Prospects for inclusive diffraction at the EIC

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EIC opportunities for Snowmass, January 28, 2021

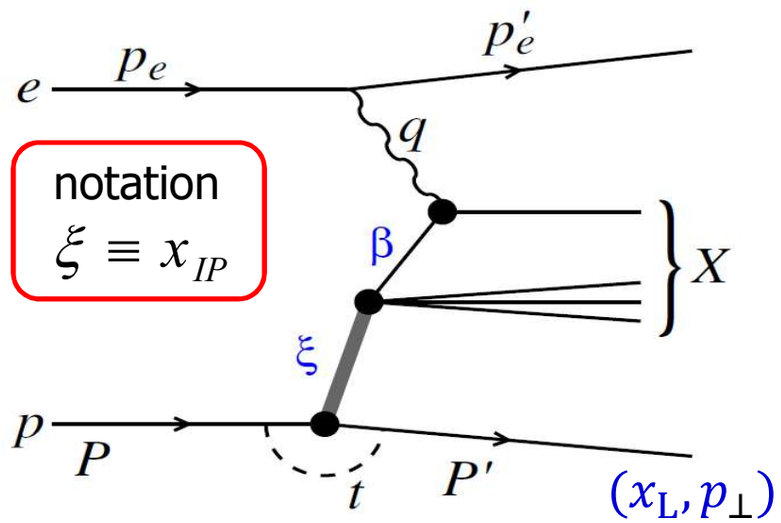
Examples of prospects for inclusive diffraction at EIC

- Forward instrumentation at EIC will allow to measure leading protons in a wider kinematic range of longitudinal momentum component and momentum transfer than at HERA
- Sensitivity to the secondary diffractive exchange - Reggeon contribution
- Precise measurement of t dependent cross section $\sigma^{D(4)}$
- Varying energies: possibility of extraction of longitudinal diffractive structure function
- Sensitivity to region of higher twists (low Q) and large z for diffractive gluon density
- First extraction of nuclear diffractive PDFs with accuracy comparable or exceeding that of proton diffractive PDFs at HERA
- Relation between shadowing and diffraction

Nestor Armesto, Paul Newman, **Wojtek Slominski**, Anna Stasto

Partial references: arXiv 1901.09076, EIC Yellow Report (to be released soon)

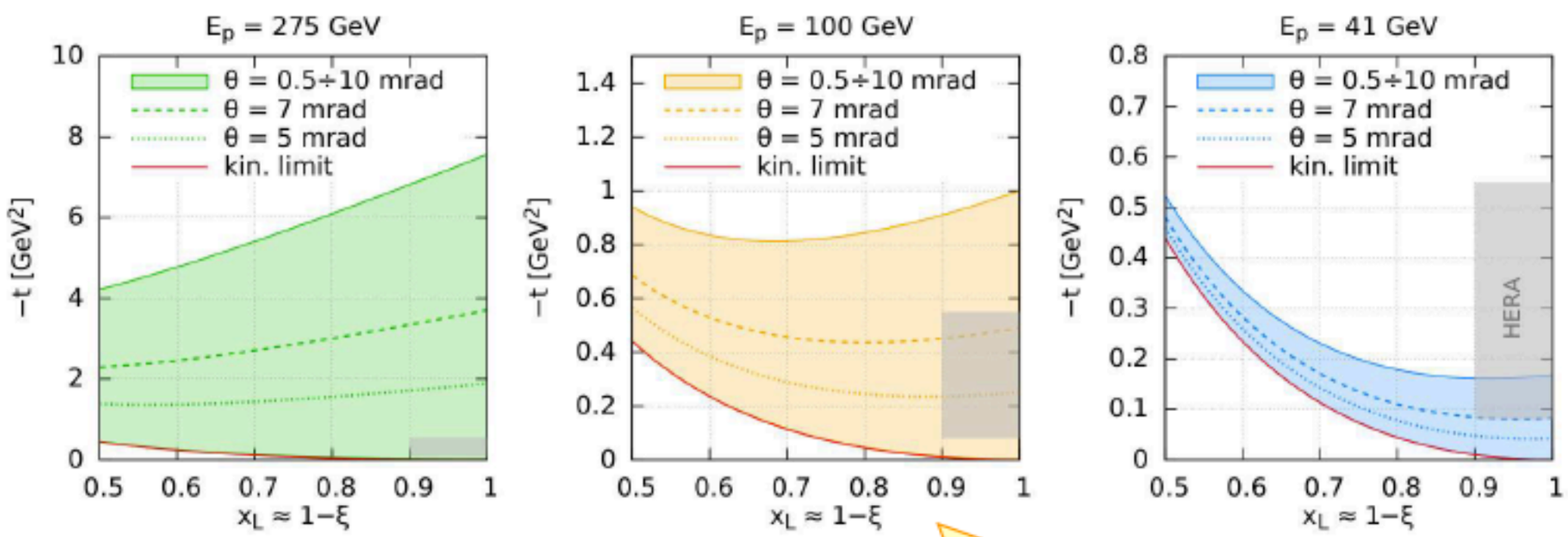
Inclusive diffraction in ep: extended range in t and x_L



$$\xi \equiv x_{IP} = \frac{Q^2 + M_X^2 - t}{Q^2 + W^2} \qquad \beta = \frac{Q^2}{Q^2 + M_X^2 - t} \qquad x_{Bj} = x_{IP}\beta$$

- EIC can tackle large $\xi \cong 1 - x_L$ regions beyond HERA
- The coverage depends on the angular acceptance

Proton tagging



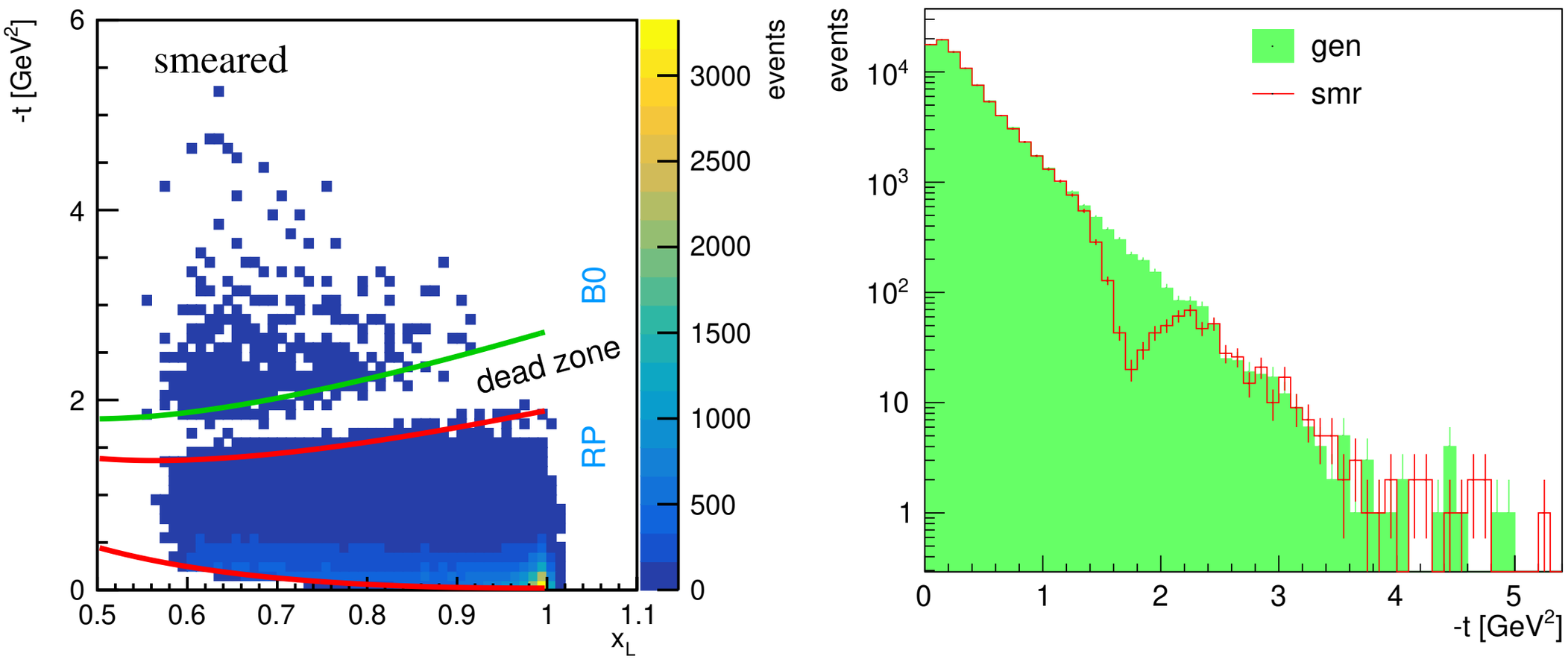
$$t = -\frac{p_\perp^2}{x_L} - \frac{(1-x_L)^2}{x_L} m_p^2 - \frac{1-x_L}{x_L}\left(M_Y^2 - m_p^2\right)$$

$x_L, p_\perp, \theta$ measured in LAB = collinear(*e*,*p*) frame

$|t|$ measured up to ~ 2 GeV², is very interesting,
e.g. for determination of the t-dependence of the secondary exchange.

Inclusive diffraction in ep: extended range in t and x_L

RAPGAP simulation



Gap in acceptance between Roman pots and B0 detectors, at relatively large value of t

Gap moves to lower t for smaller energies

Could be mitigated in the design with two EIC detectors, and different forward instrumentation in the second case.

Inclusive diffraction in ep: secondary exchange

Regge factorization works at low ξ (< 0.01).
At higher ξ, subleading exchanges (reggeons/mesons) enter the game
– they are all parametrized by a single additional "Reggeon" term

$$F^{D(4)}(z, Q^2, \xi, t) = \varphi_{\mathbf{P}}(\xi, t)\, F^{\mathbf{P}}(z, Q^2) + \varphi_{\mathbf{R}}(\xi, t)\, F^{\mathbf{R}}(z, Q^2)$$

free parameter

"Reggeon" SF ∝ pion, $F^{\mathbf{R}} = A_{\mathbf{R}}\, F^{\pi}$

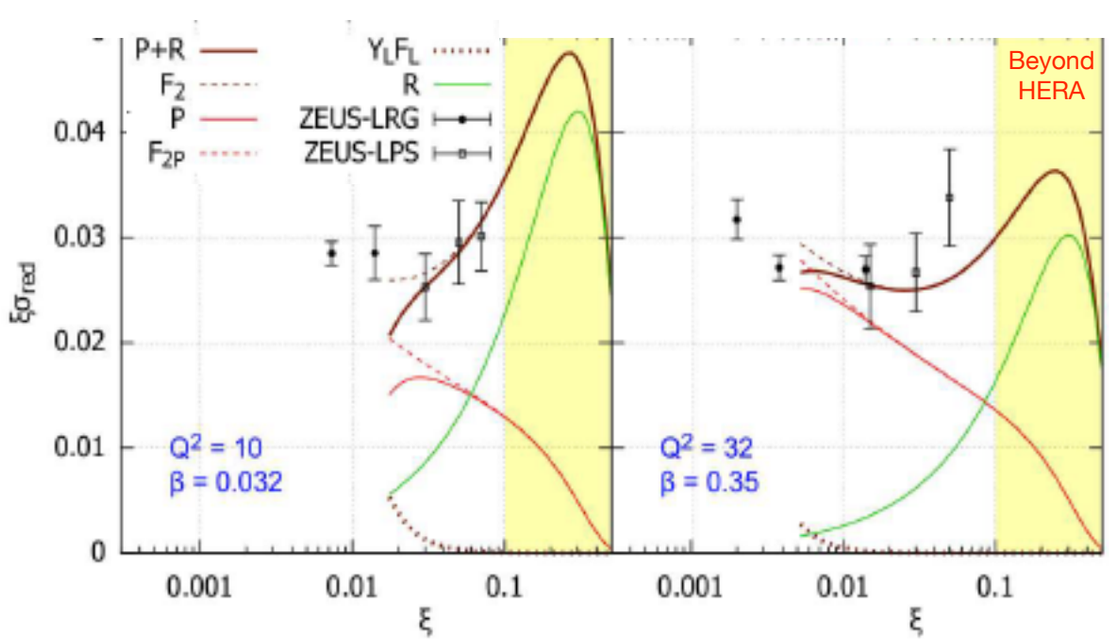
$\varphi_{\mathbf{P,R}}$ = Regge-type flux:

$$\varphi(\xi, t) \sim \frac{e^{Bt}}{\xi^{2\alpha(t)-1}} \quad \text{with } \alpha(t) = \alpha_0 + \alpha' t$$

3 parameters per flux

From HERA fits (ZEUS-SJ),
P and **R** have very different shapes in (ξ, t):

$$\xi\phi_P(\xi, t) \propto \xi^{-0.22}\, e^{-7|t|}$$
$$\xi\phi_R(\xi, t) \propto \xi^{0.6+1.8|t|}\, e^{-2|t|}$$

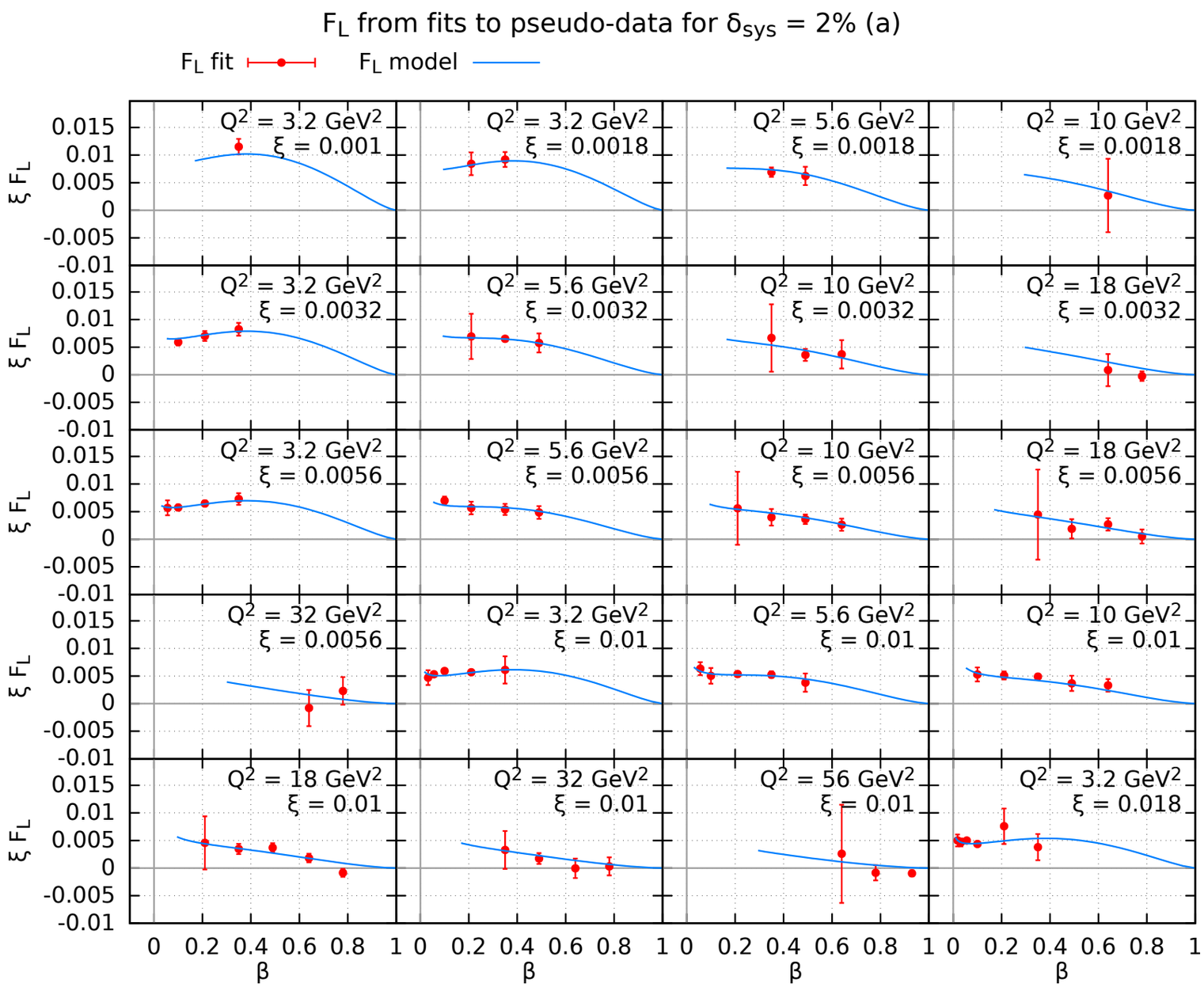


- $\mathbb{R}$ contribution grows with ξ
  - High ξ required for the determination of subleading "Reggeon" term
- Significant F_L component, ~30 times higher than at HERA
  - However, some intermediate beam energy settings needed for F_L measurements

Inclusive diffraction in ep: F_L^D

The pseudo-data are fitted to $\sigma_{\rm red} = F_2 - Y_L(y) F_L$ $\quad Y_L(y) = \frac{y^2}{1+(1-y)^2}$

F_2 and F_L are free parameters in the fit



Systematic error 2%

18 beam setups

469 bins selected such that they are common to at least four beam setups