Recent V + heavy flavour measurements with 13 TeV data

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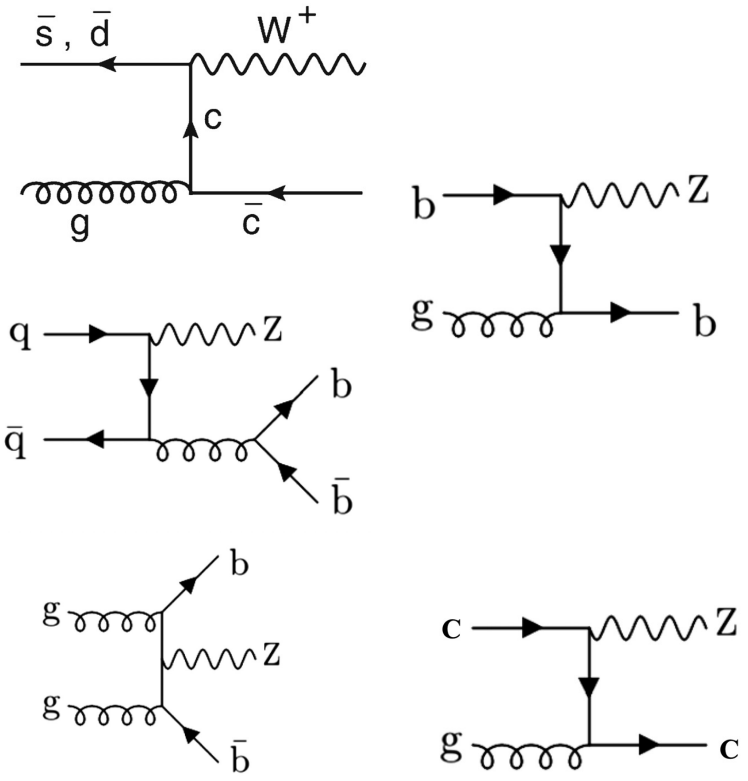
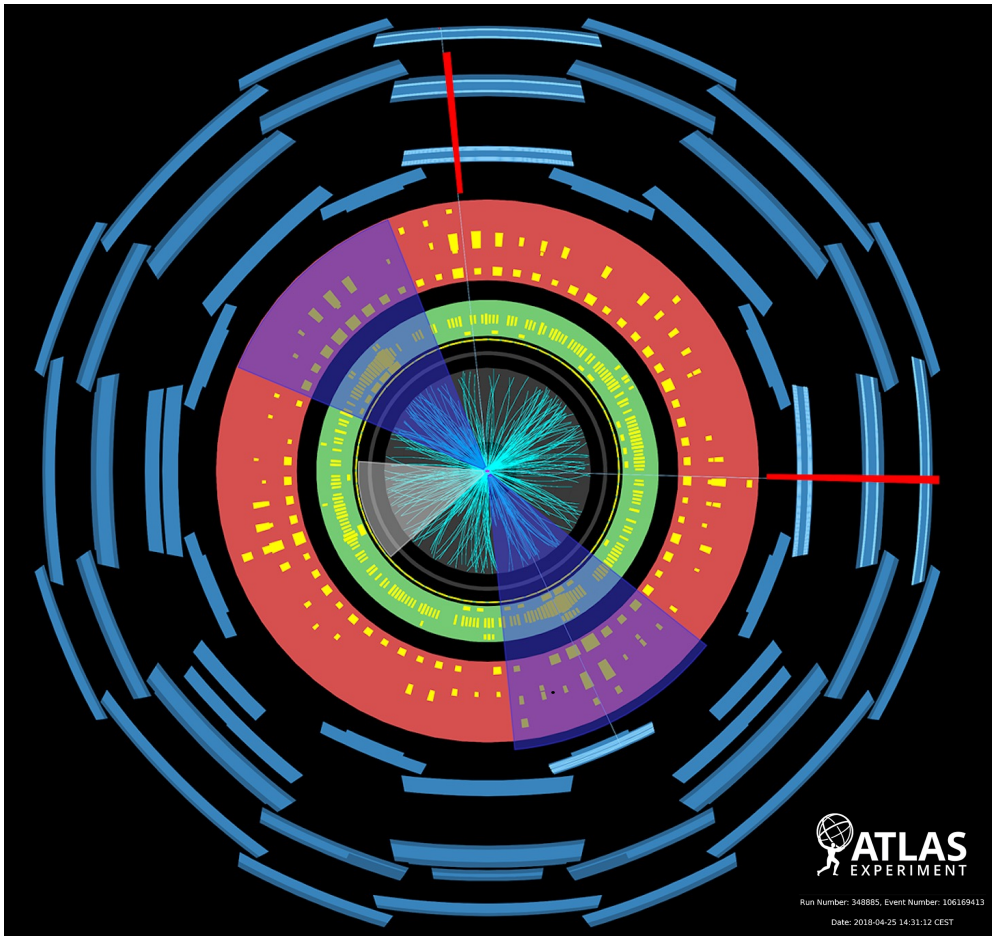
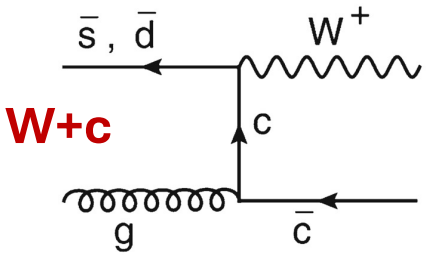
On behalf of ATLAS, CMS and LHCb



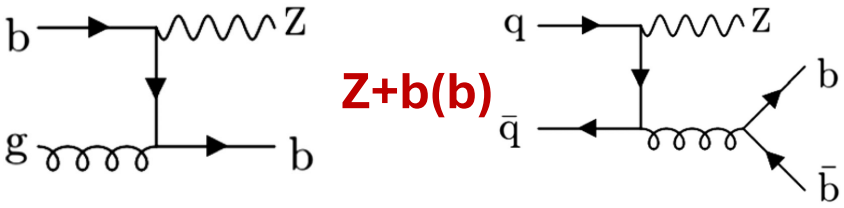


Recent V + heavy flavour measurements with 13 TeV data

Recent: ATLAS: Measurement of associated production of a **W boson and a charm** quark in pp collisions at $\sqrt{s}$= 13 TeV, Phys. Rev. D 108 (2023) 032012



Recent: CMS: Measurement of the production cross section for a **W boson in association with a charm** quark in pp collisions at $\sqrt{s}$ = 13 TeV Eur. Phys. J. C 84 (2024) 27



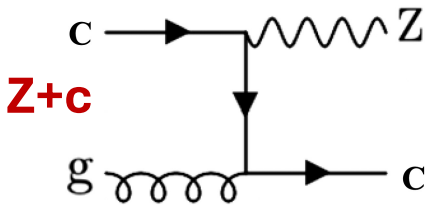
CMS: Measurement of the production cross section for **Z+b jets** in proton-proton collisions at $\sqrt{s}$ =13TeV, Phys. Rev. D 105 (2022) 092014

NEW: ATLAS: Measurements of the production cross-section for a **Z boson** in association with **b- or c-jets** in pp collisions at $\sqrt{s}$=13 TeV with the ATLAS detector, arXiv:2403.15093

CMS: Measurement of the associated production of **a Z boson with charm or bottom** quark jets in pp collisions at $\sqrt{s}$ =13TeV, Phys. Rev. D 102 (2020) 032007

LHCb: Study of **Z bosons** produced in association with **charm in the forward region**, Phys. Rev. Lett. 128 (2022) 082001

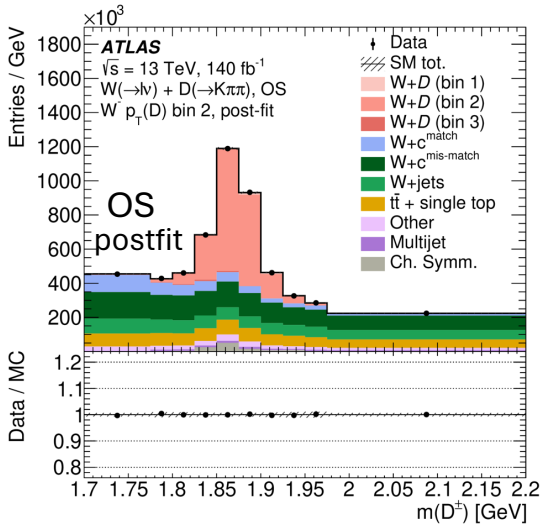
CMS: Measurement of differential cross sections for **Z bosons** produced in association with **charm jets** in pp collisions at $\sqrt{s}$ = 13 TeV, JHEP 04 (2021) 109

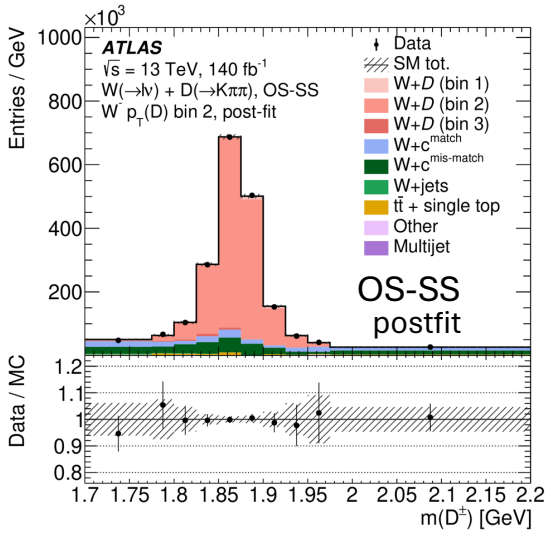


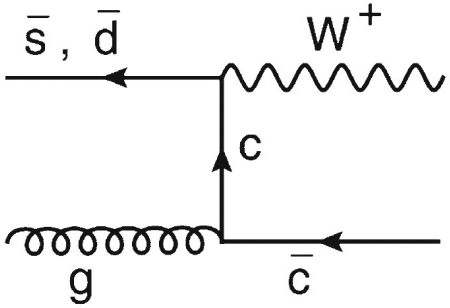
W+charm production at CMS and ATLAS

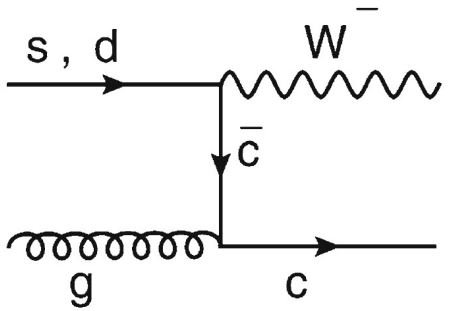
- Excellent probe of the strange quark PDF –

- $W^{\mp}$ with $\boldsymbol{D}^{\pm}$ or $\boldsymbol{D}^{*\pm}$ (ATLAS), $\mathbf{c-tagged\ jet}$ (CMS)
- Signal extracted as OS (Sig+Bak) – SS (Bak)
- Uncertainty systematics limited 4-5%
- Inclusive and differential in p_T and η, charge ratio







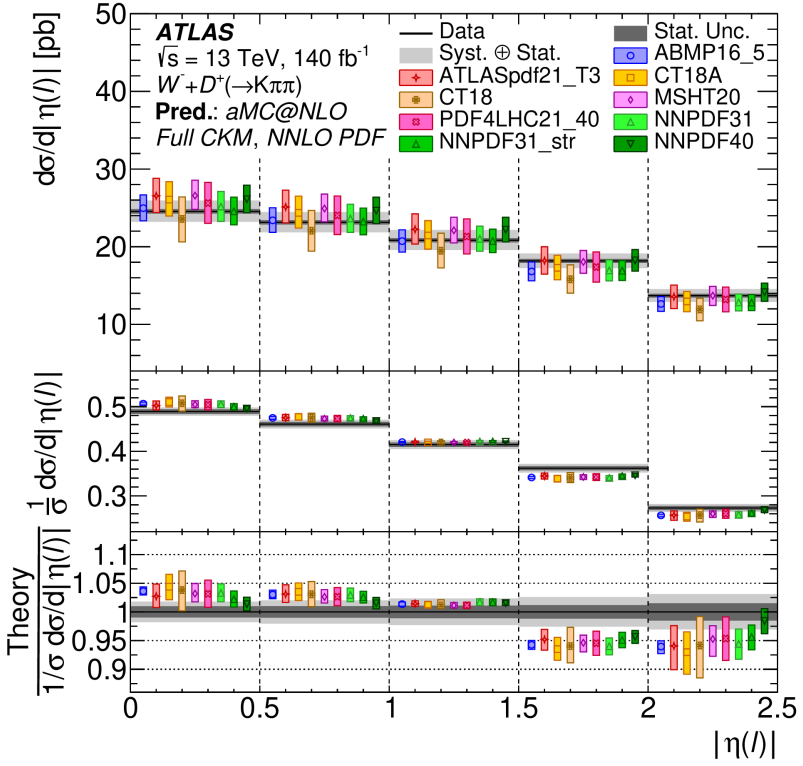


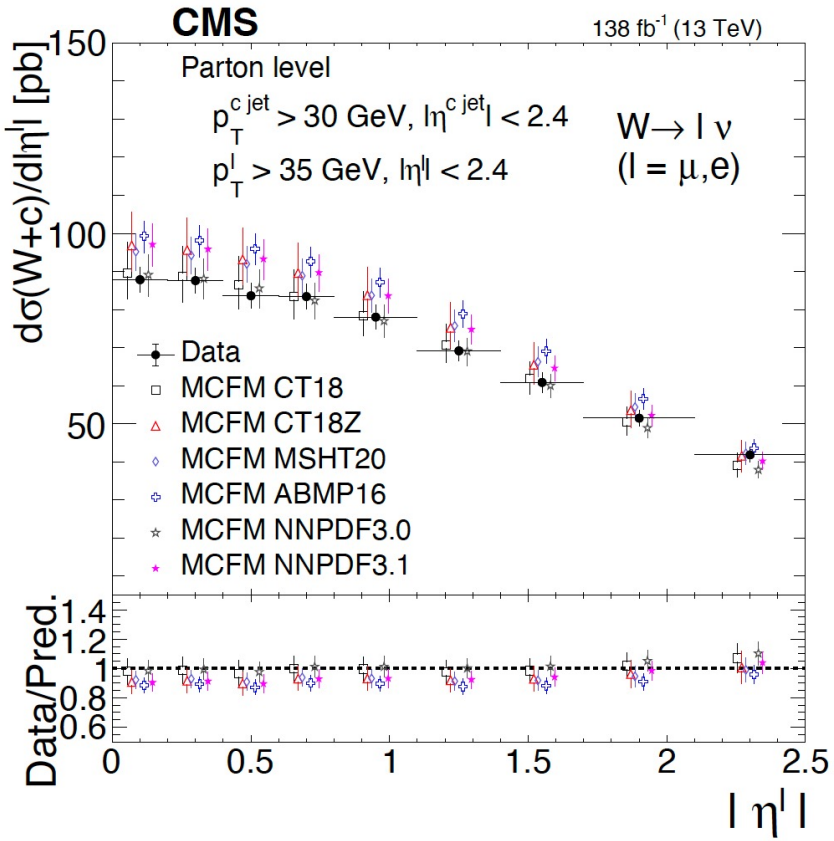
ATLAS: 140/fb
Phys. Rev. D 108 (2023) 032012

CMS: 138/fb,
Eur. Phys. J. C 84 (2024) 27

W+charm production at CMS and ATLAS: η dependence

- Differential cross-sections in bins of $\eta(\ell) \rightarrow \bar{s},s$ PDF



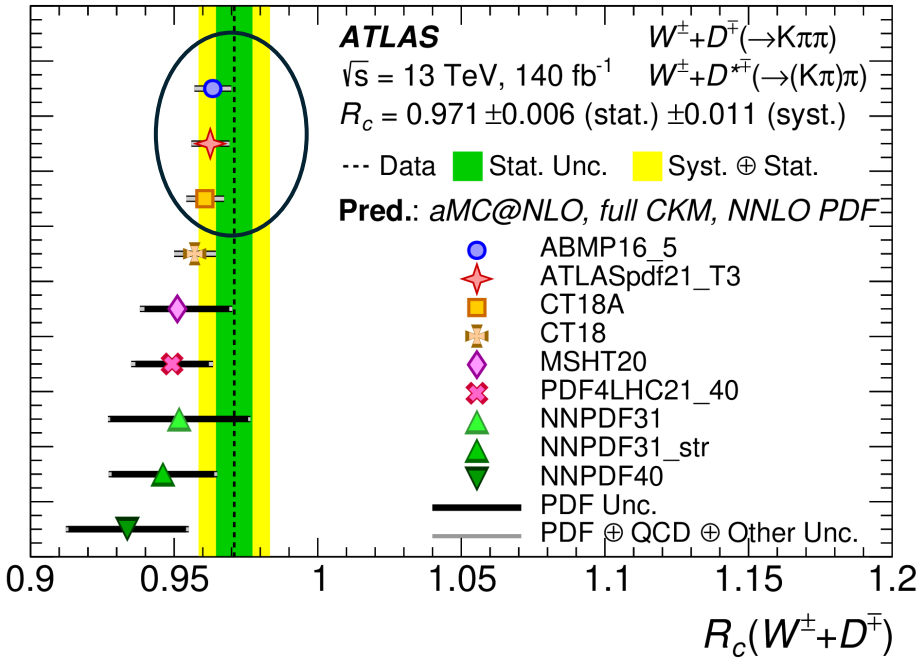


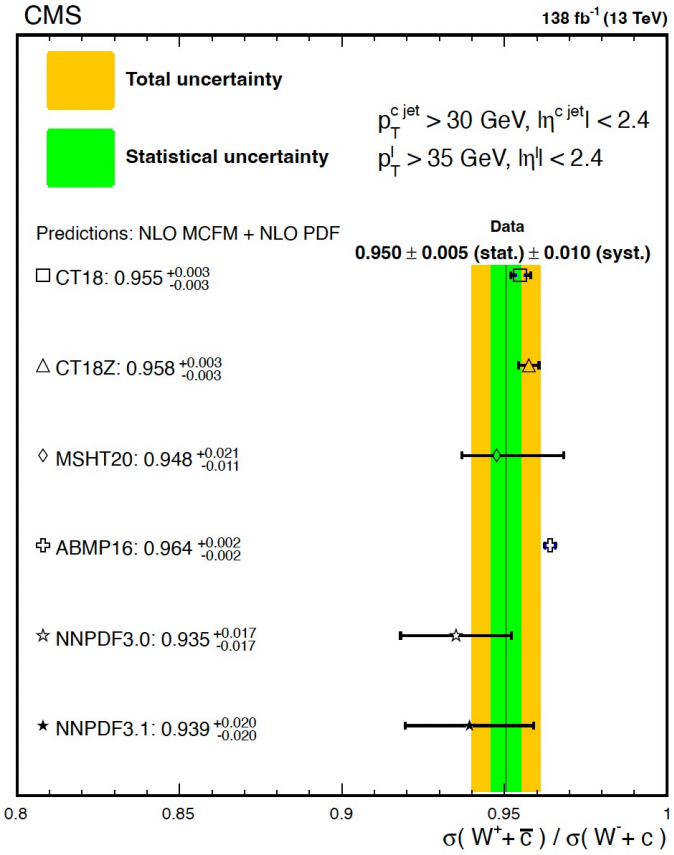
ATLAS: Data with broader η distribution than nominal MG5_aMC@NLO predictions but consistent when including PDF uncertainties

CMS: Similar trend. Data in agreement with MCFM within total uncertainties.

W+charm production at CMS and ATLAS: Charge ratio

- *W* charge ratio $R_c = \sigma W^+\bar{c} / \sigma W^-c \rightarrow$ sensitive to differences between s and $\bar{s}$ PDFs. Reduced 1 % uncertainties. CMS measured R_c also differentially in p_T and η





ATLAS: Better agreement with PDF fits that constrain the strange-quark sea to be symmetric at the starting scale: ABMP16 and CT18

↔

CMS: Data consistent with all PDF

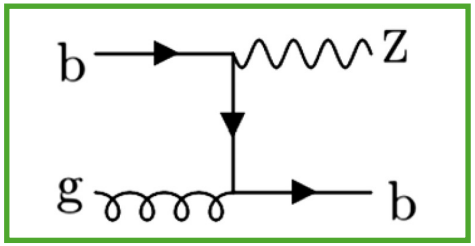
Z+b(b) measurements with 13 TeV data

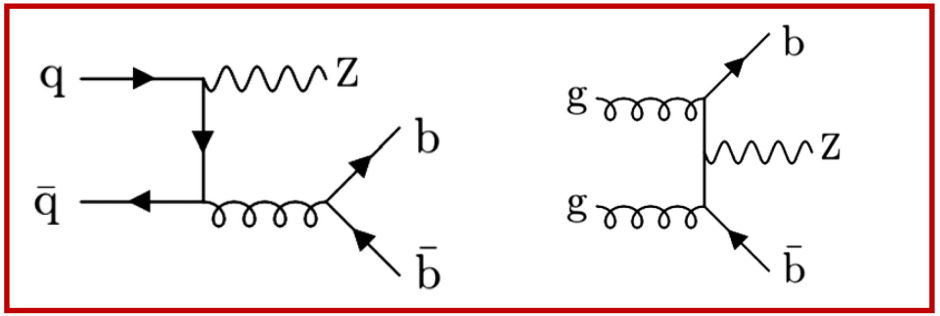
- Flavour/mass schemes, pQCD, IRC-safe b-jets, PDF -
Important background for VH($\rightarrow bb$) and BSM searches

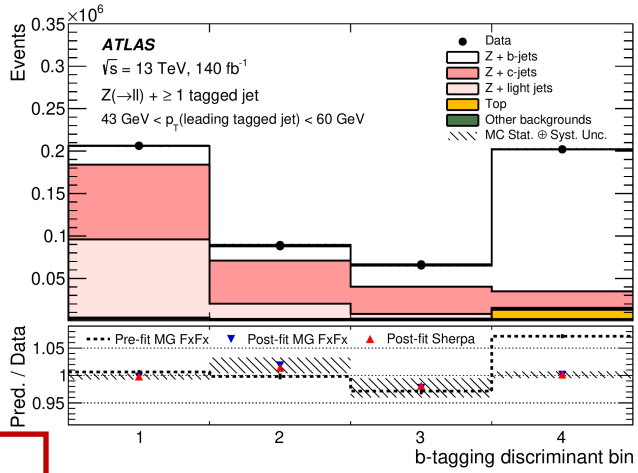
- Final states: Z + $\geq 1B$-jet, Z + $\geq 2B$-jets, p_TB > 20 GeV (ATLAS) ↔ 30 GeV (CMS)
- Backgrounds: Z+ c/l (→ SF), top (→ eμ CR)
- Theory: 5F NLO multi-leg ME+PS (MGaMC FxFx or Sherpa), CMS: older versions
  ATLAS: NNLO Z+1p fixed order with flavor dressing (Phys. Rev. Lett. 130 (2023) 161901)
- Uncertainties:
  - CMS: Z+b: 7%, Z+bb: 12%
  - ATLAS: Z+b: 6%, Z+bb: 9%

NEW: ATLAS: 140/fb:
arXiv:2403.15093

CMS: 137/fb:
Phys. Rev. D 105 (2022) 092014



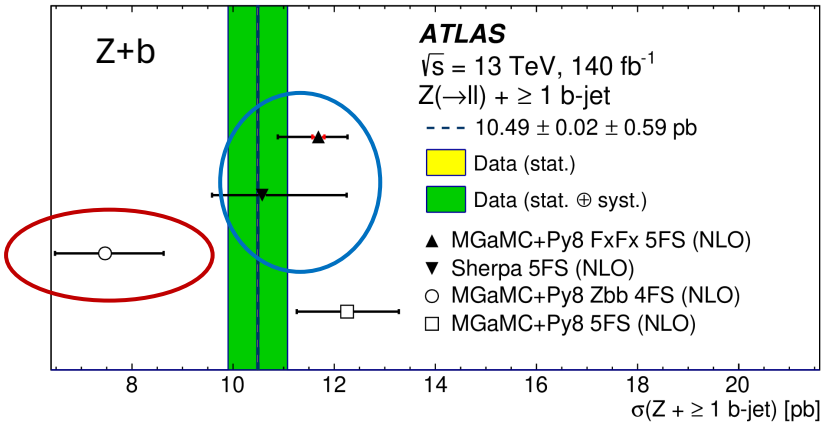


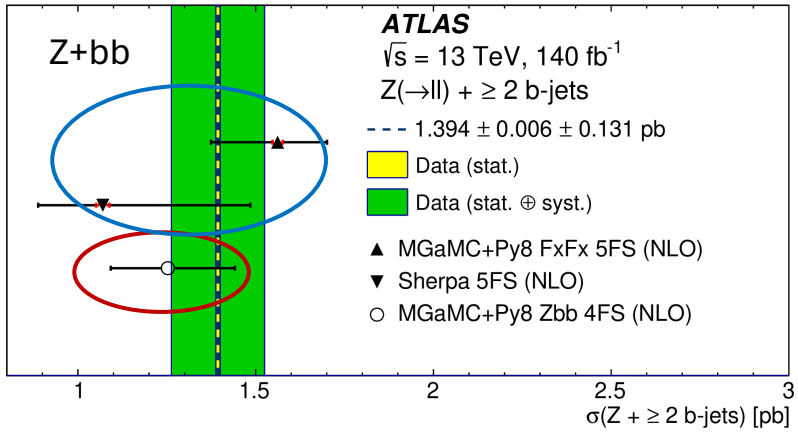


Z+b(b) measurements: Inclusive cross sections

ATLAS: p_T(B-jet) > 20 GeV, CMS: p_T(B-jet) > 30 GeV

ATLAS: 5F NLO multi-leg MC describes Z+b and Z+bb, 4F Zbb NLO describes only Z+bb

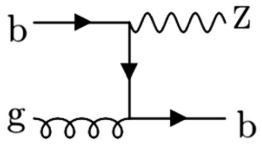


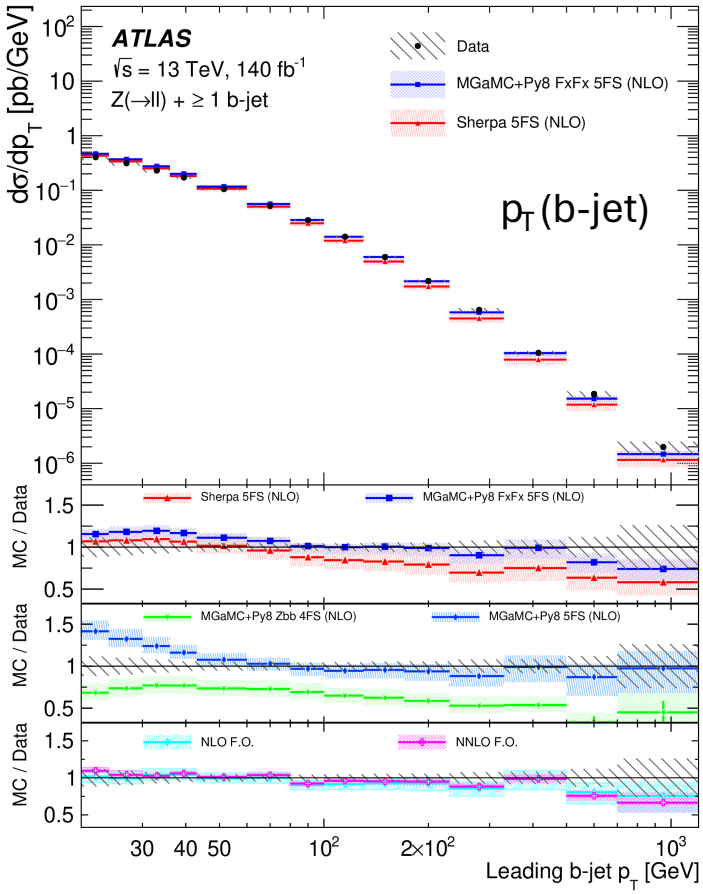


CMS: Best match of measurements with LO multi-leg predictions, NLO predictions too large

	Channel	Measured	MG5_aMC LO NNPDF 3.0 CUETP8M1	MG5_aMC LO NNPDF 3.1 CP5	MG5_aMC NLO NNPDF 3.0 CUETP8M1	MG5_aMC NLO NNPDF 3.1 CP5	SHERPA
$Z+\geq 1\,b$ jet	$e\ell$	$6.52 \pm 0.04 \pm 0.40 \pm 0.14$	6.25	6.34	7.86 ± 0.51	7.03 ± 0.47	8.02
$Z+\geq 2\,b$ jets	$e\ell$	$0.65 \pm 0.03 \pm 0.07 \pm 0.02$	0.63	0.71	0.90 ± 0.09	0.77 ± 0.07	0.84

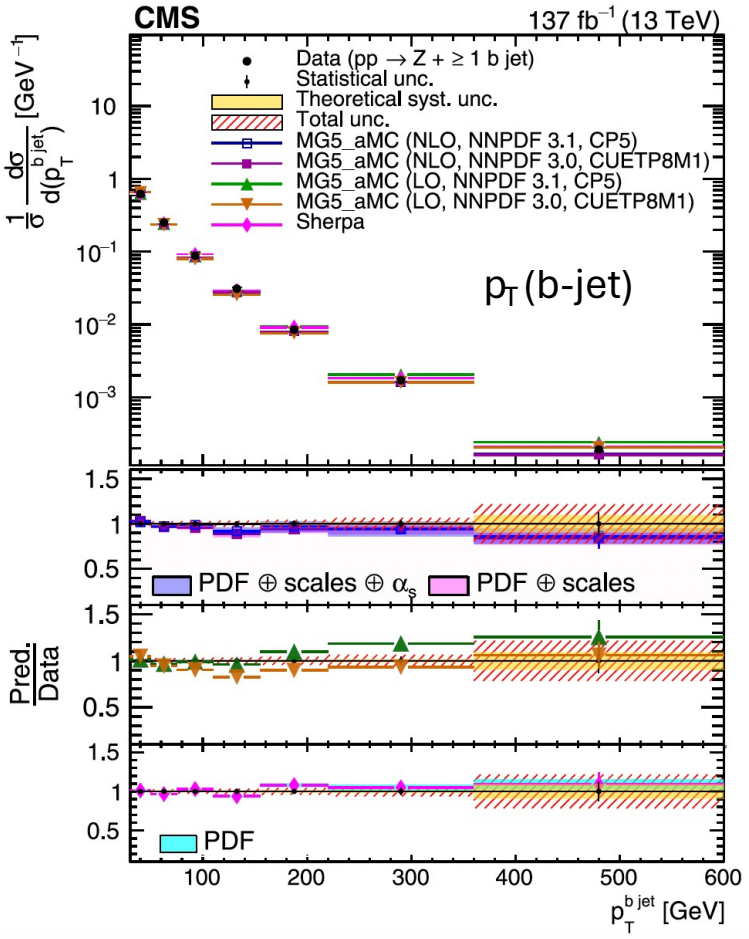
Z+b measurements: pT(b-jet)





5FS, NLO multileg

NNLO fixed order



5FS, multileg

NLO, MGaMC

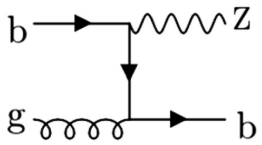
LO

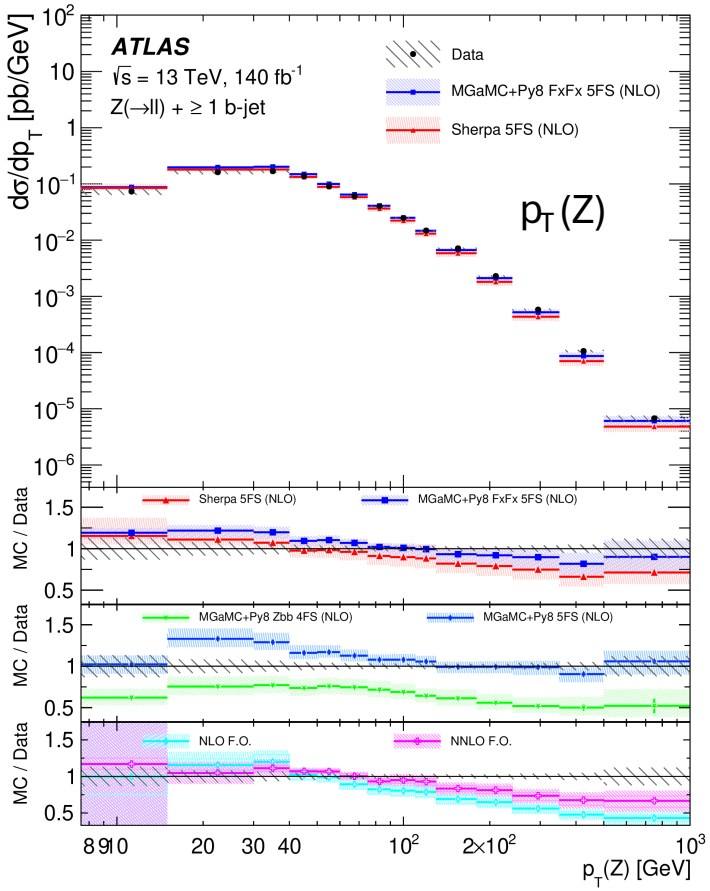
NLO, Sherpa

ATLAS: 5FS, NLO multileg and fixed order NNLO describe the data

CMS normalized: NLO shape ok, LO too hard

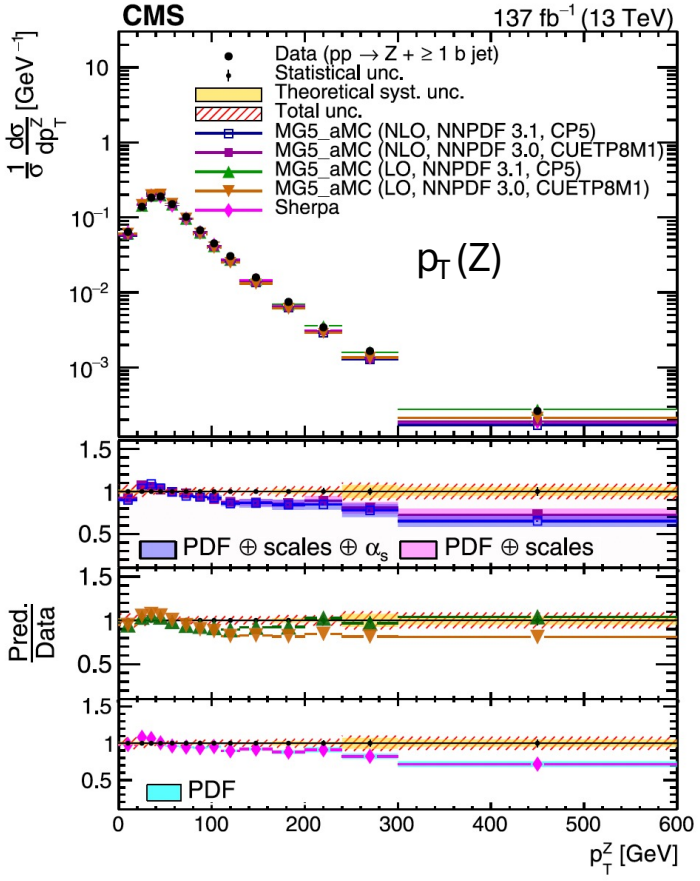
Z+b measurements: pT(Z)





5FS, NLO multileg

NNLO fixed order



5FS, multileg

NLO, MGaMC

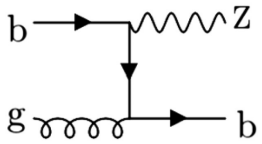
LO

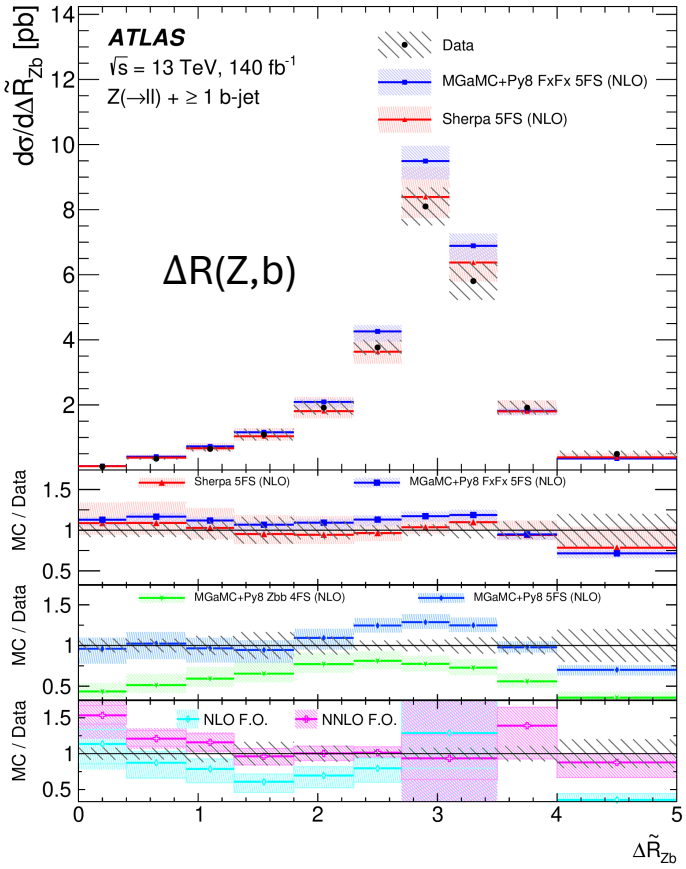
NLO, Sherpa

ATLAS: 5F NLO multileg and NNLO predict softer spectrum

CMS normalized: NLO multileg too soft, LO multileg shape ok

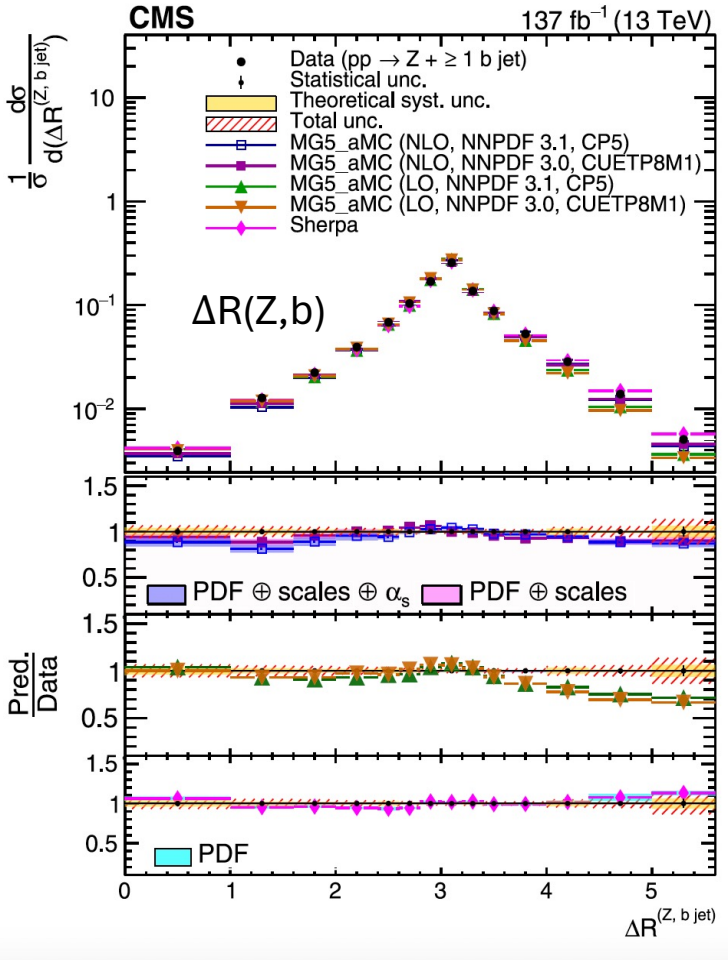
Z+b measurements: ΔR(Z,b)





5FS, NLO multileg

NNLO fixed order



5FS, multileg

NLO, MGaMC

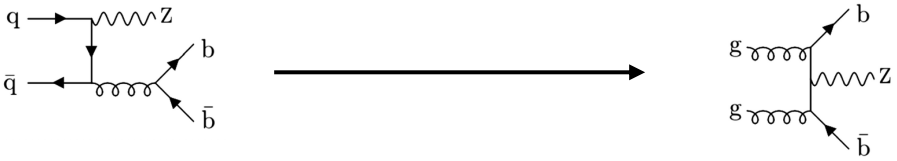
LO

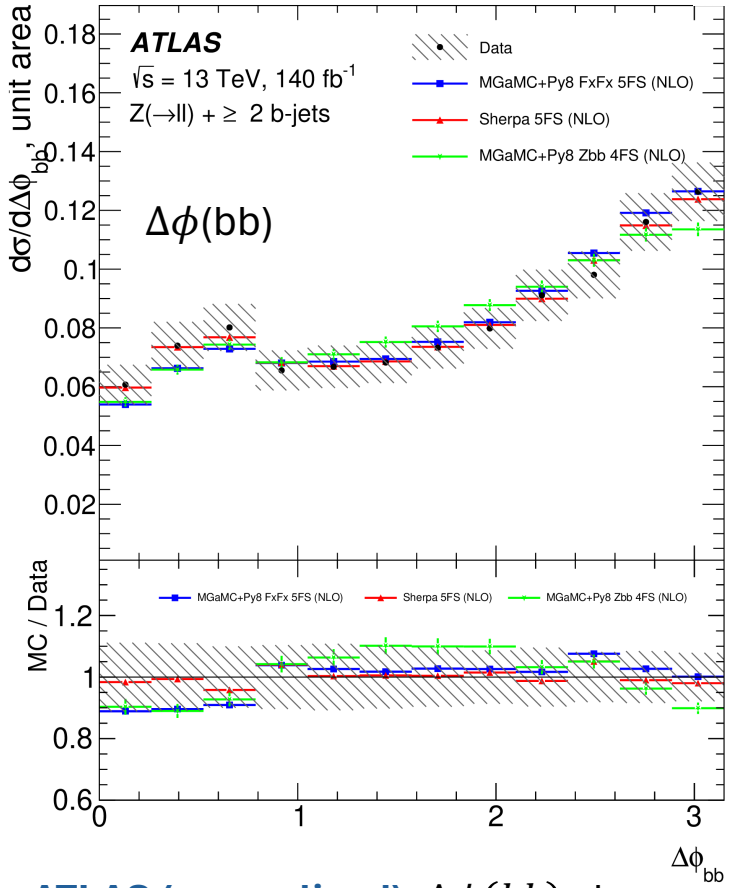
NLO, Sherpa

ATLAS: Described well by multi-leg NLO and (except for small ΔR) by NNLO

CMS normalized: NLO MC describe shape best, LO underestimates large ΔY

Z+bb measurements: $\Delta\phi$(bb) (ATLAS) - ΔR(bb) (CMS)





NLO

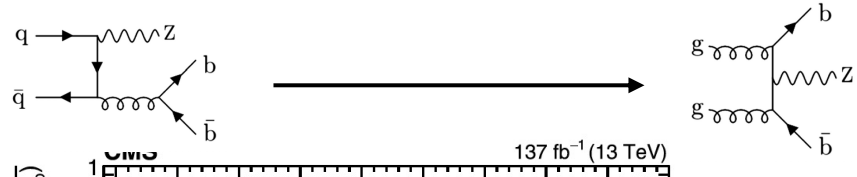
5F MGaMC

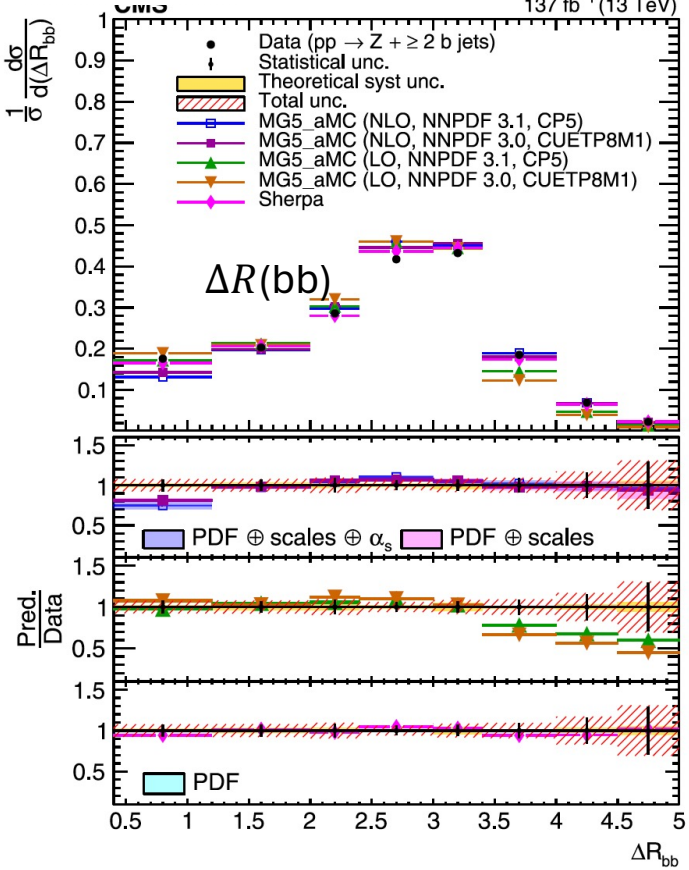
5F Sherpa

4F MGaMC

ATLAS (normalized): $\Delta\phi(bb)$ shape well described by 4F NLO and 5F NLO multi-leg.

↔





5FS, multileg

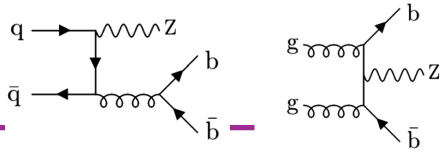
NLO, MGaMC

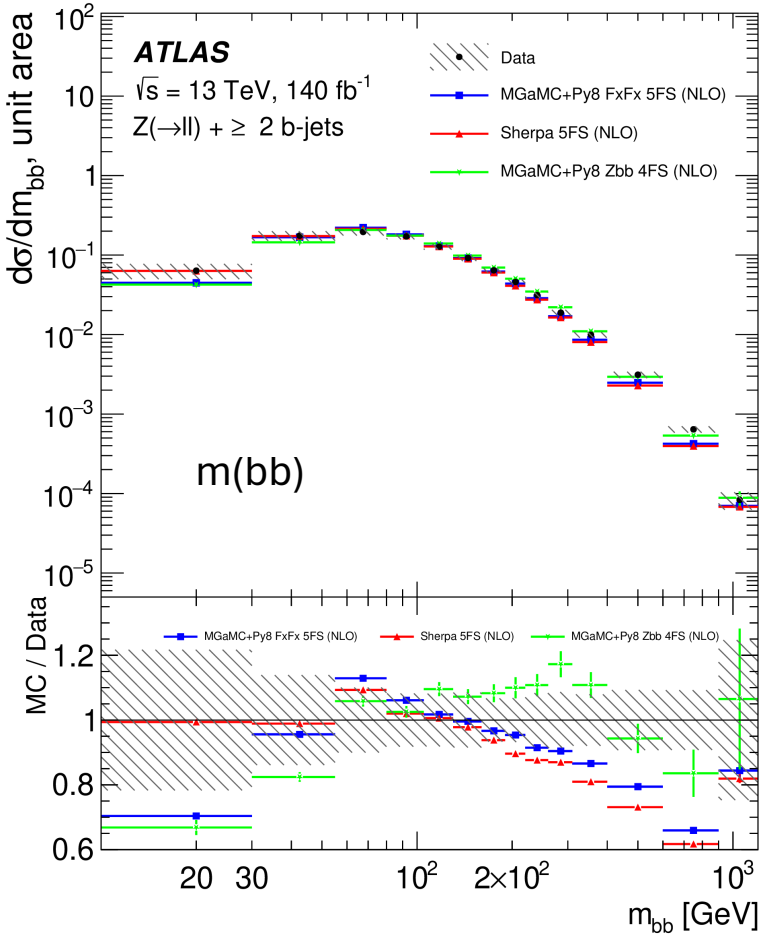
LO

NLO, Sherpa

CMS normalized: , NLO MG: sharper peak, underestimates cross section at small ΔR_{bb}
LO MC underestimates large $\Delta R(bb)$

Z+bb measurements: m(bb)



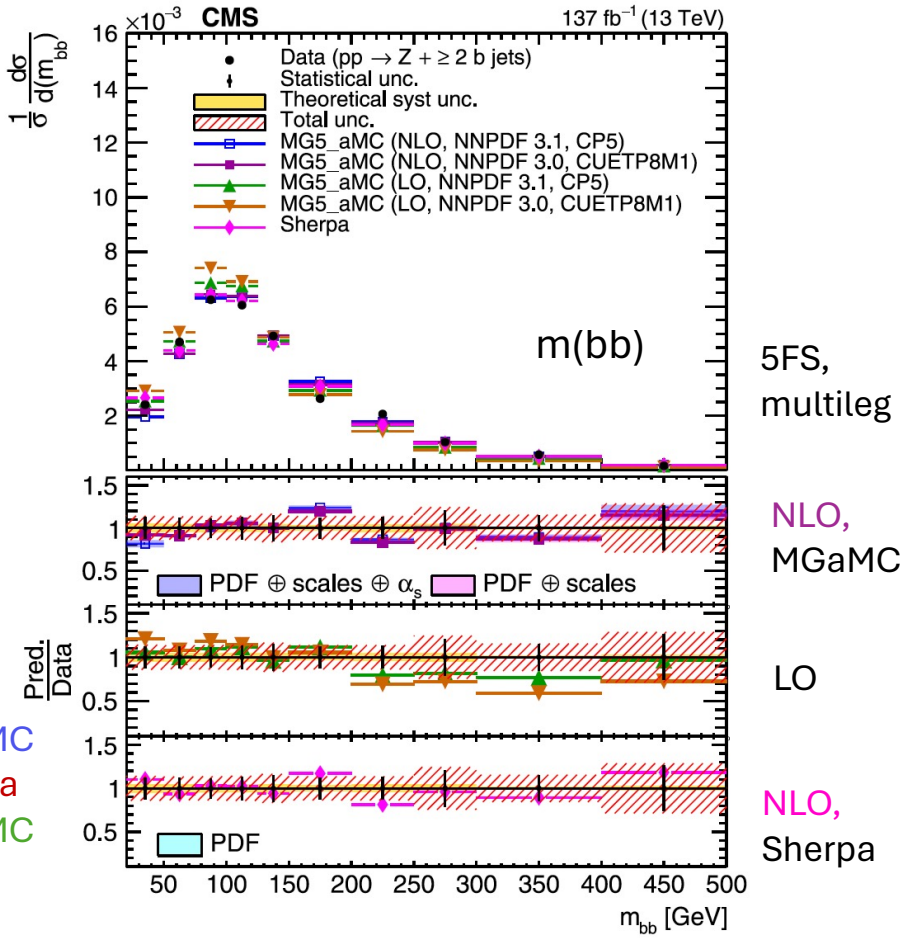


NLO

5F MGaMC

5F Sherpa

4F MGaMC



5FS, multileg

NLO, MGaMC

LO

NLO, Sherpa

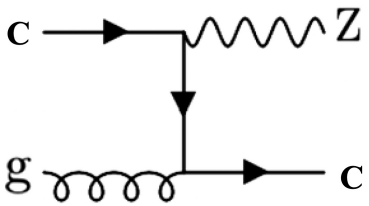
ATLAS (normalized) : 4F/5F MC predict m(bb) peak with steeper slopes

↔

CMS normalized: NLO MC: shape ok. LO underestimates high-m(bb)

Z+c measurements:

- Flavour/mass schemes, pQCD, PDF Intrinsic charm -

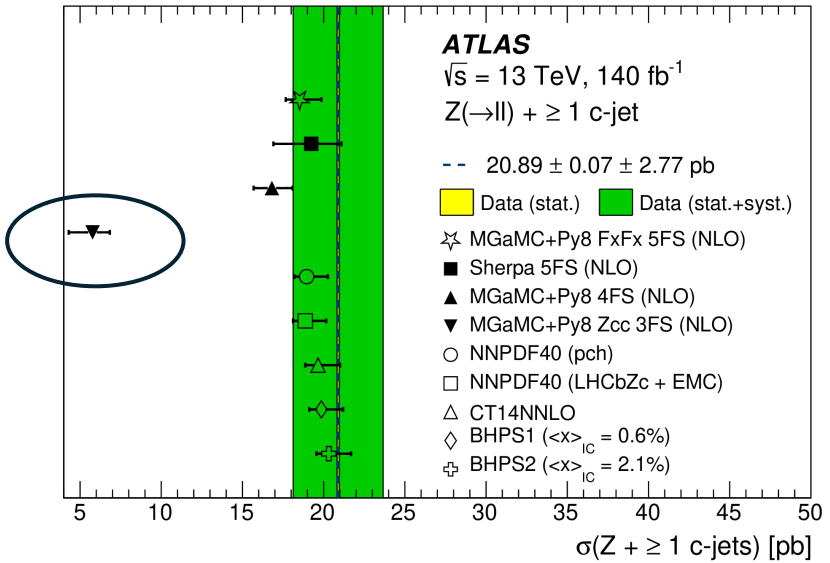


- Selections:
  - ATLAS: **pT(c-jet) > 20 GeV**, lepton $|\eta|$< ~2.5
  - CMS: **pT(c-jet) > 30 GeV**, lepton $|\eta|$< ~2.4
  - LHCb: pT(c-jet) 20GeV-100GeV, **|y| (Z): 2-4.5**
- Backgrounds: Z+l/b, top
- Uncertainties:
  - ATLAS: 13 %, CMS: 6 % (tight charm tagger), LHCb: 11%

NEW: ATLAS: 140/fb:
arXiv:2403.15093

CMS: 36/fb
JHEP 04 (2021) 109

LHCb: 6/fb
Phys. Rev. Lett. 128 (2022) 082001

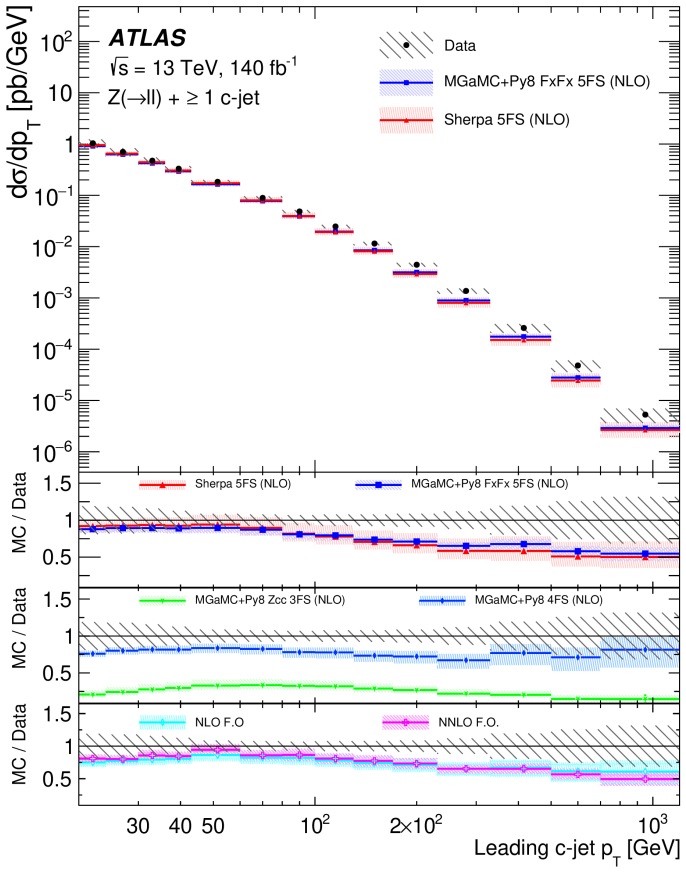


ATLAS: σ (Z+c) = 20.9 ± 0.1 (stat) ± 2.8 (sys) pb.
Compatible with all 5F predictions,
3F Zcc NLO does not describe the data

CMS*: σ (Z+c) = 13.6 ± 0.2 (stat) ± 0.8 (sys) pb
→ Discrepancy with (older) MG5_aMC (NLO) prediction of 17.6 ± 0.4 (theo) pb

*Translated from published σ (Z+c)/BF(Z→ ll)

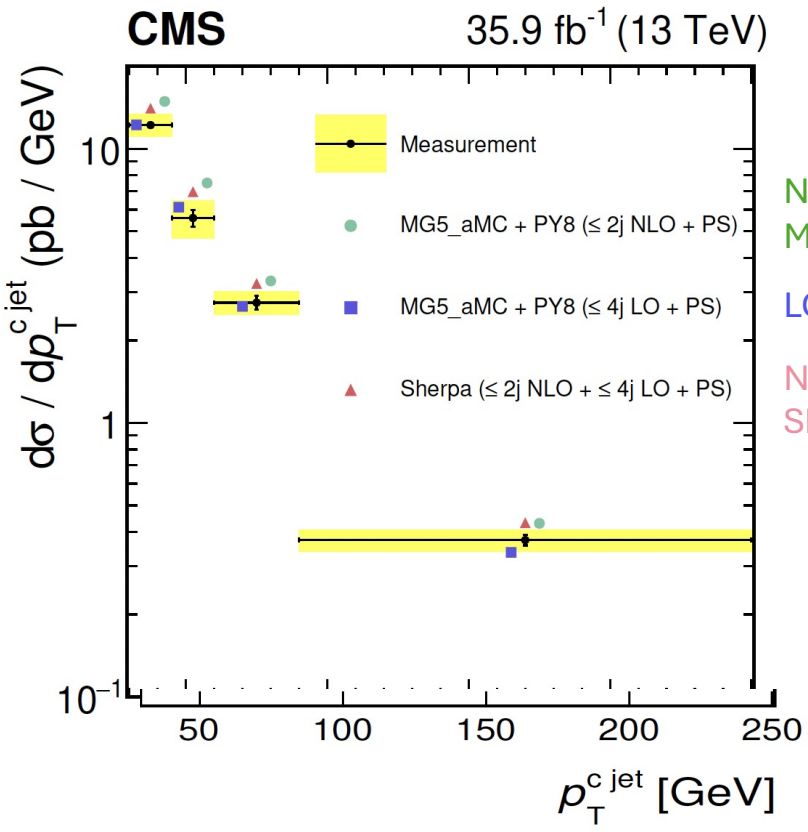
Z+c measurements: p_T(c-jet)



5FS, NLO multileg

4F NLO

NNLO fixed order



NLO MGaMC

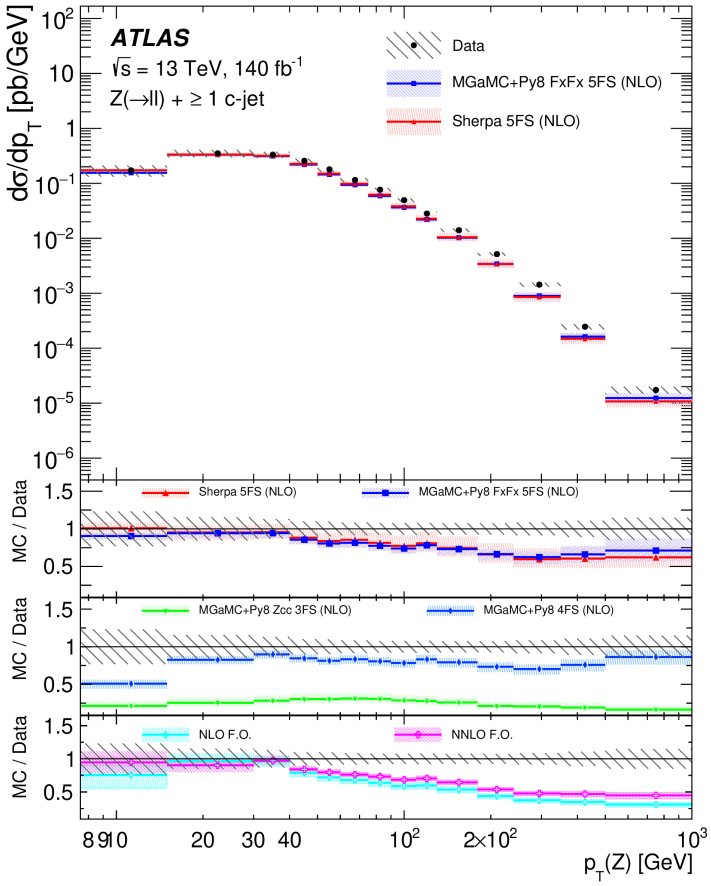
LO

NLO Sherpa

ATLAS: 5F NLO multi-leg MC and NNLO describe soft end but underestimate large p_T(c-jet). 4F NLO shape ok but offset.

CMS: All MC with too soft p_T(c-jet) shape.

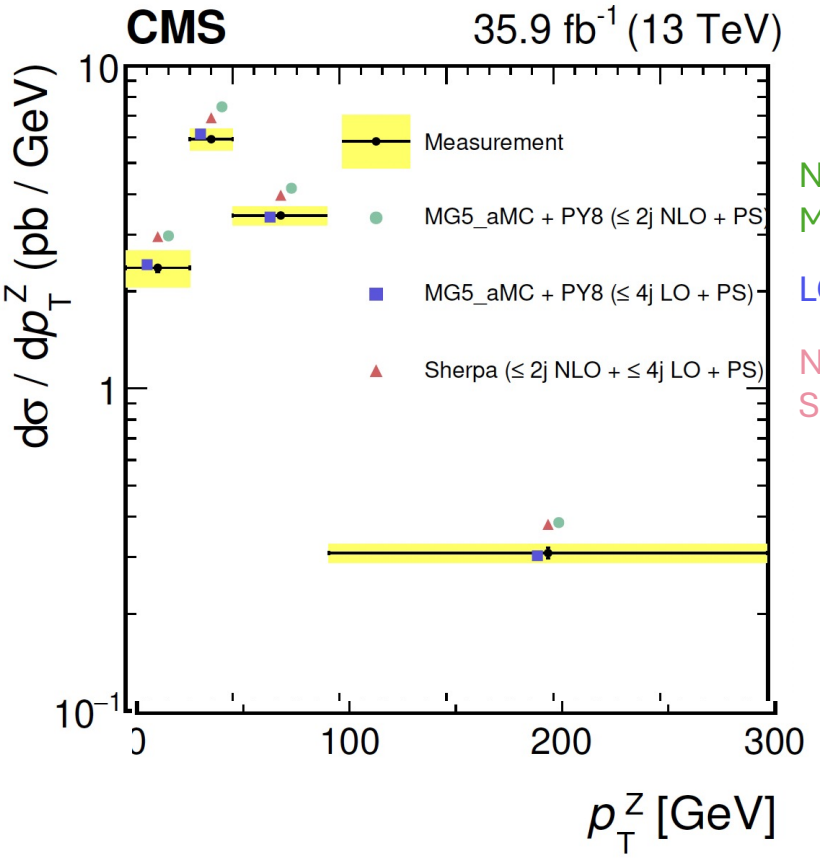
Z+c measurements: $p_T(Z)$



5FS, NLO multileg

4F NLO

NNLO fixed order



NLO MGaMC

LO

NLO Sherpa

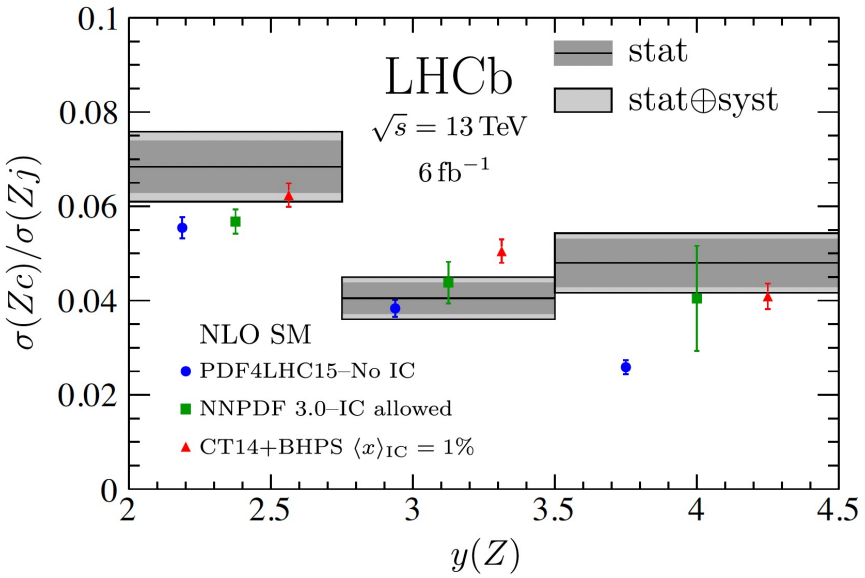
ATLAS: 5F NLO multi-leg MC and NNLO describe soft end but underestimate large p_T(c-jet). 4F NLO shape ok but offset.

↔

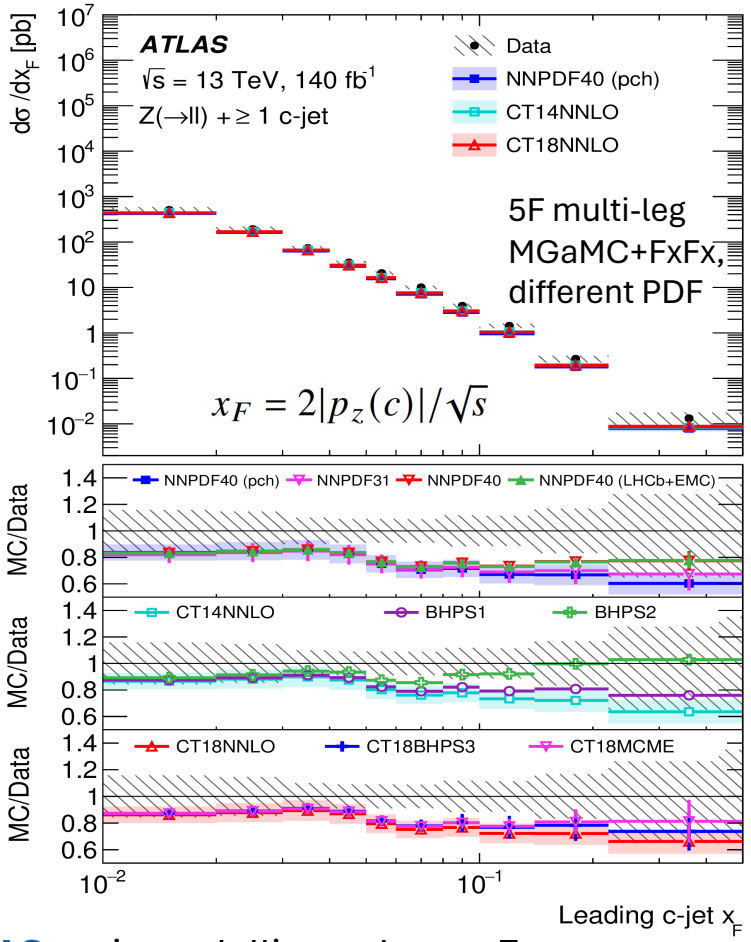
CMS: All shapes ok.

Charm PDF studies by LHCb and ATLAS

LHCb: $\mathcal{R}_j^c \equiv \sigma(Zc)/\sigma(Zj)$ in 3 bins of $y(Z)$
→ high-x charm PDF, where intrinsic (valence-like) charm (IC) would peak



no-IC fails to describe y(Z)
Better description by PDF with IC:
NNPDF 3.0 IC, CT14 BHPS (1% IC)
→ interpreted as evidence for IC by NNPDF collaboration
(Nature 608, 483-487 (2022)

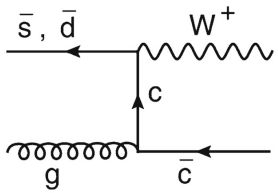


NNPDF4.0 w LHCbZc

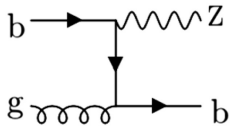
BHPS2 (2.1% IC)

ATLAS: mismodelling at large xF
- Only CT14 BHPS2 (2.1% IC) clearly improves large xF
- More realistic PDF fits: only marginal improvement for IC PDFs (e.g. NNPDF4.0 EMC+LHCbZc , last bins)

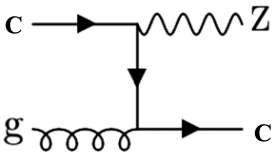
Summary



- W+charm:
  - With Run2 precision W+c becomes sensitive to s PDF
- Z+b(b):
  - Higher precision and larger data sets allow to probe flavor/mass schemes, pQCD and IRC safe b-jet definitions and proton PDF



- Z+charm:
  - LHCb data/MC discrepancy in forward bins → interpreted as IC charm
    New PDFs with IC which can be probed by Z+c data
  - Higher precision and larger data sets allow for precise differential cross-section measurements, probing flavor/mass schemes, pQCD and proton PDF



Sophisticated V+HF measurements have profited significantly from flavor-tagging improvements in LHC Run2 and from the larger data set.

Close interaction between data and theory allowed for higher measurement precision and advances in pQCD/PDF/jet definitions

Backup

Detailed Summary

- W+charm:
  - ATLAS full Run2 $|\eta|$ data broader than predictions bot ok with PDF uncertainties
  - ATLAS charge ratio prefers PDF with symmetric strange sea.
- Z+b:
  - No perfect description, 4F MC underpredicts Z+b
  - ATLAS best: 5F fixed order NNLO and multi-leg MGaMC@NLO
  - CMS: Depending on distribution LO/NLO 5F MGaMC performed better
- Z+bb:
  - ATLAS: 4F NLO and 5F multi-leg NLO describe the data
  - CMS: 5F LO multileg underestimate large Δ y
- Z+c:
  - LHCb data/MC discrepancy in forward bins → interpreted as IC charm
  - CMS: Z+c overpredicted by NLO multi-leg MC, LO describes data
  - ATLAS: 3F with large offset

    5F multi-leg describe soft end, underestimate hard end of spectra

    High-x sensitive variables compared with PDF with different IC,

NLO MC generators

CMS:

The Drell–Yan (DY) process with exclusive jet multiplicity up to 2 is simulated at next-to-leading order (NLO) precision by MADGRAPH5_aMC@NLO (denoted MG5_aMC) [16] version 2.3.2.2 for 2016 data and version 2.6.0 for the 2017–2018 data with the FXFX [17] matching between the jets from matrix element calculations and parton showers. The NNPDF 3.0 NLO and NNPDF 3.1 next-to-NLO (NNLO) PDF sets [18] are used for the 2016 and 2017–2018 data-taking periods, respectively.

A third inclusive sample has been produced with SHERPA v2.2.4 [23] to generate $pp \to Z + n$ jets events, with $n \leq 2$ at NLO and $n = 3, 4$ at LO. The merging with the SHERPA parton shower is done via the MEPS@NLO prescription [24–26] with a matching scale of 20 GeV. The NNPDF 3.0 NLO PDF and a dedicated set of tuned parton shower parameters developed by the SHERPA authors are used. In the matrix element calculation, the value of the NNPDF 3.0

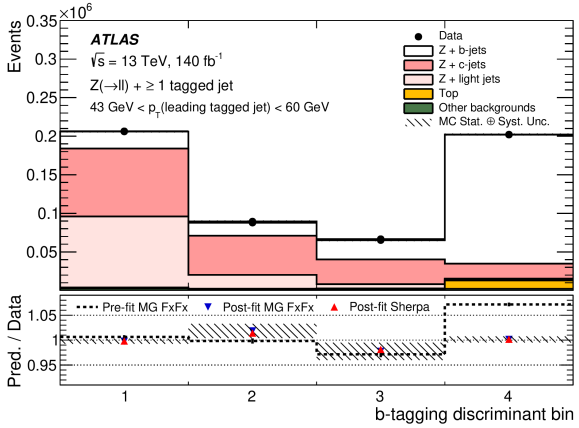
ATLAS:

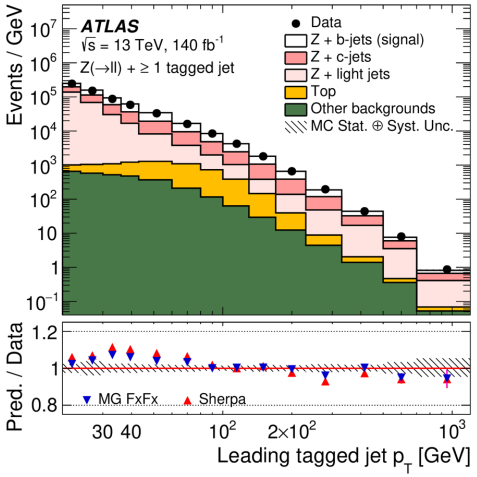
Process	Generator	Order of pQCD in ME (FS)
$Z \to \ell\ell$	MGaMC+Py8 FxFx v2.6.5	0–3p NLO (5FS)
$Z \to \ell\ell$	Sherpa 2.2.11	0–2p NLO, 3–5p LO (5FS)

Z+b(b) measurements with 13 TeV data

- Flavour/mass schemes, pQCD, IRC-safe b-jets, PDF - Important background for VH($\rightarrow bb$) and BSM searches

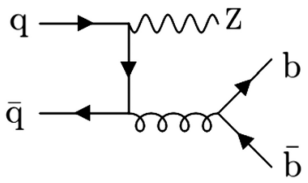
- Final states: Z($\rightarrow ll$)+ $\geq 1B$-jet, Z($\rightarrow ll$)+ $\geq 2B$-jets
  ATLAS/CMS : loose/tight b-tag, p_TB> 20/30 GeV
- Backgrounds:
  - CMS: Z+c/l SF from several CRs, tt: from eμ CR
  - ATLAS: Z+c/l SF from fit to b-tagging discr., tt: eμ CR
- Theory:
  - CMS: MGaMC FxFx 0-2p NLO, MGaMC MLM 0-4p LO, each with older and newer version, SHERPA 0–2p NLO, 3–4p LO
  - ATLAS: MGaMC FxFx 0–3p NLO, SHERPA 0–2p NLO, 3–5p LO, fixed-order NNLO Z+b (flavour –dressing), MGaMC 4F/5F NLO
- Uncertainties:
  - CMS: Z+b: 6.5%, Z+bb: 12%, (B-tag, JES , Stats for Z+2B..)
  - ATLAS: Z+b:5.6%, Z+bb: 9.4%, (B-tag, JES, Unfolding..)

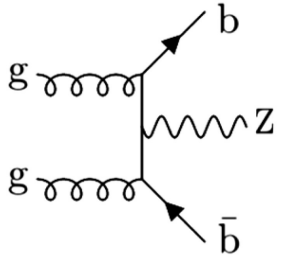


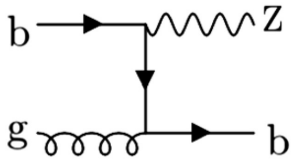


NEW: ATLAS: 140/fb:
arXiv:2403.15093

CMS: 137/fb:
Phys. Rev. D 105 (2022) 092014



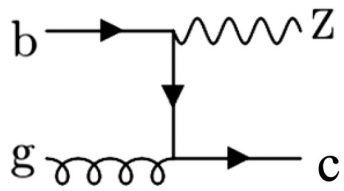




Z+c measurements:

- Flavour/mass schemes, pQCD, PDF Intrinsic charm -

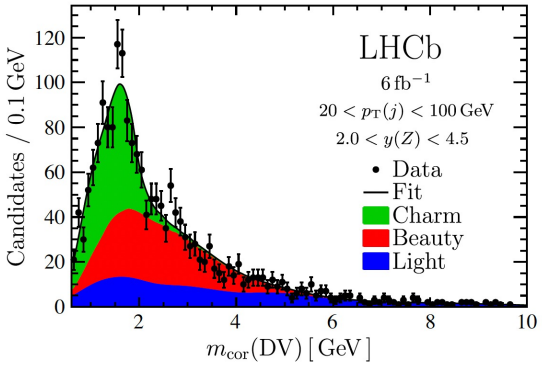
- Selections:
  - ATLAS: pT(c-jet) > 20 GeV, |y| < 2.5, lepton: $|\eta|$< ~2.5
  - CMS: pT(c-jet) > 30 GeV, |y| < 2.4, lepton: $|\eta|$< ~2.4
  - LHCb: pT(c-jet) 20GeV-100GeV, **|y| (Z): 2-4.5**
- Backgrounds:
  - ATLAS: Z+jets: fit of FT discriminant, tt in emu
  - CMS: Zjets, tt: Fit of secondary-vertex mass
  - LHCb: Z+jets: Fit of corrected mass and N(track)
- Uncertainties:
  - ATLAS: 13.3% (mostly flavour tagging, JES,..)
  - CMS: 6.2% (flavour tagging, JES..)
  - LHCb: 11% (mostly flavour tagging and DVfit)

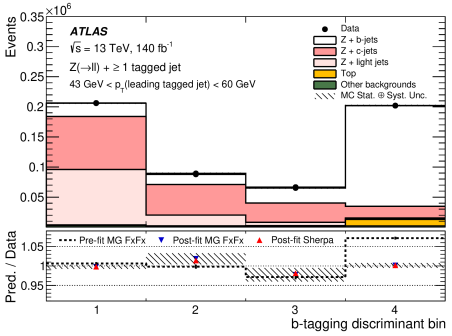


NEW: ATLAS: 140/fb:
arXiv:2403.15093

CMS: 36/fb
JHEP 04 (2021) 109

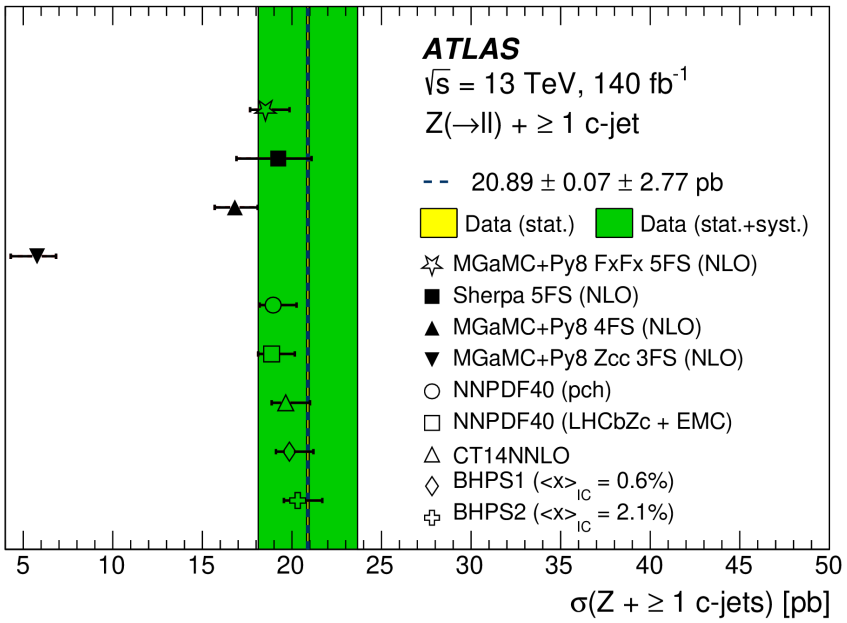
LHCb: 6/fb
Phys. Rev. Lett. 128 (2022) 082001





- Charm tagging:
  - ATLAS: Loose Z+b tagger (30% c eff.)
  - CMS: tight charm tagger (30% c eff.)
  - LHCb: DV tagger (24% c eff.)

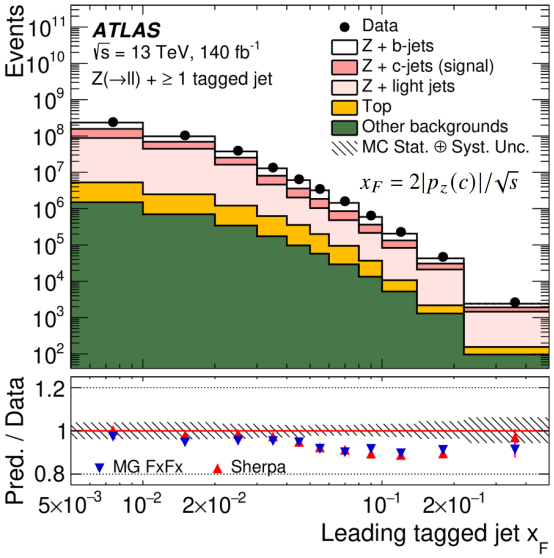
ATLAS Z+c measurements: inclusive cross section



- ATLAS
  - MGaMC FxFx 0–3p NLO
  - SHERPA 0–2p NLO, 3–5p LO
  - MGaMC 4F NLO
  - MGaMC Zcc 3F NLO
  - MGaMC FxFx with IC PDFs
  - Fixed-order NNLO flavour-dressing
- CMS
  - MGaMC multi-leg NLO
  - MGaMC multileg LO
  - Sherpa

ATLAS: σ (Z+c) = 20 ± 0.07 ± 2.77pb.
Measurements compatible with all 5F predictions,
MGaMC Zcc 3F NLO does not describe the Z+c data

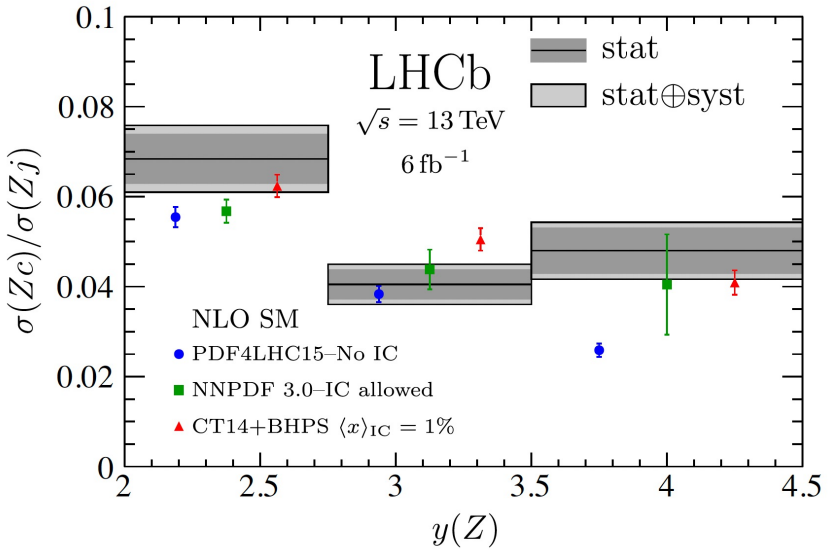
CMS: σ (Z+c)/BF(Z→ ll) = σ (Z+c)/0.0336 =
405.4 ± 5.6 (stat) ± 24.3 (exp) ± 3.7 (theo) pb
→ Discrepancy with MG5_aMC (NLO) predicted value of 524.9 ± 11.7 (theo) pb

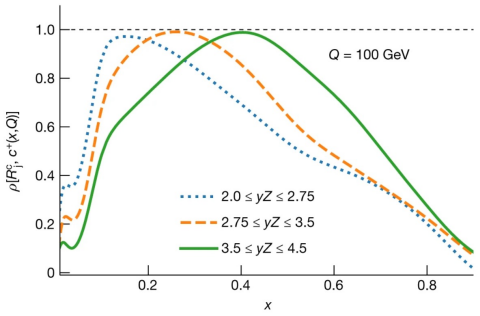


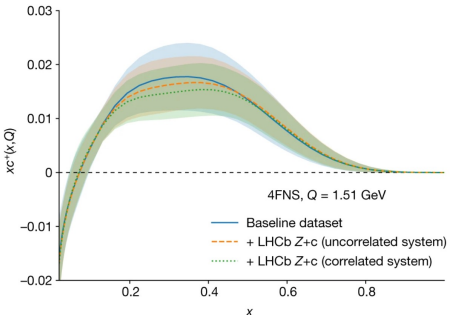
LHCb: Z+c/Z+j in the forward region

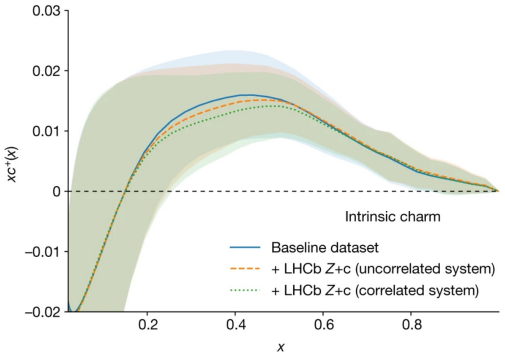
Measured $\mathcal{R}_j^c \equiv \sigma(Zc)/\sigma(Zj)$ in 3 bins of $y(Z)$

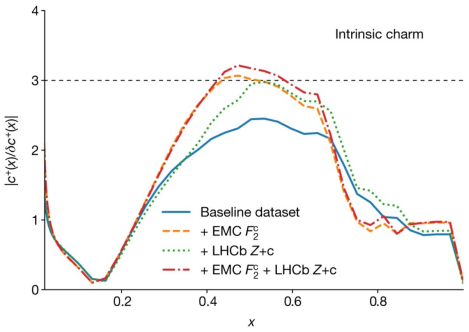
→ sensitive to high-x charm PDF, where intrinsic (valence-like) charm would peak







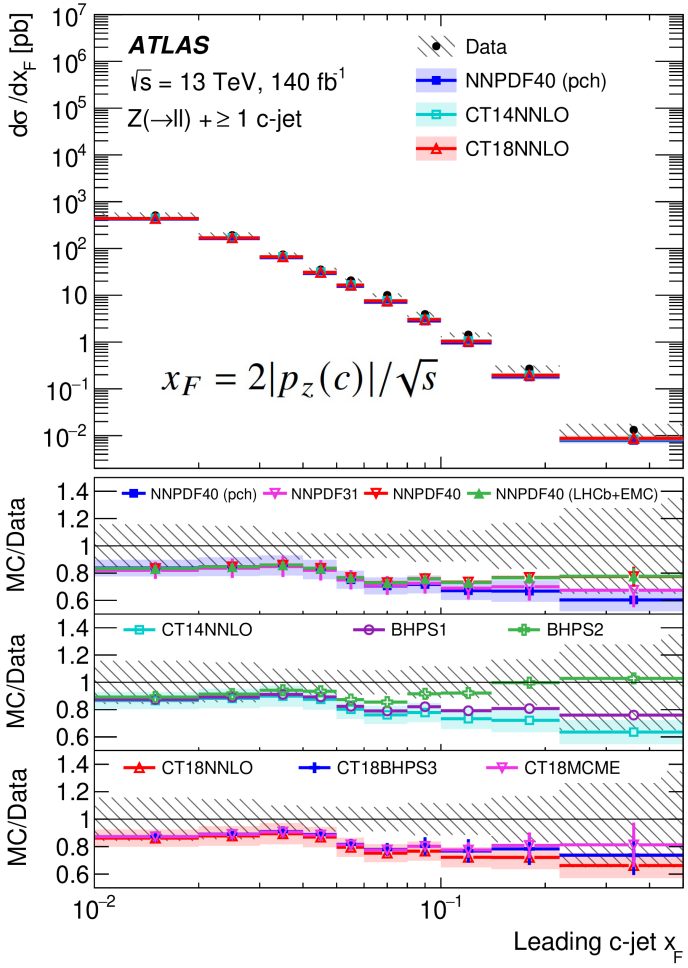




no-IC fails to describe the measured y(Z) distribution

→ interpreted as evidence for Intrinsic Charm by NNPDF collaboration (Nature 608, 483-487 (2022)

Z+c measurements: Feynman x variable x_F



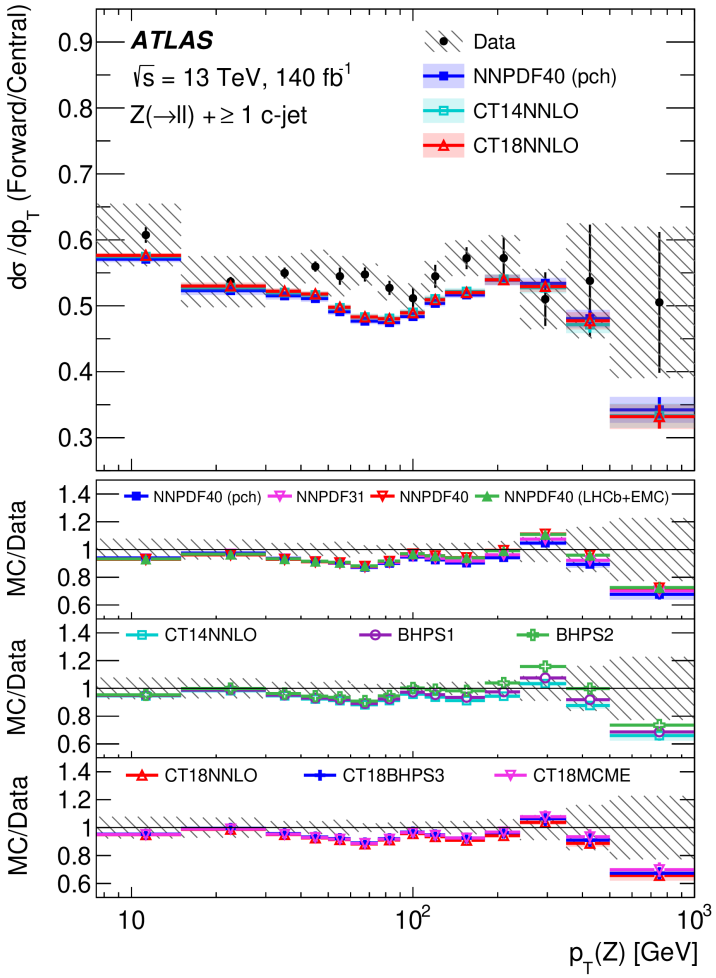
ATLAS: Comparison with 5F multi-leg MGaMC+FxFx with PDF corresponding to different IC predictions:

- NPDF31 (default)
- **NNPDF4.0 (NNLO)PCH(no IC): no intrinsic charm**
- NNPDF4.0 (NNLO): baseline, some IC
- **NNPDF4.0 (NNLO) EMC+LHCbZc: incl. LHCb Zc/Zj**
- **CT14 (NNLO) (noIC): no intrinsic charm**
- CT14 (NNLO) IC-BHPS1, older PDF, fixed 0.6% IC
- **CT14 (NNLO) IC-BHPS2, older PDF, fixed 2.1% IC**
- CT18 (NNLO) (no IC)
- CT18FC-CT18 BHPS3: BHPS3 model
- CT18FC-CT18 MCM-E: Meson-Baryon model, based on effective mass

ATLAS:

- Only BHPS2 clearly improves the description of the data.
- More realistic PDF fits: only marginal improvement for PDF with IC (last two bins)

Z+c measurements: $p_T(Z)$: central/forward ratio



ATLAS: Comparison with 5F multi-leg MGaMC+FxFx with PDF corresponding to different IC predictions:

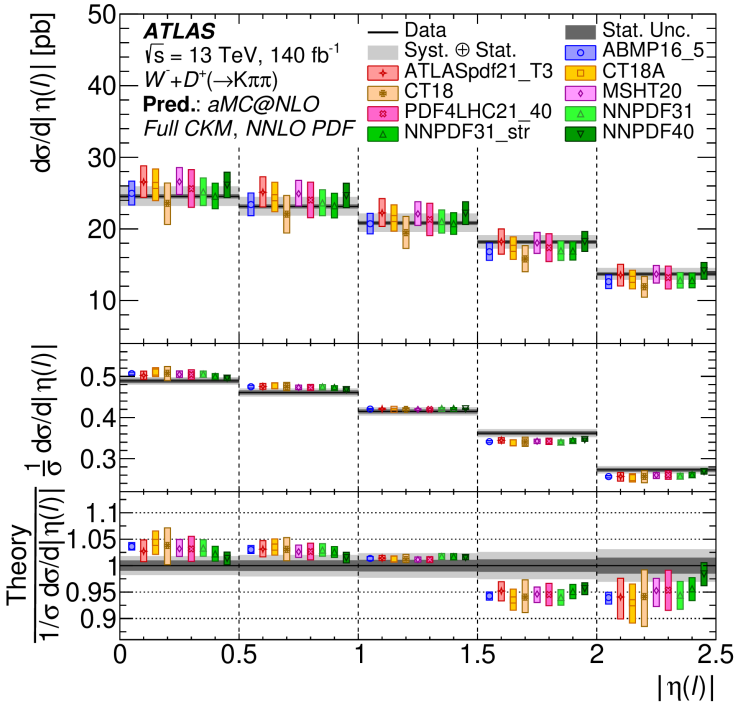
- NPDF31 (default)
- NNPDF4.0 (NNLO)PCH(no IC): only perturbative charm
- NNPDF4.0 (NNLO): baseline, some IC
- **NNPDF4.0 (NNLO) EMC+LHCbZc: incl. LHCb Zc/Zj**
- CT14 (NNLO) (noIC)
- CT14 (NNLO) IC-BHPS1, older PDF, fixed 0.6% IC
- CT14 (NNLO) IC-BHPS2, older PDF, fixed 2.1% IC
- CT18 (NNLO) (no IC)
- CT18FC-CT18 BHPS3: BHPS3 model
- CT18FC-CT18 MCM-E: Meson-Baryon model, based on effective mass

ATLAS: BHPS2 improves the description of the data in some places. The more realistic PDF fits have only marginal impact.

ATLAS W+charm production: $D^{\pm}$ $|\eta|$ dependence

Inclusive and differential (W^+, W^-) cross-sections as a function of $p_T(D)$ and $\eta(\ell)$ → s- and anti-s PDF
W charge ratios → sensitive to differences between the *s*- and anti-*s* PDFs

Channel	D^+ $\lvert\eta(\ell)\rvert$			
p-value for PDF [%]	Exp. Only	⊕ QCD Scale	⊕ Had. and Matching	⊕ PDF
ABMP16_5_nnlo	7.1	11.8	12.9	19.8
ATLASpdf21_T3	9.0	9.7	11.5	84.7
CT18ANNLO	0.7	1.0	1.1	76.0
CT18NNLO	1.4	6.1	6.3	87.6
MSHT20nnlo_as118	2.7	2.9	3.3	45.6
PDF4LHC21_40	3.9	5.3	5.6	75.8
NNPDF31_nnlo_as_0118_hessian	1.5	2.6	2.8	50.7
NNPDF31_nnlo_as_0118_strange	9.1	14.7	15.2	59.9
NNPDF40_nnlo_as_01180_hessian	9.9	10.2	10.2	43.7

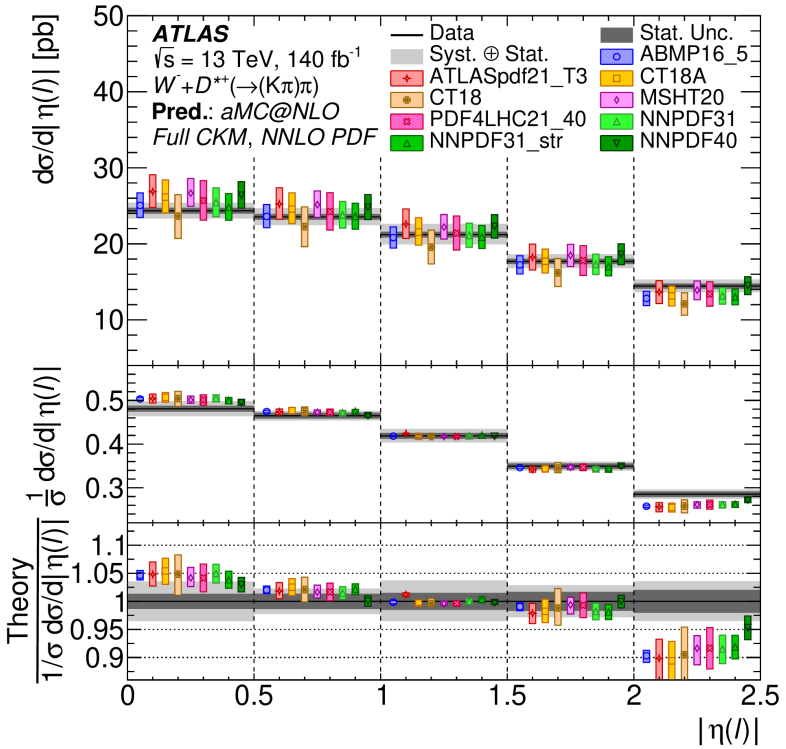


ATLAS: Data with broader η distribution than nominal aMC@NLO predictions but consistent within PDF uncertainties

ATLAS W+charm production: D*|η| dependence

Inclusive and differential (W^+, W^-) cross-sections as a function of $p_T(D)$ and $\eta(\ell)$ → s- and anti-s PDF
W charge ratios → sensitive to differences between the *s*- and anti-*s* PDFs

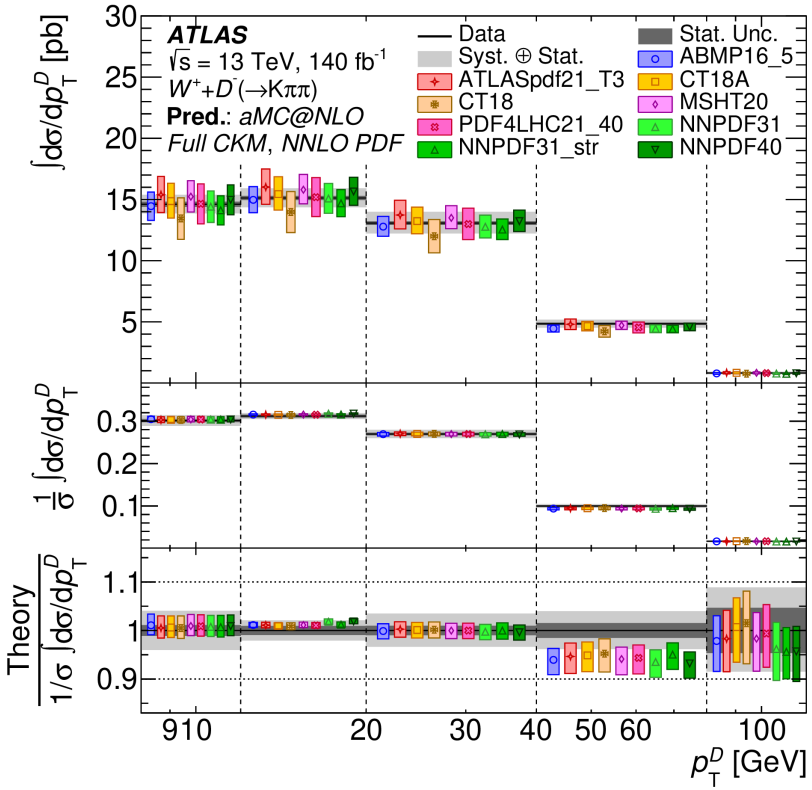
Channel	D^{*+} $\lvert\eta(\ell)\rvert$			
p-value for PDF [%]	Exp. Only	⊕ QCD Scale	⊕ Had. and Matching	⊕ PDF
ABMP16_5_nnlo	22.8	23.7	25.0	28.8
ATLASpdf21_T3	1.9	2.9	3.4	33.7
CT18ANNLO	6.5	6.9	7.8	47.3
CT18NNLO	9.4	19.2	19.7	52.8
MSHT20nnlo_as118	7.0	9.4	10.4	31.3
PDF4LHC21_40	14.2	14.2	15.2	51.4
NNPDF31_nnlo_as_0118_hessian	5.0	5.1	5.5	34.9
NNPDF31_nnlo_as_0118_strange	11.4	12.4	13.2	46.0
NNPDF40_nnlo_as_01180_hessian	4.5	6.1	6.4	36.0

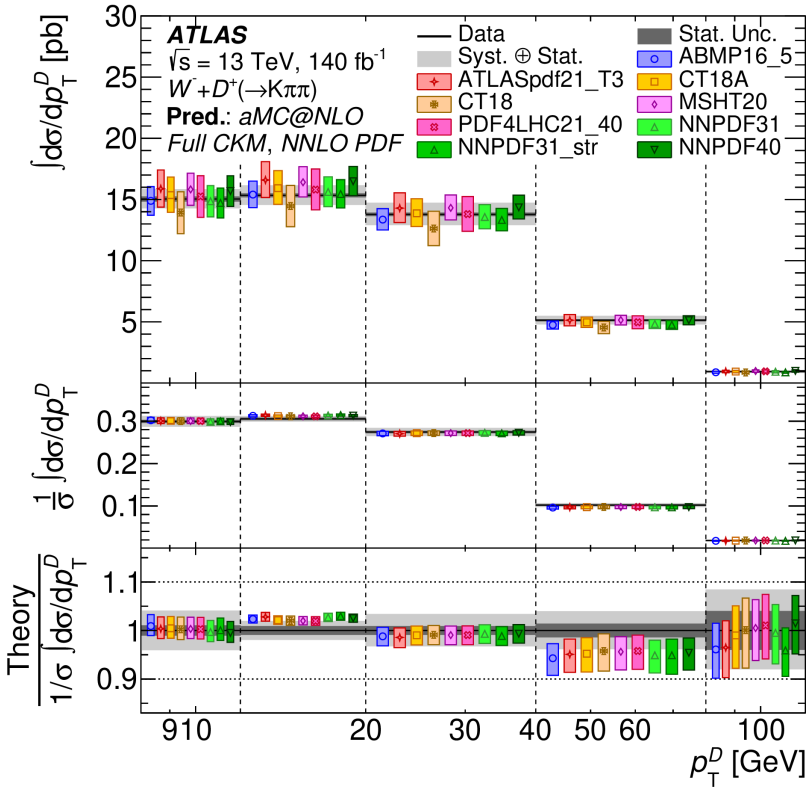


ATLAS: Data with broader η distribution than nominal aMC@NLO predictions but consistent within PDF uncertainties

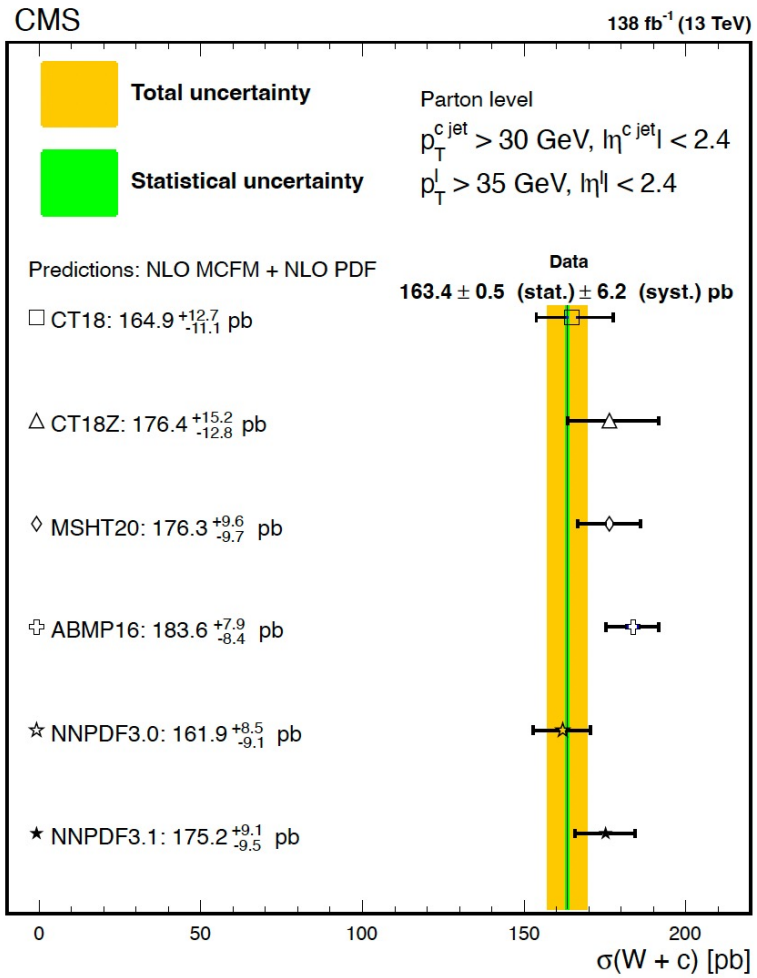
ATLAS W+charm production: pT dependence

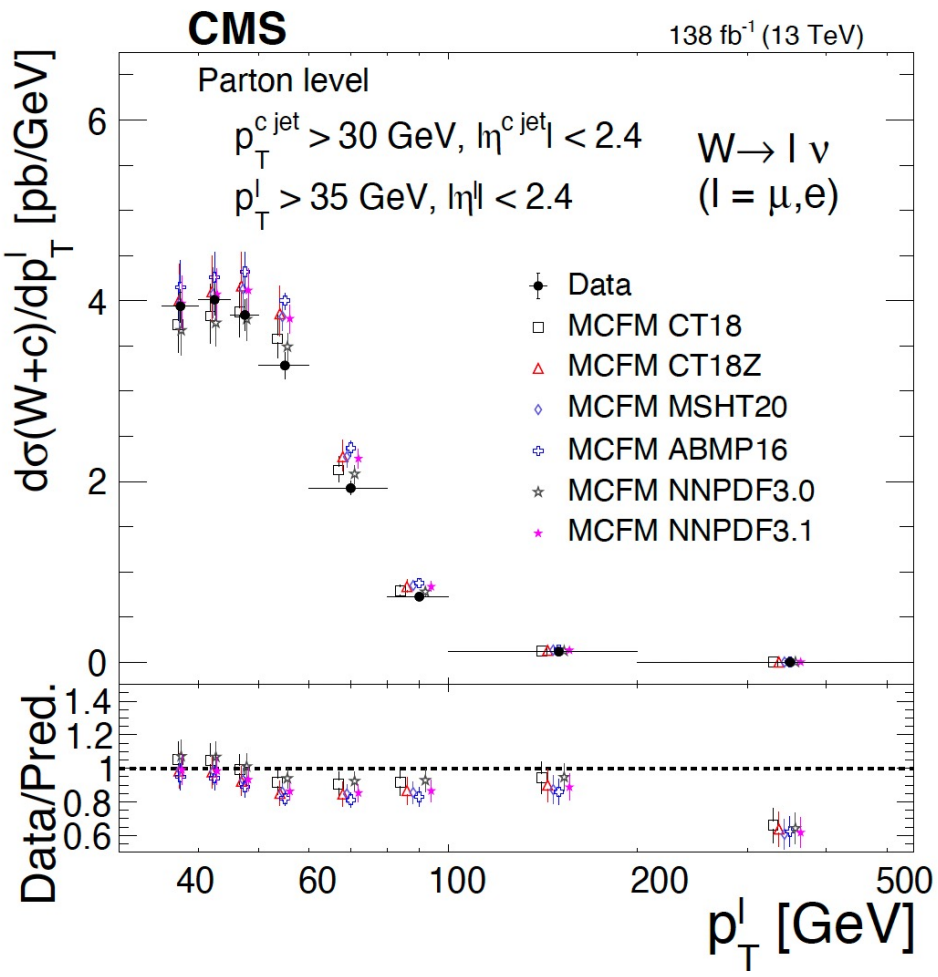
Inclusive and differential (W^+, W^-) cross-sections as a function of $p_T(D)$ and $\eta(\ell)$ → s- and anti-s PDF
W charge ratios → sensitive to differences between the *s*- and anti-*s* PDFs



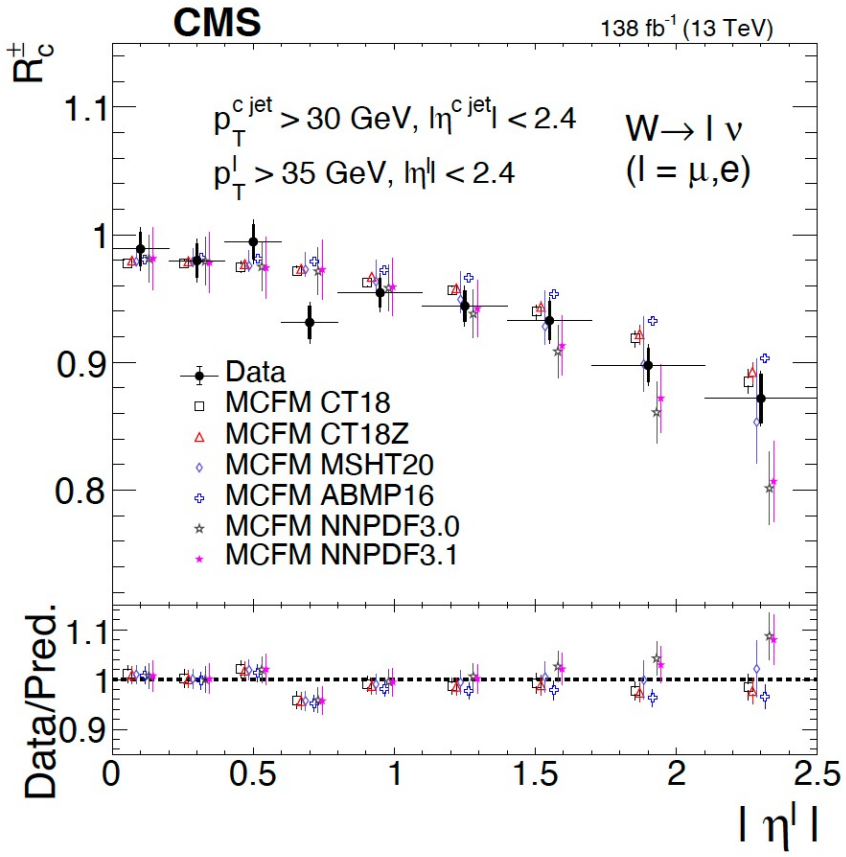


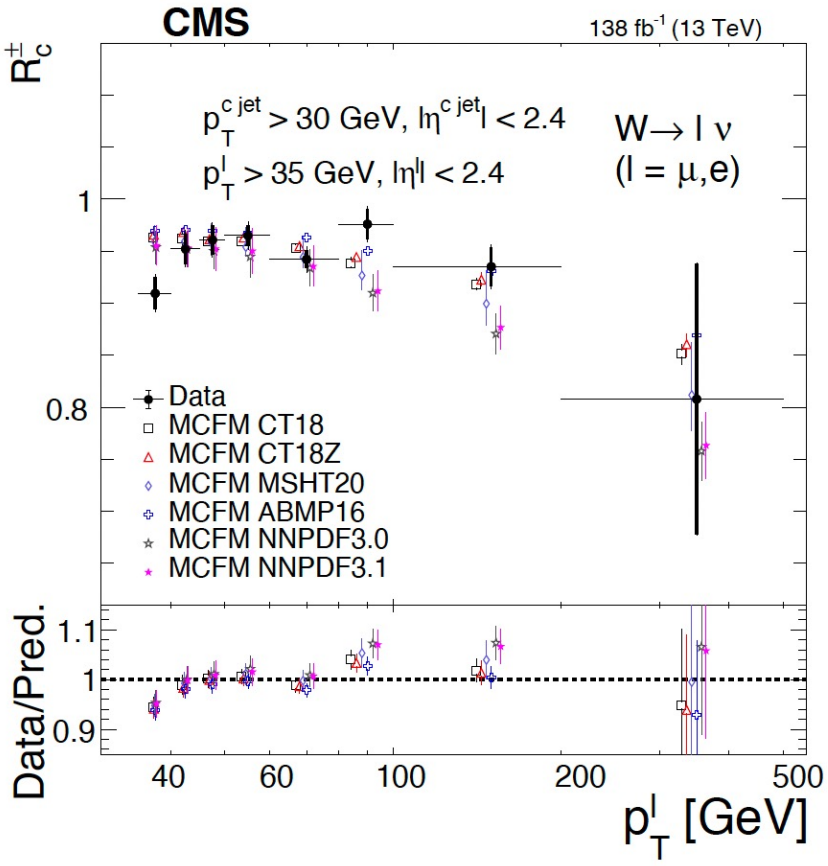
CMS W+charm production: inclusive cross sec., pT dependence



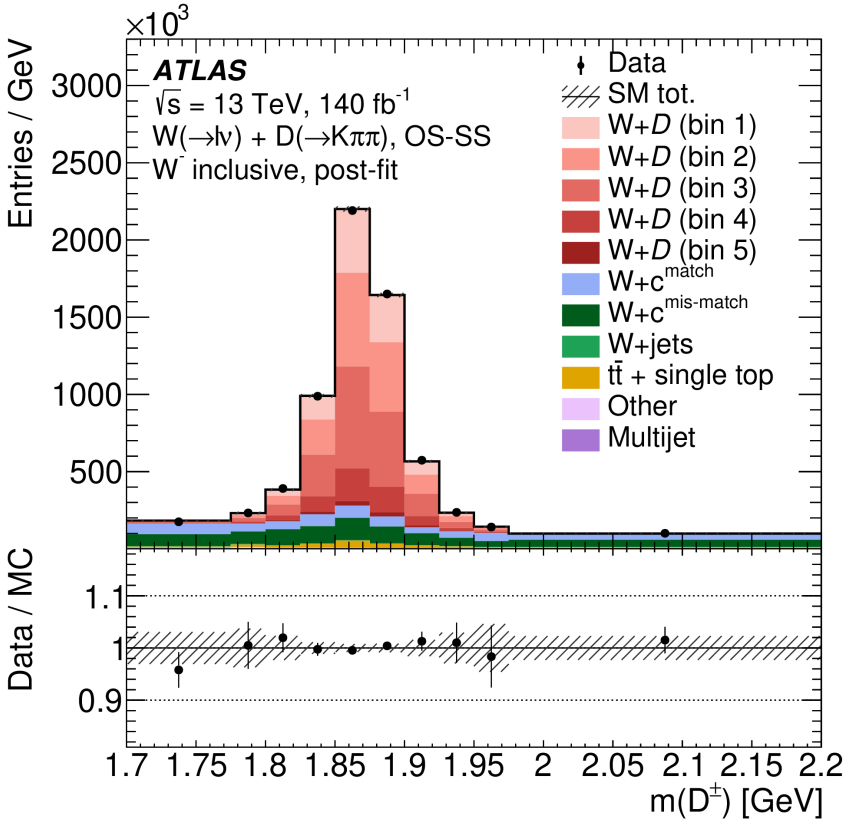


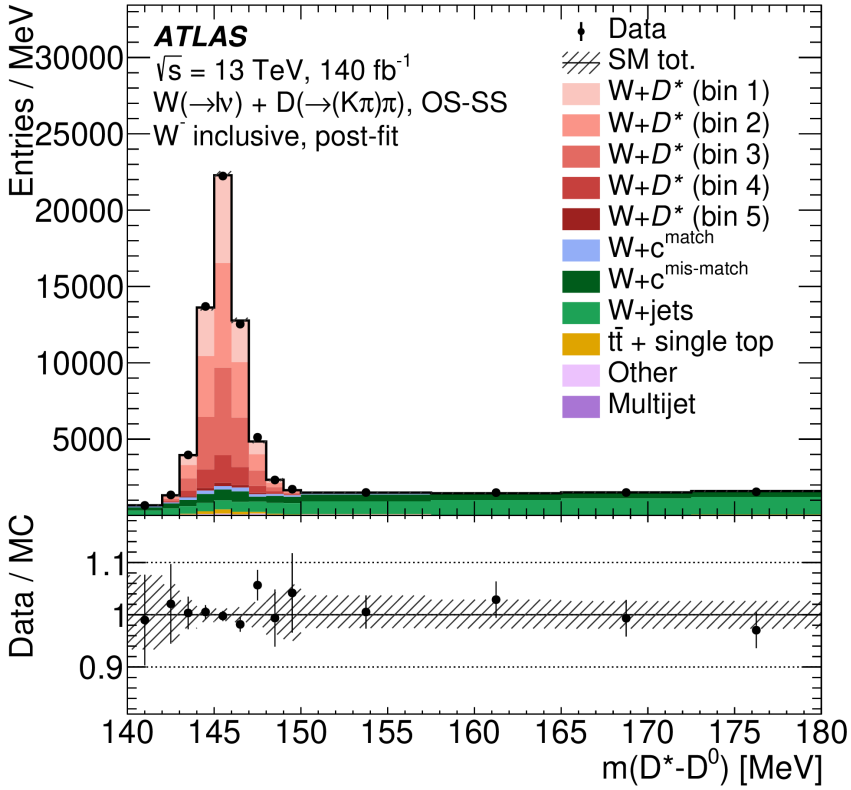
CMS W+charm production: R_c vs η and p_T



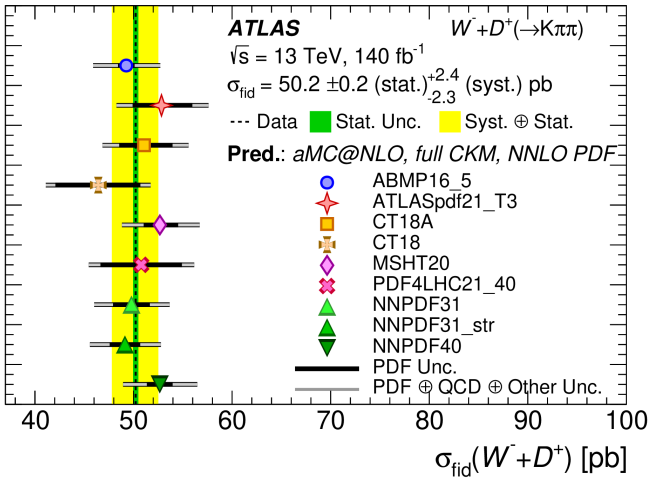


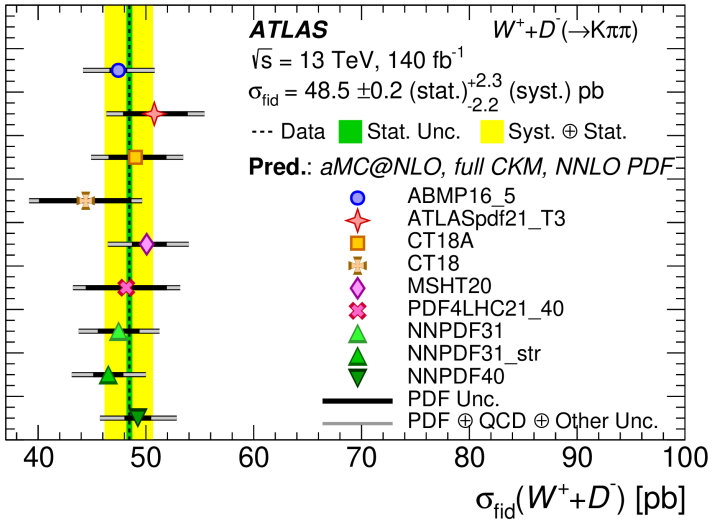
ATLAS W+charm production: signal extraction

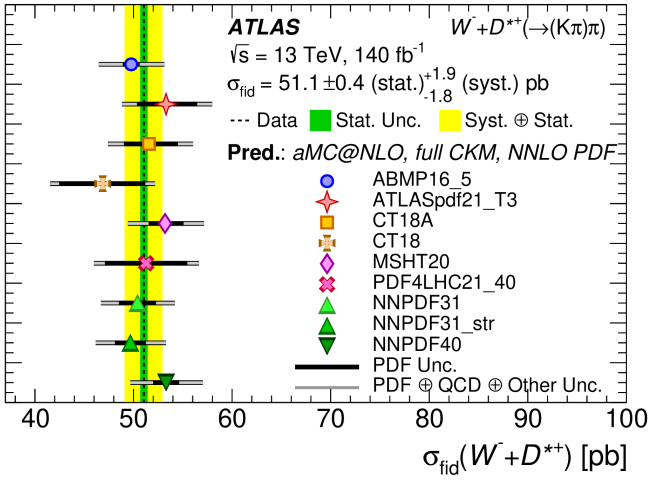


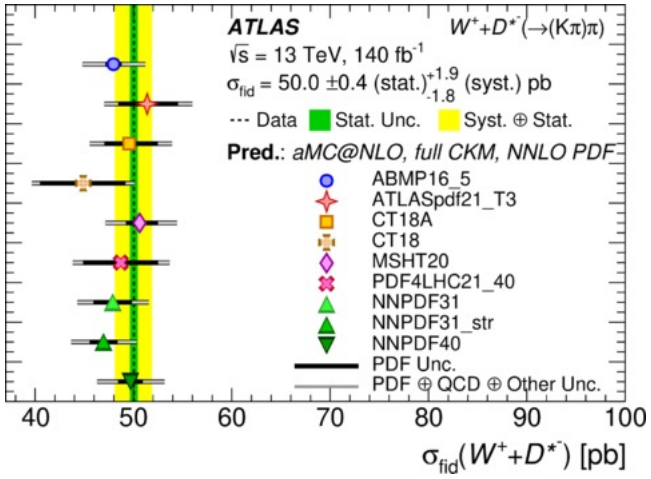


ATLAS W+charm production: cross sections

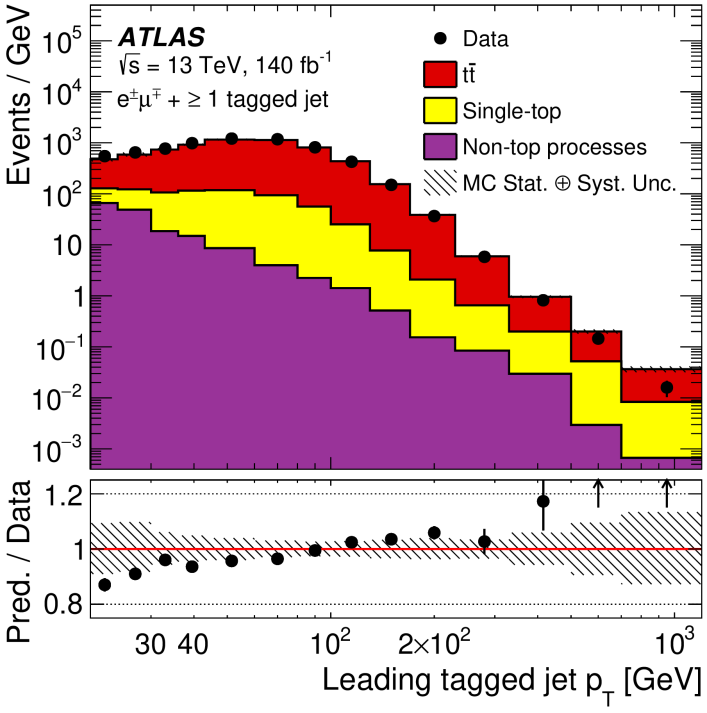


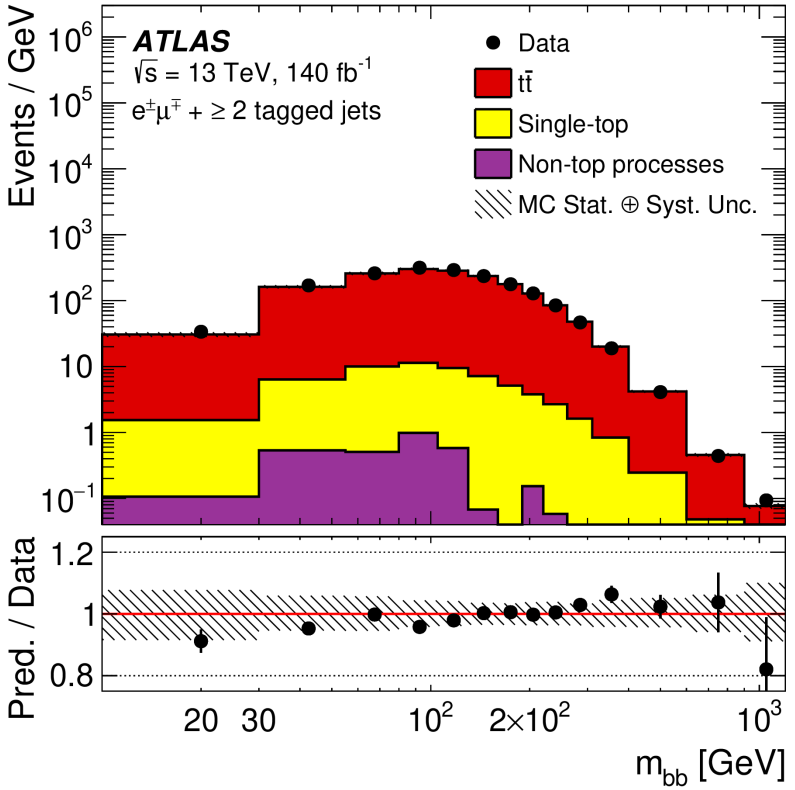




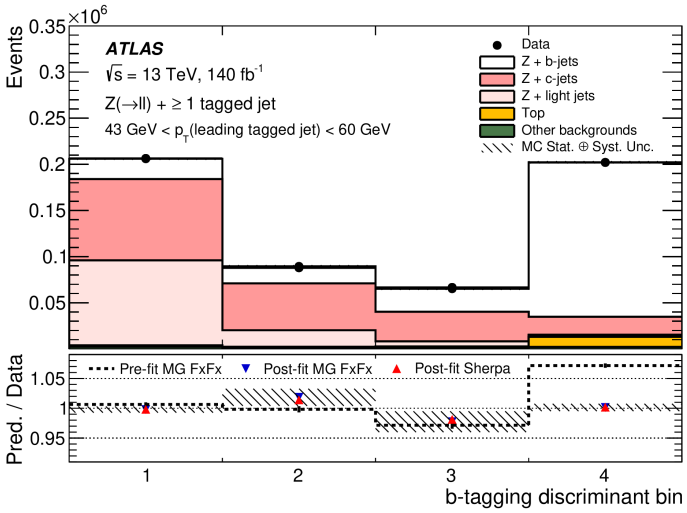


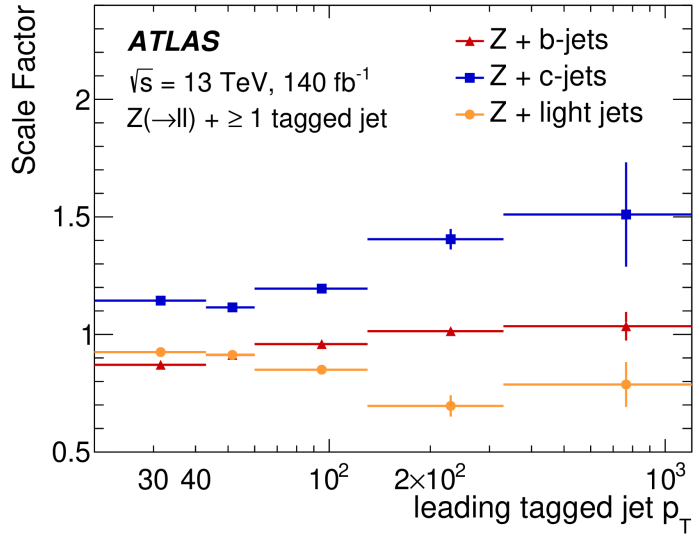
ATLAS Z+Heavy Flavour: top CR

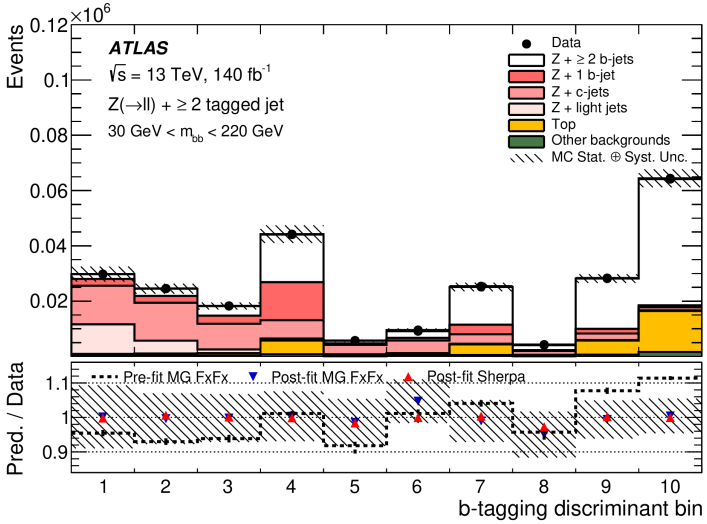


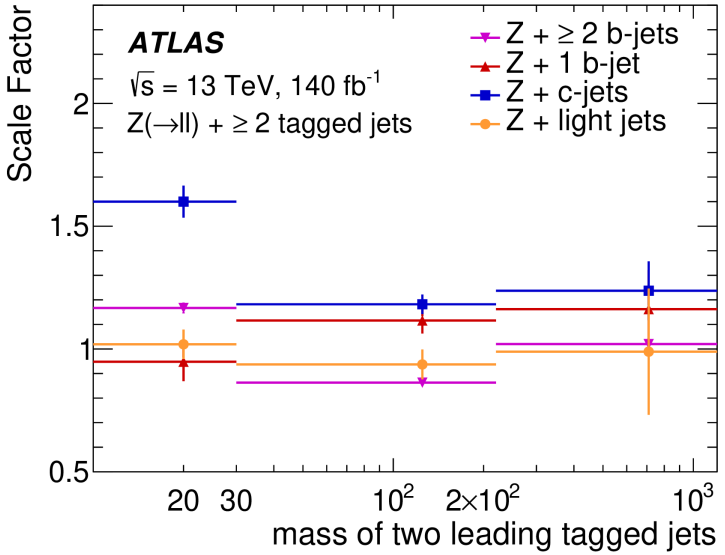


ATLAS Z+Heavy Flavour: Flavour fit

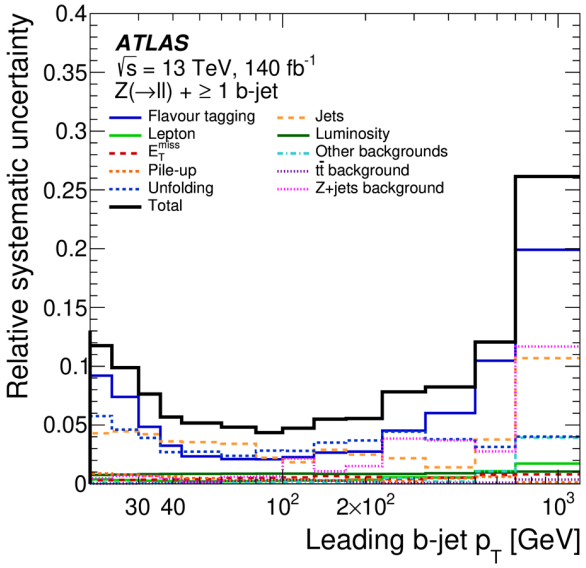


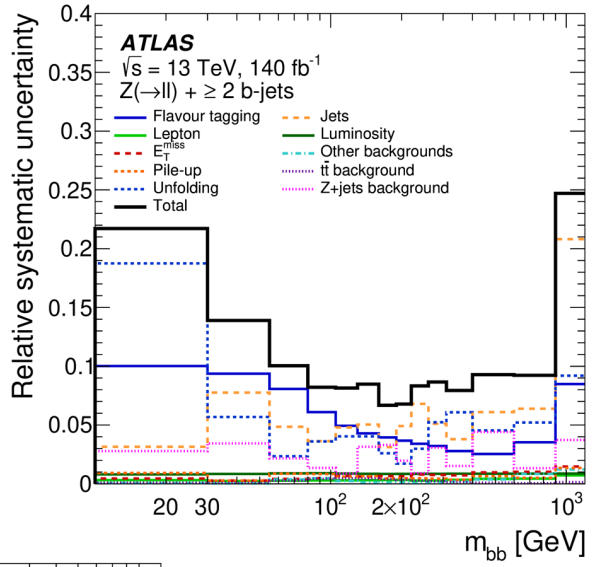


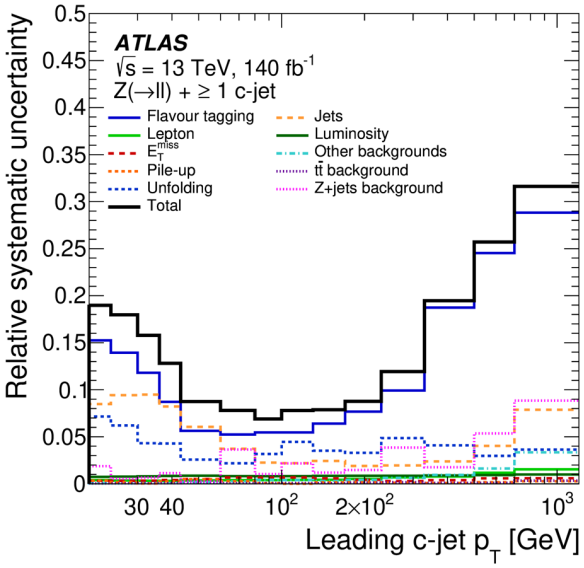




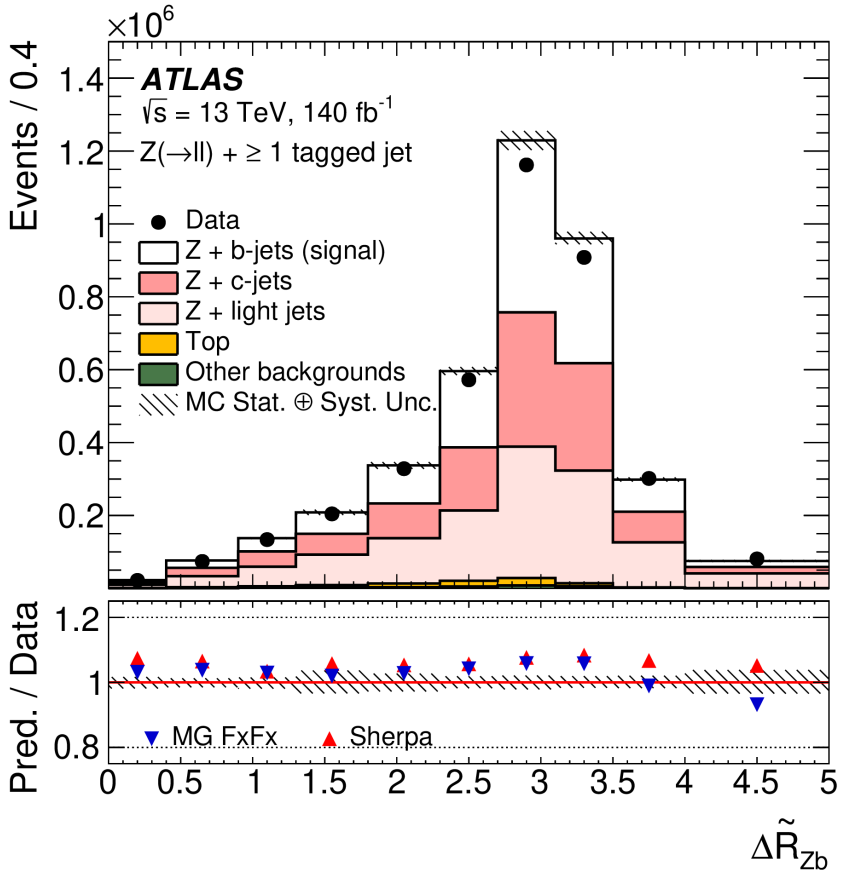
ATLAS Z+Heavy Flavour: uncertainties

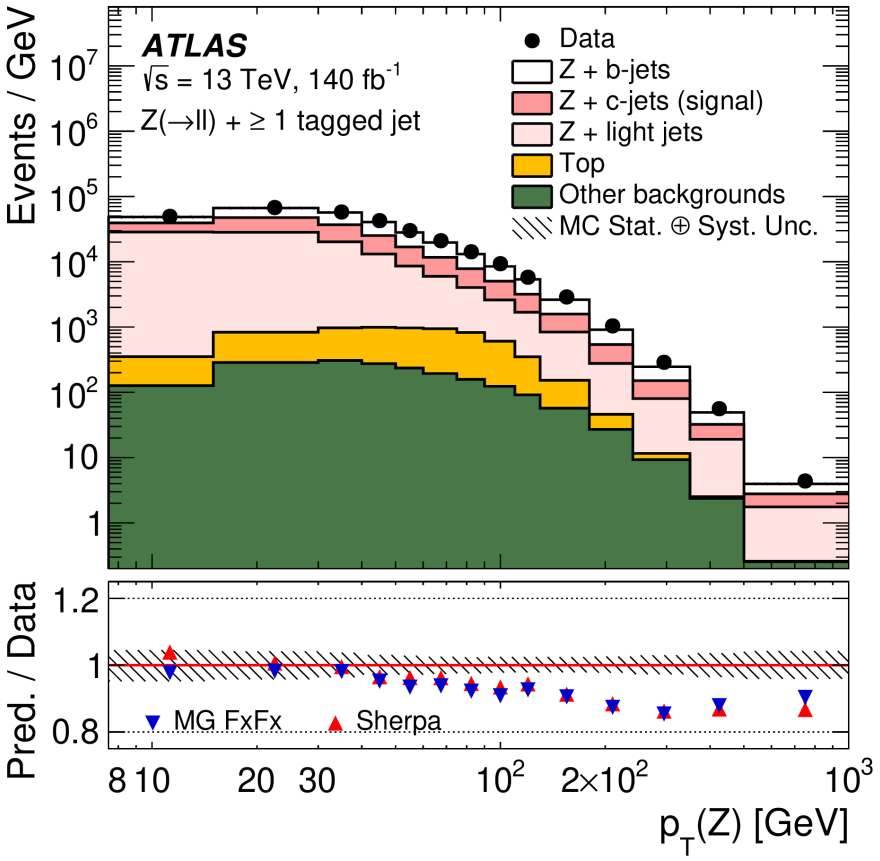




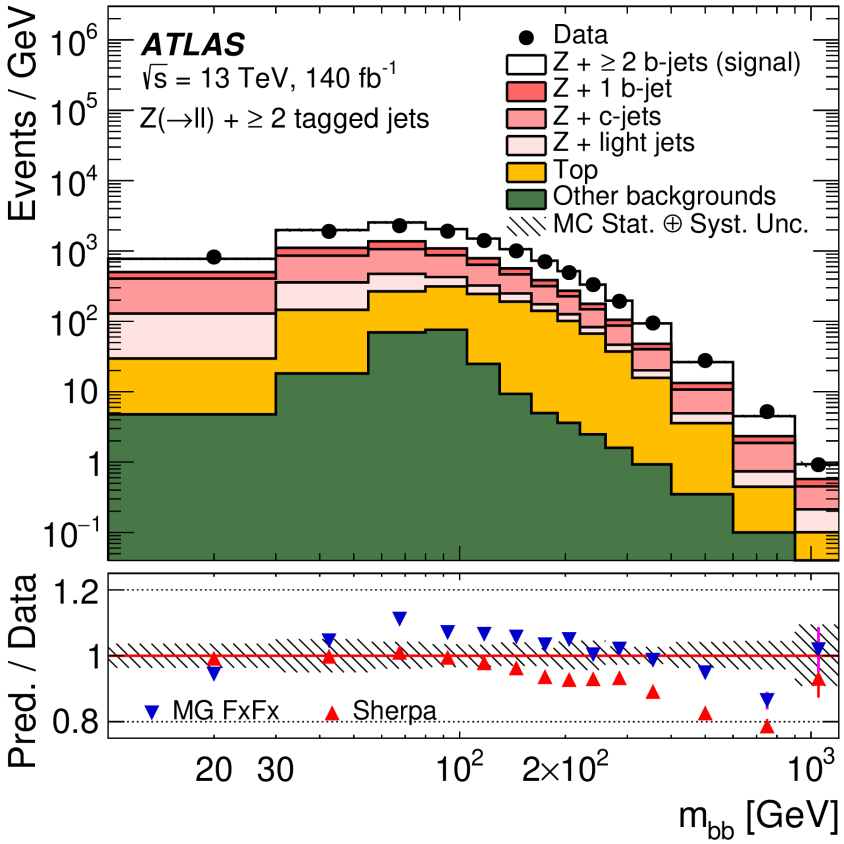


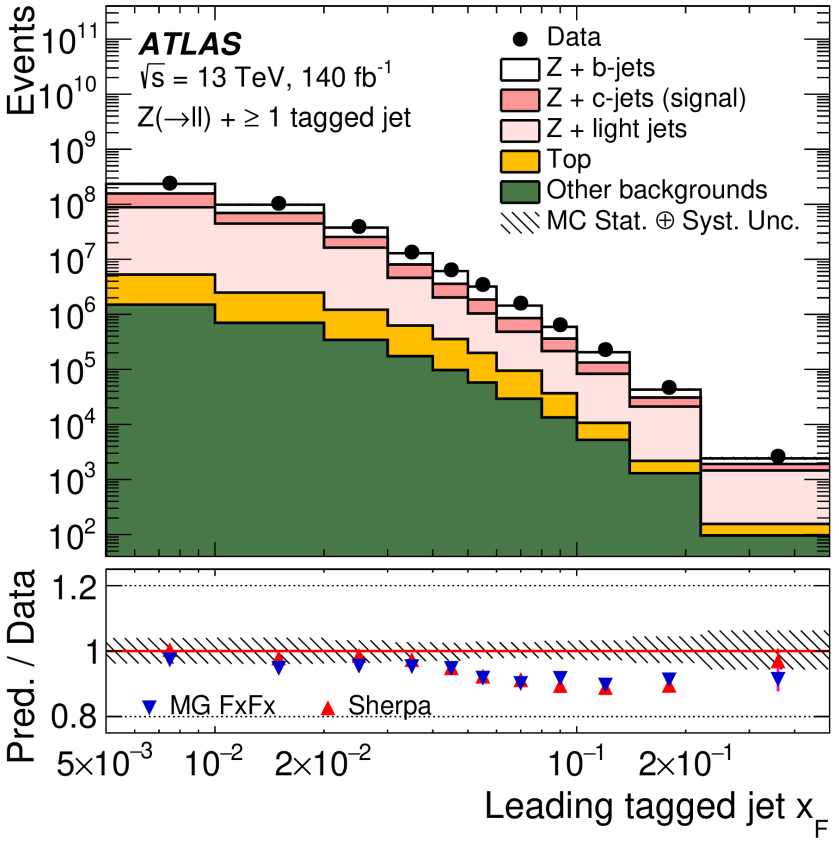
ATLAS Z+Heavy Flavour: detector-level distributions





ATLAS Z+Heavy Flavour: detector-level distributions





ATLAS Z+Heavy Flavour: unfolding