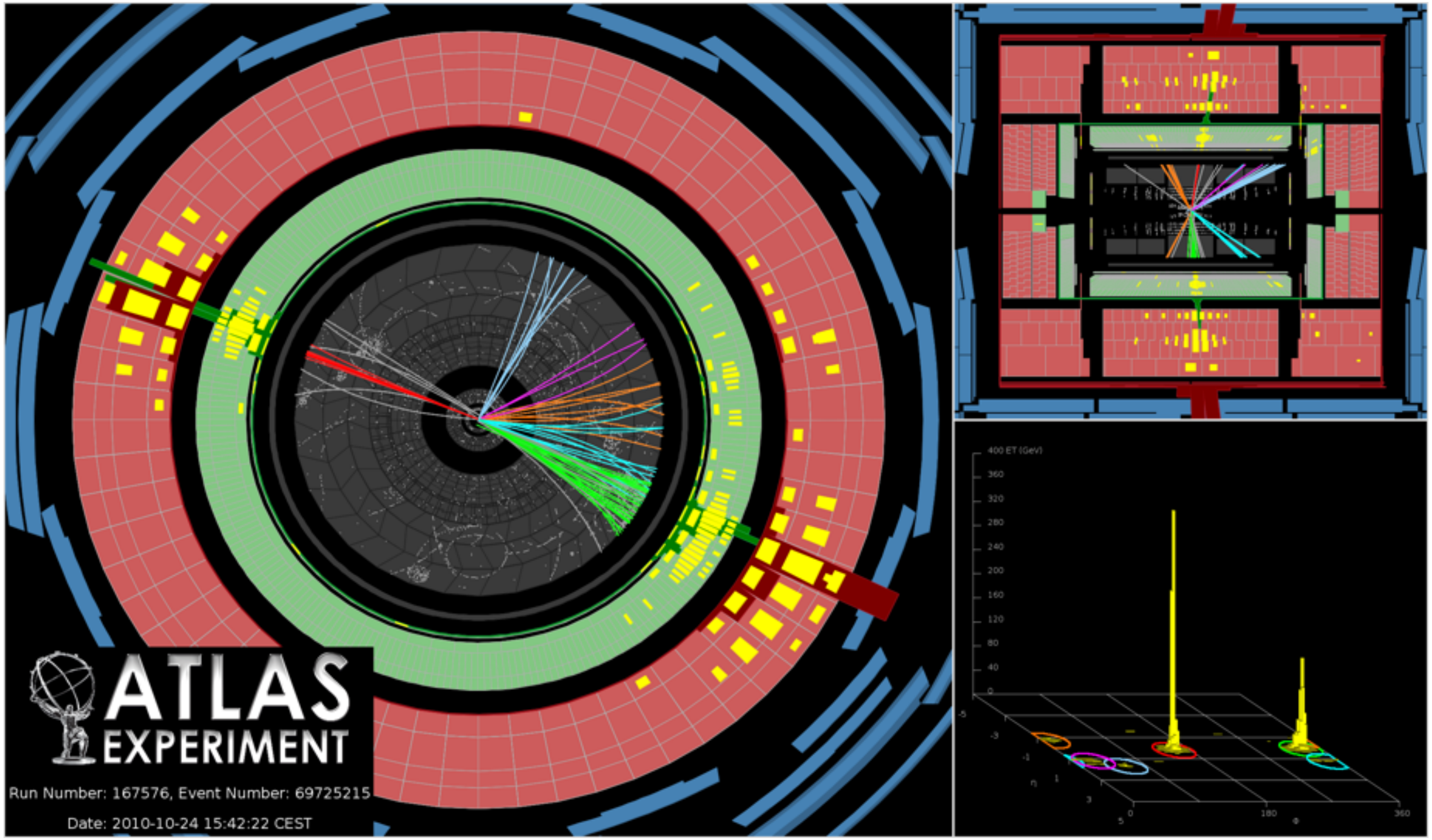
QCD RESULTS USING JETS AND PHOTONS IN ATLAS

XXVI Rencontres de Physique de la Vallée d'Aoste

February 28, 2012



David López Mateos (Harvard University),
on behalf of the ATLAS Collaboration

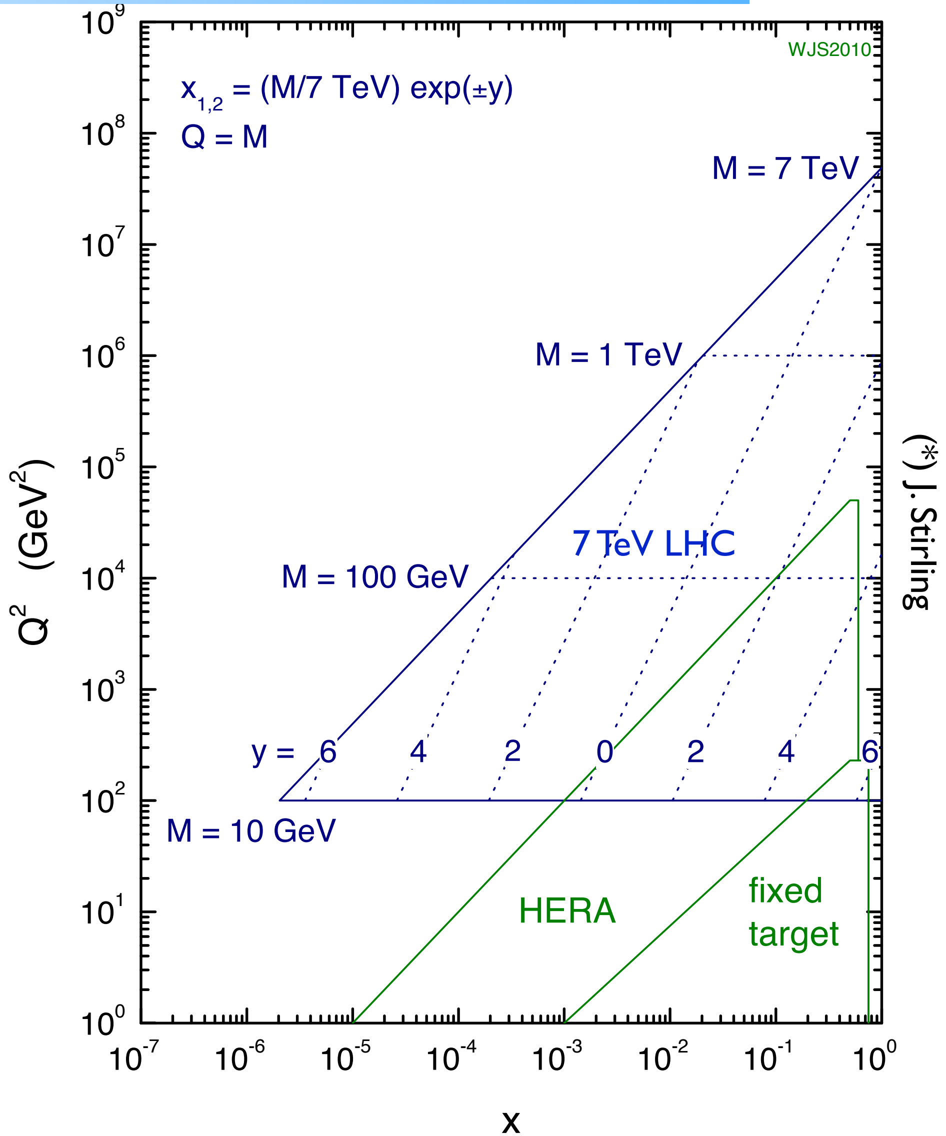
Outline

- Motivation
- The building blocks
- Benchmark measurements
- Completing the picture
- Summary
- Prospects

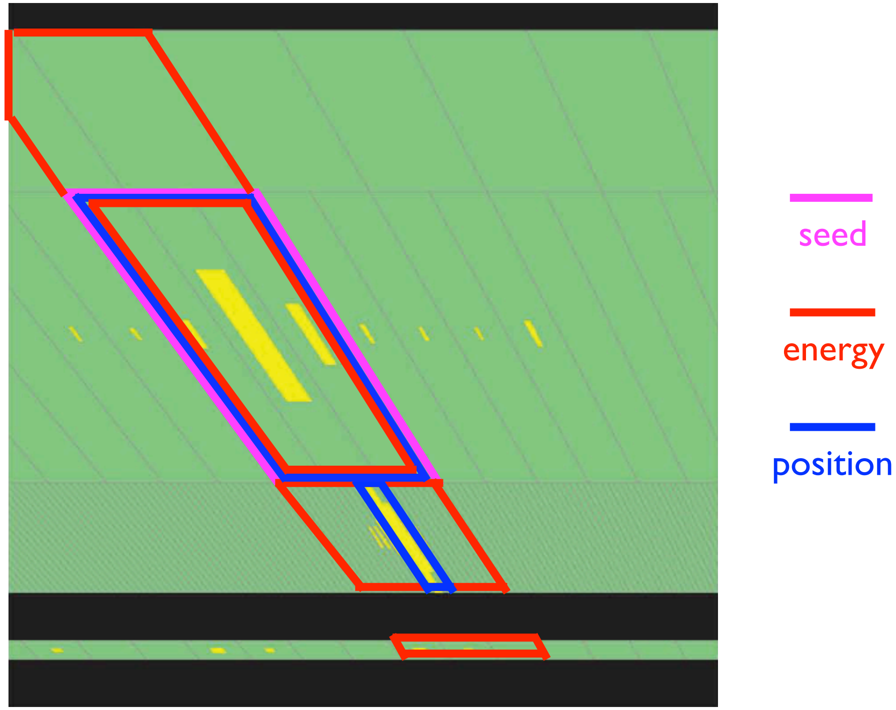
Motivation

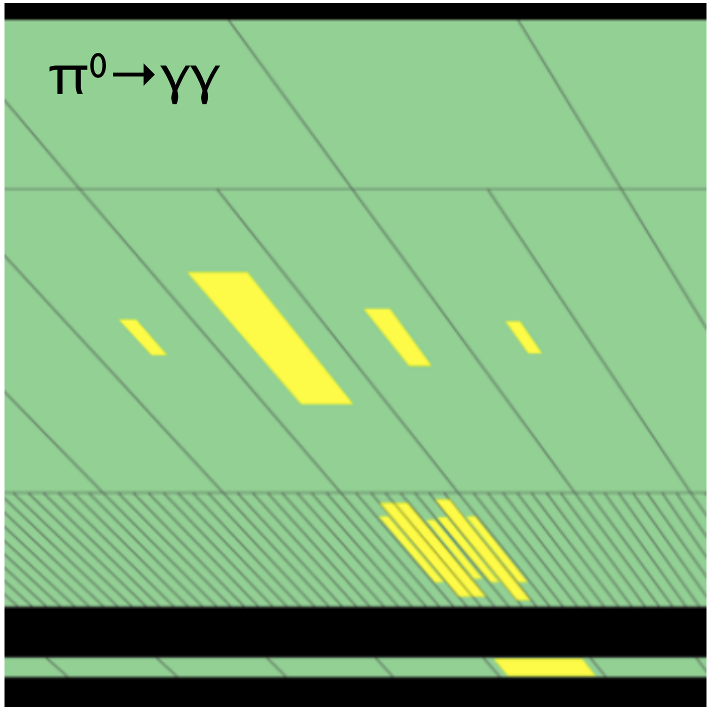
- Fundamental test of QCD in a new energy regime

- Feedback to searches of new physics



Photon Reconstruction and Identification

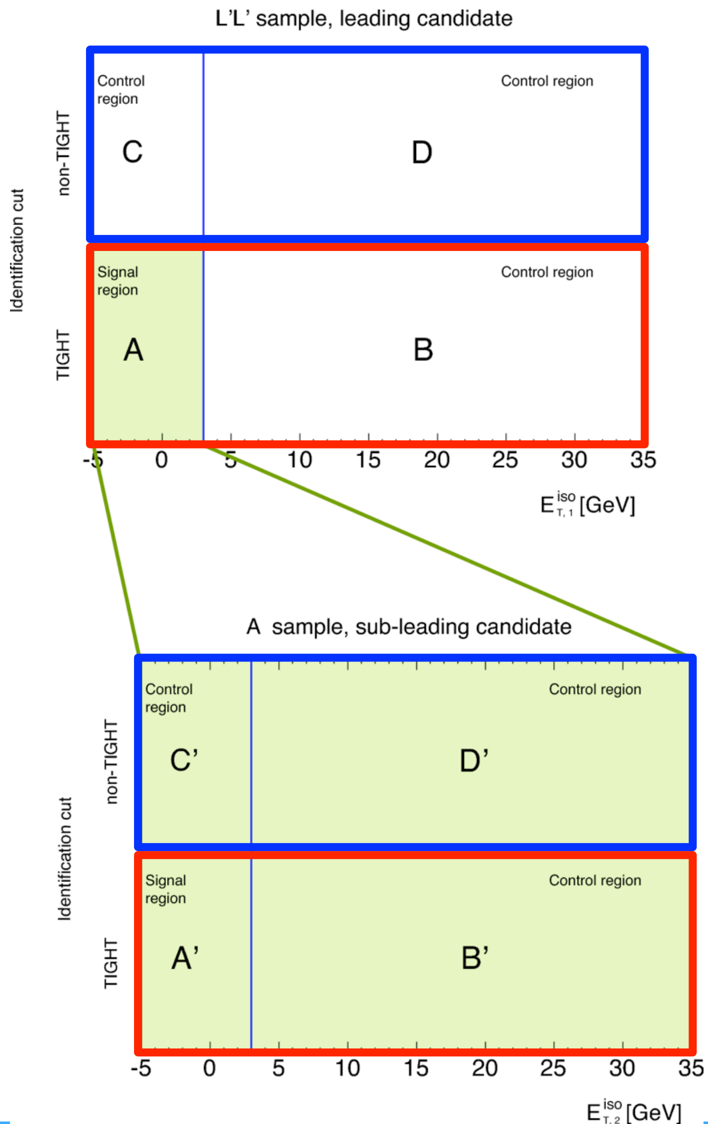


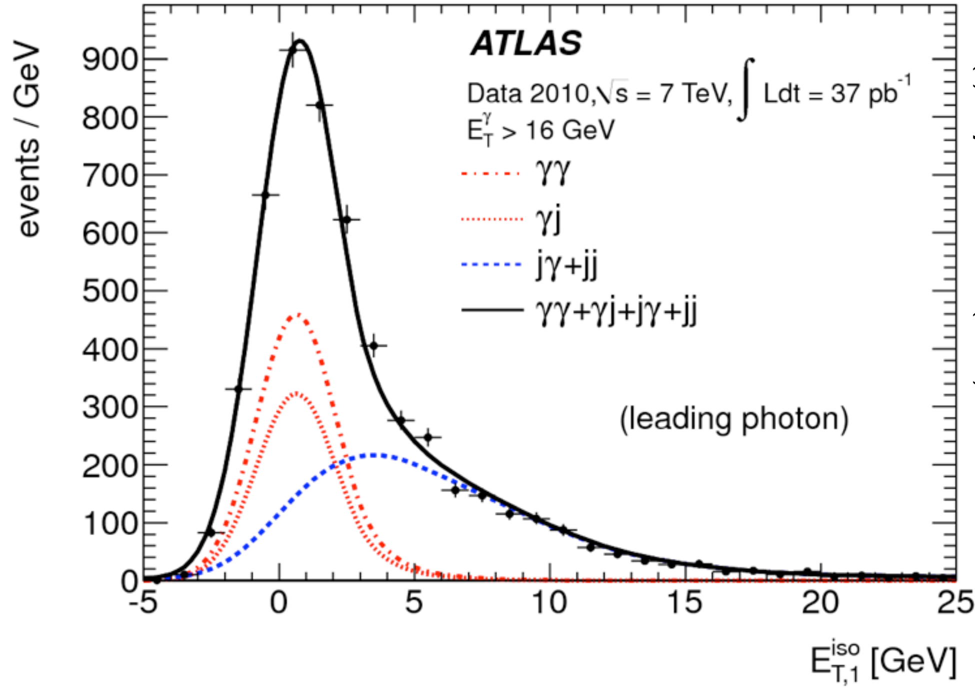


- Energy measurement: all layers

- Photon identification:
  - Granularity in all layers exploited
  - First layer eta granularity helpful for π^0 rejection

Photon Purity Calculation



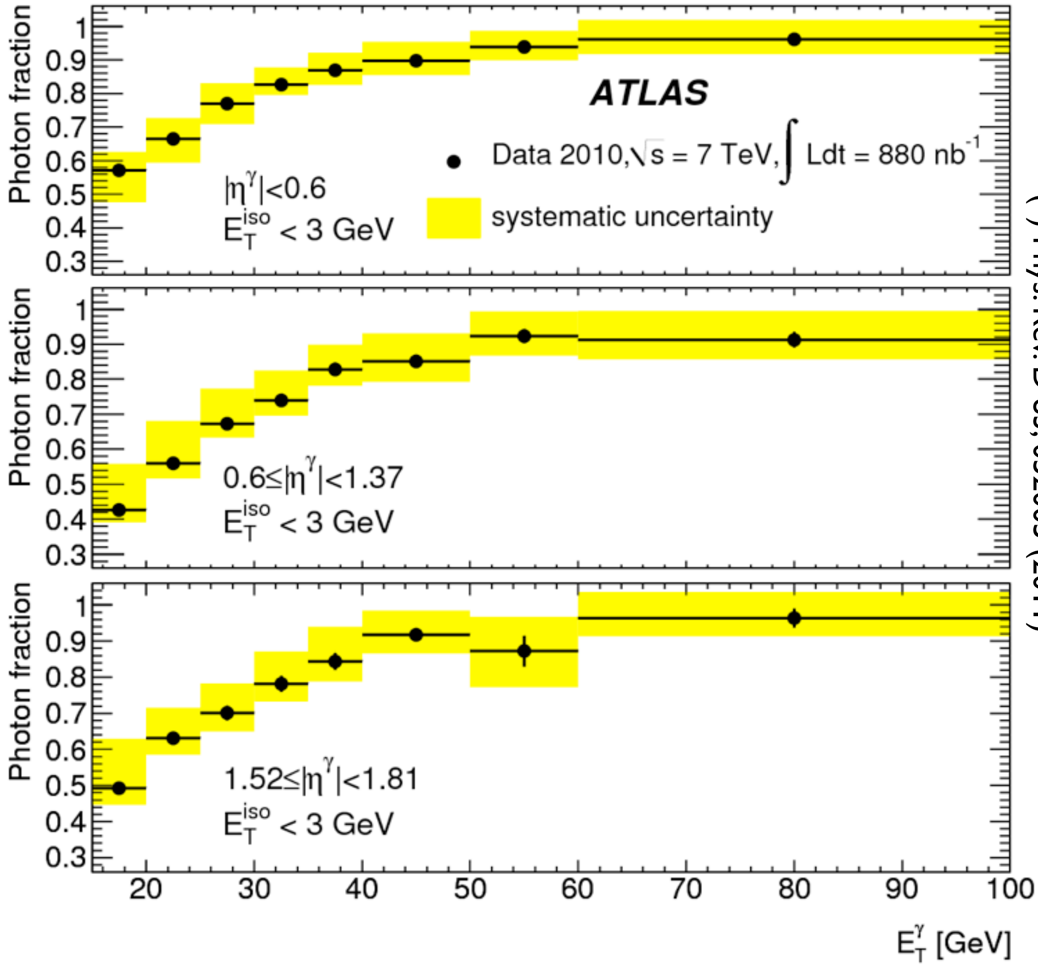


(*) Phys. Rev. D 85 (2012) 012003

- Isolation energy to increase purity
- Purity uses template fits, templates extracted from control regions
- Cross checks with additional methods

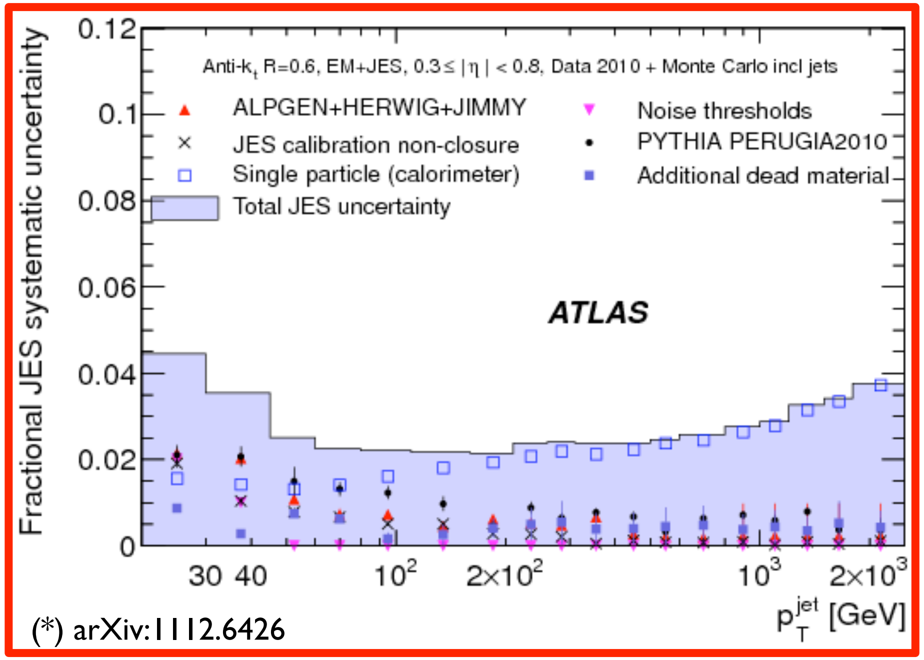
Systematic Uncertainties in Photon Purity Measurement

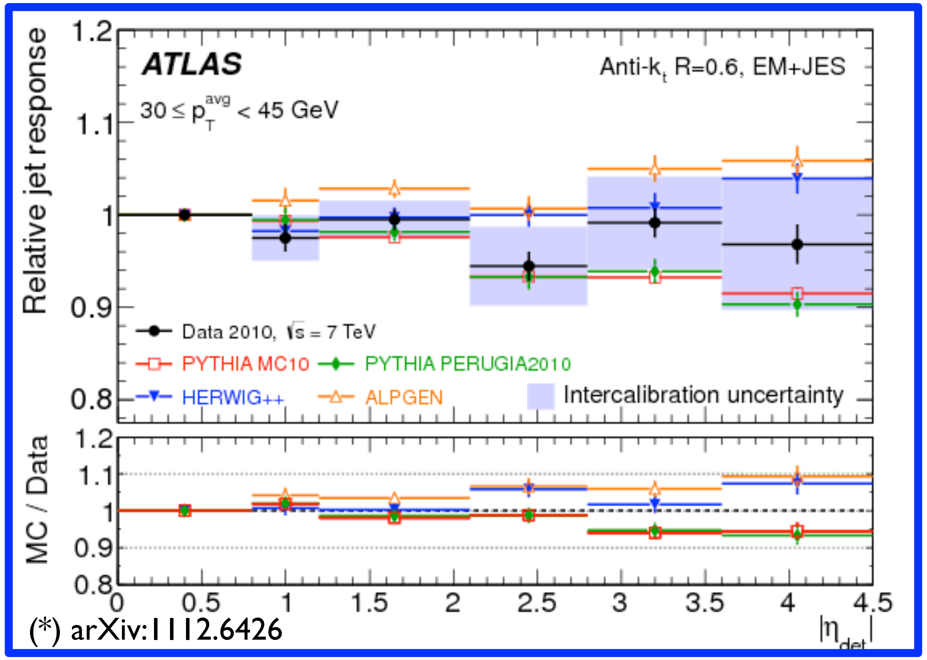
- High purity at high p_T
- Systematics dominated by identification control region definition
- Signal leakage into control regions also important systematic



(*) Phys. Rev. D 83, 052005 (2011)

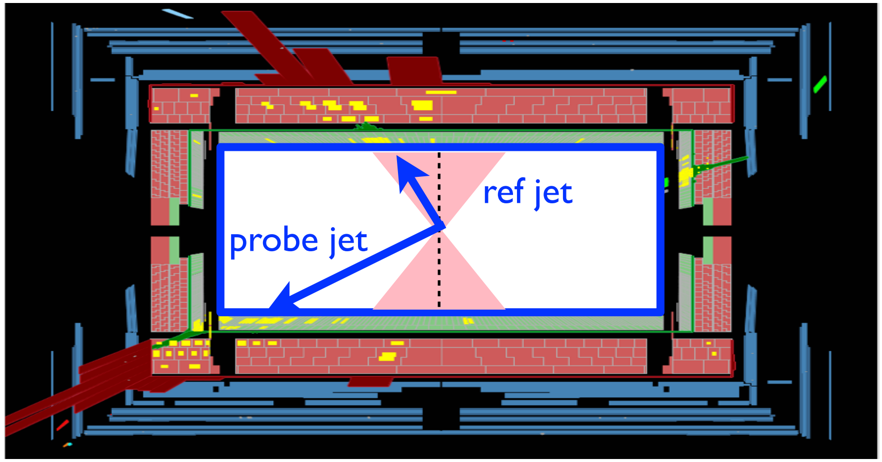
Systematic Uncertainties in the Jet Energy Scale





- Jet energy scale uncertainty primarily from single-particle analyses

- Additional uncertainties from η intercalibration results

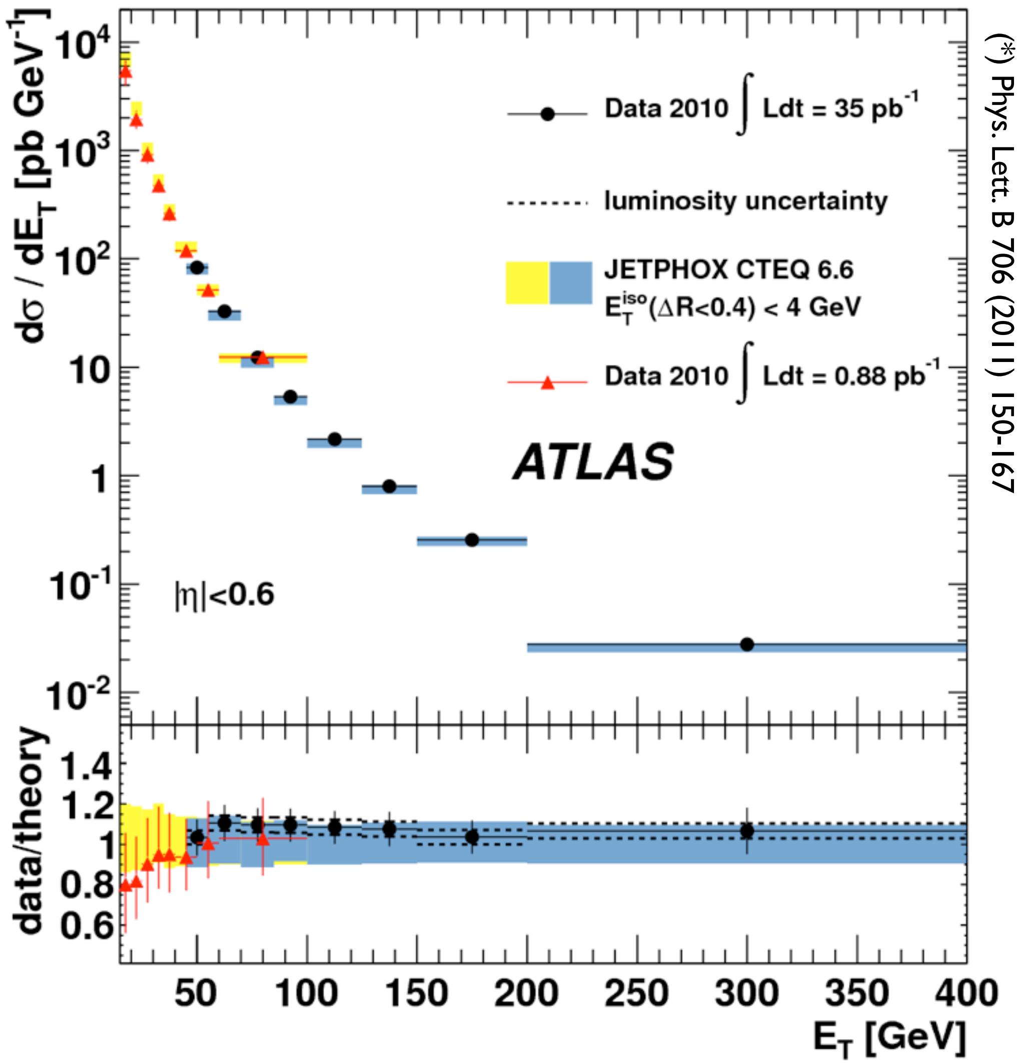


Prompt Photon Production Measurement

- Data and NLO calculation agree

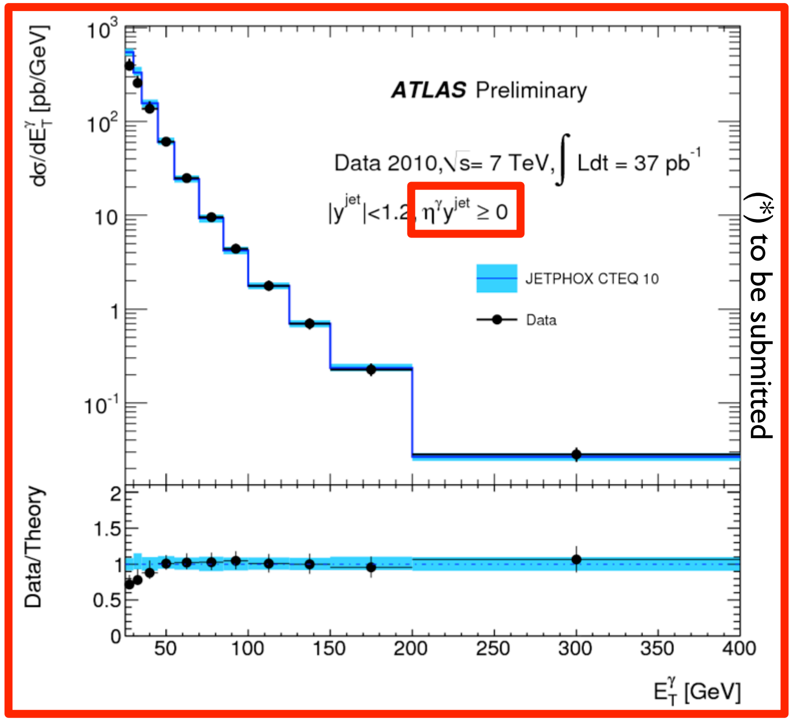
- Measurements cover E_T^{γ} from 15 to 400 GeV (and up to $|\eta|$=2.37)

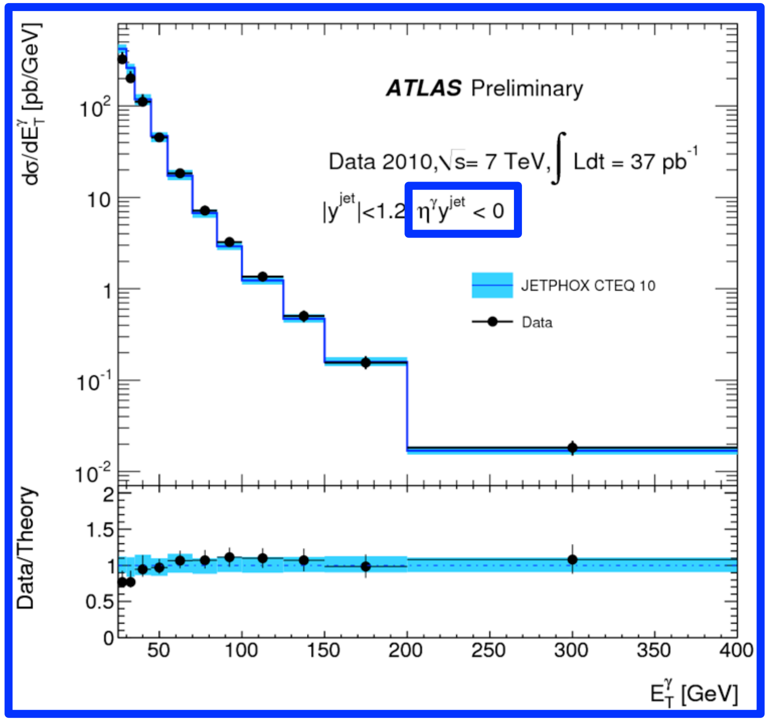
- Systematic uncertainties comparable to NLO calculation accuracy (~10%)

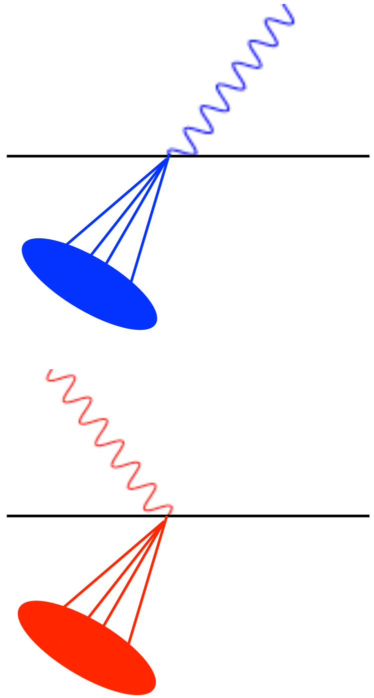


(*) Phys. Lett. B 706 (2011) 150-167

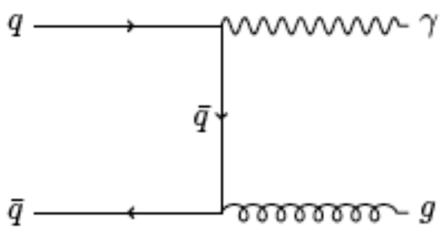
Photon+Jet Production Measurement

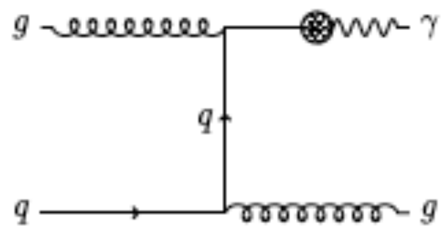






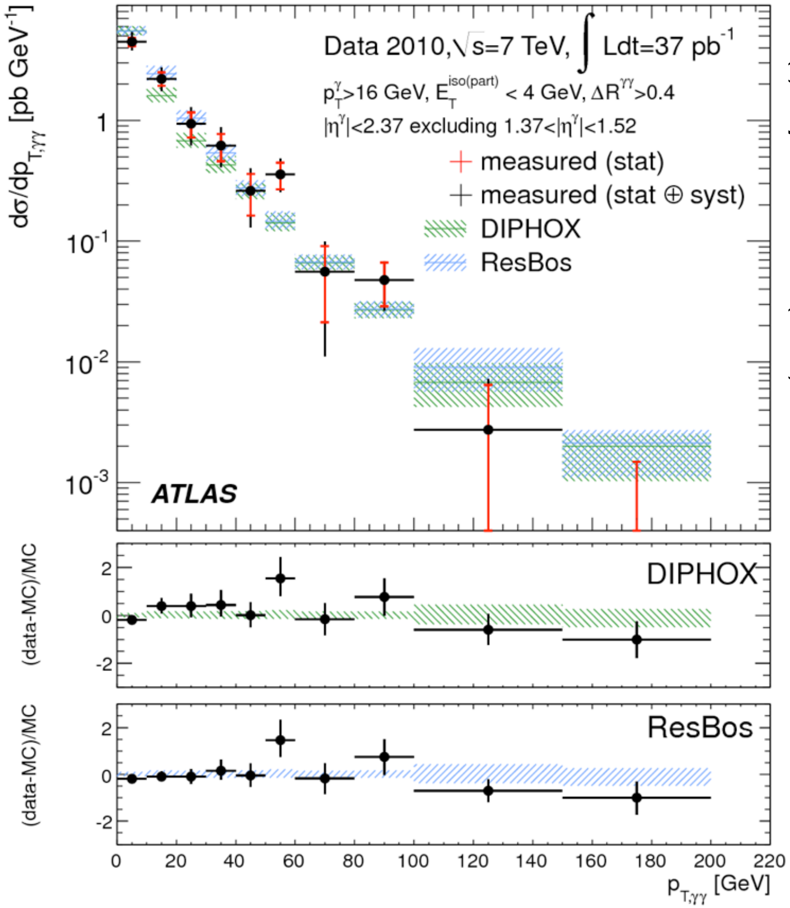
- Divide phase space to change different contributions



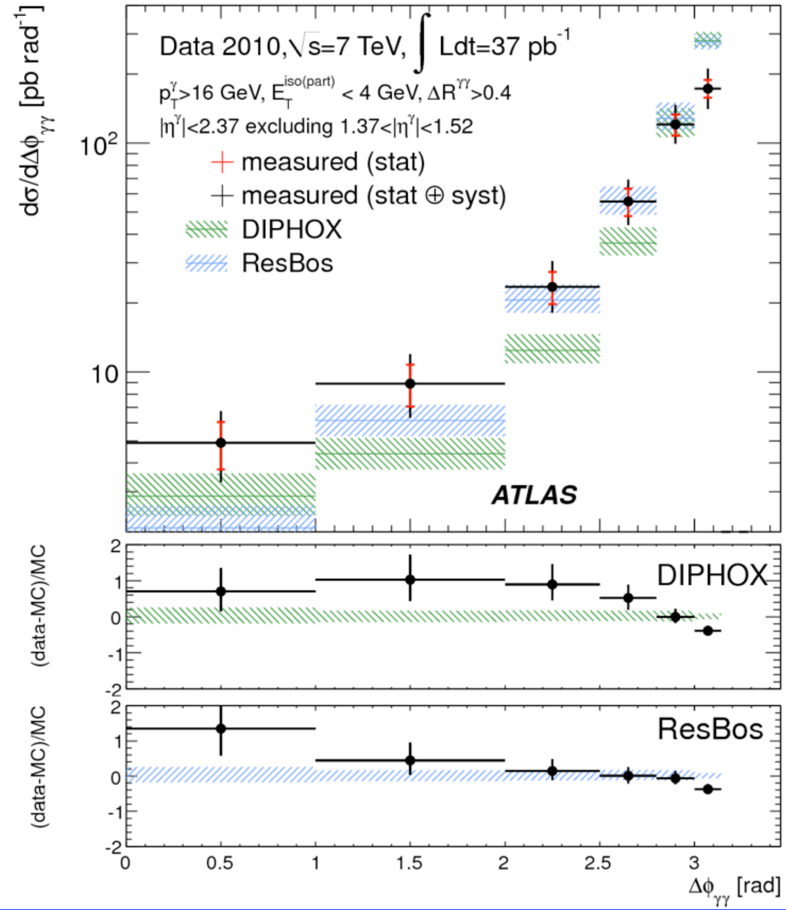


- Results consistent with prompt photon measurement

Diphoton Production Measurement



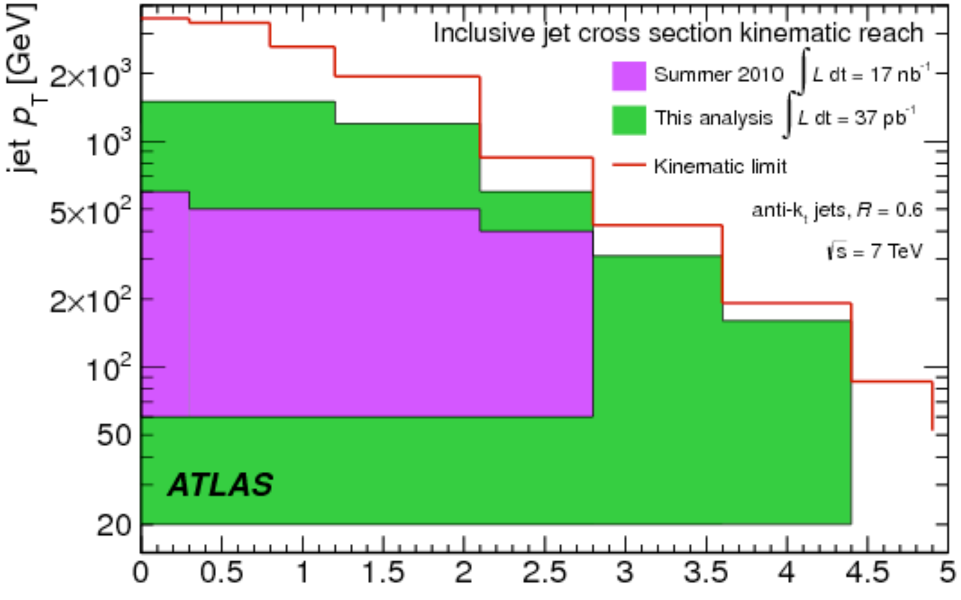
(*) Phys. Rev. D 85 (2012) 012003



(*) Phys. Rev. D 85 (2012) 012003

- Data agree with NLO calculations in $p_T^{\gamma\gamma}$ and $m^{\gamma\gamma}$ distributions
- NLO/NNLL calculations predict narrower $\Delta\varphi^{\gamma\gamma}$

Inclusive and Dijet Analyses: Important Considerations



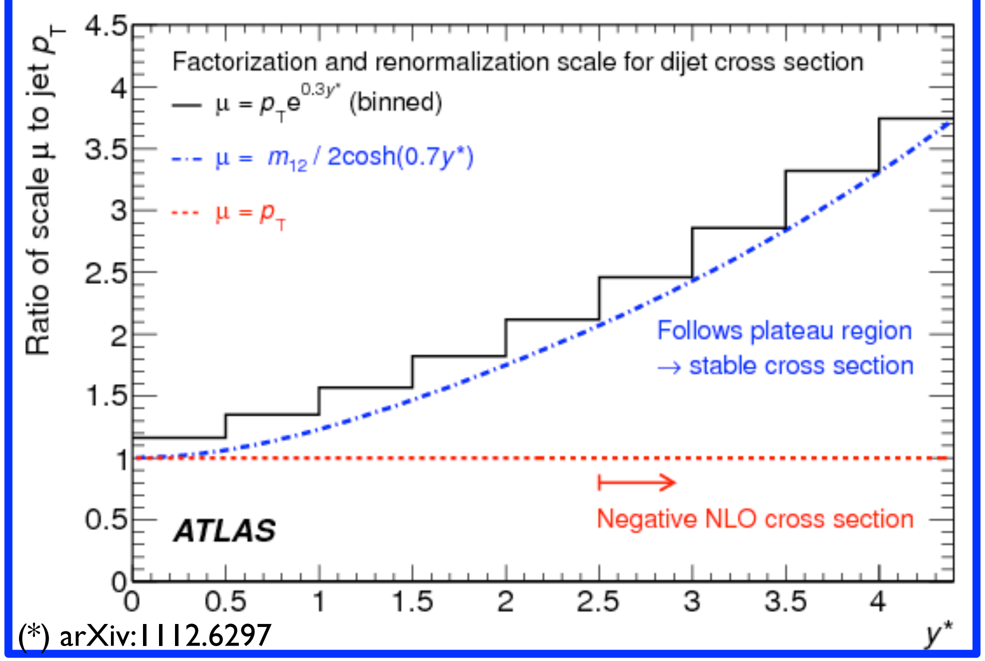
(*) arXiv:1112.6297

- 2010 final inclusive jet analysis close to reaching kinematic limit

- Dijet cross section is binned in

$$y^* = \frac{|y_1 - y_2|}{2}$$

- Enters choice of renormalization scale



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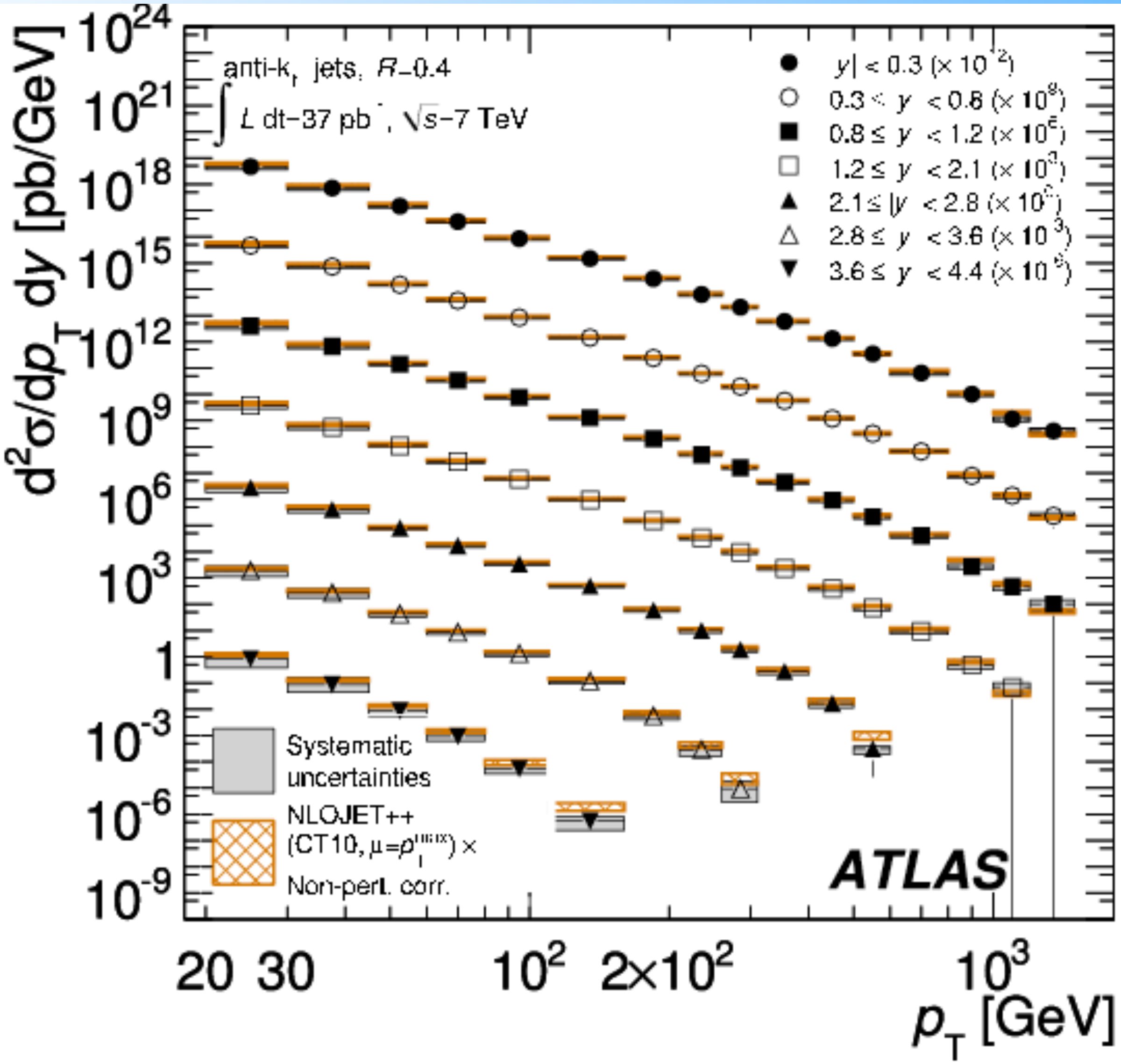
Inclusive Jet Cross Section Results



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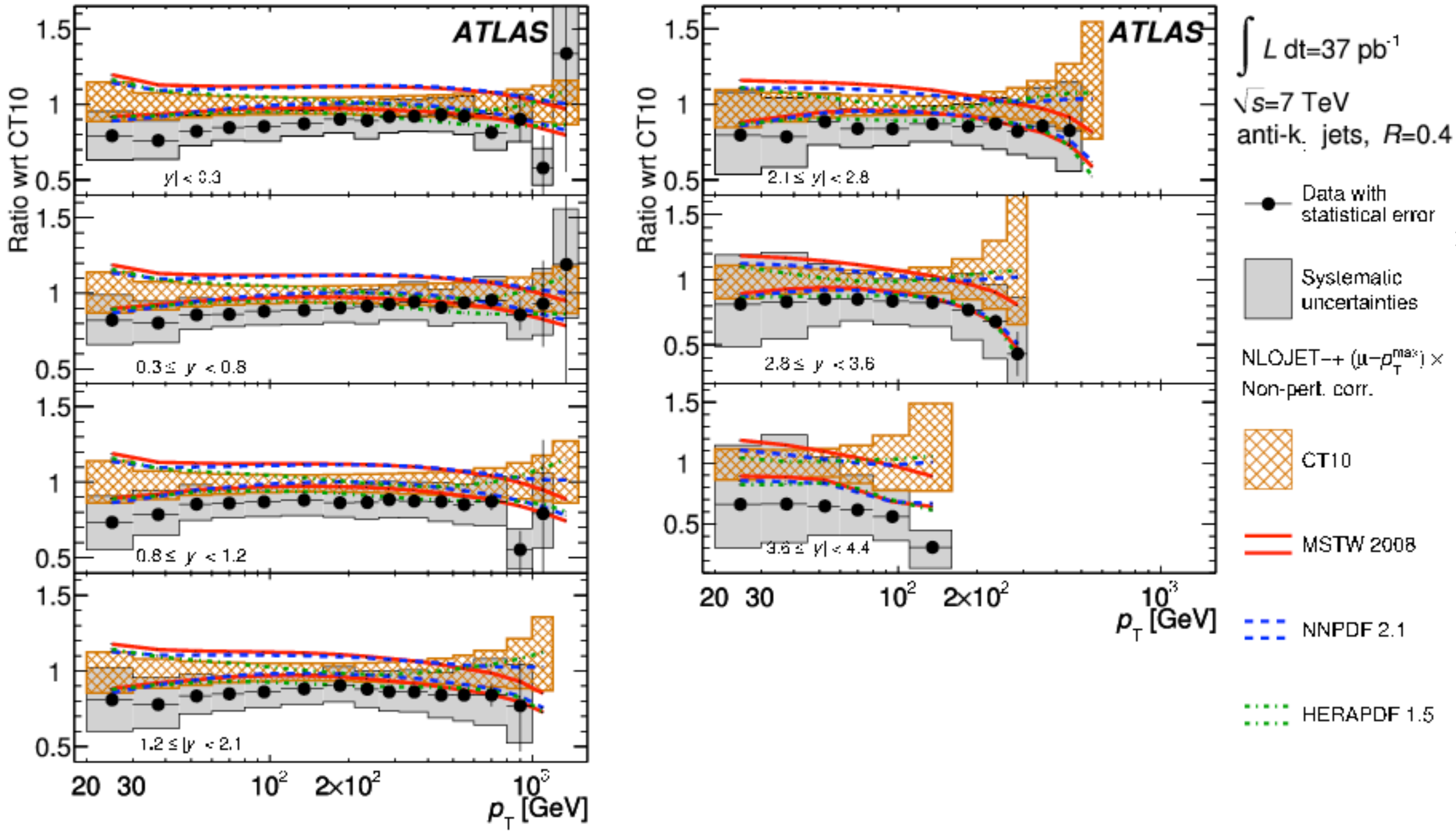
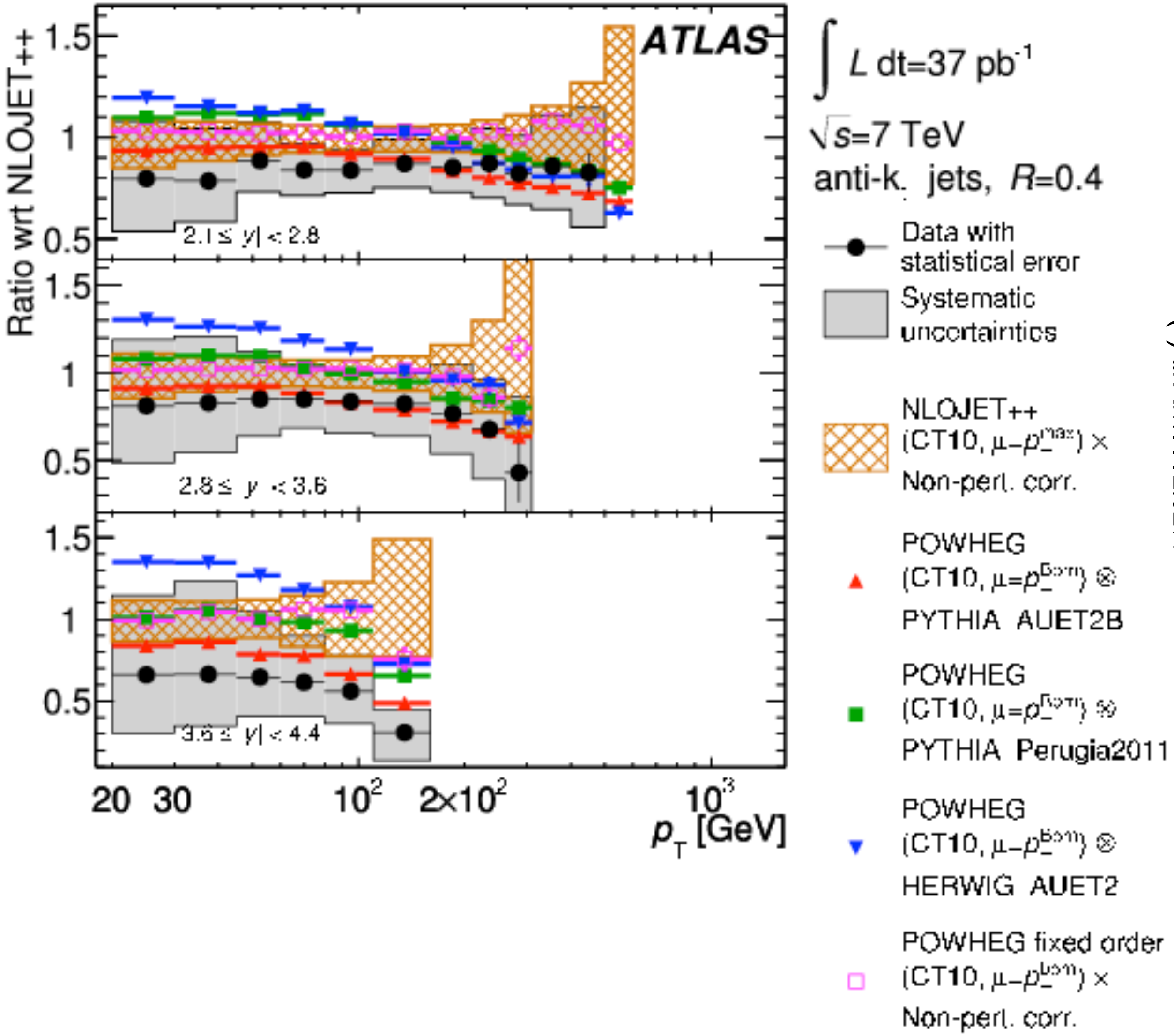


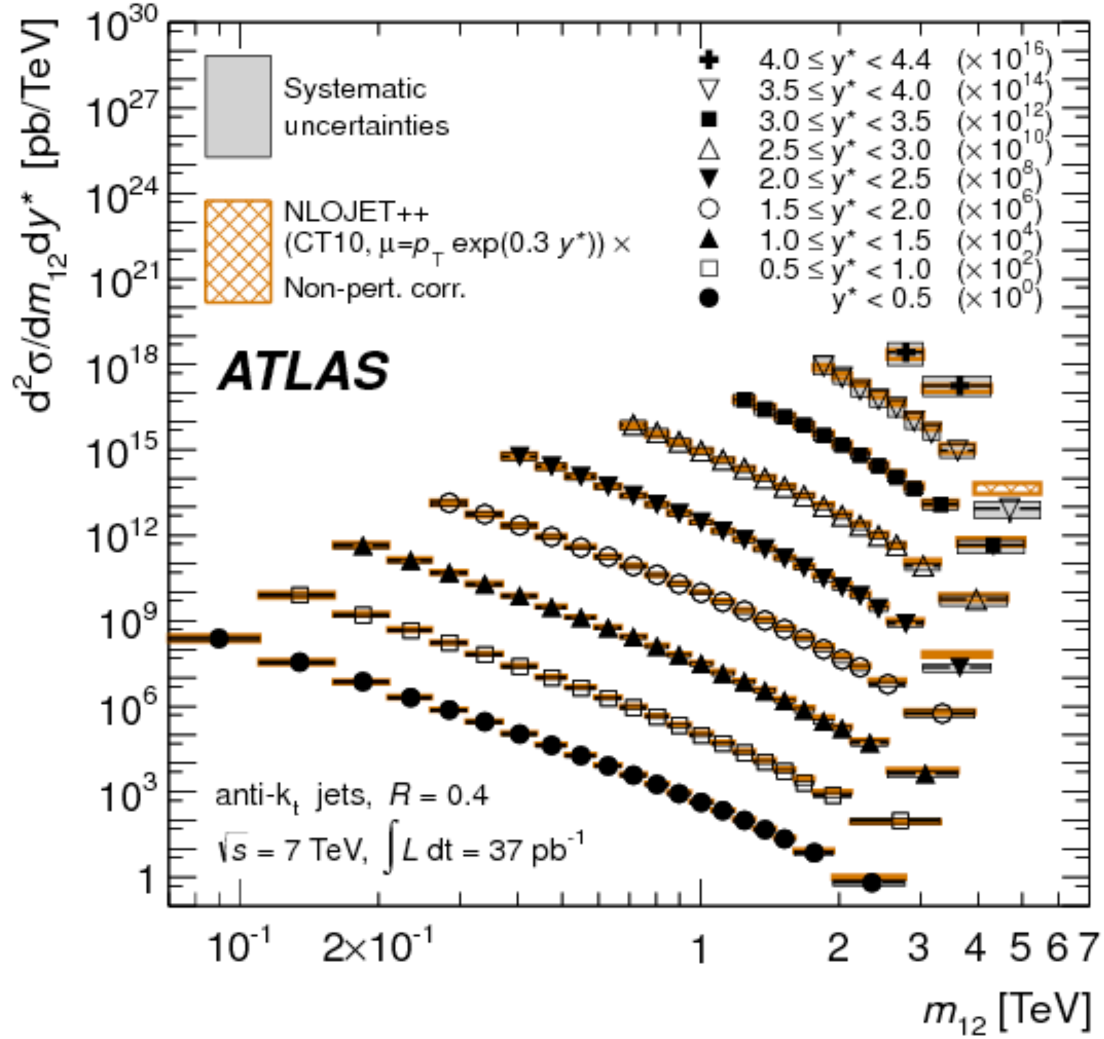
(*) arXiv:1112.6297

NLO+Parton Shower Comparisons to Data



(*) arXiv:1112.6297

Dijet Cross Section Results



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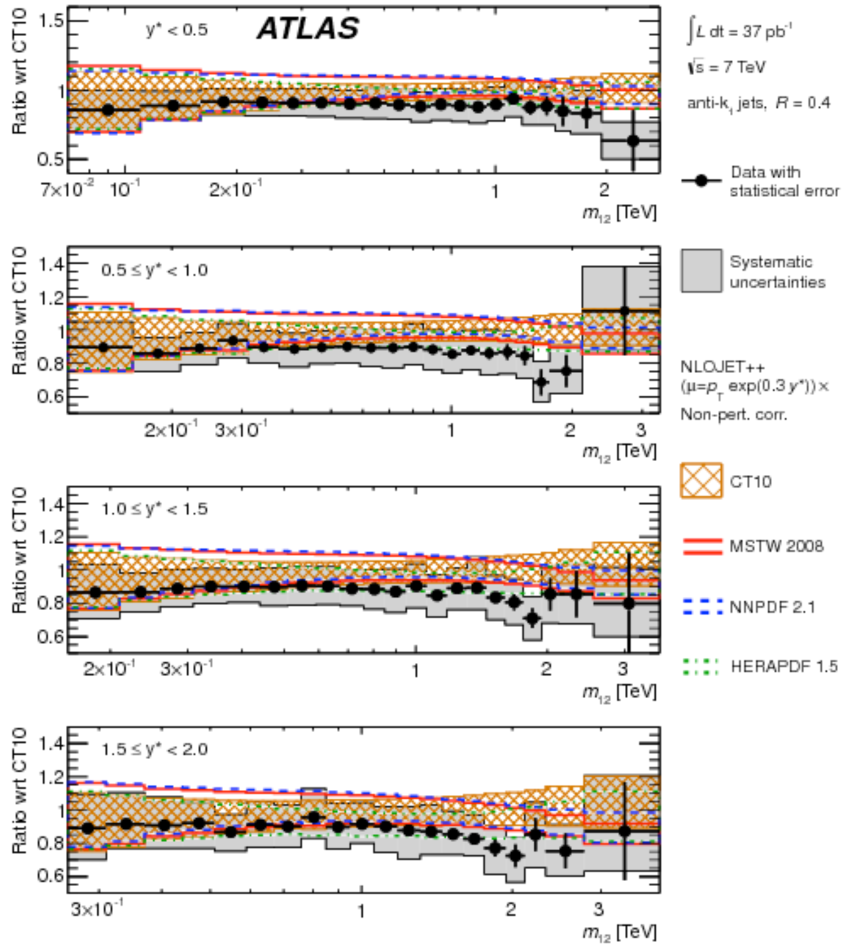
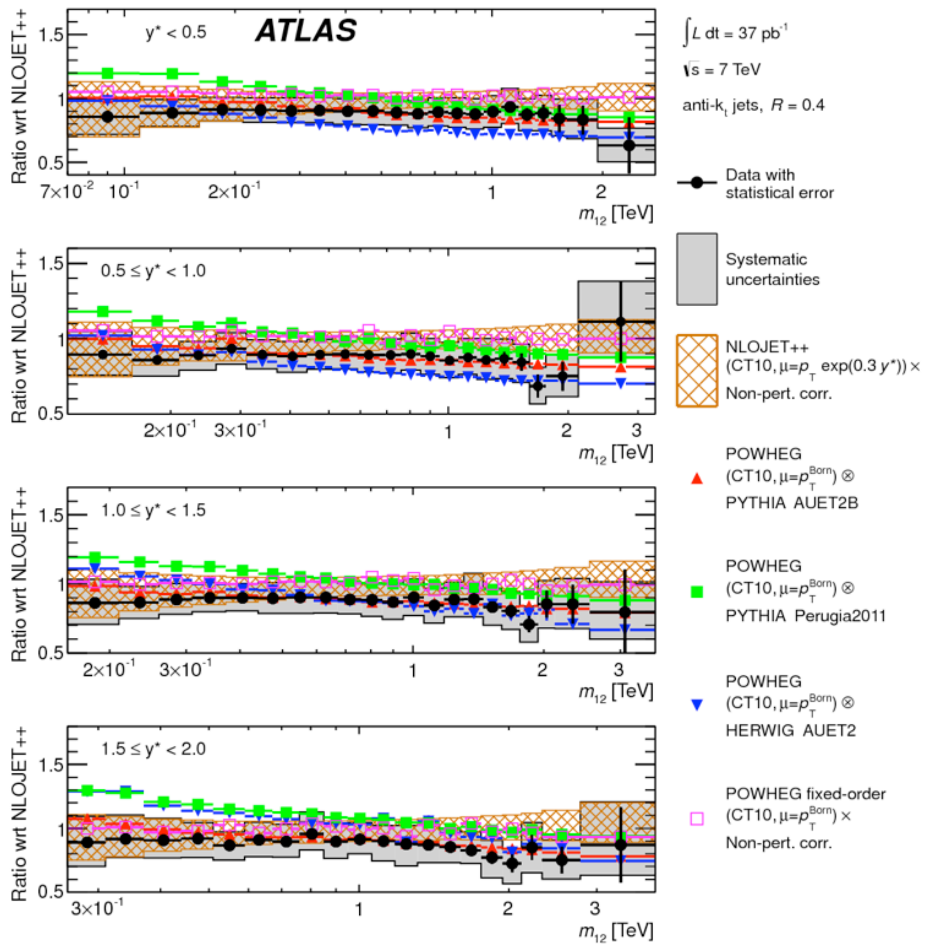
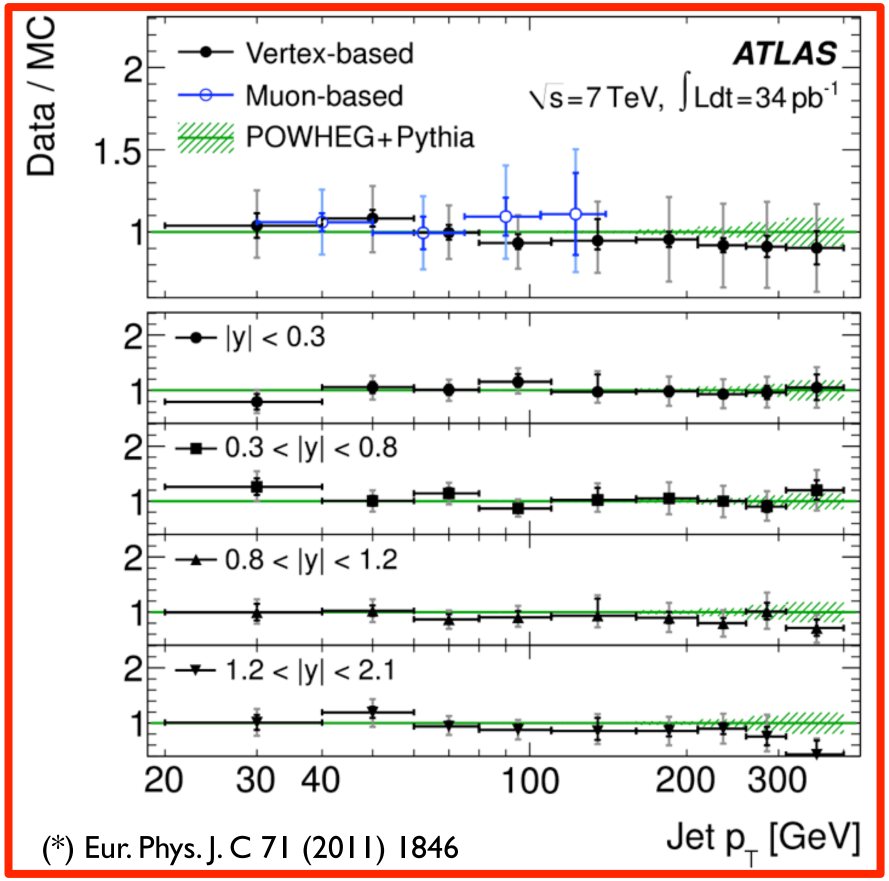
Dijet Cross Section Results



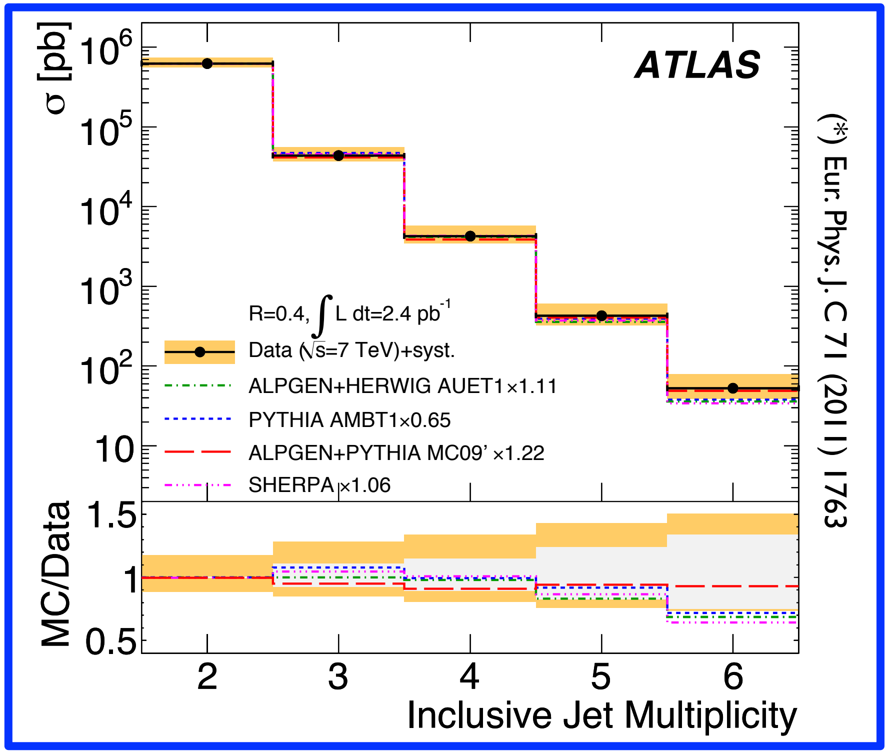


(*) arXiv:1112.6297

Other Measurements: b-jet and Multijet Cross Sections

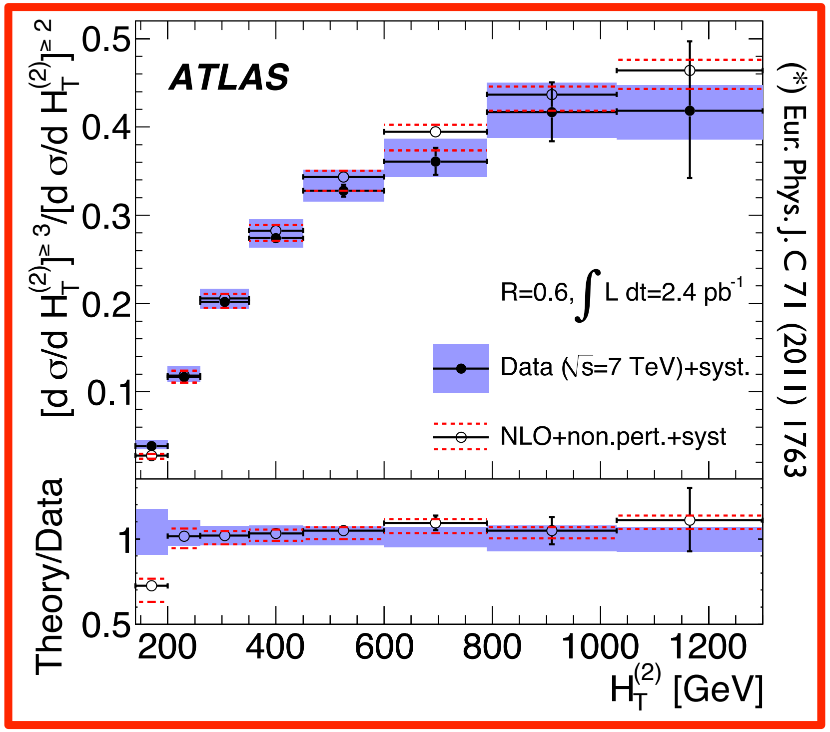


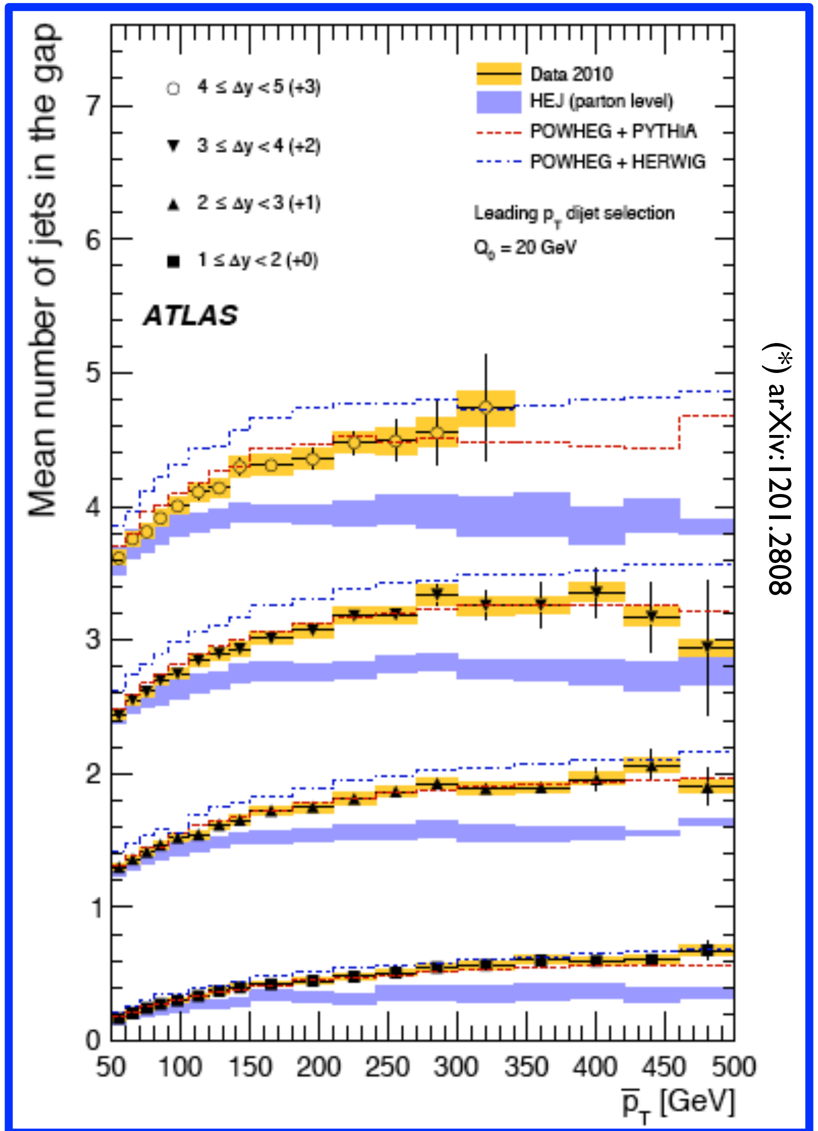
• b-jet cross section consistent with POWHEG (but not with MC@NLO)



• Inclusive jet multiplicity distribution not well described by many tunes

NLO Comparisons for Measurements with Multiple Jets





- 3-jet to 2-jet cross-section ratios compared to NLO
- Number of jets as a function of rapidity gap seem to favor NLO calculations

What We Have Learned About QCD with Jets and Photons

- Systematic comparisons with NLO and NLO+parton shower

- Generally, agreement between data and MC is found

- Measurement uncertainties comparable to theoretical uncertainties

- Comparisons with NLO+parton shower underline importance of parton shower tunes

Prospects

- Theoretical work in NLO+parton shower matching to understand importance of the parton shower tune for NLO calculations

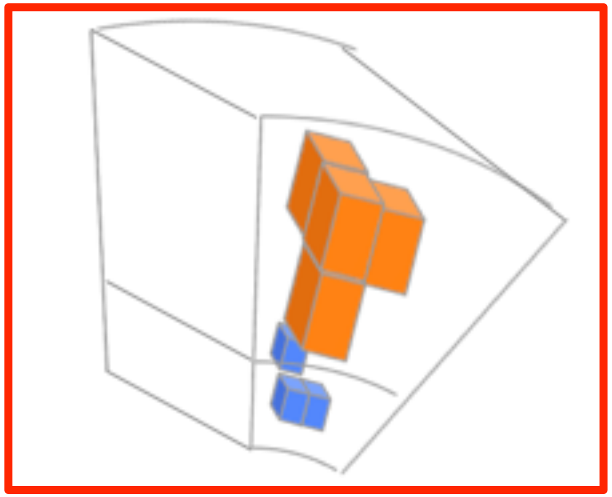
- Measurements to be used for PDF fits, α_S measurements

- Improvements in object performance developed in QCD analyses

- Jet substructure QCD measurements coming up as techniques are commissioned for searches

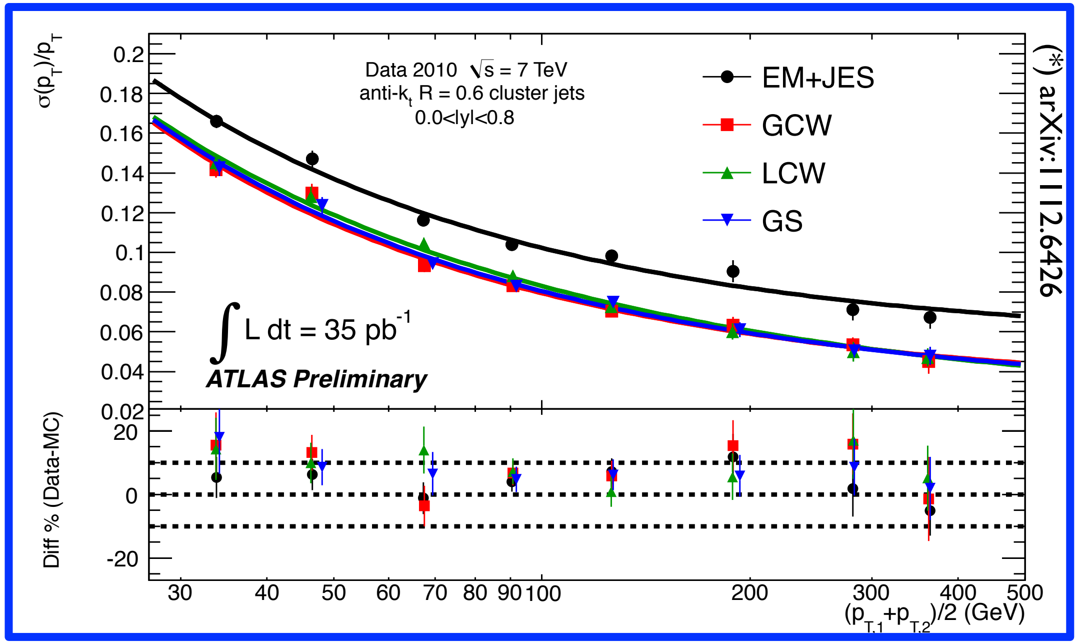
BACK-UP SLIDES

Jet Reconstruction and Performance

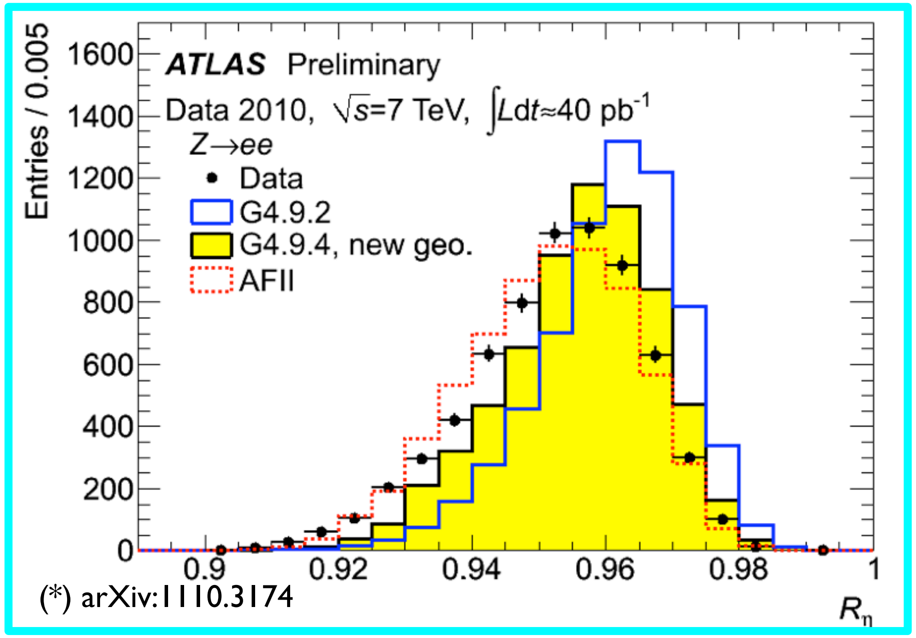


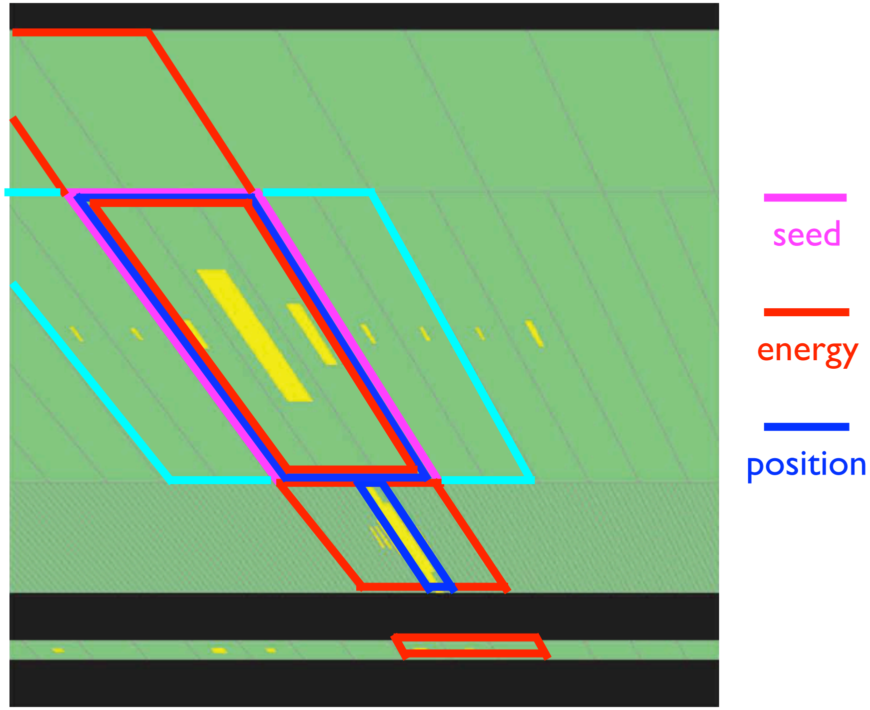
- Jet reconstruction uses clusters as inputs
- Clusters built using cells above noise (seeded with 4σ, grown with 2σ cells)
- Use anti-k_t algorithm with R=0.4 or R=0.6 to build jets from clusters

- Jets calibrated with simple correction (EM+JES)
- More sophisticated calibrations also available
- Constant term of EM+JES calibration ~5% (~3% for others)



Photon Shower Shapes



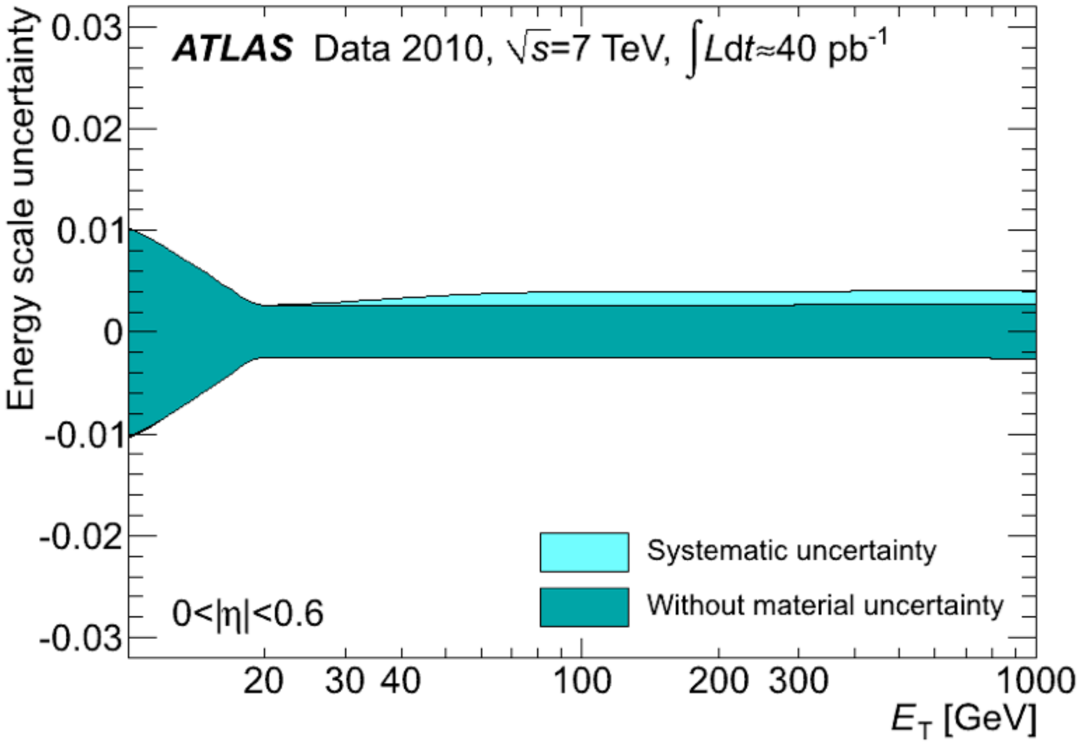


Photon Shower Shape Variables

- For loose identification:
  - Leakage R_{had} (into first hadronic layer)
  - R_η (see previous slide)
  - w_2 (RMS of energy distribution along η in 2^{nd} layer)

- For tight identification:
  - R_φ (like R_η in φ direction)
  - $w_{s,tot}$ (RMS of energy distribution along η in 1^{st} layer)
  - E_{ratio} between first and second maxima in energy profile along η
  - ΔE between the second maximum and the minimum between maxima
  - F_{side} (like R_η in 1^{st} layer)
  - $w_{s,3}$ (RMS of energy distribution along η in 1^{st} layer using 3 core strips)

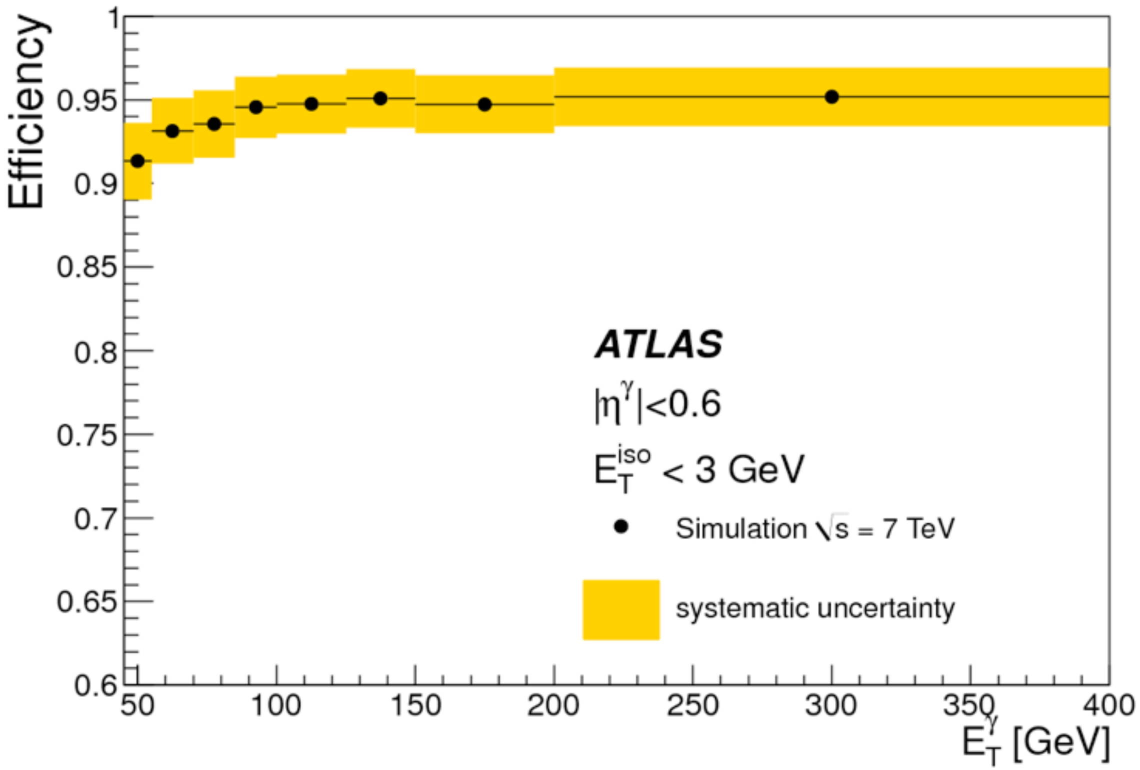
Systematic Uncertainties in Photon Energy Scale



(*) arXiv:1110.3174

- Systematic uncertainties in photon scale and resolution extrapolated from $Z \rightarrow ee$
- Studies use data/MC comparisons and different MCs to understand different effects (material, hardware failures, pile-up...)

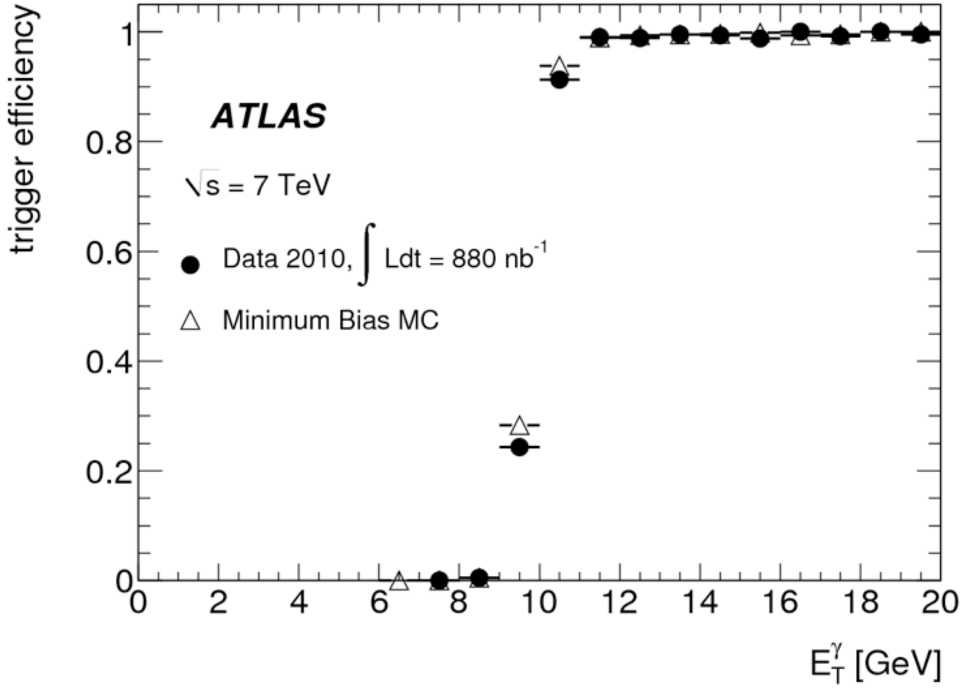
Photon Identification Efficiency and Systematic Uncertainties

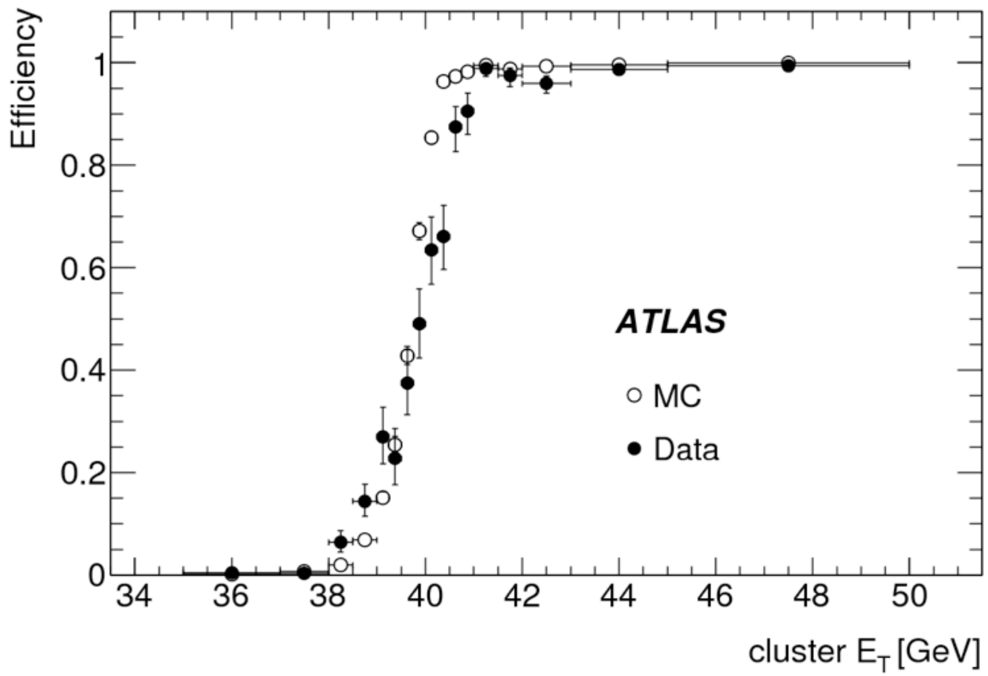


(*) Phys. Lett. B 706 (2011) 150-167

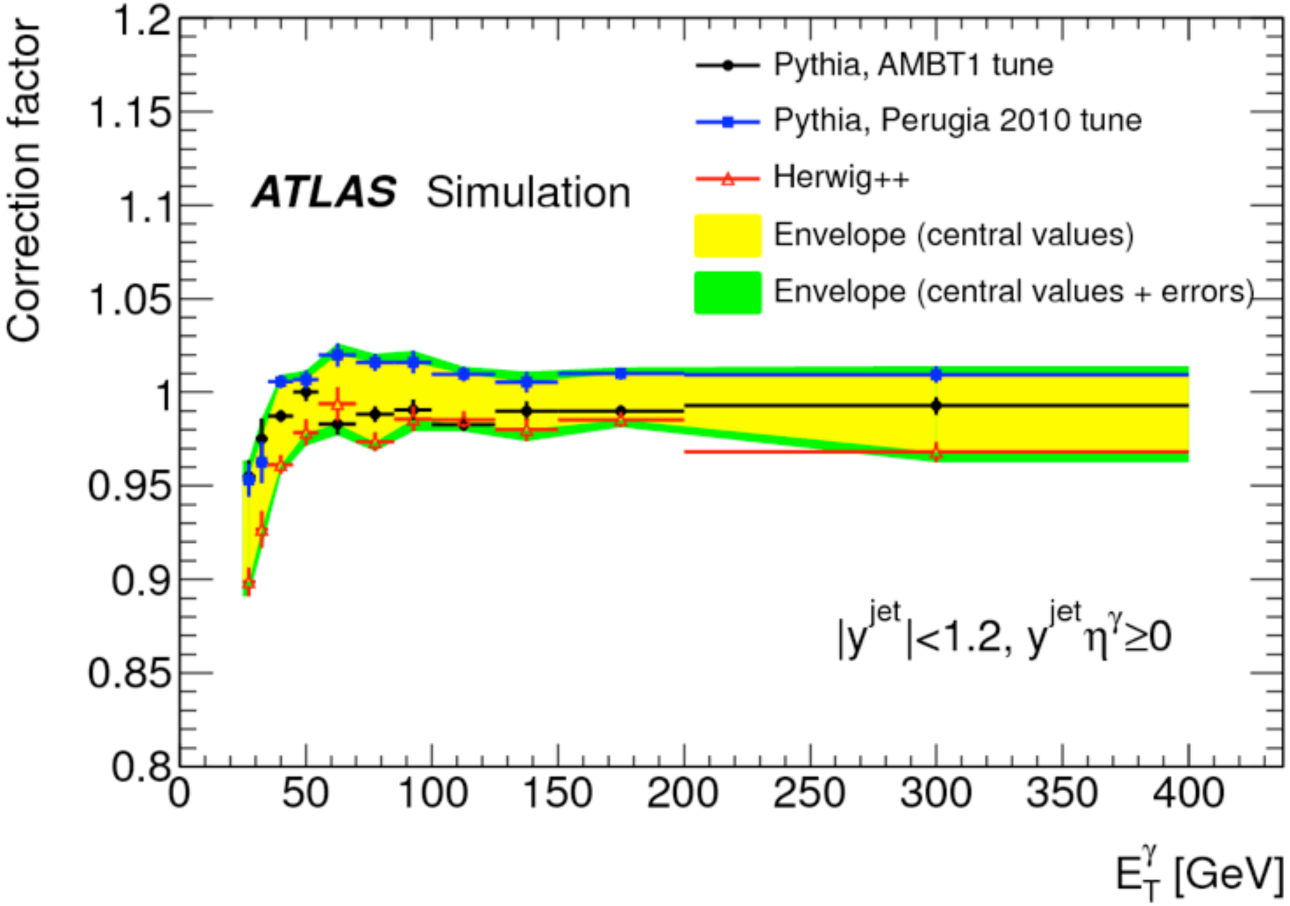
- Identification efficiency calculated after correcting MC shower shapes to data
- Uncertainties estimated varying criteria for identification and material description
- Cross-checked in Z→ee data

Photon Triggers



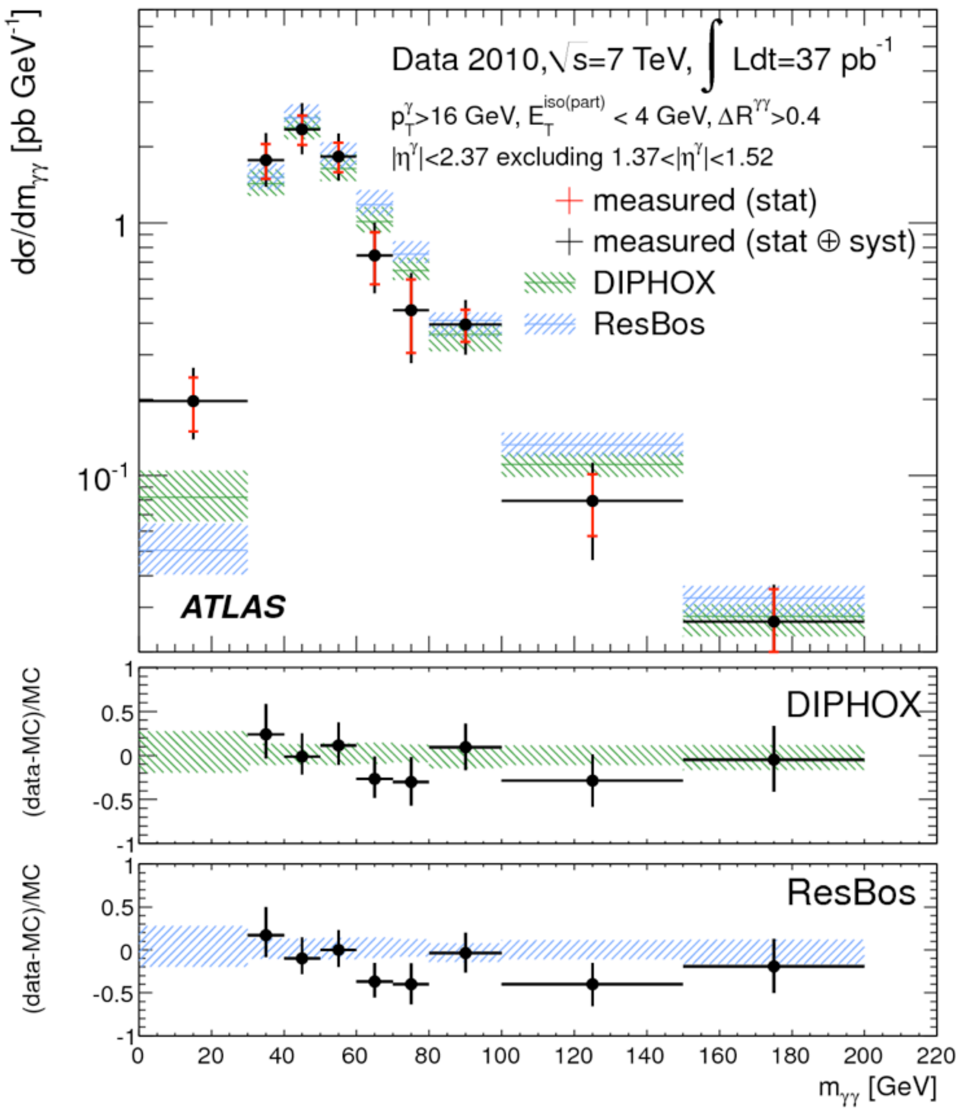


Photon+jet Non-perturbative Corrections

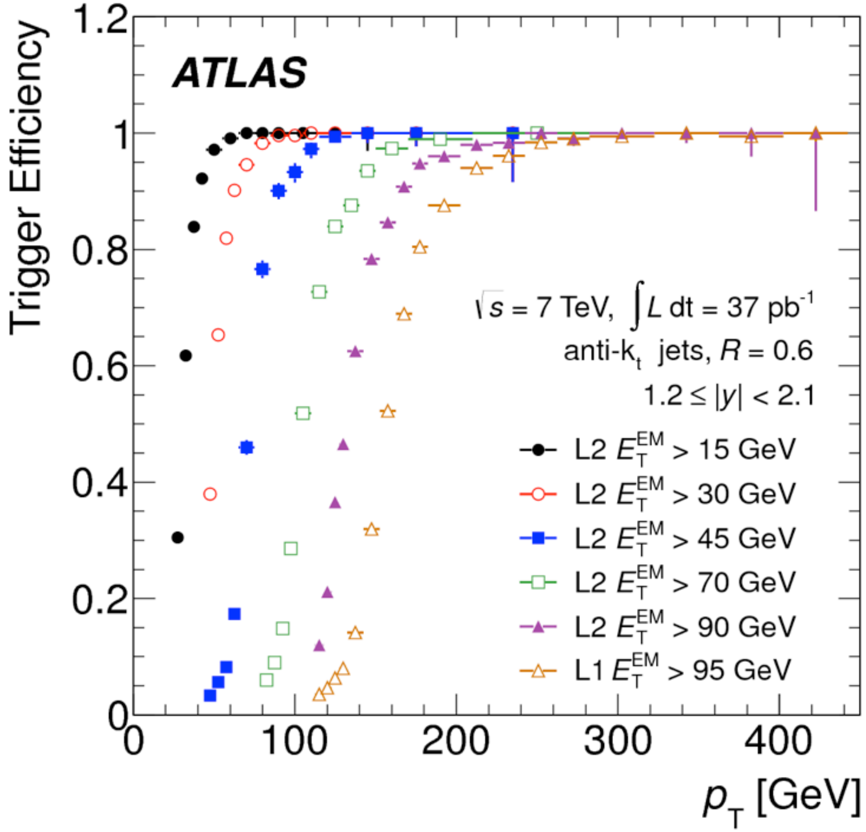


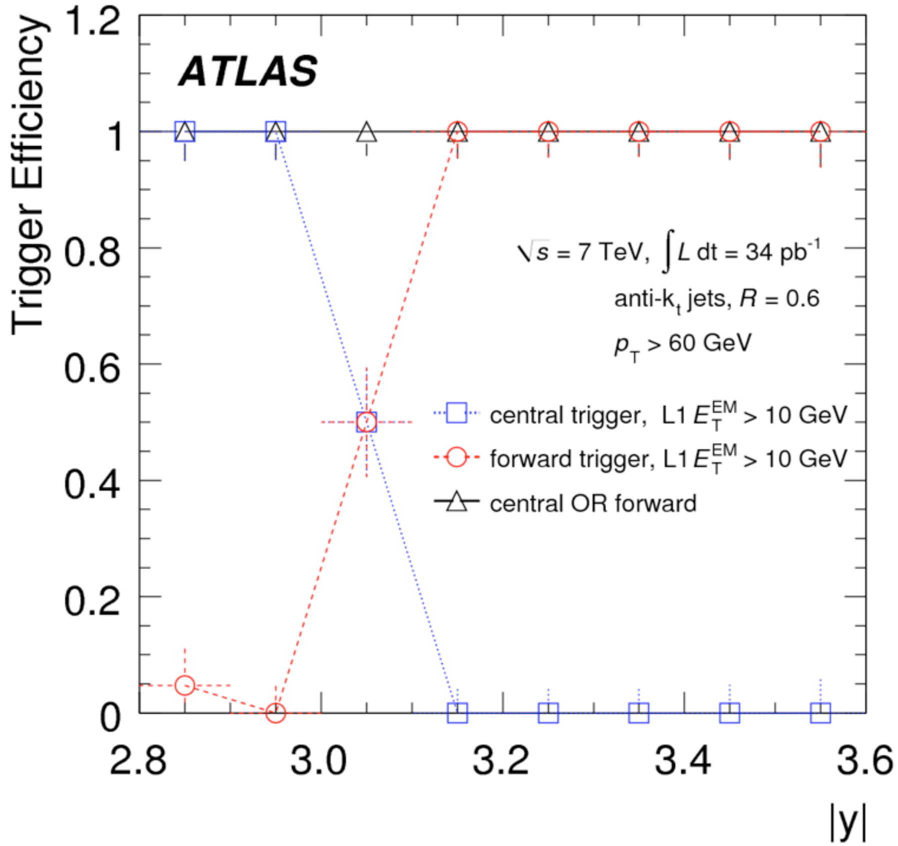
(*) to be submitted

Diphoton Invariant Mass

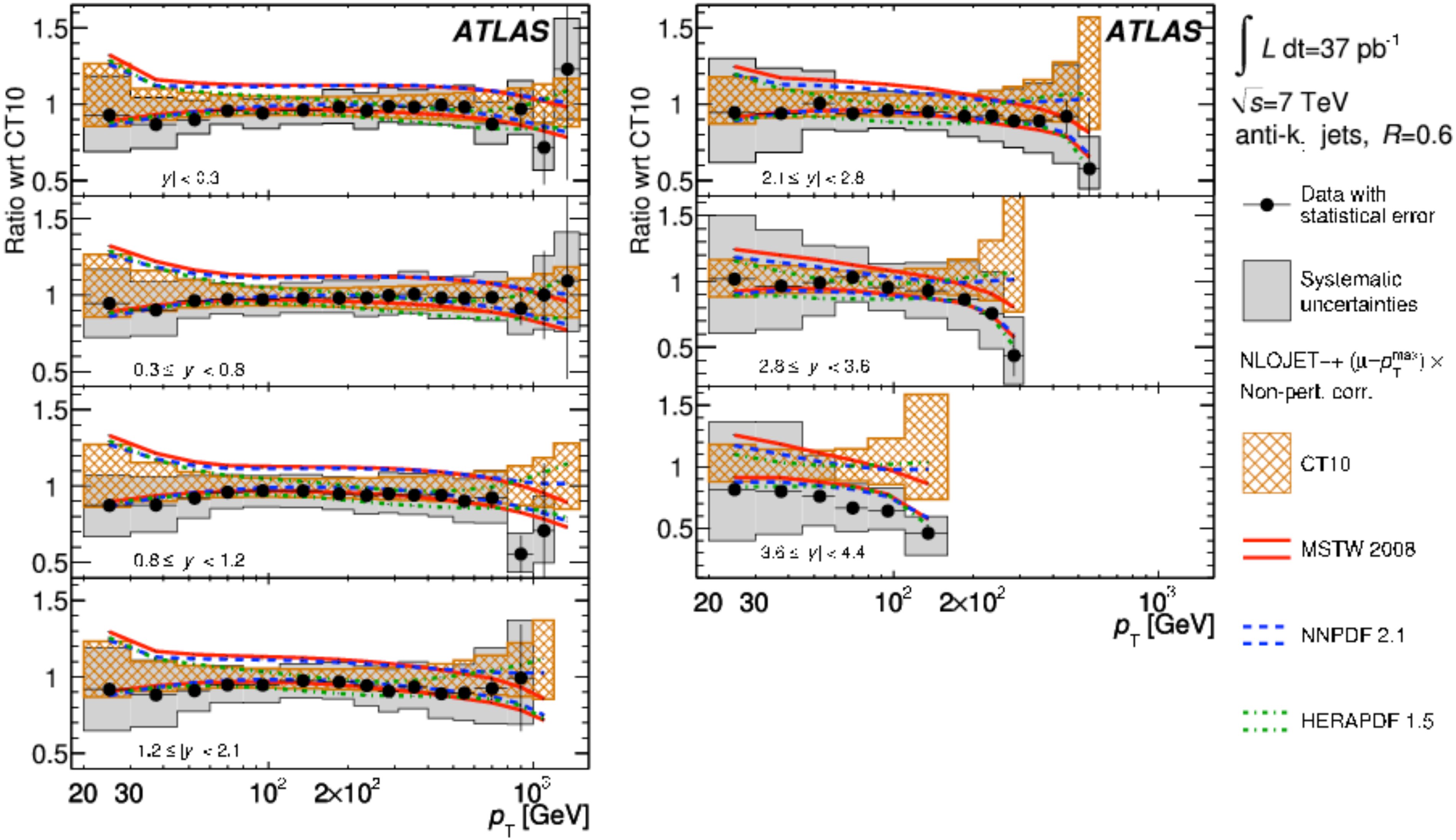


Inclusive Jet and Di-jet Triggers

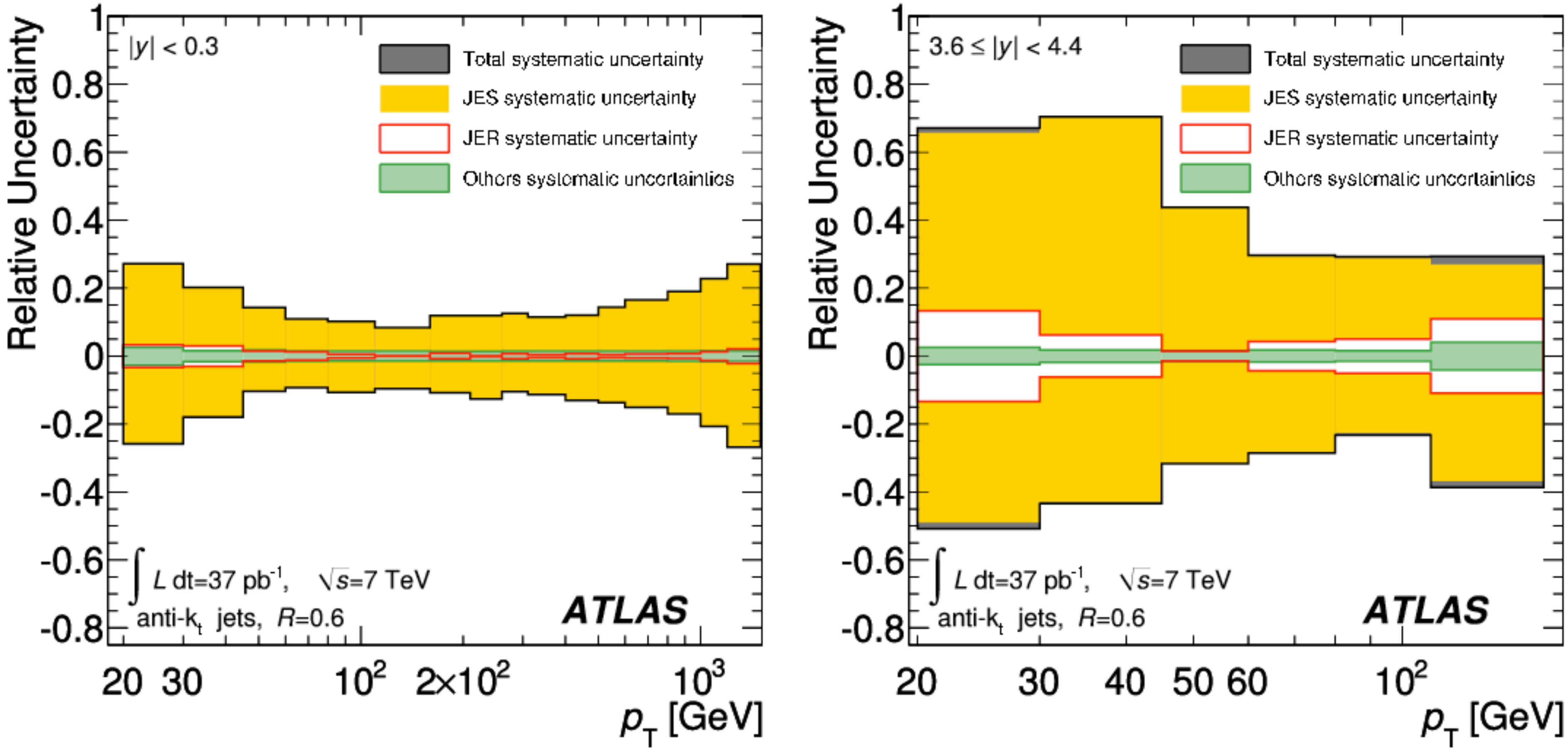




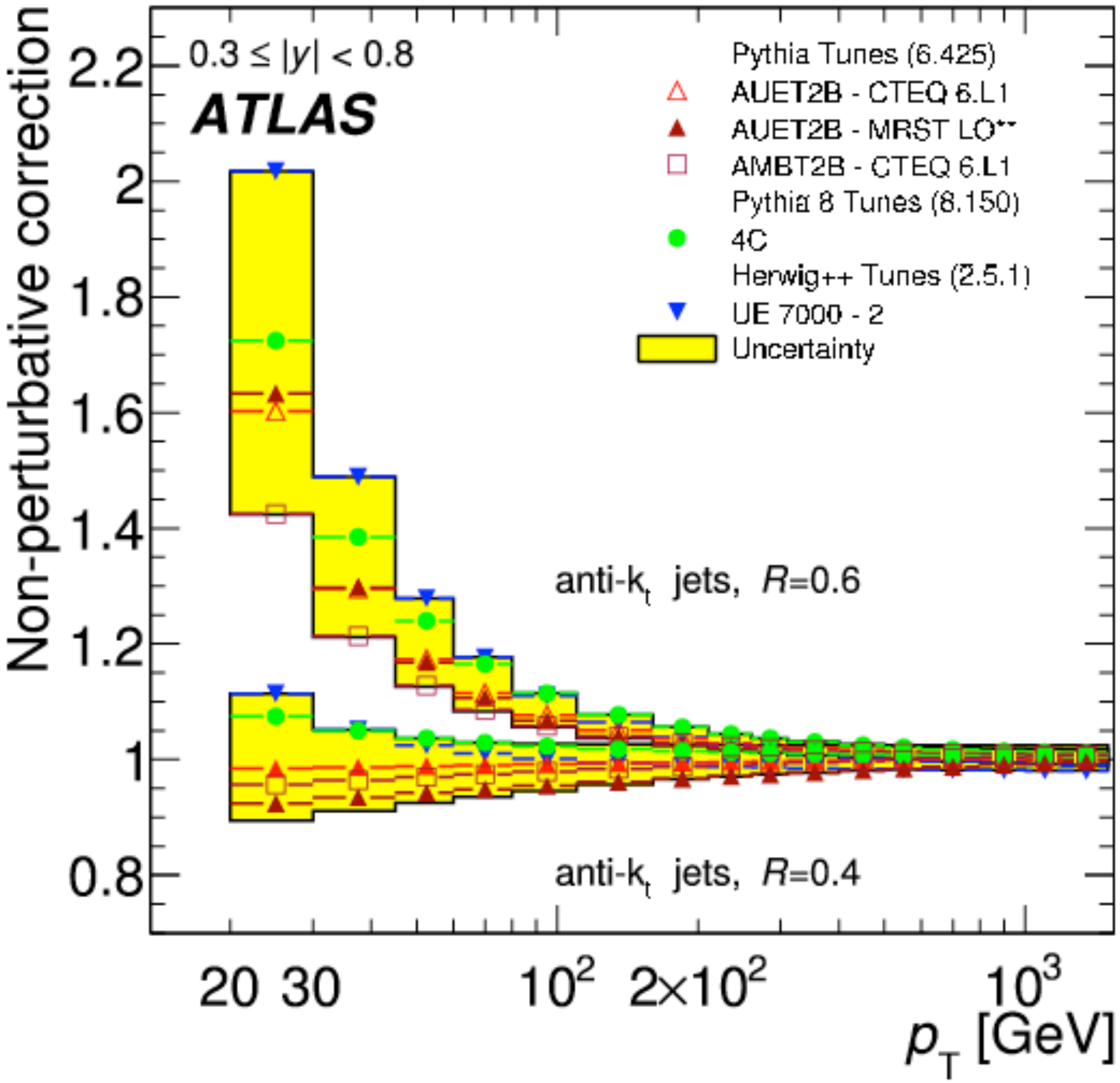
Inclusive Jet Cross Section for R=0.6



Inclusive Jet Cross Section Systematic Uncertainties



Non-perturbative Corrections to Inclusive Jet Cross Section



b-jet Cross Section Compared with MC@NLO