# Detector Geometry WG summary

M. Rama and A. Stocchi for the DGWG
SuperB general meeting, Frascati 4 December 2009

# detector geometry WG main goals

The SuperB detector as described in the Conceptual Design Report has a number of options not yet defined that have a large impact on the overal detector geometry. As the MC simulation tools for the detector are rapidly maturing, we believe it is timely to set up a Detector Geometry Working Group (DGWG) to study the physics tradeoffs of the open CDR detector options with the goal of being able to finalize the global geometry and define the subsystems of the SuperB detector within a relatively short time frame, between six months and a year. The DGWG main task will be to examine critically the open questions detailed below and provide to the proto-technical board the information necessary to make the relevant decisions. The DGWG will be led by Matteo Rama and

- Main questions:
  - do we need a forward PID?
  - do we need a backward EMC?
  - SVT-DCH transition radius, internal geometry of SVT, DCH length
  - amount and distribution of material in IFR
- The activity of the DGWG involves three areas: detector, simulation and physics

# sessions at this meeting

**09:00->*10:45* Parallel - Detector Geometry WG I** (Convener: Matteo Rama (*LNF*), Achille Stocchi (*LAL - Univeriste Paris Sud and IN2p3/CNRS*) )
Description:
Location: Aula Seminari
Phone number: +39 06 6228 8548
or http://server10.infn.it/video/index.php?page=telephone_numbers
Meeting ID: 1551

| | | |
|---|---|---|
| 09:00 | study of B->tau nu (20') ( Slides ) | Alexander Rakitin (*Caltech*) |
| 09:20 | backward EMC response in FastSim and use as PID device (20') ( Slides ) | Chih-hsiang Cheng (*Caltech*) |
| 09:40 | Geant4 studies of forward EMC (20') ( Slides ) | Stefano Germani (*PG*) |
| 10:00 | analysis of B->K(*)nu nubar - had tag (20') ( Slides ) | Elisa Manoni (*PG*) |

**11:15->*13:15* Parallel - Detector Geometry WG II** (Convener: Matteo Rama (*LNF*), Achille Stocchi (*LAL - Univeriste Paris Sud and IN2p3/CNRS*) )
Description:
Location: Aula Seminari
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Meeting ID: 1551

| | | |
|---|---|---|
| 11:15 | analysis of B->K(*)nu nubar - SL tag (20') ( Slides ) | Alejandro Perez (*LAL*) |
| 11:35 | S resolution vs layer 0 (20') ( Slides ) | Nicola Neri (*Universita' di Pisa & INFN*) |
| 11:55 | SVT external layers (20') ( Slides ) | John Walsh (*PI*) |
| 12:15 | tracking and dE/dx vs DCH length (20') ( Slides ) | Matteo Rama (*LNF*) |

**16:30->*19:30* Parallel - Detector Geometry WG III**
Description:
Location: Aula Seminari
Phone number: +39 06 6228 8548
or http://server10.infn.it/video/index.php?page=telephone_numbers
Meeting ID: 1551

| | | |
|---|---|---|
| 16:30 | FARICH (20') ( Slides ) | Evgeniy Kravchenko (*Budker INP*) |
| 16:50 | IFR (20') ( Slides ) | Gianluigi Cibinetto (*FE*) |

# fwd PID (TOF) performance with $B \rightarrow K^{(*)}\nu\nu$

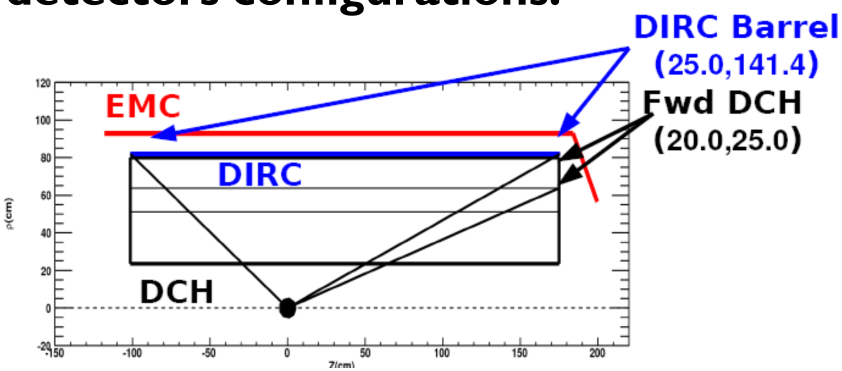
**A. Perez**

**reconstructed decays:**

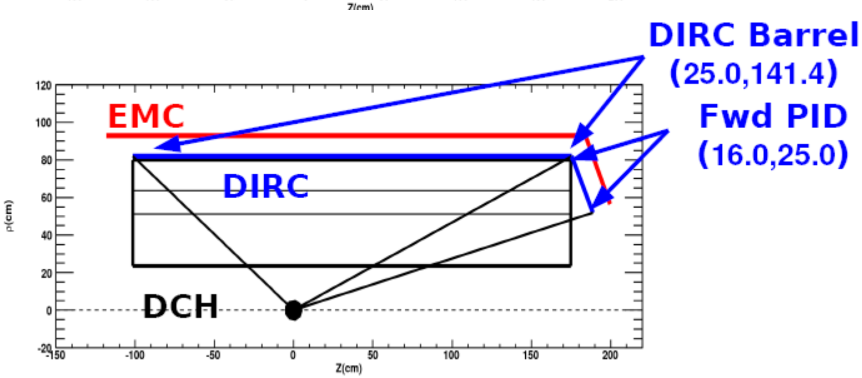
signal side: $B \rightarrow K\nu\nu$, $B \rightarrow K^*\nu\nu$
tag side: $B \rightarrow D^{(*)}l\nu$, $l=e/\mu$

SemiLeptonic tag

**detectors configurations:**




- BaBar ($\beta\gamma$ = 0.56)
  - PID in (20.0,141.4) (includes Fwd DCH)
- SuperB baseline (DG0) ($\beta\gamma$ = 0.28)
  - PID in (20.0,141.4) (includes Fwd DCH)




- SuperB baseline + FwdPiD (DGX) ($\beta\gamma$ = 0.28)
  - PID in (16.0,141.4) (increase Fwd coverage by ~5°)

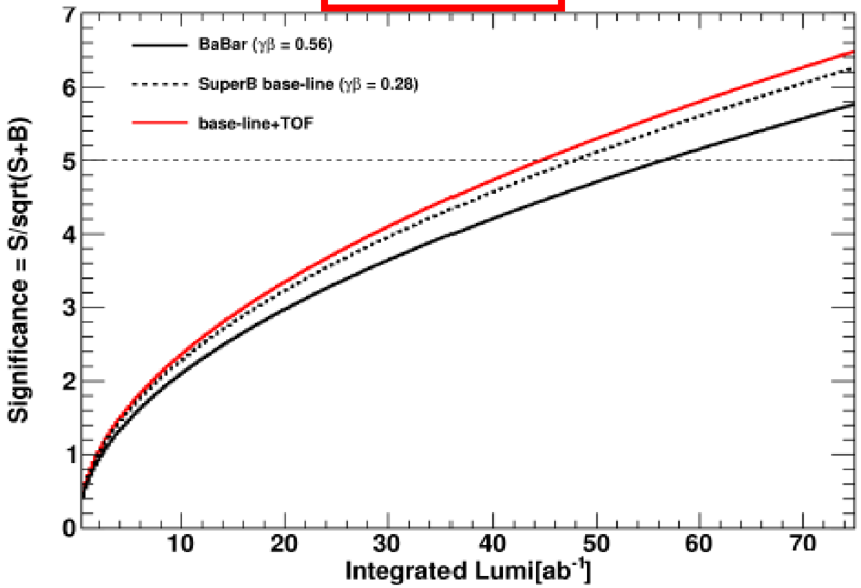
Used BaBar PID tables for PID.
Assumed performance fwd PID=DIRC

# fwd PID (TOF) with B→K$^{(*)}\nu\nu$ : reach

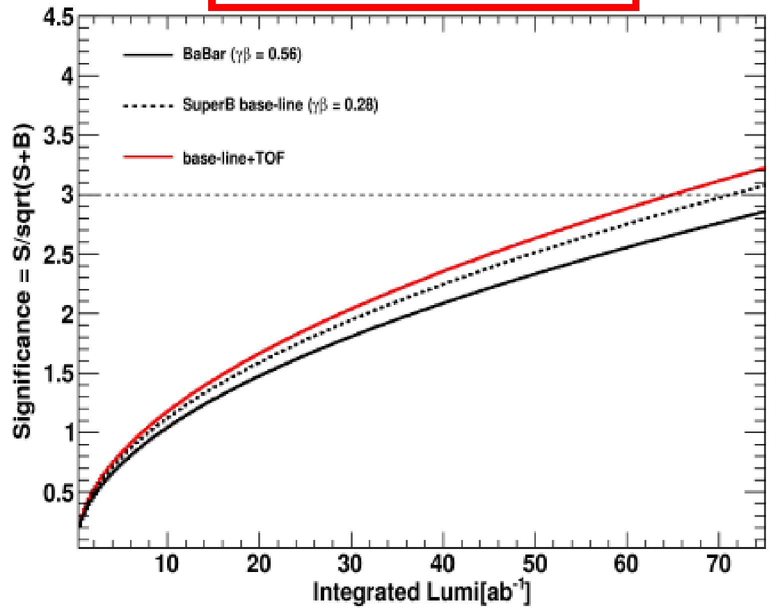
**A. Perez**

**CONCLUSIONS:**

**K$^+\nu\nu$**




**Combined K$^{*(0,+)}\nu\nu$**




5σ significance (stat-only):
- BaBar: ~55ab$^{-1}$
- SuperB-base line: ~48ab$^{-1}$
- +TOF: ~44ab$^{-1}$

**Gain on significance:**
boost ~ 7-8%
fwd PID ~ 5%

3σ significance (stat-only):
- BaBar: > 75ab$^{-1}$
- SuperB-base line: ~71ab$^{-1}$
- +TOF: ~64ab$^{-1}$

# B→K$^{(*)}\nu\nu$ with hadronic Breco tag

**E. Manoni**

Very good work to setup the Hadronic tag in FastSim

- * SemiExclusive reconstruction: search for $B \to D^{(*)}X$, with $X = n\pi\ mK\ pK_s\ q\pi^0$ and $n+m+r+q<6$, without making requirements on intermediate resonances
- * Reoconstruction steps:
  - reconstruct D→ hadrons

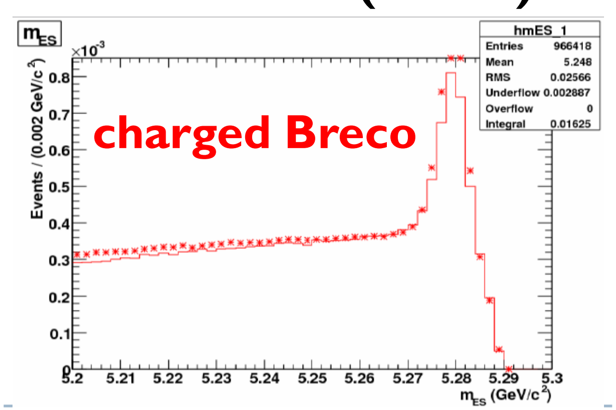
$D^{*+} \to D^0\pi^+$, $D^{*0} \to D^0\pi^0$, $D^{*0} \to D^0\gamma$

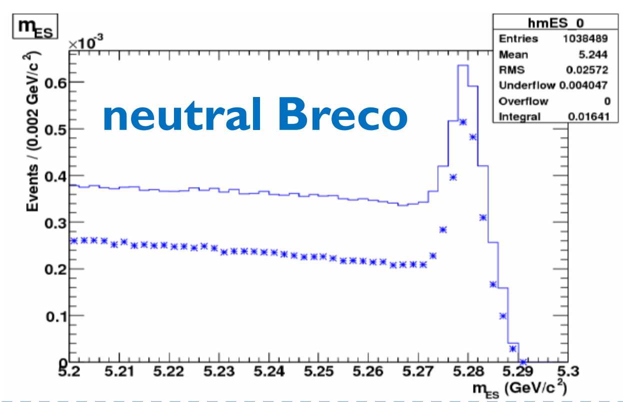
$D^0 \to K^-\pi^+$, $D^0 \to K^-\pi^+\pi^0(\gamma\gamma)$, $D^0 \to K^-\pi^+\pi^+\pi^-$, $D^0 \to K^0_S\pi^+\pi^-$

$D^+ \to K^-\pi^+\pi^-$, $D^+ \to K^-\pi^+\pi^-\pi^0$, $D^+ \to K^0_S\pi^+$, $D^+ \to K^0_S\pi^+\pi^-\pi^+$, $D^+ \to K^0_S\pi^+\pi^0$

➡ Included in November production

**fastsim vs fullSim(BaBar)**



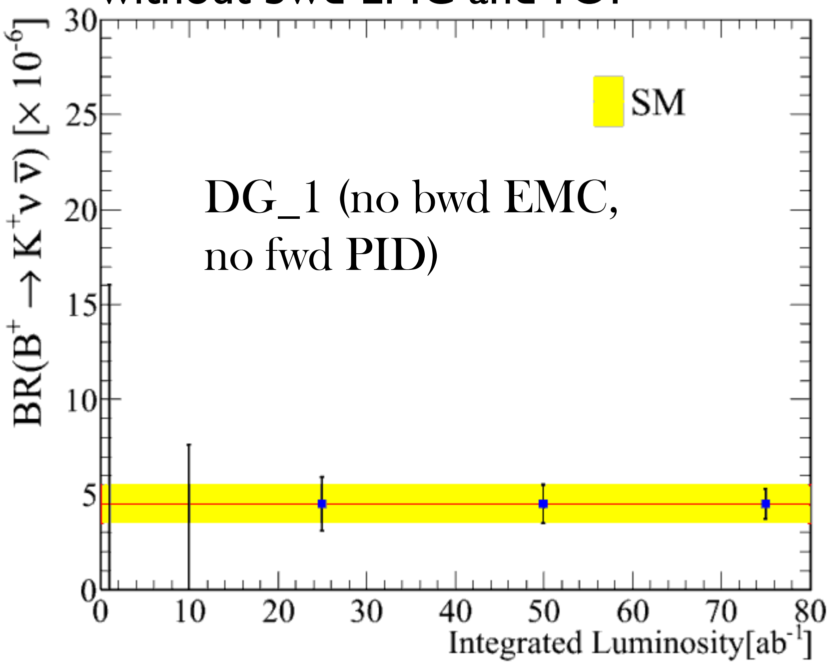
# toward the estimate of BR(B→$K^{(*)}\nu\nu$) sensitivity with the HAD tag

**E. Manoni**

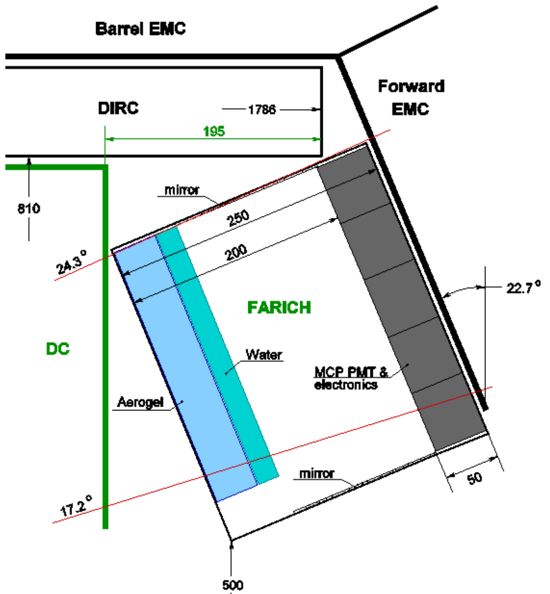
goal: estimate the impact of fwd PID and bwd EMC on BR(B→ $K^{(*)}\nu\nu$) with hadronic tag

- Analysis of B→Kνν and B→K*νν setup and performed through all the steps
- More statistics needed to improve the optimization of the selection cuts
- Need to understand some fullSim/fastSim discrepancies before quoting final quantitative results

preliminary sensitivity for SuperB without bwd EMC and TOF



# FARICH



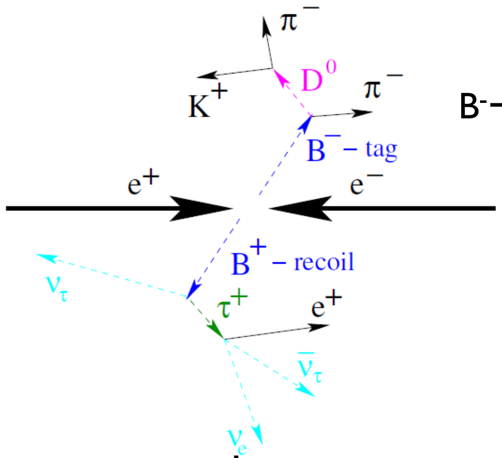

**E. Kravchenko**

- Expansion gap 200 mm
- Burle MCP PMT with 3.2x3.2 mm pixels (16x16 matrix), photoelectron collection efficiency 70%, geometrical factor 85%
- 3-layer focusing aerogel, $n_{max}$=1.07, total thickness 30 mm
- Number of PMTs ~ 450
- Number of channels ~ 115000
- Amount of material, ($X_0$) = 3.5%(aerogel)+ 2.5%(water)+ 14%(MCP PMT)+8% (support, electronics, cables) ~ 28%

- The Focusing Aerogel RICH system is suggested for SuperB forward particle identification.
- FARICH will have the best PID performance comparing with all other options.
- FARICH FastSim was delayed, but it looks it will be ready for use in the nearest future.
- |Vub| S/N ratio with forward PID will be better by ~15%
- Kaon veto procedure is very sensitive to PID coverage.

# backward EMC for B→τν study

**A. Rakitin**



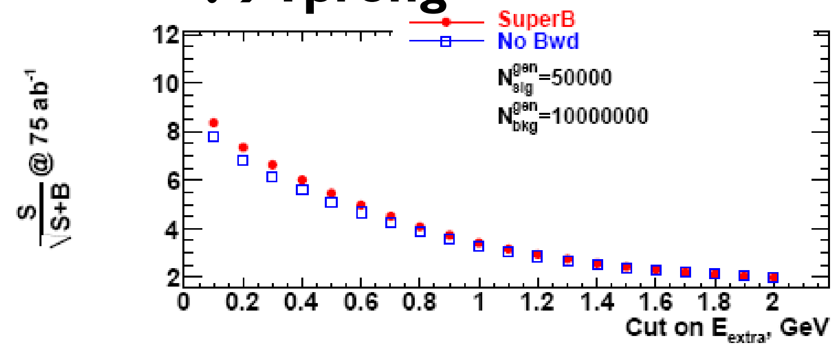

$B^- \to D^0[K^-\pi^+]\pi^-$ tag

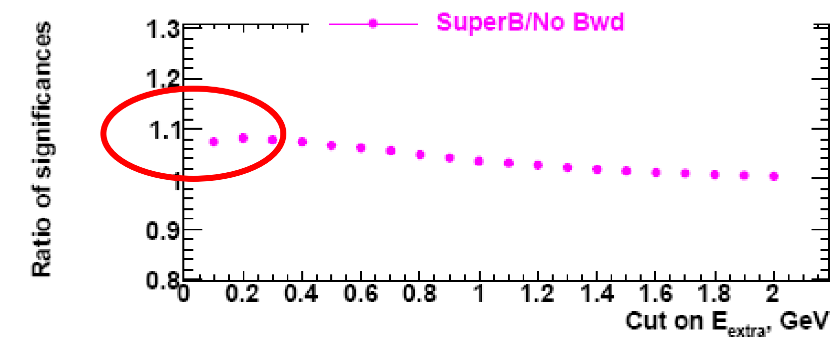
tau decay

| | $B \to \tau^+\nu_\tau$ and then... | BF($\tau$) from PDG |
|---|---|---|
| 1-prong | $\tau^+ \to e^+\nu_e\overline{\nu_\tau}$ | 17.85% |
| | $\tau^+ \to \mu^+\nu_\mu\overline{\nu_\tau}$ | 17.36% |
| | $\tau^+ \to \pi^+\overline{\nu_\tau}$ | 10.91% |
| | $\tau^+ \to \rho(\pi^+\pi^0)\overline{\nu_\tau}$ | 25.51% |
| | $\tau^+ \to \pi^+\pi^0\pi^0\overline{\nu_\tau}$ | 9.29% |
| | Total 1-prong | 80.92% |
| 3-prong | $\tau^+ \to a_1(\pi^+\pi^-\pi^+)\overline{\nu_\tau}$ | 9.32% |
| | $\tau^+ \to \pi^+\pi^-\pi^+\pi^0\overline{\nu_\tau}$ | 4.61% |
| | Total 3-prong | 13.93% |
| | Grand total | 94.85% |

Comparison in FastSim with and without bwd EMC

## τ→1prong



# backward EMC for B→τν study

A. Rakitin

**CONCLUSIONS:**

| $\tau \to \ell\nu\nu, \pi\nu$ | | $\tau \to \rho(\pi\pi^0)\nu$ | | | $\tau \to \pi 2\pi^0\nu, a_1(3\pi)\nu, 3\pi\pi^0\nu$ | |
|---|---|---|---|---|---|---|
| Mimicking decay | Rel. BF | | Mimicking decay | Rel. BF | Mimicking decay | Rel. BF |
| $B \to D^{(*(*))0}\ell\nu$<br>$B \to D^{(*)}\pi\ell\nu$<br>$B \to$ non-charm $\ell\nu$ | $\mathcal{O}(10^2\text{-}10^3)$<br>$\mathcal{O}(10^2)$<br>$\mathcal{O}(1)$ | direct $\rho$ | $B \to D^{(*(*))0}\rho$<br>$B \to J/\psi\rho$<br>$B \to$ non-charm $\rho$ | $\mathcal{O}(10^2\text{-}10^3)$<br>1.39<br>$\mathcal{O}(1)$ | Anything with final state $\pi 2\pi^0$, $3\pi$ or $3\pi\pi^0$ | ??? |
| | | indirect $\rho$ | $B \to$ stuff,<br>stuff $\to \rho + X_{missed}$ | ??? | | |
| | | $\pi^0$ + track | Anything with final state $\pi^0$ + track + $X_{missed}$ | ??? | | |
| | | $\pi^0$ + track | Special case: $B \to \pi^0\ell\nu$ (nothing is missed) | 0.55 | | |
| Done, $\sim 8\%$ improvement in $S/\sqrt{S+B}$ due to bwd EMC | | Partially done, $\sim 10\%$ imp. for direct $\rho$, need generic MC for the rest | | | Definitely need generic MC | |

results with $B \to D^0\pi$ tag

Next steps:

a) Include other signal modes and bkg decays

b) Include the main B tag modes (HAD+SL)

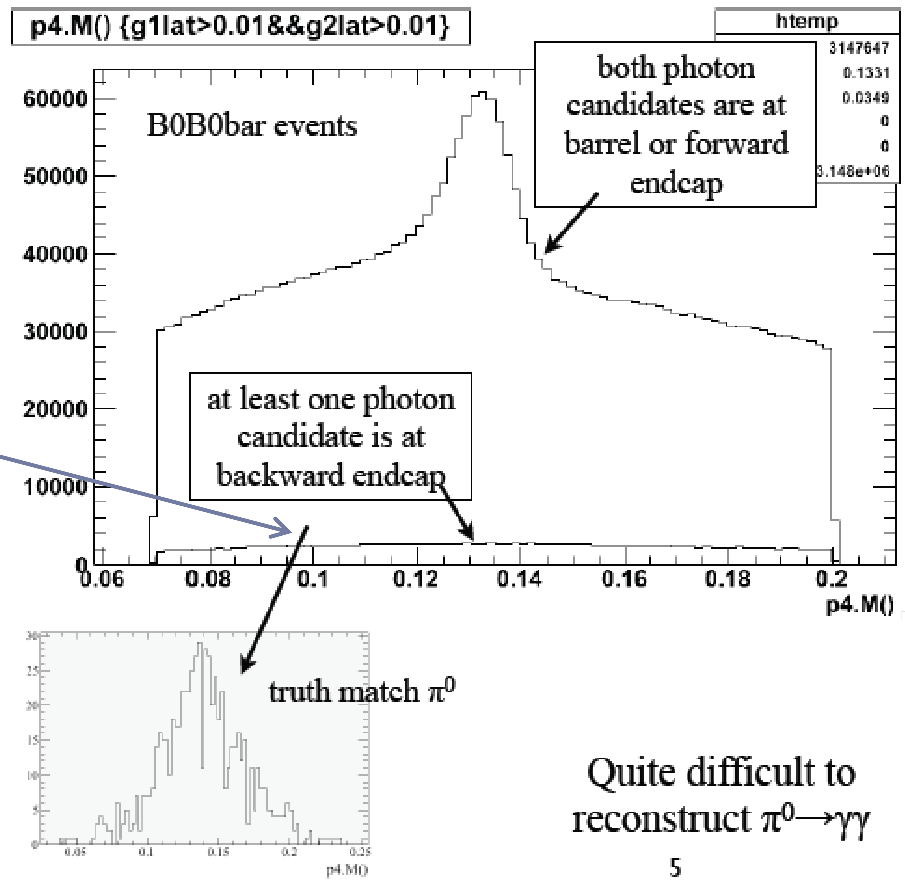
# bwd EMC simulation in FastSim

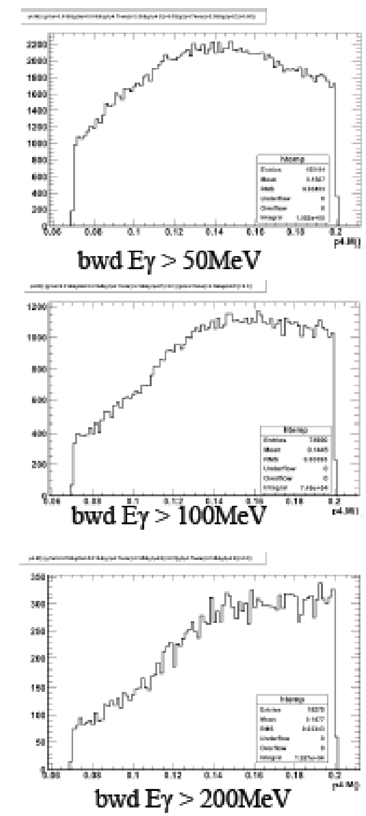
**Simulation in FastSim**

$$\frac{\sigma_E}{E} = \frac{14\%}{\sqrt{E(\mathrm{GeV})}} \oplus 1\%$$

**C. Cheng**

remember: bwd EMC as veto device

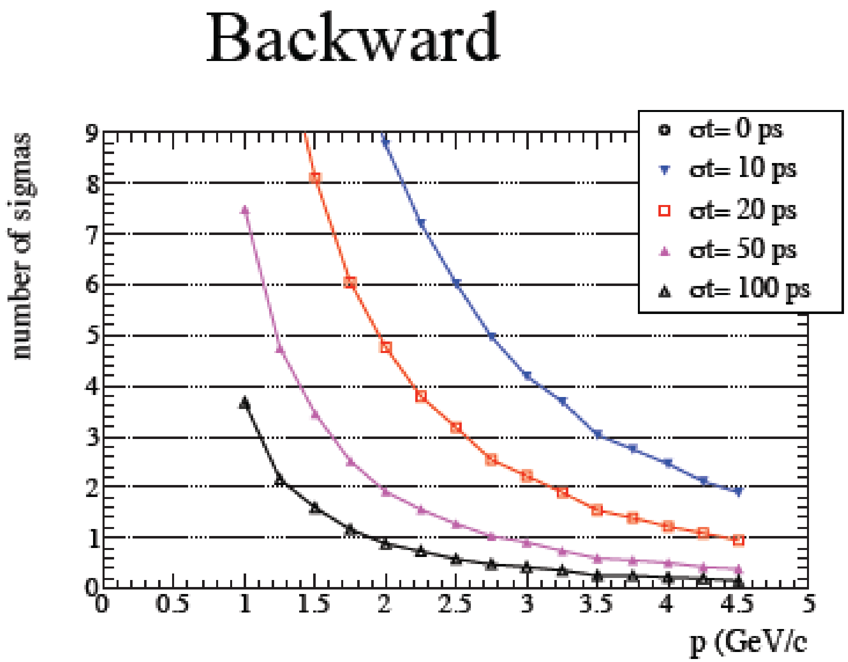


# bwd EMC as TOF device

**C. Cheng**

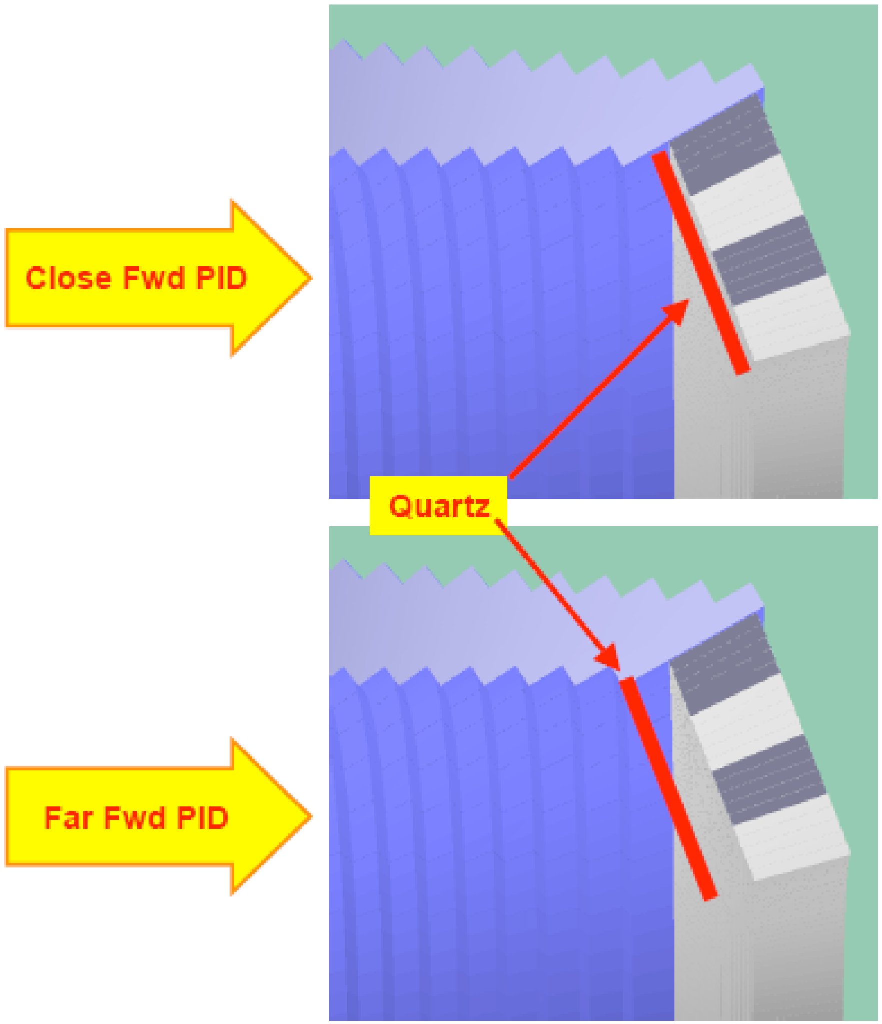
## K/π separation




With 100ps resolution we get more than 3σ separation for 1GeV/c at the backward region, ~1.5σ for 1.5GeV/c.

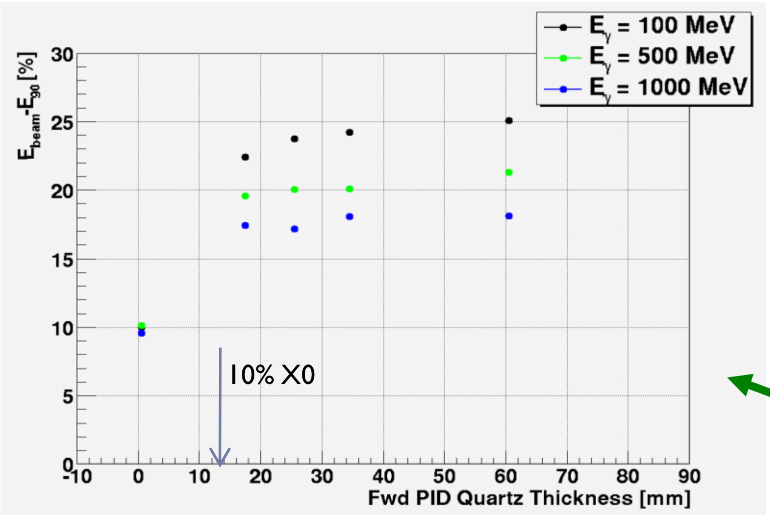
# Effect of PID material in front of fwd EMC

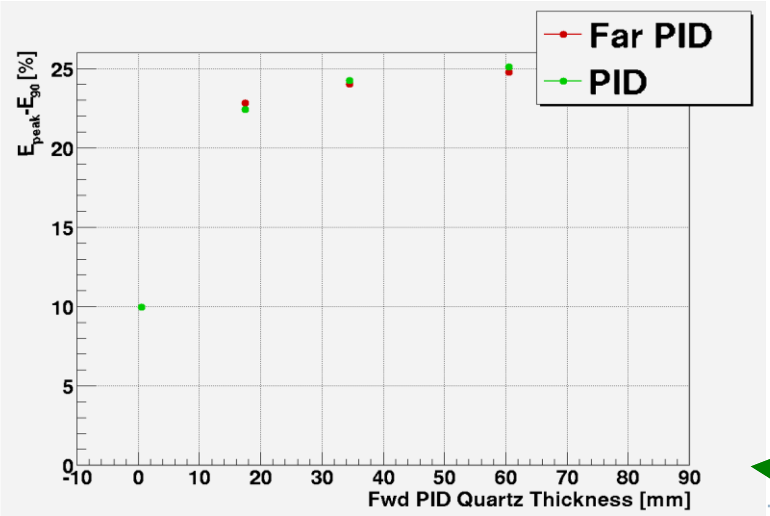
**S. Germani**



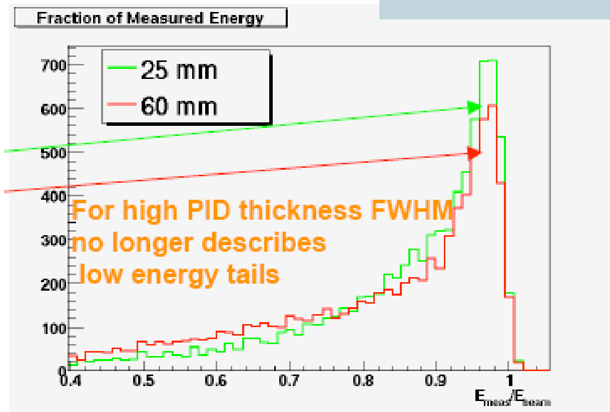

- Calorimeter with back aligned endcap
- Fwd PID simulated as pasiive material:
  - Variable thickness quartz layer
- Two option for PID positions:
  - Close to the Fwd Endcap surface
  - Far form the Fwd Endcap surface

# Effect of PID material in front of fwd EMC




**S. Germani**




CONCLUSIONS (preliminary):

- Adding the clustering algorithm, the effect of the Forward PID material is not negligible
  - what's an acceptable resolution? [TBD]
- Larger impact on low energy resolution
- Fwd PID material distance from EMC does not seem to have an impact

# IFR

**G. Cibinetto**

**Since the SLAC meeting a lot of work done to improve the reconstruction code**

- recovered muon efficiency at for low momentum tracks
- calculated the layer multiplicity for the tracks
- add cuts to the hits with very low energy deposition (<100keV)
- fixed few code bugs
- added the possibility to handle parameterization from a config file
- added the possibility to handle also background events (in progress)
- made additional detector configuration based on possible prototype layout
- added energy deposition in the EMC

Example of selection optimization vs the amount of iron (no noise or bkg here)

Table with results for different configuration

CDR baseline ↔

| mm of iron | muon efficiency | pion contamination |
|---|---|---|
| 920 (baseline) | 91.8 ± 0.1 | 1.8 ± 0.1* |
| 820 | 91.8 ± 0.1 | 1.9 ± 0.1 |
| 620 | 90.9 ± 0.1 | 2.5 ± 0.1 |

- the 620mm configuration is quite worst wrt the others (this is good).
- discriminating between 820 and 920 is still impossible (more on that later).

# IFR: next steps

**G. Cibinetto**

| configuration | muon efficiency | pion contamination |
|---|---|---|
| 920 (m.r. optim) | 85.0 ± 0.1 | 1.7 ± 0.1 |
| 920 (g.c. optim) | 86.7 ± 0.1 | 2.1 ± 0.1 |

| configuration | muon efficiency | pion contamination |
|---|---|---|
| 620 (m.r. optim) | 85.0 ± 0.1 | 2.5 ± 0.1 |
| 620 (g.c. optim) | 86.4 ± 0.1 | 2.7 ± 0.1 |

two independent optimizations (m.r., g.c.)

- move to automatic optimization (e.g., use Neural Network)

  The muon ID goodness for different detector layouts are very sensitive to the cuts optimization: now that we have a good understanding and reliability of our code we should leave this duty to some more automatic tool such as a NN or a BDT and care about the results only.

- include background

  At this point we need a background production (some 100k/1M events). We just simulate some beamstralung events to have the machinery ready, but the processing time is very high.

**proposal for prototype construction**

```
I=I=I========I====I====I====I====I====I====I=======I=====I

I2I2I     16    I  8   I   8 I   8 I   8  I   8  I   8  I     14    I   10   I
```

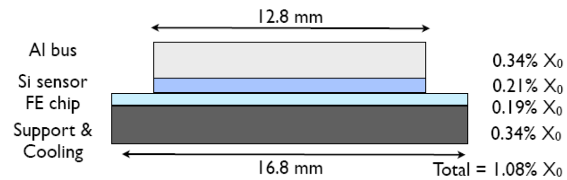
- with more/less iron
- with more active layers
- with different spacing between the layers
- changing the granularity

# SVT L0 solutions and impact on time-dependent measurements

**N. Neri**

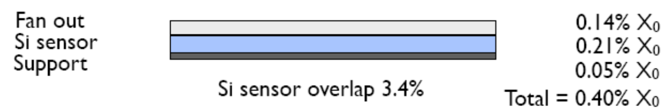
### Hybrid Pixel

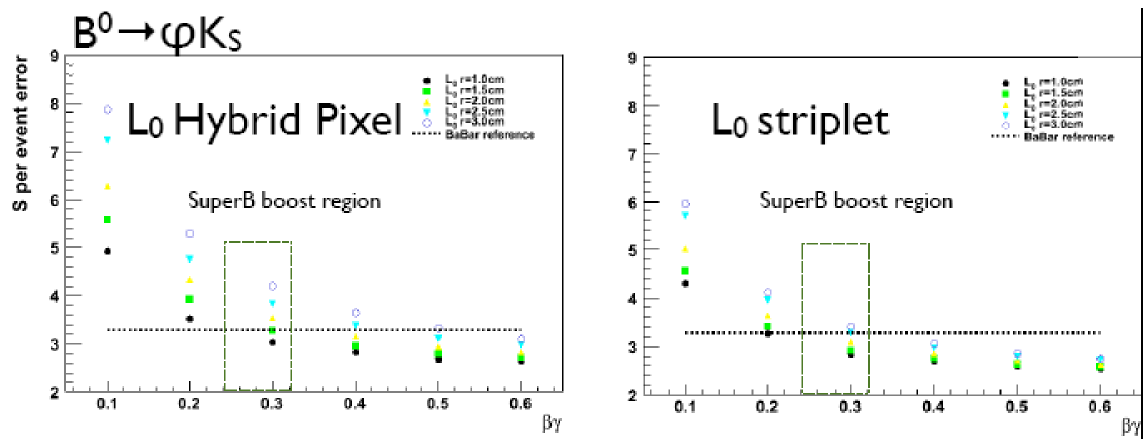
- material= 1.08% $X_0$
- digital readout
- average radius = 1.60 cm
- hit res ~ <14 μm> (ad hoc model)




### Striplets

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



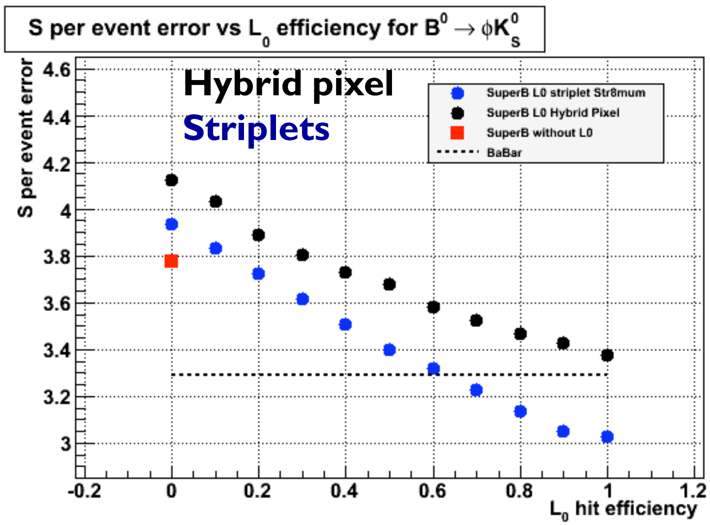




*Hybrid Pixel solution is reaching BaBar reference for S (sin(2β)) per event sensitivity with $L_0$ radius ~1.5 cm. Striplet solution can afford a larger $L_0$ radius ~2 cm where bkg is much lower.*

# L0 solutions and impact on time-dependent measurements

## Striplets vs Hybrid pixels

**N. Neri**




radius=1.6cm

many other studies shown

**CONCLUSIONS:**

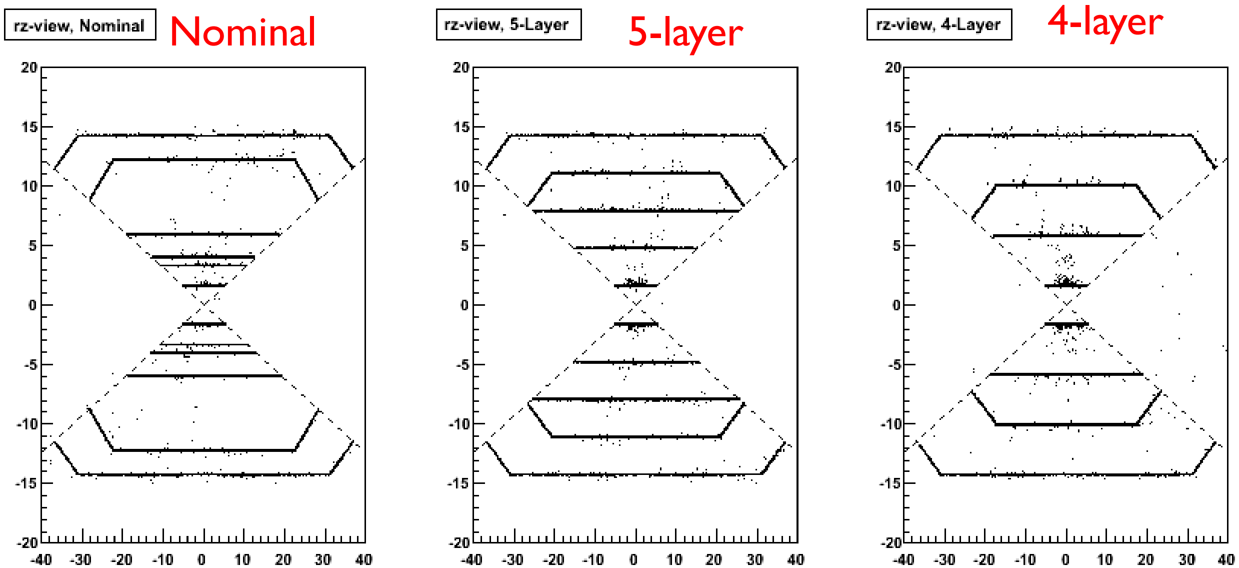
Striplets vs Hyb. Pixel

- Striplet detector seems to represent a viable solution for $L_0$ in terms of vertex and proper time resolution for time-dependent measurements in alternative to Hybrid Pixel or Maps detectors (assuming current bkg estimates on $L_0$ are robust).
- Some increase of the $L_0$ radius with respect to the nominal 1.60 cm value is possible if required for bkg reduction, up to ~2 cm, maintaining comparable $\Delta t$ resolution with BaBar.

# Study of SVT external layers

**J. Walsh**

- Default is L0 + BaBar SVT, *i.e., a 6-layer device*
- Do we need 6 layers?
- Is there an advantage to having fewer than 6 layers?
  - physics motivation
  - other considerations (money, effort, etc.)
- Compare performance of nominal SuperB design with two alternatives:
  - 5-layer device
  - 4-layer device



# Study of SVT external layers

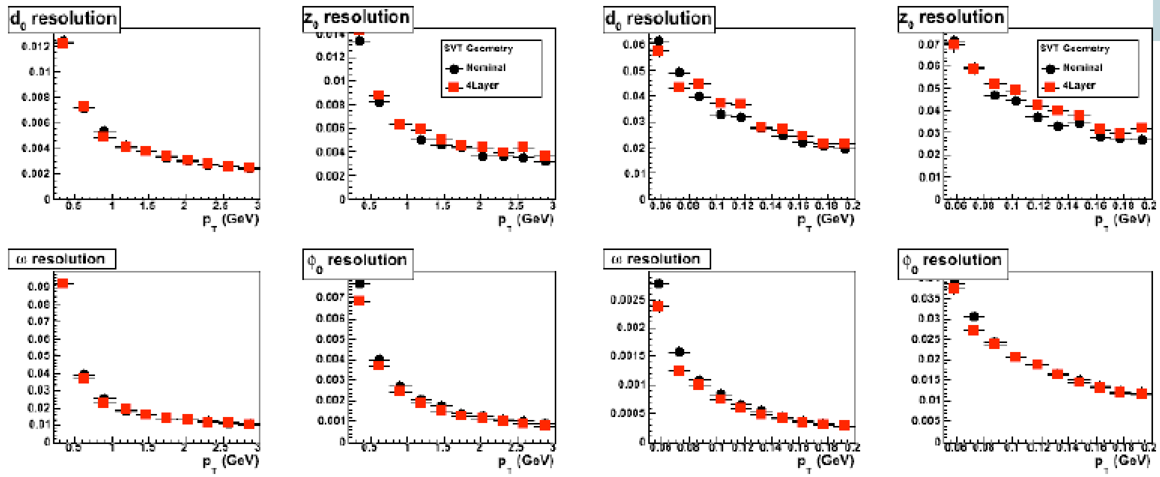
**examples**:

200 < $p_T$ < 3000 MeV

50 < $p_T$ < 200 MeV

**J.Walsh**

nominal vs
4-layer
(non perfect SVT)

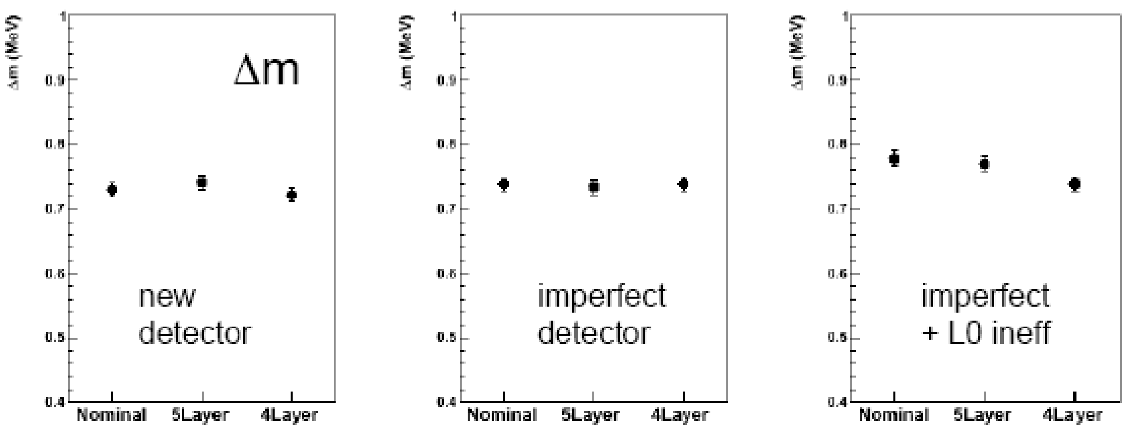



new detector

imperfect detector

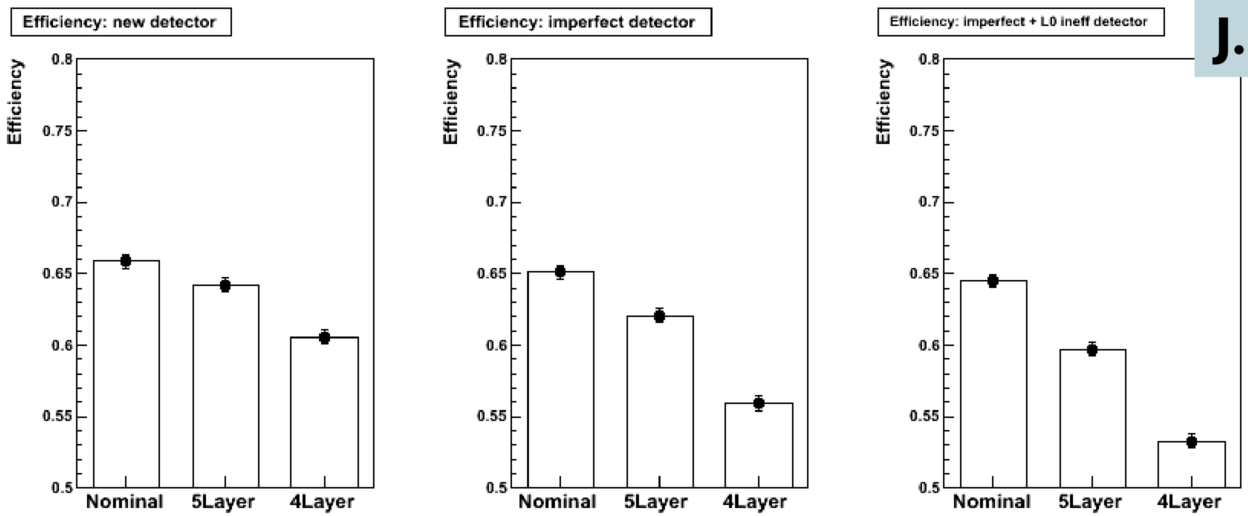
imperfect det. + L0 inefficient

D* Δm



# Study of SVT external layers

reco efficiency of B→D*K




J.Walsh

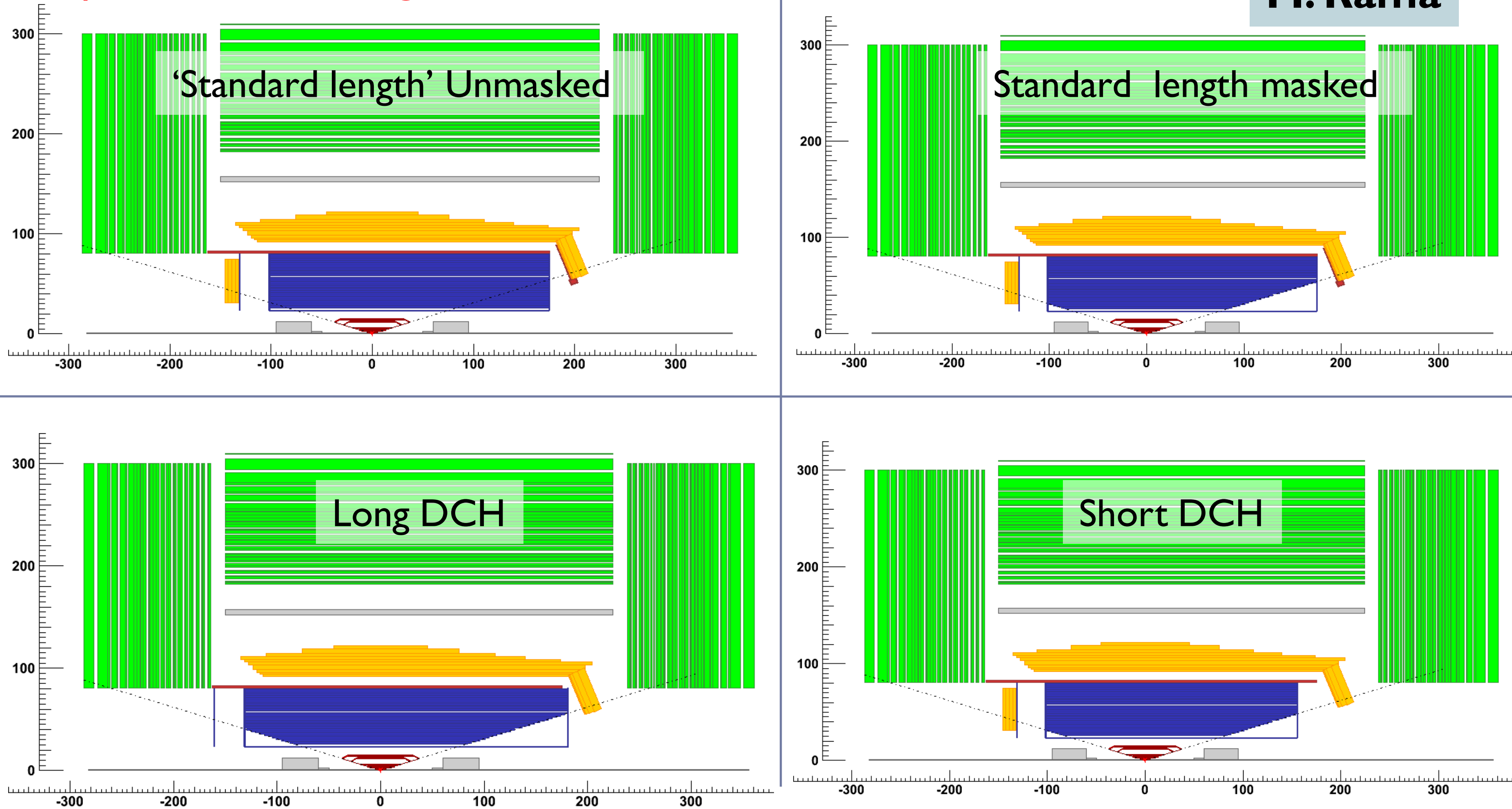
**CONCLUSIONS:**

- In all cases, gains in tracking performance in going to 4- or 5-Layer device are modest (in many cases absent)
- Efficiency for tracks and B reconstruction is reduced for the 4- and 5-Layer devices
- These results are very fresh, but it appears that the current 6-Layer design is superior to the alternatives investigated

# tracking and dE/dx vs DCH length

compare 4 DCH configurations

**M. Rama**

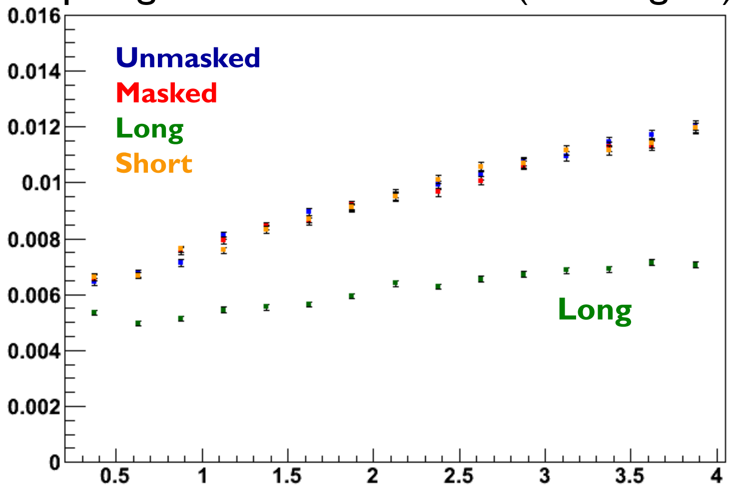


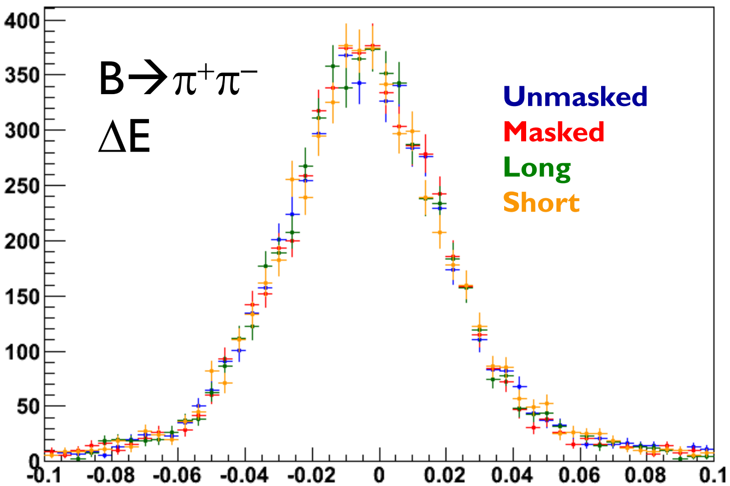
# tracking and dE/dx vs DCH length

**M. Rama**

**p resolution at θ=150°**

p degrades in short DCH (bwd region) → however, the overall effect in B reco is small




## CONCLUSIONS:

Preliminary study of tracking and $(dE/dx)_{DCH}$ performance vs DCH length

**tracking**

- significant improvement of momentum resolution in bwd region with Long DCH (no bwd EMC)
- significant worsening of momentum resolution in fwd region with Short DCH (FARICH)

BUT

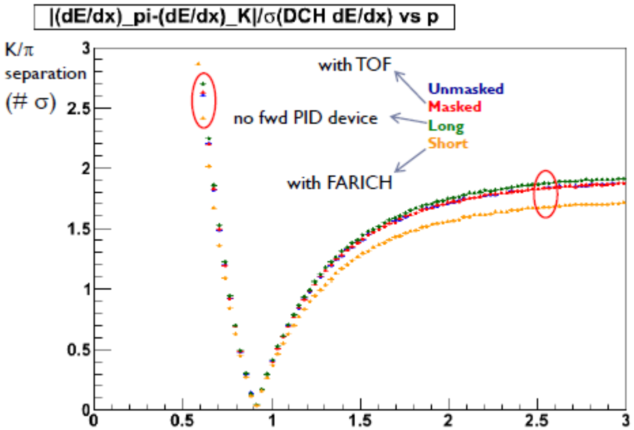
- the fraction of tracks going in fwd and bwd region is quite small (modes considered: $B \to \pi\pi$, $B \to D^*K$) → <u>Impact on B reconstruction (reco. efficiency, ΔE resolution) is very small</u>

# tracking and dE/dx vs DCH length

**M. Rama**

single particles:
K/π separation vs p at θ=23°

see drawings in sl. 10-11

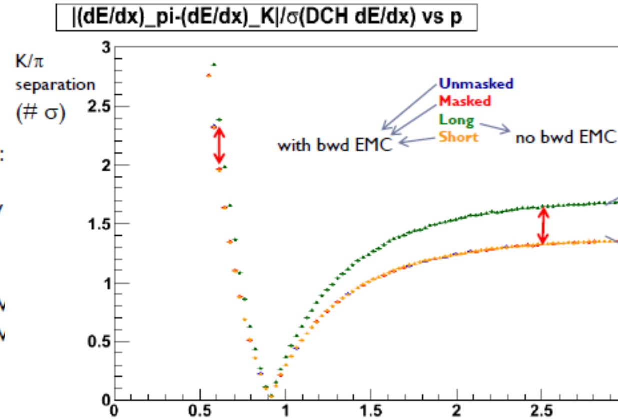



between Short and Masked:
0.16σ difference @2.5GeV
0.21σ difference @0.6 GeV

between Long and Masked:
~0.04σ difference @2.5GeV
~0.07σ difference @0.6GeV

single particles:
K/π separation vs p at θ=150°

see drawings in sl. 10-11




no bwd EMC ('Long')
~0.4σ difference @2.5GeV
~0.3σ difference @0.6GeV
with bwd EMC

## CONCLUSIONS:

dE/dx (tuned on BaBar)

- moderate improvement of K/π separation in bwd region with Long DCH (~0.4σ @2.5GeV or 0.6GeV)
- moderate worsening of K/π separation in fwd region with FARICH (~0.2σ @2.5GeV or 0.6GeV)
- negligible improvement of K/π separation in fwd region with Long DCH (no TOF)

- Eventually it is the combined dE/dx+other-PID-devices performance that must be compared

# Summary

- New detector optimization results concerning:
  - SVT L0: performance of Striplets vs Hybrid pixel
  - Number of SVT layers
  - DCH length
  - Impact of fwd PID on $B \rightarrow K\nu\nu$
  - Impact of bwd EMC on $B \rightarrow \tau\nu$
  - muon/pion separation in IFR
- Next steps:
  - Consolidate the studies related to the physics case of fwd PID and bwd EMC
  - Be ready to exploit at best the MC February Production (adding new signal modes, new tools, etc.)