Analysis of proton-lead data via reweighting

(work in progress, in collaboration with
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Outline

- Motivation
- The reweighting 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 reweighting method

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

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

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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

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

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

After the reweighting

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

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

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To quantify the accuracy

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

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

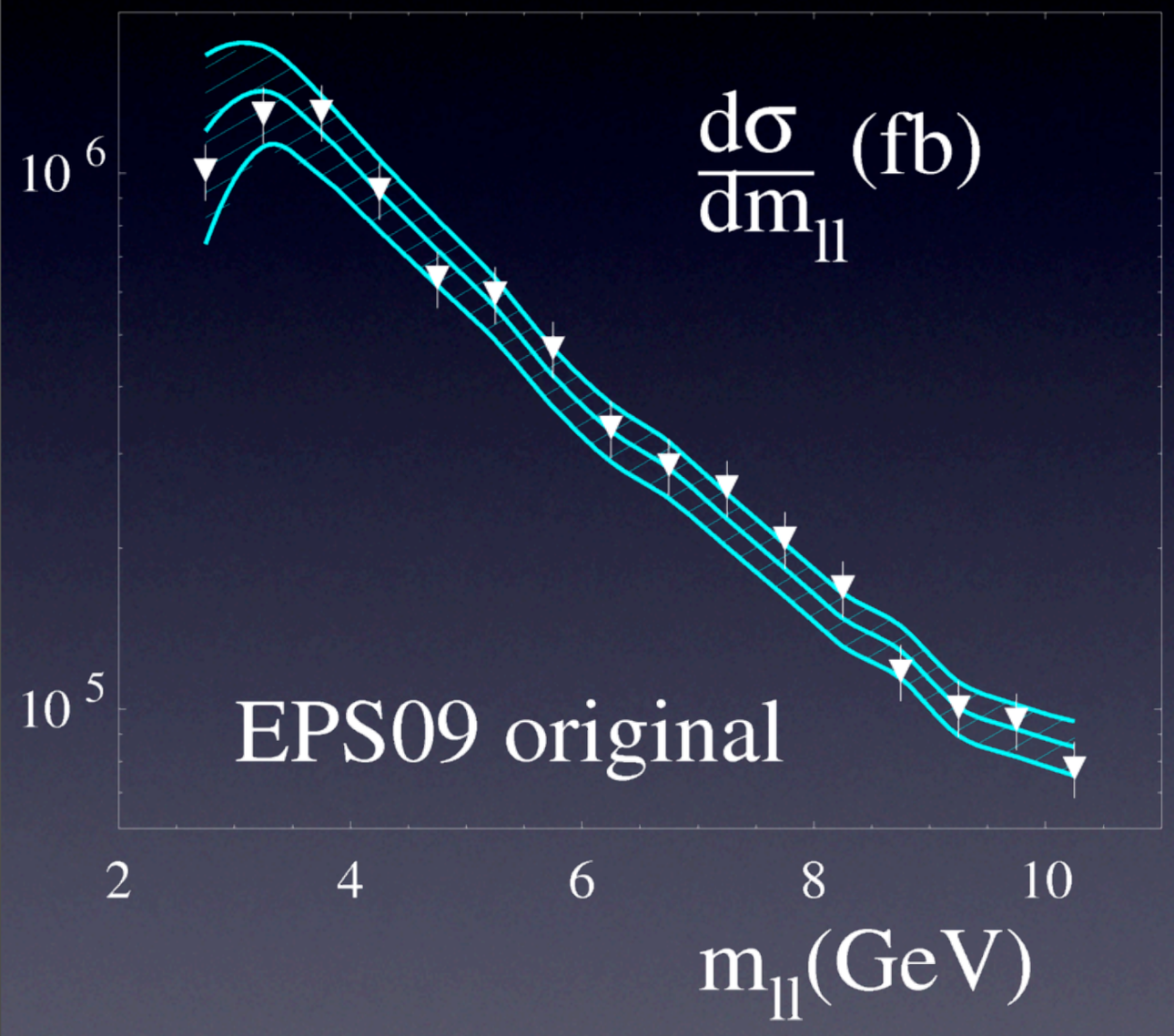
$|\eta| < 4$

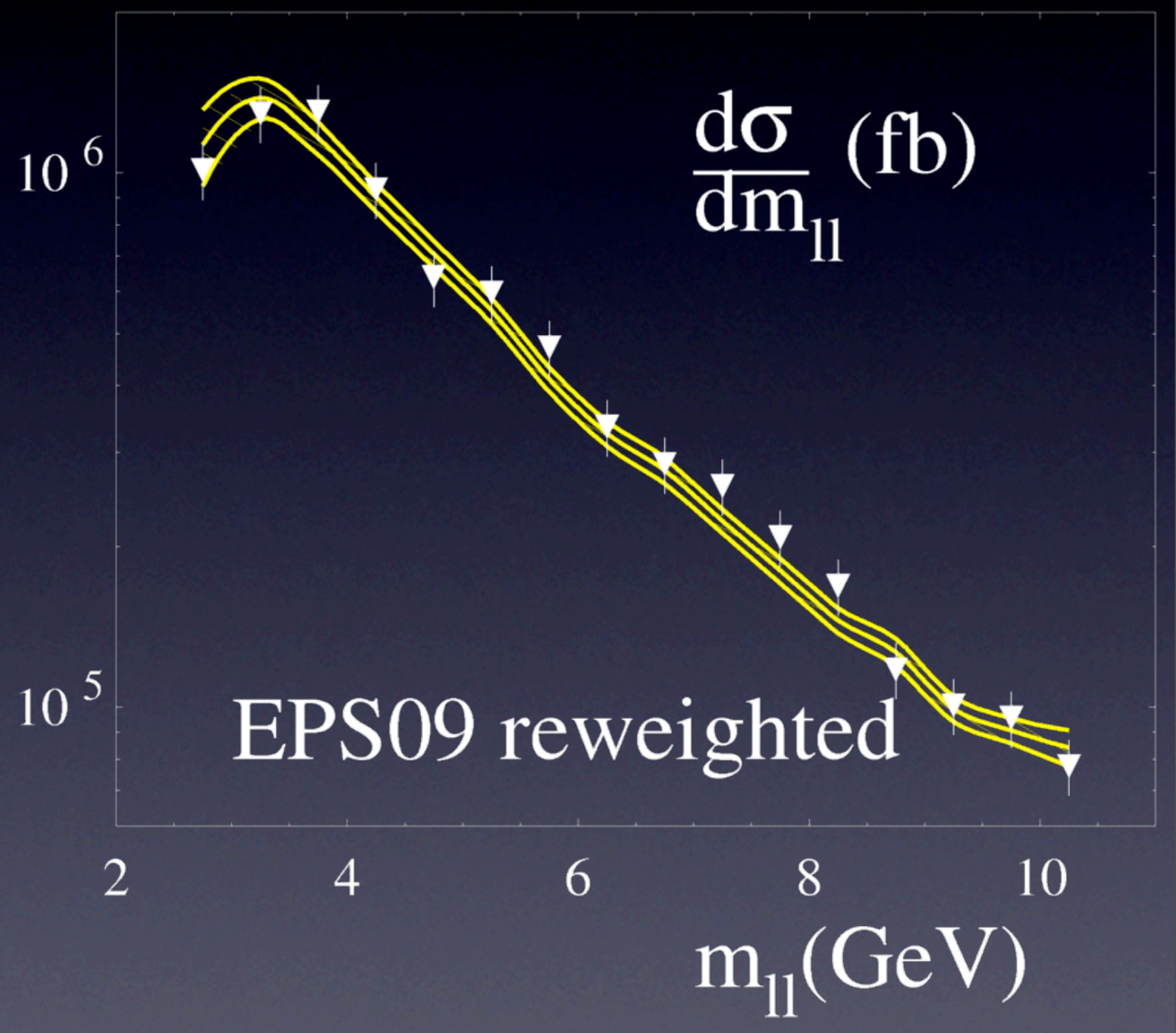
8 % systematic uncertainty

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

1000 MC replicas

pseudo data compatible with EPS09 predictions





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

pseudo data compatible with EPS09

better agreement after reweighting

EPS09 original

EPS09 reweighted

EPS09

MC replicas

$Q^2=1.69\text{GeV}^2$

R_s

R_g

X

X

Hadroproduction ($\eta = 2$)

Code from

B. Jager, A. Schafer, M. Stratmann and W. Vogelsang, Phys. Rev. D 67 (2003) 054005.

R. Sassot, P. Z and M. Stratmann, Phys. Rev. D 82 (2010) 074011.

MSTW2008 + EPS09 + DSS

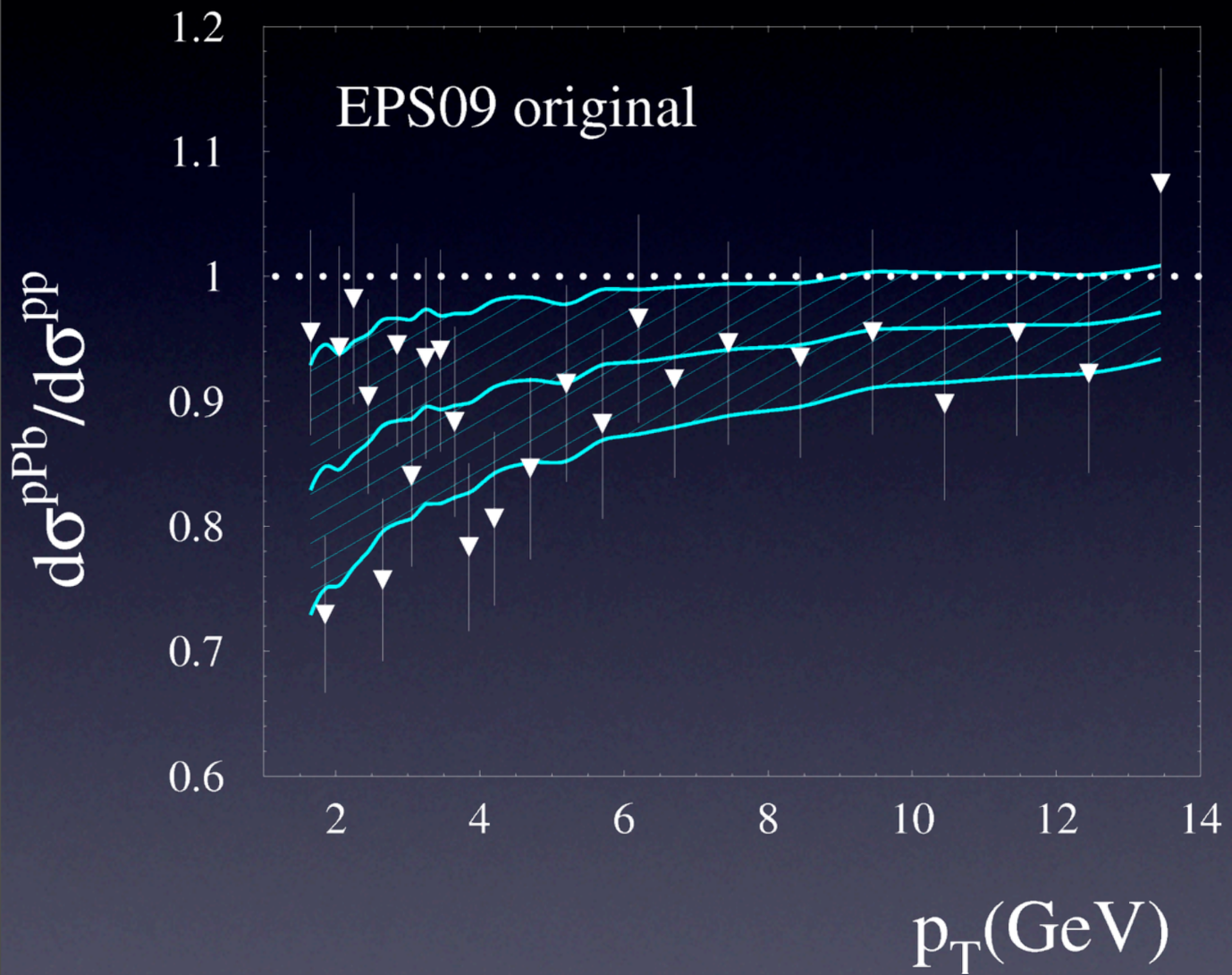
D. de Florian, R. Sassot and M. Stratmann, Phys. Rev. D 76 (2007) 074033

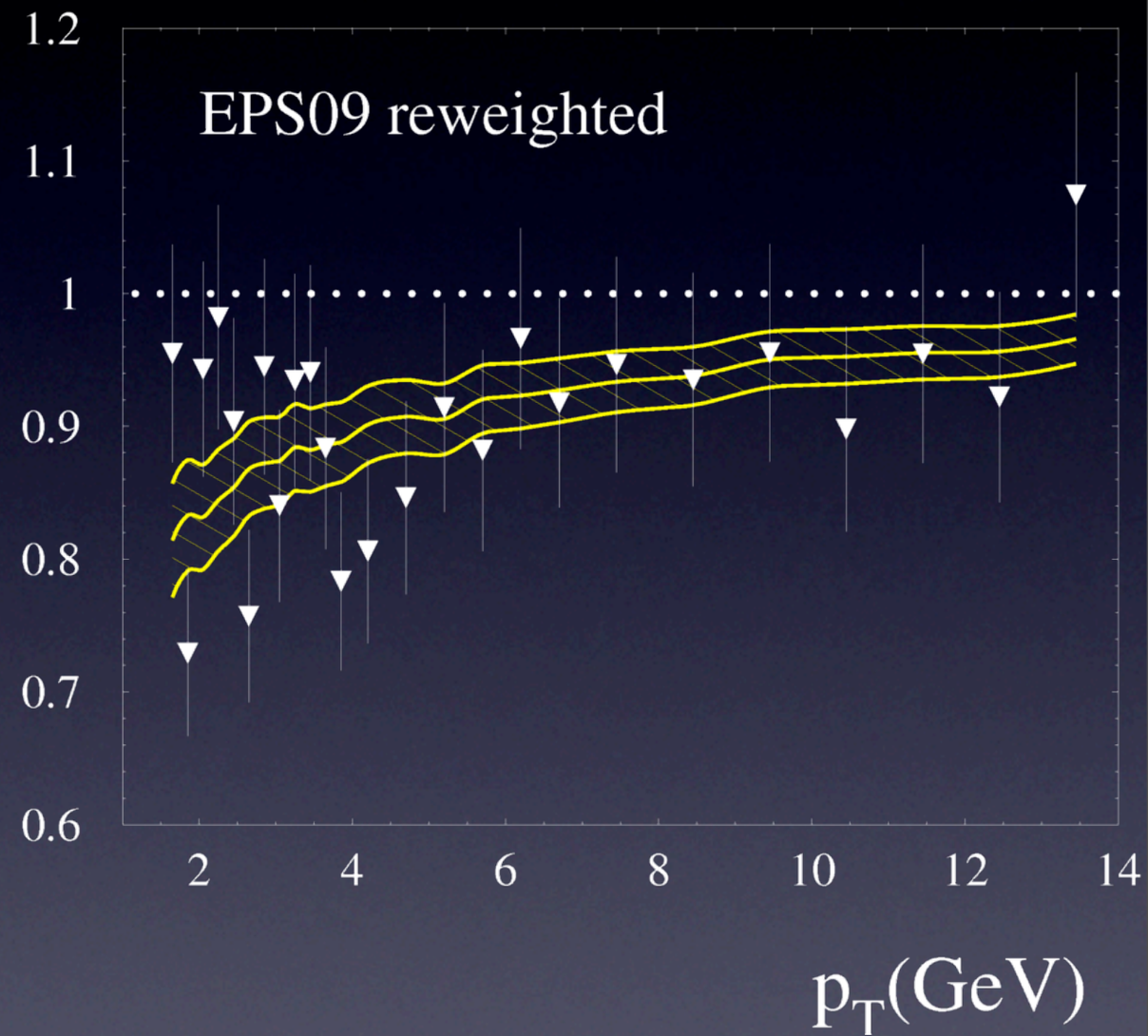
5 % systematic uncertainty

7 % normalization uncertainty

1000 MC replicas

EPS09


EPS09 original
1.2
1.1
1
0.9
0.8
0.7
0.6
$d\sigma^{pPb}/d\sigma^{pp}$
2
4
6
8
10
12
14
p_T(GeV)


EPS09 reweighted
1.2
1.1
1
0.9
0.8
0.7
0.6
2
4
6
8
10
12
14
p_T(GeV)

EPS09	χ^2 / n	$\langle\chi^2\rangle$ / n	N_{eff}
Before	0.95	1.82	-
After	0.92	1.08	612

EPS09 original

EPS09 reweighted

EPS09

MC replicas

R_S

R_g

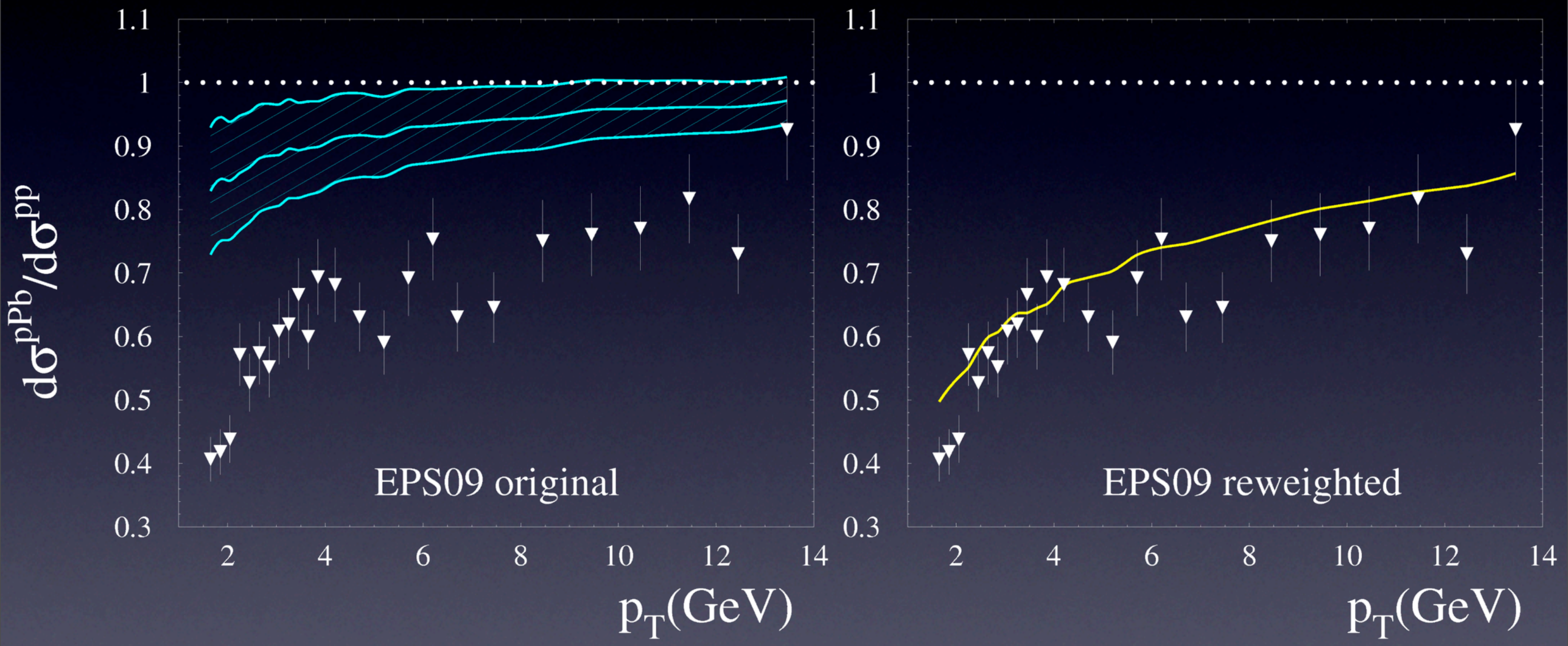
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.2
0

10^{-4} 10^{-3} 10^{-2} 10^{-1} 1

X

CGC

J. L. Albacete, A. Dumitru, H. Fujii and Y. Nara, Nucl. Phys. A 897 (2013) 1 [arXiv:1209.2001 [hep-ph]]



EPS09	χ^2 / n	$\langle\chi^2\rangle$ / n	N_{eff}
Before	0.95	1.82	-
After	0.92	1.08	612

CGC	χ^2 / n	$\langle\chi^2\rangle$ / n	N_{eff}
Before	36.43	38.62	-
After	1.85	1.85	1

Summary

EPS09 pseudodata:

estimated 50% reduction of the gluon uncertainty

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

Otherwise, refitting required