Tracking/Vertexing performances *vs* detector configurations

Nicola Neri
Università di Pisa & INFN

SuperB Workshop Perugia
16-19 june 2009

Outline

- Tracking detector configurations;
- Track parameter resolution;
- Δm resolution for $D^{*+} \to D^0 \pi^+$;
- ΔE resolution for $B^0 \to D^{*-} K^+$;
- Proper time resolution for $B^0 \to K_S K_S$;
- Summary

Tracking detector configurations

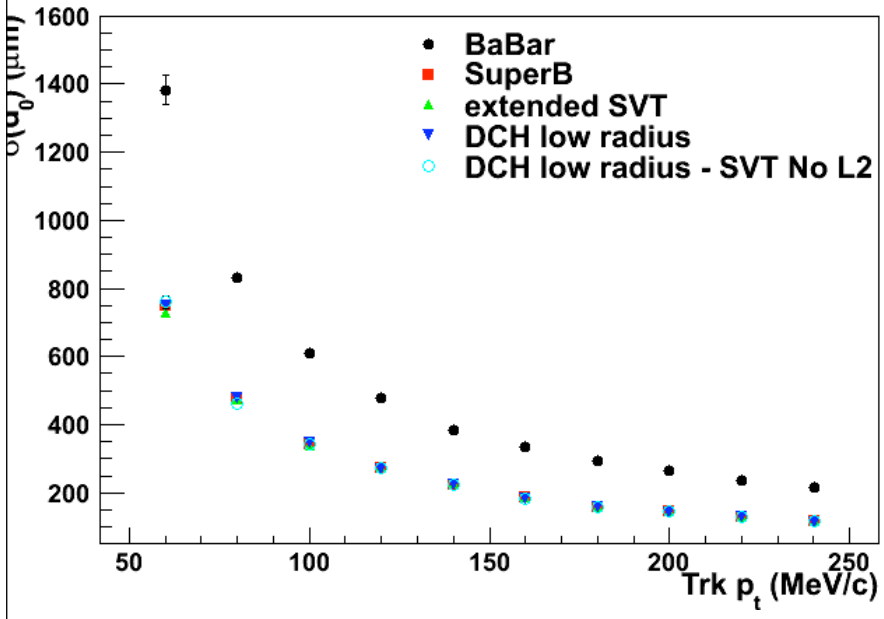
1. SuperB baseline:
   - SVT baseline: L0 (Hybrid Pixel) + L1-L5 strip detectors, ±300 rad angular coverage;
   - DCH baseline: 10 SuperLayers (4 cell layers per SL); inner radius 23.6 cm, spatial resolution 125 μm;
2. SuperB Svt Extended radius:
   - SVT baseline for L0-L2 with L3: 5.92cm →9.4cm, L4: 12.22cm →20.6cm, L5: 14.22cm →22.6cm; DCH baseline;
3. SuperB Dch Low radius:
   - SVT baseline; DCH baseline + inner SuperLayer with inner radius 17 cm;
4. SuperB Dch Low radius No L2:
   - equal to 3 but without SVT L2 (radius 4.02cm).

Event generation

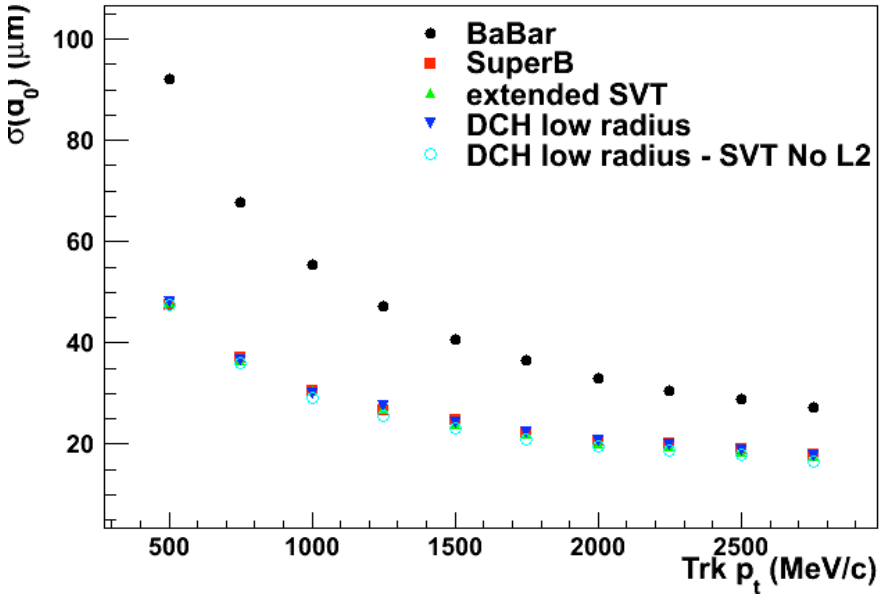
- Single track events:
  - pion tracks (no decays in flight);
  - pT $\in$ [0,4] GeV/c (uniform);
  - $|\cos(\vartheta)|<0.7$ (uniform).
- Divide in 2 sample:
  - Low pT $\in$ [0, 0.25] GeV/c
  - "High" pT $\in$ [0.5, 3.0] GeV/c

d_0 resolution

Low pT



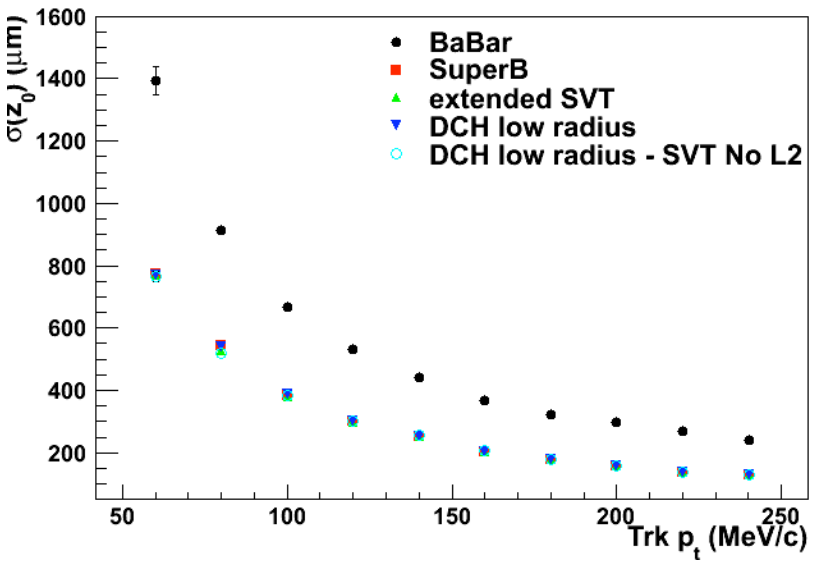
"High" pT



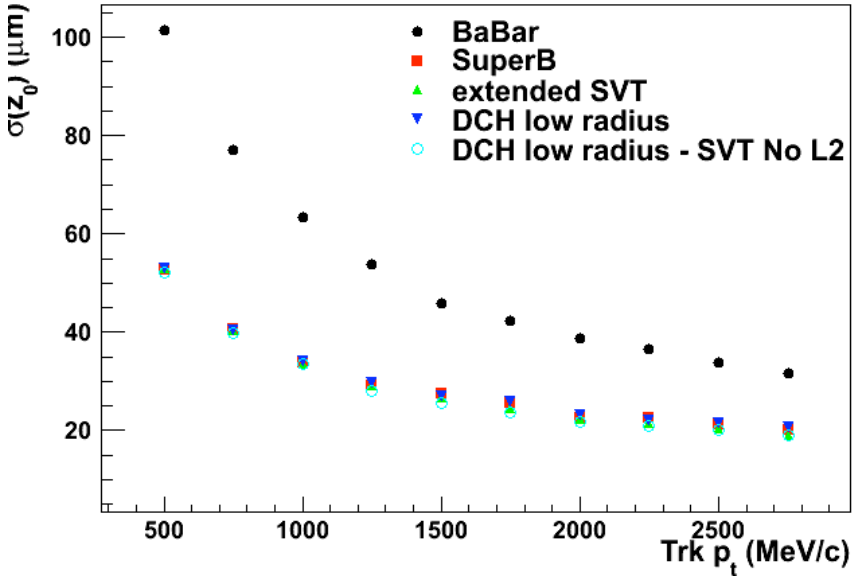
~factor 2 improvement wrt to BaBar
due to the additional L0 measurement.
No sizable difference in alternative SuperB configurations.

z_0 resolution

Low pT



"High" pT

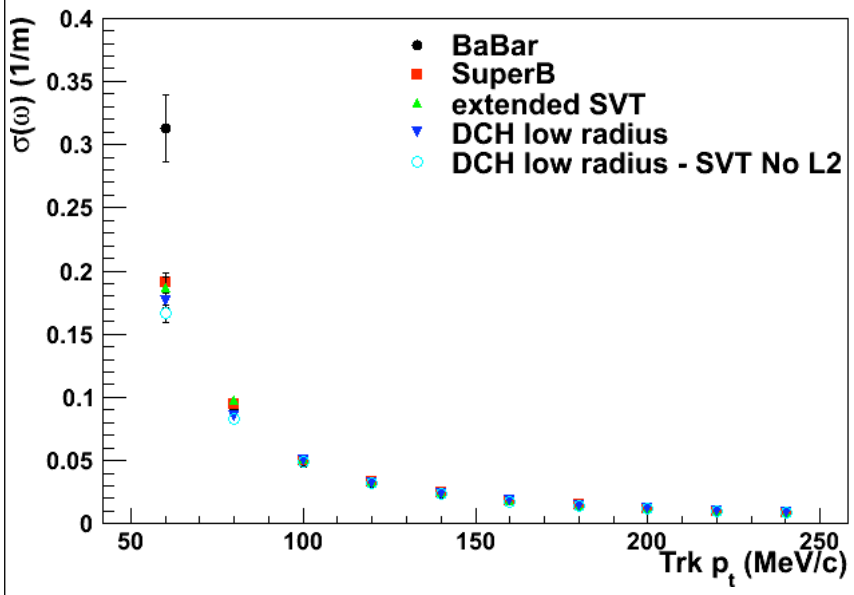


~factor 2 improvement wrt to BaBar
due to the additional L0 measurement.
No sizable difference in alternative SuperB configurations.

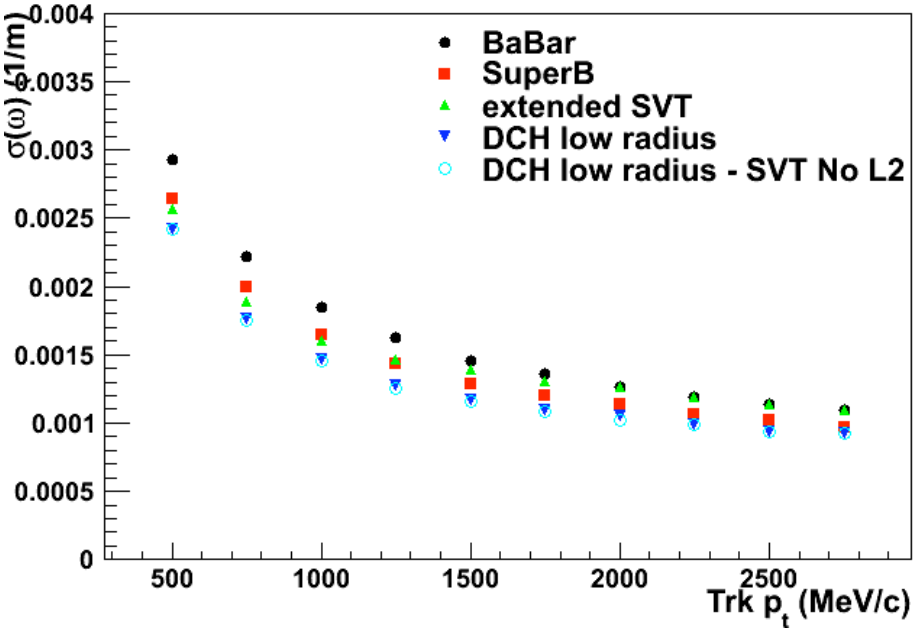
ω resolution

$\omega = 1/\rho\,(cm^{-1})$ $\phi = \phi_0 + \omega L$ L = path length

Low pT



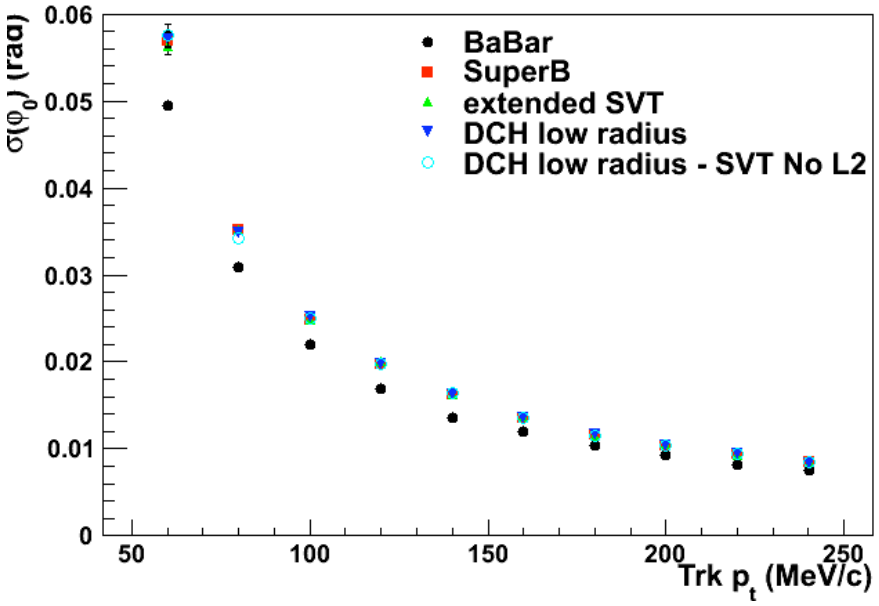
"High" pT



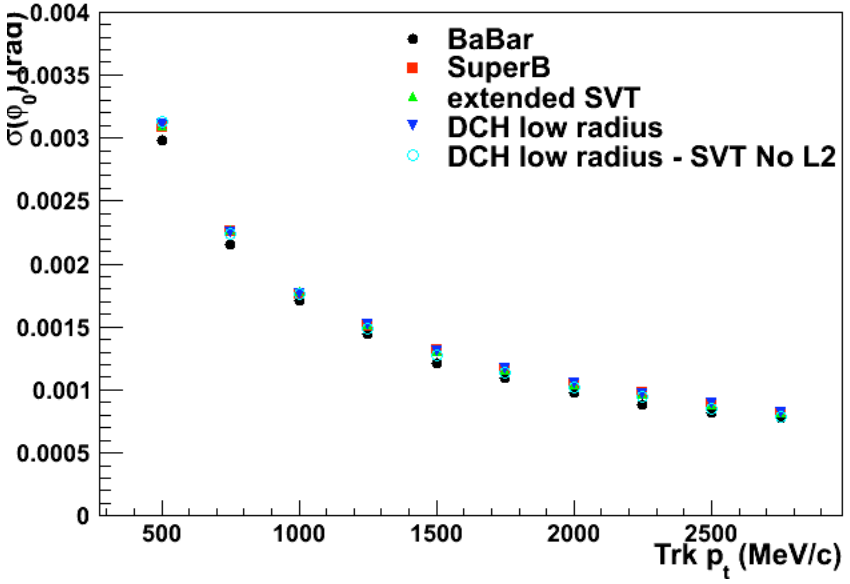
sizable improvement wrt BaBar at "high" pT:
benefit of support tube removal and low DCH radius.

ϕ_0 resolution

Low pT



"High" pT

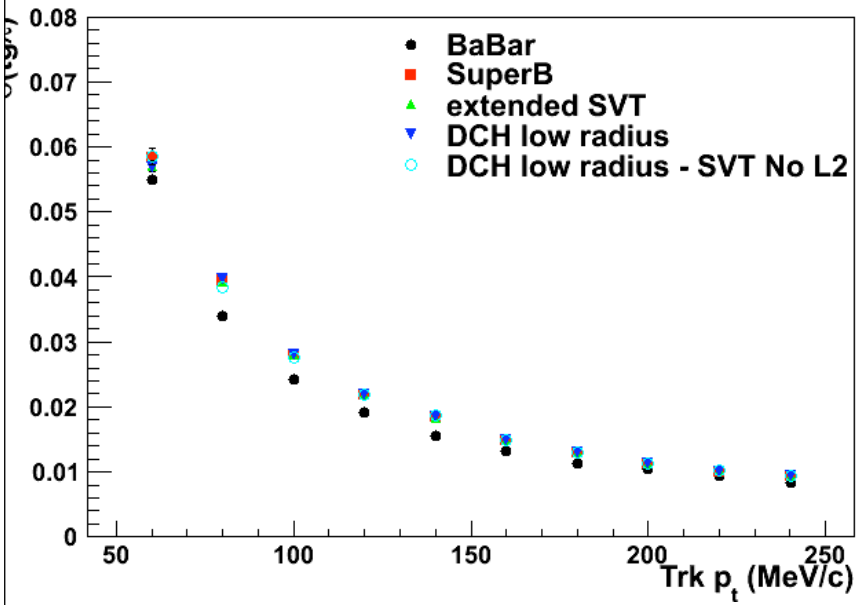


Slightly worst resolution on ϕ_0 wrt BaBar at low pT.

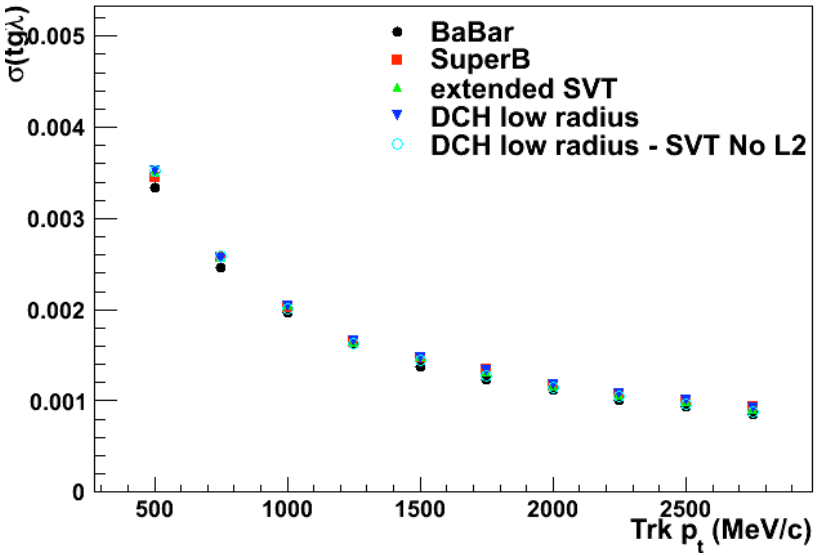
No sizable difference in alternative SuperB configurations.

tg(λ) resolution

Low pT



"High" pT

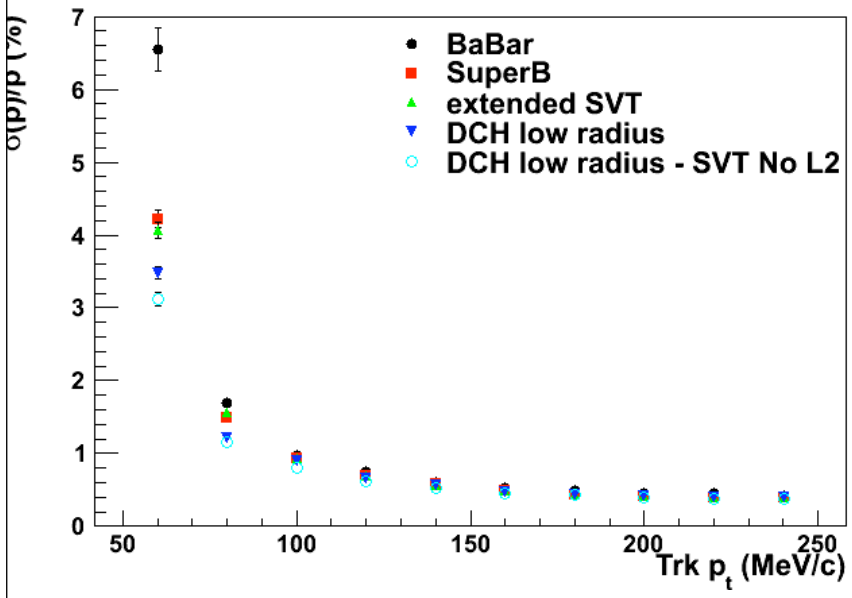


Slightly worst of resolution on tg(λ) wrt BaBar at low pT.

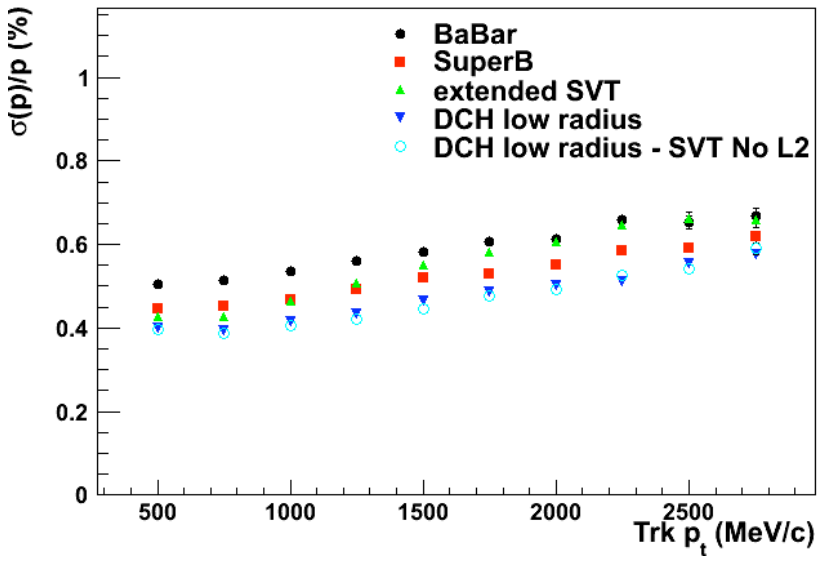
No sizable difference in alternative SuperB configurations.

σ_p/p

Low pT



"High" pT

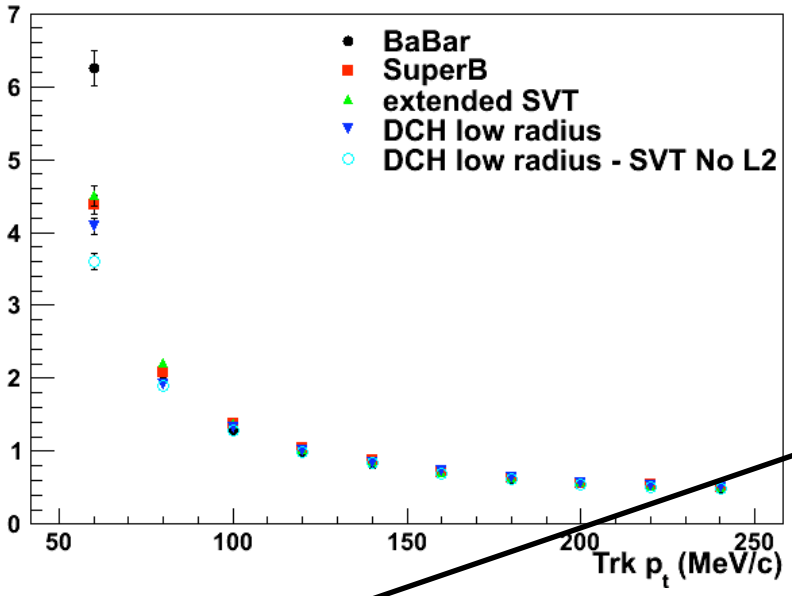


Sizable improvement wrt BaBar at "high" pT:

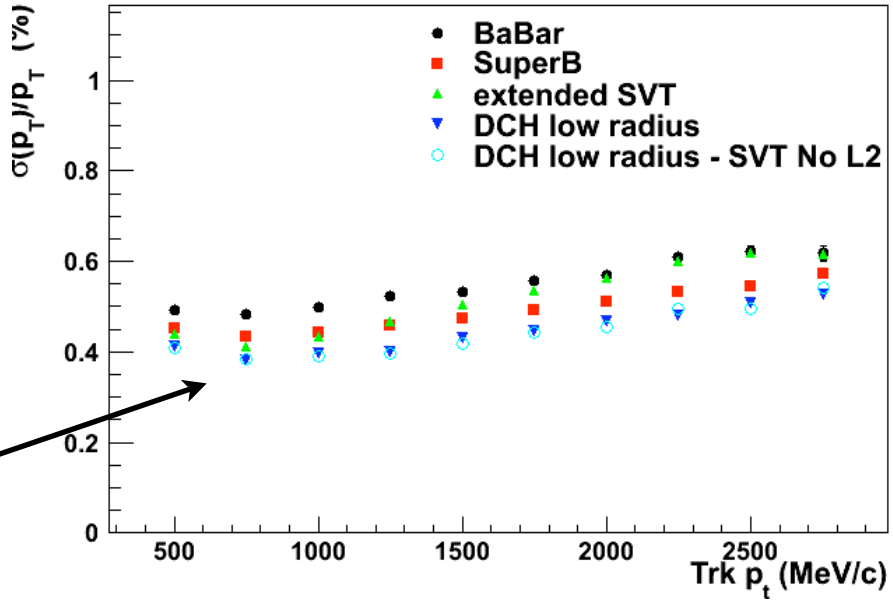
DCH lower radius improves further the measurement.

σ_{pT}/p_T

Low pT



"High" pT



$\sigma_{pT}/p_T = a \cdot pT(GeV/c) + b$

$\sigma_{p_t}/p_t = (0.13 \pm 0.01)\% \cdot p_t + (0.45 \pm 0.03)\%$

BaBar NIM

b term improves (no support tube)

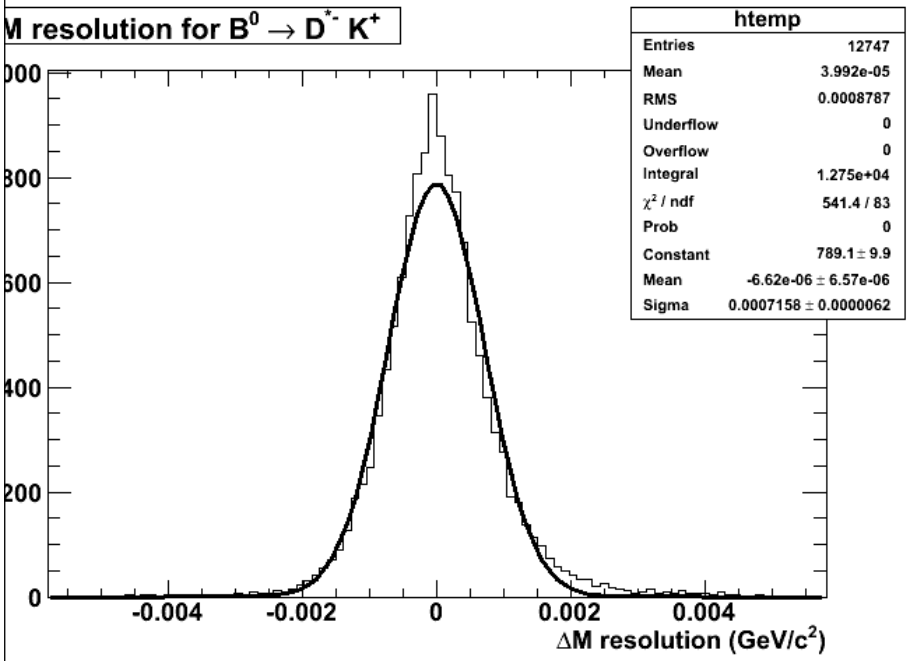
a term is smaller for SuperB baseline and DCH low radius compared to extended SVT configuration; a term is optimistic in FastSim ~0.09% (for BaBar)

Impact on Δm and ΔE

- Reconstruct $B^0 \to D^{*-} K^+$ with $D^{*-} \to \bar{D}^0 \pi^-$
  - $\Delta m = m(D^{*-}) - m(D^0)$ resolution: no mass constraint applied
  - ΔE resolution: no mass constraint applied

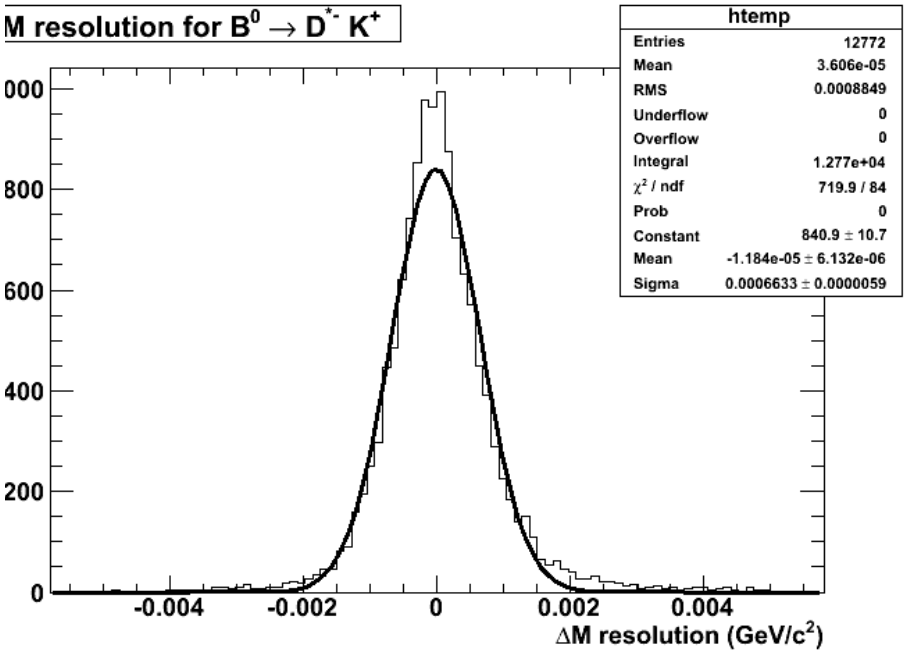
Resolution: Δm

BaBar



σ=716±6 KeV/c^2

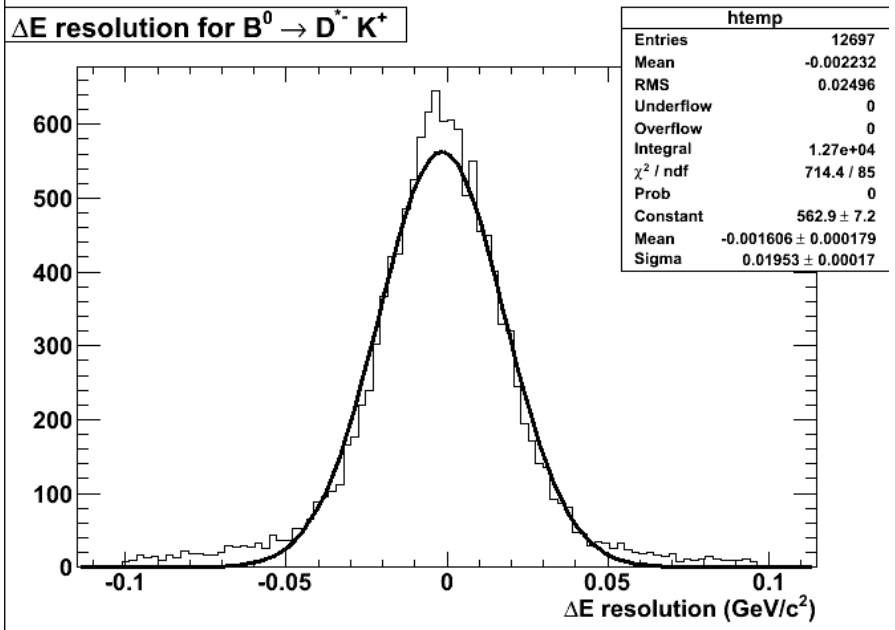
SuperB



σ=663±6 KeV/c^2

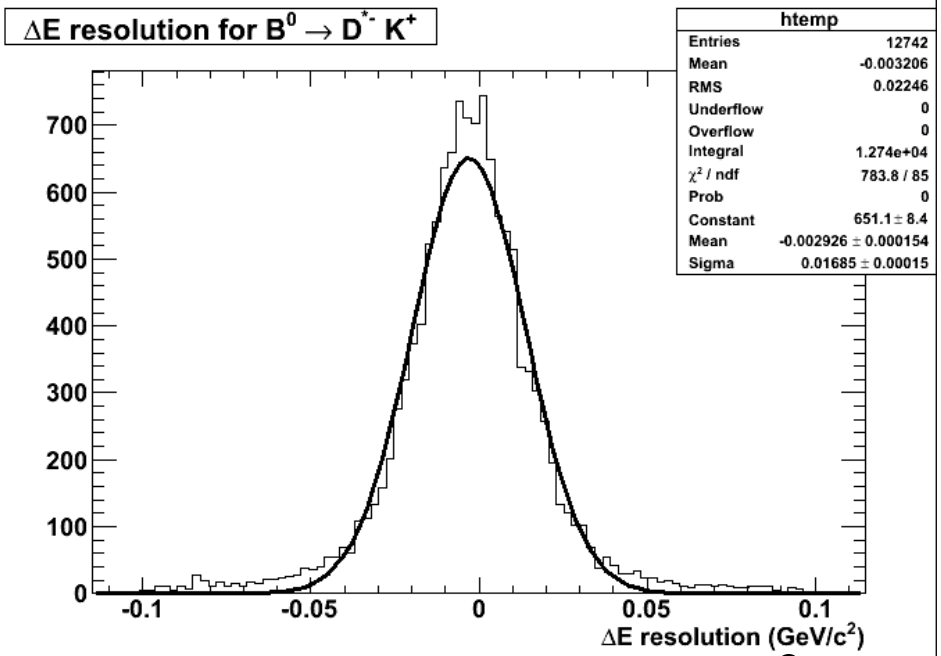
Resolution: ΔE

BaBar



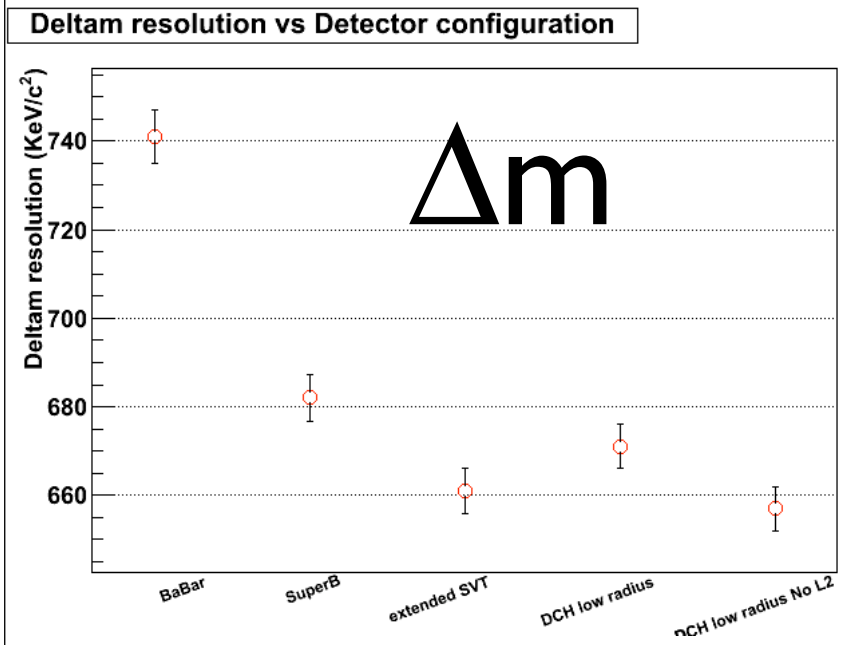
σ=19.5±0.2 MeV/c^2

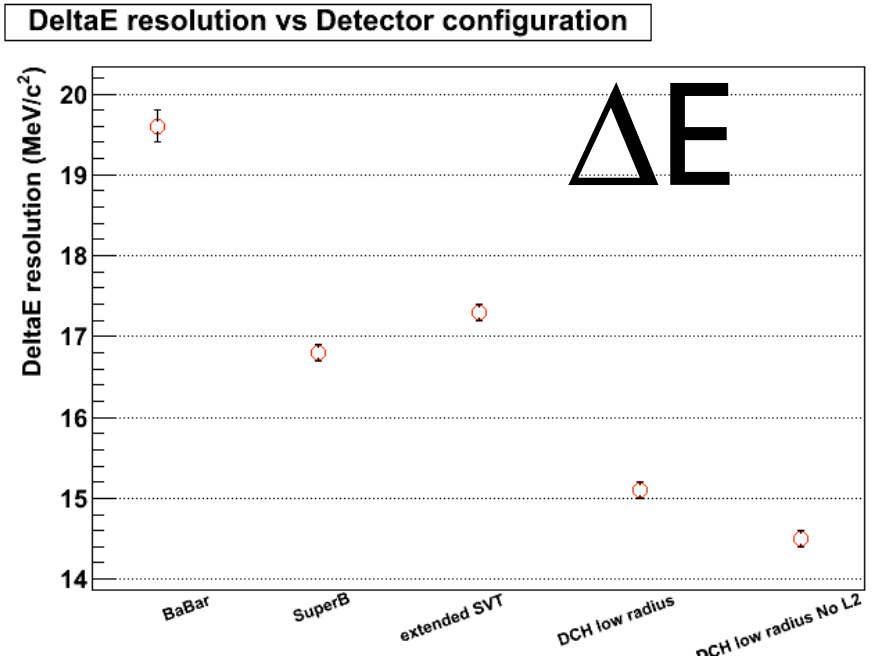
SuperB



σ=16.8±0.2 MeV/c^2

Resolution: Δm and ΔE





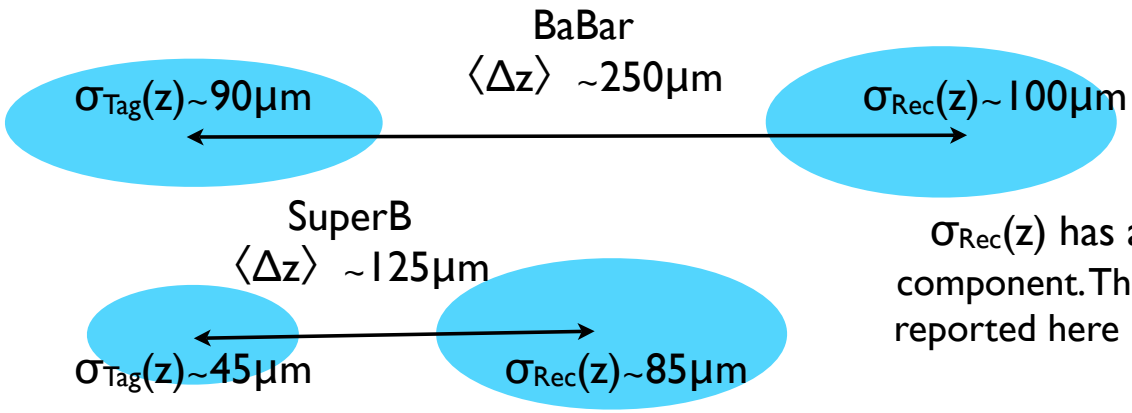
Δm (soft pion) resolution improves wrt BaBar configuration.
ΔE resolution reflects the improvements in momentum reconstruction for DCH with lower radius.

Impact on Δt resolution for $B^0 \to K_S K_S$

- Reconstruct $B^0 \to K_S K_S$ with $K_S \to \pi^+ \pi^-$
  - Δt resolution using TreeFitter vertex algorithm with beam constraint. Apply a cut on Δt error <5 ps.

Time dependent measurements: some considerations

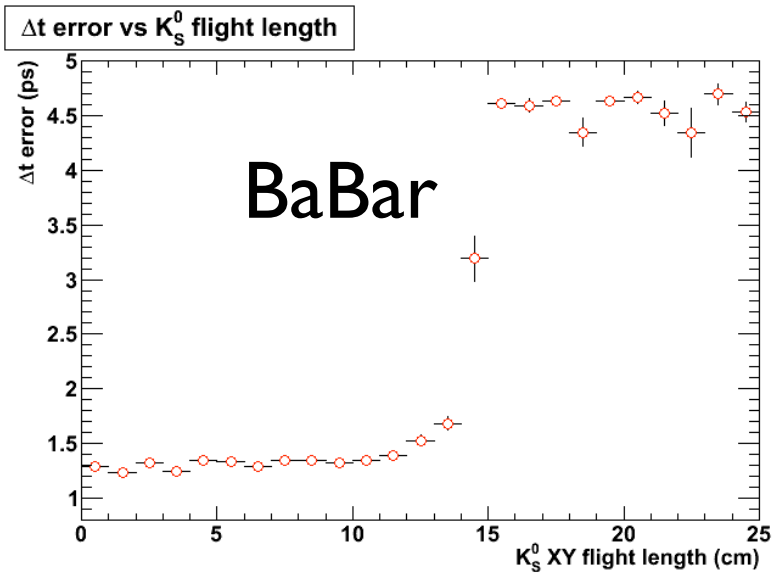
- B decays, with neutrals and K_S, partially benefit of layer$_0$ measurements. Require special attention for proper time resolution. Example for $B^0 \to K_S K_S$ according to FastSim:

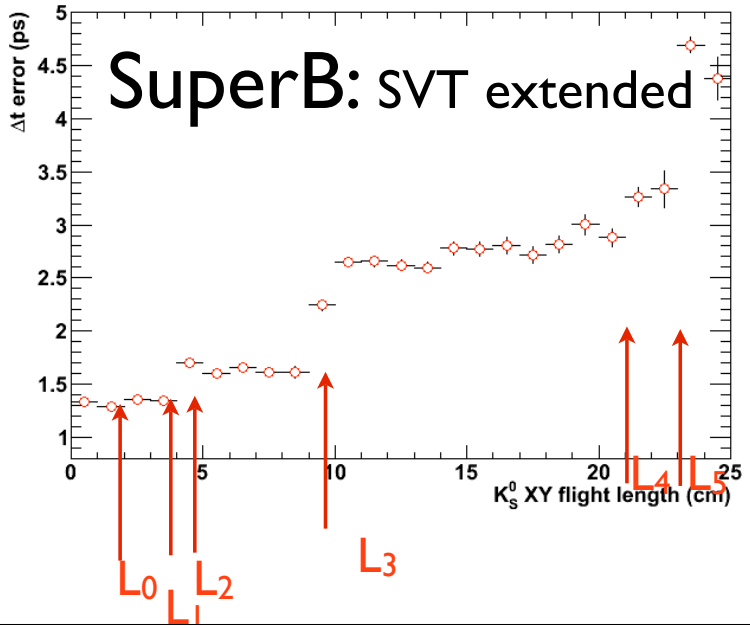


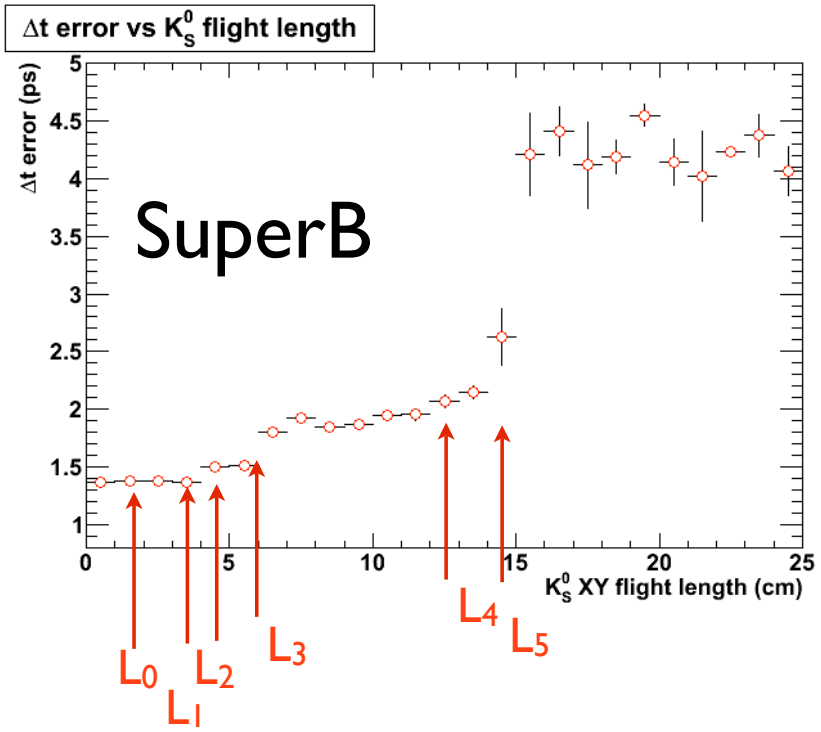
$\sigma_{Rec}(z)$ has an important tail component. The value for $\sigma_{Rec}(z)$ reported here is purely indicative.

Tag vertex resolution improves: MS dominating $\sigma_{Tag}(z) \sim r_{L0} \cdot \sqrt{X/X_0}$.
Reco vertex: small improvement thanks to more precise kinematical constraints from tag side and to the fraction of K_S decays within L0.

Proper Time resolution vs Ks XY Flight length



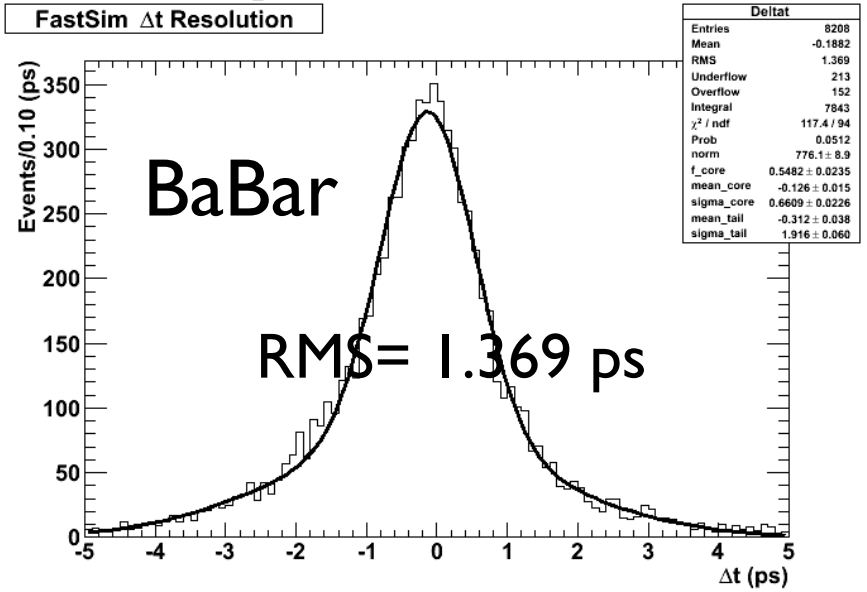


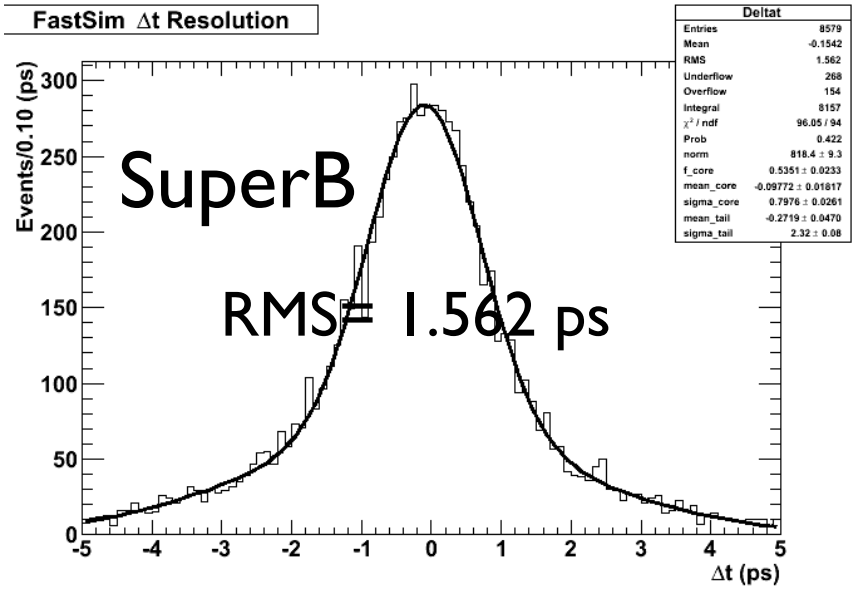


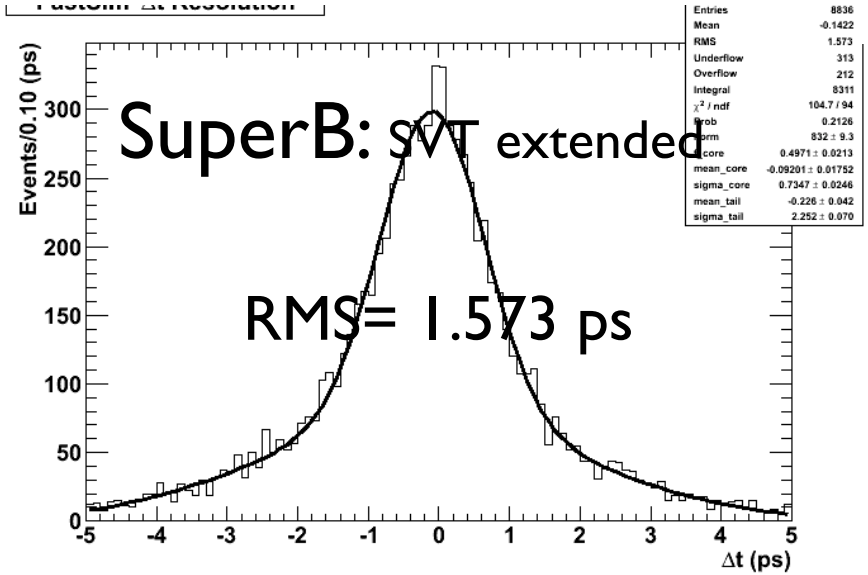
Extended SVT configuration has a smoother variation of the Δt error...

note:on x axis is reported the minimum Ks XY flight length of the event.

Proper Time Resolution $B^0 \rightarrow K_S K_S$





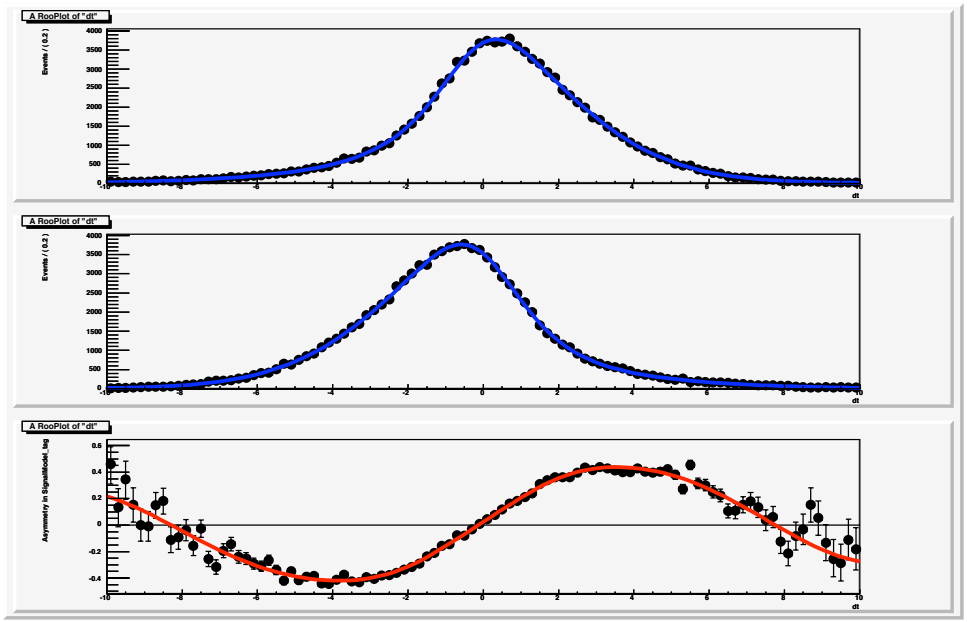


...but the overall error is similar wrt SuperB baseline.

Impact on TD measurement

ToyMC fit with perfect tagging: use 2 Gaussian proper time resolution function tuned to FastSim residual.

100K signal Evts. $S_{GEN}=0.70$



Toy MC results:

per Event Error on S

$\sigma_{BaBar} = 1.431$

$\sigma_{SuperB} = 1.608 \quad (+12\%)$

$\sigma_{ExtSVT} = 1.608 \quad (+12\%)$

No efficiency correction applied though SuperB has larger acceptance

Reduction in sensitivity at high lumi is mitigated by the systematic error:

$\sigma = \sigma_{stat}/\sqrt{N} \oplus \sigma_{syst}$

Conclusions

- Overall improvements of SuperB tracking performances wrt to BaBar.
- Reduction of DCH radius is advisable:
  - better momentum resolution;
  - better Δm and ΔE resolution;
  - no evidence of improvements in enlarging the SVT radius also for TD measurements in "special" decay modes like $B^0 \rightarrow K_S K_S$.

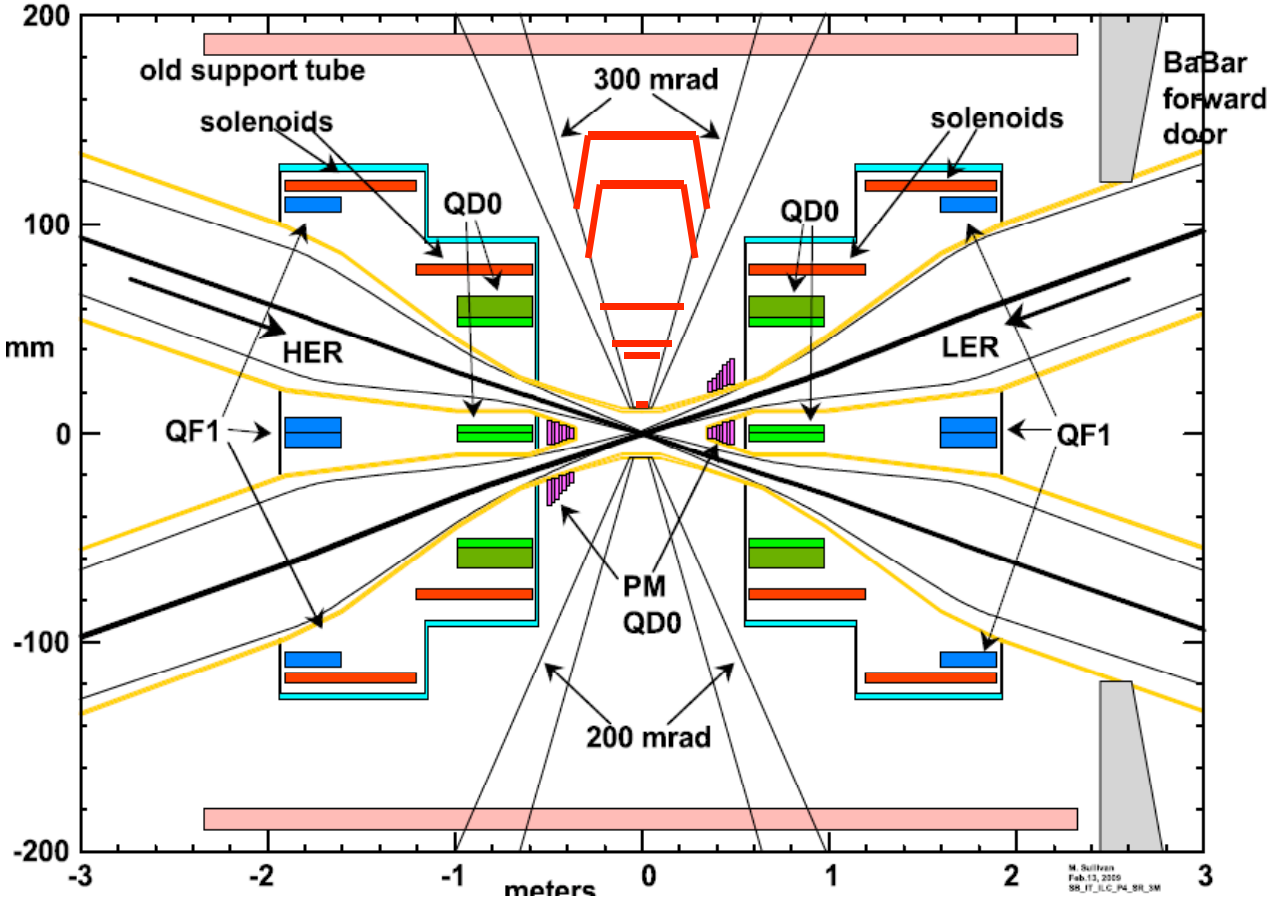
Next steps

From previous talk at DGWG:

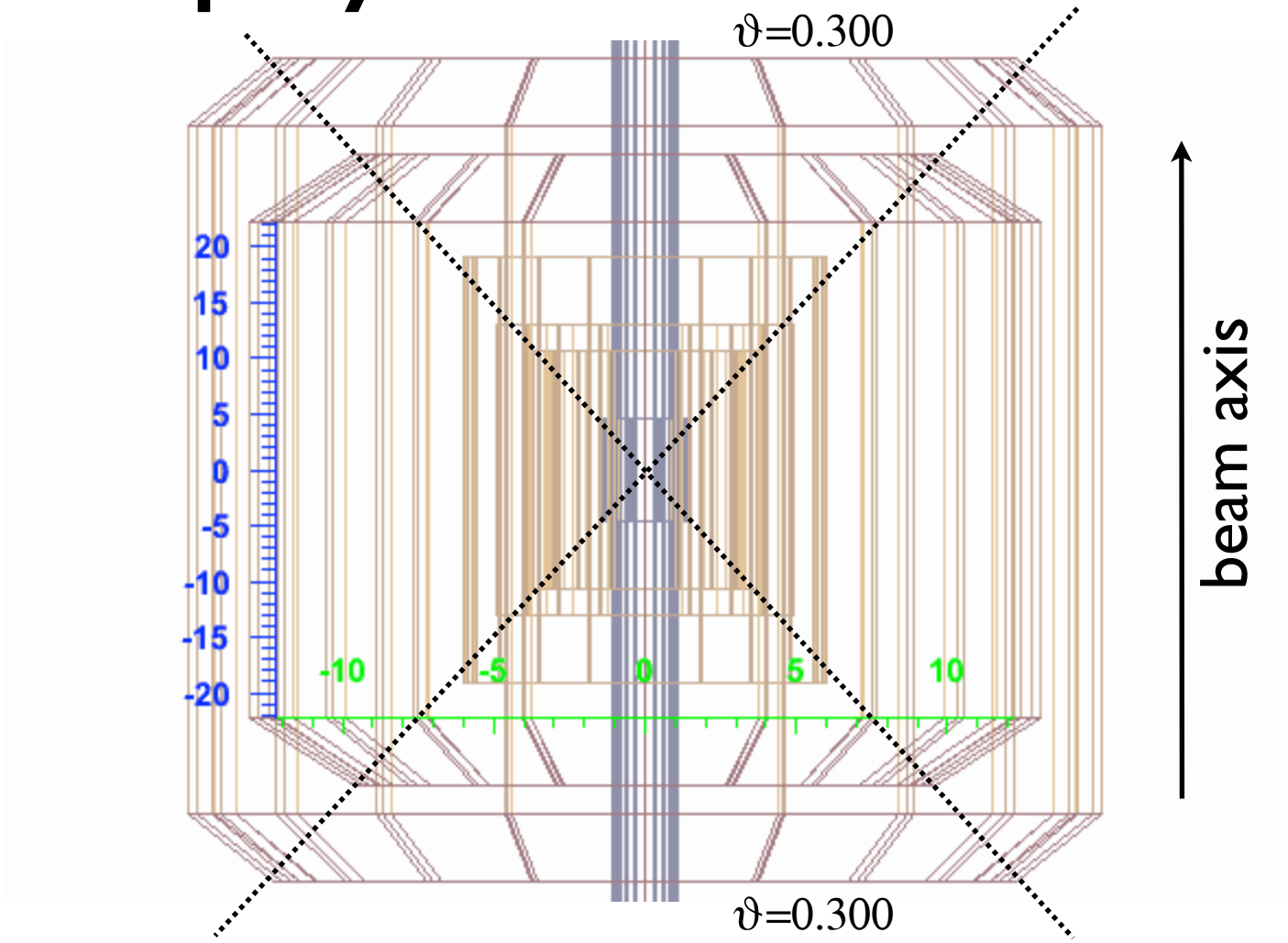
- Implement improved resolution model for Layer0. (See John's talk).☑
- Perform studies to understand pro and cons of enlarging SVT outer radius or reducing DCH inner radius, to coordinate together with DCH group:
  - track parameter resolution; ☑
  - Ks reconstruction; (related to TD measurements) ☑
  - soft pion reconstruction; ☑
  - other suggestions?
- Model the passive material at the edge of the active volume for the SVT baseline. (In progress: see Marco Bomben's talk).

Backup

Angular coverage down to 300 mrad FW and BW

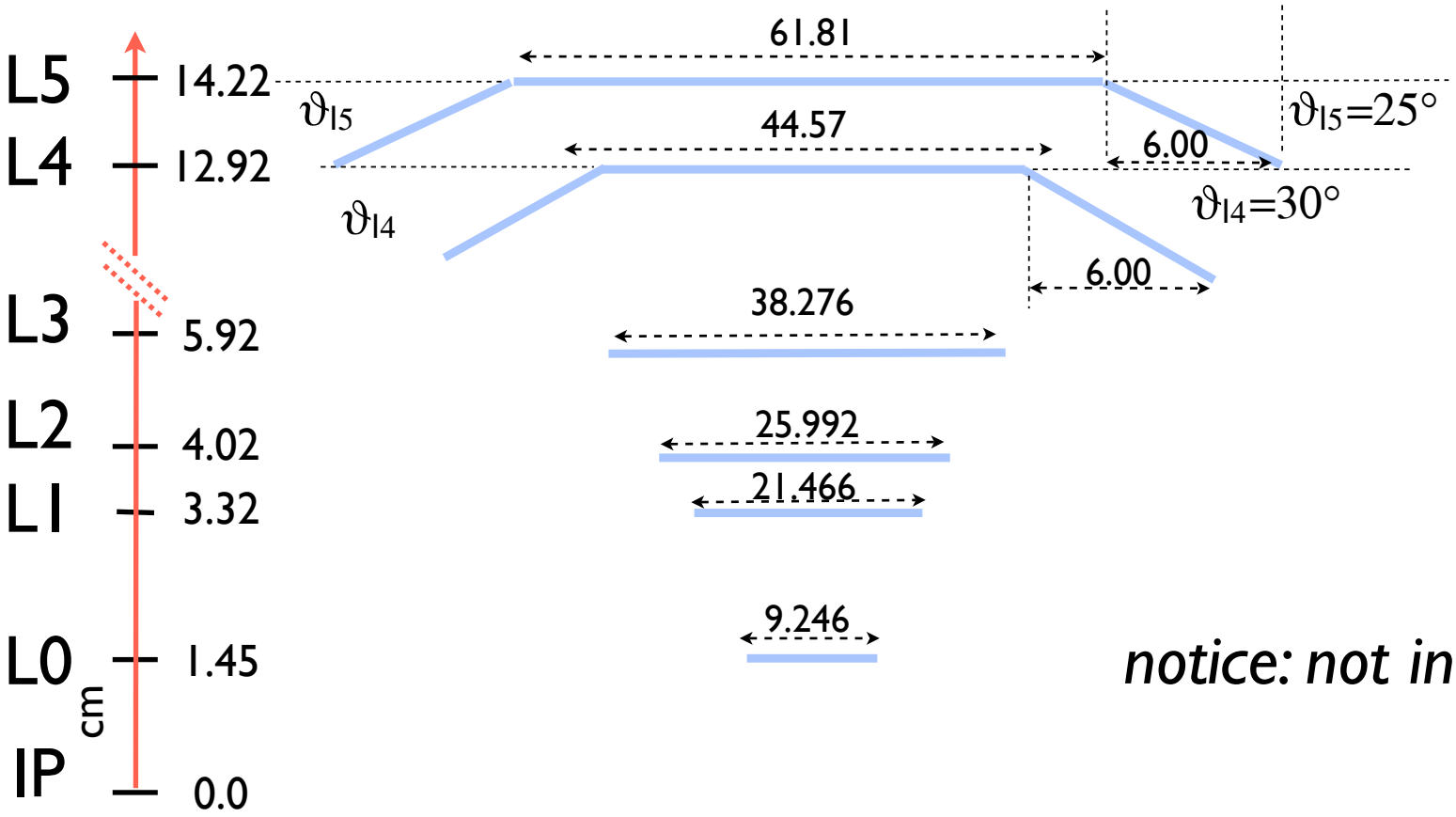


Display of SVT modules



angular coverage in CM_{25}~ 95% (BaBar SVT ~89%)

SVT layer geometry for baseline

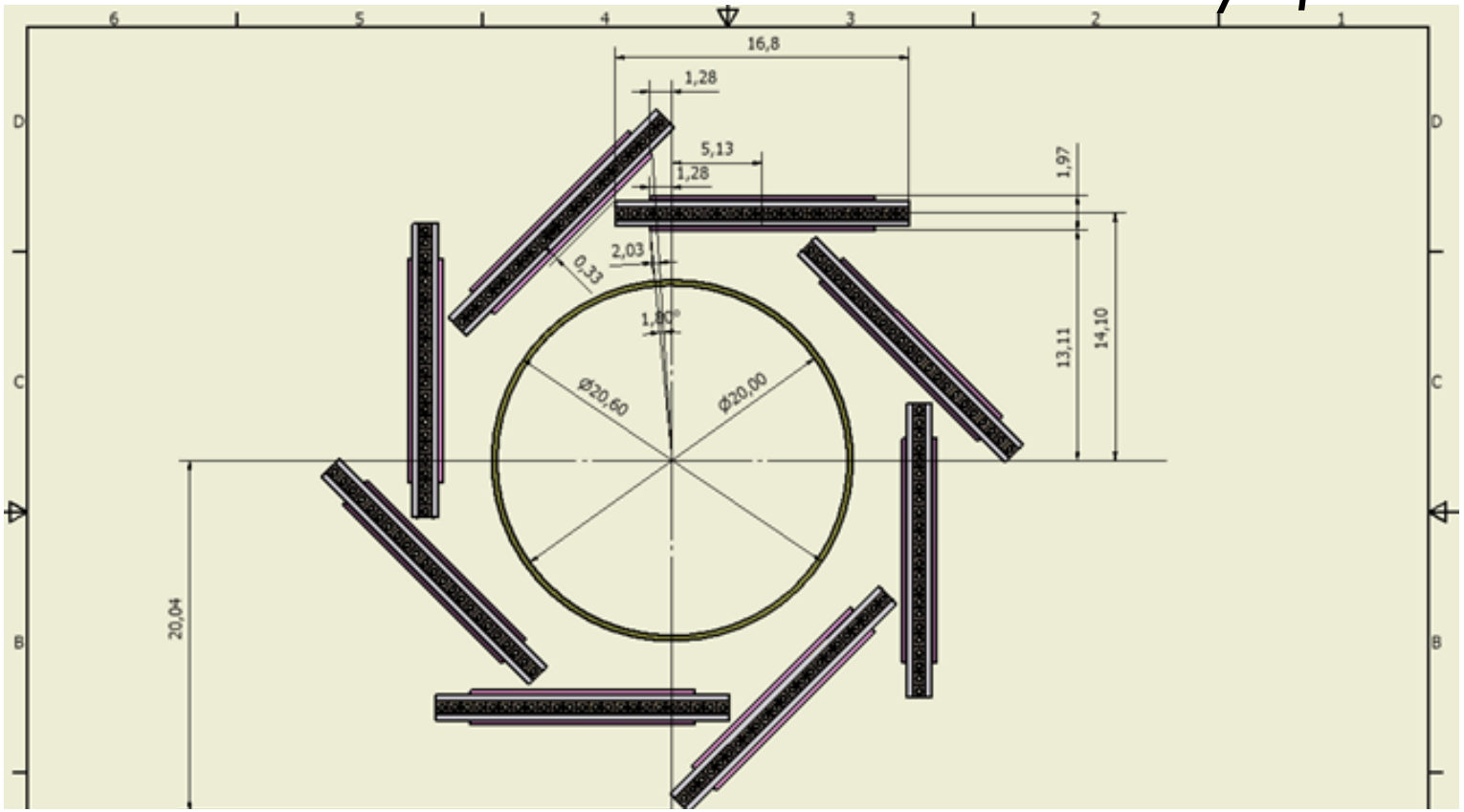


notice: not in scale

Coverage down to 300 mrad FW and BW

Pinwheel layout for L_0

courtesy of F. Bosi

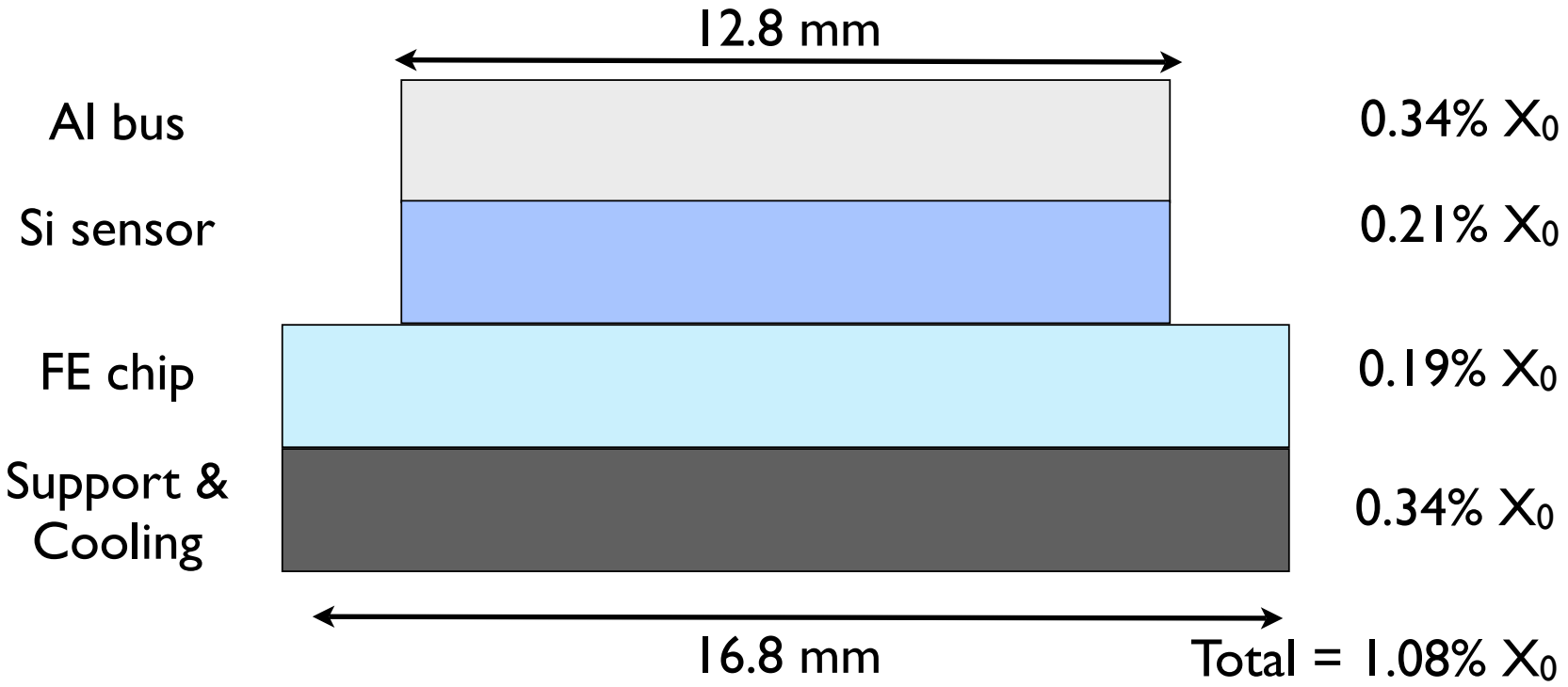


Design for MAPS solution

Mechanical design can be considered valid also for Hybrid Pixel solution though small changes could be applied when finalized design will be ready.

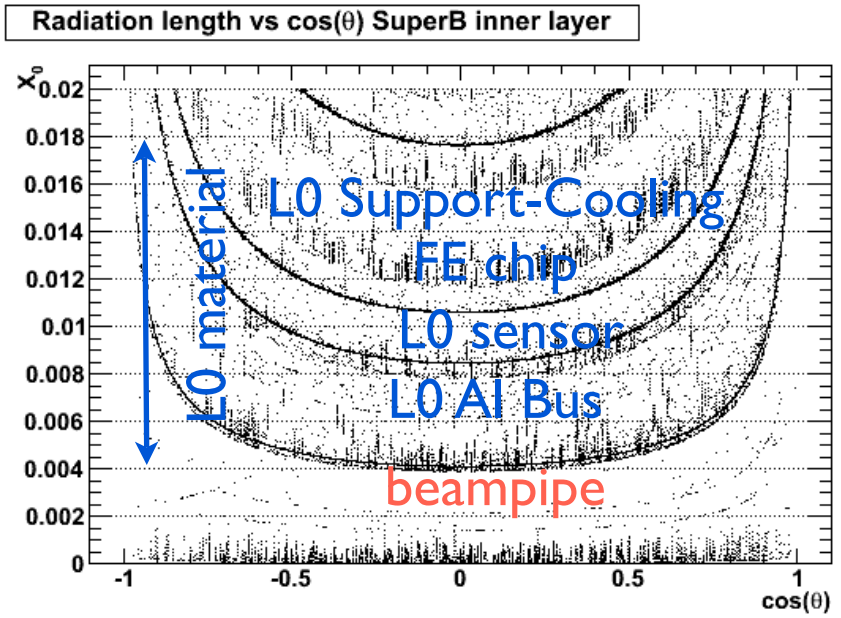
Hybrid pixel solution

- Module cross section

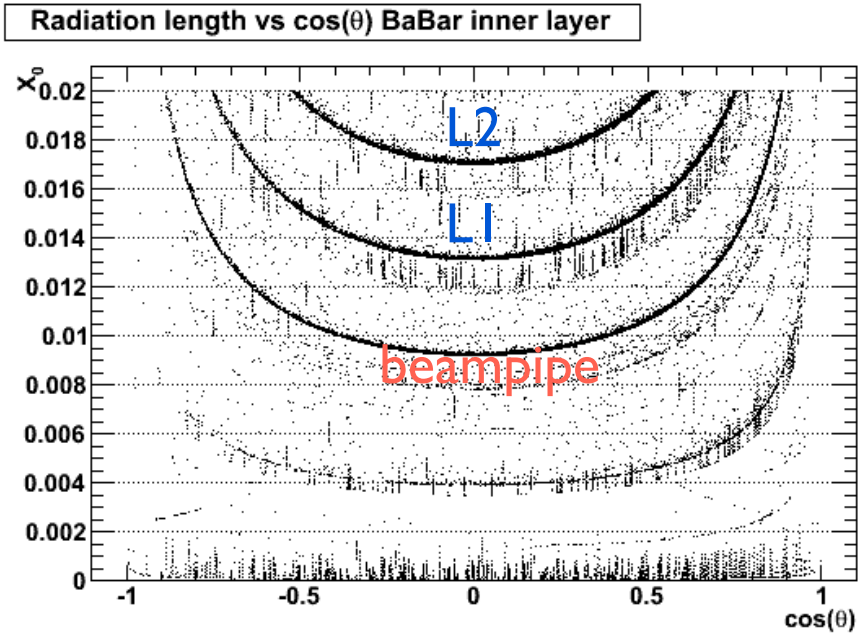


Radiation length vs cos(theta) in FastSim

SuperB

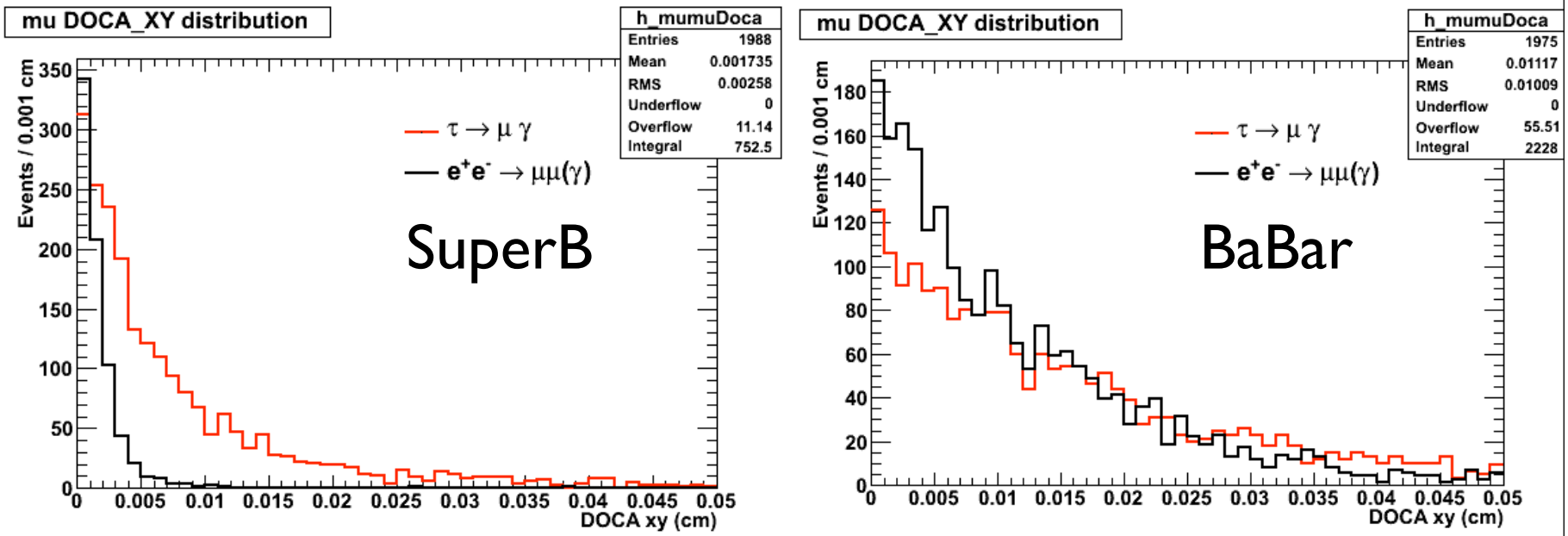


BaBar



Total amount of L0 material is ~1.36% X_0 considering overlap of passive material.
Relative amount of material for Al bus and support-cooling requires small adjustments.

Doca_xy: $\tau^- \to \mu^- \gamma$ vs $e^+e^- \to \mu^+\mu^-\gamma$



Significant improvement in DOCA_xy reconstruction.

Could help in further reducing bkg for τ LFV decays?

from G. Rizzo presentation at Tech Board

Preliminary

TDR work schedule & Milestones (III)

- Detector Optimization Studies (Still need to work on a the schedule after June 2009)

Implement Baseline SVT configuration in Fastsim (realistic version): June 2009
Material, resolution model for 50 um pitch, **extend external layers to 300 mrad**, **realistic passive material in active area**.
dE/dx and realistic modeling of the material at the edge of the coverage might require more time.
Test layer 0 performance for time dependent analysis (channel phi Ks) with realistic baseline**:** June 2009
Extension of SVT max radius vs Extension of DCH min radius: June 2009
Extend geometry to 200 mrad to allow study in DGWG (Help from DGWG people)
Evaluate performance (tracking and time dependent analysis) with L0+L1 made of hybrid pixel .by Oct 2009?
External Layer radial position optimization (channel Ks pi0) : efficiency, resolution, evaluate error on asymmetry with toy MC: by Oct-Dec 2009?

bold=done
underlined=in progress