Re-weighting Vs. re-fitting (& AFTER)

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AFTER @ LHC
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Outline

- Motivation
- The re-weighting methods
- Before AFTER
- Summary
- **AFTER**

Fitting implies ... making many, many choices

and it is ... quite time consuming

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and it is ... quite time consuming

methods to quickly assess the impact of new data on (n)PDFs

Bayesian re-weighting

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 et al. [NNPDF Collaboration], Nucl. Phys. B 855 (2012) 608.

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

N. Sato, J.F. Owens and H. Prosper, arXiv:1310.1089.

B.J.A. Watt, P. Motylinski and R.S. Thorne, arXiv:1311.5703.

N. Armesto, J. Rojo, C.A. Salgado, and P. Z., JHEP 1311 (2013) 015.

Hessian re-weighting

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

For any observable

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

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n new data points ⇒

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

For any observable

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n new data points ⇒

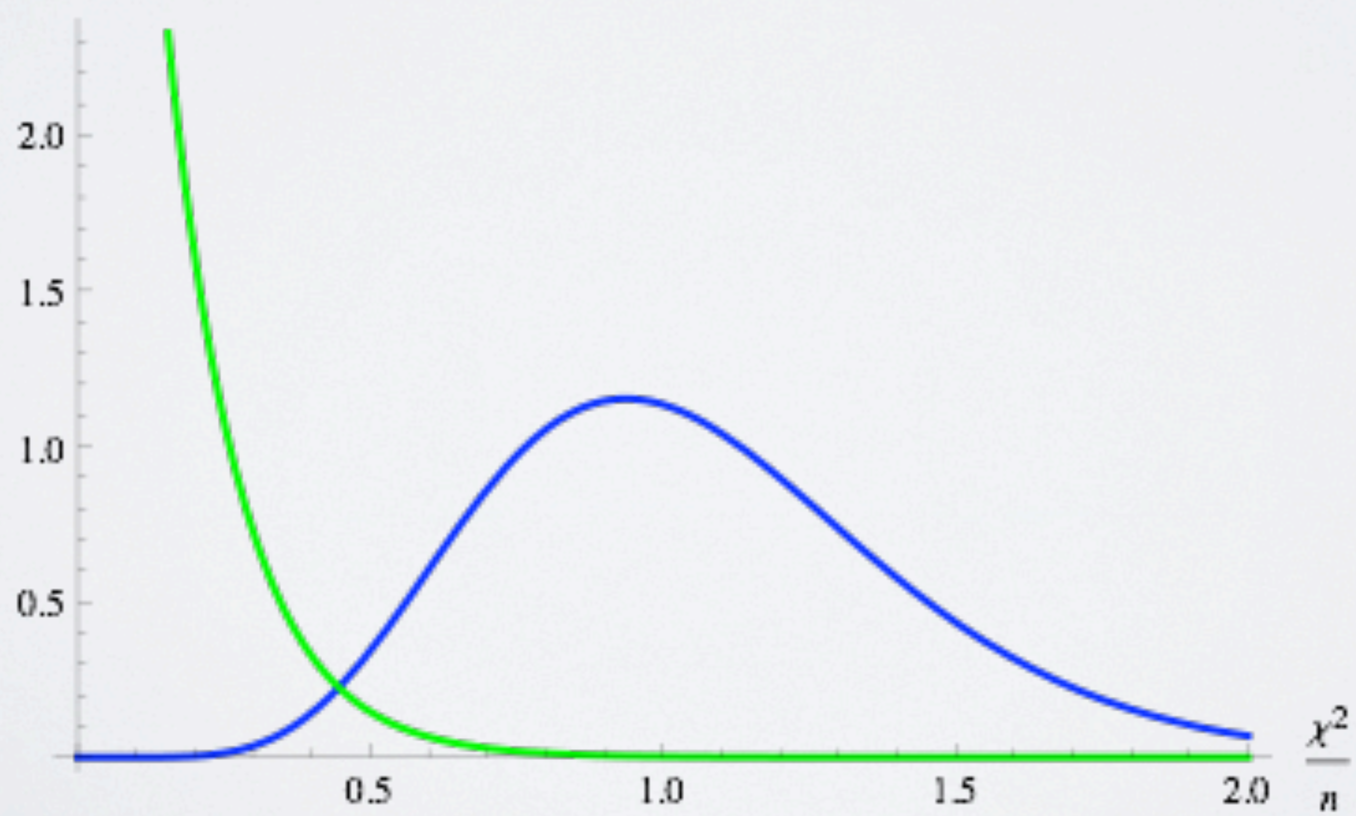
$$\mathcal{P}_{new}(f) = \mathcal{N}_\chi \mathcal{P}(\chi|f)\mathcal{P}_{old}(f)$$

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

How to choose the likelihood?

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

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



NNPDF

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

Giele-Keller

$$w_k = \frac{e^{-\chi^2_k/2}}{\frac{1}{N_{\text{rep}}} \sum_{k=1}^{N_{\text{rep}}} e^{-\chi^2_k/2}}$$

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

re-weighting

$\neq$

new fit

re-weighting
≠
new fit

To quantify the accuracy

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

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

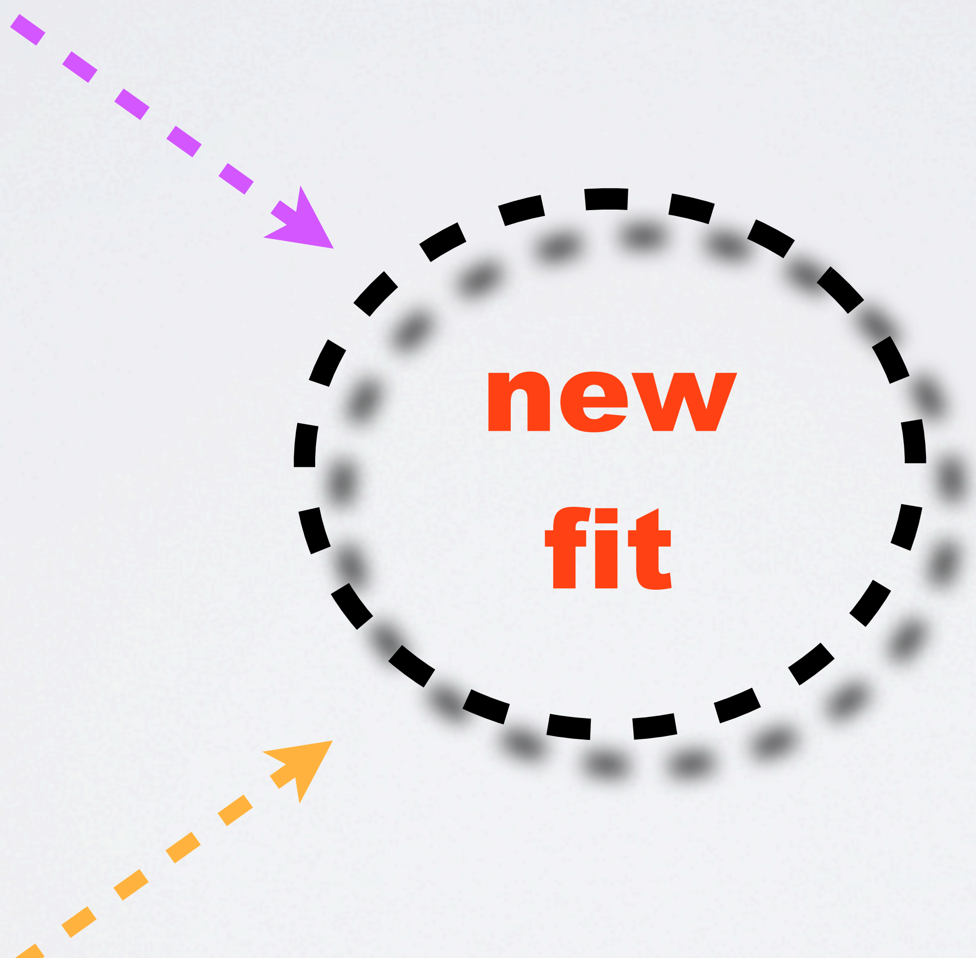
what if $N_{eff} << N_{rep}$?

Too much new information, (theory still valid)

Incompatible new data (theory no longer applies)

what if $N_{eff} << N_{rep}$?

Too much new information, (theory still valid)



Incompatible new data (theory no longer applies)

what if $N_{eff} << N_{rep}$?

Too much new information, (theory still valid)

new (n)PDF set

new fit

Incompatible new data (theory no longer applies)

what if $N_{eff} << N_{rep}$?

Too much new information, (theory still valid)

new (n)PDF set

Incompatible new data (theory no longer applies)

very exciting!

and now we put this to test ...

$$f_k(x,Q^2) = f_0(x,Q^2) + \sum_i^{N_{eig}} (f_i^{\pm}(x,Q^2) - f_0(x,Q^2))|r_{k,i}|$$

random numbers

hessian eigenvectors

central value

$k=1,\ldots,N_{rep}$ $\rightarrow$ $N_{rep}=1000$

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

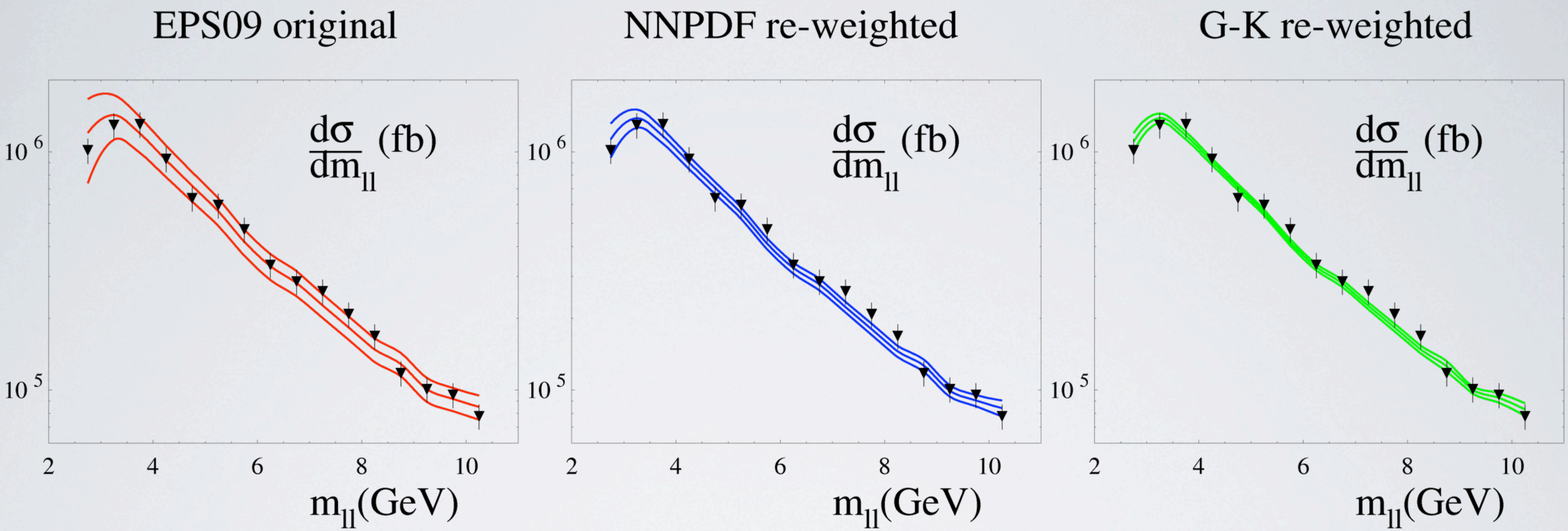
$|\eta| < 4$

8% systematic uncertainty

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

1000 MC replicas

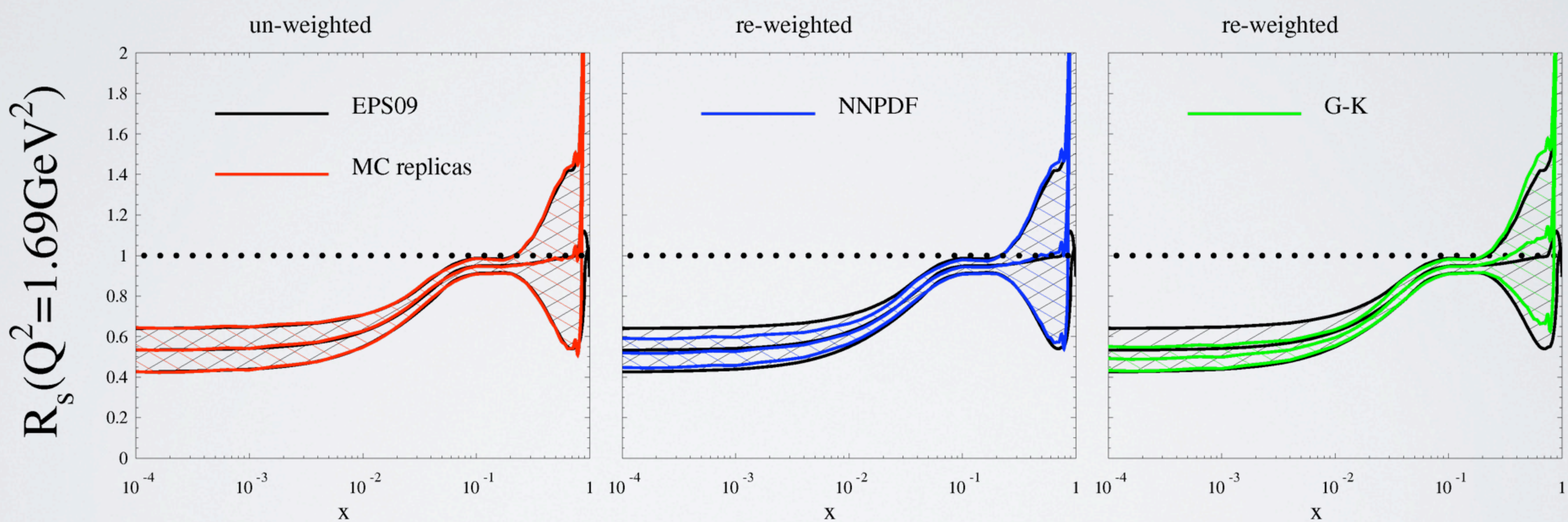
Drell-Yan



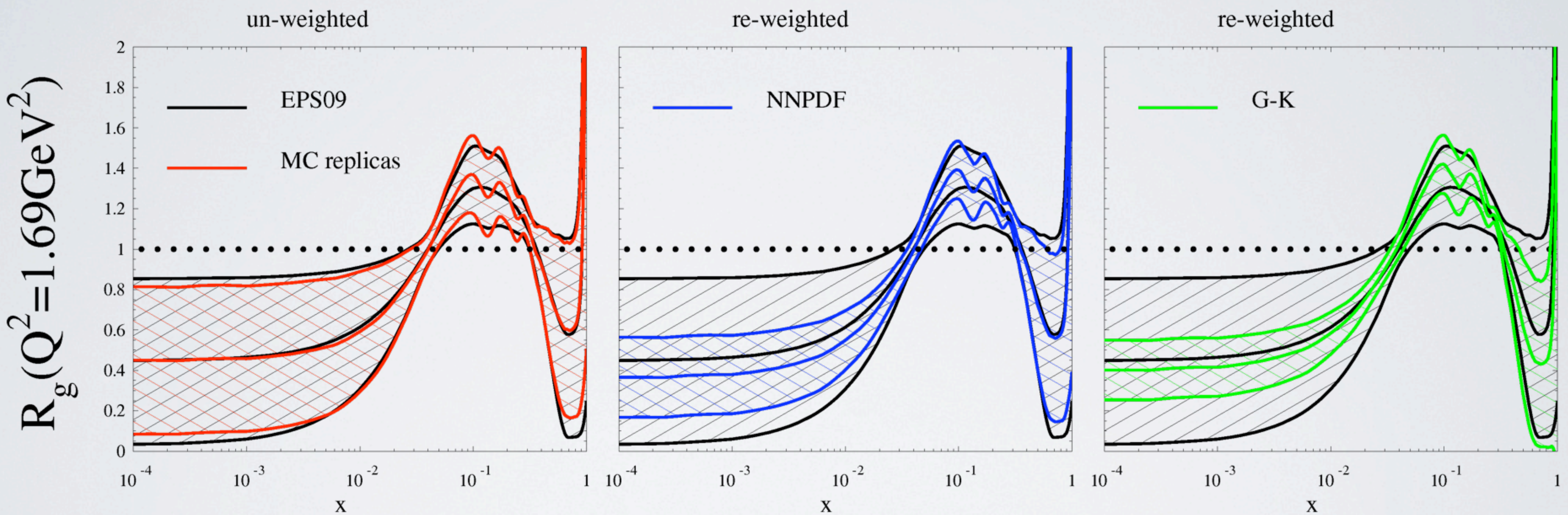
n=16	χ^2 / n	$< \chi^2 >$ / n	N_{eff}
EPS09	0.64	2.68	-
NNPDF	0.59	0.96	539
G-K	0.48	0.62	196

- No change in the valence

- Modification of the sea



Modification of the gluon



Hadro-production

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

B. Jager, A. Schafer, M. Stratmann and W. Vogelsang, Phys. Rev. D67 (2003) 054005.
R. Sassot and M. Stratmann and P.Z., Phys. Rev. D82 (2010) 074011.
D. de Florian, R. Sassot and M. Stratmann, Phys. Rev. D76 (2007) 074033.

DGLAP & CGC pseudo-data

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

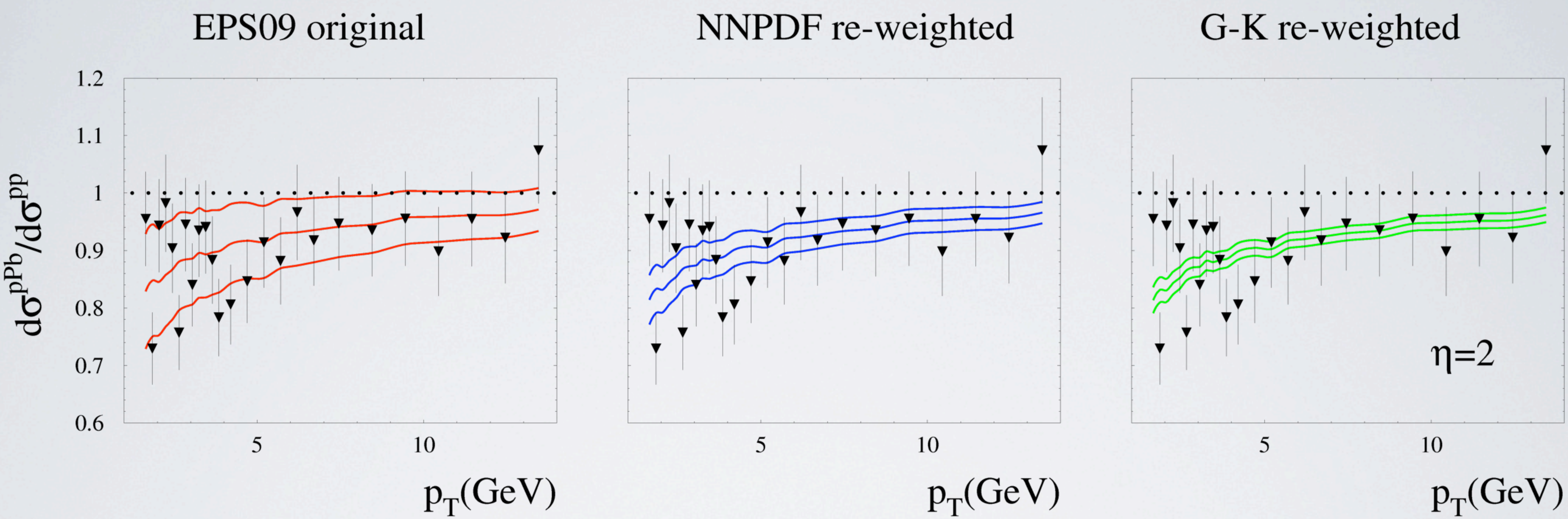
5% systematic & 7% normalization uncertainties

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

1000 MC replicas

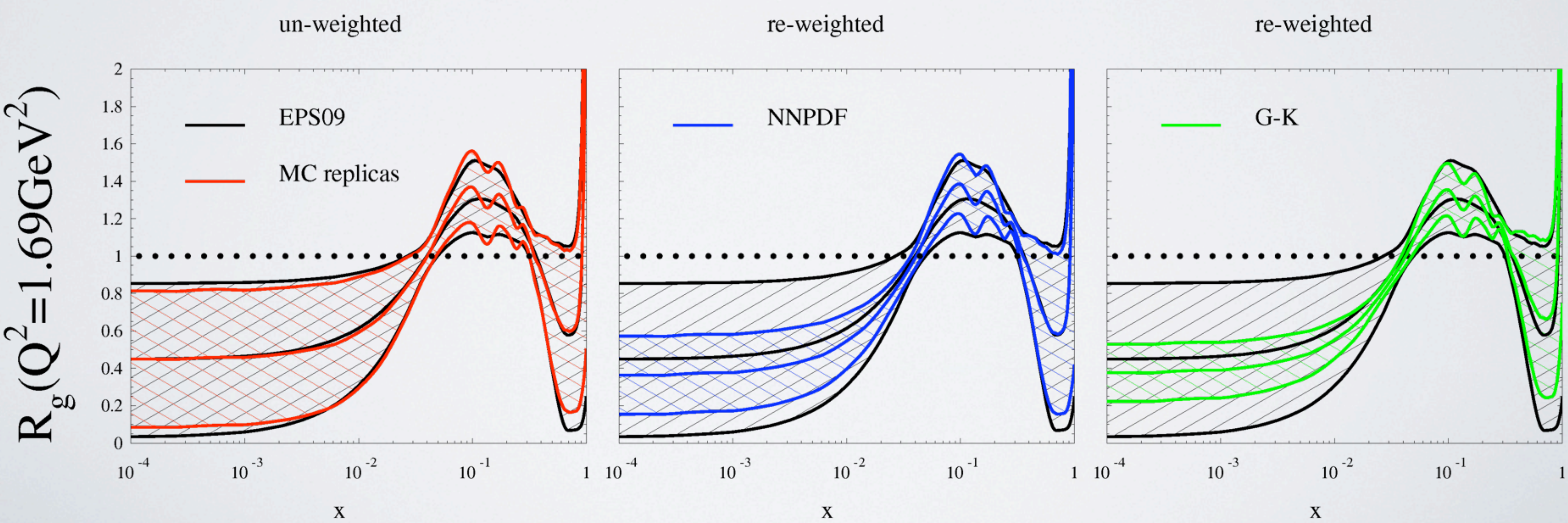
two scenarios: $\eta = 0$ & **$\eta = 2$**

DGLAP pseudo-data for $\eta=2$

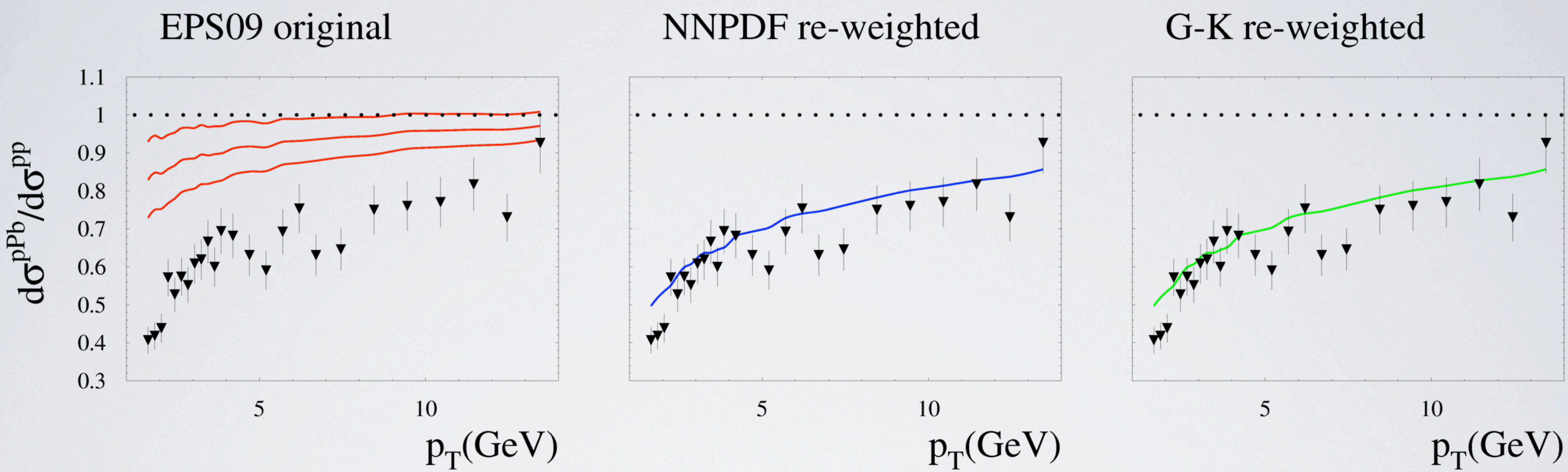


n=25	χ^2 / n	$<\chi^2>$ / n	N_{eff}
Before	0.95	1.82	-
NNPDF	0.92	1.08	612
G-K	0.91	0.95	307

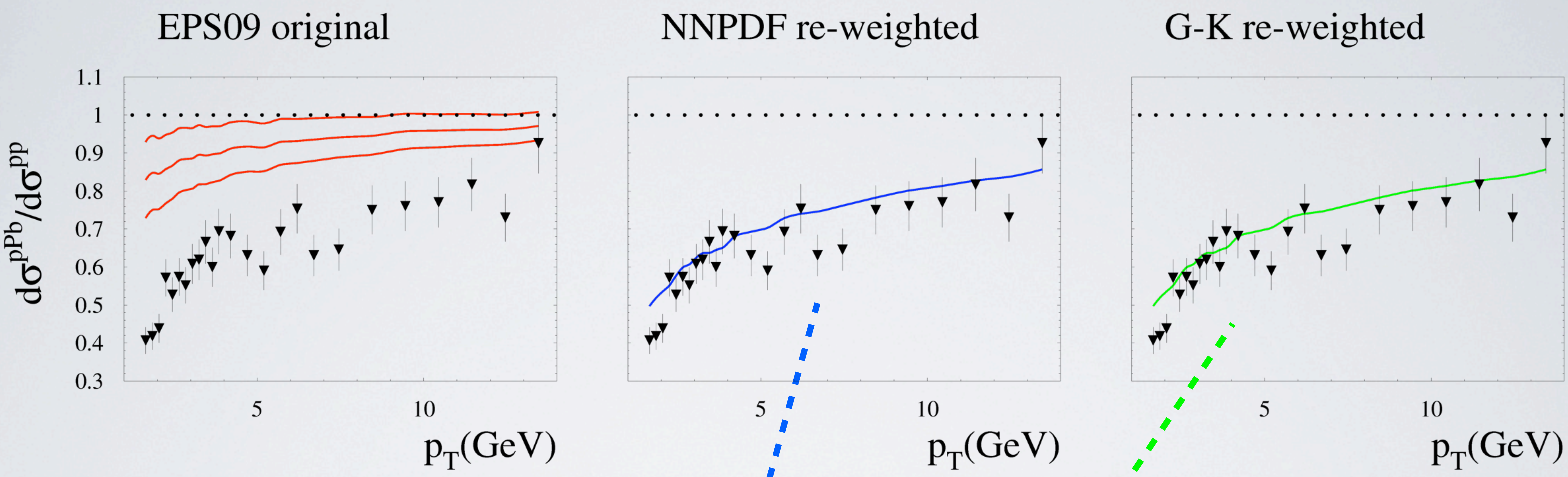
- No change in the valence
- No change in the sea
- Modification of the gluon, compatible with Drell-Yan behaviour



CGC pseudo-data for $\eta = 2$



CGC pseudo-data for $\eta = 2$



can we fit this?

CGC for $\eta = 2$

Unfortunately, ***no***, because

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

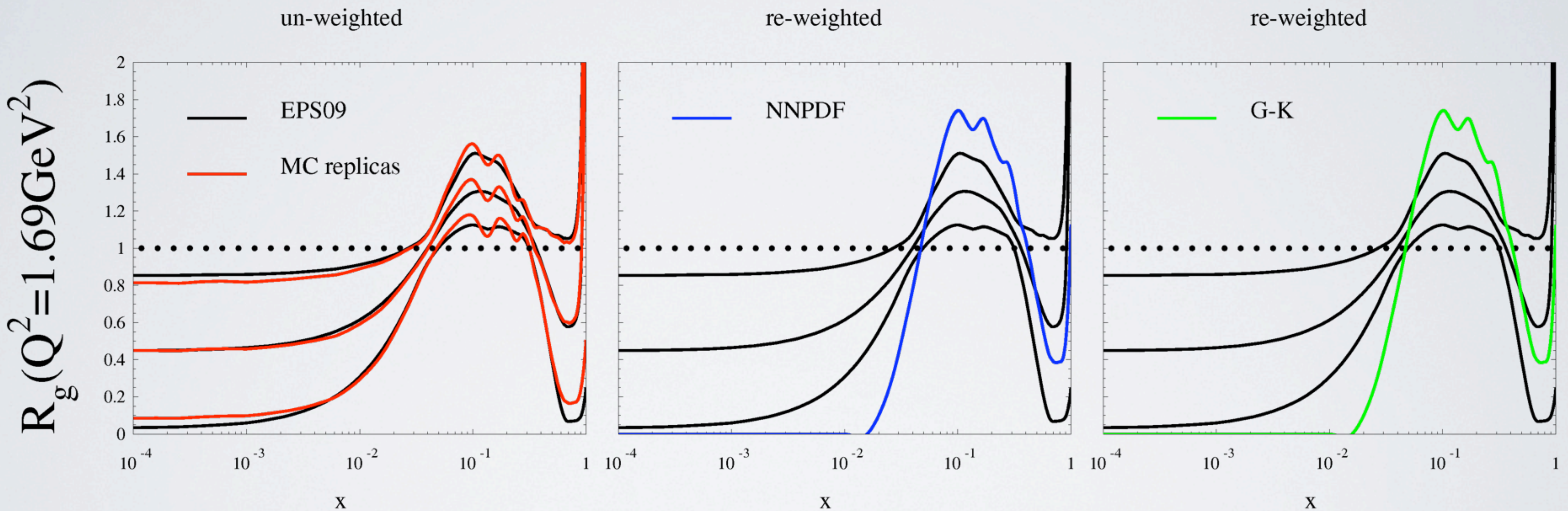
CGC for $\eta = 2$

Unfortunately, ***no***, because

n=25	χ^2 / n	< χ^2 > / n	N_{eff}
Before	36.43	38.62	-
NNPDF	1.85	1.85	1
G-K	1.85	1.85	1

and the re-weighting methods are **invalidated**

What happens with the gluons?



Summary

- gluons unconstrained (basically at any-x)
- re-weighting methods are powerful tools: fitters-independent & time saving
- compatibility of the methods under study
- hints of new phenomena
- **http://igfae.usc.es/hotlhc/index.php/software**

AFTER

- prompt photon
- deuteron target
- Drell-Yan
- hadro-production

Deuteron

- included but not included in nuclear fits
- relevant for isospin separation
- effect not small if precision required

more data would be useful

Drell-Yan

LO

$$d\sigma^{pA}_{DY} \propto e_u^2 \left[u(x_1)\bar{u}^A(x_2) + \bar{u}(x_1)u^A(x_2)\right] + e_d^2 \left[d(x_1)\bar{d}^A(x_2) + \bar{d}(x_1)d^A(x_2)\right]$$

large positive y

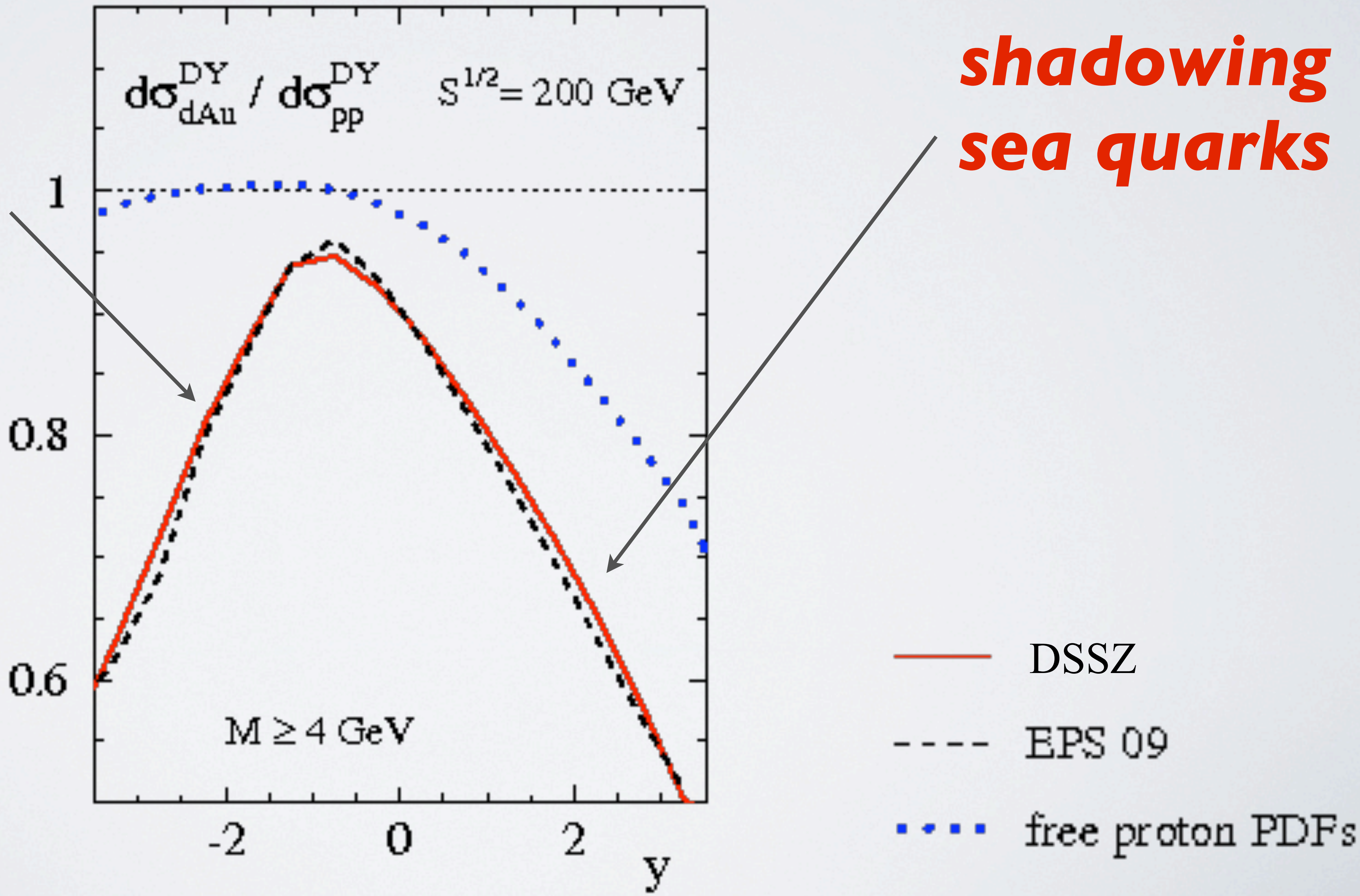
large negative y

$$x_{1,2} = \sqrt{M^2/s}\, e^{\pm y}$$

high x suppression:

EMC effect

shadowing sea quarks



Single-inclusive hadro-production

- constraints on gluon density
- only RHIC data, η=0
- final state dependent
- problem with FFs at LHC energies