RATIO MEASUREMENT OF W/Z + JETS AT ATLAS

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Vector boson (V) + jets measurements are in general an important background for new physics:

- E.g. W+Jets events are a major background for physics processes with a final state including missing transverse energy (MET) and hadronic jets, such as single top measurements and SUSY searches.

The ratio measurement \((W+\text{Jets})/(Z+\text{Jets})\) provides a high precision test of perturbative QCD since the ratio conserves information on the dynamics of V +Jets production whilst largely reducing the common systematic uncertainties associated with the measurement:

- Experimental level: largely reduced jet energy scale and luminosity uncertainties.
- Theoretical level: reduced dependence on PDFs.
Measurement performed for both the electron and muon channels and a combined cross-section.


- Measurement with exactly one associated jet.
- Ratio presented as a function of jet $P_T$ threshold.
- Comparison with LO Monte Carlos (Pythia and Alpgen) and NLO calculations (MCFM) showed good agreement between data and predictions.
For the 2011 dataset we intend to perform comparisons with LO MCs (Alpgen and Sherpa) and with NLO calculations (BlackHat +Sherpa) and to extend the analysis scope to following distributions:

- $N_{\text{jets}}$: Inclusive distribution and the ratio $N_{\text{jet}}/(N_{\text{jet}}-1)$
- Jet properties: $P_T$ and rapidity ($y$) of the 1$^{\text{st}}$, 2$^{\text{nd}}$, 3$^{\text{rd}}$ and 4$^{\text{th}}$ leading jets.
- Dijet variables: $M_{12}, \Delta R_{12}, \Delta \Phi_{12}, \Delta y_{12}$
- $P_T$ sums: $H_T$ and $S_T$.

Analysis group consists of members from QMUL, Oxford, UMass, Tufts, CERN, Santa Cruz, Michigan, Heidelberg, LBNL.
Analysis Strategy

**Electron Channel**
- Event selection with data and tuned MC
- Background subtraction
- Bayesian unfolding (RooUnfold) to correct for detector effects with Alpgen

**Muon Channel**
- Event selection with data and tuned MC
- Background subtraction
- Bayesian unfolding (RooUnfold) to correct for detector effects with Alpgen

**Detector Level**
- W
- Z

**Particle Level**
- Acceptance correction
- Ratio

**Combination**
- Comparison of final results with LO MC (Alpgen and Sherpa) and NLO calculations (BlackHat+Sherpa).

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Event Selection

- **Boson Selection:**
  - Z: $p_T(l) > 20\text{GeV}$, $66 < M_{ll} < 116\text{ GeV}$
  - W: $p_T(l) > 25\text{GeV}$, MET > 25GeV, $M_T > 40\text{GeV}$.

- **Lepton $\eta$:**
  - Electron channel: $|\eta| < 2.47$ (excluding $1.37 < |\eta| < 1.52$).
  - Muon channel: $|\eta| < 2.4$
  - Combination: Apply acceptance correction factors to correct to common phase space $|\eta| < 2.5$.
    - Acceptance correction: number of events passing fiducial phase space cut / number of events passing common phase space cut.
    - Evaluated using Alpgen signal MC.

- **Jet Selection:**
  - $p_T > 30\text{GeV}$, $|\gamma| < 4.4$, JVF > 0.75
  - $\Delta R(l,jet) > 0.5$
Data shows good agreement with current models up to $N_{\text{jet}} \geq 4$.

Here $t\bar{t}$ starts to dominate.

Data-driven estimation currently in process.

Measurement suffers at high $P_T$ due to low statistics.

Plots on this slide courtesy of Craig Sawyer, University of Oxford.
Unfolding to Particle Level

- Want to correct our data to account for detector level effects:
  - E.g. Trigger and reconstruction efficiencies and resolution.

- Bayesian iterative unfolding with RooUnfold.
  - Use Alpgen signal samples to build response matrices from events at reconstructed level and particle level.

- Apply external fake jet correction factors derived from Alpgen after background subtraction and before unfolding.
  - Accounts for reconstructed level events which are unmatched at particle level.

- Systematics associated with the unfolding procedure:
  - Model: Choice of signal MC used to unfold (e.g. Alpgen, Sherpa etc.)
  - Statistical: Limits of MC sample size used to unfold.

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Fake Corrections

Fake correction:

#events that pass both reco and particle level selections / #all reco events

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Response Matrices

Built using Alpgen signal samples.

Here each bin is normalised to the particle level entries in each column.

\[
\frac{N_{ij}}{\sum_i N_{ij}}
\]
Closure Tests

- Perform the unfolding procedure using Alpgen MC in place of data.
- Expect very good agreement.

- Unfold Sherpa signal MC using Alpgen.
- Good agreement in the low $P_T$ region.
- Low statistics at high $P_T$, unfolded results agree with the prediction within our systematic errors.
Conclusions

- $R_{\text{jets}}$ is a very high precision measurement which, with the high statistics of the 2011 ATLAS dataset, we can expand upon the 2010 analysis to include a large number of observables.

- **Current state of the analysis:**
  - Finalising unfolding procedure and associated systematics.
  - Studies ongoing to provide data-driven ttbar and QCD background estimations.
  - Aiming to publish as soon as possible.