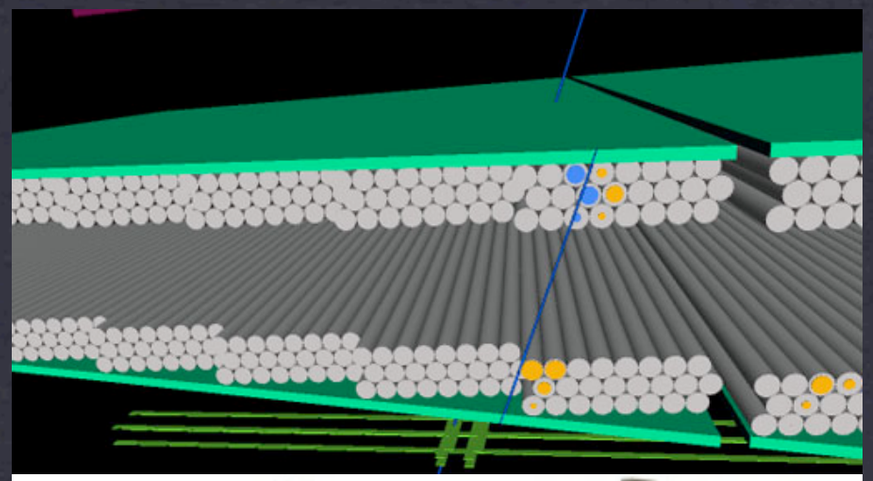

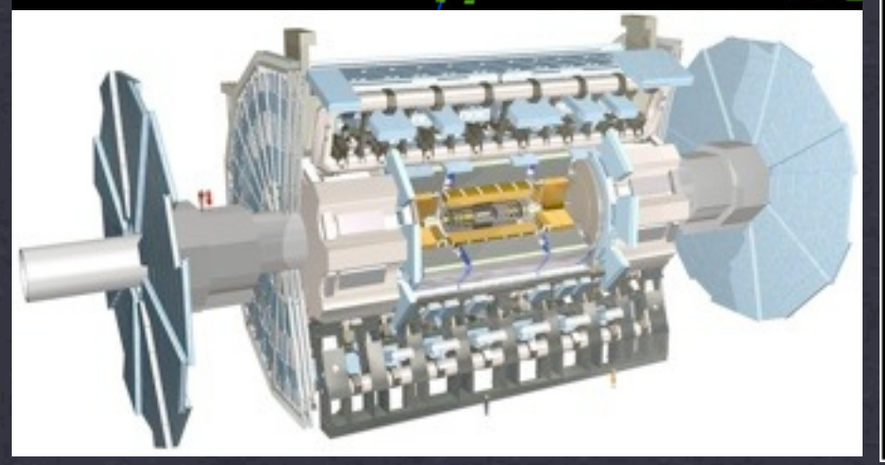

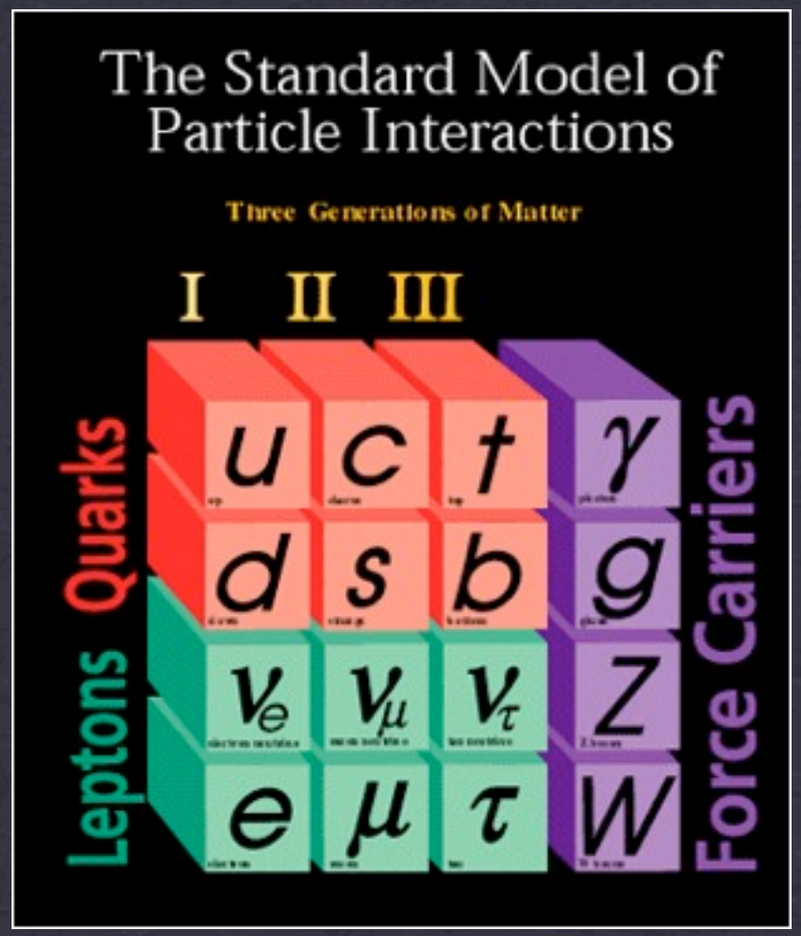

RJets (σ_W/σ_Z + jets) Measurement DPF Electroweak Parallel Session

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On Behalf of the ATLAS Collaboration

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ATLAS Rjets

- Motivation and Measurement Description
- Event Selection and Control Plots
- Background Estimation
- Systematics Summary
- Results

Motivation I/II

$$R(N_J, H_T) = \frac{\sigma_W BF(W \to \ell\nu)}{\sigma_Z BF(Z \to \ell\ell)}$$

- Measurement of the W/Z cross section ratio as a function of hadronic activity, such as:

  N_J = Number of Jets

  H_T = Scalar Sum of p_T of Selected Jets

  P_{Tlead} = p_T of Leading Selected Jet

- Examine Different Jet Multiplicities
  - Different Event Topologies
  - Sensitivity to Different Physics Channels
- Comparison to Theoretical Preditions
  - Test of the Standard Model
  - Probe of New Physics
  - Background for more targeted searches

Motivation II/II

$$R(N_J, H_T) = \frac{\sigma_W BF(W \to \ell\nu)}{\sigma_Z BF(Z \to \ell\ell)}$$

- Advantage: Cancellation of Systematics
  - Luminosity
  - Jet Systematics
  - Lepton Systematics (partial)
- Disadvantage: Limited by Z cross-section.
- This particular measurement is novel: it is the first of its kind.

Measurement and Selection I/II

- **Specific Measurement:** ATLAS R-jets measurement requiring 1-jet for electrons and muons as a function of jet p_T threshold.
  - Require exactly 1 jet with $p_T > 30$ GeV. (Antikt algorithm with a 0.4 cone size)
  - Each bin includes all selected events with jets above a jet p_T threshold (30 GeV to 200 GeV)
  - Cross section calculated in the fiducial volume of the detector.

- **Dataset:**
  - Full 2010 ATLAS dataset. Identical data quality requirements for each channel. (33.3 pb^{-1})

- **Event Selection Overview:**
  - **Lepton Selection:** $p_T > 20$ GeV, $|\eta| < 2.4$. For electrons, also veto $1.37 < |\eta| < 1.53$ due to crack in calorimeter.
  - **Lepton Quality:** Tight Electron, Isolated Combined Muon (see details on next slide), requirements loosened for the second Z lepton.
  - **W boson:** $E_{Tmiss} > 25$ GeV, $M_T > 40$ GeV; **Z boson:** 71GeV $< m_{ll} <$ 111 GeV

Measurement and Selection I/II

- **Selection Details:**

- **Trigger:** Single lepton trigger, varies by data period.

- **Primary Vertex:** 3 or more tracks and consistent with the beam spot.

- **MET Cleaning:** event rejected if likely to contain a fake or poorly measured jet.

- **Lepton:** $p_T > 20$ GeV, $|\eta| < 2.4$. For electrons, also veto $1.37 < |\eta| < 1.53$

  Electron "Tight" requirement (shower shape consistent with EM shower)

  Muons required to be measured in both Inner Detector and Muon Spectrometer.

  Muon Quality and Inner Detector hit requirements, track based isolation.

  Second electron selection is loosened to "Medium" and second muon quality cuts are relaxed.

- **W boson:** $E_{T\,miss} > 25$ GeV, $M_T > 40$ GeV; **Z boson:** $71\text{GeV} < m_{ll} < 111$ GeV

- **Jets:** $p_T > 30$ GeV, $|\eta| < 3.1$

- Tracks in jet also required to be **consistent with the primary vertex** to reject jets from cases where a secondary collision event overlaps with the primary collision. (pileup)

  Veto Events with a jet close to an electron ($\Delta R < 0.6$)

Measurement and Selection II/II

$$N^{\ell,V} = \frac{N_{data} \cdot (1 - f_{QCD}) \cdot (1 - f_{ewk})}{\epsilon^{\ell}_{trig} \cdot \epsilon^{\ell} \cdot C^{\ell}_{V}}$$

$$C^{\ell}_{V} = \frac{A^{Reco}_{V}}{A^{True}_{V}}$$

All terms are a function of jet p_T threshold.

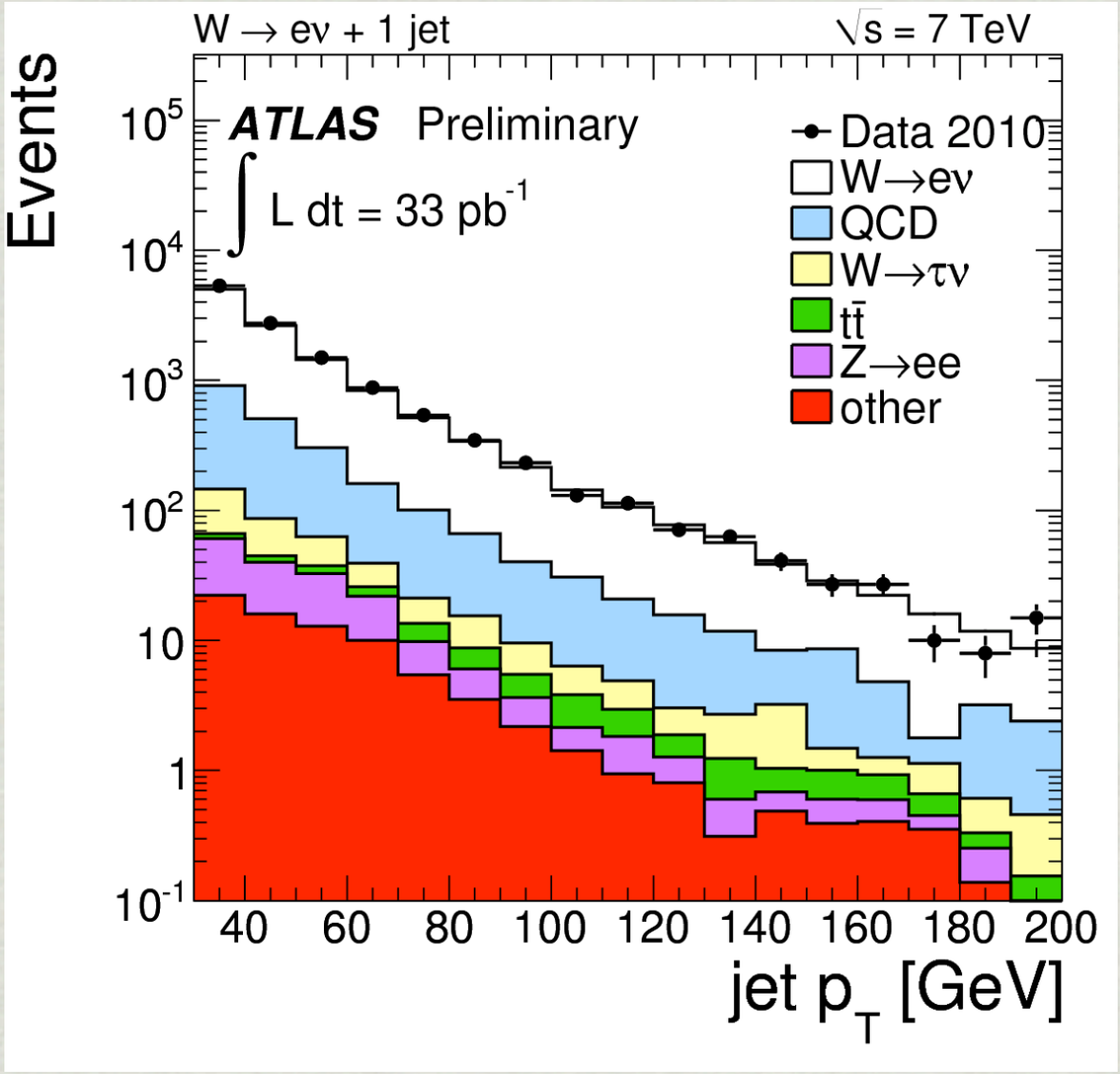
- f_{QCD}: **QCD background fraction** derived from data
- f_{ewk}: **Electroweak background fraction** estimated from MC
- ε_{trig}: **Trigger Efficiency**
- ε: **Lepton Identification Efficiency**
- C_V: **Boson Reconstruction Correction:** Corrects the observed phase space to the fiducial phase space, accounting for resolution of leptons and missing ET.

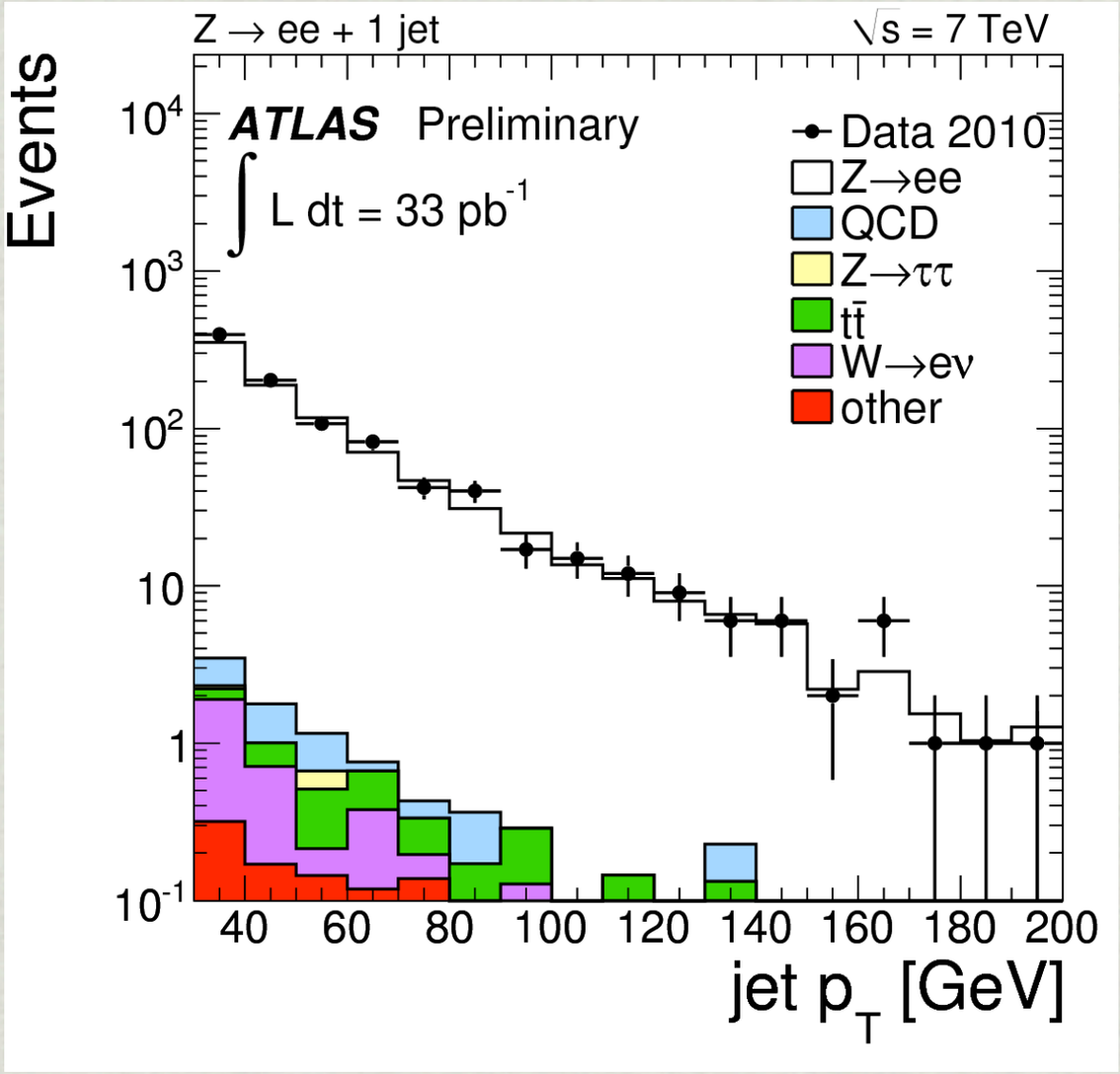
$$R_{jets} = \frac{N^{\ell,W}}{N^{\ell,Z}} \times C^{\ell}_{jet}$$

- C_{jet}: **Jet Spectrum Correction:** Accounts for remaining non-canceling effects relating to the jet kinematics.
- Reconstruction and Trigger Efficiencies are corrected unbiased control samples in data.

Control Plots I/II

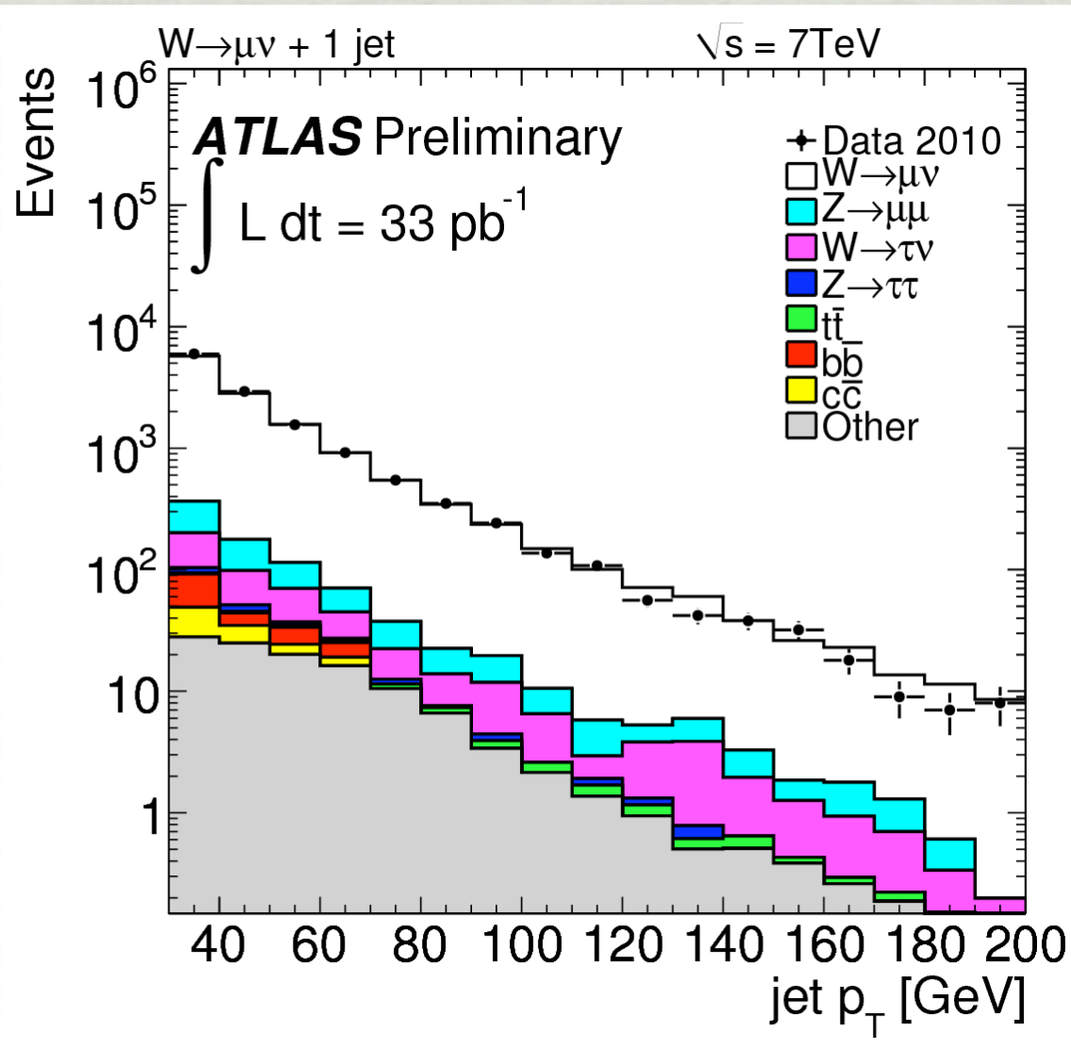
Electron Channel

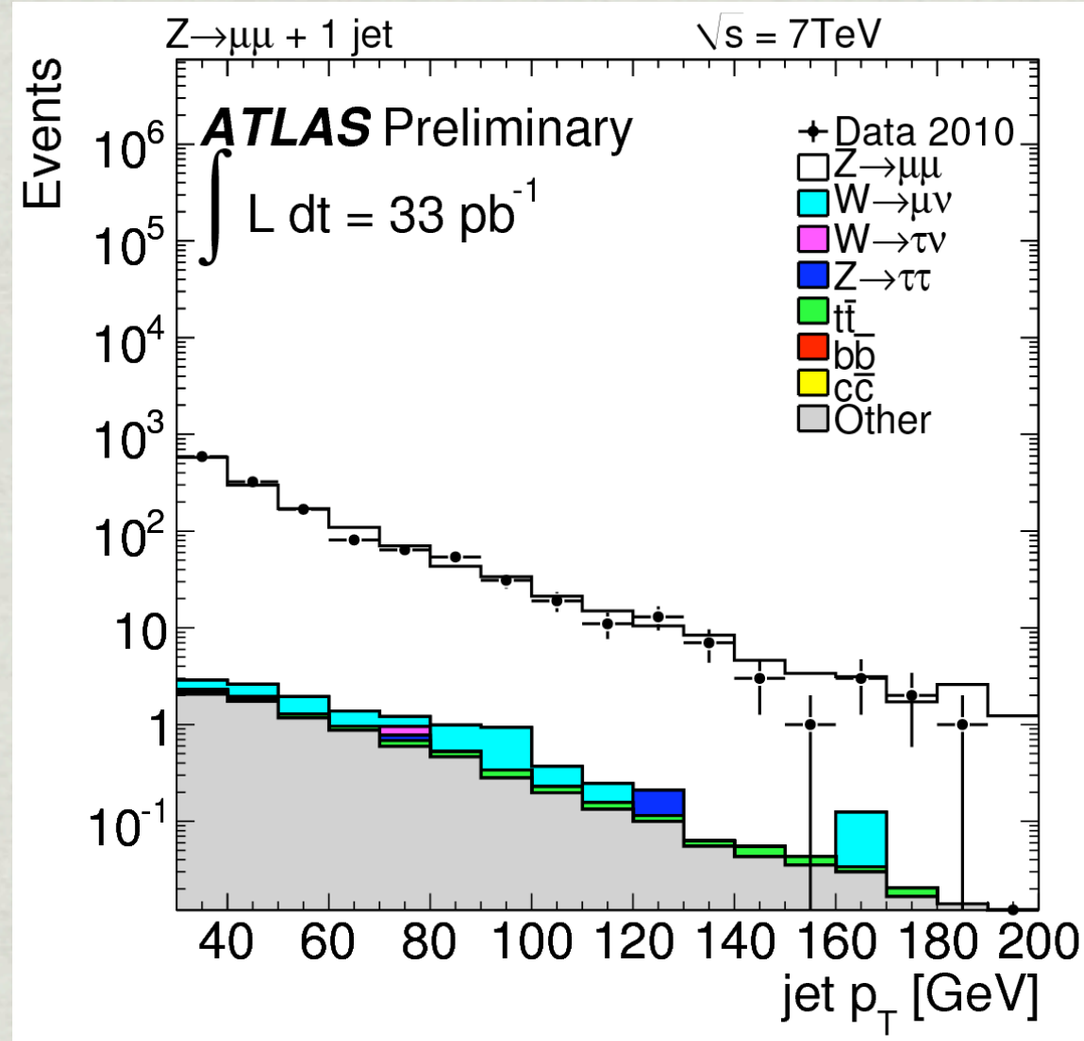




Control Plots II/II

Muon Channel



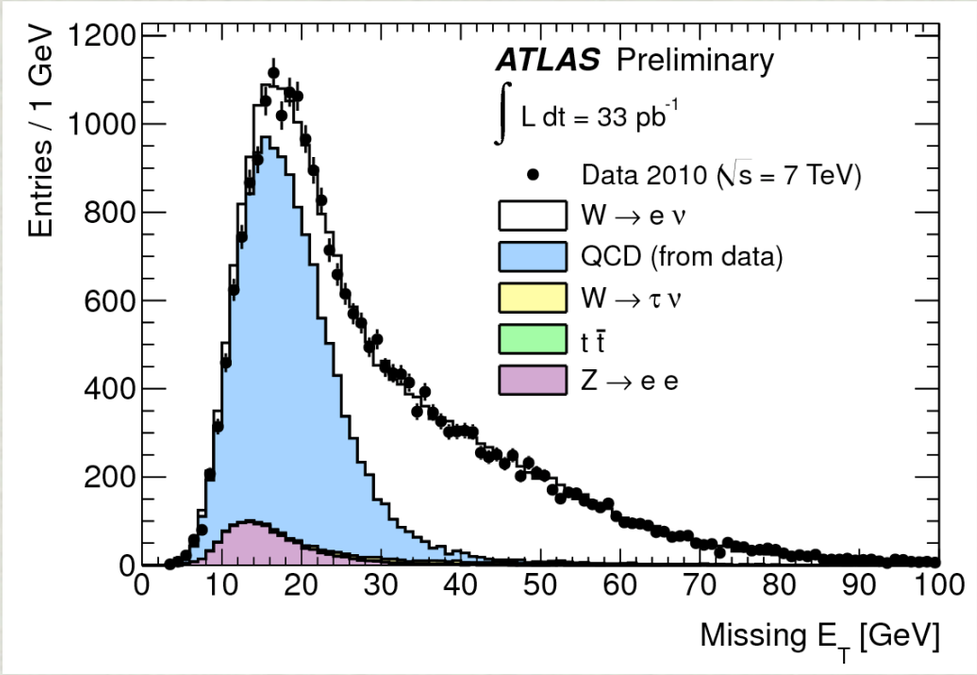


Backgrounds: QCD

- W →eν : Template Method
  - **Templating in E_{Tmiss}**, Signal and EWK backgrounds from MC.
  - **QCD shape taken from "anti-electron"**: Medium Electron + 2 tight cuts reversed + anti-isolation.
- W →μν : Isolation Efficiency
  - Comparison of the W candidates before and after isolation used to calculate QCD background:

$$N_{loose} = N_{nonQCD} + N_{QCD}$$
$$N_{iso} = \epsilon^{iso}_{nonQCD} \cdot N_{nonQCD} + \epsilon^{iso}_{QCD} \cdot N_{QCD}$$

- Z channels
  - Very small rates in both channels. Z→ee uses a similar template method to the W channel. Z→μμ compares non-isolated muon pairs in simulation and data, and uses this to scale the simulated QCD samples.



- **Fit Range:**
  15 < Missing E_T < 55 GeV
- Plot is after transverse mass requirement is applied.

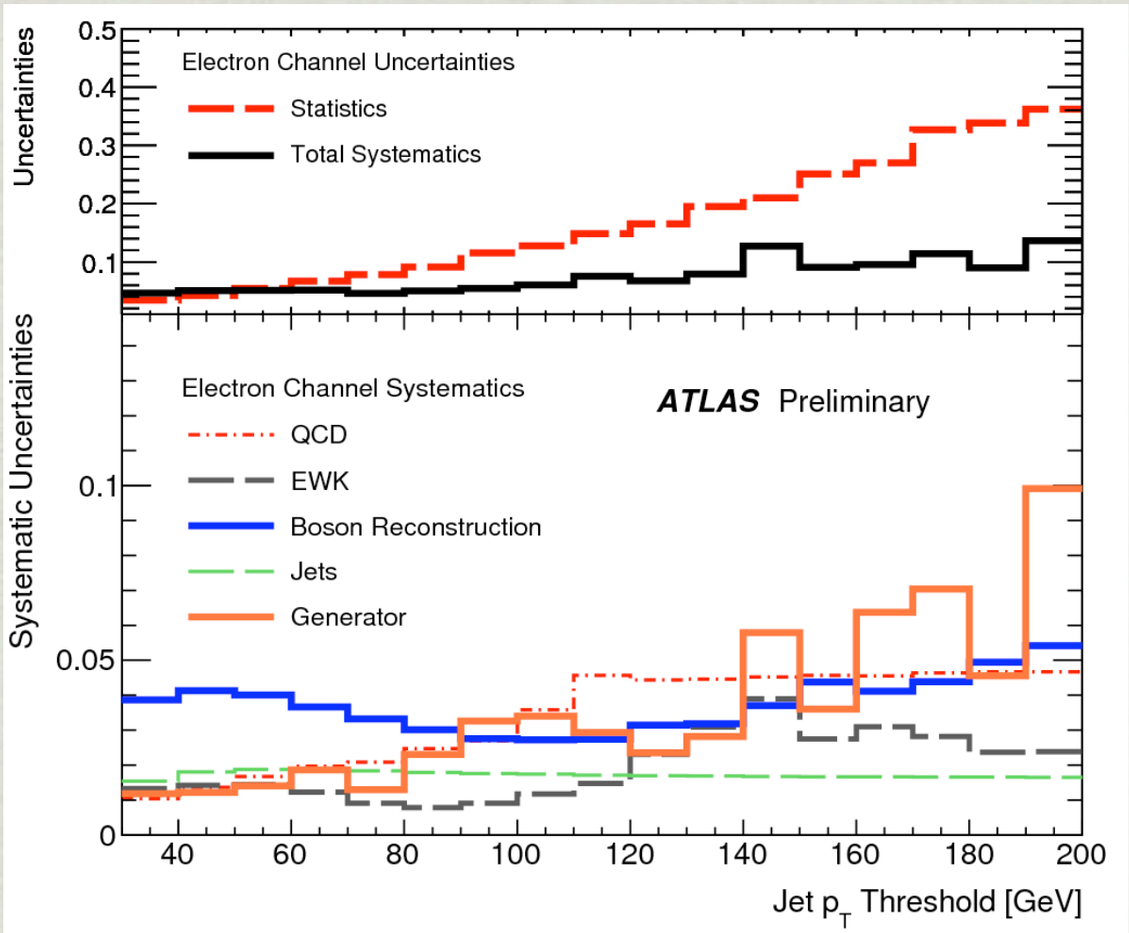
Backgrounds: Electroweak

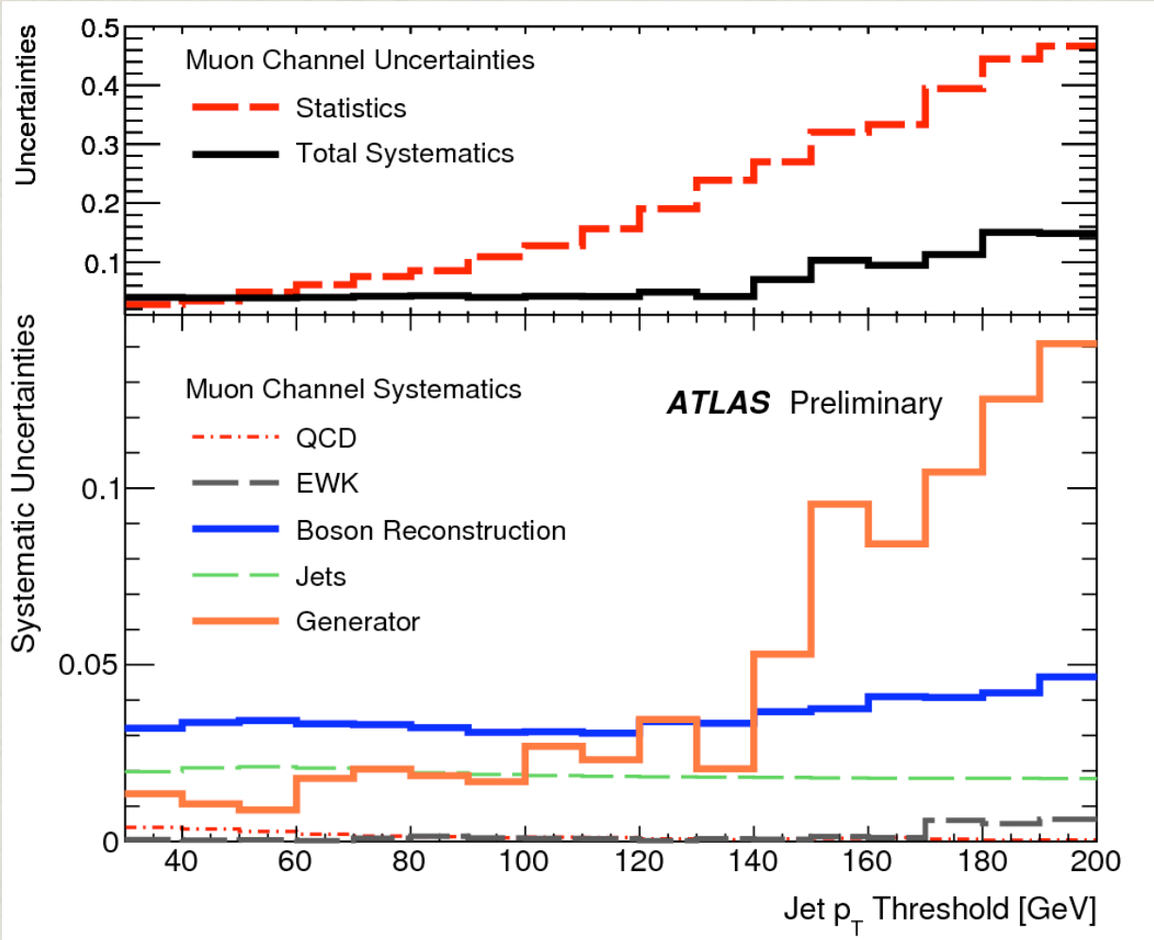
- Calculated from MC
  - Calculated as a fraction of signal plus all electroweak backgrounds.
  - These backgrounds should be proportional to the signal cross section, which means this has a smaller uncertainty than an absolute background estimate.
  - Small percentage in both channels. ~5% for the W channel, <1% for the Z channel.
  - Systematics on this are larger in the electron channel (due to lepton ID, MET resolution, etc), but the effect on the ratio is still small (~1%)

$$f^i_{ewk} = \frac{N^i_{ewk}}{N_{signal} + \sum_j N^j_{ewk}}$$

Systematics Summary

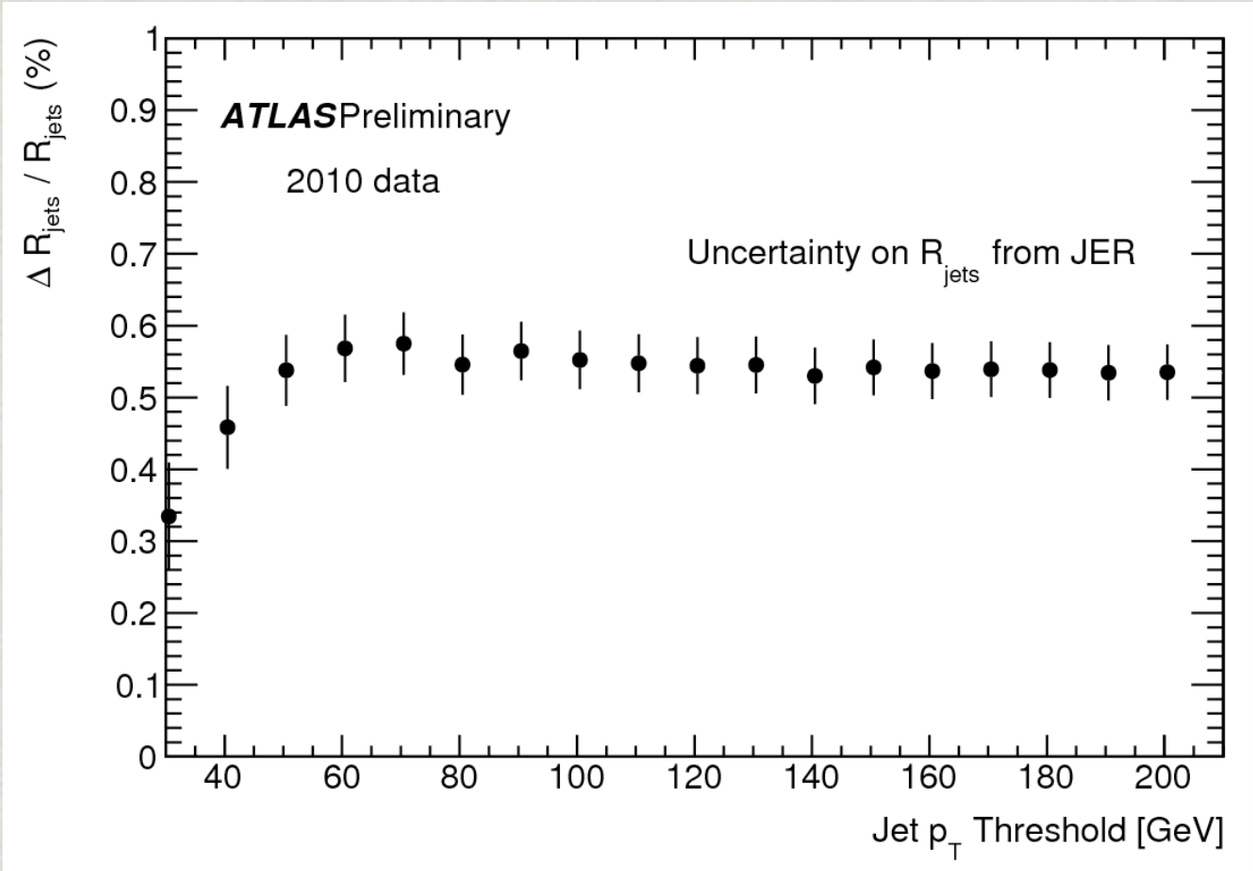
- Systematics are measured on ratio. (maximizes cancelation)
- The measurement is statistics limited over most of the p_T range.
- Systematics include varying: scale and resolution, multiple collisions, selection cuts in background and efficiency studies.
- Generator systematics based on difference of ALPGEN against PYTHIA for each input to the measurement, all impacts summed in quadrature.
- In the Muon channel the large generator systematic comes from C_V, but this is likely due to poor MC statistics in this pT range.

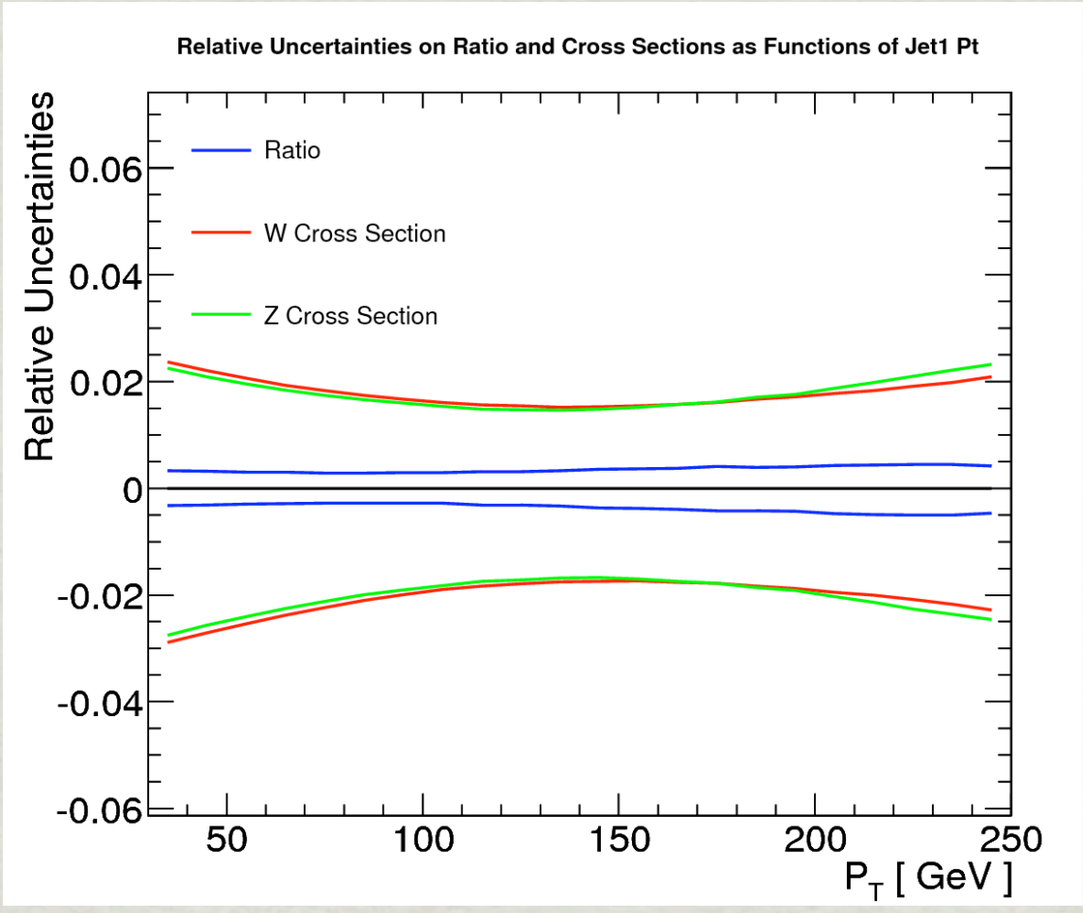




Systematics Cancelation

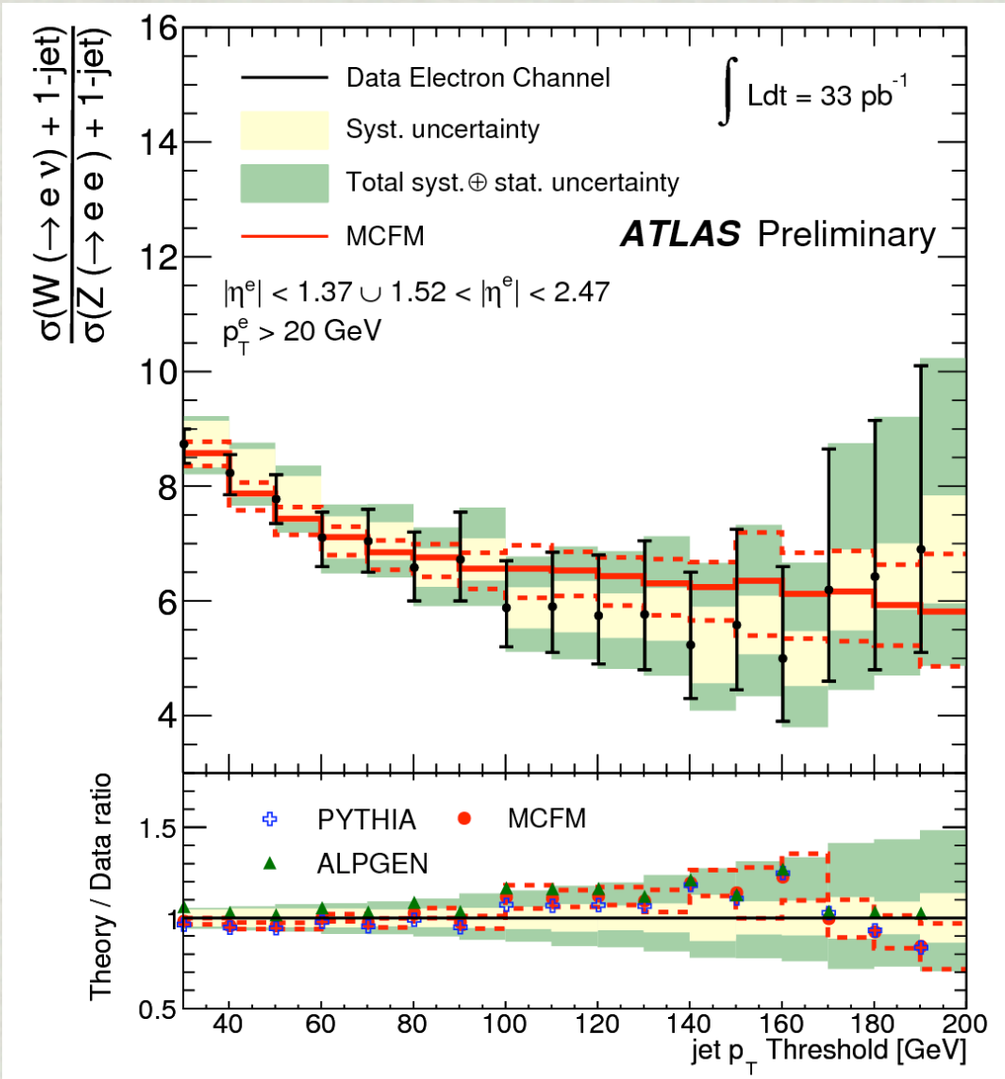
- On the lower left is the uncertainty on the ratio from the jet energy resolution. Jet energy scale uncertainties are also small.
- The lower right shows the theoretical systematics due to PDF uncertainties. As expected, these are much smaller when looking at the ratio.



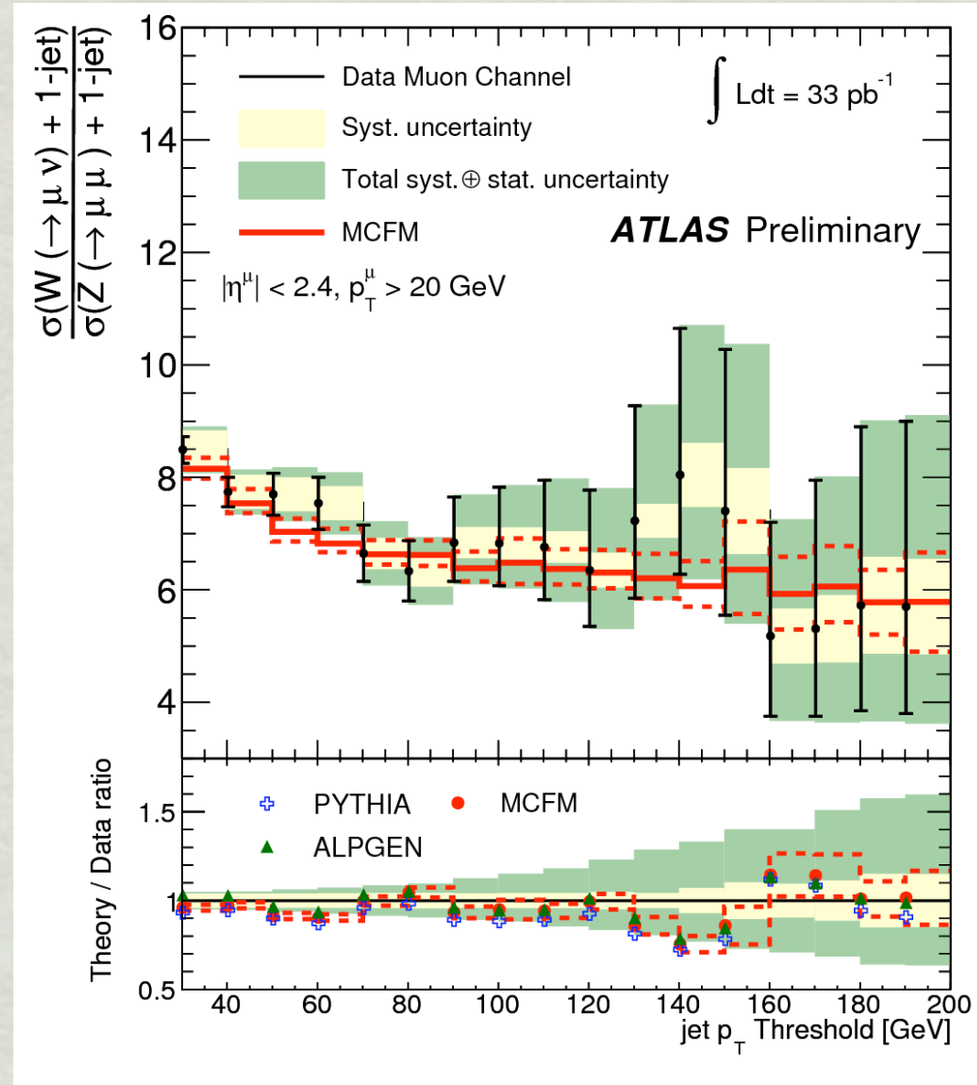


Results

Electron



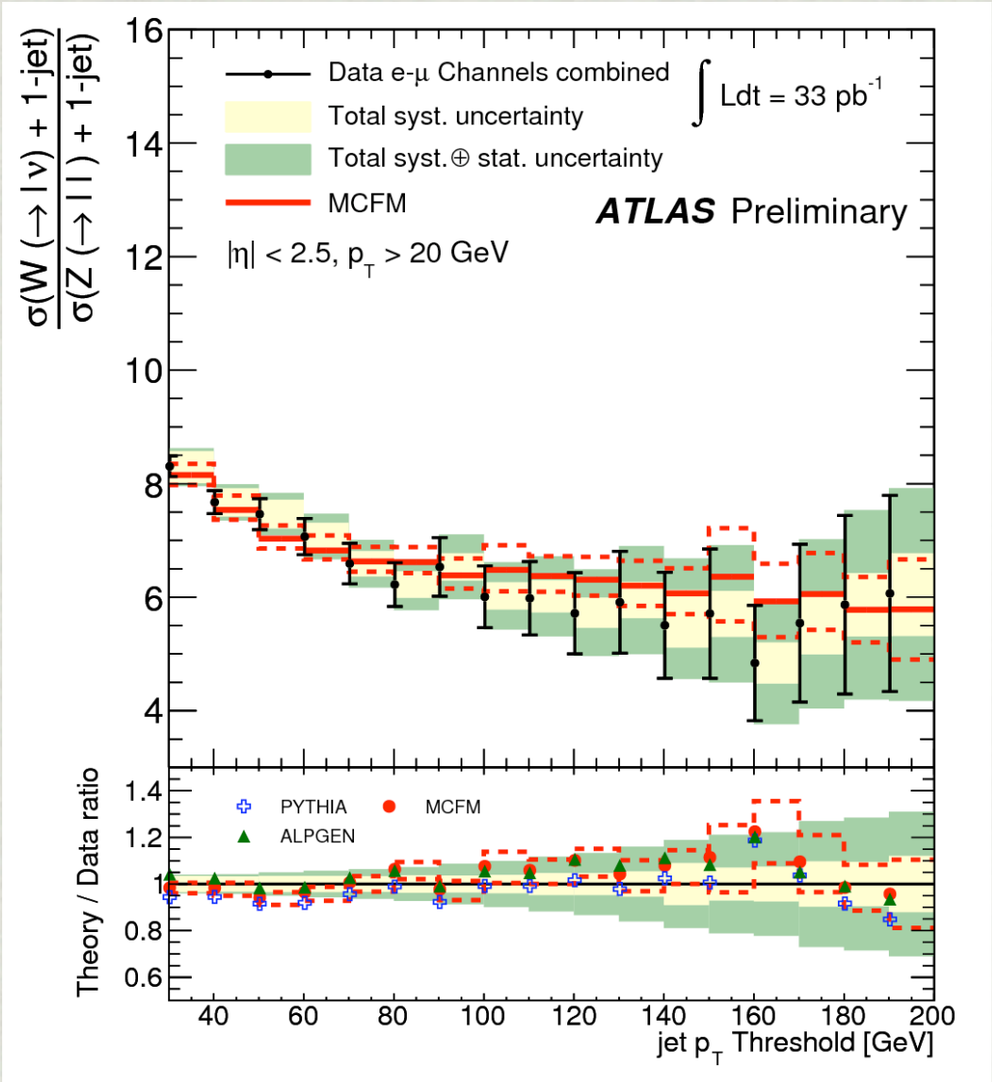
Muon



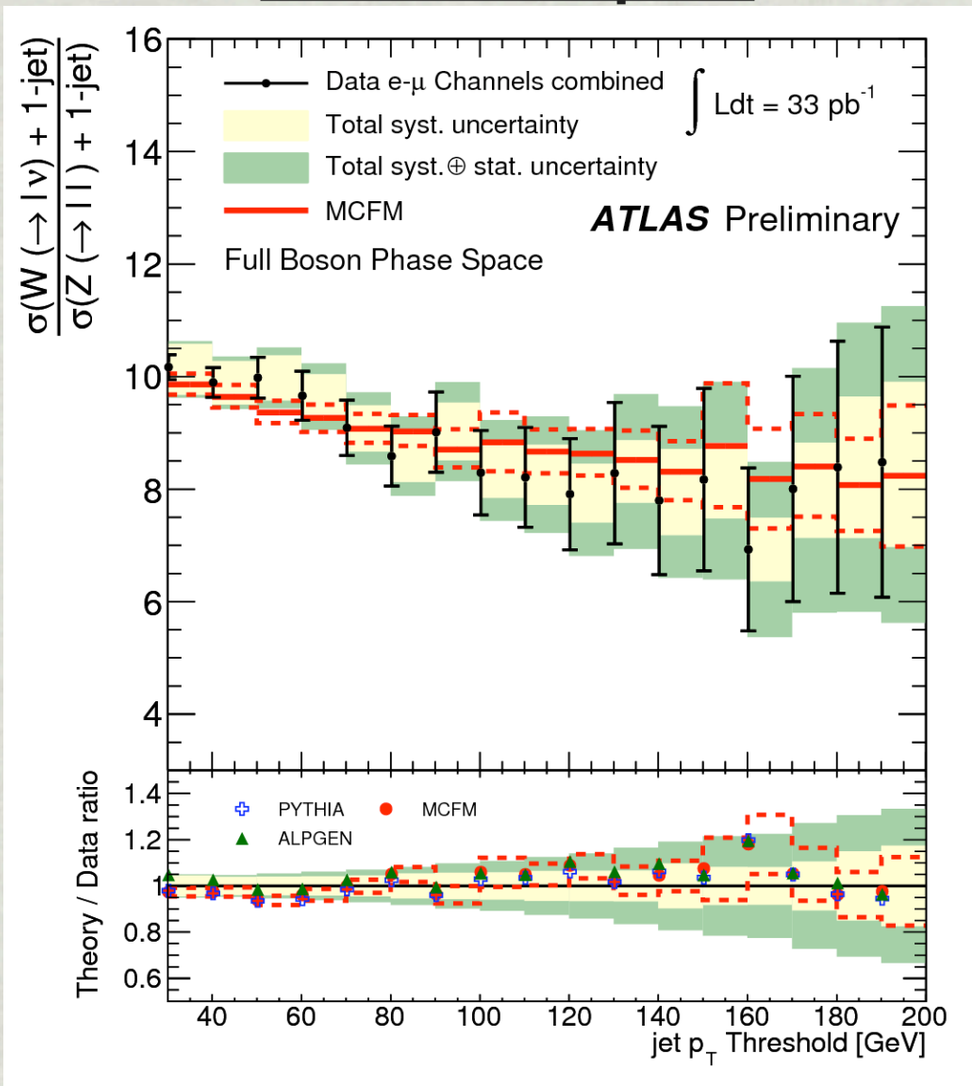
- Uncertainties added in quadrature.
- Good agreement between theory and data.
- Recall that bins are not statistically independent.
- Statistics limited past the first few jet p_T threshold bins.
- Both MC and data statistics are poor above 140 GeV or so.

Combined Results

Fiducial



Full Phase Space



- Results are extrapolated to a common phase space in order to allow direct combination: $|\eta| < 2.5$.
- The results on the right are extrapolating to the full boson phase space.
- The data is well modeled by the simulation.

Conclusions and Future Work

- Novel results: W/Z cross section ratio in 1-jet bin as a function of jet p_T.
- Results are consistent with theoretical predictions.
- Paper in preparation to be submitted to Physics Letters B.
- We plan to repeat the measurement with the full 2011 dataset. More results will be examined, particularly the two-jet bin, binned in either the scalar sum p_T or the invariant mass of the jets.
- This measurement is robust against detector and theoretical uncertainties which will become important with higher statistics.
- We hope to see exciting new results in the coming months/years!