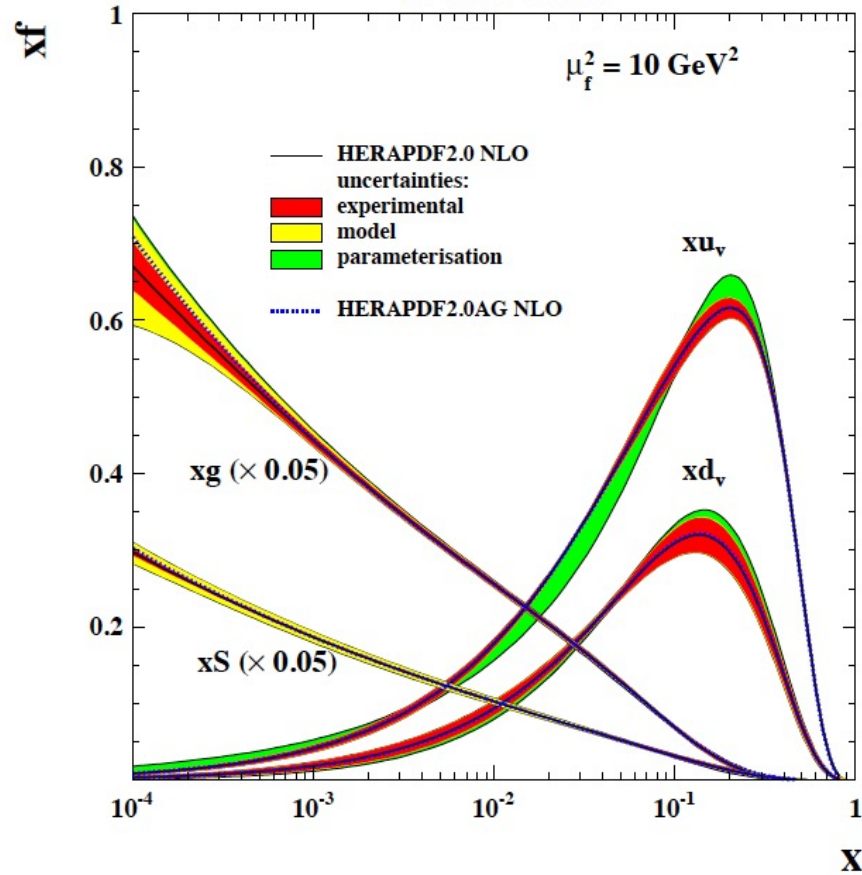# Assessing ATHENA Impact on (unpolarized proton) PDFs
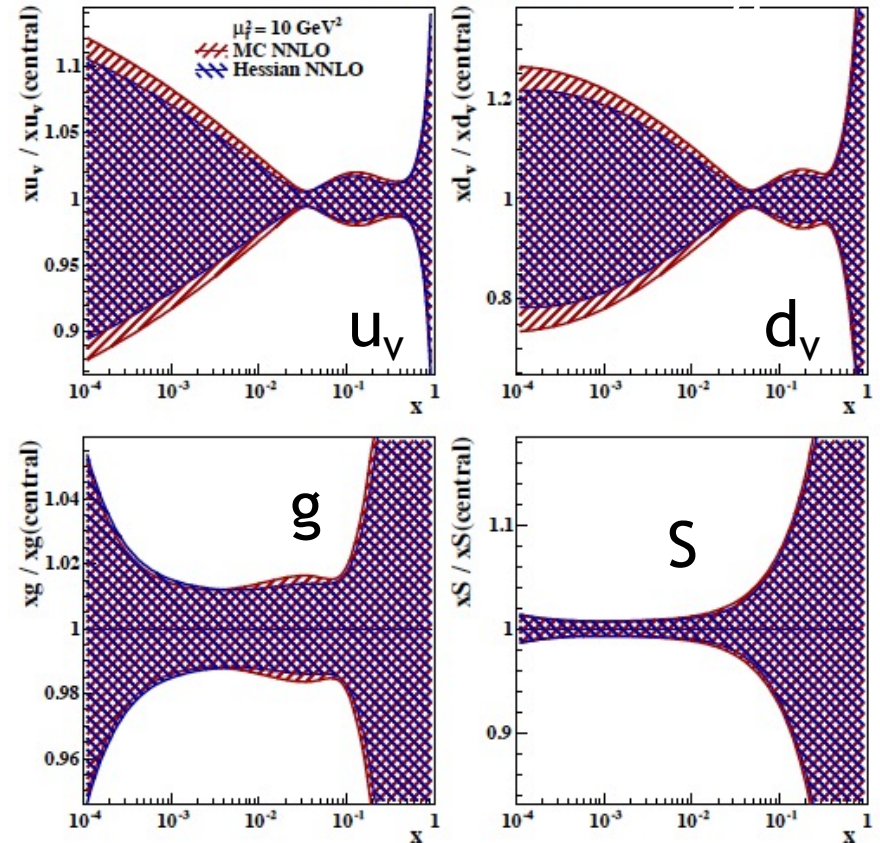
Paul Newman
(University of Birmingham)
23 August 2021

PDFs using only DIS Data (HERAPDF2.0)

- ~2% gluon precision, 1% on sea quarks for $x \sim 10^{-2}$
- Uncertainty explodes above $x = 10^{-1}$ …
  - → Kinematics link high x with high Q^2 via $Q^2 = sxy$
  - → Dynamics imply $\sigma \sim 1/Q^4$ … and HERA had limited lumi

Constraining PDFs with LHC Data

- Many pp processes are sensitive to PDFs ...
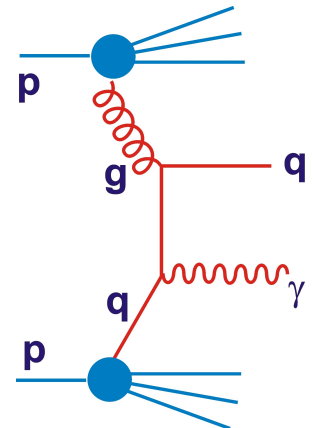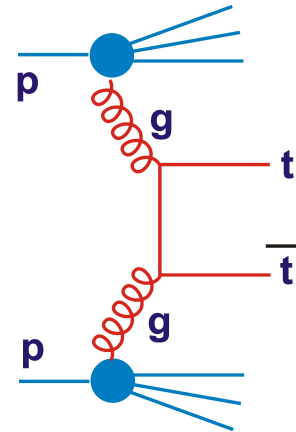
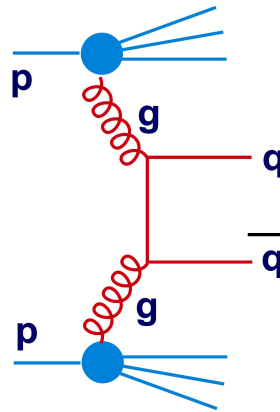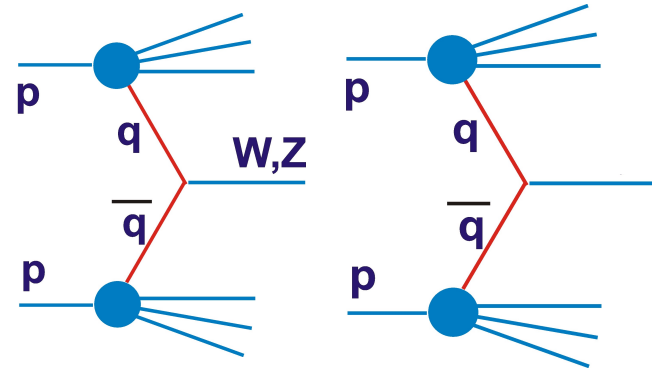- **Electroweak gauge boson production**

- **Drell Yan (away from Z pole)**

- **High pT jet production**

- **Top Quarks**
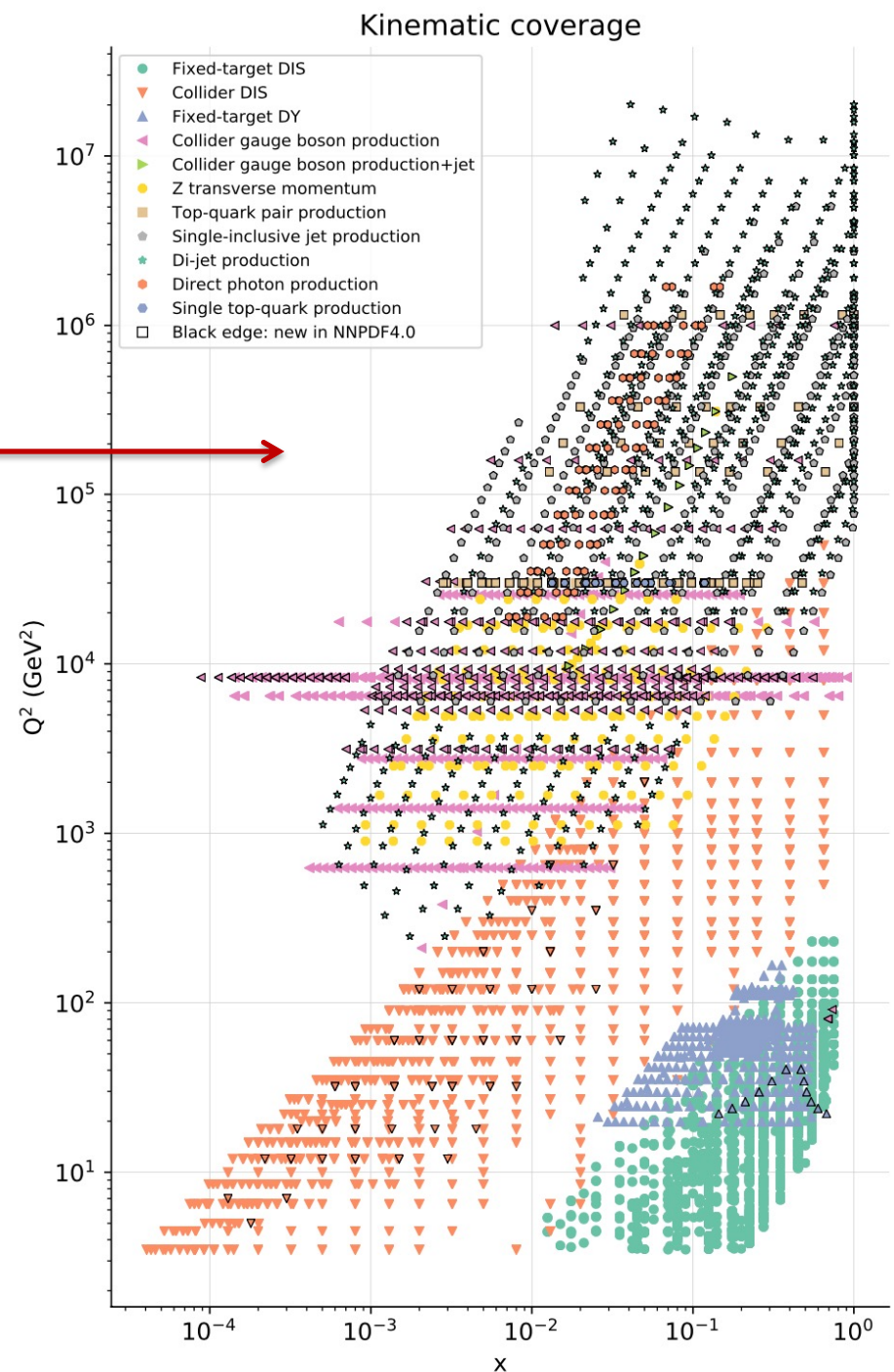
- **Direct Photons**

- **...**

Constraining PDFs with LHC Data

Large ongoing programme to better constrain the PDFs with LHC data ... e.g. NNPDF

LHC data improve the precision ...

but it is not straightforward ...

Kinematic coverage

Legend:
- Fixed-target DIS
- Collider DIS
- Fixed-target DY
- Collider gauge boson production
- Collider gauge boson production+jet
- Z transverse momentum
- Top-quark pair production
- Single-inclusive jet production
- Di-jet production
- Direct photon production
- Single top-quark production
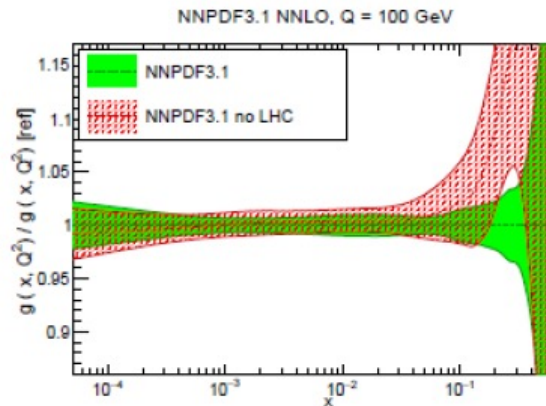- Black edge: new in NNPDF4.0

Q^2 (GeV^2) vs x

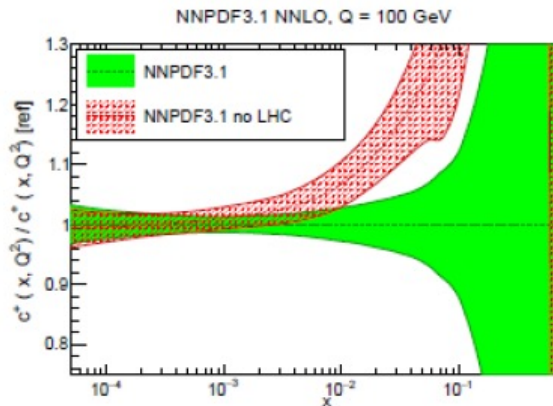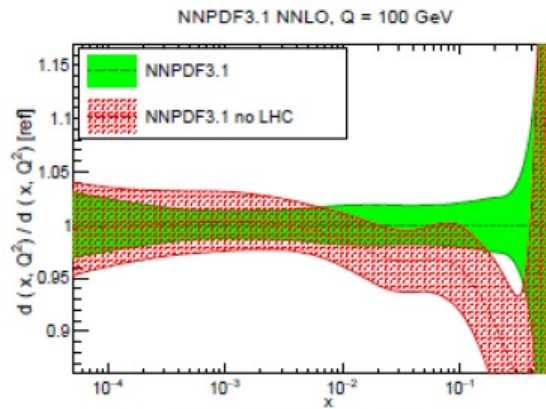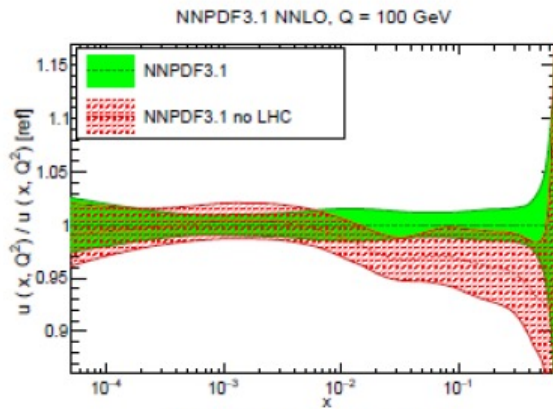# Quantitative Summary of LHC Impact

Theoretical Limitations: - Hadronisation and Underlying Event
                            - Missing higher orders (QCD & EW)
                            - Large logs needing resummations

Experimental Limitations: - Systematics (energy scale …)
                            - Correlations between measurements
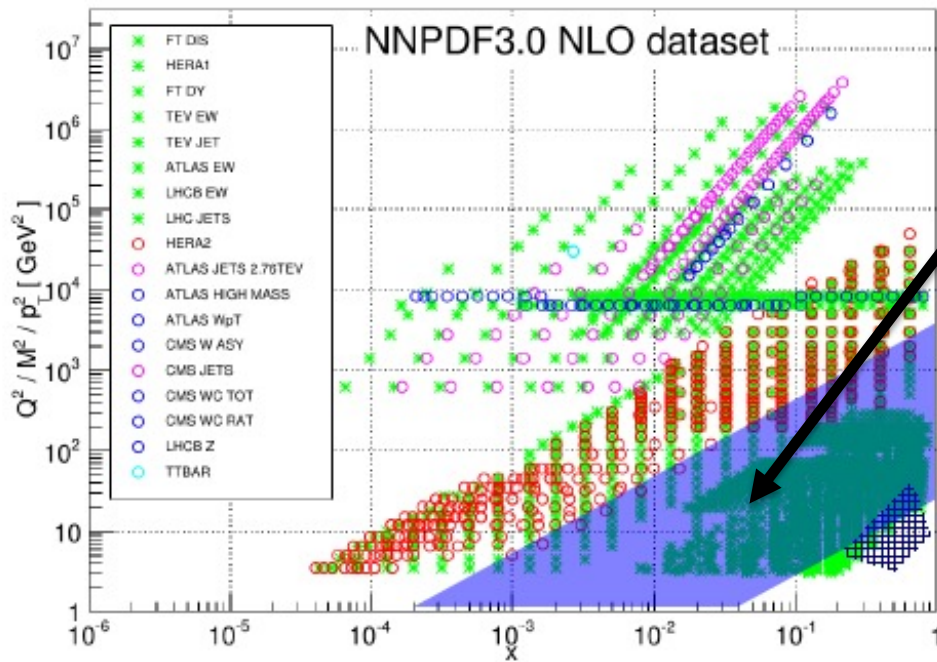

e.g.NNPDF3.1 includes LHC W,Z, jets,top

PDFs with v without including LHC data
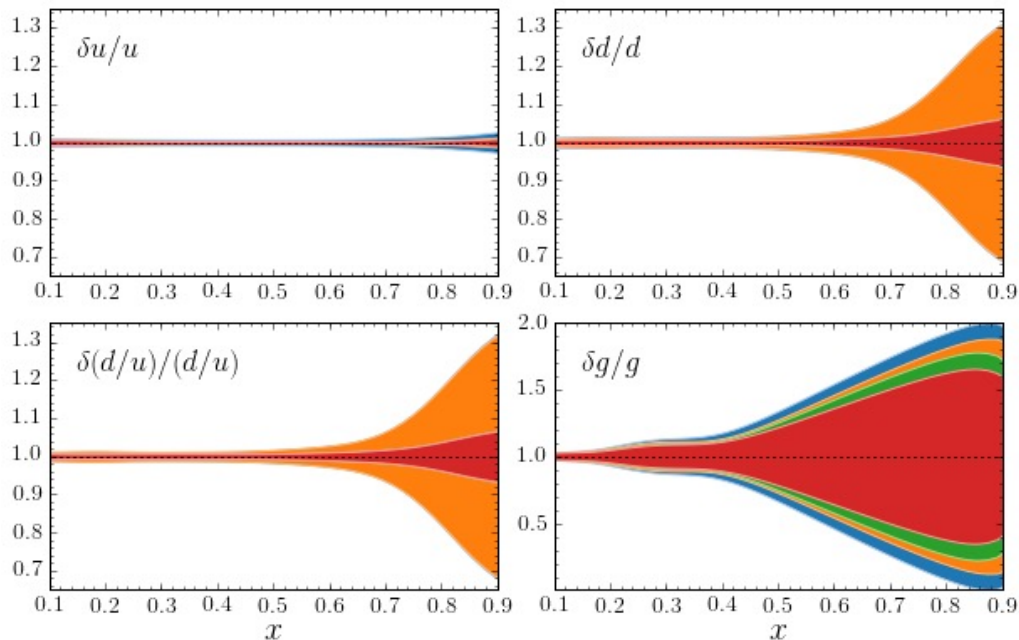
Some impact, but not transformational

Some deviations …

PDFs and the EIC

[Approximate EIC coverage]

Impact in particular at high x …
- High lumi → high x precision improved over HERA
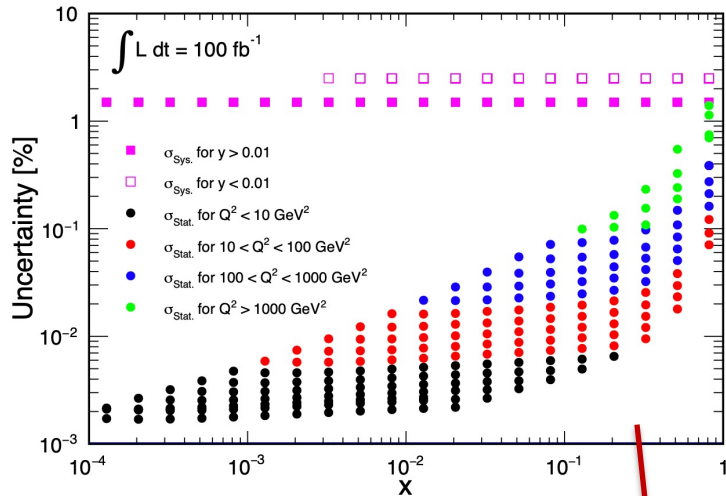-   Proton targets → avoid nuclear corrections

Example older (pre YR) study of EIC impact in CTEQ-Jlab ("CJ15") fitting framework

— CJ15
— CJ15+F2p
— CJ15+F2p+F2ntag
— CJ15+F2p+F2ntag+F2d

6
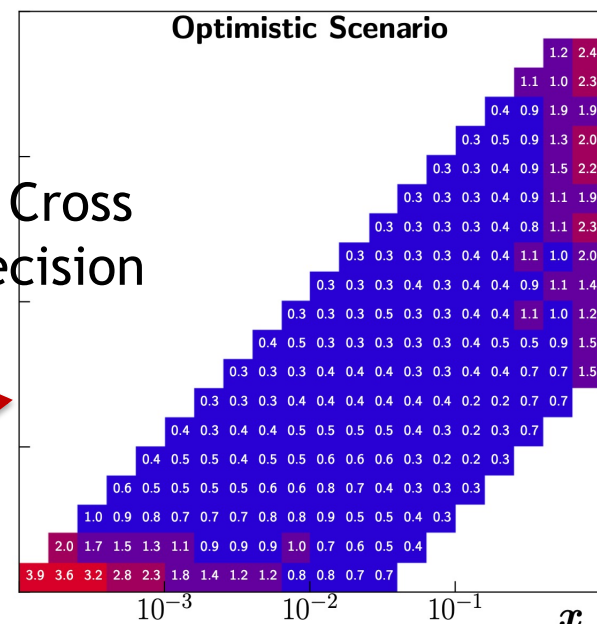
[A. Accardi et al]

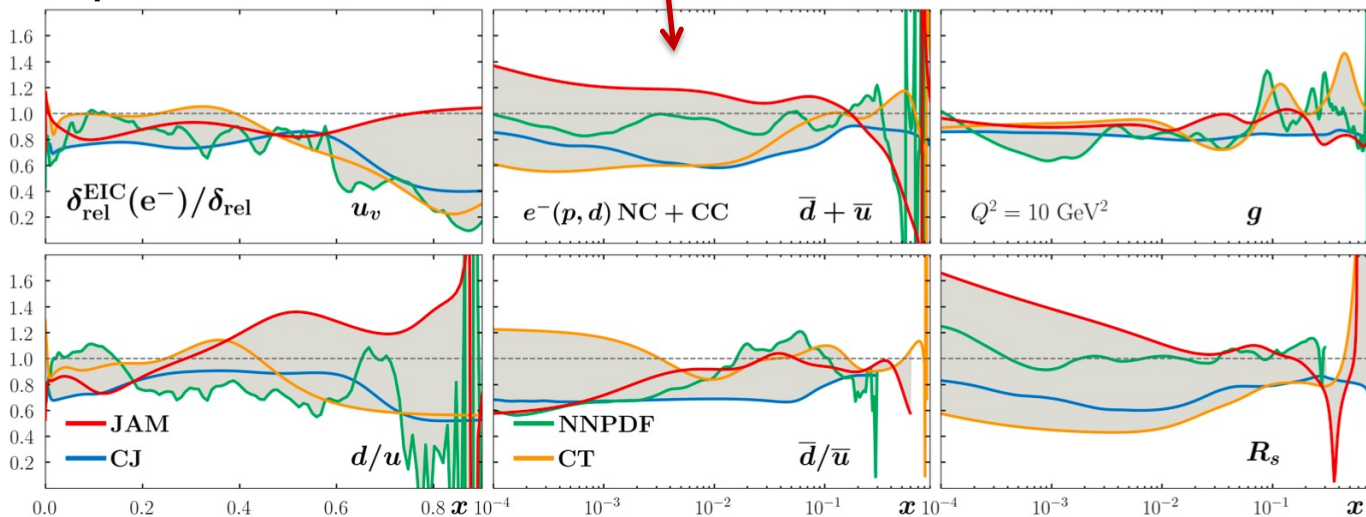# Yellow Report Studies

Data precision

Impact on Cross Section precision

- Data and cross section precision plots could be repeated?
- PDF impact results could be simpler / easier to digest?

Impact on PDFs

Possible Simple Approach for Proposal?

- Assess impact of simulated ATHENA inclusive NC, CC data on knowledge of PDFs using only DIS data (ie starting from HERA2PDF)

- Aim for 'standard' presentation (plot of relative precision with / without adding ATHENA). Emphasise large x

- Offer to work on fitting from Katarzyna Wichmann (DESY).
    → Can be done fast if we provide simulated ATHENA pseudodata (central values, uncertainties) in ASCII format
    → Can investigate impact of different assumptions on uncertainties and their correlations
    → Ready to start straight away
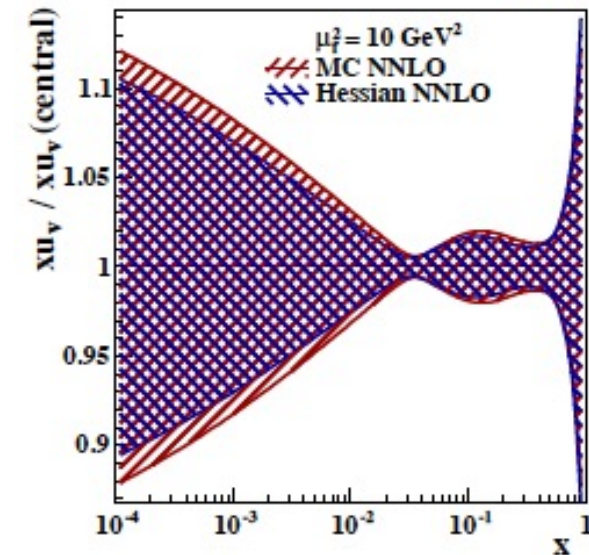
- Need to produce pseudodata ….

Other PDFs

→ Neutron PDFs from tagging protons in eD
(Nothing to add relative to Yellow Report?)

→ Polarised / spin PDFs
(Estimate precision
on e.g. double spin asymmetry and
compare with size of effect?) → Plot?

→ Nuclear PDFs
(Estimate precision
on nuclear modification ratio and
compare with size of effect ...
including low x / saturation?) → Plot?

→ Meson and Diffractive PDFs
(Exclusives group)