Vertexing studies

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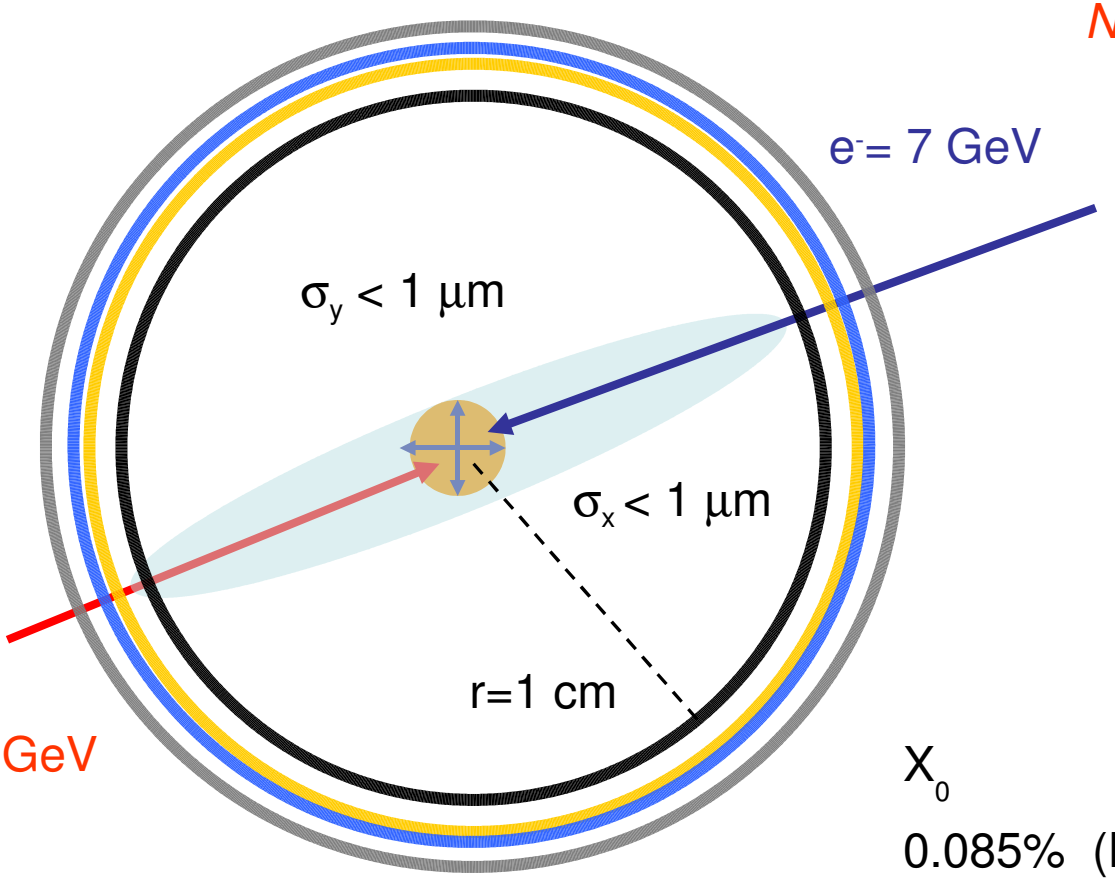
Outline

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

Interaction region SuperB

Not in scale



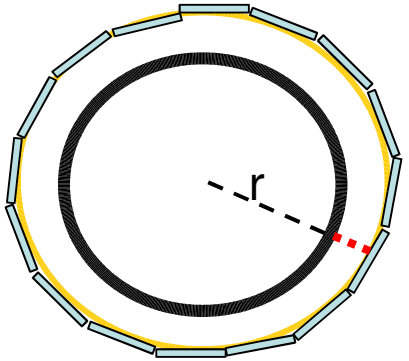
σ_z = 1 mm

- Be beam-pipe 300 μm thick
- Au foil 4 μm thick
- Water 300 μm thick
- Nickel coating 7+7 μm thick
- Plastic/Be 300 (500) μm thick

X_0	
0.085%	(Be)
0.044%	(Au)
0.083%	(H_20)
0.094%	(Ni)
0.085%	(Be)
0.391%	(0.447%) ToT

Beam-pipe scenarios

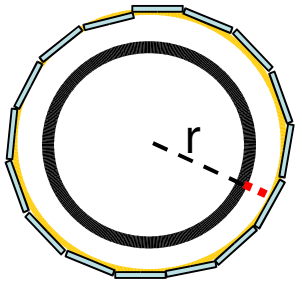
- **conservative scenario:**
  - beam pipe radius 1.5cm
  - hit resolution z,ϕ side = 10 μm
  - Radial material = 0.50%X_0



r=1.5cm

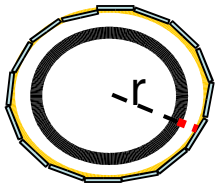
Be beam-pipe
Kapton foil
50 μm Silicon pixel

- **most likely scenario:**
  - beam pipe radius 1.0cm
  - hit resolution z,ϕ side = 10 μm
  - Radial material = 0.39% X_0



r=1cm

- **aggressive scenario:**
  - beam pipe radius 0.5cm
  - hit resolution z,ϕ side = 5 μm
  - Radial material = 0.24%X_0

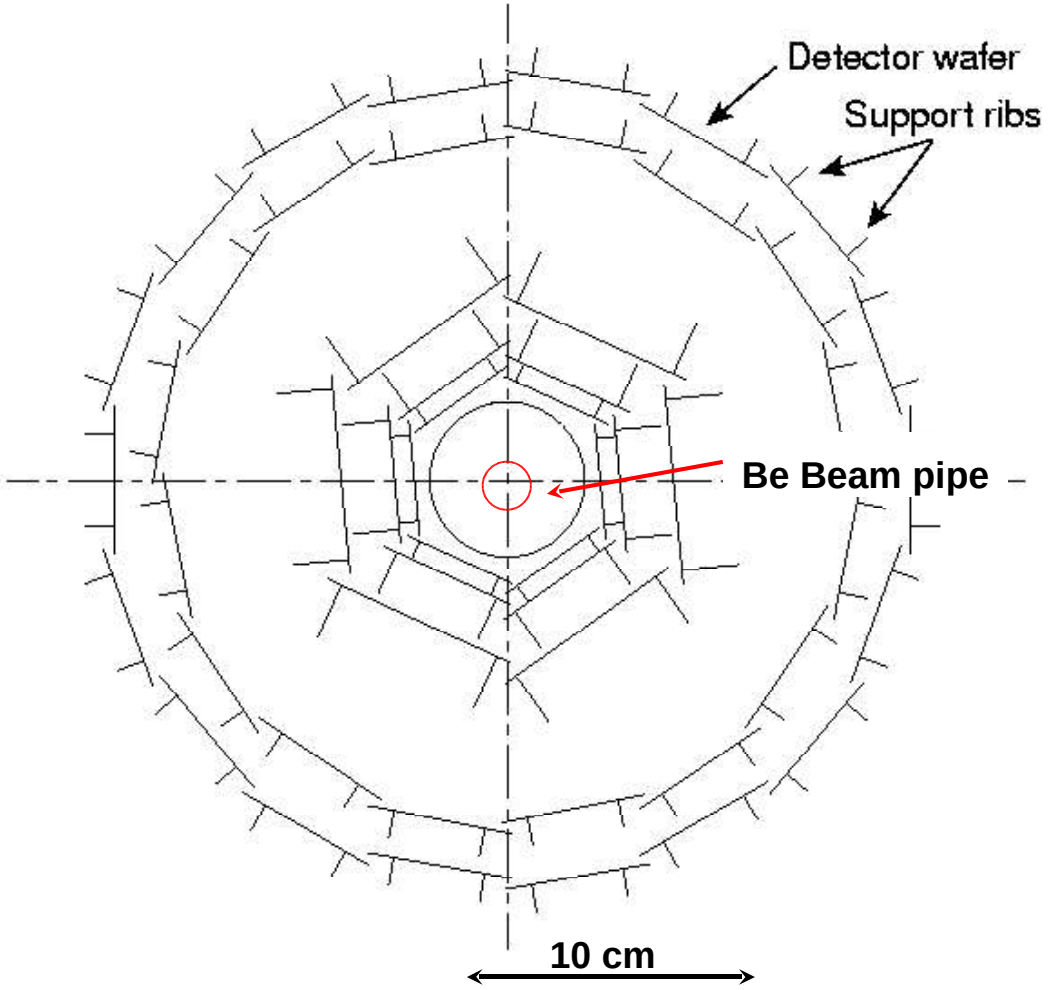


r=0.5cm

SuperB SVT Geometry

ADDED

Layer	Radius
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



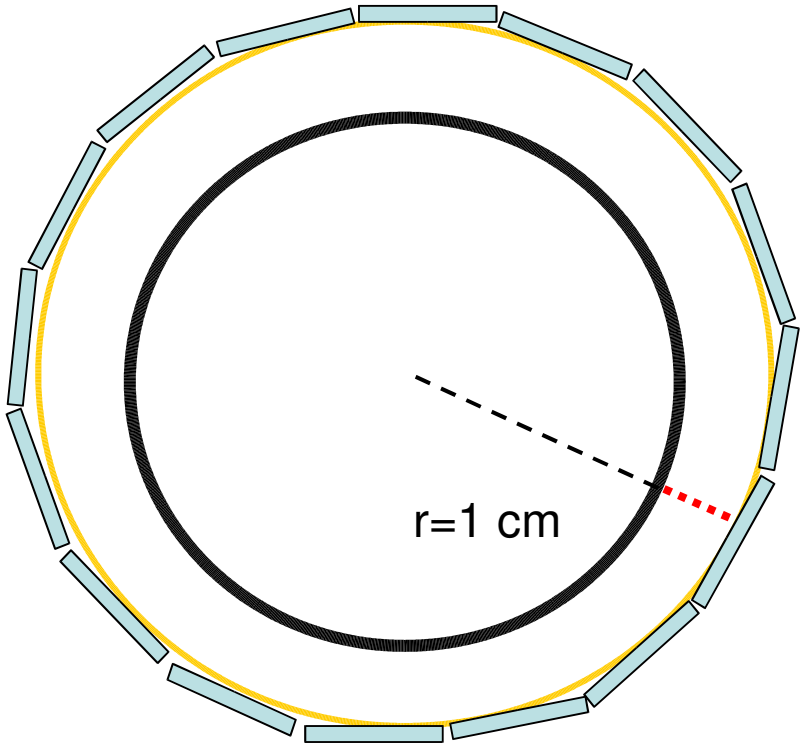
(Arched wedge wafers not shown)

- Added layer0
- Reduced beam-pipe radius 2.5→1cm
- Reduce Be thickness 1.3→0.6mm
- 4 μm Au foil before layer0

Layer0 design

New conceptual design for layer0

- Use kapton foil ~50 μm 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

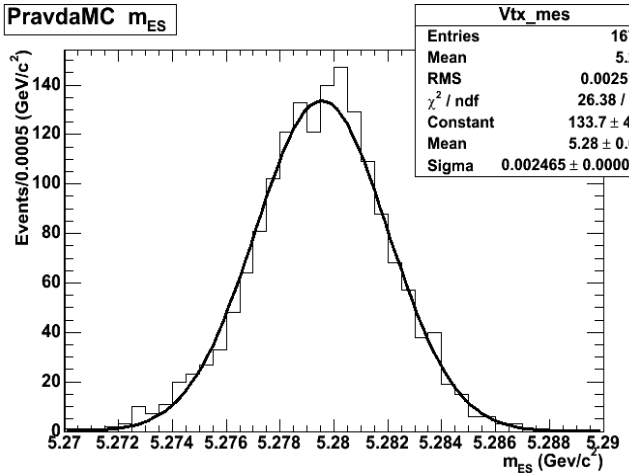
Be beampipe
Kapton foil
50 μm Silicon pixel

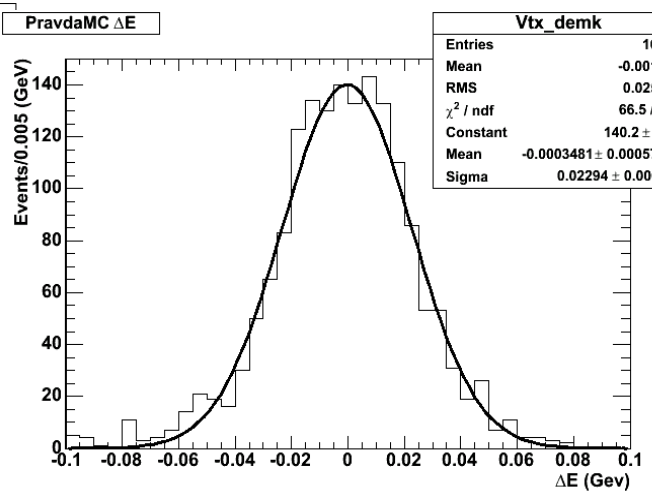
Δr ~ 500 μm
security distance

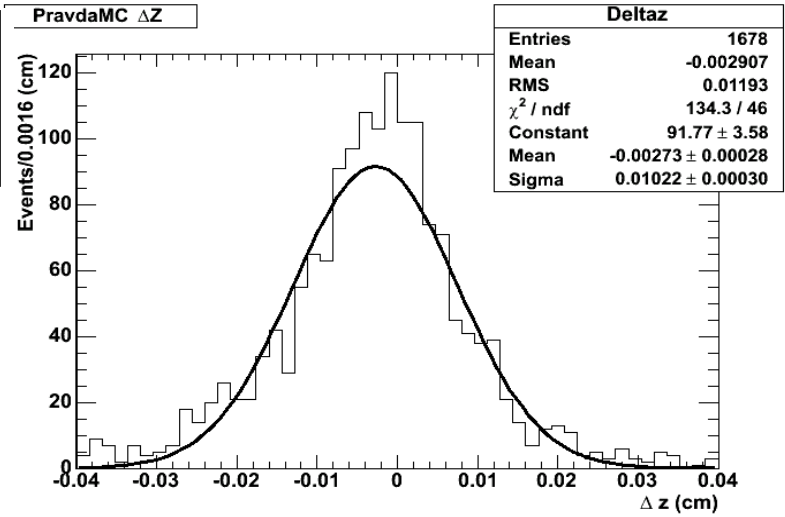
PravdaMC: simulation software

- 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.

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







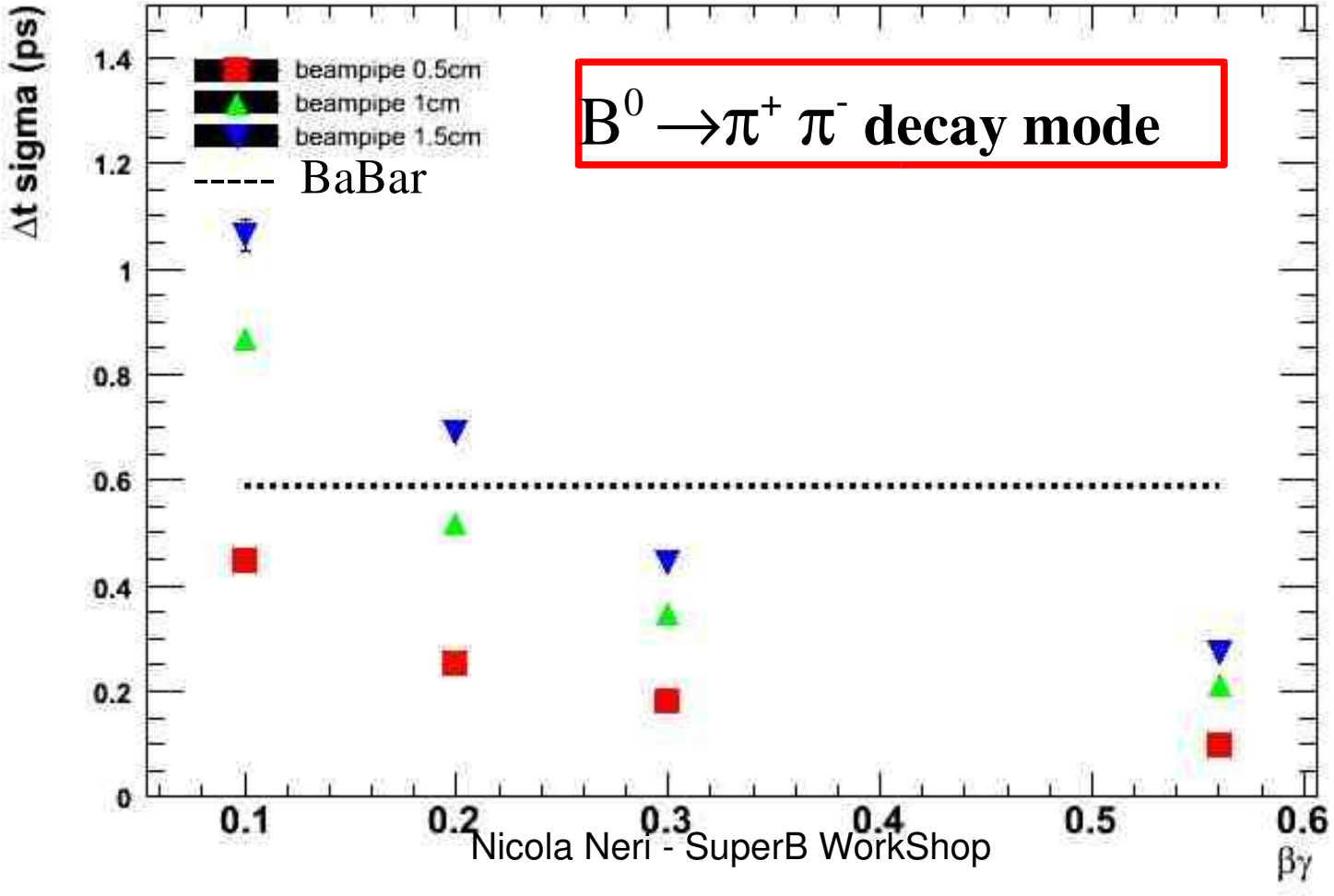
$\sigma(mES) \sim 2.5$ MeV

$\sigma(\Delta E) \sim 23$ MeV

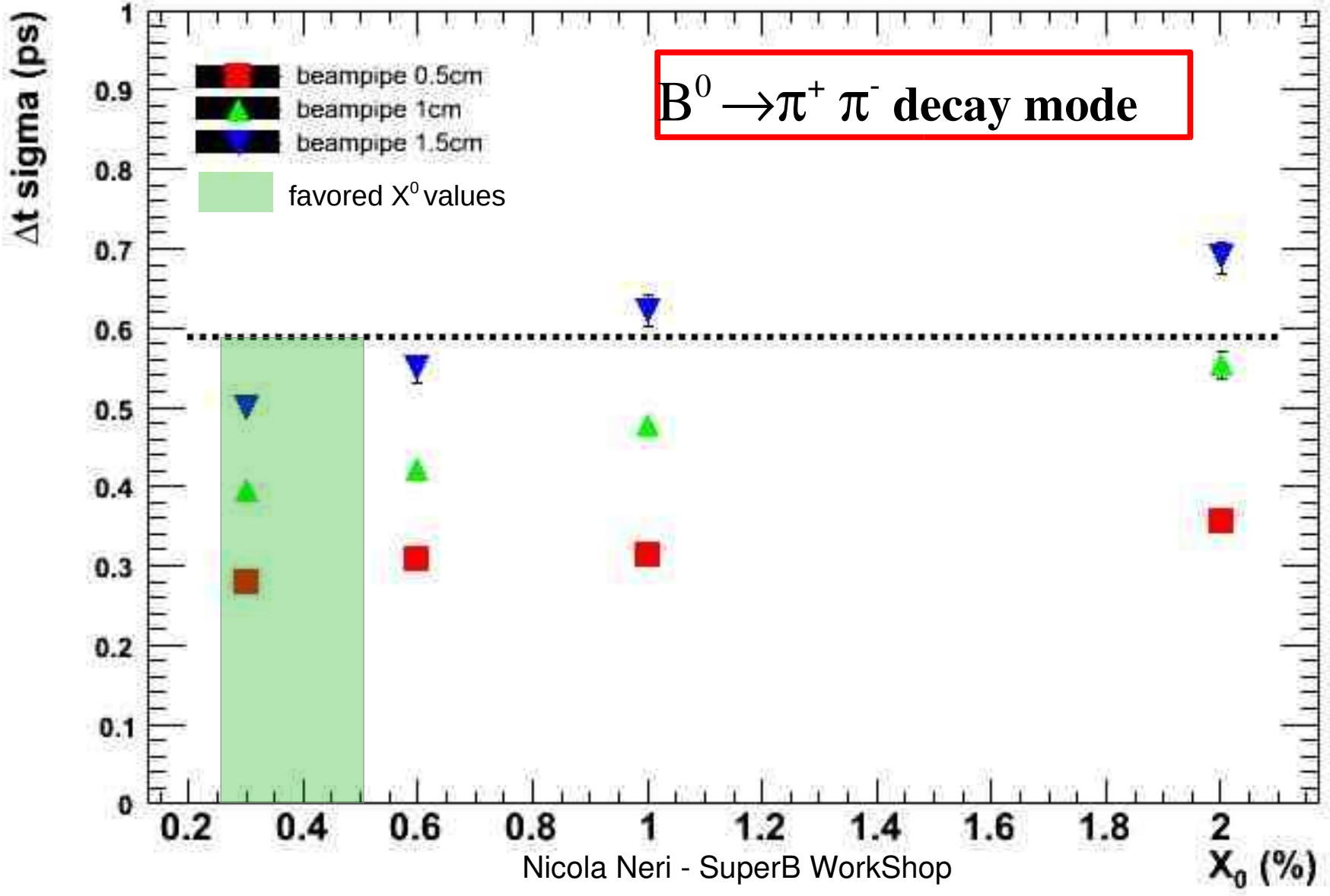
$\sigma(\Delta z) \sim 102$ μm

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

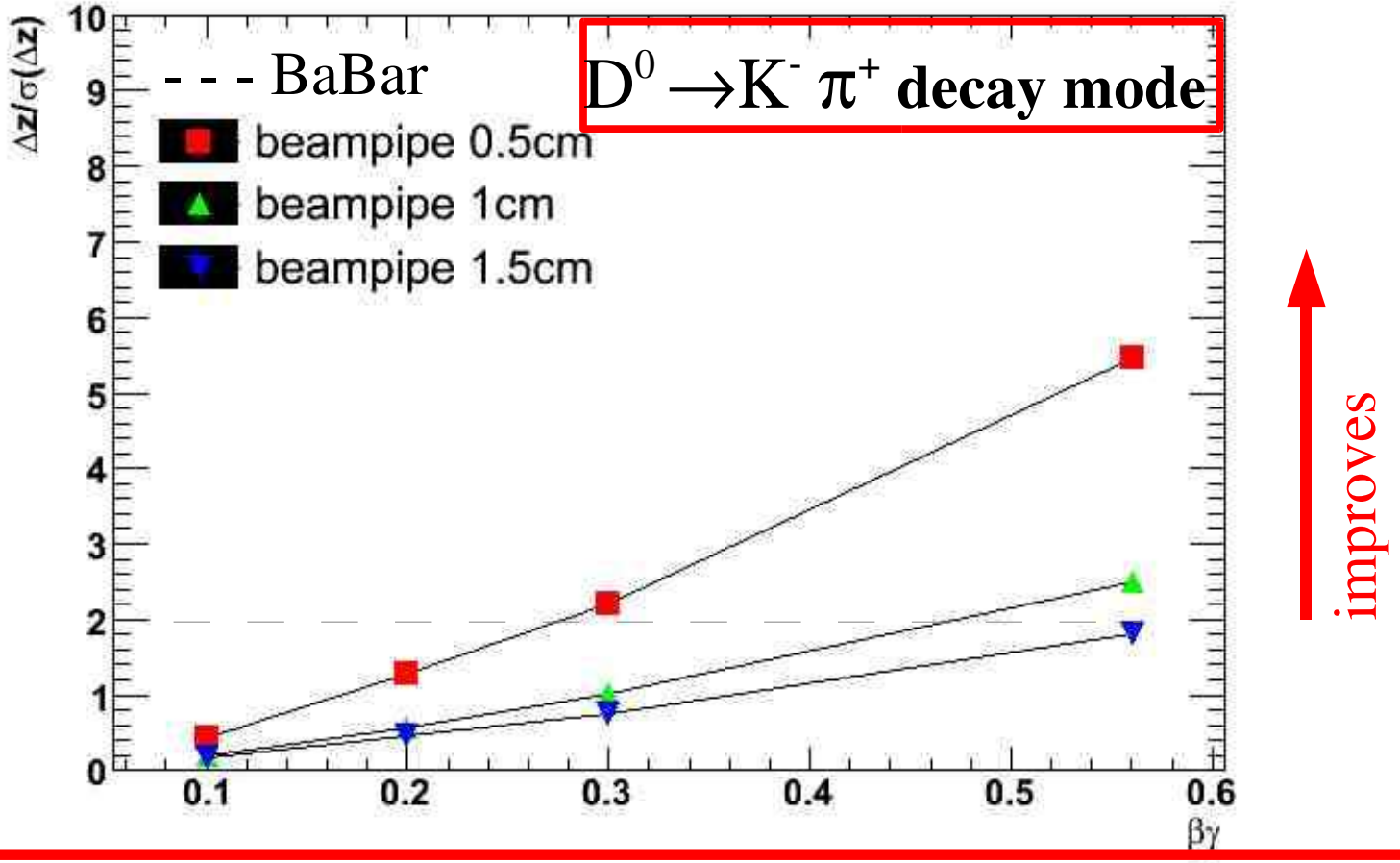
- Ks+Neutrals = $Ks\pi^0$, $KsKsKs$, $Ks\eta(\eta\to\gamma\gamma)$

vertexing is harder here.

- Layer0 impact on vertex resolution is marginal, few percent of Ks have hits in layer0.
- Beam-spot constraint will help but vertex resolution scaling law different (worst) than $B\to\pi\pi$.
- 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 is 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



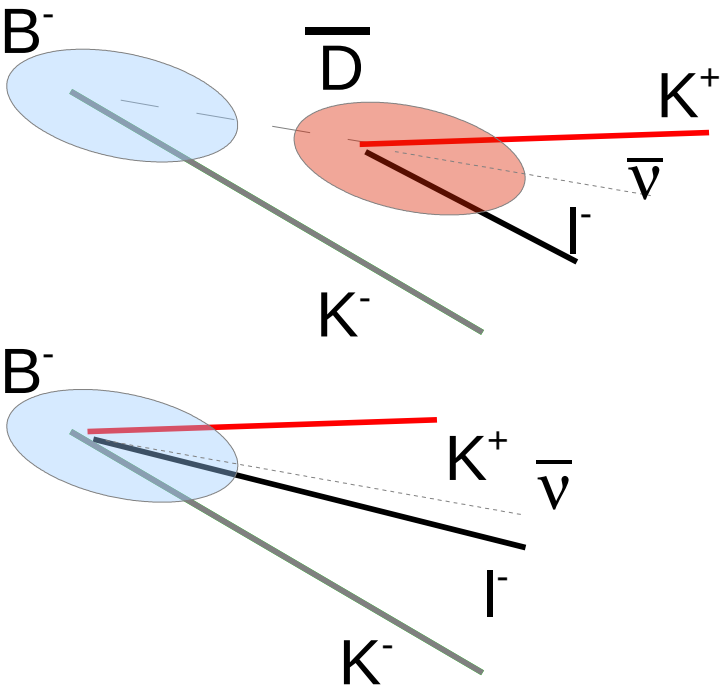
D lifetime 0.4 ps, for B it is 1.5 ps ⇒ Smaller Δz significance.

Layer0 at 0.5cm and reduction of the radial material is important.

B-D vertex separation: analysis implications

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

Rare and/or bkg dominated decay modes

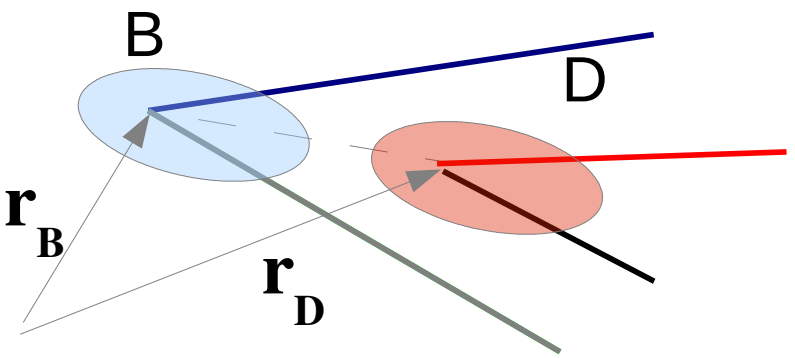


Allow to measure rb parameter relevant for the γ measurement

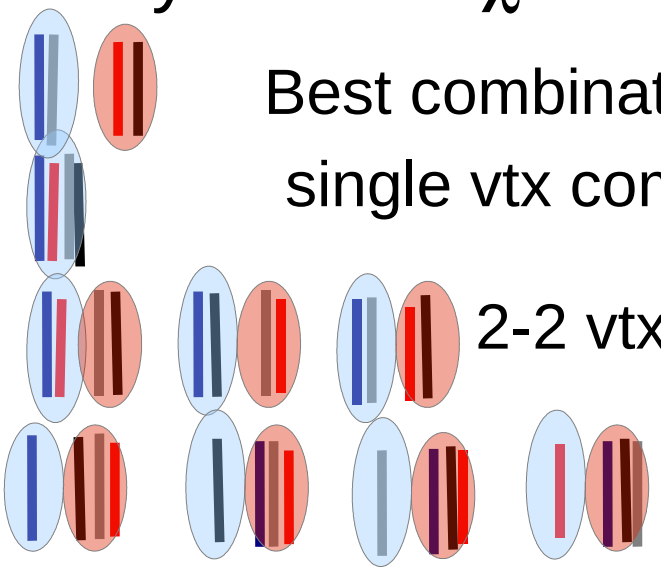
B-D vertex separation algorithm

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



$L=|\mathbf{r}_B-\mathbf{r}_D|$



Best combination

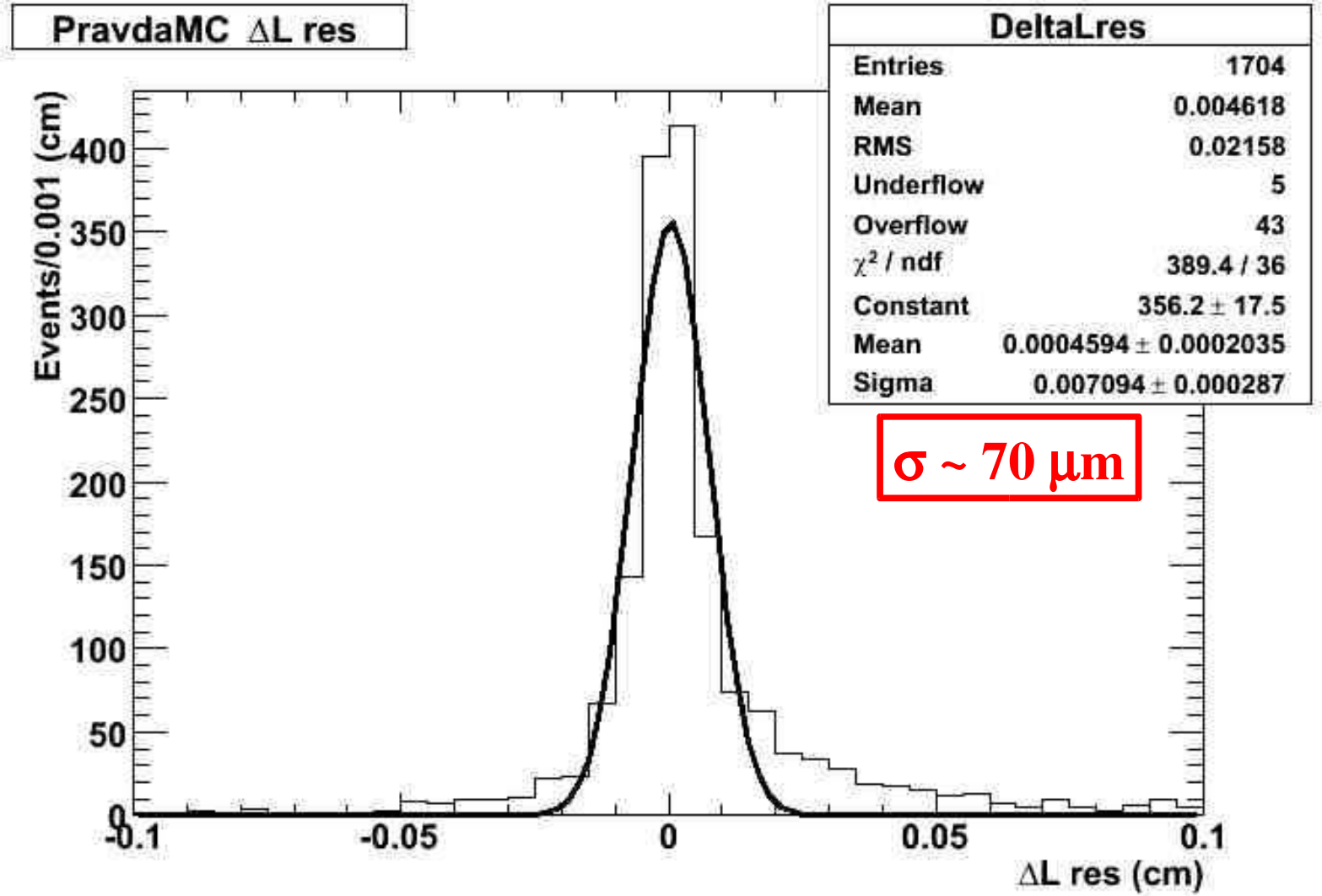
single vtx combination

2-2 vtx combination

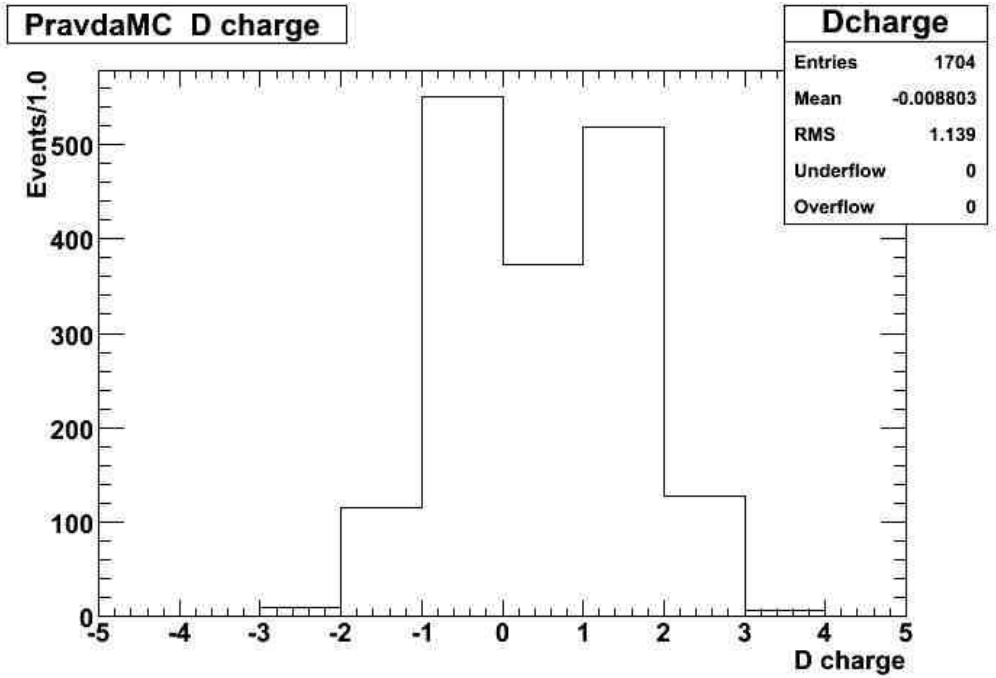
1-3 vtx combination

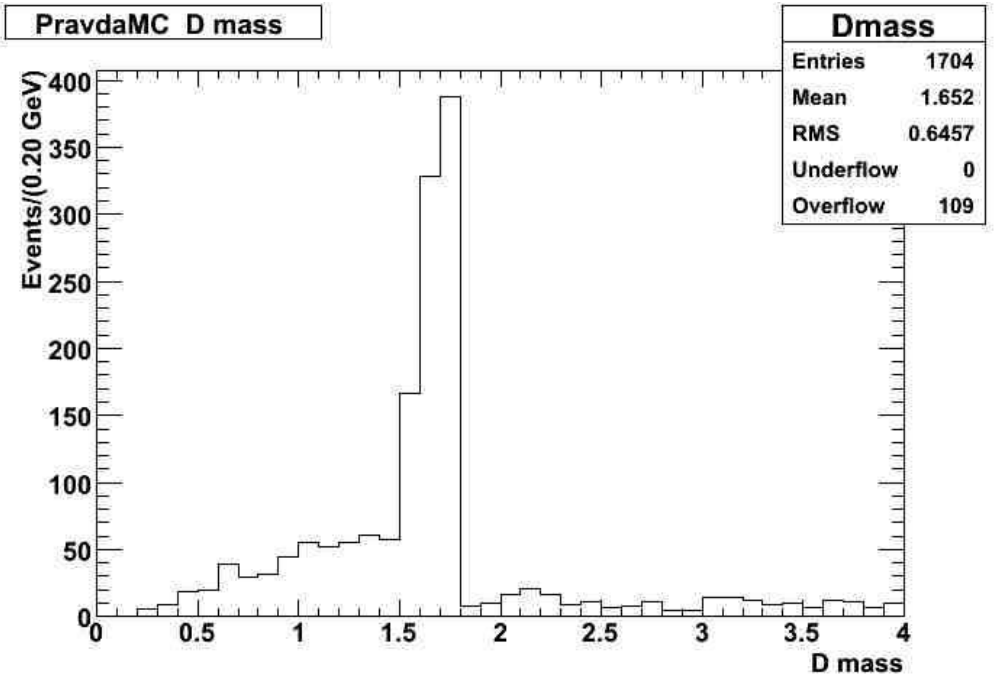
L : projected flight length resolution

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



Charm candidate: mass and charge for $B^0_{Tag} \rightarrow D^-(K\pi\pi)\pi^+$



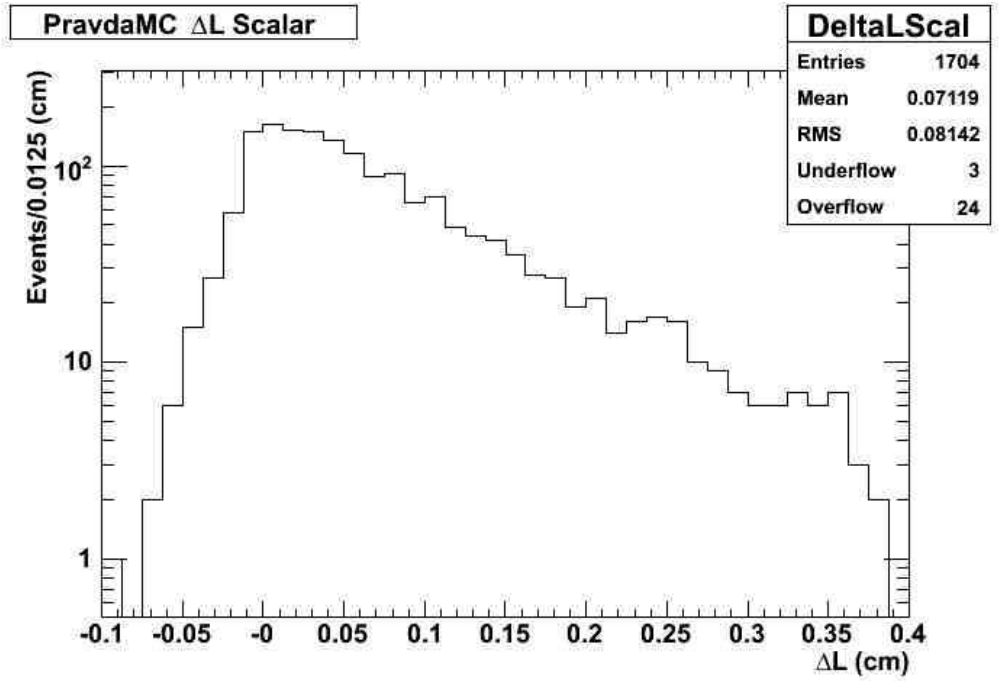


charm candidate reconstructed charge

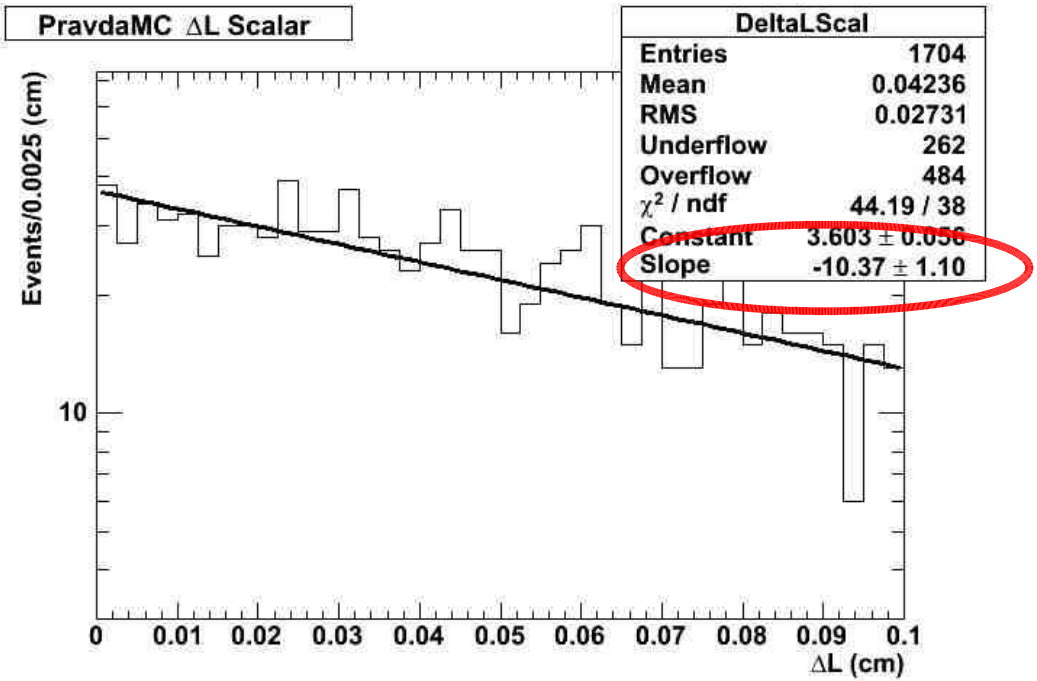
charm candidate reconstructed mass

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

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



no cut applied: vtx resolution effect.



cut L>0 to fit with exp function

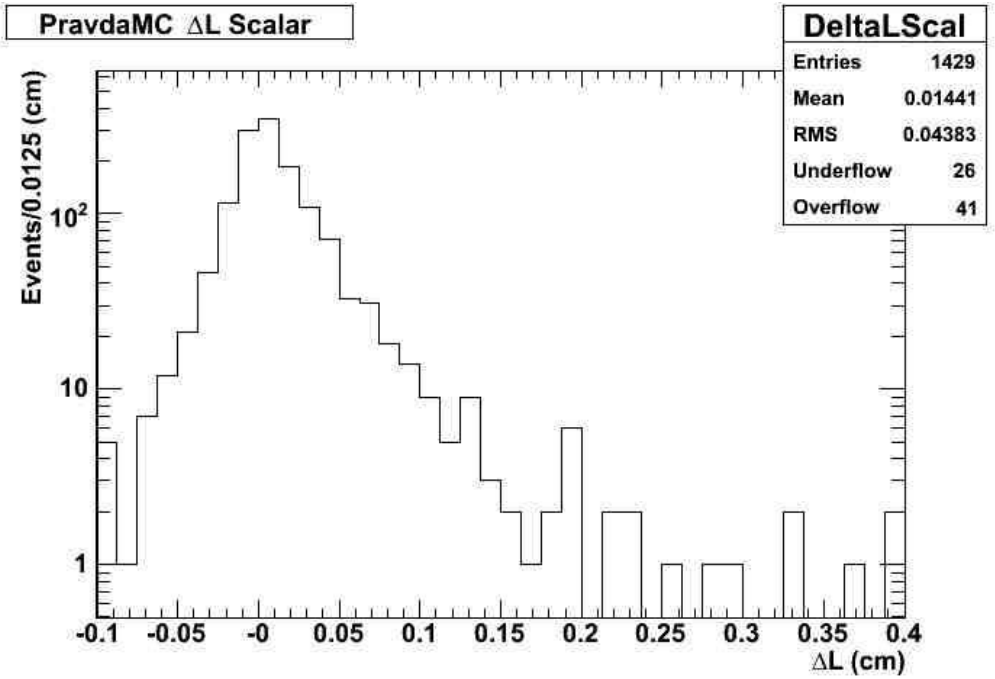
The Slope is sensitive to the charm lifetime:

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

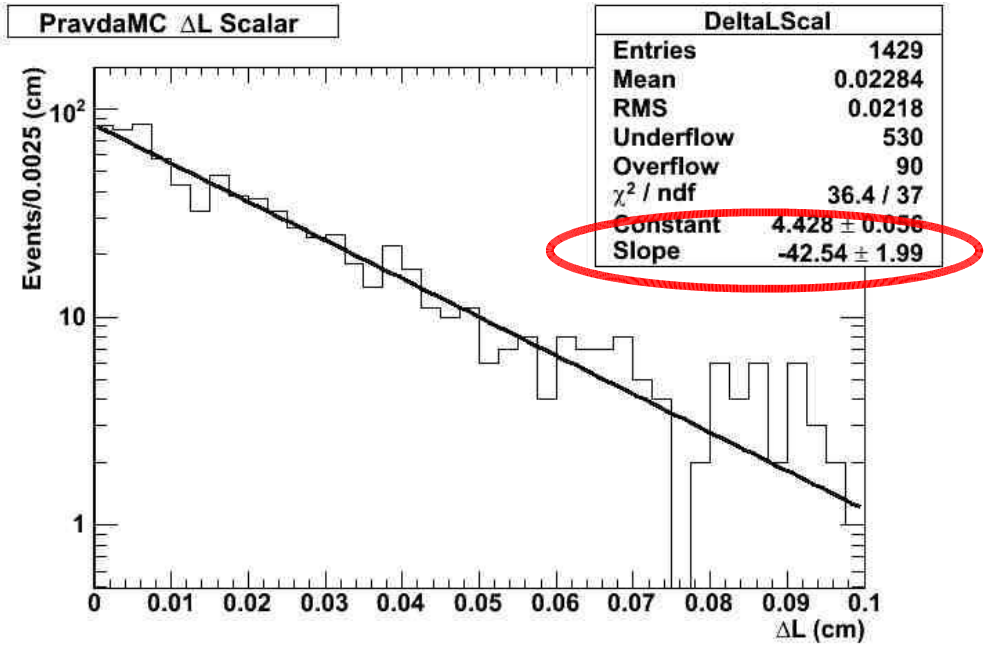
if I consider $\langle\beta\gamma\rangle \sim 1.2$ $c\tau D^+ \sim 320\ \mu m \Rightarrow$ slope ≈ -26

only crude estimate: possible algorithm bias, resolution not considered

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



no cut applied: vtx resolution effect.



cut L>0 to fit with exp function

The Slope is sensitive to the charm lifetime:

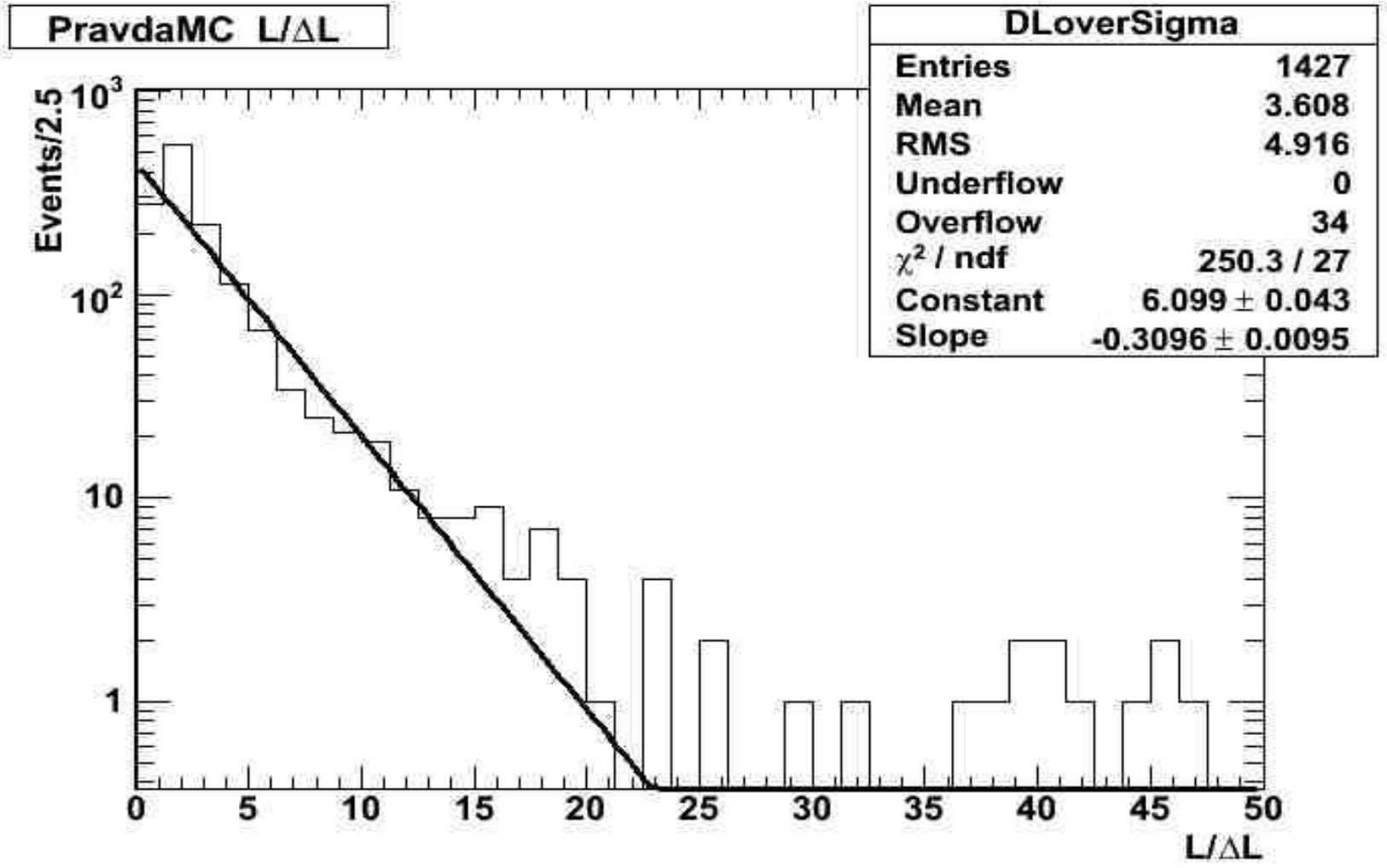
$N(x)=N_0 \exp[-x/(\beta\gamma c\tau)] = N_0 \exp(\text{slope}*x)$

if I consider $\langle\beta\gamma\rangle \sim 1$ $c\tau \sim (0.6*c\tau D^0 + 0.4*c\tau D^+) \sim 200\ \mu m \Rightarrow$ slope ≈ -50

only crude estimate: possible algorithm bias, resolution not considered

L/ΔL : flight length significance

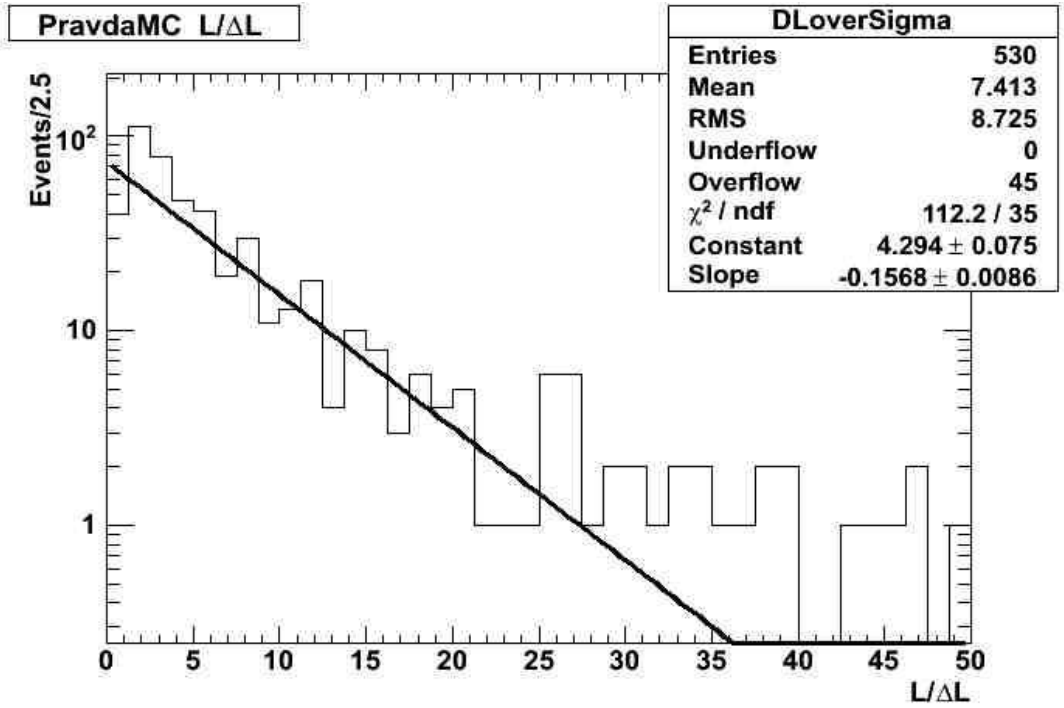
L= $|Vtx_B - Vtx_D|$ significance in Tag Side Vertex on $\mathbf{B^0\overline{B^0}}$ **events.**

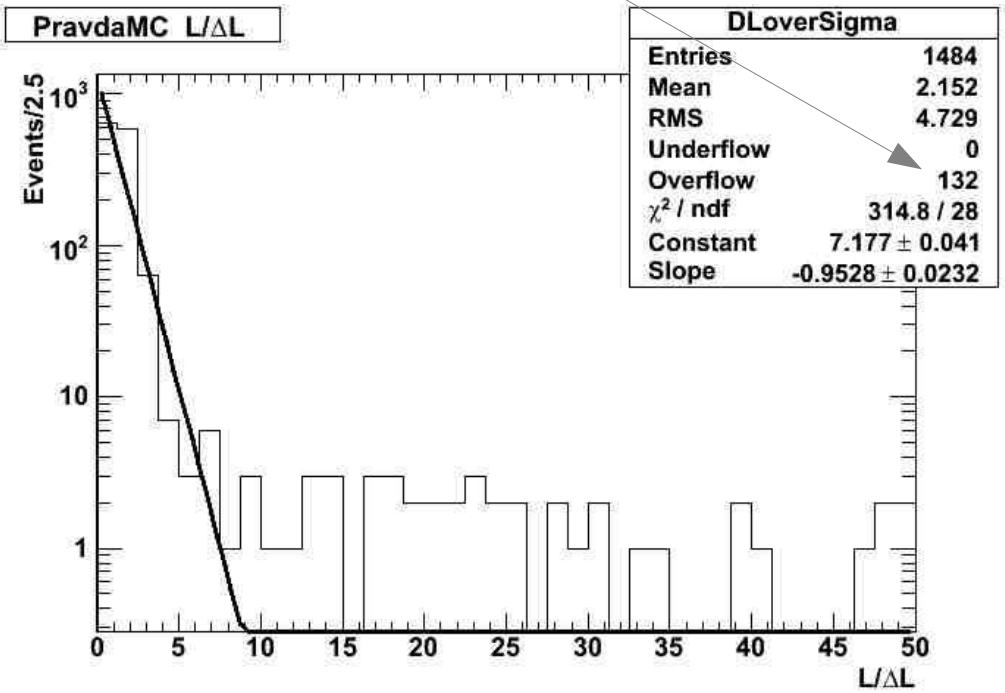


L/ΔL : flight length significance on continuum events

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

residual contamination of Ks

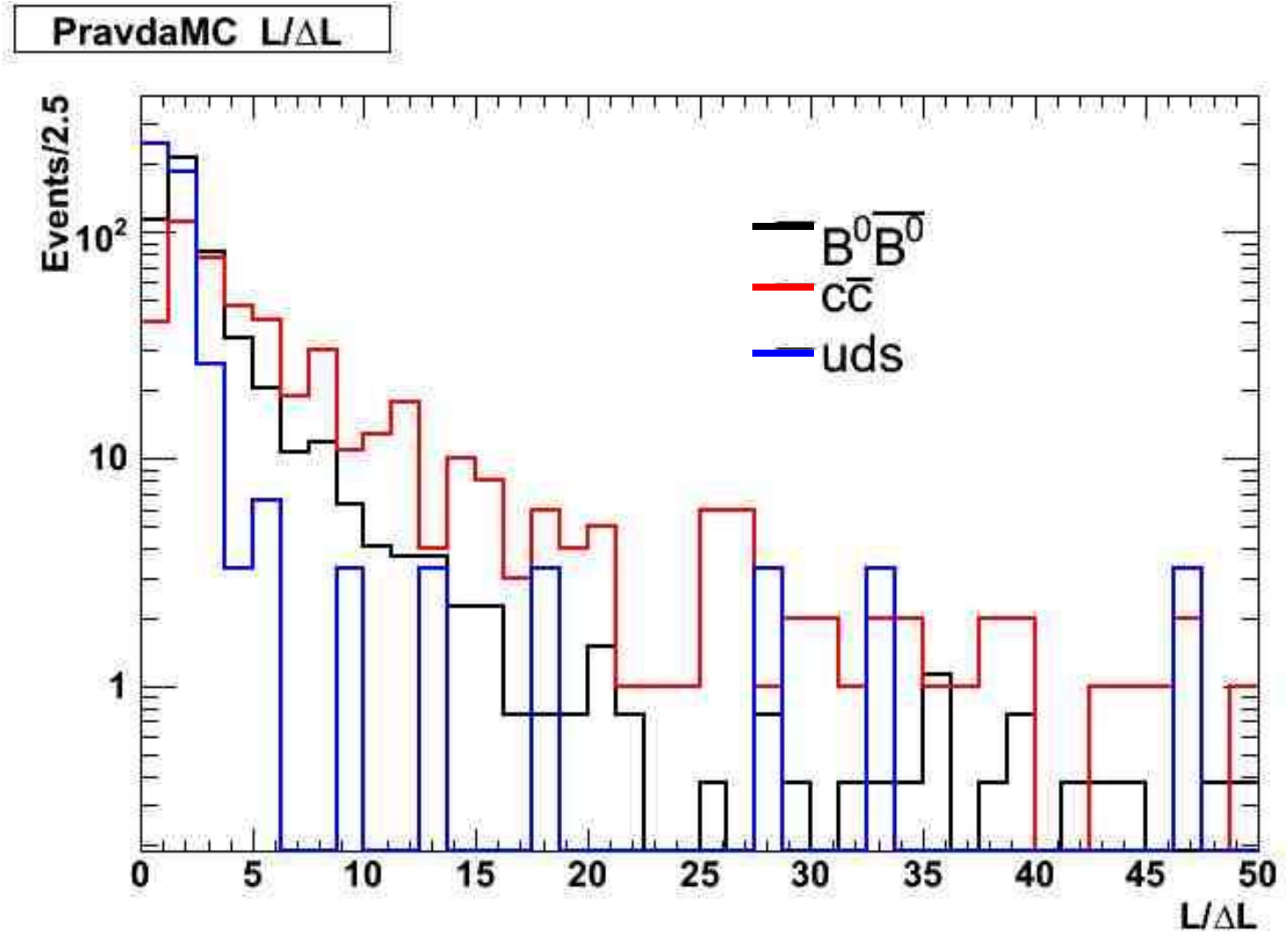




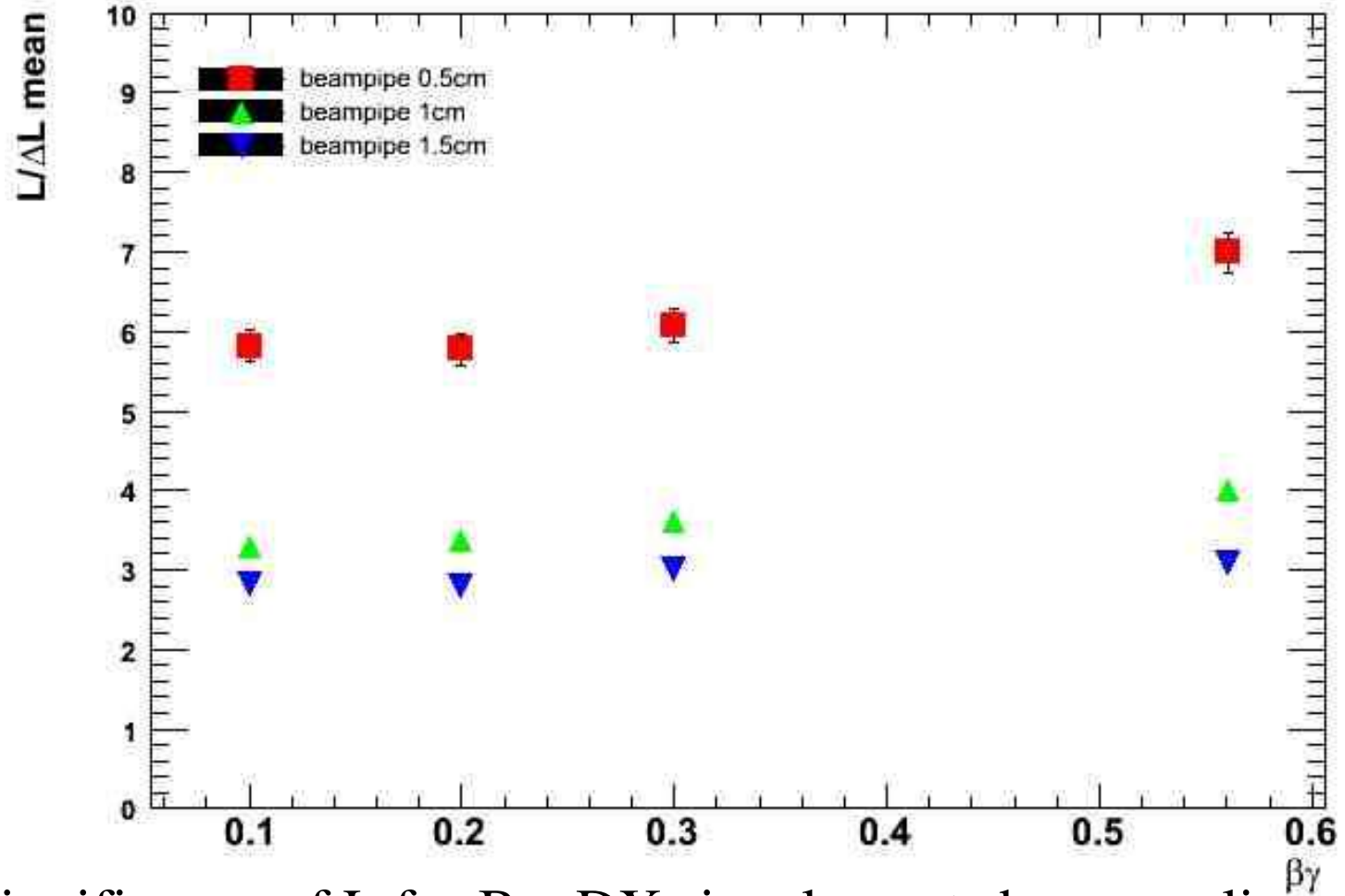
$c\bar{c}$ events

uds events have small L/ΔL

L/ΔL for signal and continuum events.



L/ΔL: small dependence on boost



The significance of L for B→DX signal events becomes linear with the boost of CM when the βγ of the CM dominates wrt to the βγ 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.
- Ks+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.