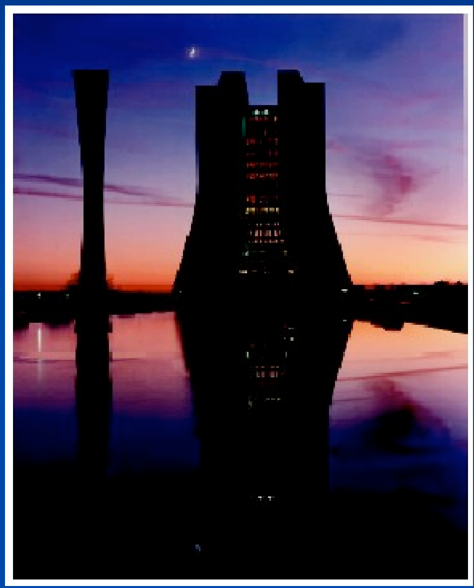
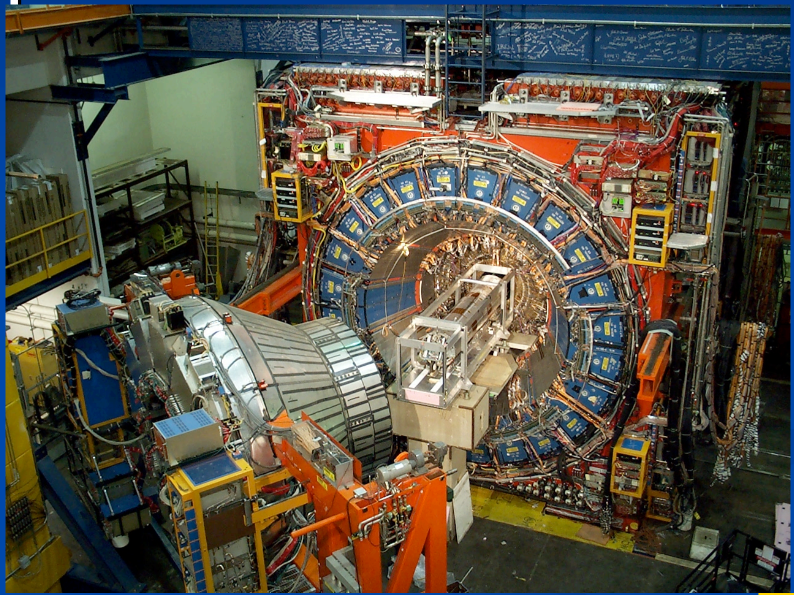
Production of photons and heavy quarks in

Mario Campanelli/ Geneva





DPF'06 Waikiki, Hi

Experimental techniques:

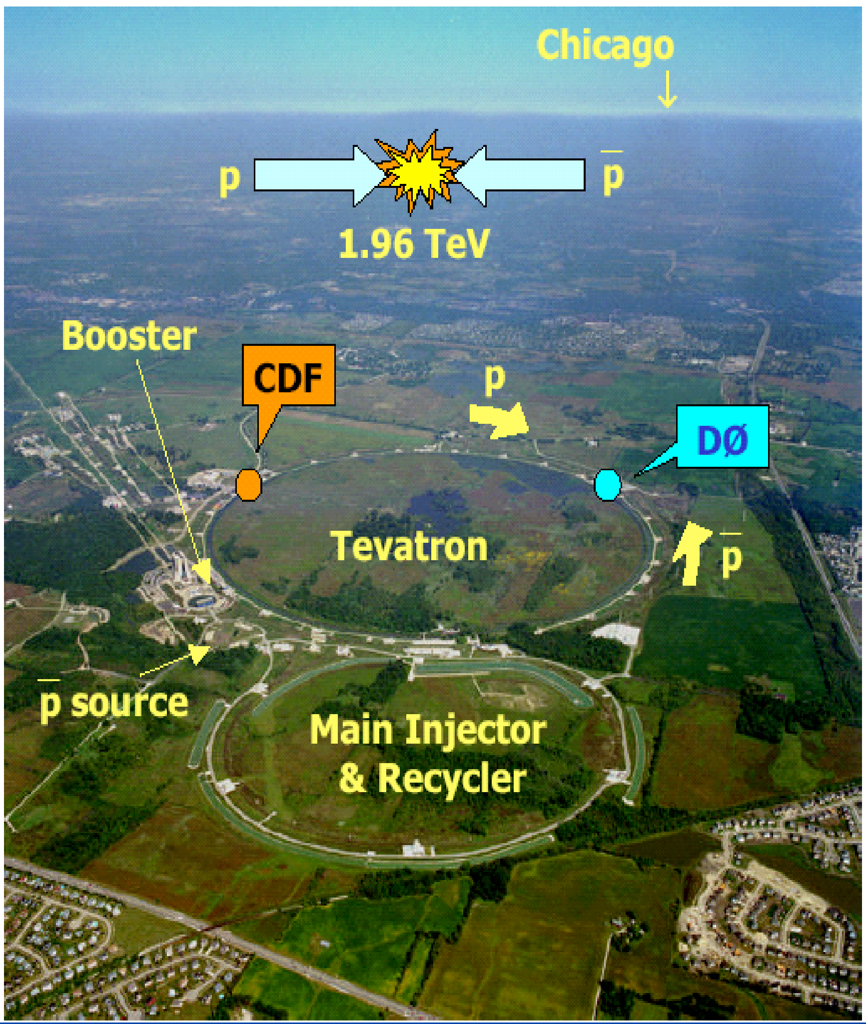
Tevatron and CDF

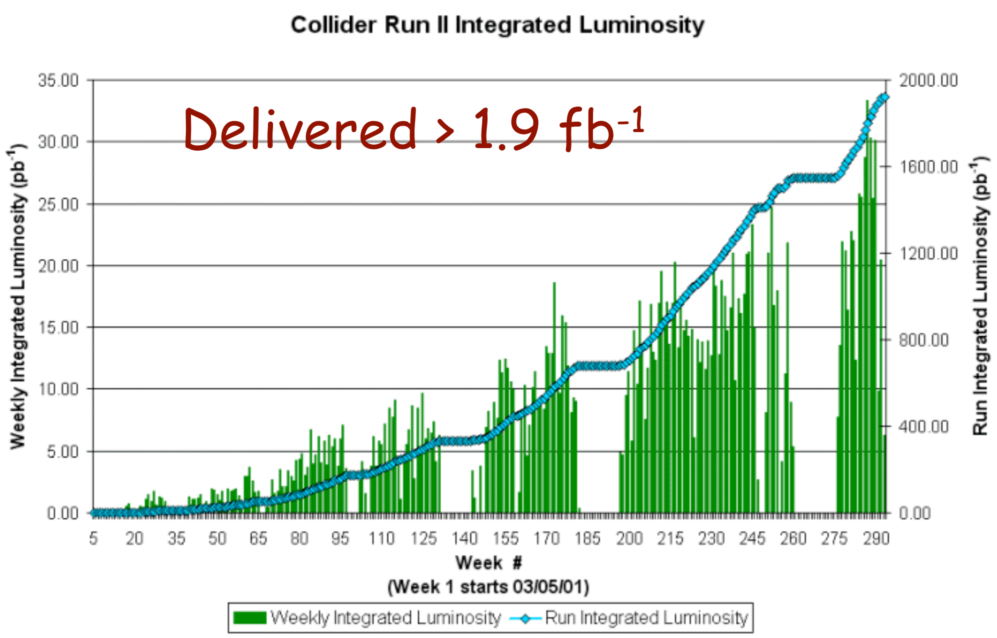
Triggering on b: SVT

Photon + heavy flavor production

The Tevatron

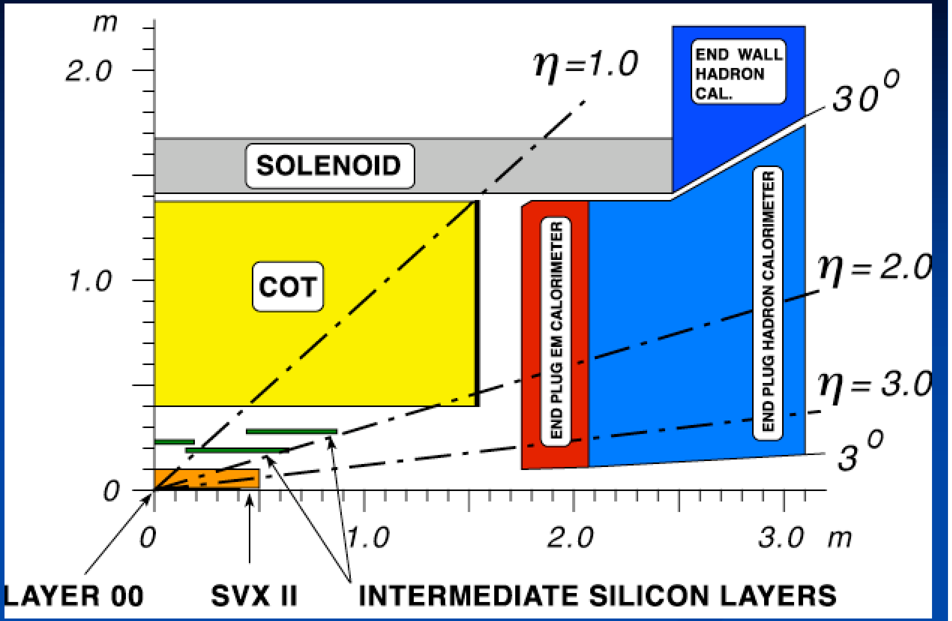
- World's largest hadron collider
- $\sqrt{s}$ = 1.96 TeV
- Peak lum >200E30
- >1.9 fb^{-1} delivered
- This analysis ~ 200 pb^{-1}

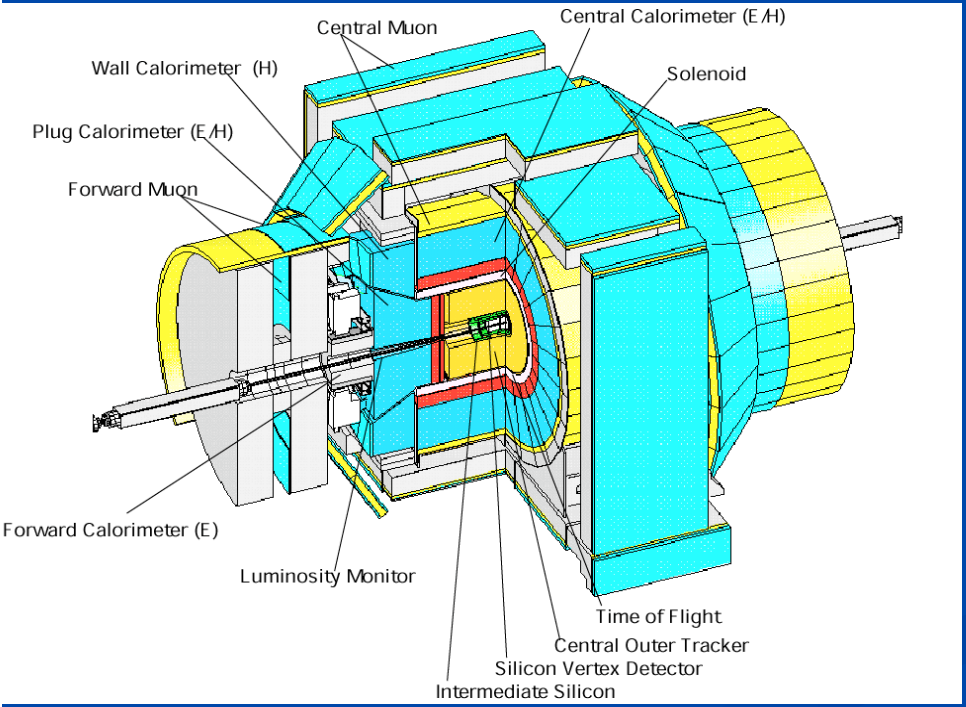




CDF II detector

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





Calorimeter

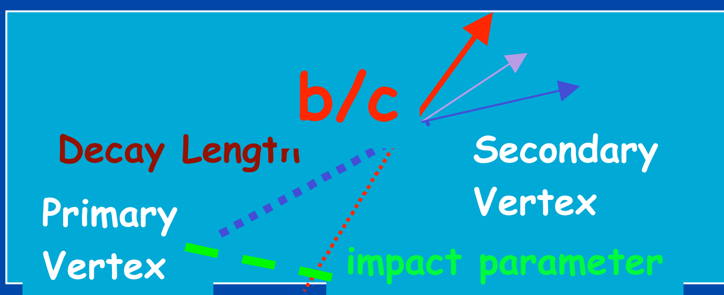
- CEM lead + scint 13.4%/$\sqrt{E_T}\oplus$2%
- CHA steel + scint 75%/$\sqrt{E_T}\oplus$3%

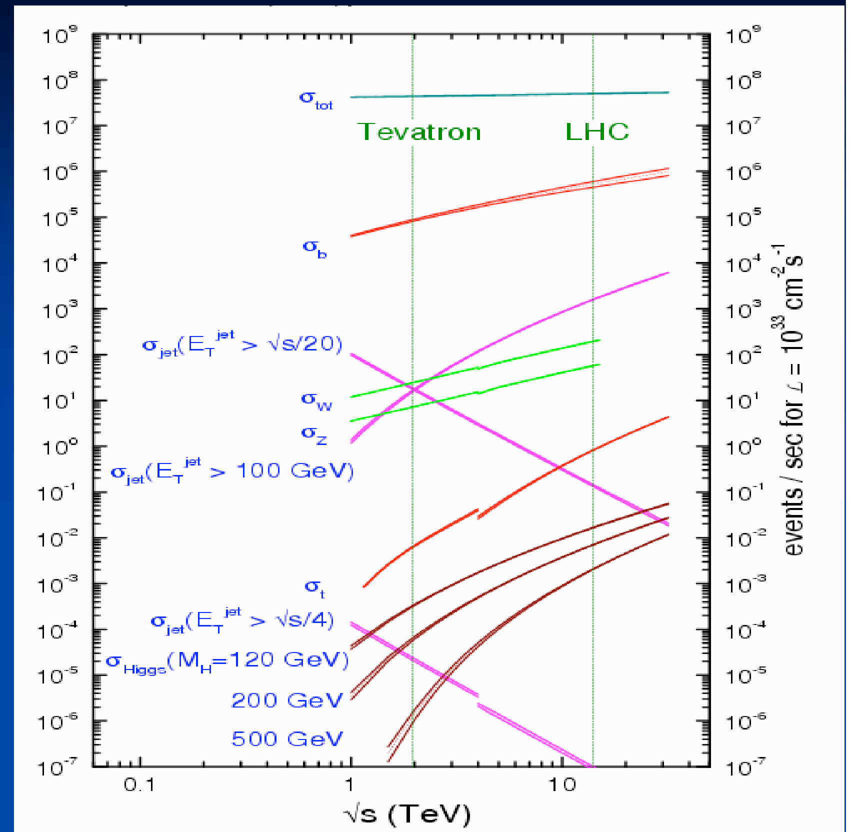
Tracking

- σ(d0) = 40μm (incl. 30μm beam)
- σ(pt)/pt = 0.15 % pt

The experimental challenge

- b production 3-4 orders of magnitude smaller than ordinary QCD; selected by longer lifetime
- c slightly higher but more difficult to isolate





Various strategies:

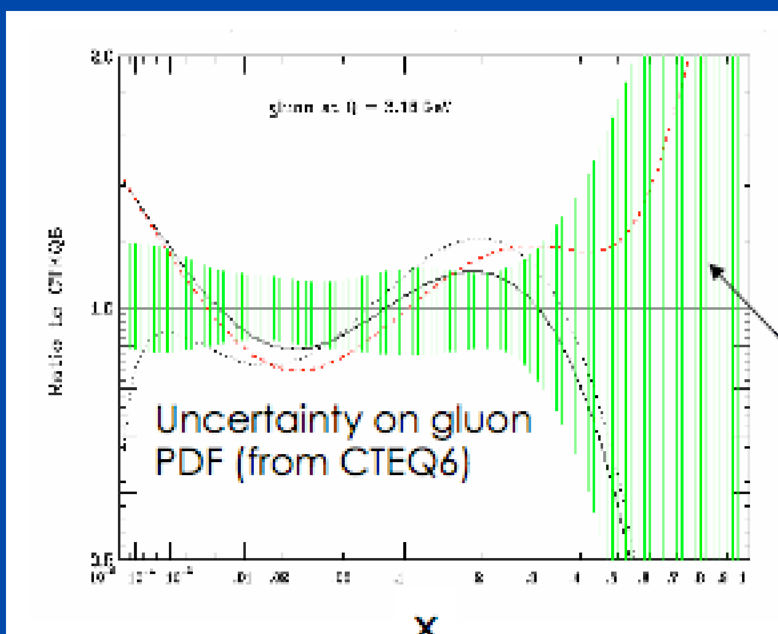
•High-pt (traditional): take unbiased prescaled triggers, identify b off-line

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

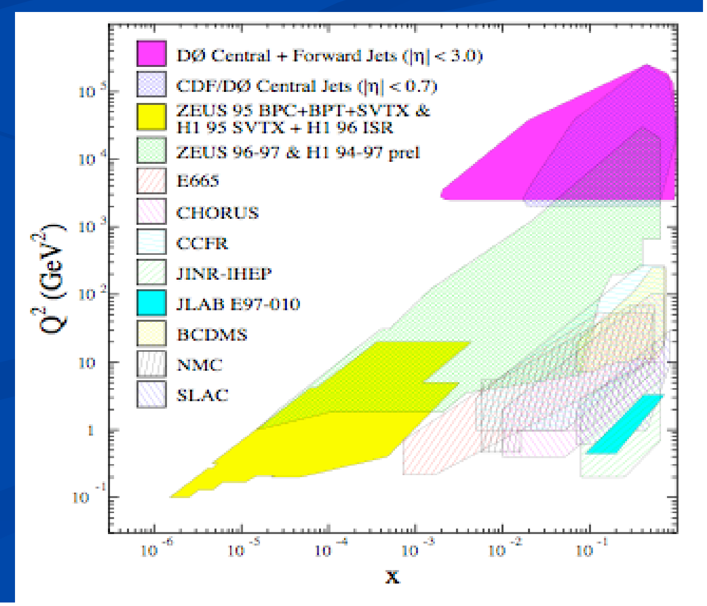
•High-pt (new): b-enriched samples

Motivations

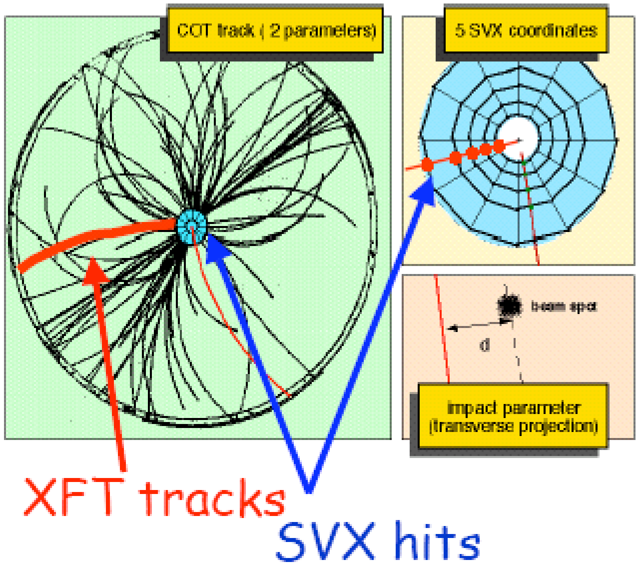
- New physics: couples mainly to third generation, photons can be produced in radiative decays of heavy states
- QCD: sensitive to Pdf of b extrapolated from gluon (high uncertainty at high x, region probed at Tevatron



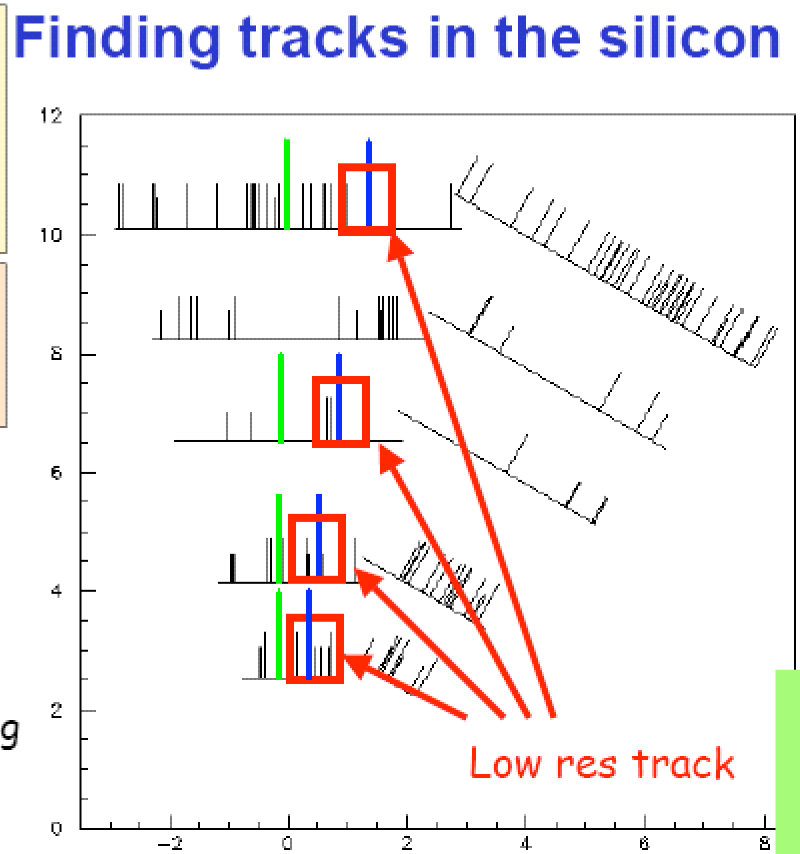
Large uncertainties!



Silicon Vertex Tracker (SVT)

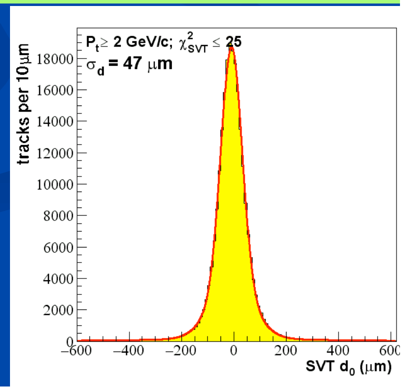


2 steps:
1. Find tracks @ low res: constant time (during readout)
2. Fit hit at full res.: time consuming depending on the number of fits



35 μm ⊕ 33 μm = σ≈47 μm (resolution ⊕ 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



Two-track trigger

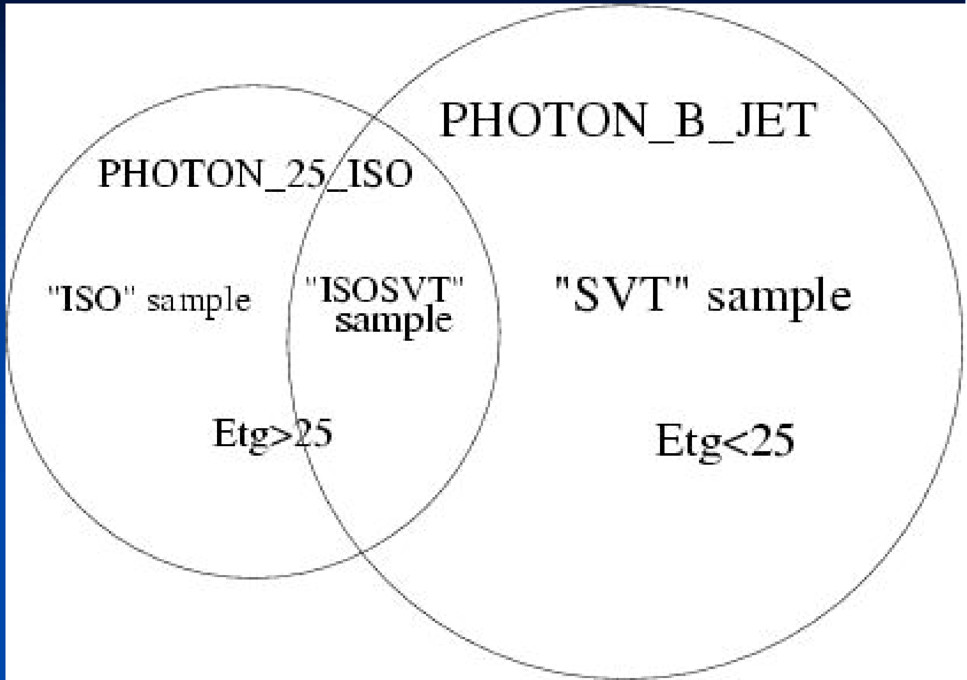
- Level 1:
  - two XFT tracks with $pT > 2$ GeV
  - $pT_1 + pT_2 > 5.5$ GeV
- Level 2:
  - $120\ \mu m < |d_0| < 1\ mm$ for each track
  - Opening angle $2^\circ < |\Delta\phi| < 90^\circ$
  - $Lxy > 200\ \mu m$

Fully hadronic b decays; other trigger paths still using SVT information exist for semileptonic and leptonic channels

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 two 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 _m
    - A jet with Et>20 GeV (eff. about 30% on b_ candidates)
  - HIGH_PT_BJET
    - 2 tracks with |d0|>120 _m
    - 2 jets with Et>20 GeV

Analysis strategy for PHOTON_BJET



Carried on in parallel on unbiased dataset PHOTON_25_ISO and SVT-based PHOTON_B_JET.

Samples overlap in region with SVT track and $E_t^\gamma > 25$.

Cross sections for “ISO” and “SVT”:

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

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

Requires trigger simulation

Hard to calculate

..but cross section in “ISOSVT” overlap region has to be the same as “ISO” after trigger efficiency correction

->trigger efficiency taken from data

Analysis strategy

What we need in the end is:

• perform the analysis on the unbiased dataset

• do the same on SVT-based events with $E(L3\gamma)>25$ GeV

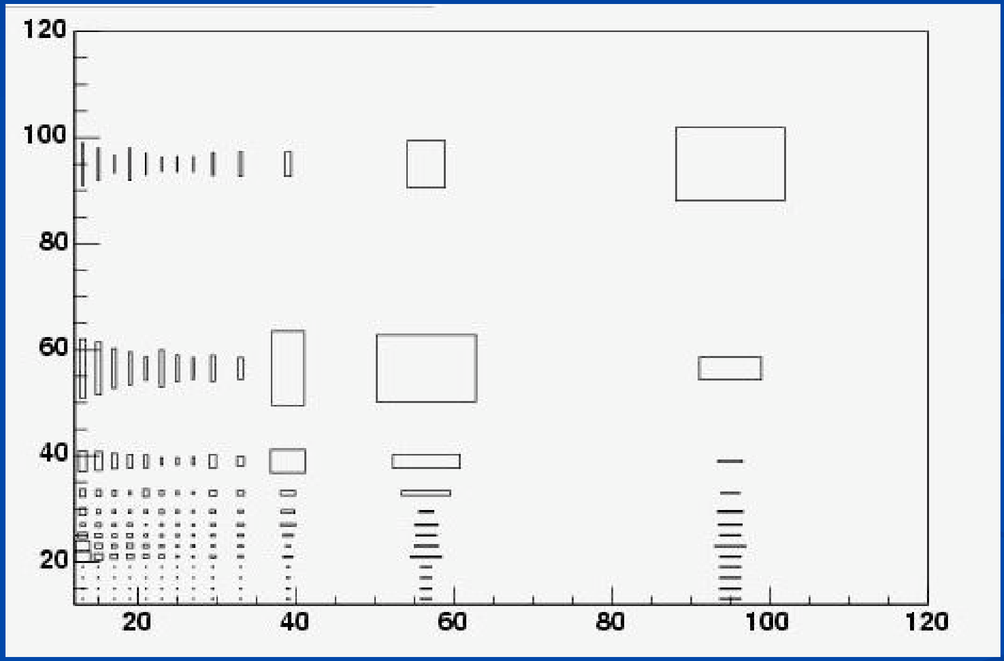
• use their ratio to extrapolate to the low photon Et region.

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

(of course correlation between photon and Et distributions are present and accounted for!)

Data treatment

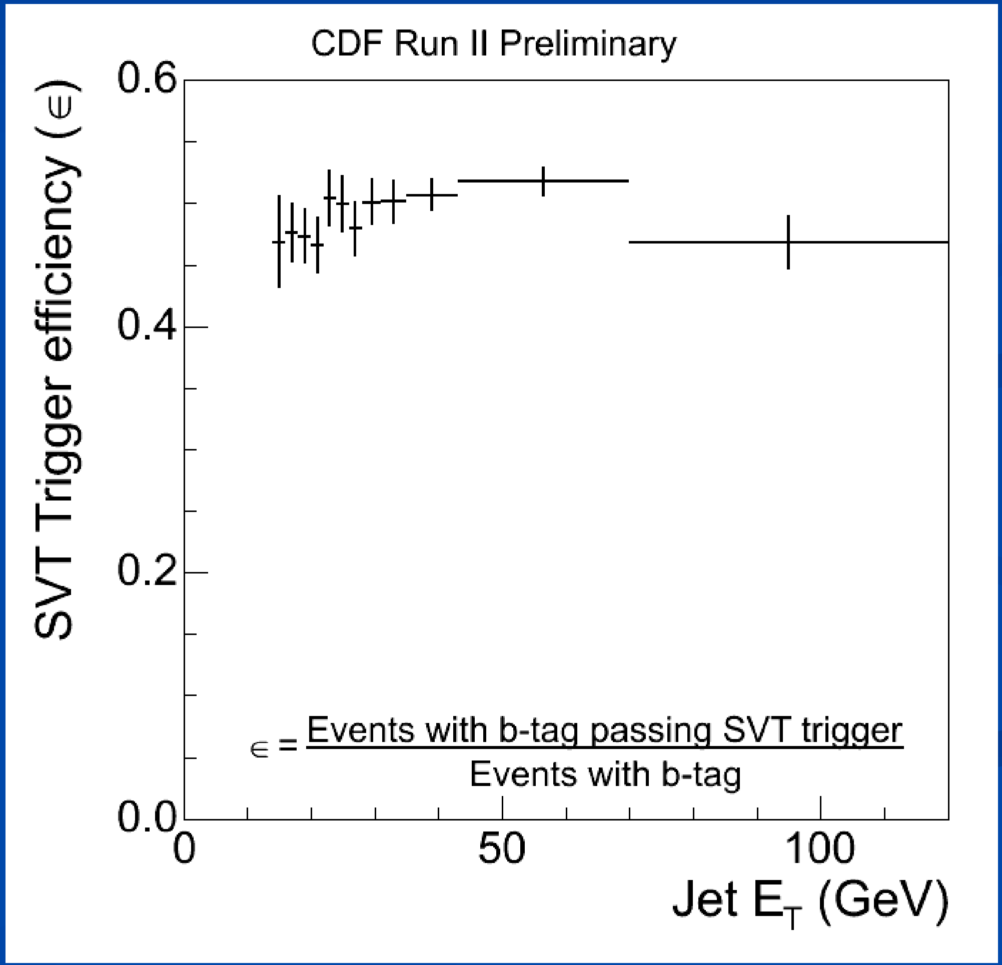
Events passing photon cuts and have a b-tagged jet are stored into a 2d histogram with asymmetric bins



Columns and rows are multiplied by efficiencies and purities for jets and photons, then resulting 2d histo projected on either axis

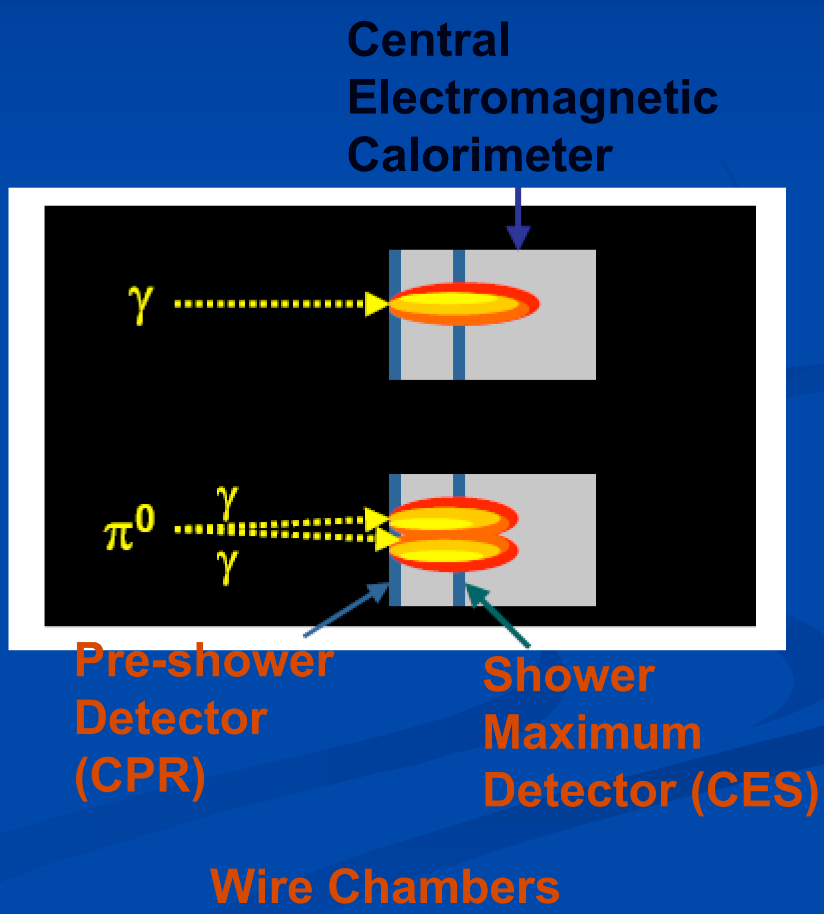
Trigger efficiency: Et dependence

Being quite stable with run number, what we really use is the efficiency as a function of Et for the various bins (also quite stable), and calculated for tagged jets (does not require photons to pass offline quality cuts, it should be independent)



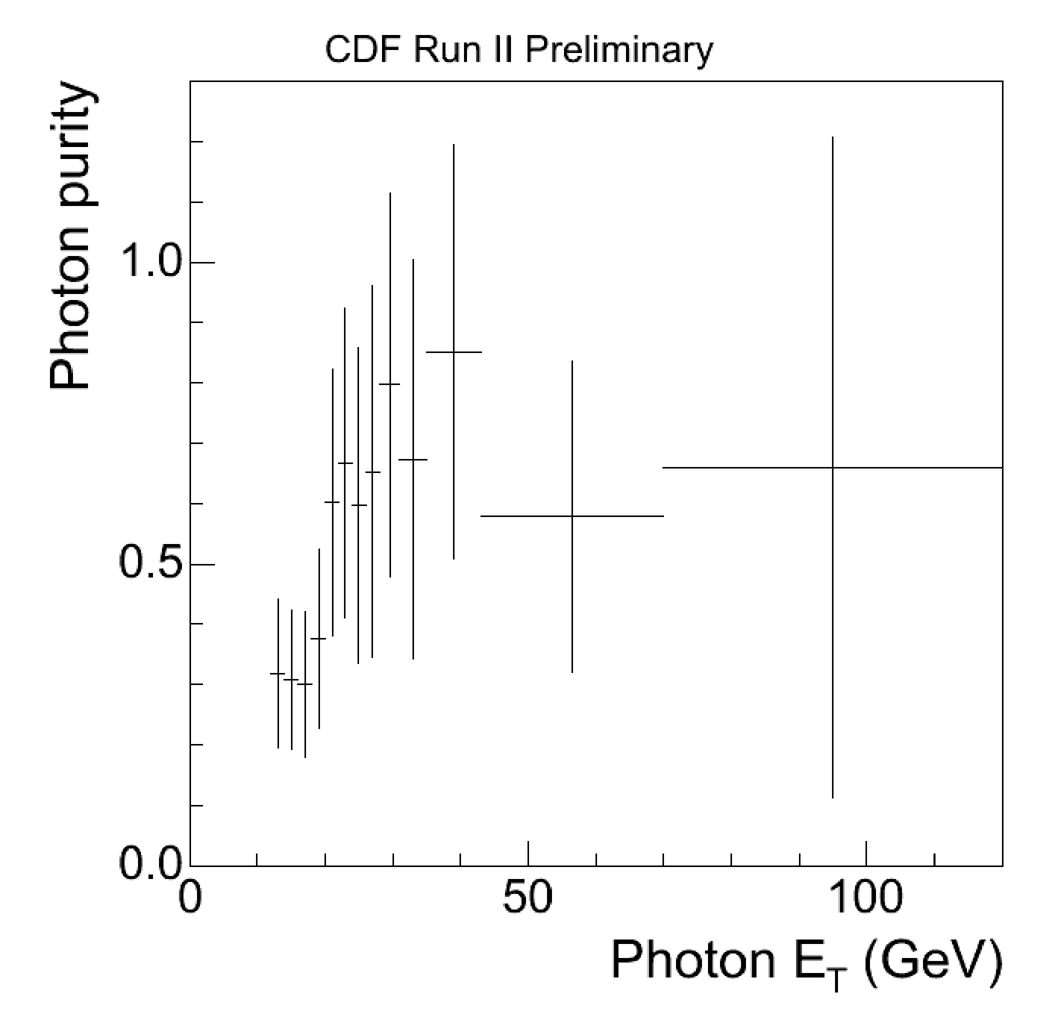
Photon identification

- No event-by-event photon identification possible: only statistical separation based on shower shape in electromagnetic calorimeter



Photon selection

Standard cuts for photon are used, and purity is calculated using fits to the CES/CPR shape distributions

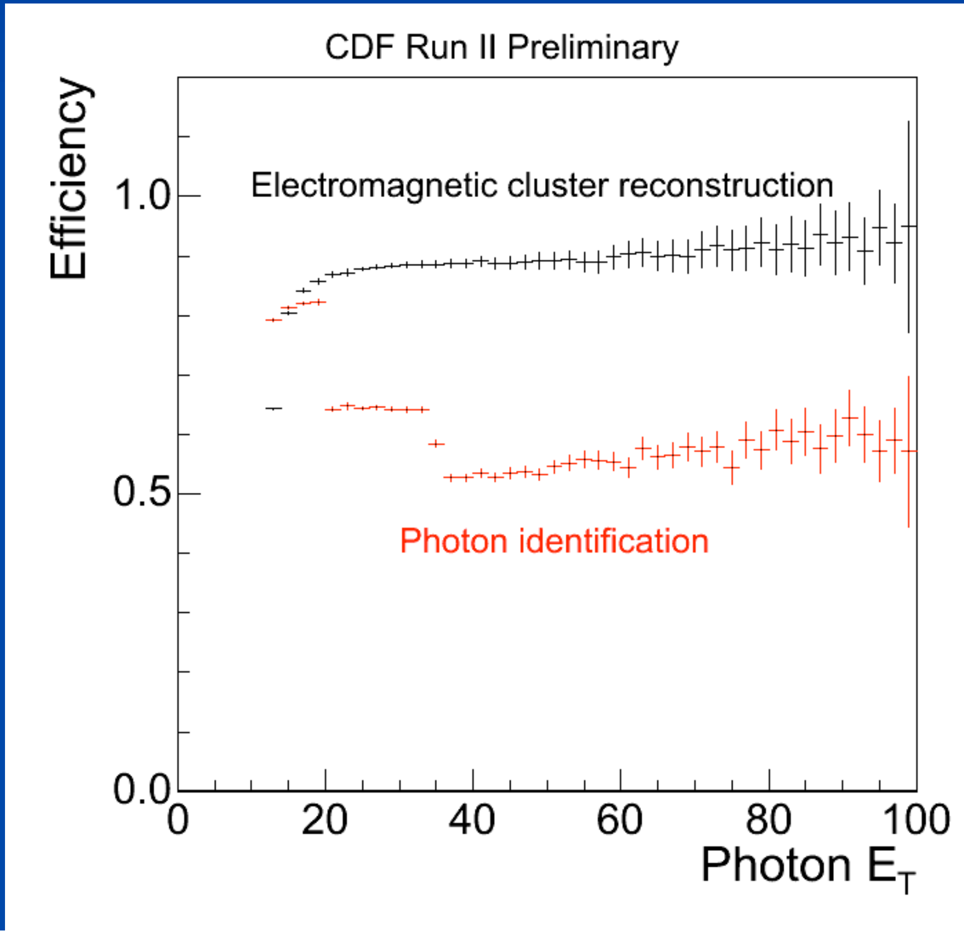


Photon efficiency

From MonteCarlo, divided into:

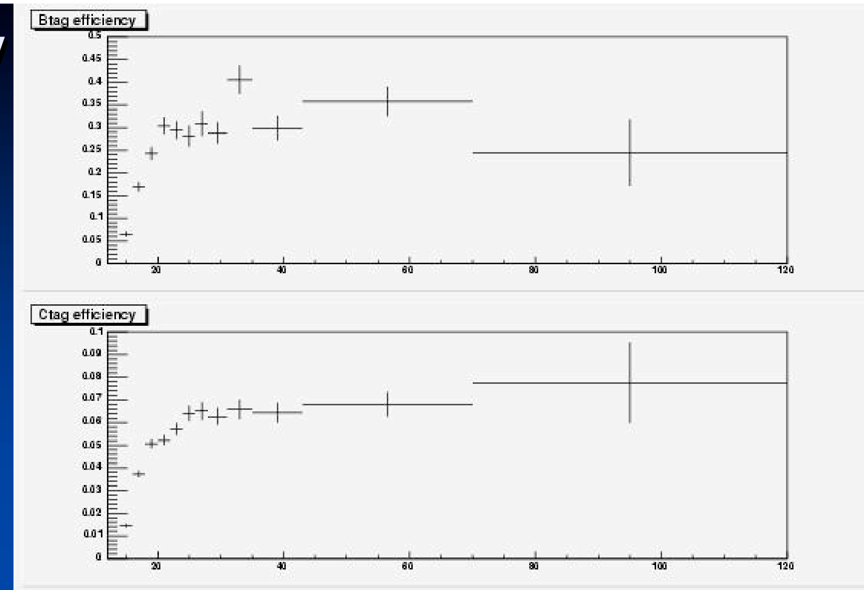
•Efficiency for finding an e.m. object

•Efficiency for this object to pass trigger and offline cuts



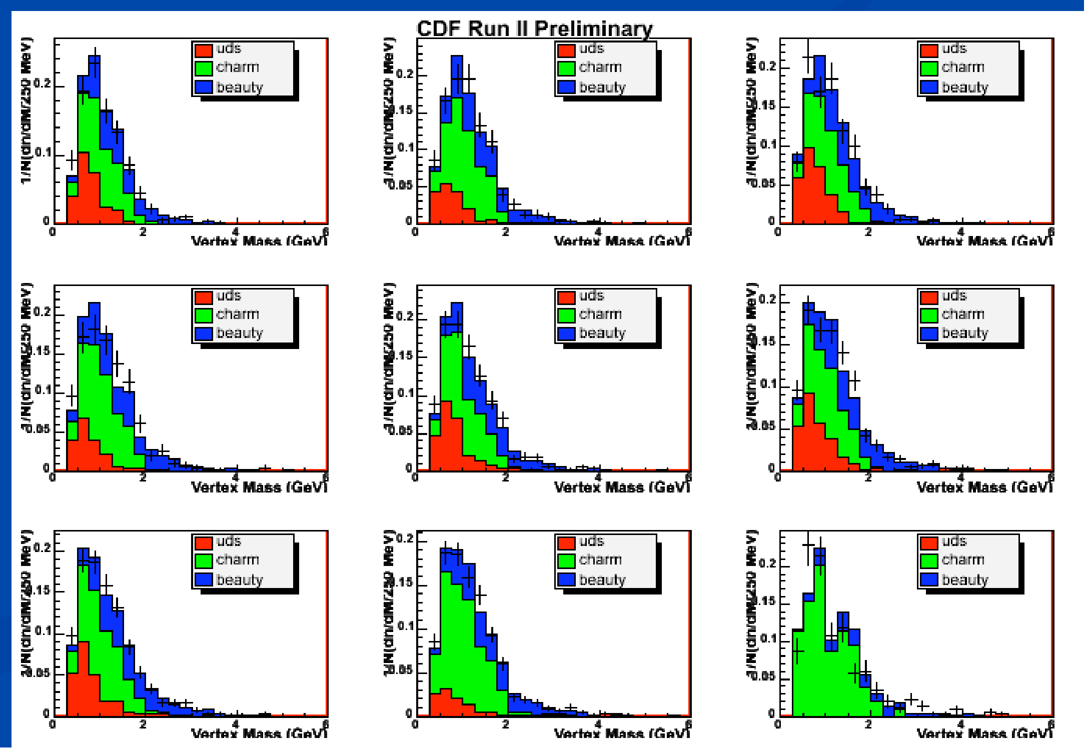
Efficiencies estimated with Pythia MC with cuts at 12 and 22 GeV,

B-tagging efficiency and purity



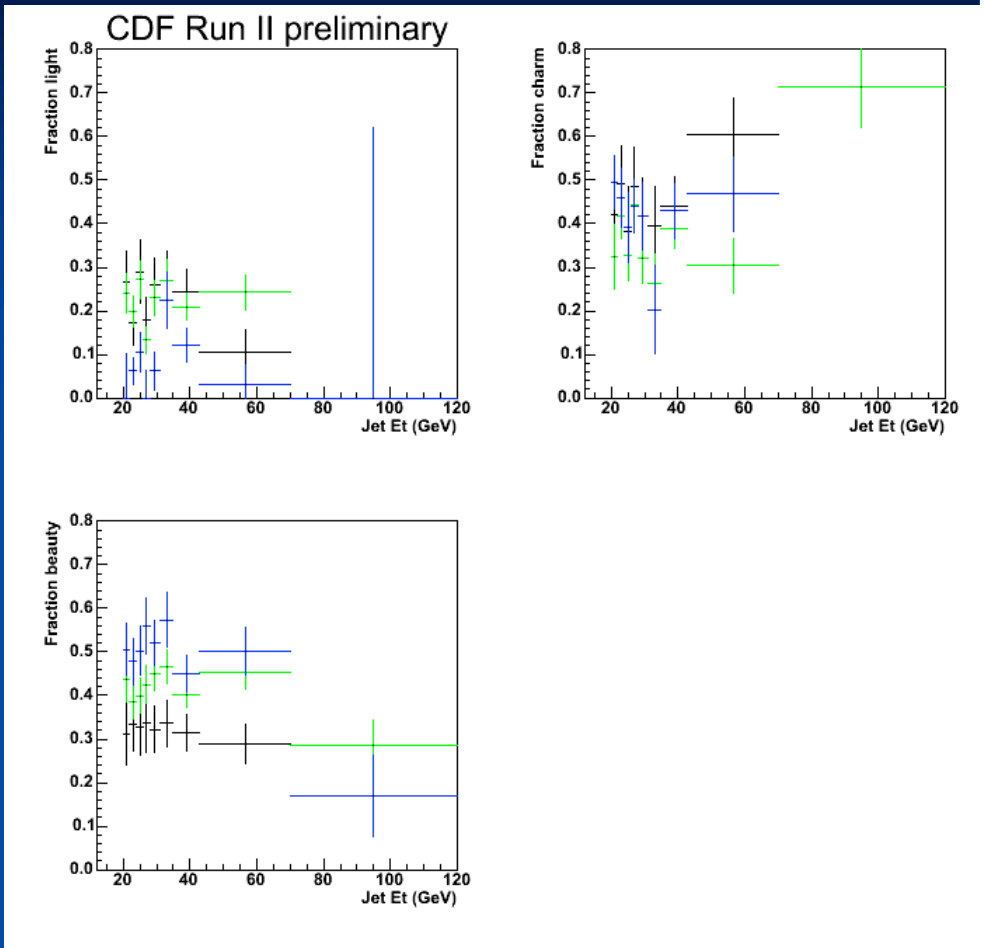
Efficiency taken from MonteCarlo, without SVT trigger requirements.

b purity comes from a fit to the secondary vertex mass to extract fractions of the different jet species



B-fractions

Calculated separately for each jet Et bin for PHOTON_25_ISO and Jet20 data, assuming generic QCD background to have the same b fraction as the events with leading π^0 mistaken as photon.



Final expected number of candidates:

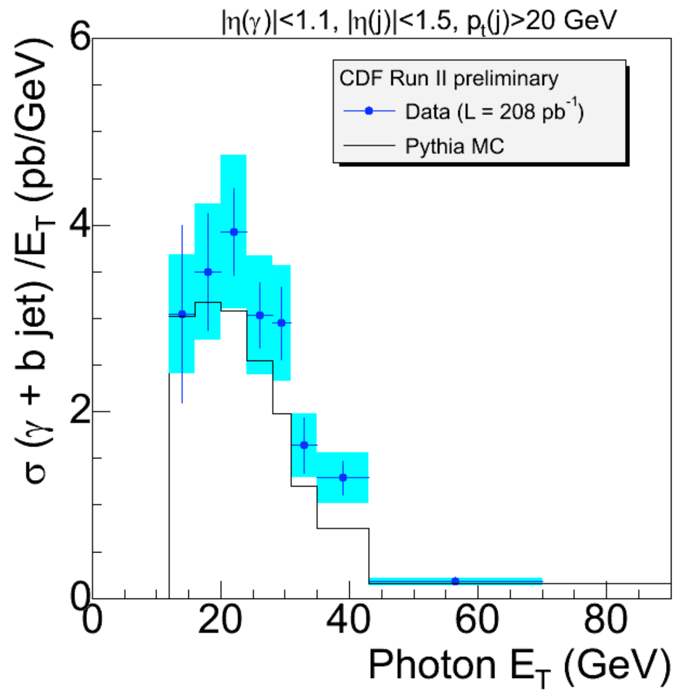
$$N_b = f_b^{ISO} * c_1 - (f_b^{QCD} * (c_1 - c_\gamma))/\epsilon_{ISO}^{tag}$$

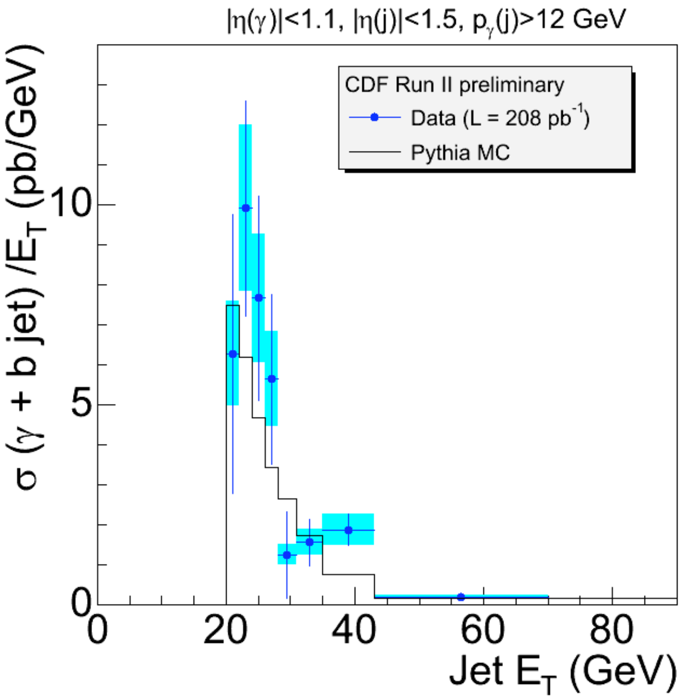
Estimation of systematics

- Luminosity: 6%
- Tagging efficiency: 4% (3% Scale factor, 2% bb fraction)
- Trigger efficiency extrapolation (from statistics):10%
- Jet energy scale: 4% (from JES group methods)
- Track multiplicity for templates: +20% -10% (from 3% efficiency)
- Photon efficiency: 1% (from Z->ee)
- Photon background: +4 -6% (from CPR/CES methods)

Summing in quadrature (assume independence) +24 -17% (21%)

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

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

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

First measurement done with SVT-based triggers at high-PT, and first public presentation!