Inclusive jet and dijet production at the LHC

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on behalf of the ATLAS and CMS collaborations

QCD at LHC - 2018

Numerous "Standard Model publications" by ATLAS and CMS

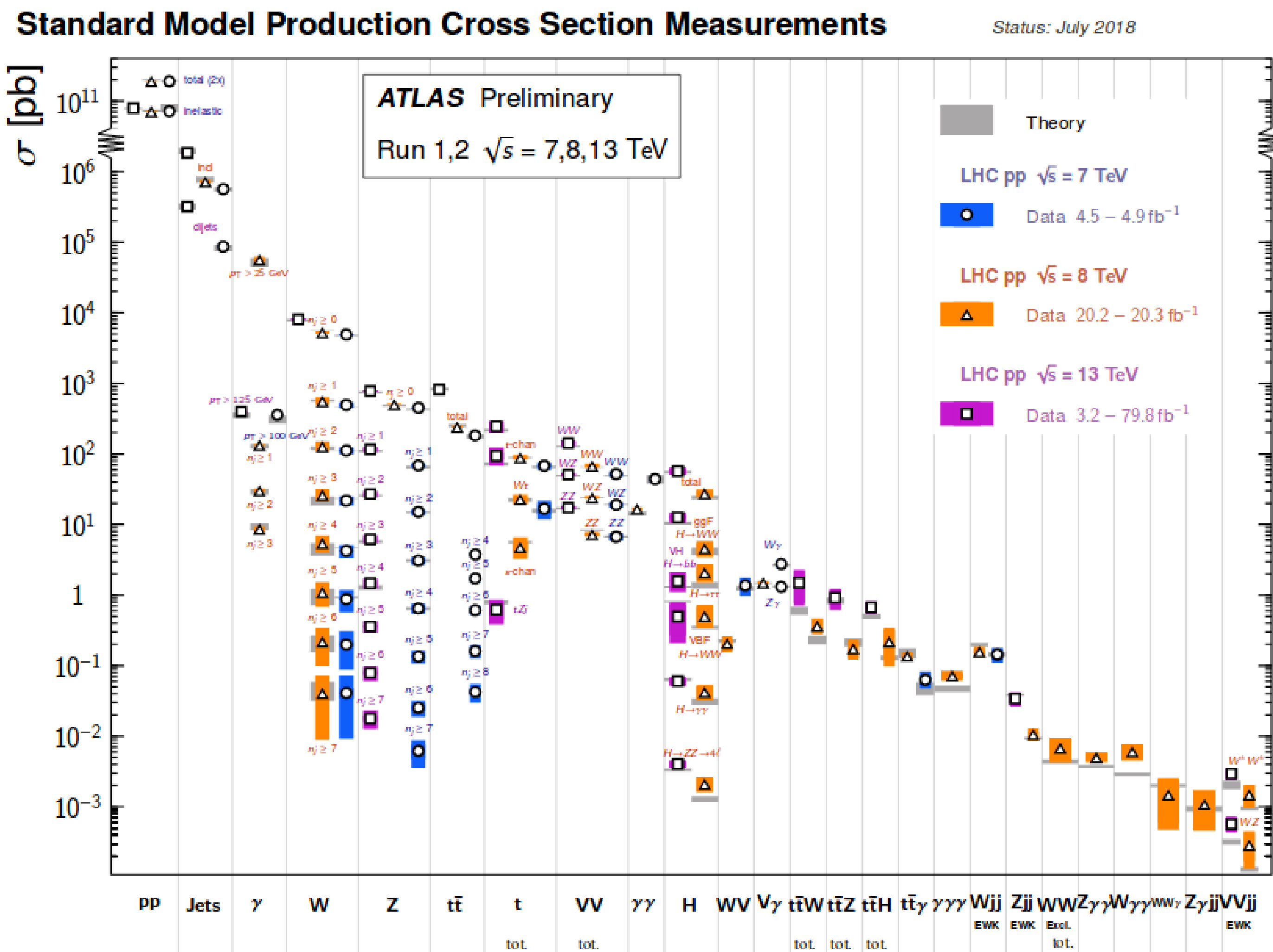
- Focusing on a few (recent) jet measurements

Motivation:

→ test SM on wide phase-space range

→ important ingredients to PDF fits

→ sensitivity to New Physics



Content of the talk:

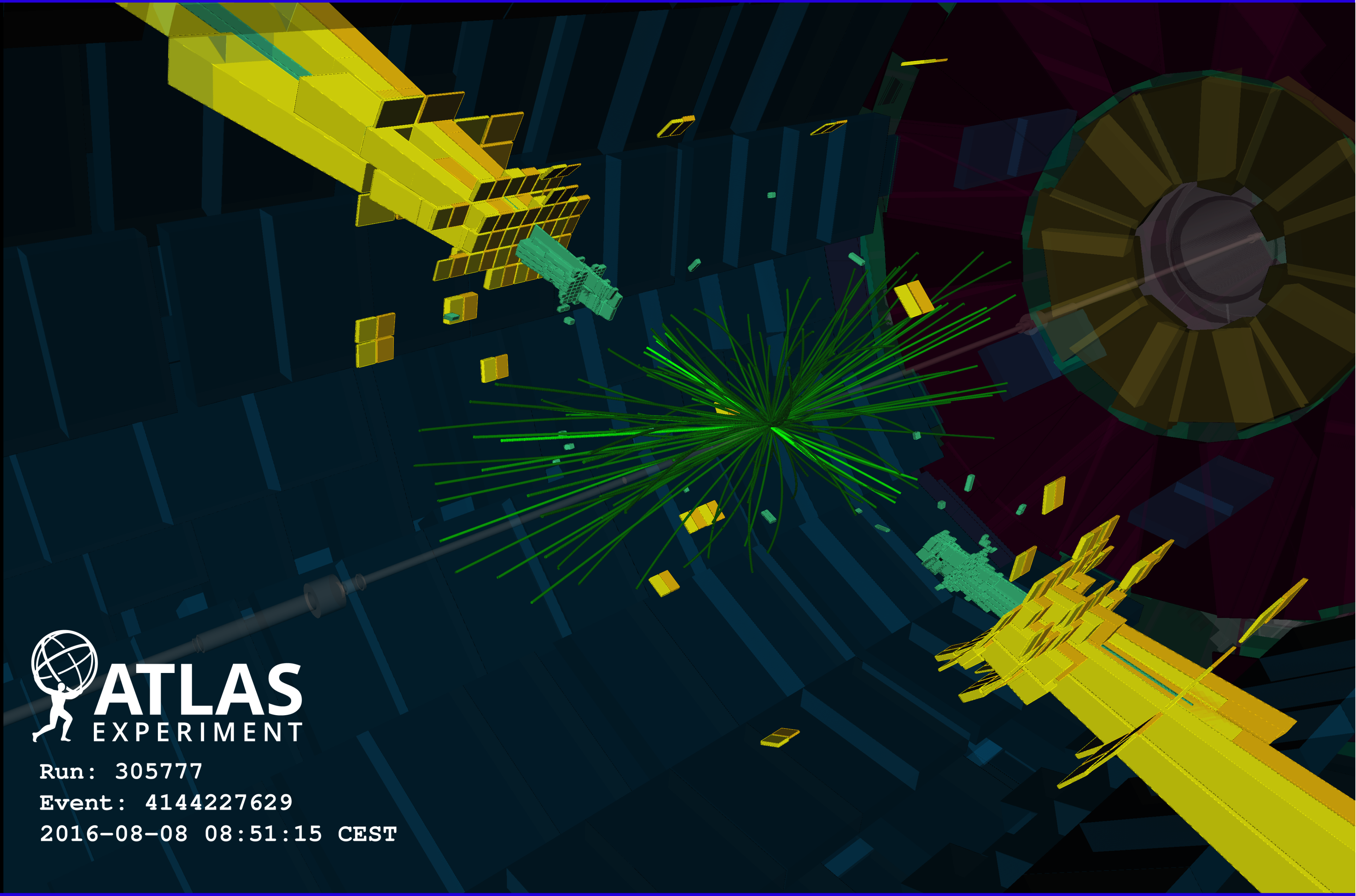
→ Inclusive jet and dijet cross-sections

→ Angular and energy correlation

Theory talk by Joao Pires

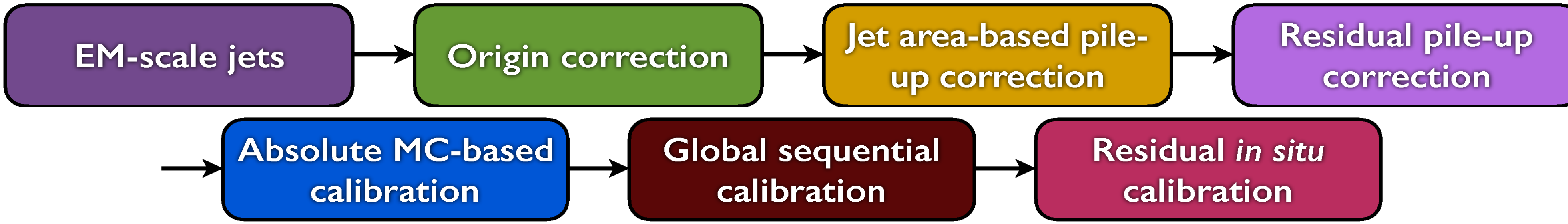
→ Quantitative data/theory comparisons

Jet production at LHC



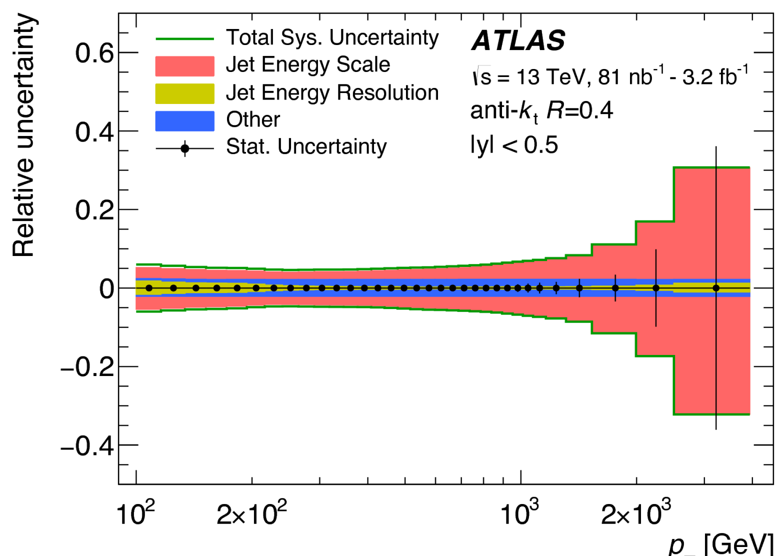
Jet calibration, resolution and uncertainties

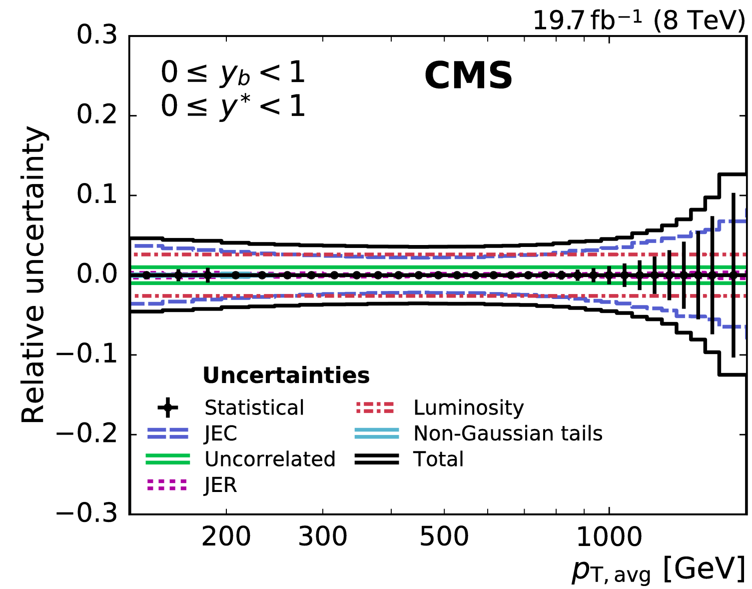
- Anti-k_T calorimeter / p-flow jets



- Uncertainties (similar for ATLAS and CMS: ~5% on wide range, sub-% statistical → *precision era*)

- in-situ baseline
- jet flavor
- pile-up





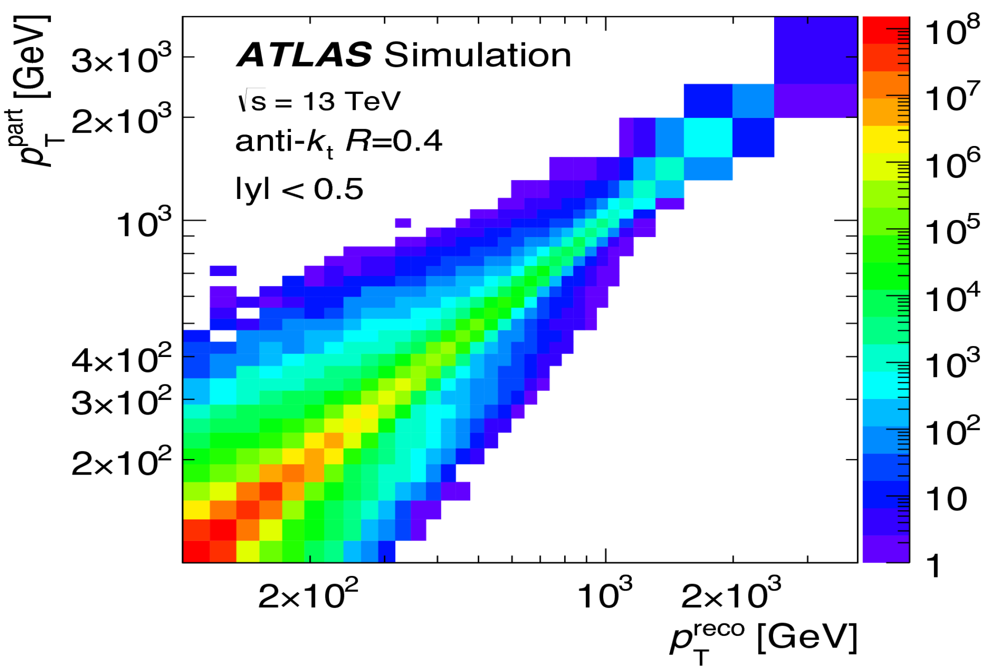
→ Sub-components (ATLAS >60; CMS ~16) allow to keep track of correlations (between phase-space regions & between measurements)

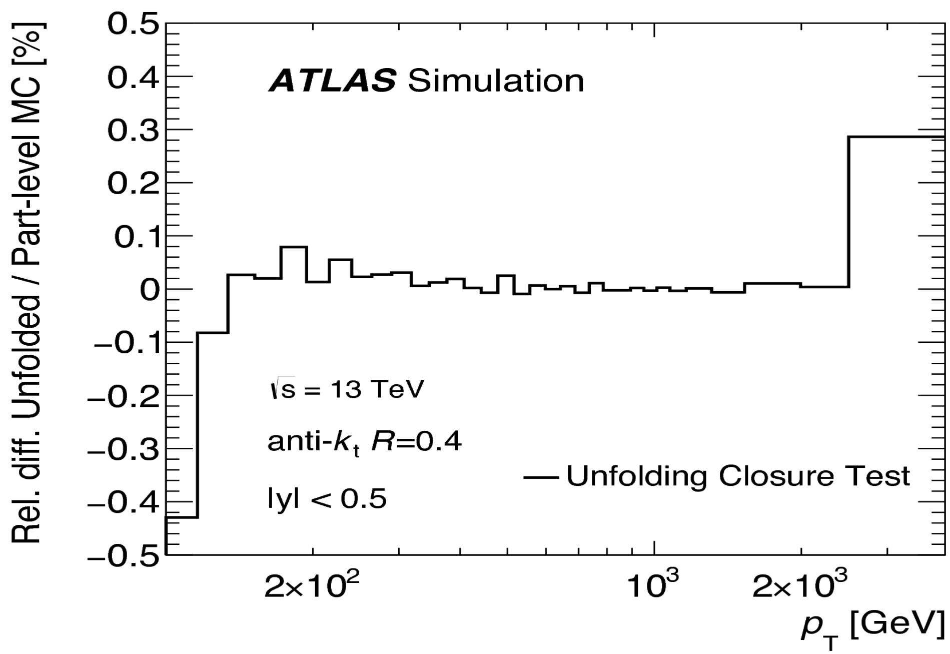
→ ATLAS: Uncertainties on the correlations available & propagated too

- Jet Energy Resolution studied in-situ (see talks by A. Dattagupta and R. Cameron)

Data correction to particle level

- Measurements corrected back to particle level using a matrix-based method (iterative or matrix inversion); #iterations: data / reco. MC, systematics
  - → Transfer matrix relating the particle level & reconstructed observable (MC); CMS: pseudo-events (from NLO + NP&EW corr.) smeared for p_T resolution
  - → In ATLAS, in-situ determination of the shape uncertainty exploiting the data/reco MC shape comparison (performed for several unfolding methods; choosing the most precise)
  - → Comparison of results using different MCs (ATLAS & CMS)





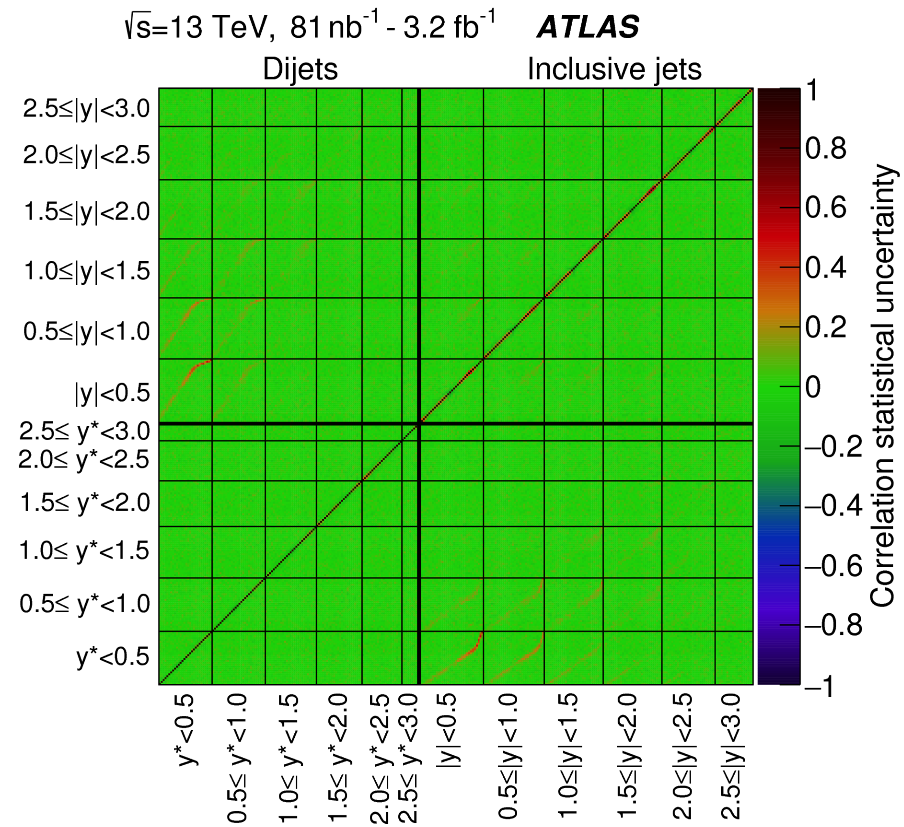
Data correction to particle level

- ATLAS: full propagation of uncertainties and correlations through the unfolding

→ statistical uncertainty (data+MC) using pseudo-experiments

- cov. matrix on data at reco. level: several entries per event (arXiv:1112.6297)

- bootstrap method to keep track of correlations between measurements e.g. for combined fits (since arXiv:1312.3524)



→ (asymmetric) systematic uncertainties using nuisance parameters; statistical significance (bootstrap method) + rebinning / smoothing

- CMS:

→ diagonal statistical uncertainties account for several entries per event and are propagated through unfolding → covariance matrix; correlations on data at reco. level to be added; Jackknife - MC in some cases

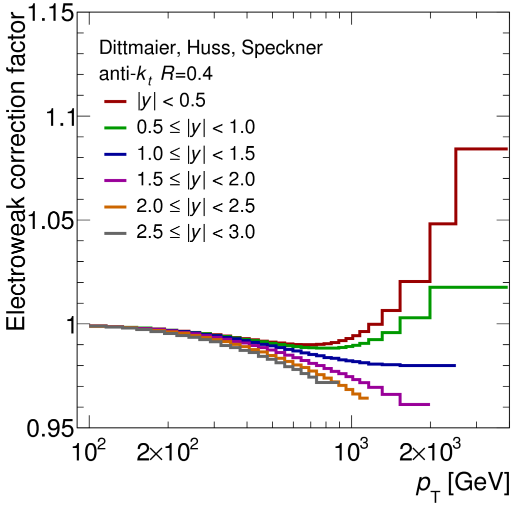
→ systematic uncertainties evaluated at reconstructed level

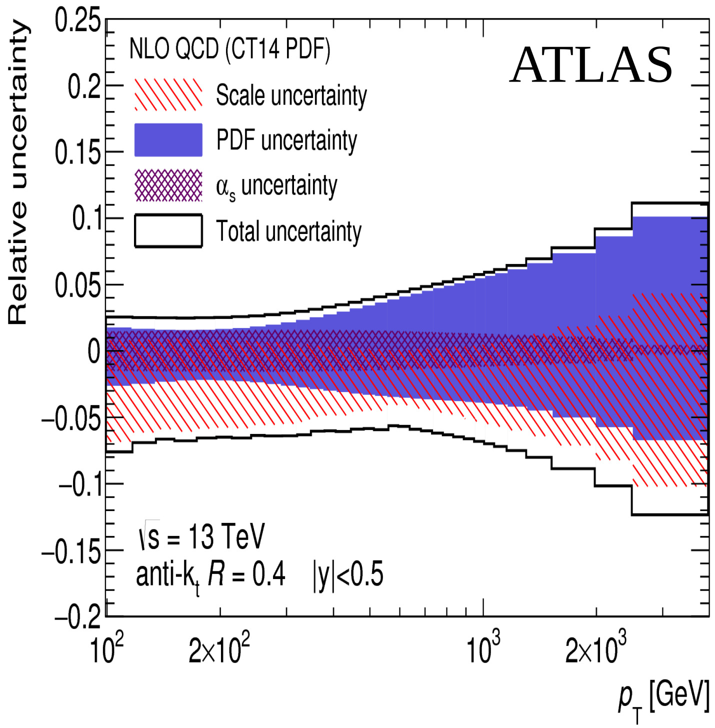
Theoretical predictions and uncertainties

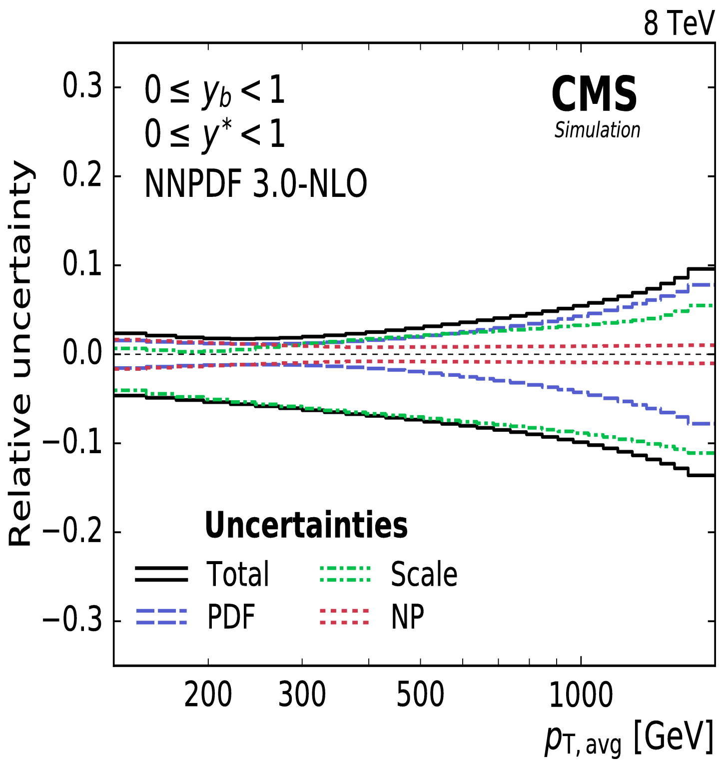
- Perturbative QCD predictions from NLOJET++
  → Uncertainties: renormalization & factorization scales (0.5 / 2 variations + (ATLAS) p_T^{jet} vs. p_T^{max} scale choice), PDFs and α_S via APPLGRID / FASTNLO
  → NNLO prediction: J.Currie et al. Phys. Rev. Lett. 118 (2017) 072002

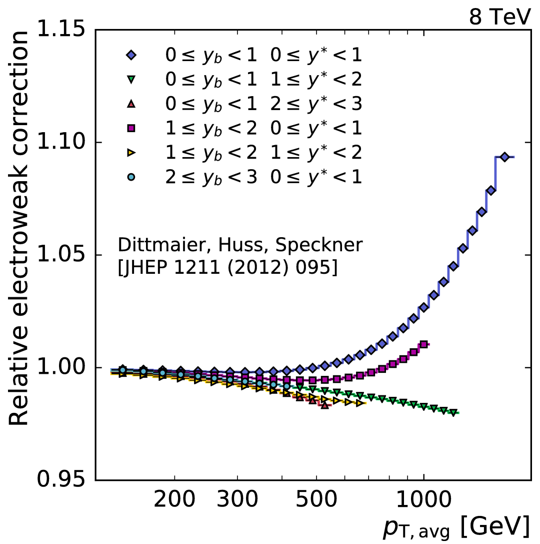
- EW corrections (inclusive jets & dijets)
  S. Dittmaier et al. JHEP 11 (2012) 095

More in Joao Pires' talk



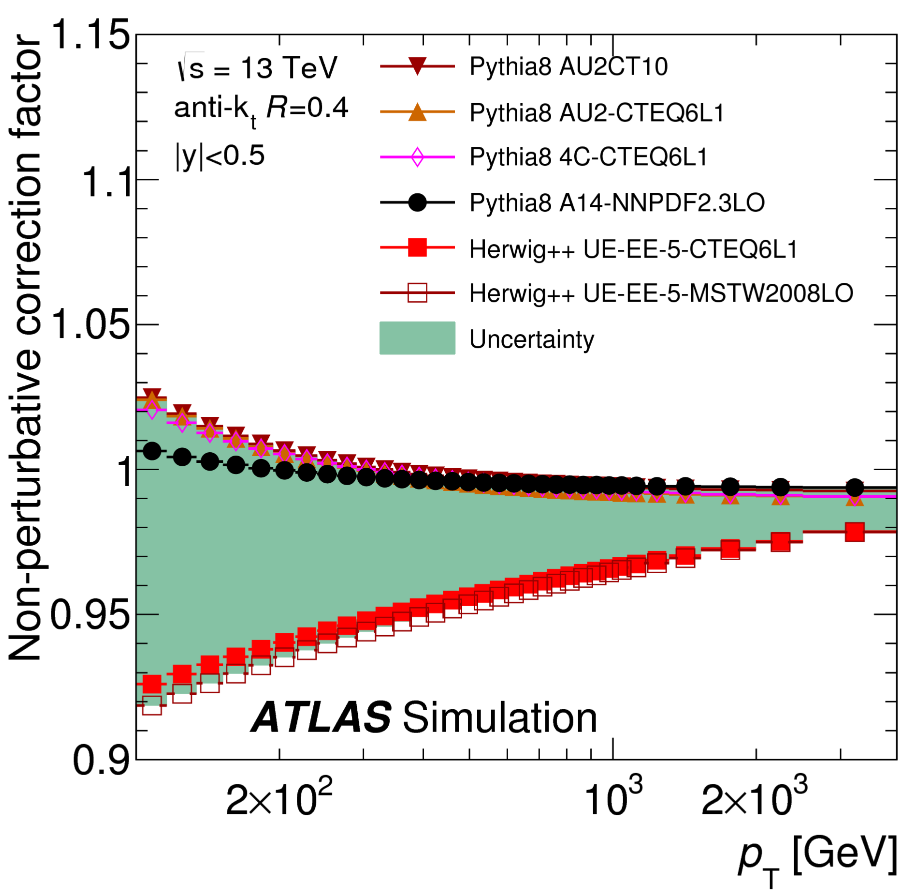


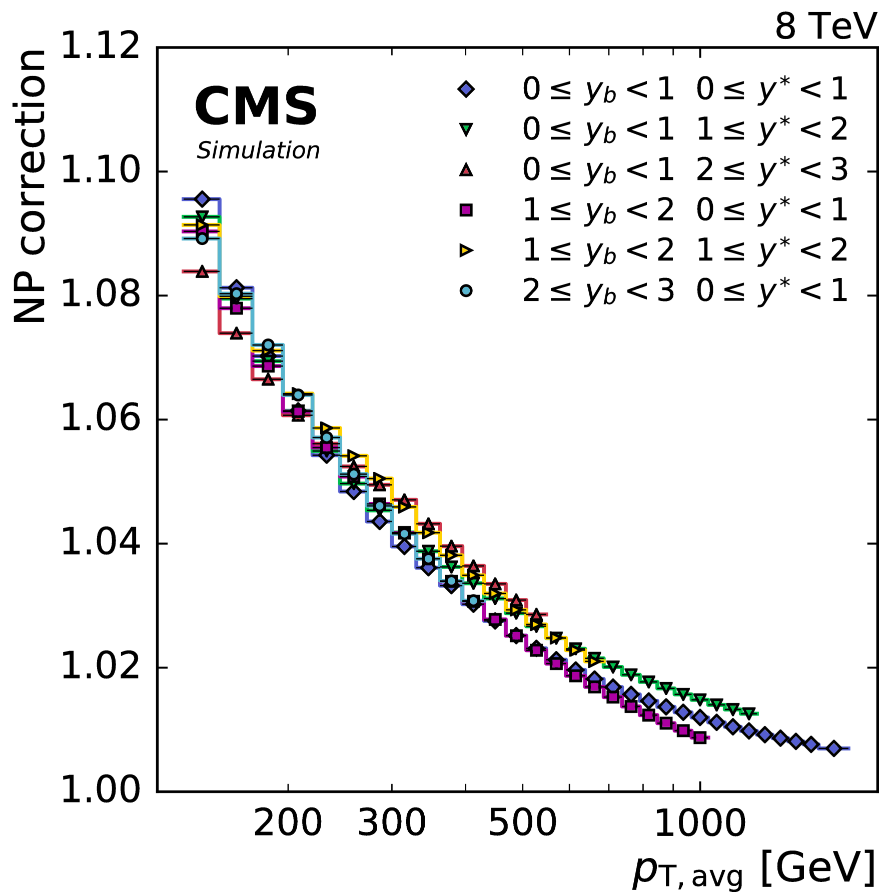




Theoretical predictions and uncertainties

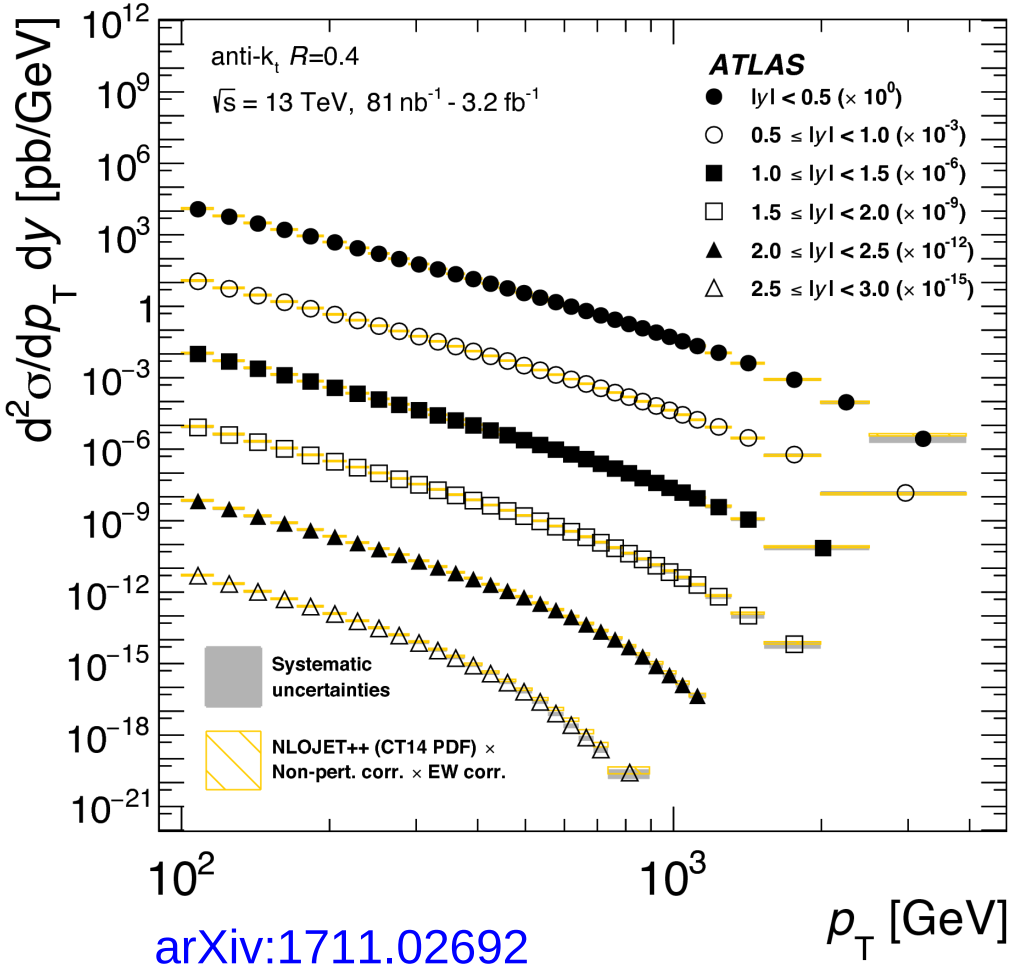
- Non-perturbative corrections (accounting for hadronization and UE / MPI) and uncertainties: various Pythia tunes + different MC generators (Herwig++); strong dependence on R
  → Additional comparisons to Powheg (NLO ME + PS)



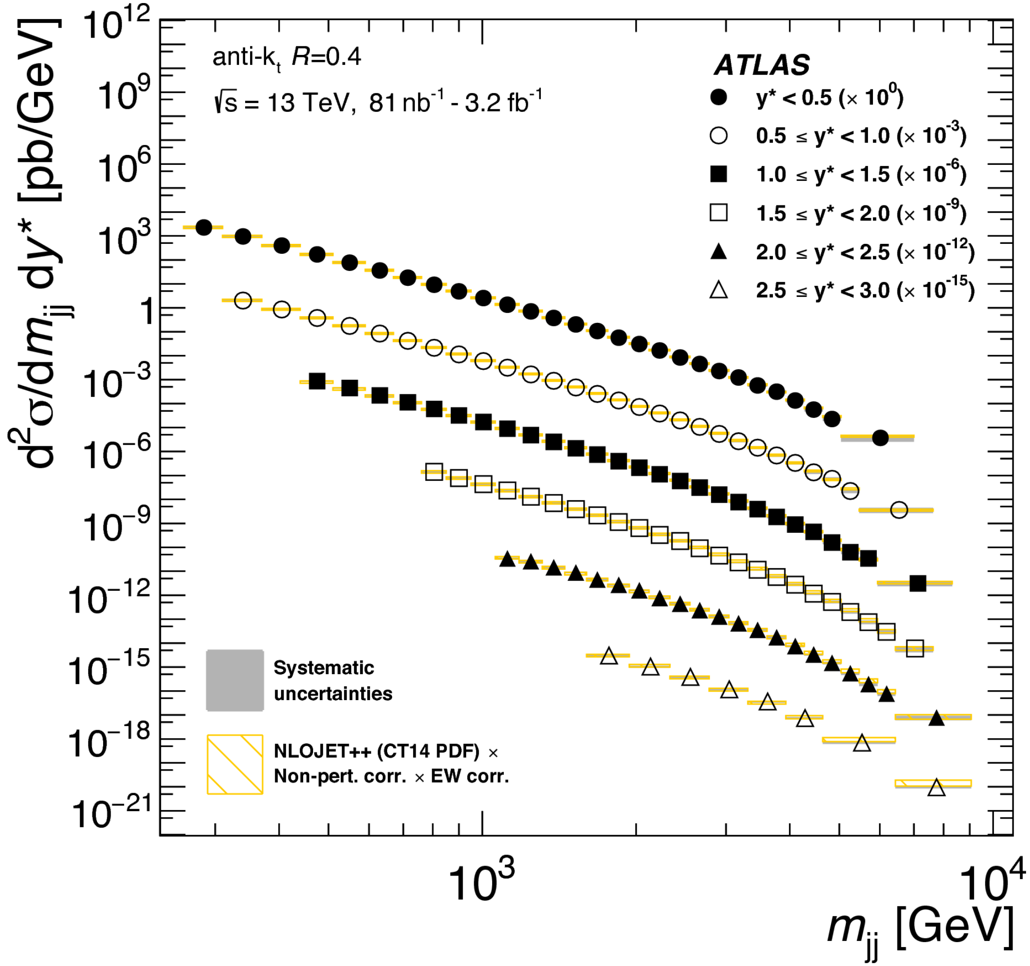


Inclusive jet and dijet cross sections - ATLAS

- Double-differential measurements for anti-k_T jets with R=0.4, √s=13 TeV, L=3.2fb^{-1} (p_T^{jet} ; |y|) (m_{jj} ; y*)



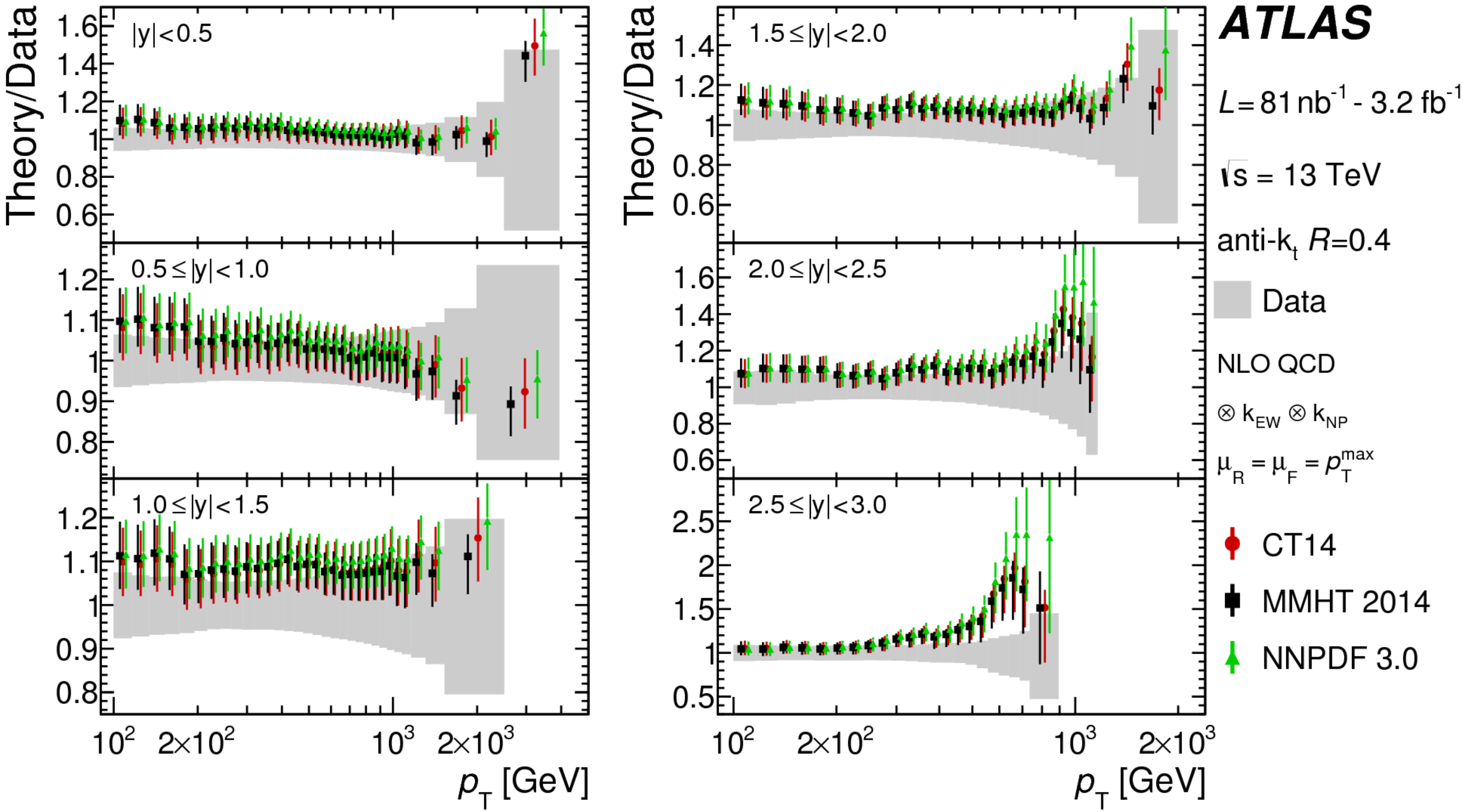
arXiv:1711.02692



- At least 2 jets: p_T^{jet} > 75 GeV, |y| < 3
- $p_T^{jet\,1} + p_T^{jet\,2}$ > 200 GeV

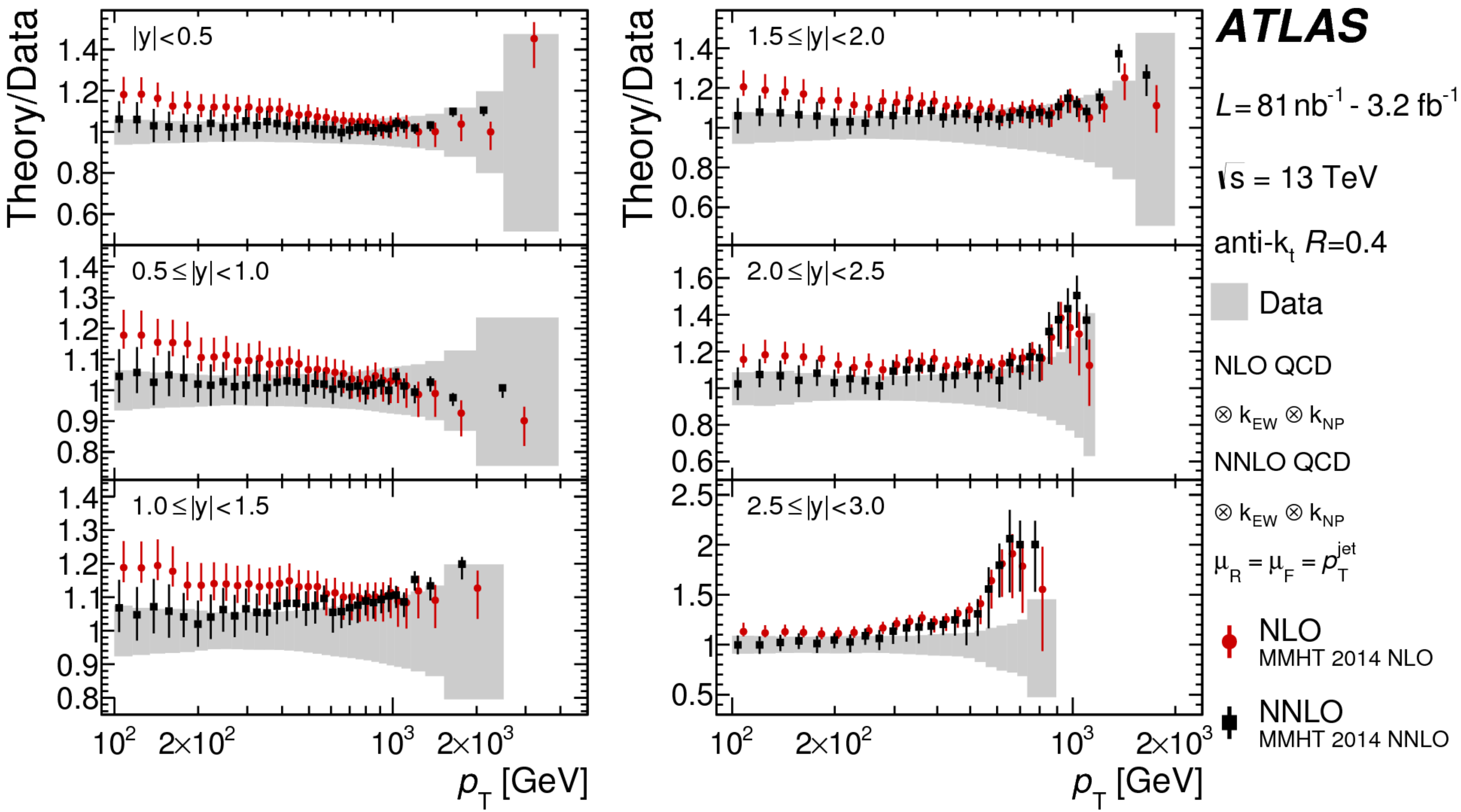
Inclusive jet cross sections: theory/data - ATLAS

- Good data/theory agreement within uncertainties observed for most PDF sets: CT14, MMHT 2014, NNPDF 3.0, HERAPDF 2.0, ABMP16

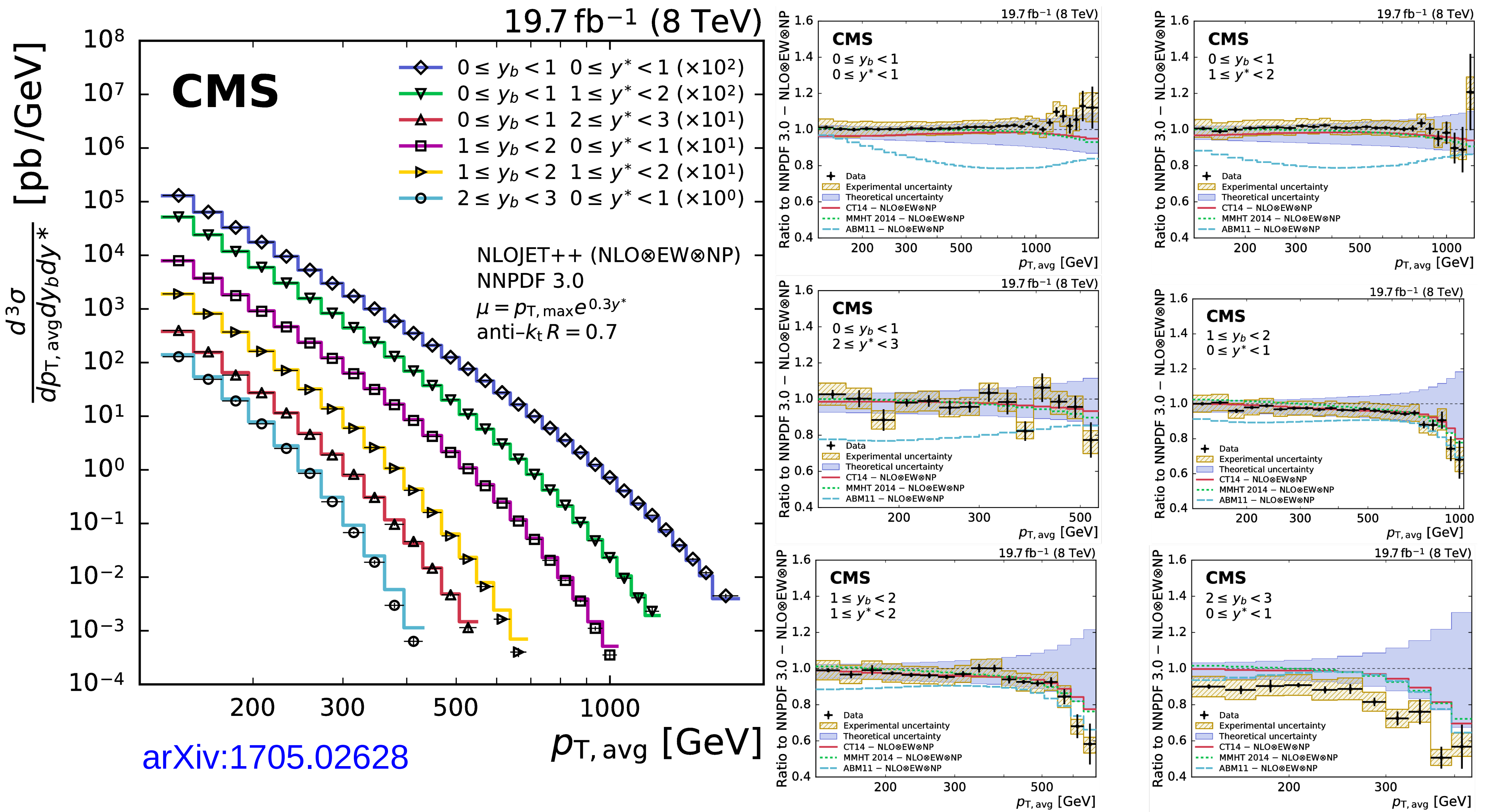


Inclusive jet cross sections: NLO/NNLO - ATLAS

- Better data/theory agreement for NNLO, when using the p_T^{jet} scale choice
- Better data/theory agreement for NLO, when using the p_T^{max} scale choice (*backup*)



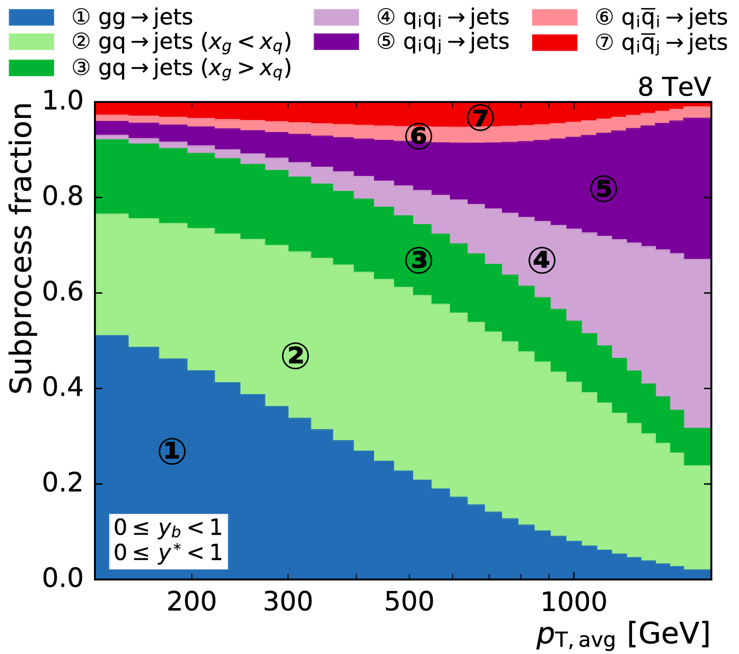
Dijet 3D measurement - CMS

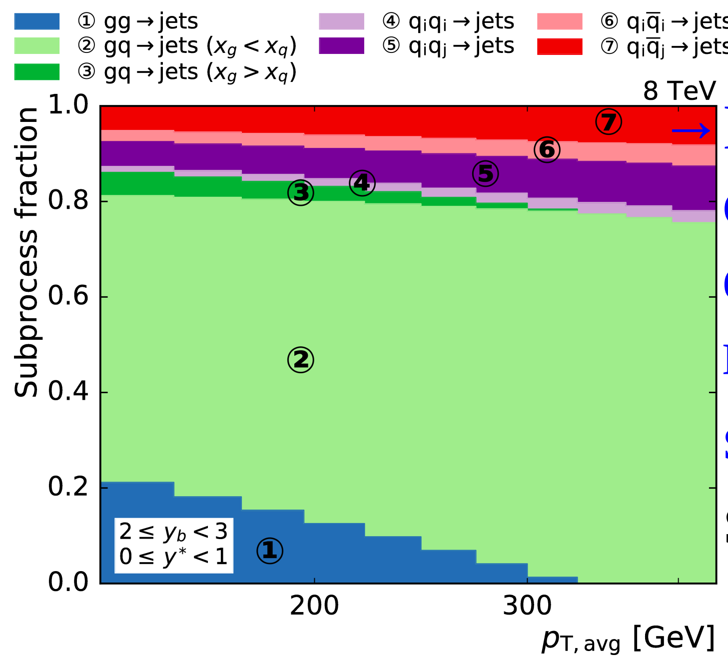


arXiv:1705.02628

- Triple-differential measurements for anti-k_T jets with R=0.7, $\sqrt{s}$=8 TeV, L=19.7fb^{-1}
- 2 leading jets: $p_T^{jet\ 1;2} > 50$ GeV, $|y| < 3$

Dijet 3D measurement - CMS

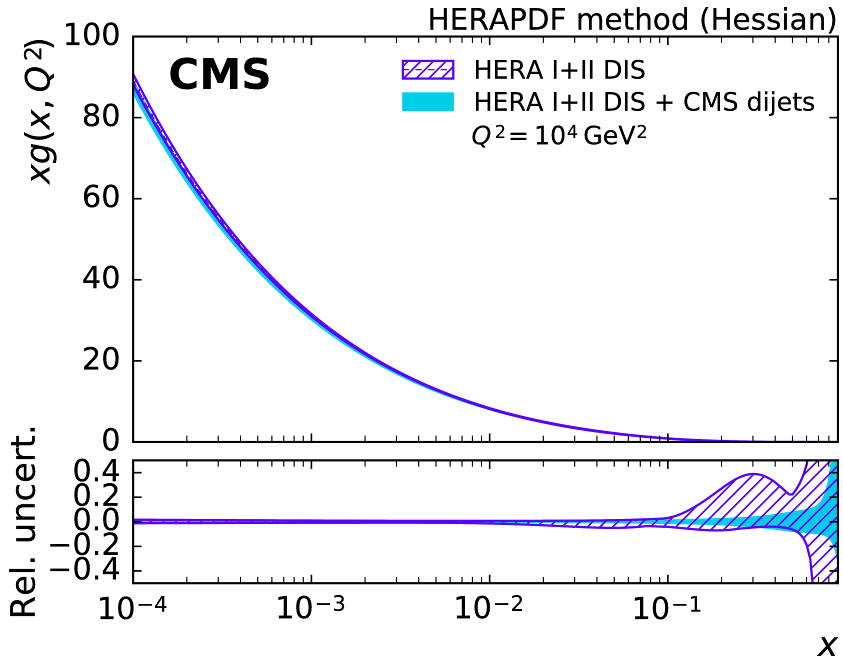


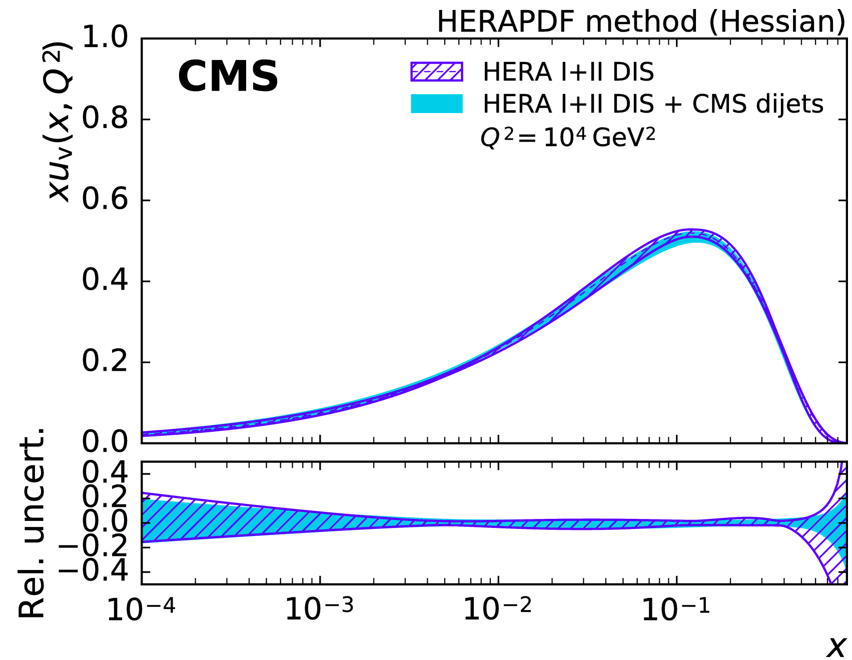


→ Different contributions of various processes in different phase-space regions:

sensitivity to PDFs

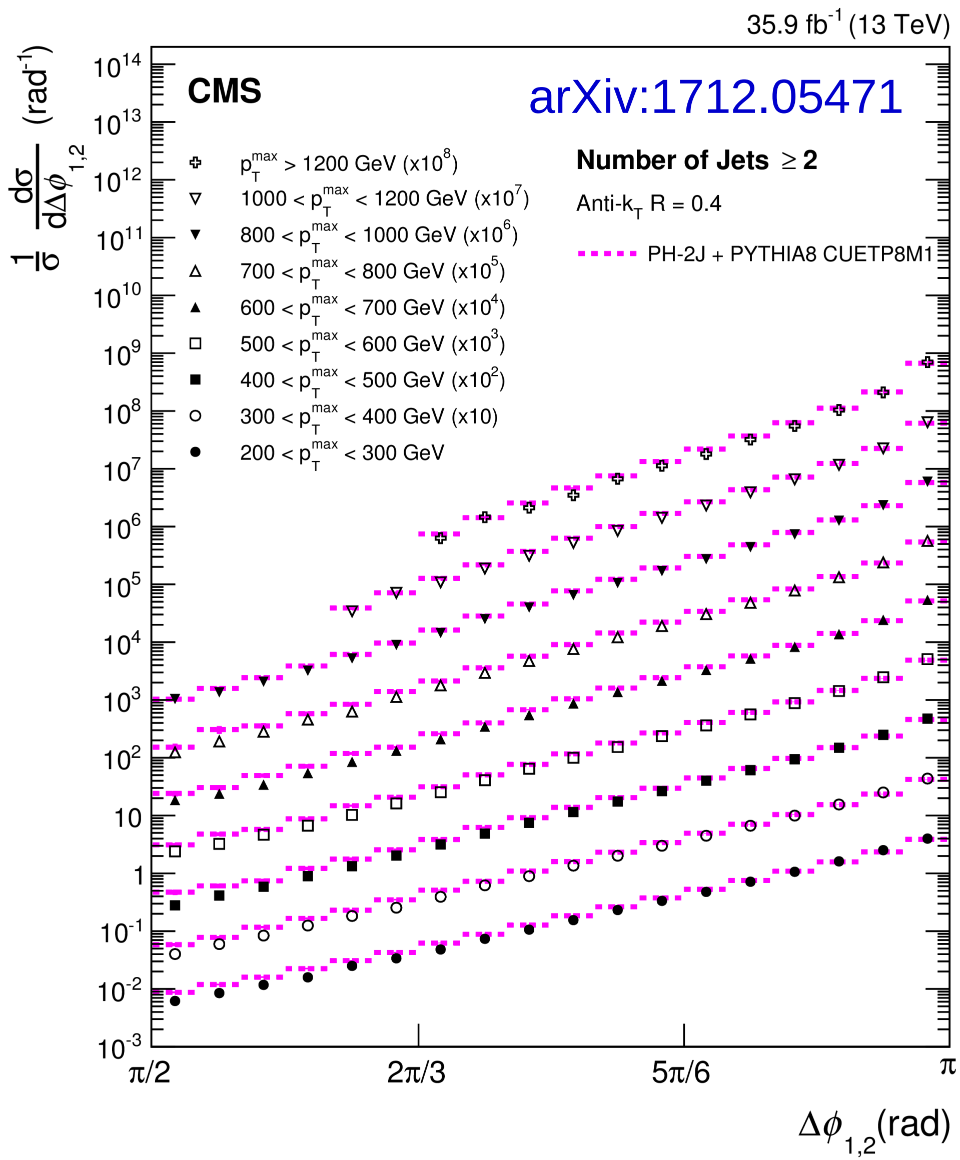
See talk by S. Chatterjee

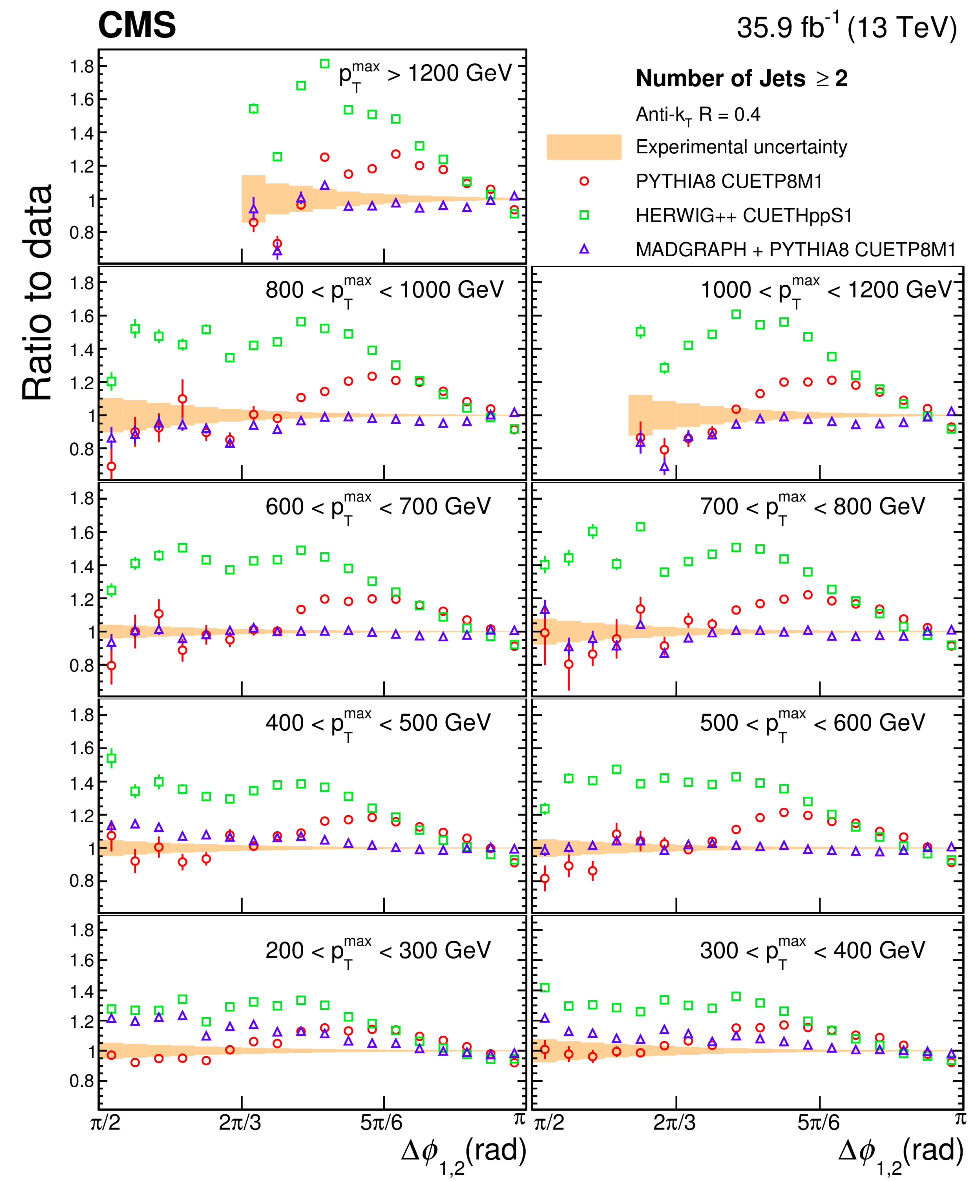




→ Jet mass measurements also entering the precision era (see talk by D. Enoque and S. Manzani)

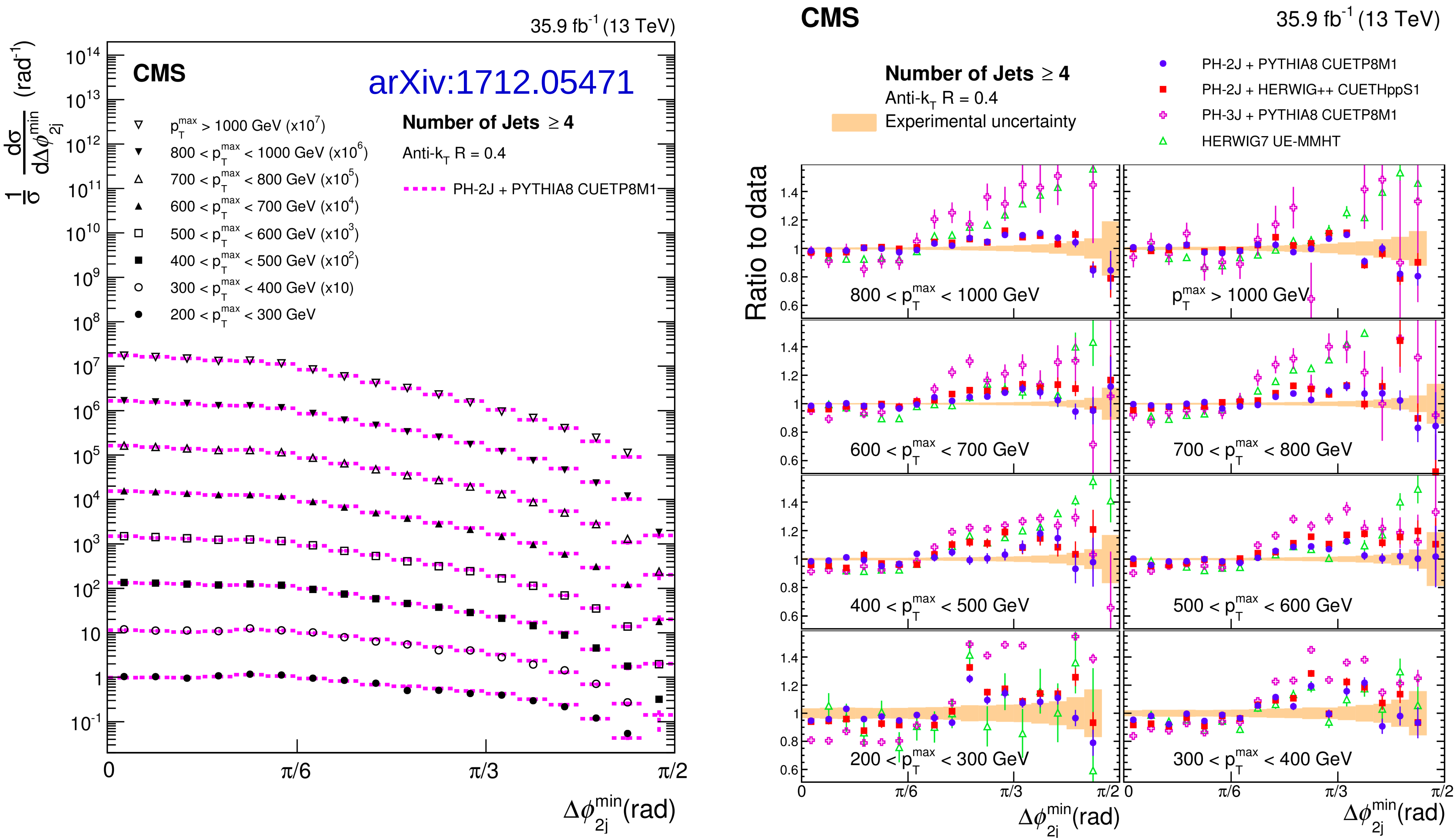
Azimuthal correlations for 2-, 3-, 4-jets by CMS





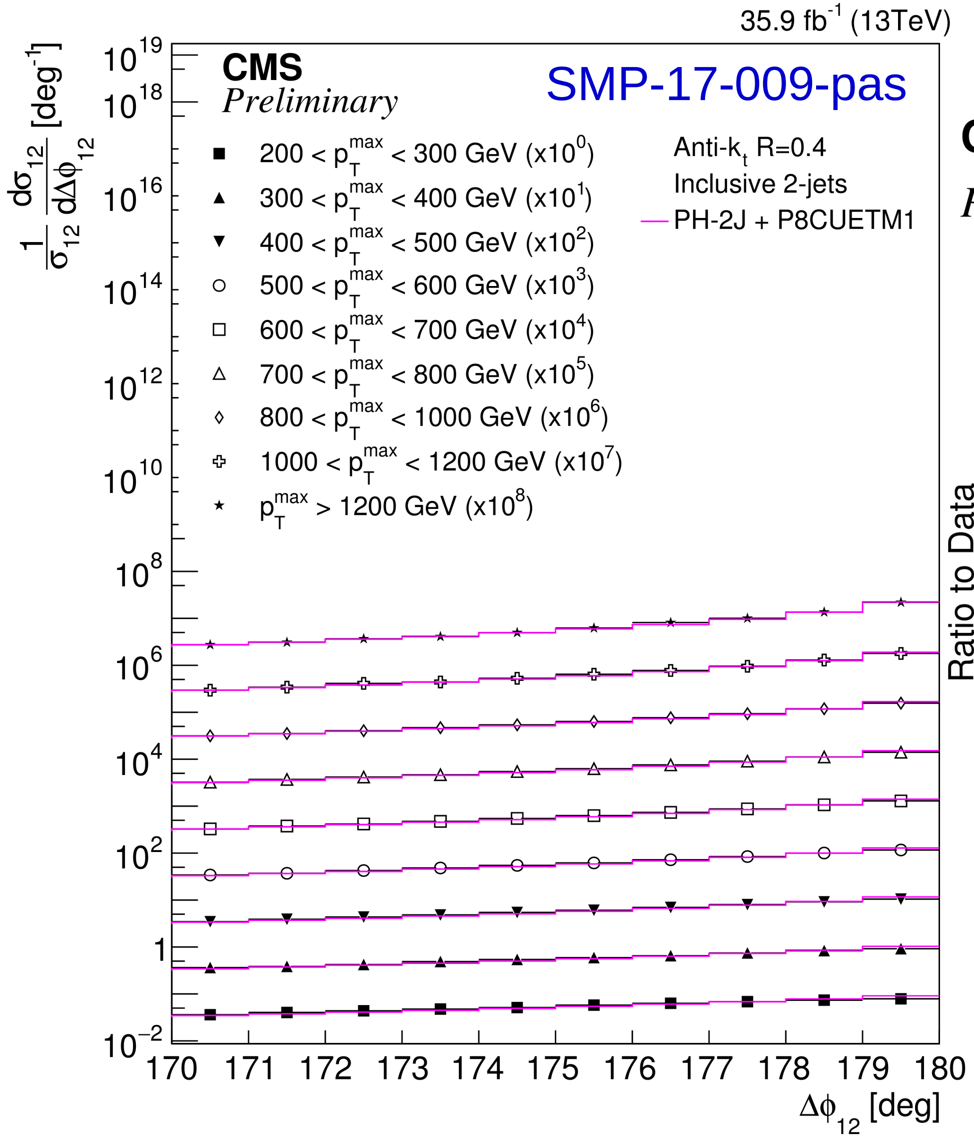
- Double differential measurements for $|y| < 2.5$ and $p_{T\,1(n)} > 200\ (100)$ GeV
- Level of data/theory agreement strongly depends on the generator

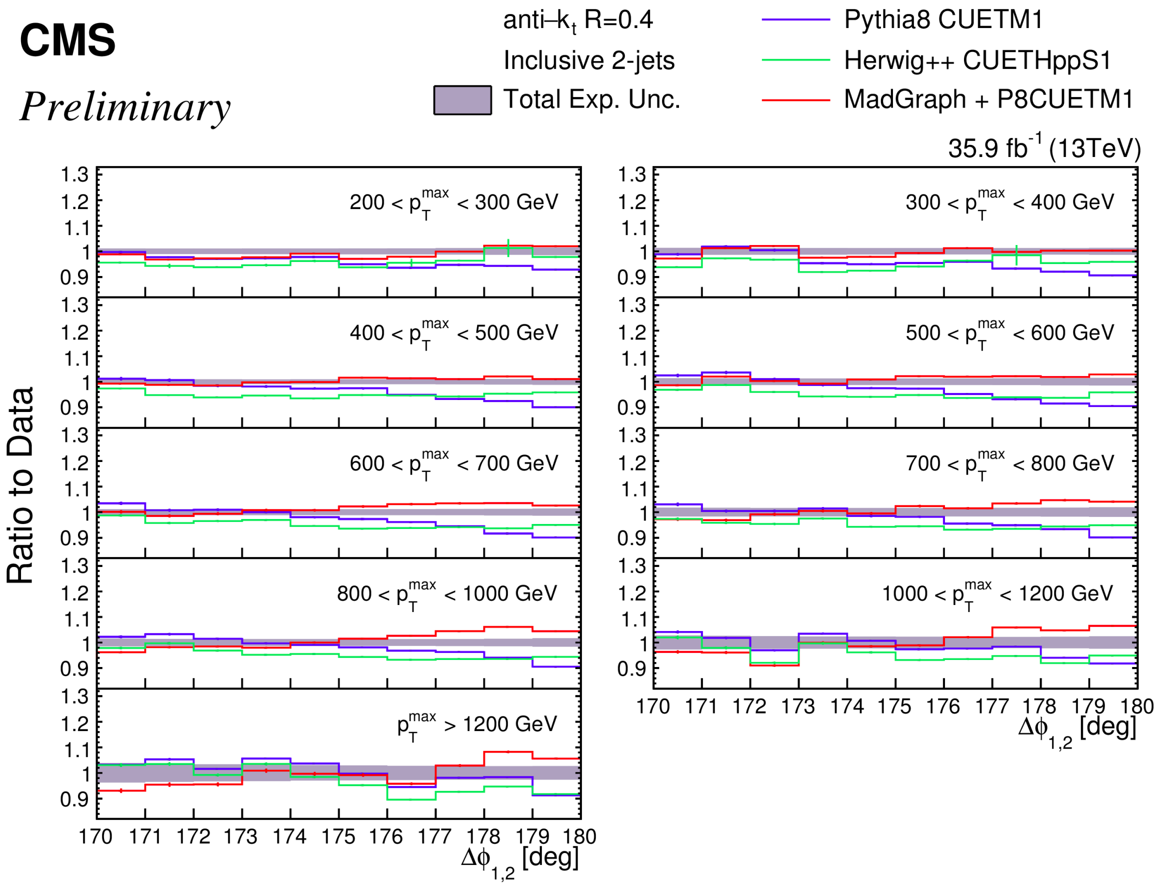
Azimuthal correlations for 2-, 3-, 4-jets by CMS



- Double differential measurements for $|y| < 2.5$ and $p_{T\,1(n)} > 200\ (100)$ GeV
- Level of data/theory agreement strongly depends on the generator

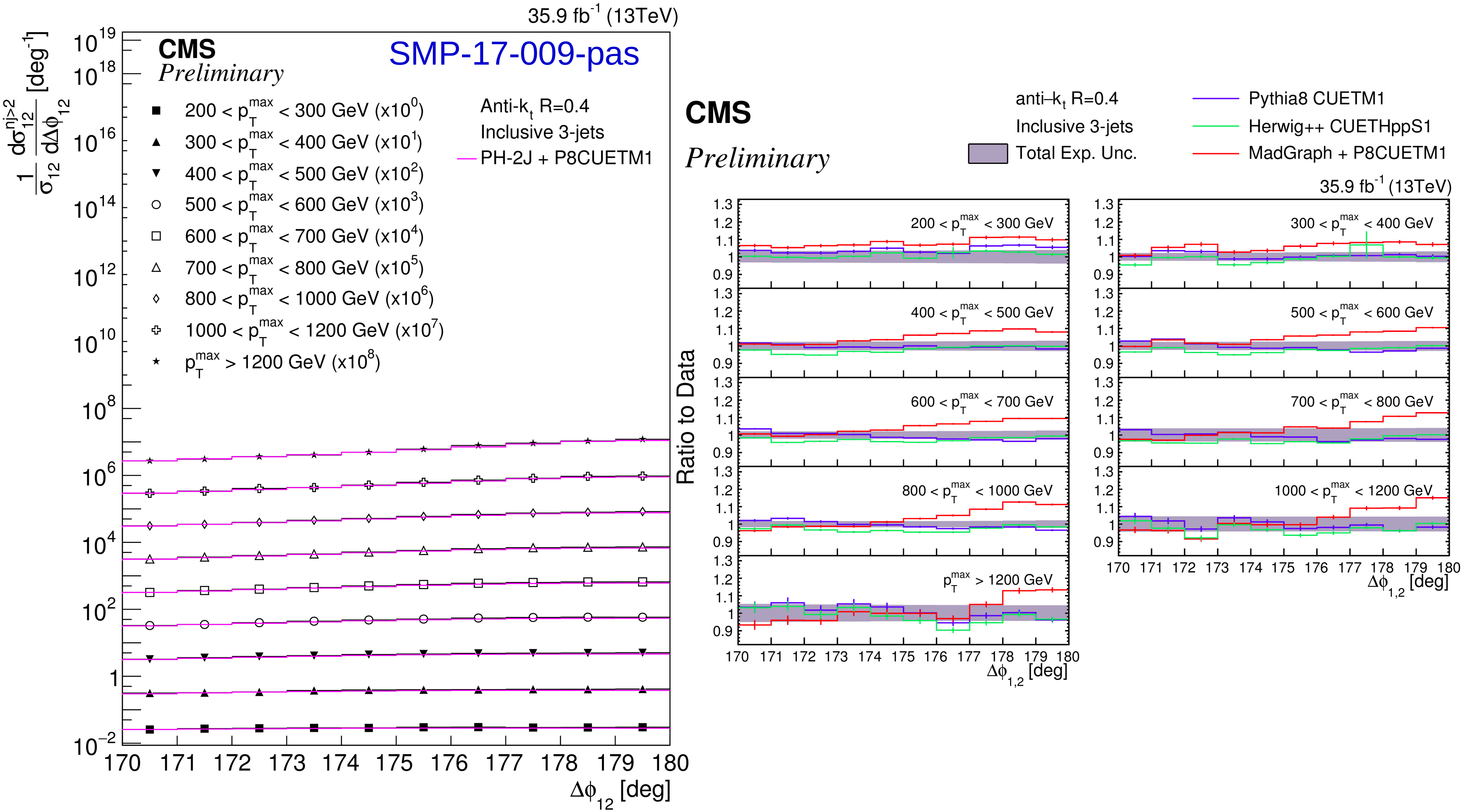
Azimuthal correlations for ~back-to-back 2-jets





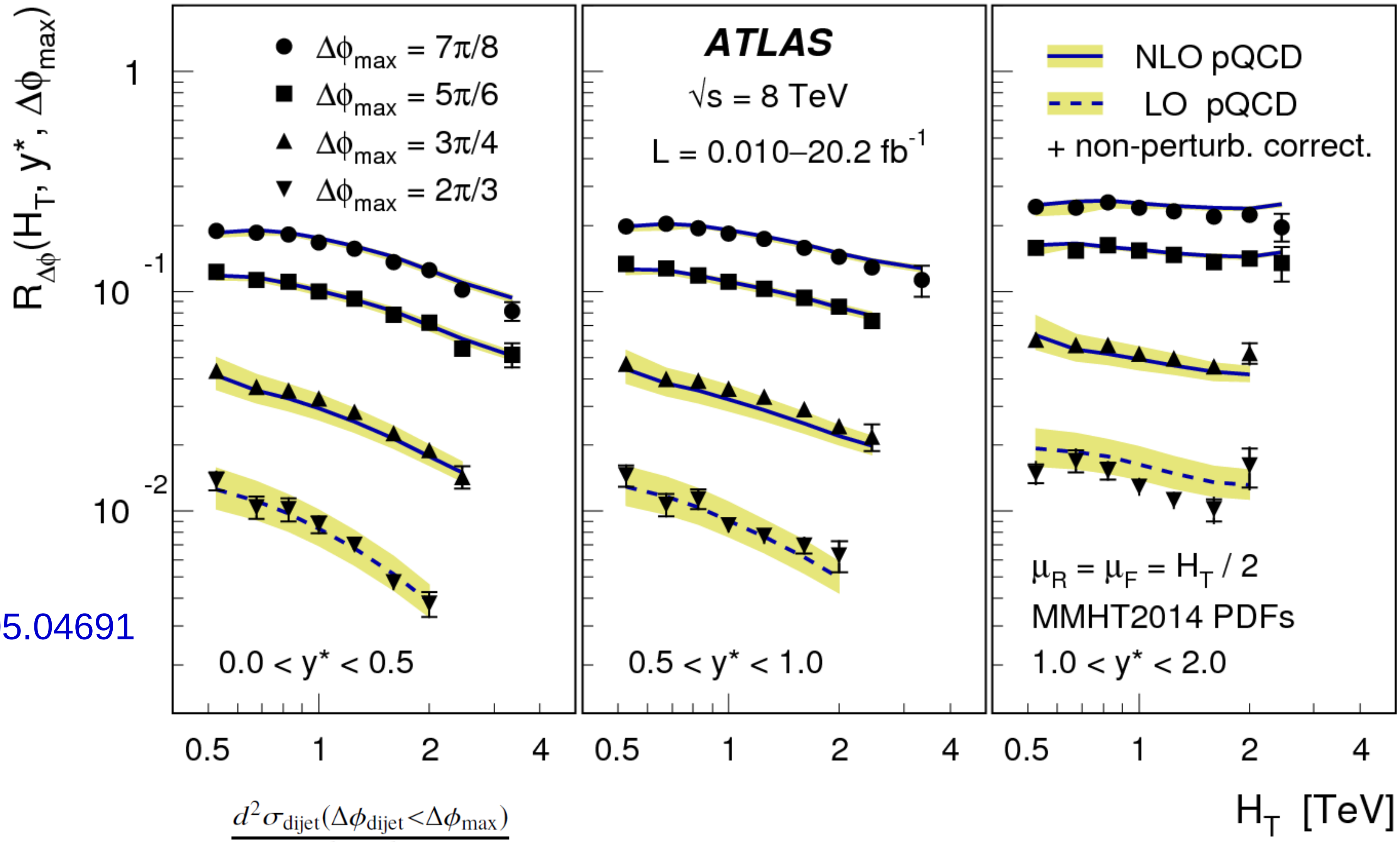
- Double differential measurements for $|y| < 2.5$ and $p_{T\,1(2)} > 200$ (100) GeV in fine $\Delta\Phi_{1,2}$ bins
- MadGraph+Pythia8 describes data somewhat better than Pythia8 and Herwig++

Azimuthal correlations for 3-jet events



- Double differential measurements for $|y| < 2.5$ and $p_{T\,1;2;3} > 200; 100; 30$ GeV
- Pythia8 and Herwig++ describe data somewhat better than MadGraph+Pythia8

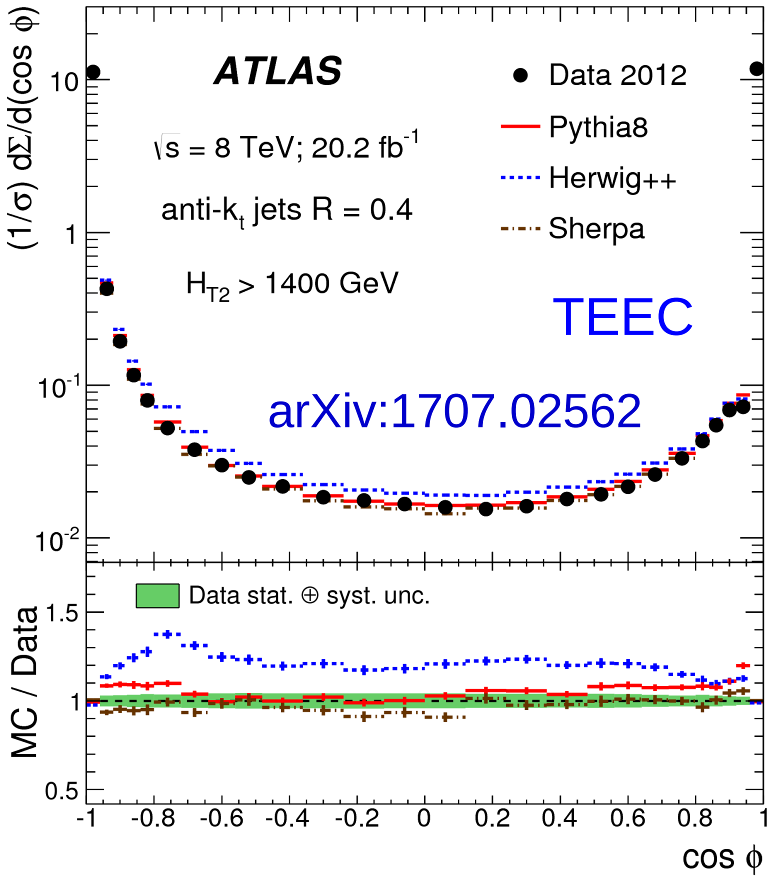
$R_{\Delta\Phi}$ - ATLAS

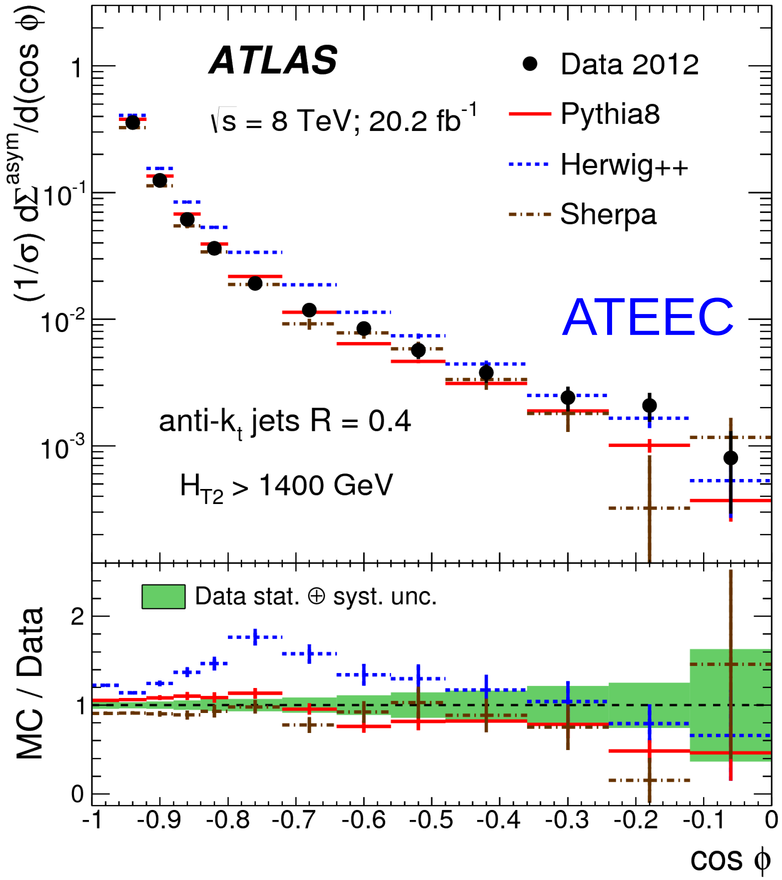


arXiv:1805.04691

$$R_{\Delta\phi}(H_T, y^*, \Delta\phi_{max}) = \frac{\frac{d^2\sigma_{dijet}(\Delta\phi_{dijet}<\Delta\phi_{max})}{dH_T\,dy^*}}{\frac{d^2\sigma_{dijet}(\text{inclusive})}{dH_T\,dy^*}}$$

- $R_{\Delta\Phi}$ measured in H_T, y* and $\Delta\Phi_{max}$ bins - sensitive to α_s (see talk by K. Rabbertz)





$$\frac{1}{\sigma}\frac{\mathrm{d}\Sigma}{\mathrm{d}\cos\phi} = \frac{1}{N}\sum_{A=1}^{N}\sum_{ij}\frac{E^A_{\mathrm{T}i}E^A_{\mathrm{T}j}}{\left(\sum_k E^A_{\mathrm{T}k}\right)^2}\delta(\cos\phi - \cos\phi_{ij}),$$

$$\frac{1}{\sigma}\frac{\mathrm{d}\Sigma^{\mathrm{asym}}}{\mathrm{d}(\cos\phi)} \equiv \frac{1}{\sigma}\frac{\mathrm{d}\Sigma}{\mathrm{d}(\cos\phi)}\bigg|_{\phi} - \frac{1}{\sigma}\frac{\mathrm{d}\Sigma}{\mathrm{d}(\cos\phi)}\bigg|_{\pi-\phi}$$

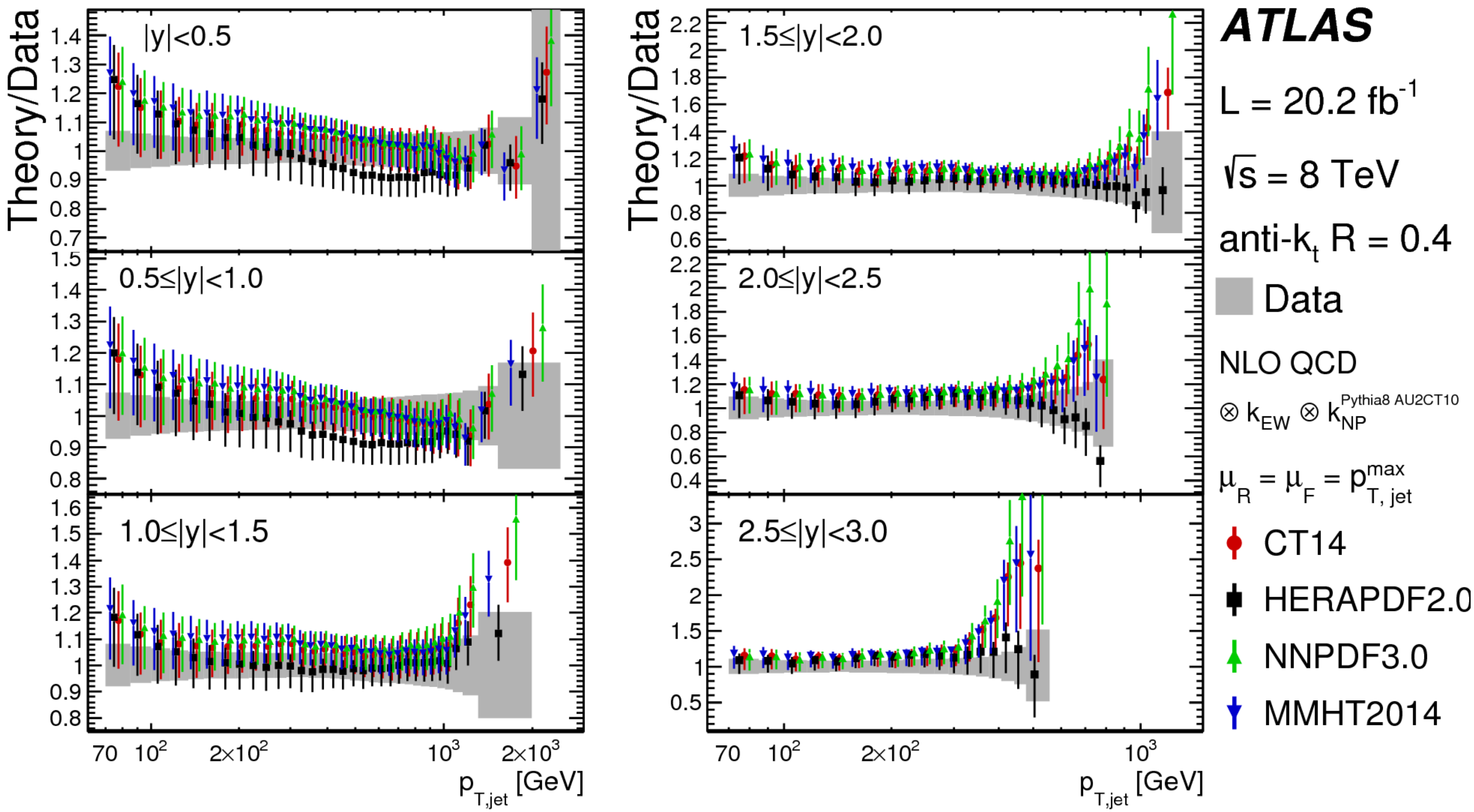
→ Energy-weighted angular distributions

- (A)EEC measured in H_{T2} and cos Φ bins - sensitive to α_s (see talk by K. Rabbertz)

Quantitative comparison between data and theory

After Joao's talk

→ Performed first for the ATLAS 8 TeV inclusive jet study (arXiv:1706.03192) and then studied for 13 TeV data too (arXiv:1711.02692)



Quantitative comparison between data and NLO QCD+NP+EW

→ χ^2 and p-values evaluated with full information on statistical and systematic uncertainties, experimental and theoretical, *with their correlations*

$$\chi^2(\mathbf{d};\mathbf{t}) = \min_{\beta_a} \left\{ \sum_{i,j} \left[d_i - \left(1 + \sum_a \beta_a \cdot \left(\boldsymbol{\epsilon}_a^{\pm}(\beta_a)\right)_i \right) t_i \right] \cdot \left[C_{\rm su}^{-1}(\mathbf{t}) \right]_{ij} \cdot \left[d_j - \left(1 + \sum_a \beta_a \cdot \left(\boldsymbol{\epsilon}_a^{\pm}(\beta_a)\right)_j \right) t_j \right] + \sum_a \beta_a^2 \right\}$$

Comparisons performed for a large number of configurations:

→ PDFs: ABM11(as for 7TeV), CT14, MMHT 2014, NNPDF 3.0, HERAPDF 2.0, ABMP16

→ Phase-space regions:

p_T ranges:

- "wide": > 70; > 100; 100 - 900; 100 - 400 GeV
- "narrow": 70 - 100; 100 - 240; 240 - 408; 408 - 642; 642 - 952; > 952 GeV

|y| ranges:

- "individual bins": |y| < 0.5; 0.5 - 1; 1 - 1.5; 1.5 - 2; 2 - 2.5; 2.5 - 3
- "full range": |y| < 3
- "pairs of consecutive bins": |y| < 1; 0.5 - 1.5; 1 - 2; 1.5 - 2.5; 2 - 3
- "central-forward pairs": |y| < 0.5 & 2.5 - 3; < 0.5 & 2 - 2.5; < 0.5 & 1.5 - 2

→ R=0.4 and R=0.6; $p_T^{\text{leading jet}}$ and p_T^{jet} scale choices

Result quantitative comparisons for "all" PDFs

- Individual |y| bins, wide p_T ranges: p-values generally > 4% (~1% or lower for R=0.6, 0.5 < |y| < 1 at 8 TeV, 1.5 < |y| < 2 at 13 TeV), decreasing when considering wider phase-space regions

- Full |y| range, wide p_T ranges: p-values << 10^{-3}
  (p_T > 100 GeV) χ^2/ndf: ~ 313-385/159 (8 TeV); 384-475/177 (13 TeV)

- Data/theory tension also seen initially by CMS in arXiv:1410.6765 when using the original data, uncertainties and correlations from arXiv:1212.6660

- CMS noticed that "Changing the correlation in the JES uncertainty from 0% to 100% produces a steep rise in χ^2/ndf" and modified the correlation model

- Good data/theory agreement on full phase-space for ATLAS dijets (13 TeV)

- Full |y| range, narrow p_T ranges: good data/theory agreement for 70 **<** p_T < 100 GeV; p-values are often below 10^{-3} for the other narrow p_T ranges

- Pairs of |y| bins(consecutive / central-forward), narrow p_T ranges at >100 GeV:
  Good data/theory agreement → *source of low p-values not in a single |y| bin, nor due to some possible central/forward tension*

- Little sensitivity to choice of non-perturbative correction and to scale choice

Role of uncertainty correlations

→ Correlations of uncertainties between various phase-space regions have a key role in χ^2 evaluation (e.g. ignoring correlations yields a very small χ^2/ndf)

→ Experimental uncertainties (examples for ATLAS measurements):

- JES in-situ statistical uncertainties: correlations well known (e.g. > 240 components for calibration using dijet balance reduce χ^2 by more than 200 units)
- JES Flavour Response, JES MJB Fragmentation, JES Pile-up Rho Topology: "2-point systematics" from comparison of various MC generators – unknown correlations

→ Theoretical uncertainties:

- α_S , PDFs: correlations (generally) well known
- Scale variations, alternative scale choice, non-perturbative corrections: "2-point systematics" – unknown correlations

→ *Good understanding of the sources of systematic uncertainties required in order to evaluate uncertainties on correlations:*

performed detailed tests using realistic alternative correlation scenarios

Testing realistic alternative correlation assumptions

→ 18 options for splitting the systematics with unknown correlations in *2 or 3 sub-components with smooth p_T and/or $|y|$ dependence*

Splitting option	Sub-component(s) definition(s), completed by complementary
1	$L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5))\cdot$ uncertainty
2	$L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5)) \cdot 0.5\cdot$ uncertainty
3	$L(p_T[\text{ TeV}], 0.1, 2.5)\cdot$ uncertainty
4	$L(p_T[\text{ TeV}], 0.1, 2.5) \cdot 0.5\cdot$ uncertainty
5	$L((\ln(p_T[\text{ TeV}]))^2, (\ln(0.1))^2, (\ln(2.5))^2)\cdot$ uncertainty
6	$L((\ln(p_T[\text{ TeV}]))^2, (\ln(0.1))^2, (\ln(2.5))^2) \cdot 0.5\cdot$ uncertainty
7	$L(\|y\|, 0, 3)\cdot$ uncertainty
8	$L(\|y\|, 0, 3) \cdot 0.5\cdot$ uncertainty
9	$L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5)) \cdot L(\|y\|, 0, 3)\cdot$ uncertainty
10	$L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5)) \cdot \sqrt{1 - L(\|y\|, 0, 3)^2}\cdot$ uncertainty
11	$L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5)) \cdot L(\|y\|, 0, 3) \cdot 0.5\cdot$ uncertainty
12	$L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5)) \cdot \sqrt{1 - L(\|y\|, 0, 3)^2} \cdot 0.5\cdot$ uncertainty
13	$L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5)) \cdot \sqrt{1 - L(\|y\|, 0, 1.5)^2}\cdot$ uncertainty $L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5)) \cdot L(\|y\|, 1.5, 3)\cdot$ uncertainty
14	$L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5)) \cdot \sqrt{1 - L(\|y\|, 0, 1)^2}\cdot$ uncertainty $L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5)) \cdot L(\|y\|, 1, 3)\cdot$ uncertainty
15	$L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5)) \cdot \sqrt{1 - L(\|y\|, 0, 2)^2}\cdot$ uncertainty $L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5)) \cdot L(\|y\|, 2, 3)\cdot$ uncertainty
16	$\sqrt{1 - L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5))^2} \cdot \sqrt{1 - L(\|y\|, 0, 1.5)^2}\cdot$ uncertainty $\sqrt{1 - L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5))^2} \cdot L(\|y\|, 1.5, 3)\cdot$ uncertainty
17	$\sqrt{1 - L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5))^2} \cdot \sqrt{1 - L(\|y\|, 0, 1)^2}\cdot$ uncertainty $\sqrt{1 - L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5))^2} \cdot L(\|y\|, 1, 3)\cdot$ uncertainty
18	$\sqrt{1 - L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5))^2} \cdot \sqrt{1 - L(\|y\|, 0, 2)^2}\cdot$ uncertainty $\sqrt{1 - L(\ln(p_T[\text{ TeV}]), \ln(0.1), \ln(2.5))^2} \cdot L(\|y\|, 2, 3)\cdot$ uncertainty

L(x, min, max) = (x-min)/(max-min)

→ Tested for *experimental and theoretical systematic uncertainties*

→ One component added to the ones listed for each option in the table, to keep total uncertainty unchanged

Testing realistic alternative correlation assumptions

→ Splitting the *theory systematic uncertainties* with unknown correlations in *6 sub-components with smooth p_T and $|y|$ dependence*

$$f_1(p_\mathrm{T}, y) = C(p_\mathrm{T}, y) \cdot c_1 / \log(M(y)/p_\mathrm{T})$$
$$f_2(p_\mathrm{T}, y) = C(p_\mathrm{T}, y) \cdot c_2 \cdot y^2 / \log(M(y)/p_\mathrm{T})$$
$$f_3(p_\mathrm{T}, y) = C(p_\mathrm{T}, y) \cdot c_3$$
$$f_4(p_\mathrm{T}, y) = C(p_\mathrm{T}, y) \cdot c_4 \cdot y^2$$
$$f_5(p_\mathrm{T}, y) = C(p_\mathrm{T}, y) \cdot c_5 \cdot \log(15 p_\mathrm{T}/M(y))$$
$$f_6(p_\mathrm{T}, y) = C(p_\mathrm{T}, y) \cdot c_6 \cdot y^2 \cdot \log(15 p_\mathrm{T}/M(y))$$
$$M(y) = \sqrt{s} \cdot \exp(-y)$$

Based on:
Phys. Rev. D81 (2010) 035018
arXiv:0907.5052 [hep-ph]

→ 3 options for various values of the coefficients (c_1- c_6)

Testing realistic alternative correlation assumptions: Results

Inclusive jets - nominal χ^2/ndf for CT14 with $p_T^{\text{leading jet}}$ scale:
321 – 360/159 (8 TeV); 419/177(13 TeV)

Splitting a single systematic: some χ^2 reduction, but still small p-values.

Splitting simultaneously several uncertainties:

→ JES Flavour Response, JES MJB Fragmentation, JES Pile-up Rho Topology:
χ^2 reduction by up to 51 units (8 TeV)

→ scale variations, alternative scale choice, non-perturbative correction:
χ^2 reduction by up to 87 units (8 TeV)
– more work needed on the correlations of theory uncertainties

→ splitting both the experimental and theoretical uncertainties:
χ^2 reduction by up to 96 units (8 TeV); 58 units (13 TeV)

→ Possible (extra) motivation for including scale uncertainties in PDF fits - in progress

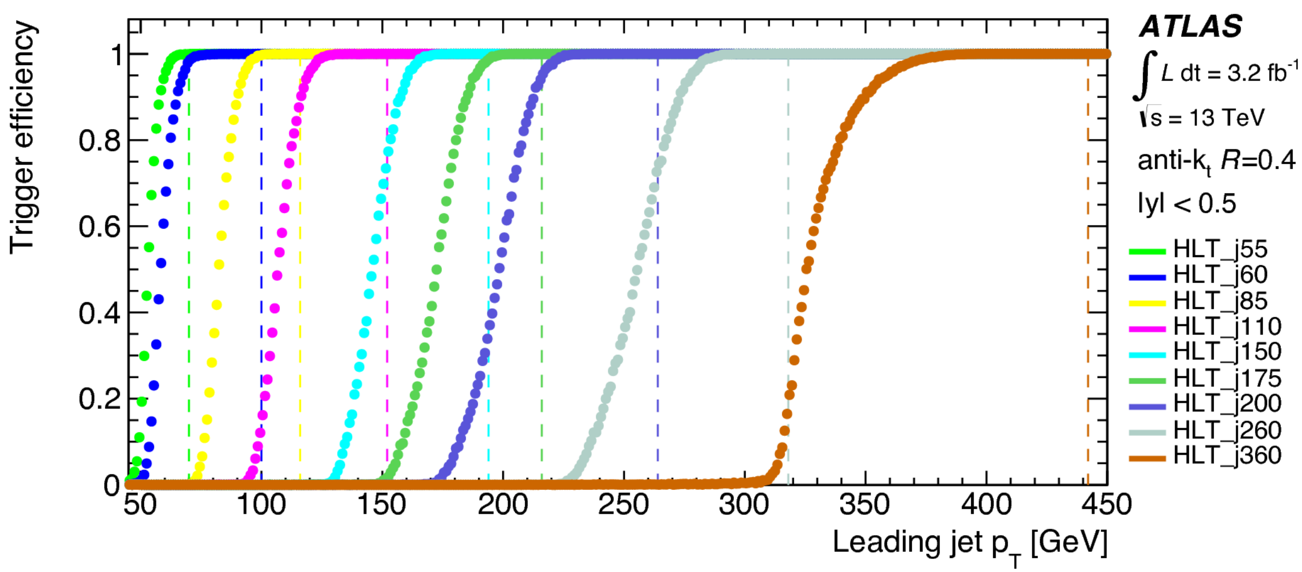
Note: there is also an uncertainty on the phase-space dependence for the size of 2-point systematics → may explain part of the observed tension

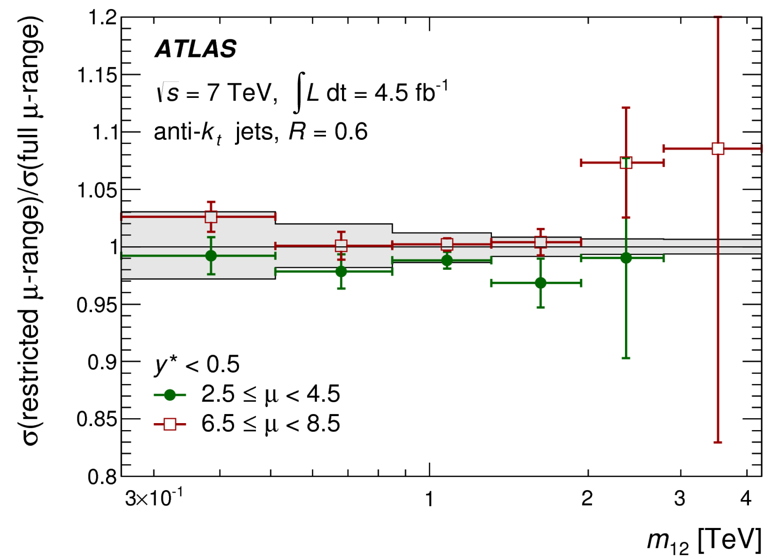
Summary and conclusions

- Numerous jet cross section measurements performed by ATLAS and CMS
- Performed detailed studies of quantitative data-theory comparisons and their sensitivity to uncertainties on correlations
- LHC data allow tests of the Standard Model, provide constraints on PDFs and are useful inputs for MC tuning
- More measurements to come at 5, 8 and 13 TeV

BACKUP

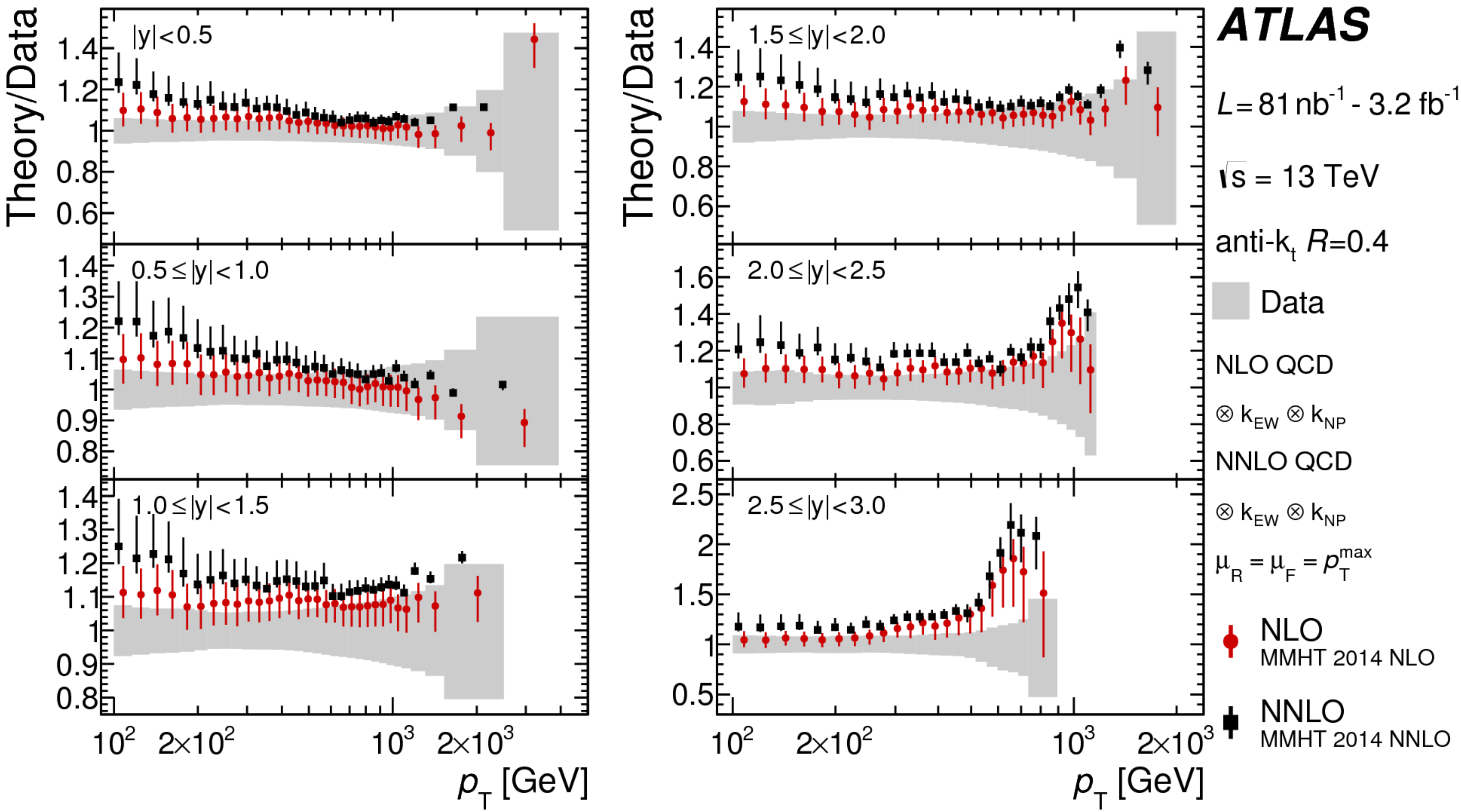
- Trigger prescales and pile-up treatment take into account variations in data-taking conditions
- Jet trigger efficiencies determined in-situ using unbiased samples
- Each trigger used in the region where it is fully efficient





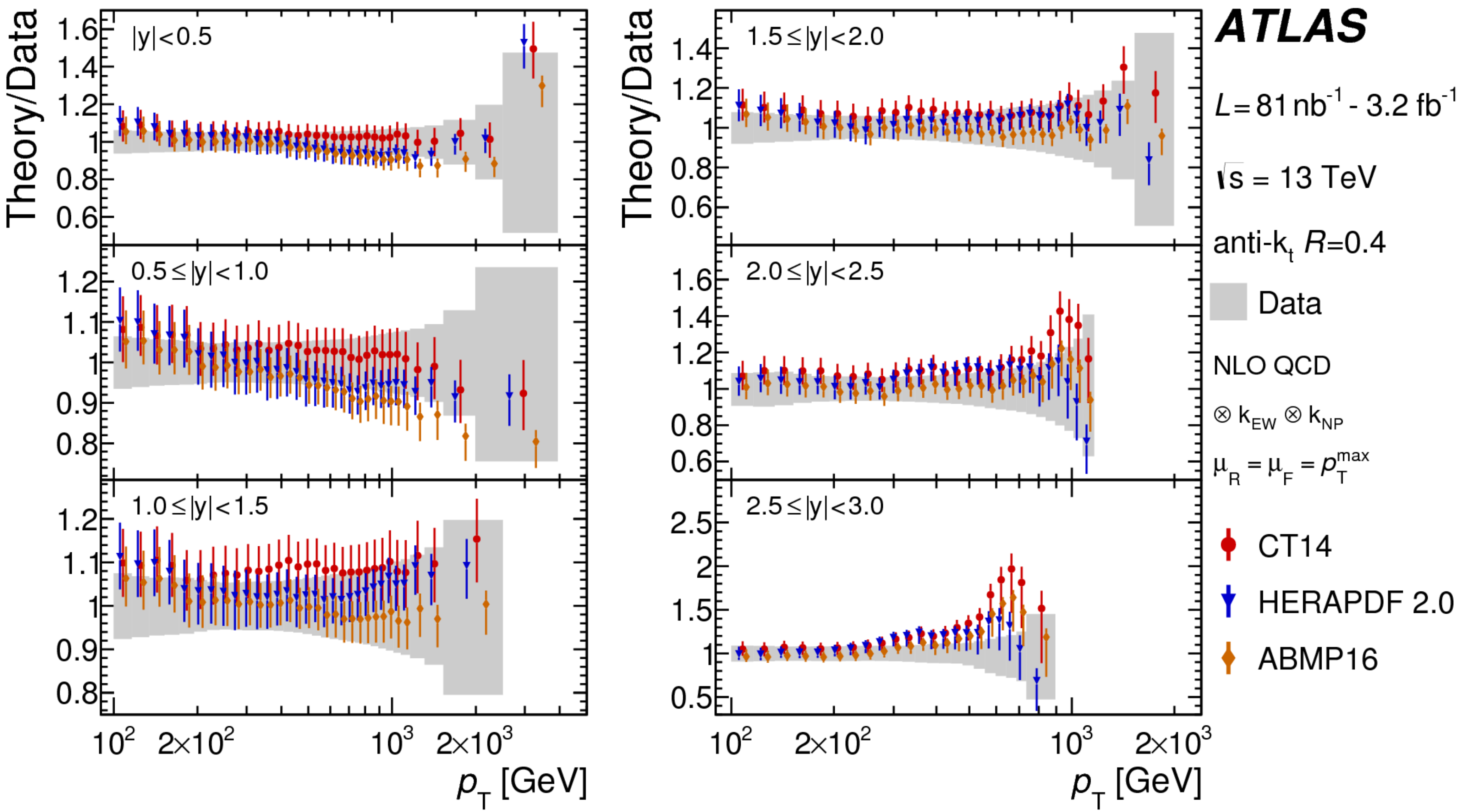
Inclusive jet cross sections: NLO/NNLO

- Better data/theory agreement for NLO, when using the p_T^{max} scale choice



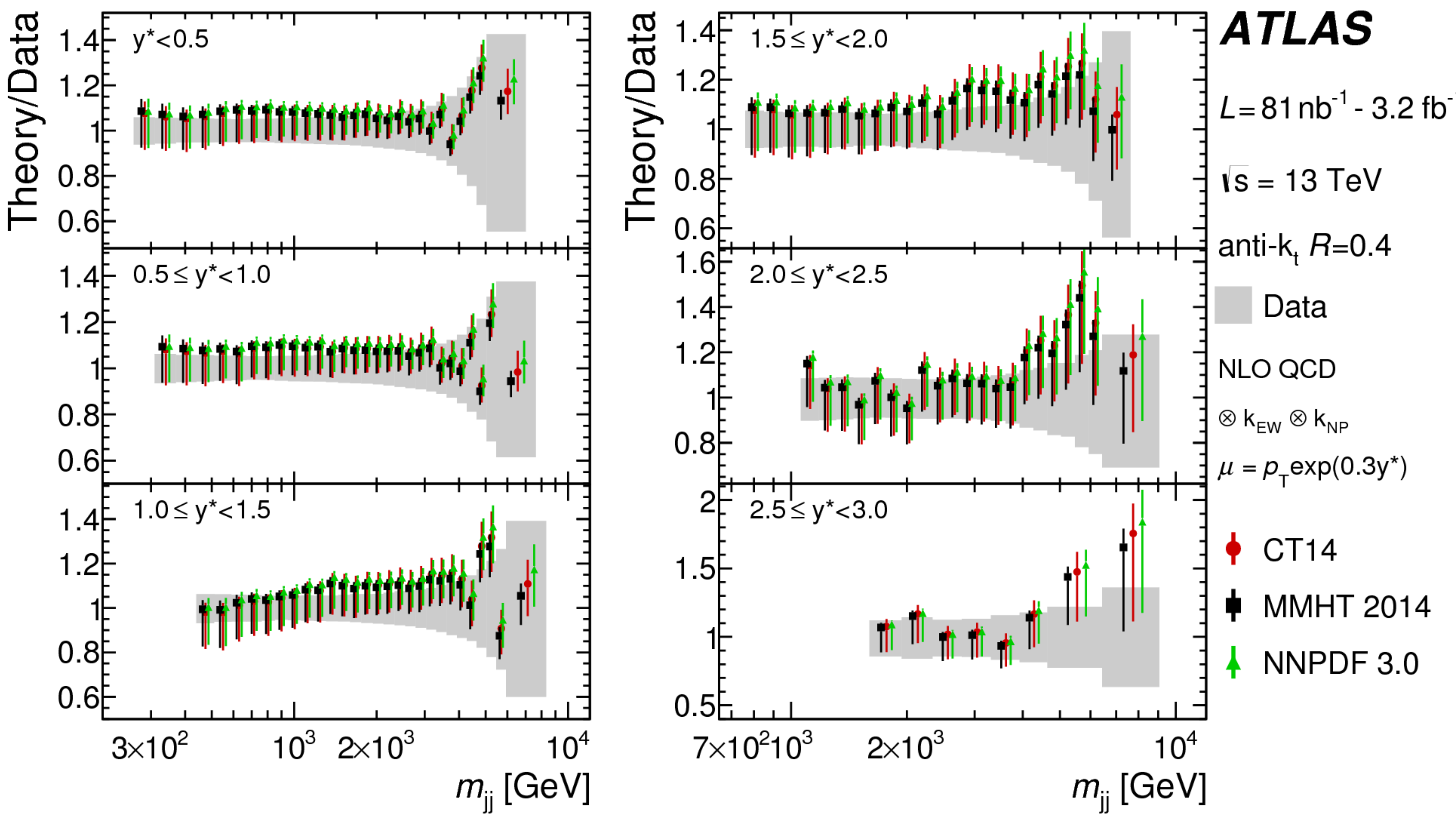
Inclusive jet cross sections: theory/data

- Good data/theory agreement within uncertainties observed for most PDF sets: CT14, MMHT 2014, NNPDF 3.0, HERAPDF 2.0, ABMP16



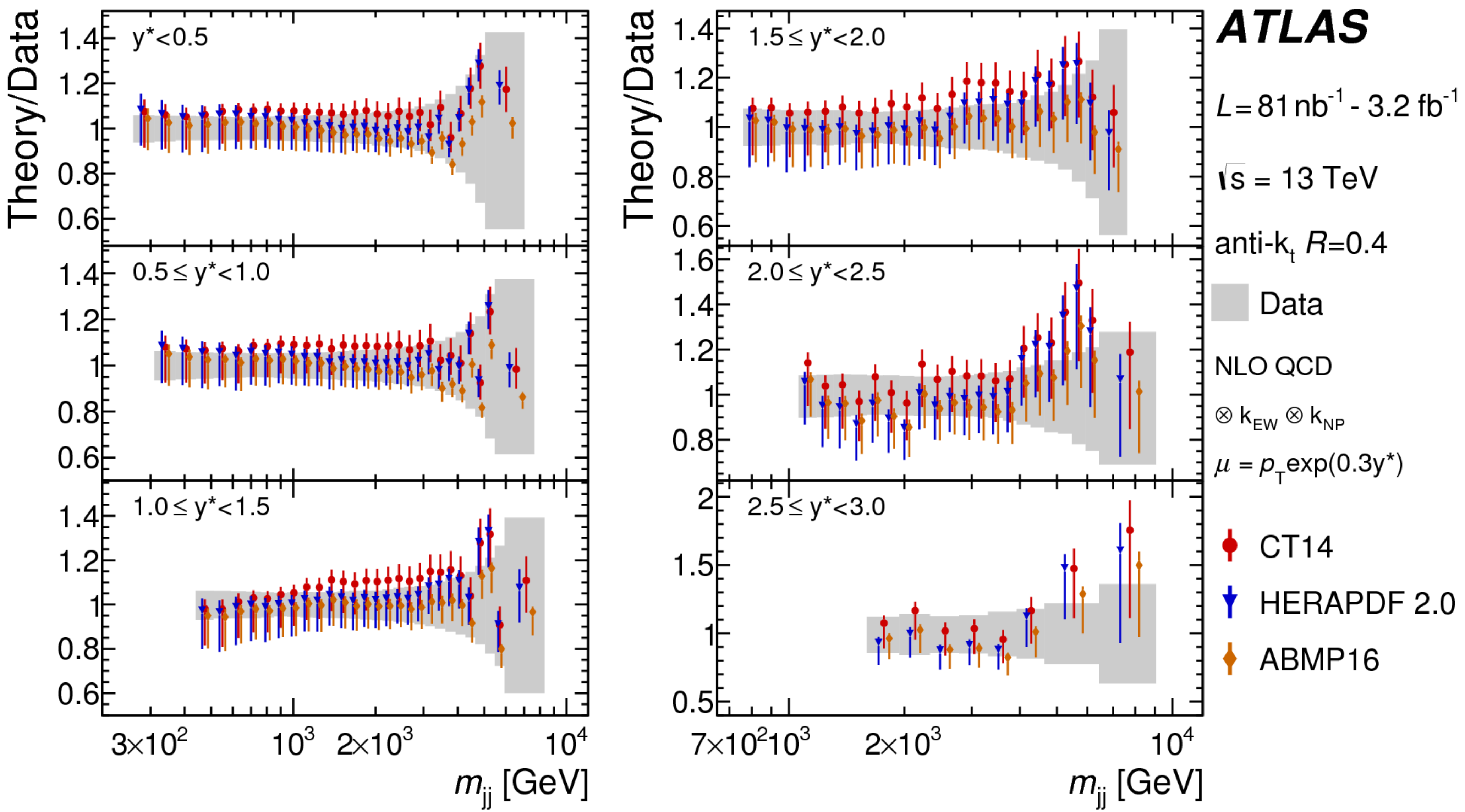
Dijet cross sections: theory/data

- Good data/theory agreement within uncertainties observed for most PDF sets: CT14, MMHT 2014, NNPDF 3.0, HERAPDF 2.0, ABMP16

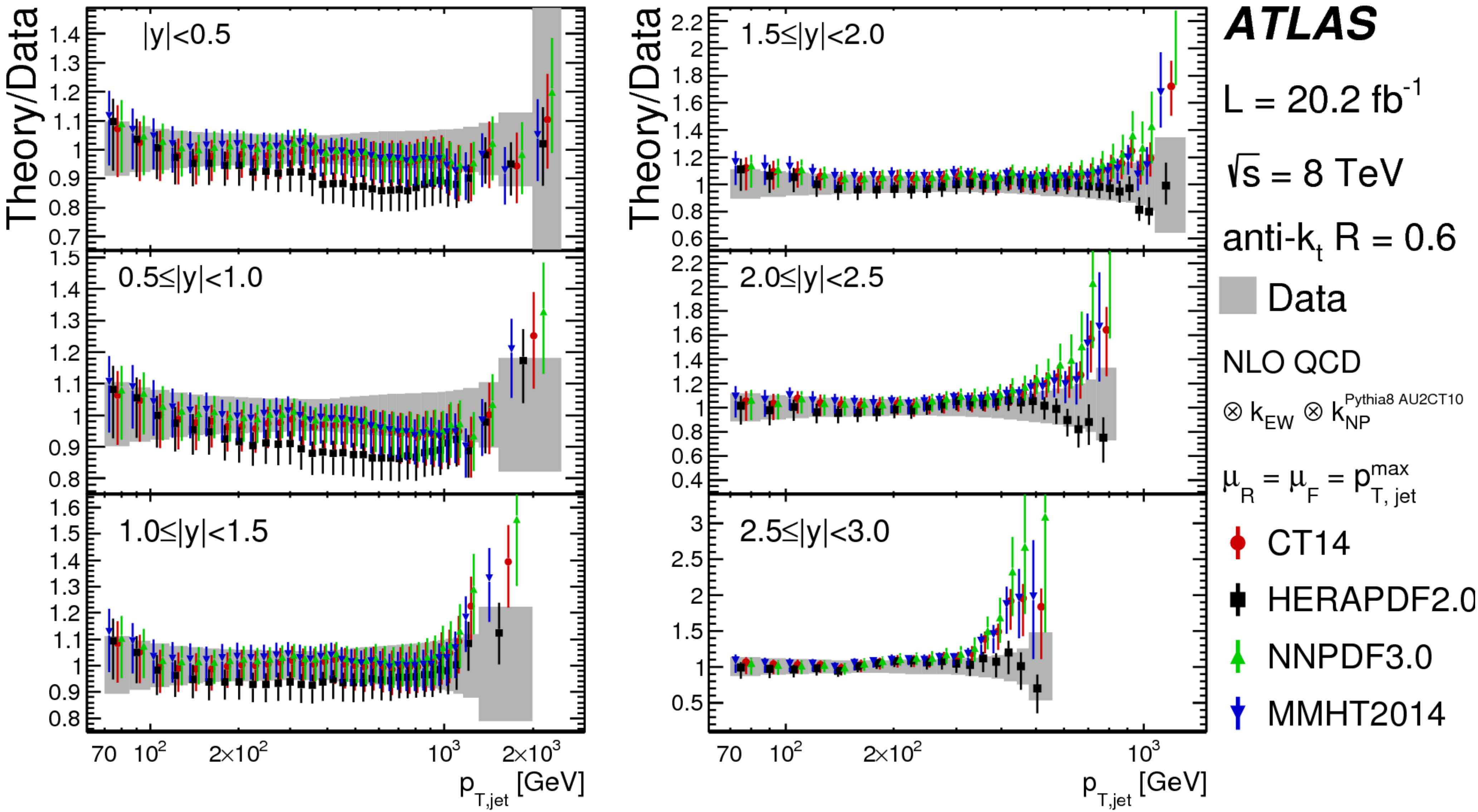


Dijet cross sections: theory/data

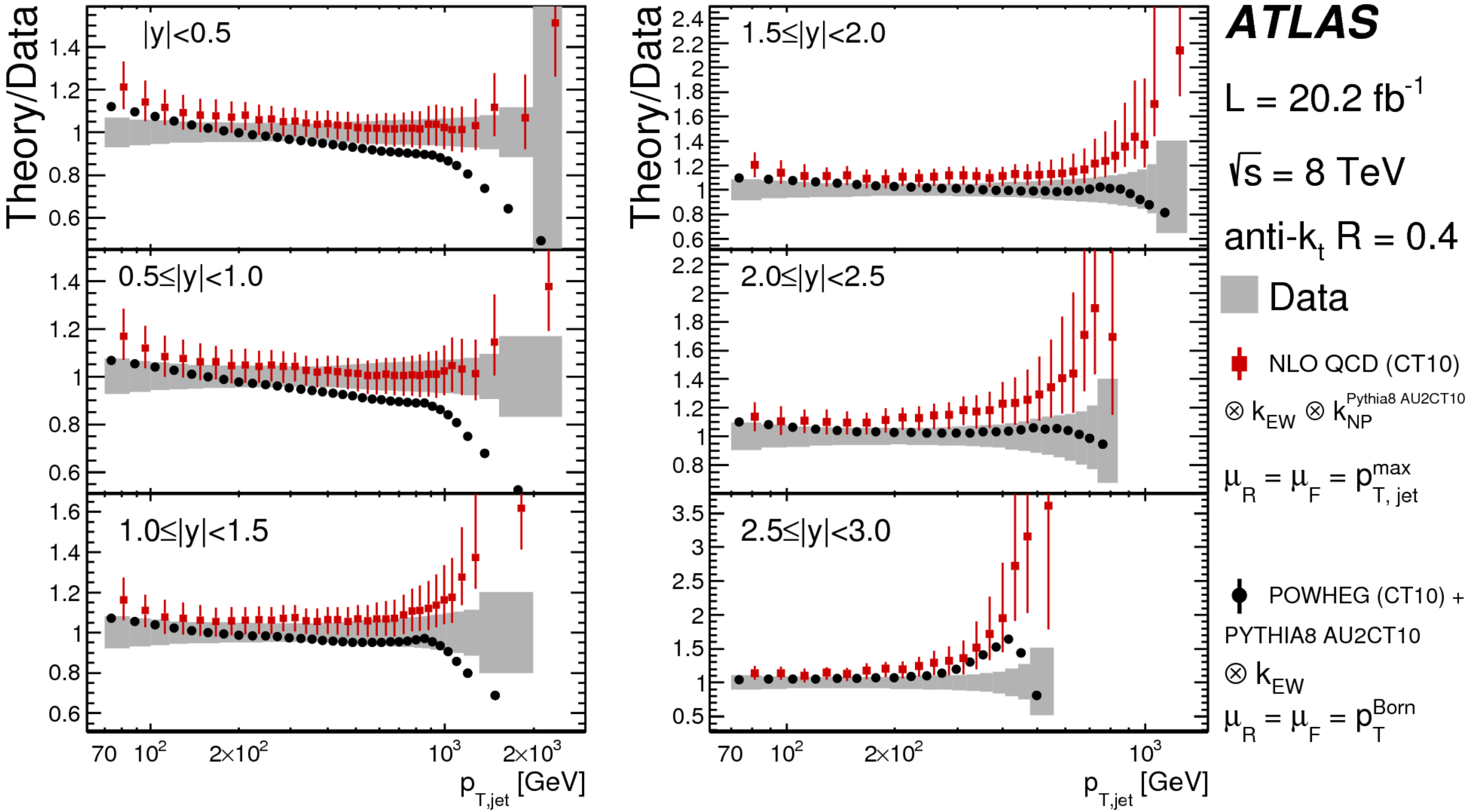
- Good data/theory agreement within uncertainties observed for most PDF sets: CT14, MMHT 2014, NNPDF 3.0, HERAPDF 2.0, ABMP16



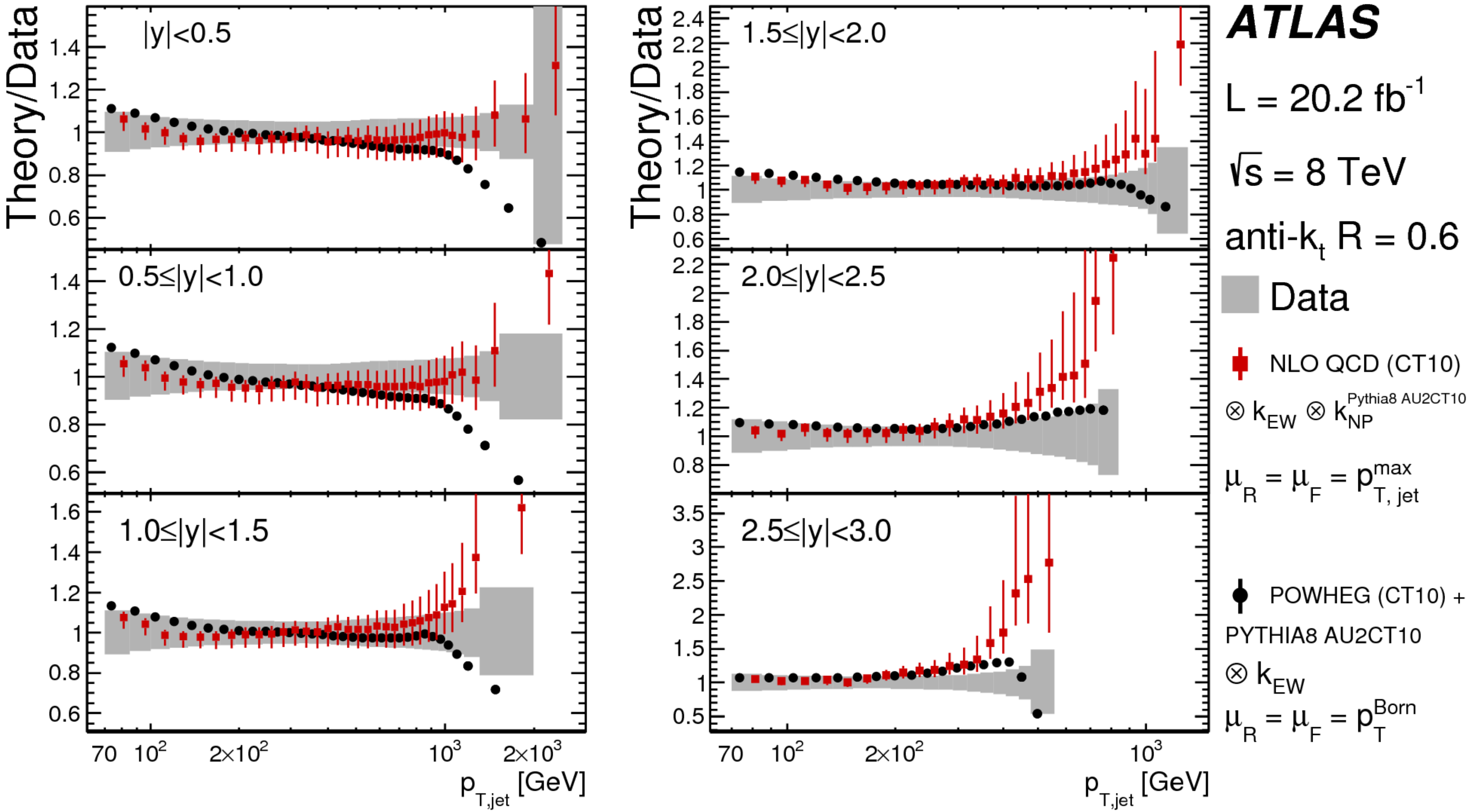
Inclusive jet cross sections at √s=8 TeV: Theory/Data



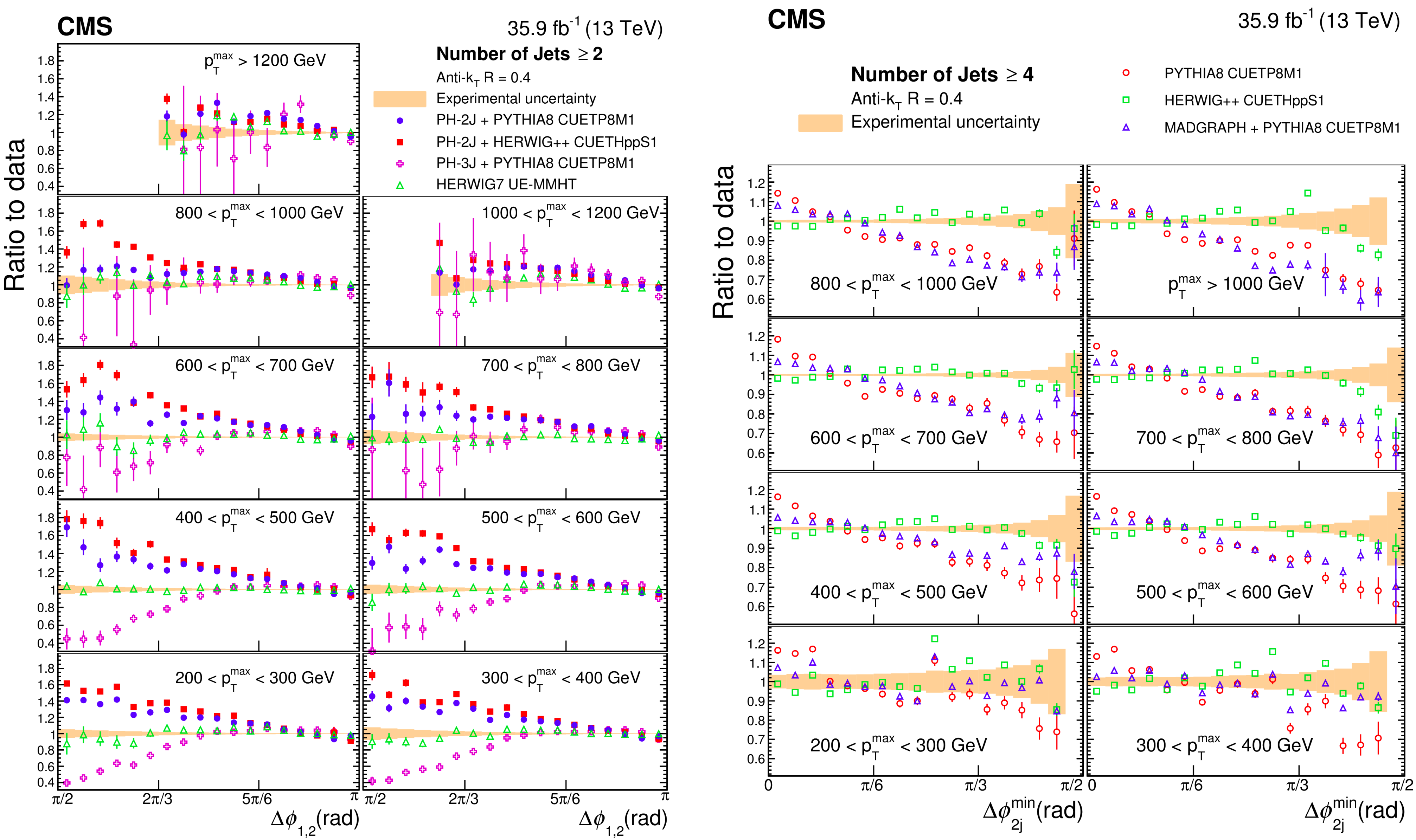
Inclusive jet cross sections at √s=8 TeV: Theory/Data



Inclusive jet cross sections at √s=8 TeV: Theory/Data



Azimuthal correlations for 2-, 3-, 4-jets by CMS



- Double differential measurements of normalized cross sections
- Level of data/theory agreement strongly depends on the generator

Quantitative comparison between data and NLO theory prediction

8 TeV – ATLAS inclusive jets (arXiv:1706.03192)

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

→ Generally good agreement for individual |y| bins

Splitting options for $R = 0.4$	CT14	NNPDF3.0
JES Flavour Response Opt 7		
JES MJB Fragmentation Opt 17		
JES Pile-up Rho topology Opt 18		
Scale variations Opt 17		
Alternative scale choice Opt 7		
Non-perturbative corrections Opt 7	268/159	257/159
JES Flavour Response Opt 7		
JES MJB Fragmentation Opt 17		
JES Pile-up Rho topology Opt 18		
Scale variations Opt 20		
Alternative scale choice Opt 17		
Non-perturbative corrections Opt 7	261/159	260/159

χ^2/ndf	$p_T^{jet,max}$ $R = 0.4$	$p_T^{jet,max}$ $R = 0.6$	p_T^{jet} $R = 0.4$	p_T^{jet} $R = 0.6$
$p_T > 70$ 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

→ Tension when including all |y| bins

Quantitative comparison between data and NLO theory prediction

13 TeV – ATLAS inclusive jets and dijets (arXiv:1711.02692)

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

→ Generally good agreement for inclusive jets for individual |y| bins

χ^2/dof all $\lvert y\rvert$ bins	CT14	MMHT 2014	NNPDF 3.0	HERAPDF 2.0	ABMP16
$p_{\mathrm{T}}^{\mathrm{max}}$	419/177	431/177	404/177	432/177	475/177
$p_{\mathrm{T}}^{\mathrm{jet}}$	399/177	405/177	384/177	428/177	455/177

→ Tension when including all |y| bins for inclusive jets

y^* ranges	CT14	MMHT 2014	NNPDF 3.0 (P_{obs})	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%
$2.0 \leq y^* < 2.5$	41%	34%	29%	3.6%	20%
$2.5 \leq y^* < 3.0$	45%	46%	40%	25%	38%
all y^* bins	9.4%	6.5%	11%	0.1%	5.1%

→ Good data/theory agreement for dijets