Charm masses vs schemes (from the talk)

- When using RT VFN standard scheme, data prefer fit with m_c=1.65 GeV
  - For mc=1.65 GeV: Total: χ^2/ndf=627.5/633
  - For mc=1.40 GeV: Total: χ^2/ndf=730.7/633

- When using RT optimal scheme, data prefer fit with m_c=1.4 GeV
  - For mc=1.65 GeV: Total: χ^2/ndf=695.4/633
  - For mc=1.40 GeV: Total: χ^2/ndf=644.6/633

- When using ACOT full scheme, data prefer fit with m_c=1.65 GeV
  - **For mc=1.65 GeV: Total: χ^2/ndf=605.7/633**
  - For mc=1.40 GeV: Total: χ^2/ndf=653.9/633

- When using FFNS scheme, data prefer fit with m_c=1.4 GeV
  - For mc=1.65 GeV: Total: χ^2/npts=852.0/565
  - For mc=1.40 GeV: Total: χ^2/npts=567.0/565

NNLO	α_S=0.1145, m_c=1.4	α_S=0.1145, m_c=1.65	α_S=0.1176, m_c=1.4	α_S=0.1176, m_c=1.65
χ^2/ndf	681/633	832/633	703/633	862/633

An unconstrained sea PDF set (HERAPDF1.0u)

Voica Radescu (Heidelberg), Sasha Glazov (DESY), Max Klein (Liverpool), Jan Kretzschmar (Liverpool), Amanda Cooper Sarkar (Oxford)

On behalf of the H1 and ZEUS collaborations

OUTLINE

- Motivation
- Settings and Method
- Results
- Summary

Introduction

- In QCD fits, main constraint on PDFs at low x comes from HERA measurements of proton F_2, dominated by gamma exchange.

$$F_2 = \frac{4}{9}(xU(x) + x\bar{U}(x)) + \frac{1}{9}(xD(x) + x\bar{D}(x))$$

U(x)=u(x)+c(x); D(x)=d(x)+s(x)

- The measurements at low x are not sensitive to individual quark flavours.

  - Standard flavour decomposition:
    - Charm and Beauty are generated dynamically ($Q^2 > m_c^2, m_b^2$)
    - In the limit $x \to 0$ and $Q^2 >> m_s^2$ we have $s \sim \bar{u} = \bar{d}$, therefore:
      → Assume at the starting scale Q_0^2 symmetry $\bar{u} = \bar{d}$ for low x
      → Use information from dimuon NuTeV data assume $s = fs\bar{D}$

Introduction (II)

- At the W, Z scale:
  - Sea quarks are mostly generated from the gluon density preserving the flavour symmetry $\bar{d}=\bar{u}=s$ and hence the differences seen at the starting scale are reduced.
  - Since the W and Z couplings differ from the gamma coupling, residual effects of various quark flavours may still be present.

$$W^+ \approx u(x)\bar{d}(x) + c(x)\bar{s}(x)$$

$$W^- \approx \bar{u}(x)d(x) + \bar{c}(x)s(x)$$

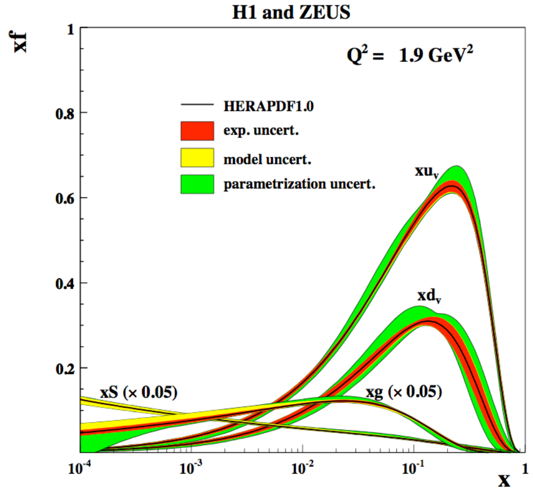
$$Z \approx 0.29(\bar{u}(x)u(x) + \bar{c}(x)c(x)) + 0.37(\bar{d}(x)d(x) + \bar{s}(x)s(x) + \bar{b}(x)b(x))$$

- What effects could be observed for W, Z cross section measurements if we relax PDF assumptions and also vary strange quark?
  - We modify PDFs at the starting scale in the QCD analyses and study effects after evolution to the W, Z masses scales.

QCD Settings

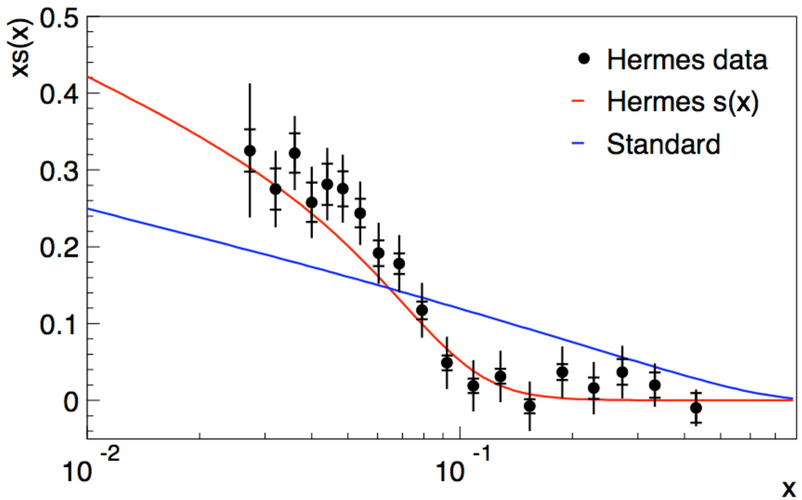
- Test PDFs are obtained from NLO QCD fit using HERAPDF1.0 settings and machinery. [Published in JHEP 1001:109,2010]
  - Fitted PDFs are:

$$u_{val}, d_{val}, g, \overline{U} = \bar{u} + \bar{c}, \overline{D} = \bar{d} + \bar{s}$$



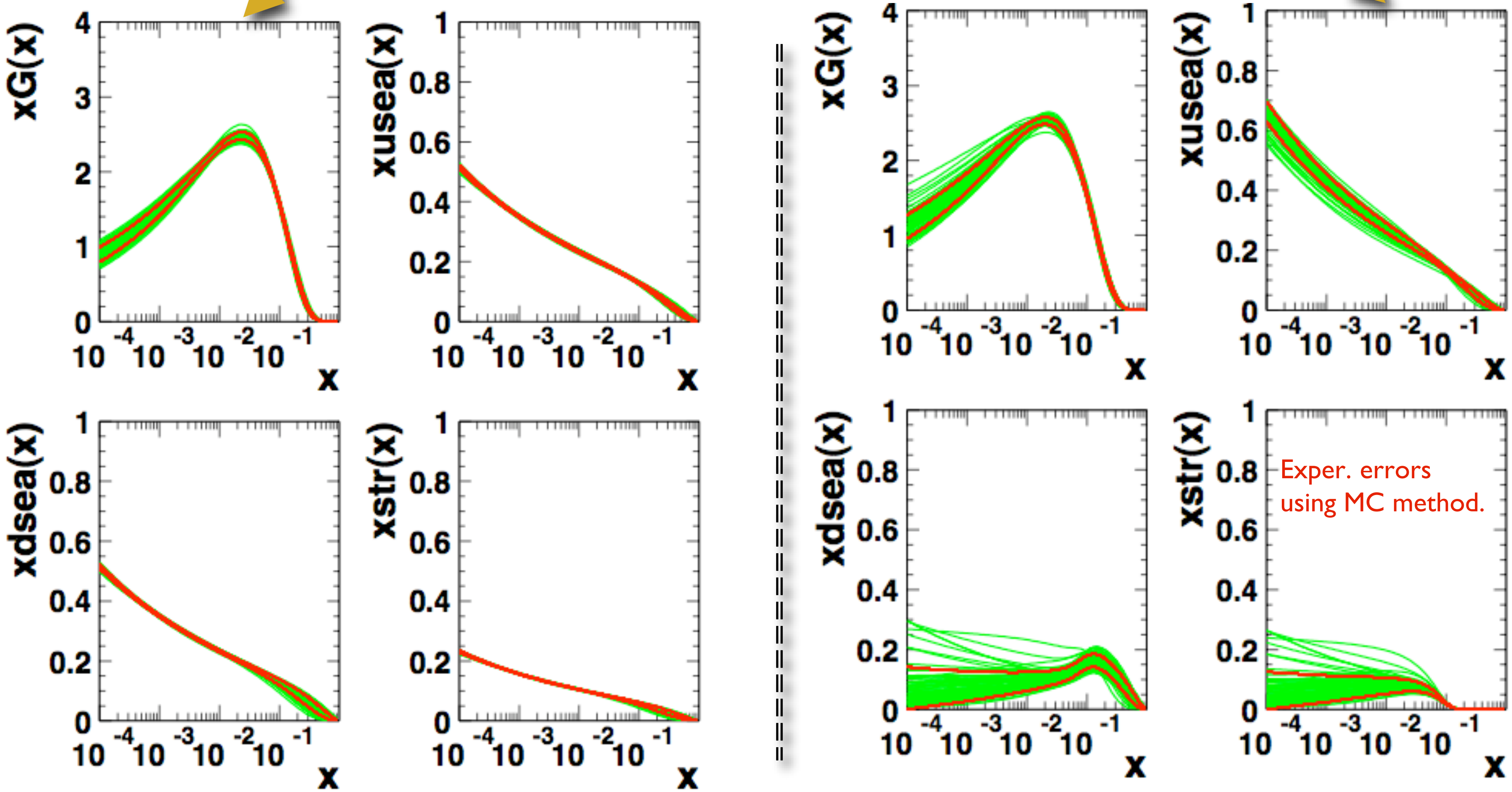
- Sea $S(x)=\overline{U}(x)+\overline{D}(x)$
- Strange $s(x)=fs\overline{D}(x)=\bar{d}(x)fs/(1-fs)$ with constant fs=0.31 at $Q_0^2=1.9$ GeV^2

- Modified Assumptions
  - Standard PDFs do not describe recent HERMES measurement [arXiv:0803.2993]
    - Strange $s(x)=fs(x)\overline{D}(x)$ using tanh function to describe HERMES data
  - Remove the $\bar{u}=\bar{d}$ constraint at low x



Standard vs Unconstrained sea PDFs

Comparison at the starting scale $Q_0^2=1.9$ GeV^2



- PDF uncertainties are estimated using Monte Carlo method [arXiV:0901.2504, p 41-42]
  - RMS of ~100 MC replicas of the data represents the PDF uncertainty
- Uncertainties increase considerable for the unconstrained low x sea PDF case!

Standard vs Unconstrained sea PDFs

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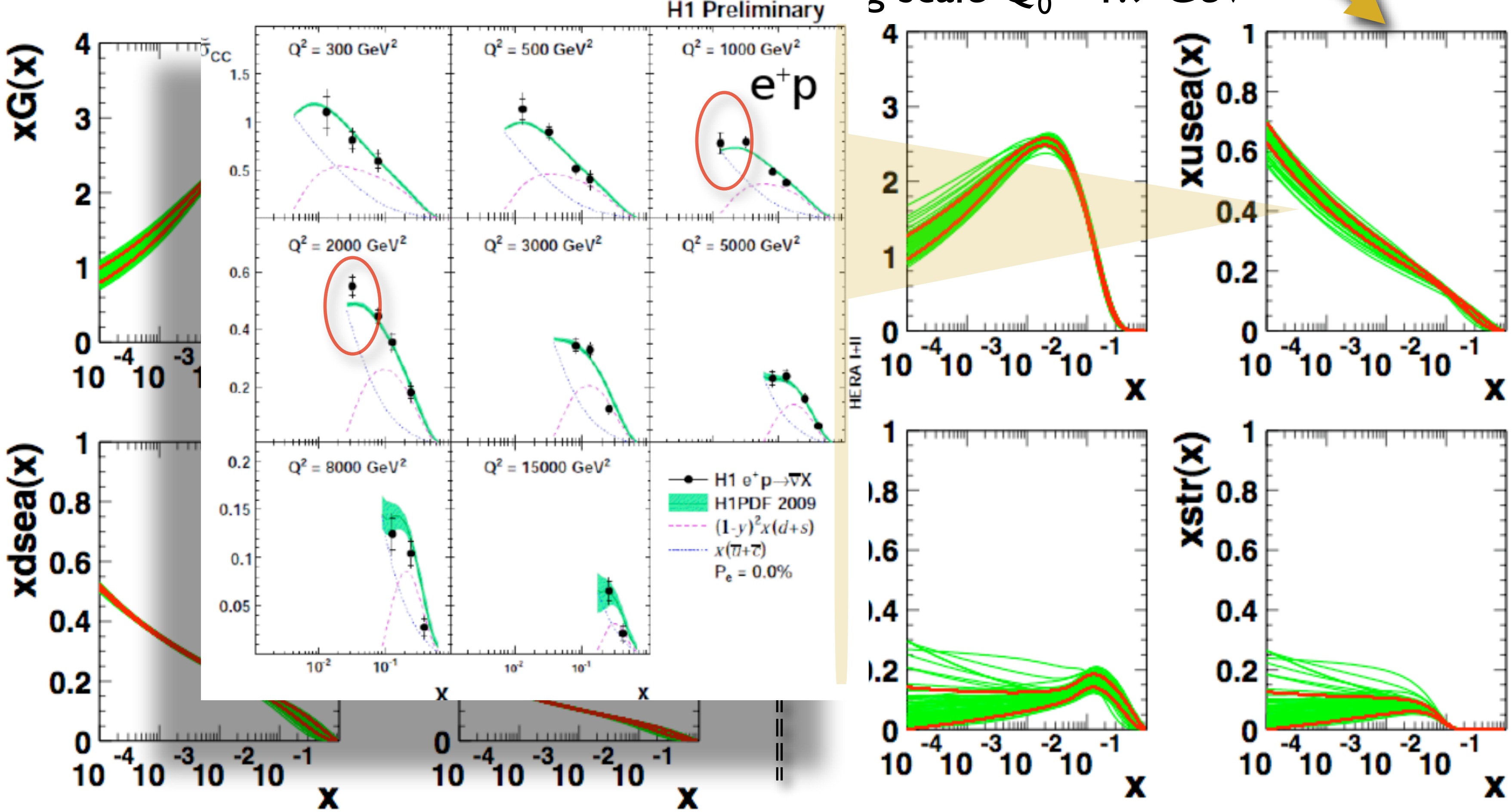

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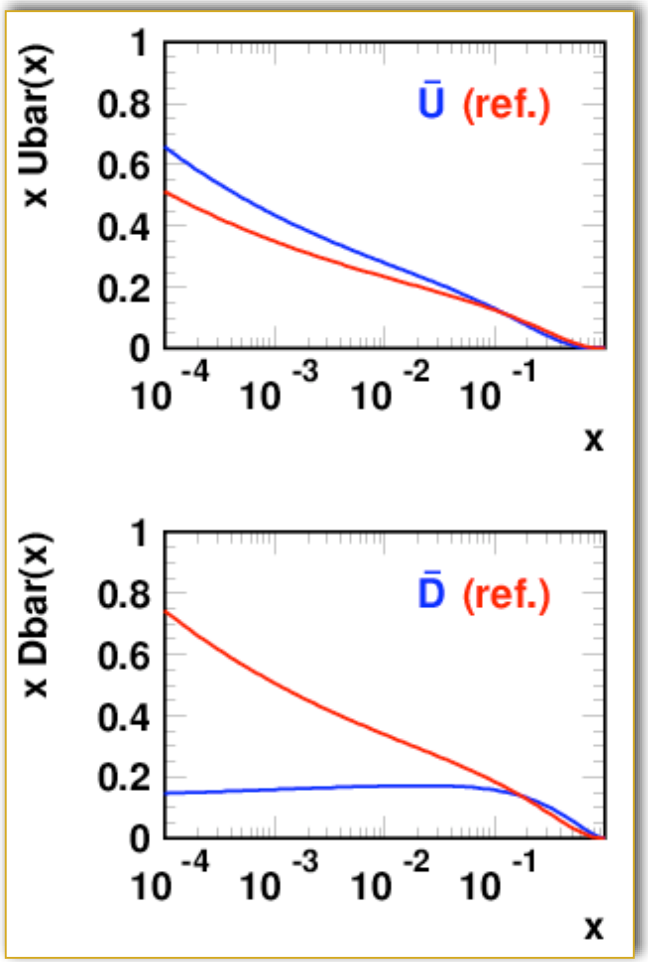
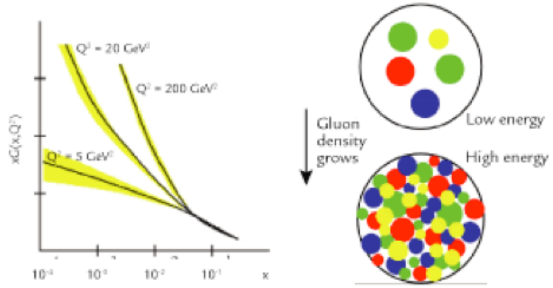
Effect of QCD evolution

- Effects are reduced when PDFs are evolved to W,Z scales, however still sizeable!

Starting Scale (Q_0^2=1.9 Gev^2)

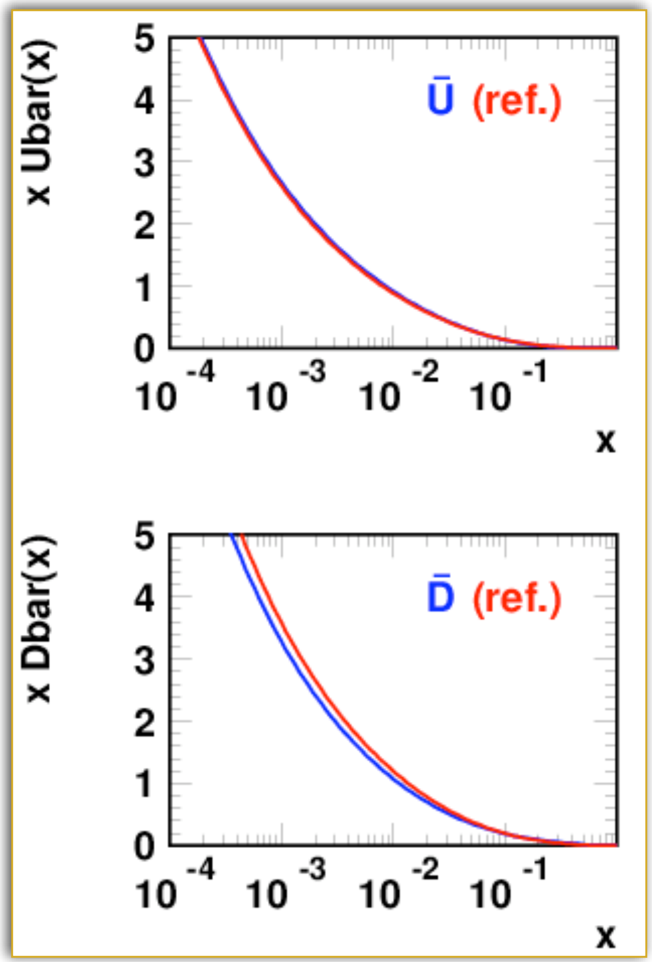




Q^2 evolution

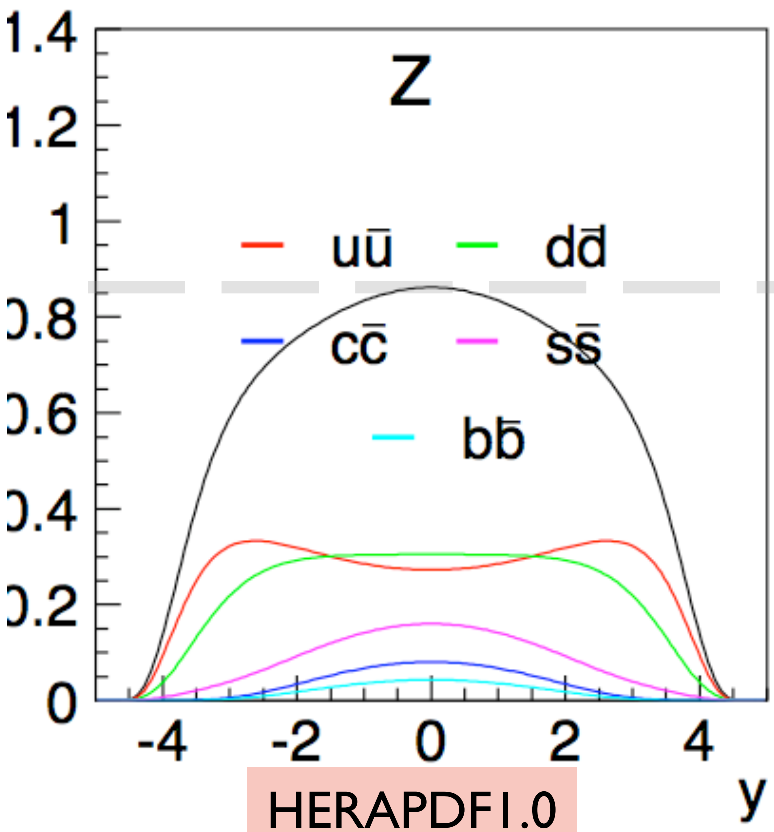
— HERAPDF1.0
— Unconstr. PDF

W mass scale (Q^2=6464 Gev^2)

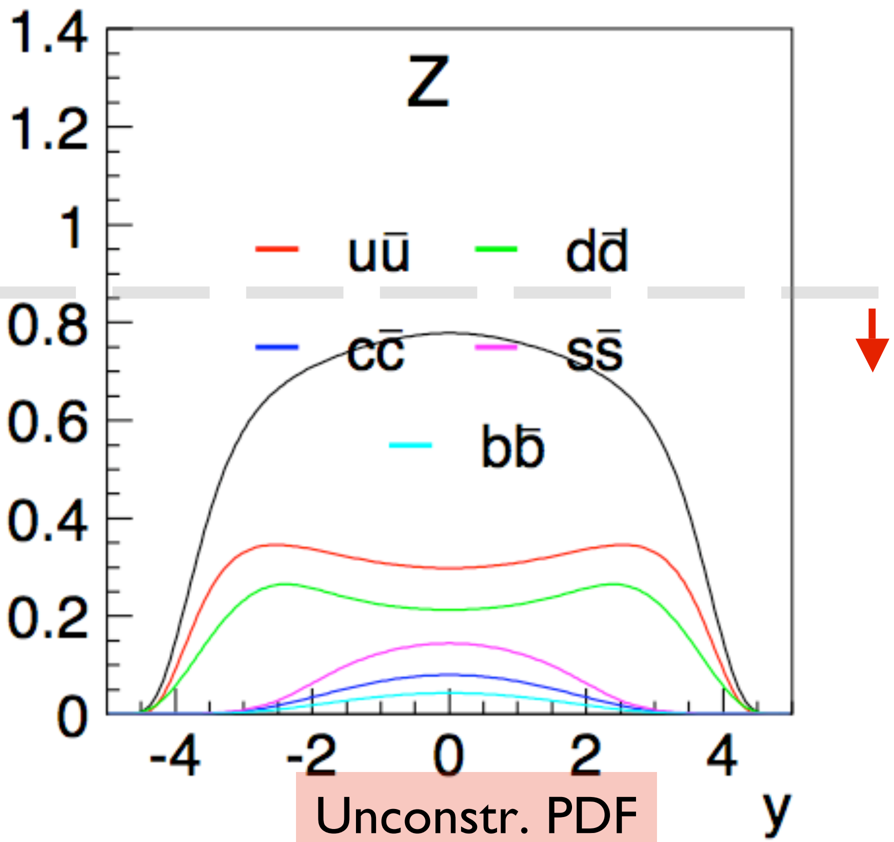


Z decomposition

- LO flavour decomposition:
  - total distribution is decreased due to large decrease of the d component which is not compensated by a slight increase of the u component.
  - overall shape changes due to obvious shape change of d component.



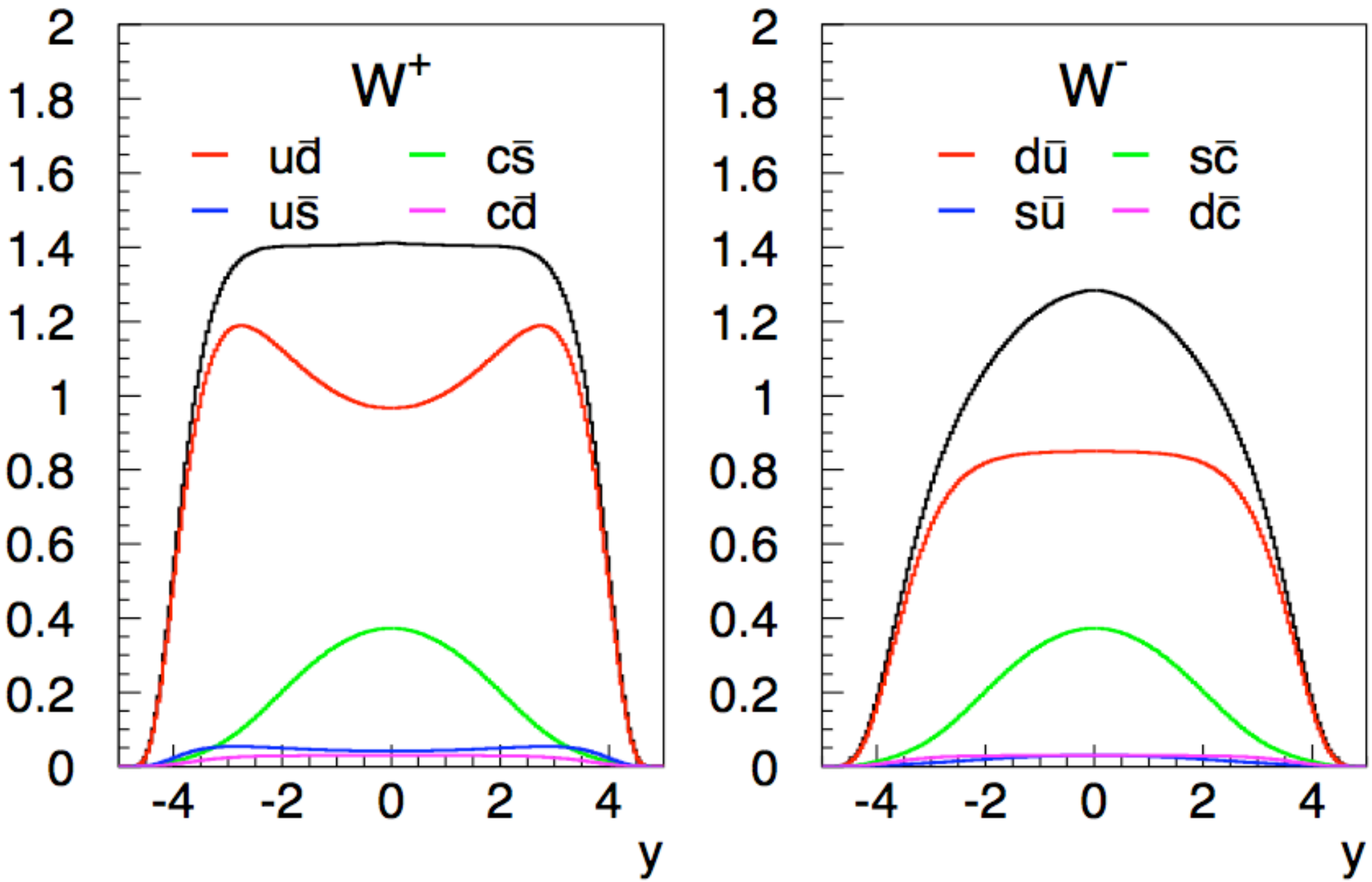
HERAPDF1.0



Unconstr. PDF

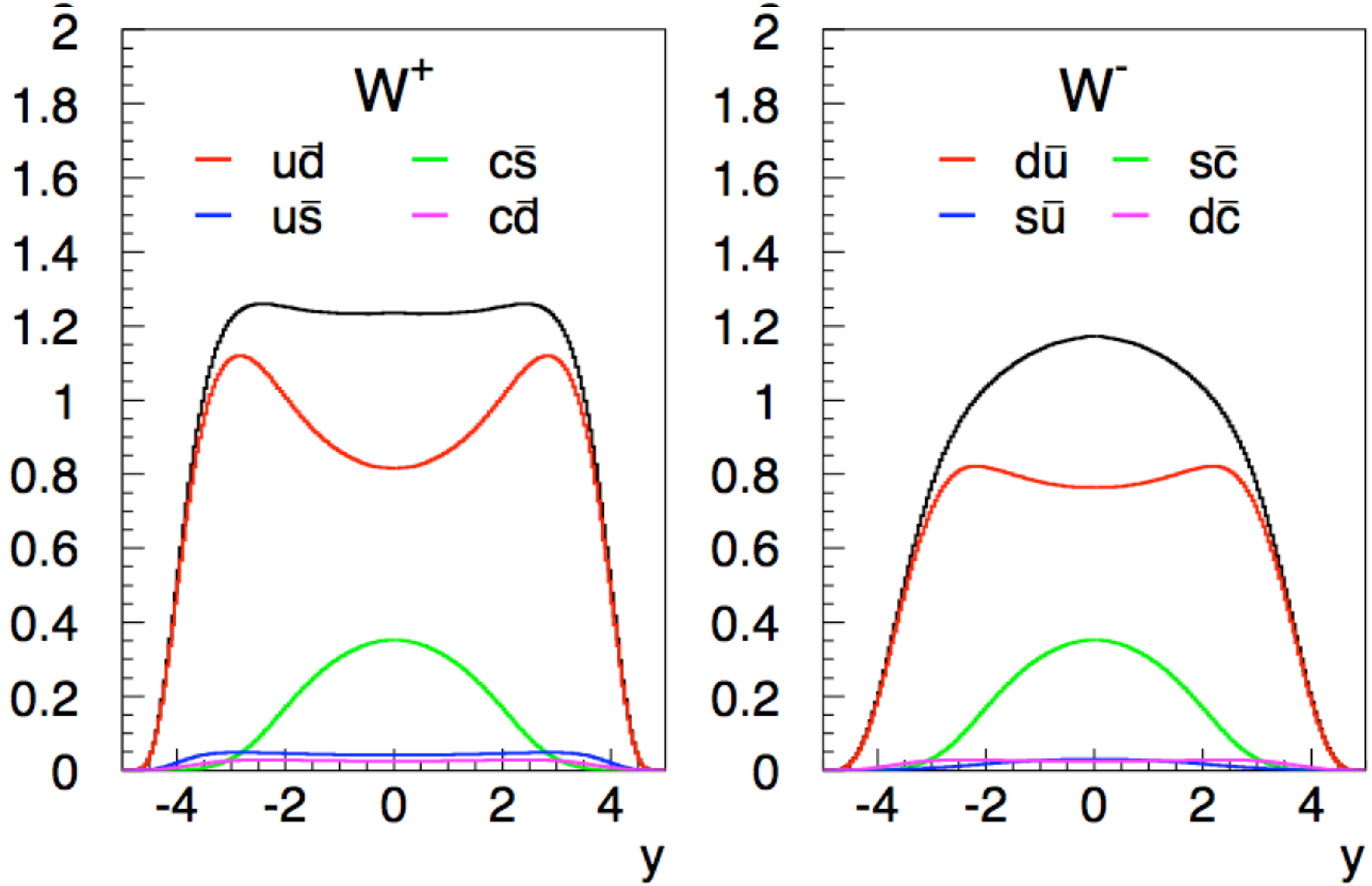
W decomposition at the LO

- Standard PDFs
  - Broken in components.



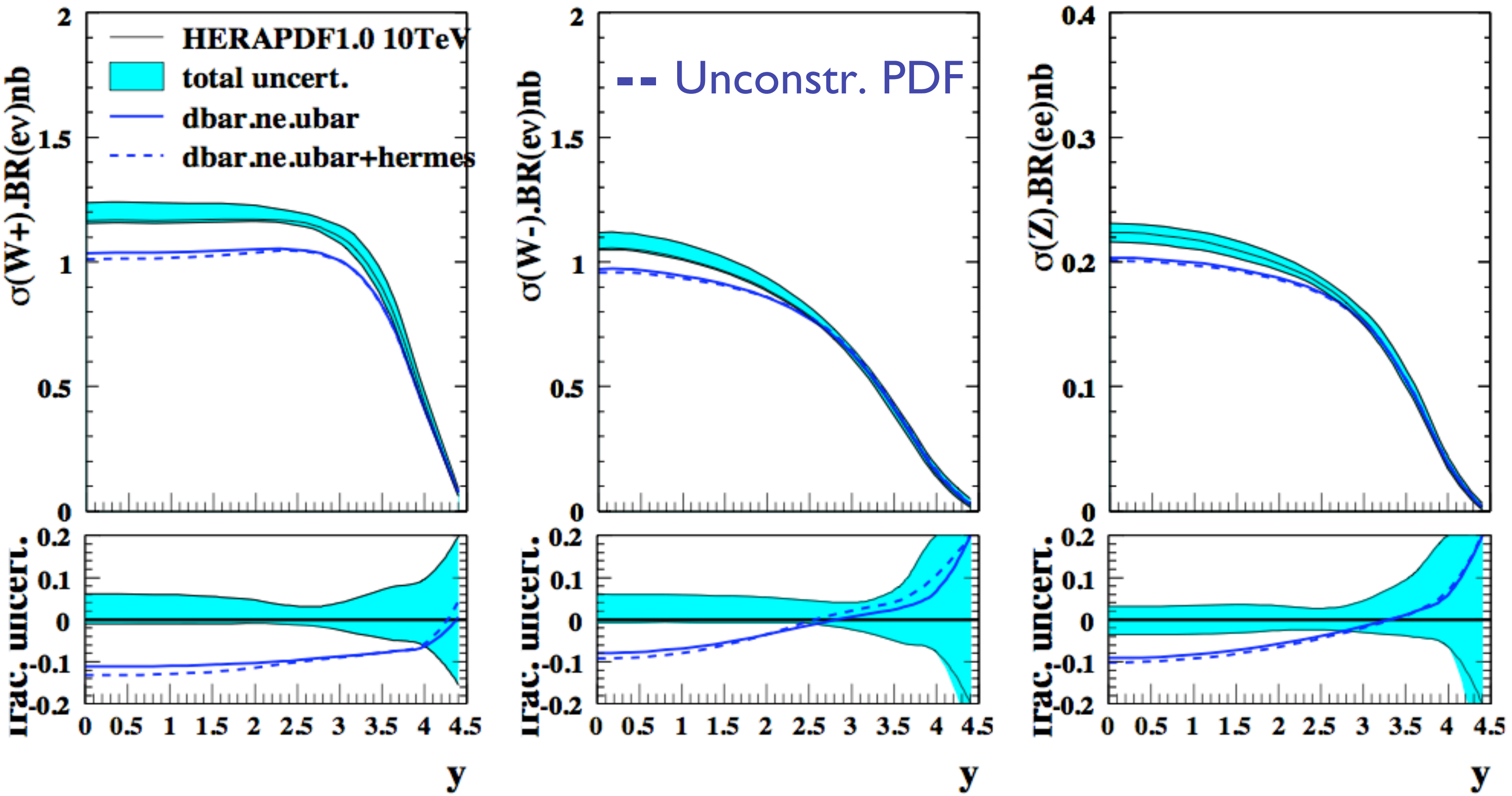
W decomposition at LO

- Unconstrained low x sea PDFs: decreased total distribution
  - Decrease of d is more sizeable than increase in u



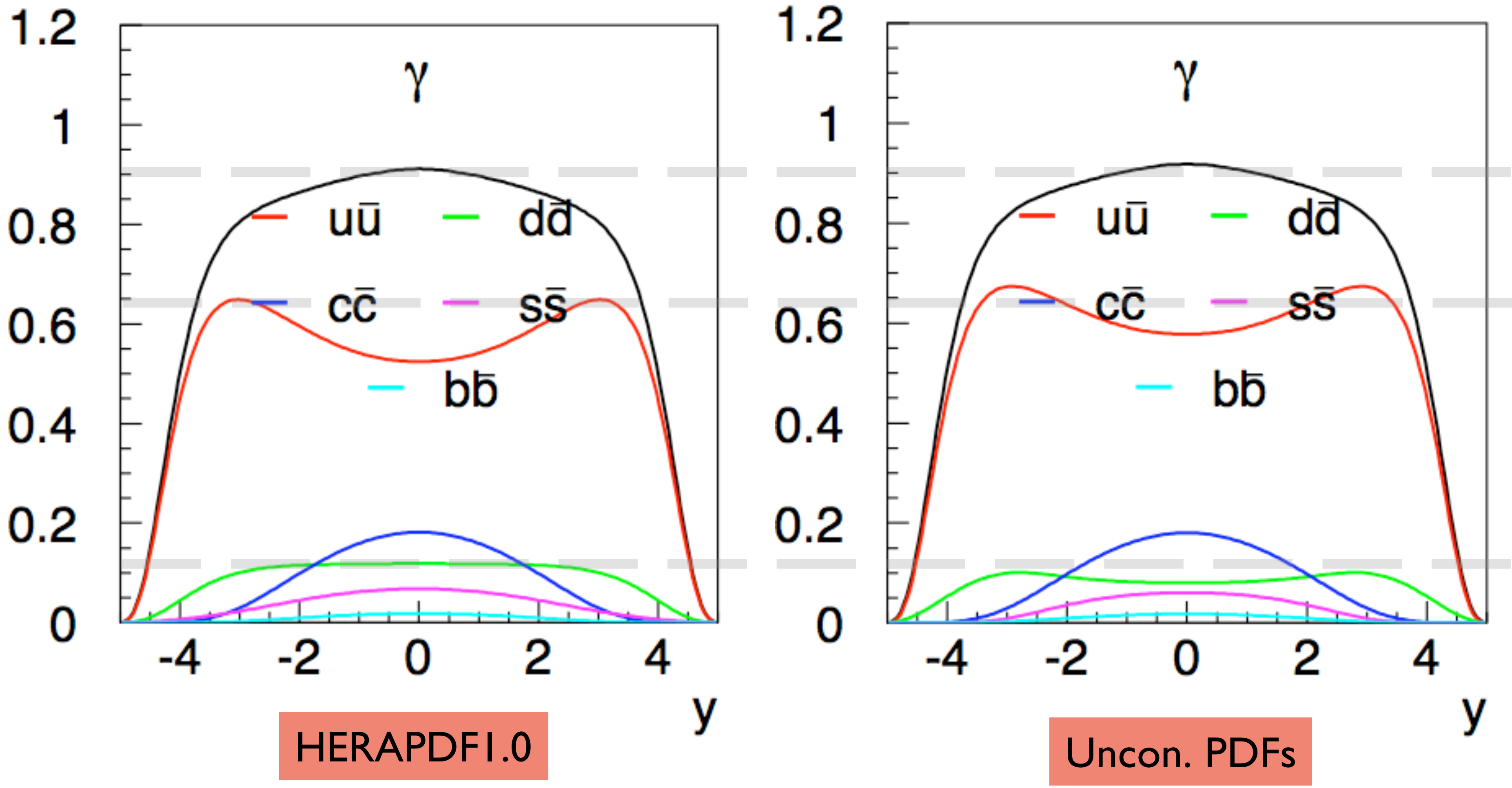
NLO W, Z cross section predictions

- Using unconstrained PDFs all distributions decrease compared to standard PDFs:
  - Up to 10% in the plateau region!
  - d(x) decreases much more than u(x) is increasing for the uncostrained PDF set, hence W,Z distributions will decrease compared to standard PDF set!



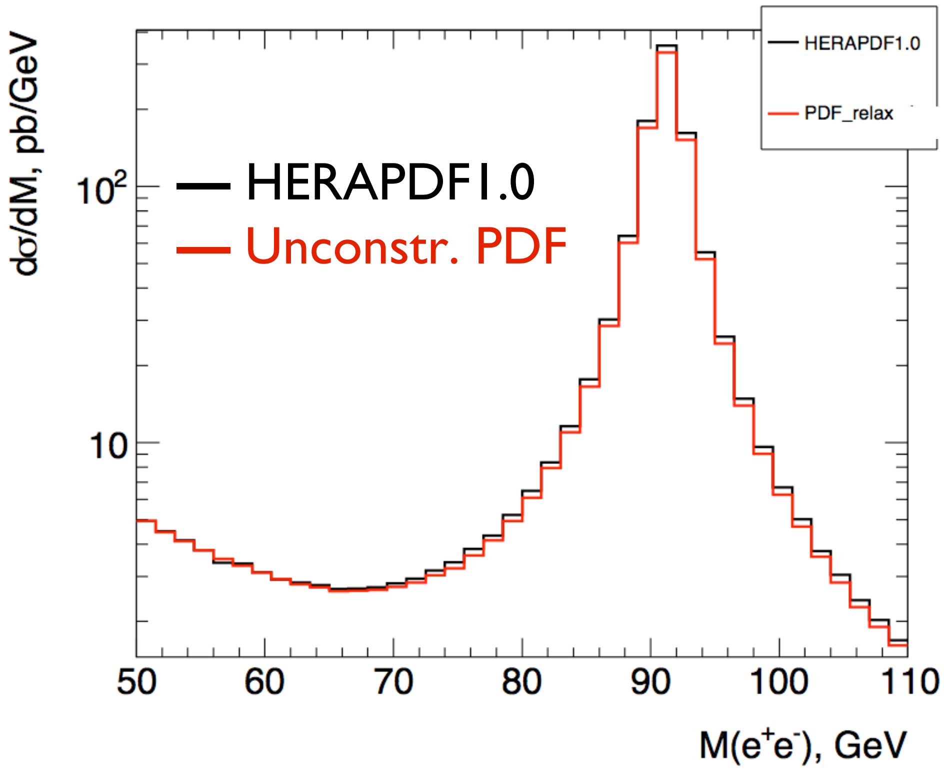
Pure photon exchange, at Mee = 60 GeV.

- Flavour decomposition for DY, photon exchange only:
  - total is distribution is constant, but flavours are different (d and u)

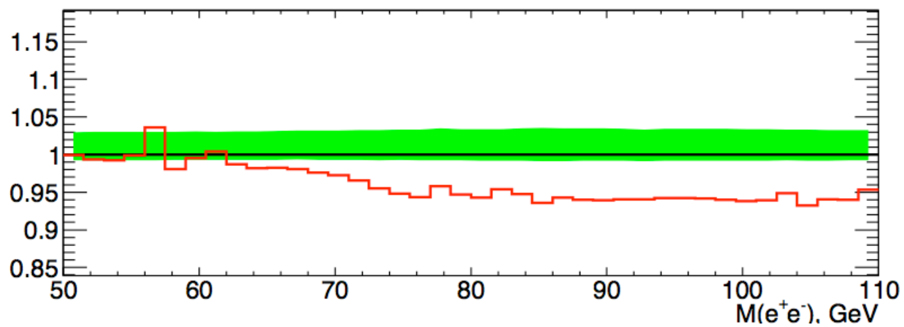


Effect on the Mee distribution

- Mass distribution is a good observable for the effect of unconstrained low x sea PDF
  - 6% variation at the peak.
  - In the region of the photon exchange (Mee of 60 GeV) we see no difference.



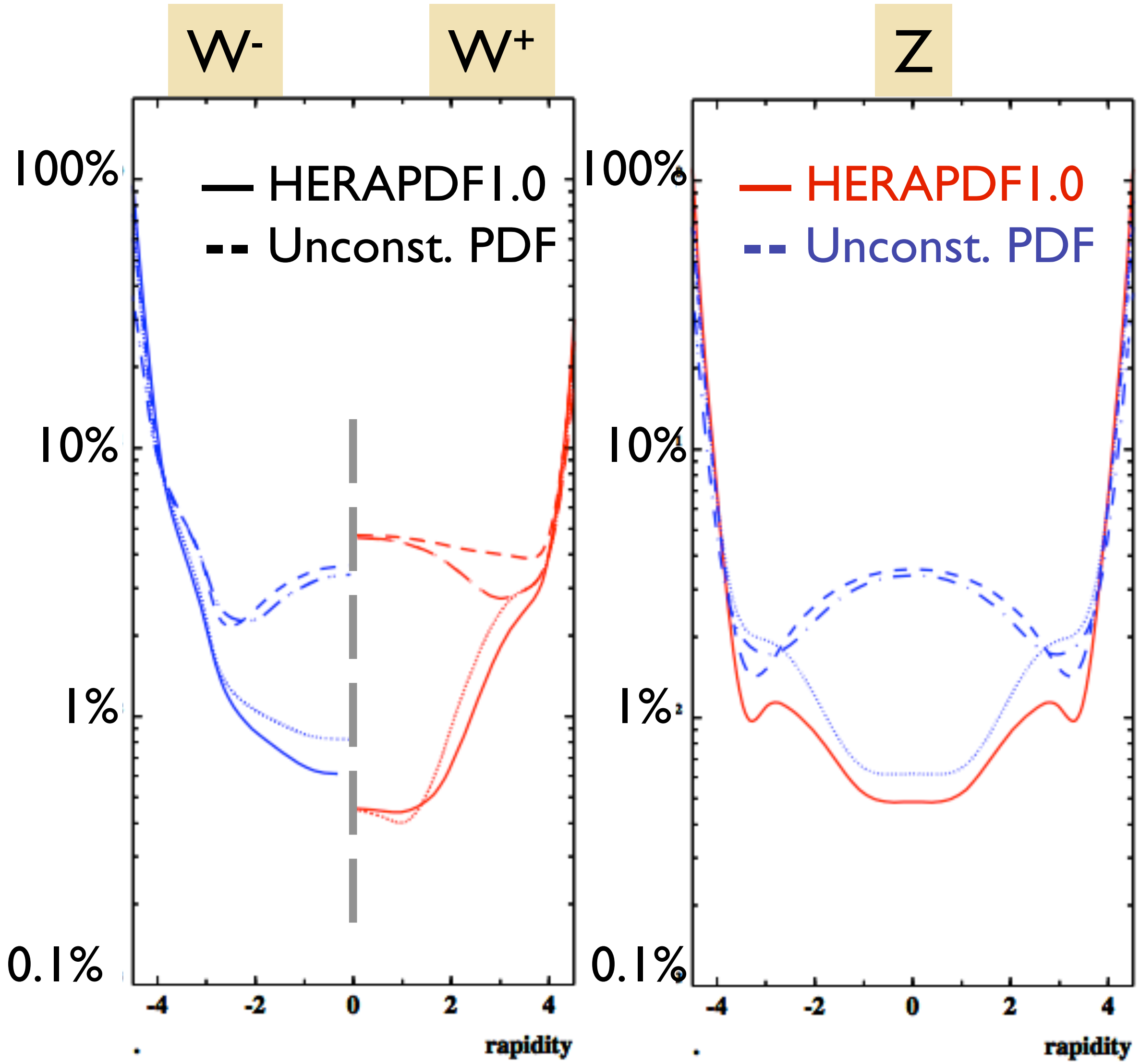
Unconstr. PDF/HERAPDF1.0



Uncertainties for Standard vs Unconstrained PDFs

Propagate experimental uncertainties of PDFs to W,Z cross sections via MC technique:

- Observe rise in the experimental uncertainty in the platform region up to 5% for the unconstrained PDF set
- Measurements of W, Z may constrain better $\bar{u}/\bar{d}$ at low x.



Summary

- Presented the effect of using an unconstrained PDF set at low x sea on the W,Z cross sections:
  - Sizeable effects are observed even after QCD evolution:
    - Up to 10 % decrease in the plateau region of the W,Z cross sections as compared to the case of using standard PDF sets;
    - Up to 5% increase of the experimental uncertainties in the plateau region of the W,Z cross sections as compared to the case of using standard PDF sets;
    - Mee – an interesting observable which shows clear effects at the MZ peak, separated from the DY region where no effects are observed.

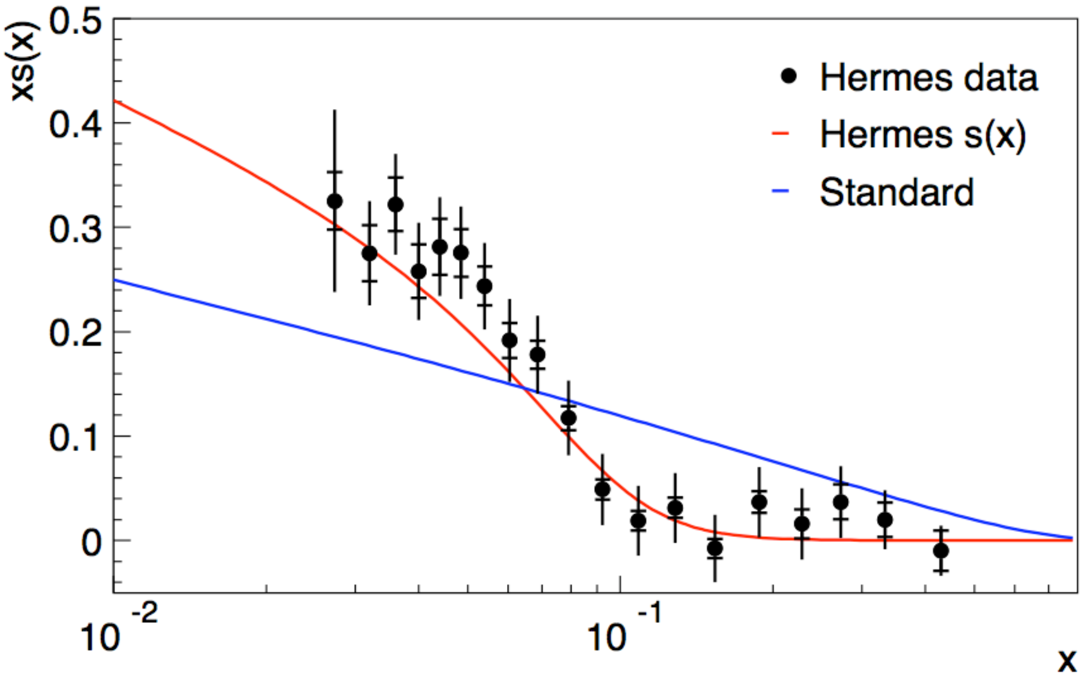
- The unconstrained low x sea PDF set is already available in the LHAPDF format compatible with v.5.8.1.

- This study rises questions related to the assumptions made to extract the PDFs which impacts the W,Z productions at the LHC
  - Could be presented at the dedicated discussion session at the Low X workshop, PDF4LHC workshop

Hermes s(x)

- Standard assumption that s(x)=fsD(x) with fs=0.31 does not describe recent HERMES measurement [arXiv:0803.2993]

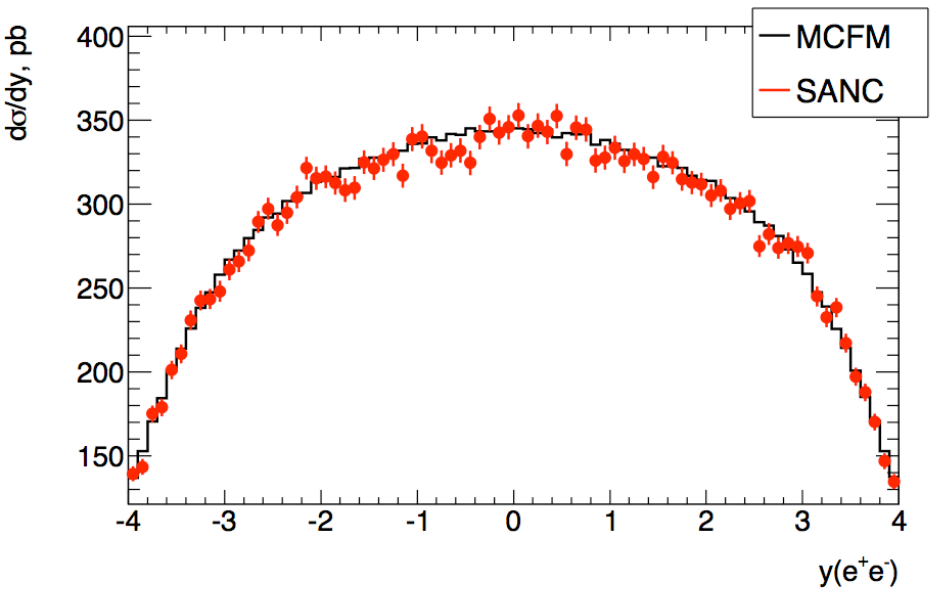
- Using fs=fs(x) with $f_s(x) = f_s(0.5(1 + \tanh(-(x - xcent)xrise)))$ gives better description of the Hermes measurement.

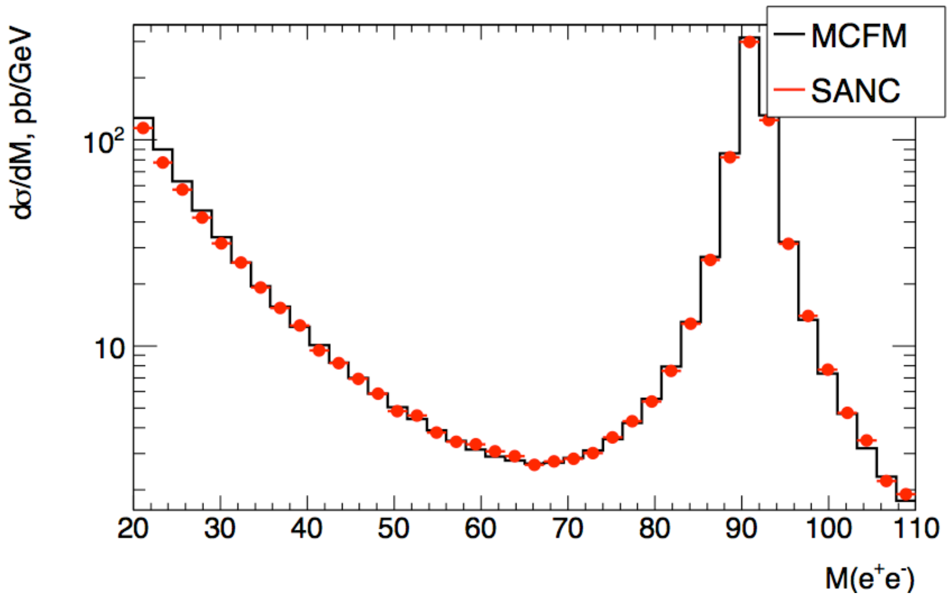


Packages used for the W,Z predictions

Various codes have been used and cross checked for NLO predictions:

- Calculations by MCFM package validated by SANC group
  - using HERAPDF1.0 set



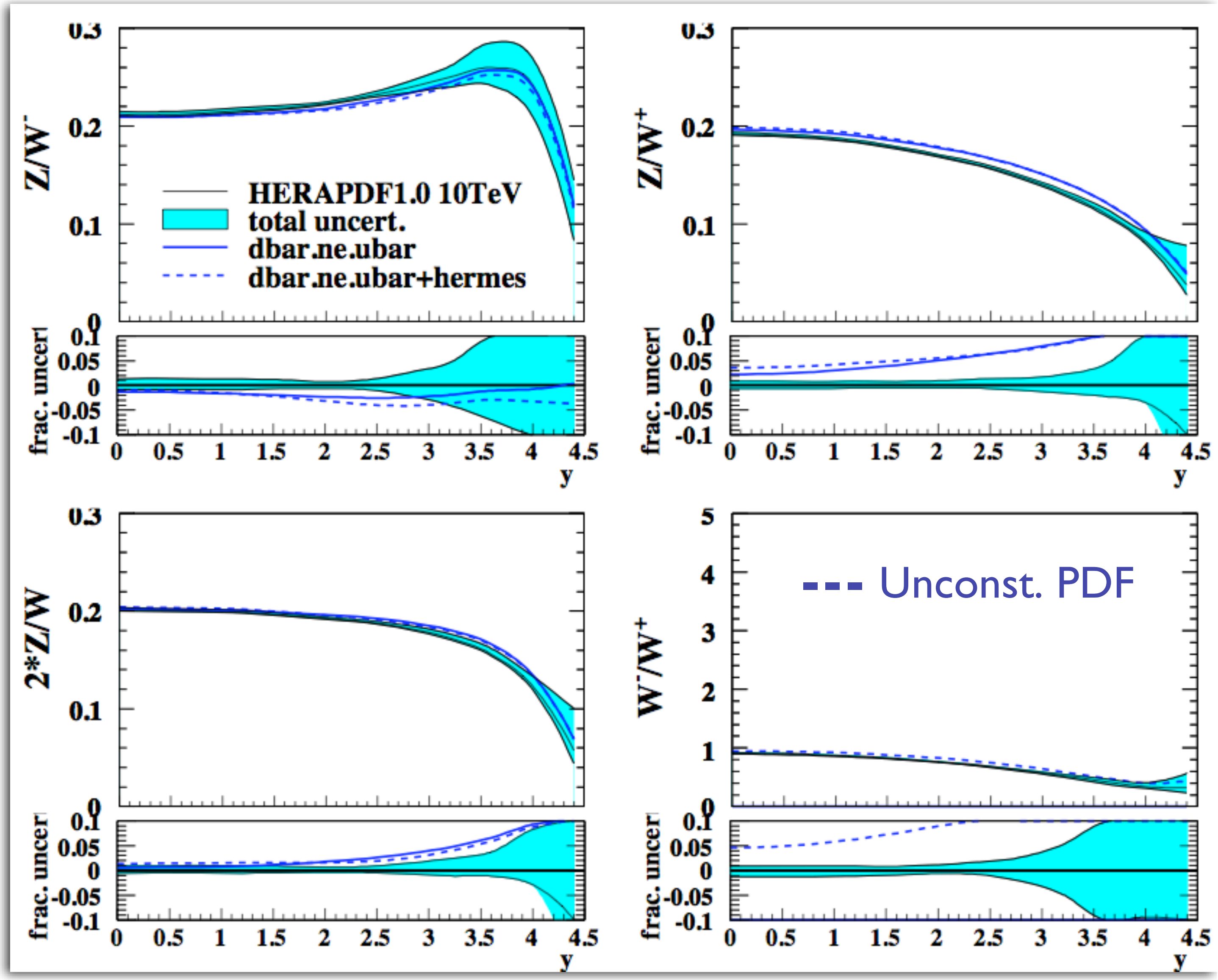


- Private NLO code from James Stirling (as used by MSTW)

Effects on Ratio Distributions

- Propagating the unconstrained low x sea PDF set to the ratios, the differences are still observed.

- Unconstrained PDFs give results outside "conventional" total error estimates



HERAPDF1.0 vs Global Fits

Differences are up to 5% at the plateau
while for the unconstrained sea PDF is 10%