Inclusive Jet Cross Section Measurement at LHC-ATLAS experiment

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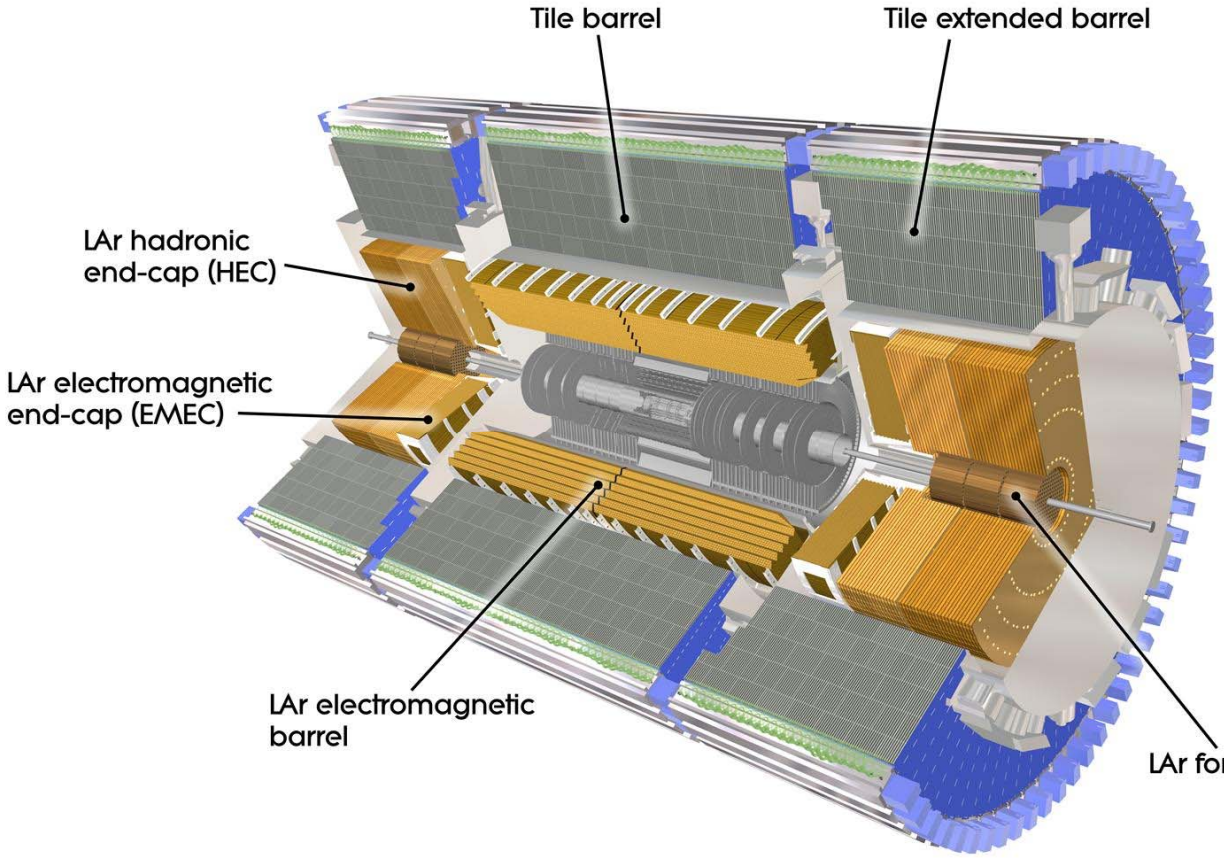
ATLAS experiment at LHC

- LHC : proton-proton collisions at $\sqrt{s} = 7\,\mathrm{TeV}$
- ATLAS calorimeter



4π coverage up to $|\eta|<4.9$

- EM (LAr) $|\eta|<3.2$
- Hadron
  - Tile $|\eta|<1.7$
  - LAr/Cu $1.5<|\eta|<3.2$
- Forward $3.1<|\eta|<4.9$

Inclusive Jet Cross Section

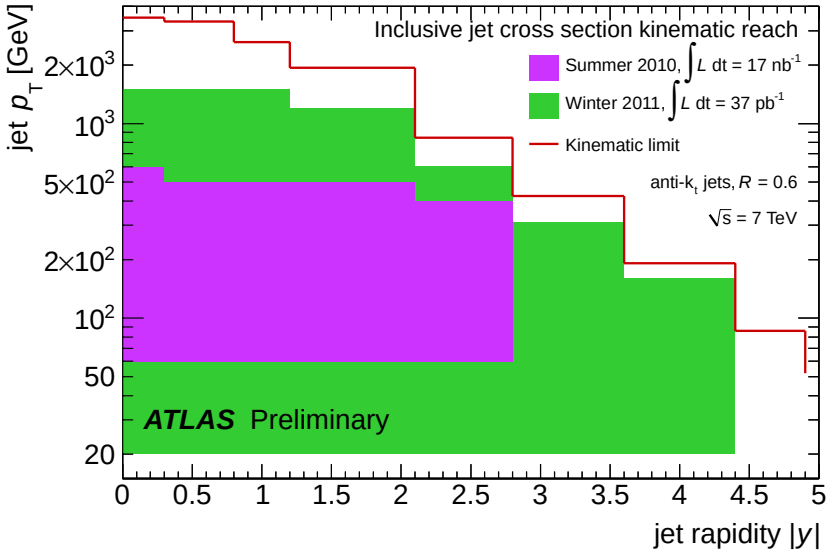
- Cross section of jet production
  - Probe for perturbative QCD in the large phase space
  - Sensitivity to parton distribution functions (PDFs)

- Measurement in ATLAS
  - Kinematic range
    - $|y| < 4.4$
    - $20\ \text{GeV} < p_T < 1.5\ \text{TeV}$

High p_T → New region

Low p_T → Soft QCD

High y → high/low-x PDFs



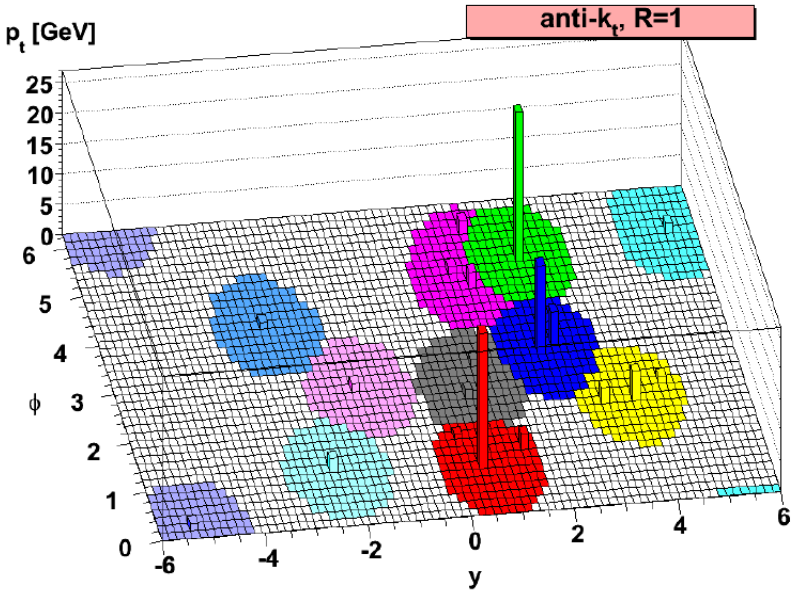
Data sets

- 2010 collision data $\int L\,dt = 37 pb^{-1}$
  - Minimum bias trigger
    - Triggered by a hit on scintillators at end-cap.
    - For measurement at low p_T (p_T<~60 GeV)
    - Collected at the very beginning of the data taking: $L < 1 nb^{-1}$
      - Low instantaneous luminosity
      - Negligible pile up
  - Central and/or forward jet triggers
    - For measurement at medium – high p_T

Jet Reconstruction

- Input: 3D topological cluster
  - Seeded by a calorimeter cell with $E > 4\,\sigma_{noise}$

- anti-k_T algorithm
  - Cone-like shape
    → Good for calibration
  - Infrared and collinear safe
    → Comparison with NLO pQCD



Cacciari, Salam, Soyez: JHEP 0804:063, 2008

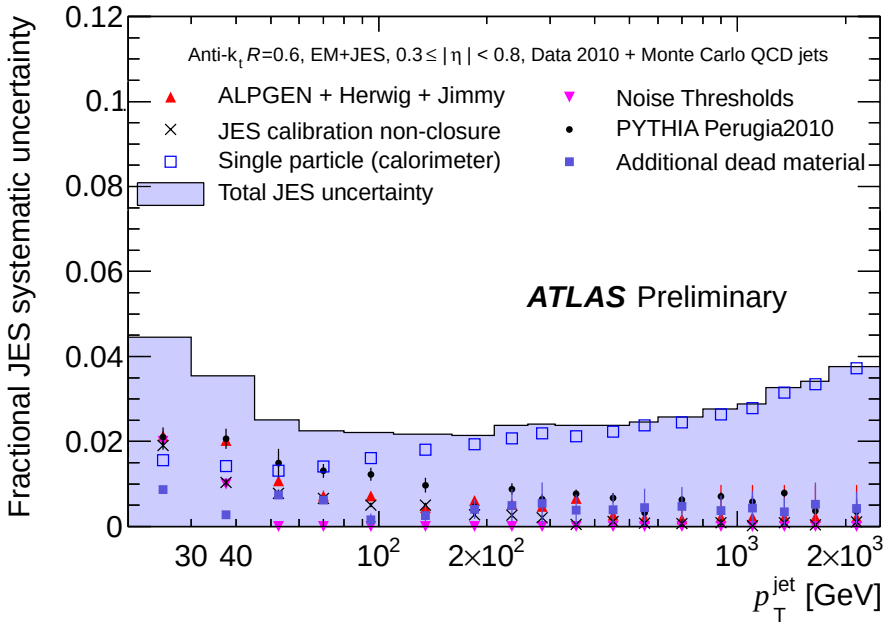
- R=0.4, 0.6
  - Different contribution of non-perturbative effect.

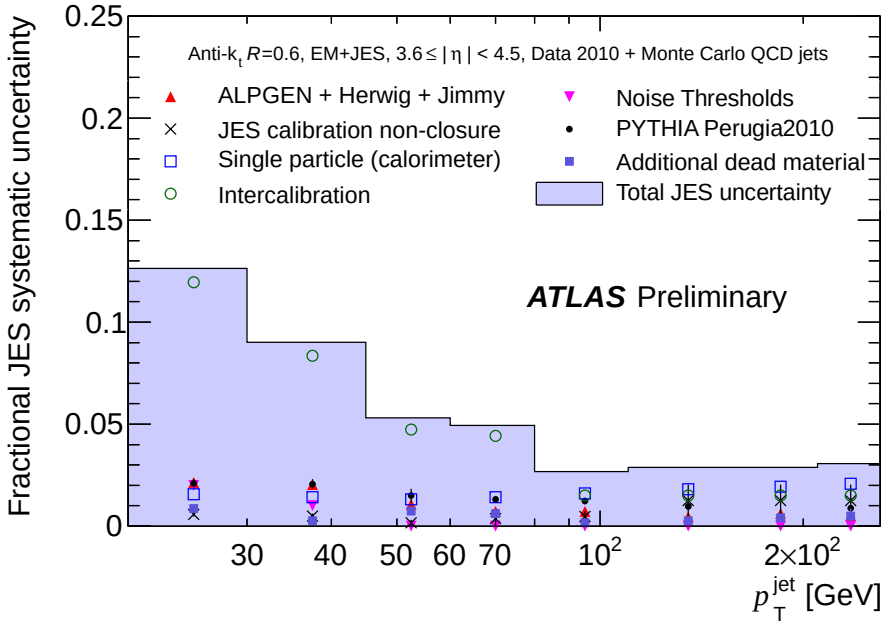
Jet Energy Scale Uncertainties

- JES uncertainty is determined from;
  - Calorimeter response to single particles
    - test beam results
    - in-situ E/p response
  - Detector simulation variation
  - Event generator variation
  - In-situ intercalibration for $|\eta|>0.8$ using dijet balance

- $< 2.5\%$ at the central region for $p_T \sim O(100)$ GeV
- 13% in the forward region.

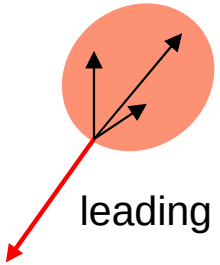
  ← Dominated by modeling of soft physics. (Considered in intercalibration)





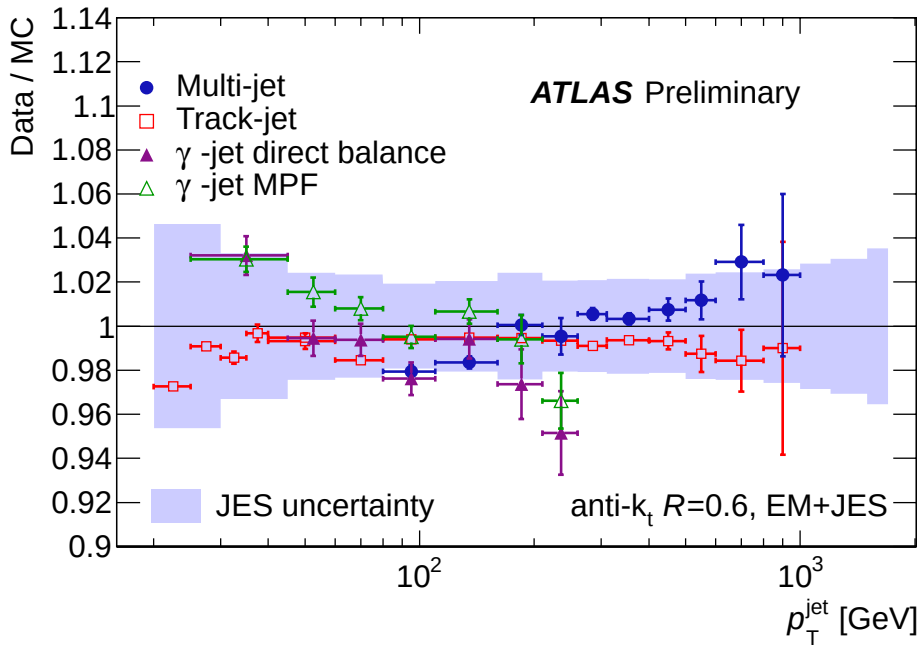
Jet Energy Scale Uncertainties - 2

- JES calibration is validated using in-situ methods.
  - photon-jet balances
  - multi-jet balance
    - Balance between the leading jet and the rest jets.
  - comparison of calorimeter energy and track momentum.



→ Differences between data and MC are well within JES uncertainty.

$0<|\eta|<1.2$



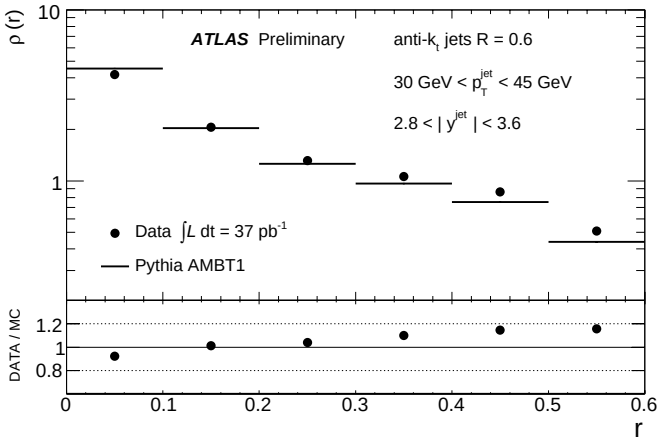
Unfolding for detector effects

- Data distributions should be corrected for
  - Detector effect (resolutions, jet reconstruction inefficiencies)
  - Restoring to truth particle level (muon, neutrinos)
- Bin-by-bin correction was used.

$$C_i = \frac{N_{\text{reco. in i-bin}}}{N_{\text{true in i-bin}}}$$

  - Requires good description of data by MC
    - Jet shape is reasonably well described even at 2.8<|y|<3.6.

      Jet shape in the central region;
      Phys. Rev. D83 052003, 2011



→ MC/Data difference is treated as source of systematic uncertainties.

Systematic Uncertainties

Following sources in the systematic uncertainties are considered.

- Jet energy scale
- Unfolding uncertainty
  - Jet energy resolution
  - Jet angular resolution
  - MC Shape
- Jet cleaning efficiency
- Trigger efficiency
- Jet reconstruction

ATLAS-CONF-2011-047

p_T [GeV]	$\|y\|$	Abs. JES	Unfolding	Cleaning	Trigger	Jet Rec.
20	2.1-2.8	$^{+40\%}_{-30\%}$	20%	0.5%	1%	2%
20	3.6-4.4	$^{+80\%}_{-50\%}$	20%	0.5%	1%	2%
100	< 0.3	10%	2%	0.5%	1%	1%

Table 1: Summary of systematic uncertainties on the inclusive jet cross section measurement for representative p_T and y regions for anti-k_t jets with $R = 0.6$.

Uncertainty of luminosity measurement: 3.4%

Theoretical predictions

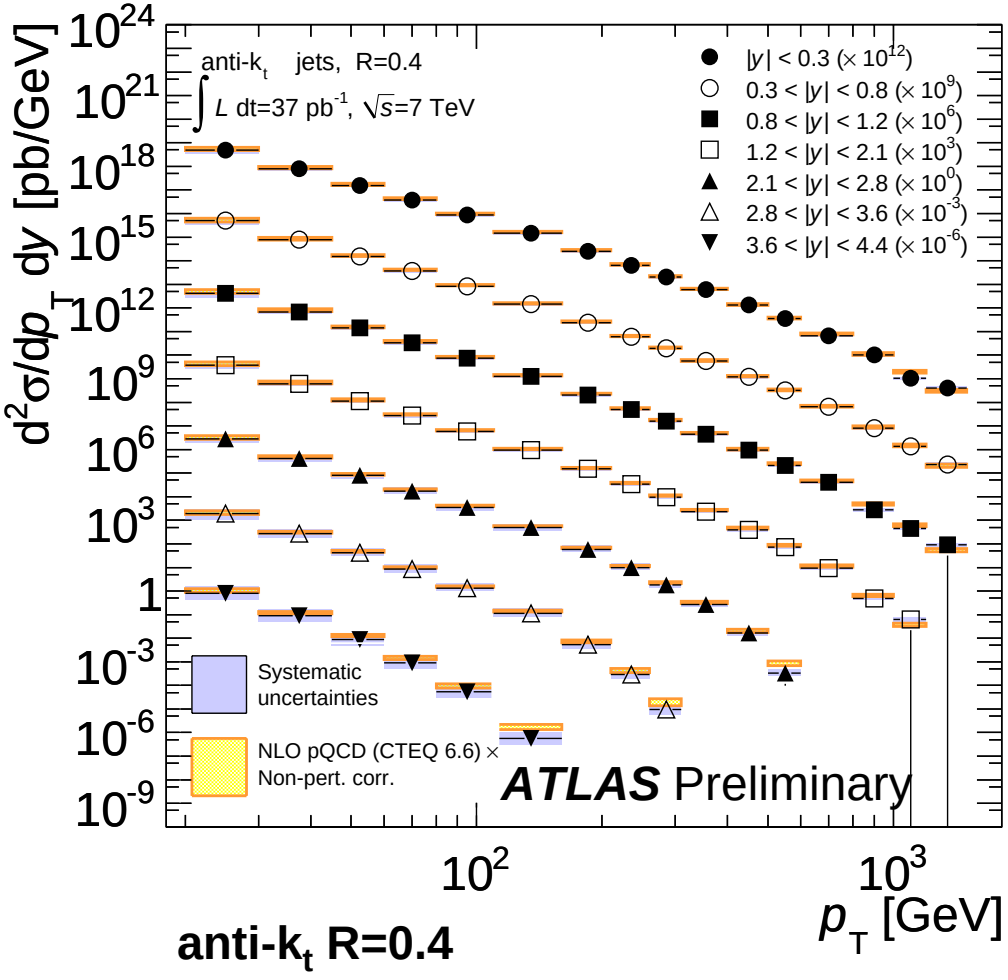
- NLO pQCD prediction + Non-perturbative corrections
  - pQCD predictions

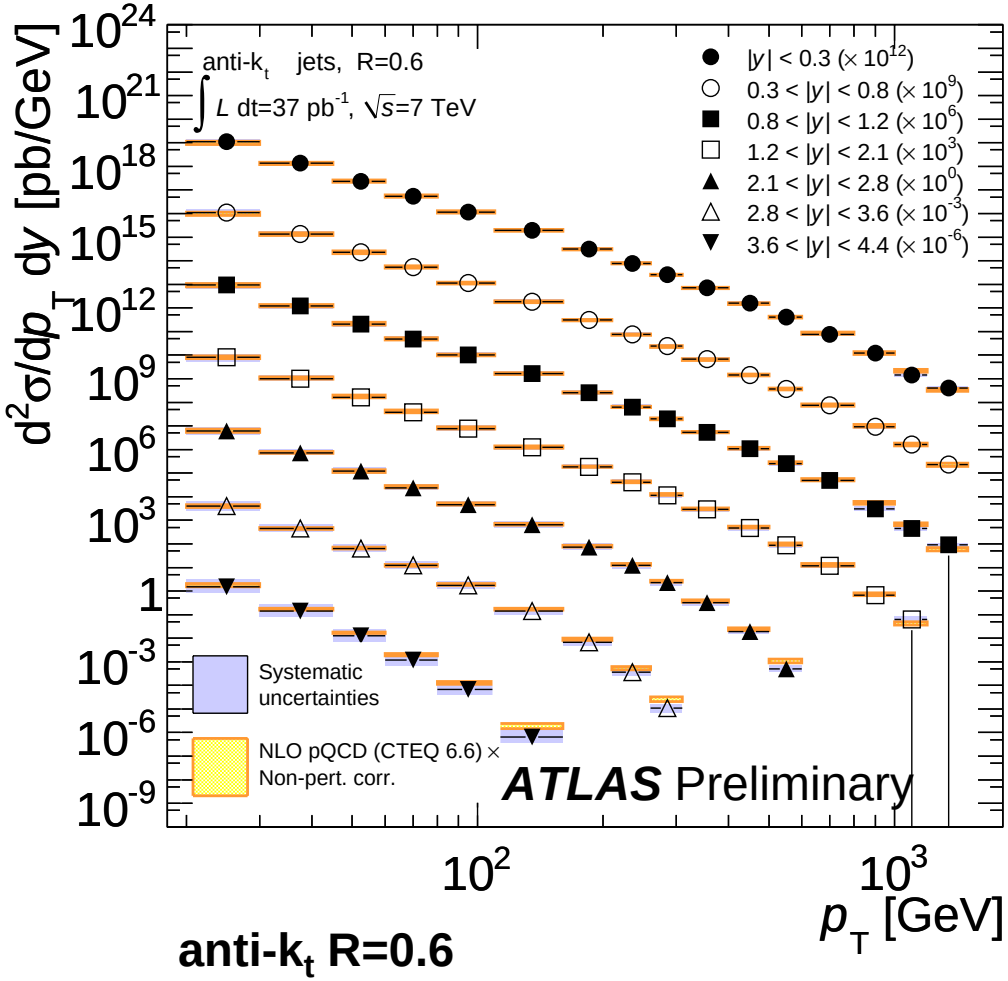
    NLOJET++ (Calculated using APPLGRID)

    Uncertainties: PDF uncertainties, α_S, μ_F, μ_R
  - Non-perturbative effects
    - Hadronization effect
    - Underlying event

    Correction factors from MC $C = \dfrac{\sigma_{Had.\mathrm{ON},UE\ \mathrm{ON}}}{\sigma_{Had.\mathrm{OFF},UE\ \mathrm{OFF}}}$
- Matrix element + Parton shower
  - NLO ME + PS : PowHeg
  - PS + Hadronization + Underlying event: Pythia, Herwig

Measured cross sections

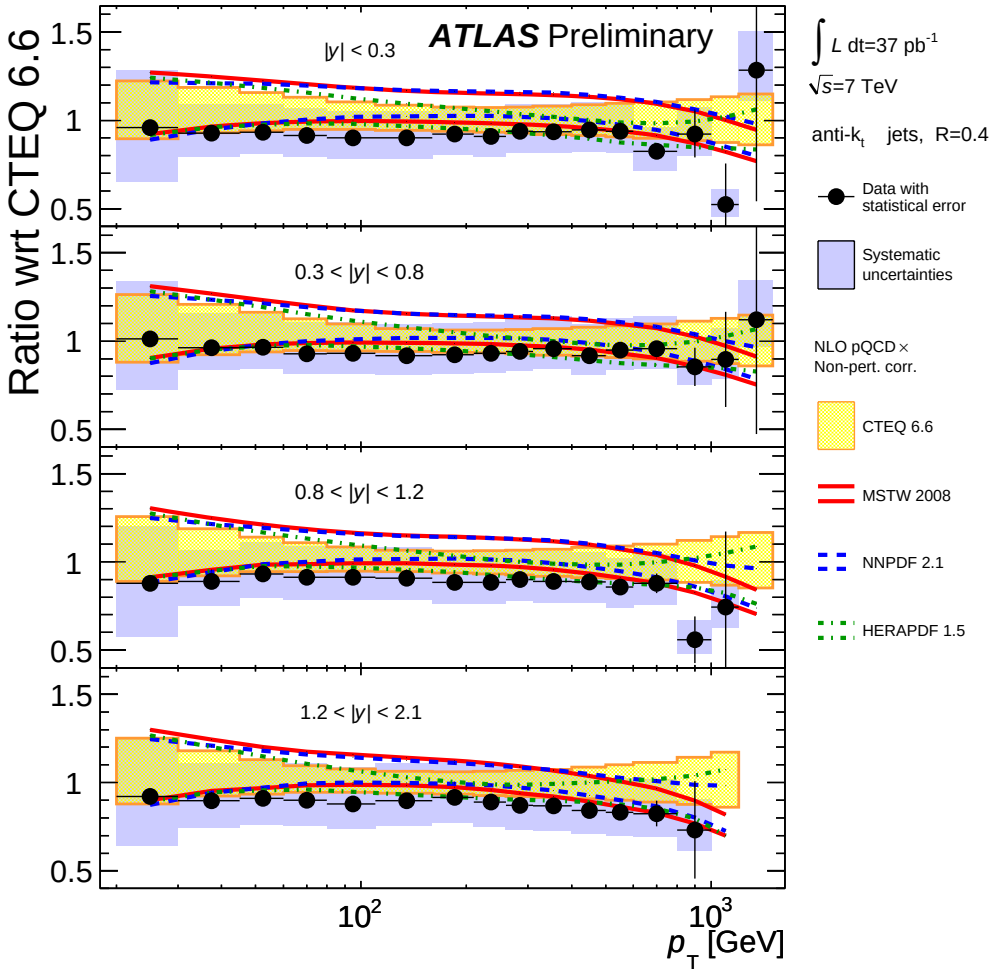


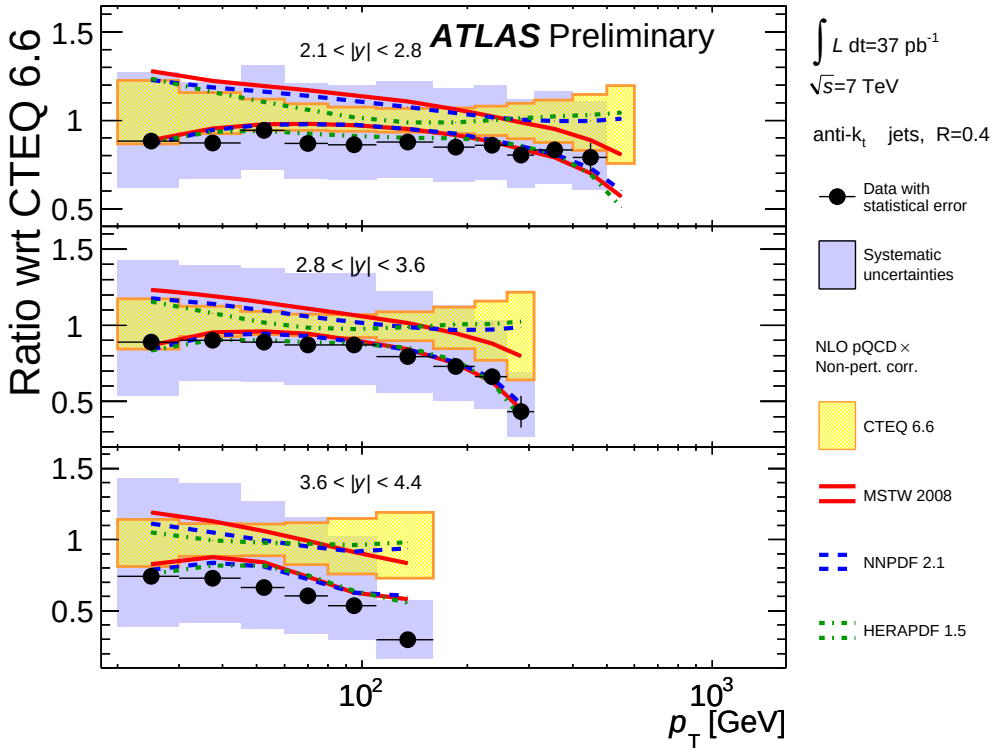


- The inclusive jet cross section is measured for 20 GeV < p_T <1.5 TeV.
- The measurement proves perturbative QCD over 10 orders of magnitude in cross sections.

Comparison with several PDFs

anti-k_t R=0.4



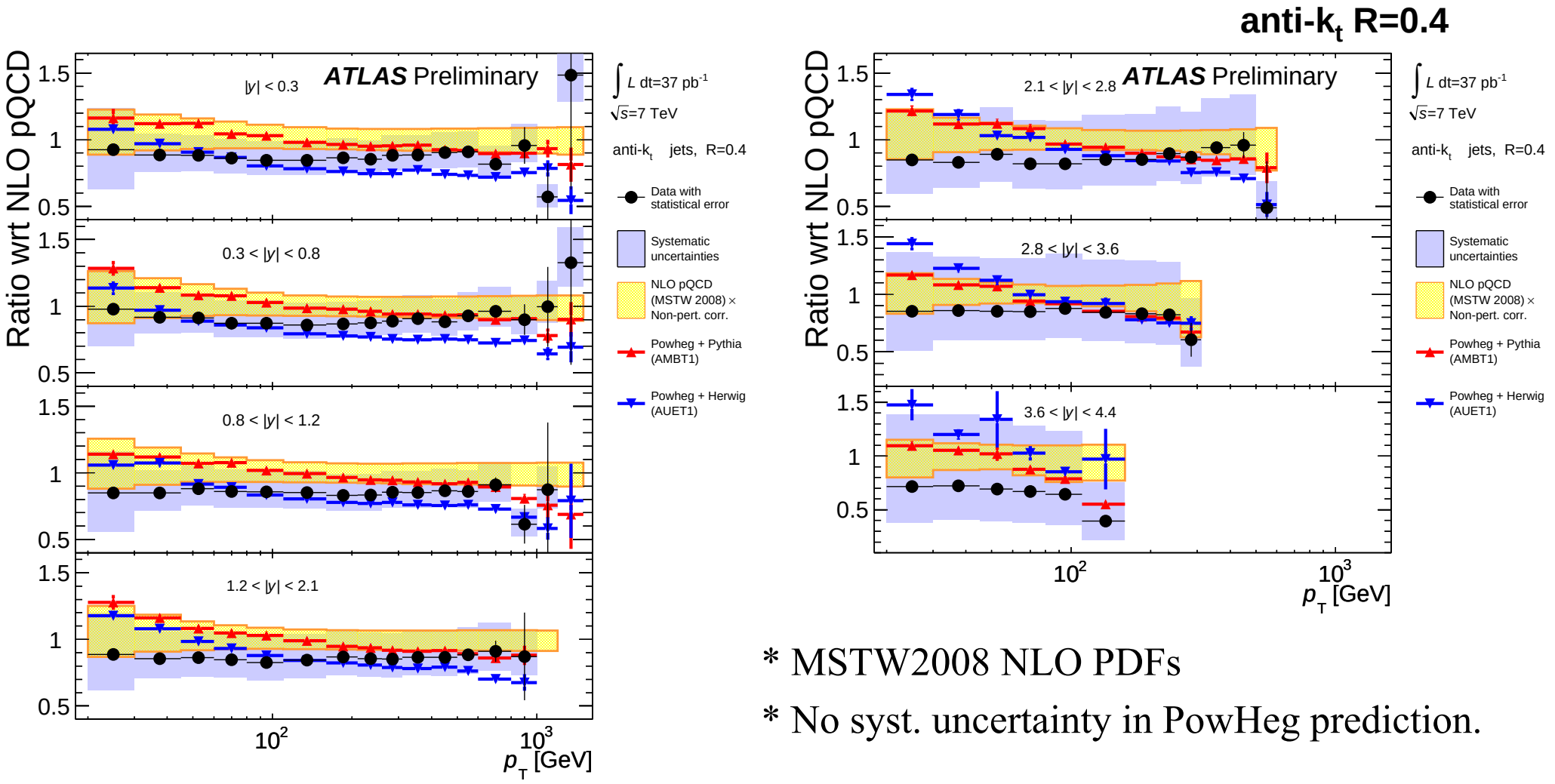


Uncertainties at the central region:

- Measurement ~ 20%
- Theory ~ 10%

- Comparison of CTEQ6.6, MSTW2008, NNPDF2.1 and HERAPDF1.5, in ratios to theory prediction with CTEQ6.6.
- All of them are in good agreement with measured cross sections.

Comparison with PowHeg



* MSTW2008 NLO PDFs
* No syst. uncertainty in PowHeg prediction.

- Comparison with predictions from NLO pQCD calculation and PowHeg calculations.
- PowHeg predictions are consistent with the measured cross section within uncertainties.

Towards 2011 measurements

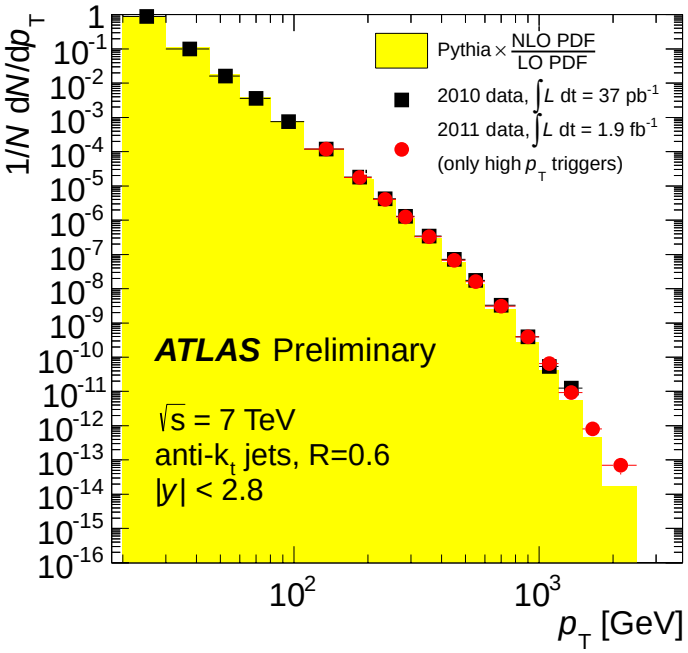
ATLAS has collected

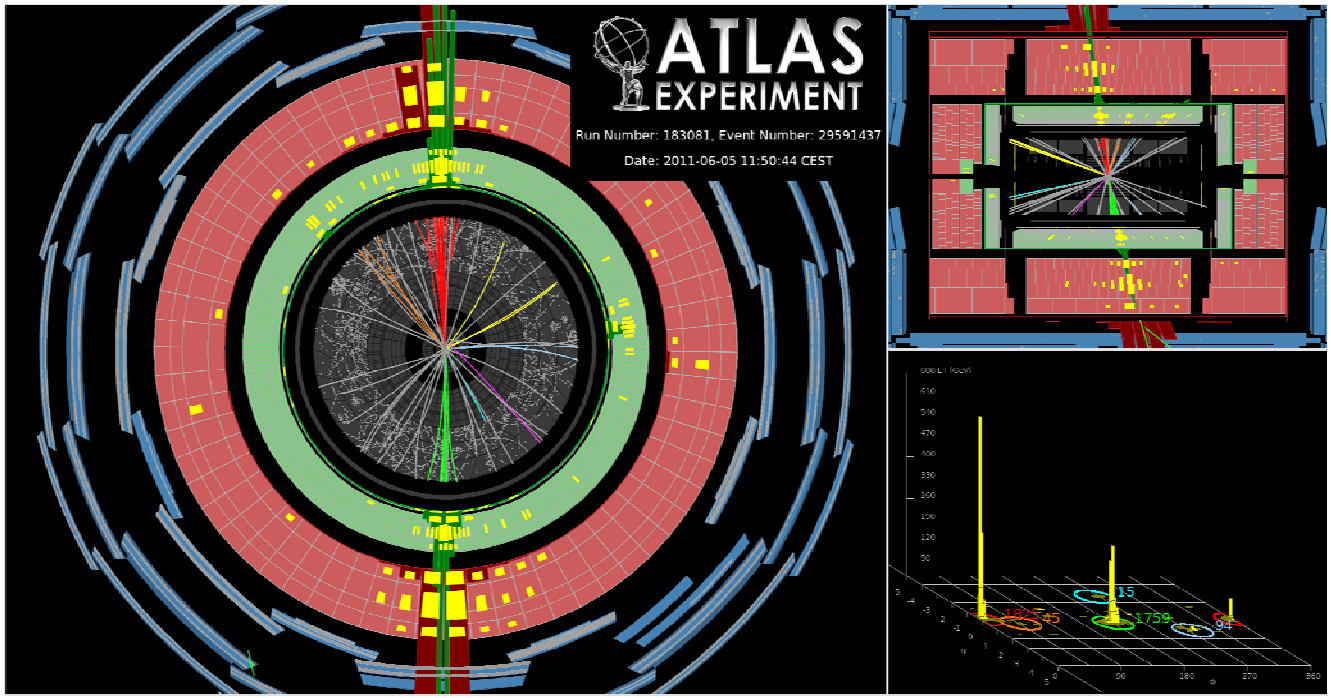
- L = 250 nb^{-1} data of sqrt(s)=2.76 TeV *pp* collision data.

  → Ratio to 2010 measurement will give precise information on QCD.

- L = 2 fb^{-1} of sqrt(s) = 7 TeV *pp* collision data.

  → Extending the measurement to the higher p_T region.





Dijet event with the two leading jets with (p_T, y) of (1.9 TeV, -0.2) and (1.7 TeV, 0.2)

Summary

Inclusive jet cross section has measured using ATLAS detector with full 2010 data of L =37pb^{-1}.

- The measurement covers the large kinematic region of
  20 GeV <p_T<1.5 TeV, |y|<4.4

Test of perturbative QCD in the TeV region.

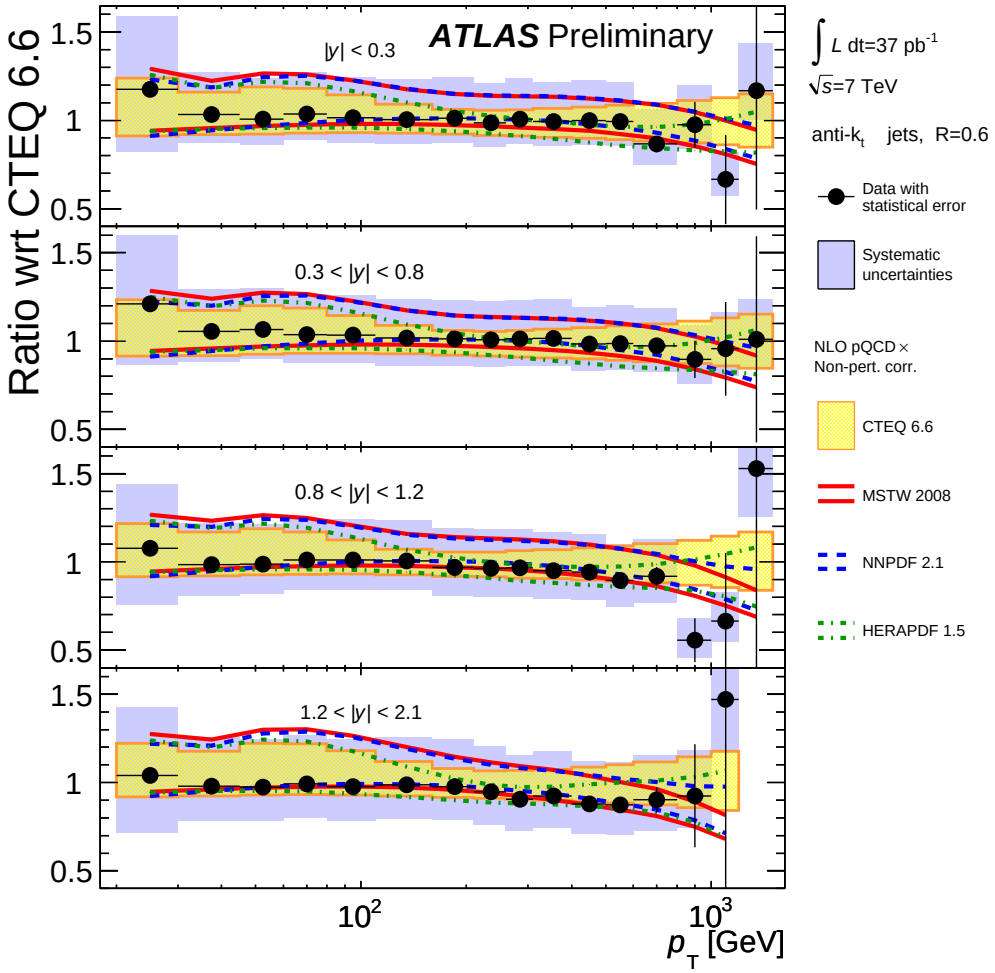
→ Good agreement with pQCD predictions is seen.

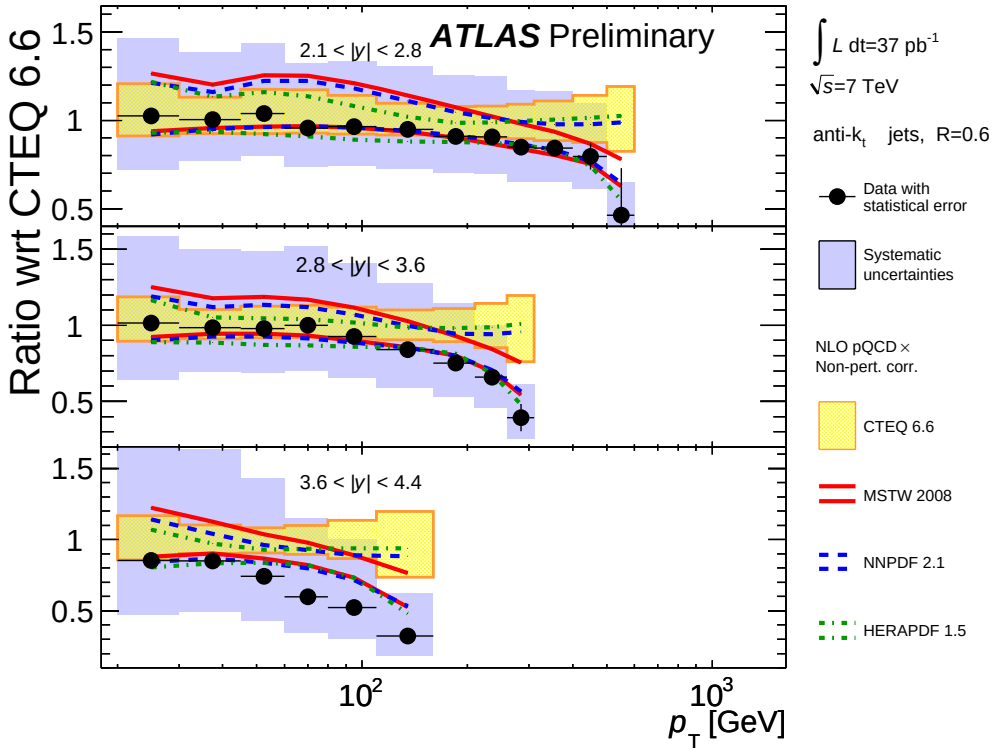
- Comparison with several PDFs.
- Comparison with NLO matrix elements + parton shower.

Would be a new input for PDF determination.

Backup

Comparison with several PDFs (R=0.6)





Comparison with PowHeg (R=0.6)