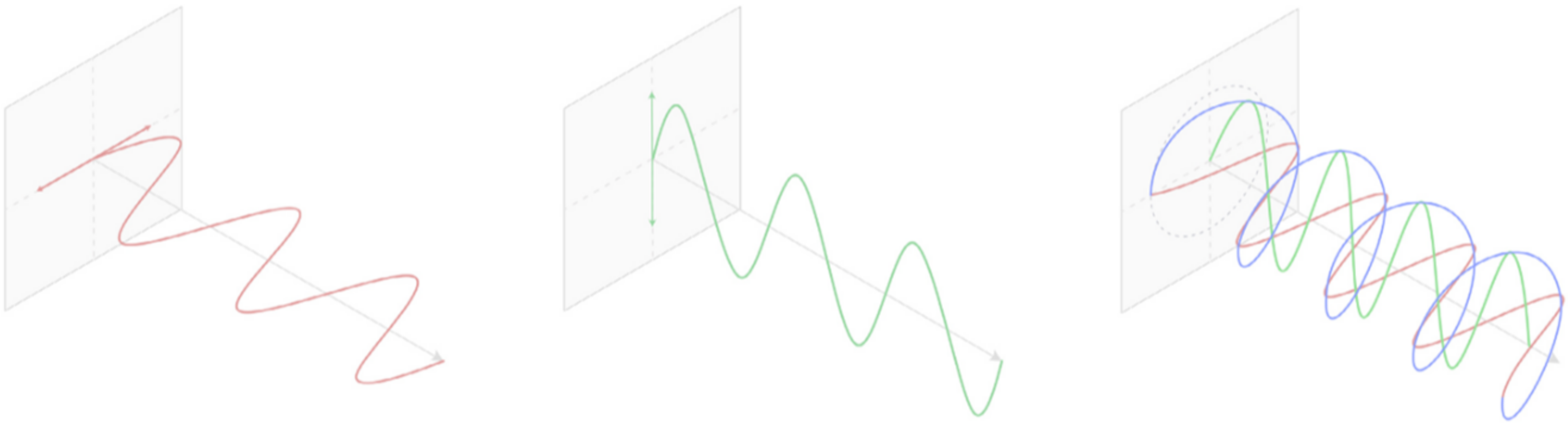


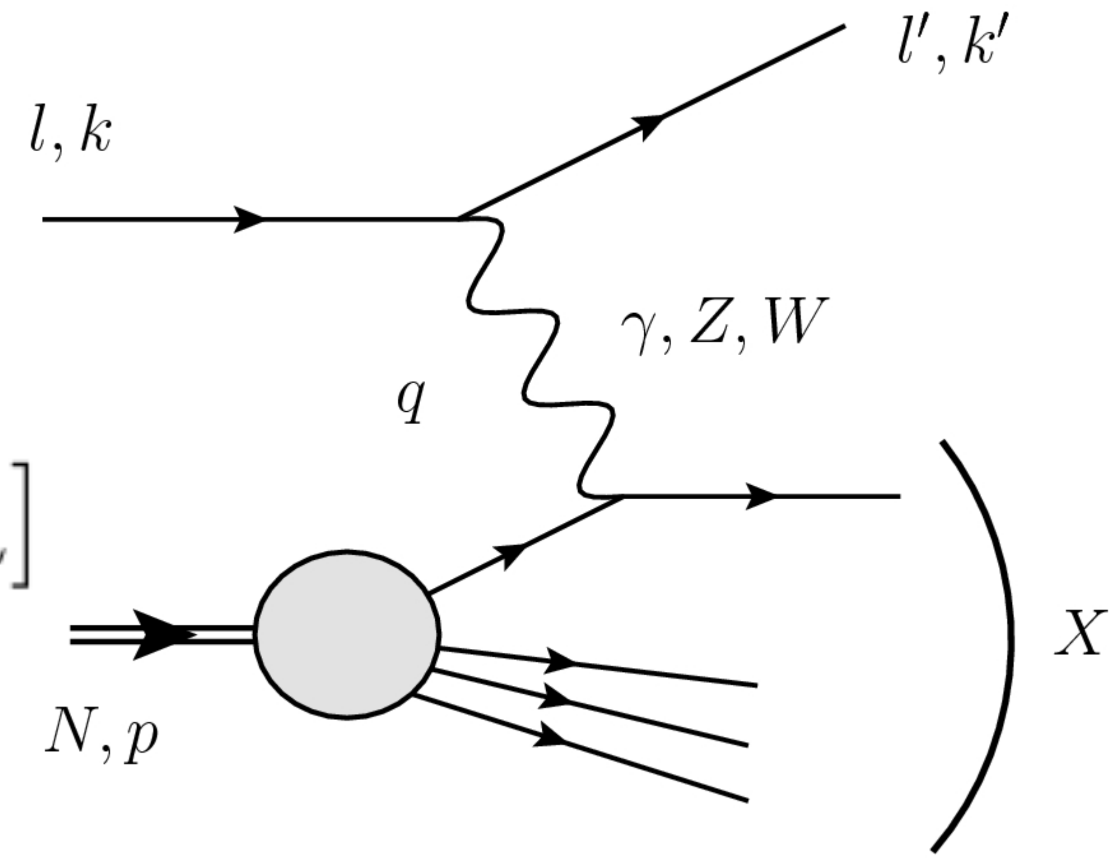
Possible measurement of transverse momentum dependence of $R = \sigma_L/\sigma_T$ with SoLID

Matteo Cerutti (CEA Paris-Saclay)
Vladimir Khachatryan (Mississipi State University)
Ye Tian (SoLID Collaboration)

SoLID Collaboration Meeting
Jefferson Lab, Newport News,
February 20, 2026

The ratio $R = \sigma_L/\sigma_T$

Commonly known as "R-ratio"



Inclusive DIS

$$\frac{d^2\sigma^i}{dxdy} = \frac{2\pi\alpha^2}{xyQ^2}\,\eta^i\left[Y_+F_2^i \mp Y_-xF_3^i - y^2F_L^i\right]$$

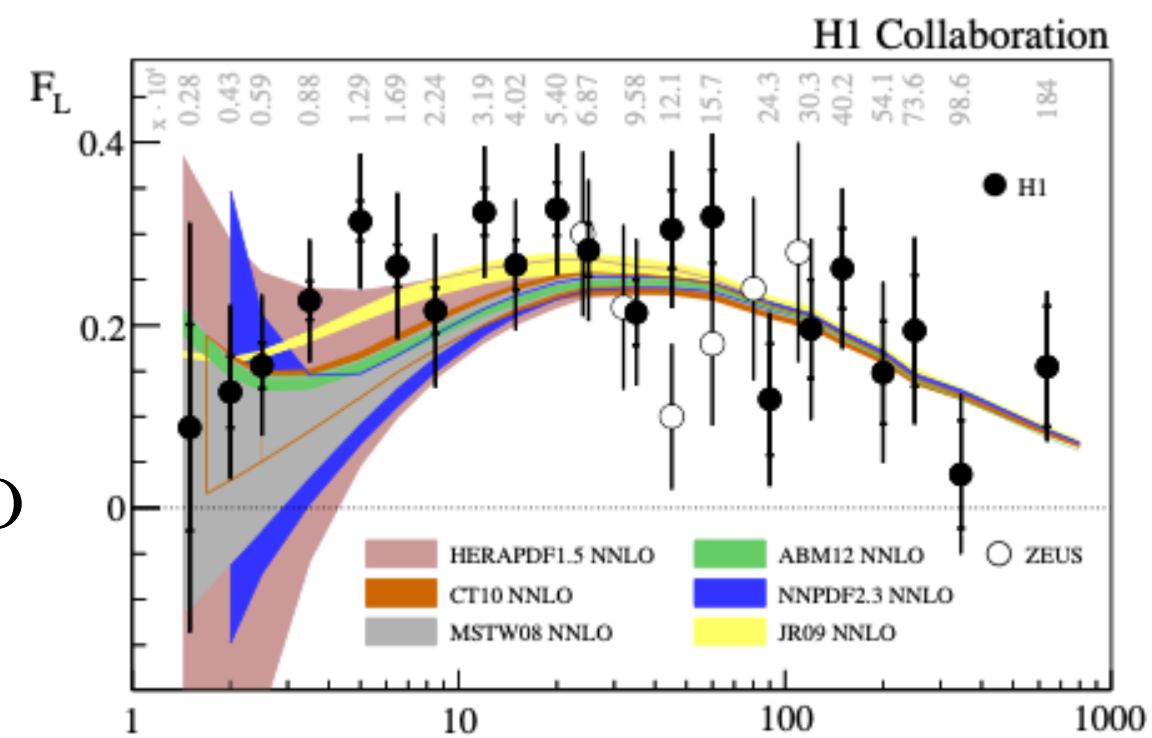
Particle Data Group (PDG), 2024

$$R = \frac{\sigma_L}{\sigma_T} = \frac{F_L(x_B, Q^2)}{F_T(x_B, Q^2)}$$

Known?

Experiment ✔

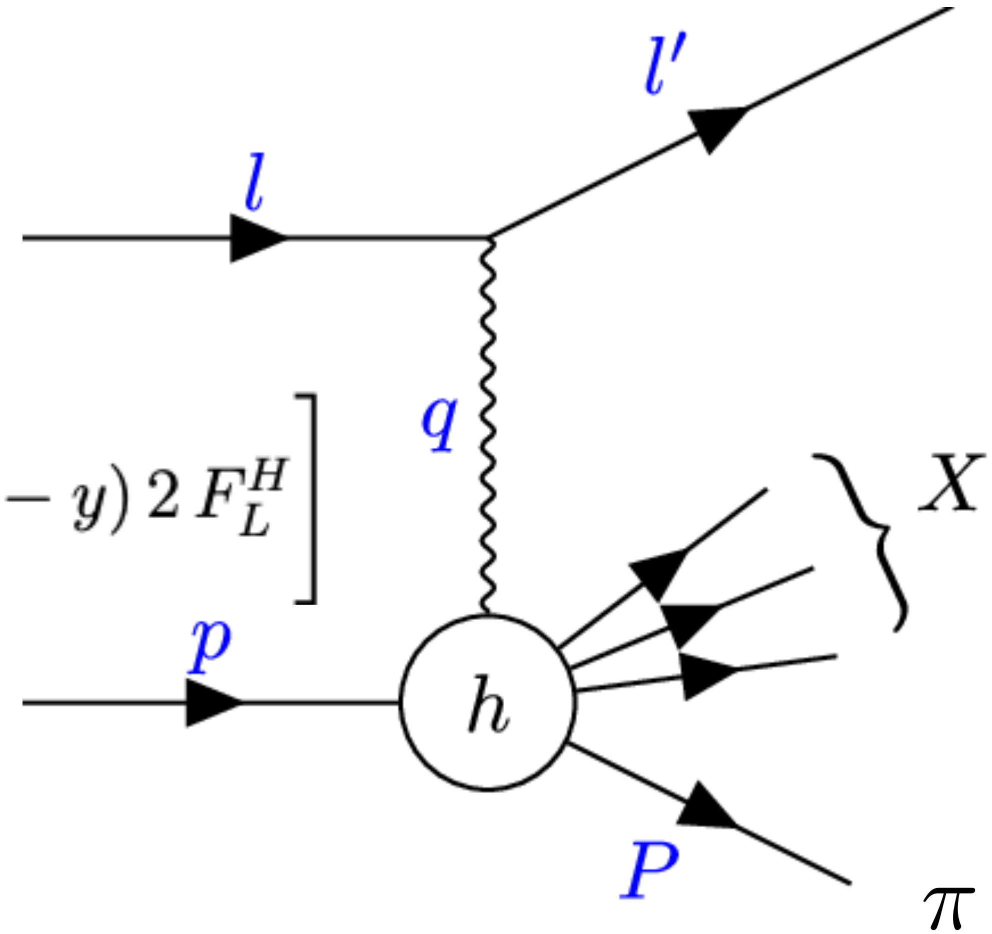
Theory ✔ $\neq 0$ only beyond LO



H1 Collaboration, EPJ C 74 (2014)

The ratio $R = \sigma_L / \sigma_T$

Commonly known as "R-ratio"



Semi-Inclusive DIS (integrated)

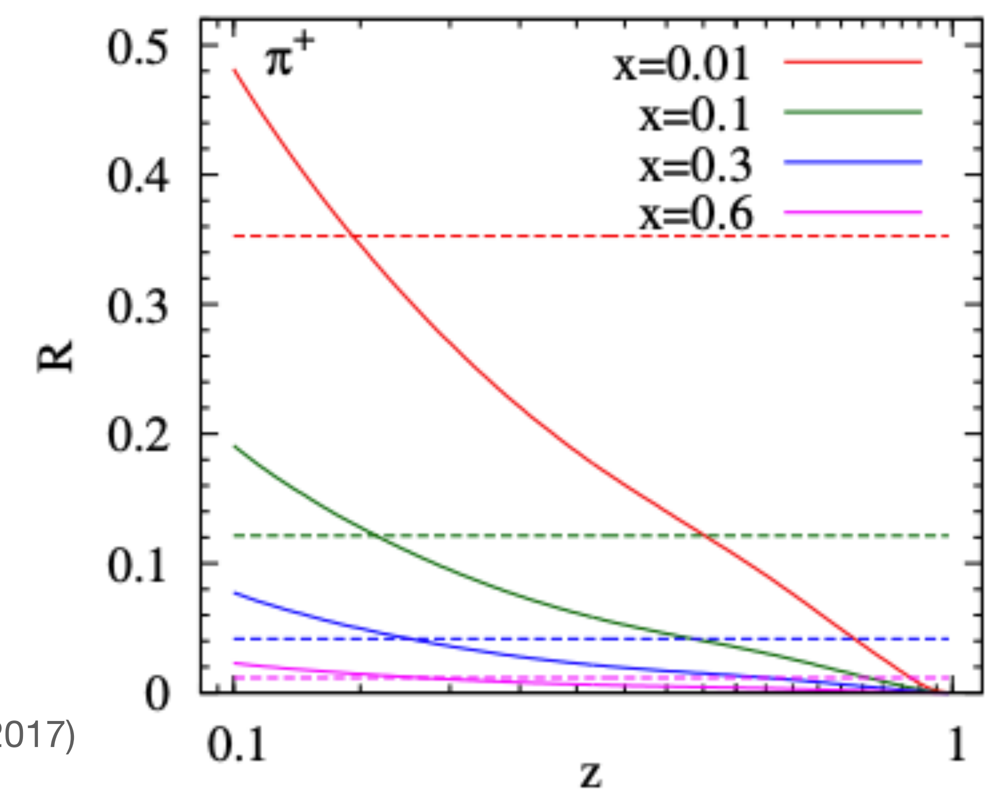
$$\frac{d\sigma^H}{dx\,dy\,dz} = \frac{2\pi\alpha^2}{x\,y\,Q^2}\left[\left[1+(1-y)^2\right] 2x\,F_1^H + (1-y)\,2\,F_L^H\right]$$

$$R = \frac{\sigma_L}{\sigma_T} = \frac{F_L(x_B, z_h, Q^2)}{F_T(x_B, z_h, Q^2)}$$

Known?

Experiment ✘

Theory ✔



Anderle, de Florian, et al., PRD 95 (2017)

The ratio $R = \sigma_L/\sigma_T$

Commonly known as "R-ratio"

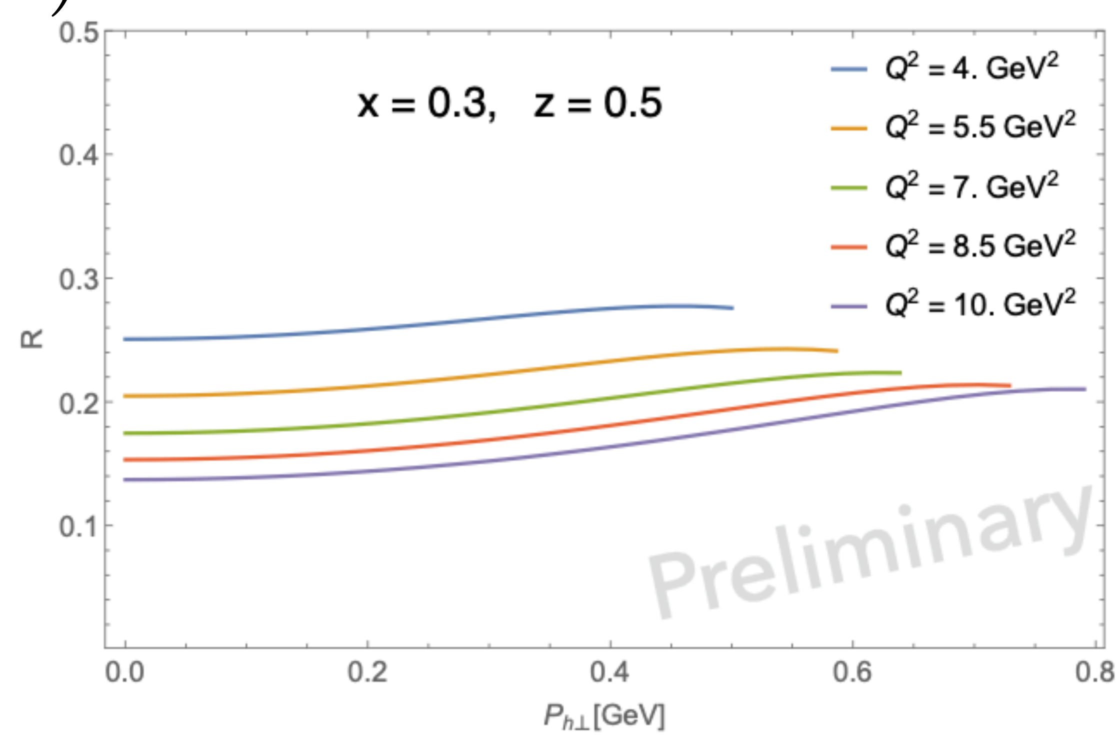
Semi-Inclusive DIS (q_T-dependent)

MAP Collaboration, JHEP 10 (2022)

$$\frac{d\sigma^{\mathrm{SIDIS}}}{dx\,dz\,d|\boldsymbol{q}_T|\,dQ} = \frac{8\pi^2\alpha^2 z^2 |\boldsymbol{q}_T|}{x\,Q^3}\frac{y^2}{1-\epsilon}\Big[F_{UU,T}(x,z,|\boldsymbol{q}_T|,Q)+\epsilon F_{UU,L}(x,z,|\boldsymbol{q}_T|,Q)\Big]$$

$$R = \frac{\sigma_L}{\sigma_T} = \frac{F_{UU,L}(x_B, z_h, |\boldsymbol{q}_T|, Q^2)}{F_{UU,T}(x_B, z_h, |\boldsymbol{q}_T|, Q^2)}$$

JLab22 White Paper, EPJ A 60 (2024)



Known?

Experiment ✘

Theory

Small q_T **?**

Large q_T ✔

Piloneta, Vladimirov, arXiv:2510.14496
Balitsky, Prokudin, arXiv:2601.18882

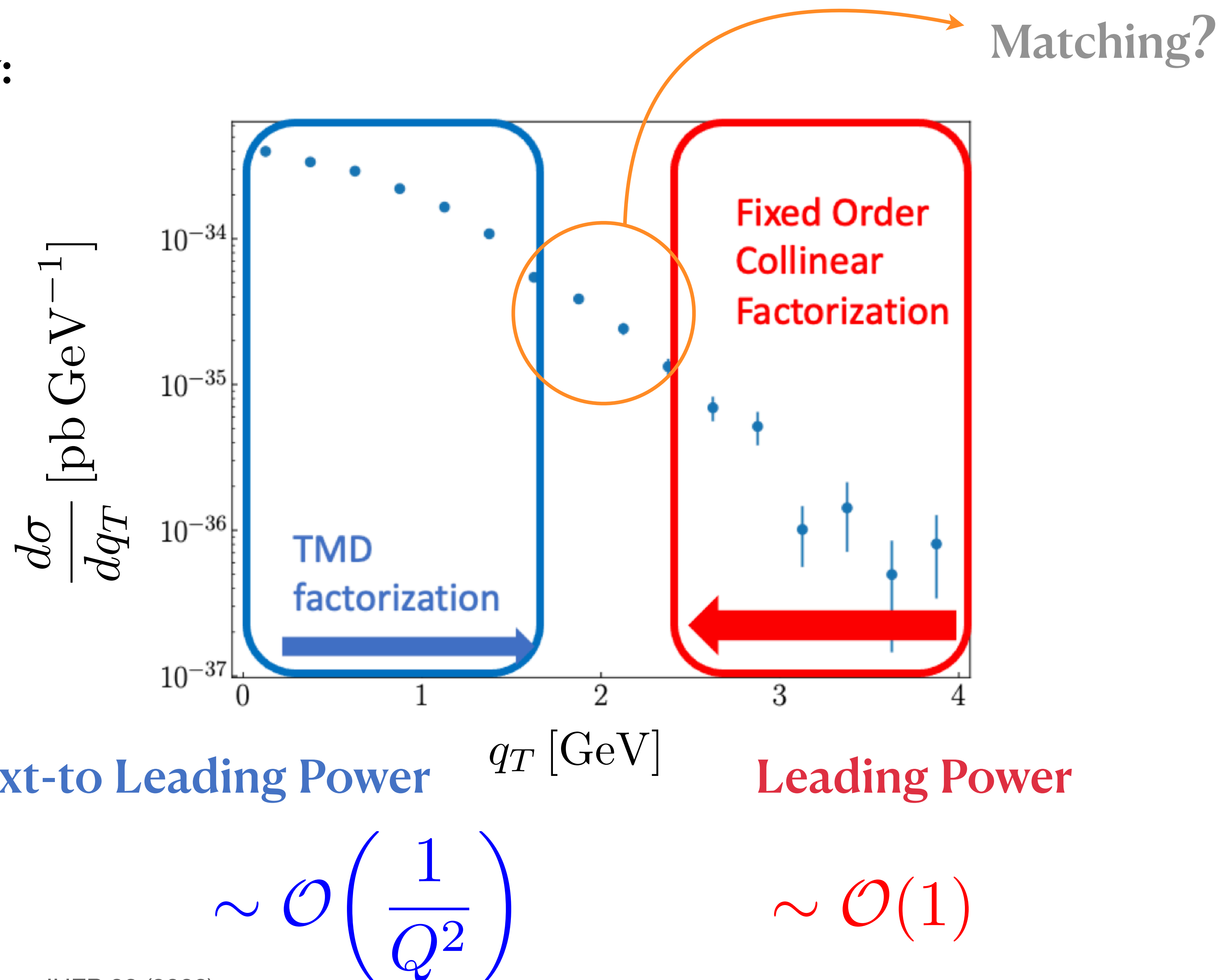
Why is it important to know R?

In general:

To understand the role of longitudinal photons in SIDIS

More specifically:

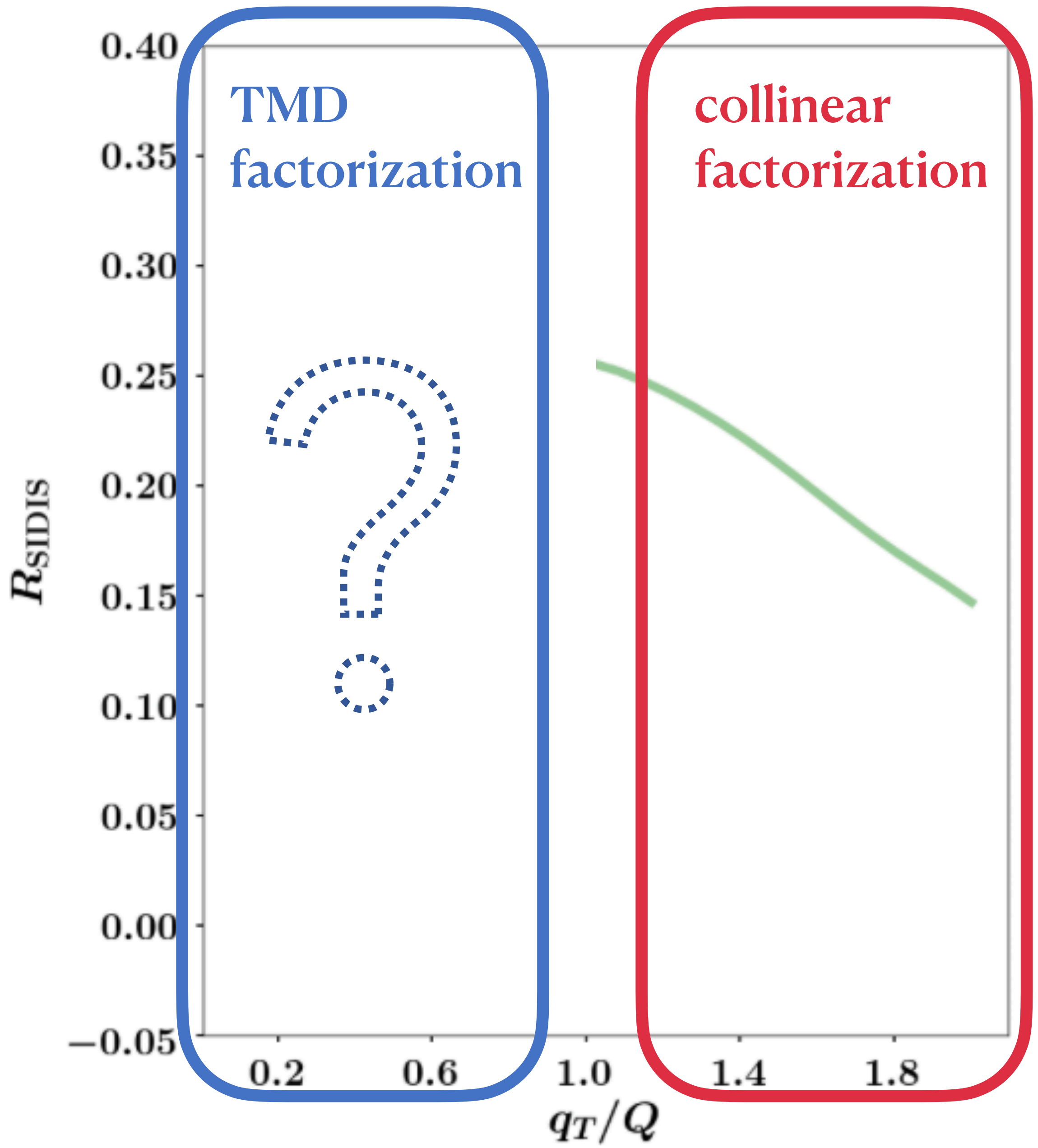
$F_{UU,L}$ is unique



Bacchetta, Boer, Diehl, Mulders, JHEP 08 (2008)

Current situation

Not clear if TMD factorization can be applied to NNLP (twist-4) structure functions



$x = 0.1$
$z = 0.5$
$Q^2 = 4\ \mathrm{GeV}^2$

Next-to-Next-to Leading Power $\sim \mathcal{O}\left(\frac{1}{Q^2}\right)$

Leading Power $\sim \mathcal{O}(1)$

Piloneta, Vladimirov, arXiv:2510.14496
Balitsky, Prokudin, arXiv:2601.18882
Bacchetta, MC, Gamberg, Whitehill, in preparation

Why is it important to know R?

Possible source of normalization mismatch in TMD fits with SIDIS data

Current information in global analyses

$$M(x, z, |\boldsymbol{P}_{hT}|, Q) = \frac{d\sigma^{\text{SIDIS}}}{dx\, dz\, d|\boldsymbol{P}_{hT}|\, dQ} \Bigg/ \frac{d\sigma^{\text{DIS}}}{dx\, dQ}$$

HERMES

COMPASS

SIDIS issue

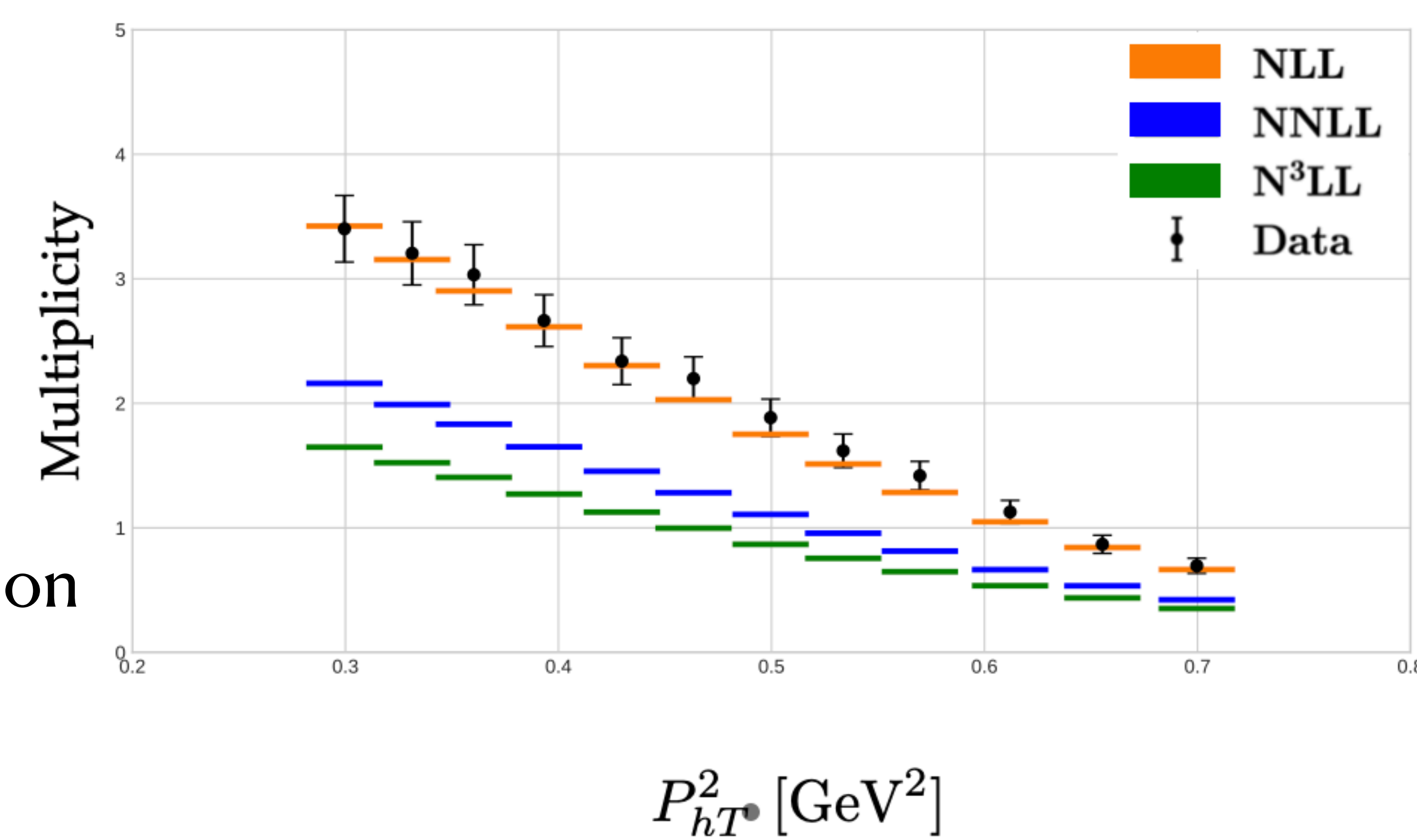
Low accuracy:

good description

High accuracy:

mismatch in normalization

MAP Collaboration, JHEP 10 (2022)



Current situation

MAP Collaboration, JHEP 10 (2022)

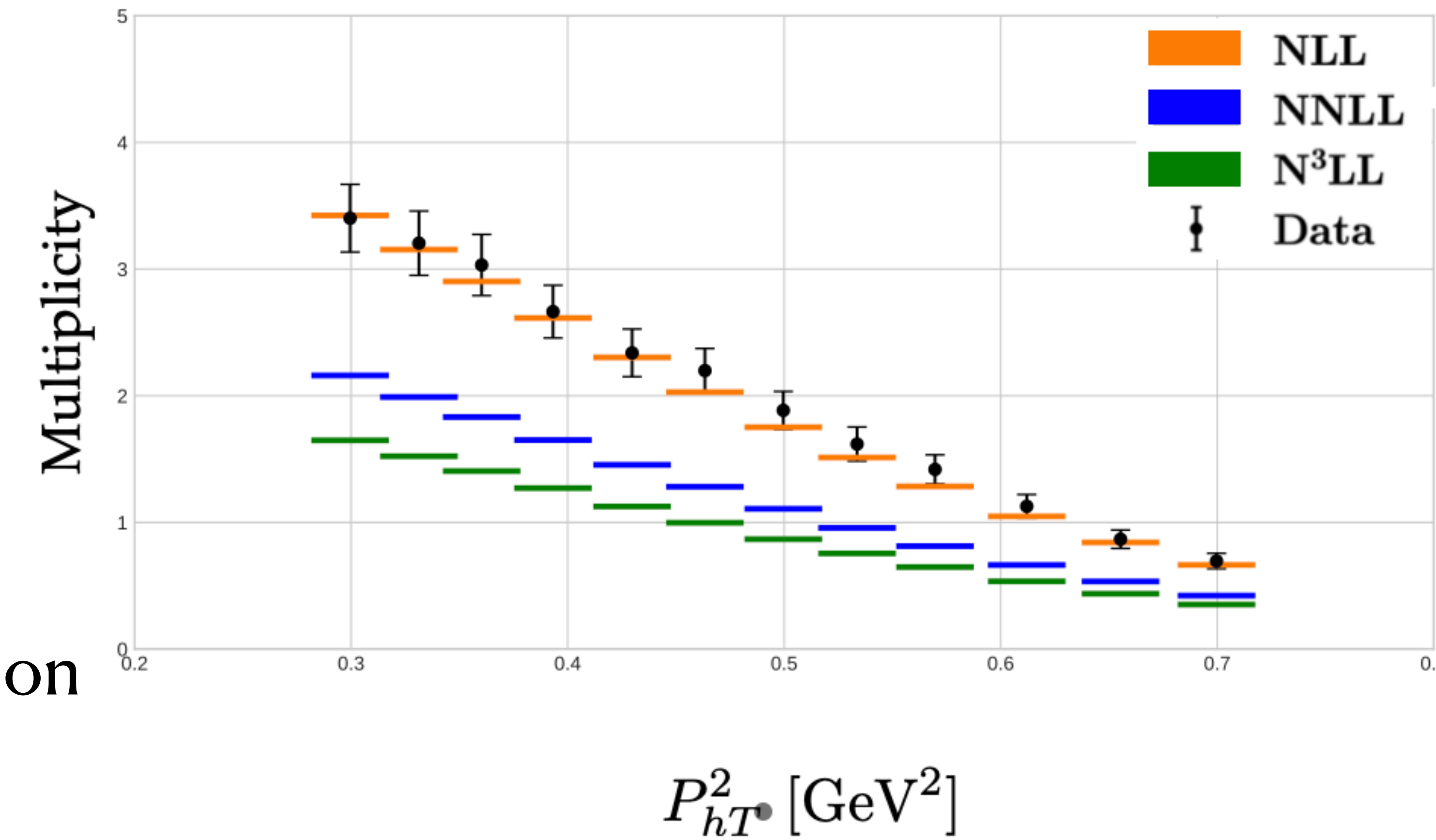
SIDIS issue

Low accuracy:

good description

High accuracy:

mismatch in normalization



Theoretical framework in TMD fits

$$M(x, z, |\boldsymbol{P}_{hT}|, Q) = \pi z |\boldsymbol{P}_{hT}| \frac{F_{UU,T}}{F_T + \epsilon F_L}$$

$F_{UU,L} = 0$

$$= \pi z |\boldsymbol{P}_{hT}| \frac{F_{UU,T} + \boxed{\epsilon F_{UU,L}}}{F_T + \epsilon F_L}$$

Need to be investigated

Theory summary

Current knowledge of the longitudinal structure function

	DIS	SIDIS (integrated)	SIDIS (qT-differential)
Experiment	✔	✘	✘
Theory	✔	✔	Large qT only

Why is it important?

- To understand the role of longitudinal photons in SIDIS
- It is unique: LP at large q_T, NNLP at small q_T. Is there a matching?
- The behavior at small q_T is unknown from the theory
- Possible source of normalization mismatch in TMD fits with SIDIS data