Update on LHCb results of particular relevance for PDFs

Ronan McNulty (UCD Dublin)

PDF meeting 23rd May 2012

Overview

- I will concentrate on the most recent results which are new since the last PDF4LHC
- Details on the measurements can be found elsewhere, in particular, Tara's talk from Monday at EW workshop.
  - 2010 W,Z results submitted to JHEP

    hep-ex 1204.1620
  - 2010 DY→μμ below the Z is conference note.

    LHCb-CONF-2012-013

Fiducial cross-sections (hep-ex 1204.1620)

Final 2010 results submitted to JHEP

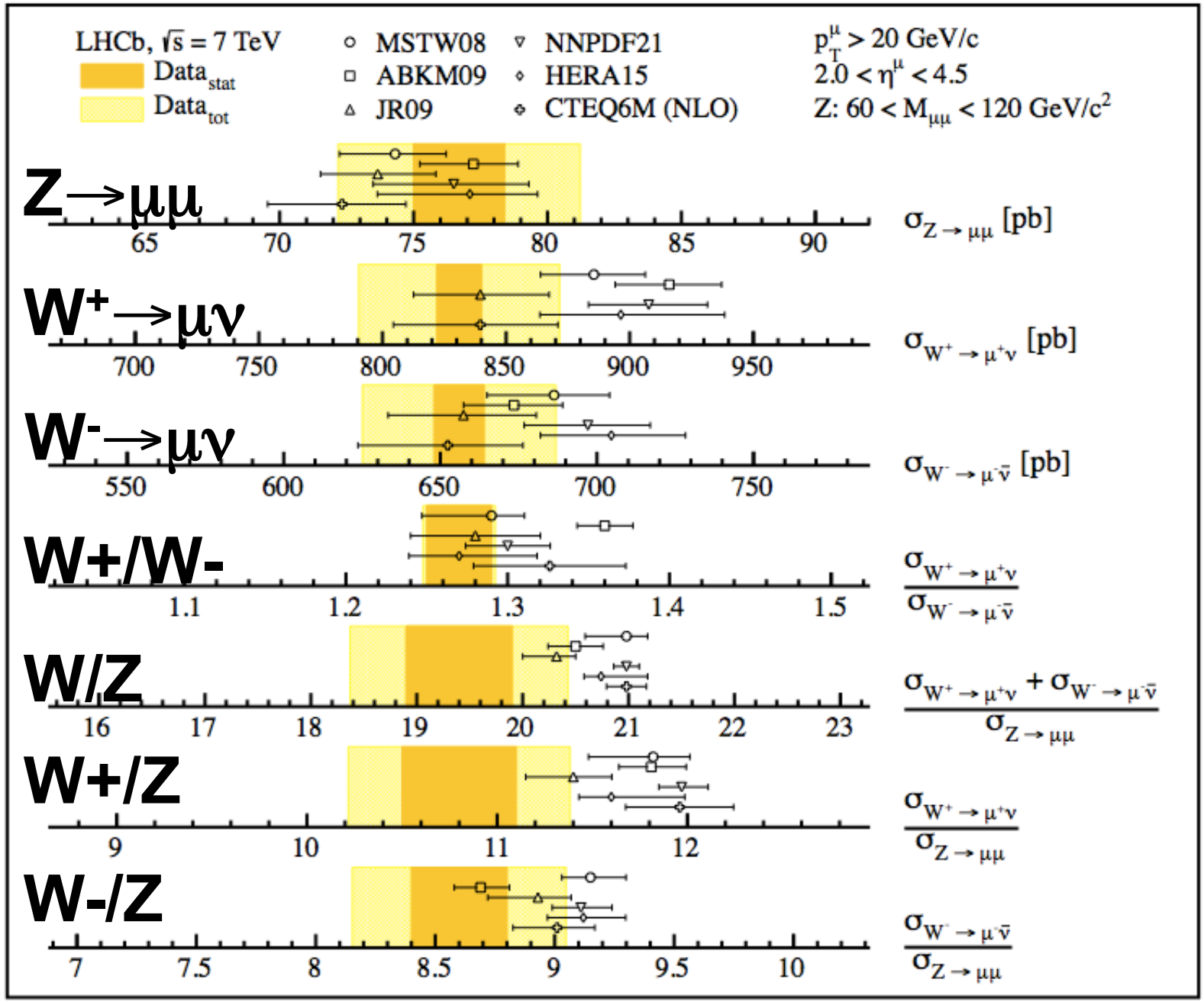
$2<\eta_\mu<4.5$

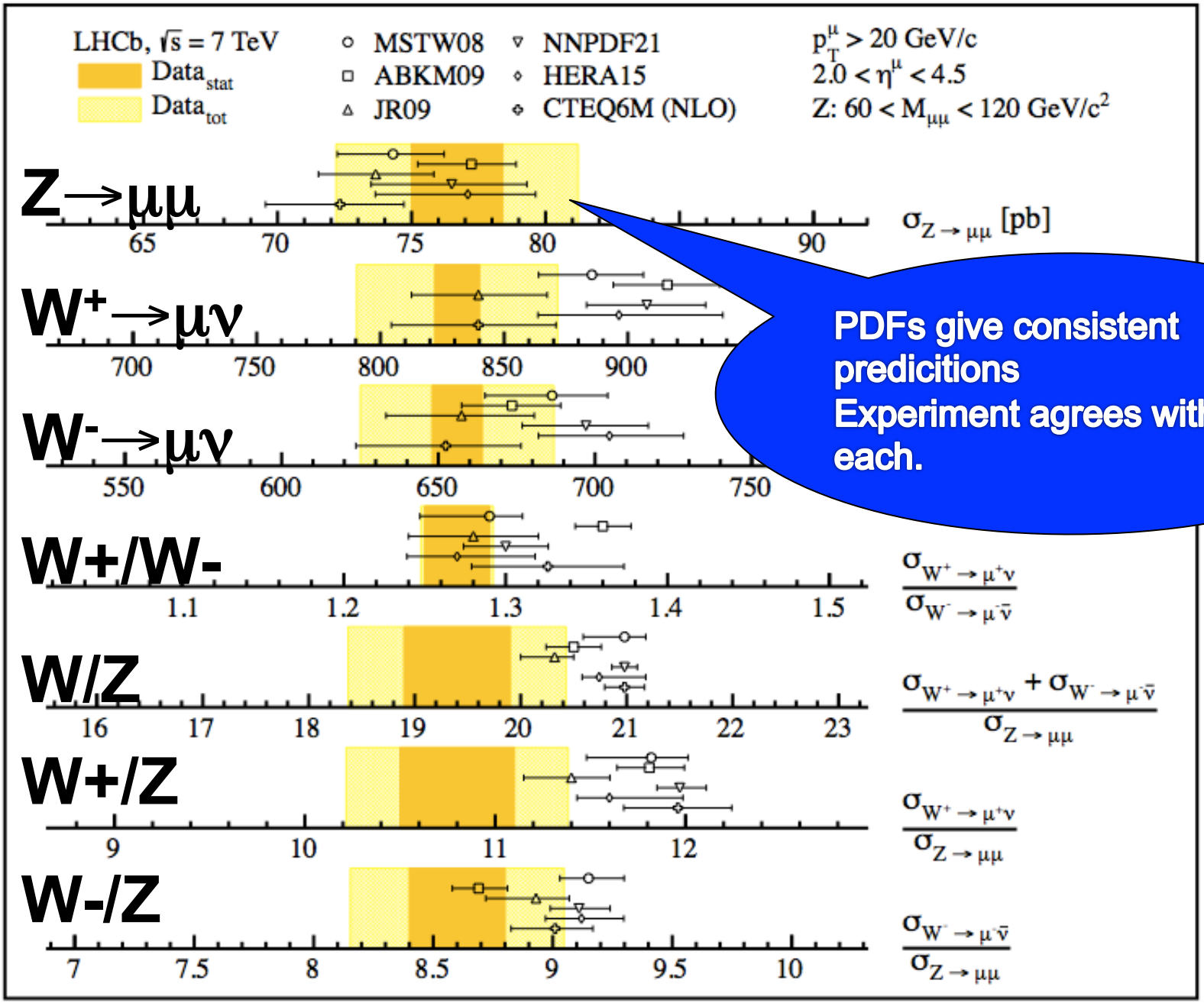
$$\sigma_{Z\to\mu\mu} = 76.7 \pm 1.7 \pm 3.3 \pm 2.7\,\text{pb}$$
$$\sigma_{W^+\to\mu^+\nu} = 831 \pm 9 \pm 27 \pm 29\,\text{pb}$$
$$\sigma_{W^-\to\mu^-\bar{\nu}} = 656 \pm 8 \pm 19 \pm 23\,\text{pb}\,,$$

Cross-sections corrected to Born level (QED) using PHOTOS interfaced to PYTHIA reweighted to DYNNLO

Source	$\Delta\sigma_{Z\to\mu\mu}$ (%)	$\Delta\sigma_{W^+\to\mu^+\nu}$ (%)	$\Delta\sigma_{W^-\to\mu^-\bar{\nu}}$ (%)
Signal purity	±0.1	±1.2	±0.9
Template shape (fit)	–	±0.9	±1.0
Efficiency (trigger, tracking, muon id)	±4.3	±2.2	±2.0
Additional selection	–	±1.8	±1.7
FSR correction	±0.02	±0.01	±0.02
Total	±4.3	±3.2	±2.9
Luminosity	±3.5	±3.5	±3.5

Most systematics are statistical in nature and will reduce ~5 with 2011 data


LHCb, √s = 7 TeV
Data_stat
Data_tot
MSTW08
ABKM09
JR09
NNPDF21
HERA15
CTEQ6M (NLO)
p_T^μ > 20 GeV/c
2.0 < η^μ < 4.5
Z: 60 < M_μμ < 120 GeV/c²
Z→μμ
65 70 75 80 85 90
σ_Z→μμ [pb]
W+→μν
700 750 800 850 900 950
σ_W+→μ+ν [pb]
W-→μν
550 600 650 700 750
σ_W-→μ-ν̄ [pb]
W+/W-
1.1 1.2 1.3 1.4 1.5
σ_W+→μ+ν / σ_W-→μ-ν̄
W/Z
16 17 18 19 20 21 22 23
(σ_W+→μ+ν + σ_W-→μ-ν̄) / σ_Z→μμ
W+/Z
9 10 11 12
σ_W+→μ+ν / σ_Z→μμ
W-/Z
7 7.5 8 8.5 9 9.5 10
σ_W-→μ-ν̄ / σ_Z→μμ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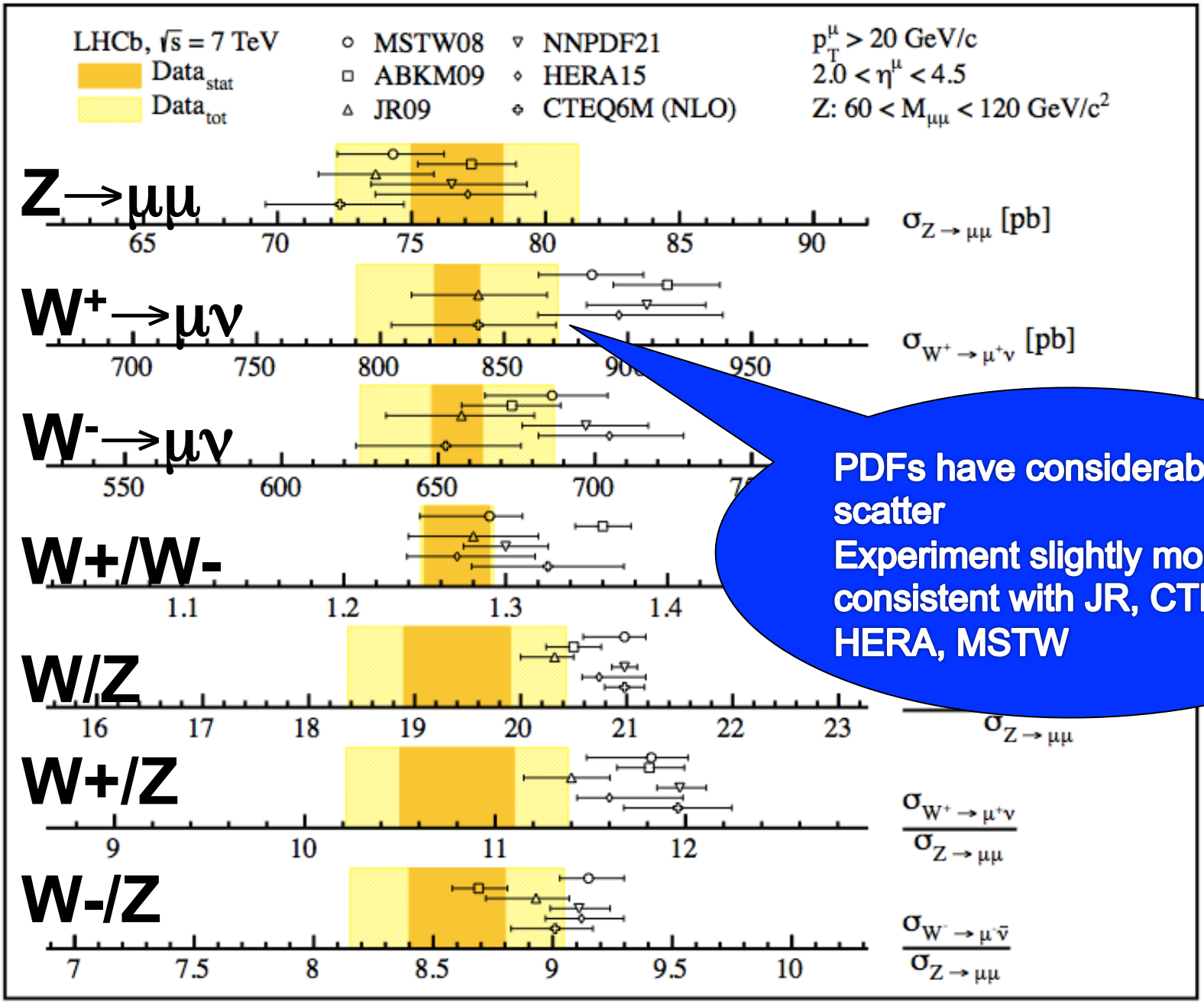
(σ_W+→μ+ν + σ_W-→μ-ν̄) / σ_Z→μμ
W+/Z
σ_W+→μ+ν / σ_Z→μμ
W-/Z
σ_W-→μ-ν̄ / σ_Z→μμ
PDFs give consistent predicitions
Experiment agrees with each.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W/Z
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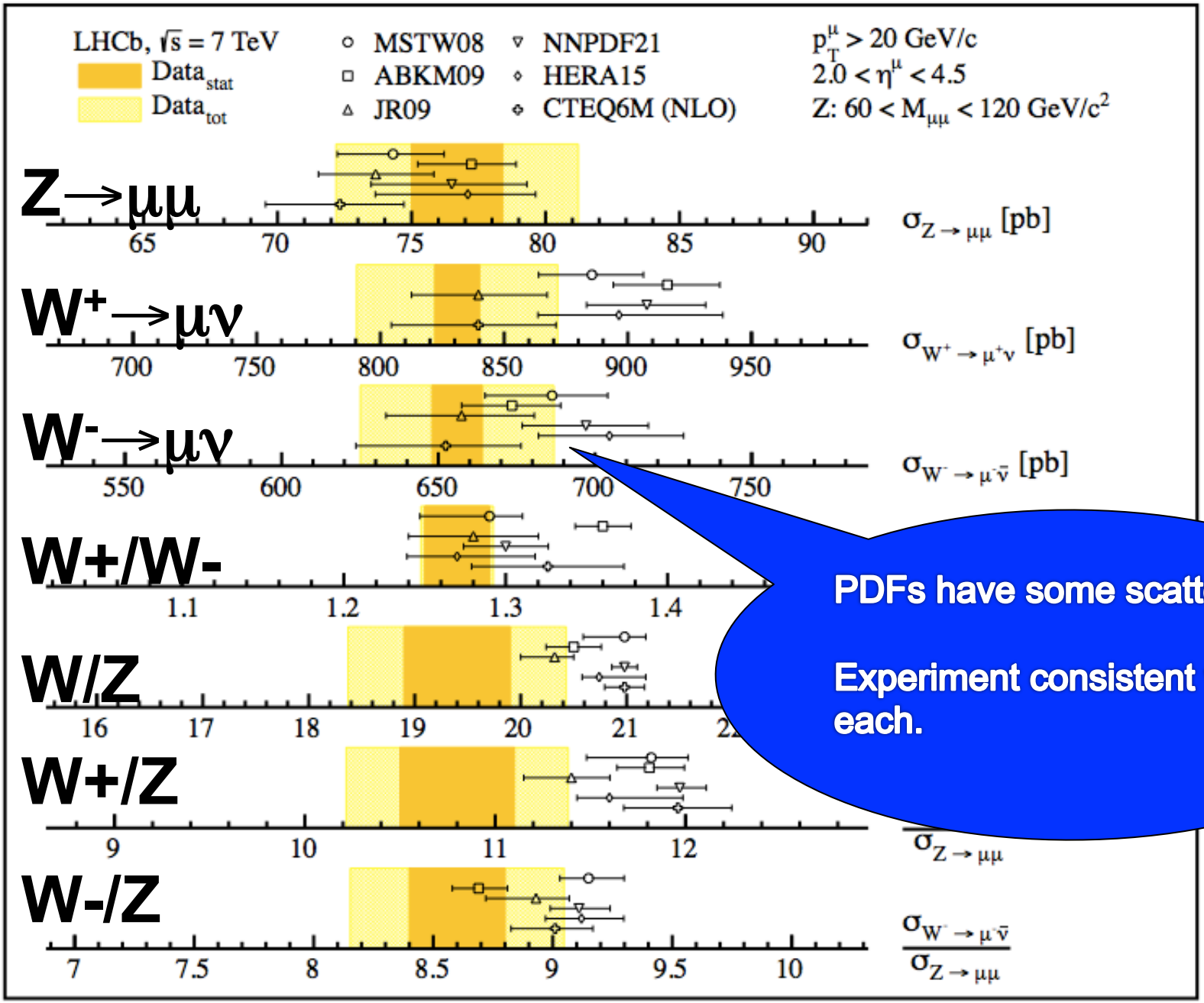
W-/Z
σ_W+→μ+ν / σ_Z→μμ
σ_W-→μ-ν̄ / σ_Z→μμ
PDFs have considerable scatter
Experiment slightly more consistent with JR, CTEQ, HERA, MSTW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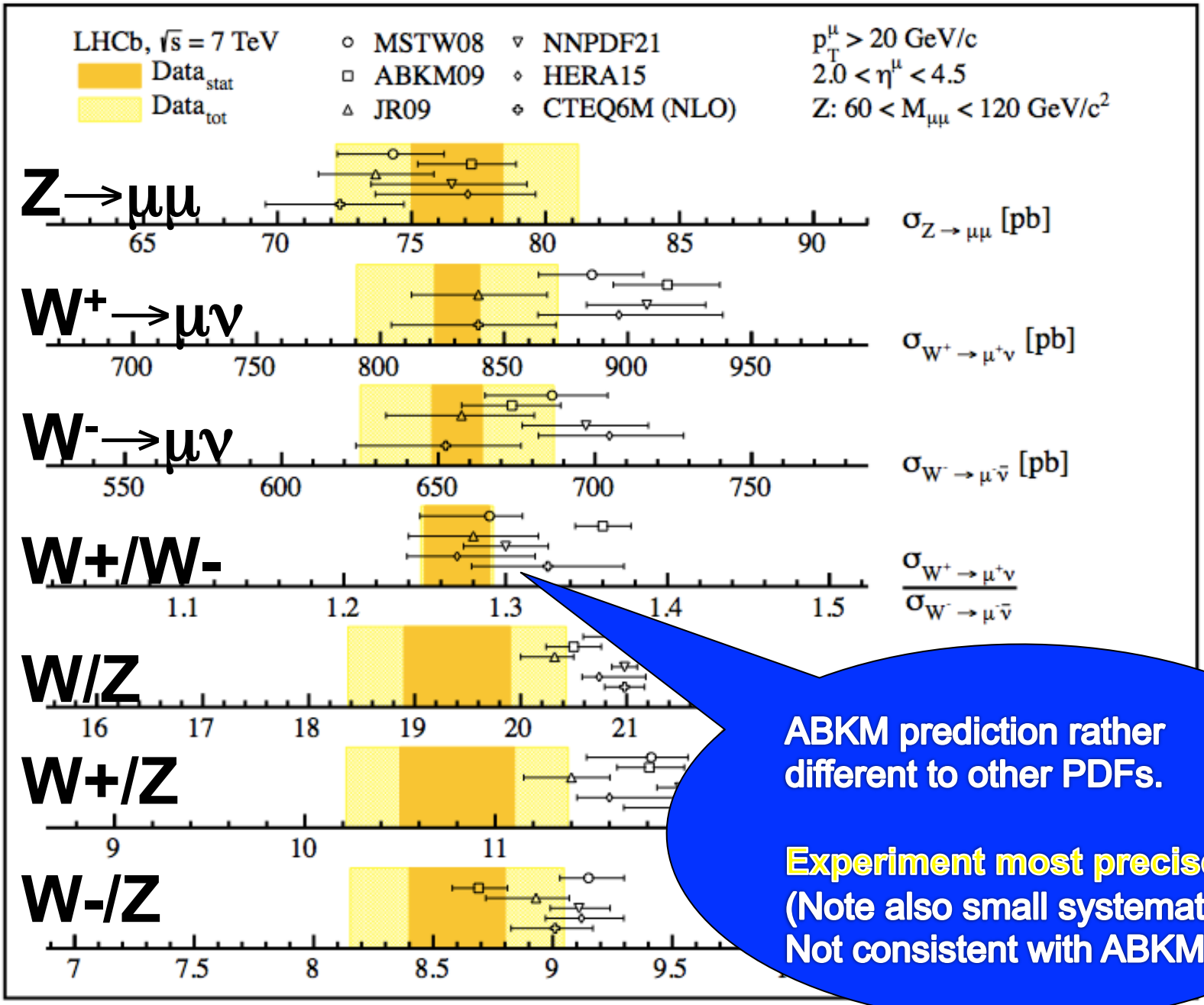
σ_W+→μ+ν [pb]
W-→μν
σ_W-→μ-ν̄ [pb]
W+/W-
W/Z
W+/Z
W-/Z
σ_W-→μ-ν̄ / σ_Z→μμ
PDFs have some scatter.
Experiment consistent with each.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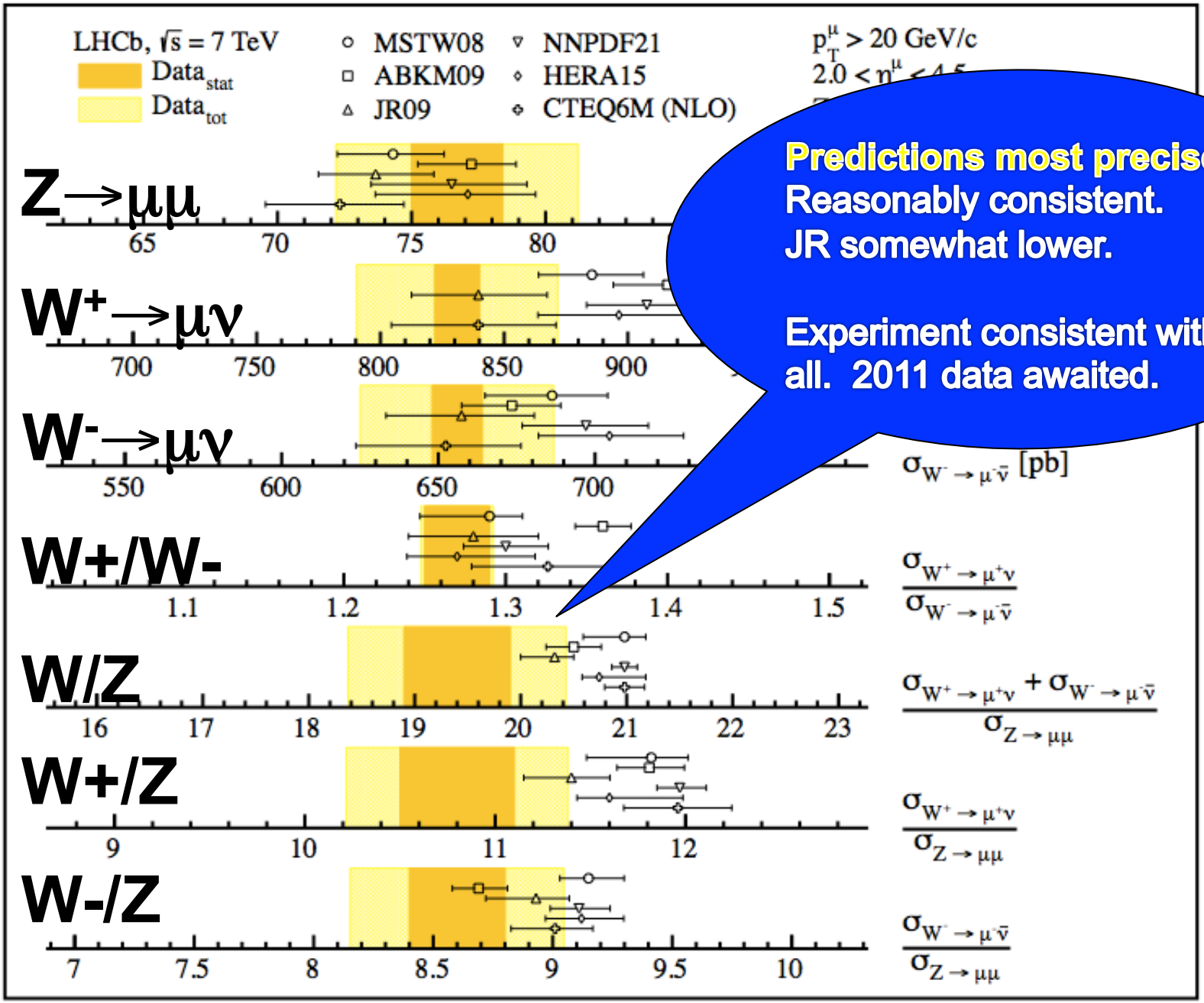
W-→μν
σ_W-→μ-ν̄ [pb]
W+/W-
σ_W+→μ+ν / σ_W-→μ-ν̄
W/Z
W+/Z
W-/Z
ABKM prediction rather different to other PDFs.
Experiment most precise.
(Note also small systematic)
Not consistent with ABKM.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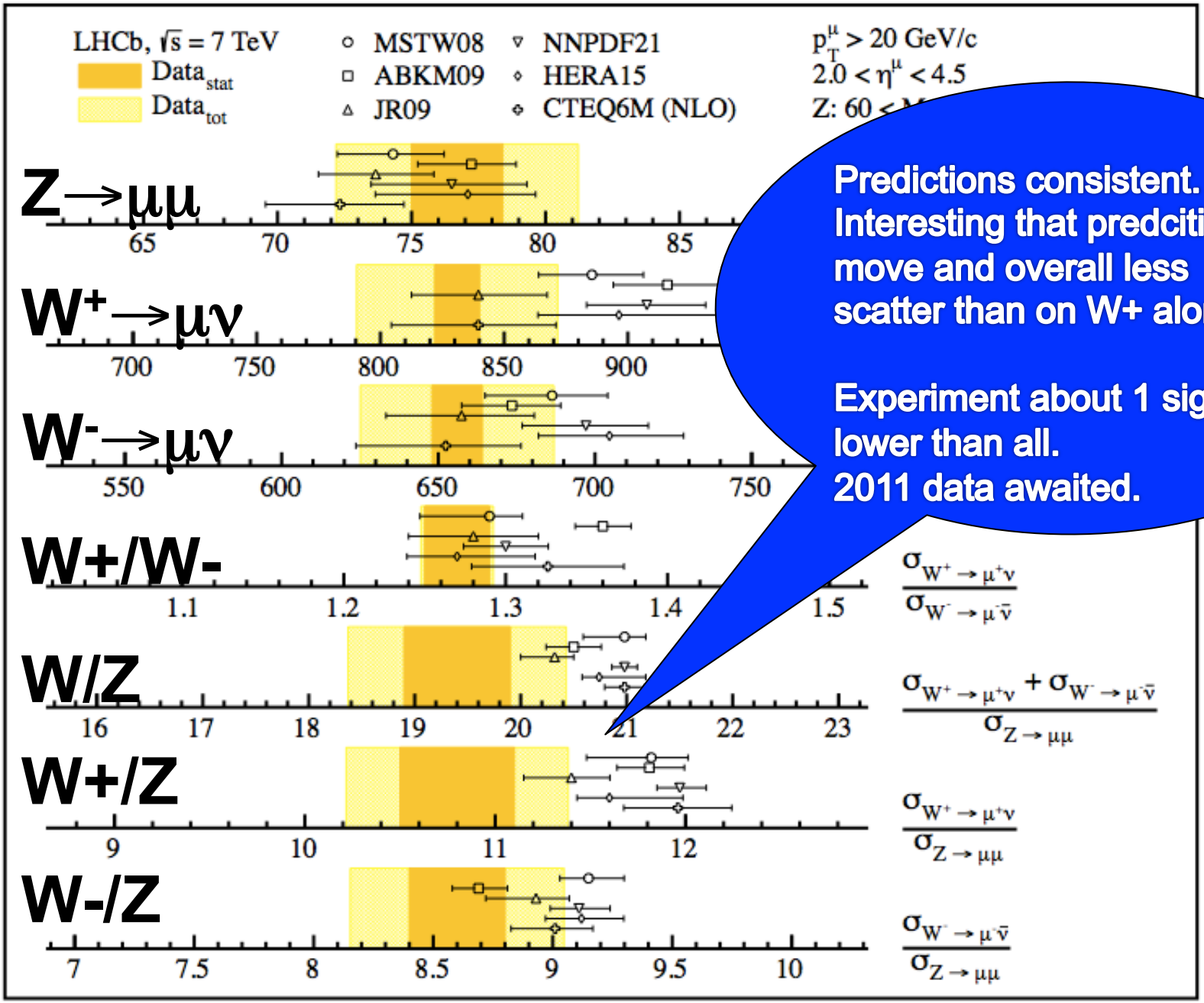
σ_W⁻→μ⁻ν̄ [pb]
σ_W⁺→μ⁺ν / σ_W⁻→μ⁻ν̄
(σ_W⁺→μ⁺ν + σ_W⁻→μ⁻ν̄) / σ_Z→μμ
σ_W⁺→μ⁺ν / σ_Z→μμ
σ_W⁻→μ⁻ν̄ / σ_Z→μμ
Predictions most precise.
Reasonably consistent.
JR somewhat lower.
Experiment consistent with all. 2011 data awaited.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700 750 800 850 900
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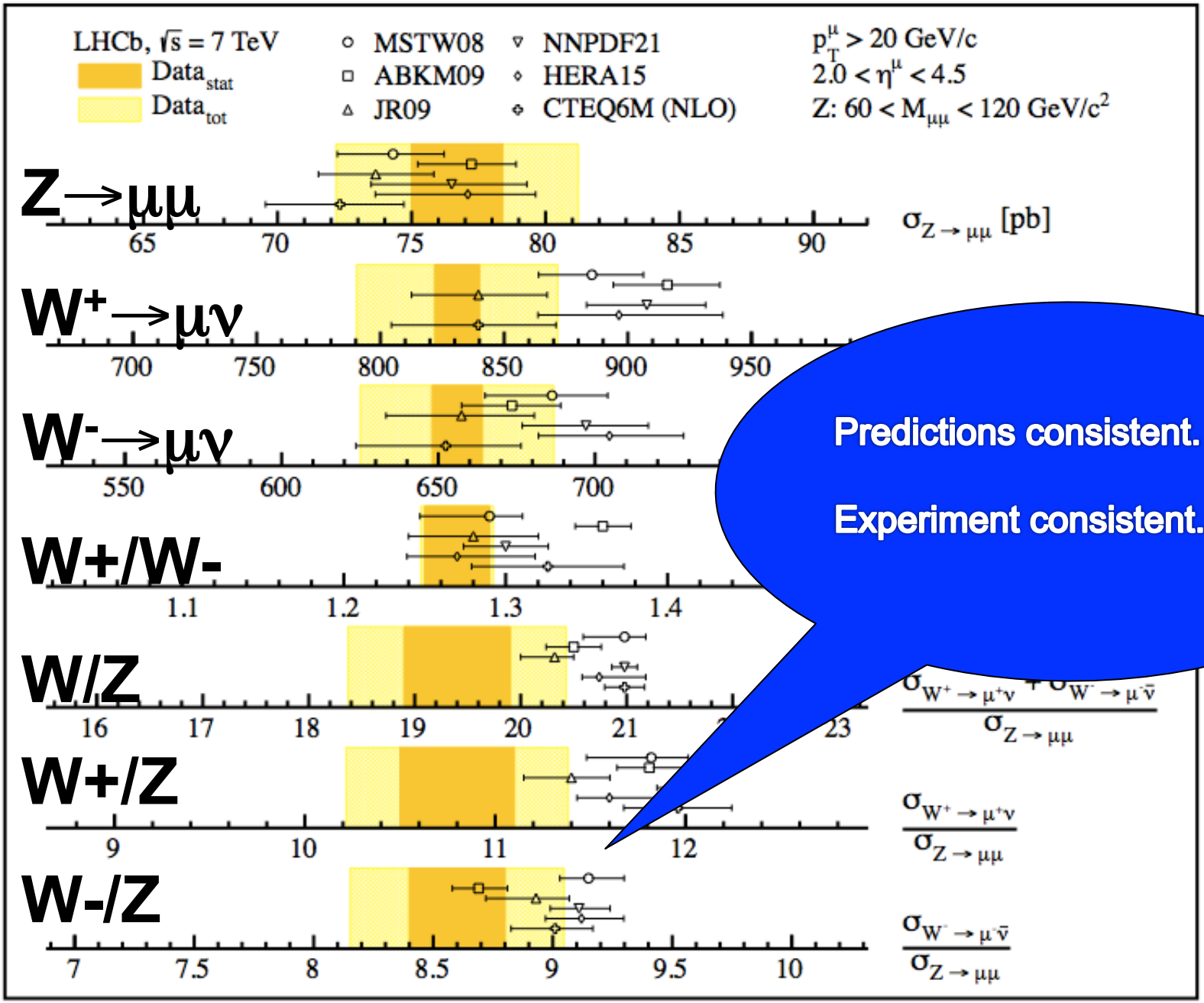
1.1 1.2 1.3 1.4 1.5
σ(W+ → μ+ν) / σ(W- → μ-ν̄)
W/Z
16 17 18 19 20 21 22 23
(σ(W+ → μ+ν) + σ(W- → μ-ν̄)) / σ(Z → μμ)
W+/Z
9 10 11 12
σ(W+ → μ+ν) / σ(Z → μμ)
W-/Z
7 7.5 8 8.5 9 9.5 10
σ(W- → μ-ν̄) / σ(Z → μμ)
Predictions consistent.
Interesting that predcitions move and overall less scatter than on W+ alone.
Experiment about 1 sigma lower than all.
2011 data awaited.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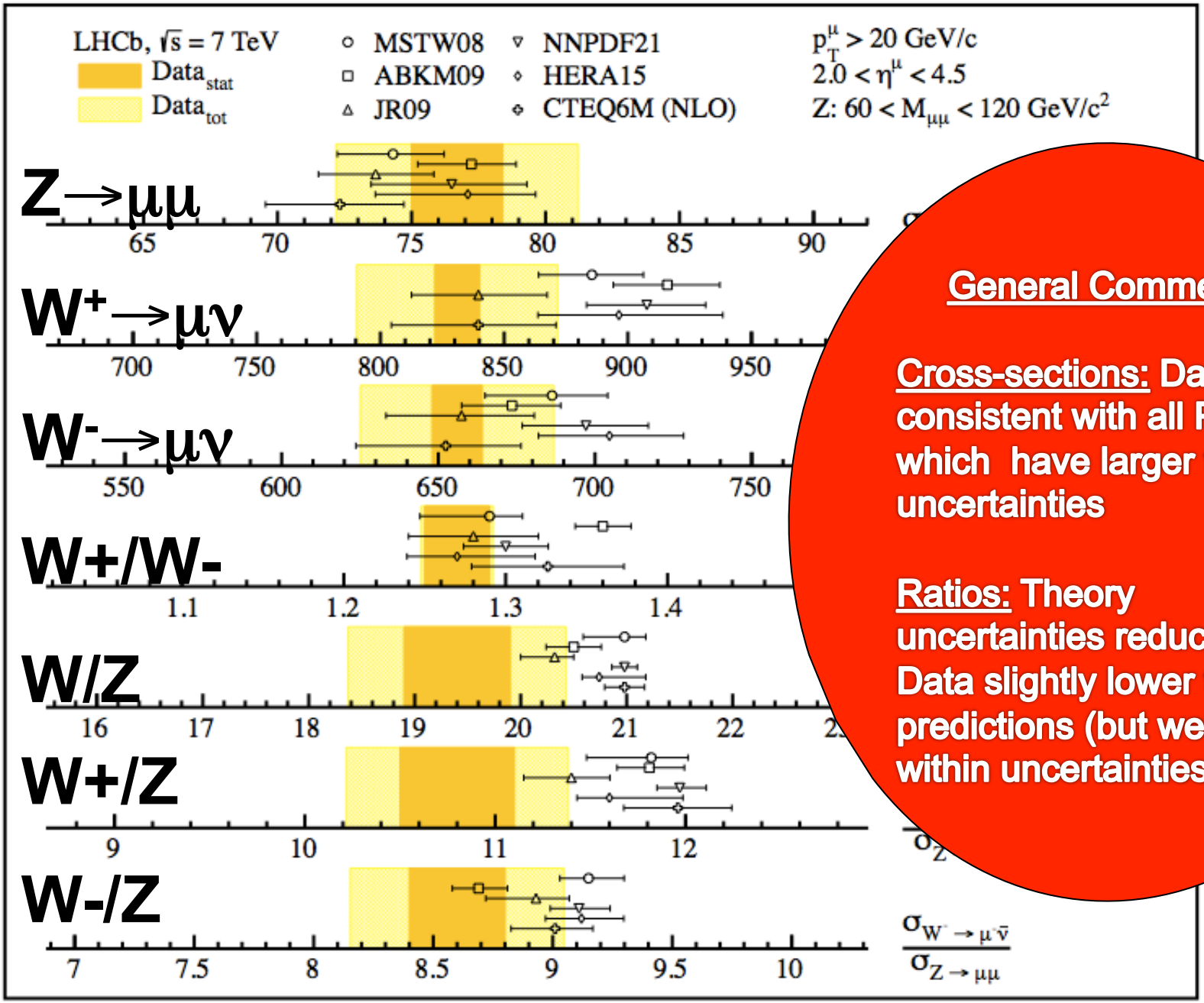
Predictions consistent.
Experiment consistent.

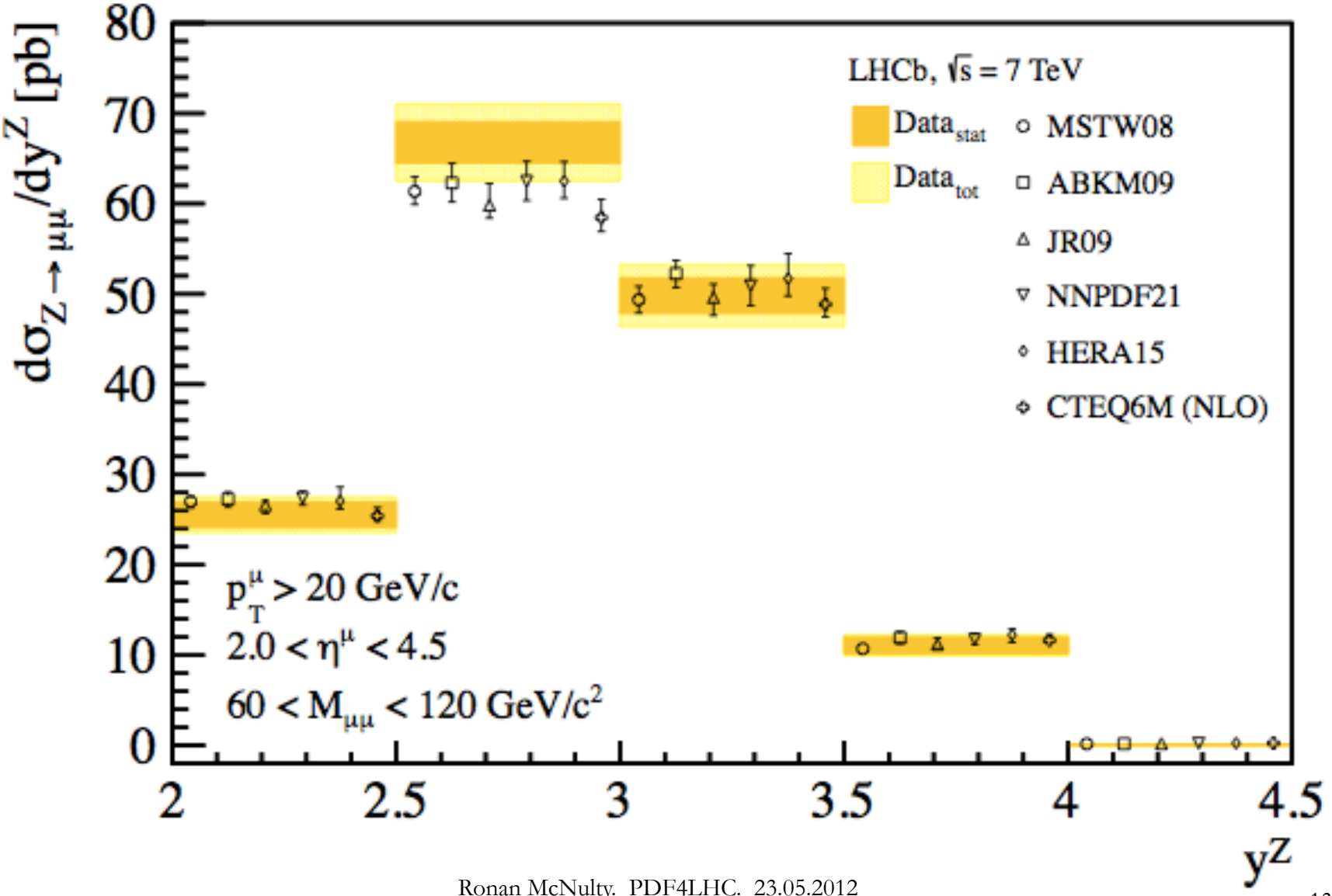


General Comments

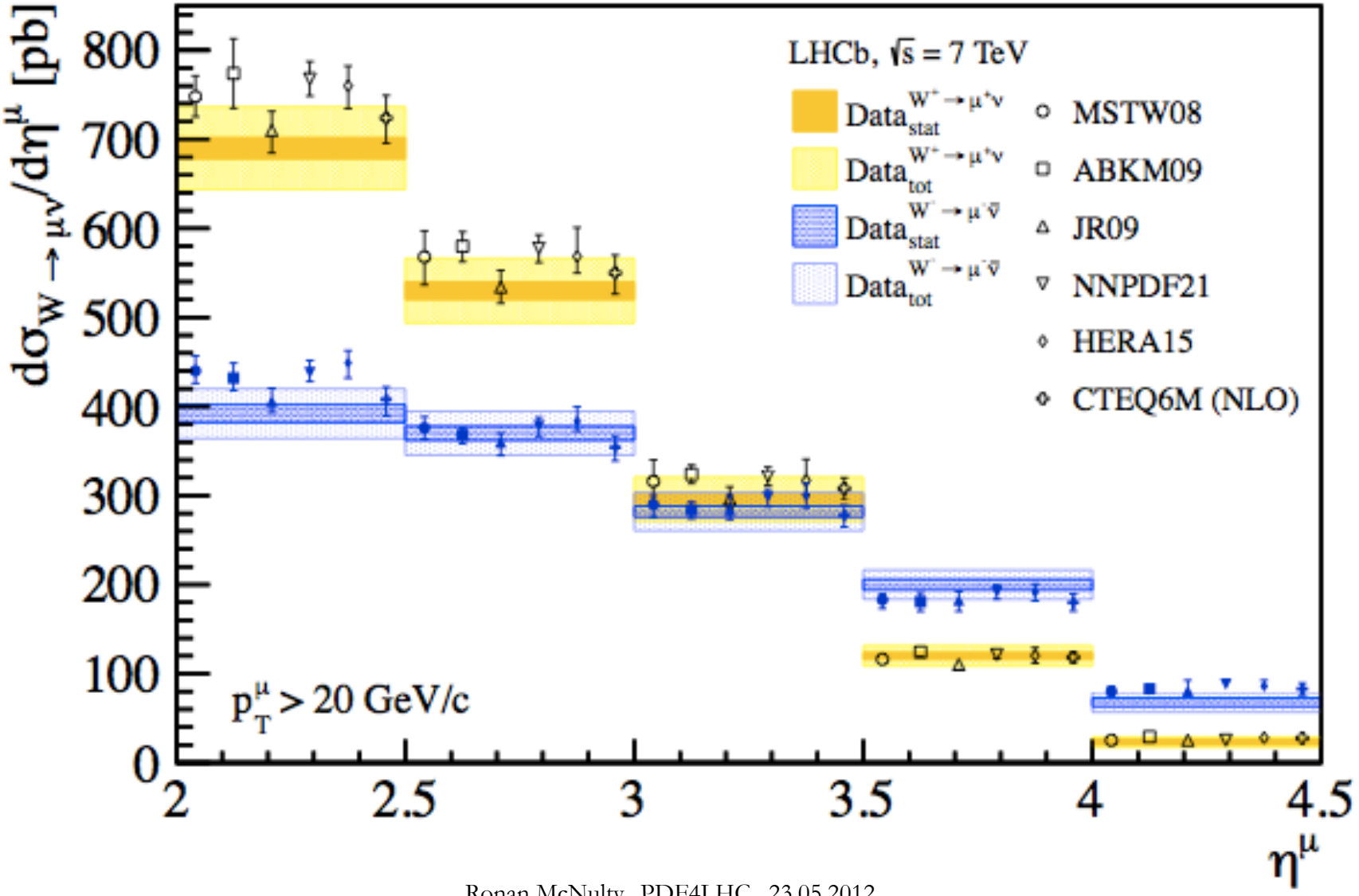
Cross-sections: Data consistent with all PDFs which have larger theory uncertainties

Ratios: Theory uncertainties reduce. Data slightly lower than predictions (but well within uncertainties)

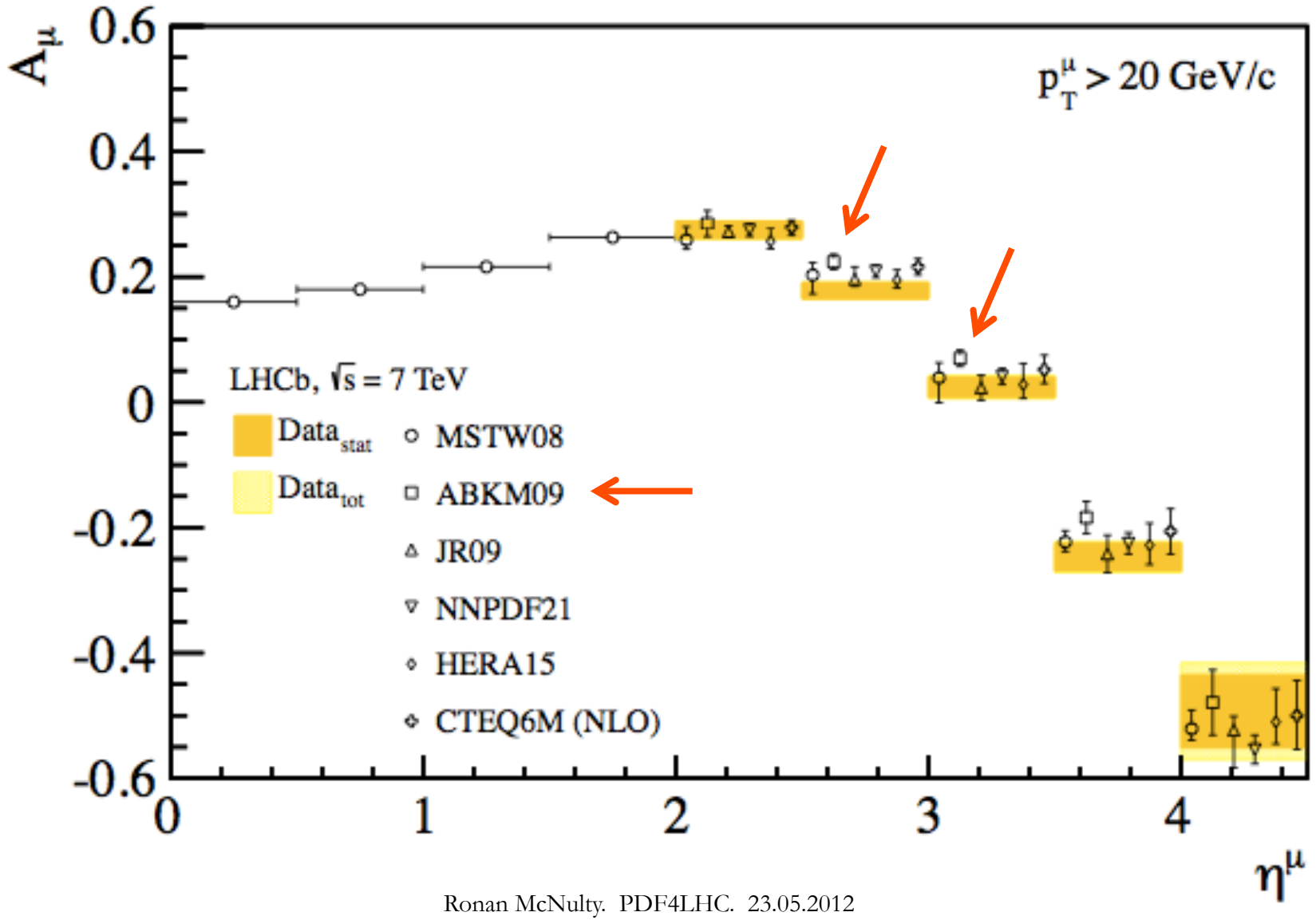
Differential Z distribution v y



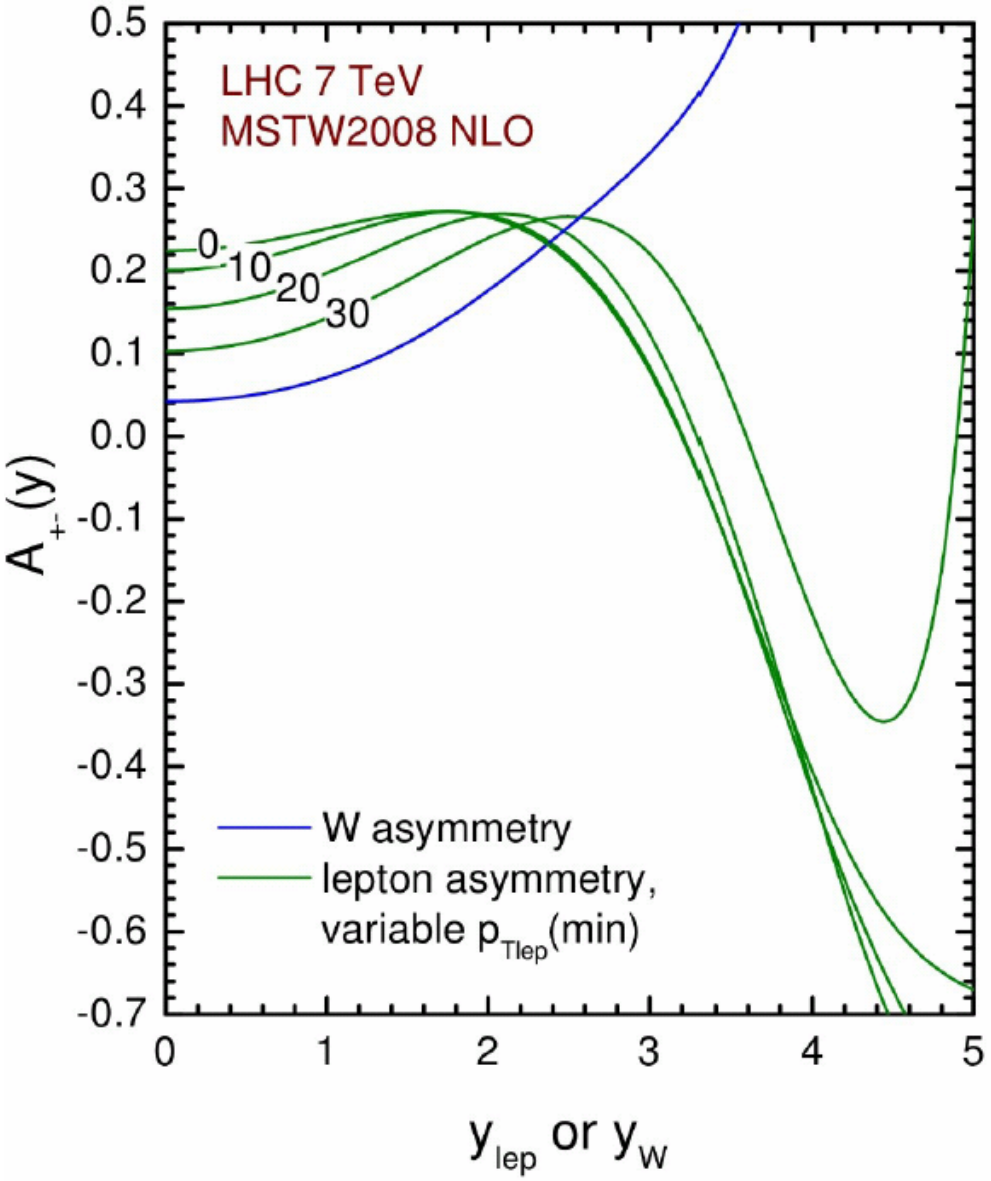
Differential W distribution v y



W charge asymmetry

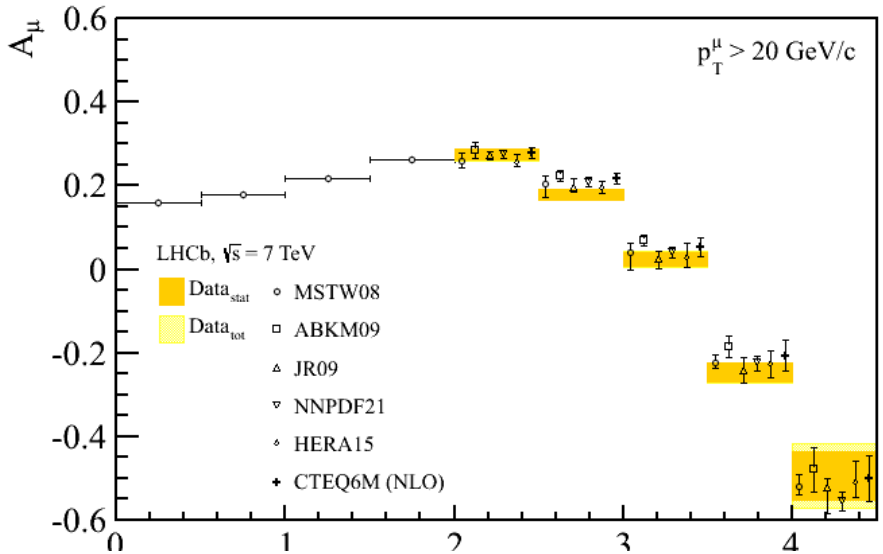


W charge asymmetry (different pt threholds)

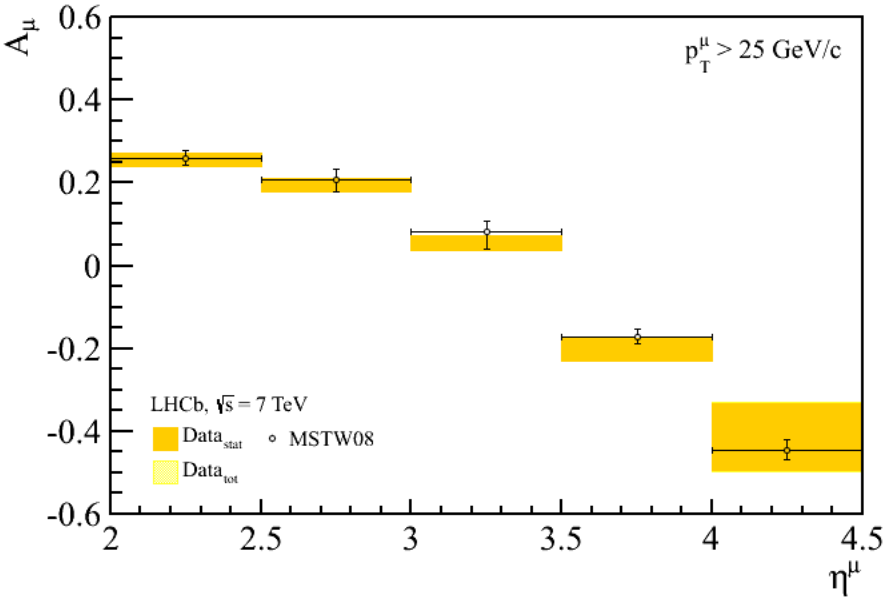


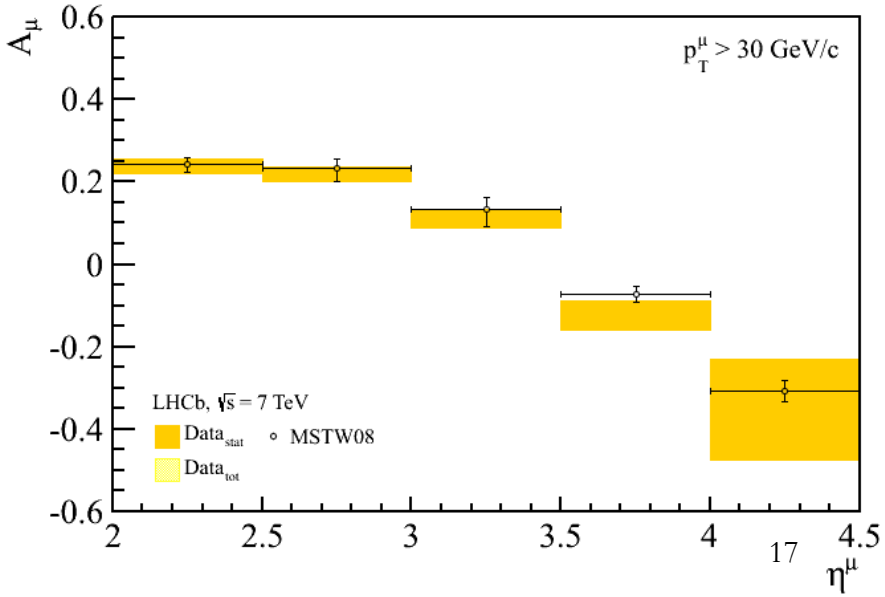
W charge asymmetry

arXiv: 1204.1620



W charge asymmetry as a function of η
P_T>20, P_T>25, P_T>30 GeV

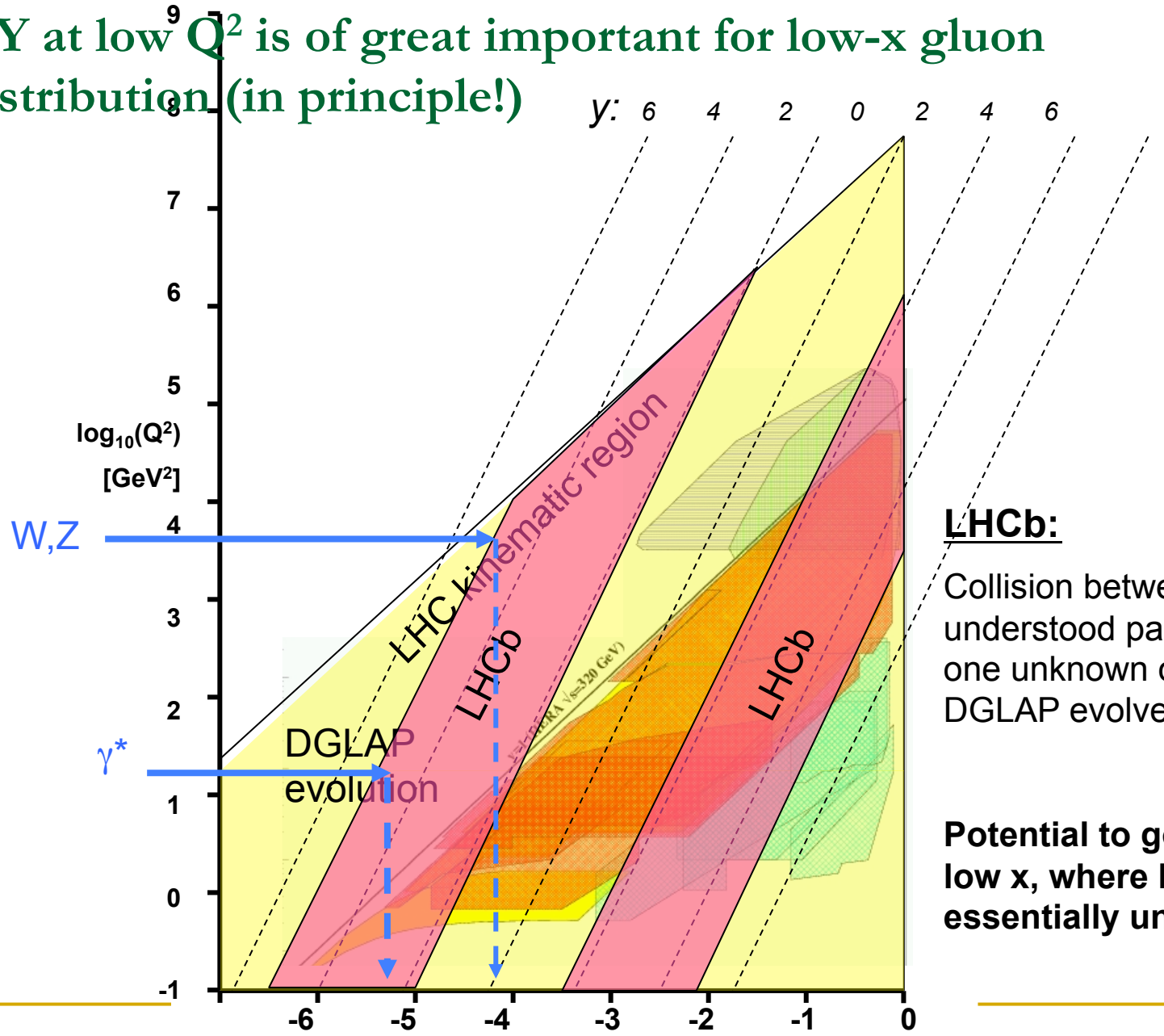




Full correlation matrix between each (pseudo)rapidity bins for W+.W-,Z available in paper for global fitting.

	$2 < \eta^{\mu}(y^Z) < 2.5$			$2.5 < \eta^{\mu}(y^Z) < 3$			$3 < \eta^{\mu}(y^Z) < 3.5$			$3.5 < \eta^{\mu}(y^Z) < 4$			$4 < \eta^{\mu}(y^Z) < 4.5$			
W^+	1															$2 < \eta^{\mu}(y^Z) < 2.5$
W^-	0.87	1														
Z	0.36	0.34	1													
W^+	0.02	0.02	0.35	1												$2.5 < \eta^{\mu}(y^Z) < 3$
W^-	0.02	0.02	0.35	0.90	1											
Z	0.47	0.44	0.45	0.45	0.45	1										
W^+	0.02	0.03	0.24	0.02	0.02	0.31	1									$3 < \eta^{\mu}(y^Z) < 3.5$
W^-	0.02	0.02	0.29	0.02	0.02	0.37	0.89	1								
Z	0.46	0.43	0.44	0.45	0.44	0.58	0.31	0.37	1							
W^+	0.04	0.05	0.35	0.04	0.04	0.45	0.05	0.04	0.44	1						$3.5 < \eta^{\mu}(y^Z) < 4$
W^-	0.02	0.02	0.40	0.02	0.01	0.52	0.02	0.02	0.51	0.80	1					
Z	0.32	0.29	0.30	0.30	0.30	0.39	0.21	0.25	0.39	0.30	0.35	1				
W^+	0.07	0.09	0.19	0.07	0.07	0.24	0.09	0.07	0.24	0.15	0.06	0.16	1			$4 < \eta^{\mu}(y^Z) < 4.5$
W^-	0.01	0.01	0.28	0.01	0.01	0.37	0.01	0.01	0.36	0.02	0.01	0.24	0.57	1		
Z	0.03	0.03	0.03	0.03	0.03	0.04	0.02	0.03	0.04	0.03	0.04	0.03	0.02	0.03	1	
	W^+	W^-	Z	W^+	W^-	Z	W^+	W^-	Z	W^+	W^-	Z	W^+	W^-	Z	

DY at low Q^2 is of great important for low-x gluon distribution (in principle!)



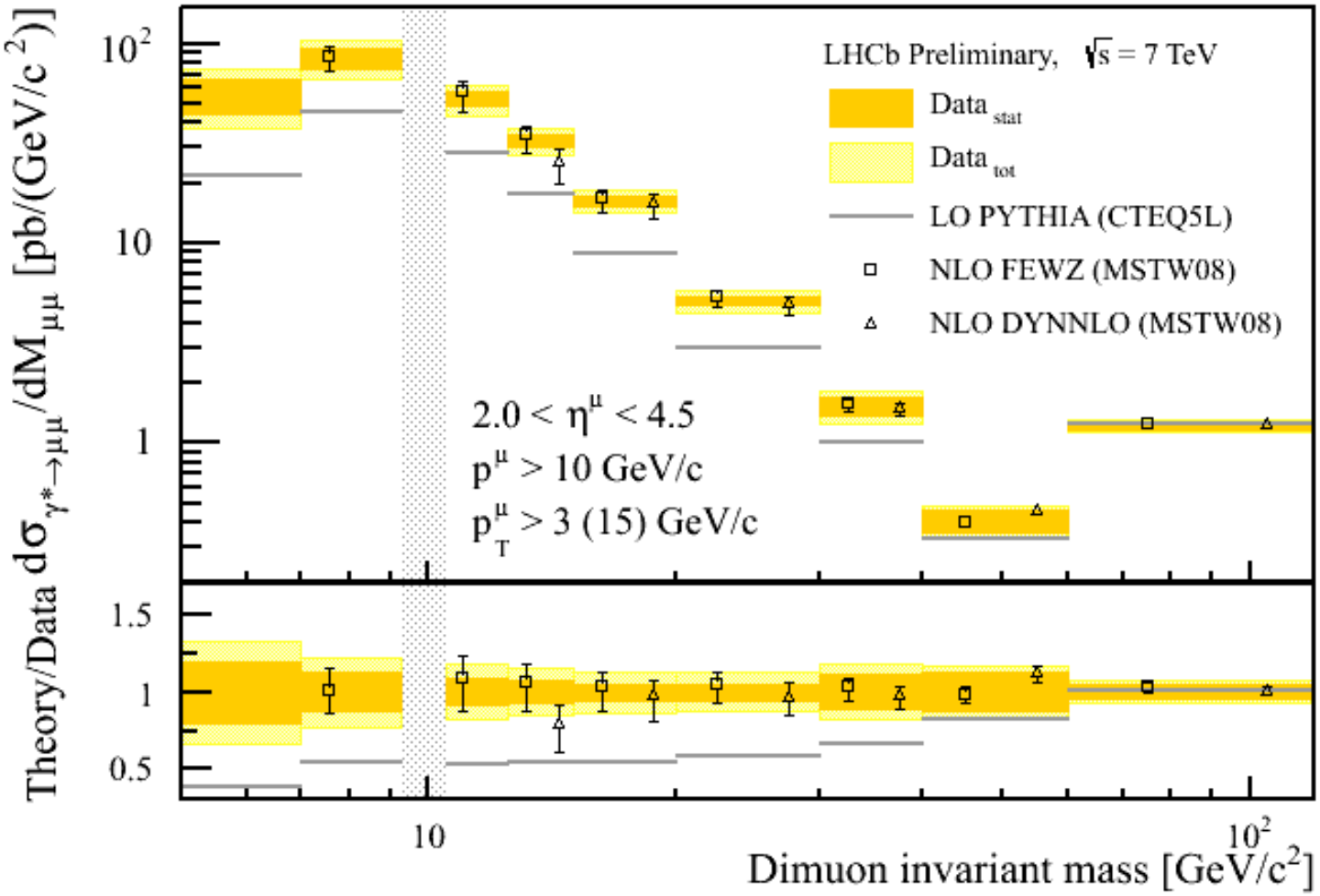
LHCb:

Collision between one well understood parton and one unknown or large DGLAP evolved parton.

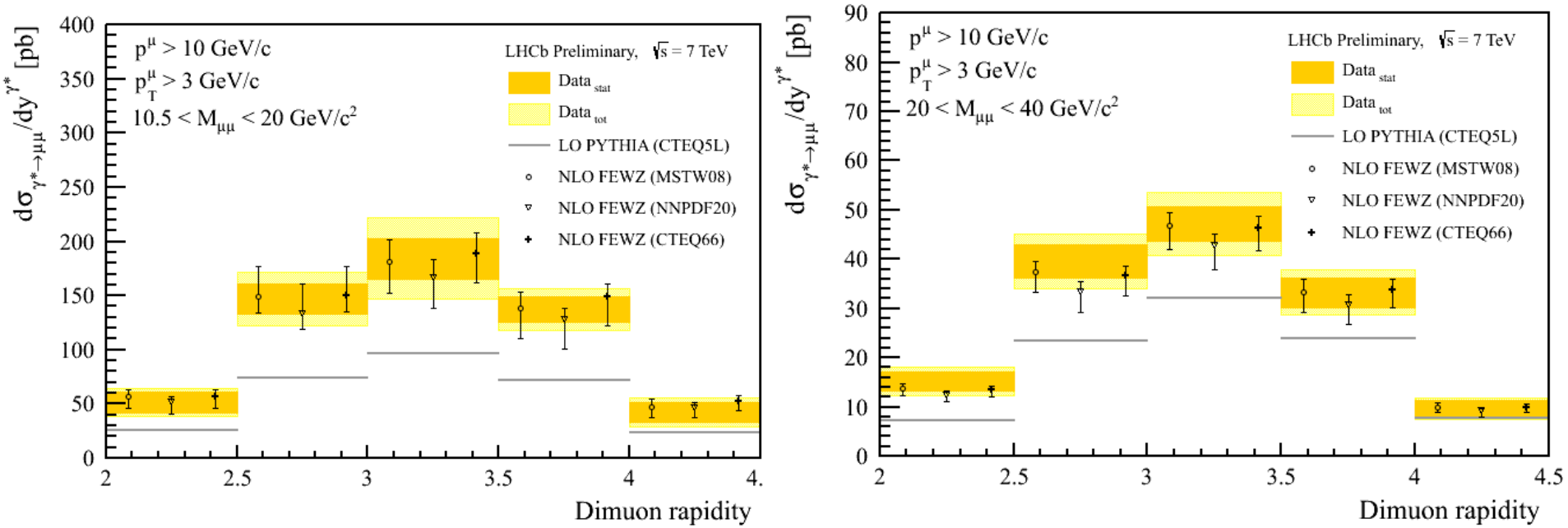
Potential to go to very low x, where PDFs essentially unknown

We measure down to mass of 5 GeV, corresponding to $x=8\times10^{-6}$.

DY→μμ cross-section measured down to 5 GeV.

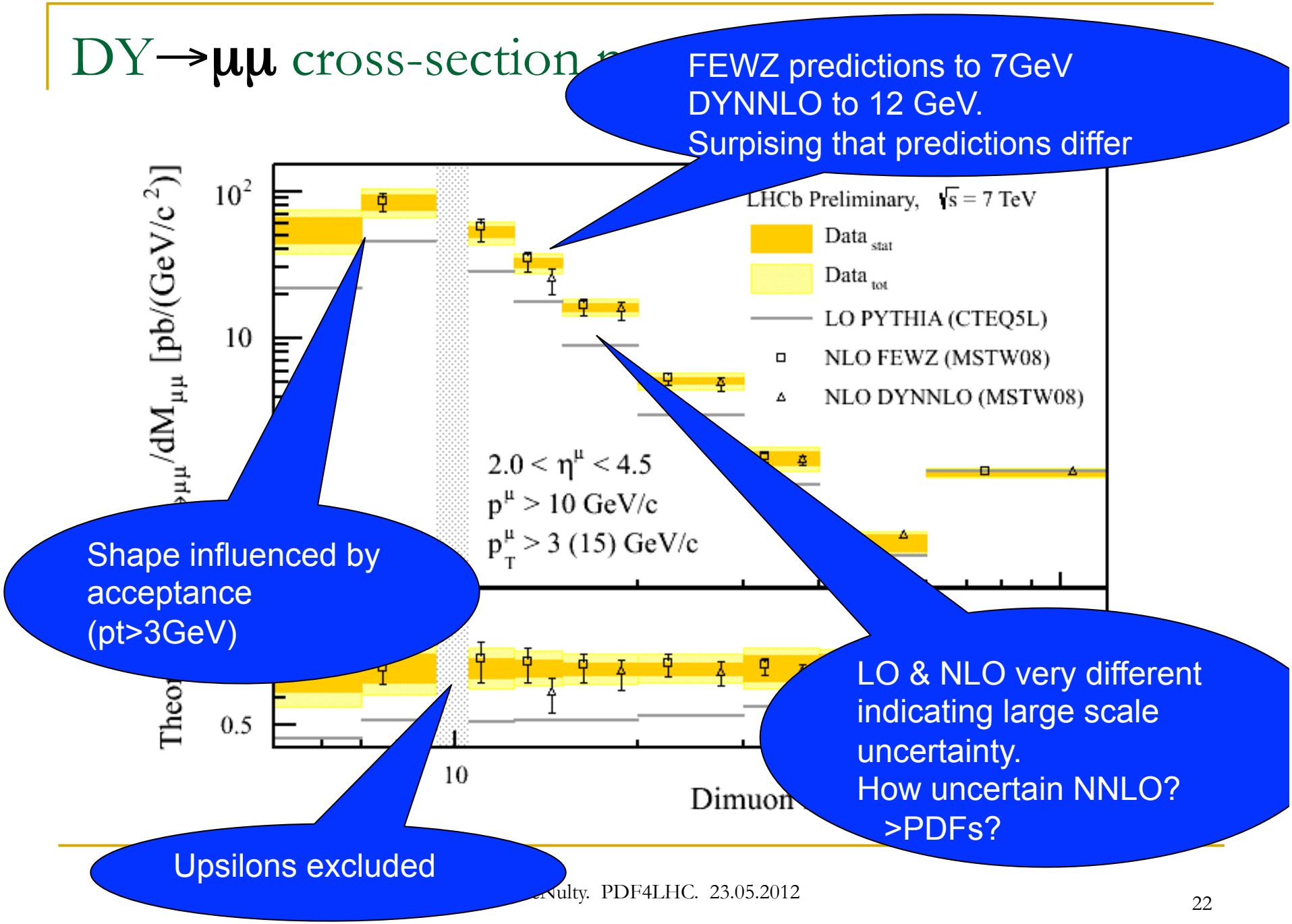


Differential distributions for two mass bins.

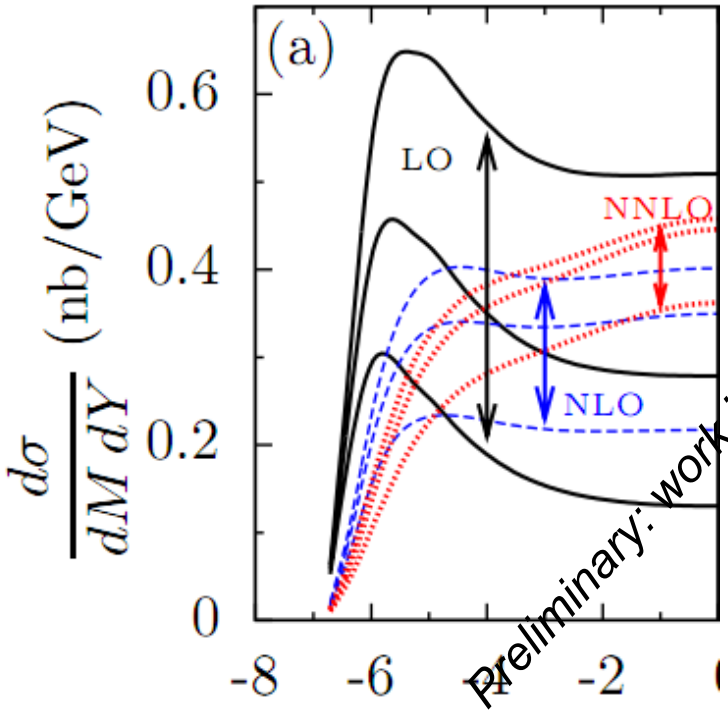


Fully double differential distributions possible with 2011 data

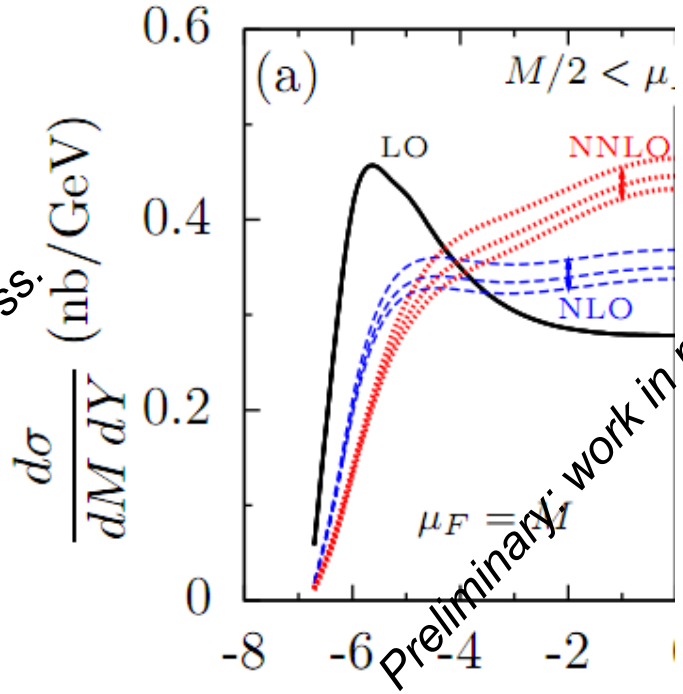
DY→μμ cross-section



From Alan Martin (mass of 6 GeV)



Changing factorisation scale



Changing renormalisation scale

Preliminary: work in progress.

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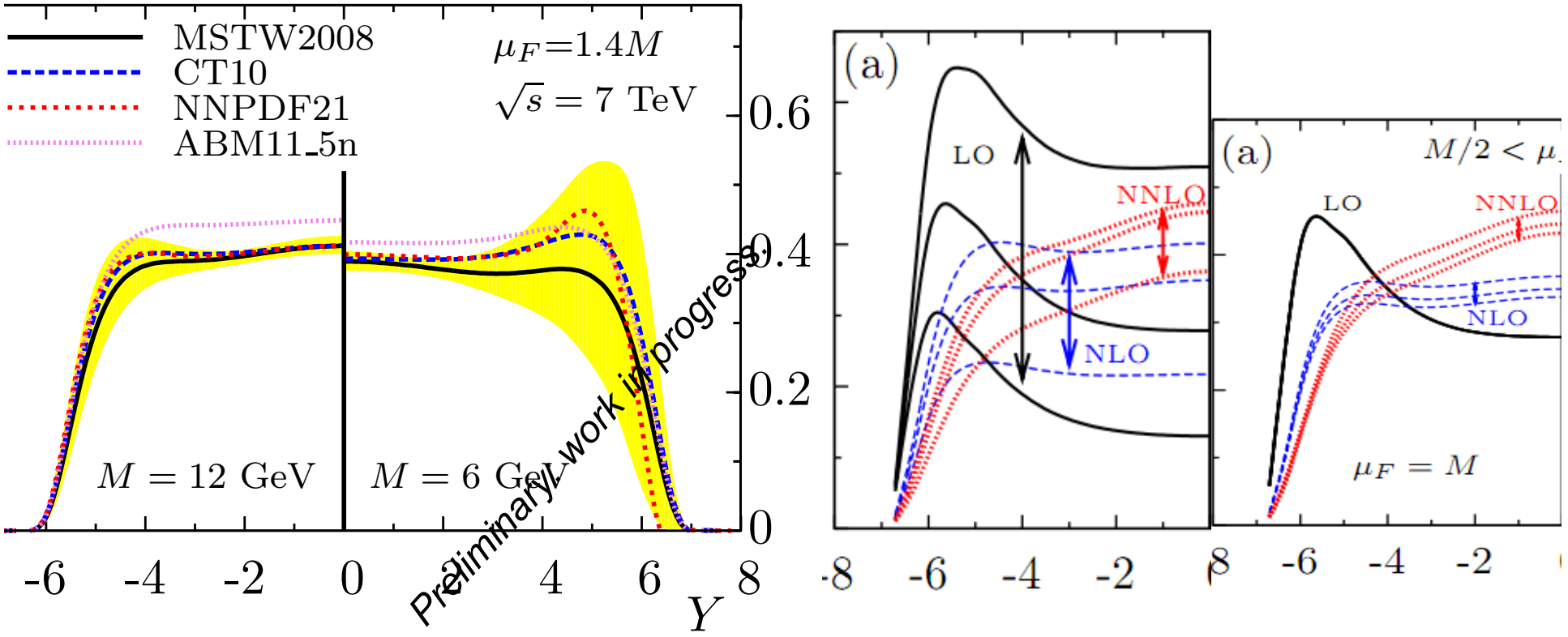
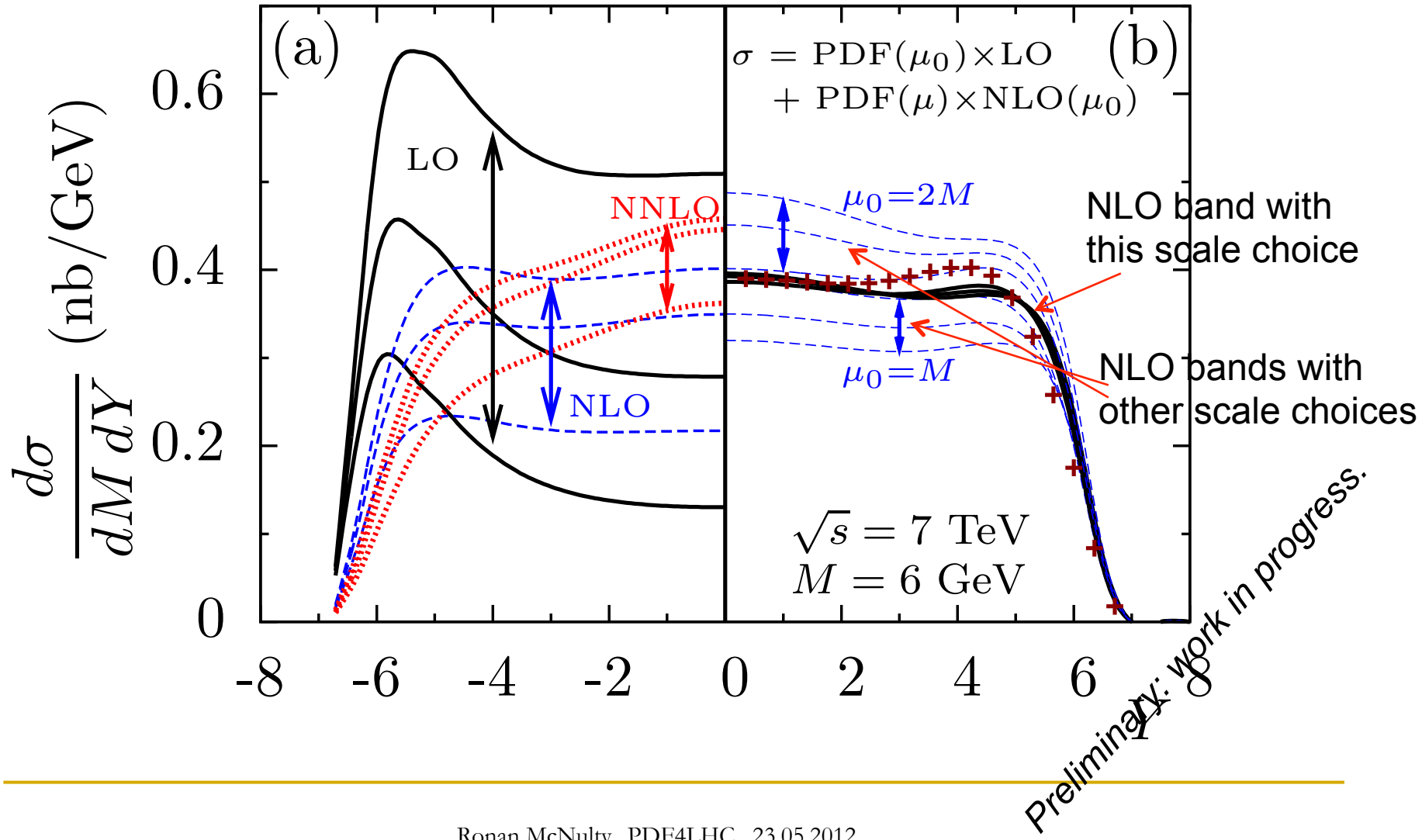
At NLO, looks like about 30% uncertainty. Factor two/three larger than the PDF uncertainty on our plots. So DY may be useless for constraining PDF

From Alan Martin (mass of 6 GeV)

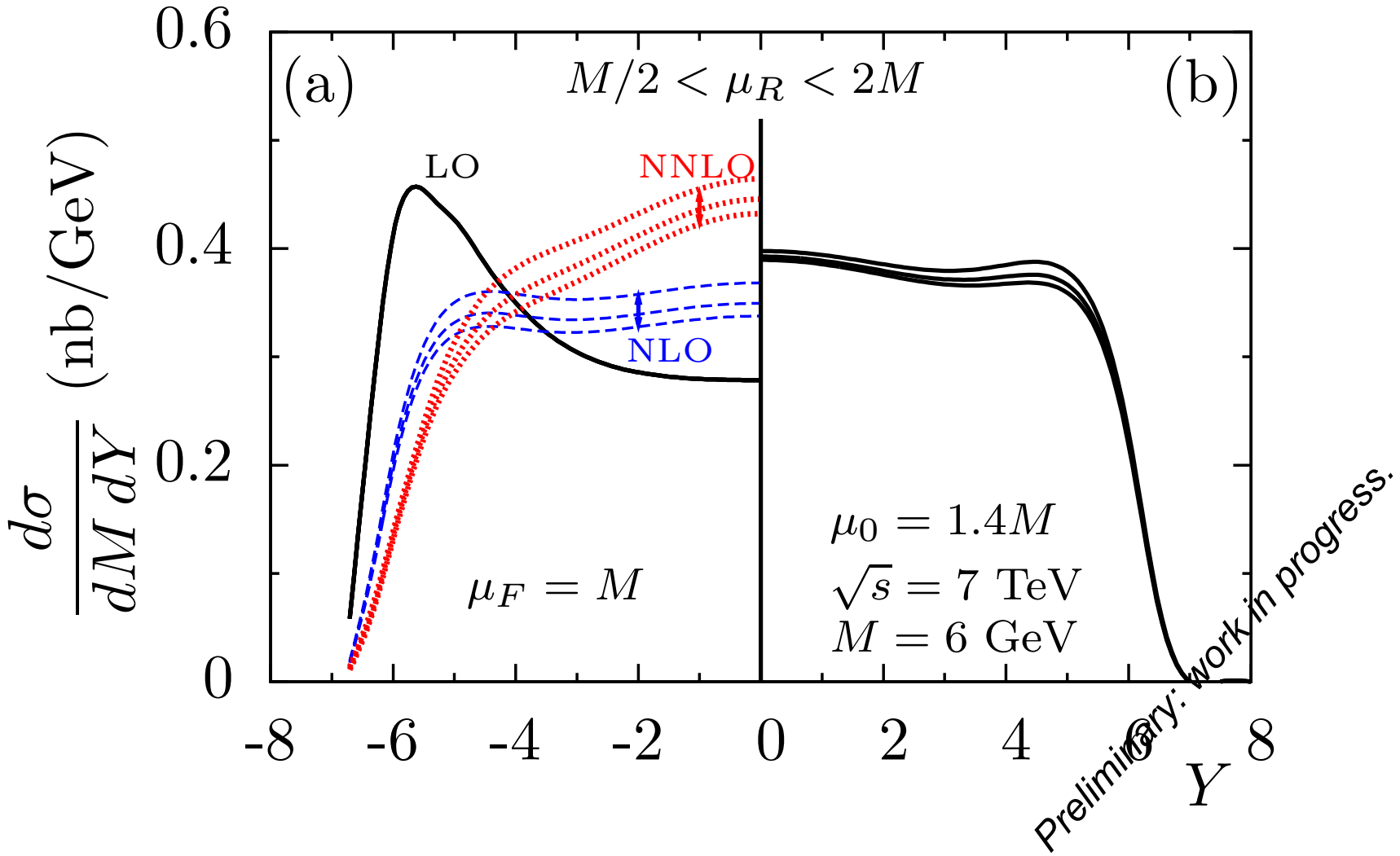


Scales roughly matched. Factorisation uncertainty ~ PDF uncertainty but renormalisation uncertainty much larger.

But by appropriate choice of factorisation scale, uncertainty minimised. Holding μ_R=M and changing μ_F about 1.4M…



Also less dependence varying μ_R about M holding μ_F=1.4M



Details in forthcoming paper from E.G. de Oliveira, A.D. Martin, M.G. Ryskin

Conclusions

- Final 2010 data integrated and differential W,Z results from LHCb available.
- Agree with theoretical predictions
- Clear sensitivity to different PDFs which will improve with 2011 data

- Preliminary results on DY down to 5 GeV giving sensitivity for PDFs down to $x=8x10^{-6}$
- However, a more precise theoretical prediction looks to be required in the low mass region if PDFs are to be extracted; work ongoing at Durham.
- “To date, there is no reliable PREDICTION for M=6, Y>4, but only guesses based on `ad hoc' risky extrapolations into a dangerous x region. LHCb data provide, for the first time, a DIRECT measurement of PDFs in an unexplored low x region.”