

PDFs: Impact of LHC at the beginning of the EIC era

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ePIC and EIC Physics Readiness Workshop

UniCal – March, 17 2026

Sources: “The Big 3”: **NNPDF**, MSHT, CT + PDF4LHC + ATLAS PDF FORUM

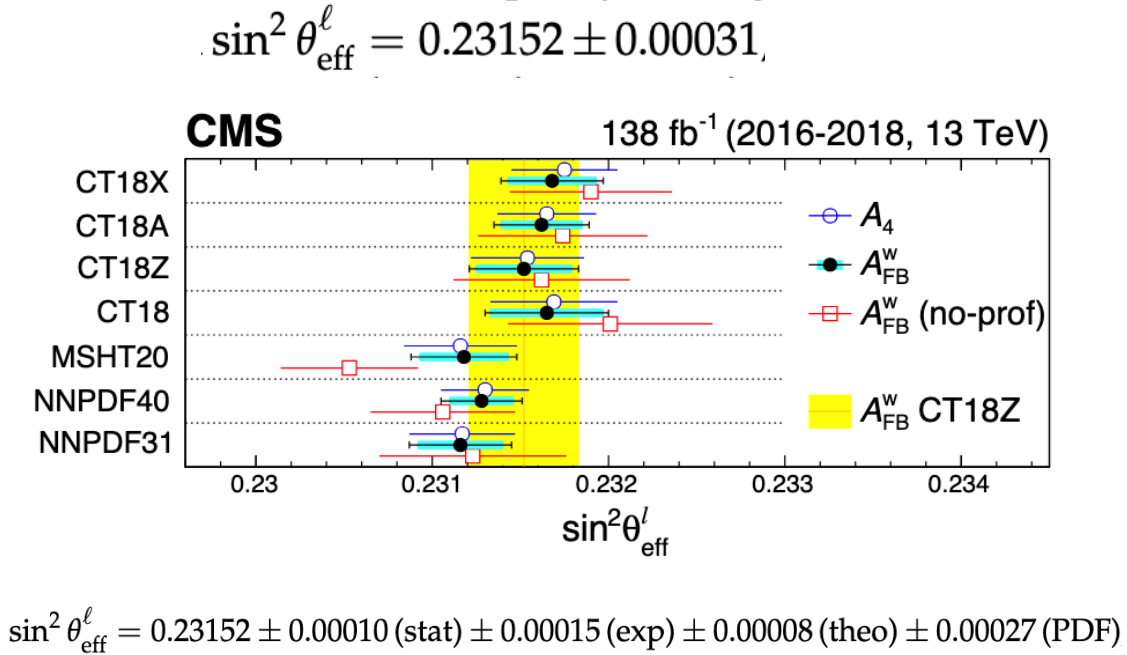


$$\text{Data} = \text{PDF} \otimes \sigma_H$$

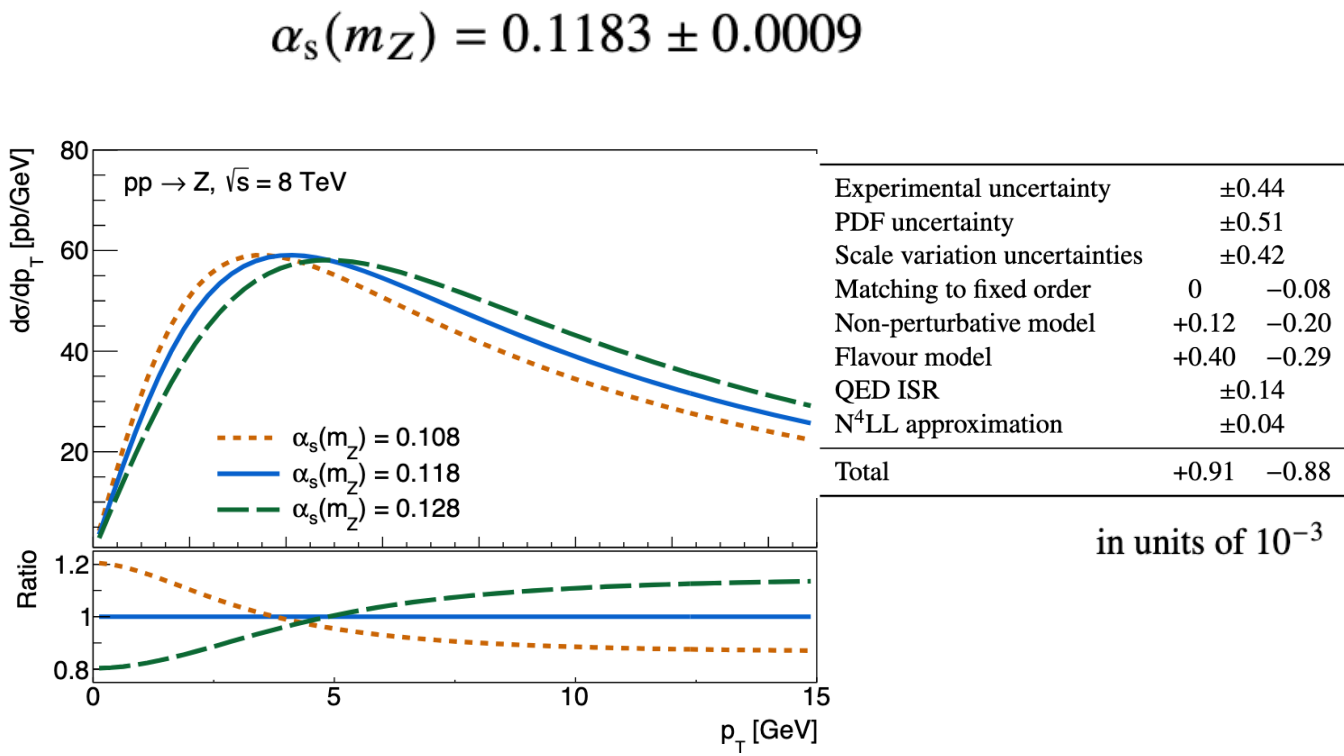
measure **fit** **predict**

Introduction/Motivation

LHC as a SM precision machine. PDFs are becoming more and more a limiting factor...



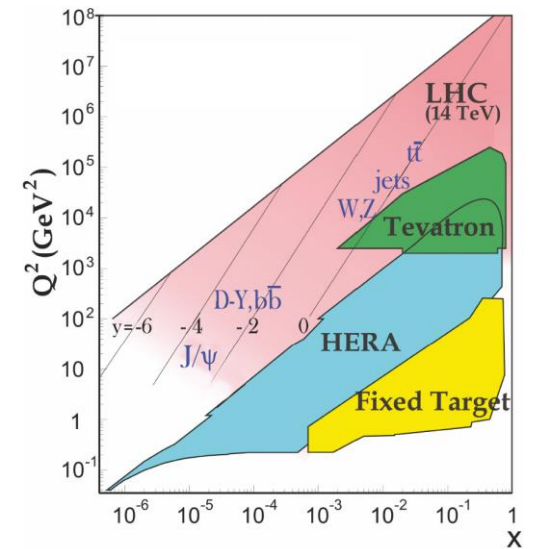
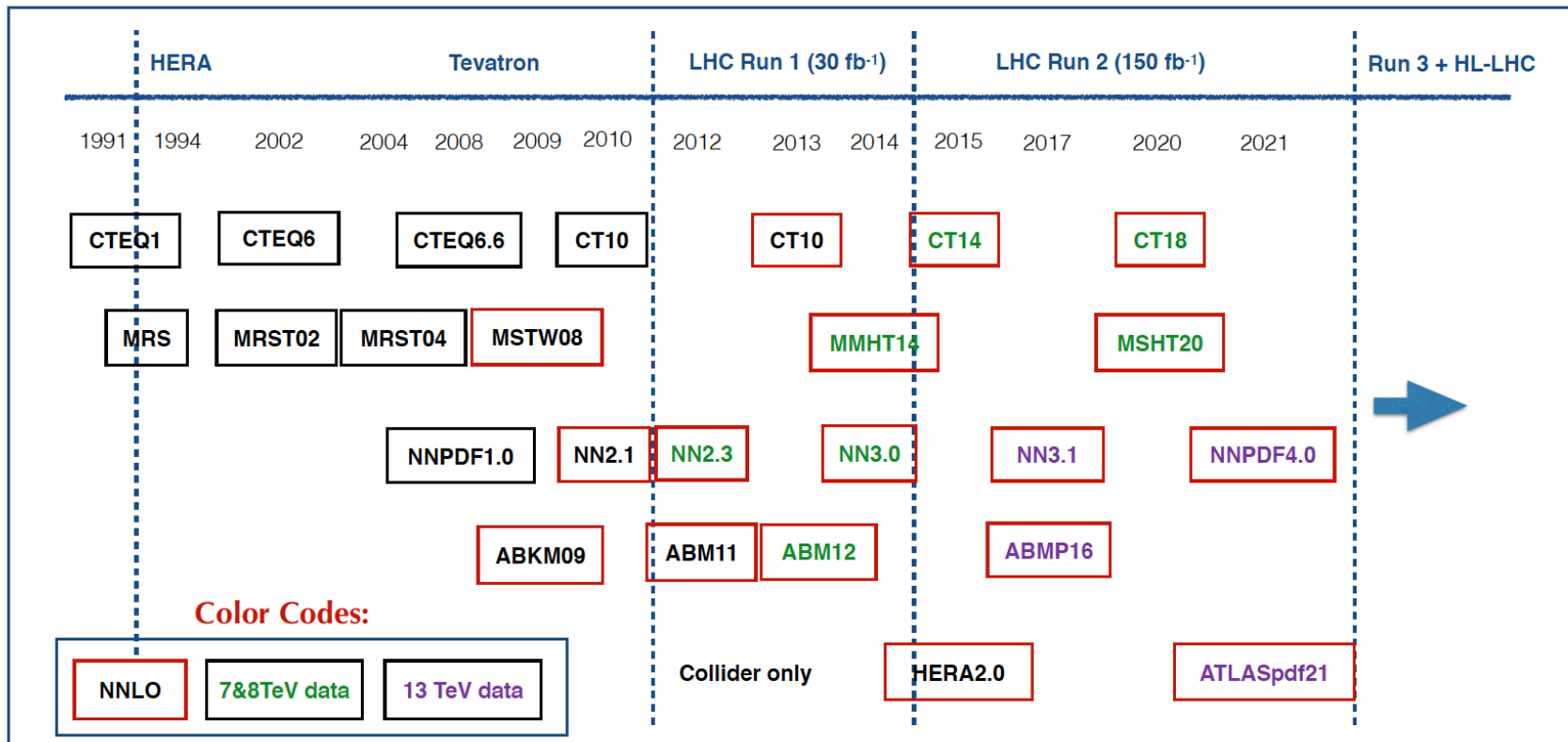
CMS, arXiv: 2408.07622



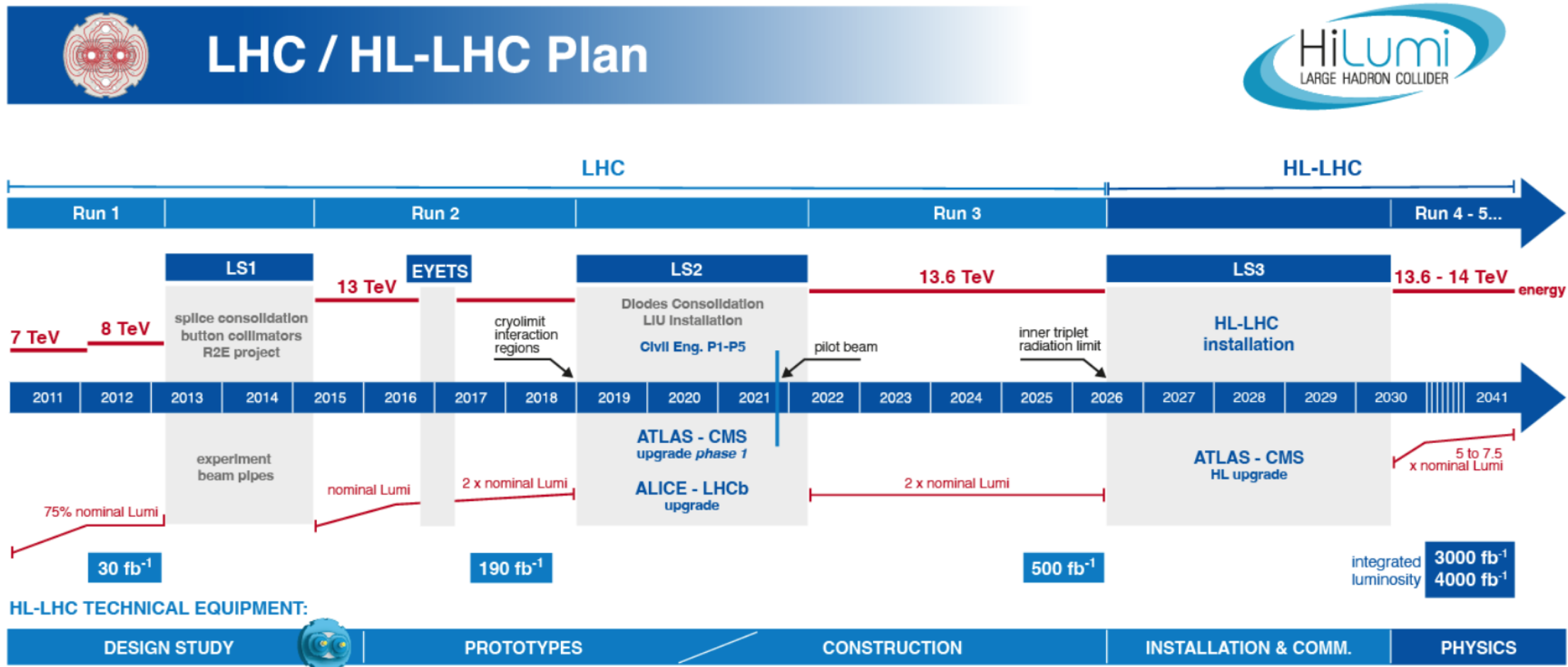
ATLAS, arXiv: 2309.12986

Groups/Collaborations active on “Global” PDFs analyses

Many groups active since the mid 80’s in the DGLAP analyses. The “modern era” of PDF fitting started at the beginning of the 90s (CTEQ1, MRS).



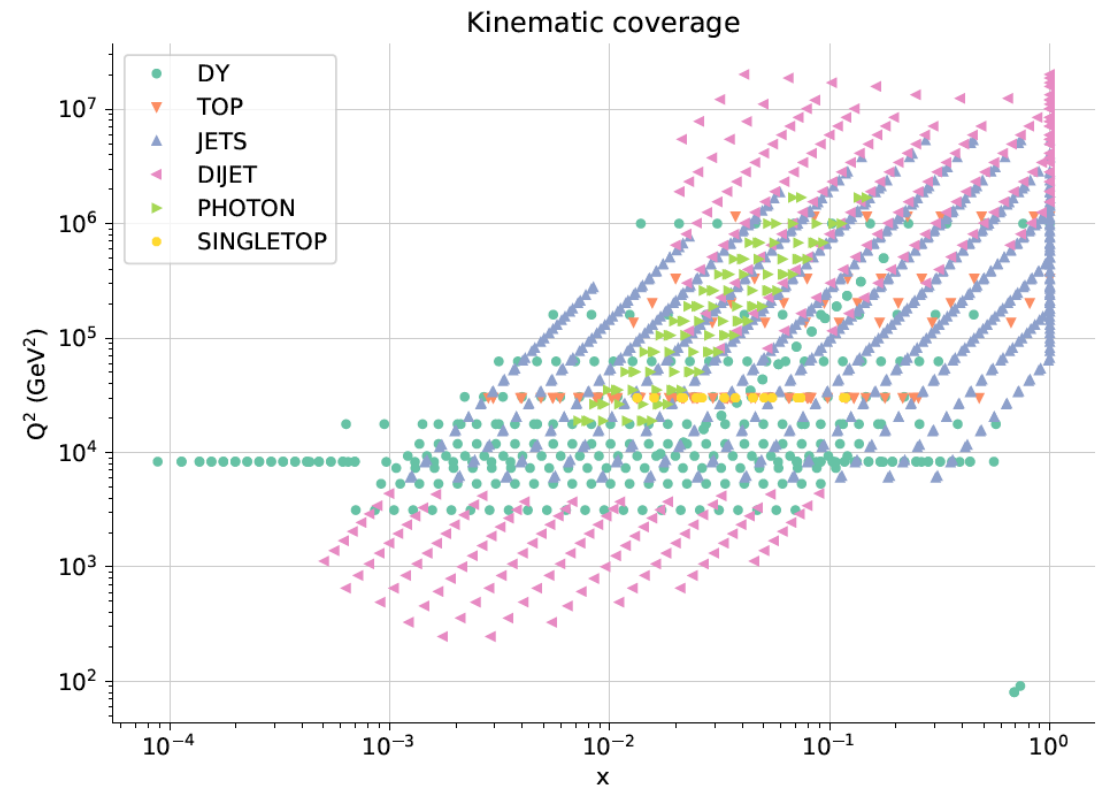
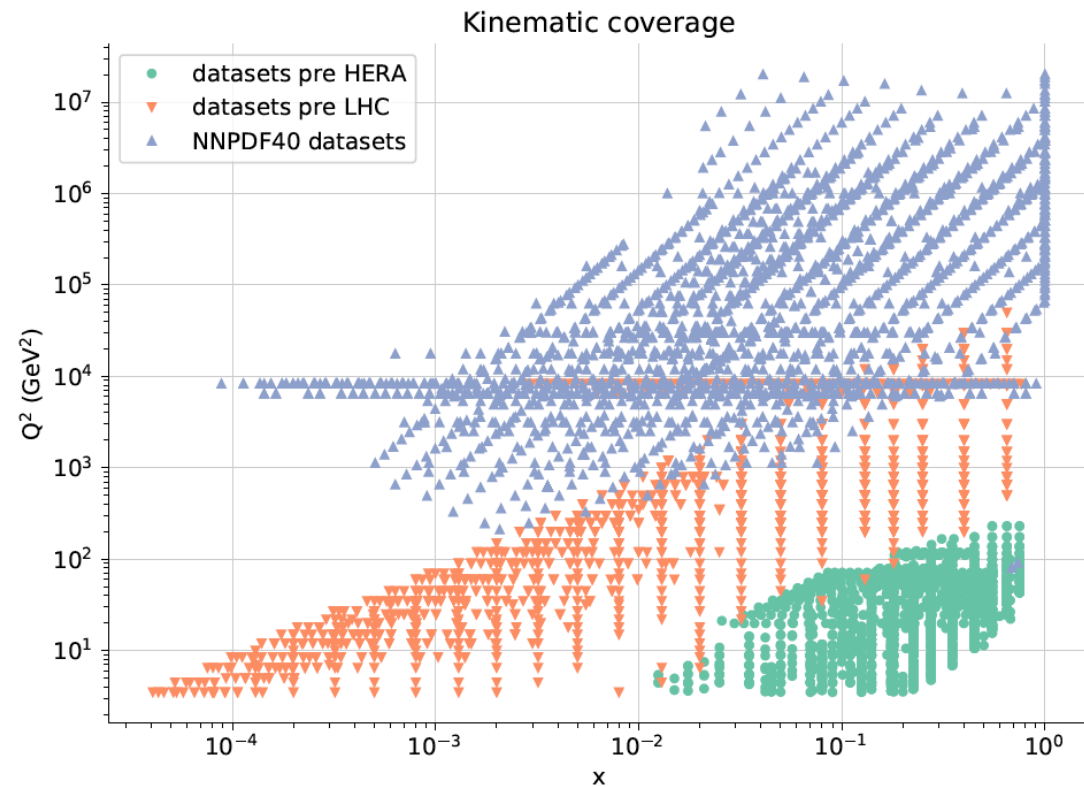
LHC/HL-LHC Plan



NNPDF4.0

arXiv: 2109.02653

Kinematic regions and observables:



NNPDF4.0

Kinematic regions and observables:

Dataset	Ref.	N_{dat}	Kin ₁	Kin ₂ [GeV]	Theory
CDF Z differential	[46]	29 (29/29)	$0.0 \leq y_{\ell\ell} \leq 2.9$	$66 \leq m_{\ell\ell} \leq 116$	Sherpa+Vrap
D0 Z differential	[47]	28 (28/28)	$0.0 \leq y_{\ell\ell} \leq 2.8$	$66 \leq m_{\ell\ell} \leq 116$	Sherpa+Vrap
[D0 W electron asymmetry]	[48]	13 (13/8)	$0.0 \leq y_e \leq 2.9$	$Q = m_W$	MCFM+FEWZ
D0 W muon asymmetry	[49]	10 (10/9)	$0.0 \leq y_\mu \leq 1.9$	$Q = m_W$	MCFM+FEWZ
ATLAS low-mass DY 7 TeV	[53]	6 (4/6)	$ \eta_\ell \leq 2.1$	$14 \leq m_{\ell\ell} \leq 56$	MCFM+FEWZ
ATLAS high-mass DY 7 TeV	[54]	13 (5/5)	$ \eta_\ell \leq 2.1$	$116 \leq m_{\ell\ell} \leq 1500$	MCFM+FEWZ
ATLAS W, Z 7 TeV ($\mathcal{L} = 35 \text{ pb}^{-1}$)	[51]	30 (30/30)	$ \eta_e, y_Z \leq 3.2$	$Q = m_W, m_Z$	MCFM+FEWZ
ATLAS W, Z 7 TeV ($\mathcal{L} = 4.6 \text{ fb}^{-1}$) (*)	[52]	61 (53/61)	$ \eta_e, y_Z \leq 2.5, 3.6$	$Q = m_W, m_Z$	MCFM+FEWZ
CMS W electron asymmetry 7 TeV	[55]	11 (11/11)	$ \eta_e \leq 2.4$	$Q = m_W$	MCFM+FEWZ
CMS W muon asymmetry 7 TeV	[56]	11 (11/11)	$ \eta_\mu \leq 2.4$	$Q = m_W$	MCFM+FEWZ
CMS DY 2D 7 TeV	[57]	132 (88/110)	$ \eta_{\ell\ell} \leq 2.2$	$20.0 \leq m_{\ell\ell} \leq 200$	MCFM+FEWZ
LHCb $Z \rightarrow ee$ 7 TeV	[59]	9 (9/9)	$2.0 \leq \eta_e \leq 4.5$	$Q = m_Z$	MCFM+FEWZ
LHCb $W, Z \rightarrow \mu$ 7 TeV	[60]	33 (29/29)	$2.0 \leq \eta_e \leq 4.5$	$Q = m_W$	MCFM+FEWZ
[ATLAS W 8 TeV] (*)	[79]	22 (—/22)	$ \eta_\ell < 2.4$	$Q = m_W$	MCFM+DYNNLO
ATLAS low-mass DY 2D 8 TeV (*)	[78]	84 (47/60)	$ y_{\ell\ell} < 2.4$	$46 \leq m_{\ell\ell} \leq 200$	MCFM+DYNNLO
ATLAS high-mass DY 2D 8 TeV (*)	[77]	48 (48/48)	$ y_{\ell\ell} < 2.4$	$116 \leq m_{\ell\ell} \leq 1500$	MCFM+FEWZ
CMS W rapidity 8 TeV	[64]	22 (22/22)	$ \eta_\ell \leq 2.3$	$Q = m_W$	MCFM+FEWZ
LHCb $Z \rightarrow ee$ 8 TeV	[61]	17 (17/17)	$2.00 < \eta_e < 4.25$	$Q = m_Z$	MCFM+FEWZ
LHCb $W, Z \rightarrow \mu$ 8 TeV	[62]	34 (29/30)	$2.00 < \eta_\mu < 4.25$	$Q = m_Z$	MCFM+FEWZ
[LHCb $W \rightarrow e$ 8 TeV] (*)	[80]	8 (—/8)	$2.00 < \eta_e < 4.25$	$Q = m_W$	MCFM+FEWZ
ATLAS $\sigma_{W,Z}^{\text{tot}}$ 13 TeV (*)	[81]	3 (3/3)	—	$Q = m_W, m_Z$	MCFM+FEWZ
LHCb $Z \rightarrow ee$ 13 TeV (*)	[82]	17 (15/15)	$2.00 < y_Z < 4.25$	$Q = m_Z$	MCFM+FEWZ
LHCb $Z \rightarrow \mu\mu$ 13 TeV (*)	[82]	18 (16/16)	$2.00 < y_Z < 4.50$	$Q = m_Z$	MCFM+FEWZ

Dataset	Ref.	N_{dat}	Kin ₁	Kin ₂ [GeV]	Theory
ATLAS $W^\pm + c$ 7 TeV (*)	[83]	22 (22/—)	$ \eta_\ell < 2.5$	$Q = m_W$	MCFM
CMS $W^\pm + c$ 7 TeV	[76]	10 (10/—)	$ \eta_\ell < 2.1$	$Q = m_W$	MCFM
CMS $W^\pm + c$ 13 TeV (*)	[84]	5 (5/—)	$ \eta_\ell < 2.4$	$Q = m_W$	MCFM
ATLAS $W^\pm + \text{jet}$ 8 TeV (*)	[93]	32 (30/30)	$0 \leq p_T^W \leq 800 \text{ GeV}$	$Q = m_W$	MCFM+N _{jetti}
ATLAS Z p_T 8 TeV ($p_T, m_{\ell\ell}$)	[63]	64 (40/44)	$12 \leq m_{\ell\ell} \leq 150 \text{ GeV}$	$30 \leq p_T^Z \leq 900$	MCFM+N _{jetti}
ATLAS Z p_T 8 TeV (p_T, y_Z)	[63]	120 (18/48)	$ y_Z < 2.4$	$30 \leq p_T^Z \leq 150$	MCFM+N _{jetti}
CMS Z p_T 8 TeV	[64]	50 (28/28))	$ y_Z < 1.6$	$30 \leq p_T^Z \leq 170$	MCFM+N _{jetti}
CMS $\sigma_{t\bar{t}}^{\text{tot}}$ 5 TeV (*)	[88]	1 (1/1)	—	$Q = m_t$	MCFM+top++
ATLAS $\sigma_{t\bar{t}}^{\text{tot}}$ 7, 8 TeV	[65]	2 (2/2)	—	$Q = m_t$	MCFM+top++
CMS $\sigma_{t\bar{t}}^{\text{tot}}$ 7, 8 TeV	[146]	2 (2/2)	—	$Q = m_t$	MCFM+top++
ATLAS $\sigma_{t\bar{t}}^{\text{tot}}$ 13 TeV ($\mathcal{L}=139 \text{ fb}^{-1}$) (*)	[134]	1 (1/1)	—	$Q = m_t$	MCFM+top++
CMS $\sigma_{t\bar{t}}^{\text{tot}}$ 13 TeV	[69]	1 (1/1)	—	$Q = m_t$	MCFM+top++
[ATLAS $t\bar{t}$ ℓ +jets 8 TeV ($1/\sigma d\sigma/dp_T^t$)]	[67]	8 (—/8)	$0 \leq p_T^t \leq 500 \text{ GeV}$	$Q = m_t$	Sherpa+NNLO
ATLAS $t\bar{t}$ ℓ +jets 8 TeV ($1/\sigma d\sigma/dy_t$)	[67]	5 (4/4)	$ y_t < 2.5$	$Q = m_t$	Sherpa+NNLO
ATLAS $t\bar{t}$ ℓ +jets 8 TeV ($1/\sigma d\sigma/dy_{t\bar{t}}$)	[67]	5 (4/4)	$ y_{t\bar{t}} < 2.5$	$Q = m_t$	Sherpa+NNLO
[ATLAS $t\bar{t}$ ℓ +jets 8 TeV ($1/\sigma d\sigma/dm_{t\bar{t}}$)]	[67]	7 (—/7)	$345 \leq m_{t\bar{t}} \leq 1600 \text{ GeV}$	$Q = m_t$	Sherpa+NNLO
ATLAS $t\bar{t}$ 2ℓ 8 TeV ($1/\sigma d\sigma/dy_{t\bar{t}}$) (*)	[89]	5 (5/5)	$ y_{t\bar{t}} < 2.8$	$Q = m_t$	ng5_aMC+NNLO
CMS $t\bar{t}$ ℓ +jets 8 TeV ($1/\sigma d\sigma/dy_{t\bar{t}}$)	[70]	10 (9/9)	$-2.5 < y_{t\bar{t}} < 2.5$	$Q = m_t$	Sherpa+NNLO
CMS $t\bar{t}$ 2D 2ℓ 8 TeV ($1/\sigma d\sigma/dy_t dm_{t\bar{t}}$) (*)	[90]	16 (16/16)	$ y_t < 2.5$	$340 \leq m_t \leq 1500$	ng5_aMC+NNLO
CMS $t\bar{t}$ ℓ +jet 13 TeV ($d\sigma/dy_t$) (*)	[91]	10 (10/10)	$ y_t < 2.5$	$Q = m_t$	ng5_aMC+NNLO
CMS $t\bar{t}$ 2ℓ 13 TeV ($d\sigma/dy_t$) (*)	[92]	11 (11/11)	$ y_t < 2.5$	$Q = m_t$	ng5_aMC+NNLO
[ATLAS incl. jets 7 TeV, R=0.6]	[73]	90 (—/90)	$ y^{\text{jet}} < 3.0$	$100 \leq p_T^{\text{jet}} \leq 1992$	NNLOjet
[CMS incl. jets 7 TeV]	[147]	133 (—/133)	$ y^{\text{jet}} < 2.5$	$100 \leq p_T^{\text{jet}} \leq 2000$	NNLOjet
ATLAS incl. jets 8 TeV, R=0.6 (*)	[86]	171 (171/171)	$ y^{\text{jet}} < 3.0$	$70 \leq p_T^{\text{jet}} \leq 2500$	NNLOjet
CMS incl. jets 8 TeV (*)	[87]	185 (185/185)	$ y^{\text{jet}} < 3.0$	$74 \leq p_T^{\text{jet}} \leq 2500$	NNLOjet
ATLAS dijets 7 TeV, R=0.6 (*)	[148]	90 (90/90)	$0.0 \leq y^* \leq 3.0$	$260 \leq m_{jj} \leq 4270$	NNLOjet
CMS dijets 7 TeV (*)	[74]	54 (54/54)	$ y_{\text{max}} < 2.5$	$200 \leq m_{jj} \leq 5000$	NNLOjet
[CMS 3D dijets 8 TeV] (*)	[149]	122 (122/122)	$0.0 < y_b, y^* < 3.0$	$133 \leq p_{T,\text{avg}} \leq 1780$	NNLOjet
[ATLAS isolated γ prod. 8 TeV] (*)	[100]	49 (—/—)	$ \eta_\gamma < 2.37$	$E_T^\gamma < 1500$	MCFM+NNLO
ATLAS isolated γ prod. 13 TeV (*)	[101]	53 (53/53)	$ \eta_\gamma < 2.37$	$E_T^\gamma < 1500$	MCFM+NNLO
ATLAS single t R_t 7 TeV (*)	[94]	1 (1/1)	—	$Q = m_t$	ng5_aMC+NNLO
CMS single t $\sigma_t + \sigma_{\bar{t}}$ 7 TeV (*)	[95]	1 (1/1)	—	$Q = m_t$	ng5_aMC+NNLO
ATLAS single t R_t 8 TeV (*)	[96]	1 (1/1)	—	$Q = m_t$	ng5_aMC+NNLO
CMS single t R_t 8 TeV (*)	[97]	1 (1/1)	—	$Q = m_t$	ng5_aMC+NNLO
ATLAS single t R_t 13 TeV (*)	[98]	1 (1/1)	—	$Q = m_t$	ng5_aMC+NNLO
CMS single t R_t 13 TeV (*)	[99]	1 (1/1)	—	$Q = m_t$	ng5_aMC+NNLO
ATLAS single t 7 TeV ($1/\sigma d\sigma/dy_t$) (*)	[94]	4 (3/3)	$ y_t < 3.0$	$Q = m_t$	ng5_aMC+NNLO
ATLAS single t 7 TeV ($1/\sigma d\sigma/dy_{\bar{t}}$) (*)	[94]	4 (3/3)	$ y_{\bar{t}} < 3.0$	$Q = m_t$	ng5_aMC+NNLO
ATLAS single t 8 TeV ($1/\sigma d\sigma/dy_t$) (*)	[96]	4 (3/3)	$ y_t < 2.2$	$Q = m_t$	ng5_aMC+NNLO
ATLAS single t 8 TeV ($1/\sigma d\sigma/dy_{\bar{t}}$) (*)	[96]	4 (3/3)	$ y_{\bar{t}} < 2.2$	$Q = m_t$	ng5_aMC+NNLO

LHC	$pp \rightarrow \text{jet} + X$	$gg, qg, q\bar{q} \rightarrow 2j$	g, q	$0.001 \lesssim x \lesssim 0.5$
	$pp \rightarrow (W^\pm \rightarrow \ell^\pm \nu) + X$	$u\bar{d} \rightarrow W^+, d\bar{u} \rightarrow W^-$	$u, d, \bar{u}, \bar{d}, g$	$x \gtrsim 10^{-3}$
	$pp \rightarrow (Z \rightarrow \ell^+ \ell^-) + X$	$q\bar{q} \rightarrow Z$	q, \bar{q}, g	$x \gtrsim 10^{-3}$
	$pp \rightarrow (Z \rightarrow \ell^+ \ell^-) + X, p_\perp$	$gq(\bar{q}) \rightarrow Zq(\bar{q})$	g, q, \bar{q}	$x \gtrsim 0.01$
	$pp \rightarrow (\gamma^* \rightarrow \ell^+ \ell^-) + X, \text{Low mass}$	$q\bar{q} \rightarrow \gamma^*$	q, \bar{q}, g	$x \gtrsim 10^{-4}$
	$pp \rightarrow (\gamma^* \rightarrow \ell^+ \ell^-) + X, \text{High mass}$	$q\bar{q} \rightarrow \gamma^*$	\bar{q}	$x \gtrsim 0.1$
	$pp \rightarrow W^+ \bar{c}, W^- c$	$sg \rightarrow W^+ c, \bar{s}g \rightarrow W^- \bar{c}$	s, \bar{s}	$x \sim 0.01$
	$pp \rightarrow t\bar{t} + X$	$gg \rightarrow t\bar{t}$	g	$x \gtrsim 0.01$
	$pp \rightarrow D, B + X$	$gg \rightarrow c\bar{c}, b\bar{b}$	g	$x \gtrsim 10^{-6}, 10^{-5}$
	$pp \rightarrow J/\psi, \Upsilon + pp$	$\gamma^*(gg) \rightarrow c\bar{c}, b\bar{b}$	g	$x \gtrsim 10^{-6}, 10^{-5}$
$pp \rightarrow \gamma + X$	$gq(\bar{q}) \rightarrow \gamma q(\bar{q})$	g	$x \gtrsim 0.005$	

Dataset	Ref.	N_{dat}	Kin_1	Kin_2 [GeV]	Theory
CDF Z differential	[46]	29 (29/29)	$0.0 \leq y_{\ell\ell} \leq 2.9$	$66 \leq m_{\ell\ell} \leq 116$	Sherpa+Vrap
D0 Z differential	[47]	28 (28/28)	$0.0 \leq y_{\ell\ell} \leq 2.8$	$66 \leq m_{\ell\ell} \leq 116$	Sherpa+Vrap
[D0 W electron asymmetry]	[48]	13 (13/8)	$0.0 \leq y_e \leq 2.9$	$Q = m_W$	MCFM+FEWZ
D0 W muon asymmetry	[49]	10 (10/9)	$0.0 \leq y_\mu \leq 1.9$	$Q = m_W$	MCFM+FEWZ
ATLAS low-mass DY 7 TeV	[53]	6 (4/6)	$ \eta_\ell \leq 2.1$	$14 \leq m_{\ell\ell} \leq 56$	MCFM+FEWZ
ATLAS high-mass DY 7 TeV	[54]	13 (5/5)	$ \eta_\ell \leq 2.1$	$116 \leq m_{\ell\ell} \leq 1500$	MCFM+FEWZ
ATLAS W, Z 7 TeV ($\mathcal{L} = 35 \text{ pb}^{-1}$)	[51]	30 (30/30)	$ \eta_e, y_Z \leq 3.2$	$Q = m_W, m_Z$	MCFM+FEWZ
ATLAS W, Z 7 TeV ($\mathcal{L} = 4.6 \text{ fb}^{-1}$) (*)	[52]	61 (53/61)	$ \eta_e, y_Z \leq 2.5, 3.6$	$Q = m_W, m_Z$	MCFM+FEWZ
CMS W electron asymmetry 7 TeV	[55]	11 (11/11)	$ \eta_e \leq 2.4$	$Q = m_W$	MCFM+FEWZ
CMS W muon asymmetry 7 TeV	[56]	11 (11/11)	$ \eta_\mu \leq 2.4$	$Q = m_W$	MCFM+FEWZ
CMS DY 2D 7 TeV	[57]	132 (88/110)	$ \eta_{\ell\ell} \leq 2.2$	$20.0 \leq m_{\ell\ell} \leq 200$	MCFM+FEWZ
LHCb Z $\rightarrow ee$ 7 TeV				$Q = m_Z$	MCFM+FEWZ
LHCb W, Z $\rightarrow \mu\mu$ 7 TeV				$Q = m_W$	MCFM+FEWZ
[ATLAS W 8 TeV] (*)				$Q = m_W$	MCFM+DYNLLO
ATLAS low-mass DY 2D 8 TeV (*)	[78]	84 (47/60)	$ y_{\ell\ell} < 2.4$	$46 \leq m_{\ell\ell} \leq 200$	MCFM+DYNLLO
ATLAS high-mass DY 2D 8 TeV (*)	[77]	48 (48/48)	$ y_{\ell\ell} < 2.4$	$116 \leq m_{\ell\ell} \leq 1500$	MCFM+FEWZ
CMS W rapidity 8 TeV	[64]	22 (22/22)	$ \eta_\ell \leq 2.3$	$Q = m_W$	MCFM+FEWZ
LHCb Z $\rightarrow ee$ 8 TeV	[61]	17 (17/17)	$2.00 < \eta_e < 4.25$	$Q = m_Z$	MCFM+FEWZ
LHCb W, Z $\rightarrow \mu\mu$ 8 TeV	[62]	34 (29/30)	$2.00 < \eta_\mu < 4.25$	$Q = m_Z$	MCFM+FEWZ
[LHCb W $\rightarrow e$ 8 TeV] (*)	[80]	8 (—/8)	$2.00 < \eta_e < 4.25$	$Q = m_W$	MCFM+FEWZ
ATLAS $\sigma_{W,Z}^{\text{tot}}$ 13 TeV (*)	[81]	3 (3/3)	—	$Q = m_W, m_Z$	MCFM+FEWZ
LHCb Z $\rightarrow ee$ 13 TeV (*)	[82]	17 (15/15)	$2.00 < y_Z < 4.25$	$Q = m_Z$	MCFM+FEWZ
LHCb Z $\rightarrow \mu\mu$ 13 TeV (*)	[82]	18 (16/16)	$2.00 < y_Z < 4.50$	$Q = m_Z$	MCFM+FEWZ

DY: W,Z (rapidity, asymmetries)

Ref.	N_{dat}	Kin_1	Kin_2 [GeV]	Theory
			m_W	MCFM
			m_W	MCFM
			m_W	MCFM
			m_W	MCFM+N _{jetti}
			$p_T^Z \leq 900$	MCFM+N _{jetti}
			$p_T^Z \leq 150$	MCFM+N _{jetti}
			$p_T^Z \leq 170$	MCFM+N _{jetti}
[88]	1 (1/1)	—	$Q = m_t$	MCFM+top++
[65]	2 (2/2)	—	$Q = m_t$	MCFM+top++
[146]	2 (2/2)	—	$Q = m_t$	MCFM+top++
[134]	1 (1/1)	—	$Q = m_t$	MCFM+top++
			m_t	MCFM+top++
			m_t	Sherpa+NNLO
			m_t	Sherpa+NNLO
			m_t	Sherpa+NNLO
[67]	7 (—/7)	$345 \leq m_{t\bar{t}} \leq 1600 \text{ GeV}$	$Q = m_t$	Sherpa+NNLO
[89]	5 (5/5)	$ y_{t\bar{t}} < 2.8$	$Q = m_t$	ng5_aMC+NNLO
[70]	10 (9/9)	$-2.5 < y_{t\bar{t}} < 2.5$	$Q = m_t$	Sherpa+NNLO
[90]	16 (16/16)	$ y_t < 2.5$	$340 \leq m_t \leq 1500$	ng5_aMC+NNLO
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[73]	90 (—/90)	$ y^{\text{jet}} < 3.0$	$100 \leq p_T^{\text{jet}} \leq 1992$	NNLOjet
[147]	133 (—/133)	$ y^{\text{jet}} < 2.5$	$100 \leq p_T^{\text{jet}} \leq 2000$	NNLOjet
			$p_T^{\text{jet}} \leq 2500$	NNLOjet
			$p_T^{\text{jet}} \leq 2500$	NNLOjet
			$m_{jj} \leq 4270$	NNLOjet
			$200 \leq m_{jj} \leq 5000$	NNLOjet
[149]	122 (122/122)	$0.0 < y_b, y^* < 3.0$	$133 \leq p_{T,\text{avg}} \leq 1780$	NNLOjet
			$E_T^\gamma < 1500$	MCFM+NNLO
			$E_T^\gamma < 1500$	MCFM+NNLO
[94]	1 (1/1)	—	$Q = m_t$	ng5_aMC+NNLO
[95]	1 (1/1)	—	$Q = m_t$	ng5_aMC+NNLO
			$Q = m_t$	ng5_aMC+NNLO
			$Q = m_t$	ng5_aMC+NNLO
			$Q = m_t$	ng5_aMC+NNLO
[94]	4 (3/3)	$ y_t < 3.0$	$Q = m_t$	ng5_aMC+NNLO
[94]	4 (3/3)	$ y_t < 3.0$	$Q = m_t$	ng5_aMC+NNLO
[96]	4 (3/3)	$ y_t < 2.2$	$Q = m_t$	ng5_aMC+NNLO
[96]	4 (3/3)	$ y_t < 2.2$	$Q = m_t$	ng5_aMC+NNLO

W+c, W/Z +jet

DY: Z pT

t-tbar production

Inclusive jet, dijet

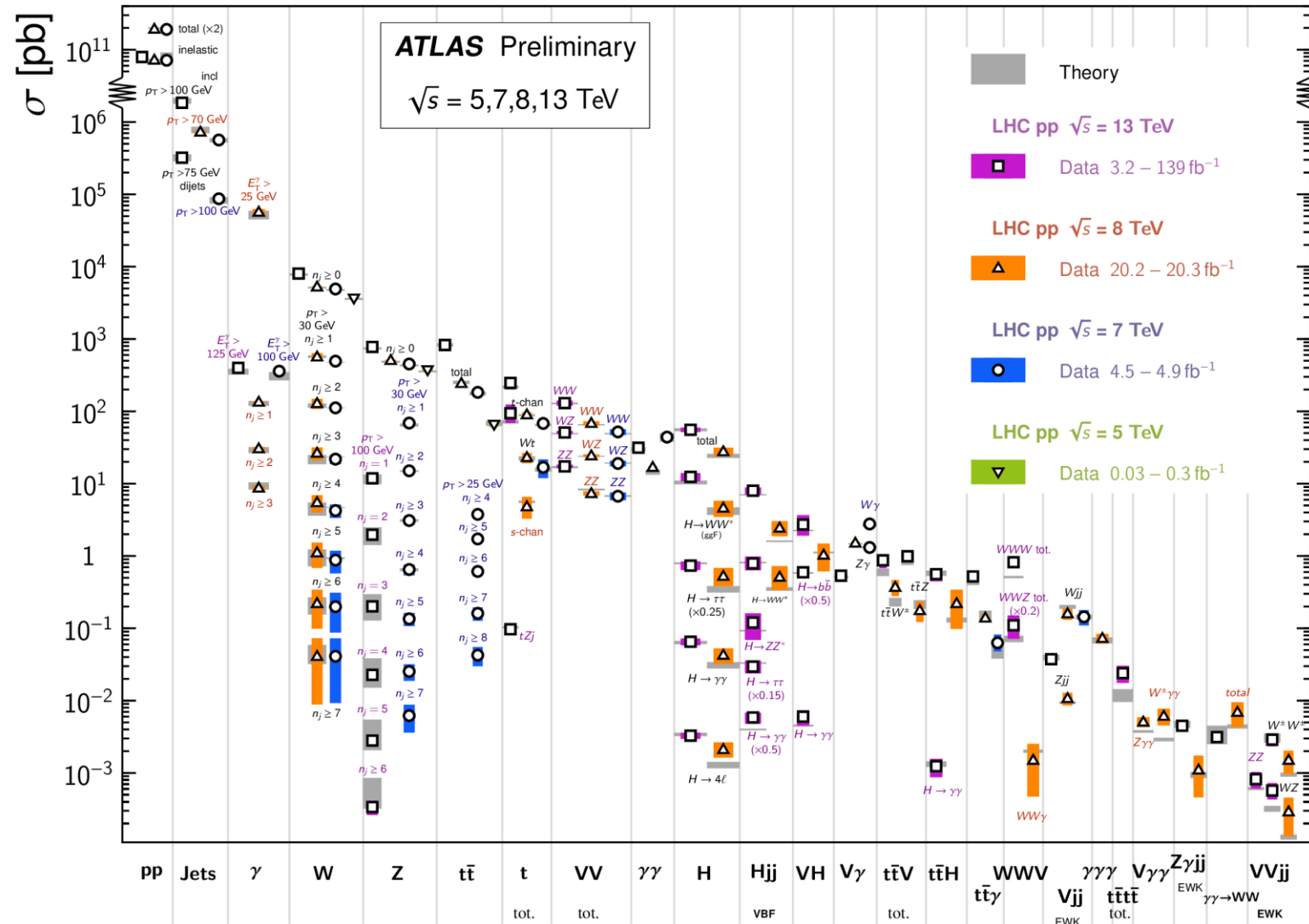
Prompt γ

Single top

LHC: SM Production cross sections

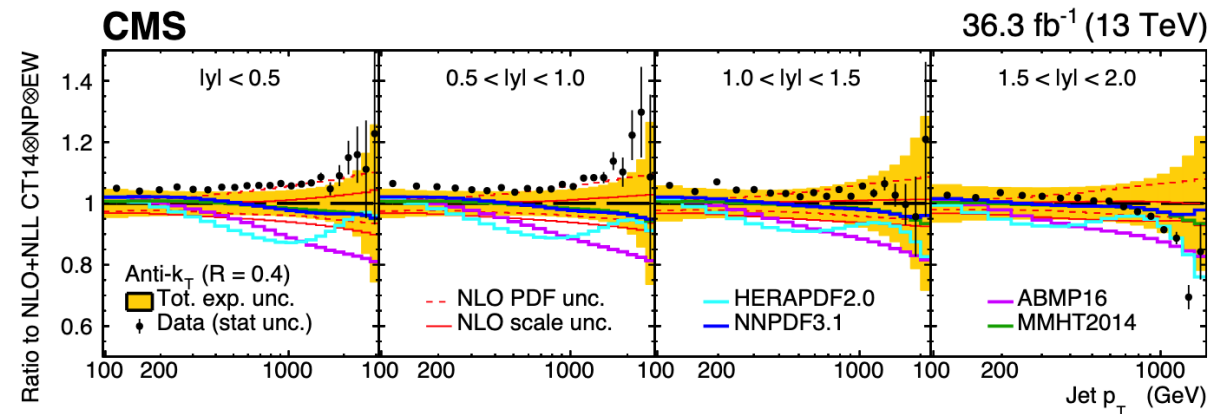
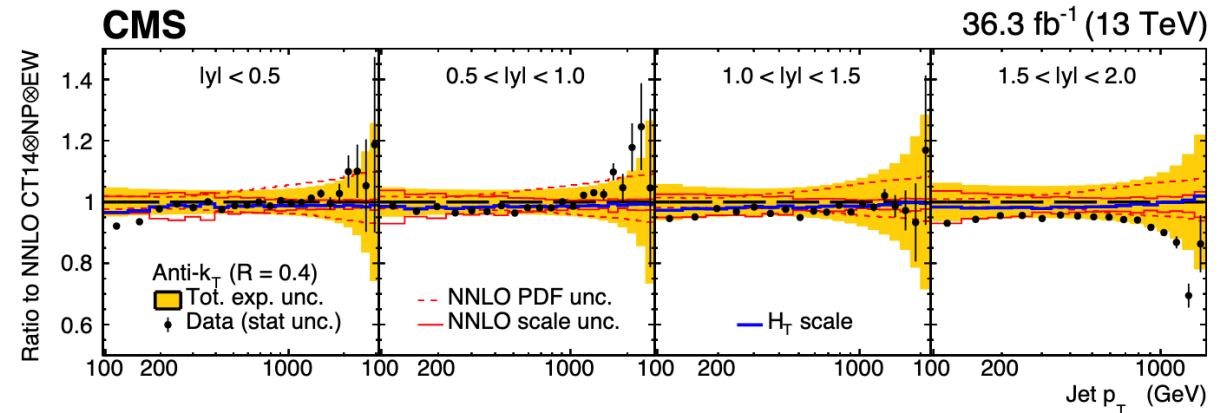
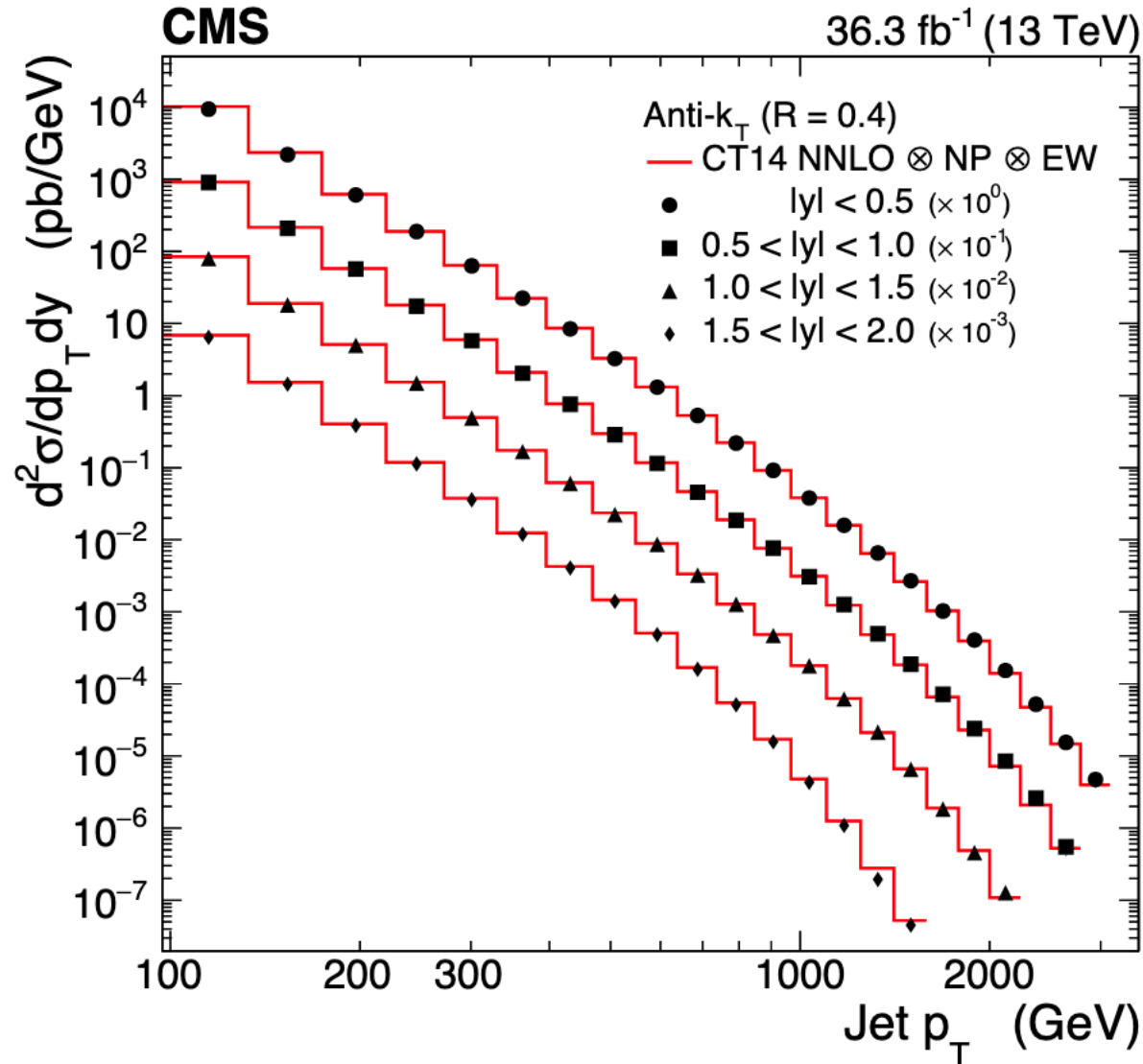
Standard Model Production Cross Section Measurements

Status: February 2022



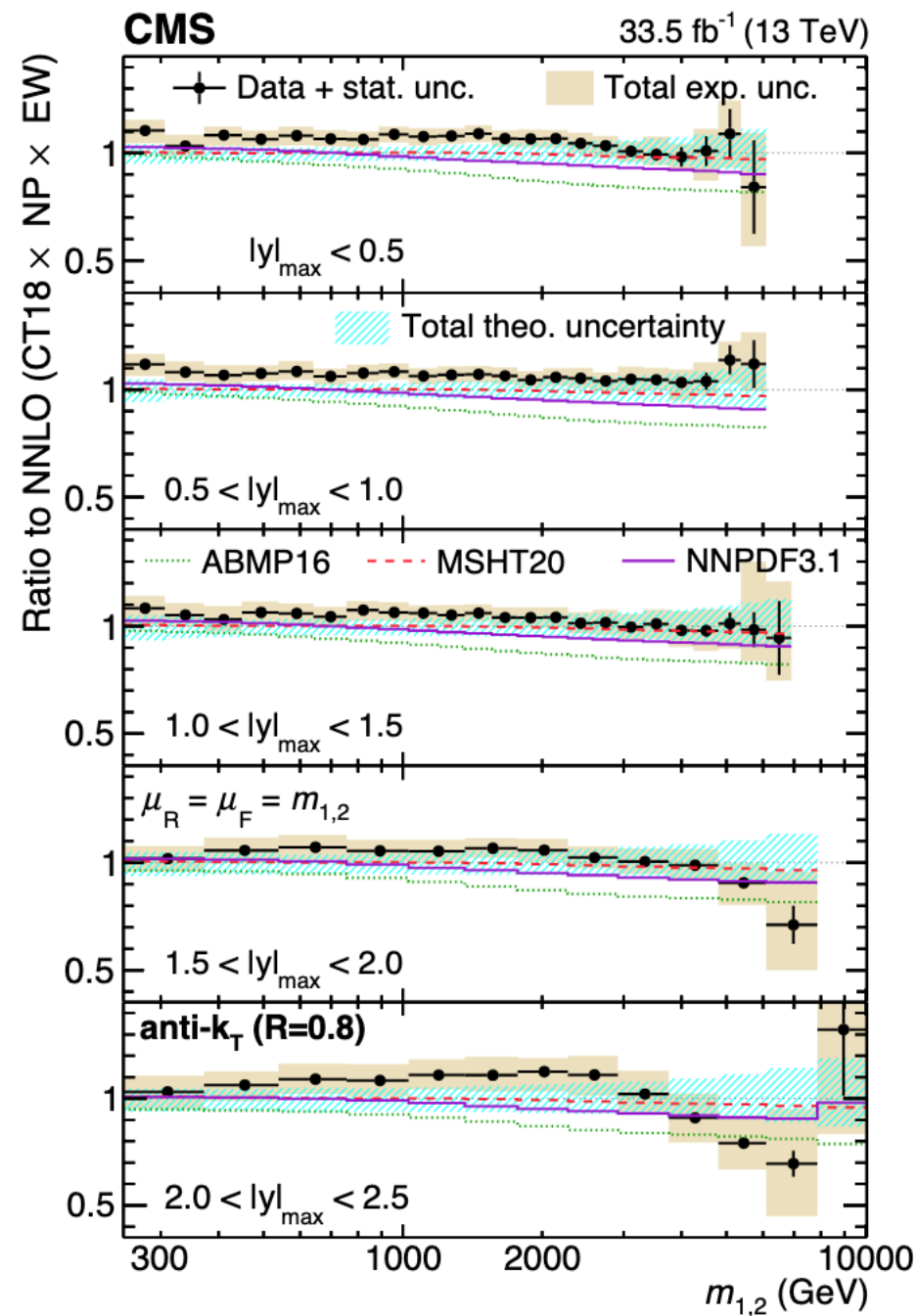
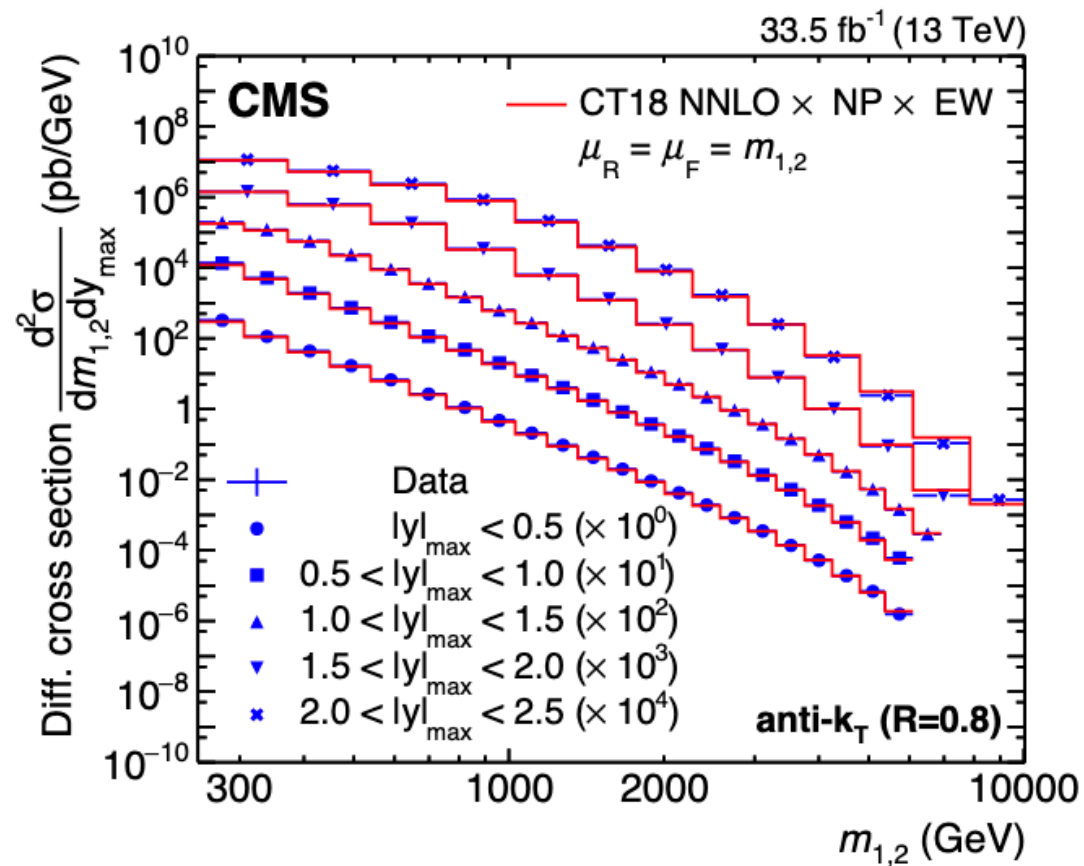
LHC: Inclusive jet production

arXiv:2111.10431



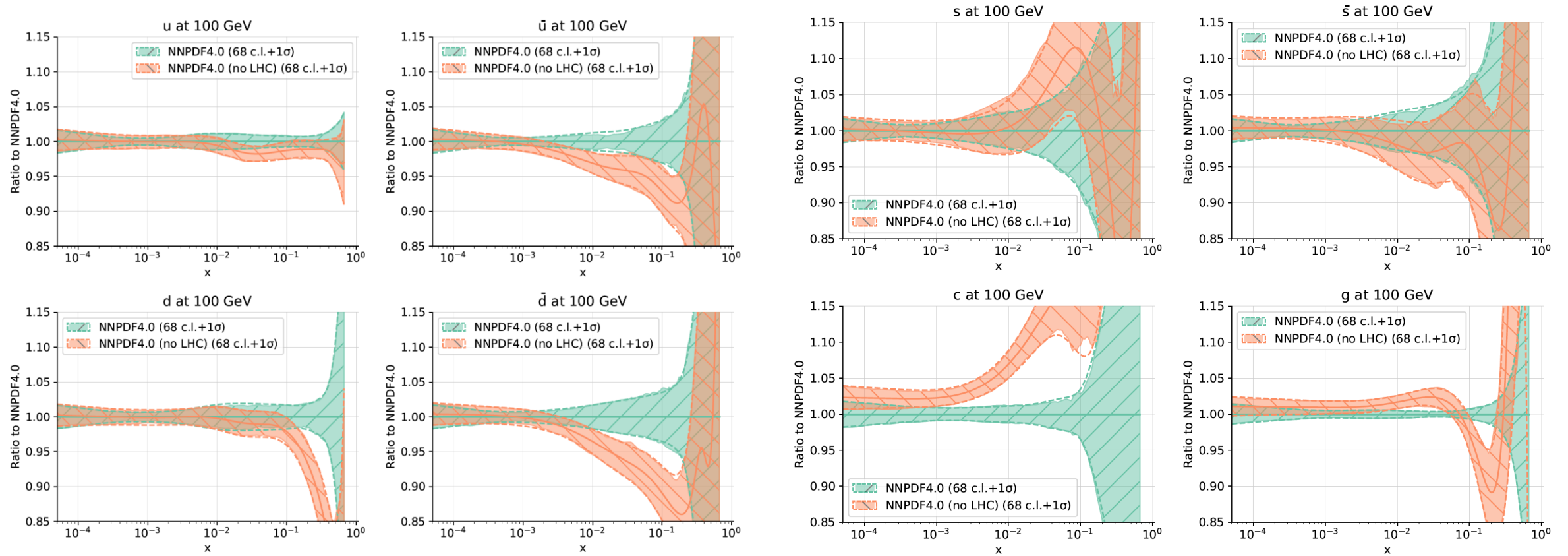
LHC: di-jet production

arXiv:2312.16669



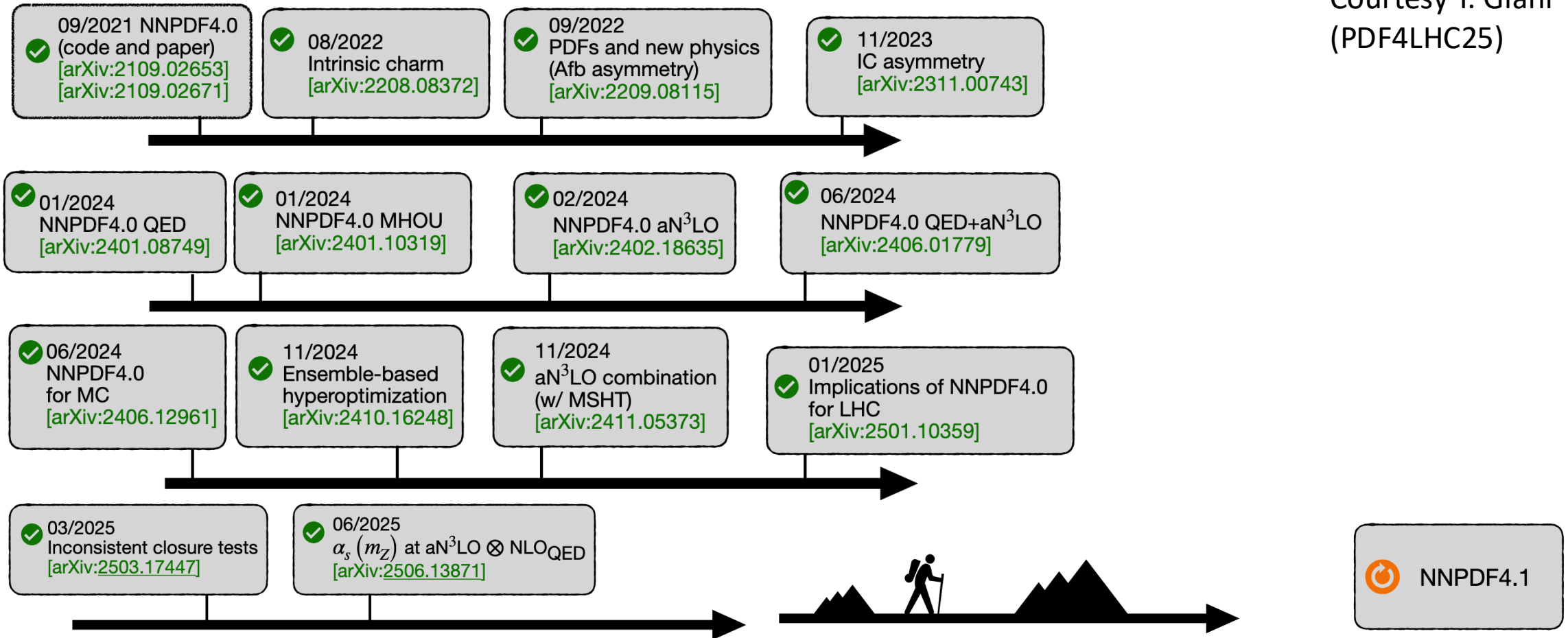
NNPDF4.0

Impact of LHC data:

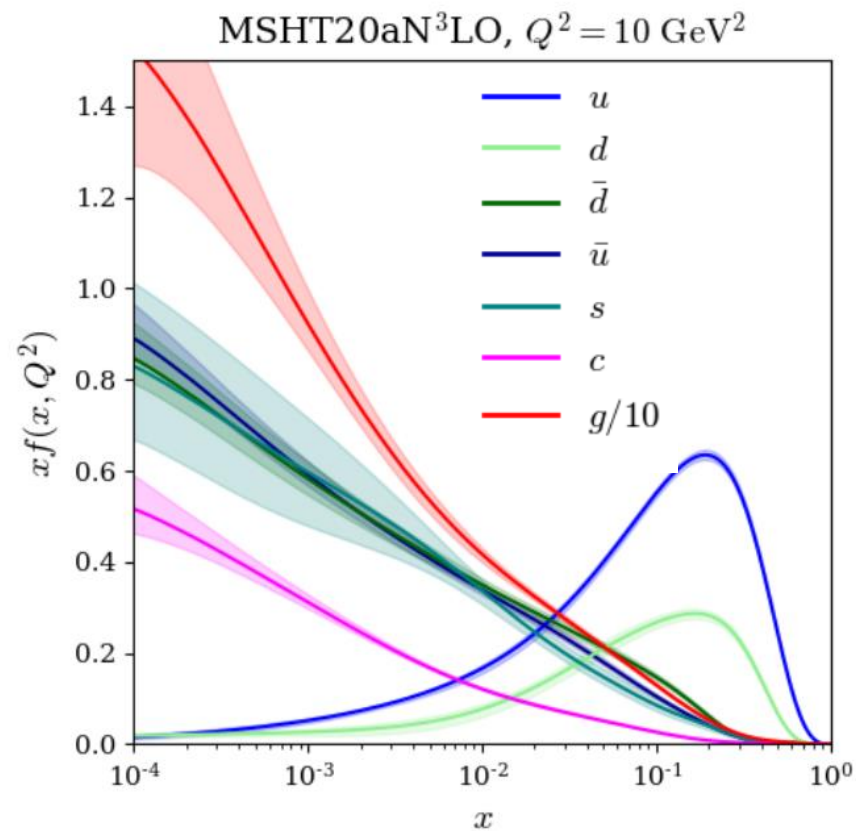
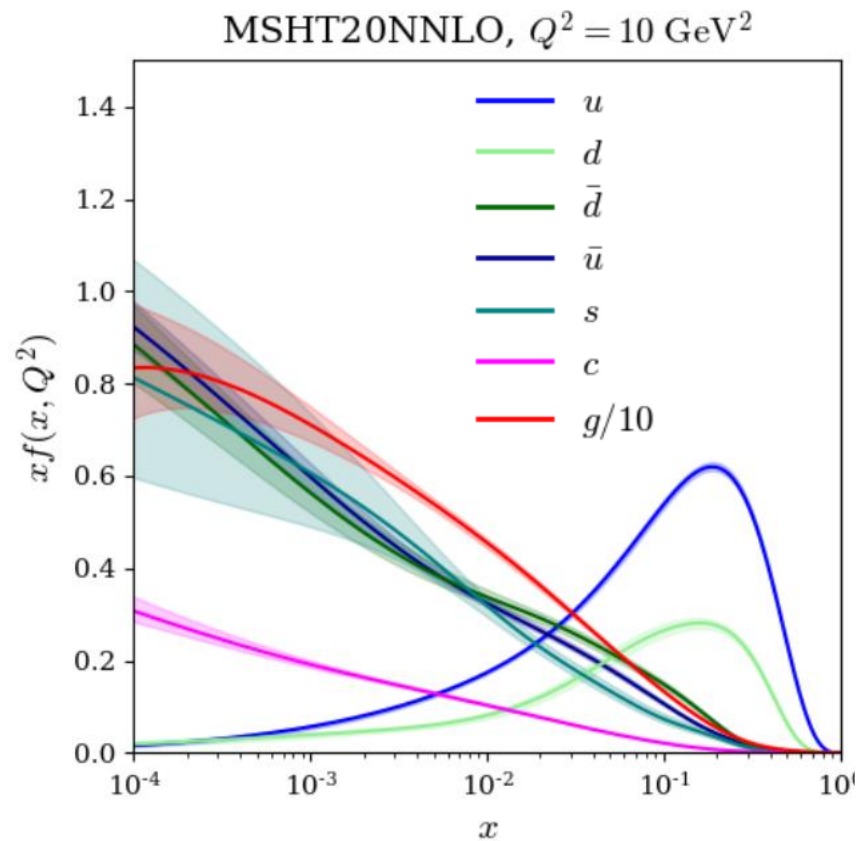


NNPDF timeline: from NNPDF4.0 ...

Courtesy T. Giani
(PDF4LHC25)

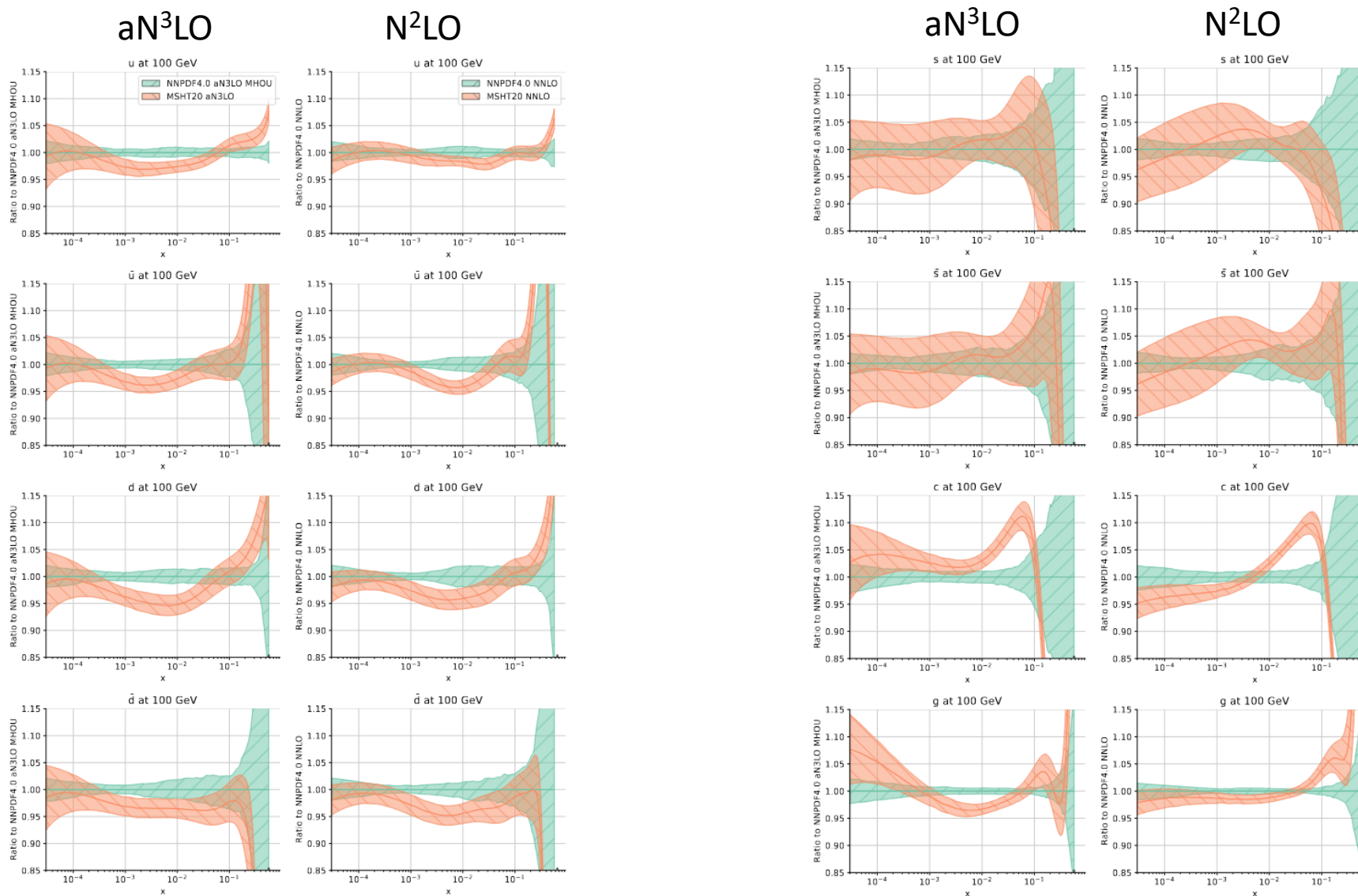


MSTH20 aN³LO

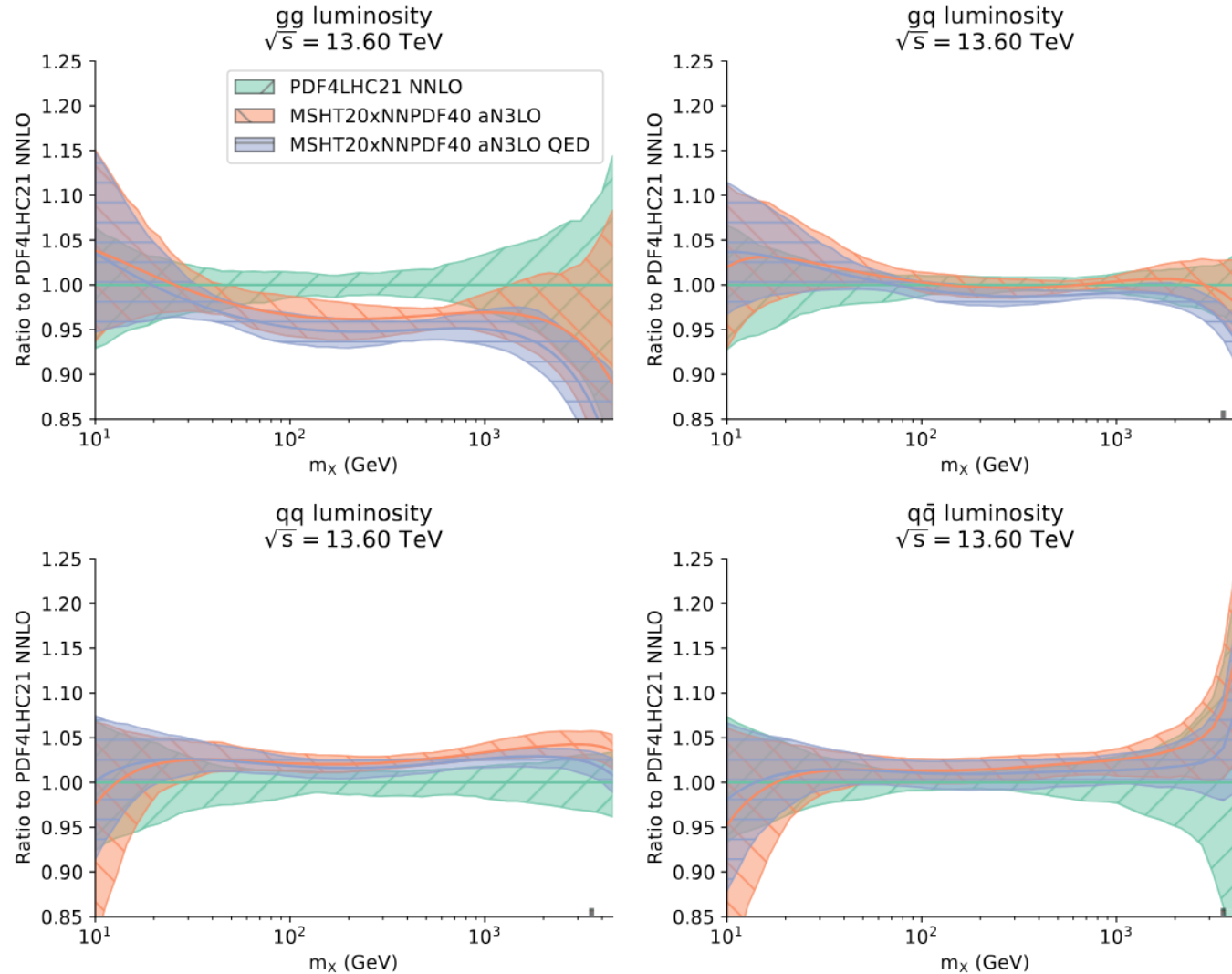


Note the strong change on the gluon at low- x (and also on charm)

MSHT20 and NNPDF4.0 @ aN3LO

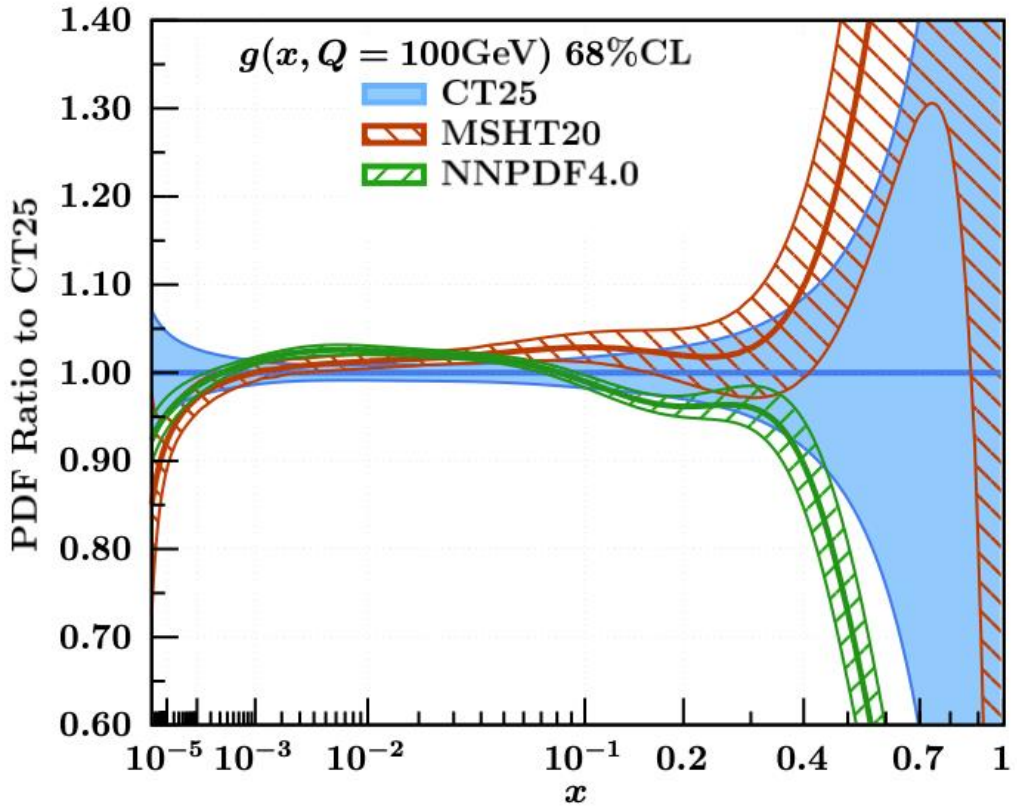
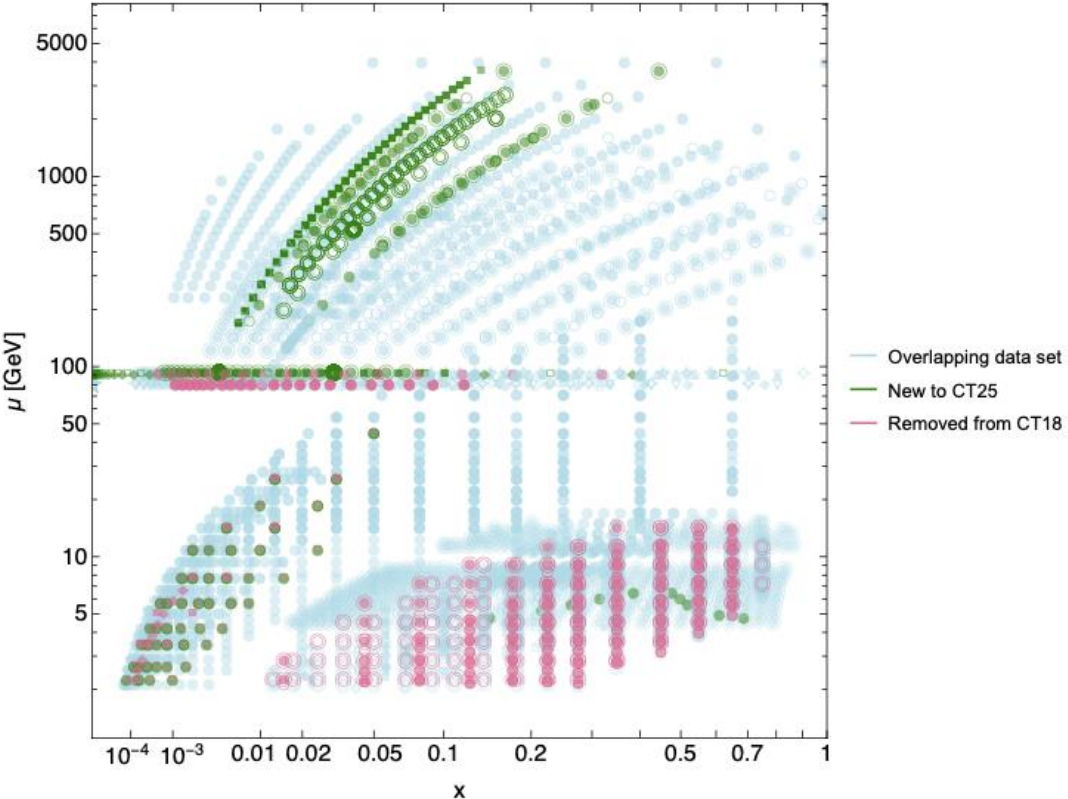


MSHT20 and NNPDF4.0 @ aN3LO (combined!)



arXiv: 2411.05373

CT25 (Preview)



DGLAP Fits challenges

Differences between the PDF sets persist...

Highly non-trivial inversion problem:

$$\text{Data} = \text{PDF} \otimes \sigma_H$$

The diagram shows the equation $\text{Data} = \text{PDF} \otimes \sigma_H$. Below the equation, three red arrows point upwards to the terms: 'measure' points to 'Data', 'fit' points to 'PDF', and 'predict' points to ' σ_H '. The words 'measure', 'fit', and 'predict' are written in blue.

- LHC datasets increasingly systematics dominated. Many nuisance parameters!
- “Tensions” among datasets
- Proper treatment of uncertainty correlations (not always precisely known)
- Quantifications of theoretical uncertainties
- Parametrizations and model assumptions
- Closer tests

Clear understanding and/treatment of uncertainties and comparison of methodologies essential

.

Final Remarks

Impressive progress in the last few years:
precise/high-energy LHC data matched by
state-of-the-art theoretical predictions
(aN3LO + QED +EW)

Large impact of LHC data on new generations of PDFs

Combination of CMS, ATLAS and LHCb measurements
may increase the potential of the LHC (Run 1,2 and 3)
Data even further (if fully pursued).

It is an easy guess that these trends will continue in
the years to come...

