Bayesian re-weighting of nuclear PDFs

in collaboration with Néstor Armesto, Juan Rojo & Carlos Salgado
(arXiv: 1309.5371)

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Workshop on Saturation Signals
23th & 24th October 2013 - University of Utrecht

Outline

- Motivation
- The re-weighting method
- Pseudo data:
  - Drell-Yan
  - Hadroproduction
- Summary

Fitting implies ...

choices:

experiment, theory, parameterization

it is:

time consuming (**months/years**)
cumbersome (extremely)

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methods to quickly assess the impact of new data on PDFs

The re-weighting method

Developed:

W.T. Giele and S. Keller, Phys. Rev. D58 (1998) 094923.

R. D. Ball et al. [NNPDF Collaboration], Nucl. Phys. B 849 (2011) 112 [Erratum-ibid. B 854 (2012) 926] [Erratum-ibid. B 855 (2012) 927].

R. D. Ball, V. Bertone, F. Cerutti, L. Del Debbio, S. Forte, A. Guffanti, N. P. Hartland and J. I. Latorre et al. [NNPDF Collaboration], Nucl. Phys. B 855 (2012) 608.

Extended:

G. Watt and R. S. Thorne, JHEP (2012) 052.

Other:

H. Paukkunen and C. A. Salgado, Phys. Rev. Lett. 110, 212301 (2013).

For any observable

$$\langle \mathcal{O} \rangle = \frac{1}{N_{\rm rep}} \sum_{k=1}^{N_{\rm rep}} \mathcal{O}[f_k]$$

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n new data points ⇒

$$\mathcal{P}_{new}(f) = \mathcal{N}_\chi \mathcal{P}(\chi|f) \mathcal{P}_{old}(f)$$

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n new data points ⇒

$$\mathcal{P}_{new}(f) = \mathcal{N}_\chi \mathcal{P}(\chi|f)\mathcal{P}_{old}(f)$$

with

$$\mathcal{P}(\chi|f) \propto (\chi^2(y,f))^{\frac{1}{2}(n-1)} e^{-\frac{1}{2}\chi^2(y,f)}$$

After the reweighting

$$\langle \mathcal{O} \rangle_{\text{new}} = \frac{1}{N_{\text{rep}}} \sum_{k=1}^{N_{\text{rep}}} w_k \mathcal{O}[f_k]$$

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where

$$w_k = \frac{(\chi^2_k)^{\frac{1}{2}(n-1)} e^{-\chi^2_k/2}}{\frac{1}{N_{\rm rep}} \sum_{k=1}^{N_{\rm rep}} (\chi^2_k)^{\frac{1}{2}(n-1)} e^{-\chi^2_k/2}}$$

$$\chi^2_k(y, f_k) = \sum_{i,j=1}^{n} (y_i - y_i[f_k]) \sigma^{-1}_{ij} (y_j - y_j[f_k])$$

re-weighting

$\neq$

new fit

re-weighting
≠
new fit

To quantify the accuracy

$$N_{\text{eff}} \equiv \exp\left\{\frac{1}{N_{\text{rep}}}\sum_{k=1}^{N_{\text{rep}}} w_k \log(N_{\text{rep}}/w_k)\right\}$$

Drell-Yan

MCFM + MSTW2008 + EPS09

J. M. Campbell and R. K. Ellis, Phys. Rev. D 62 (2000) 114012.
A. D. Martin, W. J. Stirling, R. S. Thorne and G. Watt, Eur. Phys. J. C 63 (2009) 189.
K. J. Eskola, H. Paukkunen and C. A. Salgado, JHEP 0904 (2009) 065.

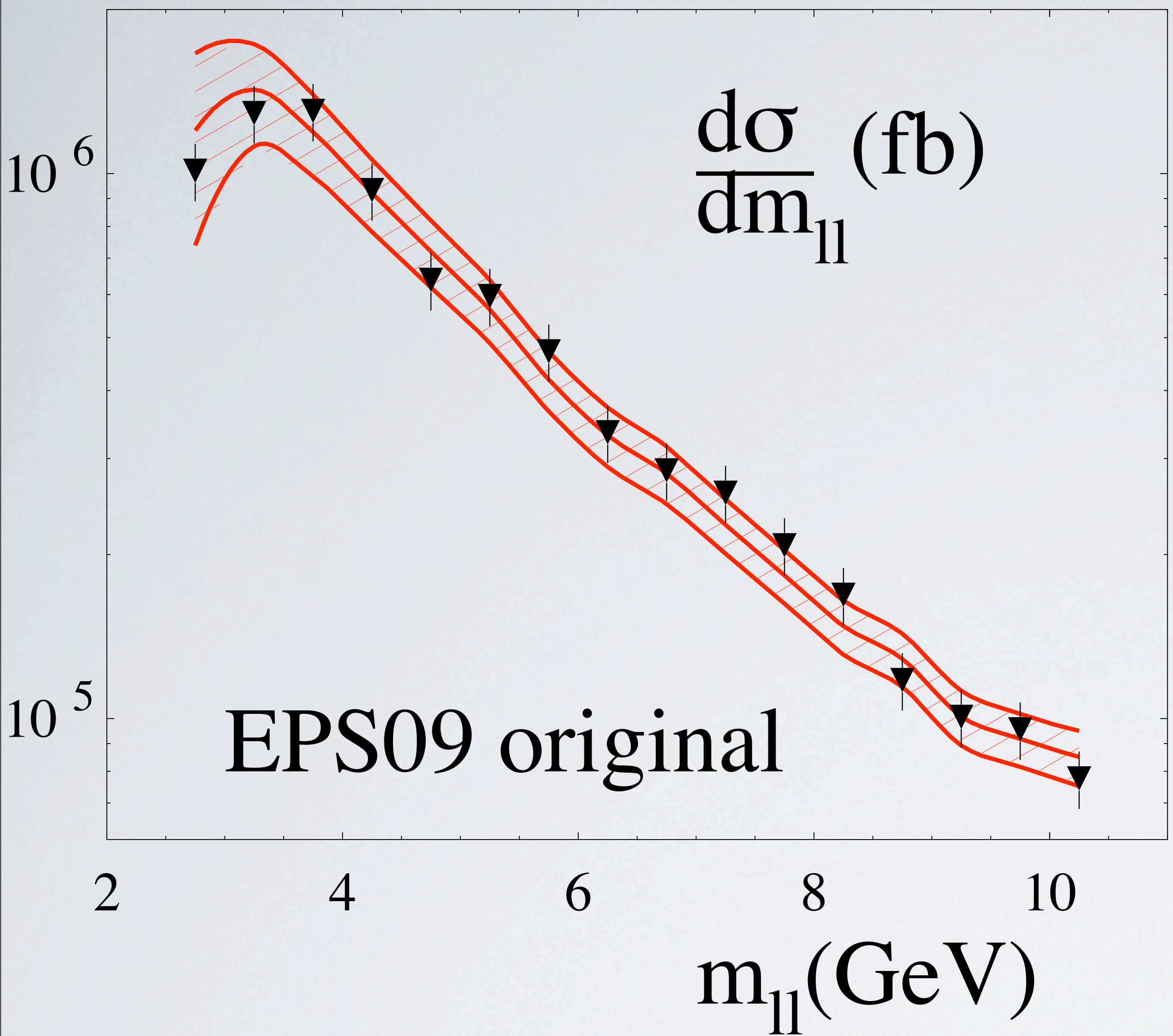
No p_T cuts

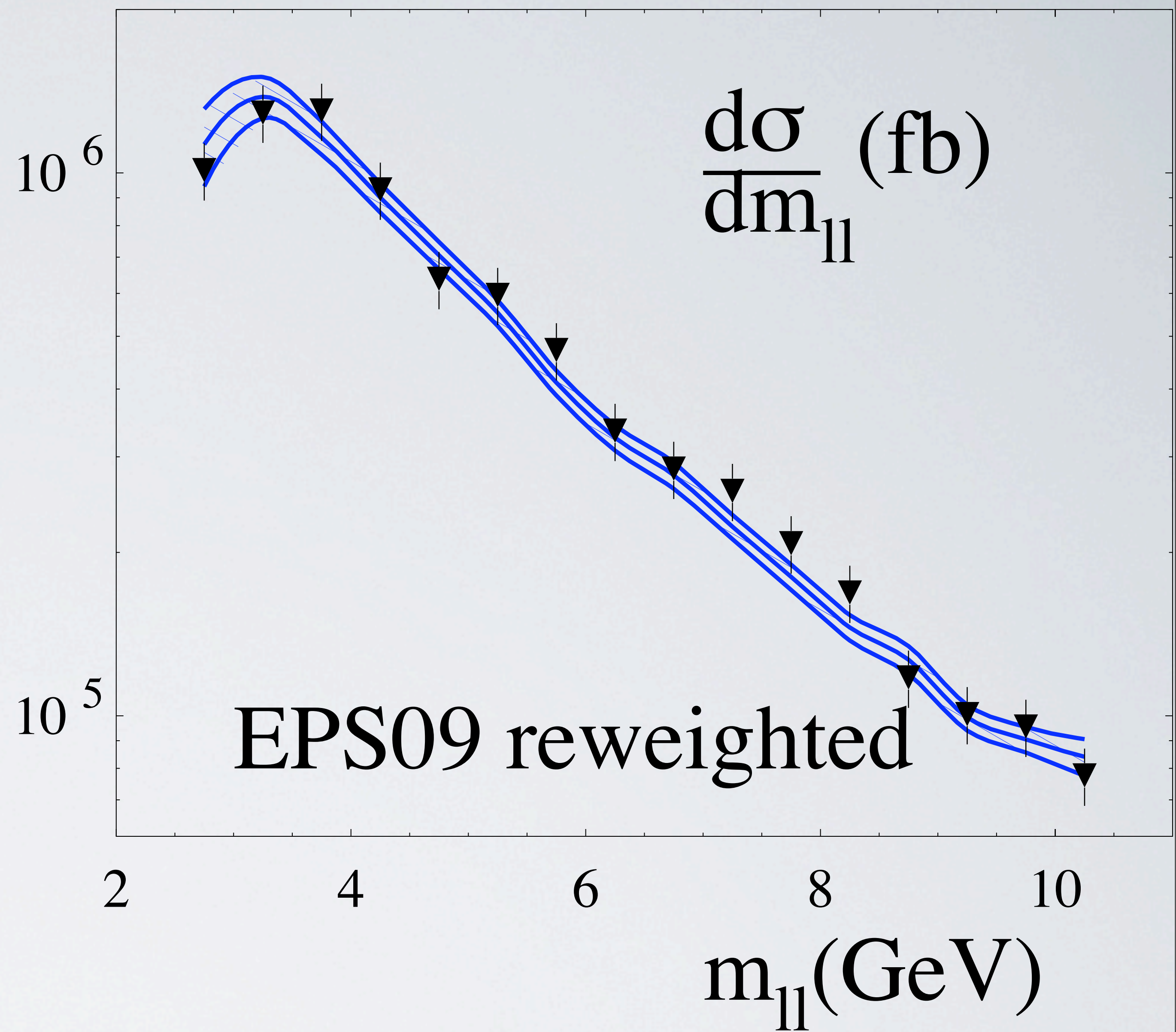
$|\eta| < 4$

8% systematic uncertainty

$L_{int} = 30\ nb^{-1}$

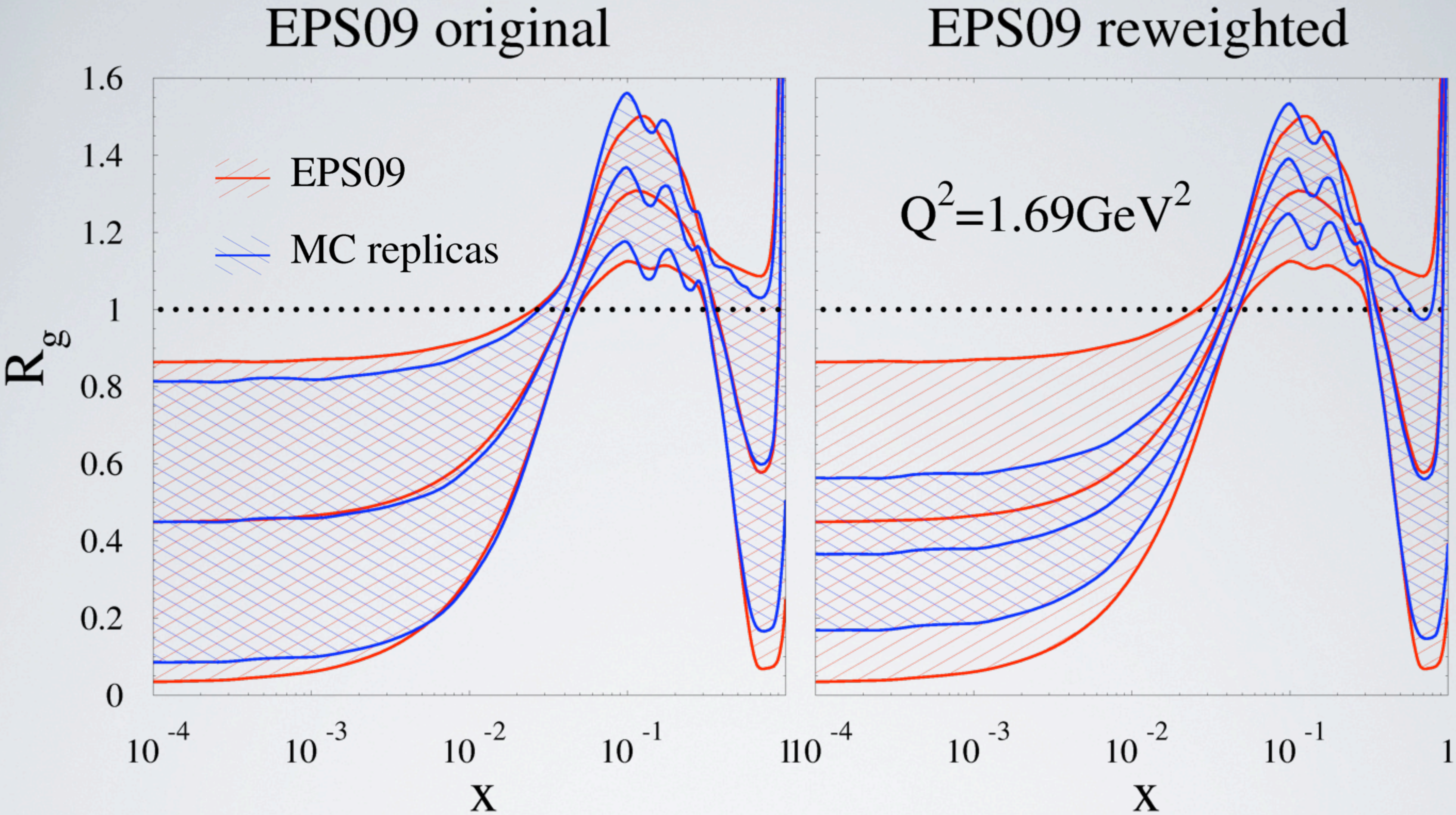
1000 MC replicas





n=16	χ^2 / n	< χ^2 > / n	N_{eff}
Before	0.64	2.68	-
After	0.59	0.96	539

- No change in the valence
- Slight modification for the sea



- No change in the valence
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gluon!

Hadroproduction

Code for pPb→h+X + MSTW2008 + EPS09 + DSS

D. de Florian, R. Sassot and M. Stratmann, Phys. Rev. D 76 (2007) 074033.

DGLAP & CGC pseudodata

J. L. Albacete, A. Dumitru, H. Fujii and Y. Nara, Nucl. Phys. A 897 (2013) 1.

5% systematic & 7% normalization uncertainties

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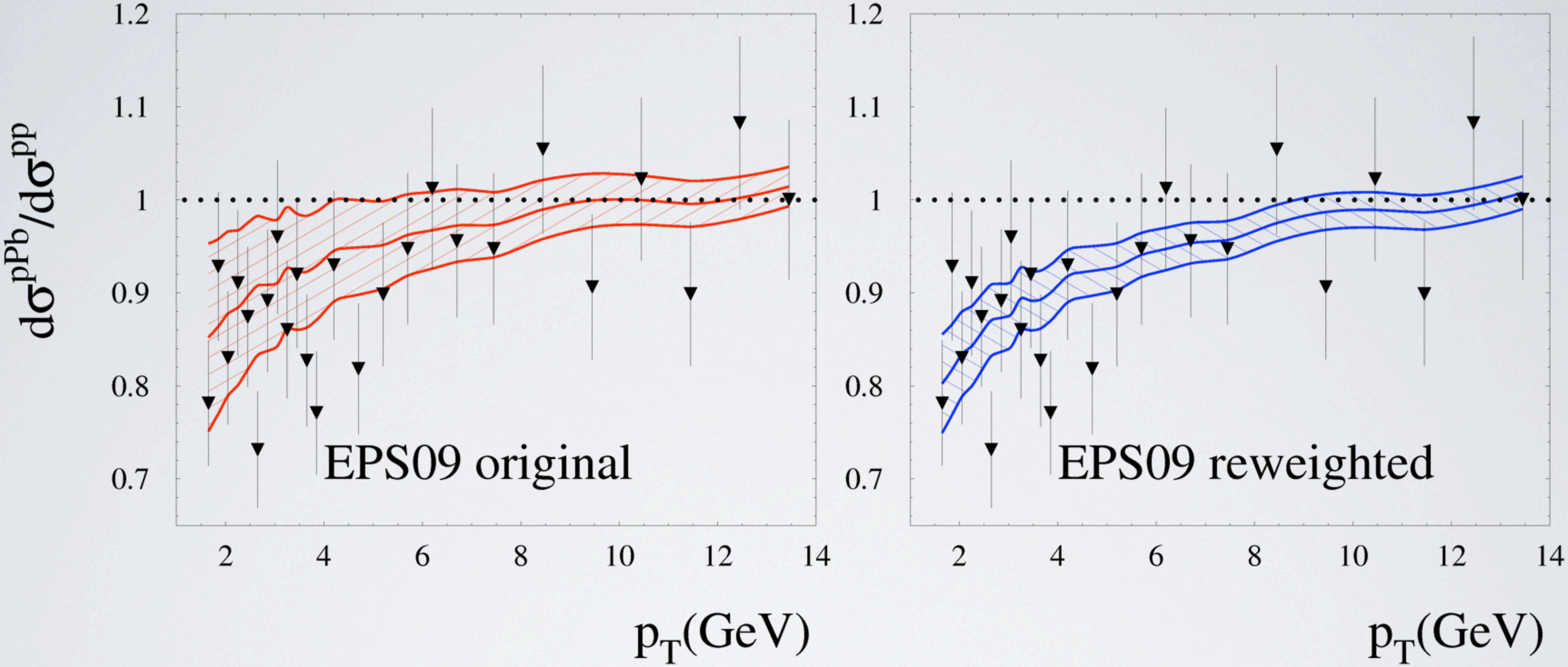
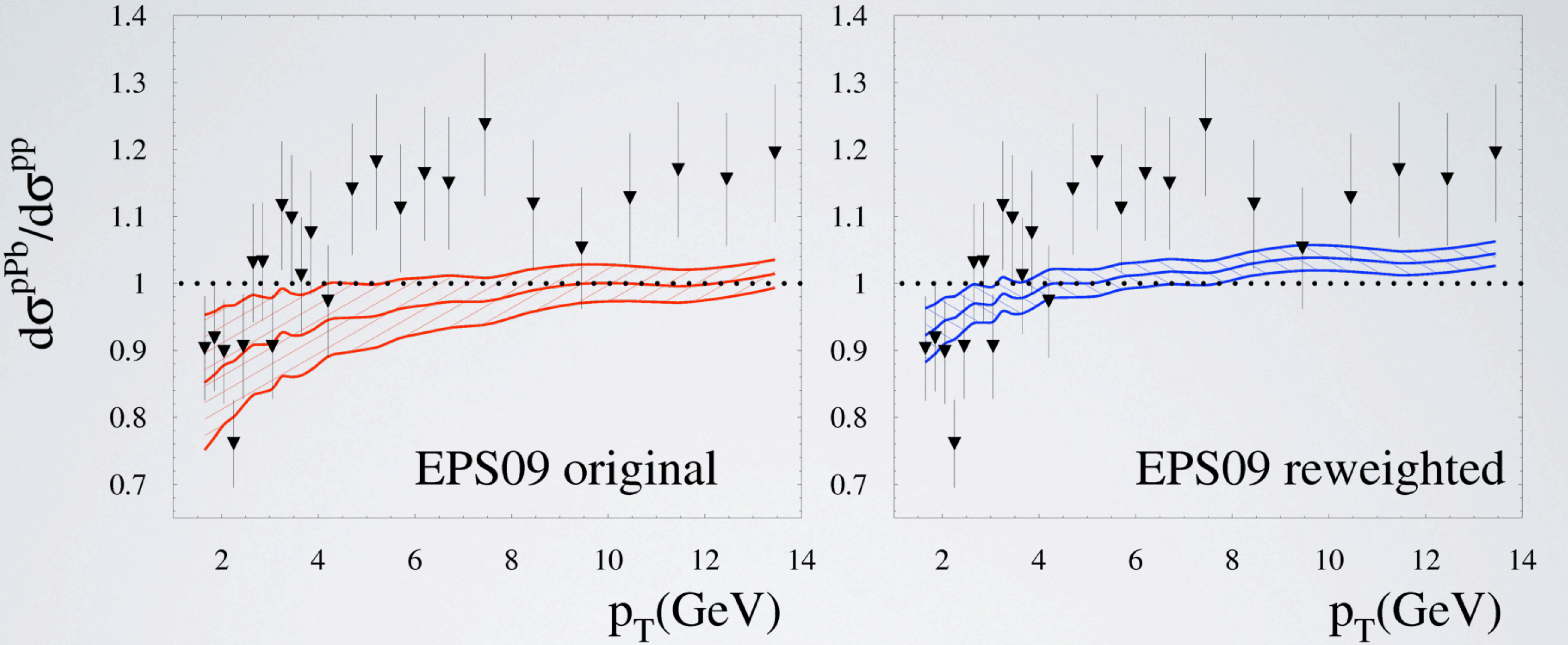
two scenarios: $\eta = 0$ & $\eta = 2$

DGLAP for $\eta = 0$



n=25	χ^2 / n	$< \chi^2 > / n$	N_{eff}
Before	1.11	1.75	-
After	0.84	1.02	624

CGC for $\eta = 0$

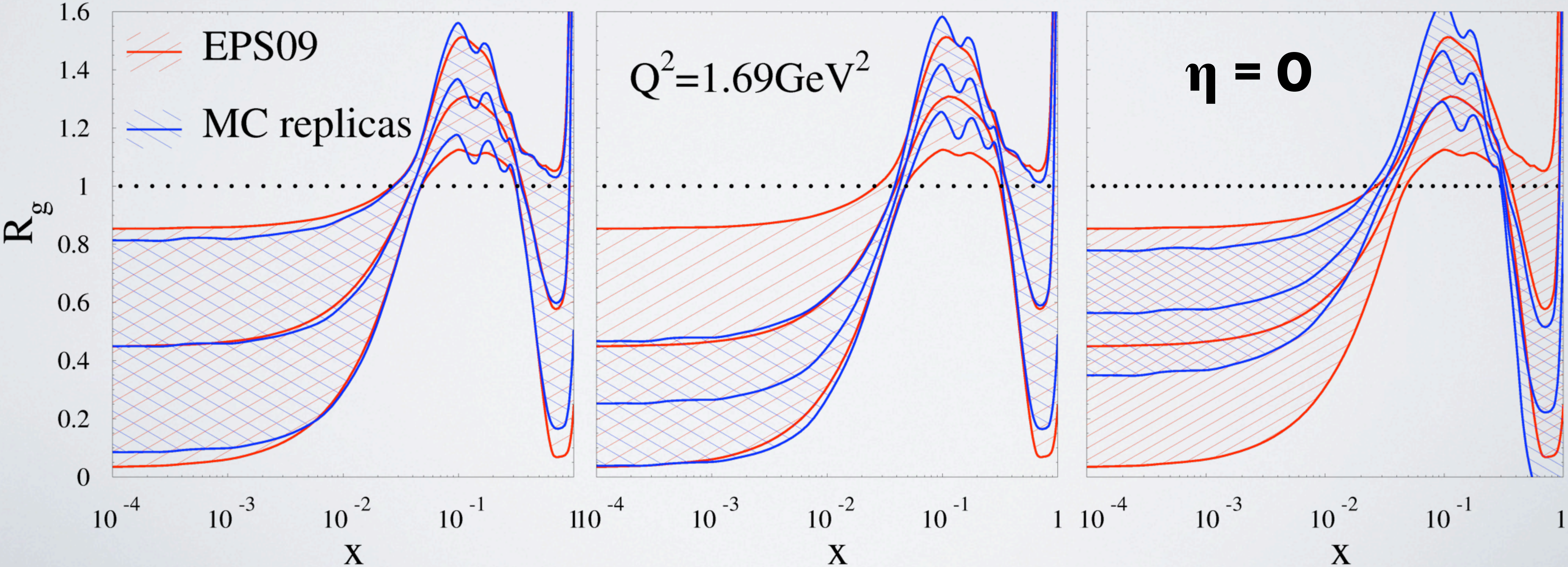


n=25	χ^2 / n	< χ^2 > / n	N_{eff}
Before	2.25	2.76	-
After	1.50	1.58	229

No change in the valence,

change in the sea

DGLAP



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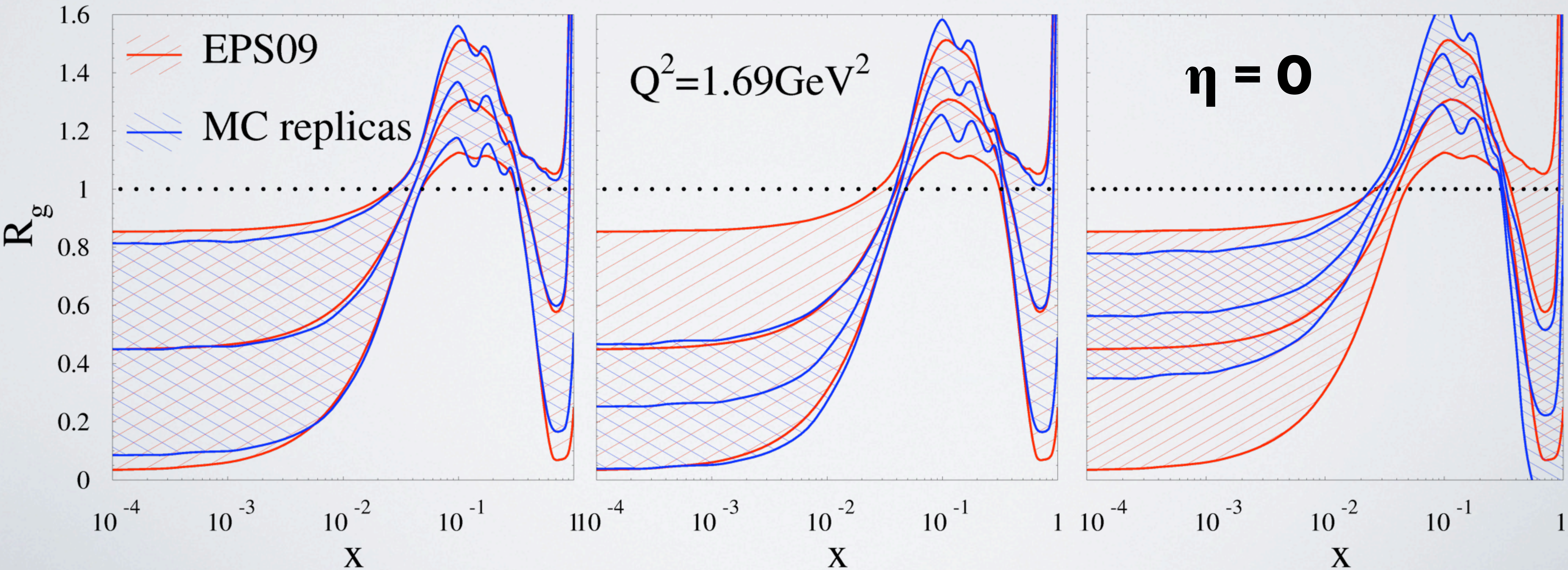
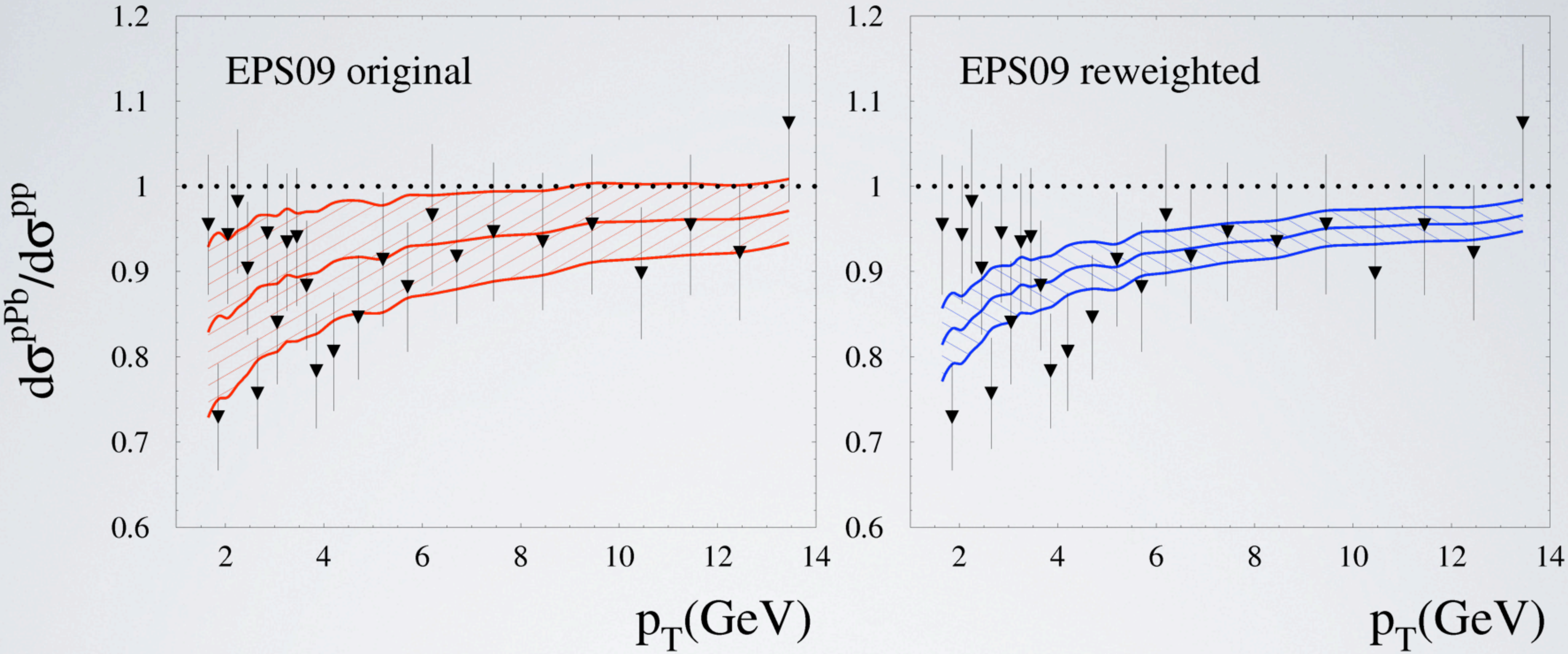
DGLAP

CGC



DGLAP for $\eta = 2$



n=25	χ^2 / n	< χ^2 > / n	N_{eff}
Before	0.95	1.82	-
After	0.92	1.08	612

DGLAP for $\eta = 2$

- No change in the valence
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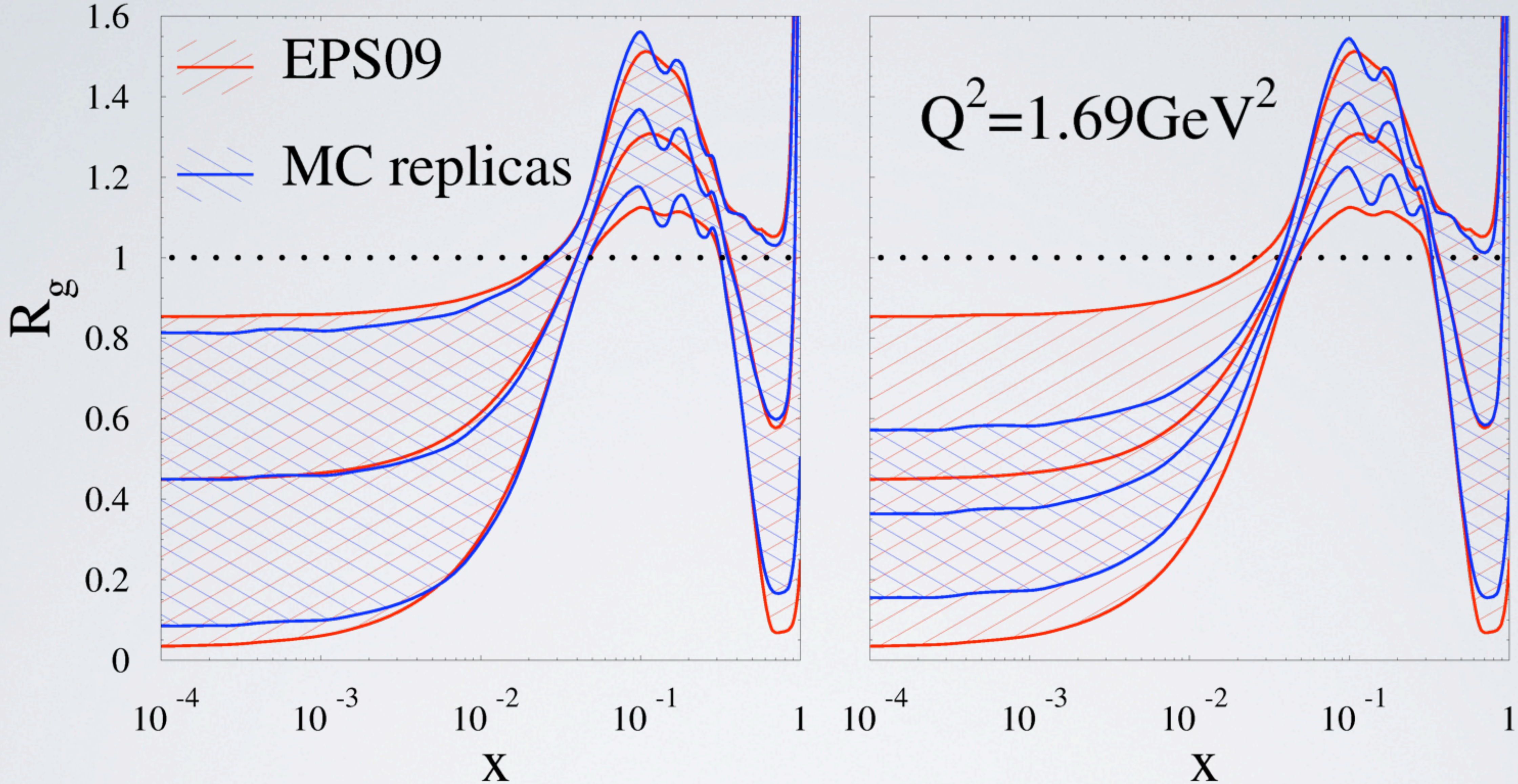
DGLAP for $\eta = 2$



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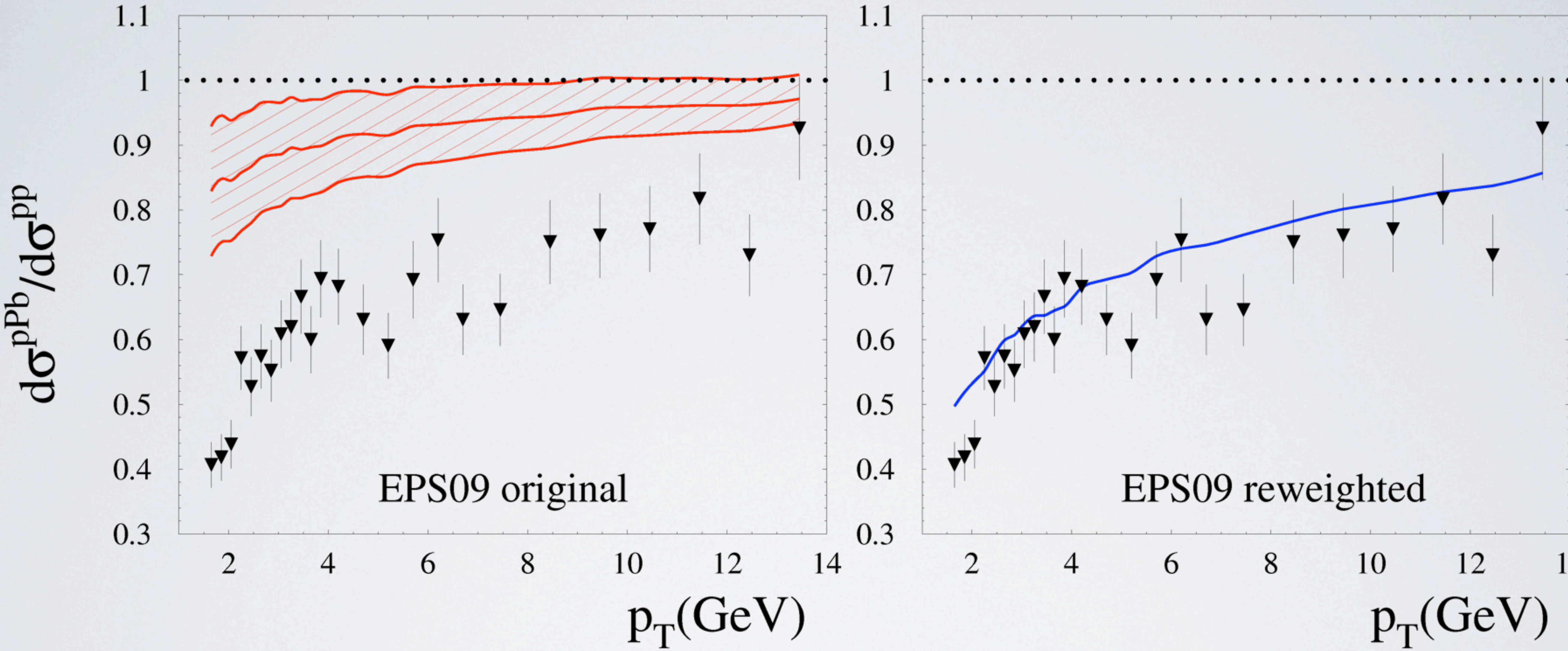
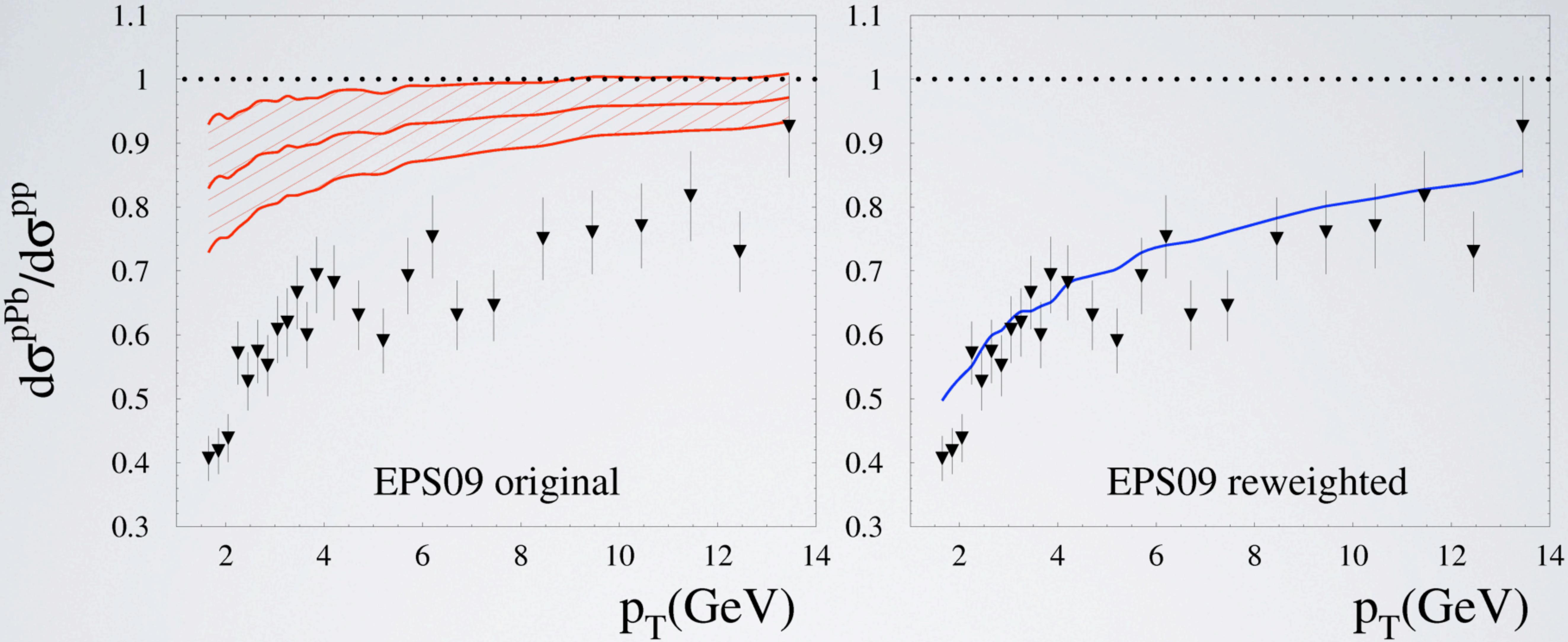
CGC for $\eta = 2$



$d\sigma^{pPb}/d\sigma^{pp}$
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
2
4
6
8
10
12
14
EPS09 original
EPS09 reweighted
p_T(GeV)
p_T(GeV)

CGC for $\eta = 2$



We can fit this, right?

CGC for $\eta = 2$

Unfortunately, *no*, because

n=25	χ^2 / n	< χ^2 > / n	N_{eff}
Before	36.43	38.62	-
After	1.85	1.85	

CGC for $\eta = 2$

Unfortunately, *no*, because

n=25	χ^2 / n	< χ^2 > / n	N_{eff}
Before	36.43	38.62	-
After	1.85	1.85	**1**

and the re-weighting method is invalidated

CGC for $\eta = 2$

Unfortunately, *no*, because

n=25	χ^2 / n	$< \chi^2 > / n$	N_{eff}
Before	36.43	38.62	-
After	1.85	1.85	**1**

and the re-weighting method is invalidated

So? What happens with the gluons?

They are **completely suppressed** for $x < 10^{-2}$

Summary

if data ~ predictions ⇒ time saving!

Otherwise, refitting required

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all DGLAP & $\eta = 0$ CGC pseudodata:

30-50% reduction of the gluon uncertainty

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CGC pseudodata at $\eta = 2$: no conclusions

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- ongoing comparison with other methods
- same with DSSZ nuclear PDFs coming soon

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EPS09 Monte Carlo replicas available at

http://igfae.usc.es/hotlhc/index.php/software