6th SuperB Collaboration Meeting 11-14 December 2012 INFN - LNF

CP Violation at the Charm threshold: *SuperB* vs *SuperD* vs *Others,* preliminary studies

Based on Bevan-Inguglia SuperB Internal Note SB-PHY-2012-020 + recent update

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SuperB

A Bet On Super*B*...

A Bet On Super*B*...

Outline

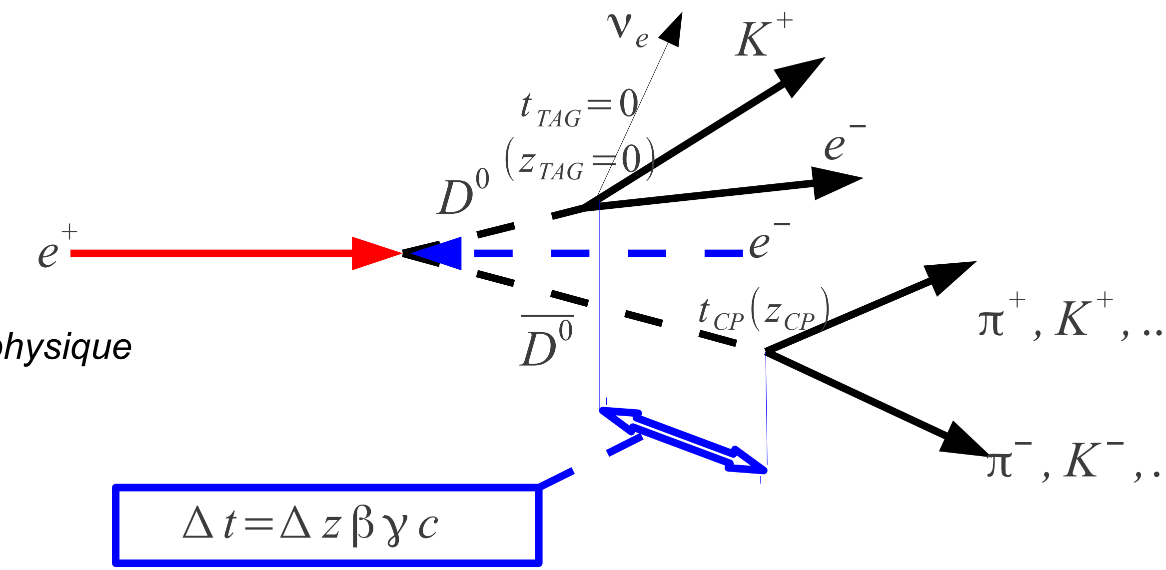
- Short introduction on time-dependent analysis
- Reconstruction and vertexing: $D^0 \rightarrow \pi^+ \pi^-$
- 4-layers SVT performances
- Reconstruction and vertexing: $D^0 \rightarrow K_S^0 \pi^0$
- 4-layers SVT performances
- Considerations and Conclusions

TDCPV in Charm

A. Bevan- G. Inguglia- B. Meadows:
*)Phys. Rev. **D** 84, 114009, arXiv:1106.5075

*)"The Time-Dependent CP Violation in Charm"
G. Inguglia, Proceedings of “Les Rencontres de physique de la vallee d'aoste” arXiv:1204.2303

*) SuperB Internal Note SB-PHY-2012-020



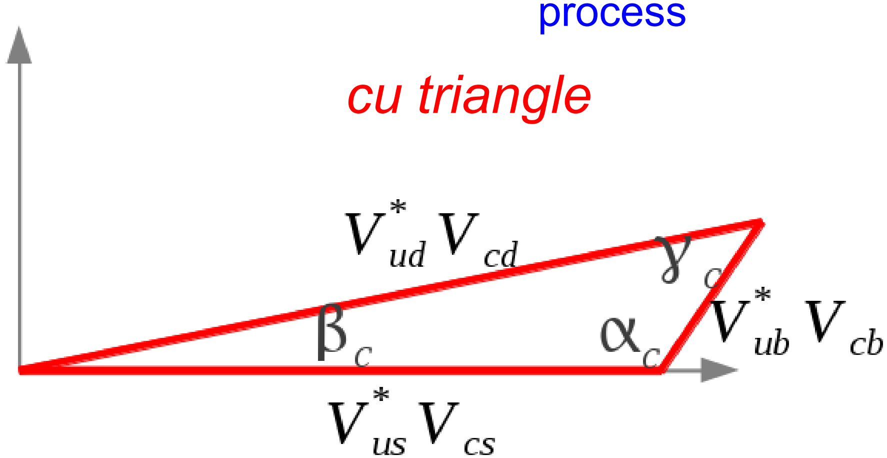
$$A_{CP}^{Phys}(\Delta t) = \frac{\overline{\Gamma^{Phys}}(\Delta t) - \Gamma^{Phys}(\Delta t)}{\overline{\Gamma^{Phys}}(\Delta t) + \Gamma^{Phys}(\Delta t)} = -\Delta\omega + \frac{(D+\Delta\omega)e^{\Delta\Gamma\Delta t/2}(|\lambda_f|^2-1)\cos\Delta M\Delta t + 2\Im(\lambda_f)\sin\Delta M\Delta t}{(1+|\lambda_f|^2)h_+/2 + h_-\Re(\lambda_f)}$$

$$\lambda_f = \left|\frac{q}{p}\right| e^{i\phi_{MIX}} \left|\frac{\overline{A}}{A}\right| e^{i\phi_{CP}} = \left|\frac{q}{p}\right| e^{i\phi_{MIX}} e^{-2i\phi_T^W}$$

= if tree-dominated process

Remember from the mixing Part of this talk:

$$x = \frac{\Delta M}{\Gamma}$$
$$y = \frac{\Delta \Gamma}{2\Gamma}$$



$$\alpha_c = arg\left[\frac{-V_{ub}^* V_{cb}}{V_{us}^* V_{cs}}\right] = (111.5 \pm 4.2)^o$$

$$\beta_c = arg\left[\frac{-V_{ud}^* V_{cd}}{V_{us}^* V_{cs}}\right] = (0.0350 \pm 0.0001)^o$$

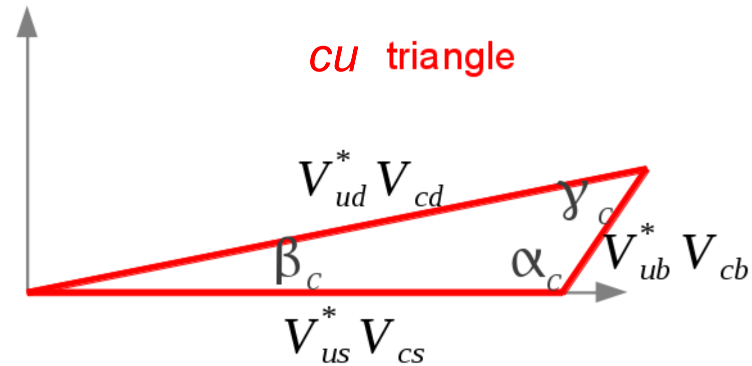
$$\gamma_c = arg\left[\frac{-V_{ub}^* V_{cb}}{V_{ud}^* V_{cd}}\right] = (68.4 \pm 0.1)^o$$

Numerical Results

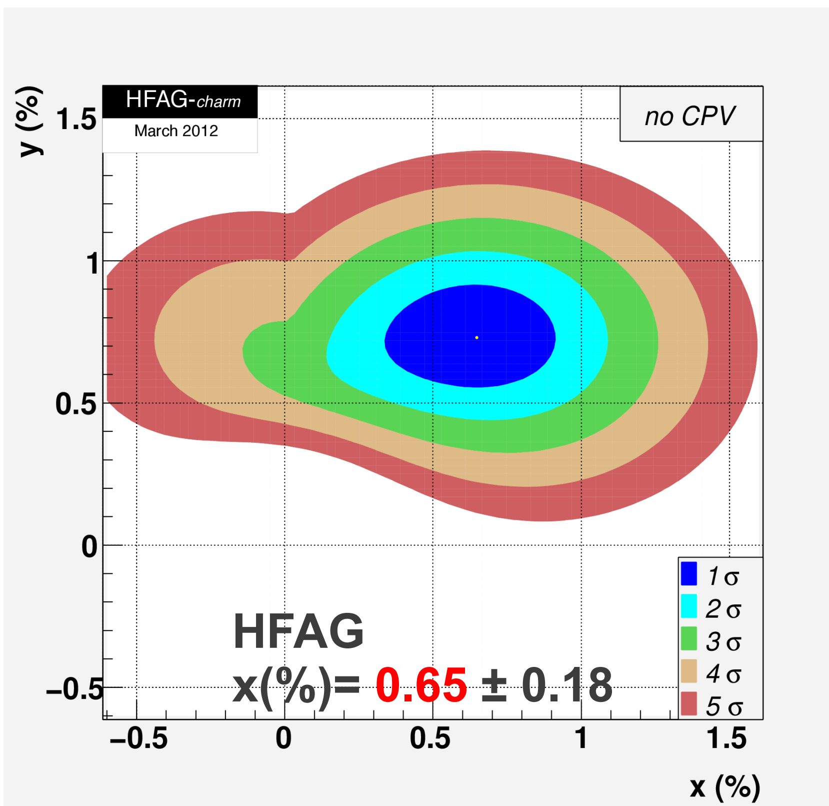
ϕ_{MIX} $\beta_{c,eff}$ x

Parameter	SuperB $\Psi(3770)$ SL	SuperB $\Psi(3770)$ SL+K	SuperB $\Upsilon(4S)$ $\pi_s^\pm$	LHCb $\pi_s^\pm$	Belle II $\pi_s^\pm$
$\sigma_{\phi_{\pi\pi}} = \sigma_{arg(\lambda_{\pi\pi})}$	5.7°	2.4°	2.2°	3.0°	2.8°
$\sigma_{\phi_{KK}} = \sigma_{arg(\lambda_{KK})}$	3.5°	1.4°	1.6°	1.8°	1.8°
$\sigma_{\beta_{c,eff}}$	3.3°	1.4°	1.4°	1.9°	1.7°

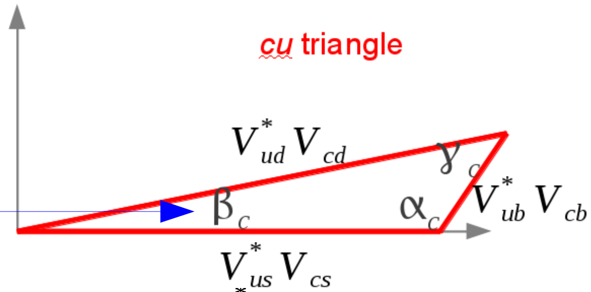
$$\sigma_{\phi_{KK}} = \sigma_{arg(\lambda_{KK})} = \sigma_{\phi_{MIX}}$$



Experiment/HFAG	$\sigma_x(\phi = \pm 10^o)$	$\sigma_x(\phi = \pm 20^o)$
Super$B$ $[\Upsilon(4S)]$		
$D^0 \to \pi^+\pi^-$	0.12%	0.06%
$D^0 \to K^+K^-$	0.08%	0.04%
Super$B$ $[\Psi(3770)]$		
$D^0 \to \pi^+\pi^-(SL)$	0.30%	0.15%
$D^0 \to \pi^+\pi^-(SL+K)$	0.13%	0.06%
$D^0 \to K^+K^-(SL)$	0.19%	0.10%
$D^0 \to K^+K^-(SL+K)$	0.08%	0.04%
LHCb		
$D^0 \to \pi^+\pi^-$ $(1.1\ \text{fb}^{-1})$	0.40%	0.20%
$D^0 \to K^+K^-$ $(1.1\ \text{fb}^{-1})$	0.22%	0.11%
$D^0 \to \pi^+\pi^-$ $(5.0\ \text{fb}^{-1})$	0.15%	0.08%
$D^0 \to K^+K^-$ $(5.0\ \text{fb}^{-1})$	0.09%	0.04%
Belle II		
$D^0 \to \pi^+\pi^-$	0.14%	0.07%
$D^0 \to K^+K^-$	0.10%	0.04%
HFAG	0.20%	



Just to stress you...



$$\alpha_c = arg\left[\frac{-V_{ub}^* V_{cb}}{V_{us}^* V_{cs}}\right] = (111.5 \pm 4.2)^o$$

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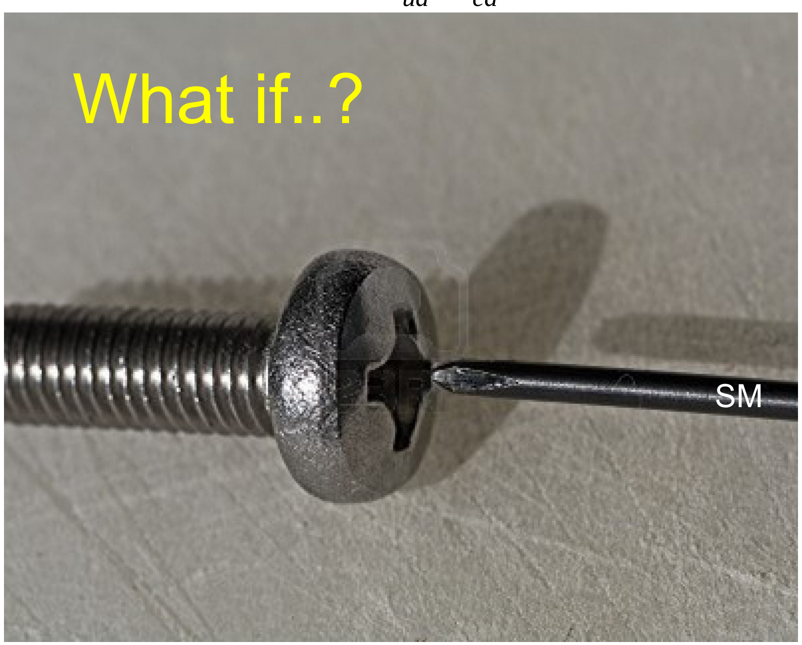


-When looking for new physics, a measurement of the $\beta_{c,eff}$ angle in the charm triangle represents the best place to start with for a few reasons.

- No running or planned experiments can measure the exact value of this angle, since it is too small. Any measurement of this angle has to be consistent with zero. If a large value would be measured, then there is new physics.

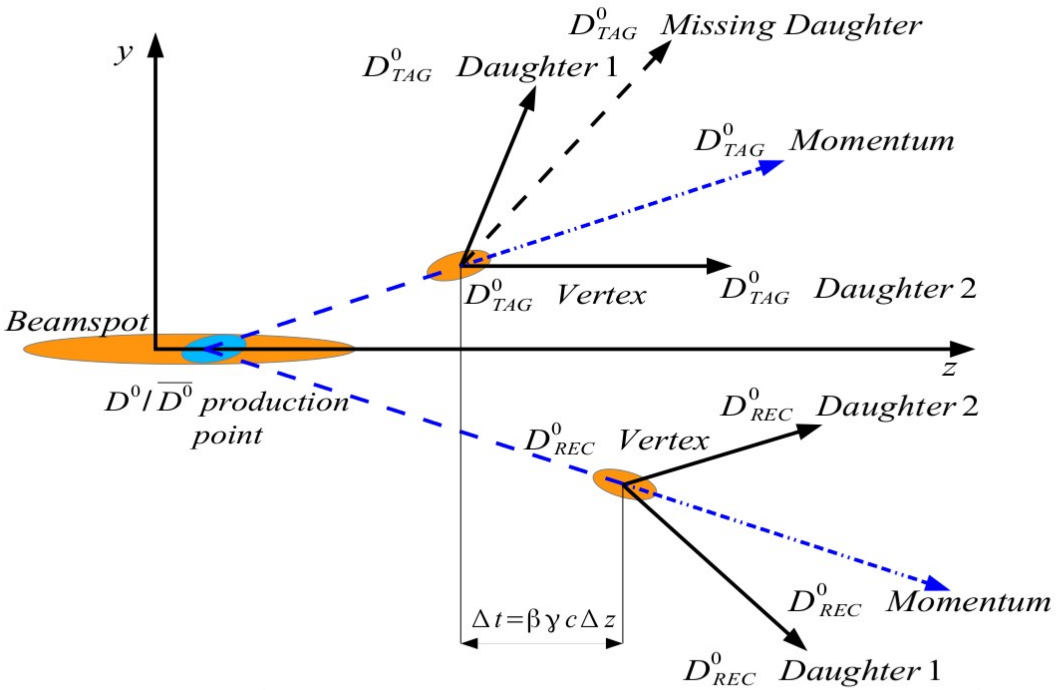
-LHCb measurements on time-integrated CP violation may suggest a large value of this angle.

-At charm threshold a first measurement of this angle would require only three months of data taking, while years for other experimental environments.

-Few ab^{-1} of data at charm threshold has not competitors in such a measurement.

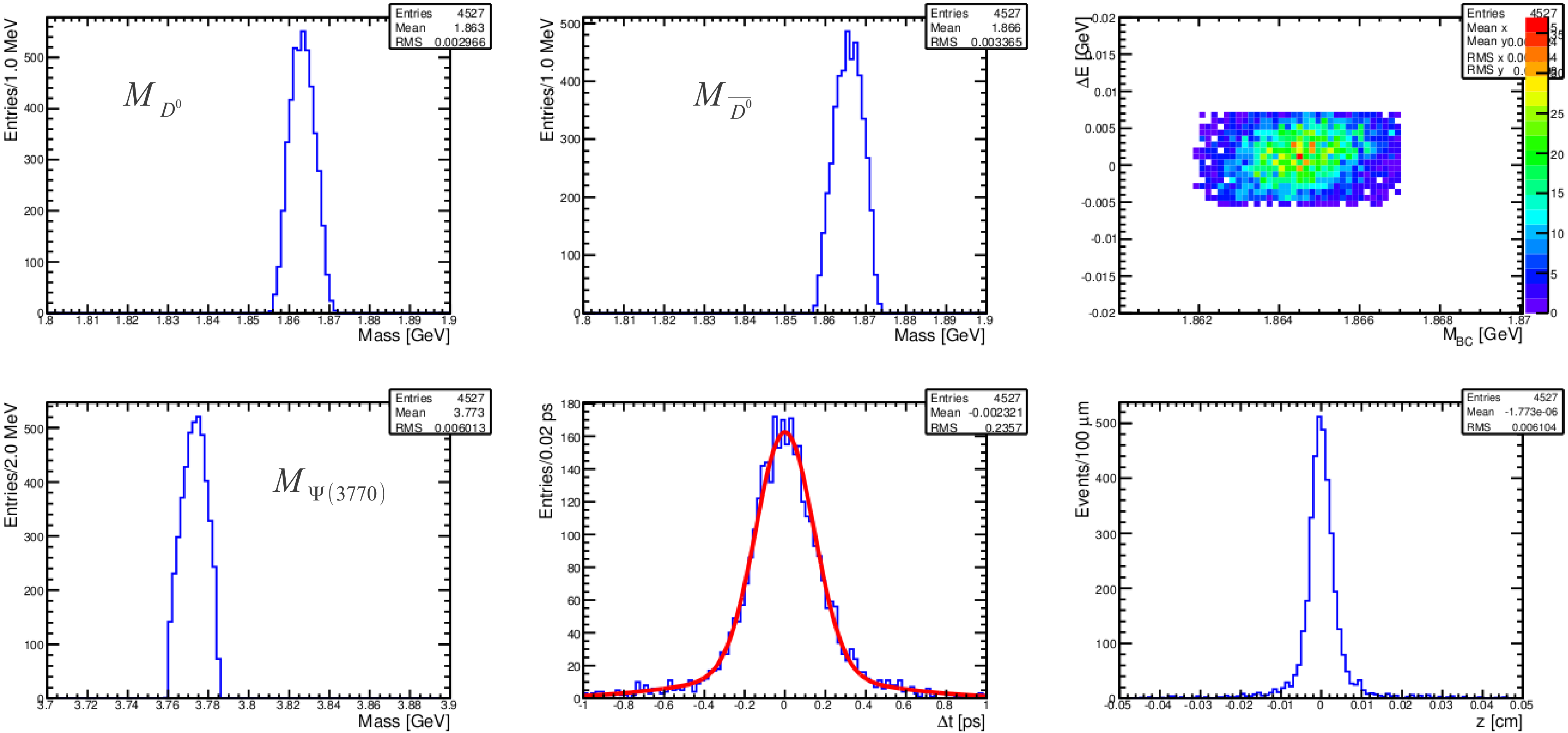
FastSim at Charm Threshold: SuperB configuration with bg=0.56 and SVT Layers 0-1-2-3-4-5

$$e^+ e^- \rightarrow \Psi'' \rightarrow D^0 \overline{D^0} \rightarrow \pi^+ \pi^- \quad K^+ e^- \overline{\nu_e}$$



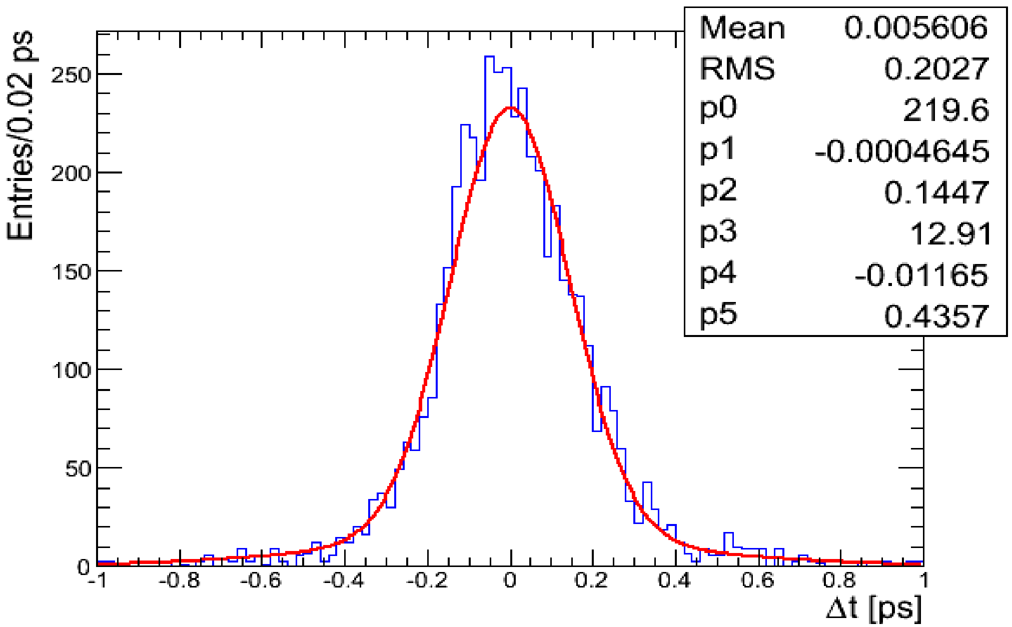
Please check the SB-PHY-2012-020 for all the details of the study and for comparison with bg=0.28 , 0.9

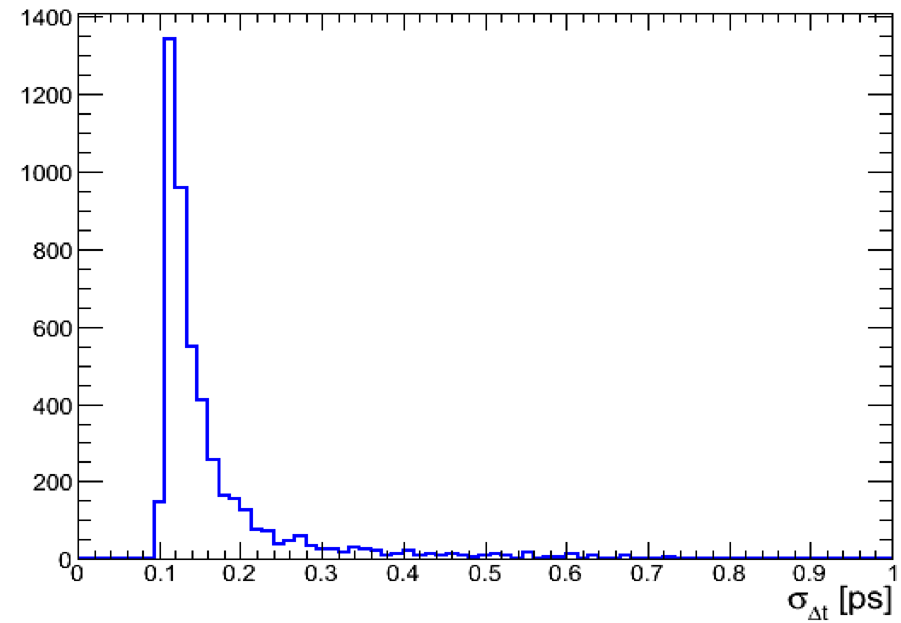
$$e^+ e^- \to \Psi'' \to D^0 \ \overline{D^0} \to \pi^+ \pi^- \ K^+ e^- \overline{\nu_e}$$

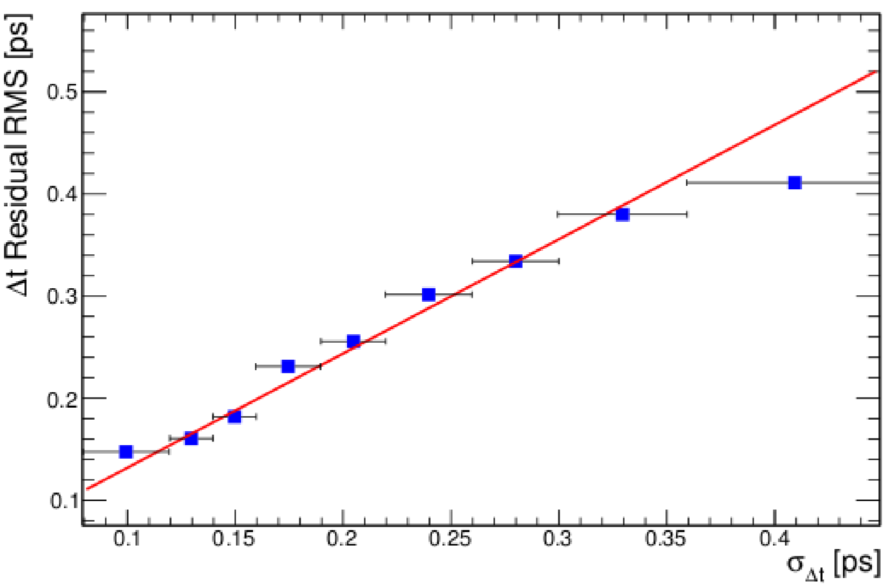


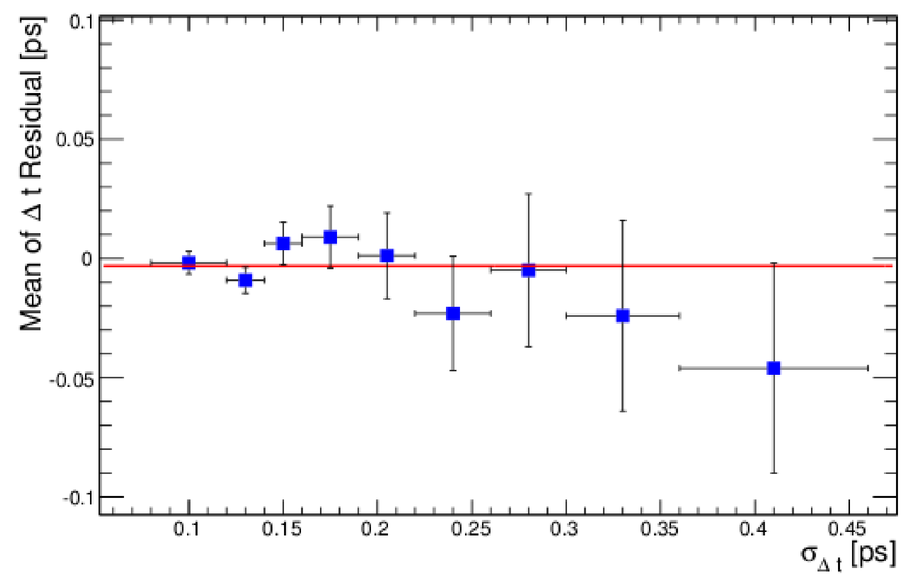
Detailed results of the analysis are available in SB-PHY-2012-020

$$e^+e^- \to \Psi'' \to D^0\ \overline{D^0} \to \pi^+\pi^-\ K^+ e^- \overline{\nu_e}$$



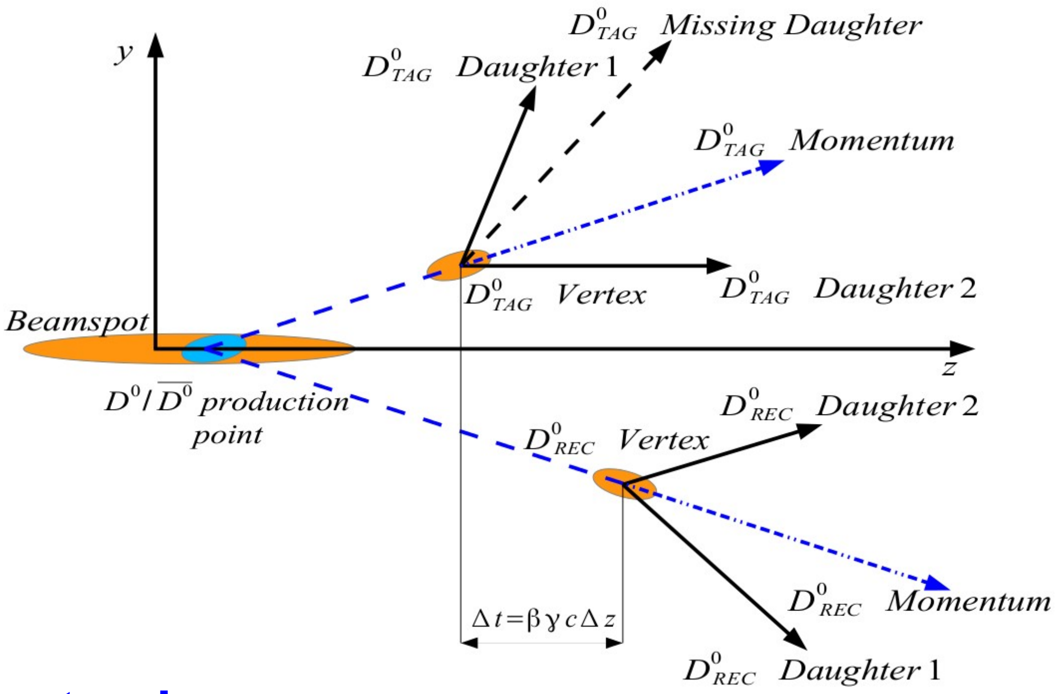






FastSim at Charm Threshold: New configuration with bg=0.56 and SVT Layers 0-1-4-5

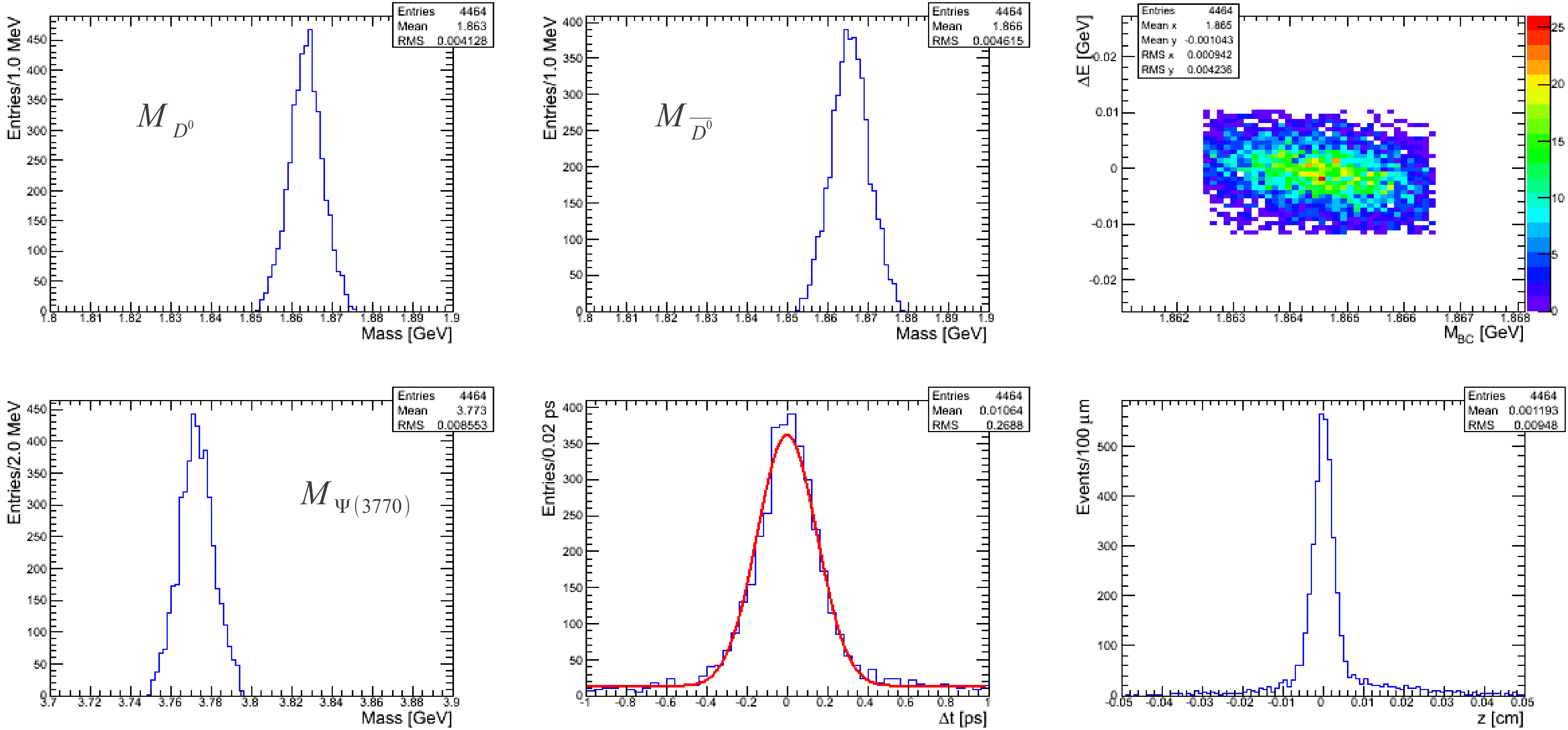
$$e^+ e^- \rightarrow \Psi'' \rightarrow D^0 \overline{D^0} \rightarrow \pi^+ \pi^- \quad K^+ e^- \overline{\nu}_e$$



Preliminary study...

FastSim at Charm Threshold: New configuration with bg=0.56 and SVT Layers 0-1-4-5

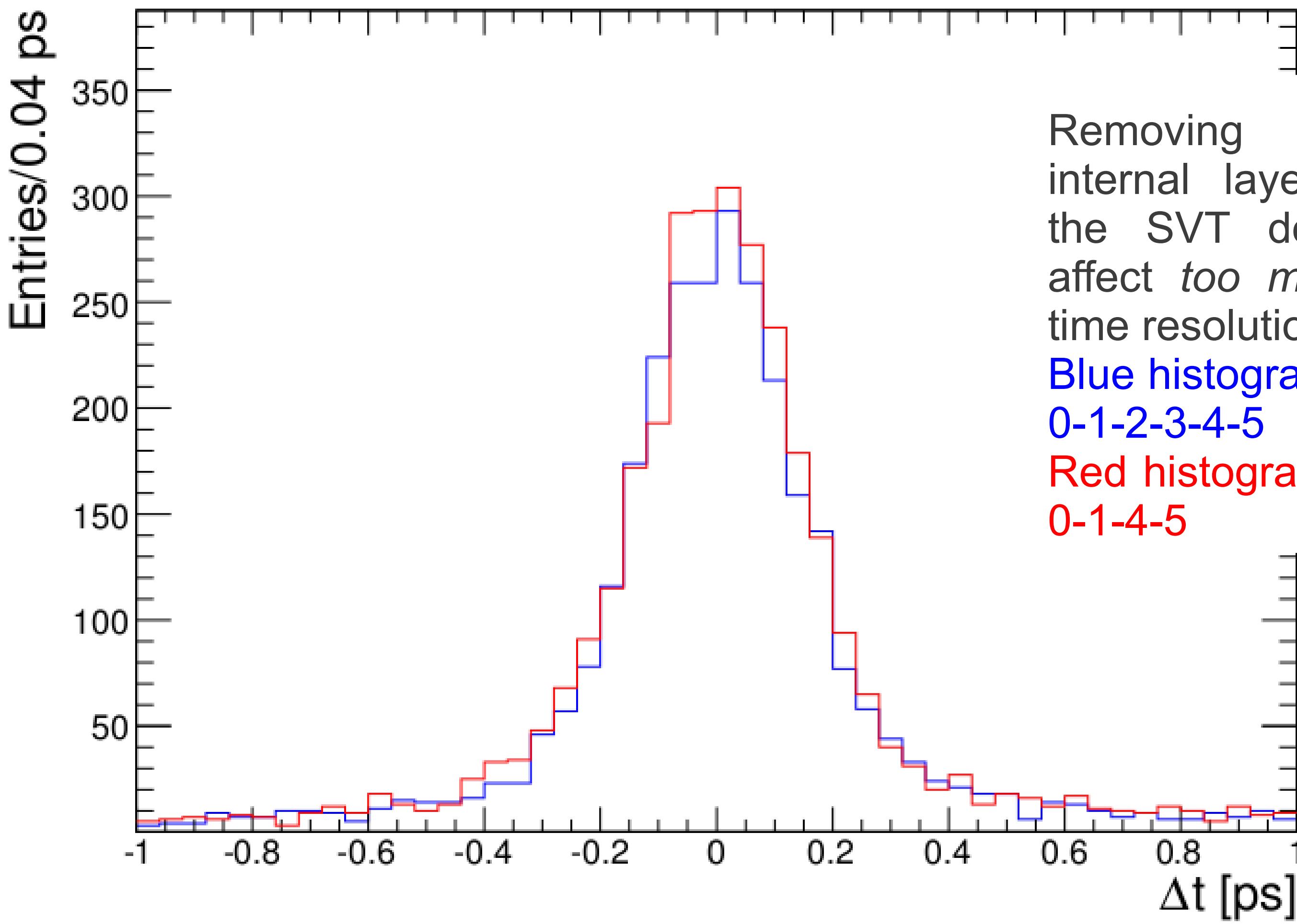
$$e^+e^- \rightarrow \Psi'' \rightarrow D^0\ \overline{D^0} \rightarrow \pi^+\pi^-\ K^+e^-\overline{\nu}_e$$



Detailed results of the analysis will be available soon..

FastSim at Charm Threshold, bg=0.56 : 6-layers SVT vs 4-layers SVT

$$e^+ e^- \rightarrow \Psi'' \rightarrow D^0 \ \overline{D^0} \rightarrow \pi^+ \pi^- \ K^+ e^- \overline{\nu_e}$$



Removing two internal layers from the SVT does not affect *too much* the time resolution.

Blue histogram: SVT 0-1-2-3-4-5

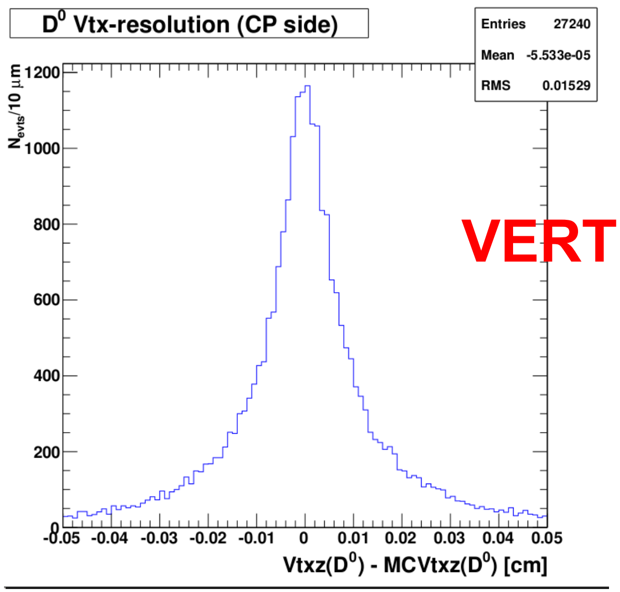
Red histogram: SVT 0-1-4-5

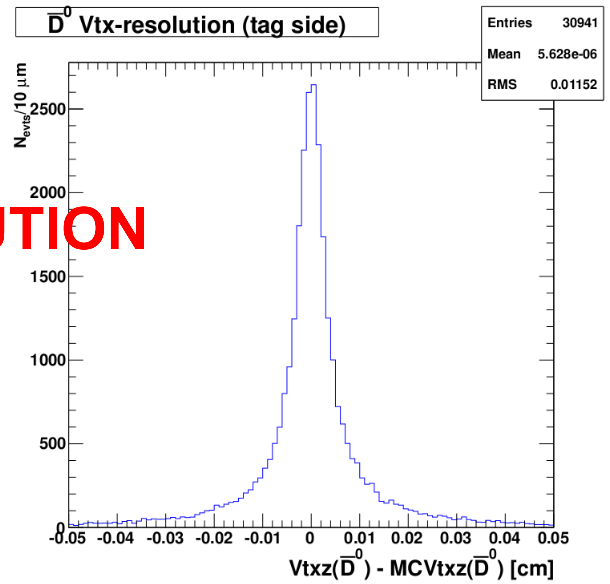
Detailed results of the analysis will be available soon..

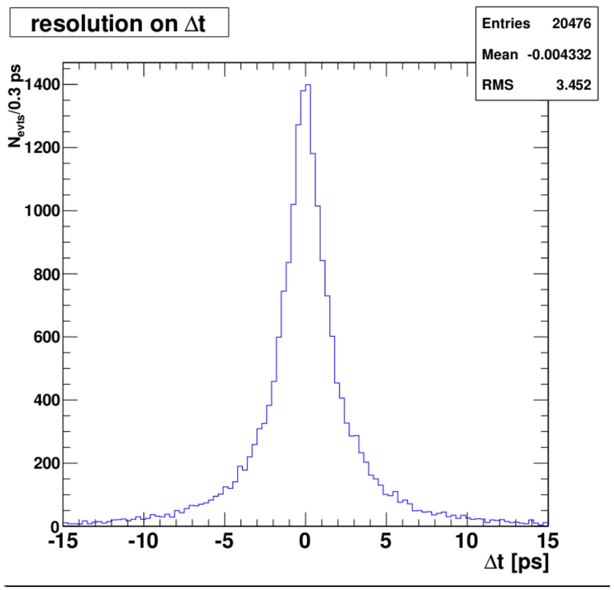
From Alexander Hahn, QMUL

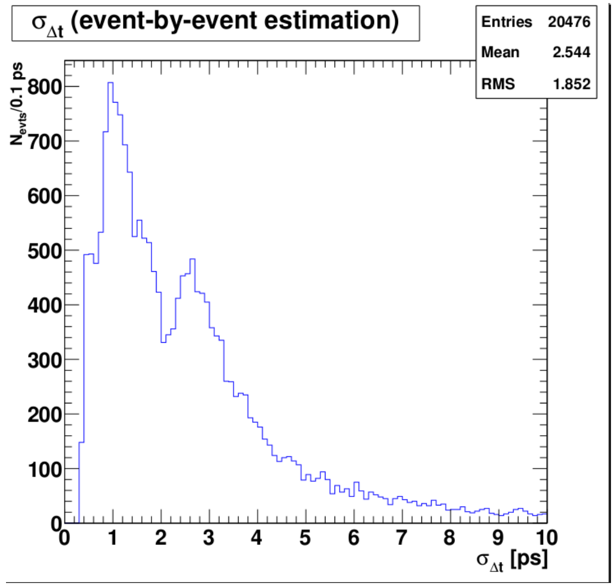
$$e^+e^- \rightarrow \Psi'' \rightarrow (D^0)\ (\overline{D^0}) \rightarrow (K^0_S\pi^0)\ (\pi^+\pi^-) \rightarrow (\pi^+\pi^-\gamma\gamma)\ (\pi^+\pi^-)$$

VERTEX RESOLUTION

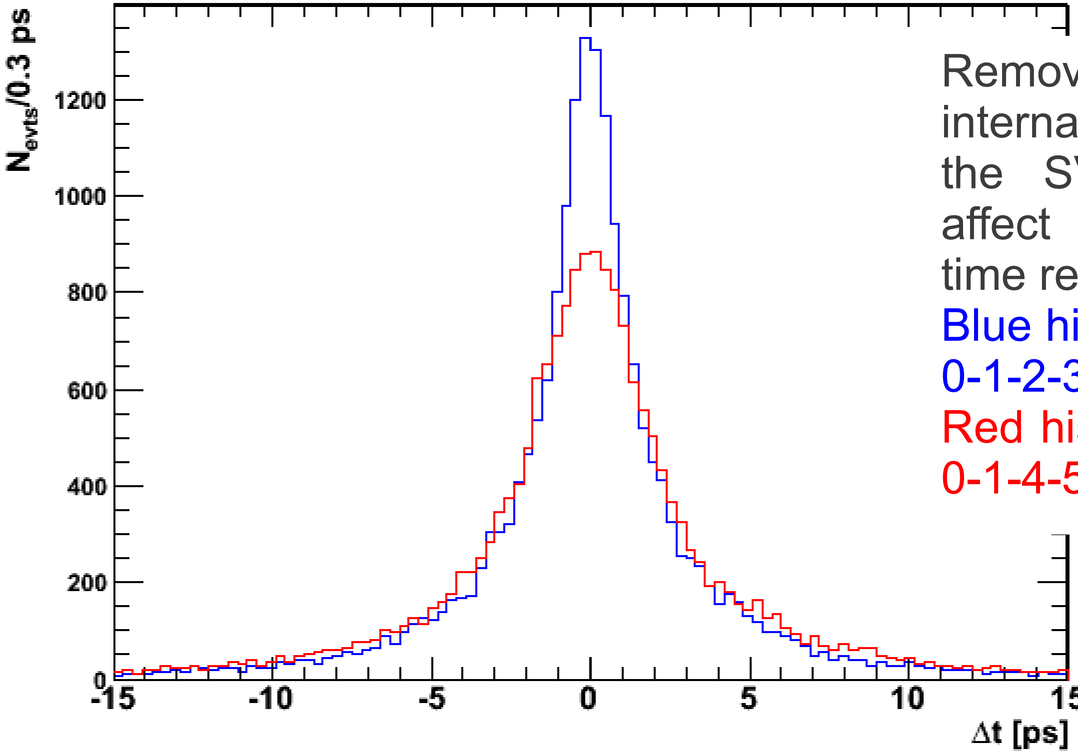








FastSim at Charm Threshold, bg=0.28 : 6-layers SVT vs 4-layers SVT



Removing two internal layers from the SVT does not affect *too much* the time resolution.

Blue histogram: SVT 0-1-2-3-4-5

Red histogram: SVT 0-1-4-5

Detailed results of the analysis will be available soon..

Consideration and Conclusion

- Time-dependent studies at the charm threshold are moving forward.

- Results of this preliminary analysis show that a time-dependent analysis can be performed at the charm threshold with bg=0.56 obtaining a very good time resolution. This same study has shown that a time-dependent analysis for the decay channel of the D^0 meson to $K_S\ \pi^0$ can be performed but it has a price, and the price is efficiency...we can do it, but loosing efficiency..What does it mean? It means that with a boost factor bg=0.56, in the worst case scenario, we can perform time-dependent measurements in ANY CHANNEL...but now we have bg=0.38, so get in touch and see what to do...

- The SuperB project has been cancelled, but we can still move forward and evaluate how realistic is the possibility to build a super charm/tau factory. We can do it...no, we have to do it...

- At charm threshold one may think to have a 4-layers SVT rather than a 6-layers SVT, reducing the cost and the material. We have shown that such a solution would not affect drastically the time and vertex resolution.

- One should also consider that with a few ab^{-1} of data collected at charm threshold (1.0 ab^{-1} ~six months) the measurement of time-dependent CP violation in charm, and the consequent measurement of the angle $\beta_{c,eff}$, there are not competitors.

  We shouldn't go through this new experiment..we MUST do it..let's start...

...Many Thanks...