Measurement of jet production in association with ttbar.

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DESY

Outline

- Introduction and motivation
- Measurement
- Event selection
- Monte Carlo simulation
- Background
- Systematics
- Results
- Conclusions and next steps

Introduction and motivation

- Measurement of the multiplicity spectrum of jets produced in association with top–anti-top pairs (ATLAS-CONF-2011-142)
- Cross section for one additional jet measured by CDF (conf note 9850)
- Done in semi-leptonic channels (e+jets and mu+jets). Cut-and-count analysis. Unfolding to particle level planned.
- Test of pQCD
  - Study radiation at high momentum scales
  - Constraining generator models. Jet multiplicity distribution particularly sensitive to initial state radiation (ISR).
- Potential reduction of systematics in other top quark measurements.
- Understanding background for new physics: SUSY, heavy charged Higgs, ttH, Technicolor, di-boson scattering

Measurement

- Measurement done in leptons+jets channels (e+jets and mu+jets).
- Cut-and-count analysis.
- Measure spectrum for three different pT thresholds: 25 GeV, 40 GeV, and 60 GeV.
- Current results compare reconstructed jet multiplicity with simulation.
- Unfolding to particle level planned.
- Latest public results use 0.70 fb^{-1}. Update to full 2011 data set (5 fb^{-1}) underway.

Event selection

> *e*+jets channel

- Calorimeter trigger.
- Exactly one electron with Et > 25 GeV, |eta| < 2.47, excluding 1.36 < |eta| < 1.52 transition region. Veto other leptons
- MET > 35 GeV
- W transverse mass > 25 GeV

> *μ*+jets channel:

- Muon spectrometer trigger.
- Exactly one muon with Et > 20 GeV, |eta| < 2.5. Veto other leptons.
- MET > 20 GeV
- W transverse mass + MET > 60 GeV

> Both channels

- >= 4 jets with pT > 25 GeV, |eta| < 2.5. Anti-kT algorithm with distance parameter 0.4.
- At least one b-tagged jet. "SV0" algorithm, based on decay length significance. Working point at 50% efficiency.

Monte Carlo simulation

- Top signal: MC@NLO + HERWIG + JIMMY
- ISR variations: AcerMC + Pythia. Shift applied to MC@NLO sample
- W+jets, Z+jets: Alpgen + Herwig. Generating W/Z + light quarks, W+bb, W+c, W+cc, Z+bb. Overlap removed through angular matching.
- Single top: MC@NLO
- Di-boson (WW, WZ, ZZ): HERWIG
- Pile-up overlay: Pythia 6
- Pile-up profile of simulation re-weighted to match that of data.

Background

- Dominating backgrounds are QCD, W+jets, and single top.
- QCD and W+jets data-driven, rest from Monte Carlo.
- W+jets shape from ALPGEN as in last slide.
- W+jets normalization from W charge asymmetry measurement.
- QCD background estimated using data-driven methods.
  - Electron channel: anti-electron method
  - Muon channel: matrix method

Systematic uncertainties

- Dominated by
  - Jet Energy Scale at high jet multiplicity, and
  - Background normalization and b-tagging efficiency at low jet multiplicity.

Uncertainty	nJet=4	nJet=5	nJet≥6
Statistical	2.8 %	3.6 %	4.9 %
Jet energy scale	4.2 %	12.5 %	26.8 %
Jet reconstruction	1.2 %	1.8 %	2.8 %
b-tag requirement	9.4 %	9.5 %	9.2 %
Lepton identification	0.6 %	0.6 %	0.6 %
Trigger efficiency	5.7 %	5.7 %	5.6 %
Additional interactions	1.8 %	2.0 %	2.0 %
PDF	1.5 %	1.5 %	1.6 %
W+jets normalisation	9.6 %	5.9 %	4.5 %
W+jets heavy flavour	7.5 %	4.3 %	3.4 %
W+jets shape	0.5 %	1.0 %	2.0 %
QCD normalisation	8.2 %	5.0 %	3.2 %
QCD shape	0.1 %	0.1 %	0.3 %
Other backgrounds	1.0 %	0.6 %	0.7 %
Luminosity	3.7 %	3.7 %	3.7 %
MC statistics	1.0 %	1.3 %	1.9 %
Total	19.6 %	19.9 %	30.5 %

μ channel

Uncertainty	nJet=4	nJet=5	nJet≥6
Statistical	3.4 %	4.3 %	6.5 %
Jet energy scale	5.9 %	13.8 %	31.7 %
Jet reconstruction	1.8 %	1.0 %	1.9 %
b-tag requirement	9.4 %	9.0 %	8.8 %
Lepton identification	2.6 %	2.6 %	2.6 %
Trigger efficiency	0.5 %	0.4 %	0.4 %
Additional interactions	1.3 %	1.6 %	1.2 %
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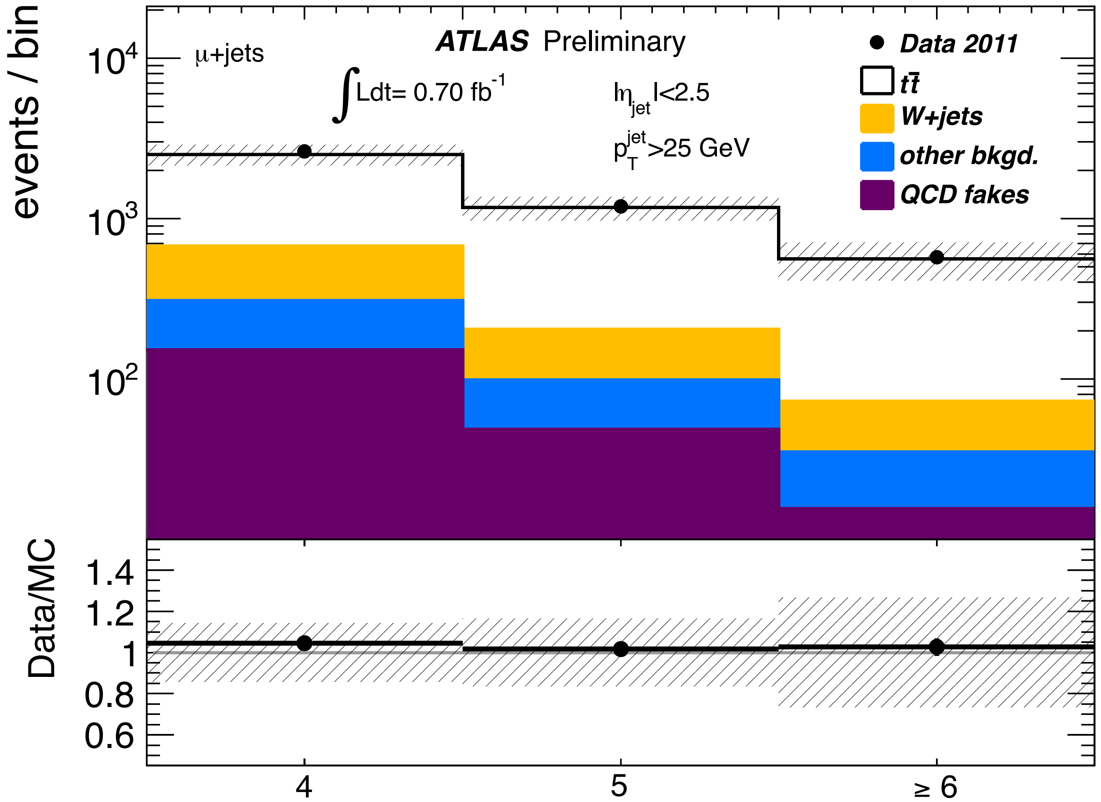
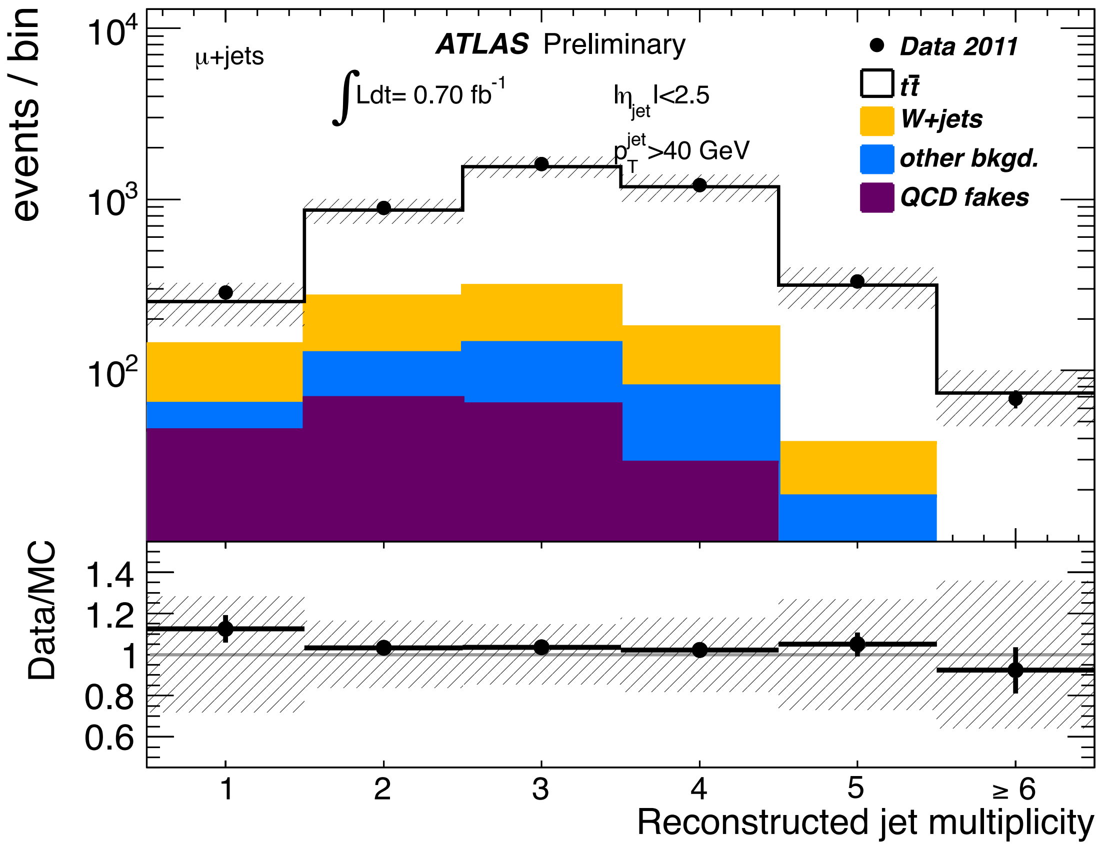
QCD shape	2.7 %	5.0 %	0.3 %
Other backgrounds	1.1 %	0.9 %	0.6 %
Luminosity	3.7 %	3.7 %	3.7 %
MC statistics	1.3 %	1.8 %	2.6 %
Total	19.1 %	20.8 %	34.9 %

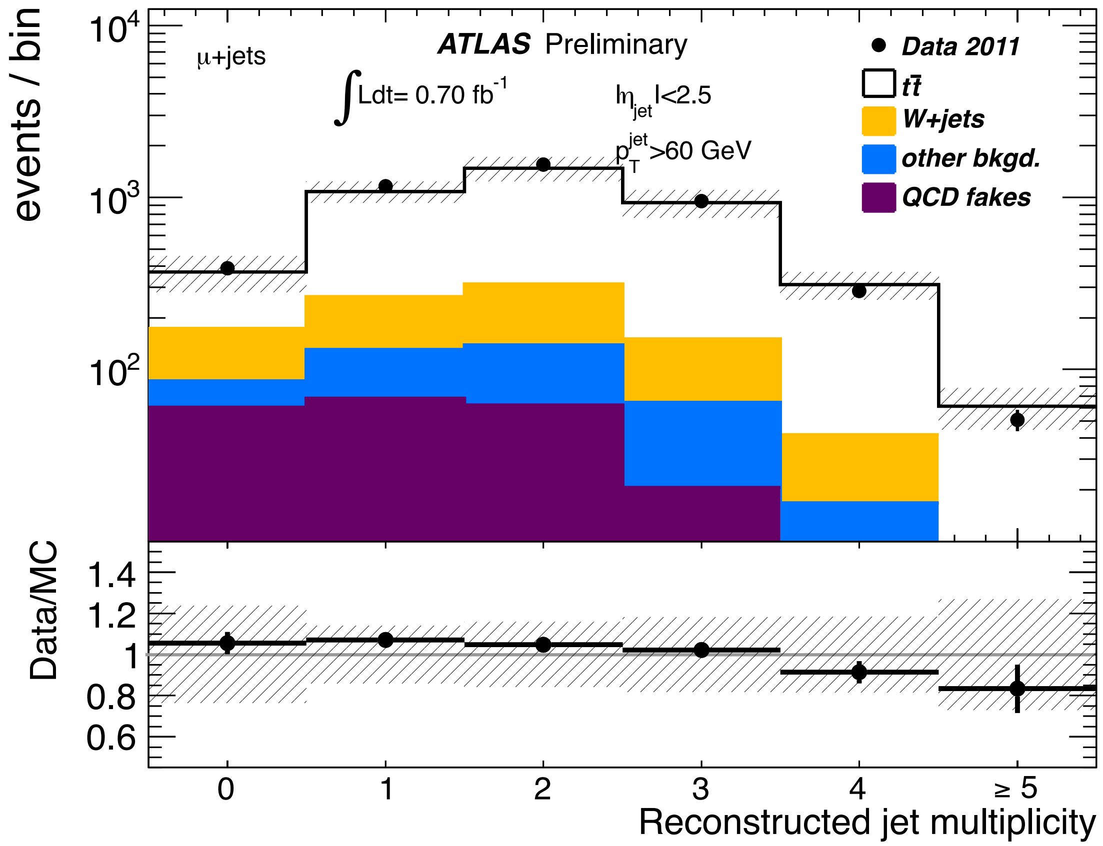
e channel

Results: Jet multiplicity, μ channel

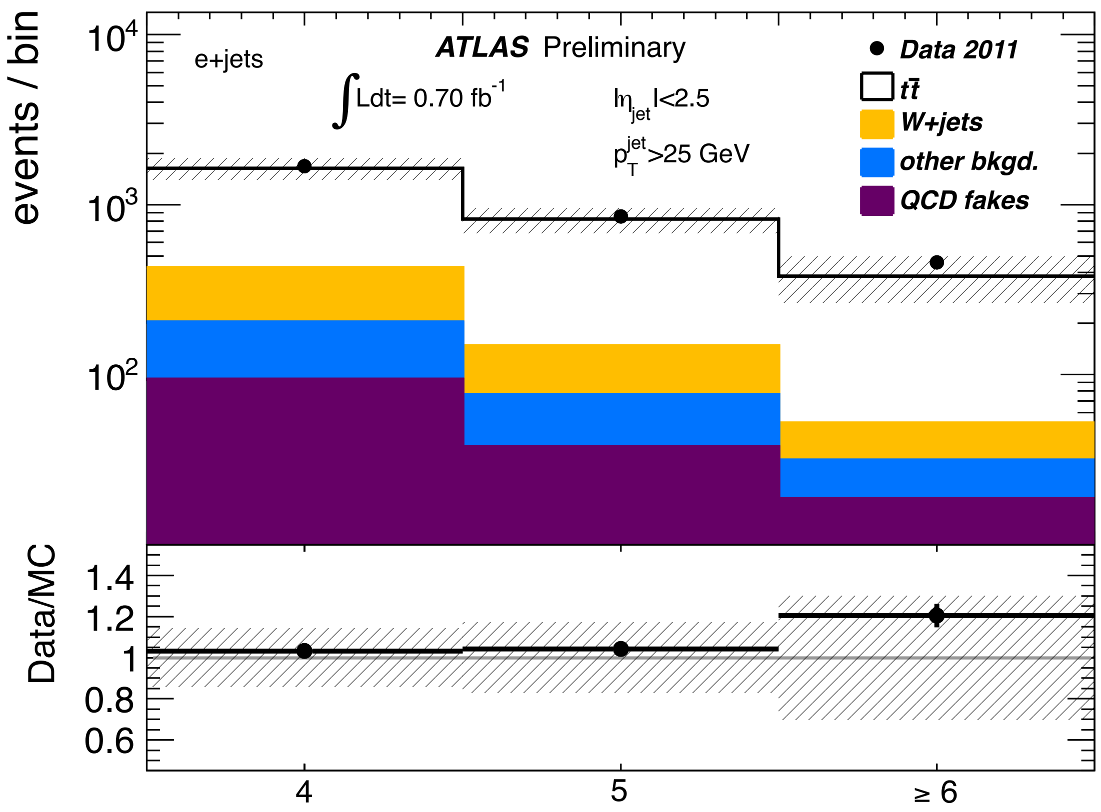


Sample	nJet=4	nJet=5	nJet≥6
$t\bar{t}$	1837	966	487
W+jets	367	106	37
QCD multijet background	151	48	16
Single top quark	121	39	14
Z+jets	28	9	5
Dibosons	6	2	<1
Total expected	2511	1170	559
Data	2626	1191	574

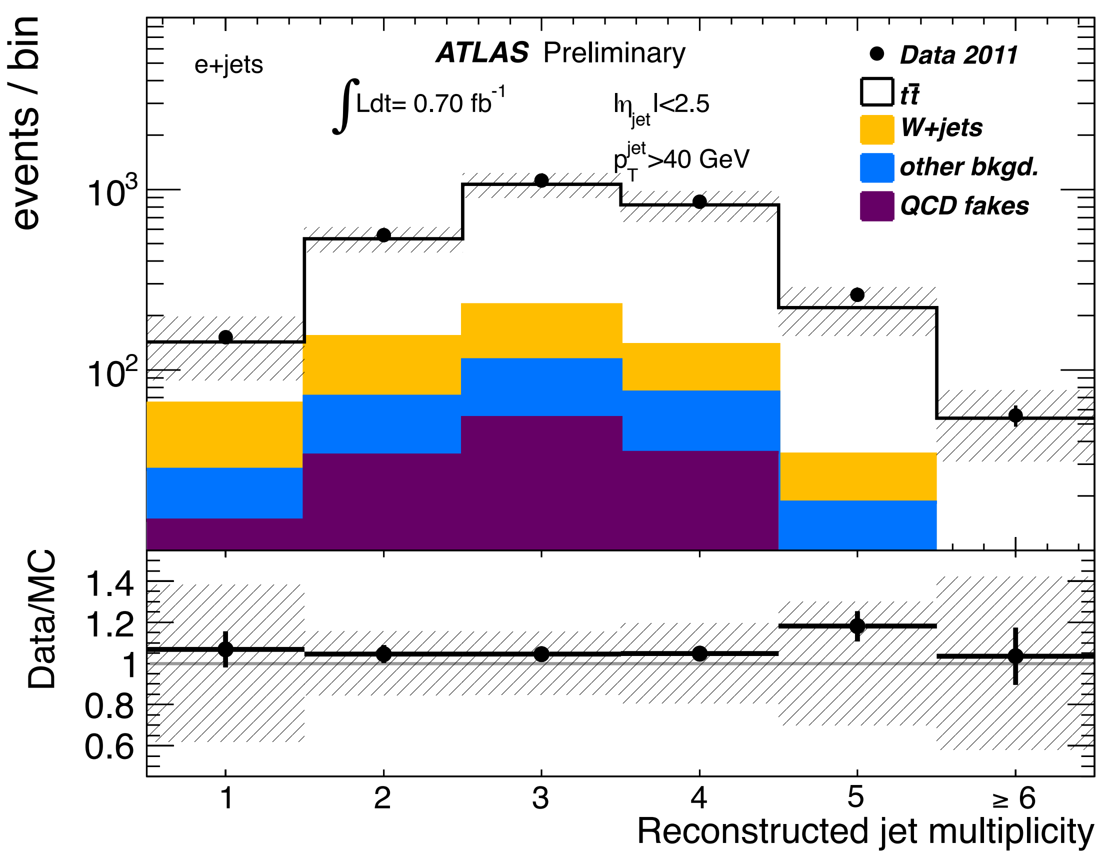


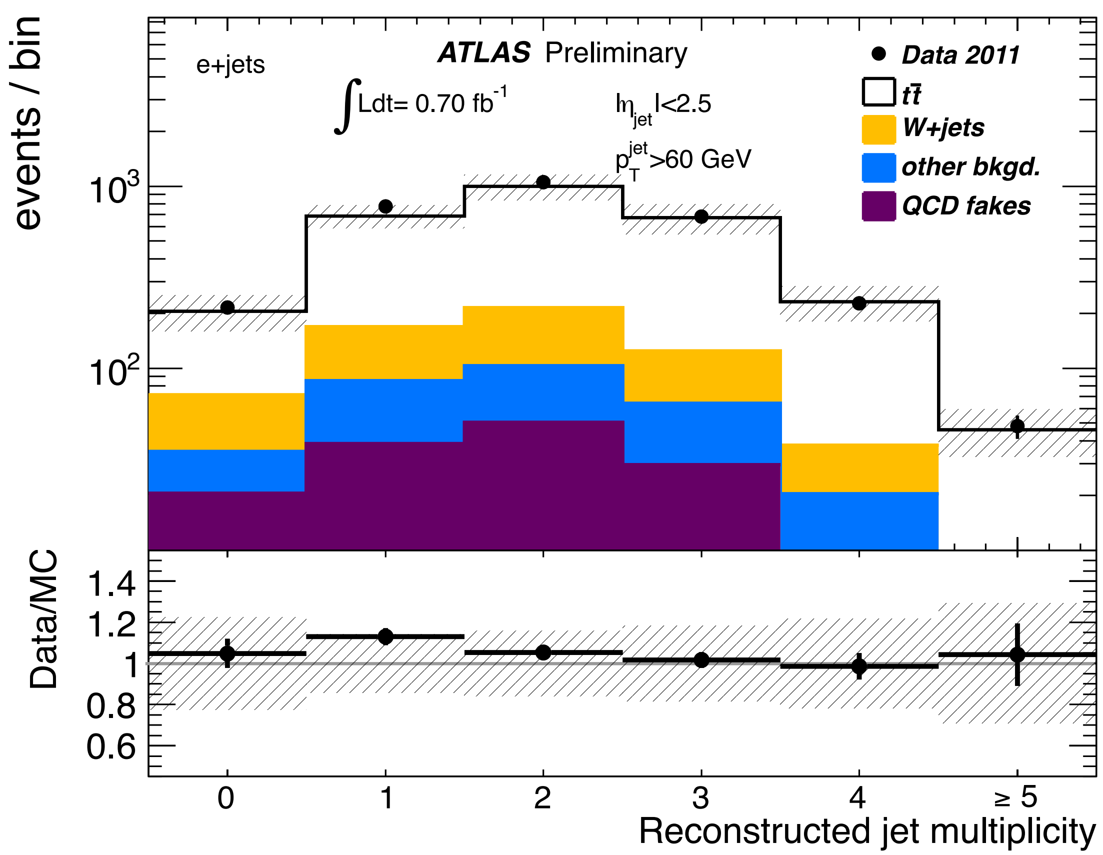


Results: Jet multiplicity, e channel

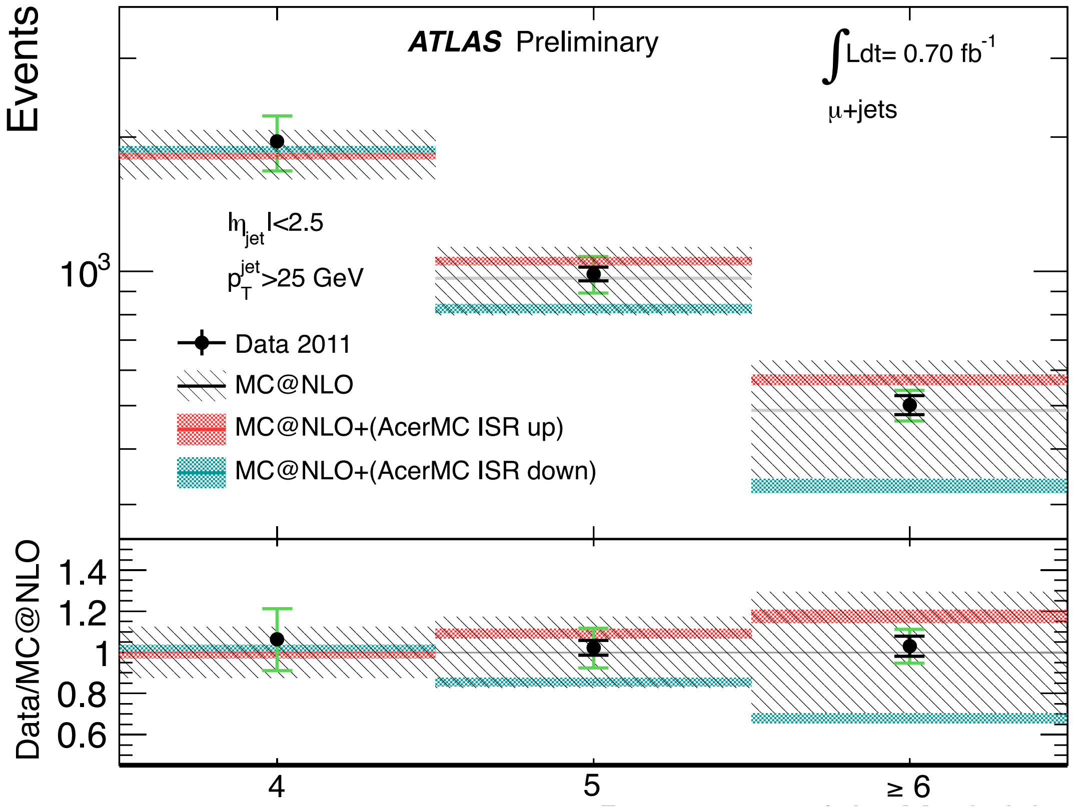


Sample	nJet=4	nJet=5	nJet≥6
$t\bar{t}$	1212	673	328
W+jets	222	71	21
QCD multijet background	94	38	19
Single top quark	85	29	10
Z+jets	21	9	3
Dibosons	4	1	<1
Total expected	1638	820	380
Data	1689	855	457

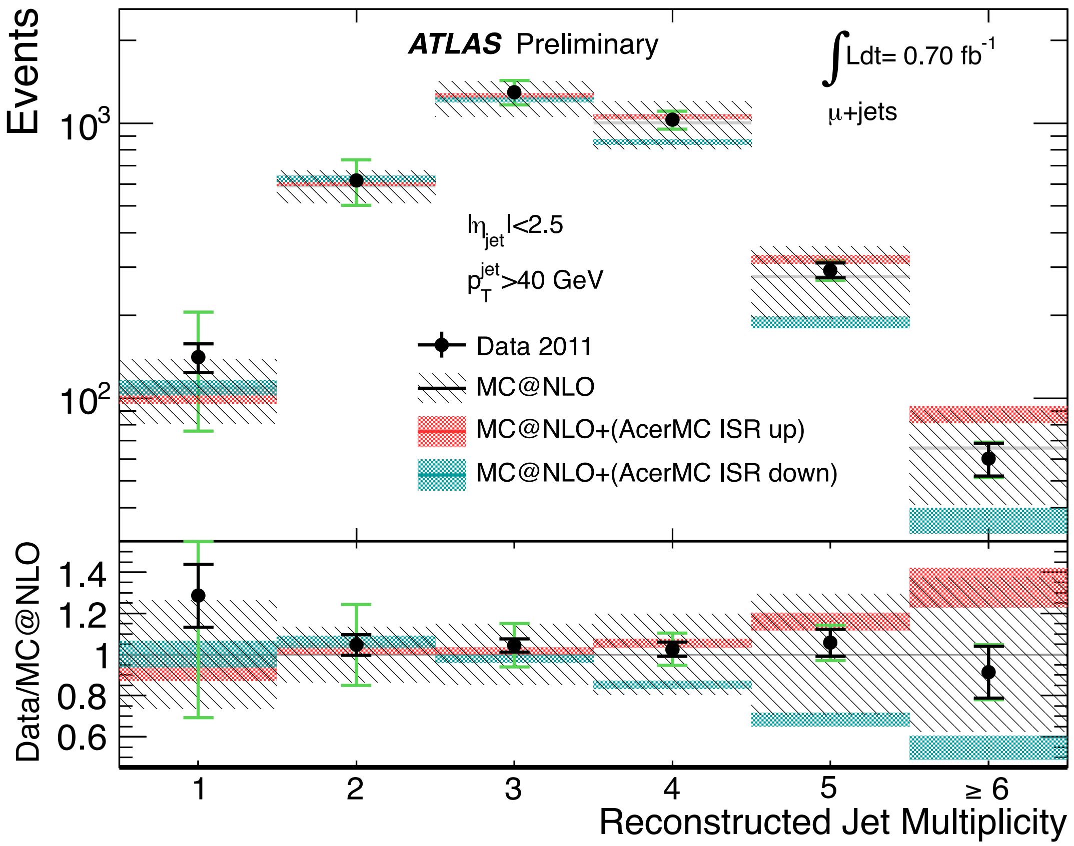


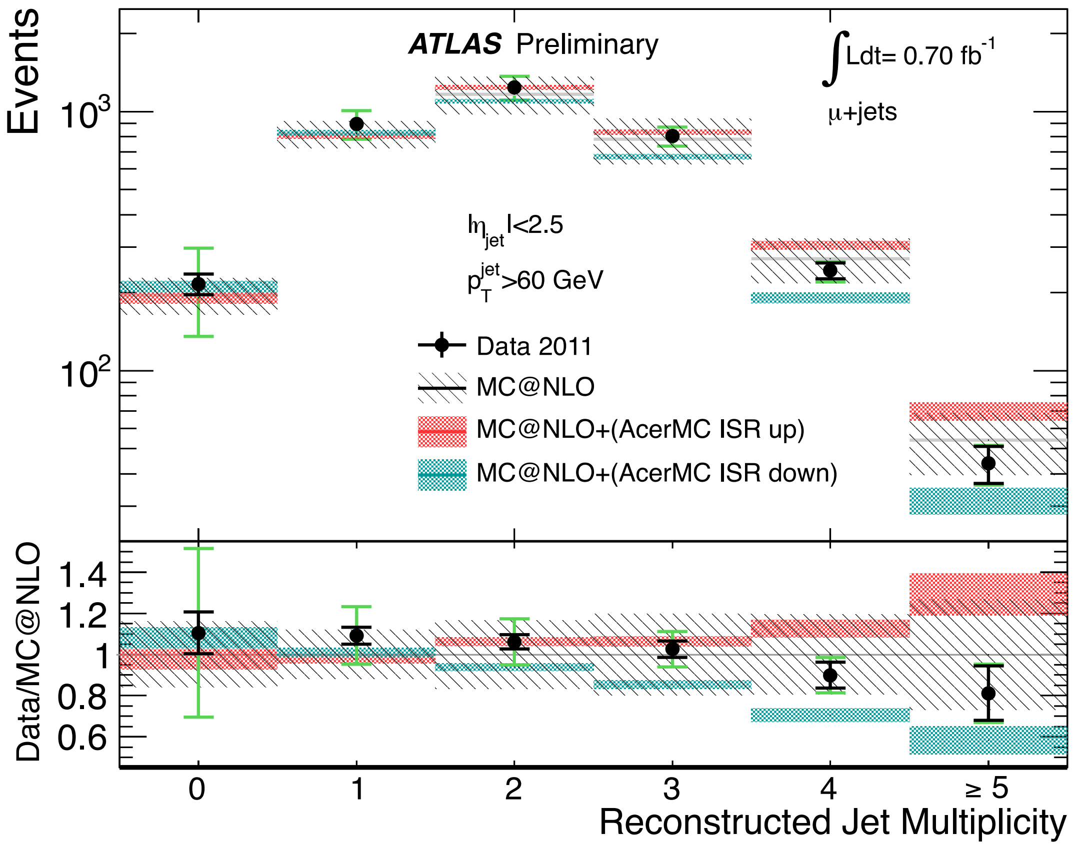


Results: Jet multiplicity after background subtraction, μ channel

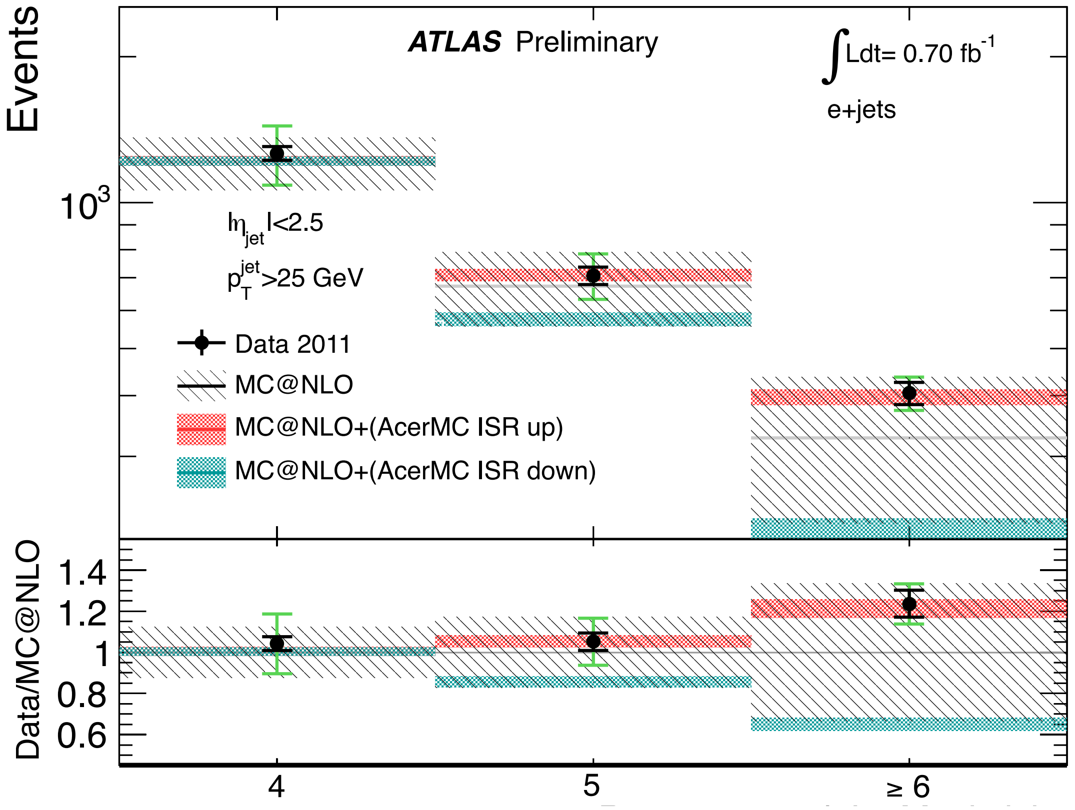


- Results after background subtraction.
- Black error bars: Data statistical uncert.
- Green error bars: + background normalization
- Hatched band: Signal acceptance uncertainty
- Red/Blue bands: MC statistical uncert.





Results: Jet multiplicity after background subtraction, e channel



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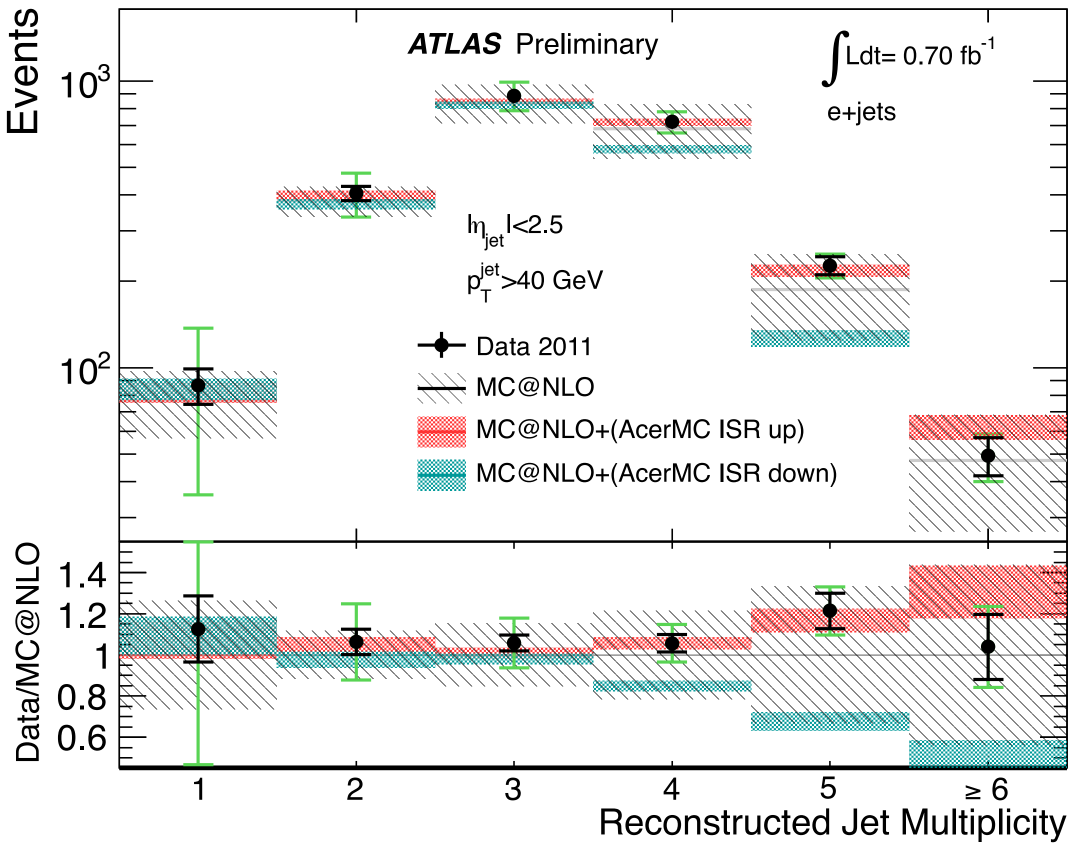

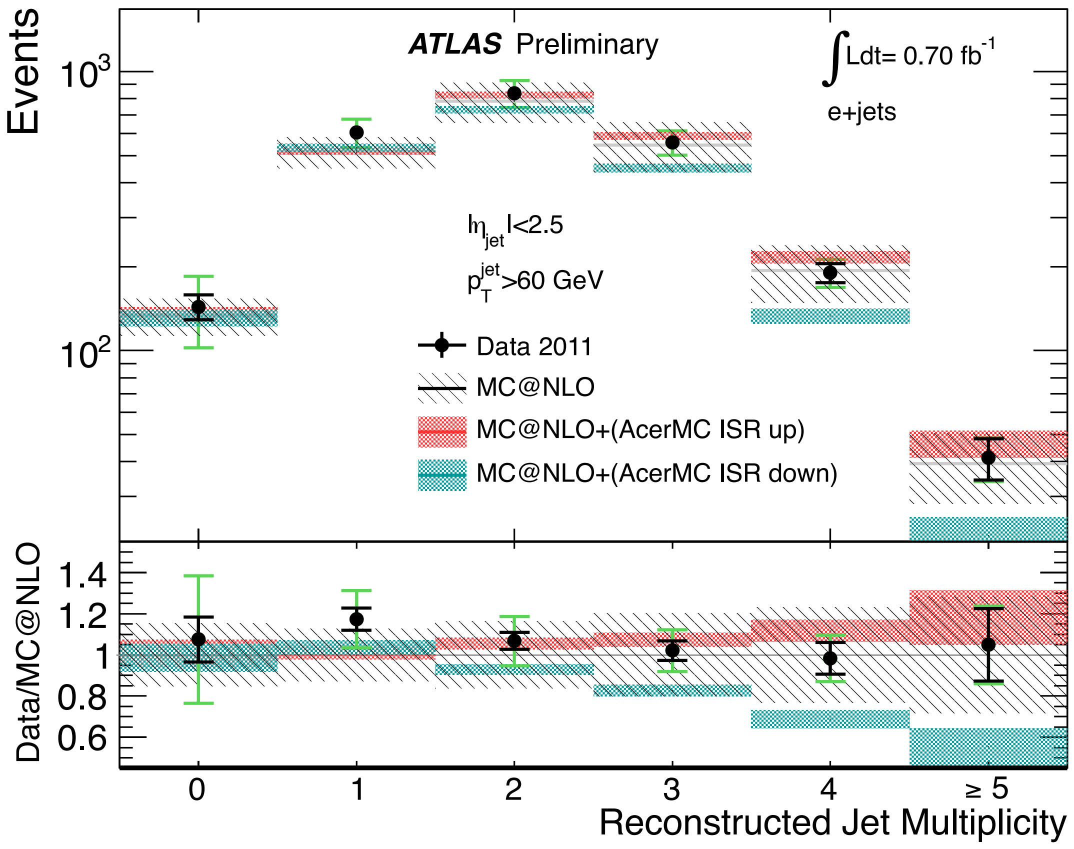

Conclusions and next steps

- No deviation from MC@NLO predictions is observed, within the uncertainties of the measurement.
- Comparison with different ISR variations shown, but no distinction can be made with current uncertainties.
- Dominated by systematics at low multiplicity and statistics at high multiplicity.
- Use whole 2011 data set (5 fb^{-1})
- Unfold to particle level.
- In general, work on reducing systematics: Jet Energy Scale, b-tagging.
- Use Powheg ttbar + 1 additional parton Monte Carlo.
- Using njet ratios to reduce systematics.
- Strategies to handle pile-up: JVF (Jet Vertex Fraction) cut studied.