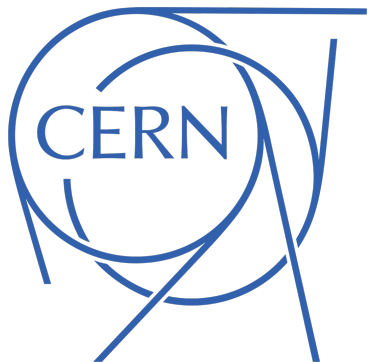


# *Impact of inclusive EIC data on collinear PDFs*

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B. Schmookler, R. Thorne, K. Wichmann



Forward physics and QCD  
at the LHC and EIC  
Bad Honnef (Germany)  
23-27/10/2023

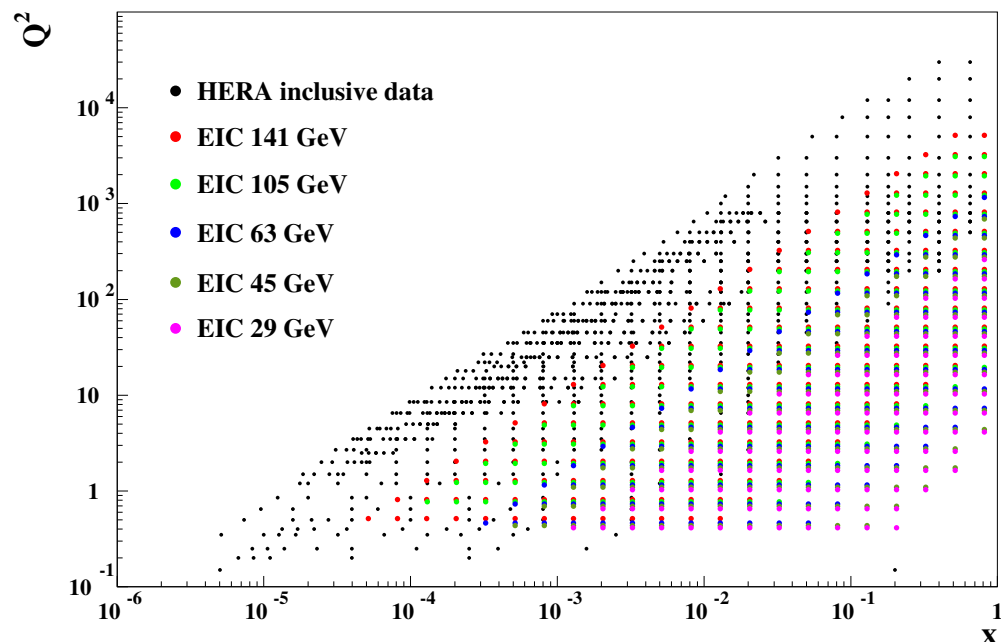
**WILHELM UND ELSE  
HERAEUS-STIFTUNG**



# PDFs at the EIC

- **EIC** will be the first
  - **eA collider**
  - **High lumi ep collider**
  - **Polarised target collider**
- Detailed simulation work to optimise resolution throughout phase space → 5 bins per decade in  $x$  and  $Q^2$
- Kinematic coverage:  $Q^2 > 1$  GeV<sup>2</sup>,  $0.01 < y < 0.95$ ,  $W > 3$  GeV
- Lower  $y$  accessible in principle, but easier to rely on overlaps between data at different  $\sqrt{s}$

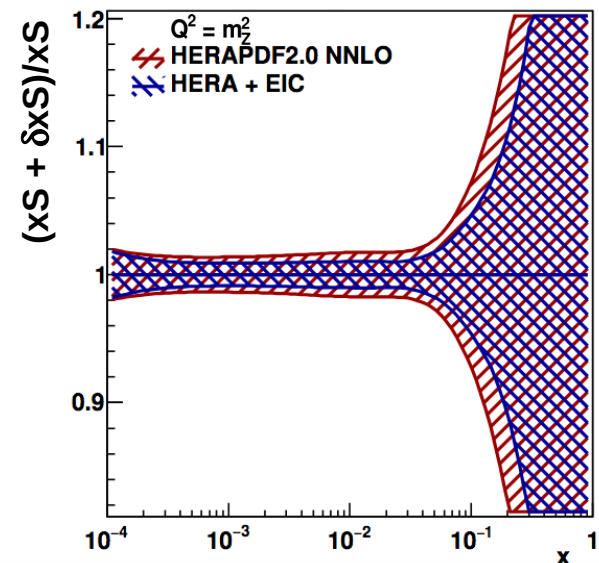
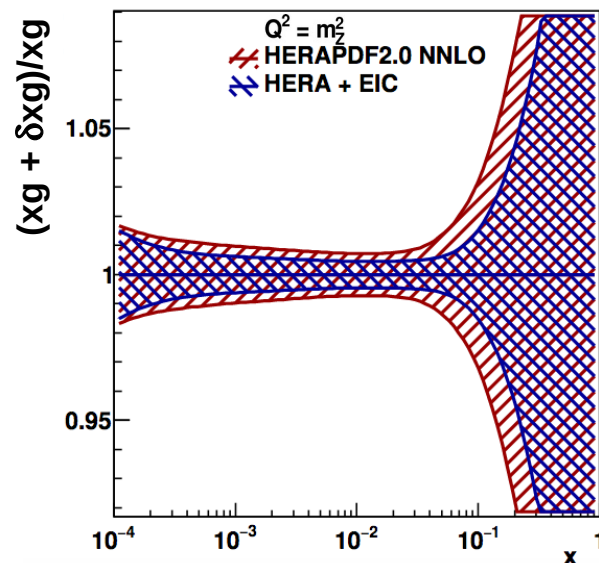
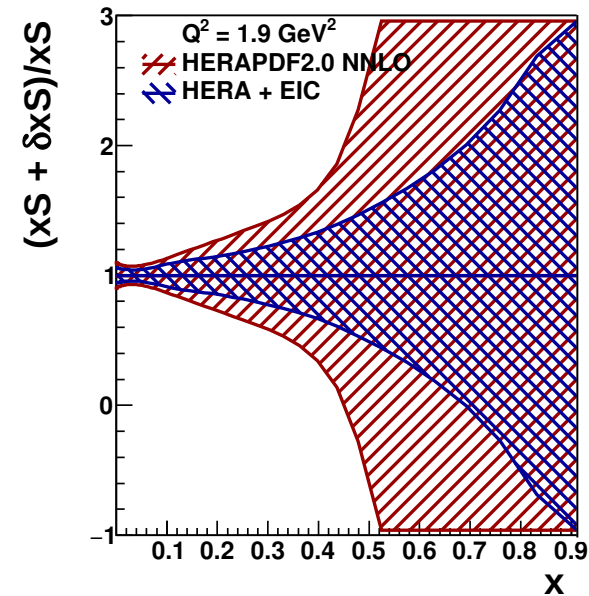
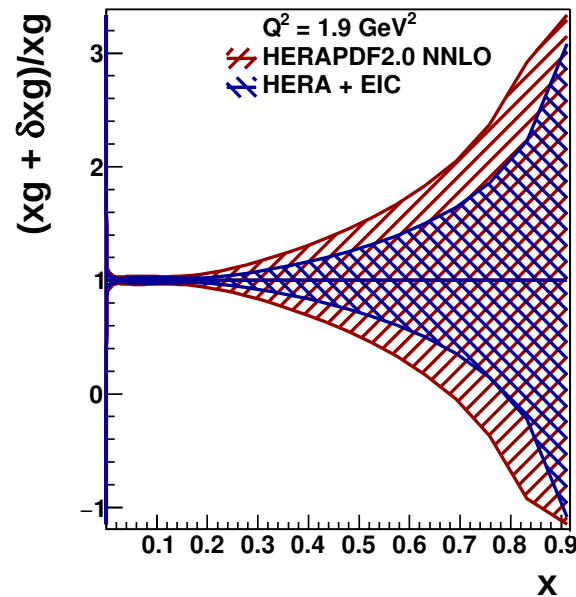
e-beam E	p-beam E	$\sqrt{s}$ (GeV)	inte. Lumi. (fb <sup>-1</sup> )
18	275	140	15.4
10	275	105	100.0
10	100	63	79.0
5	100	45	61.0
5	41	29	4.4



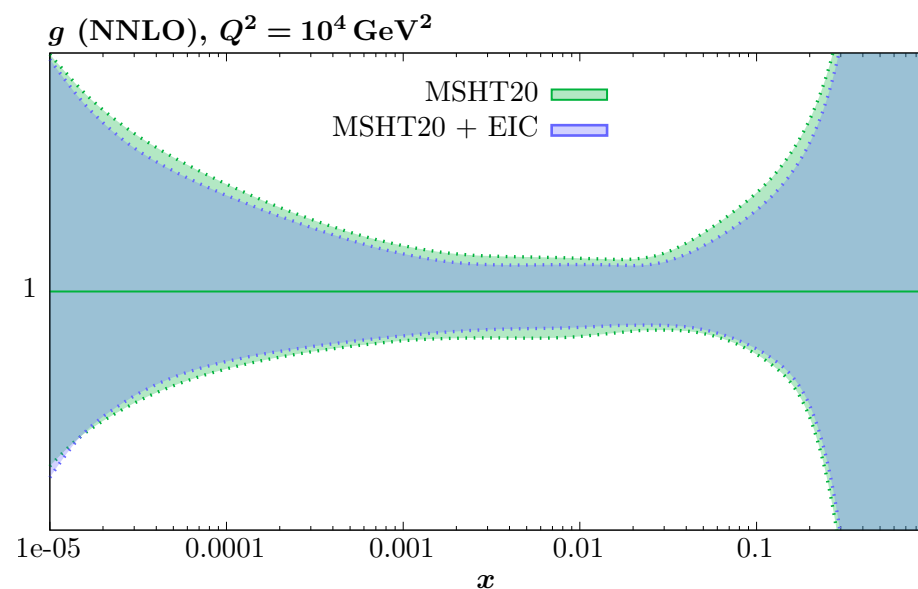
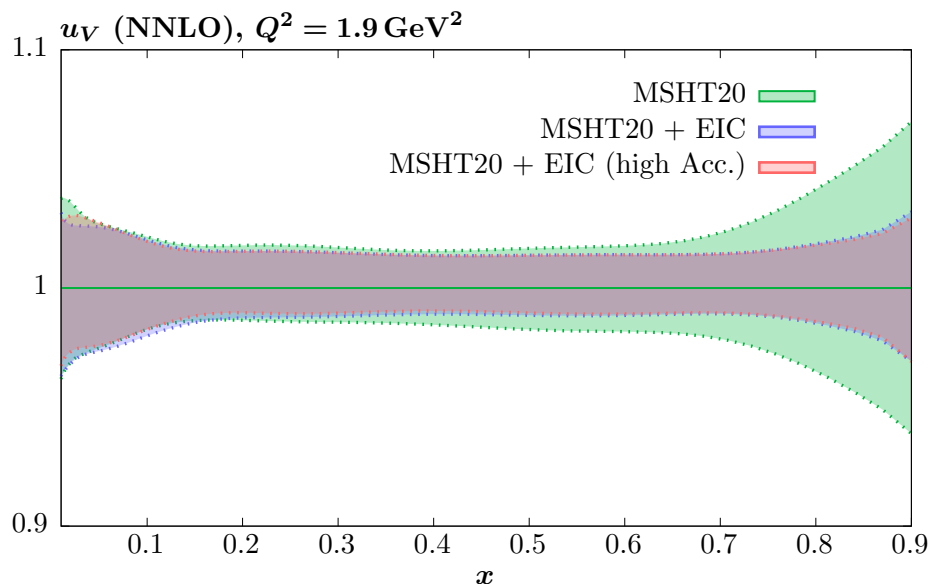
- Dominant sources at HERA were:
  - Electron energy scale (intermediate  $y$ )
  - Photoproduction background (high  $y$ )
  - Hadronic energy scale/noise (low  $y$ )
- **EIC will improve in all areas** – systematics assumptions in YR:
  - 1.5-2.5% point-to-point uncorrelated
  - 2.5% normalisation (uncorrelated between different  $\sqrt{s}$ )

# Impact of EIC on HERAPDF

- 'DIS-only' fits
- Using xFitter framework
- HERA data have limited high- $x$  sensitivity due to kinematic correlation between  $x, Q^2$  and  $1/Q^4$  factor in cross section
- Fractional total uncertainties w/wo EIC data along with HERA
- Linear  $x$  scale
- **EIC data** will bring **significant reduction in uncertainties for all parton species at large  $x$**



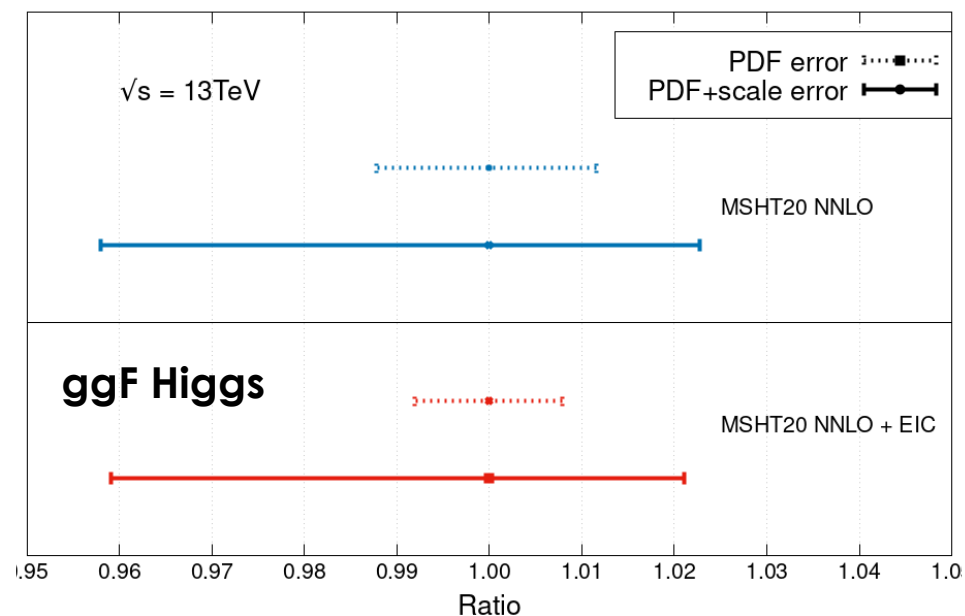
# Impact of EIC on MSHT20



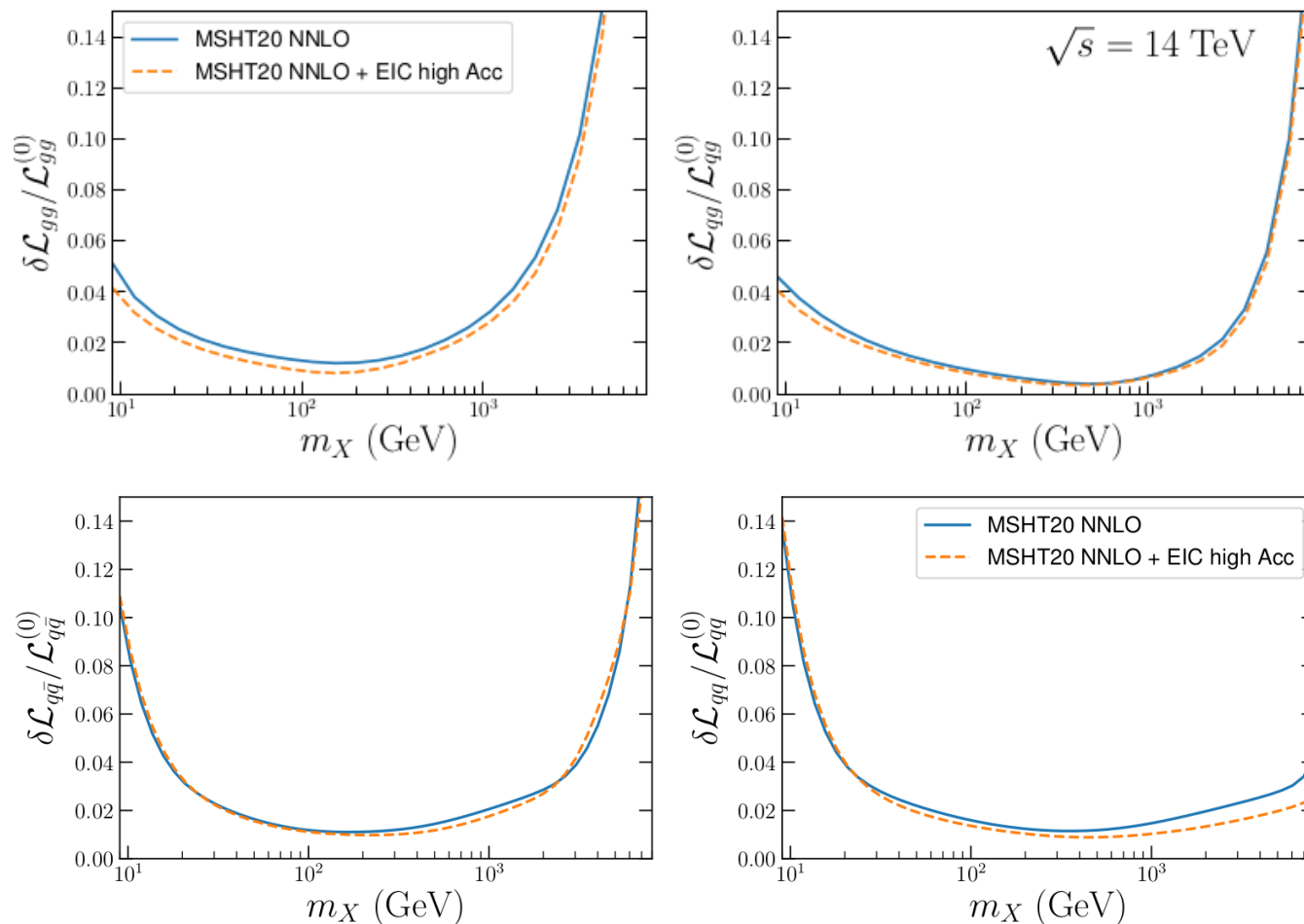
EIC  $\rightarrow y > 10^{-2}$

EIC (high Acc.)  $\rightarrow y > 10^{-3}$

**Small but valuable improvements  
in all parton species at all  $(x, Q^2)$**



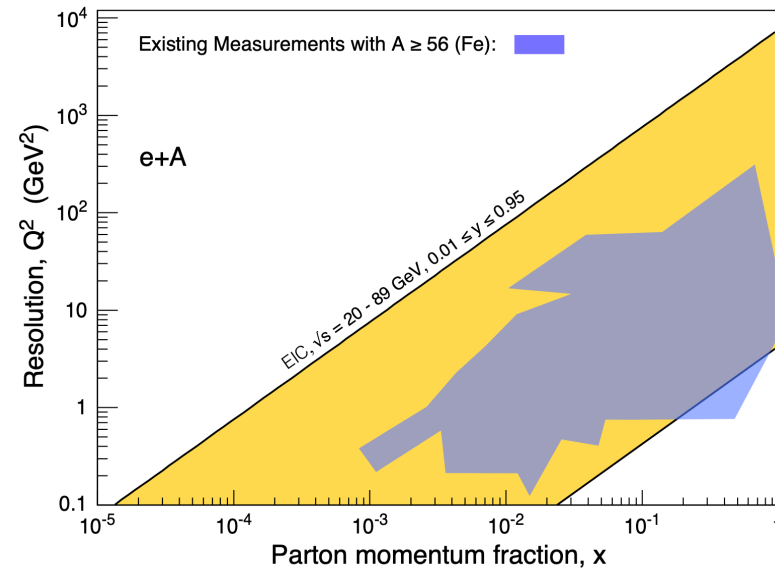
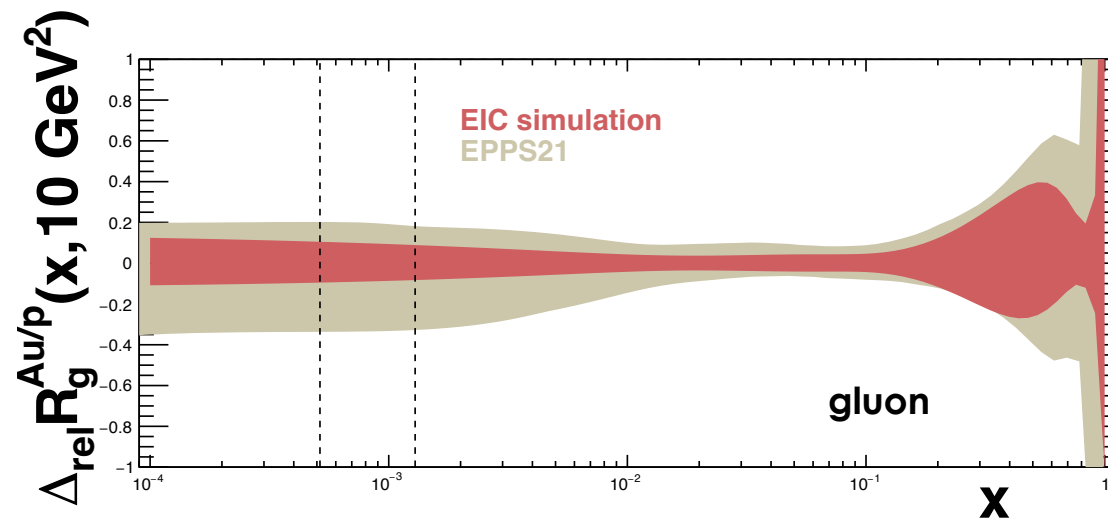
# Impact of EIC on MSHT20



- Largest effect on the gluon-gluon luminosity
- This reflects the reduction in the gluon uncertainties across a range of x values

# Nuclear PDFs

- EIC will have revolutionary impact on eA phase space → most promising environment to observe novel low x effects!
- Studies performed in xFitter framework to assess sensitivity of EIC relative to EPPS21



Projected uncertainty on nuclear modification factor

- Factor  $\sim 2$  improvement at  $x \sim 0.1$
- Very substantial improvement in newly accessed low- $x$  region
- Similar compelling improvements for quarks at low- $x$  in particular

# Summary

- General Purpose Detectors at the EIC may provide transformational input to collinear PDFs with wide-ranging impact
- Precision on all proton PDF species from an experimentally and theoretically cleaner DIS-only extraction
- Key to optimising sensitivity to new BSM physics near to kinematic limit at the LHC and elsewhere
- eA measurements in the low  $x$  region for the first time
- Nuclear PDFs (especially gluon) in the low  $x$  region
- Key to EIC physics programme of exploring new strong interaction dynamics in densely packed gluon systems