Recent QCD results from ATLAS

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DESY

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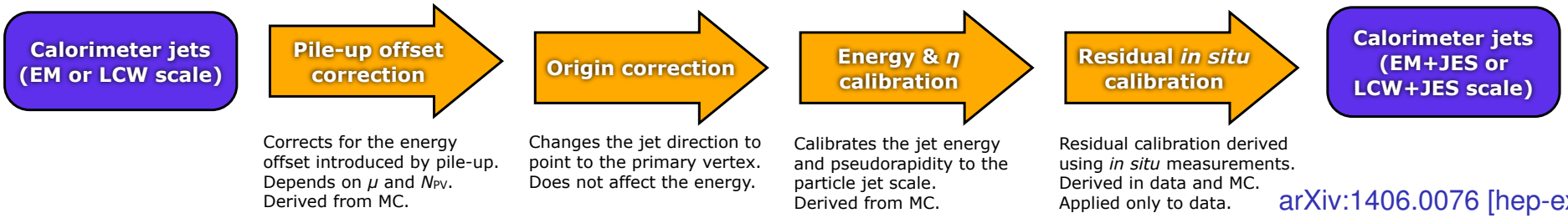
Outlook

1. Jet measurements
2. W-production in association with jets and W–jet/Z–jet ratios
3. Production of Z-boson in association with b-jets
4. Summary

Jet measurements. JES uncertainty



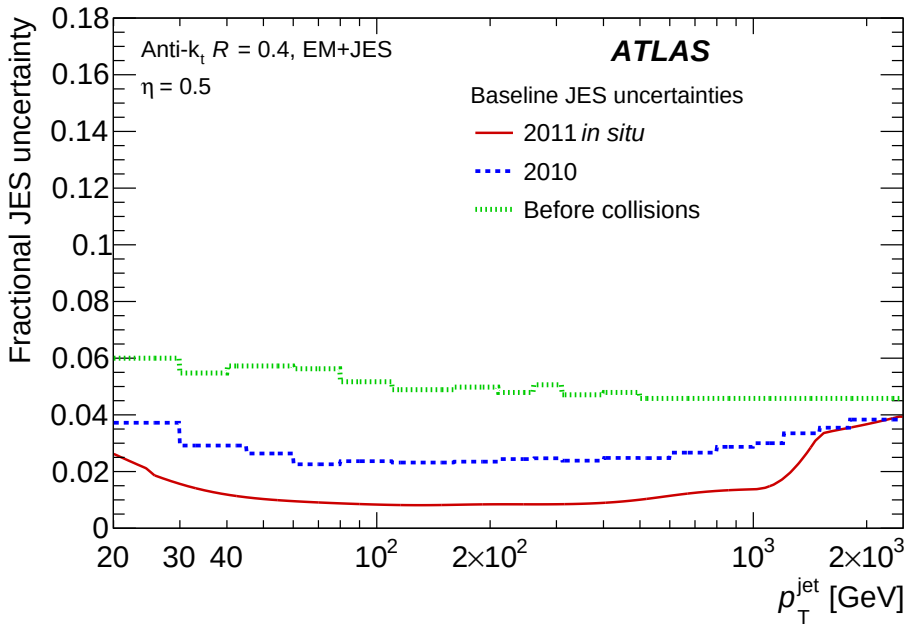
arXiv:1406.0076 [hep-ex]

Three jet cross-section measurements with the same JES systematics

- Dijet production JHEP05(2014)059
- Inclusive jet cross-section arXiv:1410.8857
- Three-jet mass spectrum arXiv:1411.1855

Jets are defined with anti-k_t alg. two jet sizes: R=0.4 and R=0.6

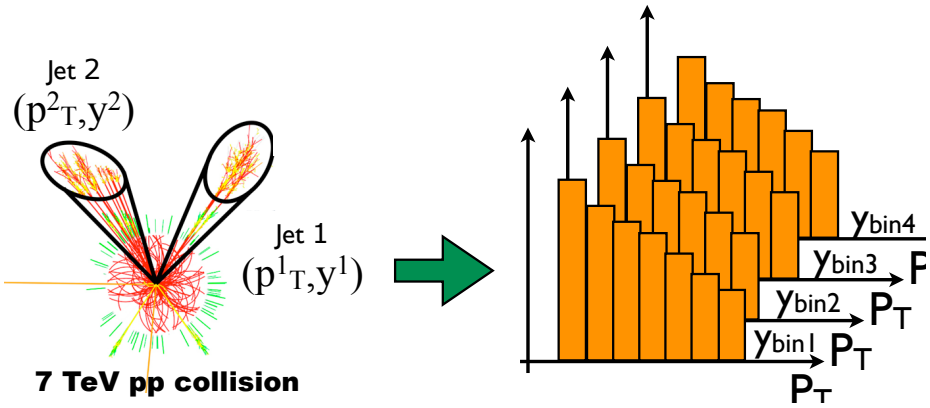
Combination of in situ measurements (Z/γ–jet, multi-jet)

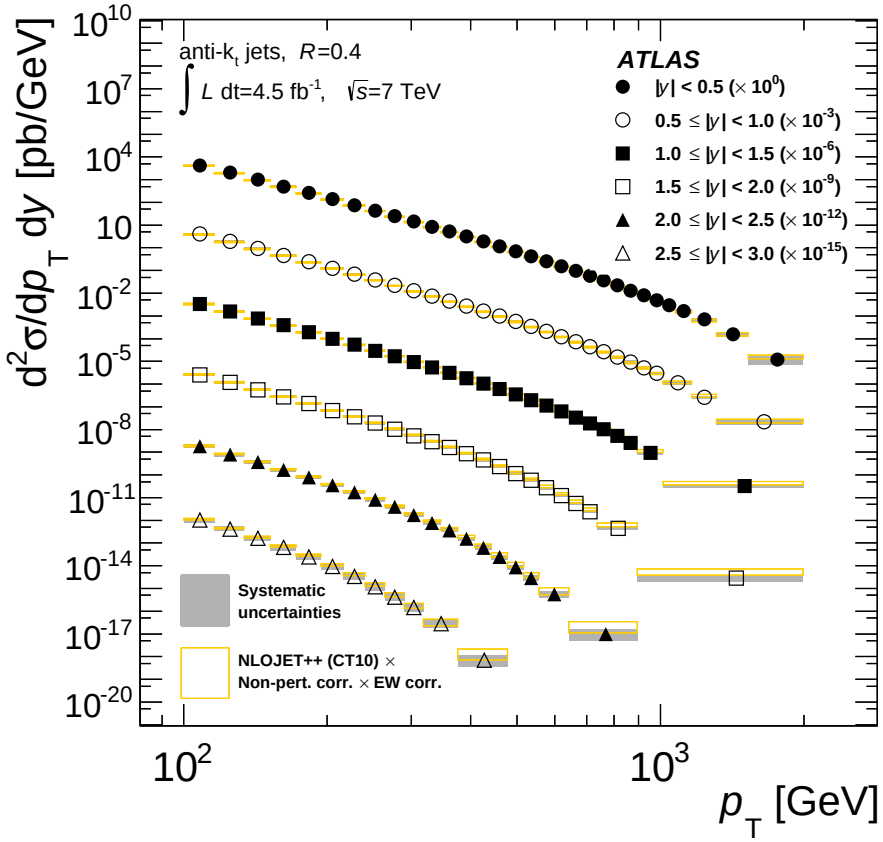


$\sim 5^{\times}$ reduction in the JES uncertainty

Jet measurements. Inclusive jet p_T

arXiv:1410.8857





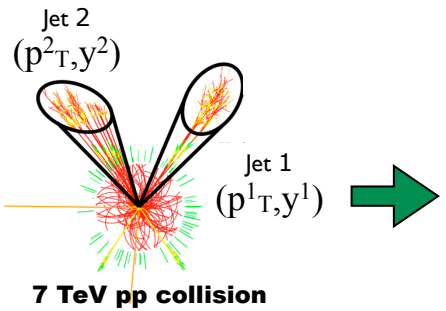
- $p_T >$ 100 GeV, binned according to resolution
- $|y| < 3$, six rapidity bins, in steps of 0.5
- Theory: NLOJET++ $\times$ NPC $\times$ EW
- non-pert. correction : Pythia/Herwig with various tunes

- theory is corrected for EW effects

Good agreement between data and theory over 7 orders of magnitude

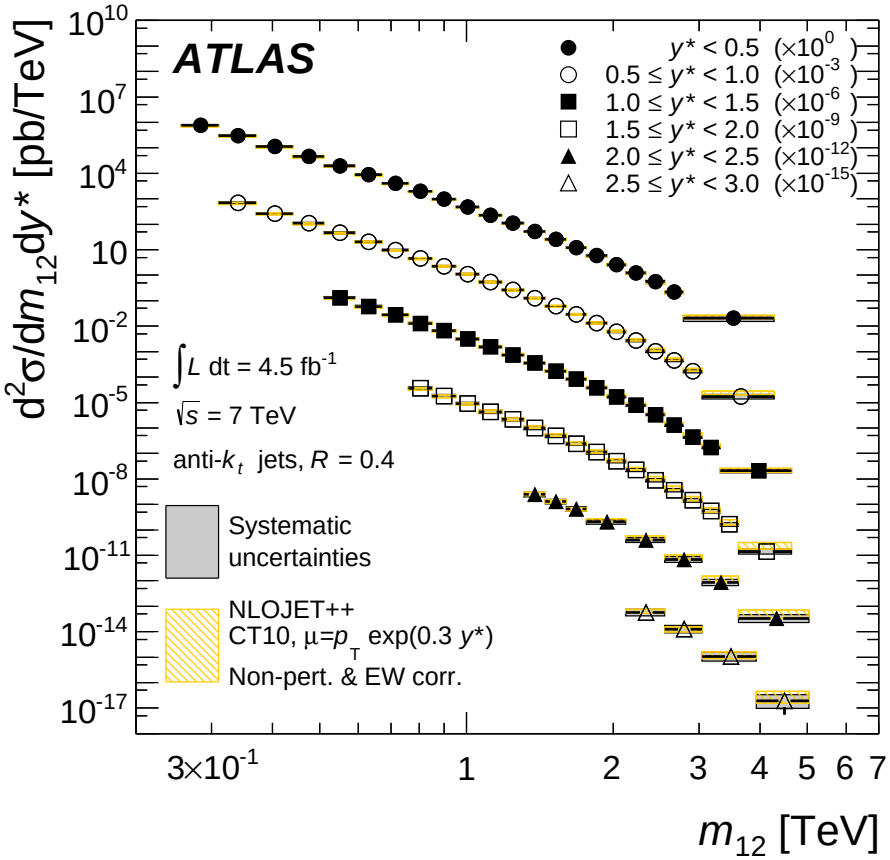
Jet measurements. Dijet mass

JHEP05(2014)059



$$m_{12} = \sqrt{p_1 + p_2}$$
$$y^* = |y_1 - y_2|/2$$

- $p_T^1 > 100$ GeV, $p_T^2 > 50$ GeV, $|y^{jet}| < 3$
- $|y^*| < 3$, six rapidity separation bins, in steps of 0.5
- Theory: NLOJET++ $\times$ NPC $\times$ EW
- non-pert. correction : Pythia/Herwig with various tunes

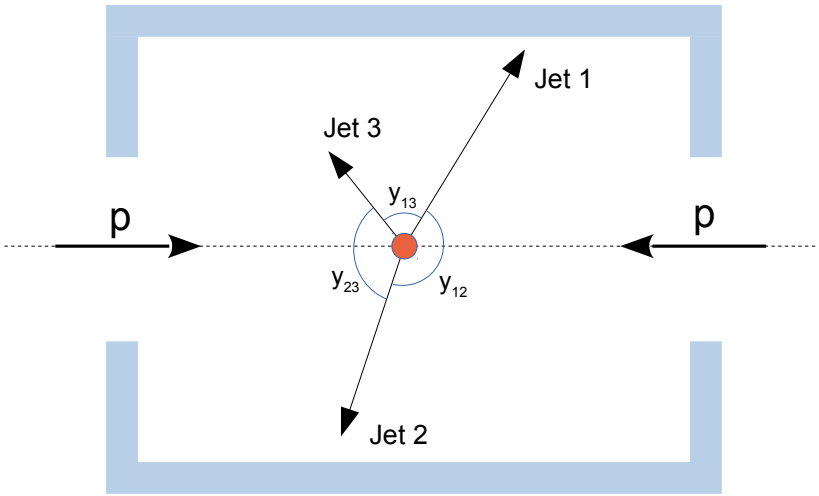


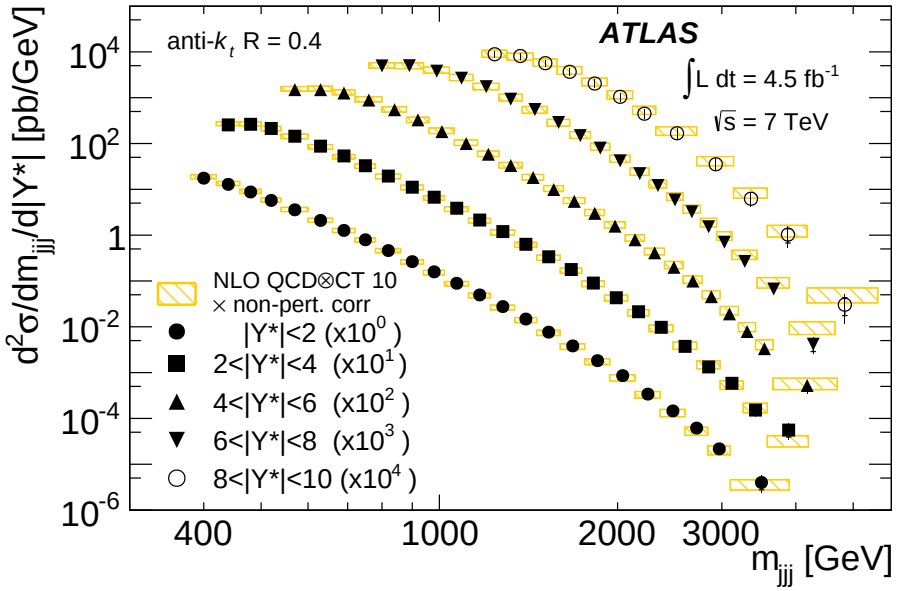
- theory is corrected for EW effects

Good agreement between data and theory over 7 orders of magnitude

Jet measurements. Three-jet mass

arXiv:1411.1855



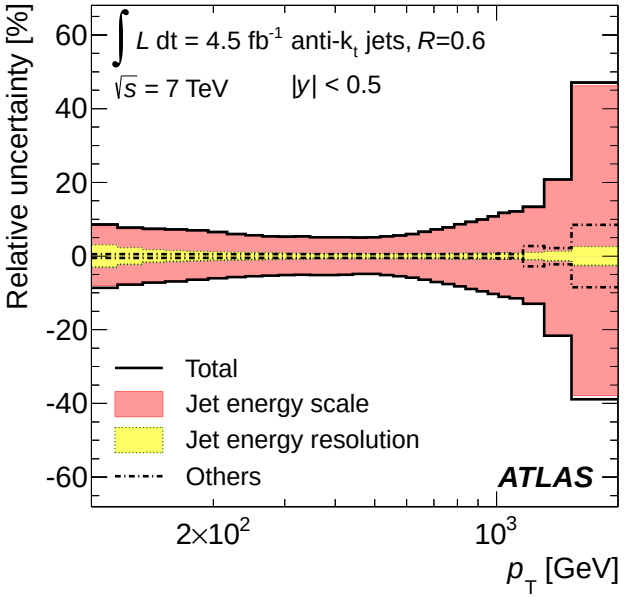


- $p_{\mathrm{T}}^1 > 150$ GeV, $p_{\mathrm{T}}^2 > 100$ GeV, $p_{\mathrm{T}}^3 > 50$ GeV, $|y^{jet}| < 3$
- $Y^* = |y_1 - y_2| + |y_1 - y_3| + |y_2 - y_3|$
- $|Y^*| < 10$, five rapidity separation bins, in steps of 2

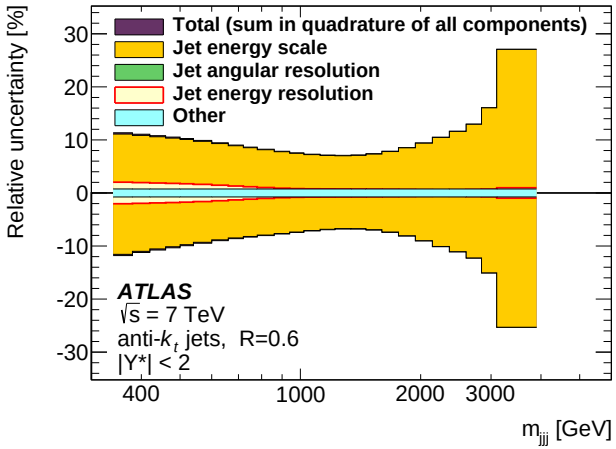
- Theory: NLOJET++ × NPC
- non-pert. correction : Pythia/Herwig with various tunes
- no EW correction is available

Good agreement between data and theory over 6 orders of magnitude

Experimental uncertainies



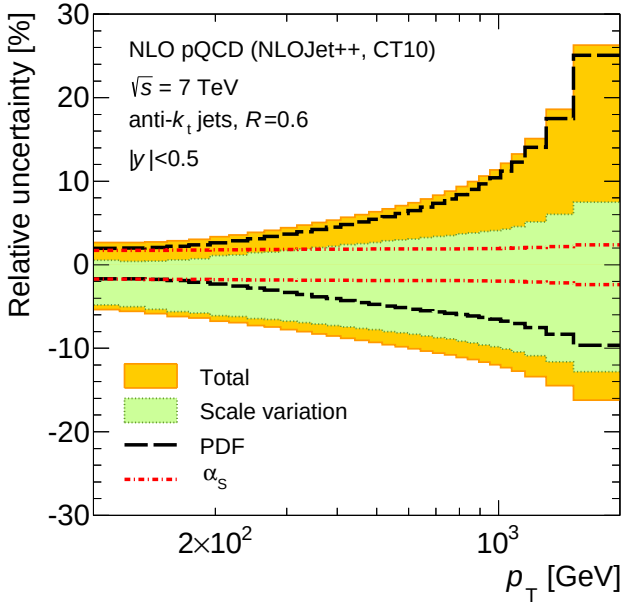
inclusive jets



three-jet mass

- JES – largest source of uncertainty
- JER, JAR are also considered
- Jet quality selection, unfolding - are the subdominant
- 64 components of JES uncertainty are propagated through the measurement
- In the most precise regions the total uncertainty is $\sim 8 - 10\%$
- Uncertainty increases in the high-p_{T}, high-mass regions

Theory uncertainies



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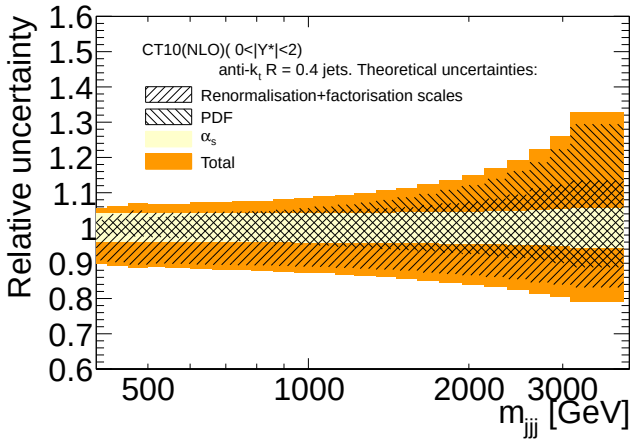
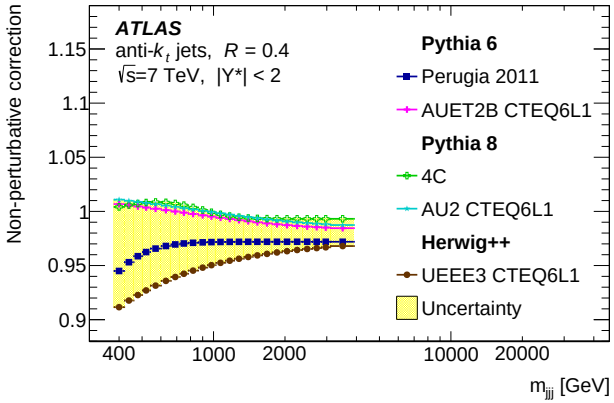


three-jet mass

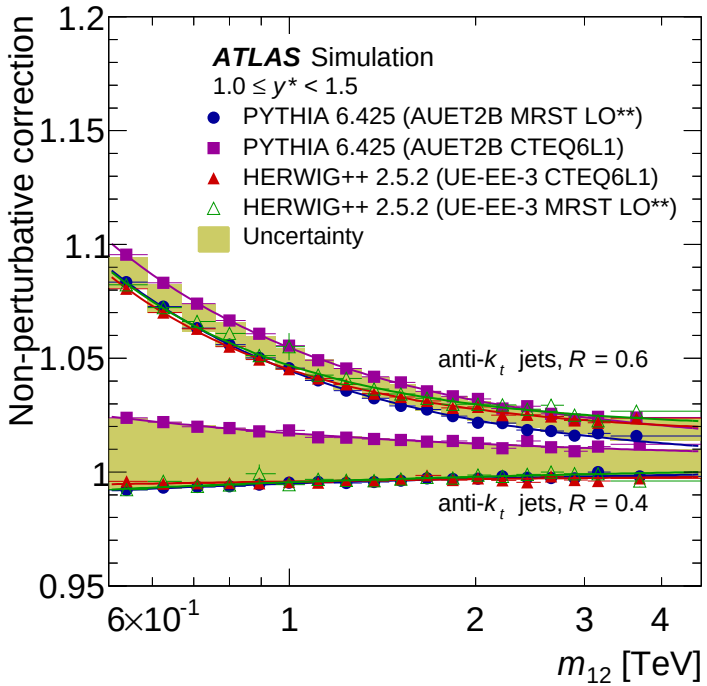
- Theory uncert. : PDF+scale+α_s+corr. Scale is the dominant
- Scale choice
  - inclusive jets : $p_{\mathrm{T}}^{jet}{}_{max}$ in the event
  - dijets : $p_{\mathrm{T}}^{jet}{}_{max} \times e^{0.3*y^*} \sim m_{12}$
  - three-jet mass : m_{jjj}

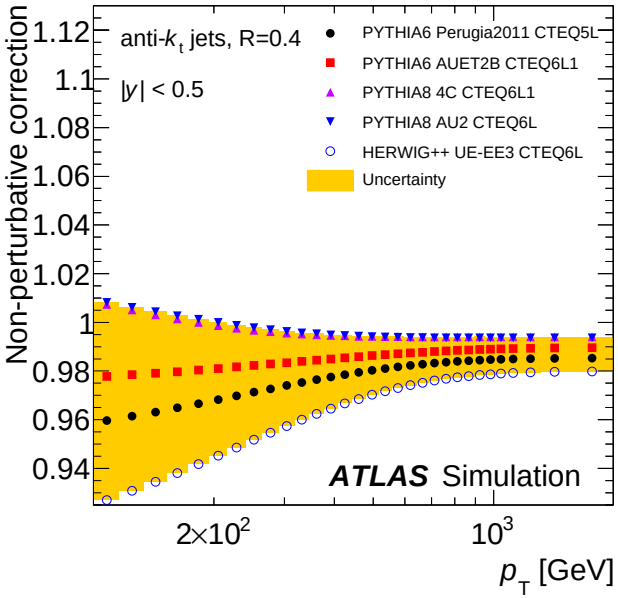
Non-perturbative corrections



three-jet mass

$$C_{\mathrm{NP}} = \frac{\left.\frac{d^2\sigma}{d\mathcal{O}}\right|_{\mathrm{NP\ on}}}{\left.\frac{d^2\sigma}{d\mathcal{O}}\right|_{\mathrm{NP\ off}}}.$$

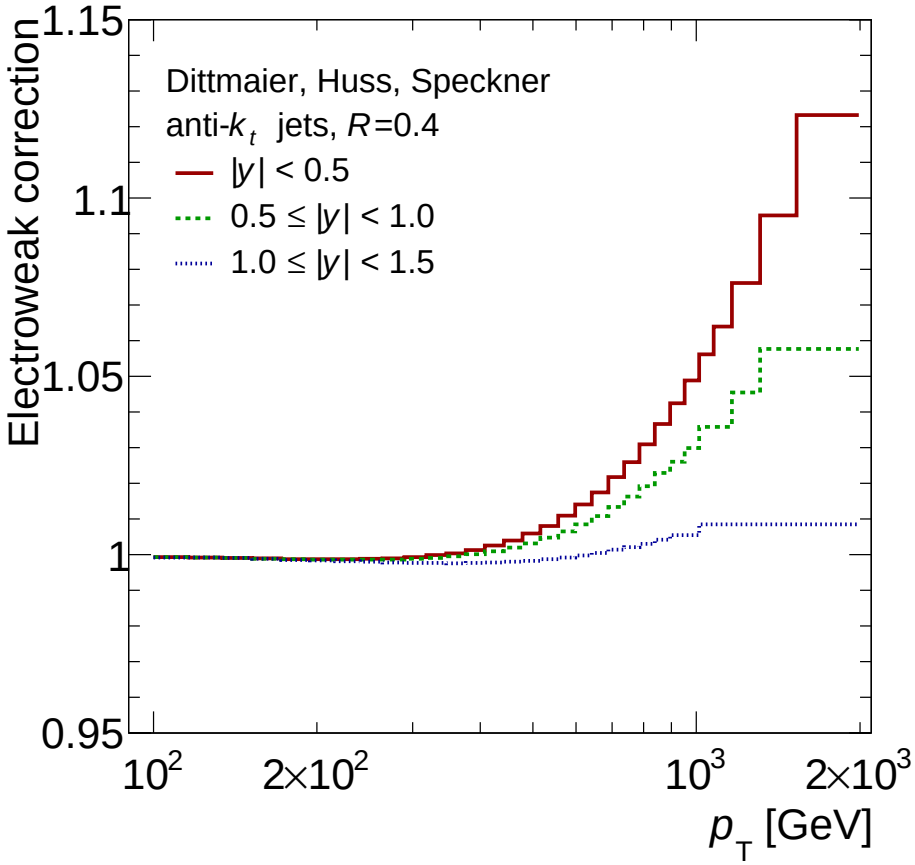




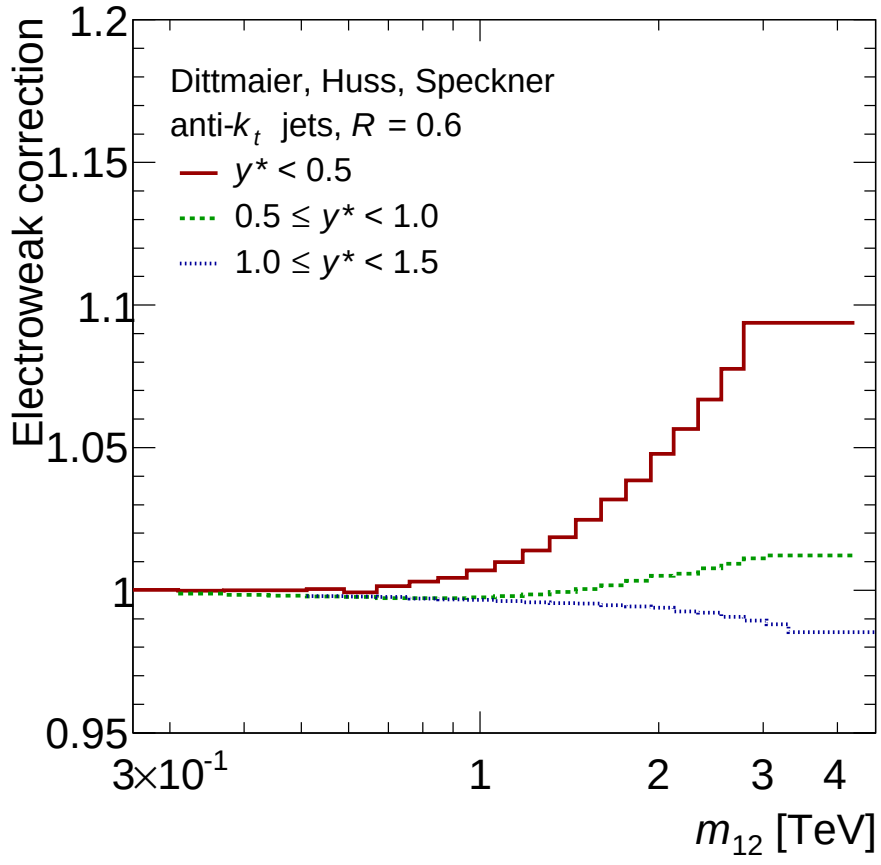
inclusive jets

- One tune is used for the nominal
- Uncertainty - envelope of the different tunes
- 5–10% in the low p_T(mass) region
- negligibly small in the high-p_T range

Electroweak corrections



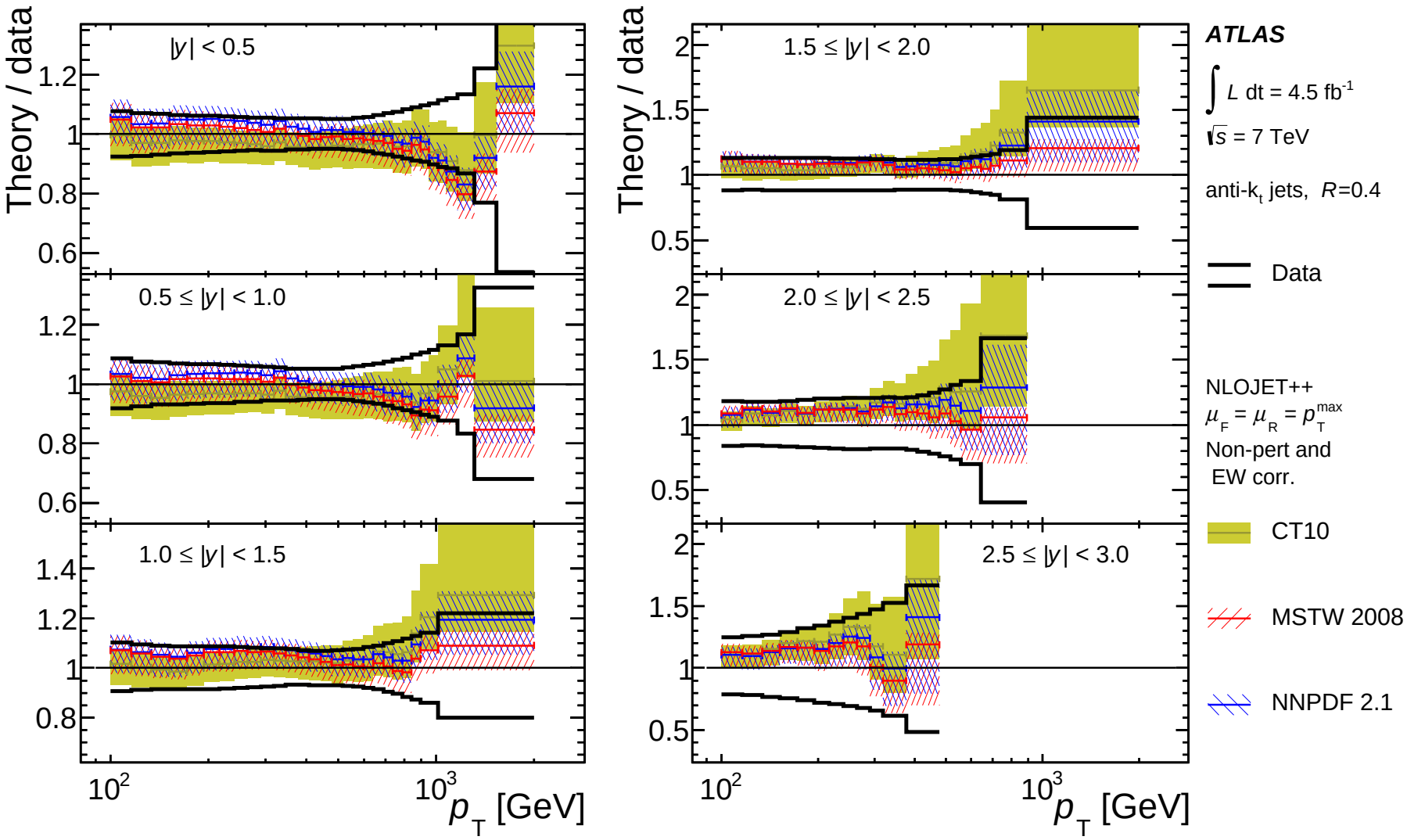
inclusive jets



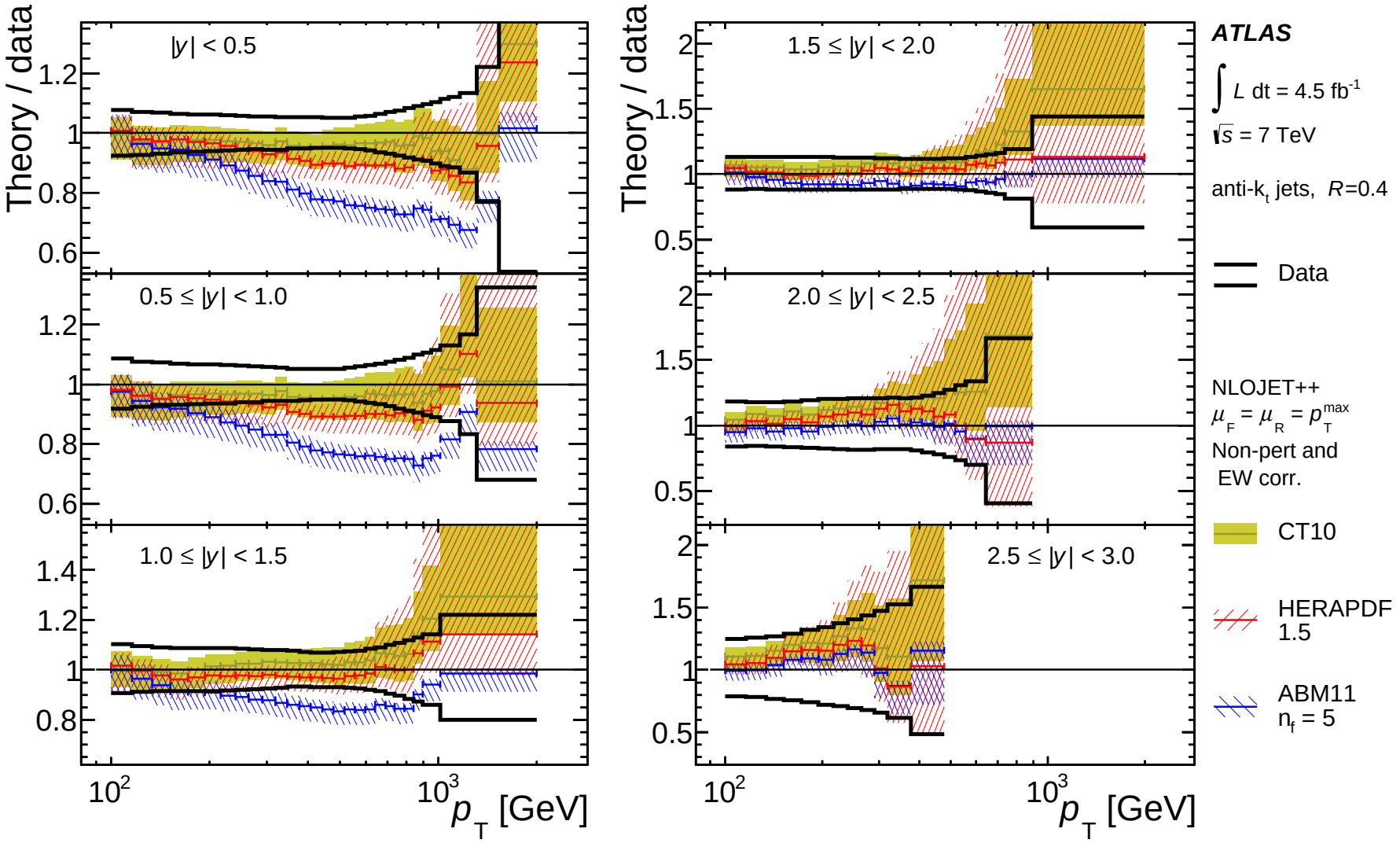
dijets

- Very small impact for p_T(mass) below 600(1000) GeV
- Up to 10% effect in the high-p_T(mass) range

Inclusive jets. Detailed comparison to theory (I)



Inclusive jets. Detailed comparison to theory (II)



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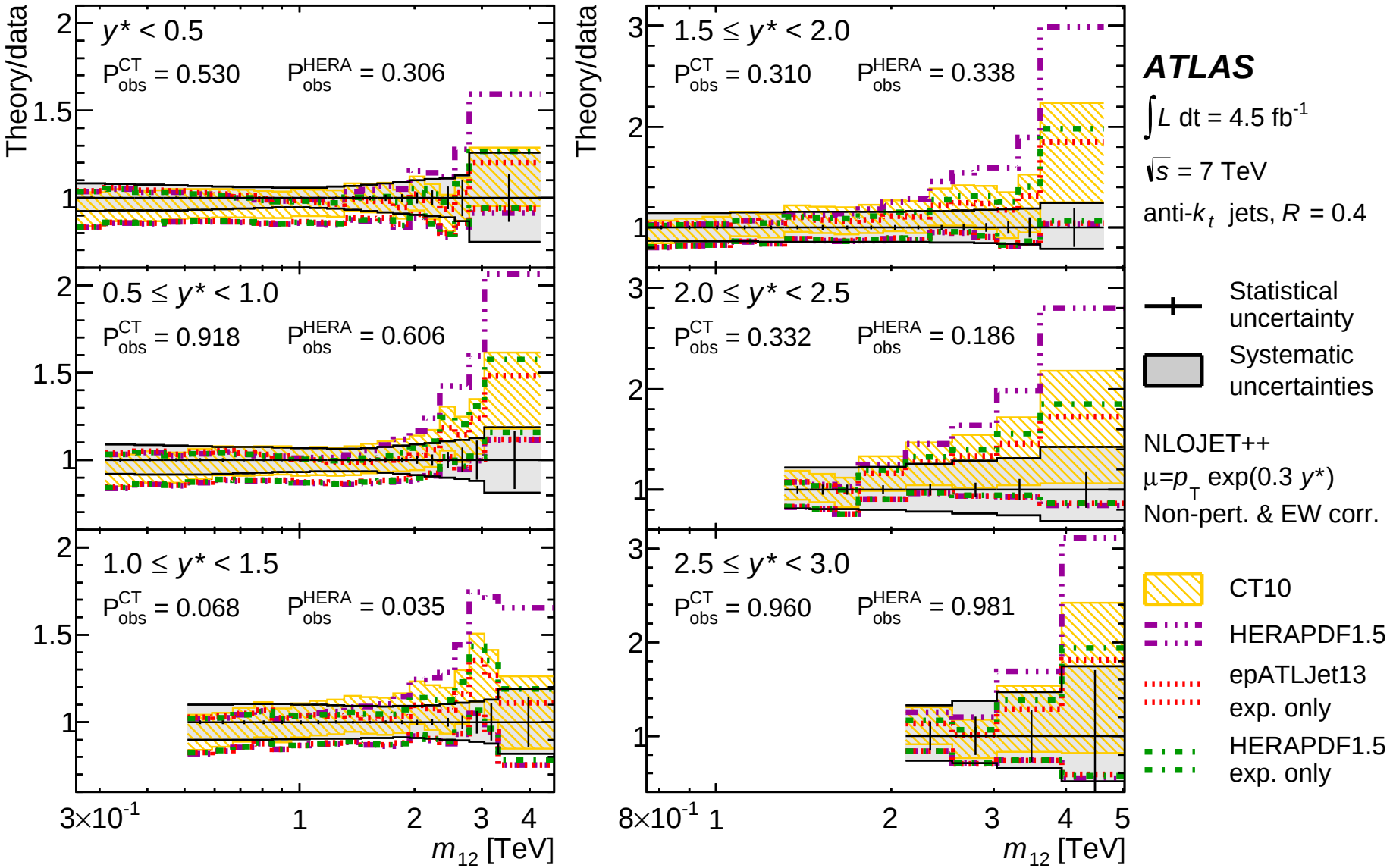
Dijets. Detailed comparison to theory (I)



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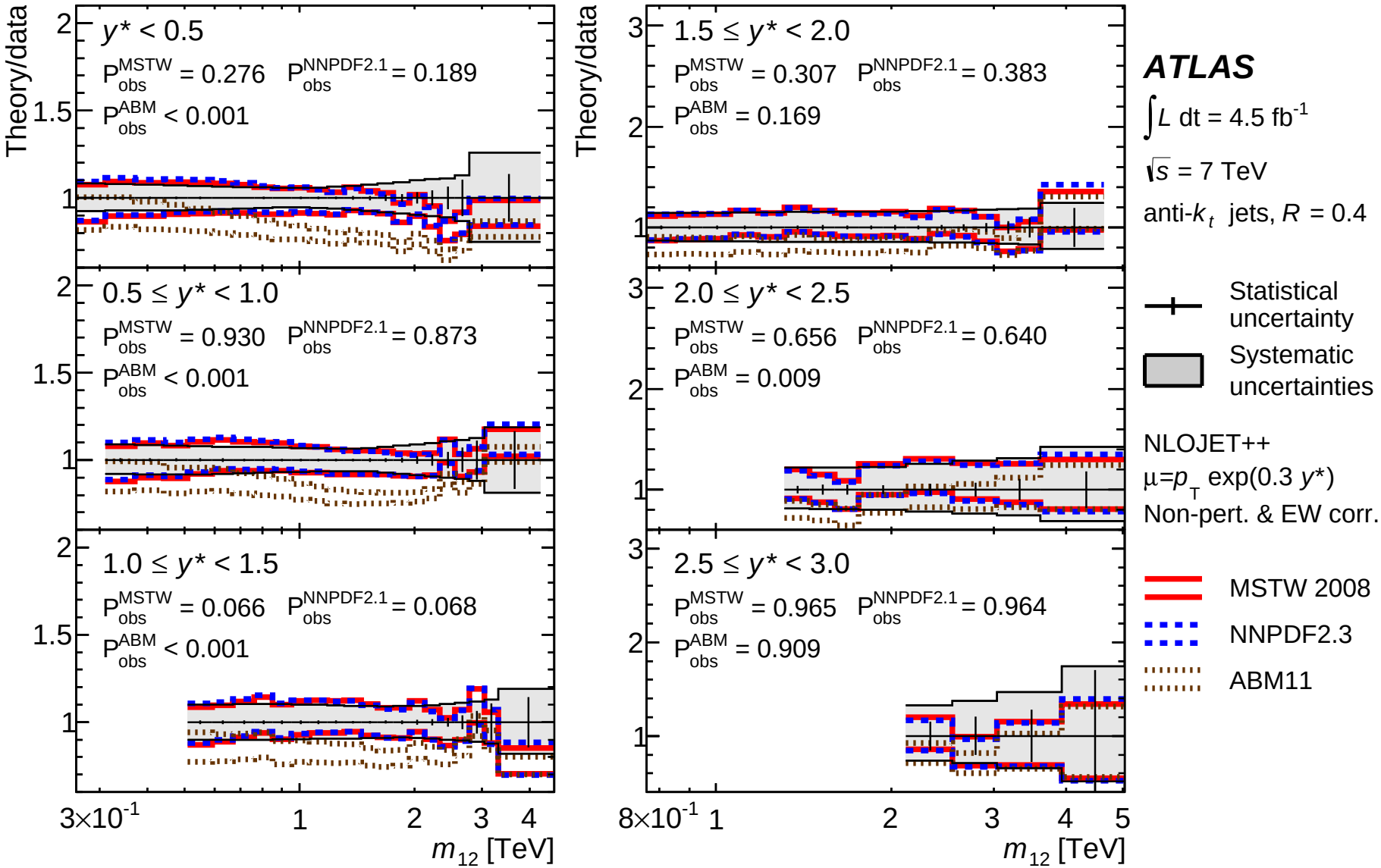
Dijets. Detailed comparison to theory (II)



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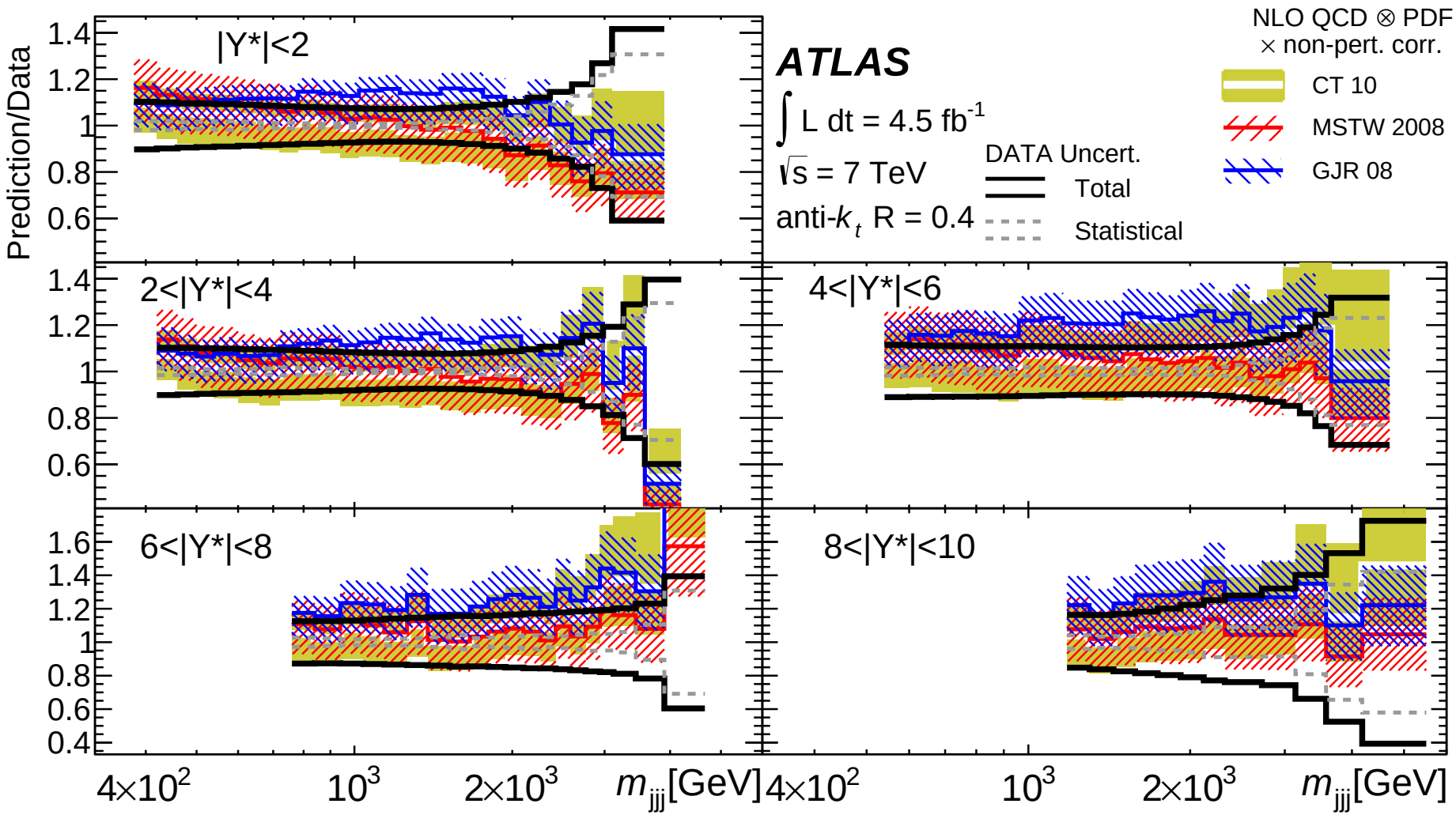
Three-jets. Detailed comparison to theory (I)



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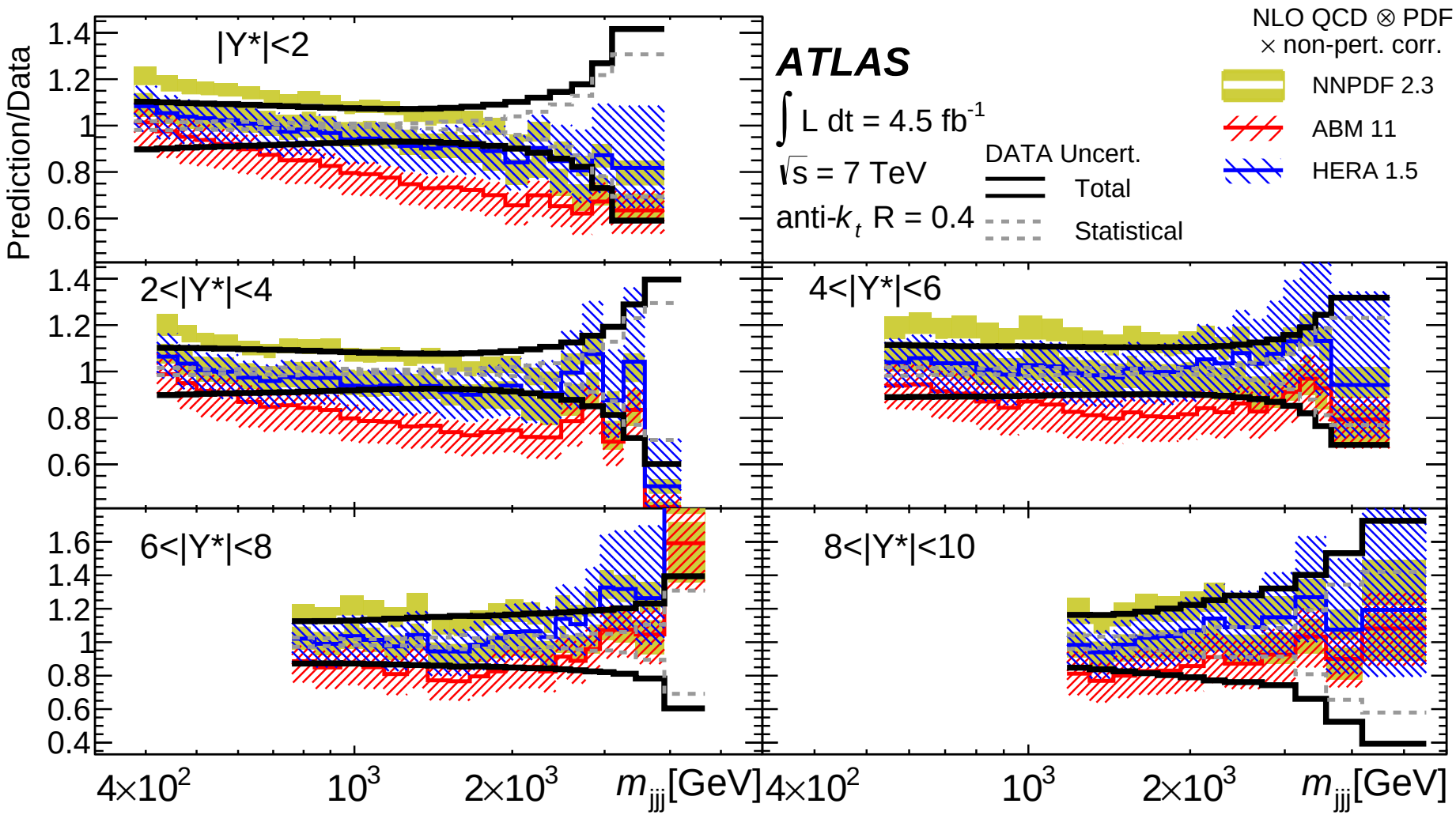
Three-jets. Detailed comparison to theory (II)



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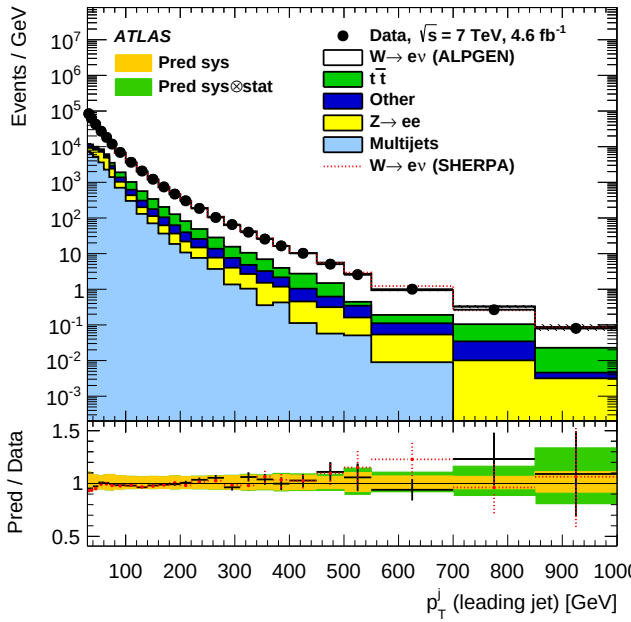
W-production in association with jets and W–jet/Z–jet ratios

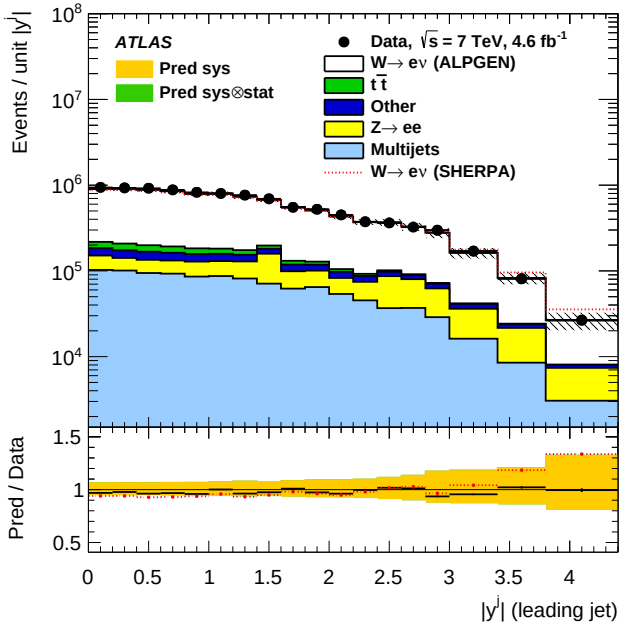
Same systematics and binning between W/Z–jets measurements allows to measure cross-section ratios $\rightarrow$ reduction of exp. uncertainties

- W–jets cross-sections(arXiv:1409.8639)
- R–jets cross-sections(arXiv:1408.6510)
- Z–jets cross-sections(JHEP07(2013)032)

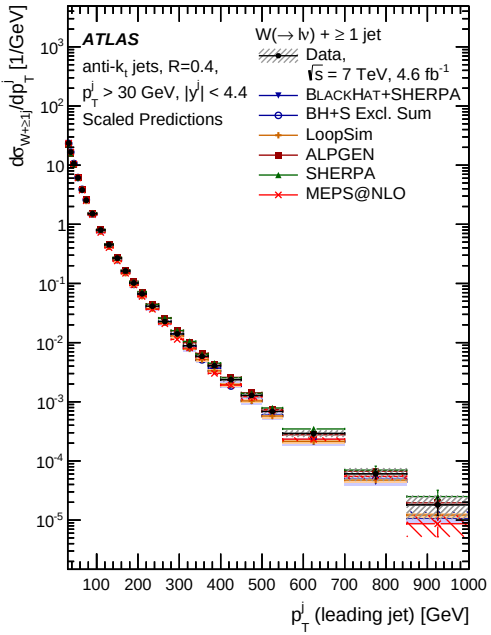
$p_{\mathrm{T}}^{jet} > 30$ GeV, $|\eta^{jet}| < 4.4$
Many interesting results

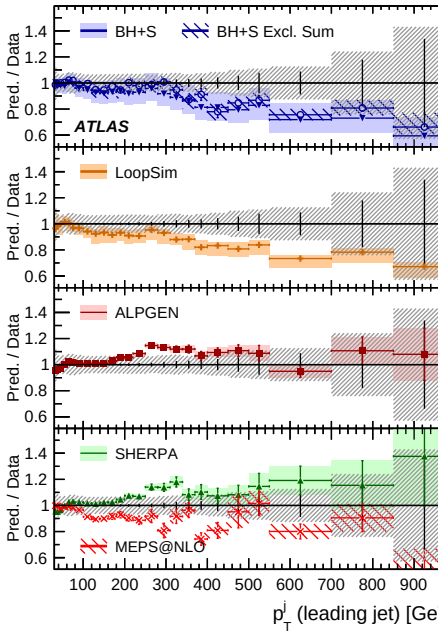
Will discuss only a few examples . . .

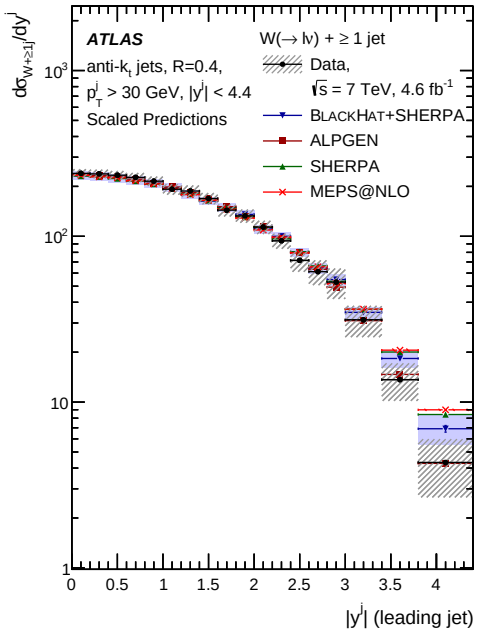


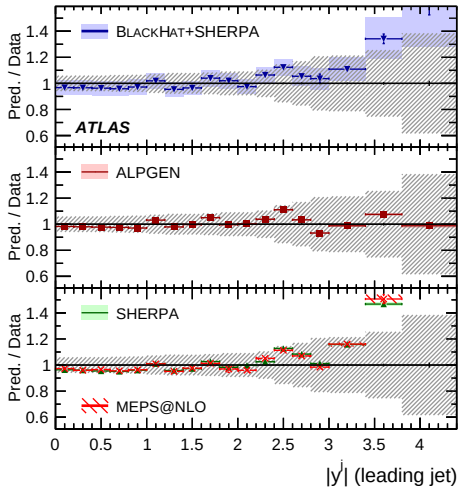


W–jet. Leading jet p_{T} and rapidity





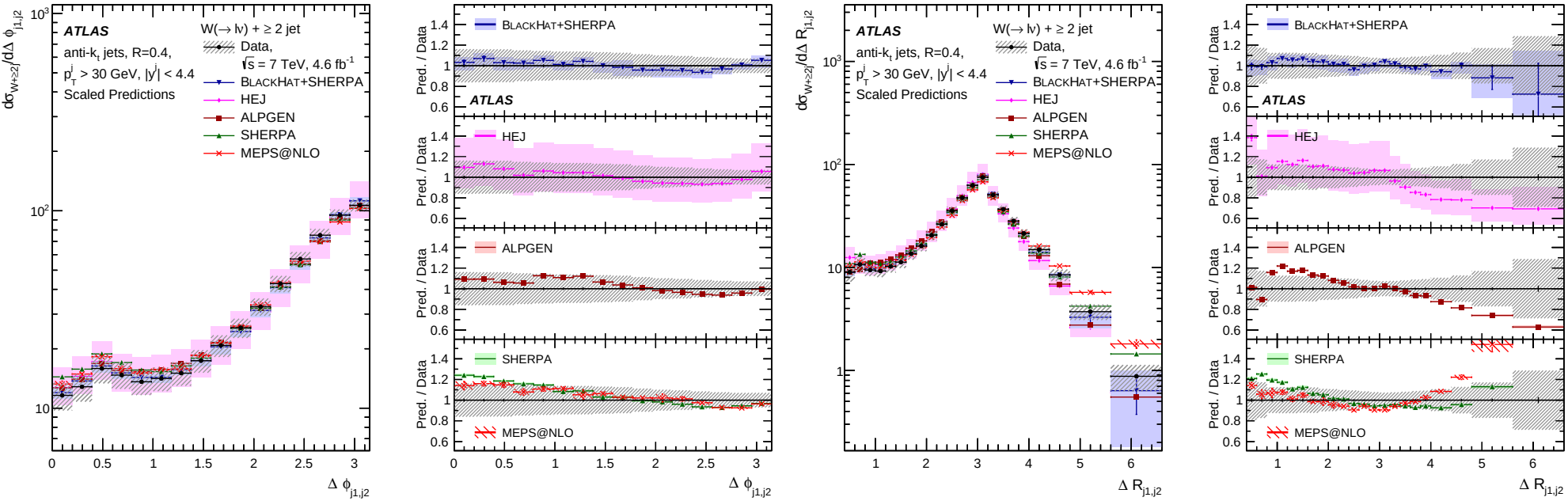




- Very good agreement between NLO calculations and data for jet rapidity distribution
- NLO theory undershoots data at high-p_{T}.

Interesting input for MC tuning PDF studies

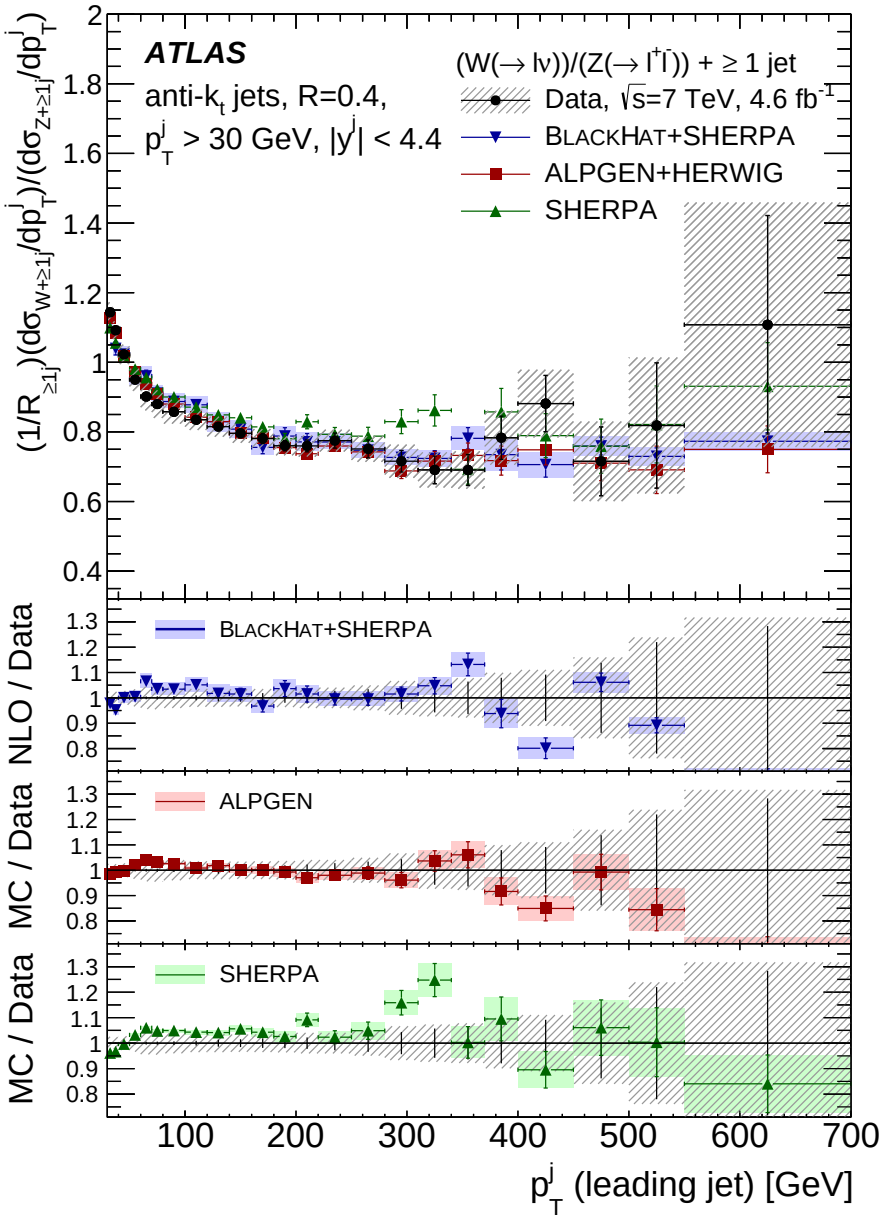
W–jet. Angles between two jets

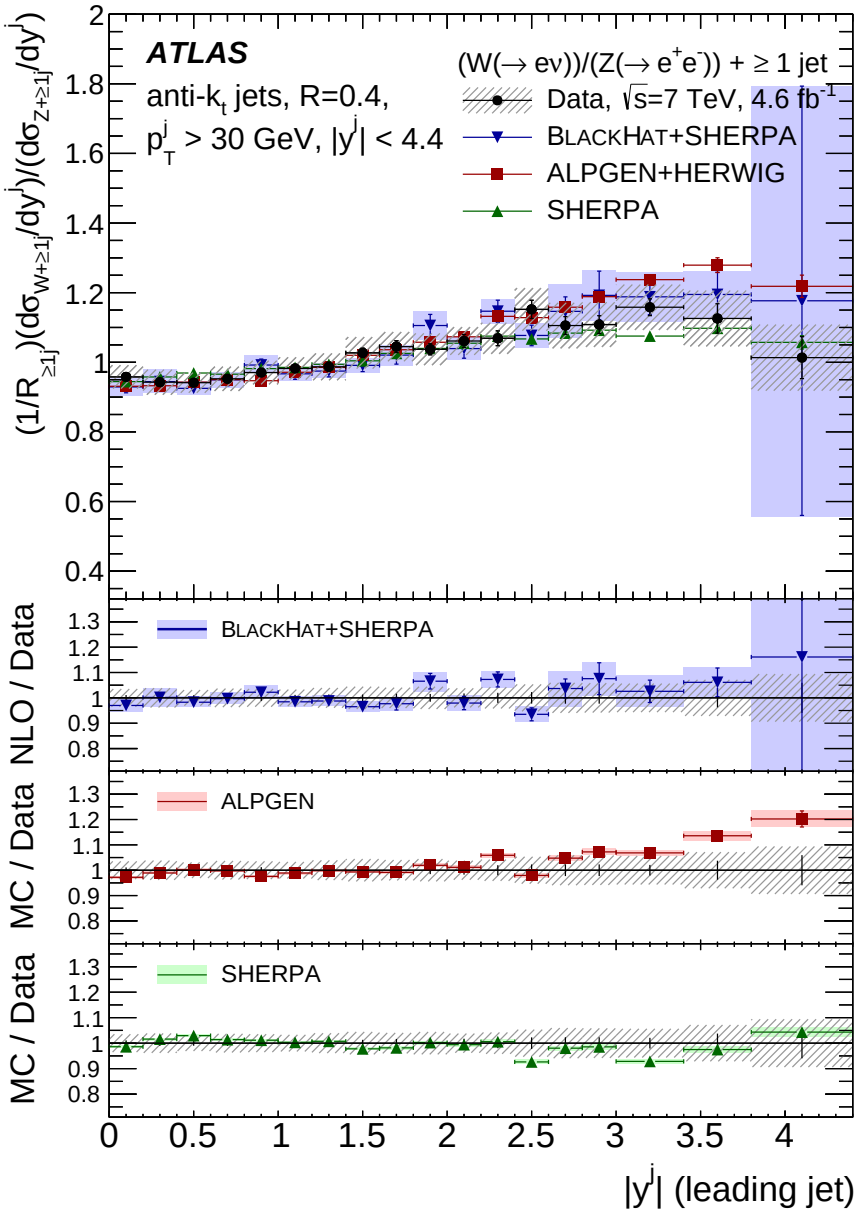


- Very good agreement between NLO calculations and data for $\Delta\varphi$ and ΔR
- LO multileg predictions agree with data within uncertainties, but has some trends.

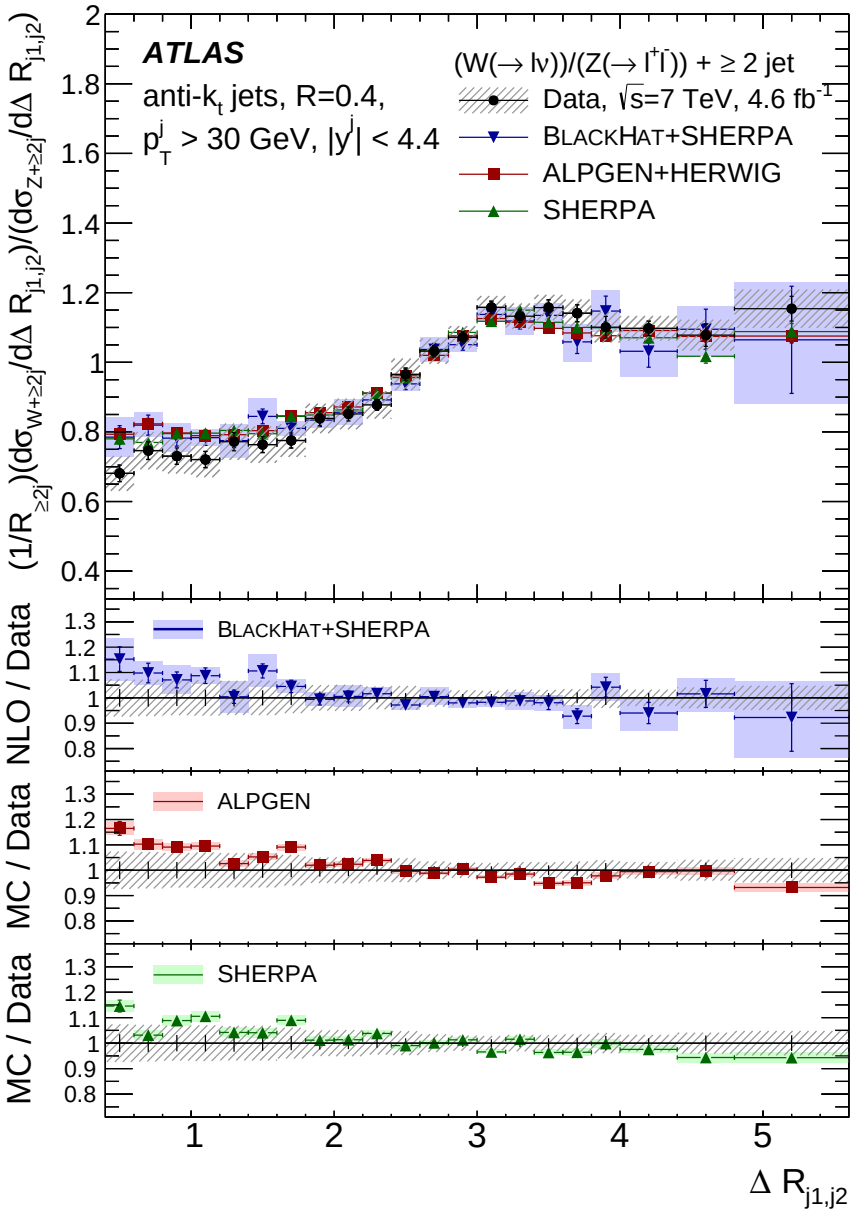
Interesting input for MC tunings

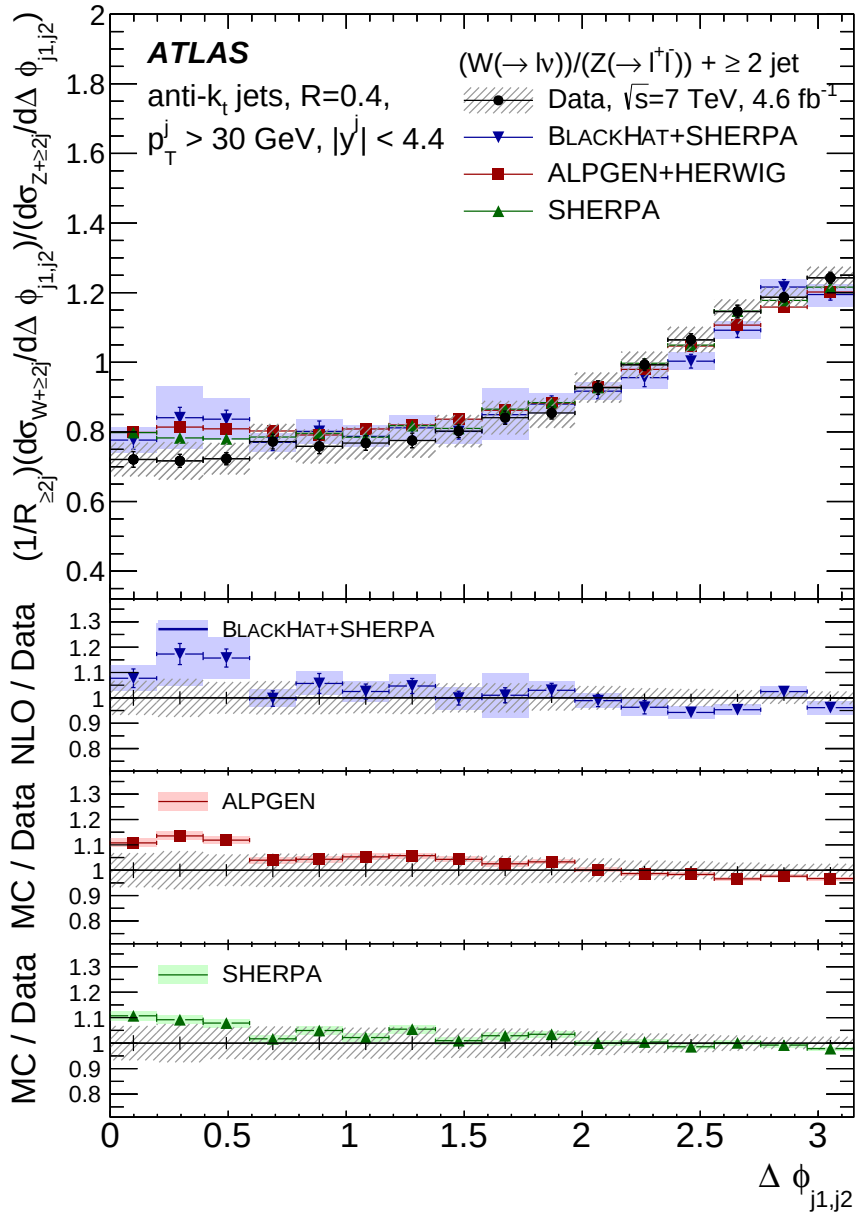
R–jet. Leading jet p_T and rapidity



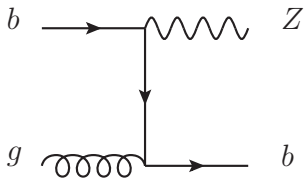


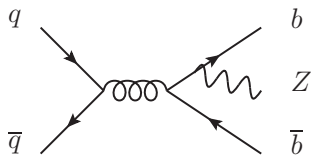
R–jet.Angles between two leading jets

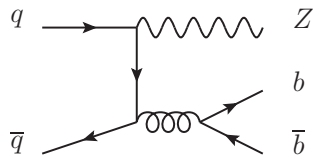




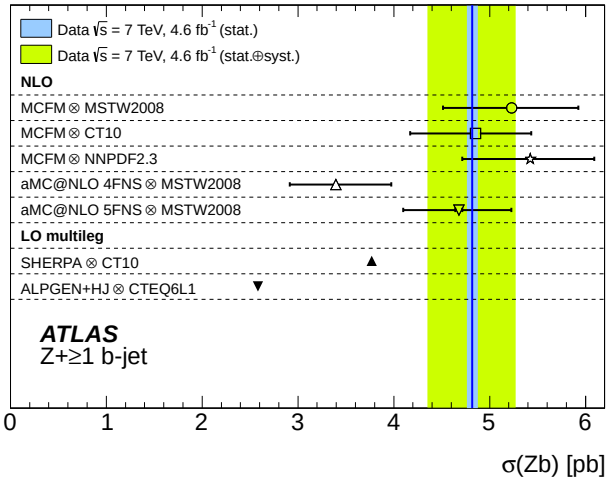
Production of Z-boson in association with b-jets

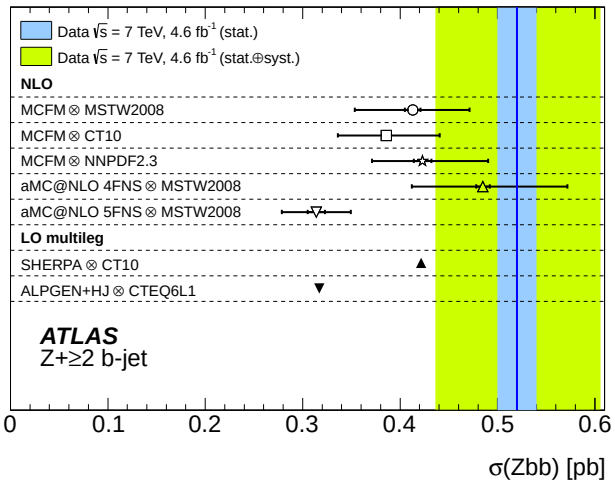






arXiv:1407.3643

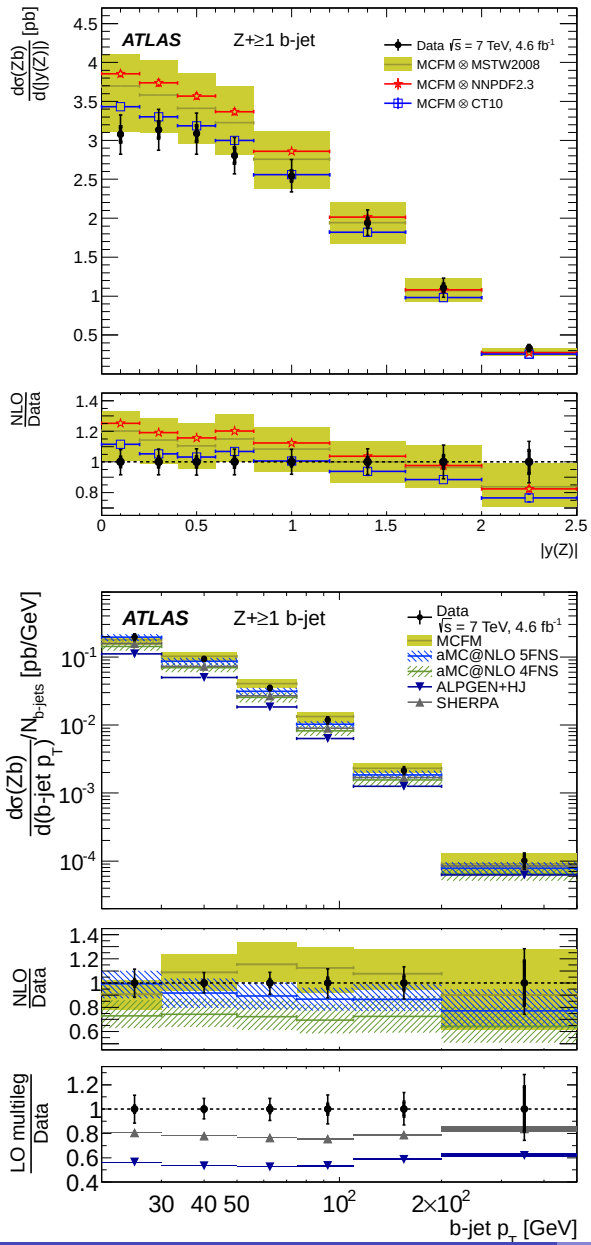




Clean experimental signature : leptonically decaying Z + HF jet

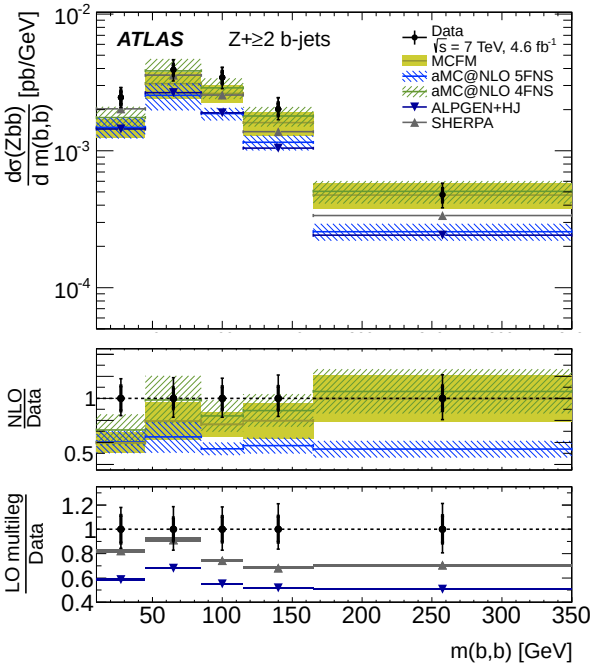
- Allows to test the associated heavy flavour production
- Large uncertainies in theory calculations $\rightarrow$ measurement provides important constraints
- Probes b-quark PDF (5FNS)

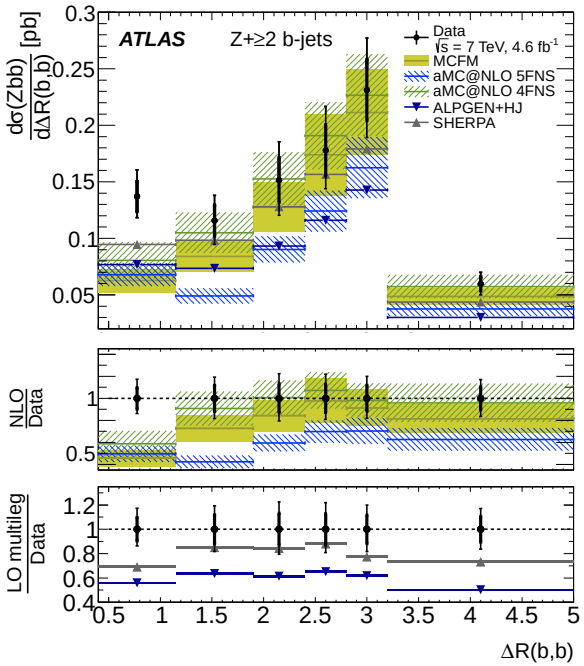
Z-b-jet. PDF sensitivity

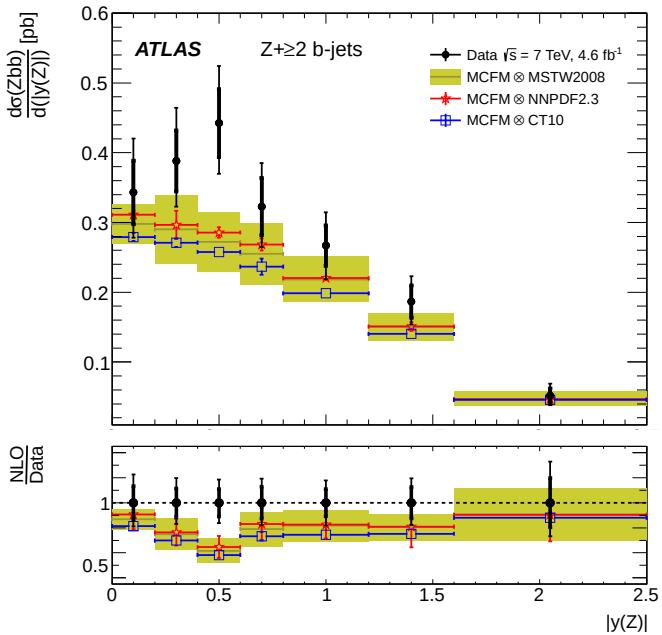


- Inner bar – stat. uncert.
- Outer bar – total uncert.
- MCFM is corrected for QED FSR, hadronisation, MPI
- Theory uncert. : PDF+scale+α_s+corr. Scale is the dominant
- Best PDF sensitivity from y_Z in 1b-jet channel
- b-jet p_{T} spectrum potentially is very interesting for PDF studies (need more precise theory . . .)

Z-b-jet. Two b–jets in the FS







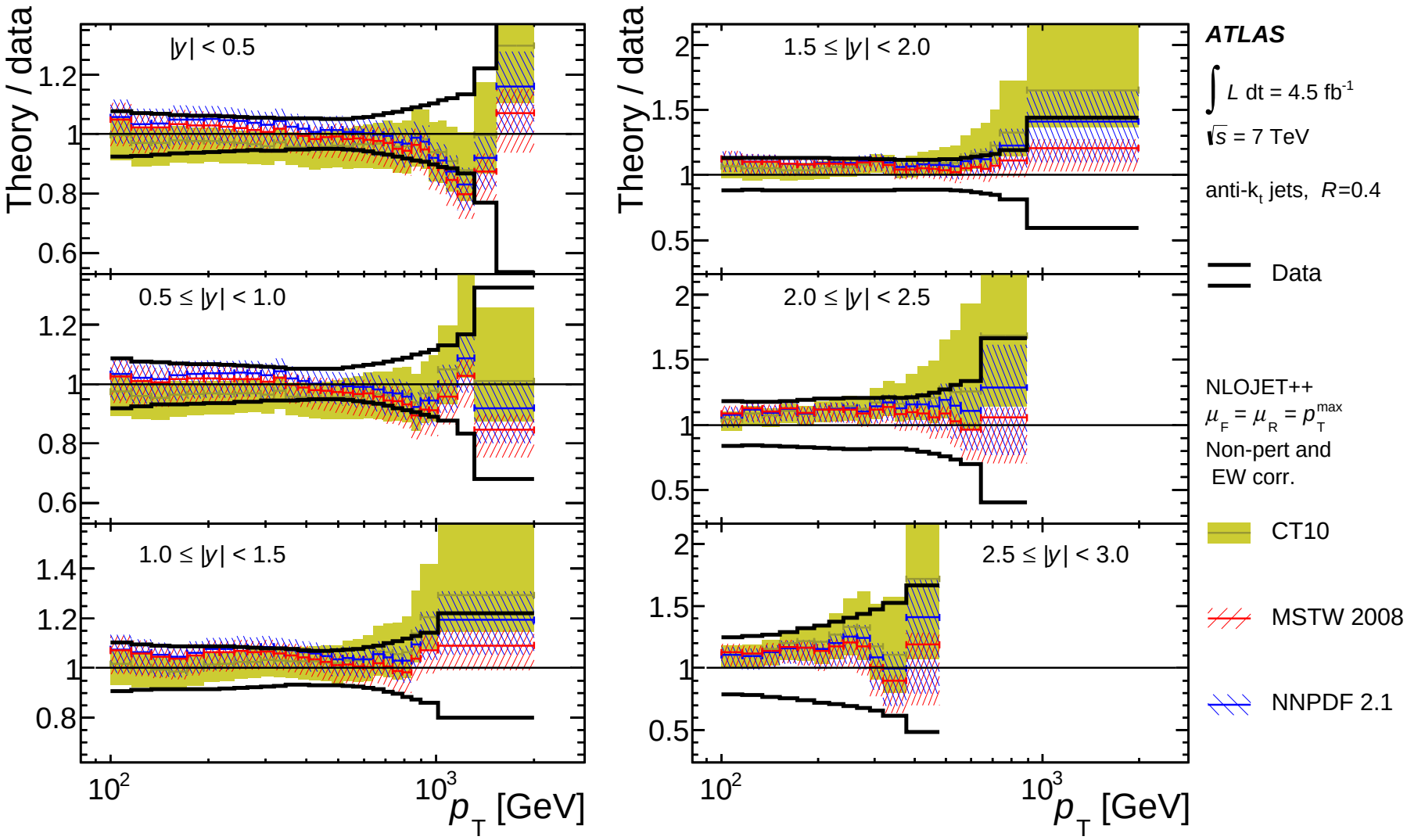
- y_Z in 2b-jet channel has some theory problems
- di-b-jet mass is quite well described by NLO
- angle between two b–jets is not described by NLO theory at low ΔR values

Summary

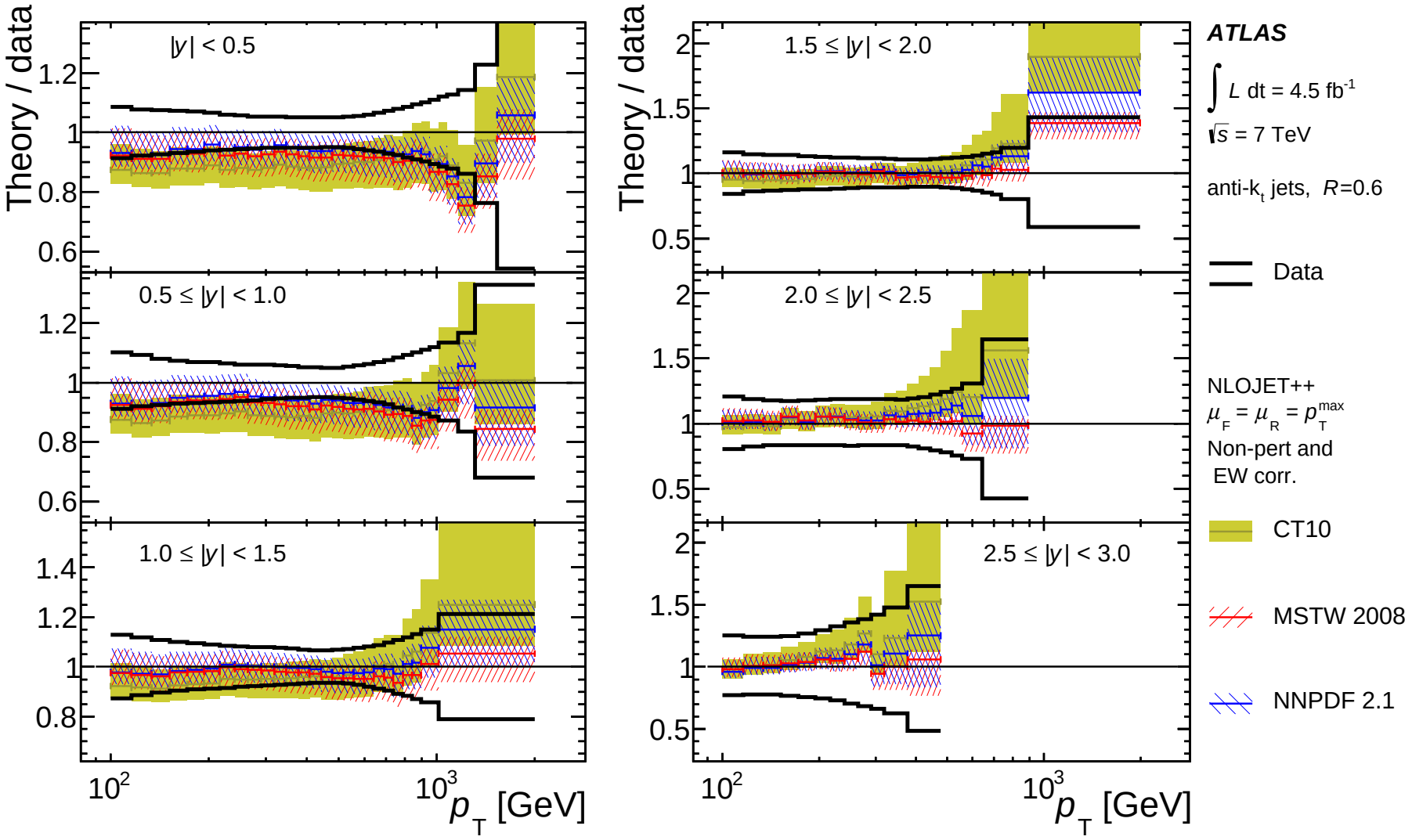
- Three new jet cross-section measurements at 7 TeV using 2011 dataset are presented :
  - common set of systematic uncertainies
  - statistical correlations between cross-sections
  - provide constraints on high-x gluon and α_s running
  - three scenarios of syst. uncert. correlations are provided : nominal+ weak+strong
- W–jets and R–jets : new observables for MC tuning and PDF analysis
- Z-b-jets : test predictions for HF production and provides constraints on the b-quark PDF

Back-up

Inclusive jets. Detailed comparison to theory (I)

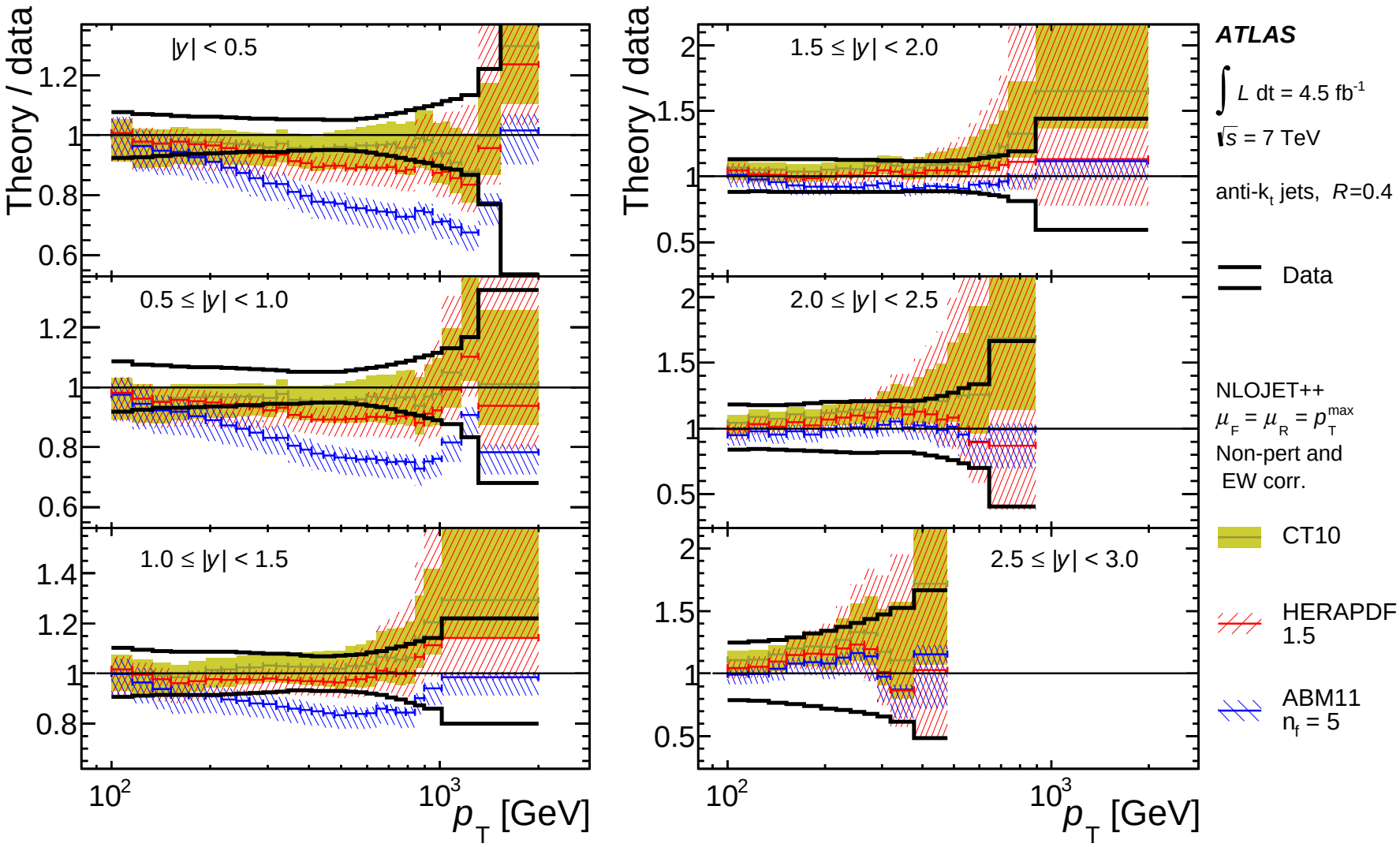


Inclusive jets. Detailed comparison to theory (II)



different set of PDFs

Inclusive jets. Detailed comparison to theory (I)



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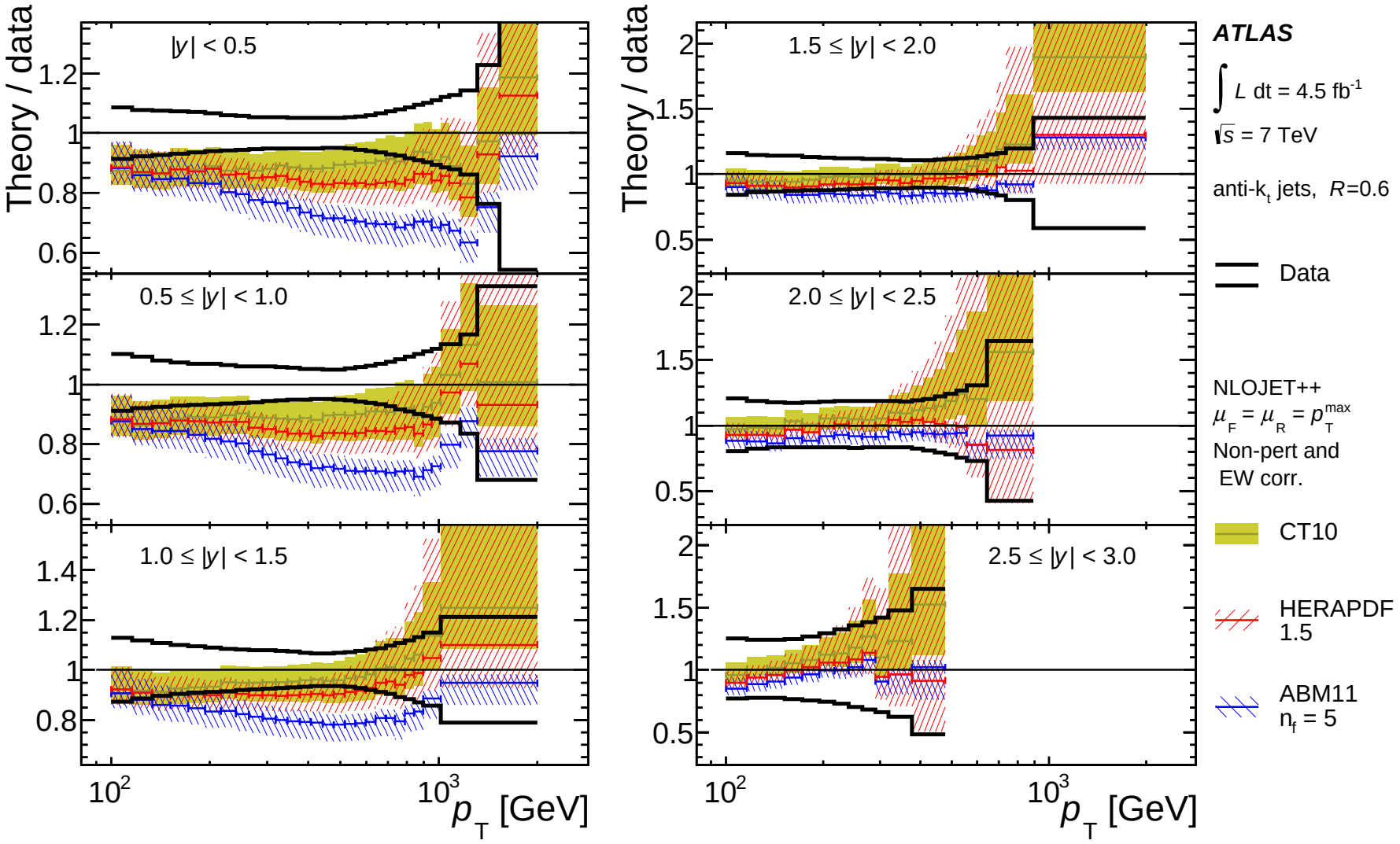

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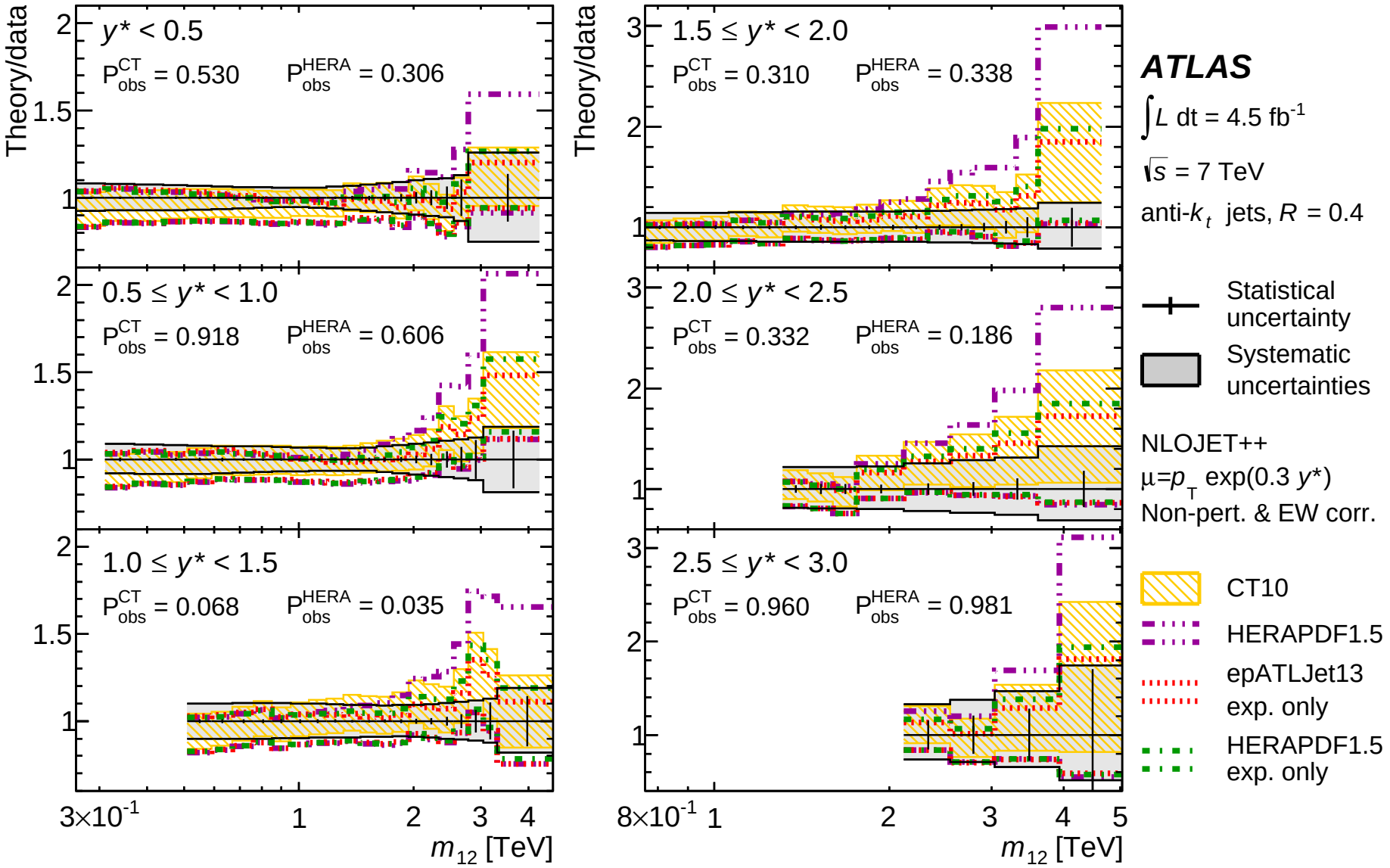
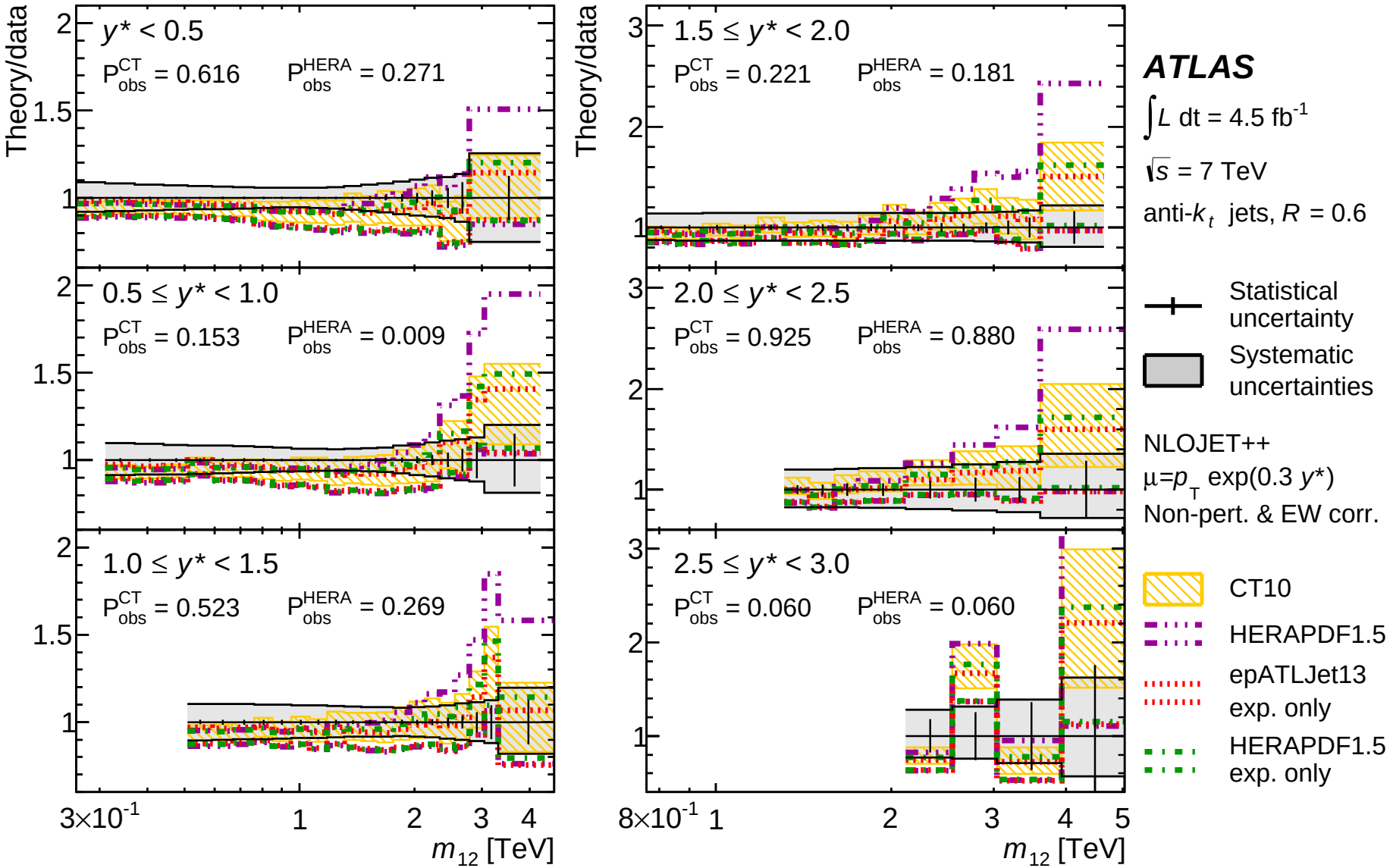


Dijets. Detailed comparison to theory (II)



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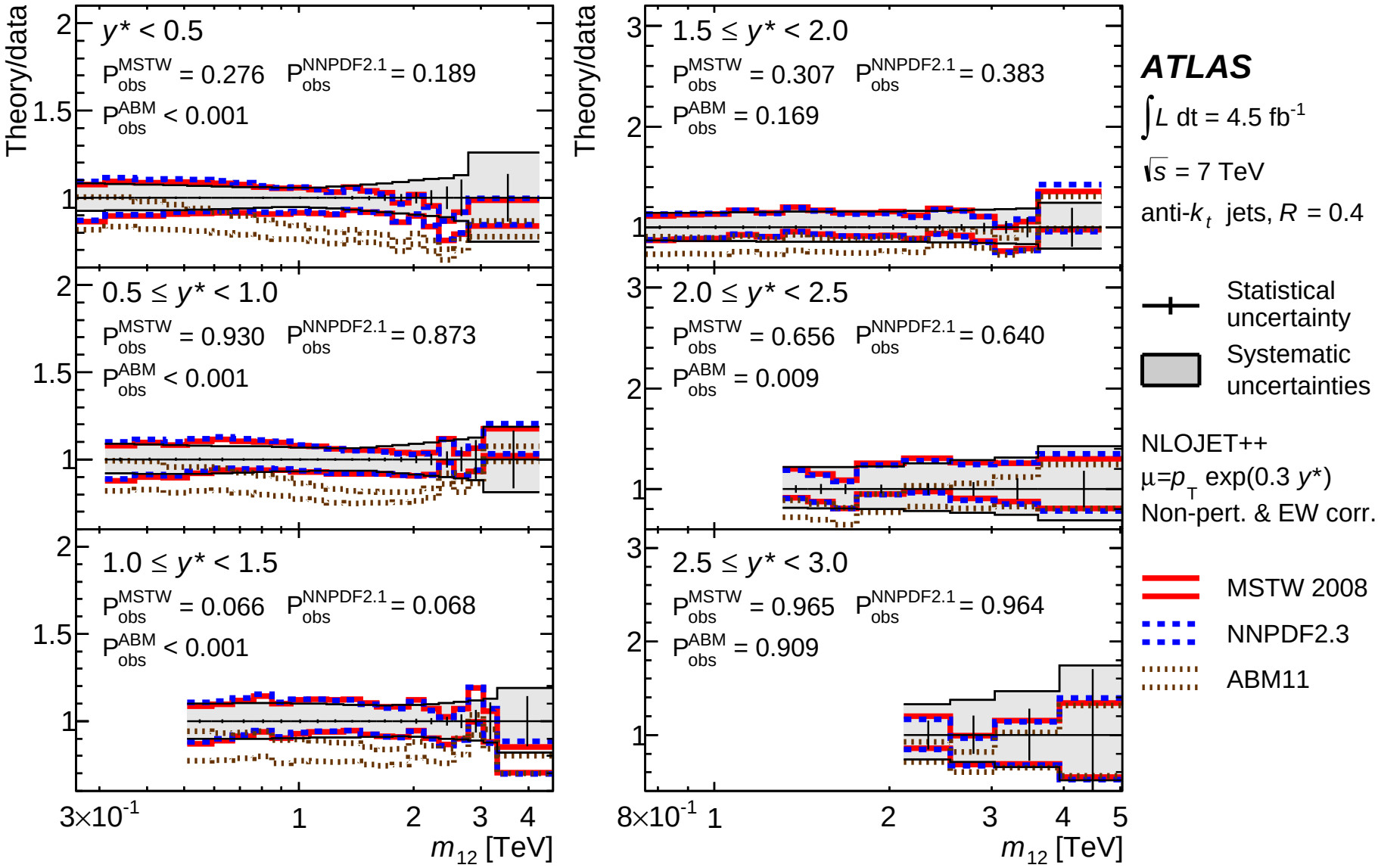
Dijets. Detailed comparison to theory (I)



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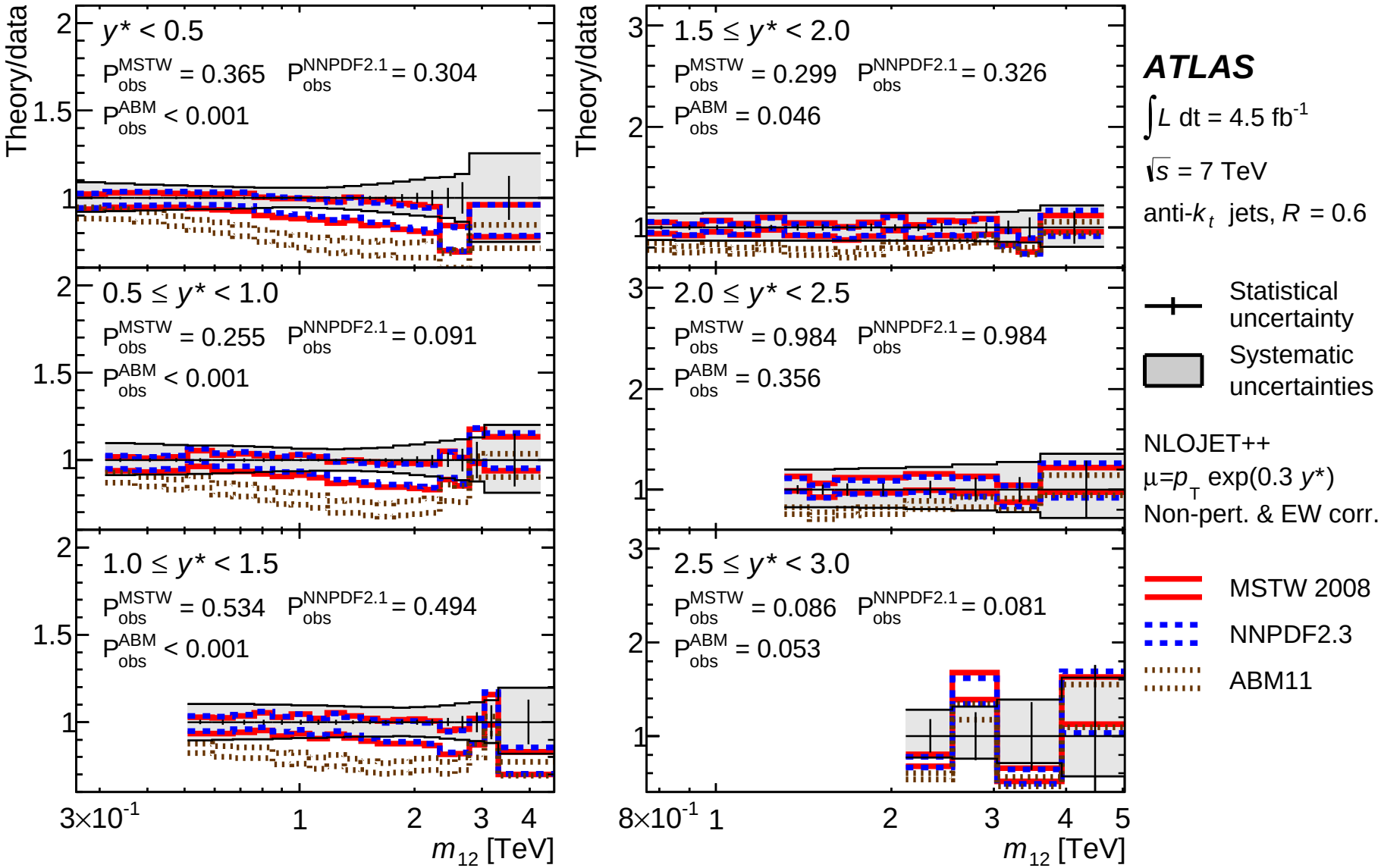

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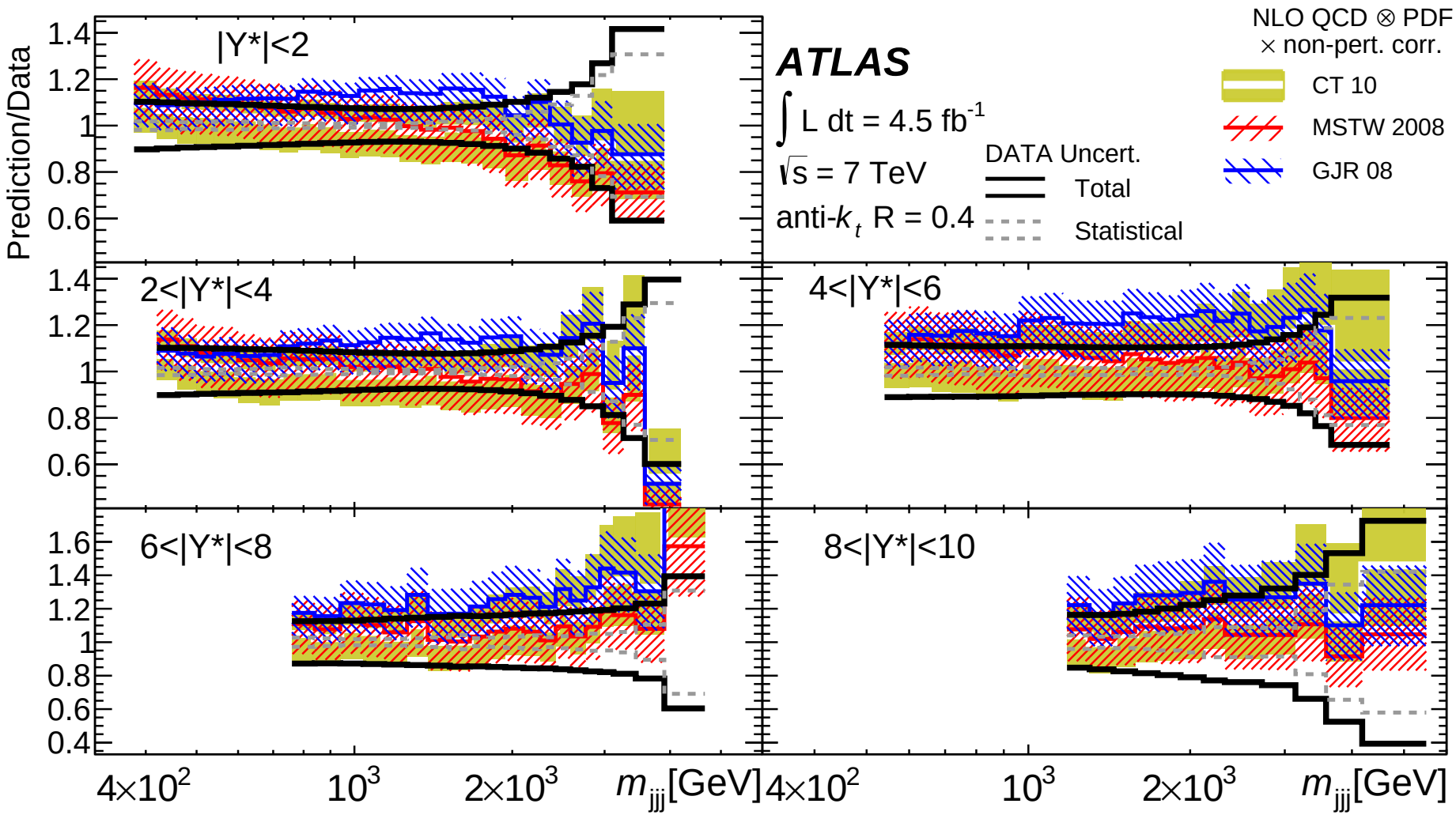
Three-jets. Detailed comparison to theory (I)



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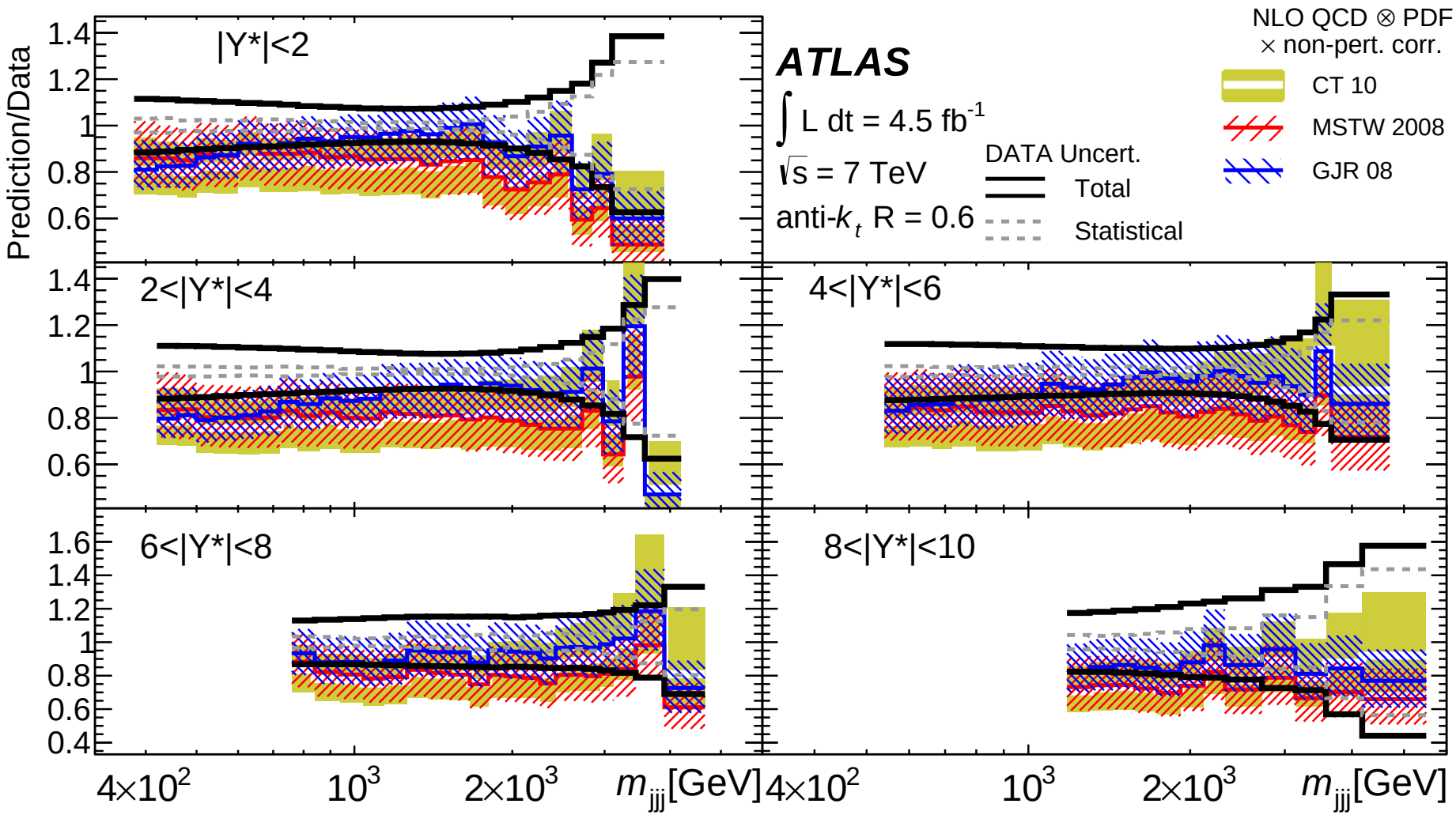
Three-jets. Detailed comparison to theory (II)



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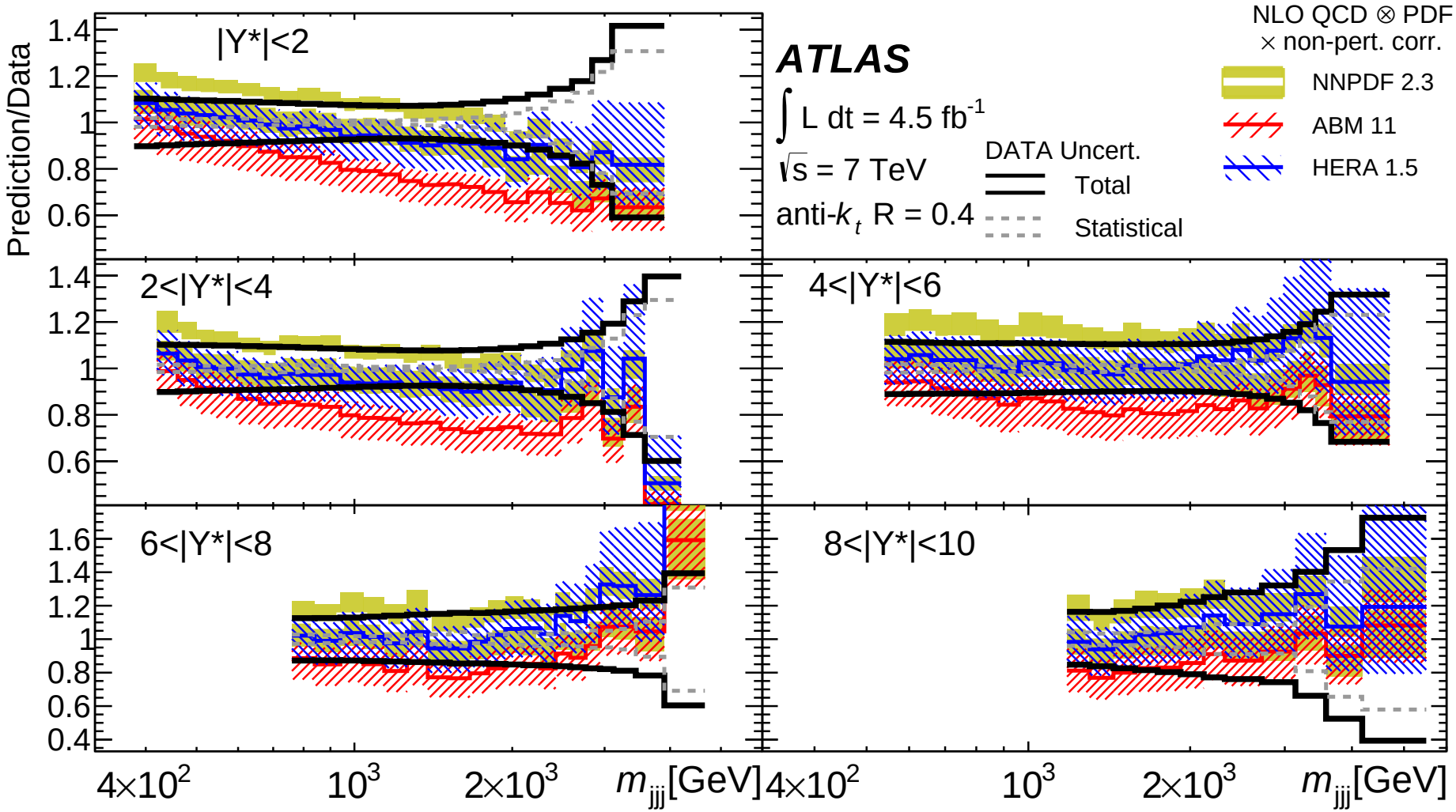

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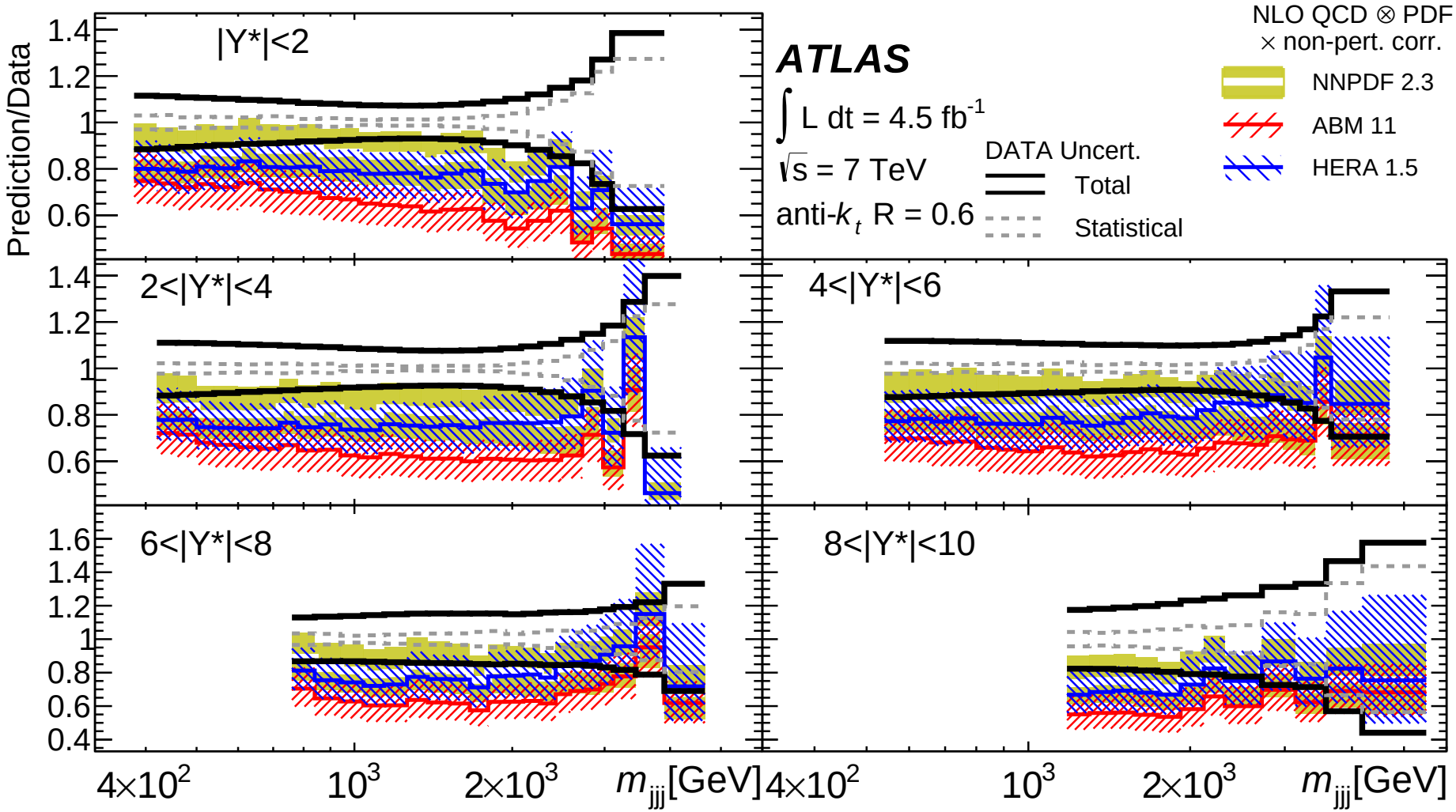
Three-jets. Detailed comparison to theory (II)



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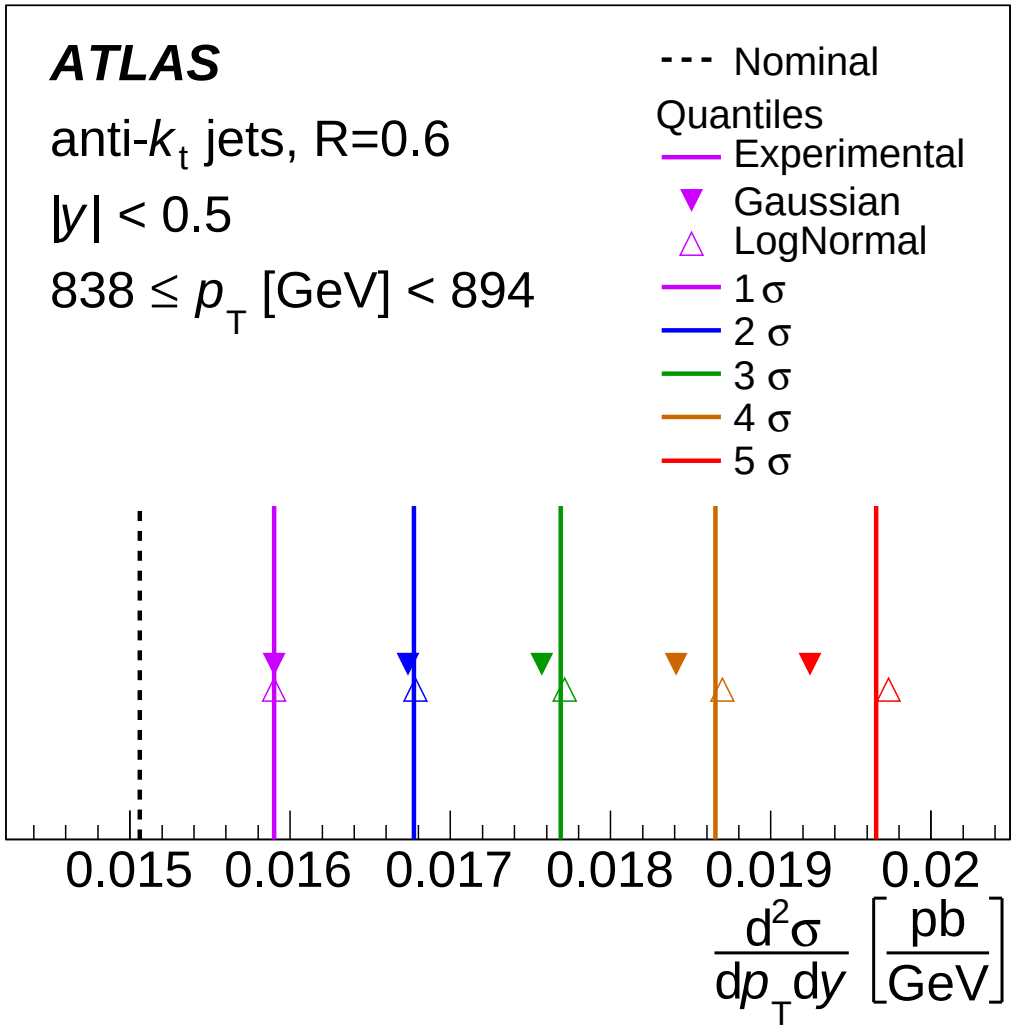
Inclusive jets. Test of gaussianity of uncertainies



Uncertainty in the energy deposited in the EM calorimeter