

***EIC Letter of Interest:
Higher twist effects in inclusive
and diffractive nuclear structure functions
– contribution to discussion***



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Generalities

- **The team:** K. Golec-Biernat, M. Sadzikowski, W. Słomiński, LM
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- **Motivation – the legacy of HERA:**
Evidence for multiple scattering effects in inclusive and diffractive structure functions at small x :
 - *successful description of HERA data for both types of nucleon structure functions in the saturation models (Golec-Biernat and Wuesthoff)*
 - *fits of the structure functions with contributions from higher twist effects*
- **Glue saturation and higher twist effects are different manifestations of the multiple scattering effects.**
The twist expansion suits better the DGLAP approach
The saturation approach may be used to estimate HT corrections

Higher twist corrections in small x regime

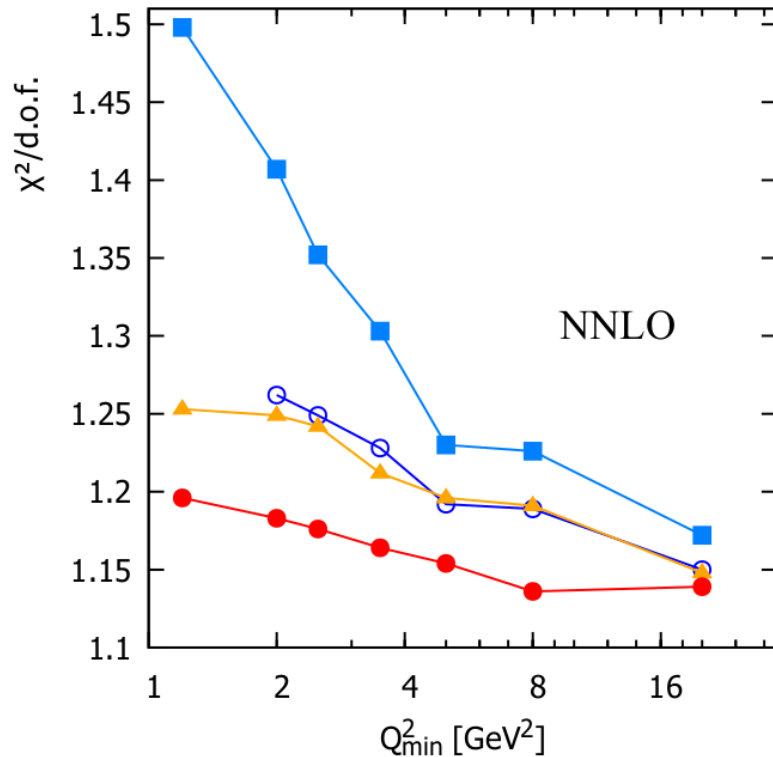
- **Observables:**
structure functions F_2 and F_L in inclusive and diffractive DIS
- At small x higher twist corrections to F_2 and F_L are related to **two gluon distributions** and are enhanced by the gluon density: $xg(x, Q^2) \sim x^{-\lambda}$
→ **novel information on nucleon and nuclei structure**
- Currently theory does not give unique predictions for higher twist corrections, also the information from HERA is not sufficient to constrain well the non-perturbative matrix elements
→ **need for modeling and new calculations**
- **Theoretical studies** of twist decomposition of proton structure functions at small x:
 - the GBW and BGBK saturation model [done]
 - BFKL framework [done at the LL order]
 - Balitsky-Kovchegov framework

DIS and DDIS at HERA: evidence of higher twist effects at small x with the onset at $Q_0^2 \sim 5 \text{ GeV}^2$

- Take data with $Q^2 > Q_{\text{min}}^2$
- Fit with DGLAP and DGLAP + higher twist corrections from the GBW saturation model and calculate $\chi^2 / \text{d.o.f}$

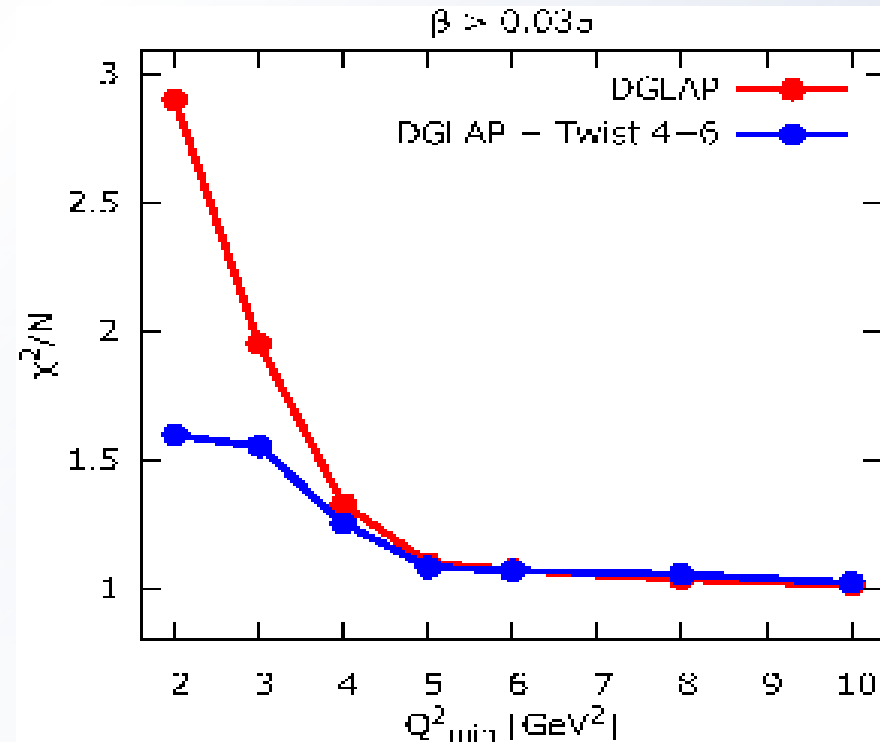
DIS

[M. Sadzikowski, W. Słomiński, K. Wichmann, LM, 2017]



Diffractive DIS

[M. Sadzikowski, W. Słomiński, LM, 2012]



Interplay of small x and higher twist effects

- The basis of the fits shown is DGLAP leading twist plus higher twist effects at small x from the GBW saturation model
- **Note:** Similar improvement of DGLAP fits to HERA data may be achieved by the BFKL resummation of the leading twist contribution
[R. D. Ball, V. Bertone, M. Bonvini, S. Marzani, J. Rojo and L. Rottoli, 2018]
- **Discriminative power of the Electron Ion Collider:**
DIS at HERA reaches significantly smaller values of x than EIC, but relative multiple scattering effects at EIC are enhanced by $\sim A^{1/3}$ that should lead to the same enhancement of the higher twist effects → EIC data combined with HERA data should permit to disentangle small x and higher twist effects

Conclusions

– relevance of HT effects and the research to be done

Benchmark scale Q_0^2 for observing higher twist corrections:

- Q_0^2 grows with cms energy squared S like $\sim S^{0.3}$
- Q_0^2 grows with the nucleus mass number A like $\sim A^{1/3}$

Onset of Higher Twist effects at EIC at $S^{1/2} = 100$ GeV: $Q^2 > 10$ GeV²

Important corrections to determination of nuclear pdfs

To be done:

- *Complete the theoretical estimates of higher twist effects from theory (BFKL, BK) and compute the coefficient functions for twist 4 gluon operators to the virtual photon beyond the leading order*
- *Constrain the free parameters to HERA data and provide estimates for the nuclear structure functions, both inclusive and diffractive*