

# Analysis of proton-lead data via reweighting

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

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# Outline

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- Motivation
- The reweighting method
- Pseudo data:
  - Drell-Yan
  - Hadroproduction
- Summary

# Fitting implies ...

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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 reweighting method

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## Developed:

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

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

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n new data points  $\Rightarrow$

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

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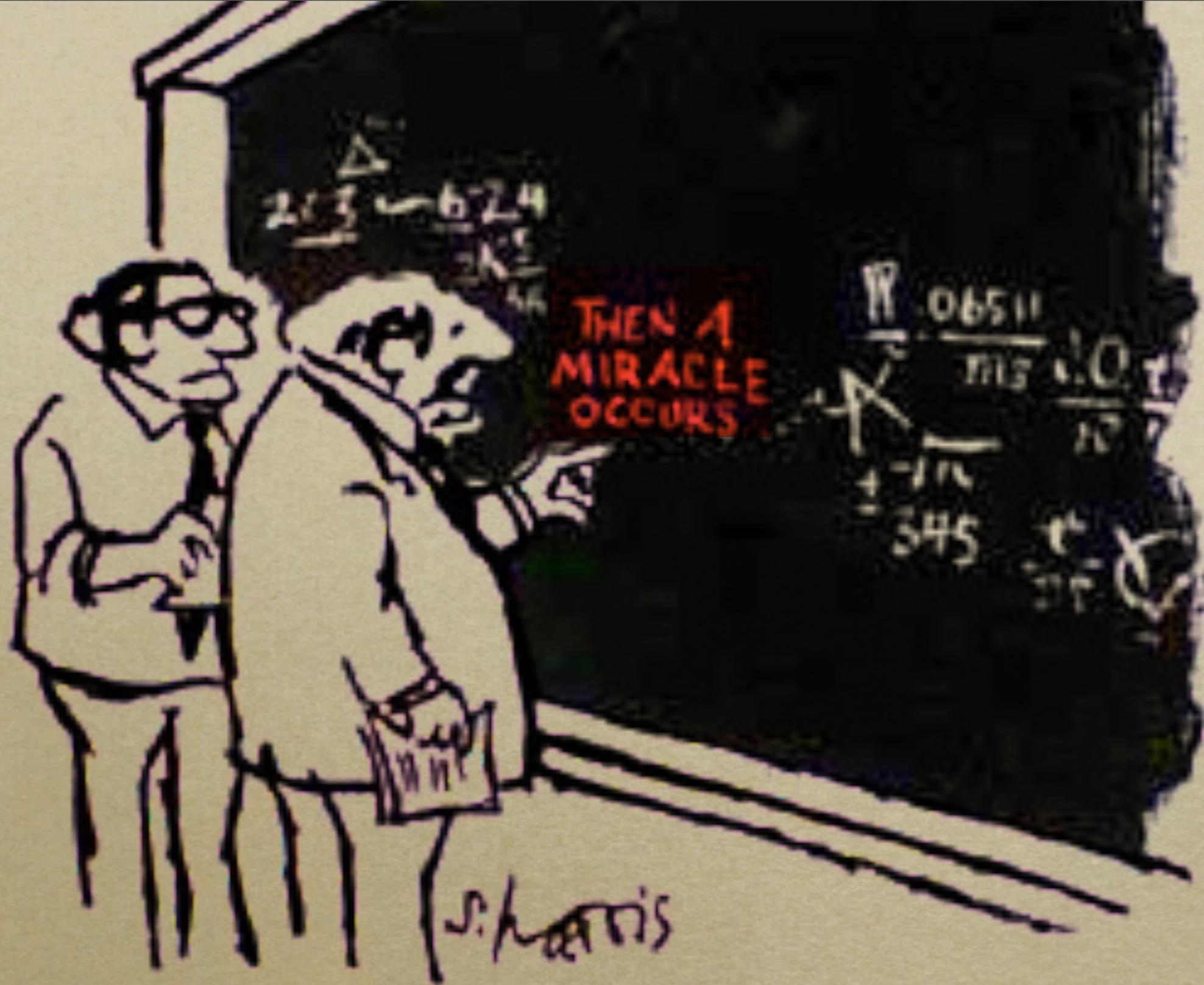
n new data points  $\Rightarrow$

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

with

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

$$\chi_k^2(y, f_k) = \sum_{i,j=1}^n (y_i - y_i[f_k]) \sigma_{ij}^{-1} (y_j - y_j[f_k])$$



"I THINK YOU SHOULD BE MORE EXPLICIT  
HERE IN STEP TWO."

# After the reweighting

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

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

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

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.

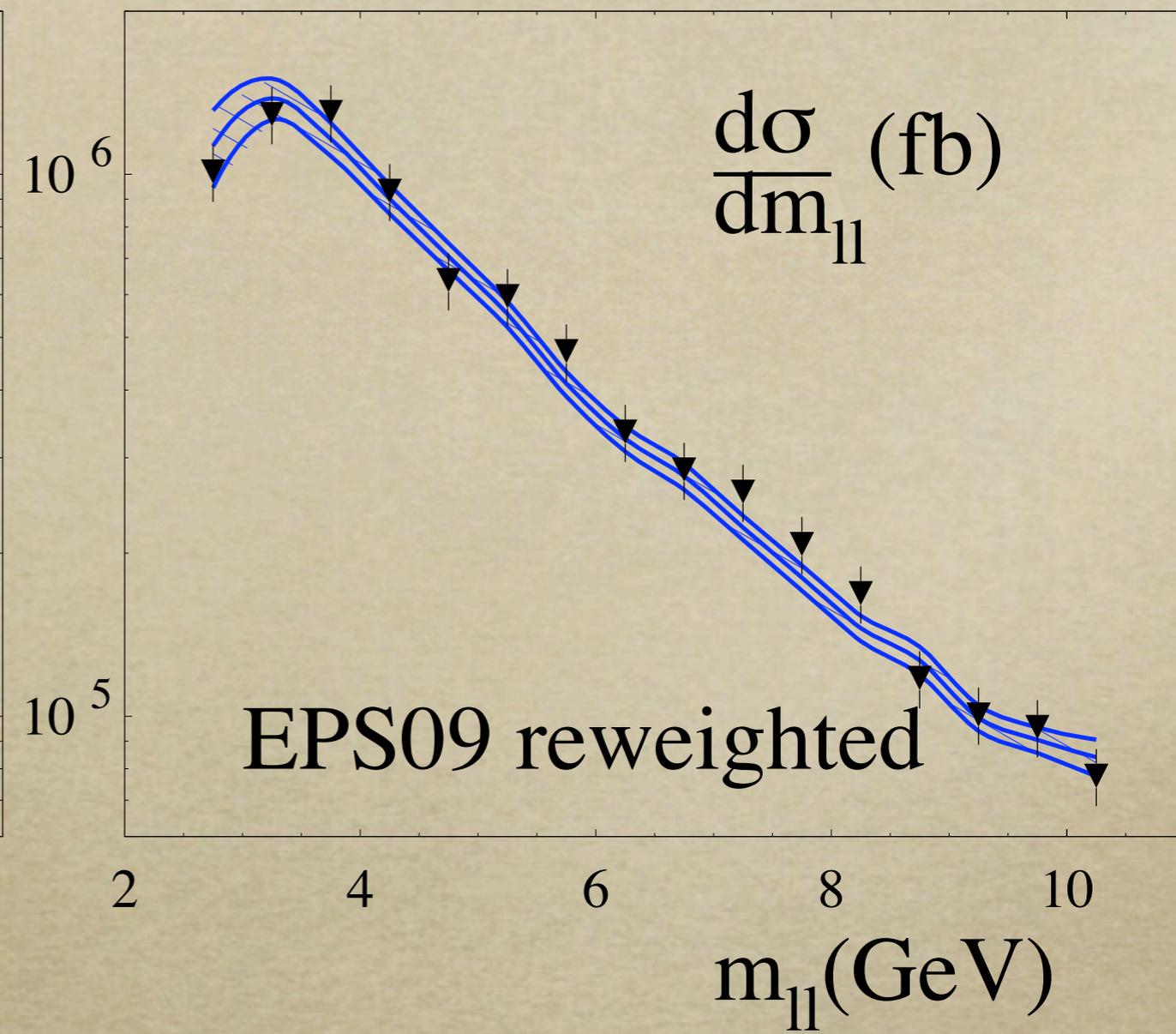
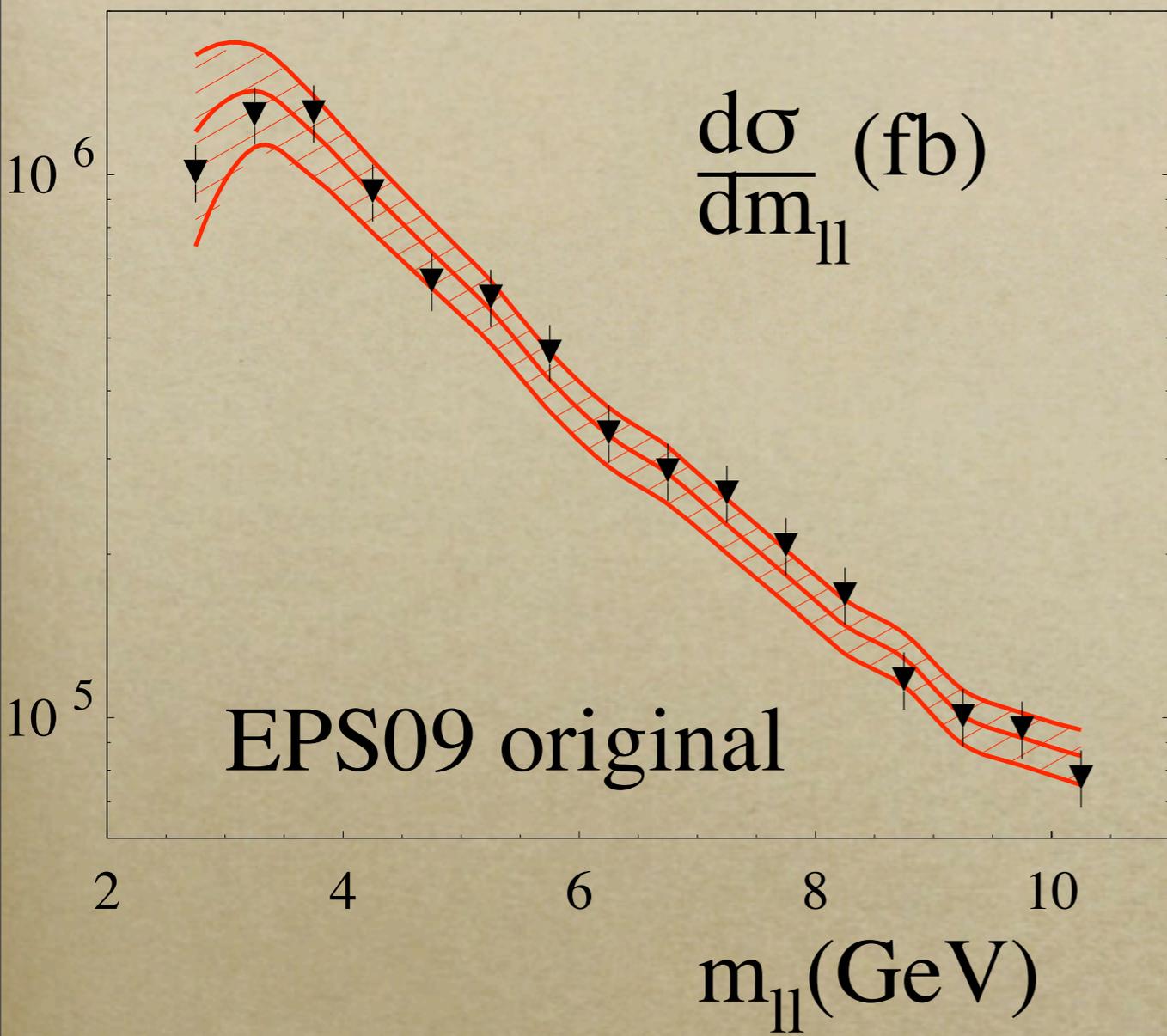
No  $p_T$  cuts

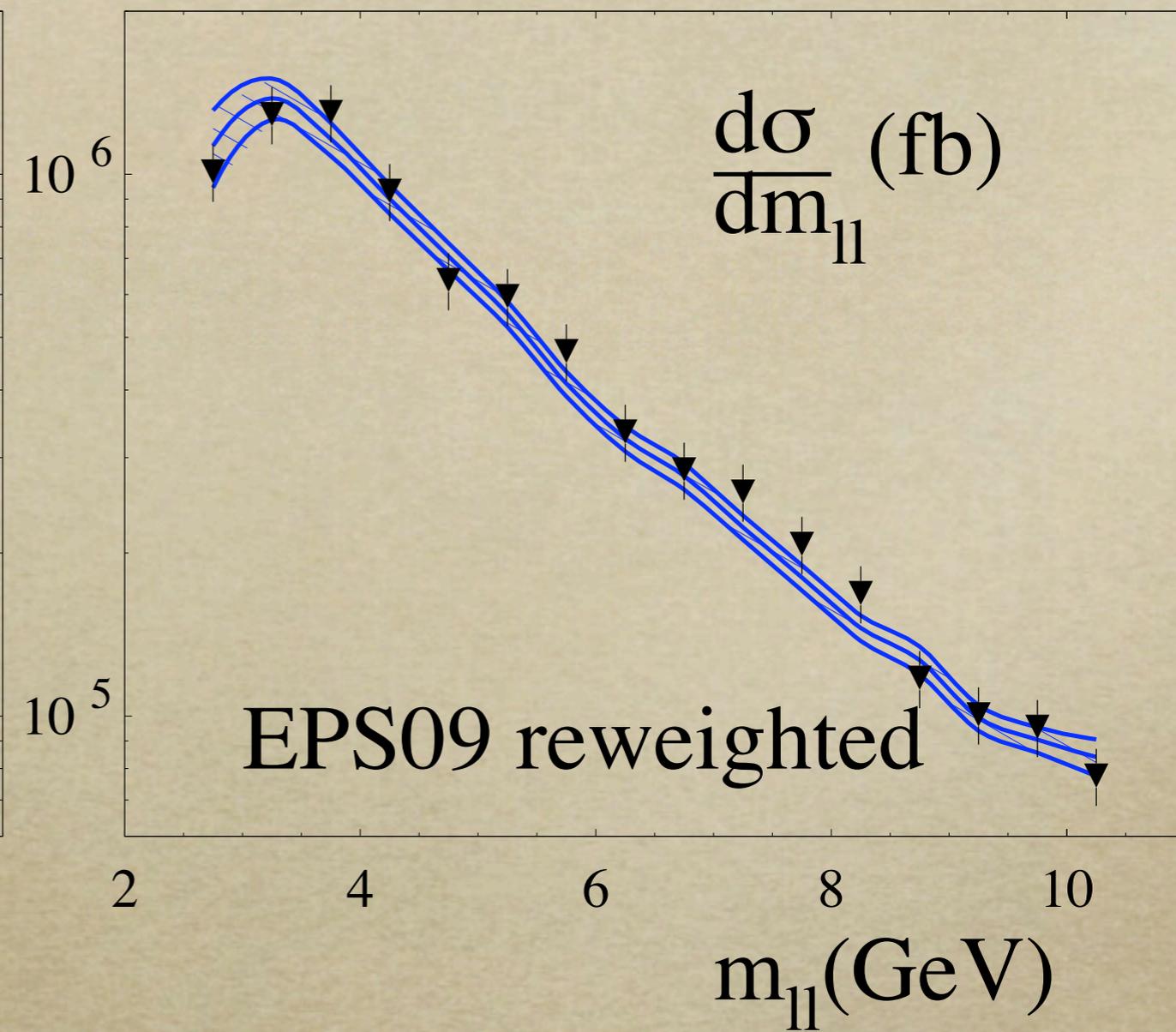
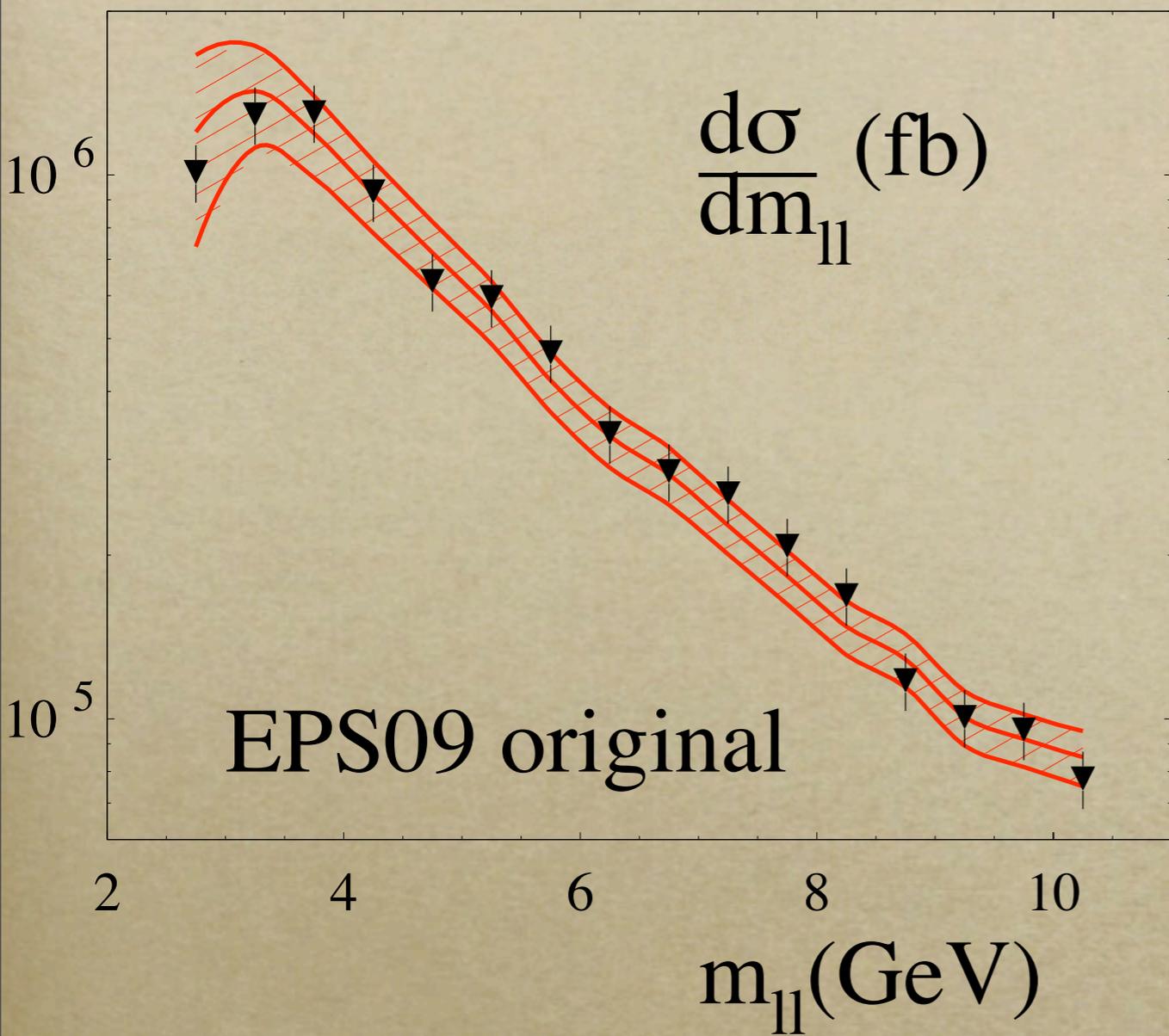
$|\eta| < 4$

8% systematic uncertainty

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

1000 MC replicas



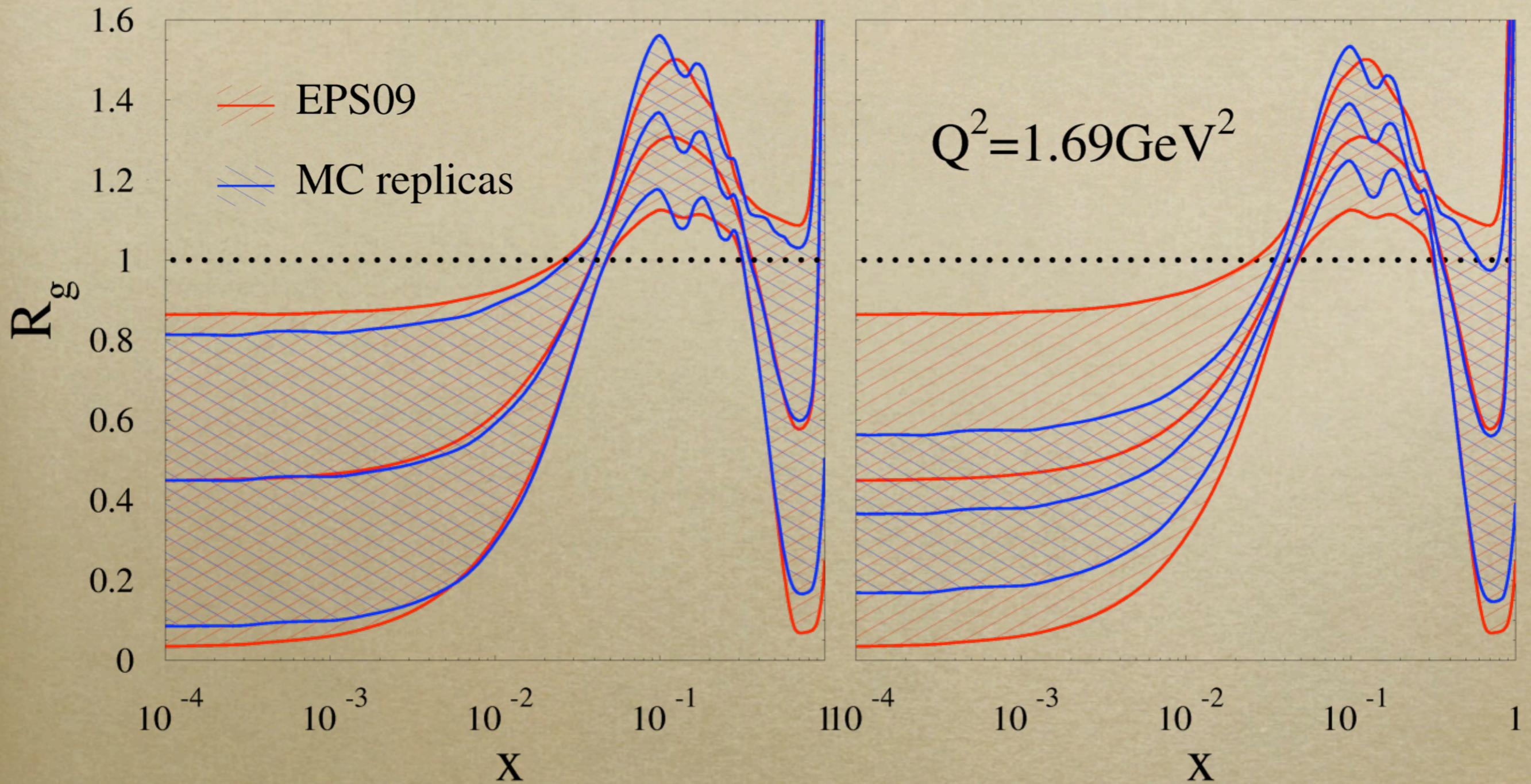


n=16	$\chi^2 / n$	$\langle \chi^2 \rangle / n$	$N_{\text{eff}}$
Before	0.64	2.68	-
After	0.59	0.96	539

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

EPS09 original

EPS09 reweighted



No change in the valence



Slight modification for the sea

# Hadroproduction

Code for  $pp \rightarrow X$  + MSTW2008 + EPS09 + DSS

B. Jager, A. Schafer, M. Stratmann and W. Vogelsang, Phys. Rev. D 67 (2003) 054005.  
D. de Florian, R. Sassot and M. Stratmann, Phys. Rev. D 76 (2007) 074033

$\eta = 0$  &  $\eta = 2$

DGLAP & CGC pseudodata

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

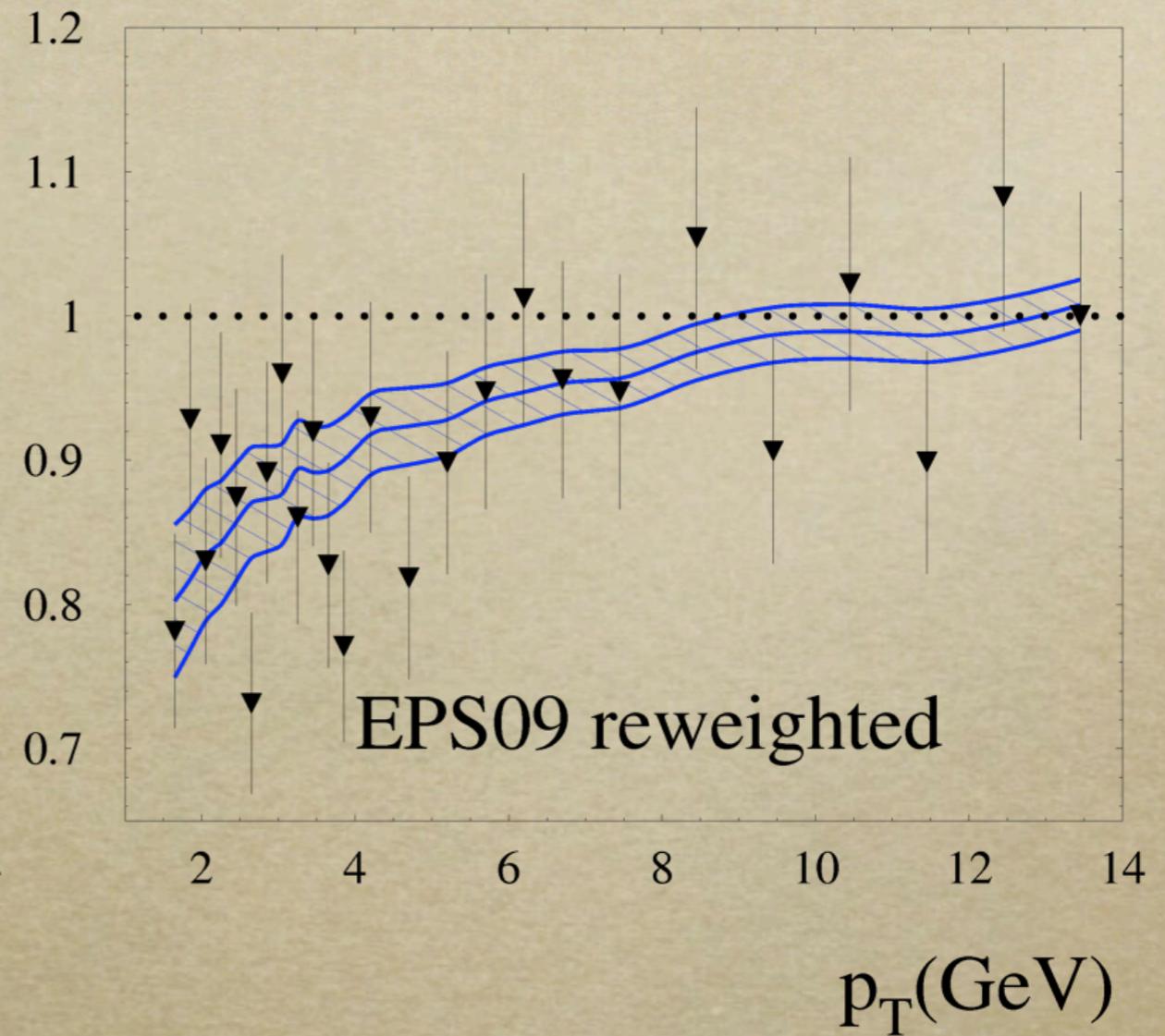
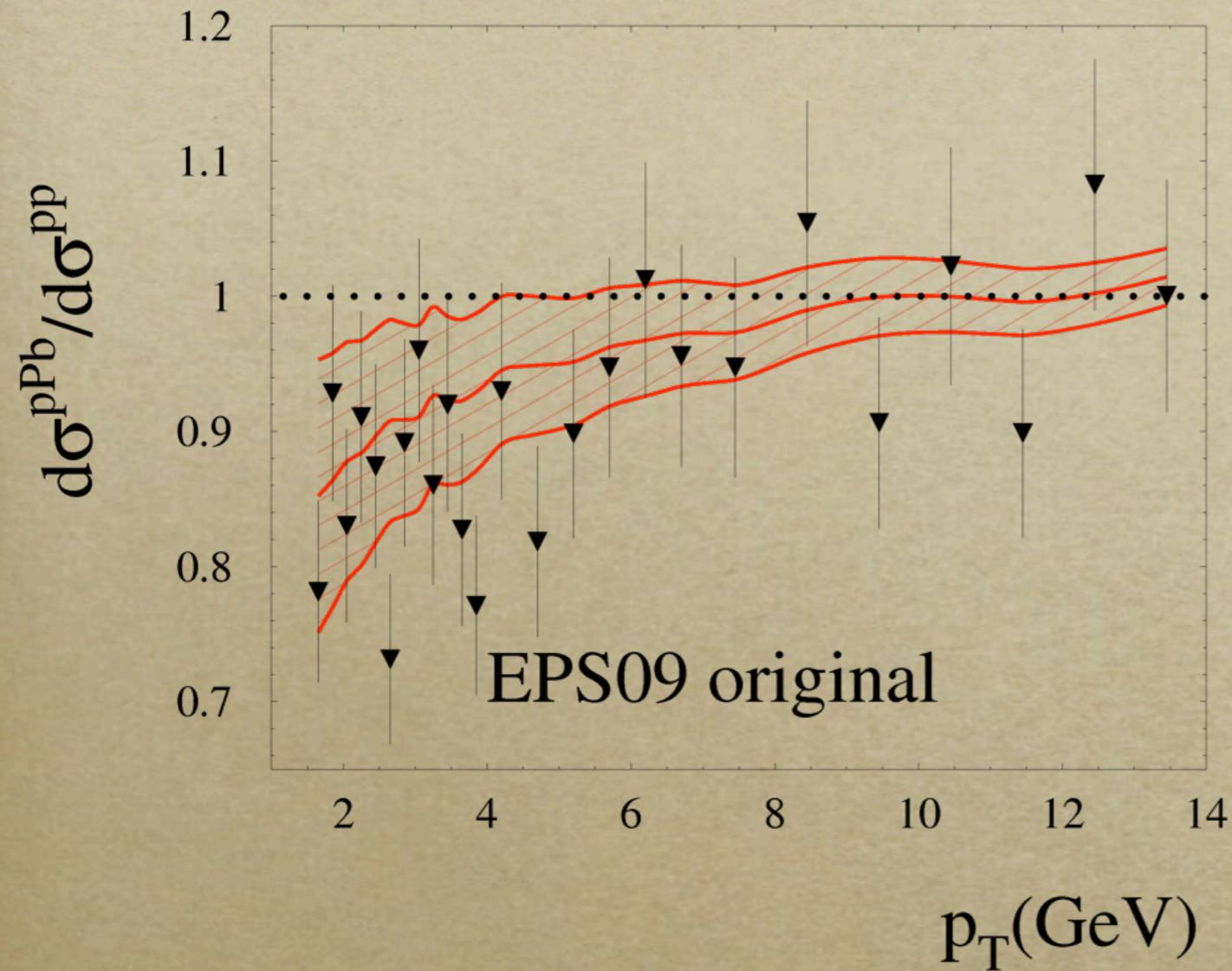
5% systematic & 7% normalization uncertainties

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

1000 MC replicas

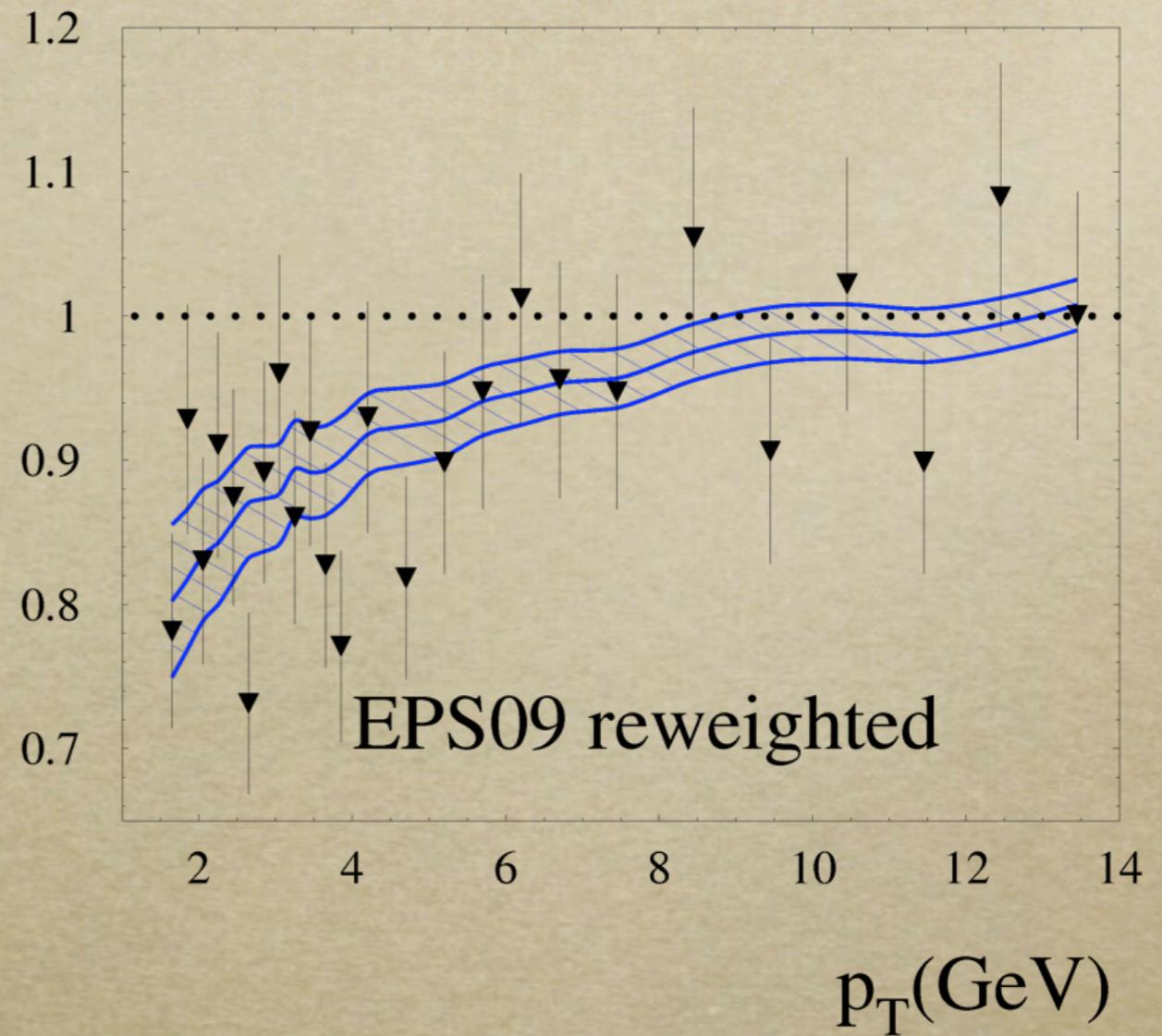
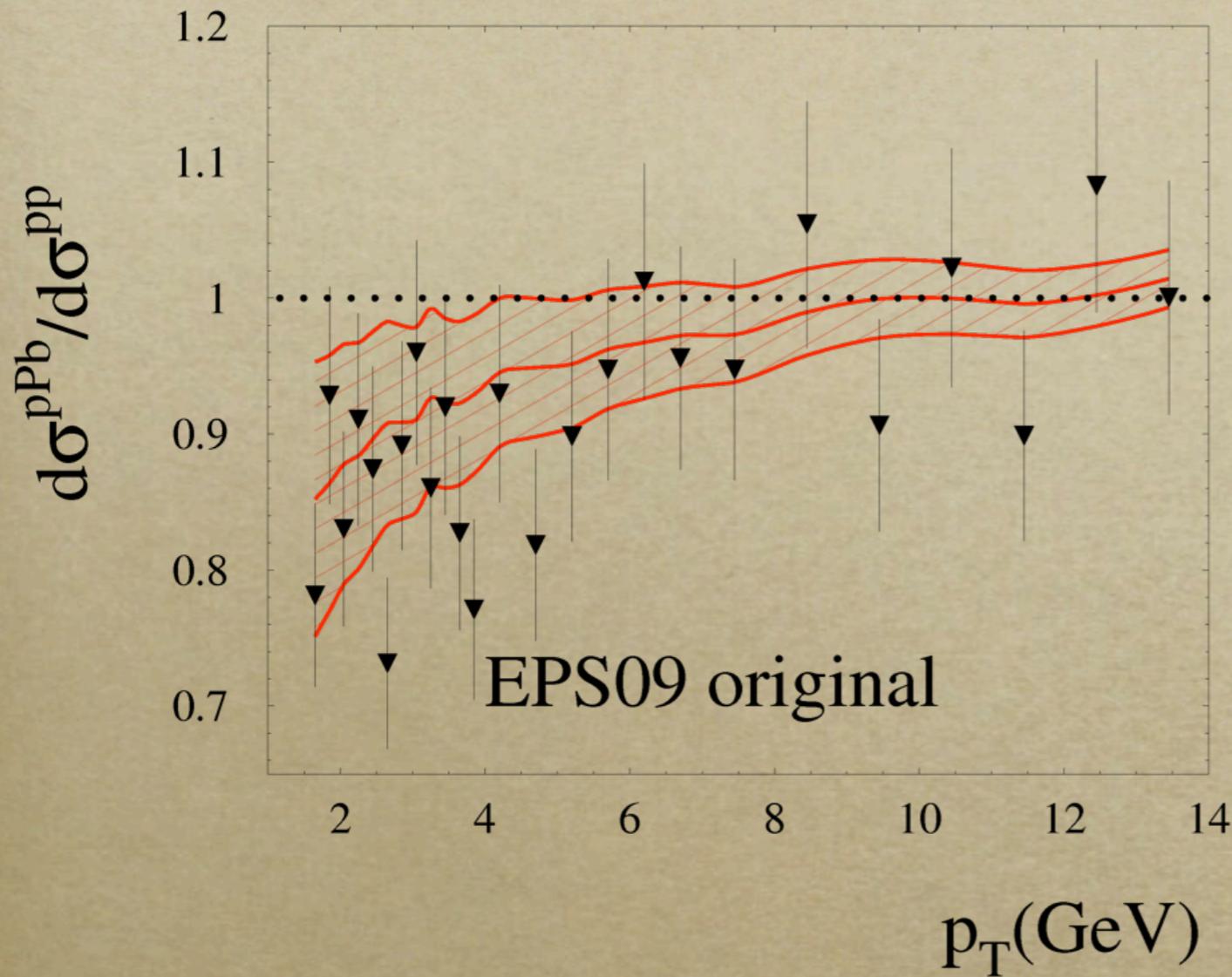
# $\eta = 0$

# DGLAP - pseudodata



# $\eta = 0$

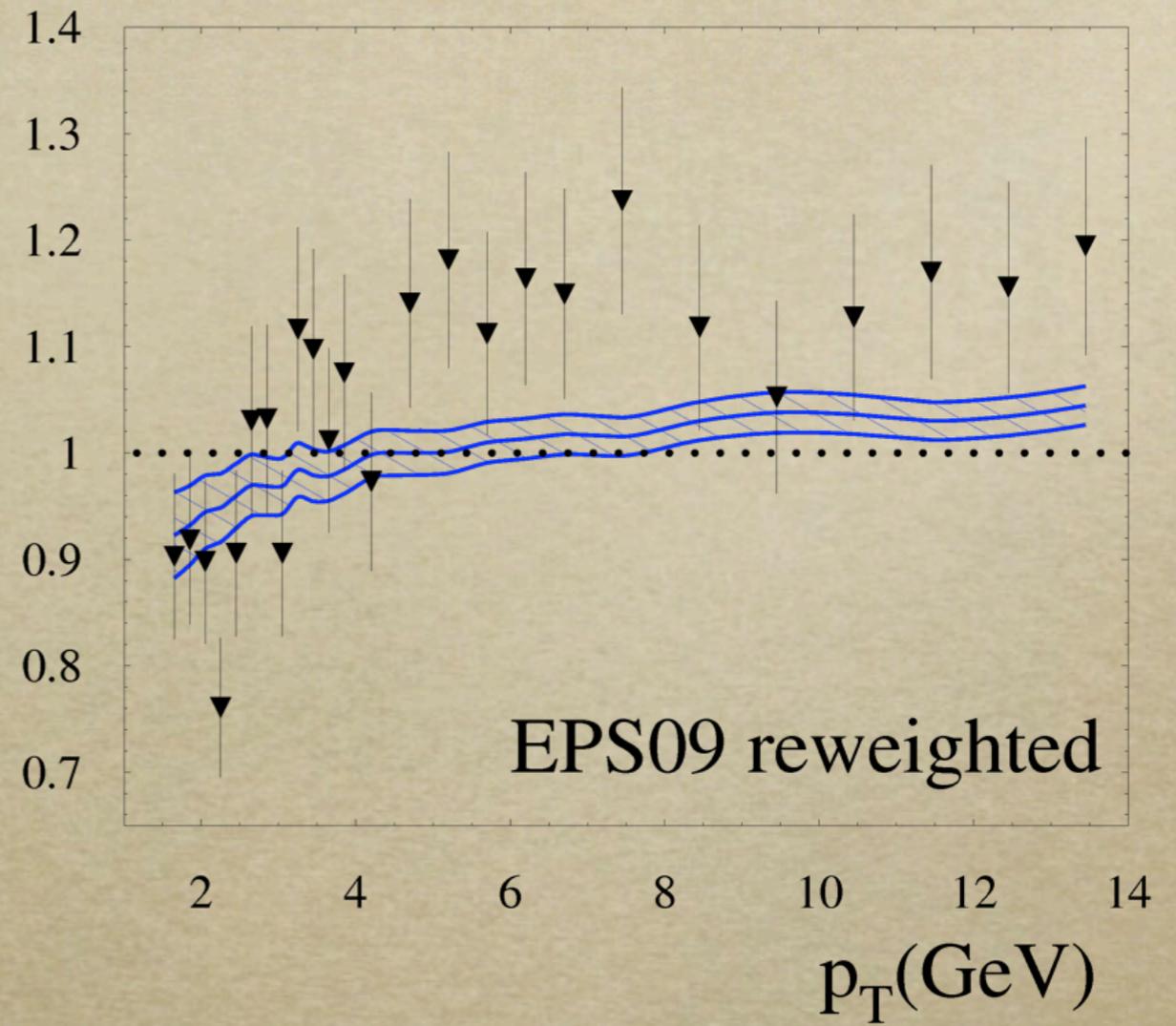
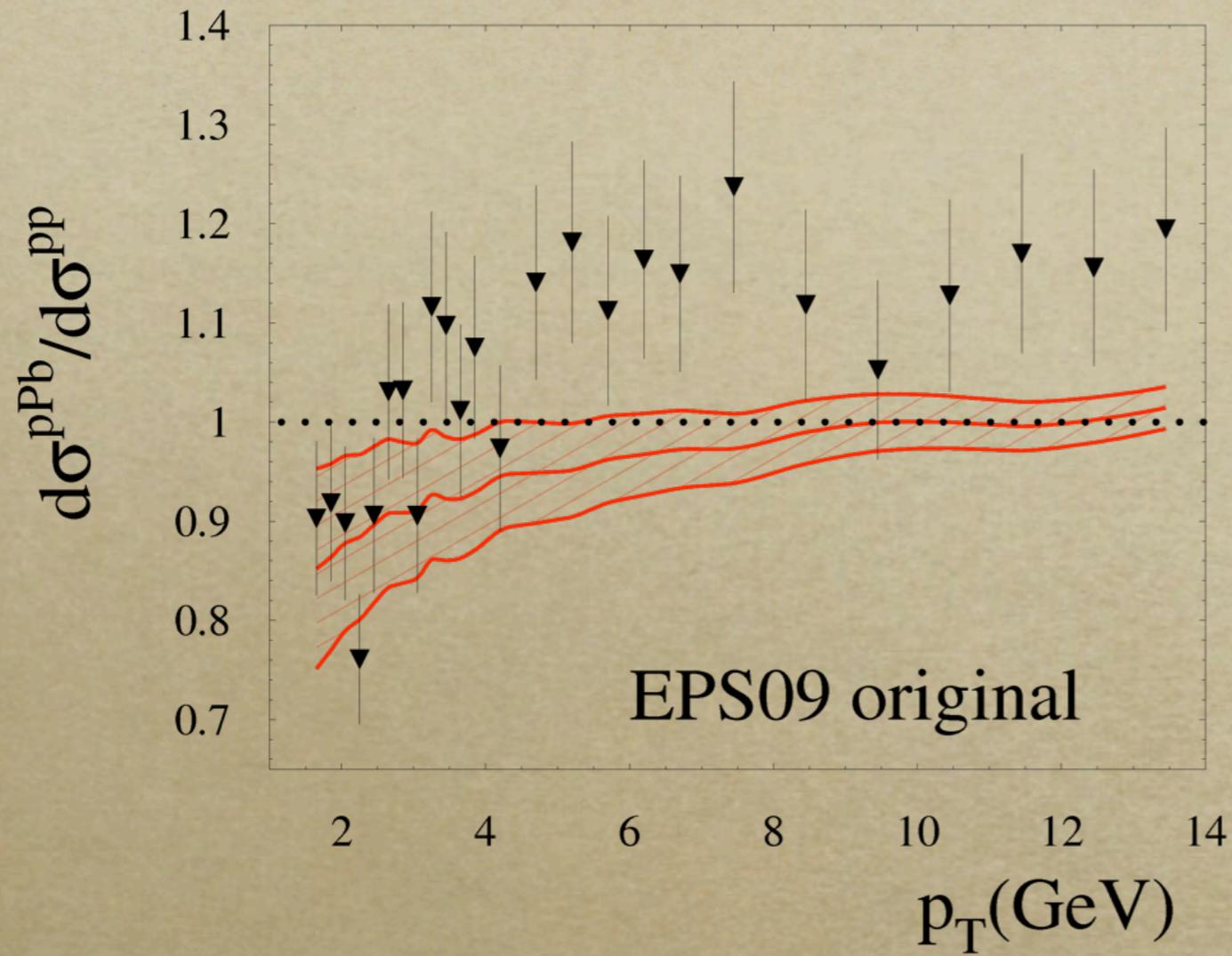
# DGLAP - pseudodata



n=25	$\chi^2 / n$	$\langle \chi^2 \rangle / n$	$N_{\text{eff}}$
Before	1.11	1.75	-
After	0.84	1.02	624

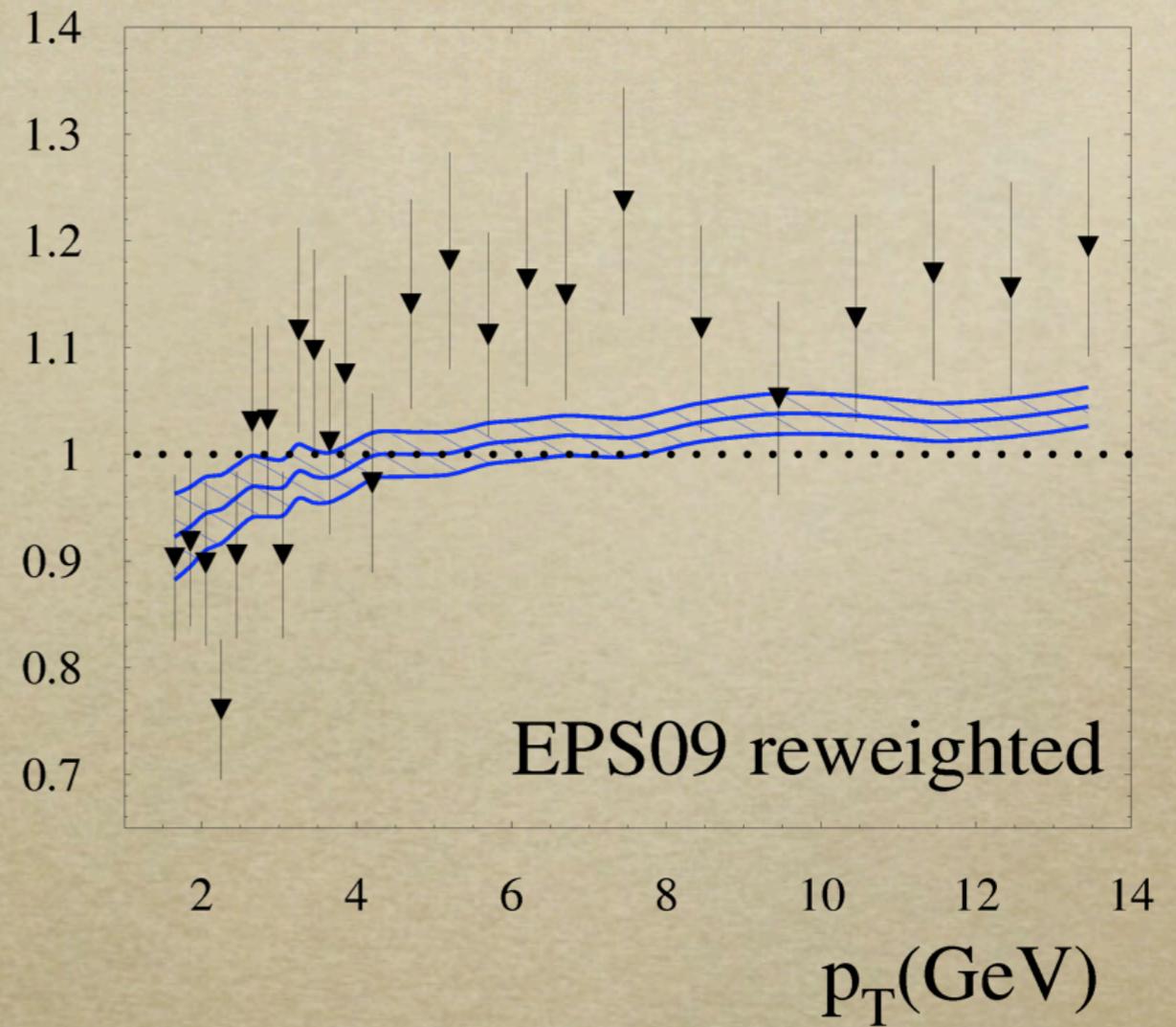
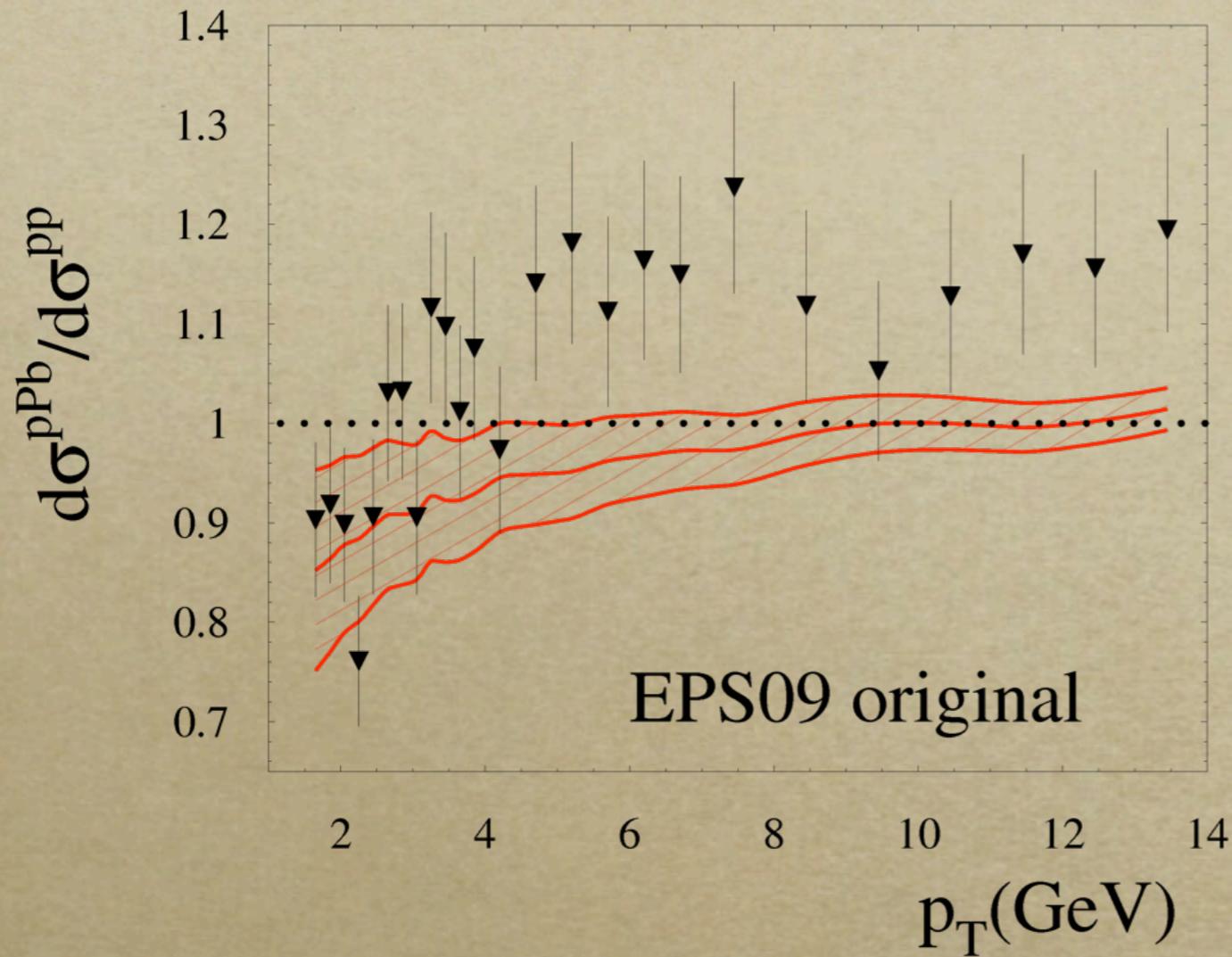
# $\eta = 0$

# CGC - pseudodata



# $\eta = 0$

# CGC - pseudodata



n=25	$\chi^2 / n$	$\langle \chi^2 \rangle / n$	$N_{\text{eff}}$
Before	2.25	2.76	-
After	1.50	1.58	229

**No** change in the valence,  
change in the sea



**DGLAP**

Change in the valence,  
**no** change in the sea



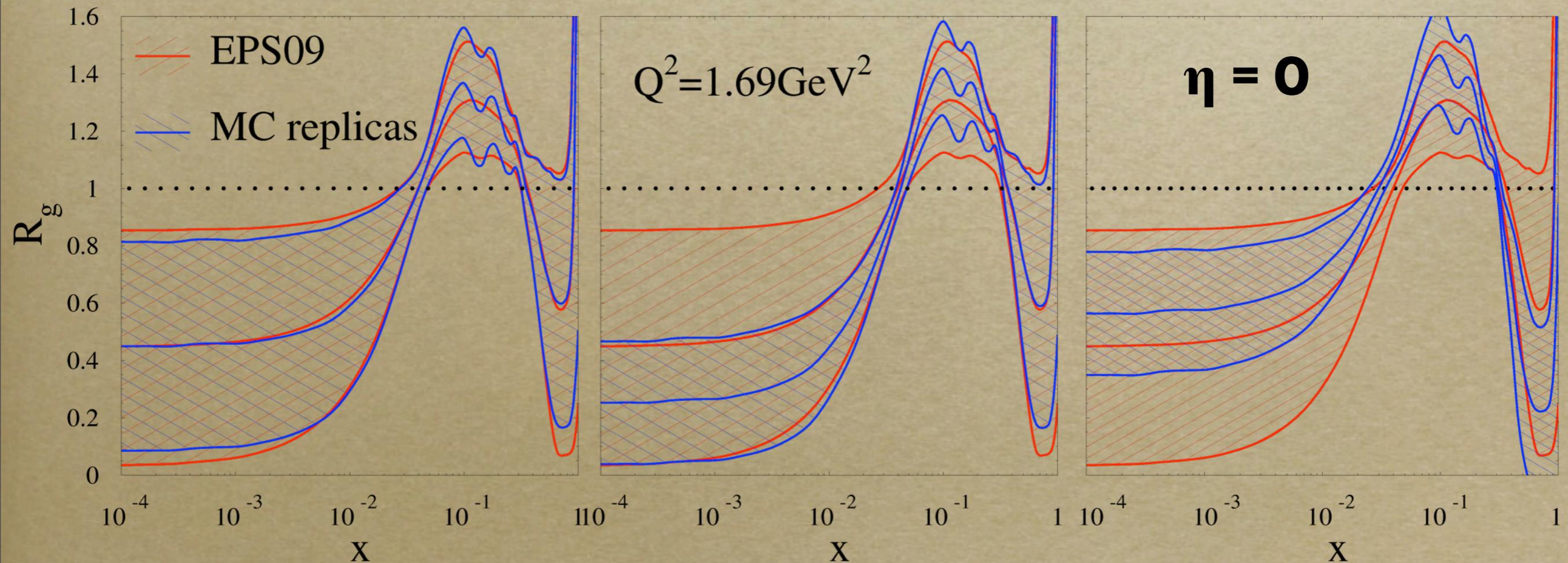
**CGC**

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Change in the valence,  
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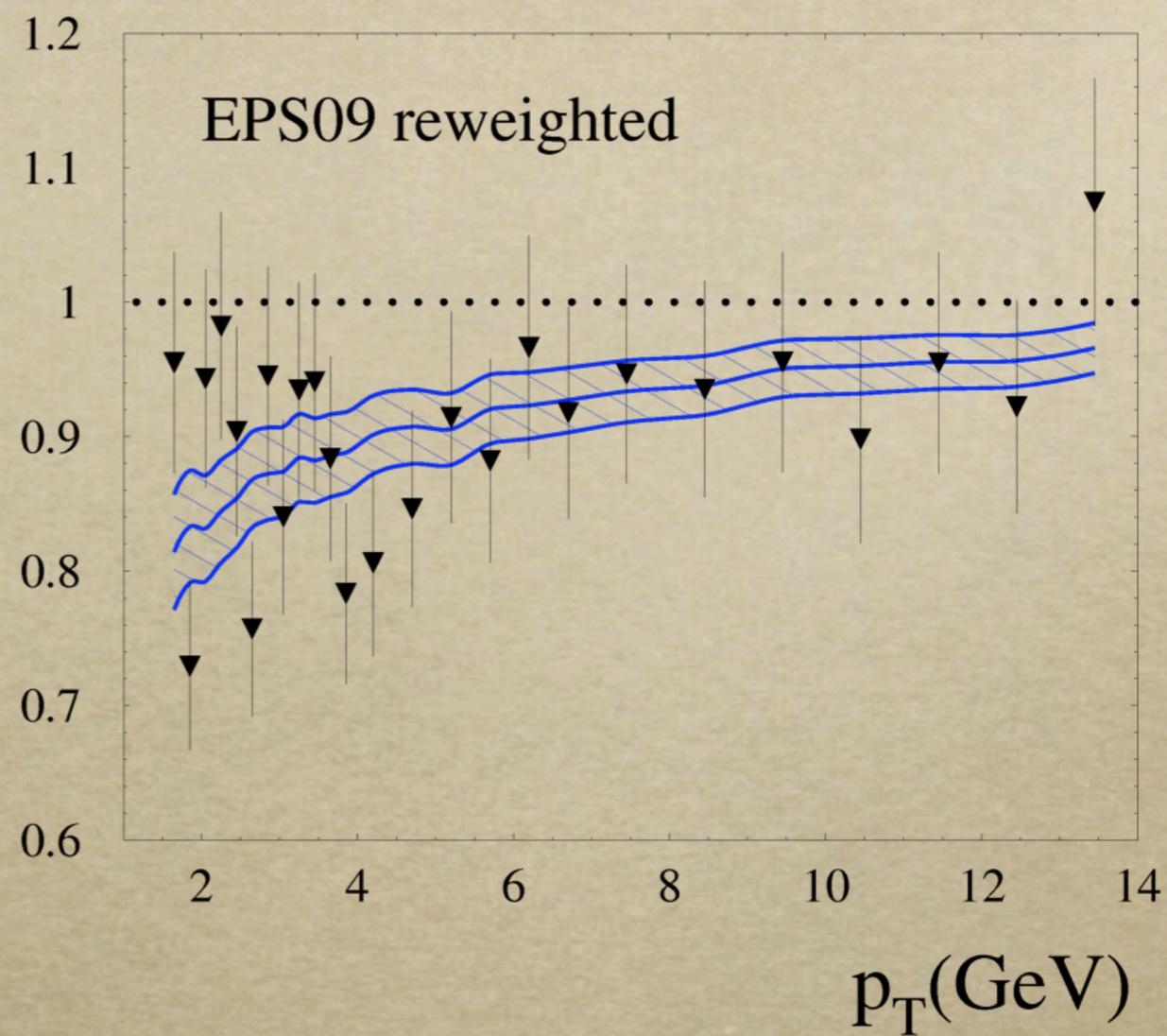
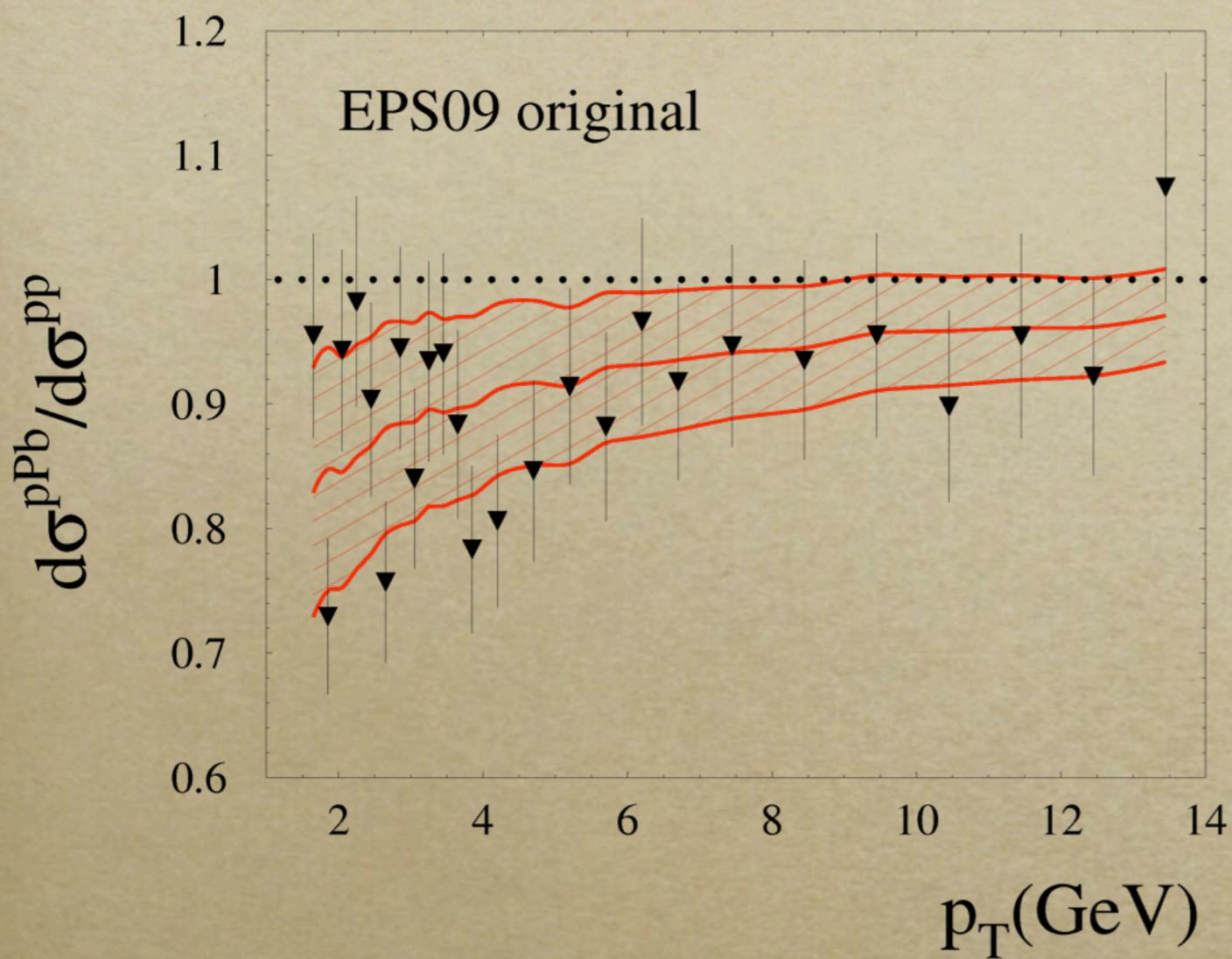
**DGLAP**

**CGC**



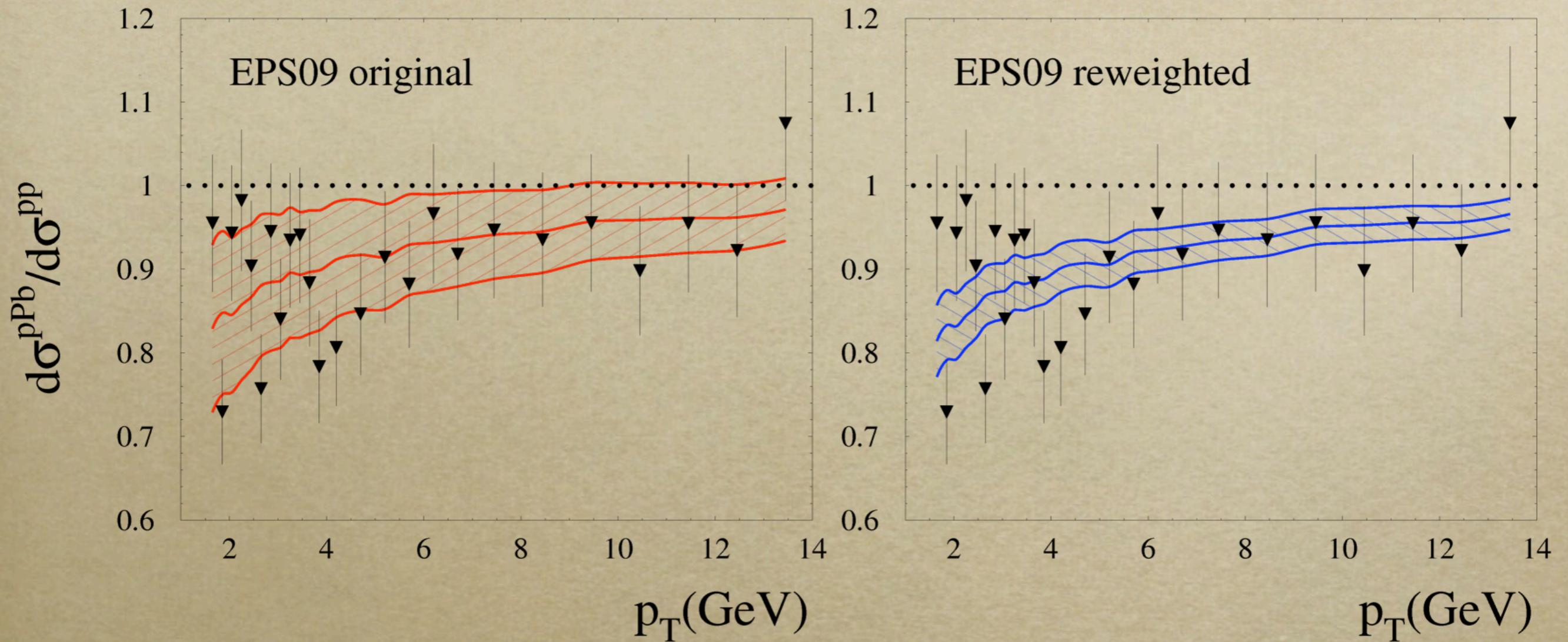
# $\eta = 2$

# DGLAP - pseudodata



# $\eta = 2$

# DGLAP - pseudodata



n=25	$\chi^2 / n$	$\langle \chi^2 \rangle / n$	$N_{\text{eff}}$
Before	0.95	1.82	-
After	0.92	1.08	612

$$\eta = 2$$

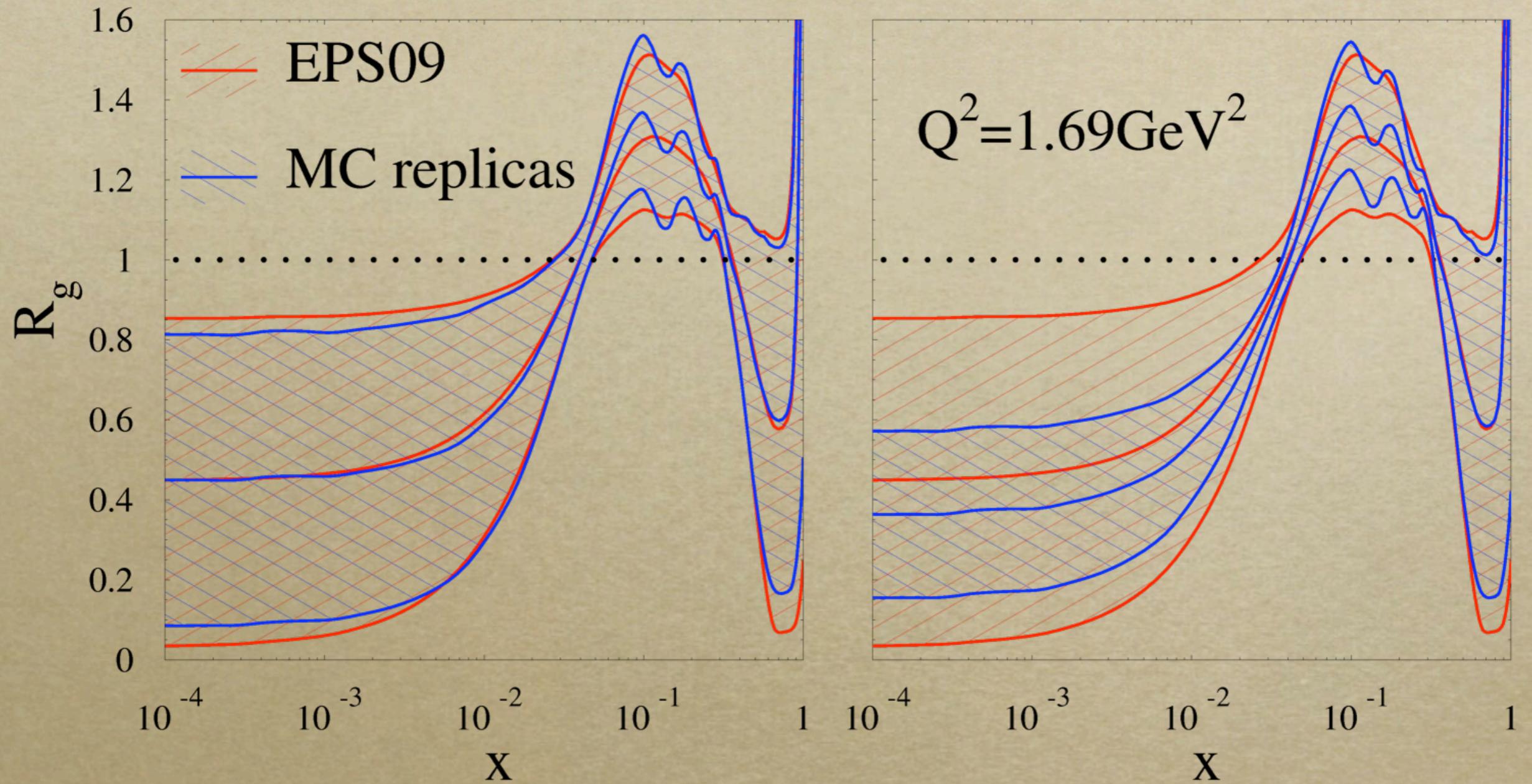


No change in the valence



Slight modification for the sea

# DGLAP



$\eta = 2$



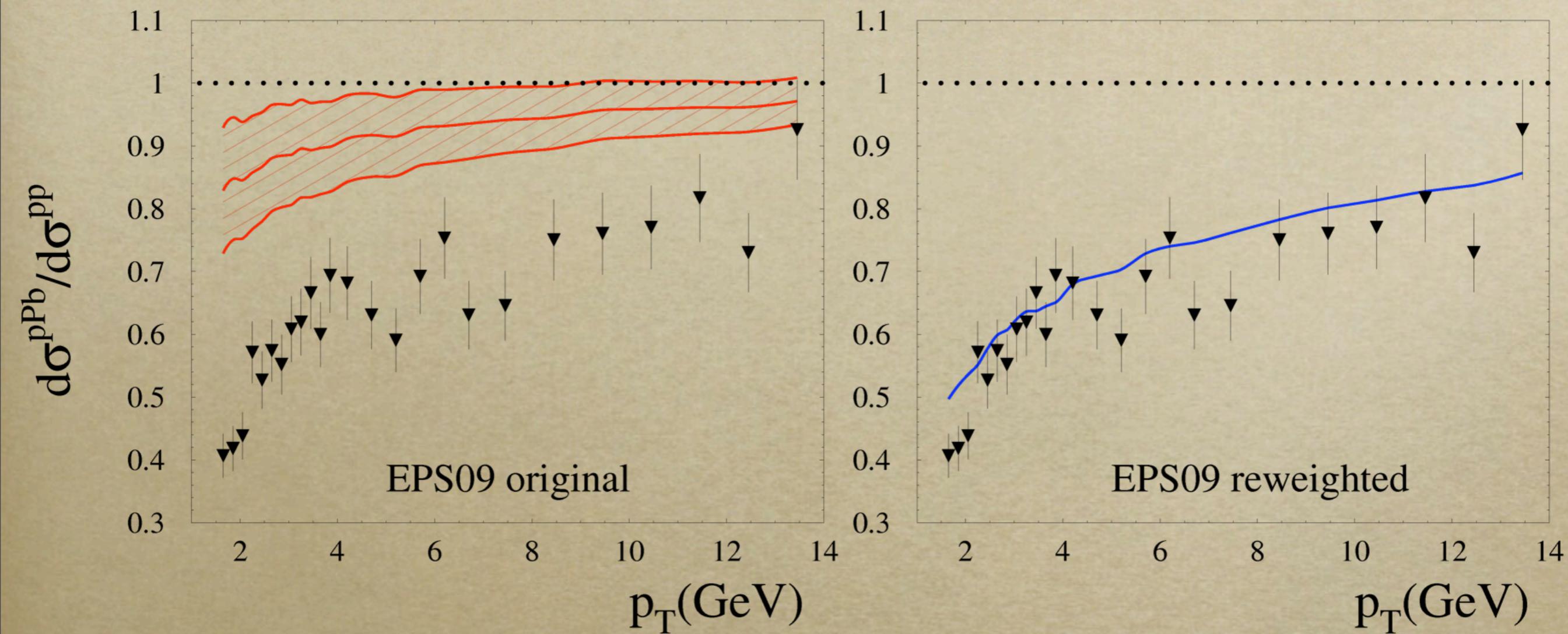
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Slight modification for the sea

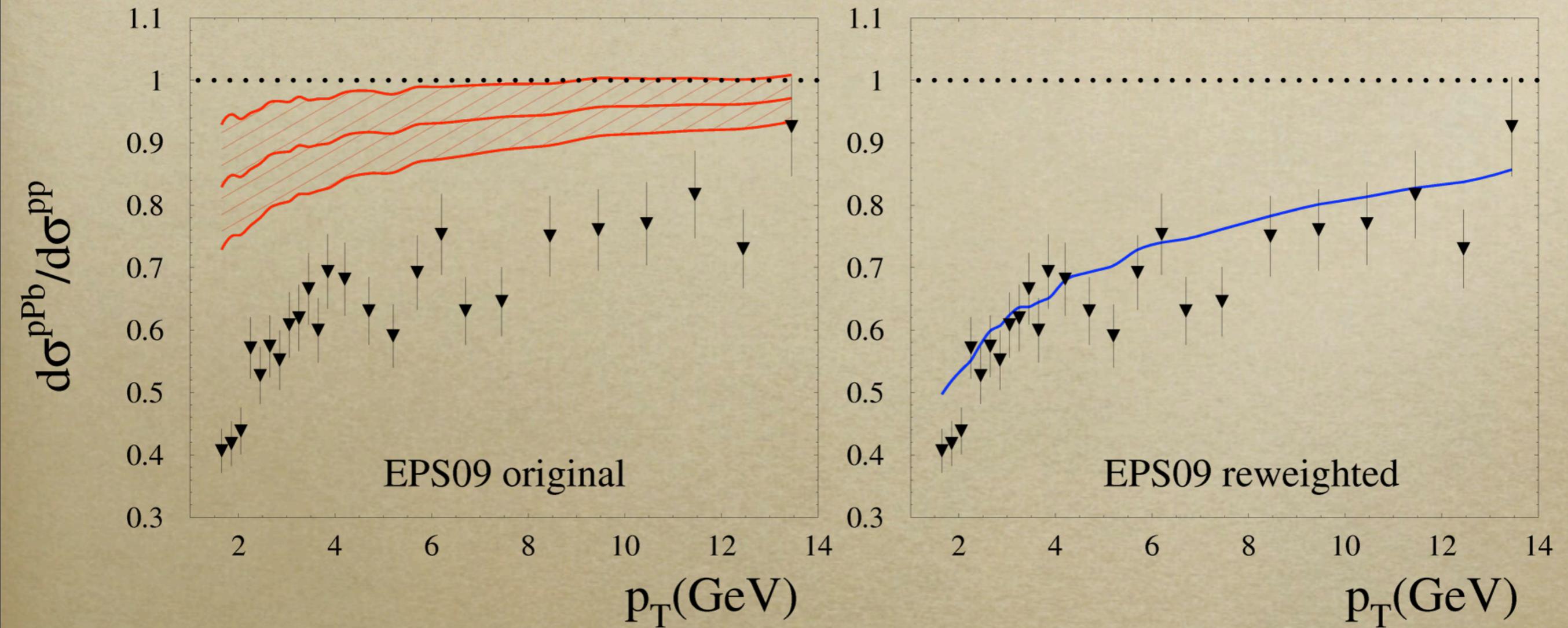
# $\eta = 2$

# CGC - pseudodata



# $\eta = 2$

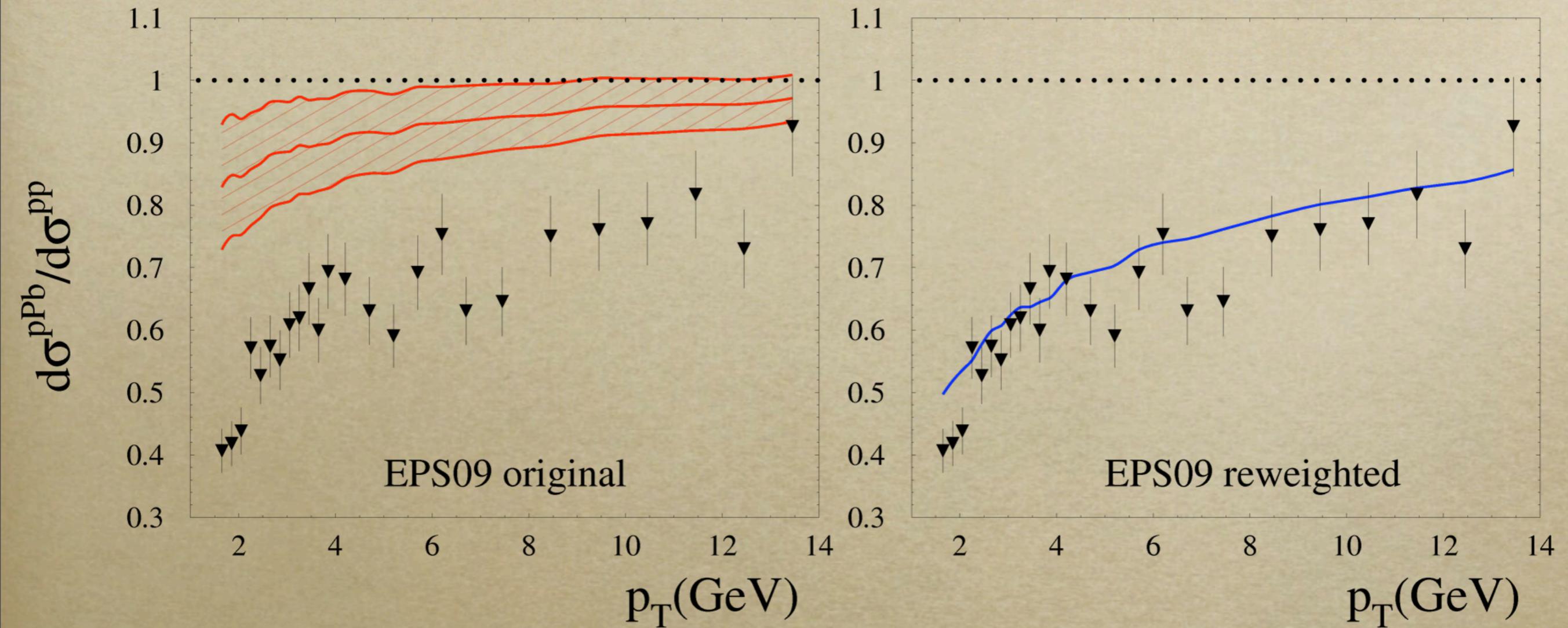
# CGC - pseudodata



n=25	$\chi^2 / n$	$\langle \chi^2 \rangle / n$	$N_{\text{eff}}$
Before	36.43	38.62	-
After	1.85	1.85	

# $\eta = 2$

# CGC - pseudodata



n=25	$\chi^2 / n$	$\langle \chi^2 \rangle / n$	$N_{\text{eff}}$
Before	36.43	38.62	-
After	1.85	1.85	<b>1</b>

# Summary

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DGLAP pseudodata:

50% reduction of the gluon uncertainty

CGC pseudodata:

$\eta = 0$  : 30% reduction of the gluon uncertainty

$\eta = 2$  : no conclusions

# Summary

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if data  $\sim$  predictions  $\Rightarrow$  time (money) saving!

Otherwise, refitting required

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EPS09 Monte Carlo replicas available at

**<http://igfae.usc.es/hotlhc/index.php/software>**