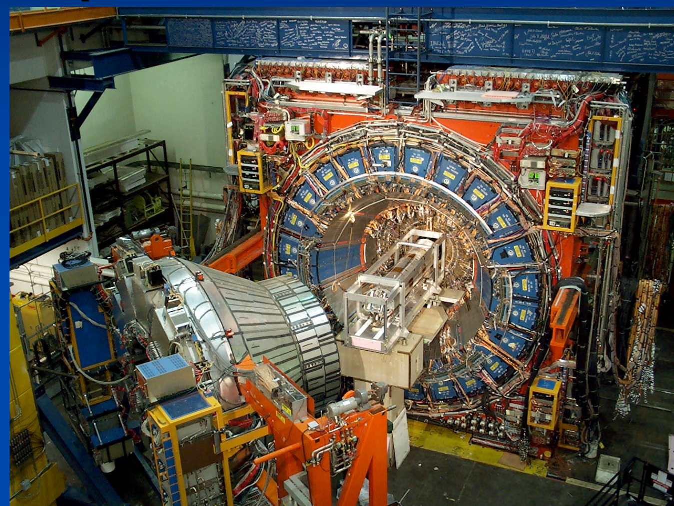
Production of photons and heavy quarks in

Mario Campanelli/ Geneva



Moriond QCD

La Thuile 2007

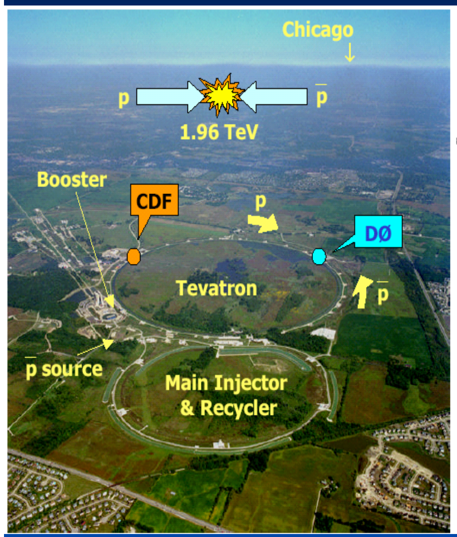
Experimental techniques:

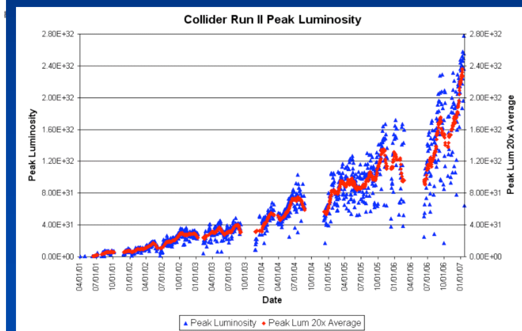
Tevatron and CDF

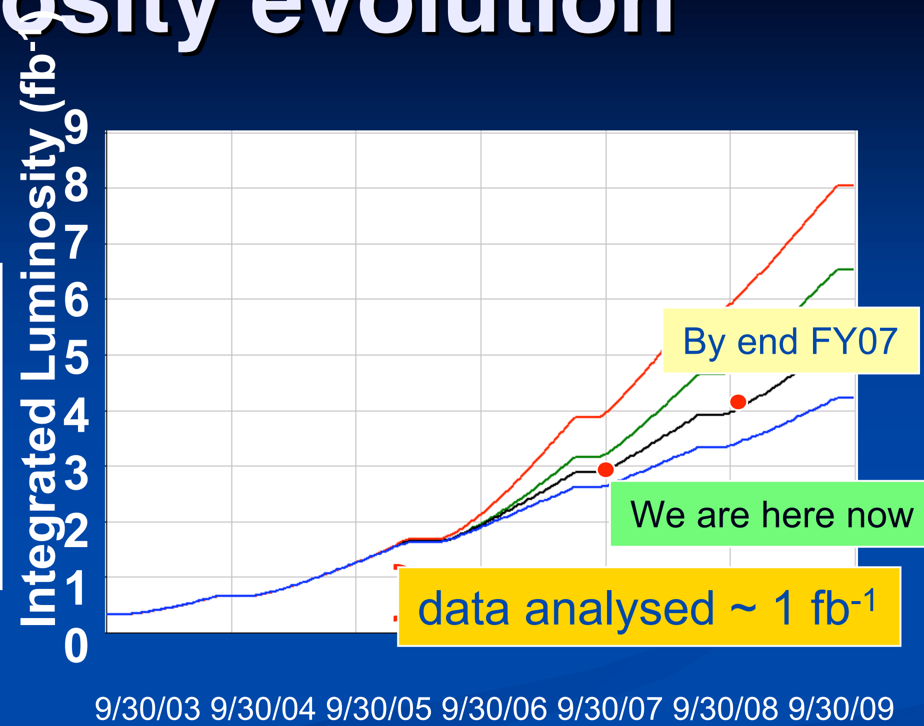
Triggering on b: SVT

Photon + heavy flavor production

Tevatron luminosity evolution



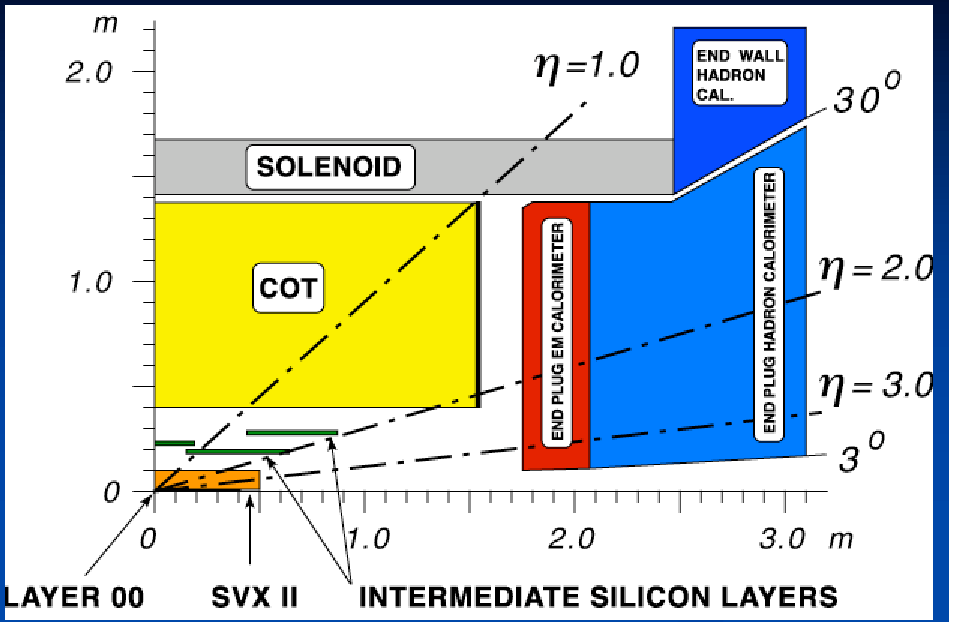


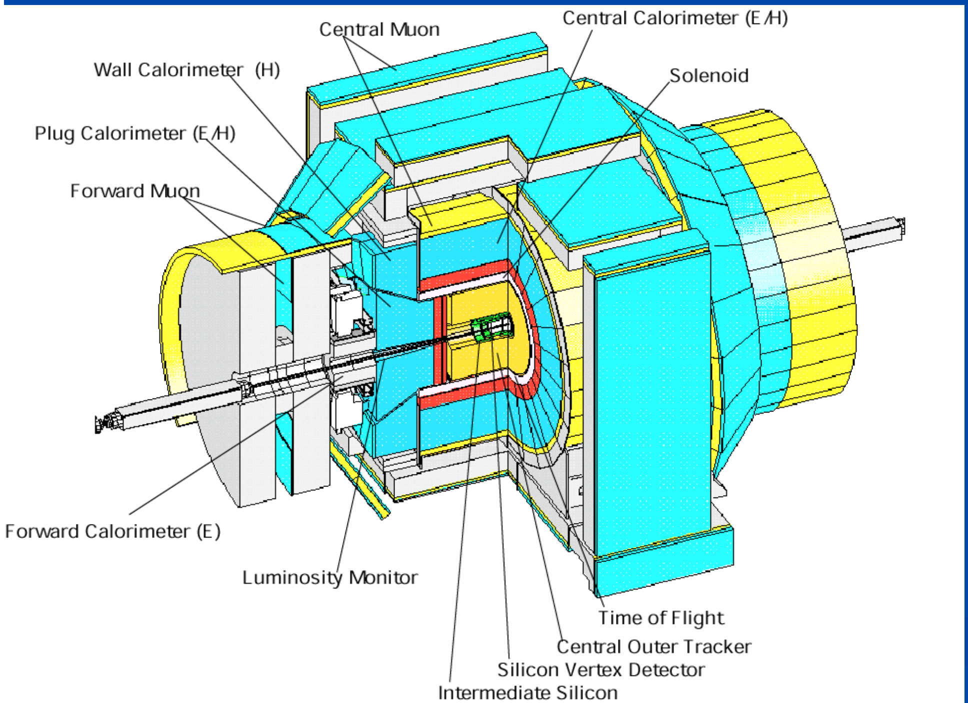


- Highest initial Lum store: $270e^{30}$
- Best integrated Lum week: 45 pb^{-1}
- Best integrated Lum month (January): 165 pb^{-1}
- More than 2 fb^{-1} already collected
- 27 months left before shutdown (Oct'09)

CDF II detector

- CDF fully upgraded for Run II:
  - Si & tracking
  - Extended calorimeters range
  - L2 trigger on displaced tracks
  - High rate trigger/DAQ





Calorimeter

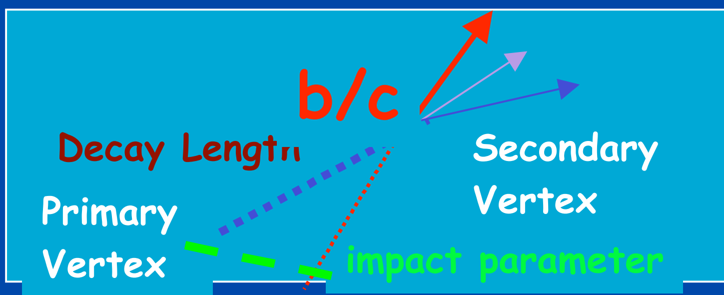
- CEM lead + scint $13.4\%/\sqrt{E_T} \oplus 2\%$
- CHA steel + scint $75\%/\sqrt{E_T} \oplus 3\%$

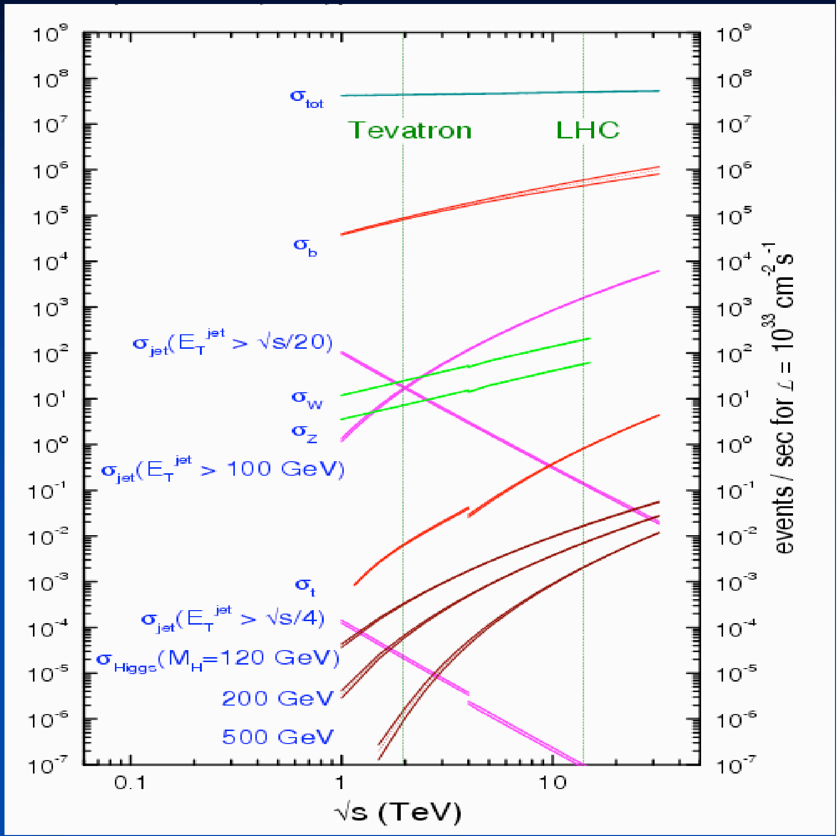
Tracking

- $\sigma(d0)$ = 40μm (incl. 30μm beam)
- $\sigma(pt)/pt$ = 0.15 % pt

B production in hadron colliders

- b production 3-4 orders of magnitude smaller than ordinary QCD; selected by longer lifetime





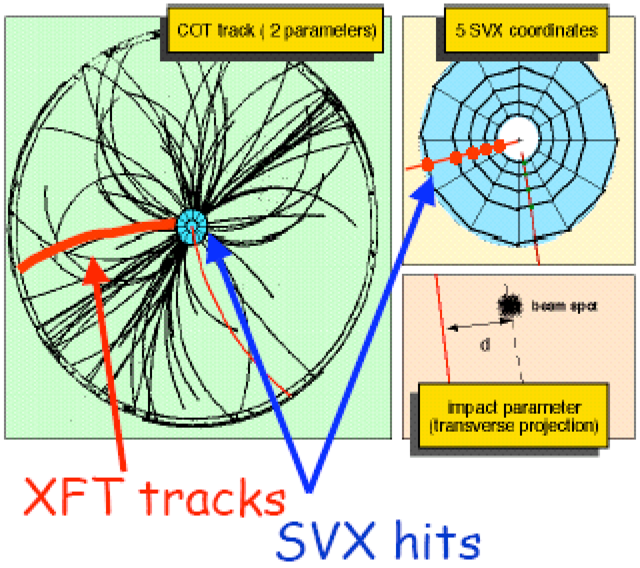
Various strategies:

•High-pt (traditional): take unbiased prescaled triggers, identify b off-line

•Low-pt: use on-line impact-parameter information to trigger on hadronic decays

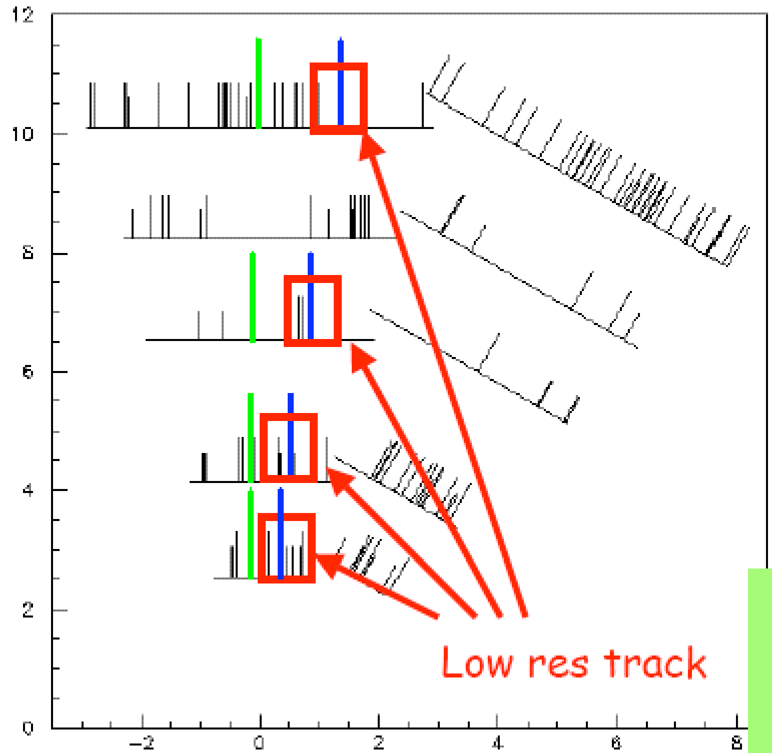
•High-pt (new): b-enriched samples

Silicon Vertex Tracker (SVT)

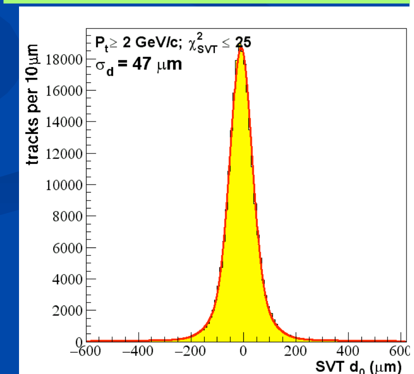


2 steps:
1. Find tracks @ low res: constant time (during readout)
2. Fit hit at full res.: time consuming depending on the number of fits

Finding tracks in the silicon



$35\ \mu m \oplus 33\ \mu m = \sigma \approx 47\ \mu m$ (resolution $\oplus$ beam)



On-line tracking reconstruction allows design of specific triggers for heavy flavors; widely used in low-pt physics, first measurement to use it at high pt

Low-Pt B Physics Triggers

Largely improved

Completely new

Di-muon

$J/\psi \to \mu\mu$

$B \to \mu\mu$

Two muons with:

$p_T(\mu) > 1.5$ GeV/c

One displaced track + lepton (e, μ)

$B \to l\nu X$

Lepton:

$p_T(l) > 4.0$ GeV/c

Track:

$p_T > 2.0$ GeV/c,

$d_0 > 120\ \mu m$

Two displaced tracks

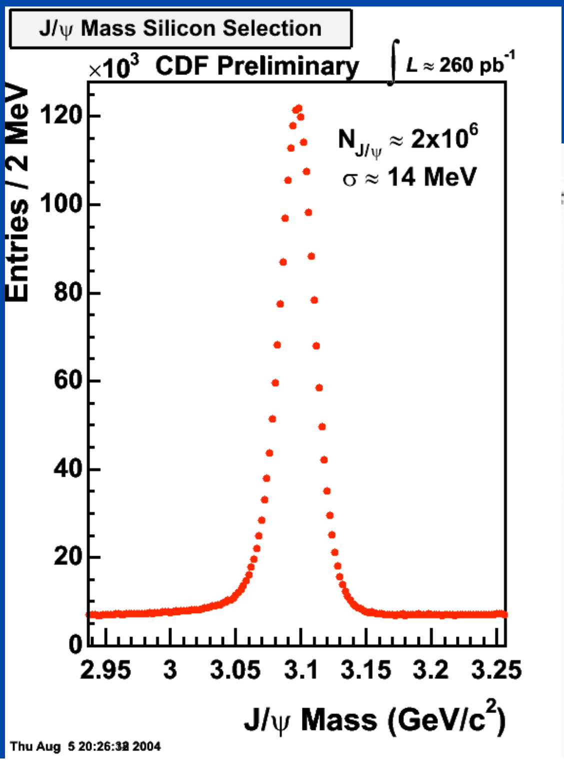
$B \to hh$

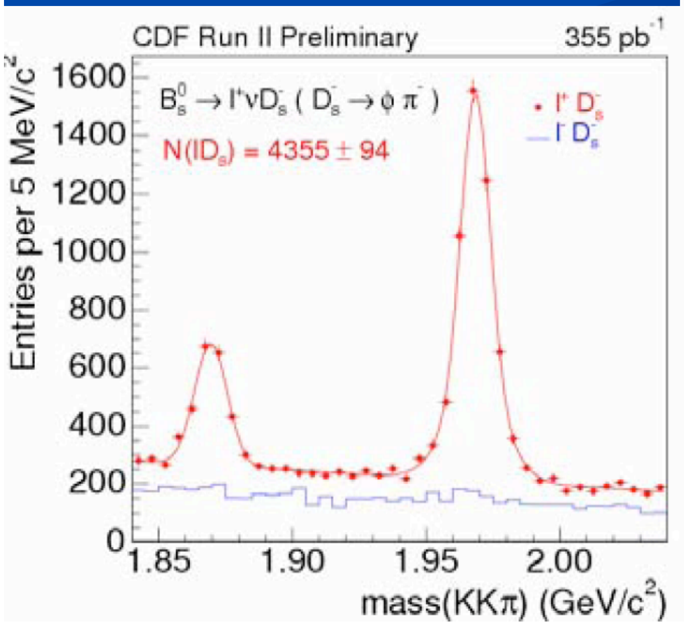
Two tracks with:

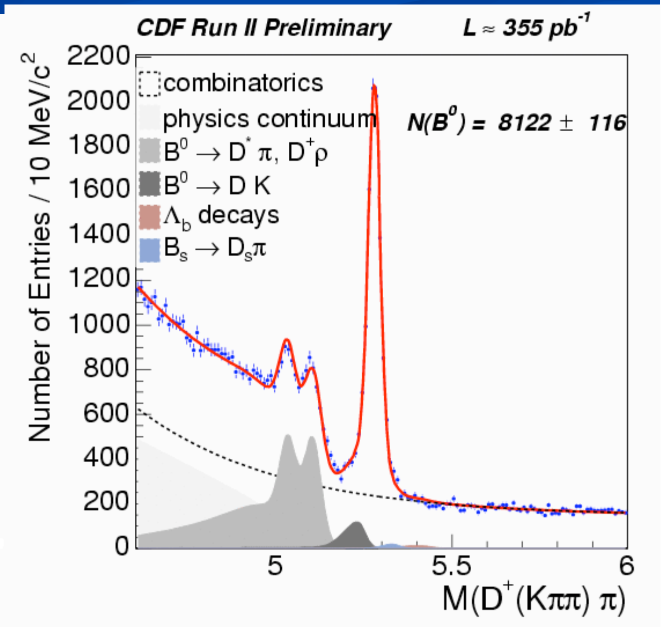
$p_T > 2.0$ GeV/c

$\Sigma p_T > 5.5$ GeV/c

$d_0 > 100\ \mu m$



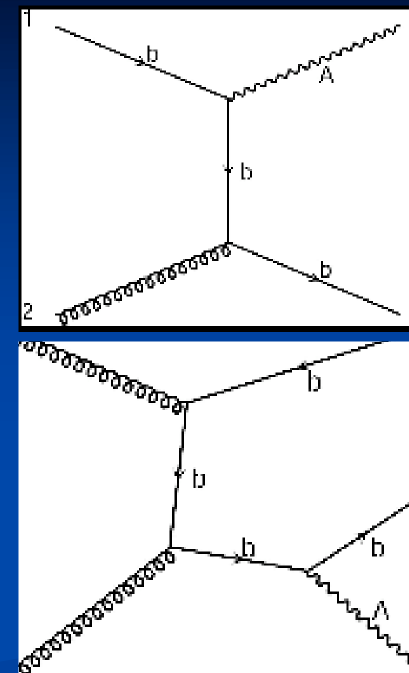




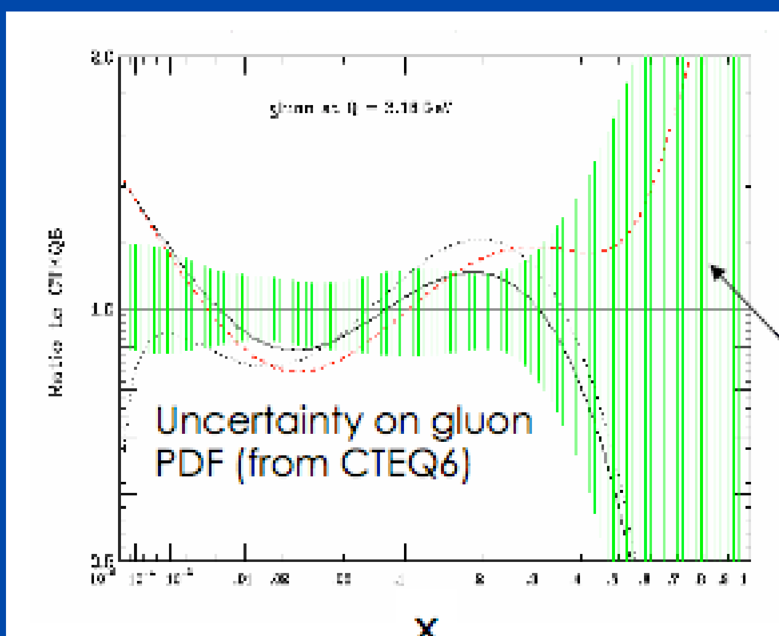
Using the SVT at high Pt

- Apart from its main use on b-decay physics, SVT-based datasets can be used at high Pt. We have several trigger paths that use SVT information to enhance b content in high-Pt events.
- Conceived to search for new physics, we are now analyzing these datasets to measure QCD properties:
  - PHOTON_BJET
    - A photon with Et>12 GeV
    - A track with |d0|>120 μm
    - A jet with Et>20 GeV (eff. about 30% on b_ candidates)
  - HIGH_PT_BJET
    - 2 tracks with |d0|>120 μm
    - 2 jets with Et>20 GeV

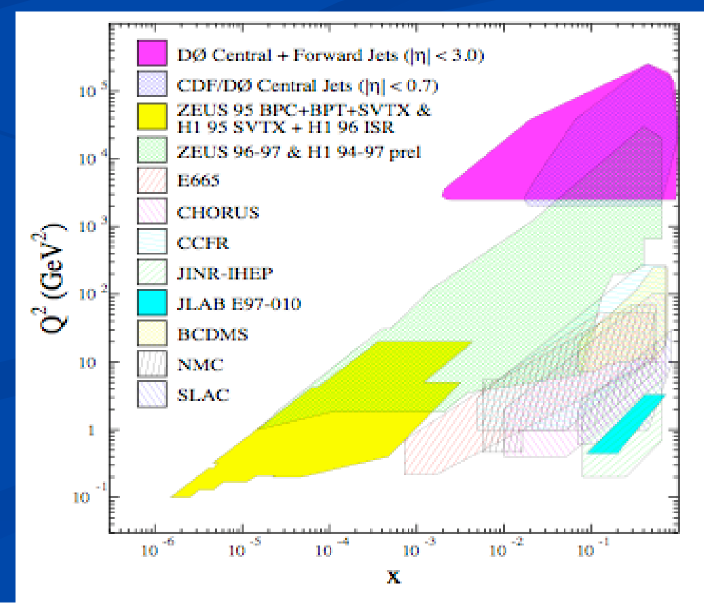
Measuring b + γ: motivations



- New physics: couples mainly to third generation, photons can be produced in radiative decays of heavy states
- QCD: sensitive to PDF's of b extrapolated from gluon (high uncertainty at high x, region probed at Tevatron)



Large uncertainties!

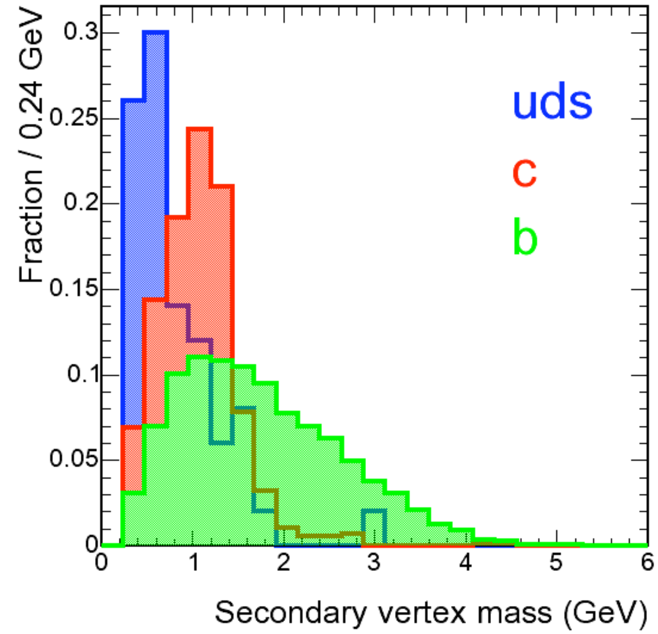


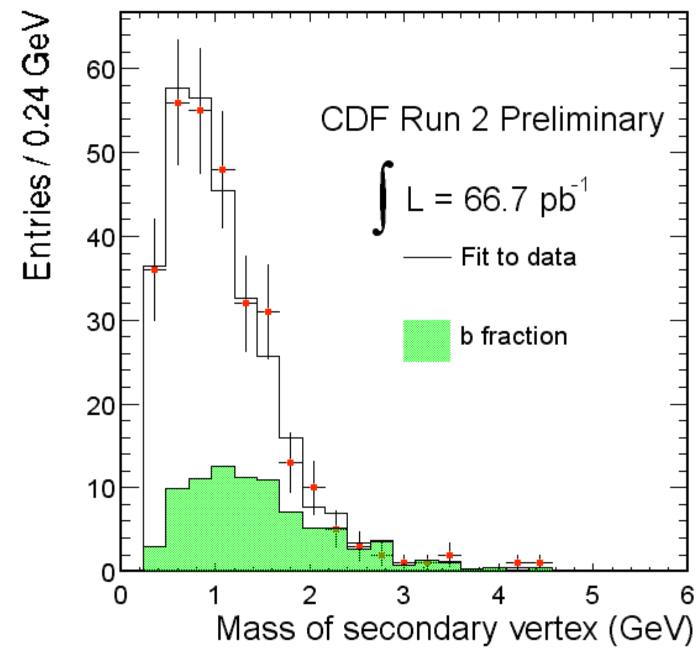
Photon + b/c Analysis - old style

Use Et > 25 GeV unbiased photon dataset, without jet requirements at trigger level:

Off-line cuts:

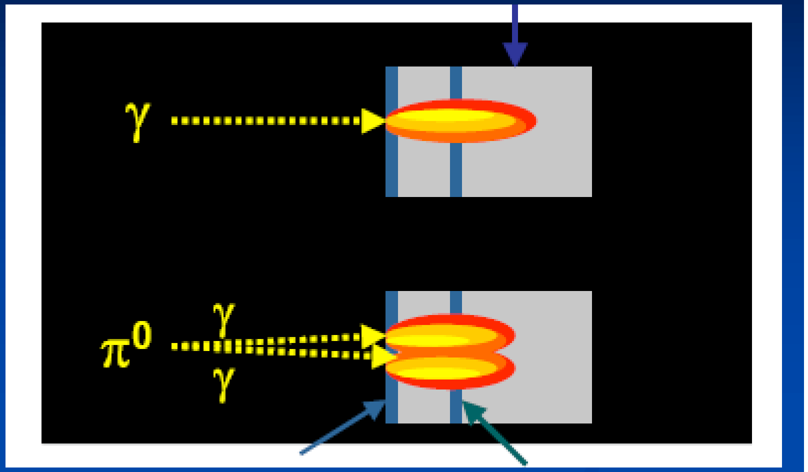
- $|\eta(\gamma)|<1.0$
- jet with secondary vertex
- Determine b, c, uds contributions
- Subtract photon background using shower shape fits

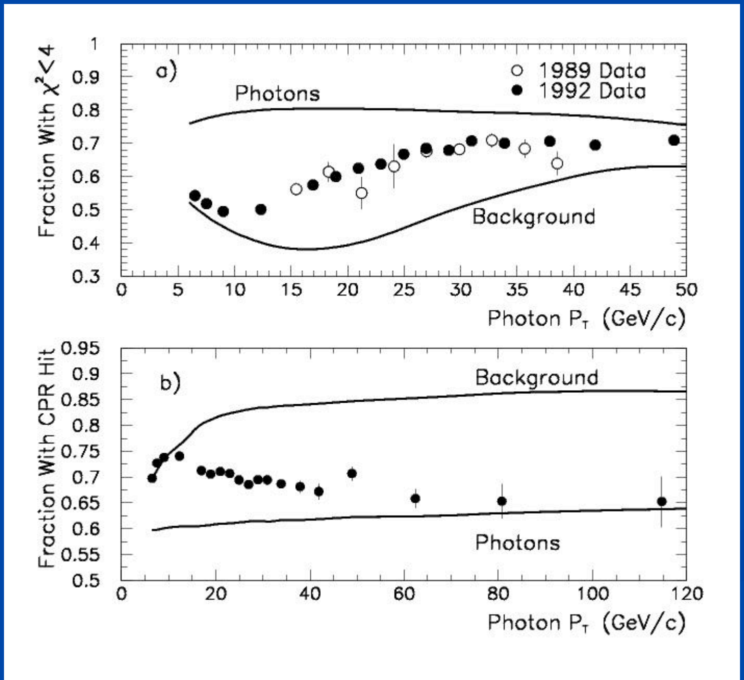




Photon identification

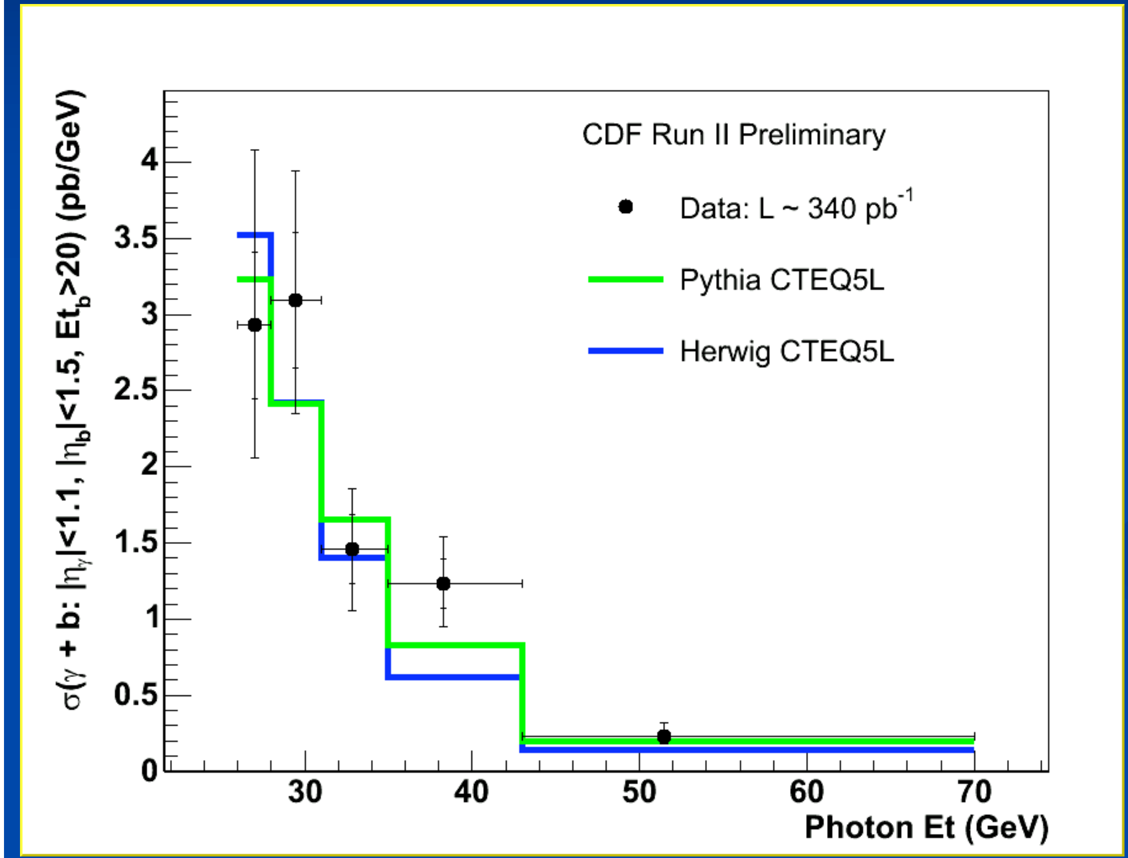
No event-by-event photon identification possible: only statistical separation based on shower shape measured by tracking devices inside the calorimeter





Photon purities as a function of Et taken from test-beam data

First Run II photon + b result



Data:

42.0 ± 3.8+8.8 -7.0 pb

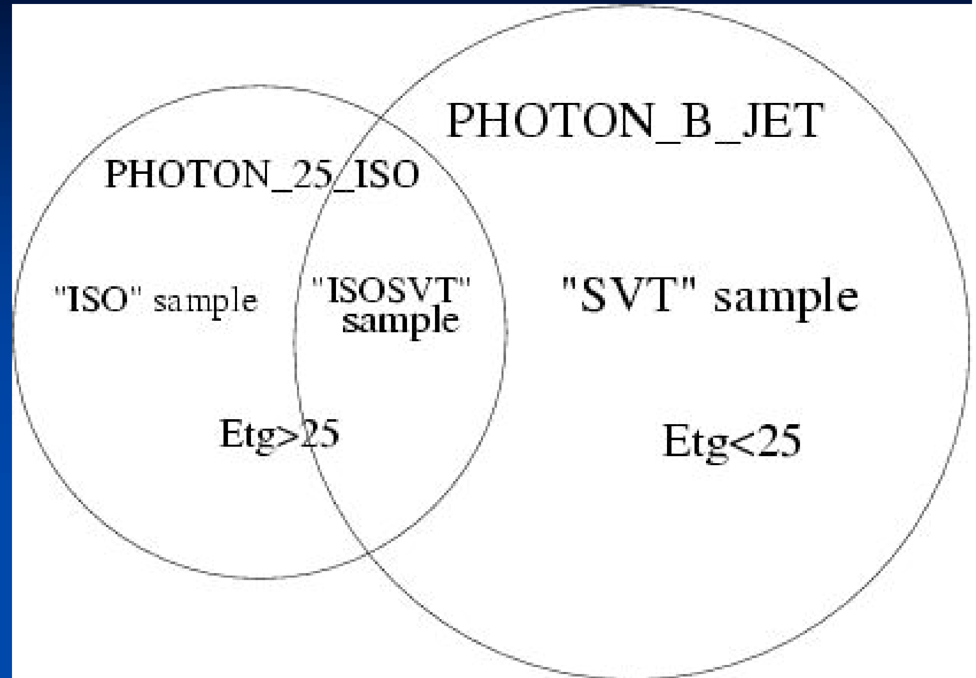
Pythia: 33.6 ± 0.3 pb

HERWIG: 29.5 ± 0.3 pb

Cross sections and ratio agree with LO predictions from MC.

Then new b + photon analysis

Using the SVT-based dataset PHOTON_B_JET the trigger threshold on photon Et can be lowered from 25 to 12 GeV without prescale!



$$\sigma_{ISO} = N_{ISO} f^{b}_{ISO} / \epsilon^{tag}_{ISO} / \mathcal{L}$$

$$\sigma_{SVT} = N_{SVT} f^{b}_{SVT} / \epsilon^{tag}_{SVT} / \epsilon^{trig}_{SVT} / \mathcal{L}$$

Requires trigger simulation

Hard to calculate

Trigger efficiency can be computed directly from data using the overlap region (ISOSVT), where events have photon Et above 25 GeV and an SVT track

Analysis strategy

What we need in the end is:

- perform the analysis on the unbiased dataset

- do the same on SVT-based events with Level 3 trigger Et(γ)>25 GeV

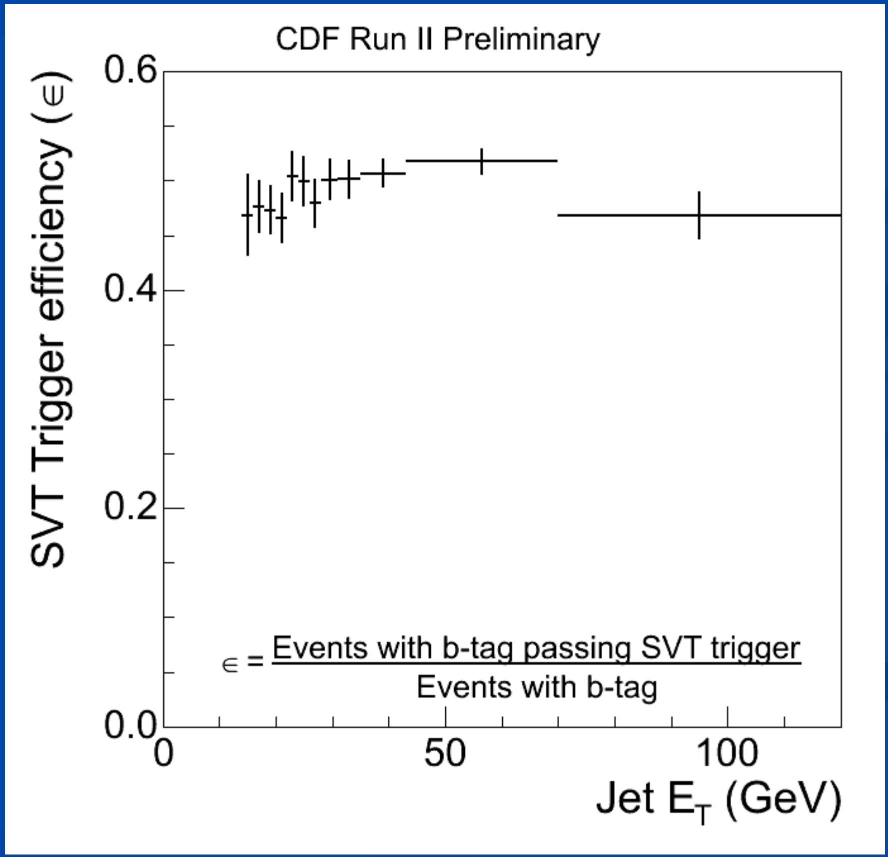
- use their ratio to extrapolate to the low photon Et region.

This only requires the hypothesis that the jet quantities are independent on the photon energy

Trigger efficiency: Et dependence

Quite stable over time

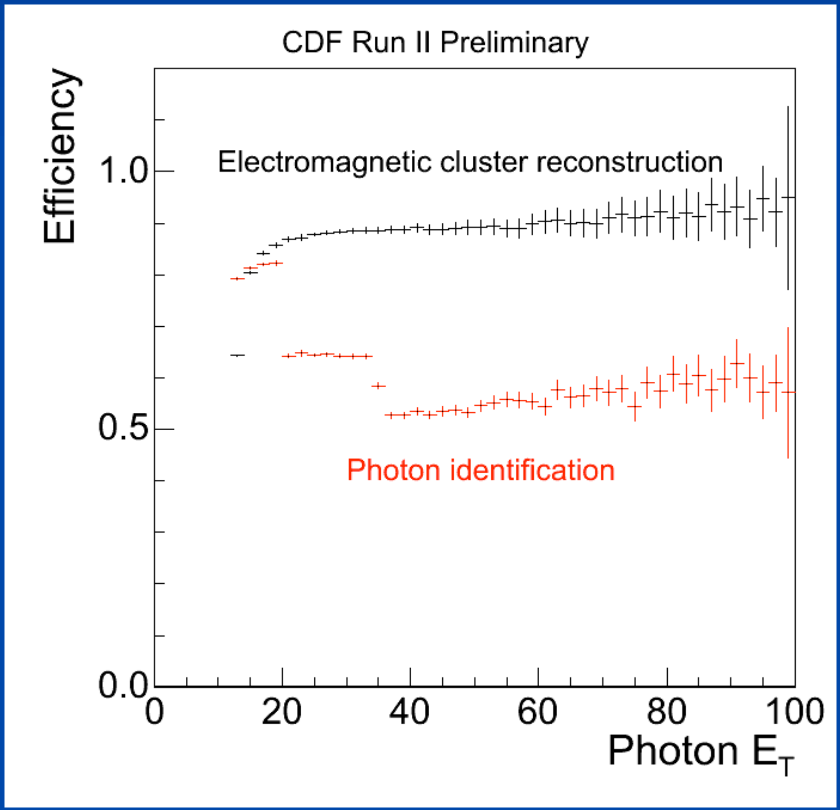
what we really use is the efficiency as a function of Et for the various bins (also quite stable), and calculated for tagged jets

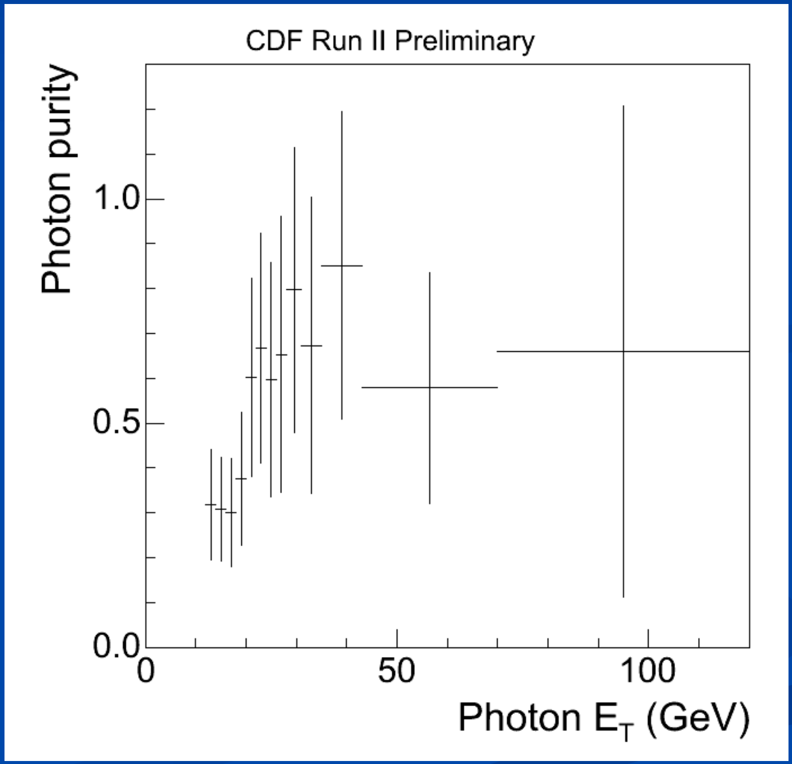


Photon and b efficiency and purity

Photon efficiencies estimated with Pythia MC;

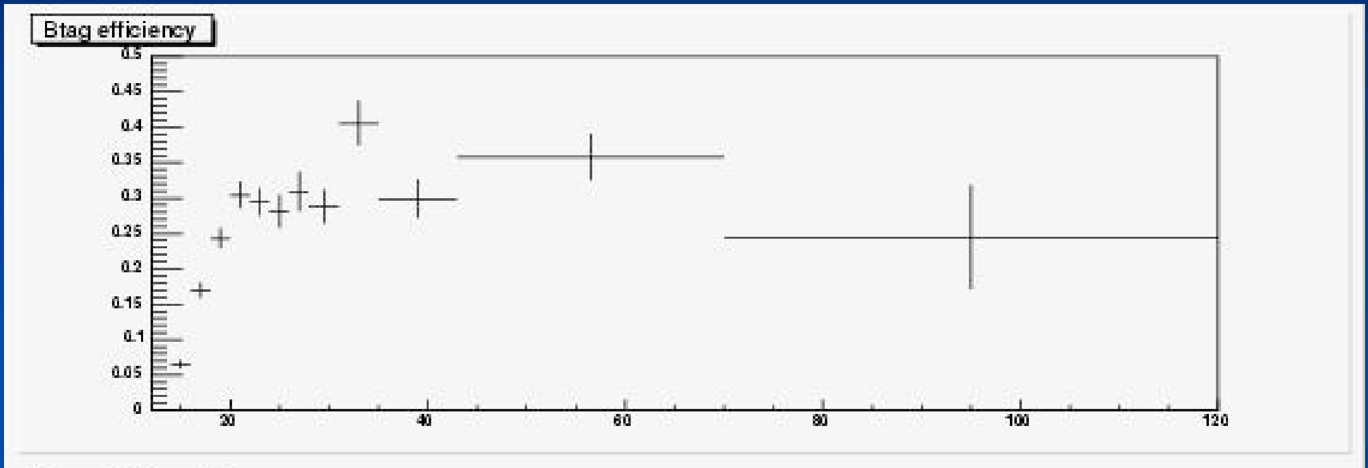
Purity is calculated using fits to the CES/CPR shape distributions

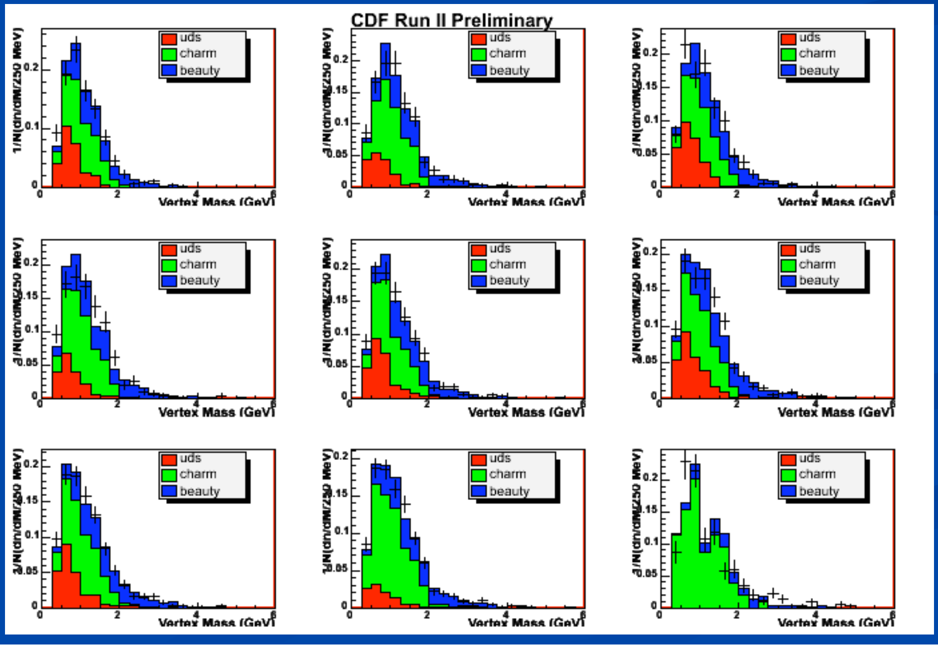


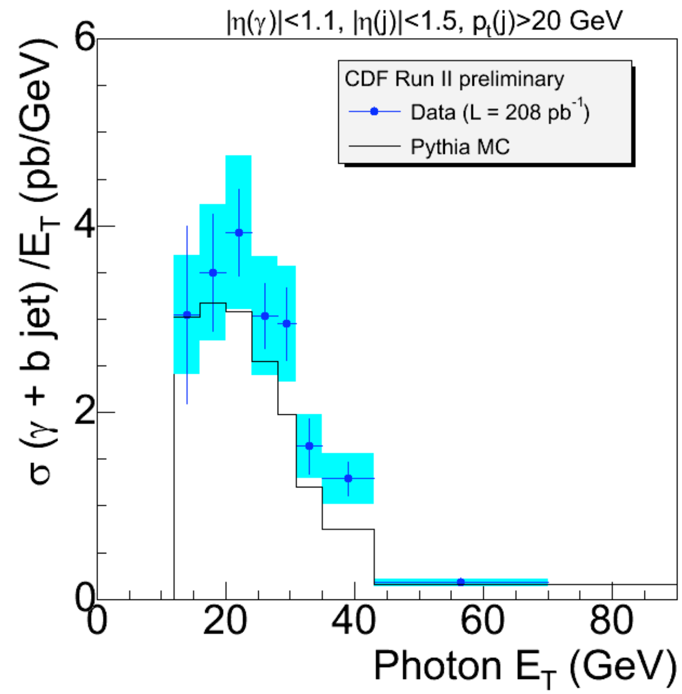


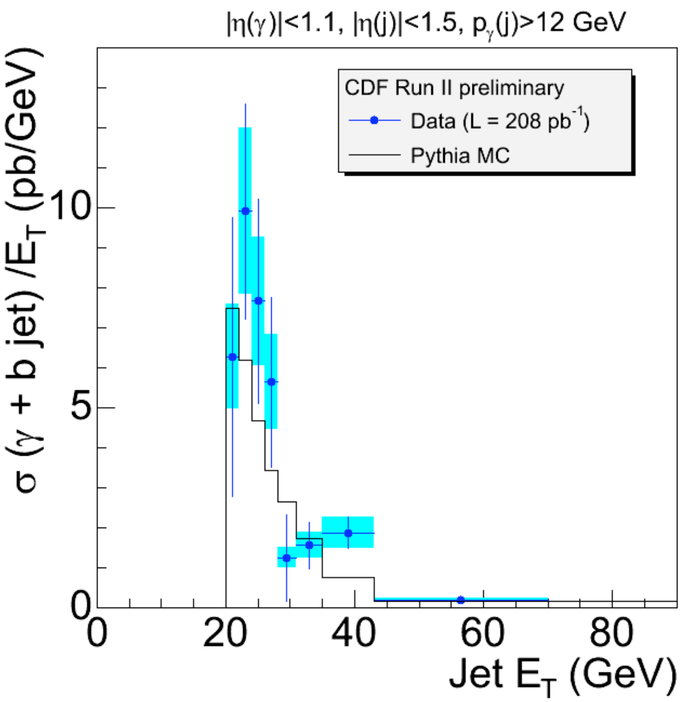
B efficiency and purity

B efficiency from MonteCarlo, purity from secondary vertex mass









B-photon cross section

Very good agreement with previous measurement based on PHOTON_25_ISO (~45% candidate overlap)

Data:

90.5 ± 6.0 (stat.) +21.7 -15.4 (syst) pb

Pythia gen. Level: 69.3 pb

- Luminosity: 6%
- Trigger efficiency extrapolation (from statistics):10%
- Jet energy scale: 4% (NIM **A566:375-412,2006**)
- Tracking efficiency inside jet
- B purity templates: +20% -10%

Conclusions

B-photon cross section was measured in the SVT-based dataset using the unbiased trigger as normalization channel

Measurement performed down to photon Et of 12 GeV

A bit higher than LO predictions, as many other measurements involving b quarks. Waiting for comparisons with NLO

B purity systematics already dominate for the total cross-section, almost for single bins.

New methods being developed to reduce systematic errors even reducing the sample

SVT-based datasets start to have an impact also on high-Pt physics (also bb, Higgs searches etc.)