Updates on LHeC impact to PDFs with xFitter

M. Bonvini, F. Giuli

'PDFs and Low-x at LHeC/FCC-eh' meeting

30/09/2019

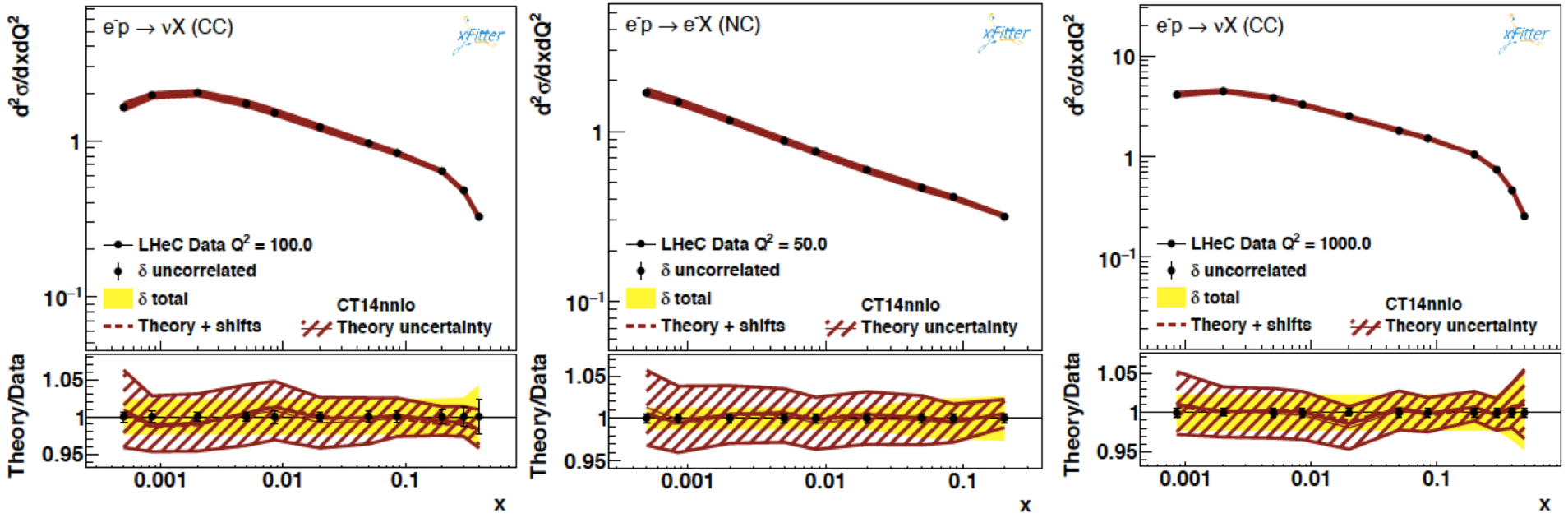
New pseudo-data

- This presentation is an update regarding previous studies presented by M. Bonvini here (January 2019)
- We regenerated pseudo-data starting from the kinematics in Max's files using APFEL with a given input PDF, allowing fluctuations of the generated data according to their uncertainty (again from Max's files)
- Two input PDFs:
  - NNPDF31_nnlo_as_0118 (January 2019)
  - **CT14nnlo** (now) – smoother shape at low-x
- QCD perturbative order: NNLO
- VFNS: FONLL
- m_c = 1.46 GeV
- m_b = 4.5 GeV
- We keep the information on beam polarization in Max's files
- ST DEV for fluctuations: sum in quadrature of all **uncorrelated** uncertainties

APFEL is used ONLY to compute DIS cross-section and NOT the evolution

Validation of the new dataset

- To make sure the generated dataset is correct, we have xFitter in 'non-fit' mode with both the input PDFs and using APFEL with the same settings
- The obtained theoretical predictions are in well agreement with the new pseudo-data
- Here, results shown for CT14nnlo



PDF parametrisation

- The new general parametrisation presented here has been used

arXiv:1902.11125 [Bonvini,FG]

$$xf(x,\mu_0^2) = Ax^B(1-x)^C[1 + Dx + Ex^2 + F\log(x) + G\log^2(x) + H\log^3(x)]$$

- We adopted for the following set of parameters:

$$xu_v(x,\mu_0^2) = A_{u_v}\, x^{B_{u_v}}(1-x)^{C_{u_v}}\left[1 + D_{u_v}x + E_{u_v}x^2 + F_{u_v}\log x + G_{u_v}\log^2 x\right],$$

$$xd_v(x,\mu_0^2) = A_{d_v}\, x^{B_{d_v}}(1-x)^{C_{d_v}}\left[1 + D_{d_v}x + E_{d_v}x^2 + F_{d_v}\log x + G_{d_v}\log^2 x\right],$$

$$x\bar{u}(x,\mu_0^2) = A_{\bar{d}}\, x^{B_{\bar{d}}}(1-x)^{C_{\bar{u}}}\left[1 + D_{\bar{u}}x + F_{\bar{d}}\log x + G_{\bar{d}}\log^2 x\right],$$

$$x\bar{d}(x,\mu_0^2) = A_{\bar{d}}\, x^{B_{\bar{d}}}(1-x)^{C_{\bar{d}}}\left[1 + D_{\bar{d}}x + F_{\bar{d}}\log x + G_{\bar{d}}\log^2 x\right],$$

$$xs(x,\mu_0^2) = x\bar{s}(x,\mu_0^2) = \frac{f_s}{1-f_s}x\bar{d}(x,\mu_0^2), \qquad f_s = 0.4 \text{ fixed}$$

$$xg(x,\mu_0^2) = A_g\, x^{B_g}(1-x)^{C_g}\left[1 + F_g\log x + G_g\log^2 + H_g\log^3 x\right].$$

- 24 free parameters to be minimised in the fit
- Sum rules in xFitter adjusted accordingly

Quality of the fit

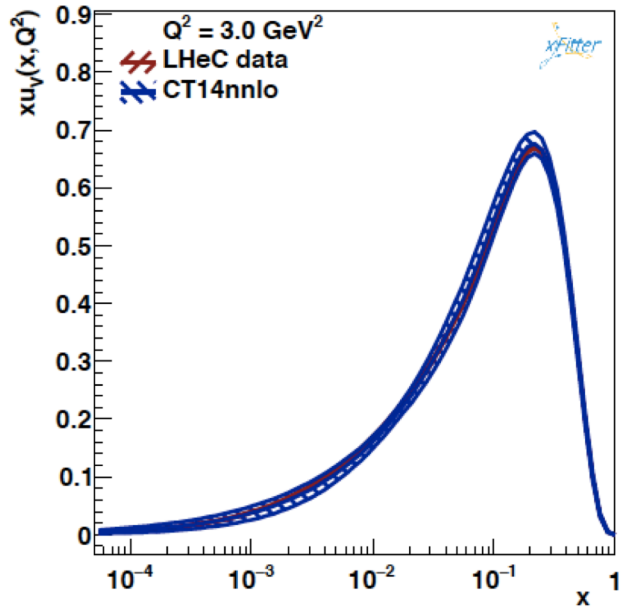
- So we performed a NNLO fit to inclusive LHeC data only (no HF data yet), treating all the systematic uncertainties as **correlated**
- **HF_SCHEME = TR** (in order to be less biased in the fit)
- A good description of the data is achieved - **χ^2/dof ~ 1.22**

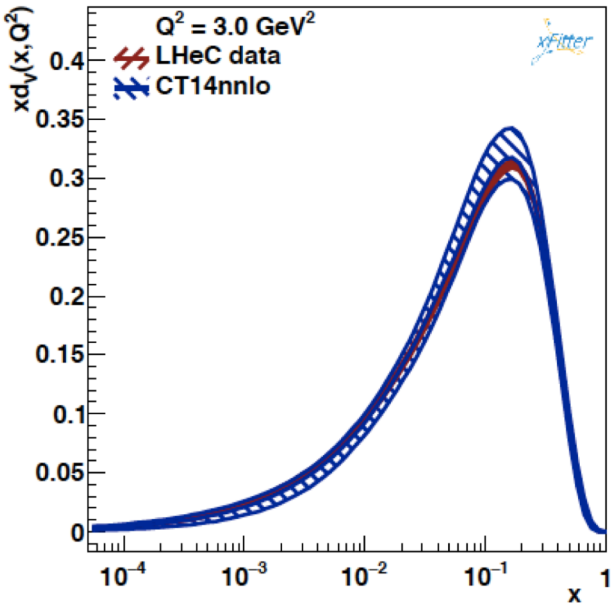
Dataset	LHeC data
datlhec160ccem	95 / 93
datlhec160ncem	182 / 128
datlhec760ccem	160 / 114
datlhec760ccep	135 / 113
datlhec760ccepp	164 / 109
datlhec760ncem	154 / 150
datlhec760ncep	156 / 150
datlhec760ncepp	157 / 148
Correlated χ^2	3.1
Log penalty χ^2	-12.38
Total χ^2 / dof	1193 / 981

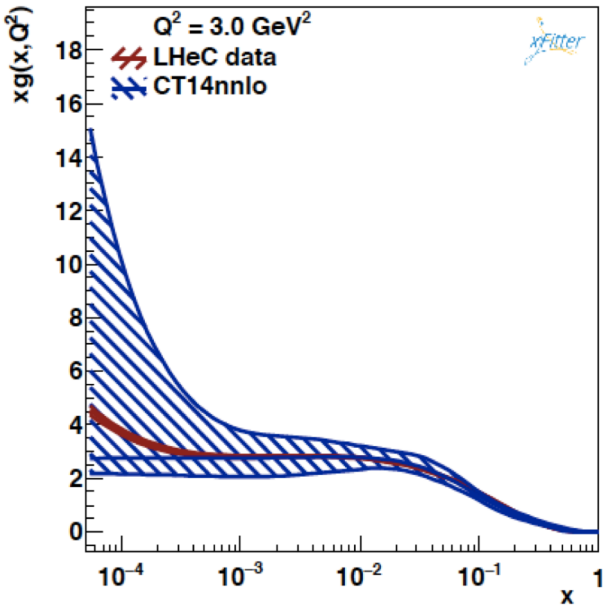
PDF comparison

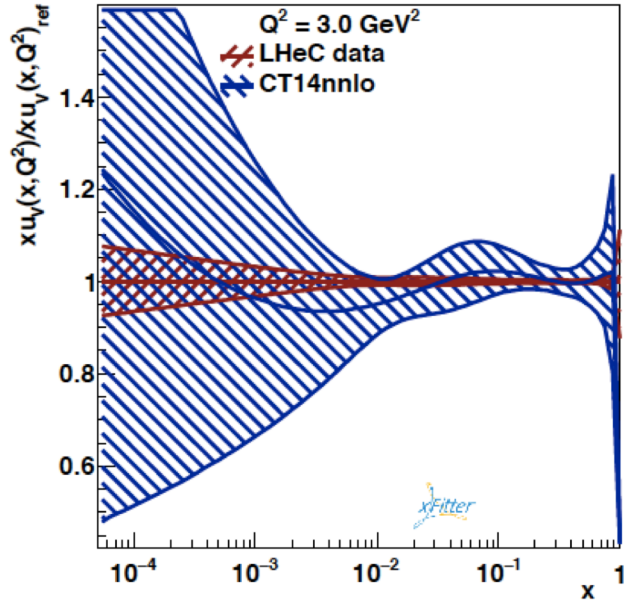
- We compared out fit to:
  - CT14nnlo (input PDF set)
  - A fit to final combined HERA data using the same general PDF parametrisation **arXiv:1902.11125 [Bonvini,FG]**
  - NNPDF31sx_nnlonllx_as_0118
- In both cases, a remarkable reduction of PDF uncertainties is obtained

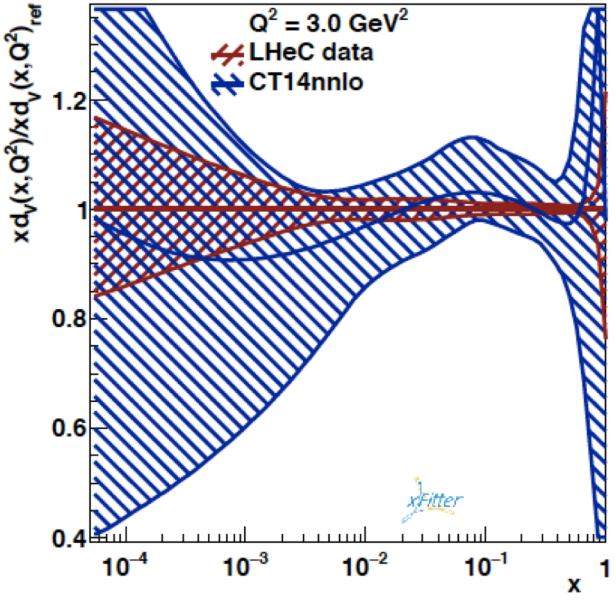
Comparison to CT14nnlo

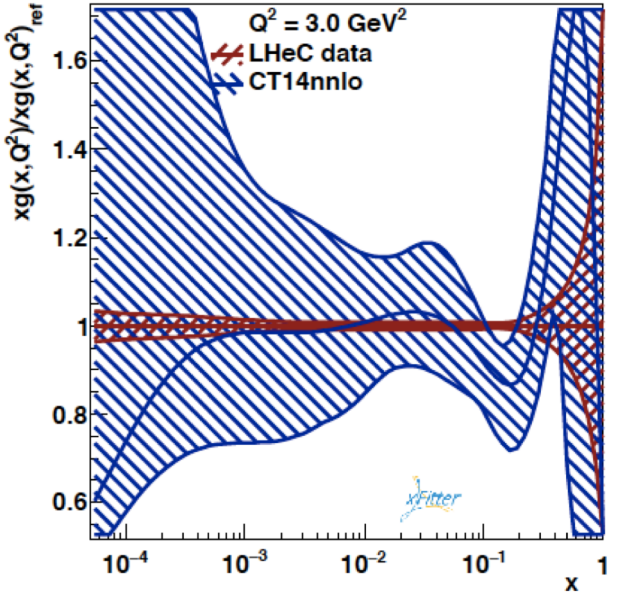




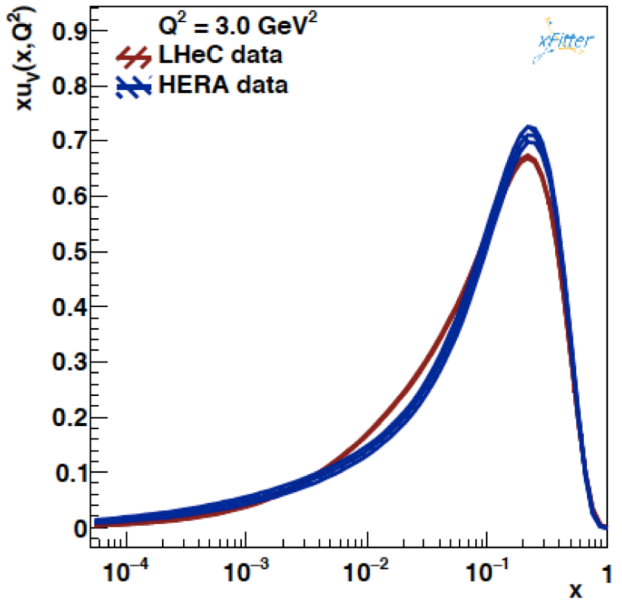


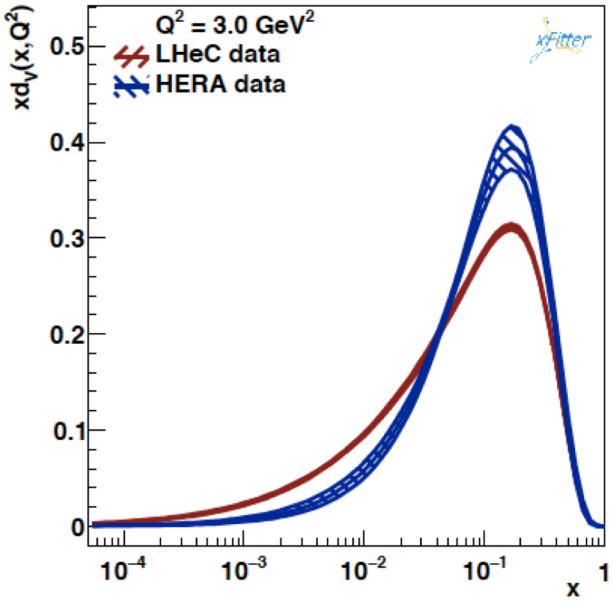


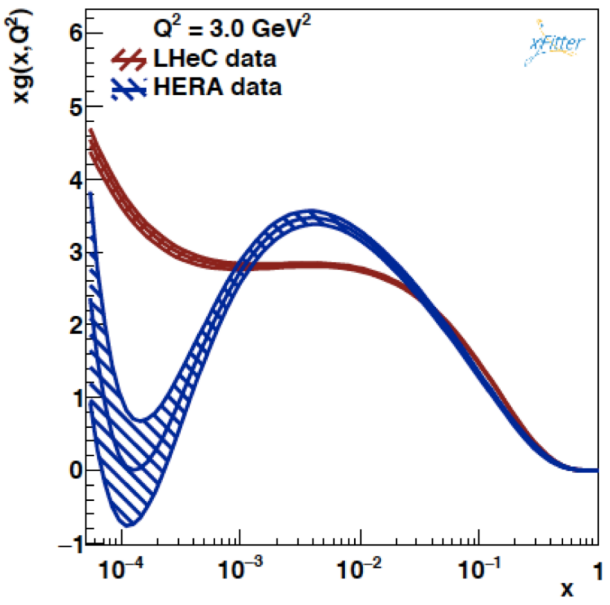


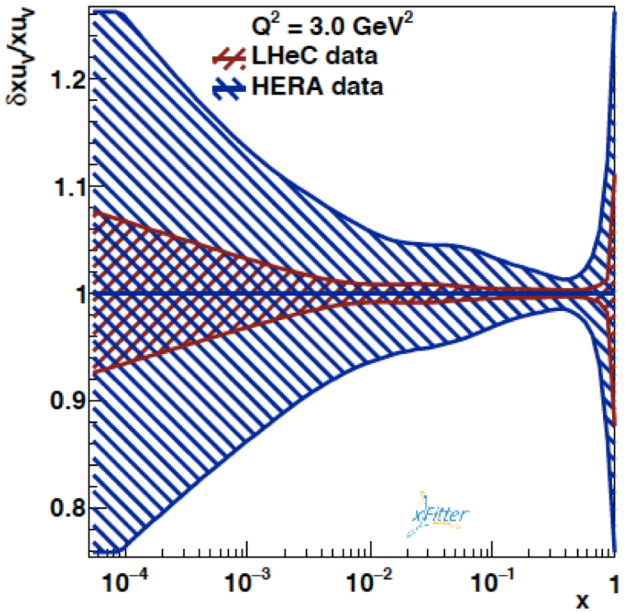


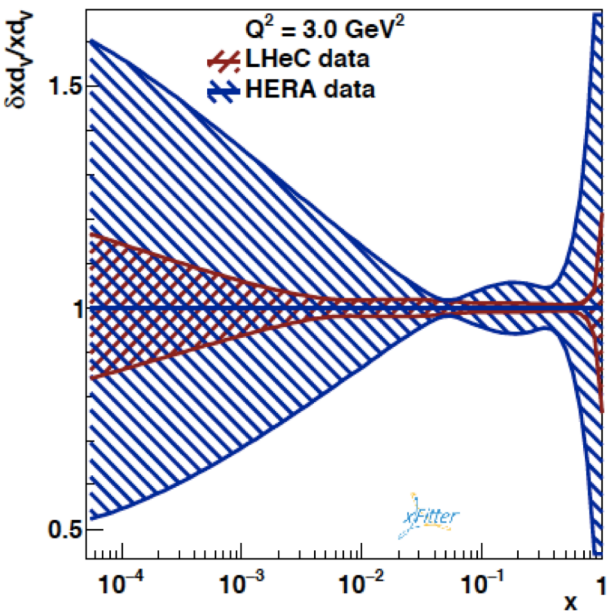
Comparison to PDFs from HERA data

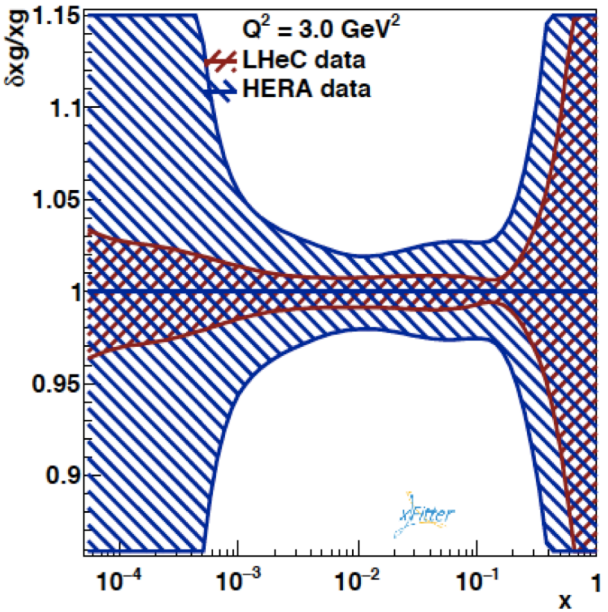




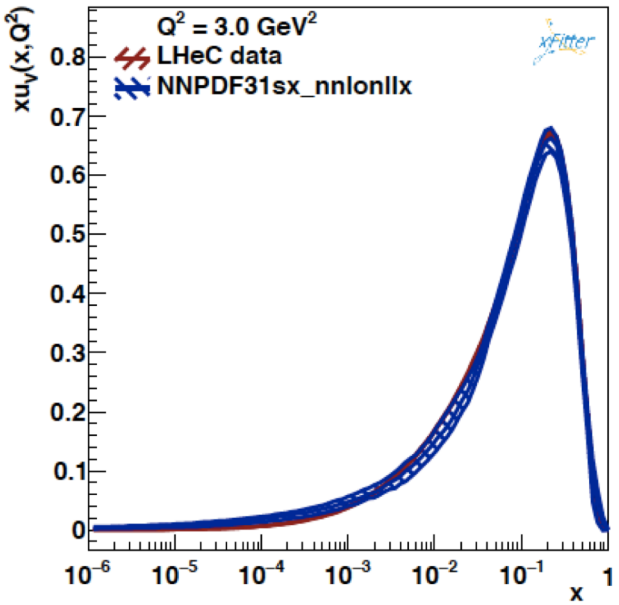


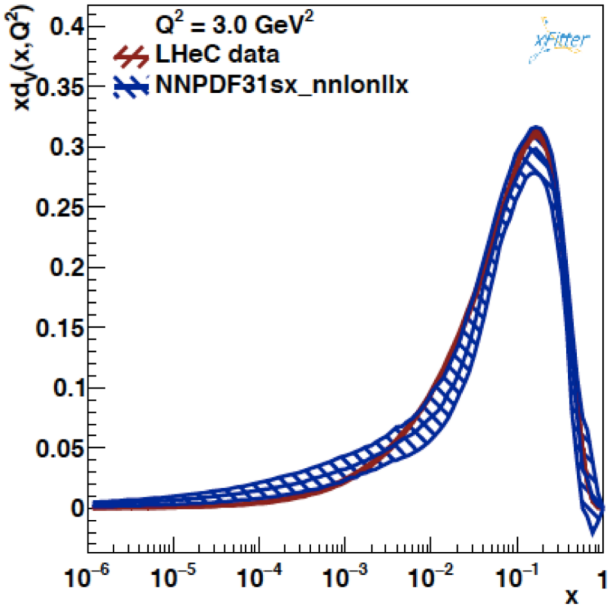


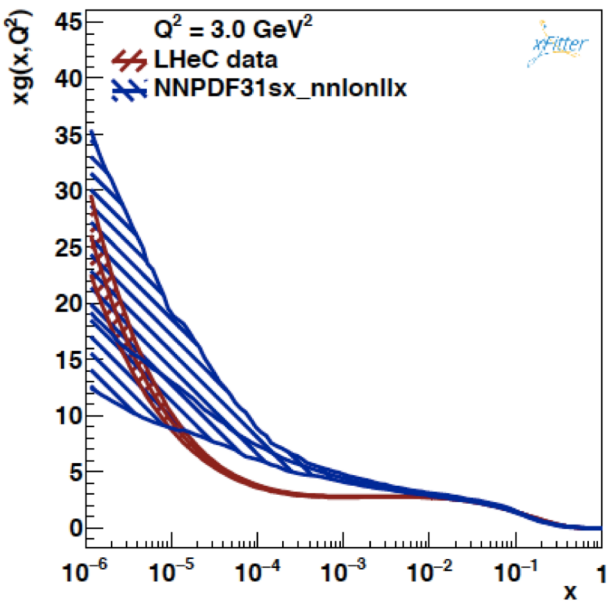


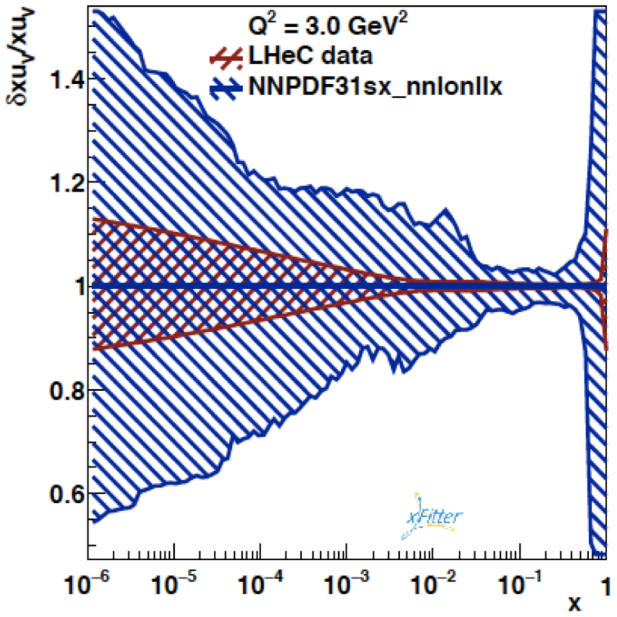


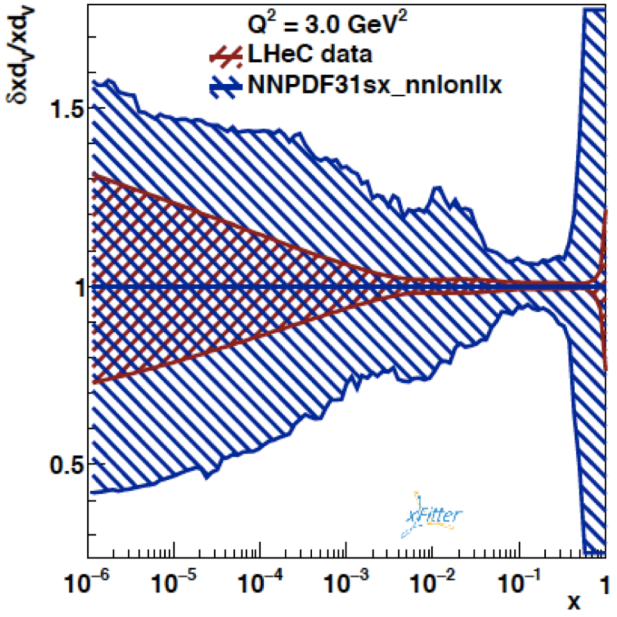
Comparison to NNPDF31sx

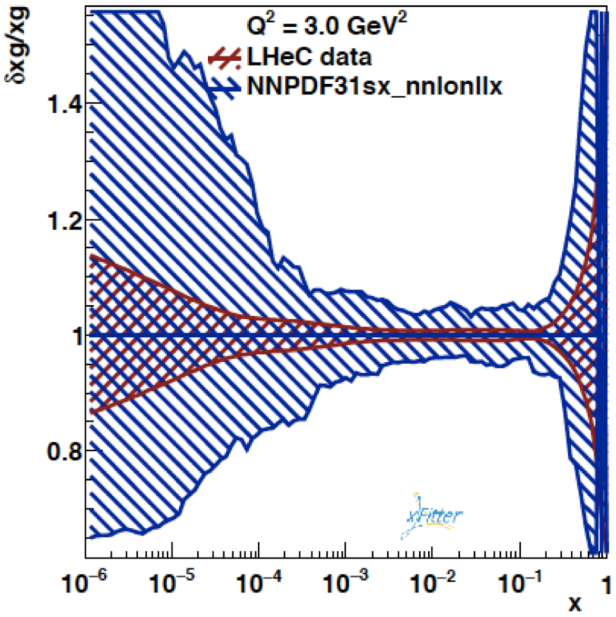




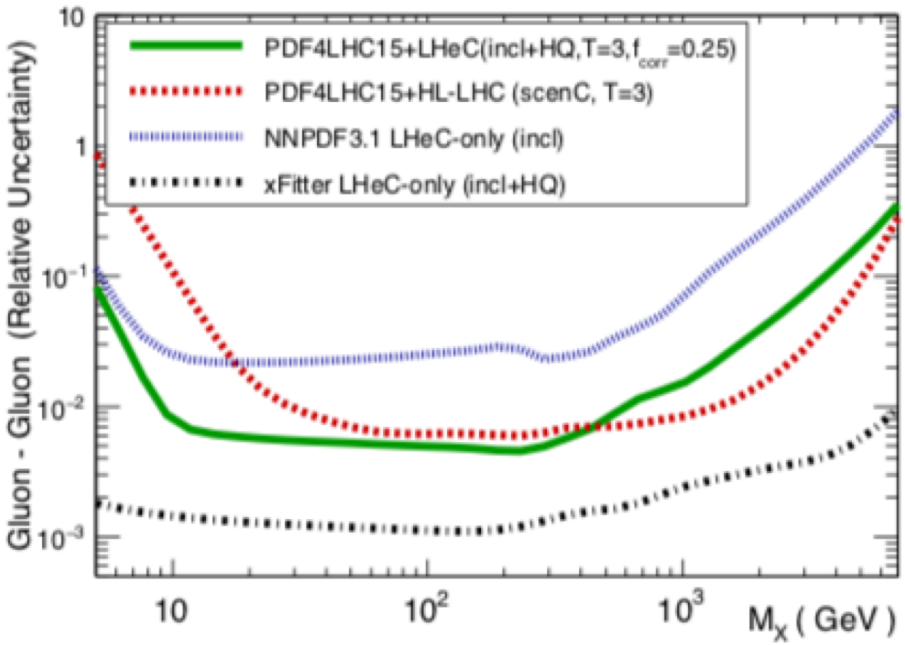


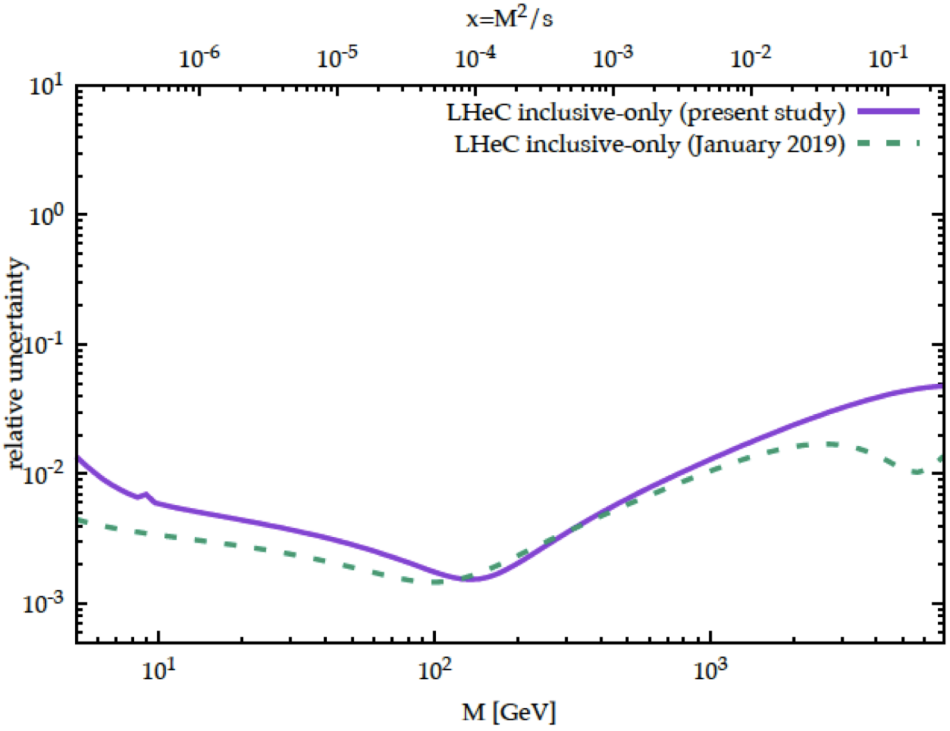






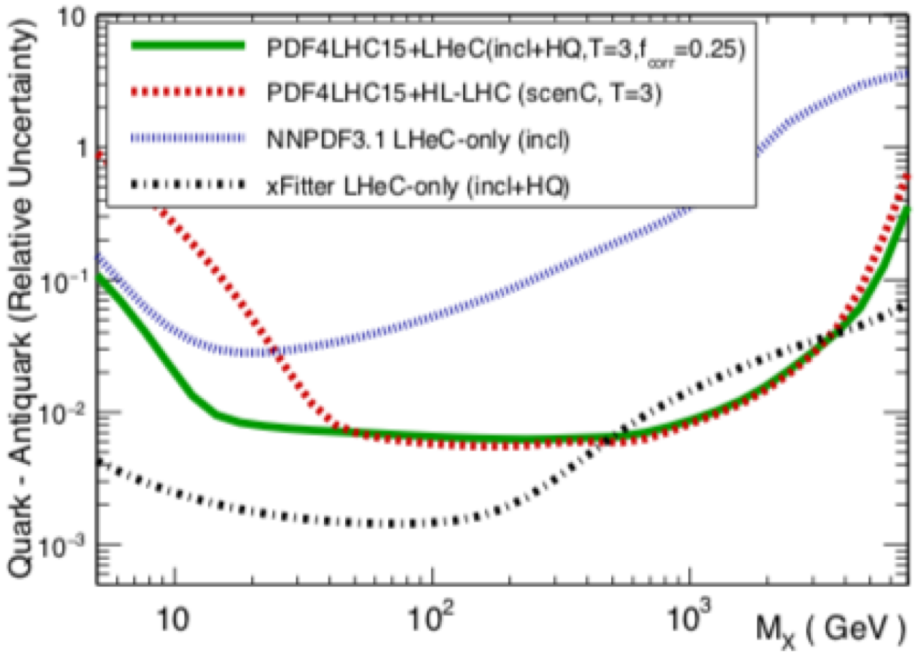
gg luminosity

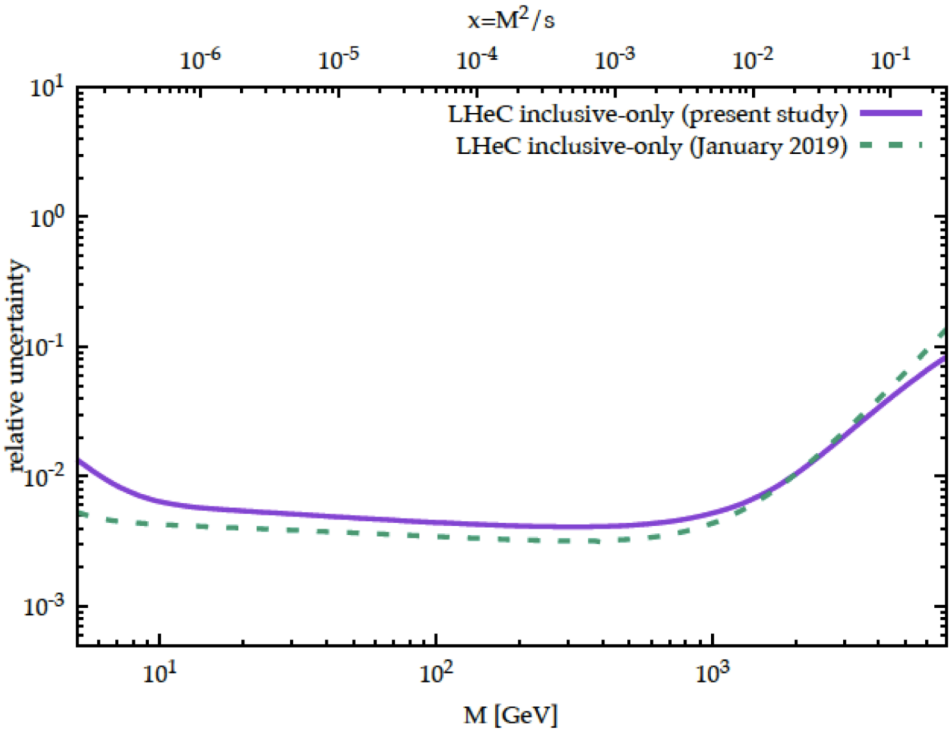




- Differences wrt studies presented earlier in January:
  - Different pseudo-data
  - PDF parametrisation (now additive, previously multiplicative)
  - Fit quality (now χ^2/dof ~ 1.22, previously χ^2/dof ~ 3)
- Larger uncertainty in the low-x regime wrt what shown in January (but still smaller than what found by Juan)

Quark-antiquark luminosity





- Differences wrt studies presented earlier in January:
  - Different pseudo-data
  - PDF parametrisation (now additive, previously multiplicative)
  - Fit quality (now χ^2/dof ~ 1.22, previously χ^2/dof ~ 3)
- Larger uncertainty in the low-x regime wrt what shown in January (but still smaller than what found by Juan)

Conclusions and outlook

- We have created a new dataset staring from a different input PDF:
  - CT14nnlo (smoother shape at low-x)
- We have introduced a new, more flexible, parametrization for the PDFs
- The obtained χ^2/dof ~ 1.22 is good
- Our PDF uncertainties are smaller than:
  - NNPDF31sx
  - Uncertainties of a PDF fit to HERA data using the same general PDF parametrization
- To-do list:
  - Studies with small-x resummation
  - Estimate model uncertainties
  - Inclusion of heavy flavour data
- Nestor, could you please give us the pseudo-data generated with saturation?