SVT detector studies for

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on behalf of SVT group

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Outline

- Summary and outcome of CDR studies
- Benefits of improved vertexing at SuperB and identification of benchmark channels
- Fast simulation and full simulation studies
- Planning for the TDR
- Conclusions

Goal of CDR studies

Main question to answer for CDR:

"Feasibility of time dependent analysis with reduced energy asymmetry imposed by new machine design."

Studied proper time resolution as a function of relevant parameters:

- Center of mass boost
- Beampipe radius and radial material
- SVT configuration and technology

Studied also the performances of new vertex detector: vertex resolution, effect of new beamspot constraints, B-D vertex separation, vertexing at Charm threshold, etc.

SuperB SVT concept

In order to meet the requirements for proper time resolution, 0.6ps BaBar resolution (from Fast Simulation), we considered a new SVT design adding a layer0 detector close to the IP: ~1-1.5 cm radius.

Layer0 requirements: capability to operate at high rates ($O(10)$ MHz/cm^2), with minimum material budget (<1% X_0) and with high intrinsic resolution (~10 μm). Possible technologies:

- MAPS: rate up to 100 MHz/cm^2, material ~0.5% X_0, reso~10μm ★★★

  Technology is not available yet. Strong R&D effort.

- Hybrid pixels: good rate capability, material ~1.0% X_0, reso~10μm ★★

  Technology already available. Material budget is a limiting factor.

- Striplets: limited rate capability, material ~0.5% X_0, reso~10μm ★

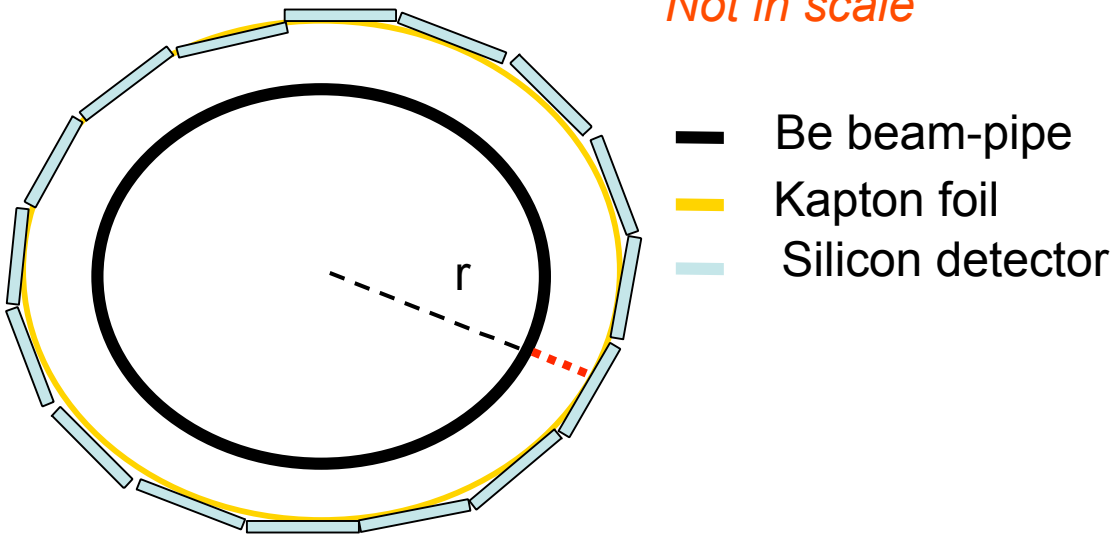
  Technology already available. Rate capability is a limiting factor.

Simulation setup

Use PravdaMC fast-simulation with current SVT detector with additional layer0.

Layer0 scenario:

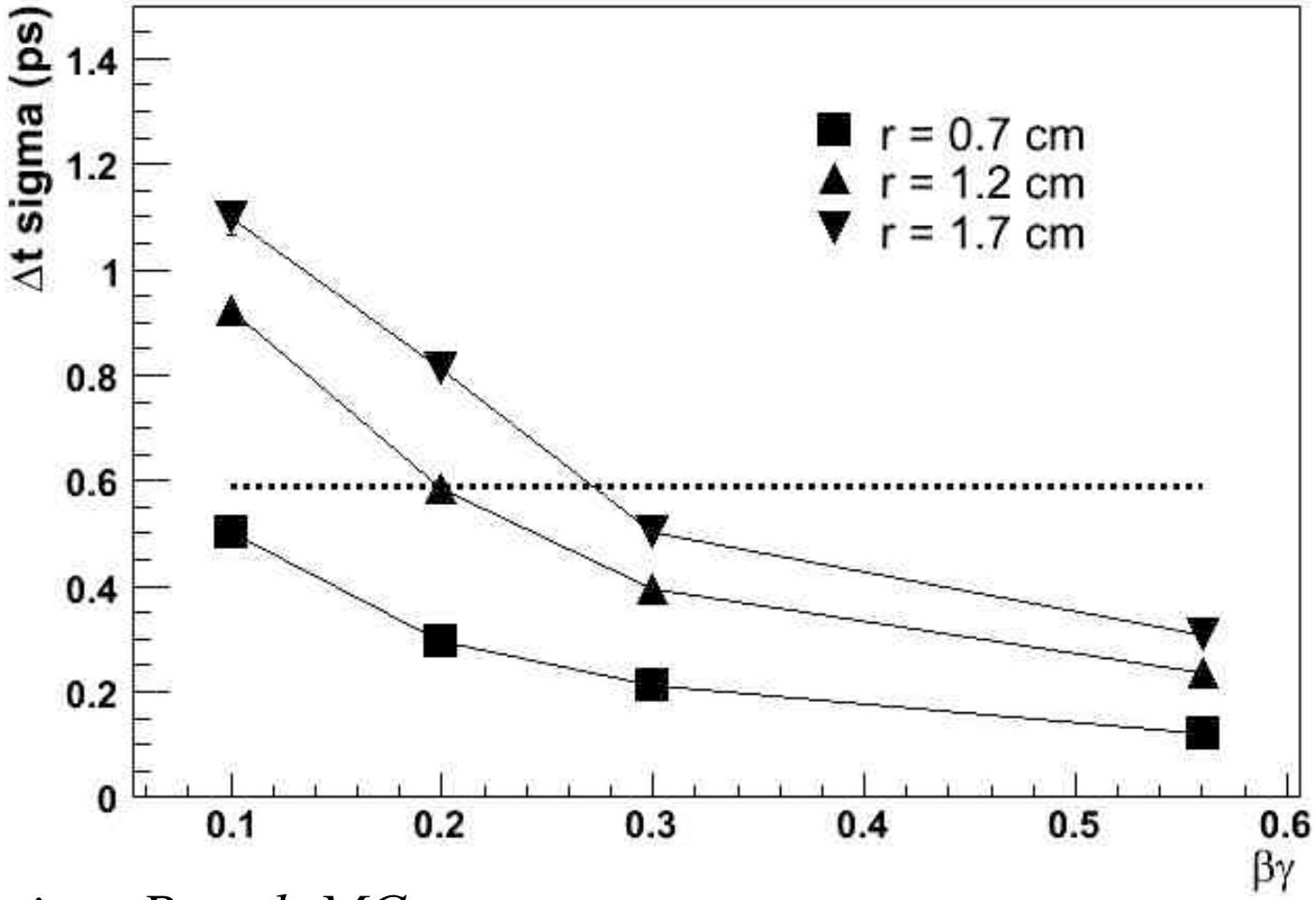
- beam pipe inner radius 1cm
- beam pipe outer radius 1.1 cm
- layer0 radii = 1.2, 1.5, 1.7 cm
- material for L0 = [0.2-1.5] % X0
- hit resolution = [5-15] μm



Caveat: considering $B \to \pi\pi$ decay mode in this study.

Example of physics studies: Δt resolution in $B \to \pi\pi$ decays *vs* $\beta\gamma$

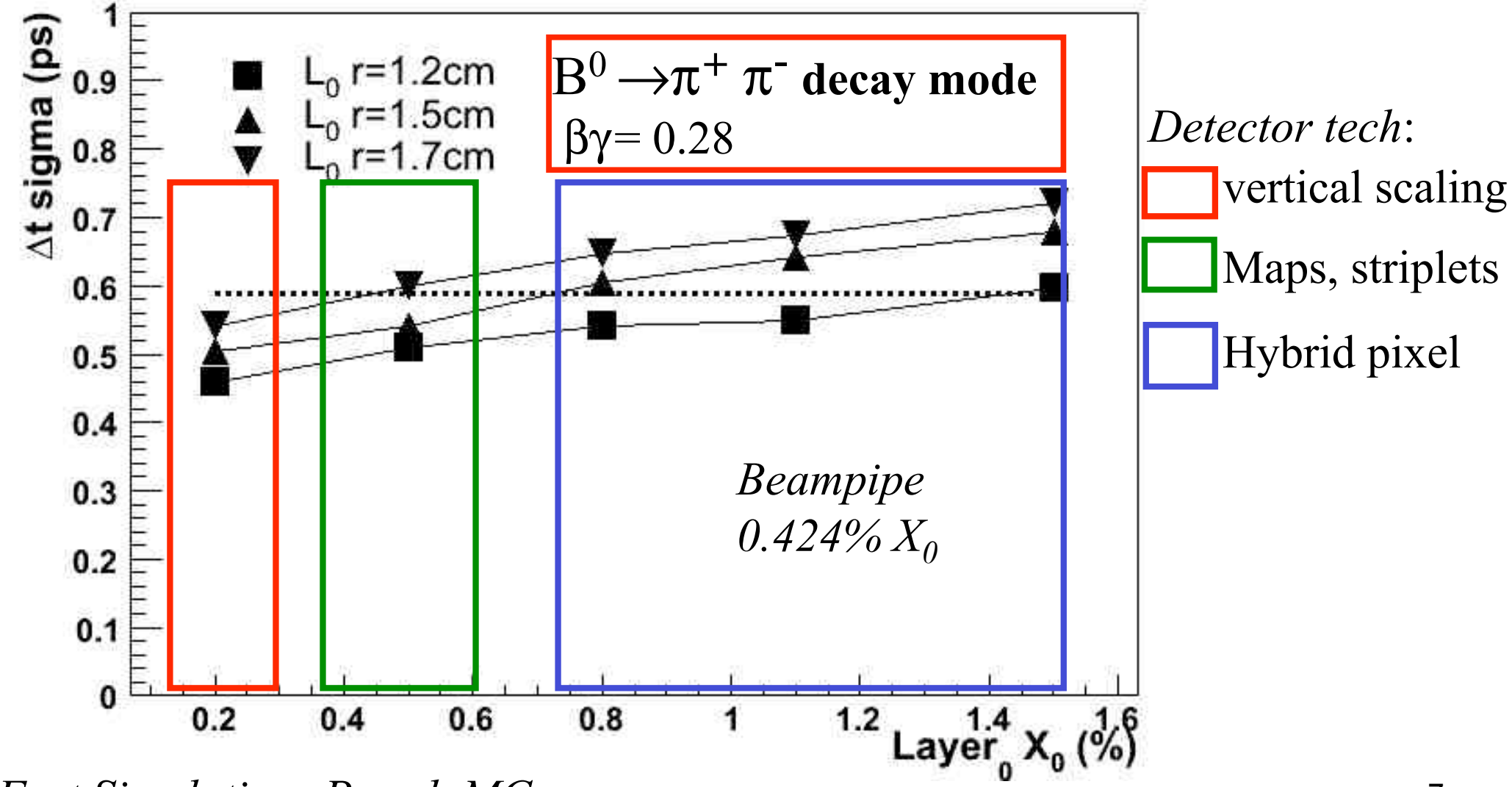
15 μm intrinsic detector resolution



Fast Simulation: PravdaMC

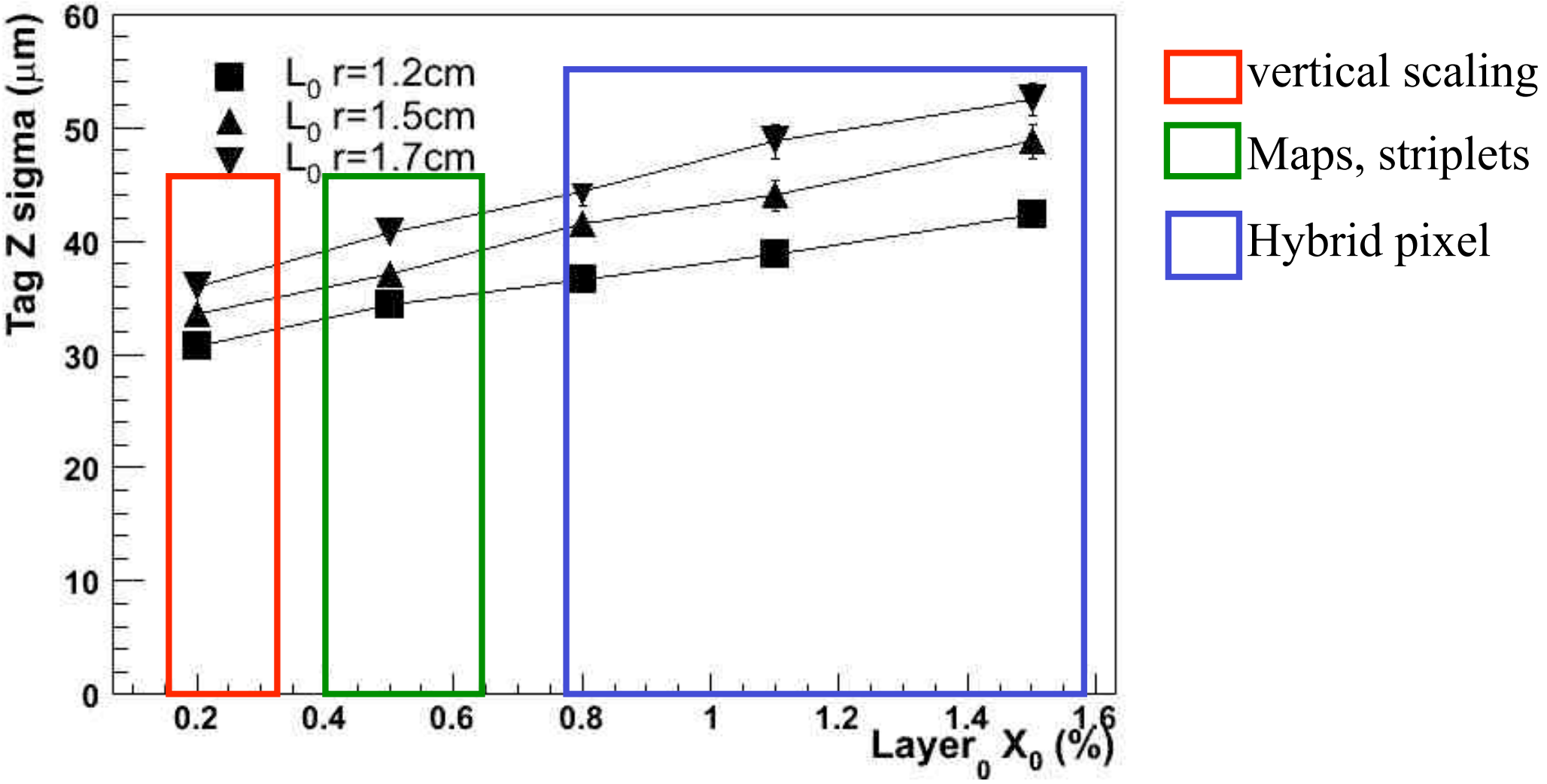
Example of physics studies: Δt resolution in $B \to \pi\pi$ decays *vs* L_0 X_0(%)

10 μm intrinsic detector resolution



Fast Simulation: PravdaMC

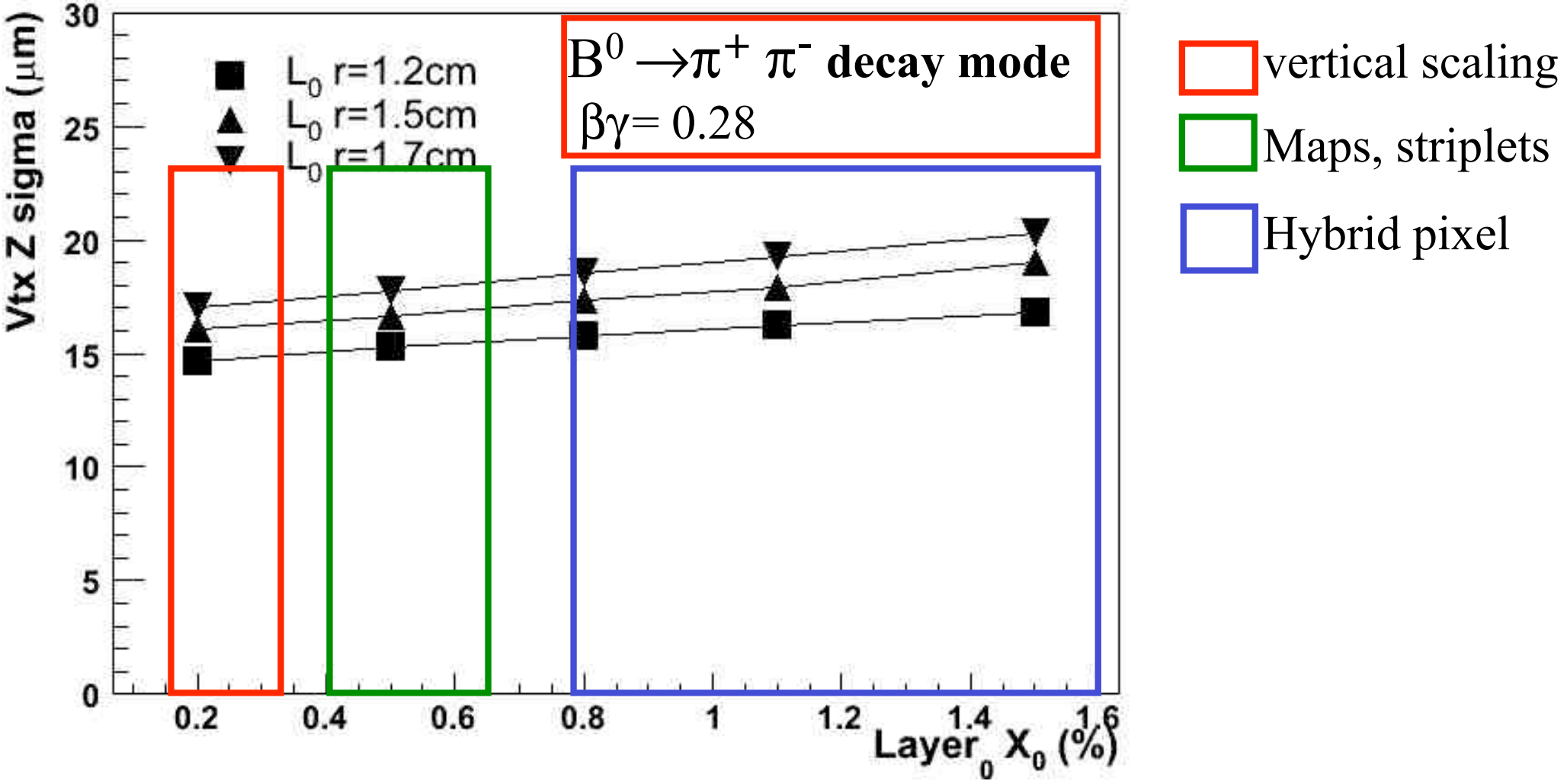
Tag vertex resolution
10 μm intrinsic detector resolution



Fast Simulation: PravdaMC

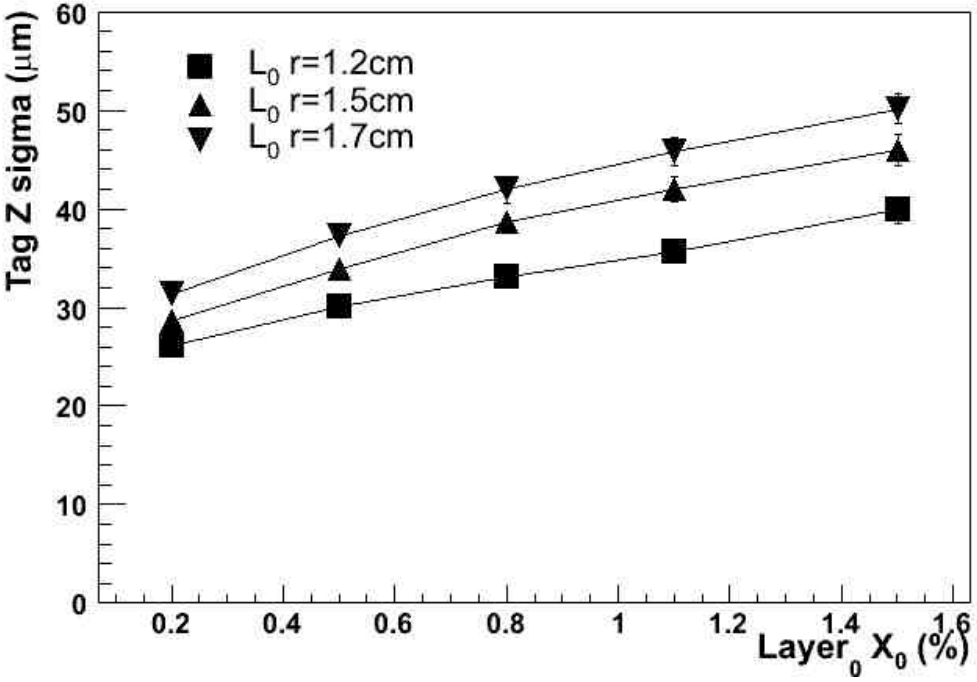
CP vertex resolution

10 μm intrinsic detector resolution

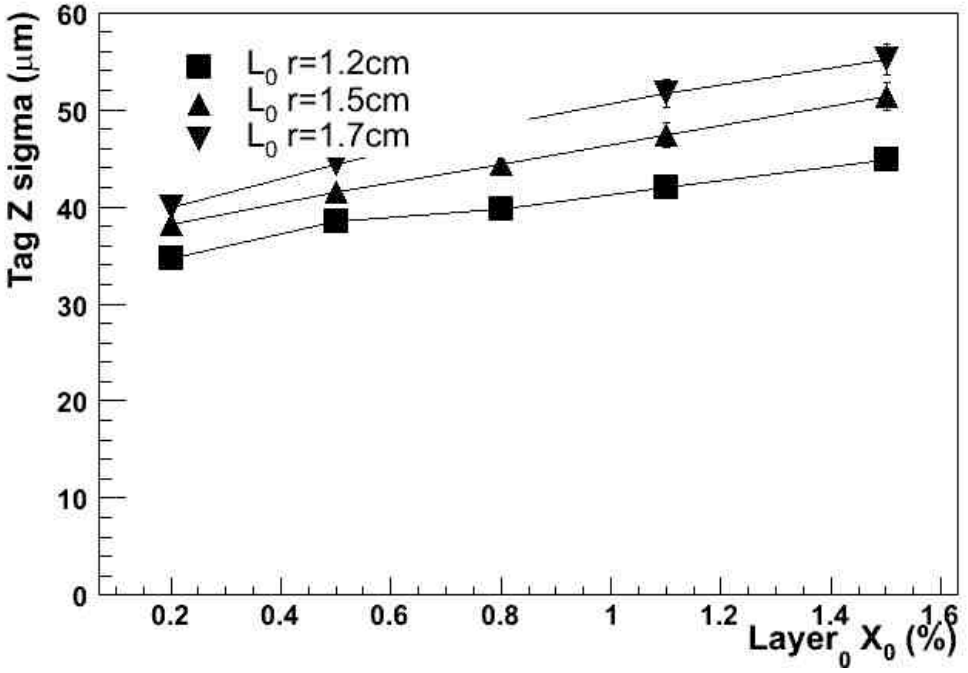


Fast Simulation: PravdaMC

Effect of hit resolution on Tag Vtx



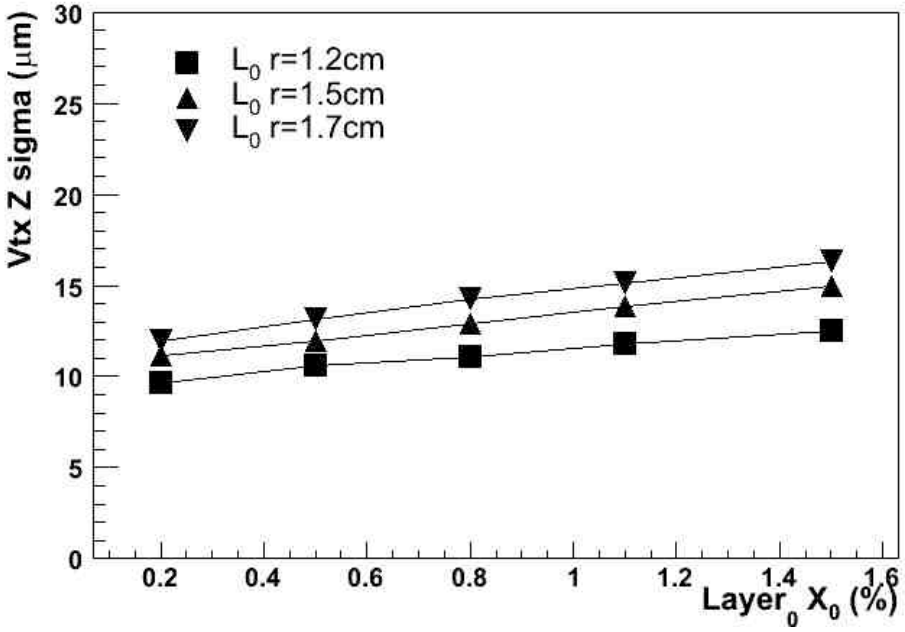
5 μm intrinsic resolution



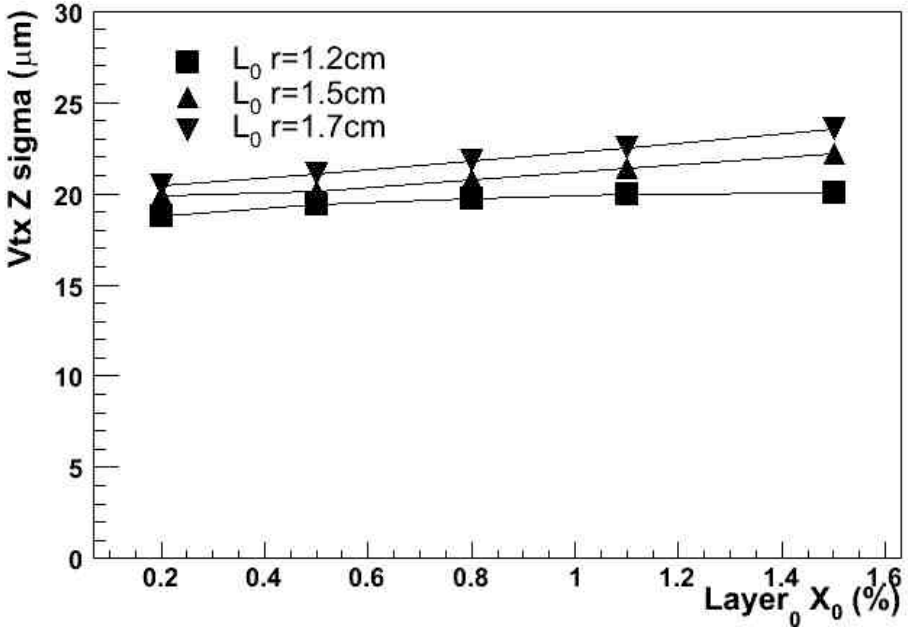
15 μm intrinsic resolution

Fast Simulation: PravdaMC

Effect of hit resolution on CP Vtx $B \to \pi\pi$



5 μm intrinsic resolution



15 μm intrinsic resolution

Fast Simulation: PravdaMC

Main results after CDR studies

- Boost fixed to $\beta\gamma$=0.28 and beampipe material 0.42 X_0%
- With no major R&D, Δt resolution is already within BaBar standard (Hybrid pixel, striplets).
- For MAPS (best solution) heavy R&D is still required.
- Hybrid Pixel could represents an alternative solution for L0 already. Some R&D is needed to reduce the pitch and the total material budget.
- L0 radius at 1.2 cm and material budget below 1% are requested.
- Hit resolution (below 10μm) is also an important parameter.

Towards TDR: optimization of Vertex-Tracker detector

- CDR studies have investigated a new detector concept for SuperB.
- TDR studies should optimize the detector design:
  - Define figure of merits to optimize: vertex resolution, reco efficiency, PID, bkg suppression.
  - Study vertex resolution on decays where layer0 has minimal impact $B^0 \rightarrow Ks\pi^0$, $B^0 \rightarrow KsKs$
  - For bkg rejection: LFV decays (i.e. $\tau \rightarrow \mu\gamma$), Vub measurement could benefit of improved vertex resolution.

Example of TDR studies

New ideas for tracking, vertexing and analysis techniques should be investigated in the context of a completely different scenario for vertex resolution with respect to BaBar and Belle experiments

- Detector layout: coverage, layer radii, pitch, module shapes.
- Impact of additional layer0 for reconstruction of low p_t tracks.
- Optimize the efficiency on Ks reconstruction: fix layer5 radius and DCH radial distance (no support tube at SuperB).
- dE/dx capability: decision on readout electronics
- Study the pattern recognition capabilities

Future Work/ Tools

- Most of the studies will require Fast Simulation (optimization studies).
- Complete Geant simulation is useful to confirm Fast Simulation results and required for specific detailed studies (i.e. patter recognition).

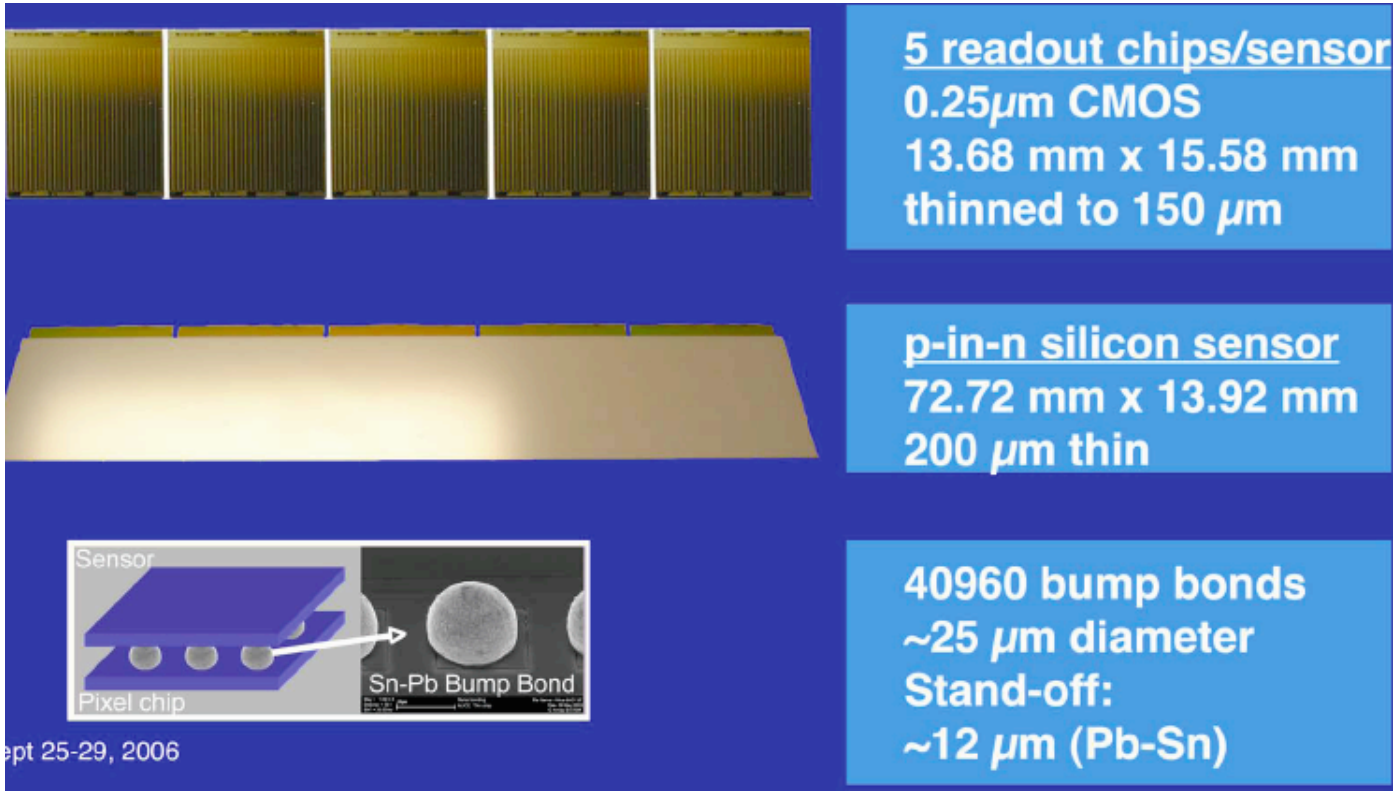
Backup slides

Status of art for vertex resolution studies for TD analysis

- MAPS and striplet solutions have been studied for CDR. Resolution for Δt is within BaBar standard (0.6ps according to fast-simulation).
- Decision of usability of striplet detectors is pending on more complete bkg simulation studies which are ongoing.
- Investigation of hybrid pixel technology is worthy in order to have an additional backup solution for layer0.

Hybrid Pixel: an example

- Alice pixel detectors



Material budget X_0

0.37 % sensor
0.30 % cooling
0.10 % support
0.17 % cable bus

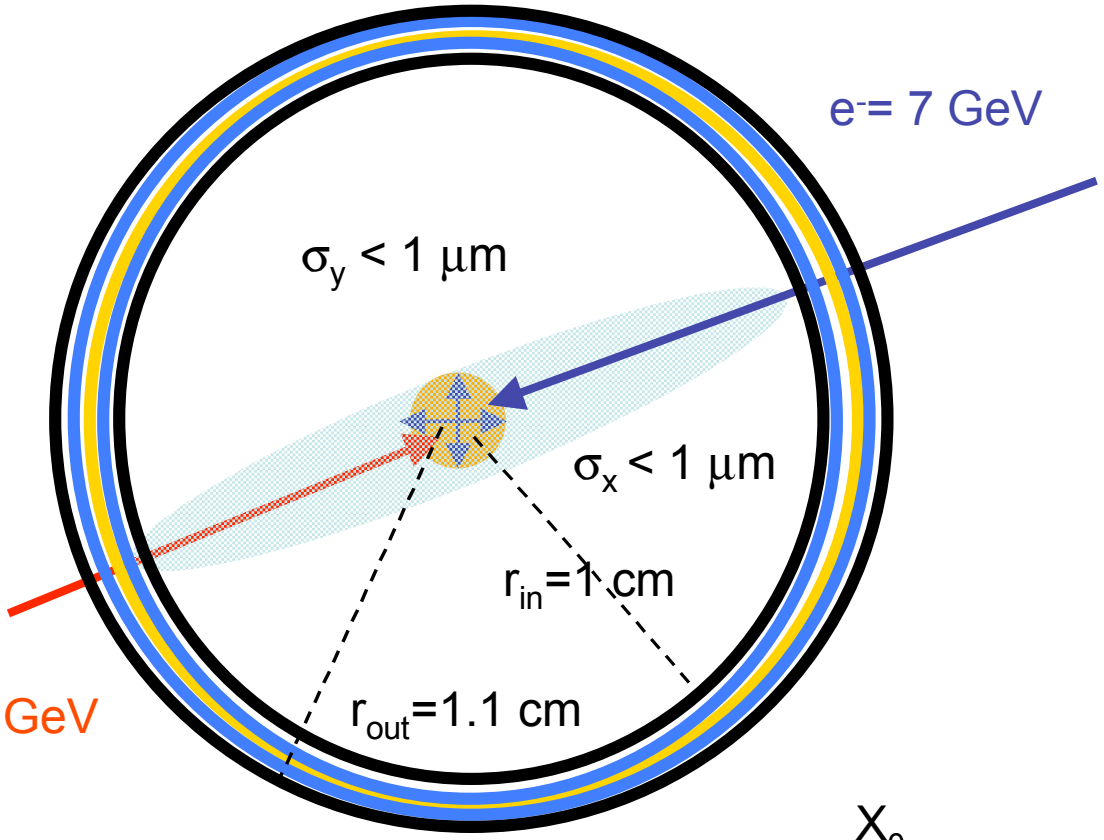
0.94 % X_0 Total

Margins of improvements: for cooling, support and sensor ~0.8% X_0 feasible. 10 μm hit resolution can be reached with smaller pixel cells and analogic readout. □

Future of R&D projects is "vertical integration" detectors ~0.2% X_0 limit

Interaction region SuperB

Not in scale



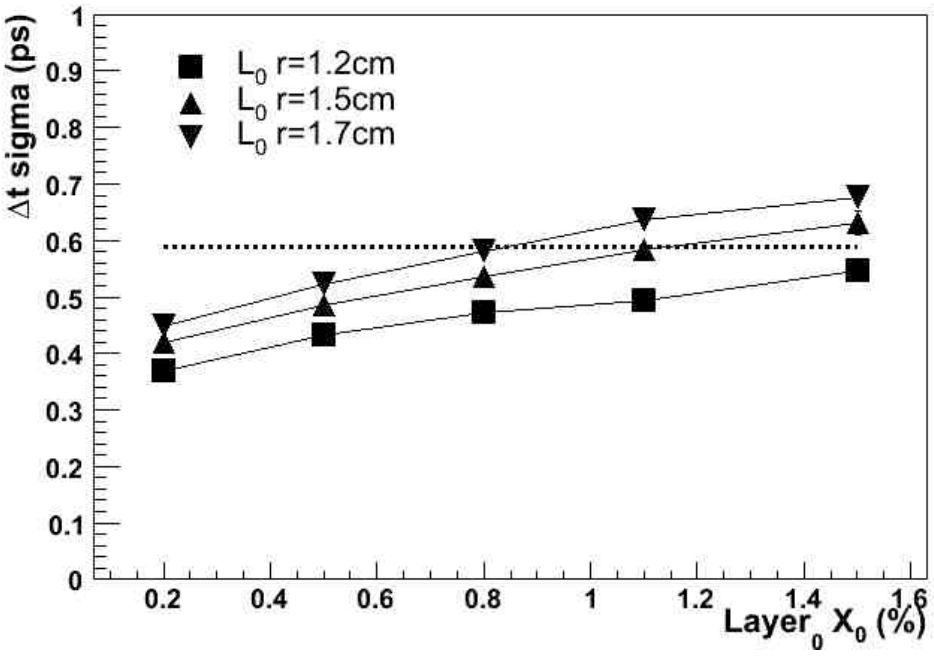
σ_z = 1 mm

- Be beam-pipe 600 μm thick
- Au foil 4 μm thick
- Water 300 μm thick
- Nickel coating 7 μm thick

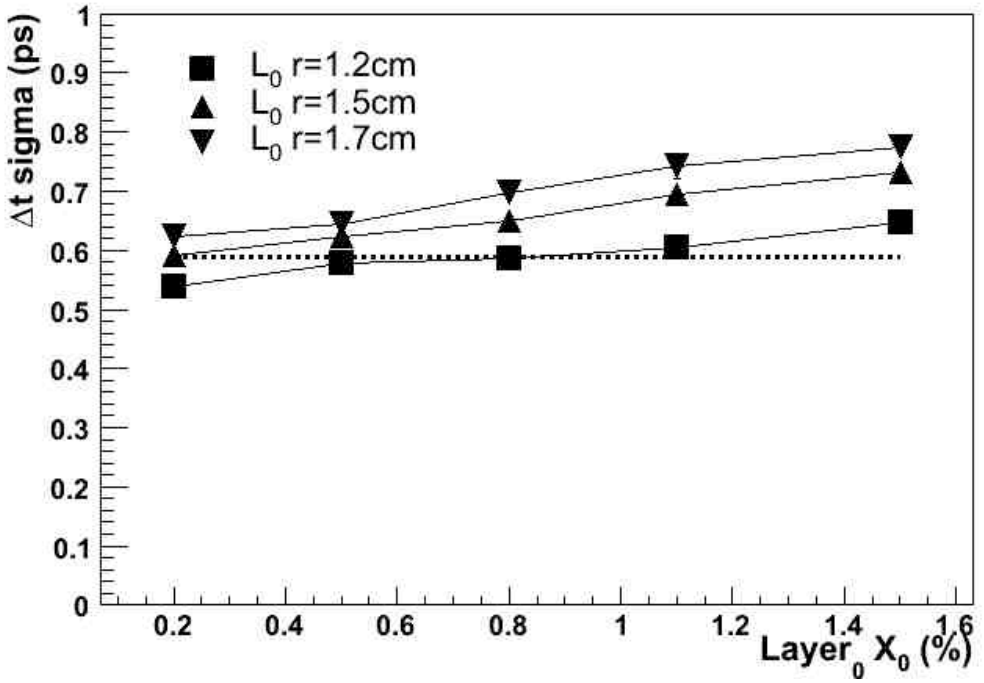
X_0	
0.170%	(Be)
0.121%	(Au)
0.083%	(H_20)
0.050%	(Ni)
0.424%	X_0 ToT

Impact on Δt resolution:

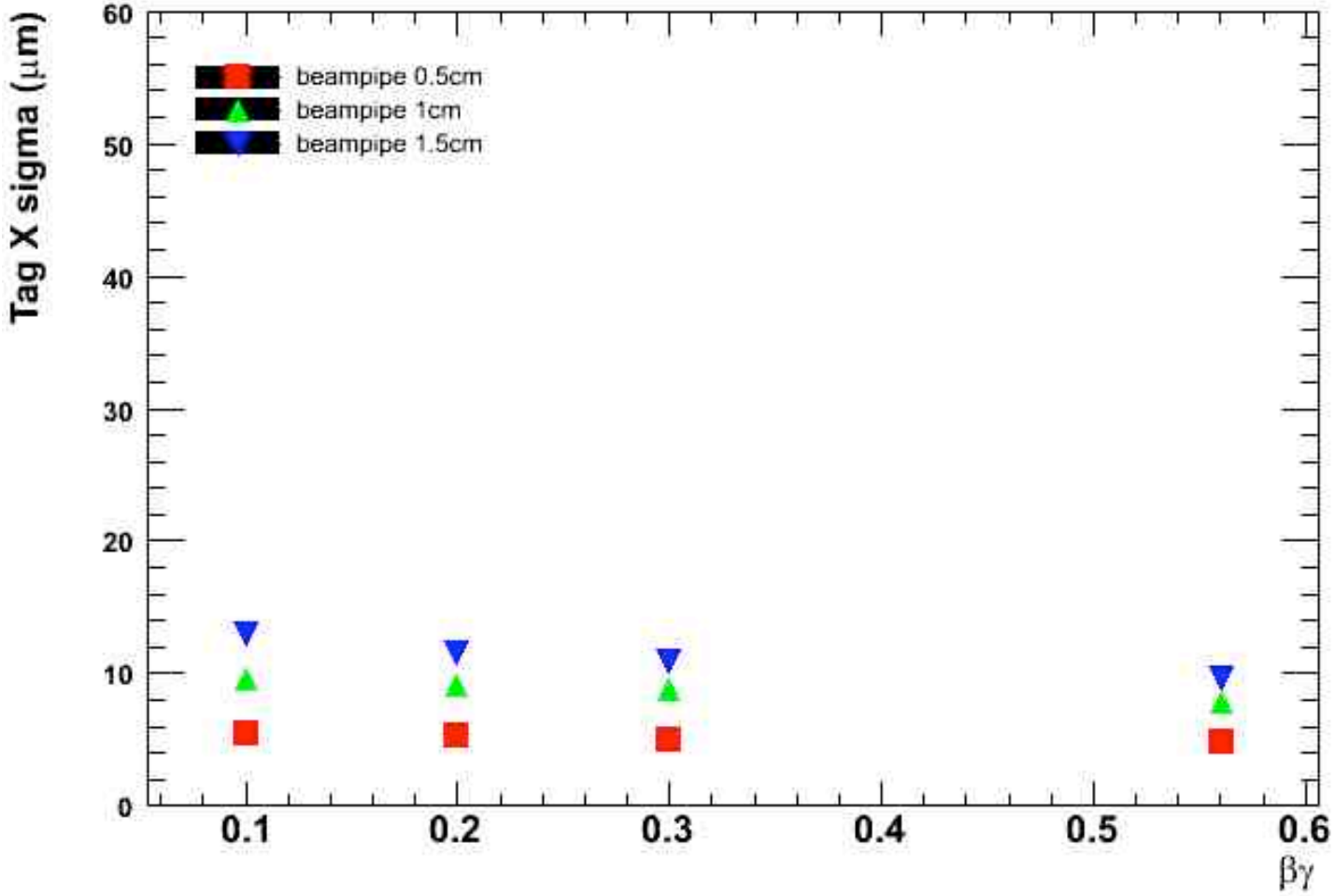
CP Vtx $B \rightarrow \pi\pi$

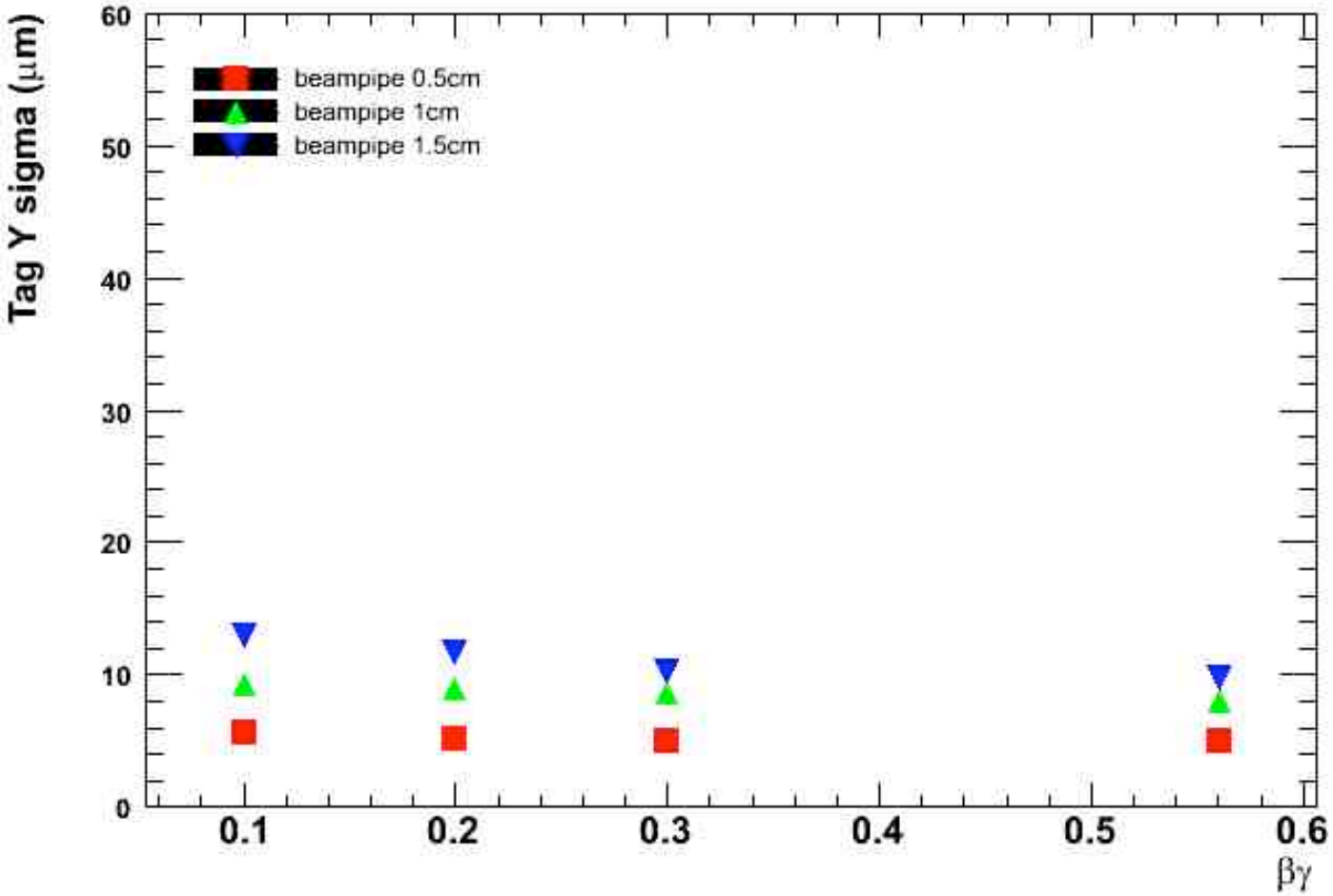


5 μm intrinsic resolution



15 μm intrinsic resolution


Tag X sigma (μm)
60
50
40
30
20
10
0
beampipe 0.5cm
beampipe 1cm
beampipe 1.5cm
0.1
0.2
0.3
0.4
0.5
0.6
βγ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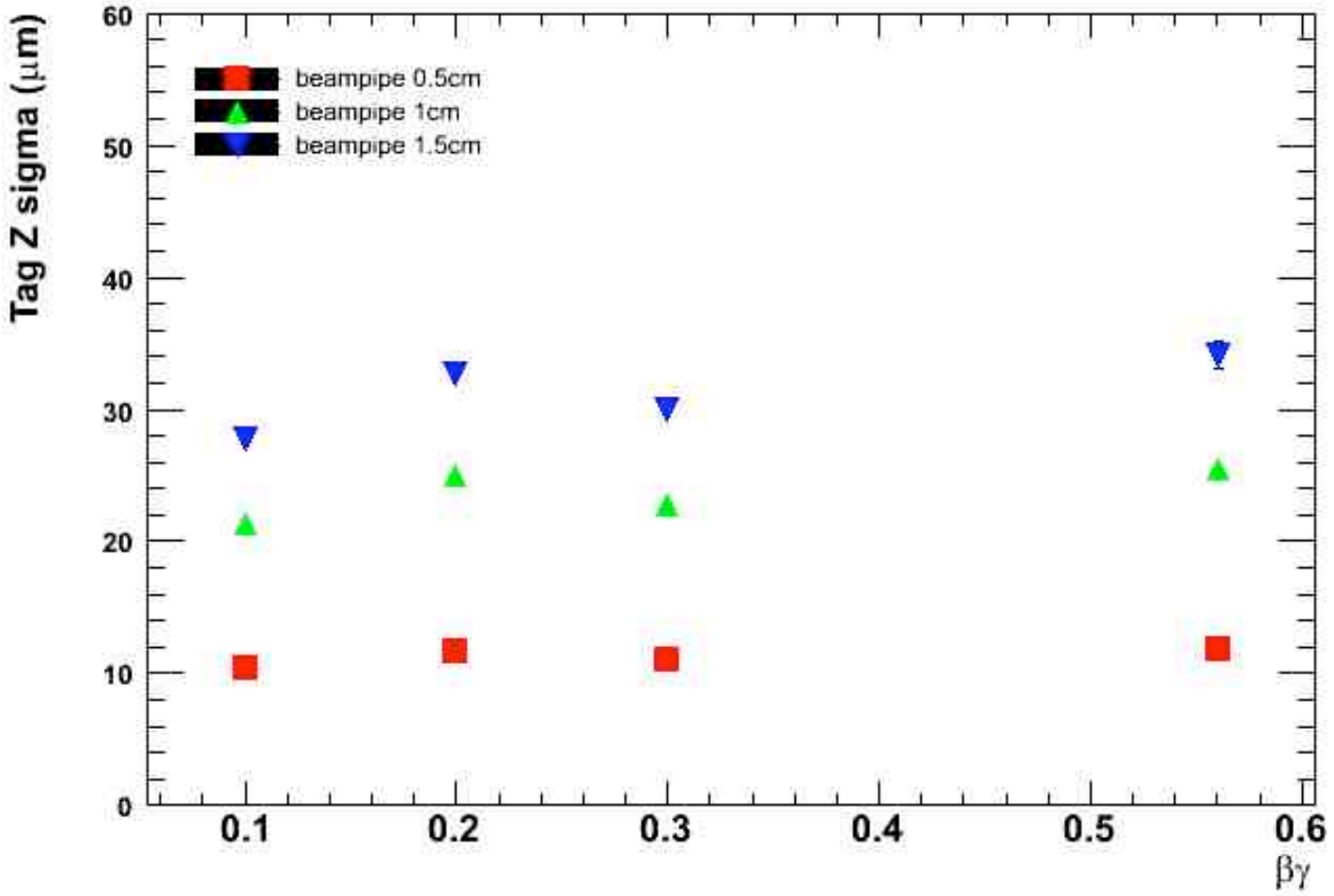
βγ


Tag Z sigma (μm)
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beampipe 0.5cm
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βγ