

Vertexing studies

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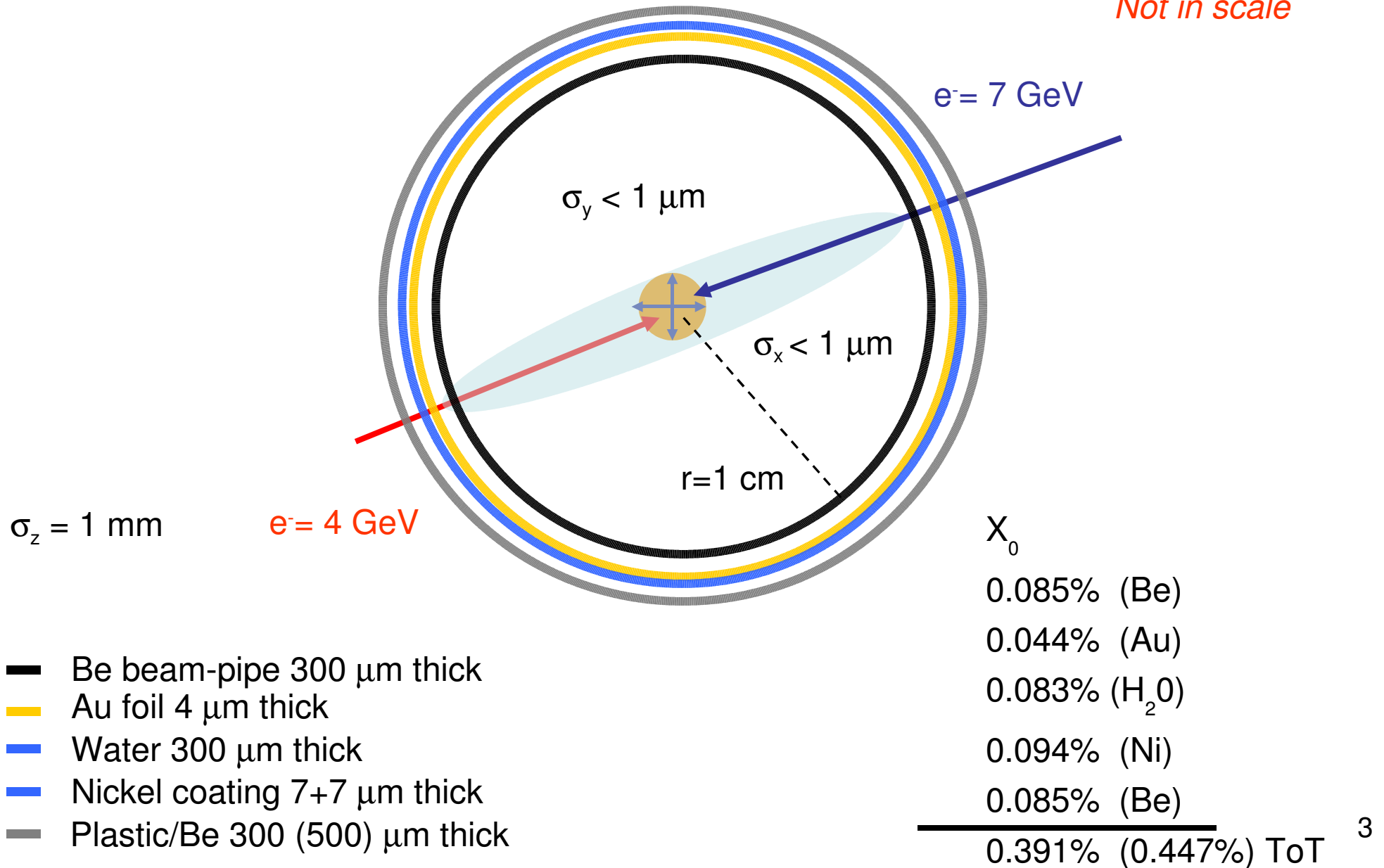
SLAC - 14 june 2006

Outline

- Beam-pipe layout
- Vertex Detector layout
- PravdaMC simulation
- Δt Resolution for TD analysis: B and D analysis
- Some issues about K_S +Neutrals decay modes
- B-D vertex separation: preliminary results

Interaction region SuperB

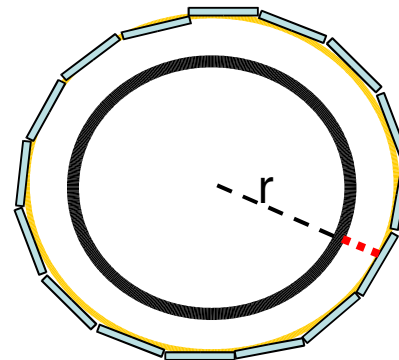
Not in scale



Beam-pipe scenarios

- **conservative scenario:**

- beam pipe radius 1.5cm
- hit resolution z, ϕ side = $10 \mu\text{m}$
- Radial material = $0.50\% X_0$

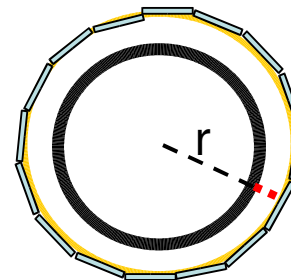


$r=1.5\text{cm}$

- Be beam-pipe
- Kapton foil
- $50 \mu\text{m}$ Silicon pixel

- **most likely scenario:**

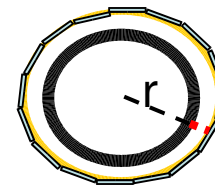
- beam pipe radius 1.0cm
- hit resolution z, ϕ side = $10 \mu\text{m}$
- Radial material = $0.39\% X_0$



$r=1\text{cm}$

- **aggressive scenario:**

- beam pipe radius 0.5cm
- hit resolution z, ϕ side = $5 \mu\text{m}$
- Radial material = $0.24\% X_0$



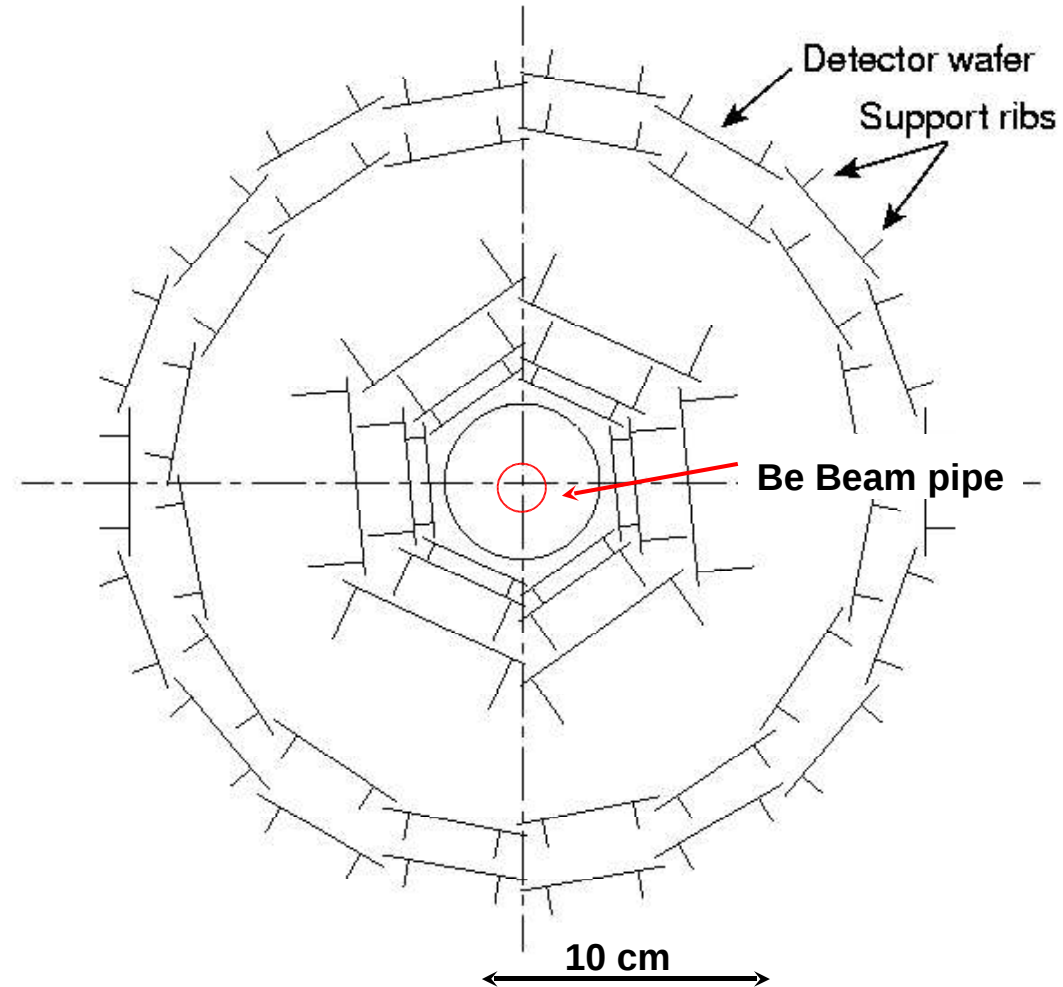
$r=0.5\text{cm}$

SuperB SVT Geometry

<u>Layer</u>	<u>Radius</u>
0	1.05 cm
1	3.3 cm
2	4.0 cm
3	5.9 cm
4	9.1 to 12.7 cm
5	11.4 to 14.6 cm

ADDED →

- Added layer0
- Reduced beam-pipe radius $2.5 \rightarrow 1\text{ cm}$
- Reduce Be thickness $1.3 \rightarrow 0.6\text{ mm}$
- $4\text{ }\mu\text{m}$ Au foil before layer0

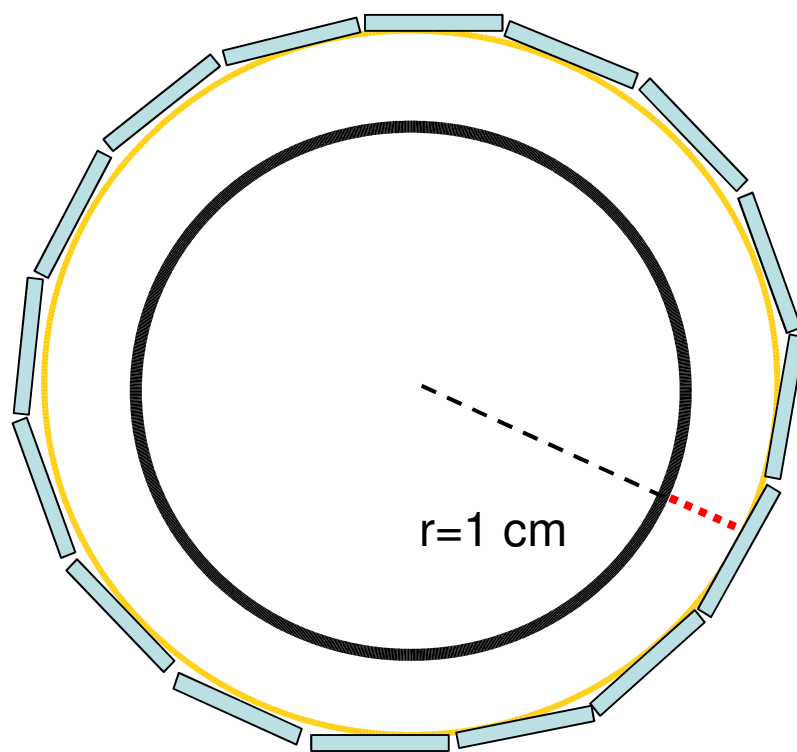


(Arched wedge wafers not shown)

Layer0 design

New conceptual design for layer0

- Use kapton foil $\sim 50\text{ }\mu\text{m}$ as support structure for the Si pixel
- Beam pipe radius set the radial distance for the layer0
- Rule of thumb: vertex resolution improves almost linearly with layer0 radial distance



Not in scale

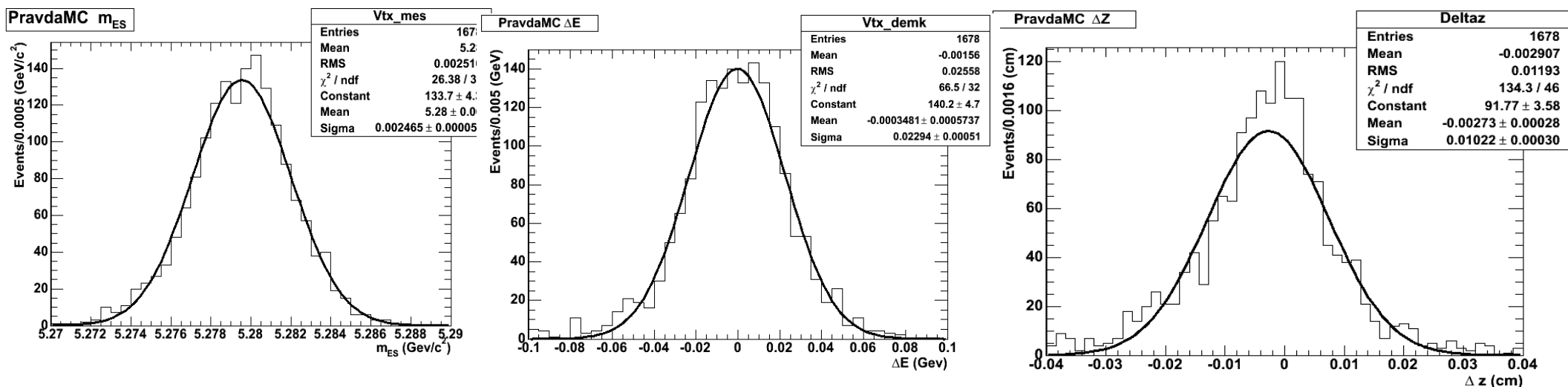
$\Delta r \sim 500\text{ }\mu\text{m}$
security distance

- Be beampipe
- Kapton foil
- $50\text{ }\mu\text{m}$ Silicon pixel

PravdaMC: simulation software

- PravdaMC is a fast simulation software which uses parametrization to simulate detector response.
- It has been validated and tested. It is able to reproduce current detector performances up to a good level of accuracy.

$B^0 \rightarrow \pi^+ \pi^-$ decay mode



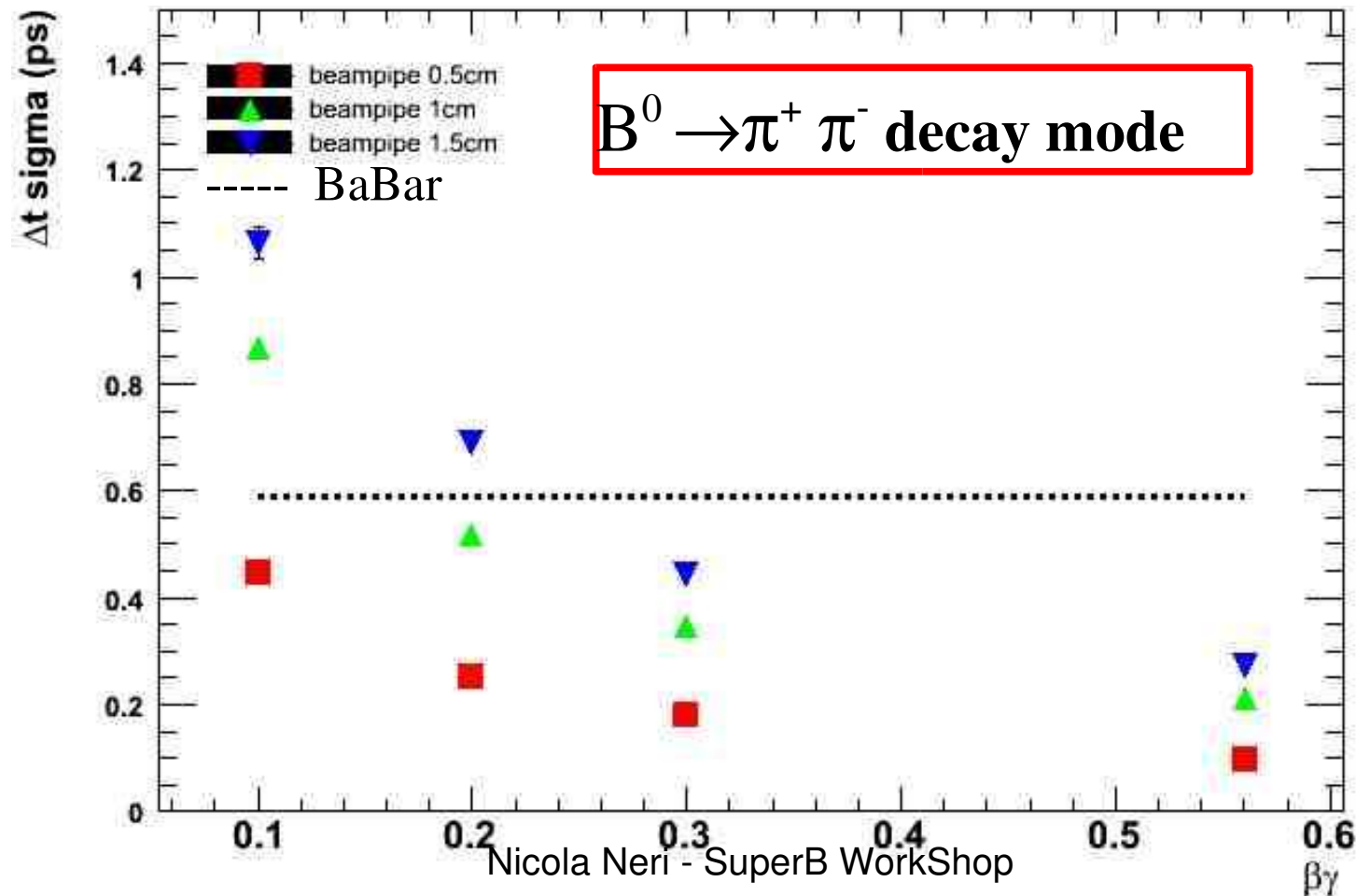
$$\sigma(m_{ES}) \sim 2.5 \text{ MeV}$$

$$\sigma(\Delta E) \sim 23 \text{ MeV}$$

$$\sigma(\Delta z) \sim 102 \mu\text{m}$$

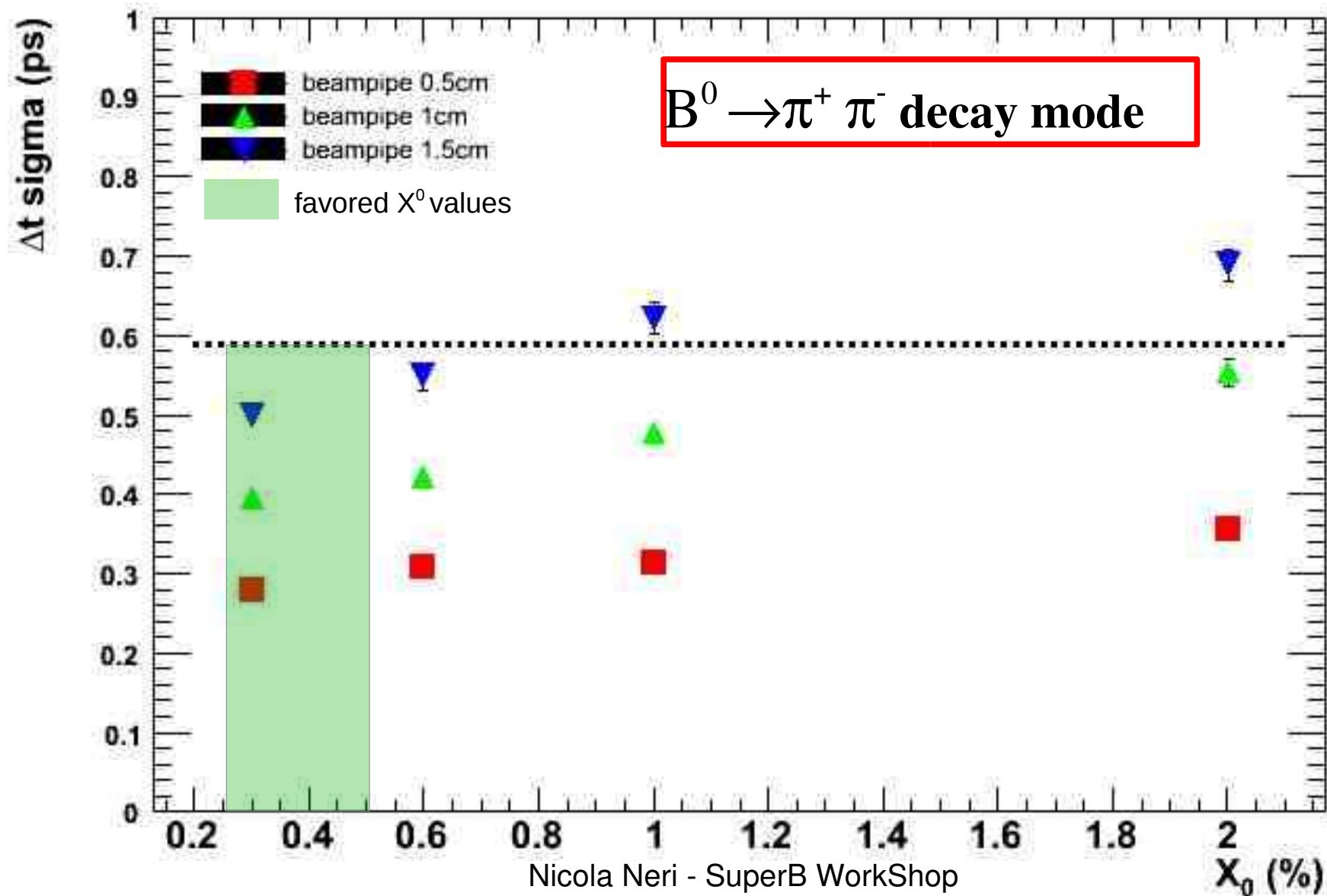
Δt resolution in B decays: exact method

$$\Delta z = \beta_z \gamma \gamma_{CP}^{cms} c \Delta t + \gamma \gamma_{CP}^{cms} p_{z,CP}^{cms} \left[\frac{|L_z^{CP}|}{|p_{z,CP}|} + \frac{|L_z^{TAG}|}{|p_{z,TAG}|} \right]$$



Δt resolution in B decays vs X_0 (%)

with a boost of $\beta\gamma$ 0.28



Issues on Ks+Neutrals decay modes

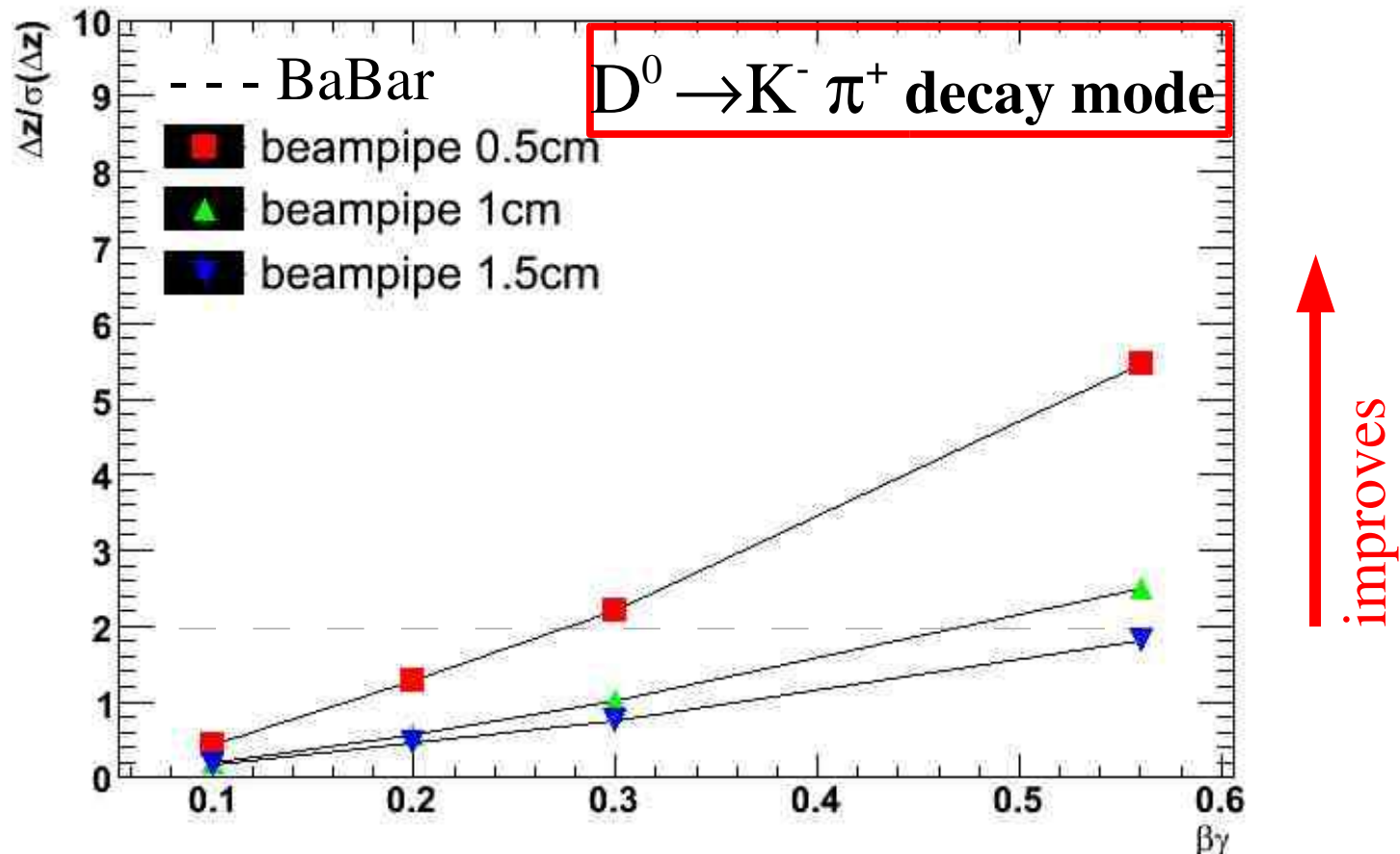
- $K_s + \text{Neutrals} = K_s \pi^0, K_s K_s K_s, K_s \eta (\eta \rightarrow \gamma \gamma)$

vertexing is harder here.

- Layer0 impact on vertex resolution is marginal, few percent of K_s have hits in layer0.
- Beam-spot constraint will help but vertex resolution scaling law different (worst) than $B \rightarrow \pi \pi$.
- It is likely the B_{CP} vertex will dominate the Δt resolution, once reached optimal performances of Tag Vertexing.
- PravdaMC simulations are in progress. Preliminary results seems promising... but a deeper study required.

Δz resolution in D decays at Ψ_{3770}

Assume $\sigma(\text{Tag})=\sigma(\text{Vtx})$: low track multiplicity, no charm bias in Tag vtx

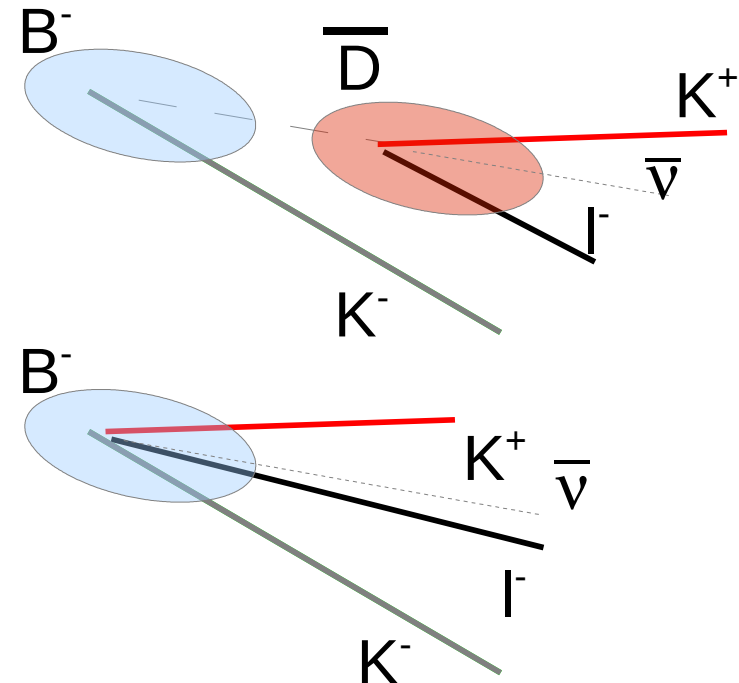


D lifetime 0.4 ps, for B it is 1.5 ps $\Rightarrow$ Smaller Δz significance.
Layer0 at 0.5cm and reduction of the radial material is important.

B-D vertex separation: analysis implications

- Continuum bkg rejection:
 - use $L/\Delta L$ as Fisher discriminant variable
- Tagging Topological algorithm
 - define a dipole= $L \cdot D$ charge and exploit D sign-B flavor correlation

Rare and/or bkg dominated decay modes

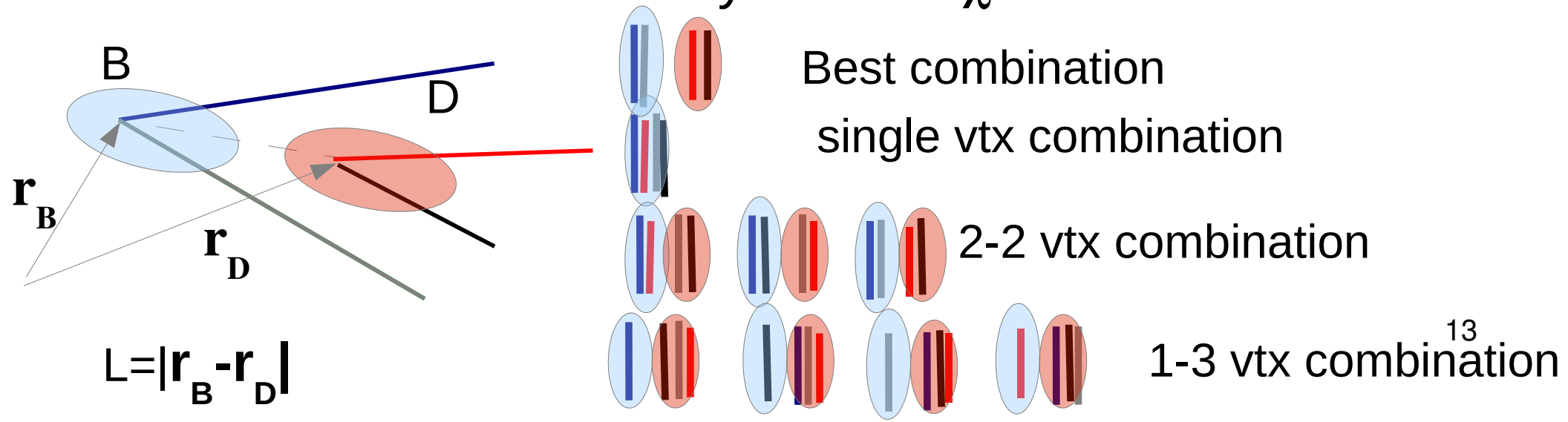


Allow to measure rb parameter
relevant for the γ measurement

B-D vertex separation algorithm

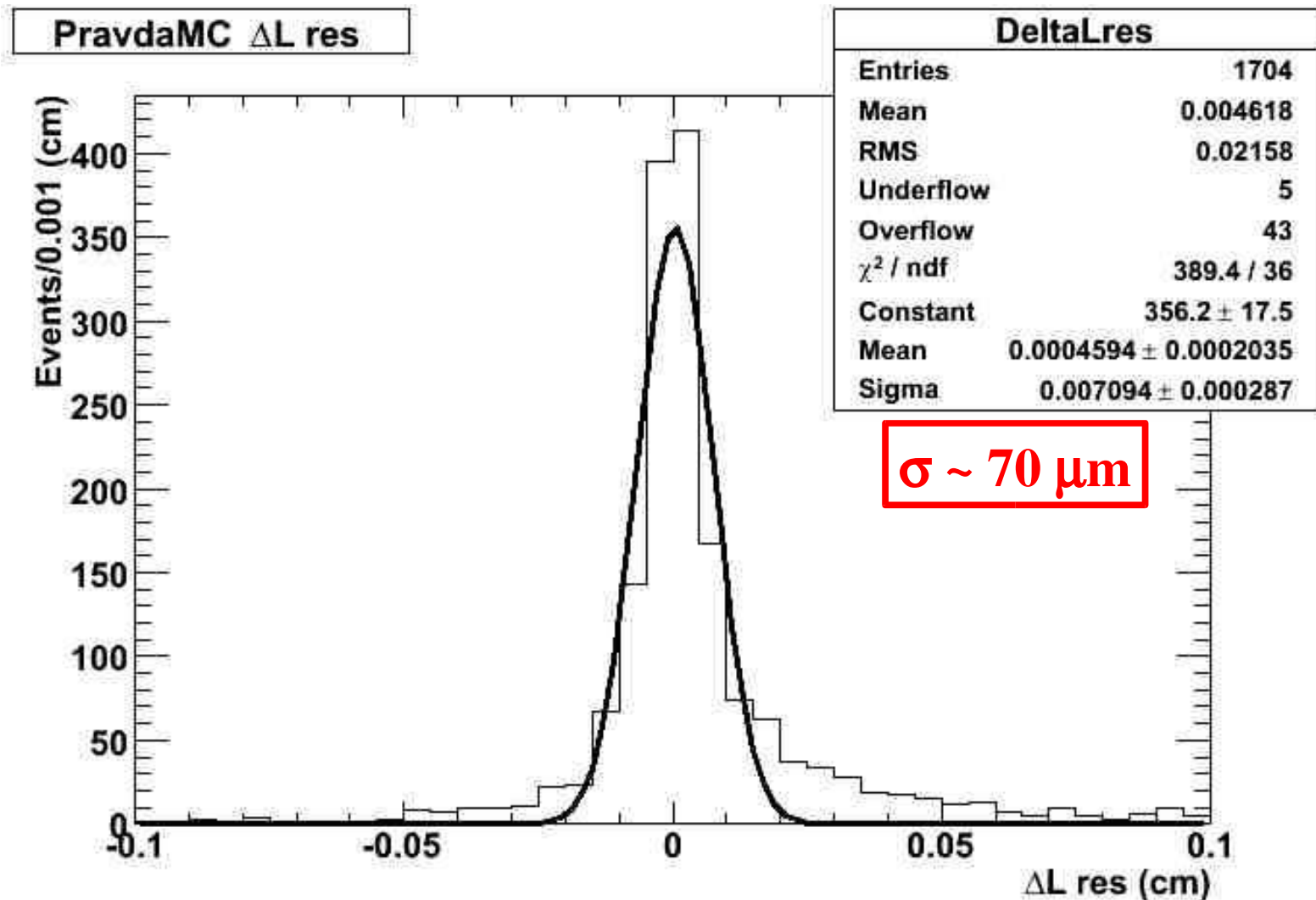
Two vertex algorithm on Tag Side (F. Martinez-Vidal ®)

- consider all combinations of two vertices of the ROE
- minimize the sum of the χ^2 of the candidate B-D vertices
- assign the B vertex to the closest vertex to the B pseudo-track determined using the B_{CP} information
- consider 2 vertices only if better χ^2 wrt one vertex



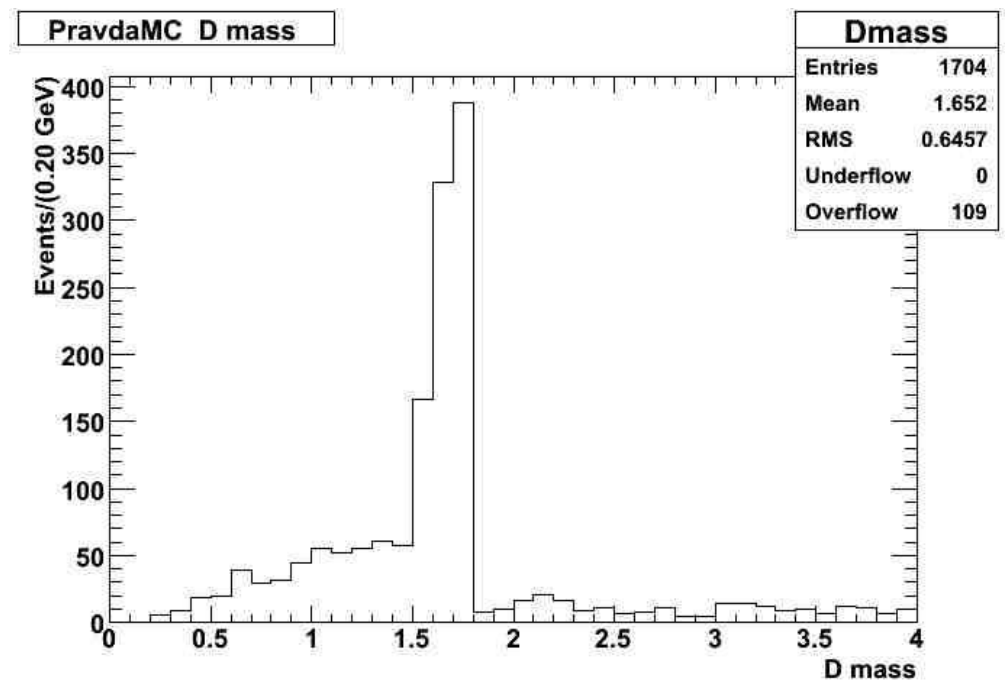
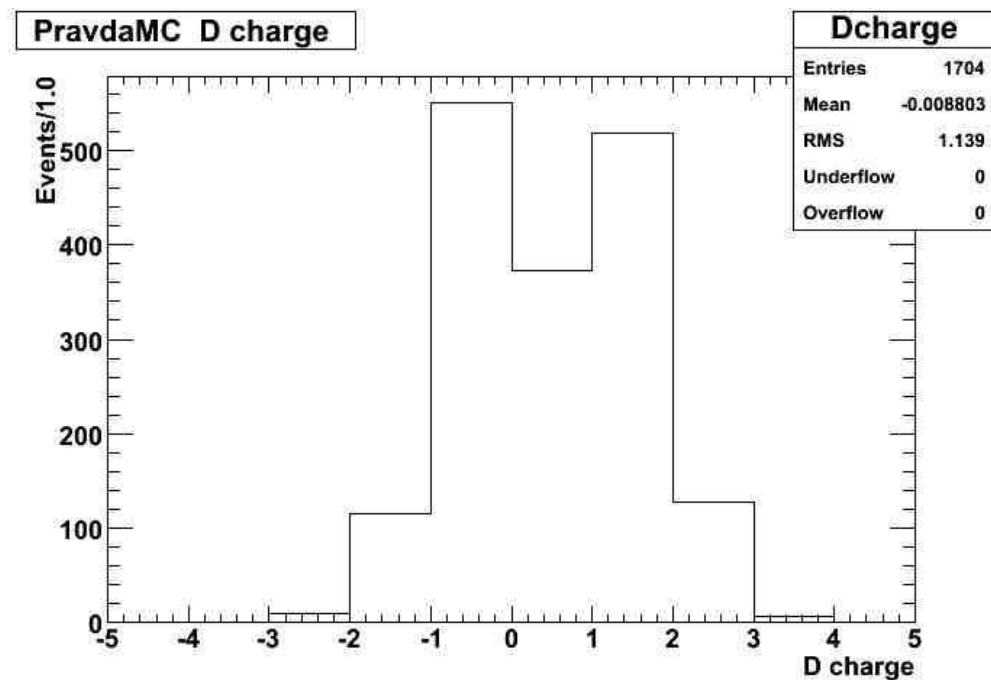
L : projected flight length resolution

$L = (Vtx_B - Vtx_D) \cdot \hat{p}_D$ resolution in Tag Side Vertex events $B^0 \rightarrow D^-(K\pi\pi)\pi^+$



Charm candidate: mass and charge

$$\text{for } B^0_{\text{Tag}} \rightarrow D^-(K\pi\pi)\pi^+$$

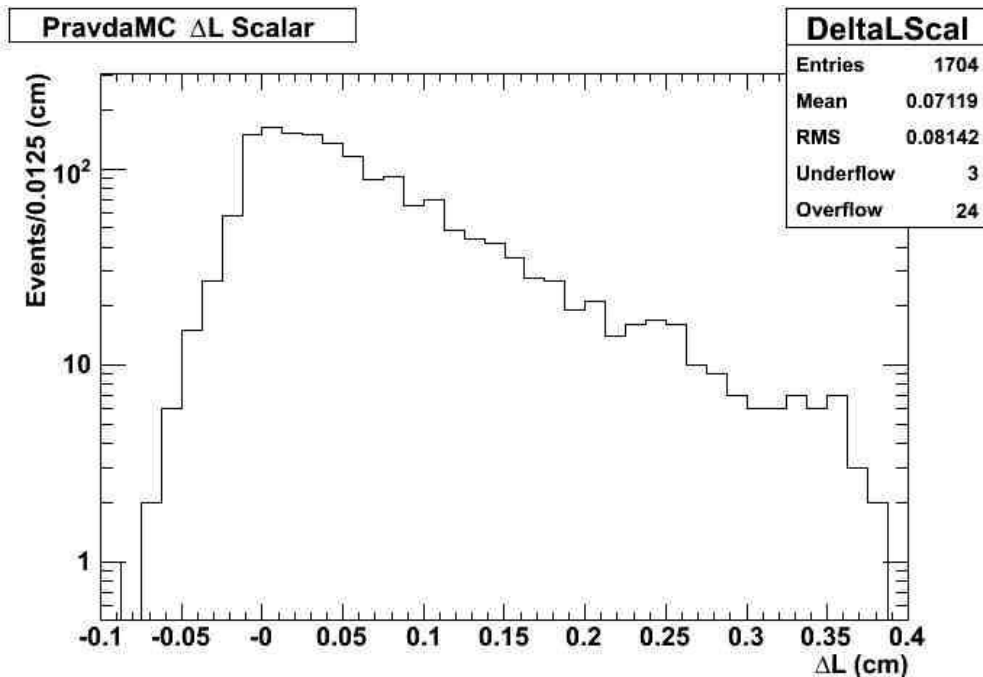


charm candidate reconstructed charge

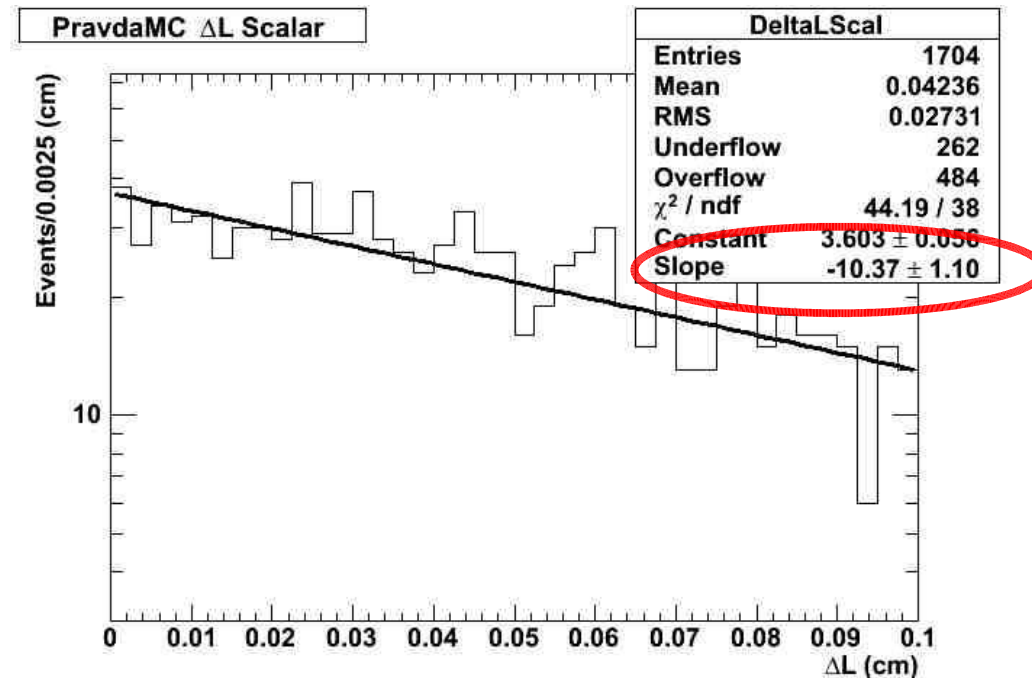
charm candidate reconstructed mass

$$L = (Vtx_B - Vtx_D) \cdot \hat{p}_D \text{ distribution}$$

$$\text{for } B^0_{\text{Tag}} \rightarrow D^-(K\pi\pi)\pi^+$$



no cut applied: vtx resolution effect.



cut $L > 0$ to fit with exp function

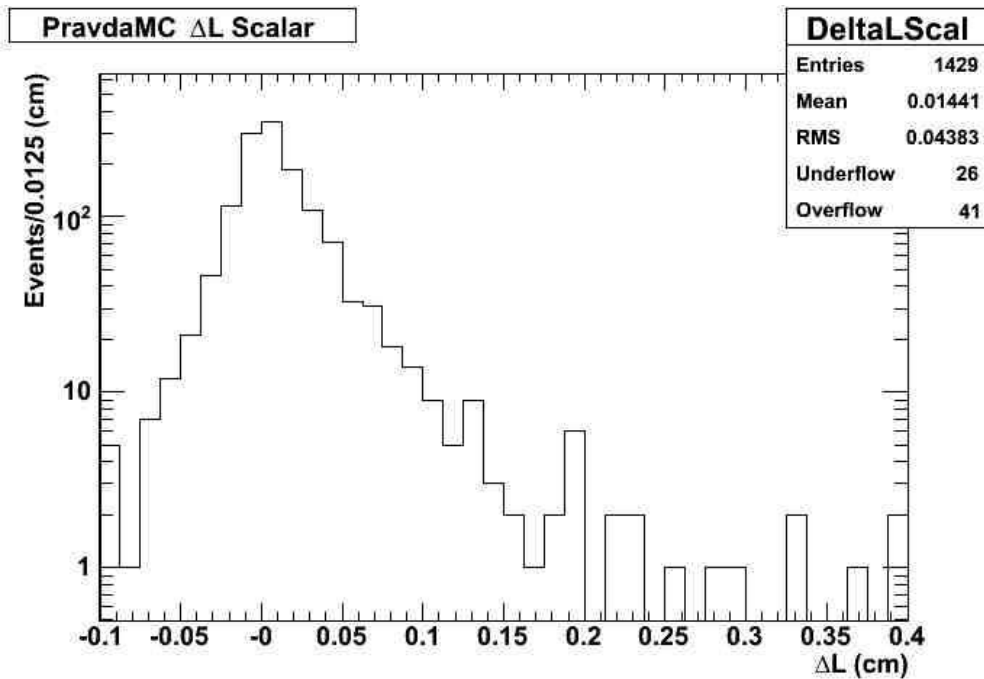
The Slope is sensitive to the charm lifetime:

$$N(x) = N_0 \exp[-x/(\beta\gamma c\tau)] = N_0 \exp(\text{slope} \cdot x)$$

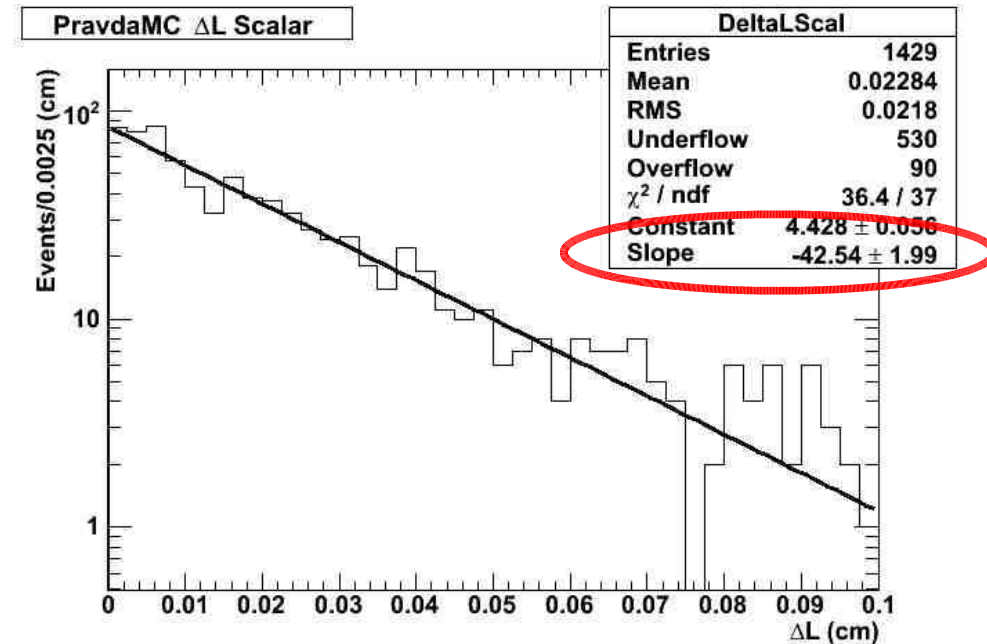
if I consider $\langle\beta\gamma\rangle \sim 1.2$ $c\tau_{D^+} \sim 320 \mu\text{m} \Rightarrow \text{slope} \approx -26$

only crude estimate:
possible algorithm bias,
resolution not considered

$L = (Vtx_B - Vtx_D) \cdot \hat{p}_D$ distribution on
generic $B\bar{B}$ events



no cut applied: vtx resolution effect.



cut $L > 0$ to fit with exp function

The Slope is sensitive to the charm lifetime:

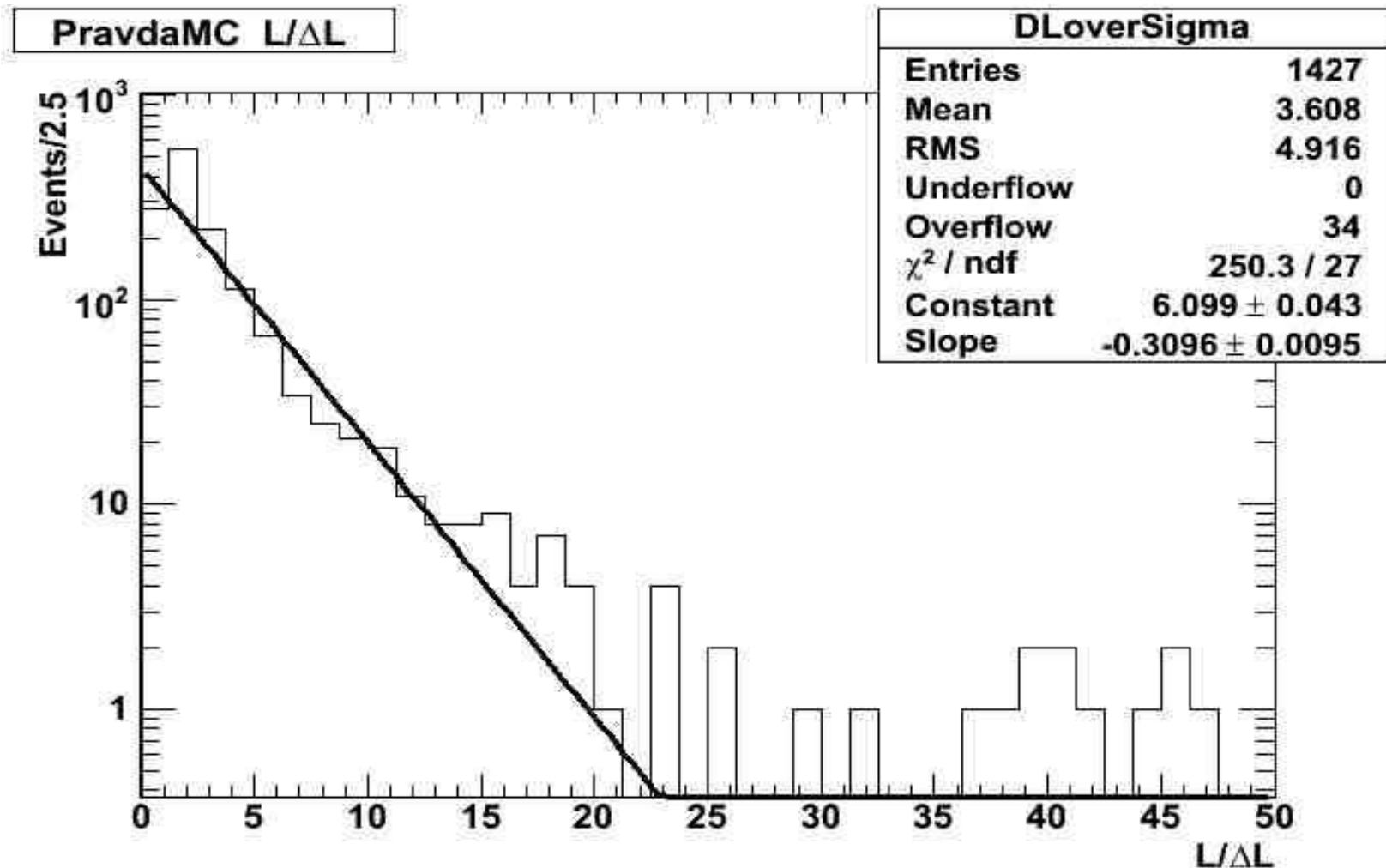
$$N(x) = N_0 \exp[-x/(\beta\gamma c\tau)] = N_0 \exp(\text{slope} \cdot x)$$

if I consider $\langle\beta\gamma\rangle \sim 1$ $c\tau \sim (0.6 \cdot c\tau_{D^0} + 0.4 \cdot c\tau_{D^+}) \sim 200 \mu\text{m} \Rightarrow \text{slope} \approx -50$

only crude estimate:
possible algorithm bias,
resolution not considered

$L/\Delta L$: flight length significance

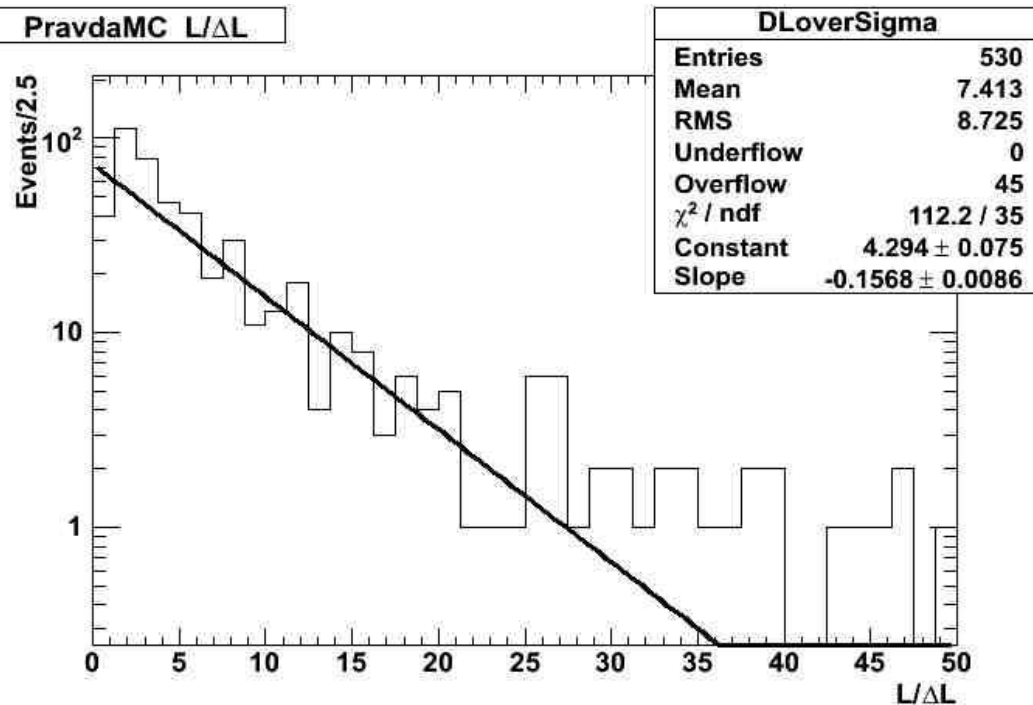
$L = |V_{tx_B} - V_{tx_D}|$ significance in Tag Side Vertex on $B^0\bar{B}^0$ events.



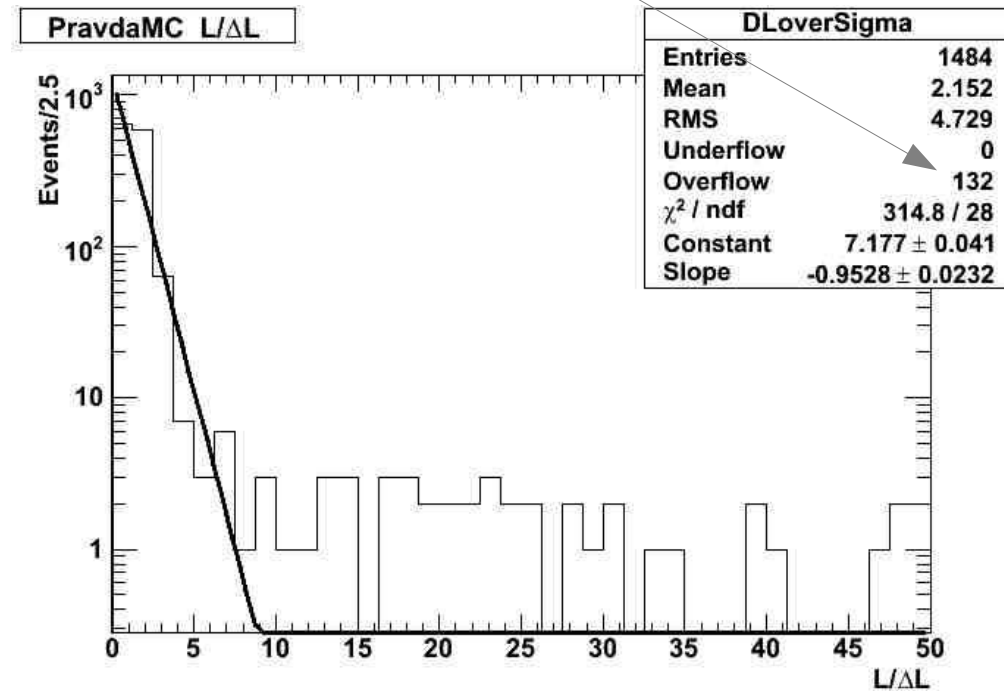
L/ Δ L : flight length significance on continuum events

$L = |V_{tx_B} - V_{tx_D}|$ significance in Tag Side Vertex on **uds, $c\bar{c}$ events**

residual contamination of Ks

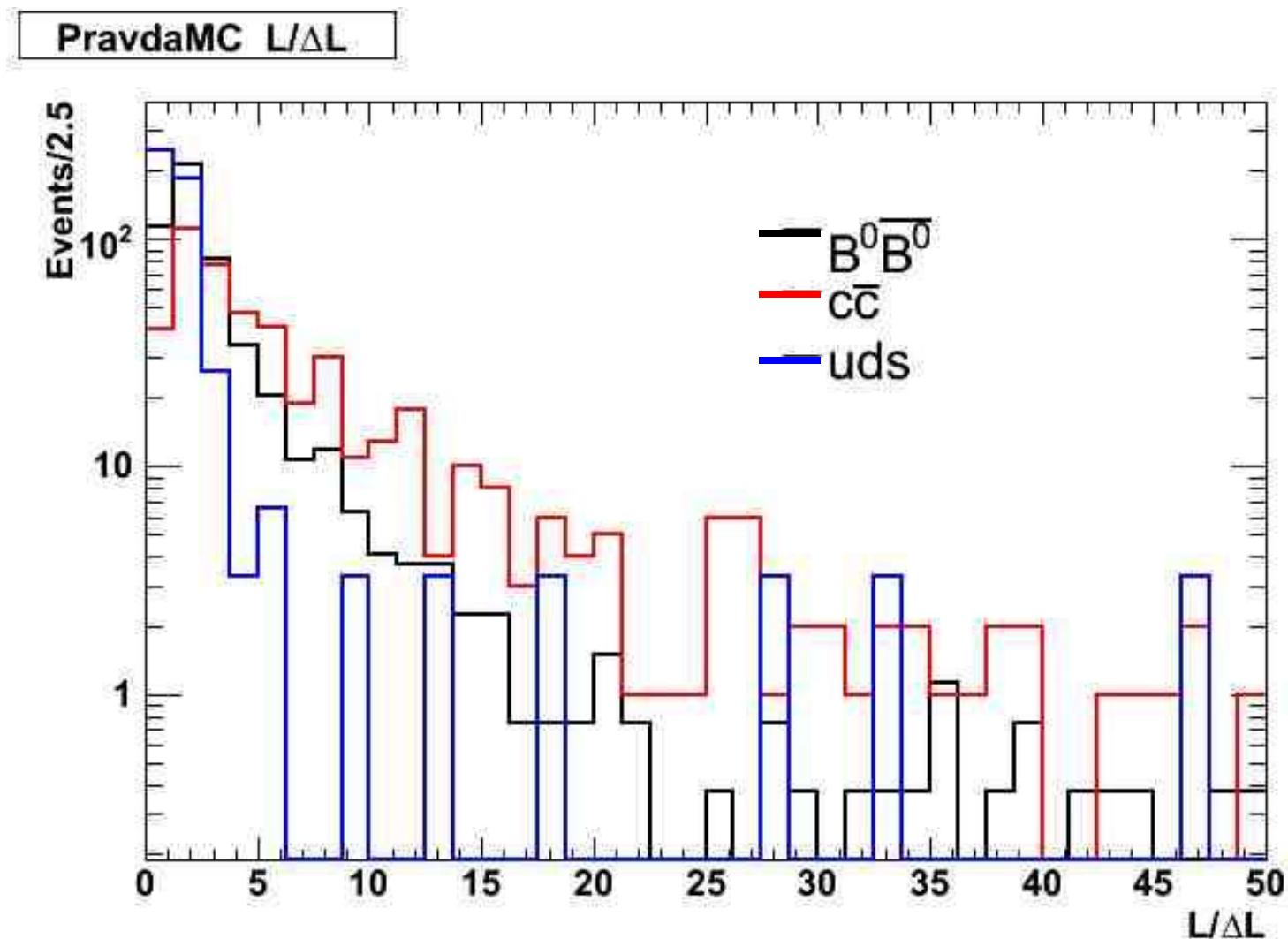


$c\bar{c}$ events

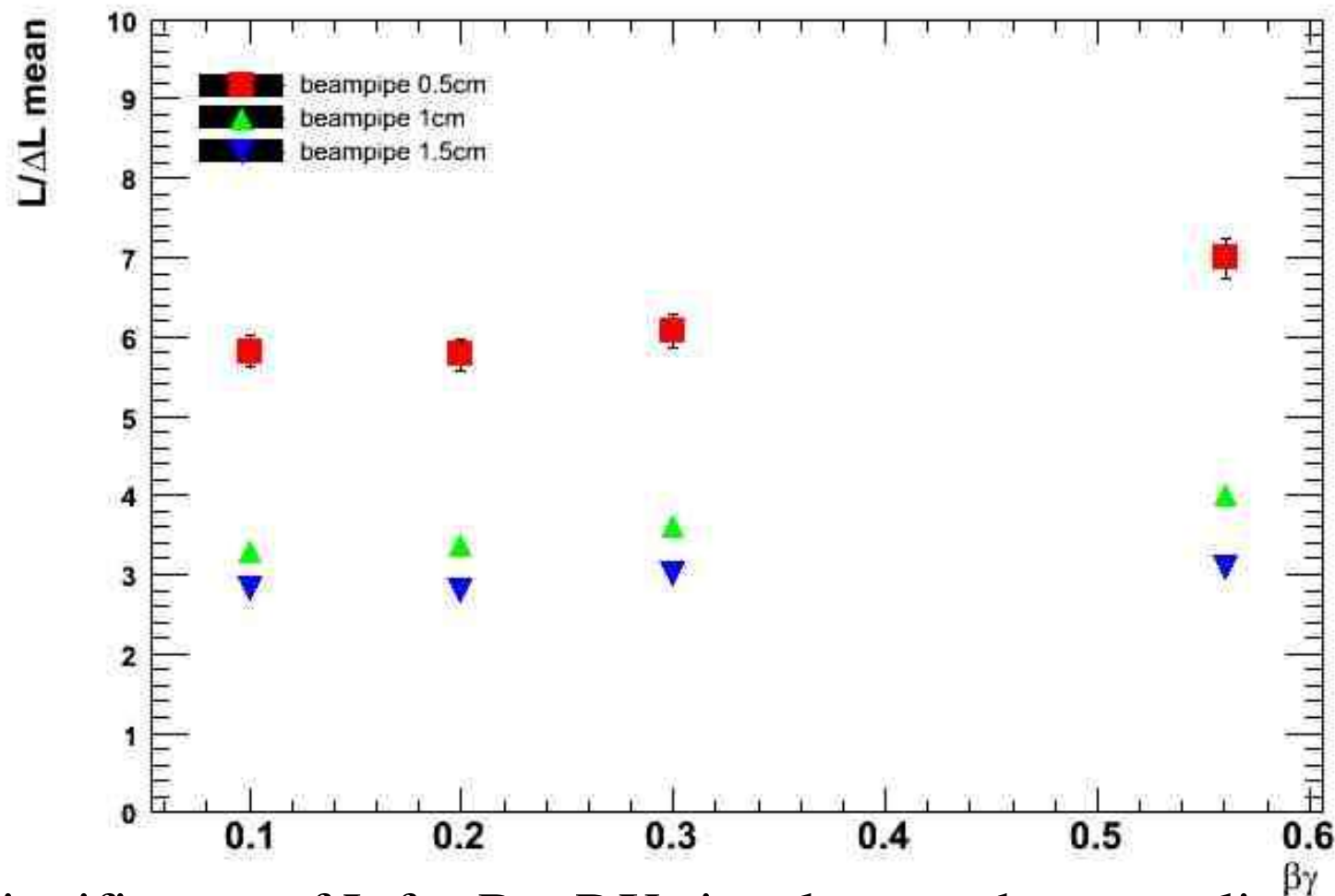


uds events have small L/ Δ L

$L/\Delta L$ for signal and continuum events.



$L/\Delta L$: small dependence on boost



The significance of L for $B \rightarrow DX$ signal events becomes linear with the boost of CM when the $\beta\gamma$ of the CM dominates wrt to the $\beta\gamma$ from the B decay.

Conclusions

- New beam-pipe design has a cooling system. Radial material has been kept to minimum but not a critical parameter.
- Time dependent measurements will take advantage of smaller beam-pipe radius and thinner radial material, allowing lower boost parameters.
- $K_S + \text{Neutrals}$ decay modes need a deeper study since could dominate the Δt resolution once optimal tagging performances will be achieved.
- Preliminary results on B-D vertex separation look promising with possible major impact on analysis techniques.