Heavy flavor jets using the SVT trigger
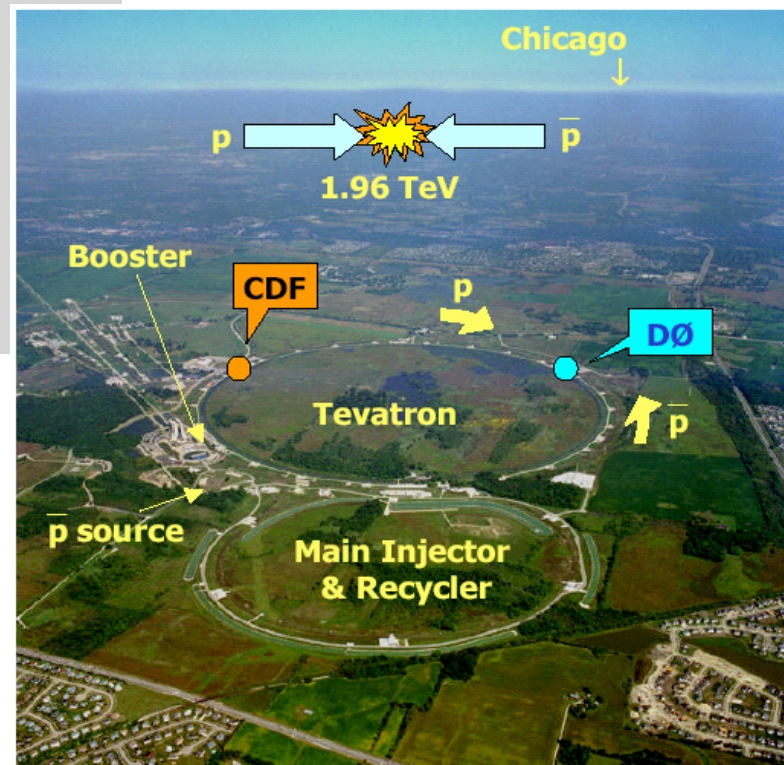
- **the bb cross section measurement** (Sofia)
- **photon + b-jet cross section** (Mario)
- **photon + bb di-jet production** (Mario & Till H.)

Sofia Vallecorsa

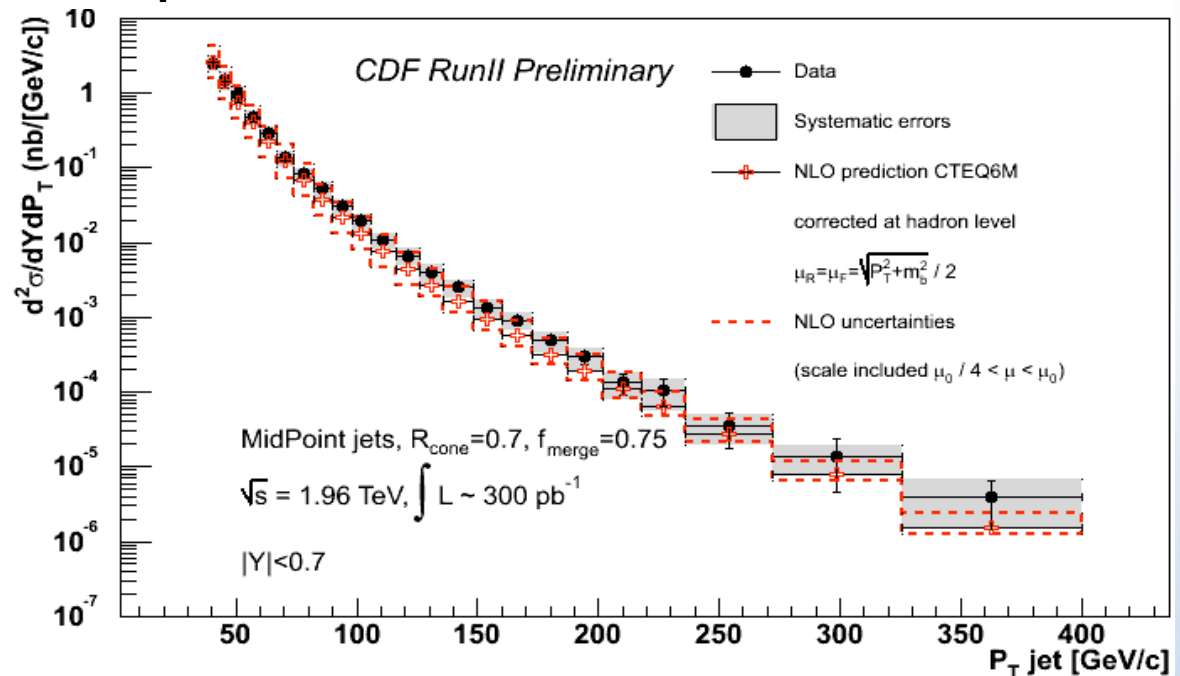Journée de réflexion du DPNC

Cartigny - 14 sept 2007

b jets at the Tevatron

- **bb CROSS SECTION** AND **CORRELATION** GIVE A INFORMATION ON b PRODUCTION MECHANISM
- GOOD TEST TO **NLO VS LO** PREDICTIONS
- **ASSOCIATED γ PRODUCTION** IS PROMISING CHANNEL TO LOOK FOR **NEW PHYSICS**
- SENSITIVE TO b CONTENT IN THE p PDF

CDF HAS MEASURED THE
INCLUSIVE B-JET CROSS
SECTION

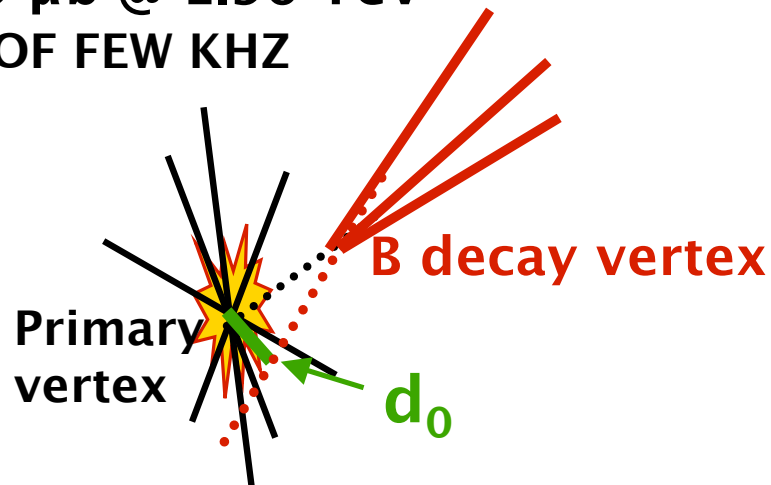**Monica!**

Silicon Vertex Trigger

σ(bb)∼50 μb @ 1.96 TeV
-> RATE OF FEW KHZ

B decay vertex

Primary vertex

d_0
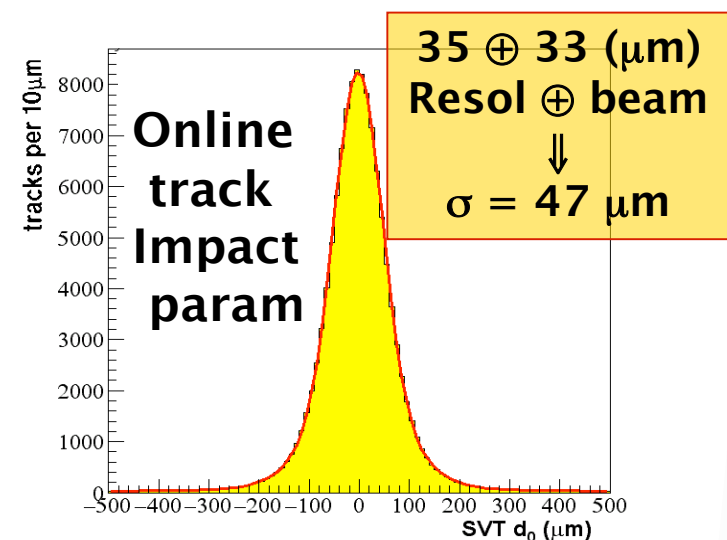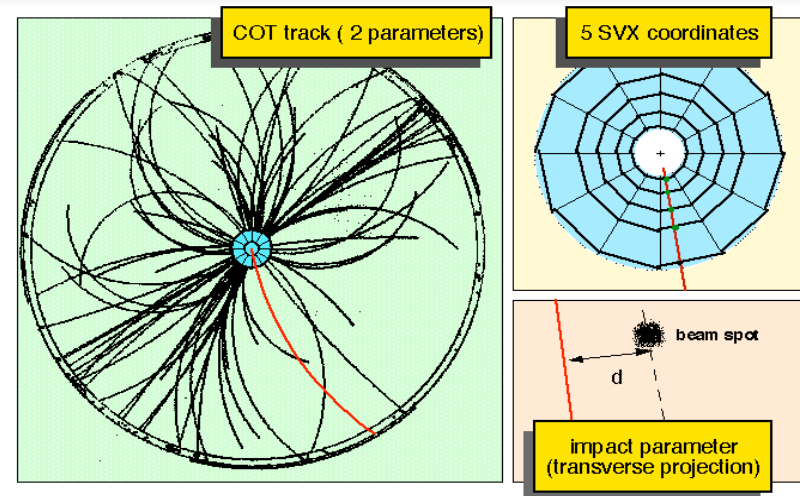
LONG LIFETIME (∼1.5 ps) OF B-HADRON

-> DEDICATED IMPACT PARAMETER TRIGGER
   BASED ON SILICON DETECTOR HITS
   AND L1 FAST TRACKER INFO

USE @ HIGH PT:
SEARCH FOR NEW PHYSICS
NEW FOR QCD STUDIES

COT track (2 parameters)

5 SVX coordinates

beam spot

d

impact parameter
(transverse projection)

tracks per 10μm

Online
track
Impact
param

35 ⊕ 33 (μm)
Resol ⊕ beam
⇓
σ = 47 μm

SVT d_0 (μm)

SVT selected samples

The three analyses make use of the SVT trigger at level 2: NO PRESCALE - MANY "b" events!

bb DI-JET CROSS SECTION

HIGH_PT_BJET

- **2 SVT TRACKS** $|d_0| > 100 \ \mu m$
- **2 JETS** $E_t > 20$ GeV
- **TRACK-JET MATCHING** $(\Delta\phi)$

ANALYSIS STRATEGY:
Apply offline tighter selection to have 100% trig eff.

γ + b CROSS SECTION
γ + bb CROSS SECTION

PHOTON_BJET

- **ISOLATED PHOTON** $E_t > 12$ GeV
- **SVT TRACK** $|d_0| > 120 \ \mu m$
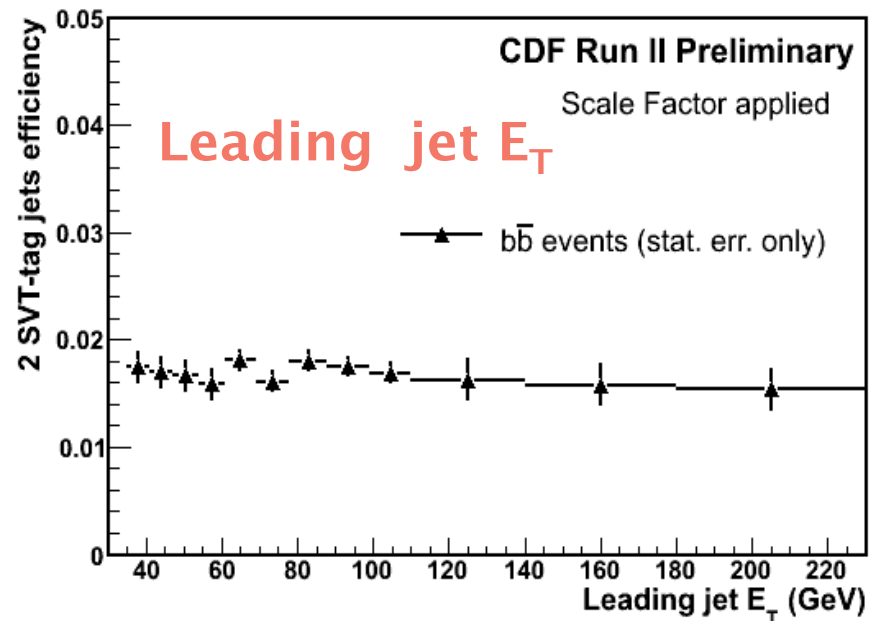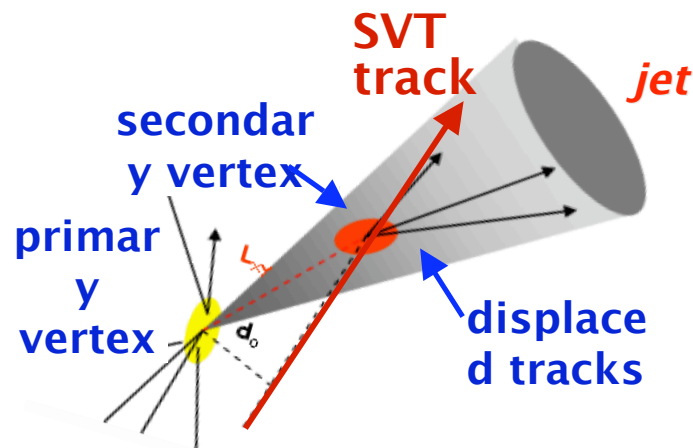- **JET** $E_t > 20$ GeV

ANALYSIS STRATEGY:
Calculate trig eff. from data using inclusive sample as reference
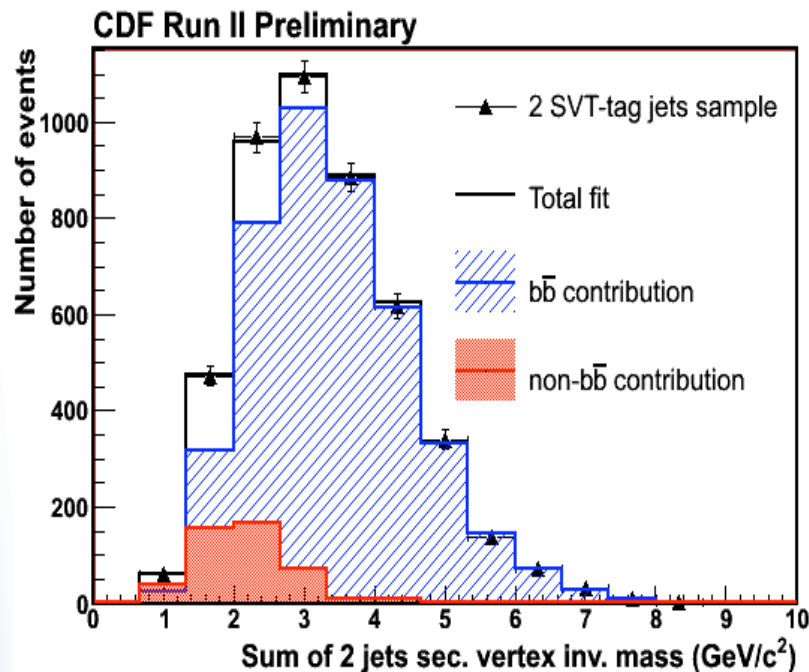
bb di-jet cross section

(Sofia)

- **TWO JETS in THE CENTRAL CALORIMETER REGION** $|\eta|<1.2$

  ENERGY CORRECTED FOR DETECTOR EFFECTS

- 2 **SVT TRACKS** $|d_0|>120$ μm, $p_T> 2$ GeV

  GEOMETRICAL (ΔR) TRACK – JET MATCHING

- **JETS ARE IDENTIFIED AS b–JETS**

  USING A SECONDARY VERTEX TAGGING ALGORITHM
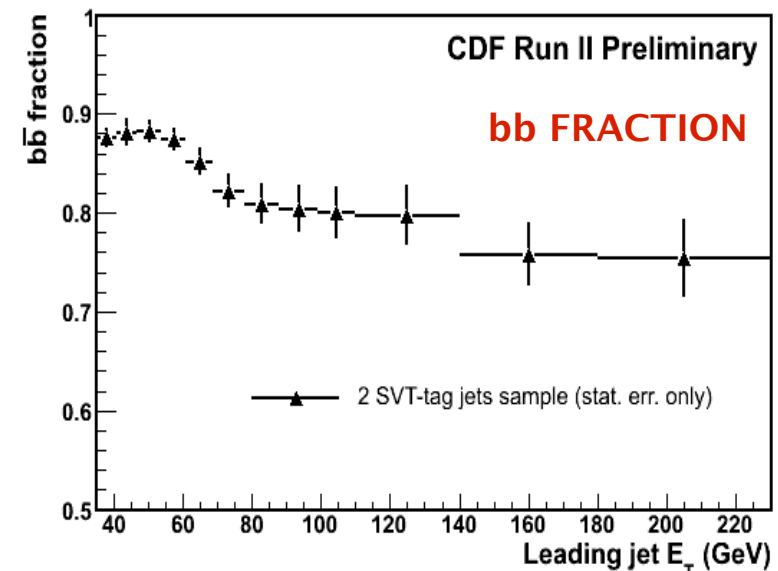
b purity of tagged jets

(Sofia)

EXTRACT b JET FRACTION FROM DATA:

FIT SHAPE OF SECONDARY VERTEX INVARIANT MASS

In the 2 tagged jet sample:

- SUM SEC. VTX MASS OF 2 JETS
- BUILD bb AND NON−bb TEMPLATES
- FIT DATA using TFRACTIONFITTER

SVT + TAG selection has low efficiency BUT very high purity >80%

bb di-jet cross section

(Sofia)

260 pb⁻¹

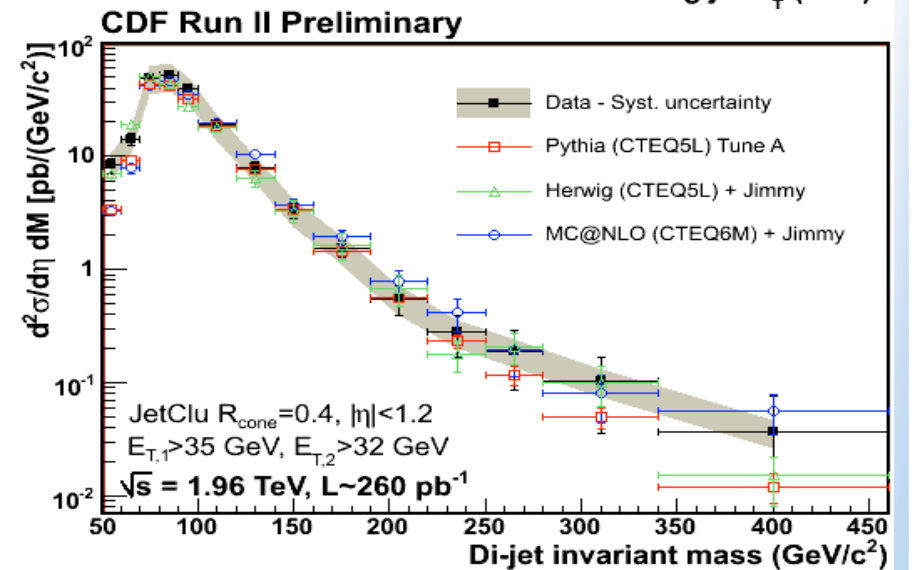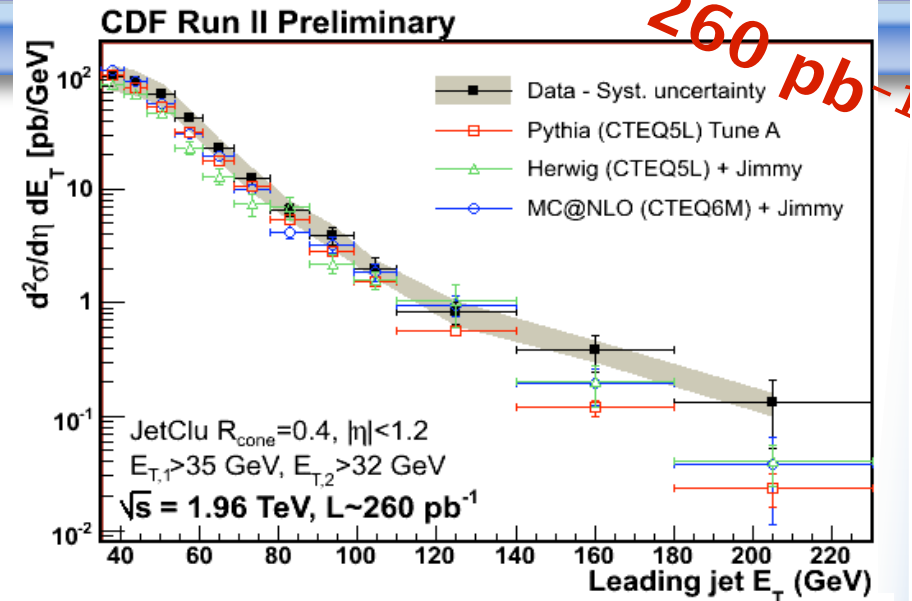**Data are compared to:**
- PYTHIA (TUNE A)
- HERWIG + JIMMY
- NLO MC@NLO + JIMMY

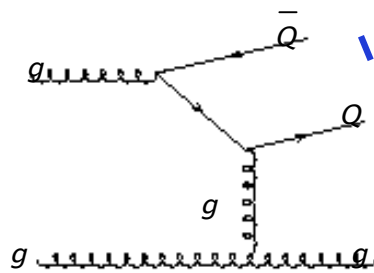**Main systematic uncertainties:**
- Jet Corrections 15-20%
- b fraction 7%

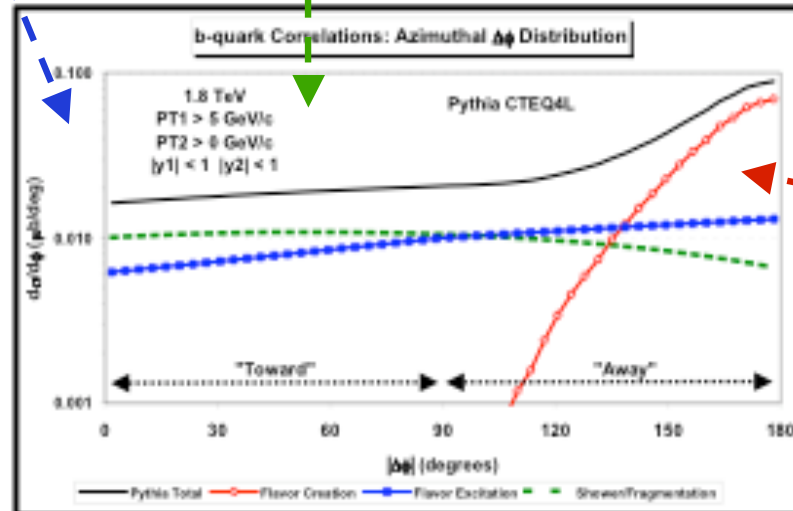| CDF Run II Preliminary	σ [pb]
	$|\eta_{1,2}| < 1.2,\ E_{T,1} > 35$ GeV, $E_{T,2} > 32$ GeV
Data	$\sigma = 5664 \pm 168$ (stat.) ± 1270 (syst.)
Pythia (CTEQ5L) Tune A	$\sigma = 5136 \pm 52$ (stat.)
Herwig (CTEQ5L) + Jimmy	$\sigma = 5296 \pm 98$ (stat.)
MC@NLO (CTEQ6M) + Jimmy	$\sigma = 5421 \pm 105$ (stat.)

Δφ distribution

Δφ CORRELATION IS SENSITIVE TO PRODUCTION MECHANISMS

FLAVOUR EXCITATION

SHOWERING

GLUON SPLITTING
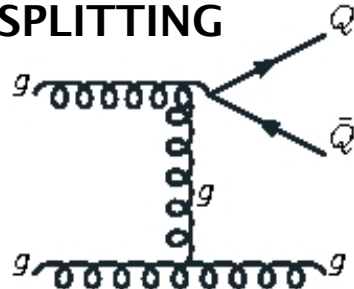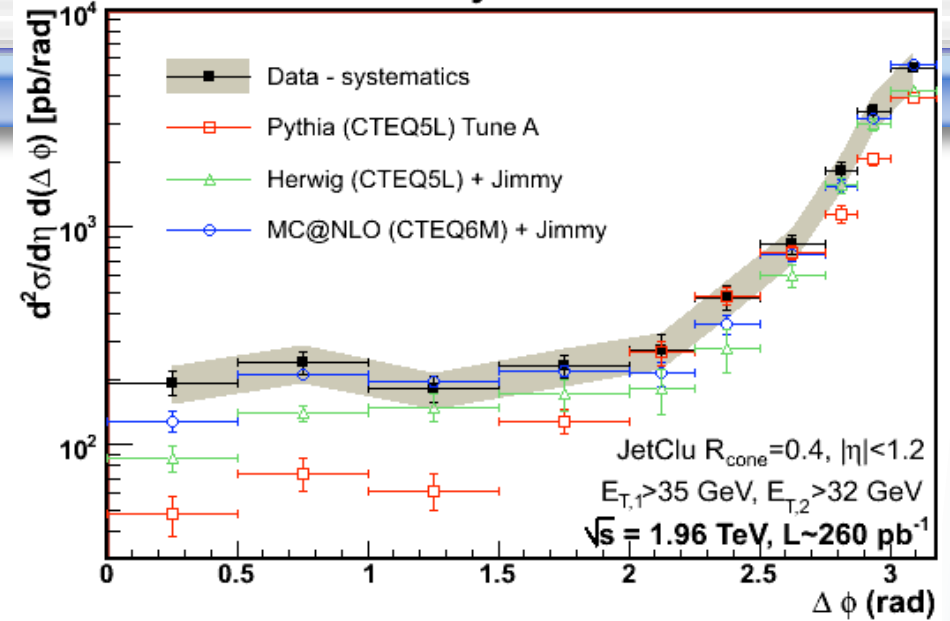
FLAVOUR CREATION
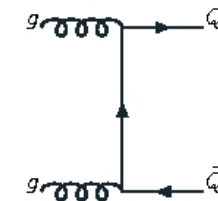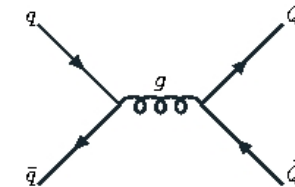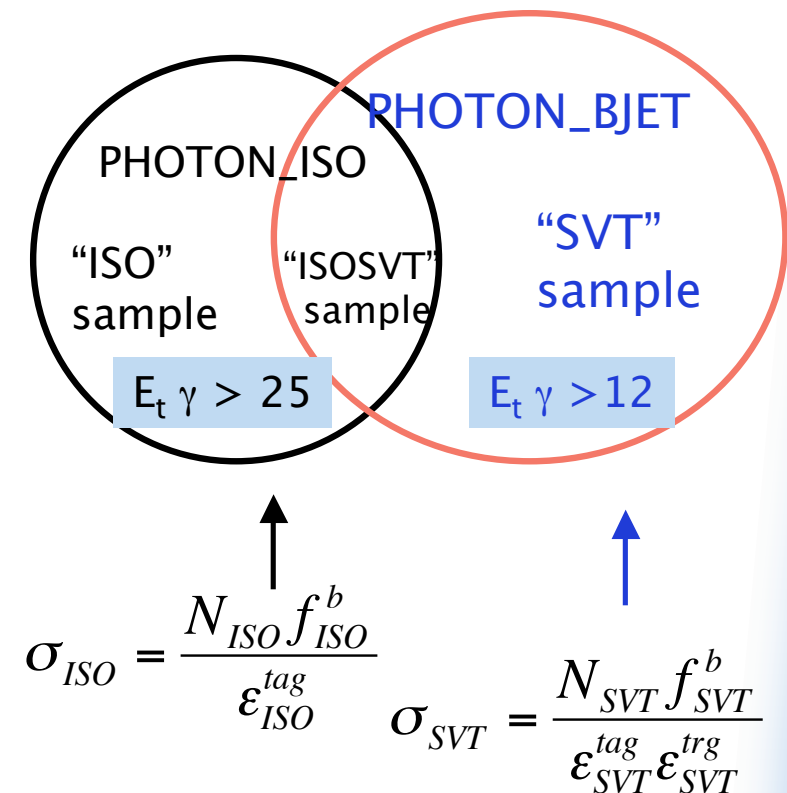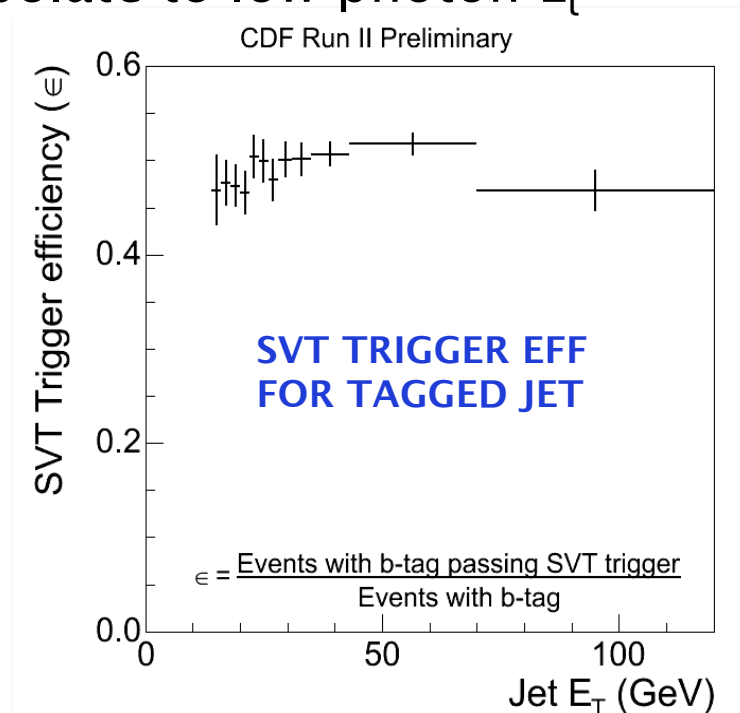
Photon + b–jet

Use inclusive photon sample to get SVT trigger efficiency

–> ASSUME JET/PHOTON INDEPENDENCE

- Look at the overlap region
 - Photon E_t>25 GeV + SVT track
- Extrapolate to low photon E_t

CDF Run II Preliminary

SVT Trigger efficiency (ϵ)

**SVT TRIGGER EFF
FOR TAGGED JET**

$\epsilon = \dfrac{\text{Events with b-tag passing SVT trigger}}{\text{Events with b-tag}}$

Jet E_T (GeV)

PHOTON_BJET

PHOTON_ISO

"ISO"
sample

"ISOSVT"
sample

"SVT"
sample

$E_t\,\gamma > 25$

$E_t\,\gamma > 12$

$$\sigma_{ISO} = \frac{N_{ISO}f^{b}_{ISO}}{\varepsilon^{tag}_{ISO}}$$

$$\sigma_{SVT} = \frac{N_{SVT}f^{b}_{SVT}}{\varepsilon^{tag}_{SVT}\varepsilon^{trg}_{SVT}}$$

Event selection

(Mario)

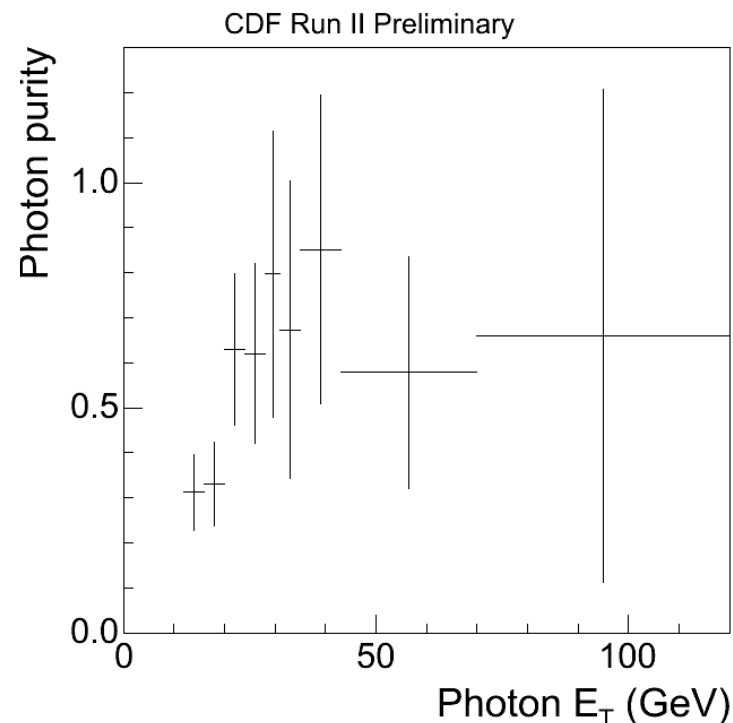**JET SELECTION:**
– TAGGED JET E_T > 20 GeV, $|\eta|$<1.5
– B PURITY FROM SECVTX MASS FIT
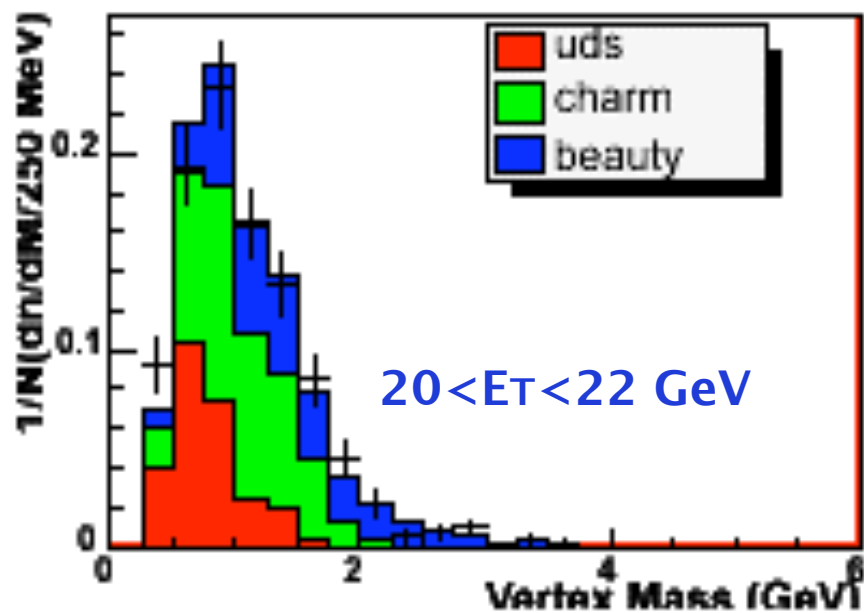
PHOTON SELECTION:
– E_T > 12 GeV, $|\eta|$<1.1
– γ/π^0 BAKGD is SEPARATED USING
  FIT TO **CES/CPR** SHOWER SHAPE

20<ET<22 GeV

CDF Run II Preliminary

Photon + b–jet

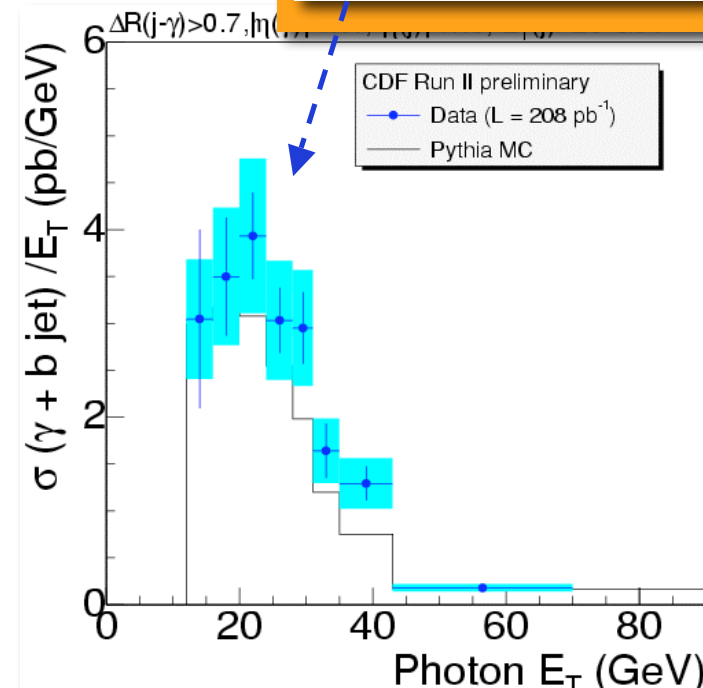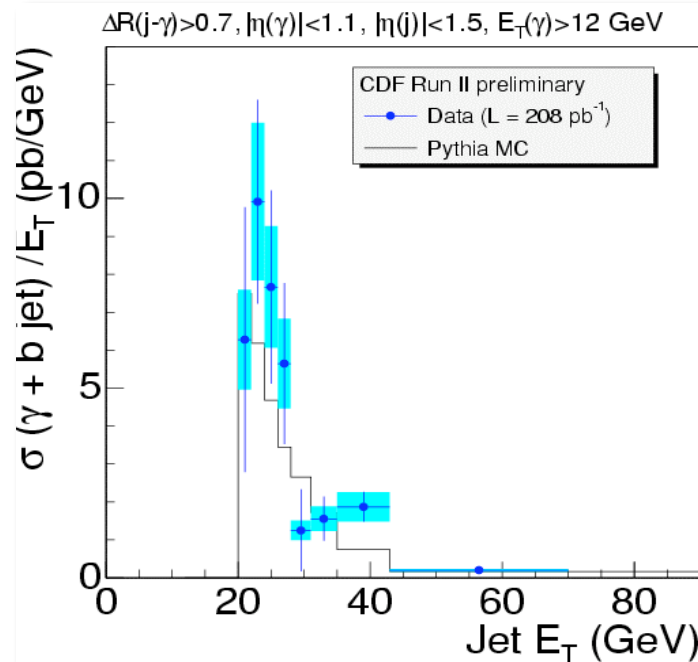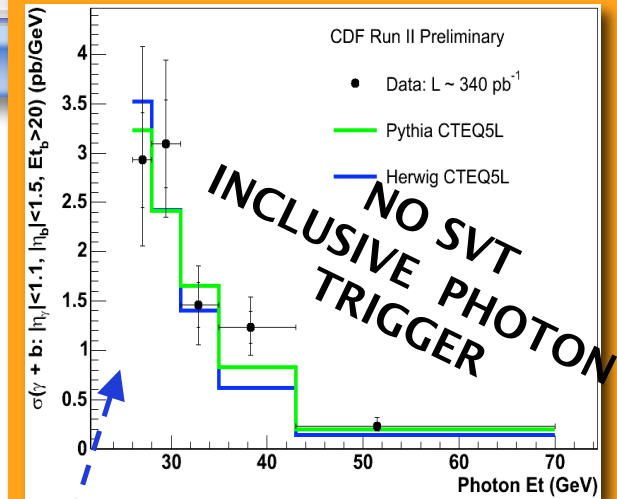## MAIN SYSTEMATICS:
- TRIGGER EFFICIENCY 10%
- TAGGING PURITY 10–20%
- PHOTON BKGD 6%

DATA: 90.5 ± 6.0 (stat.) +21.7 −15.4 (syst) pb

PYTHIA: 69 pb

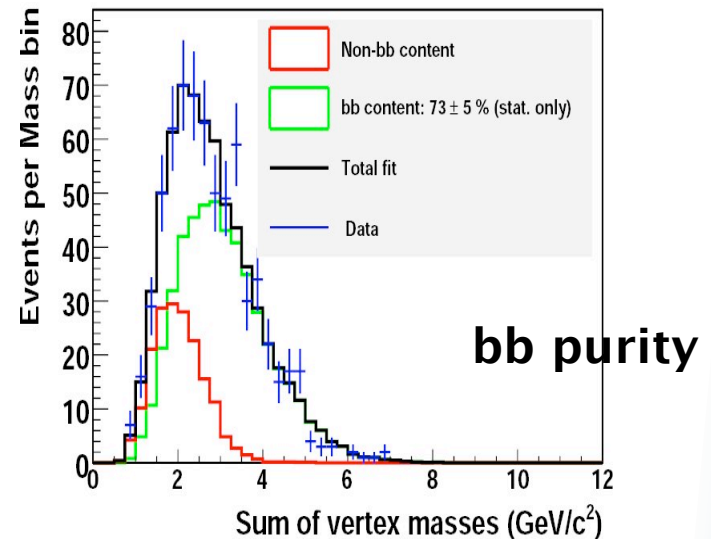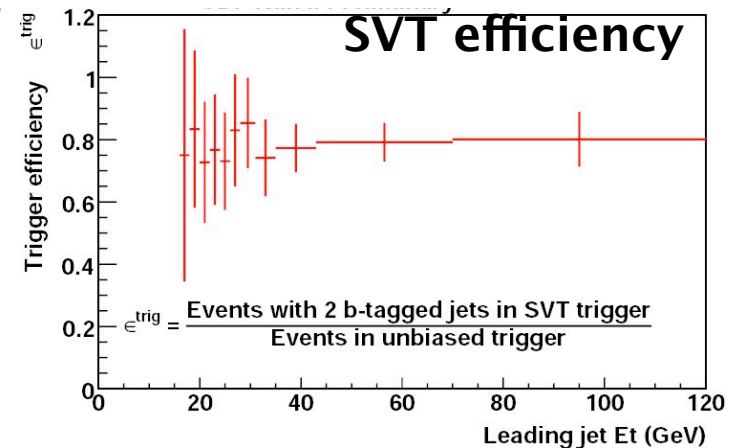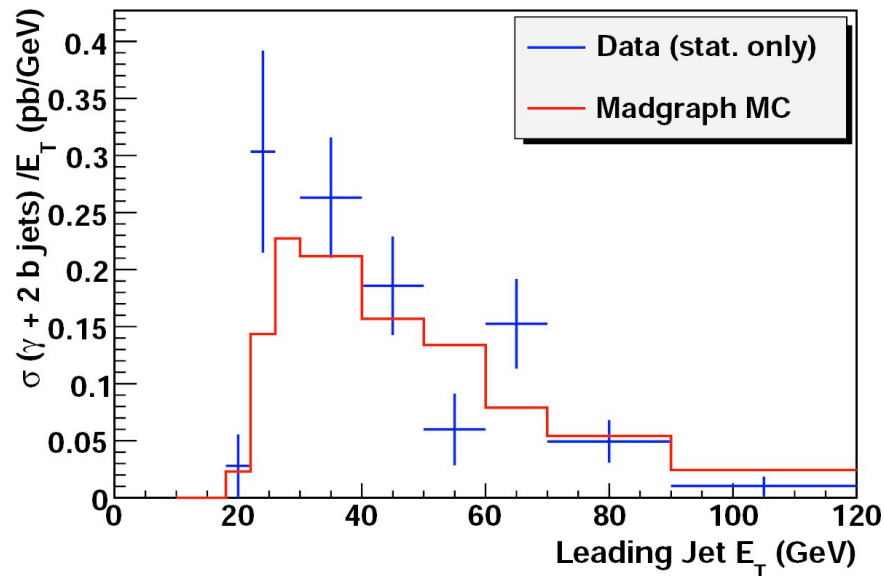LOWER THRESHOLD ON γ E_T THAN PREVIOUS MEASUREMENT

NO SVT INCLUSIVE PHOTON TRIGGER

CDF Run II Preliminary
- Data: L ~ 340 pb^{-1}
- Pythia CTEQ5L
- Herwig CTEQ5L

$\sigma(\gamma + b: |\eta_\gamma|<1.1, |\eta_b|<1.5, Et_b>20)$ (pb/GeV)

Photon Et (GeV)

$\Delta R(j-\gamma)>0.7, |\eta(\gamma)|<1.1, |\eta(j)|<1.5, E_T(\gamma)>12$ GeV

CDF Run II preliminary
- Data (L = 208 pb^{-1})
- Pythia MC

$\sigma(\gamma + b\ jet)/E_T$ (pb/GeV)

Jet E_T (GeV)

$\Delta R(j-\gamma)>0.7, |\eta(\gamma)|$

CDF Run II preliminary
- Data (L = 208 pb^{-1})
- Pythia MC

$\sigma(\gamma + b\ jet)/E_T$ (pb/GeV)

Photon E_T (GeV)

Photon + bb di-jet

(Till &Mario)

Same analysis strategy as b+γ analysis

Event selection:
- photon Et> 12 GeV, $|\eta|$<1.1
- 2 SECVTX tagged jet:
  - ◆ Et > 20 GeV, Et>15 GeV, $|\eta|$ < 1.5
- Isolation: $\Delta R(\gamma, jet) > 0.7$

SVT efficiency

$\epsilon^{trig} = \dfrac{\text{Events with 2 b-tagged jets in SVT trigger}}{\text{Events in unbiased trigger}}$

Trigger efficiency ϵ^{trig}

Leading jet Et (GeV)

σ (γ + 2 b jets) /E_T (pb/GeV)

— Data (stat. only)
— Madgraph MC

Leading Jet E_T (GeV)

Events per Mass bin

Non-bb content
bb content: 73 ± 5 % (stat. only)
Total fit
Data

bb purity

Sum of vertex masses (GeV/c²)

Summary

- **bb cross section:**
  - comparison to **NLO** is good
  - $\Delta\phi$ distribution confirms contribution from different **production mechanisms**
  - the role of the **UE simulation** is not negligible to correctly describe data
- **b+γ cross section:**
  - measurement extended down to $E_t(\gamma)>12$ GeV
  - data is above **LO** prediction

- **Different examples show the use of SVT at HIGH PT is understood**

- **Geneva is proving a good expertise on heavy flavour QCD at CDF!**

Additional MC comparison

Both LO and NLO predictions are enhanced by adding multi-parton interaction simulation:
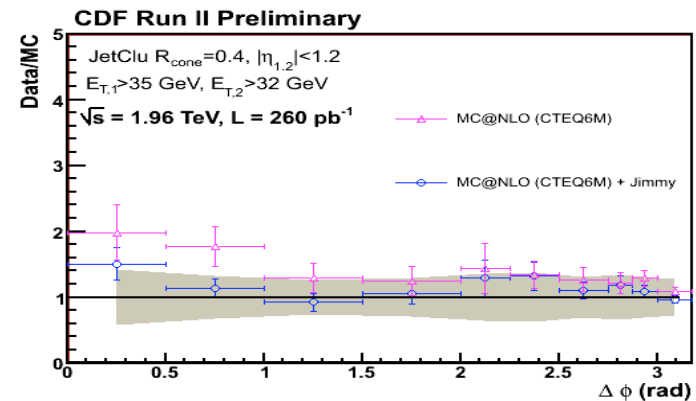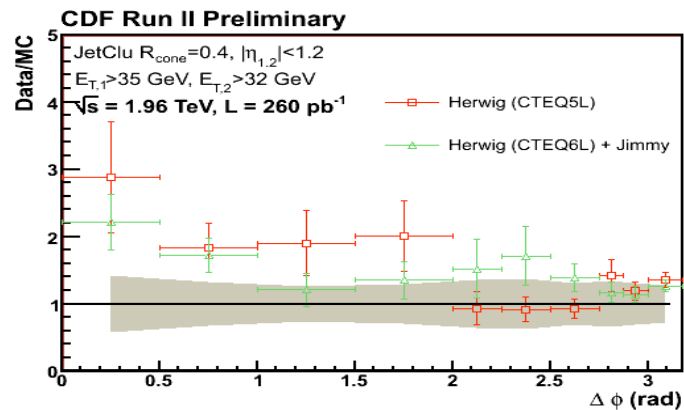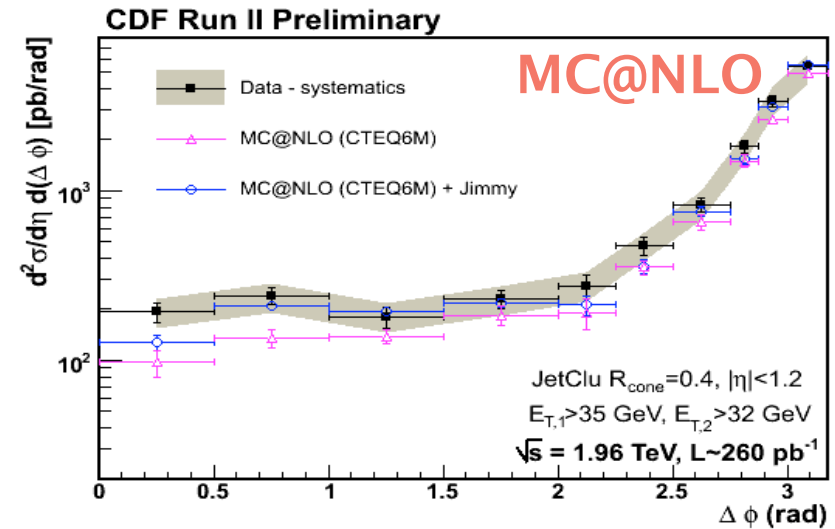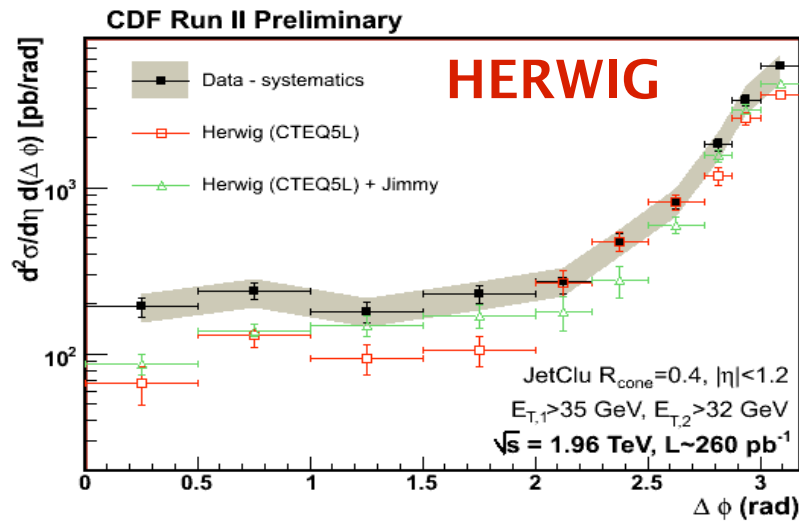
Bkup
HIGH_PT_BJET

Level 1
> Two 5GeV towers
> Two XFT tracks pt>2GeV/c

Level 2
> Two clusters (Et>15 GeV, $|\eta|$<1.5)
> Two SVT tracks |d0|>100μm
> Cluster–SVT matching ($|\Delta\phi|$<0.7)

Level 3
> Two cone–04 jets Et>20 GeV
> Two COT tracks matched to SVT (|d0|>100 μm)
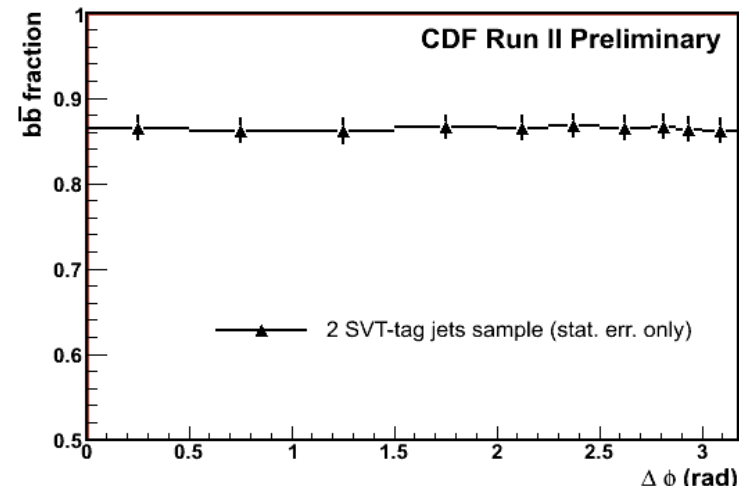> Two Si tracks matched to SVT (|d0|>80 μm)

Bkup

SVT–tag efficiency & bb fraction
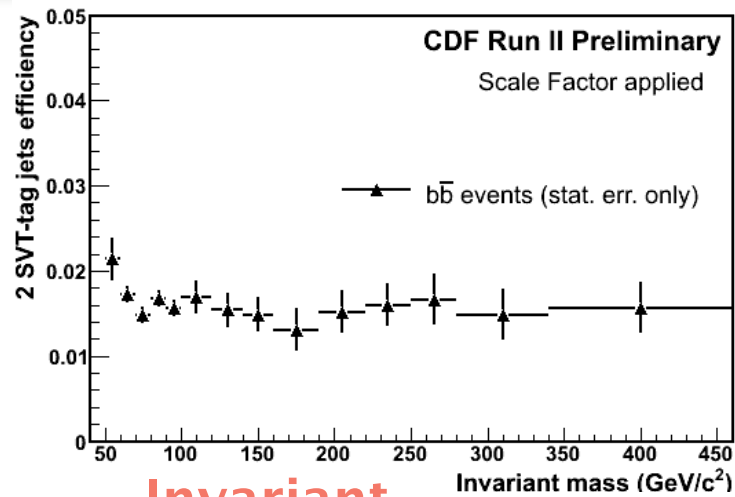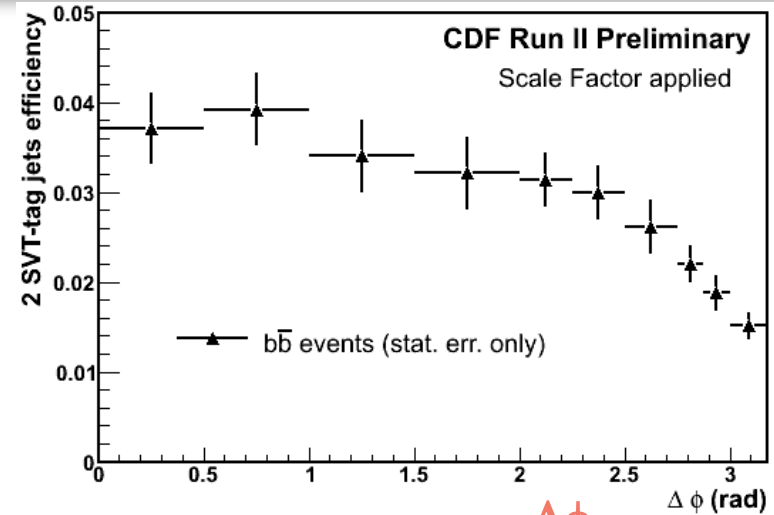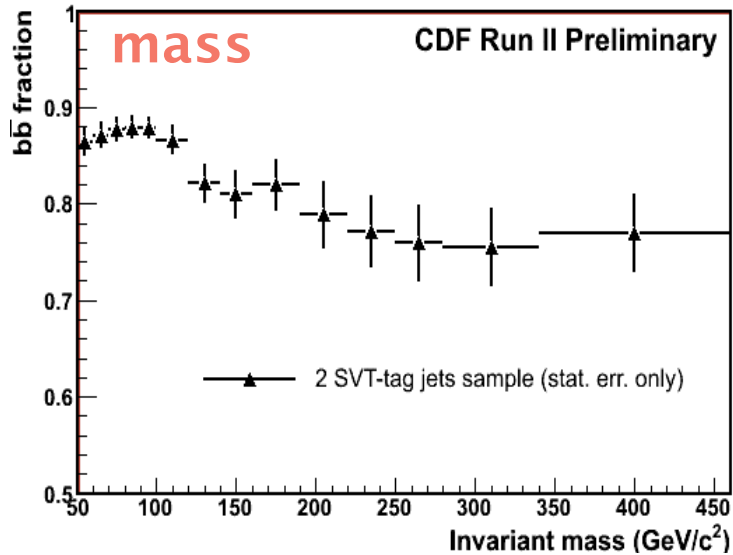
Syst. uncertainties
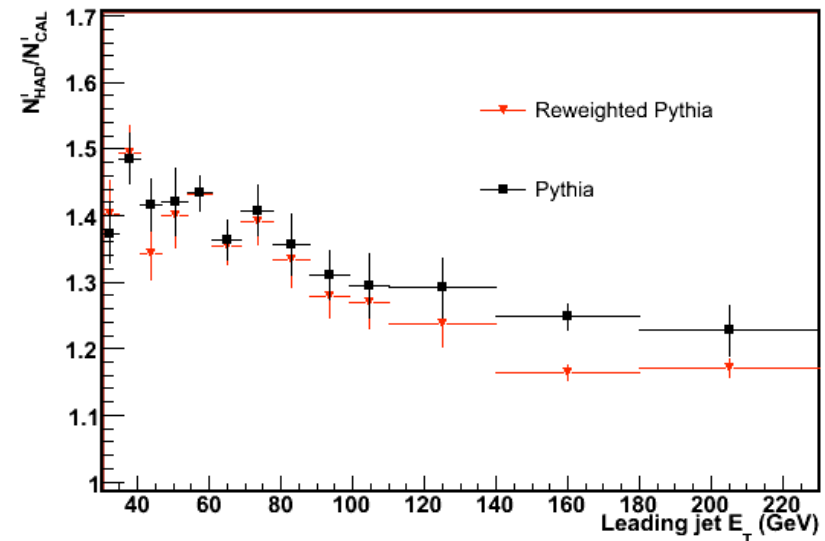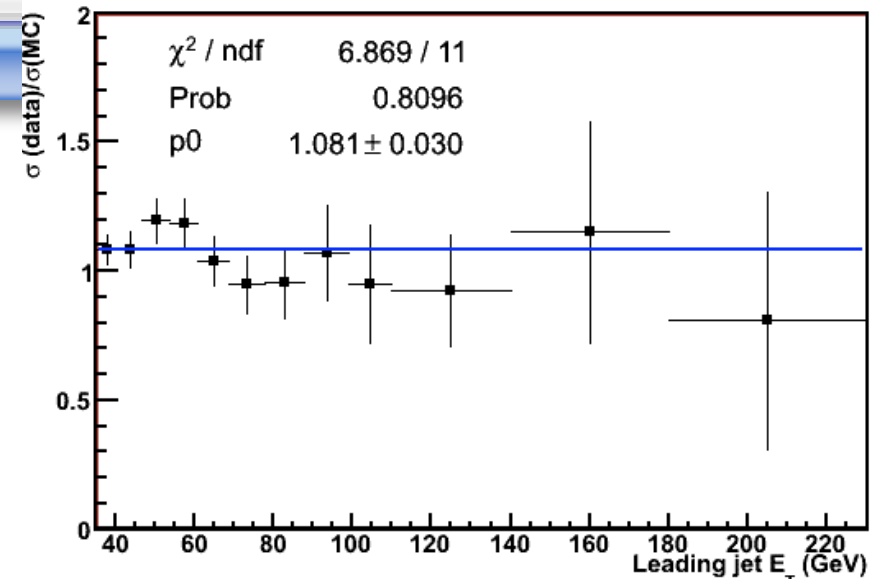
TOTAL SYSTEMATIC UNCERTAINTIES ARE ~20–25 %

- **JET ENERGY SCALE (15%–20%),**
- **LUMINOSITY (6%)**
- **UNFOLDING FACTORS (4%)**
  – E_T DEPENDENCE DATA/MC
- **TAGGING EFFICIENCY (4%)**
  – b QUARK MULTIPLICITY
    INSIDE THE JET
- **B–PURITY (~7%) (fraction fit)**
  – COMPOSITION OF NO–b
    TEMPLATES
    (b/c/LIGHT RATIOS)
  – SECONDARY VERTEX MASS RECO
    (TRACKING EFFICIENCY IN DATA AND MC)

CDF Run II Preliminary

Total syst. uncertainty (luminosity 6% incl.)
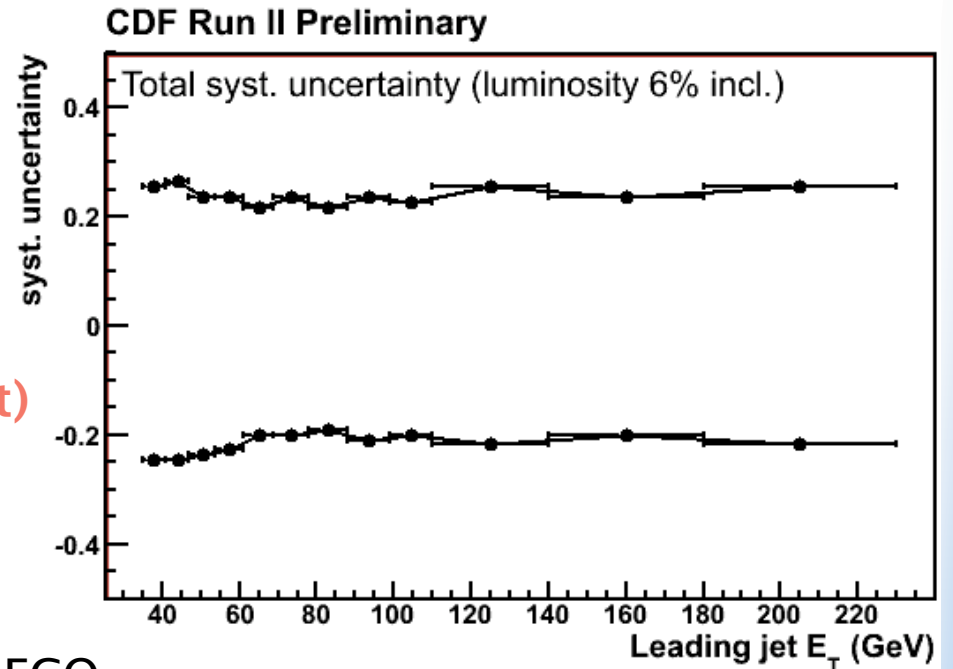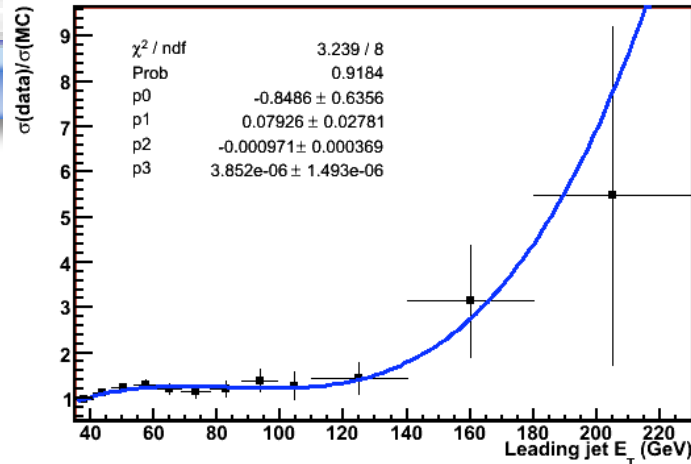
Unfolding

- Compare Et spectrum in data and MC.
- Ratio Data/MC after unfolding data cross section
- Fit ratio to third order polinomial
- Reweight MC
- Calculate new unfolding
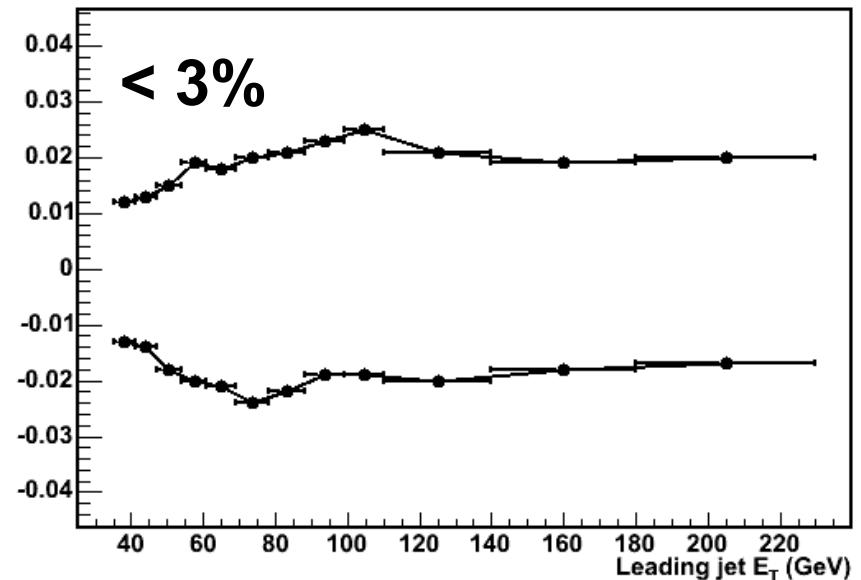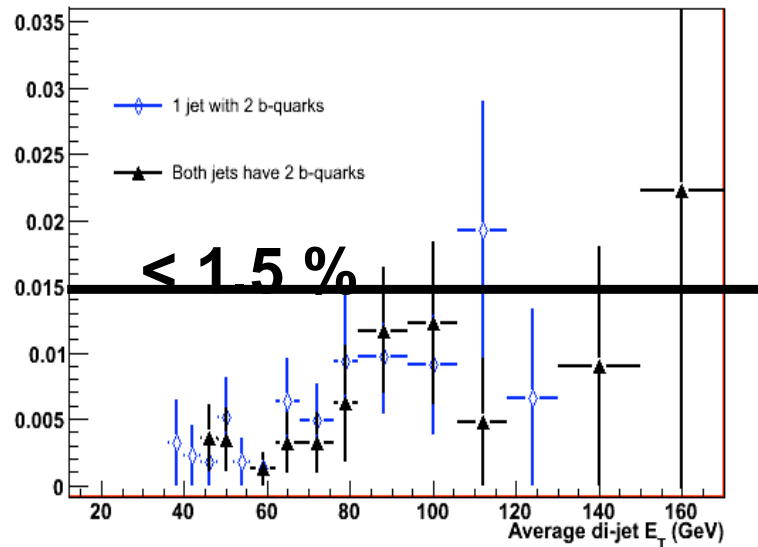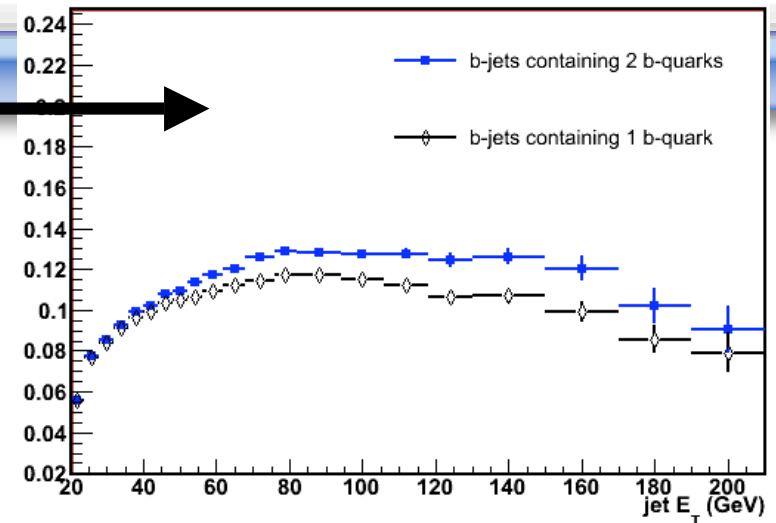- Take the difference as a syst. err.

b multiplicity in the jet

Eff. is different according to b content in the jet

In 2SVT-tagged jets events select couples with:

- **One jet including 2b quarks**
- **Two jets including 2b quarks**

< 1.5 %

< 3%

Bkup

Systematic uncertainties: