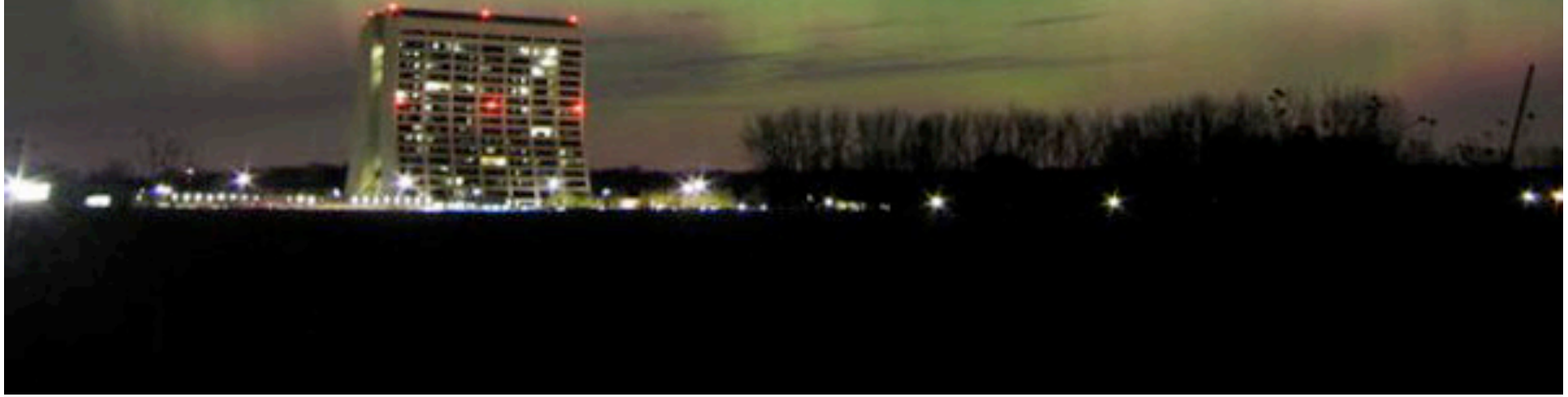
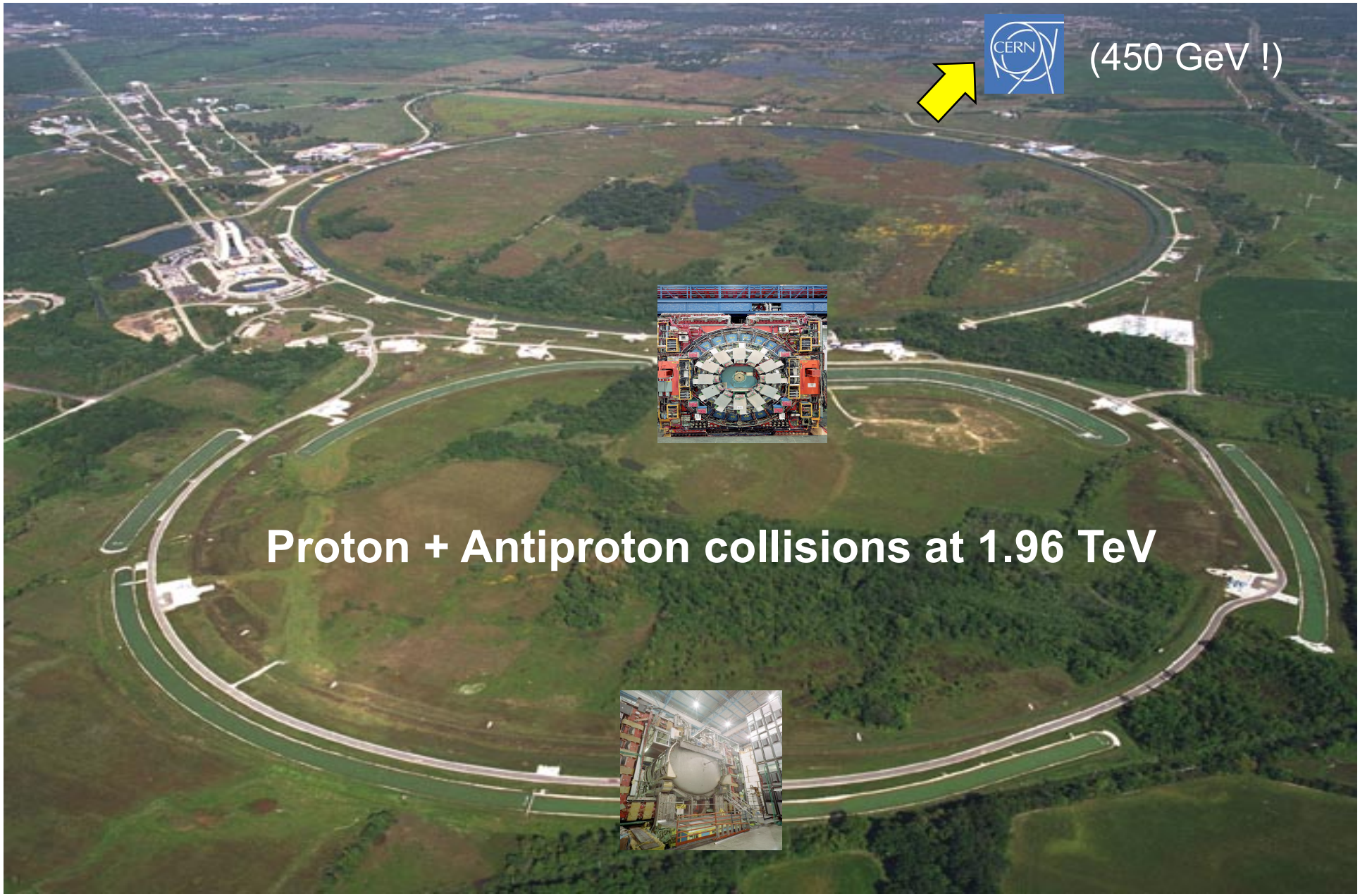
Tevatron PDF Constraints

XXXVIII International Symposium on Multiparticle Dynamics
DESY : Sep 16 2008

Mark Lancaster
University College London

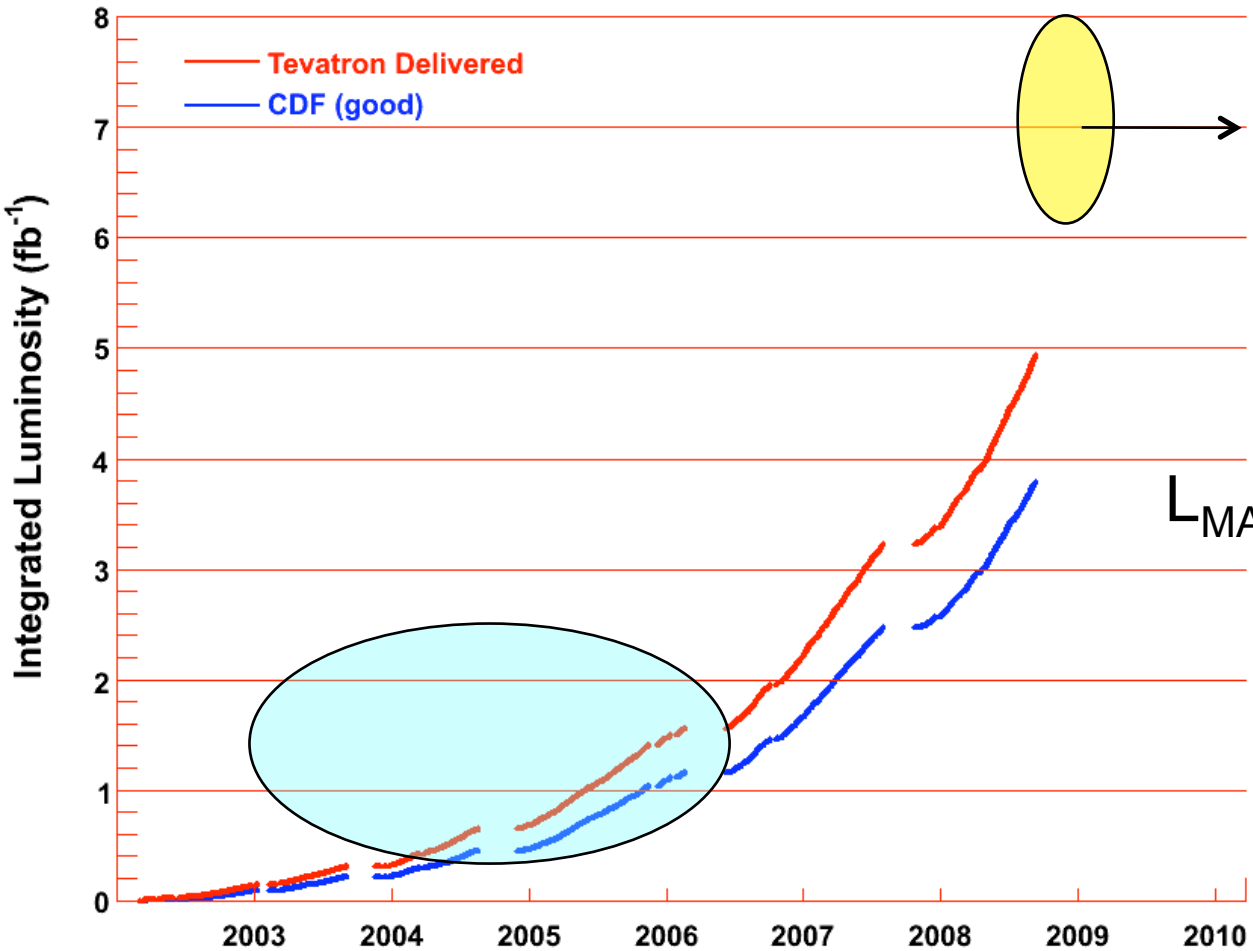


Fermilab Tevatron



Tevatron Datasets

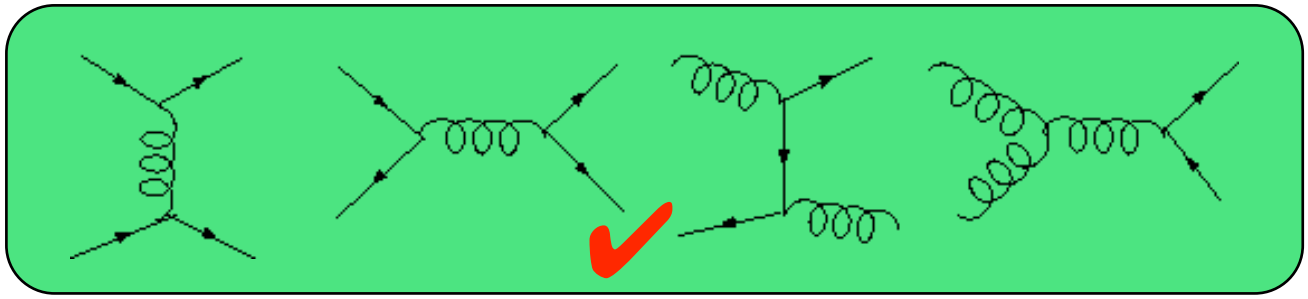
- 4fb^{-1} under analysis now. Ultimate PDF constraints from 6-8 fb^{-1}
- results / current PDF constraints from 0.2 – 2fb^{-1} datasets



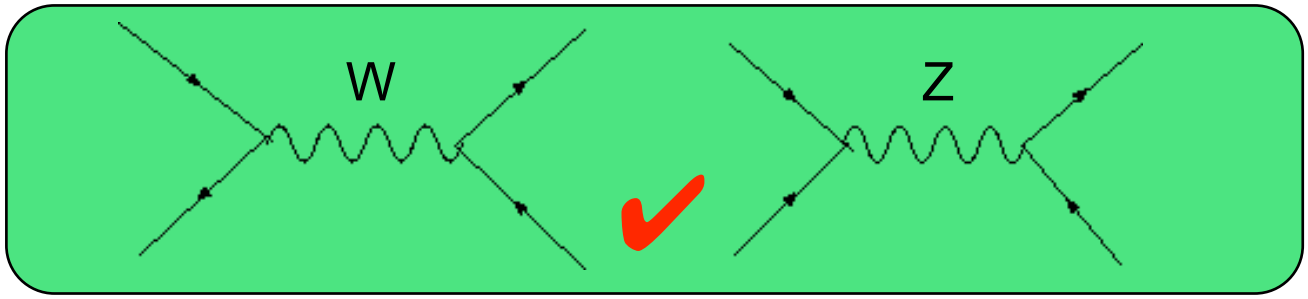
Final datasets

$L_{MAX} \sim 3x10^{32}$ cm^{-2}s^{-1}

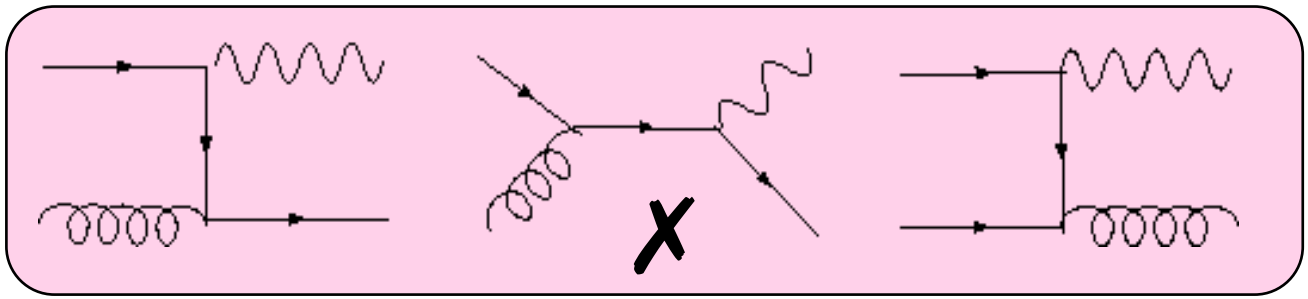
Processes Measured for PDFs



INCLUSIVE JETS



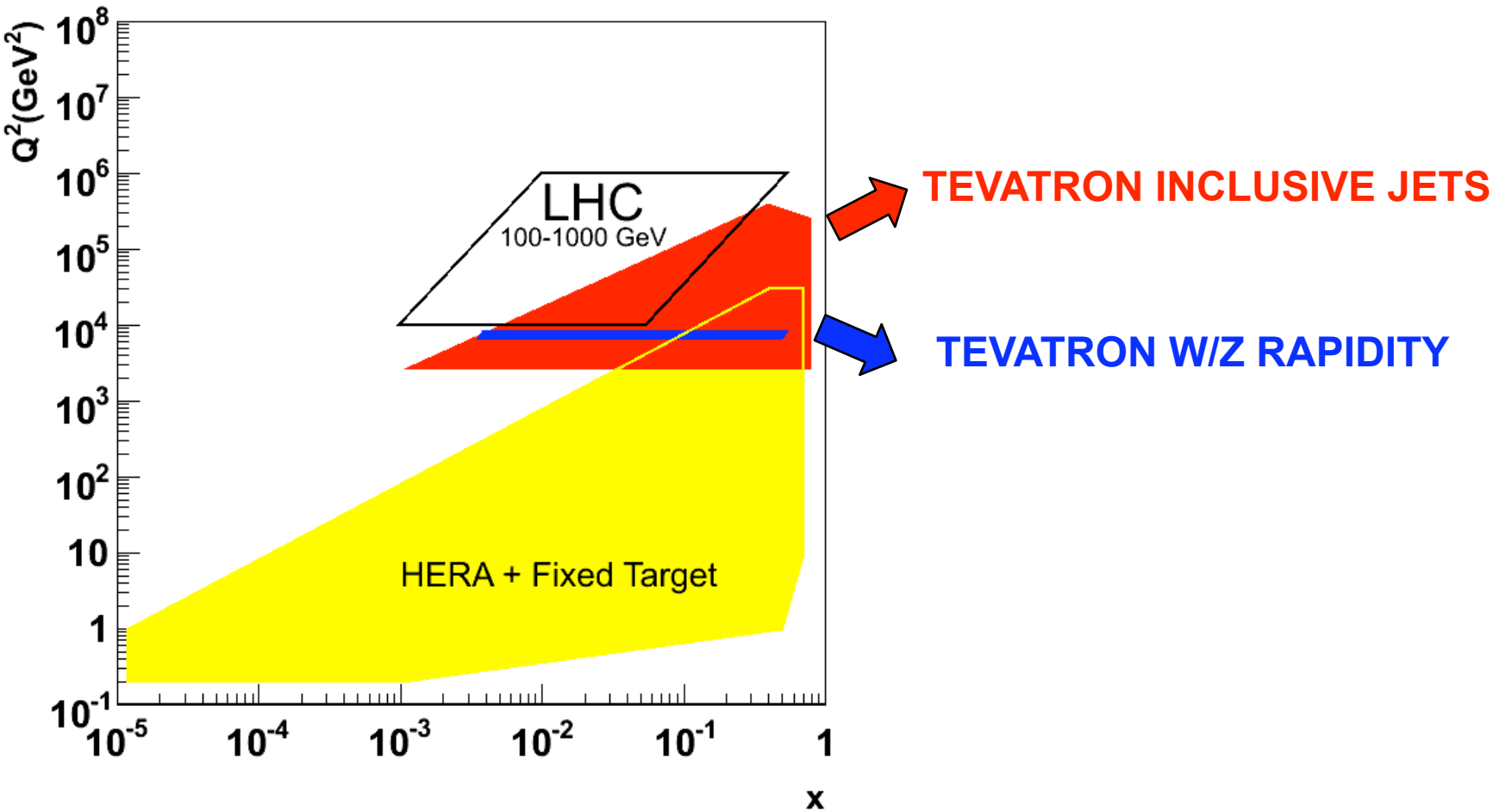
W/Z RAPIDITY



W/Z/γ + JET/HF

Tevatron Kinematic Region

- Tevatron data provide 10% of the data-points in the PDF fits
- Complement HERA and fixed-target data providing constraints at high-Q^2

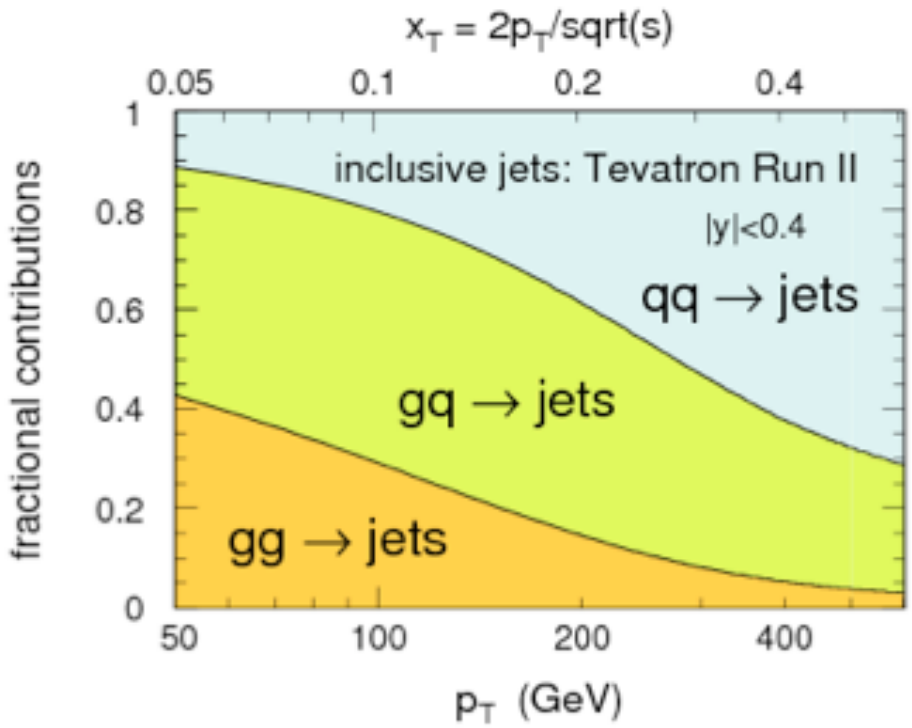


Tevatron Inclusive Jets

Two run-2 datasets presently being fitted

1. D0 : Phys. Rev. Lett. 101 062001 (2008)
   - 0.70 fb^{-1} : cone algorithm : $50 < E_T < 600$ GeV; $|y| < 2.4$.
2. CDF Phys. Rev. D75 092006 (2007)
   - 1.0 fb^{-1} : k_T algorithm : $54 < E_T < 700$ GeV; $|y| < 2.1$.

   CDF Midpoint cone data being used as a cross-check (hep-ex/0807.2204)

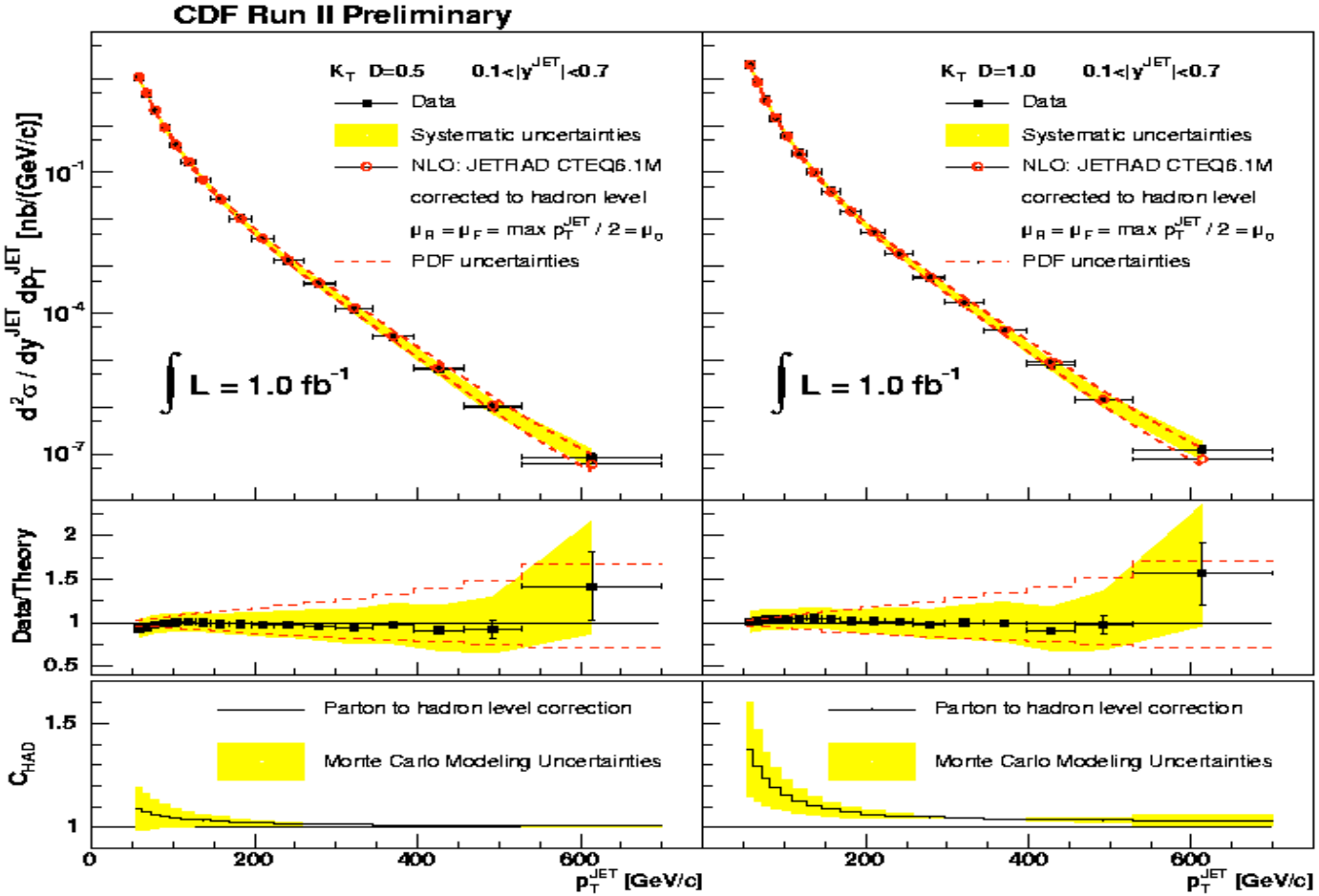


Predominant impact is on *high-x gluon*

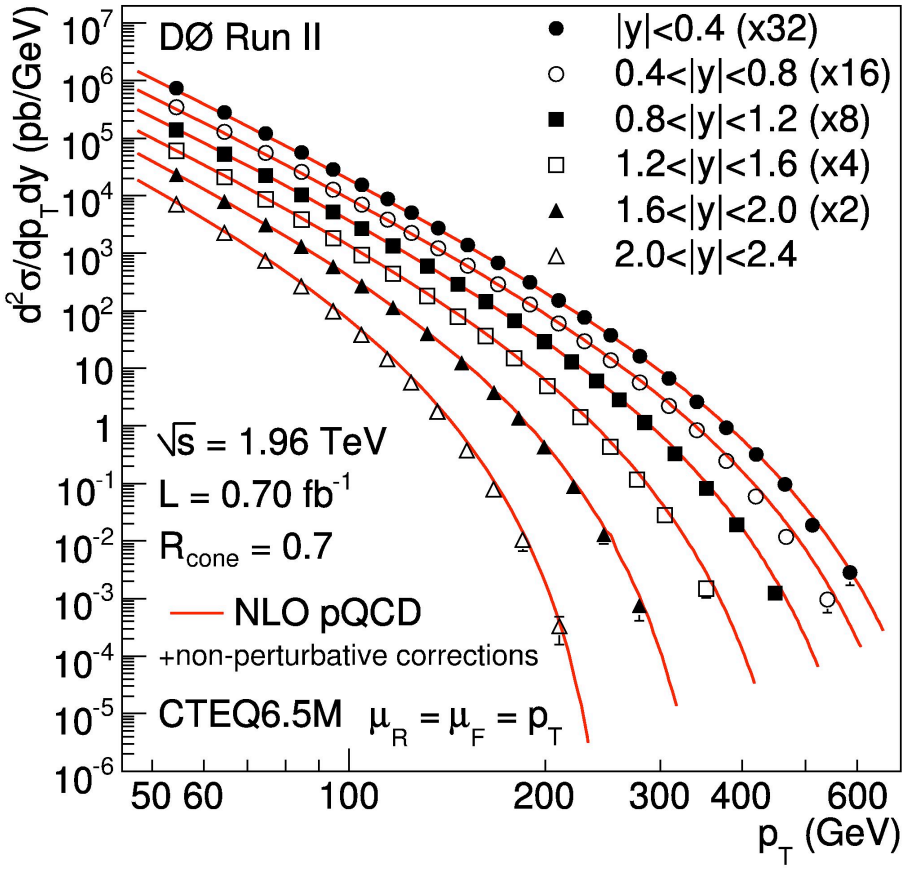
New Physics at LHC

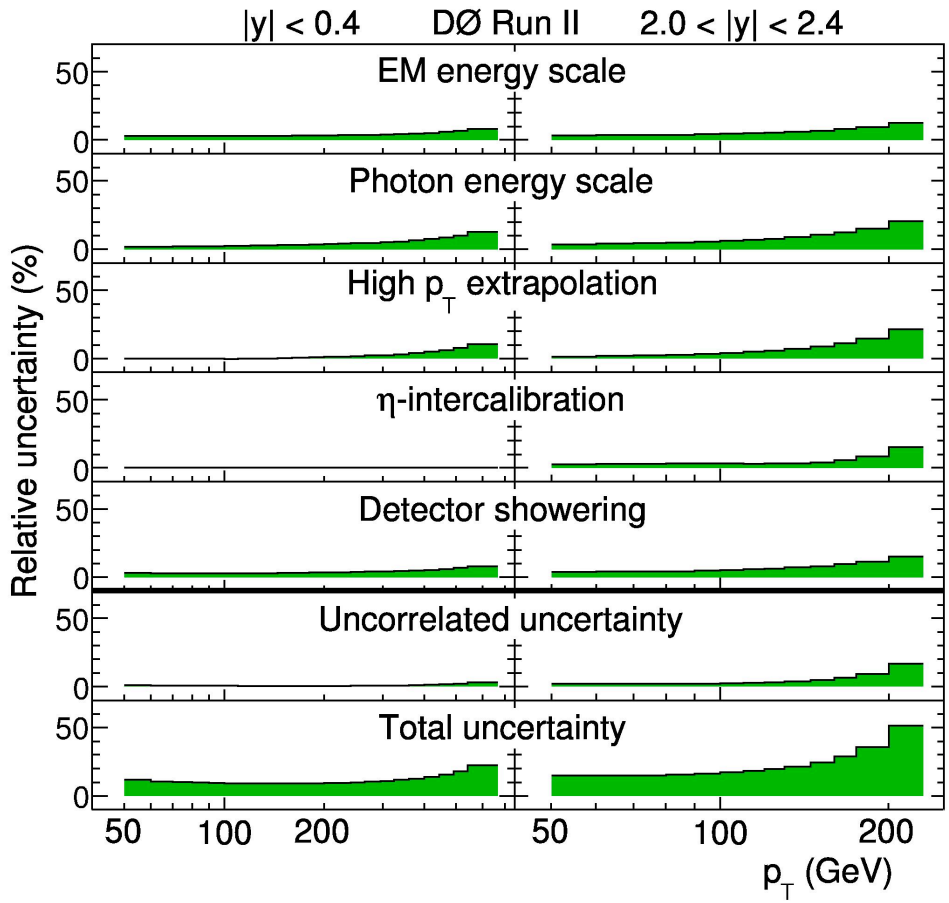
Tevatron Inclusive Jets

Run-2 data greater stats and control of corrections to parton level



Tevatron Inclusive Jets

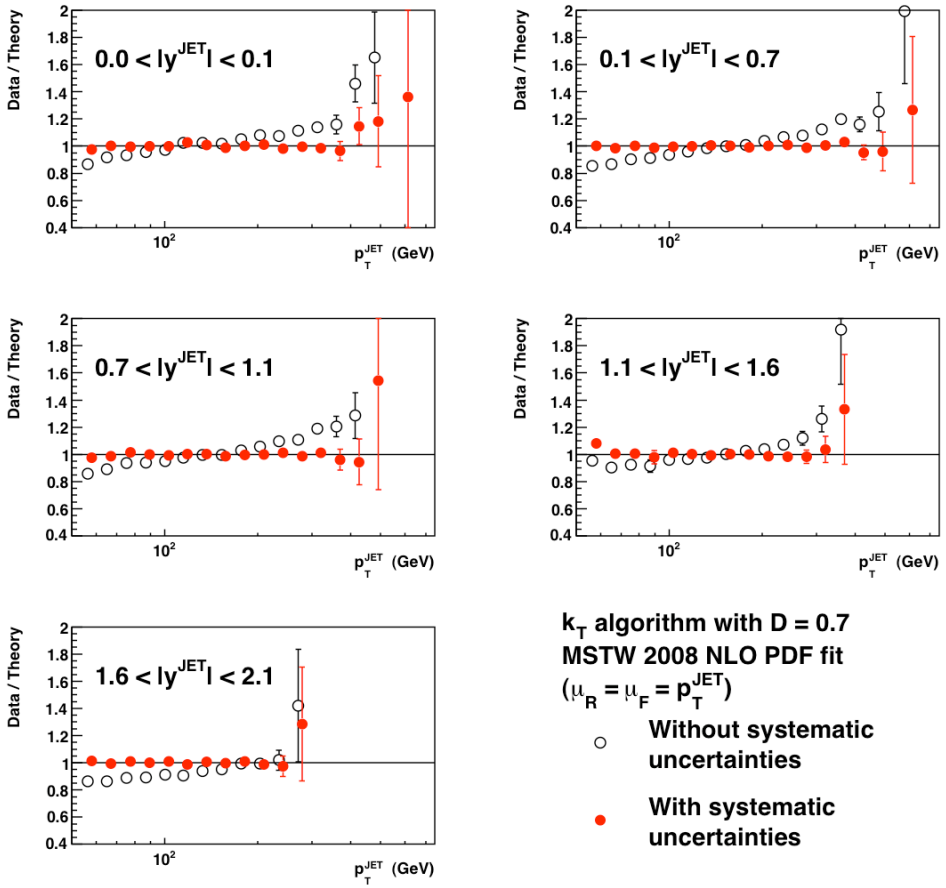




Tevatron Inclusive Jets

PDF fits have greater stability using scale = p_T (not $p_T/2$)

CDF Run II inclusive jet data, χ^2 = 56 for 76 pts.

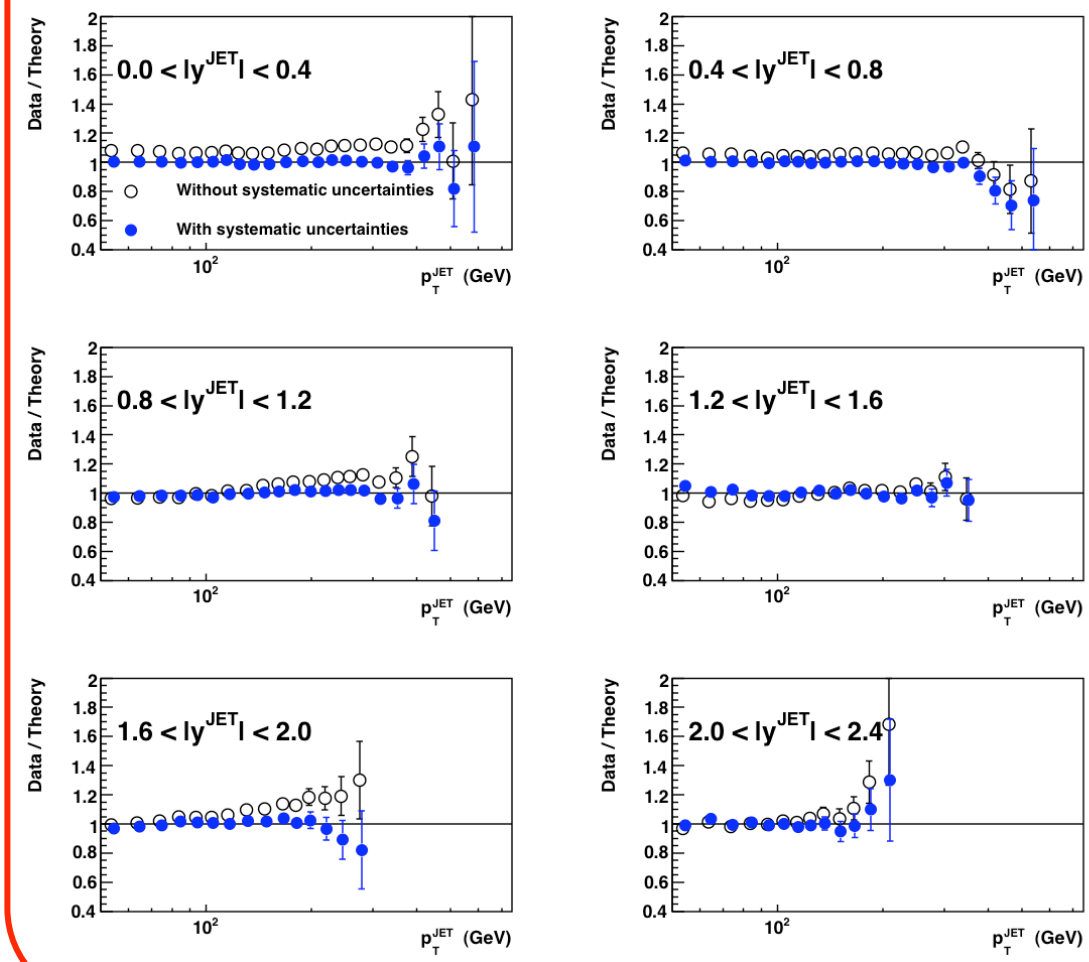


Excellent description when account for correlated systematics

Tevatron Inclusive Jets

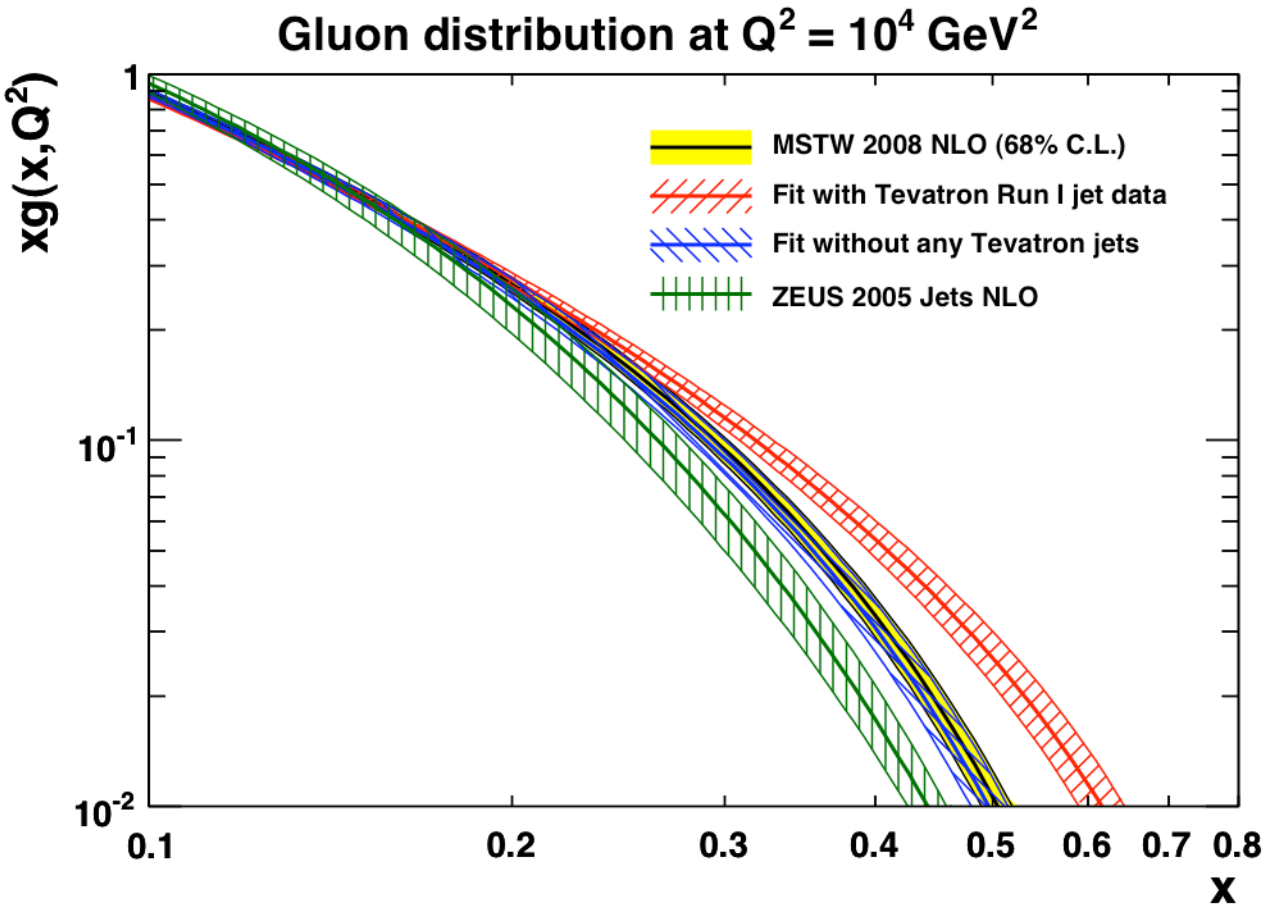
DØ Run II inclusive jet data (cone, R = 0.7)

MSTW 2008 NLO PDF fit ($\mu_R = \mu_F = p_T^{JET}$), χ^2 = 114 for 110 pts.



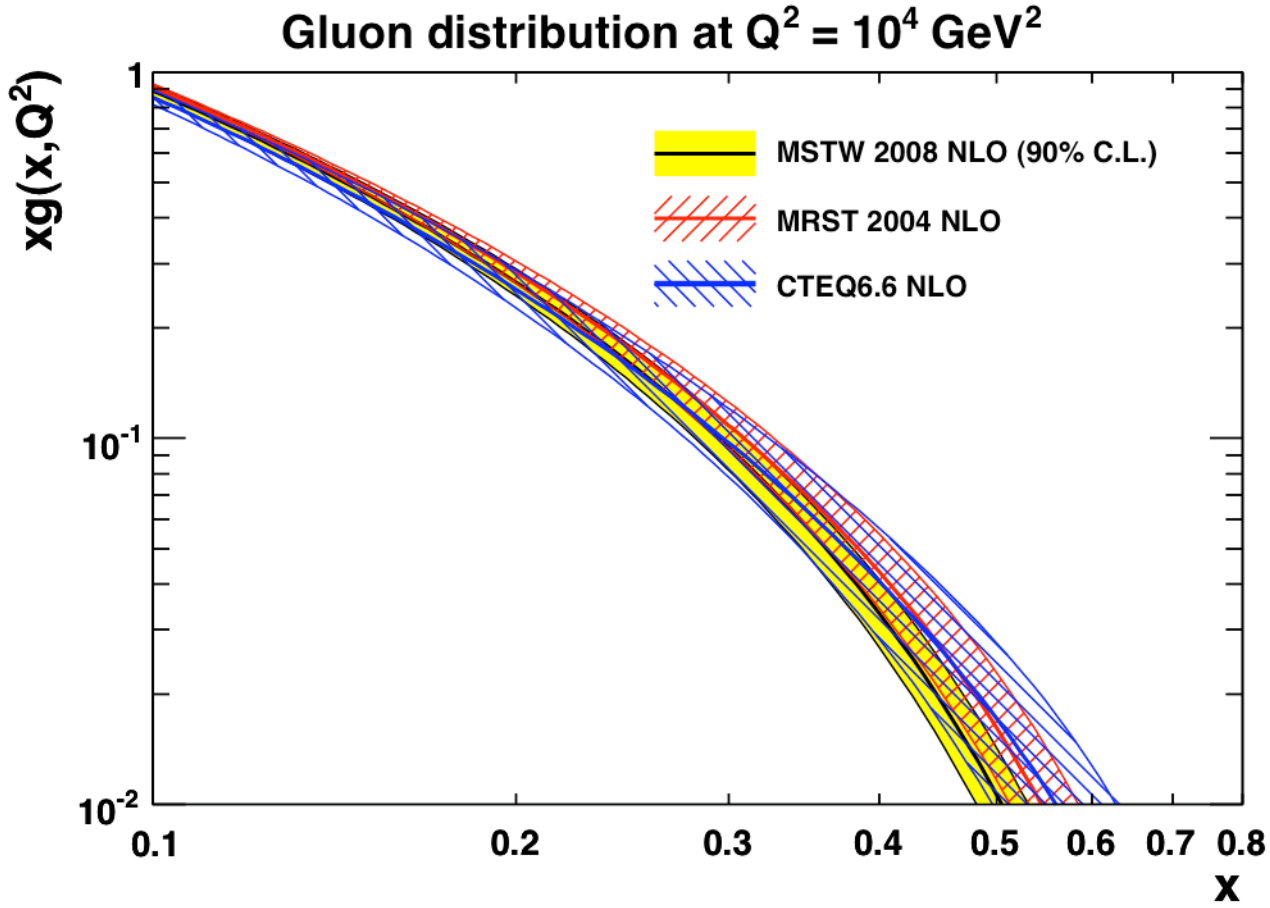
Data constrain gluon for 0.01< x < 0.5

Tevatron Inclusive Jets : Gluon Impact

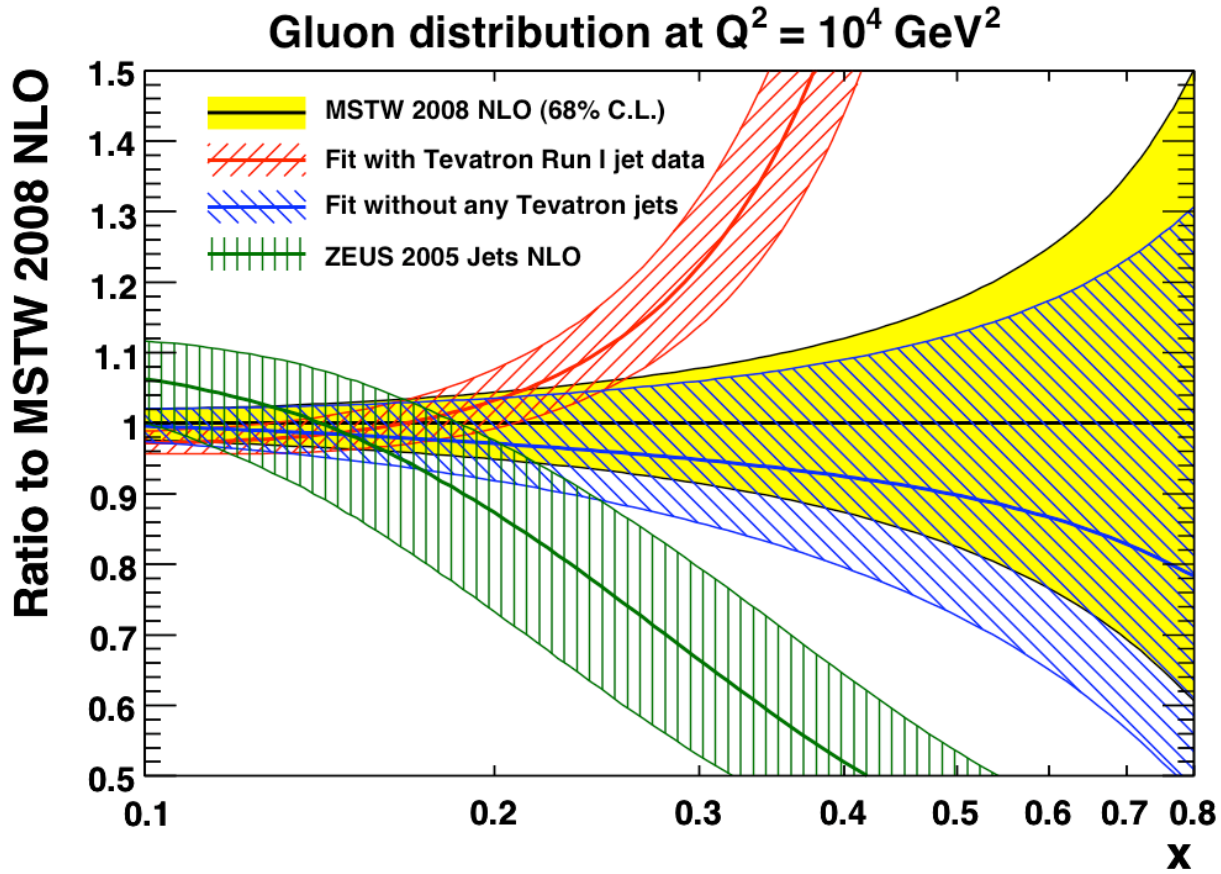


Data now prefer a smaller (softer) high-x distribution than previous fits and consistent with fit without jet data but ZEUS-fit softer still (functional form issue?)

Tevatron Inclusive Jets : Gluon Impact



Tevatron Inclusive Jets : Gluon Impact



Differences in $x > 0.3$ region but data still not yet precise enough to significantly reduce the gluon variance (50%) at highest x values.

Further progress from higher stats studies of energy scale systematics

Tevatron : W & Z rapidity constraints

Data presently being used in fit :

1. 0.4 fb^{-1} D0 Z-ee rapidity – Phys. Rev D 76 012003 (2007)
2. 2.0 fb^{-1} CDF Z-ee rapidity – `http://www-cdf.fnal.gov/physics/ewk/2008/dszdy`
3. 0.3 fb^{-1} D0 W-μv charge asymmetry – Phys. Rev. D 77 011106(R) (2008).
4. 0.2 fb^{-1} CDF W-ev - Phys. Rev. D71 051104 (2005).

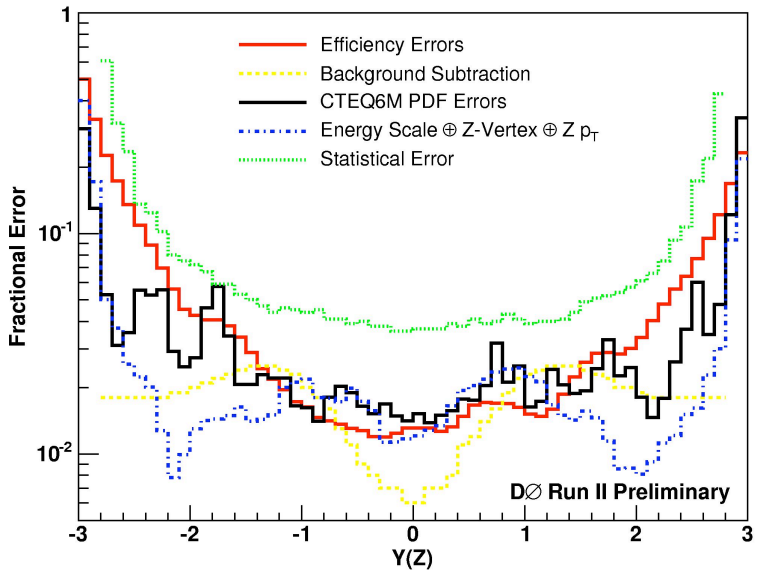
Latest CDF/D0 W charge asymmetry not yet included due to inconsistencies.

Mainly sensitive to up and down-quark distributions but up-quark already well constrained by e_Q^2 weighted F_2 and so **Tevatron W/Z data mostly constrain down quark.**

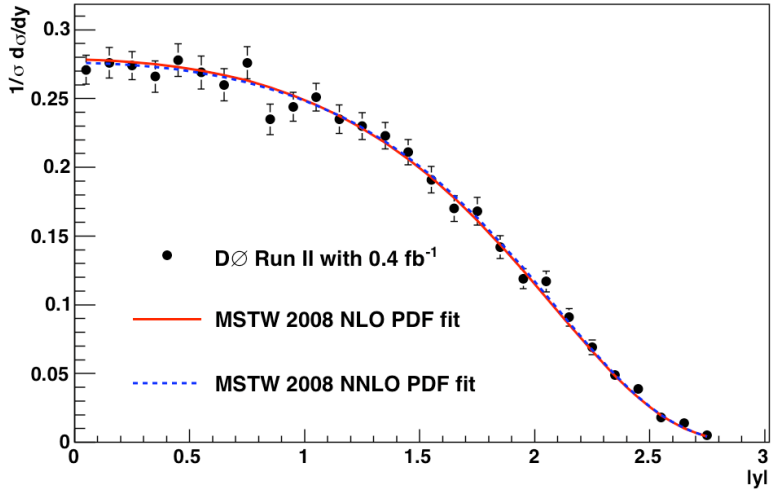
Tevatron : Z rapidity constraints

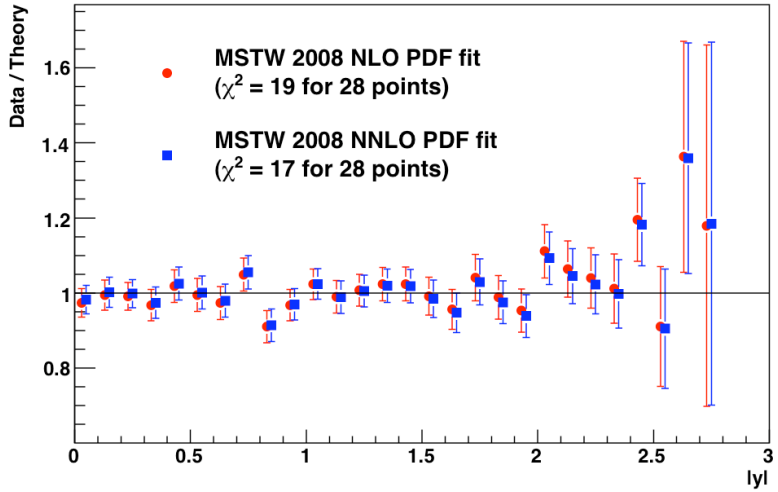
$$Y_Z = 0.5 \ln\left(\frac{x_p}{x_{\overline{p}}}\right)$$

High Y_Z
Probes one high *x*
& one low *x* parton



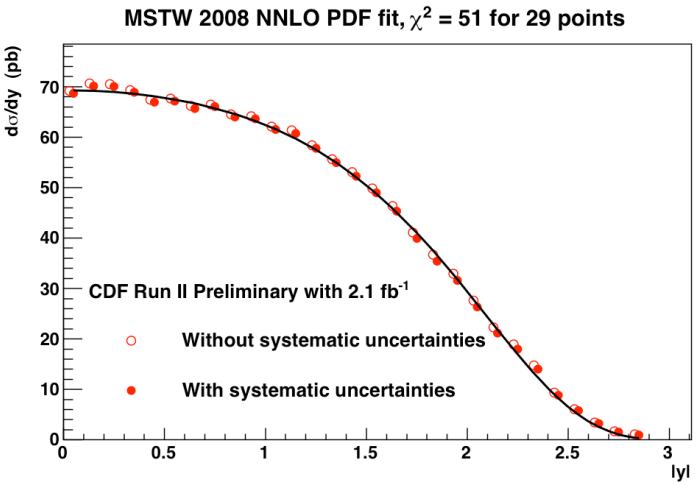
Z/γ* rapidity shape distribution from DØ

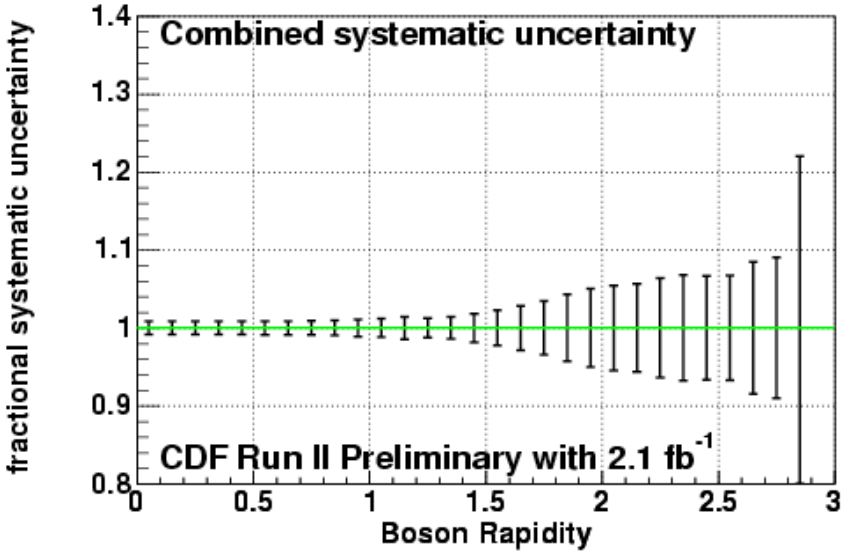


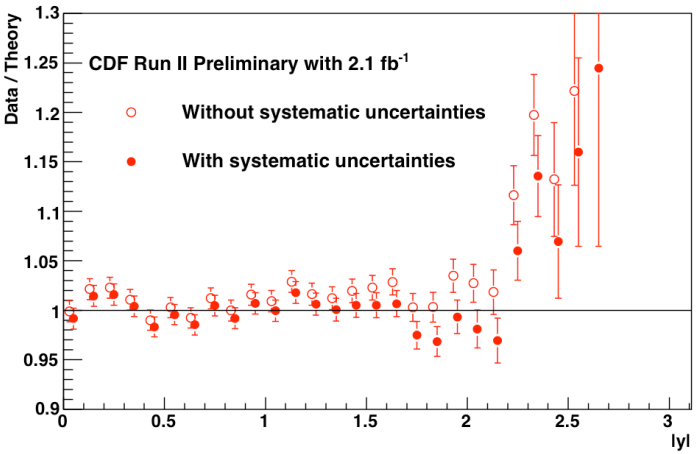


Tevatron : Z rapidity constraints

Z/γ* rapidity distribution from CDF

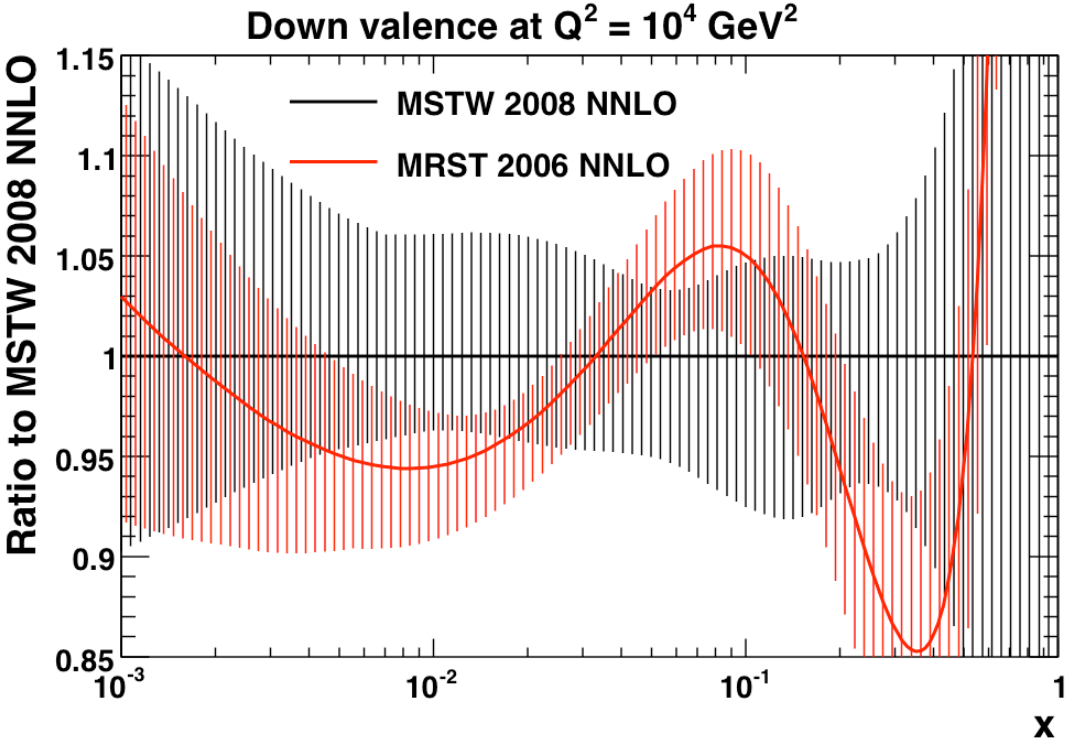






PDF	χ^2/df
CTEQ 6.1M NLO	39/29
MRST NNLO	56/29
MSTW NNLO (2008)	51/29

Tevatron : Z rapidity constraints

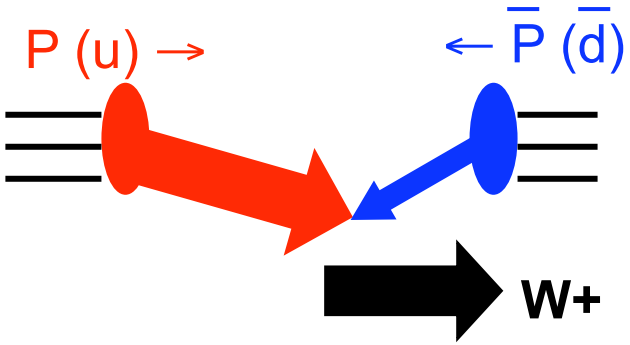


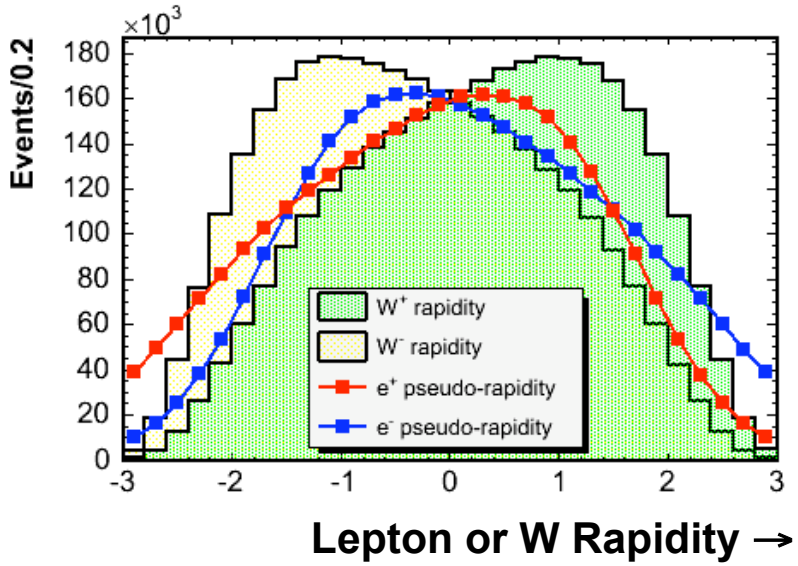
More d_V parameters allowed to vary in fit compared to previous fits.

So despite better constraining data the variance in d_V is now larger !!!

Tevatron : W Charge Asymmetry

W^+ boosted in proton direction
since u quark momentum > d quark





In general we measure a lepton charge asymmetry

$$\cos\theta^* = \sqrt{1 - 4E_T^2/M_W^2}$$

Angle between lepton and proton in W rest frame

$$y_l = y_W \pm \frac{1}{2}\ln\left(\frac{1+\cos\theta^*}{1-\cos\theta^*}\right)$$

$$d\sigma(l^+)/d\eta_l - d\sigma(l^-)/d\eta_l \approx u(x_1)d(x_2)(1-\cos\theta^*)^2 + \underline{\bar{d}(x_1)\bar{u}(x_2)(1+\cos\theta^*)^2} - d(x_1)u(x_2)(1+\cos\theta^*)^2$$

Anti-quark term enhanced at low E_T

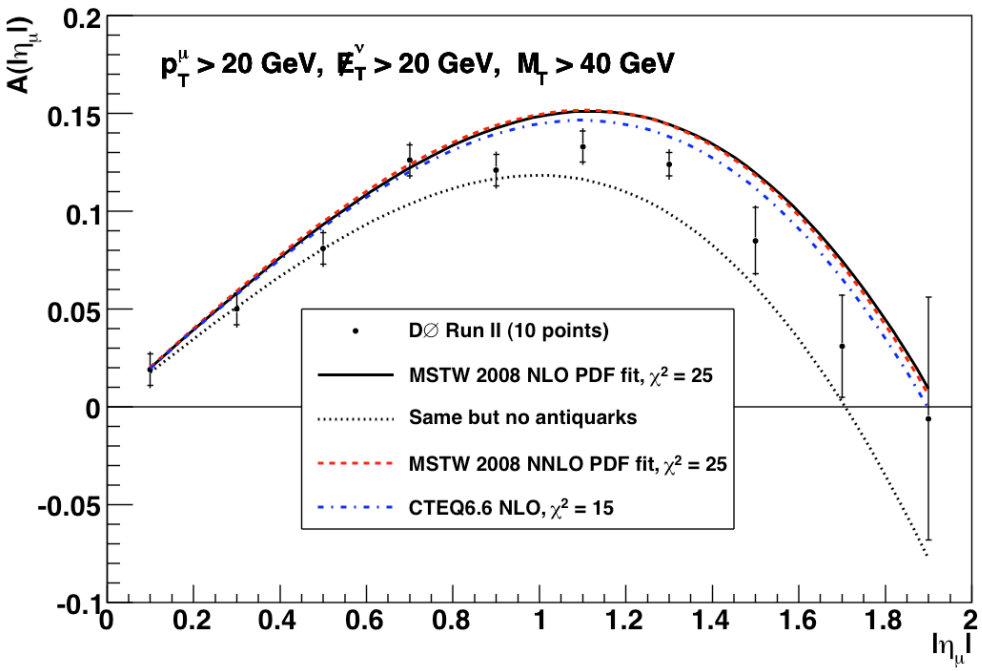
Measurements E_T bins can provide some distinction between sea & valence

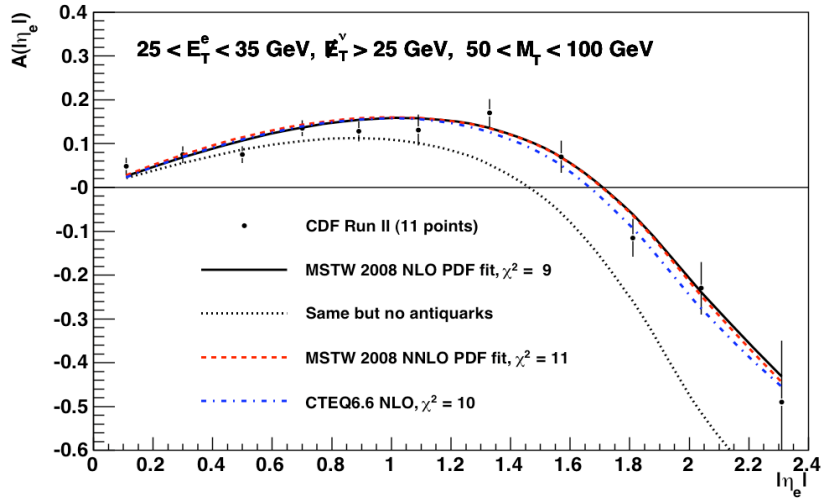
Tevatron : W Charge Asymmetry

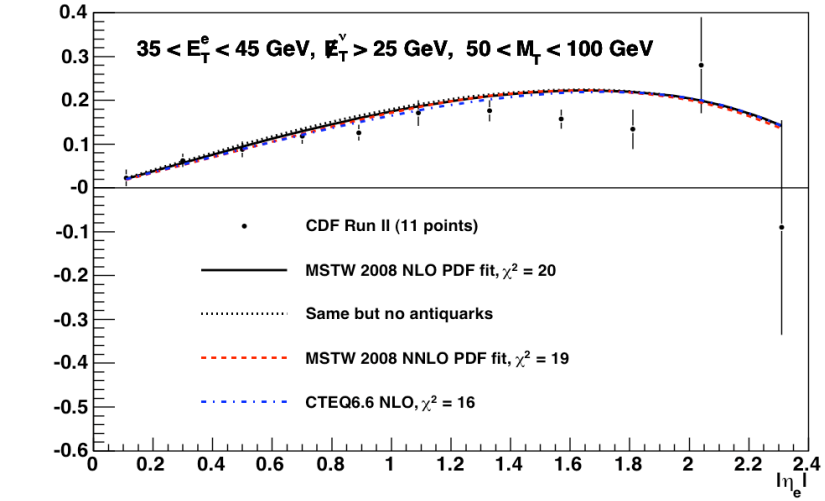
CDF data on lepton charge asymmetry from W→eν decays

Anti-quark discriminating power at low E_T

DØ data on lepton charge asymmetry from W→μν decays







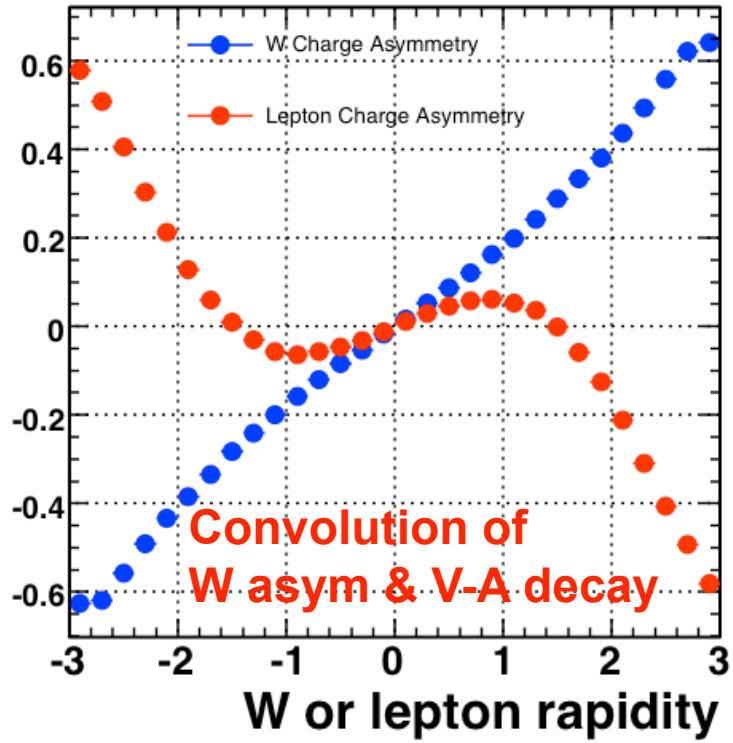
Tevatron : Latest W Charge Asymmetry

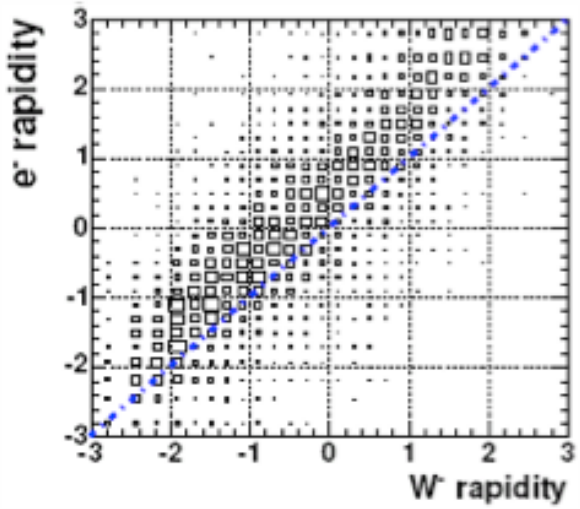
- CDF unfolds back to measure asymmetry using W rapidity : $1fb^{-1}$

http://www-cdf.fnal.gov/physics/ewk/2007/WChargeAsym/W_Charge_Asymmetry.html

- D0 W-ev measurement with $0.75fb^{-1}$ differential in E_T

arXiv:/0807.3367 [hep-ex]



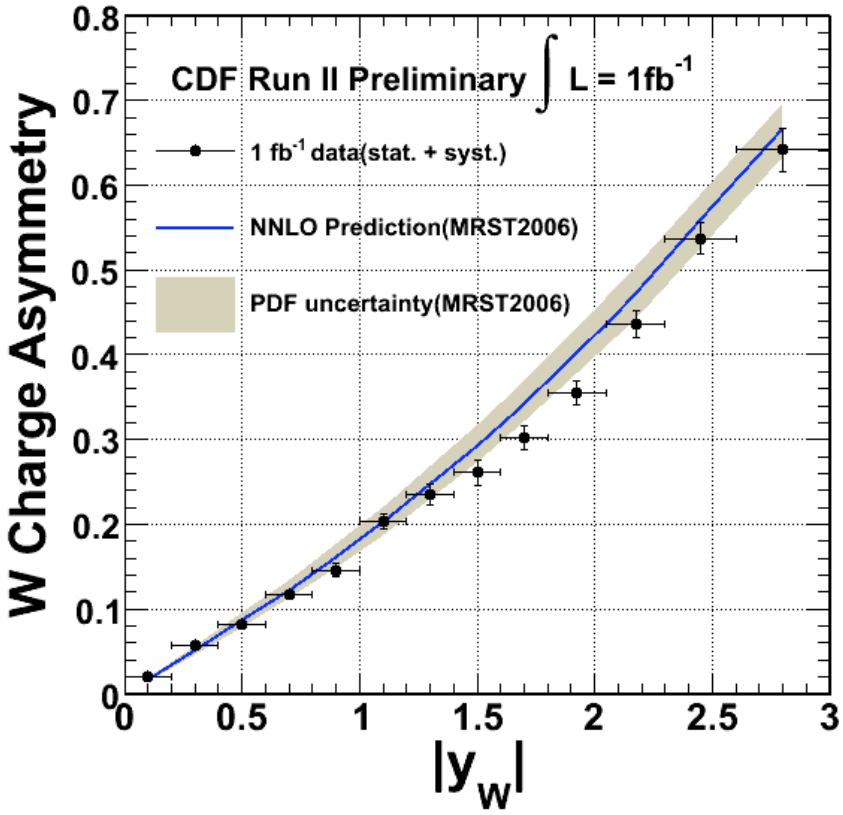


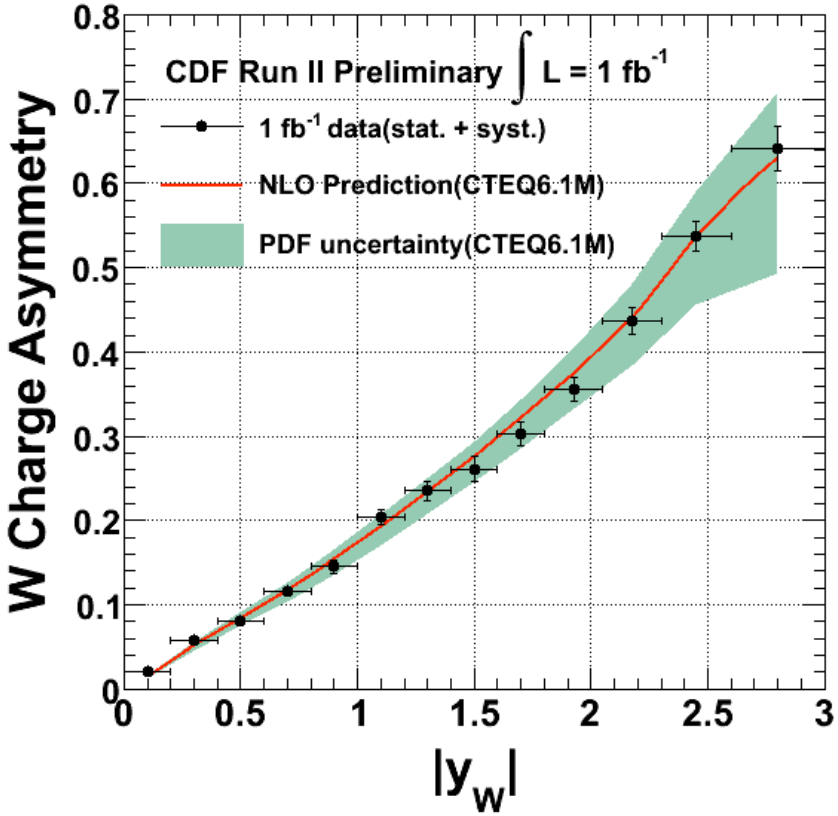
Lepton prefers to decay against W boost

CDF : Latest W Charge Asymmetry (Y_W)

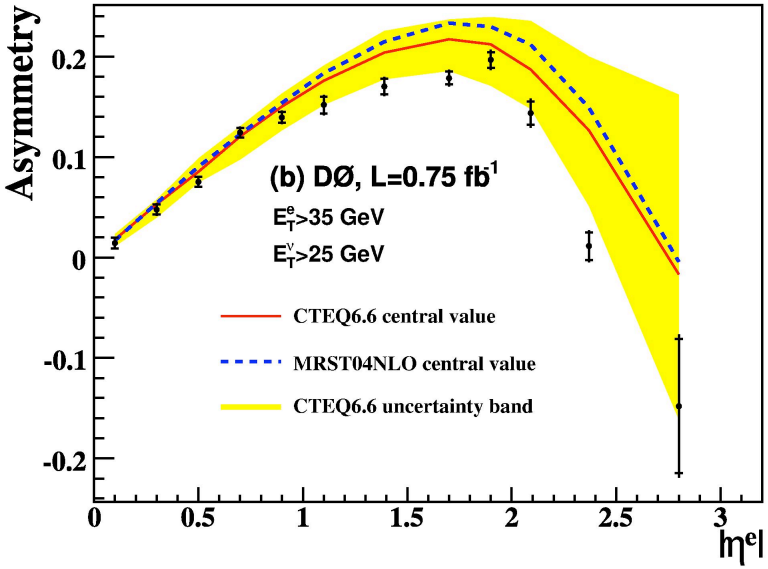
Weight data with 2 choices of Yw based on Mw kinematic constraint and MC

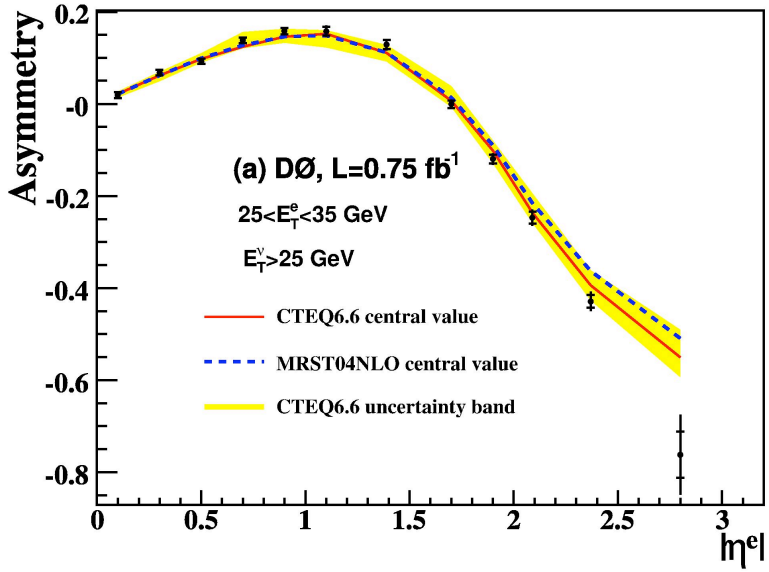
Iterate to remove dependence on MC input parameters (PDFs etc)

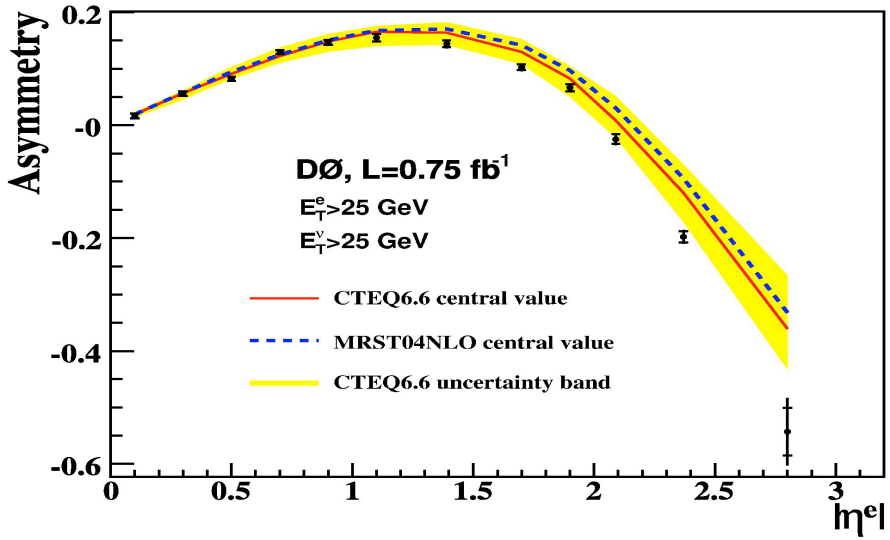




D0 : Latest W Charge Asymmetry (Y_l)

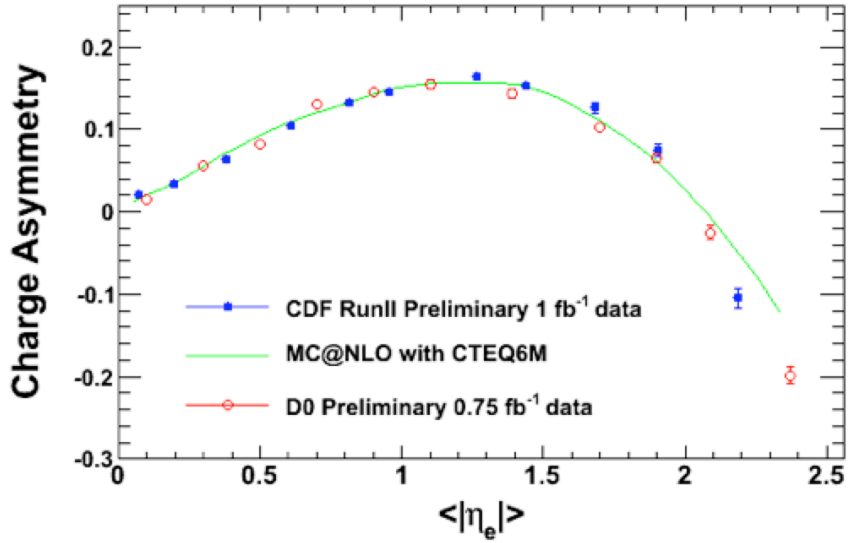






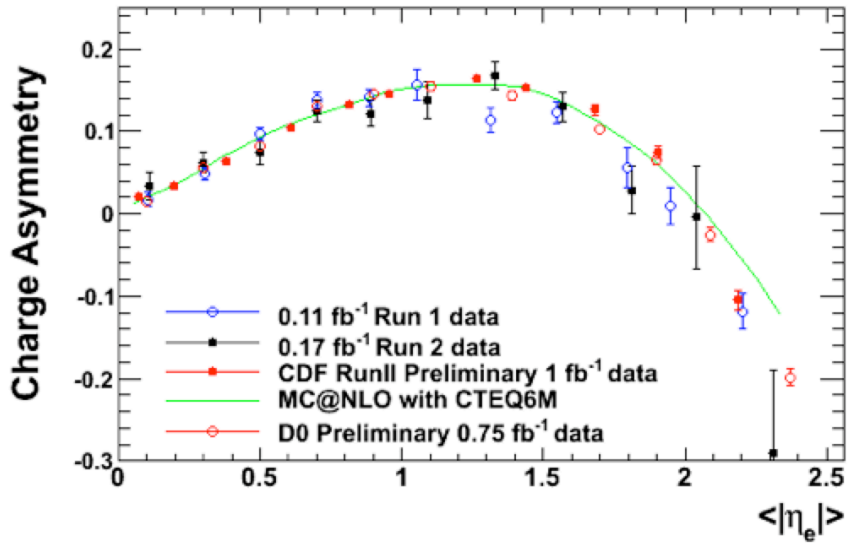
Both latest CDF/D0 data should be providing improved d/u constraints but life is never that simple…

Comparison of Latest W Charge Asymm.



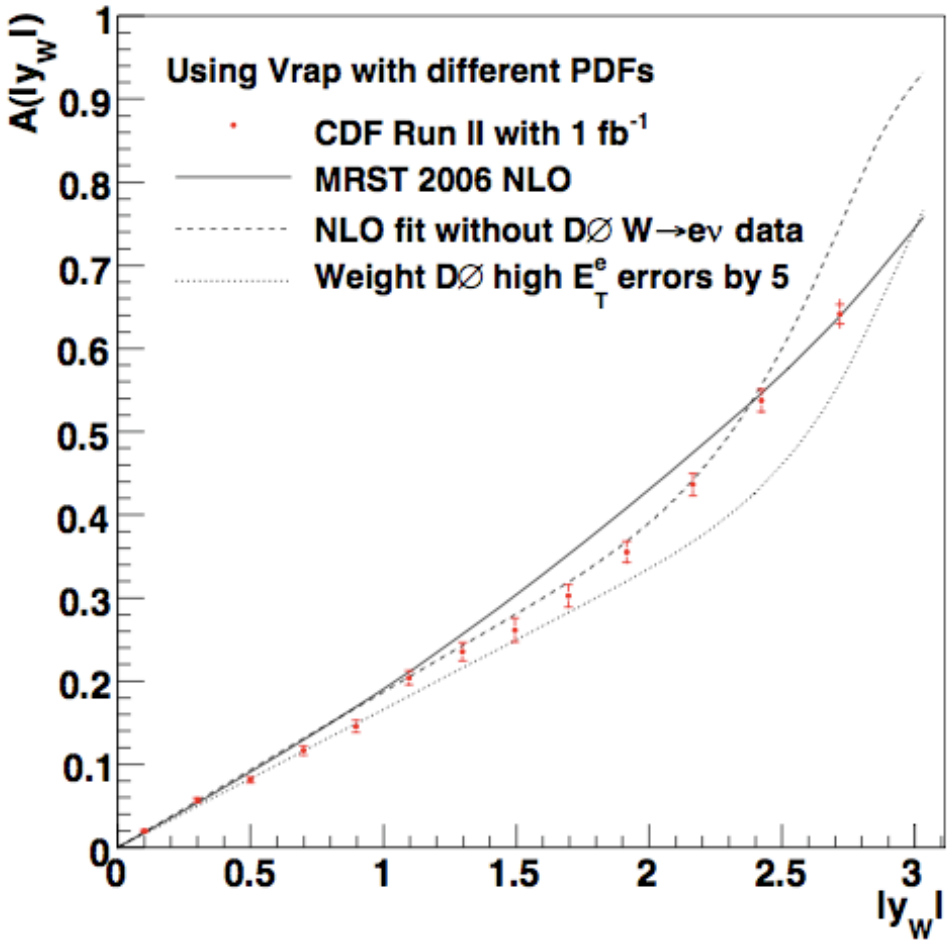
CDF provides stat. only η_l data in addition to Y_W results.

For $0.8 < \eta_l < 2.0$: D0 data **below** CDF



Comparison of Latest W Charge Asymm.

CDF/D0 inconsistency is significant



NLO fit without D0 fits CDF OK

or

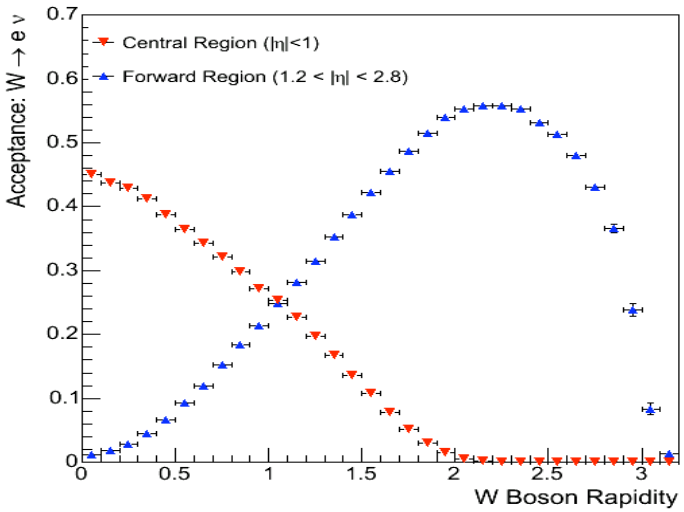
NLO fit to weighted D0 is below CDF

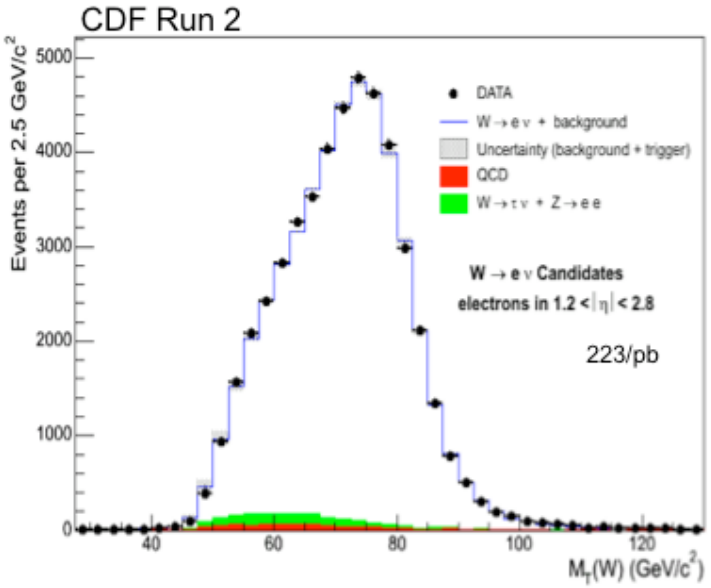
Under investigation by CDF/D0:

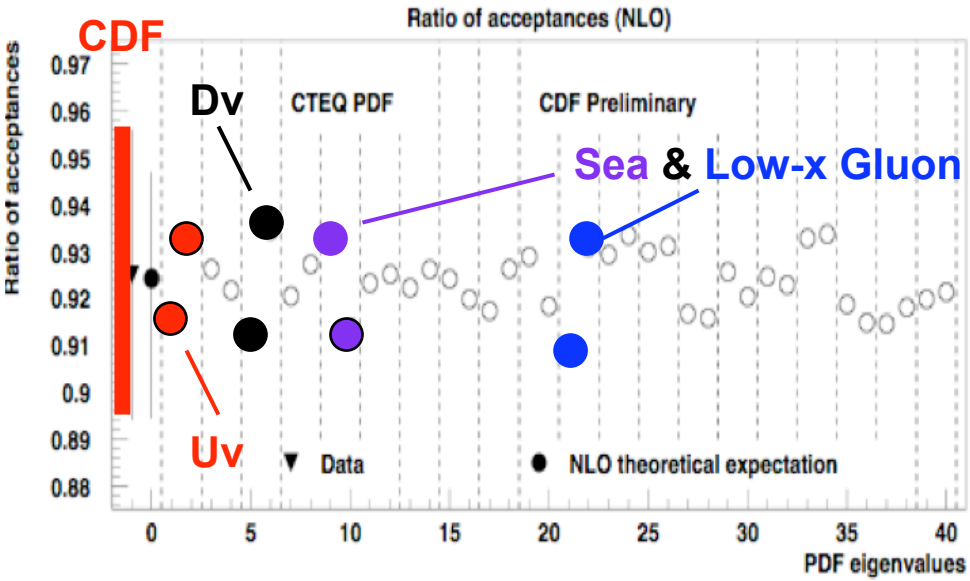
- backgrounds, cut consistency, E_T scale, smearing, charge mis-id.

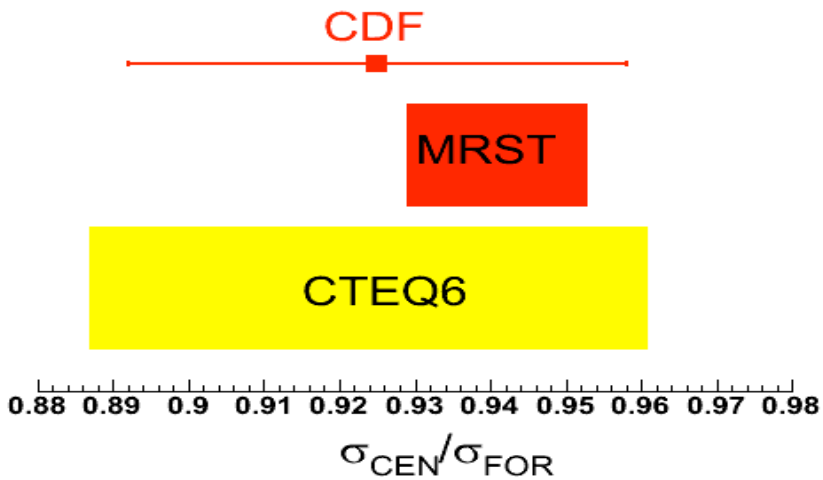
Tevatron : Other potential constraints

Forward W Cross Section : CDF : Phys. Rev. Lett. 98, 251801 (2007)



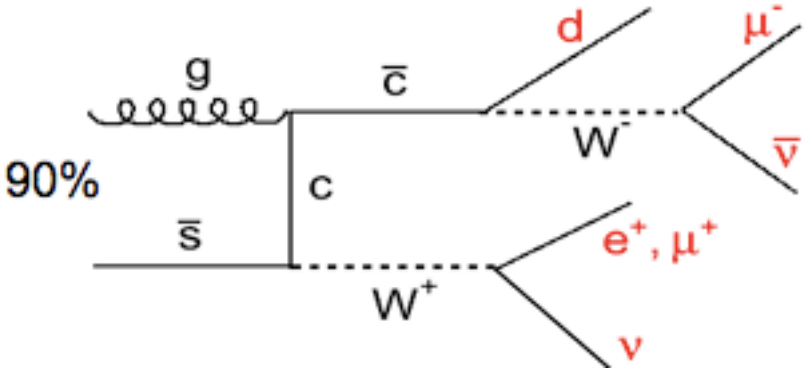


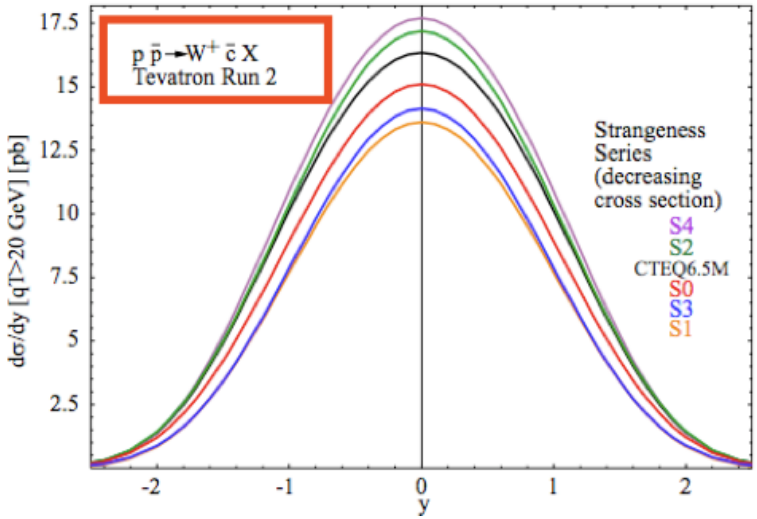




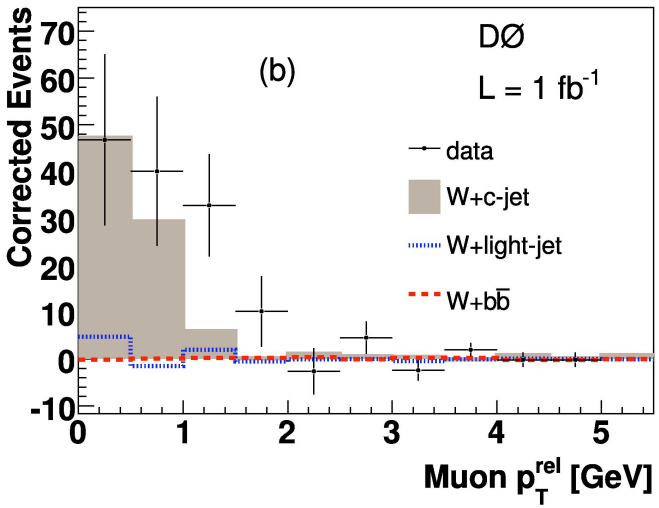
W + Charm

Measurements presently statistically dominated but have potential to probe strange quark at high Q^2

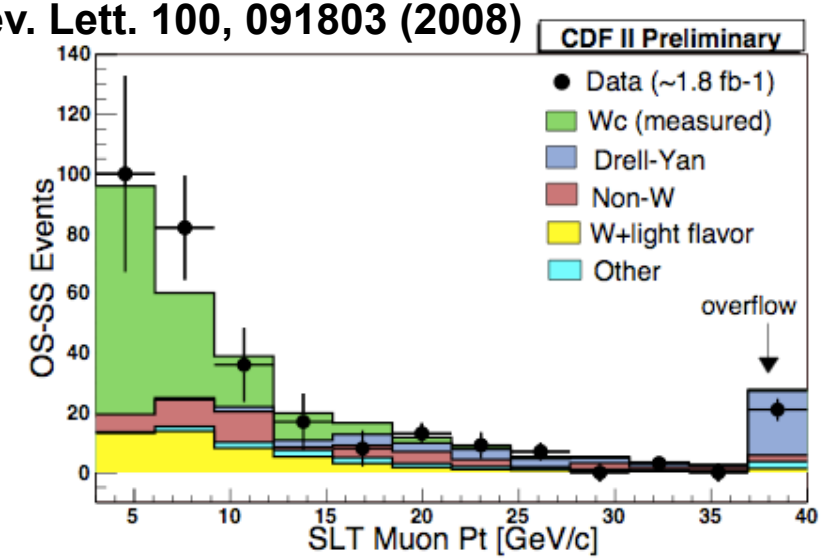




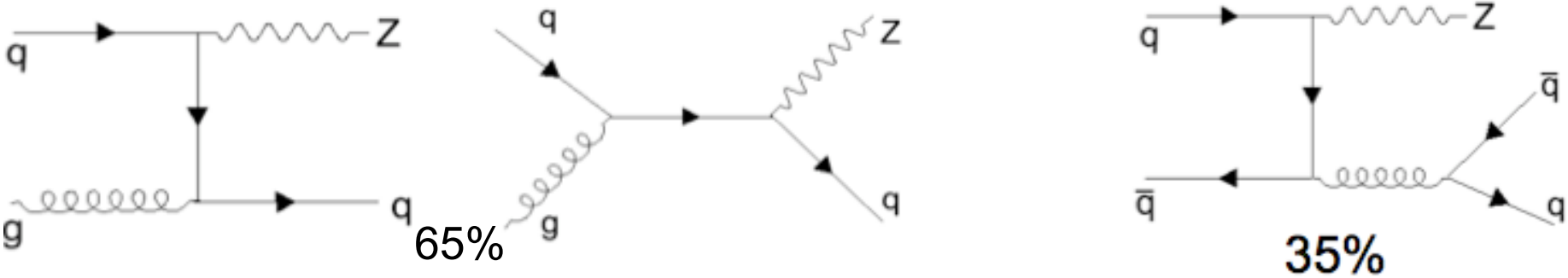
PLB 666 23 (2008)



Phys. Rev. Lett. 100, 091803 (2008)



Z / Gamma + b


q
Z
g
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Z
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q̄
q
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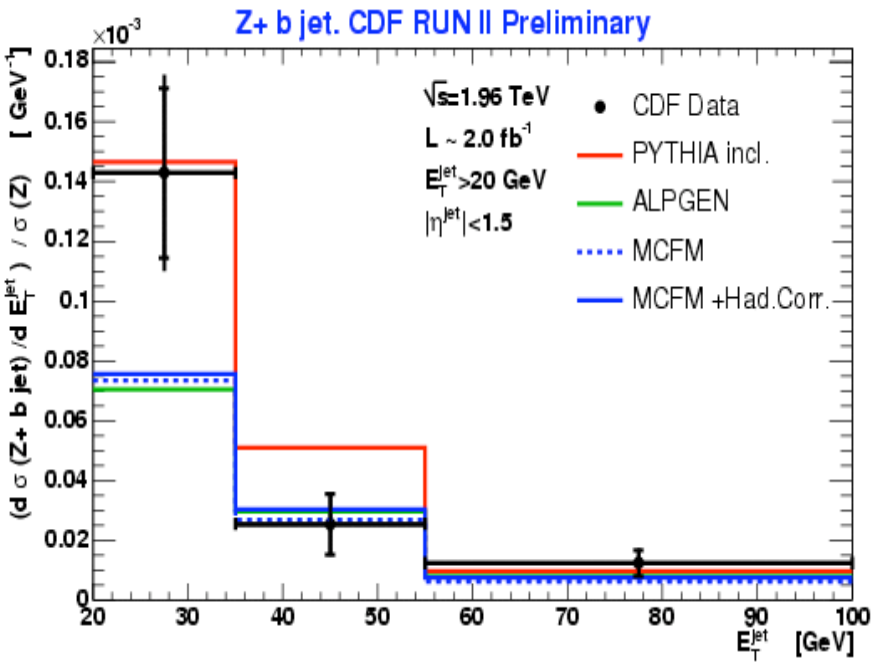
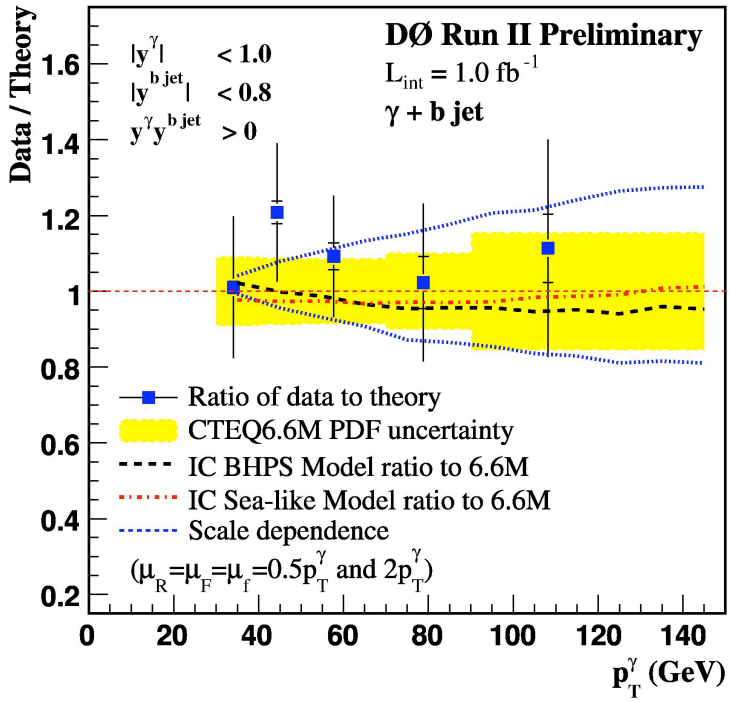

Z+ b jet. CDF RUN II Preliminary
×10⁻³
√s=1.96 TeV
L ~ 2.0 fb⁻¹
E_T^jet>20 GeV
|η^jet|<1.5
CDF Data
PYTHIA incl.
ALPGEN
MCFM
MCFM +Had.Corr.
(d σ (Z+ b jet) /d E_T^jet) / σ (Z) [GeV⁻¹]
E_T^jet [GeV]


DØ Run II Preliminary
L_int = 1.0 fb⁻¹
γ + b jet
|y^γ| < 1.0
|y^b jet| < 0.8
y^γ y^b jet > 0
Ratio of data to theory
CTEQ6.6M PDF uncertainty
IC BHPS Model ratio to 6.6M
IC Sea-like Model ratio to 6.6M
Scale dependence
(μ_R=μ_F=μ_f=0.5p_T^γ and 2p_T^γ)
Data / Theory
p_T^γ (GeV)

Gamma + Jet

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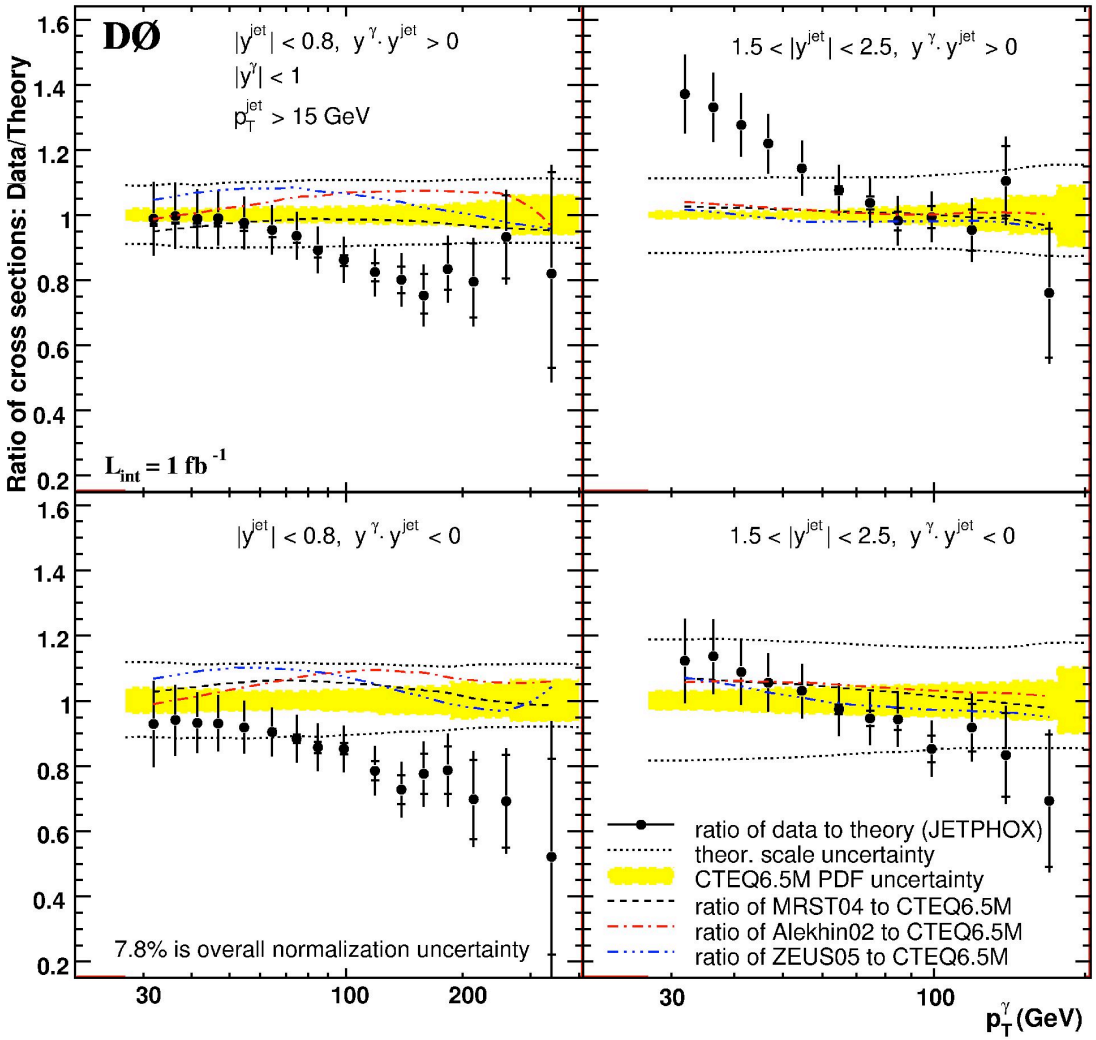
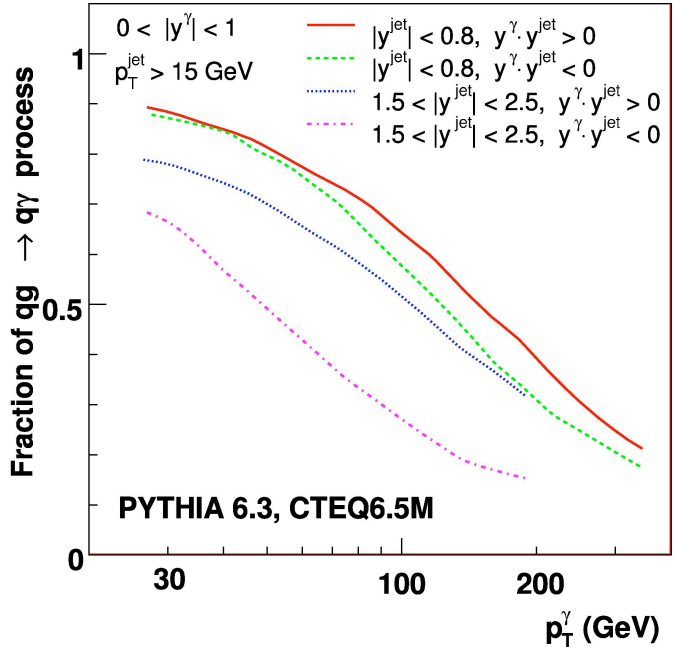
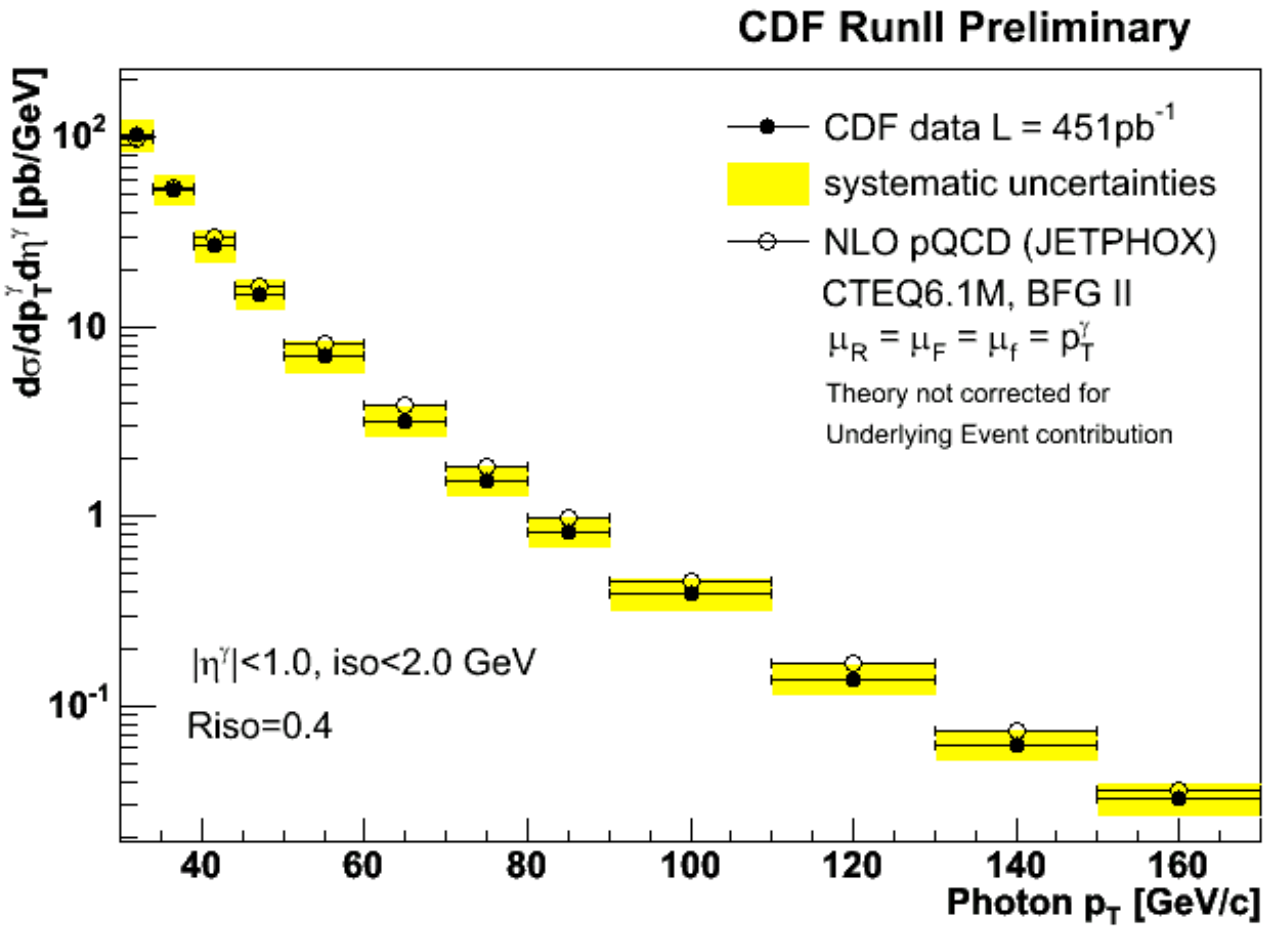




Inclusive Photon



Conclusion

Present PDF constraints from 0.2 – 2fb-1 of data coming from inclusive jets (gluon) and W/Z rapidity distributions (down-quark)

Despite significant increases in precision the gluon & down-quark variance is not substantially reduced.

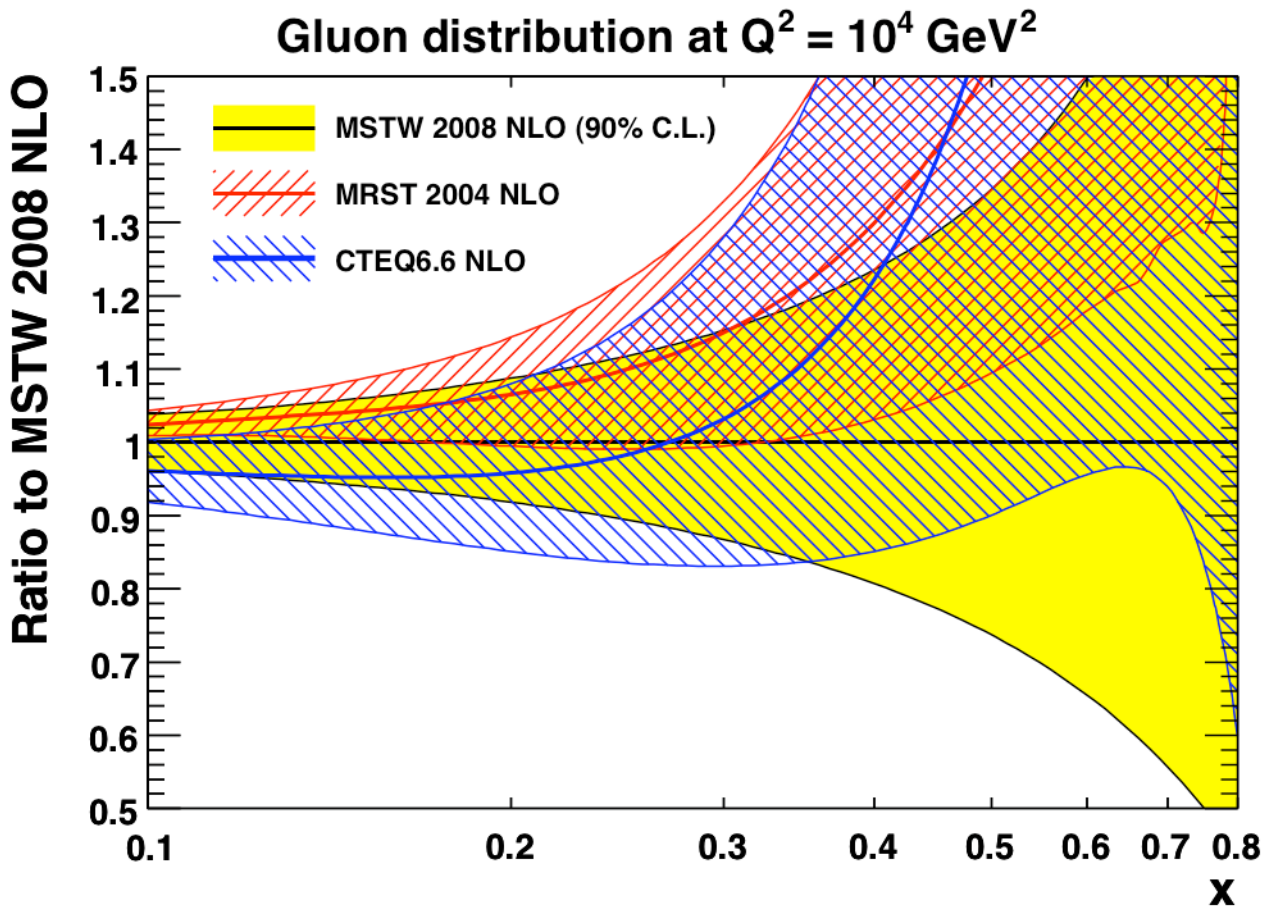
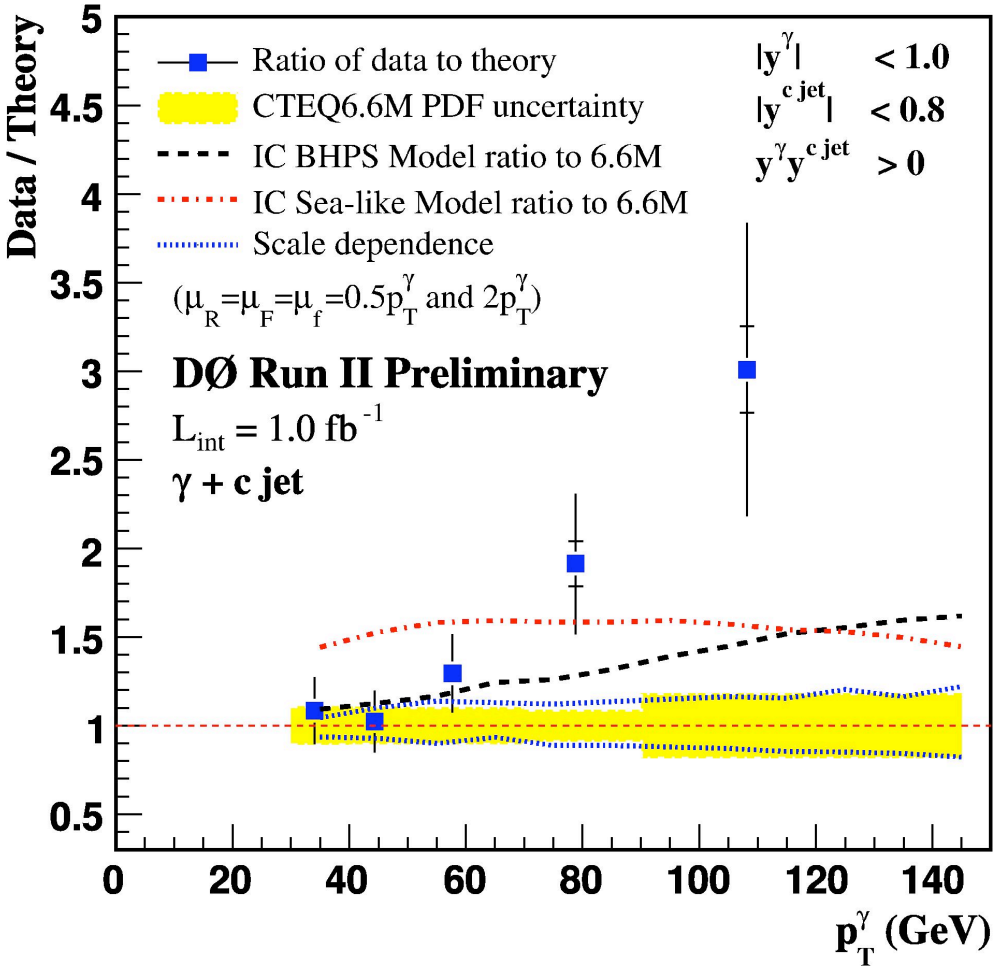
Other processes – W/Z/γ+HF; γ+JET presently limited by statistics and systematics of underlying QCD but hopefully there is some scope here.

We have $4fb^{-1}$ data in-hand now and expect this to double in next 2 years so expect PDF information into the LHC-era. Our experience is that these constraints don't come easily in a hadron collider !

Thanks to Graeme Watt and Robert Thorne for providing plots & details from the MSTW analysis – more in James' talk.

End

Backup : Gluon Uncertainties



Backup : D0 – Gamma + Charm