Z+jets Results from CDF

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On behalf of CDF collaboration

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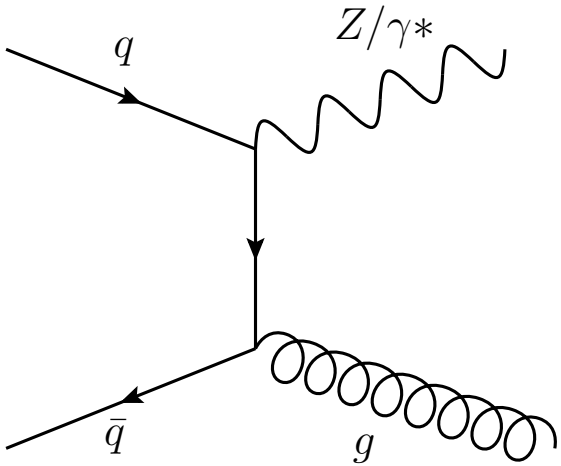
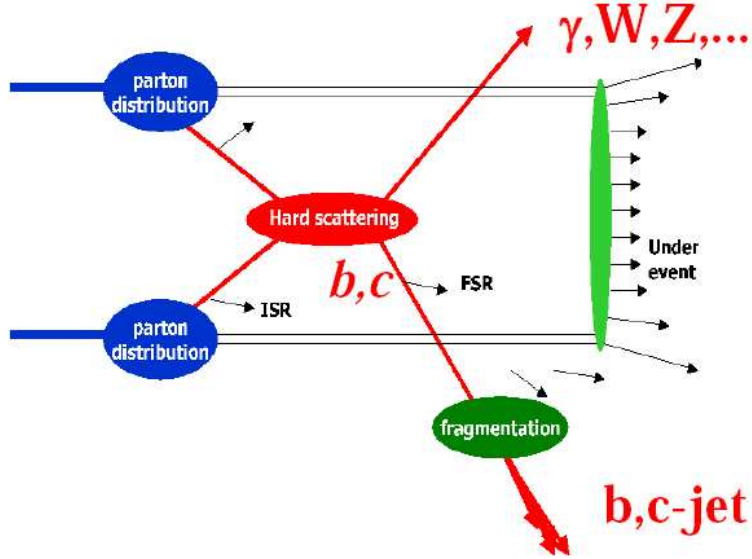




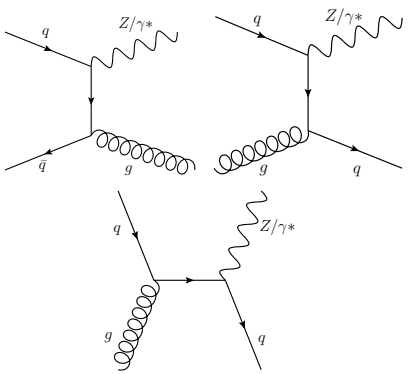
Z+jet cross section measurement

Differential cross section measurements as function of p_T^{jet} , Y^{jet} and N^{jet}

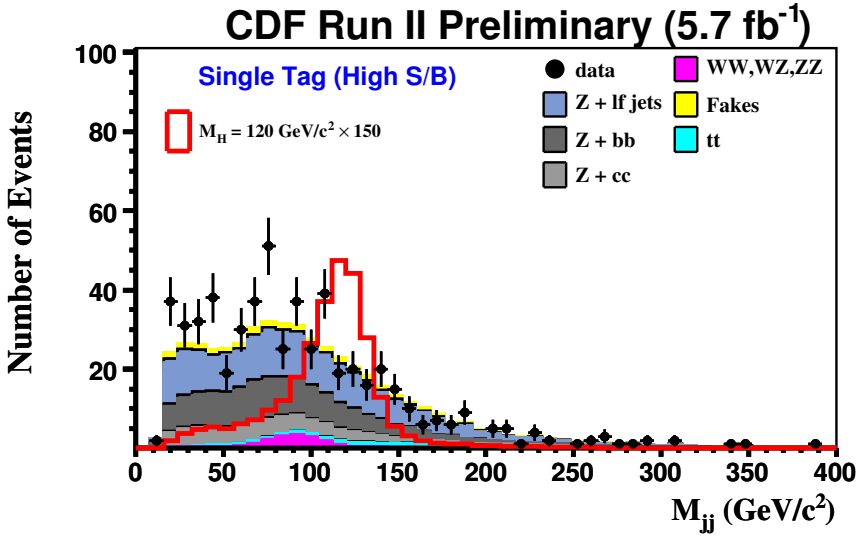
$Z + b-$ jet cross section measurement

Jets cross section ratio measurements with respect to Z inclusive and Z+jets cross section

Motivation

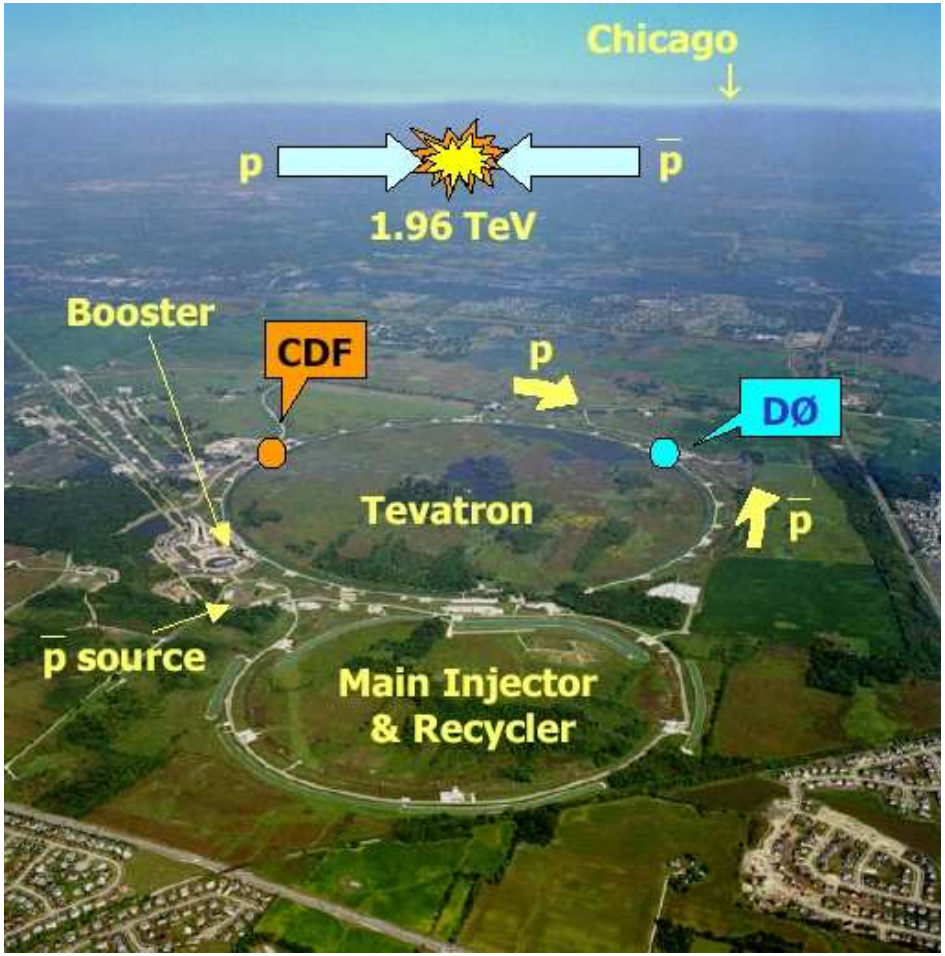


- Test of pQCD prediction
- Background to many searches for new physics
- test/tune difference MC models
- Large theoretical uncertainties

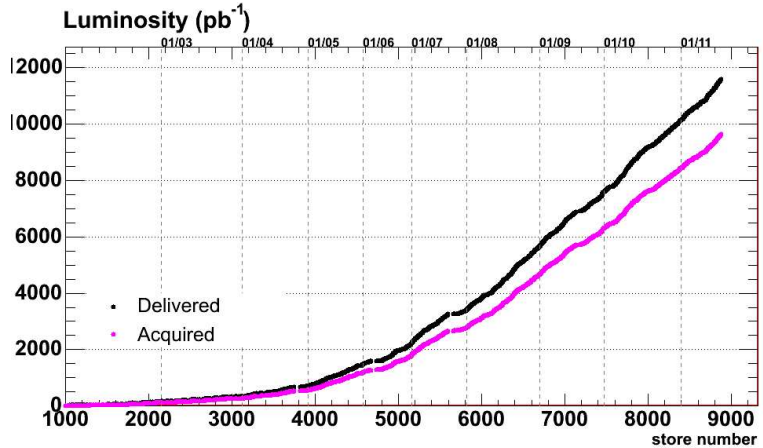


Dedicated measurements on Z+jets crucial

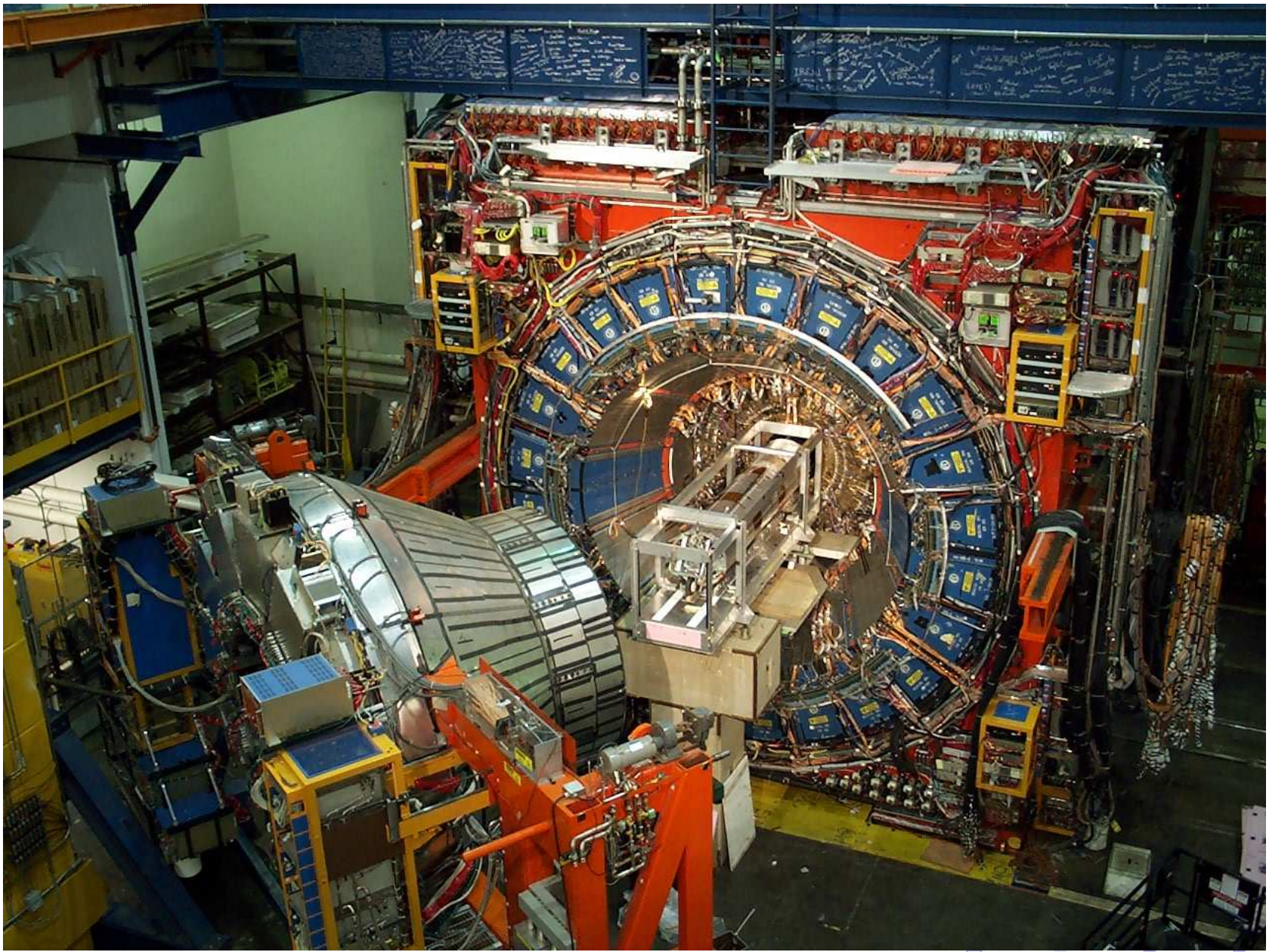
TeVatron

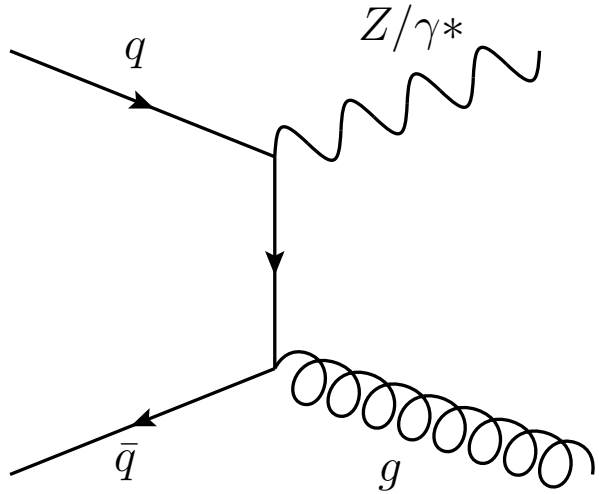


- p $\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV
- peak of instantaneous luminosity $\sim 4 \cdot 10^{32}\ cm^{-2}s^{-1}$
- $\geq$ 10 fb^{-1} of delivered luminosity



Collider Detector at Fermilab



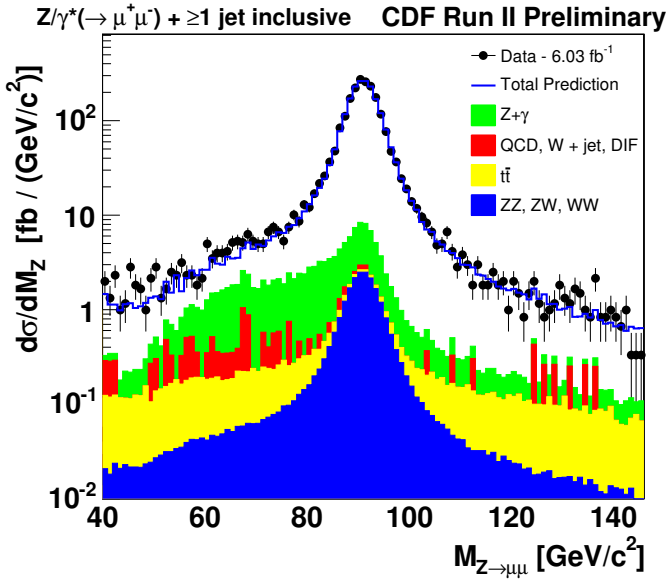


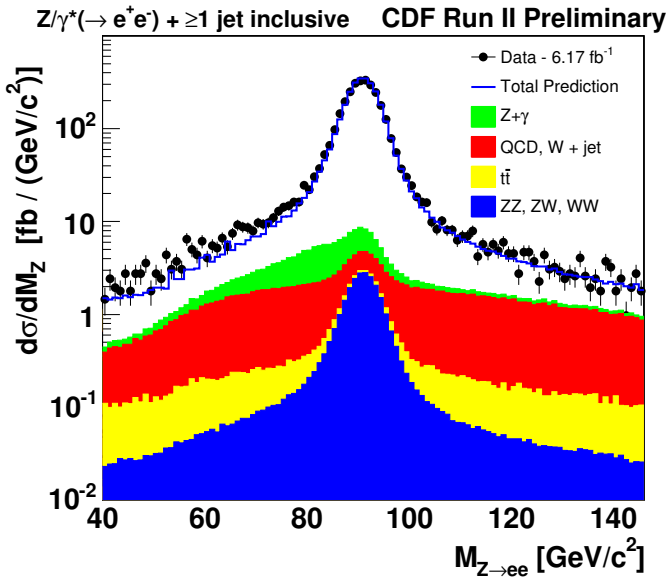
Z+ jets cross section measurement

Z + jets Measurement definition

- Leptons
  - Electrons
    - $E_T^l \geqslant 25\ GeV/c$
    - $|\eta^l| \leqslant 1.0$
    - $1.2 \leqslant |\eta_2^e| \leqslant 2.8$
  - Muons
    - $p_T^l \geqslant 25\ GeV/c$
    - $|\eta^l| \leqslant 1.0$
- Z Boson
  - $66 \leqslant M_Z \leqslant 116\ GeV/c^2$
- Jets
  - Midpoint algorithm
  - $\Delta R_{cone} = 0.7$
  - $p_T^{jet} \geqslant 30\ GeV/c$
  - $|Y^{jet}| \leqslant 2.1$

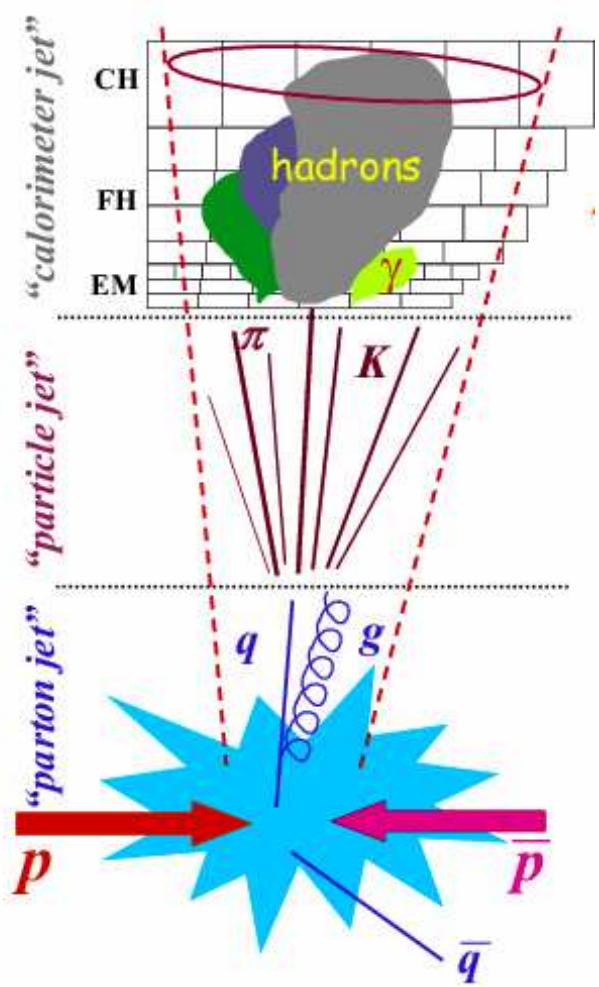
Bkg calculated with MC and data driven technique ($\leq 10\%$)





Unfolding

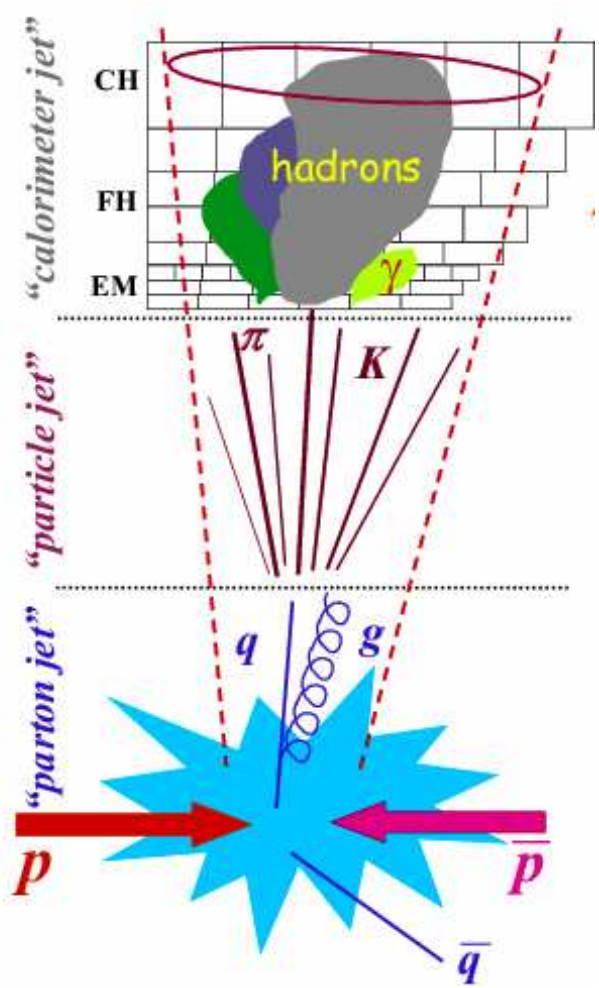
- Calorimeter jets are unfolded back to hadron level jets
- Account for resolution effects
- Account for detector acceptance of $Z \rightarrow l^+l^-$ reconstruction
- Bin by bin unfolding for each distribution
- Alpgen + Pythia MC



$$U = \frac{(Hadron\ level\ jets - Kinematic\ Z \rightarrow l^+l^-)}{(Calorimeter\ jets - Reconstructed\ Z \rightarrow l^+l^-)}$$

NLO prediction

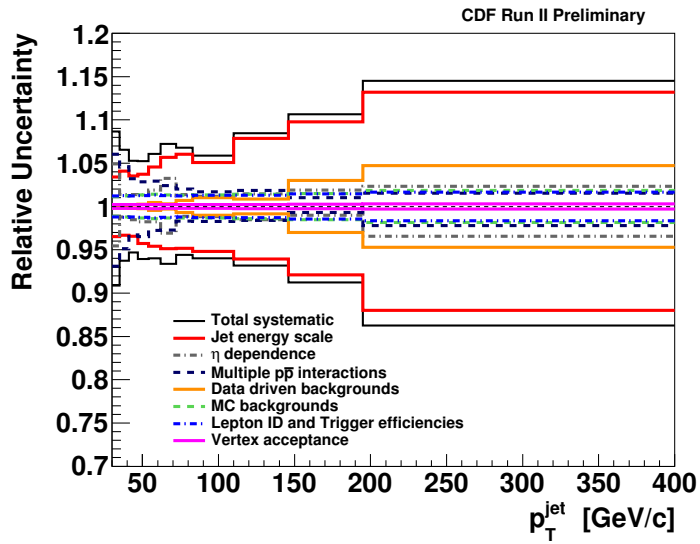
- NLO pQCD prediction
  MCFM J.Campbell, R.K.Ellis: Phys.Rev.D 65:113007(2002)
- PDF set CTEQ6.1M
- Renormalization and factorization scale
  $\mu_0 = \sqrt{M_Z^2 + P_T^2(Z)}$
- Parton level cross sections are corrected to hadron level for non-pQCD contributions $\rightarrow$ Underlying Event and fragmentation



$$C_{Had} = \frac{(\textbf{Hadron } \textit{level jets } \textbf{with } \textit{Underlying Event})}{(\textbf{Parton } \textit{level jets } \textbf{without } \textit{Underlying Event})}$$

Systematic uncertainties

- Jet Energy Scale $3 - 15\%$
- Data driven backgrounds $1 - 5\%$
- Monte Carlo backgrounds $1 - 3\%$
- Trigger and Lepton ID efficiencies 2%
- Vertex acceptance $< 0.1\%$

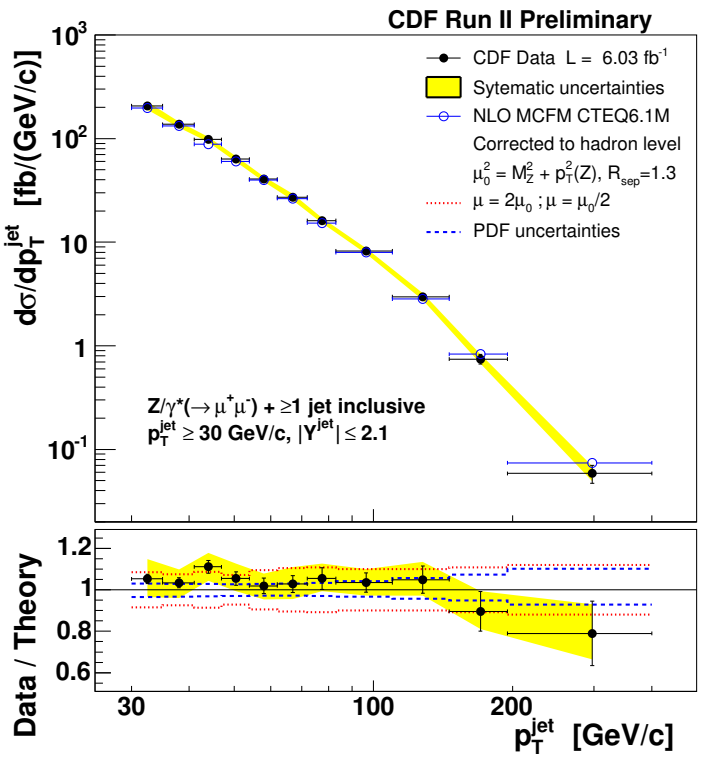


Uncertainties on the theoretical prediction

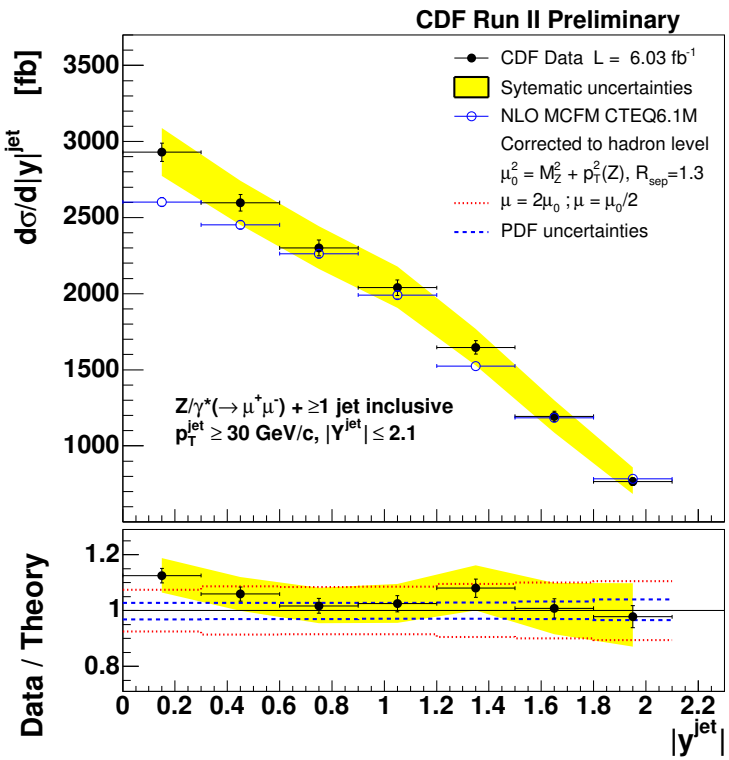
- PDF (Hessian method)
- Dependence on μ_0 scale

$Z_{\mu\mu}$ + jets Results with 6 fb^{-1}

Inclusive jet p_T

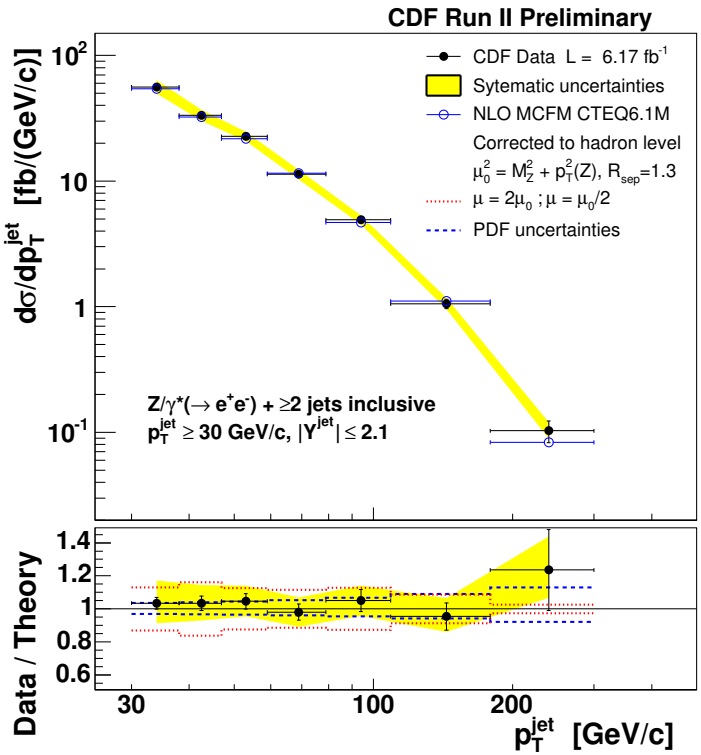


Inclusive jet Rapidity

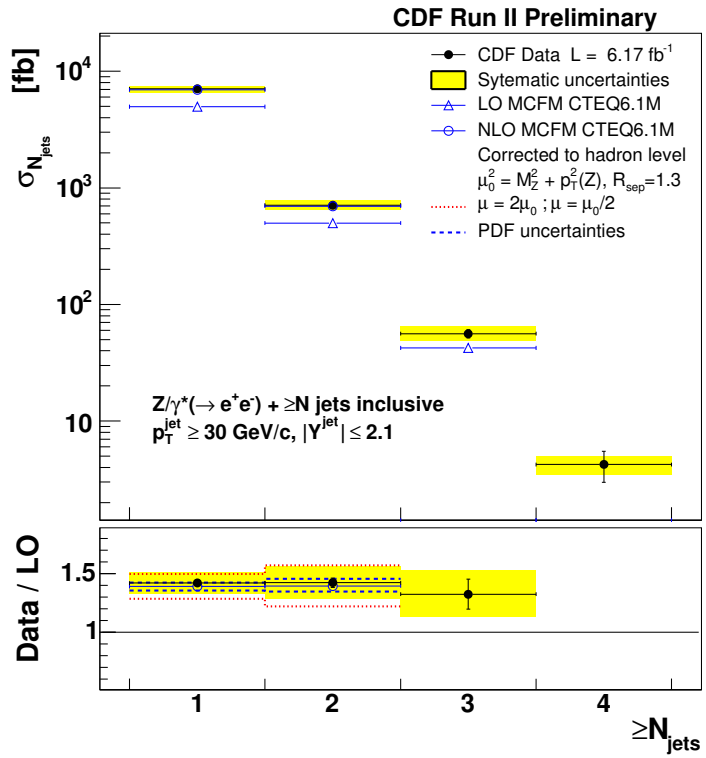


Z_{ee} + jets Results with 6 fb^{-1}

Inclusive jet p_T

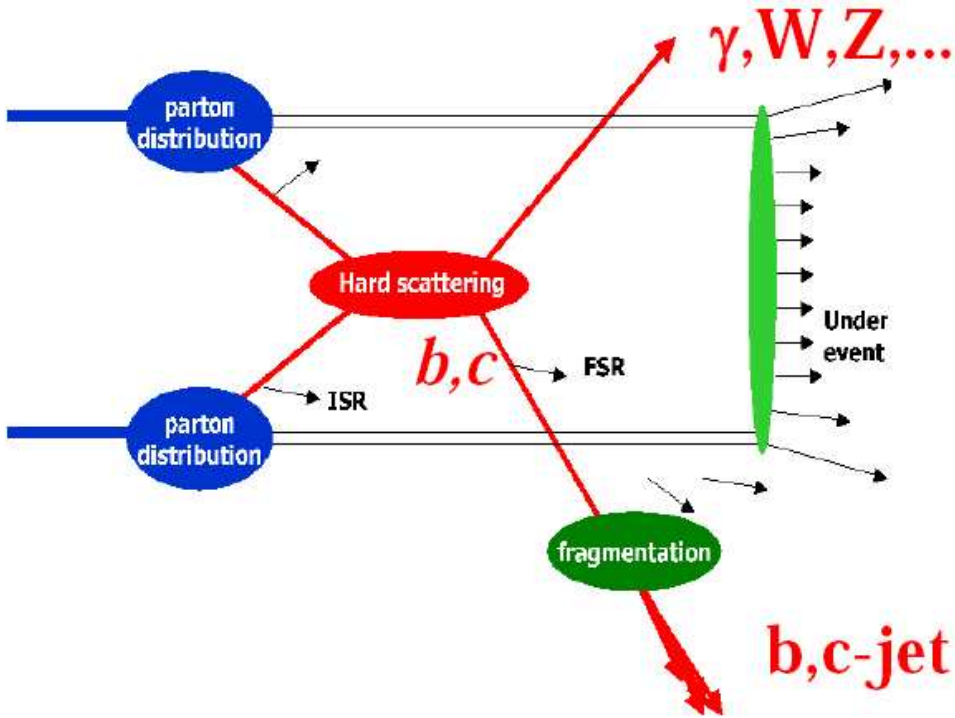


Inclusive jet Multiplicity



Working on electron and muon channels combination

First measurement in the 4 jet bin at CDF

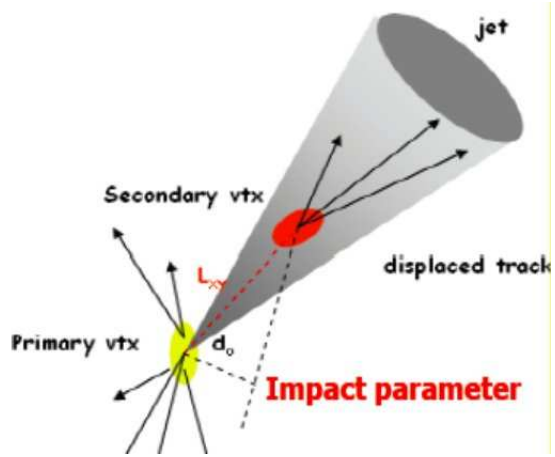


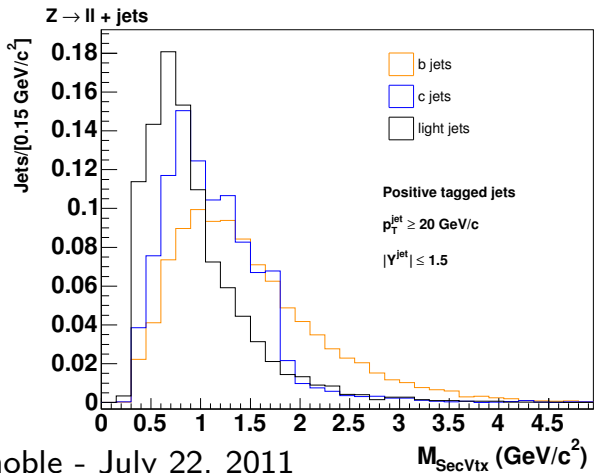
$Z + b-$ jets cross section measurement

Z + b-jets Measurement definition

- Measure $\frac{\sigma(Z+\mathrm{b})}{\sigma(Z)}$ and $\frac{\sigma(Z+\mathrm{b})}{\sigma(Z+\mathrm{jet})}$ to reduce systematic uncertainties
- $Z \rightarrow l^+l^-$, where l could be muon or electron
- Improve muon identification efficiency with ANN $\Rightarrow$ 30 % gain in Z acceptance

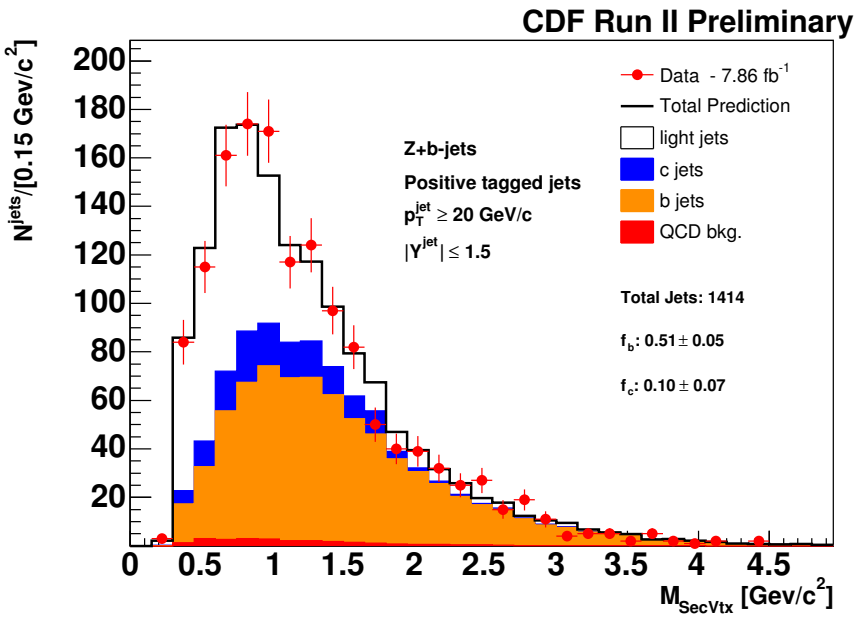
- jets
  - Midpoint algorithm
  - $\Delta R_{cone} = 0.7$
  - $p_T^{jet} \geqslant 20\ GeV/c$
  - $|Y^{jet}| \leqslant 1.5$





- b identification
  - Secondary Vertex Tagger
  - Extract b-jet composition from a fit to Secondary Vertex Mass

Z + b-jets Results with 8 fb^{-1}



Main Systematic uncertainty due to vertex mass template modeling ($\sim 9\%$).
Other systematics coming from b tag efficiency, JES and backgrounds.

	Measured	NLO $Q^2 = m_Z^2 + p_{T,Z}^2$	NLO $Q^2 =< p_{T,jet}^2 >$
$\frac{\sigma(Z+\mathrm{b})}{\sigma(Z)}$	$2.84 \pm 0.29 \pm 0.29 \times 10^{-3}$	2.3×10^{-3}	2.8×10^{-3}
$\frac{\sigma(Z+\mathrm{b})}{\sigma(Z+\mathrm{jet})}$	$2.24 \pm 0.24 \pm 0.26 \times 10^{-2}$	1.8×10^{-2}	2.2×10^{-2}

Conclusions

Z+jets differential cross sections measured with 6 fb^{-1} of data in electron and muon channel.

- measurements found in agreement with NLO prediction
- working on electron/muon combination and distributions in the 3 jet multiplicity

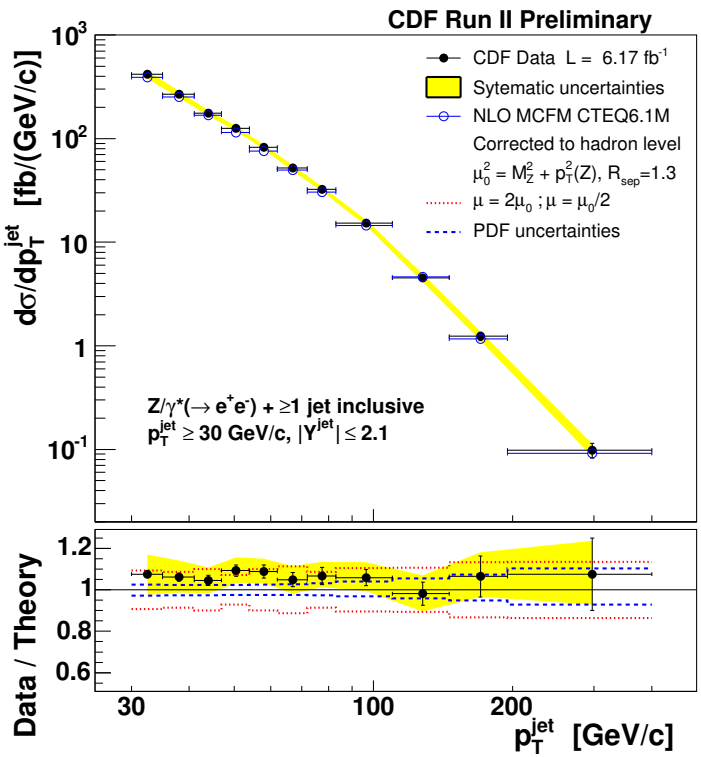
Z+b-jet cross section measurement was performed respect to inclusive Z cross section and Z+jet cross sections with 8 fb^{-1}:

- measurements in agreement with NLO prediction
- reduced the uncertainty from previous measurements to $\sim 15\%$

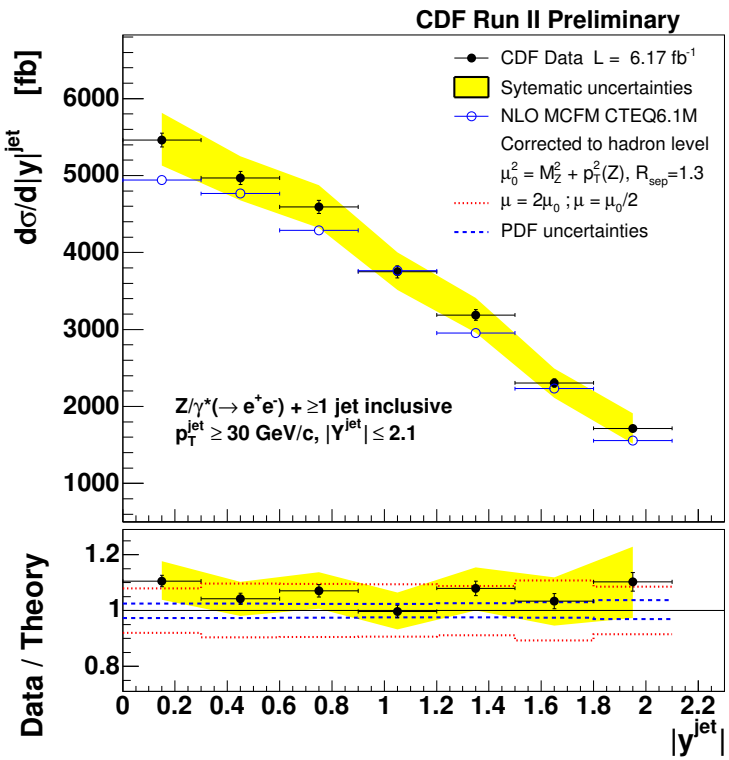
Back up

Z+jets results

Inclusive jet p_T

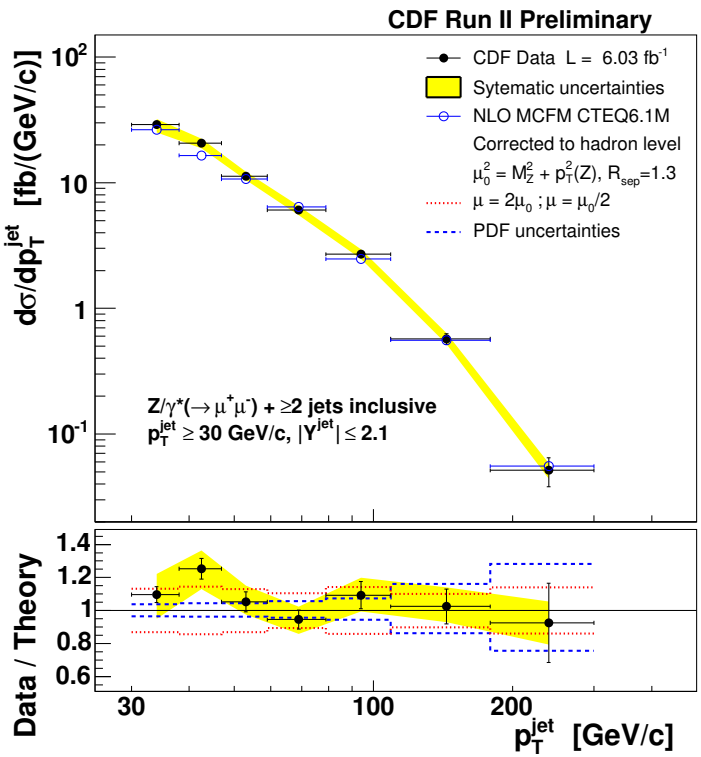


Inclusive jet Rapidity

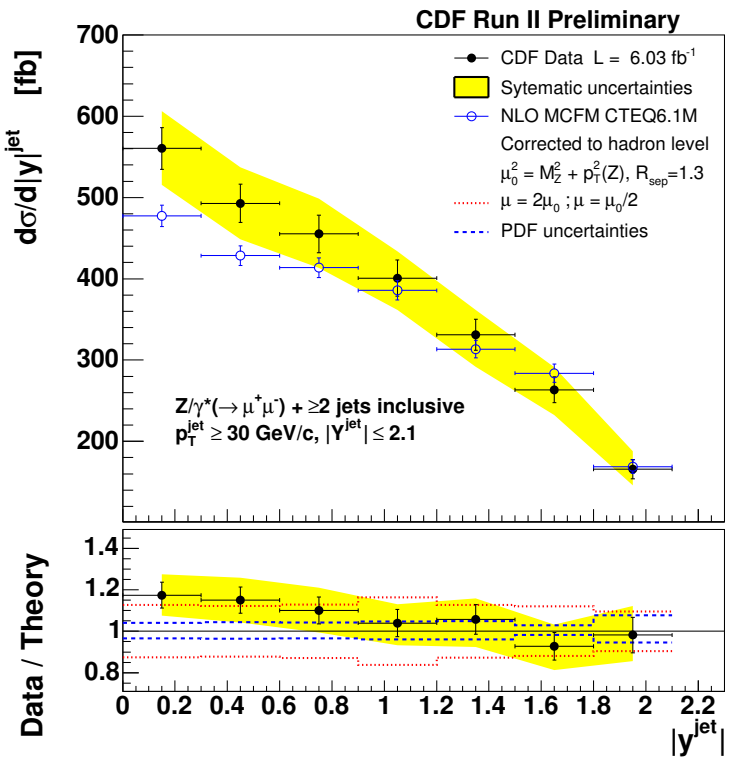


Z+jets results

Inclusive jet p_T

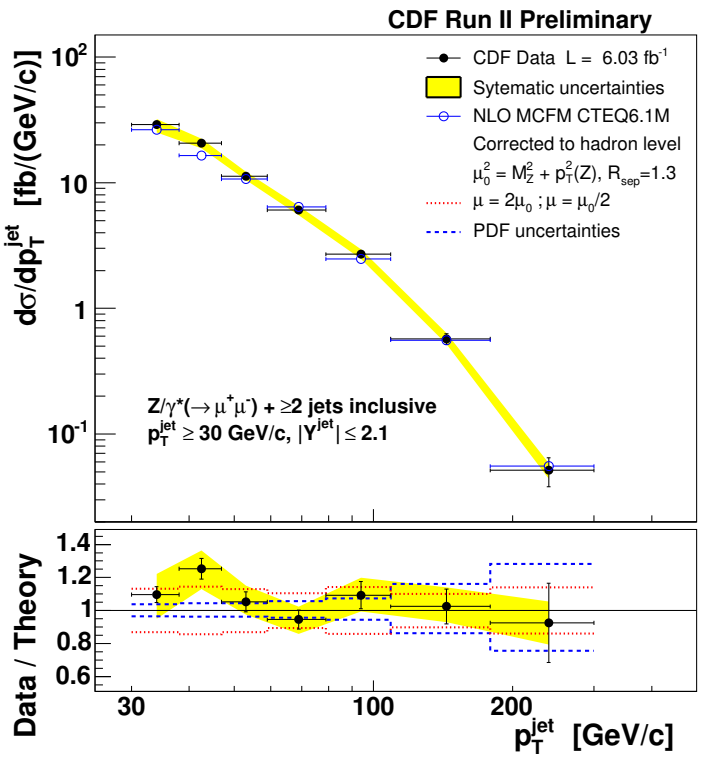


Inclusive jet Rapidity



Z+jets results

Inclusive jet p_T



Inclusive jet Multiplicity

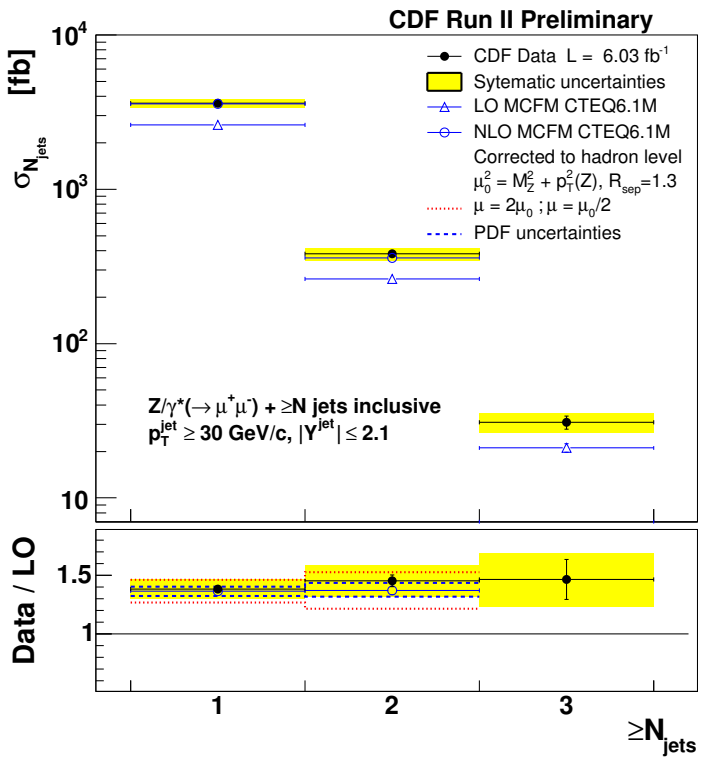


Table of Systematics for Z+b-jet cross section

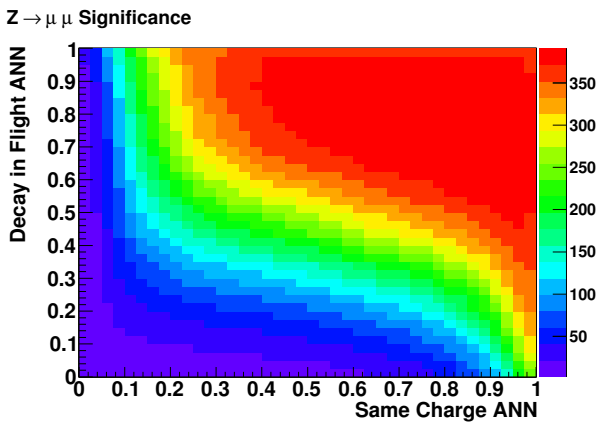
Systematic	$\frac{\sigma(Z+\mathrm{b})}{\sigma(Z)}$
JES	1.7%
b-tag $\epsilon\epsilon$	5.2%
Template modeling	8.8%
Backgrounds	0.8%

Muon Identification with ANN

3 Data driven samples

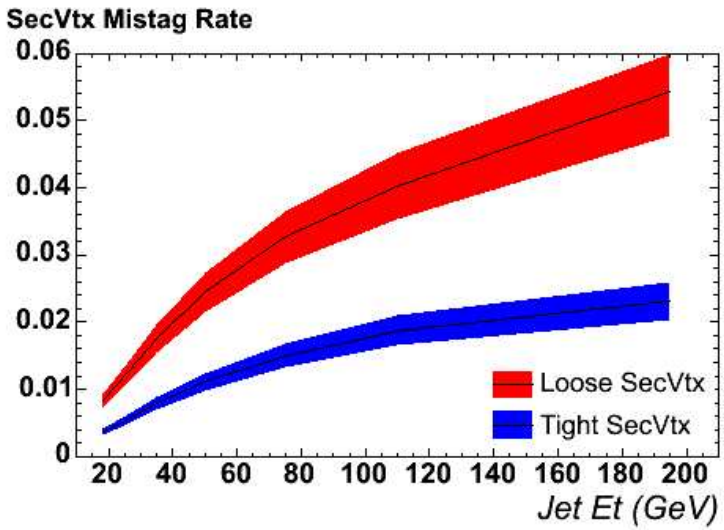
- **Real Muons**
  Tight selection muons from $Z \rightarrow \mu\mu$
- Backgrounds
  - from W+jet samples
  - from Same Charge muon pairs

- ANN Selection optimized the significance on inclusive $Z \rightarrow \mu^+\mu^-$ signal
- Muon ID efficiency is $\sim 97\%$ and gain 30 % in Z acceptance.

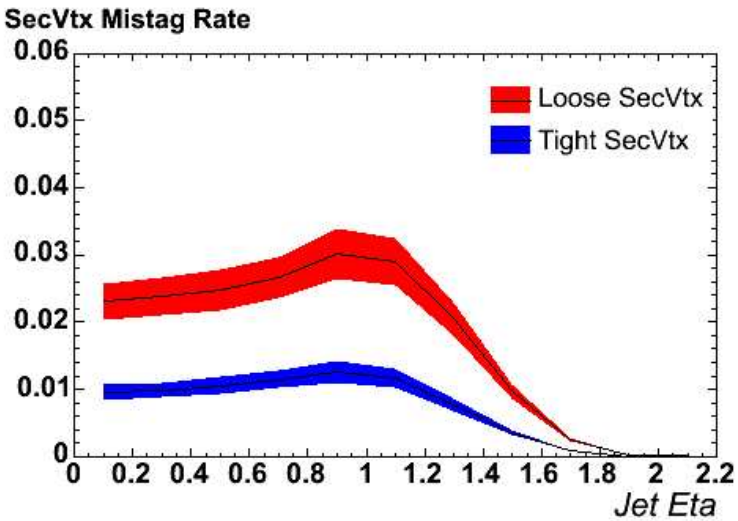


SecVtx Tagger Mistag

jet E_T

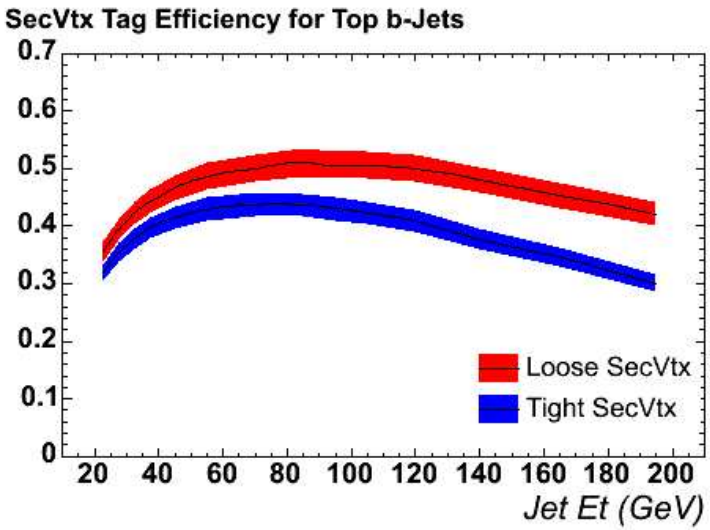


jet η



SecVtx Tagger Efficiency

jet E_T



jet η