QCD results from CDF

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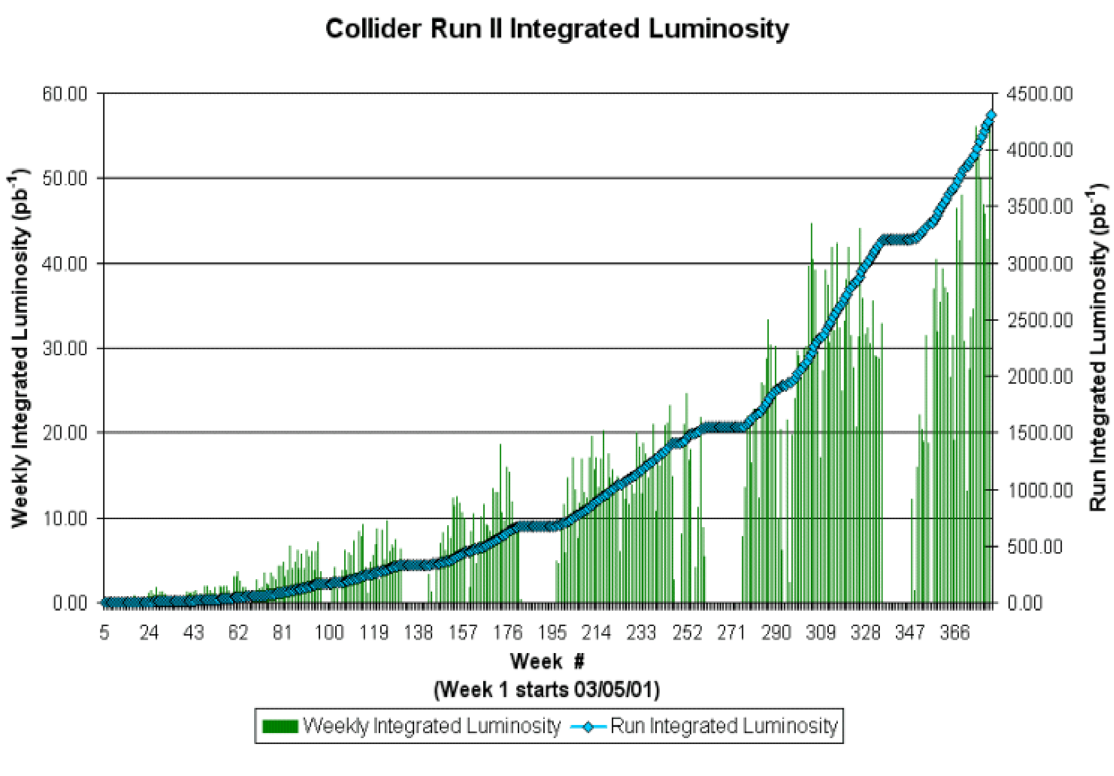
Low-x workshop, Kolimpari

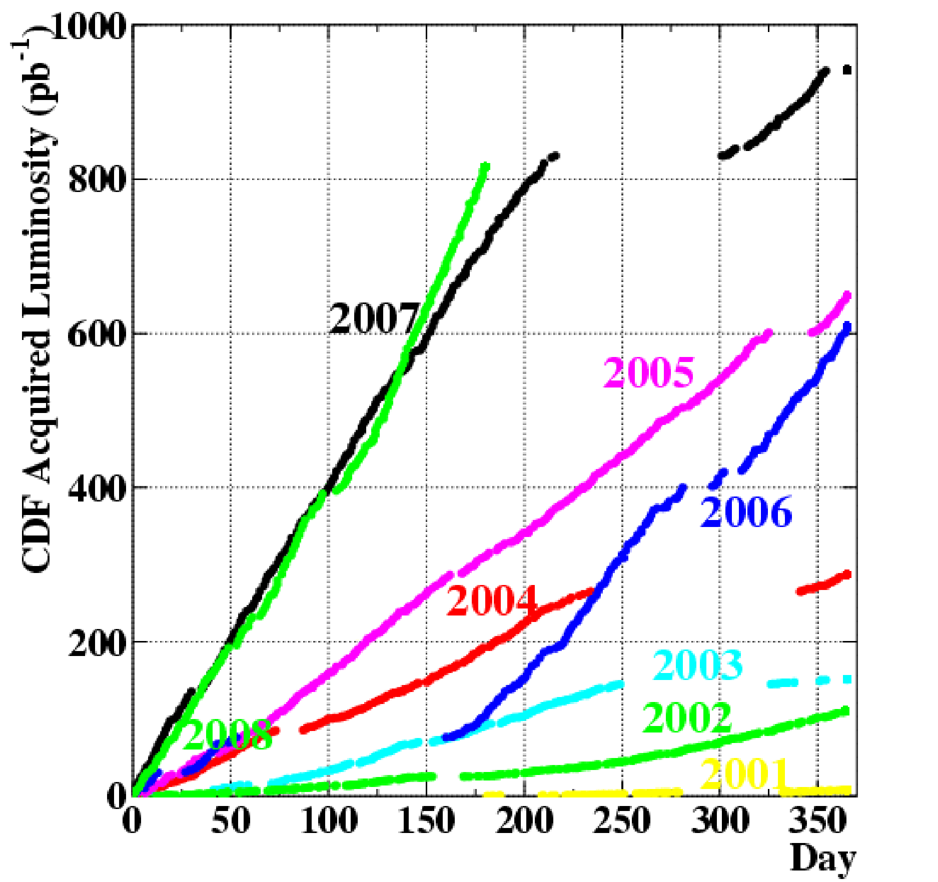
Layout

- Experimental highlights
- Jet and dijet production
- Minimum bias studies
- Pdf-constraining measurements

Tevatron performances

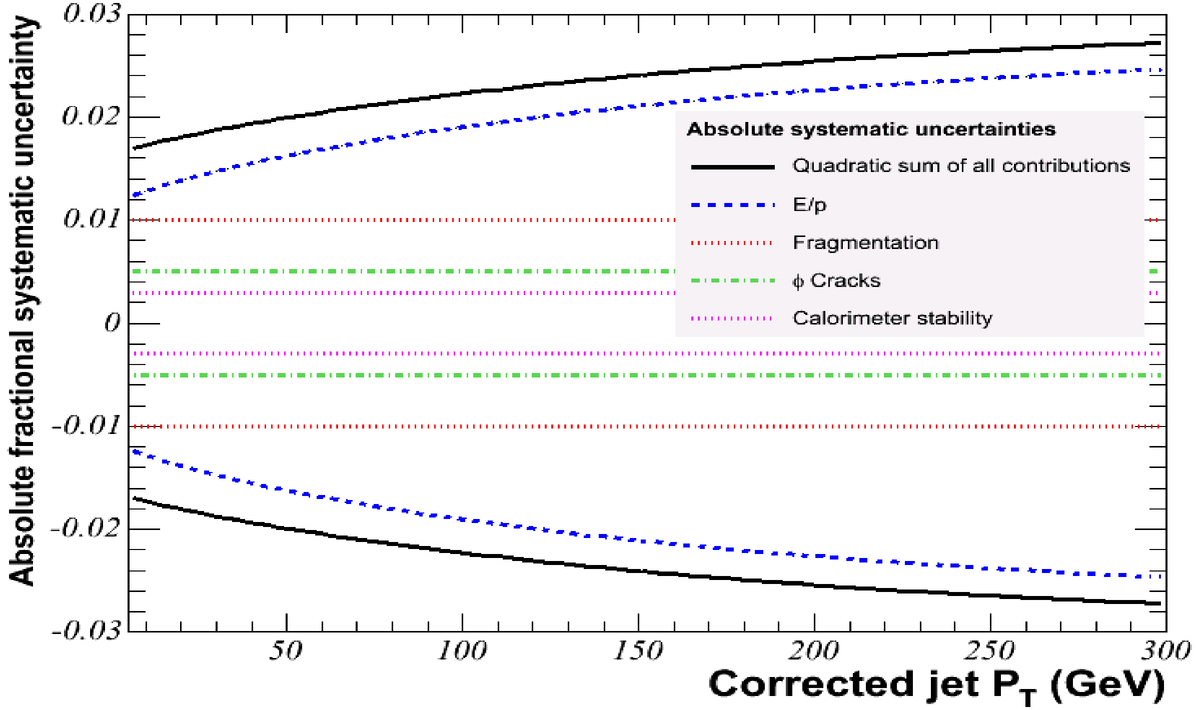
After a slow RunII startup, and a spectacular performance recovery in the following years, the Tevatron is now running steadily at maximum performance collecting about 1 fb^{-1} per year



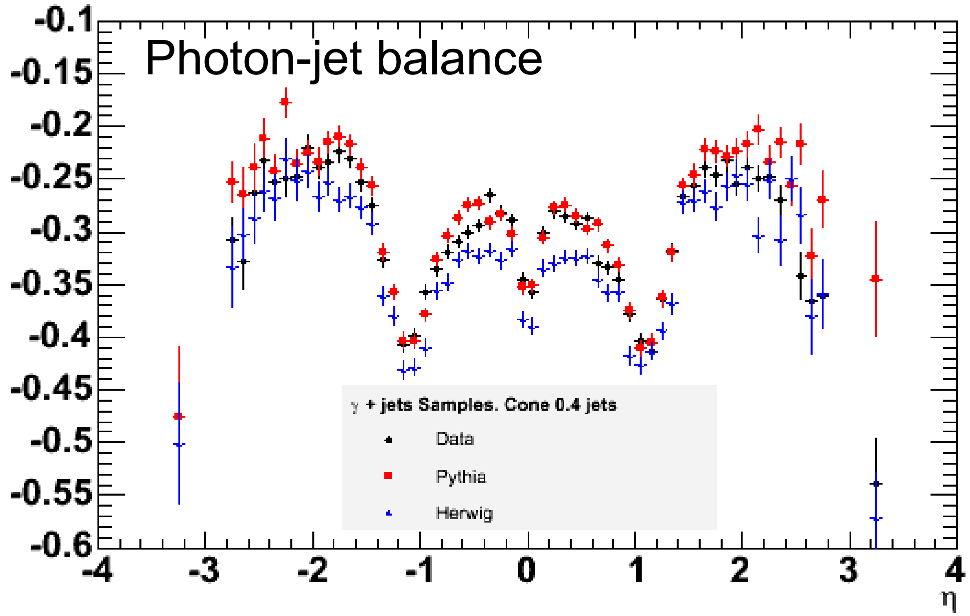


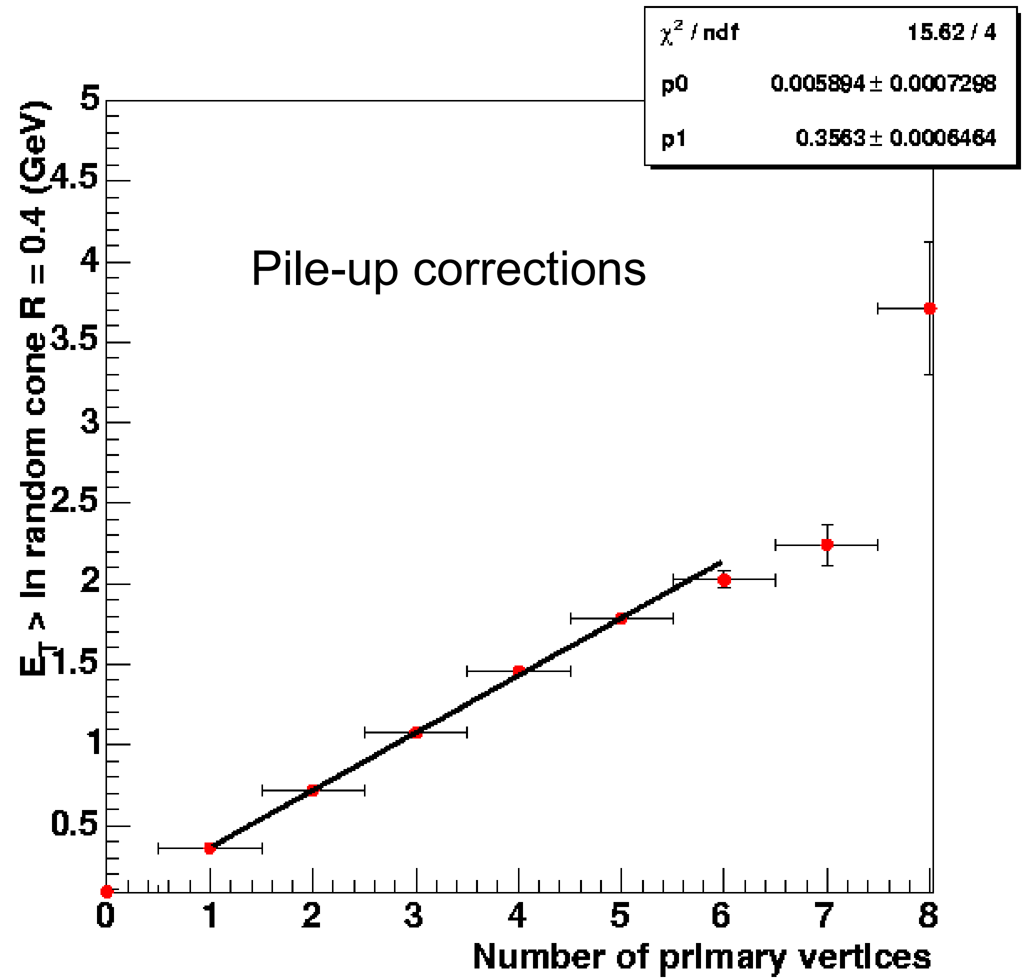
Jet calibration in CDF

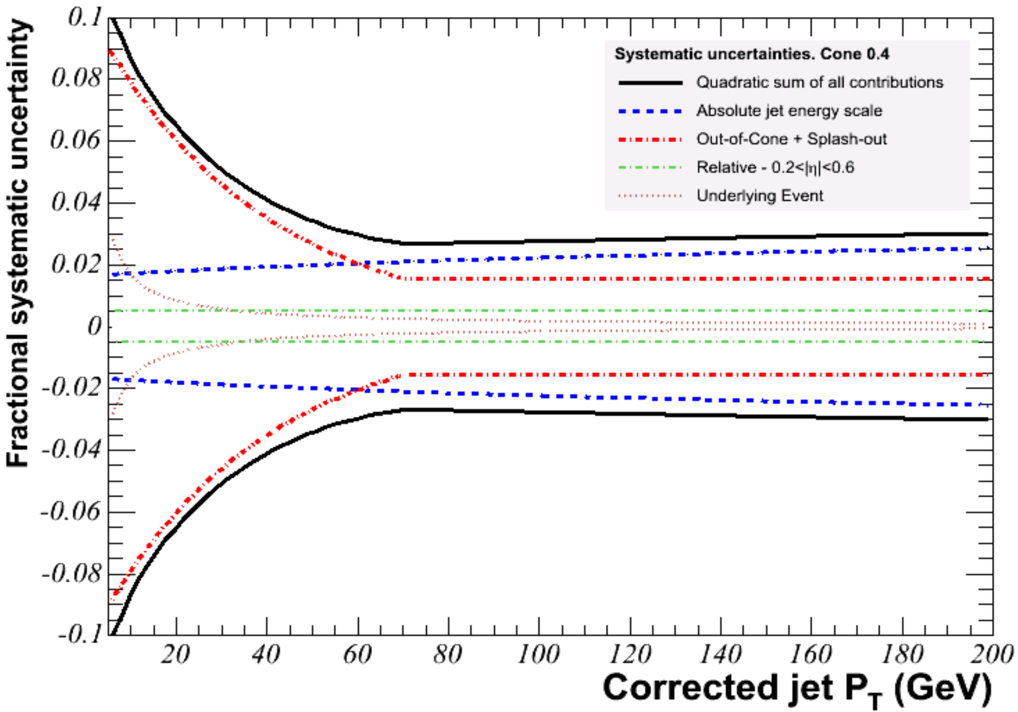
- Various steps:
- Non-linearity of response (photon-jet and central-forward matching)
- absolute scale (from MonteCarlo and test-beam comparisons)
- Corrections (underlying event and pileup corrections)



Jet calibrations



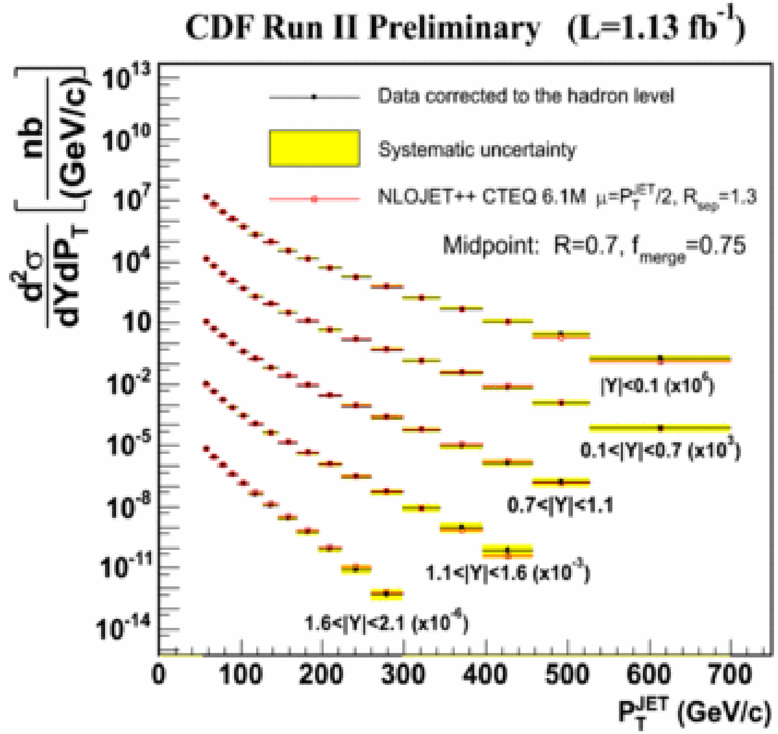


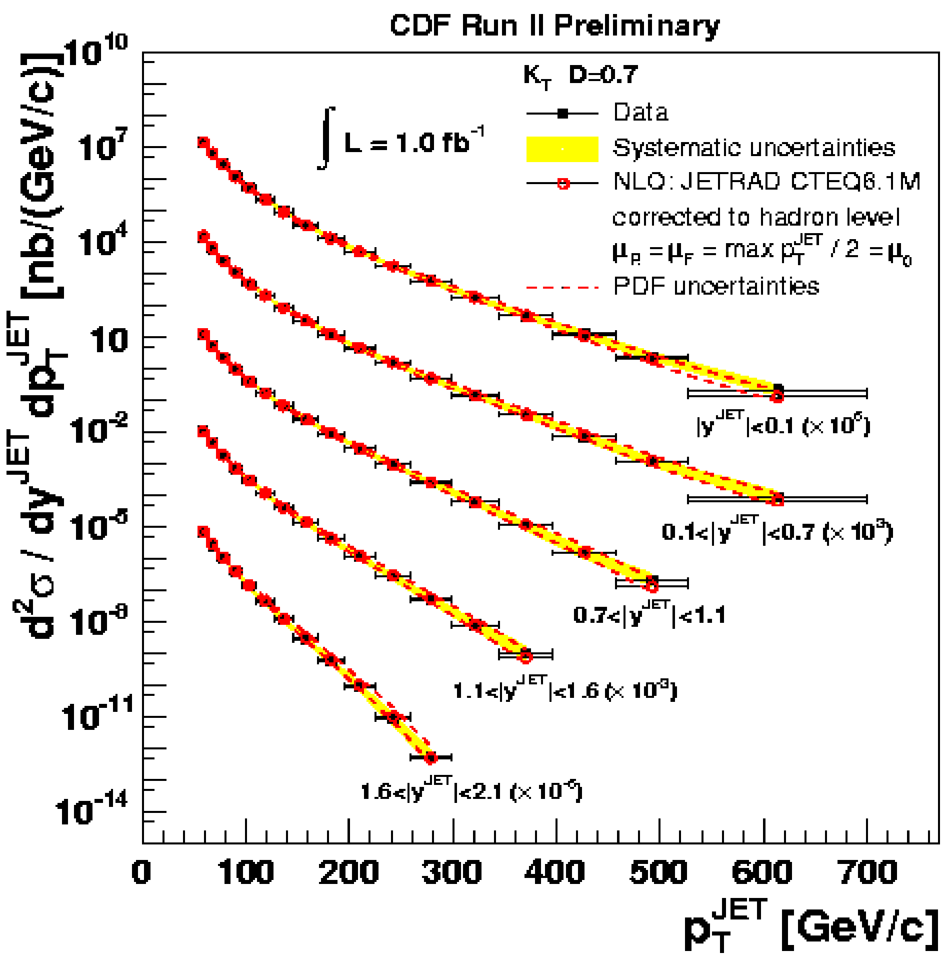


Total relative uncertainties

Inclusive jet measurements

Inclusive cross section measured using the MidPoint (default) and Kt algorithms





$k_{T,i} = p^2_{T,i}$; $k_{T,(i,j)} = \min(p^2_{T,i};p^2_{T,j})*\Delta R^2_{i,j}/D^2$
S.D.Ellis, D.E. Soper, Phys. Rev. D 48, 3160 (1993)

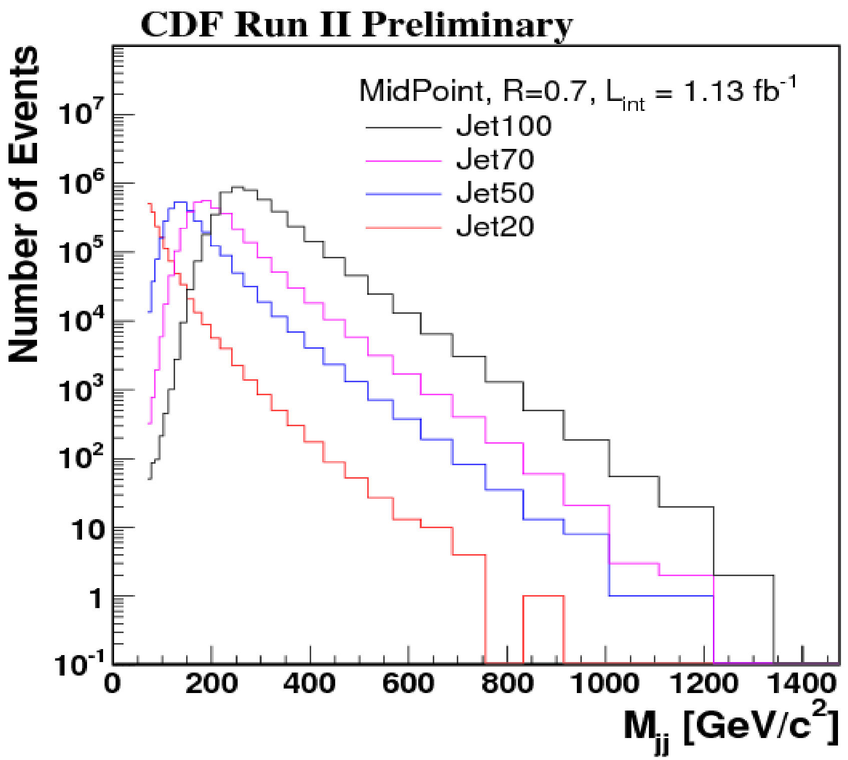
Jet pT corrected for pileup (up to 6 events), subtracting a constant value (determined to equalize slope at high and low pileup) times the number of reconstructed verteces.

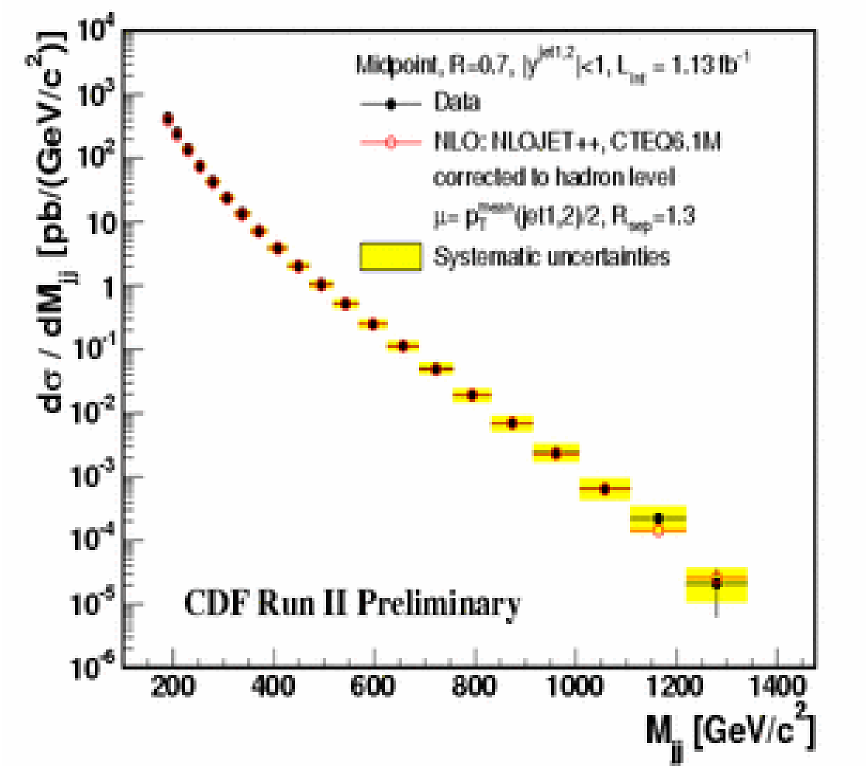
Pdf implications for these measurements will be discussed later

Dijet measurements

Midpoint cone jets

As previous analyses, uses a patchwork of different jet trigger thresholds





Good agreement with NLOJET++, no indication for resonances nor increase at high mass

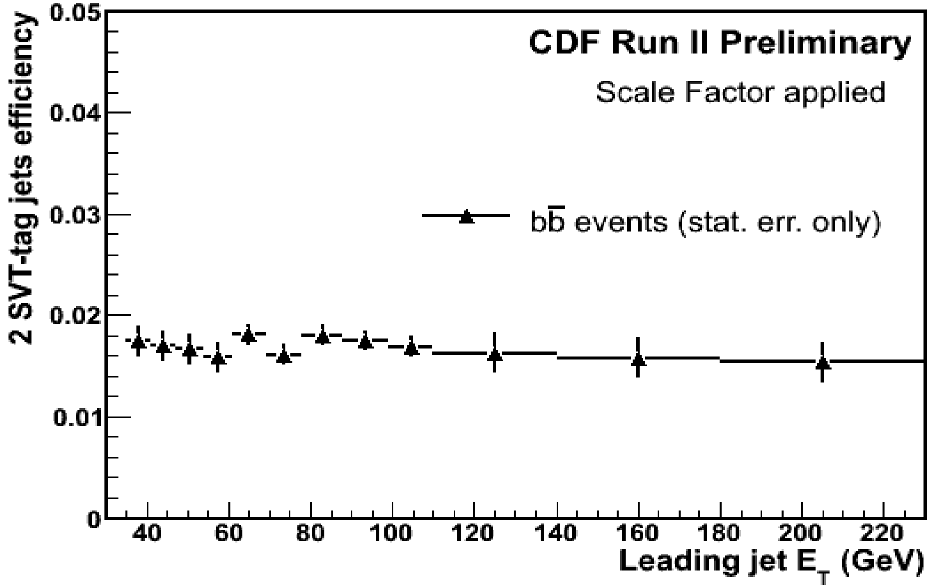
We can be smarter on triggering: bb cross section

260 pb^{-1} of data taken with b-enhanced trigger based on impact parameter no prescale

Efficiency about 2% vs 10% of just requiring 2 b-tags

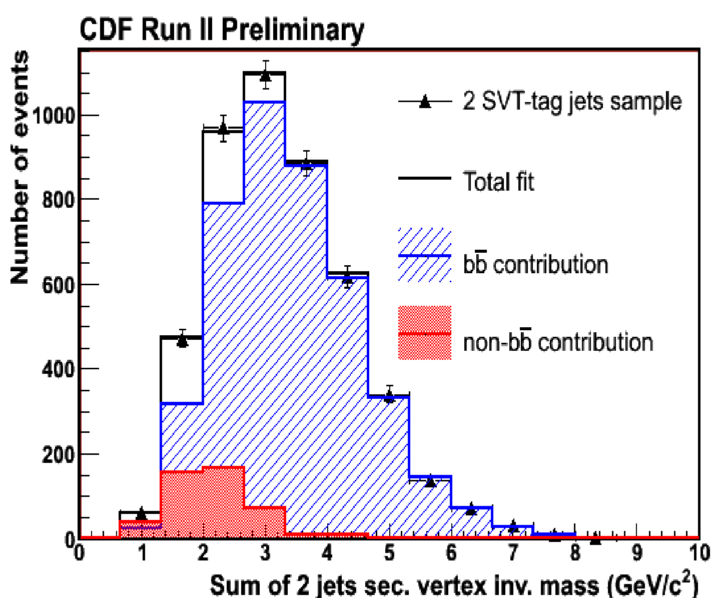
b-enhanced trigger « costs » just about a factor 2 per jet

In the absence of a control sample, trigger efficiency computed from MC with tighter cuts than online



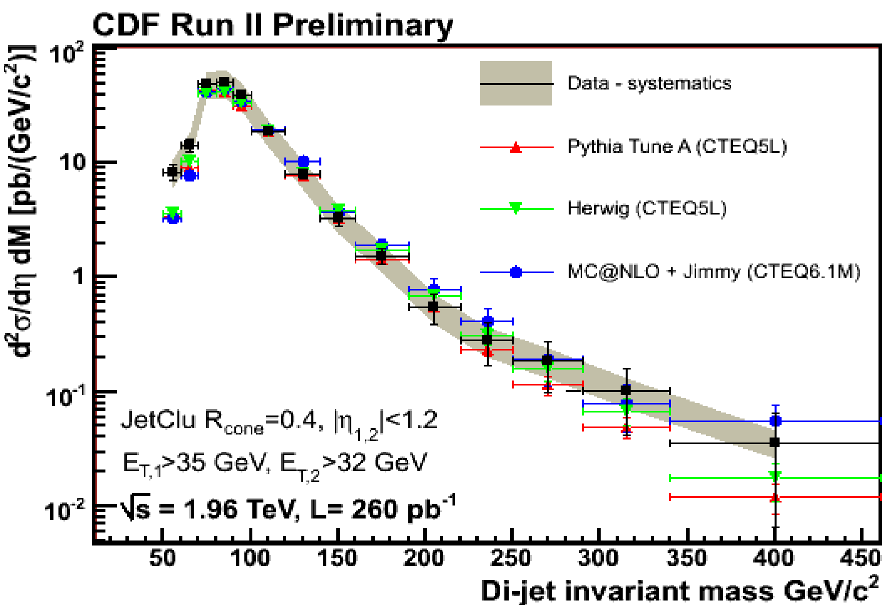
B purity from a fit to the sum of invariant mass of the secondary verteces.

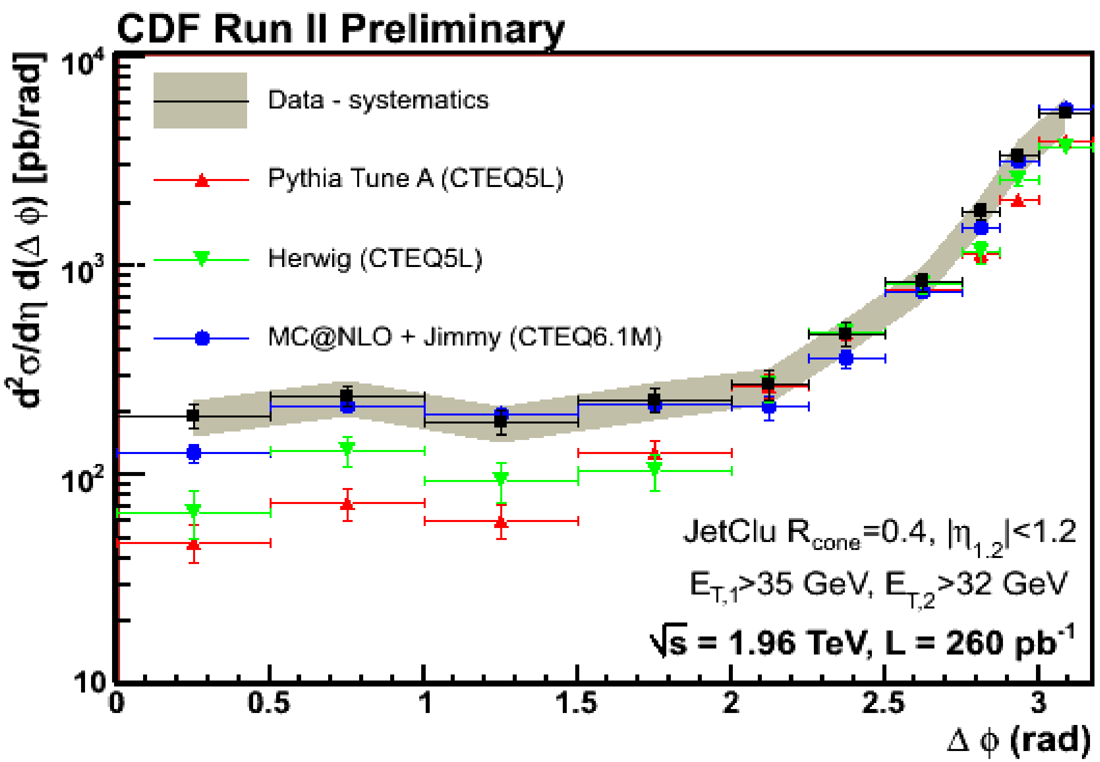
Very high (around 90%) due to double SVT + offline tag requirement



B dijet results

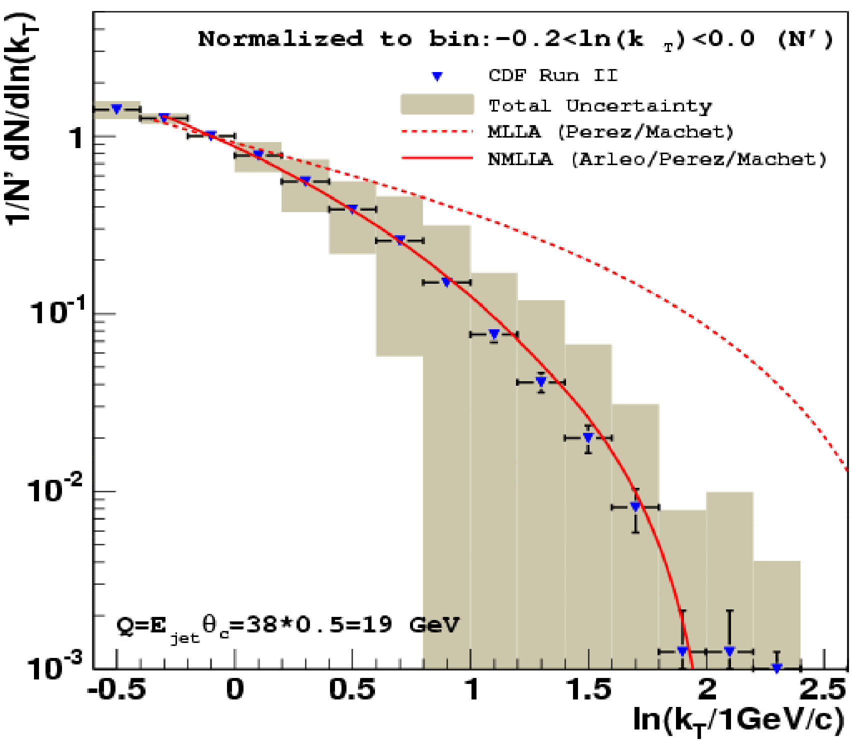
Much more statistics and better control of systematics yield a much better result
The eccess of events at small angle between the jets (gluon-splitting) is due partly to the presence of higher-orders (MCNLO) and partly to multiple parton interactions (JIMMY)
B-enhanced trigger can be used for precision measurements!

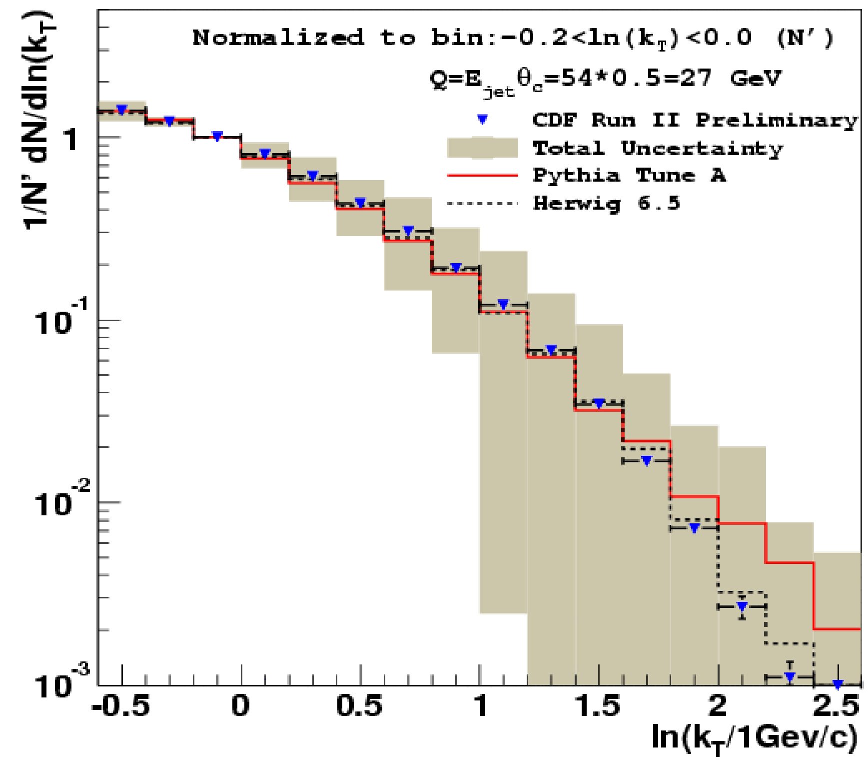




So, how well we understand fragmentation?

Measurements of kT distributions for particles within 0.5 of the jet axis in dijet events with masses from 60 to 740 GeV. Data are compared to Modified Leading Log and Next-to-Modified Leading Log, as well as PYTHIA and Herwig

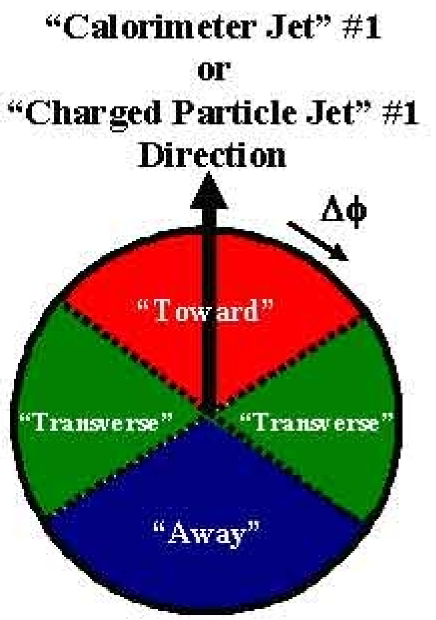




Analytical calculations close (or better) to MonteCarlo codes

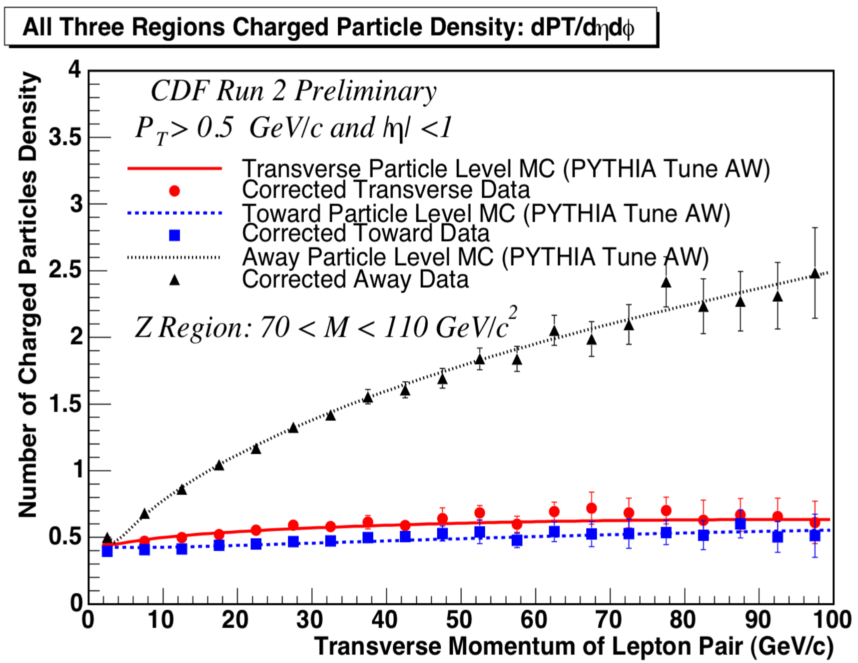
Underlying event studies

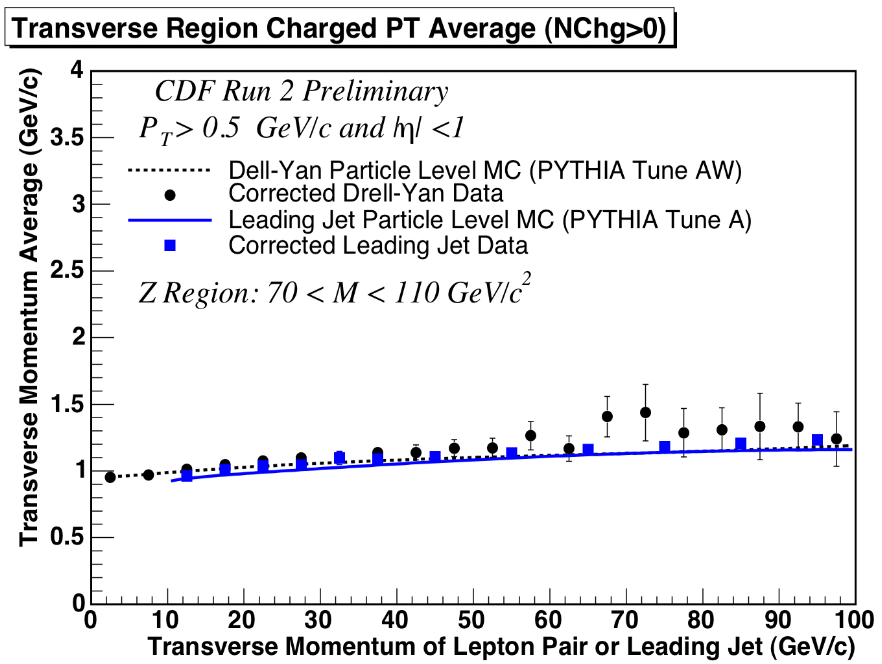
Traditionally performed in QCD events splitting the detector according to leading jet direction:



A recent follow-up of this method is to use Drell-Yann processes to define the direction of the leading process. This is a cleaner determination of the underlying event, being the Z a color singlet

This analysis: look for leptonic Z decay in a 70-110 GeV mass window. Take charged particles with pT>0.5 GeV and |eta|<1

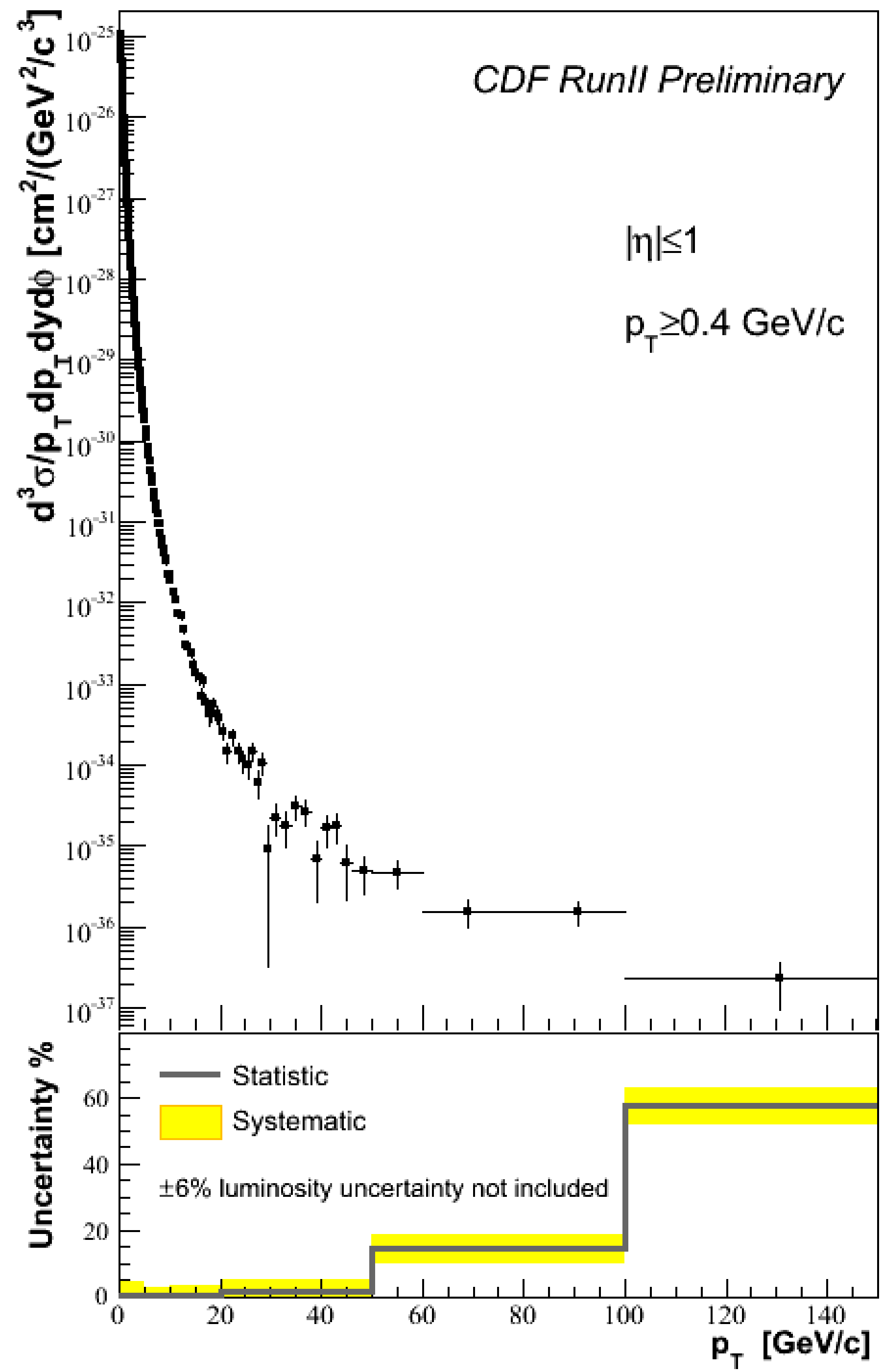


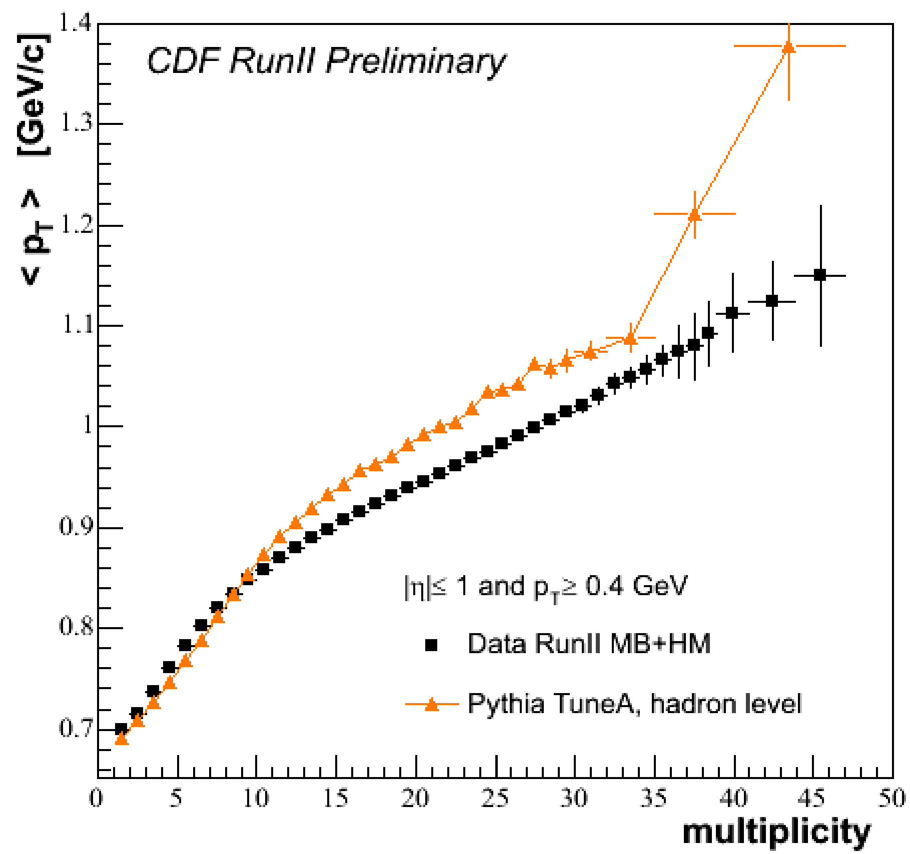


Good agreement with tuned Pythia and small differences with leading jet method

Minbias cross section

Taken with a specific trigger to go down to 0.4 GeV tracks. Differential cross section spanning 11 orders of magnitude. Event characteristics corrected back to hadron level and compared with TuneA

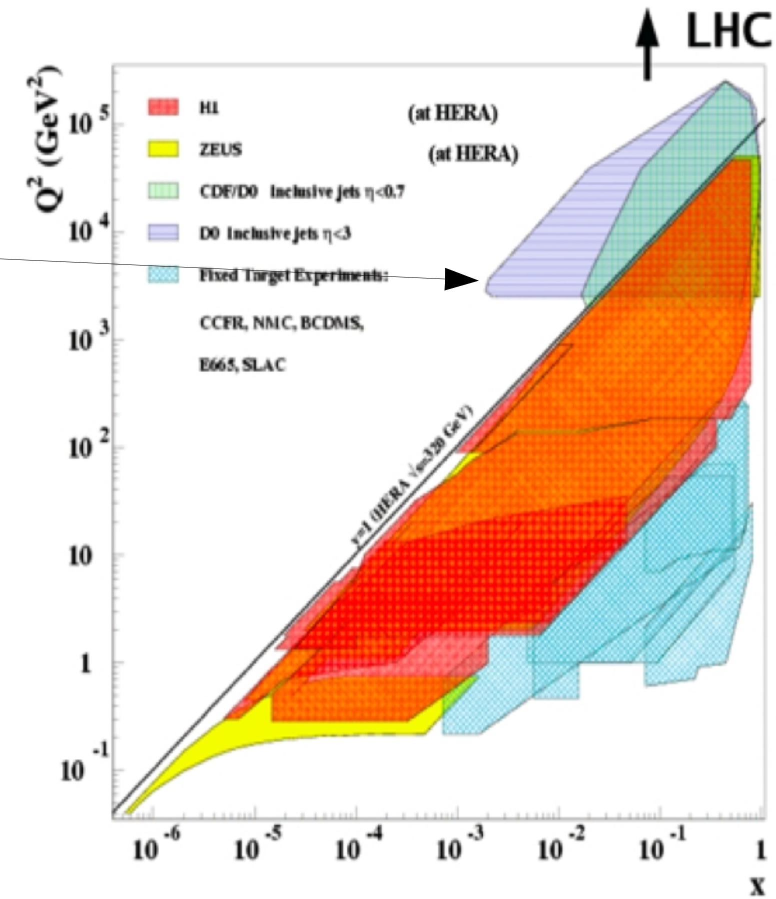




PDF's from the Tevatron

Some measurements start to be dominated by Pdf uncertainties -> can be converted into constraints.

Tevatron kinematic range closer to LHC less uncertainty on extrapolation (relatively) Low-x region largely benefits from forward jets (D0)



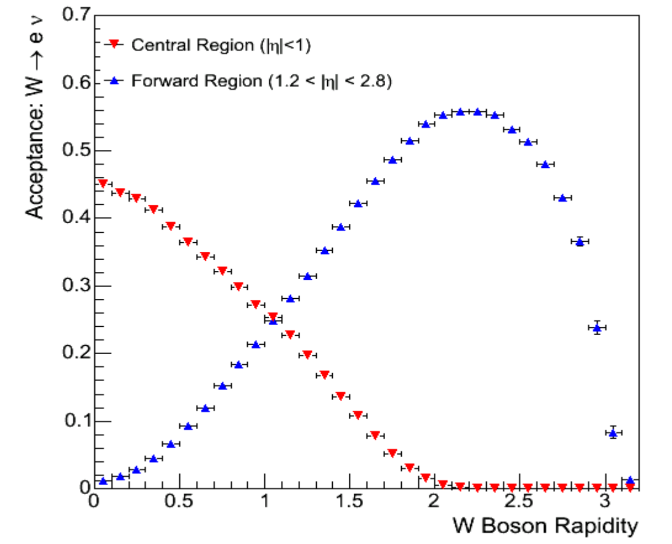
Some measurements (asymmetries) largely benefit from having a proton-antiproton collider (better do them now...)

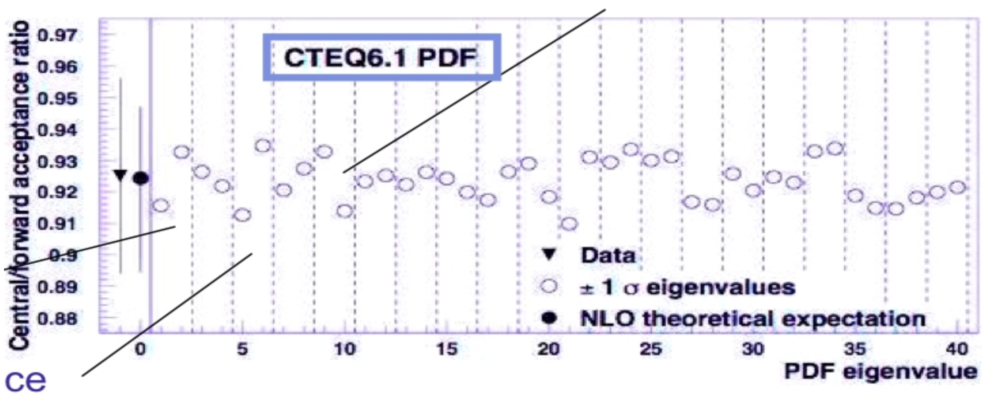
Main measurements:

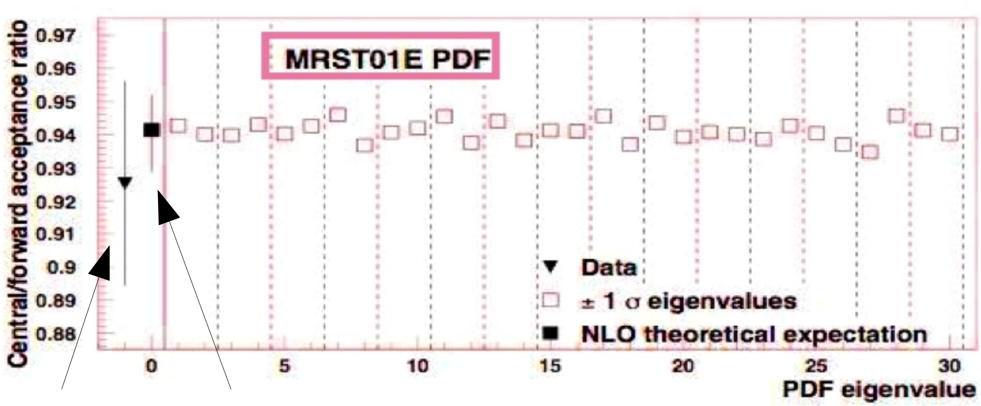
• W asymmetry, Z eta distribution
• jet production, heavy flavor plus bosons

Central/forward ratio for W's

Plug electrons give good acceptance for forward W's. Central/forward ratio sensitive to Pdf's:

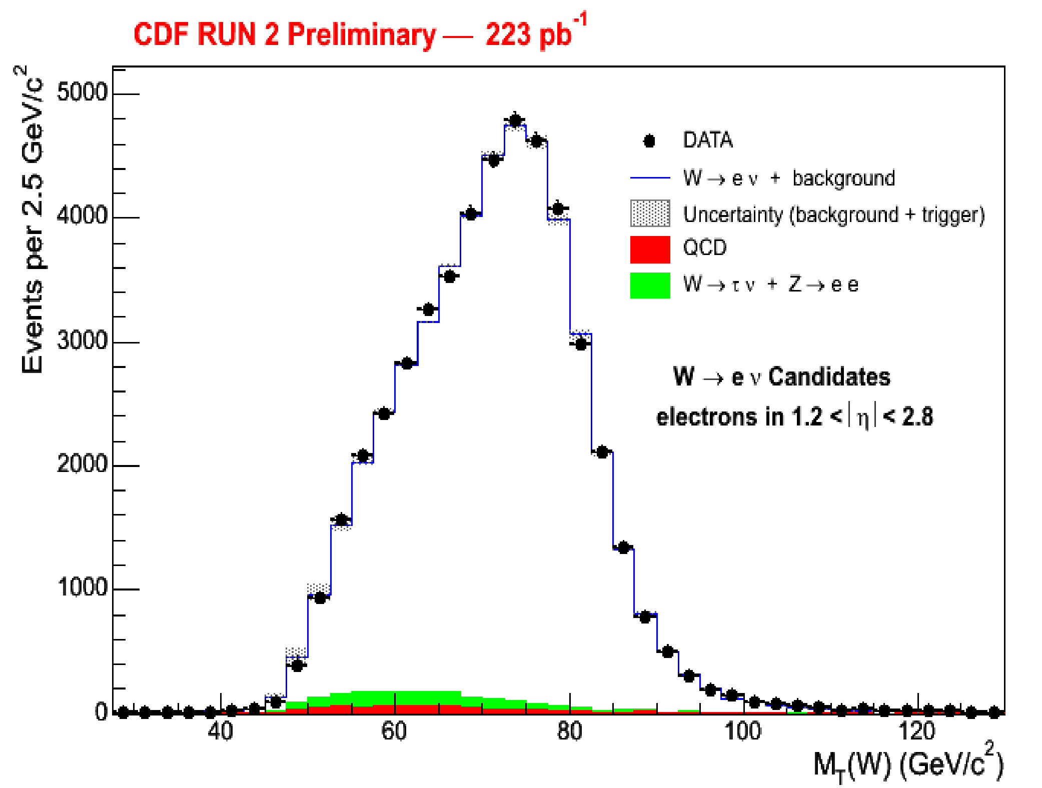






CDF RunII

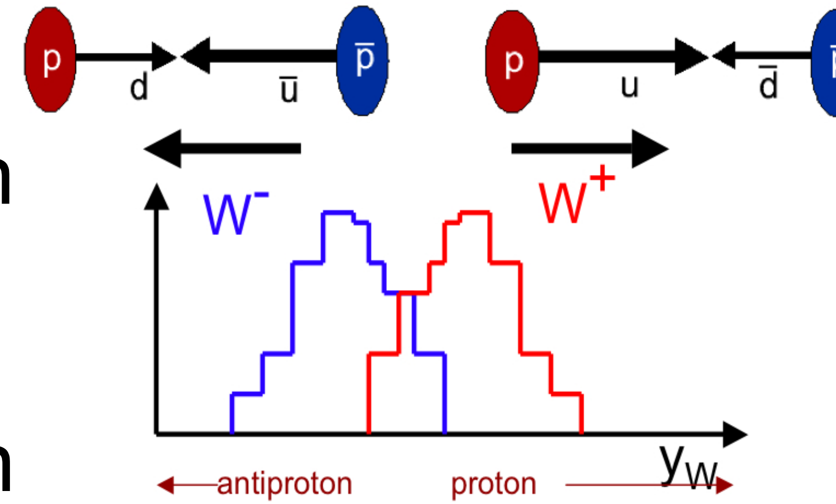
Pdf prediction

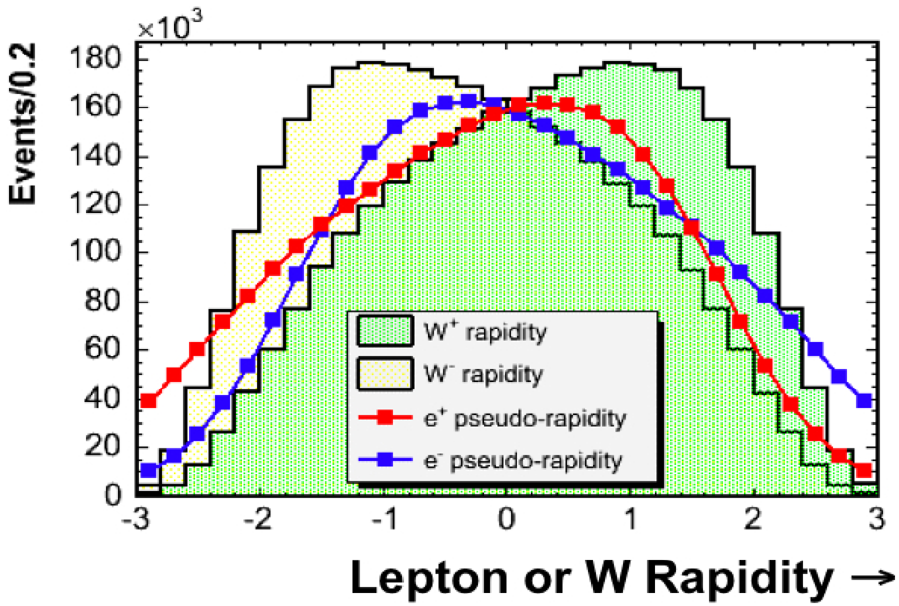


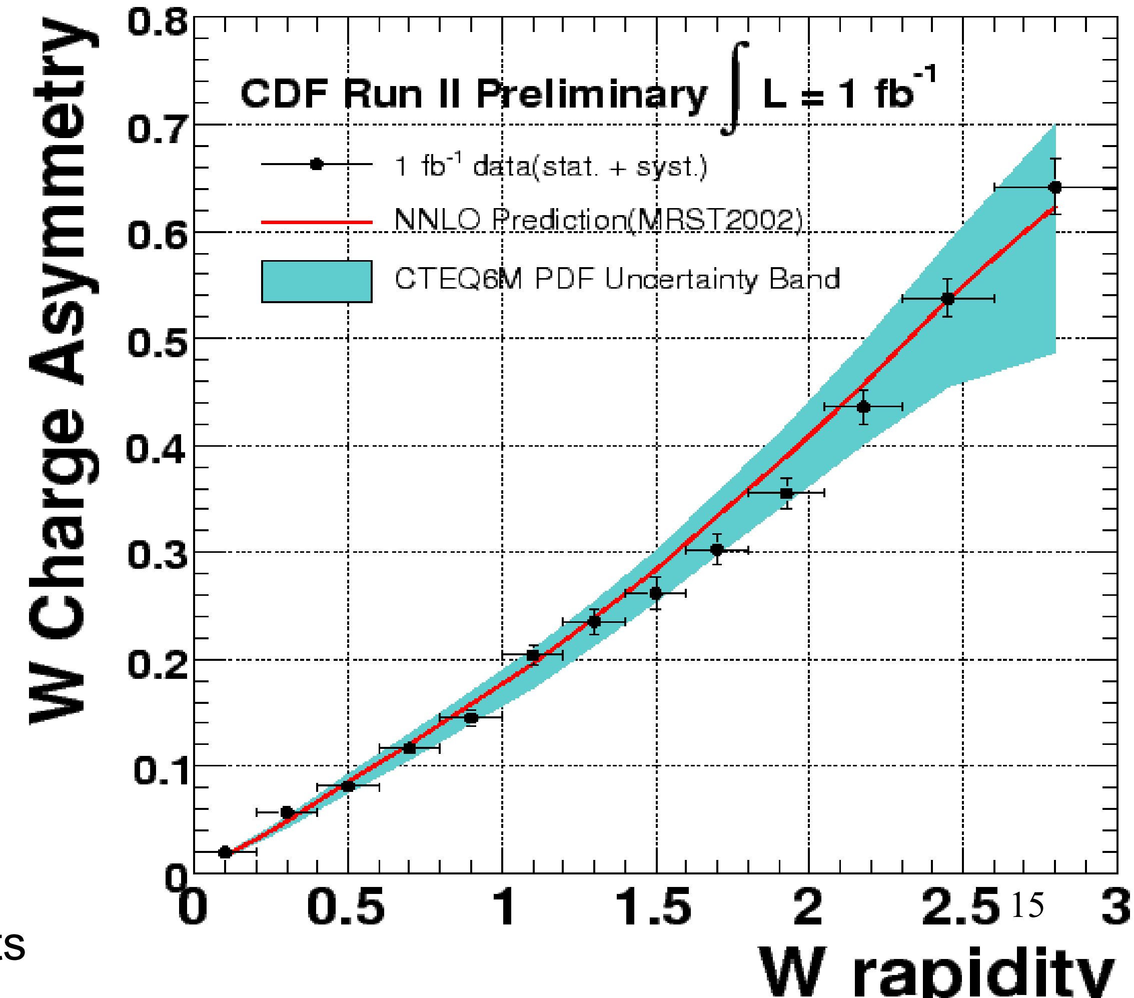
W charge asymmetry

Comes from harder distribution of u wrt d. Sensitive to u(x)/d(x).

What really measured is lepton asymmetry:



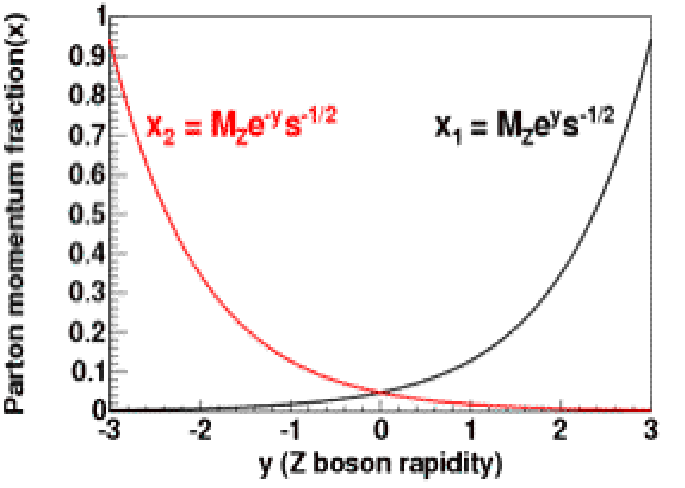


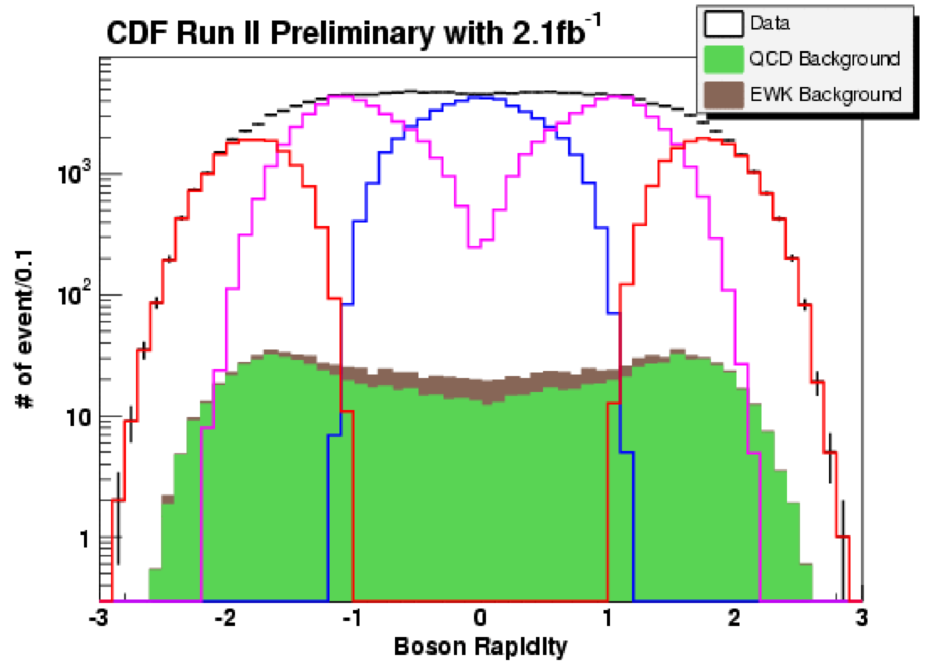


Experimental errors smaller than CTEQ systematics
this measurement will constrain next Pdf fits

Drell-Yan rapidity distribution

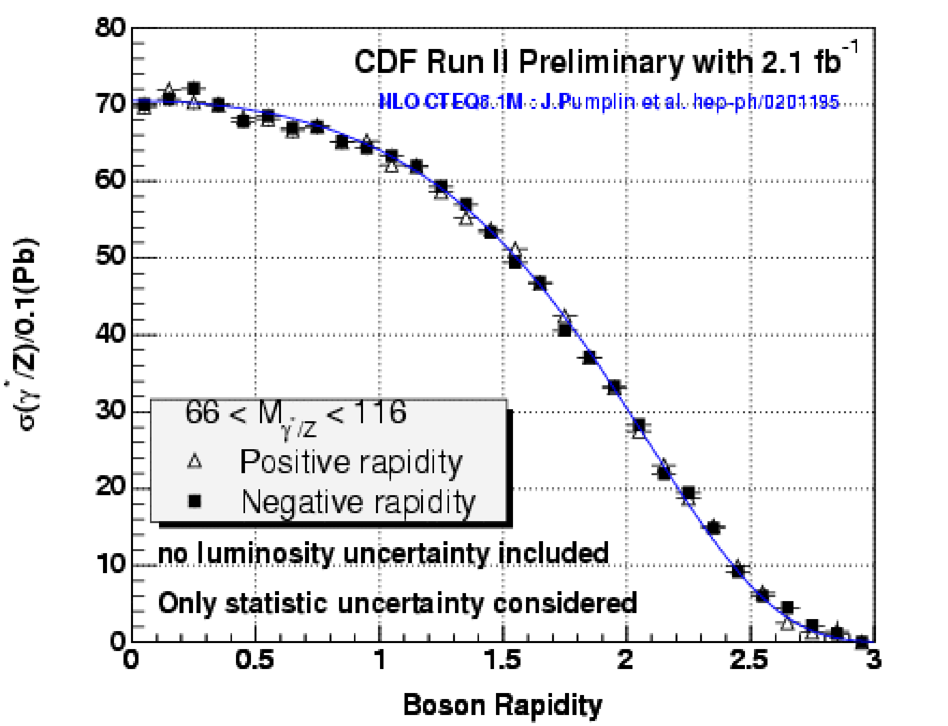
Z rapidity depends on momentum fraction of the two partons:



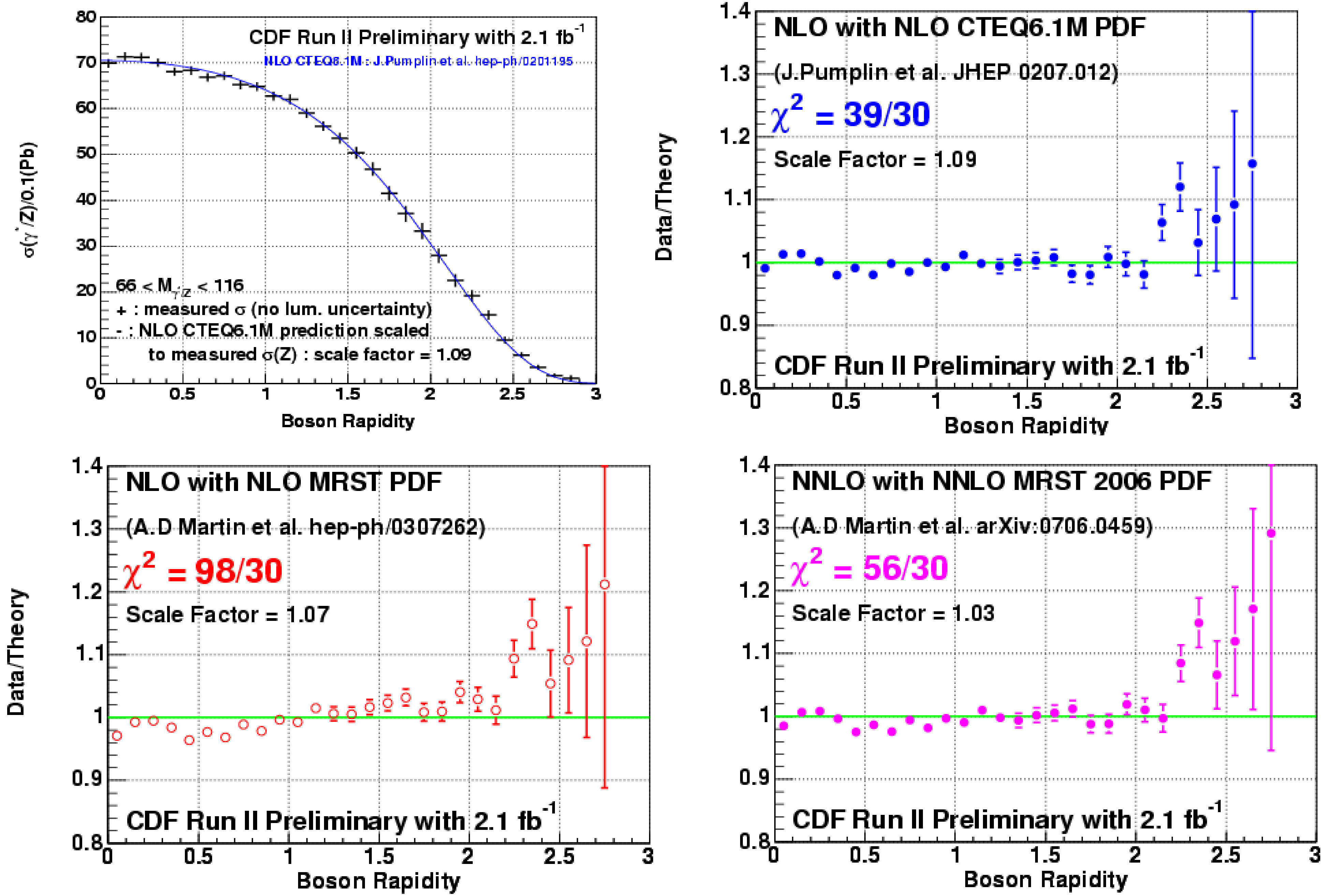


Measure Z->ee (mass range 66-116 GeV) in central-central, central-plug and plug-plug configuration

Eta distribution is symmetric and can be combined



Z rapidity distribution and Pdf's



Bad agreement with MRST NLO, better with NNLO, larger scale factor for CTEQ

QCD measurements: back to inclusive jet cross sections

The high-Et end of the jet cross section is very sensitive to Pdf uncertainties->its measurement helps contraining them:

J. Pumplin et al. hep-ph/0512167

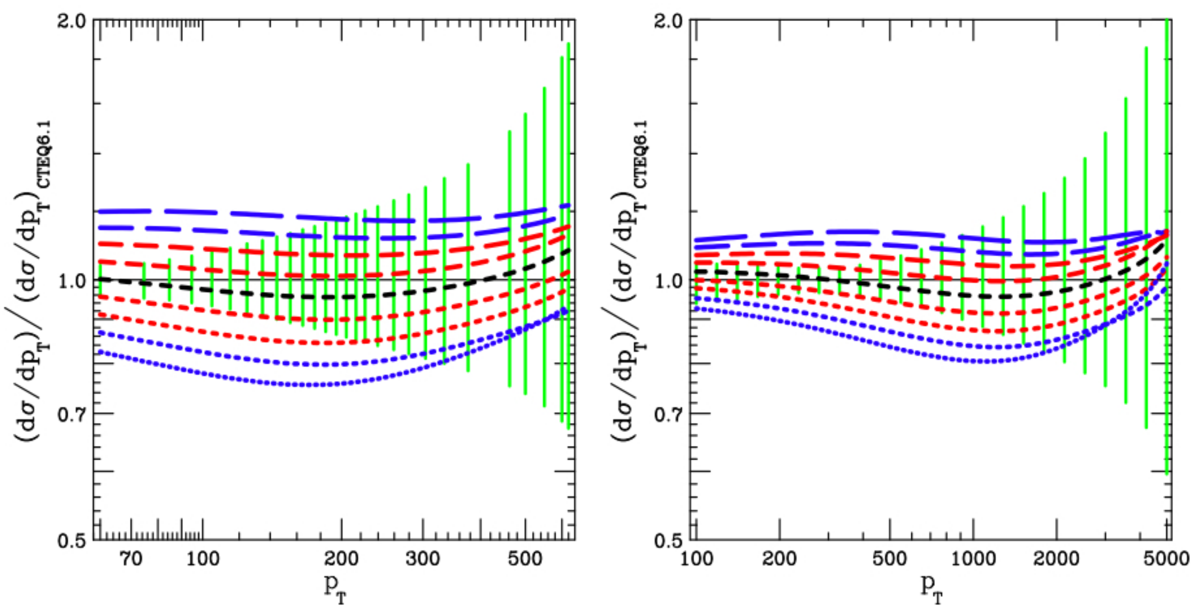
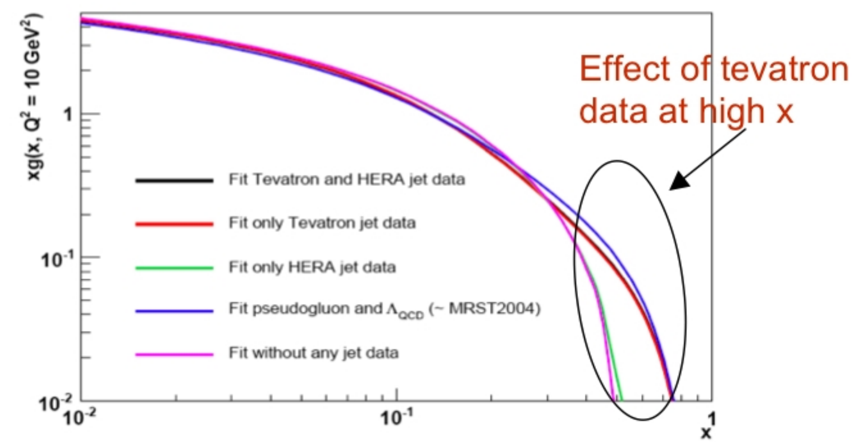
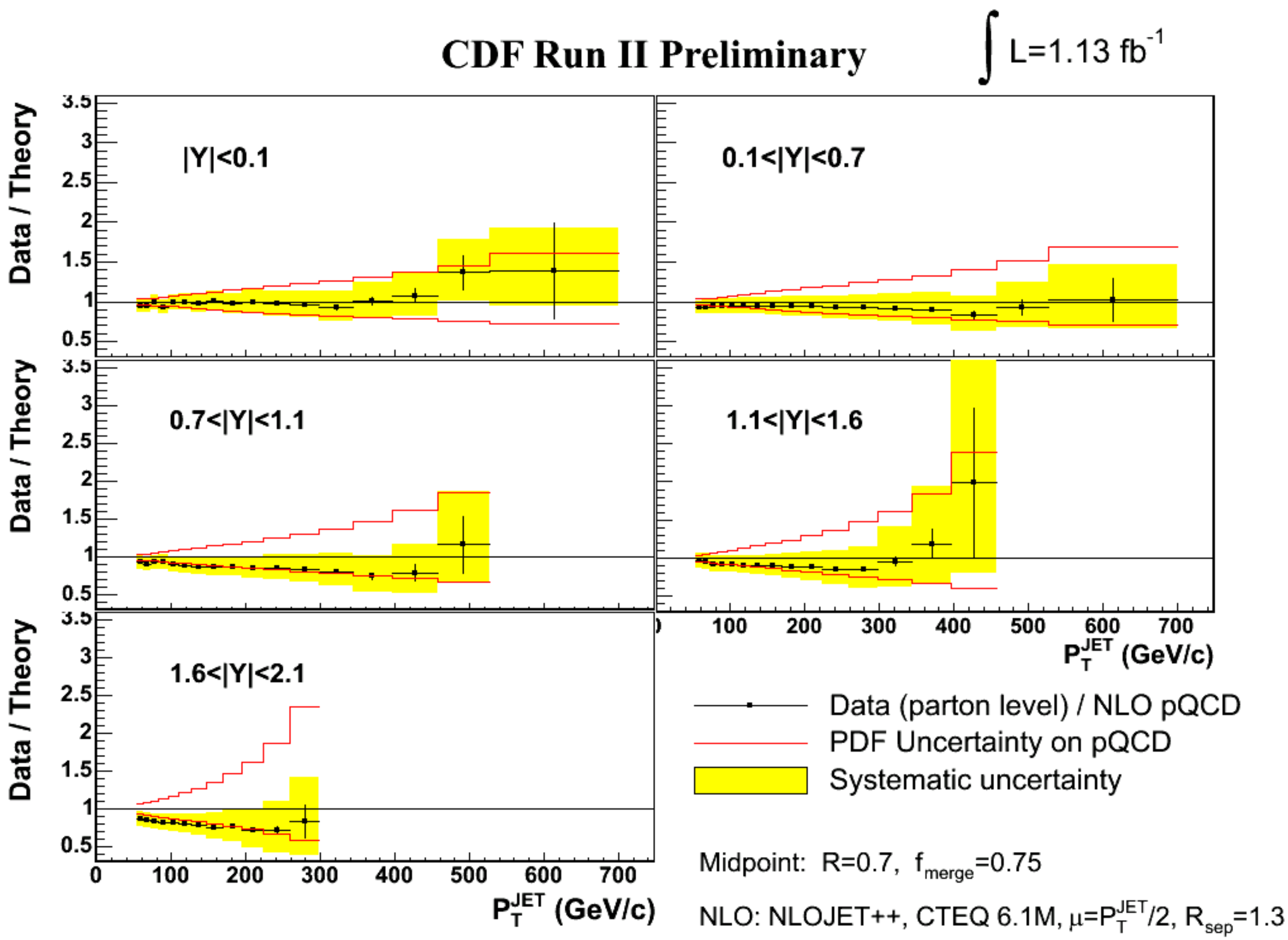


Figure 9: Uncertainties of inclusive jet predictions for Tevatron (a); and LHC (b).



Tevatron data already very important in the high-x region

Inclusive jet cross section results vs Pdf uncertinties



Midpoint analysis has more statistics, but similar results obtained by the Kt measurement

Heavy-flavor Pdf's: W + charm

Pdf contributions on cross section uncertainties: 5-10% (H.Lai et al., hep-ph/07/02268)

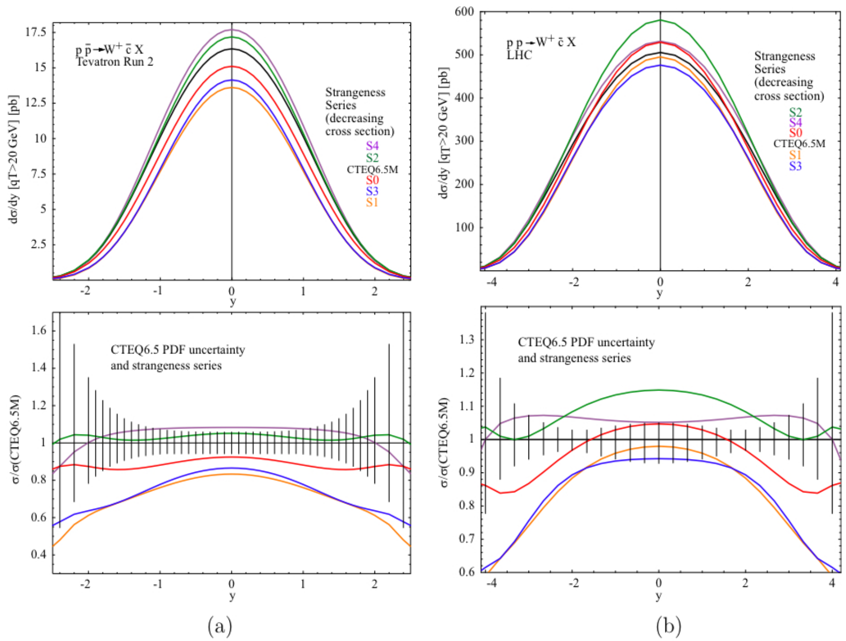
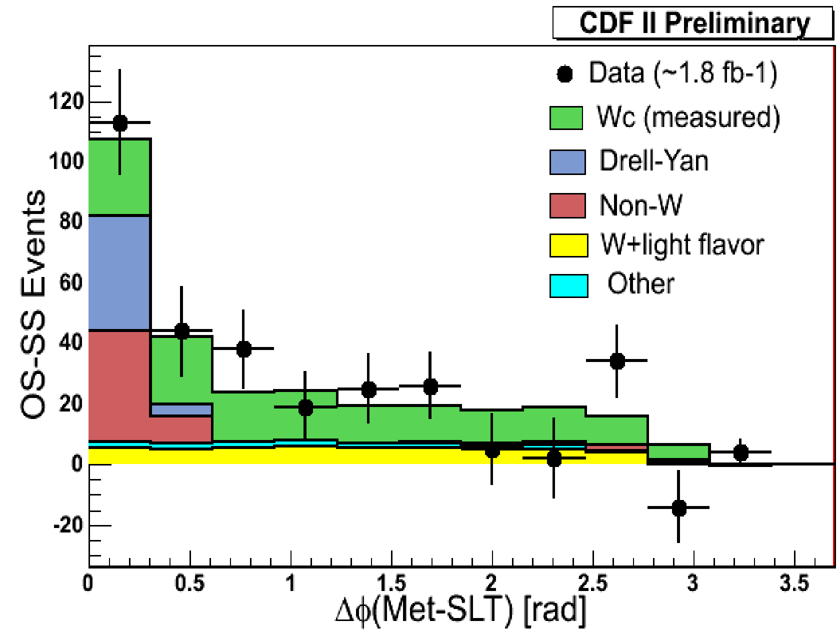
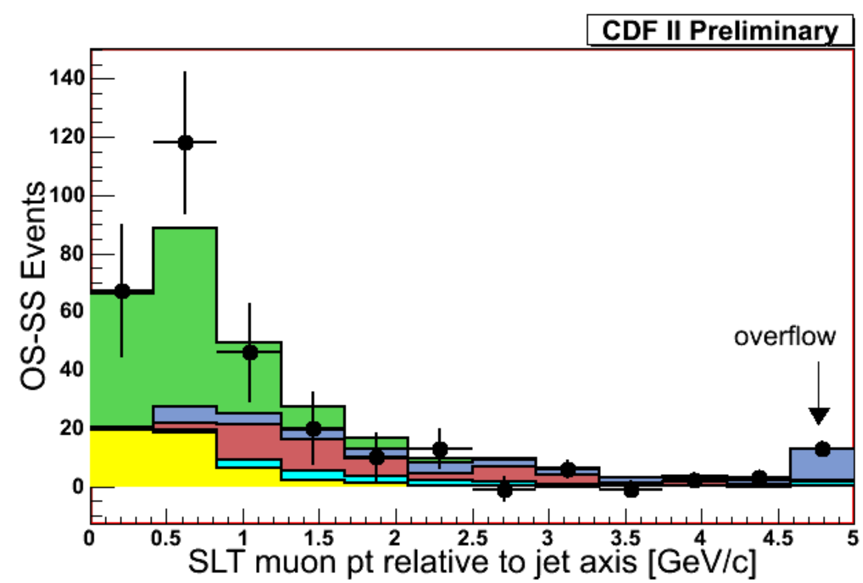


Figure 6: The rapidity distribution $d\sigma/dy$ at $q_T > 20$ GeV (top panel) and its fractional uncertainty (bottom panel) at the Tevatron Run-2 (left) and the LHC (right).



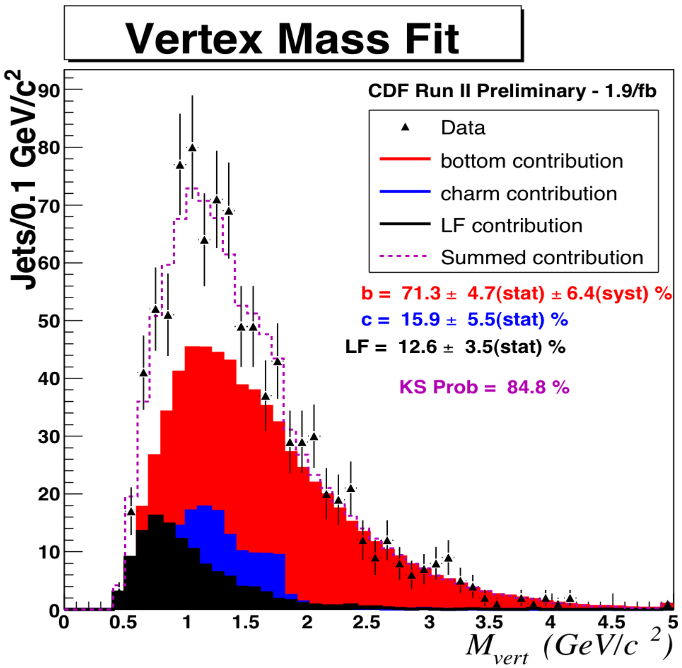


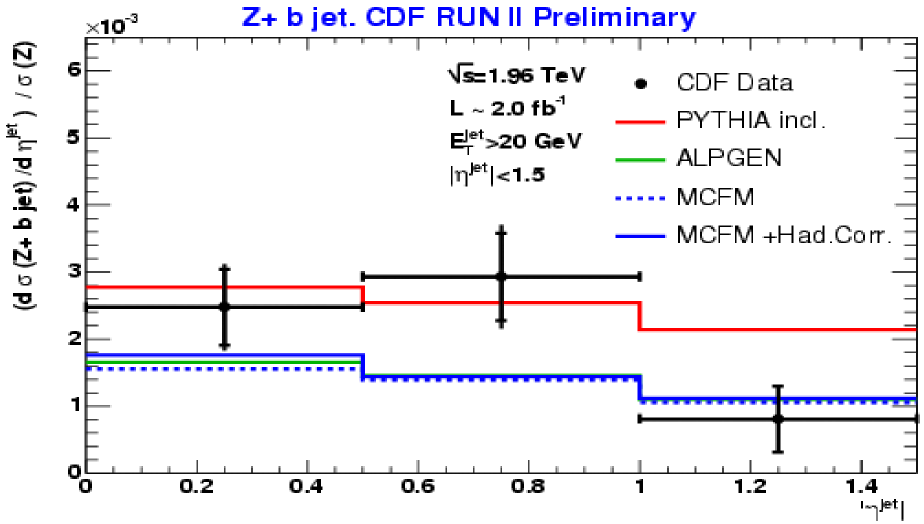
CDF measurement with soft muon tagger:
sigma{Wc}(ptc>20 GeV, |eta|<1.5)*BR(W->e nu)
= 9.8+/-2.8(stat)+1.4-1.6(sys)+/-0.6(lum)pb

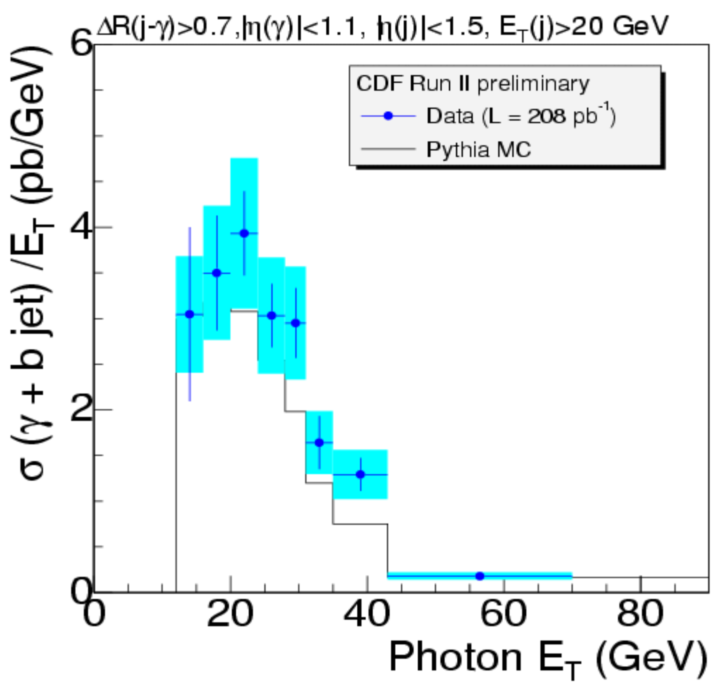
more statistics needed to impact Pdf measurement

Beauty Pdf from b jets and Z/W/γ

B-fraction calculated fitting invariant mass of b-tagged jet with templates for different quark flavors







In all cases other systematics like jet energy scale, b-purity (tracking), luminosity etc. (~10-15%) are larger than Pdf's uncertainties (2-3%). It is unlikely that these measurements will provide Pdf constraints in near future, since not probing the very high-Et region

Conclusions

QCD studies are a major component of CDF physics program, per se and in preparation for the LHC.

Around 4 fb^{-1} have been collected, realistically one can expect about 1.5 more

- most of the analyses have to be updated to the full luminosity

Inclusive jet and dijet production (also HF, with and without special trigger) measured with good precision

Studies of jet structure and minimum bias show that our modeling (if not understanding) of fragmentation works quite well

We contribute to Pdf fits, especially in high-x region

...yet, QCD can still provide some nice surprise at the LHC!