ATLAS Italia

Pisa, 29/10/2010

QCD and jets in ATLAS

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On behalf of the Pisa Group

Activity of Pisa group

Implication in QCD physics & Jet Energy Scale studies

JES uncertainty is a large source of systematics for many measurements and discoveries involving jets in final state

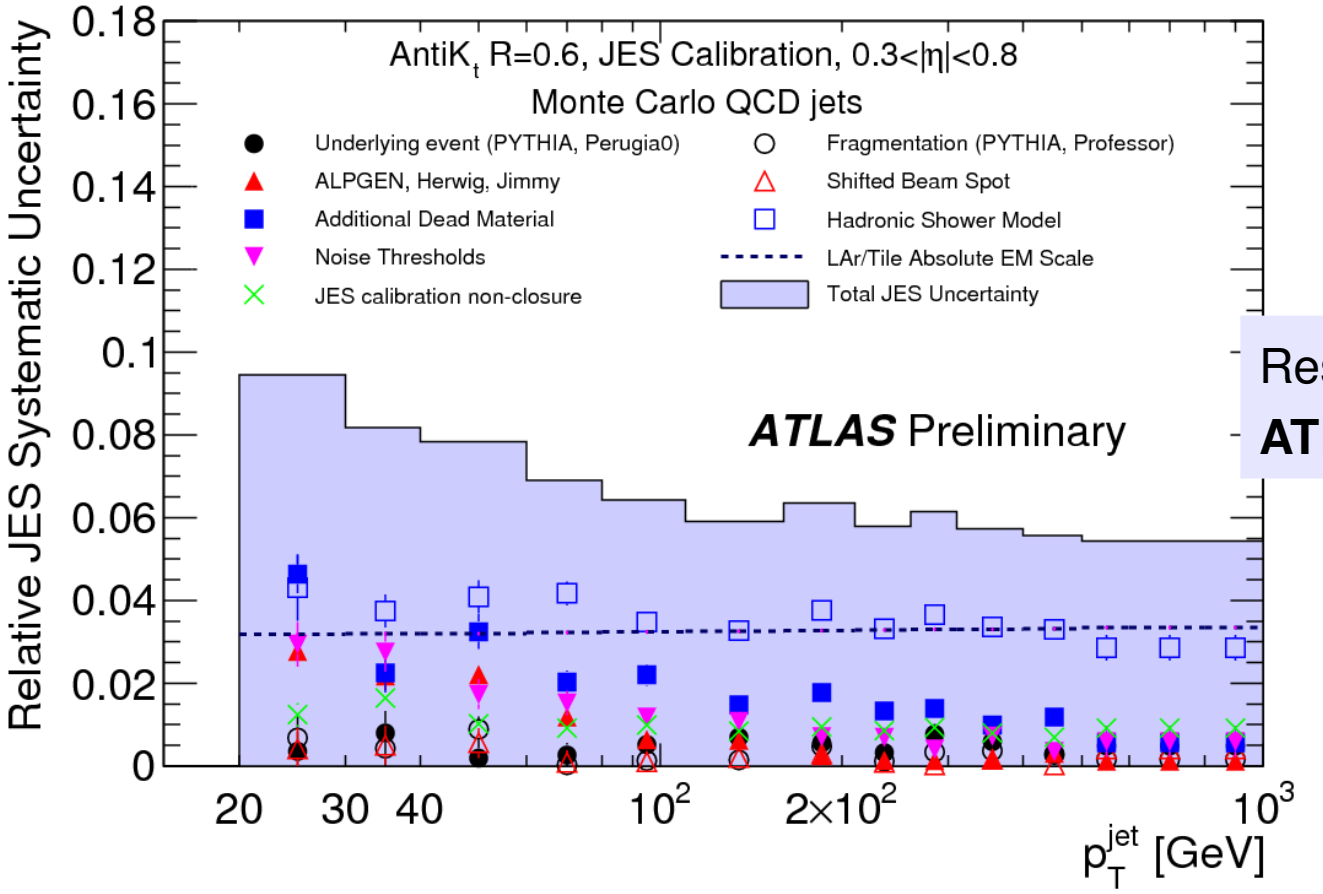
- Validation of the JES
  - JES uncertainty from simulation
  - JES uncertainty from data
    - *Using E/p with single particles*
    - *Using photon + jet events*
- Cross-section measurements
  - Inclusive jet & di-jet cross section
  - Multi-jet cross section
  - Photon + jet cross section

JES uncertainty from MC

- Many sources of systematics on JES
  - Uncertainty on detector description, experimental conditions and calibration methods
    - *Dead material in low p_T region :* ~4%
    - *Energy scale of the calorimeters (from test-beams) :* ~3%
  - Uncertainty on simulation of the hadron showers in calorimeters : ~4%
  - Uncertainty due to MC events generator
    - *Fragmentation, underlying events*
- JES estimated varying the parameters of the simulation, and of the jets reconstruction/calibration
  - Generators : Alpgen + Herwig+Jimmy, Pythia with different tunes
  - Hadronic shower model : various physics lists
  - Dead material quantity...

JES uncertainty from MC : results

- Overall JES uncertainty :
  - 10% (low p_T) to 6.5% (p_T>100 GeV) in central region
  - 10% to 7% in end-cap region
    - *Using di-jet balance to propagate JES uncertainty from central region to end-cap region*



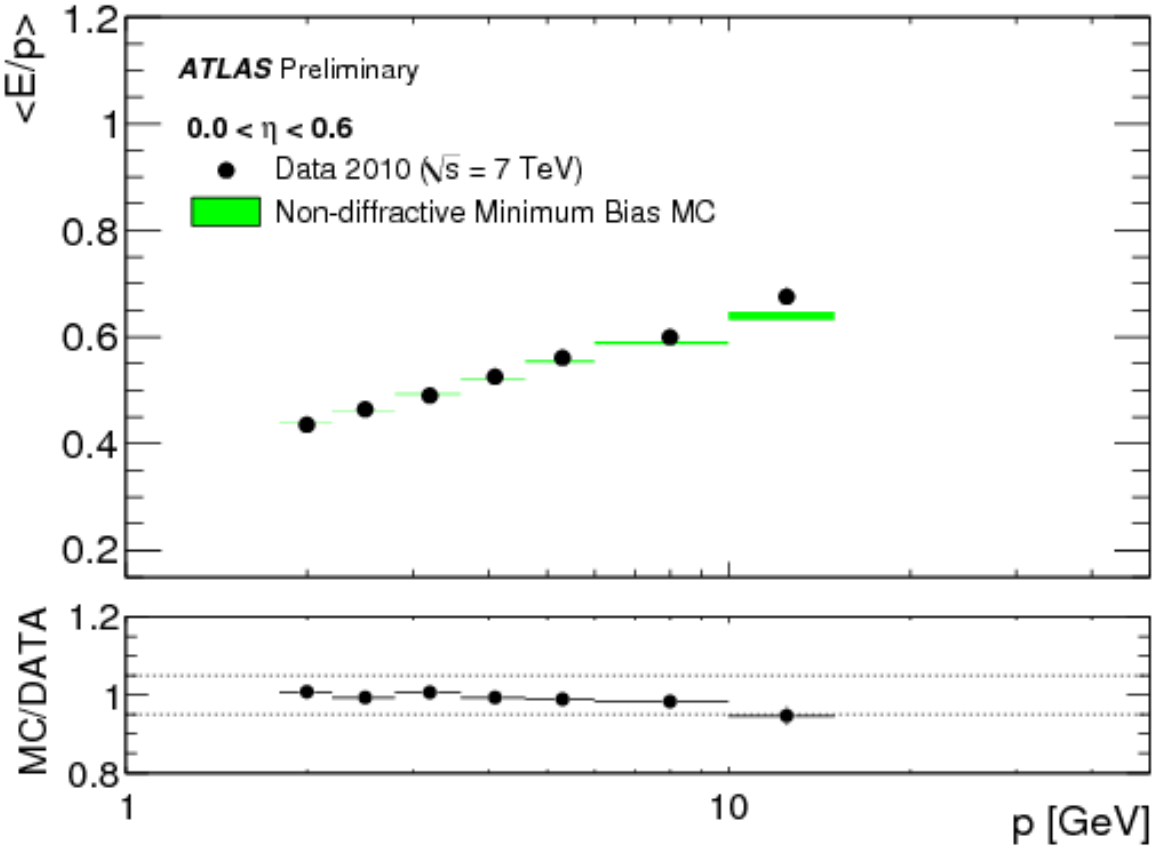
Results published in an ATLAS NOTE
ATLAS-CONF-2010-056

Next steps to reduce JES uncertainty

- Use $Z \rightarrow e^+e^-$ in em calorimeter (~2% on calo scale uncertainty)
- Improve the MC-based jet calibration
  - Better treatment in the gap region η=3.2
- Apply pile-up corrections (so far included in uncertainties)
- Use in-situ methods to determine the JES uncertainty (MC-based JES uncertainty is over-estimated)
  - Get uncertainty on dead material and shower model from E/p study
    - *Results are ready, but not yet used.* See next slides
  - Better understanding of the fragmentation/UE uncertainty using photon+jet events. Ongoing : See next slides
  - Di-jet η-intercalibration, multi-jet balancing to check JES up to 1TeV
- Goal is to achieve 3-4% JES uncertainty

JES uncertainty from single particles

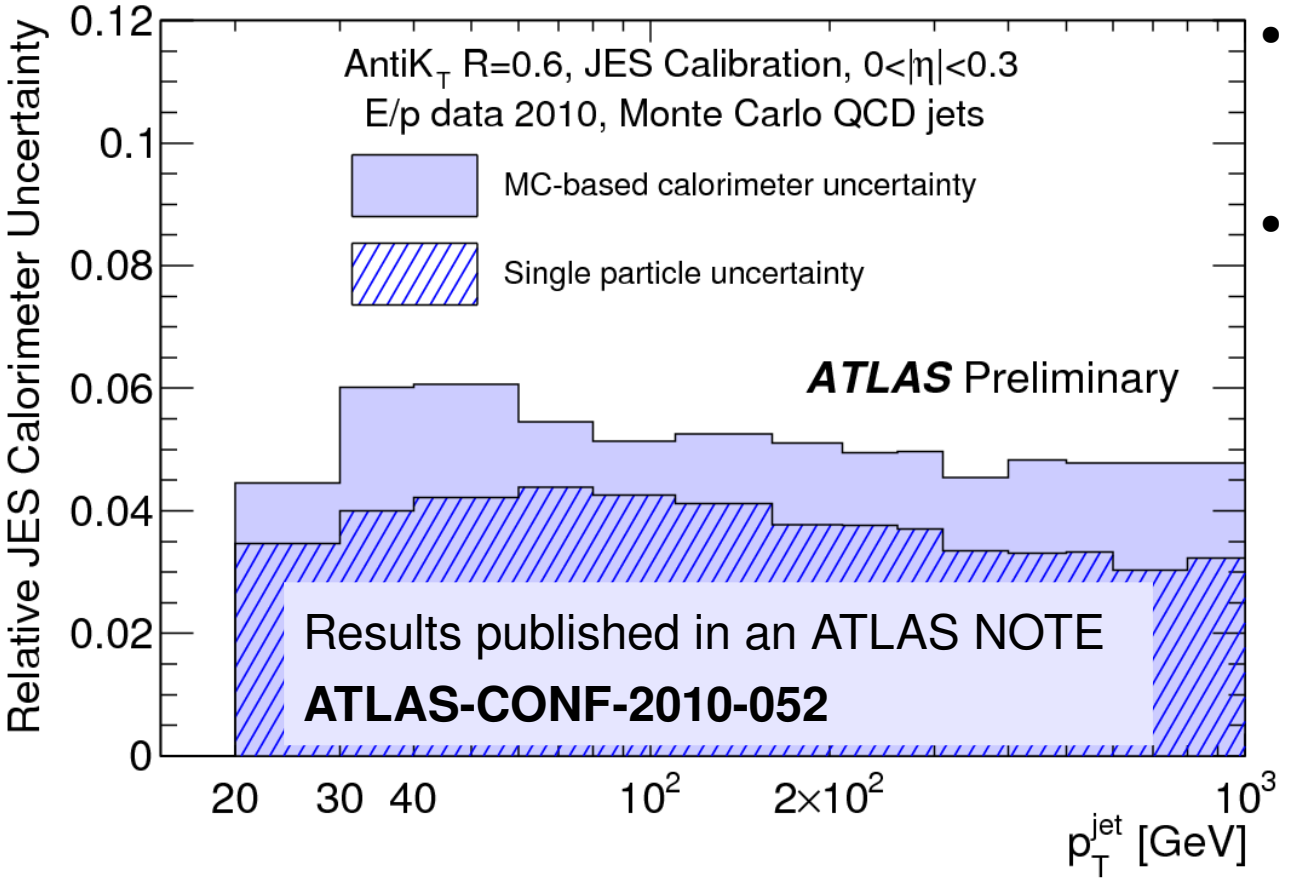
- Calorimeters response to single isolated hadrons
  - E : energy deposit of an isolated charged particle
  - p : associated track momentum
    - *E/p gives an experimental hint on the calo response*



- MC/DATA comparison
  - Agreement with 5%
  - Sources of systematics
    - *Shower description*
    - *Calo energy scale*
    - *Dead material description*

JES uncertainty from single particles

- Uncertainty on single hadron energy can be propagated to the Jet Energy Scale
  - Convolution between particles/Clusters p_T-spectrum of a Jet and the uncertainty on single particle calo reconstruction



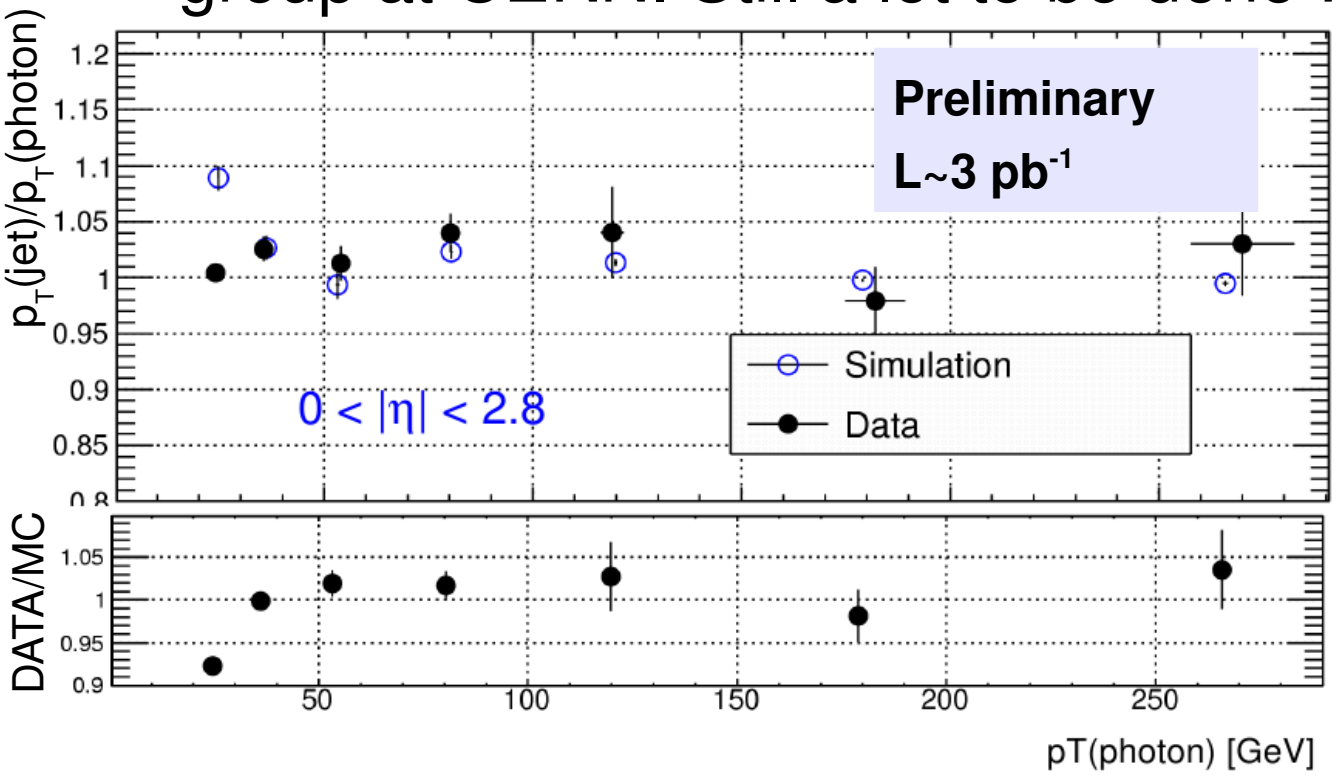
- JES uncertainty : 1% bias ± 3-4%
- Can be compared to the MC-based approach (only for instrumental effects)
  - *MC-based JES uncertainty higher : as mentioned slide 5 it is probably overestimated*

JES from photon+jet events

- Very important to give a data-based estimate of the JES uncertainty
  - $\sigma(p_T^{\gamma} > 17$ GeV) ~ 220 nb
  - JES can be checked for p_T ~ 20 to 200 GeV
- Photon used as a reference for the jet energy scale
  - $p_T^{\gamma} \sim p_T^{jet}$
  - p_T^{γ} (or $E' = p_T^{\gamma} \times \cosh(\eta^{jet})$) used as reference p_T(or E) for the jet
- MC/Data comparison at various steps of the jet calibration
  - Uncalibrated jet, Calibrated jet (3 different strategies to be validated)

JES from photon+jet events

- First results shown during the last ATLAS Calibration Workshop (Pisa, Sept. 2010)
  - Preliminary results : fair MC/data agreement (difference <10%)
- Work in progress, in collaboration with a small working group at CERN. Still a lot to be done :



- Study of the systematics (bias of the method, generators...)
- Study of the effect of QCD background (~30% at low p_T ?)
- A CONF Note is under preparation

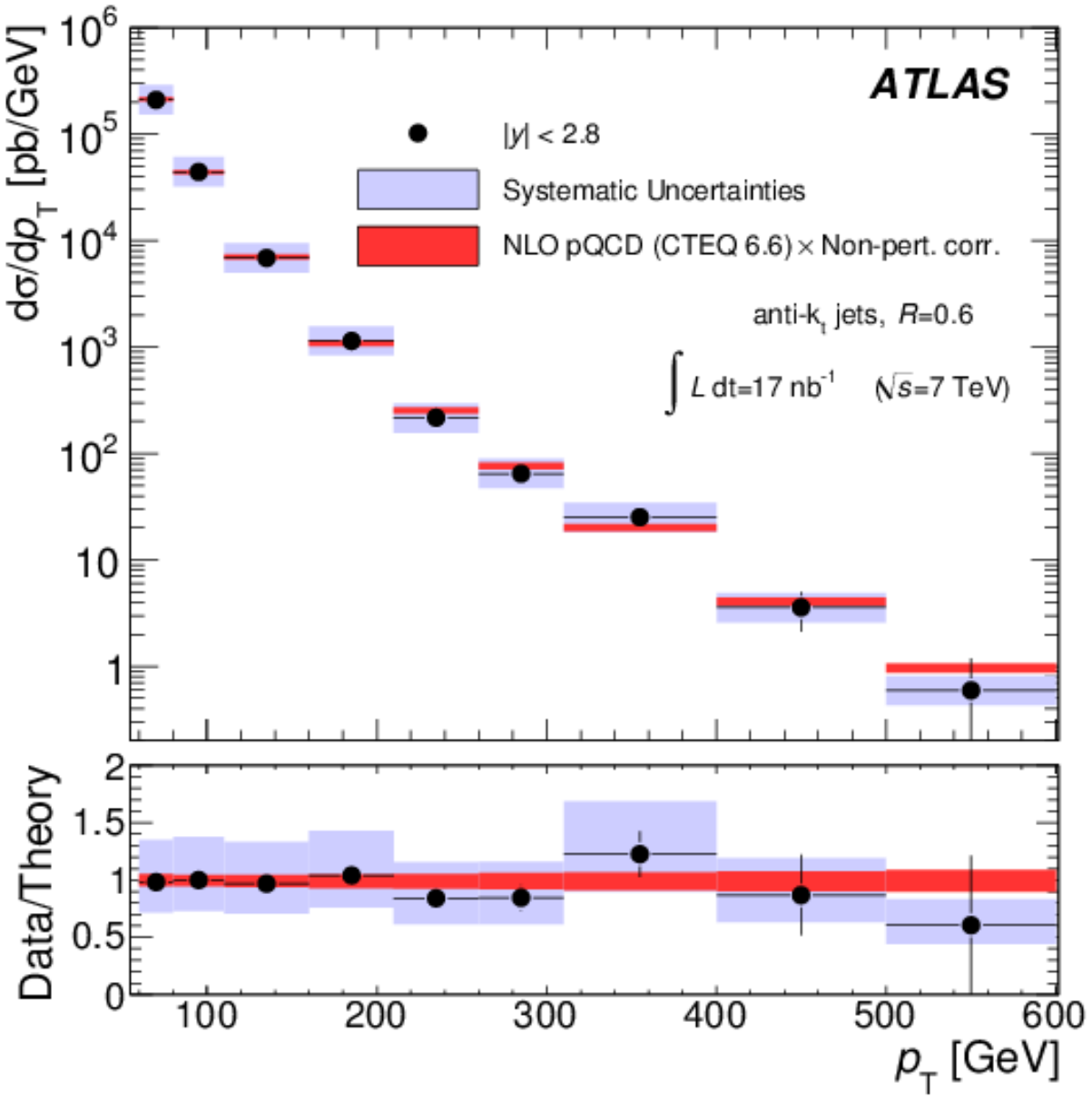
Cross section measurements

- QCD jets inclusive cross section
- Multi-jet cross section
- Photon-jet inclusive cross section

Inclusive jet/di-jet cross-section

- First measurement in a previously unmeasured kinematic regime (up to 600 GeV)
- Unfolding of the detector effect done on MC-basis
- Dominant uncertainty : 10% on JES = 40% on cross section
- DATA/MC comparison have been made for several generators and tunes
  - Alpgen+Herwig+Jimmy, pythia

Inclusive jet/di-jet cross-section



- Good agreement between theory and data, validating the perturbative QCD approach in a new kinematic range.

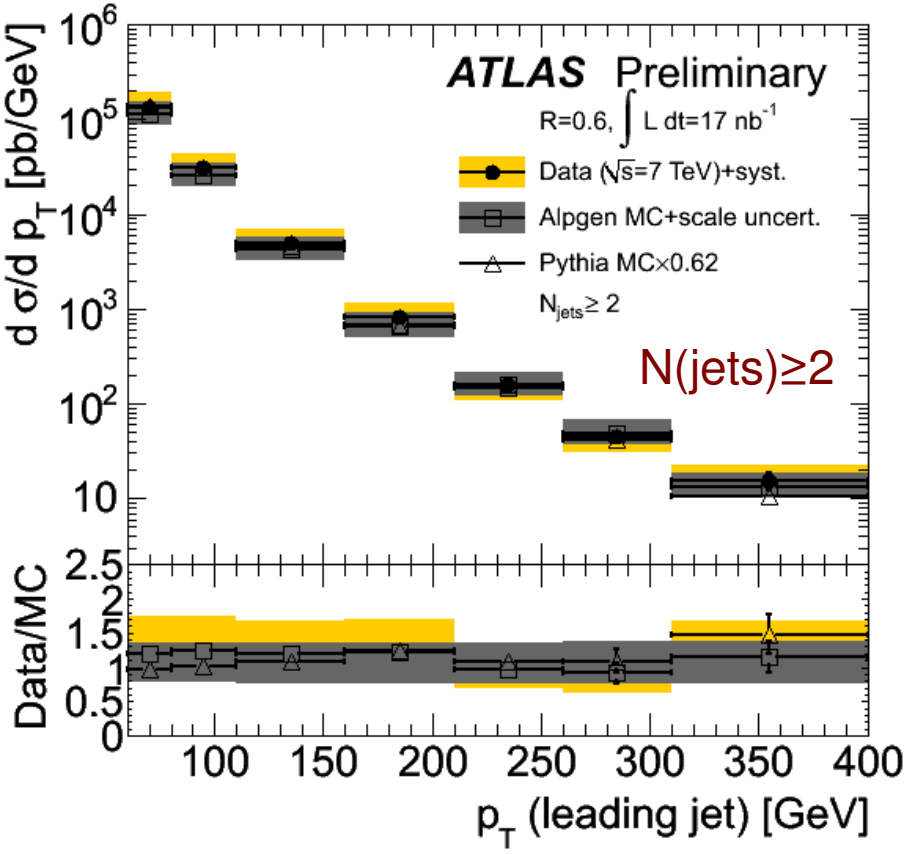
Results published in an ATLAS NOTE
CERN-PH-EP-2010-034

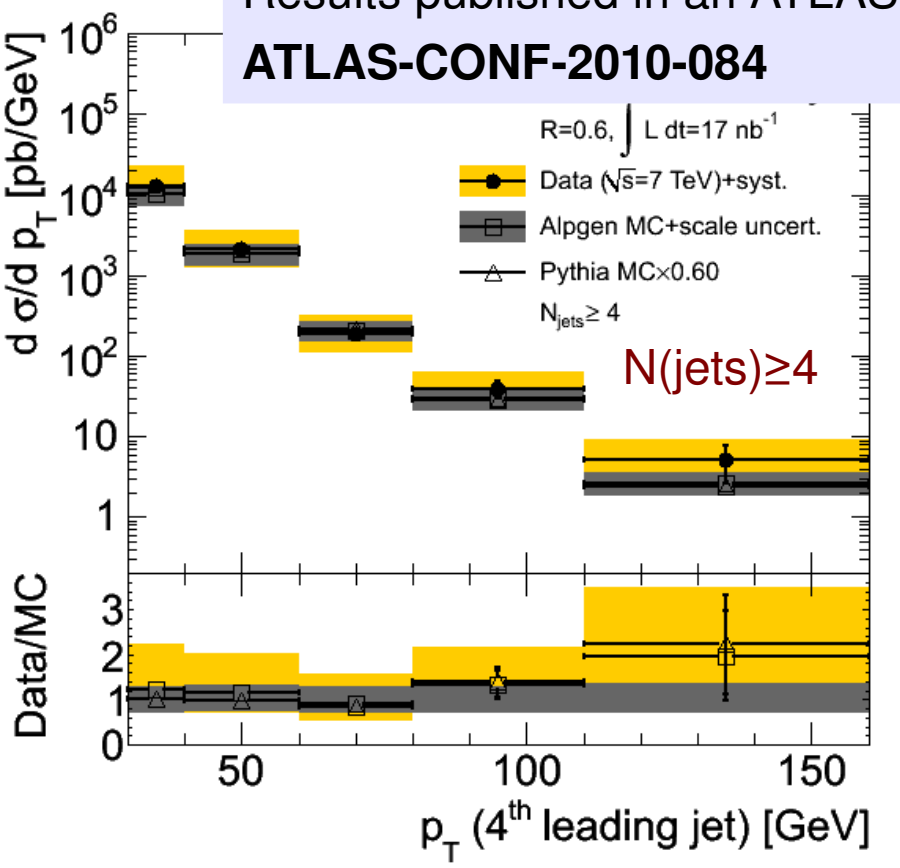
Multi-jet cross-section

- Multi-jets : events with more than 2 jets in final state
- Rich testing for perturbative QCD at high energy
  - Multi-jets from QCD constitute an important background for many channels of interest : good understanding required
- Multi-jet cross section and ratios σ(n-1 jets)/σ(n jets) measured on data (p_T>30 GeV, |y|<2.8)
  - Unfolding of the detector effects done on MC-basis
  - Systematics sources have been studied
- DATA/MC comparison have been made for several generators and tunes
  - Alpgen+Herwig+Jimmy, pythia

Multi-jet cross-section

Results published in an ATLAS NOTE
ATLAS-CONF-2010-084

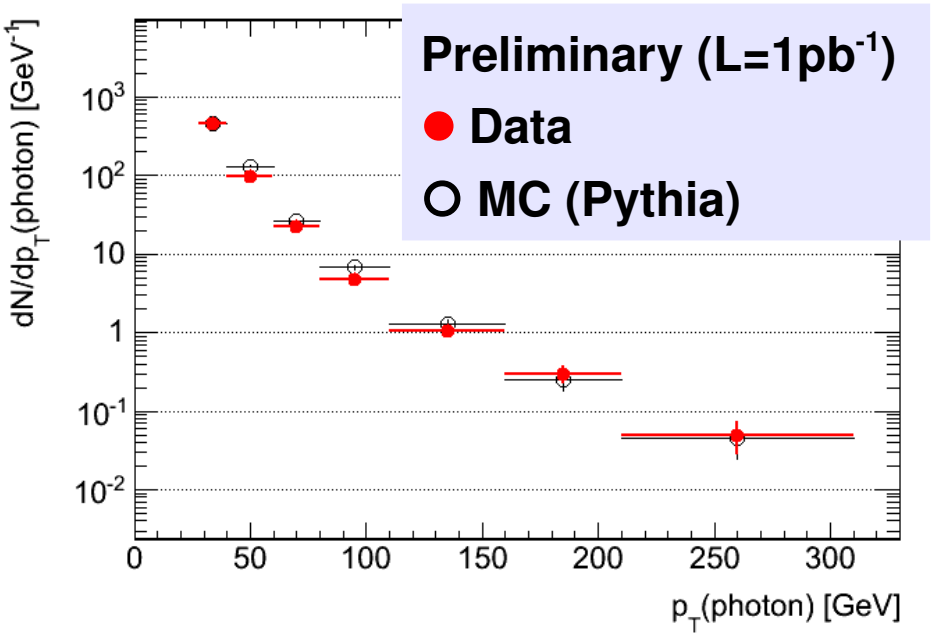




- Measurements well described within uncertainties
- Cross-section ratios for many jets (up to 4) are better described by leading order matrix element calculation (Alpgen) than by leading log approximation (pythia)

Photon+jet cross-section

- Differential cross section measurement $d^3\sigma/dp_T^{\gamma}dy^{\gamma}dy^{jet}$ in different regions of $y^{\gamma}.y^{jet}$ can constrain the gluon pdf in low p_T range
- To make this measurement
  - Unfolding of the detector/selection/acceptance effects
  - Estimate and subtraction of the QCD back-ground
- Some preliminary results
  - MC/Data comparison after selection
  - The agreement is encouraging
  - Still a lot to do : this activity started only recently, with very few persons contributing



Conclusions and perspectives

- Activity on QCD and jets with the early data taking has been concluded by publications
  - E/p studies : July 2010, 300 μb^{-1}
  - JES uncertainty : July 2010, 7 nb^{-1}
  - JES uncertainty with photon + jet : in preparation...
  - Multi-jet cross section : Aug. 2010, 17 nb^{-1}
  - Inclusive jet/dijet cross section : October 2010, 17 nb^{-1}
- Work is still going-on
  - Improve estimate of the JES uncertainty (use in-situ methods)
    - *Reduce it down to 3-4 %*
  - Improve the Jet calibration
    - *pile-up corrections and resolution optimisation*
  - Redo all cross section measurements with larger luminosity (L=25 pb^{-1})