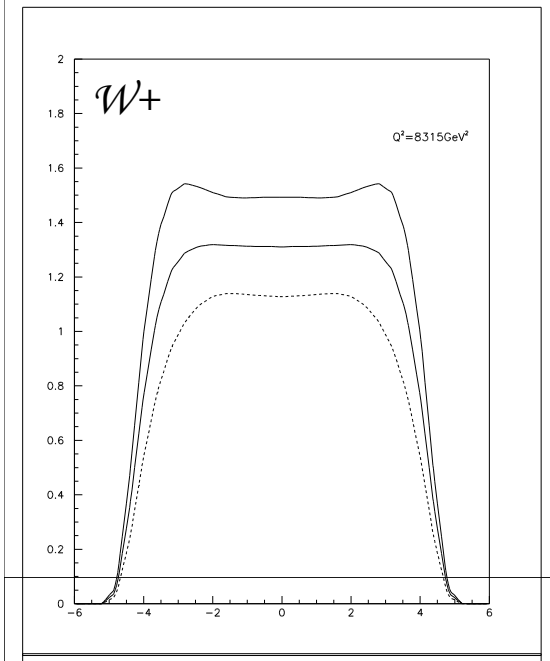
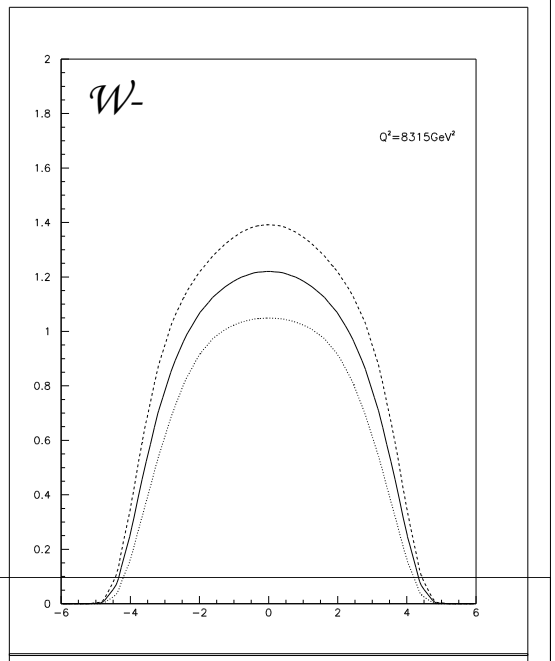
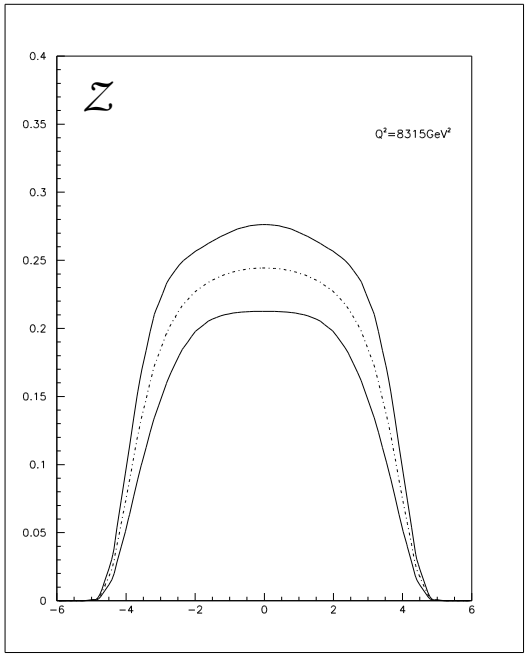
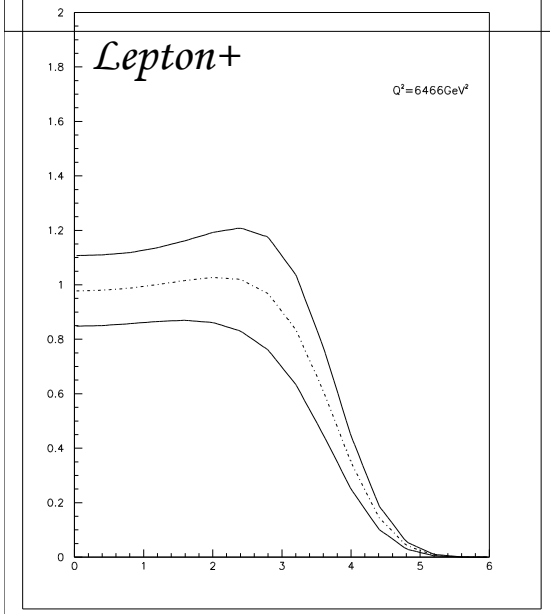
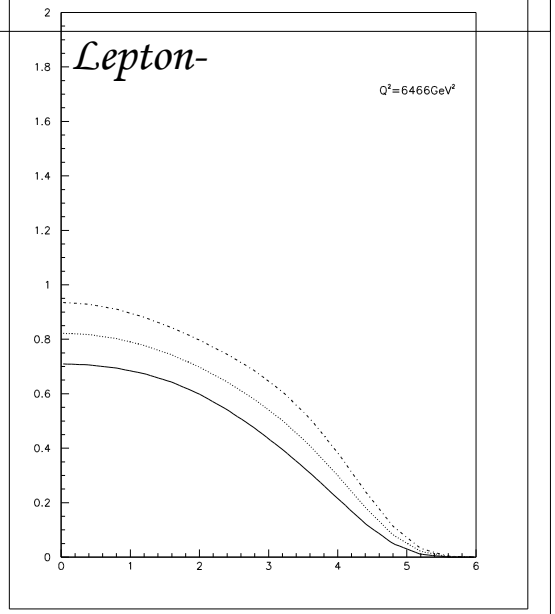
What has HERA data ever done for us?











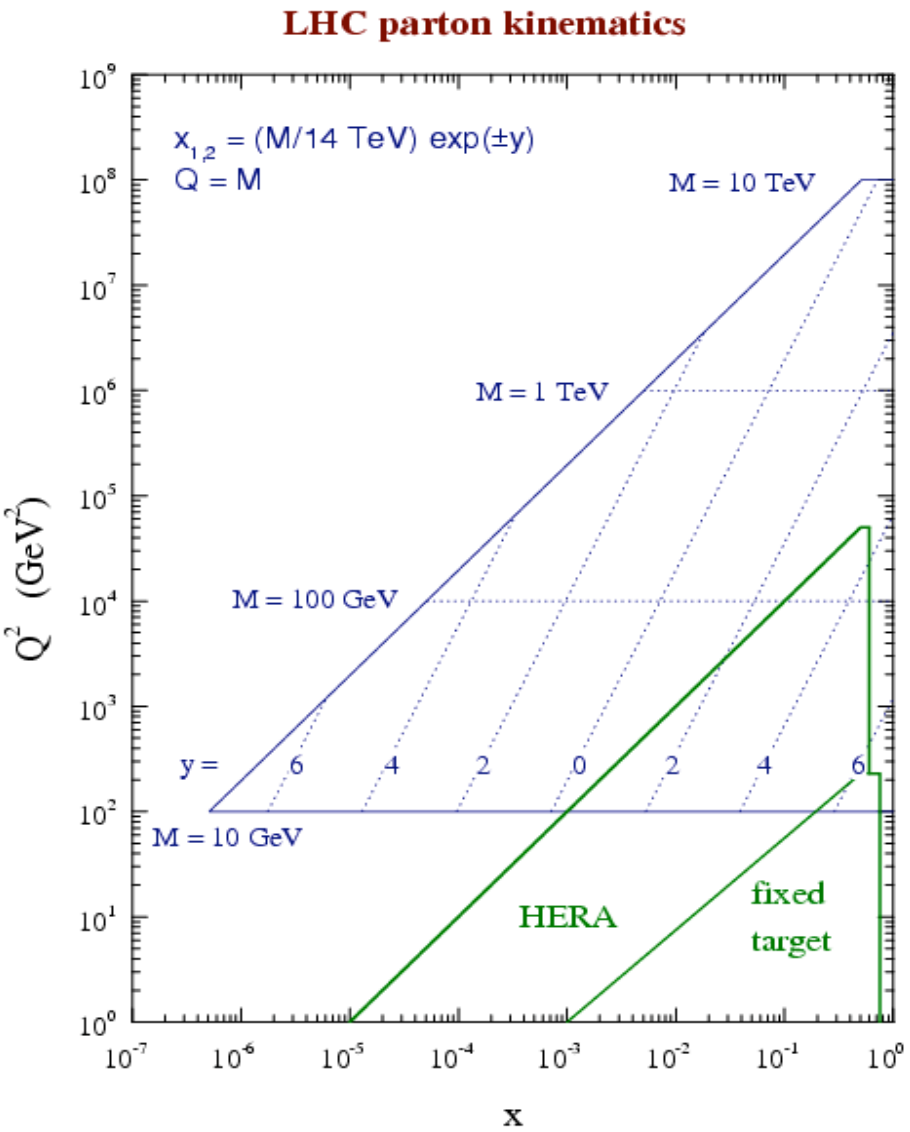
Pre-HERA W+/W-/Z and

W+/- _ lepton+/- rapidity spectra

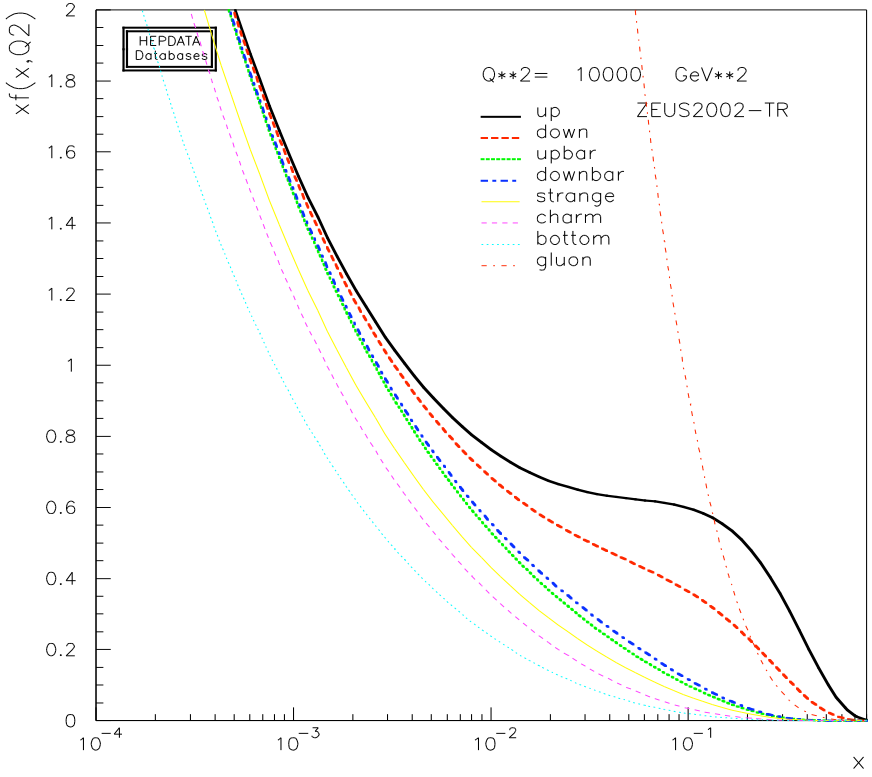
~ ± 15% uncertainties !

Why? Because the central rapidity range AT LHC is at low-x (5 10^{-4} to 5 10^{-2})

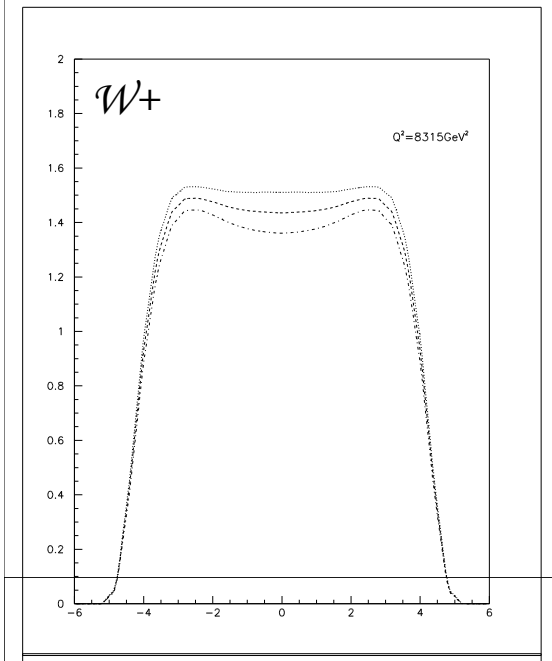
NO WAY to use these cross-sections as a good luminosity monitor

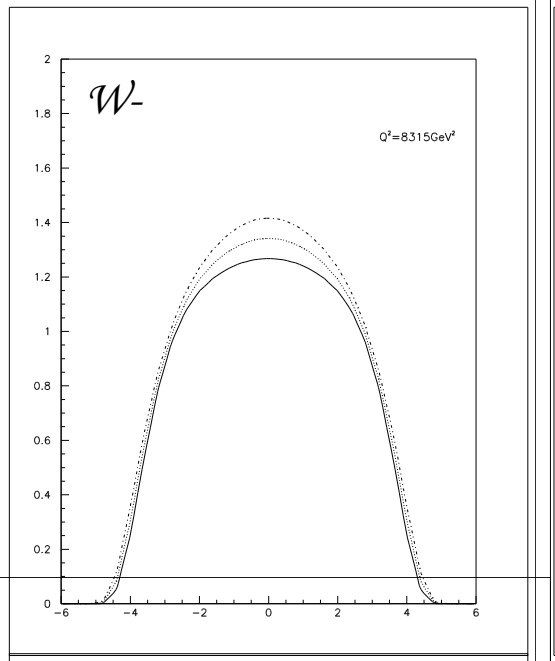


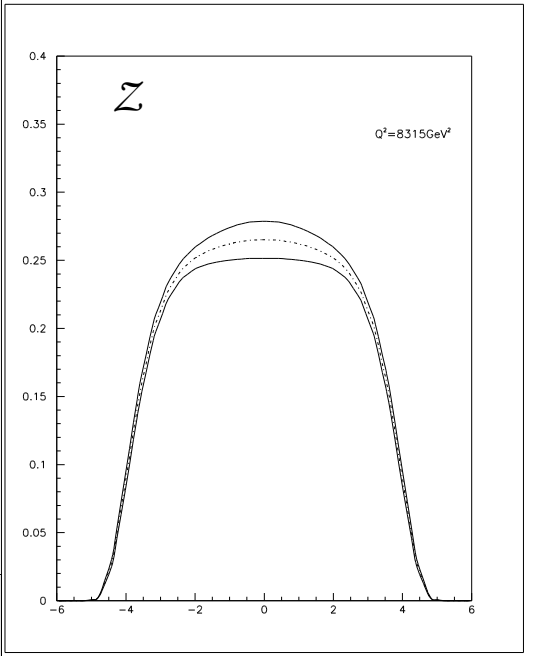
It's the HERA data that give the information at central rapidity = low-x

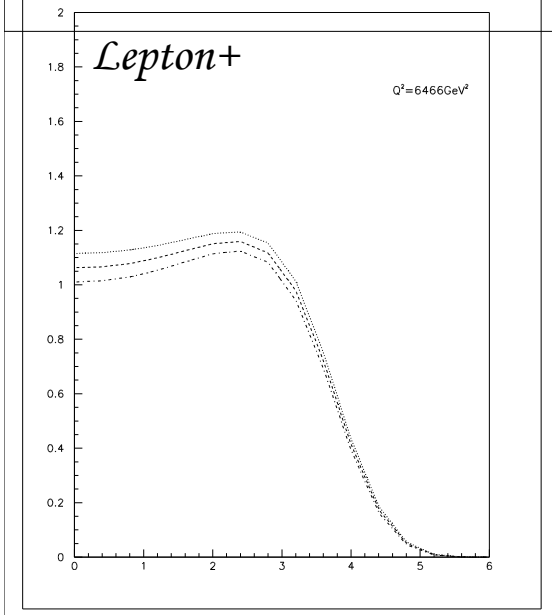


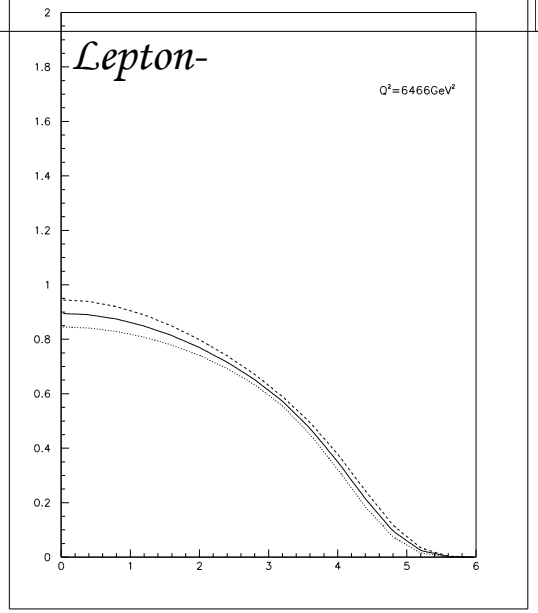
And at low-x and Q2=10000 GeV2
The PDFs are glue dominated











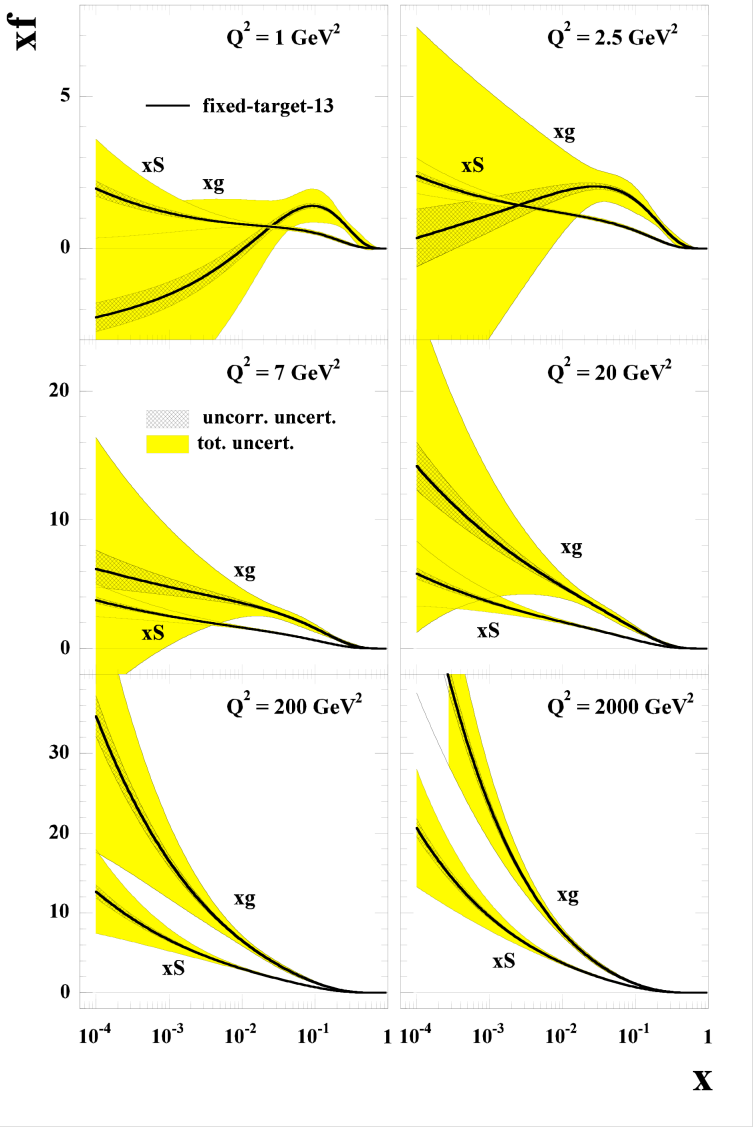
Post-HERA W+/W-/Z and

W+/- _ lepton+/- rapidity spectra

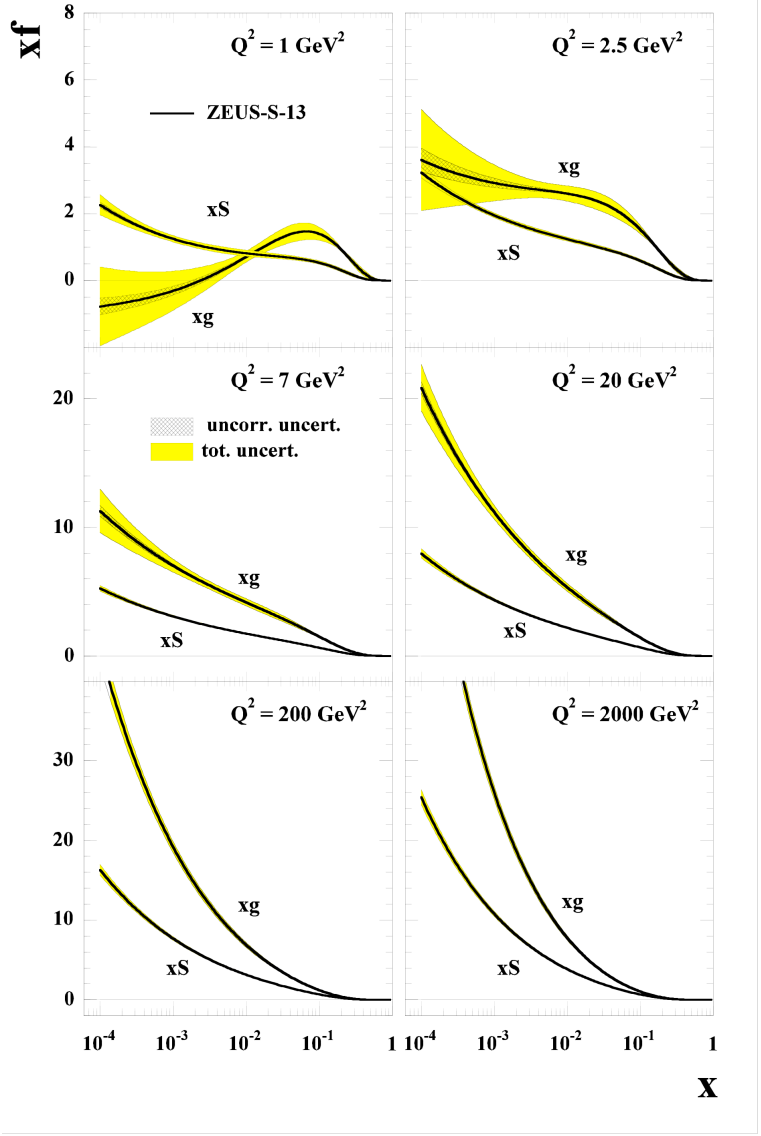
~ ± 5% uncertainties !

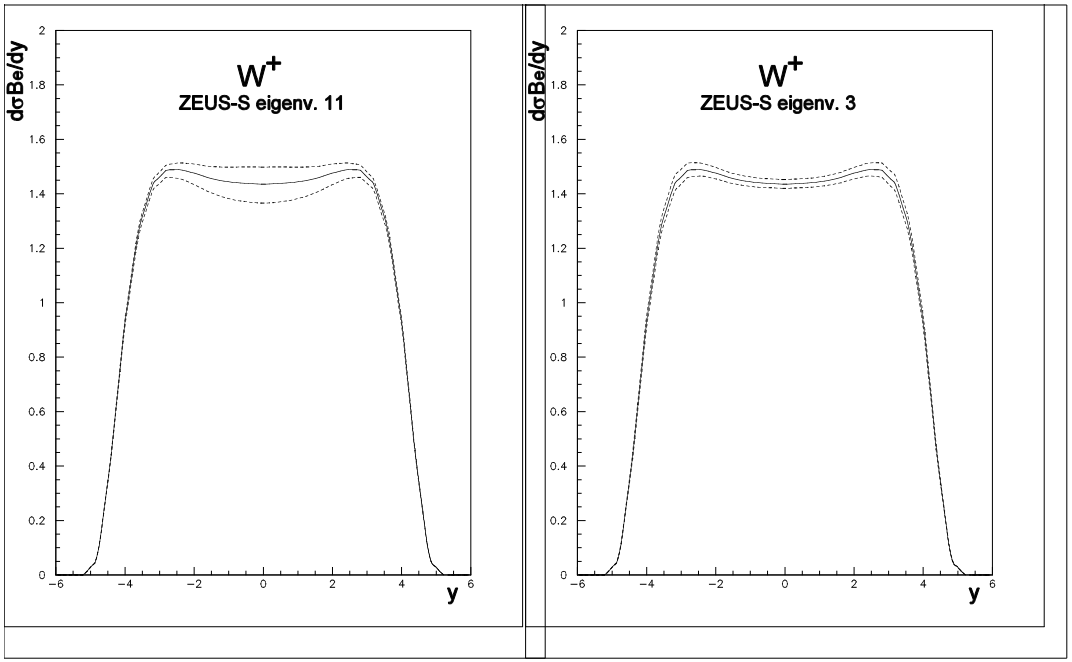
Why? Because there has been a tremendous improvement in our knowledge of the low-x glue and thus of the low-x sea

Pre-HERA sea and glue distributions



Post HERA sea and glue distributions





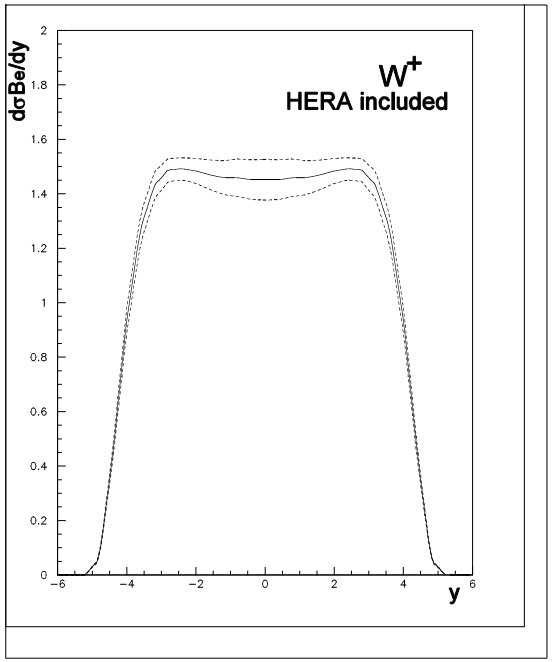
As a further illustration that it's dominantly the gluon PDF uncertainty which dominates the PDF errors on the W spectra, here are the contributions due to eigenvectors 11 and 3, which are dominated by parameters relating to the mid (approx $10^{-2} < x < 10^{-1}$) to low-x ($x < 10^{-2}$)gluon parametrization at Q2_0 = GeV^2.

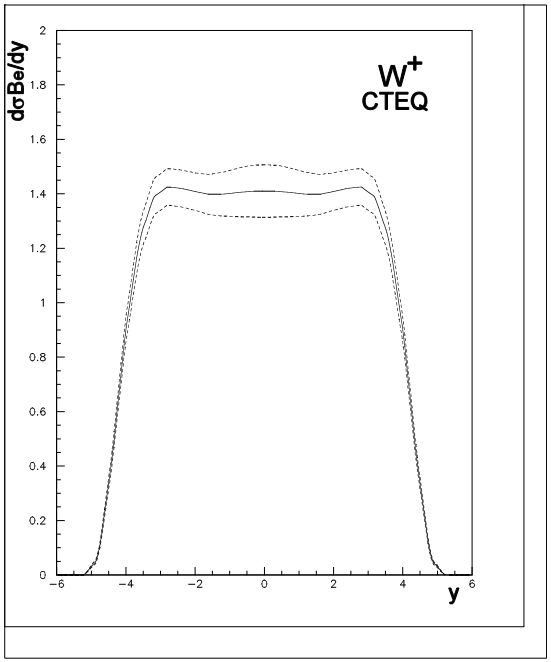
For Q2 >> Q2_0 , glue _ q qbar splitting feeds these uncertainties into uncertainties on q,qbar at lower-x.

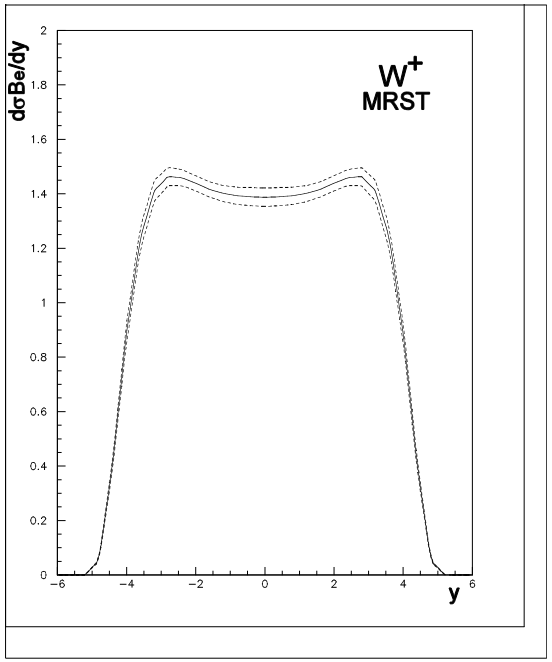
Hep-ex/0509002 explores the possibility that measurements of W rapidity spectra at the LHC may be able to constrain the PDFs further, using ATLFAST simulation of the ATLAS detector and estimates of background contamination and charge misidentification

It also discusses technical issues of k-factor reweighting from LO to NLO, and PDF reweighting to simulate all the eigenvector PDF sets without having to regenerate. I will not repeat these discussions here.

I'll just give a 'bottom-line' summary







Note that different PDF fitting groups have somewhat different estimates of both the central values and the uncertainties of the W spectra

From LHAPDF eigenvectors

At y=0 the total uncertainty is

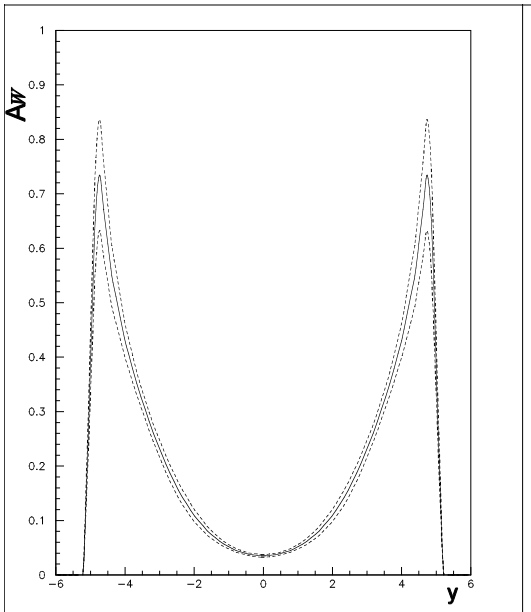
~ ±6% from ZEUS

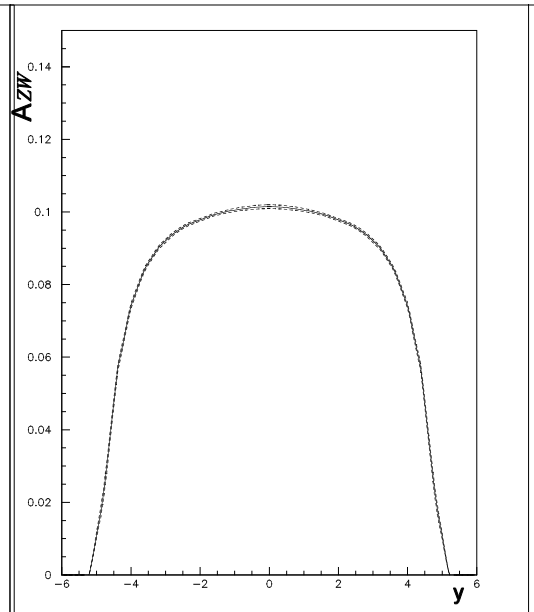
~ ±4% from MRST01E

~ ±8% from CTEQ6.1

ZEUS to MRST01 central value difference ~5%

To improve the situation we NEED to be more accurate than this**:~3%**



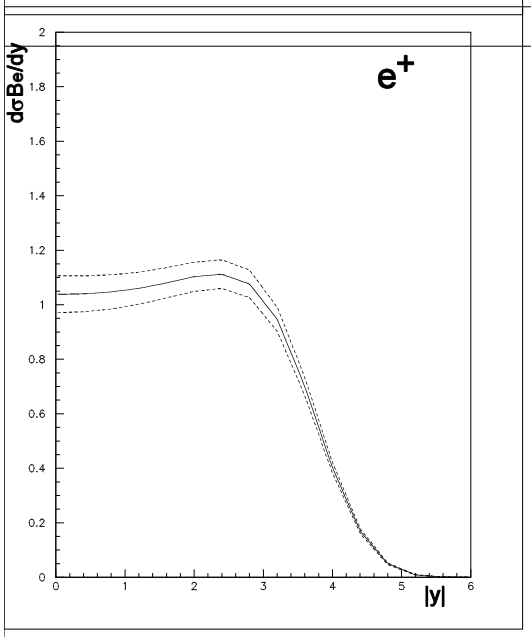


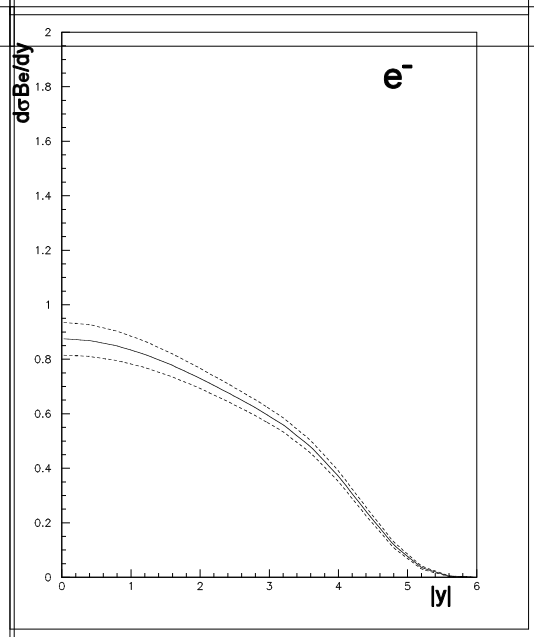
Because the uncertainties in W+,W- and Z spectra are all coming from the gluon PDF there is cancellation in the ratios

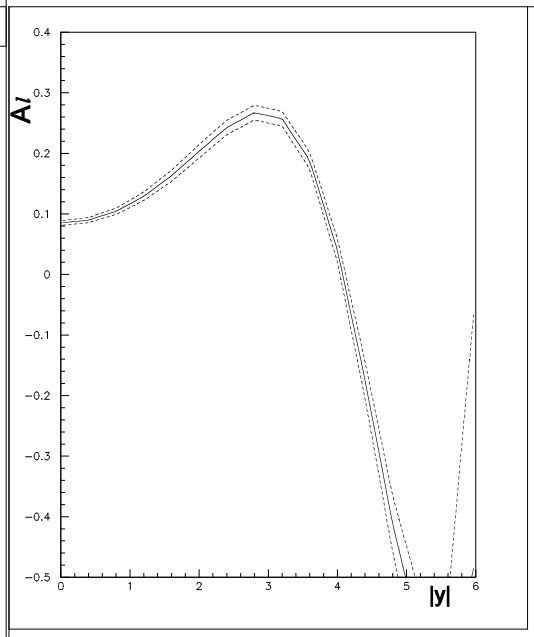
$A_W = (W^+ - W^-)/(W^+ + W^-)$

$Z_W = Z/(W^+ + W^-)$

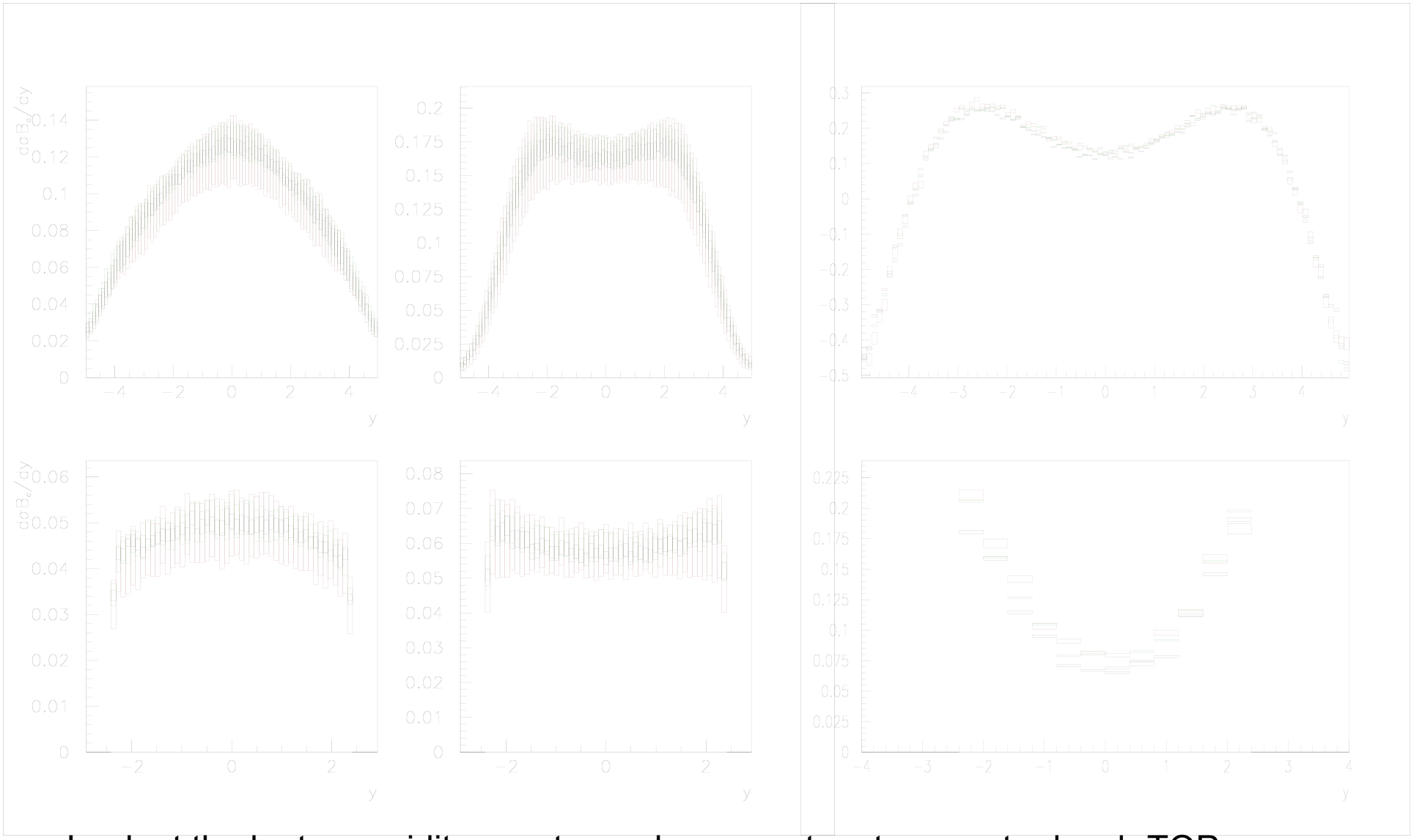
But we will actually measure the leptons from the W decay







And the lepton asymmetry $A_l = (l^+ - l^-/(l^+ + l^-)$. Uncertainty in this is about 4% at y=0, as opposed to about 8% for the lepton rapidity spectra themselves (using CTEQ6.1M PDFS)



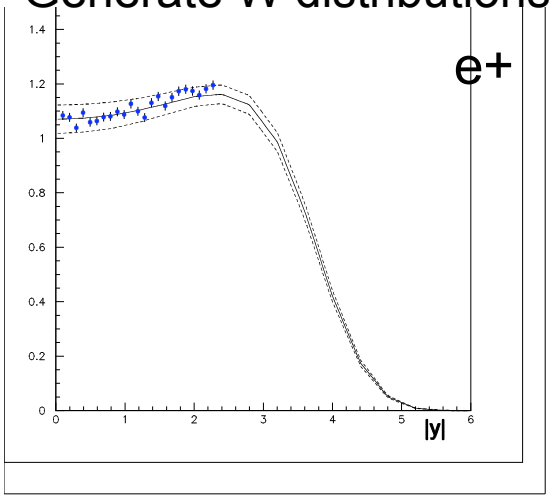
Look at the lepton rapidity spectra and asymmetry at generator level -TOP

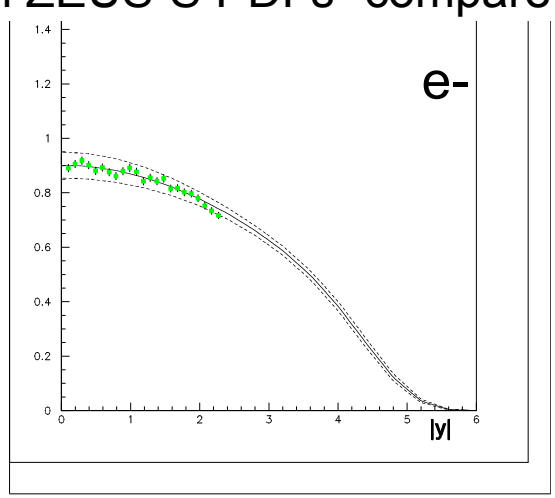
and after passing through ATLFAST –BOTTOM

Generation with HERWIG+k-factors using CTEQ6.1M ZEUS_S MRST2001 PDFs with full uncertainties

Study the effect of including the W Rapidity distributions in **global PDF Fits**
by how much can we reduce the PDF errors?

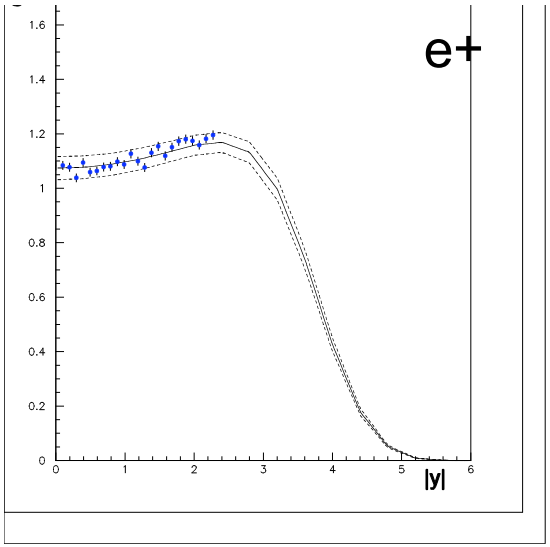
Generate W distributions with ZEUS-S PDFs- compare to current level of uncertainty

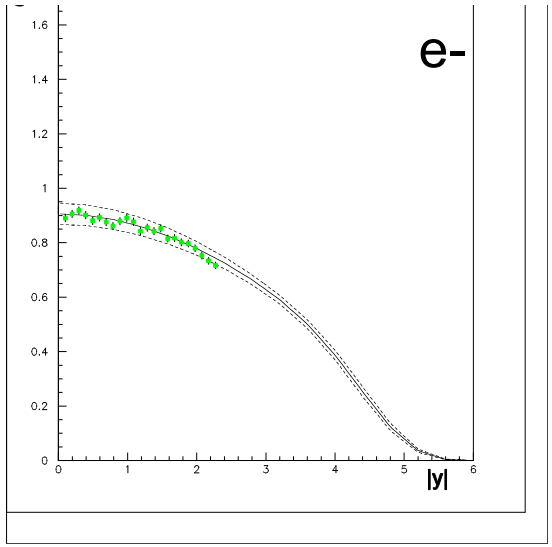




Data at generator level
plus cuts, no smearing

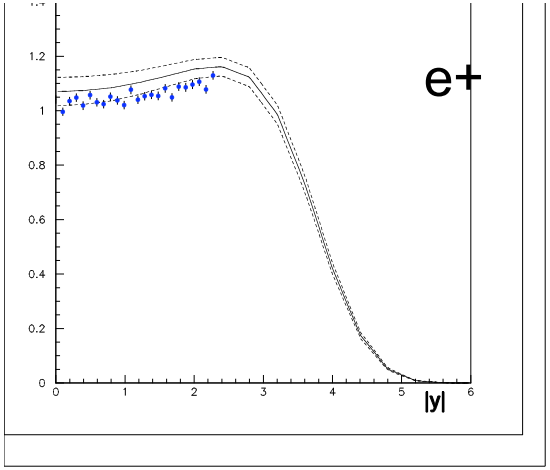
Including this generated data in the ZEUS PDF fit – reduces the PDF uncertainties

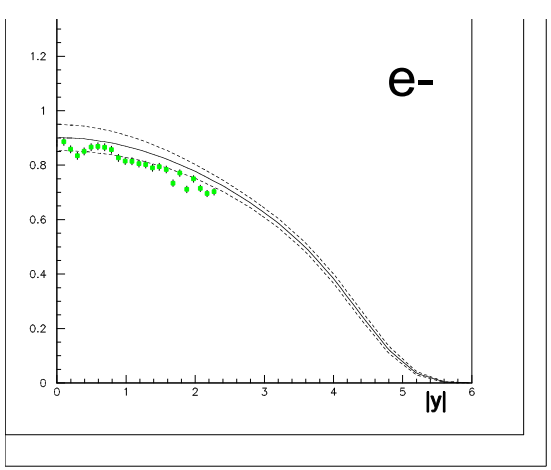




, _ particularly low-x gluon parameter
xg(x) = x ⁻– , _ = -.199 ± .046
Before including this data becomes _ = -.196 ± .029
after inculding this data
Error on low-x gluon parameter reduced by ~35%

But would it work if the W distributions were generated with another PDF?
Generate W distributions with CTEQ6.1M PDFs- compare to ZEUS-S predictions

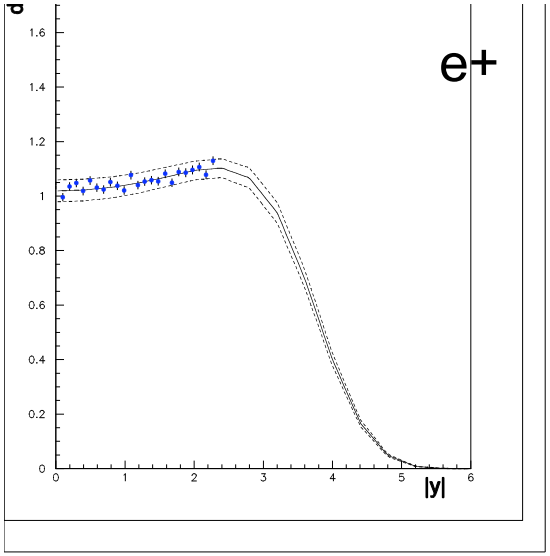


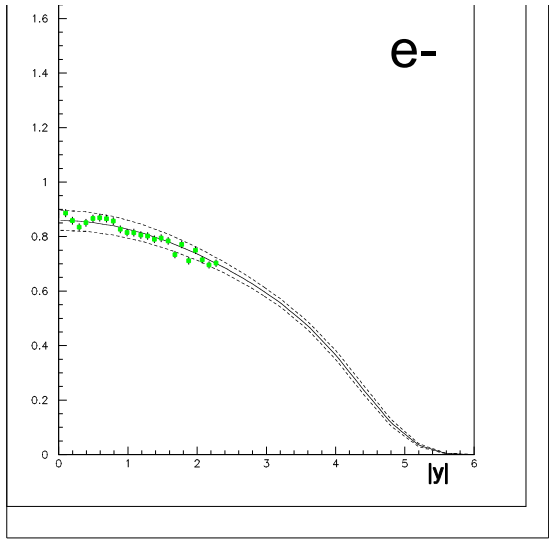


Data at generator level plus cuts, no smearing

Central values are different

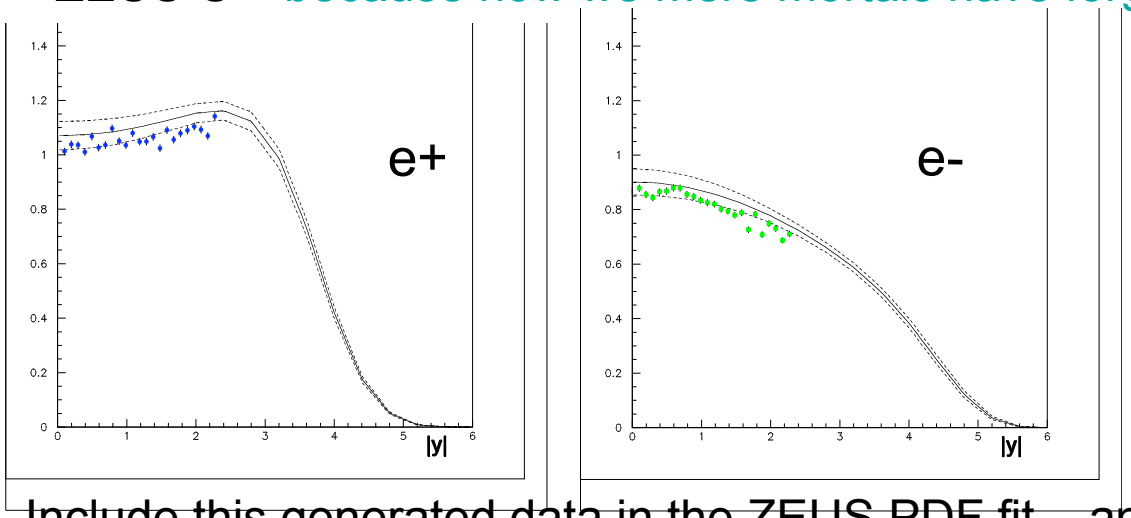
Include this generated data in the ZEUS PDF fit – and it shifts the central values of the ZEUS gluon PDF as well as reducing the PDF uncertainties





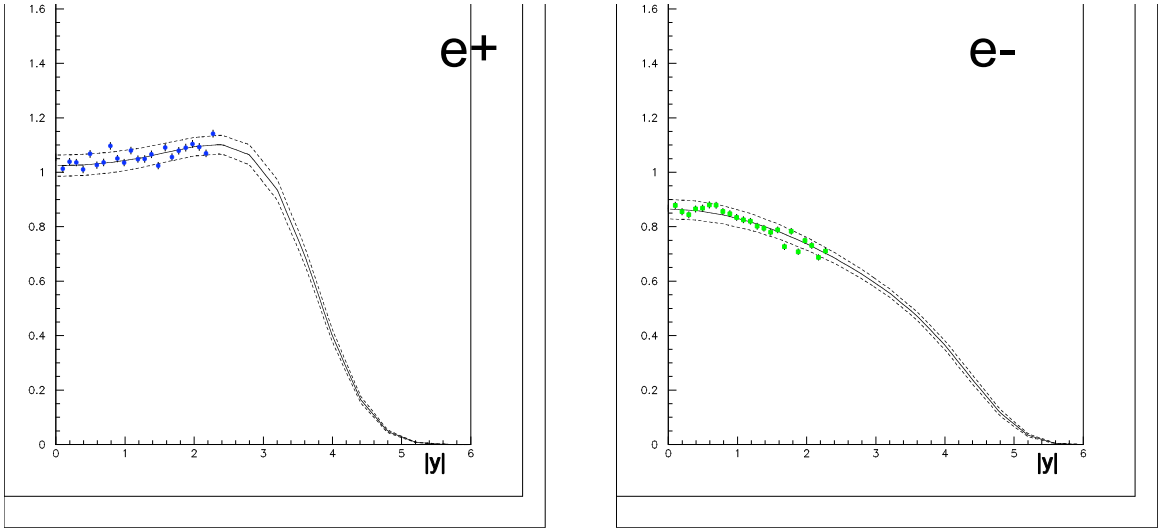
low-x gluon parameter
xg(x) = x ⁻– , _ = -.199 ± .046
before including this data
becomes _ = -.189 ± .029
–after including these pseudodata- It does work the uncertainty is reduced and the central value shifted to reflect the preference of the pseudodata.

Finally be realistic generate W distributions with CTEQ6.1 PDFs as if GOD told you this is the truth - pass through ATLFAST detector simulation and correct simulated data from Detector level to Generator level using a different PDF-ZEUS-S – because now we mere mortals have forgotten the truth



Data at ATLFAST detector level + correction

Include this generated data in the ZEUS PDF fit – and it shifts the central values of the gluon PDF as well as reducing the PDF uncertainties



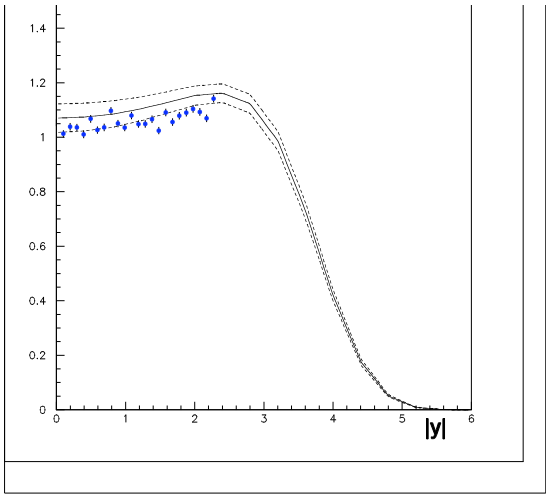
low-x gluon parameter

xg(x) = x $^{-}$– , _ = -.199 ± .046 before including this pseudodata becomes _ = -.181 ± .030 after including the pseudodata. Passing through the detector simulation and correcting with the ‘wrong’ PDF still gives results consistent with the ‘true’ PDF.

ONE SLIDE soundbite- Study of the effect of including the LHC W Rapidity distributions in global PDF Fits **by how much can we reduce the PDF errors?**

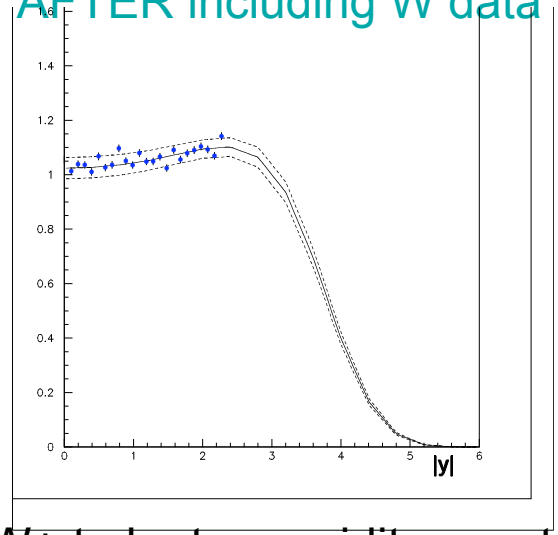
Generate data with CTEQ6.1 PDF, pass through ATLFAST detector simulation and then include this pseudo-data in the global ZEUS PDF fit.
Central value of prediction shifts and uncertainty is reduced

BEFORE including W data



W+ to lepton rapidity spectrum data generated with CTEQ6.1 PDF compared to predictions from ZEUS PDF

AFTER including W data



W+ to lepton rapidity spectrum data generated with CTEQ6.1 PDF compared to predictions from ZEUS PDF AFTER these data are included in the fit

Specifically the low-x gluon shape parameter _, xg(x) = x ⁻– , was
_ = -.199 ± .046 for the ZEUS PDF before including this pseudo-data
It becomes _ = -.181 ± .030 after including the pseudodata