4^{th} **July 2003**

Tagging secondary vertices produced by beauty decay and studies about the possibilities to detect charm in the forward region at the ZEUS experiment at HERA

1^{st} Year Transfer Report

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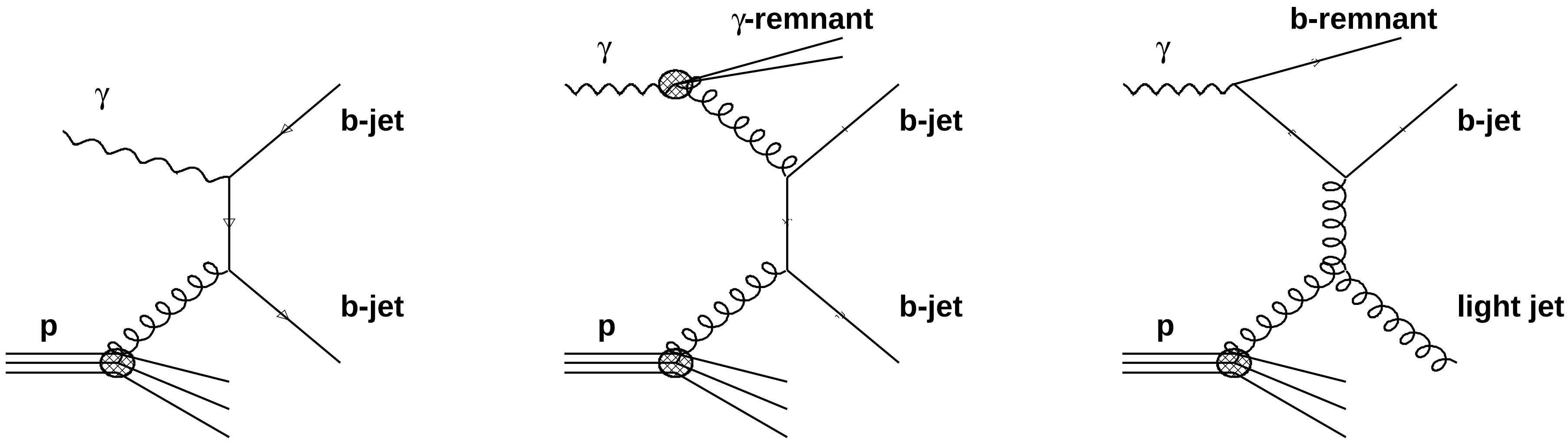
Outline

- Introduction
- Search for secondary vertices
- Preliminary comparison Monte Carlo - 2002 data
- Studies about the possibility to tag charm in the forward region at ZEUS

Beauty Production at HERA



Direct

Resolved

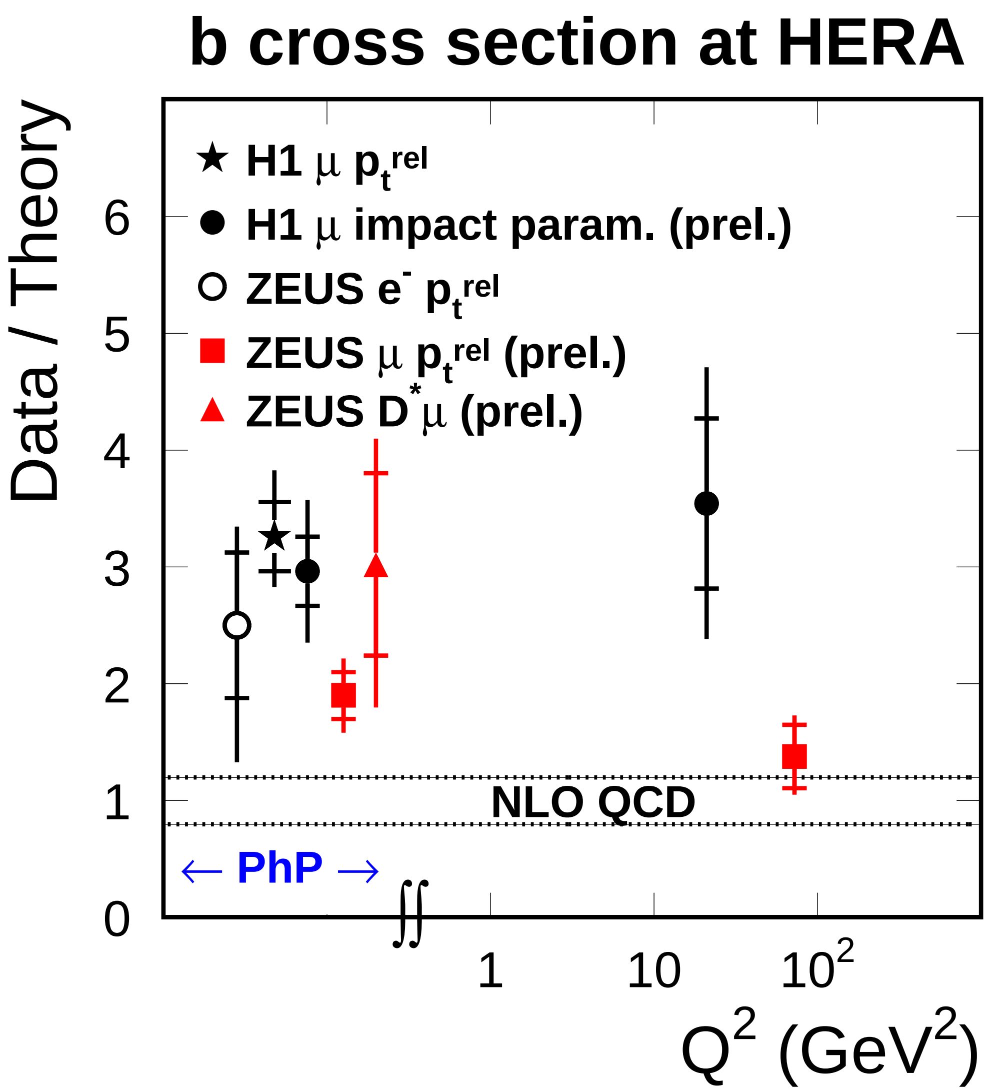
Flavour Excitation

Problem

The cross section for the beauty production processes, measeured in:

- hadroproduction interactions in $p\bar{p}$ collision at Tevatron
- $\gamma\gamma$ interactions at e^+e^- collider LEP
- γp and DIS interactions at HERA

is found to be higher than the theoretical predictions based on NLO-QCD calculations



Experimental methods used so far at HERA:

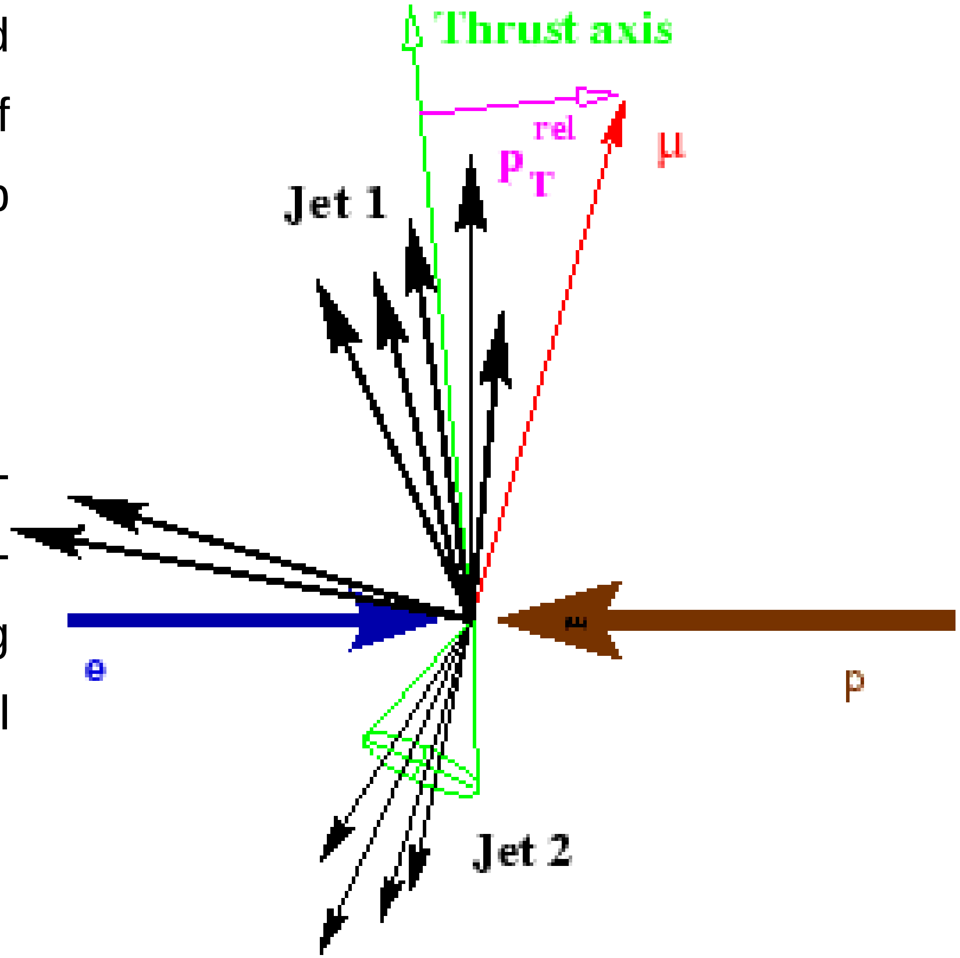
- Different experimental methods are used to tag beauty quark in the event; one of the more frequently used exploits the b semileptonic decay:

  ▷ b $\longrightarrow \mu\, \nu_\mu$ X

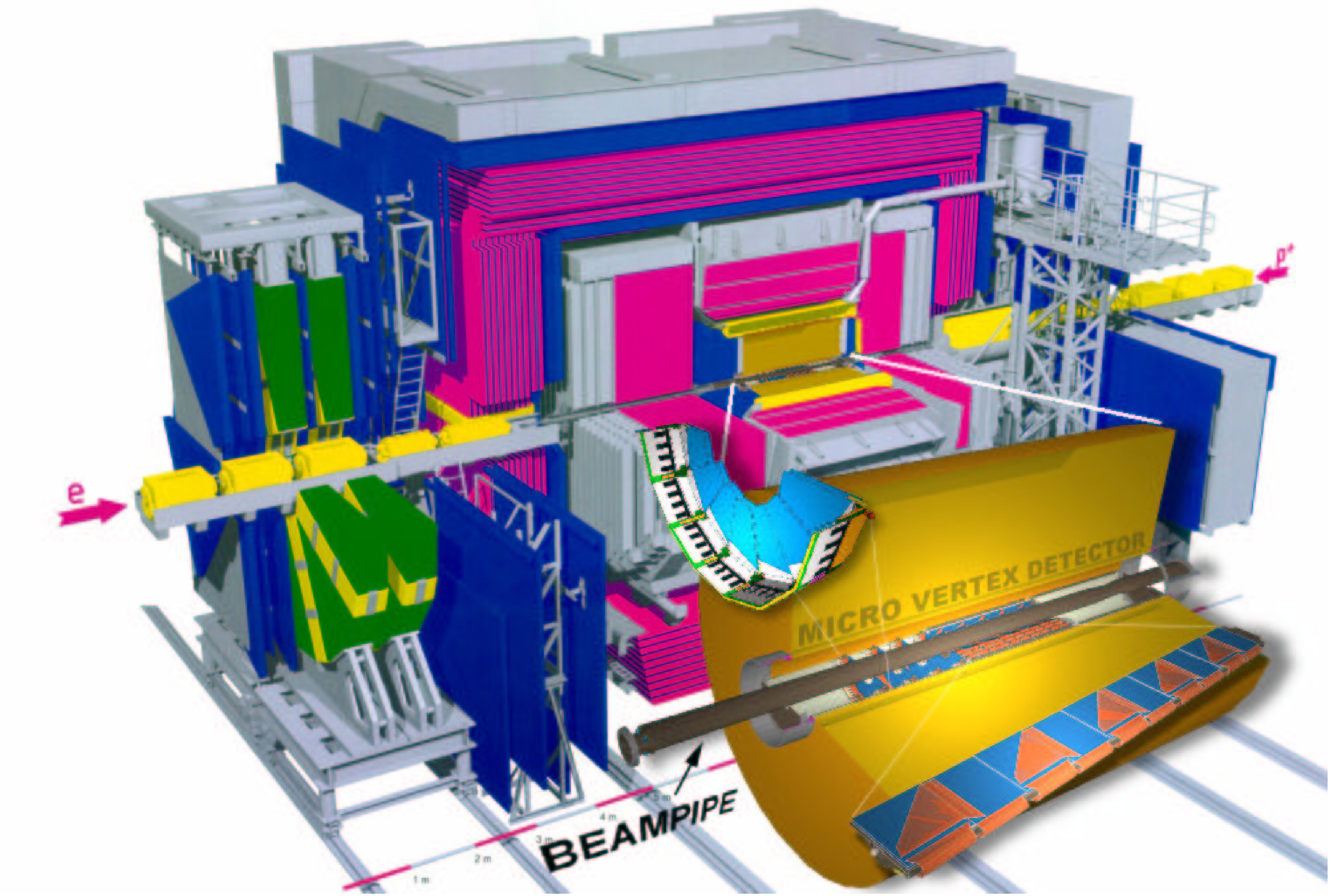
- The more recent results at ZEUS concerning the measurement of the b production cross section are obtained selecting events with 2 jets and one μ in the final state:

  ▷ e + p $\longrightarrow dijet + \mu$ +X

- Transverce momentum method (calculated with respect to the jet axis):



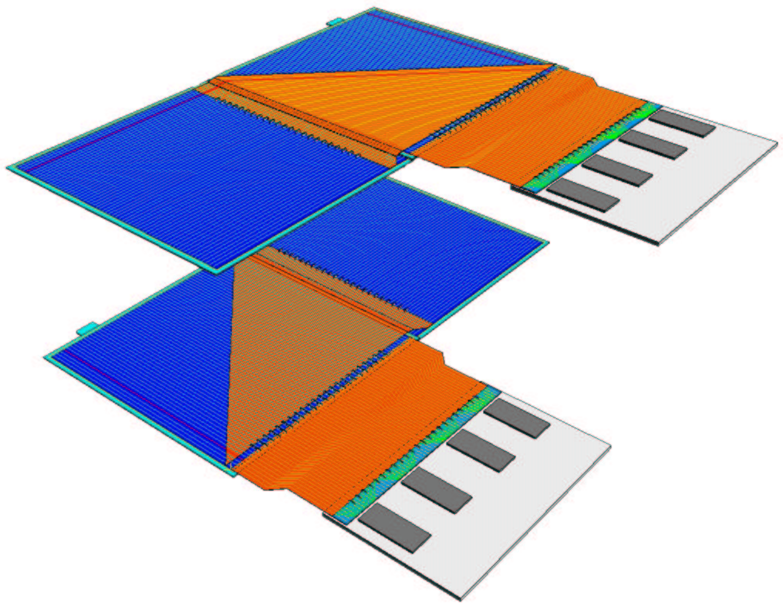
ZEUS detector at HERA

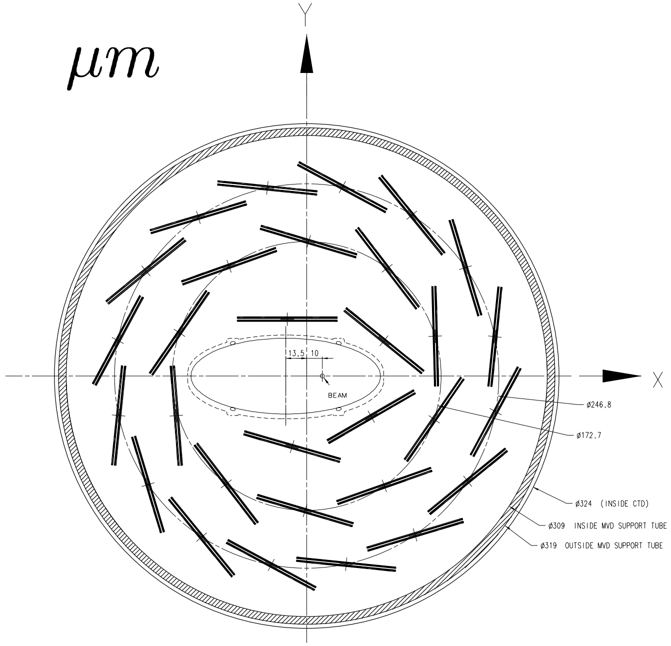


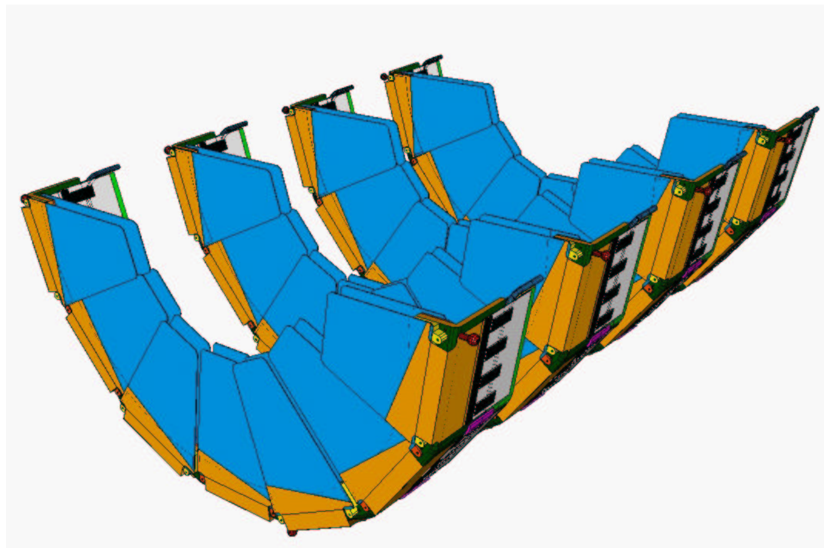
Silicon Microvertex Detector (MVD)

Technical characteristics:

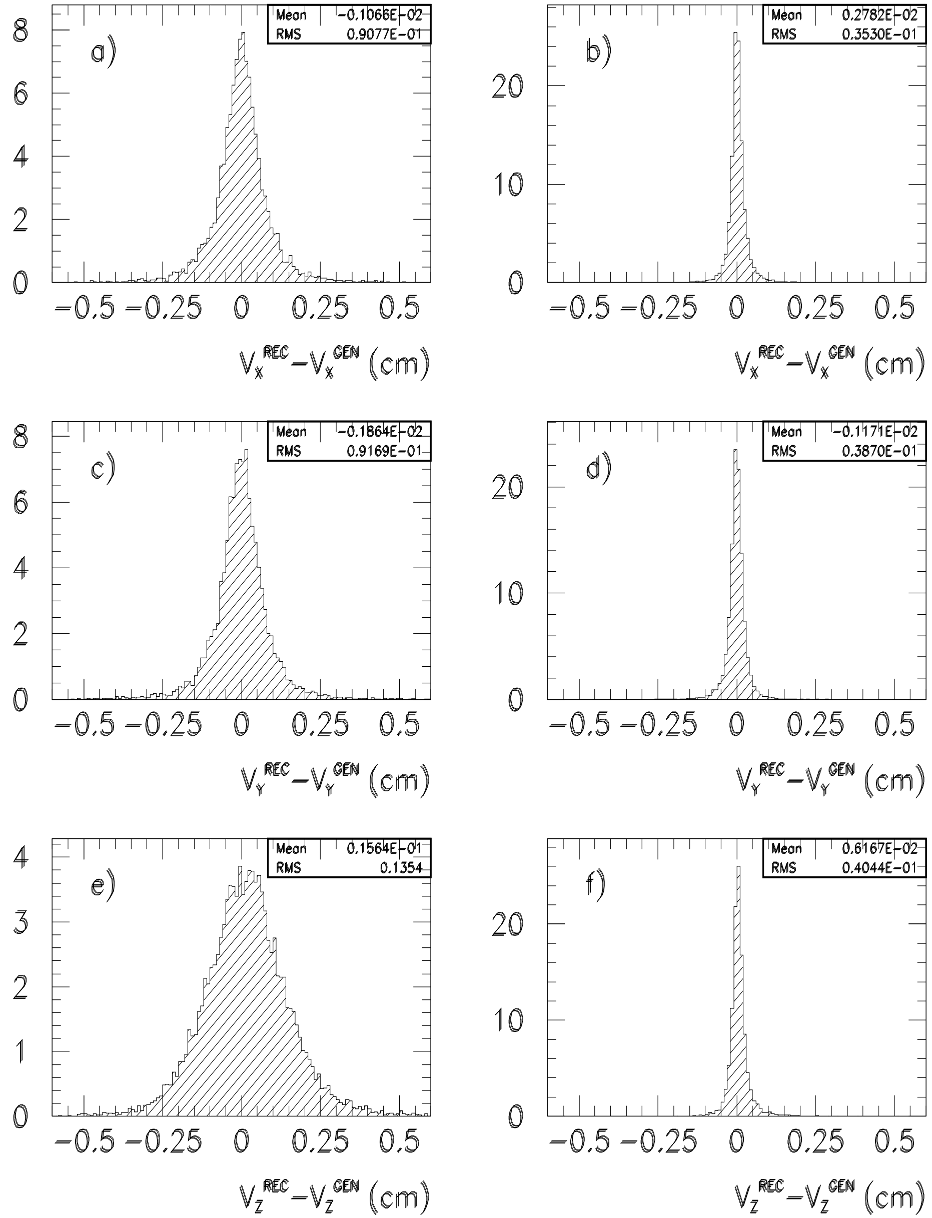
- angular coverage $10^\circ < \theta < 160^\circ$
- measurement of 3 position for each track in 2 independent projections
- hit intrinsic resolution up to 20 μm
- discrimination between 2 tracks up to 200 μm







Primary vertex resolution:

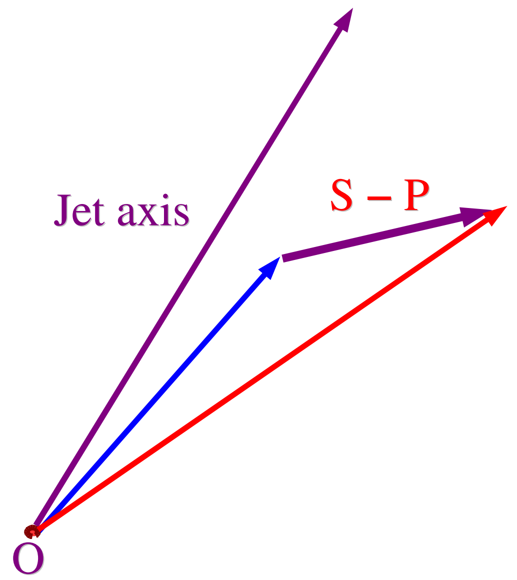


$b\bar{b}$ photoproduction Monte Carlo sample:

- LEFT: CTD only
- RIGHT: CTD + MVD

Tagging secondary vertices:

- Algorithm to reconstruct secondary vertices produced by the decay of mesons containing b:
  L=distance covered by an hadron before his decay, measured in the lab frame.
- L is used to calculate the proper decay lenght distribution through:
  L=$c\gamma t_p$



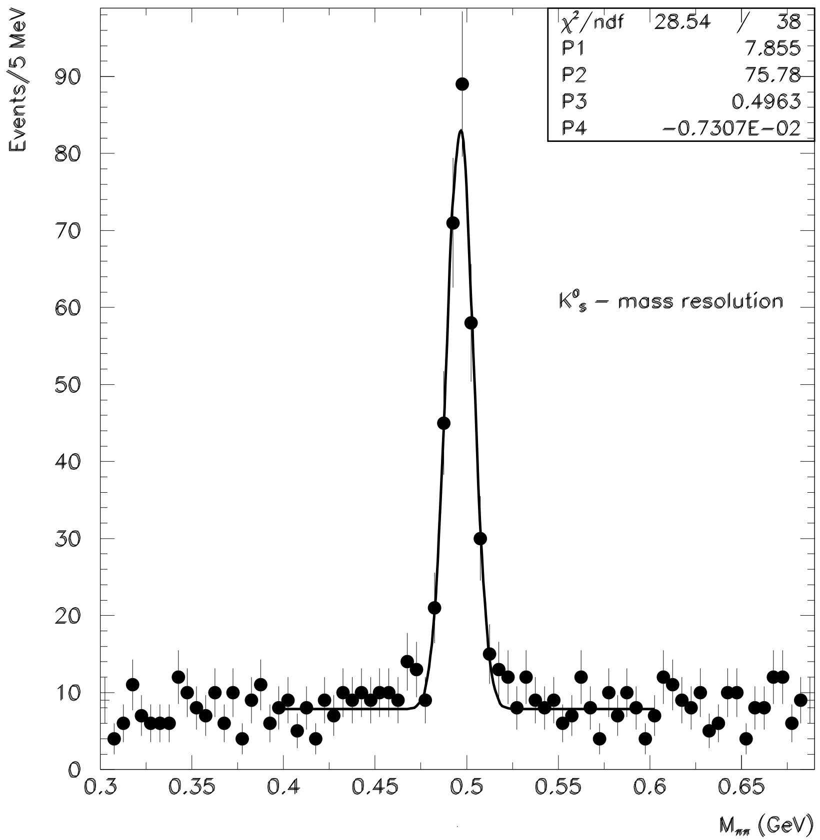
- FIXED Primary vertex! (X_V, Y_V, Z_V)=(1.75,0.,0.)
- NOTE: We do not recompute the primary vertex.

Reference Sample:

- Rejected events with reconstructed electron with $E_e > 5$ GeV (no DIS events)
- at least 2 jets recon. (massive scheme) with $P_{T1,2}^{jet} > 5$ GeV/c and $|\eta^{jet}| < 2.5$
- other “standard” cuts

Track selection for the secondary vertices fit:

- $P_t > P_{tmin}$ **(0.5 GeV)**
- $N_{SL}^{CTD} > 3$
- **tot** $\#MVD$ **hits** > 4
- χ^2 **track** < 100
- **removed** K_s^0

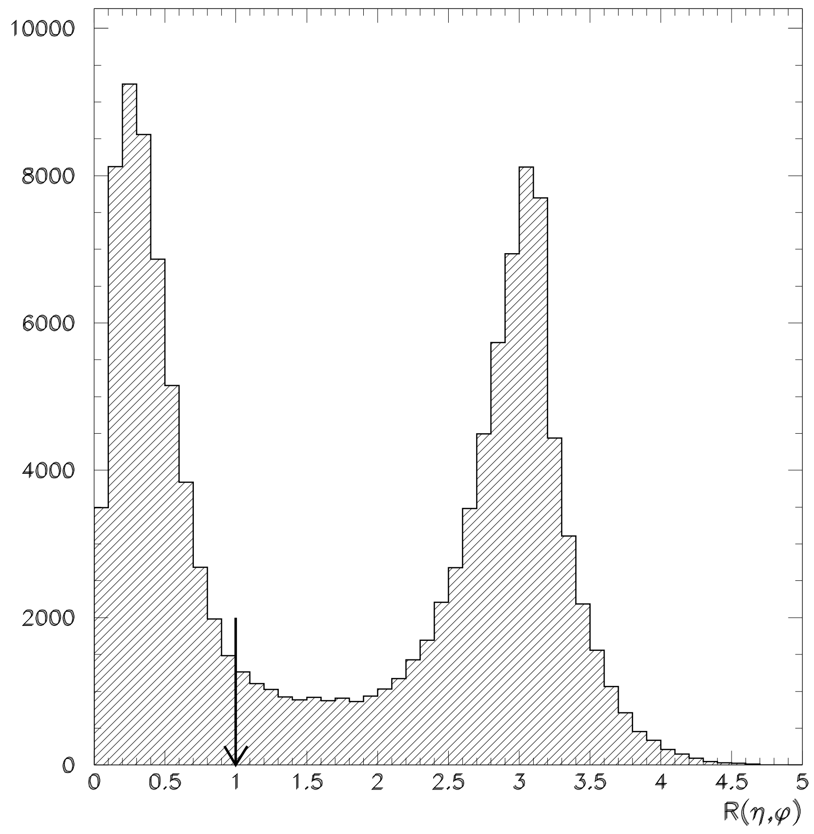


Tracks-Jet Association:

- each track has been associated to the nearest jet in the plane (η, ϕ) using the distance R:

$$R = \sqrt{(\eta_{tr} - \eta_{jet_{1,2}})^2 - (\phi_{tr} - \phi_{jet_{1,2}})^2}$$

- the set of the track associated to the same jet are the input to the vertex fit



Decay distance studies:

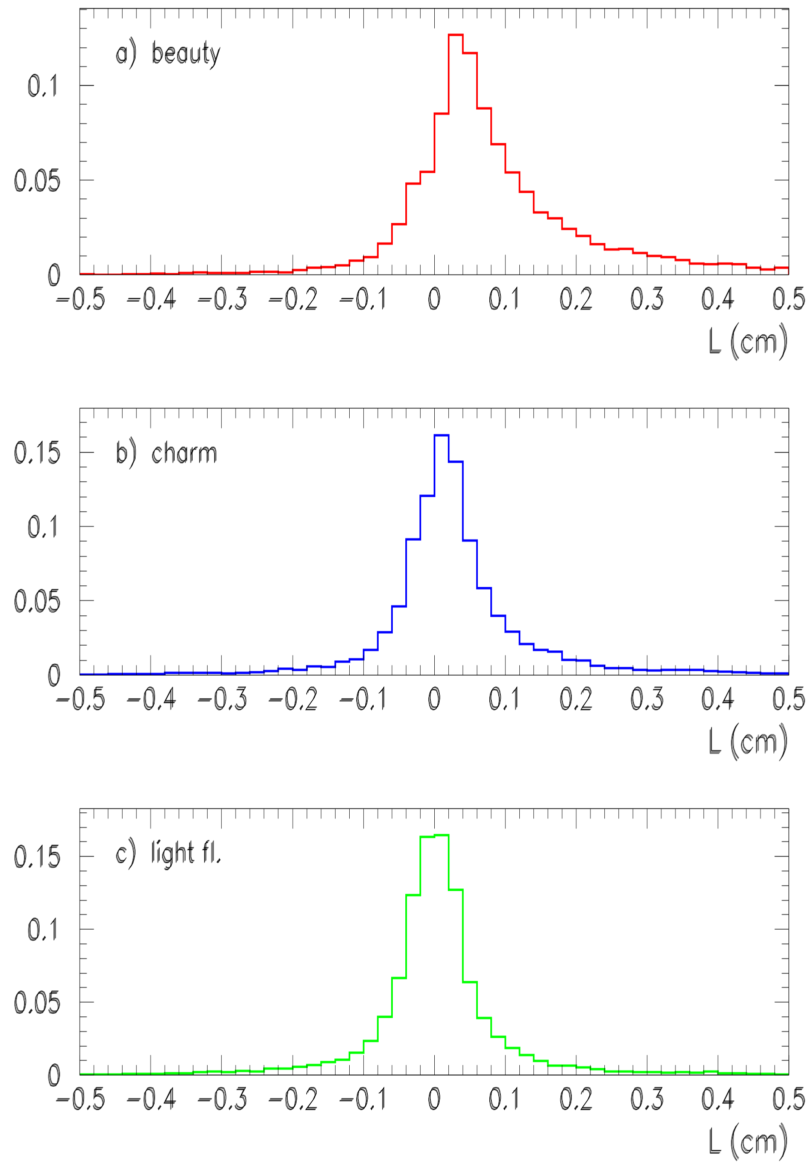
- The decay distance has been defined as:

$$L = \mid \vec{S} - \vec{P} \mid sign((\vec{S} - \vec{P}) \cdot j)$$

- where $\vec{P}$ and $\vec{S}$ are the position vectors of the primary and secondary vertex.

$L > 0$ upstream the primary vertex

$L < 0$ downstream the primary vertex



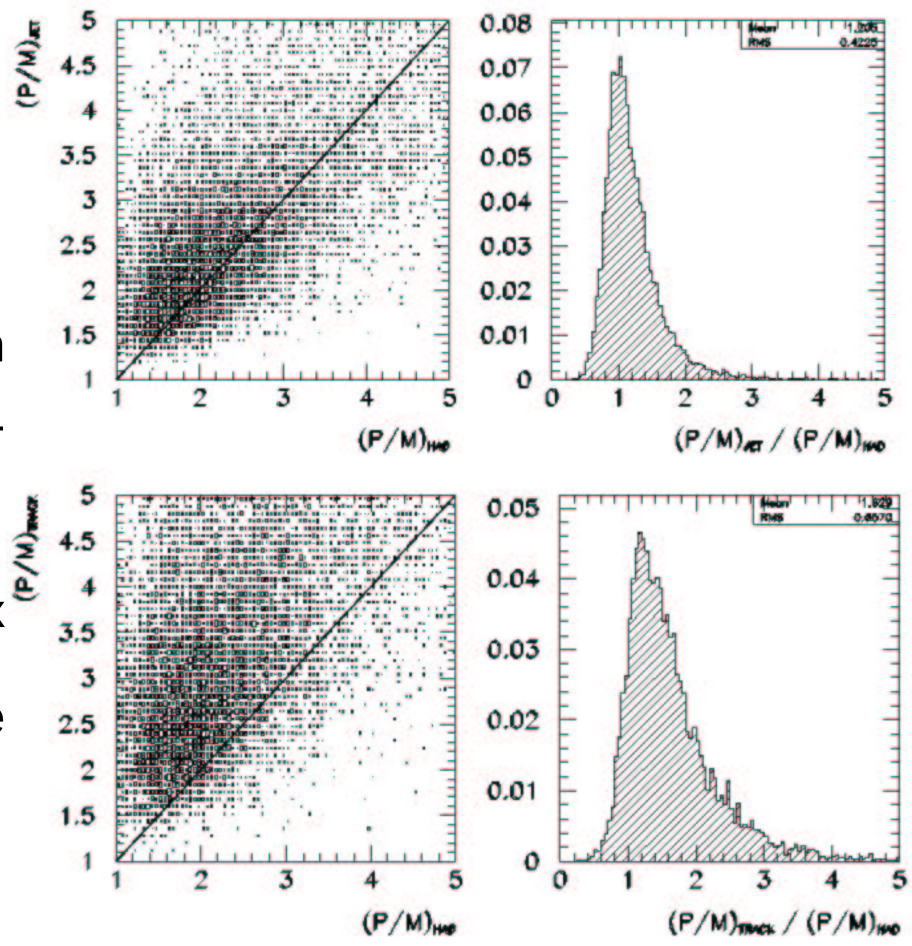
Proper decay distance:

If M is the reconstructed hadron mass and P is the momentum:

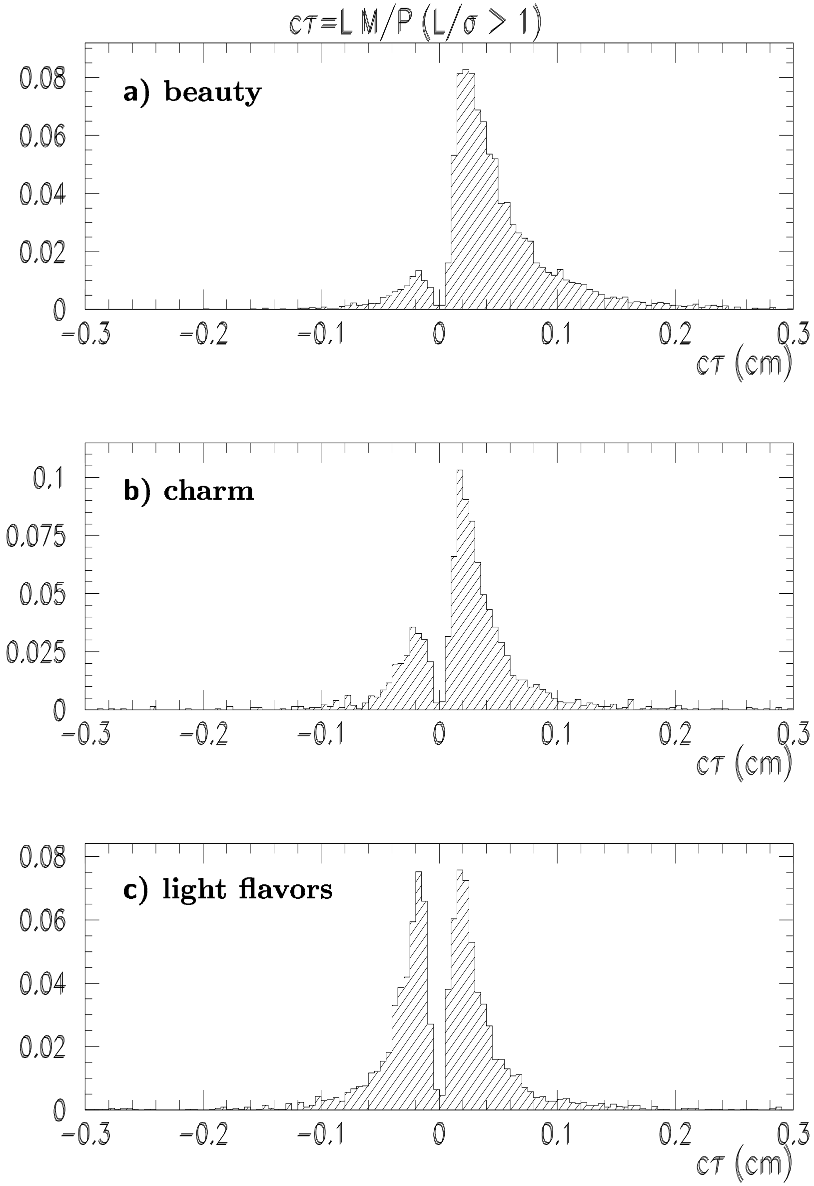
$$ct_p \equiv c\tau = \frac{L}{\beta\gamma} = L\frac{M}{P}$$

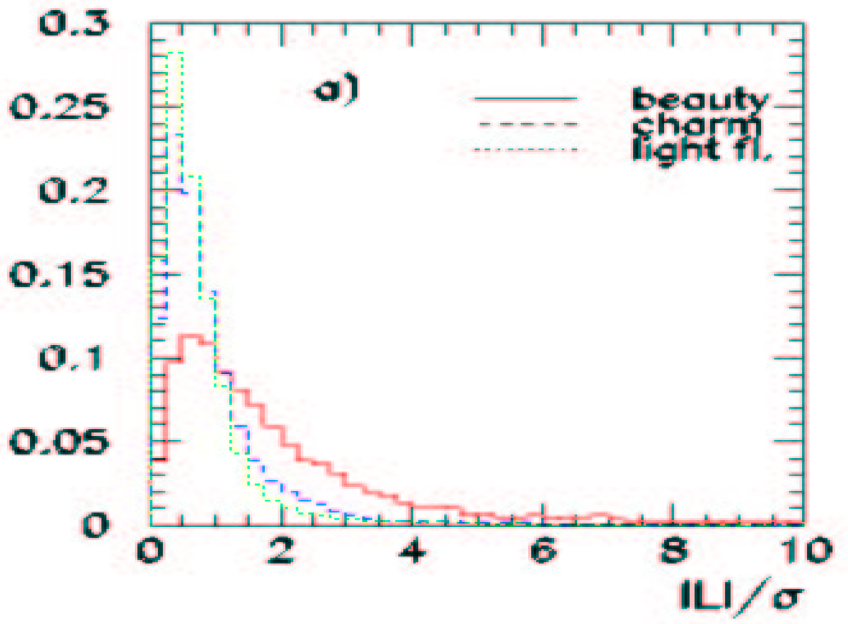
Experimentally M and P are measured with quantities calculated from the available observables, in our case:

- tracks associated to the secondary vertex
- kinematic reconstructed quantities of the jets with a tag of secondary vertex



Significance cut and proper decay distance:





- applied significance cut $\mid L \mid /\sigma > 1$ to improve the ratio signal/background
- $c\tau$ distributions consistent with the mean lifetime of hadrons containing heavy quarks

First comparison 2002 data - Monte Carlo

TLT selection applied on data:

- 2 jets with $E_T > 8$ GeV, $\eta < 2.5$
- $P_z/E < 1$
- $E - P_z < 100$
- $R_{xy} < 0.2$ where

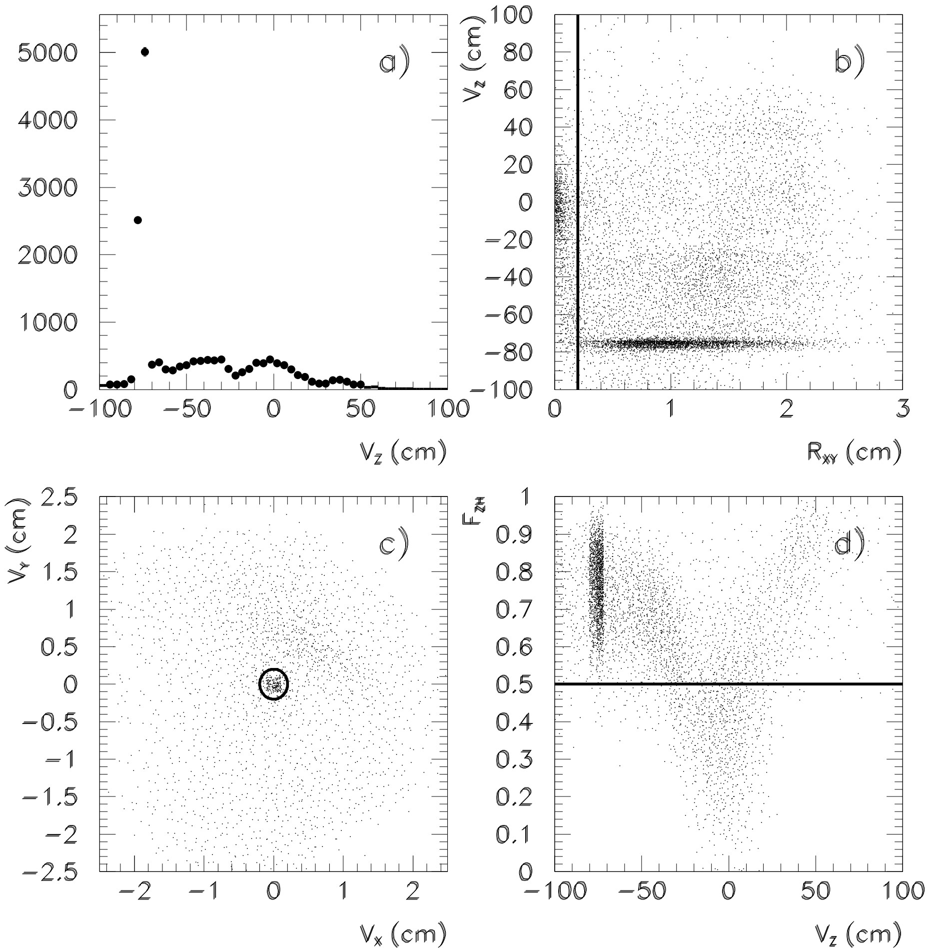
$$R_{xy} = \sqrt{(V_x - \bar{V_x})^2 + (V_y - \bar{V_y})^2}$$

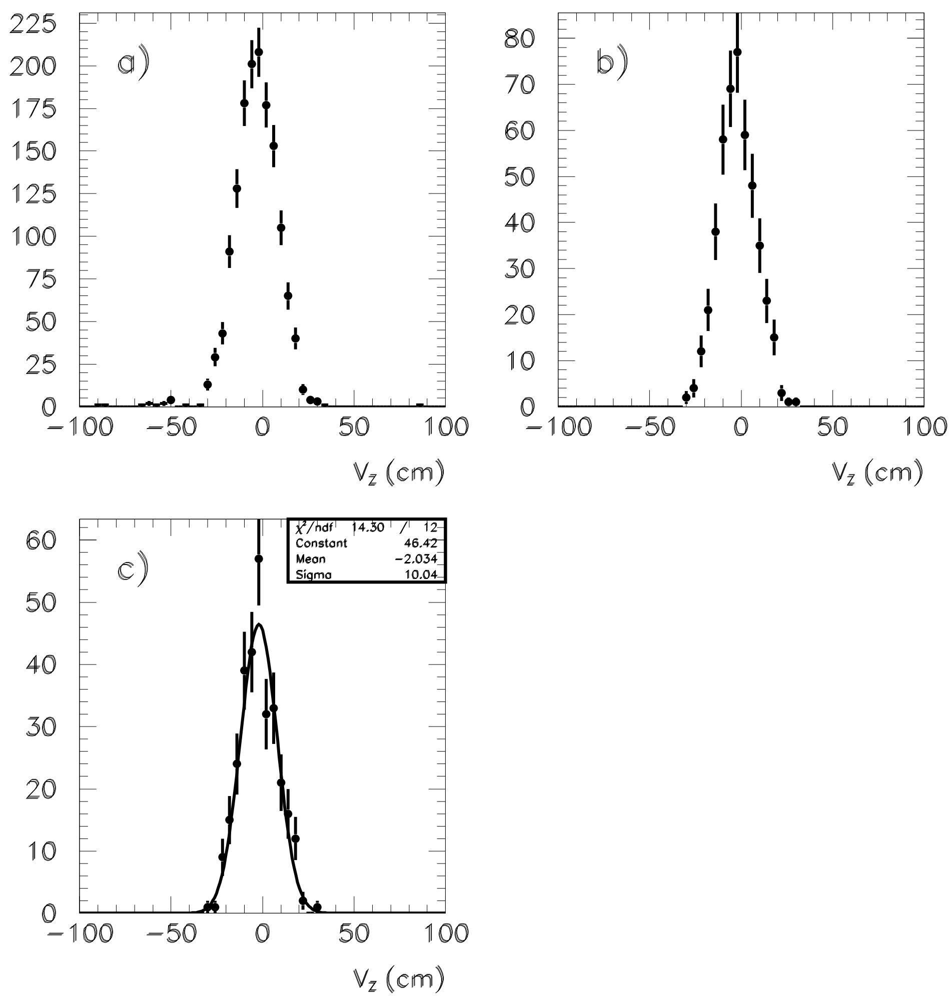
- $F_{ZH} < 0.5$ where

$$F_{z_H} = \frac{N^{helix}(z_H > 30cm)}{N^{helix}_{tot}}$$

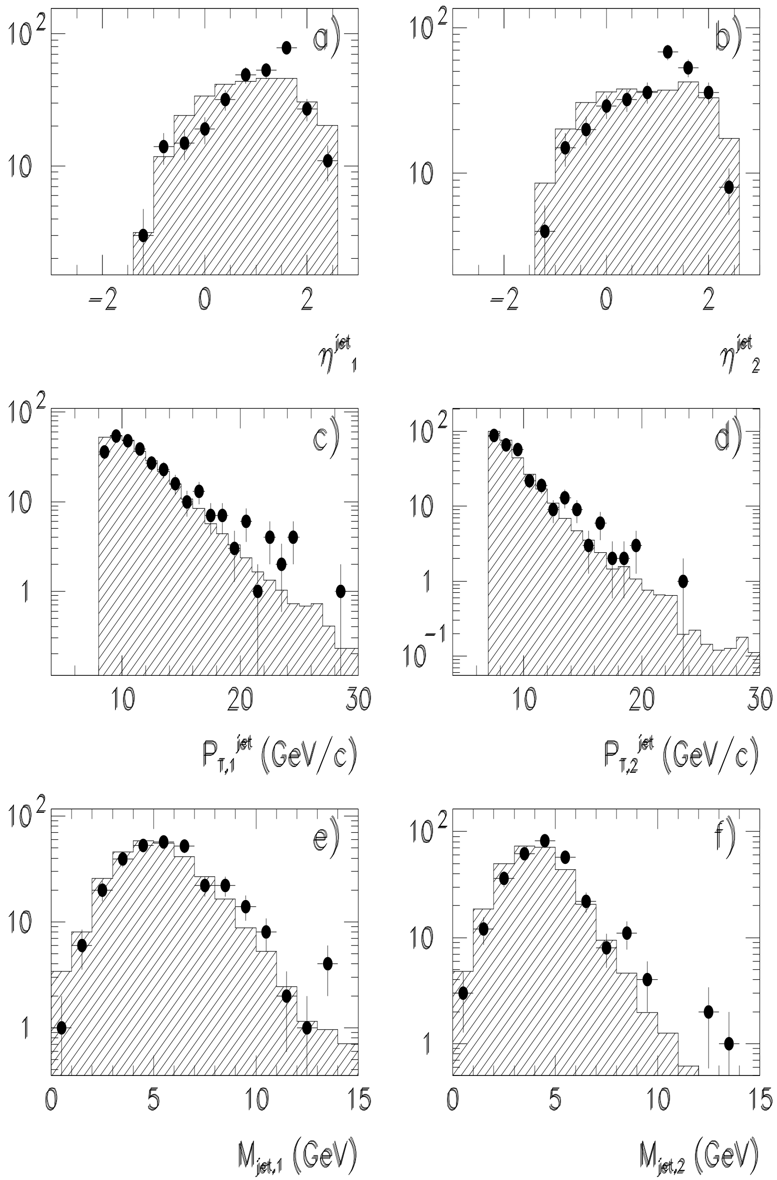
- at least 2 jet with $P_{T1} > 8$ GeV/c and $P_{T2} > 7$ GeV/c and $|\eta^{jet}|$<2.5
- rejection events with $E_e' > 5$ GeV and $y_{el} \leq 0.9$
- $0.2 < y_{JB} < 0.8$

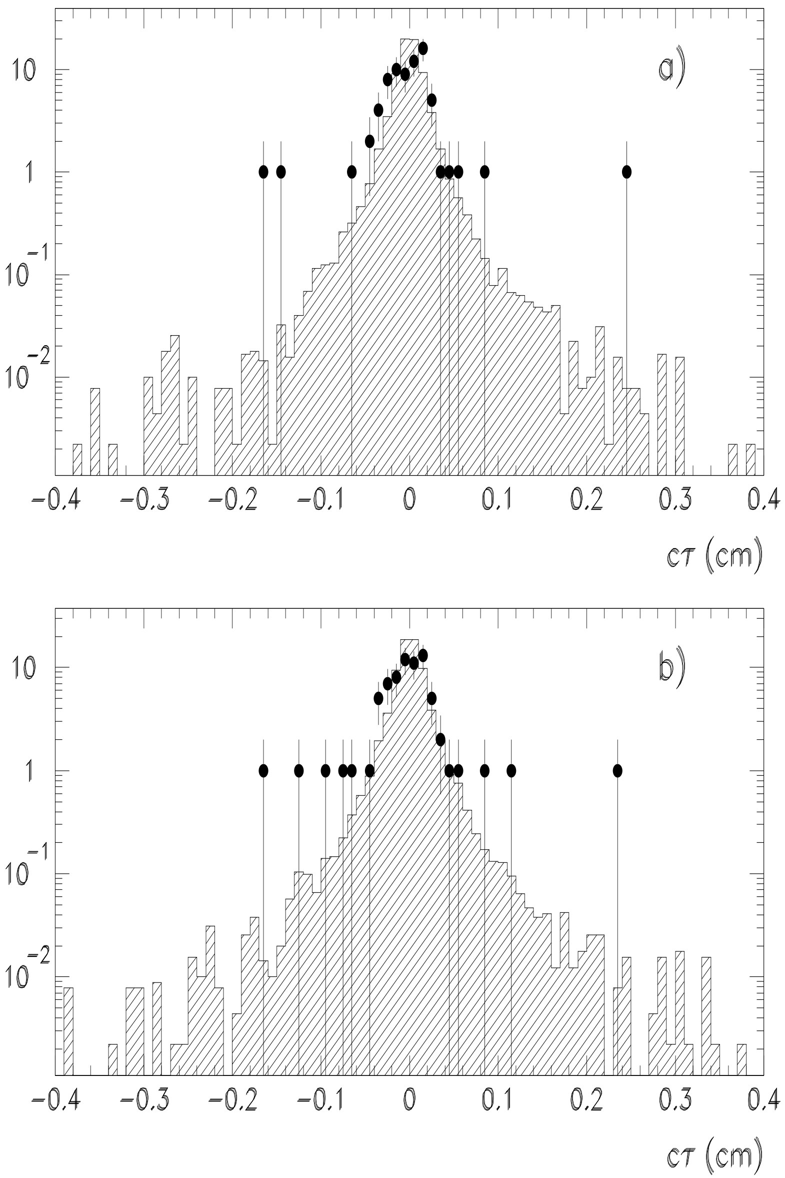
Comparison data-Monte Carlo





Comparison data-Monte Carlo





Capability to tag charm in the forward region:

Charm is tagged trough the decay:

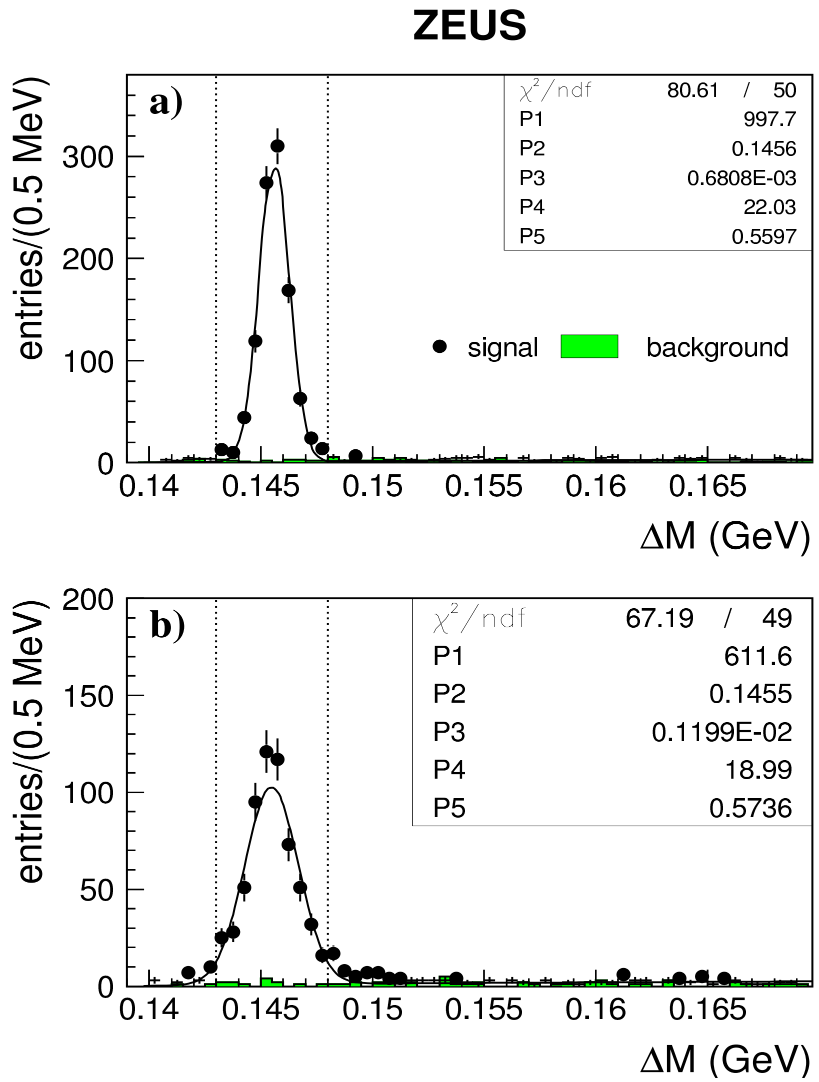
- we considered the decay channel:

$$D^{*\pm} \rightarrow D^0/\bar{D}^0\pi^\pm$$

$$D^0/\bar{D}^0 \rightarrow \pi^\pm K^\mp$$

- MC RAPGAP general D mesons DIS sample ($Q^2 > 0.6\, GeV^2$)
- tracks with 3 SL CTD (-2 < η < 2)
- cuts on D^*: -2 < η < 2 and $p_t > 1.5$ GeV/c
- ONLY CTD information!!!
- ΔM signal is smaller and wider:

  30$\%$ less signal, 50$\%$ wider



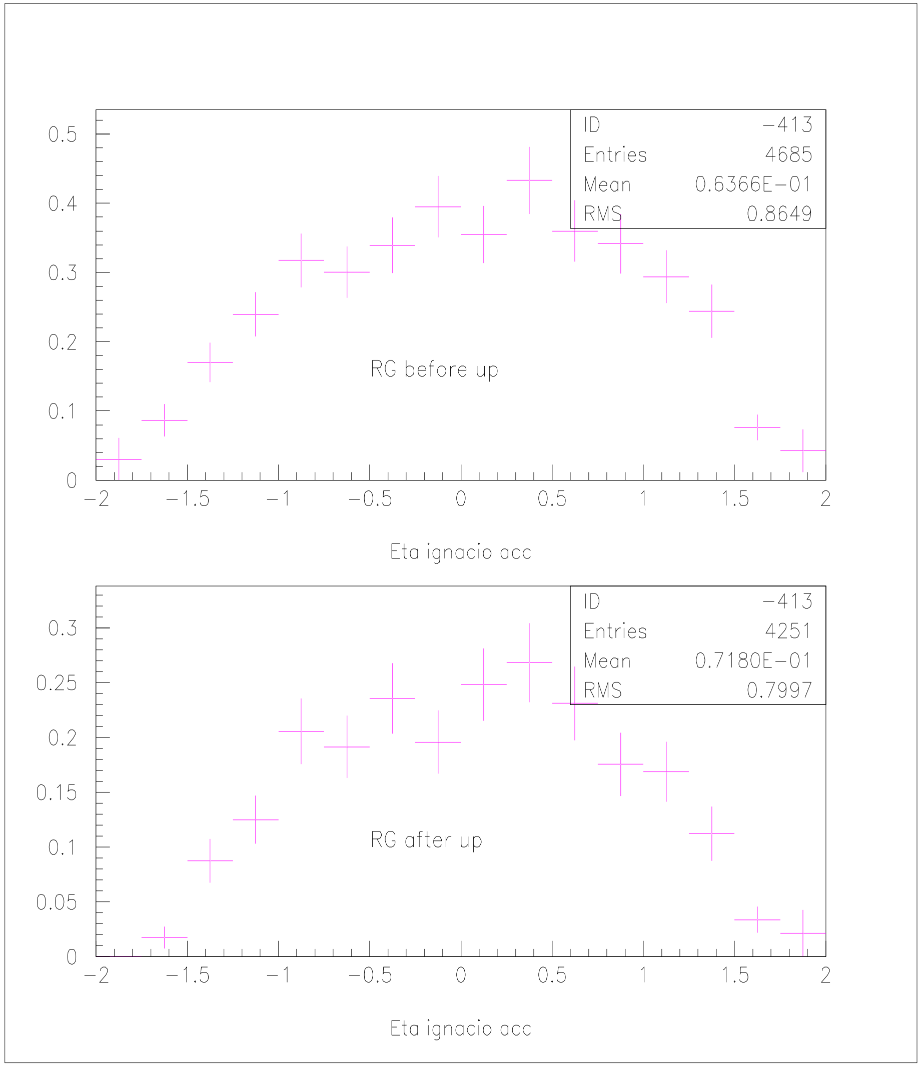
Capability to tag charm in the forward region:

- acceptance as a function of $\eta(D^*)$ before and after the upgrade
- number of D^* candidates on 100000 events:

  before the upgrade=1040

  after the upgrade=609

- Significantly reduced!!
- $\longrightarrow$ effect of the MVD material on slow pion
- Analysis is not possible with CTD-ONLY info $\longrightarrow$ MVD (+ STT) information will be necessary!



Future plans:

Beauty tagging with secondary vertices:

- high luminosity running (summer 2003) new b-result from ZEUS
- implement Kalman filter technique to the vertex fitting
- combine this algorithm with the selection of a high transverce momentum muon to have a double tag of the beauty decay (impact parameter studies)

Charm production in the forward region:

- implement Kalman filter technique to match the STT tracks with MVD cluster