Description of the full q_T spectrum of low Q Drell Yan production

IV Sardinian Workshop on Spin

Lorenzo Rossi

In collaboration with S. Camarda and G. Ferrera

June 12th

Istituto Nazionale di Fisica Nucleare

UNIVERSITÀ DEGLI STUDI DI MILANO

Short Recap

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Drell Yan production

$$h_1(p_1) + h_2(p_2) \;\rightarrow\; V + X \;\rightarrow\; \ell_1 + \ell_2 + X$$

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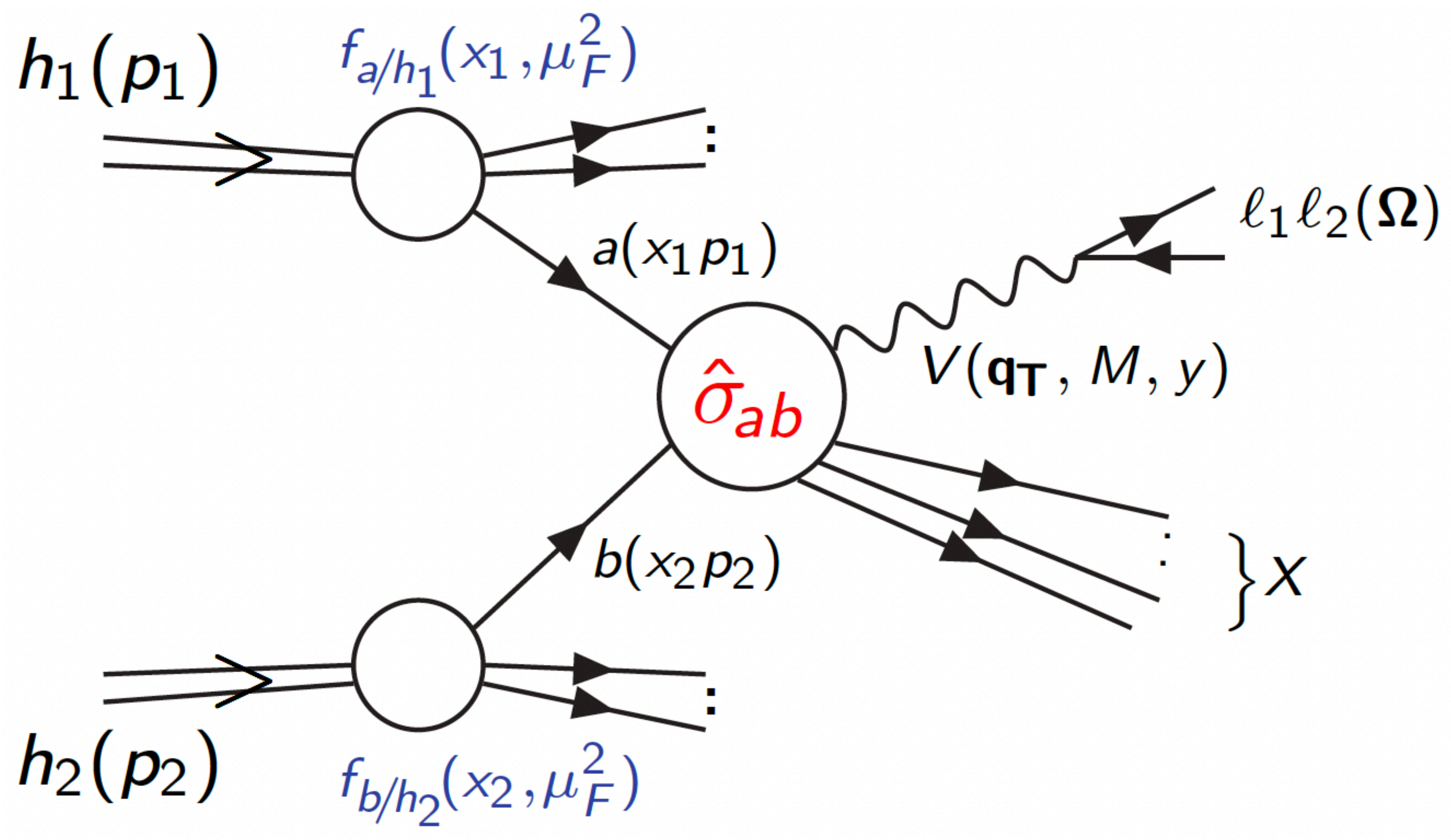

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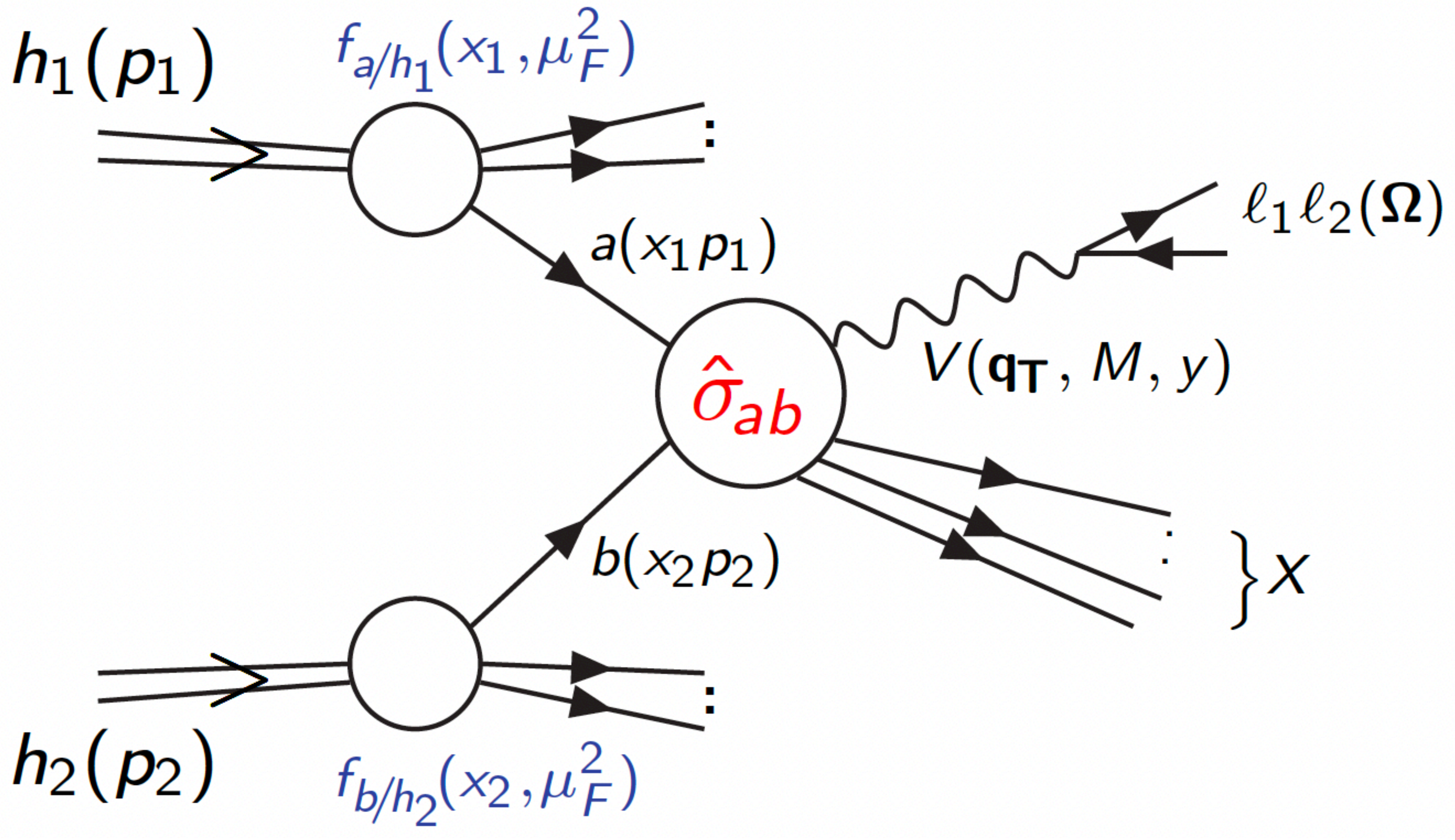

$$\frac{d\sigma}{d^2\mathbf{q_T}\, dM^2\, dy\, d\Omega} = \sum_{a,b} \int_0^1 dx_1 \int_0^1 dx_2\, f_{a,h_1}(x_1, \mu_F^2)\, f_{b,h_2}(x_2, \mu_F^2)\, \frac{d\hat{\sigma}_{ab}}{d^2\mathbf{q_T} dM^2 d\hat{y} d\Omega}(\alpha_S(\mu_R^2), \mu_R^2, \mu_F^2)$$

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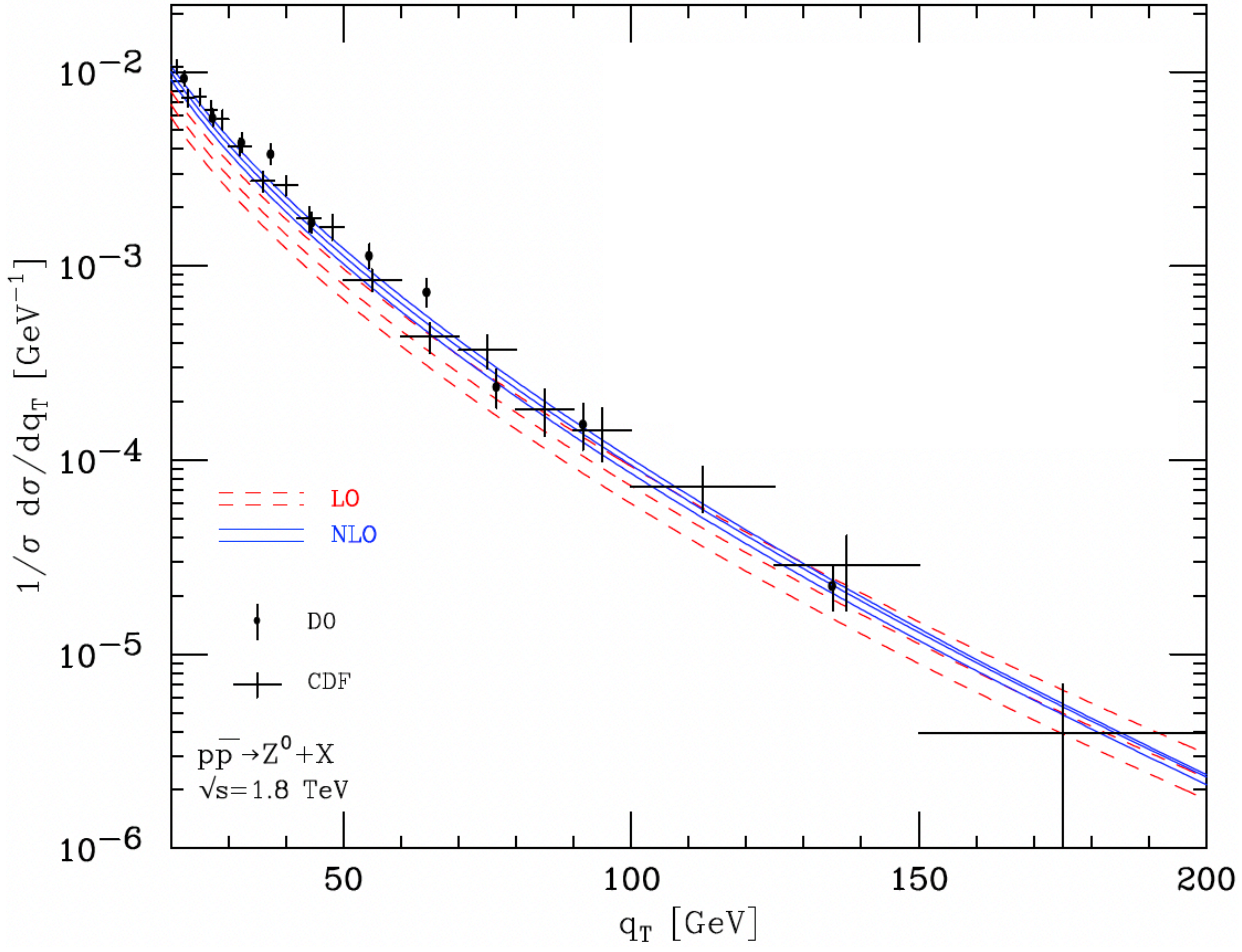

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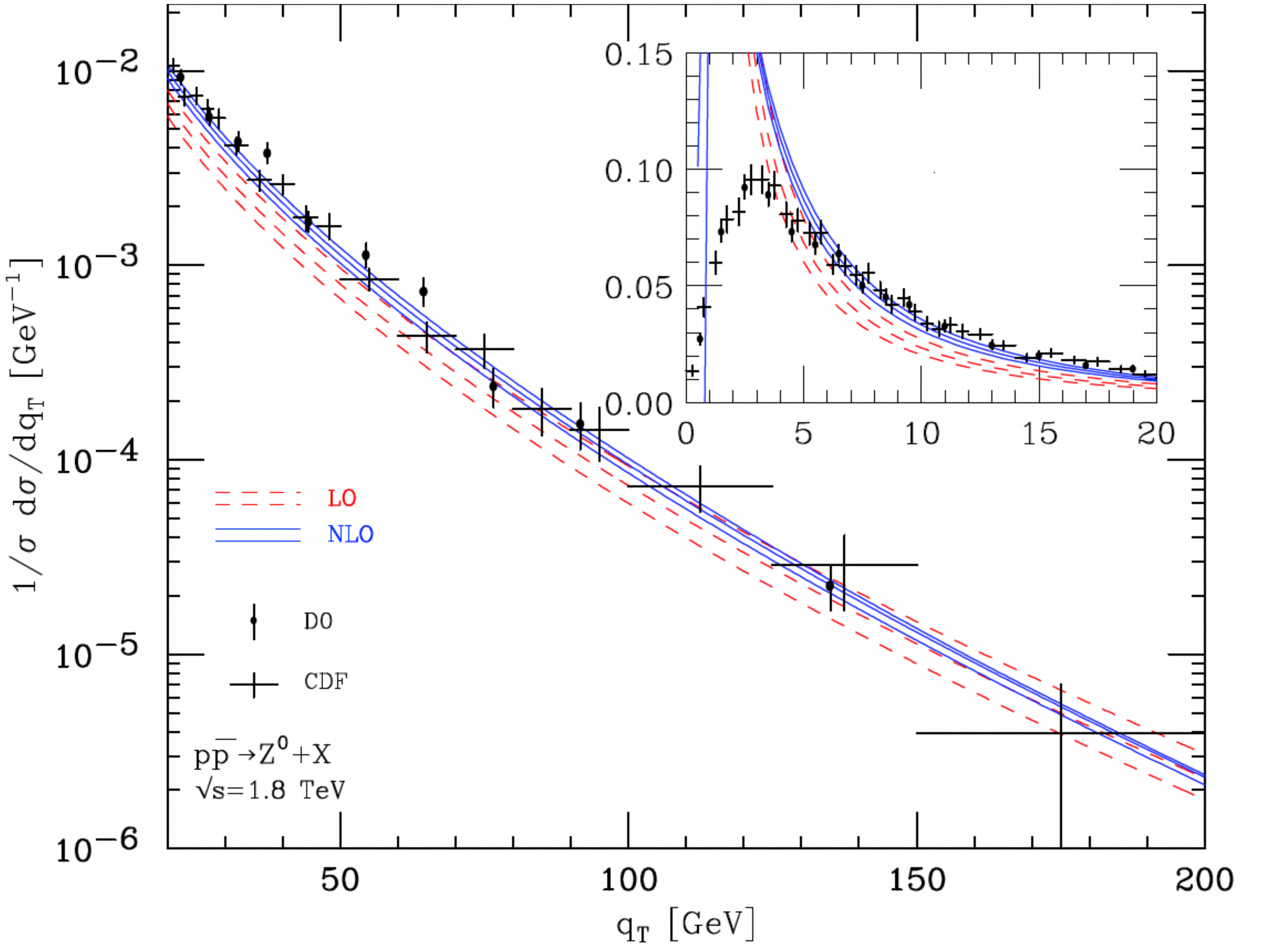

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Short Recap

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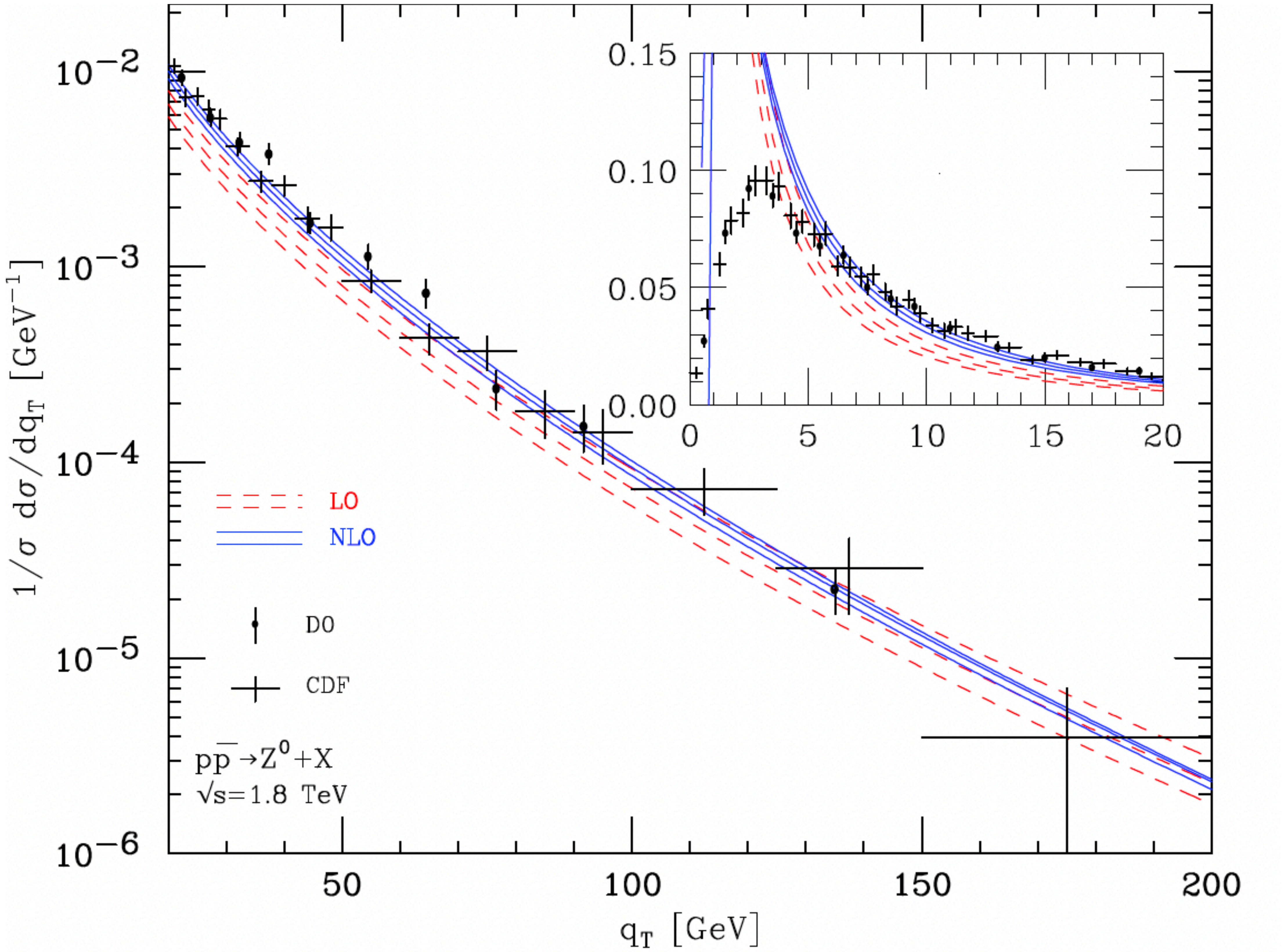

When $q_T \ll M$:

$$\int_0^{q_T^2} d\bar{q}_T^2 \frac{d\hat{\sigma}_{q\bar{q}}}{d\bar{q}_T^2} \sim 1 + \alpha_S[c_{12}L_{q_T}^2 + c_{11}L_{q_T} + \ldots]$$

$$+\alpha_S^2[c_{24}L_{q_T}^4 + \ldots + c_{21}L_{q_T} + \ldots] + \mathcal{O}(\alpha_S^3)$$

whit $\alpha_S^n L_{q_T}^m = \alpha_S^n \log^m\left(\frac{M^2}{q_T^2}\right) \gg 1$

q_T resummation in QCD

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$$\boxed{\frac{d\hat{\sigma}}{d^2\mathbf{q_T}} = \frac{d\hat{\sigma}^{(\mathrm{res})}}{d^2\mathbf{q_T}} + \frac{d\hat{\sigma}^{(\mathrm{fin})}}{d^2\mathbf{q_T}}}$$

JHEP 05 (2001) 025, Phys.Lett.B 564 (2003) 65-72, Nucl.Phys.B 737 (2006) 73-120

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In impact parameter space:

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In Mellin space:

$$W_N(b, M) = \hat{\sigma}^{(0)} H_N(\alpha_S) \times \exp\{G_N(\alpha_S, L)\}$$

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Connection with CSS formalism

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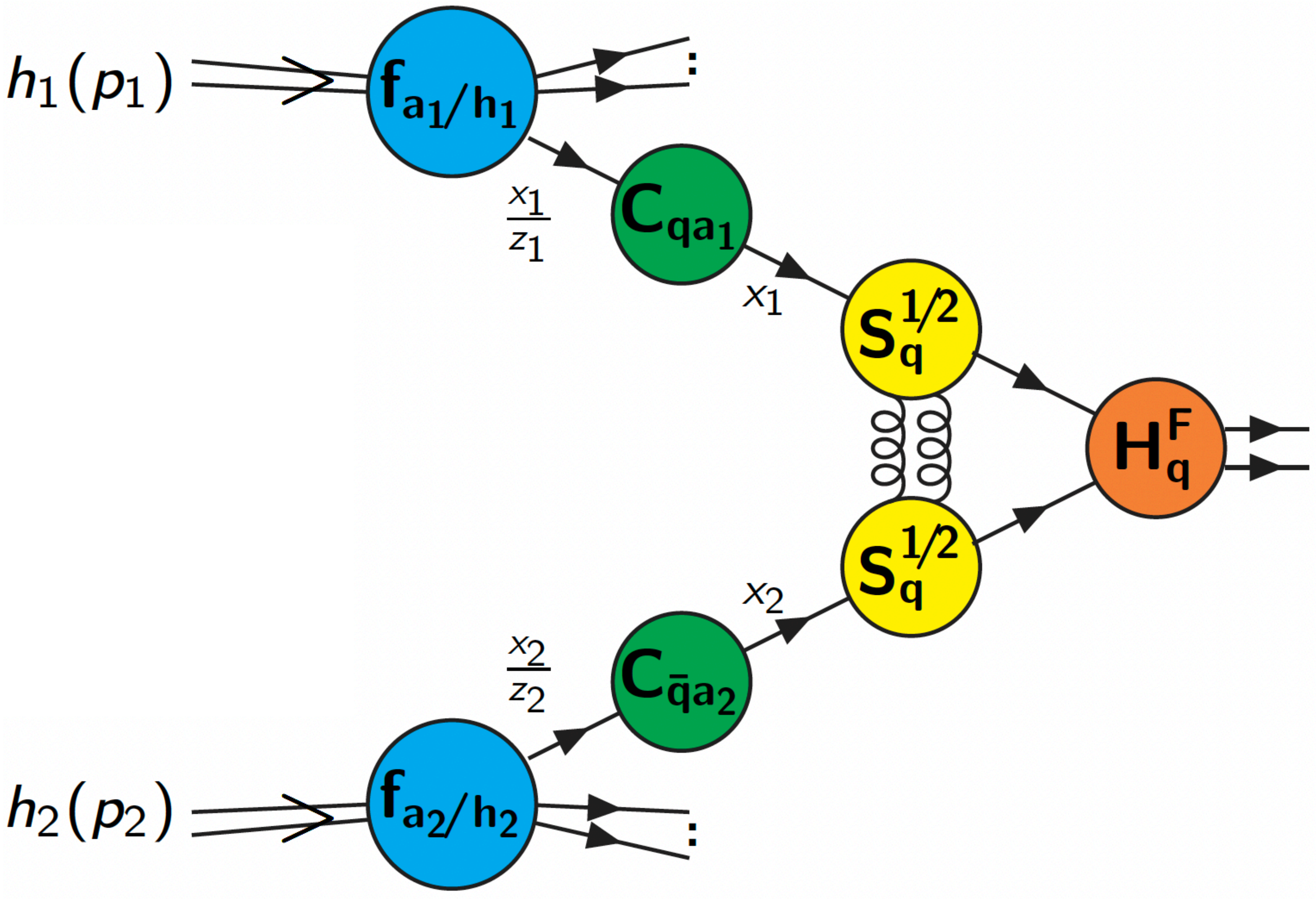

Nucl.Phys.B 261 (1985) 104-142

Connection with CSS formalism

$$
\frac{d\sigma_F^{(res)}}{dq_T^2} = \frac{M^2}{s}\,\sigma_{q\bar{q}}^{(0)}\,H_q^F(M^2)\sum_{a_1 a_2}\int \frac{d^2\mathbf{b_T}}{2\pi}\,e^{i\mathbf{b_T}\cdot\mathbf{q_T}}\,S_q(M,b)
$$

$$
\times \int_{x_1}^{1}\frac{dz_1}{z_1}\,C_{qa_1}(z_1;\alpha_s(\mu_b^2))\,f_{a_1/h_1}(x_1/z_1,\mu_b^2)\int_{x_2}^{2}\frac{dz_2}{z_2}\,C_{\bar{q}a_2}(z_2;\alpha_s(\mu_b^2))\,f_{a_2/h_2}(x_2/z_2,\mu_b^2)
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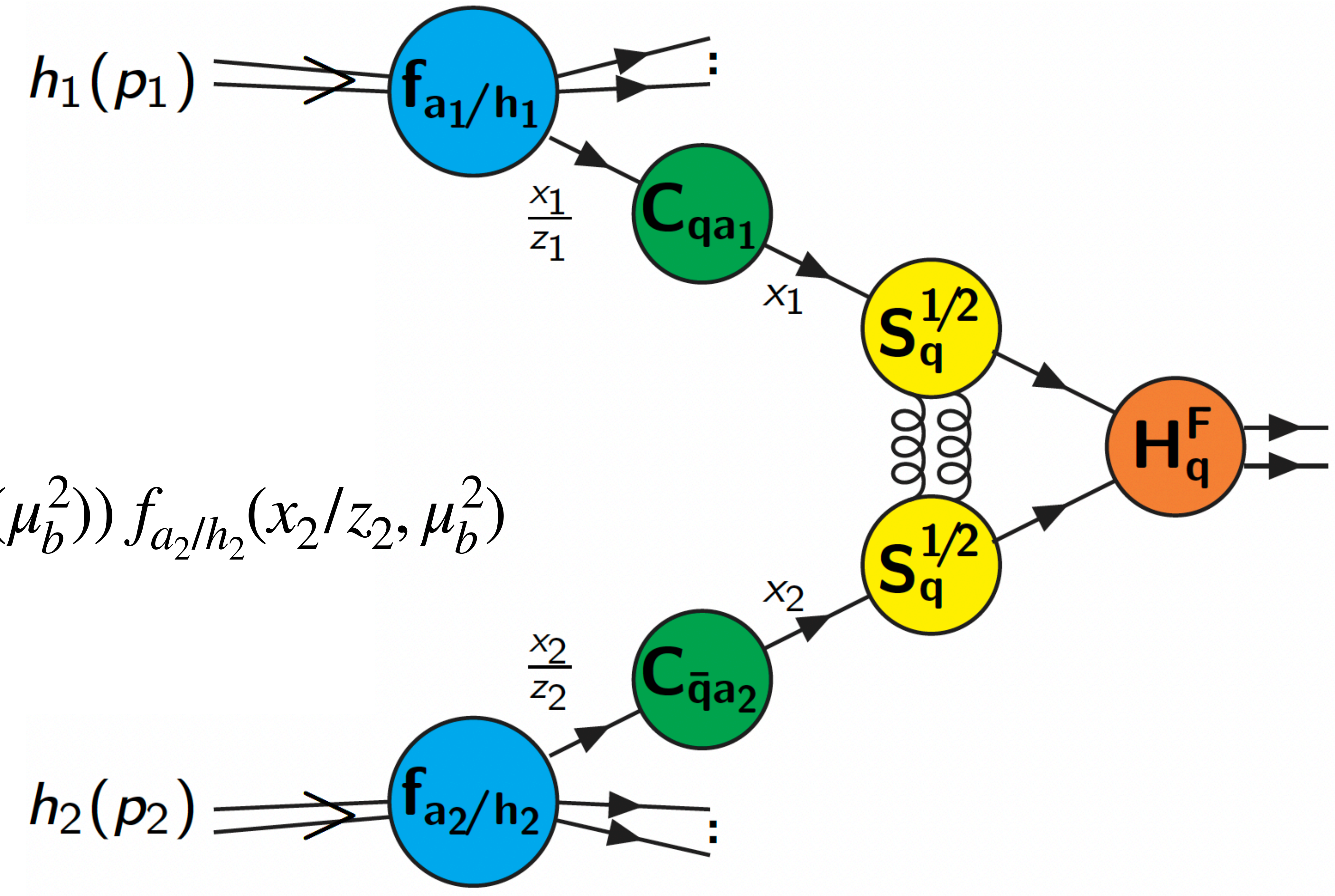

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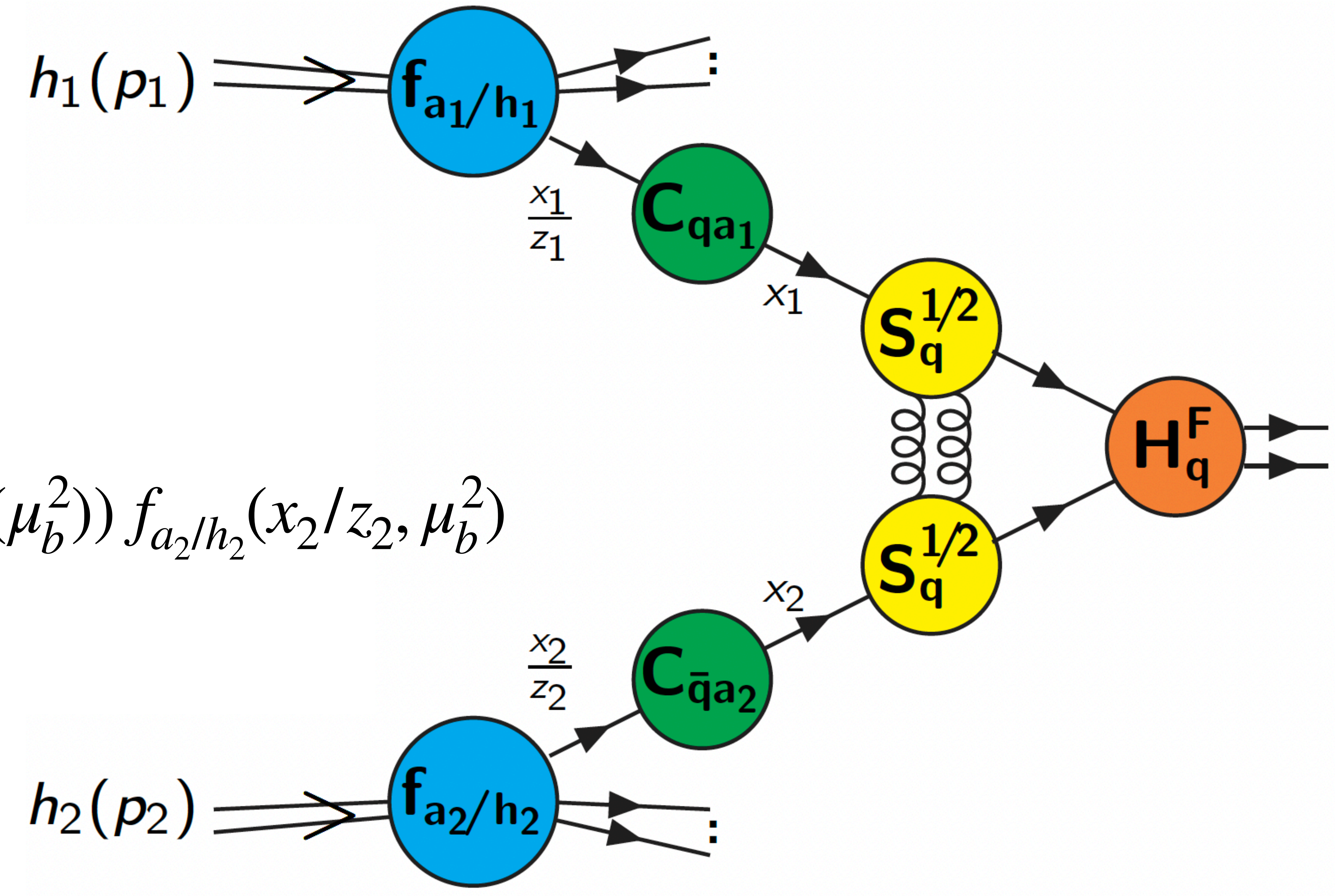

$\boxed{\text{Exactly the same expression as before}}$

Application of q_T resummation

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Eur.Phys.J.C 80 (2020) 3, 251

Application of q_T resummation

DYTurbo

Eur.Phys.J.C 80 (2020) 3, 251

Study of the full q_T spectrum
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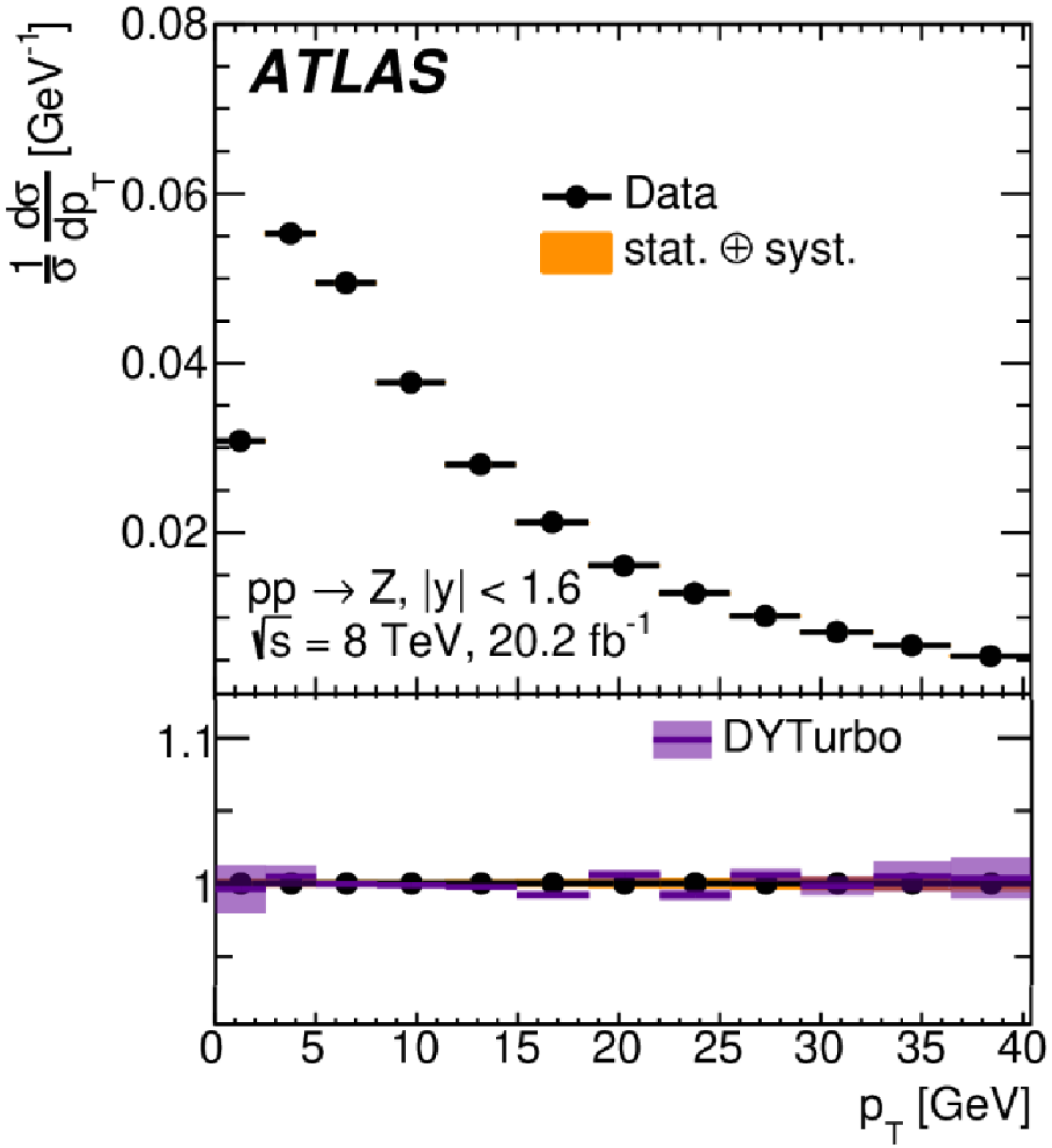

Eur. Phys. J. C 84 (2024) 315

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Eur.Phys.J.C 80 (2020) 3, 251

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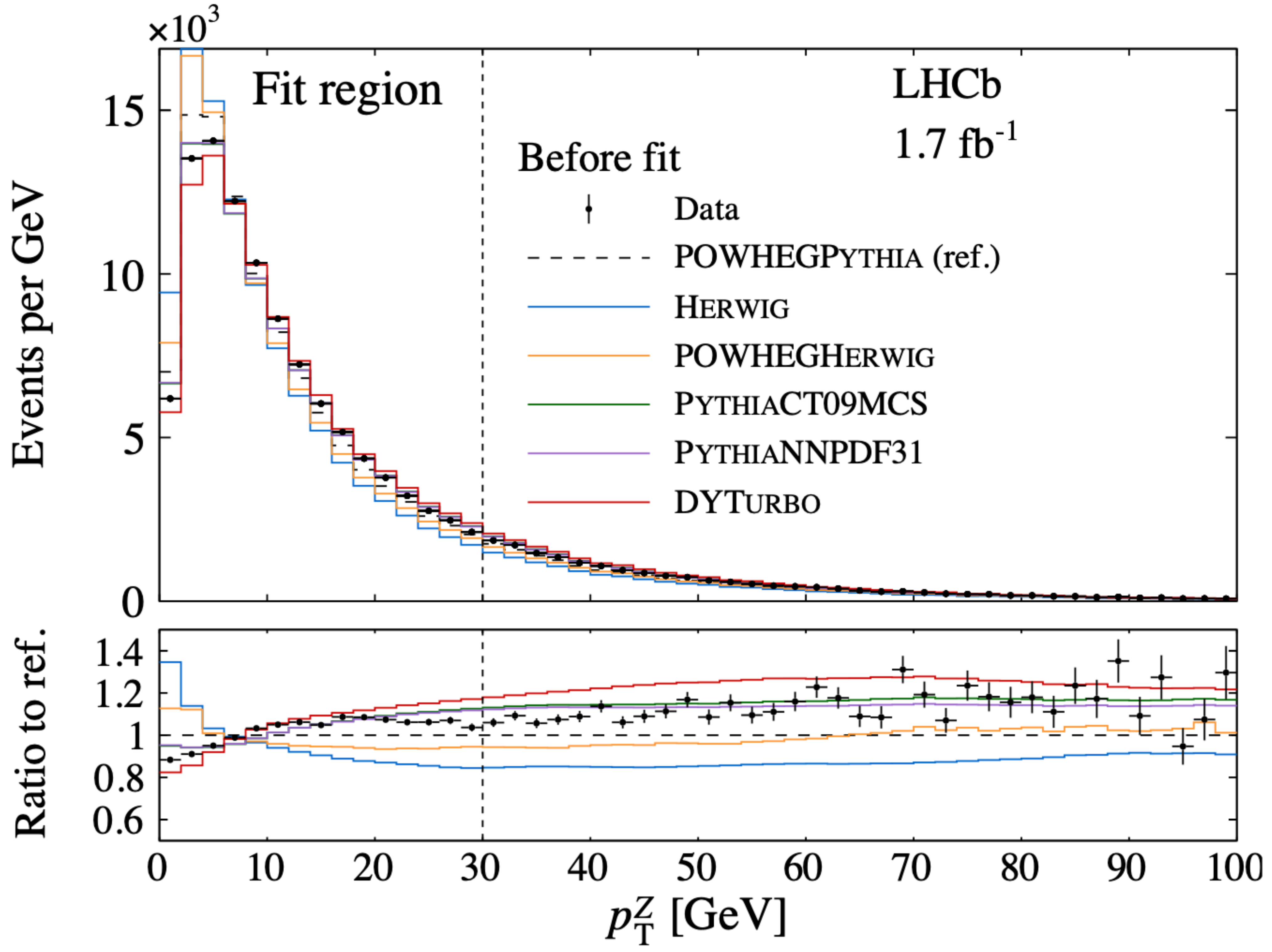
Study of the Z and $W^{\pm}$ boson masses



Application of q_T resummation

Eur.Phys.J.C 80 (2020) 3, 251

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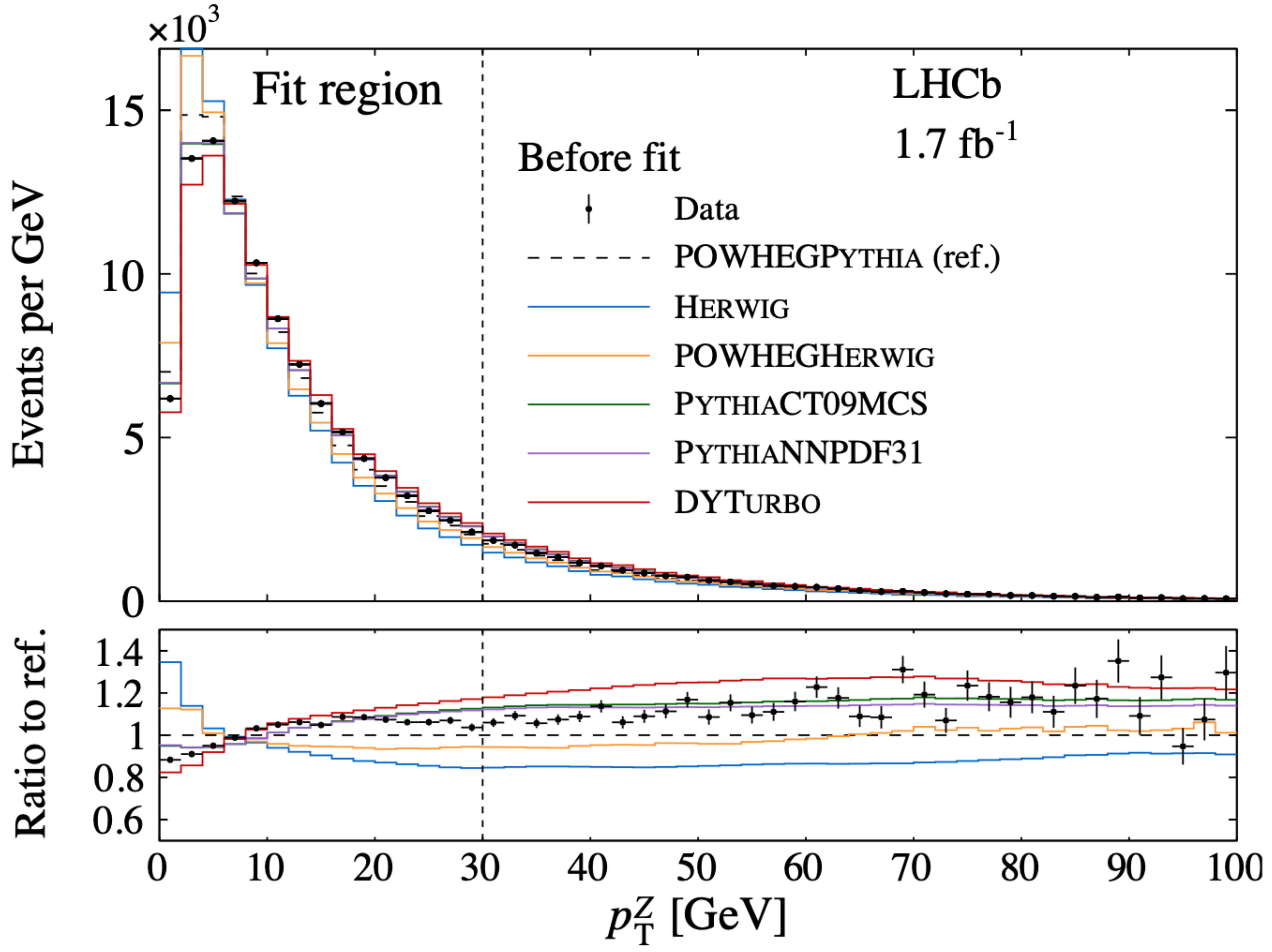
And at low invariant mass?



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README.md

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Download

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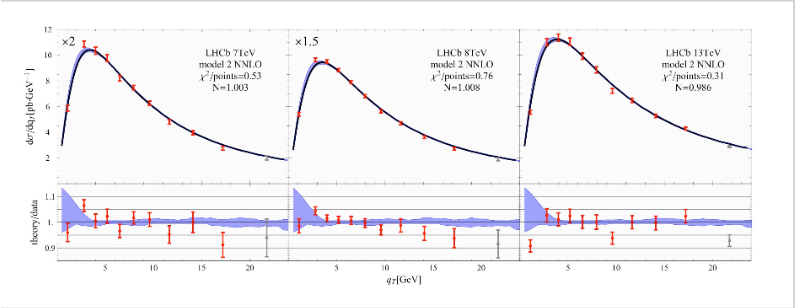

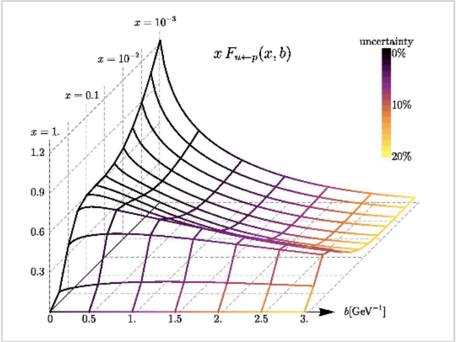

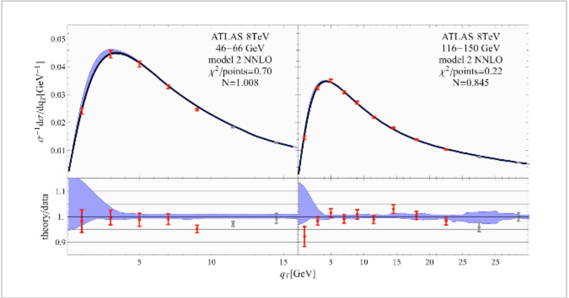

News

12 Dec 2019: Version 2.02 released (+manual update).

23 Feb 2019: Version 1.4 released (+manual update).

21 Jan 2019: Artemide now has a repository.

Archive of older links/news.

Articles, presentations & supplementary materials

Extra pictures for the paper arXiv:1902.08474

Seminar of A.Vladimirov in Pavia 2018 on TMD evolution.

Link to the text in Inspire.

Archive of older links/news.

Download

Recent version/release can be found in repository

About us & Contacts

If you have found mistakes, or have suggestions/questions, please, contact us.

Some extra materials can be found on Alexey's web-page

Alexey Vladimirov Alexey.Vladimirov@physik.uni-regensburg.de

Ignazio Scimemi ignazios@fis.ucm.es

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Or only the finite part…

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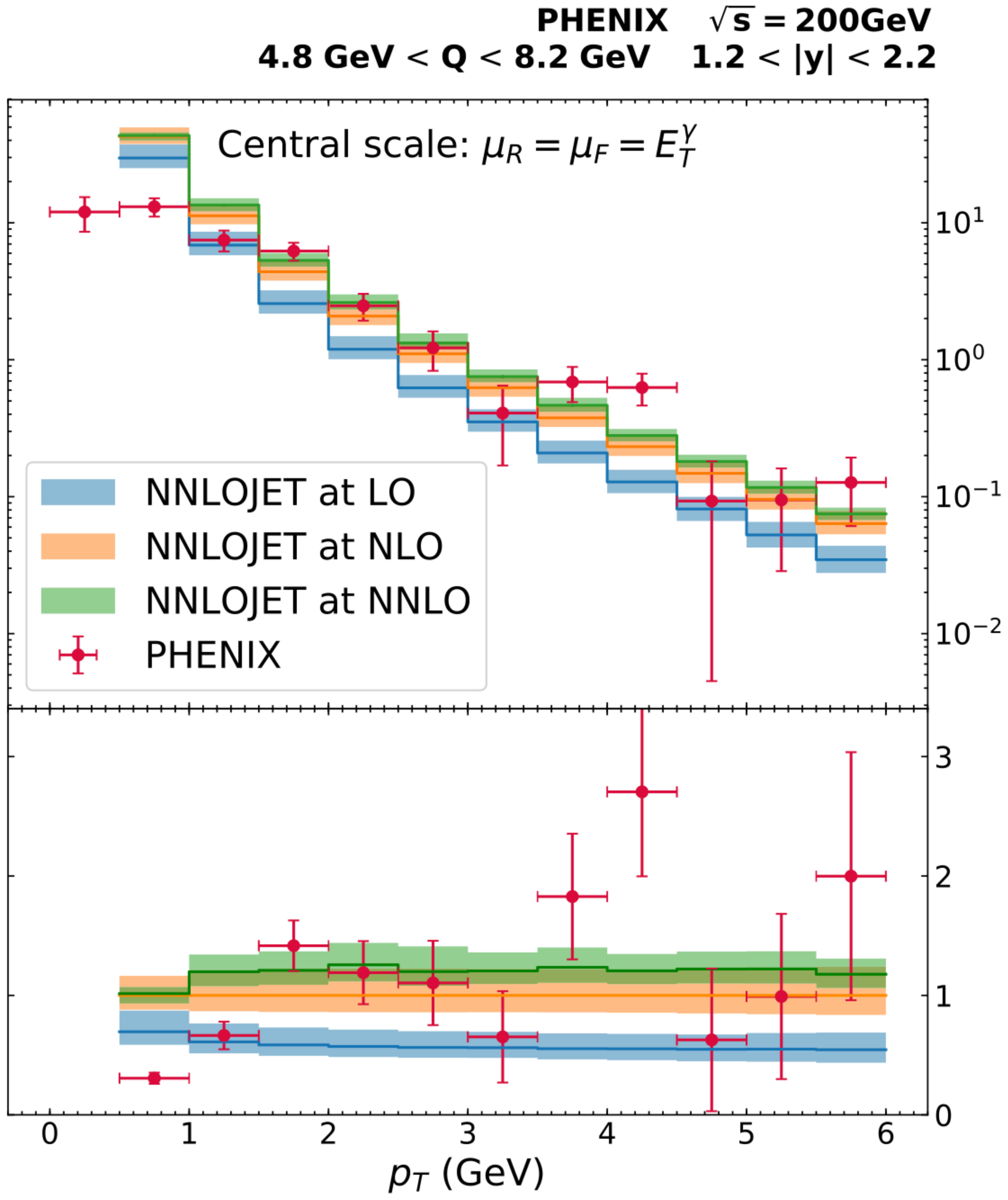

Physics Letters B 829 (2022) 137111

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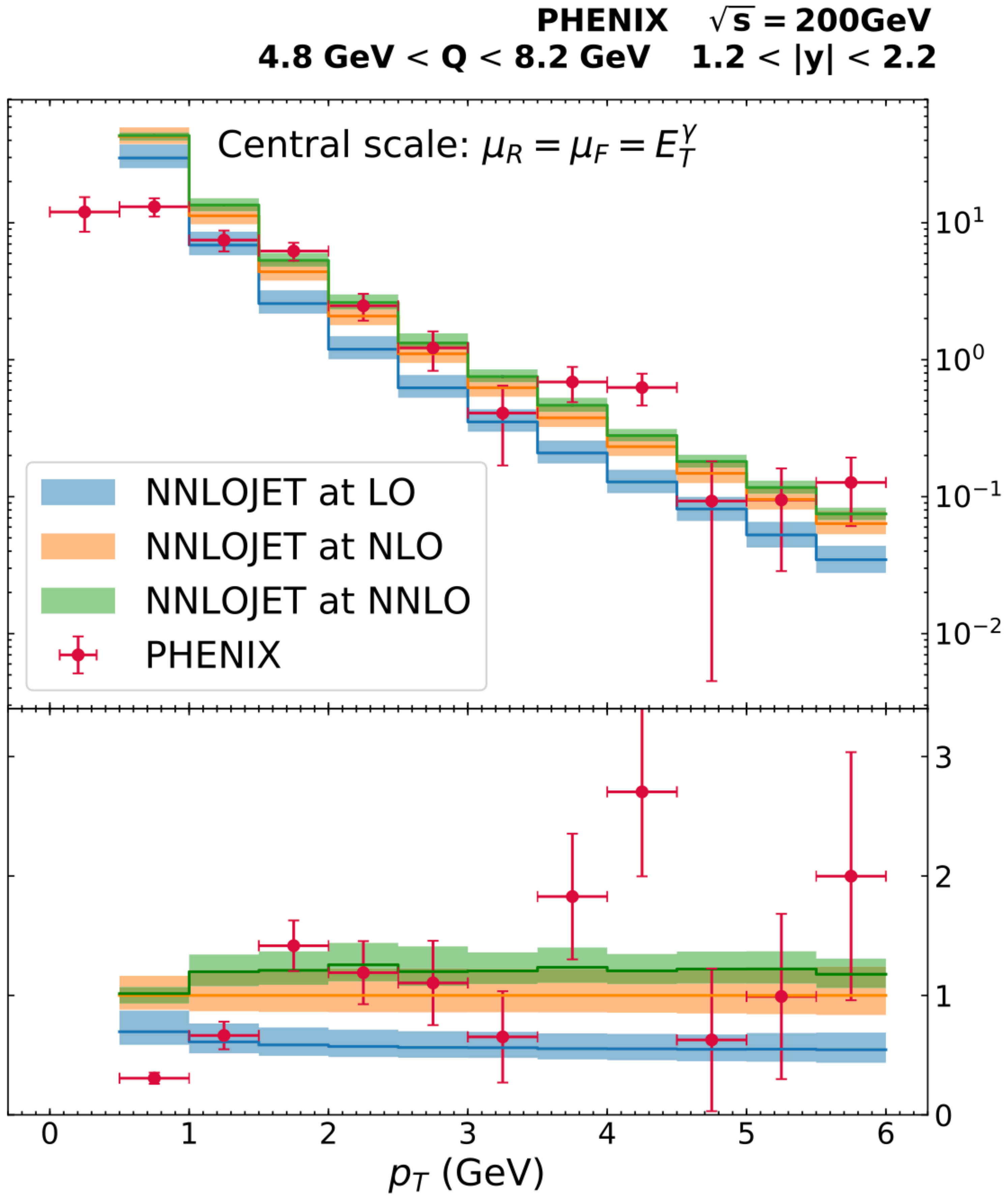

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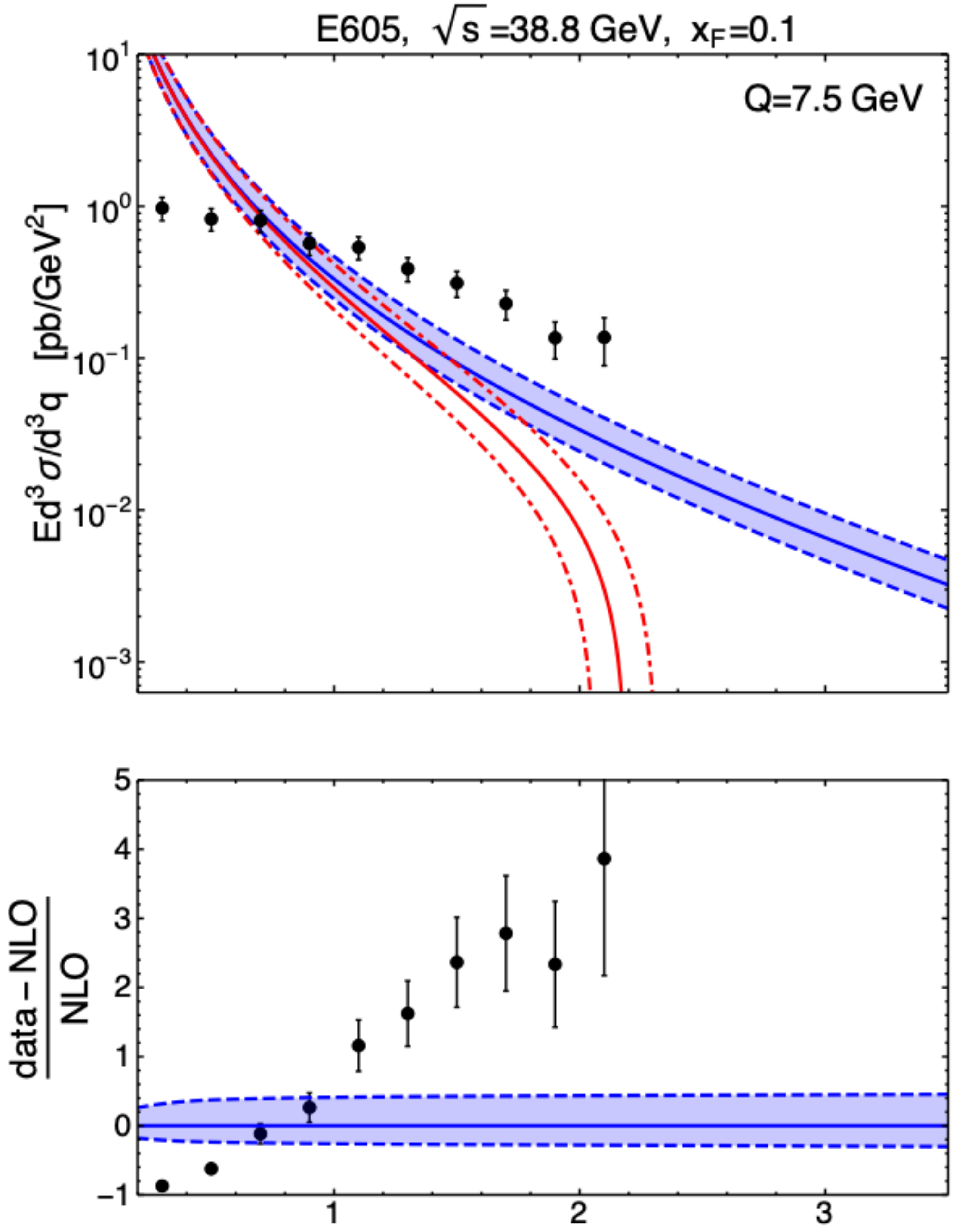

Phys.Rev.D 100 (2019) 1, 014018

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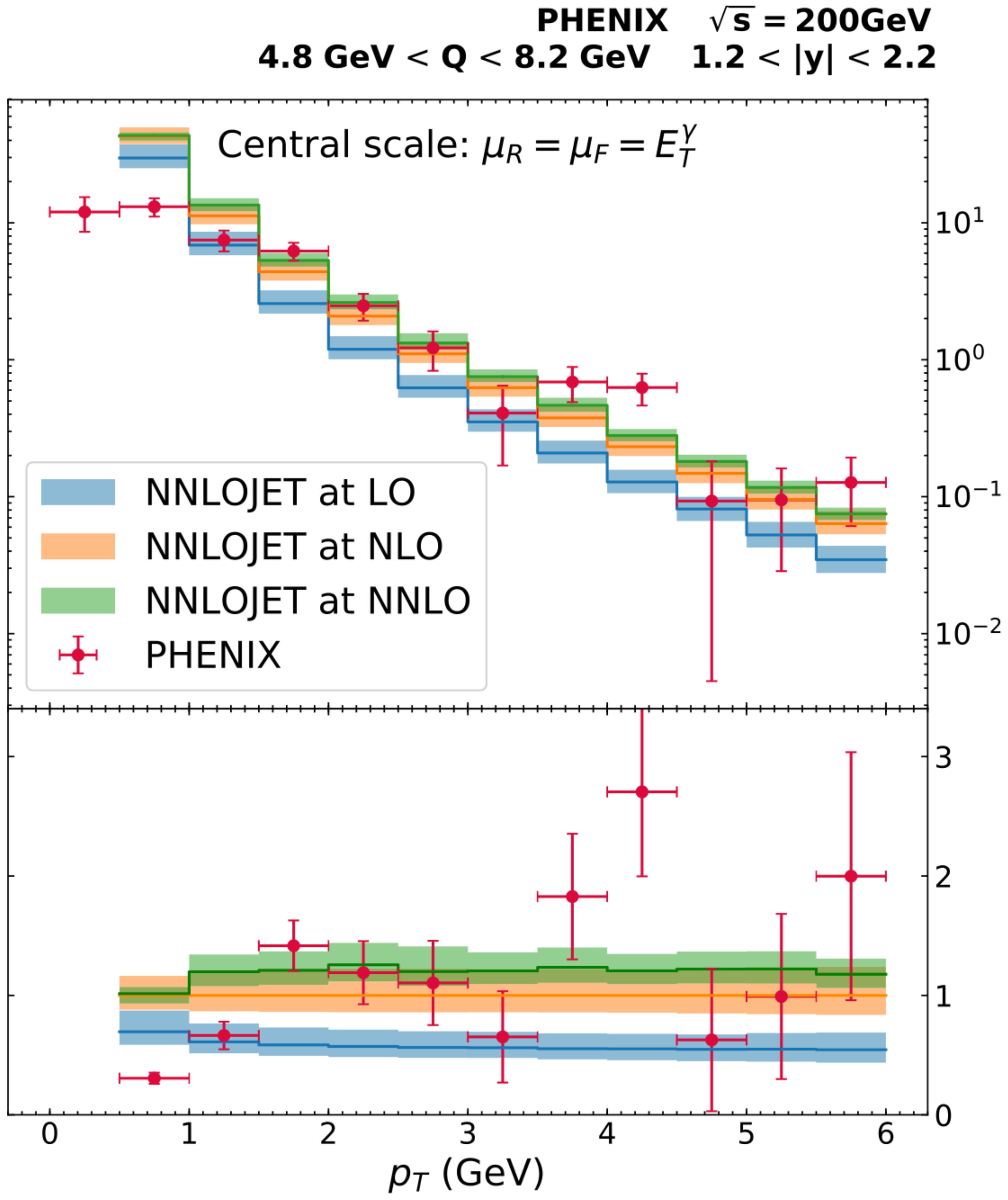

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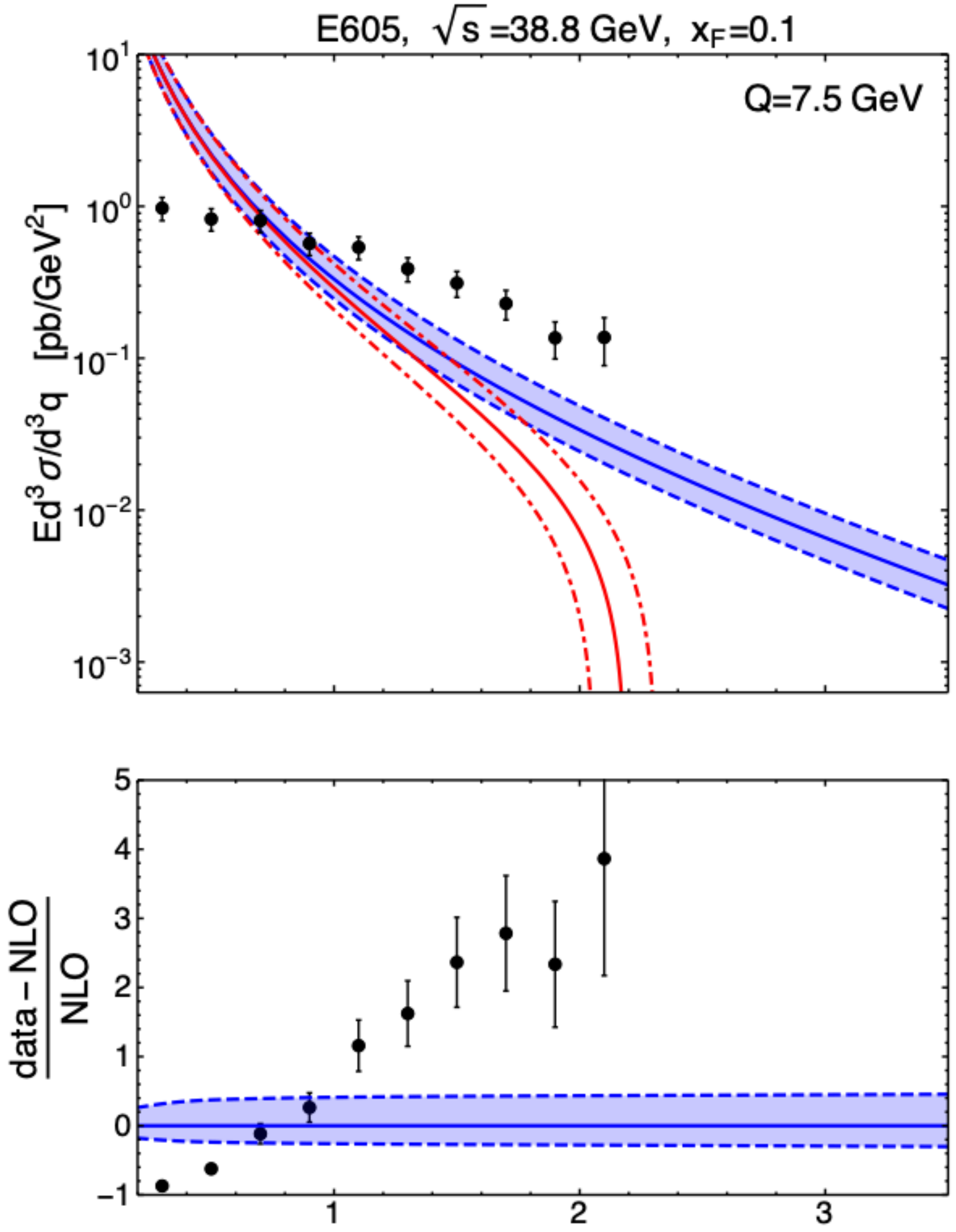
Problem in the description of the data



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Study of low invariant mass data

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Finite part + *Resummed part*

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E288 200 GeV	$Ed^3\sigma/d^3\boldsymbol{q}$	19.4	4 - 9	$y = 0.40$
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ATLAS 8 TeV on-peak	$(1/\sigma)d\sigma/d\|\boldsymbol{q}_T\|$	8000	66 - 116	$\|y\| < 0.4$ $0.4 < \|y\| < 0.8$ $0.8 < \|y\| < 1.2$ $1.2 < \|y\| < 1.6$ $1.6 < \|y\| < 2$ $2 < \|y\| < 2.4$
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Study of low invariant mass data

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$$\int_0^\infty d^2\mathbf{q_T} \frac{d\sigma}{d^2\mathbf{q_T}} = \sigma^{tot}$$

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Phys.Rev.D 91 (2015) 7, 074020

Study of low invariant mass data

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Phys.Rev.D 91 (2015) 7, 074020

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Study of low invariant mass data

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4 non-perturbative parameters

Study of low invariant mass data

Study of low invariant mass data

Eur.Phys.J.C 80 (2020) 3, 251

Study of low invariant mass data

DYTurbo

Eur.Phys.J.C 80 (2020) 3, 251

xFitter

arxiv:2206.12465

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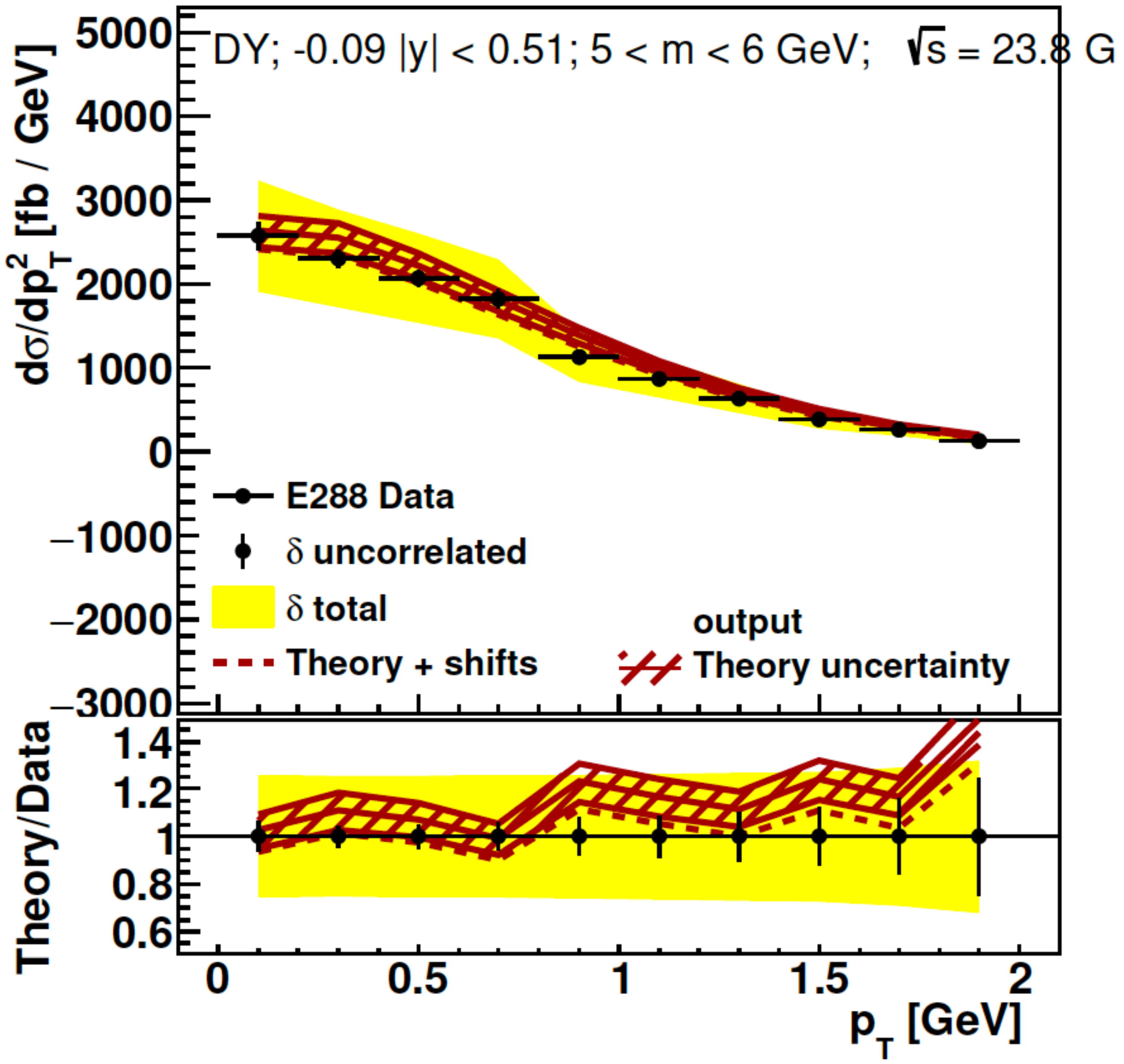
We have high-q_T data!

Study of low invariant mass data

Study of low invariant mass data

E288 300 GeV, $5 < Q < 6$



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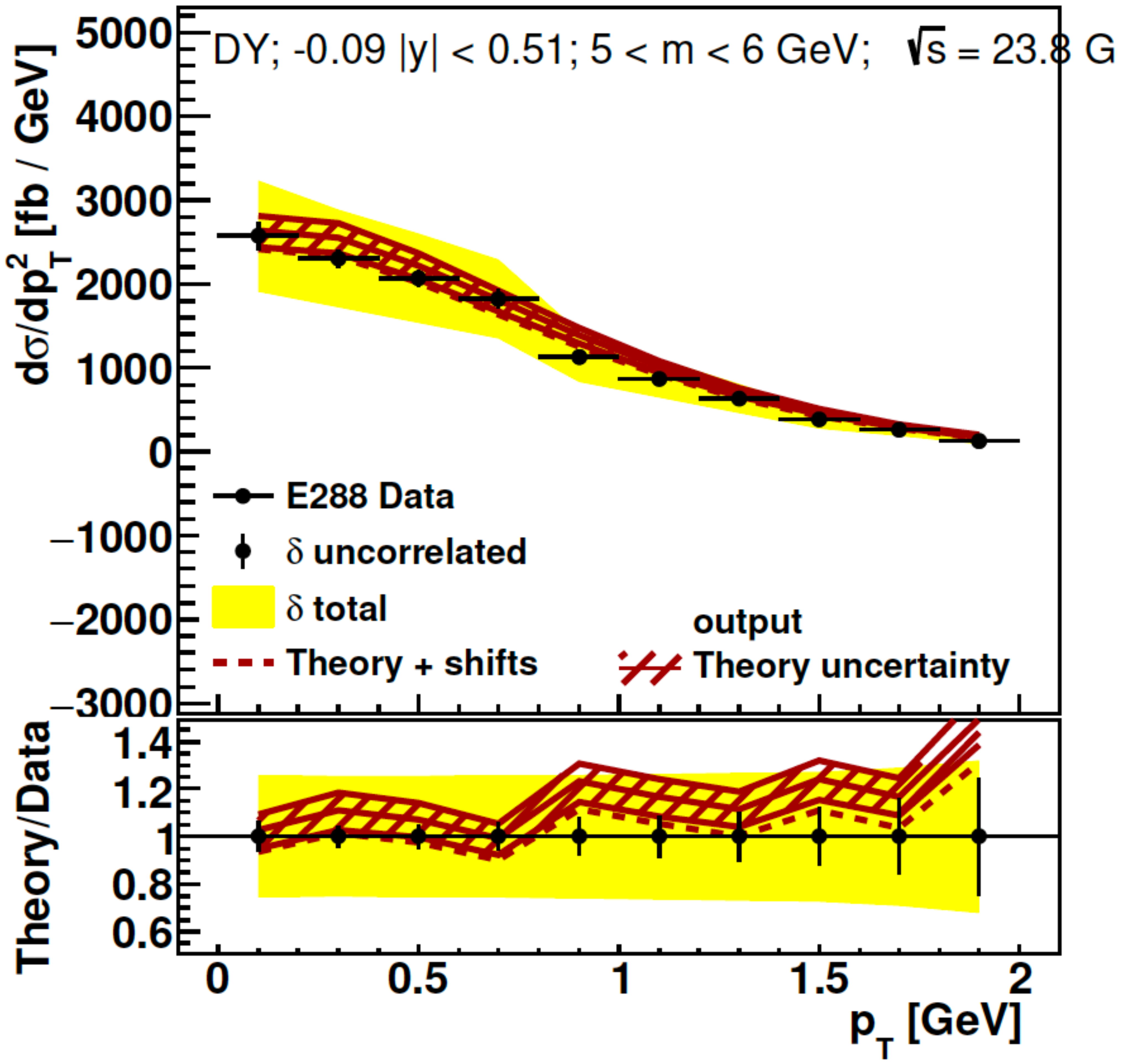

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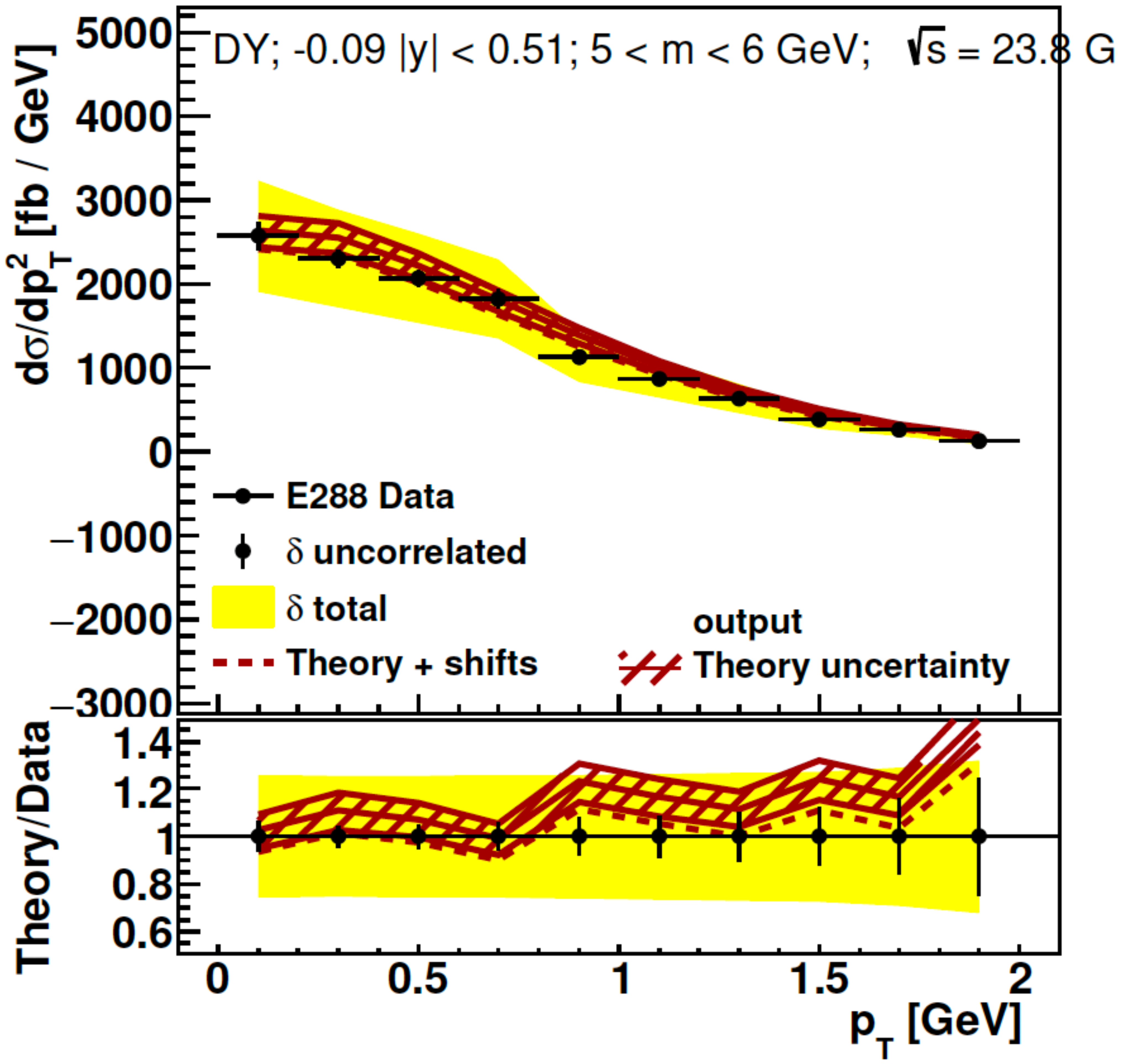

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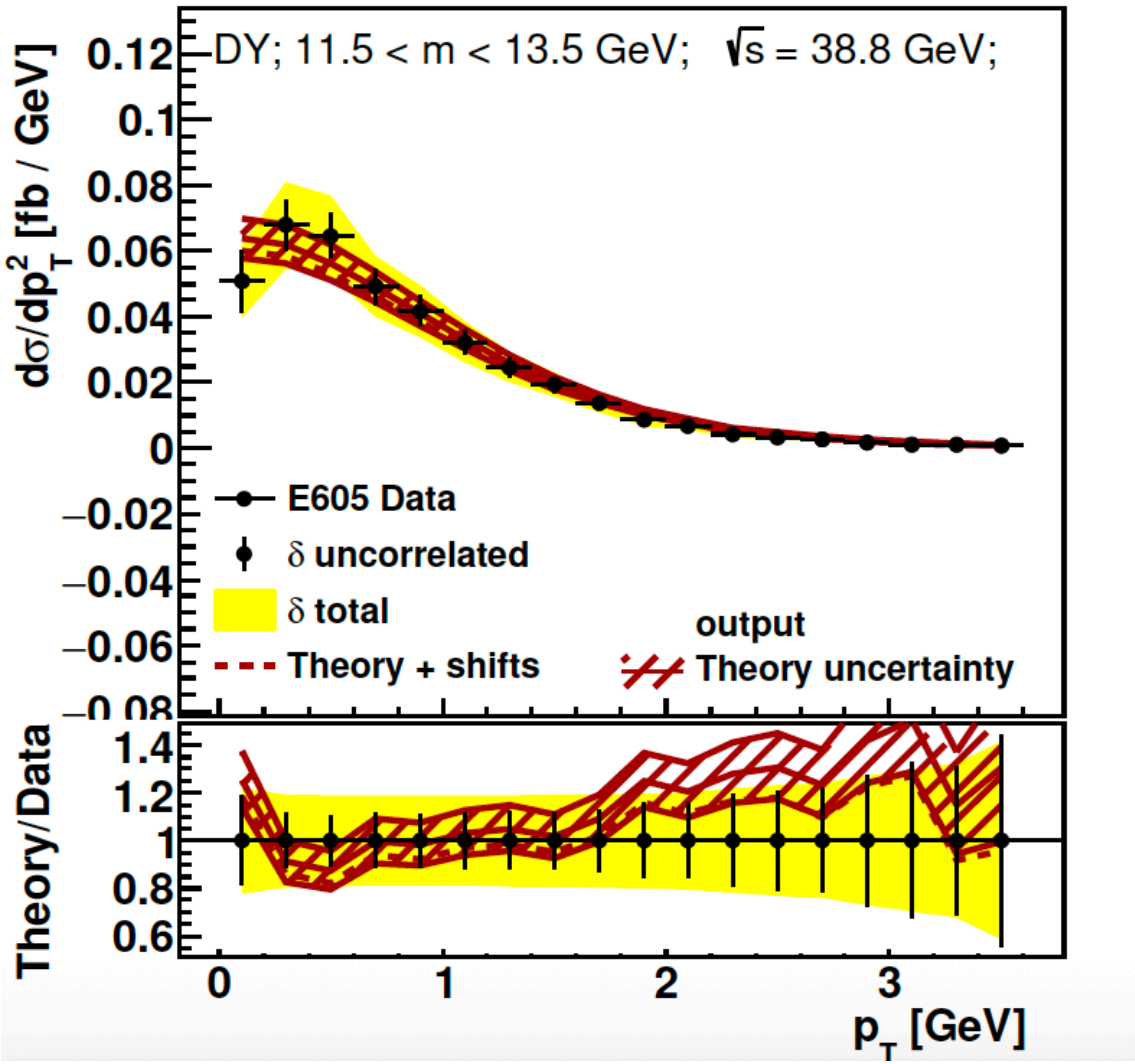

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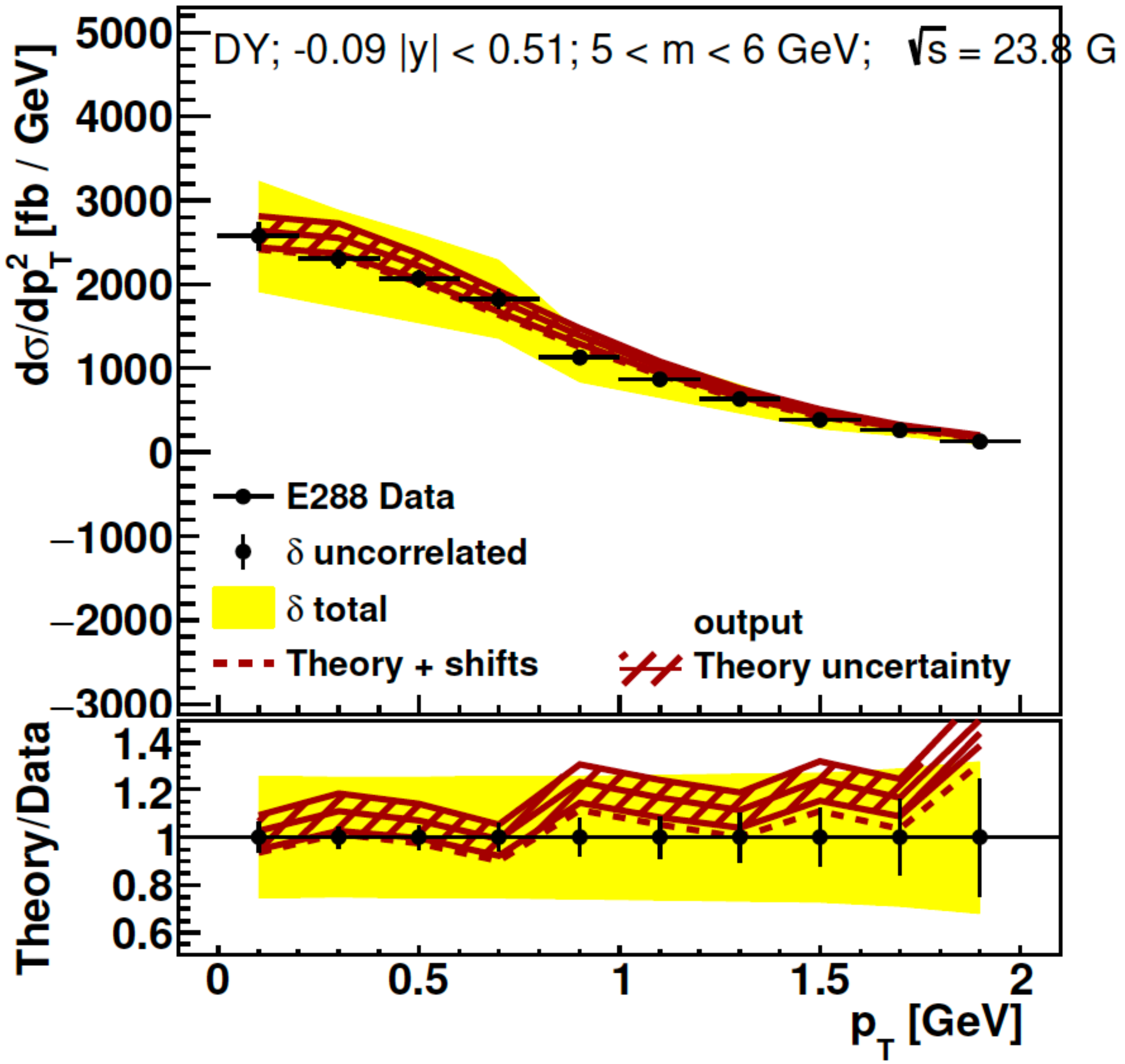

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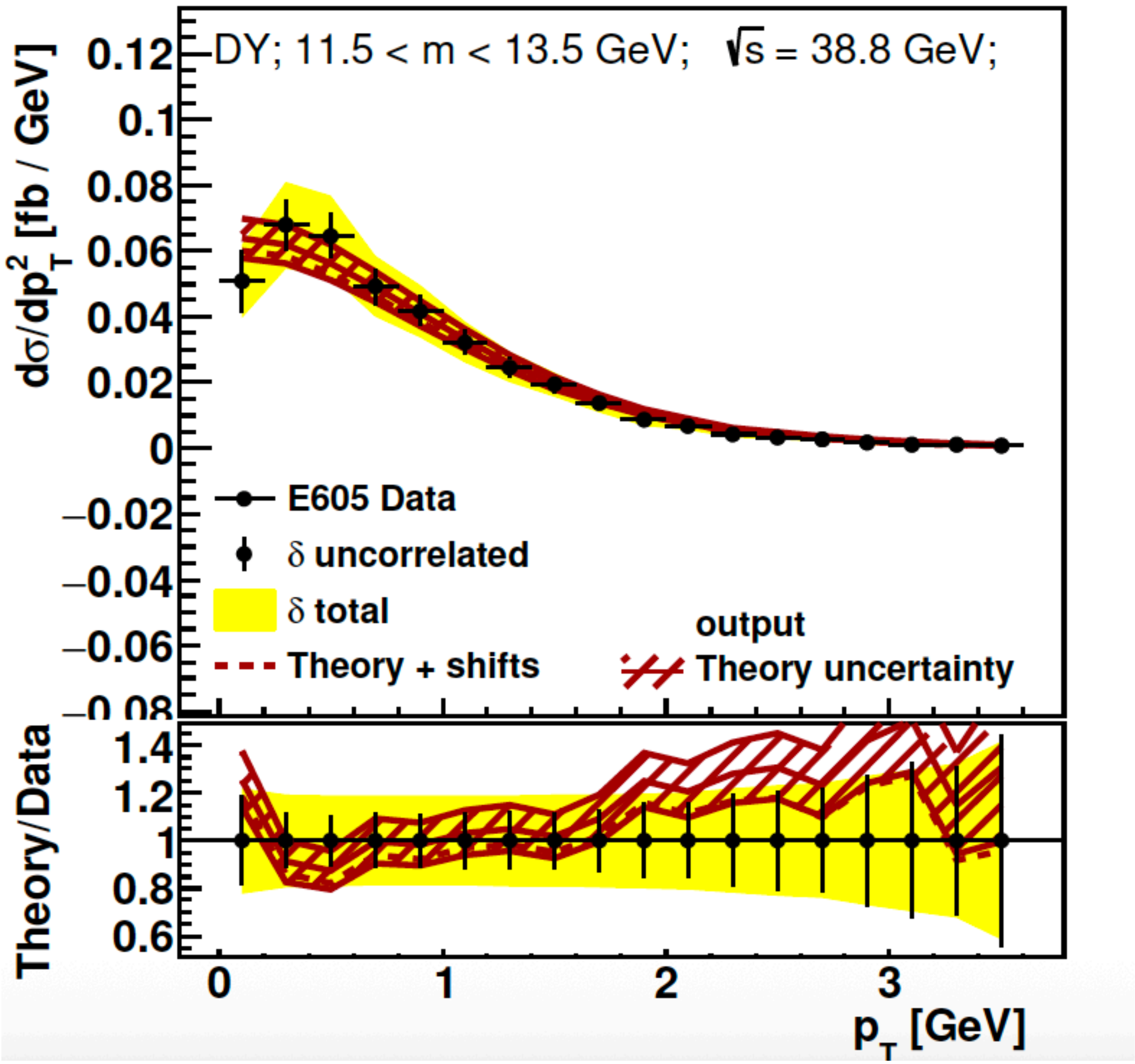

$$\chi^2/N_{data} = 0.79$$

Study of low invariant mass data

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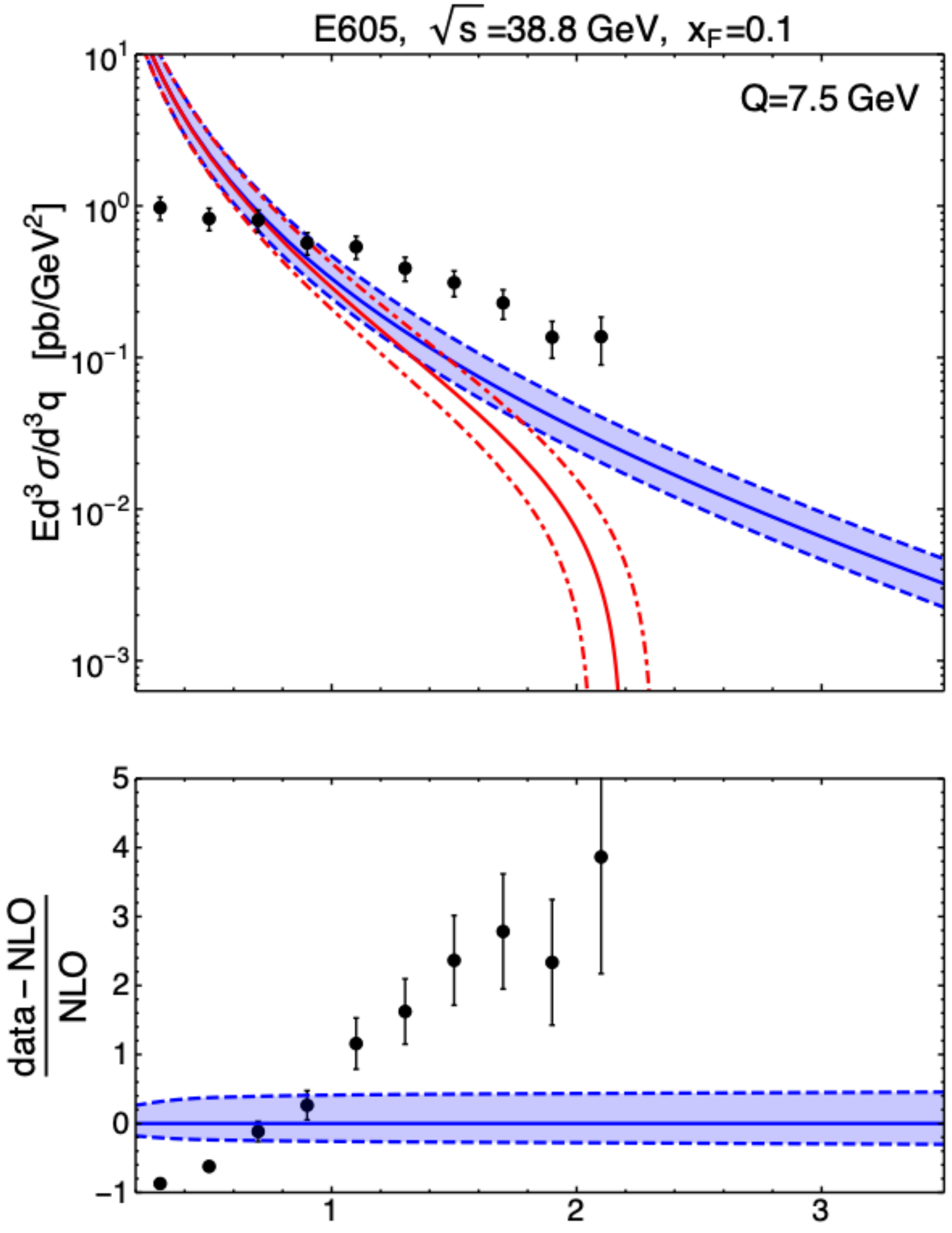
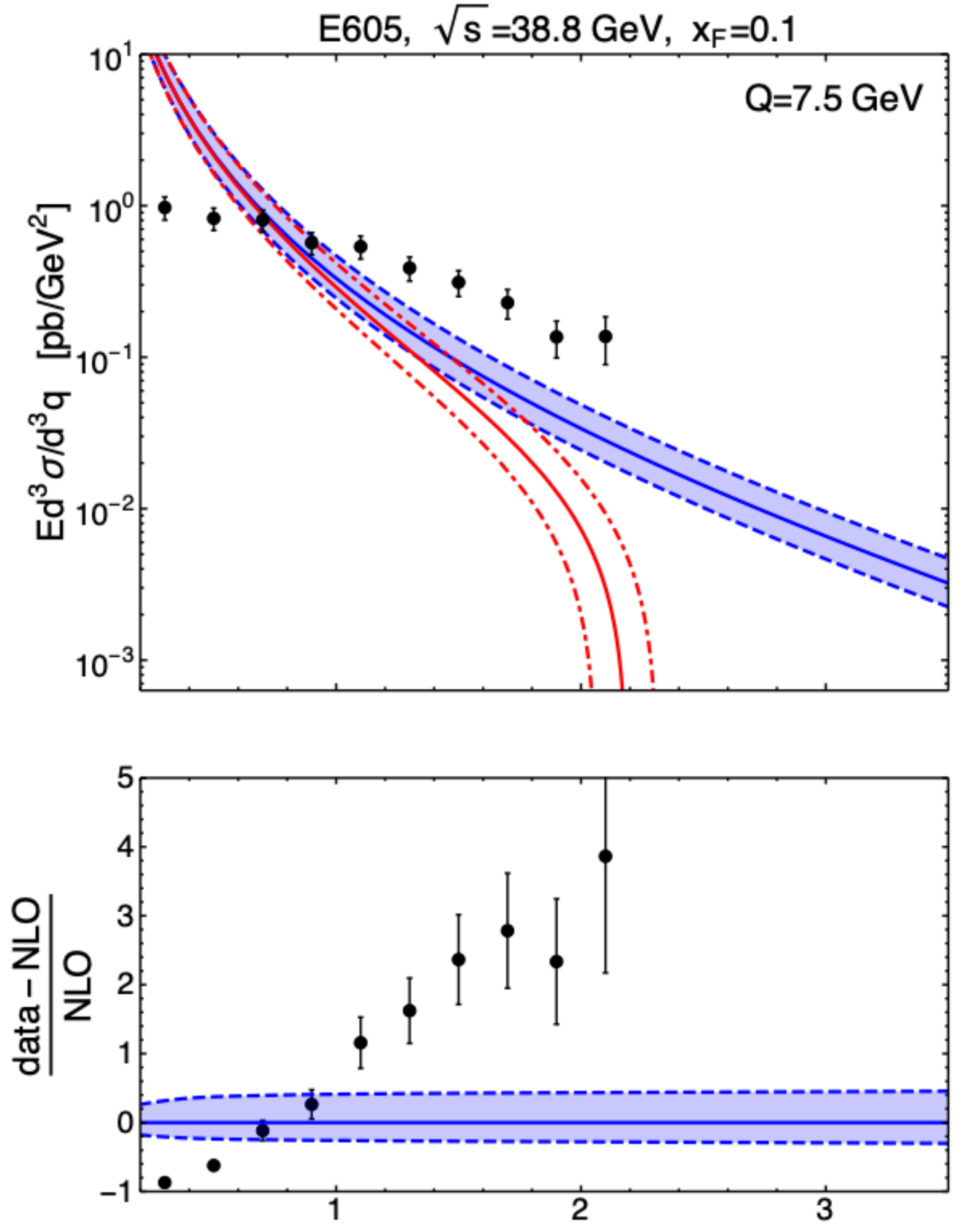


Phys.Rev.D 100 (2019) 1, 014018

Study of low invariant mass data



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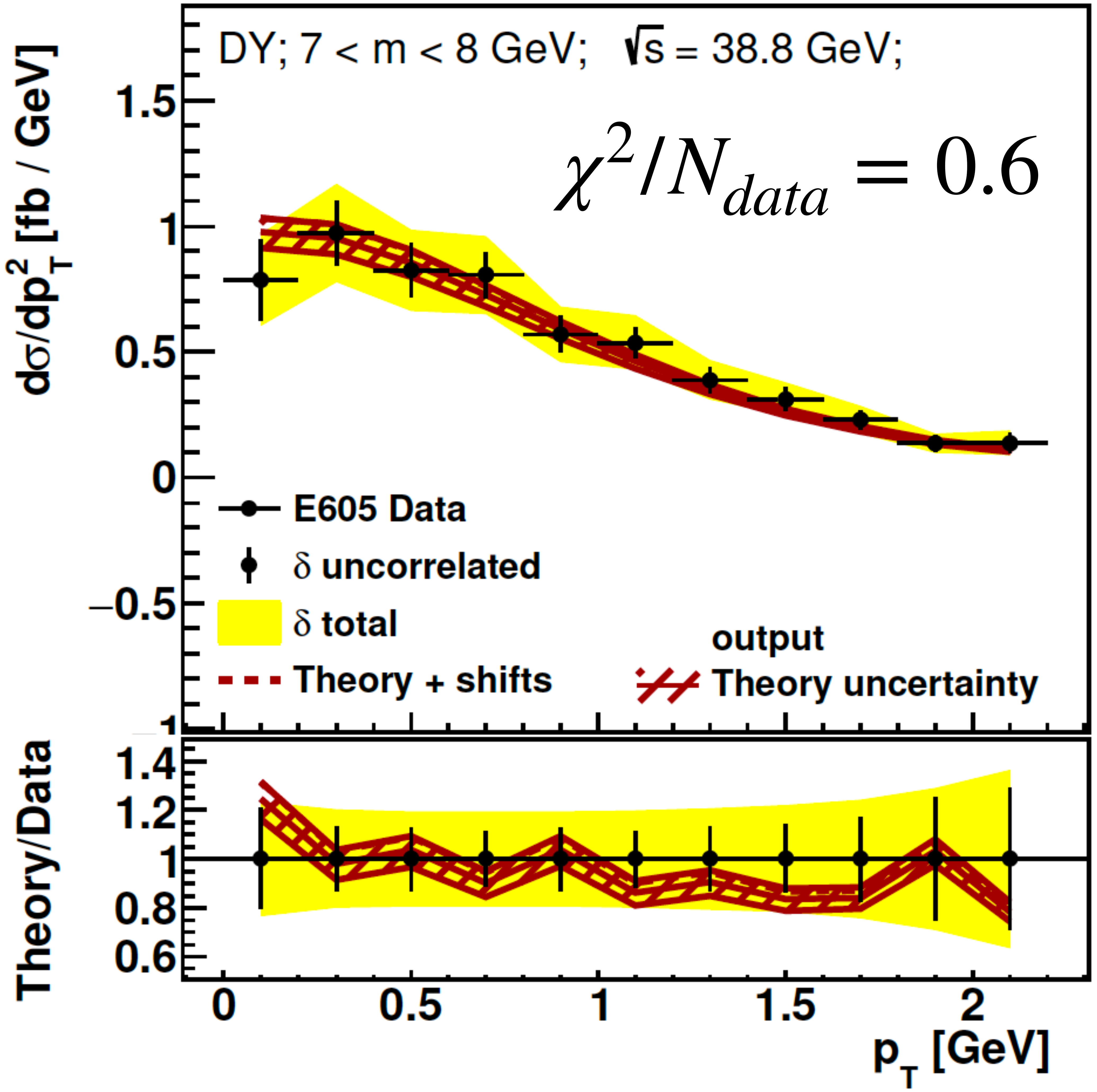

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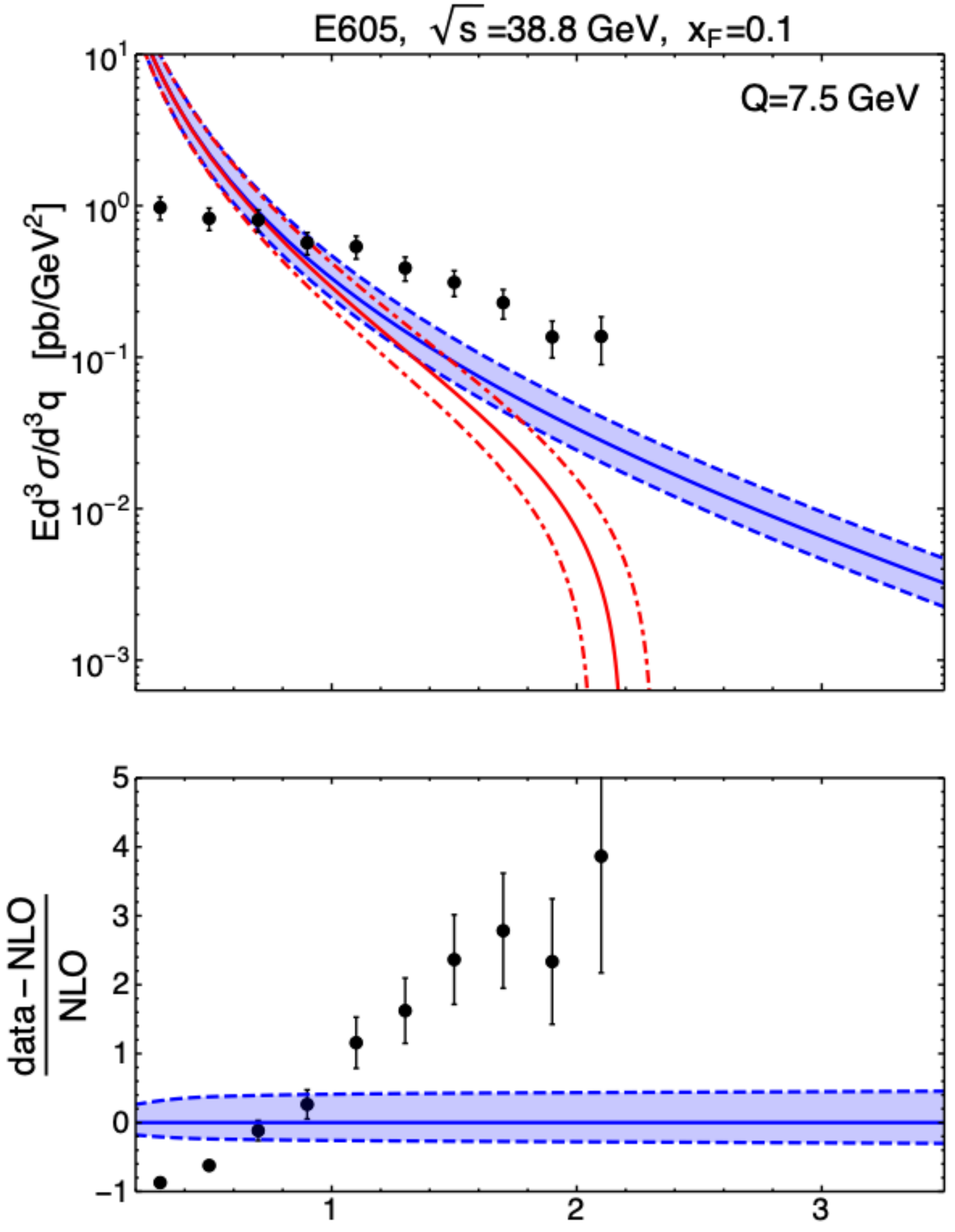

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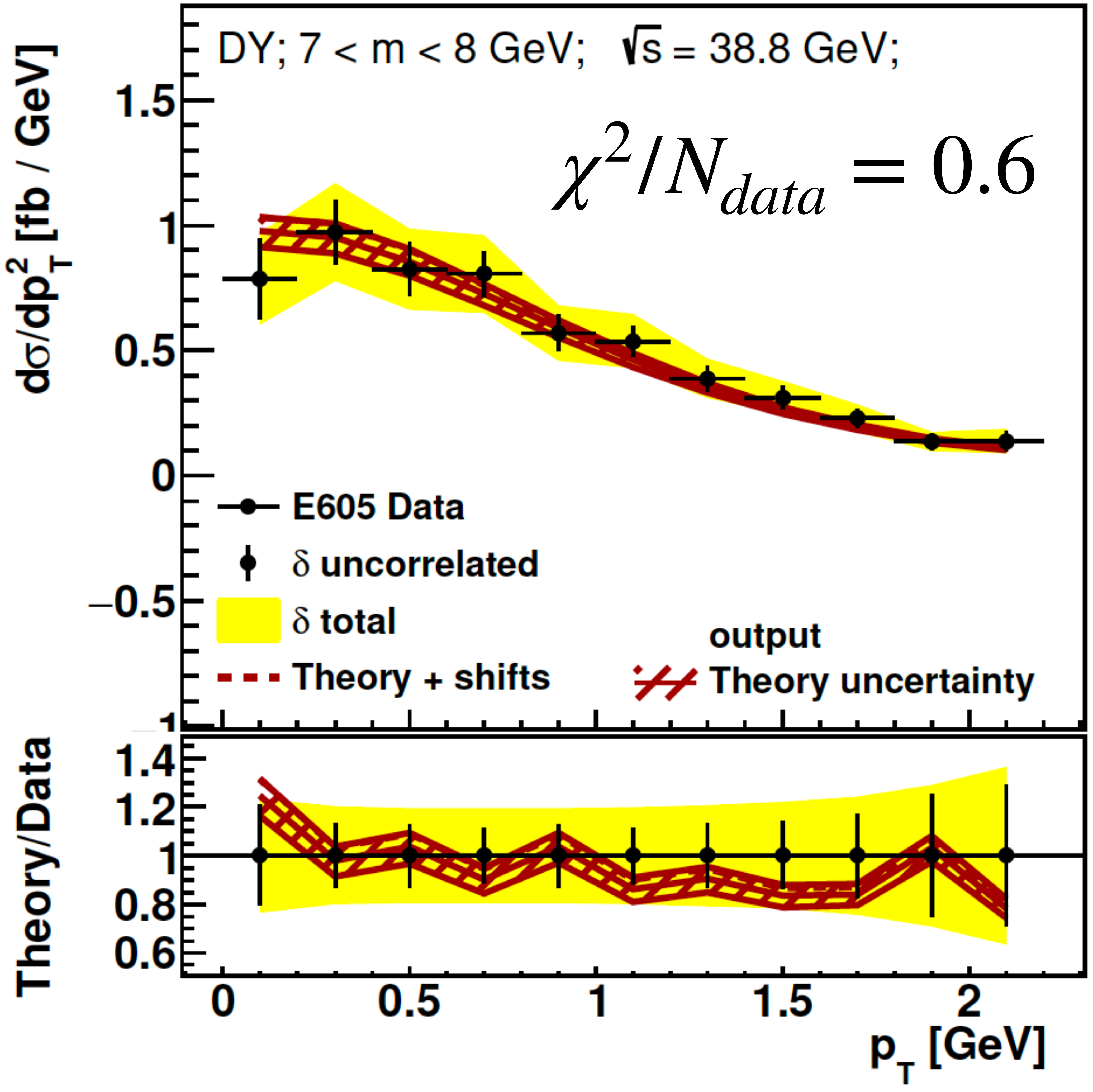
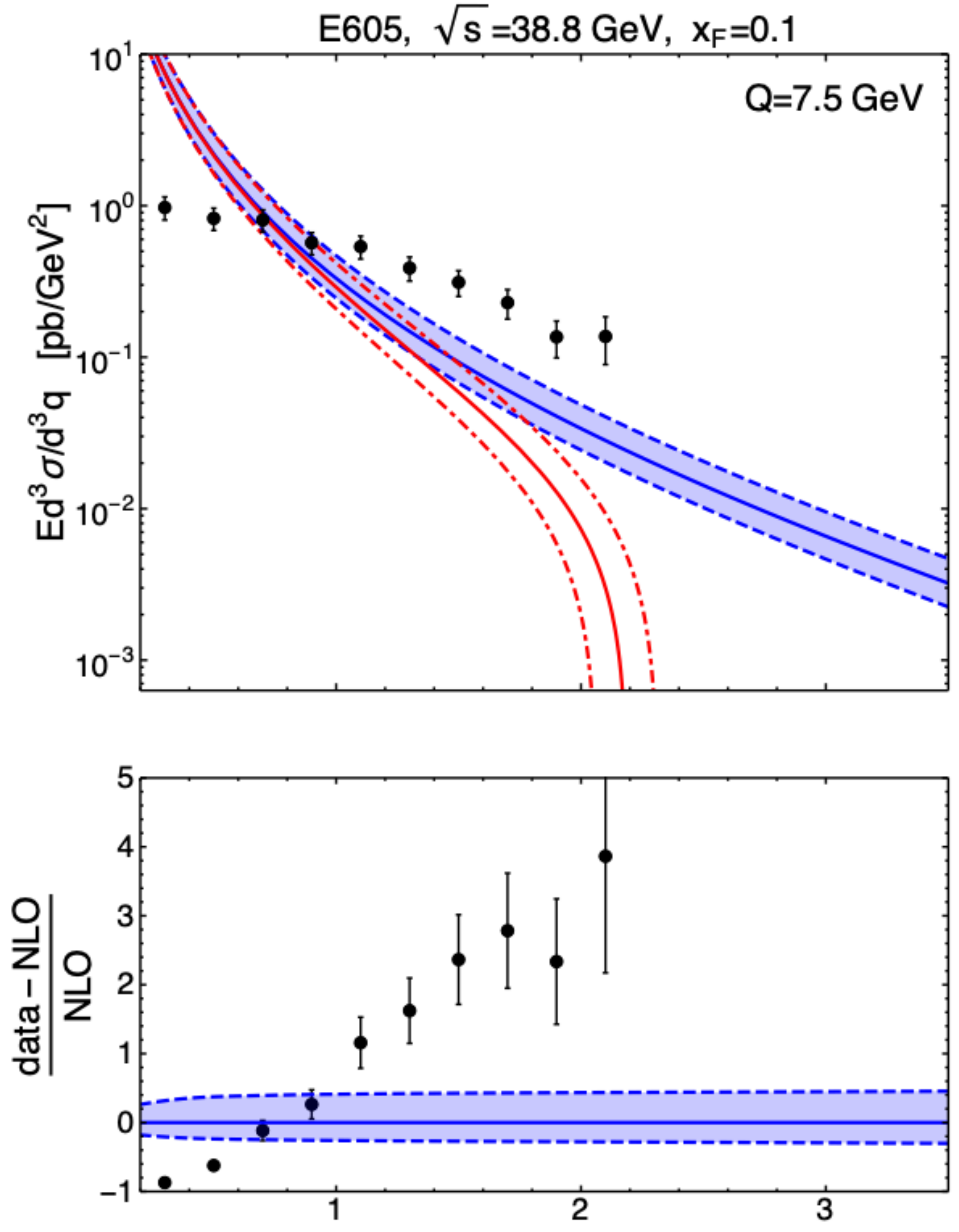


Starting point

Study of low invariant mass data



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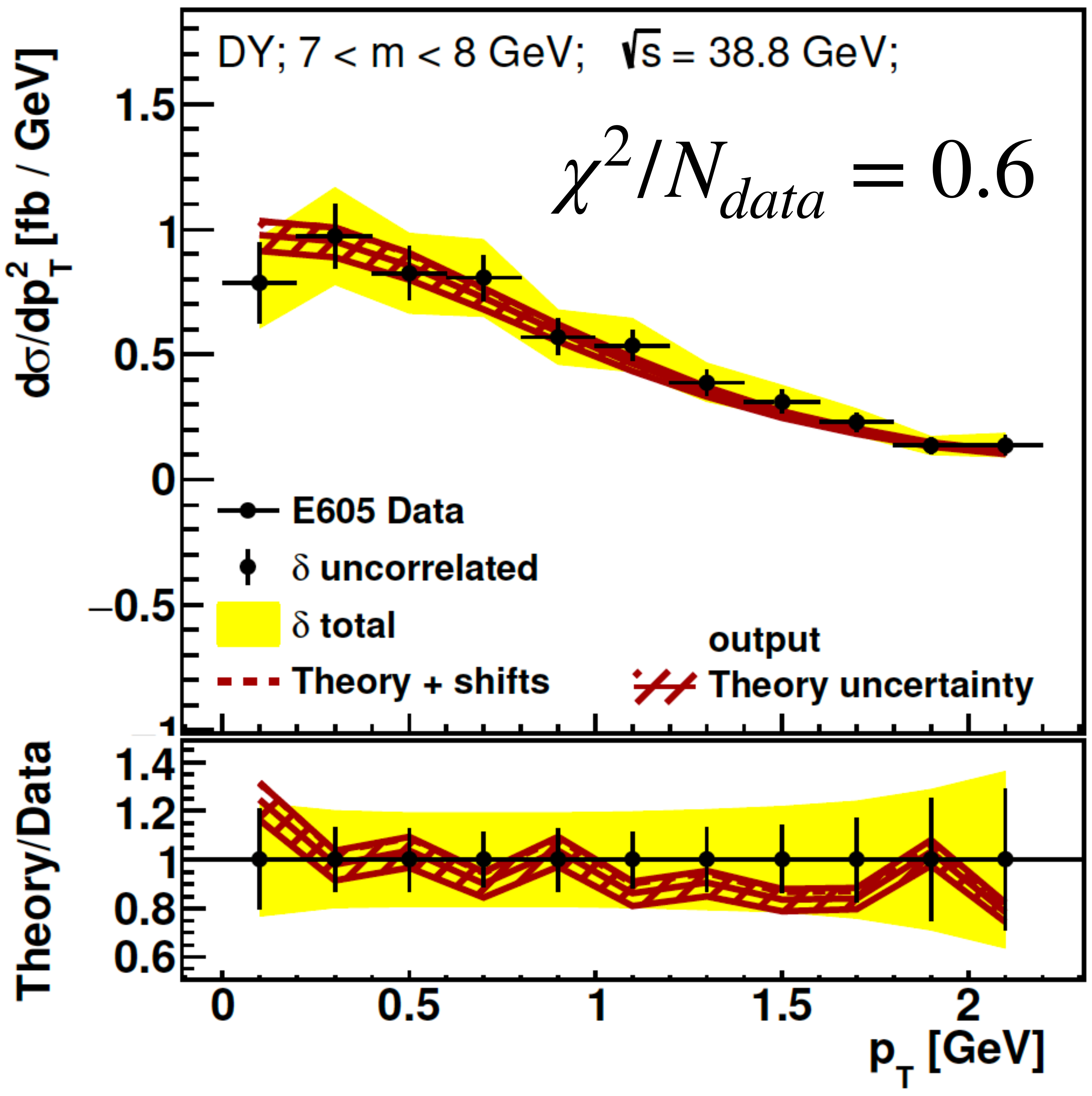

Starting point → ***Arrival point***

Study of low invariant mass data

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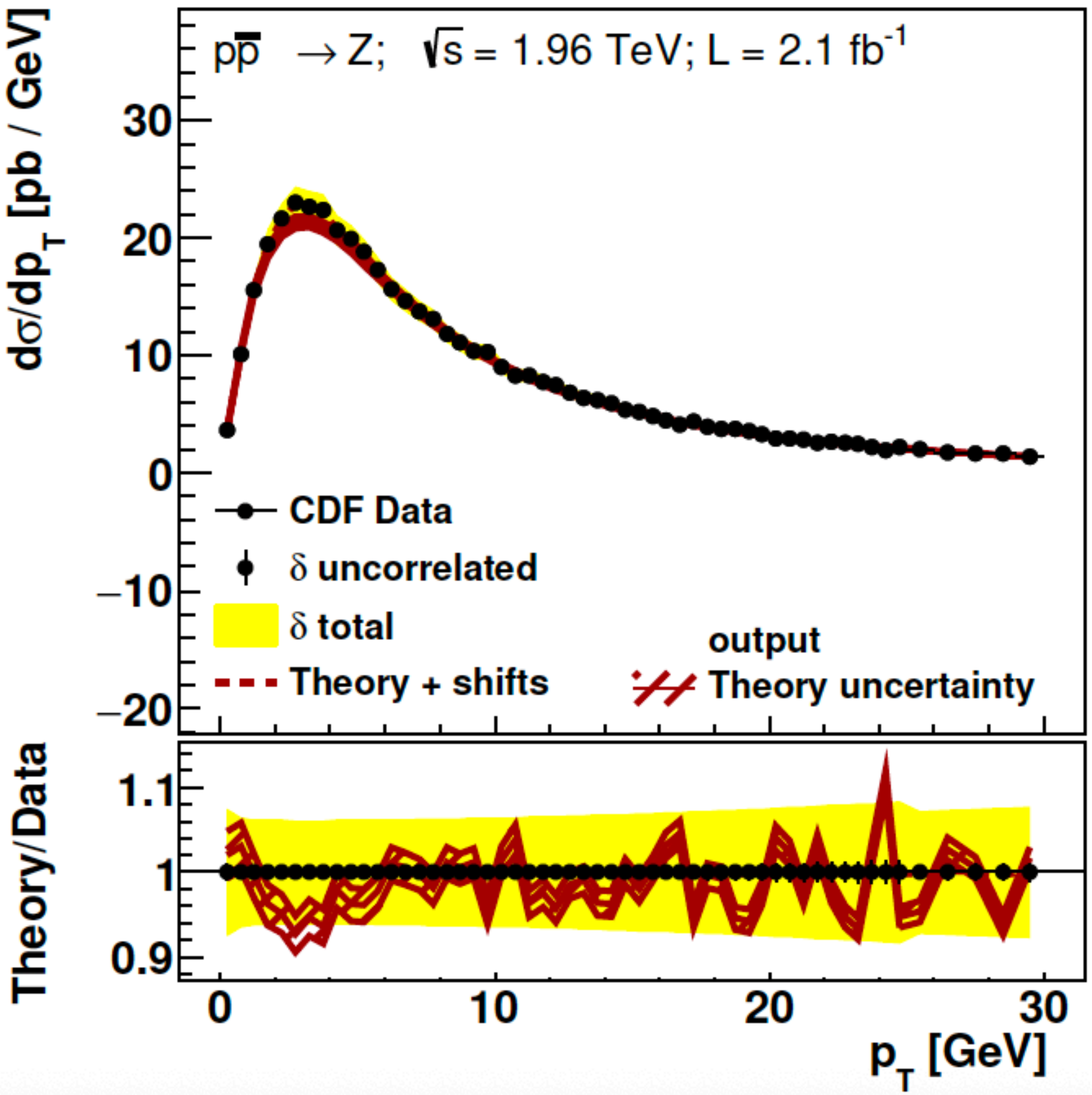

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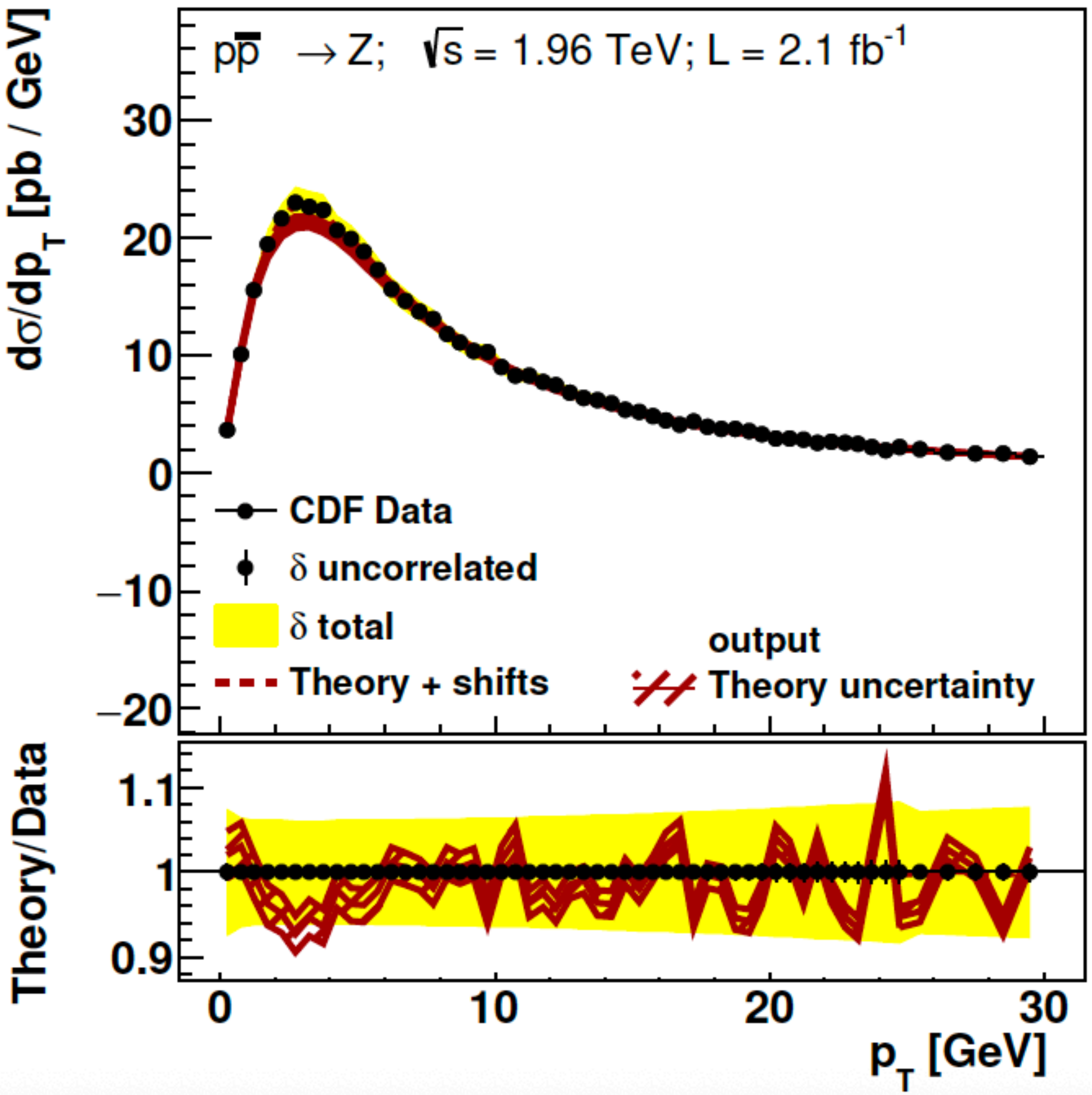

High invariant mass data remain well descrbed

Extracted Collins Soper Kernel

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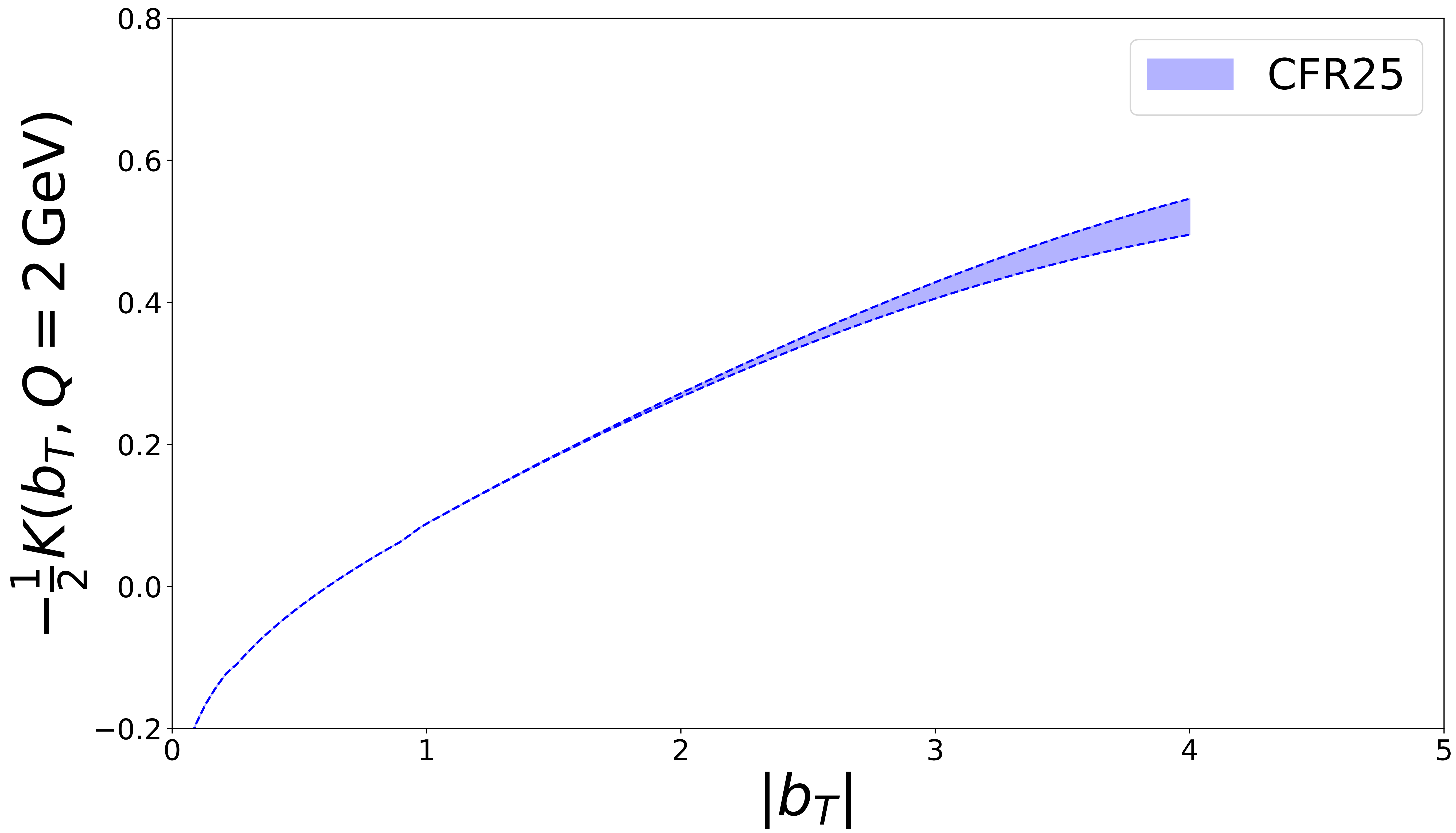

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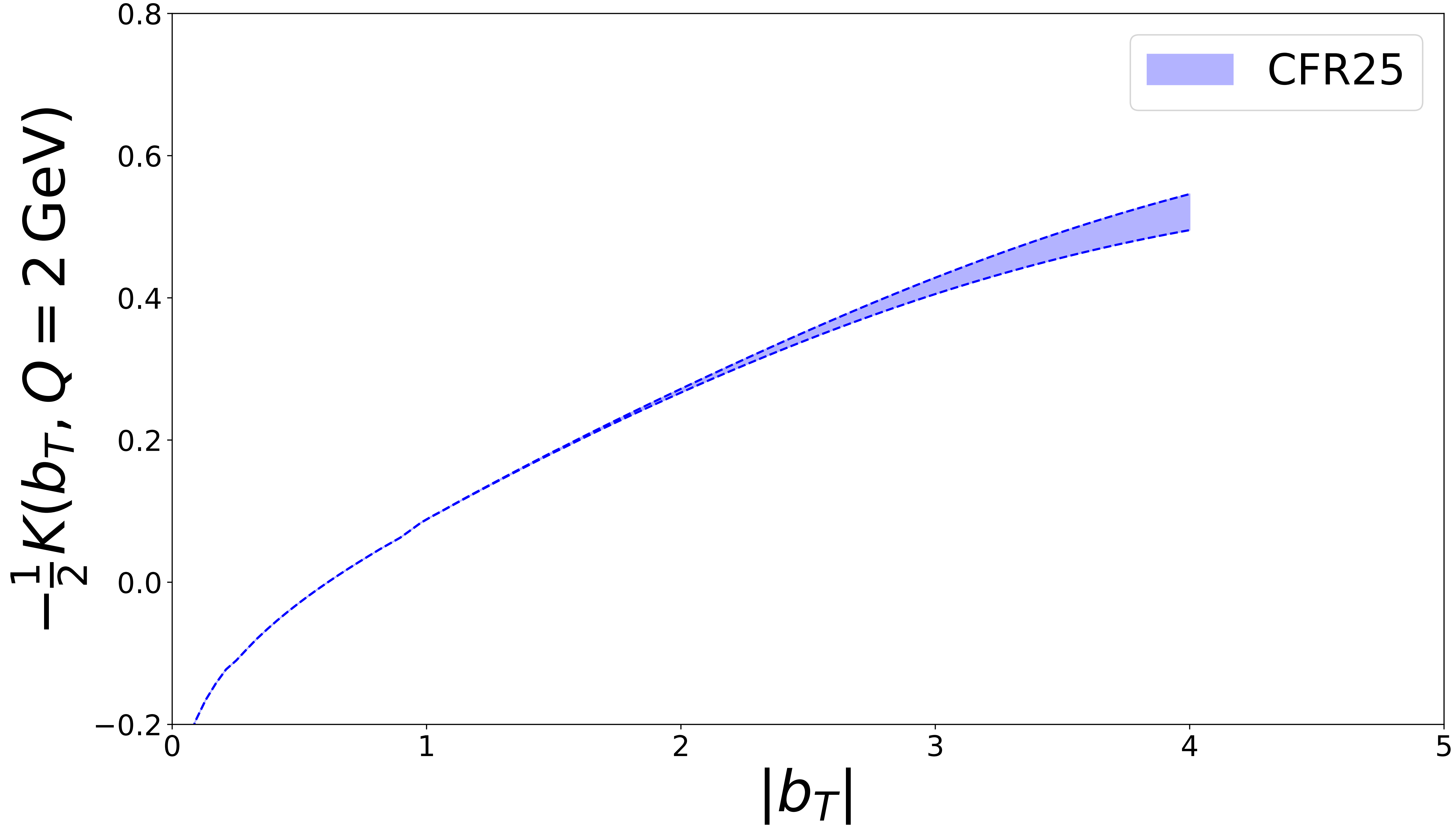

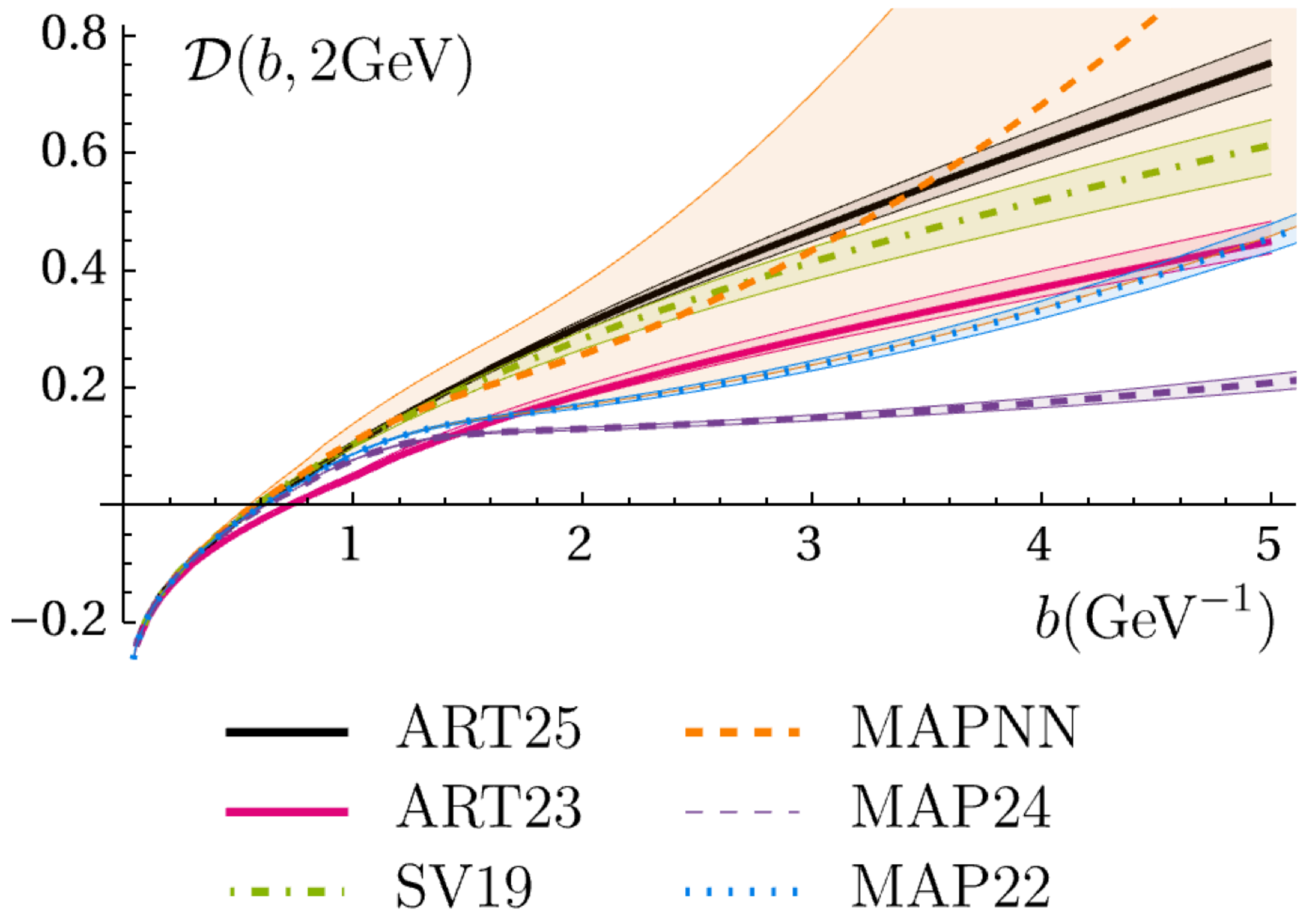

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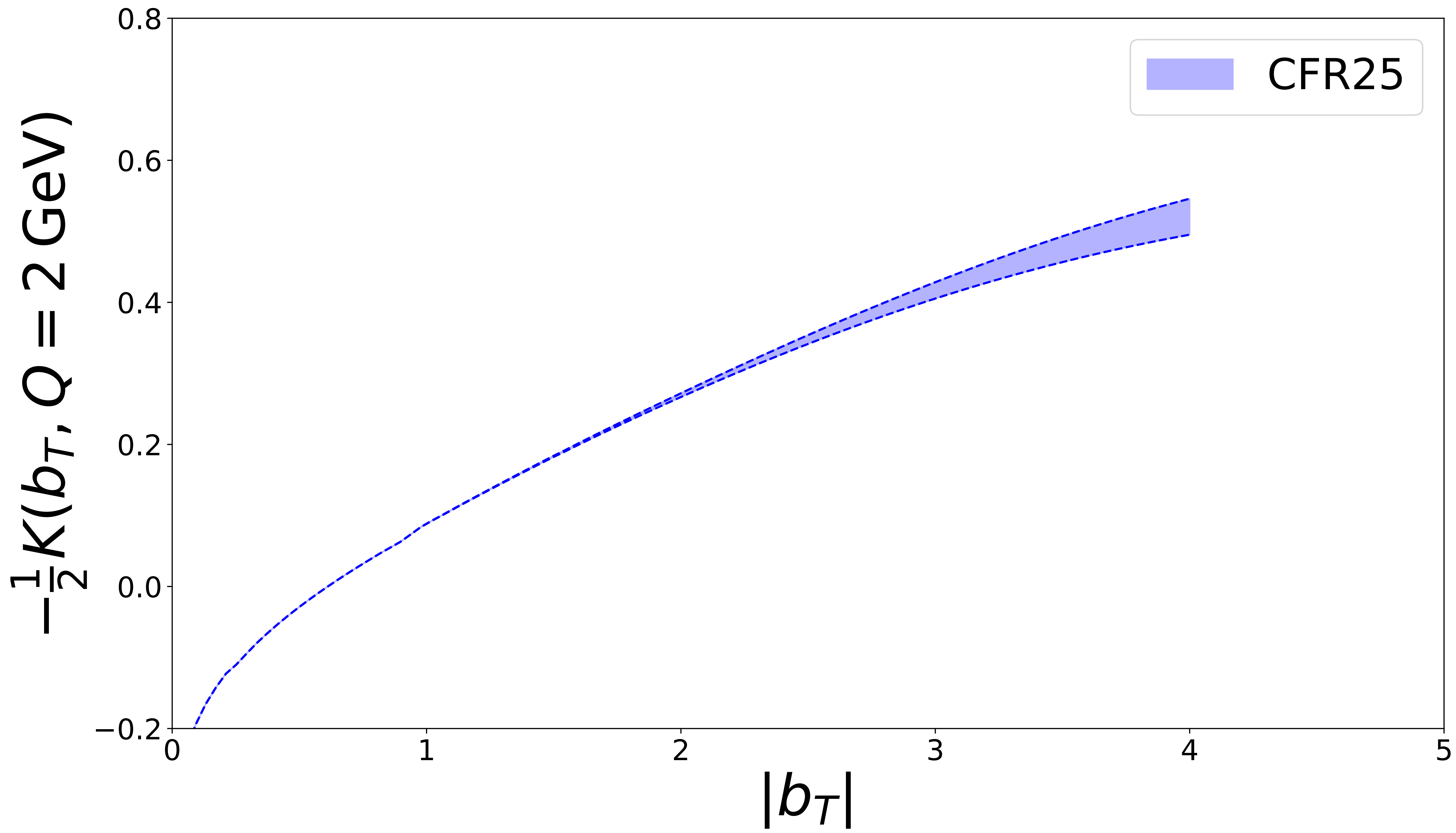

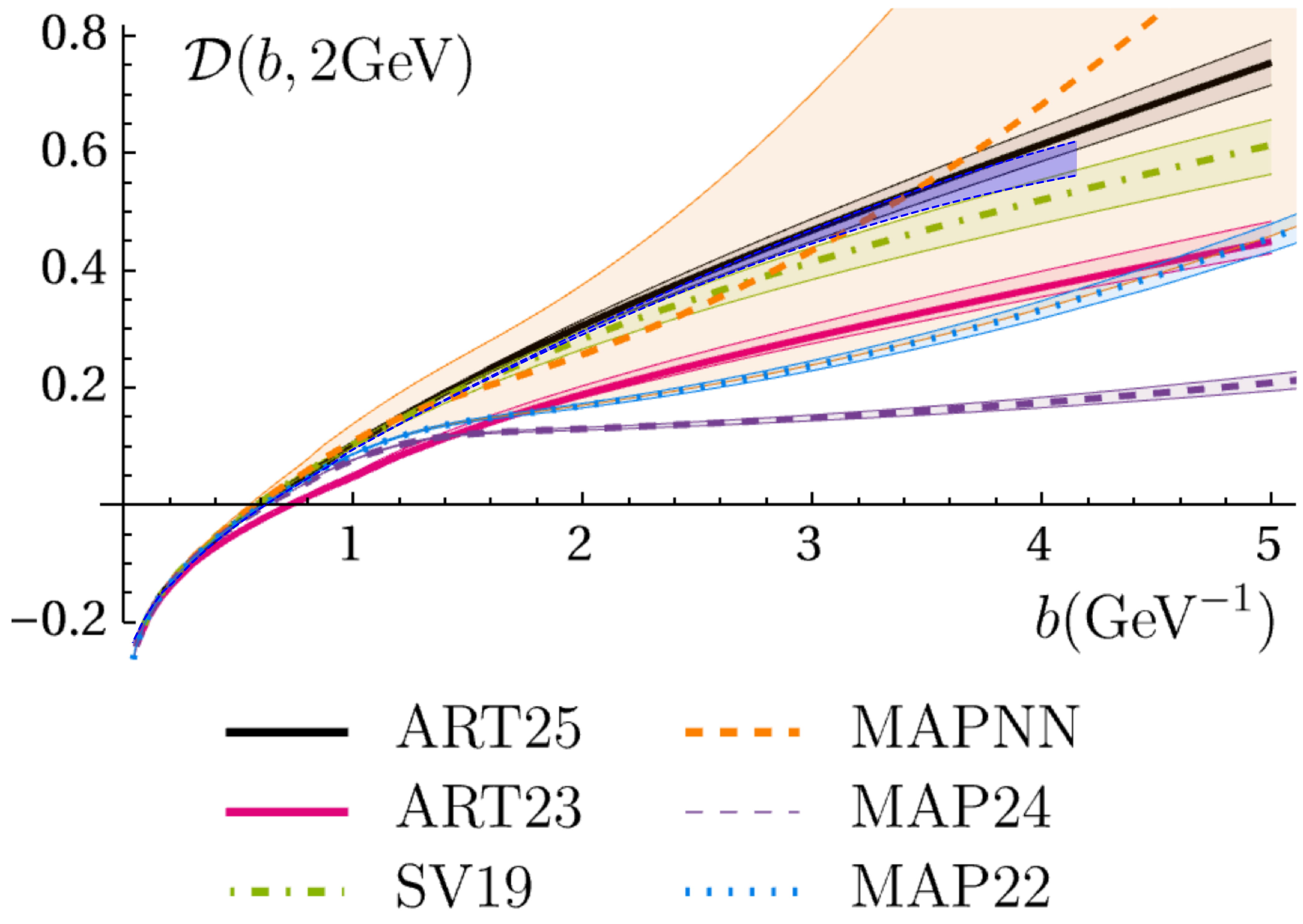

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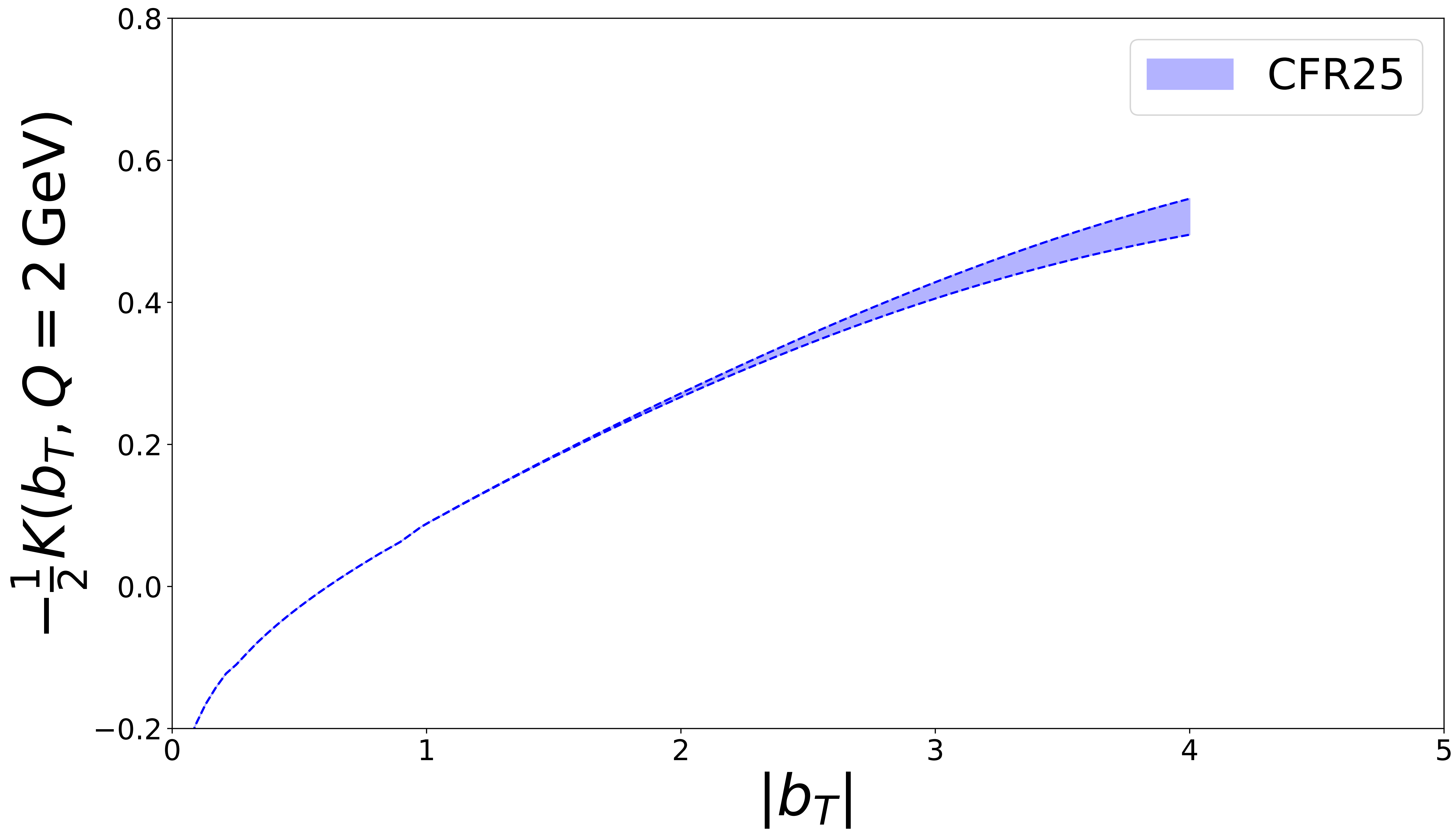

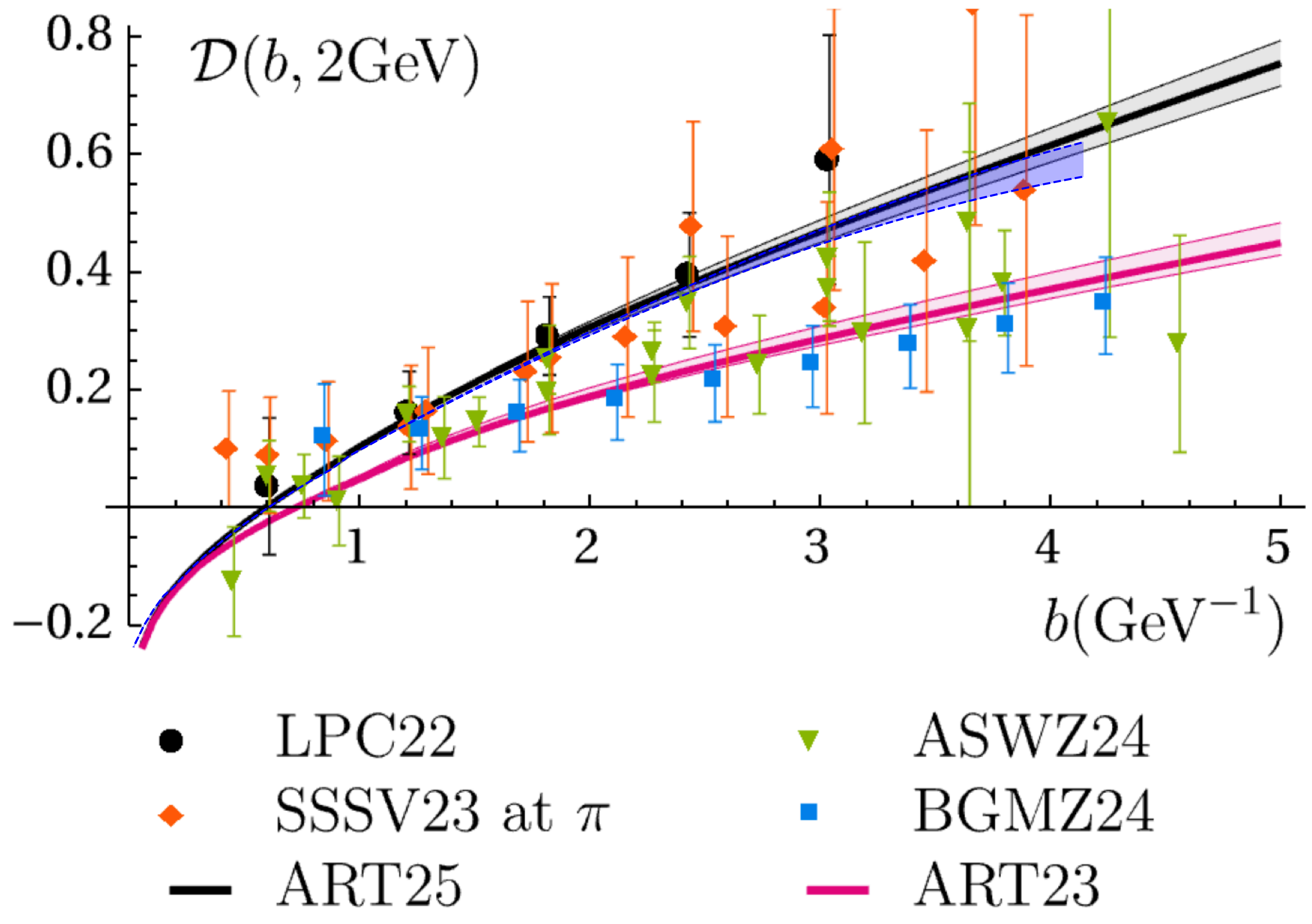

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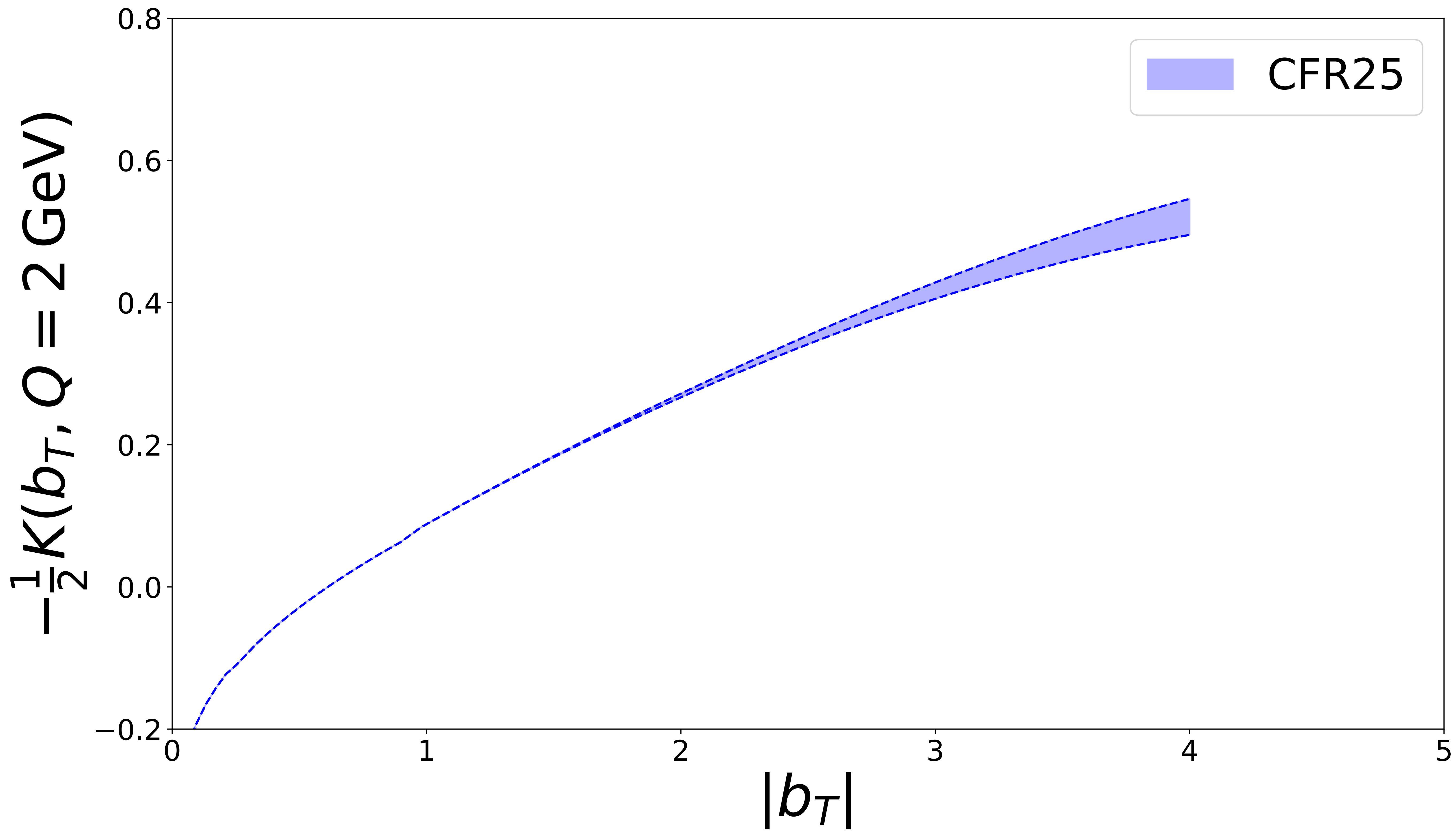

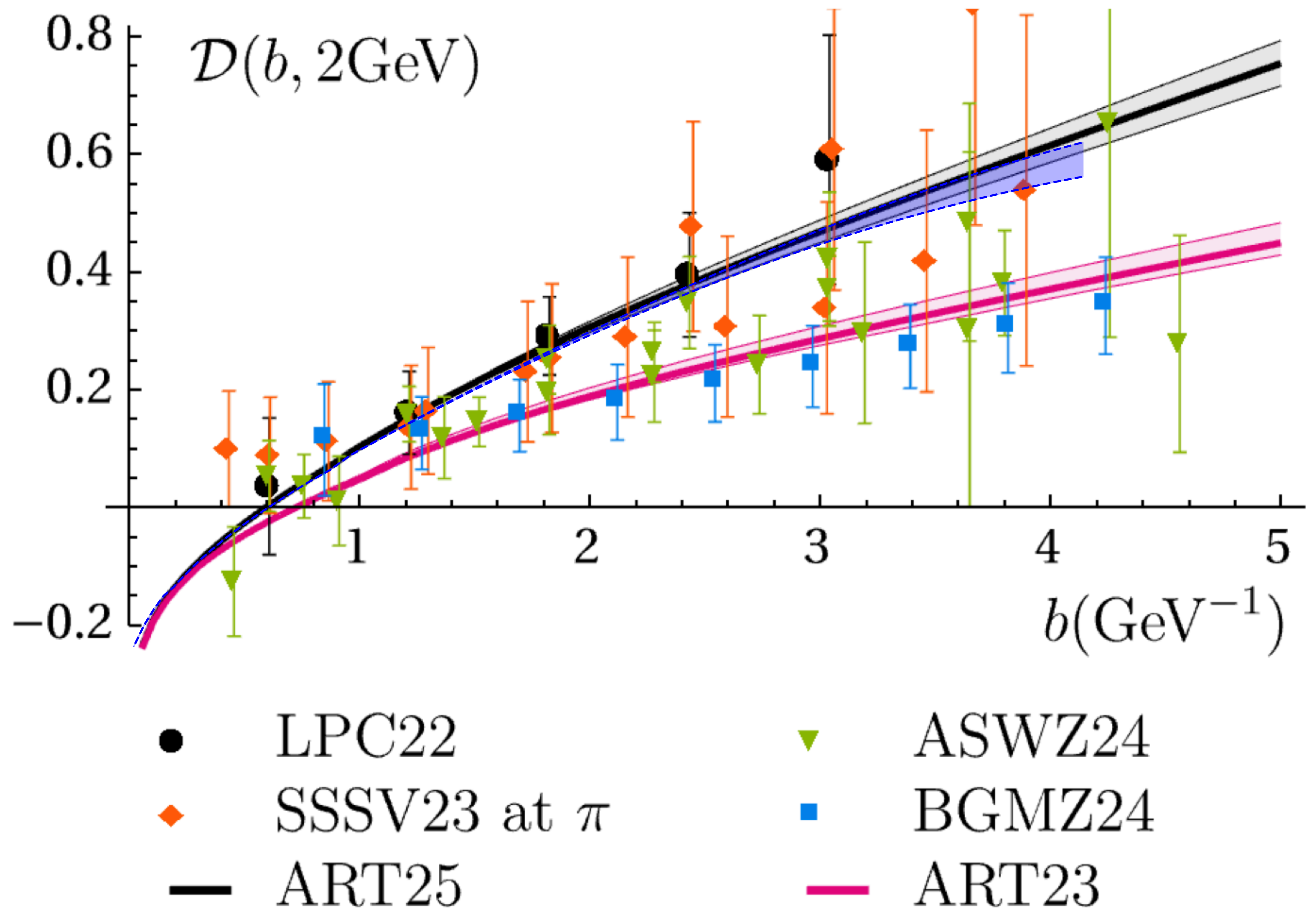

We are working on the choice of the non perturbative (hyper)parameters…

Conclusions and outlook

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- Study of the available data-sets

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