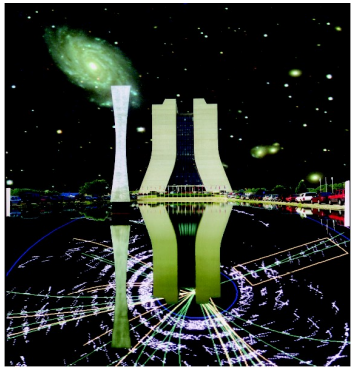


W/Z+Jets Results from CDF

Stefano Camarda

IFAE - Barcelona

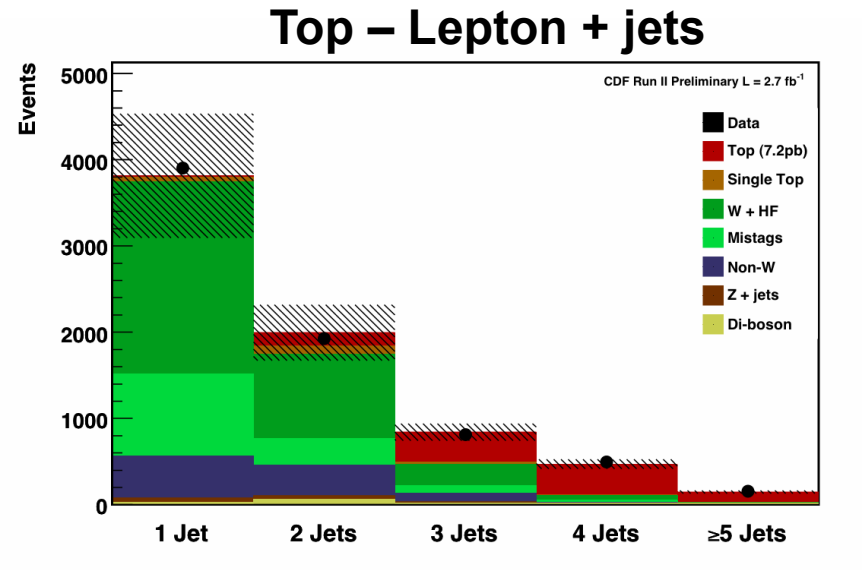
On Behalf of
CDF Collaboration

ICHEP

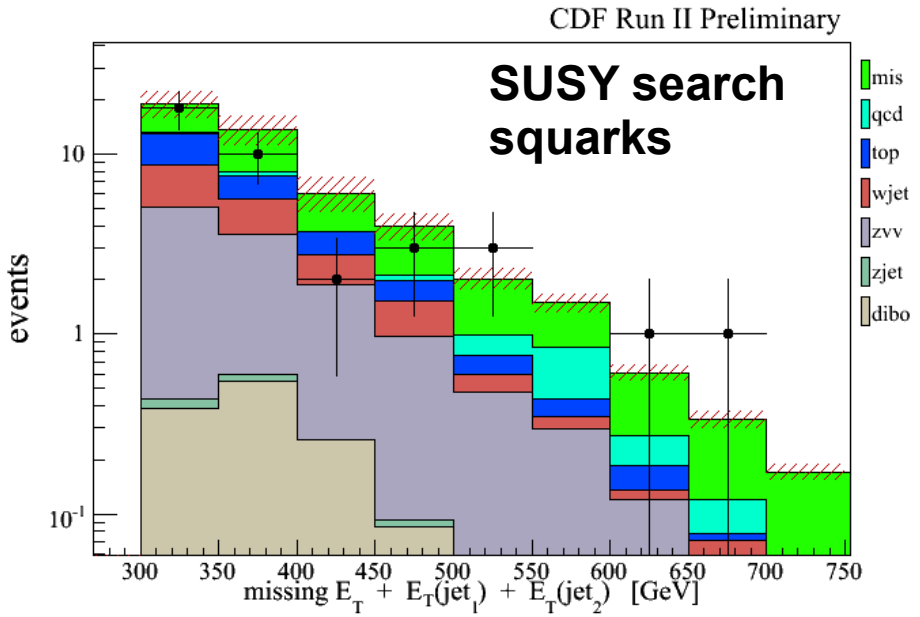
July 22-28, 2010

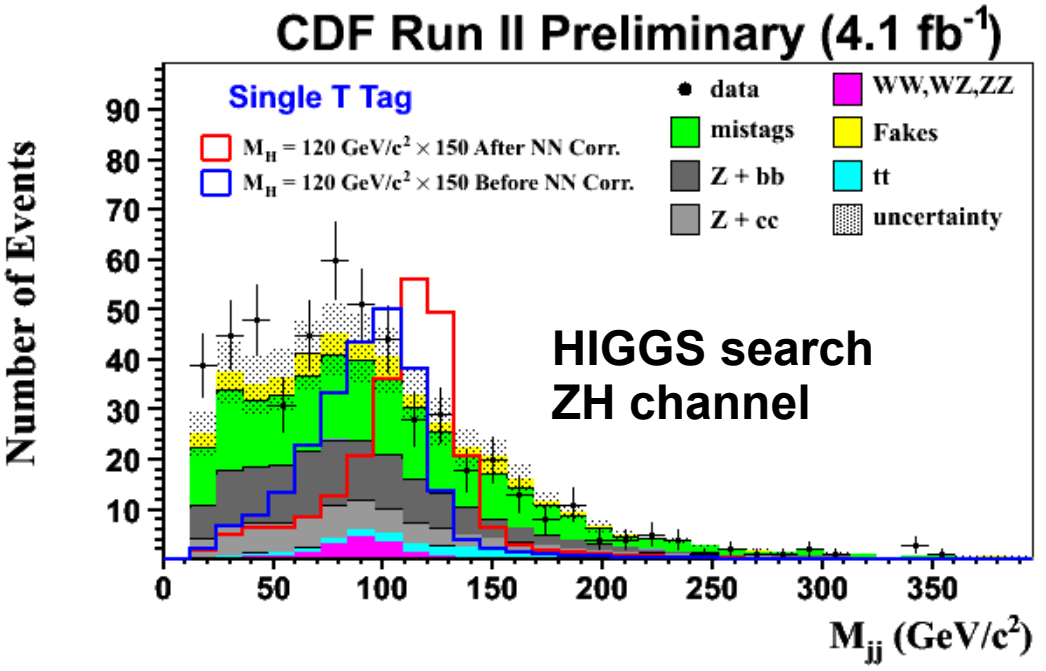
Paris

Motivation



- Test perturbative QCD at high Q^2
- Background for top measurements and new Physics searches
- 30% - 40% uncertainty in some of the processes (boson + HF)





Latest W/Z + jets results from CDF

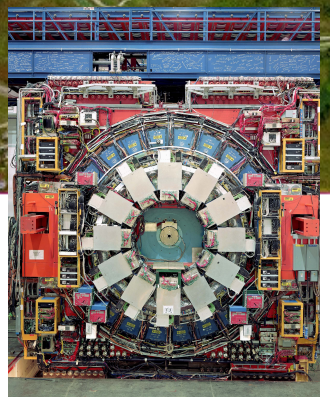
New results with 4 to 6 fb^{-1}

- $Z \rightarrow \mu^+\mu^-$ + jets production cross section
- W + charm production cross section
- Z + jet P_T-balance

Previous results

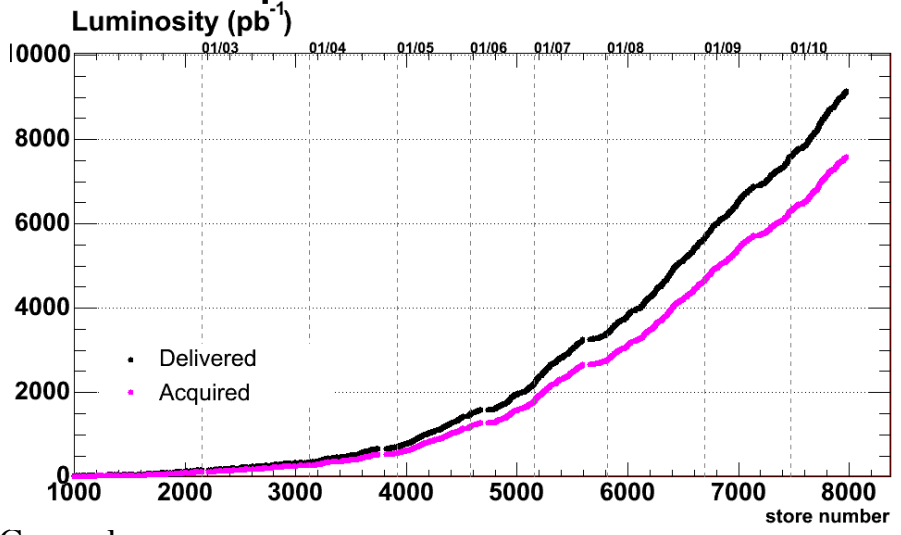
- $Z \rightarrow ee$ + jets — PRL 100, 102001 (2008)
- $W \rightarrow e\nu$ + jets — PRD 77, 011108(R) (2008)
- Z + b — PRD 79, 052008 (2009)
- W + b — PRL 104, 131801 (2010)

Tevatron and CDF



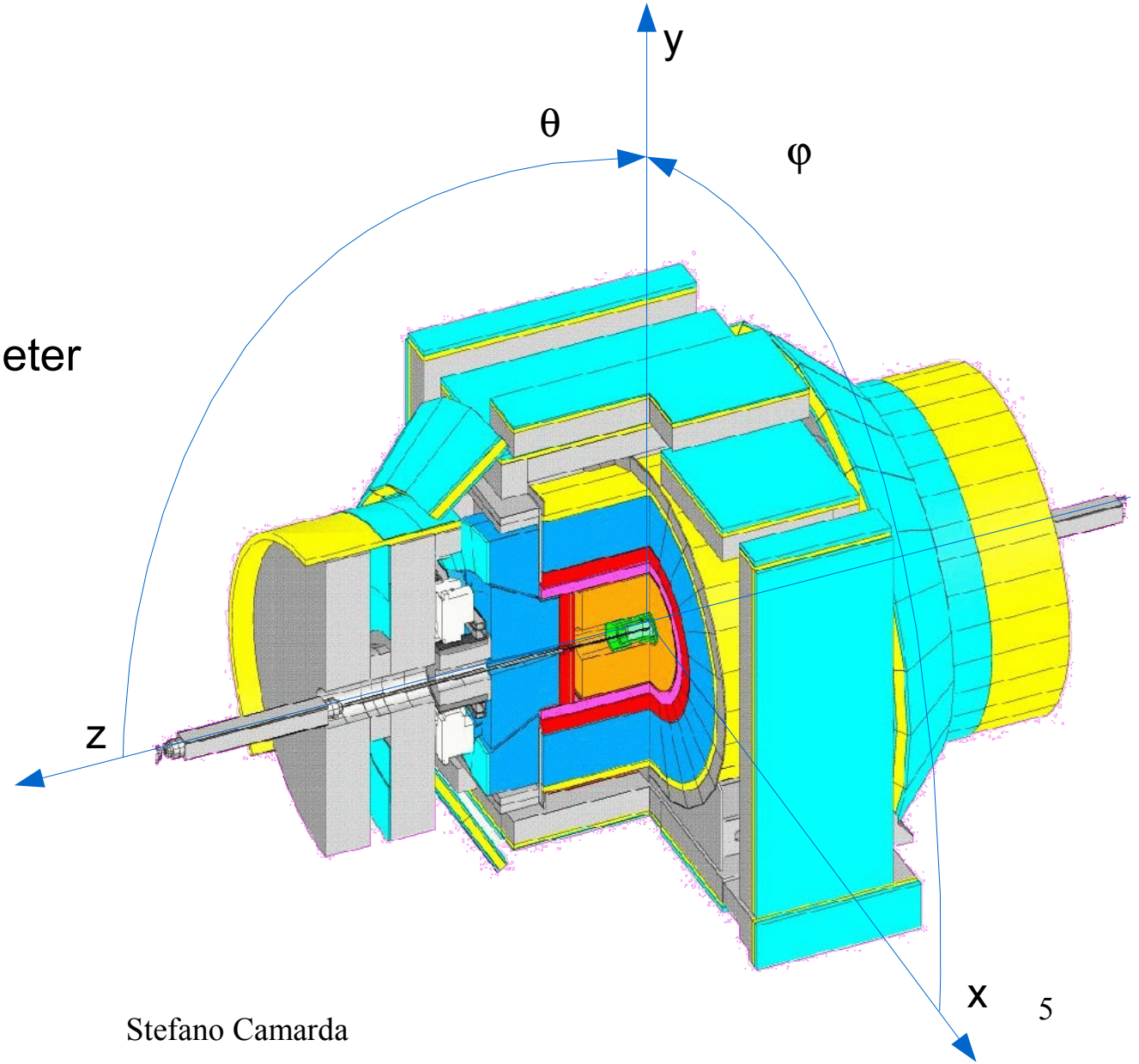
Collider
Detector at
Fermilab

- $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV
- Peak instantaneous luminosity ~ 4 x 10^{32} cm^{-2} s^{-1}
- 7.5 fb^{-1} of integrated luminosity on tape



CDF Detector

- Tracking system
  - Silicon detectors
  - Drift chambers COT
- 1.4 T Magnetic field
- Calorimeter
  - Electromagnetic calorimeter
  - Hadronic calorimeter
- Muon detectors
  - Wire chambers
  - Scintillators
- 3 Level Trigger System
  - Level 3 → ~ 100 Hz



$Z/\gamma^* \rightarrow \mu^+\mu^- +$ jets

Updated results with 6 fb^{-1}

Kinematic region

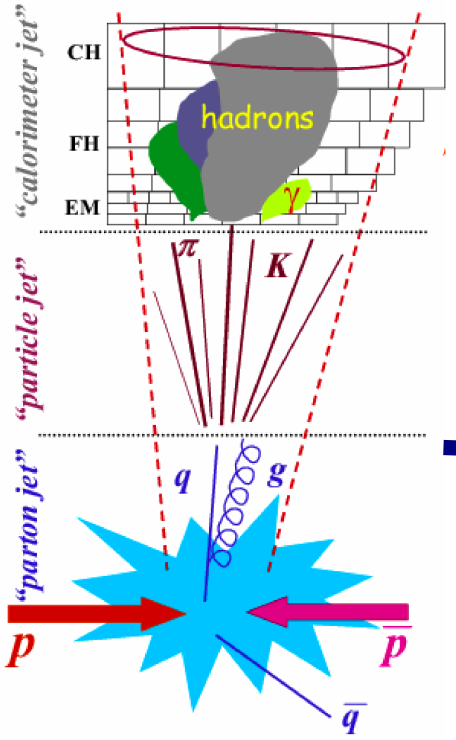
Muons

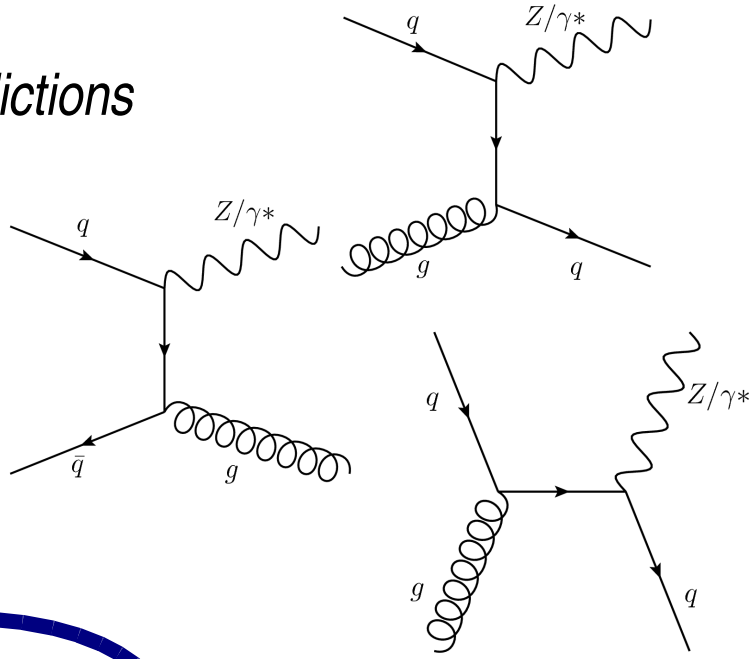
- $P_T > 25$ GeV/c
- $|\eta| < 1.0$
- $66 < M_{\mu\mu} < 116$ GeV/c^2

Jets Midpoint R = 0.7

- $P_T > 30$ GeV/c
- $|Y| < 2.1$

- *Important background for ZH → ll bb, SUSY MET + jets*
- *Test pQCD NLO predictions*





Measurements are unfolded back to Hadron level

Background estimation

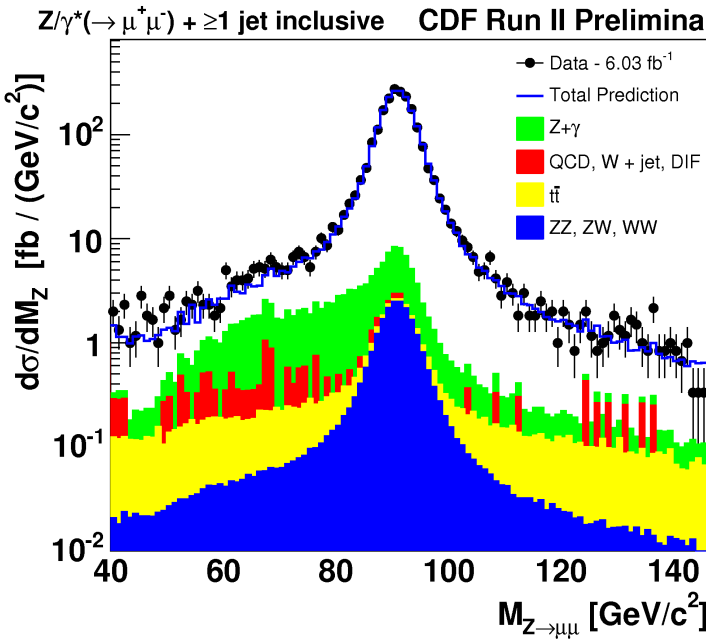
Data driven backgrounds

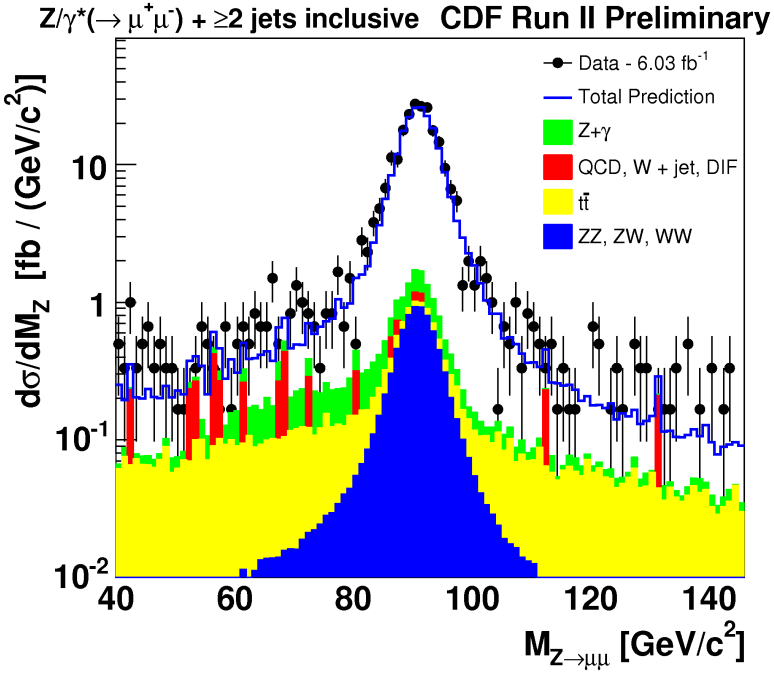
(Same Charge tracks)

- QCD dijet
- W + jet
- μ fakes

MC backgrounds

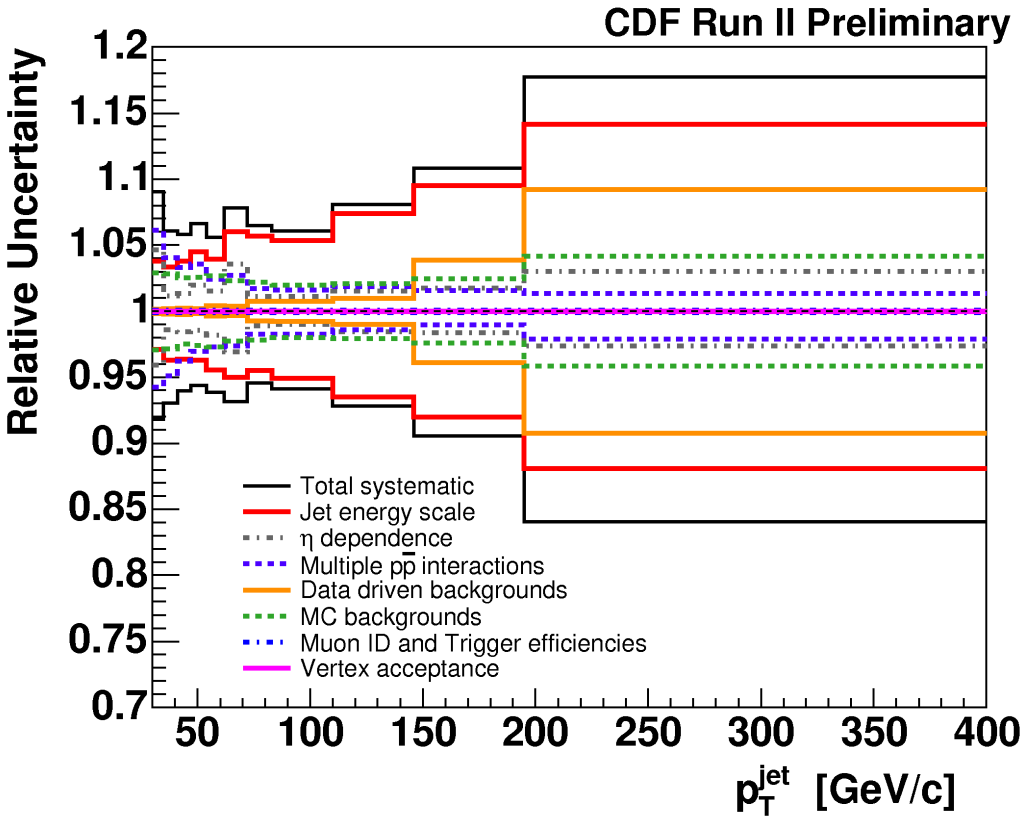
- Z + γ
- Top
- Diboson
- Z → ττ





- ~13000 Z + ≥1 jet data events in 6 fb-1
- Total backgrounds between 5%-10%
- Main background is Z+γ

Systematic uncertainties

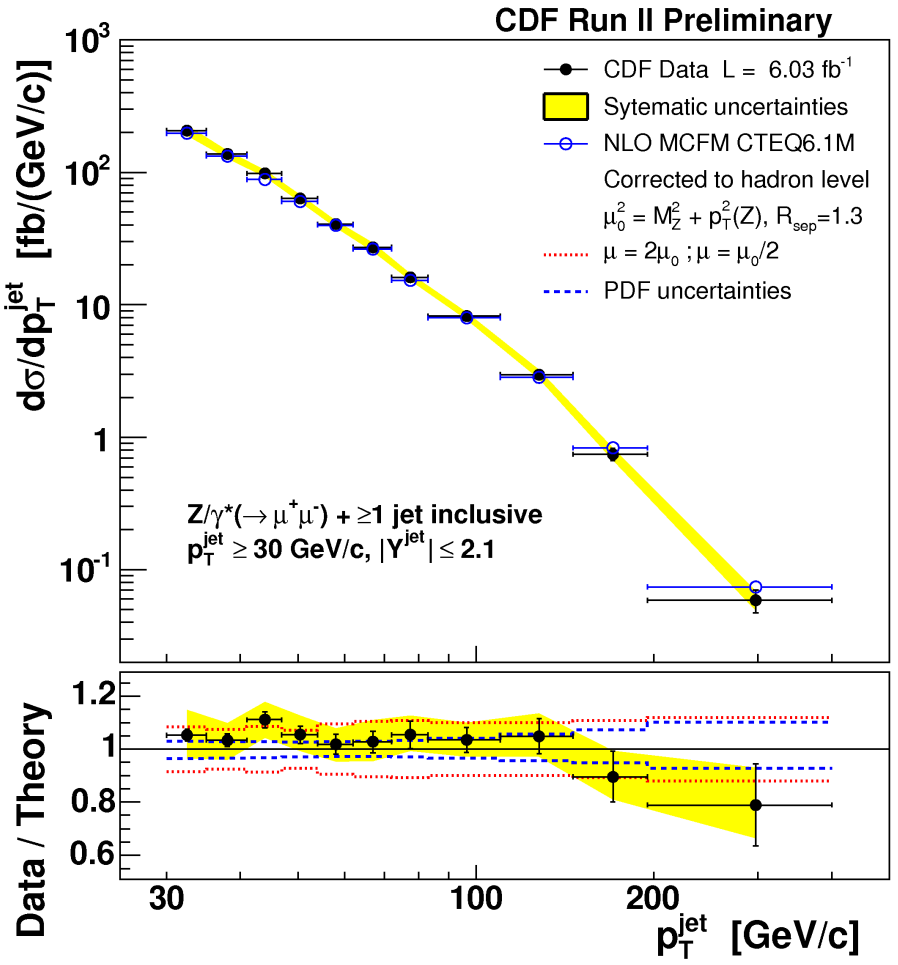


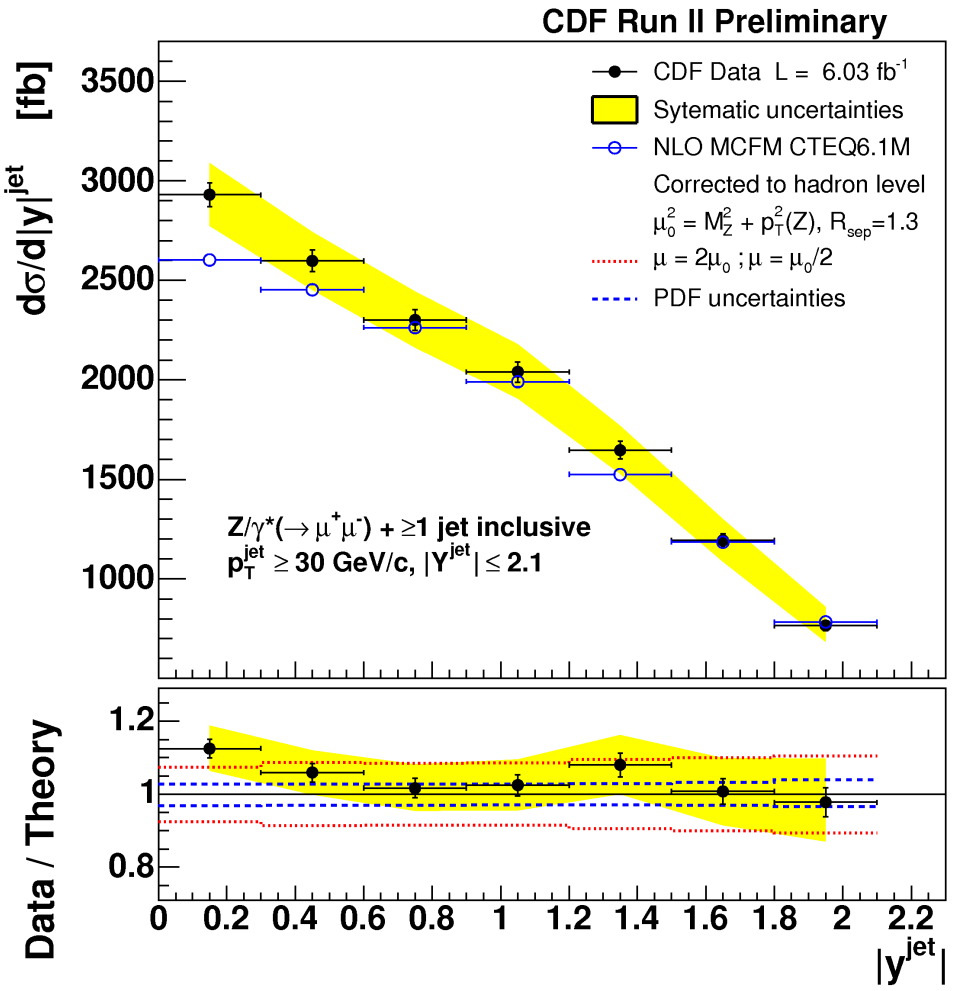
5% to 15% systematic uncertainties

Jet Energy Scale is the dominant

- Jet Energy Scale 3 – 15%
- Data driven backgrounds 1 – 8%
- Monte Carlo backgrounds 1 – 3%
- Trigger and Muon ID efficiencies < 1%
- Multiple pp interaction 1 – 6%
- Primary Vertex acceptance < 1%

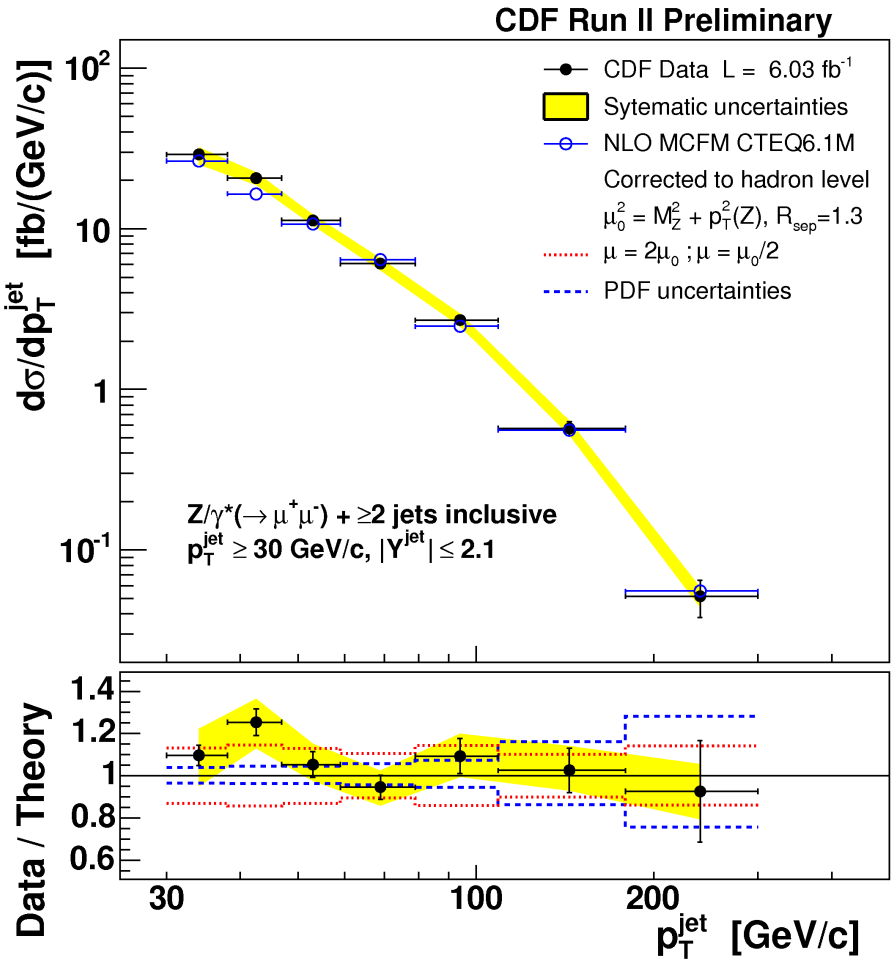
$Z/\gamma^* \rightarrow \mu^+\mu^- + \geq 1$ jet

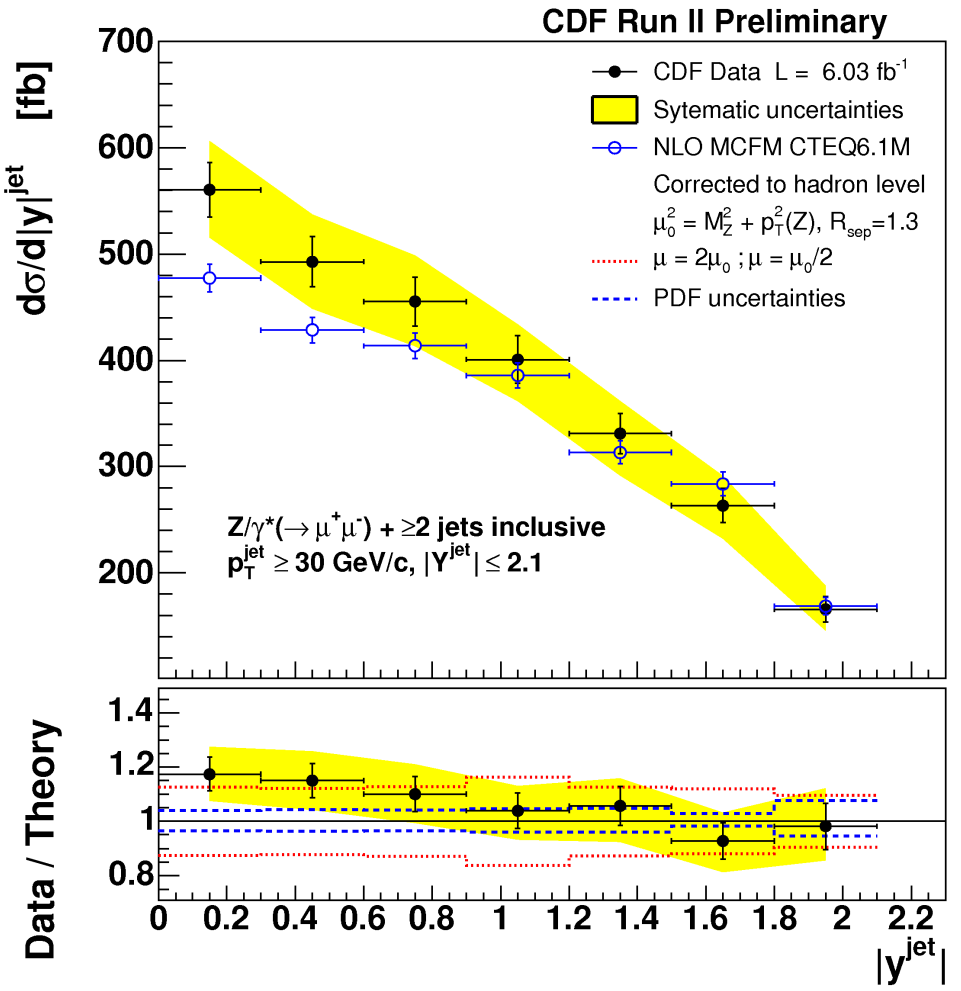




Good agreement with NLO prediction (MCFM) corrected for non-pQCD effects

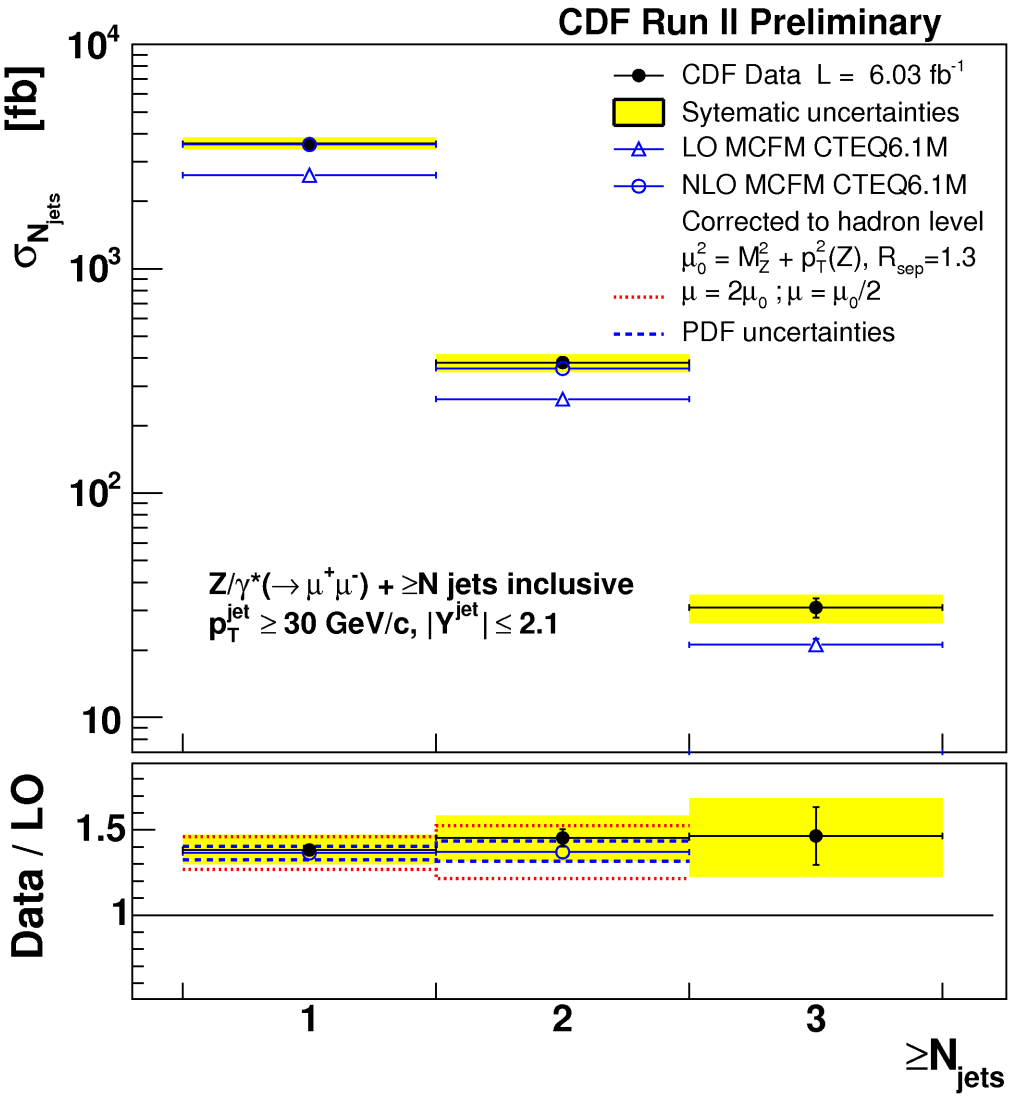
$Z/\gamma^* \rightarrow \mu^+\mu^- + \geq 2$ jet





Good agreement with NLO prediction (MCFM) corrected for non-pQCD effects

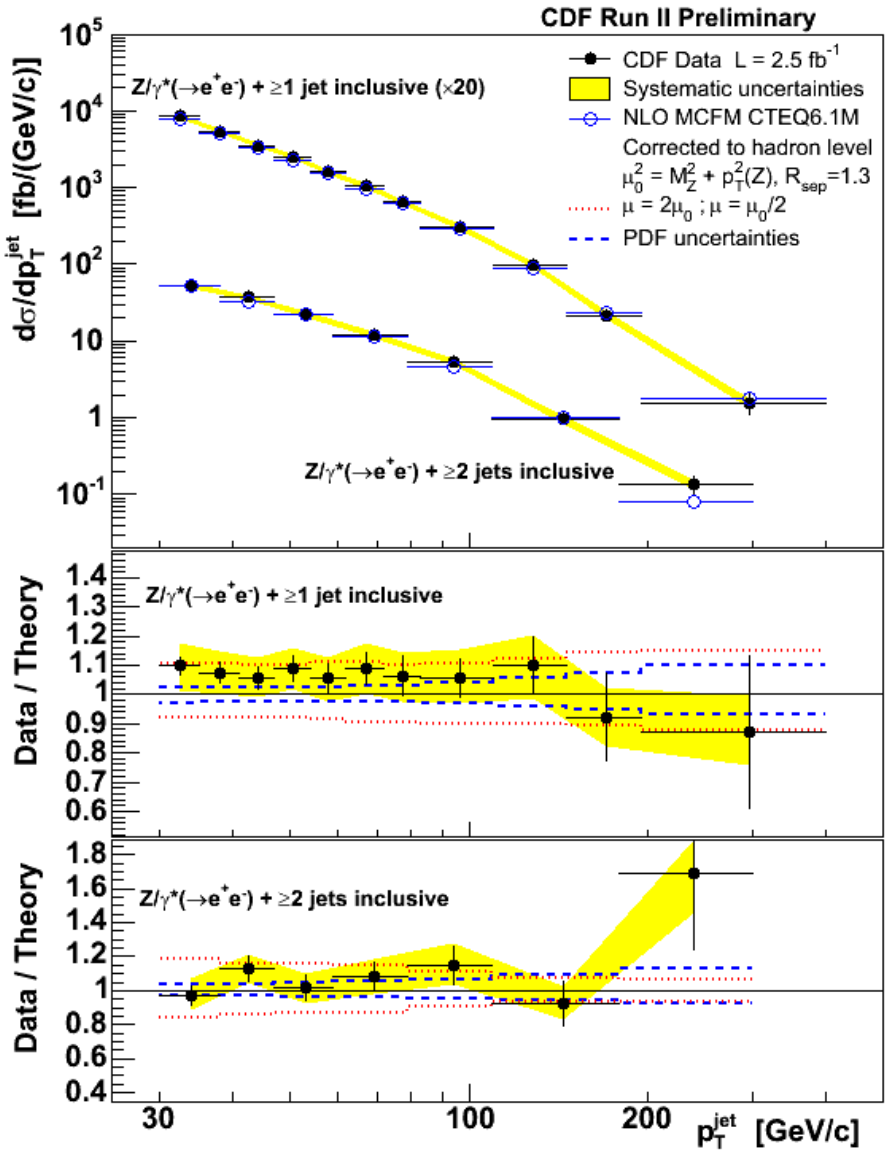
$Z/\gamma^* \rightarrow \mu^+\mu^- + \geq N$ jets



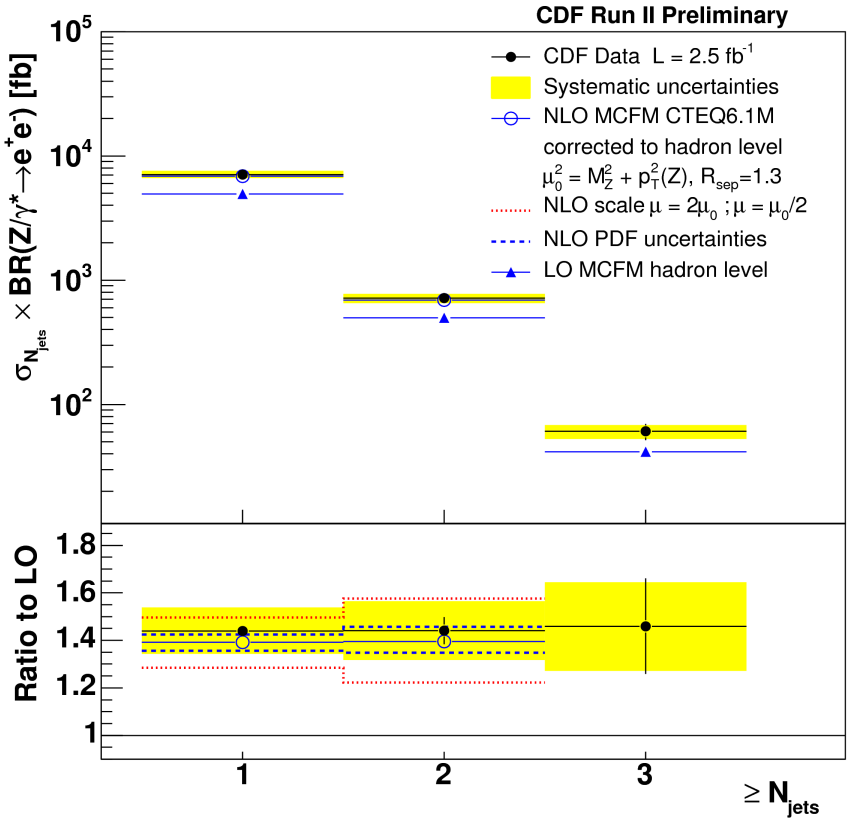
Good agreement between data and NLO prediction in ≥1 jet and ≥2 jets bins
Data suggest a ratio to LO of ~ 1.4

- ~130 events in ≥3 jets bin
- 10 events of Z+ ≥4 jets

$Z/\gamma^* \rightarrow e^+e^- +$ jets



- Measurement on the e^+e^- channel Published in PRL 100, 102001 (2008) with 1.7 fb^{-1}
- Updated measurement with 2.5 fb^{-1}

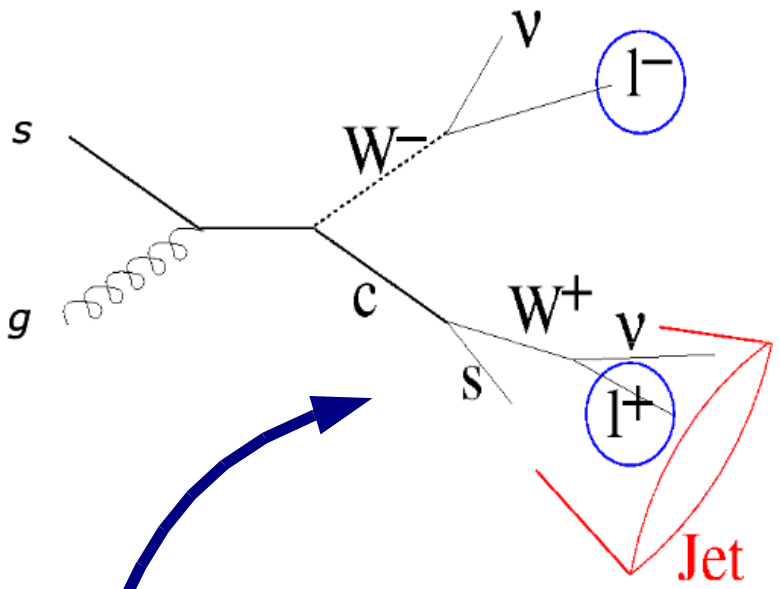


Plan to combine muons and electrons channels

W + single c Production

New results based on 4.3 fb^{-1}

- Probe s-content of proton at high Q^2
  g+s ~ 90% g+d ~ 10%
- Background for single-top, W + H

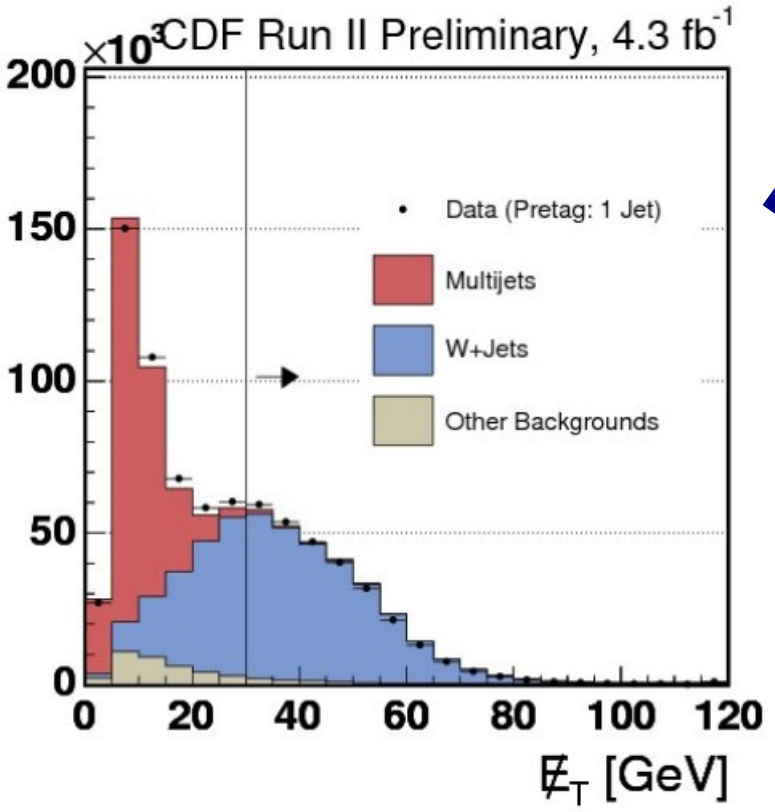


Event Selection

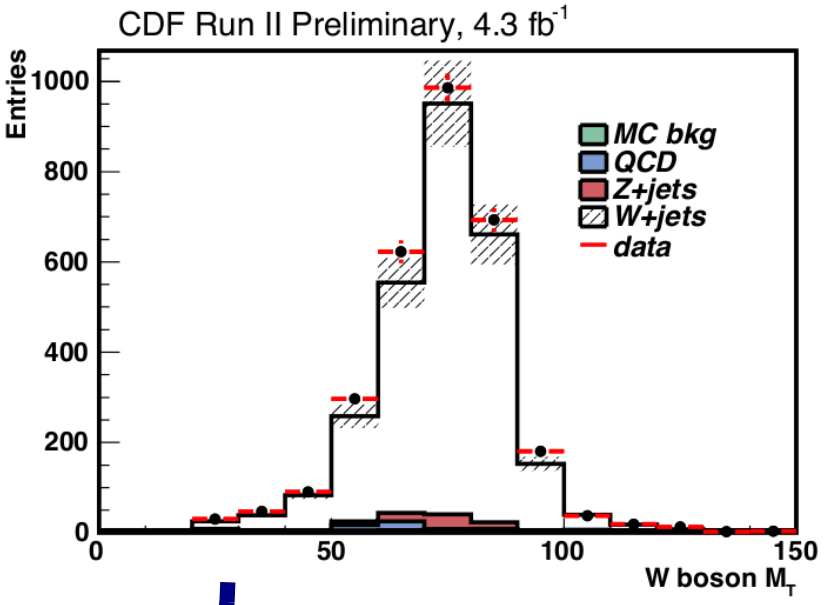
- W → lν selected by high p_T e,μ + MET
- JETCLU R = 0.4 jet with E_T > 20 GeV/c and |η| < 2.0
- Charm-jet identified by soft electron tagging (SLT_e) algorithm
- Exploit opposite charge correlation between W lepton and SLT electron

$$\sigma_{W+c} \times Br(W \to l\nu) = \frac{N_{data}^{OS-SS} - N_{bkg}^{OS-SS}}{\epsilon \cdot A \cdot L}$$

W + charm background



QCD background is estimated by a fit to the MET spectrum



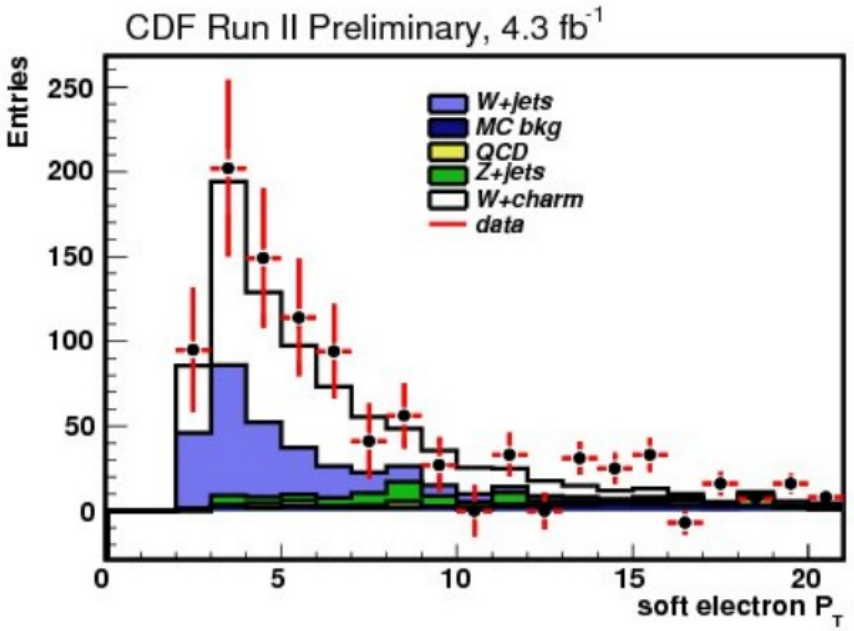
Background validation in OS+SS control region

Main backgrounds:

- Fake W (QCD)
- W + light jets
- Drell-Yan

W + charm result

Soft electron tagger validation



Main systematic uncertainties:

- Q^2 10%
- SLT tagging efficiency 8.8%
- Luminosity 8.3%
- PDF 8%
- ISR/FSR 7%
- Jet Energy Scale 6%

Charm p_T > 20 GeV/c and $|\eta|$ < 1.5

$$\sigma_{W+c} \times Br(W \to l\,\nu) = 21.1 \pm 7.1(stat) \pm 4.6(syst)\ pb$$

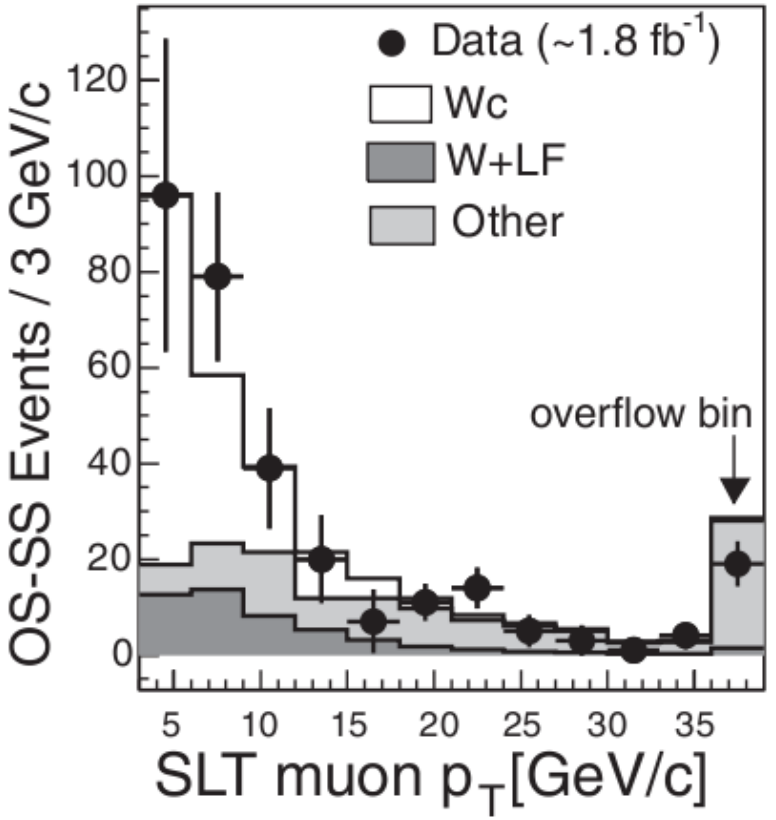
$$NLO\ prediction\ (MCFM): 11.0^{+1.4}_{-3.0}\ pb$$

Data and NLO in reasonable agreement

W + charm – μ channel

Previous result with 1.8 fb^{-1} in the charm → μ channel

Soft muon tagger validation



Charm p_T > 20 GeV/c and $|\eta|$ < 1.5

$$\sigma_{W+c} \times Br(W \to l\,\nu) = 9.8 \pm 2.8(stat)^{+1.4}_{-1.6}(syst) \pm 0.6(lum)\ pb$$

$$NLO\ prediction\ (MCFM): 11.0^{+1.4}_{-3.0}\ pb$$

W + b-jets

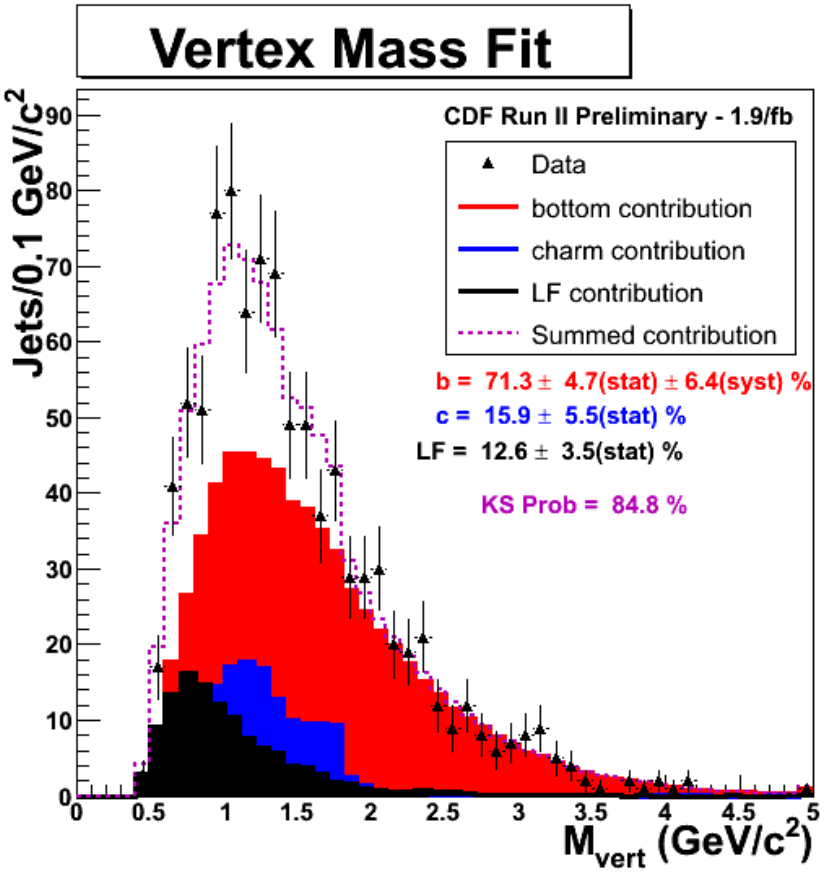
Both e and μ channel

- P_T > 20 GeV/c
- |η| < 1.1
- MET > 25 GeV

One or two jets (JETCLU R=0.4)

- E_T > 20 GeV
- |η| < 2.0

Result with 1.9 fb^{-1}



b-quark composition extracted from fit to secondary vertex mass

$$\sigma_{W+b} \times Br(W \to l\nu) = 2.74 \pm 0.27 \pm 0.42\ pb$$

$$ALPGENv2 + PYTHIA\,6.3 = 0.78\ pb$$

$$NLO\ pQCD = 1.22 \pm 0.14\ pb$$

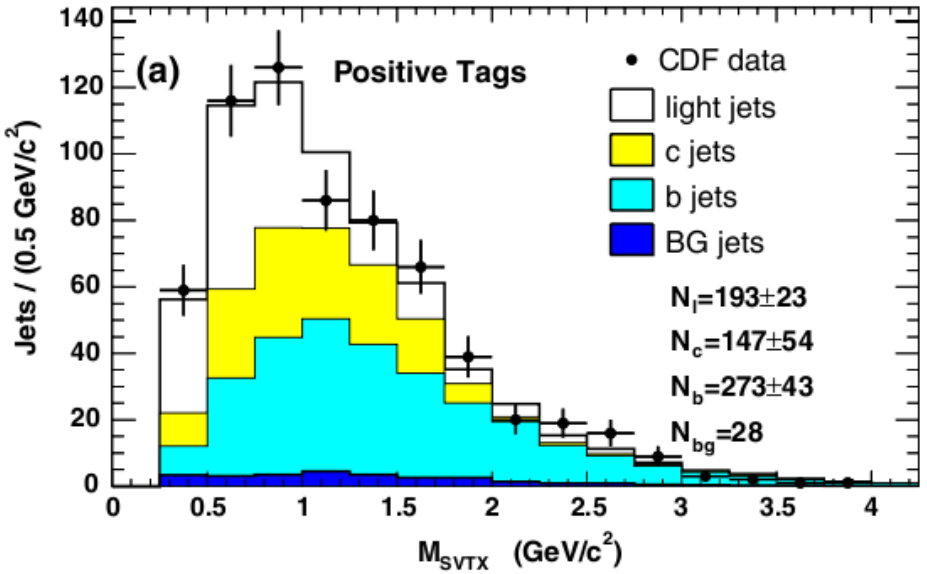
Measured Xs is higher than NLO prediction

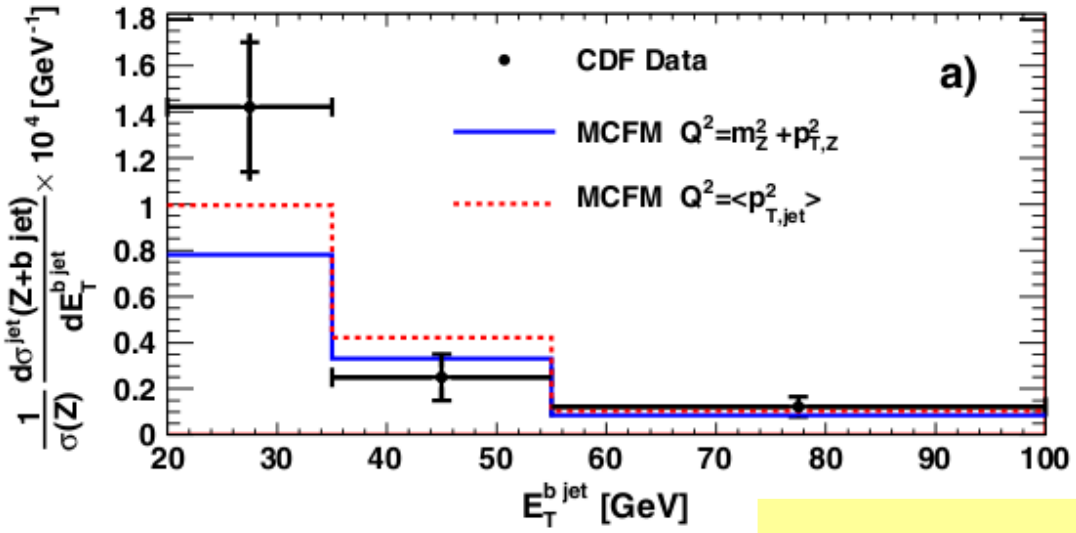
Z + b-jets

Result with 2 fb^{-1}

Both e and μ channel, jets with E_T > 20 GeV and $|\eta|$ < 1.5 (JETCLU R = 0.7)

b-quark composition extracted from fit to secondary vertex mass





$$\frac{\sigma_{Z+b-jet}}{\sigma_Z} = 3.32 \pm 0.53 \pm 0.42 \times 10^{-3}$$

MCFM: $2.3 \times 10^{-3} \left(Q^2 = M_Z^2 + P_{T,Z}^2\right)$

$2.8 \times 10^{-3} \left(Q^2 = <P_{T,Jet}^2>\right)$

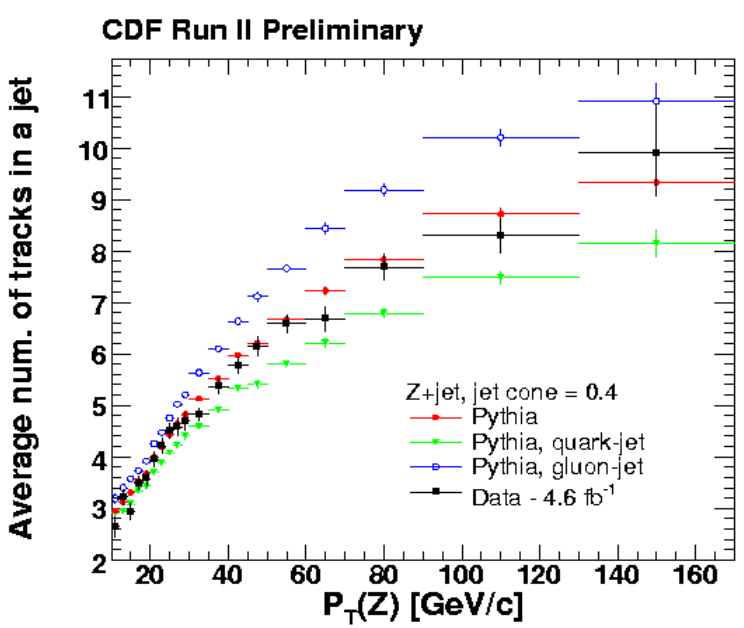
Measurement in agreement with NLO prediction (large uncertainties in both data and theory)

Z+jet P_T balance

Large Z + jets sample, can be used for jets studies

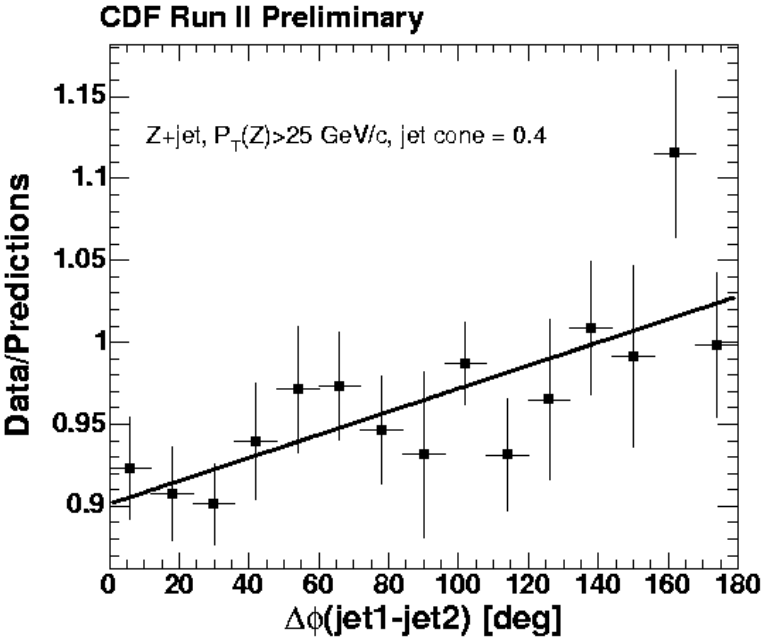
New study based on 4.6 fb^{-1}

- Reduce uncertainties on measured energy of hadronic jets
- Test QCD jet modeling
- Check quark-gluon composition



P_T-balance definition

$\langle P_T(jet1)/P_T(Z) \rangle$



Out-of-cone radiation

Mismodeling of large angle FSR in the MC is limiting the uncertainty in hadronic jets energy

Summary

- New results on Z + jets in good agreement with NLO predictions
- W + single charm in reasonable agreement
- Z + jet P_T balance open new possibilities to improve jet energy measurement

  → Z + jets prospects for 6 fb^{-1} e/μ channels combination
  → Z/W + HF need more data and better predictions