Study of the performances of Hybrid Pixel with Atlas FE-I4

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Outline

- Different L0 solutions in FastSim
- First results
- Summary

L_0 solutions: striplets vs Hybrid pixels

Hybrid Pixel

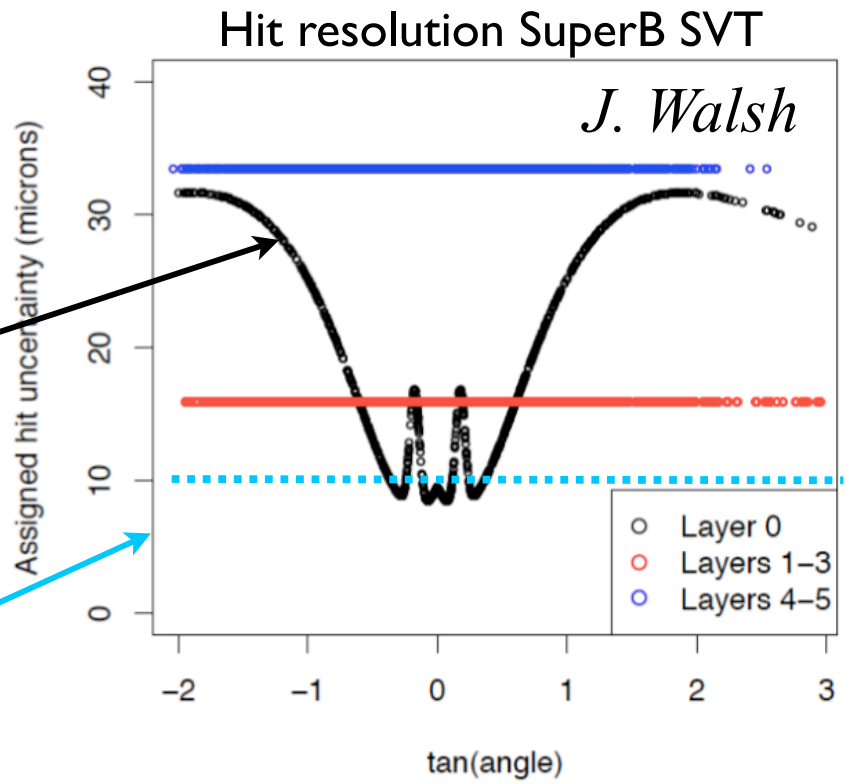
Digital 50x50

- material= 1.08% X_0
- digital readout
- average radius = 1.60 cm
- hit res ~ <14 μm> (ad hoc model)
- efficiency = 95%

Striplets

Baseline

- material= 0.4% X_0
- analog readout
- average radius = 1.60 cm
- hit res ~ 8 μm (core gaussian)
- efficiency = 90%



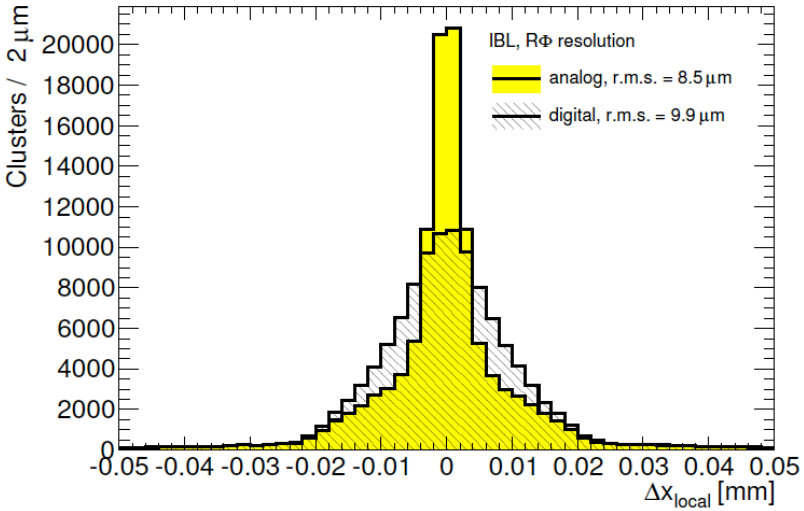
Hybrid pixels with Atlas FE-I4 chip

Hybrid Pixel with FE-I4

- material= 1.08% X_0
- "analog" readout with 8 bit ToT
- average radius = 1.60 cm
- pitch 50 µm x 250 µm in (r-phi,z)
- hit res ~ <8.5 µm> r-phi
- hit res ~ <47 µm> z
- efficiency = 99.9%

Analog 50x250

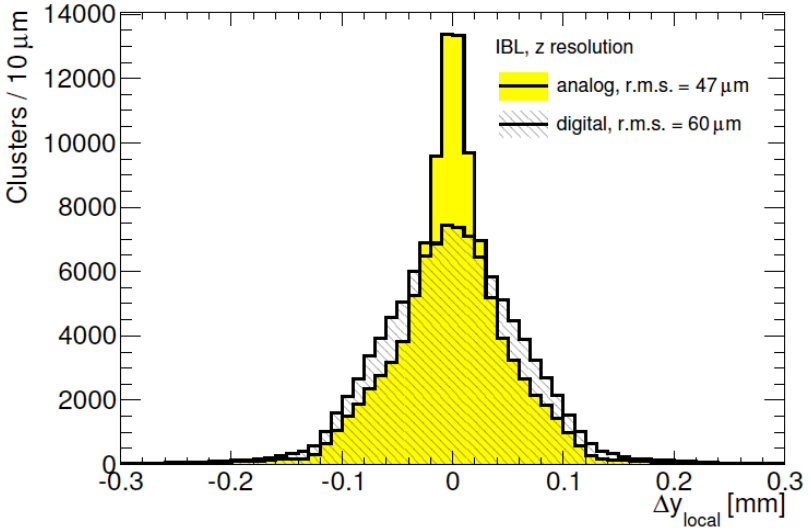
CERN-LHCC-2010-013
ATLAS TDR 19



Hybrid Pixel with FE-I4 rotated

- material= 1.08% X_0
- "analog" readout with 8 bit ToT
- average radius = 1.60 cm
- pitch 250 µm x 50 µm in (r-phi,z)
- hit res ~ <47 µm> r-phi
- hit res ~ <8.5 µm> z
- efficiency = 99.9%

Analog 250x50



Hybrid pixels with Atlas FE-I4 chip

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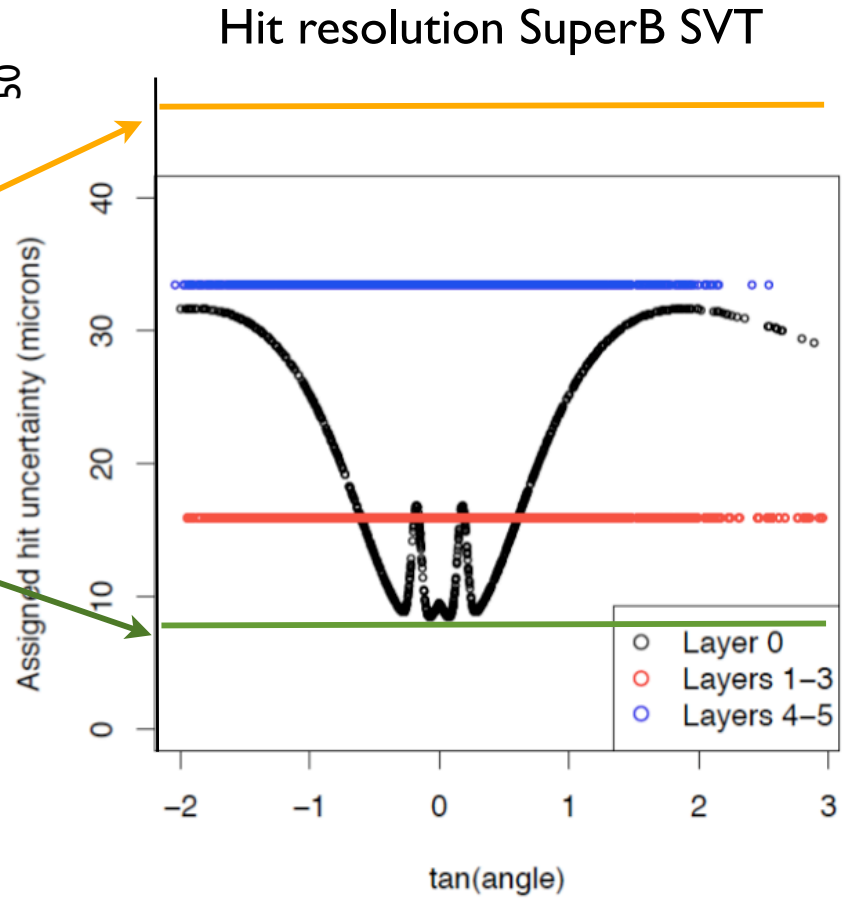
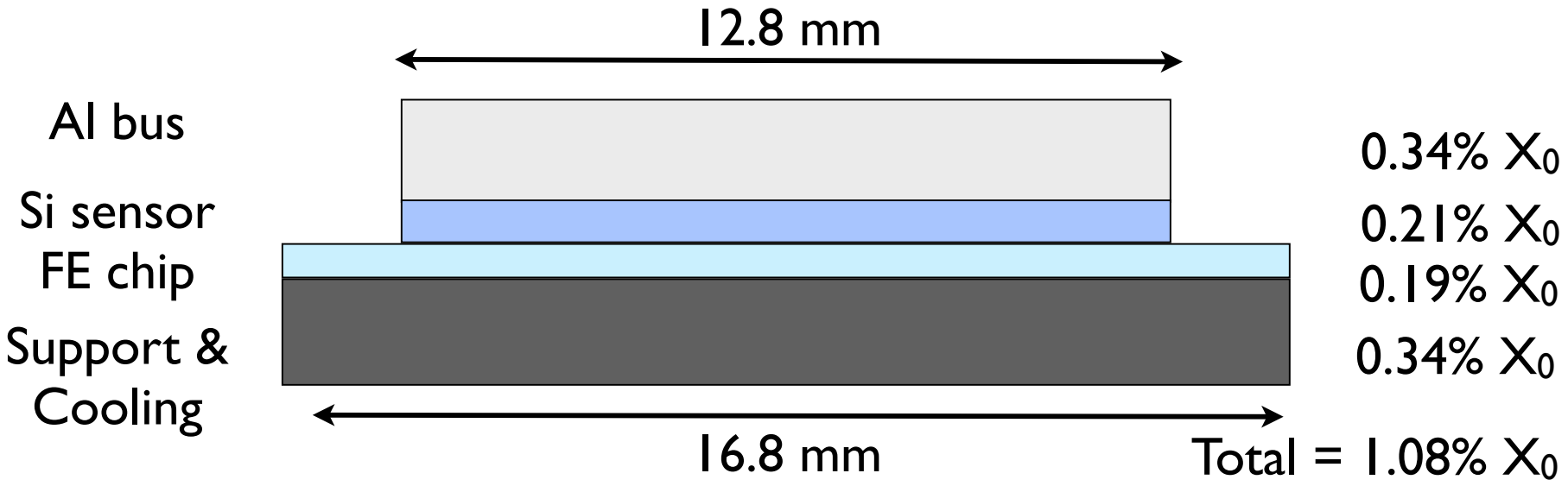
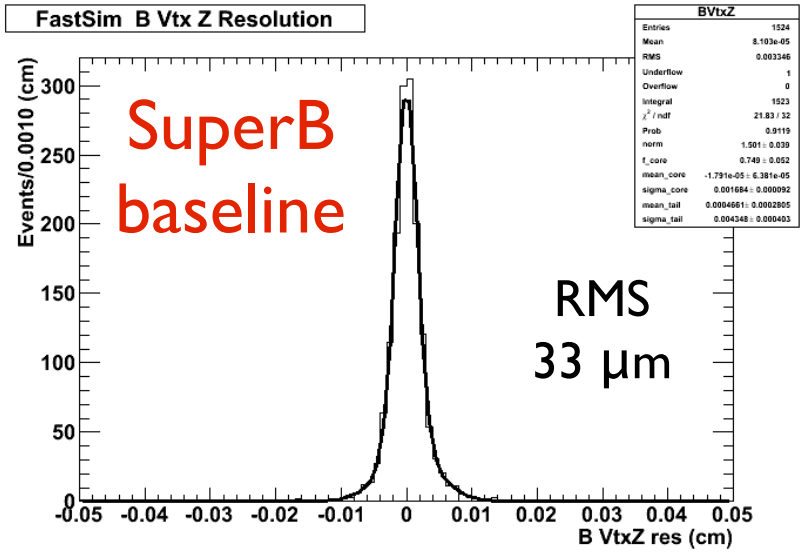


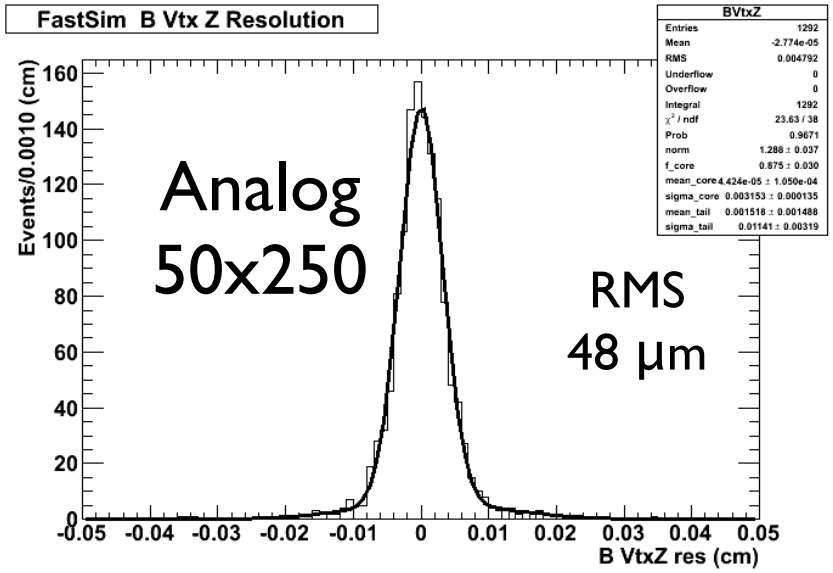
Hybrid pixel solution

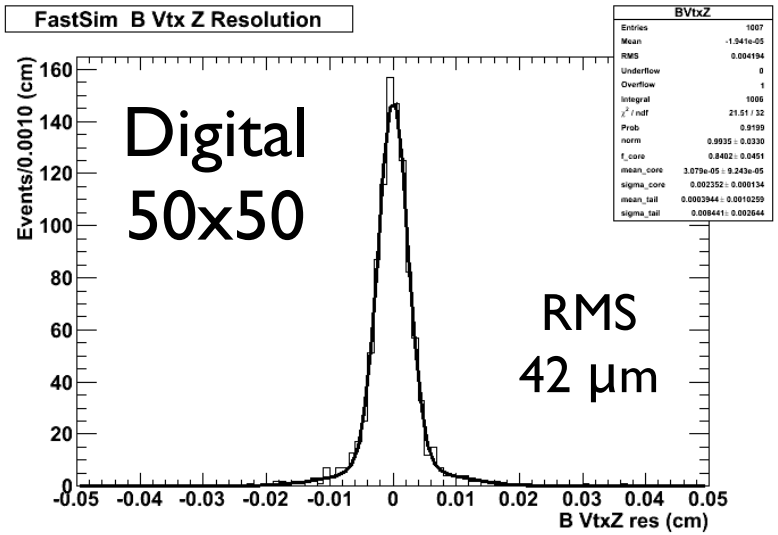
- Module cross section

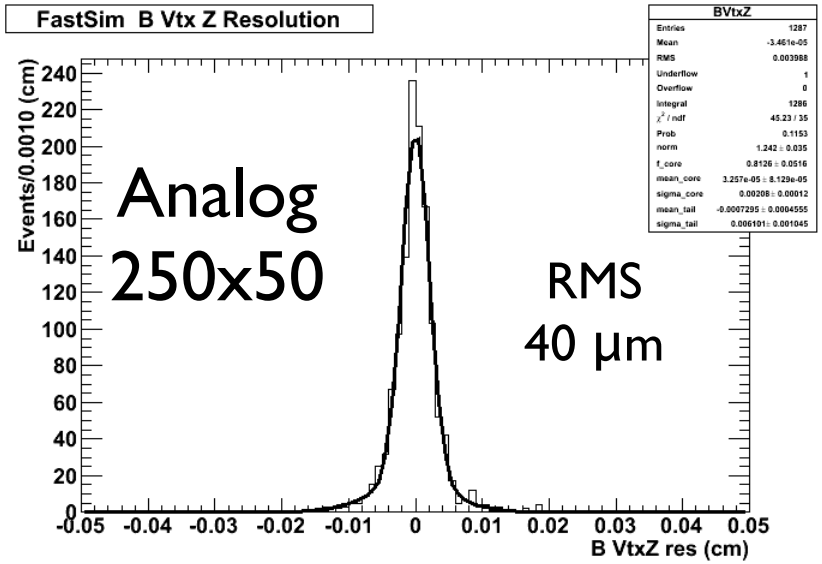


Decay vertex resolution

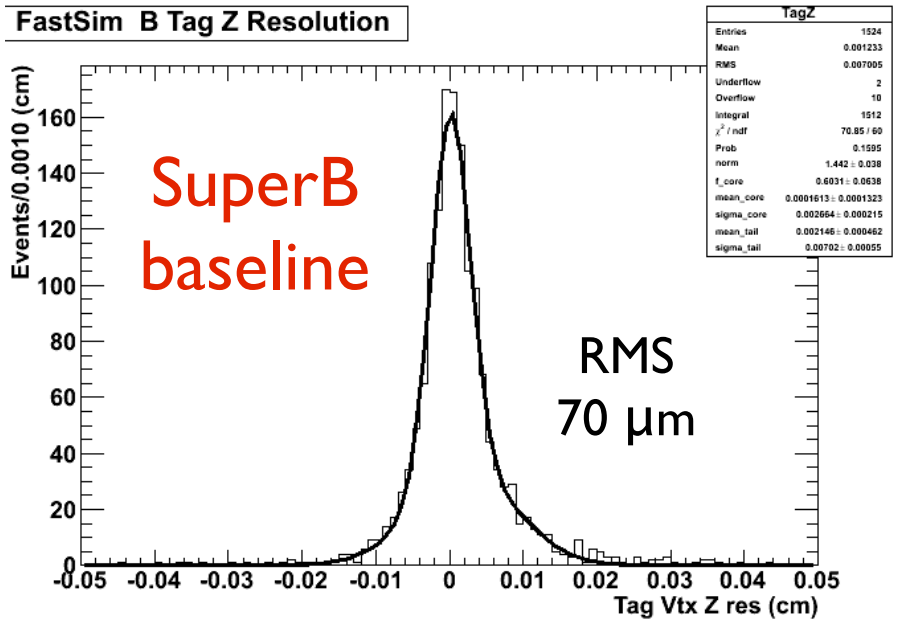


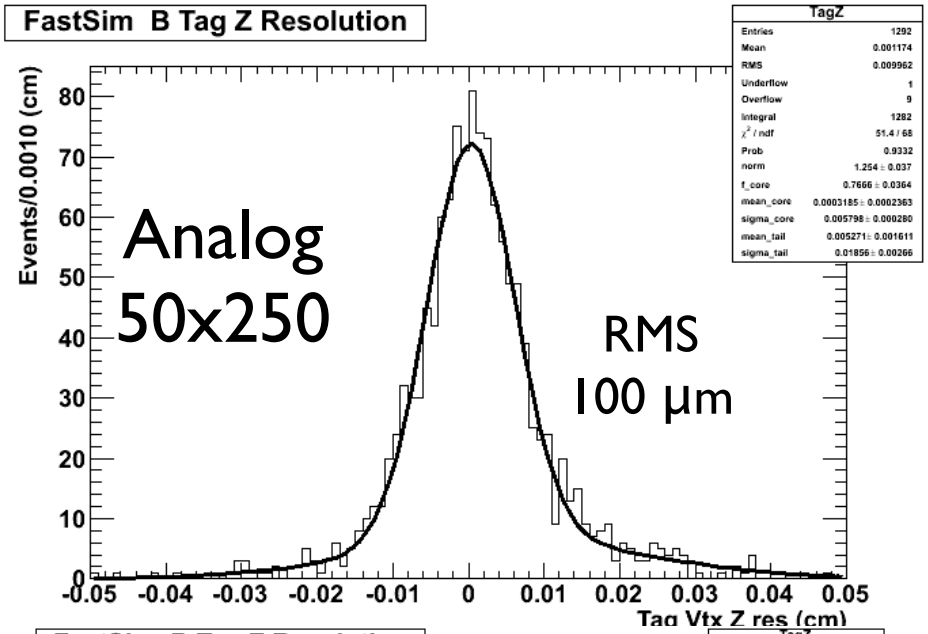


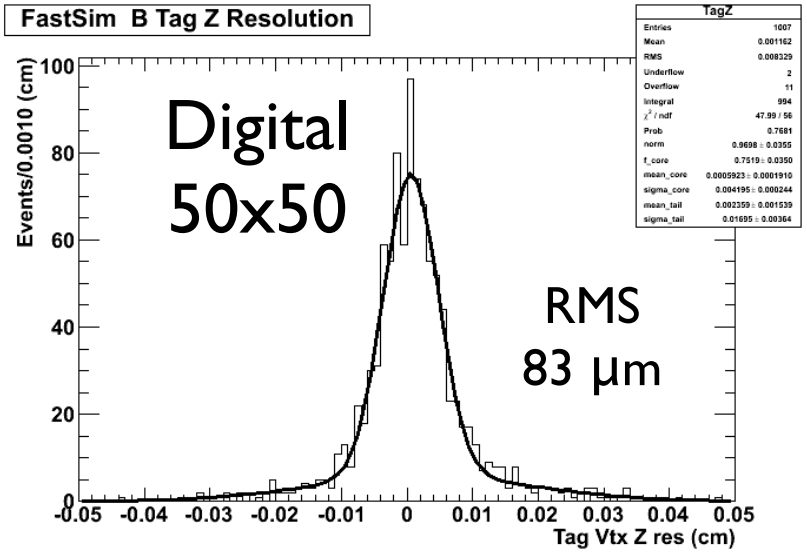


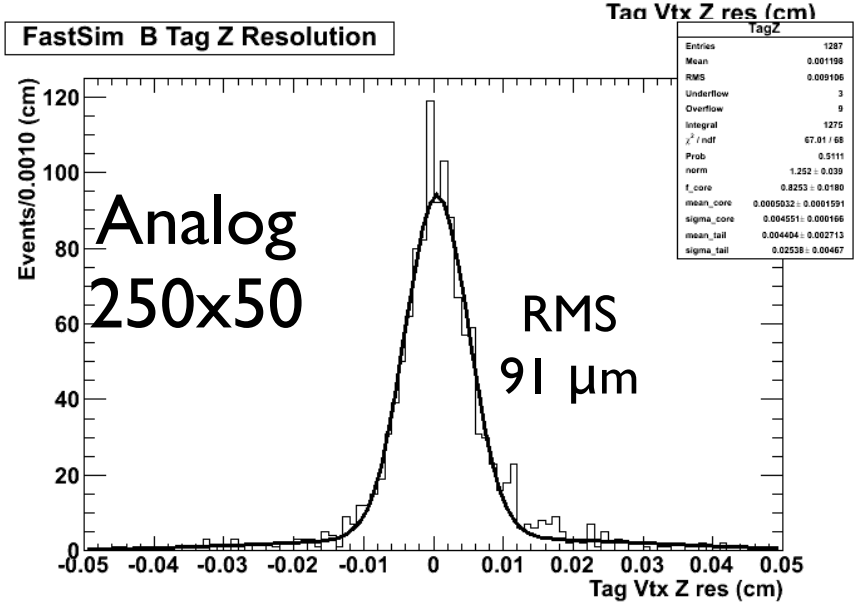


Tag side vertex resolution

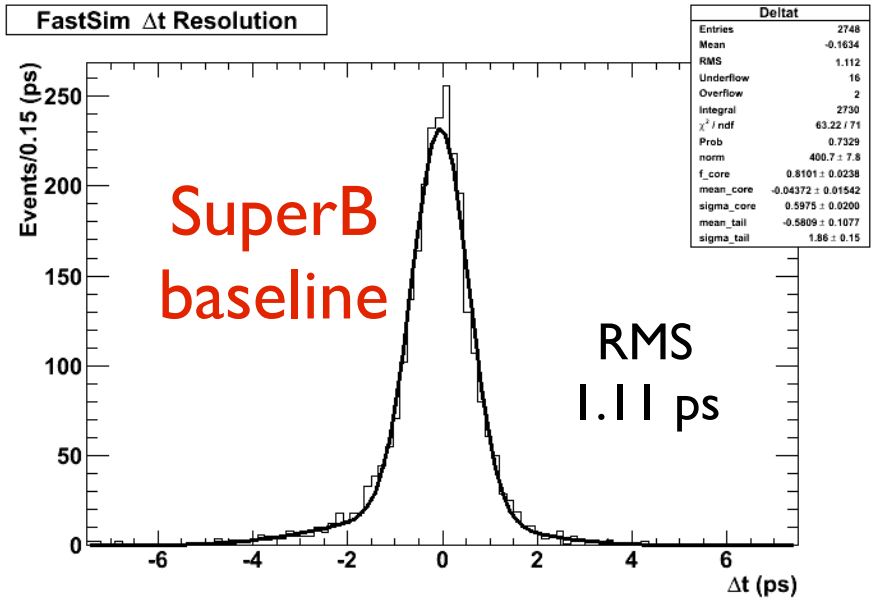


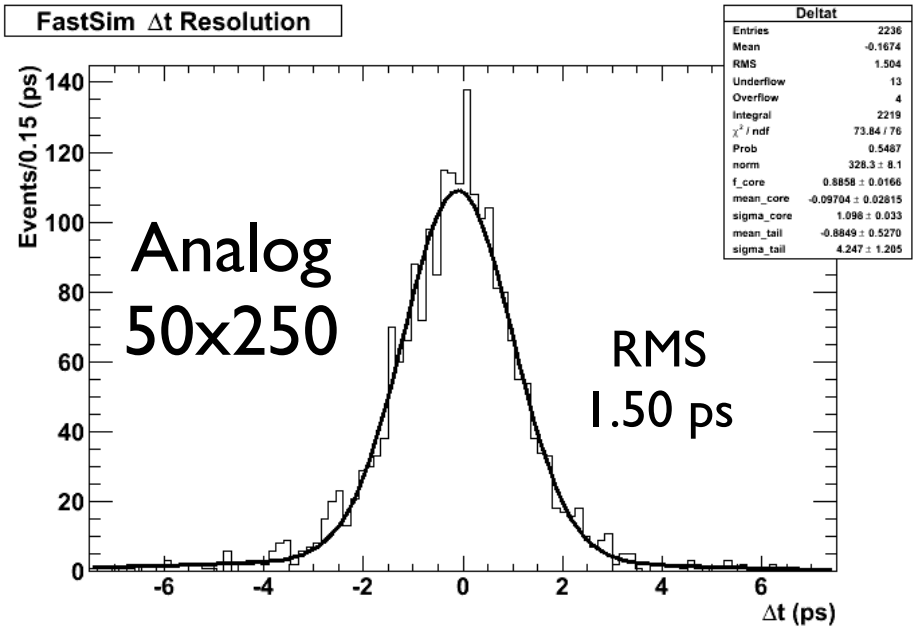


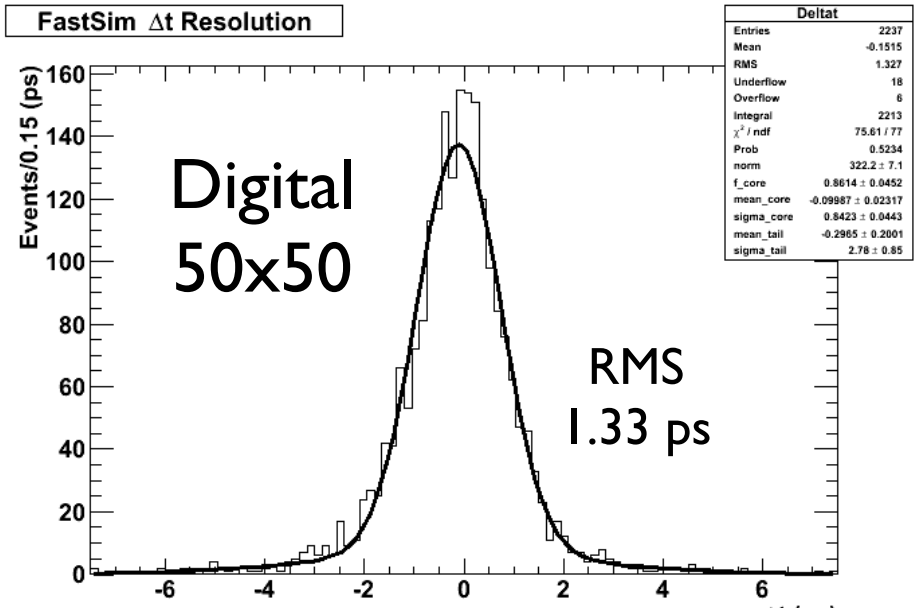


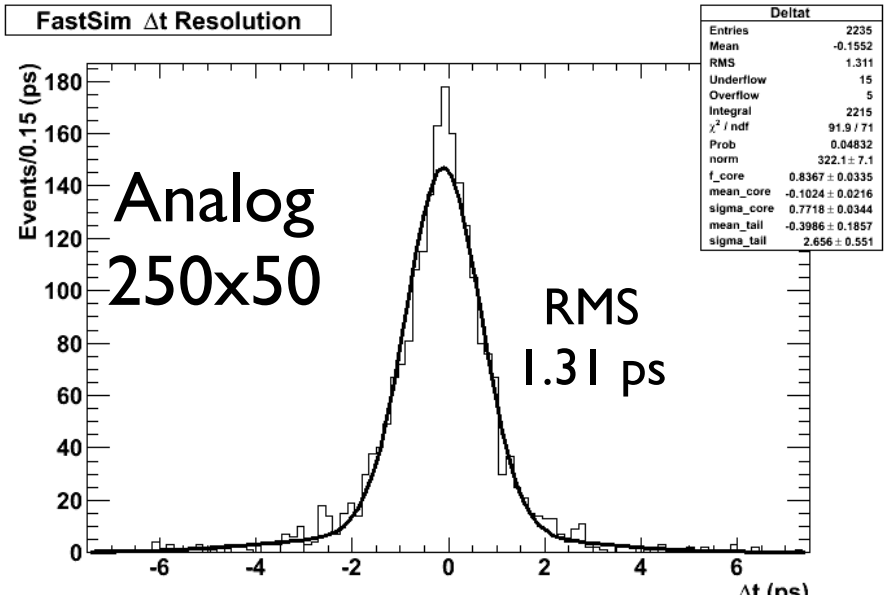


Δt resolution

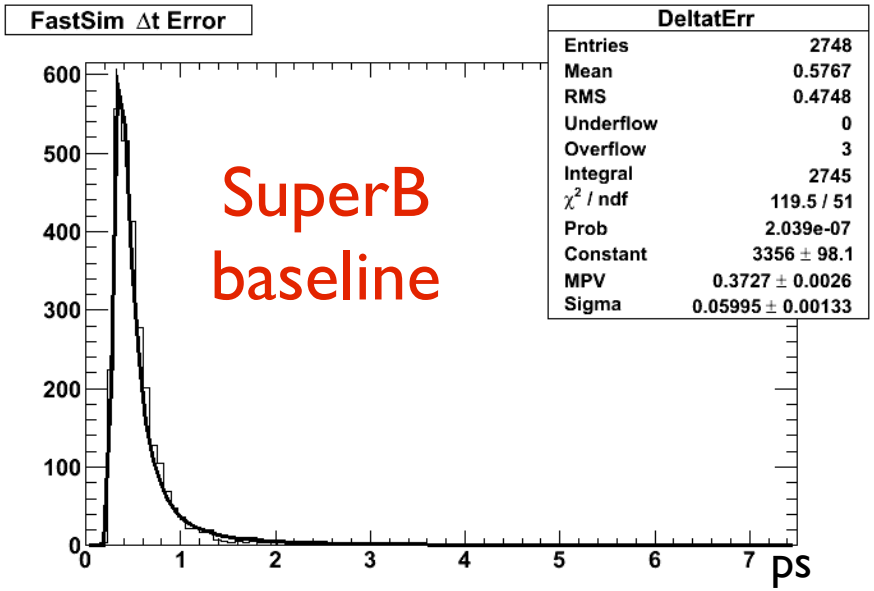


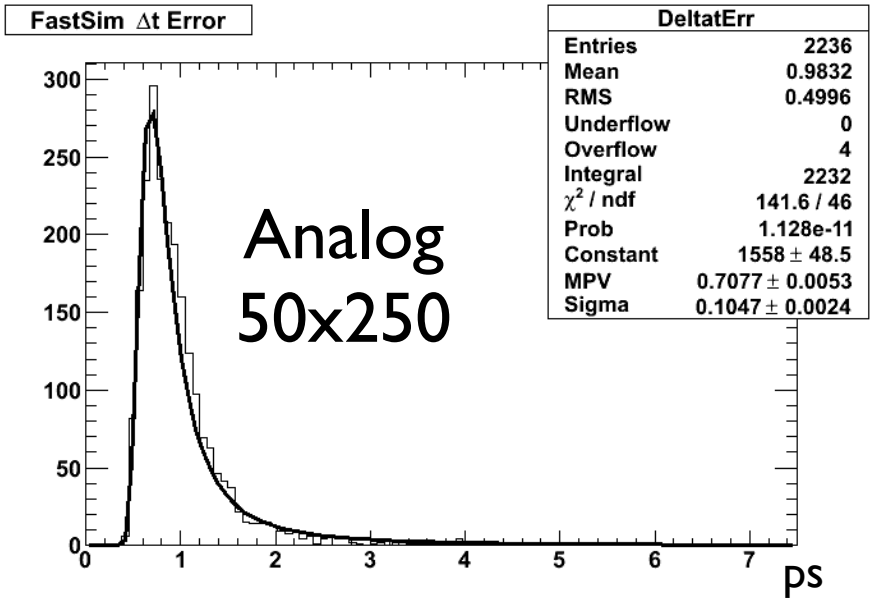


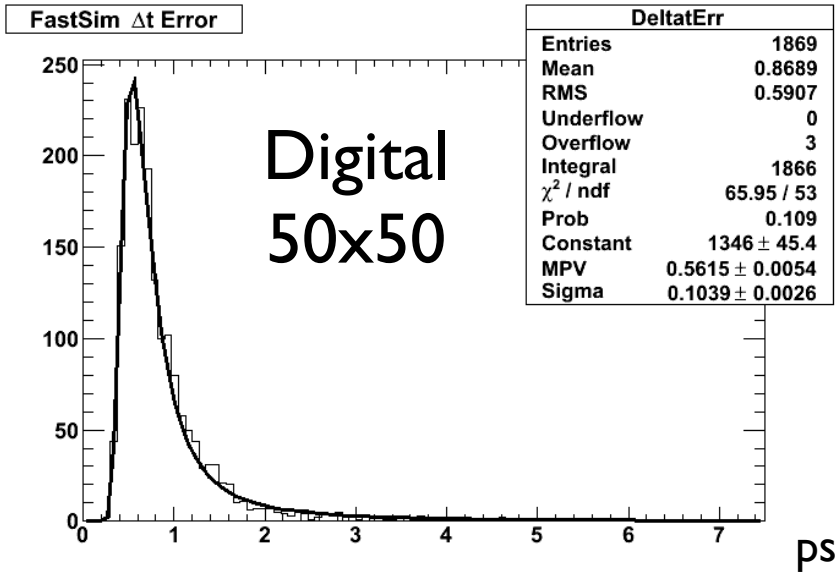


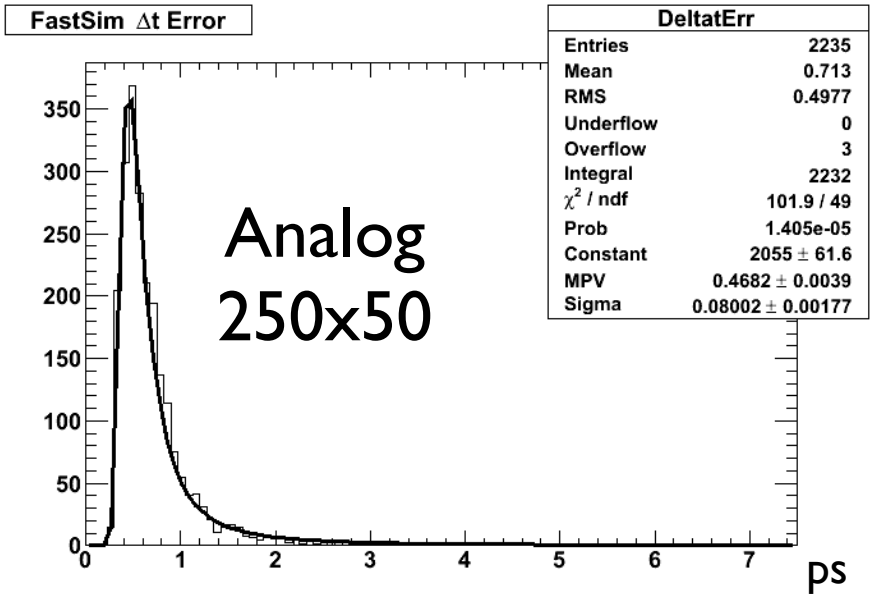


Δt error distribution

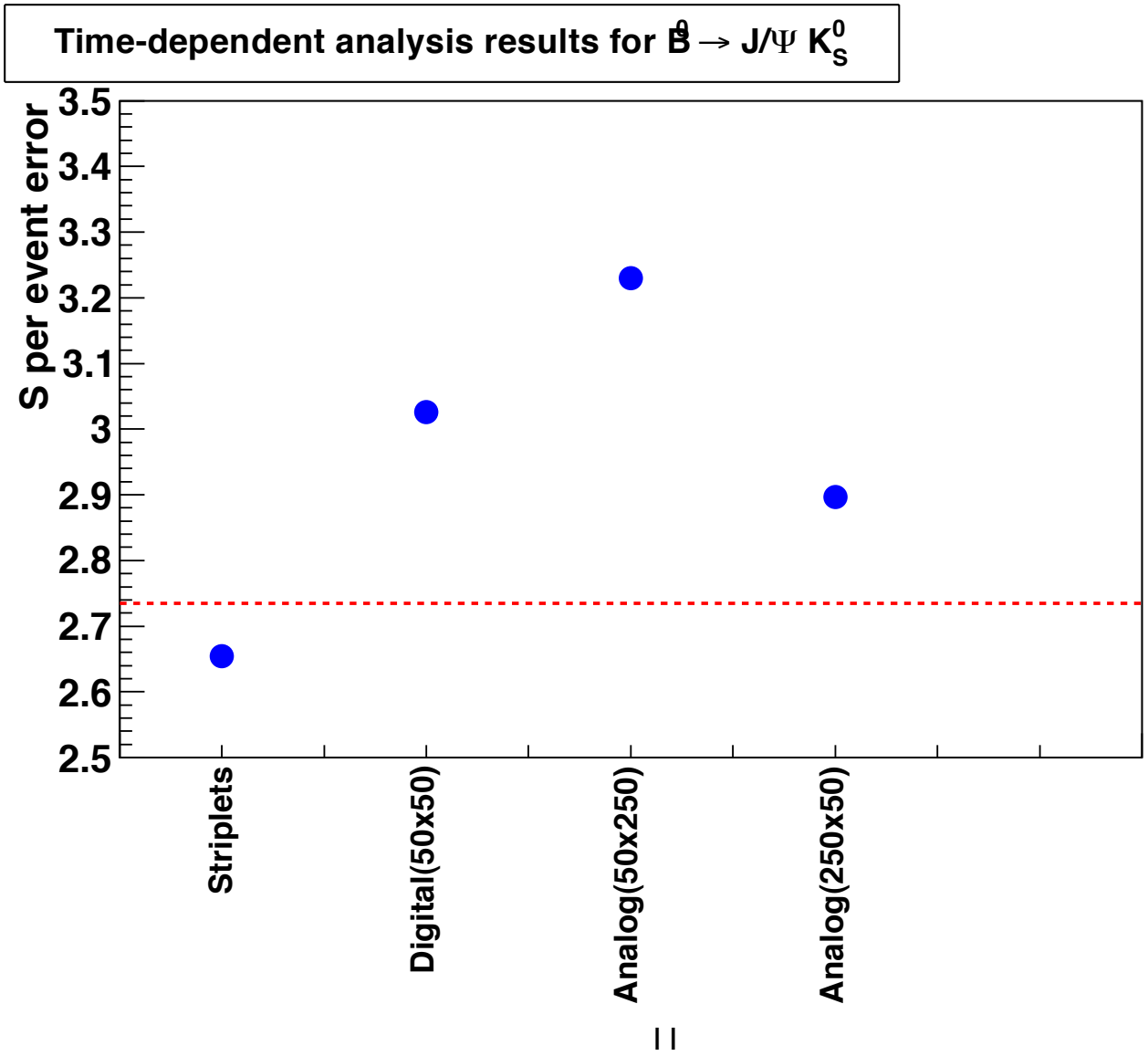








S per event error



BaBar reference

Summary

- Preliminary results show that there is a sizable worsening of the performances when using Atlas FEE (50x250) FE-I4 chip.
- If the Atlas FEE FE-I4 could be used in the rotated configuration (250x50) the performances would be comparable with the Hybrid Pixel solution developed within the SuperB R&D.

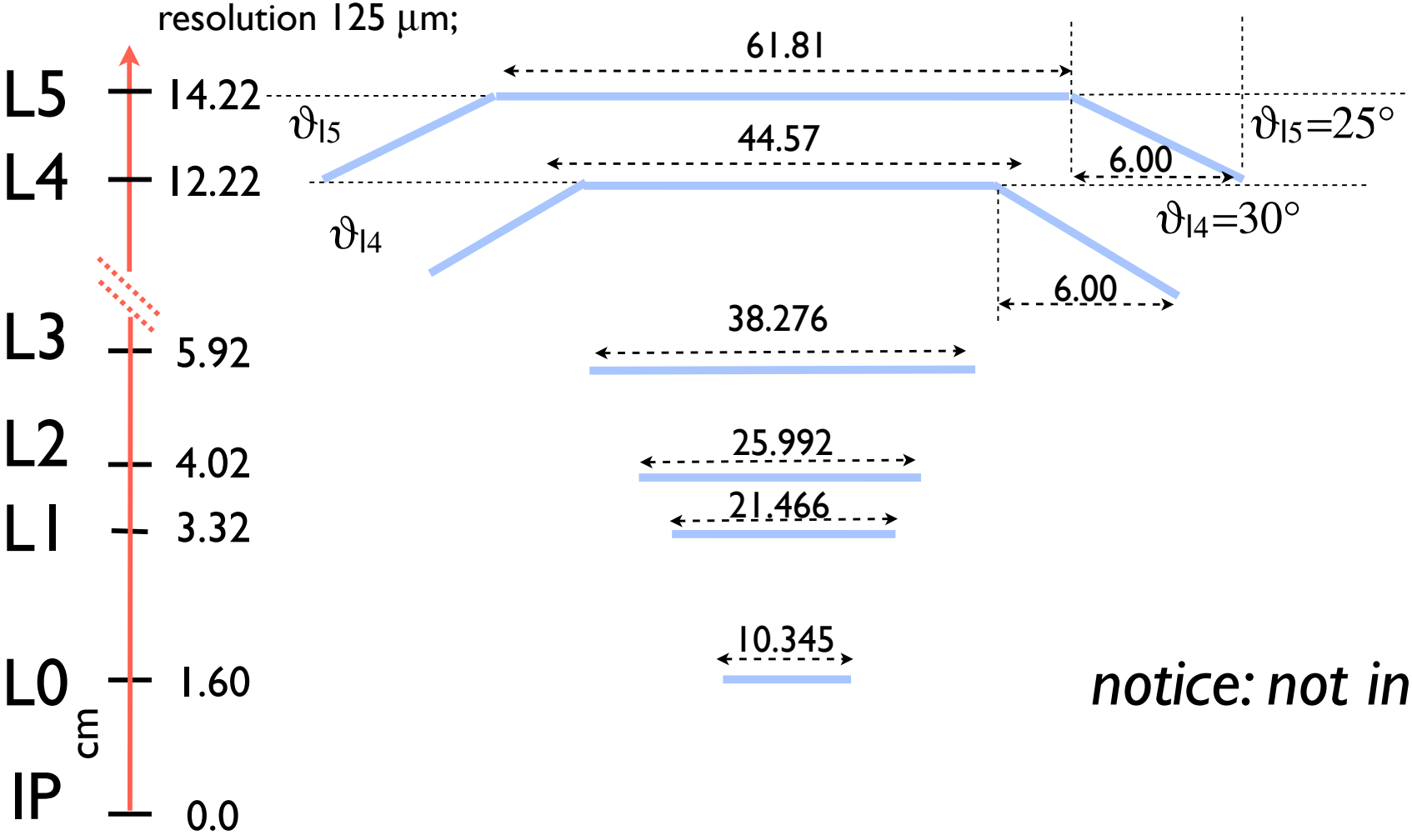
Backup slides

Introduction

- The baseline in FastSim for the Silicon Vertex Tracker (SVT) of SuperB consists in a 6 layer silicon detector;
- an additional Layer0 (L_0), at smaller radius, was introduced in order to maintain adequate proper-time resolution for B decays, in presence of a reduced center-of-mass boost: in BaBar was $\beta\gamma=0.56$, in SuperB will be $\beta\gamma=0.24$;
- the angular coverage of the SVT will reach ±300 mrad in the FW-BW direction;
- the outer layers (L_4-L_5) will have similar arch shape as in BaBar, and L_1-L_5 layers will be placed at almost identical radial position as in BaBar;
- the layer L_0 solution for the SVT baseline in FastSim *(as today)* is striplets: 200µm silicon, 0.4 % X_0, 8µm hit resolution.

1. SuperB baseline in Fast Sim:

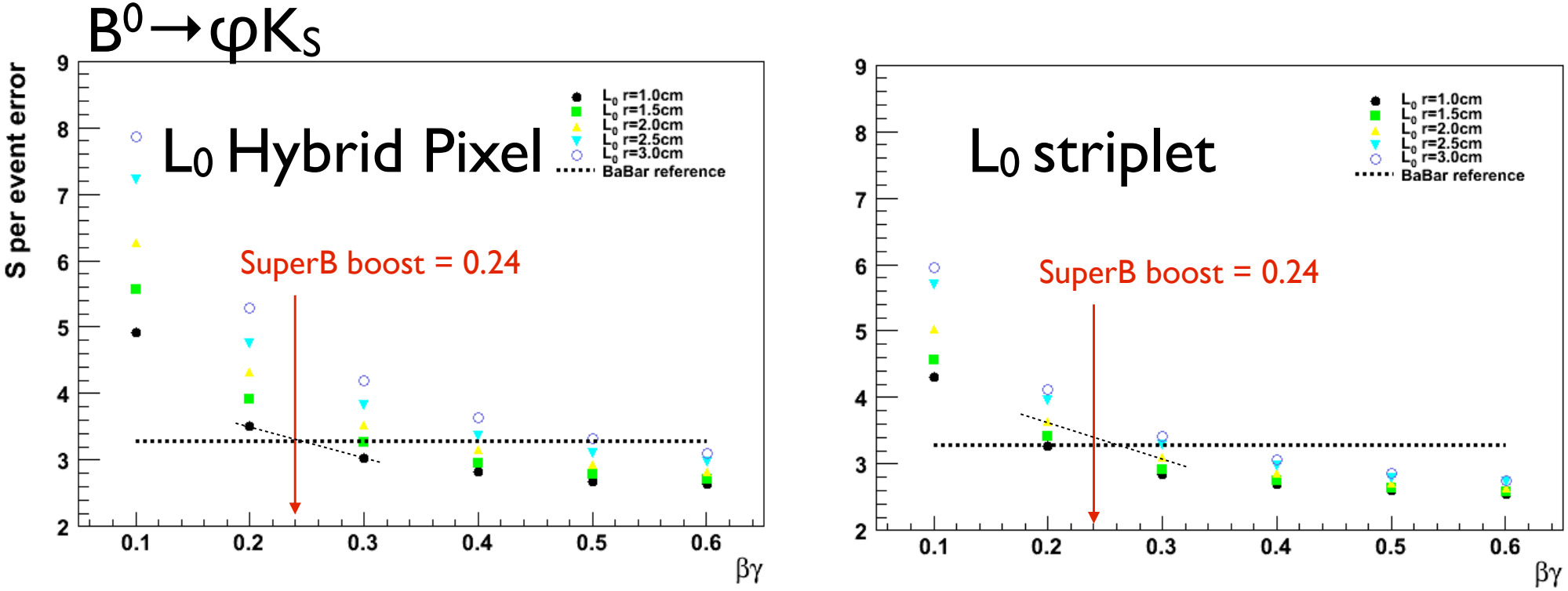
- SVT baseline: L0 + L1-L5 strip detectors, ±300 mrad angular coverage;
- DCH baseline: 10 SuperLayers (4 cell layers per SL); inner radius 23.6 cm, spatial resolution 125 μm;



notice: not in scale

Coverage down to 300 mrad FW and BW

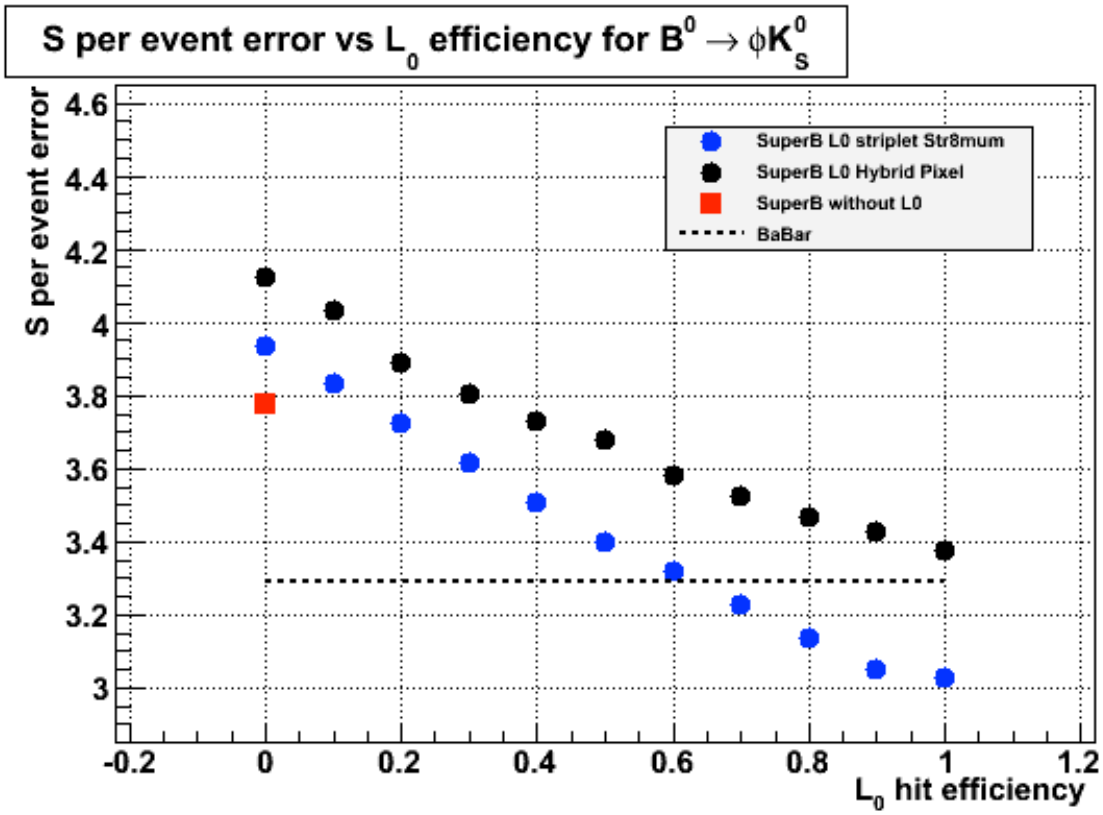
Striplet vs Hybrid Pixel: S per event error



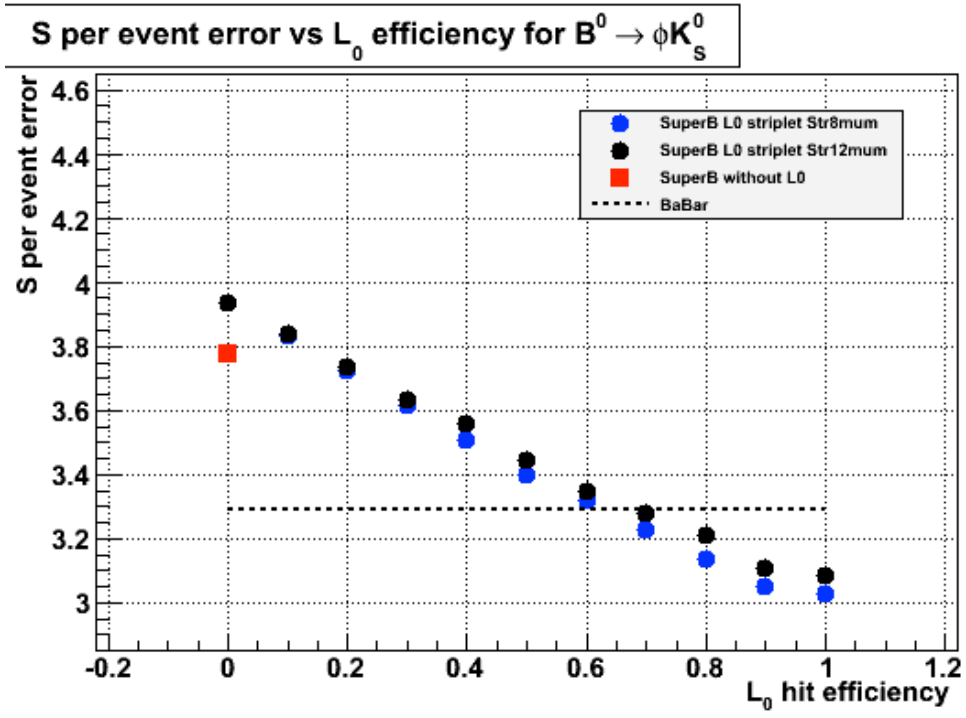
Hybrid Pixel solution is reaching BaBar reference for S (sin(2β)) per event sensitivity with L_0 radius ~1.0 cm. Striplet solution can afford a larger L_0 radius ~2.0 cm where bkg is lower.

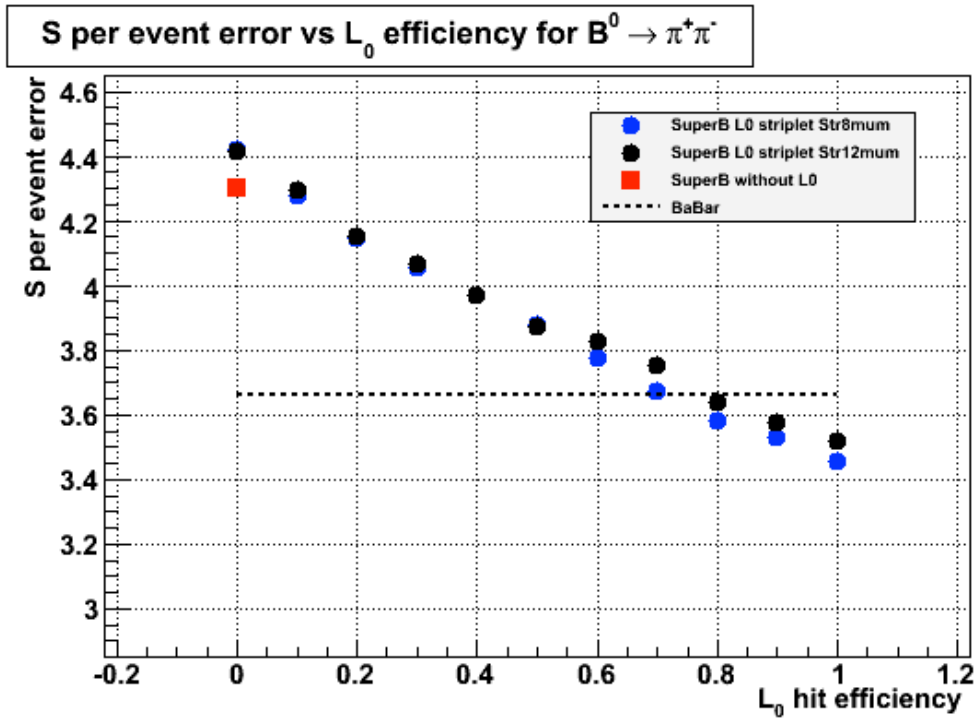
Striplet vs Hybrid Pixels vs

degraded hit efficiency



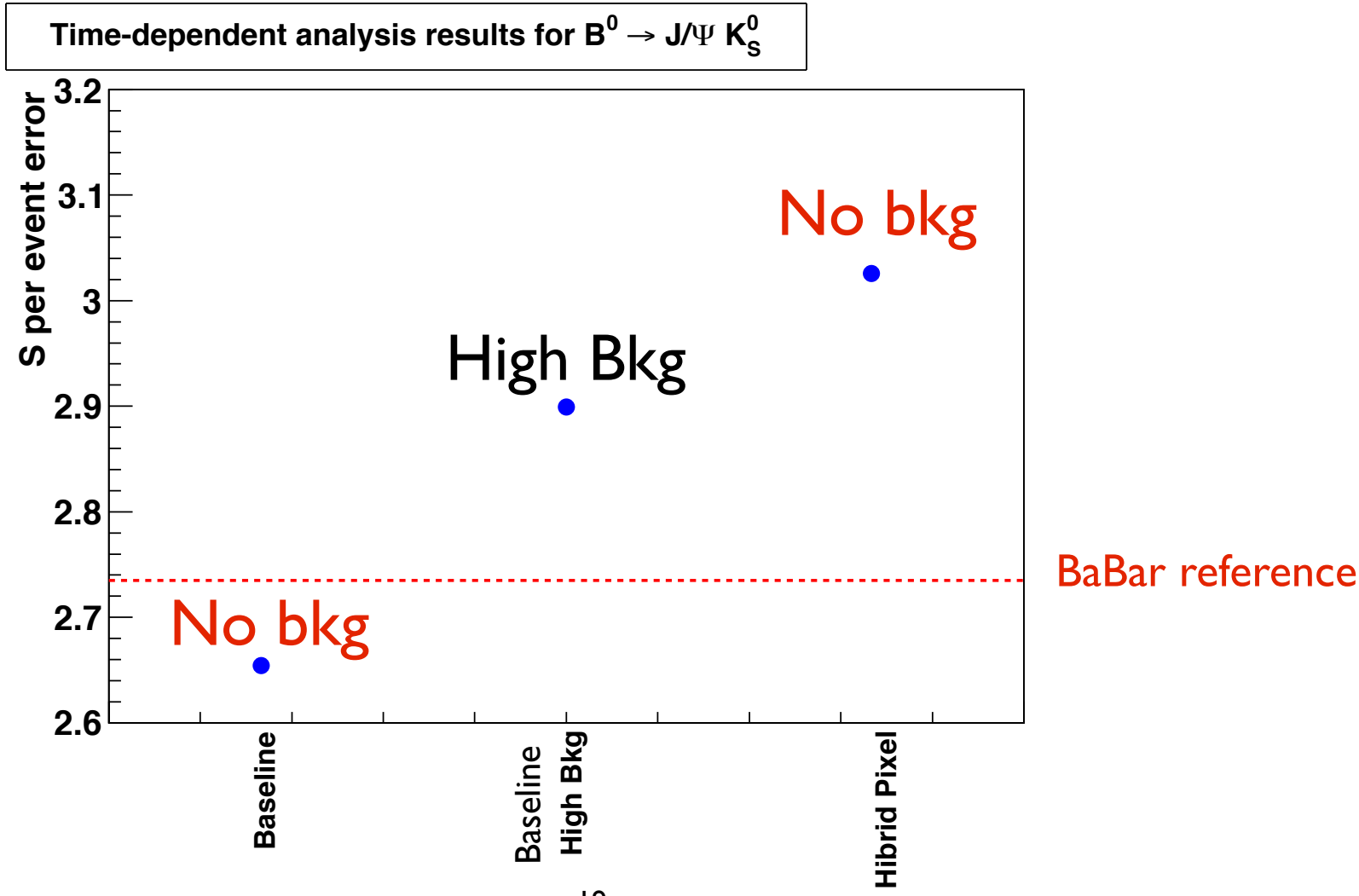
Striplet performance vs degraded hit resolution





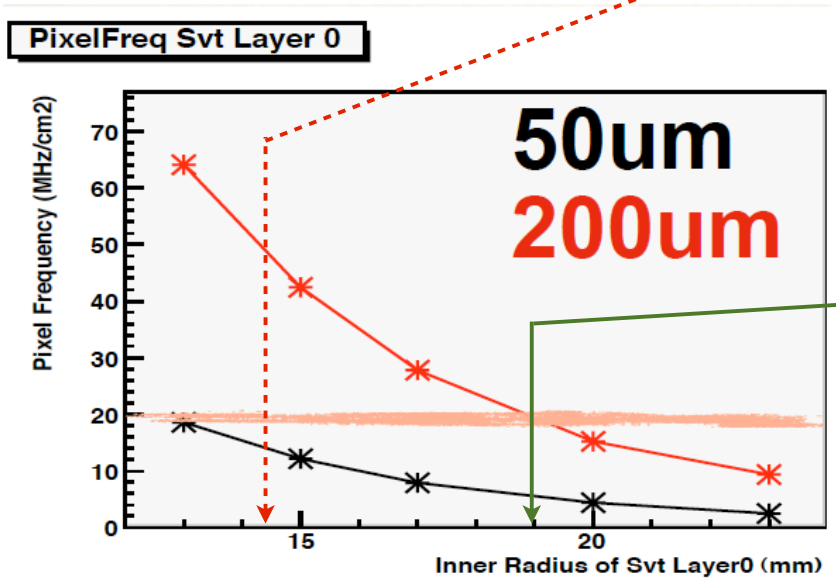
Nominal resolution 8 μm.
Considering 50% worsening (12 μm) from high occupancy in L_0. Rough estimate (to be studied in detail) but seems to be a second order effect.

Impact on S per event error



Background rate in L_0

Max rate: 20 MHz/cm²
50um @ <13mm
200um @ ~19mm



R. Cenci

In pinwheel geometry average radius <r> is about 1.12×min(radius).
Riccardo found with L_0 min(radius)=1.3 cm (<r>~1.45) a bkg rate of ~56MHz/cm² in his latest bkg study presented at Caltech meeting, Dec 2010).

Striplet solution with <r>=1.9cm (min(radius) =1.7cm) seems to satisfy both proper-time resolution and bkg rate requirements.

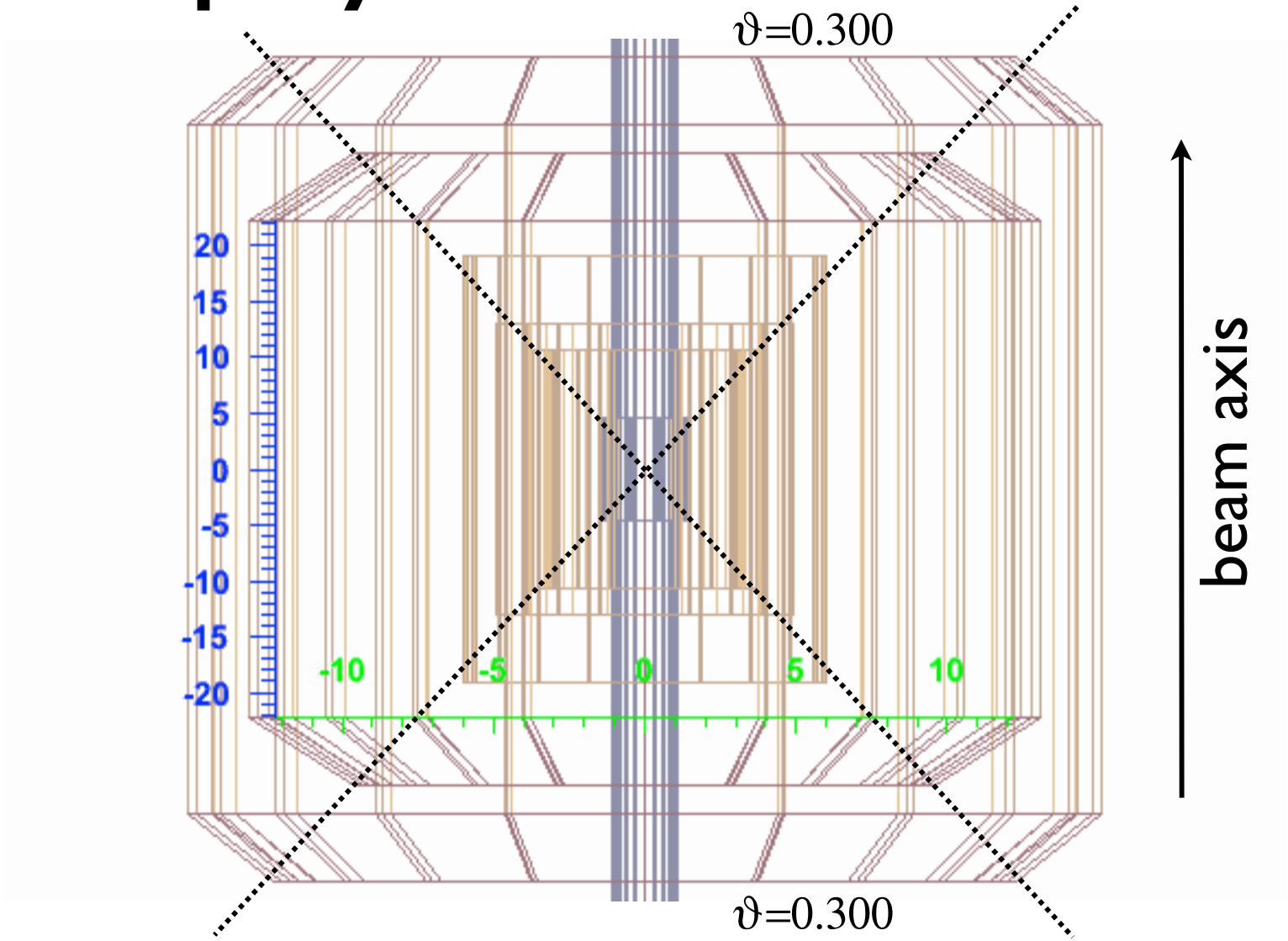
Plans for further studies

- Update of FastSim configuration:
  - modeling of material budget for L_0 solutions for striplets and pixels according to recent developments;
  - possible changes in detector geometry (e.g. radius of layers);
- Implement a more realistic model for striplets in FastSim, with strips tilted at 45 degrees wrt detector.
- Evaluate impact of bkg hits on hit resolution and pattern recognition using FastSim.
- Should we consider time-dependent measurements at DDbar threshold? With E_{cm}~ 4 GeV the average momentum of particles is reduced and material budget in SVT is more relevant.

Hit Merging and PatRec Confusion in FastSim

- Reference: Doug Roberts talk at Orsay 2009, "Hit Confusion".
- In FastSim there is the possibility of evaluating the impact of bkg on hit resolution and on pattern recognition quality.
  - Hit Merging depends on resolution of the detector;
  - Pattern Recognition quality depends on the resolution of the track;
- Work To Do: PatRec Confusion code is corrently broken (Dave Brown will fix it) and striplet model is not currently modeled correctly in FastSim (I will work on that). That requires changes in `PacDet,PacEnv,PacTrk` packages.

Display of SVT modules

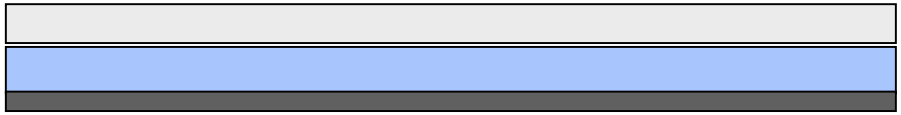


angular coverage in CM_{23}~ 95% (BaBar SVT ~89%)

Striplet solution

- Module cross section

Fan out
Si sensor
Support

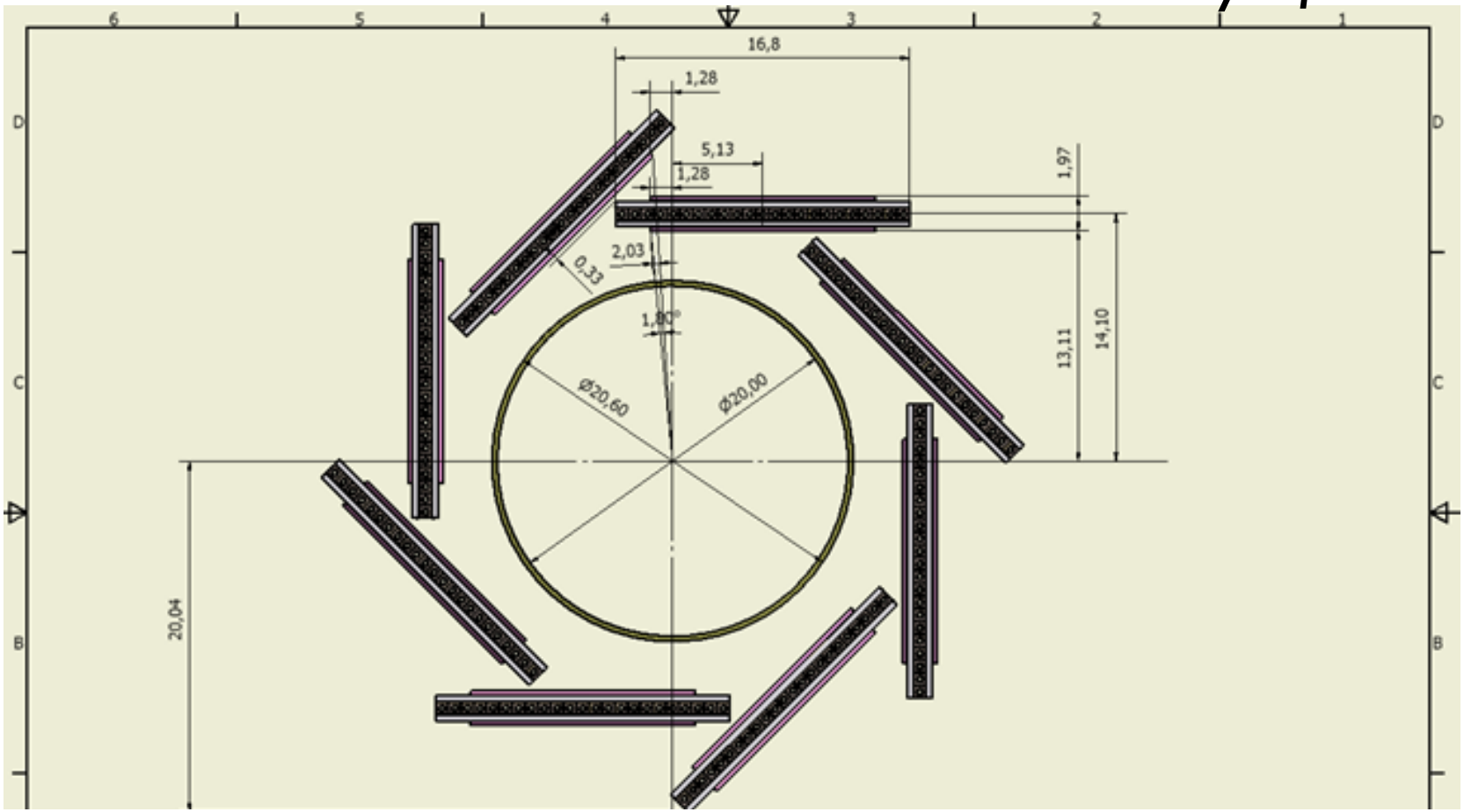


Si sensor overlap 3.4%

0.14% X_0
0.21% X_0
0.05% X_0
Total = 0.40% X_0

Pinwheel layout for L_0

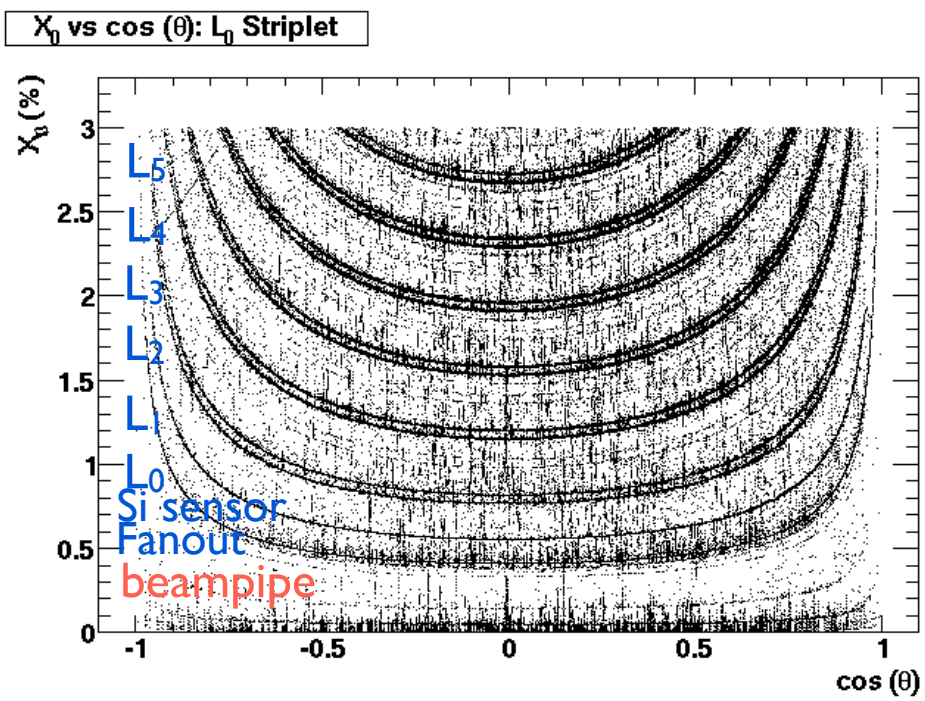
courtesy of F. Bosi

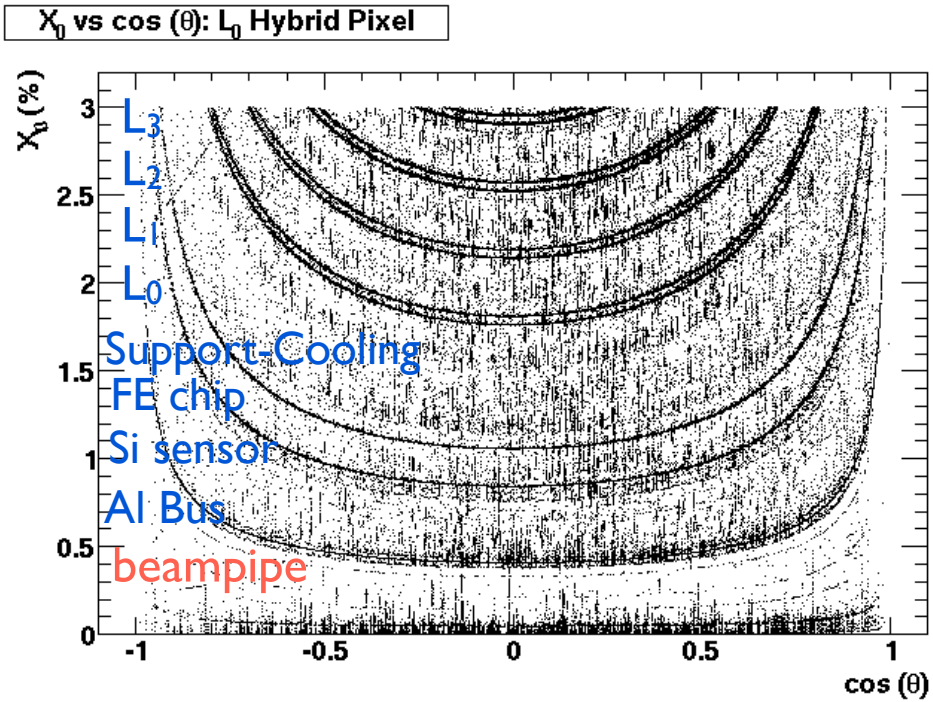


Design for MAPS solution

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

L_0 solutions and SVT material





Total SVT material is about 3.3% (2.4%) X_0 for L_0 Hybrid pixel (Striplets) solution.