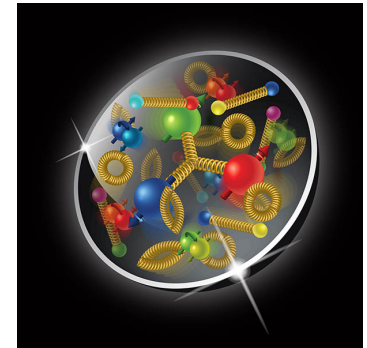


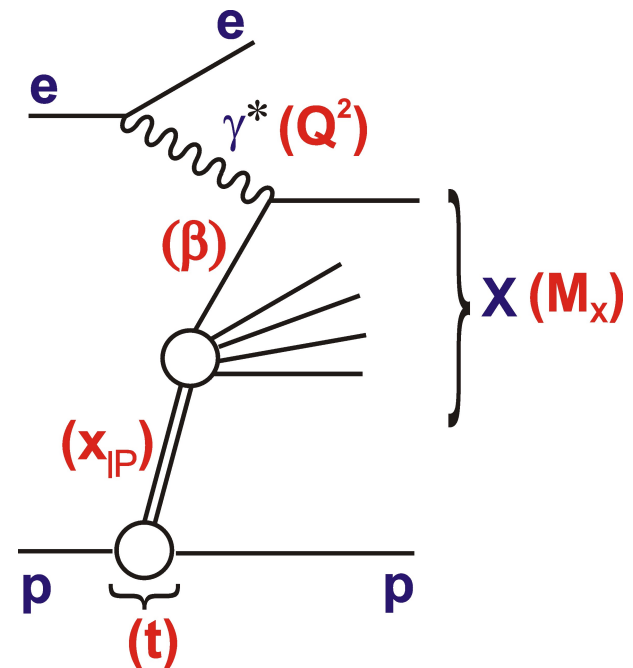
Inclusive Diffraction and the EIC

UK EIC Workshop
28 July 2020

Paul Newman
(University of Birmingham)



- Work done in collaboration with Nestor Armesto, Wojciech Smolinski and Anna Stasto
- See Phys Rev D100, 074022 (2019) and talks in EIC Yellow Report 'Diffraction and Tagging' Physics Working Group



Motivation for Diffraction

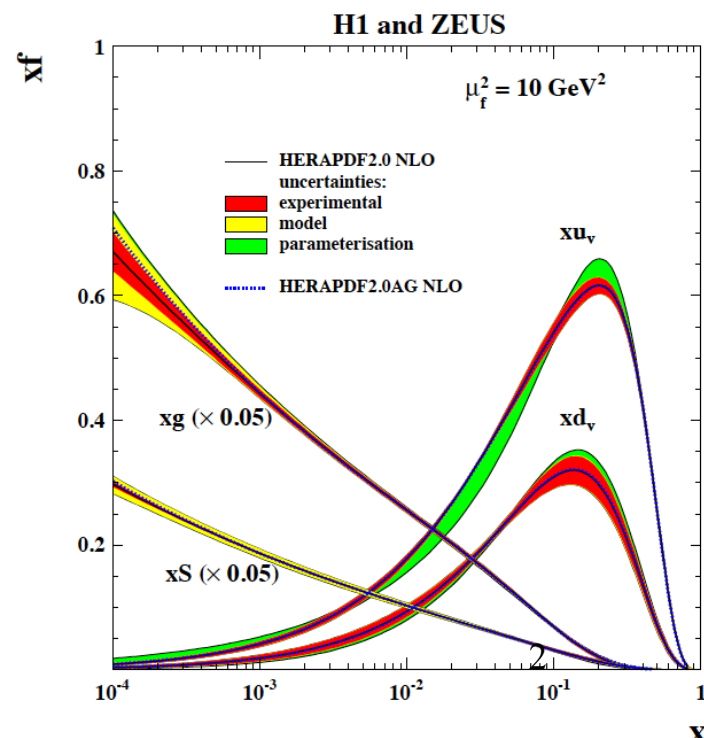
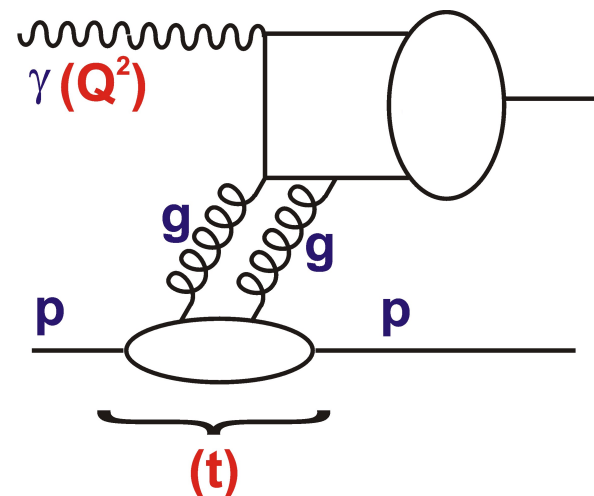
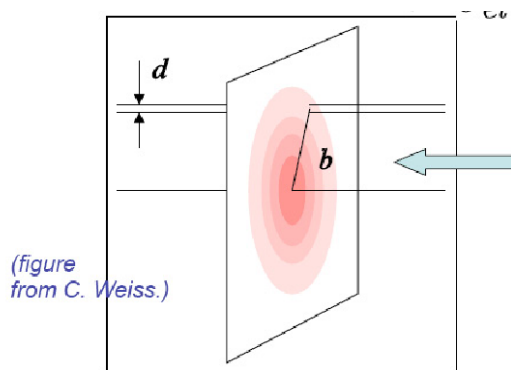
Microscopic interpretation as 2 gluon (or other parton) exchange:

1) Sensitivity to correlations between partons and transverse structure

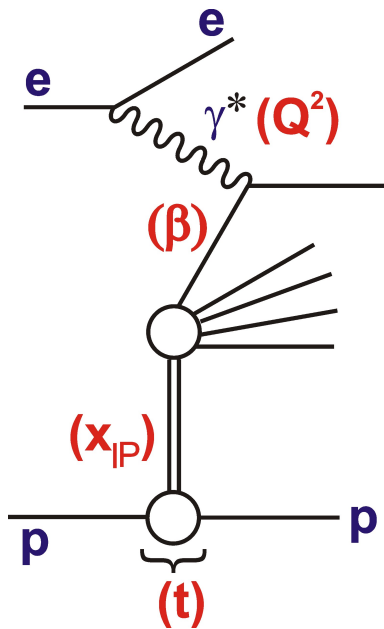
2) Additional variable t gives access to impact parameter (b) dependent amplitudes

3) In eA, sensitivity to (pathologically rising?) low x gluon \rightarrow non-linear / saturation?

\rightarrow Large t (small b) probes densest packed part of proton?..



Inclusive Diffraction and Semi-Inclusive (Diffractive) PDFs



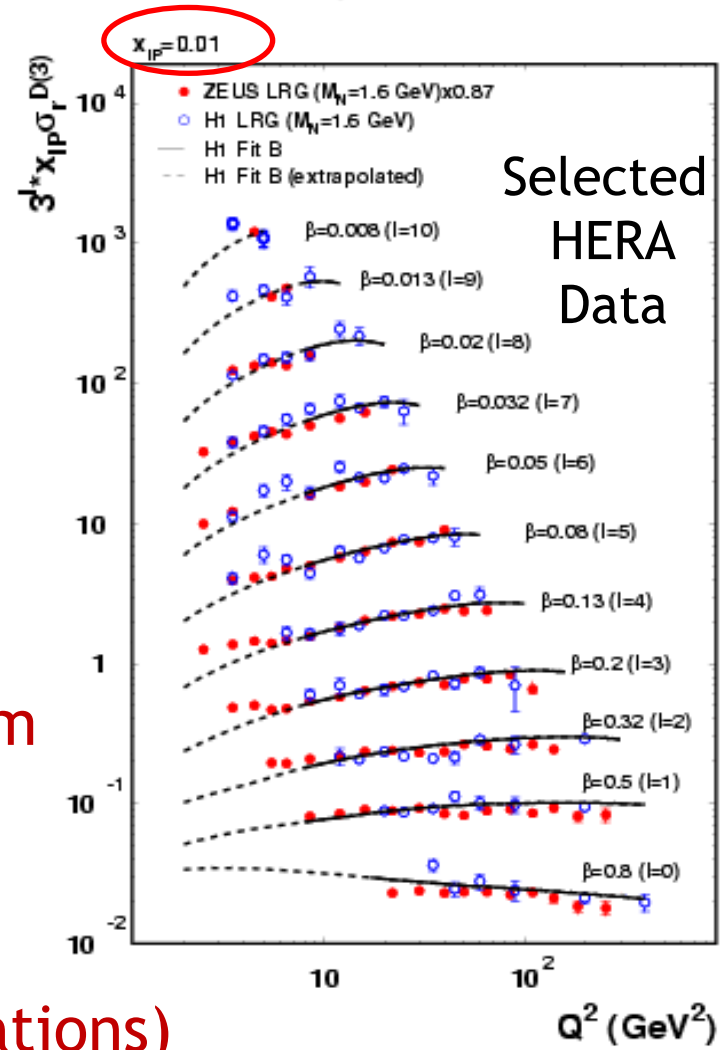
$$x_{IP} \equiv \xi = x_{IP}/p$$

$$\beta \equiv z = x_{q,g}/IP$$

- $ep \rightarrow eXp$ with proton 4-momentum barely changed has a leading twist contribution at $\sim 10\%$ of total x-sec

- Rich topic at HERA (>100 publications)

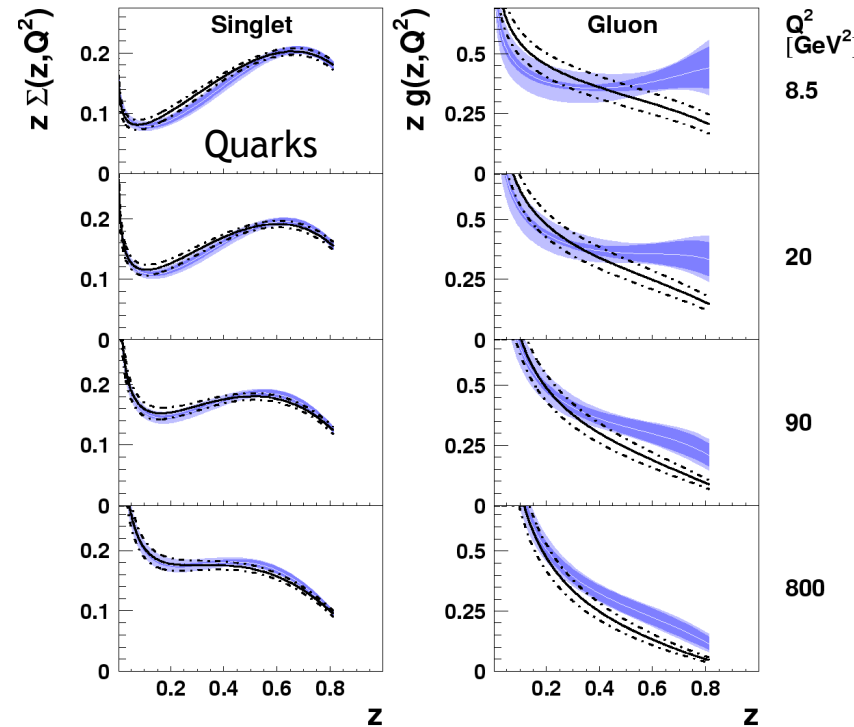
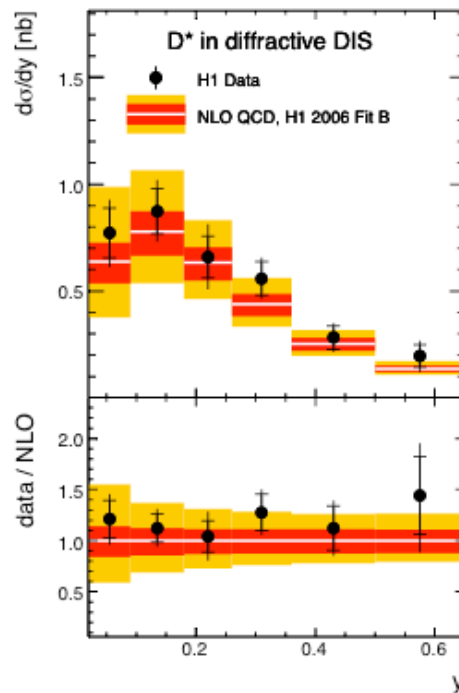
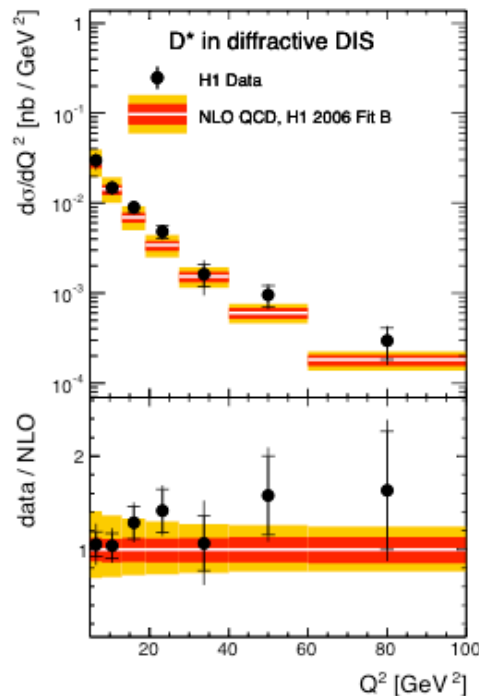
- Two components to exchange ('Pomeron' and 'Reggeon')



Diffractive Parton Densities (DPDFs) at HERA

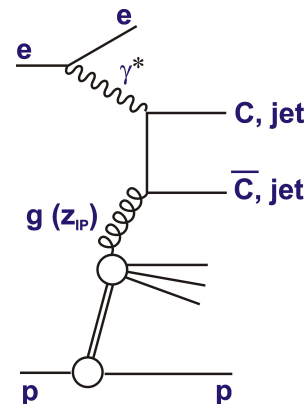
- DPDFs extracted from HERA data (recently extended to NNLO)

... provide remarkably good description of all final state diffractive observables throughout HERA range



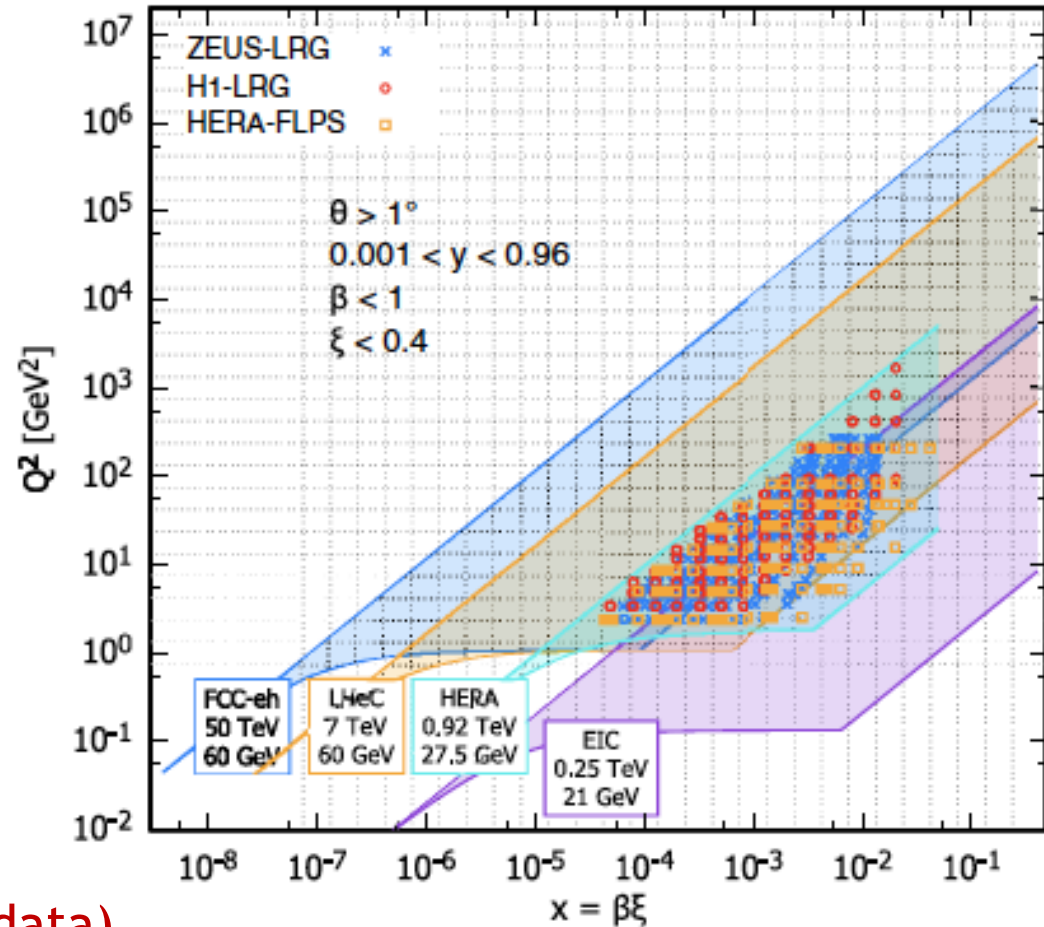
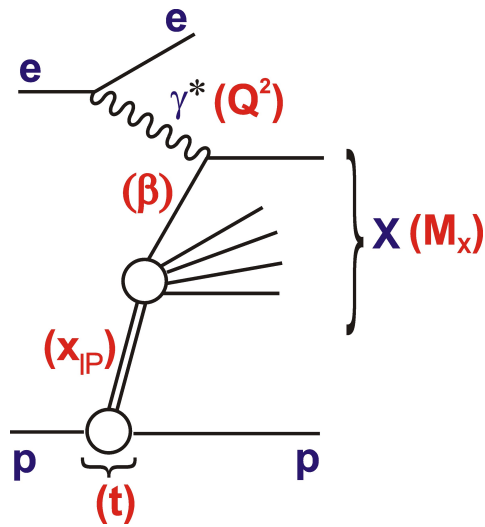
H1 2006 DPDF Fit A
 (exp. error)
 (exp.+theor. error)

H1 2006 DPDF Fit B
 (exp.+theor. error)



Comparisons limited by available phase space for final states⁴

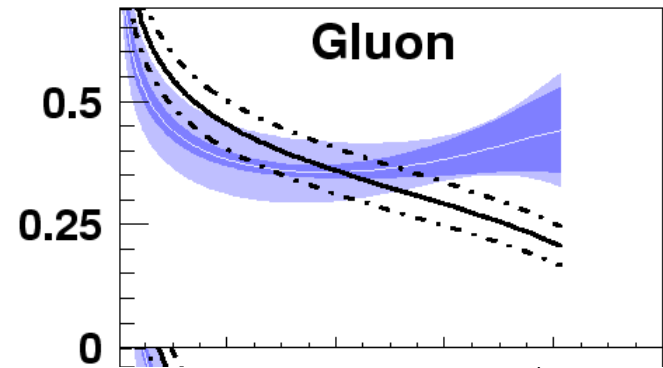
Diffraction at EIC



Lower centre of mass energy than HERA, but

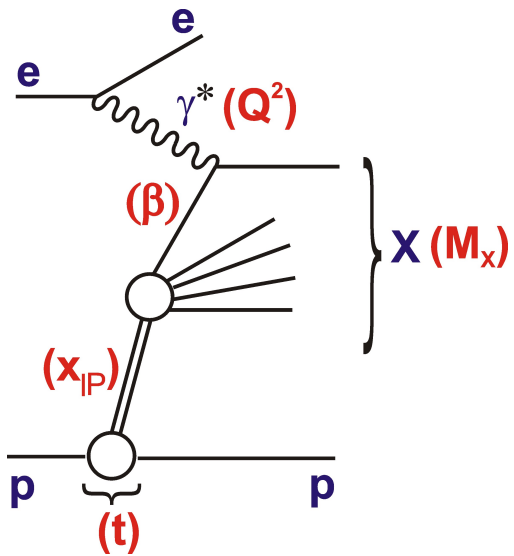
- Fills gap in kinematic plane at large x (there are no fixed target data)
→ Sensitivity to poorly constrained structure at large momentum fraction (β or z)

- Inclusive diffraction has never been studied with nuclear or polarised targets



[A couple of initial studies follow - work in progress]

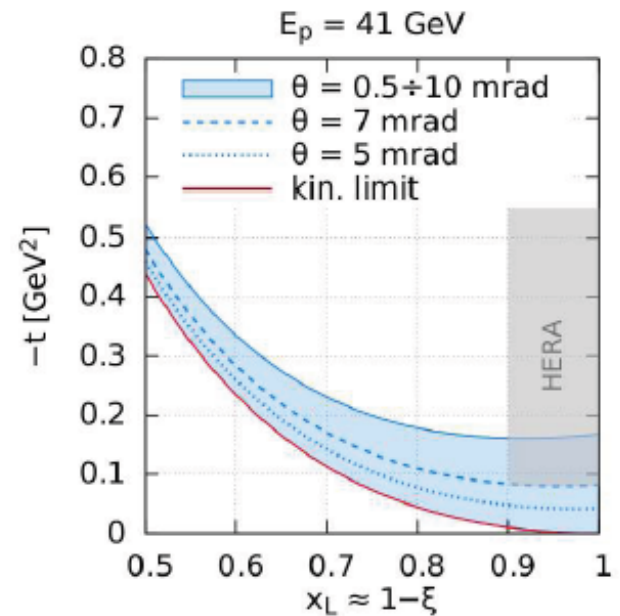
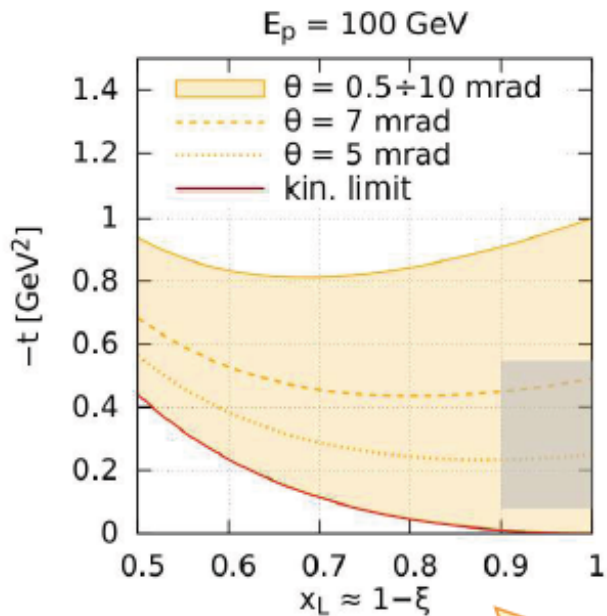
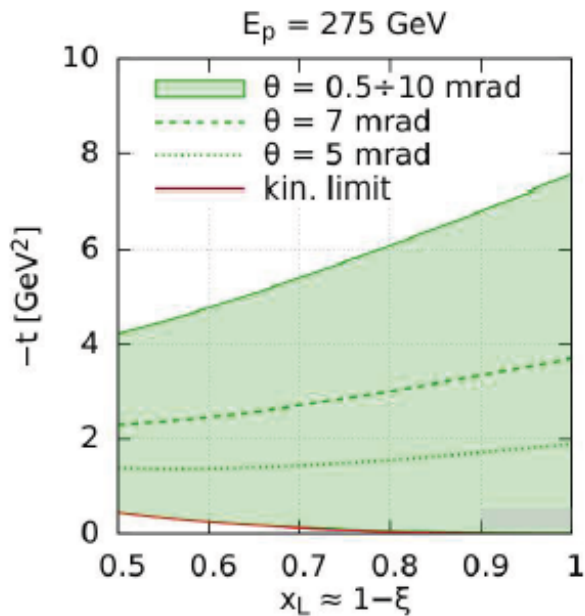
Inclusive Diffraction in ep at EIC: Scattered proton kinematics



$$t \approx -p_T^2 \qquad x_L = E'_p/E_p$$

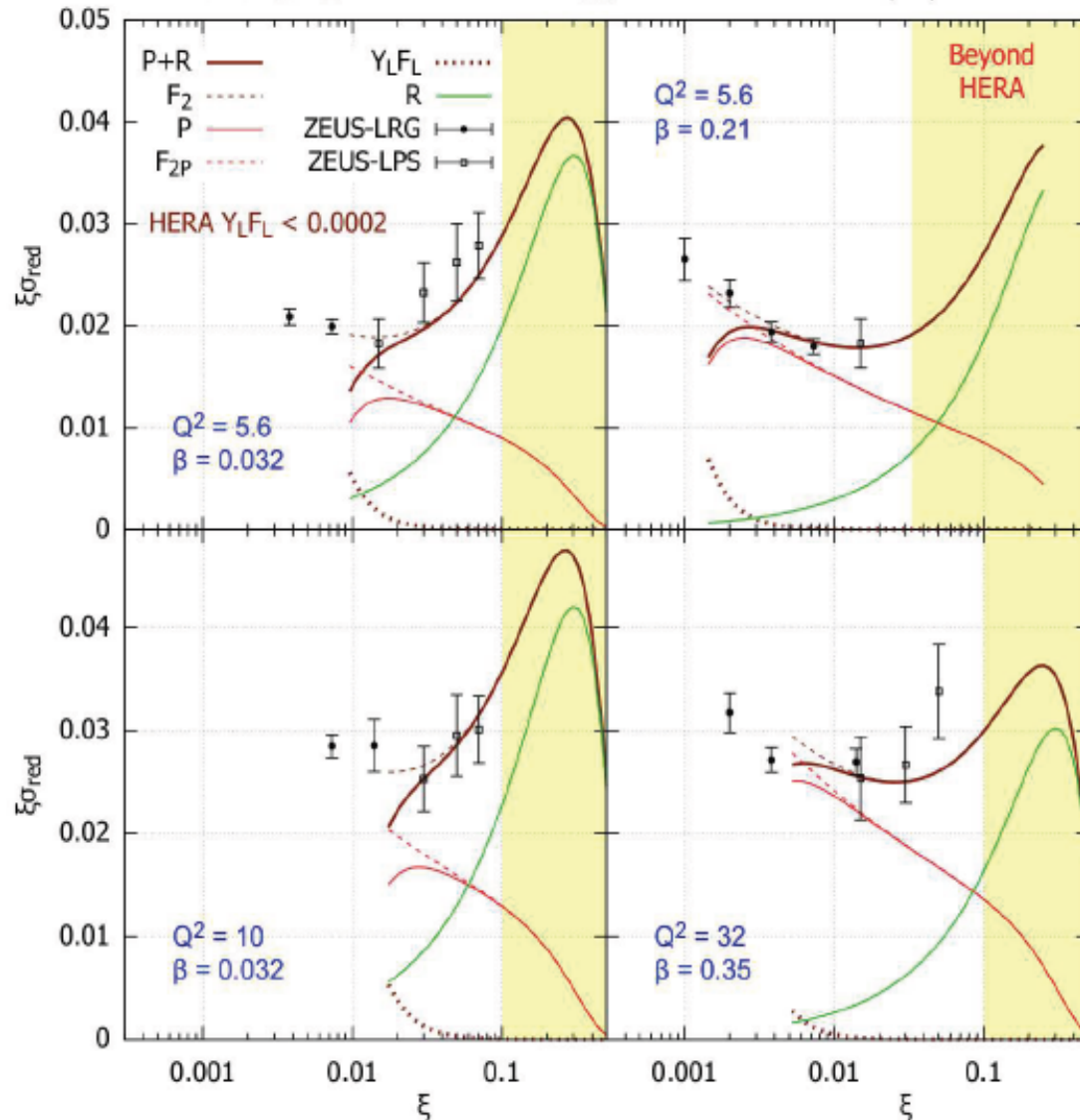
Planned EIC Roman pots provide:

- Good coverage in most interesting large x_L , low $|t|$, diffractive region for all \sqrt{s}
- Interesting coverage at smaller x_L at large \sqrt{s} (sub-leading 'Reggeon' exchanges)



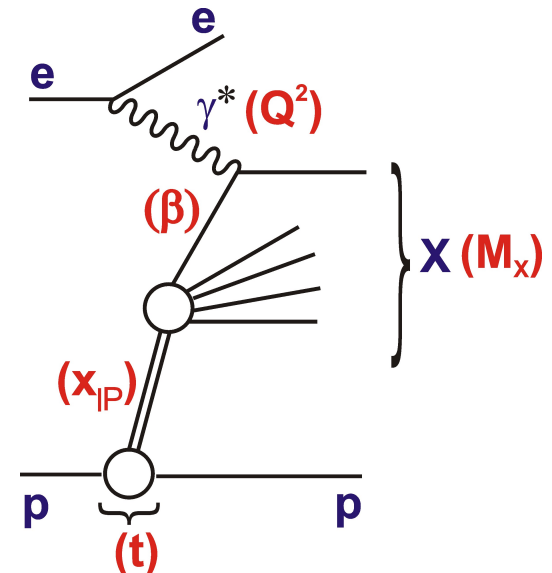
Inclusive Diffraction in ep at EIC: Sensitivity to sub-leading (non-pomeron) exchange

P, R, F_2 , F_L contributions to σ_{red} for 275×18 GeV (SJ)



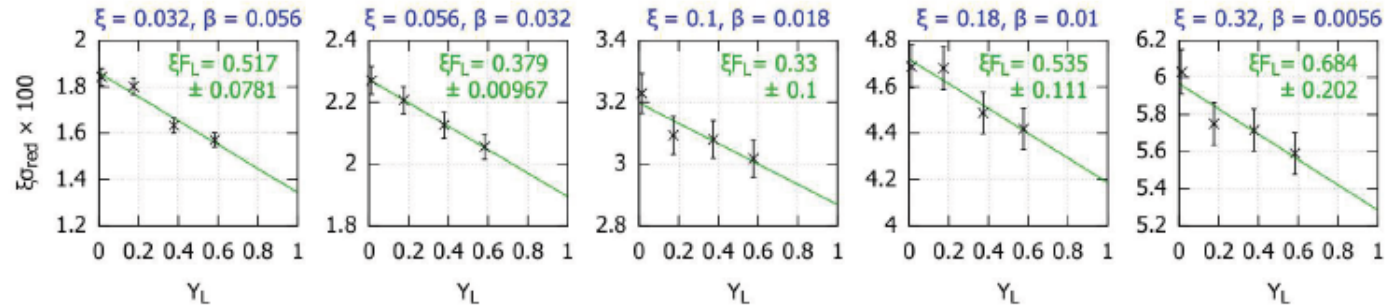
→ Yellow shaded region at large x_L is previously unexplored

→ Opportunity to understand sub-leading Reggeon (meson) exchanges and measure their structure



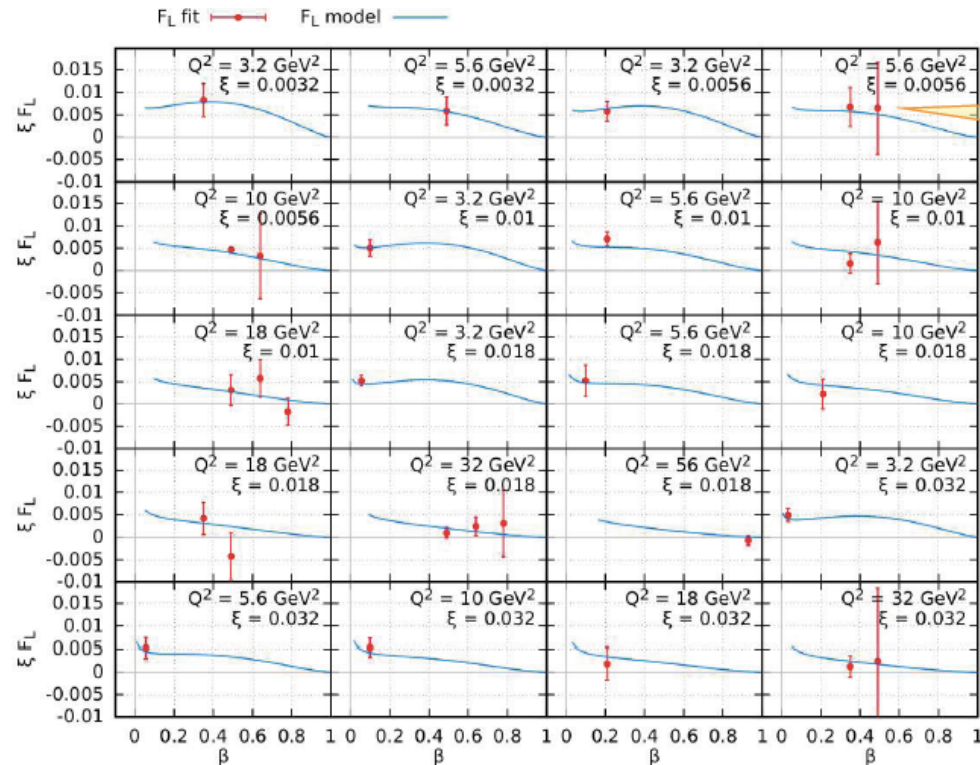
Inclusive Diffraction in ep at EIC: Sensitivity to diffractive longitudinal structure function

$$Q^2 = 5.6 \text{ GeV}^2, \delta_{\text{sys}} = 2\%$$



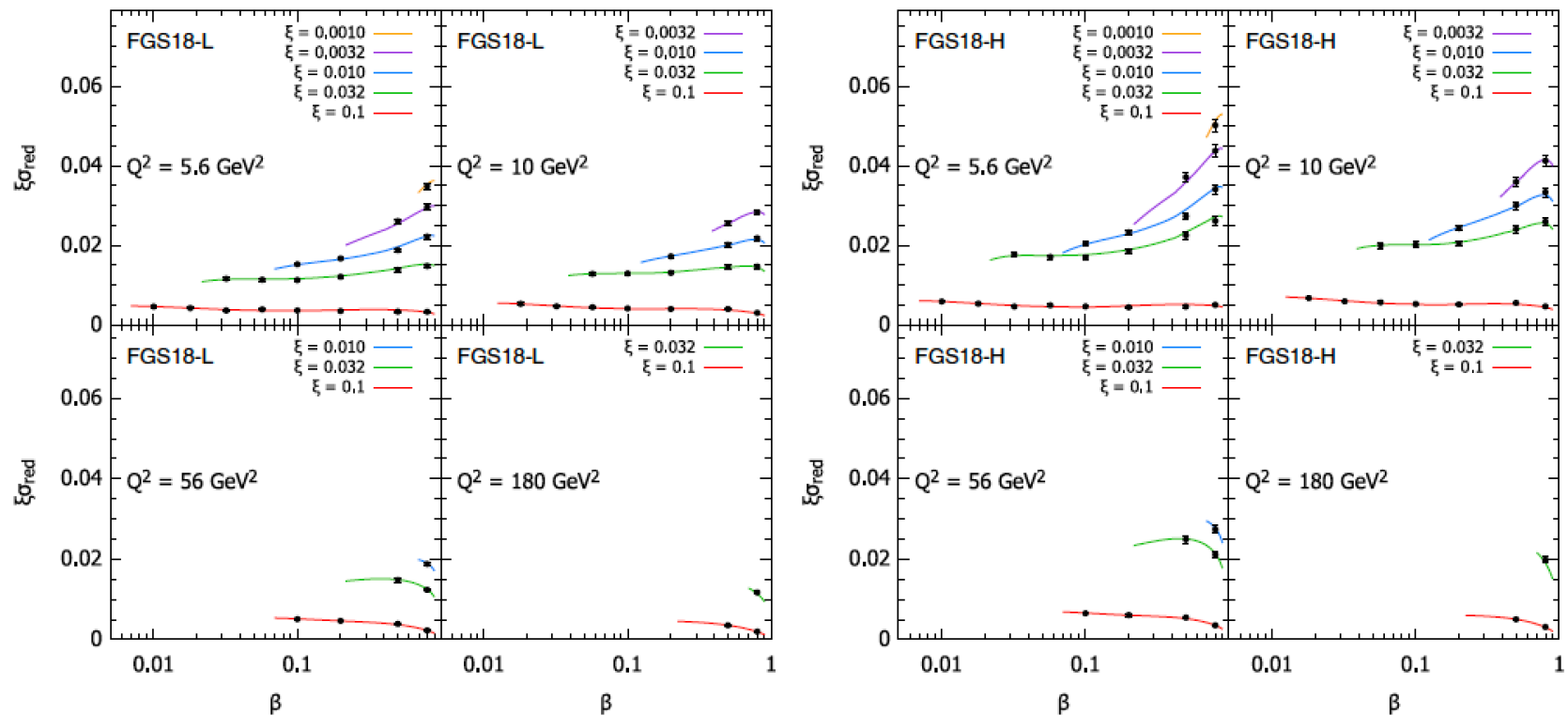
$$\sigma_{\text{red}}^D = F_2^D - \frac{y^2}{1 + (1 - y)^2} F_L^D$$

- Measurement at same (ξ, t, β, Q^2) and varying \sqrt{s} (hence y) gives sensitivity to F_L^D (Rosenbluth plots)
- First simulations look promising
- Precision strongly dependent on correlations between systematics at different \sqrt{s}



Inclusive Diffraction from Nuclei at EIC: Selected Simulated Data for $e \text{ Au} \rightarrow e X \text{ Au}$

- Inclusive diffraction from nuclei never previously studied
- Comparing eA / ep may reveal non-linear (satur'n) dynamics



Simulations based on different versions of FGS model →

- illustrates accessible kinematic range and ability to distinguish between (widely varying) models

SUMMARY

- Inclusive diffraction is a potentially rich topic at EIC, with sensitivity to transverse structure of target and nature of colourless exchanges
- Promising aspects under study:
 - Sensitivity to diffractive (IP) exchange structure at large momentum fractions (z , β) and to longitudinal structure function
 - Sensitivity to sub-leading (IR) exchange
 - Coherent diffraction from nuclear targets
- Further aspects to be tackled:
 - Diffraction from polarised proton and light ion targets
 - Relation to transverse structure of target, Generalised Parton Densities ...