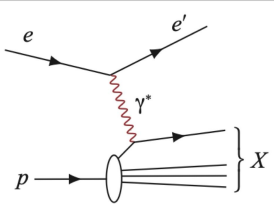


Inclusive Physics at EIC early running

Stephen Maple (U. Birmingham), Win Lin (SBU)

Updated on 11/25/2025

UNIVERSITY OF BIRMINGHAM

Stony Brook University

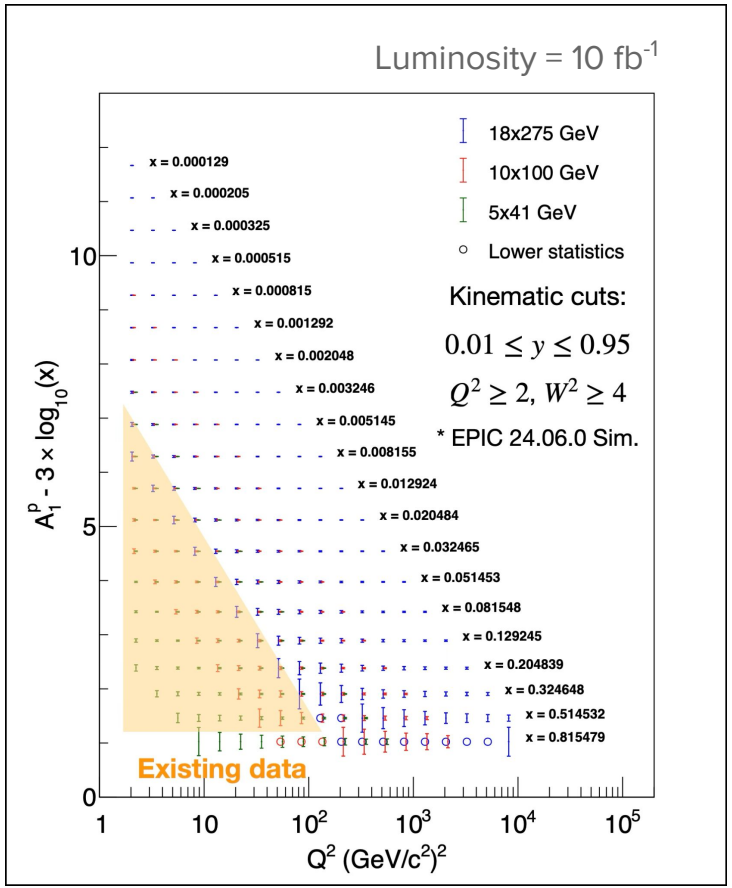
Center for Frontiers in Nuclear Science

Potential projects

	Species	Energy (GeV)	Luminosity/year (fb-1)	Electron polarization	p/A polarization
YEAR 1	e+Ru or e+Cu	10 x 115	0.9	NO (Commissioning)	N/A
YEAR 2	e+D e+p	10 x 130	11.4 4.95 - 5.33	LONG	NO TRANS
YEAR 3	e+p	10 x 130	4.95 - 5.33	LONG	TRANS and/or LONG
YEAR 4	e+Au e+p	10 x 100 10 x 250	0.84 6.19 - 9.18	LONG	N/A TRANS and/or LONG
YEAR 5	e+Au e+3He	10 x 100 10 x 166	0.84 8.65	LONG	N/A TRANS and/or LONG
Note: the eA luminosity is per nucleon					

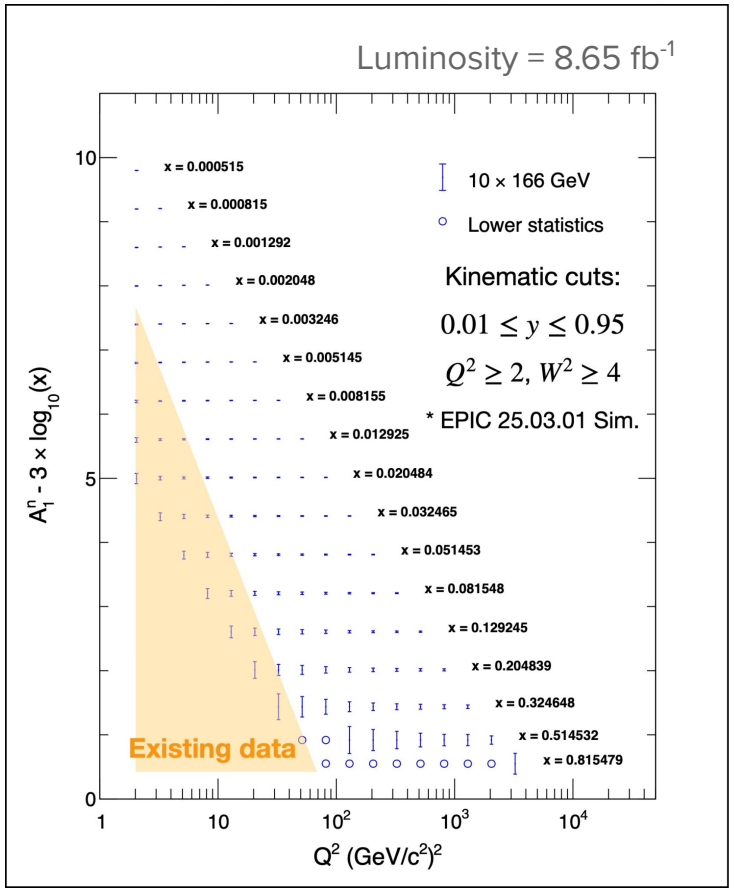
- ep cross sections, F_2, F_L, α_s (projections available)
- A_1^p, g_1^p (simulation available, projections are in progress)
- $A_1{}^3He$, A_1^n, g_1^n (projections available)
- eAu cross-sections (work in progress)

Double Spin Asymmetry for ep DIS

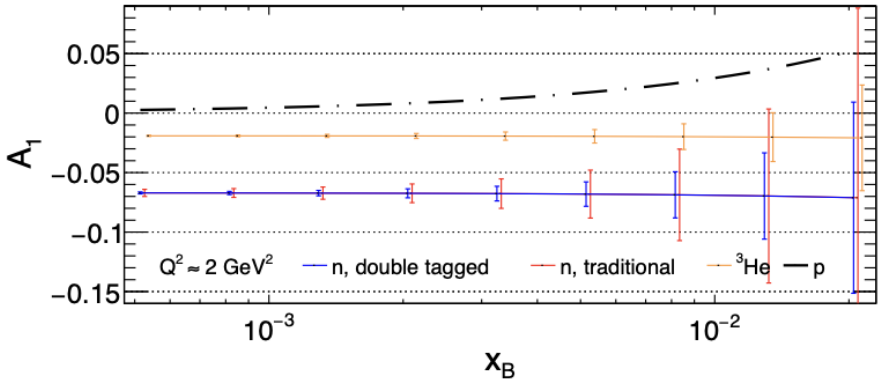


- $A_{||}$ can be measured starting in year 2
- $A_{\perp}$ can be measured starting in year 3
- ep 10x130 GeV will cover area similar to 10x100 GeV
- ep 10x250 will cover between 10x100 GeV and 18x275 GeV
- Pythia 6 samples generated, will submit to simulation campaign soon
- Shown are statistical uncertainties for EIC nominal settings. A_1 uncertainty is statistically dominated.

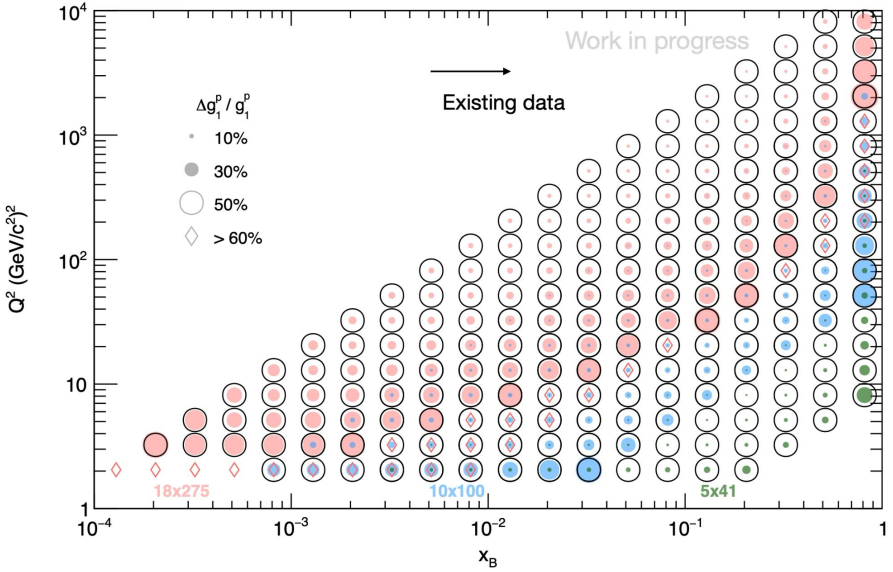
Double Spin Asymmetry for en DIS

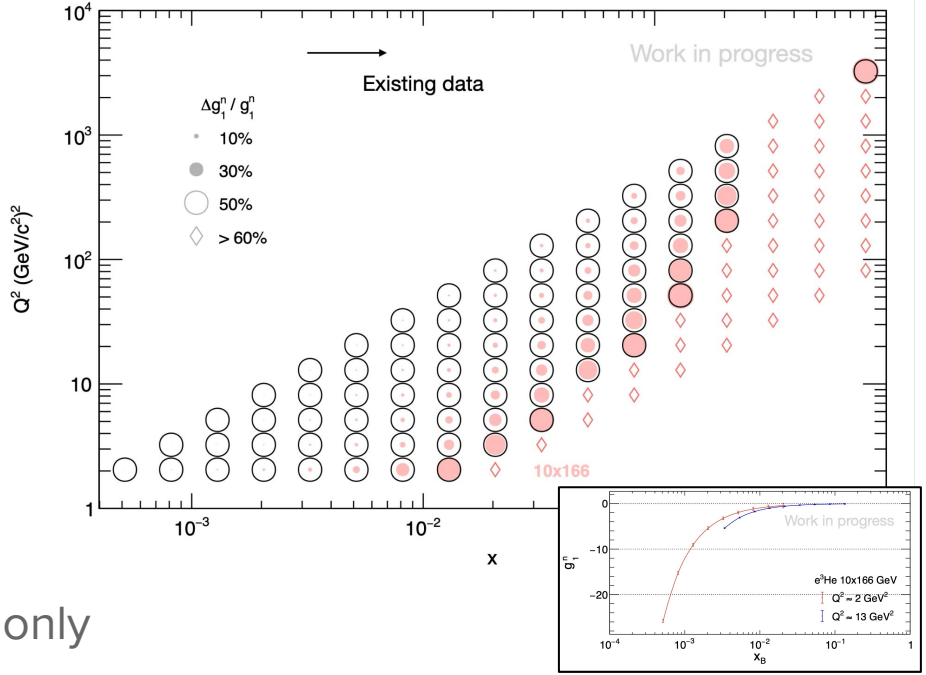


- Can be extracted from $A_1{}^3He$ (traditional) and measured via double spectator tagging



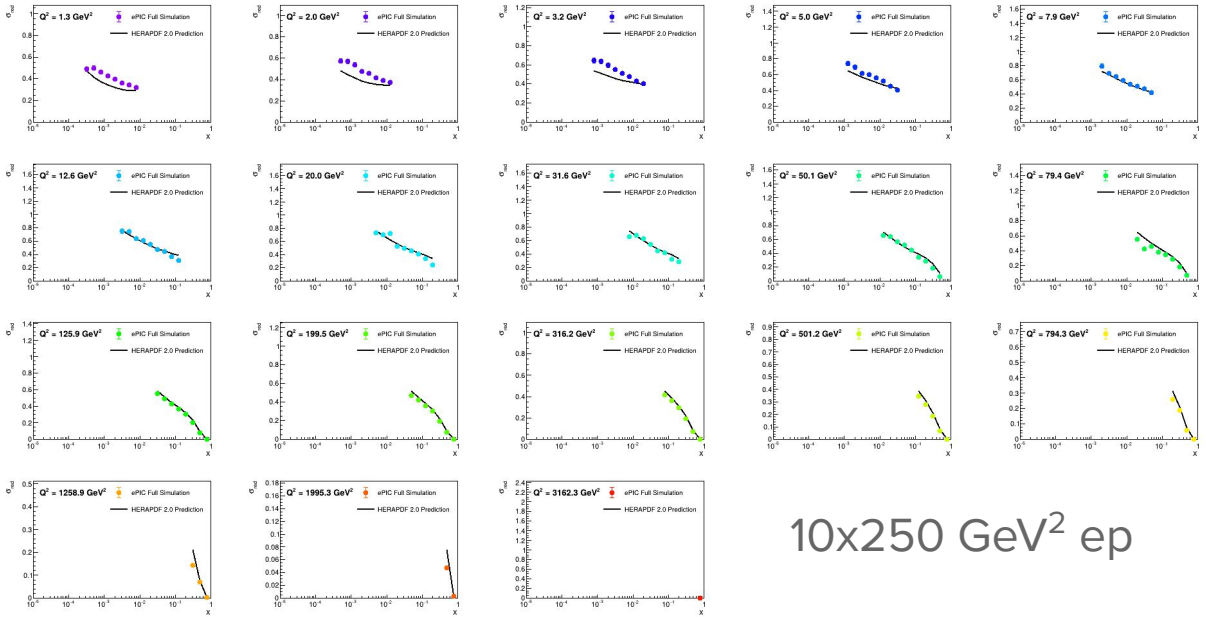
Spin dependent structure function, g_1





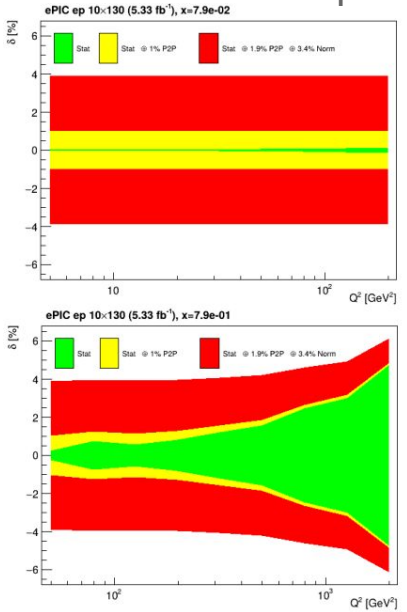
- Shown are statistical uncertainties only
- Low x data is important for studying the quark and gluon spin contributions and the Bjorken sum

ep reduced cross sections (hence F_2)



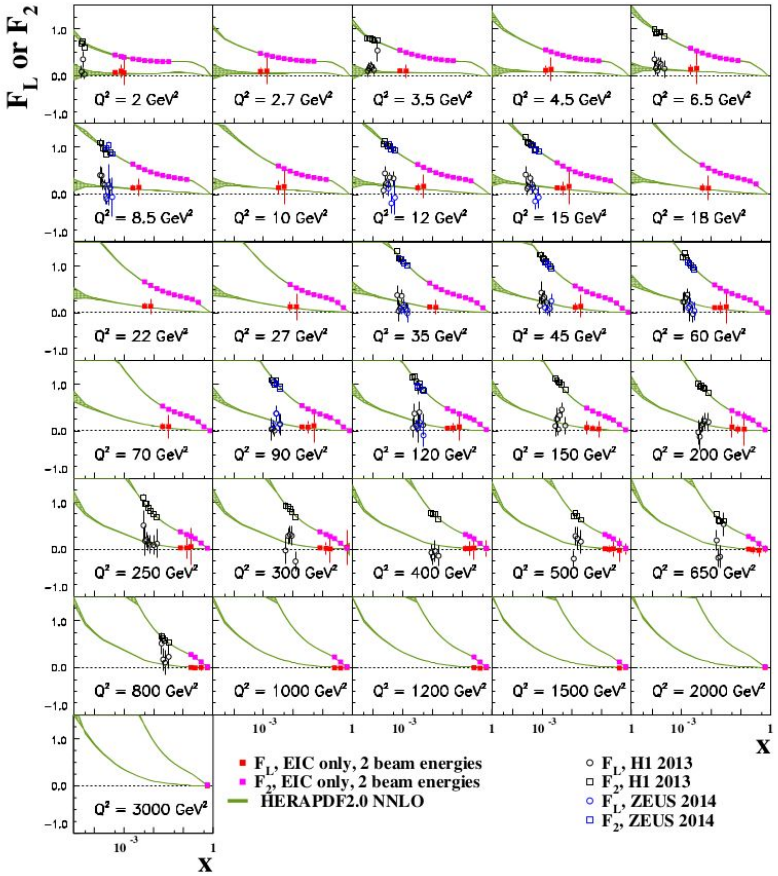
10x250 GeV^2 ep

10x130 GeV^2 ep



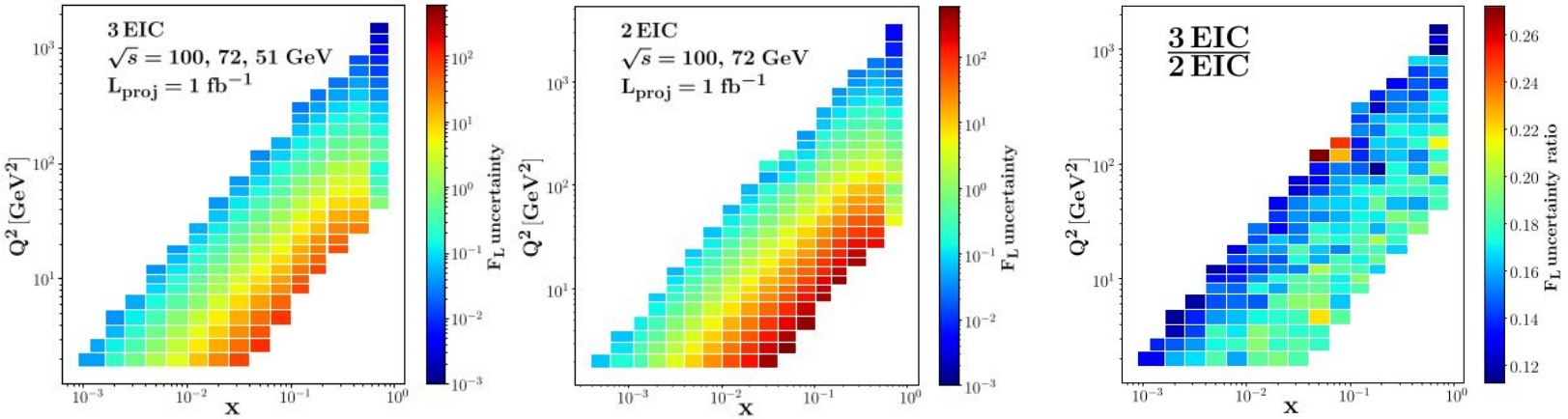
- σ_{red} can measured for any beam config - if F_L taken from theory prediction, F_2 can be extracted in each beam config (model-dependent)
- **Above:** ePIC full sim (pythia6 events) compared to pdf prediction
  - Statistical uncertainties (9.18 fb^{-1}) on plot - but very small (up to a few percent at highest x and Q^2)

(Model-independent) proton structure functions



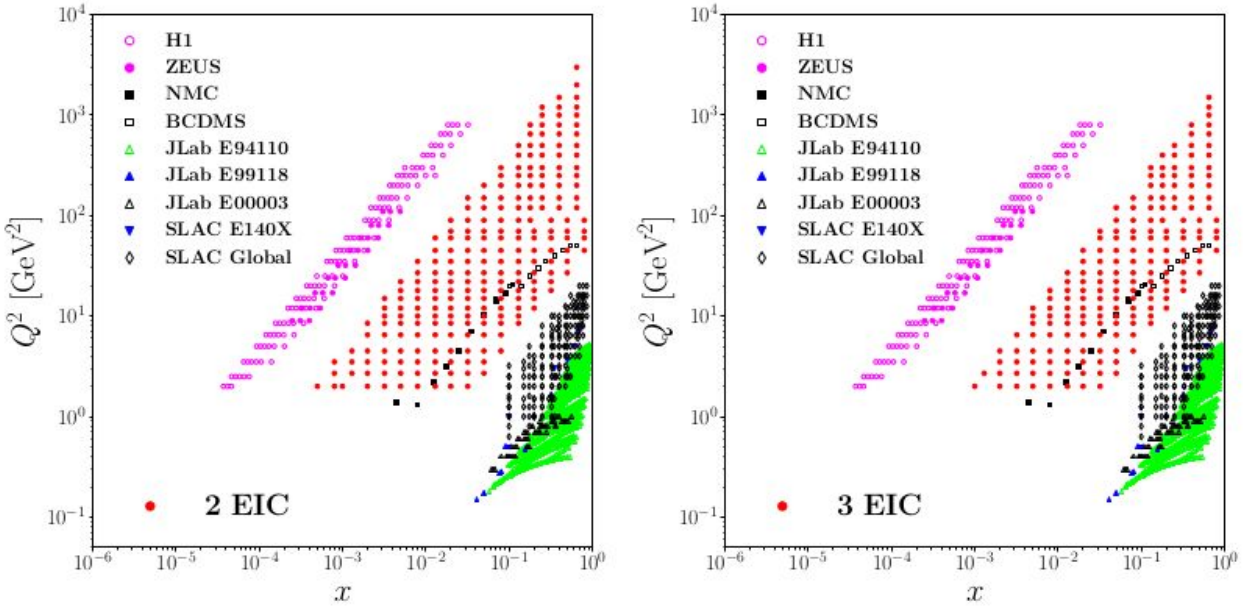
- For 2 (ideally 3+) beam energy configurations, F_L and F_2 can be simultaneously extracted (model independent) in overlap region
- Plot shows possible points and errors, compared to HERAPDF 2.0 and HERA data
  - Assume 10x130 and 10x250 GeV^2 ep configs and stat errors from 1 fb^{-1} per config
  - Conservatively assume 1.9% point-to-point uncorrelated uncertainty and 3.4% normalisation fully correlated between configs
  - Only points with δF_L<0.5 are plotted - F_L point available for each F_2 point, but large errors

Uncertainty on F_L



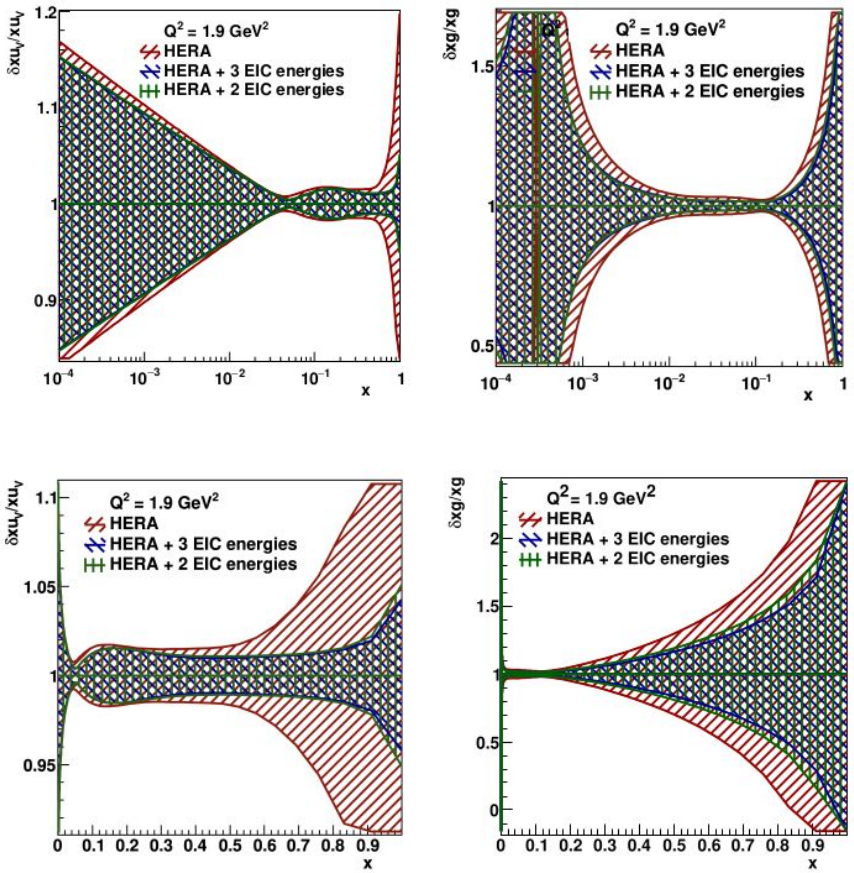
- Require 2 or more σ_{red} measurements to extract F_L
- **Adding a third, lower, beam energy config (5x130 GeV^2) offers a factor of ~5 improvement in uncertainty**

Phase space for F_L and model independent F_2



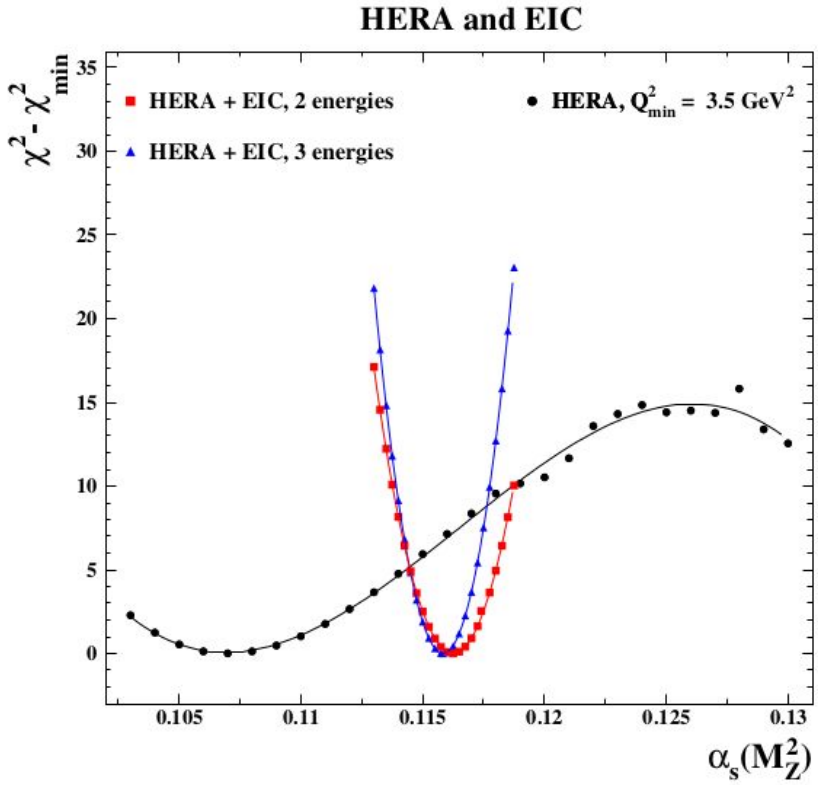
- Early Science EIC bridges gap between fixed target and HERA, if 2+ ep configs are run
- Note that right-hand plot has smaller phase space as a requirement of 3 overlapping σ_{red} measurements is chosen in this case

Impact on proton PDFs (HERAPDF 2.0)



- Potentially large improvement in up-valence and gluon PDFs at large x with 2+ ep beam configs in early science
- Moderate improvement at low x
- Only small difference for 2 vs 3 ep configs, and only at large x

Extraction of α_s (combining EIC with HERA)



- Potential to combine Early Science EIC with HERA to constrain $\alpha_s(M_z^2)$
- Highly competitive precision:
  - 2 beams: 0.1162 ± 0.0008
  - 3 beams: 0.1158 ± 0.0006