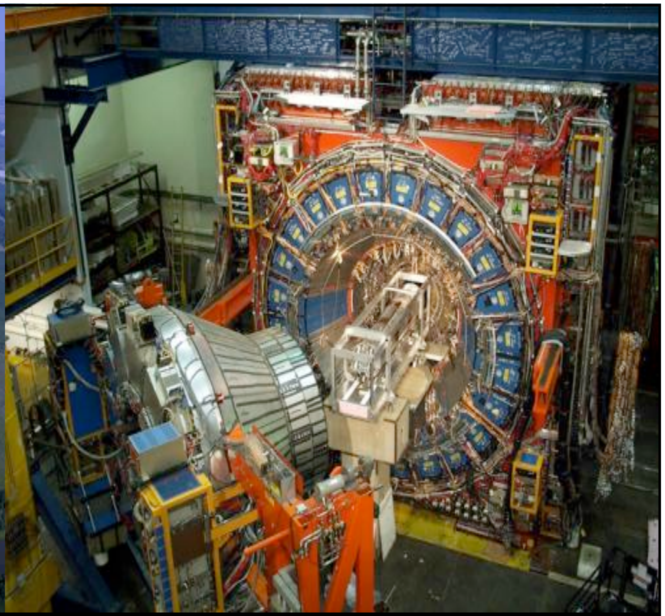

PDF constraints from CDF

Sarah Malik

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Introduction

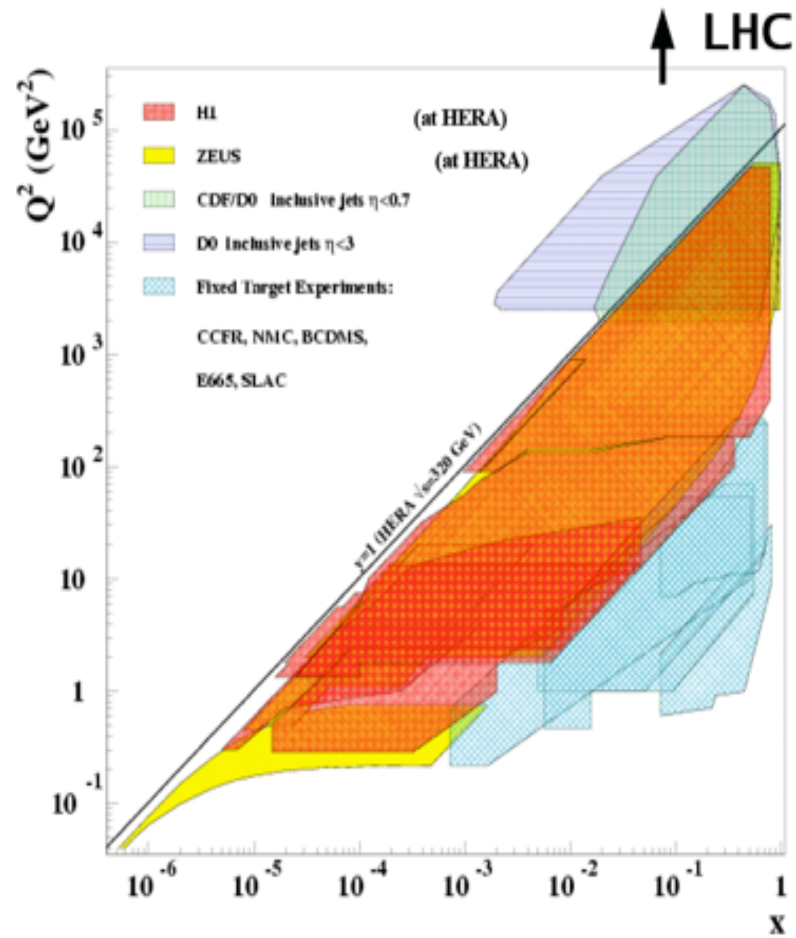
- As statistics increase→ PDF uncertainties becoming significant for precision measurements at the Tevatron: e.g M_W

M_W dominant systematics ($W \to e\nu$):
Lepton Scale : 30
PDF : 11

- Tevatron probes regions of x, Q^2 between that accessible to HERA and LHC.

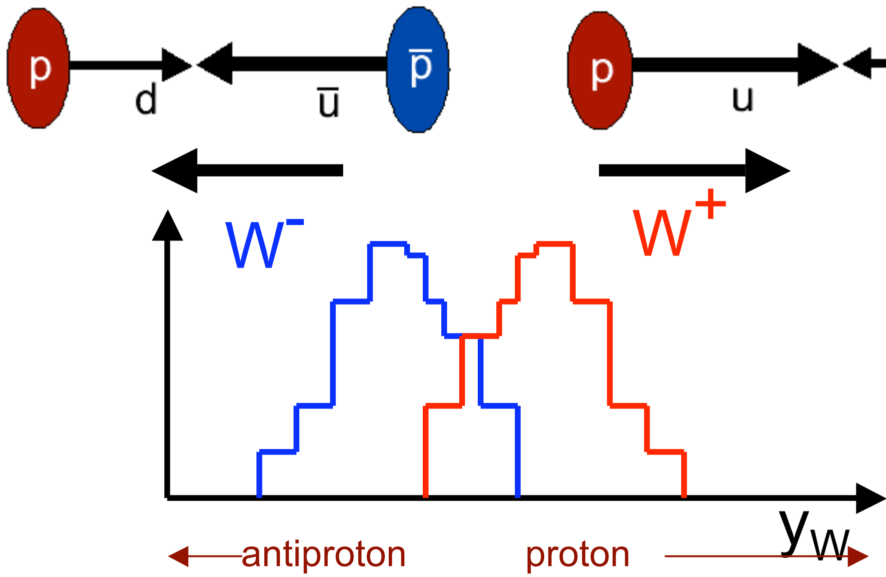
Measurements at CDF providing PDF constraints:

- Electroweak : W charge asymmetry, Z cross-section, Forward Ws.
- QCD: inclusive jets, Z+b-jet, W+charm.



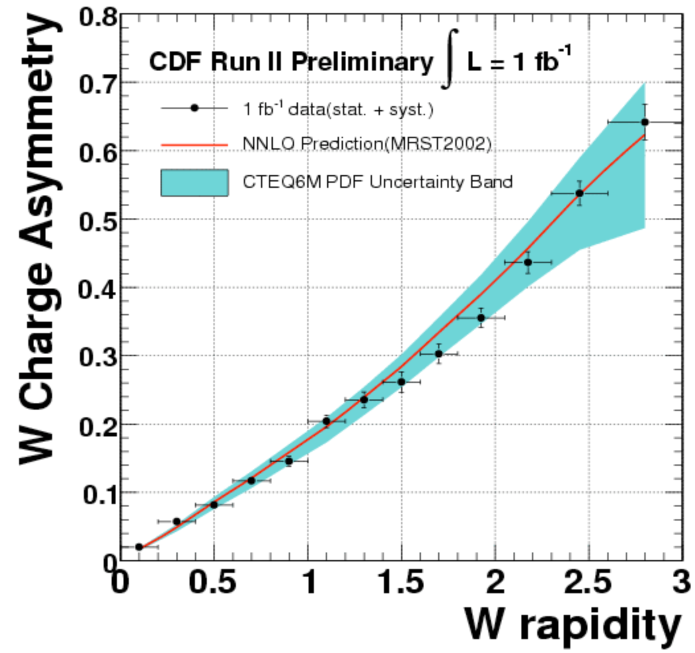
W Charge Asymmetry

1 fb^{-1}



- u quarks carry more momentum than d quarks.
- W^+ boosted in the p direction.
- W^- boosted in the $\bar{p}$ direction.

Asymmetry sensitive to d(x)/u(x) ratio



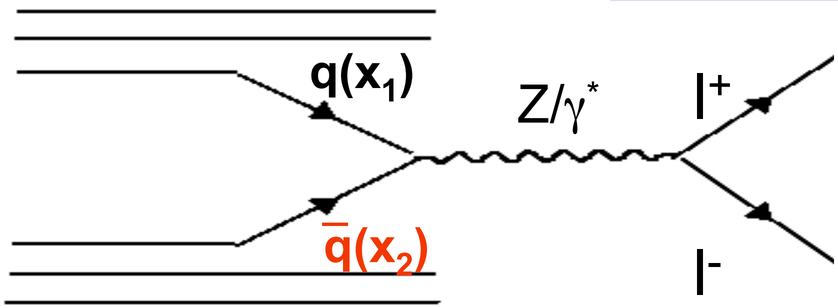
Good agreement with NNLO prediction using MRST2002 PDFs.

Experimental uncertainty is less than current PDF uncertainty ($y_W > 1.5$)

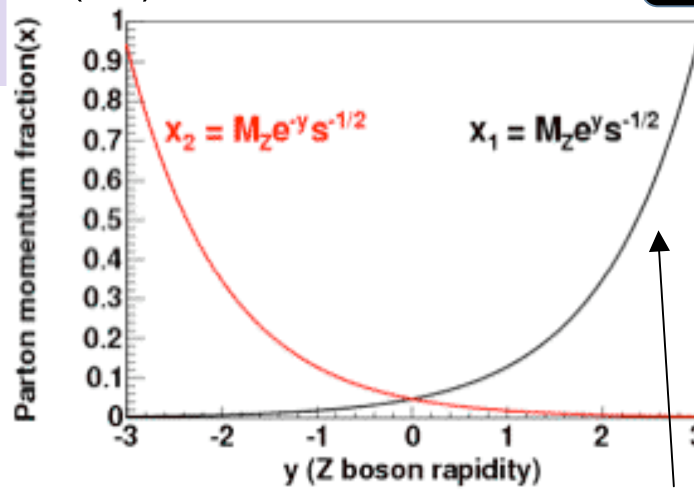
Z/γ^* rapidity

$$x_{1,2} = \frac{M_W}{\sqrt{s}} e^{\pm y_Z}$$

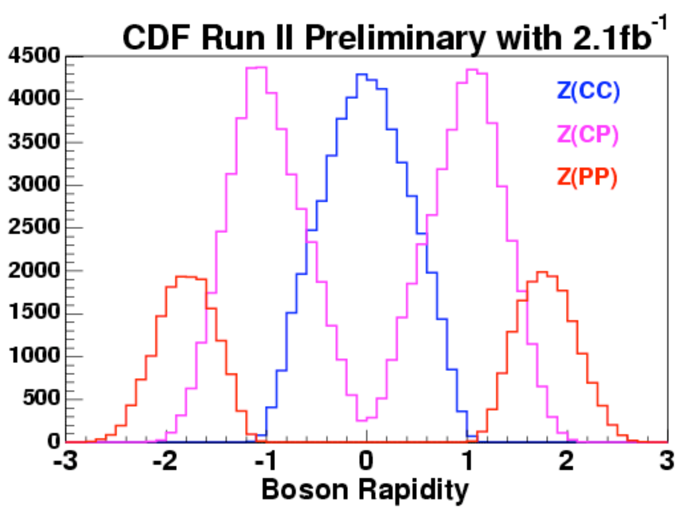
2.1 fb^{-1}

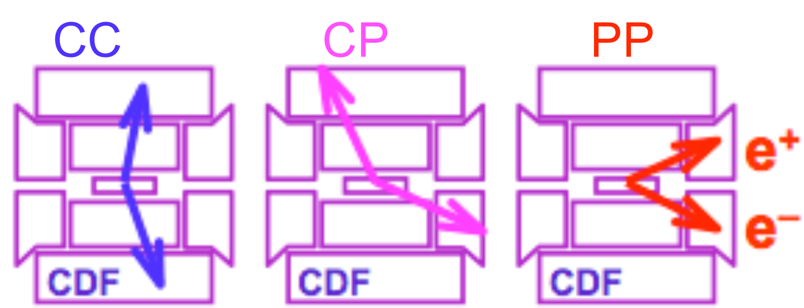


(LO)



- High y_Z probes one high x parton and one low x parton

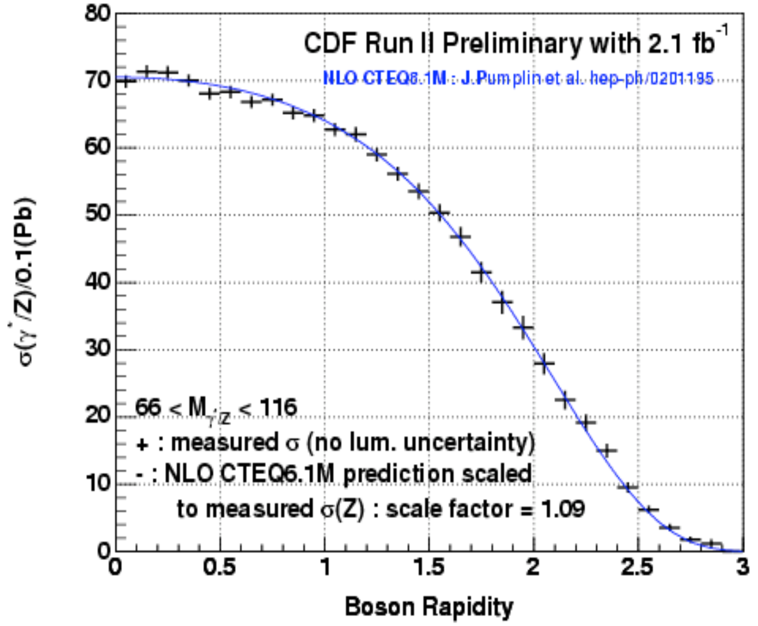


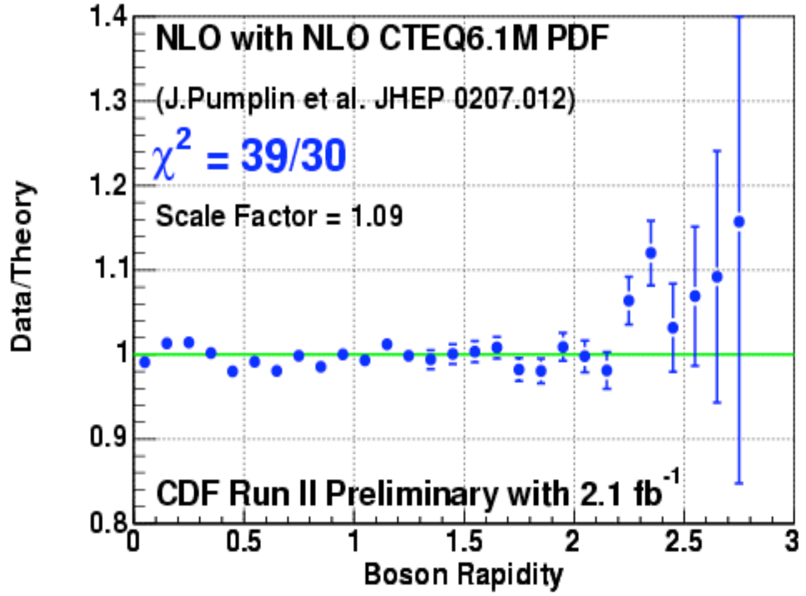


dσ/dy$_Z$

2.1 fb^{-1}

- dσ/dy for electron decay channel

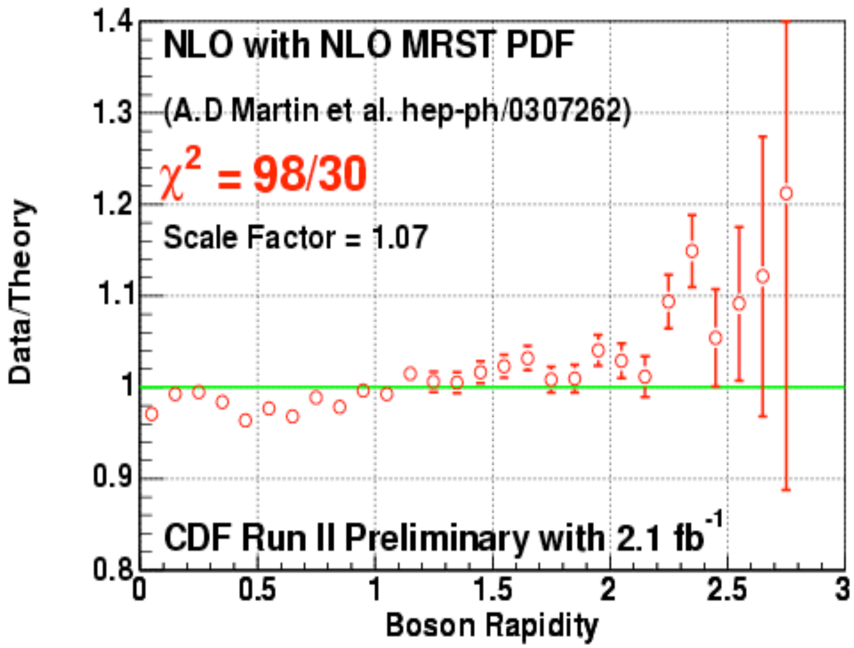


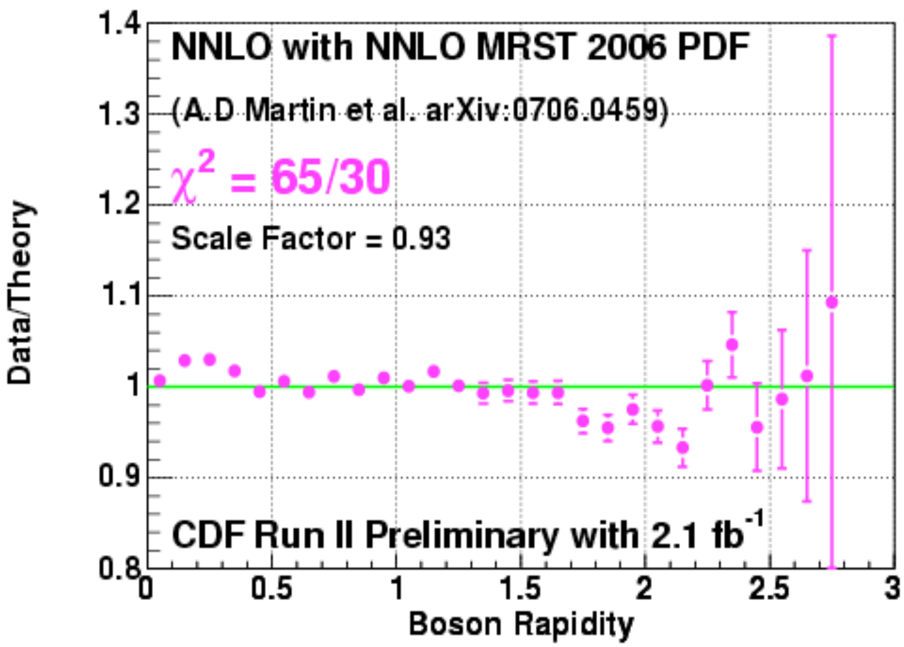


Good agreement with NLO prediction

$d\sigma/dy_Z$

2.1 fb^{-1}

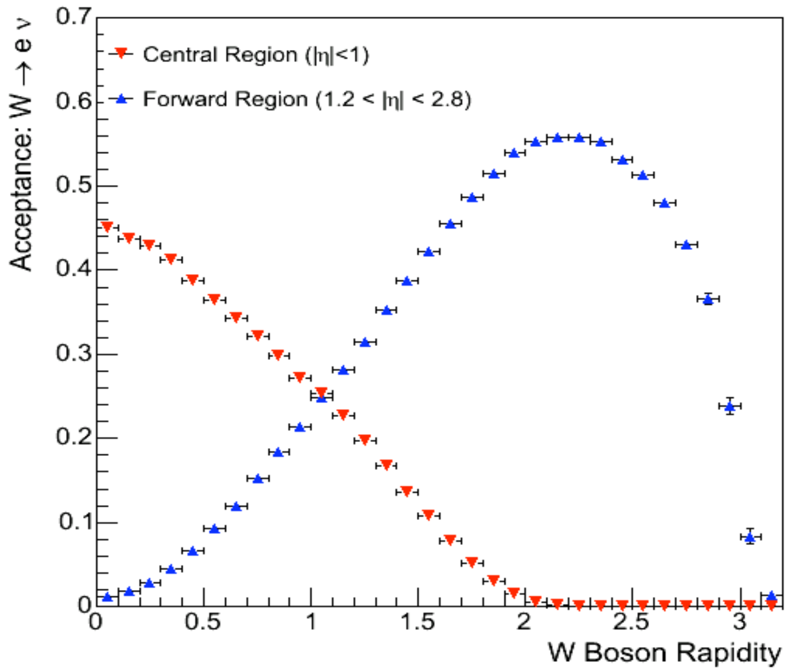




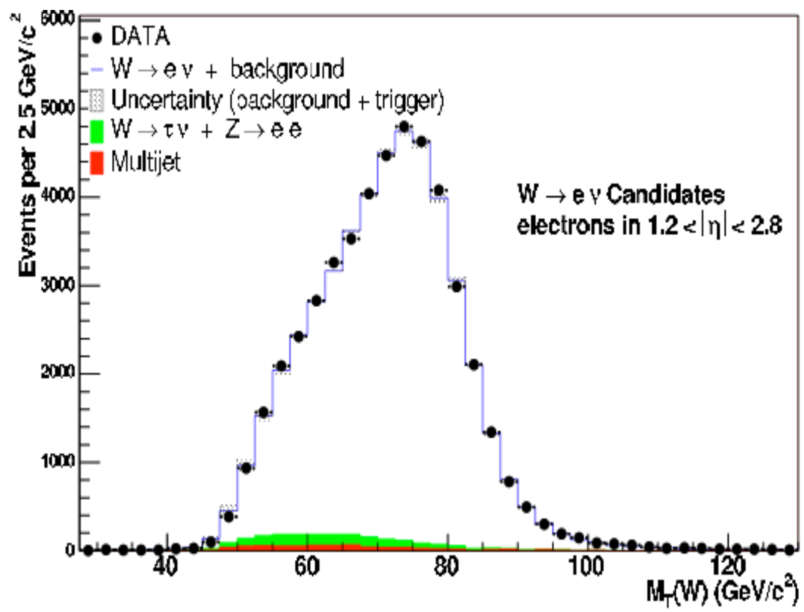
Better agreement with NNLO(MRST) prediction

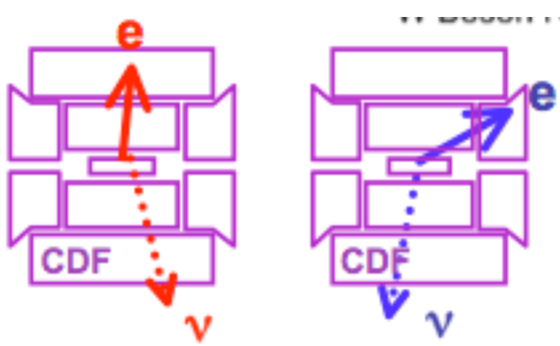
Forward W

223 pb^{-1}



- W→eν cross-section measured in the forward region.





- σ_{tot} for forward electrons consistent with σ_{tot} previously measured using central electrons

Forward W

223 pb^{-1}

Define visible cross-section : $\sigma_{vis} = \sigma_{tot} \times A$

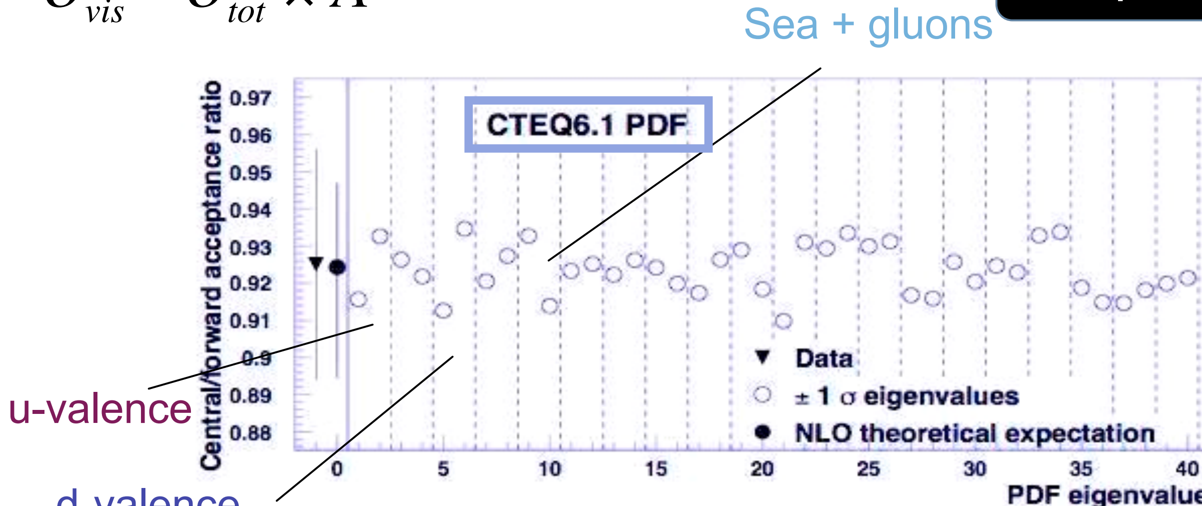
$$R_{\exp} = \frac{\sigma_{vis}^{cen}}{\sigma_{vis}^{forw}}, \quad \mathrm{R}_{\mathrm{th}} = \frac{A_{vis}^{cen}}{A_{vis}^{forw}}$$

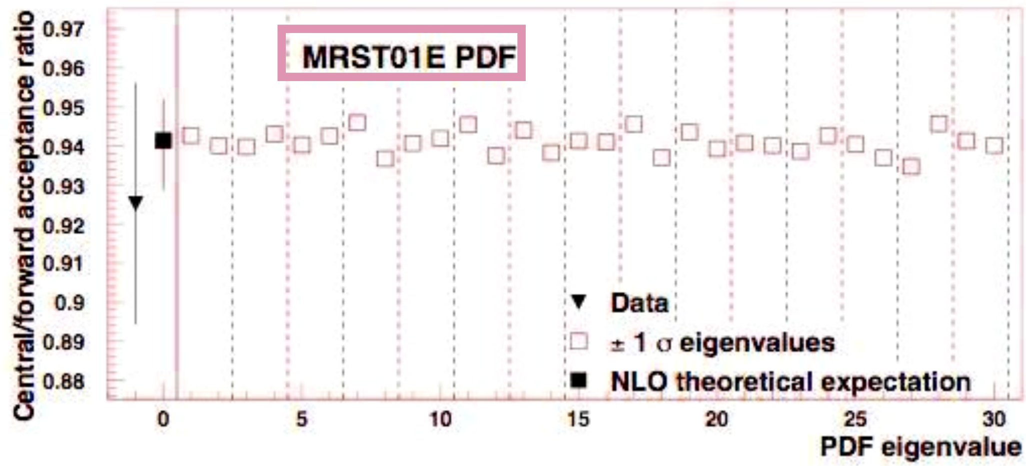
$$R_{\exp} = 0.925 \pm 0.033$$

$$R_{\mathrm{CTEQ6.1}} = 0.924 \pm 0.037$$

$$R_{\mathrm{MRST01E}} = 0.941 \pm 0.012$$

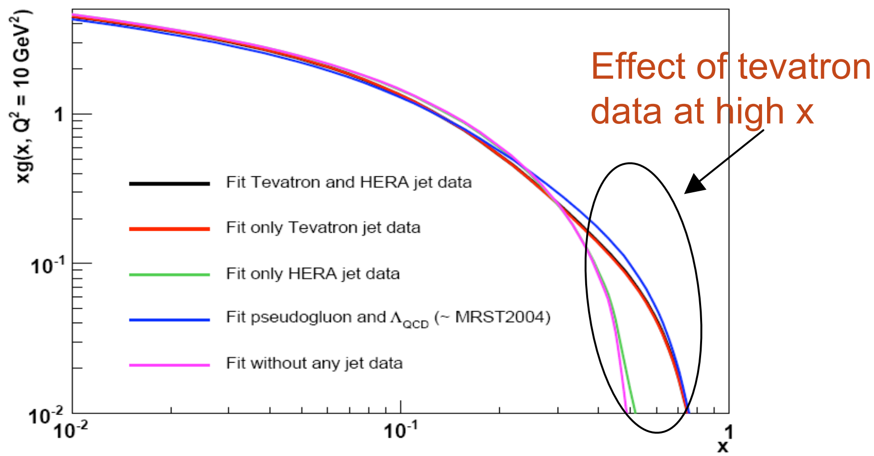
- R_{exp} sensitive to PDFs.
- CTEQ in better agreement with data than MRST01
- Uncertainties in R_{exp} expected to go down with statistics.
- Promising for future PDF fits.

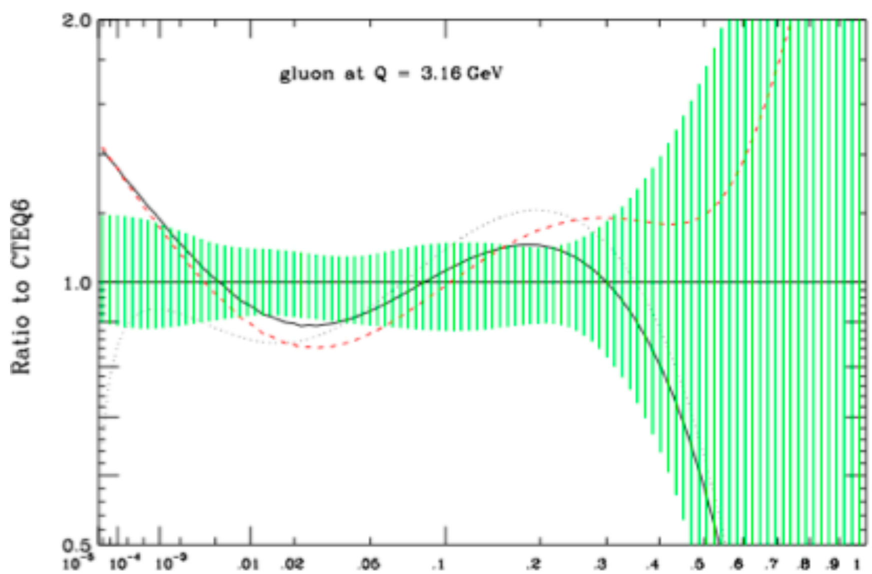




Inclusive jet production

- Inclusive jet cross-section powerful constraint on gluon PDF- most uncertain PDF at high x.
- 5 bins of rapidity.
- New physics not expected at high rapidity, this region used to constrain PDFs.
- 2 jet algorithms used: MidPoint, kT





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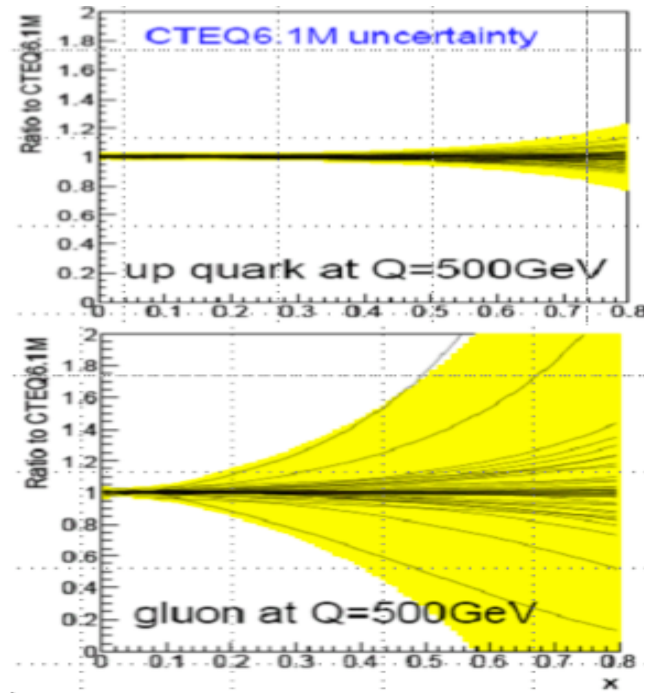


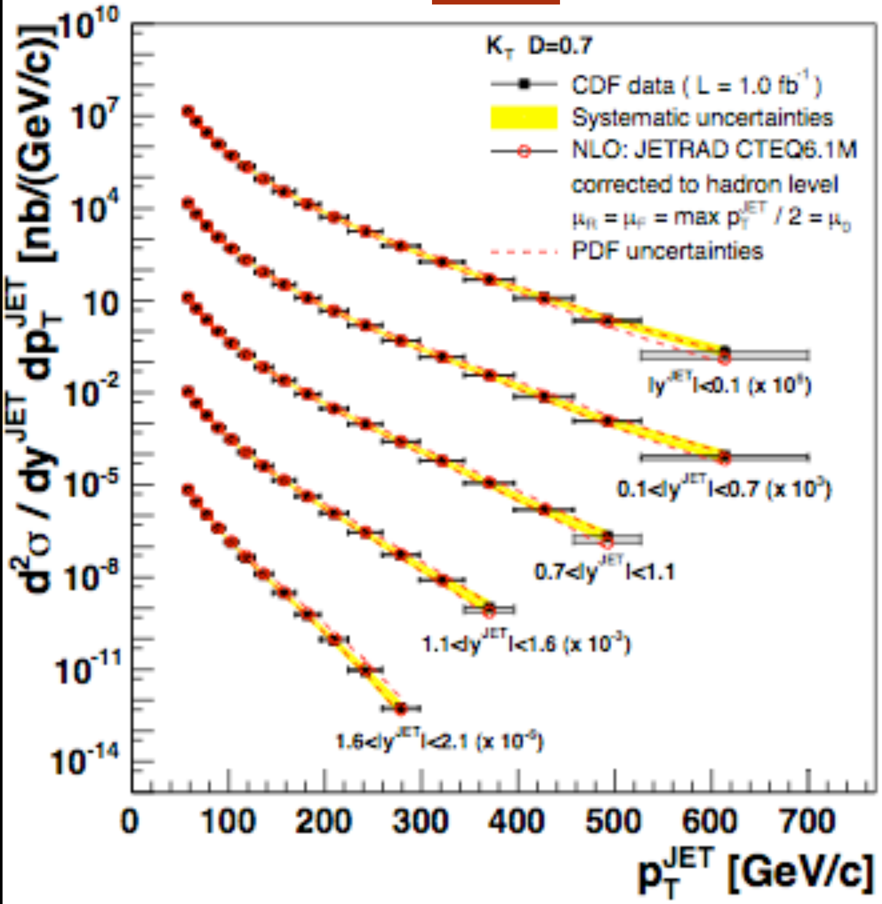
Inclusive jet production

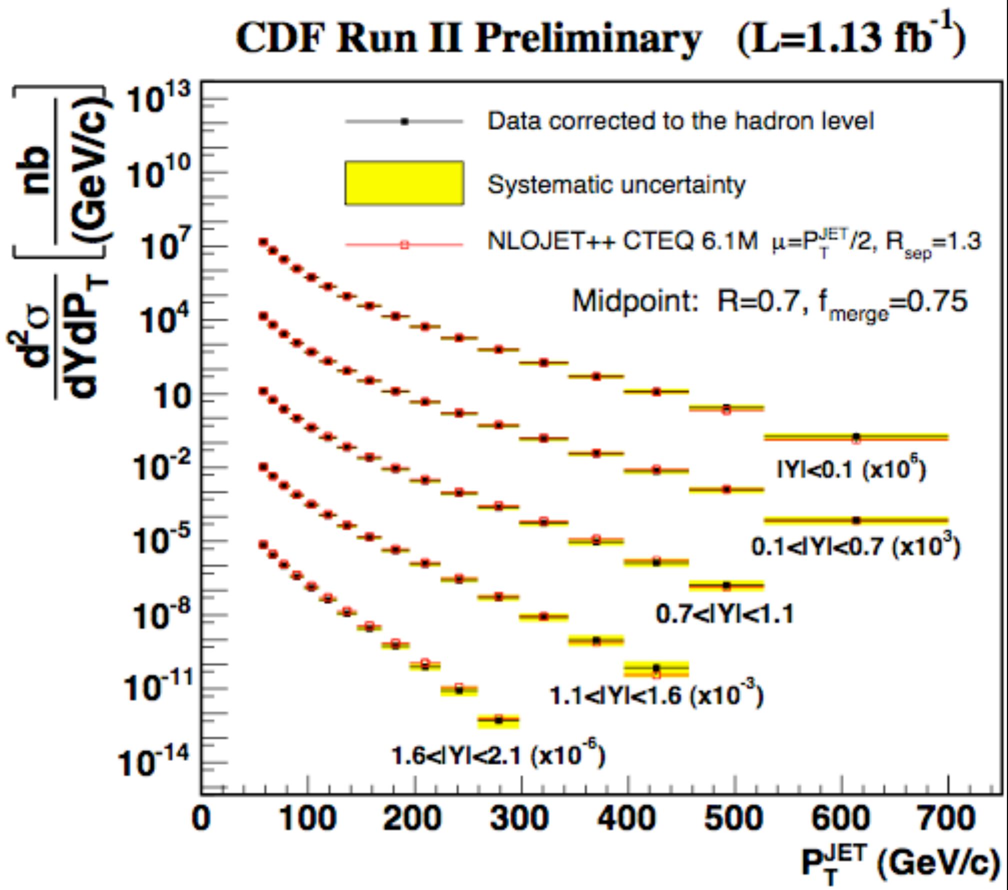
1.0 fb^{-1}

kT

MidPoint

1.13 fb^{-1}

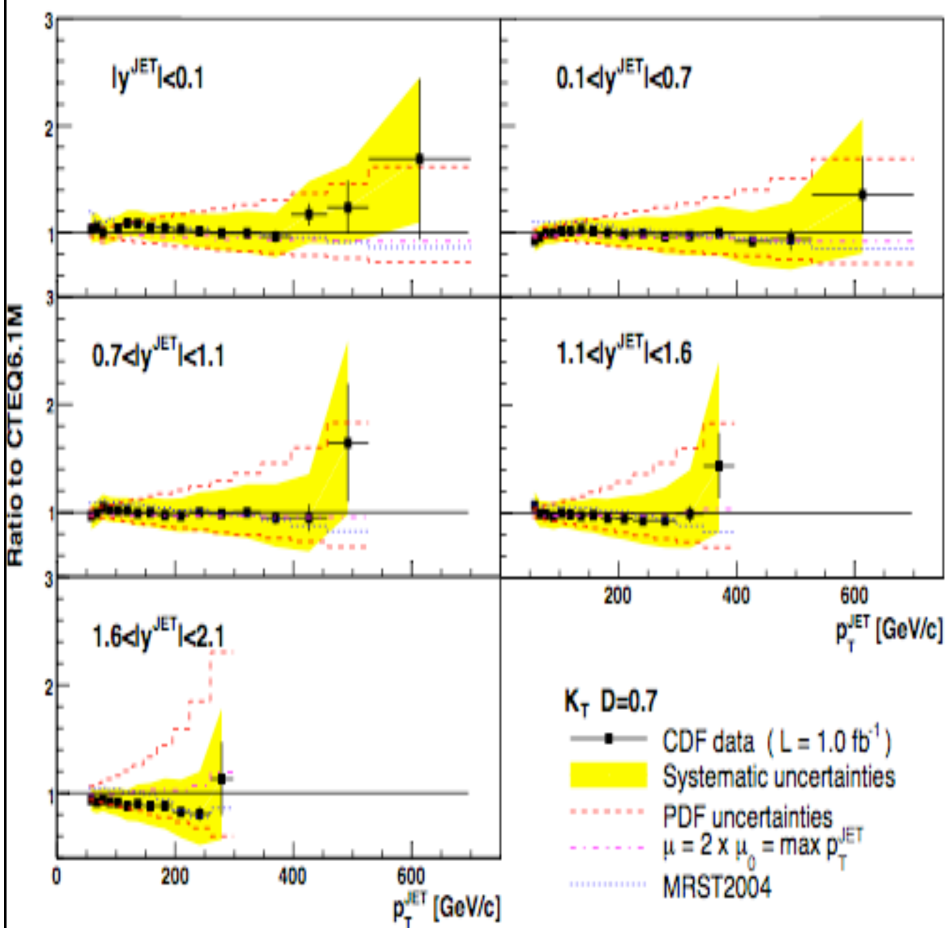




Inclusive jet production

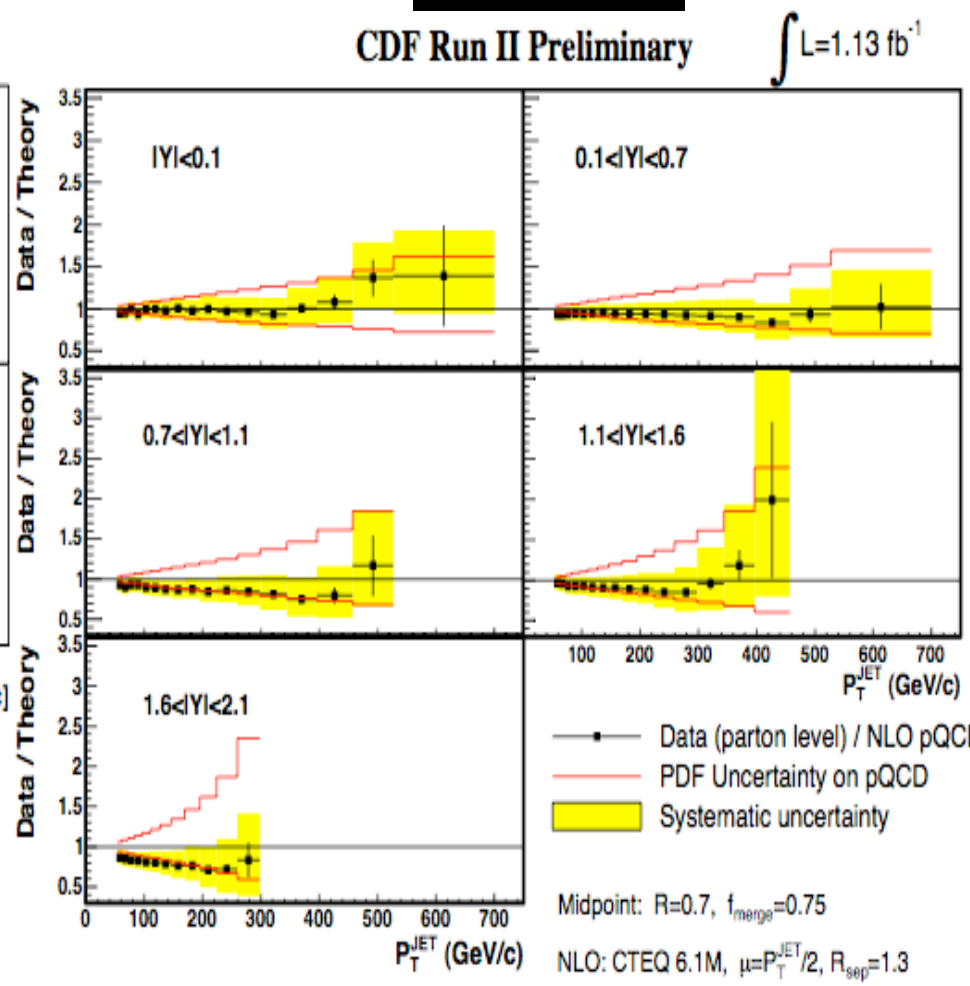
$1.0\ fb^{-1}$

kT



MidPoint

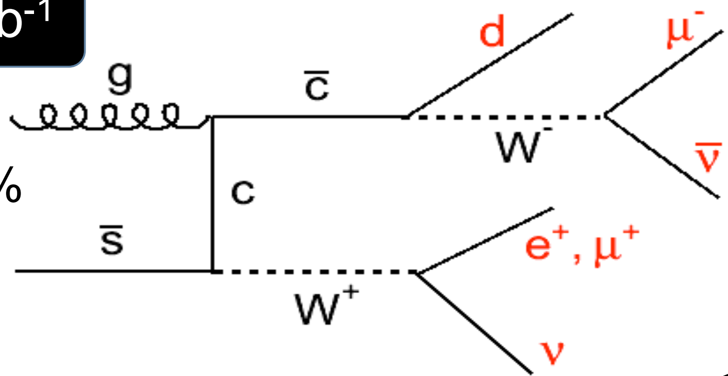
$1.13\ fb^{-1}$



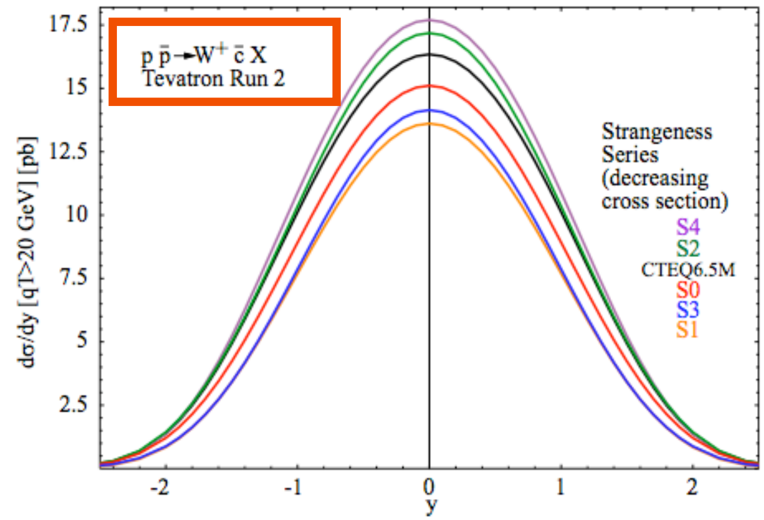
W+charm

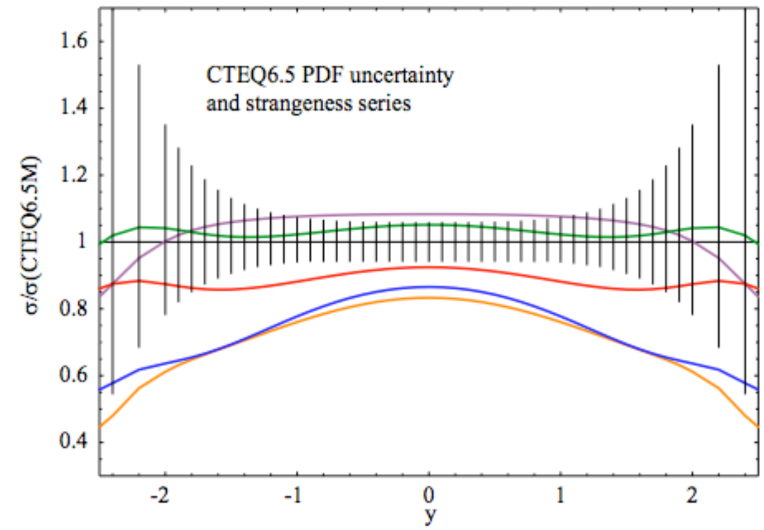
1.8 fb^{-1}

90%



W+charm cross-section sensitive to s-quark PDF





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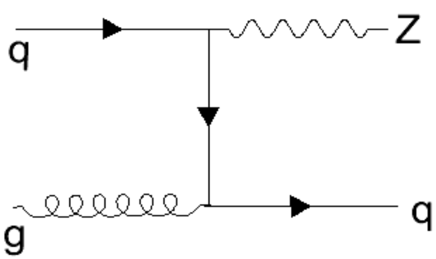
$$\sigma_{Wc} \times \mathrm{BR}(W \to \ell\nu) = 9.8 \pm 2.8(\mathrm{stat.})^{+1.4}_{-1.6}(\mathrm{sys.}) \pm 0.6(\mathrm{lum})\mathrm{pb}$$

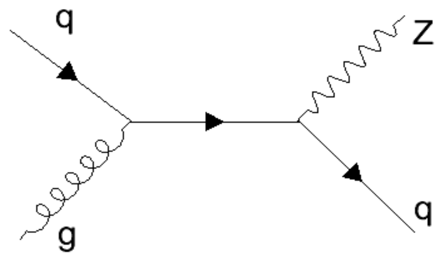
Measurement agrees with NLO calculation: $11.0^{+1.4}_{-3.0}$ pb

Statistics dominated- expect precision of ~15% by end of Run 2.

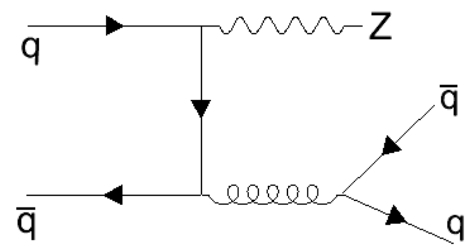
Z + b-jet

2.0 fb^{-1}

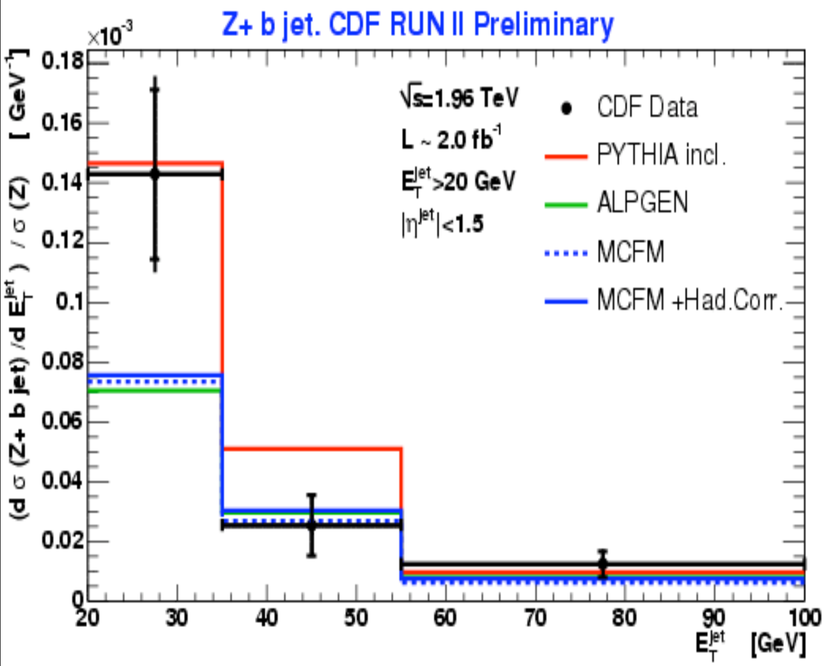




65%



35%



- σ(Z+b-jet) sensitive to b-quark density.
- $Z \rightarrow l^+l^-$, where l = e,μ
- σ(Z+b-jet) extracted from ratio σ(Z+b-jet)/σ(Z)
- σ(Z+b-jet) = 0.86±0.14±0.12pb.
- Measured cross-section is ~2σ higher than NLO QCD calculation
- Ratio measured differentially.
- Ratio shows good agreement with Pythia at low jet E_T.
- ALPGEN(LO) and MCFM(NLO) undershoot data.

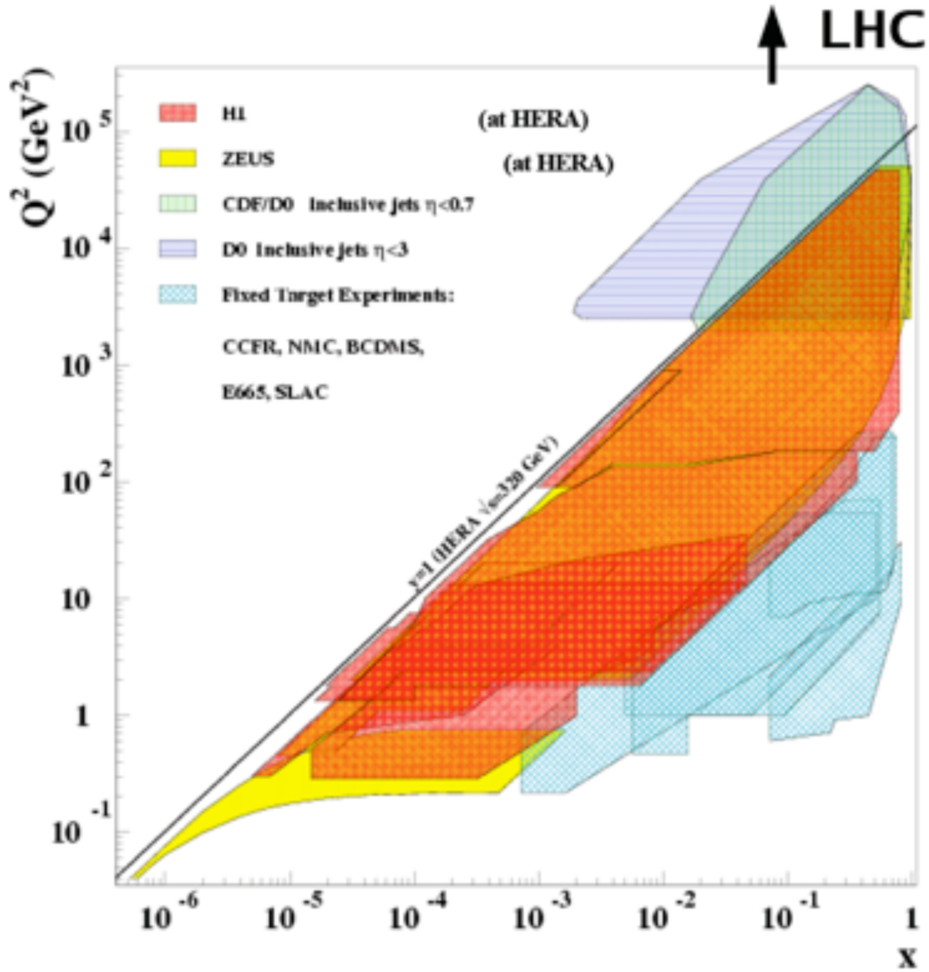
Conclusion

- Many analyses at CDF with PDF-constraining power.
- For some, the uncertainty on data is smaller than uncertainty on PDFs and will make significant contribution to future PDF fits.

- W charge asymmetry

- inclusive jets

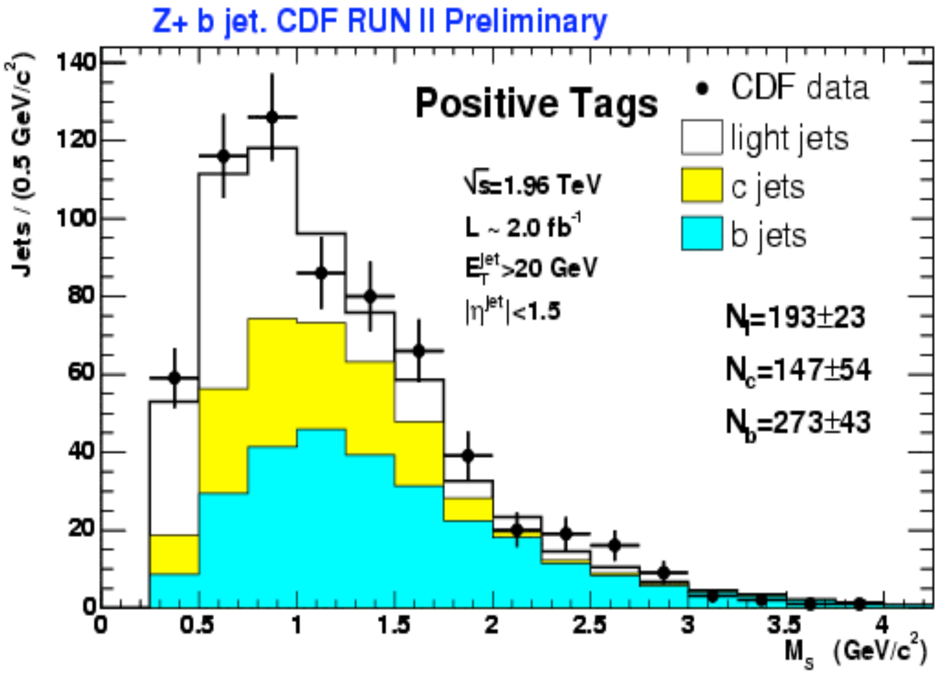
- Other analyses with larger statistics will also provide constraints in future.



Backup slides

Z+b-jet Cross Section

2.0 fb^{-1}



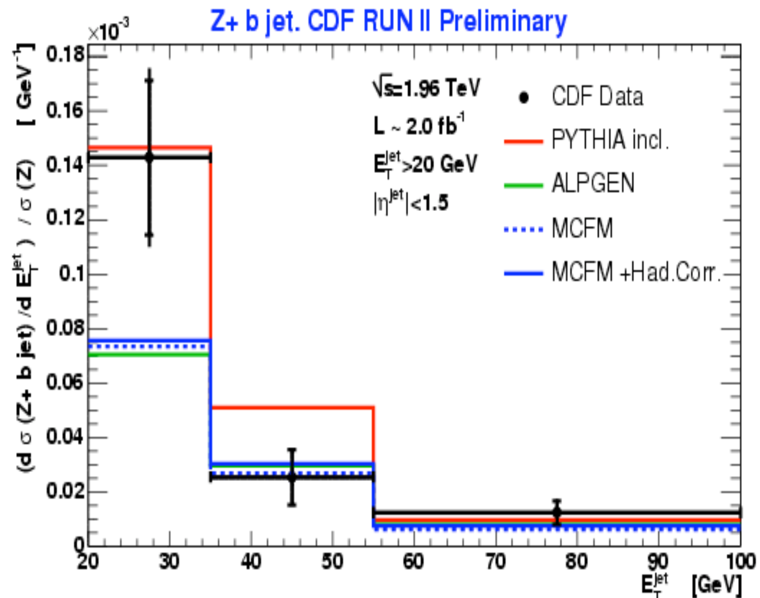
- $Z \rightarrow l^+l^-$, where $l = e,\mu$

$e^+e^-/\mu^+\mu^-$ pair with invariant mass consistent with M_Z

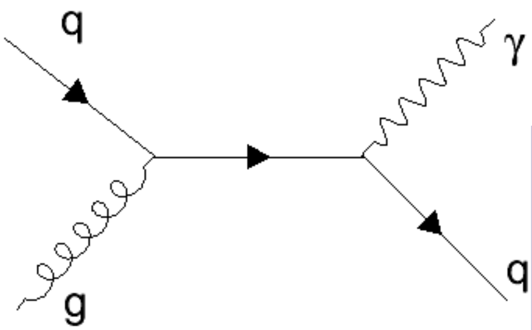
- b-jet - displaced secondary vertex, E_T > 20 GeV, $|\eta|$ < 1.5.
- S_M = mass of charged particles forming secondary vertex.

Measured cross-section is ~2σ higher than NLO QCD calculation.

Cross-section ratio σ(Z+b-jet)/ σ has also been measured differentially, as function of jet p_T, jet η, Z p_T, number of jets.



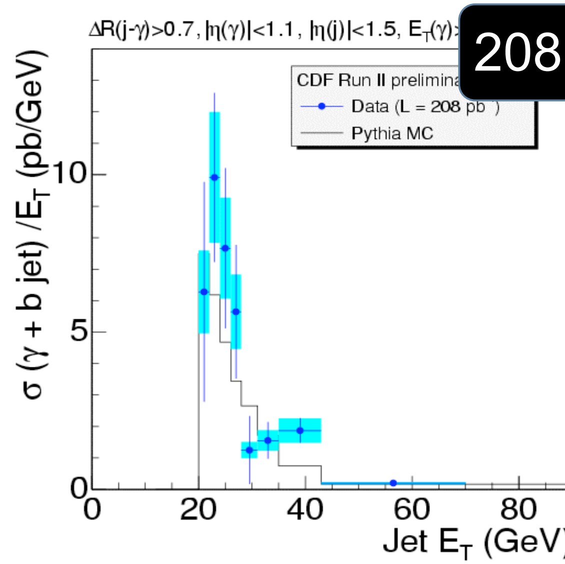
γ+b-jet Production

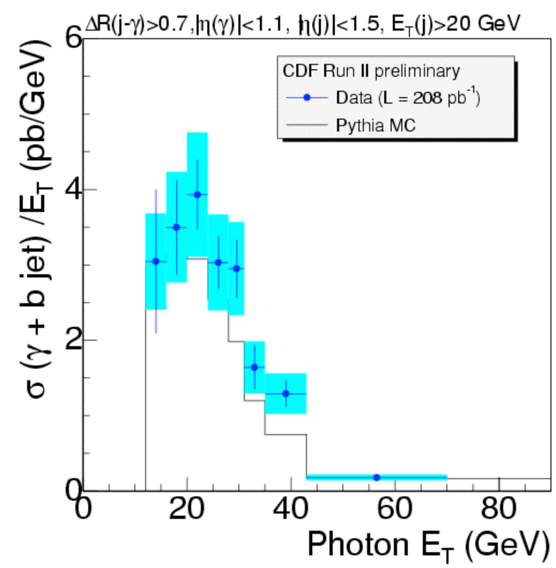


Method similar to Z+b-jet.

- γ + displaced track trigger
- $E_T^{\gamma} > 12$ GeV, $|\eta^{\gamma}| < 1.1$
- jet ($E_T > 20$ GeV, $|\eta| < 1.5$) with secondary vertex
- Cross-section as function of photon E_T and jet E_T.

208 pb^{-1}

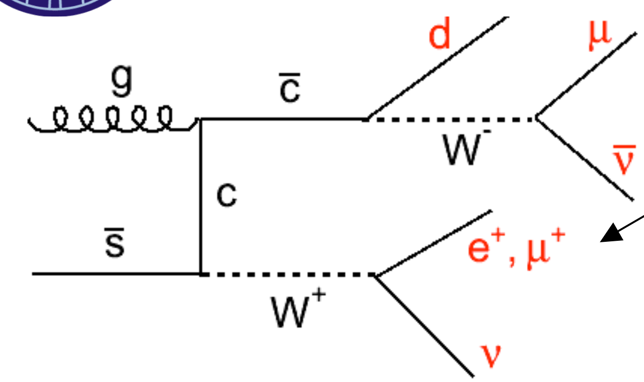




- Agreement within errors with LO Pythia.
- Already limited by systematics (Tracking efficiency, jet energy scale)

W+charm

1.8 fb^{-1}



- Must have opposite charge
- Electron and muon channels considered for W decay

$$A = \frac{(N_{OS} - N_{SS})}{(N_{OS} + N_{SS})}$$

- Charge correlation allows extraction of W+c signal from large background

- Use CTEQ5L PDFs and PYTHIA used for MC simulation → get expected number of OS-SS events from background sources
- #Wc = #OS-SS(observed) - #OS-SS(expected).

$$\sigma_{Wc} \times \mathrm{BR}(W \to \ell\nu) = 9.8 \pm 2.8(\mathrm{stat.})^{+1.4}_{-1.6}(\mathrm{sys.}) \pm 0.6(\mathrm{lum})\mathrm{pb}$$

Measurement agrees with NNLO calculation: $11.0^{+1.4}_{-3.0}\,\mathrm{pb}$