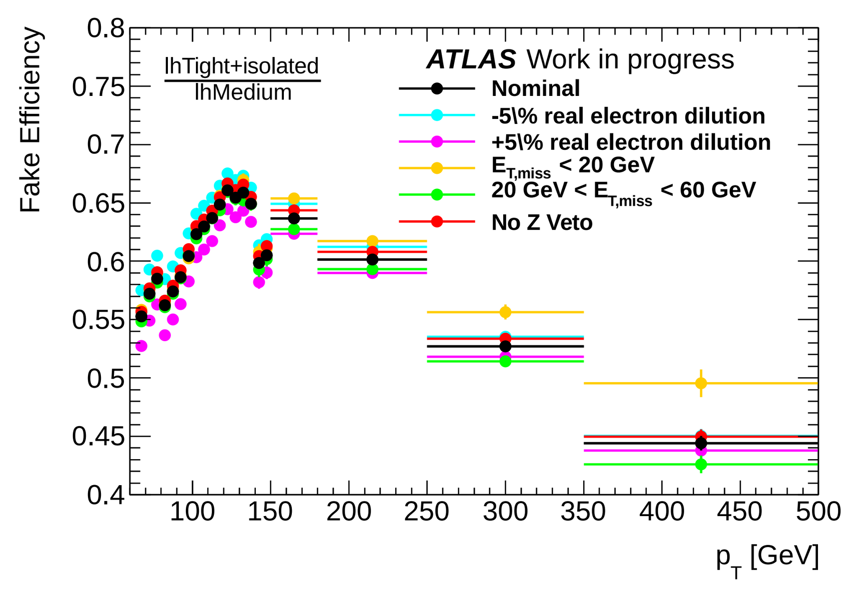
$$\epsilon_F N_F = \frac{\epsilon_F}{\epsilon_R - \epsilon_F}\left[\epsilon_R (N_L + N_T) - N_T\right]$$

- "tight" selection $\rightarrow$ signal selection
- "loose" selection $\rightarrow$ as loose as possible, containing "tight" electrons
- "loose" level $\rightarrow$ loosest unprescaled trigger which collects this sample

HLT_e140_lhloose for p_T> 145 GeV



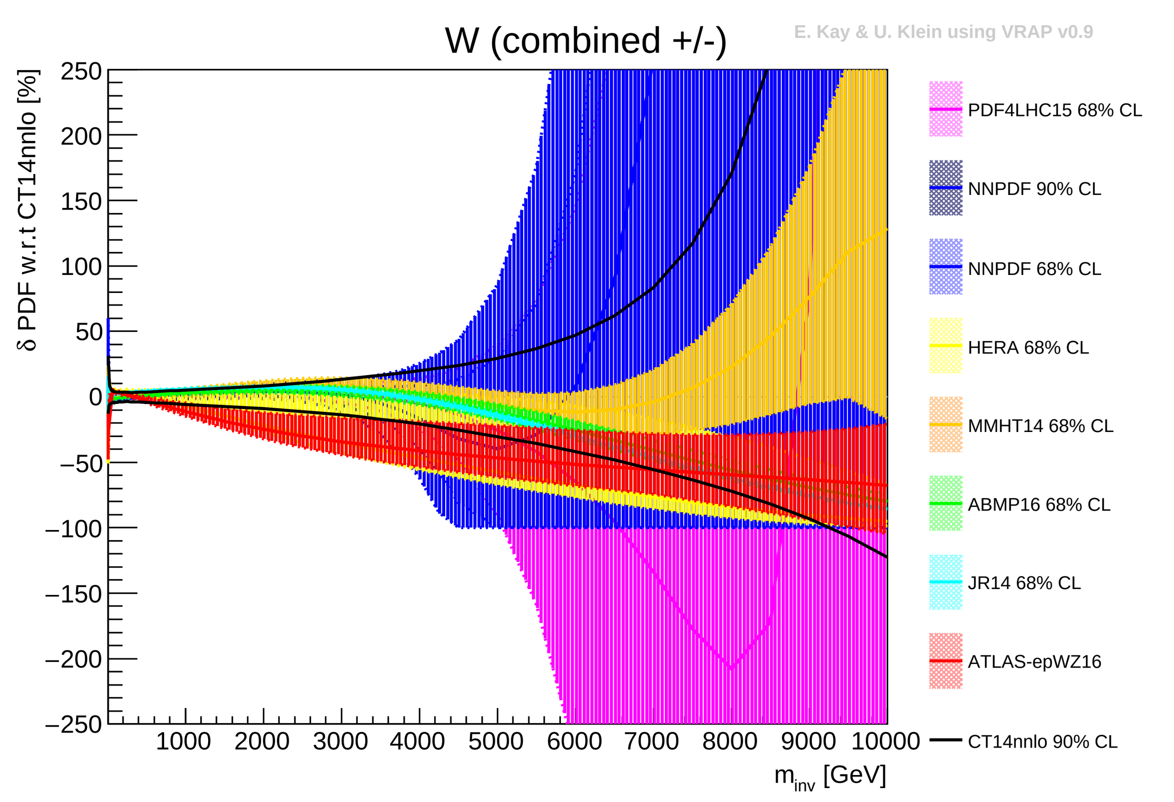
HLT_e60_lhmedium for p_T< 145 GeV



- The selections which define the multijet control region for ϵ_F are varied to obtain a systematic uncertainty on this background.

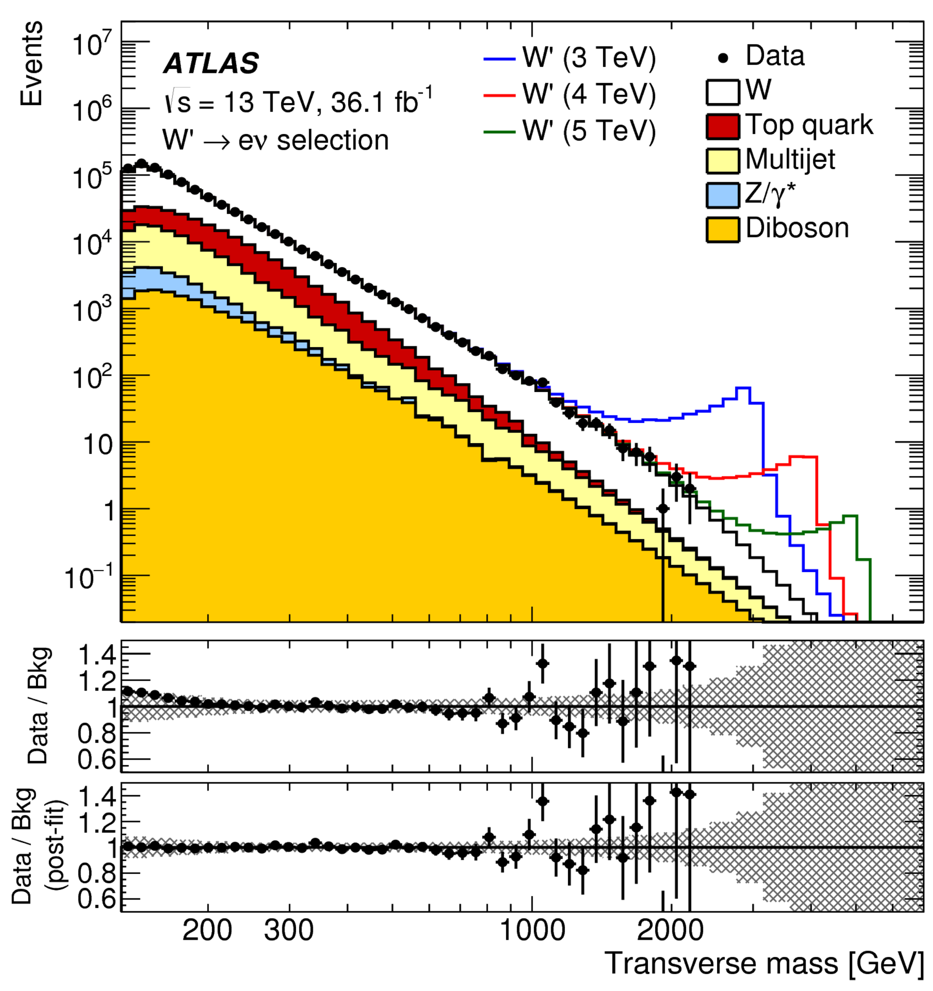
4 Theoretical Uncertainties

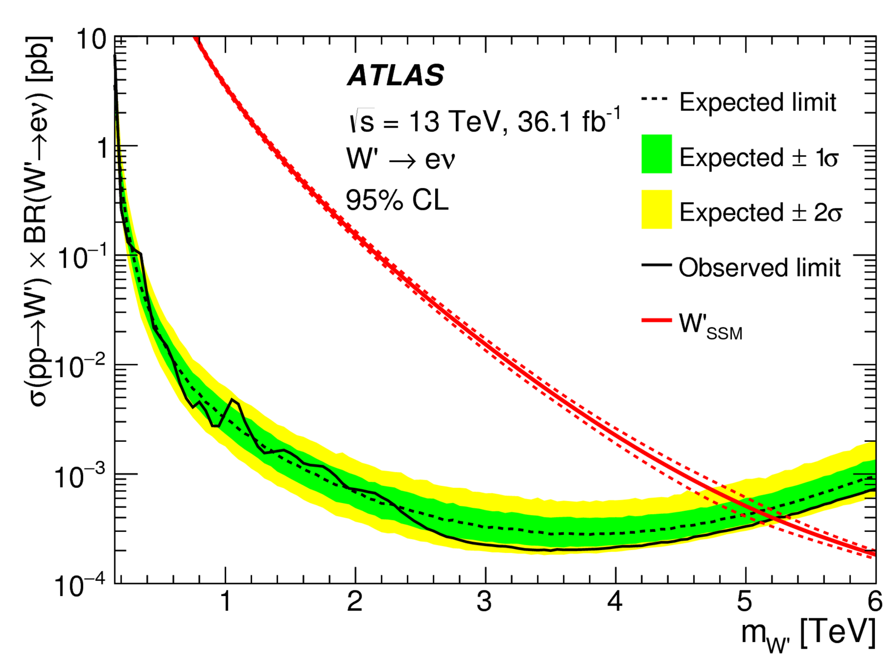
- Signal & dominant CCDY background samples are corrected to best theory knowledge:
  - Signal $\rightarrow$ NNLO$_{QCD}$
  - CCDY $\rightarrow$ NNLO$_{QCD}$ & NLO$_{EW}$
- For searches at the TeV scale, understanding of the parton structure of the proton becomes a dominant source of uncertainty.
- Additional theoretical uncertainties for background:
  - PDF & α_S for nominal set
  - PDF choice uncertainty



Ratios of the central values and uncertainties at NNLO QCD for all modern PDF sets to the CT14 (nominal) central values for the CCDY process.

5 Results





- No significant excess above the SM is observed.
- Limits are set using the Bayesian Analysis Toolkit [2].
- W' SSM masses below 5.2 TeV are excluded at 95% confidence level for the electron channel.
- This result was published on arXiv [3].
- This search could be strengthened through combination with other analyses, such as Z' searches and searches with W' decays to dibosons.
  - Work is in progress to also set frequentist limits in order to facilitate such combinations.

[1] C.-W. Chiang, N. D. Christensen, G.-J. Ding, and T. Han, "Discovery in Drell-Yan Processes at the LHC," *Physical Review D*, vol. 85, Jan. 2012.

[2] F. Beaujean, A. Caldwell, D. Kollar, and K. Kroninger, "BAT: The Bayesian analysis toolkit," *J. Phys. Conf. Ser.*, vol. 331, p. 072040, 2011.

[3] M. Aaboud *et al.*, "Search for a new heavy gauge boson resonance decaying into a lepton and missing transverse momentum in 36 fb^{-1} of pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS experiment," *arXiv:1706.04786*, 2017.

ellis.kay@cern.ch