HERAPDF2.0 approach to ATHENA data

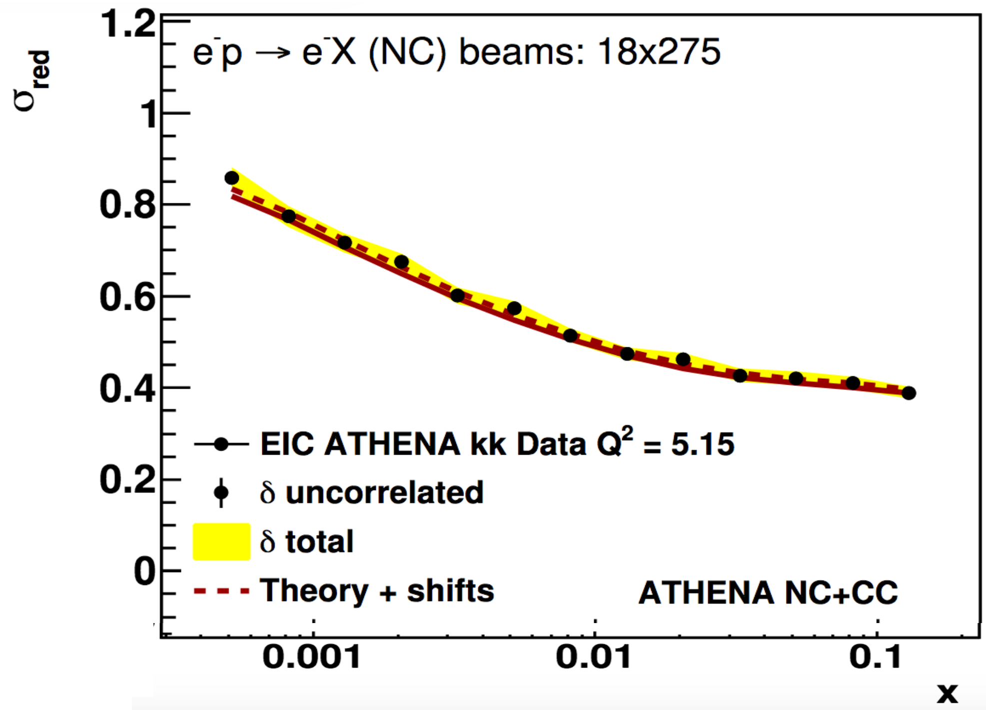
Studying impact of ATHENA data on parton distributions in proton using HERAPDF2.0 framework

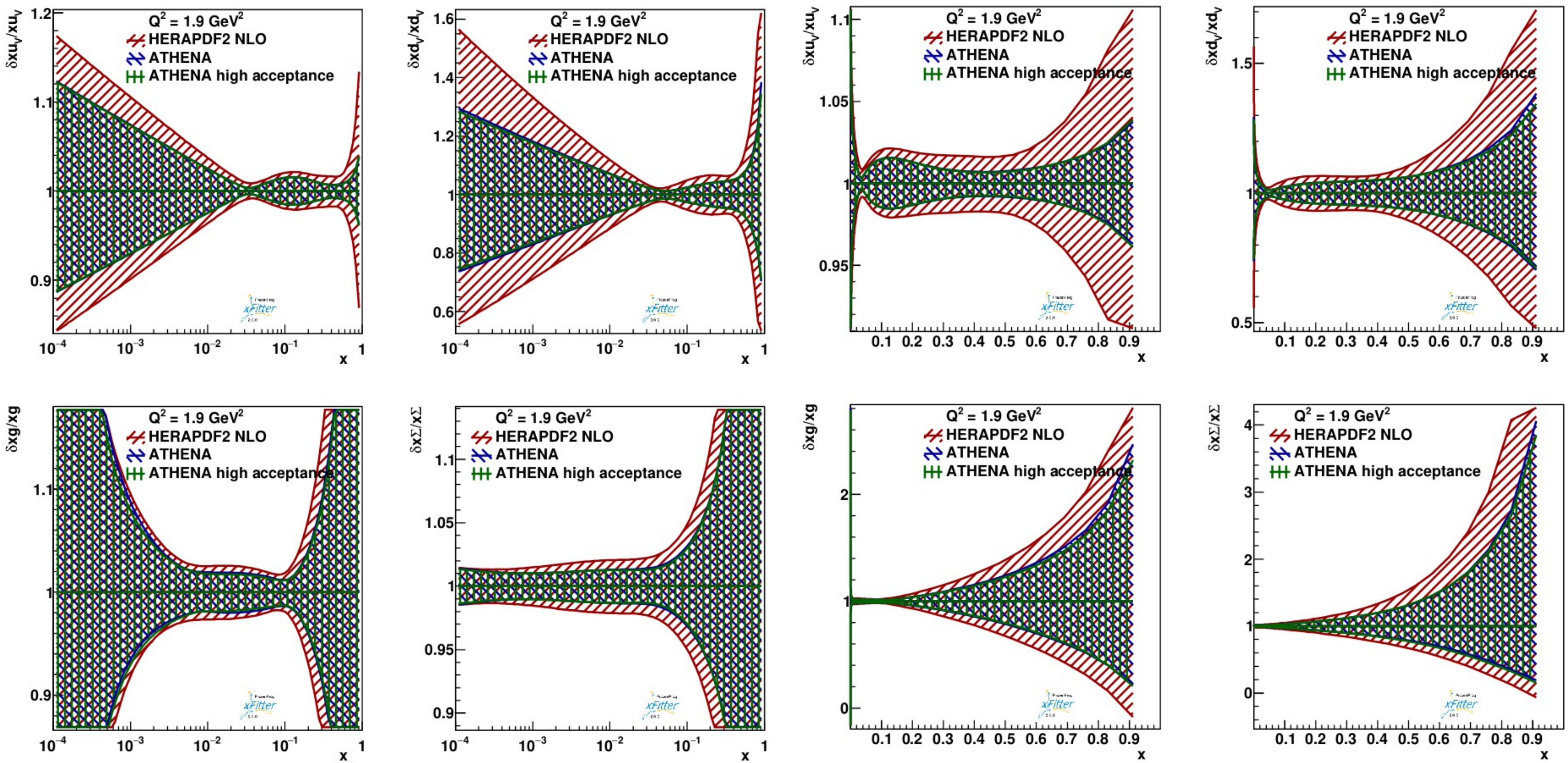
Update

ATHENA data → from yellow report & HERAPDF2

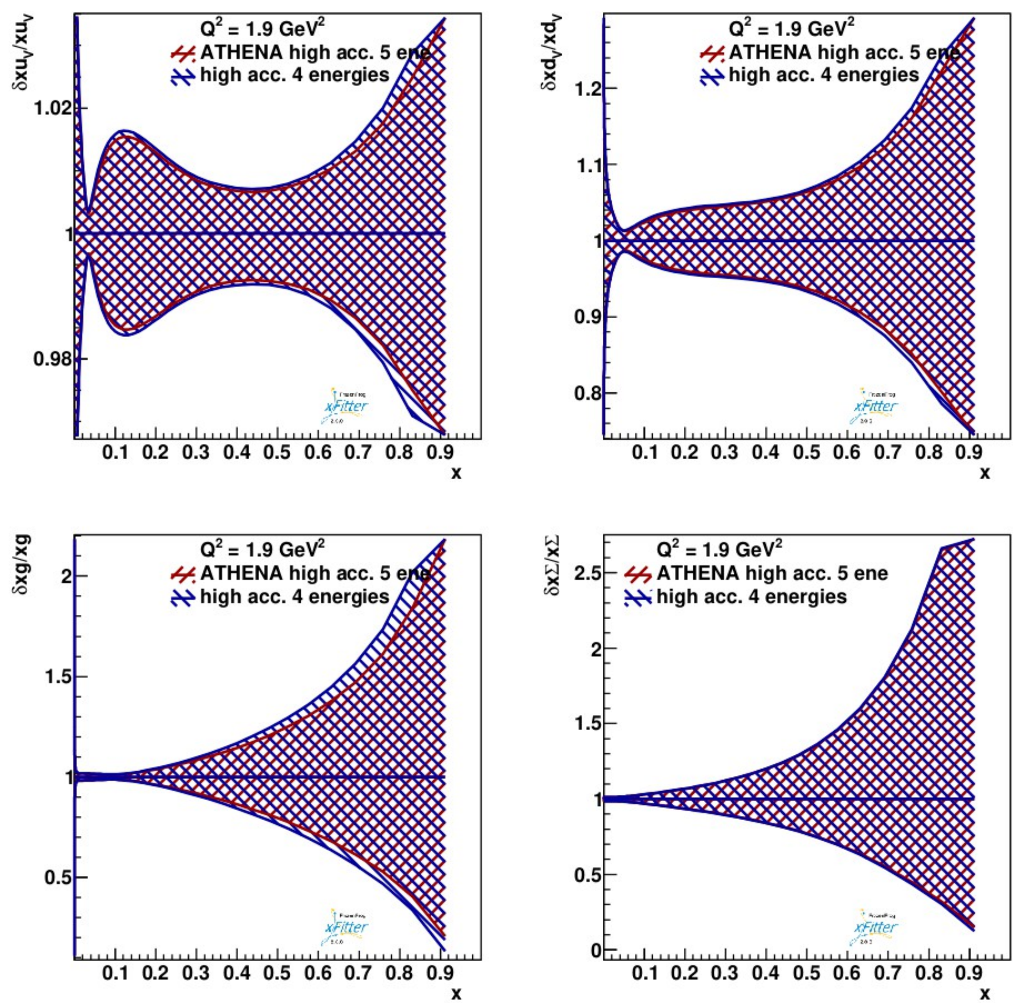
- ATHENA pseudo-data used in fits:
  1) Get prediction from HERAPDF2.0 NLO in ATHENA x-Q^2 grid
  2) Smear with uncorrelated uncertainties point-by-point
  3) Smear with correlated systematic uncertainty each sample (same factor for each sample)

- ATHENA uncertainties used in fits, files from Barak:
  - Statistical
  - Total uncorrelated
  - Total correlated
- Bins & uncertainties according to EIC yellow report, optimistic & pessimistic options
- New numbers/estimates of statistical and systematic uncert.

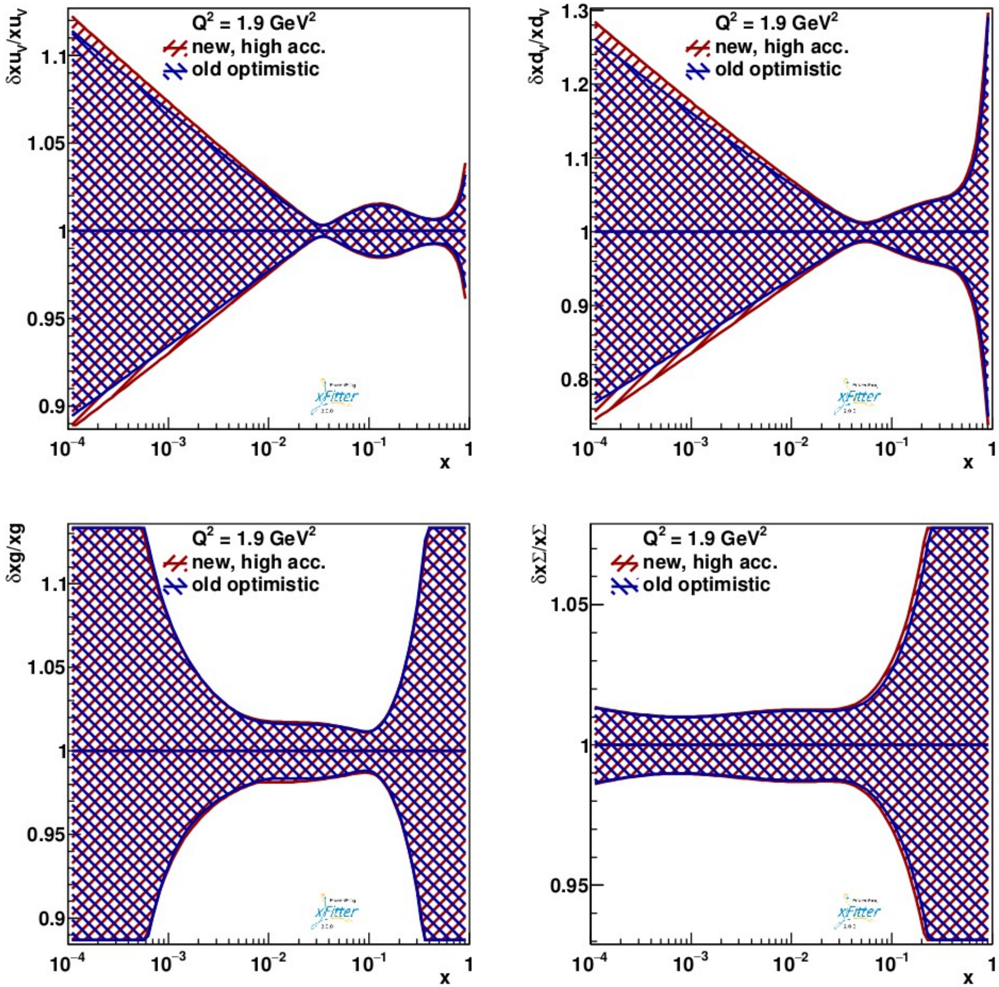




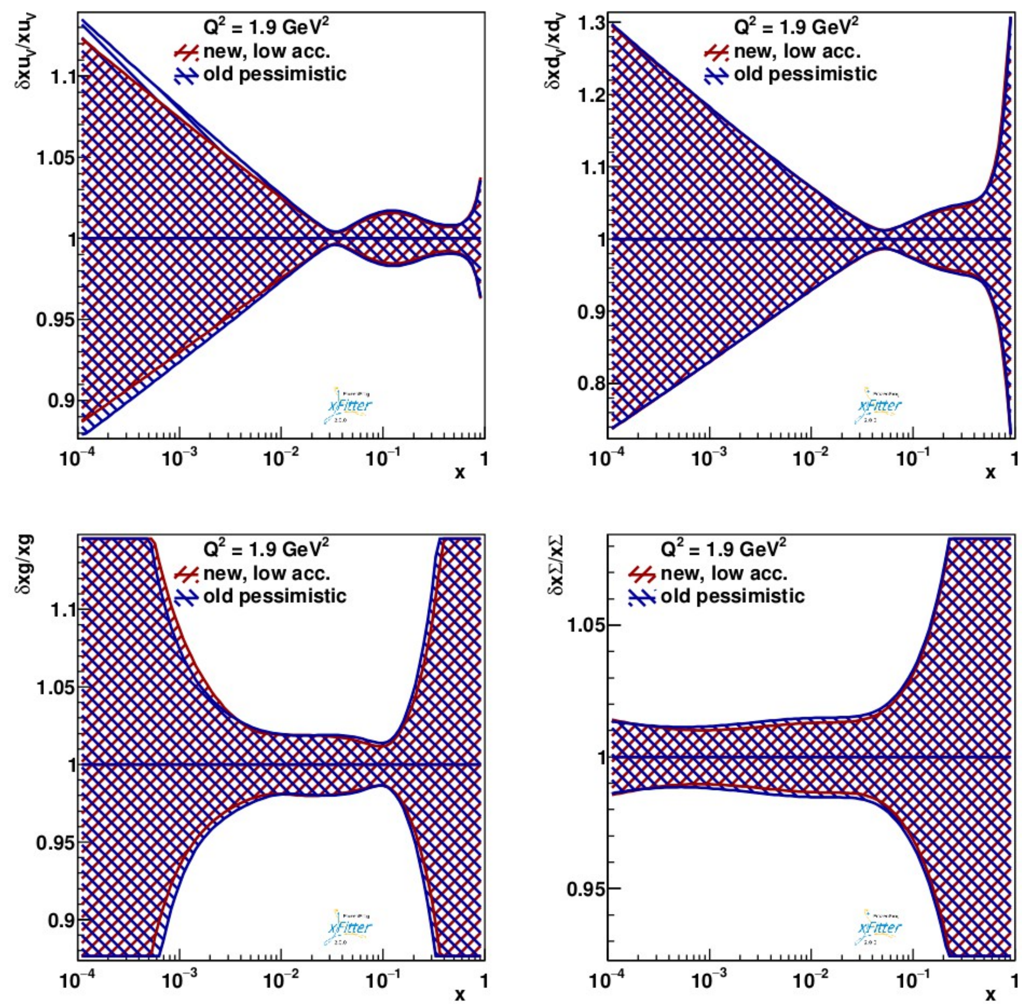
Q^2 = 1.9 GeV^2
HERAPDF2 NLO
ATHENA
ATHENA high acceptance
$\delta xu_v/xu_v$
$\delta xd_v/xd_v$
$\delta xg/xg$
$\delta x\Sigma/x\Sigma$
x
xFitter



- Nice to notice – adding extra energy increases sensitivity to high-x gluon (because of the extra beam energy – better F_L estimation – more direct info on gluon from DIS)



$\delta x u_V / x u_V$
$\delta x d_V / x d_V$
$\delta xg/xg$
$\delta x\Sigma/x\Sigma$
Q^2 = 1.9 GeV^2
new, high acc.
old optimistic
x



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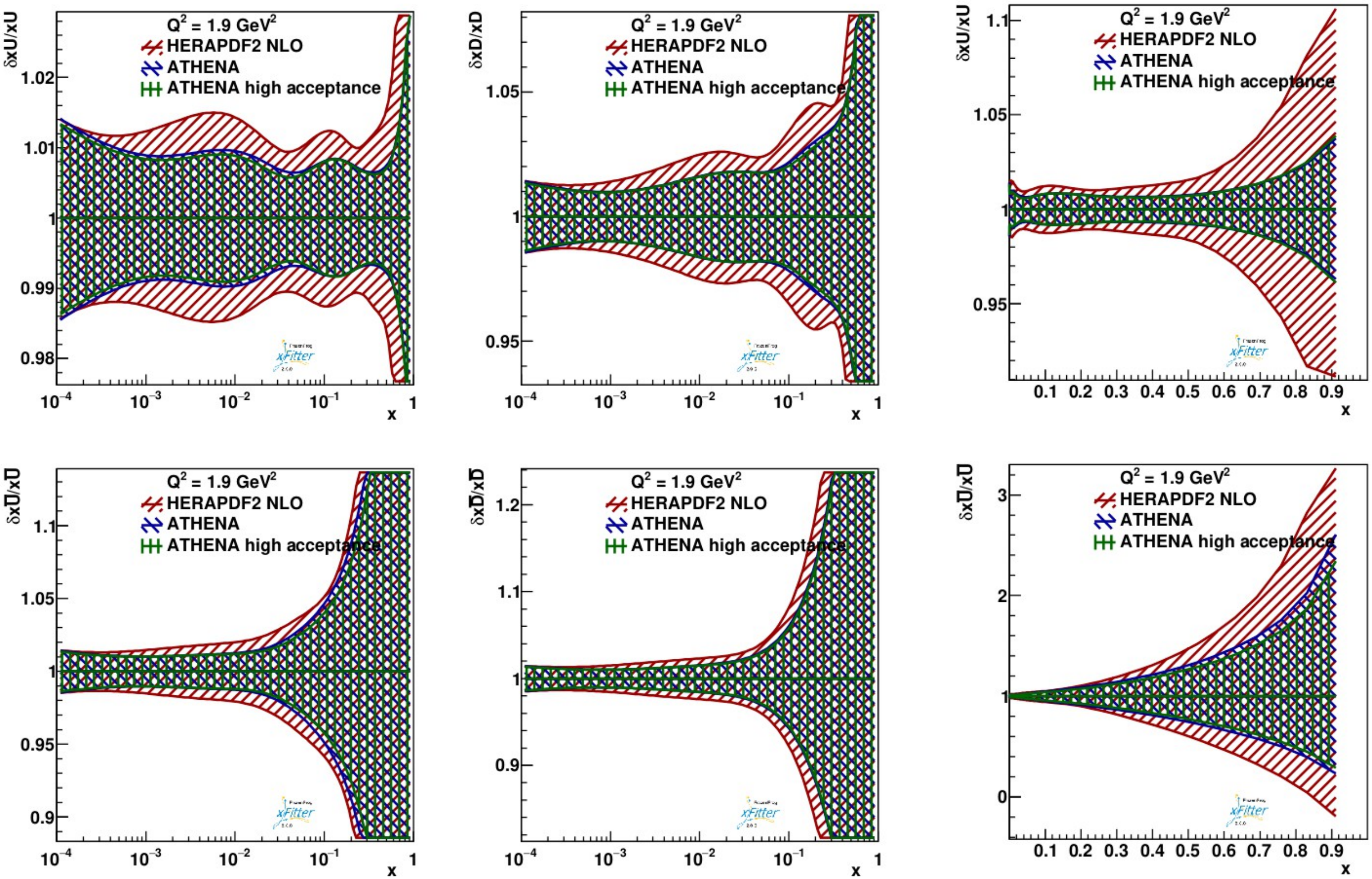
Q^2 = 1.9 GeV^2
new, low acc.
old pessimistic
x

K. Wichm


δxU/xU
δxD/xD
δxŪ/xŪ
δxD̄/xD̄
Q² = 1.9 GeV²
HERAPDF2 NLO
ATHENA
ATHENA high acceptance
x

THENA

Estimates for other PDF sets

- Impact of new data on given PDFs can be quantitatively estimated with profiling of eigenvectors or reweighting of replicas, under **assumption** that new data are compatible with these PDFs
- Profiling is performed using χ^2 which includes both experimental and theoretical uncertainties arising from PDF variations:

$$\chi^2(\boldsymbol{b}_{\rm exp}, \boldsymbol{b}_{\rm th}) = \sum_{i=1}^{N_{\rm data}} \frac{\left(\sigma_i^{\rm exp} + \sum_\alpha \Gamma_{i\alpha}^{\rm exp} b_{\alpha,{\rm exp}} - \sigma_i^{\rm th} - \sum_\beta \Gamma_{i\beta}^{\rm th} b_{\beta,{\rm th}}\right)^2}{\Delta_i^2} + \sum_\alpha b_{\alpha,{\rm exp}}^2 + \sum_\beta b_{\beta,{\rm th}}^2$$

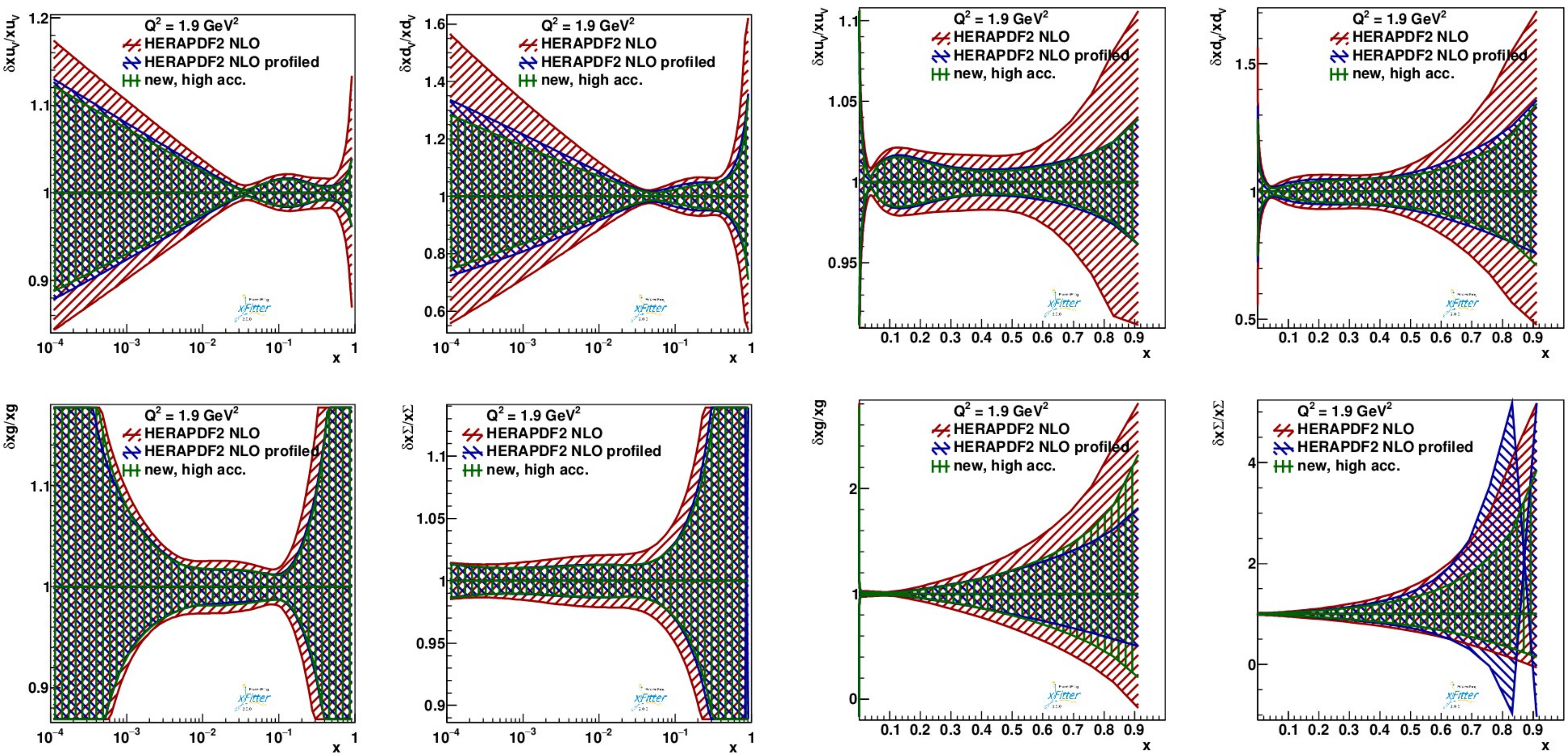
Here $b_{\alpha,{\rm exp}}$ and $b_{\beta,{\rm th}}$ are nuisance parameters for correlated experimental ($\Gamma_{i\alpha}^{\rm exp}$) and theoretical ($\Gamma_{i\beta}^{\rm th}$) uncertainties, respectively

- $b_{\beta,{\rm th}}$ which minimise χ^2 with new data are interpreted as optimisation (profiling) of PDFs

Example profiling presented using MSHT20 NLO PDF

Profiling using HERAPDF2 NLO set - cross check with full fit

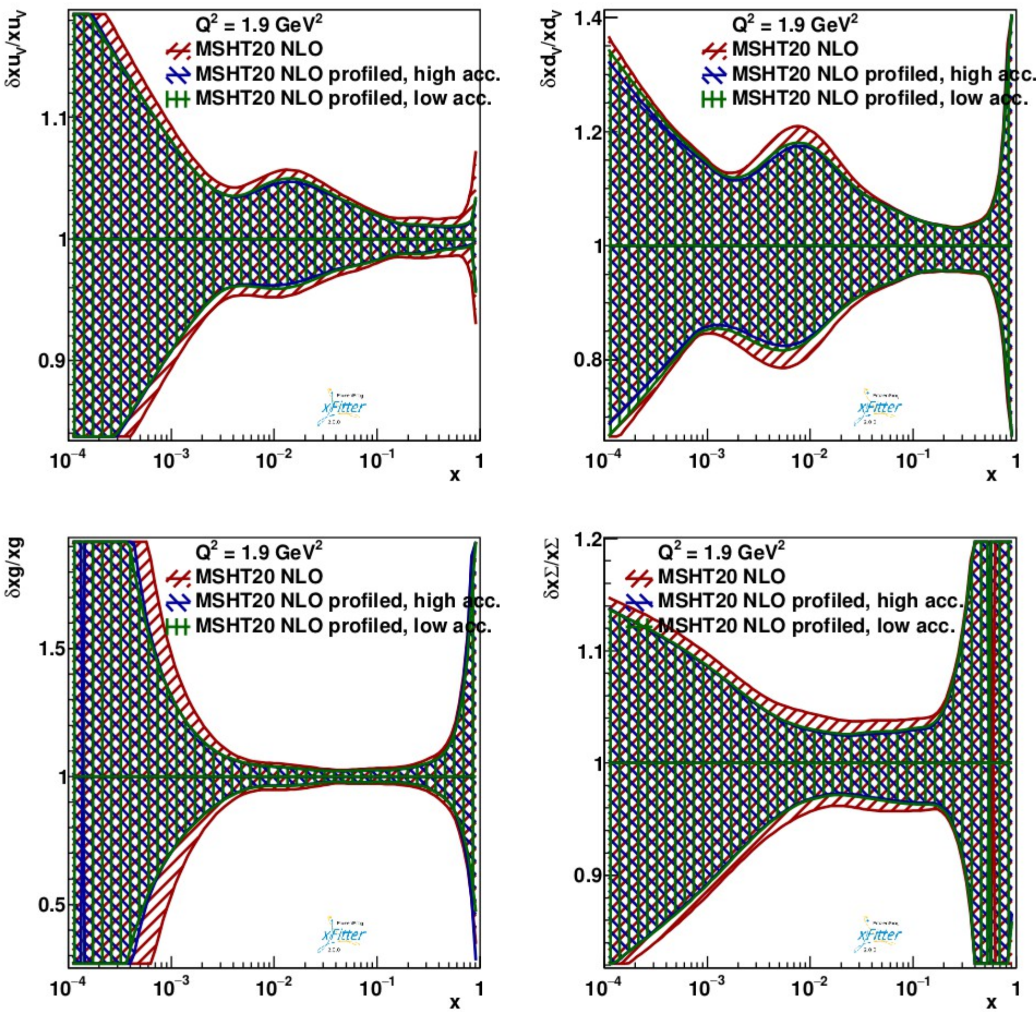
- Pseudo-data done using HERAPDF2 set → obviously there is consistency

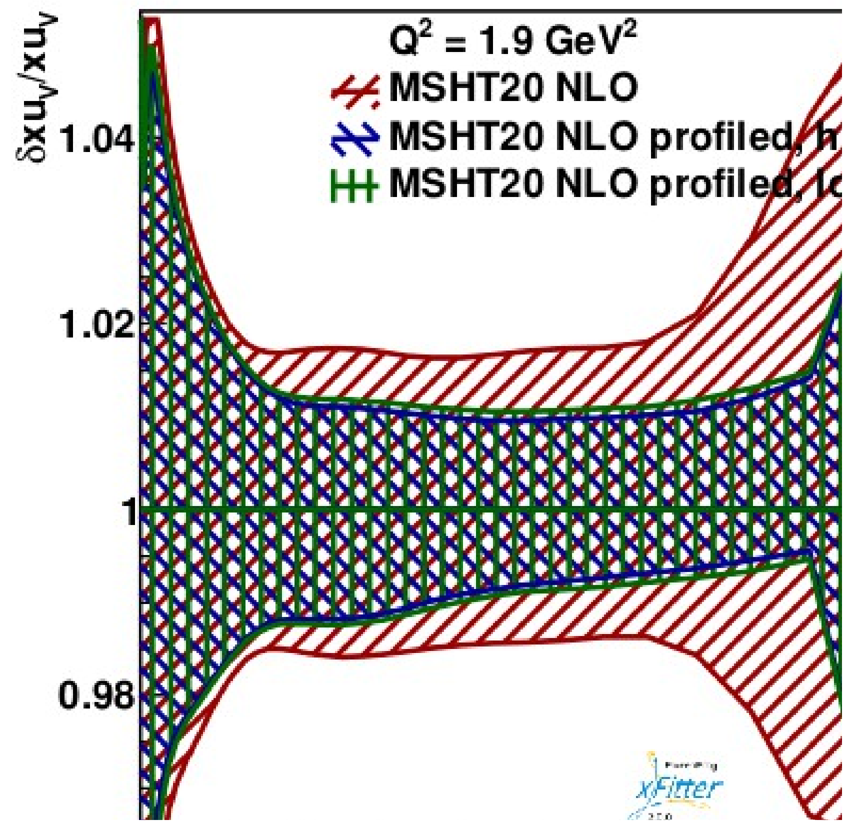


K. Wi

Profiling using MSHT20 NLO set

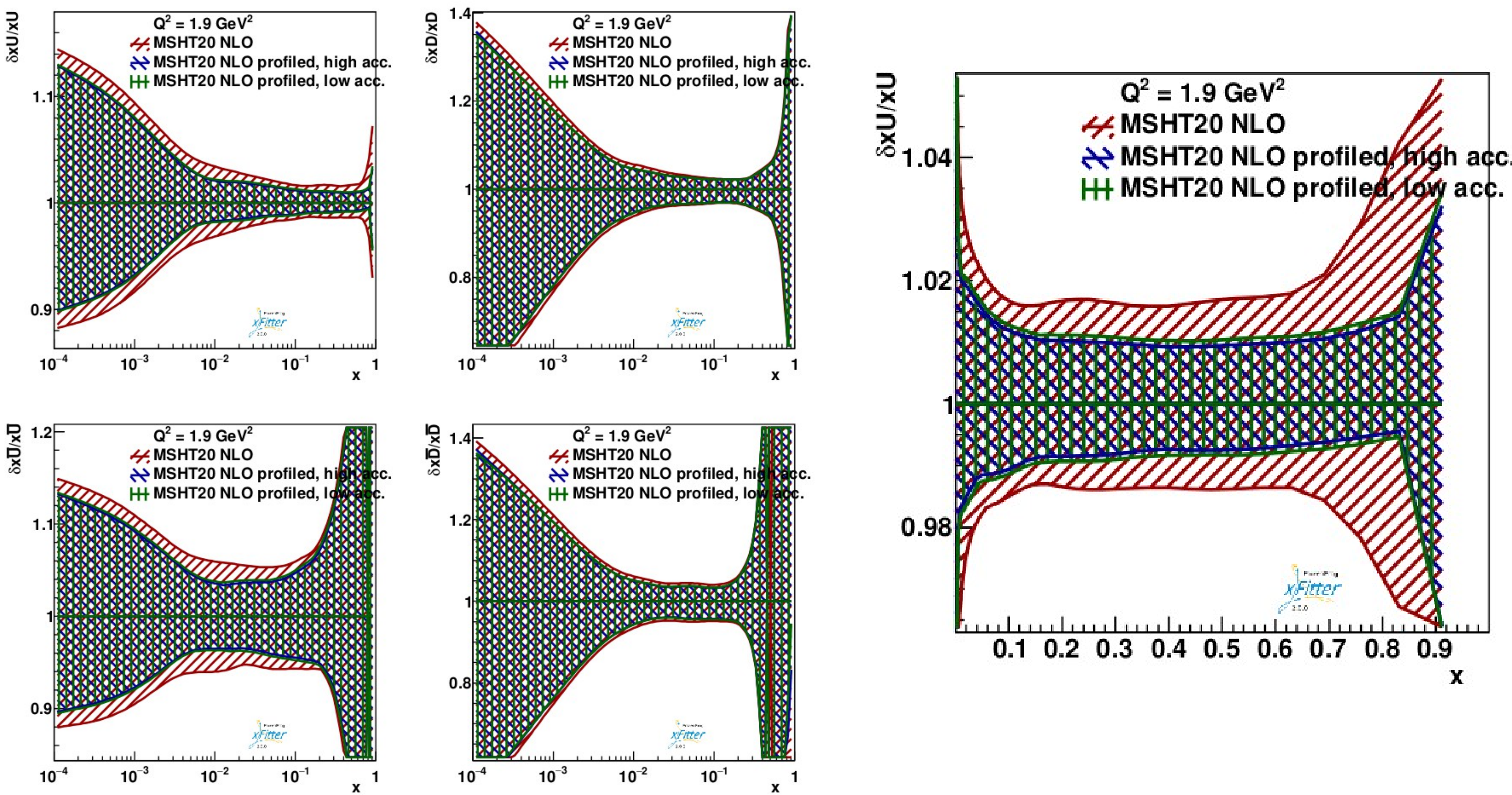
- Pseudo-data done using MSHT20 set → obviously there is consistency





Profiling using MSHT20 NLO set

- Pseudo-data done using MSHT20 set → obviously there is consistency



This can be done for other sets like CT18 etc.

1 fb^{-1} HERA data – exclusively! - used as input to global QCD fit HERAPDF2.0

- Parton densities parametrised @ $Q^2 = 1.9\ GeV^2$

$$xf(x) = Ax^B(1-x)^C(1+Dx+Ex^2)$$

$$xg(x), xu_v(x), xd_v(x), x\bar{U}(x), x\bar{D}(x)$$

- Evolution using DGLAP equations
- 14 parameters determined in paramerisation scan
- Heavy quarks from Roberts-Thorne Variable Flavor Number Scheme

QCD fits performed using HERAFitter package
www.herafitter.org

Analysis presented here is done @ NLO
→ can be easily repeated @ NNLO

Analysis presented here includes experimental uncertainties only
→ total uncertainty can be easily included