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The impact of the errors of collinear functions in describing unintegrated SIDIS data

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SIDIS in the LARGE q_T regime

Collinear Factorization:

$$\frac{d\sigma}{dx_{Bj}\,dy\,dz_h\,dP_T^2} = \left(\frac{\alpha_S}{\pi}\right) \sum_{i\,j} \int_{x_{Bj}}^{x_{MAX}} \frac{dx}{x} \int_{z_h}^{z_{MAX}} \frac{dz}{z} \times$$

$$\times\, f_i\left(\frac{x_{Bj}}{x}, Q^2\right) \left[\frac{d\hat{\sigma}_{i\,j}}{dx\,dy\,dz\,dq_T^2}\, \delta\left(z^2\, Q^2 \left(\frac{P_T^2}{z_h} - \frac{1-x}{x}\,\frac{1-z}{z}\right)\right)\right] D_j\left(\frac{z_h}{z}, Q^2\right)$$

In general:

MEASURED $\longrightarrow \mathcal{O} = H \otimes \sum_i F_i$ $\longleftarrow$ **EXTRACTED** from experimental data

COMPUTED at FO in perturbation theory

Depending on the α_s order the collinear functions will be labeled by: LO, NLO, NNLO...

M. Anselmino, M. Boglione, A. Prokudin, and C. Türk,
"Semi Inclusive Deep Inelastic Scattering processes from small to large P_T"

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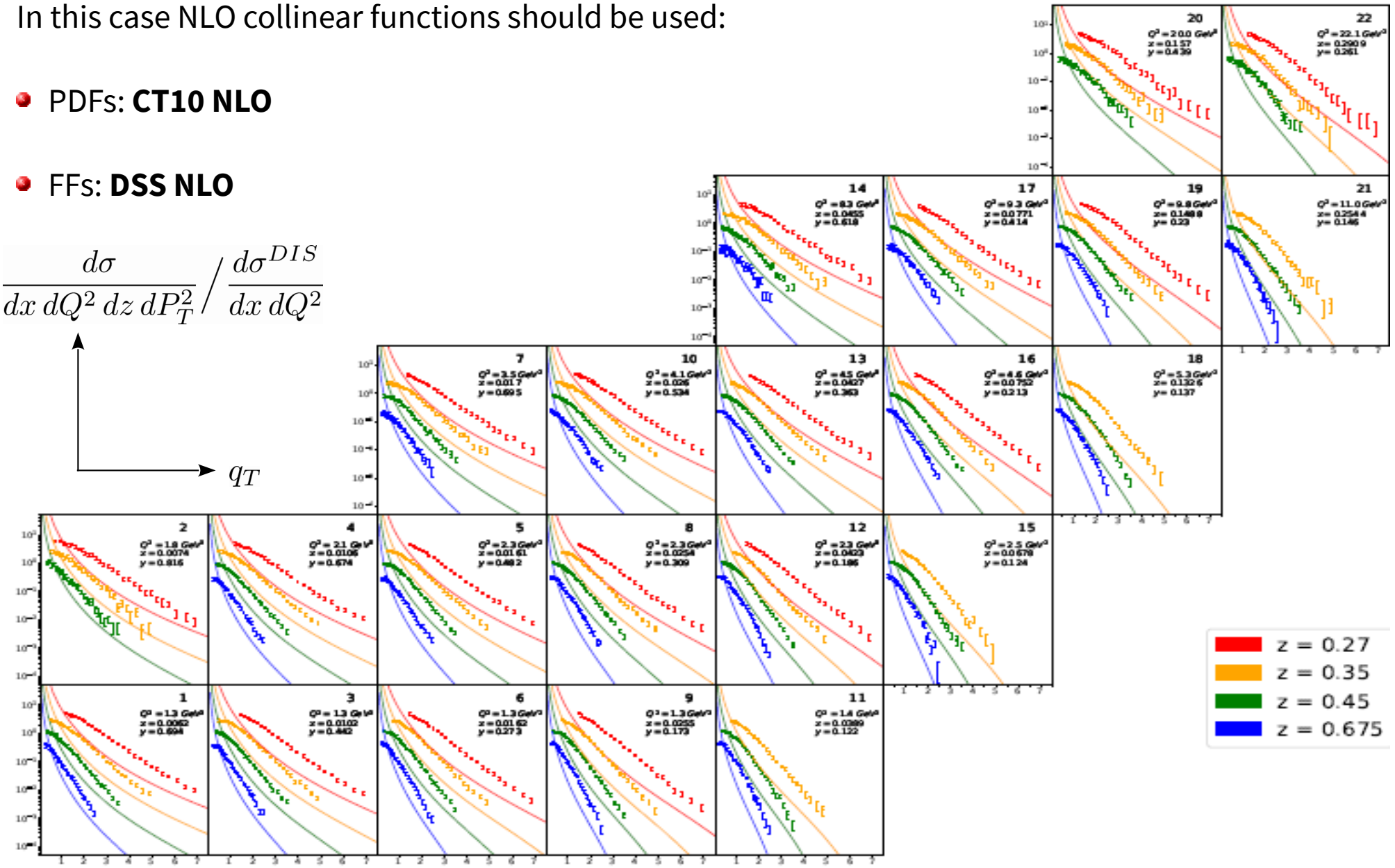
Comparison with COMPASS data

In this case NLO collinear functions should be used:

- PDFs: **CT10 NLO**
- FFs: **DSS NLO**

$$\frac{d\sigma}{dx\,dQ^2\,dz\,dP_T^2} \Big/ \frac{d\sigma^{DIS}}{dx\,dQ^2}$$

q_T



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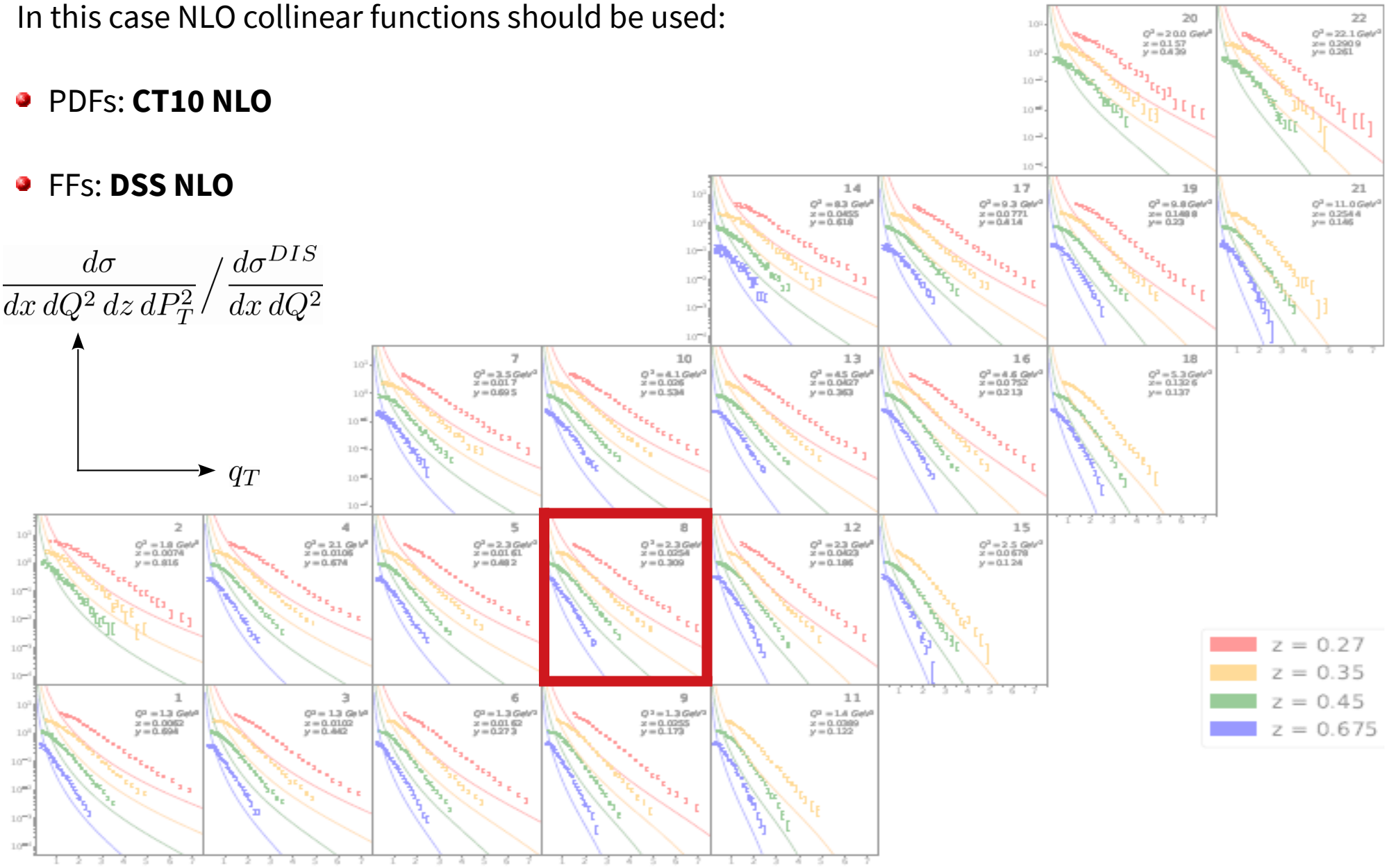

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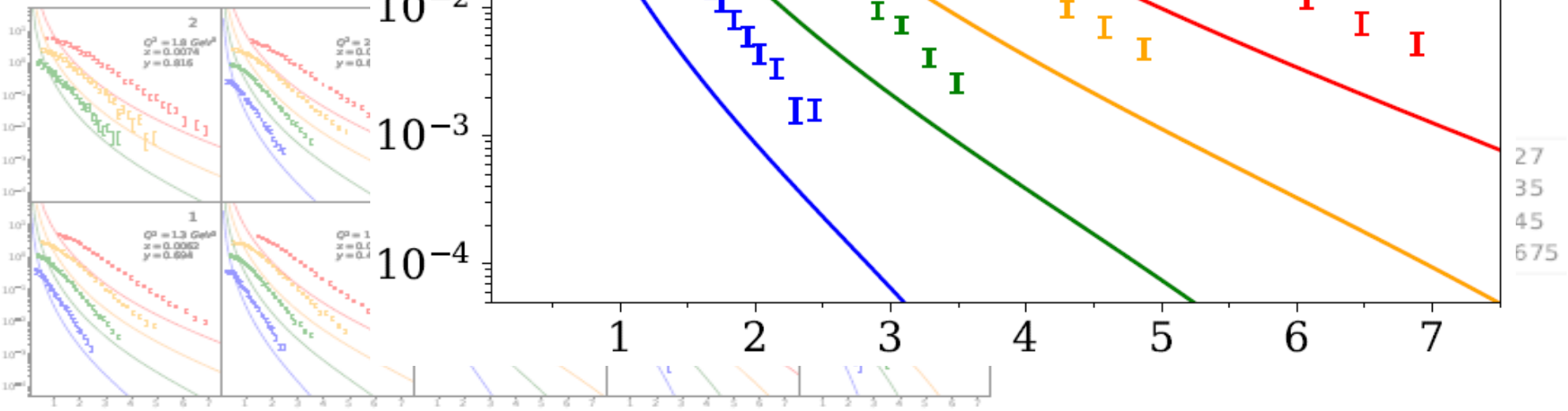
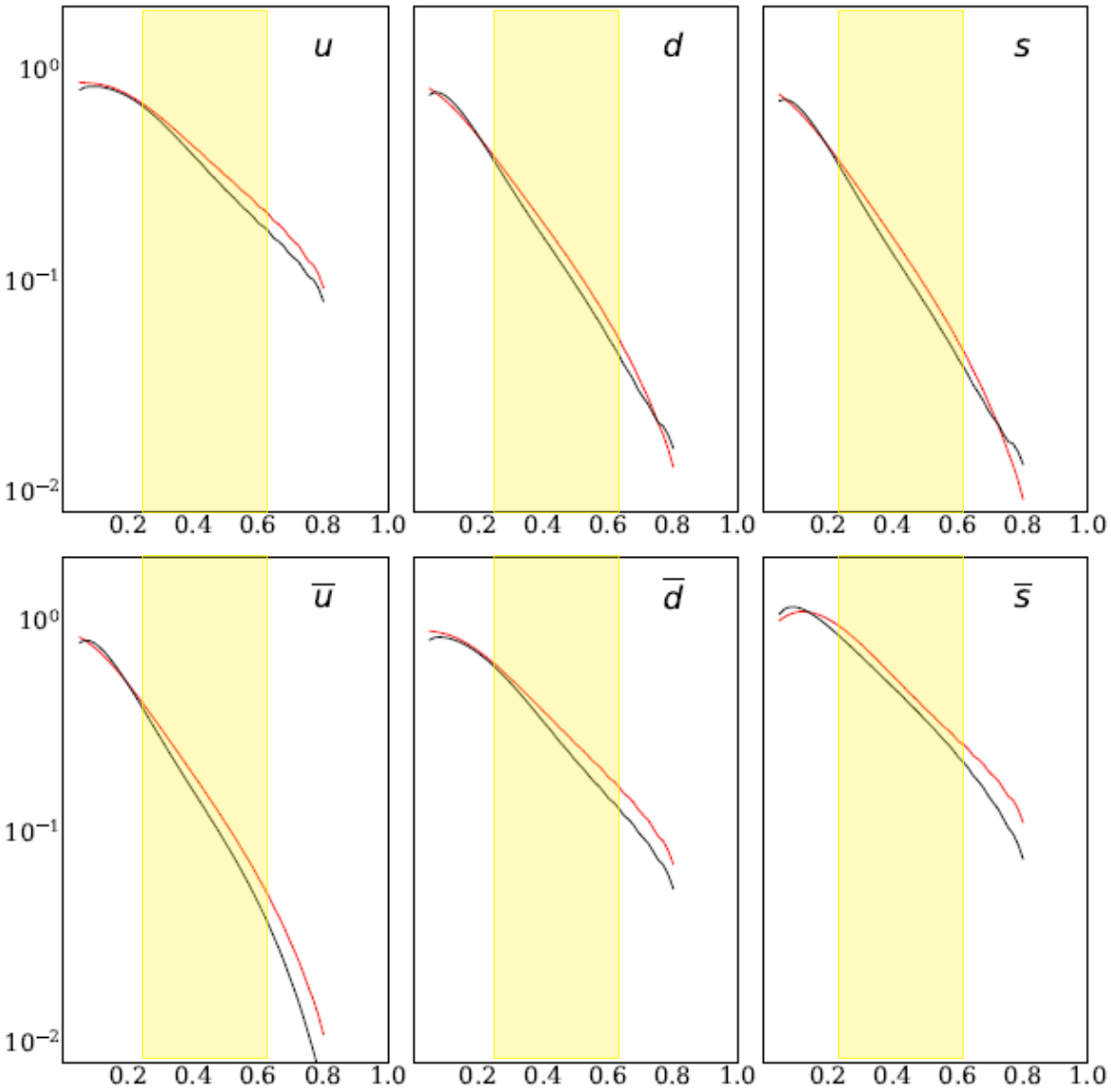
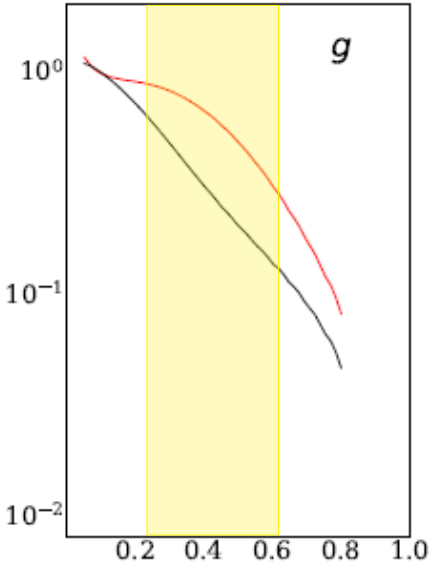


A different choice for FFs



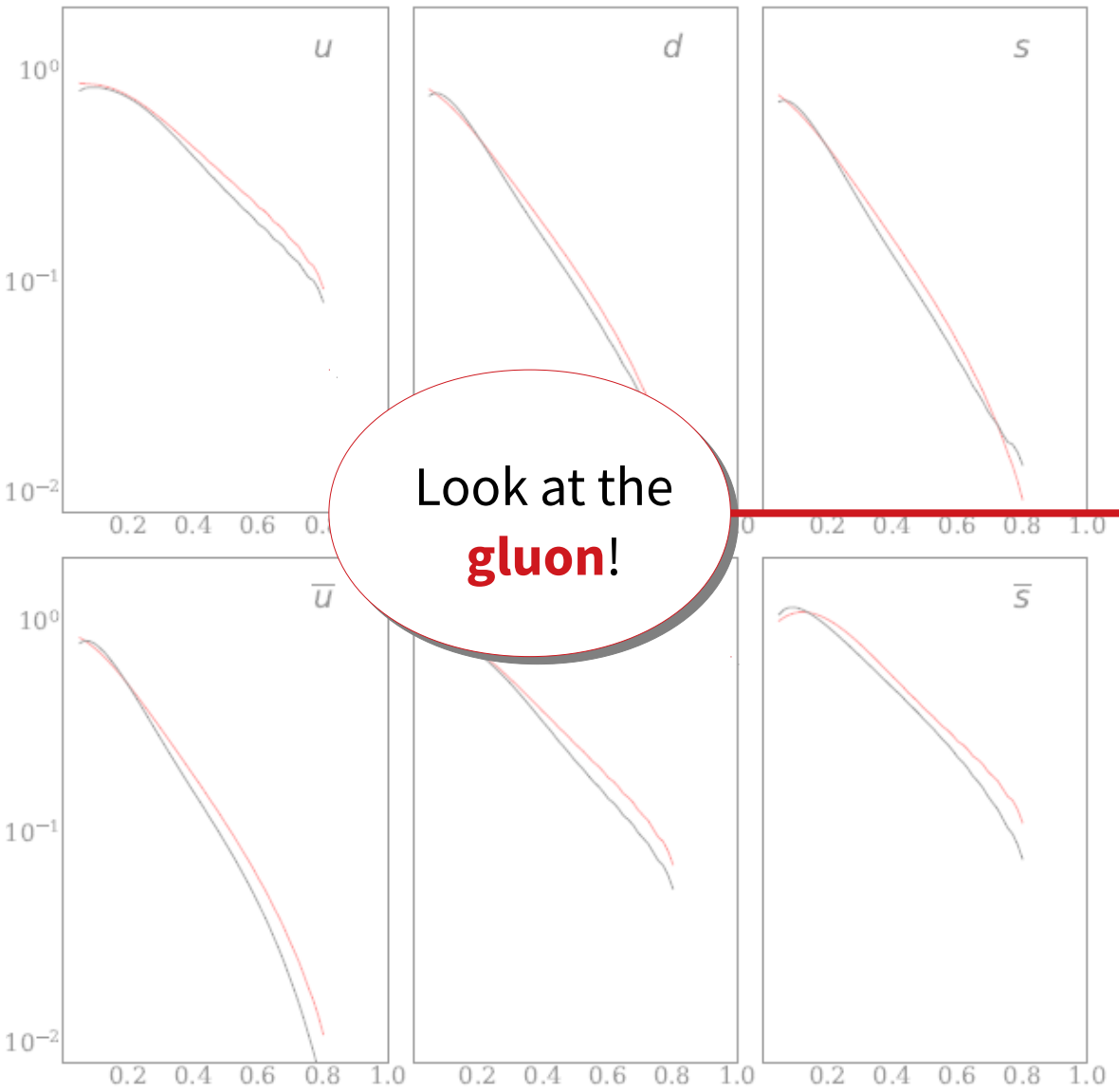
DSS at LO

DSS at NLO

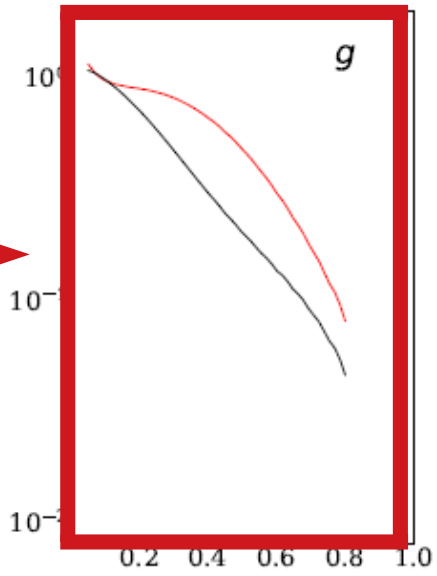


$$Q^2 = 10\ GeV^2$$

A different choice for FFs



Look at the **gluon**!



DSS at LO

DSS at NLO

Comparison with COMPASS DATA

Basically, the only change is in the **fragmenting gluon contribution:**

- PDFs: **CT10 NLO**
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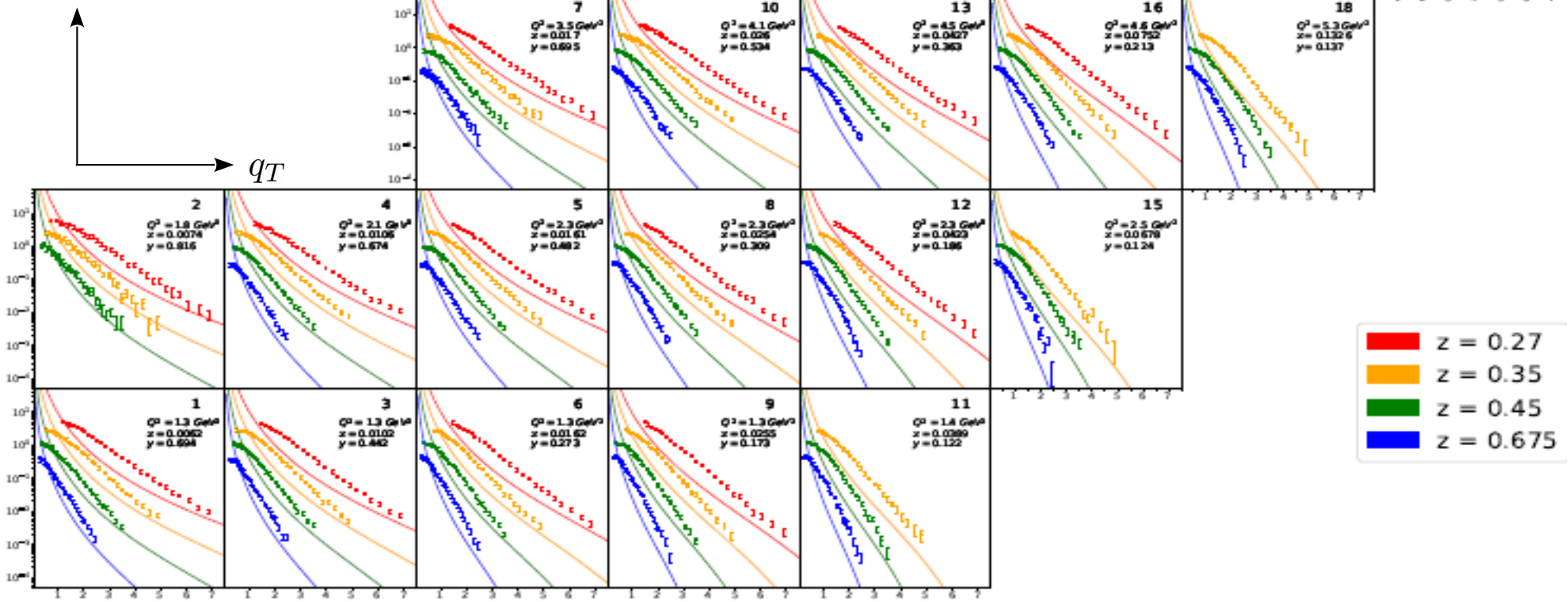

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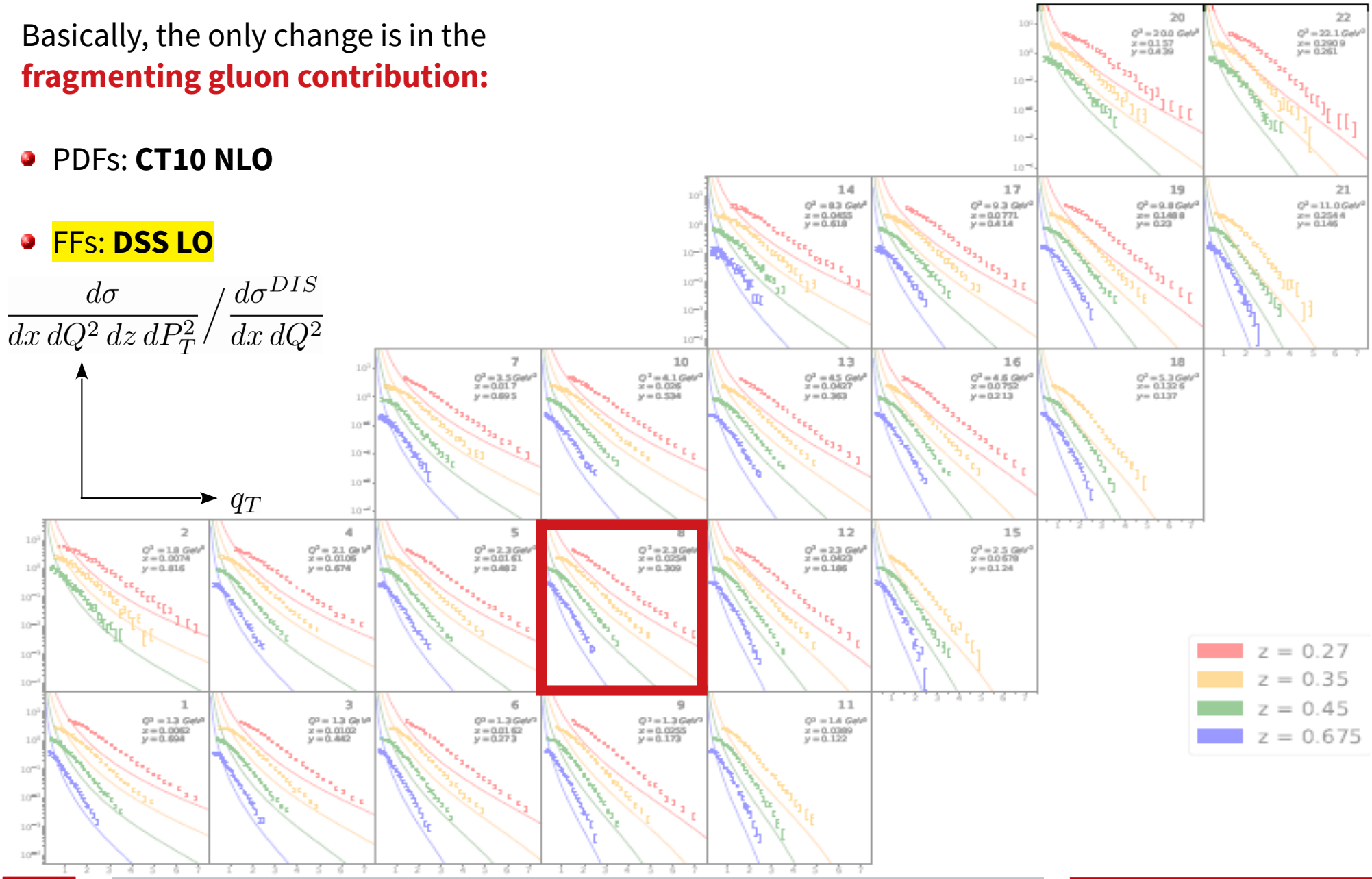

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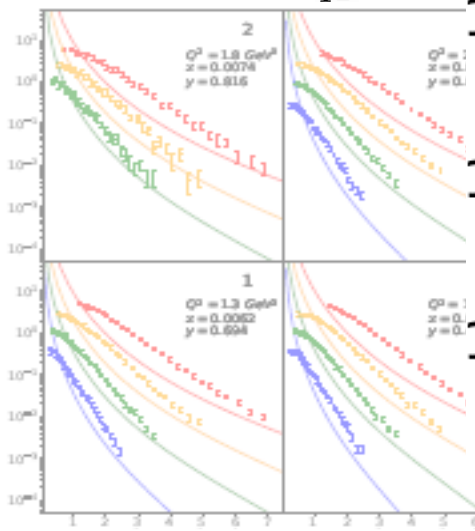
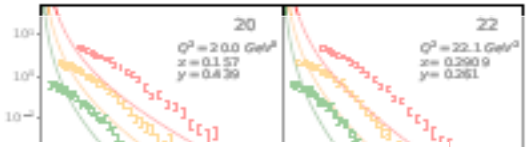
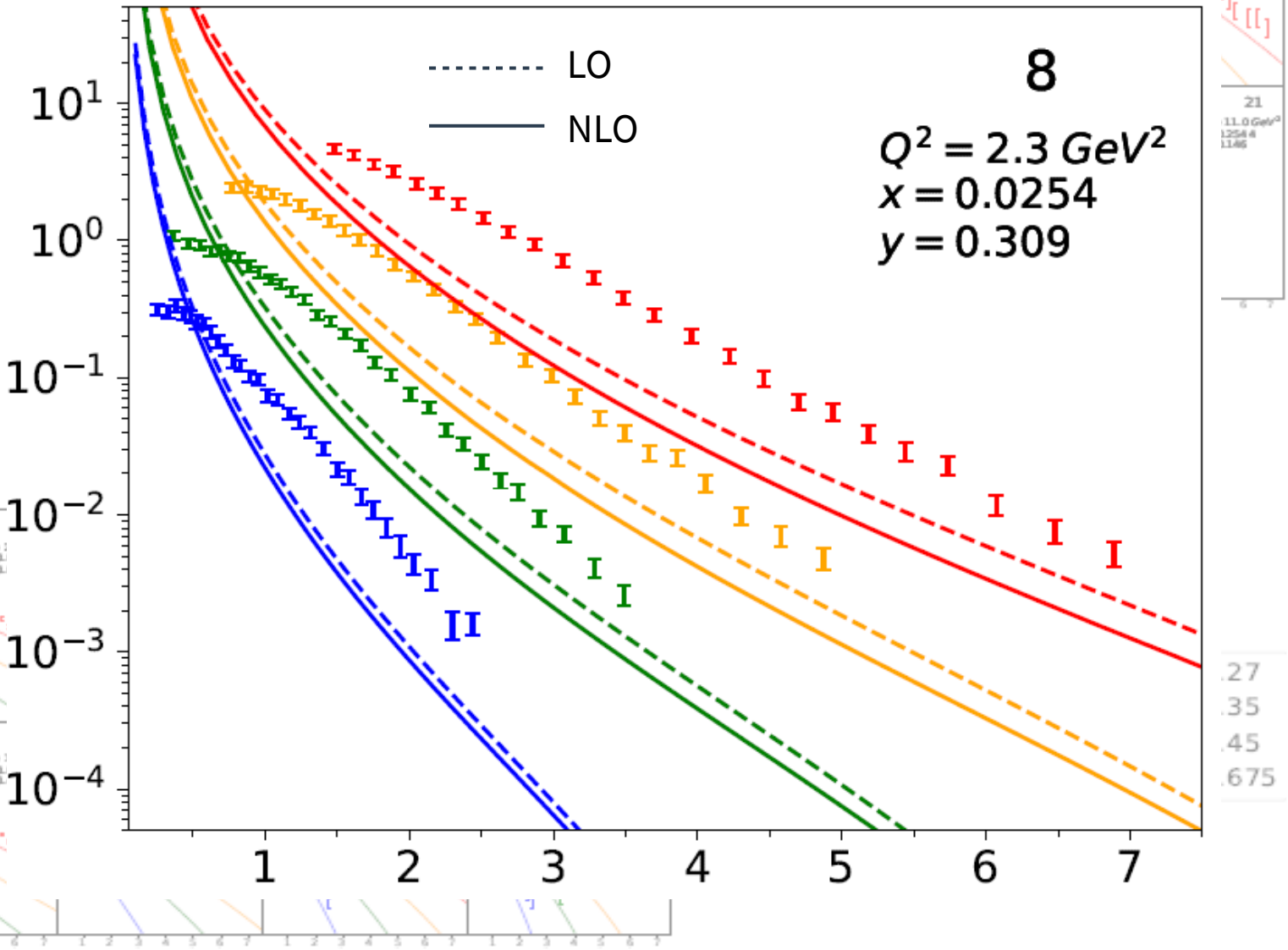




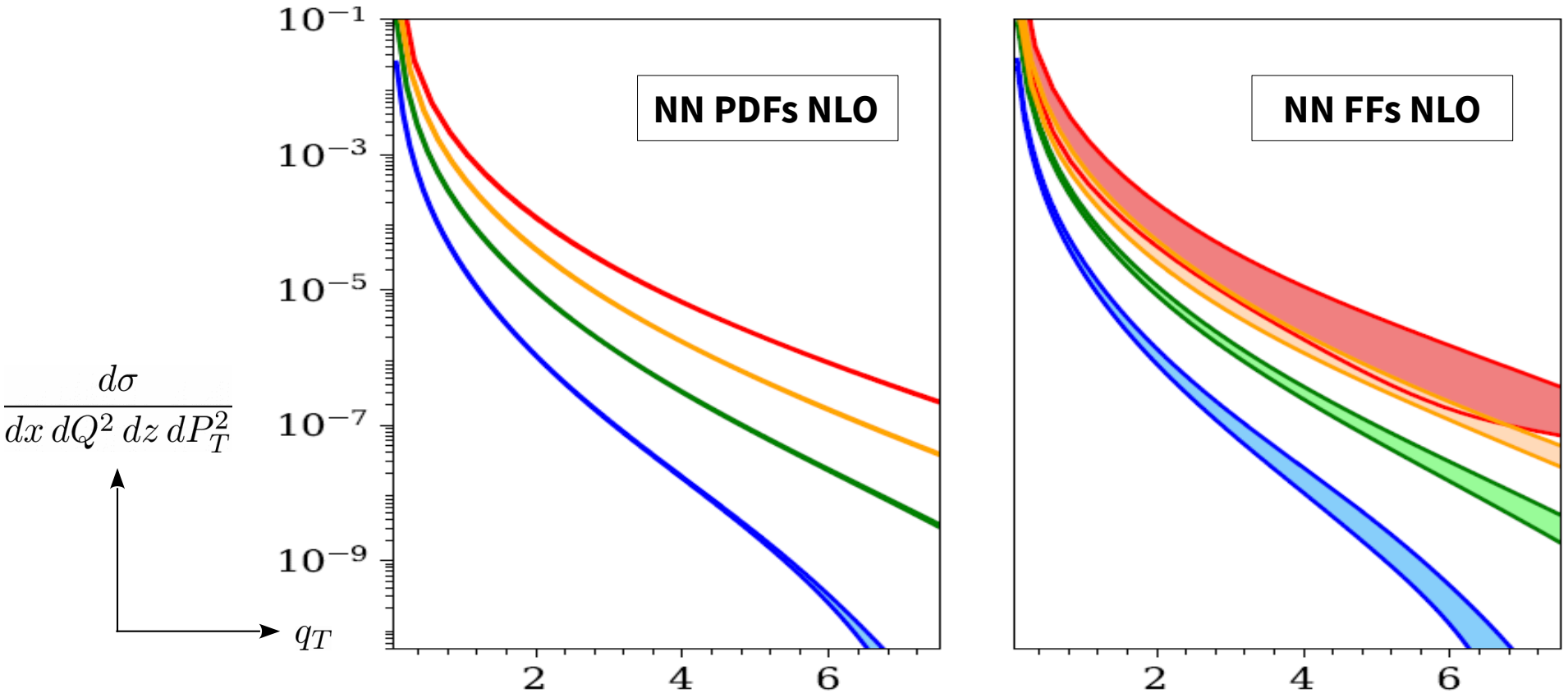


Errors and Collinear Functions

How much does the **error associated to the extraction of the collinear functions** affect the SIDIS cross section at large q_T?

$$Q^2 = 2.1\ GeV^2$$
$$x = 0.0106$$
$$y = 0.674$$

NEURAL NETWORK SETS



Errors and Collinear Functions

How much the

The error associated to the PDFs is **negligible** in comparison with that of FFs.

$$Q^2 = 2.1\ GeV^2$$
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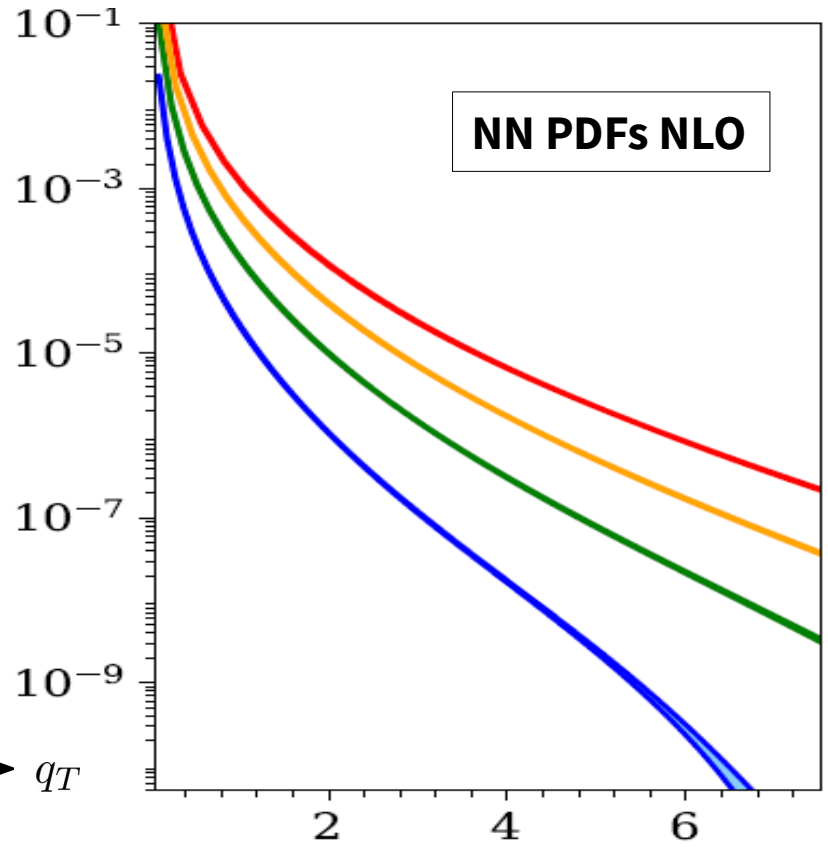
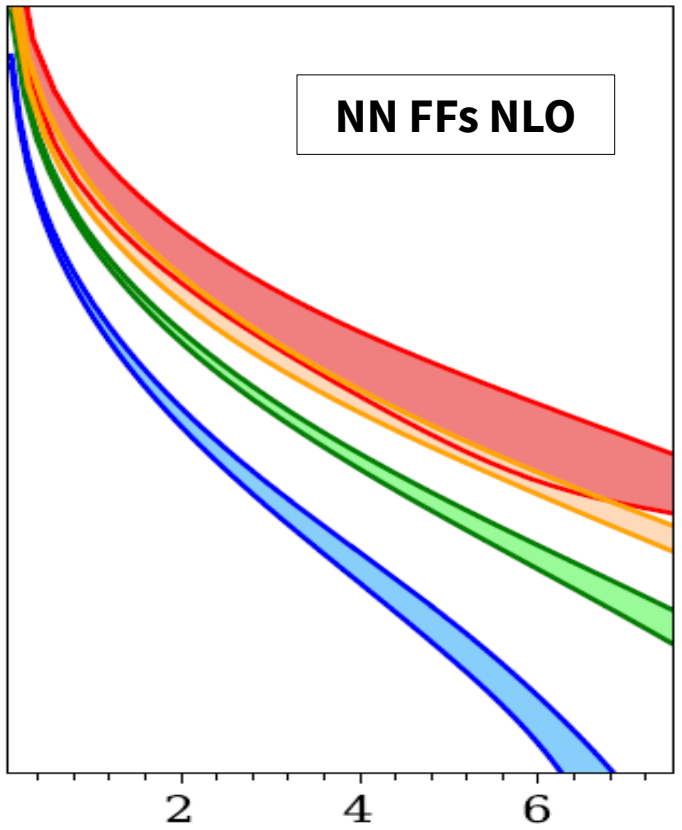
NEURAL N WORK SETS

$$\frac{d\sigma}{dx\, dQ^2\, dz\, dP_T^2}$$

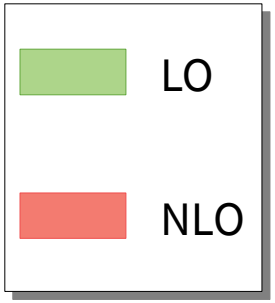


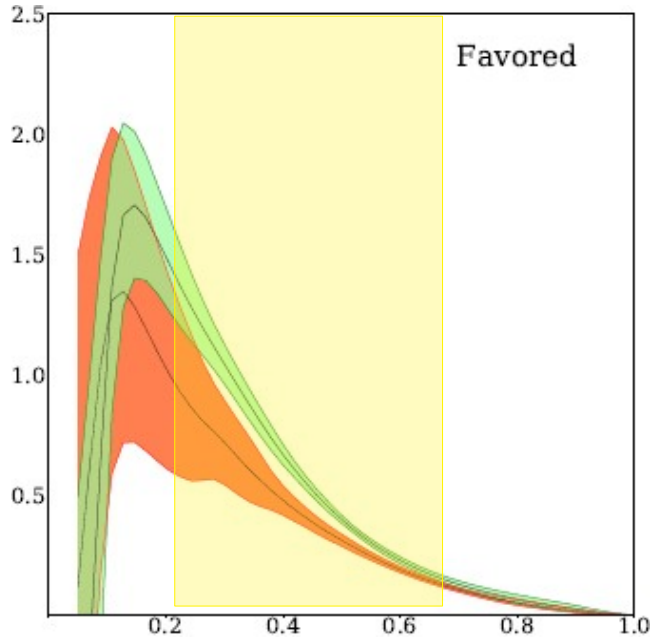
NN PDFs NLO

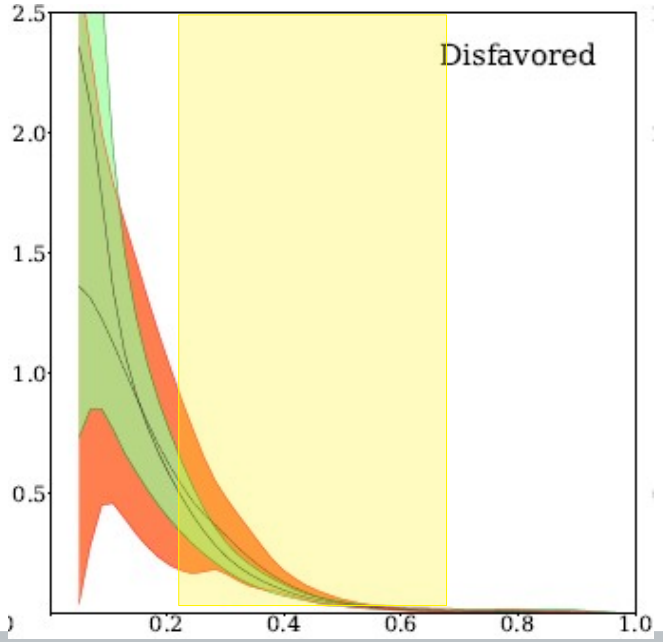


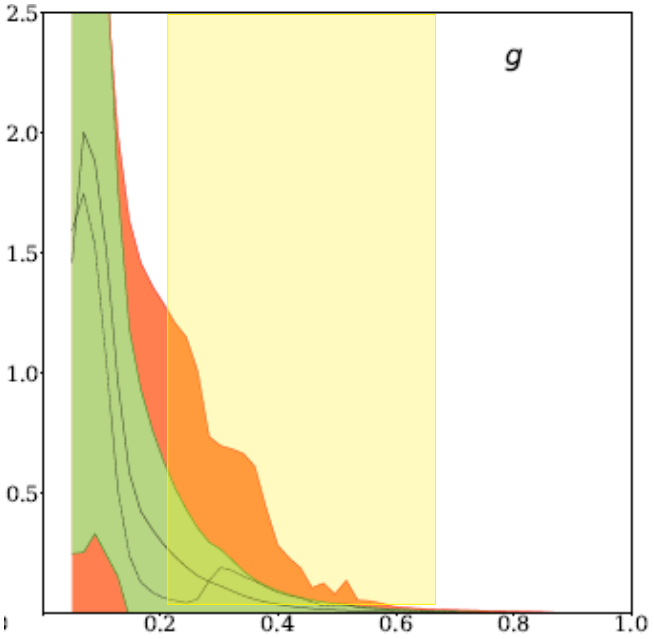
NN FFs NLO

Neural Network FFs









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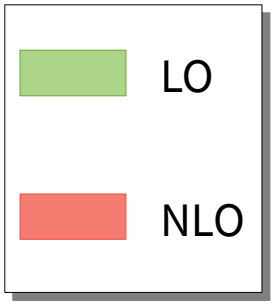

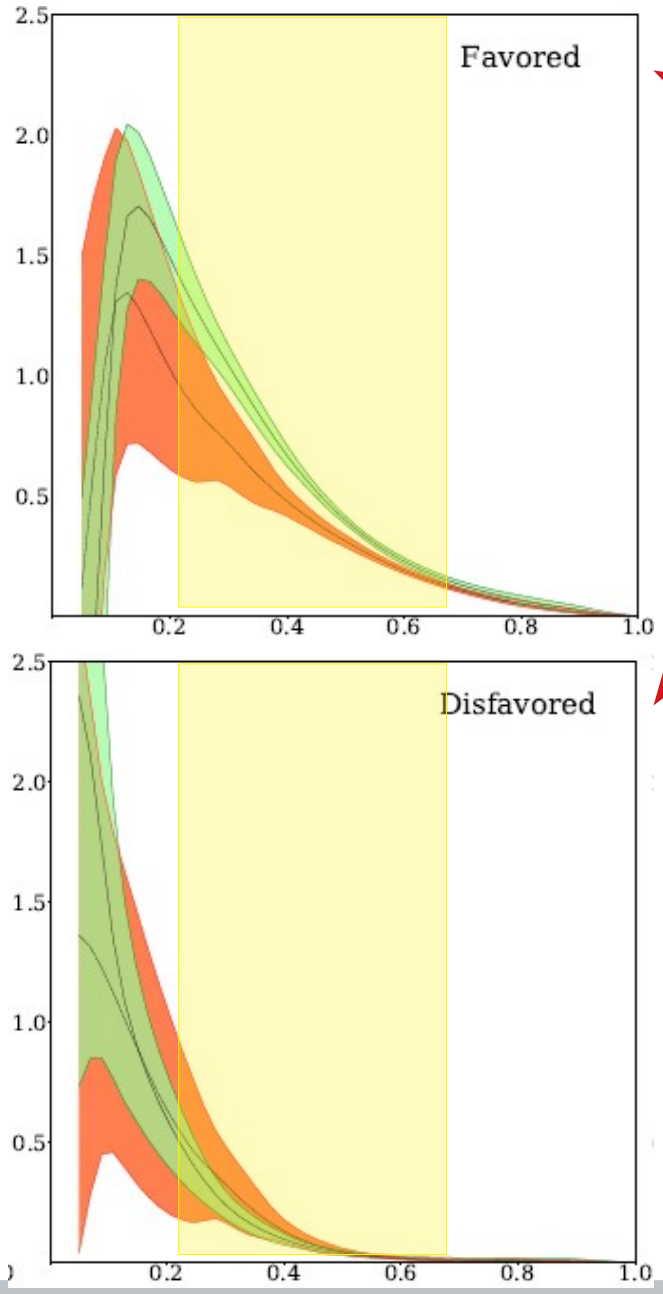

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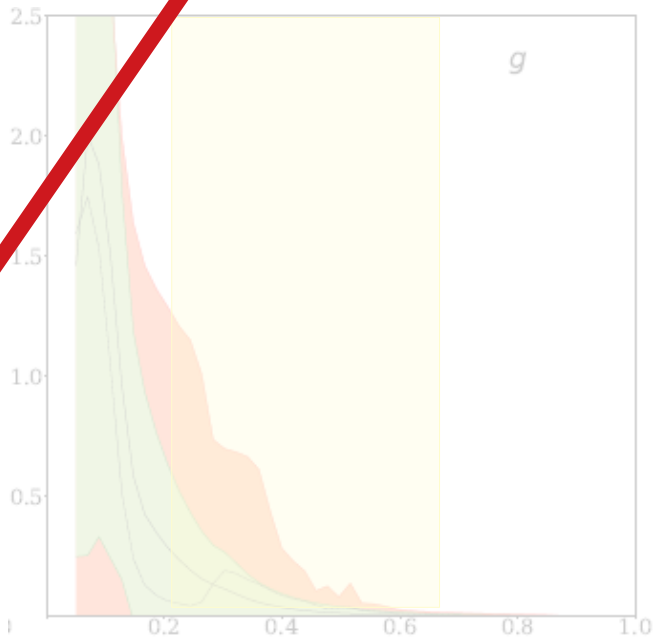


Neural Network FFs

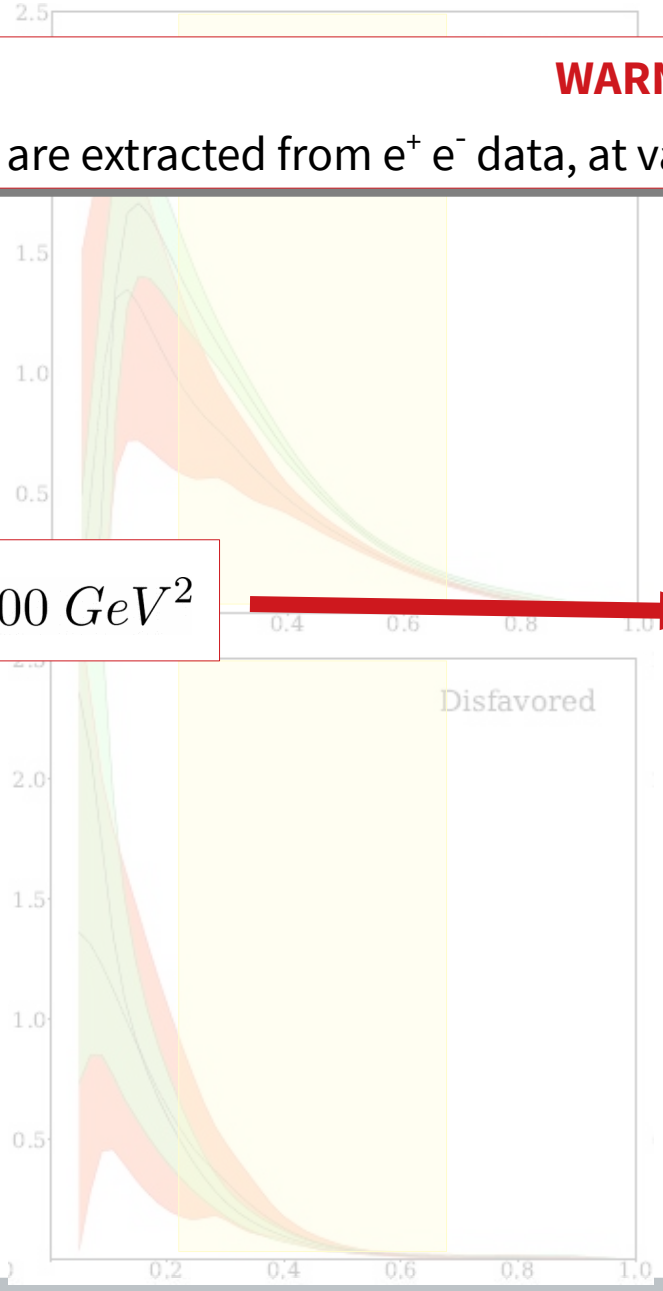
WARNING!

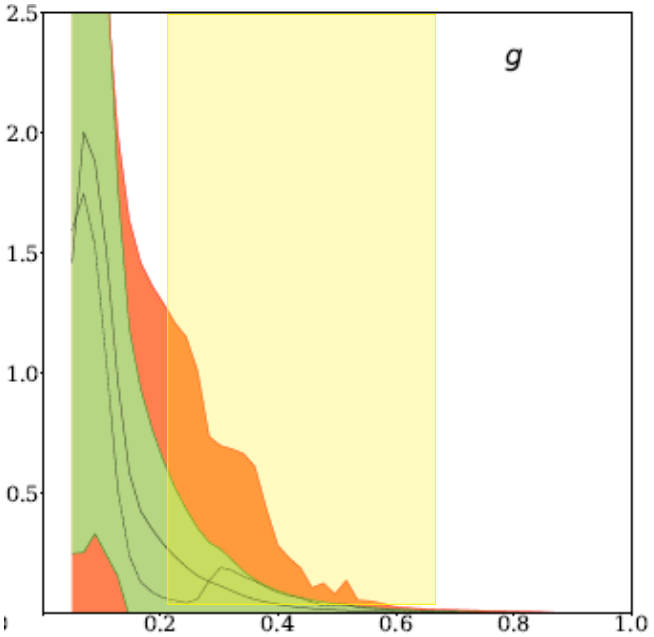
The FFs are extracted from $e^+ e^-$ data, at values of Q^2 much larger than in COMPASS.

LO

NLO

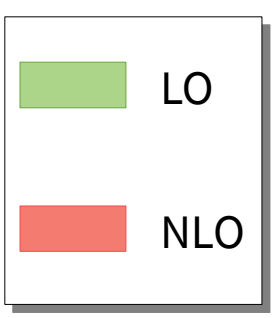
$Q^2 = 100\ GeV^2$

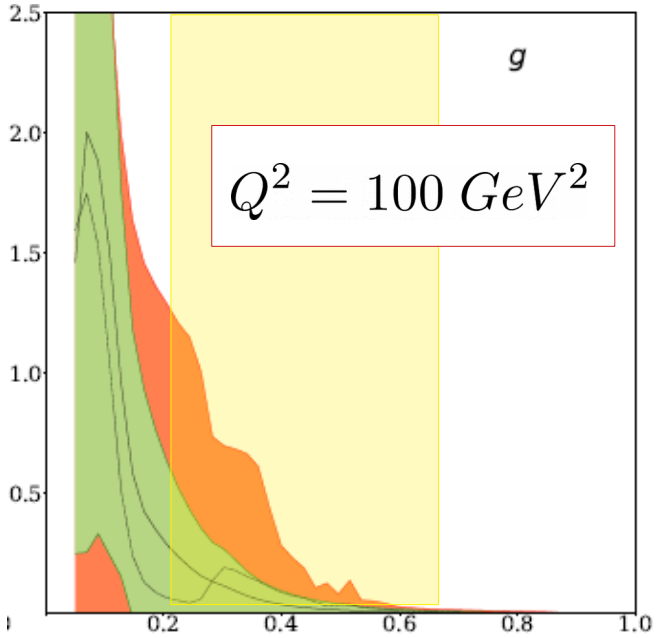


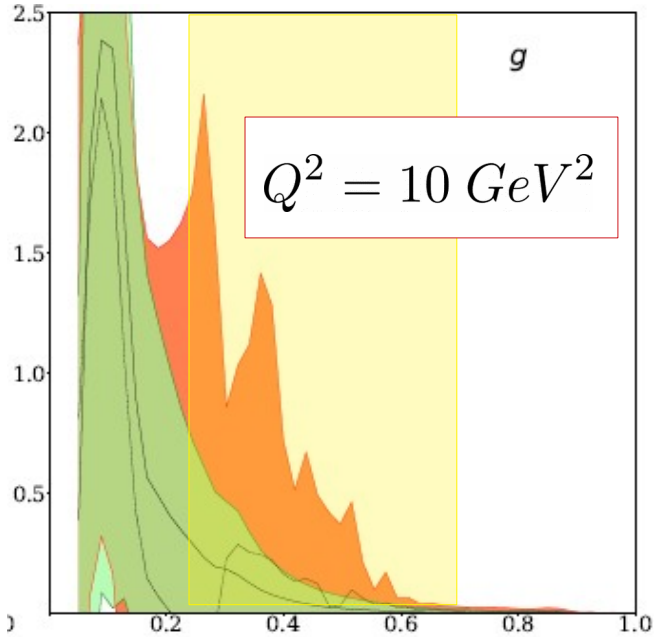


NN FF at NLO vs NN FFs at LO

...This is what happens using a COMPASS-like Q^2:







NN FFs: Comparison in the SIDIS cross section

The error bars associated to NLO FFs are on average **larger**:

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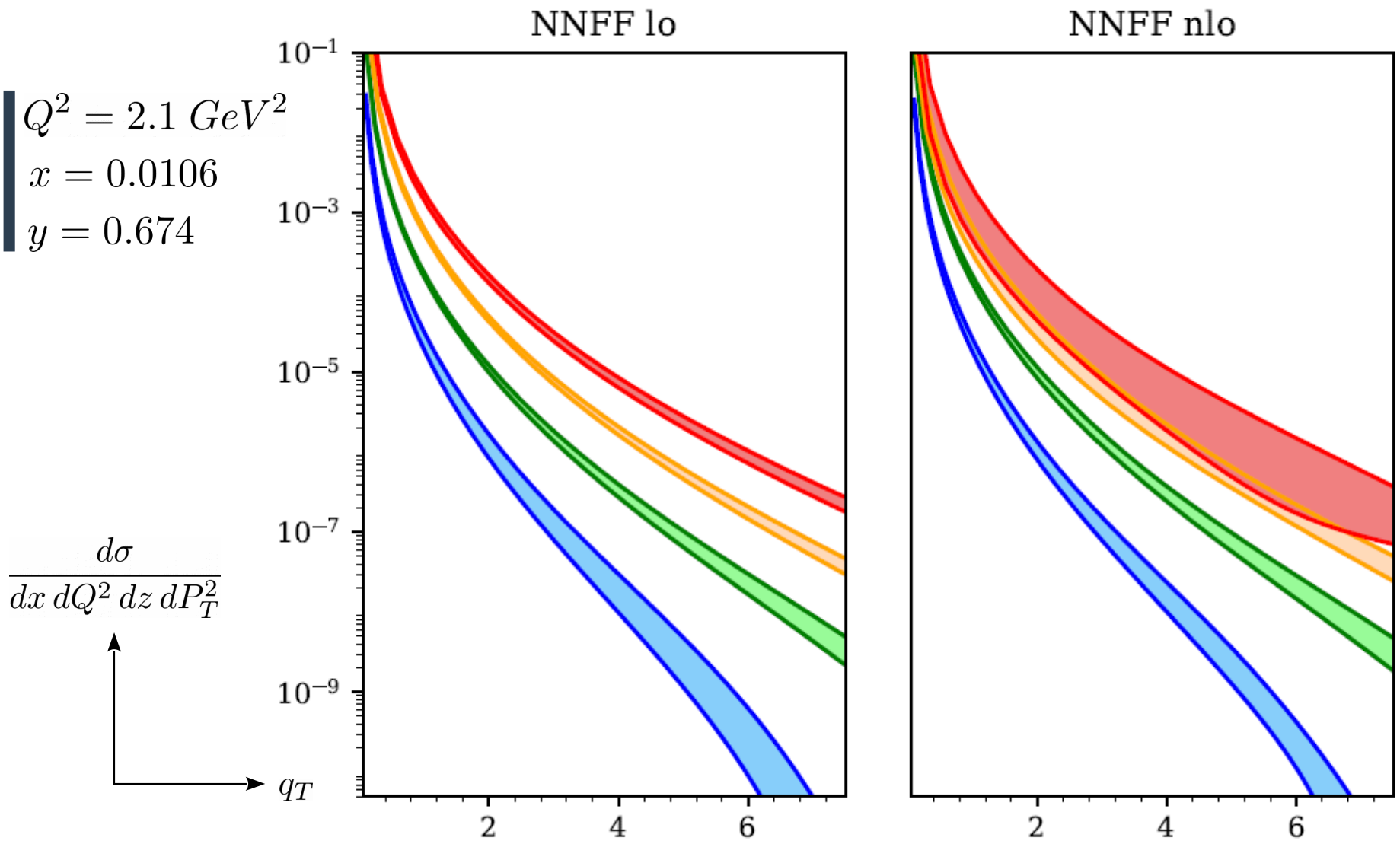

SIDIS in the LOW q_T regime

TMD Factorization:

$$\frac{d\sigma}{dx_{Bj}\, dy\, dz_h\, dq_T^2} = \pi\, z^2\, H\left(Q;\, \mu\right) \int \frac{d^2\vec{b_T}}{(2\pi)^2}\, e^{i\, \vec{q_T}\cdot\vec{b_T}} \sum_j e_j^2\, \widetilde{F}\left(x,\, b_T, \mu, \zeta_F\right)\, \widetilde{D}\left(z,\, b_T, \mu, \zeta_D\right)$$

TMD FUNCTIONS

The **TMD PDF** is a complex object...

$$\widetilde{F}\left(x,\, b_T, \mu, \zeta_F\right) = \sum_j \int_x^1 \frac{d\hat{x}}{\hat{x}}\, C_{f\, j}\left(\frac{x}{\hat{x}}\right) f_j\left(\hat{x}, \mu_b\right) \times$$

$$\times\, exp\left\{\frac{1}{2}\, log\left(\frac{\zeta_F}{\mu^2}\right) \widetilde{K}\left(b_*\, \mu_b\right) + \int_{mu_b}^{Q} \frac{d\mu}{\mu} \gamma_F\left(\mu, \frac{\zeta_F}{\mu^2}\right)\right\} \times M_F\left(x,\, b_T\right)$$

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TMD FUNCTIONS

Same collinear functions used in collinear factorization!

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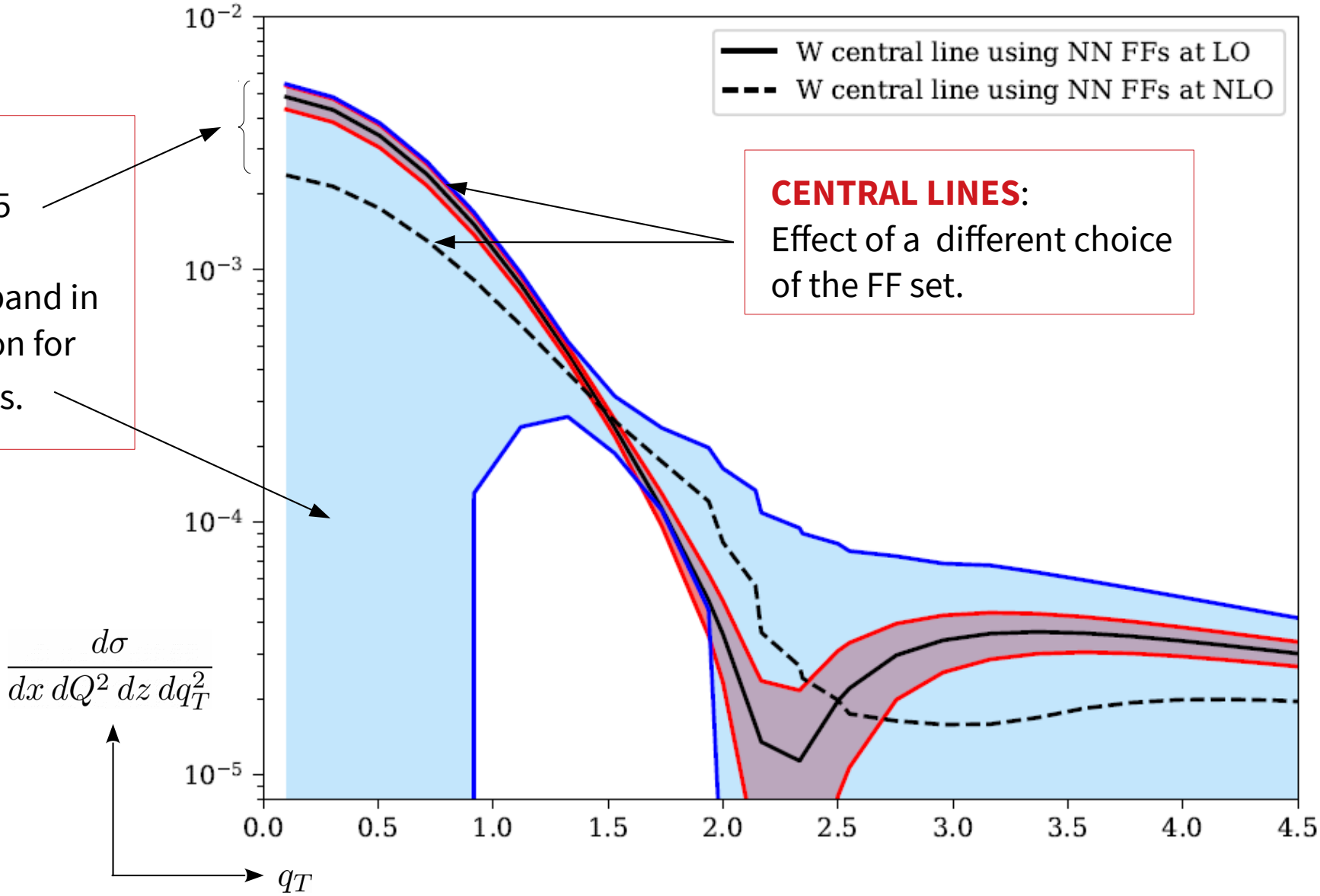
Errors of Collinear Functions in the W-TERM

ERRORS:

- Factor of ~ 5
- Very large band in low q_T region for the right FFs.

CENTRAL LINES:
Effect of a different choice of the FF set.



BACK UP SLIDES

A different choice for FFs

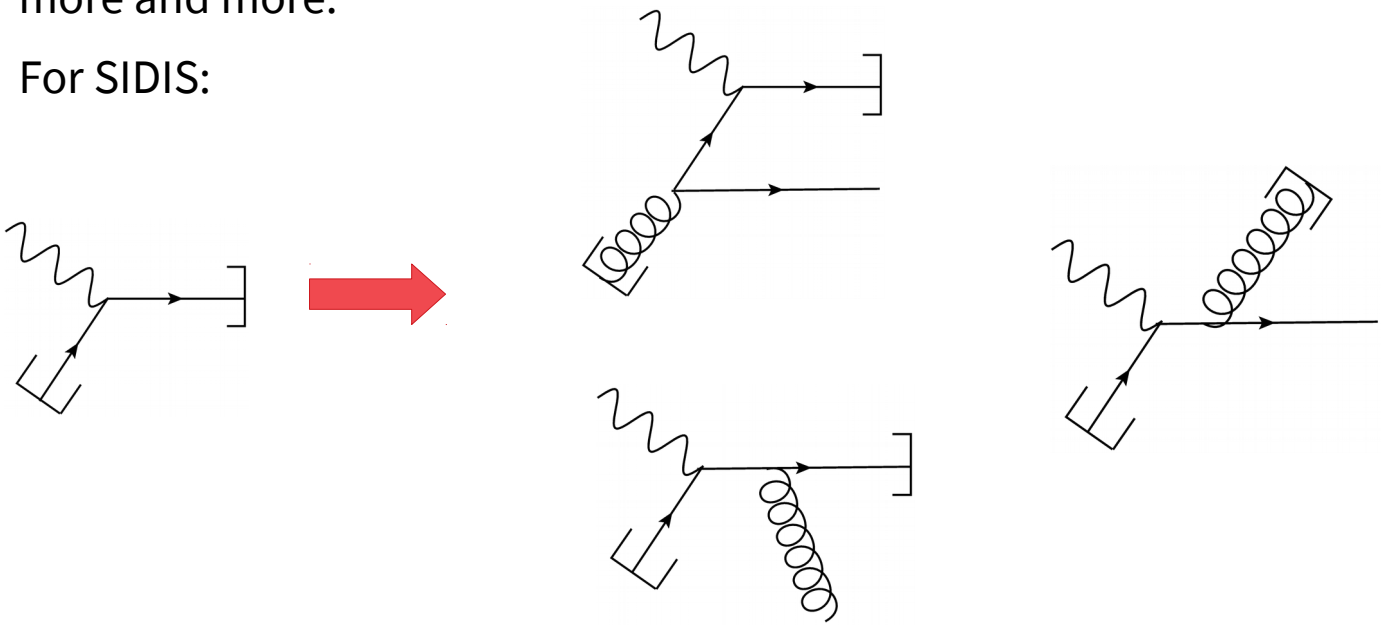
Let's consider again the collinear factorization theorem:

$$\mathcal{O} = H \otimes \sum_i F_i$$

As the order of α_s increases, the **HARD** part grows since the **phase space enlarges** more and more.

As a consequence the **COLLINEAR FUNCTIONS** contribution decreases.

For SIDIS:



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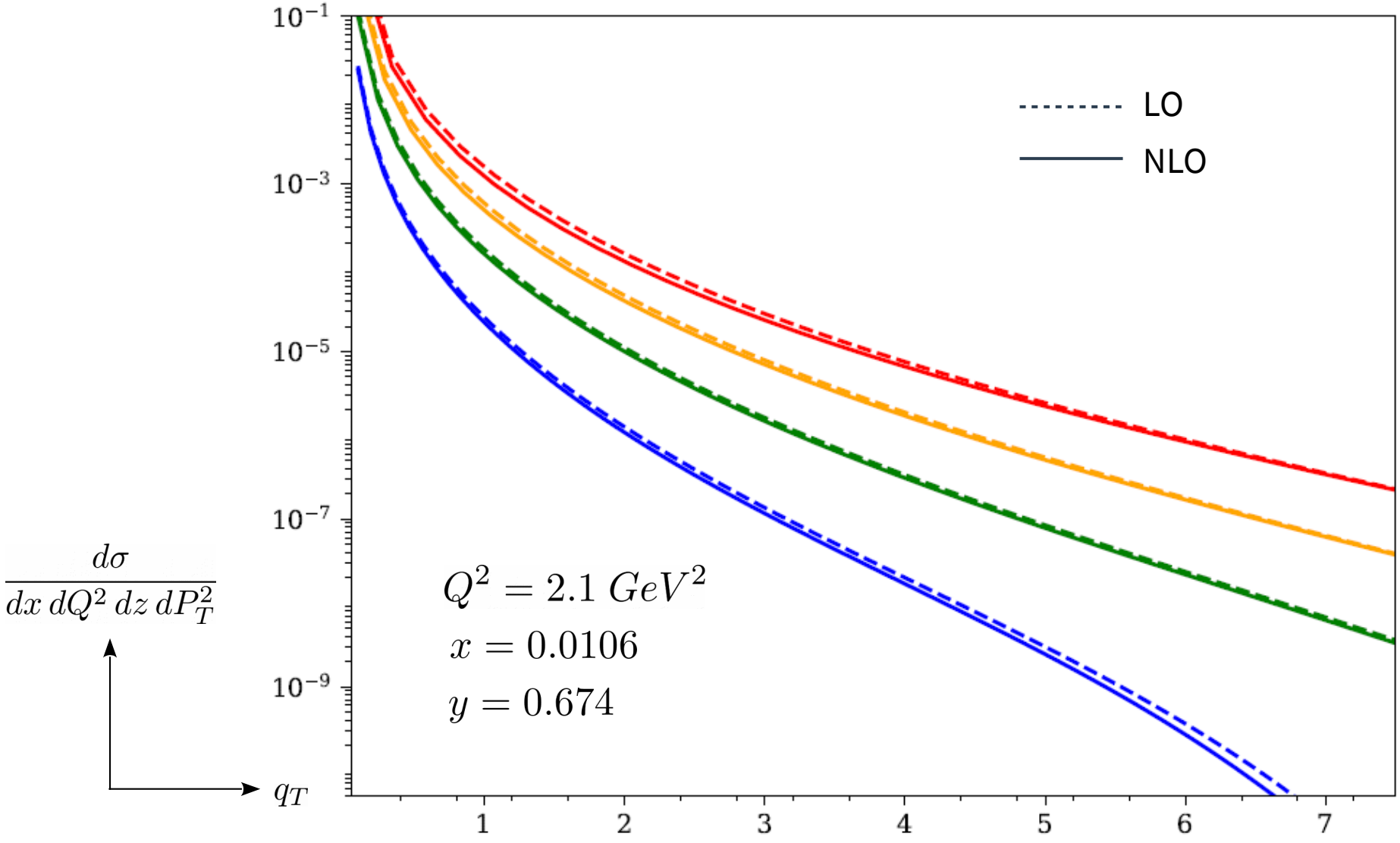
Central lines for NN FFs: