Measurement of the inclusive jet and dijet production with the ATLAS detector

Zdenek Hubacek
Czech Technical University in Prague

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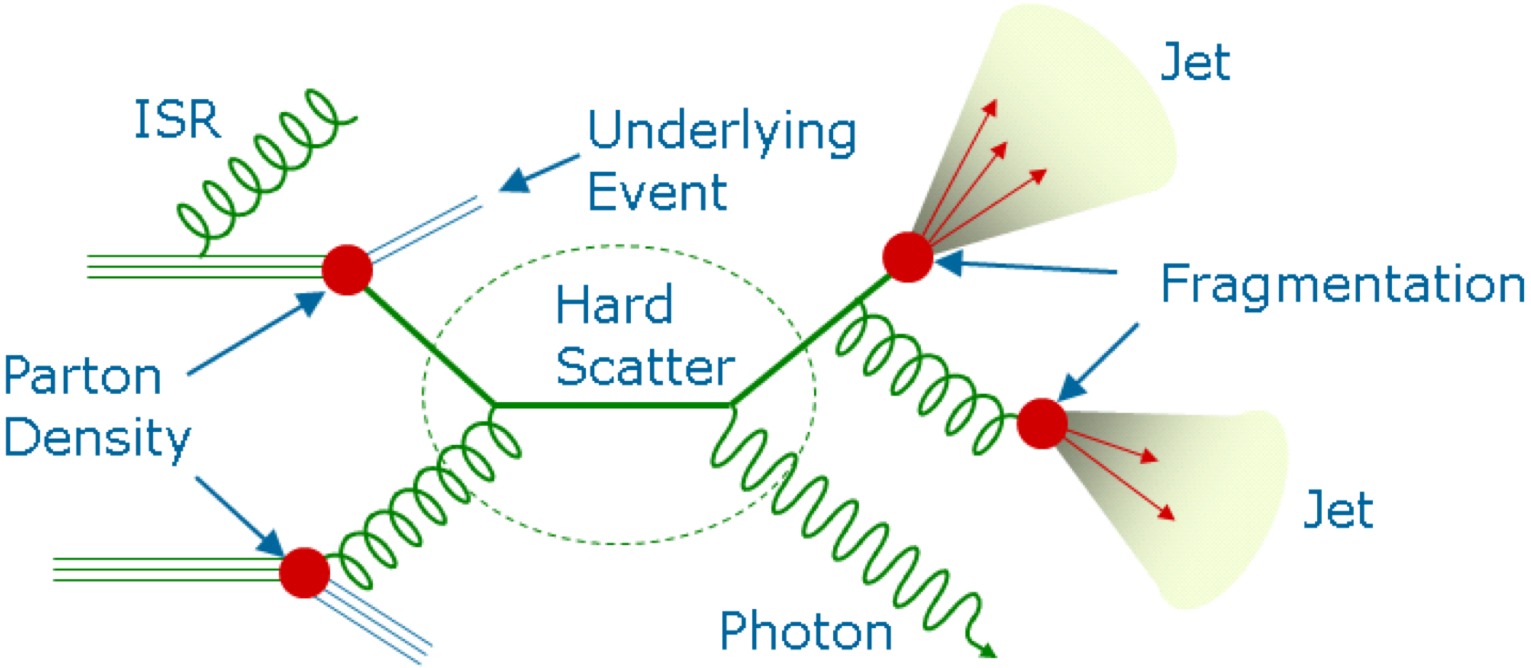
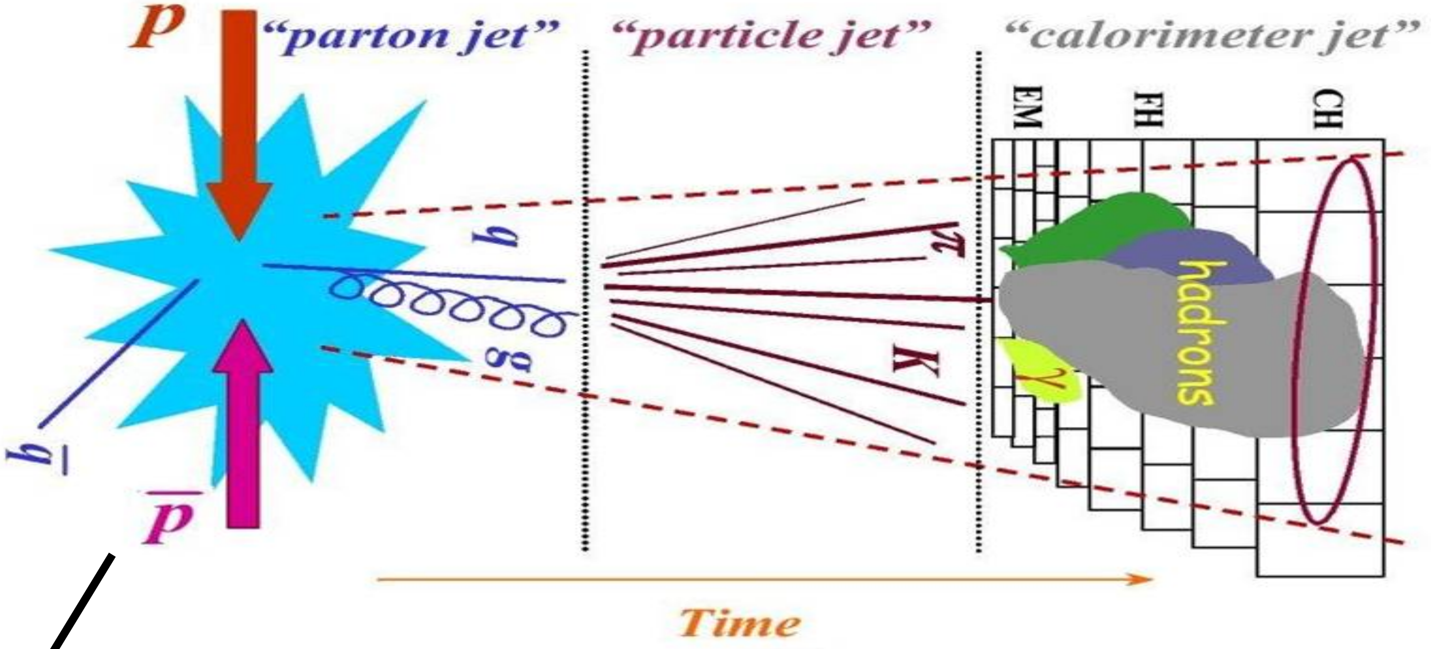
Outline

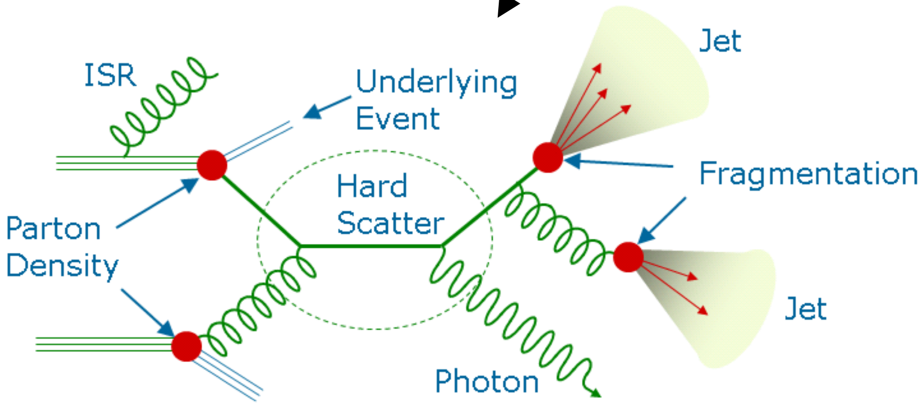
- Inclusive jet and dijet cross section measurements use jet probes to study the underlying dynamics of the proton-proton scattering
  - Proton structure (PDFs)
  - Strong coupling constant α_S
  - pQCD matrix elements



Jet modelling



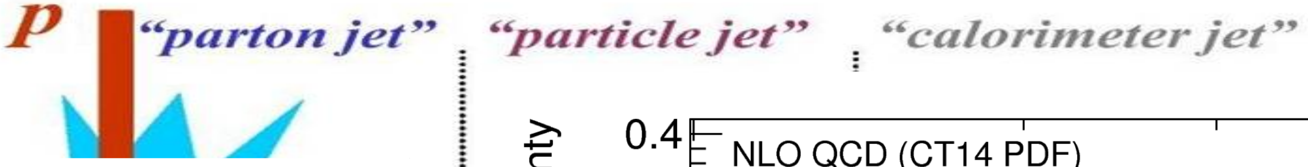
Jets defined from input collections using the anti-k_T jet algorithm

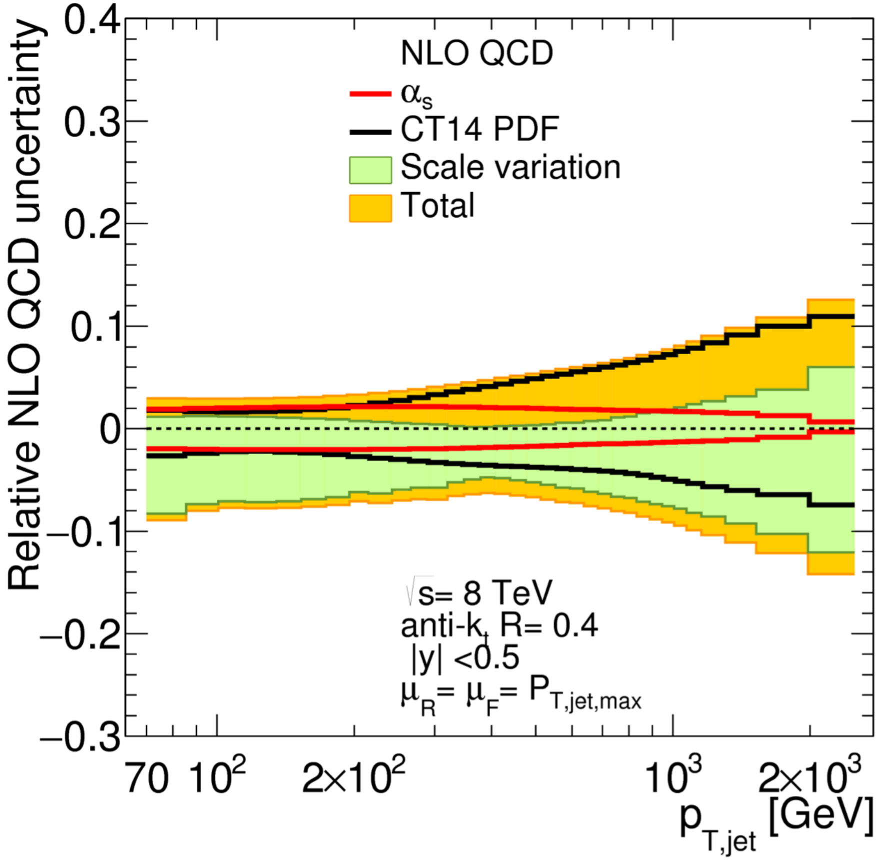


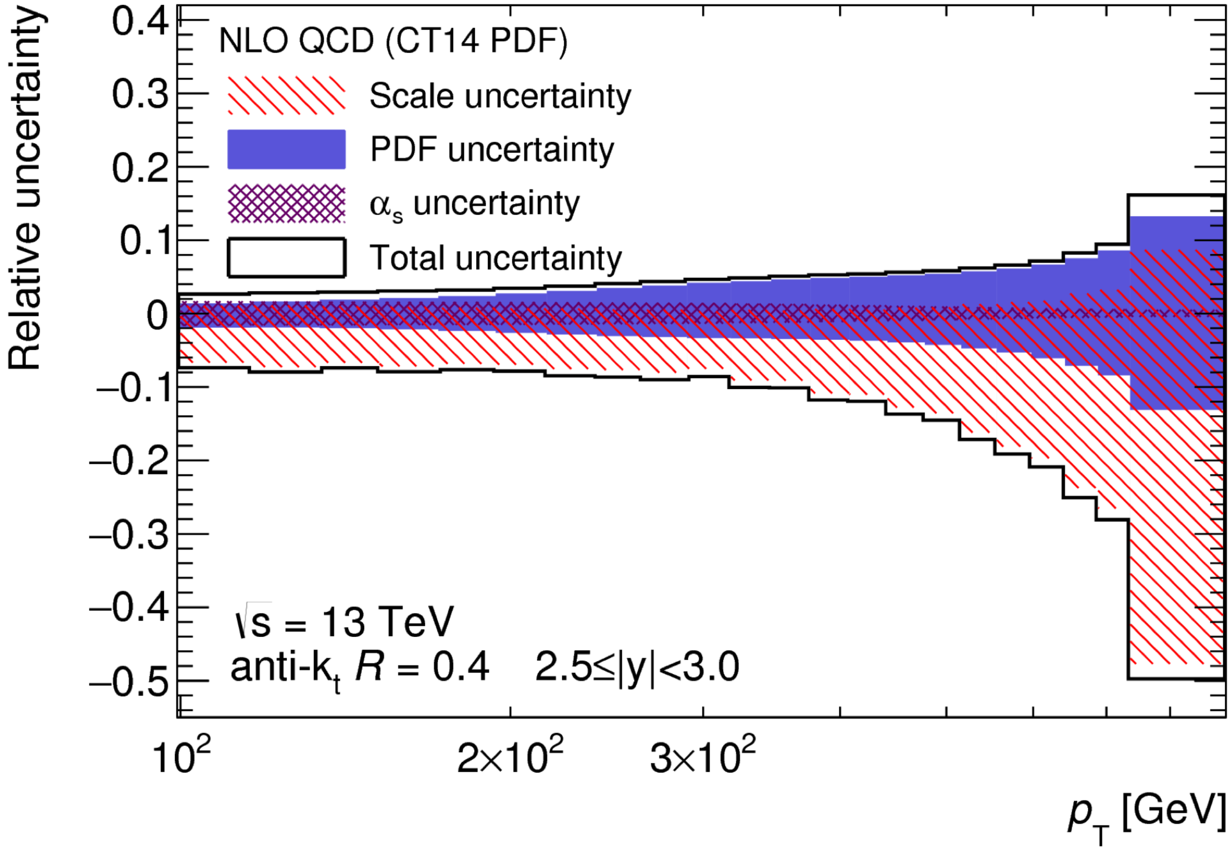
$$\sigma_{H_1H_2\to X} = \sum_{i,j} \int \mathrm{d}x_1 \mathrm{d}x_2 \; f_{i/H_1}(x_1,\mu_F) f_{j/H_2}(x_2,\mu_F) \times \hat{\sigma}_{ij\to X}\left(x_1P_1, x_2P_2, \alpha_s(\mu_R), \frac{Q}{\mu_F}\right),$$

→ pQCD predictions – LO, NLO, NNLO (new!) …

Typical theory (NLO) uncertainties

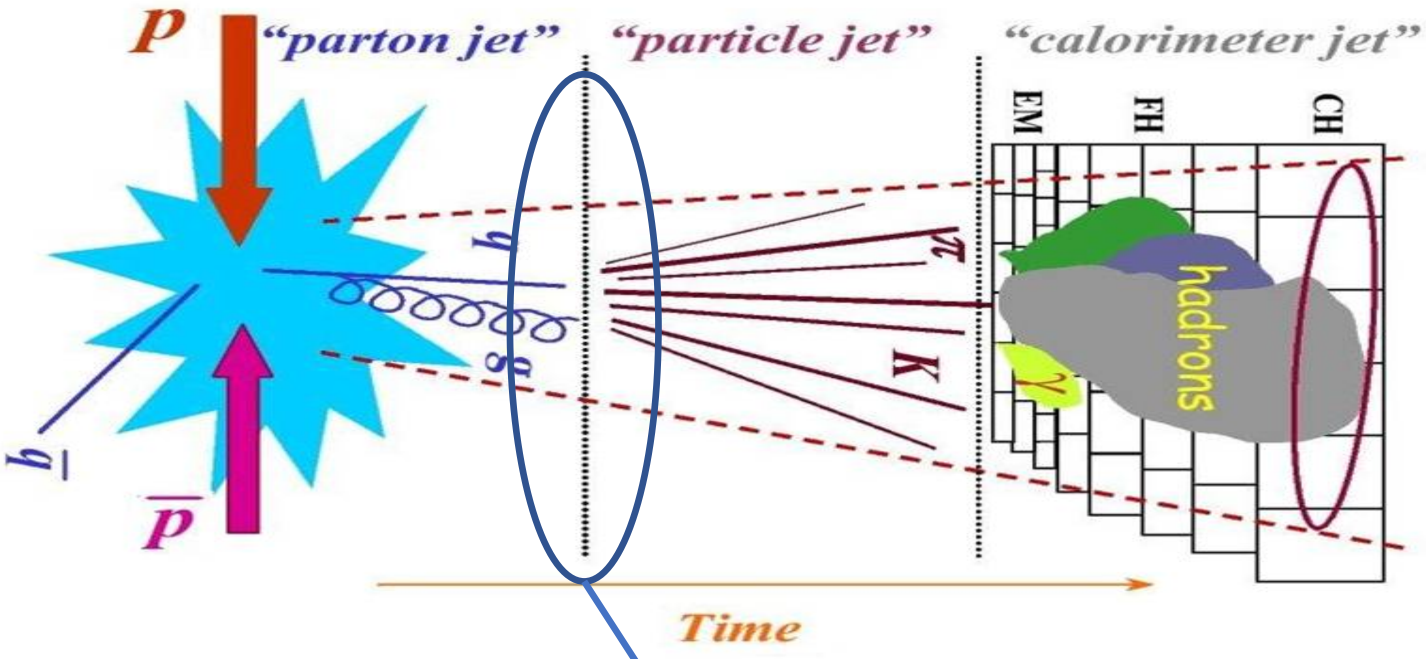


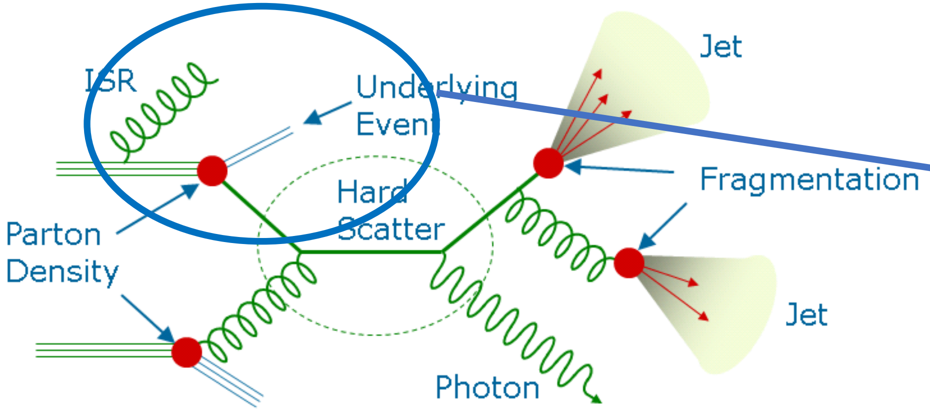




Part
Der

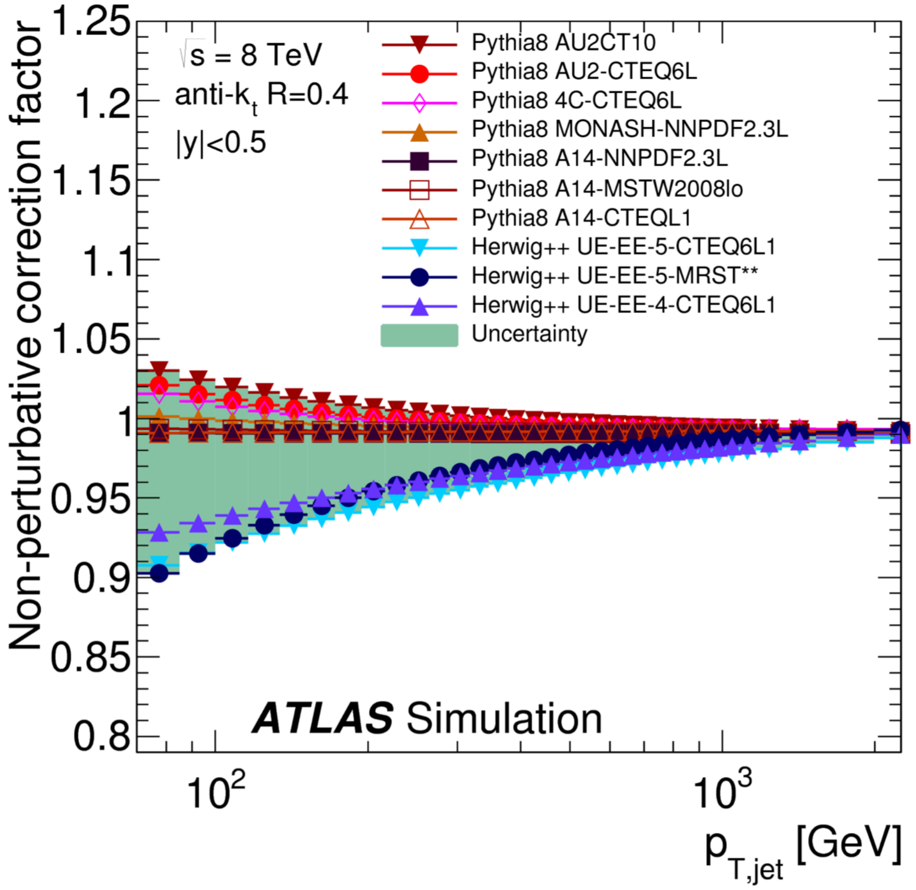
Nonperturbative corrections

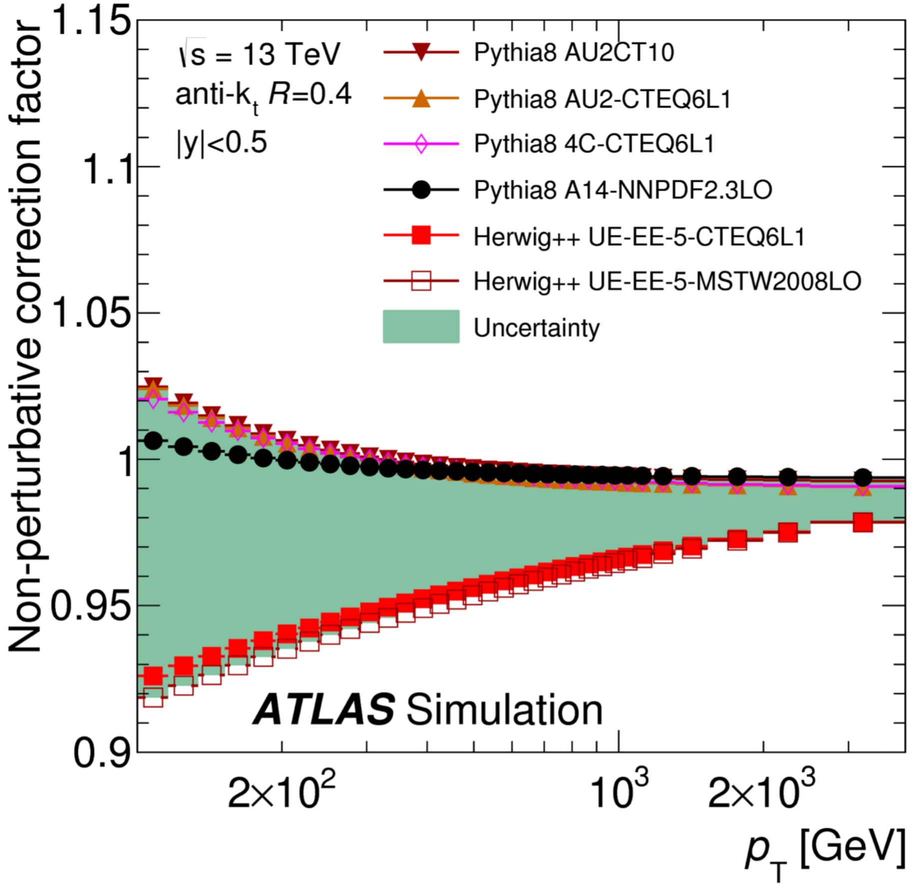




Typically Monte Carlo (Pythia/Herwig) – model dependent correction factor applied to pQCD prediction

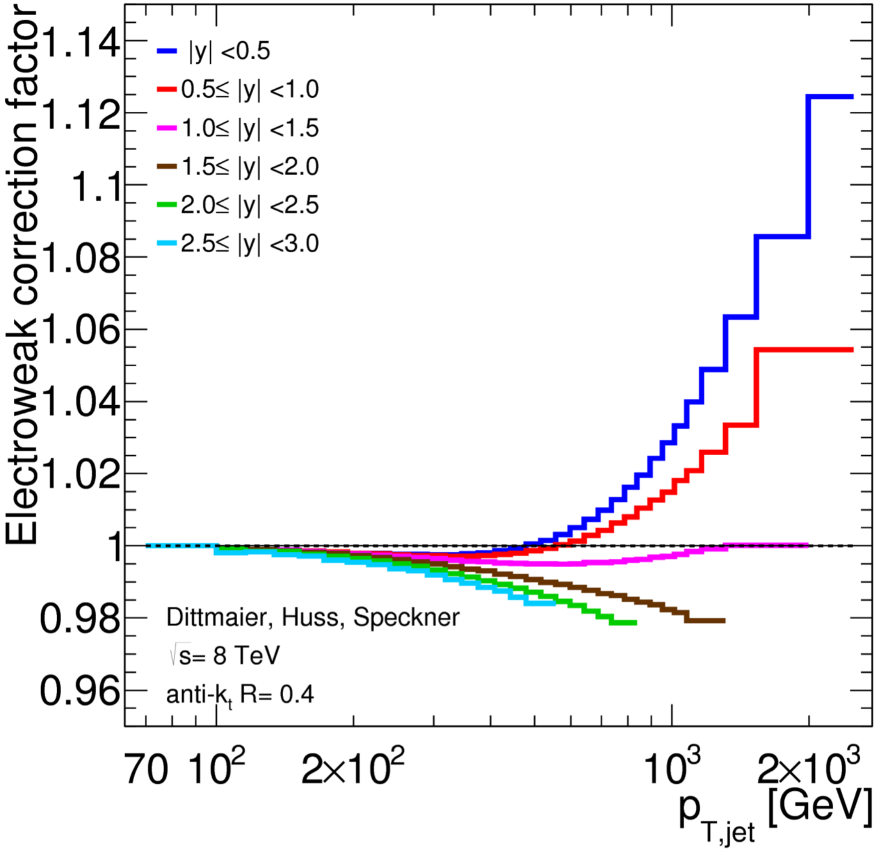
Nonperturbative corrections

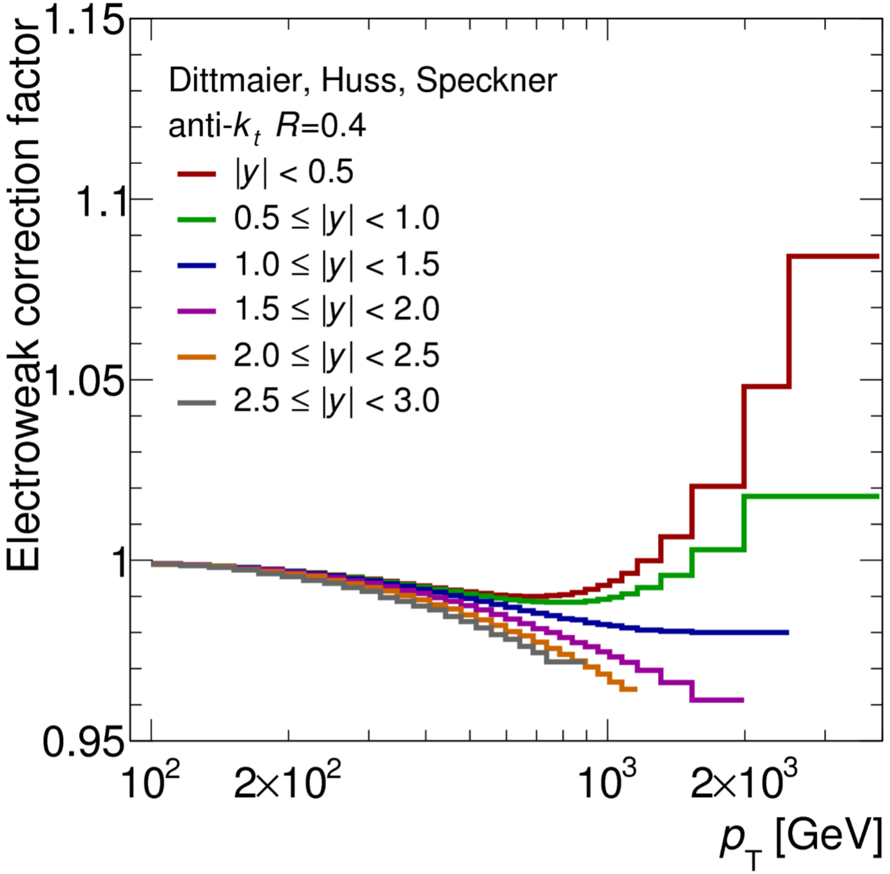




Pythia8 AU2CT10 used as default at √s = 8TeV, Pythia8 A14-NNPDF2.3LO default at √s = 13TeV

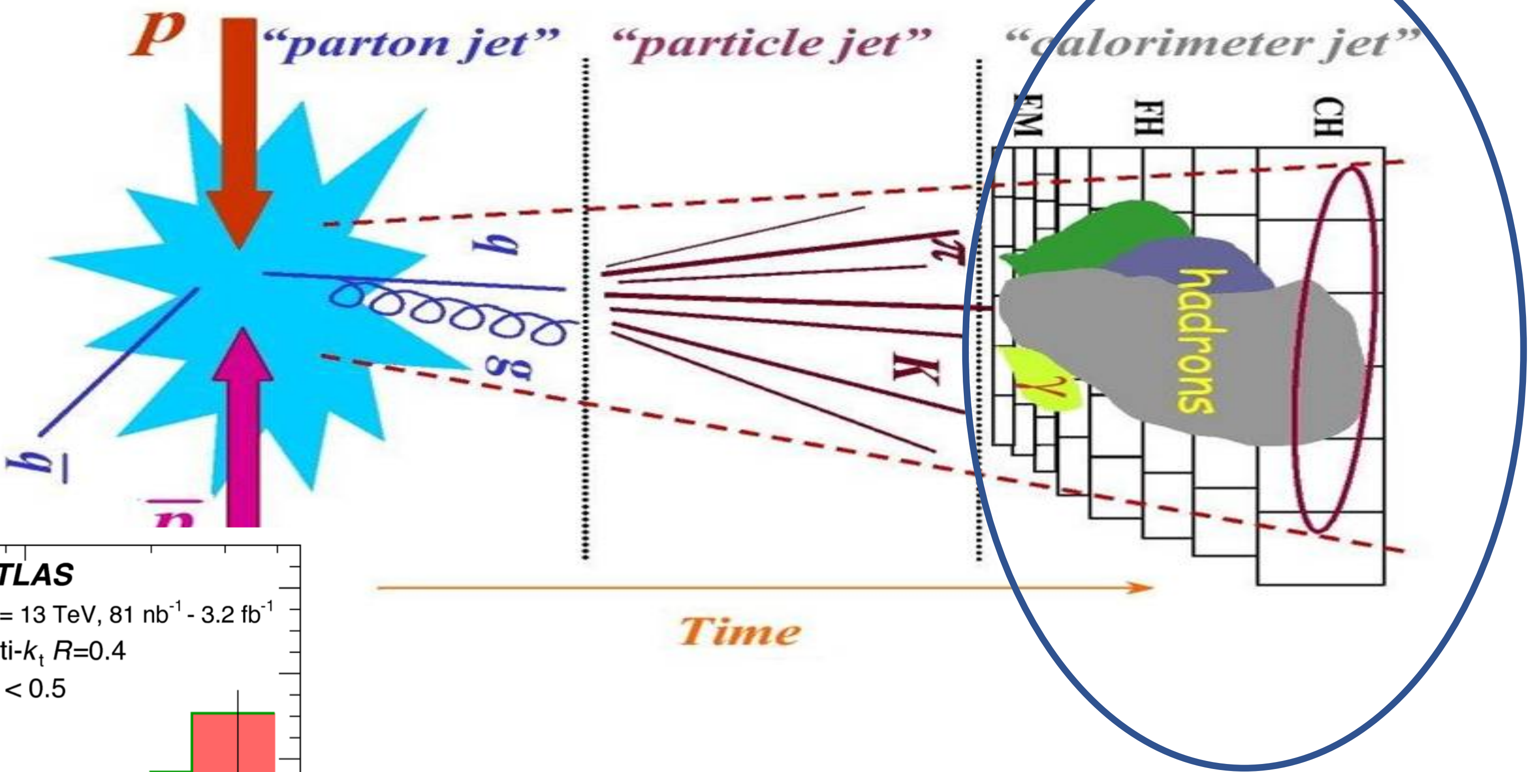
Electroweak corrections

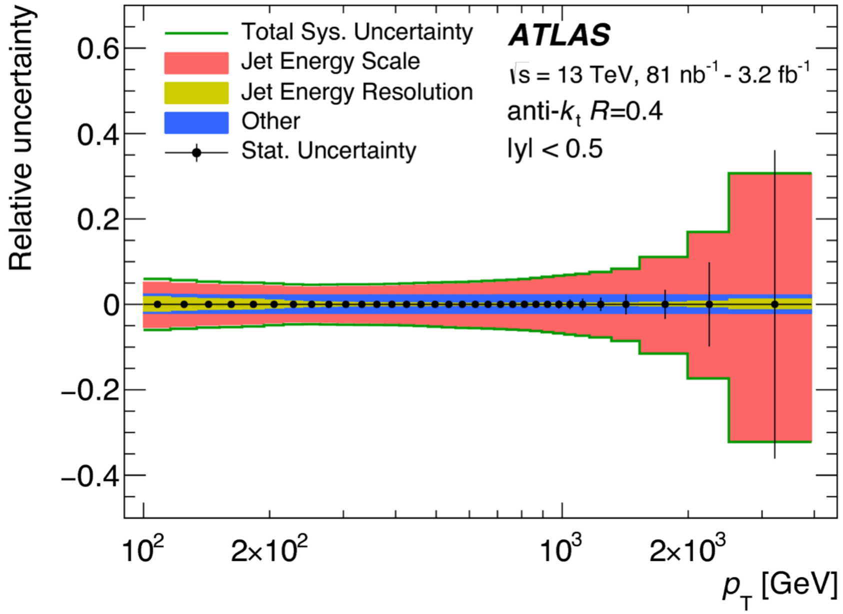




S. Dittmaier, A. Huss and C. Speckner, JHEP 11 (2012) 095

Experimental uncertainties



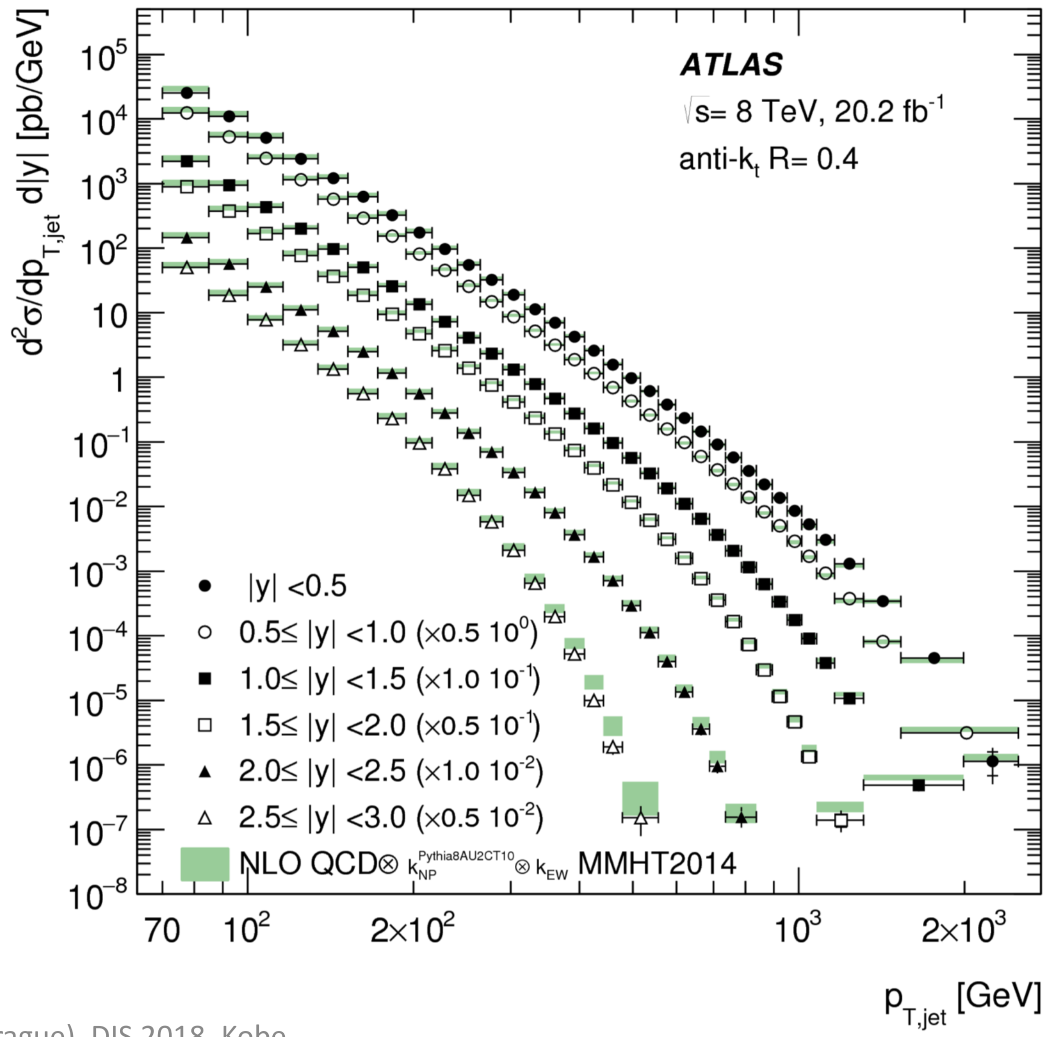


Jet energy scale calibration, jet energy resolution, unfolding of detector effects, correlation of uncertainties

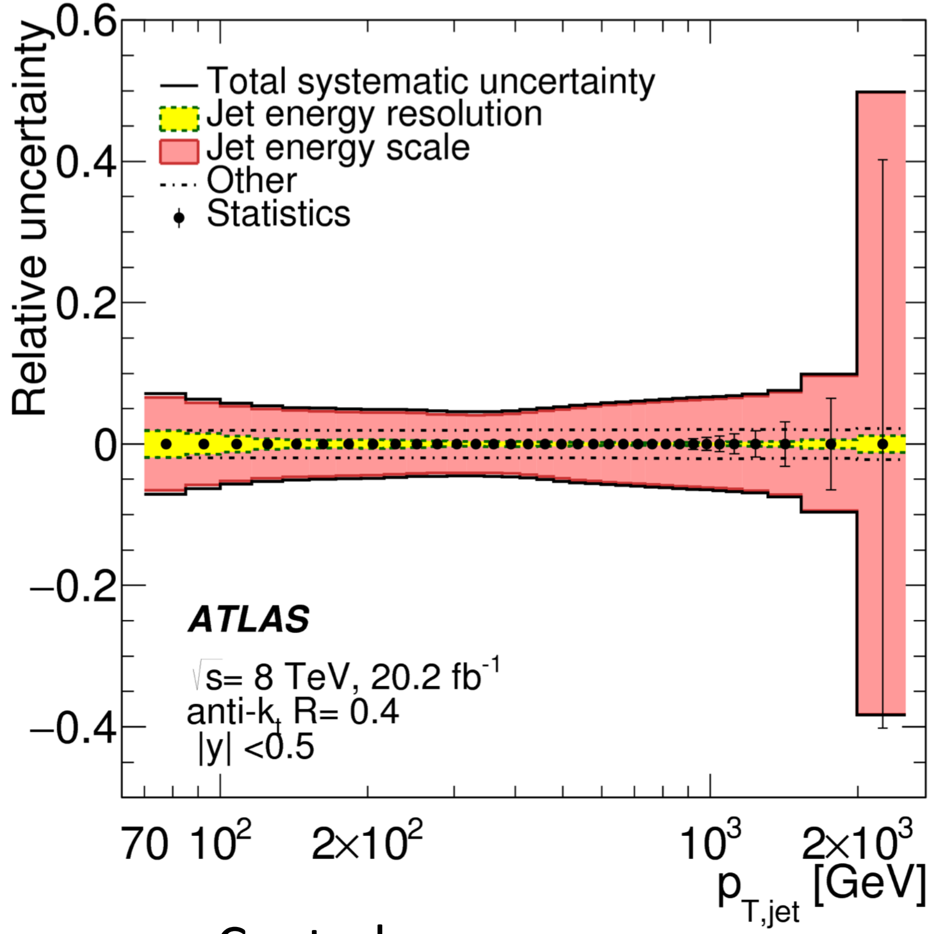
Inclusive jet cross section at √s = 8TeV

- 2 jet collections: Anti-k_T R=0.4, 0.6
- Double differential cross section in p_T and y
- 70 GeV < p_T < 2500 GeV
- |y| < 3.0
- $\mathcal{L}$ = 20.2 fb^{-1}

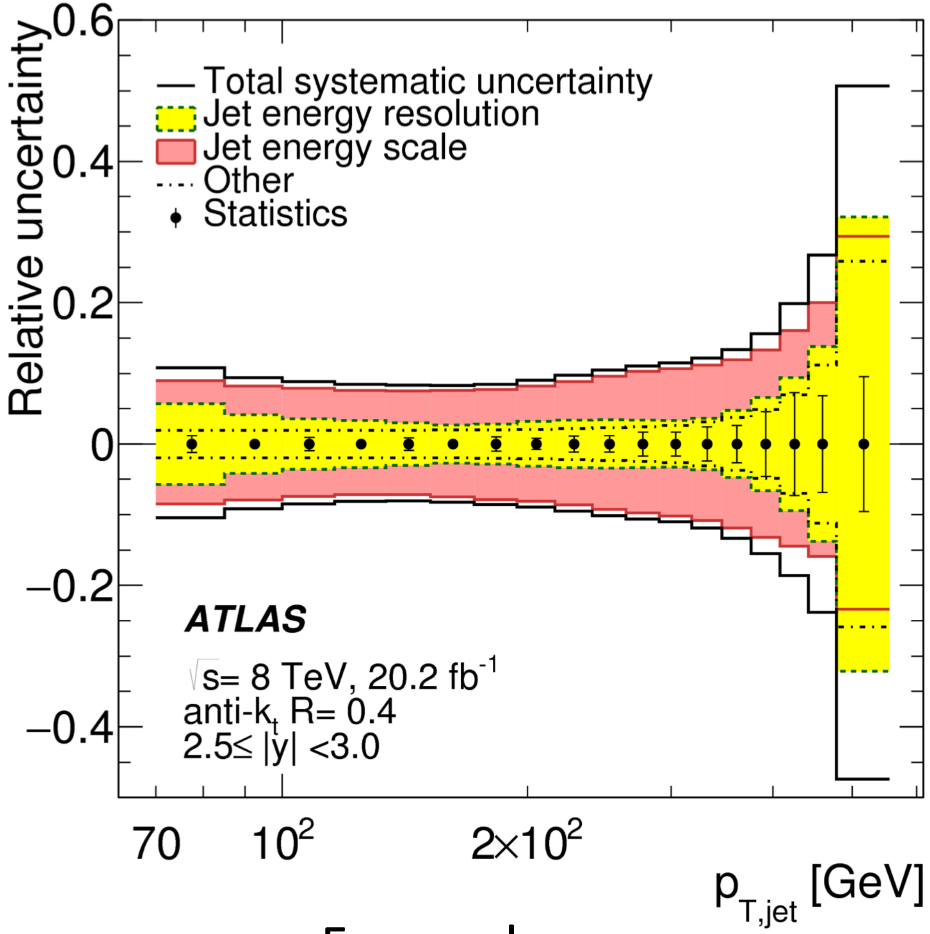
[JHEP 09 (2017) 020]



Experimental uncertainties

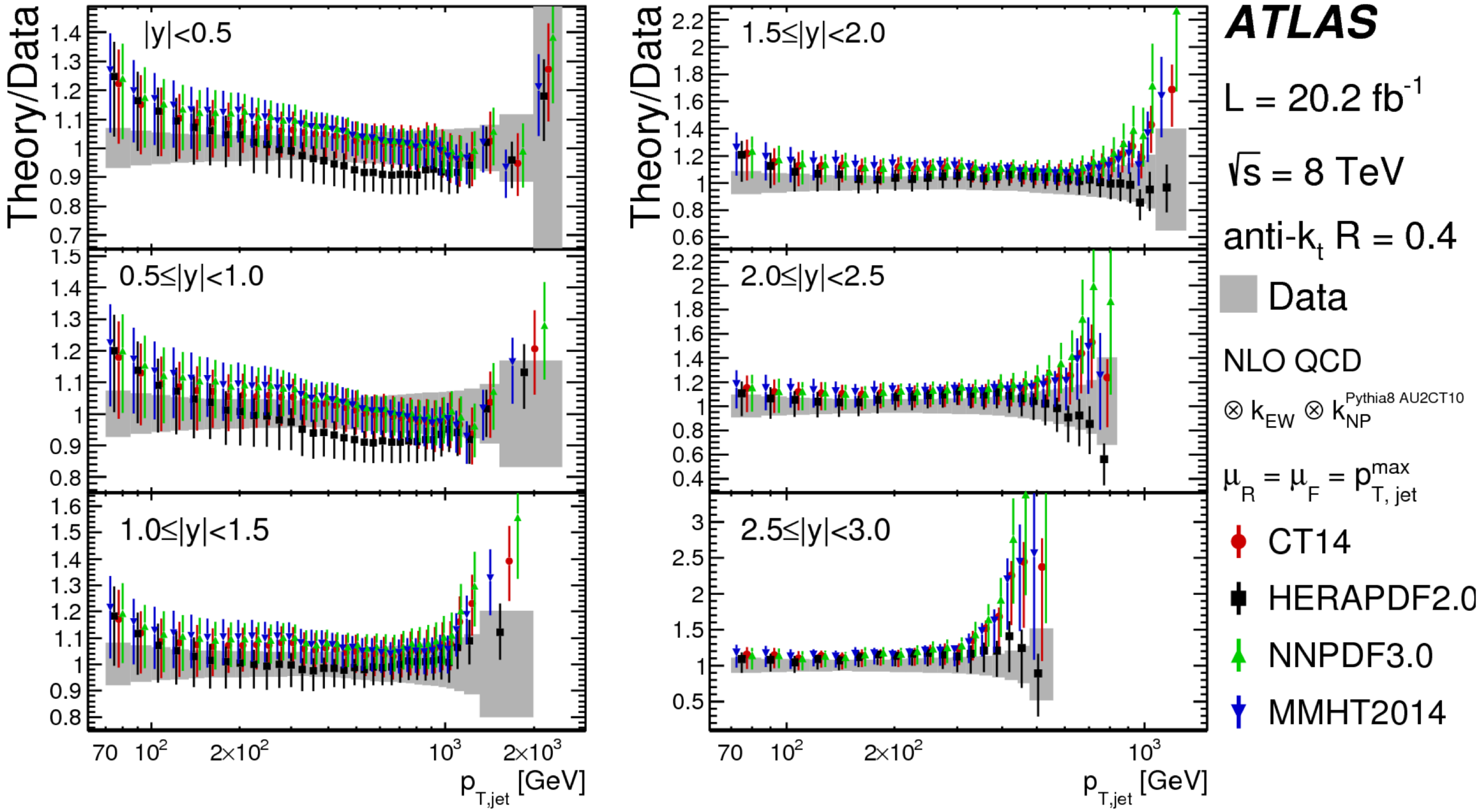


Central

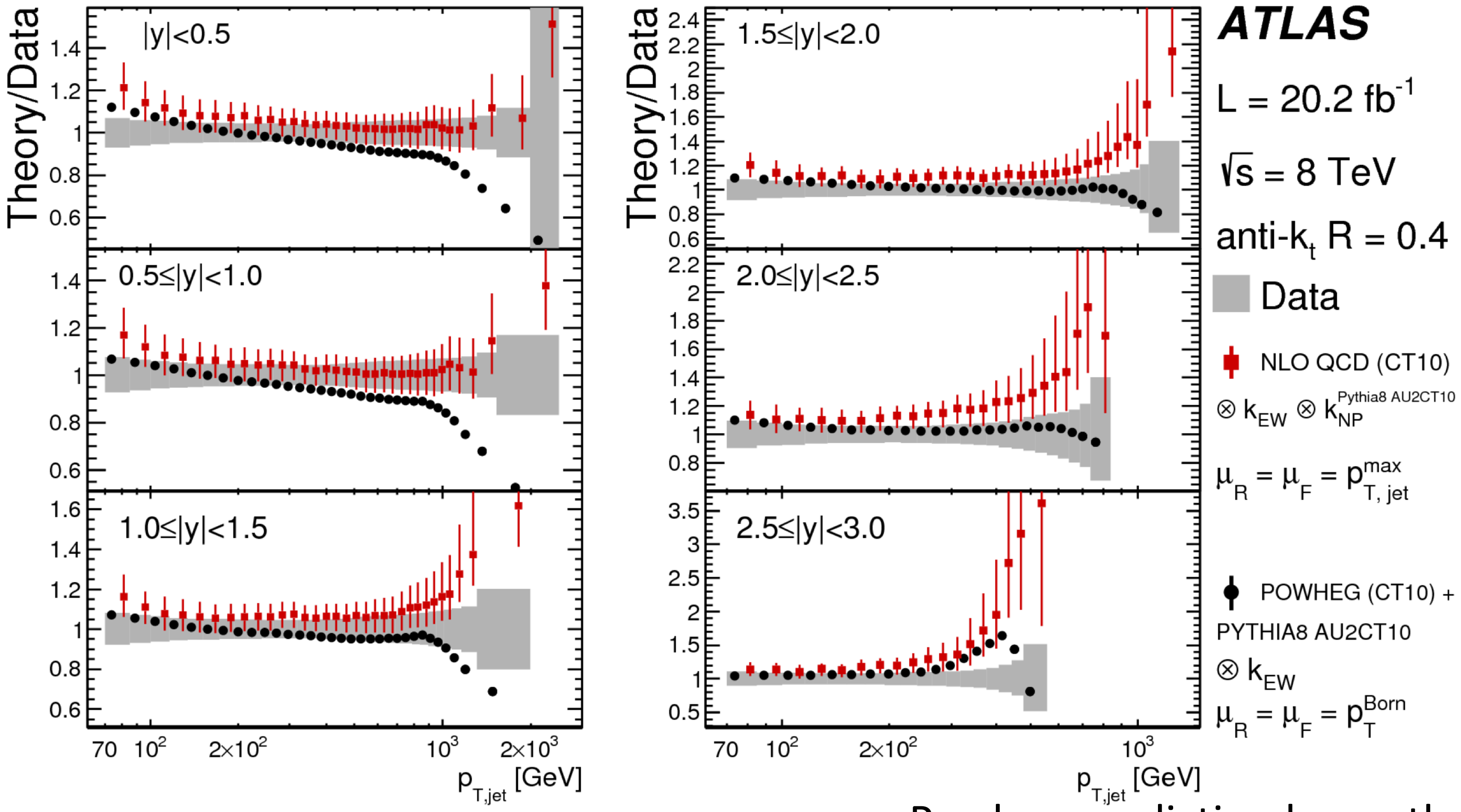


Forward

Comparison with theory predictions



Comparison to Powheg



Powheg prediction lower than NLOJET++

Quantitative comparison of data to NLO QCD

- The χ^2 value and the corresponding observed p-value, P_{obs}, are computed taking into account the asymmetries and the correlations of the experimental and theoretical uncertainties.

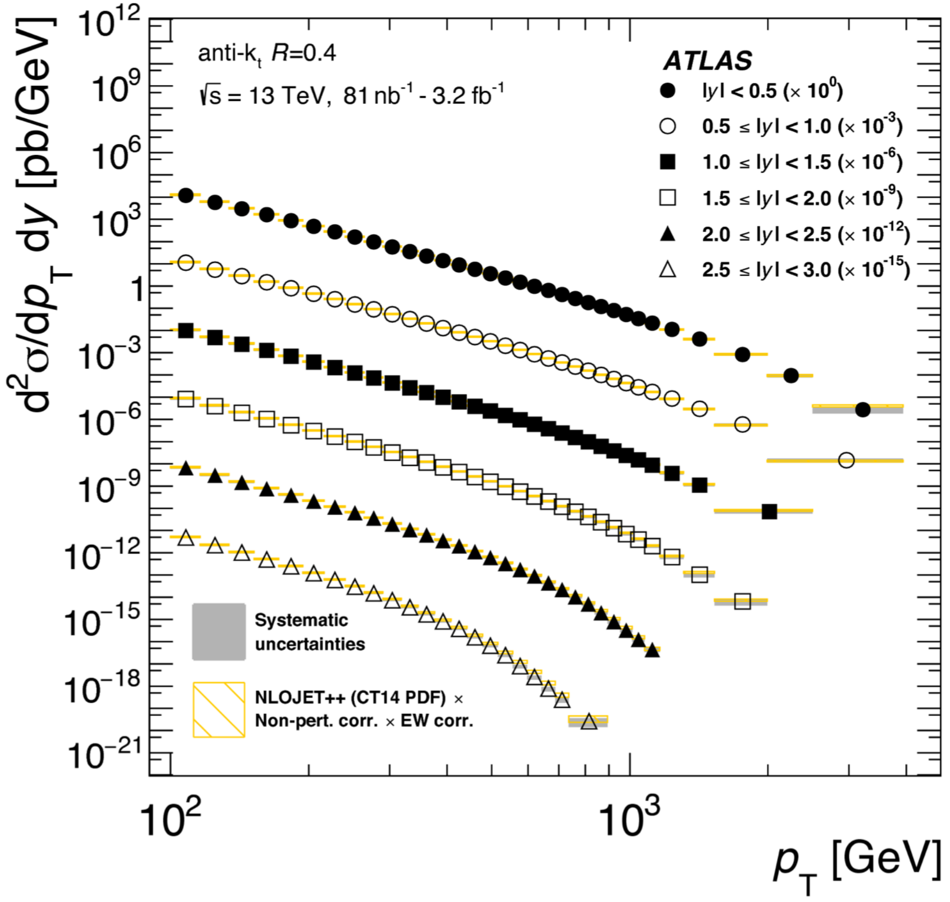
Rapidity ranges	P_{obs} CT14	MMHT2014	NNPDF3.0	HERAPDF2.0
Anti-k$_t$ jets $R = 0.4$				
$\|y\| < 0.5$	44%	28%	25%	16%
$0.5 \le \|y\| < 1.0$	43%	29%	18%	18%
$1.0 \le \|y\| < 1.5$	44%	47%	46%	69%
$1.5 \le \|y\| < 2.0$	3.7%	4.6%	7.7%	7.0%
$2.0 \le \|y\| < 2.5$	92%	89%	89%	35%
$2.5 \le \|y\| < 3.0$	4.5%	6.2%	16%	9.6%
Anti-k$_t$ jets $R = 0.6$				
$\|y\| < 0.5$	6.7%	4.9%	4.6%	1.1%
$0.5 \le \|y\| < 1.0$	1.3%	0.7%	0.4%	0.2%
$1.0 \le \|y\| < 1.5$	30%	33%	47%	67%
$1.5 \le \|y\| < 2.0$	12%	16%	15%	3.1%
$2.0 \le \|y\| < 2.5$	94%	94%	91%	38%
$2.5 \le \|y\| < 3.0$	13%	15%	20%	8.6%

χ^2/ndf	$p_T^{jet,max}$		p_T^{jet}	
	$R = 0.4$	$R = 0.6$	$R = 0.4$	$R = 0.6$
$p_T > 70$ GeV				
CT14	349/171	398/171	340/171	392/171
HERAPDF2.0	415/171	424/171	405/171	418/171
NNPDF3.0	351/171	393/171	350/171	393/171
MMHT2014	356/171	400/171	354/171	399/171
$p_T > 100$ GeV				
CT14	321/159	360/159	313/159	356/159
HERAPDF2.0	385/159	374/159	377/159	370/159
NNPDF3.0	333/159	356/159	331/159	356/159
MMHT2014	335/159	364/159	333/159	362/159
$100 < p_T < 900$ GeV				
CT14	272/134	306/134	262/134	301/134
HERAPDF2.0	350/134	331/134	340/134	326/134
NNPDF3.0	289/134	300/134	285/134	299/134
MMHT2014	292/134	311/134	284/134	308/134
$100 < p_T < 400$ GeV				
CT14	128/72	149/72	118/72	145/72
HERAPDF2.0	148/72	175/72	141/72	170/72
NNPDF3.0	119/72	141/72	115/72	139/72
MMHT2014	132/72	143/72	122/72	140/72

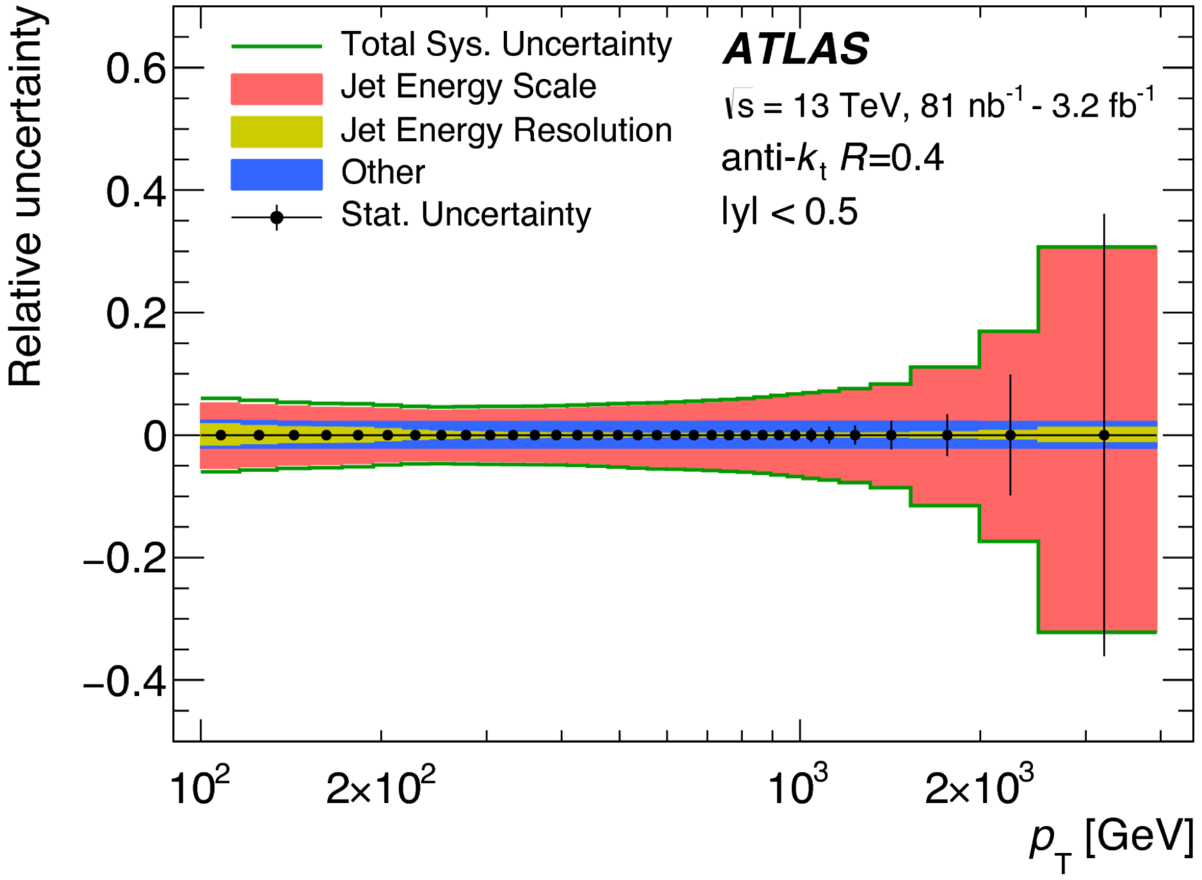
Inclusive jet cross section at √s = 13TeV

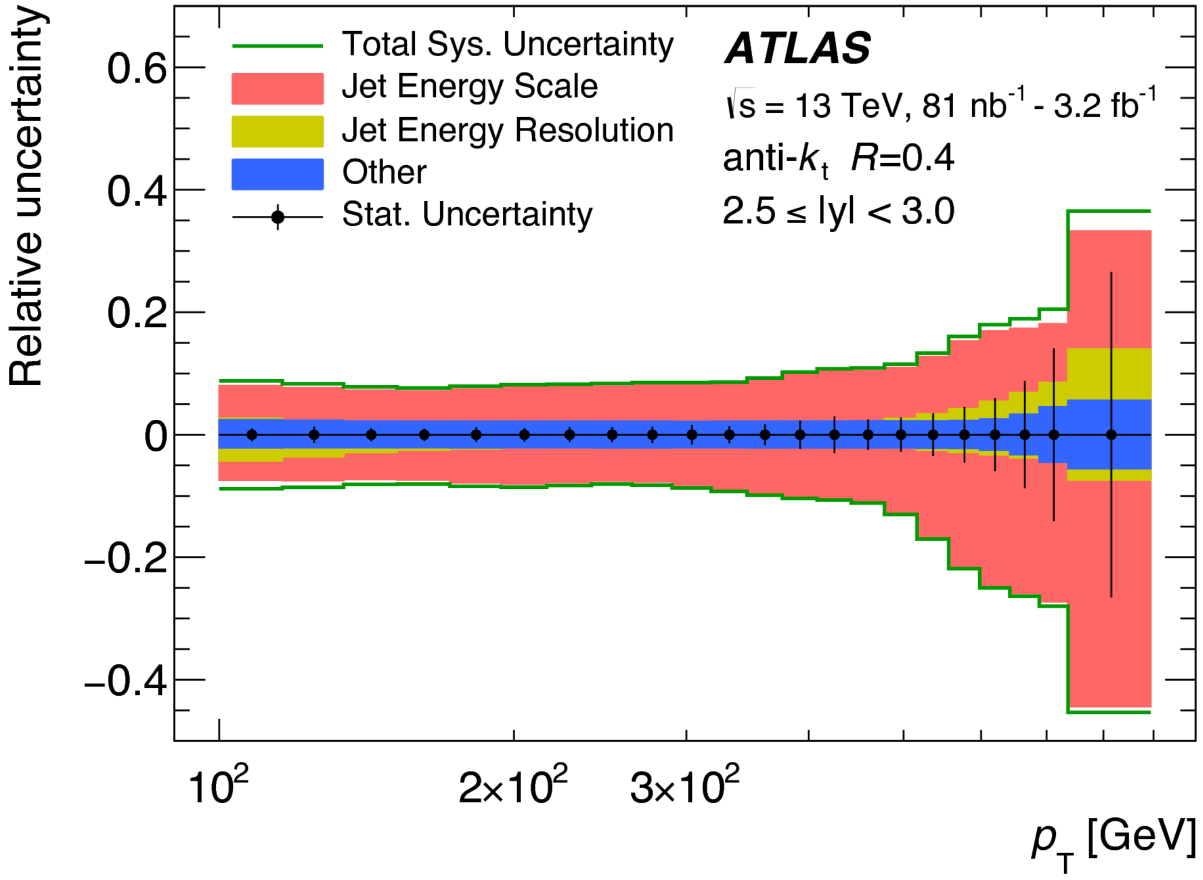
- Anti-k_T R=0.4
- 100 GeV < pT < 3500 GeV
- |y| < 3.0
- $\mathcal{L}$ = 3.2 fb^{-1}

arXiv:1711.02692

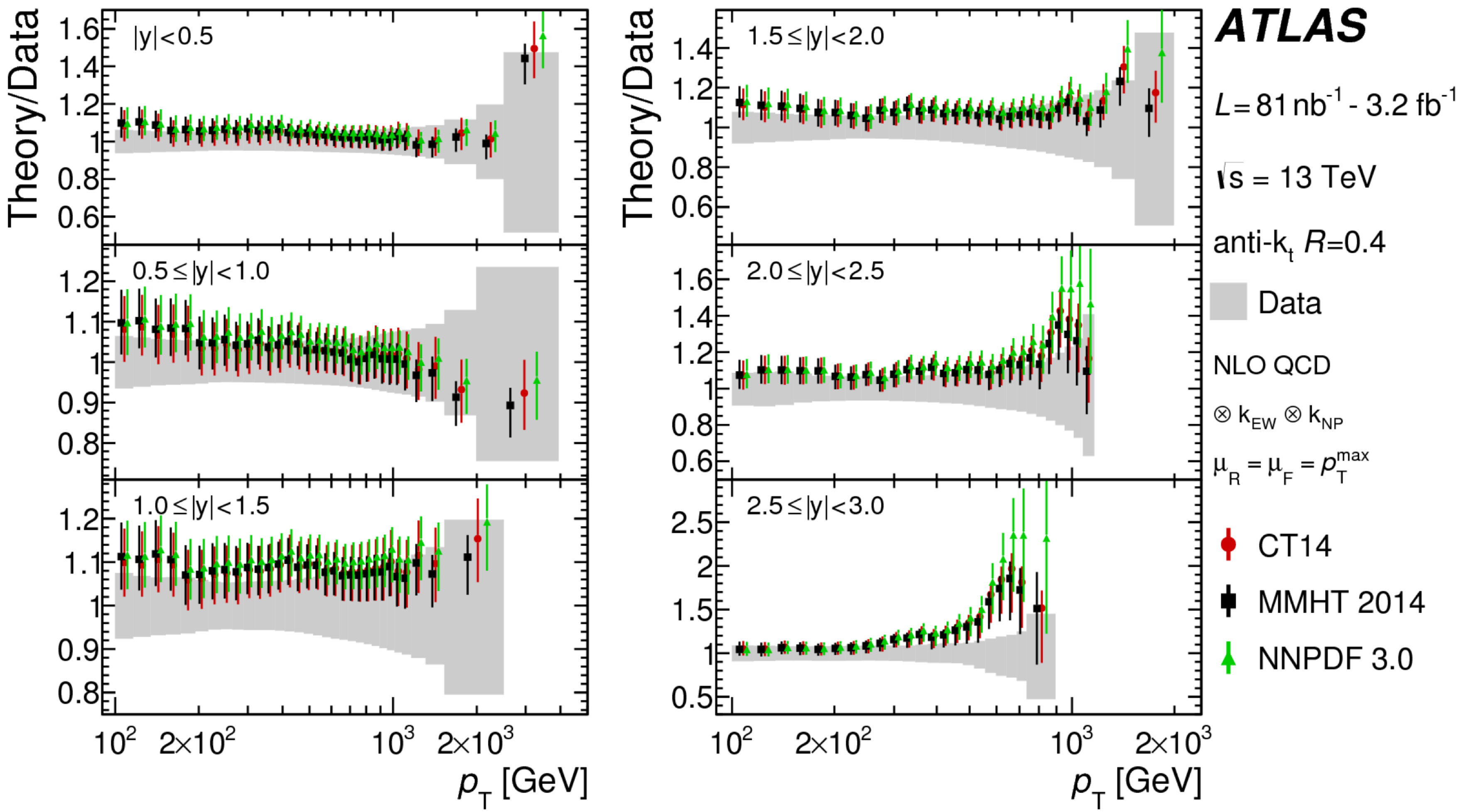


Experimental uncertainties



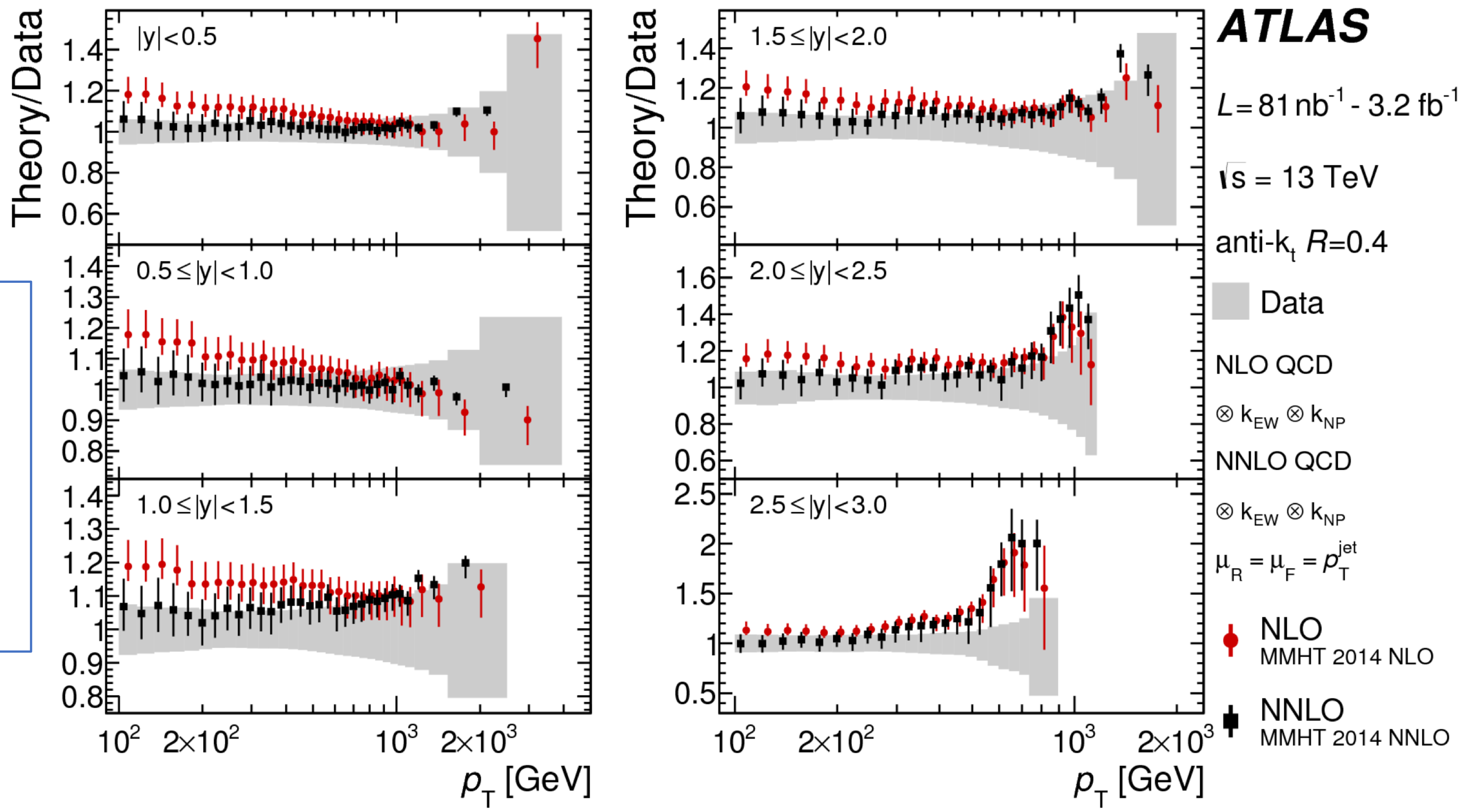


Comparison to NLO pQCD



Comparison also to HERAPDF2.0 and ABMP16 in backup

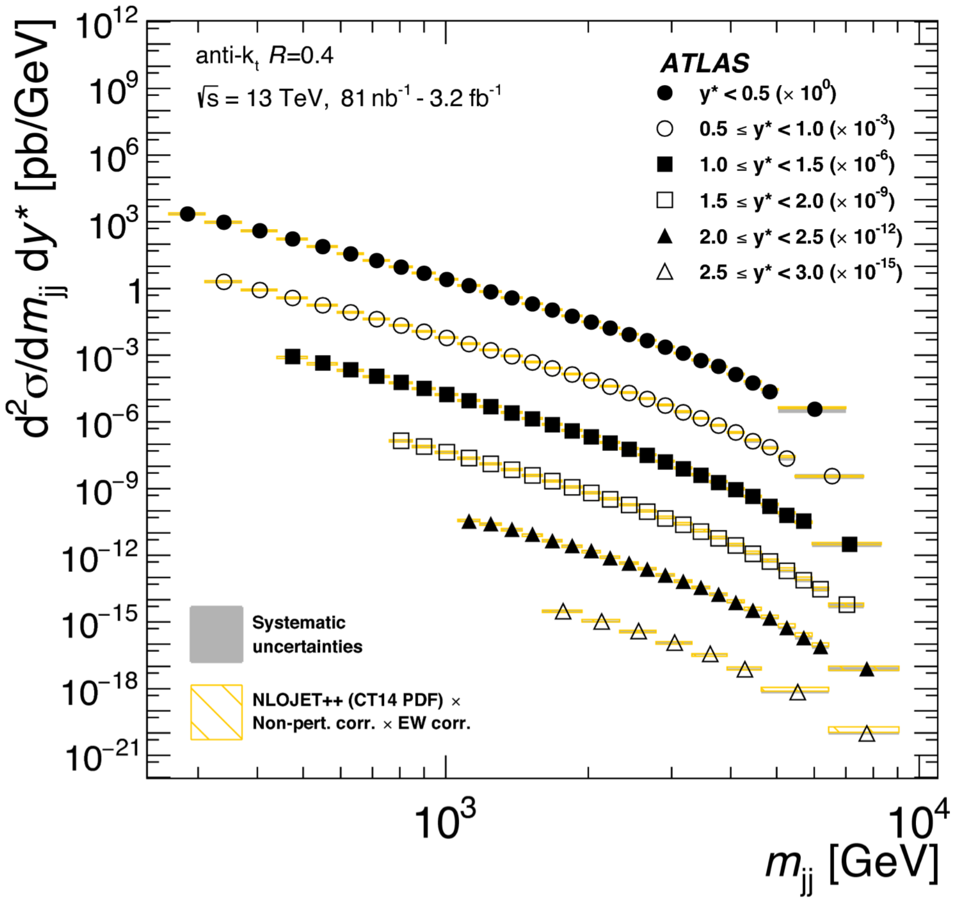
Comparison to first NNLO predictions



Jet pT scale used in this figure!
pTmax scale choice also available in backup
No PDF uncertainty on NNLO

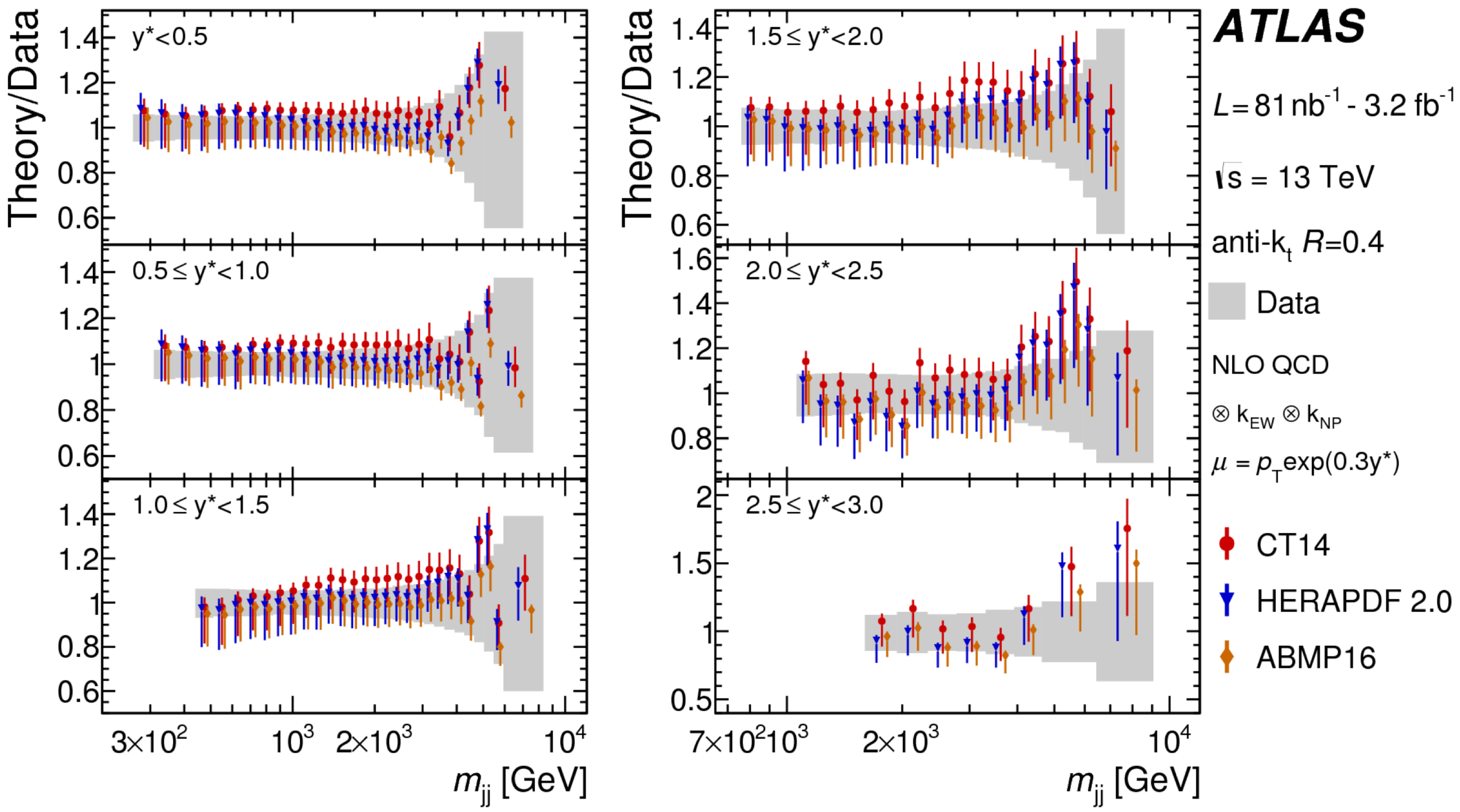
Dijet cross section √s = 13TeV

- At least 2 jets (anti-k_T, R=0.4) with p_T>75 GeV and |y| < 3.0
- $H_{T,2} = p_{T1}+p_{T2} > 200$ GeV
- Double differential in m_{jj} and $y^*=1/2|y_1-y_2|$
- $\mathcal{L}$ = 3.2 fb^{-1}



ATLAS-STDM-2016-03

Comparison to NLO pQCD



CT14, MMHT2014, NNPDF 3.0 available in backup

Quantitative data/theory comparison

Inclusive jets

Rapidity ranges	P_{obs} CT14	MMHT 2014	NNPDF 3.0	HERAPDF 2.0	ABMP16
$p_{\mathrm{T}}^{\mathrm{max}}$					
$\|y\| < 0.5$	67%	65%	62%	31%	50%
$0.5 \leq \|y\| < 1.0$	5.8%	6.3%	6.0%	3.0%	2.0%
$1.0 \leq \|y\| < 1.5$	65%	61%	67%	50%	55%
$1.5 \leq \|y\| < 2.0$	0.7%	0.8%	0.8%	0.1%	0.4%
$2.0 \leq \|y\| < 2.5$	2.3%	2.3%	2.8%	0.7%	1.5%
$2.5 \leq \|y\| < 3.0$	62%	71%	69%	25%	55%
$p_{\mathrm{T}}^{\mathrm{jet}}$					
$\|y\| < 0.5$	69%	67%	66%	30%	46%
$0.5 \leq \|y\| < 1.0$	7.4%	8.9%	8.6%	3.4%	2.0%
$1.0 \leq \|y\| < 1.5$	69%	62%	68%	45%	54%
$1.5 \leq \|y\| < 2.0$	1.3%	1.6%	1.4%	0.1%	0.5%
$2.0 \leq \|y\| < 2.5$	8.7%	6.6%	7.4%	1.0%	3.6%
$2.5 \leq \|y\| < 3.0$	65%	72%	72%	28%	59%

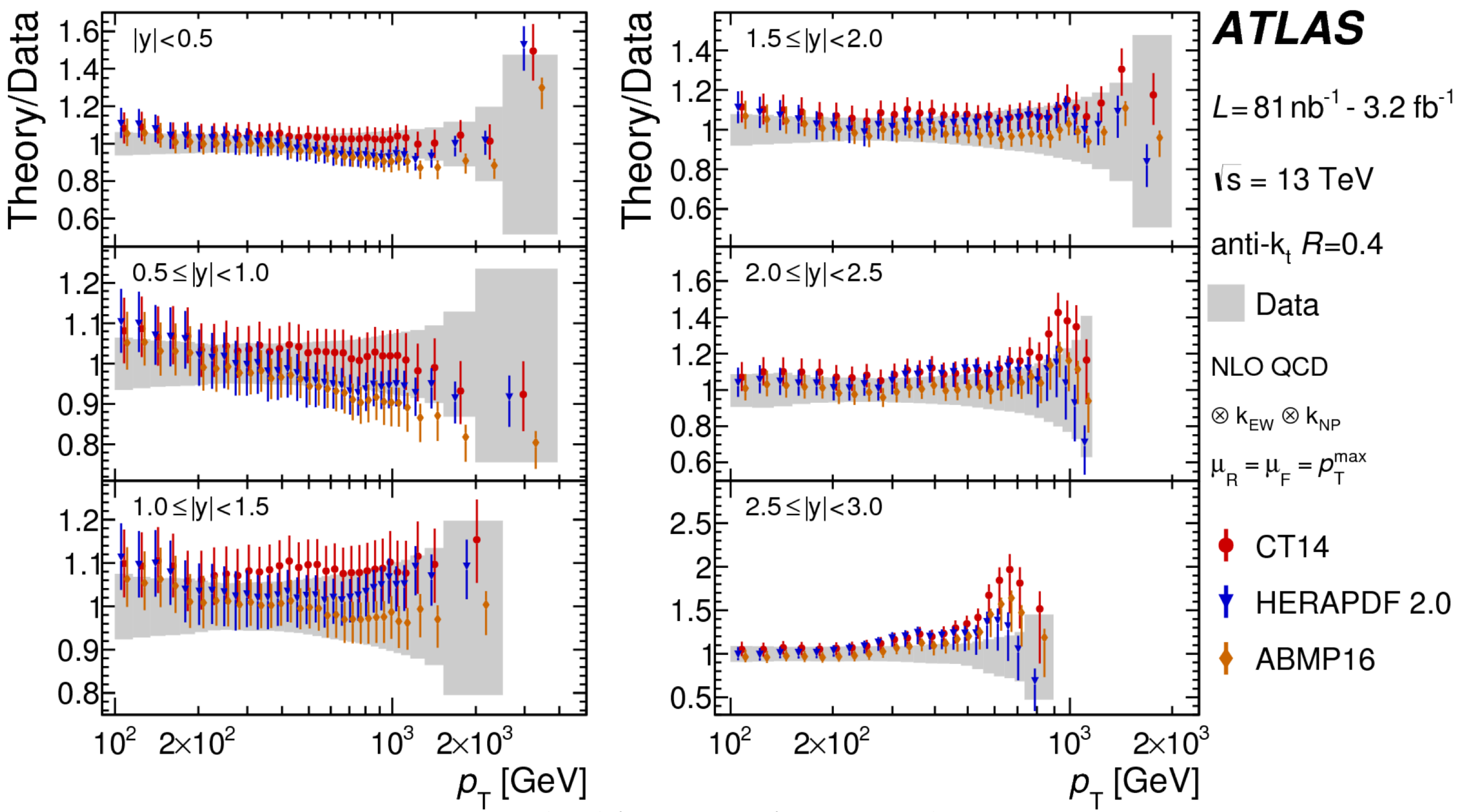
Dijets

y^* ranges	P_{obs} CT14	MMHT 2014	NNPDF 3.0	HERAPDF 2.0	ABMP16
$y^* < 0.5$	79%	59%	50%	71%	71%
$0.5 \leq y^* < 1.0$	27%	23%	19%	32%	31%
$1.0 \leq y^* < 1.5$	66%	55%	48%	66%	69%
$1.5 \leq y^* < 2.0$	26%	26%	28%	9.9%	25%
$2.0 \leq y^* < 2.5$	43%	35%	31%	4.2%	21%
$2.5 \leq y^* < 3.0$	45%	46%	40%	25%	38%
all y^* bins	8.1%	5.5%	9.8%	0.1%	4.4%

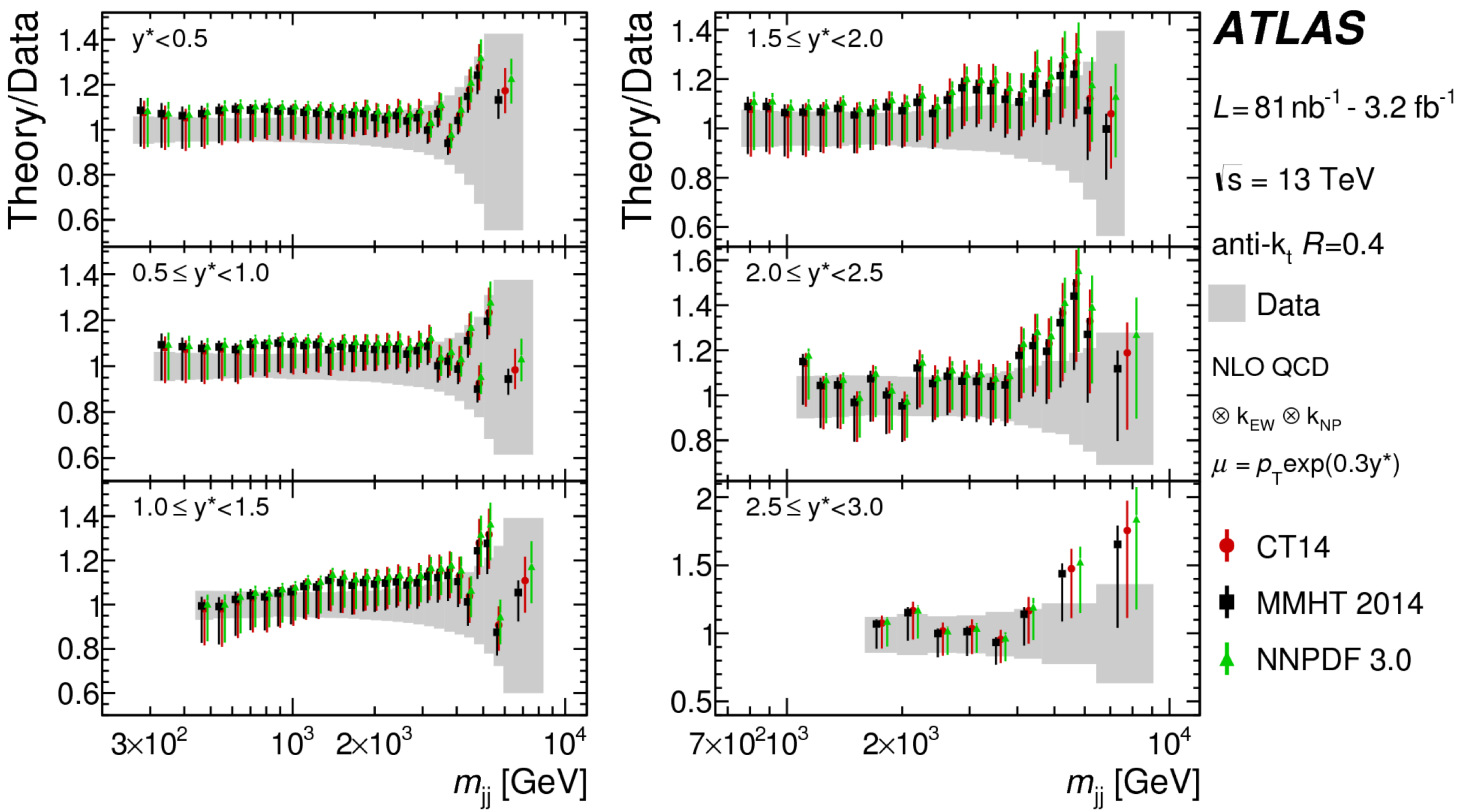
Summary

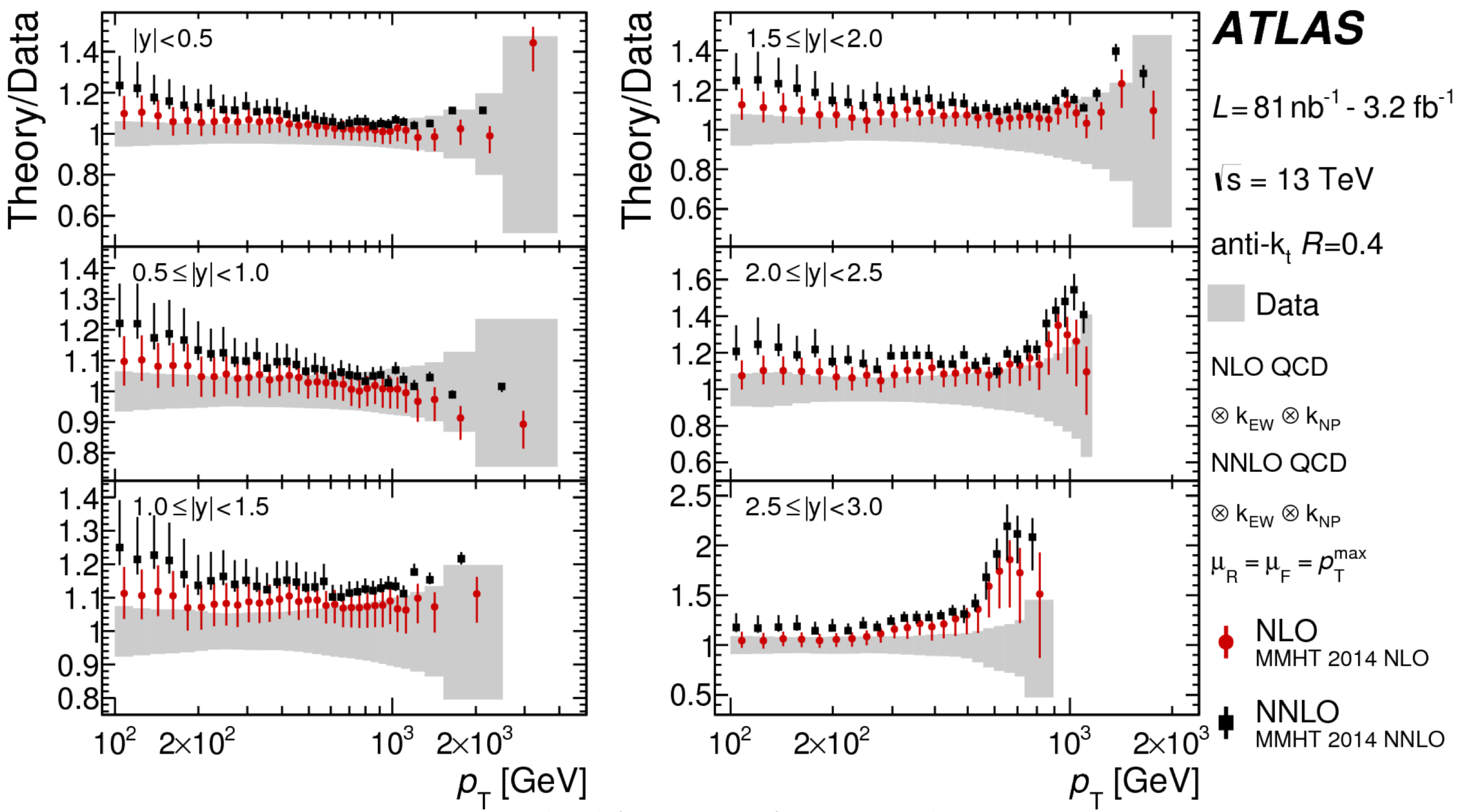
- Jets provide good probes to study inner proton dynamics
  - Could be used for constraining the proton structure functions
- Inclusive jet and dijet cross section measurements compared to various pQCD predictions corrected for nonperturbative and electroweak effects
  - NLO predictions from NLOJET++ and Powheg
  - New NNLO predictions from NNLOJET
  - Good agreement observed with pQCD calculations, though strong tensions are present when considering all pT and rapidity bins
  - tension can be reduced, but not completely resolved, using alternative correlation scenarios for the experimental and theoretical two-point systematic uncertainties.

Backup



Theory/Data
|y|<0.5
0.5≤|y|<1.0
1.0≤|y|<1.5
1.5≤|y|<2.0
2.0≤|y|<2.5
2.5≤|y|<3.0
p_T [GeV]
ATLAS
$L = 81\ nb^{-1}$ - $3.2\ fb^{-1}$
$\sqrt{s}$ = 13 TeV
anti-k_t R=0.4
Data
NLO QCD
$\otimes\ k_{EW} \otimes k_{NP}$
$\mu_R = \mu_F = p_T^{max}$
CT14
HERAPDF 2.0
ABMP16


Theory/Data
y*<0.5
0.5≤ y*<1.0
1.0≤ y*<1.5
1.5≤ y*<2.0
2.0≤ y*<2.5
2.5≤ y*<3.0
1.4
1.2
1
0.8
0.6
1.6
2
1.5
0.5
3×10^2
10^3
2×10^3
10^4
7×10^2
m_{jj} [GeV]
ATLAS
$L = 81\,nb^{-1}$ - $3.2\,fb^{-1}$
$\sqrt{s}$ = 13 TeV
anti-k_t R=0.4
Data
NLO QCD
⊗ k_{EW} ⊗ k_{NP}
$\mu = p_T \exp(0.3y^*)$
CT14
MMHT 2014
NNPDF 3.0


ATLAS
$L = 81\,\mathrm{nb}^{-1} - 3.2\,\mathrm{fb}^{-1}$
$\sqrt{s}$ = 13 TeV
anti-k_t R=0.4
Data
NLO QCD
$\otimes\, k_{EW} \otimes k_{NP}$
NNLO QCD
$\otimes\, k_{EW} \otimes k_{NP}$
$\mu_R = \mu_F = p_T^{max}$
NLO
MMHT 2014 NLO
NNLO
MMHT 2014 NNLO
Theory/Data
|y|<0.5
0.5≤|y|<1.0
1.0≤|y|<1.5
1.5≤|y|<2.0
2.0≤|y|<2.5
2.5≤|y|<3.0
p_T [GeV]