Recent ATLAS measurement sensitive to PDFs

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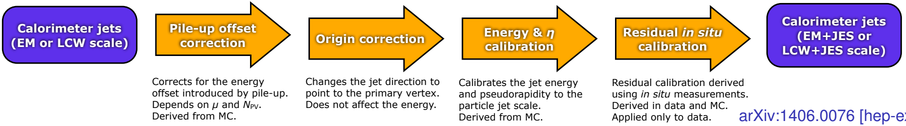
DESY

November 3, 2014

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. Simultaneous measurements of the $t\bar{t}$, WW,and $Z \rightarrow \tau\tau$ production cross-sections : AIDA
5. PDF uncertainties in W-boson mass
6. Summary

Jet measurements. JES uncertainty

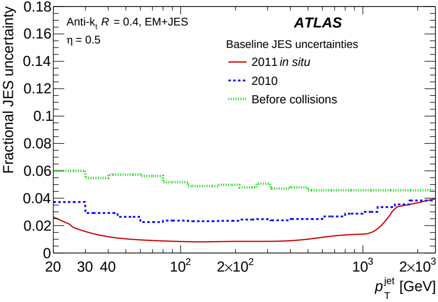


arXiv:1406.0076 [hep-ex]

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 ATLAS-CONF-2014-045

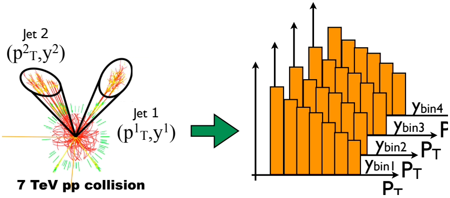
Combination of in situ measurements (Z/γ–jet, multi-jet)

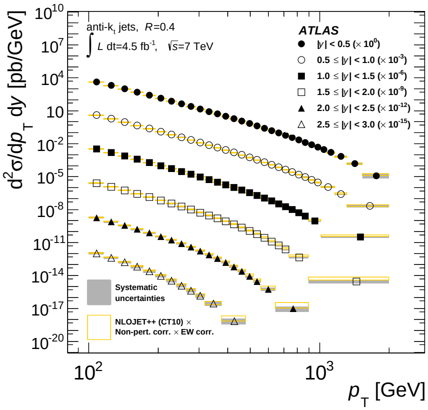


$\sim 5^{\times}$ reduction in the JES uncertainty

Jet measurements. Inclusive jet p_T

arXiv:1410.8857

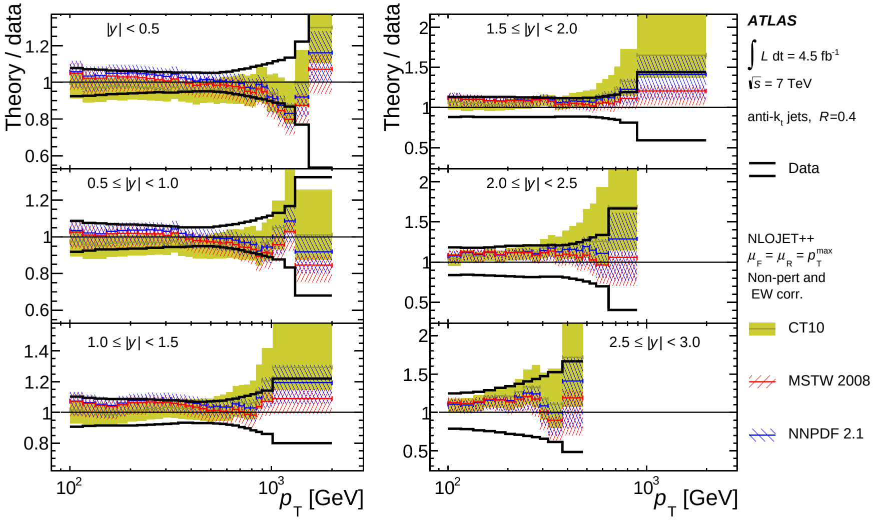




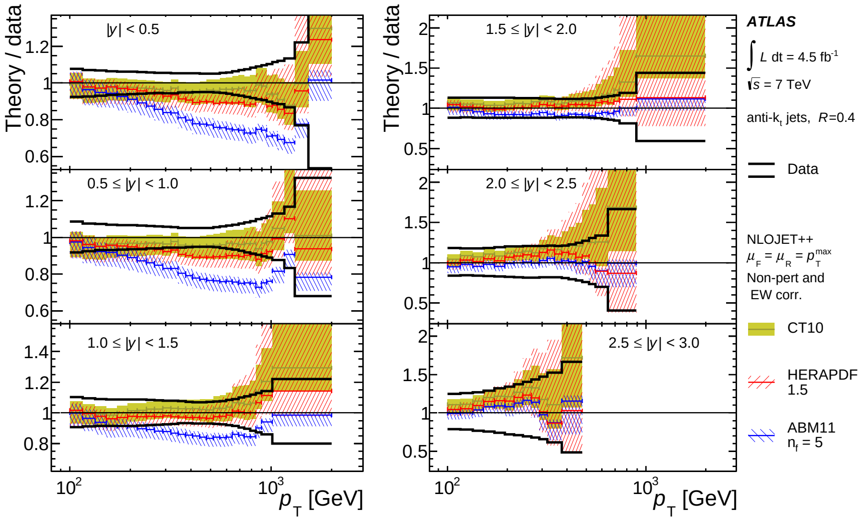
- $p_T > 100$ GeV, binned according to resolution
- $|y| < 3$, six rapidity bins, in steps of 0.5
- Theory: NLOJET++ $\times$ NPC $\times$ EW
- non-pert. correction : Pythia/Herwig with various tunes
- theory is corrected for EW effects

Good agreement between data and theory over 7 orders of magnitude

Inclusive jets. Detailed comparison to theory (I)



Inclusive jets. Detailed comparison to theory (II)



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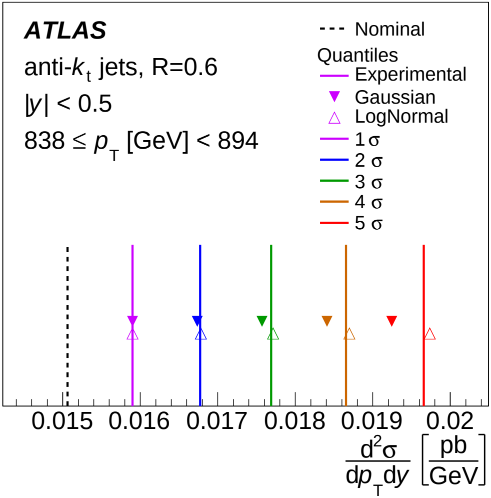
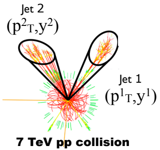
Inclusive jets. Test of gaussianity of uncertainies



Uncertainty in the energy deposited in the EM calorimeter

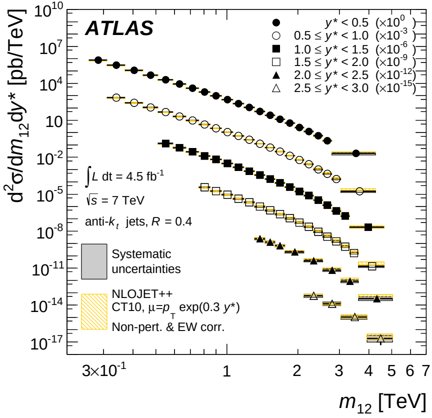
Jet measurements. Dijet mass

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

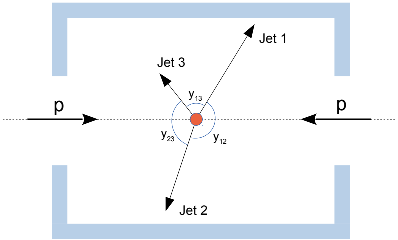


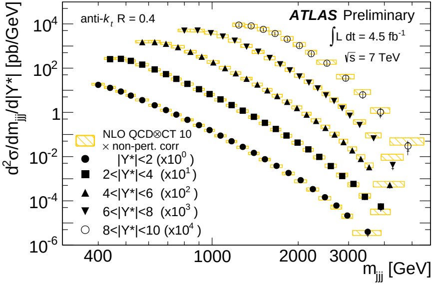
- theory is corrected for EW effects

Good agreement between data and theory over 7 orders of magnitude

Jet measurements. Three-jet mass

ATLAS-CONF-2014-045



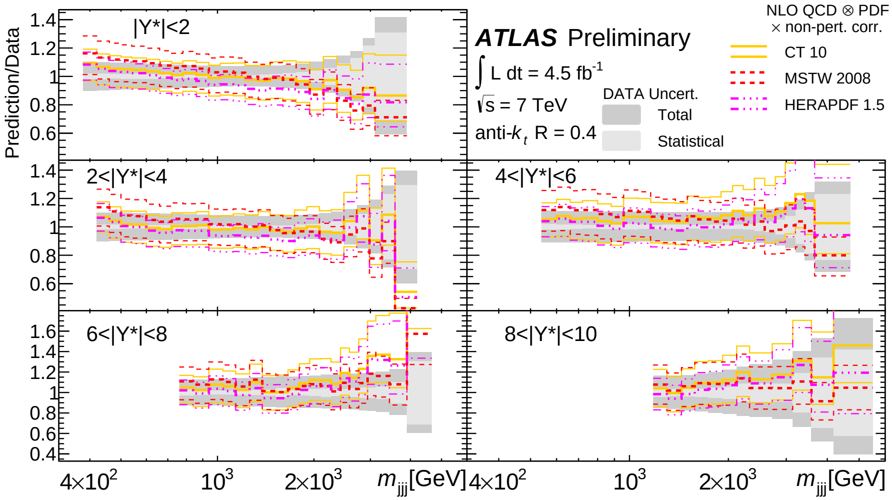


- $p_{\mathrm{T}}^1 > 150$ GeV,$p_{\mathrm{T}}^2 > 100$ GeV,$p_{\mathrm{T}}^3 > 50$ GeV, $|y^{jet}| < 3$
- $Y^* = |y_1 - y_2| + |y_1 - y_3| + |y_2 - y_3|$
- $|Y^*| < 10$, five rapidity separation bins, in steps of 2

- 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

Three-jets. Detailed comparison to theory (I)



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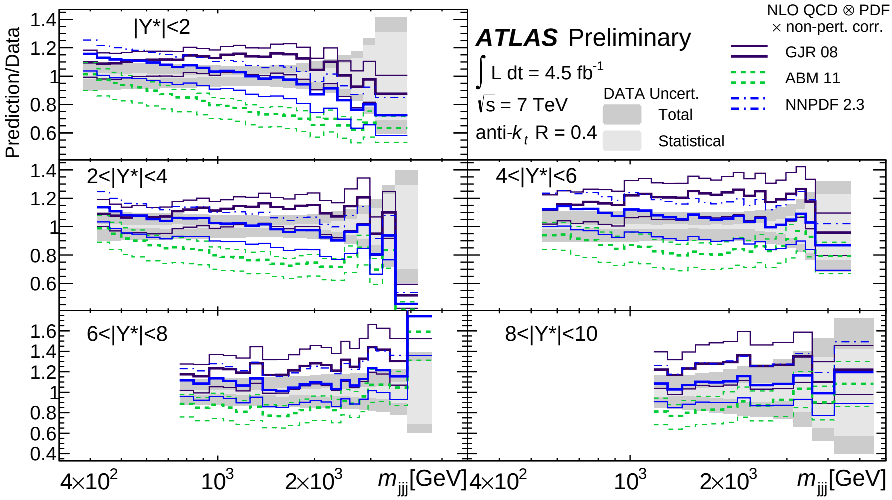
Three-jets. Detailed comparison to theory (II)



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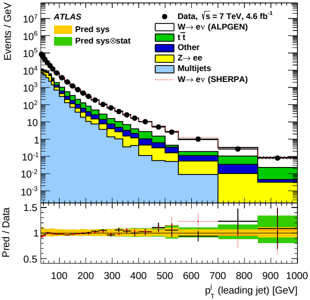
W-production in association with jets and W–jet/Z–jet ratios

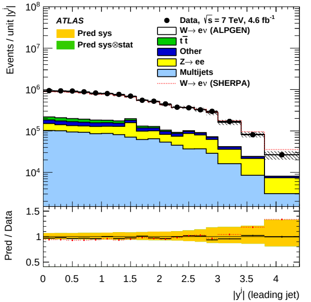
Same systematics and binning between W/Z–jets measurements allows to measure cross-section ratios $\rightarrow$ reduction of exp. uncertainties

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

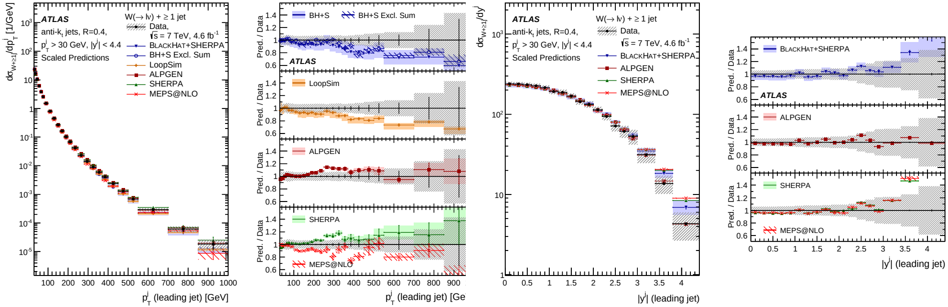
Many interesting results

Will discuss only a few examples which are the most relevant for PDFs studies





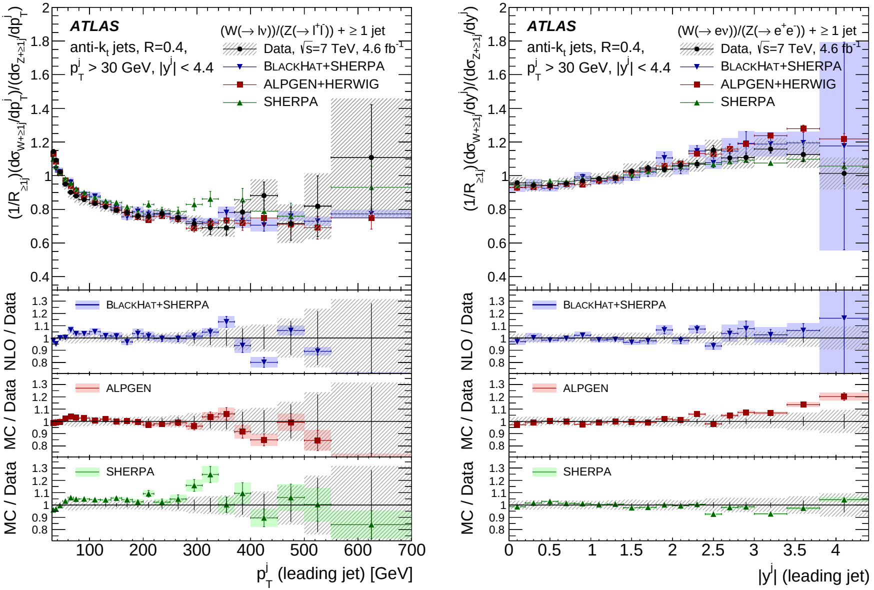
W–jet. Leading jet p_{T} and rapidity



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

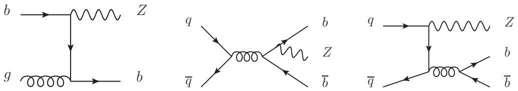
Interesting input for MC tuning PDF studies

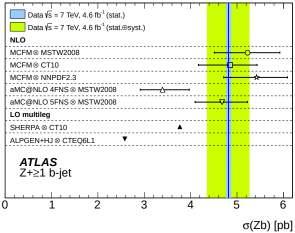
R–jet. Leading jet p_T and rapidity

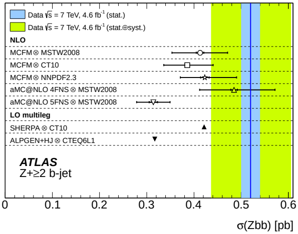


Production of Z-boson in association with b-jets

arXiv:1407.3643



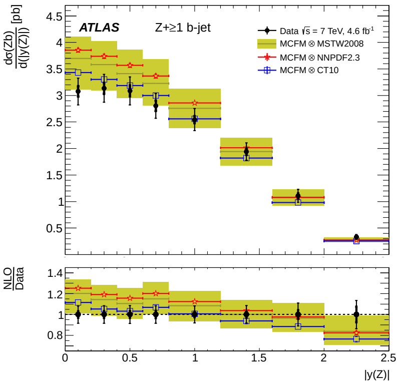


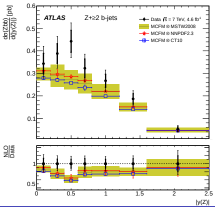


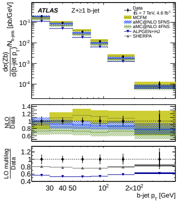
Clean experimental signature :
leptonically decaying Z + HF jet

- Allows to test the associated heavy flavour production
- Large uncertainies in theory calculations → 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
- 2b-jet channel is not very sensitive to PDFs (splitting)
- b-jet p_{T} spectrum potentially is very interesting for PDF studies (need more precise theory . . .)

Simultaneous measurements of the $t\bar{t}$, WW,and $Z \rightarrow \tau\tau$ production cross-sections : AIDA

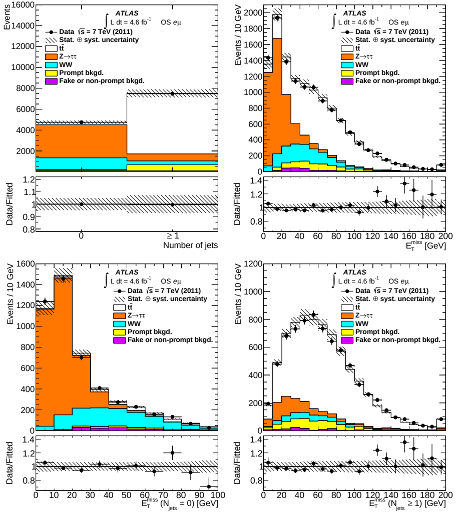
arXiv:1407.0573

High accuracy in theoretical prediction $\rightarrow$ good experimental test

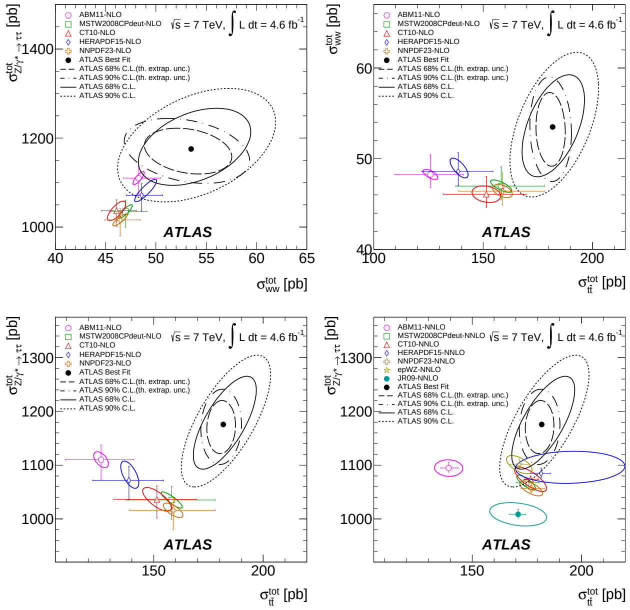
- Study of the common final state ($e\mu$)-events
- two-dimensional parameter space ($E_{\mathrm{T}}^{\mathrm{miss}}$, N_{jets})

Allows to "see" correlation between cross-section induced by a use of common PDFs in MC

measurements are consistent with dedicated analyses



AIDA results. Total cross-section



Fiducial results are corrected to the total phase-space

- NNLO calculations describe data much better than NLO
- scale uncert. @NLO is the dominant source
- PDF uncert. @NNLO is the dominant source

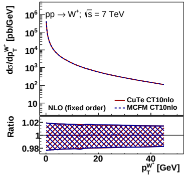
NLO - MCFM

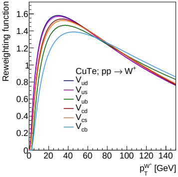
NNLO - FEWZ, TOP++

PDF uncertainties in W-boson mass

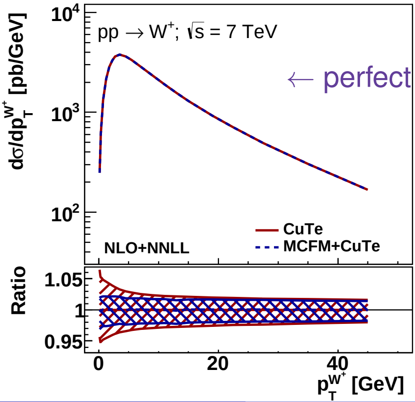
ATL-PHYS-PUB-2014-015

pure NLO





Flavour-dependent reweighting



← perfect match

The extraction of m_W from the p_{T}^{ℓ} spectrum, is likely to be limited by theoretical uncertainties

This study addresses

- u and d PDF uncertainties on the average W polarisation
- strange PDF uncertainty on the charm-initiated W-production
- impact of the muon momentum resolution on the PDF uncertainties

TOOLS:

- MCFM (W-jet LO, finite width, leptonic decay, spin correlations)
- CuTe (NLO+NNLL, ZWA, no decay)

→ need to combine two tools

- Dedicated PDF set : HERA I data, $m_{ch} = 1.38$ GeV, $m_b = 4.75$ GeV, $m_t = 3.5$ TeV, $r_s = \bar{s}/\bar{d} = 1$, $Q_0^2 = 1.7$ GeV^2 13p→26 hessian errors, 4 model vars :m_{ch} ↕, r_s ↕

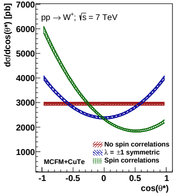
Methodology

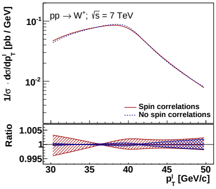
Event selection

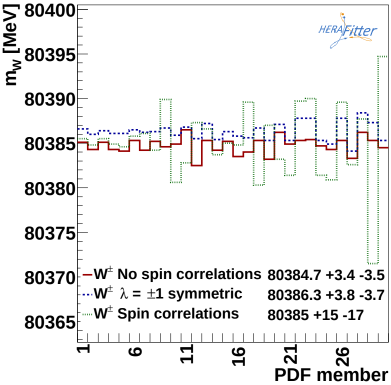
- $|\eta^{\ell}| < 2.4$
- $p_{\mathrm{T}}^{\nu} > 30\ \mathrm{GeV}$
- $M_T > 60\ \mathrm{GeV}$
- $30 < p_{\mathrm{T}}^{\ell} < 50\ \mathrm{GeV}$

- Test sample: normalised p_{T}^{ℓ} spectrum with $M_W = 80.385\ \mathrm{GeV}$. Stat. uncert. corresponds to $5\mathrm{fb}^{-1}$
- Set of p_{T}^{ℓ} templates as a function of M_W
- calculate χ^2 profile and fit it with parabolic function to get minima and uncertainty

W-polarisation

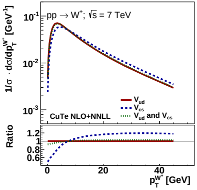


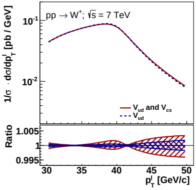


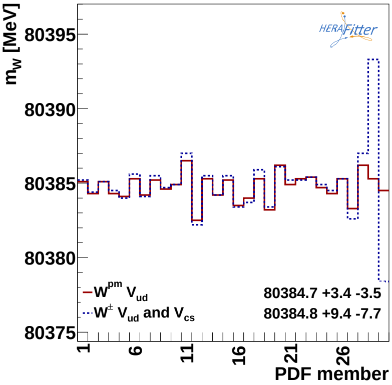


- The uncertainty on the u and d valence and sea PDF translates into an uncertainty in the average W polarisation, which affects the p_{T}^{ℓ} distribution
- Disentangle the impact of polarisation: Keep only u and d quarks
  1. Randomise decay angle of leptons in th W rest frame
  2. Sign flip to the lepton momentum
  3. Full spin correlations
- Dramatic shrink of PDF uncert. with spin corr. off
  - ~ 20 MeV in W^+ (mostly r_s); ~ 25 MeV in W^- (many); ~ 15 MeV for $W^\pm$ due to some cancellations

Charm quark and strange PDF







- A charm-initiated production changes the W kinematics
- Disentangle the impact of the charm: Randomise decay angle of leptons
  1. Switch between configurations with only light quarks, only charm and standard mix
- Dramatic shrink of PDF uncert. without initial state charm
  - $\sim 3(6)$ MeV in $W^+(W^-)$ increases to $\sim 8(10)$ MeV in $W^+(W^-)$. (mostly r_s)

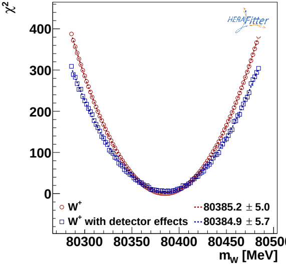
Total PDF uncertainies

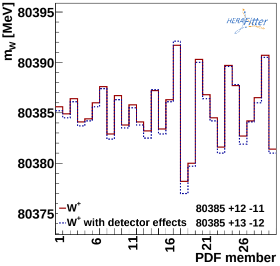
- 12(20) for $W^+(W^-)$
- 10 for $W^\pm$

There is some cancellation of uncertainies for the combination of polarisation and charm-induced effects.

Detector effects (muon p_T)

Muon p_T is smeared according to (arxiv:1404.4562)





PDF uncert. increases by $\sim$ 10%

SUMMARY of PDF uncertainties

	MW-NLO	CT10nlo	MSTW2008CPdeutnlo	NNPDF30_nlo_as_118
W^+	+13 -12	+18 -22	+11 -10	+8 -10
W^-	+22 -22	+18 -23	+11 -10	+8 -9
$W^\pm$	+11 -11	+14 -18	+7 -7	+6 -5

- reasonable uncert. for the dedicated PDF set
- W^- : larger uncert. due to limited constraining power of HERA I data

SUMMARY of biases

	MW-NLO	CT10nlo	MSTW2008CPdeutnlo	NNPDF30_nlo_as_118
W^+	-9	-0.1	-20	-1.2
W^-	+48	+0.2	+13	+12
$W^\pm$	+16	0.0	-6	+5

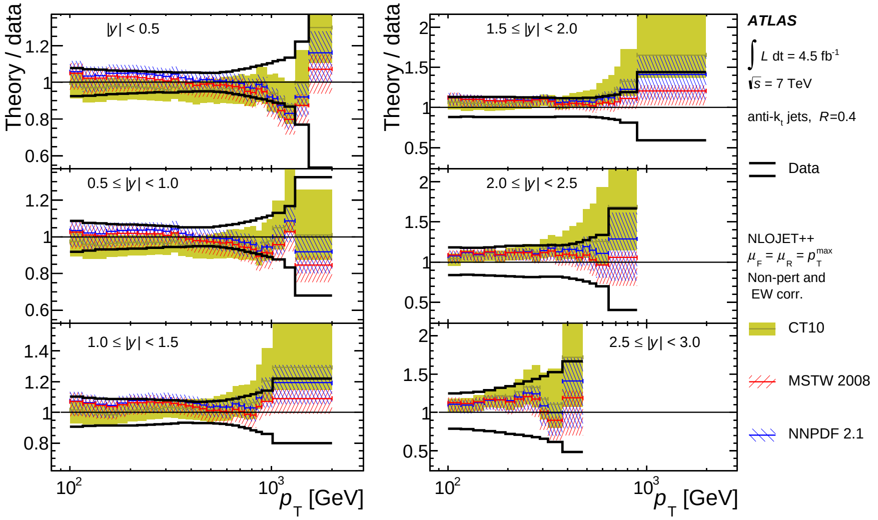
- very large bias for the dedicated PDF set
- charge dependent analysis brings considerable improvement in the PDF uncertainies

Summary

- Three new jet cross-section measurements at 7 TeV are presented : provide constraints on gluon PDF and α_s
- *W*–jets and *R*–jets : new observables for MC tuning and PDF analysis
- *Z*-b-jets : provide constraints on the *b*-quark PDF
- AIDA analysis : broader test of the Standard Model
- Theoretical uncertainties in *W*-boson mass are studied

Back-up

Inclusive jets. Detailed comparison to theory (I)



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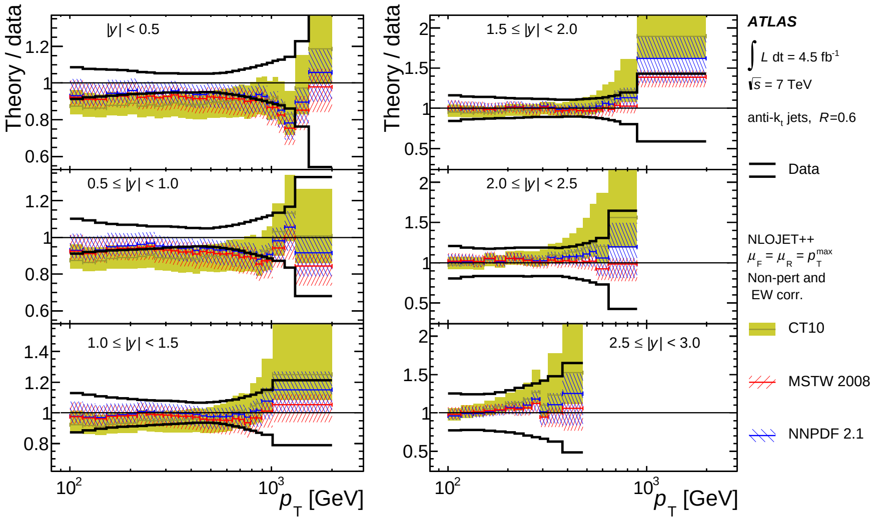

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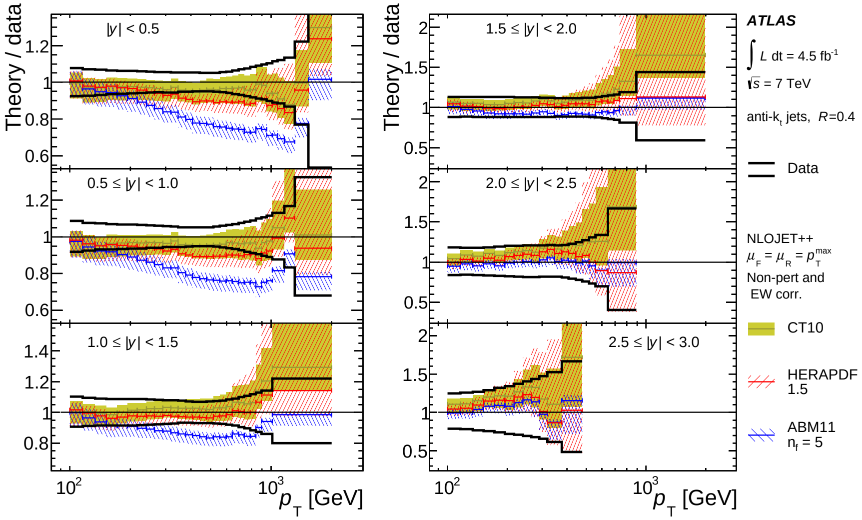

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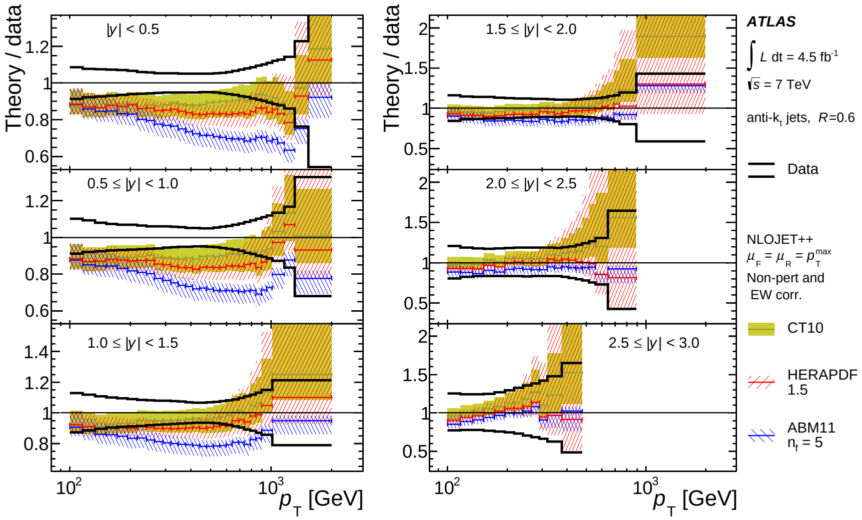

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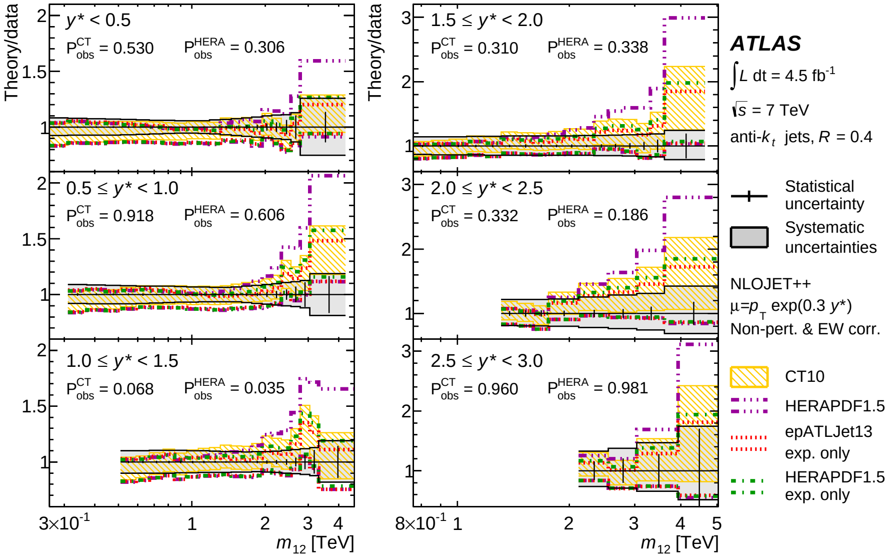
Dijets. Detailed comparison to theory (I)



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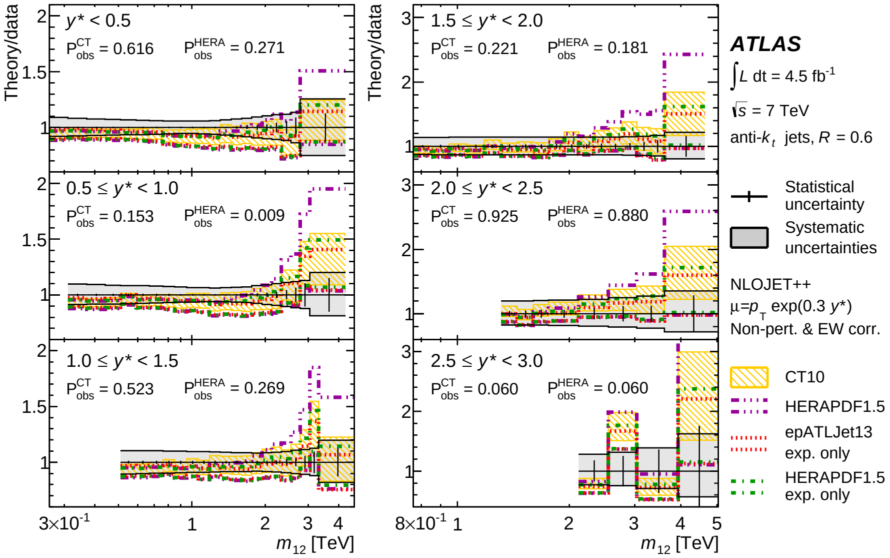

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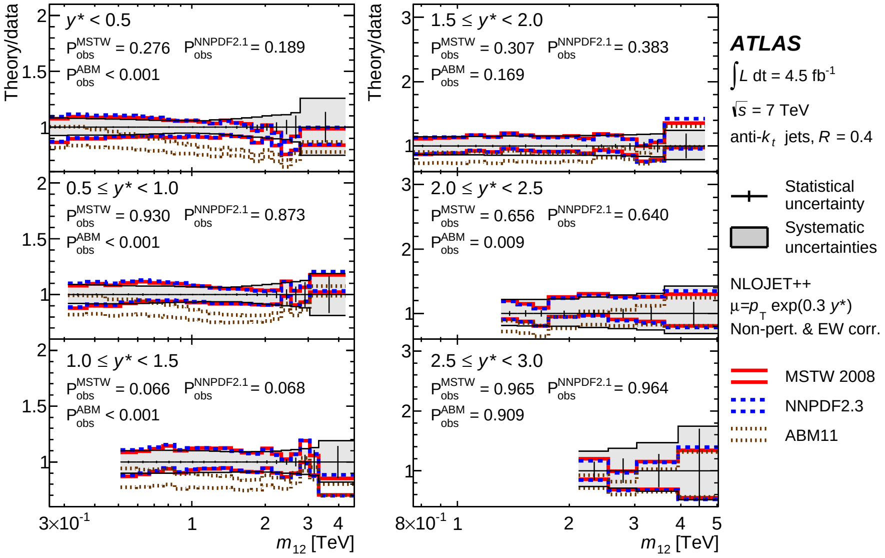

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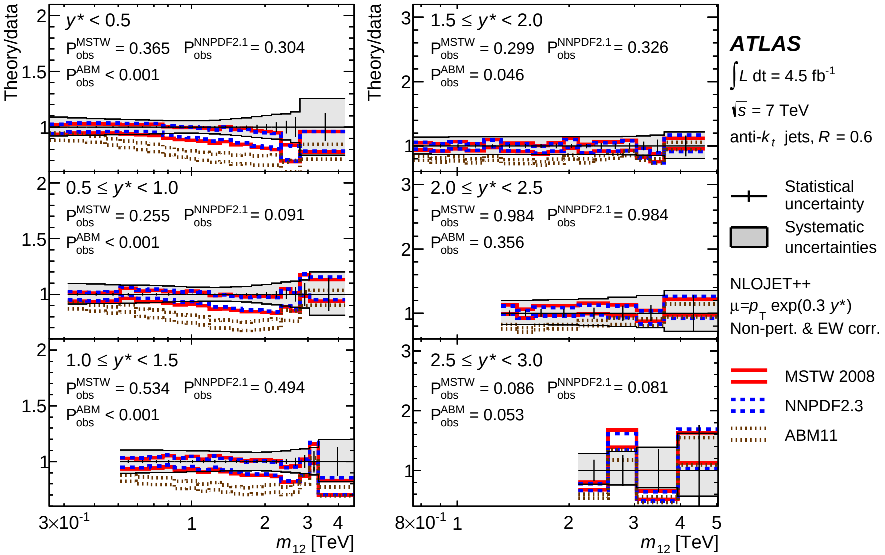

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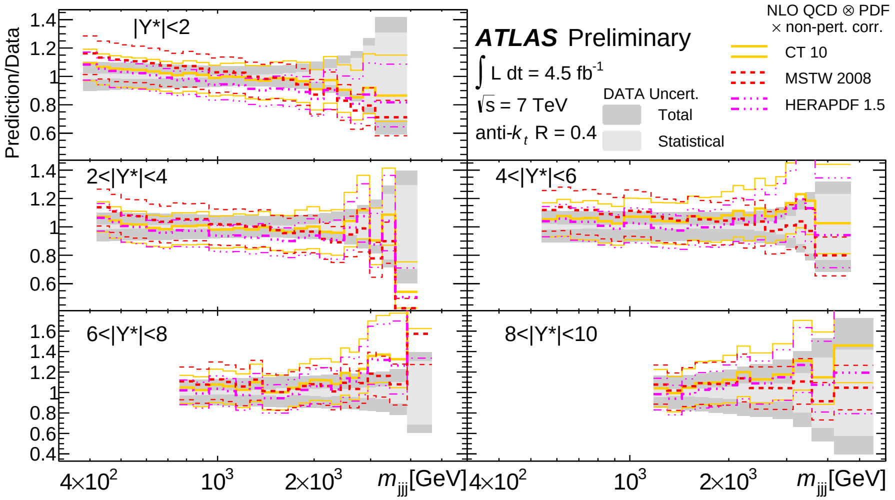

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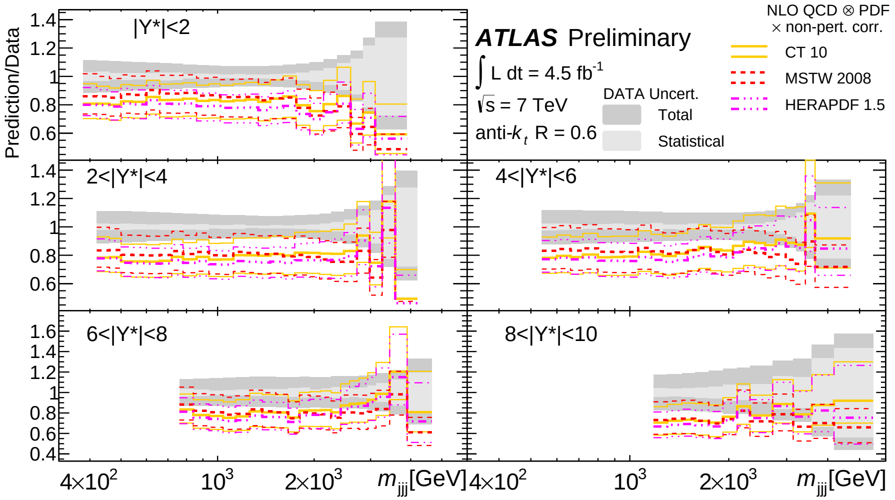

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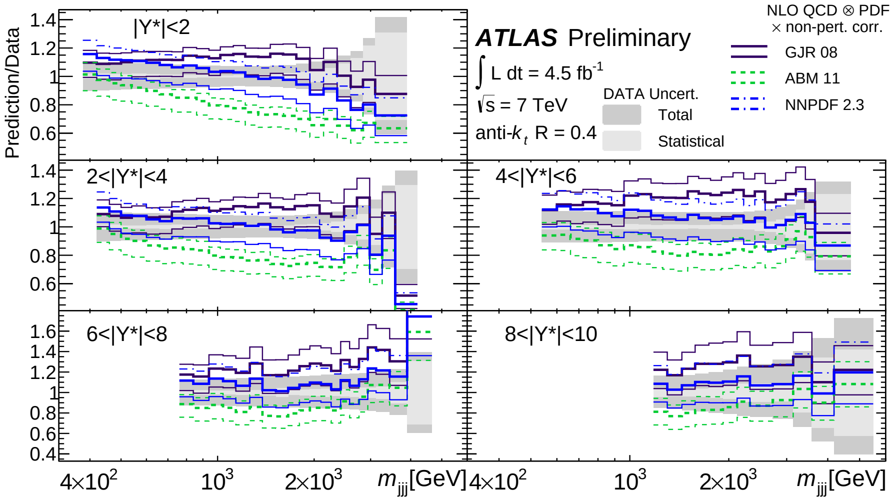

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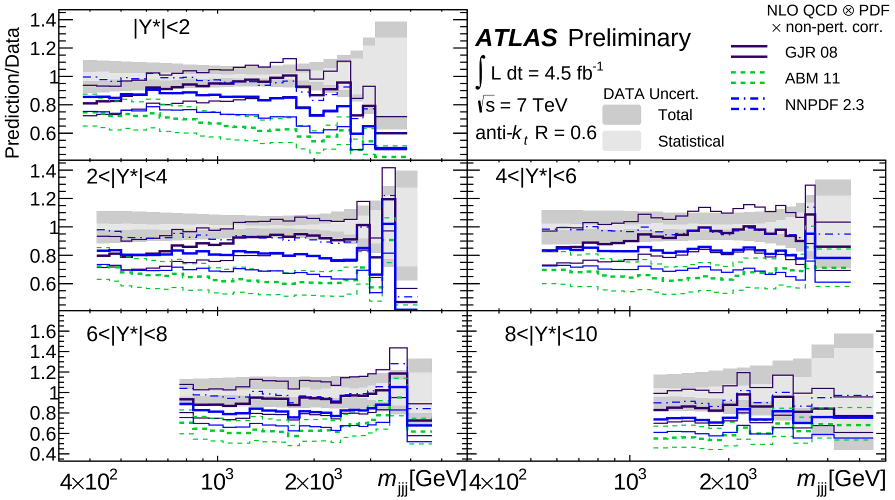

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