Low x & Diffractive Physics at the LHeC and FCC-he

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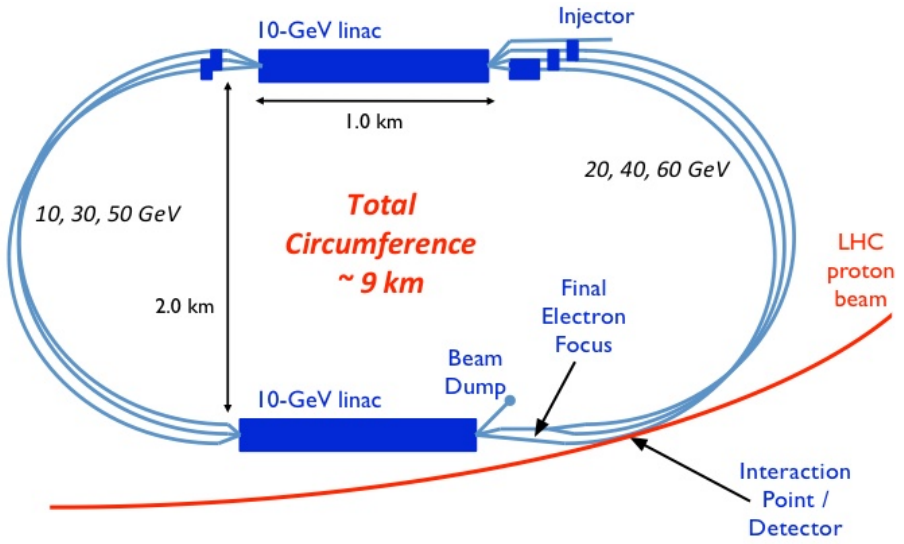
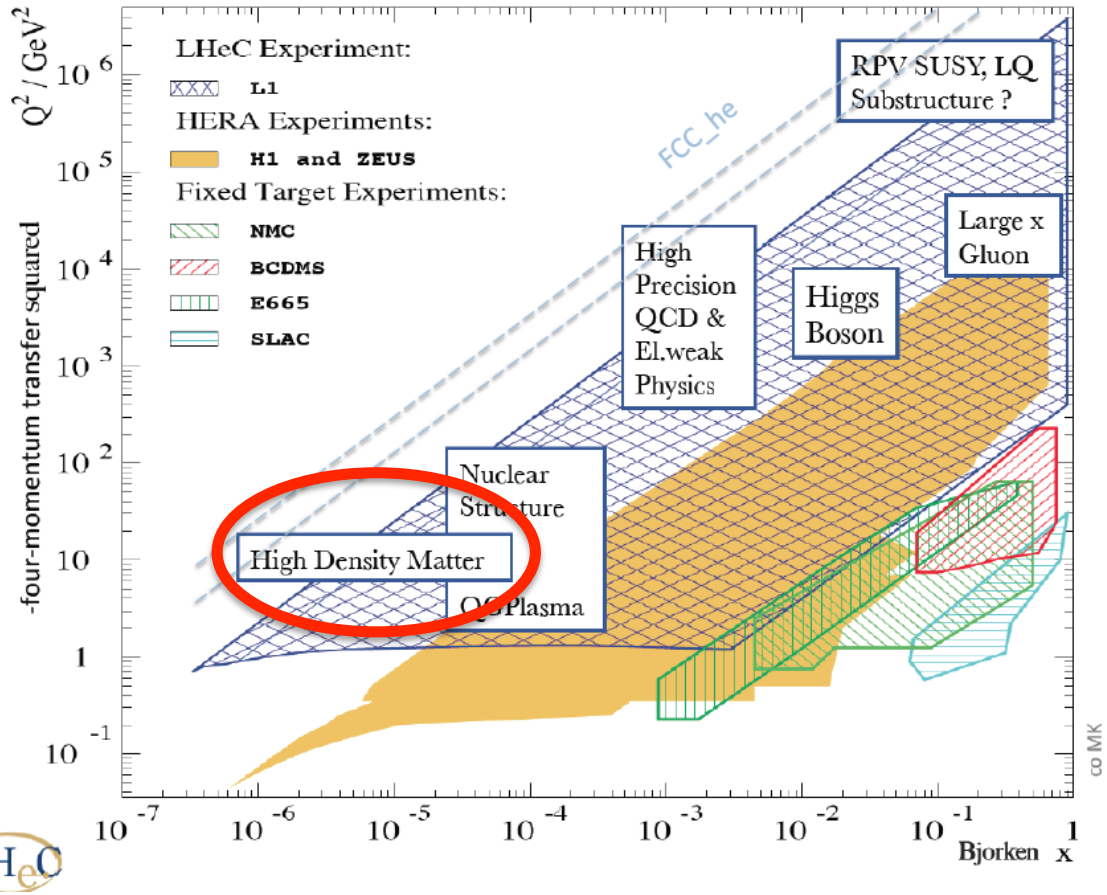
Birmingham University

(with Nestor Armesto and Anna Stasto)

- Resources
- FCC-he
- LHeC





Conceptual Design Report (July 2012)

Substantial low x chapter

(81 pages, 34 authors)

☺ This is a very strong starting point which remains valid

☹ Little progress since then and limited short-term prospects

Thoughts on How to Proceed

Not easy to resurrect old LHeC analyses (some dating back > 5 years) or to persuade colleagues to re-engage

→ better known / clearer structure and aims would help

→ would help to have a new generation of talent

Topic 1) Basic evaluation of FCC-he relatively straightforward

- Kinematic ranges for F_2, F_L, F_2^D, VMs, σ_{tot}

with reasonable detector acceptance assumptions, including proton tagging.

→ Still hope to get some of this for early 2015, probably based on work among us and perhaps small number of others.

→ See later

- No plan to repeat e.g. 'Observability of low x saturation' studies… already clear from LHeC and there are no significant new constraints

Thoughts on How to Proceed

More sophisticated work requires different level of commitment and / or up-to-date code and/or expertise.

Topic 2) Underlying physics sensitivity of LHeC pseudodata

- Interpretation of DVCS in terms of GPDs
- Interpretation of F2D in terms of DPDFs

→ Needs new effort (grant applic'ns pending)

→ See later

Topic 3) Improvement of LHeC pseudodata

- Full evaluation of systematics etc based on detector simulations and DD4HEP (see Peter and Paul)

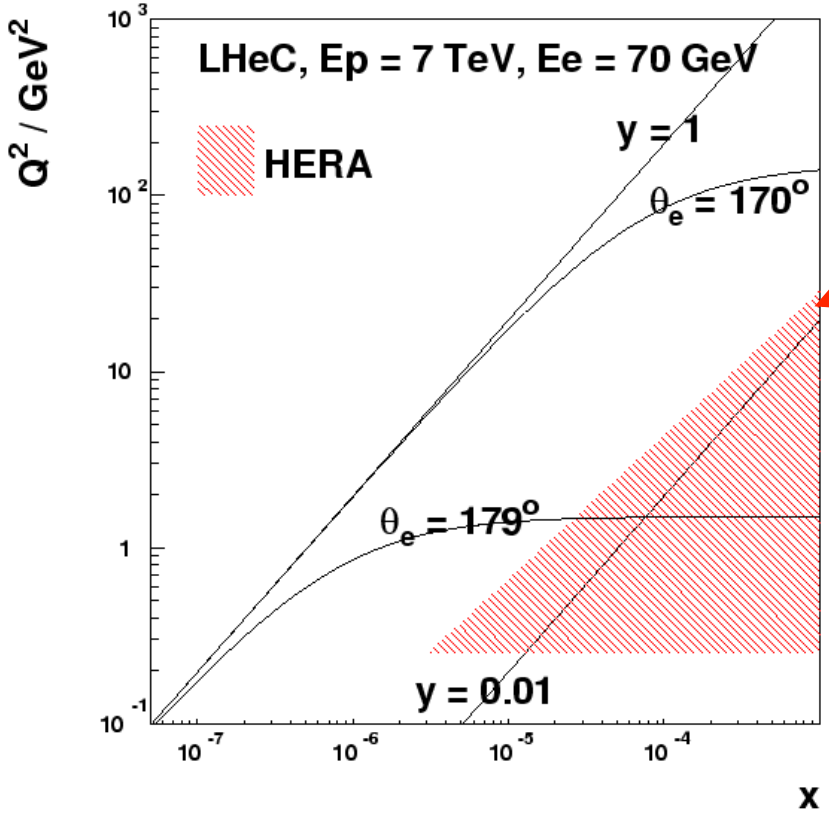
→ PRN (with Juraj B) has 2 masters students again

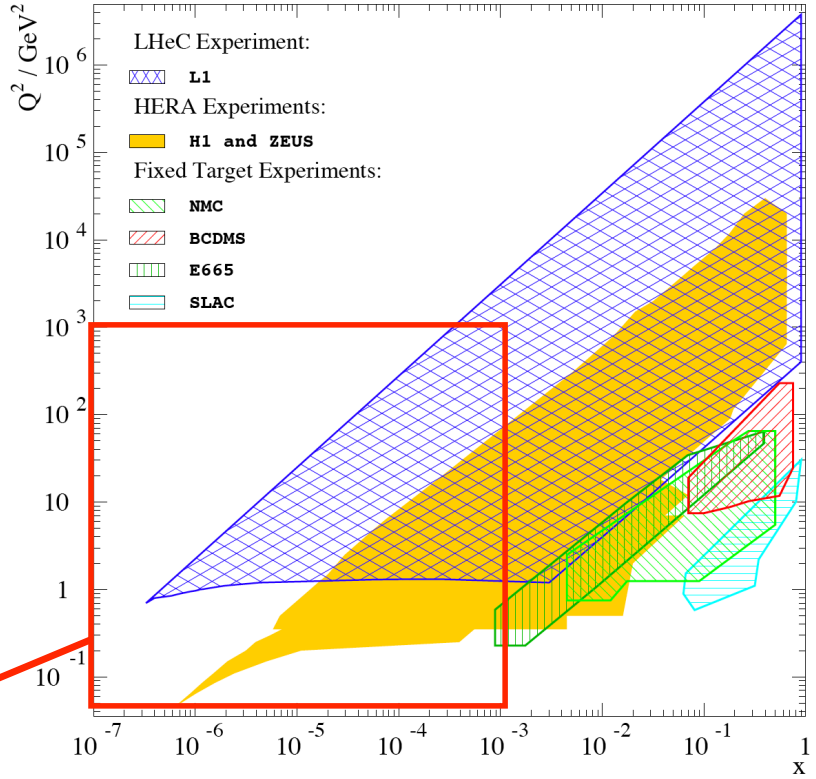
→ Longer-term project?

A few ideas for discussion follow on what might be possible for a Yellow Report and what might be highest priority beyond.

1) Extend Basic Studies from LHeC to FCC-he

Access to Q^2=1 GeV^2 in ep mode for all x > 10^{-6} requires scattered electron acceptance to 179°





Small angle forward acceptance similarly important for hadronic final state studies - e.g. forward (Mueller-Navalet) jets.

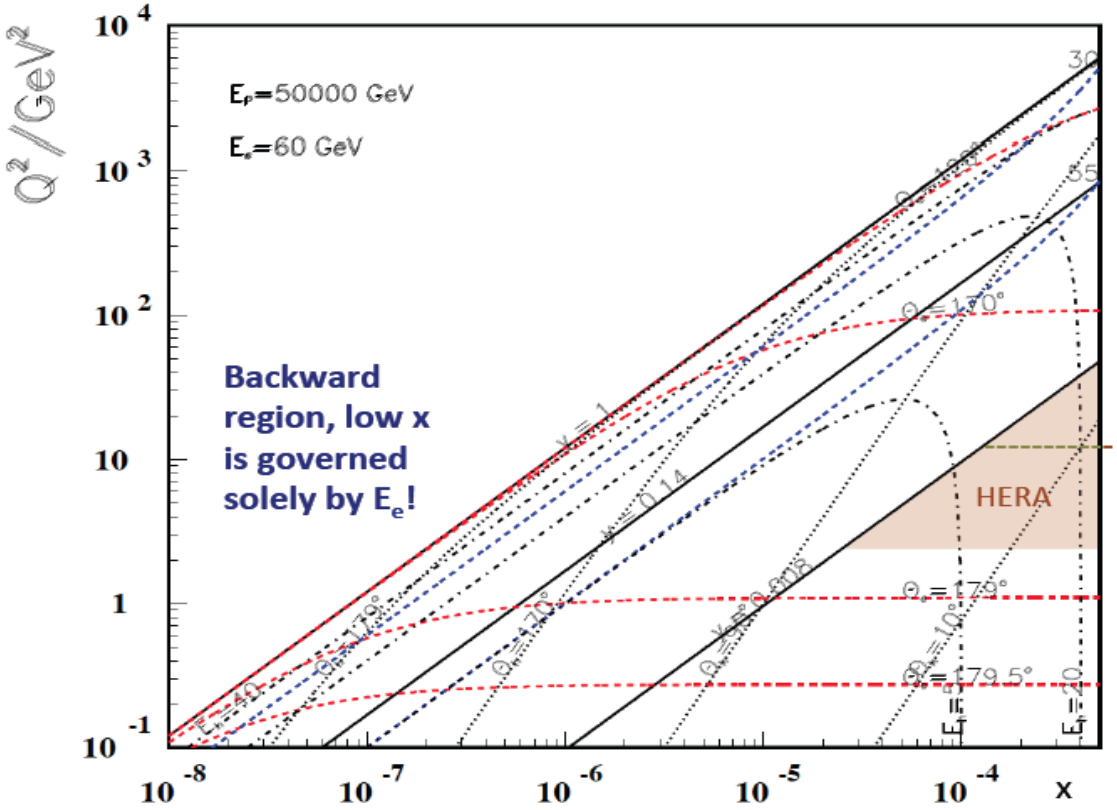
Corresponding start-point for FCC-he

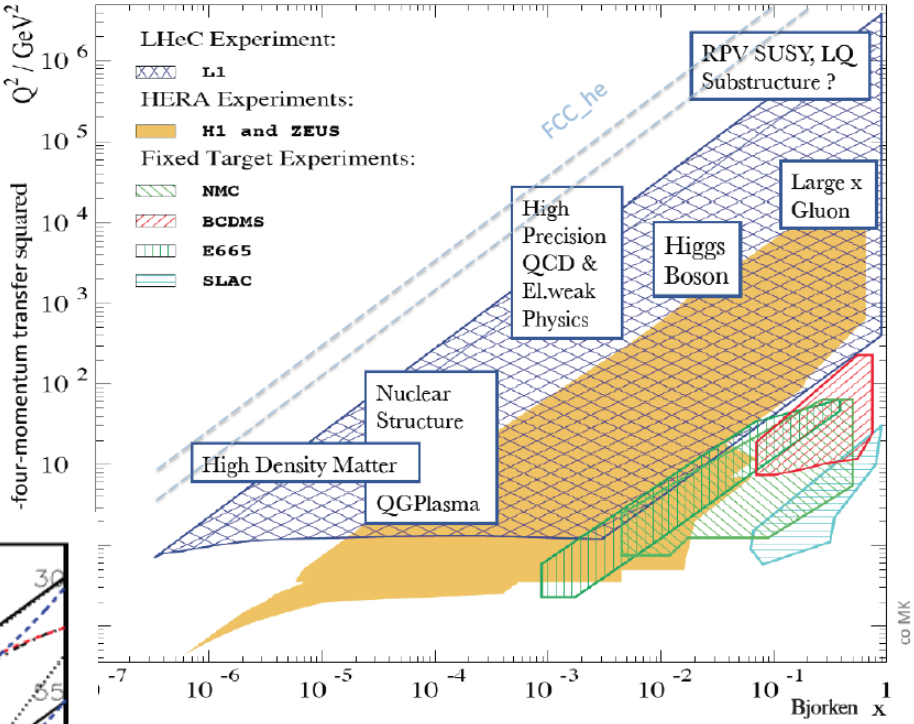
Q^2 limit of acceptance driven solely by E_e

→Assuming E_e = 60 GeV, a 1° acceptance covers all at

$Q^2 > 1$ GeV^2 … to $x < 10^{-7}$

$Q^2 > 100$ GeV^2 … to $x = 10^{-5}$





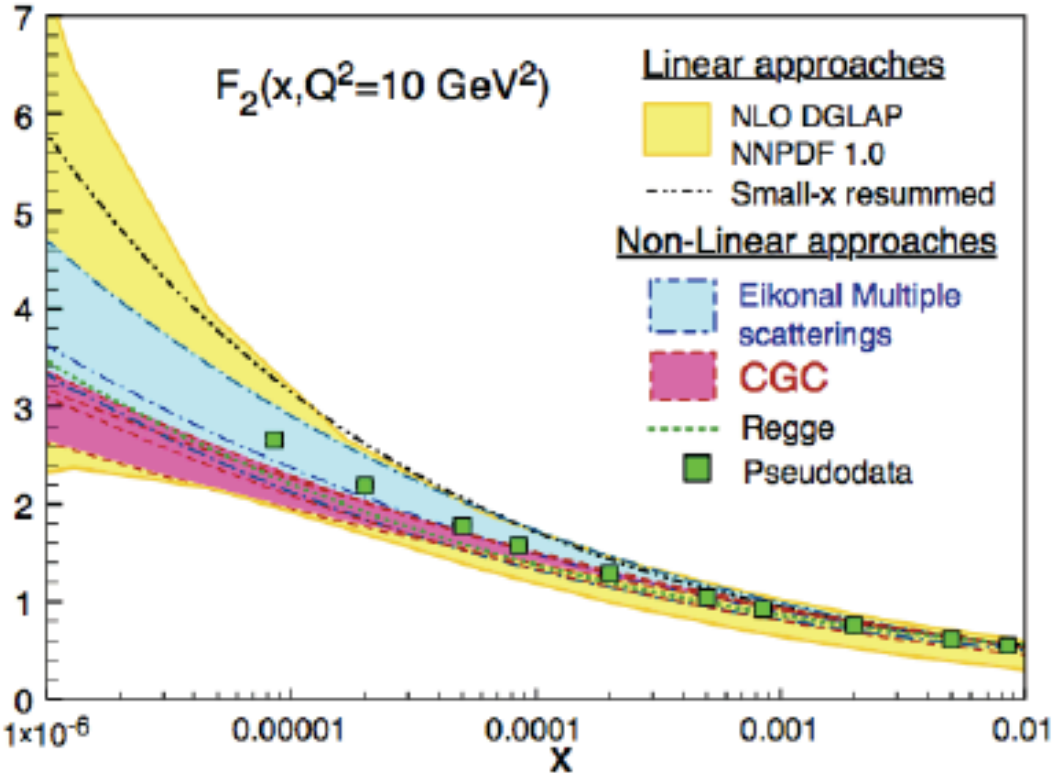
Most relevant low x cross sections are large …

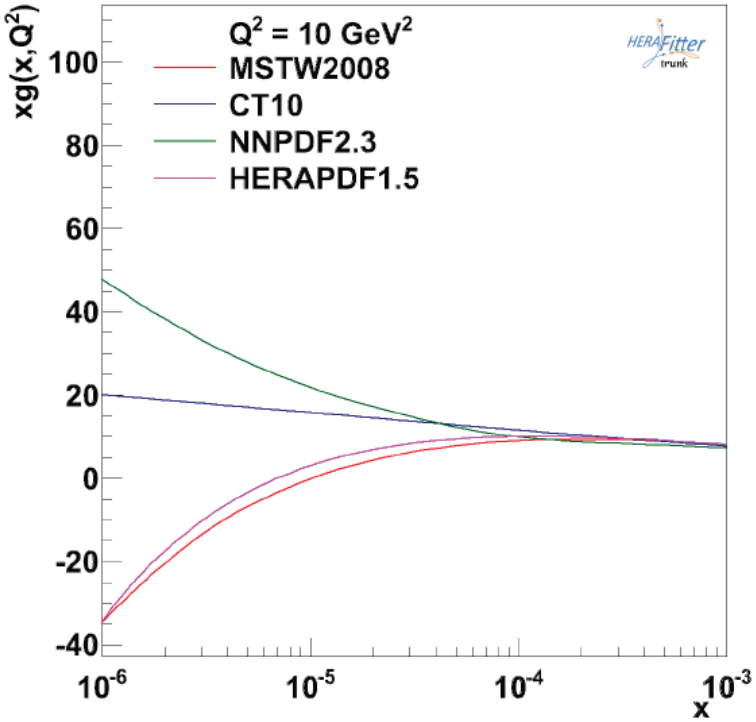
… a really mouth-watering low x laboratory!

Low x Gluon Density

Absolutely no reason to believe DGLAP works at $x < 10^{-4}$

Just comparing pseudodata with models is a good illustration of (unique) power of future DIS data





Easy to add FCC points … kinematic range is known and can't see the errors anyway!

Diffraction - e.g. J/Ψ Photoproduction

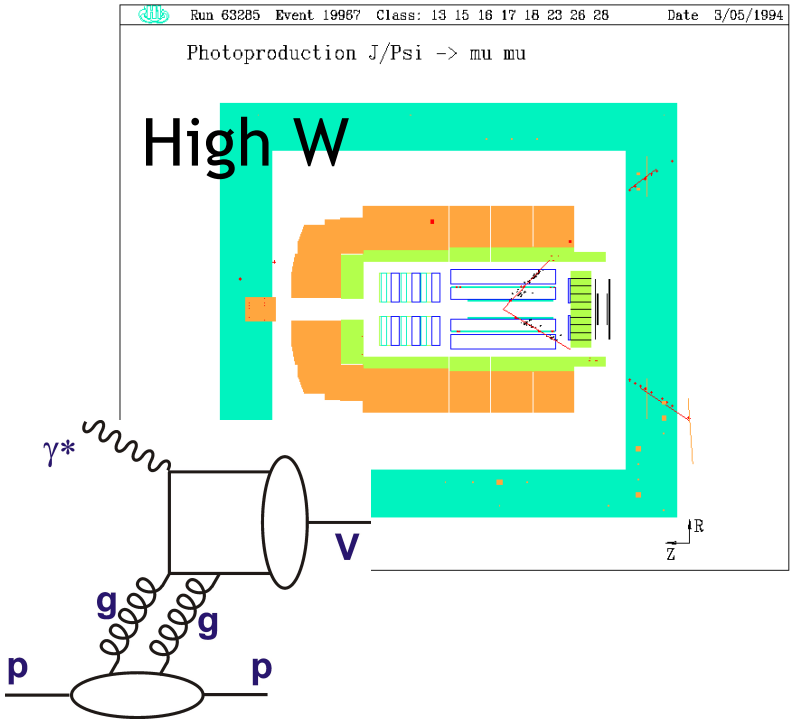
- (Even) more asymmetric γp kinematics good @ high W / low x

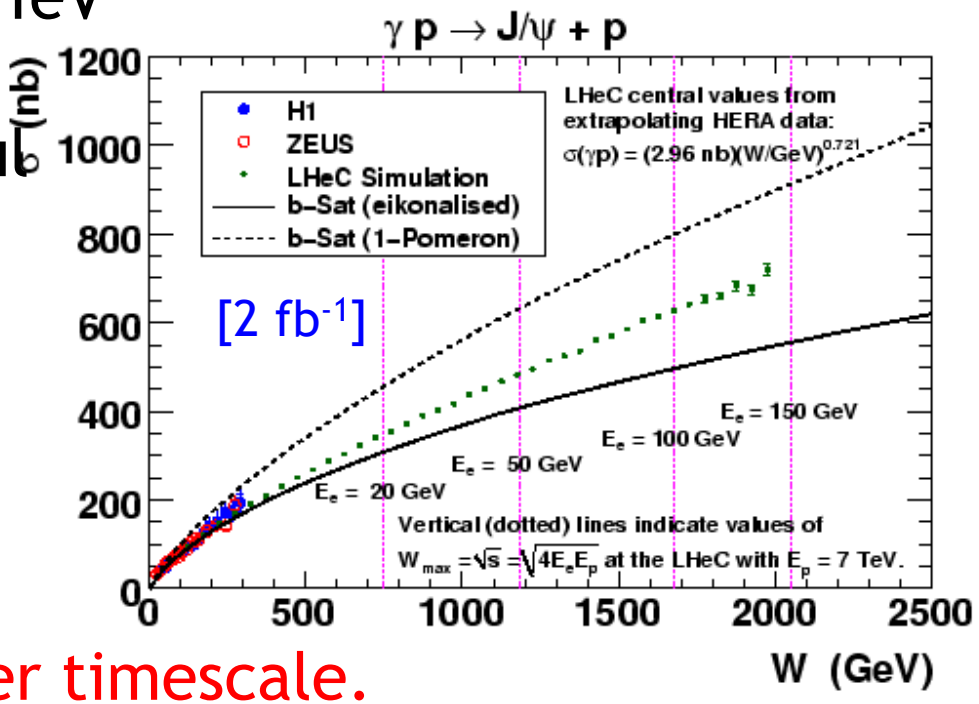
- Basic kinematic range for a 1º acceptance may be evaluated fast.

- FCC-he J/Ψ kinematic limit ~ 3 TeV

- Also, upsilon may be more useful

- Inclusive diffraction → basic kinematic range could be evaluated fast → TeV-scale guaranteed 1- selection!

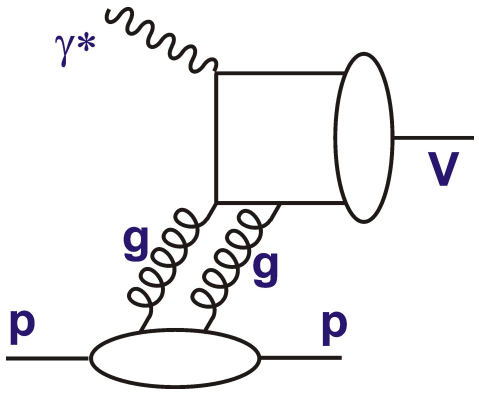




- More detailed studies on a longer timescale.

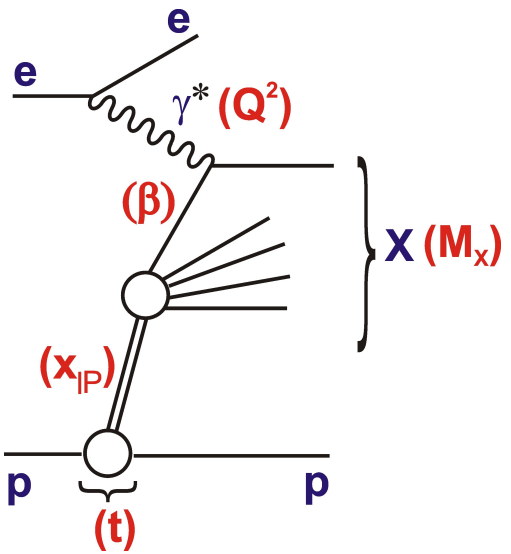
2) Interpreting Exclusive LHeC Pseudodata

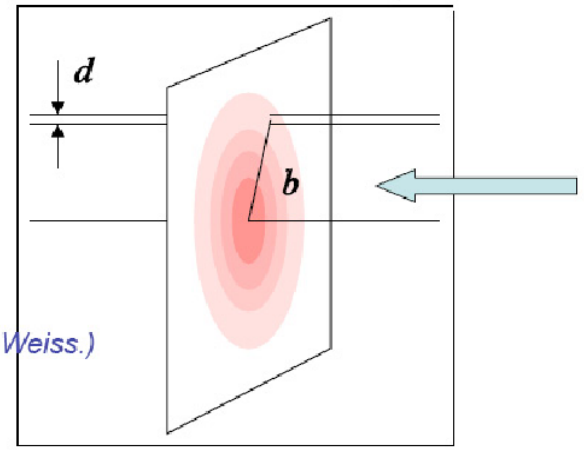
1) [Low-Nussinov] interpretation as 2 gluon exchange enhances sensitivity to low x gluon



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

→ Large t (small b) probes densest packed part of proton?



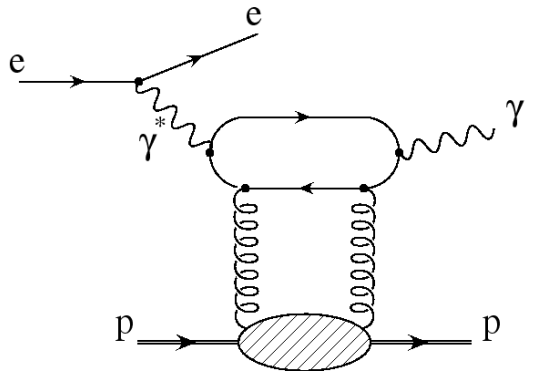


(figure from C. Weiss.)

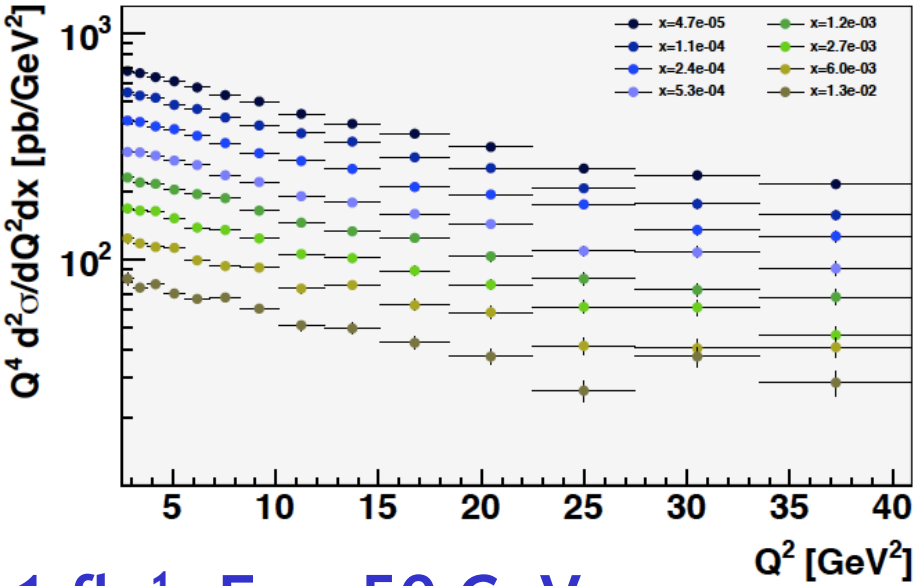
Central black region growing with decrease of x.

Deeply Virtual Compton Scattering at LHeC

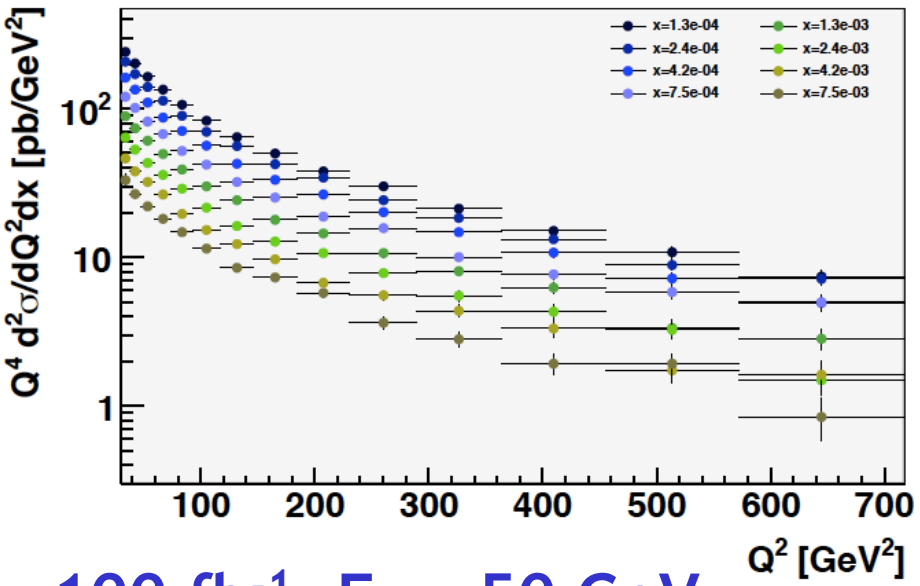
- No VM wavefunction complications
- Exceptionally sensitive to spatial distributions and correlations of partons in proton → Nucleon Tomography



Huge LHeC kinematic range → W~1TeV, Q^2~1000 GeV^2



1 fb^{-1}, E_e = 50 GeV,
1° acceptance, p_T^γ > 2 GeV



100 fb^{-1}, E_e = 50 GeV,
10° acceptance, p_T^γ > 5 GeV

Resulting impact on GPDs etc still to be evaluated

DVCS → Generalised Parton Densities

LHeC Simulations (Laurent Favart) were based on FFS model in MILOU generator

Deeply Virtual Compton Scattering at a Proposed High-Luminosity Electron-Ion Collider

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[b] *Department of Physics, University of Zagreb, Zagreb, Croatia*

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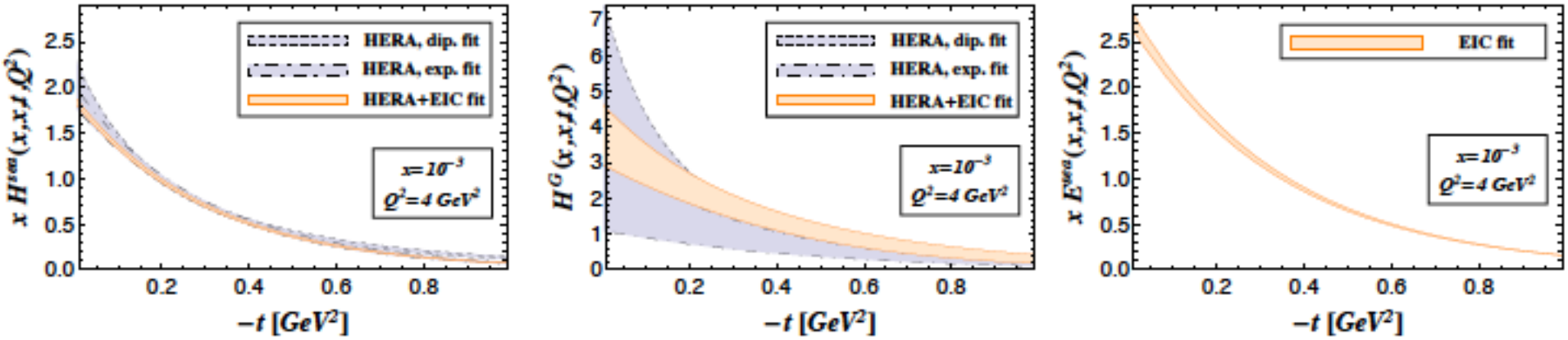
ABSTRACT: Several observables for the deeply virtual Compton scattering process have been simulated in the kinematic regime of a proposed Electron-Ion Collider to explore the possible impact of such measurements for the phenomenological access of generalized parton distributions. In particular, emphasis is given to the transverse distribution of sea quarks and gluons and how such measurements can provide information on the angular momentum sum rule. The exact lepton energy loss dependence for the unpolarized t-differential electroproduction cross section, needed for a Rosenbluth separation, is also reported.

The same framework was recently used for a detailed study of DVCS in the EIC context (arXiv:1304.0077).

Dieter Mueller (and Kreso Kumericki have expressed interest in extending to LHeC (but progress beyond that is slow).

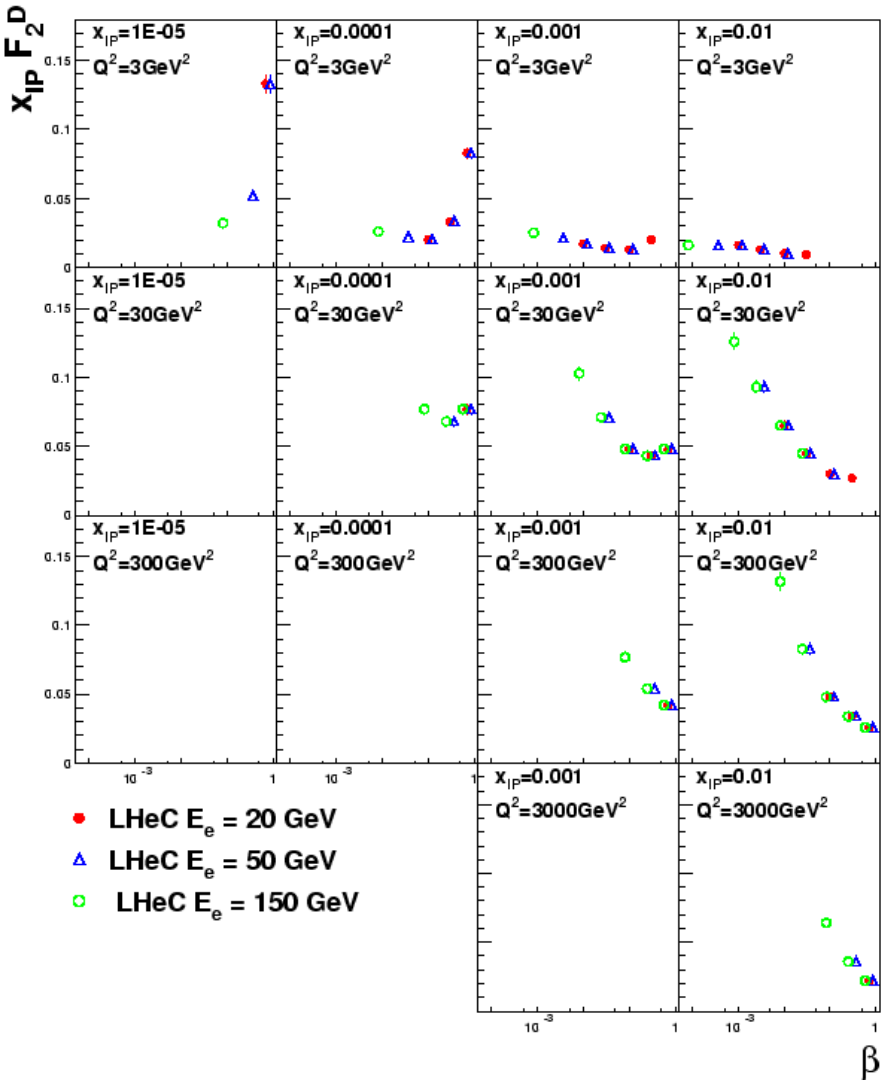
Brief Notes on the EIC Paper

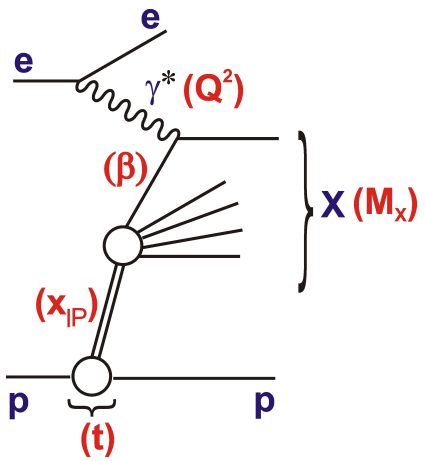
- MILOU (tuned @ HERA) to generate DVCS pseudo-data for EIC.
- Unpolarised x-sections + lepton spin and charge asymmetries
- Considered polarised protons as well as leptons
- Included statistical uncertainties,
- No detector simulation - ~5% systematics assumed
- Sensitivities to GPDs extracted and discussed.

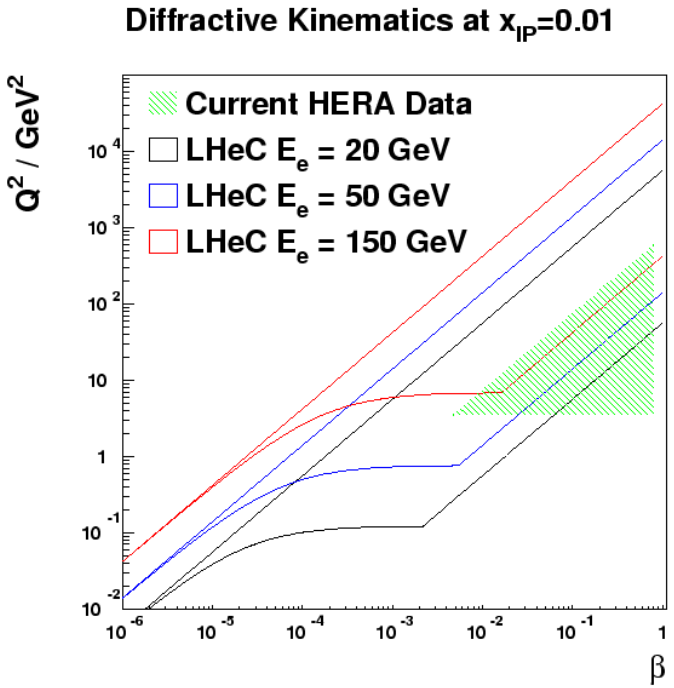


- Would be very good to see this for LHeC!
- Initial chat with DM, “no chance for E without transversely polarised target. Gluonic H may be most promising”

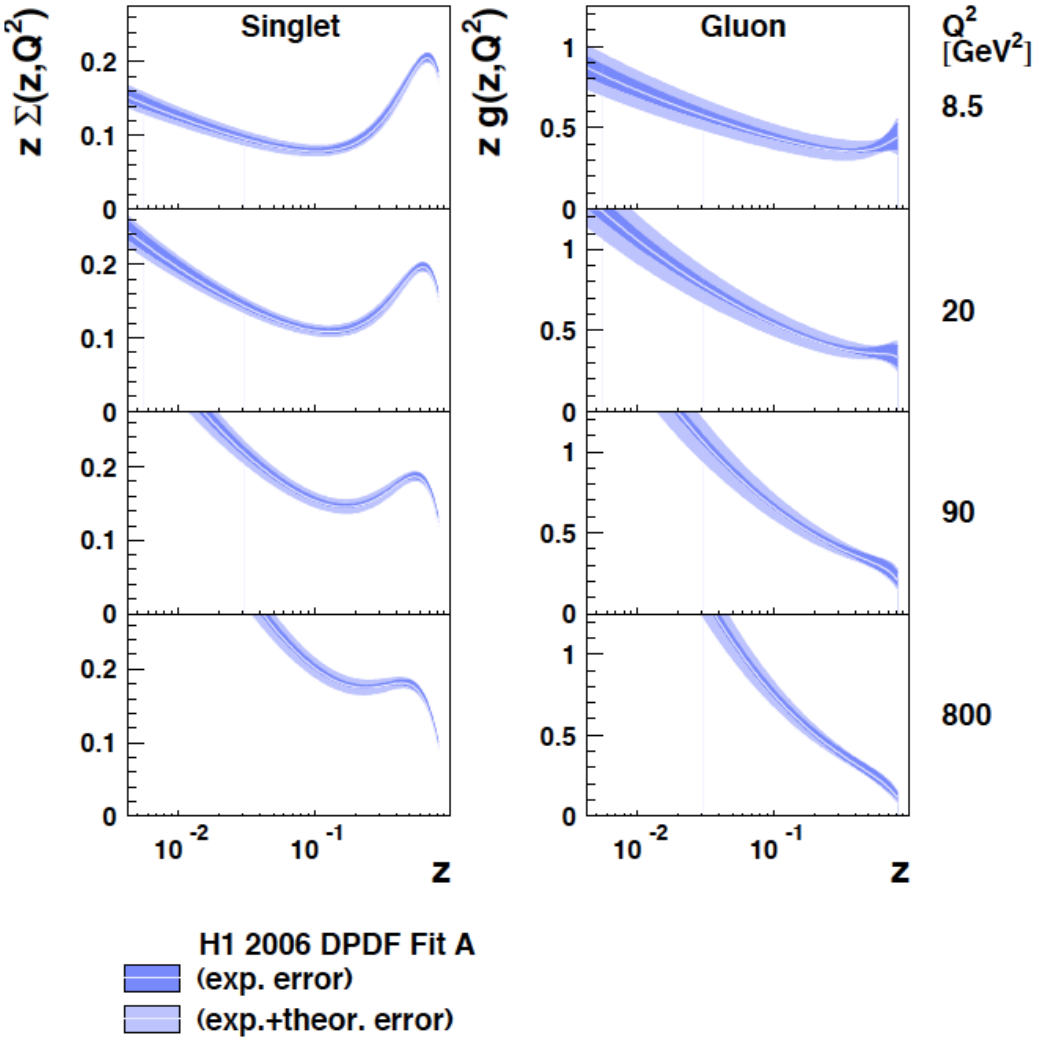
Inclusive Diffractive DIS / Diffractive PDFs







So far we just evaluated kinematic range and produced pseudo-data, which couldn't be well represented in 2D

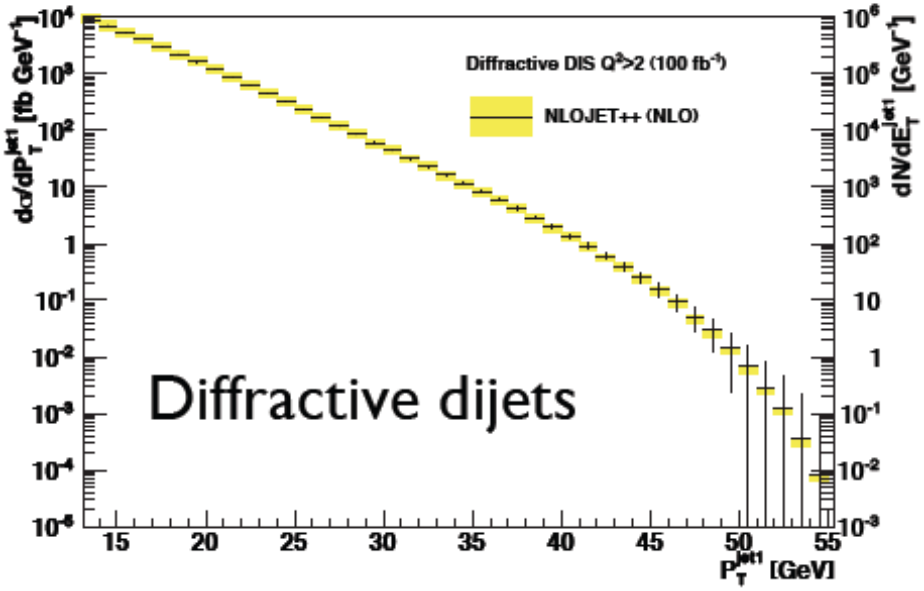


Inclusive Diffraction / Diffractive PDFs

Extracting DPDF sensitivity from pseudo-data is a natural next step.

… not much expertise / time, but it's in HERA-Fitter …

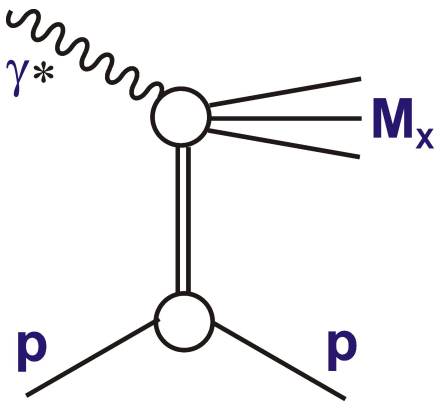
Additional sensitivity at high x from LHeC diffractive jets pseudo-data can also be evaluated

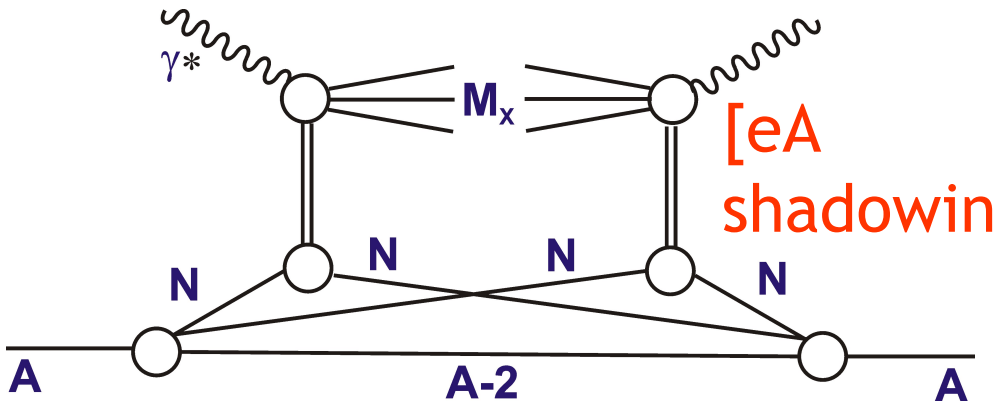


F_2^D and Nuclear Shadowing

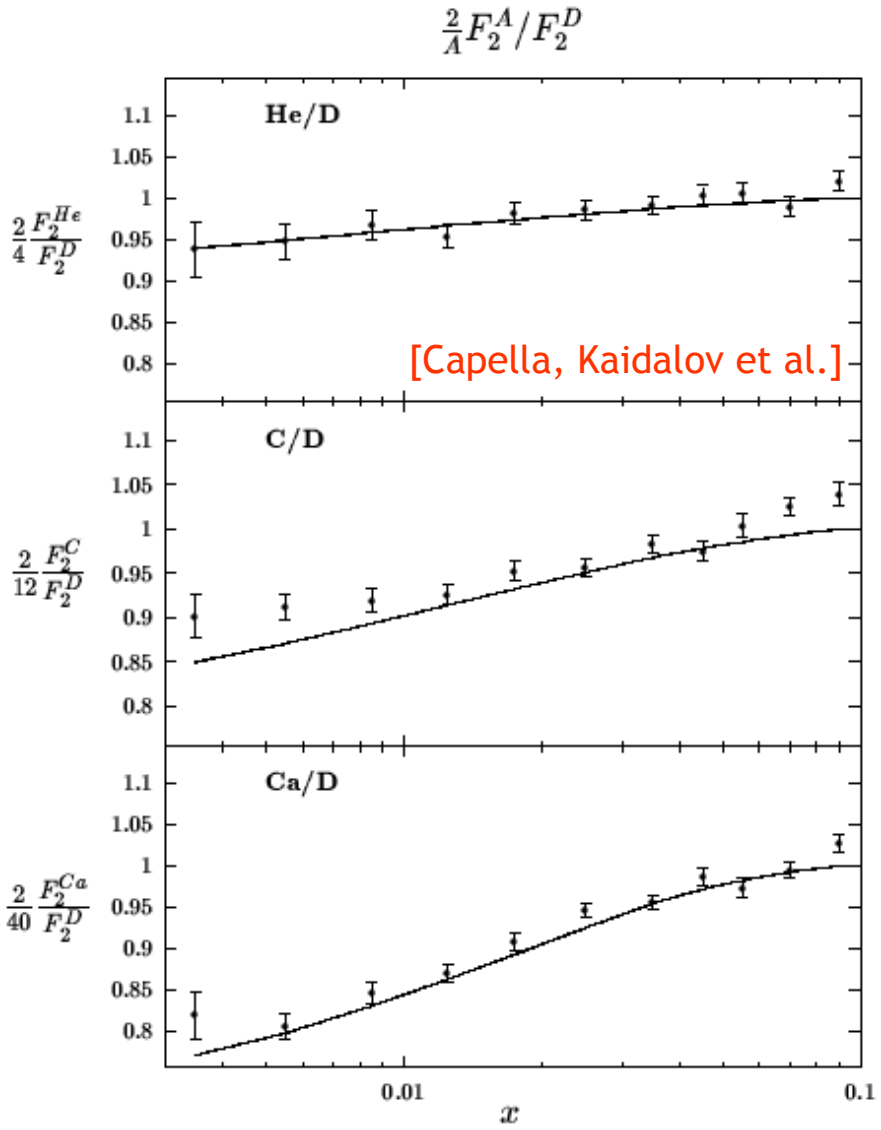
Nuclear shadowing can be described (Gribov-Glauber) as multiple interactions, starting from ep DPDFs

[Diff DIS]





[eA shadowing]



Starting point for connecting LHeC ep and eA … has yet to be investigated quntitatively!

Other Ideas?

Completely new topics opened up by high lumi / enlarged rapidity phase space:

- Exclusive dijet production (cf recent ZEUS result)

- Multi-gaps / Central exclusive photoproduction?

- $\gamma\gamma \rightarrow \gamma\gamma$, WW etc for anomalous QGPs

- Novel applications such as UHE neutrinos

Comments and Further Suggestions very Welcome