Inclusive jet production measured with ATLAS and constraints on PDFs

(on behalf of the ATLAS collaboration)

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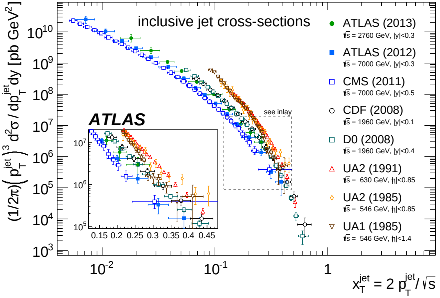
DESY

23-Apr-2013

Introduction

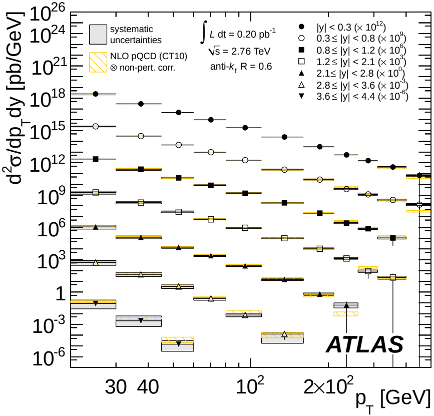


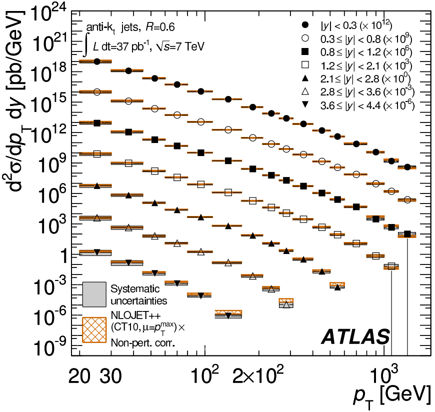
Inclusive jet cross-section as a function of p_T at different centre-of-mass energies $\sqrt{s}$ from various experiments.The used clustering algorithms, jet definitions, jet parameters and the used rapidity regions vary among the measurements. Hence, only a qualitative comparison is possible.

Outlook

- Inclusive jet cross-section at $\sqrt{s} = 2.76$ TeV
  - start of 2011 data taking
  - $\mathcal{L} = 0.20$ pb^{-1}
  - $20 < p_T < 430$ GeV; $|y| < 4.4$
- Ratio $\rho(y, p_T) = \frac{d^2\sigma(\sqrt{s}=2.76\ \text{TeV})}{d^2\sigma(\sqrt{s}=7\ \text{TeV})}$
- scaling measurement $x_T = \frac{2p_T}{\sqrt{s}}$
- PDF constraints from combined analysis of ATLAS jets $d^2\sigma\left(\sqrt{s} = 2.76\ \text{TeV}\right)$, $d^2\sigma\left(\sqrt{s} = 7\ \text{TeV}\right)$ and HERA I data (JHEP 1001:109,2010)

ATLAS Inclusive Jet Cross Section

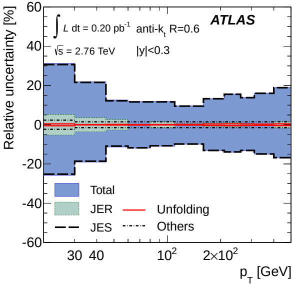


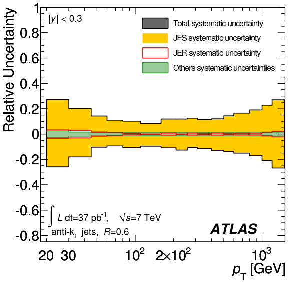


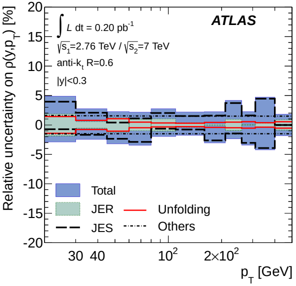
data points are unfolded from detector effect; pQCD corrected for non-perturbative effects; good agreement with theory over 8 orders of magnitude

arXiv:1304.4739 Phys.Rev. D86 (2012) 014022

Inclusive jet cross section. Total systematic uncertainty in the central rapidity bin

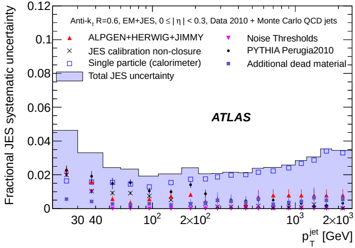


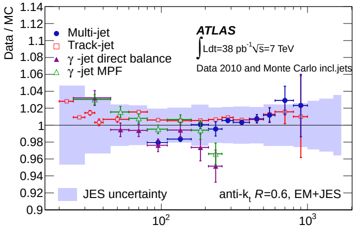




- JES – jet energy scale
- JER – jet energy resolution
- others – trigger, reconstruction jet selection efficiencies; angular resolution; unfolding

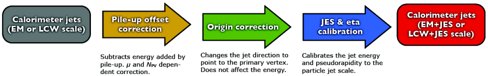
Jet energy scale and its uncertainty





Eur.Phys.J. C73 (2013) 2304

Jet calibration



- Six (+1 in forward bins) JES components
- Calorimeter response is the dominating one with complex correlation.
- The others are independent and 100% correlated between bins
- In-situ techniques confirm the single particles based JES uncertainty
- same calibration is used in two datasets ⇒ systematic uncertainties are correlated

Correlation of jet energy scale uncertainty

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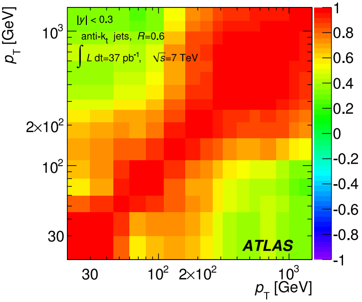
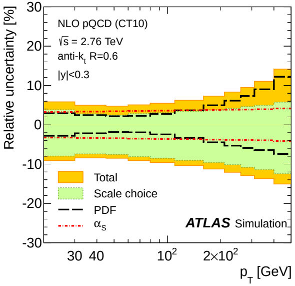
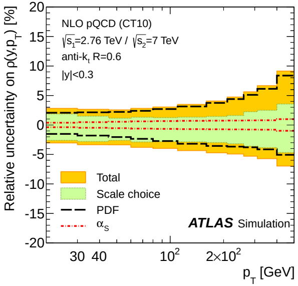


Correlation between pT-bins (right) of the total systematic uncertainty on the inclusive jet cross section measurement for anti-kt jets with R=0.6 in the 7 TeV dataset

- In total 87 sources of correlated systematic uncertainties (89 for the jet measurement at $\sqrt{s} = 2.76\ \mathrm{TeV}$)
- JES uncertainty correlation is described by 73 nuisance parameters in the full (p_T , η) phase space.
- nuisance parameters are correlated between 2.76 TeV and 7 TeV datasets.

Inclusive jet cross section. Theory prediction (NLO)

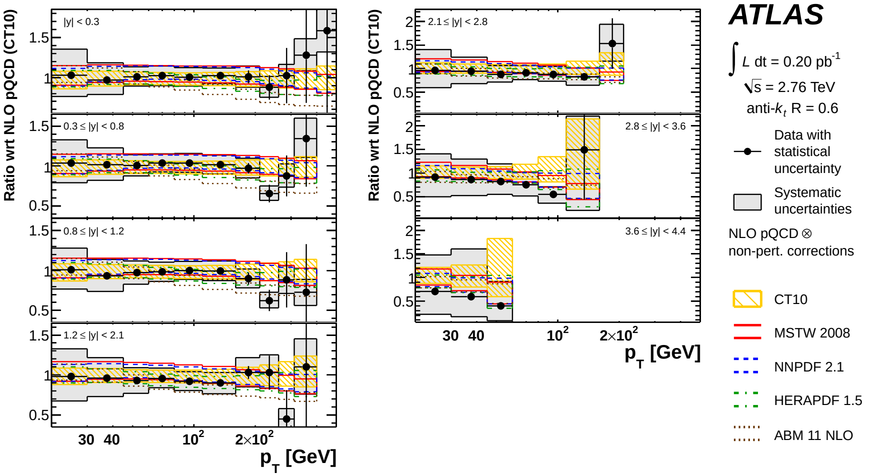




- NLOJET++
- default scale : $\mu_R = \mu_F = p_{\mathrm{T}}^{\max}(y_i)$
- scale uncertainty : independent up/down variations by a factor of 2 (excluding $\mu_R * \mu_F = 4(1/4)$).
- α_S is taken from the corresponding PDF set
- CT10, MSTW 2008, NNPDF 2.1 (100), HERAPDF 1.5 and ABM 11 NLO ($n_f = 5$) are used for comparisons
- the bin-wise ratio of cross sections with and without hadronisation and the underlying event
- default tune : Pythia 6+AUET2B+CTEQ6L1

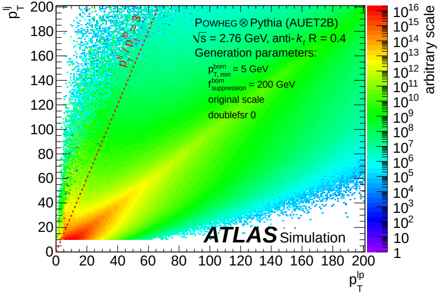
Inclusive jets at $\sqrt{s} = 2.76$ TeV. ThEORY vs DATA

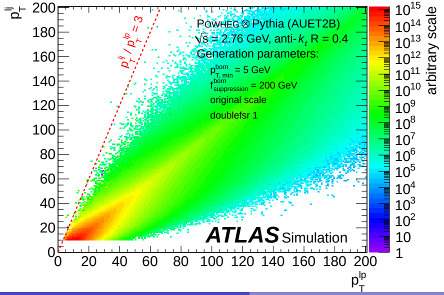
Luminosity uncertainty 2.7%(not shown)



The measurement is consistent with all the theory predictions using different PDF sets within their systematic uncertainties

Inclusive jets at $\sqrt{s} = 2.76$ TeV. PoWHEG predictions



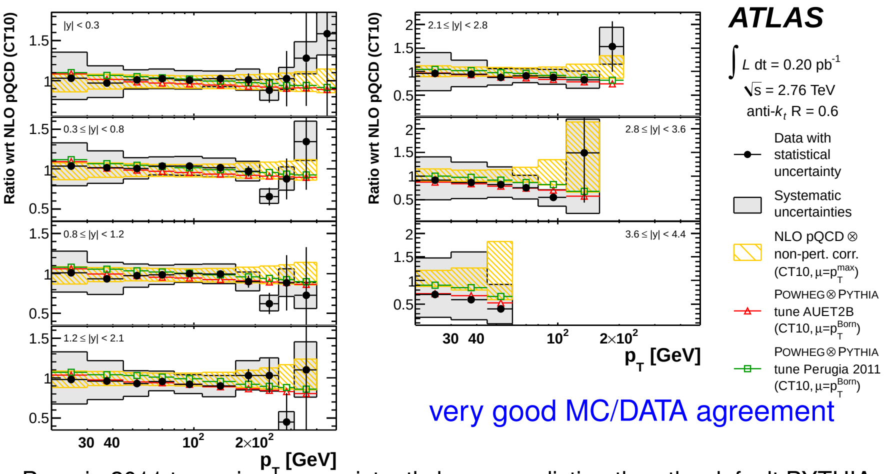


After input from ATLAS a new version was released with modified matching scale: http://arxiv.org/abs/1303.3922

- Revision 2169 : Using the Powheg option doublefsr=1
- Origin is due to Powheg Box 1.0 not including the opposite p_T ordering of quark/gluon splitting

Inclusive jets at $\sqrt{s} = 2.76$ TeV. PoWHEG vs DATA

Luminosity uncertainty 2.7%(not shown)

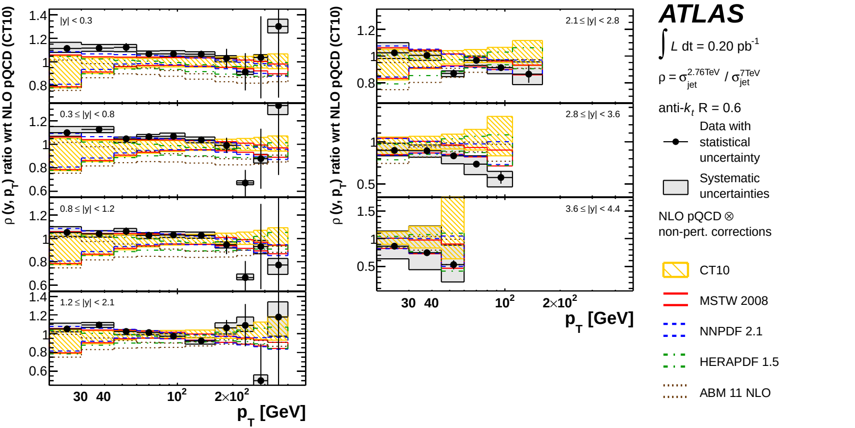


very good MC/DATA agreement

The Perugia 2011 tune gives a consistently larger prediction than the default PYTHIA tune AUET2B, which is generally in closer agreement with data. New PoWHEG version is used. Only statistical uncertainty is shown for PoWHEG.

Inclusive jets ratio. ThEORY vs DATA

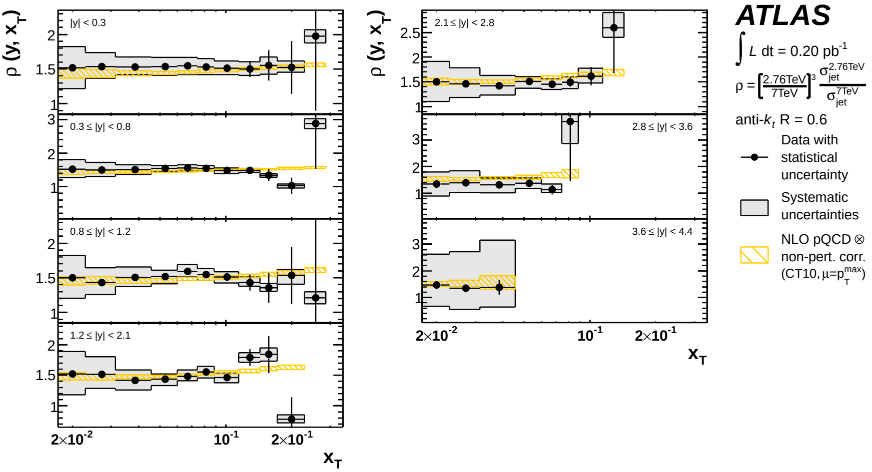
Luminosity uncertainty 4.3%(not shown)



Very small experimental systematic uncertainties . The measured points are slightly higher than the predictions in the central rapidity regions and are lower in the forward rapidity regions. The deviation is more pronounced for the prediction using the ABM 11

Inclusive jets ratio. ThEORY vs DATA in x_T bins

Luminosity uncertainty 4.3%(not shown)



Very small theory uncertainties . The experimental uncertainties cancel partially.

PDF fit

Jet cross sections at $\sqrt{s} = 2.76$ and $\sqrt{s} = 7$ TeVare fitted simultaneously, together with HERA I data

HERAPDF-inspired ansatz

$$
\begin{aligned}
xu_v(x) &= A_{u_v} x^{B_{uv}} (1-x)^{C_{uv}} \\
&\times (1 + E_{u_v} x^2), \\
xd_v(x) &= A_{d_v} x^{B_{dv}} (1-x)^{C_{dv}}, \\
x\bar{U}(x) &= A_{\bar{U}} x^{B_{\bar{U}}} (1-x)^{C_{\bar{U}}}, \\
x\bar{D}(x) &= A_{\bar{D}} x^{B_{\bar{D}}} (1-x)^{C_{\bar{D}}}, \\
xg(x) &= A_g x^{B_g} (1-x)^{C_g} \\
&- A'_g x^{B'_g} (1-x)^{C'_g}
\end{aligned}
$$

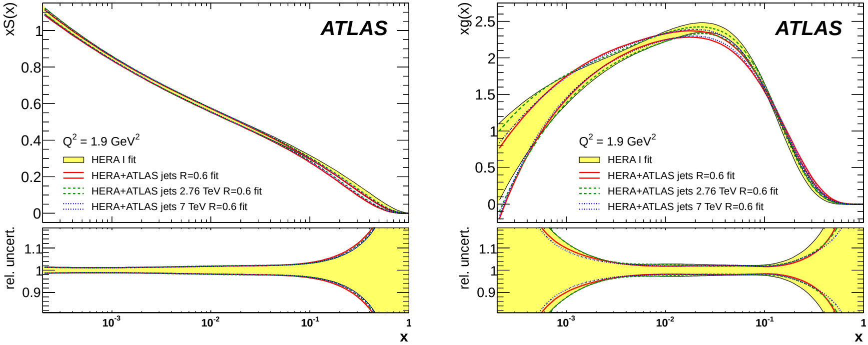
Here $\bar{U} = \bar{u}$ whereas $\bar{D} = \bar{d} + \bar{s}$. The parameters A_{u_v} and A_{d_v} are fixed using the quark counting rule and A_g using the momentum sum rule. The normalisation and slope parameters, A and B, of $\bar{u}$ and $\bar{d}$ are set equal such that $x\bar{u} = x\bar{d}$ at $x \to 0$.

- consistent treatment of JES systematics correlations between two ATLAS jet datasets
- $\alpha_S(M_Z) = 0.1176$
- $p_T^{\min}(jet) = 45$ GeV (ATLAS)
- strange fraction $f_s = 0.31$
- starting scale $Q_0^2 = 1.9$ GeV^2
- $m_c = 1.4$ GeV; $m_b = 4.75$ GeV
- $Q^2_{\min} = 3.5$ GeV^2 (HERA)
- flexible form of gluon distribution with $C'_g = 25$

In total 13 free parameters to describe the parton densities

PDF constraints

- The gluon momentum distribution tends to be harder after the inclusion of the jet data
- PDF sensitivity: different beam energies probe different x, Q^2 for the same η and p_{T} bins



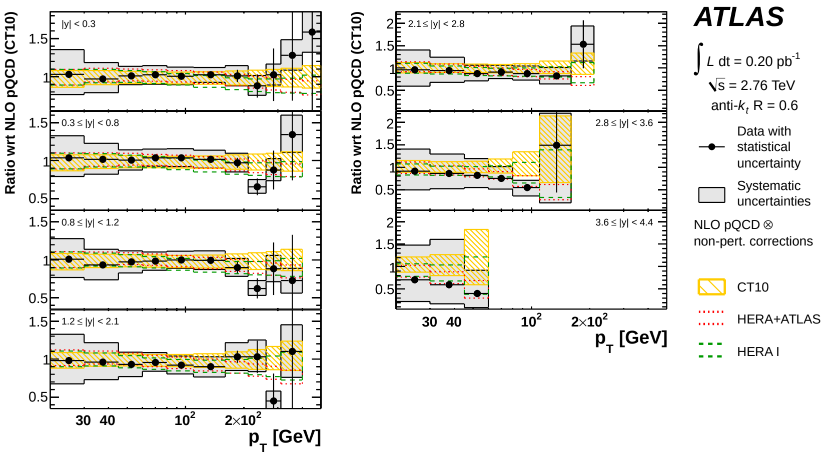
- Very good fit quality is found for both radius parameters
- Shifts of systematics are typically smaller than 0.5σ
- very similar results for fits with $R = 0.4$ and $R = 0.6$ jets

Conclusions

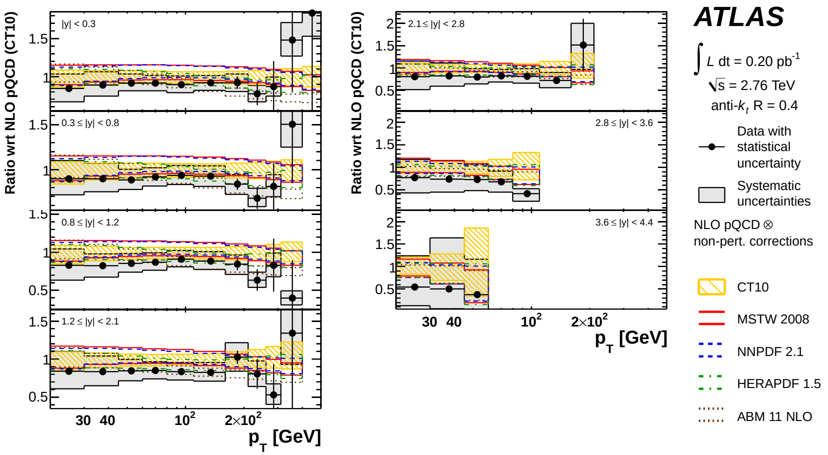
- The measurement of inclusive jet cross-section at $\sqrt{s} = 2.76$ TeV is performed as a function of the jet transverse momentum in bins of jet rapidity
- The ratio of the inclusive cross-sections $\frac{d^2\sigma(\sqrt{s}=2.76 \text{ TeV})}{d^2\sigma(\sqrt{s}=7 \text{ TeV})}$ is measured
- The measurements are compared to fixed-order NLO QCD corrected for non-perturbative effects
- The comparison to predictions from NLO matrix elements with matched parton shower MC is done
- An NLO pQCD analysis in the DGLAP formalism has been performed

BACK-UP

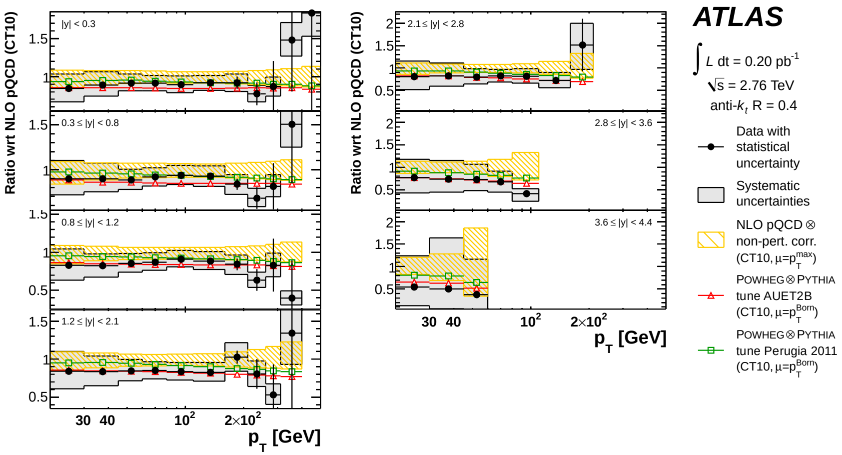
Measurement compared to theory with the fitted PDF



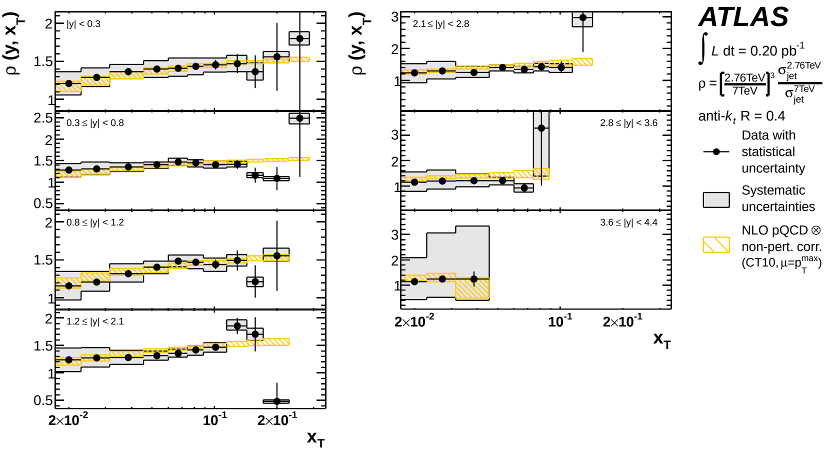
NLOQCD comparison with R=0.4



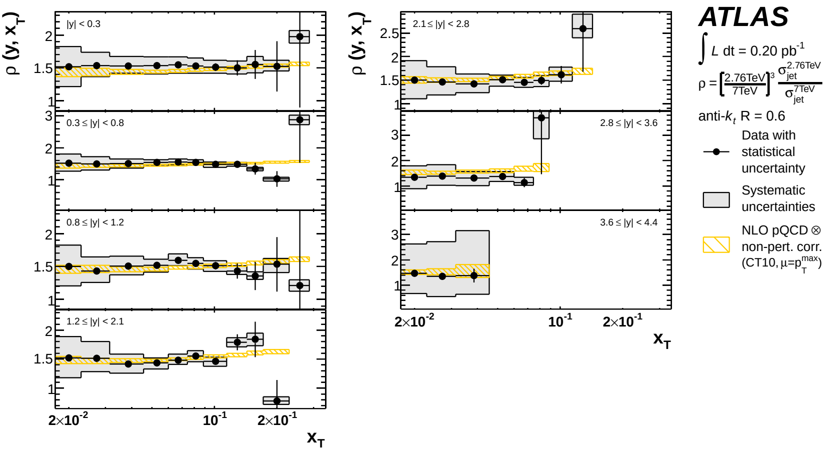
PoWHEG comparison with R=0.4



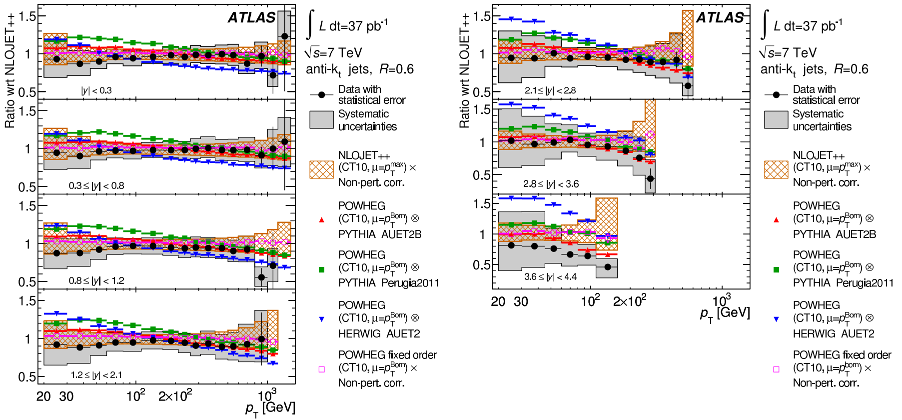
x_T comparison with R=0.4



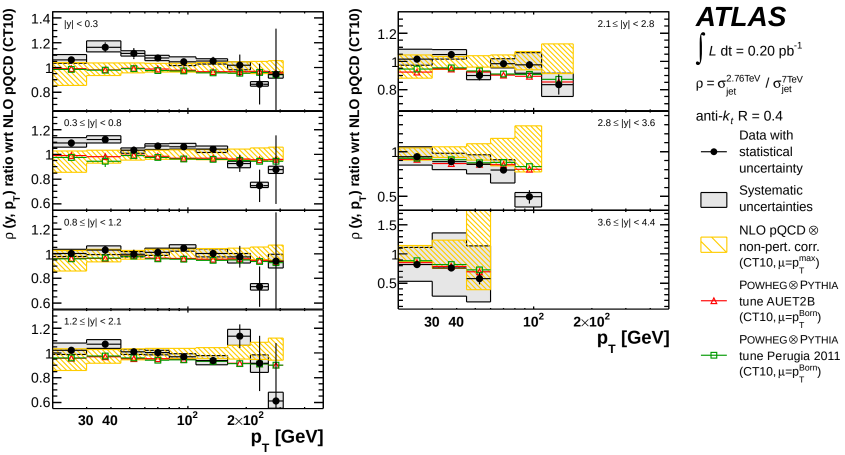
x_T comparison with R=0.6



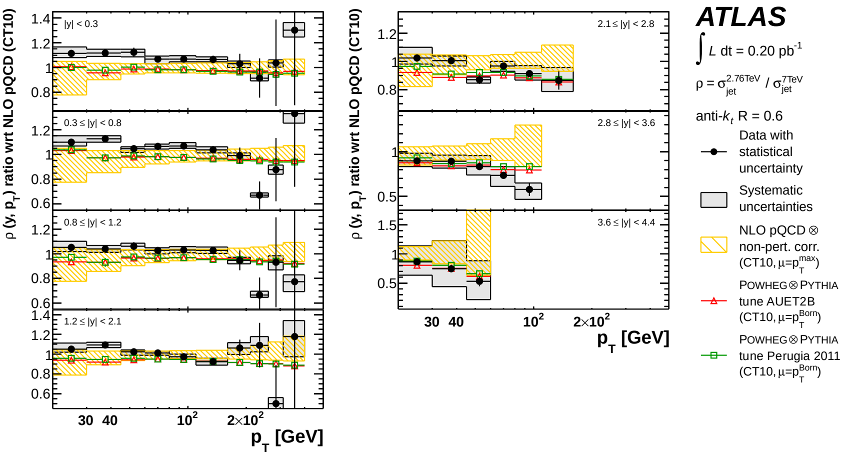
Powheg comparison at $\sqrt{s} = 7$ TeV



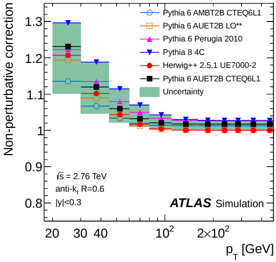
Powheg comparison with ratios

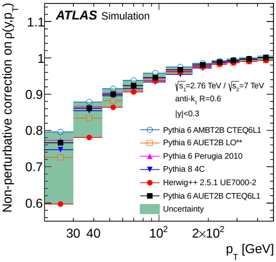


Powheg comparison with ratios



Inclusive jet cross section. Theory prediction (non-perturbative)





- the bin-wise ratio of cross sections with and without hadronisation and the underlying event
- default tune : Pythia 6+AUET2B+CTEQ6L1
- various tunes are used to assign systematic uncertainty
- a ratio of corrections at $\sqrt{s} = 2.76$ TeV and $\sqrt{s} = 7$ TeV is calculated to correct $\rho(y, p_{\mathrm{T}})$