W and Z +jets Measurements

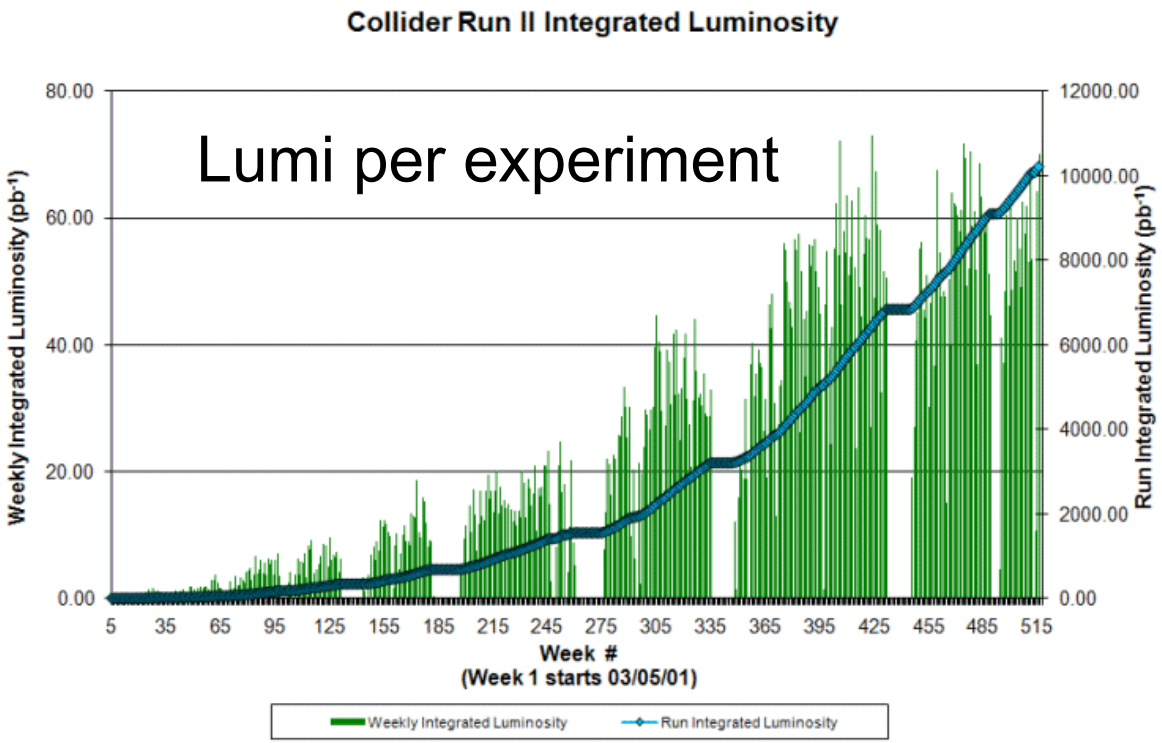
UNIVERSITY OF LIVERPOOL

IOP Half Day Meeting on VBF,
Oxford February 2011

Contents

- Tevatron running
- Inclusive Z from Tevatron
- Z+jets from Tevatron
- W+jets from Tevatron
- Z/W+jets from ATLAS
- Z/W+bjets
- Summary

Tevatron

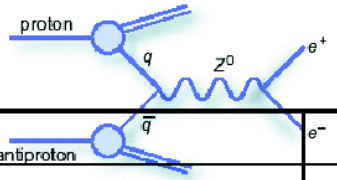


9 fb^{-1} now recorded by each experiment

Measurements In this talk based on ≤6 fb^{-1}

Expect ~10 fb^{-1} per experiment recorded by September 2011

Inclusive γ^*/Z Cross Section



	e	μ
Number observed events	4242	1785
Estimated Bkg events	62 ± 18	13 ±13
Acceptance	0.3182 ± 0.0040	0.1392 ± 0.0027
Efficiency	0.713 ± 0.012	0.713 ± 0.015
Luminosity	72.0 ± 4.3 pb^{-1}	72.0 ± 4.3 pb^{-1}

$\sigma_{\gamma^*/Z}$ (μ)	248.0 ±5.9 stat ± 7.6 syst ±14.9 lum (pb)
$\sigma_{\gamma^*/Z}$ (e)	255.8 ±3.9 stat ± 5.5 syst ±15.4 lum (pb)
$\sigma_{\gamma^*/Z}$ (e+μ)	254.9 ±3.3 stat ± 4.6 syst ±15.2 lum (pb)

NNLO @ $\sqrt{s}$=1.96 TeV: 251.3 ± 5.0 pb (Stirling, van Neerven)

Good agreement between SM and data
Data errors dominated by 6% lumi uncertainty

W/Z+jets Introduction

•Test of pQCD in multijet environment

– Presence of W/Z ensure high perturbative scales

- Precise theory predictions

– Clean environment: leptonic final state

- provides clean signature, low BG

– High statistics allows precision tests

• Test of MC Models

– Key sample to validate available MC tools using experimental data

Main measurement is Z+jets due to ease of measurement. Some older results on W+jets

CDF Z+jets

- **Preliminary Results 6 fb-1**
  Measurements are performed in the kinematic range defined as:
- 2 electrons with E_T > 25 GeV:
  One central e, $|\eta_e|$ < 1.0, Second e $|\eta_e|$ < 1.0 or 1.2 < $|\eta_e|$ < 2.8

OR 2 central muons , $|\eta_\mu|$ < 1.0 , with P_T > 25 GeV

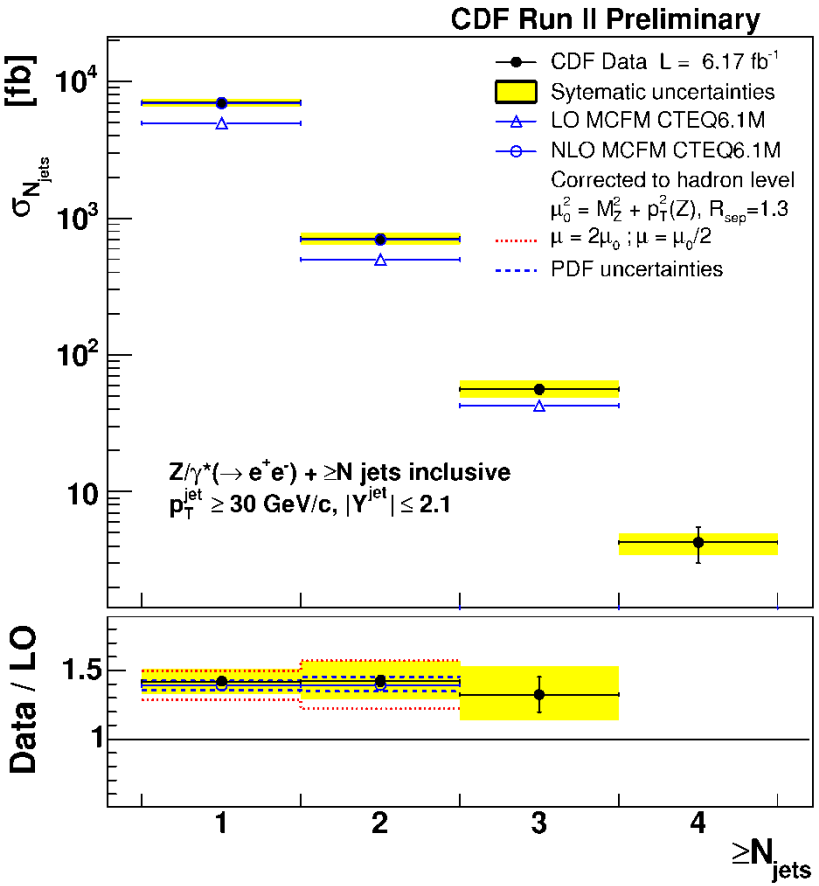
Measurements are defined for hadron level:

- Z mass window: 66 < M_{ee} < 116 GeV/c^2
- $\Delta R(e,\text{jet})$ > 0.7
- Jets are reconstructed using the MidPoint algorithm with R=0.7
  with $p_T$jet > 30 GeV/c and $|y_{\text{jet}}|$ < 2.1

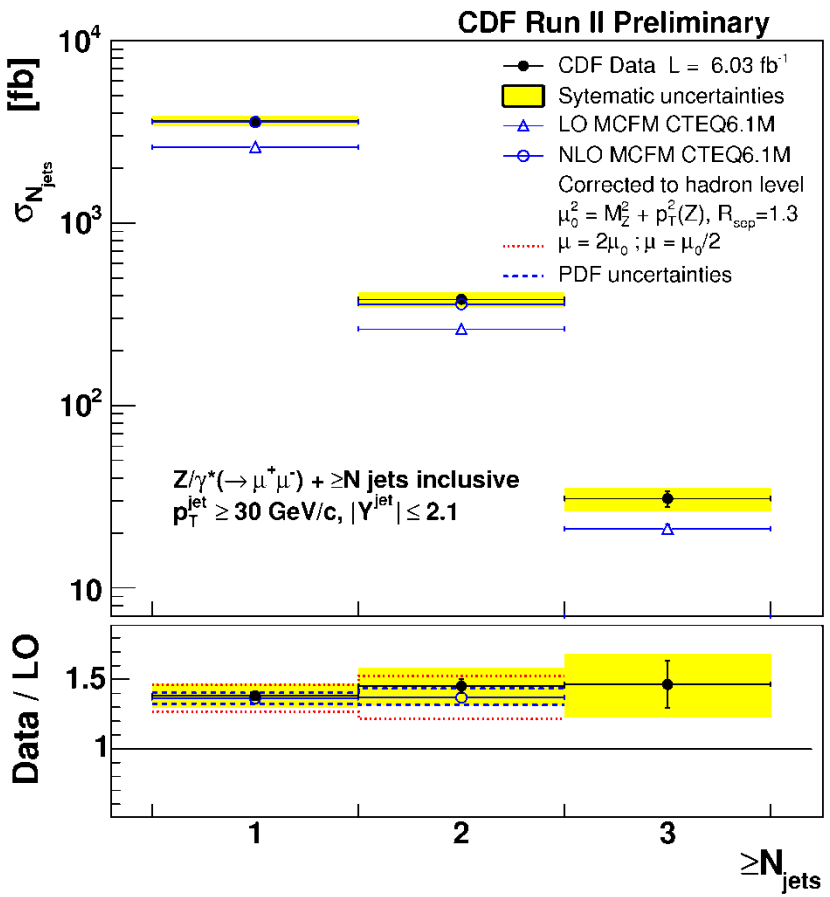
- Theory NLO MCFM : CTEQ6.1M $\mu=M_Z^2+p_T^2(Z)$
- Corrected hadronisation and Underlying Event, estimated from Pythia - Tune A

CDF Z+jets

Z→ee



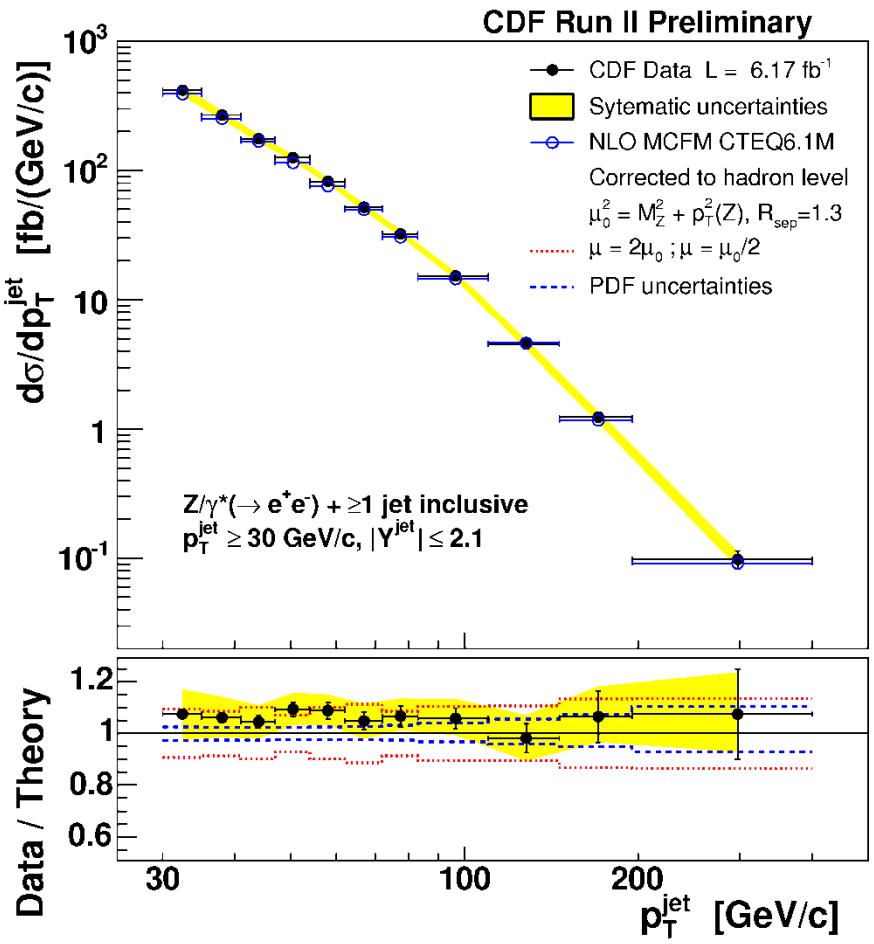
Z→μμ



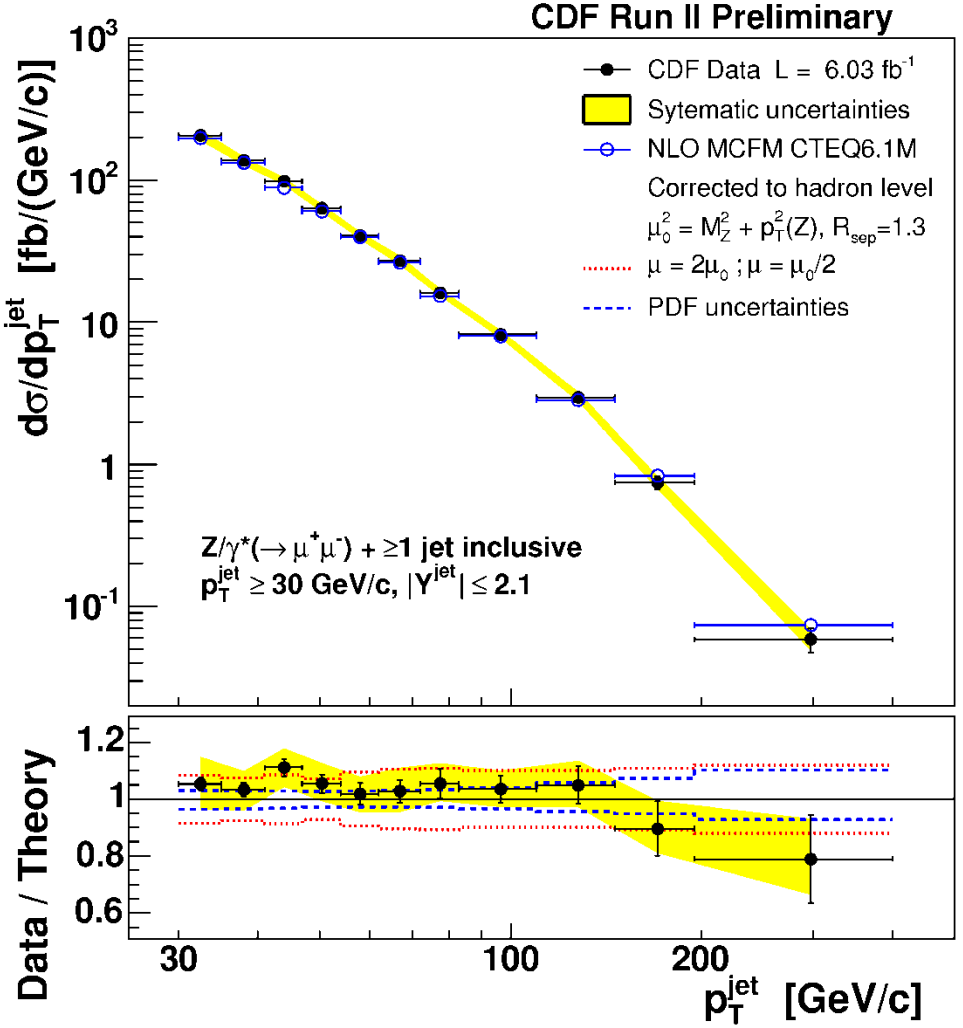
Good agreement with NLO

CDF Z+jets

Z→ee



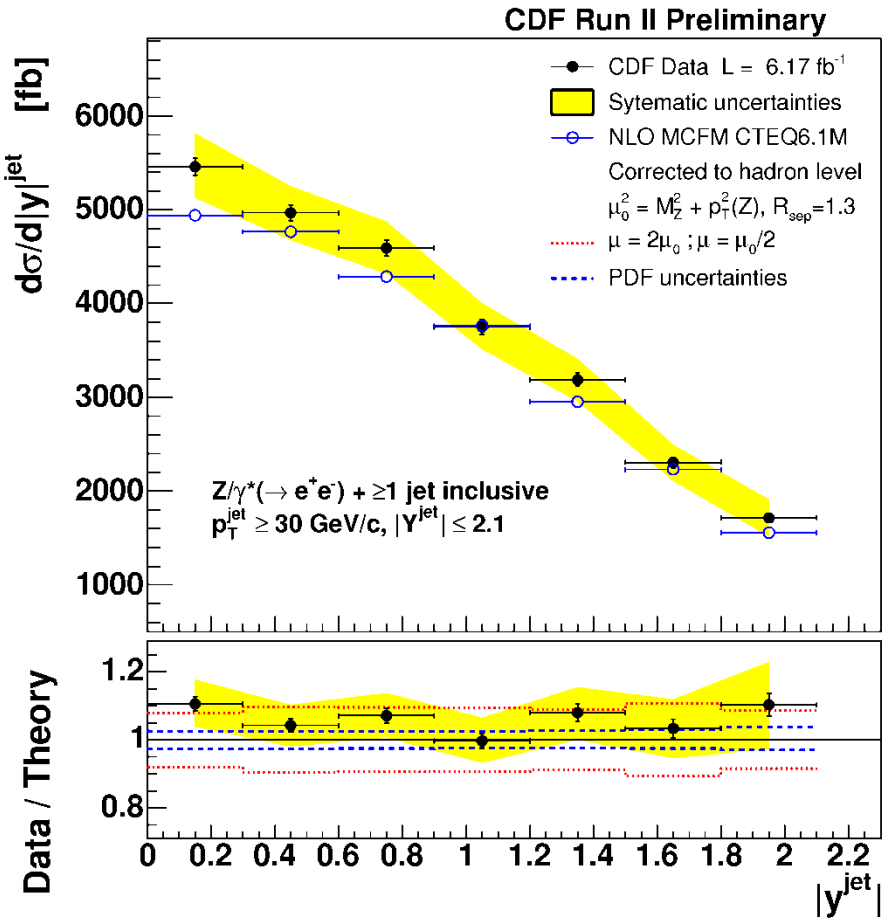
Z→μμ



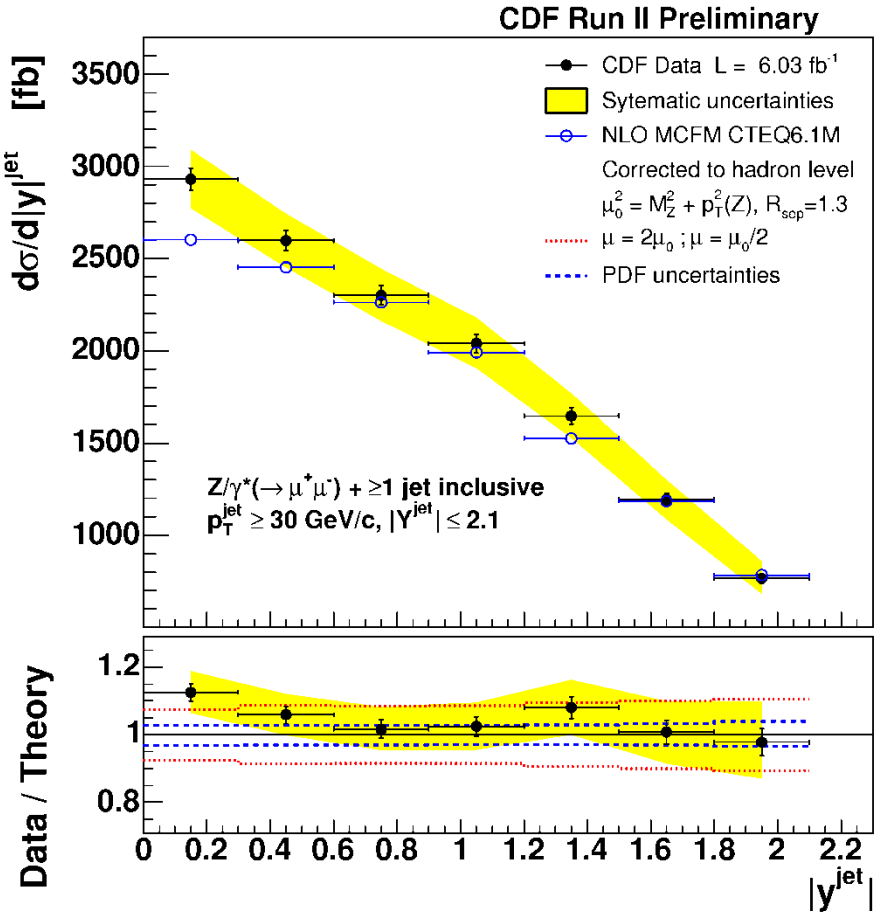
Good agreement with NLO

CDF Z+jets

Z→ee



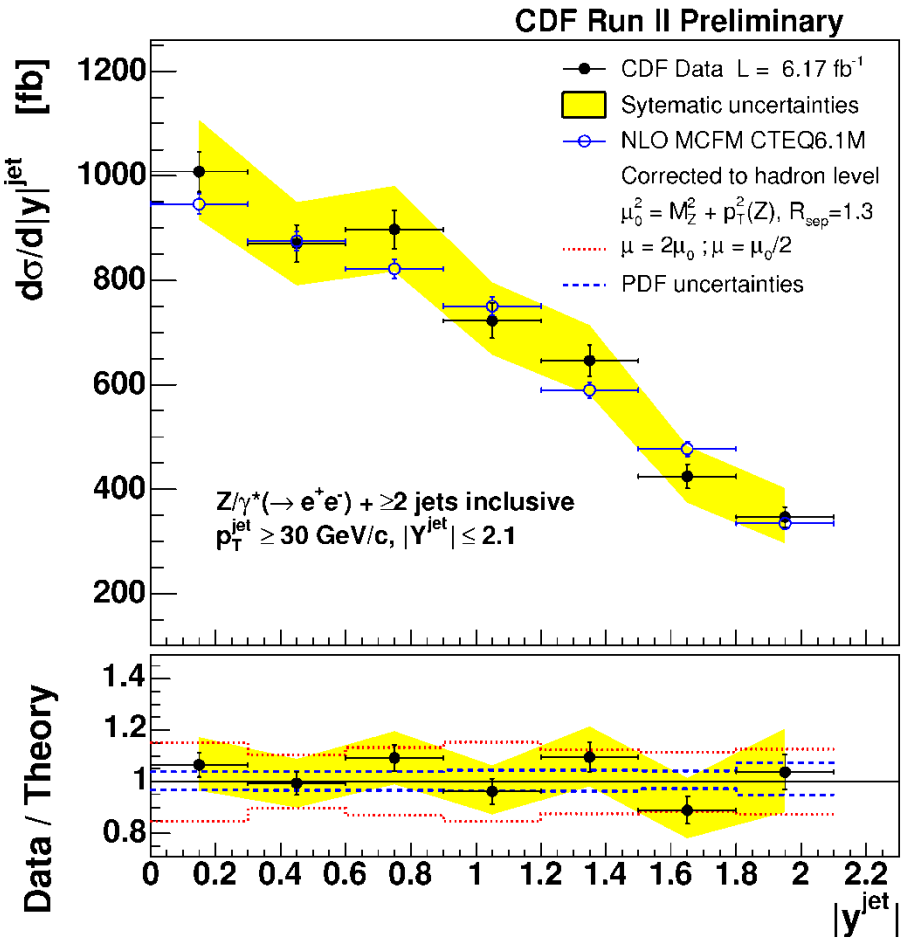
Z→μμ



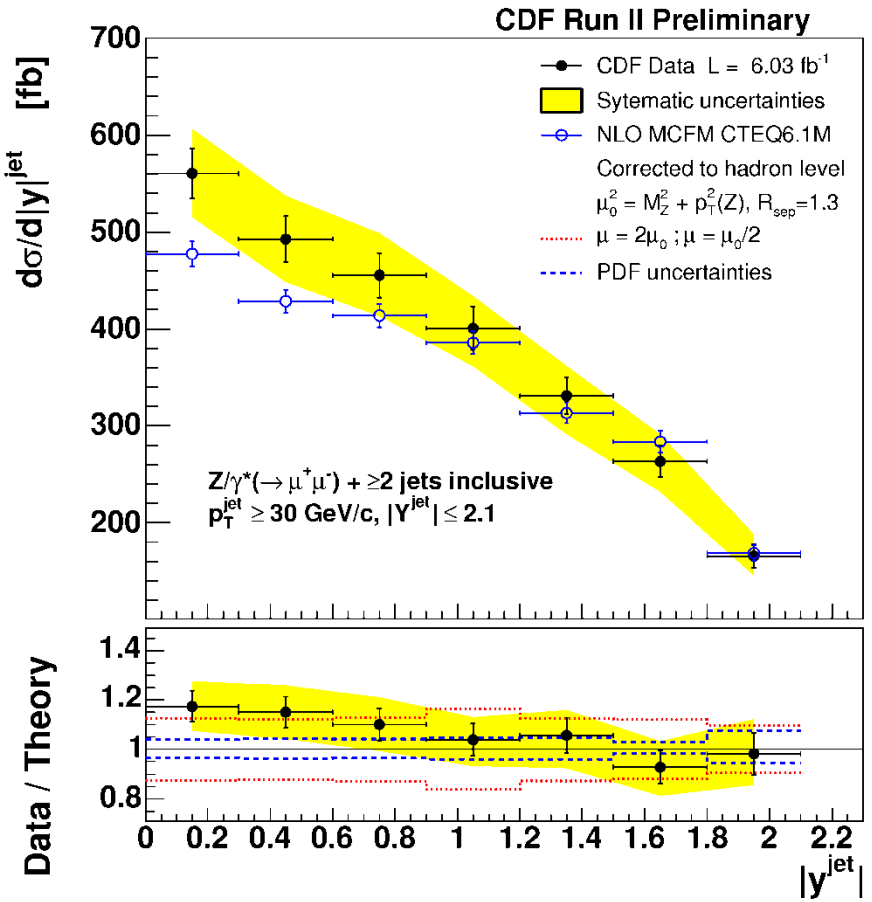
Good agreement with NLO

CDF Z+jets (2 jets)

Z→ee

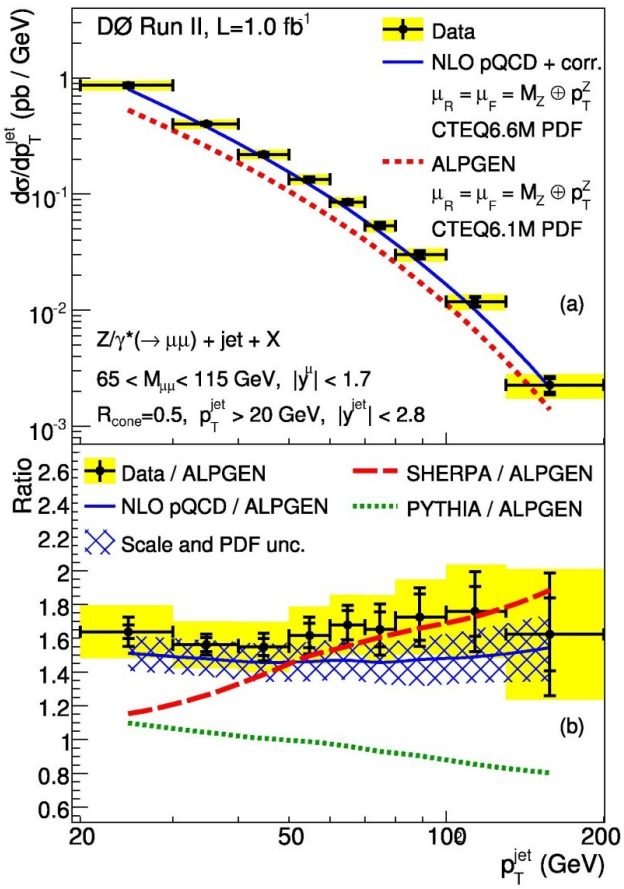


Z→μμ

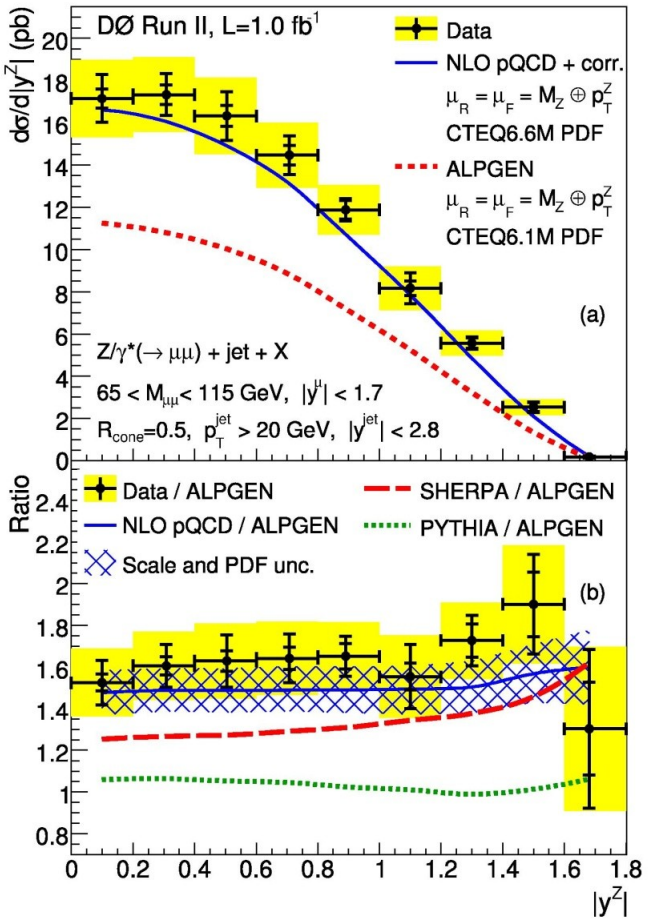


Good agreement with NLO

D0 Z+jets

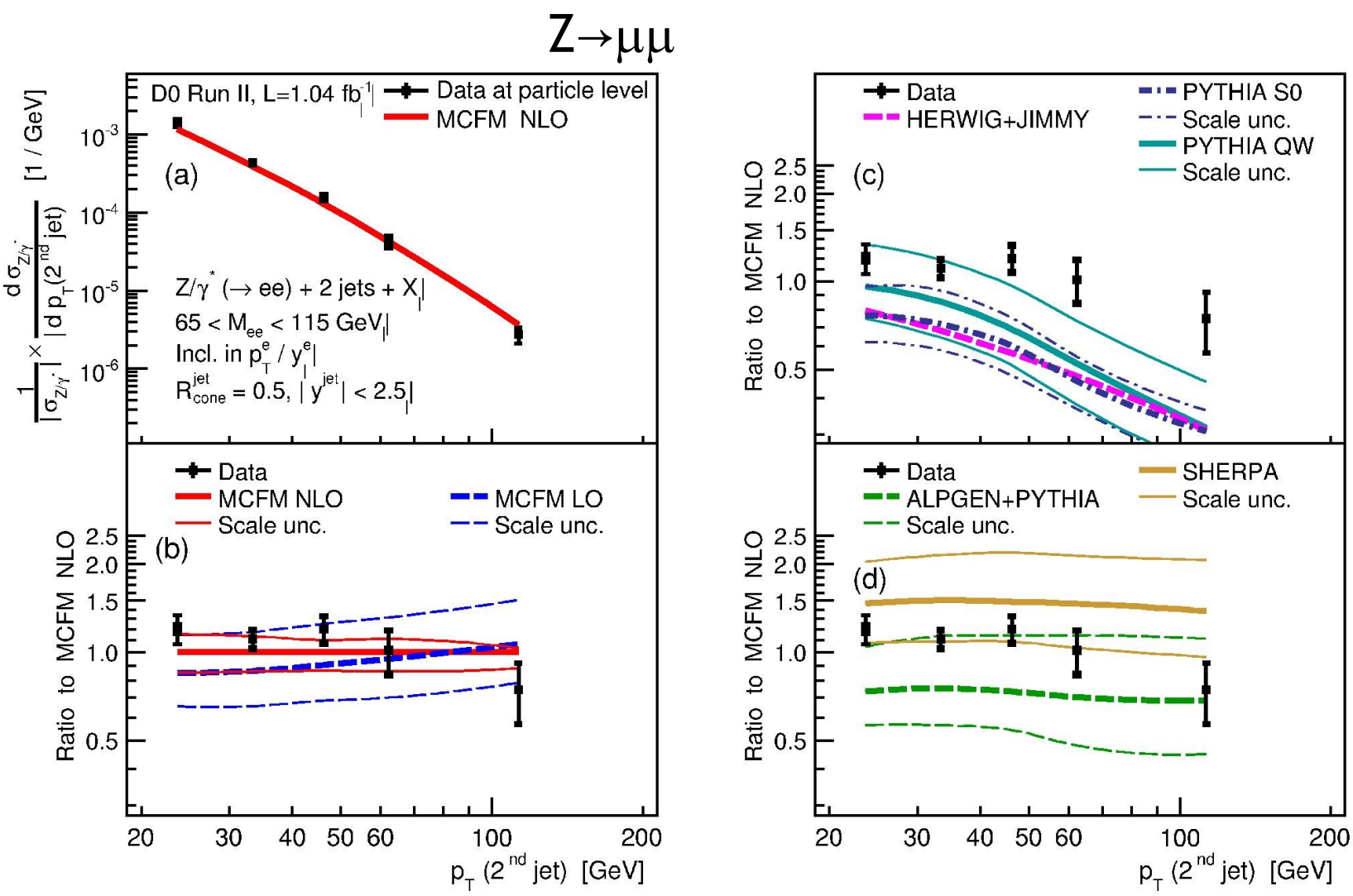


Z→μμ



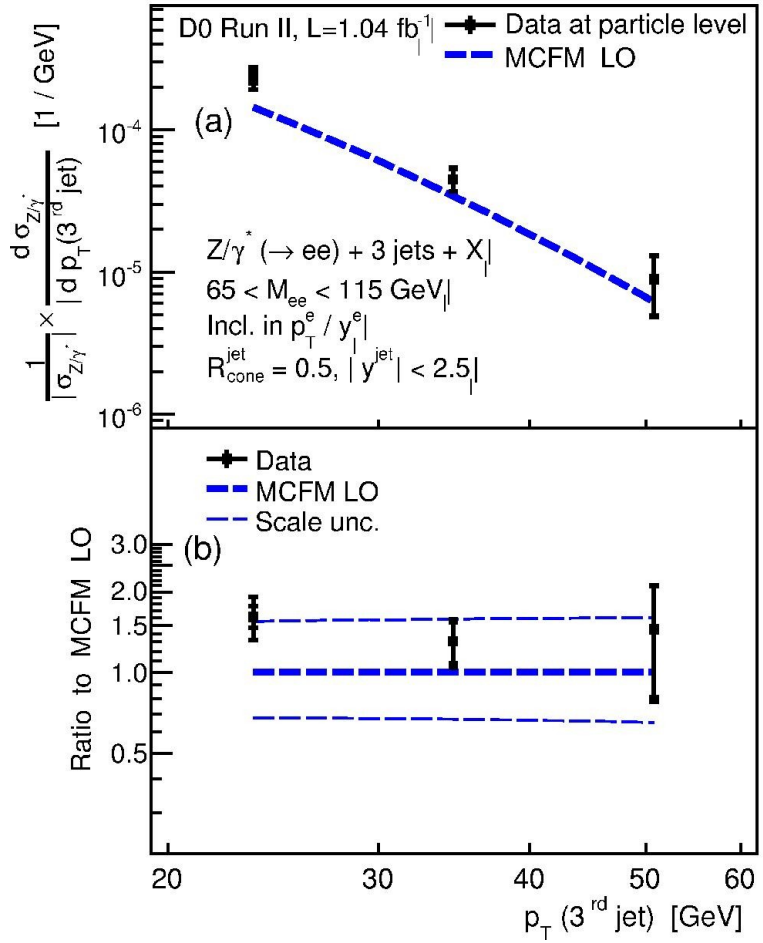
- Good agreement with NLO
- Alpgen shape reasonable
- Some differences for SHERPA and PYTHIA

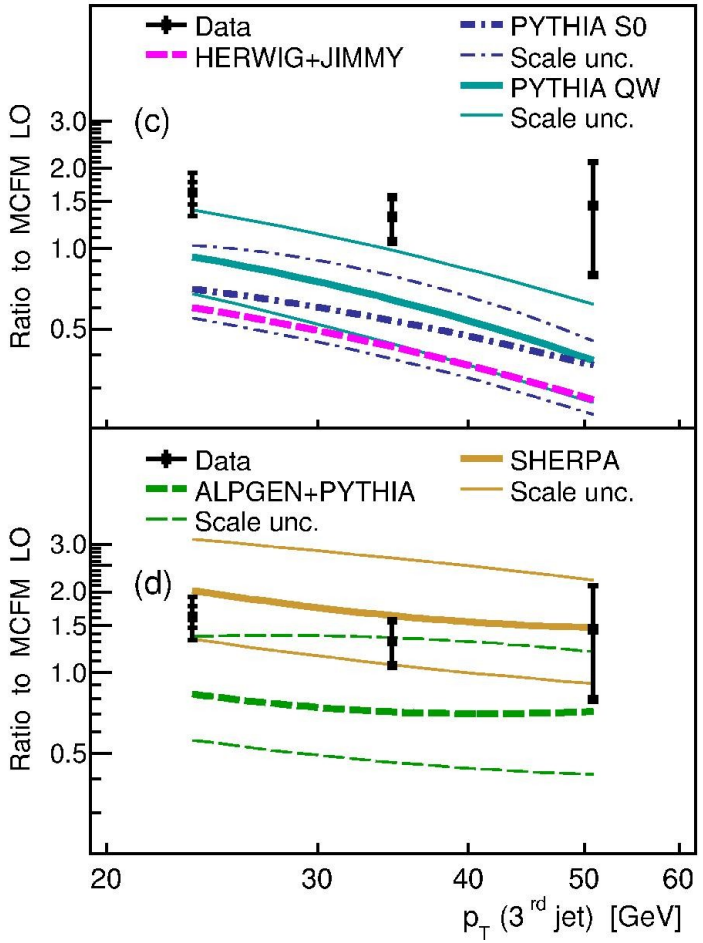
D0 Z+jets (2nd jet)



D0 Z+jets (3rd jet)

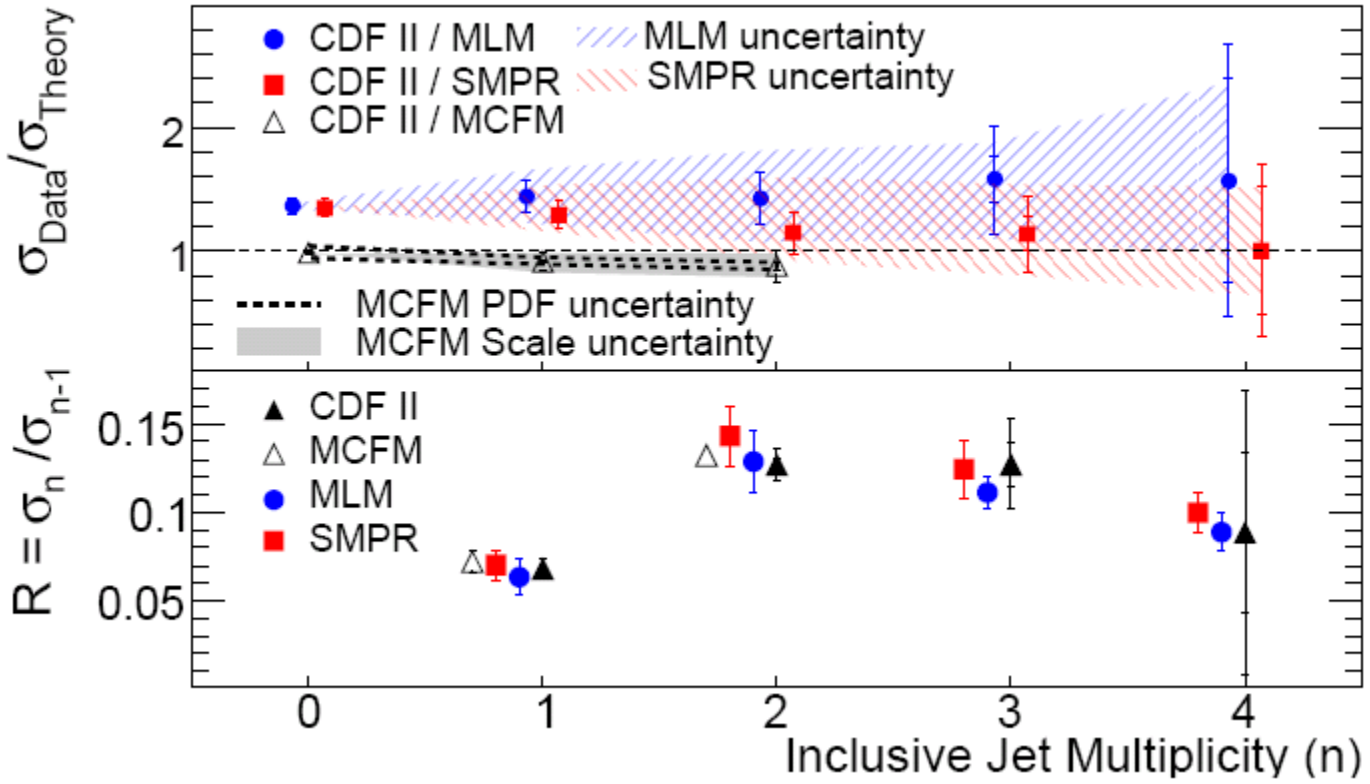
Z→μμ





CDF W+jets

W→eν

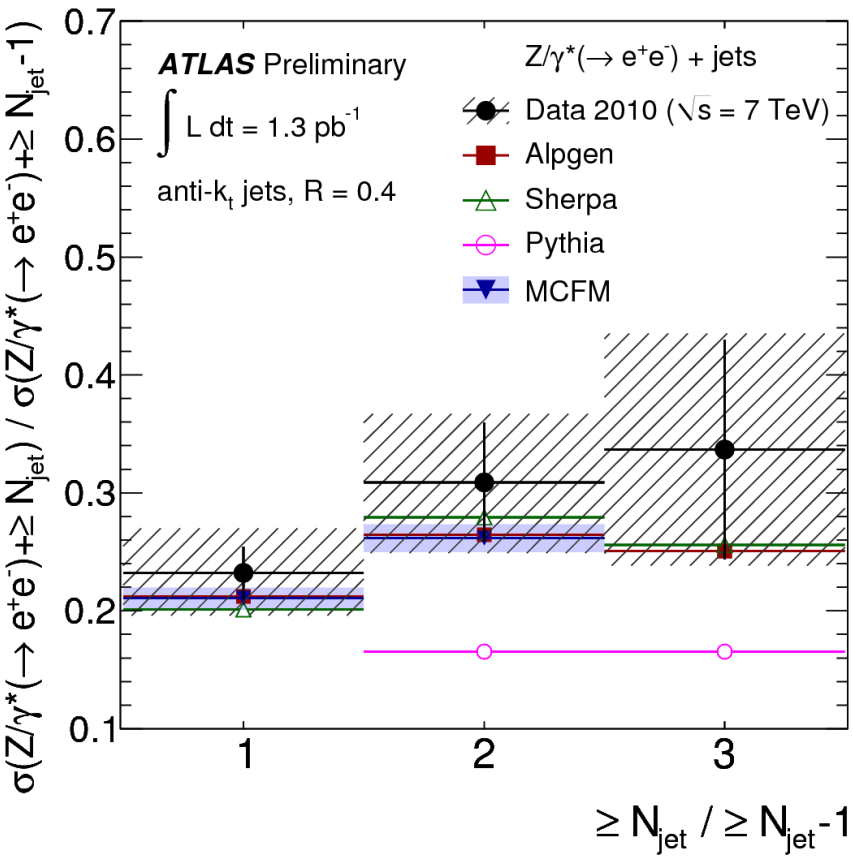


Phys. Rev. D 77, 011108(R)(2008)

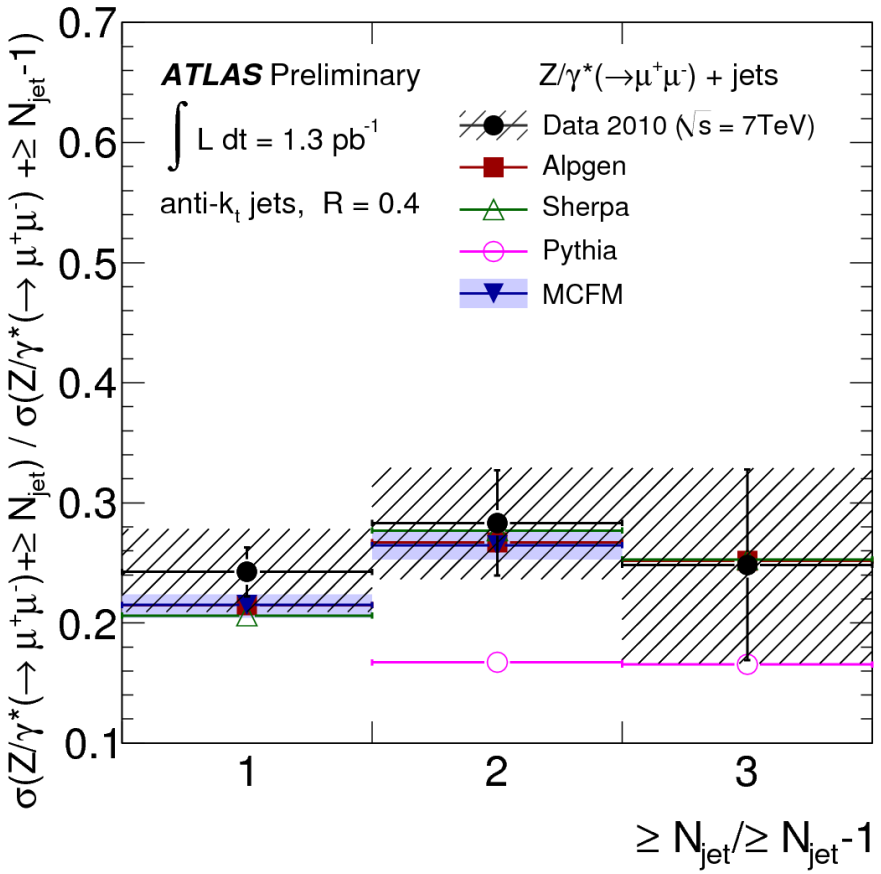
Good agreement with NLO and LO shape

ATLAS Z+jets

Z→ee

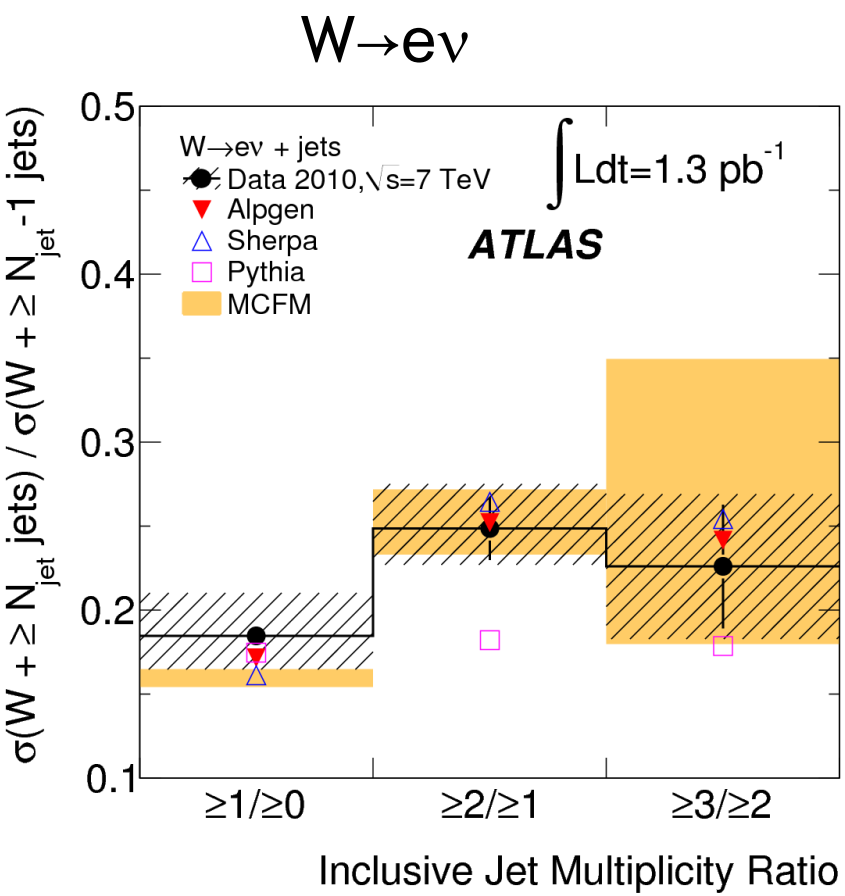


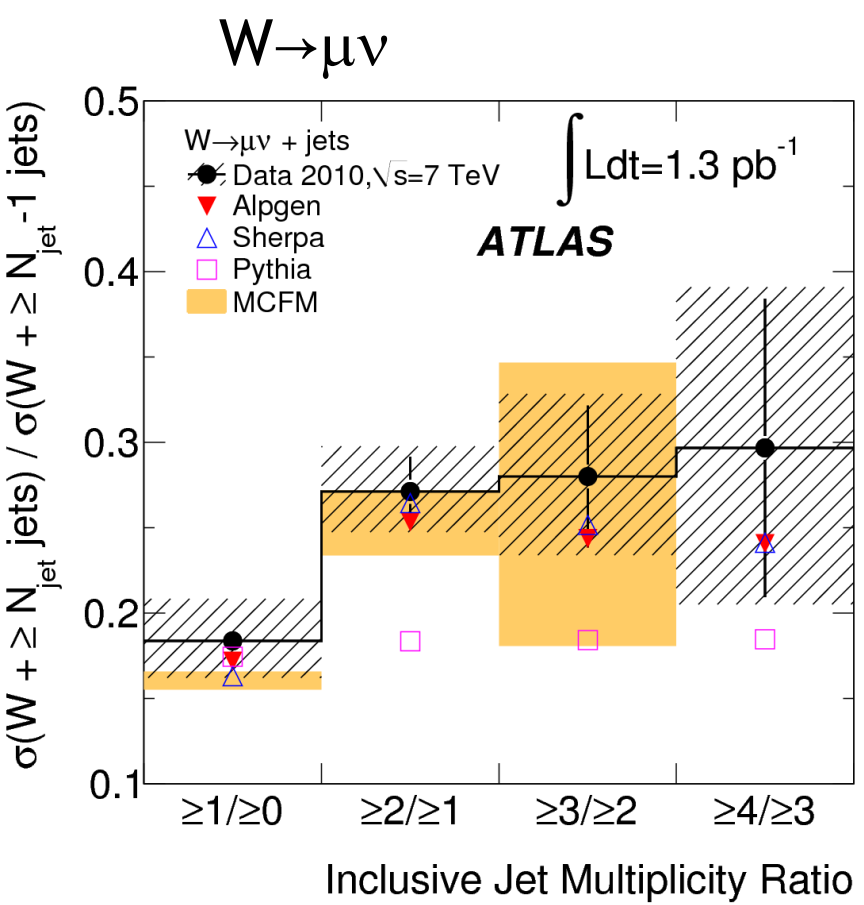
Z→μμ



- Good agreement with NLO and shape of ALPGEN+SHERPA
- PYTHIA way off

ATLAS W+jets





- Good agreement with NLO and shape of ALPGEN+SHERPA
- PYTHIA way off

Z+b-jet Results

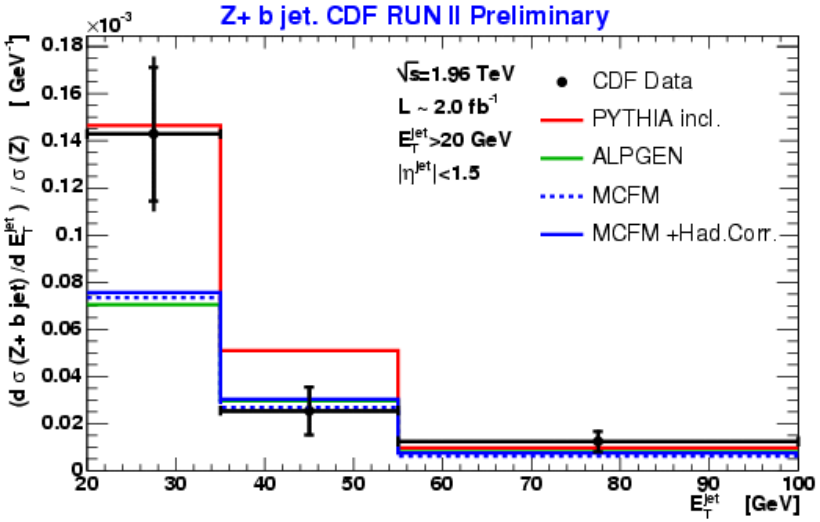
E_T<20 GeV, |η|<1.5	CDF Data	PYTHIA	ALPGEN	HERWIG	NLO	NLO +U.E+hadr.
$\sigma(Z+b\,\text{jet})$	$0.86 \pm 0.14 \pm 0.12$ pb	–	–	–	0.51 pb	0.53 pb
$\sigma(Z+b\,\text{jet})/\sigma(Z)$	$0.336 \pm 0.053 \pm 0.041\%$	0.35%	0.21%	0.21%	0.21%	0.23%
$\sigma(Z+b\,\text{jet})/\sigma(Z+\text{jet})$	$2.11 \pm 0.33 \pm 0.34\%$	2.18%	1.45%	1.24%	1.88%	1.77%

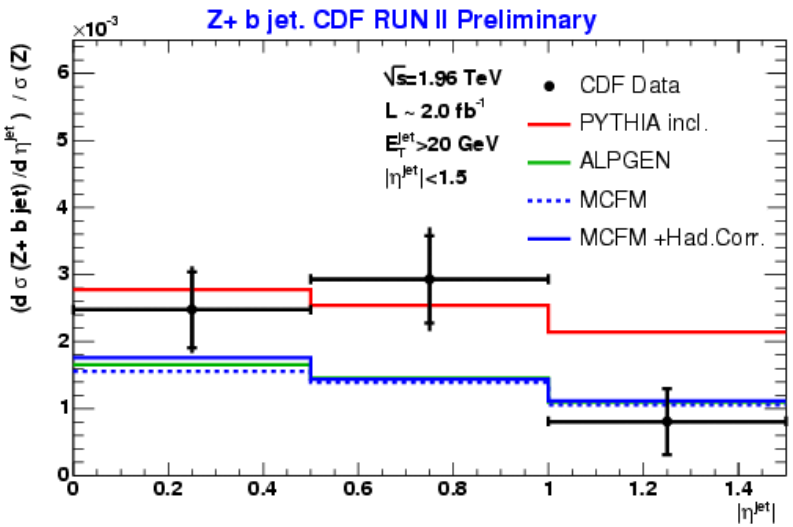
- CDF Good agreement with PYTHIA, but ALPGEN, HERWIG, NLO a little low
- NLO calculated with MCFM ~2σ lower than data so not very big disagreement
- D0 Measurement agrees well with NLO (MCFM 1.85%)

$$\sigma(Z+b\text{jet})/\sigma(Z+\text{jet}) = 1.93 \pm 0.27\% \text{ for } E_T^{\text{jet}} > 20\,\text{GeV}, |\eta| < 2.5.$$

- D0 Also agree with CDF!

Z+bjets differential distributions





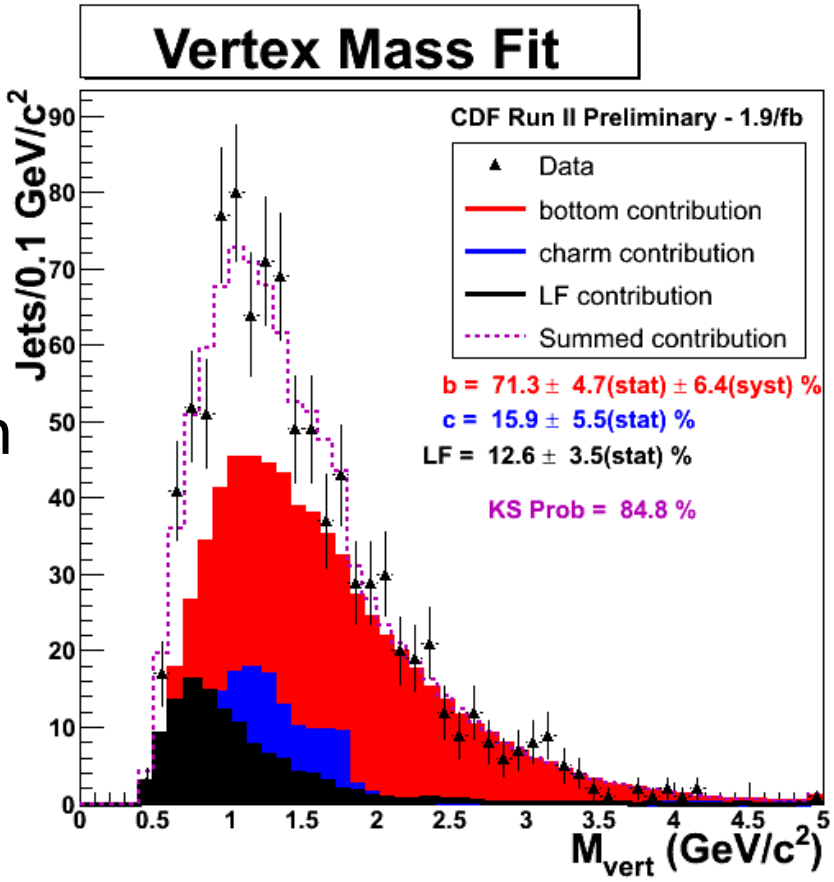
W+bjets

CDF Measurement
2.74±0.27±0.42 pb

is above NLO QCD prediction

1.22±0.14 pb

No real understanding yet.



Summary

- CDF+D0 have made precise differential measurements of W/Z+jets
- Experimental accuracy <10% (dominated by hadron energy scale)
- NLO QCD describes all the data with an accuracy of around 10%
- ALPGEN described shape of Tevatron data
- First results from LHC show good agreement with NLO and shape of ALPGEN+SHERPA
- PYTHIA not sufficient to describe LHC data
- Z+bjets reasonably well described by NLO QCD
- W+bjets data is in excess of NLO QCD