

# Unpolarized TMDs: latest results

Matteo Cerutti

# Previous works

## PV17 fit

8059 SIDIS + DY data

NLL Accuracy

Mean variables

$$\chi_R^2 = 1.55$$

*Bacchetta, Delcarro, Pisano, Radici, Signori, arXiv:1703.10157*

# Previous works

## PV17 fit

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## PV19 fit

353 DY data

N3LL Accuracy

Integrated variables

$$\chi_R^2 = 1.02$$

*Bacchetta, Bertone, Bissolotti, Bozzi, Delcarro, Piacenza, Radici, arXiv:1912.07550*

# Goal

New Global fit:

Simultaneously extraction of unpolarized TMD PDFs and FFs

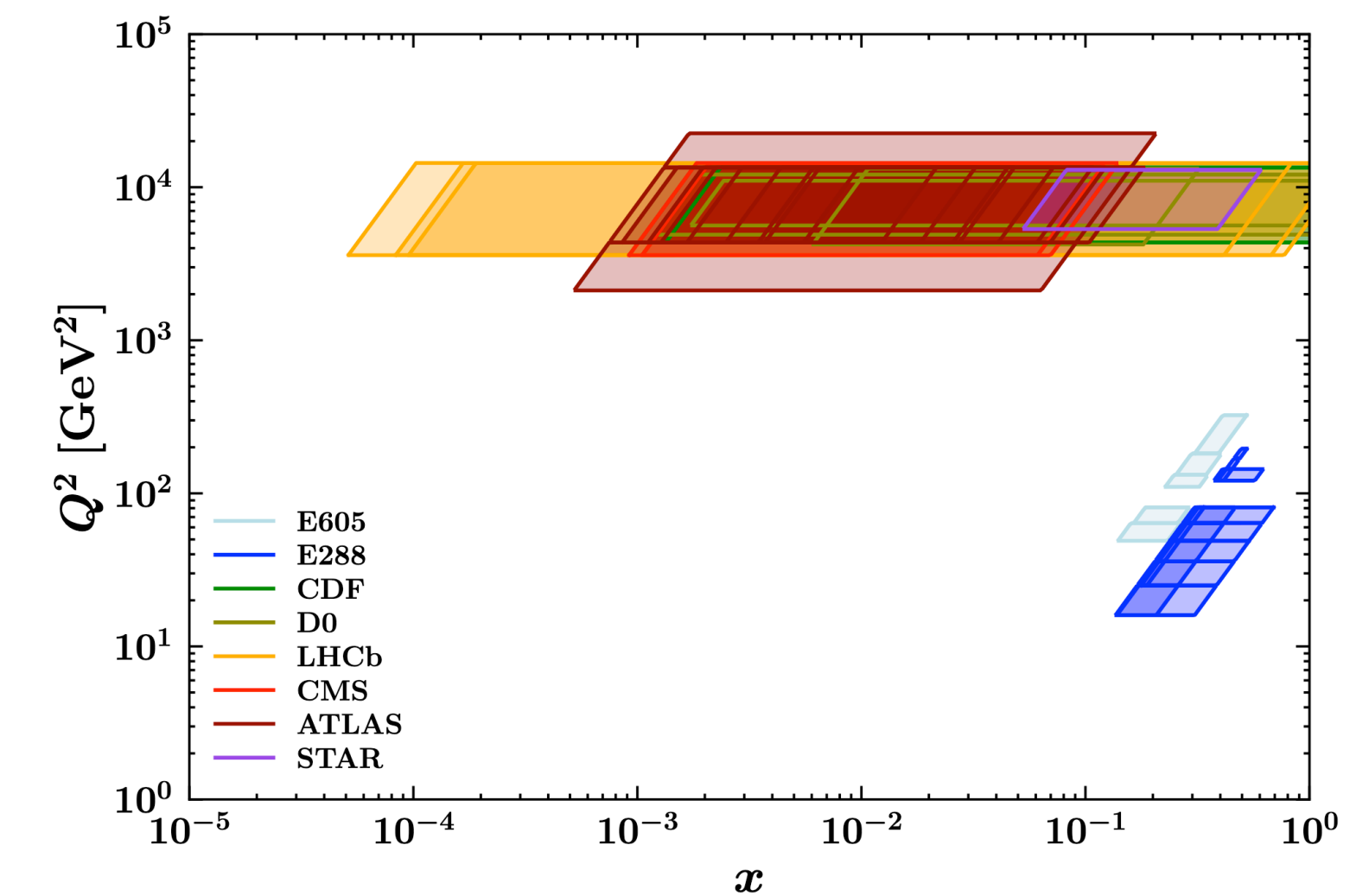
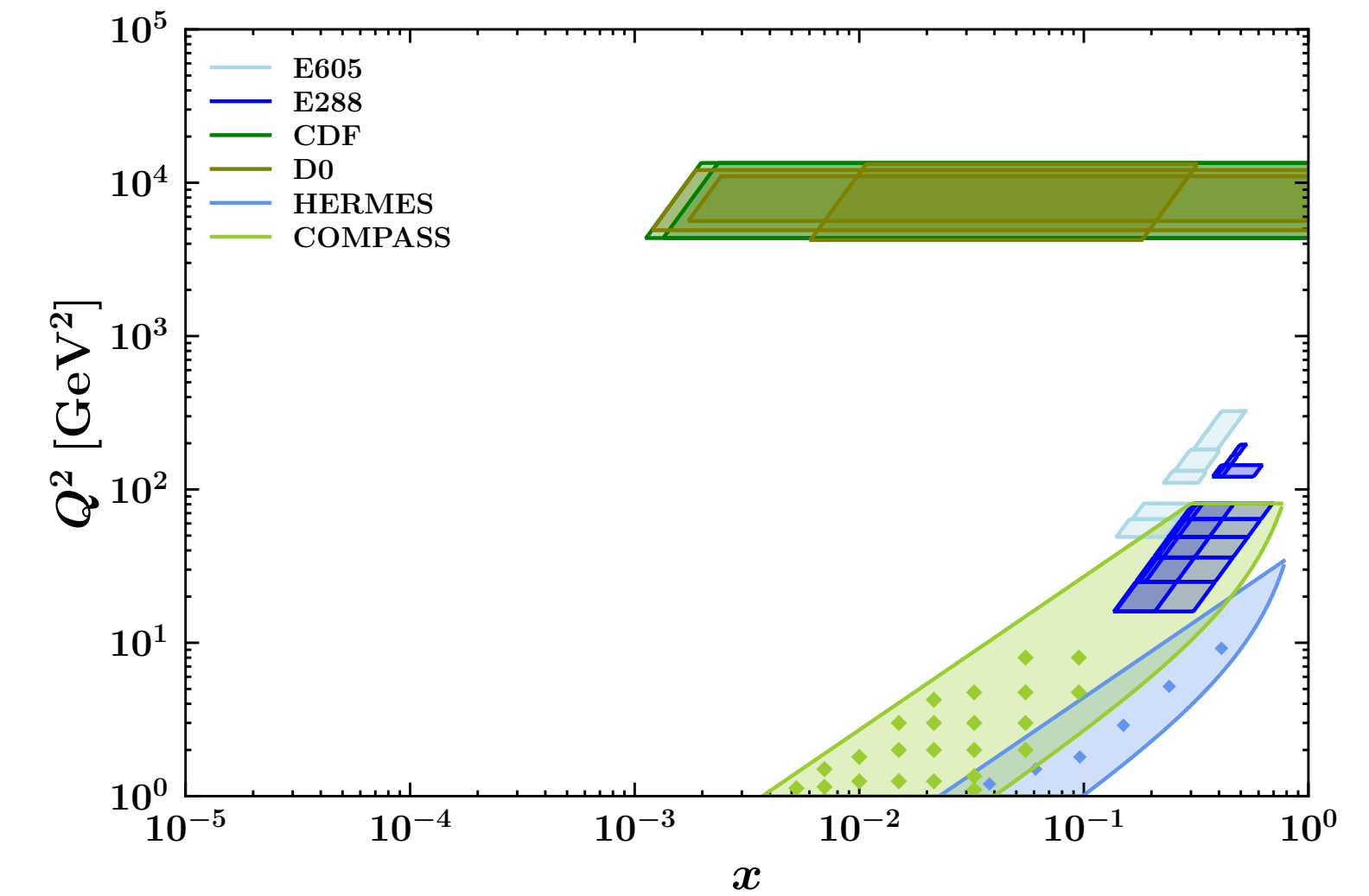
- SIDIS + Drell Yan



# Goal

## New Global fit

✓ SIDIS + Drell Yan



# Goal

## New Global fit

- ✓ SIDIS + Drell Yan
- Integrated variables

# Goal

## New Global fit

✓ SIDIS + Drell Yan

✓ Integrated variables

MapCollaboration / NangaParbat

Code Issues Pull requests Actions Projects Wiki Security Insights Settings

master 2 branches 3 tags

Go to file Add file Code

vbertone Merge pull request #6 from Synar/Minuit2CompilationFix 3f67f85 3 days ago 617 commits

FitResults	deleting unnecessary Report	4 months ago
bin	reorganising the code using cmake	3 years ago
cards	Working on SIDIS	5 months ago
cli	little update	2 months ago
data	NewFolder E615xF and switch low high	2 months ago
doc	code to check PV19grids	6 months ago
inc/NangaParbat	Makes compilation compatible with more architectures by che...	6 days ago
rawdata	Aggiunti dati sezione d'urto in funzione dixF per pione	2 months ago
resources	Add files via upload	9 months ago
run	removing ATLAS Low Mass	2 months ago
src	Merge branch 'MapCollaboration:master' into Minuit2Compilat...	6 days ago

About

Nanga Parbat: a fitting framework for the determination of the non-perturbative component of TMD distributions

Readme

MIT License

Releases 3

v1.4.0 Latest on 13 Dec 2019

+ 2 releases

Packages

No packages published

Publish your first package

<https://github.com/MapCollaboration>

# Goal

## New Global fit

- ✓ SIDIS + Drell Yan
- ✓ Integrated variables
- Up to N2LL/N3LL



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## New Global fit

- ✓ SIDIS + Drell Yan
- ✓ Integrated variables
- Up to N2LL/N3LL





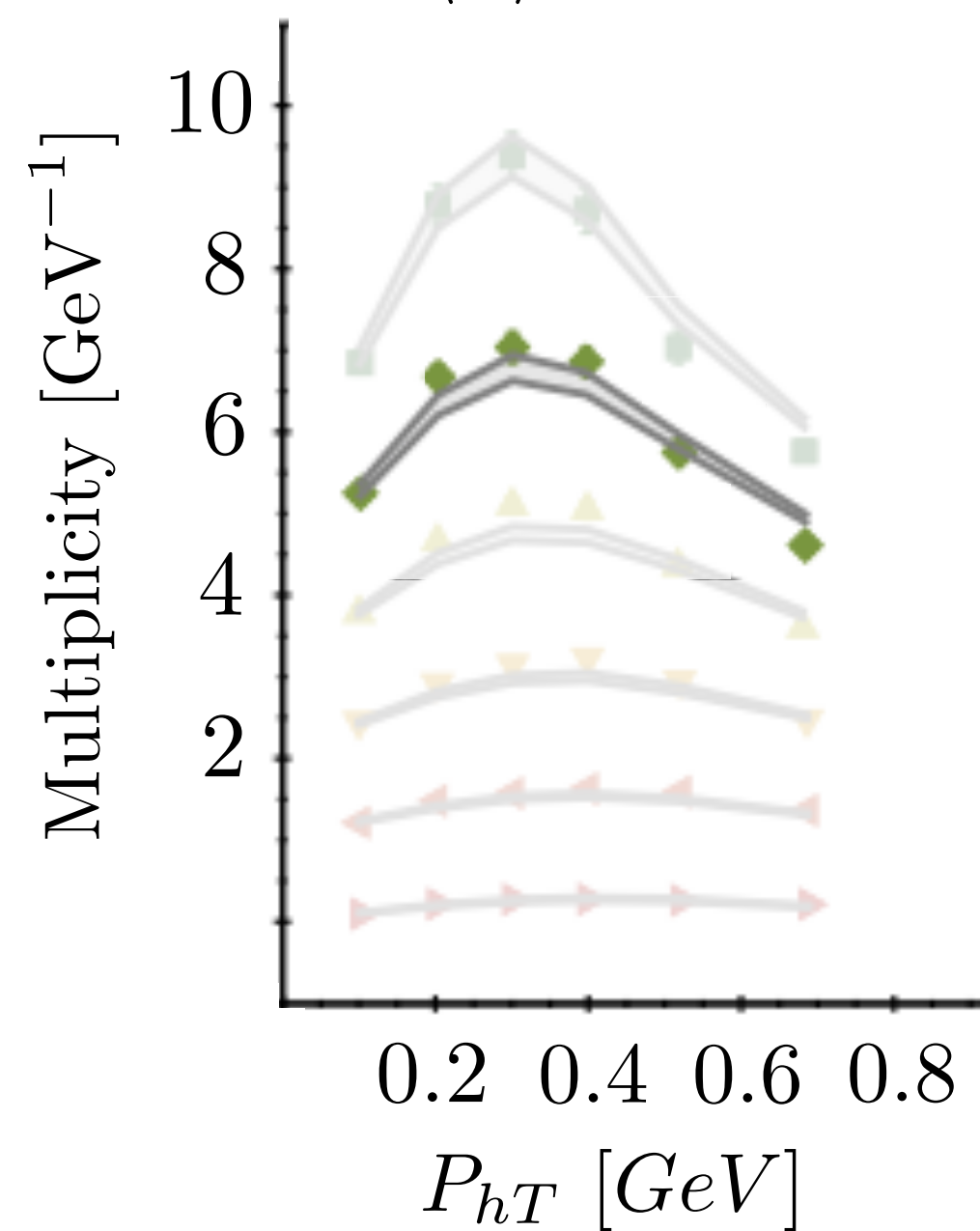
# Results at NLL

## HERMES multiplicities

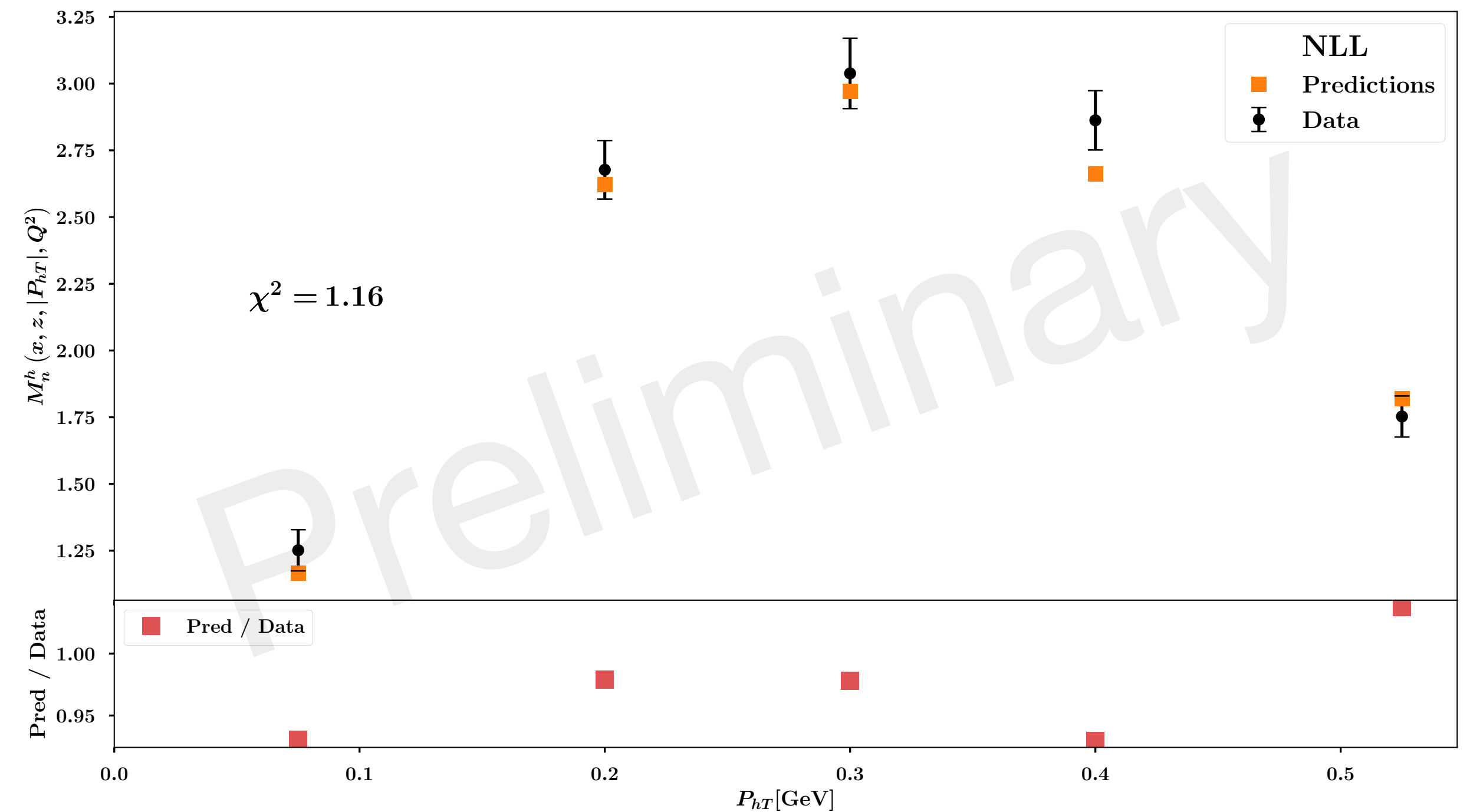
What we expected

$$\langle Q^2 \rangle = 2.9 \text{ GeV}^2$$

$$\langle x \rangle = 0.15$$



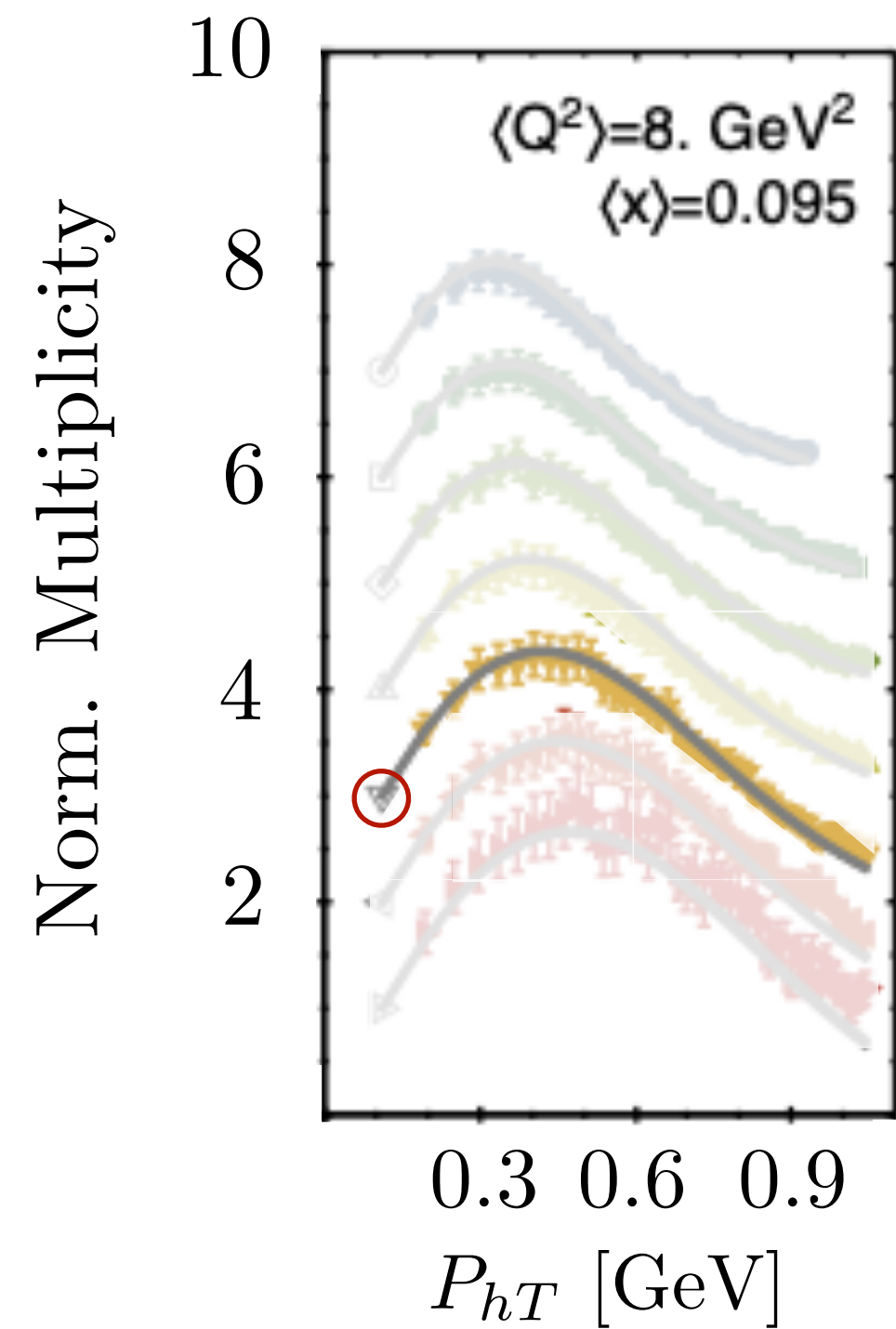
What we found



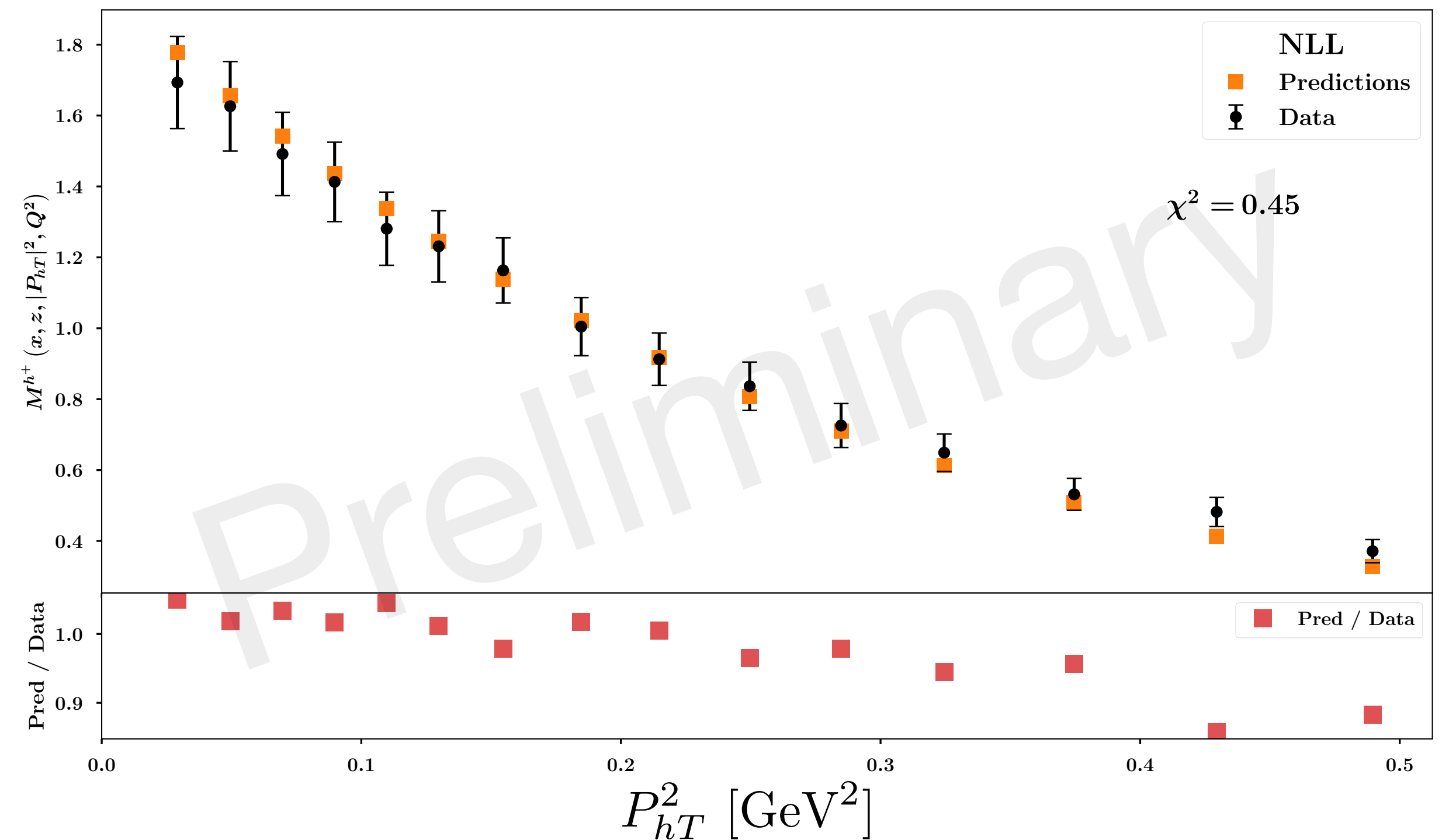
# Results at NLL

## COMPASS multiplicities

What we expected



What we found

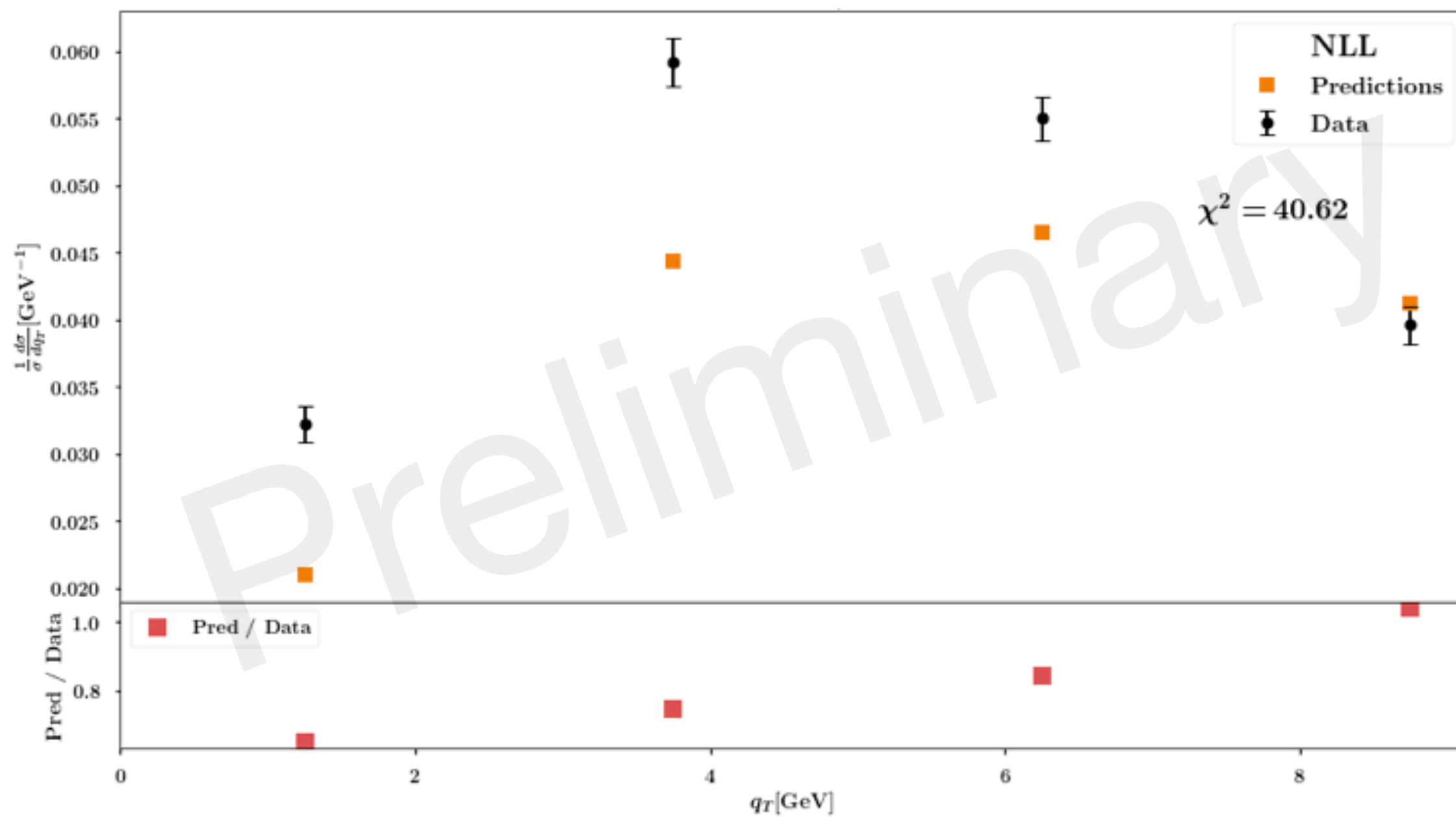


# Results at NLL

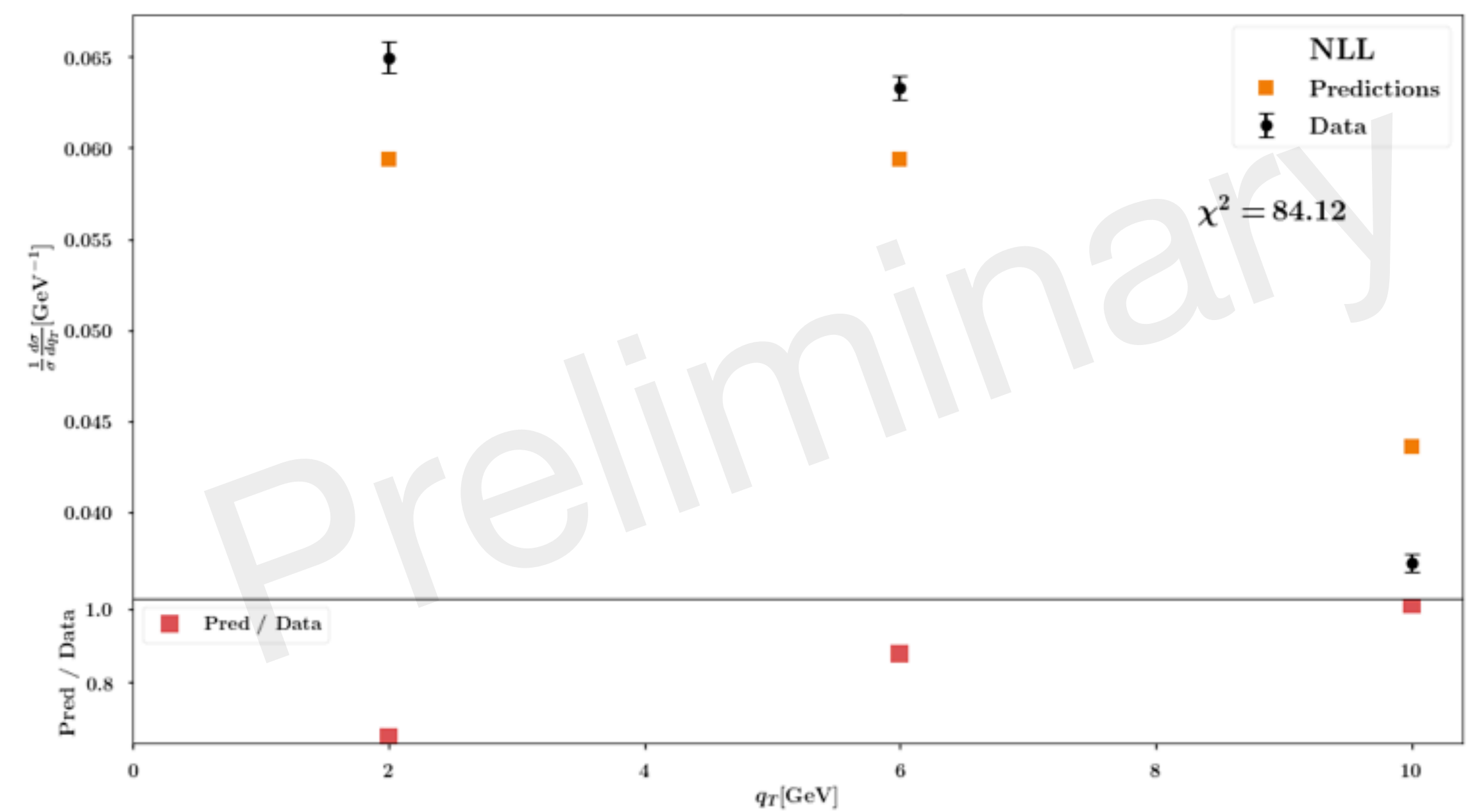
## Drell Yan dataset

We need to increase the accuracy

CMS 7 TeV



D0 Run II muons

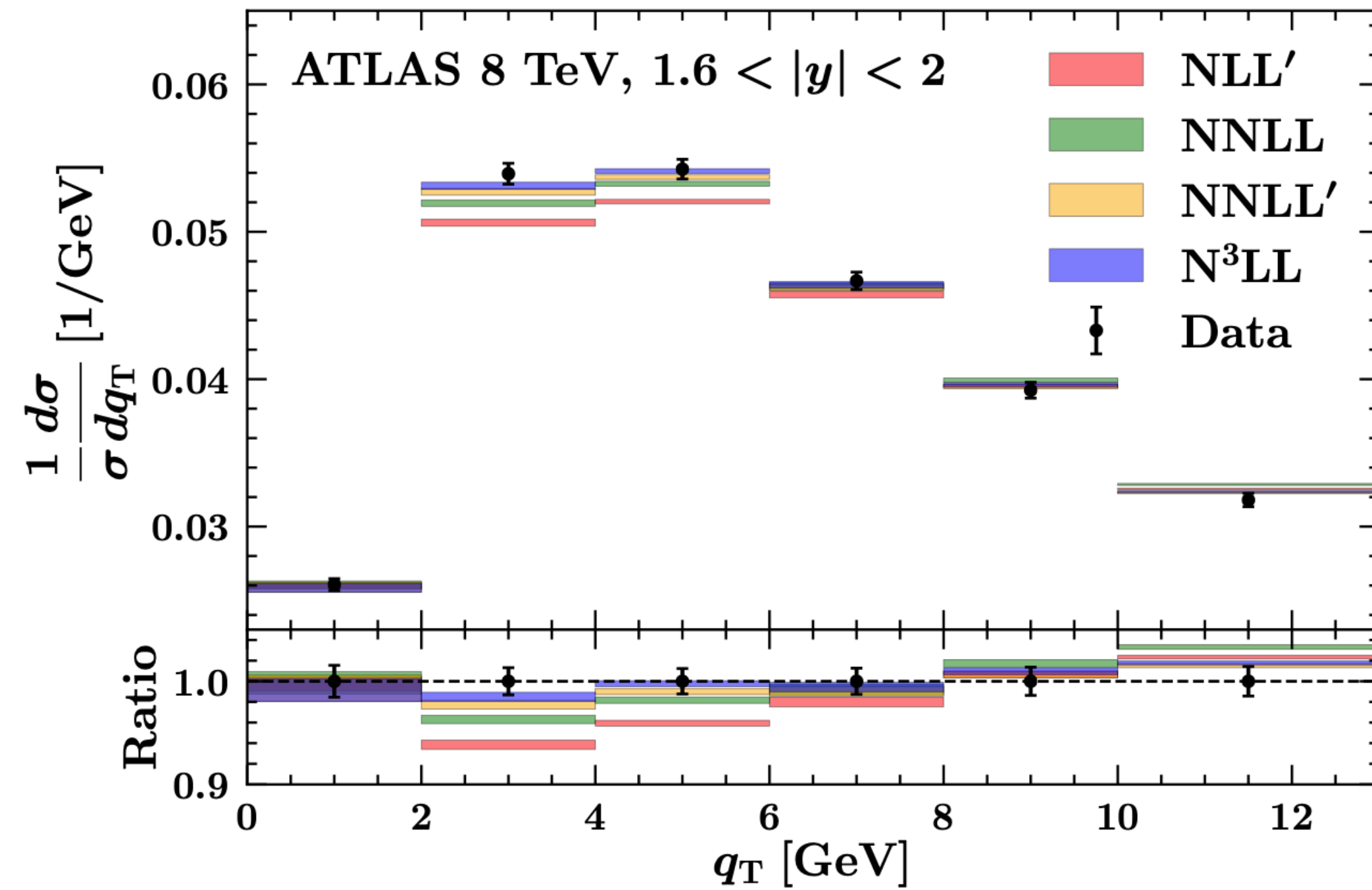




# Beyond NLL...

## Accuracy at NNLL and N3LL

What we expected



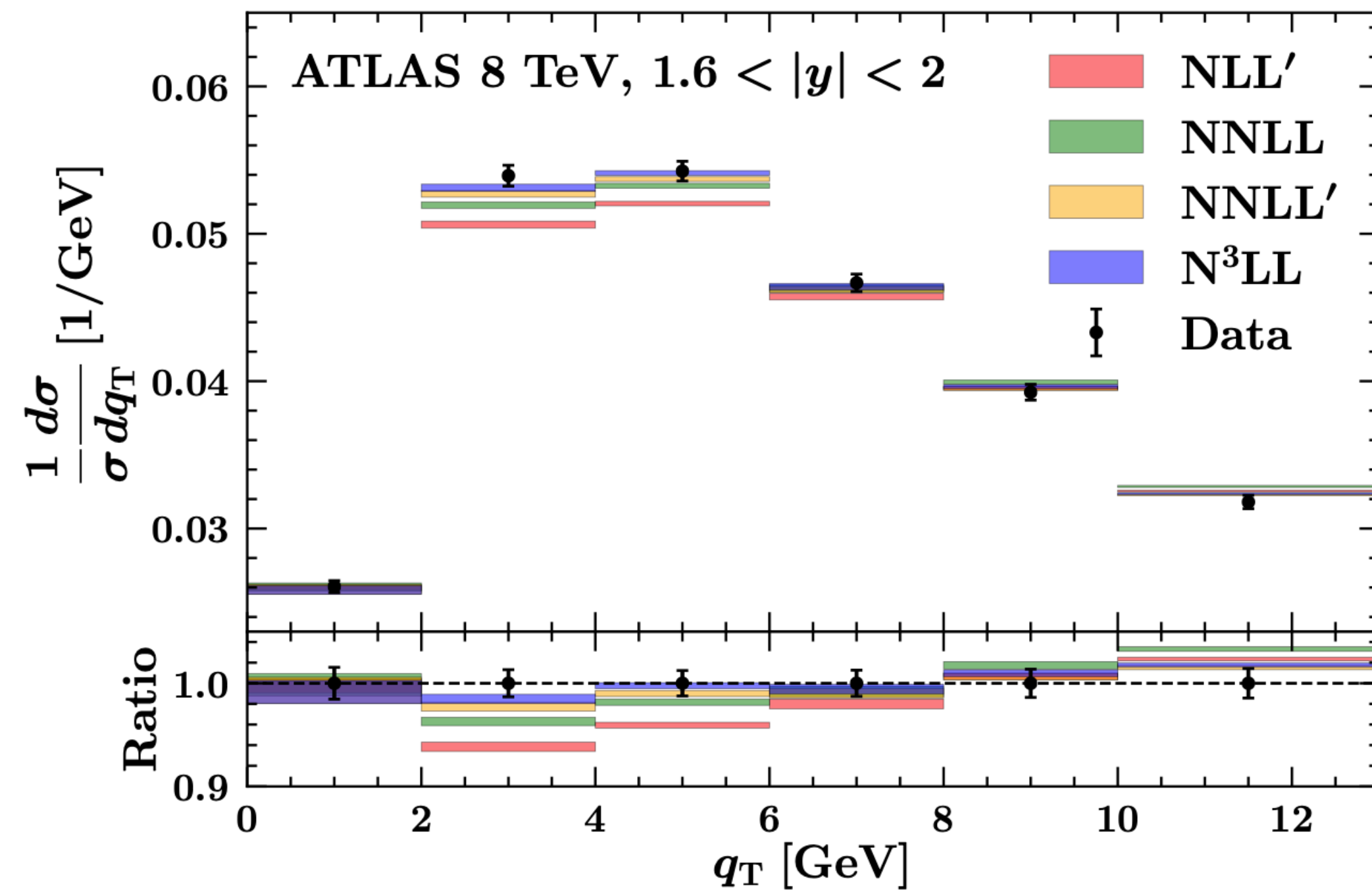
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# Beyond NLL...

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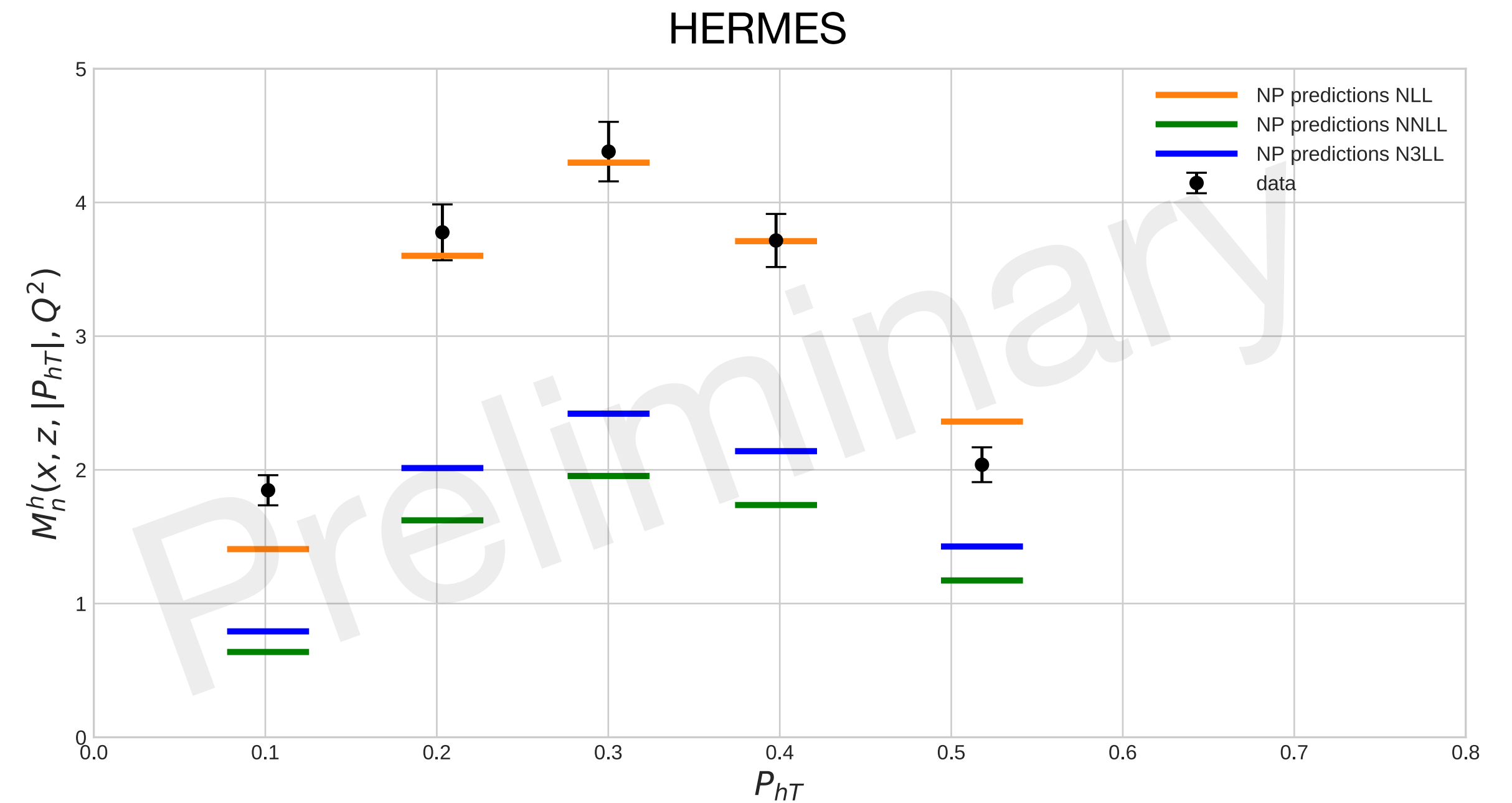
What we expected

$Q \sim 100 \text{ GeV}$



What we get

$Q \sim 2 \text{ GeV}$

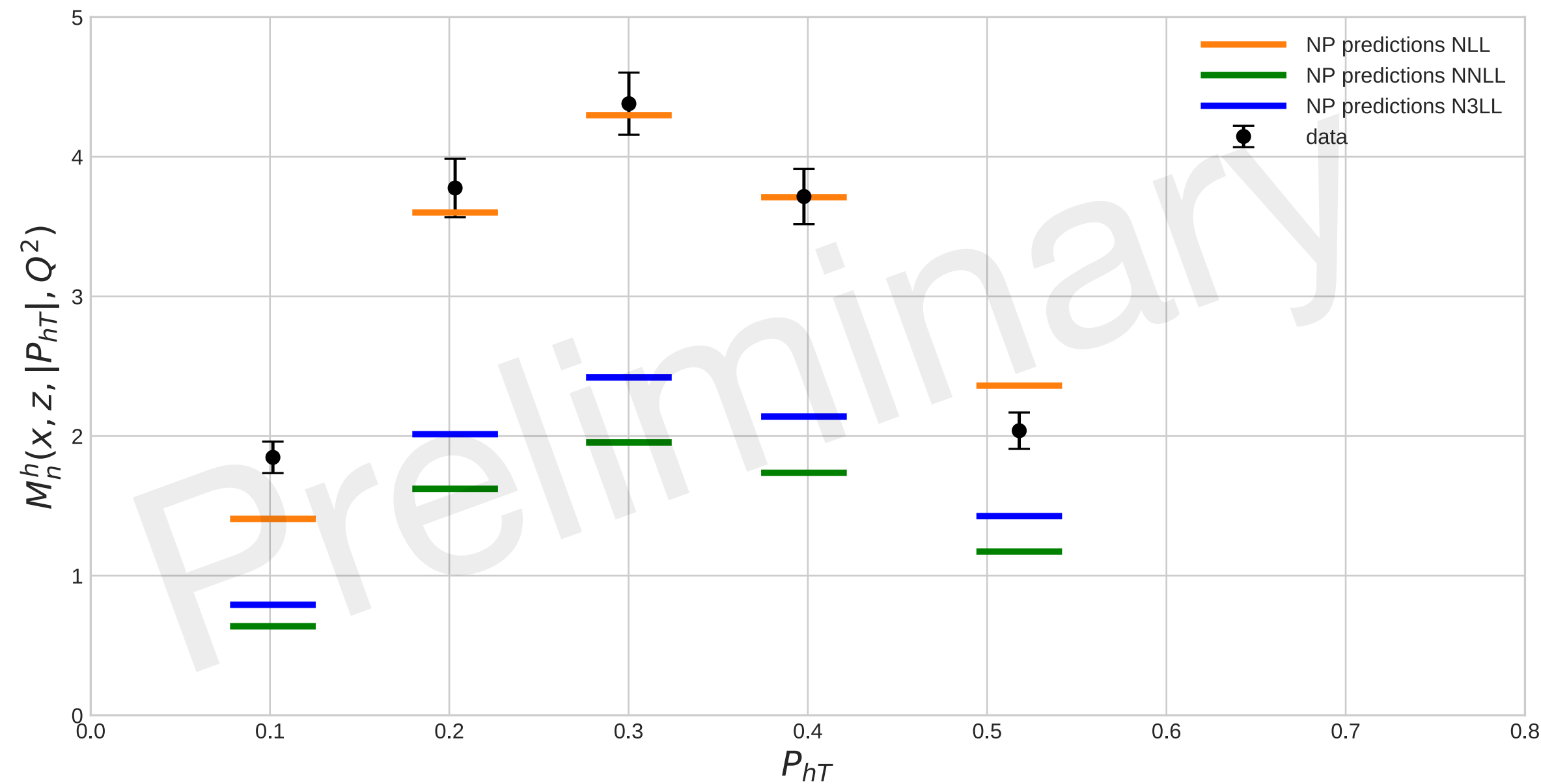


Bacchetta, Bertone, Bissolotti, Bozzi, Delcarro, Piacenza, Radici, arXiv:1912.07550

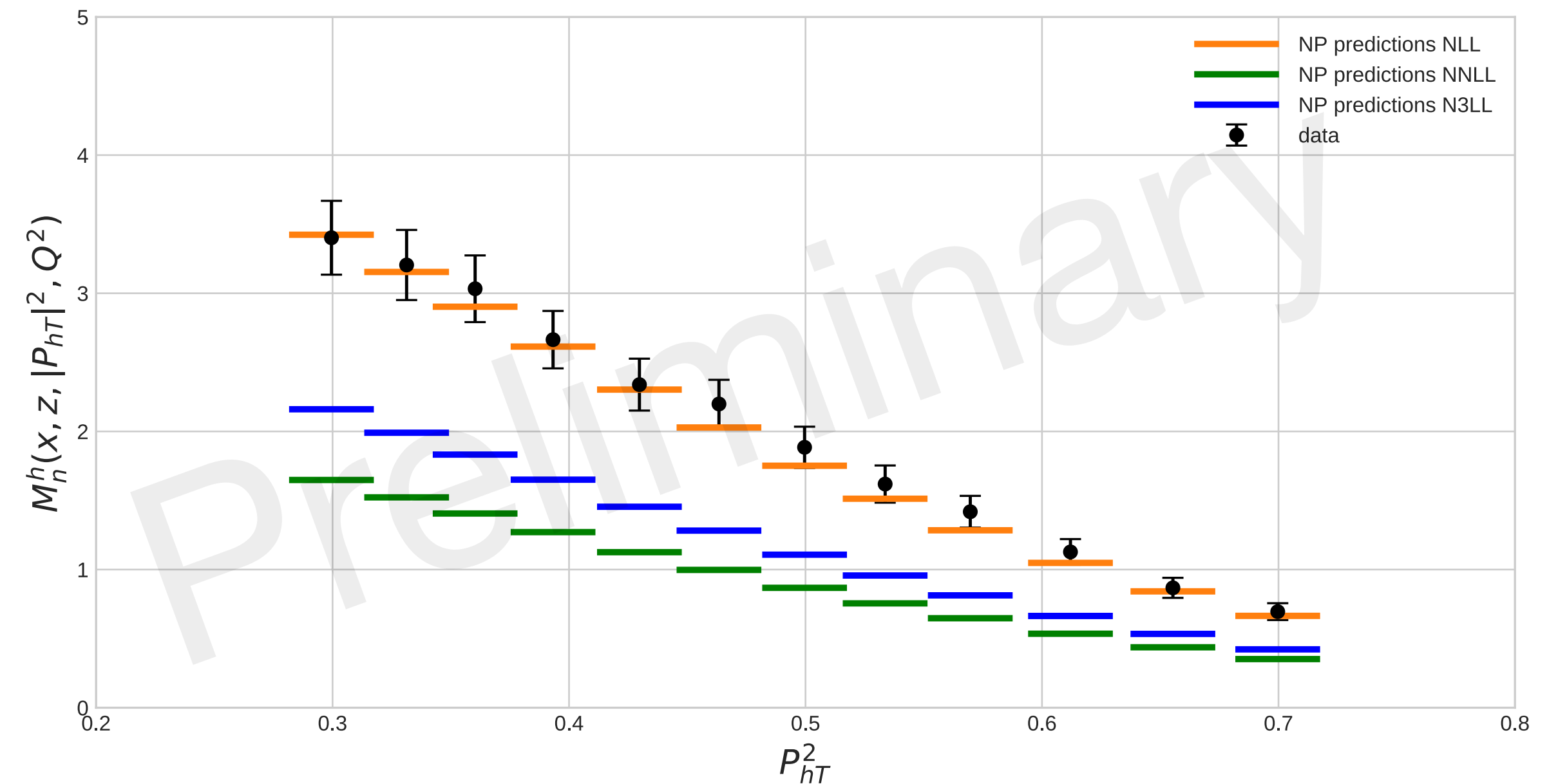
# Beyond NLL...

## Accuracy at NNLL and N3LL

### HERMES multiplicity



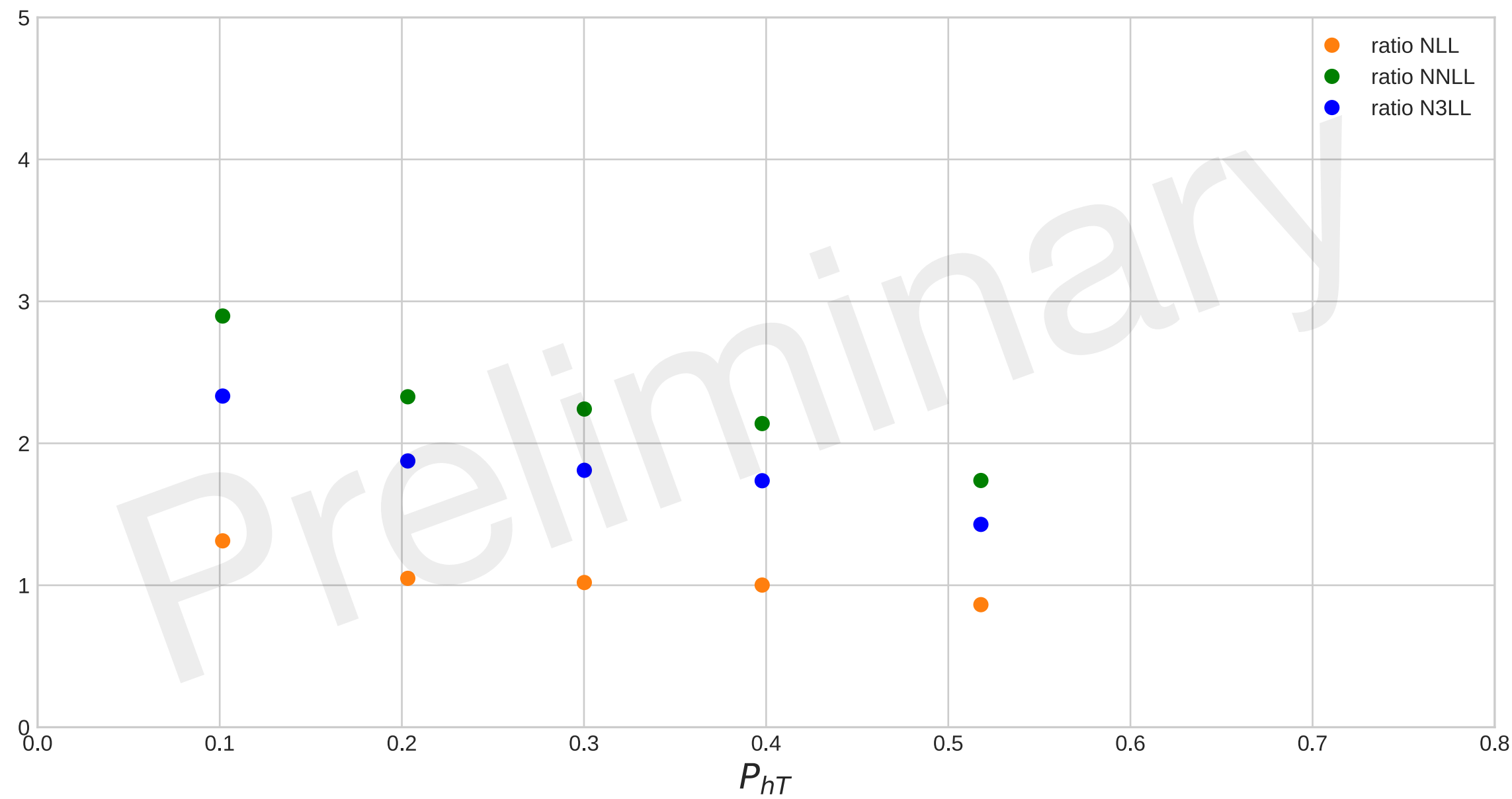
### COMPASS multiplicity



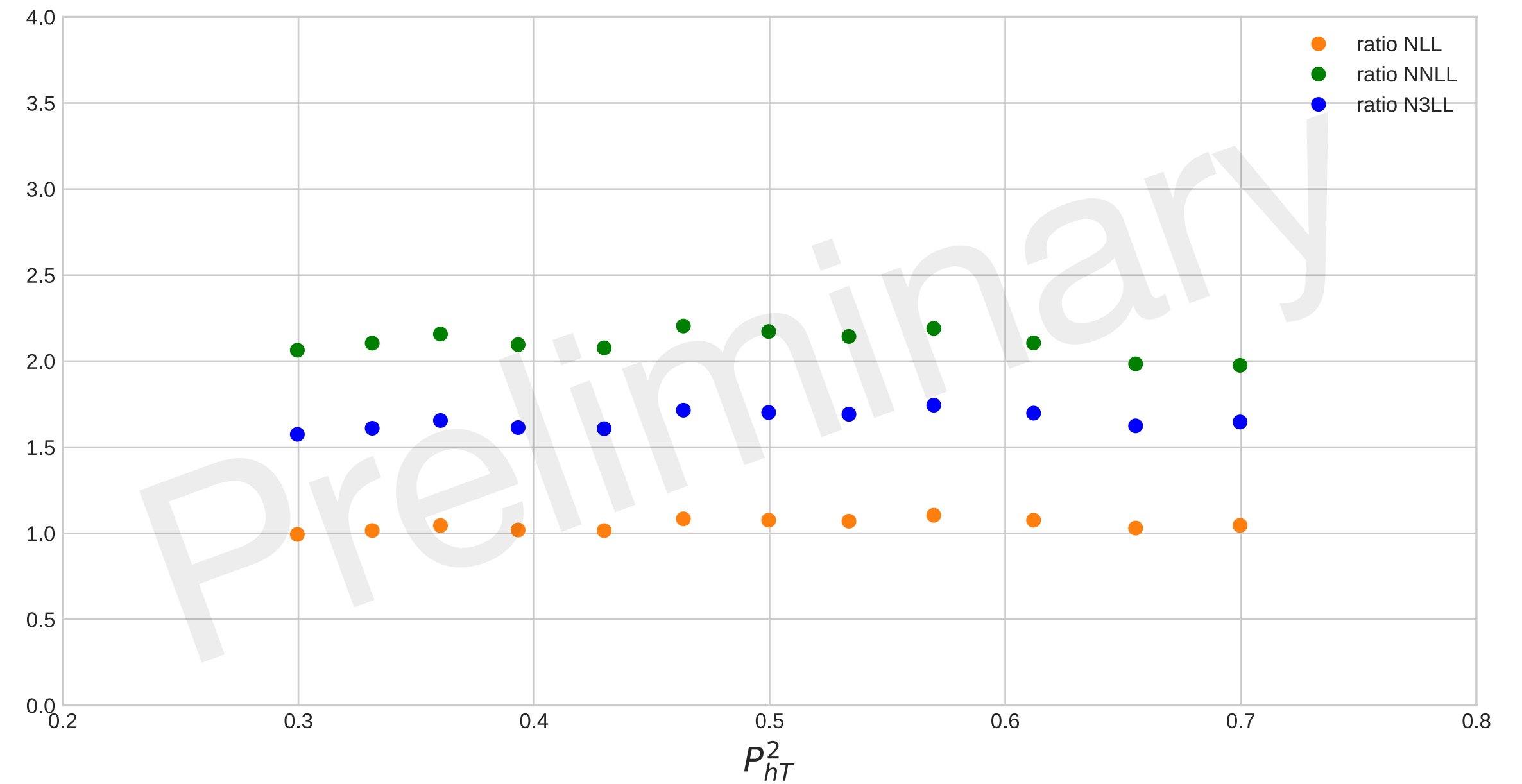
# Beyond NLL...

## Ratio Data/Predictions

HERMES multiplicity



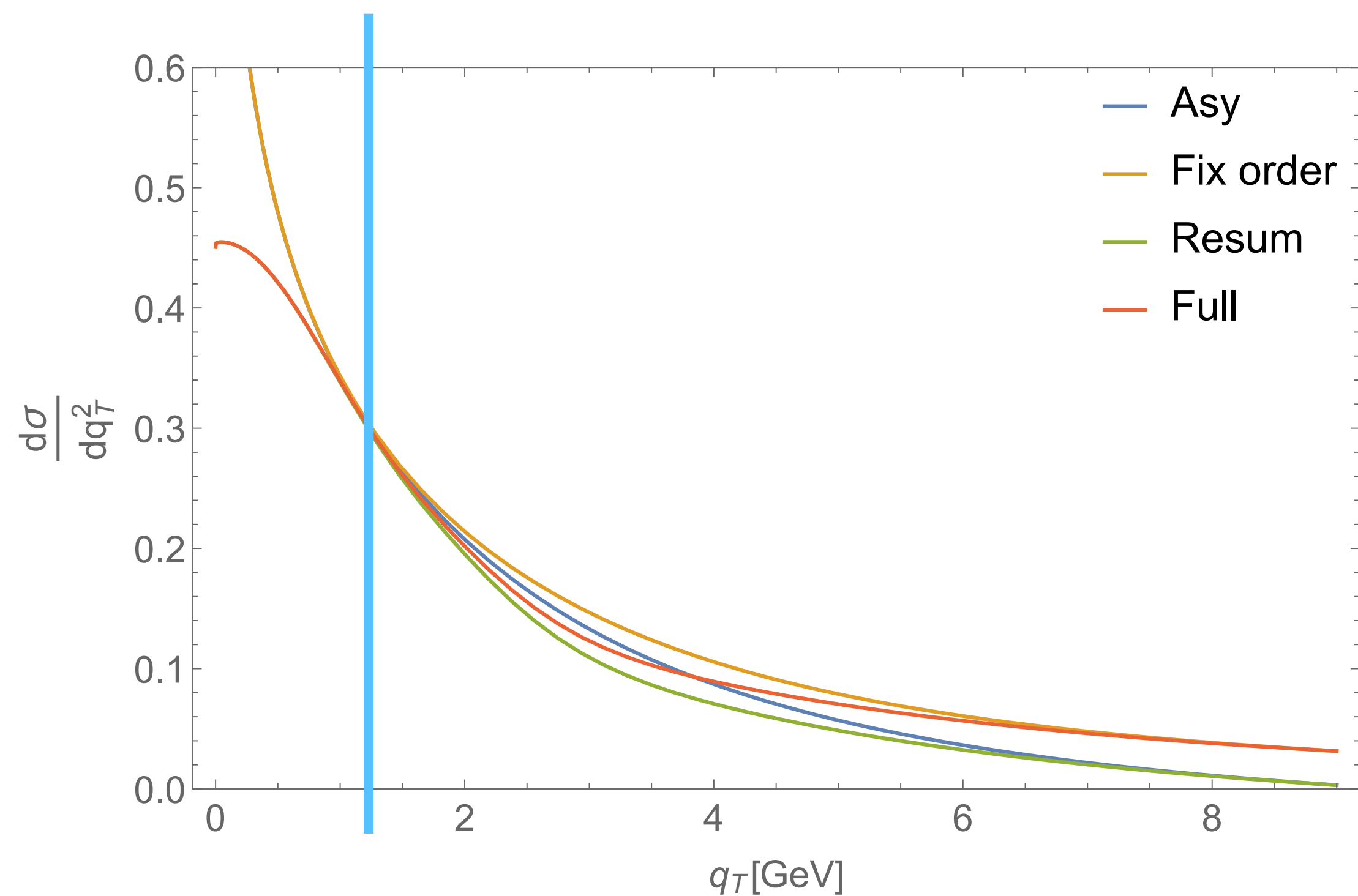
COMPASS multiplicity



Almost constant!

# Where is the problem?

Ideal situation at high Q

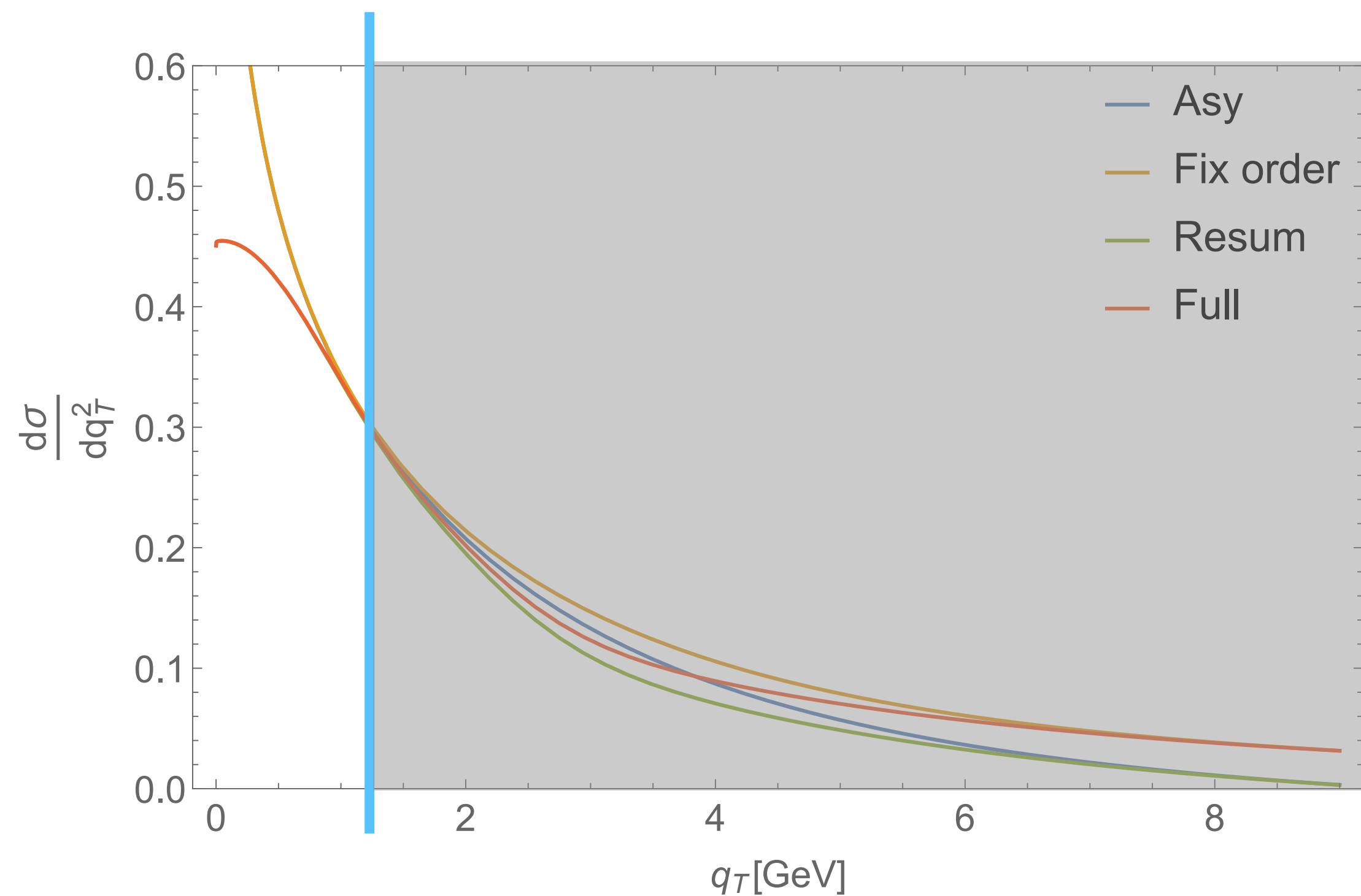


## Standard approach

- Resummed contribution is dominant where the Asymptotic term is close to the Fixed Order

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Ideal situation at high Q

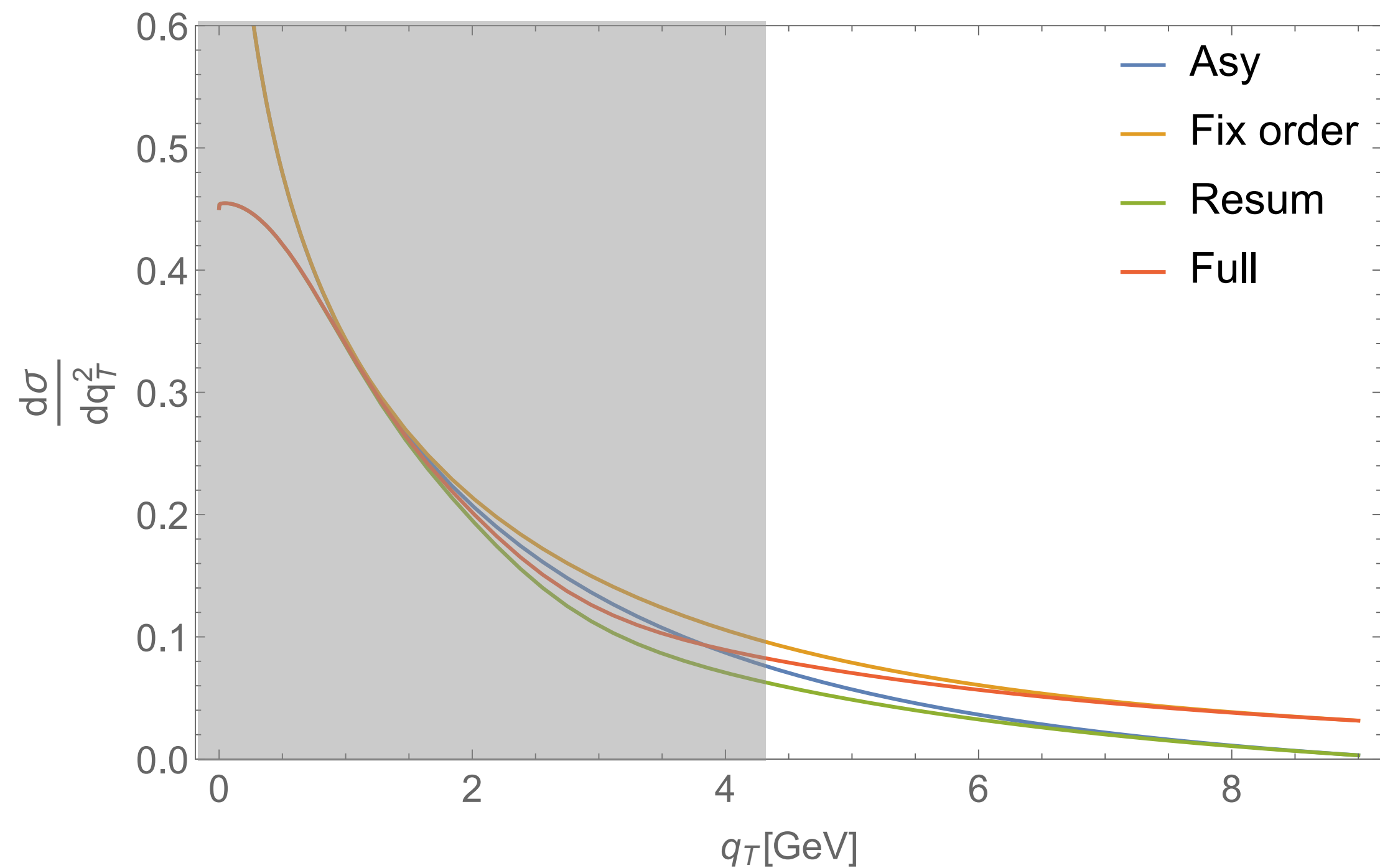


## Standard approach

- Resummed contribution is dominant where the Asymptotic term is close to the Fixed Order  $\longrightarrow$  **TMD Region**

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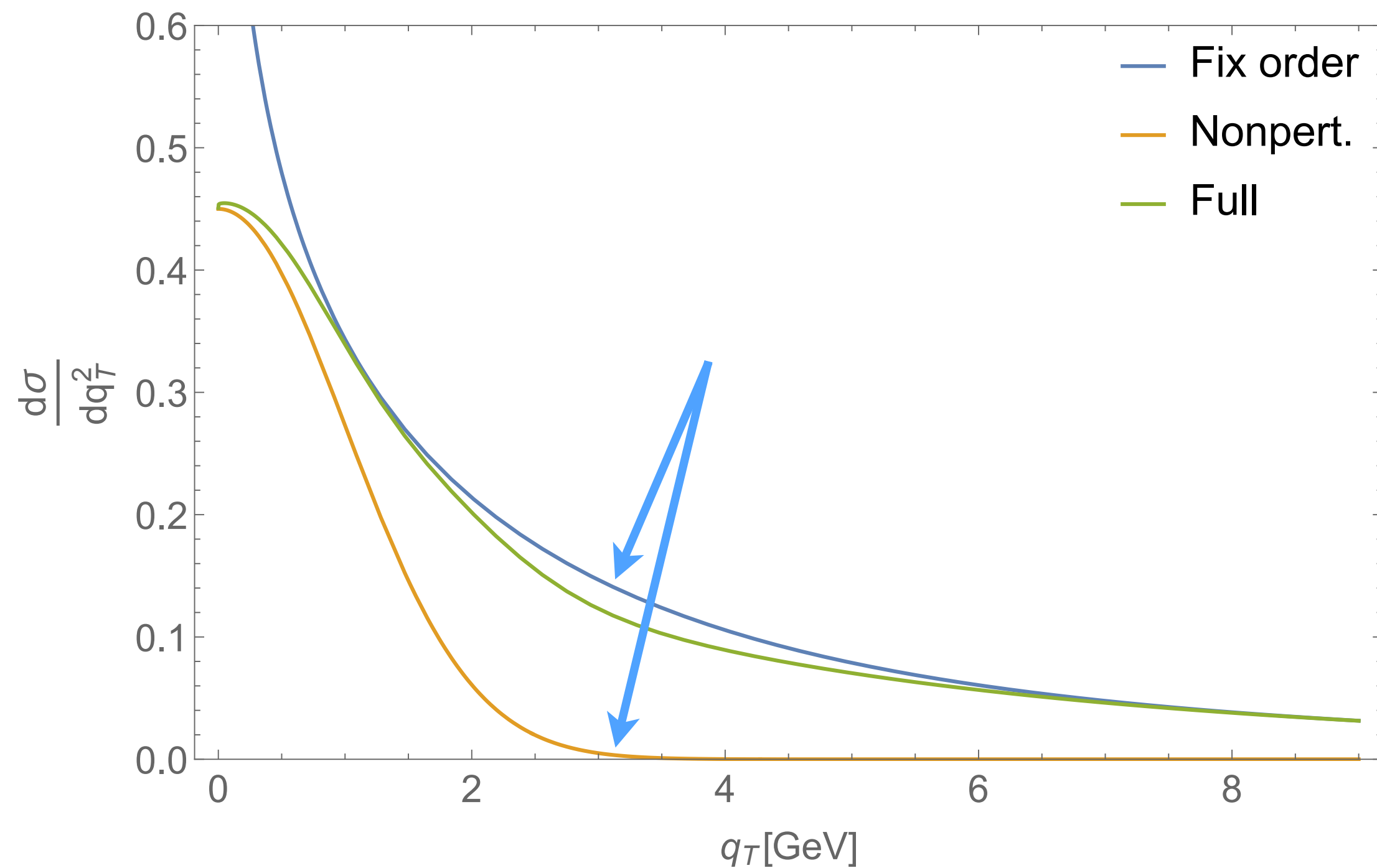


## Standard approach

- Resummed contribution is dominant where the Asymptotic term is close to the Fixed Order
- From a certain value of  $q_T$  the total cross section follows the Fixed Order term

# Where is the problem?

Ideal situation at high Q



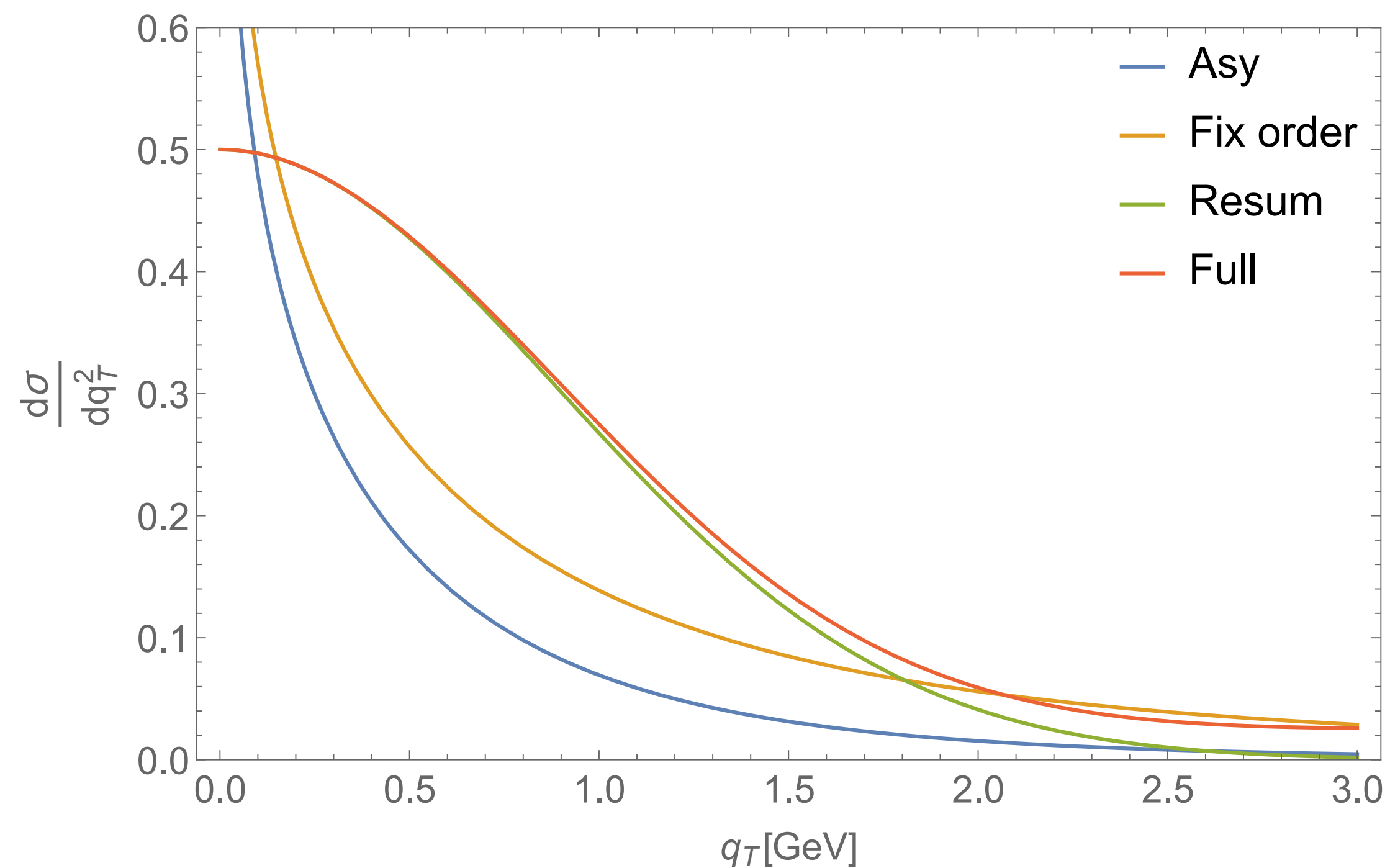
## Standard approach

- Collinear result is mostly given by the integral of the Fixed Order
- The Non-Perturbative term is only a small correction



# Where is the problem?

Real situation at low Q

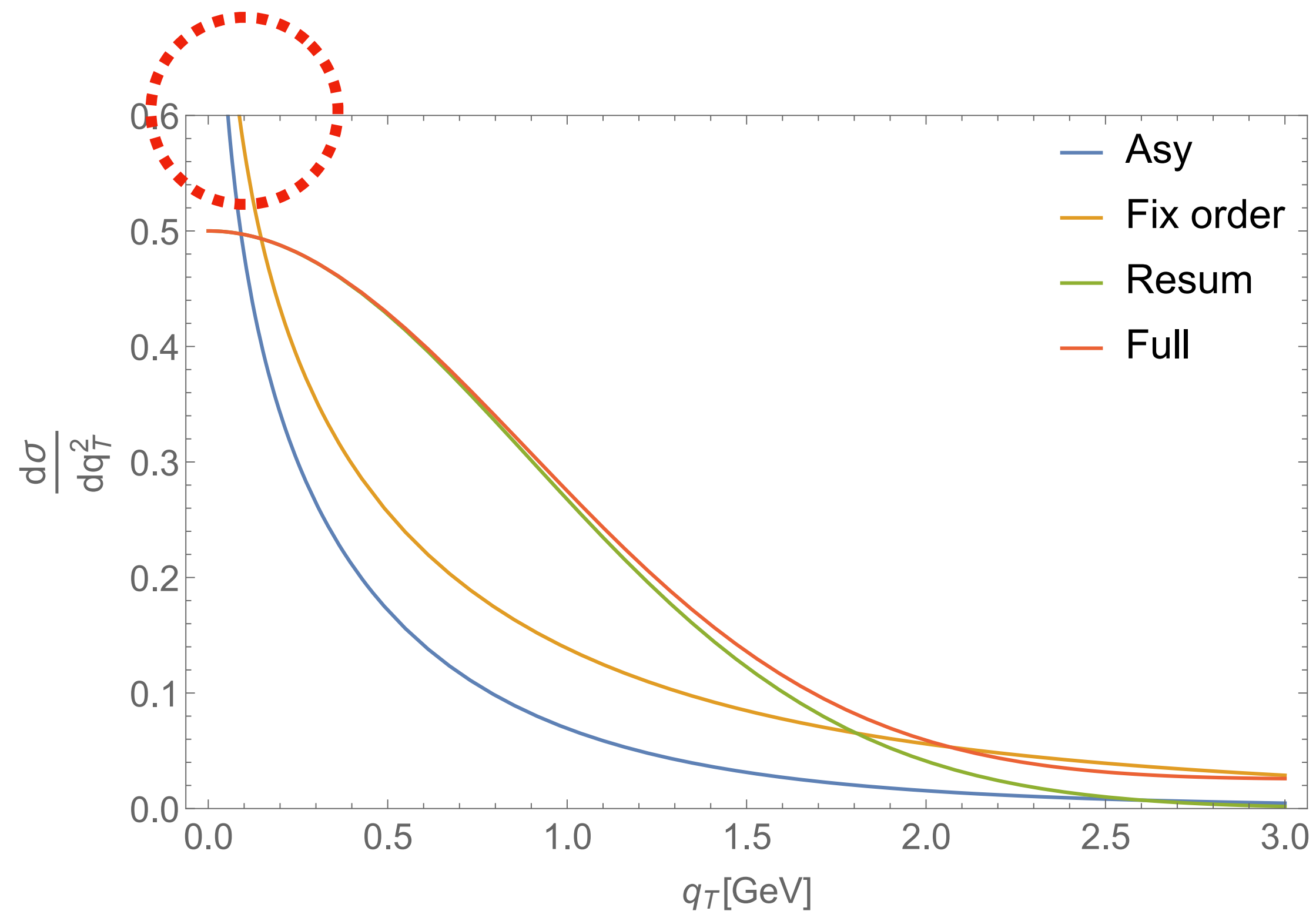


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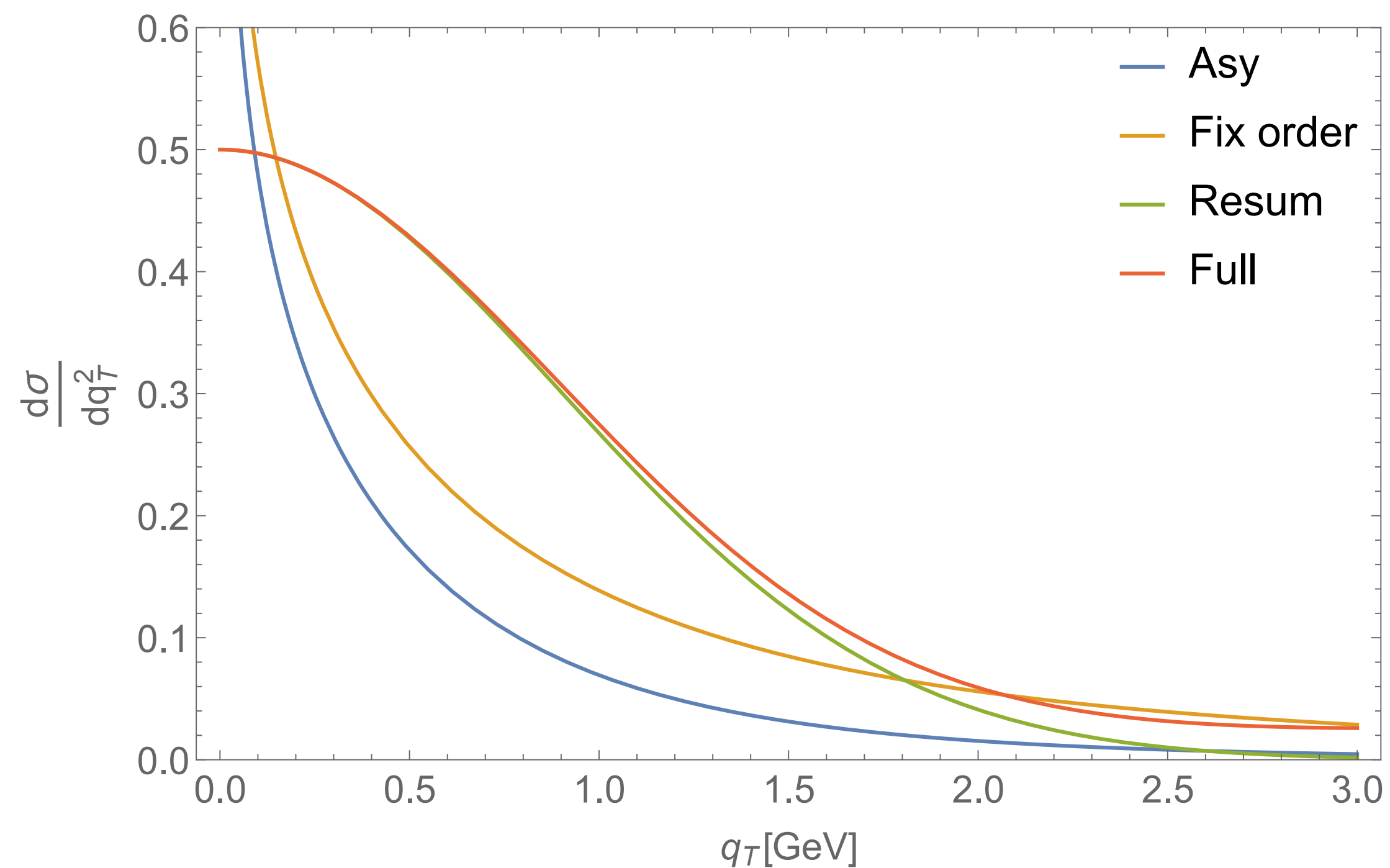


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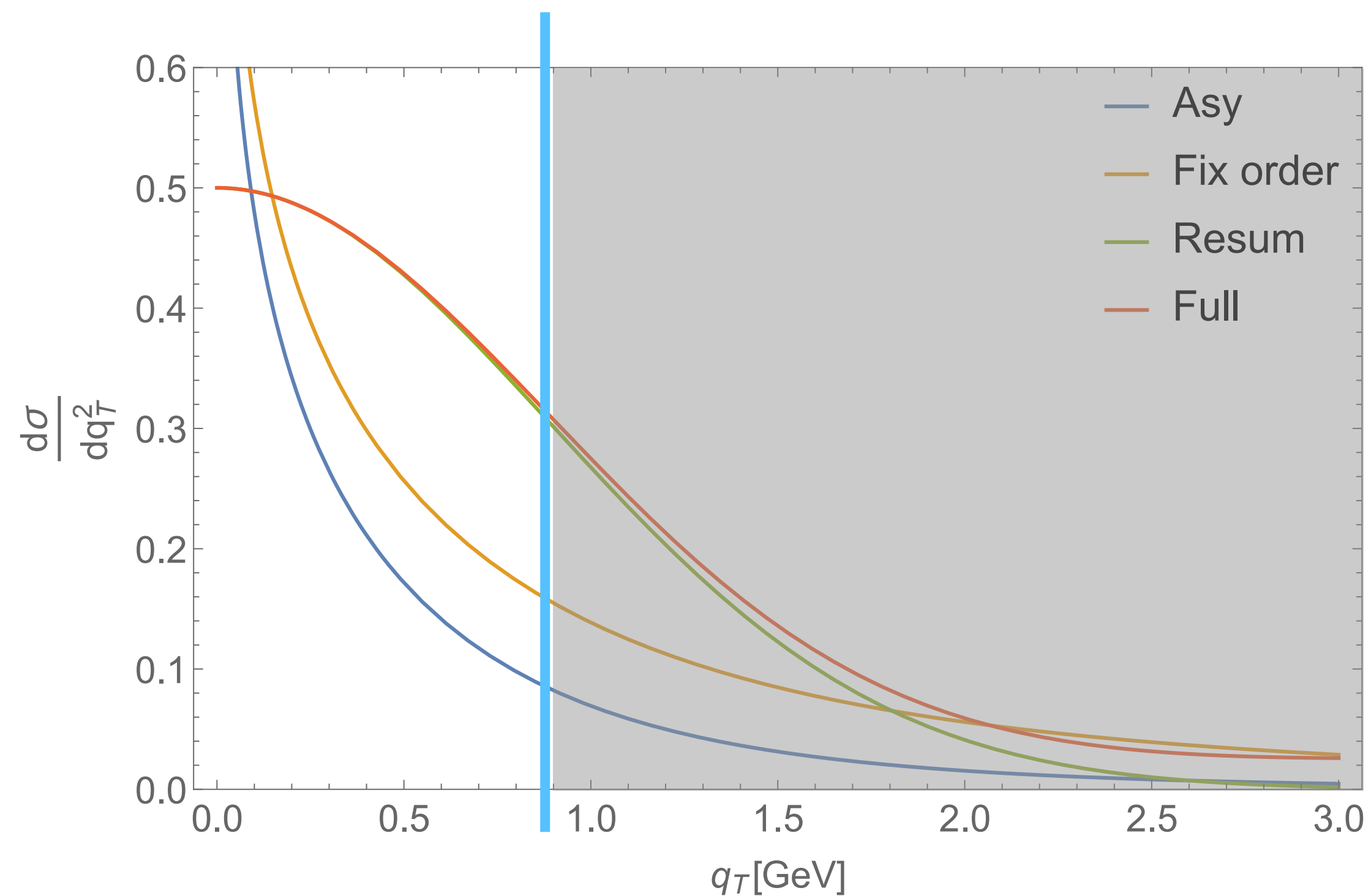


## Non-Perturbative approach

- Resummed contribution is dominant where the Asymptotic term is close to the Fixed Order OR the Non-Perturbative contributions dominates

# Where is the problem?

Real situation at low Q



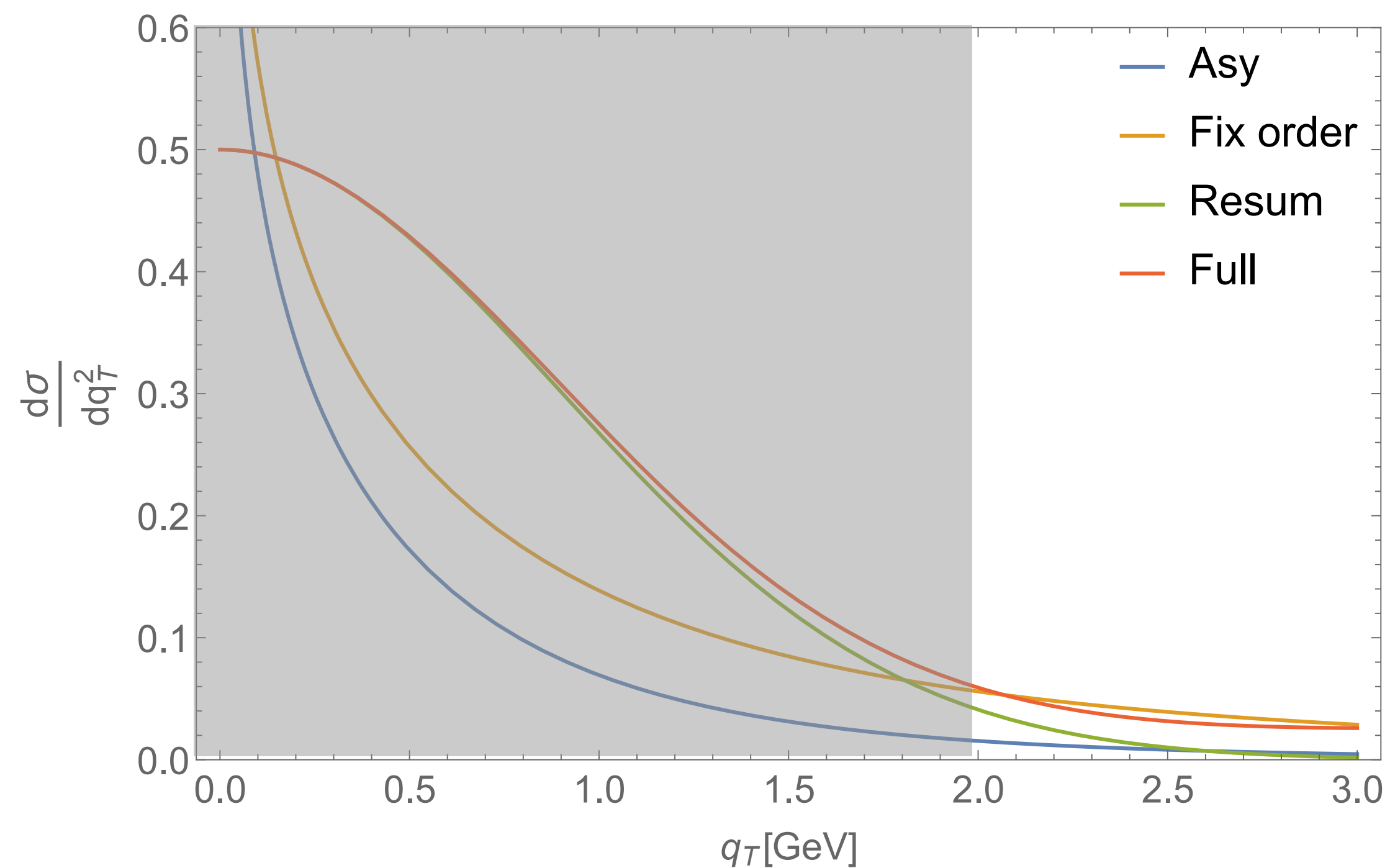
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→ TMD Region

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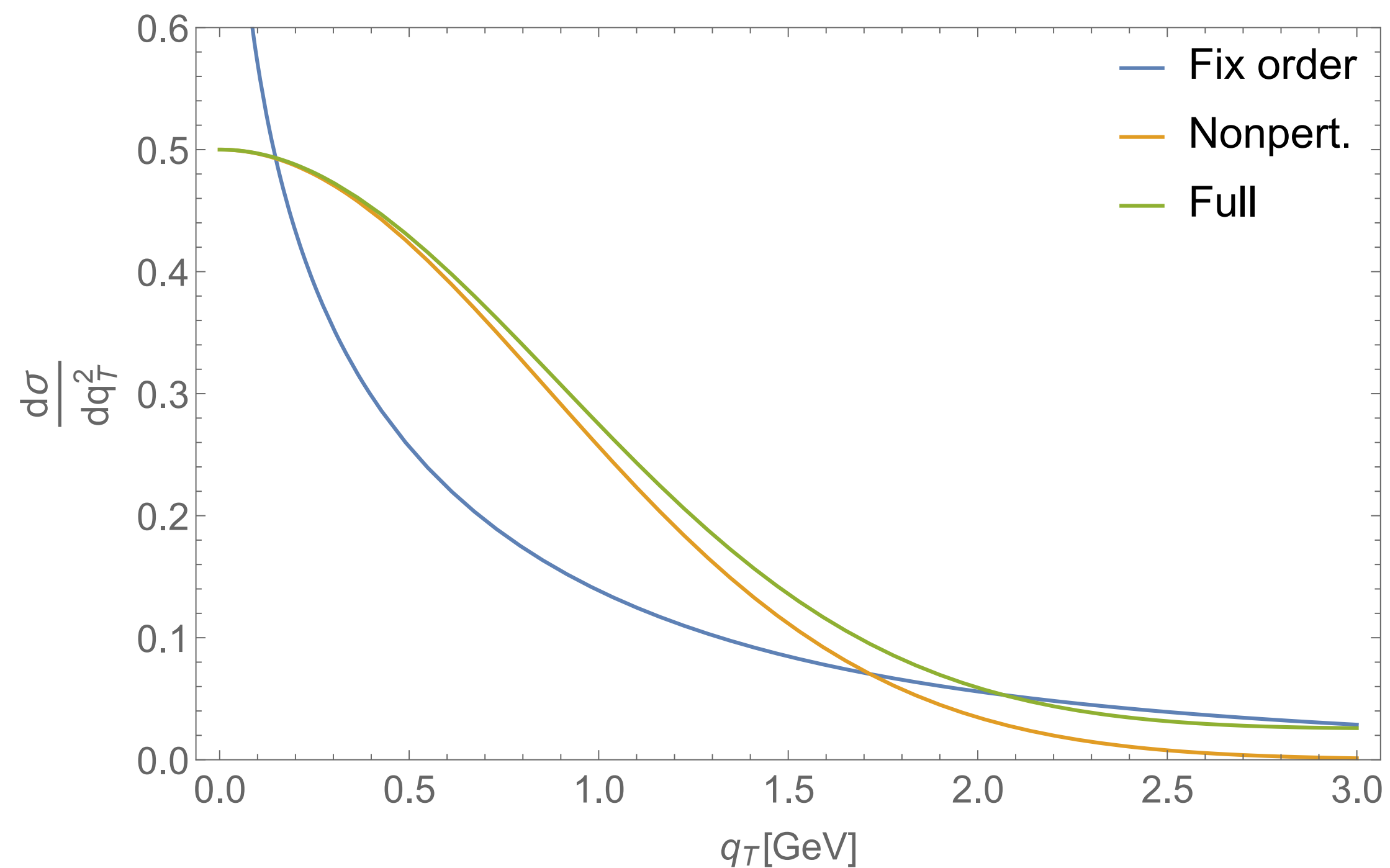


## Non-Perturbative approach

- Resummed contribution is dominant where the Asymptotic term is close to the Fixed Order OR the Non-Perturbative contributions dominates
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# Where is the problem?

Real situation at low Q

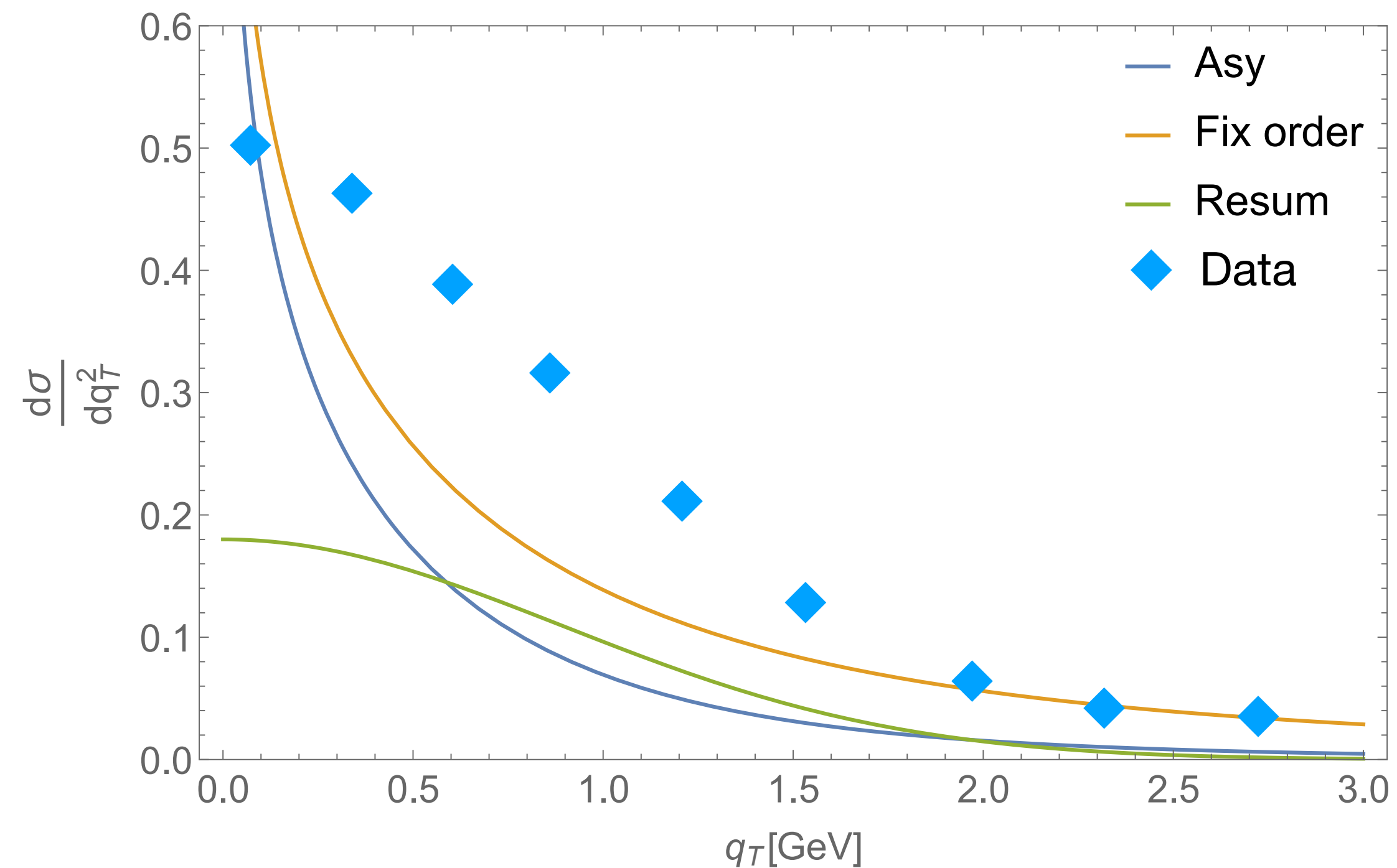


## Non-Perturbative approach

- Collinear result is no more mostly given by the integral of the Fixed Order
- The Non-Perturbative term is not only a small correction, but is even larger than the Fixed Order contribution

# Where is the problem?

Present situation at low Q



- The Resummed contribution is too small to explain the experimental data
- The Resummed contribution should have been dominant at low Q
- Suppression due to higher order contributions in the Hard Factor

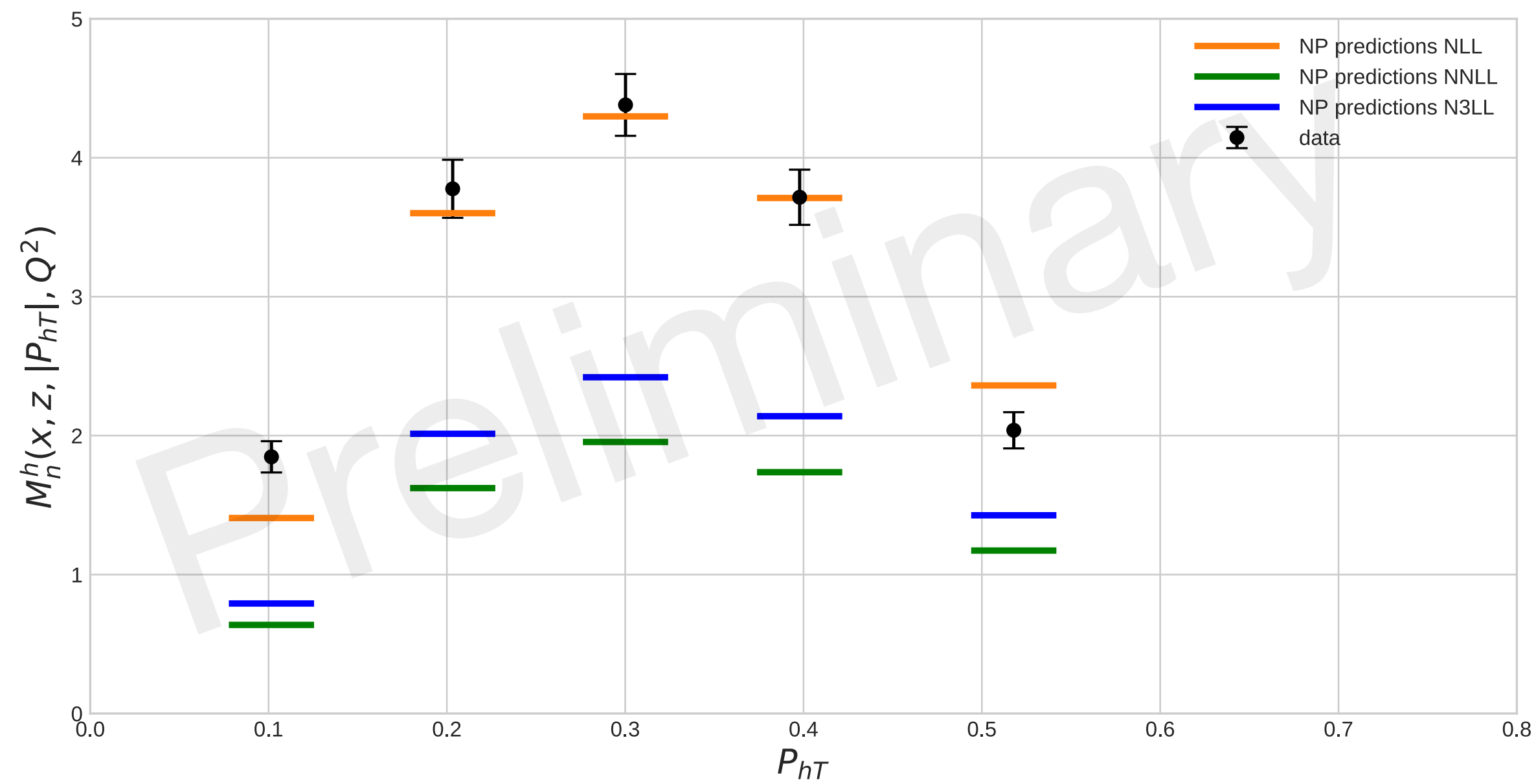


# Where is the problem?

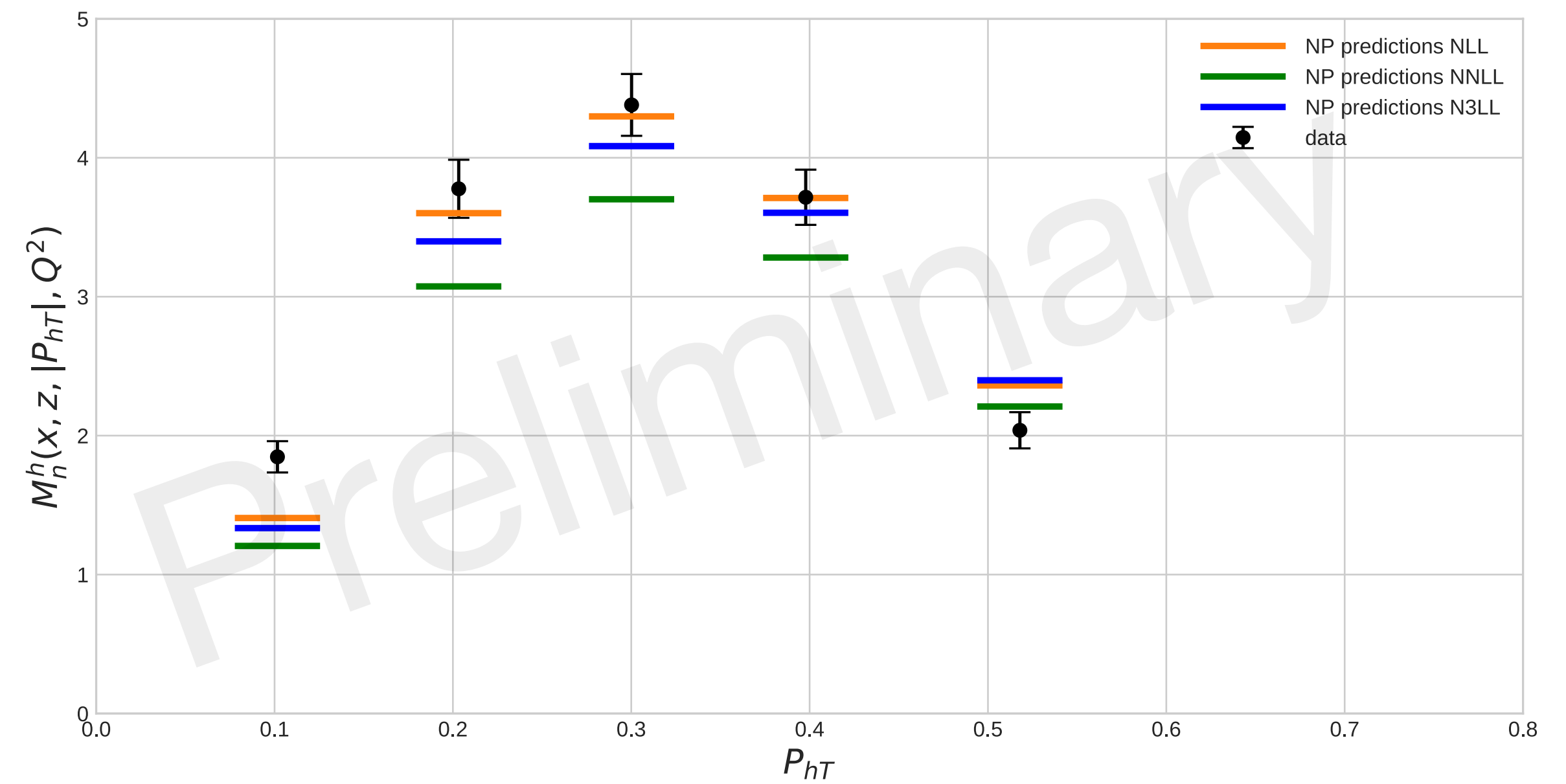
Present situation at low Q

HERMES multiplicity

Full Hard Factor



Hard Factor = 1





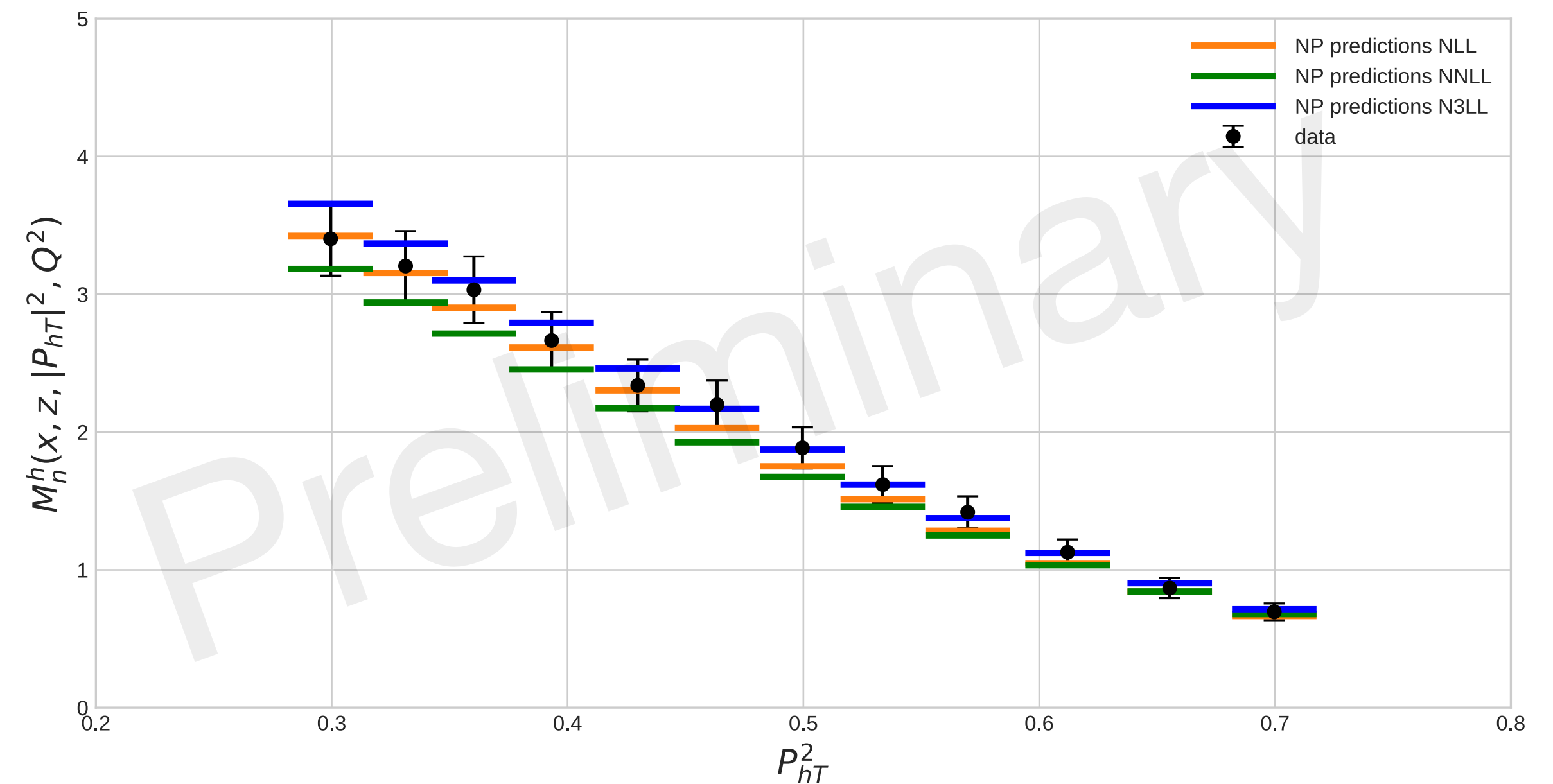
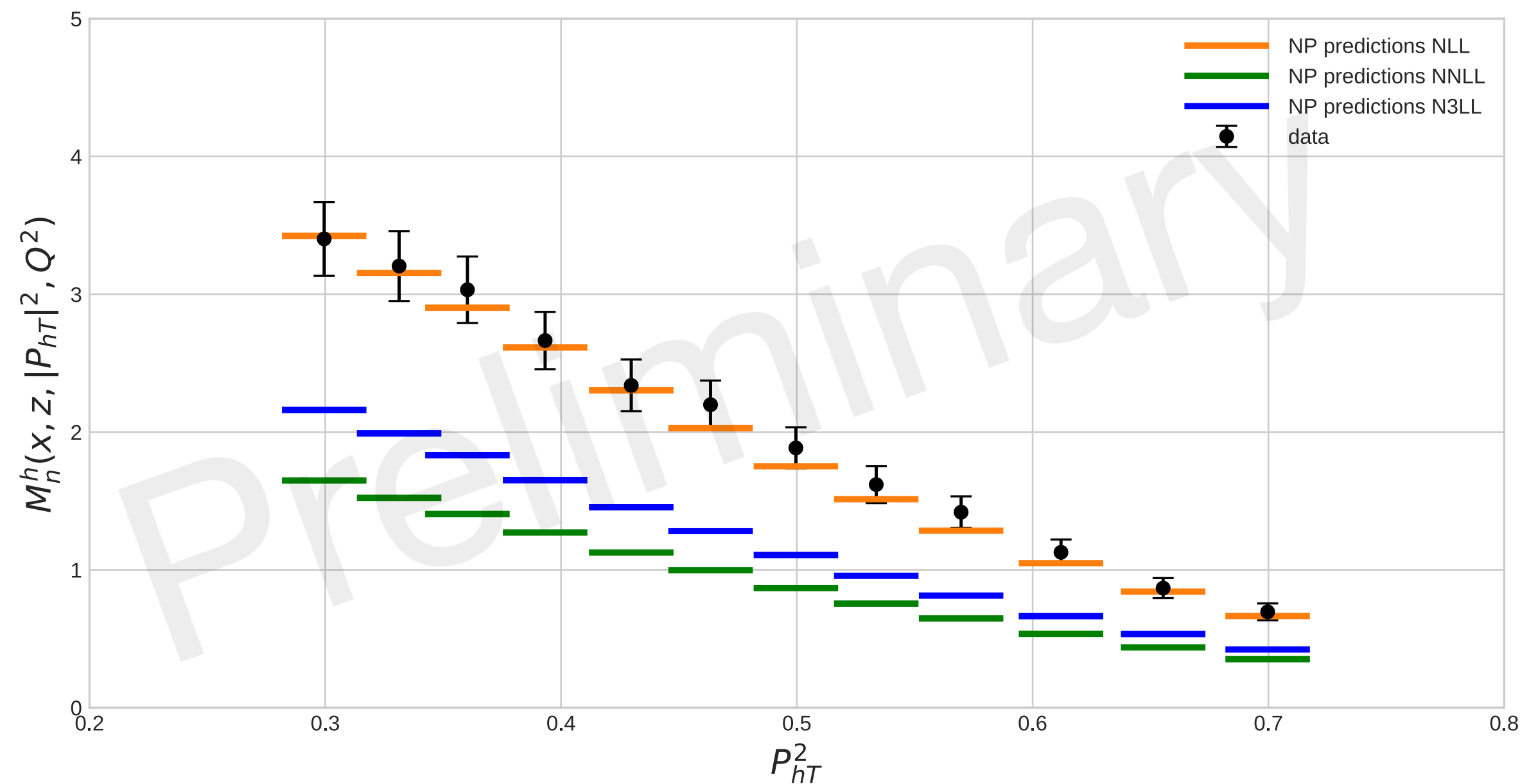
# Where is the problem?

Present situation at low Q

COMPASS multiplicity

Full Hard Factor

Hard Factor = 1



# Our possible solution

Introduction of a normalization prefactor that restores the real situation at low  $Q$

$$w(x, z, Q) = \frac{\frac{d\sigma^h}{dx dQ^2 dz}}{\int W d^2 \mathbf{q}_T}$$

*Proposed by F. Piacenza in his Ph.D. thesis*

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Introduction of a normalization prefactor that restores the real situation at low Q

$$w(x, z, Q) = \frac{\frac{d\sigma^h}{dx dQ^2 dz}}{\int W d^2 \mathbf{q}_T}$$

$$\left. \frac{d\sigma^h}{dx dQ^2 dz} \right|_{O(\alpha_S)} = \sigma_0 \sum_{f, f'} \frac{e_f^2}{z^2} (\delta_{f'f} + \delta_{f'g}) \frac{\alpha_S}{\pi} \left\{ [D_1^{h/f'} \otimes C_1^{f'f} \otimes f_1^{f/N}](x, z, Q) + \frac{1-y}{1+(1-y)^2} [D_1^{h/f'} \otimes C_L^{f'f} \otimes f_1^{f/N}](x, z, Q) \right\}$$

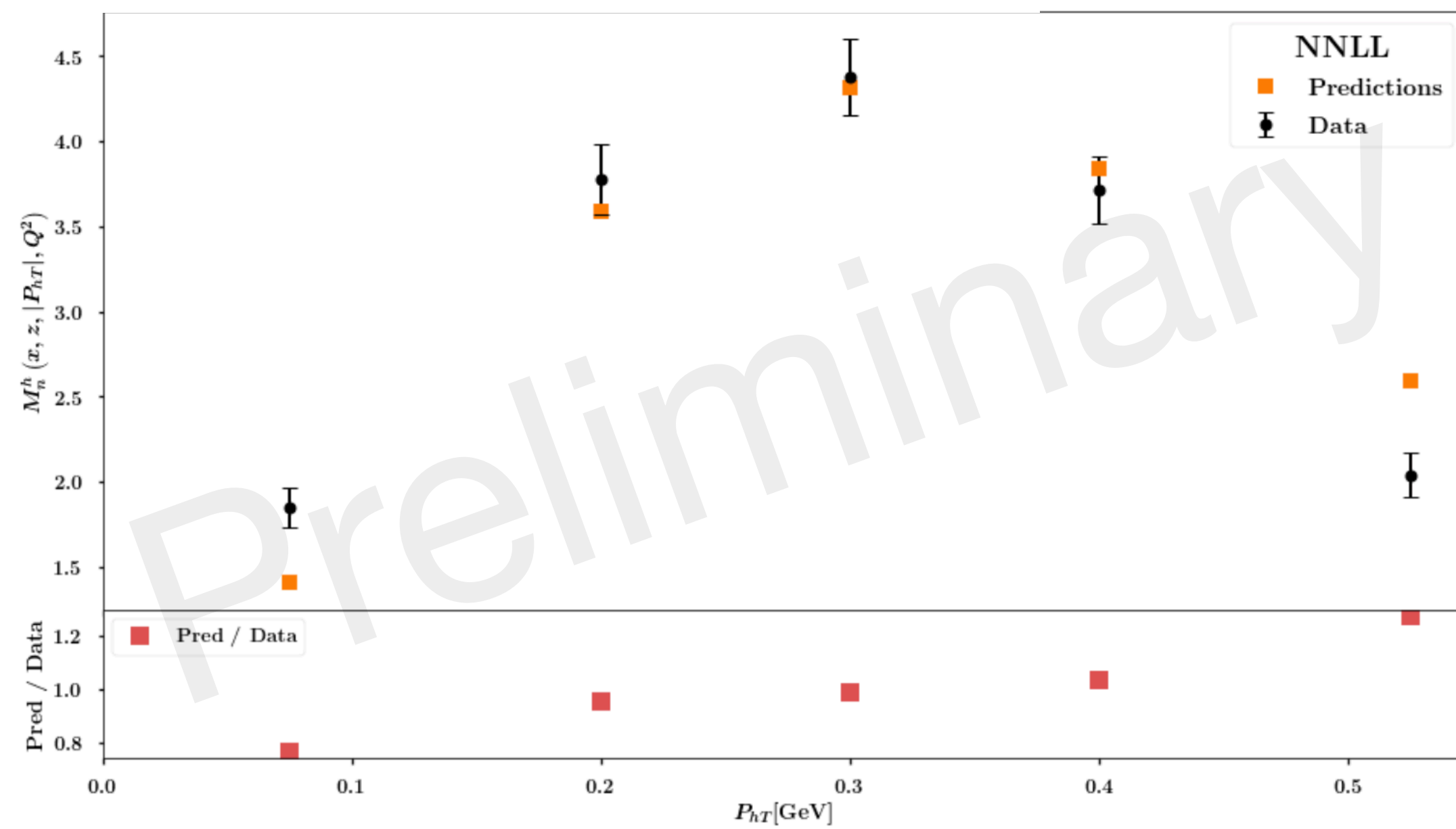
$$\int W \Big|_{O(\alpha_S)} = \sigma_0 \sum_{f, f'} \frac{e_f^2}{z^2} (\delta_{f'f} + \delta_{f'g}) \frac{\alpha_S}{\pi} [D_1^{h/f'} \otimes C_{\text{TMD}}^{f'f} \otimes f_1^{f/N}](x, z, Q)$$

*Proposed by F. Piacenza in his Ph.D. thesis*

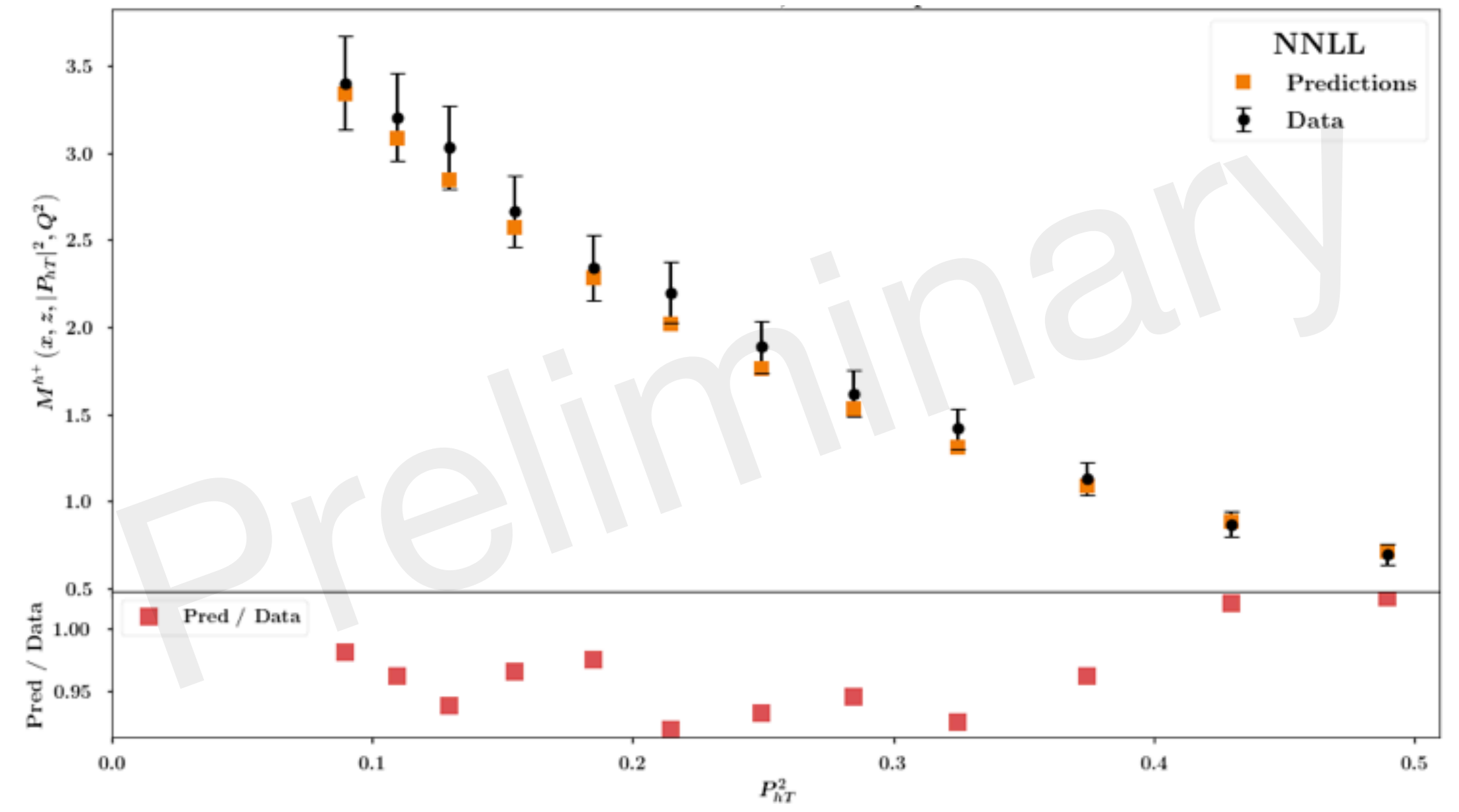
# Outcome

Predictions with the inclusion of the normalization prefactors

HERMES multiplicity



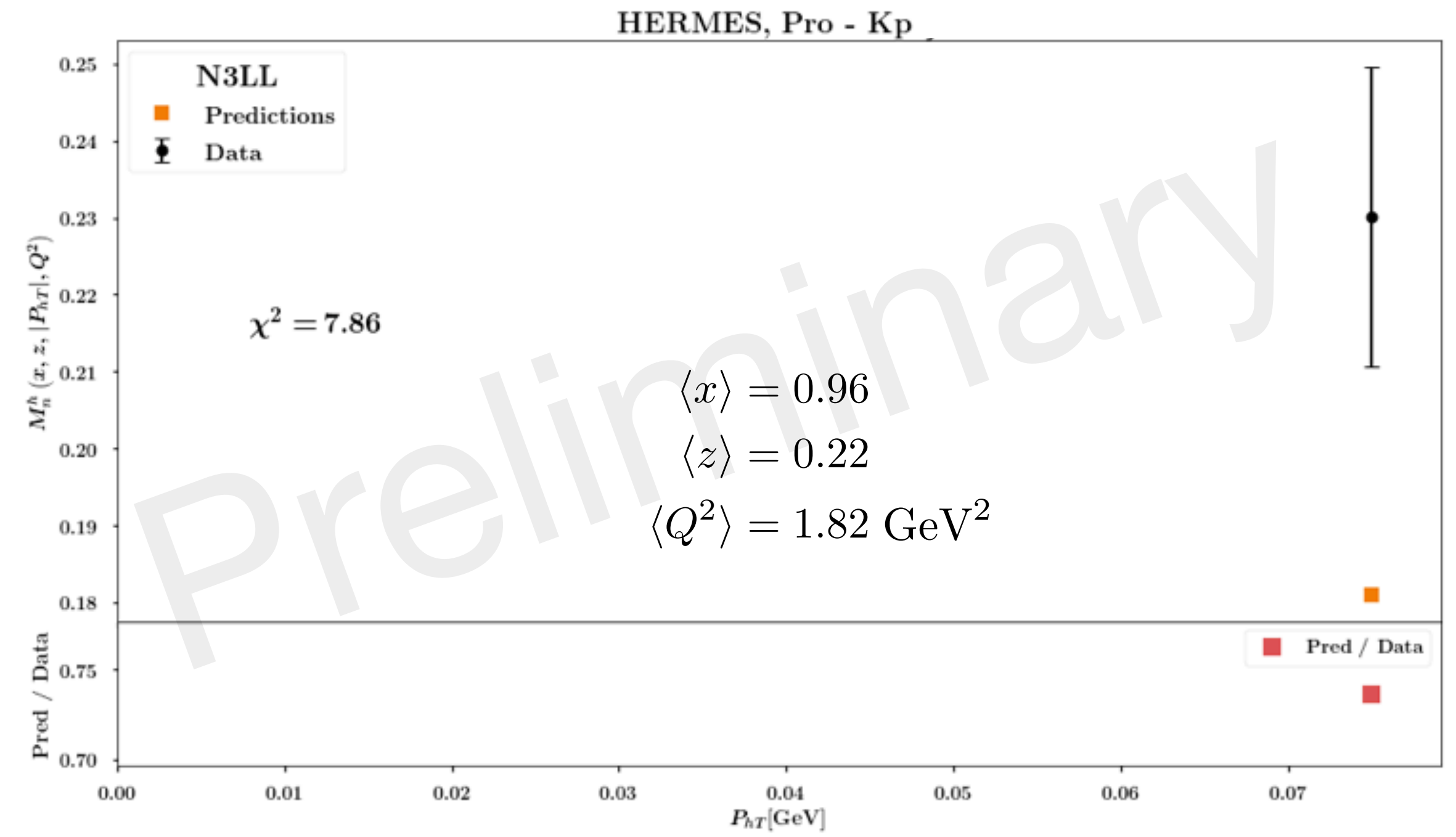
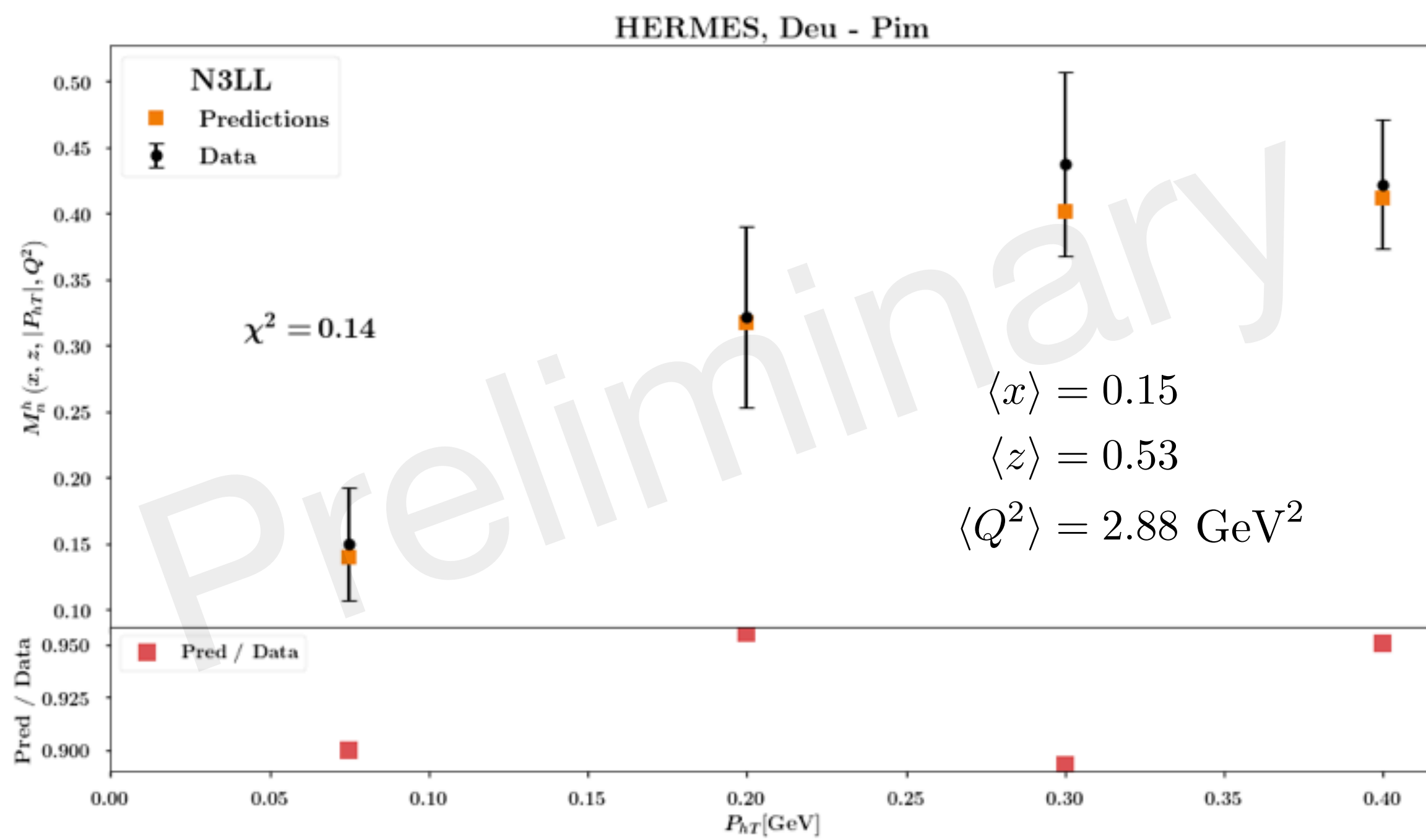
COMPASS multiplicity



# Preliminary results ~ N3LL

Good quality of the fit (with some exceptions)

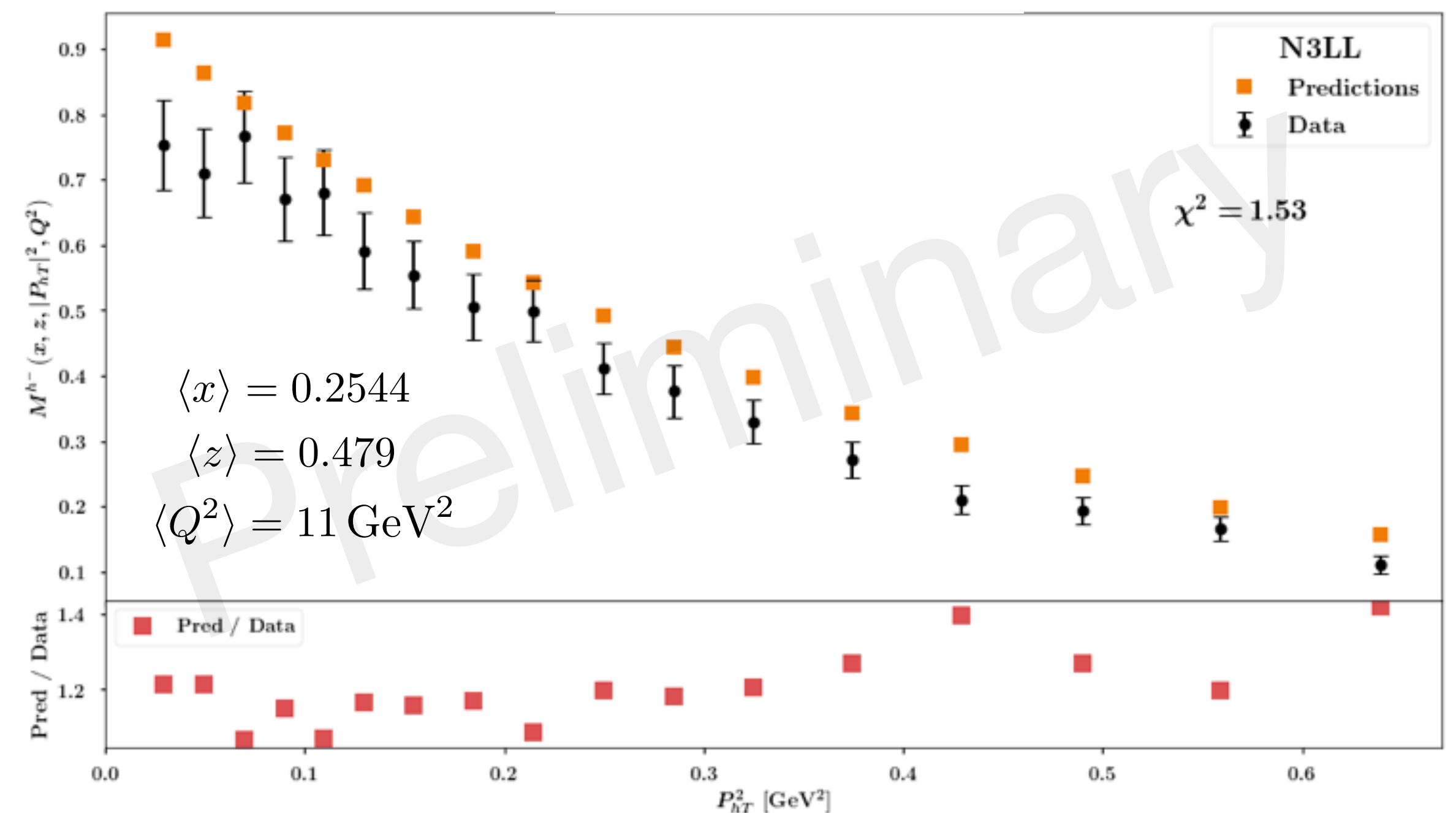
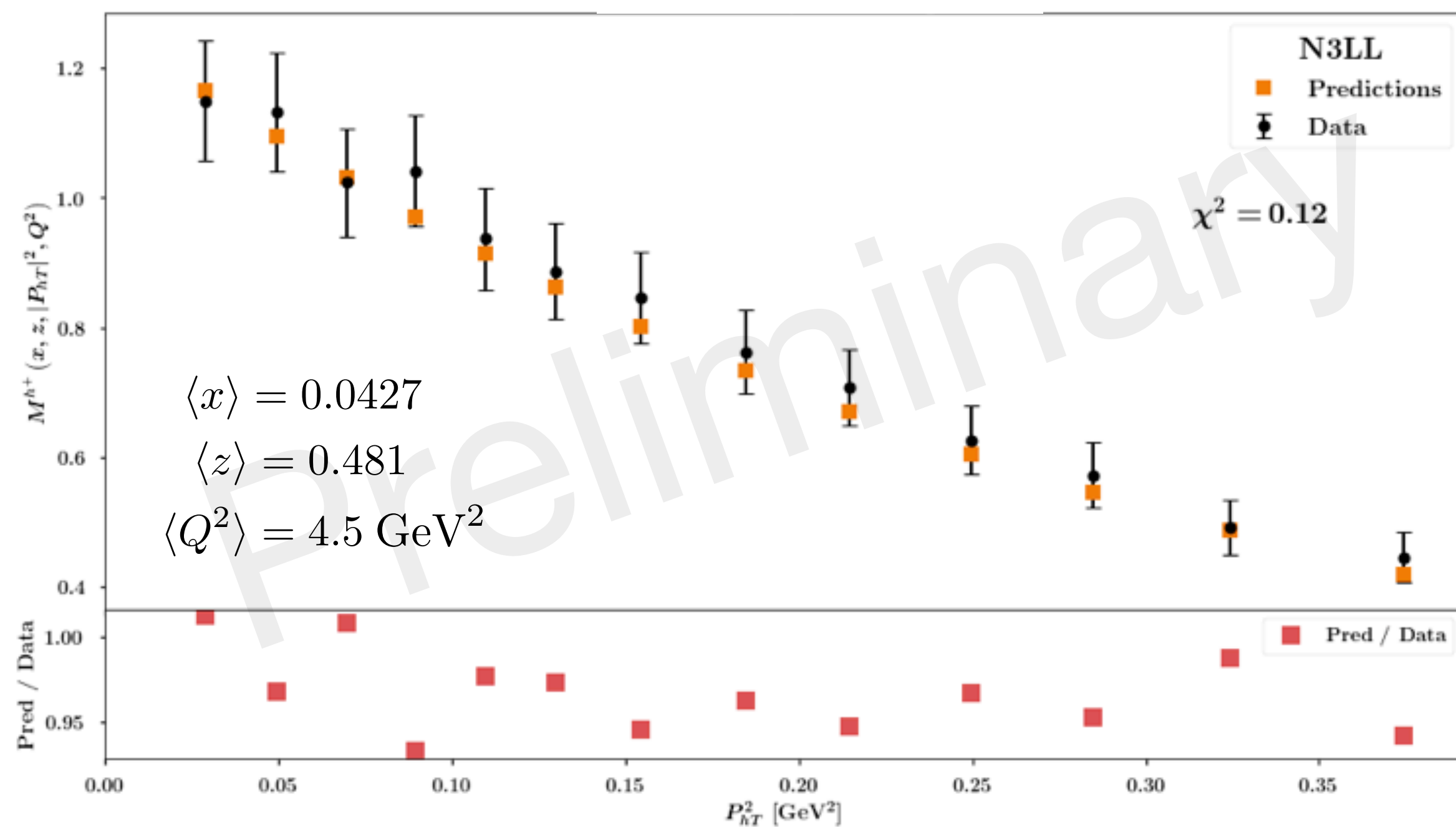
HERMES multiplicity



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COMPASS multiplicity

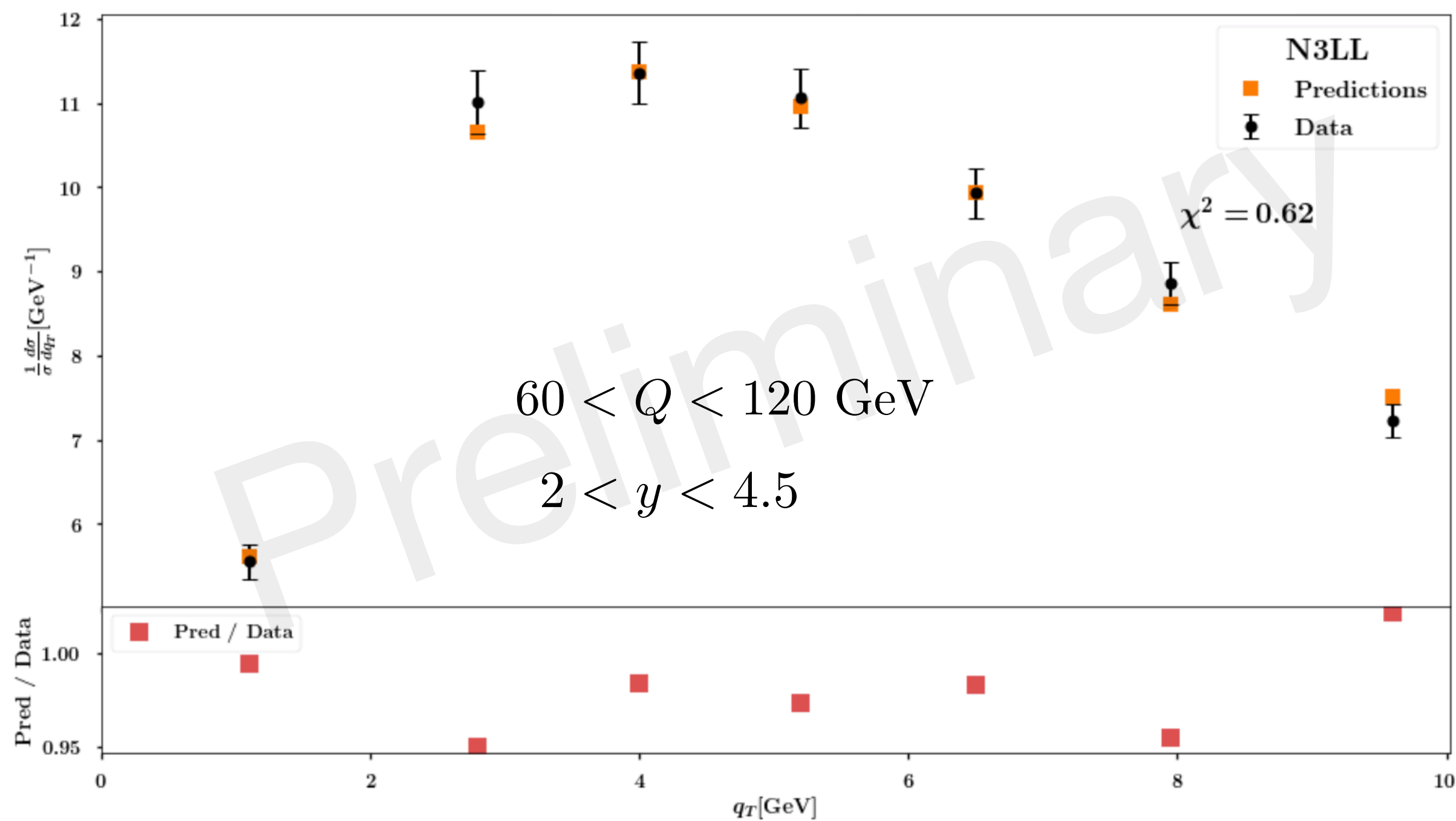


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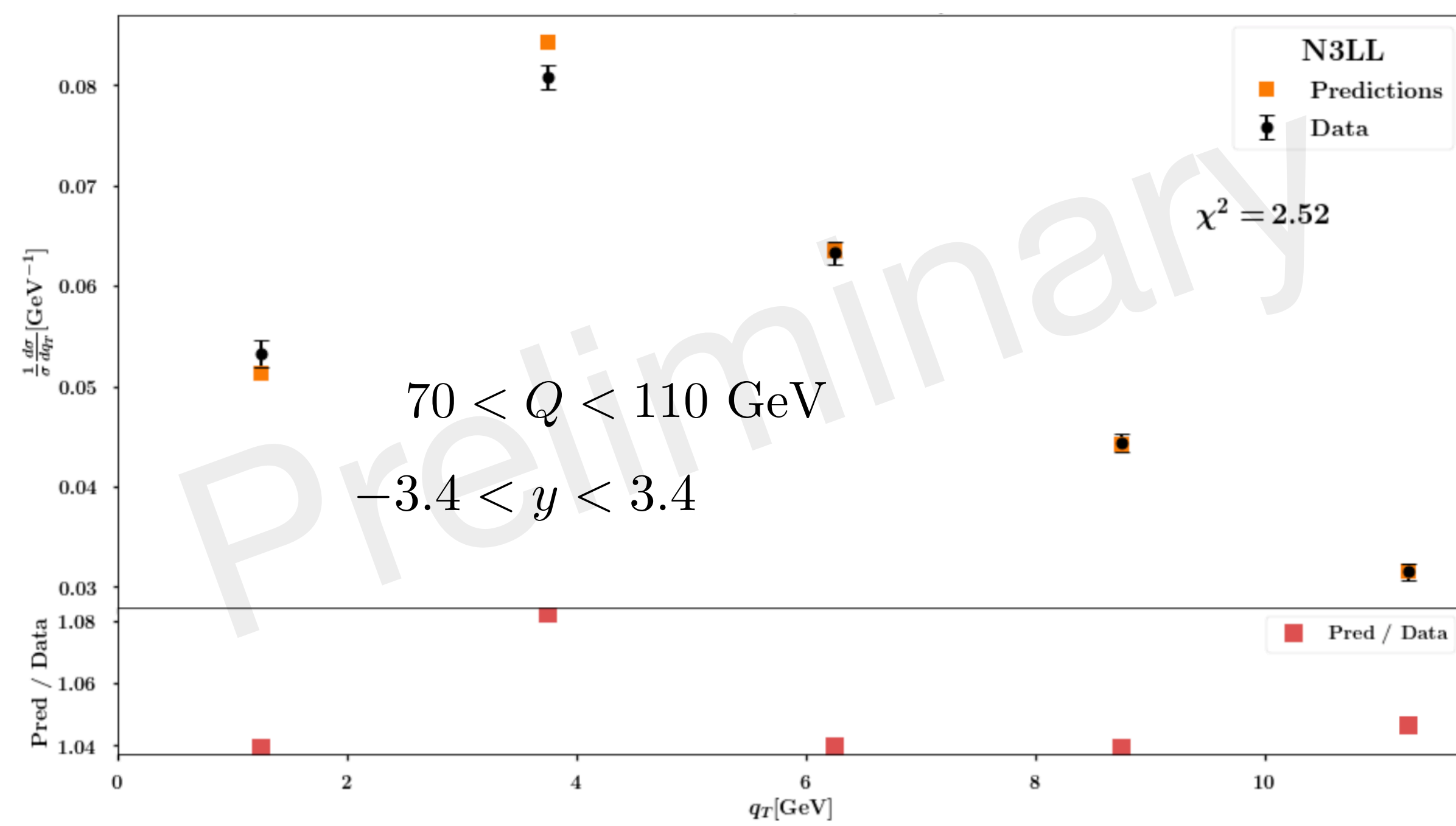
Good quality of the fit (with some exceptions)

Drell-Yan dataset

LHCb 13 TeV



D0 run II



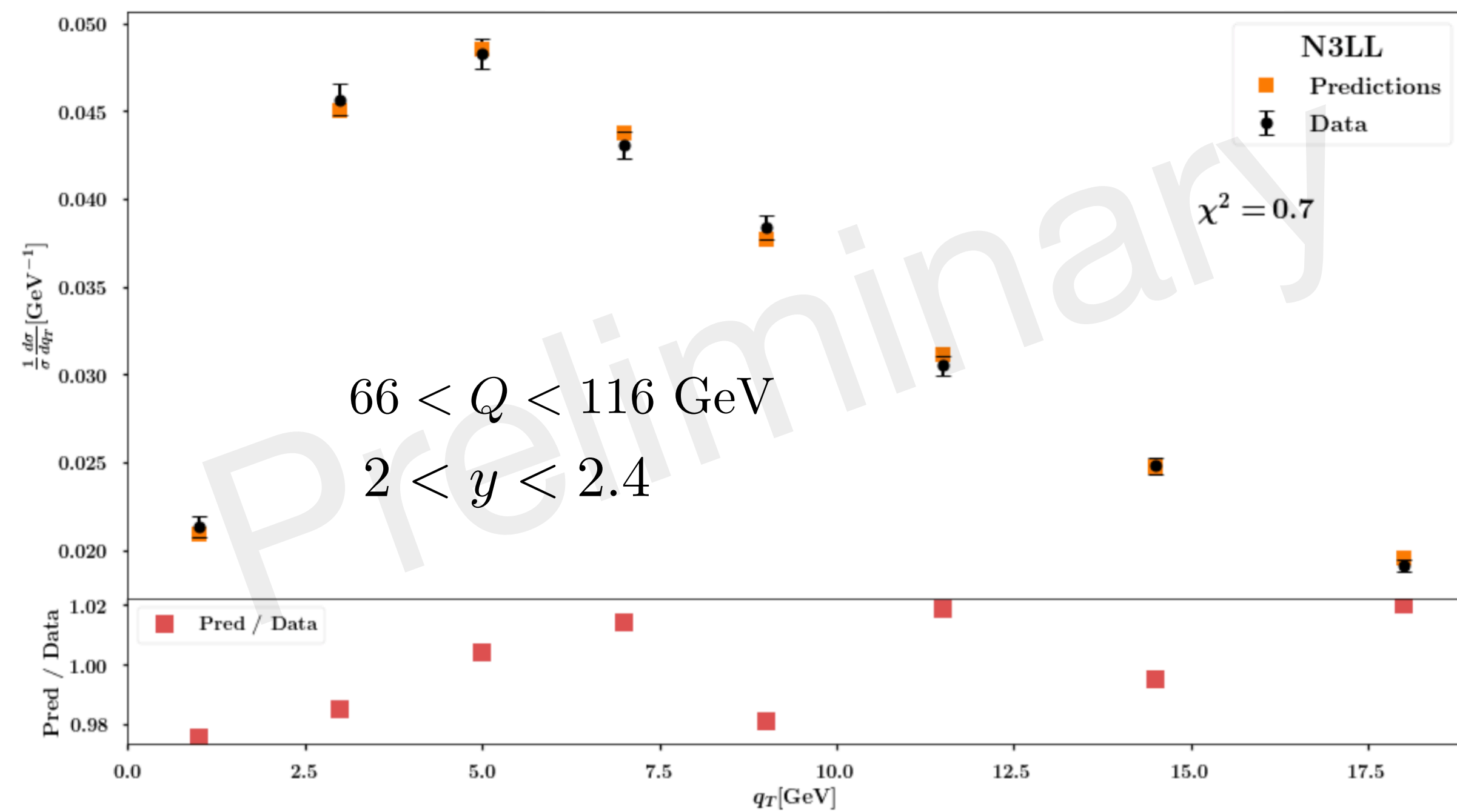


# Preliminary results ~ N3LL

Not good description of the ATLAS dataset

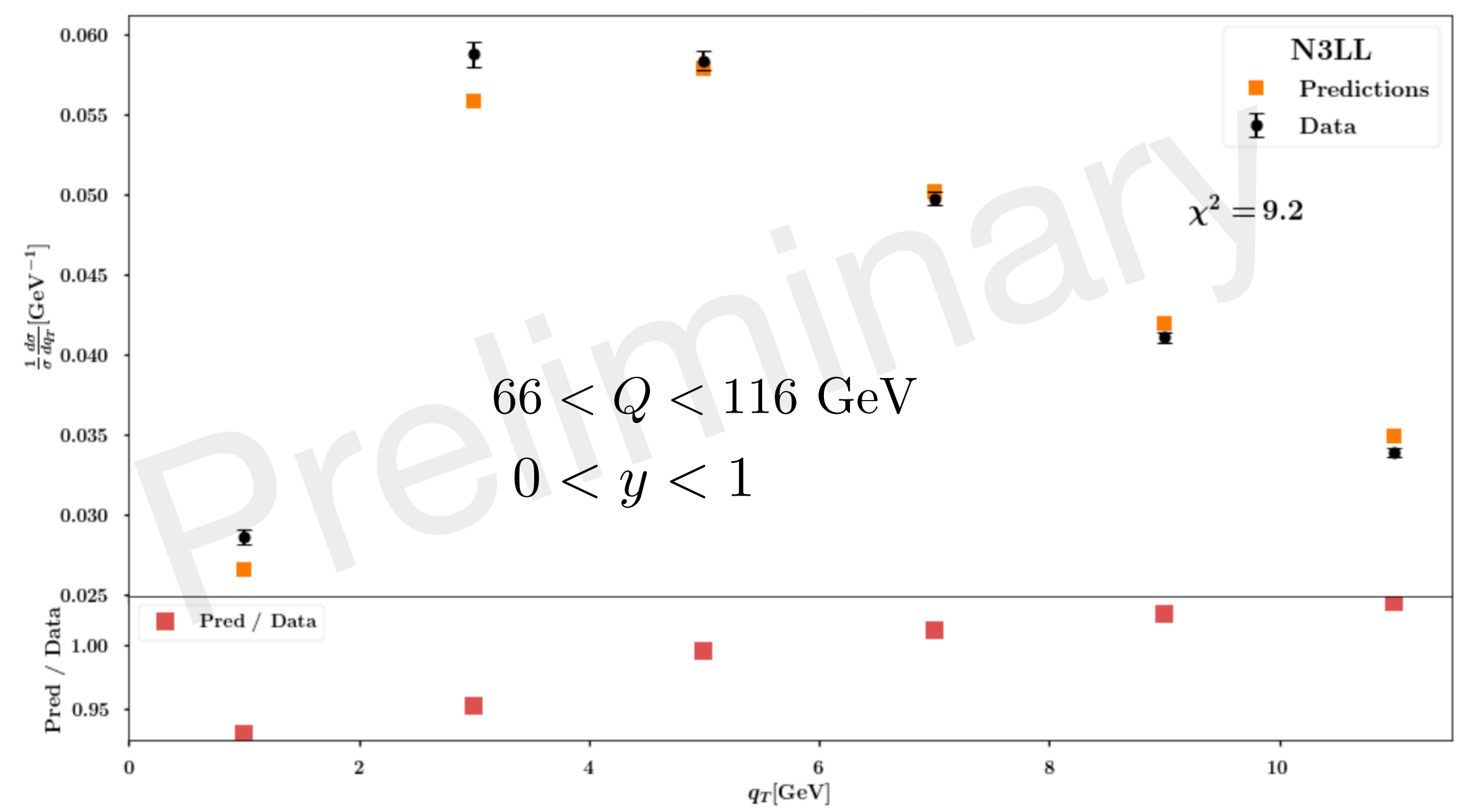
Best described dataset

ATLAS 8 TeV



Worst described dataset

ATLAS 7 TeV





# Recap&Conclusions

- We want to perform a global fit of SIDIS and Drell Yan data at the best possible accuracy to simultaneously extract TMD PDFs and FFs
- We checked that the description of the SIDIS dataset is good at NLL, but not for Drell Yan sets
- Going beyond NLL we are able to describe the shape of the SIDIS multiplicities but not the normalization
- We identified the problem in the contribution of the Resummed term, which is suppressed by the higher order corrections in the Hard Factor
- By introducing new normalization coefficients, we are able to properly describe SIDIS data also beyond NLL, but not at all ATLAS data

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# Backup slide

Data selection 2017

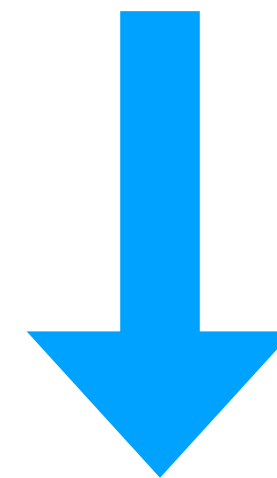
$$Q^2 > 1.4 \text{ GeV}^2$$

$$0.2 < z < 0.7$$

$$P_{hT}, q_T < \text{Min}[0.2 Q, 0.7 Qz] + 0.5 \text{ GeV}$$

Data selection 2019

$$q_T < 0.2 Q$$



New global fit

DY

$$q_T < 0.2 Q$$

SIDIS

$$P_{hT} < \text{Min}[\text{Min}[0.2 Q, 0.5 Qz] + 0.3 \text{ GeV}, Q]$$



# Backup slide

$$\frac{d\sigma^X}{dq_T d\dots}(\text{matched}) = W + Y,$$

$$W \equiv \frac{d\sigma^X}{dq_T d\dots}(\text{TMD}), \quad (3.29)$$

$$Y \equiv \frac{d\sigma^X}{dq_T d\dots}(\text{F.O.}) - \frac{d\sigma^X}{dq_T d\dots}(\text{asy}),$$

*Source: F. Piacenza's Ph.D. thesis*