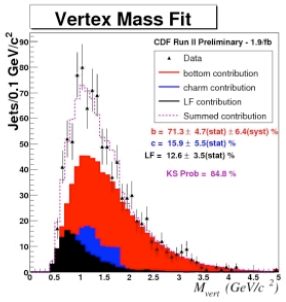
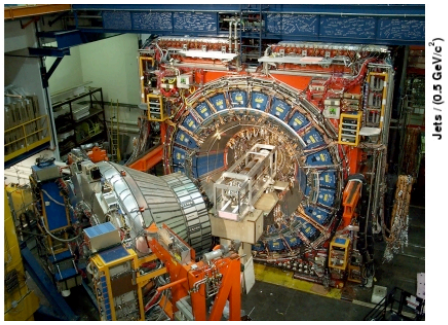
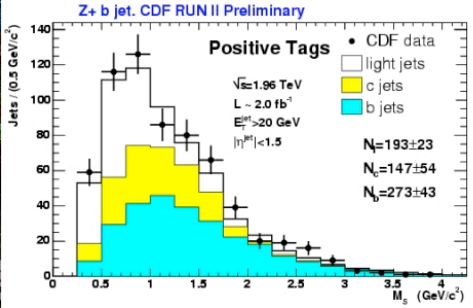
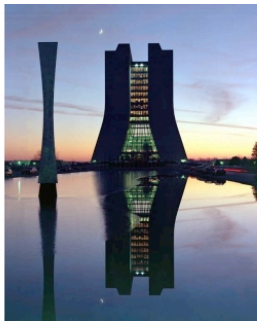


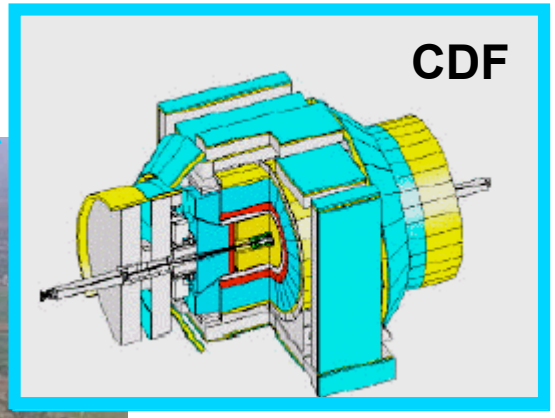


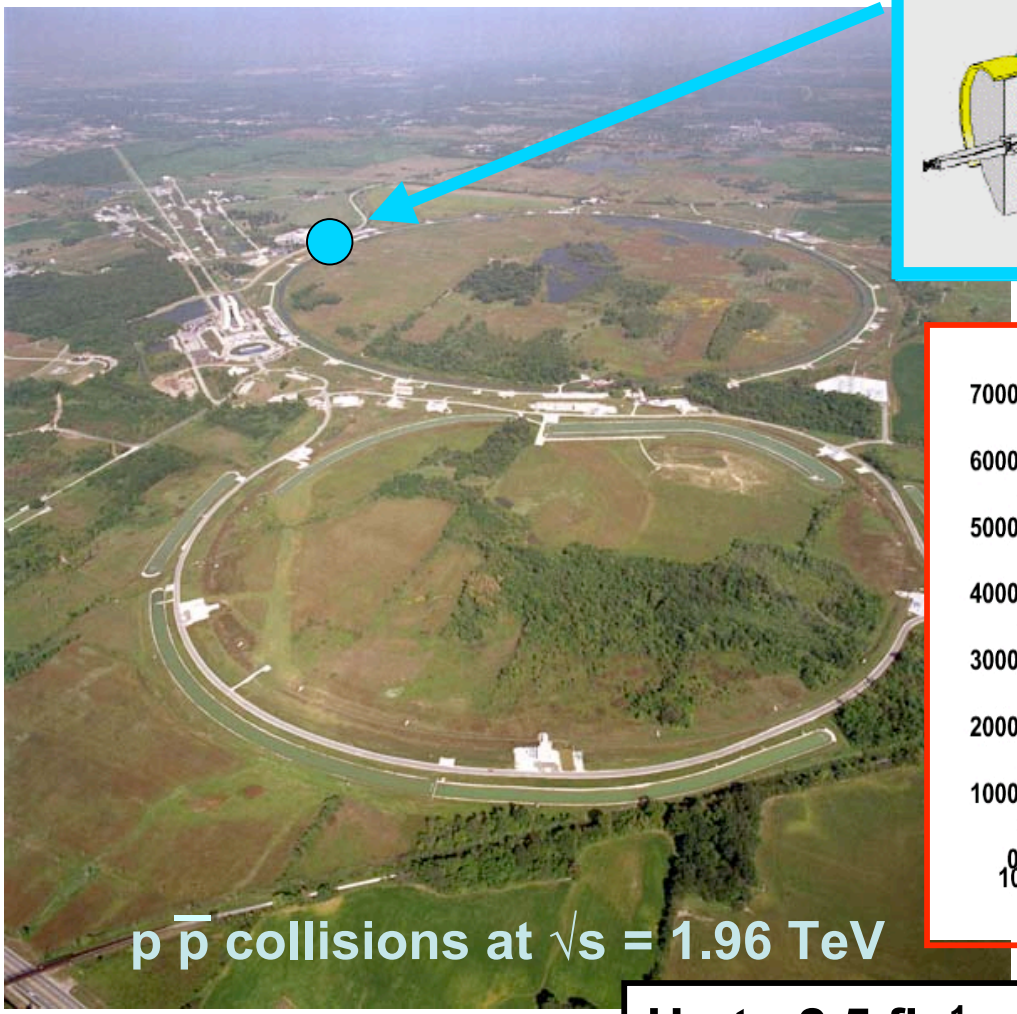


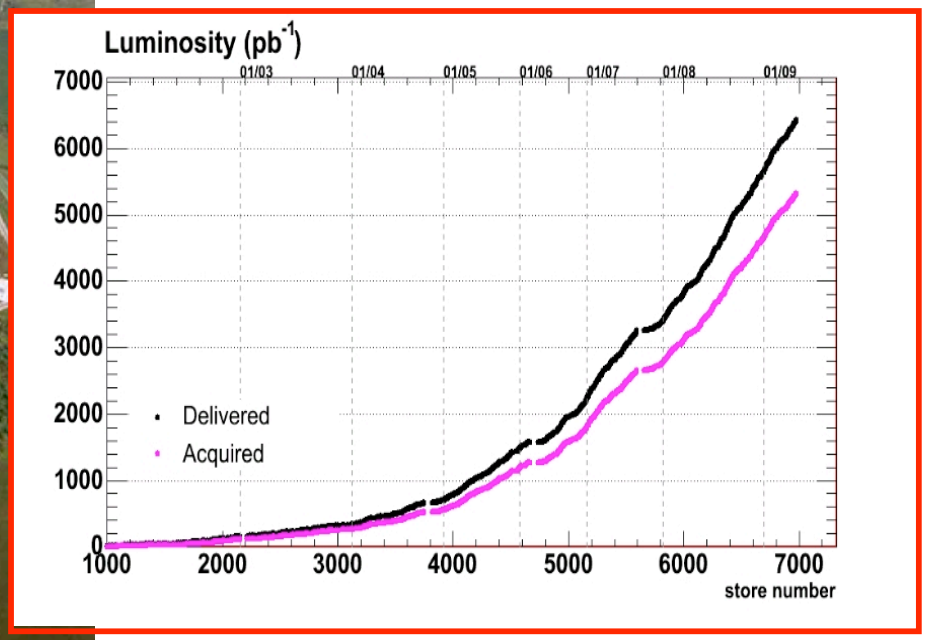


W / Z + jet production at CDF

Tara Shears
UNIVERSITY OF LIVERPOOL





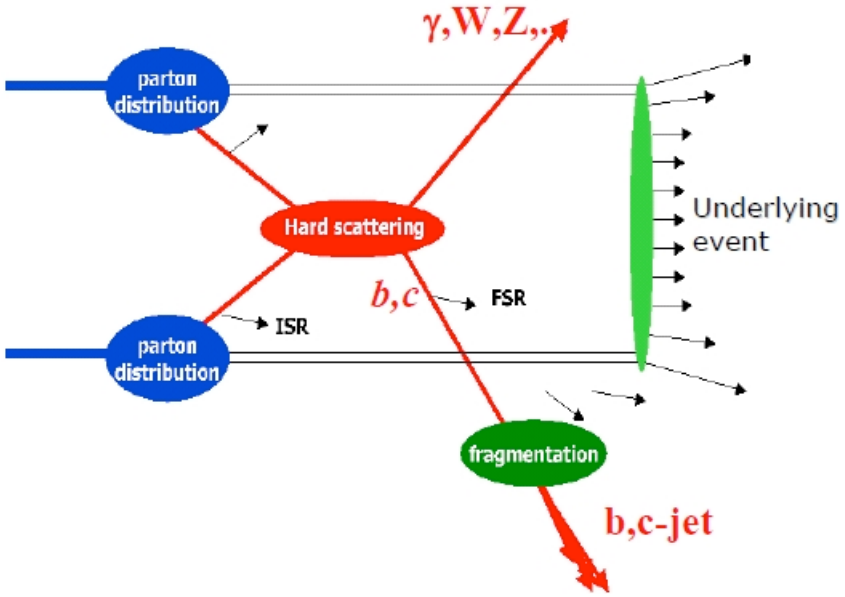


Up to 2.5 fb^{-1} used in reported analyses

QCD tests:

•Test of perturbative QCD (W, Z ensures high Q^2)

• W, Z + b jet production potentially sensitive to b content of proton



Background process:

• Standard Model (eg. top)

• New physics (Higgs, SUSY)

Inclusive measurements:

- W + jets — Phys. Rev. D 77, 011108(R) (2008)
- Z + jets — Phys. Rev. Lett. 100 102001 (2008): 1.7 fb^{-1}

Heavy flavour measurements:

- Z+ b jets — hep-ex/0812.4458 (2008)
- W+ b jets

Not included:

- W + c jets — Phys. Rev. Lett. 100 091803 (2008)
- Inclusive W, Z — See H. Fox, talk [95]

$W(\rightarrow e\nu_e)$ + jets

Z(→ee) + jets

0.32 fb^{-1}

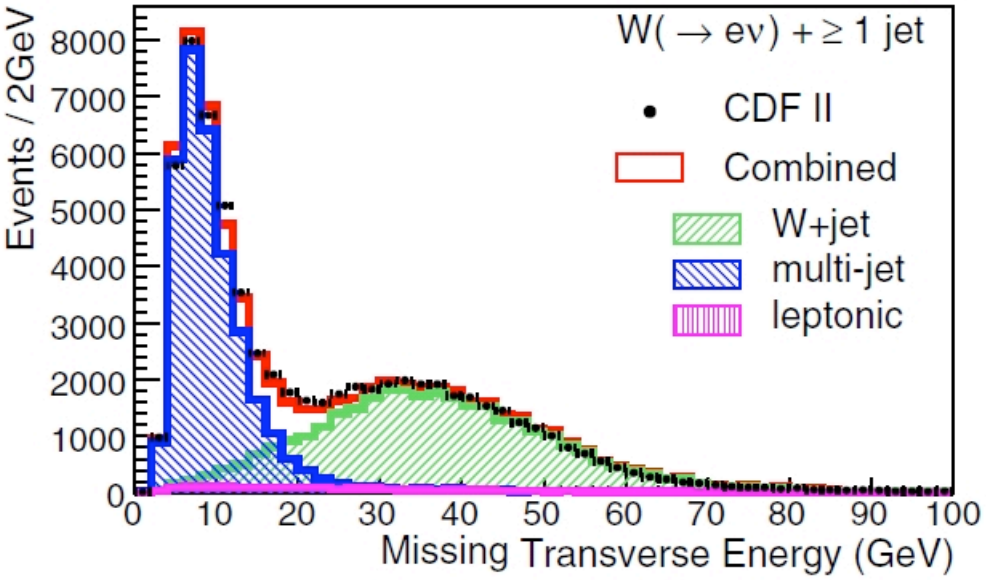
Trigger on high E_T central electron

Identify W:
$E_T^e > 20$ GeV, $|\eta^e| < 1.1$
Missing $E_T > 30$ GeV
$m_T > 20$ GeV/c^2

Identify jets; Jetclu cone 0.4 jet with $E_T > 20$ GeV, $|\eta| < 2.0$

$\Delta R^{e\text{-jet}} > 0.52$

Measure σ at hadron level as function of E_T^{jet} cf. LO, NLO predictions



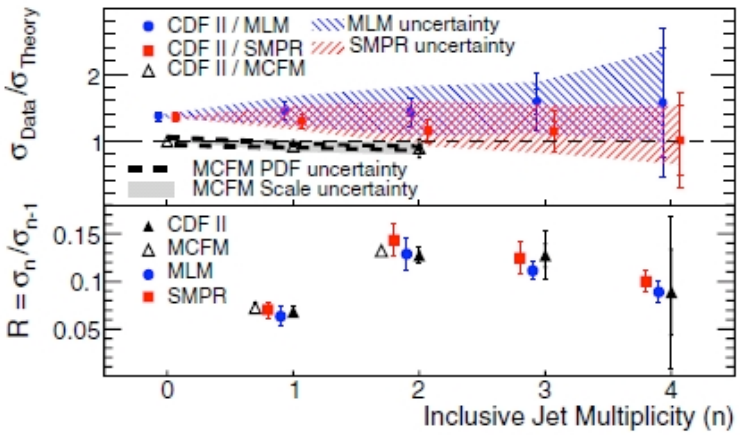
Backgrounds ~ 10-40 % → 90 % depending on E_T^{jet}

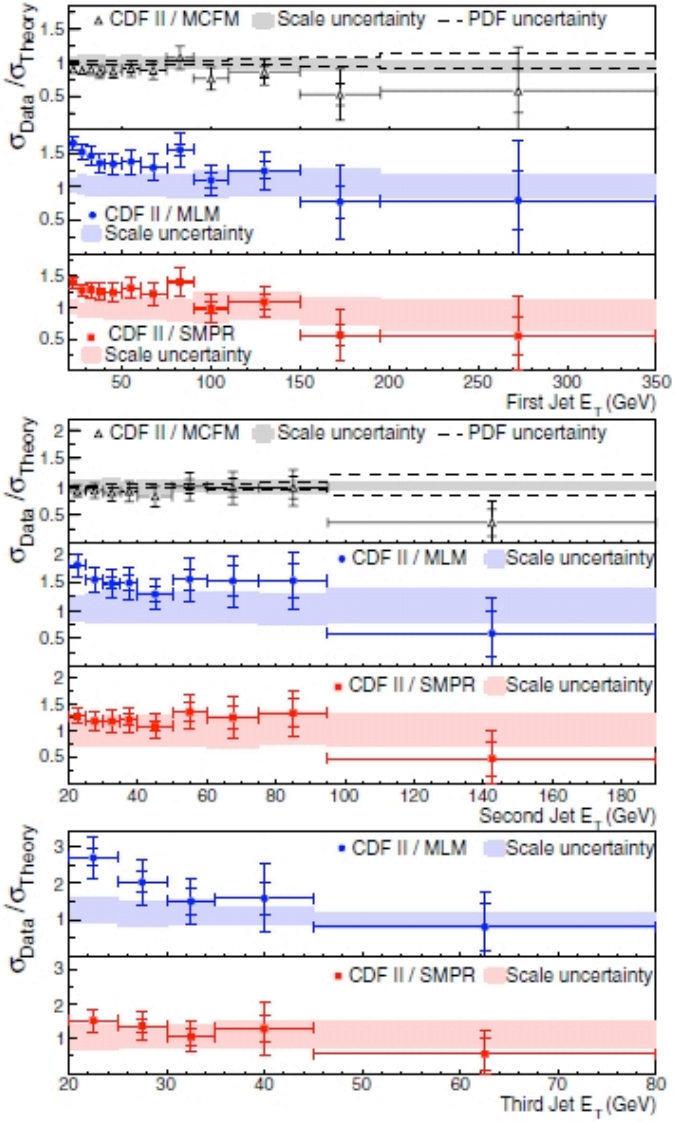
Systematics: ~ 20 % → 50-80 %

• jet energy scale (background) at low (high) E_T^{jet}

$W(\rightarrow e\nu_e)$ + jets

$Z(\rightarrow ee)$ + jets





NLO: MCFM (W + 1 and 2 jet available)

LO: ME+PS + nonpQCD correction:

SMPR: Madgraph, CTEQ6L, Pythia, S. Mrenna and P. Richardson, J. High Energy Phys. 05 (2004) 040.

MLM: Alpgen, CTEQ5L, Herwig, J. Alwall *et al.*, arXiv:0706.2569.

Agreement with NLO good.

LO low.

Trigger on high E_T central electron

Identify Z:
E_T^e > 25 GeV,
$|\eta^e_1|$<1.0, $|\eta^e_2|$<1.0 OR 1.2<$|\eta^e_2|$<2.8,
66 < M_{ee} < 116 GeV/c^2

Identify jet; midpoint cone 0.7 jet , R_{sep}1.3, with p_T>30 GeV, | y |<2.1

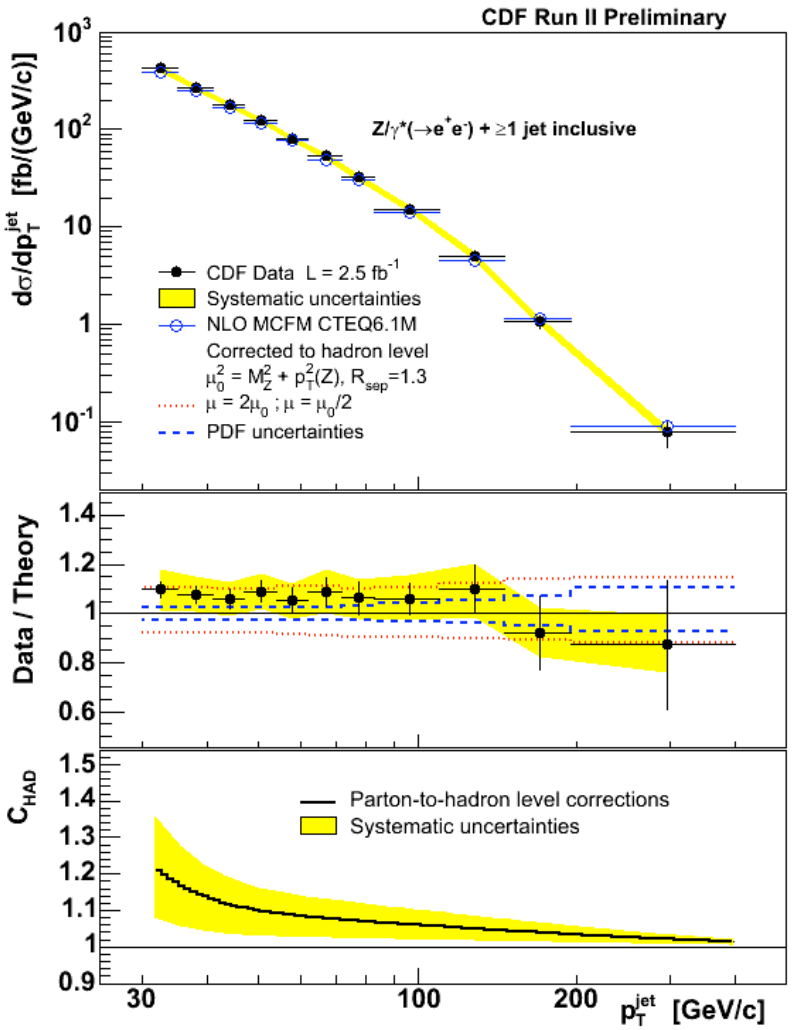
Measure σ at hadron level as function of p_T^{jet}, cf. NLO predictions.

Backgrounds low (~12% for ≥1 jet)

Good agreement with NLO (MCFM + CTEQ6M, corrected for UE, fragmentation)

Corrections largest at low E_T

2.5 fb^{-1}



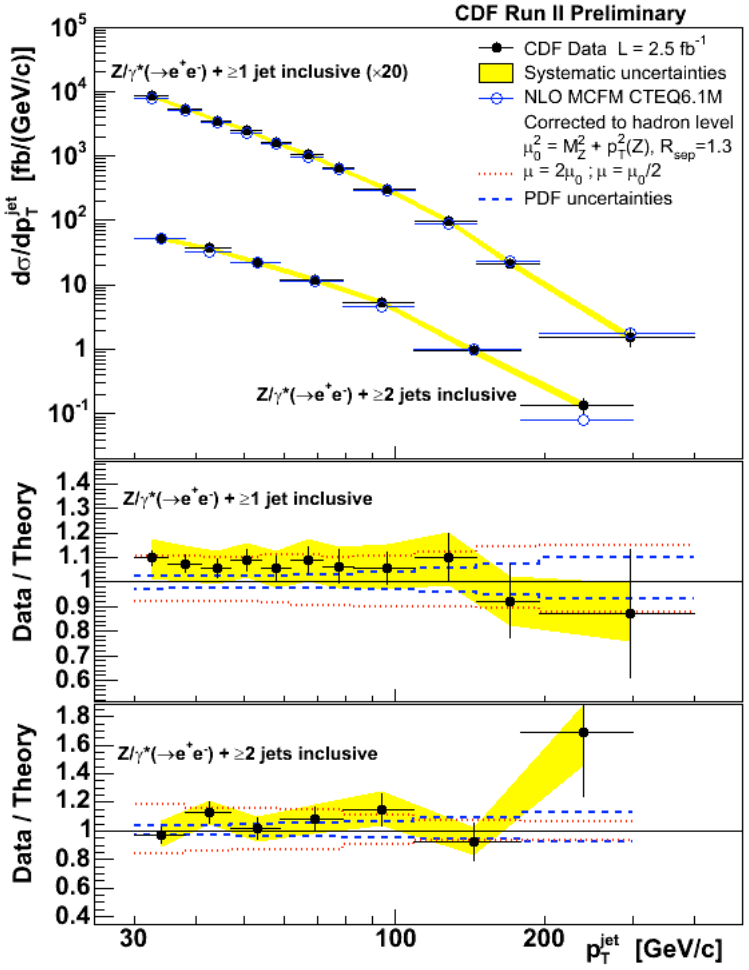
W(→eν$_e$) + jets

Z(→ee) + jets

Systematics dominated by:

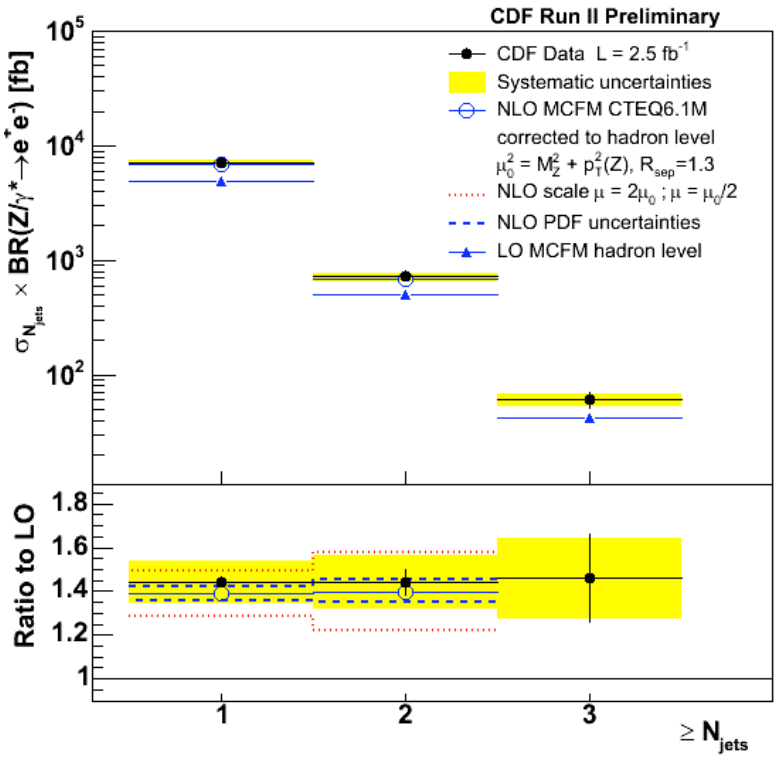
scale dependance (th.)

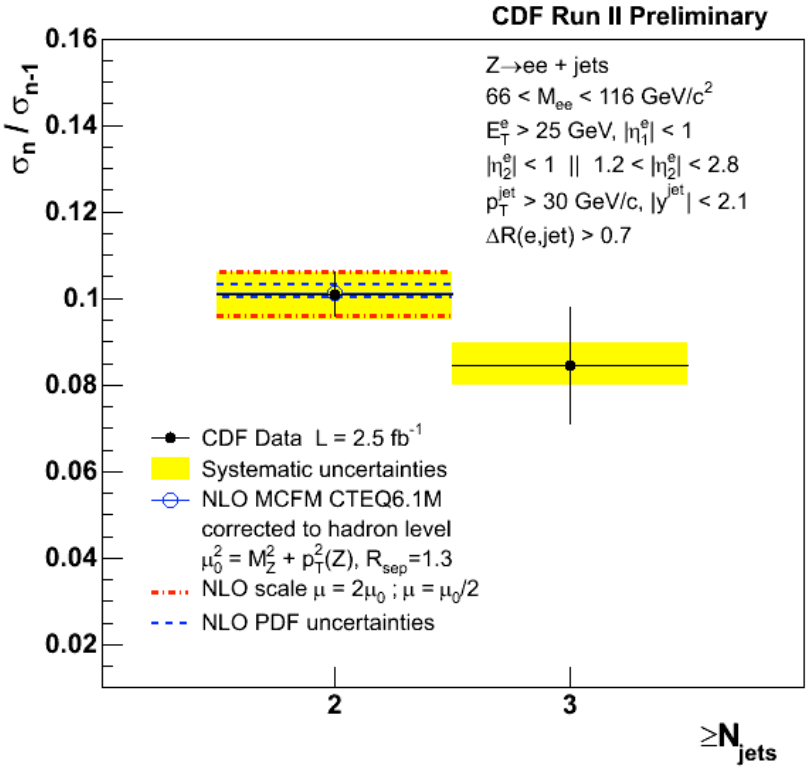
jet energy scale (exp.).



W(→eν$_e$) + jets

Z(→ee) + jets





NLO describes data well

LO low by factor 1.4

Z(→ee,μμ) + b jets

W(→eν$_e$,μν$_\mu$) + b jets

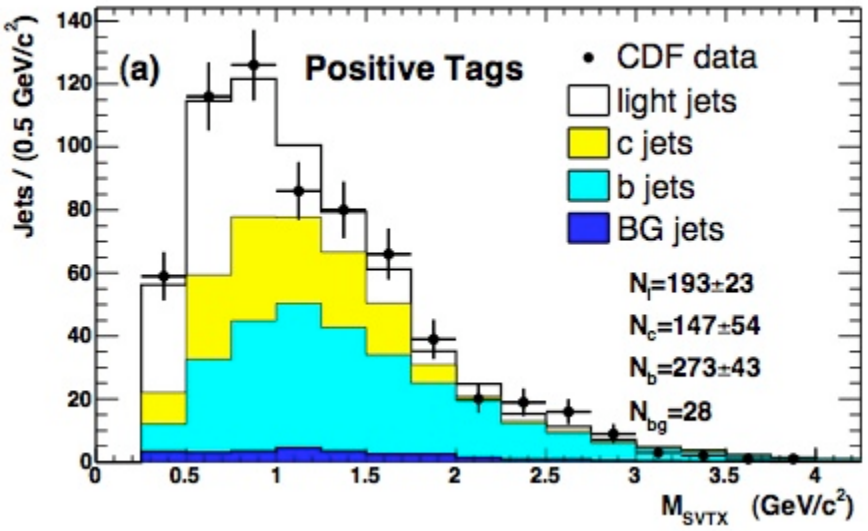
2 fb^{-1}

Trigger on Z→**e$^+$e$^-$** (|η|<2.5), **μ$^+$μ$^-$**(|η|<1.5)

Identify b jet; Jetclu cone 0.7 jet with Et>20 GeV, | η |<1.5, secondary vertex tag.

Estimate b fraction by secondary vertex tag, fit sec. vertex mass to MC templates to obtain b fraction.

Measure σ at hadron level, compare to LO, NLO



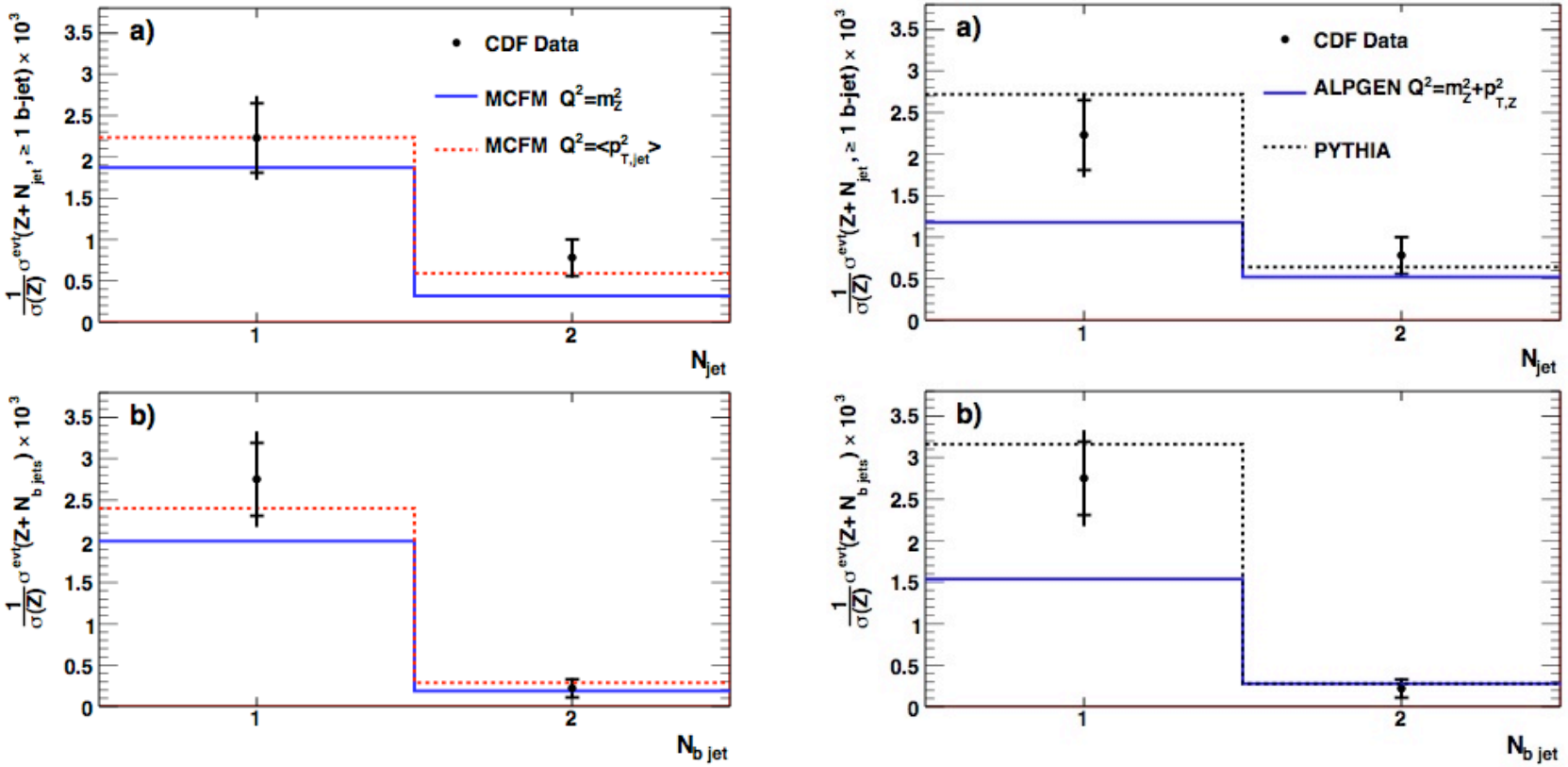
Main sys: E_T modelling (8%)

	data	Alpgen	Pythia	MCFM ($Q^2=m_Z^2+p_{TZ}^2$)	MCFM ($Q^2=\langle p_{Tjet}\rangle^2$)
$\frac{\sigma(Z+b)}{\sigma(Z)}$	(3.32 ± 0.53 ± 0.42)x10^{-3}	2.1x10^{-3}	3.5x10^{-3}	2.3x10^{-3}	2.8x10^{-3}
$\frac{\sigma(Z+b)}{\sigma(Z+j)}$	(2.08 ± 0.33 ± 0.34) %	1.5 %	2.2 %	1.8 %	2.2 %

Z(→ee,μμ) + b jets

W(→eν_e,μν_μ) + b jets

NLO **LO**



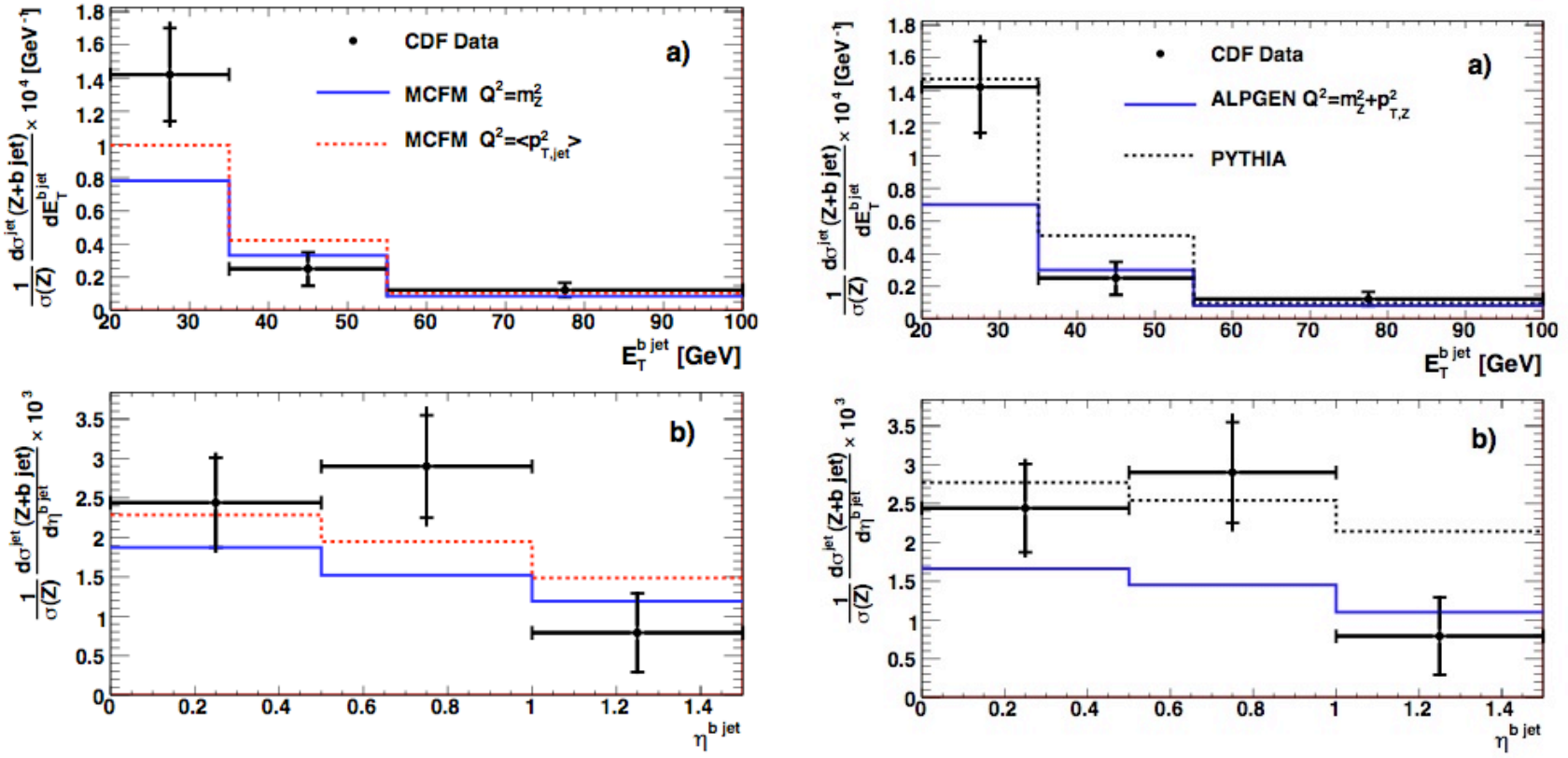
NLO, LO at low scale describe data well.

NLO, LO at high scale are low.

Z(→ee,μμ) + b jets

W(→eν_e,μν_μ) + b jets

NLO **LO**



NLO, LO at low scale describe data well.

NLO, LO at high scale are low.

Z(→ee,μμ) + b jets

W(→eν$_e$,μν$_\mu$) + b jets

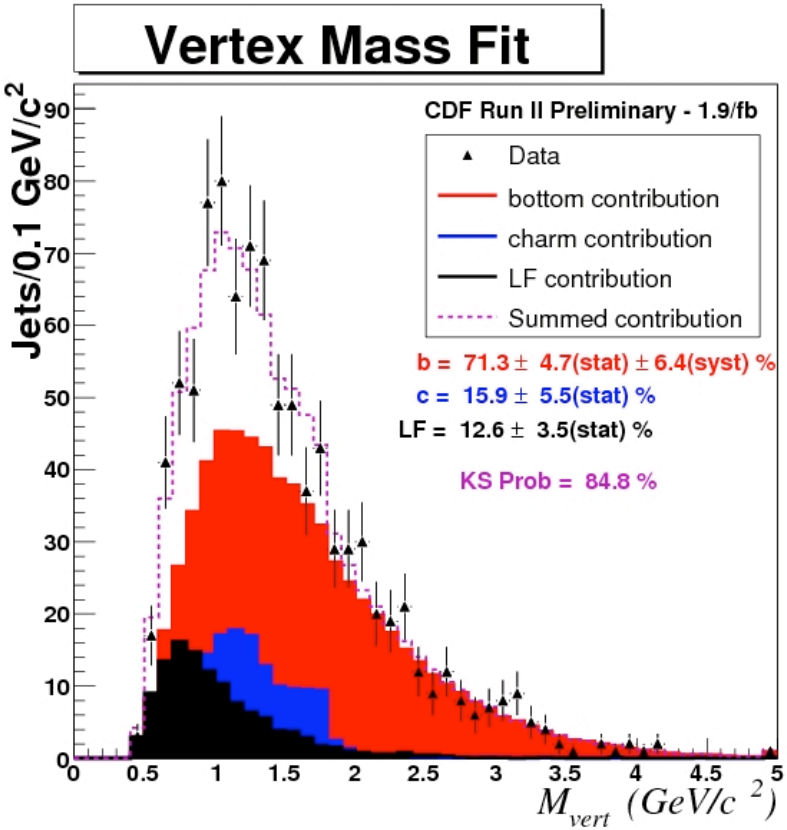
1.9 fb^{-1}

Trigger on high E_T central electron or muon

Identify W:
e: E_T > 20 GeV, |η| < 1.1
μ: p_T> 20 GeV/c, |η| < 1.0
ν: Missing E_T> 25 GeV

Identify b jet; Jetclu cone 0.4 jet with E_T>20 GeV, | η |<2.0, sec. vertex.

Compare inclusive cross-section to LO : ALPGEN + CTEQ5L



Yield: ~ 496 signal events, ~180 background (70% tt or single t)

Results:

in events with a $p_T > 20$ GeV/c, $|\eta| < 1.1$ electron or muon, a $p_T > 25$ GeV/c neutrino, and 1 or 2 $E_T > 20$ GeV, $|\eta| < 2.0$ jets regardless of species.

Data: $\sigma_{bjets}(W + b\ jets) \times BR(W \rightarrow l\nu) = 2.74 \pm 0.27 \pm 0.42$ pb

LO: ALPGEN: **$\sigma \cdot BR$ = 0.78 pb**

LO factor 3 low (nb. high scale)

- **awaiting NLO comparison.**

W/Z + jet production measured at CDF on datasets up to 2.5 fb^{-1}

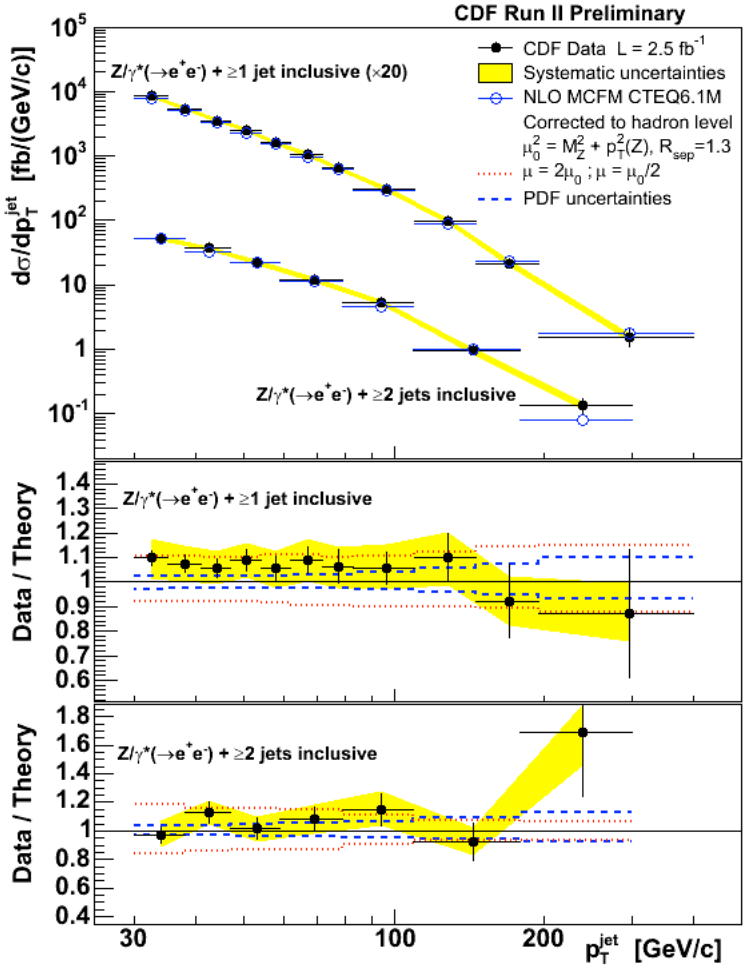
Inclusive measurements:

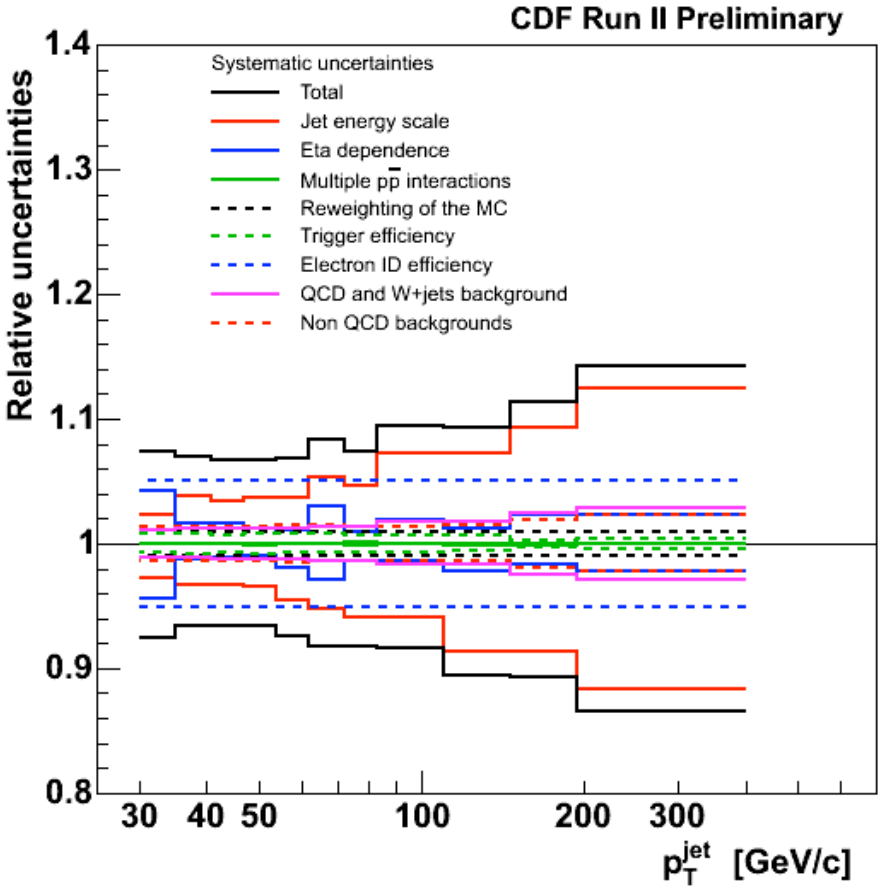
- LO estimates low
- NLO estimates show good agreement
- correction for U.E. and fragmentation needed at low E_T^{jet}

Heavy flavour measurements:

- NLO, LO estimates at high scales low.
- NLO, LO estimates at lower scales agree with data.

Backup





Systematic dominated by scale dependance (th.), jet energy scale (exp.).

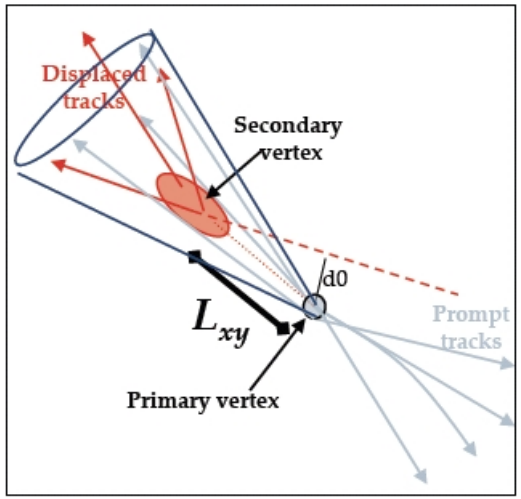
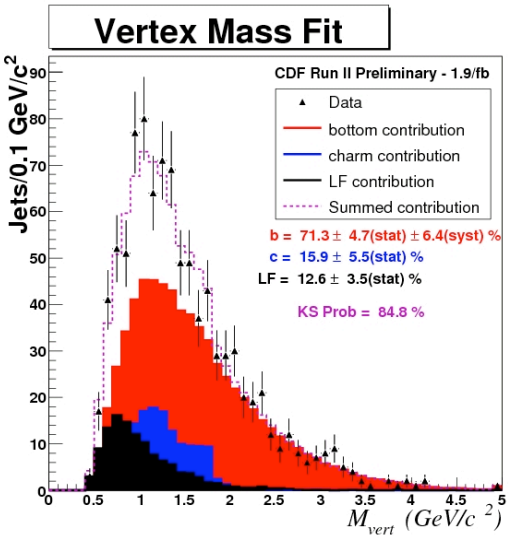
Identifying b jets

Tagging algorithm:

Consider tracks in $\eta-\phi$ 0.4 cone around jet axis

Find secondary vertex from displaced tracks

Large transverse displacement = b tagged.

Purity: fit invariant mass to template shapes (MC or data), 45-70%

Efficiency: 20-40% dependent on operating point.