W follow up

Ignazio Scimemi, in collaboration with D. Gutierrez-Reyes, S. Leal-Gomez, hep-ph/2011.05351

10-14/05/2021

W production

$$h_1 h_2 \to W^+(W^-) \to l^+(l^-) + \nu_l(\bar{\nu}_l)$$

D. Gutierrez-Reyes, S. Leal-Gomez, I.S. arXiv: 2011.05351

- We need to control the ratio qT/Q
- The fiducial cross section

$$\frac{d\sigma}{dm_T^2 dy dq_T^2} = \int_0^\infty \frac{dQ^2}{Q^4} \frac{8}{N_c} \frac{\alpha_{\rm em}^2}{s} I_W(Q^2, q_T, m_T^2) \frac{1}{(4s_W^2)^2} \frac{Q^4}{(Q^2 - M_W^2)^2 + \Gamma_W^2 M_W^2} \times \sum_{ff'} |V_{ff'}|^2 e_f e_{f'} W_{f_1 f_1}^{ff'}(Q^2, q_T, x_1, x_2).$$

Hadronic tensor

$$W_{f_1 f_1}^{ff'}(Q, q_T, x_1, x_2, \mu, \zeta) = \int \frac{|\mathbf{b}| d|\mathbf{b}|}{2} J_0(|\mathbf{b}||\mathbf{q}|) f_{1,f\leftarrow q}(x_1, \mathbf{b}, \mu, \zeta) f_{1,f'\leftarrow q}(x_2, \mathbf{b}, \mu, \zeta)$$

W production

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Transverse mass definition in the leptonic tensor

$$I_W(Q^2, m_T^2, q_T) = \int \frac{d^3 l}{2E}\frac{d^3 l'}{2E'}[ll' - (ll')_T]\theta(\text{cuts})\delta^{(4)}(l + l' - q)\delta(Q^2 - m_T^2 - f(l, l'))$$

Matching to PDF scale variation

$$f_{1,f\leftarrow h}(x,b) = \int_x^1 \frac{dy}{y} \sum_{f'} C_{f\leftarrow f'}\left(y, \mathbf{L}_{\mu_{\mathrm{OPE}}}, a_s(\mu_{\mathrm{OPE}})\right) f_{1,f'\leftarrow h}\left(\frac{x}{y}, \mu_{\mathrm{OPE}}\right) f_{\mathrm{NP}}(x,b),$$

$$D_{1,f\to h}(z,b) = \frac{1}{z^2} \int_z^1 \frac{dy}{y} \sum_{f'} y^2 \mathbb{C}_{f\to f'}\left(y, \mathbf{L}_{\mu_{\mathrm{OPE}}}, a_s(\mu_{\mathrm{OPE}})\right) d_{1,f'\to h}\left(\frac{z}{y}, \mu_{\mathrm{OPE}}\right) D_{\mathrm{NP}}(z,b)$$

$$\mu_{\mathrm{OPE}} = \left(\frac{C_0}{b} + 2\right) c_4 \ (\textit{Naive, these plots: overestimate in the non-perturbative region})$$

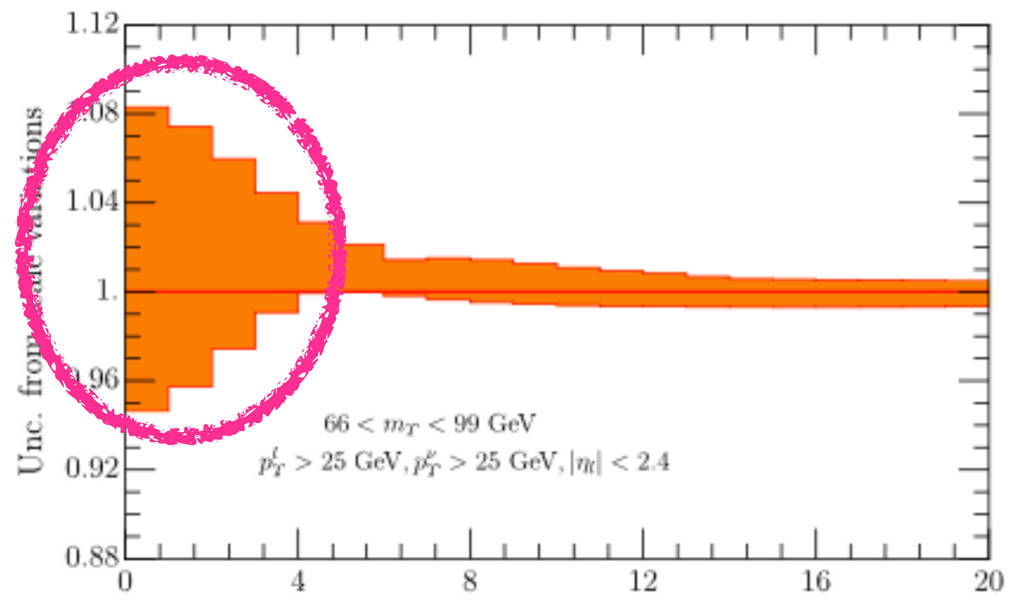
$$\mu_{\mathrm{OPE}} = \left(\frac{C_0}{b} c_4 + 2\right) \ (\textit{Future plots: error estimate in the perturbative region})$$

Input of the model

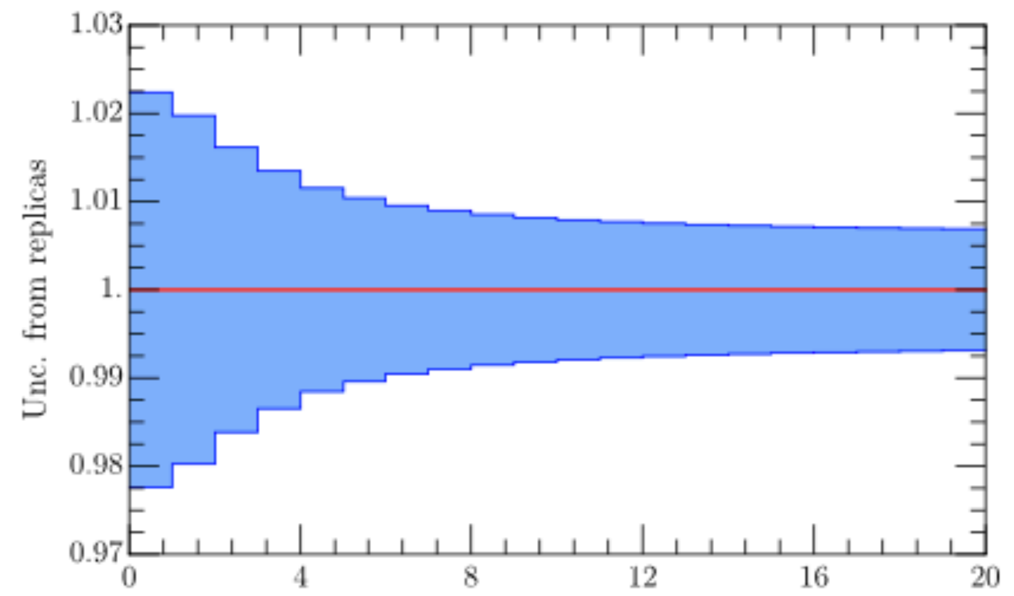
Errors in W^- spectrum

- The first 3 errors are the main ones: Work in progress to reduce some of them (scale variation, PDF sets: I. Scimemi talk at DIS2021)

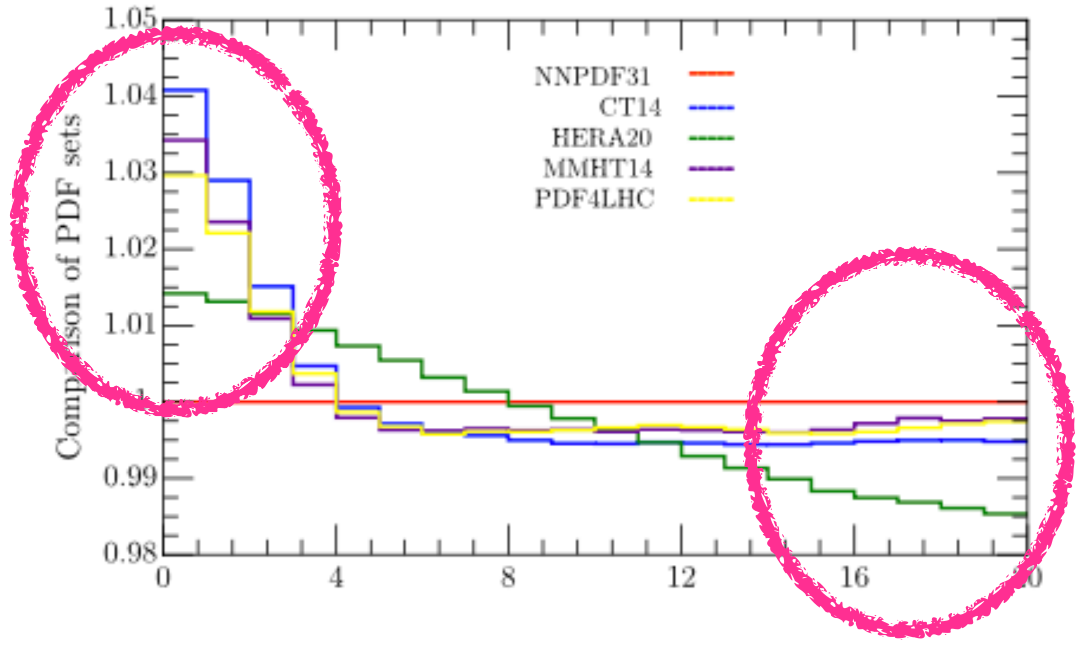
Scale variations



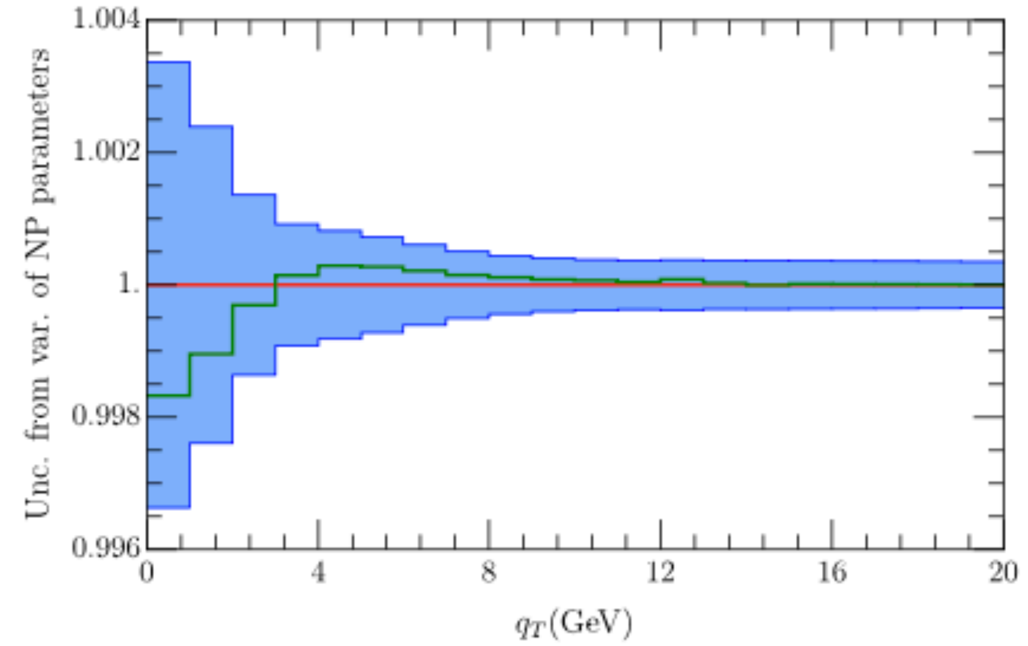
NNPDF31 replicas (1000)



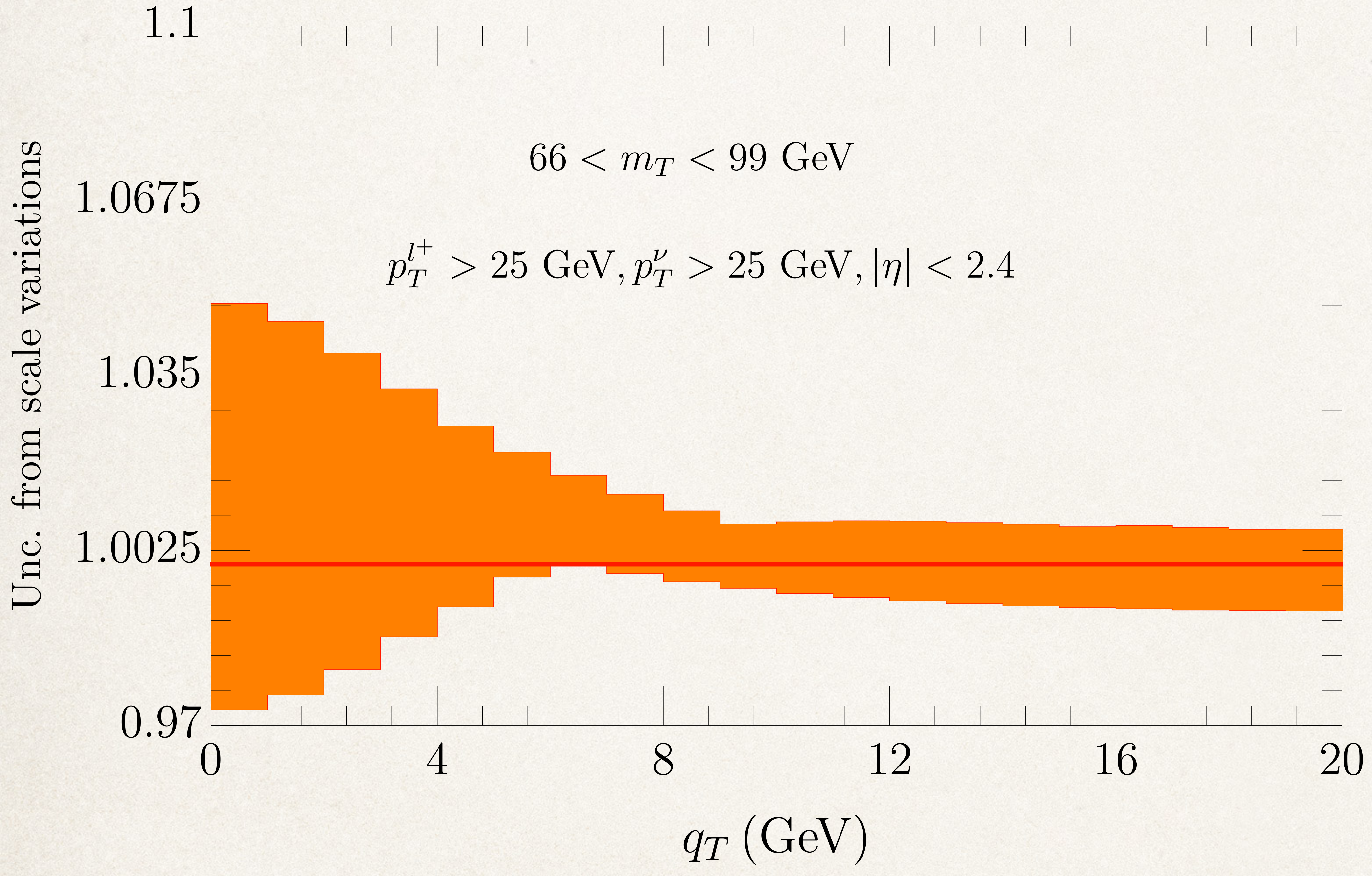
PDF sets



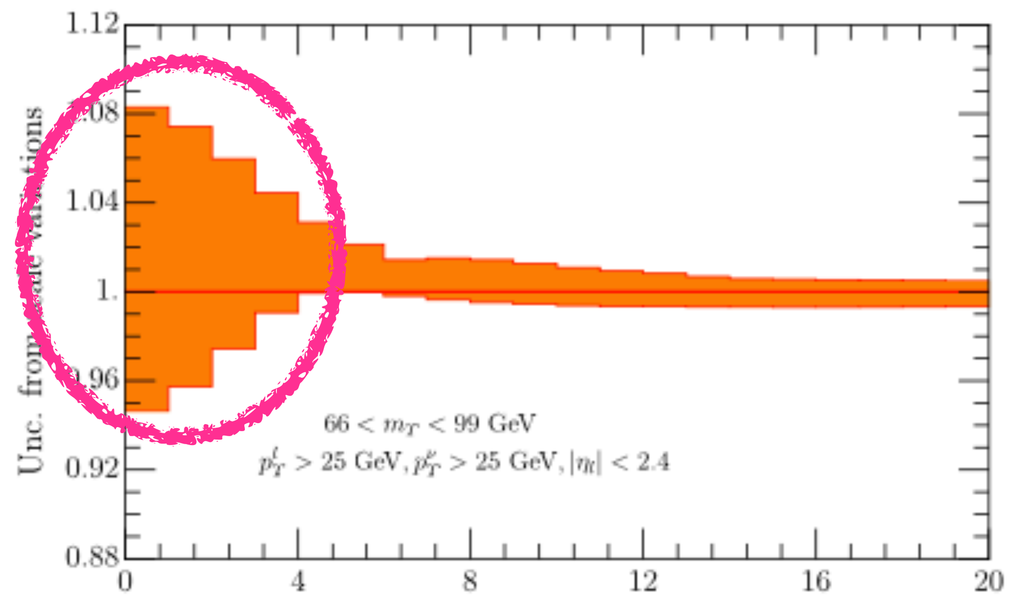
Extracted TMD parameters



Errors in W^- spectrum (scale variation new estimate)



Scale variations



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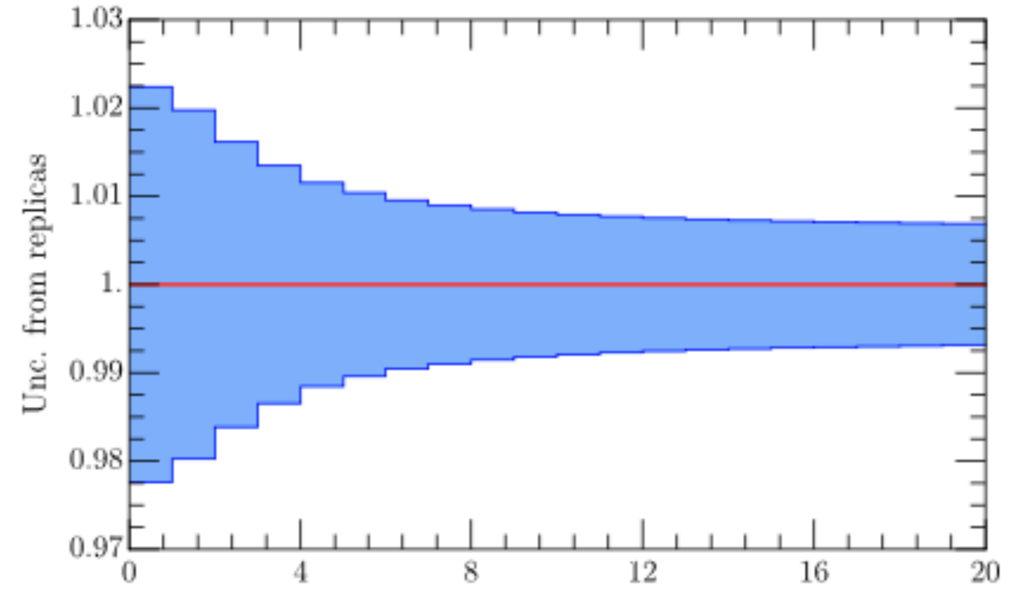

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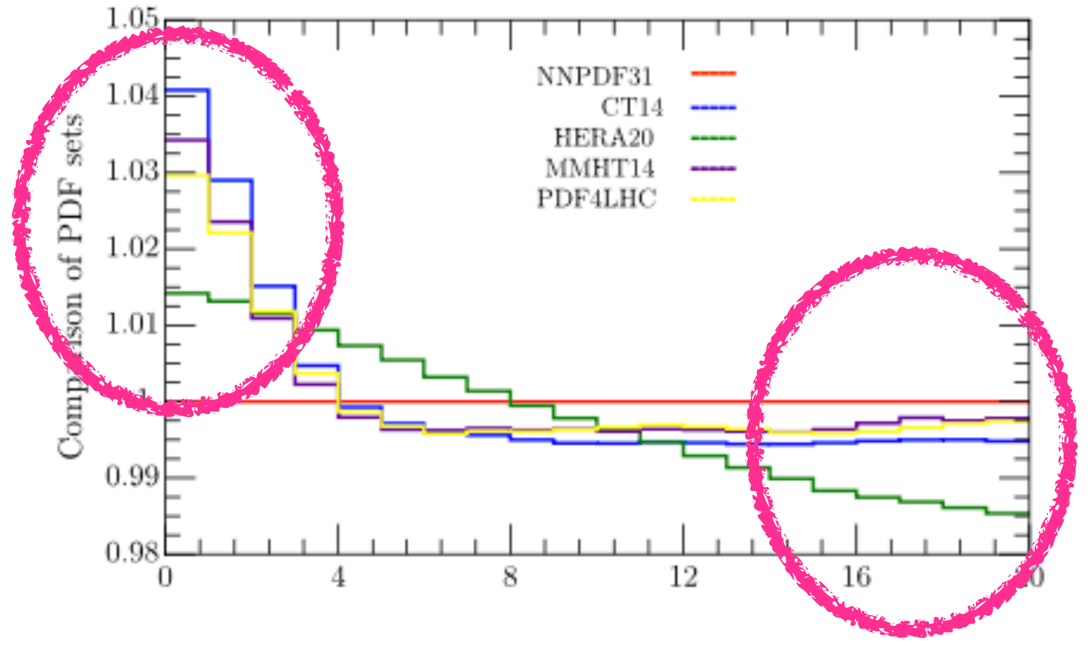
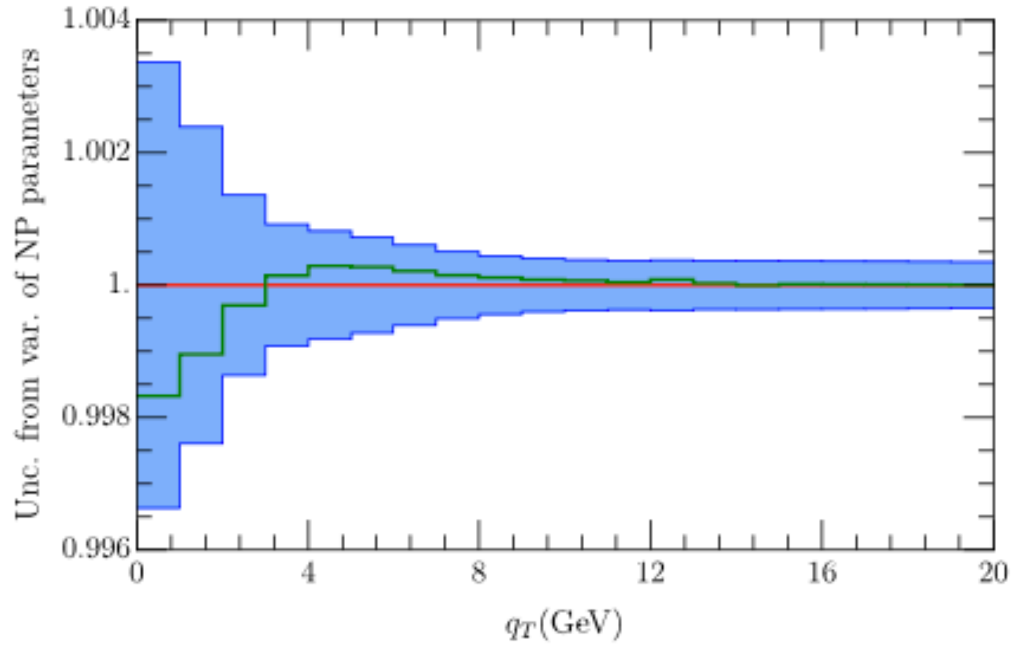
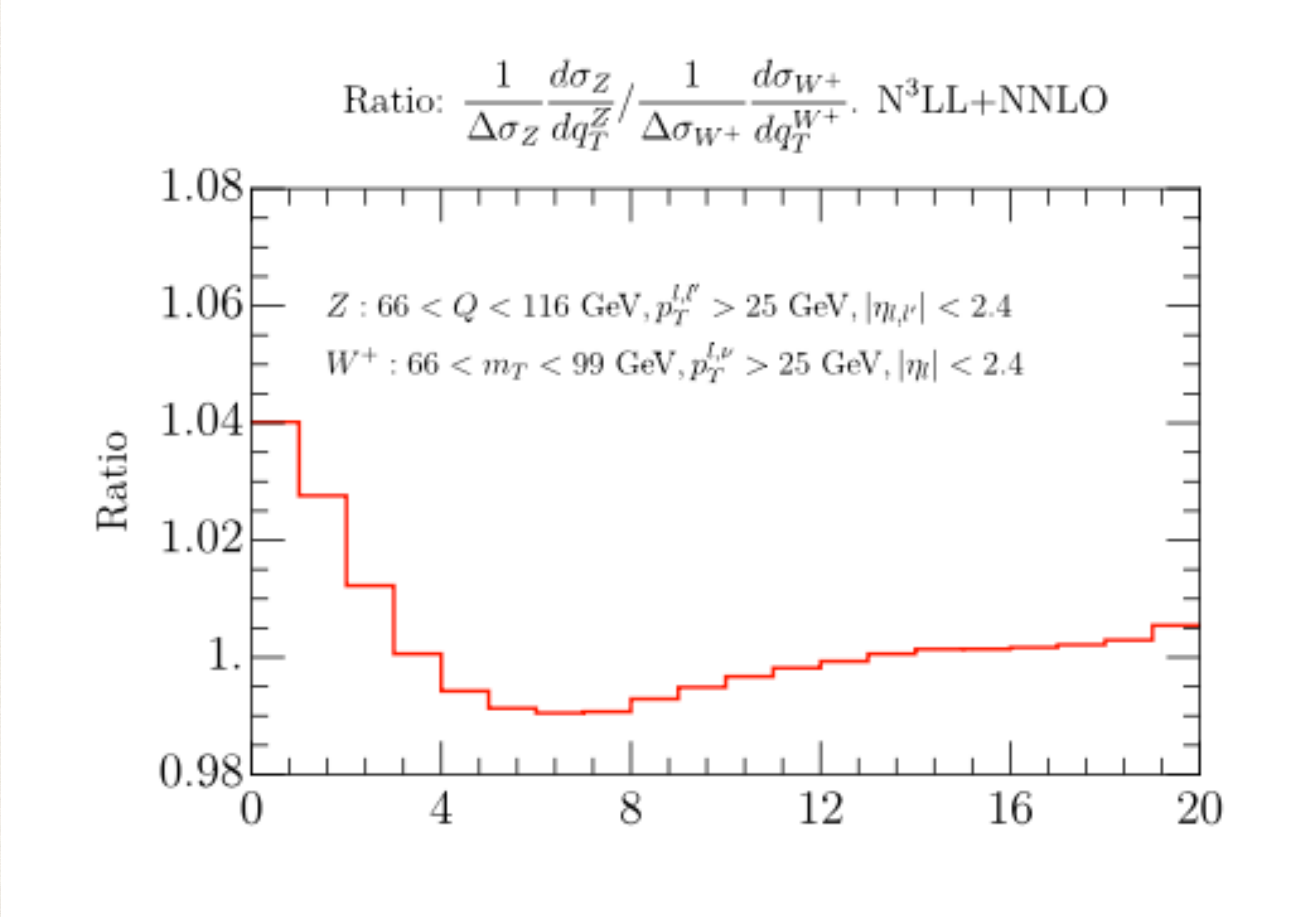


Extracted TMD parameters

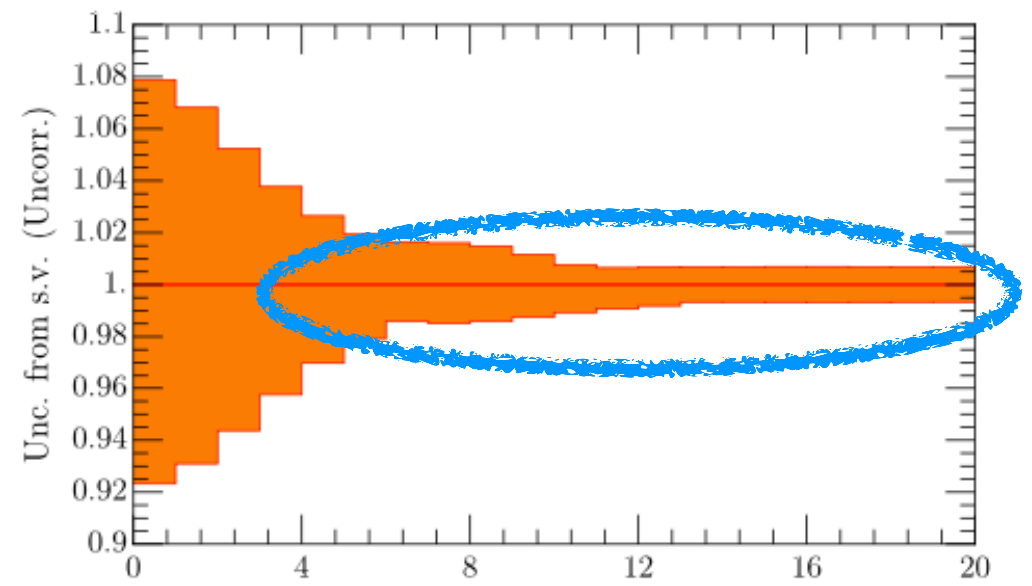


Errors in $p_T^Z / p_T^{W^+}$ spectrum

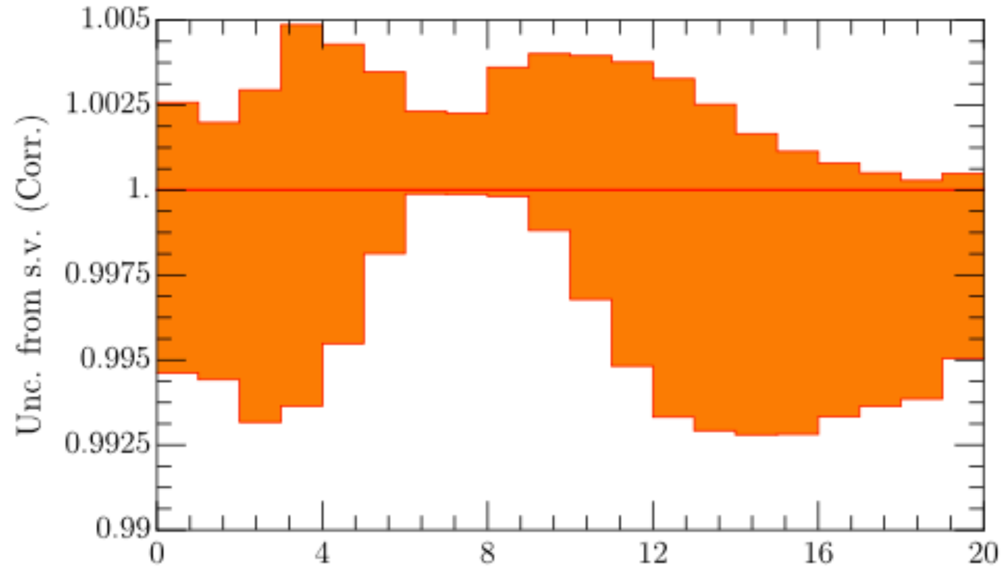
- Ongoing discussion on correlated uncorrelated error



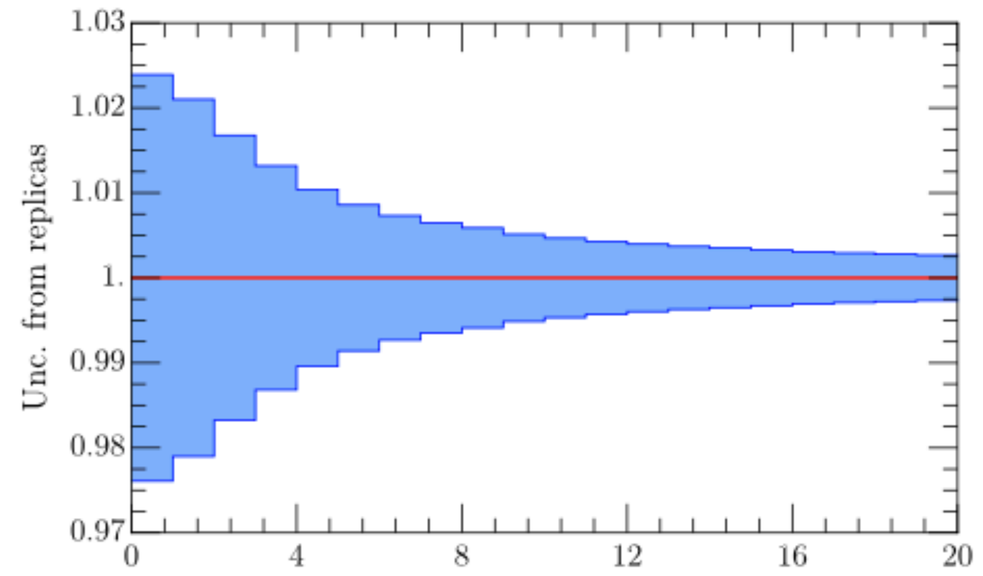
UnCorrelated Scale variations



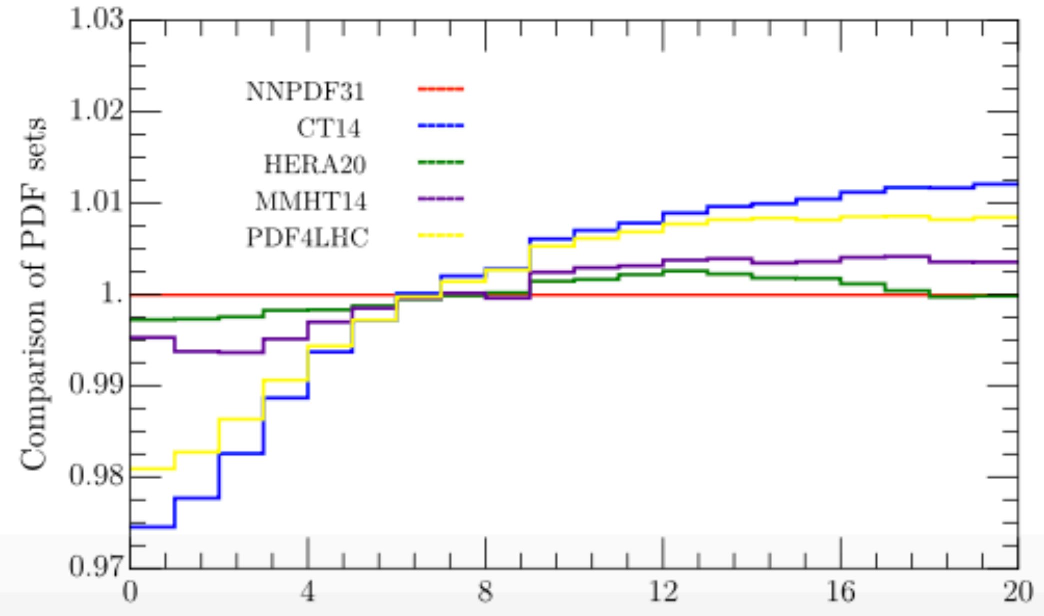
Correlated Scale variations



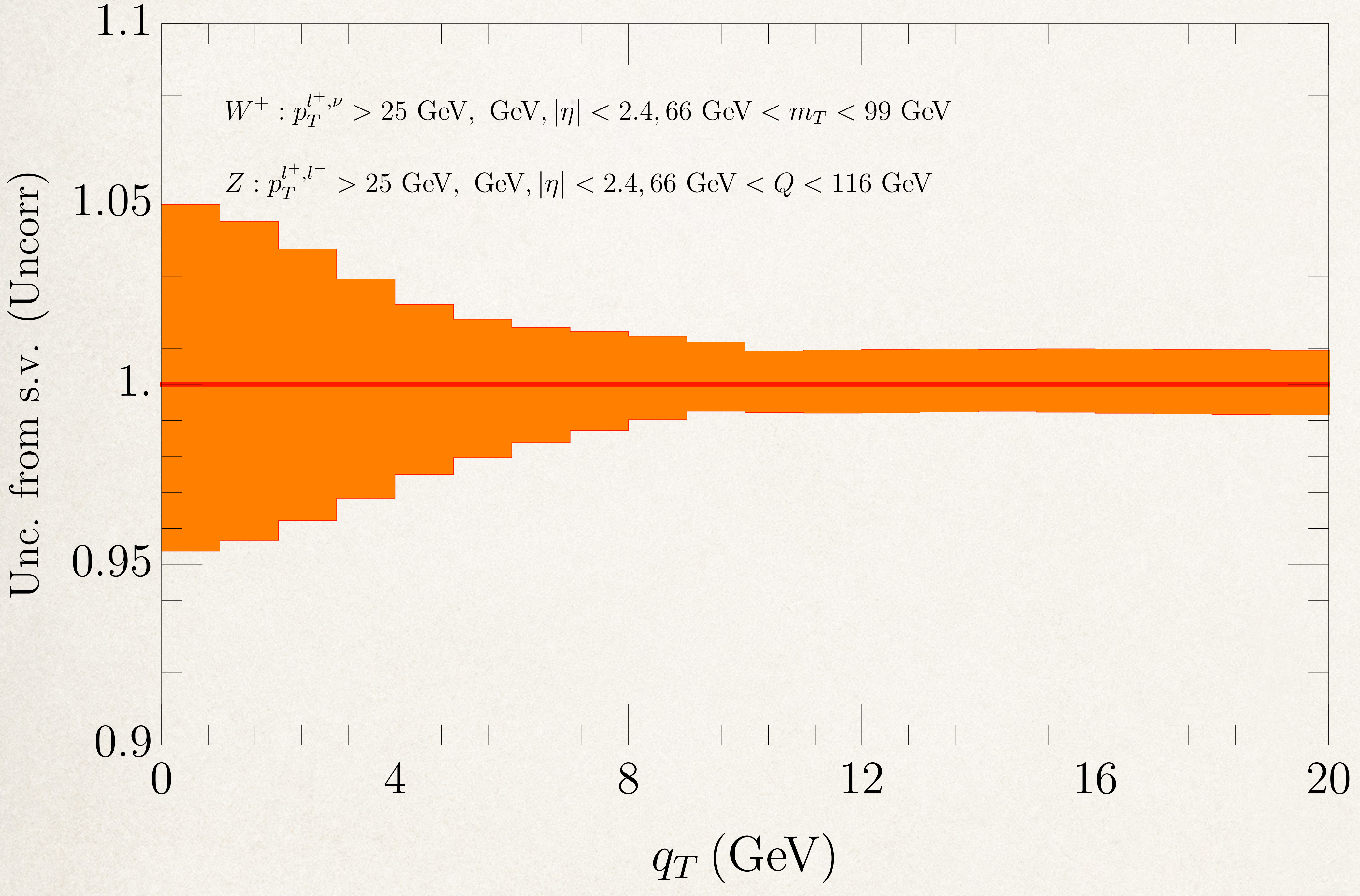
NNPDF31 replicas (1000)



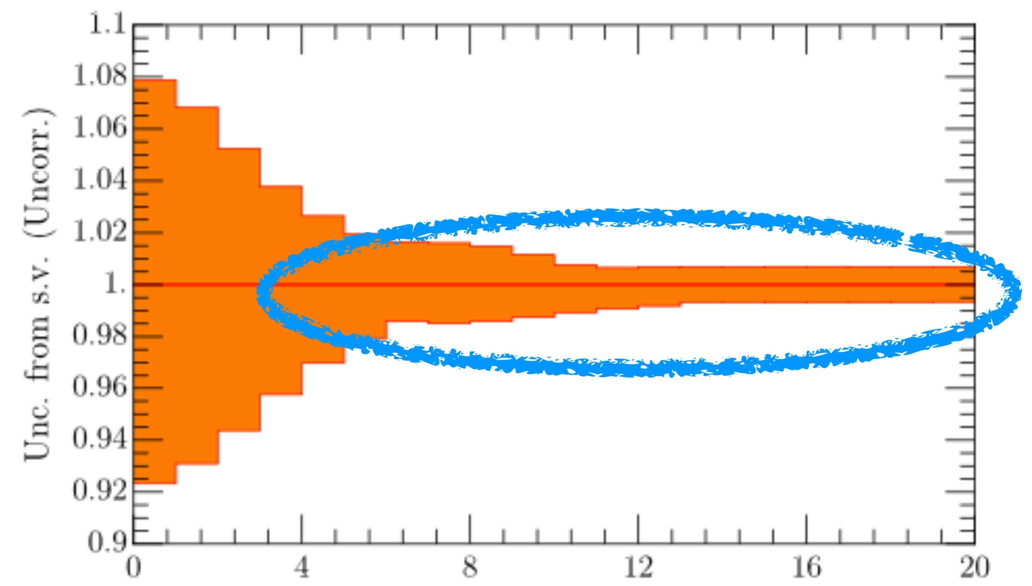
PDF sets



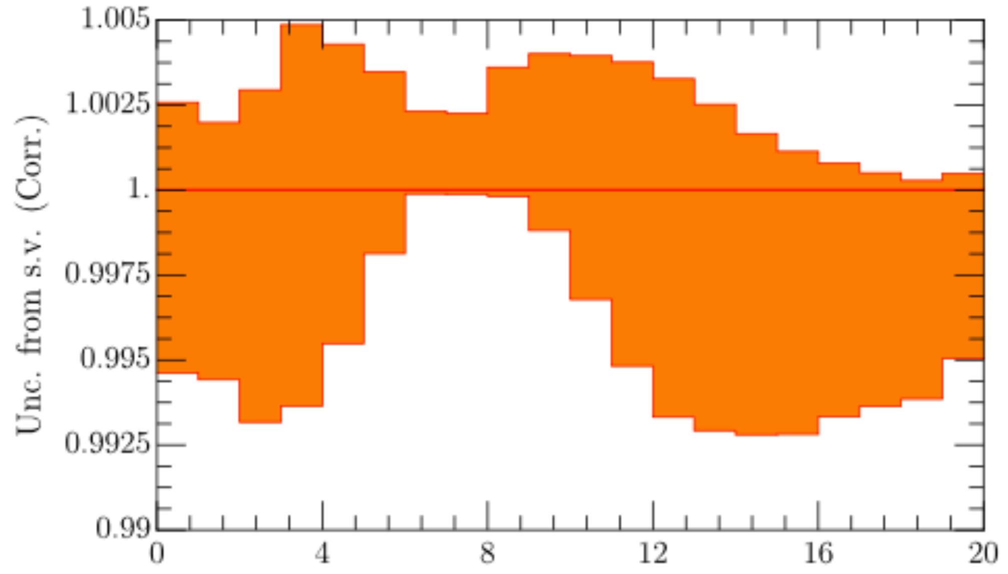
Errors in $p_T^Z / p_T^{W^+}$ spectrum (scale variation new estimate)



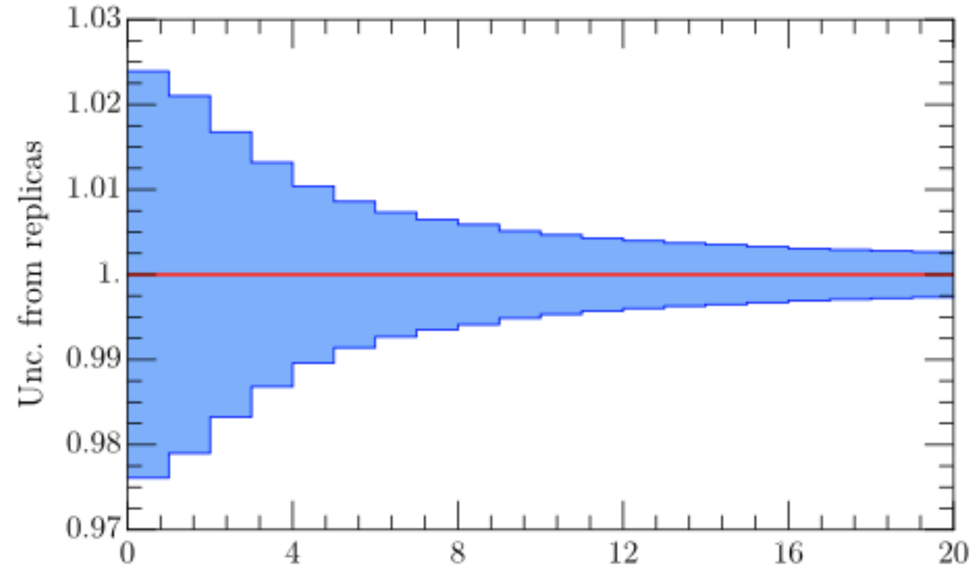
UnCorrelated Scale variations



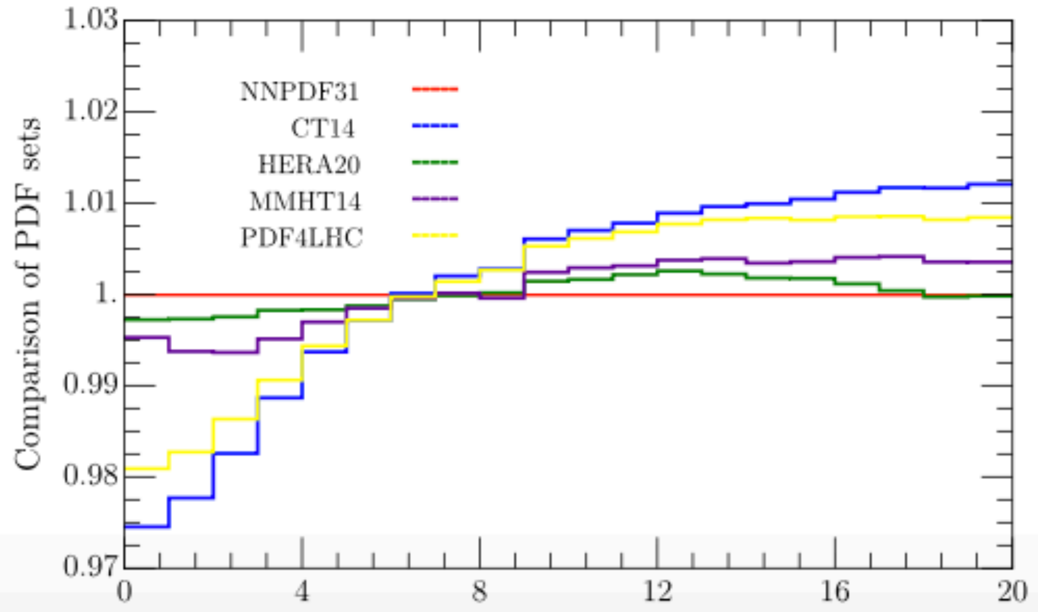
Correlated Scale variations



NNPDF31 replicas (1000)

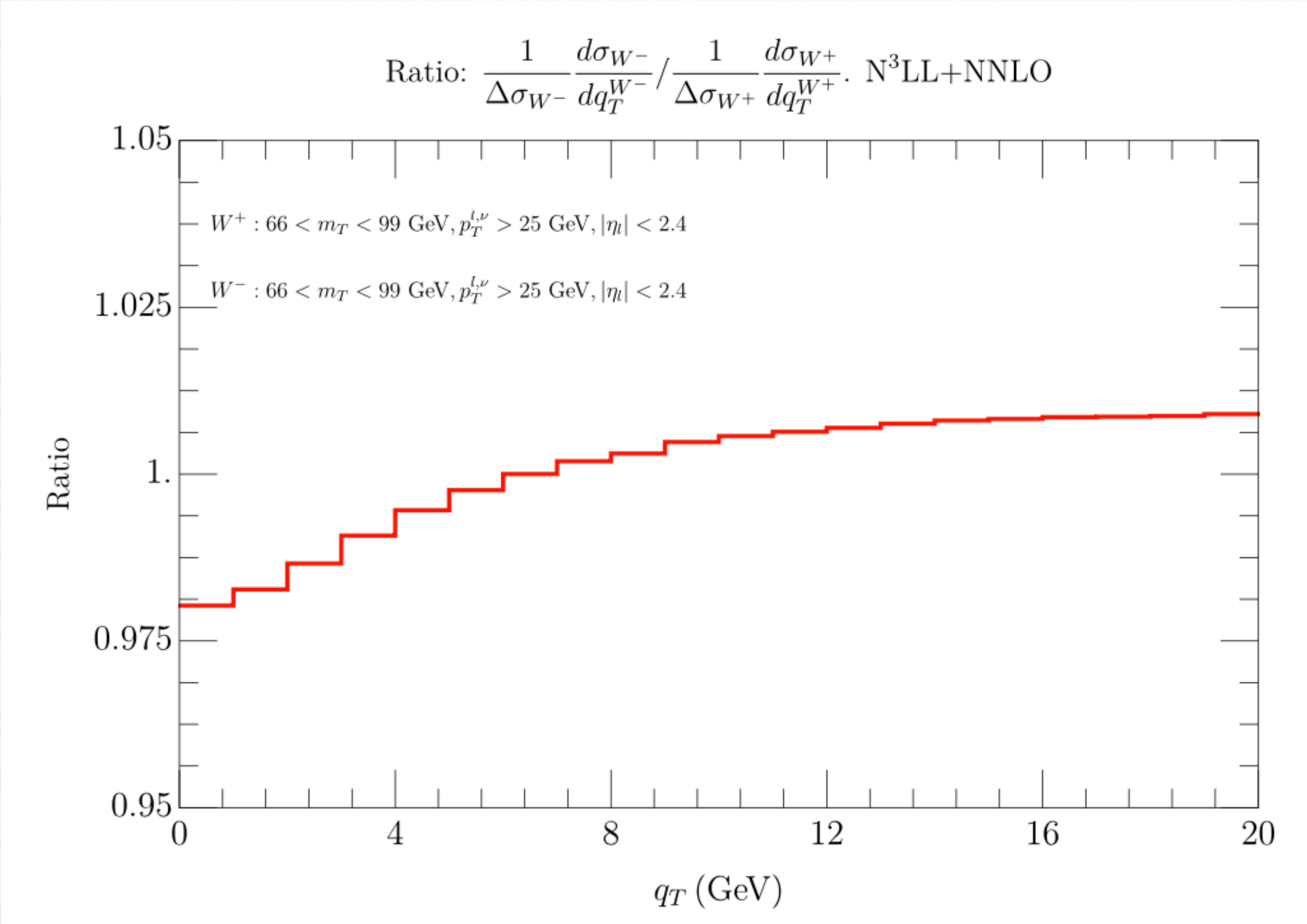


PDF sets

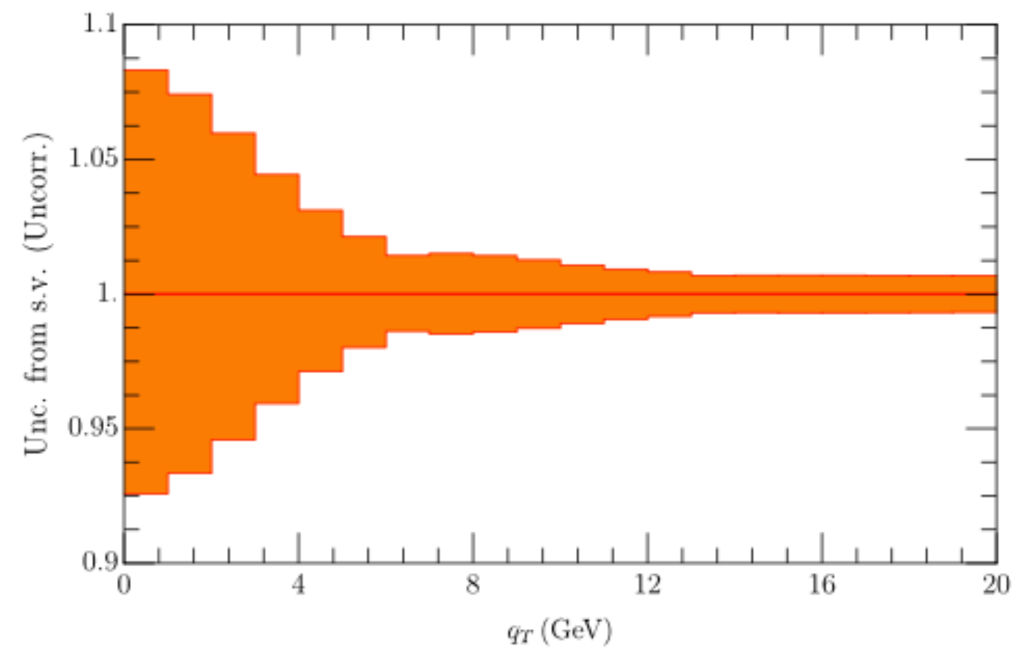


Errors in $p_T^{W^-}/p_T^{W^+}$ spectrum

- Ongoing discussion on correlated uncorrelated error



UnCorrelated Scale variations



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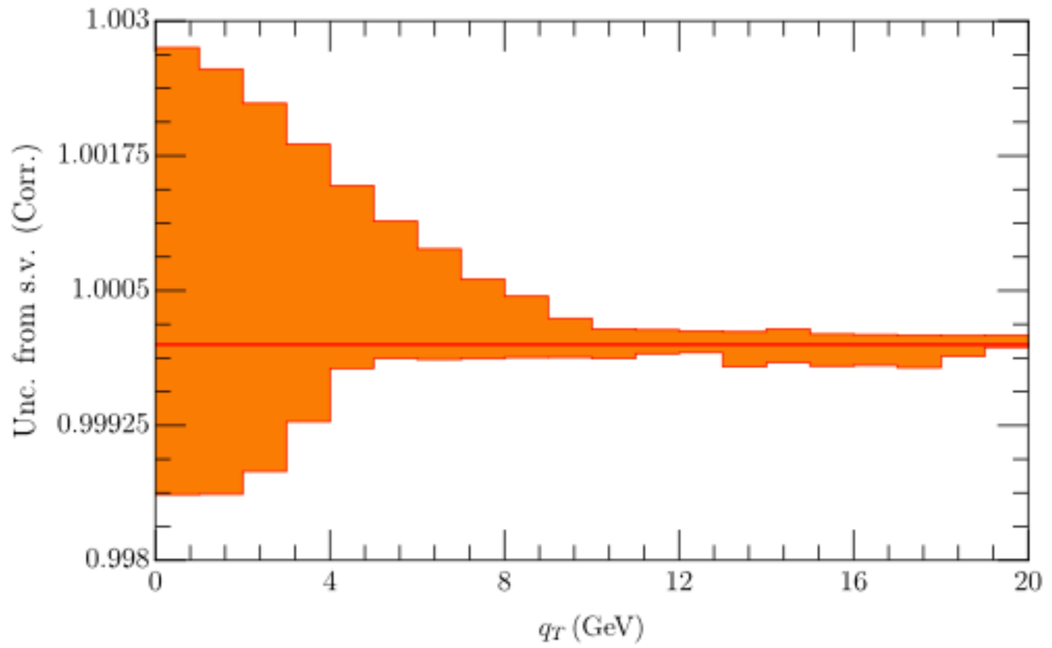
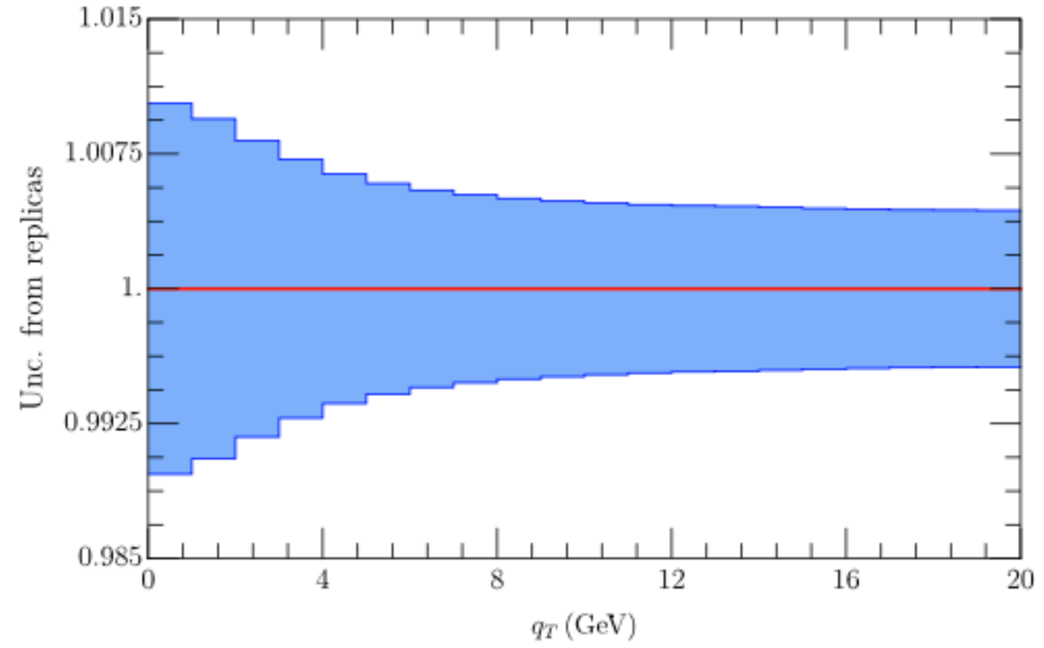
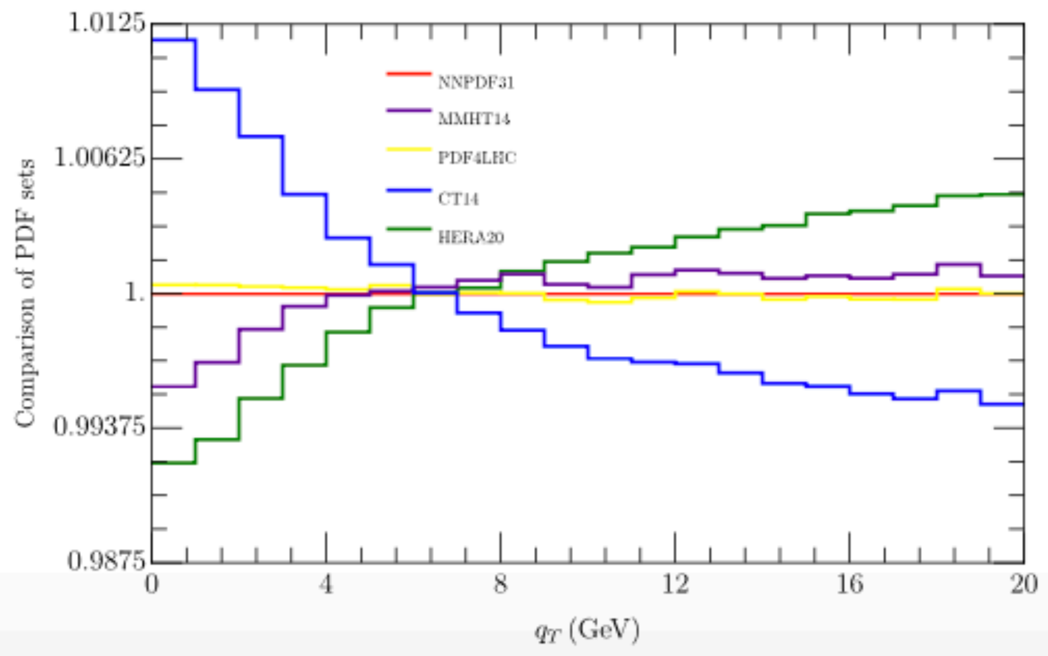


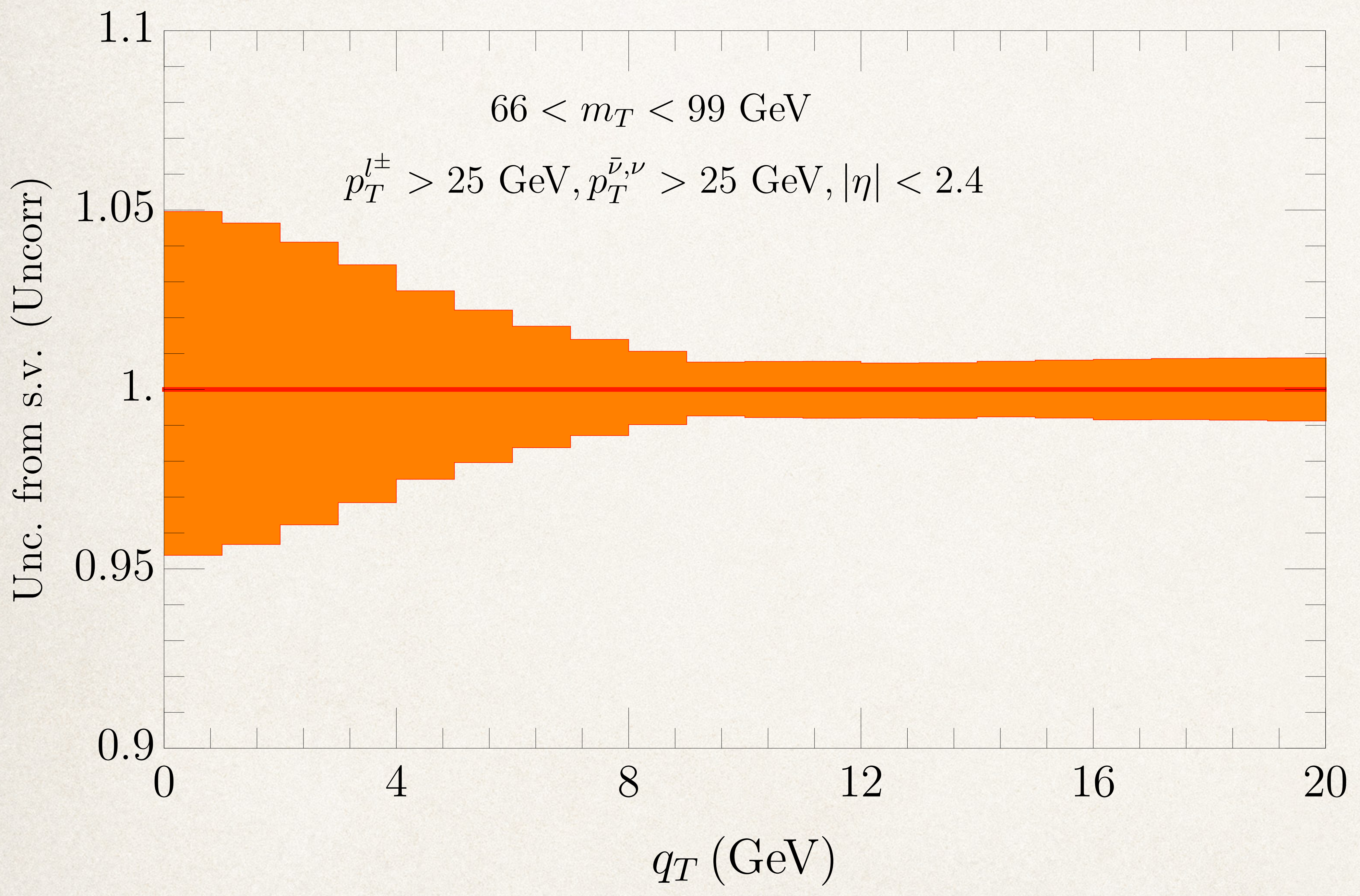
NNPDF31 replicas (1000)



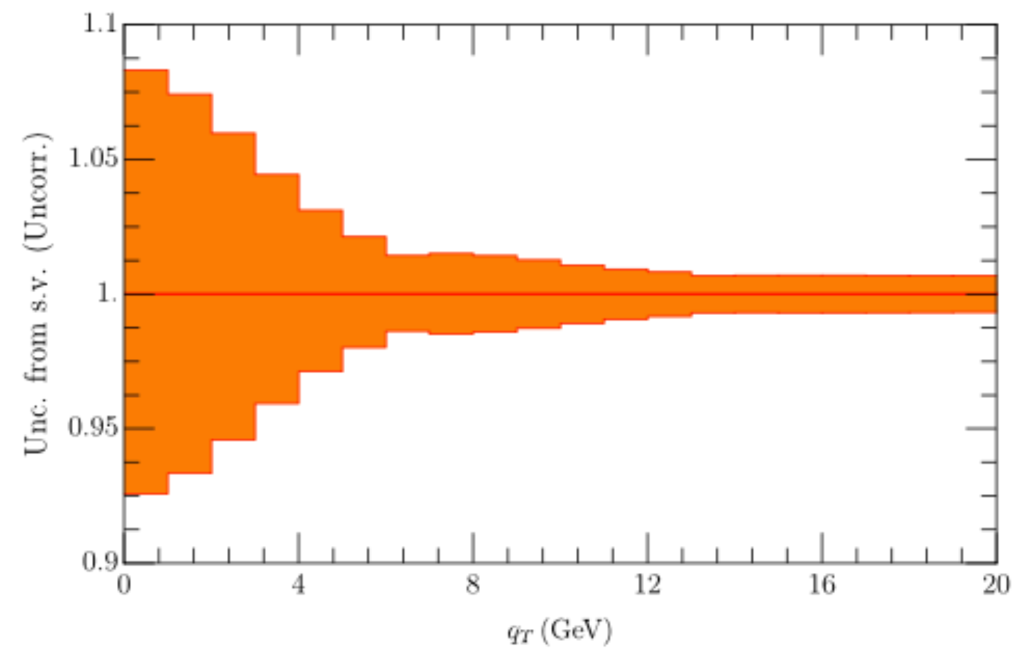
PDF sets



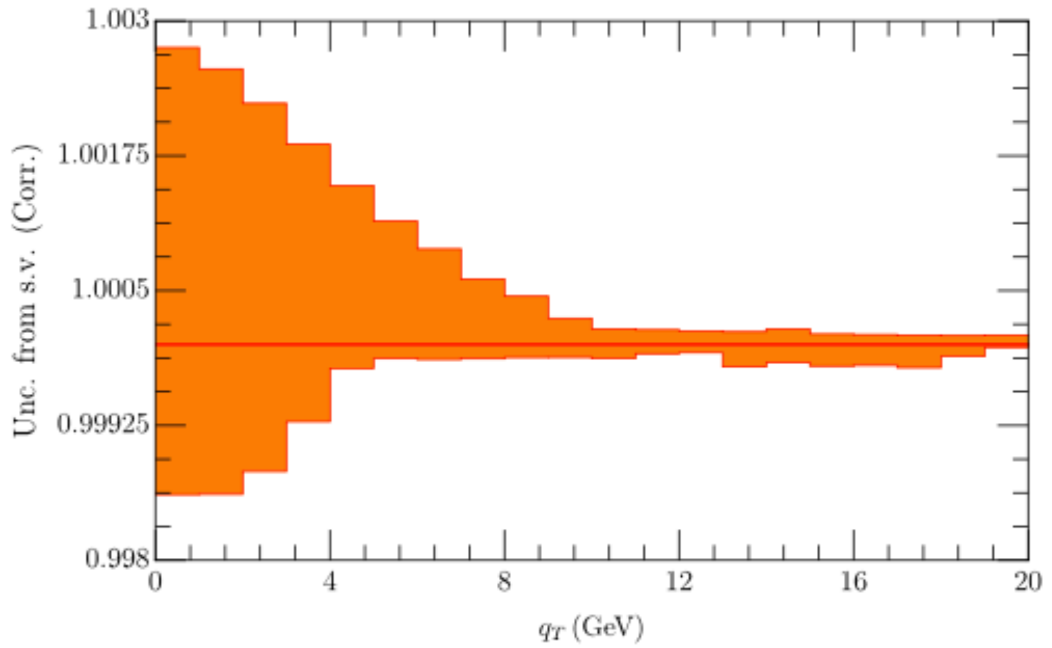
Errors in $p_T^{W^-}/p_T^{W^+}$ spectrum (scale variation new estimate)



UnCorrelated Scale variations



Correlated Scale variations



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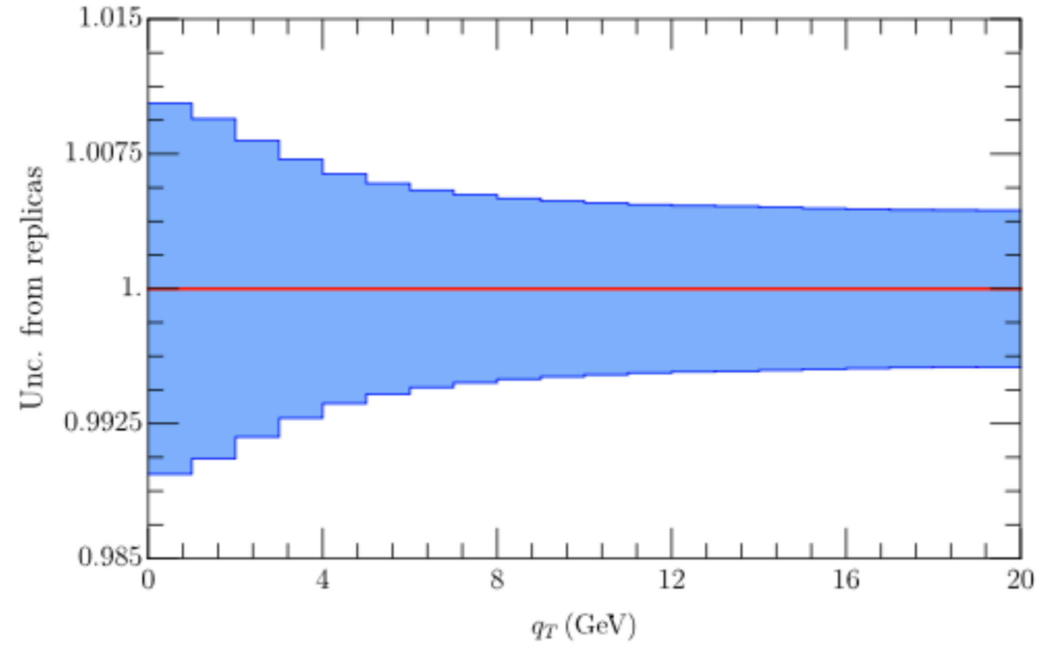

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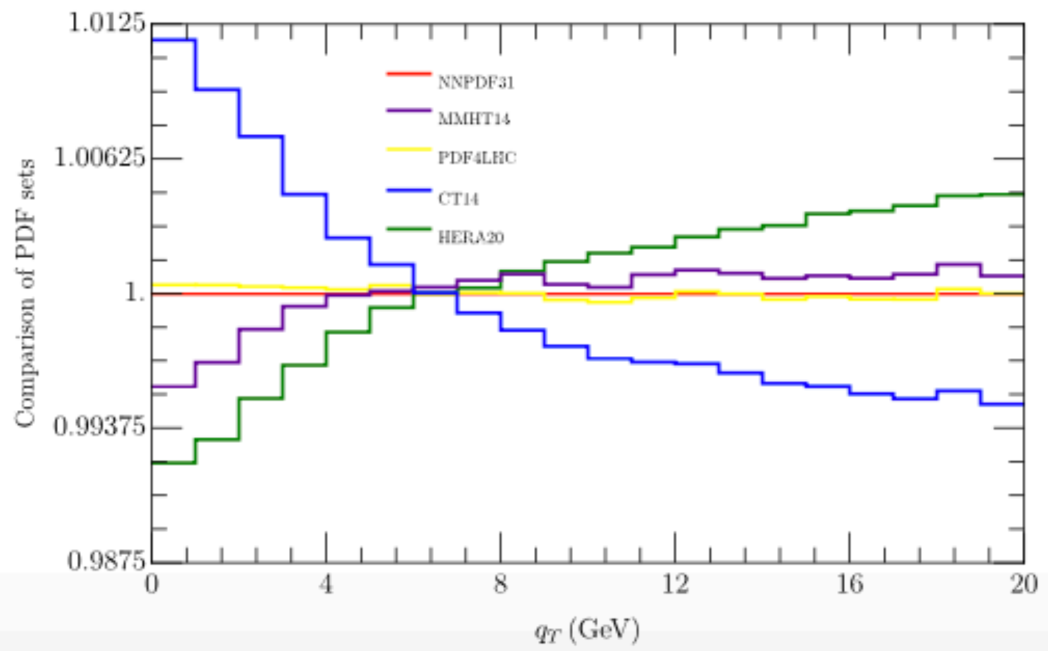
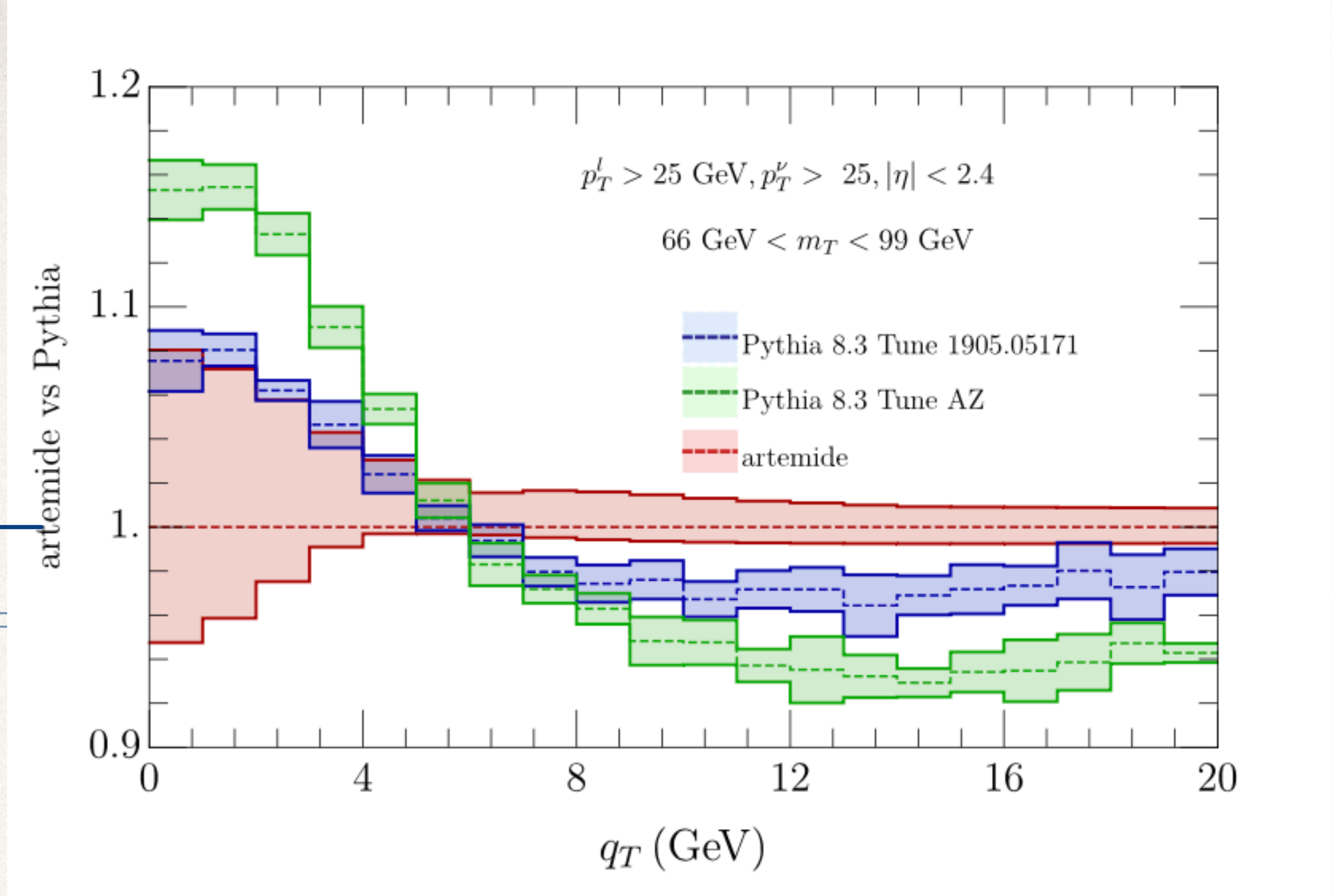
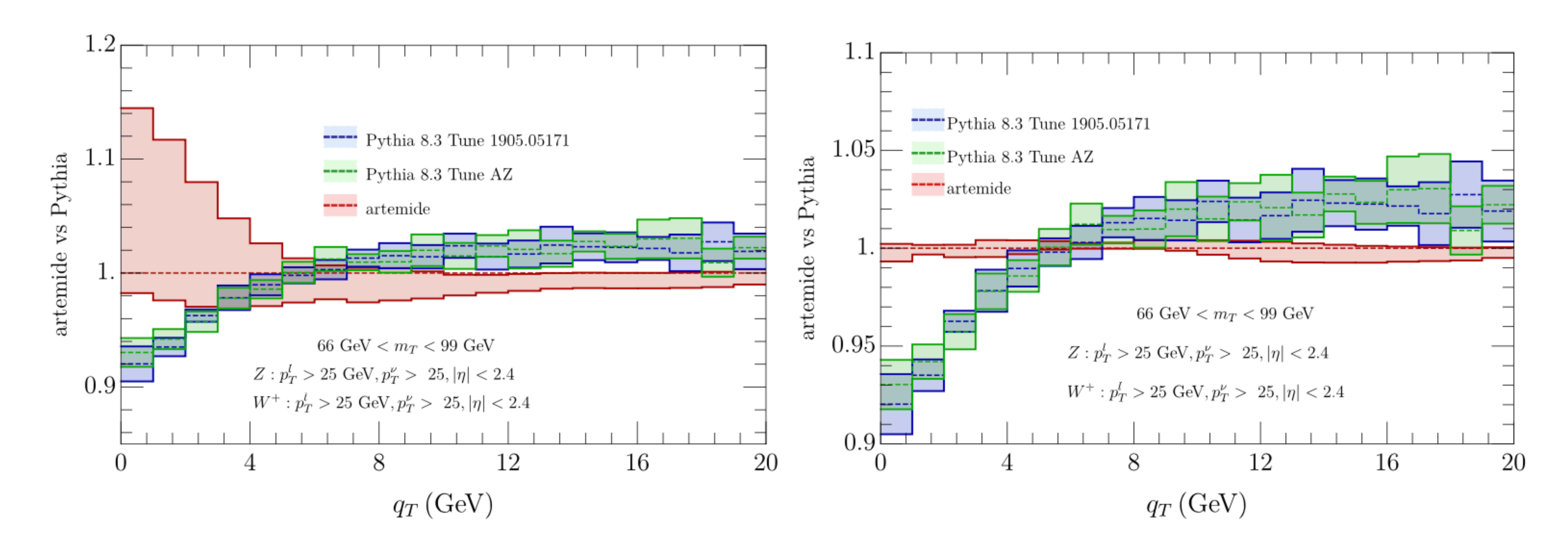


Pythia tunings

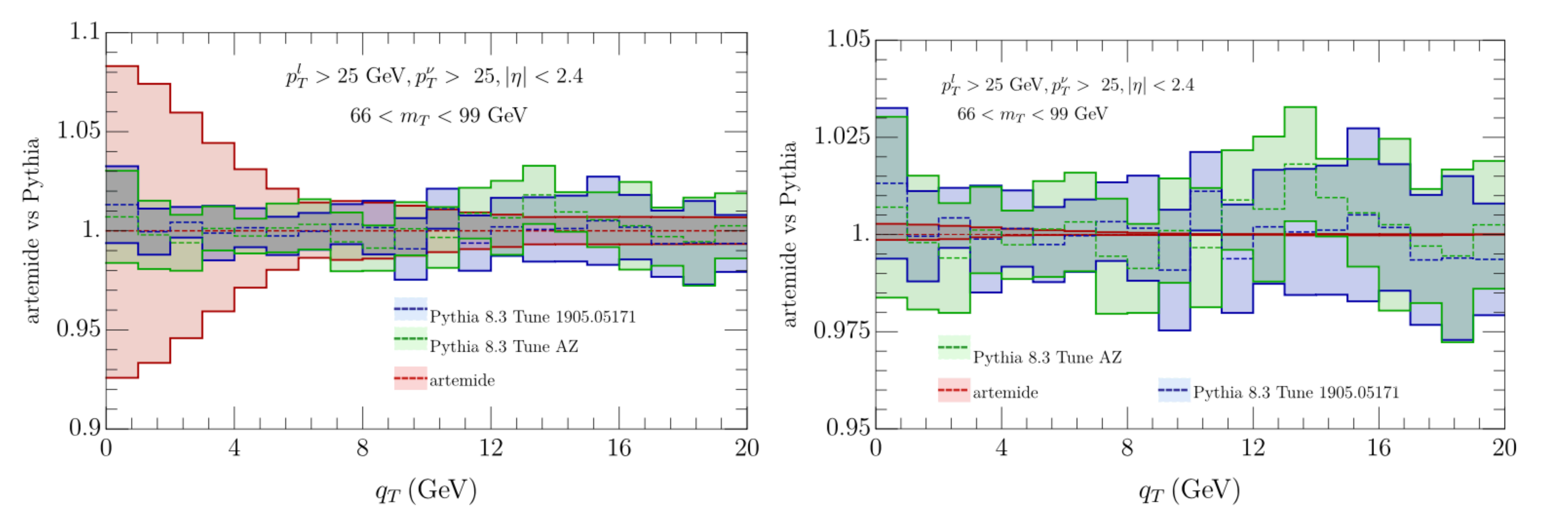
W^-



$p_T^Z / p_T^{W^+}$

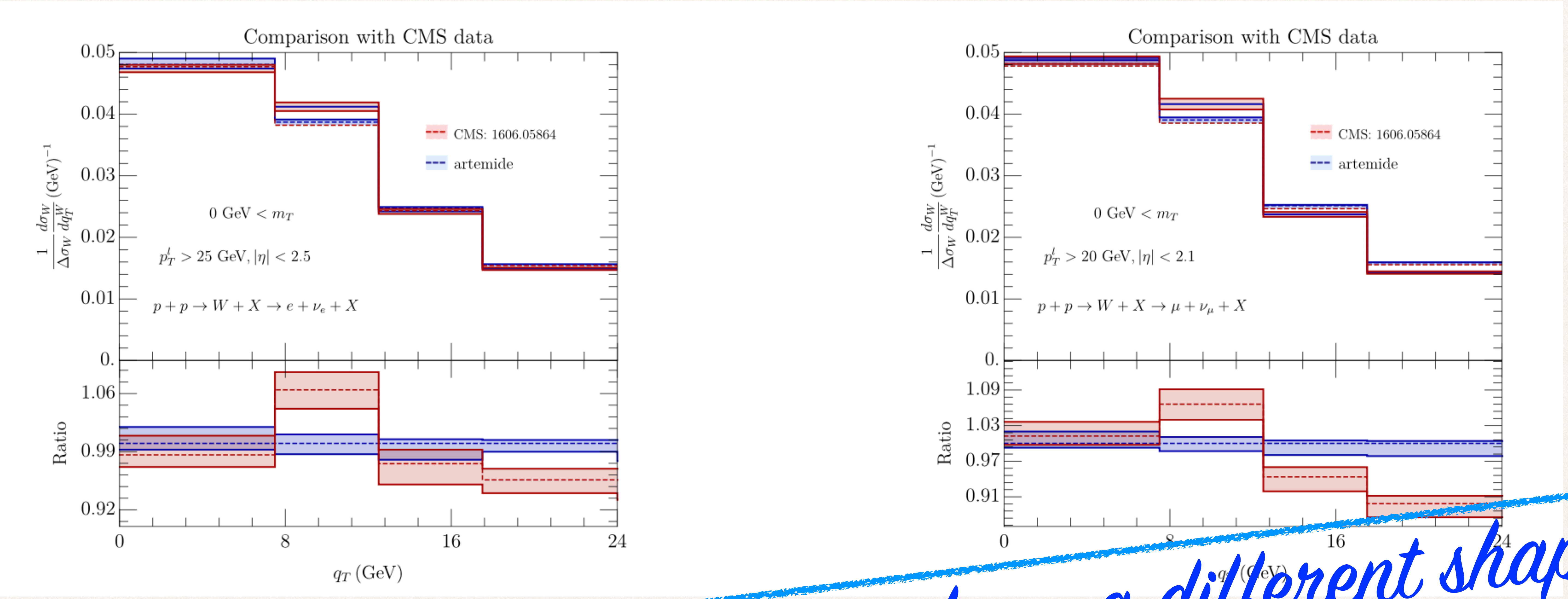


- The are noticeable differences among tunings



$p_T^{W^-} / p_T^{W^+}$

Comparison with data



Surprise: electrons and muons have a different shape!!

Comparison with data

	CDF $\sqrt{s} = 1.8$ TeV	D0 $\sqrt{s} = 1.8$ TeV	ATLAS	CMS $e\nu$	CMS $\mu\nu$
Number of points	10	10	2	4	4
NNPDF31	0.540	1.485	0.463	1.674	3.165
HERA20	0.469	1.591	0.271	1.563	3.721

Surprise: electrons and muons have a different shape!!

Work in progress: S. Leal-Gomez, J.J. Sanz Cillero, I. S., A. Vladimirov

Back slides

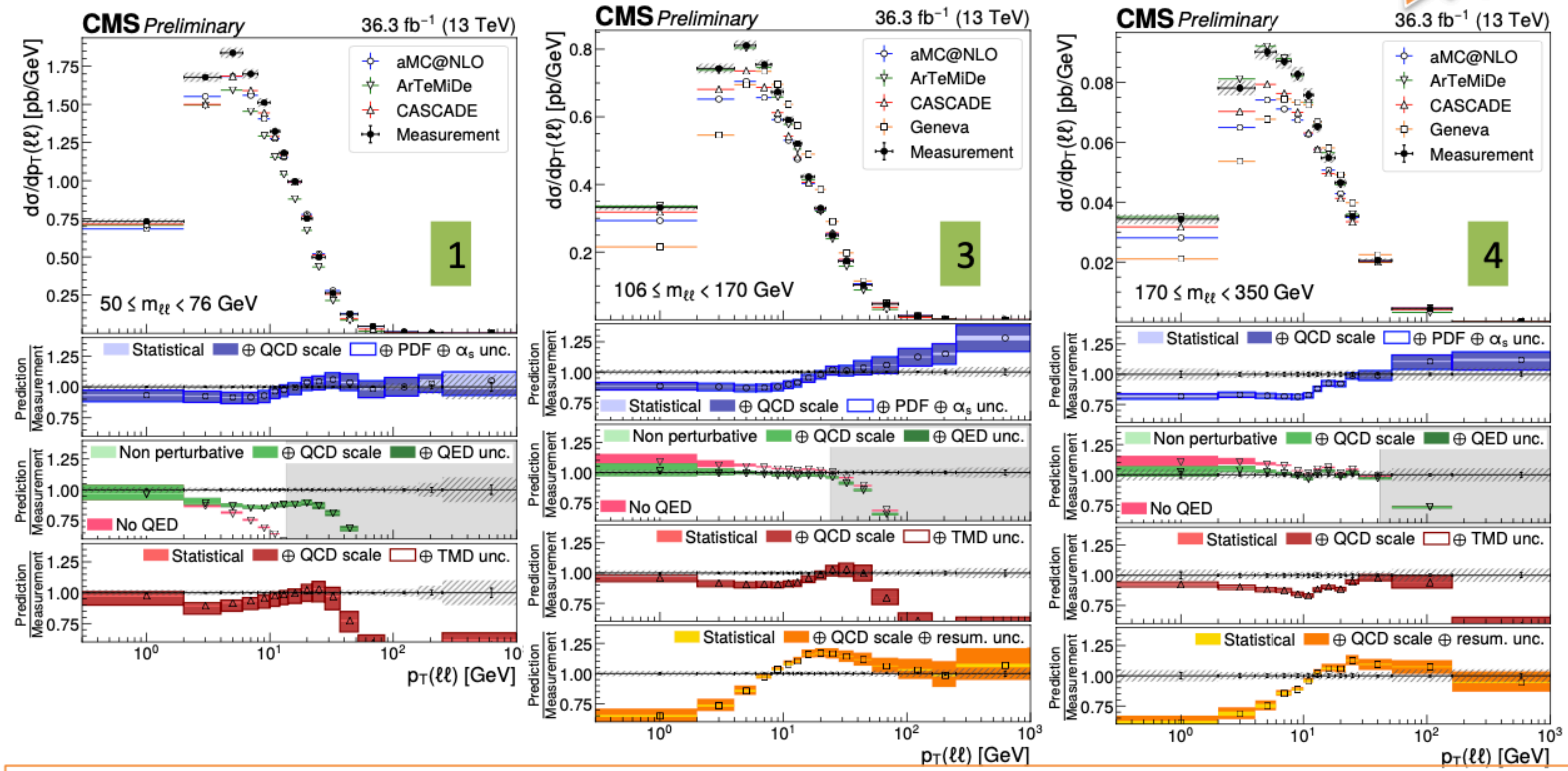
Drell-Yan pT dependence over a wide mass range

PAS-SMP-20-003

36.3 fb^{-1}

Unfolded to fiducial space

NEW



See talk of Louis Moureaux

→ amc@NLO+ Pyhthia8 gives overall good description

→ Failing to describe the low p_T, failure increasing for higher m(ll)

→ Cascade (amc@NLO 0j + PBTMD) describes the low p_T better fails at high p_T due to missing orders in ME

→ ArTeMiDe gives the best description in its validity region

→ GENEVA predicts a harder p_T spectrum (α_s choice)

B. Bilin DIS2021

TMD and PDF sets: bias removing

Work in progress with M. Bury, F. Hautmann, S. Leal Gomez, A. Vladimirov, P. Zurita

Spread among different sets

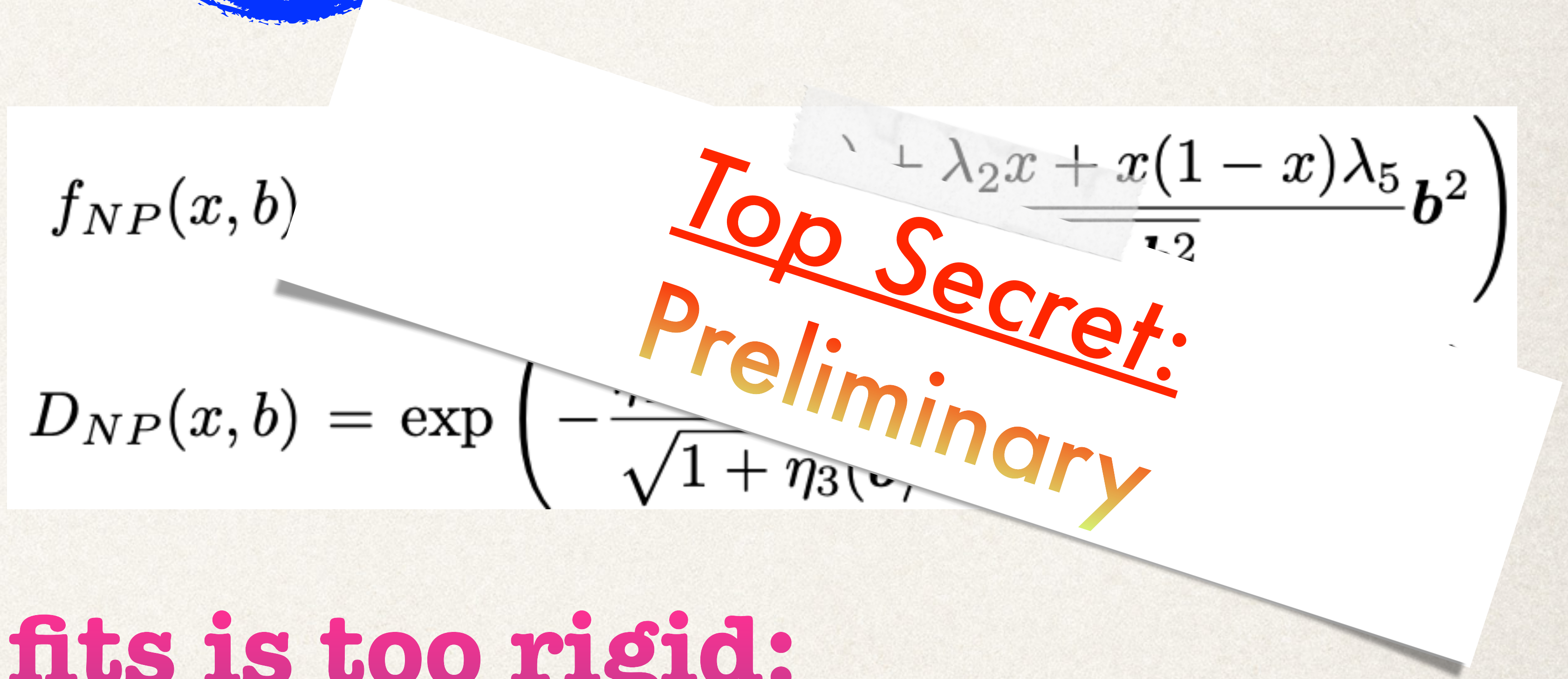
$$F_{f\leftarrow h}(x,\mathbf{b}) = \sum_{f'}\int_x^1 \frac{dy}{y} C_{f\leftarrow f'}(y,\mathbf{L}_{\mu_{\text{OPE}}}, a_s(\mu_{\text{OPE}})) f_{f'\leftarrow h}\left(\frac{x}{y},\mu_{\text{OPE}}\right) f_{\text{NP}}(x,b)$$

SV19 ansatz:

$$f_{NP}(x,b) = \exp\left(-\frac{\lambda_1(1-x)+\lambda_2 x + x(1-x)\lambda_5}{\sqrt{1+\lambda_3 x^{\lambda_4}\boldsymbol{b}^2}}\boldsymbol{b}^2\right)$$

$$D_{NP}(x,b) = \exp\left(-\frac{\eta_1 z+\eta_2(1-z)}{\sqrt{1+\eta_3(\boldsymbol{b}/z)^2}}\frac{\boldsymbol{b}^2}{z^2}\right)\left(1+\eta_4\frac{\boldsymbol{b}^2}{z^2}\right)$$

BHLSVZ21 ansatz:



The non-perturbative ansatz used in previous fits is too rigid:
We need flavor dependence of the ansatz to compensate the differences in different PDF sets

TMD and PDF sets: preliminary results

PDF	χ^2/N
NNPDF31	0.97
HERA20	0.90
CT18	0.98
MSHT20	0.88

The spread in the fit quality does not depend on PDF sets