W/Z pair production at LHC

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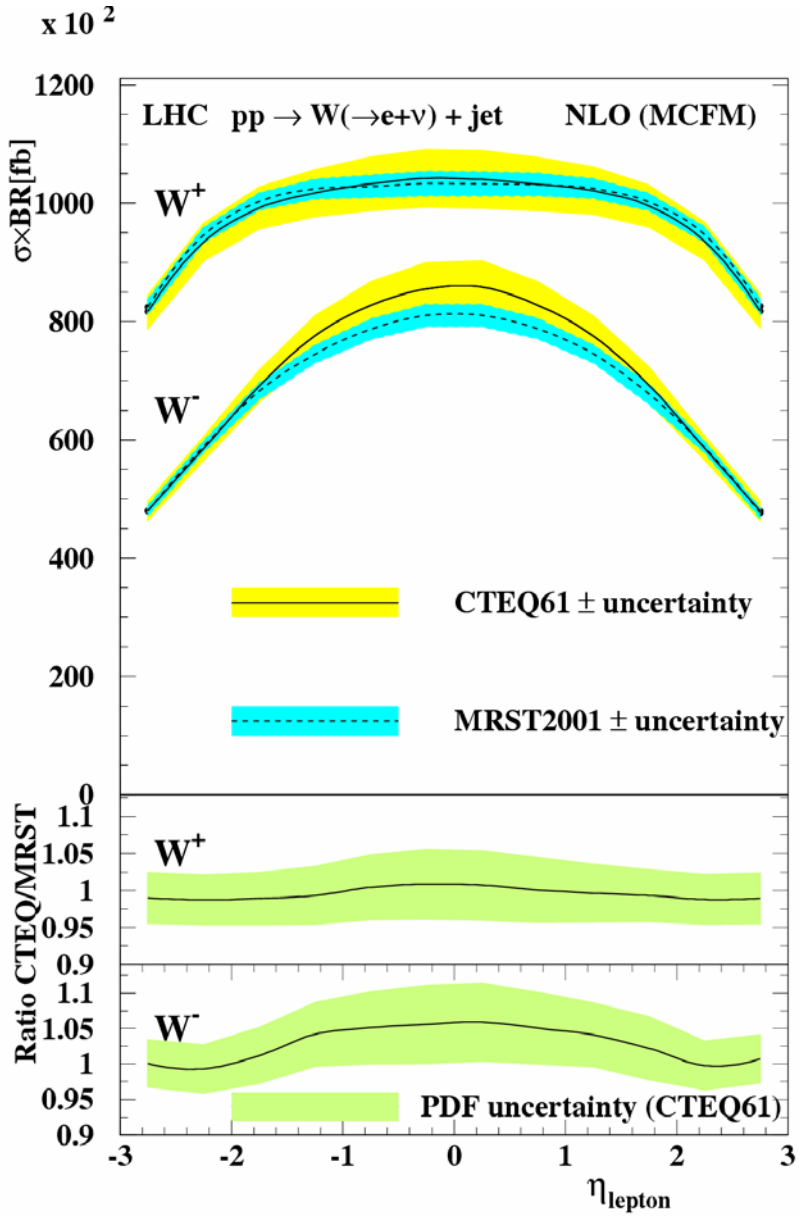
Motivation

- Study of theoretical systematic uncertainties of W/Z pair production
  - Related to PDF's
  - Perturbative, from missing higher orders
- NLO calculation with MCFM4.0 interfaced to LHAPDF3.0
- differential distributions with experimental cuts
- continuation of W/Z + jet studies

p_T^{lept} >25 GeV	$\|\eta^{lept}\|$< 3.0
W case: E_T^{miss} >25 GeV	R(lepton-lepton)> 0.2

Results presented in January: pp→W+jet



PDF uncertainty formula for eigenvectors
CTEQ61M (40), MRST2001E(30)

$$\Delta_{PDF} = \frac{1}{2}\sqrt{\sum_{i=1}^{N}\left(PDF_i^{+} - PDF_i^{-}\right)^2}$$

Relative PDF uncertainties

- W^+ 3.5 % forward – 5 % central
- W^- 3.3 % forward – 5.5 % central
- largest contribution from CTEQ members a15 (high x gluon)

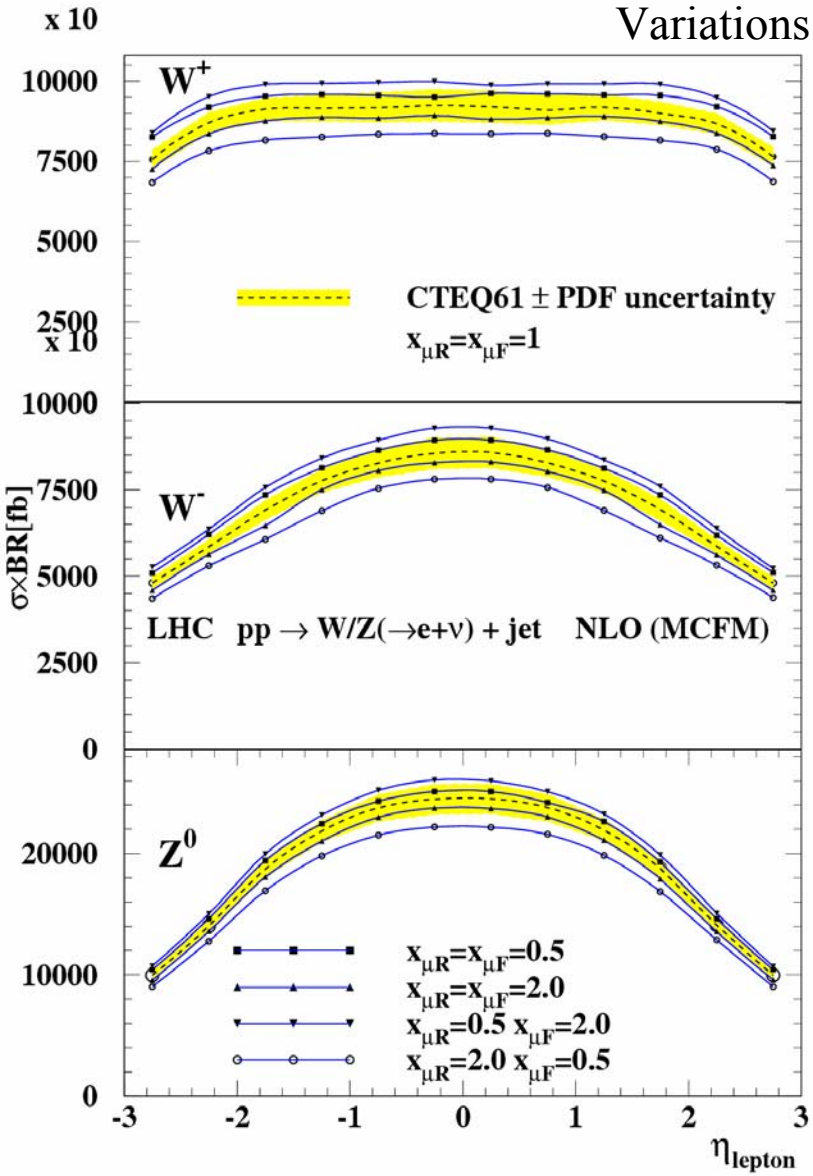
→ PDF uncertainty from CTEQ twice as large as MRST

→ CTEQ/MRST consistent within CTEQ band
~5% difference for central W^-

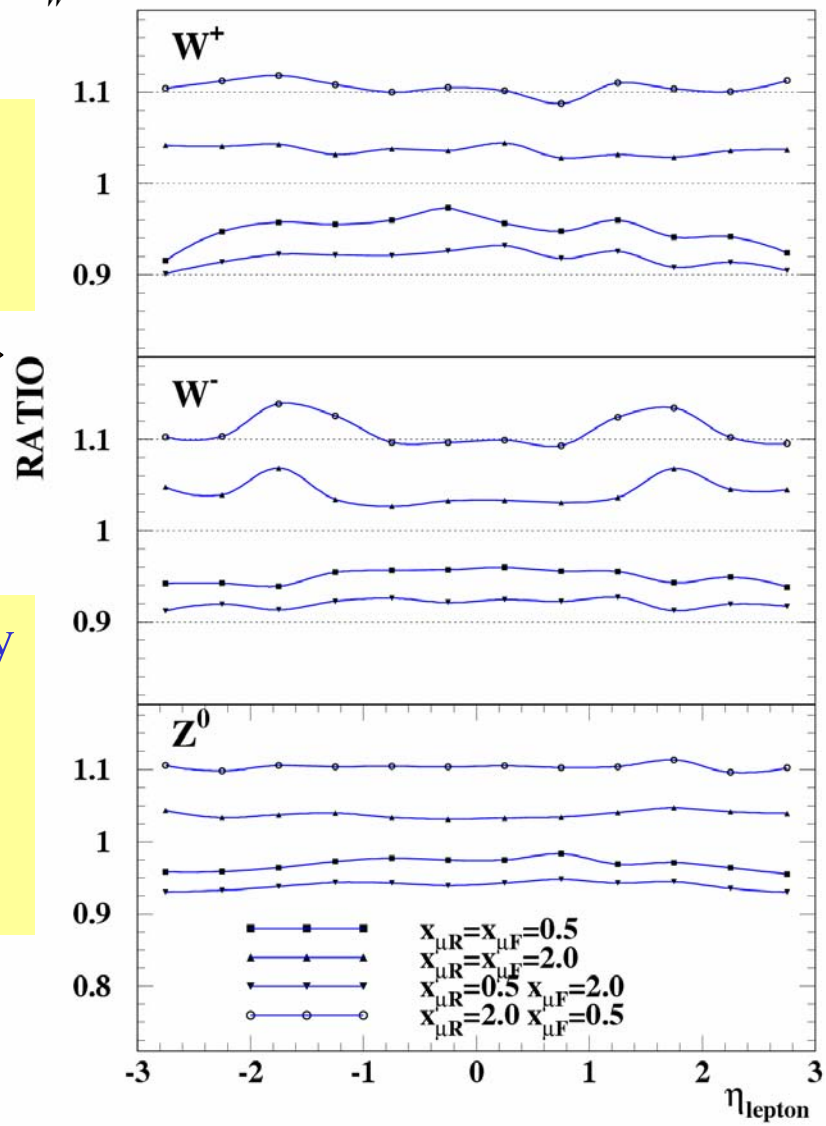
Perturbative uncertainties: scale variation

Nominal scales $\mu_R = \mu_F = M_W$ (resp. M_Z)

Variations $\frac{1}{2} < x_\mu < 2, \ \mu = x_\mu \cdot M_W$



Ratio wrt nominal scales



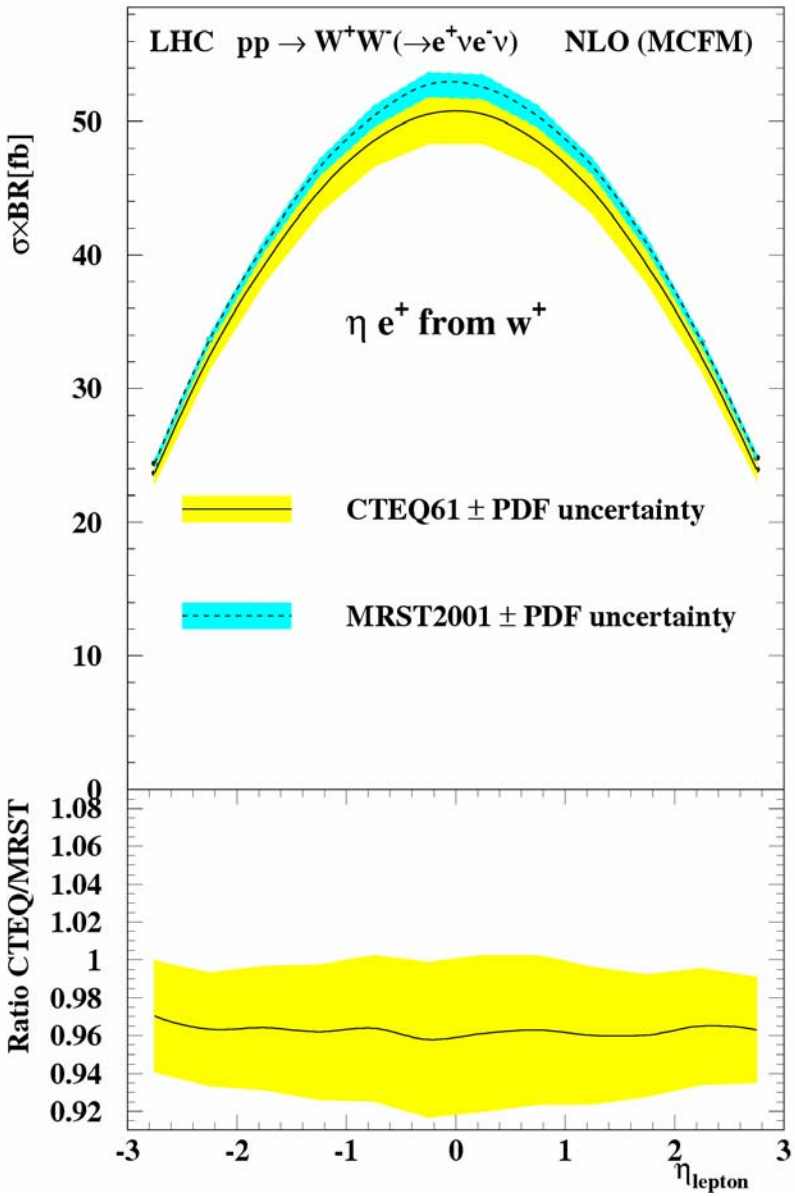
scale uncertainty +/- 10 % dominated by asymmetric scales

Total cross sections and uncertainties

	W^+ +jet	W^- +jet	Z^0 +jet	W^+	W^-
CTEQ61[pb]	1041.4	784.4	208.38	5595	4003
Δ_{PDF}[pb]	± 44.5	± 34.4	± 8.97	± 282	± 221
Δ_{PDF}[%]	± 4.3	± 4.4	± 4.3	± 5.0	± 5.5
MRST2001	1045.8	799.3	211.53	5480	4109
Δ_{PDF}[pb]	± 17.6	± 14.8	± 3.67	± 103	± 83.4
Δ_{PDF}[%]	± 1.7	± 1.9	±1.7	±1.9	±2.0
Δ_{Pert}[pb]	± 97.1	± 74.7	± 17.6		
Δ_{Pert}[%]	± 9.2	± 9.5	± 8.5		
exclusive	756.5	580.6	155.4		

Scale dependence at NNLO:
W^+: 1.05%
W^-: 1.03%
Z^0: 0.90%

WW pair production with leptonic final states

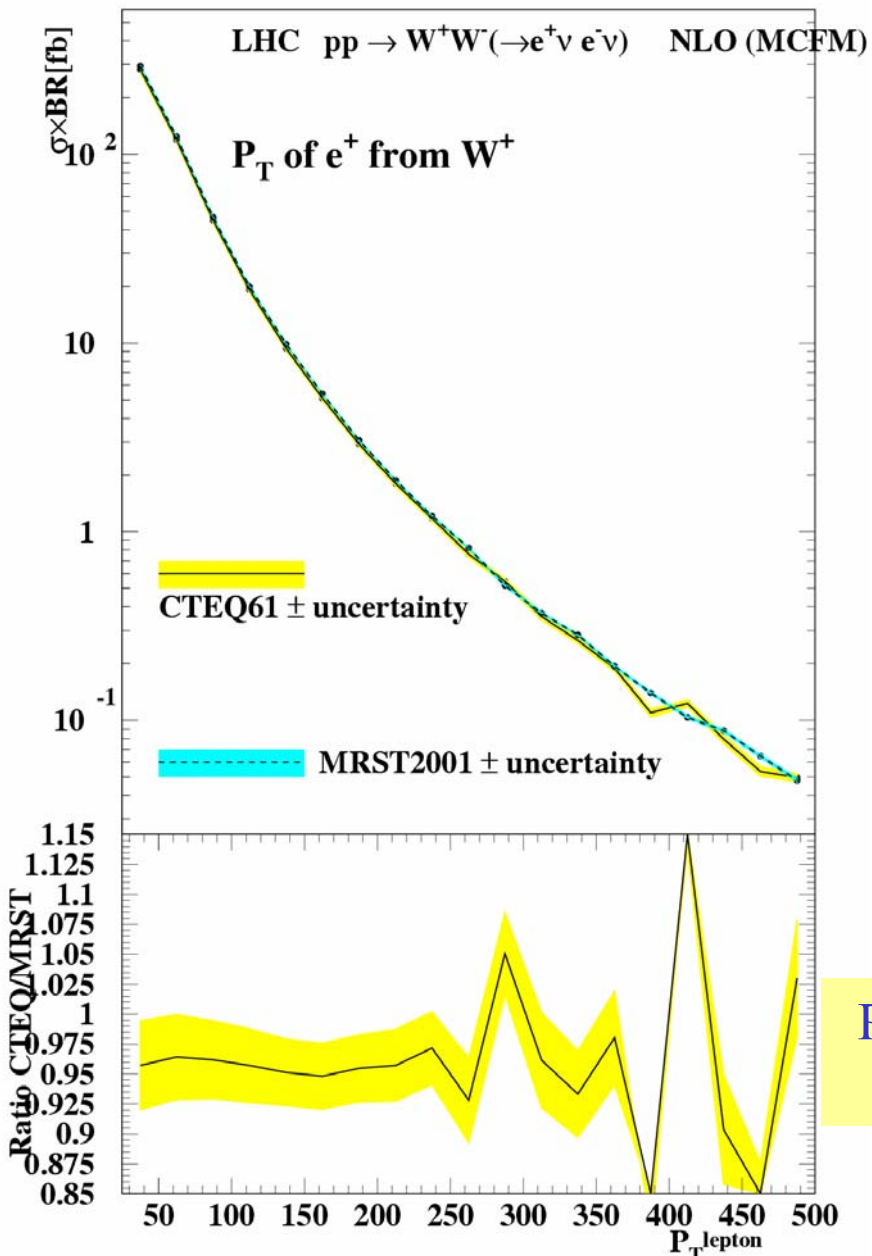


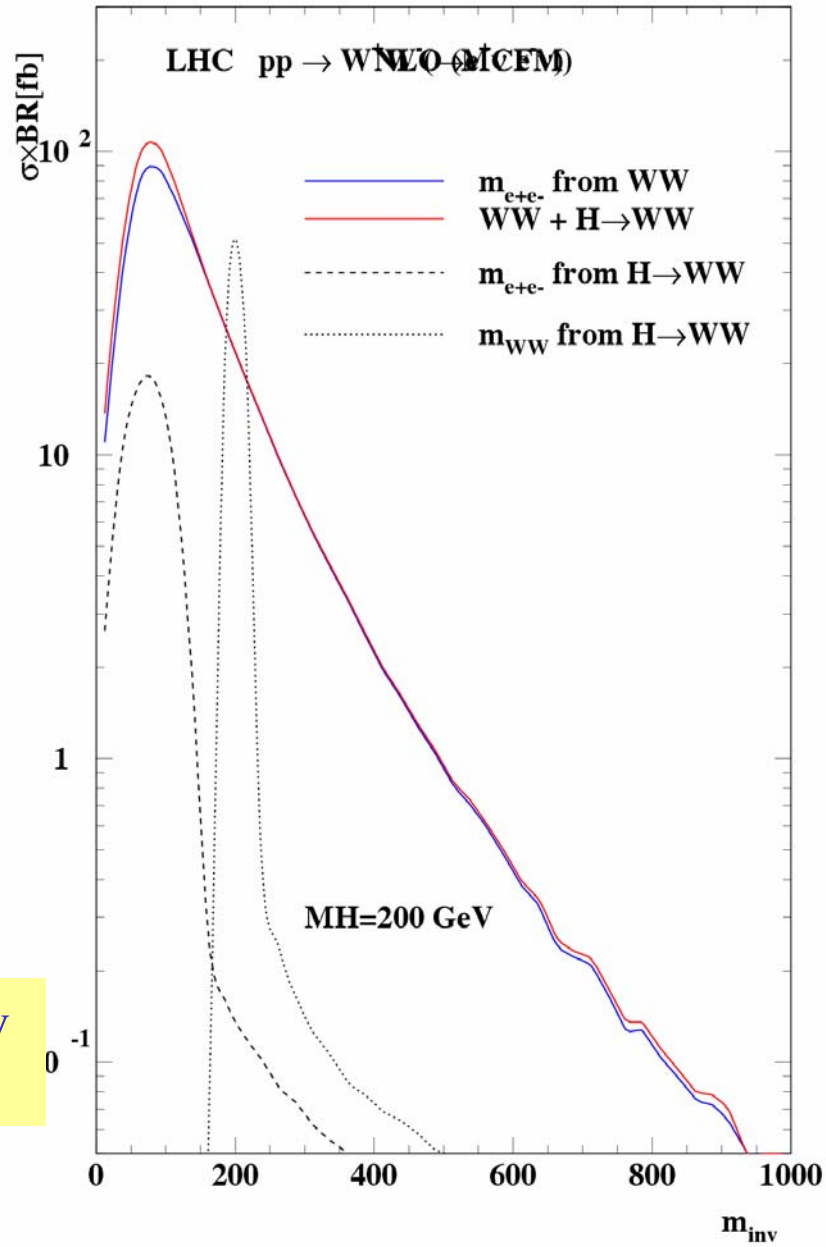
Experimental cuts for two leptons

p_T^{lept} >25 GeV
$\|\eta^{lept}\|$< 3.0
E_T^{miss} >25 GeV
R(lepton-lepton)> 0.2

PDF uncertainty +/- 3-4 % CTEQ and MRST consistents

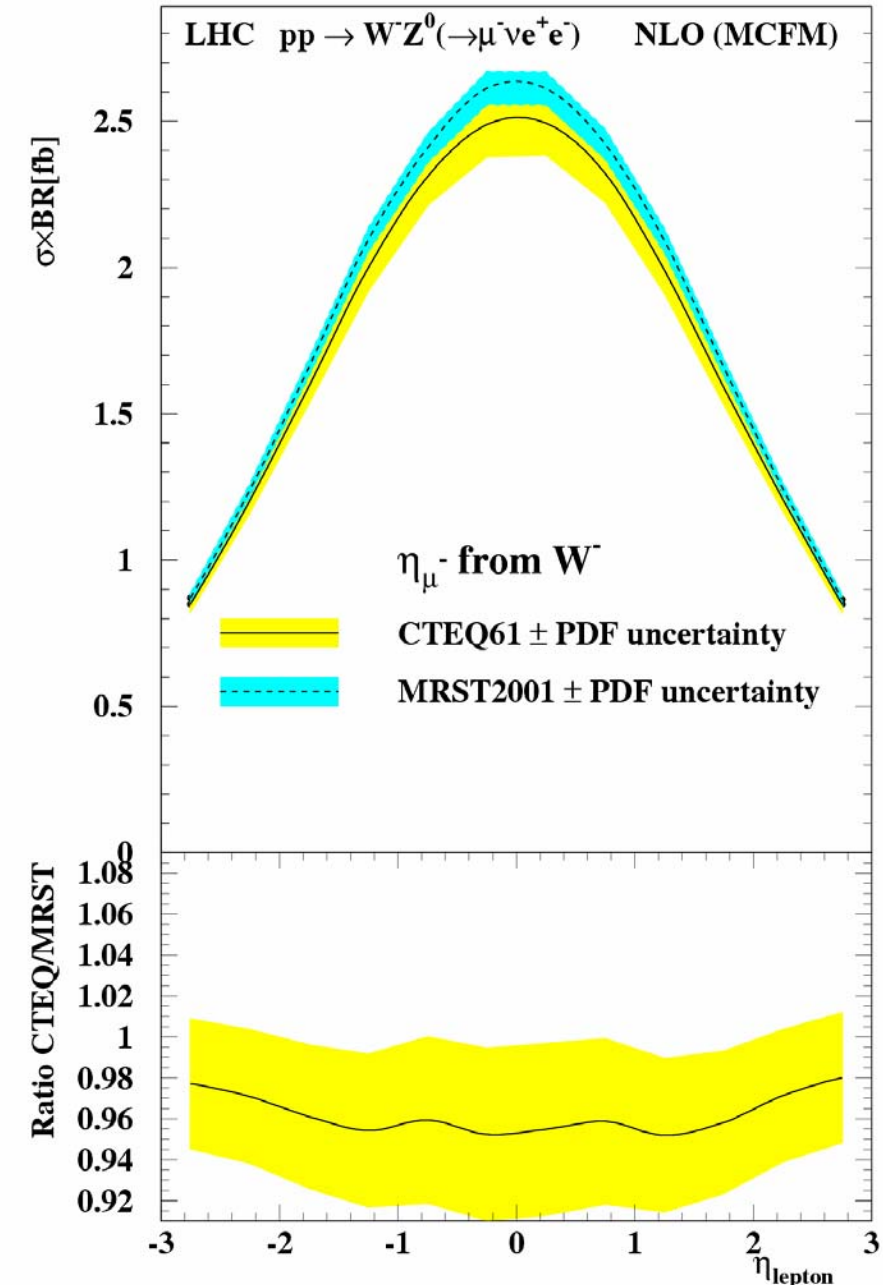
WW pair production: P_T and M_{inv}





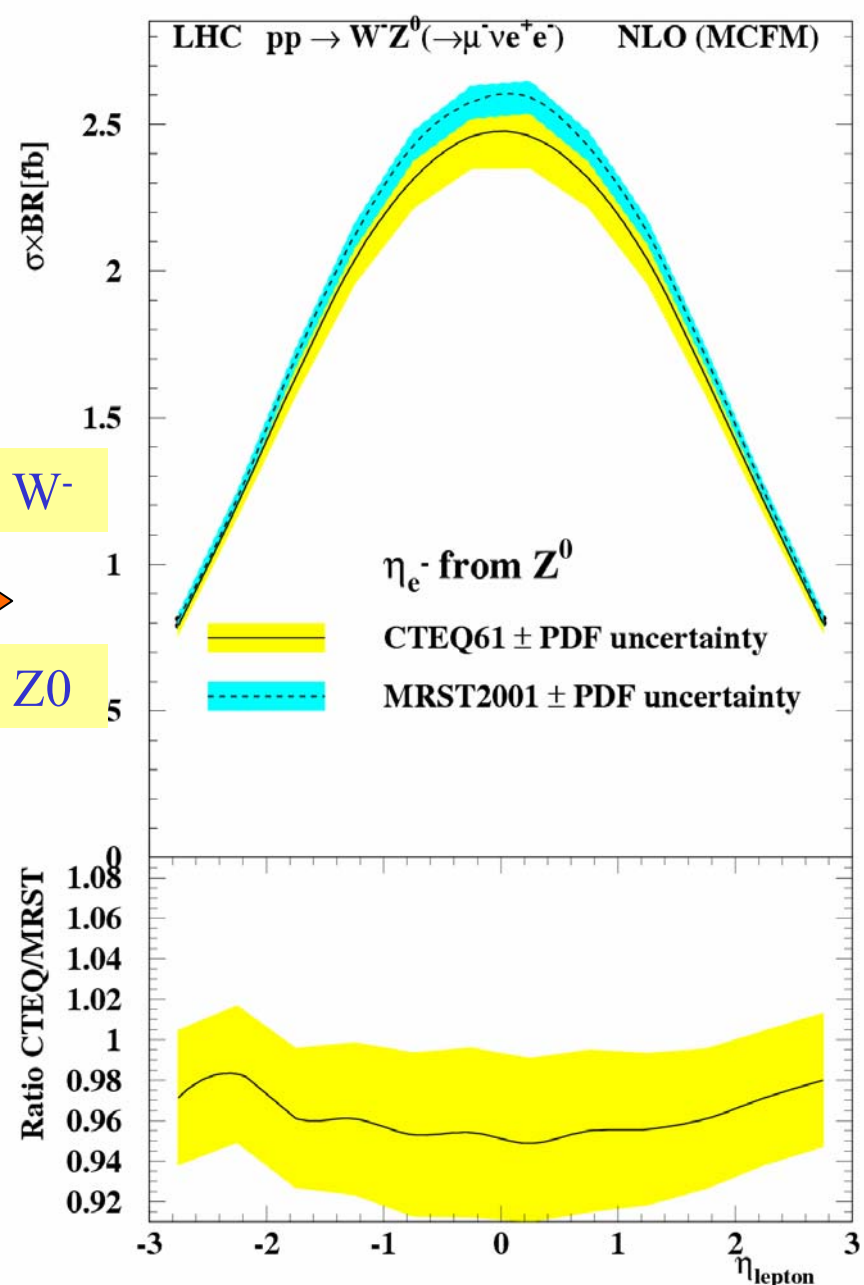
PDF uncertainty
+/- 3-4 %

Mixed pair production W^-Z^0

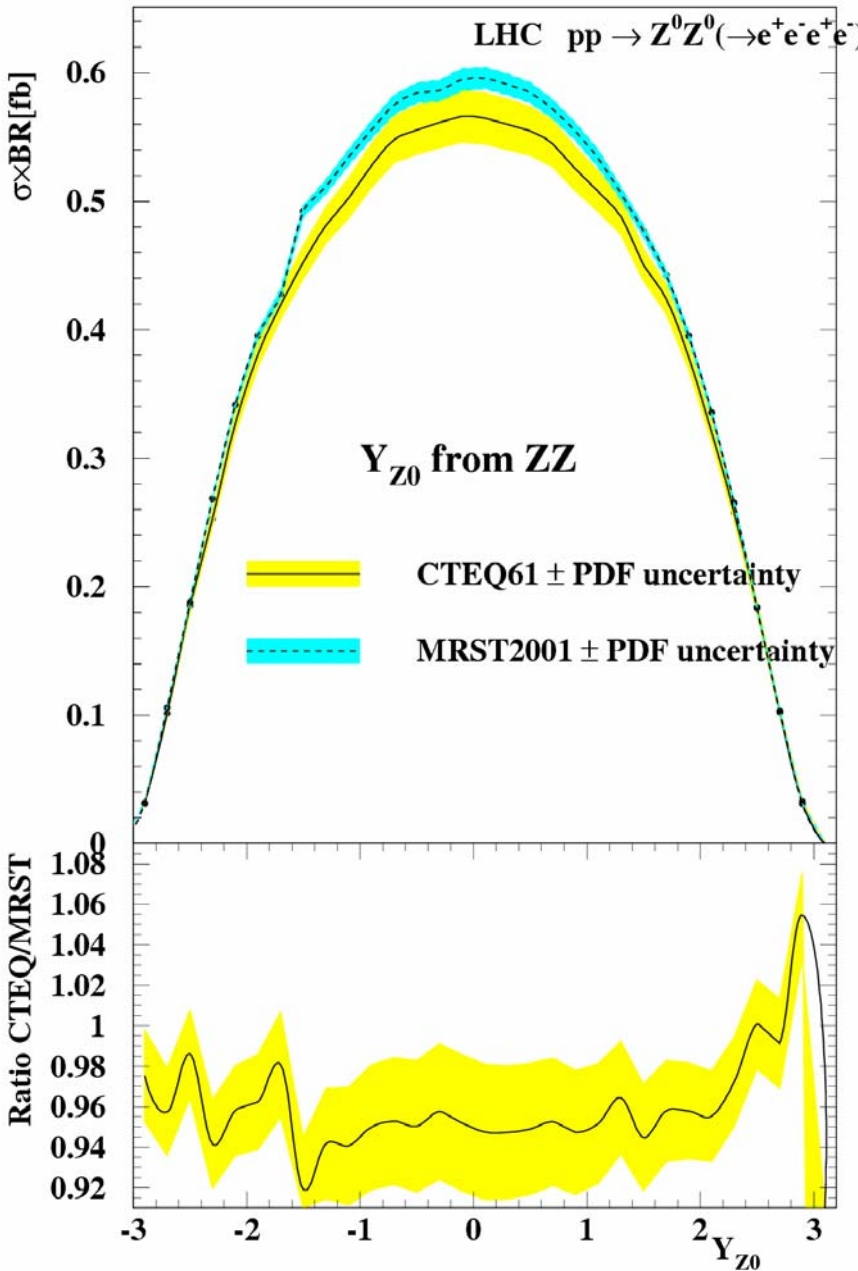


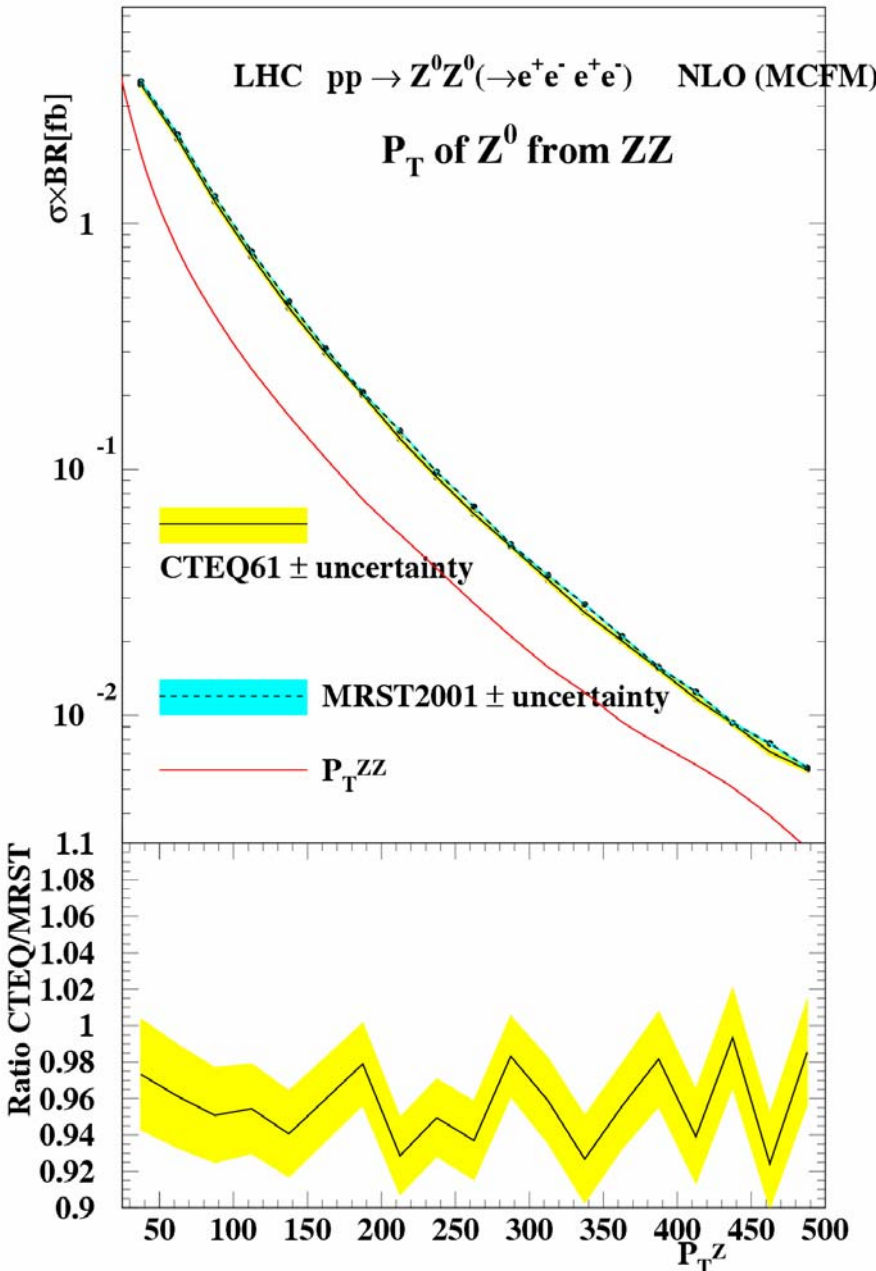
lepton from W^-

lepton from Z0

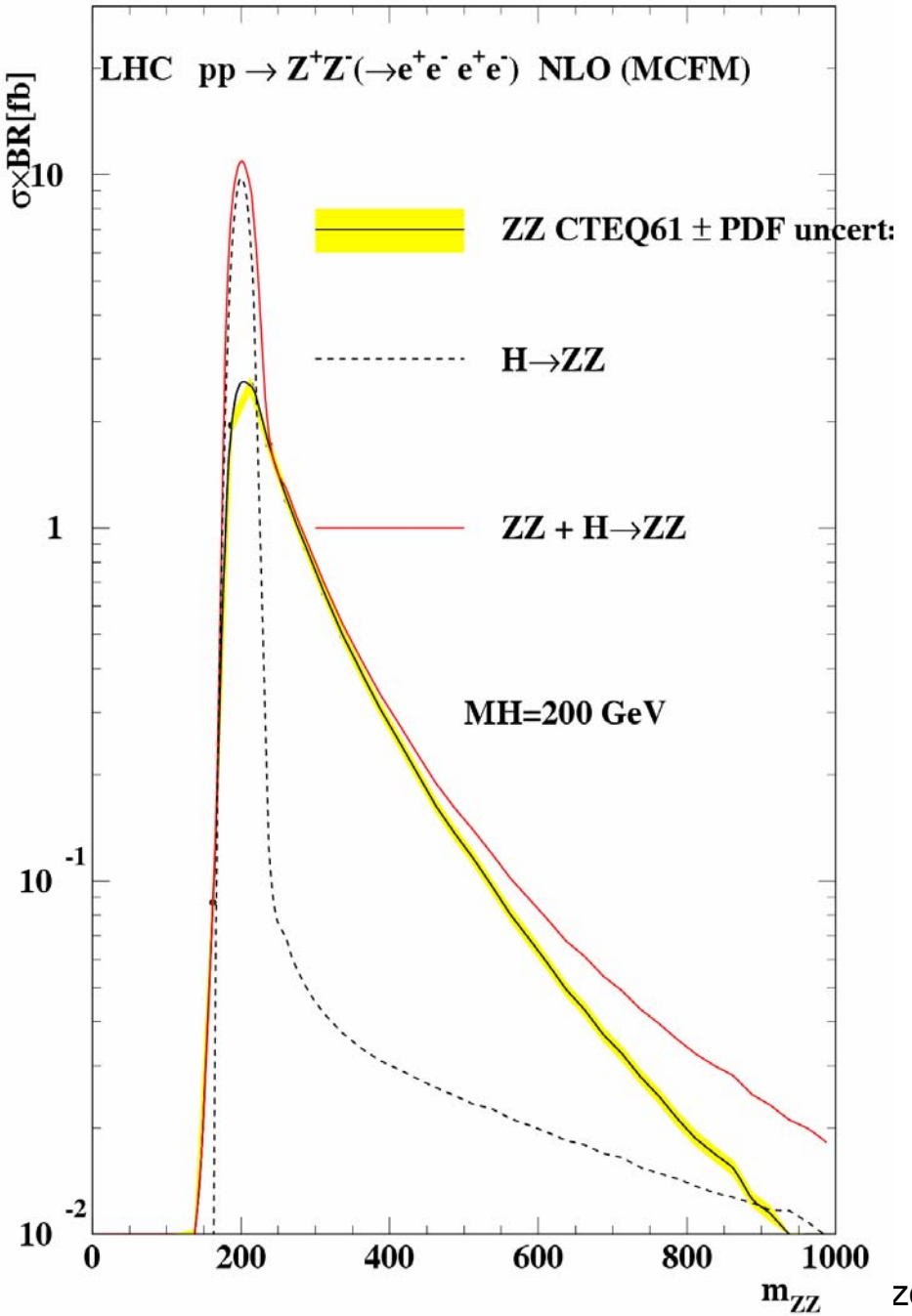


ZZ pair production





ZZ pair production



Scale dependence

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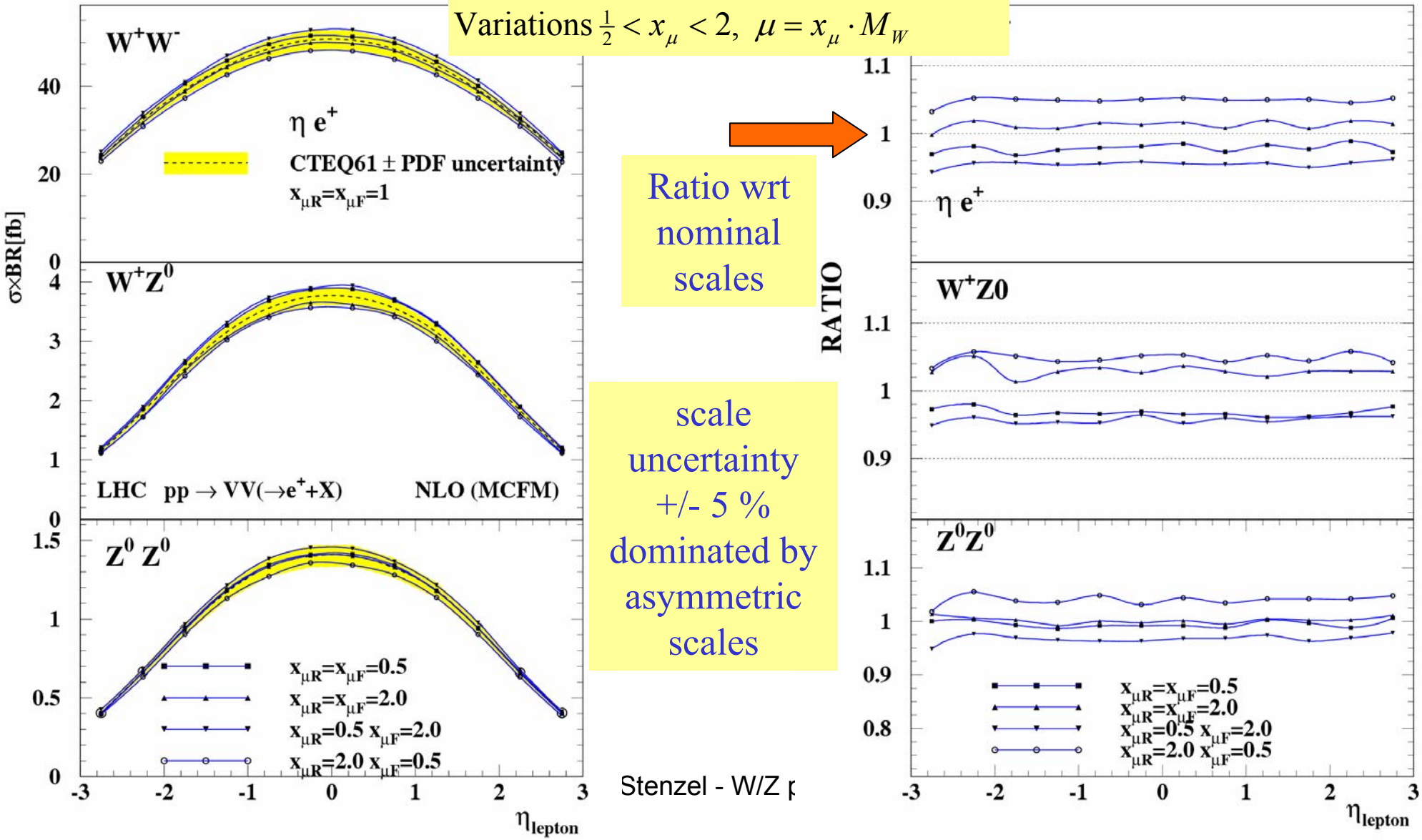
Variations $\frac{1}{2} < x_\mu < 2,\ \mu = x_\mu \cdot M_W$



Ratio wrt nominal scales

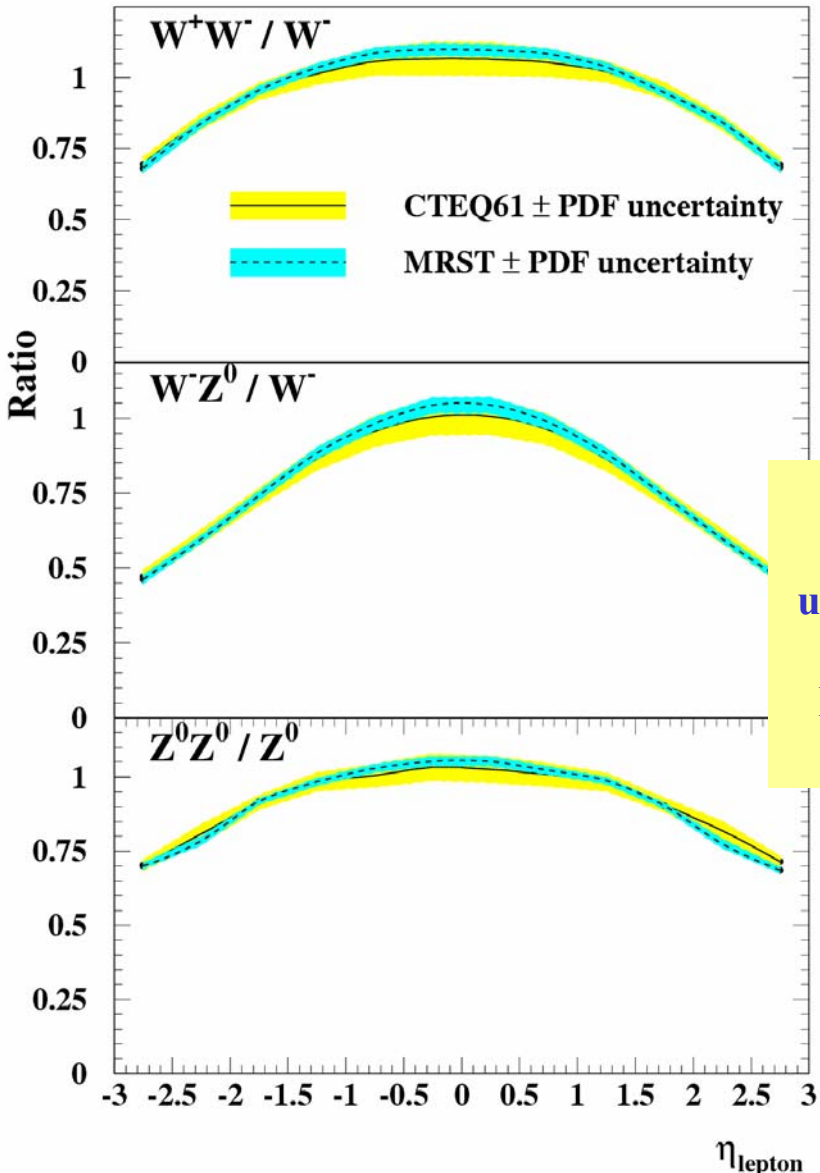
scale uncertainty +/- 5 % dominated by asymmetric scales

Total cross sections and uncertainties

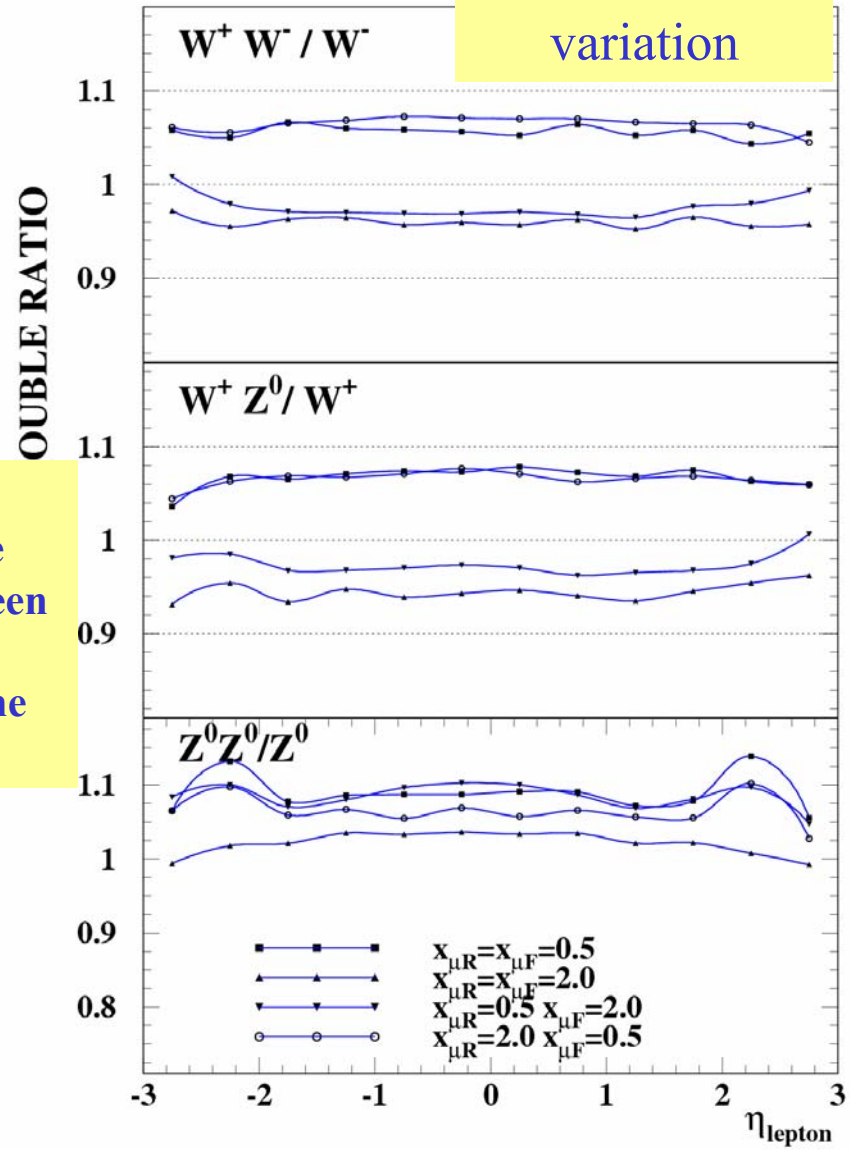
	$W^+ + W^-$	$W^+ + Z^0$	$W^- + Z^0$	$Z^0 + Z^0$
CTEQ61[fb]	475.72	31.803	20.774	11.745
Δ_{PDF}[fb]	± 17.02	± 1.12	± 0.796	± 0.483
Δ_{PDF}[%]	± 3.6	± 3.5	± 3.8	± 4.1
MRST2001	494.18	32.552	21.624	12.343
Δ_{PDF}[fb]	± 6.3	± 0.489	± 0.412	± 0.186
Δ_{PDF}[%]	± 1.3	± 1.5	±1.9	±1.6
Δ_{Pert}[fb]	± 22.1	± 1.49	± 0.97	± 0.38
Δ_{Pert}[%]	± 4.6	± 4.7	± 4.7	± 3.4

Ratio VV/V for lepton pseudo-rapidity

Double Ratio for scale variation



PDF and scale uncertainties are uncorrelated between VV and V
No reduction in the ratio!



Conclusions

- study of WW,WZ and ZZ production with experimental cuts
- differential distributions (rapidity, $P_{T,}$ m_{inv})
- systematic uncertainties:
  - PDF : 3.5-4%
  - Perturbative 3.6 – 4.1 %
- Systematics for VV and V is uncorrelated, does not cancel in the VV/V ratio

Summary of uncertainties

	W/Z	W/Z + jet	WW/ZZ
Δ_{PDF}[%]	± 5.3	± 4.3	± 3.7
Δ_{Pert}[%]	± 5.4	± 9.1	± 3.8