Plans for V+jets studies

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On behalf of the Atlas Collaboration

Content:

- Introduction
- Experimental set up
- Analysis preparation
- Generator studies

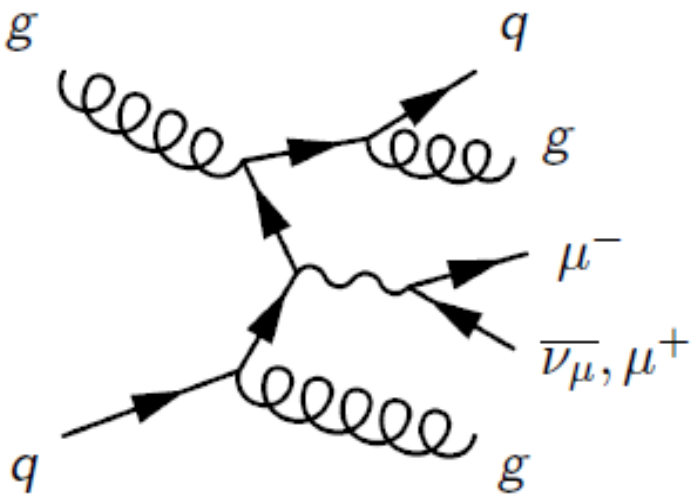
W/Z+jet at LHC

Probing QCD:

- PDF in unexplored region (high Q^2, low x)
- NLO calculations of W/Z (p_t spectrum)
- Large phase space for additional jets

Background for (new) physics:

- Top Quarks: W/Z+2/4 jet signatures
- SUSY: Leptons+Jets+Missing Energy
- Higgs Boson: Z+b/W+b



Calibration and Benchmark:

- In-situ calibration of lepton efficiencies
- Jet energy balancing
- Missing transverse energy resolution

Expected data set

Assuming 100 pb^{-1} at 7 TeV LHC energy:

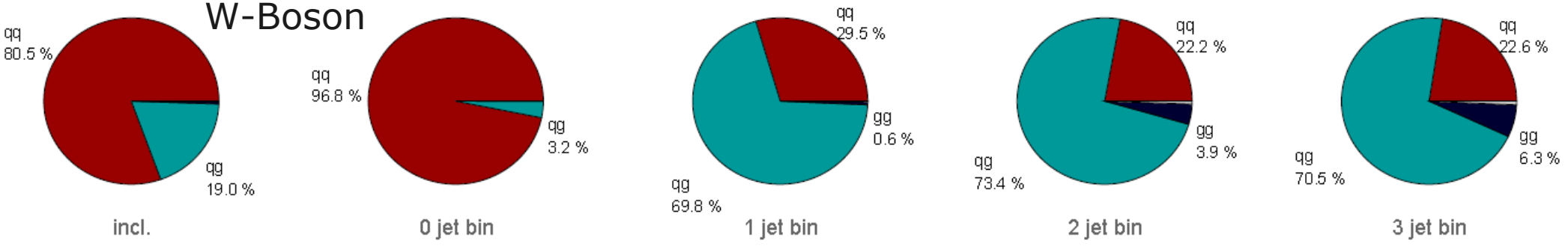
→ 90K W events per leptonic ($l\nu$) channel

→ 9K Z events per leptonic (ll) channel

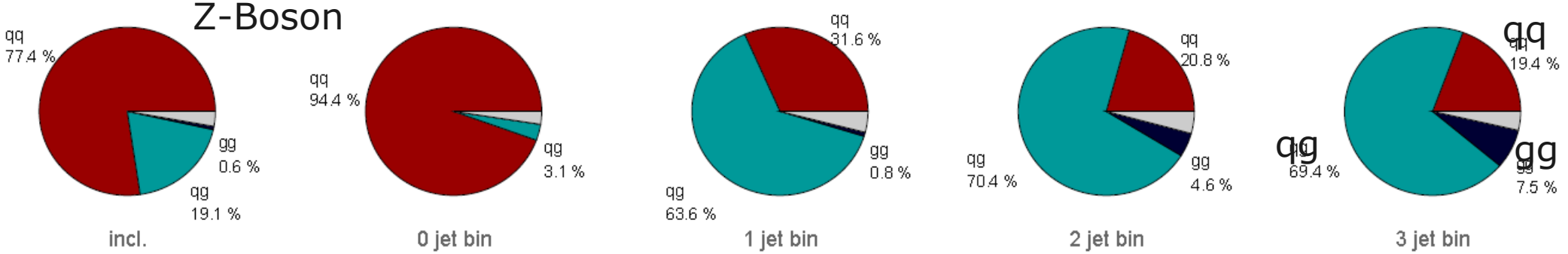
→ a few 100 W+4jet and Z+3jets events

Production (initial state) mechanism depends on final state (Sherpa 1.1.3, 20 GeV hadron jets):

W-Boson



Z-Boson



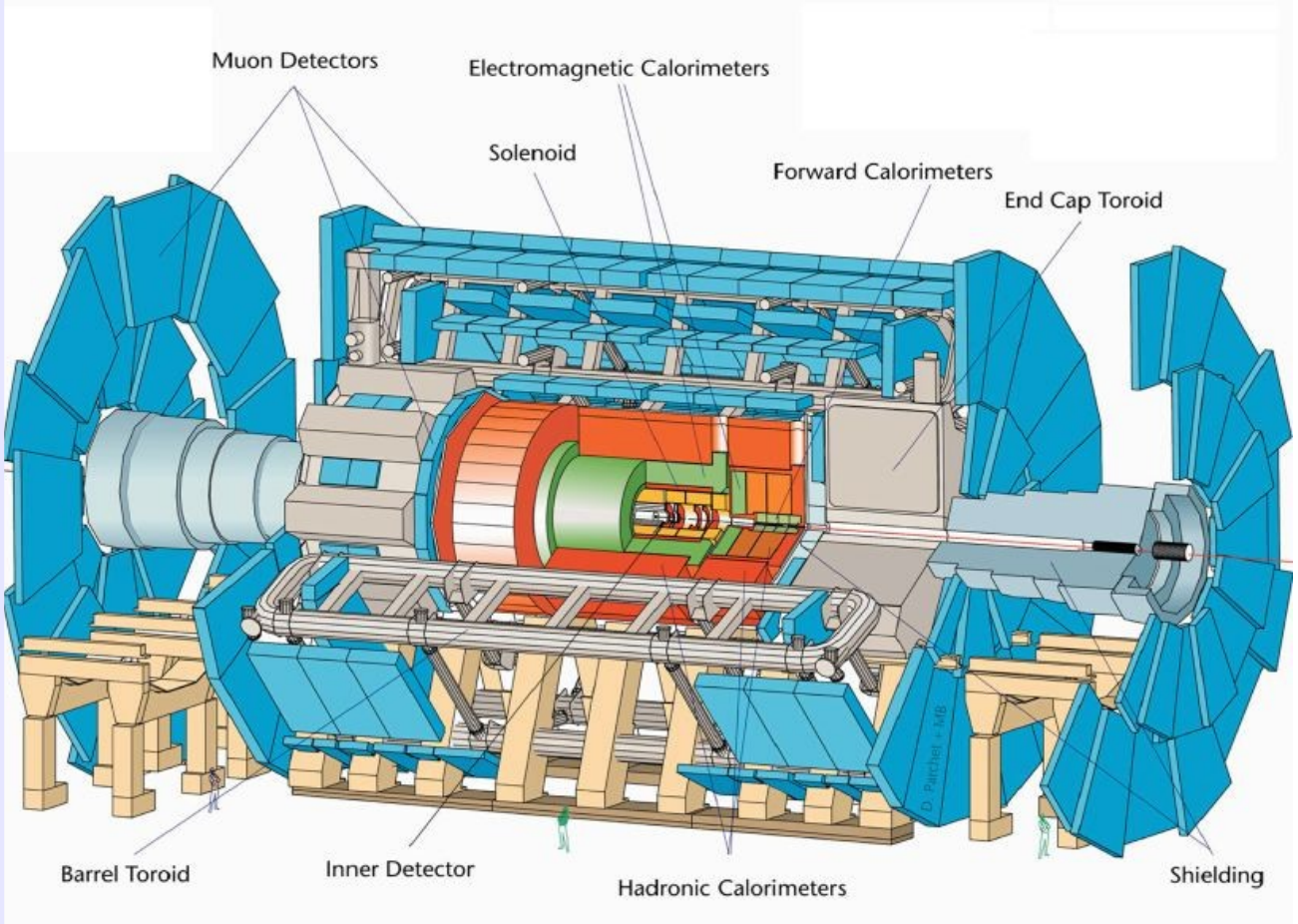
Atlas Detector

Tracking system consists of 3 pixel layer, 4 silicon strips and TRT

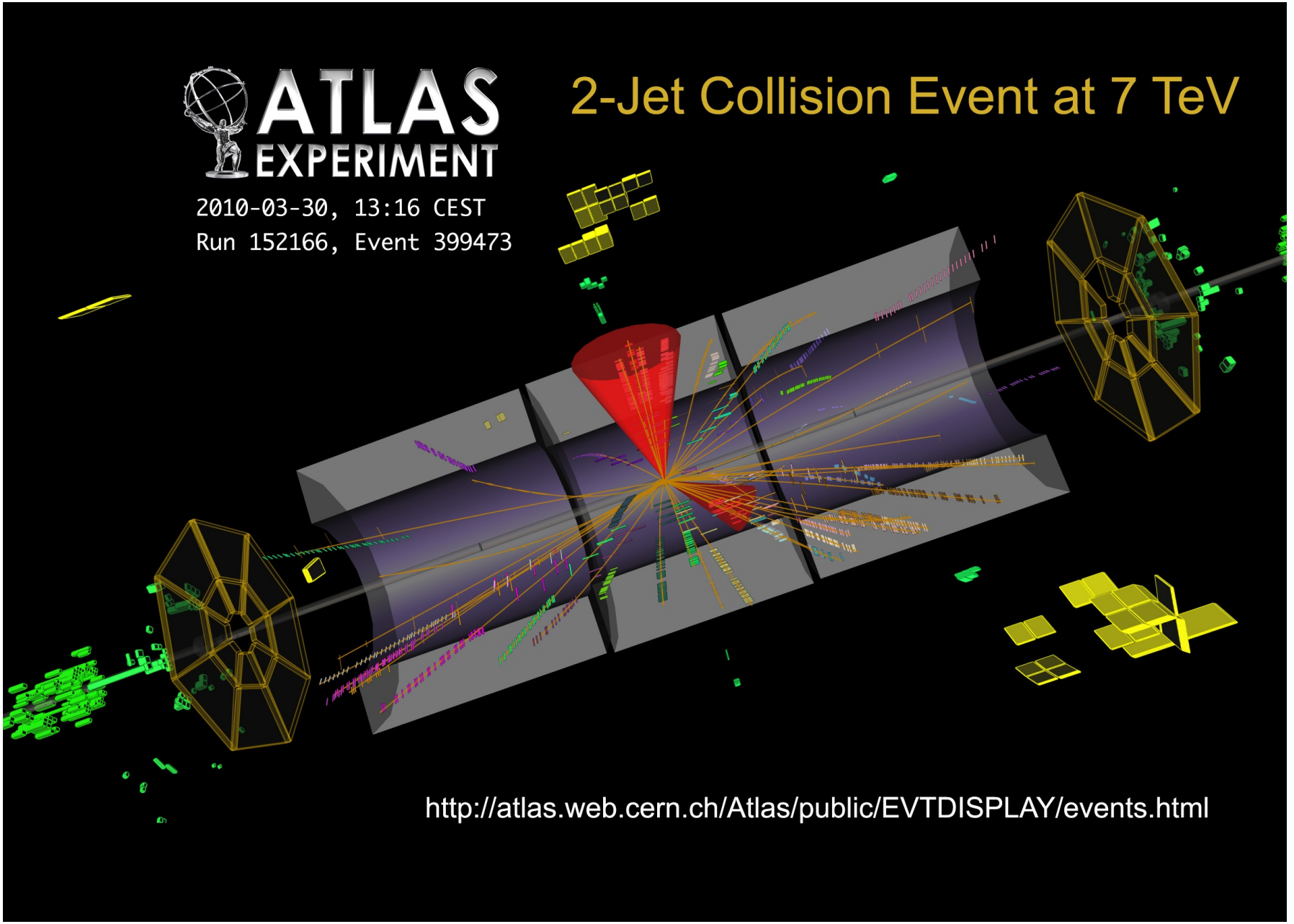
Electron and Jets:

Liquid Argon Calorimeter+Tile barrel

Large Muon Toroid System



Event from first data taking



Selection Strategy

For V+jets:

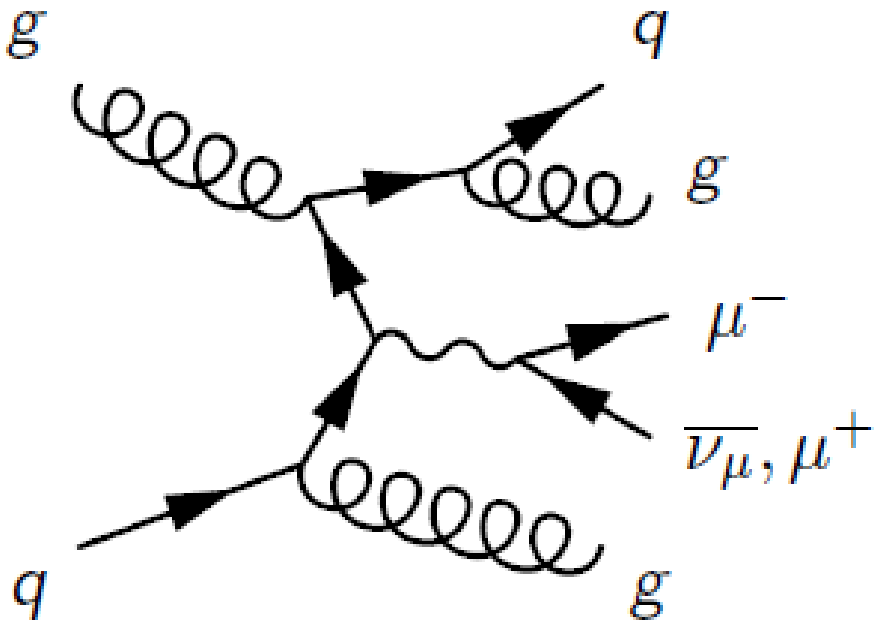
→Trigger on lepton(s)

→Select high energetic lepton

→Select Boson:

- W: Missing Energy
- Z: Mass M_{ll}

→Reconstruct and count jets



Planned Measurements

Cross sections:
- W+n jet
- Z+n jet

Cross section
At the beginning large systematics (jet energy scale, luminosity)

Ratios:
- W(n jet)/Z(n jet)
- W(n jet)/W(inclusive)
- Z(n jet)/Z(inclusive)

A lot of systematics cancel out (luminosity, fragmentation, jet energy scale for W/Z...), different systematics for different measurements,nice for background subtraction studies ...

Other:
- Underlying event in W/Z
- Heavy flavors in W/Z

Use robust b-tagging algorithm for first data

Analysis examples

Analysis examples

Examples shown here:

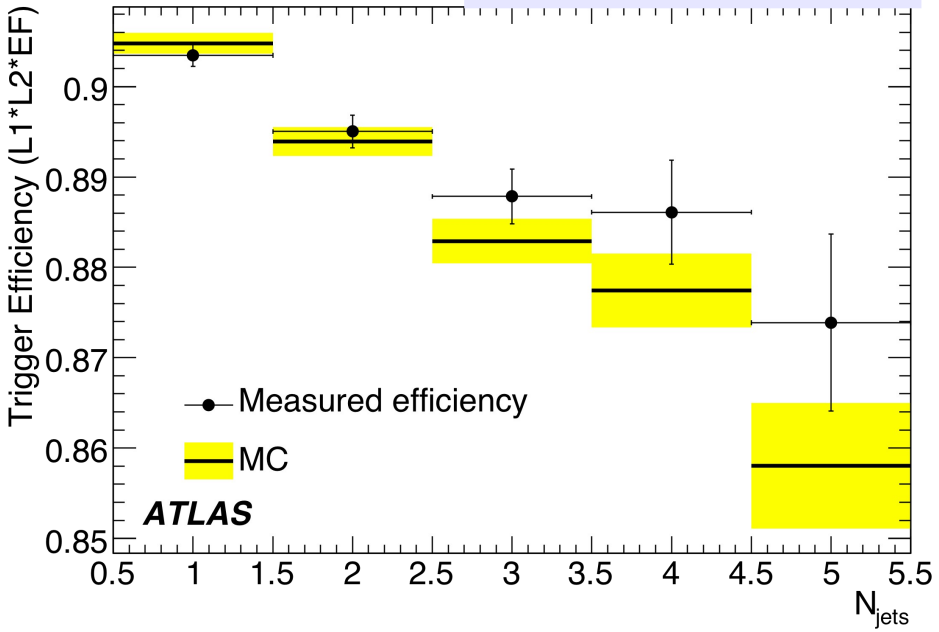
- Energy 14 TeV and 1 fb^{-1} Luminosity
- Preparation for 7 TeV is ongoing:
  - Changed some important selection parameters:
    - Cone jets → anti-kt jets
    - Better Lepton isolation criteria
- NLO calculations with MCFM using scale $m_V^2+p_t^2$
- Events generated with Alpgen 2.05 and Herwig
  - PDF is CTEQ6L, Matching with MLM
  - Special matching studies for heavy flavour (overlap removal)

In situ calibration of trigger

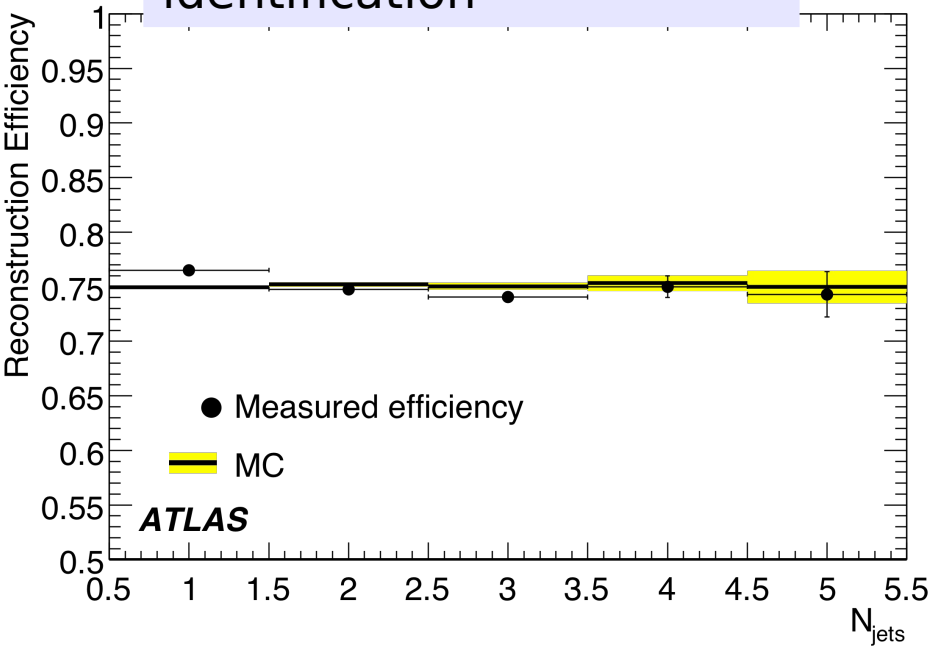
Data driven efficiency:

- "Tag and Probe"
- Z+jet with 25 GeV isolated electrons
- Trigger efficiency affected by hadronic activity

Trigger efficiency



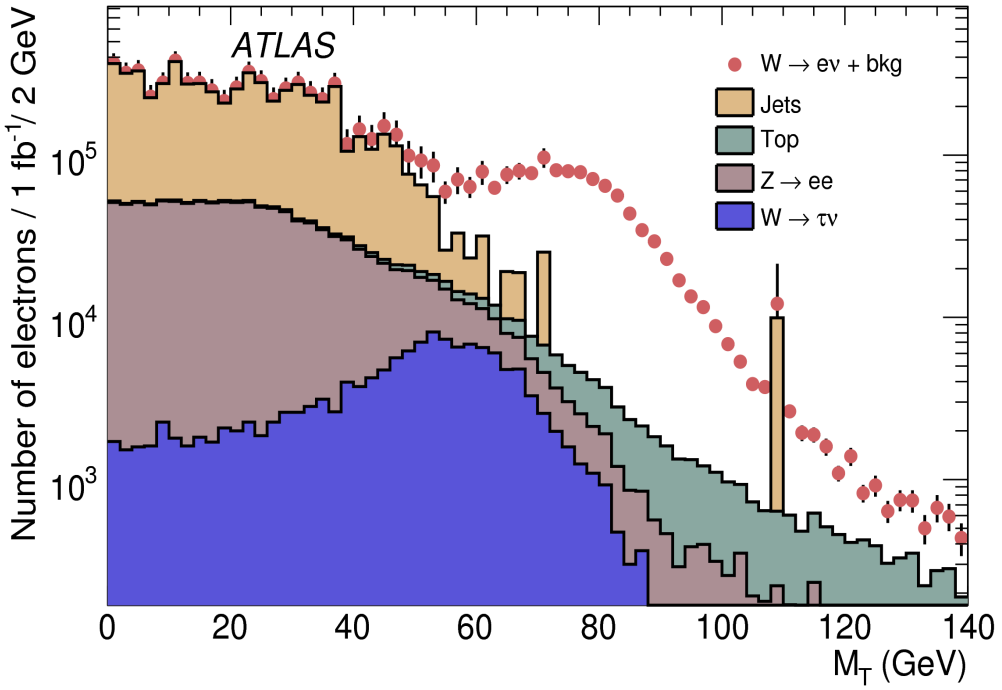
Reconstruction + identification

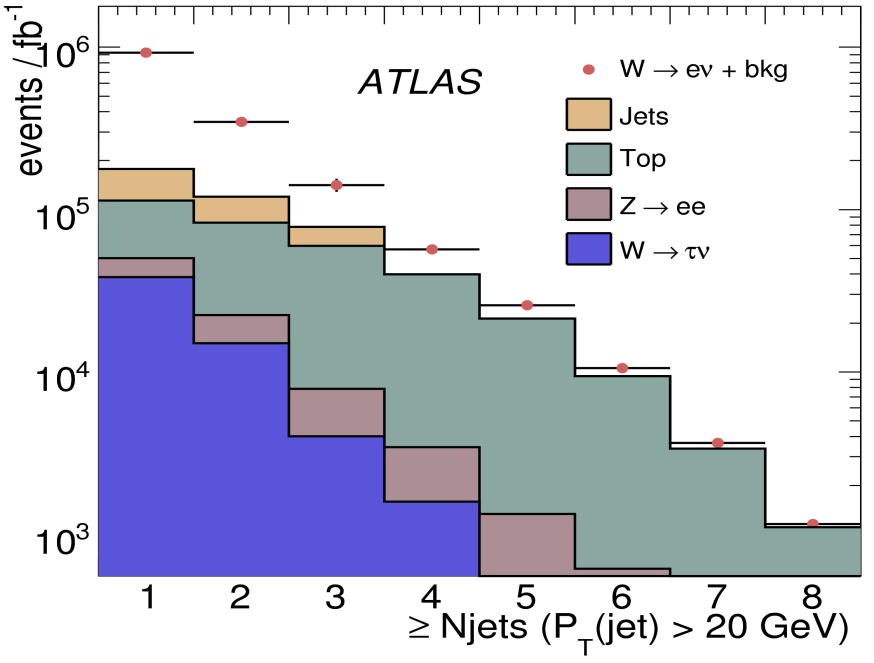


W selection

W → e ν:

- Isolated electron with p_t > 20 GeV
- Missing energy > 25 GeV
- 20 GeV Cone jets with R=0.4
- Data driven methods to estimate background





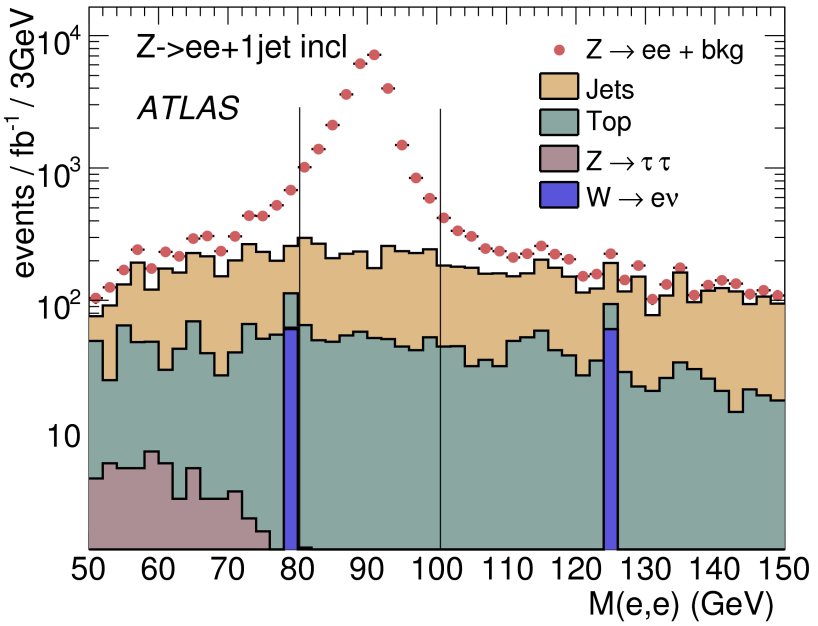
Z+jet selection

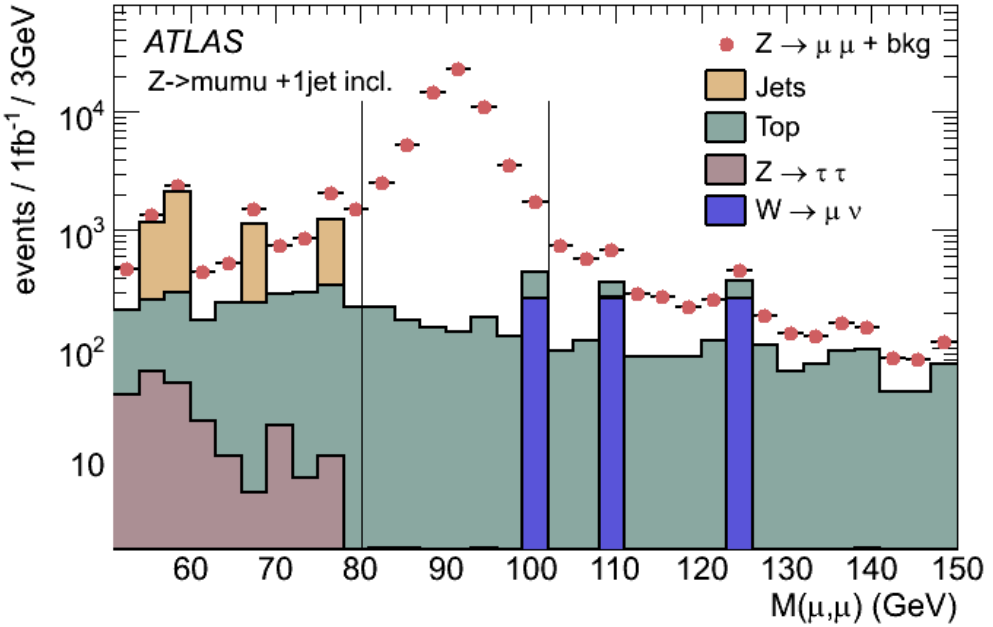
Z → ee:

- Isolated di-Electron or single Electron trigger
- Electron: E_t>25 GeV
- Cone jets (R=0.4) E_t>40 GeV
- Background: Side band fits

Z → μμ:

- Isolated di-Muon trigger
- Muon: p_t>15 GeV
- Cone jets (R=0.4) E_t>40 GeV
- Pretty small background

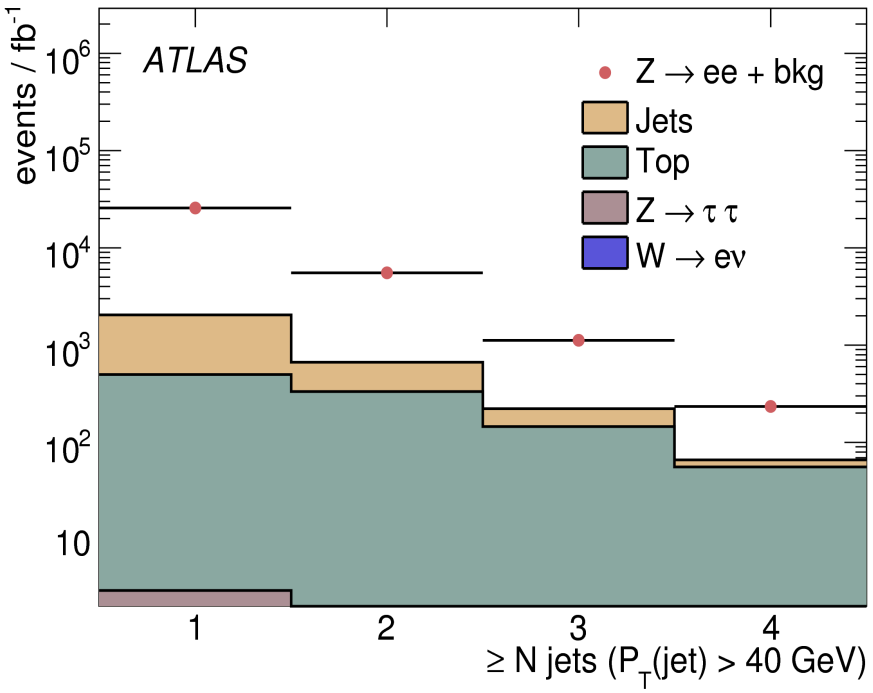


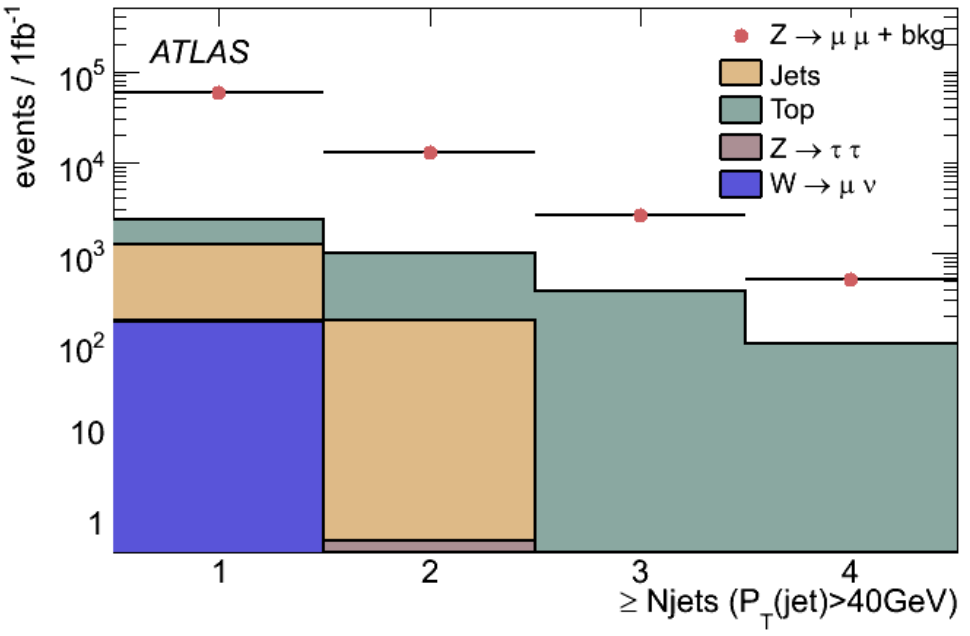


Z+jet spectrum

N jet distribution:

- huge sample with 1 fb^{-1} @ 14 TeV
- Expected events for 7 TeV and 100 pb^{-1} : a few 100 in 3 jet bin

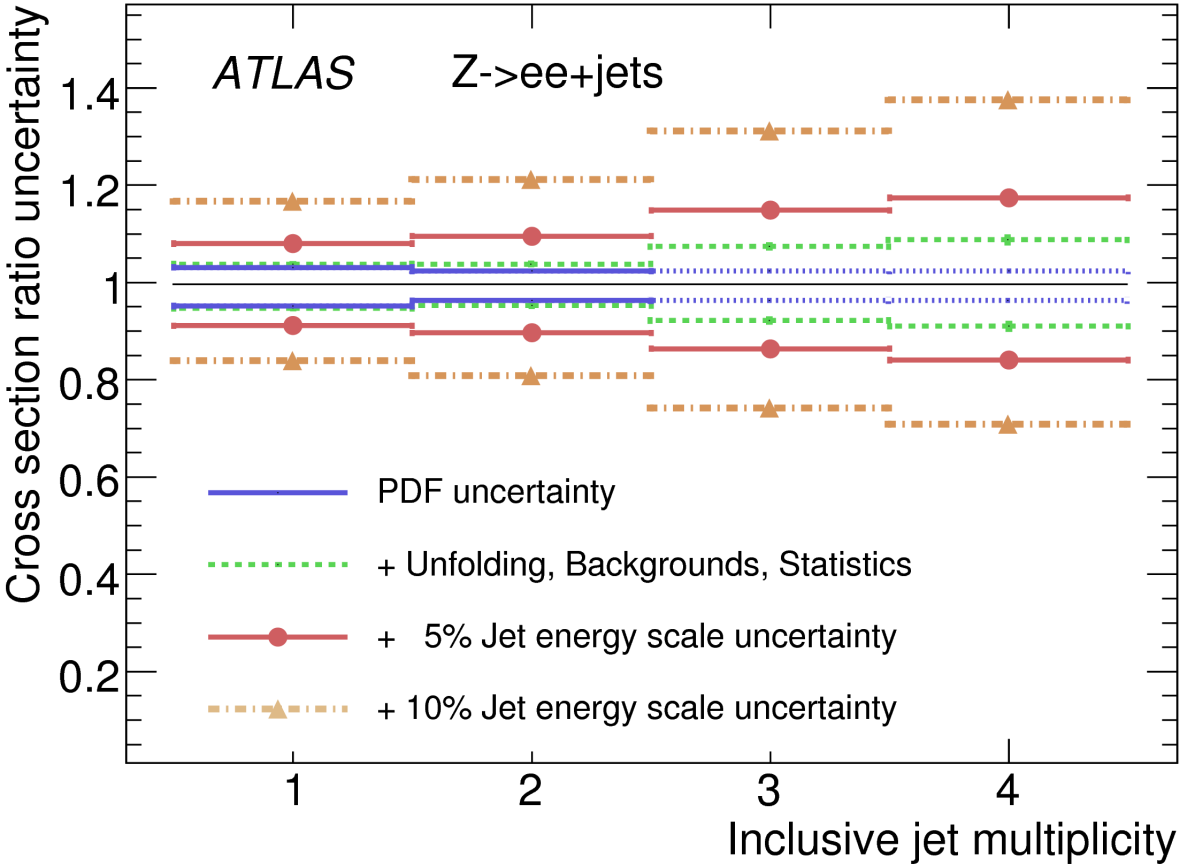




Systematics for Z(n+jet)/Z(inc.)

Early data:

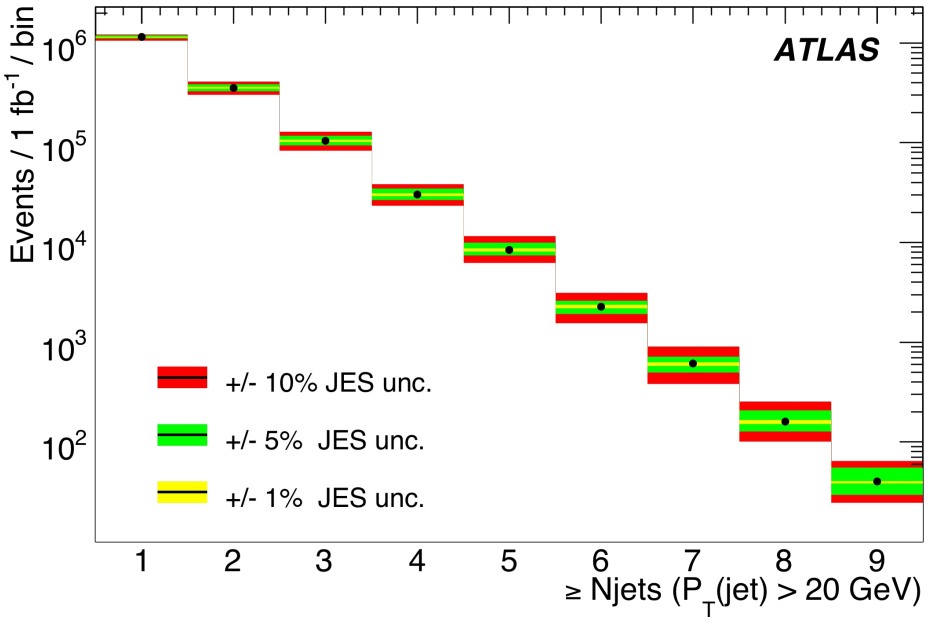
- Z(njet)/Z(inclusive)
- Systematic will be dominated by jet energy scale
- Luminosity additional systematic for cross section.

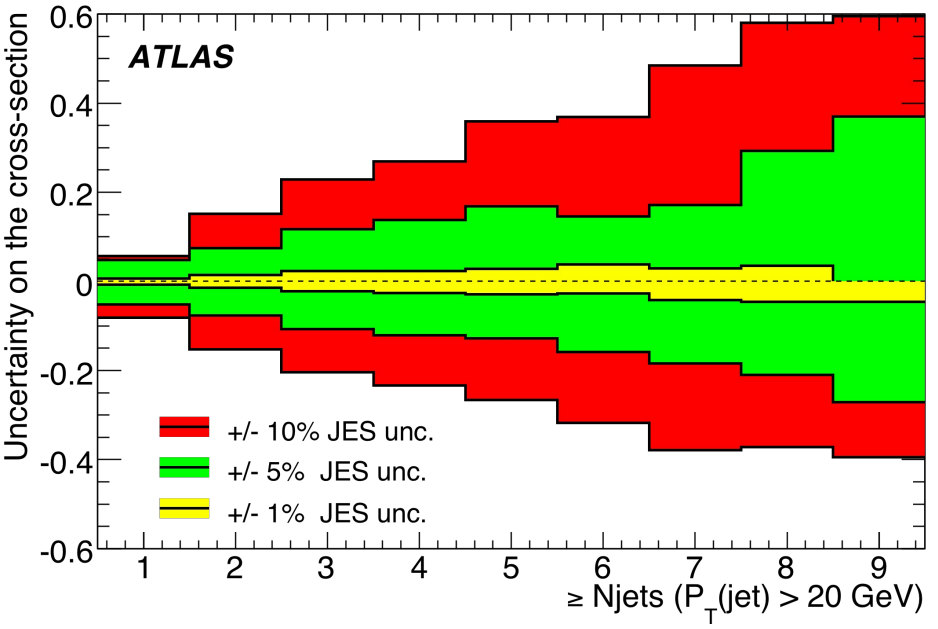


Jet energy scale

Jet energy scale:

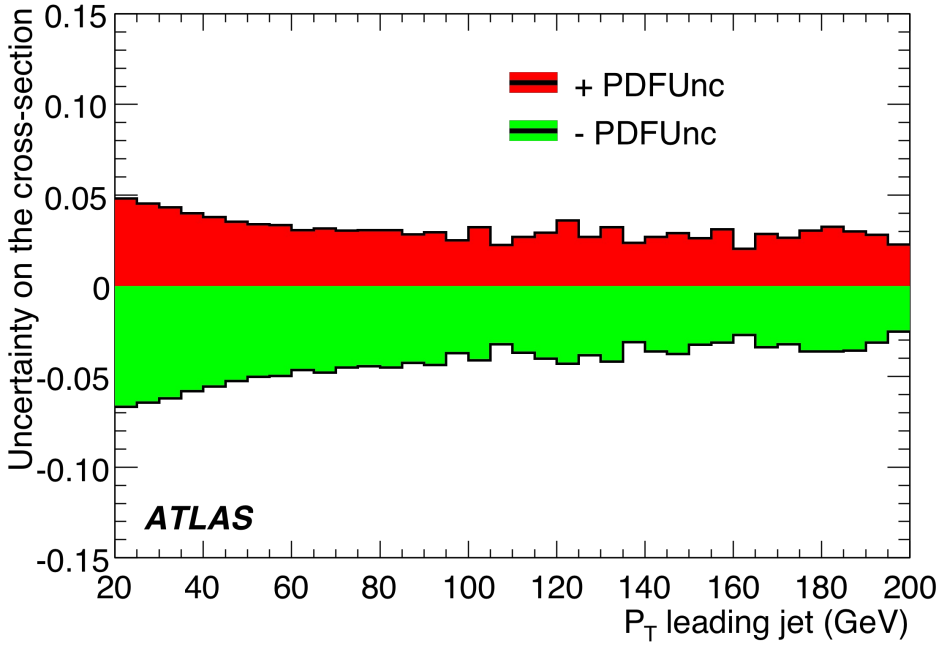
- Jet energy scale is large systematic for Z(njet)/Z(incl.)

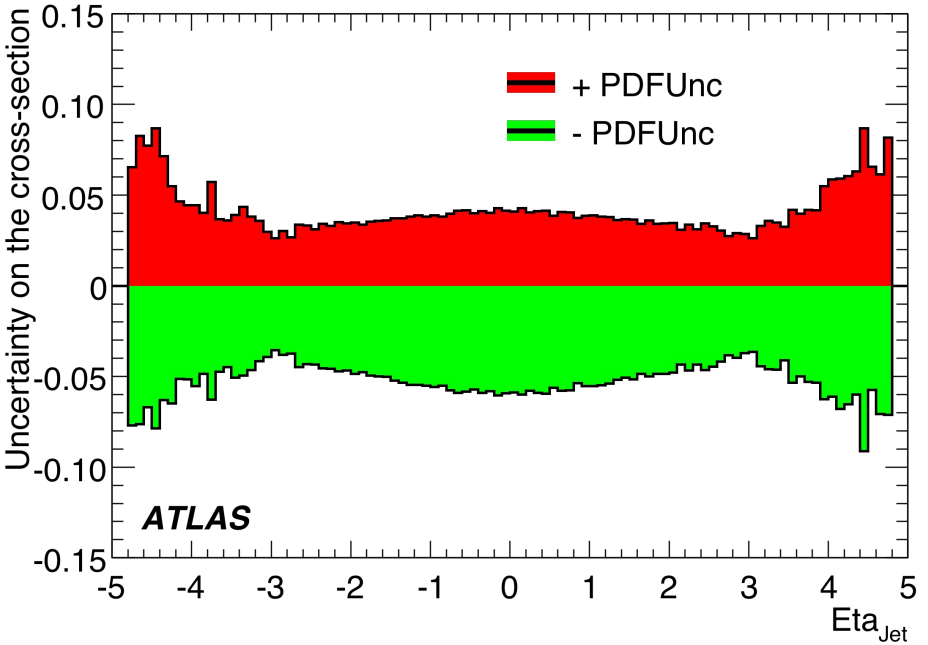




PDF uncertainties

- Using CTEQ6L errors
- Not the dominating systematics at the beginning of LHC





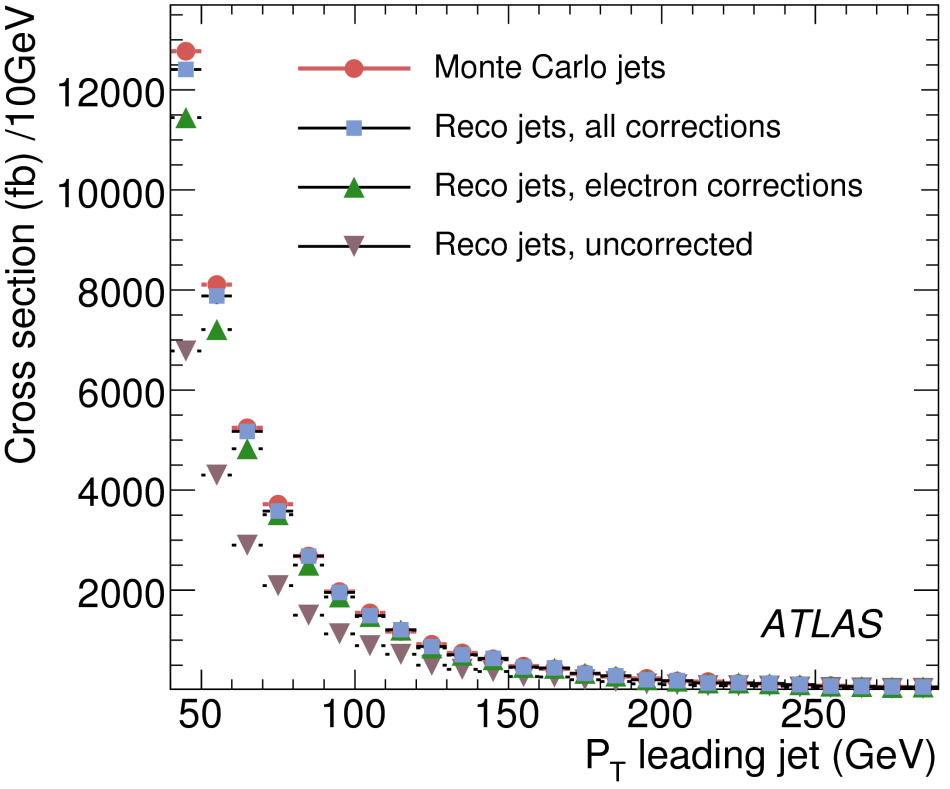
Correction to compare at generator level

Correct back to hadron level jets to compare with generator

- Electrons: Trigger, Acceptance, Selection efficiency
- Jet efficiency and p_t resolution
- (Underlying event and fragmentation corrections mostly important p_t<40 GeV)

Shown bin-to-bin correction: Also more sophisticated unfolding methods are prepared

Unfolding also used for Njet-spectrum (W/Z ratios etc)



Systematics summary

Systematics are different for different measurements:

- W+jets and Z+jets Cross sections:
  - Jet energy scale
  - Luminosity

- W(n jet)/W(inclusive) and Z(n jet)/Z(inclusive):
  - Jet energy scale
  - Different background composition in different bins:
    - QCD (huge uncertainty)
    - High number of jets: ttbar

- W(n jet)/Z(n jet):
  - Differences between W and Z selections:
  - Missing Energy
  - Ttbar background from N=4

Generator Studies

Monte Carlo generators

Pythia (Parton Shower)

- Easy to generate events
- Widely used for W,Z inclusive studies

Alpgen 2.13

- HERWIG for PS and hadronization, with MLM matching
- Pythia for systematics
- One sample for each jet multiplicity
- Also separate heavy flav. production
- Up to W+6jets, Z+6jets feasible
- PDF cteq6L1

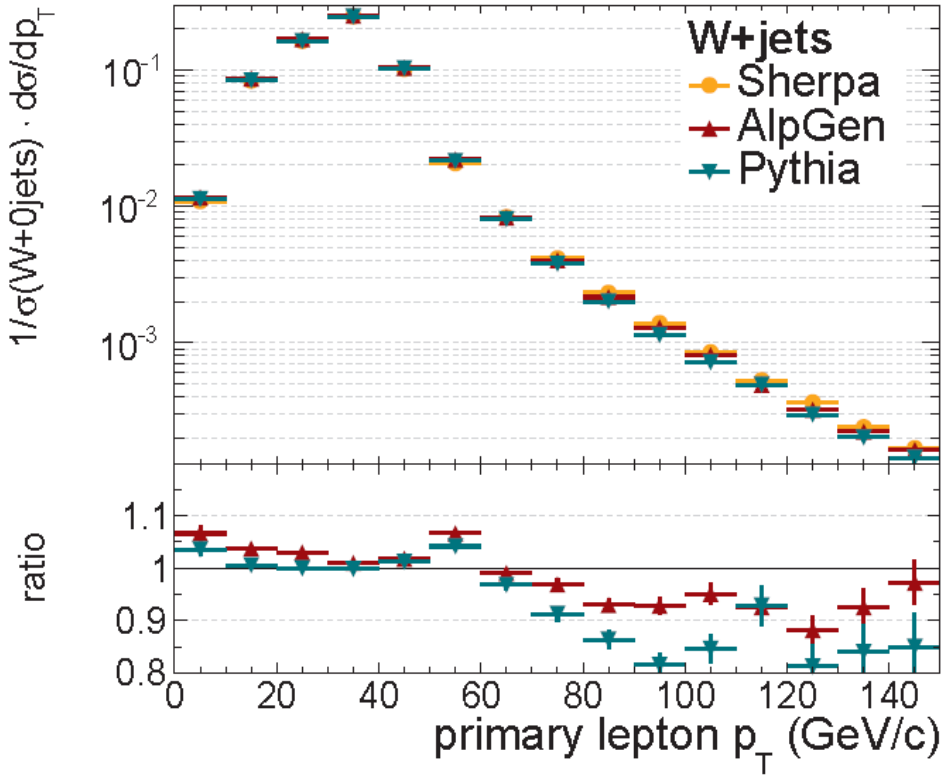
Sherpa Version 1.1.3

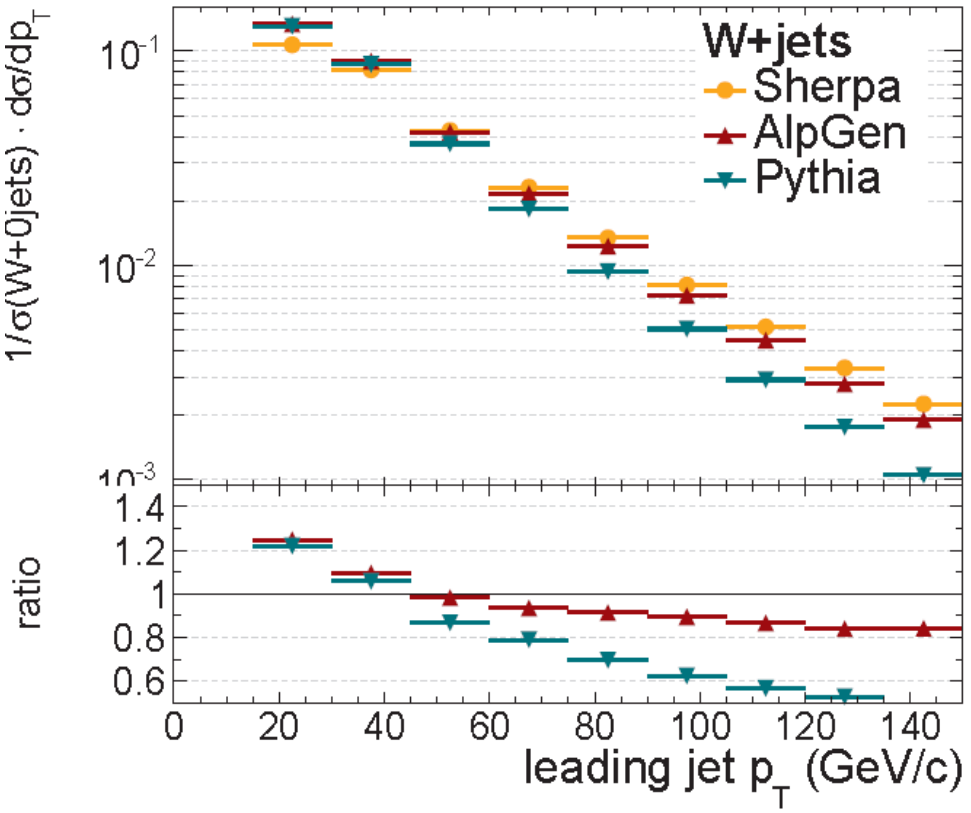
- CKKW ME/PS matching
- Samples inclusive (all jet multiplicities)
- Enhancement factors to enhance heavy flavour/high jet multiplicities
- Z+4jet, W+4jet: very long time for phase space integration
- Sherpa 1.2 in validation (W/Z+5jet faster then 4jet in 1.1.3)
- PDF cteq6L1

HELAC

- Validation the interface to atlas software
- First study for gamma+jets

Jet/Boson

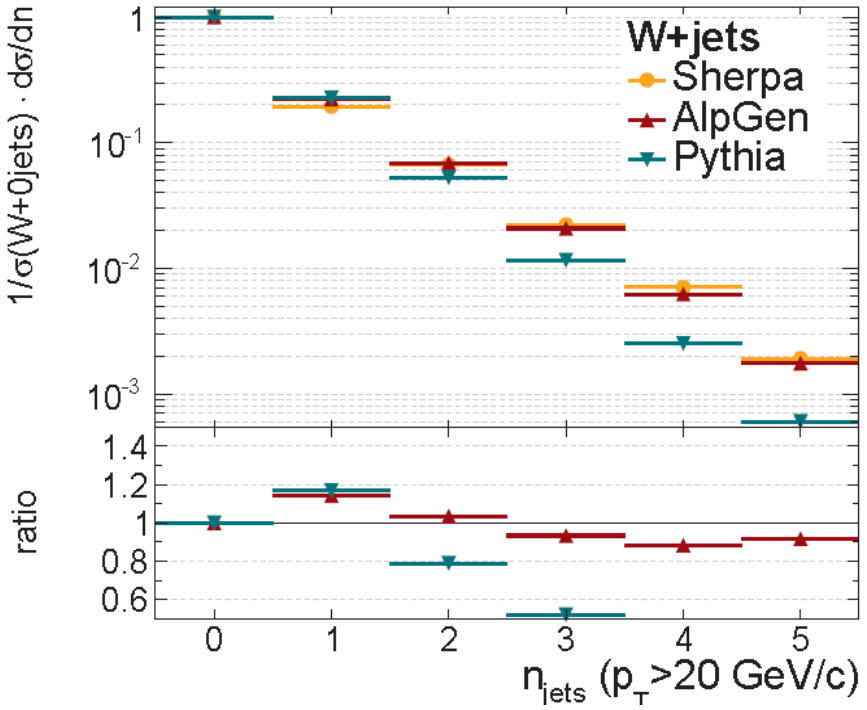


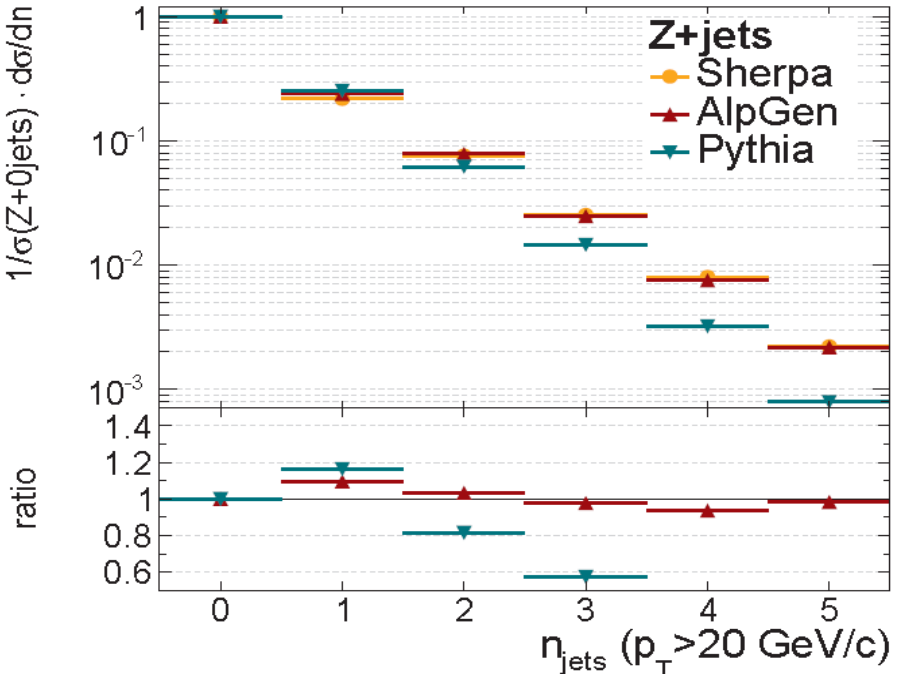


Lepton and leading jet pt:

➔ Sherpa a bit harder spectrum (knows feature)

W/Z njet distribution





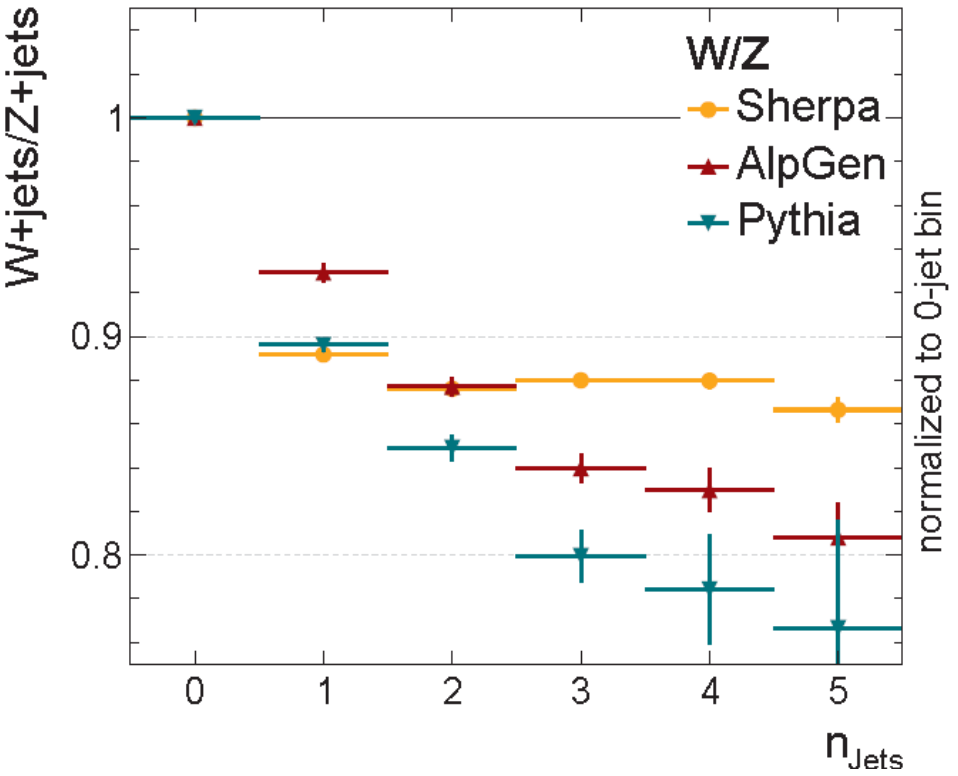
Njet for W(left) and Z(right):

- Alpgen and Sherpa agree up to 15%
- Mostly driven by higher p_t of jets

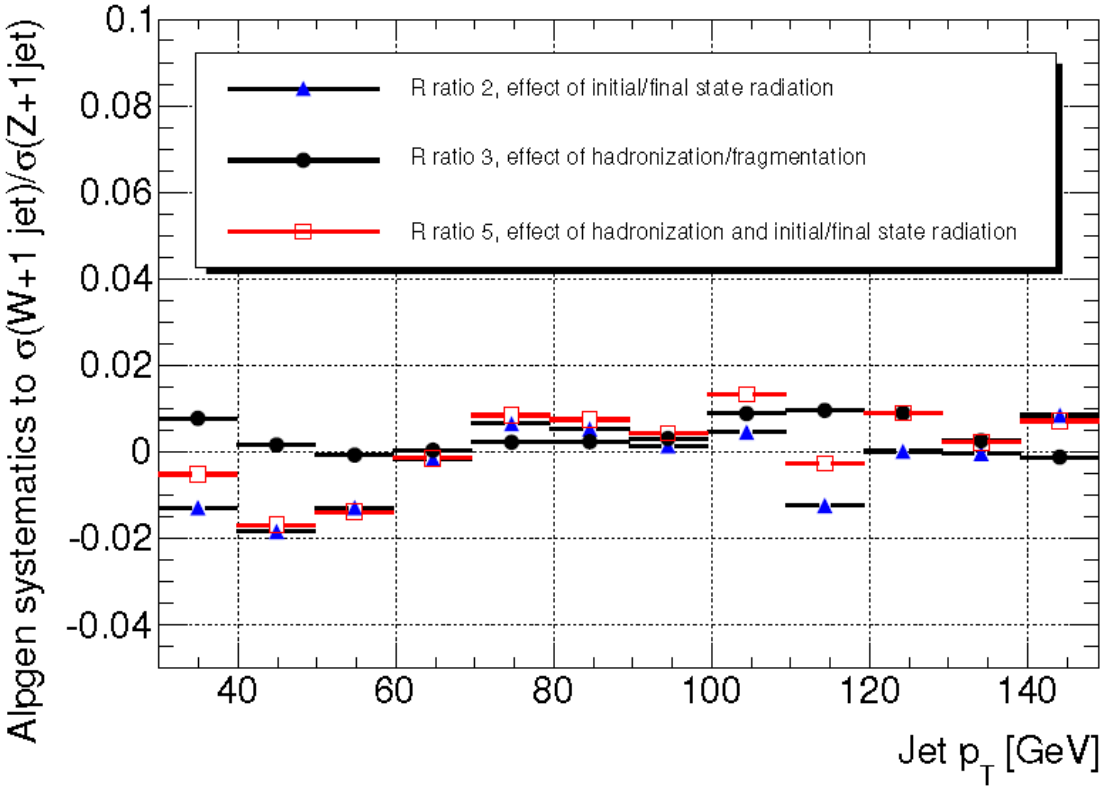
W/Z Ratio

Ratio normalized to W(0jet)/Z(0jet)

- Sherpa: constant from njet=1, tested that the ratio is 1 for $m_W=m_Z$
- Alpgen: more smooth behavior

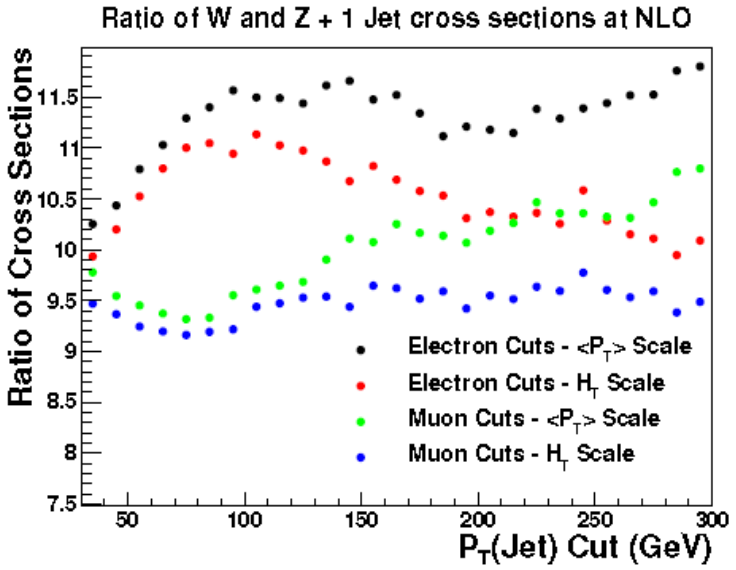


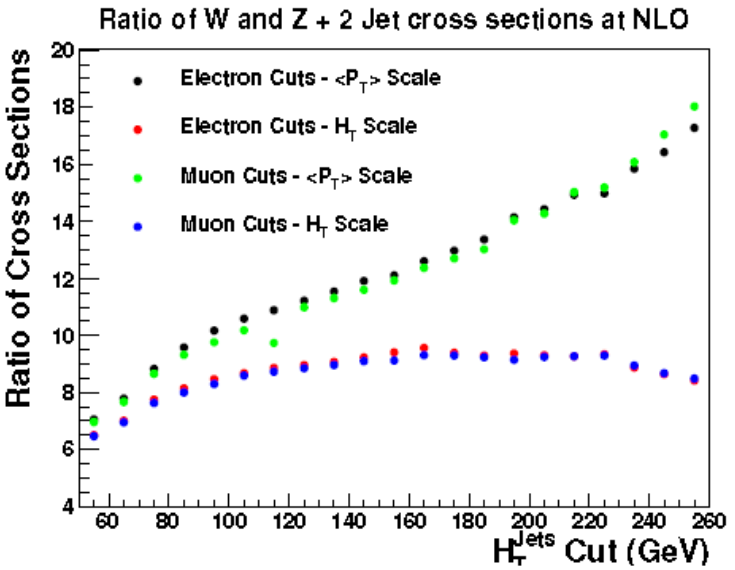
Hadron./Fragmentantion and initial/final state radiation



Hadronization/fragmentation and initial/finale state radiation do not influence the ratio

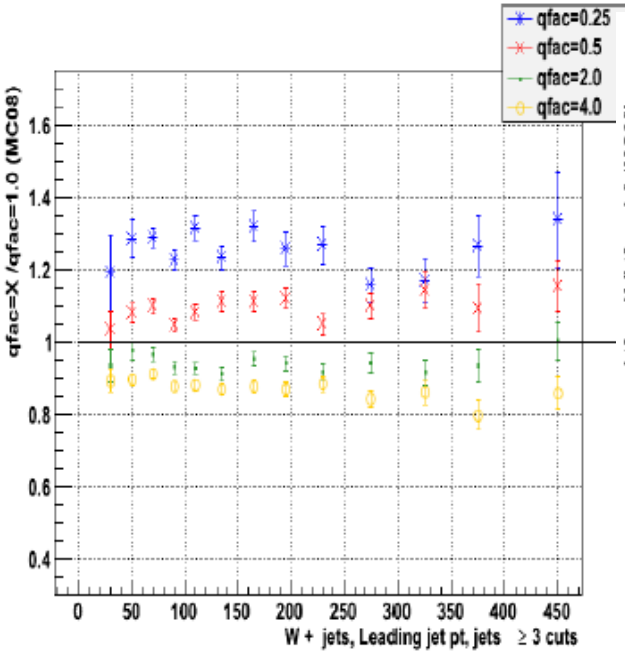
MCFM scale variations

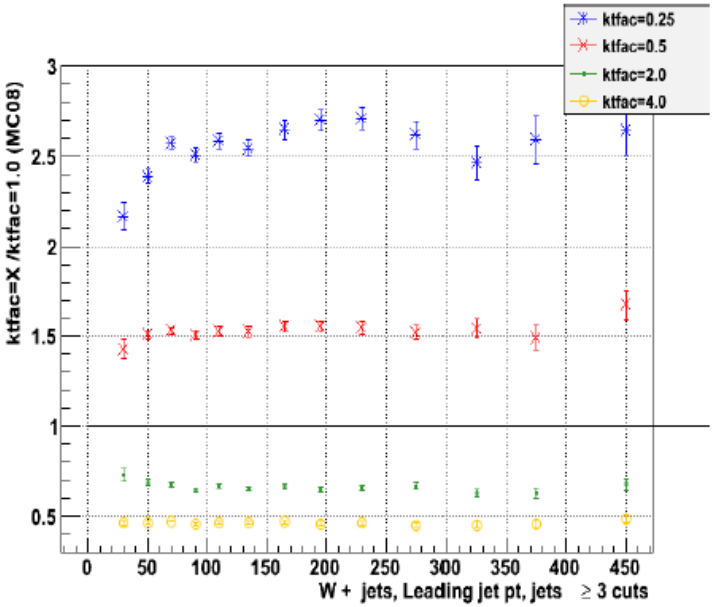


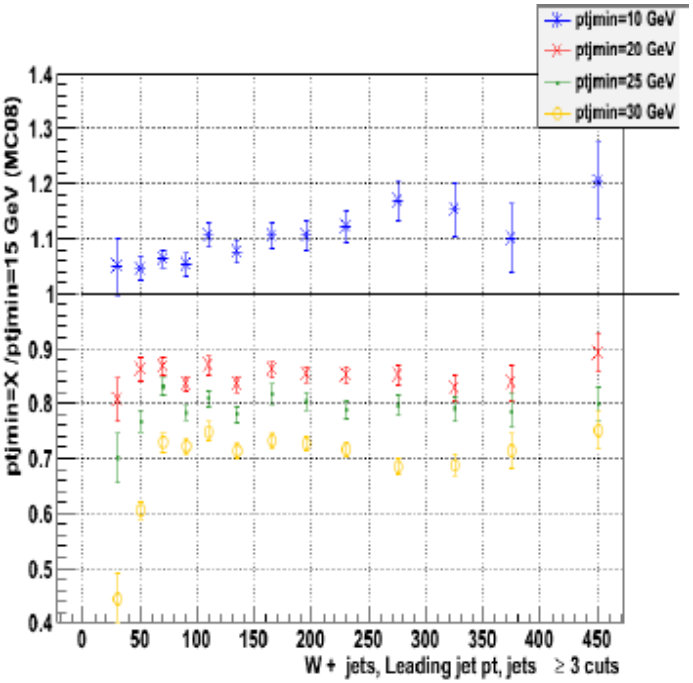


Ratio has large scale dependence of functionals choise of scale

Alpgen parameter variations







Variation of matching parameters in alpgen:

- Qfrac
- Ktfrac
- Ptjmin

Large X-sections variation but shapes are stables except for high ptjmin

Summary

- W/Z+jets at LHC ideal to study pertubative QCD
  - Important backgroudn for ttbar and dominant background for SUSY
- LHC: few 100 leptonic W+4jet and Z+3jet per 100 pb^{-1} at 7 TeV
- Atlas has a broad spectrum of analysis for W/Z+jets:
  - Cross sections
  - Cross section ratios (eliminate uncertaincies)
- Dominating Systematics at start:
  - Jet energy scale
  - Luminosity
  - background
- LO Generators show different behavior even for W/Z ratio, even for ratios, need of measurement
  - interessting to look into NLO W+3jet like blackhat/sherpa