b–jets and $Z + b$–jets at CDF

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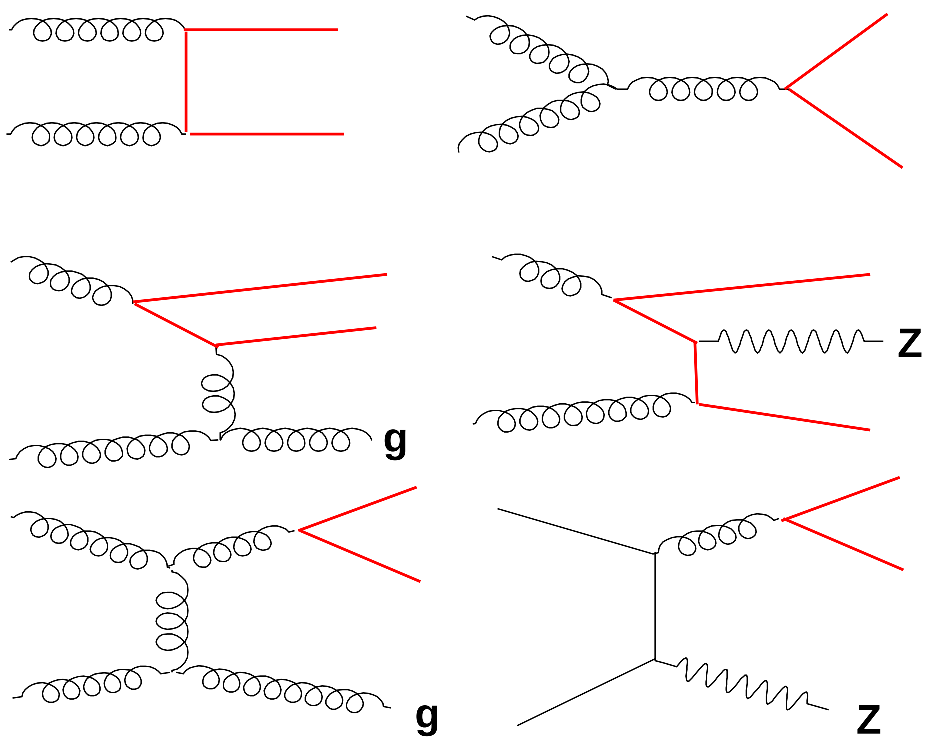
for the CDF collaboration

- introduction
- detector
- jet reconstruction & b–tagging
- analysis strategy
- inclusive b jet production
- $Z + b$ jet production
- conclusions

introduction

measurement of heavy flavour production in hadron collisions is an important test of QuantumChromoDynamics



Flavour Creation

Flavour Excitation

Gluon Splitting

QCD HF production is important background to many rare processes

inclusive b–jet production is sensitive to all mechanisms
$Z + b$–jet sensitive to F.E. and G.S.

Tevatron

$p\bar{p}$ collisions, 1.96 TeV centre–of–mass energy

$\mathcal{L} \sim 10^{32} cm^{-2} s^{-1}$, expect $\sim$ 3 interactions per bunch crossing

reported results use up to $\sim 340 pb^{-1}$

CDF detector

calorimeter
- Pb + scint. (EM)
- Fe + scint. (Had)

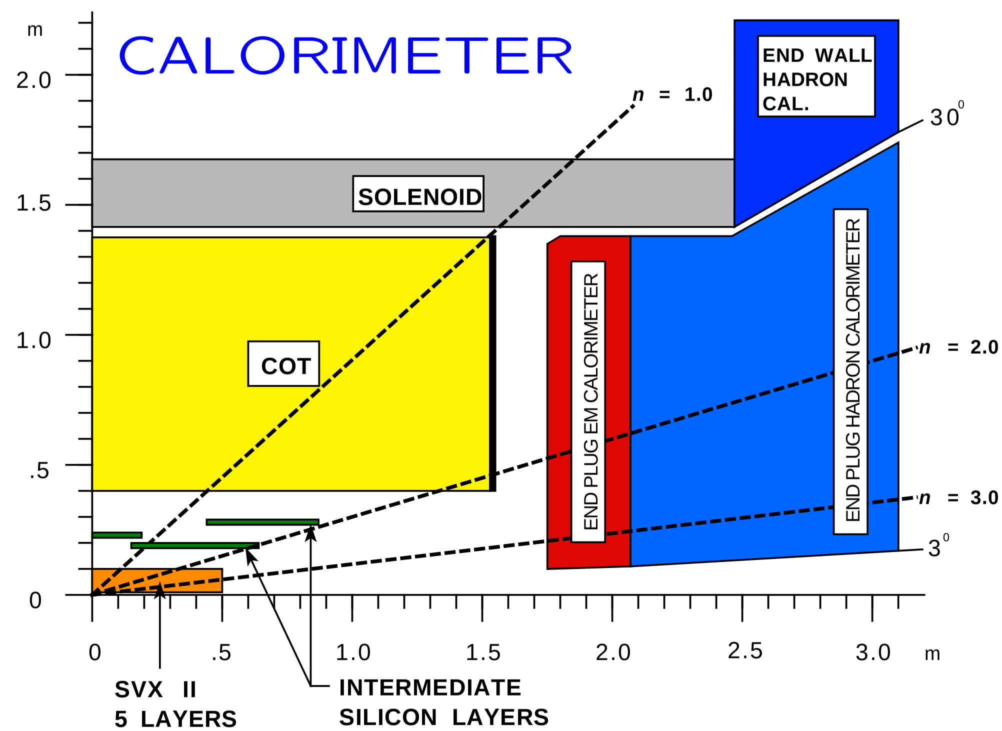
3–d tracking in 1.4 T B–field

COT: wire chamber
- 96 wire planes in total

silicon:
- up to 8 layers
- radius 1.2 → 28 cm, $|\eta| < 2$

muon chambers

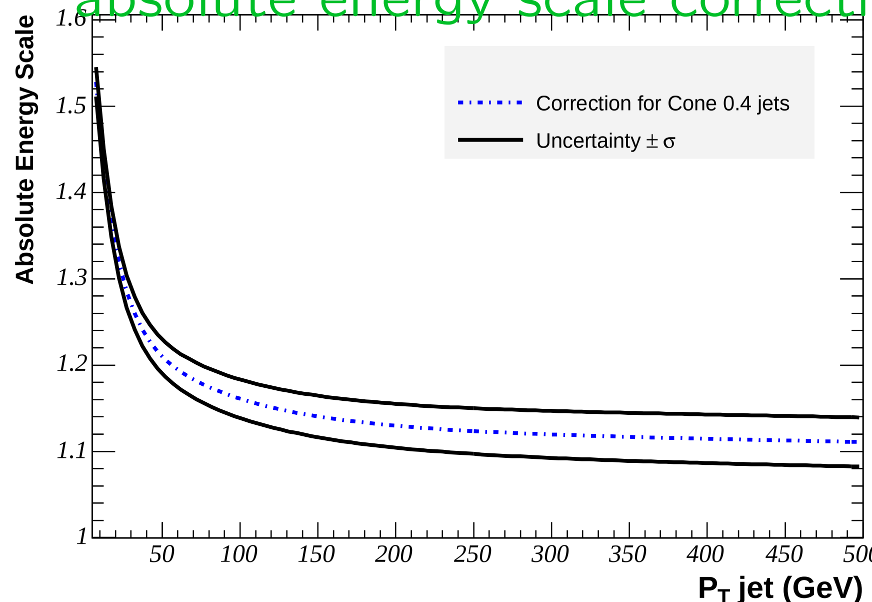
CDF Tracking Volume

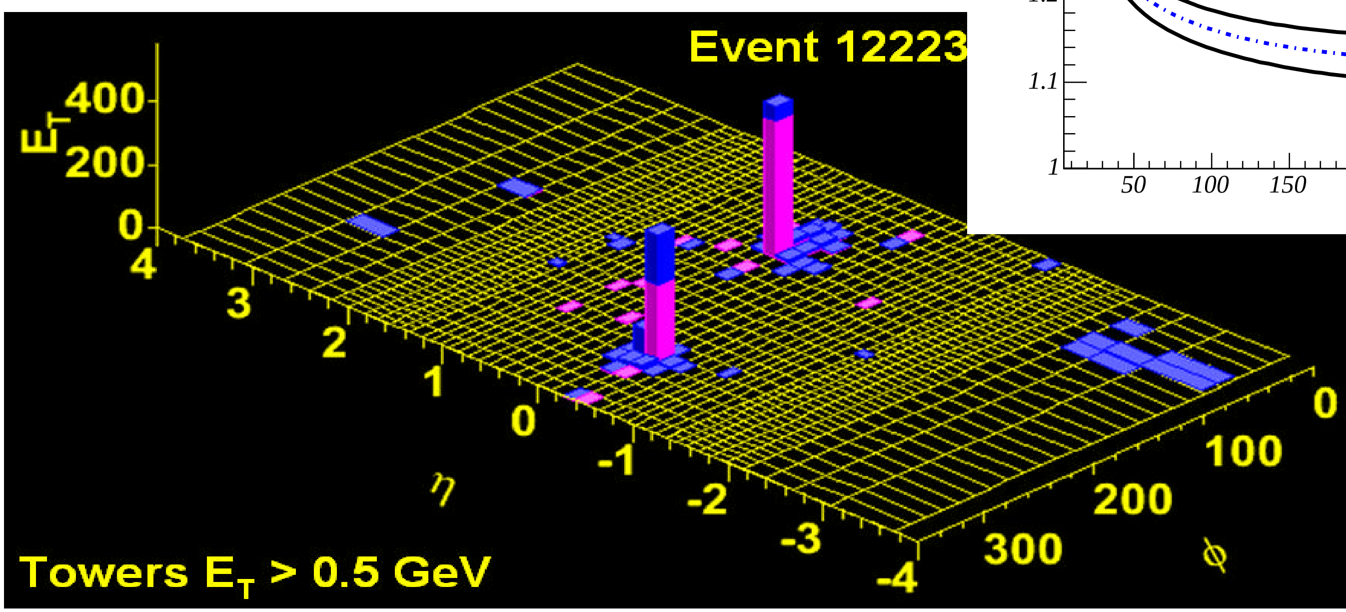


jet identification

- jets identified in calorimeter
- cone algorithm in $\eta - \phi$ space, typical radius 0.7
- jet energy corrections:
  - detector effects
  - absolute energy scale
  - Underlying Event
  - multiple interactions
  - calorimeter $\rightarrow$ hadrons

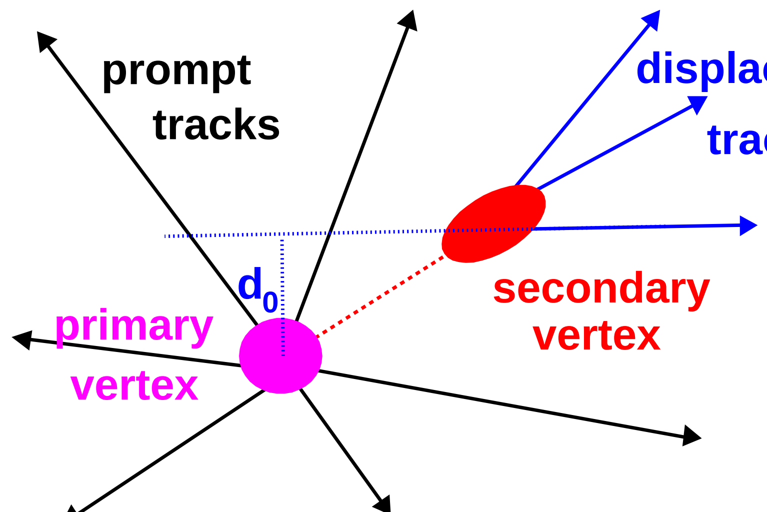
absolute energy scale correction





b jet identification

exploit long B hadron lifetime ($c\tau \sim 450\mu m$)
$\rightarrow$ identify displaced vertices
$\rightarrow$ silicon vertex detector crucial



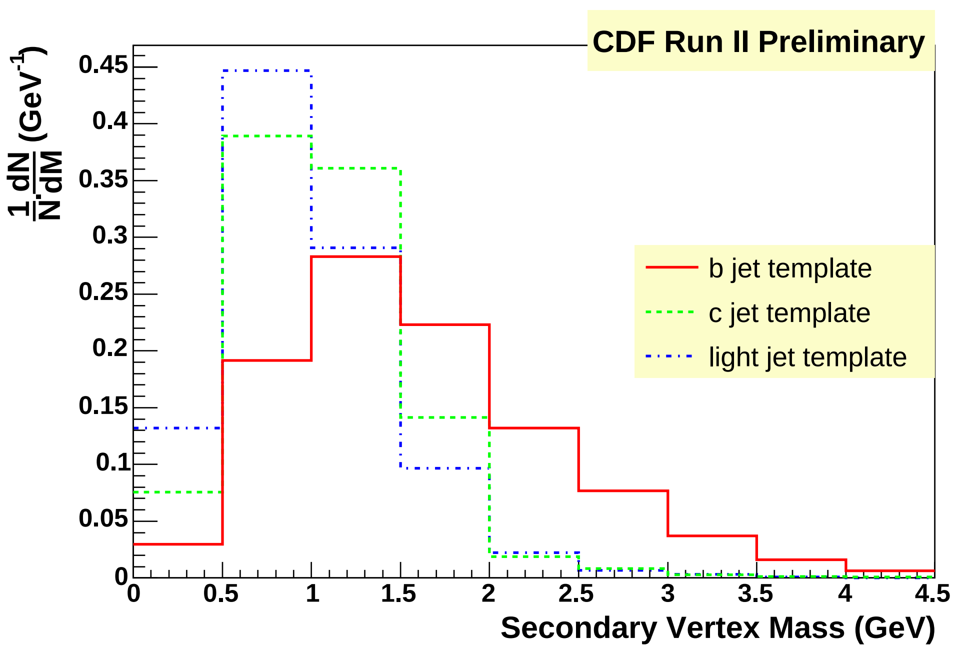
- consider tracks in $\eta - \phi$ cone of 0.4 around jet axis
- identify vertex using displaced tracks
- L_{xy}: separation from primary vertex in $x - y$ plane, projected onto jet axis
- "b–tagged" $\equiv L_{xy}/\sigma_{Lxy} > 7.5$

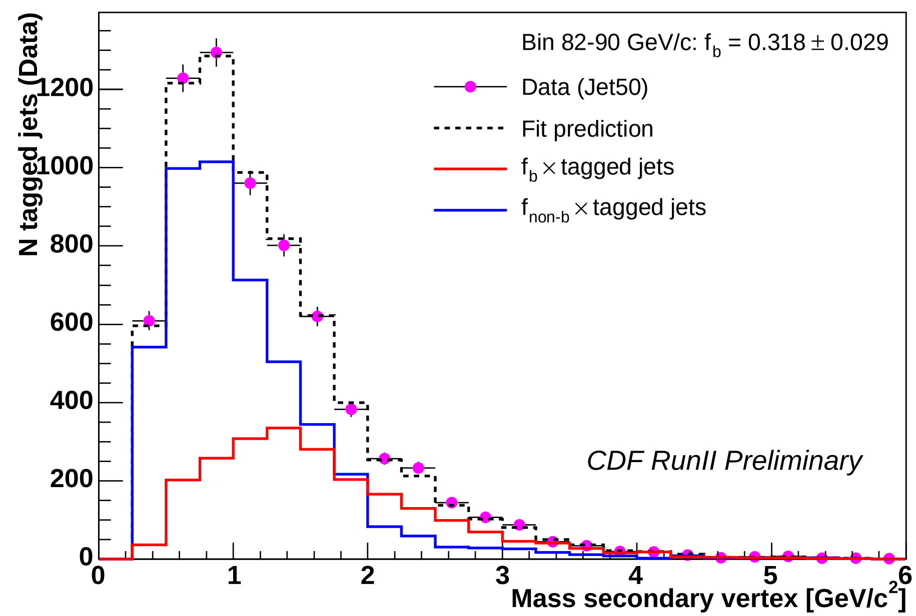
general analysis strategy

⇒ select events with b–tagged jets

⇒ estimate true b–jet yield using secondary vertex mass fit

vertex mass allows separation between tagged b, c and light jets

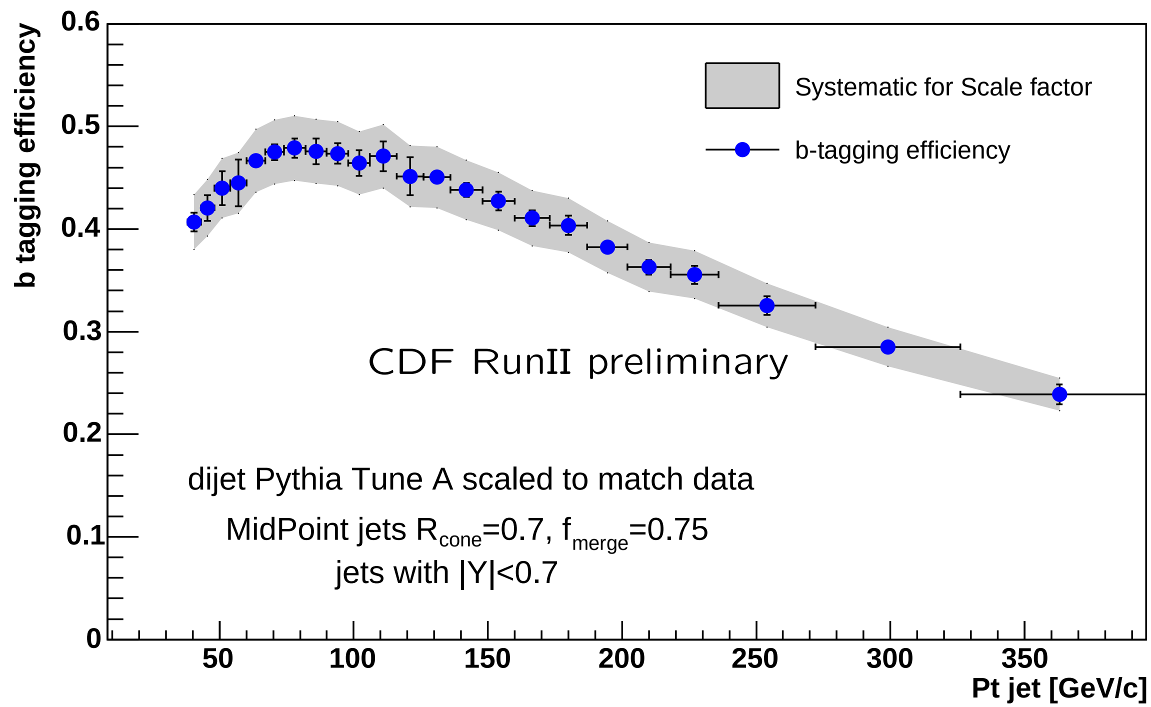




estimate b–fraction of tagged jets by fitting secondary vertex mass spectrum

general analysis strategy (II)

⇒ correct for b–tag efficiency (typically using corrected MC)



⇒ correct for kinematic acceptance

⇒ extract cross–section

inclusive b jet cross–section

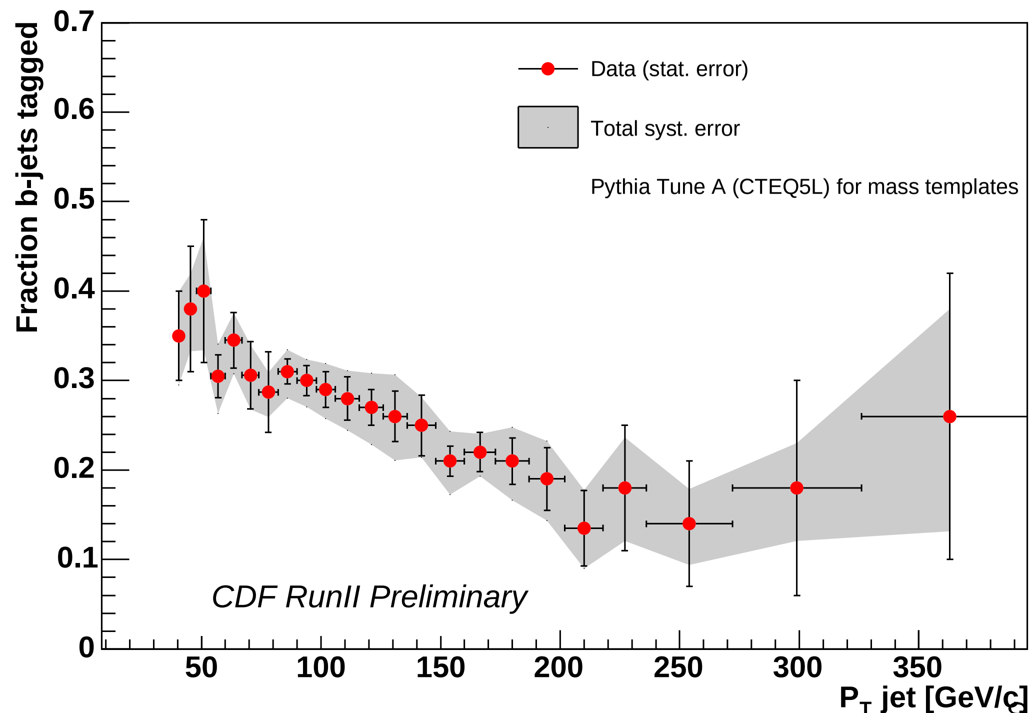
around $300pb^{-1}$ of data analysed

events triggered by jet triggers requiring calorimeter energy deposits with various E_T thresholds 5 $\rightarrow$ 100 GeV

consider central (rapidity $|y| < 0.7$) & high momentum (38 GeV/c $< p_T <$ 400 GeV/c) b–tagged jets

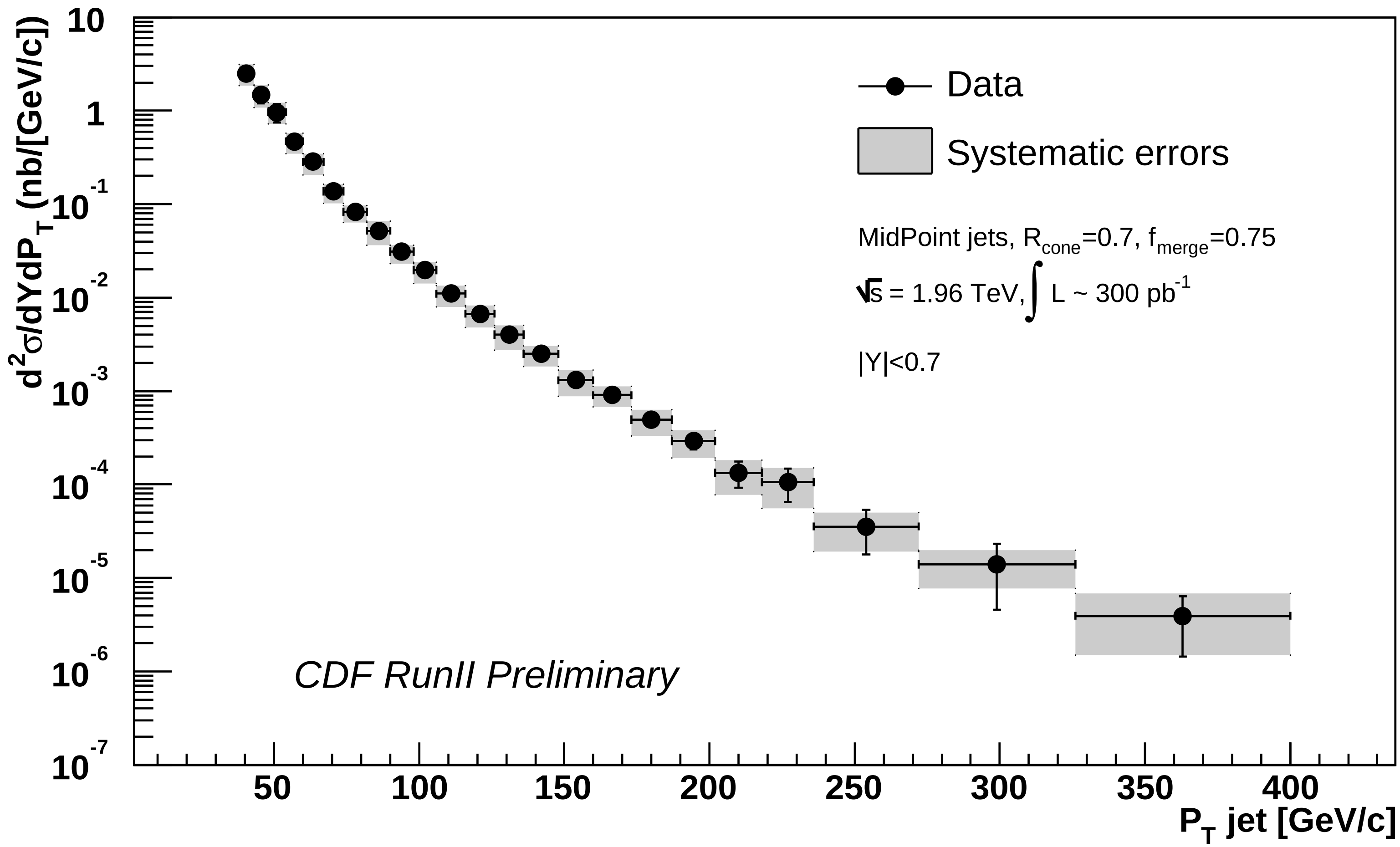
p_T dependent correction for true b fraction and b–tagging efficiency

measure cross–section for b–jet production as a function of jet p_T



inclusive b jet cross–section: results

measured inclusive b–jet cross section as a function of jet p_T



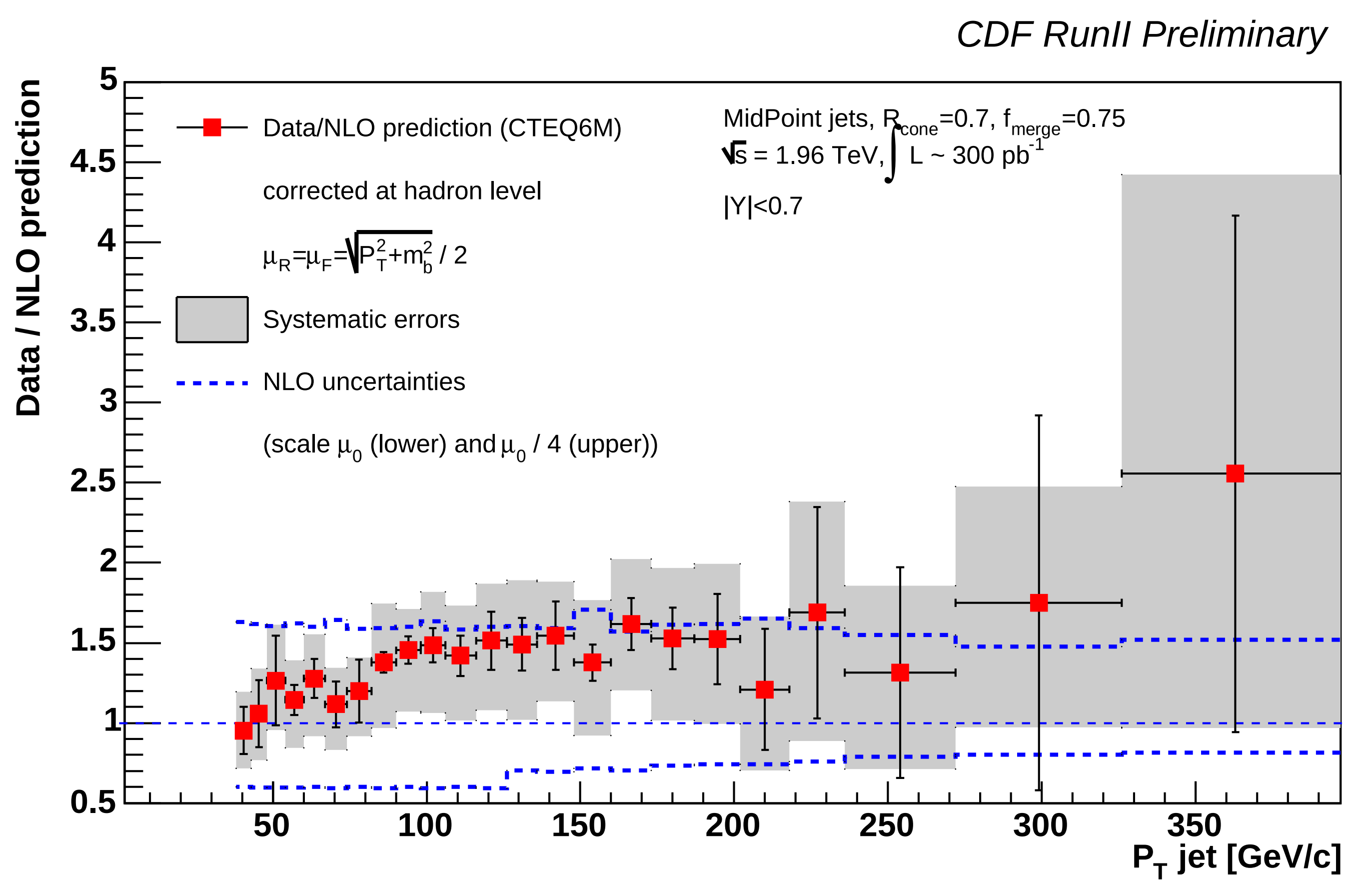
inclusive b jet cross–section: NLO comparison

NLO from M.Mangano and S.Frixione (Nucl. Phys. B483, 321 (1997))

$gg \to Q\overline{Q}$, $q\bar{q} \to Q\overline{Q}$, $gg \to Q\overline{Q}g$, $q\bar{q} \to Q\overline{Q}g$, $qg \to Q\overline{Q}q$

theory uncertainty dominated by factoriz. and renormaliz. scales

NLO prediction corrected for Underlying Event and Hadronisation



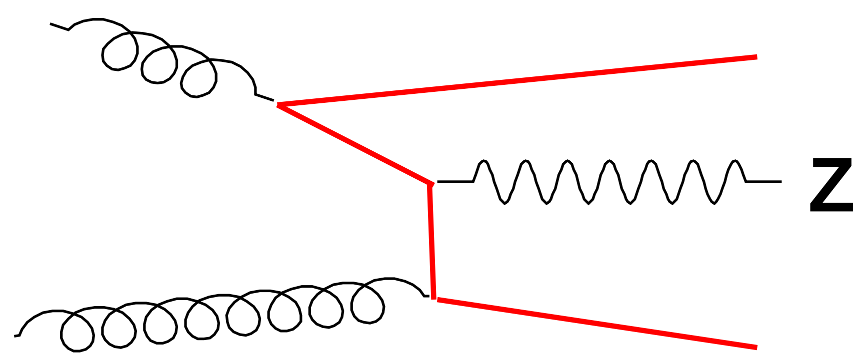
good agreement

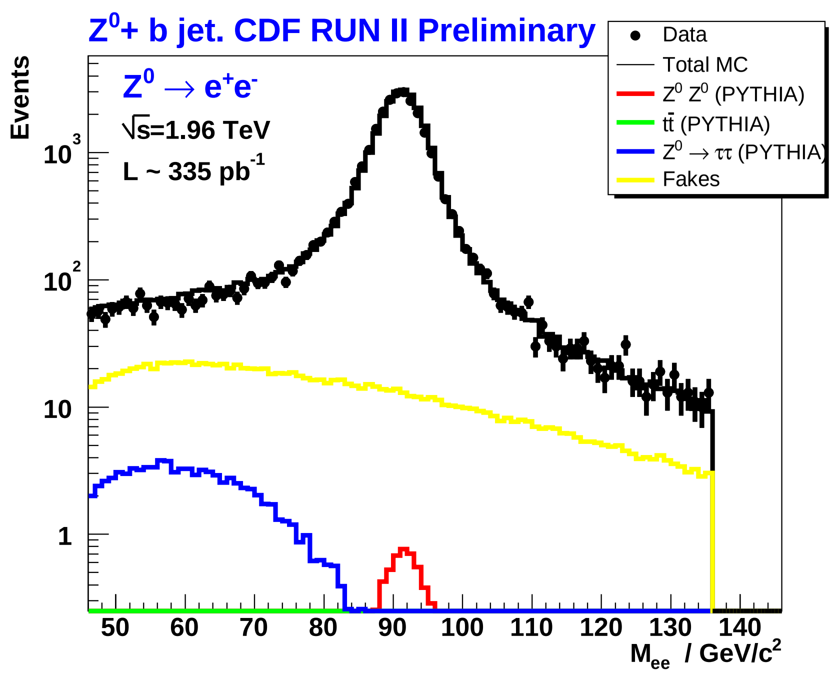
$Z + b$–jet cross–section

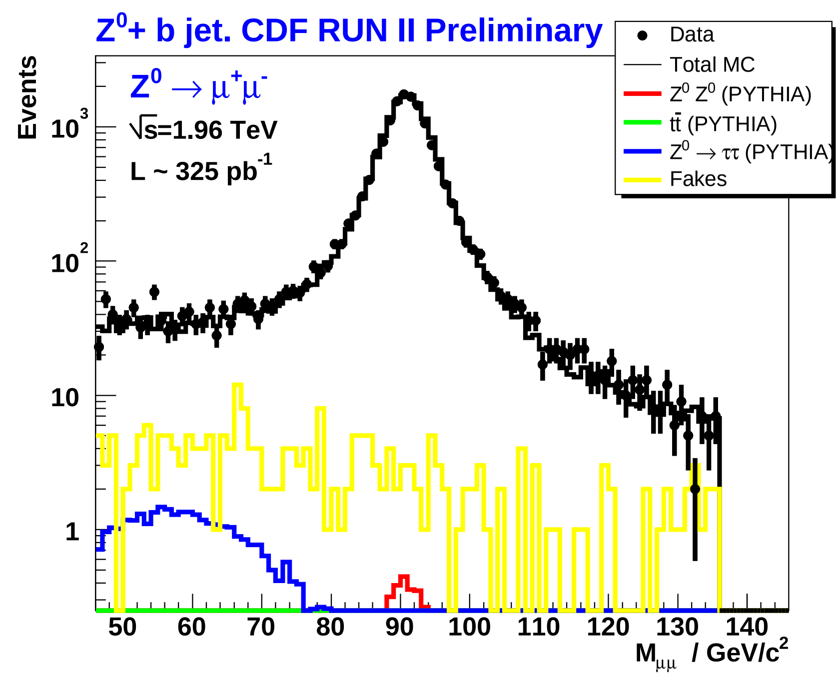
sensitive to "b content of proton"
important background to Higgs & new physics

analysed around $330 pb^{-1}$

events triggered by high E_T lepton
select Z^0 decays into e^+e^- and $\mu^+\mu^-$, $66 < m_{ll} < 116$ GeV







$Z + b$–jet cross–section

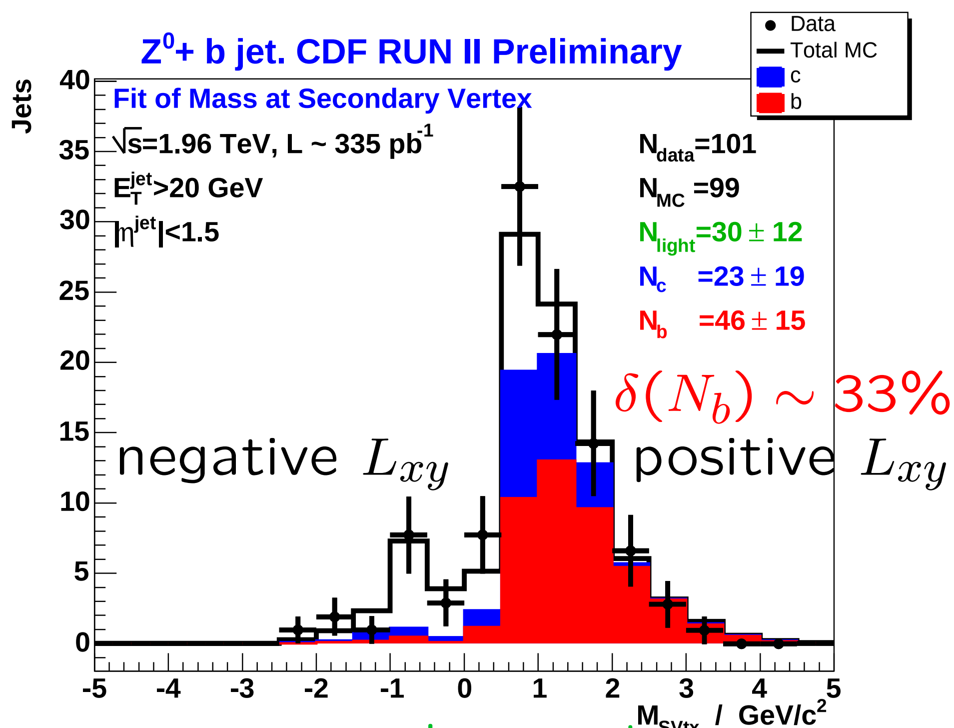
require additional tagged jet with E_T >20 GeV, $|\eta| < 1.5$

small backgrounds from non–Z^0:

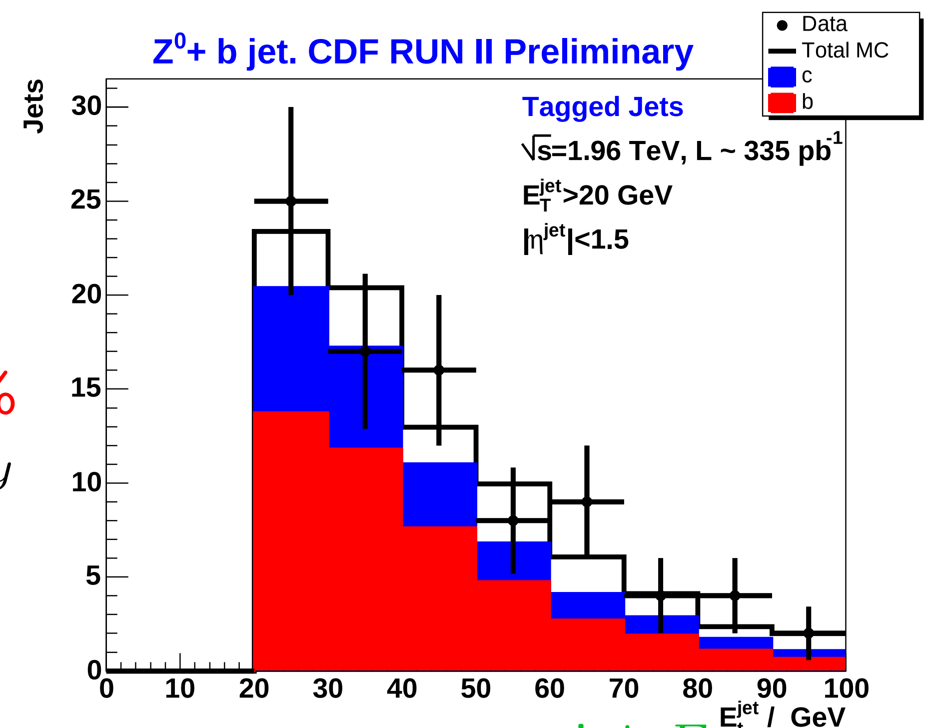
Background	e channel (%)	μ channel (%)
Fake	4.2 ± 1.2	1.7 ± 0.8
$t\bar{t}$	1.2 ± 0.2	1.6 ± 0.3
$Z^0 Z^0$	1.3 ± 0.3	1.5 ± 0.3

fit for c and b fractions

limited statistics → measure total cross–section



secondary vertex mass



jet E_T

$Z + b$–jet cross–section

measure ratios & cross–section for:

$Z^0 + b$–jets (cone 0.7, $E_T > 20$ GeV, $|\eta| < 1.5$)

extract $\sigma(Z^0 + b - jet)/\sigma(Z^0 + jet)$ and $\sigma(Z^0 + b - jet)/\sigma(Z^0)$

combine with CDF measurement of $\sigma(Z^0)$ to extract $\sigma(Z^0 + b - jet)$

NLO predictions from MCFM, corrected for U.E. and hadronization

high scale $m_Z \Rightarrow$ small theory scale uncertainty

	CDF RunII measurement	NLO (MCFM)
$\sigma(Z^0 + b - jet)/\sigma(Z^0 + jet)$	$0.0237 \pm 0.0078 \pm 0.0033$	0.0185
$\sigma(Z^0 + b - jet)/\sigma(Z^0)$	$0.0038 \pm 0.0012 \pm 0.0005$	0.0021
$\sigma(Z^0 + b - jet)$	$0.96 \pm 0.32 \pm 0.14$ pb	0.52 pb

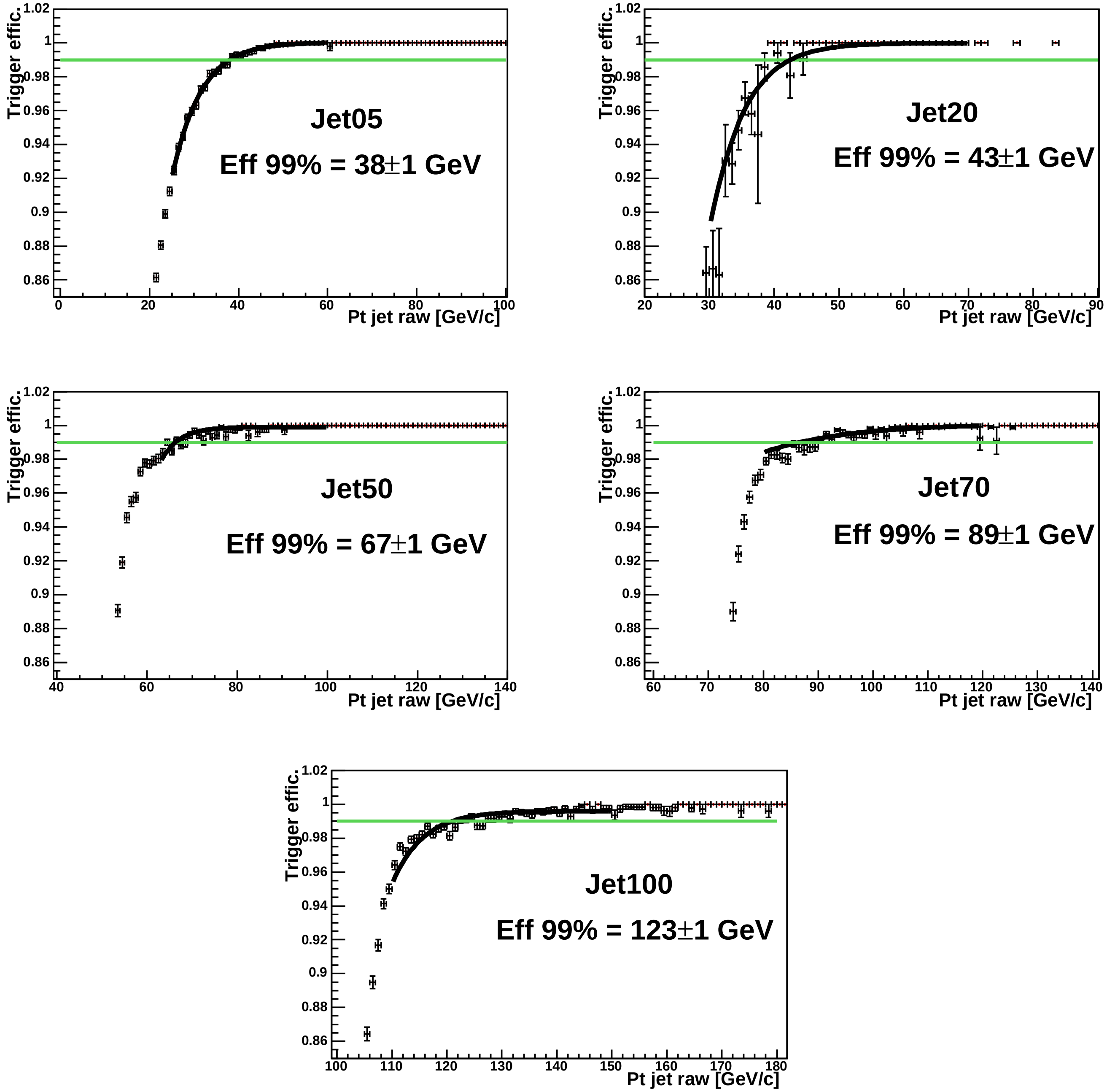
good agreement with NLO predictions

conclusions

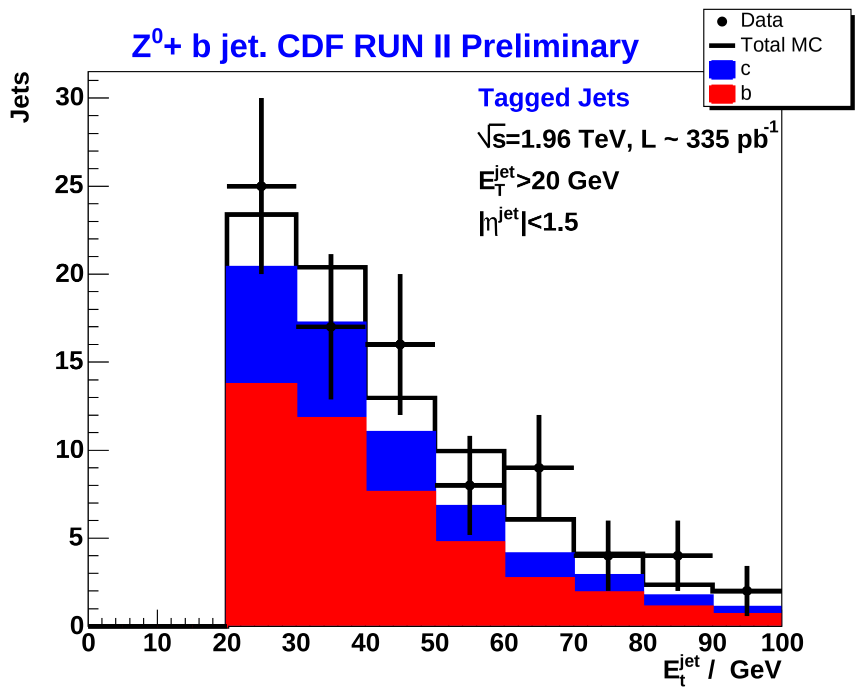
CDF has measured b–jet production in several topologies

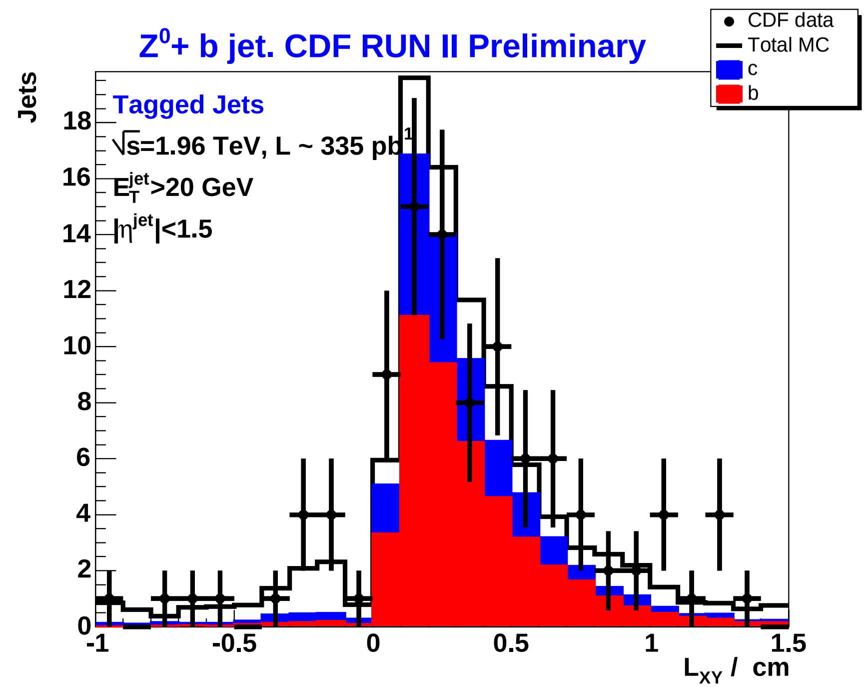
measurements sensitive to different production mechanisms

heavy flavour production at CDF in agreement with NLO predictions back-up slides



Jet05
Eff 99% = 38±1 GeV
Jet20
Eff 99% = 43±1 GeV
Jet50
Eff 99% = 67±1 GeV
Jet70
Eff 99% = 89±1 GeV
Jet100
Eff 99% = 123±1 GeV
Trigger effic.
Pt jet raw [GeV/c]





Cone0.7, $E_T^{\rm jet} > 20$ GeV, $\lvert\eta^{\rm jet}\rvert < 1.5$, $\sqrt{s} = 1.96$ TeV, $L \sim 335\,{\rm pb}^{-1}$	CDF RUNII Preliminary Data	PYTHIA TuneA (CTEQ5L)	NLO J. Campbell	NLO with Had, UE
$\sigma(Z^0 + b\,{\rm jet})$	$0.96 \pm 0.32 \pm 0.14$ pb	0.83 pb	0.48 pb	0.52 pb
$\sigma(Z^0 + b\,{\rm jet})/\sigma(Z^0)$	$0.0038 \pm 0.0012 \pm 0.0005$	0.0034	0.0019	0.0021
$\sigma(Z^0 + b\,{\rm jet})/\sigma(Z^0 + {\rm jet})$	$0.0237 \pm 0.0078 \pm 0.0033$	0.0207	0.0185	0.0185