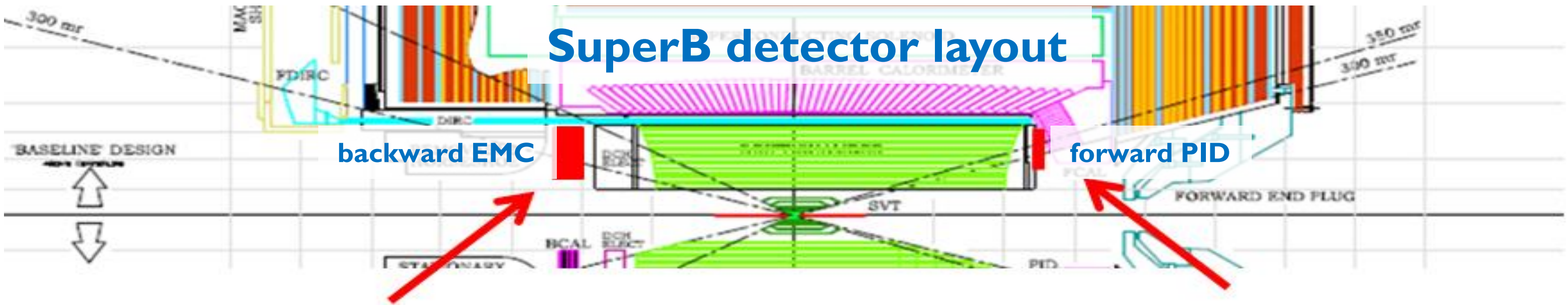
Impact of forward PID and backward EMC on Physics. A summary of the DGWG studies.

M. Rama/A. Stocchi on behalf of the DGWG
Joint meeting of detector geometry task forces, 15 Dec 2010

Outline



potential pros and cons studied so far

Backward EMC:

↑ **increased EMC angular coverage**

tested with:

-) $B \to K^{(*)}\nu\nu$ and $B \to \tau\nu$ physics reach

↓ **reduction of the drift chamber length**

tested with:

-) track & B reco. vs DCH length

Forward PID:

↑ **increase of PID efficiency**

tested with:

-) $B \to K^{(*)}\nu\nu$ and $B \to \tau\nu$ physics reach

↓ **material in front of the forward EMC**

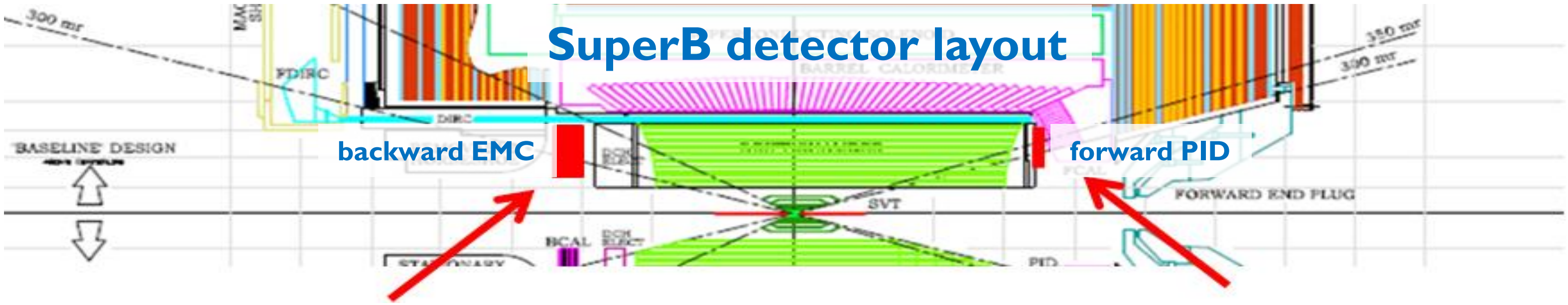
tested with:

-) Geant4 study and FastSim study

↓ **reduction of the drift chamber length**

tested with:

-) track & B reco. vs DCH length



Increase of PID efficiency

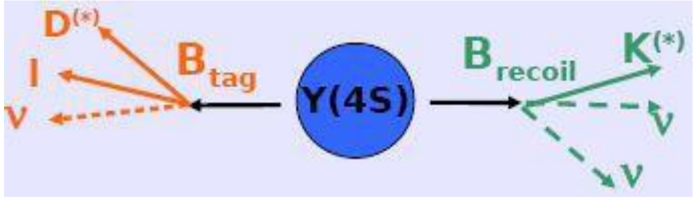
$B \to K^{(*)}\nu\nu$ and $B \to \tau\nu$ analysis overview

- Physics reach studies based on the entire dataset of the FastSim Summer 2010 production
  - millions of signal events
  - ~ 4ab^{-1} of generic BB events for each detector geometry (filtered with 'cocktails')
  - additional samples for analysis and FastSim validation
  - 'machine' backgrounds included
- SuperB detector layouts with/without fwd TOF and bwd EMC
- $B \to K^{(*)}\nu\nu$ and $B \to \tau\nu$ selected using the B recoil technique to fight the huge level of backgrounds

many thanks to the production team

the B recoil analysis

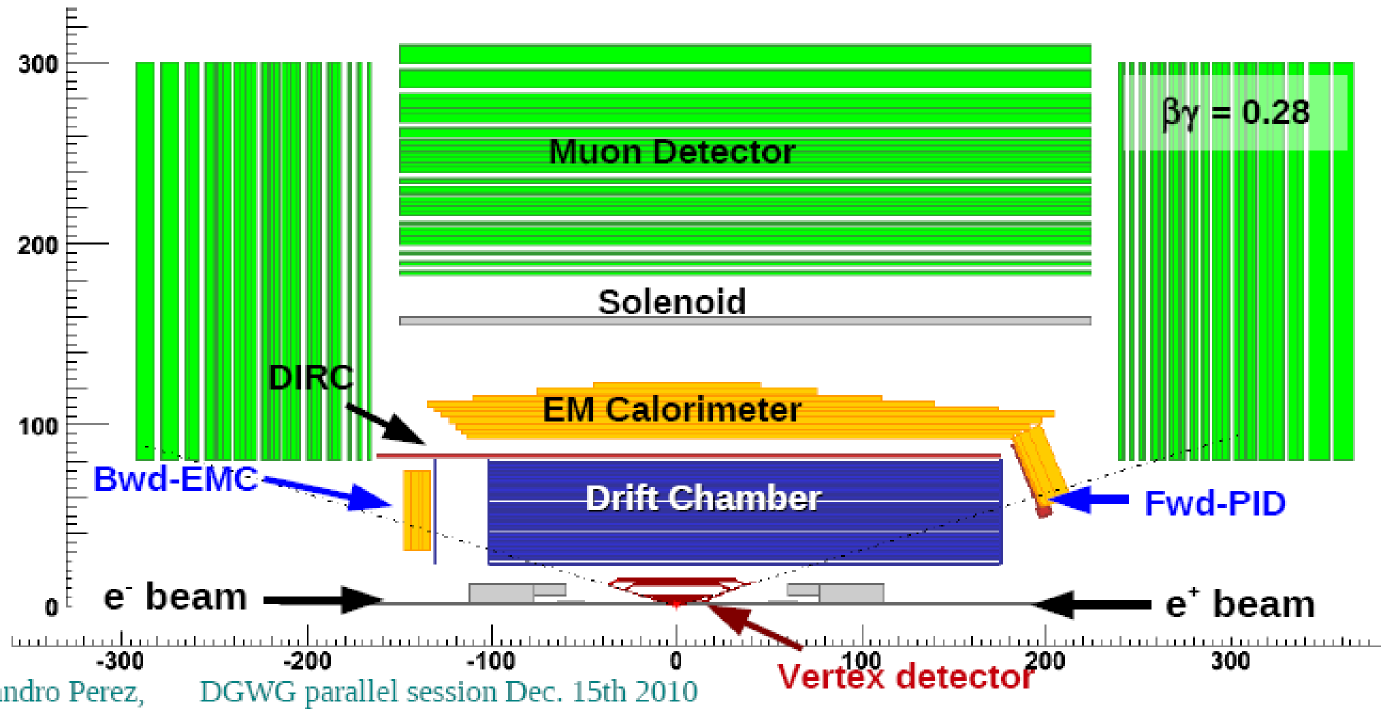
1: reconstruct a B into a hadronic or semileptonic final state



2: Look for $B \to K^{(*)}\nu\nu$ or $B \to \tau\nu$ in the rest of the event

Detector geometries

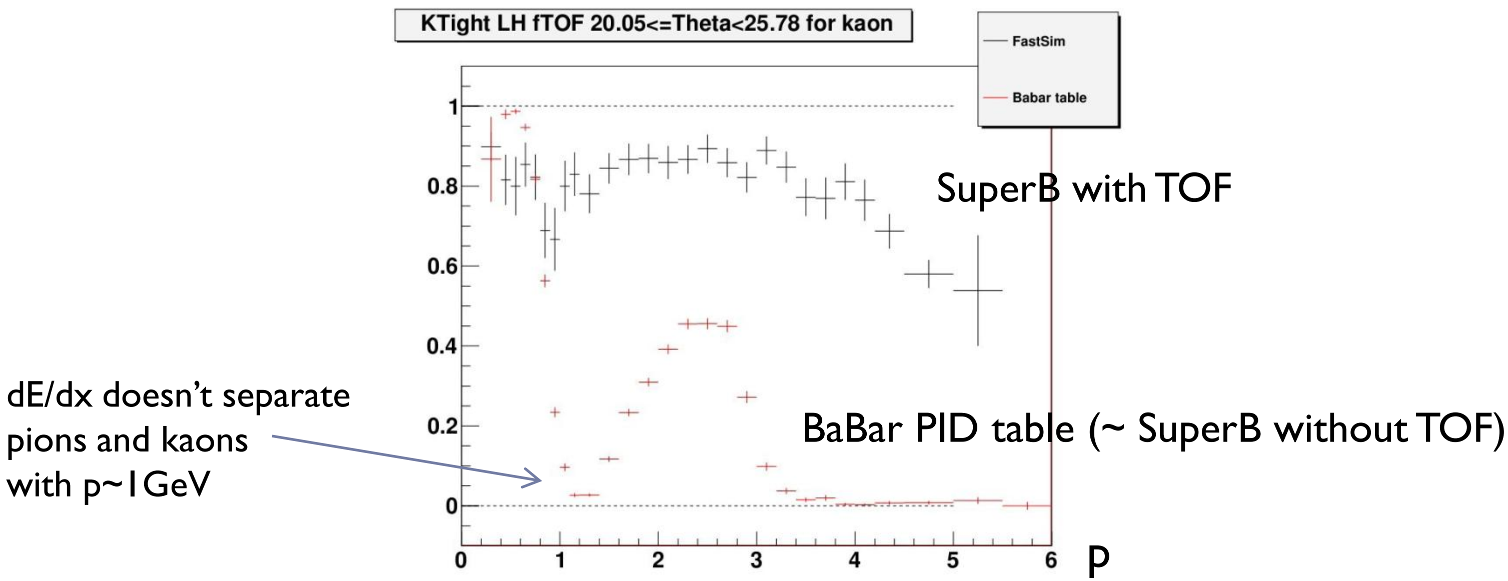
- BaBar ($\beta\gamma = 0.56$) (**DG_BaBar**)
- Baseline configuration: BaBar with reduced boost ($\beta\gamma = 0.24$)
- Generated geometries:
  - Baseline + Bwd-EMC + Fwd-PID (quartz) (**DG_4**)
  - Baseline + Bwd-EMC + Fwd-PID (air) (**DG_4a**)



Analysis strategy

- Develop Kaons selectors for the two configurations:
  - without forward TOF
  - with forward TOF
- Apply the PID selector to both the B tag and signal sides
- Compare the results with and without fwd PID

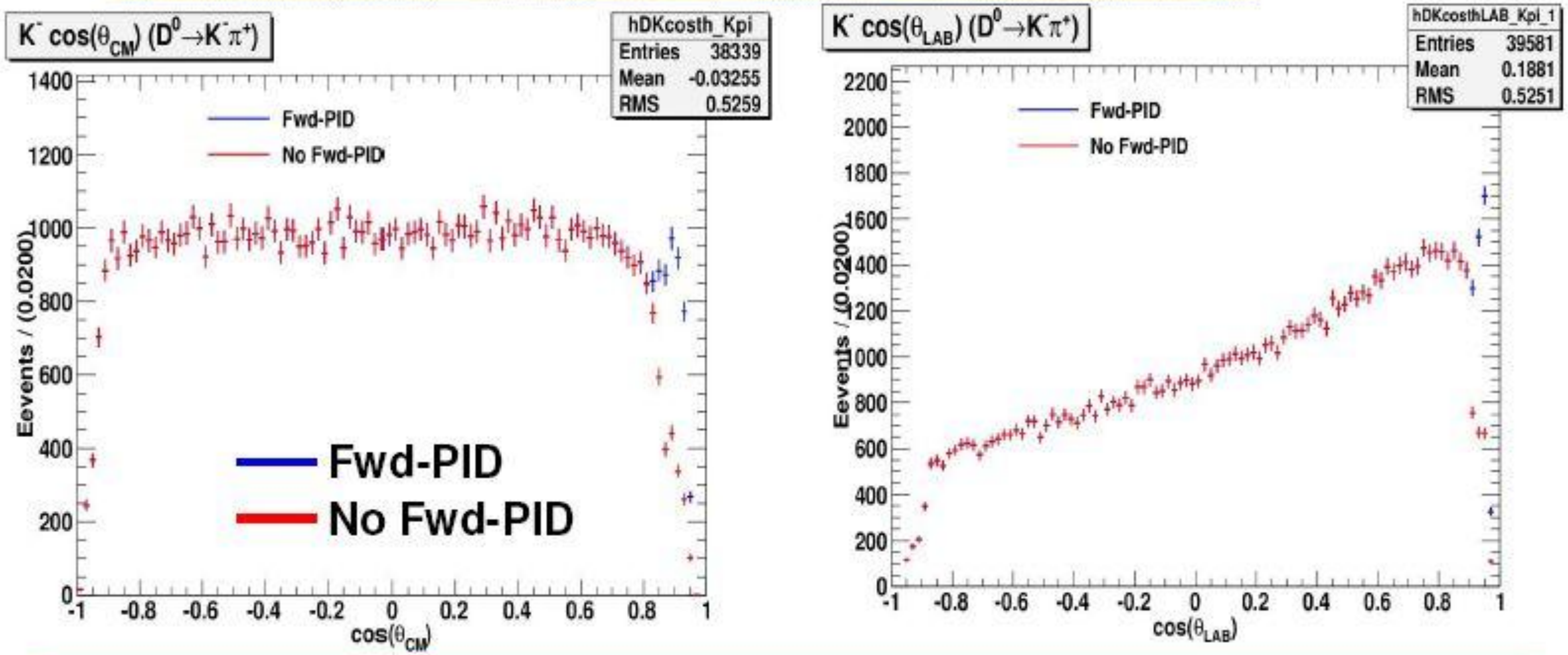
Kaon efficiency vs p in the forward region with and without TOF



Kaon efficiency vs polar angle

Fwd-PID studies: $B^+ \to K^+ \nu\nu$

A. Perez



- Events in the Fwd region (15-25 degrees) are 5% of the total sample if cos(θ) (CM) is flat
- f-TOF seems to recover the events in the Fwd
- Gain from fTOF not expected to be higher than 5% for each identified kaon

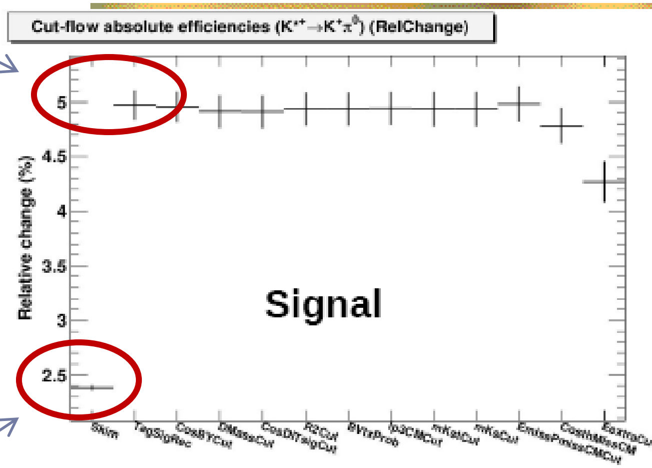
in fact, it is 2.0-2.5 %

B→K*+νν with semileptonic B tag

Fwd-PID studies: $B \to K^{*+} \nu\nu$

A. Perez

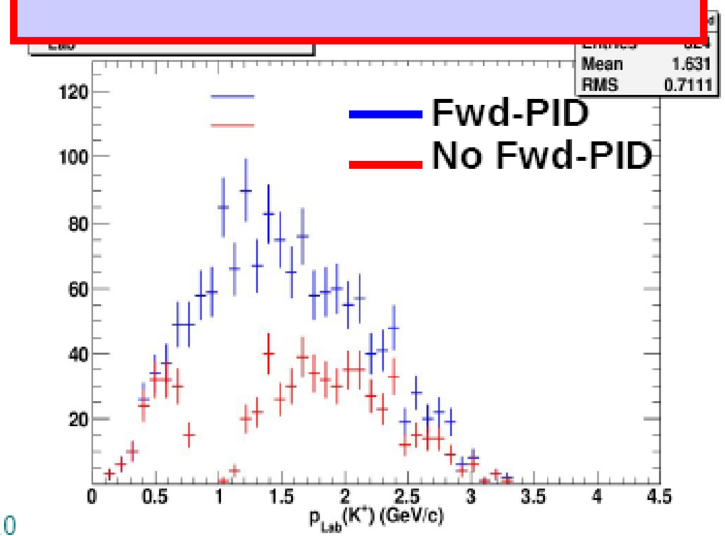
gain on B signal side



gain on B tag side

$K^{*+} \to K^+ \pi^0$

- **Signal:** - Tag-side: 2.4 %
  - Sig-side: 2.6 ± 0.1%
- **B^+B^-:** - Tag-side: 2.3 %
  - Sig-side: 2.1 ± 0.1%
- **B^0B^0:** - Tag-side: 2.0 %
  - Sig-side: 0.0 ± 0.1%



2.4% efficiency relative gain from K on tag side
Another 2.6% gain from K on signal side

Alejandro Perez, DGWG parallel session Dec. 15th 2010

B→K*⁰νν with hadronic B tag

DGWG session — December 14, 2010

E. Manoni

$B^0 \to K^{*0}(K^+\pi^-)\nu\nu$: Cut flow efficiency

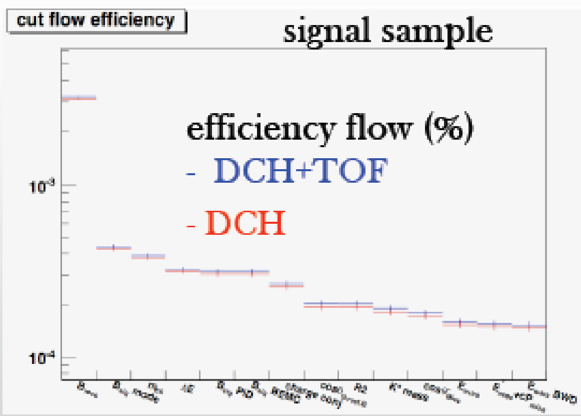
$\delta\varepsilon/\varepsilon$	signal MC	B^0 Cock
B_{reco} reconstr.	$(2.95 \pm 0.18)\%$	$(2.490 \pm 0.009)\%$
B_{reco} sel.	$(3.0 \pm 0.6)\%$	$(2.8 \pm 0.6)\%$
B_{sig} reconstr.	$(1.8 \pm 0.7)\%$	$(2.1 \pm 1.0)\%$
Full sel.	$(4.2 \pm 1.0)\%$	-

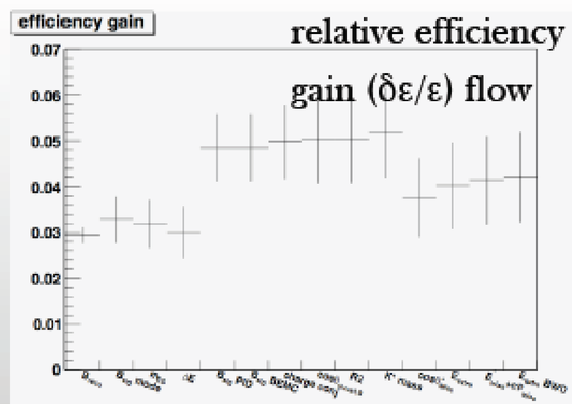
eff. increase
Btag side → (B_{reco} sel.)
signal side → (B_{sig} reconstr.)

efficiency on Breco reconstr. and sel. normalized to # of gen evts

efficiency on Bsig reconstr. normalized to # of sel Breco events

totalsel efficiency normalized to # of gen evts





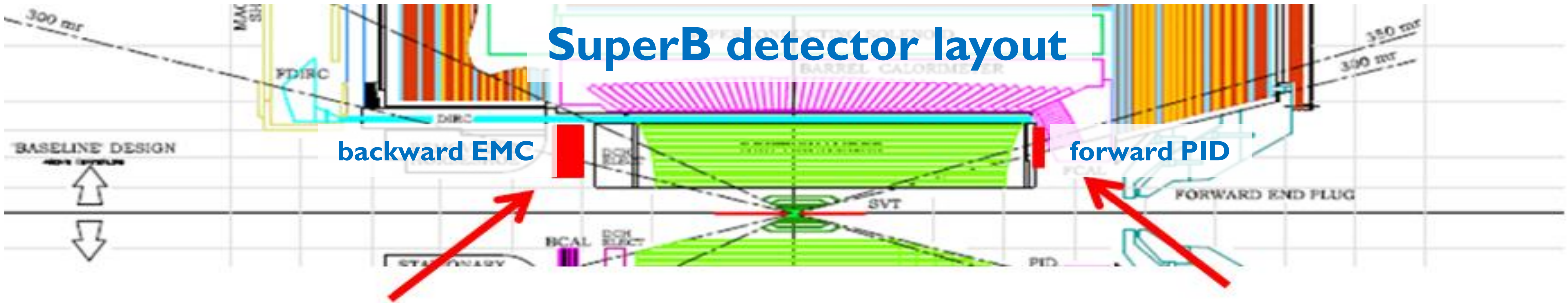
elisa manoni — infn perugia — 9

Conclusions for fwd TOF

- The results of the hadronic and SL analyses are overall consistent

E. Manoni
A. Perez

- 2.0-2.5% efficiency gain per identified $K^{\pm}$
  - The efficiency of signal plus Breco tag increases by ~4.5% (~2.5%) when there is (not) a $K^{\pm}$ in the signal final state
  - The Breco tag background increases as well (~2.5%)
  - S/sqrt(S+B) increases by ~1-4 % depending on the mode

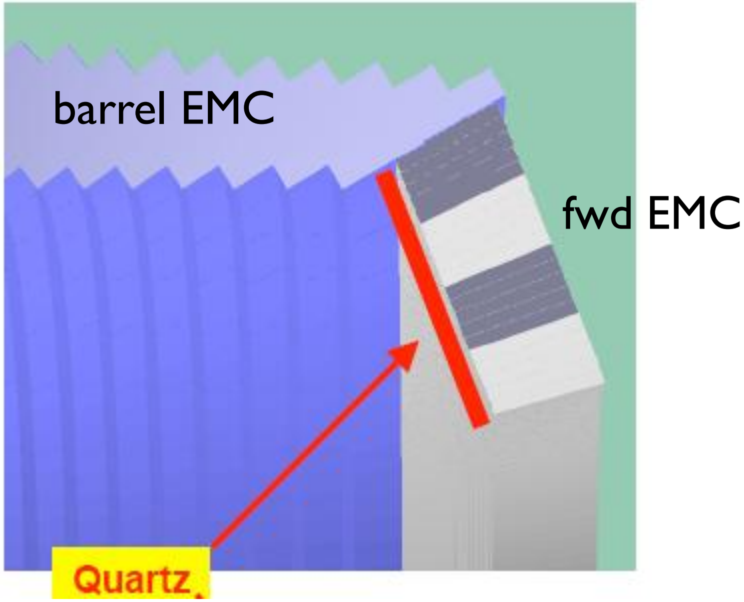


Material in front of the forward EMC

Geant4 study

S. Germani

- Private production of single photons with Bruno
- Mix with RadBhabha events from February production
- Sum all energy deposits in a given Time Windows
  - 300 ns Barrel
  - 100 ns Fwd
- Perform clustering
  - Usually several clusters from background
- Assign cluster to the Signal Photon

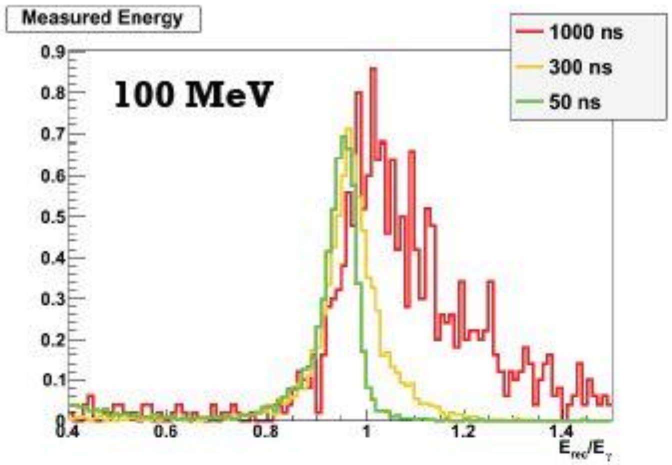


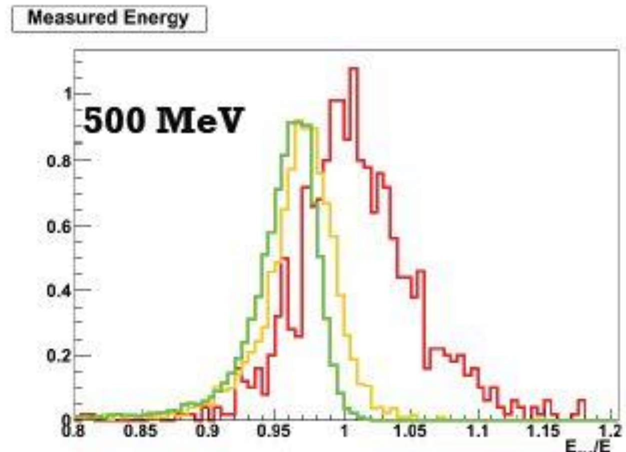
E_{reco}/E_{γ} vs time window width

Time Window Width

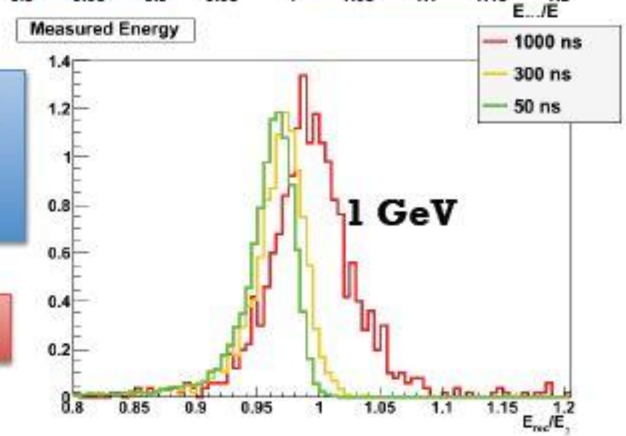
S. Germani

Geant4





For large windows resolution and distribution shape entirely dominated by background



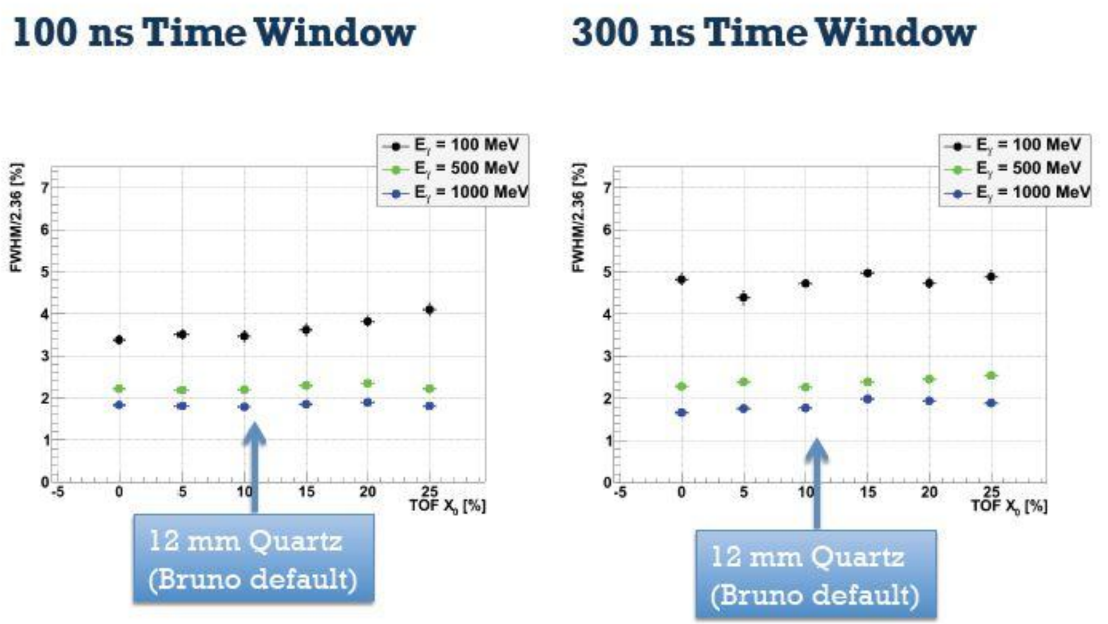
From Now On Time Window = 300 ns

For this distributions there is material FTOF-like ~10%X_0

fwd EMC: E resolution vs PID material

PID Thickness Effect on σ_E

S. Germani



shown at Elba'10

preliminary results

Preliminary results. Since the bkg makes the E distribution more Gaussian, it is assumed in these plots that the FWHM is a good estimator.

preliminary

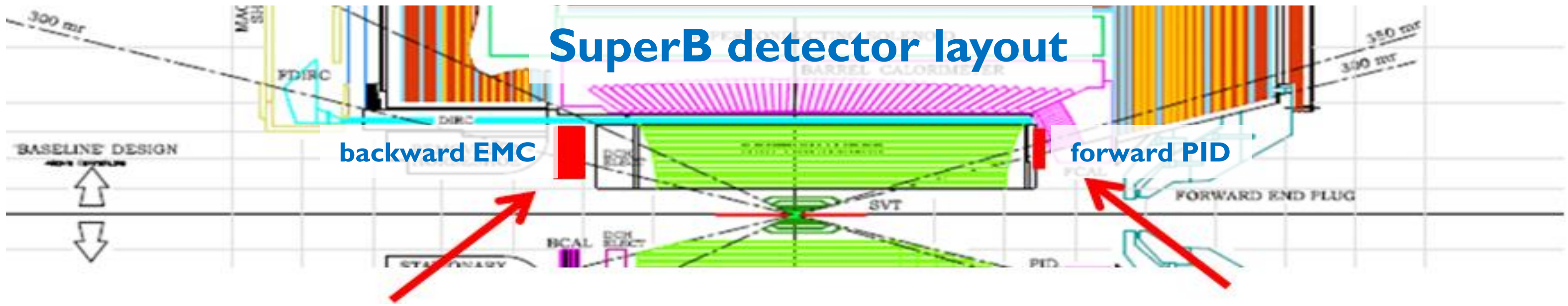
Conclusions with Bruno S. Germani

- Background with current Time Widow has a non negligible effect on Energy Resolution
- Fwd PID material up to 25% X_0 has a small effect on Energy Resolution at low energies
- Effect on Anglular Resolution is not clear
- Time Window width play a dominant role
  - Increasing the width material effect is completely masked by background
  - Time Window width may be improved to reduce background effects

FastSim study A. Perez

Analysis of B→K(*)νν performed on DG_4 (fwd TOF) and DG_4a (fwd TOF 'made of air'): no significant difference found (in principle it could affect Breco tag)

Work in progress also by Elisa Manoni.



Increased EMC angular coverage
(backward EMC)

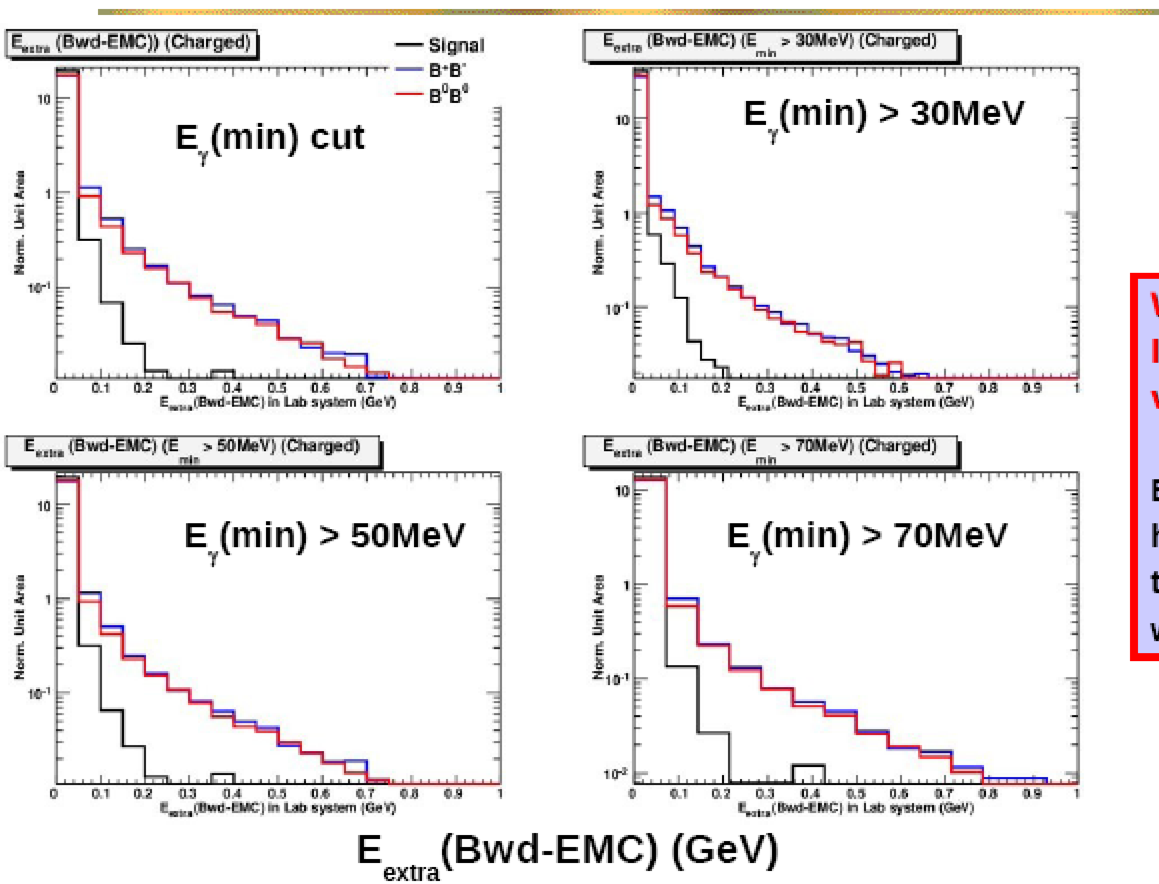
Strategy

- Same $B \rightarrow K^{(*)}\nu\nu$ and $B \rightarrow \tau\nu$ analyses as for the forward PID studies (see sl. 4 and 5)
- Backward EMC used as veto device ➔ Bsig and Btag are still reconstructed without neutrals from the bwd EMC
- Build E_{extra}(bwd): sum of extra neutrals seen in the bwd EMC
- Use E_{extra}(bwd) as an additional selection quantity. Optimize the cut to increase S/sqrt(S+B)

B→K*νν SL tag

A. Perez

E_{extra}(bwd) for signal and BB background as a function of the minimum γ energy cut



Signal
B^+B^-
B^0B^0

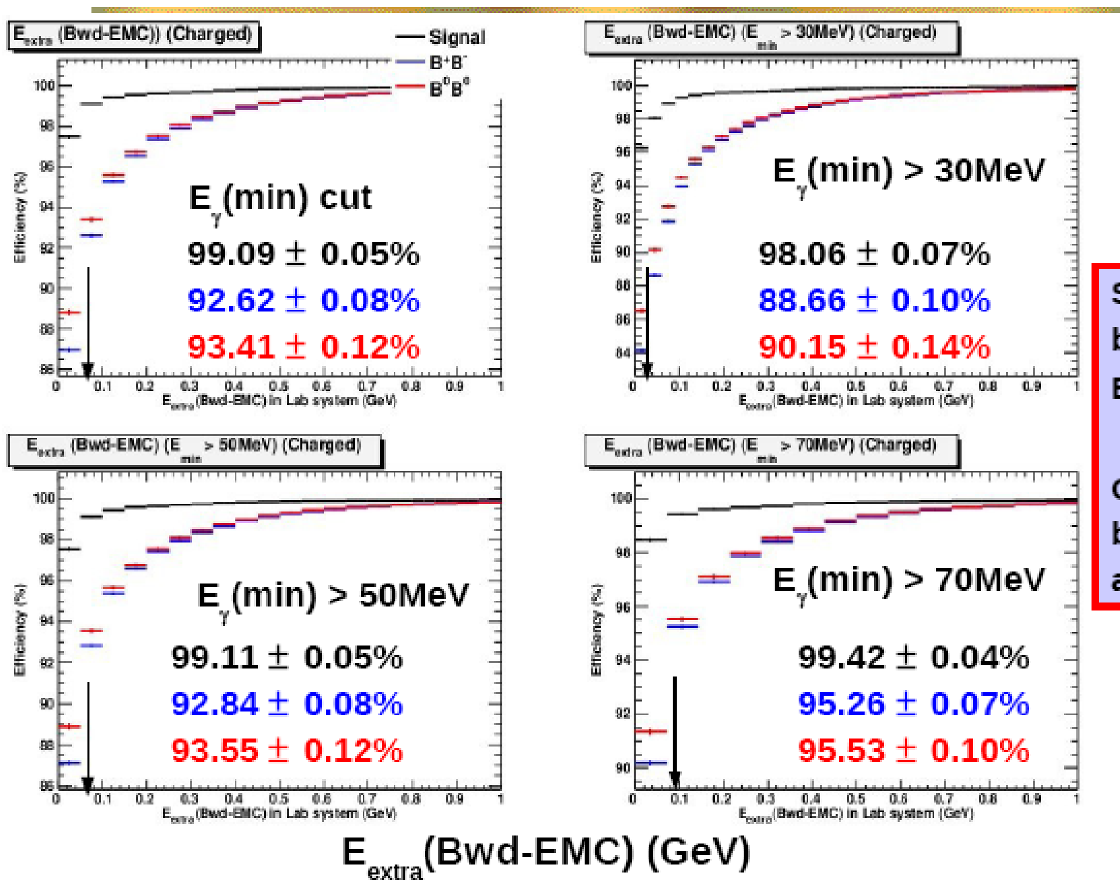
Warning: log-scale in the vertical scale

Backgrounds have longer tails to high values w.r.t signal

B→K*νν SL tag

A. Perez

Optimization of the E_{extra}(bwd) cut for different values of the minimum γ energy cut



Seems that it is better to use E_γ(min) > 30MeV

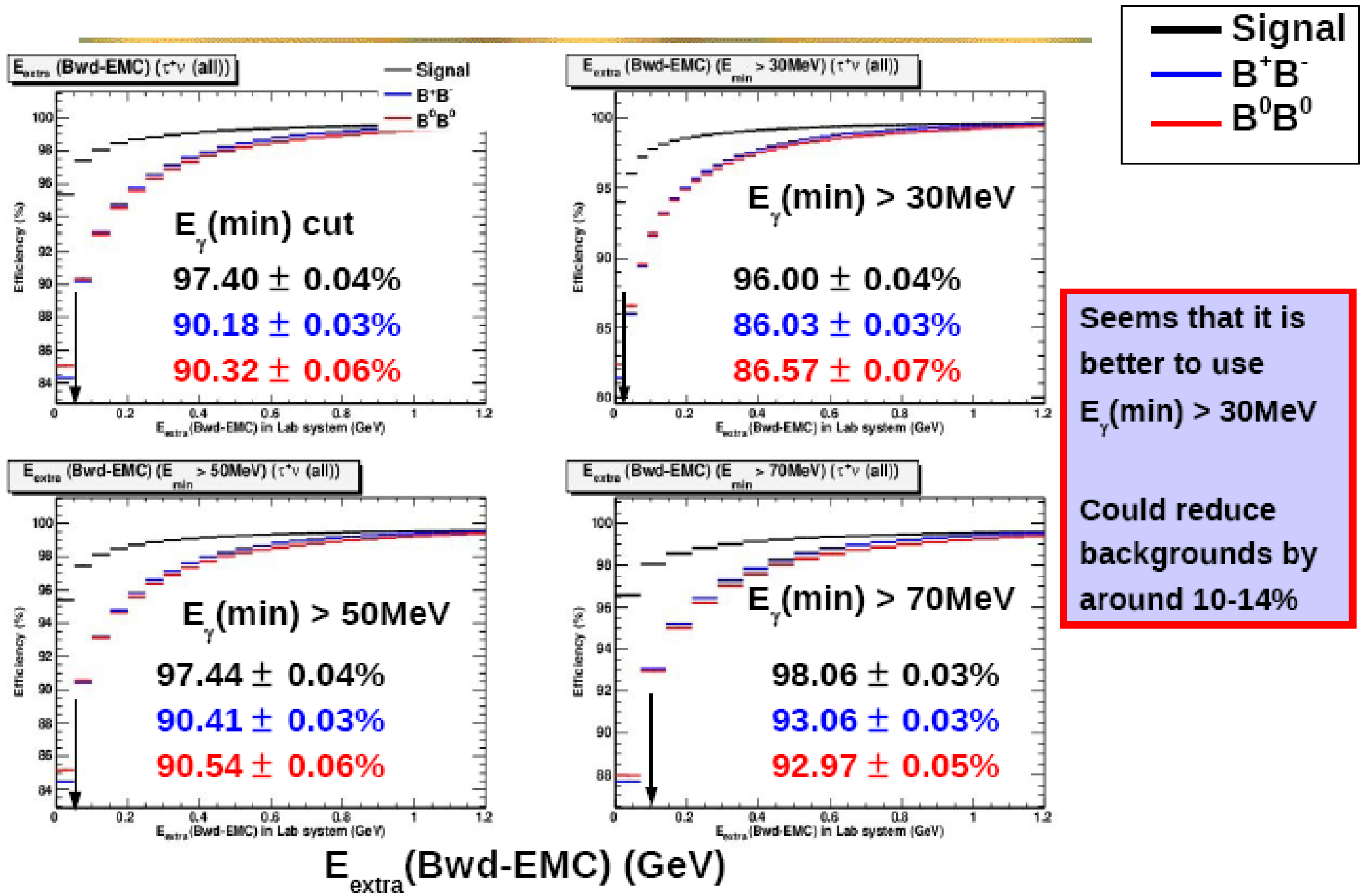
Could reduce backgrounds by around 10%

8-10% background reduction keeping the signal efficiency around 98%

B→τν SL tag

A. Perez

Optimization of the E_{extra}(bwd) cut for different values of the minimum γ energy cut



Seems that it is better to use E_γ(min) > 30MeV

Could reduce backgrounds by around 10-14%

10-14% background reduction keeping the signal efficiency around 96-98%

$B \rightarrow K^{(*)}\nu\nu$ HAD tag

E. Manoni

EMC session — December 15, 2010

Eextra_bwd cut: results

* EextraBwd < 0.05 GeV:

$B^0 \rightarrow K^{*0}\nu\bar{\nu}$					
Sample	N_{sel}	ε_{tot}	$N_{sel,Bwd}$	$\varepsilon_{tot,Bwd}$	$\delta\varepsilon/\varepsilon$
$B^0 \rightarrow K^{*0}\nu\bar{\nu}$	727	$(24.5 \pm 0.9) \times 10^{-5}$	719	$(24.2 \pm 0.9) \times 10^{-5}$	$(-1.1 \pm 0.4)\%$
B^0 had cocktail	76	$(20 \pm 2) \times 10^{-8}$	60	$(16 \pm 2) \times 10^{-8}$	$(-21 \pm 7)\%$
$S/\sqrt{B}$	83 ± 7		93 ± 9		

$B^+ \rightarrow K^{*+}(K_s\pi^+)\nu\bar{\nu}$					
Sample	N_{sel}	ε_{tot}	$N_{sel,Bwd}$	$\varepsilon_{tot,Bwd}$	$\delta\varepsilon/\varepsilon$
$B^+ \rightarrow K^{*+}\nu\bar{\nu}$	223	$(7.1 \pm 0.5) \times 10^{-5}$	222	$(7.0 \pm 0.5) \times 10^{-5}$	$(-0.5 \pm 0.4)\%$
B^+ had cocktail	48	$(12.0 \pm 1.7) \times 10^{-8}$	40	$(10.0 \pm 1.7) \times 10^{-8}$	$(-17 \pm 7)\%$
$S/\sqrt{B}$	32 ± 4		35 ± 5		

values similar to SL analysis

$$\delta\left(\frac{S}{\sqrt{(B)}}\right) = \frac{\left(\frac{S}{\sqrt{(B)}}\right)_{bwd} - \left(\frac{S}{\sqrt{(B)}}\right)_{nobwd}}{\left(\frac{S}{\sqrt{(B)}}\right)_{nobwd}} =$$

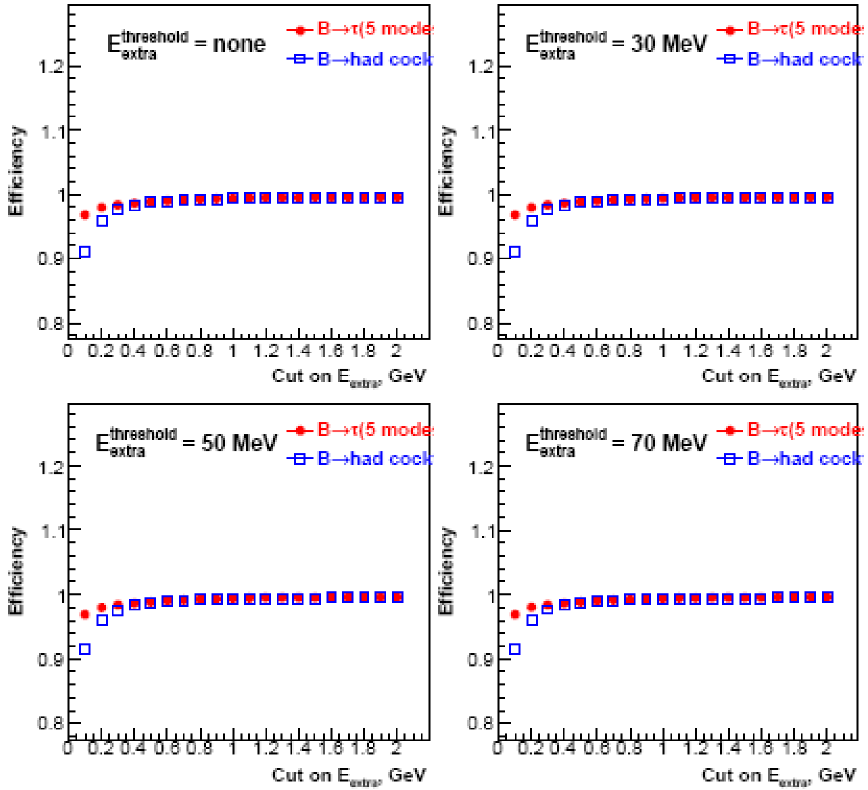
$K\pi : (10 \pm 3)\%$

$K_s\pi : (8 \pm 3)\%$

B→τν HAD tag

A. Rakitin

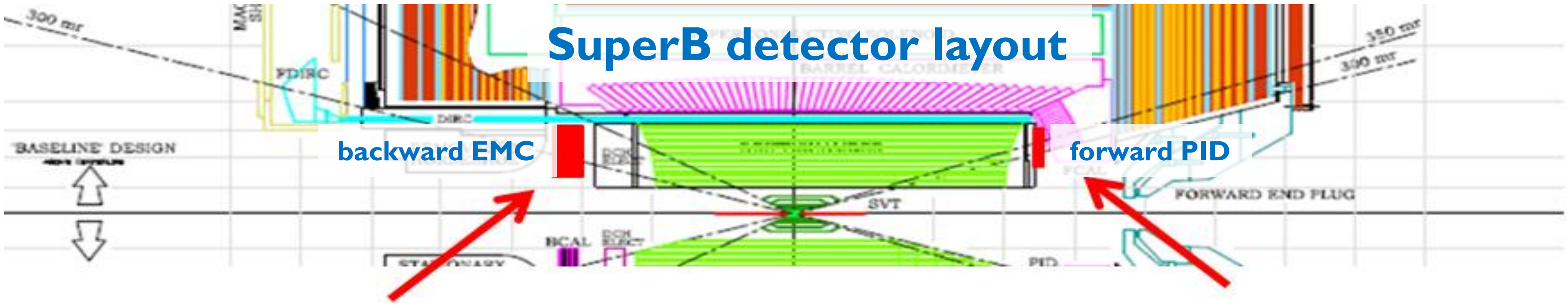
Signal and background efficiency as a function of the cut on E_{extra}(bwd)



Checks in progress. Final results expected at the next meeting

Conclusions for bwd EMC

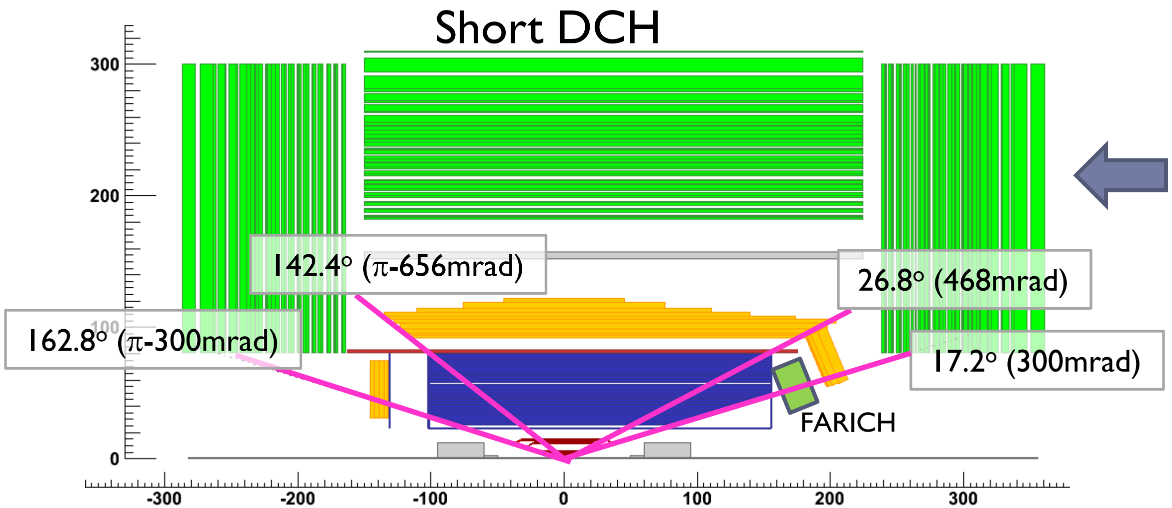
- Possible to use E_{extra}(bwd) to suppress ~10-20% of BB background with a ~98% signal efficiency
- S/sqrt(S+B) change=3.7% with B→K(*)νν SL tag. 5-10% change with B→$K^{(*)}$νν HAD tag (large uncertainty)



Reduction of the drift chamber length

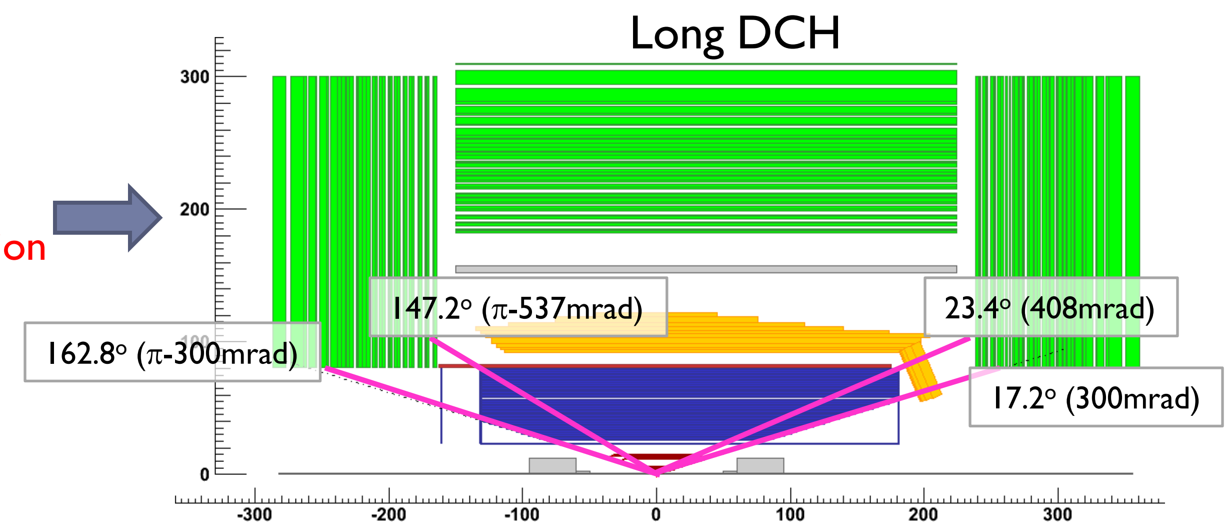
Short and long DCH compared to the baseline

M. Rama



-20cm in the forward region

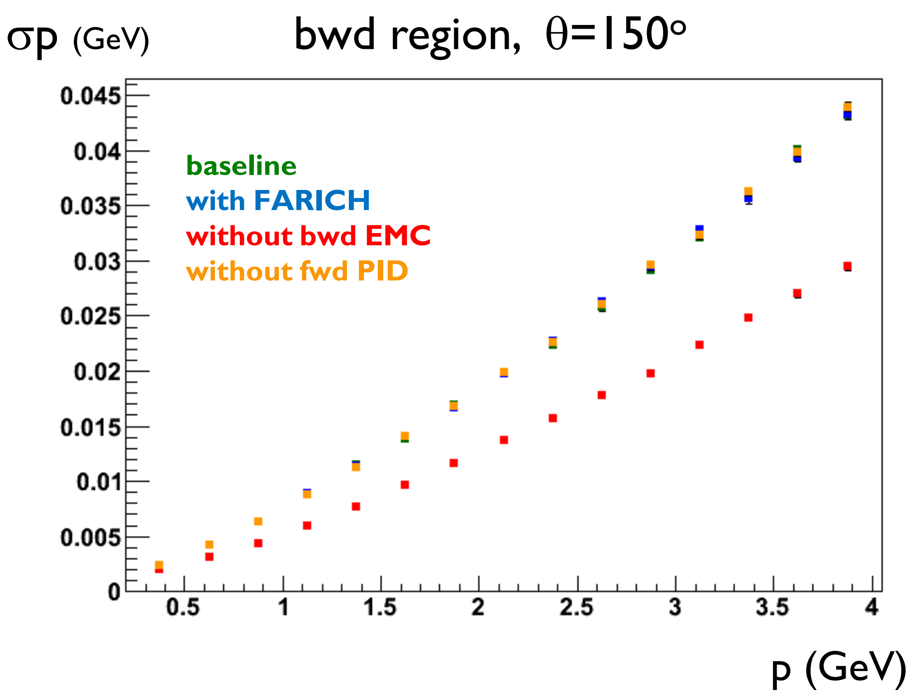
+6cm in the forward region
+20cm in the backward region

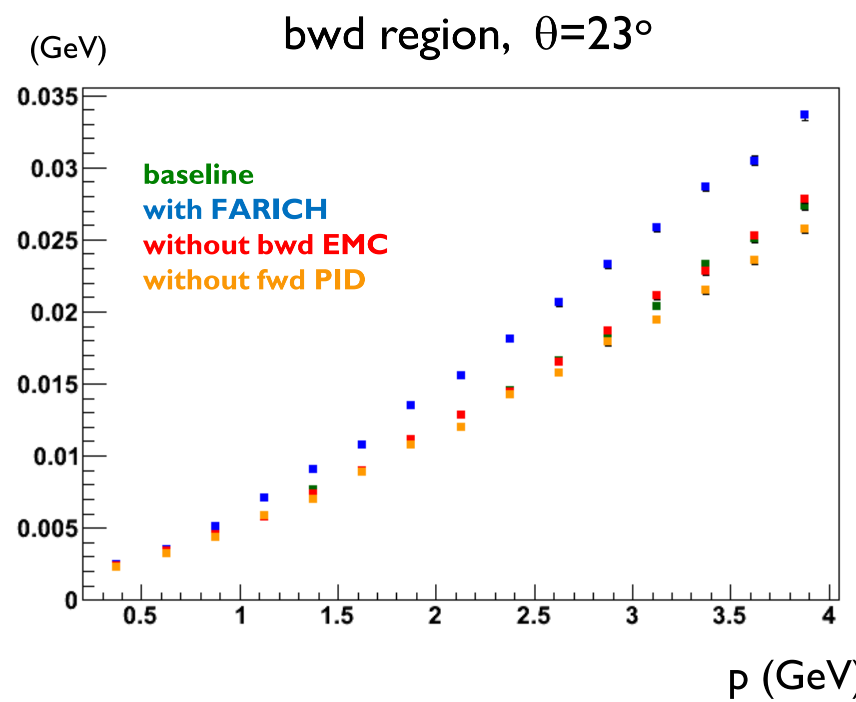


single particles:
p resolution at θ=23° and θ=150°

FastSim

Note: the stat errors are smaller than the squares size





p resolution in long DCH improves by ~30% in bwd region (for θ=150°)

p resolution in short DCH worsens by ~20% in fwd region (for θ=23°)
negligible effect in Long DCH vs. Masked DCH

Reconstruction efficiency of $B \rightarrow \pi^+\pi^-$

FastSim

DCH configuration	reco. efficiency [%] (|ΔE|<100 MeV)
baseline	82.2 ± 0.1
20cm shorter in fwd region (FARICH)	81.2 ± 0.1
20cm longer in bwd region (no bwd EMC)	82.6 ± 0.1
6cm longer in fwd region (no fwd PID)	82.1 ± 0.1

DCH configuration	reco. efficiency [%] (|ΔE|<60 MeV ~2.5σ)
baseline	77.6 ± 0.1
20cm shorter in fwd region (FARICH)	76.7 ± 0.1
20cm longer in bwd region (no bwd EMC)	78.1 ± 0.1
6cm longer in fwd region (no fwd PID)	77.6 ± 0.1

Check

Are the numbers in the previous slide expected?

$$\Delta E = E_B - E_{beam} = \sqrt{m_{\pi 1}^2 + p_1^2} + \sqrt{m_{\pi 2}^2 + p_2^2} - E_{beam}$$ in CM frame.

$$\sigma(\Delta E)^2 = \sum_{i=1,2} p_i^2 \Big/ \left(m_{\pi,i}^2 + p_i^2\right) \sigma(p_i)^2$$

If $\sigma(p_l) \rightarrow 1.2\ \sigma(p_l)$ then on average $\sigma(\Delta E) \rightarrow 1.10 \sigma(\Delta E)$ [for Bs with one track in the forward region]

Since the fraction of reco. Bs with 1 track in the fwd region is ~10%: $\sigma(\Delta E) \rightarrow \sim 1.01\ \sigma(\Delta E)$

Assuming a Gaussian distribution for ΔE, a $\pm 2.5\sigma$ window correspond to a $2.5/1.01=2.475\sigma$ cut. The efficiency loss in this case would be ~0.1%. Due to the tails the loss is larger, but it remains ≤1%. **Consistent with what observed.**

Reconstruction efficiency of $B^0 \rightarrow D^{*-}K^+$

FastSim

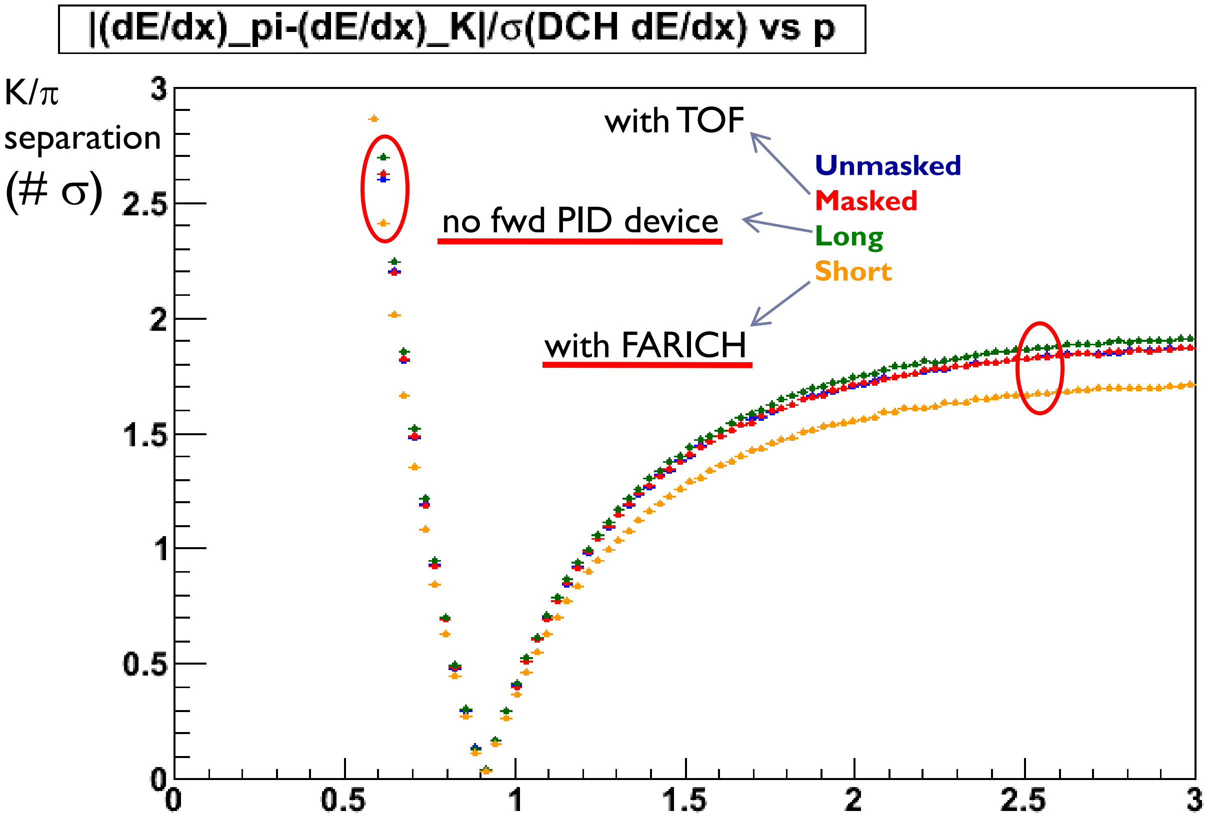
DCH configuration	reco. efficiency [%] ($\|\Delta E\|$<100 MeV)
baseline	70.9 ± 0.1
20cm shorter in fwd region (FARICH)	70.2 ± 0.1
20cm longer in bwd region (no bwd EMC)	70.9 ± 0.1
6cm longer in fwd region (no fwd PID)	71.2 ± 0.1

DCH configuration	reco. efficiency [%] ($\|\Delta E\|$<50 MeV ~2.5σ)
baseline	65.5 ± 0.2
20cm shorter in fwd region (FARICH)	64.8 ± 0.2
20cm longer in bwd region (no bwd EMC)	65.9 ± 0.2
6cm longer in fwd region (no fwd PID)	65.9 ± 0.2

similar relative changes as for $B \rightarrow \pi\pi$

dE/dx degradation vs DCH length

K/π separation vs p at θ=23°



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

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

Conclusion of DCH length study

M. Rama

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

tracking

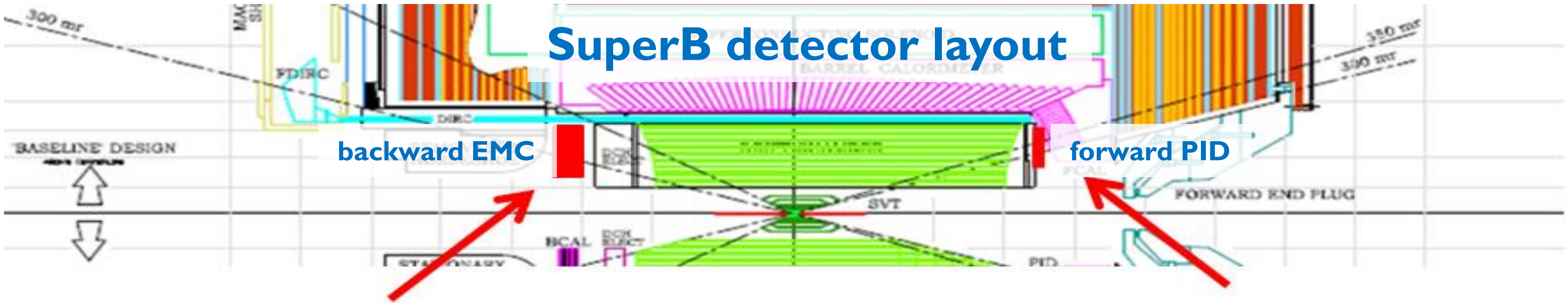
- significant improvement of momentum resolution in bwd region with long DCH (no bwd EMC)
- significant worsening of momentum resolution in fwd region with short DCH (FARICH)

BUT

- the overall impact on B reconstruction is small (modes considered: $B \rightarrow \pi\pi$, $B \rightarrow D^*K$). The variation of the selection efficiency for a 2.5σ ΔE selection window is $\leq 1\%$.

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)


SuperB detector layout
backward EMC
forward PID
BASELINE DESIGN
FDIRC
DIRC
SVT
BCAL
FORWARD END PLUG
PID
300 mr
350 mr
300 mr

Summary

Summary I

Forward PID:

increase of PID efficiency

-) 2.0-2.5% efficiency gain per identified $K^{\pm}$. Therefore:

- The efficiency of signal + Breco tag increases by ~4.5% (~2.5%) when there is (not) a $K^{\pm}$ in the signal final state
- The Breco tag background increases as well (~2.5%). No significant background increase in the signal-side (errors still large)
- S/sqrt(S+B) increases by ~1-4 % depending on the mode

material in front of the forward EMC

-) No significant E degradation observed up to X_0~25% using Bruno. Preliminary.

-) No significant E degradation observed with FastSim

reduction of the drift chamber length

-) ~1% relative efficiency loss in $B \rightarrow \pi^+\pi^-$ or $B^+ \rightarrow D^{*-}K^+$ with a 20cm shorter DCH (FARICH)

-) Moderate worsening of dE/dx K/π separation in forward region with FARICH. E.g: -0.2σ at 2.5 GeV at θ=23deg. The variation is largely compensated by the fwd PID performance.

Summary II

Backward EMC:

increase d EMC angular coverage

-) 10-20% BB background reduction with ~98-99% signal efficiency in both $B \to K^{(*)}\nu\nu$ and $B \to \tau\nu$ SL tag . ~5% increase of S/sqrt(S+B)

reduction of the drift chamber length

-) ~0.5% relative efficiency gain if the DCH is 20cm longer (no backward EMC)

-) Moderate improvement of dE/dx K/π separation in backward region with no bwd EMC. E.g: $+0.4\sigma$ at 2.5 GeV at θ=150deg. But variations may be compensated by a possible PID capability of the bwd EMC.

backup

B recoil technique

Recoil Analysis Technique (II)

- Aim: collect as many as possible fully/partially reconstructed B mesons in order to study the properties of the recoil
- 1st step: reconstruction D→hadrons

$D^{*+} \to D^0\pi^+$	$D^0 \to K^-\pi^+$	$D^+ \to K^-\pi^+\pi^-$
$D^{*0} \to D^0\pi^0$	$D^0 \to K^-\pi^+\pi^0(\gamma\gamma)$	$D^+ \to K^-\pi^+\pi^-\pi^0$
$D^{*0} \to D^0\gamma$	$D^0 \to K^-\pi^+\pi^+\pi^-$	$D^+ \to K^0_S\pi^+$
	$D^0 \to K^0_S\pi^+\pi^-$	$D^+ \to K^0_S\pi^+\pi^-\pi^+$
		$D^+ \to K^0_S\pi^+\pi^0$

2nd step:

Hadronic Breco:

- Use D as a seed and add X to have system compatible with B hypothesis ($X = n\pi^\pm\ mK^\pm\ rK^0_S\ q\pi^0$ and $n+m+r+q<6$)
- Sample of 1100 B decay modes with different purities
- Kinematics constrained completely
- Low reconstruction efficiencies (~0.4%)

Semi-Leptonic Breco:

- Use D as a seed and a lepton to form a Dl pair ($l = e^\pm,\mu^\pm$)
- Sample of 14 B decay modes
- Kinematics is unconstrained due to neutrino
- Higher reconstruction efficiencies (~2.0%)

Alejandro Perez, Elba SuperB workshop, Physics parallel session July 3rd 2010 6

fwd EMC: E_{reco}/E_{γ} (no background)

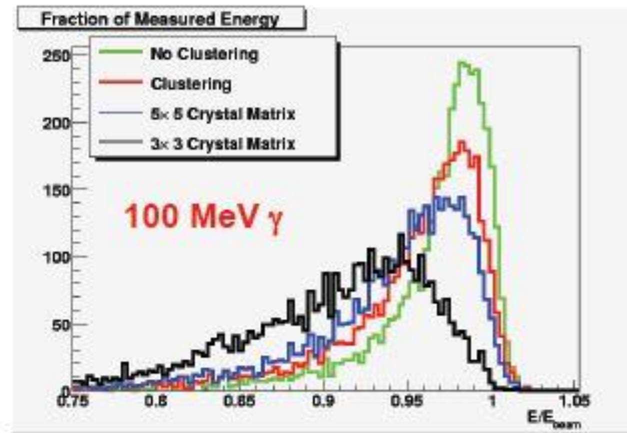
Slides

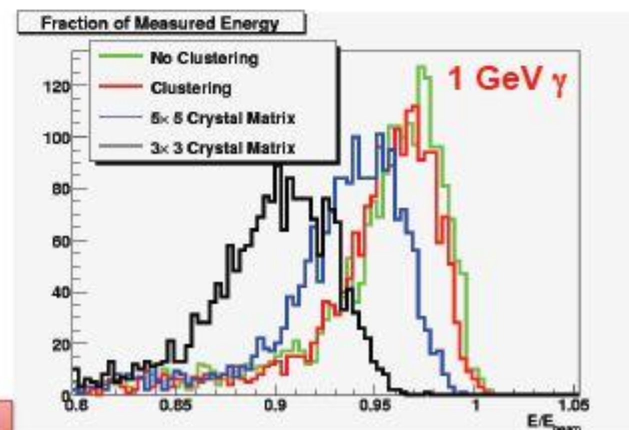
Geant4

Clustering

S. Germani

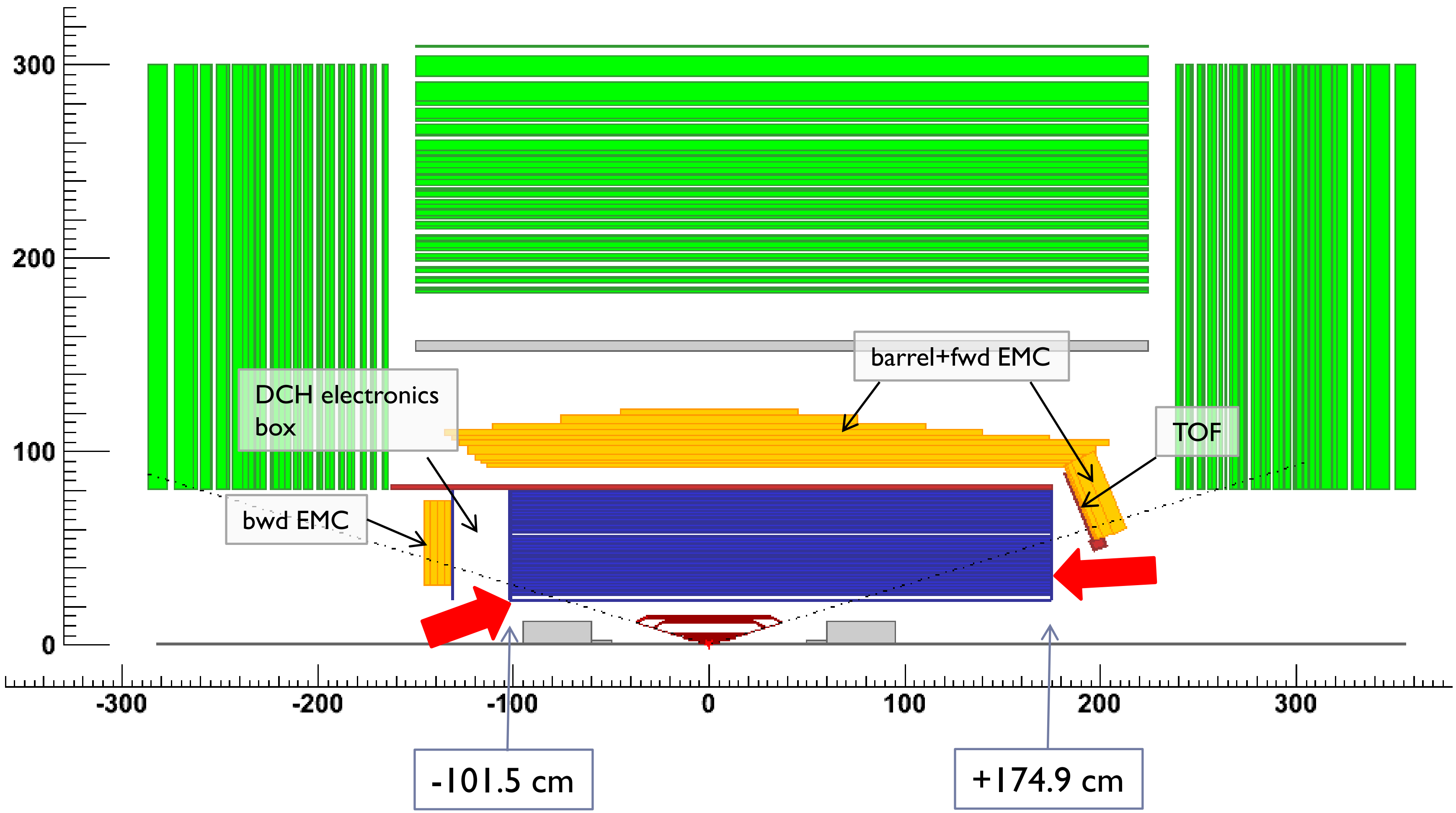
- No Clustering:
  - $E_{crystal}$ > 1 MeV
  - Same as slac meetiong
- Clustering :
  - Clustering algorithm as (supposed to be) in BaBar:
    1. Start from maximum energtyCrystal
    2. Look for crystal arount ME Xtal
    3. Sum crystal energy if **E > digi threshold** (0.2 - 0.5 MeV)
    4. If a Crystal around the ME one has **E > seed threshold** (2-3 MeV) look around it too
  - Adapted for LSO
- 5 x 5 - 3 x 3 Matrix
  - Take maximum energy crystal and a matrix of crystal arount it



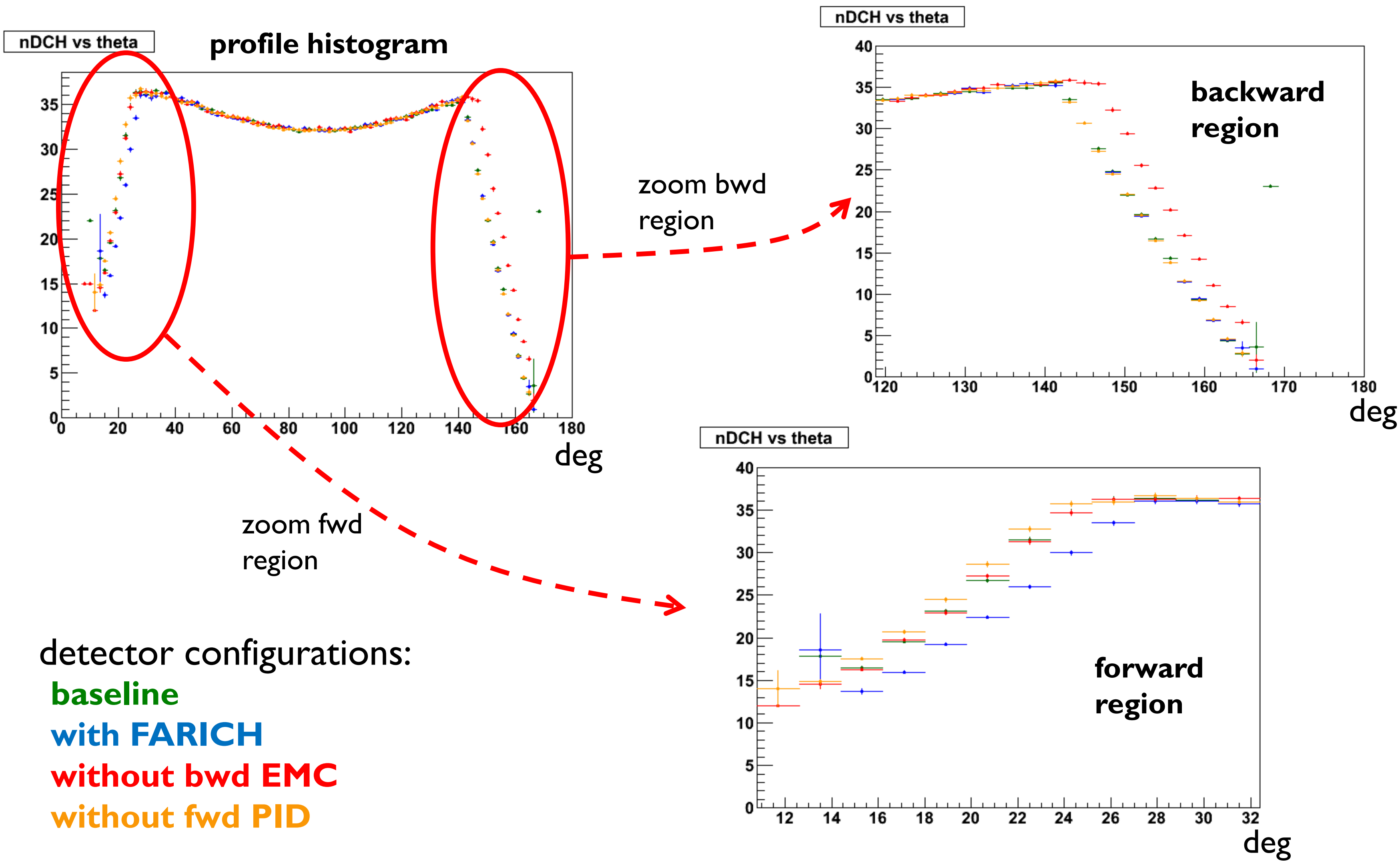


From Nov. 09 Frascati Meeting

baseline DCH



drift chamber hits as a function of the polar angle



detector configurations:

baseline

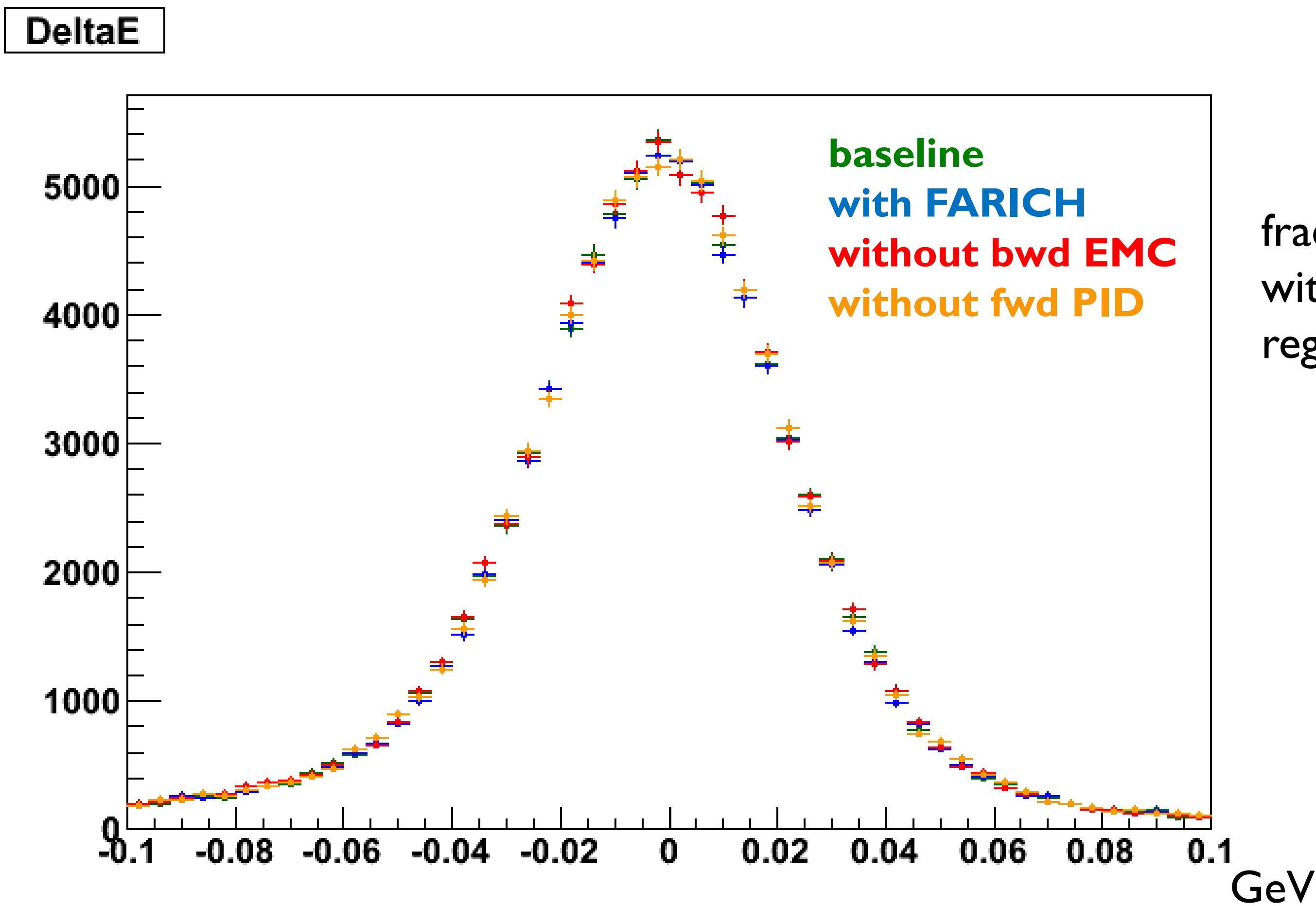
with FARICH

without bwd EMC

without fwd PID

Effect on $B \to \pi^+\pi^-$ reconstruction

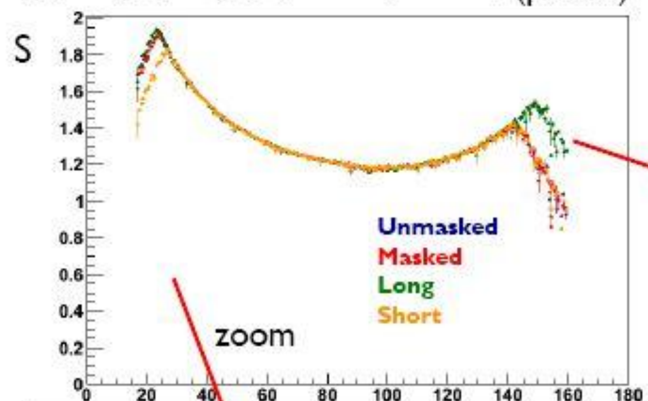
high momentum range complementary to $B^0 \to D^{*-}K^+$, $D^{*-} \to D^0\pi^-$, $D^0 \to K\pi$

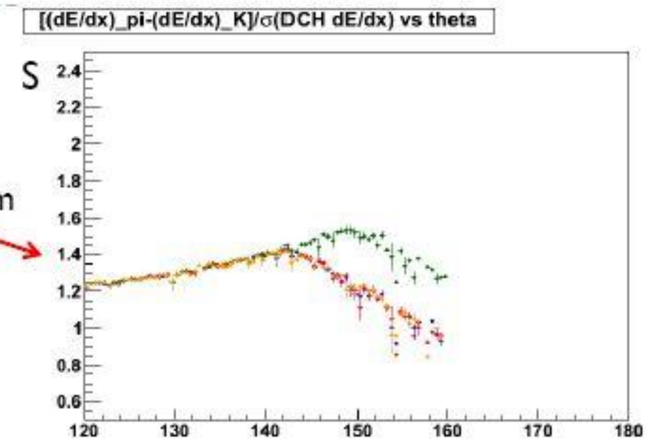


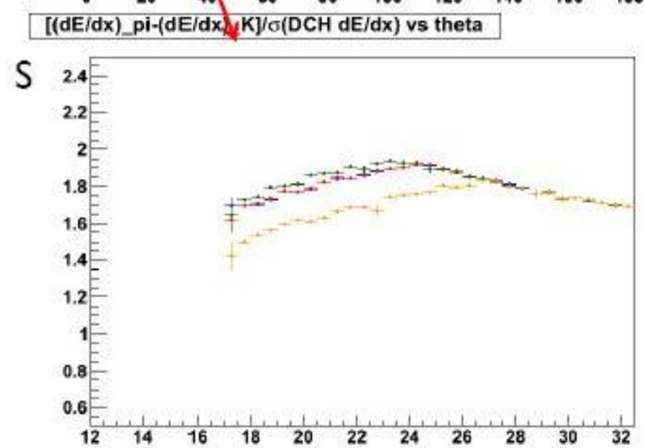
fraction of reco. B with 1 track in fwd region: ~10%

the effect on the overall ΔE distribution is hardly visible

tracks from B→ππ: DCH dE/dx K-π separation vs theta







S=[Expected_dE/dx(pi)-Expected_dE/dx(K))]/σ(dE/dx)

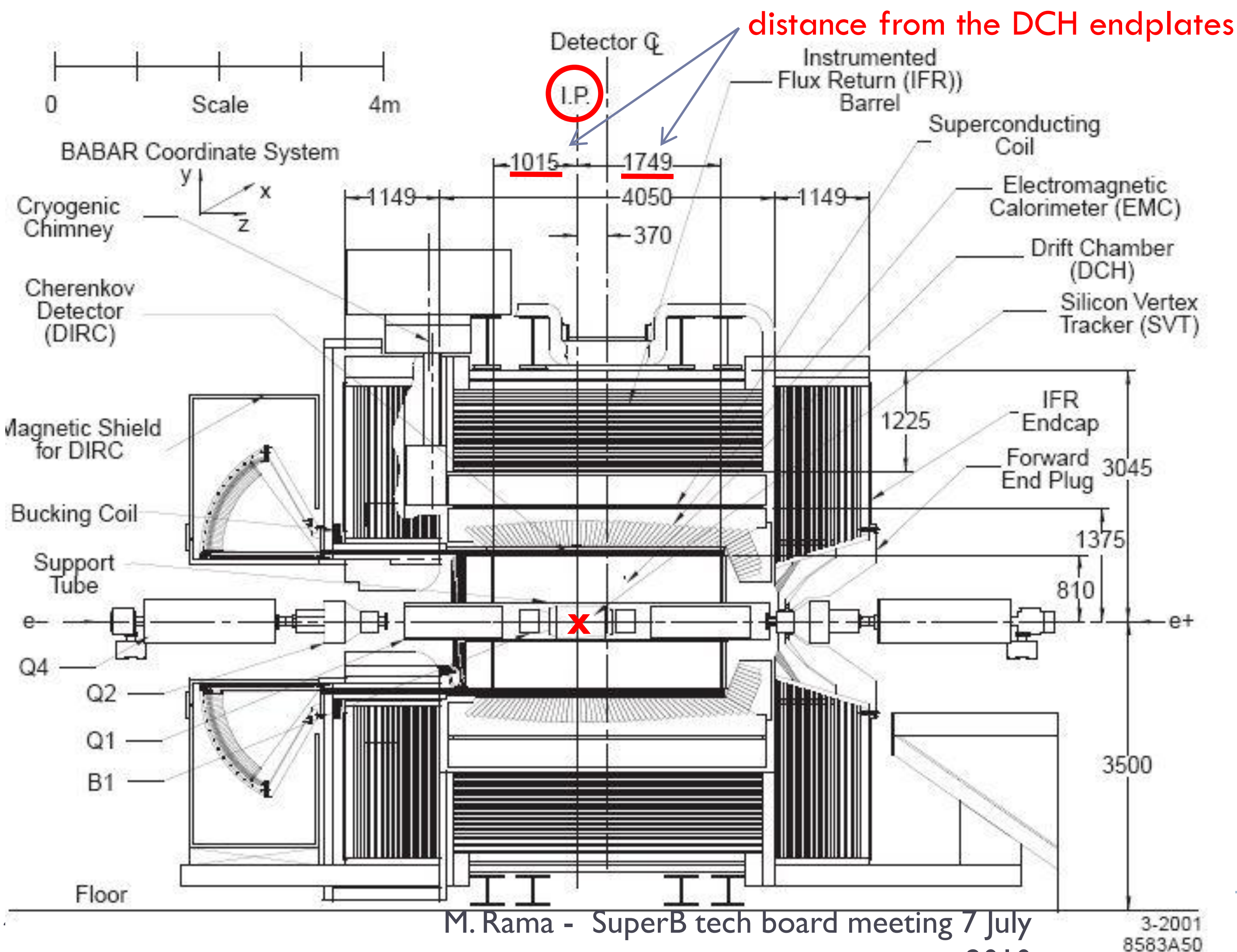
Long DCH w.r.t. Masked:

- 3.6% of tracks fall in the fwd region, where the dE/dx separation increases by ~0.06σ
  - to be compared with TOF pi/K separation in this momentum range (3.2-3.6 GeV)
- 2.8% of tracks fall in the bwd region, where the dE/dx separation increases by ~0.3σ
  - to be compared with possible PID from the bwd calorimeter in this momentum range (1.9-2.2 GeV)

Short DCH w.r.t. Masked:

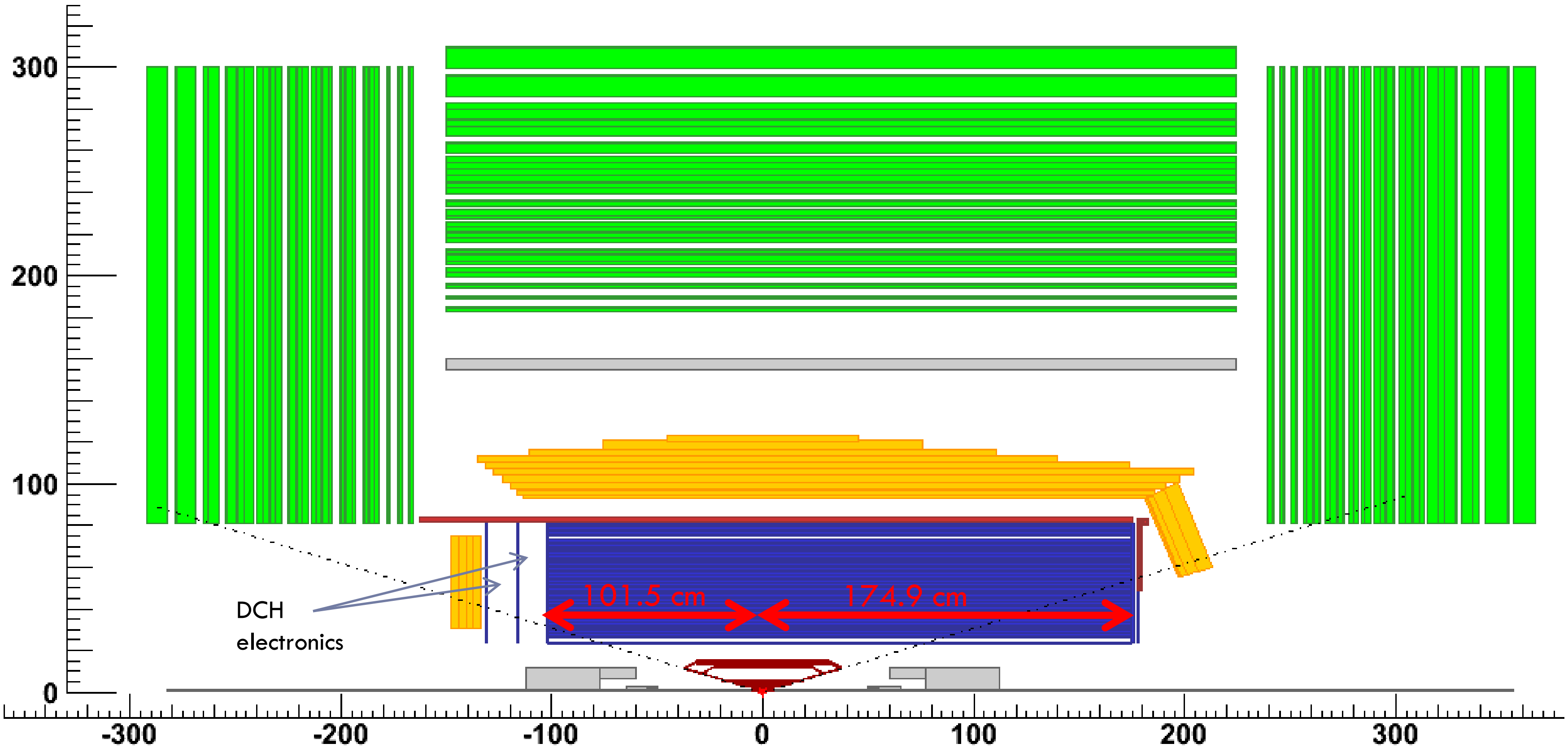
- 3.6% of tracks fall in the fwd region, where the dE/dx separation decreases by ~0.2σ

IP position in BaBar



IP position in FastSim

The current IP position in FastSim is the same as in BaBar (in both the SuperB and the BaBar configurations)



EMC coverage vs IP position

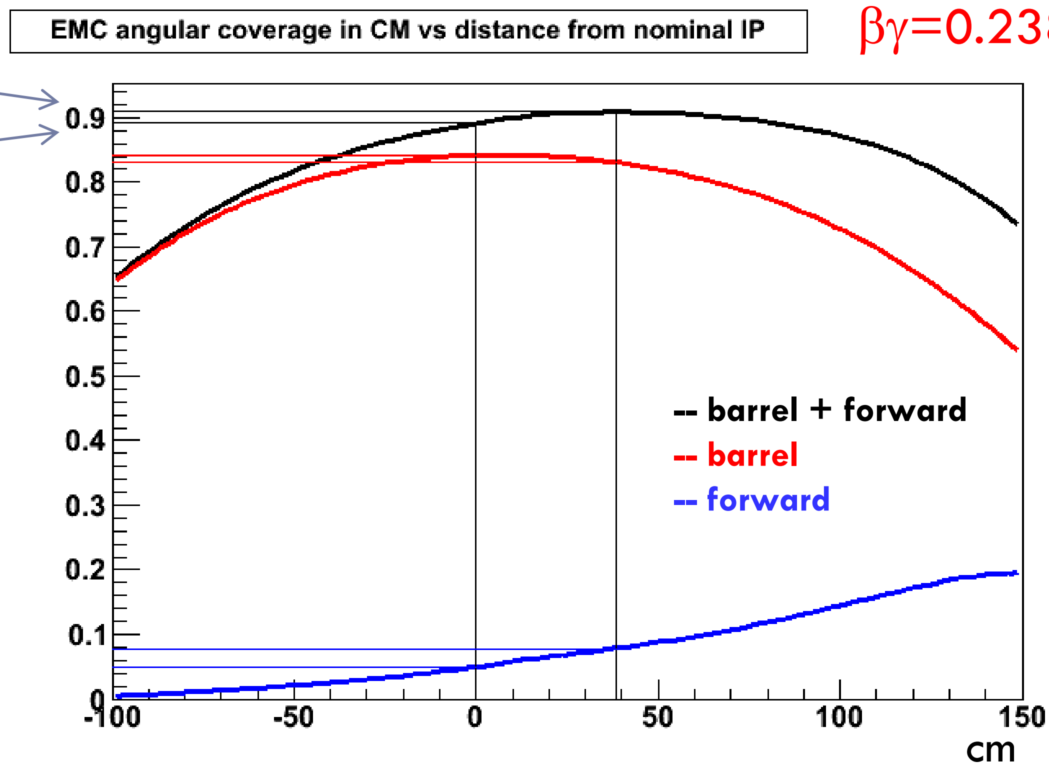
EMC (barrel+fwd) angular coverage in CM as a function of the IP position w.r.t. the nominal (= BaBar) position

$\beta\gamma$=0.238

CM frame

max cov: 90.9%

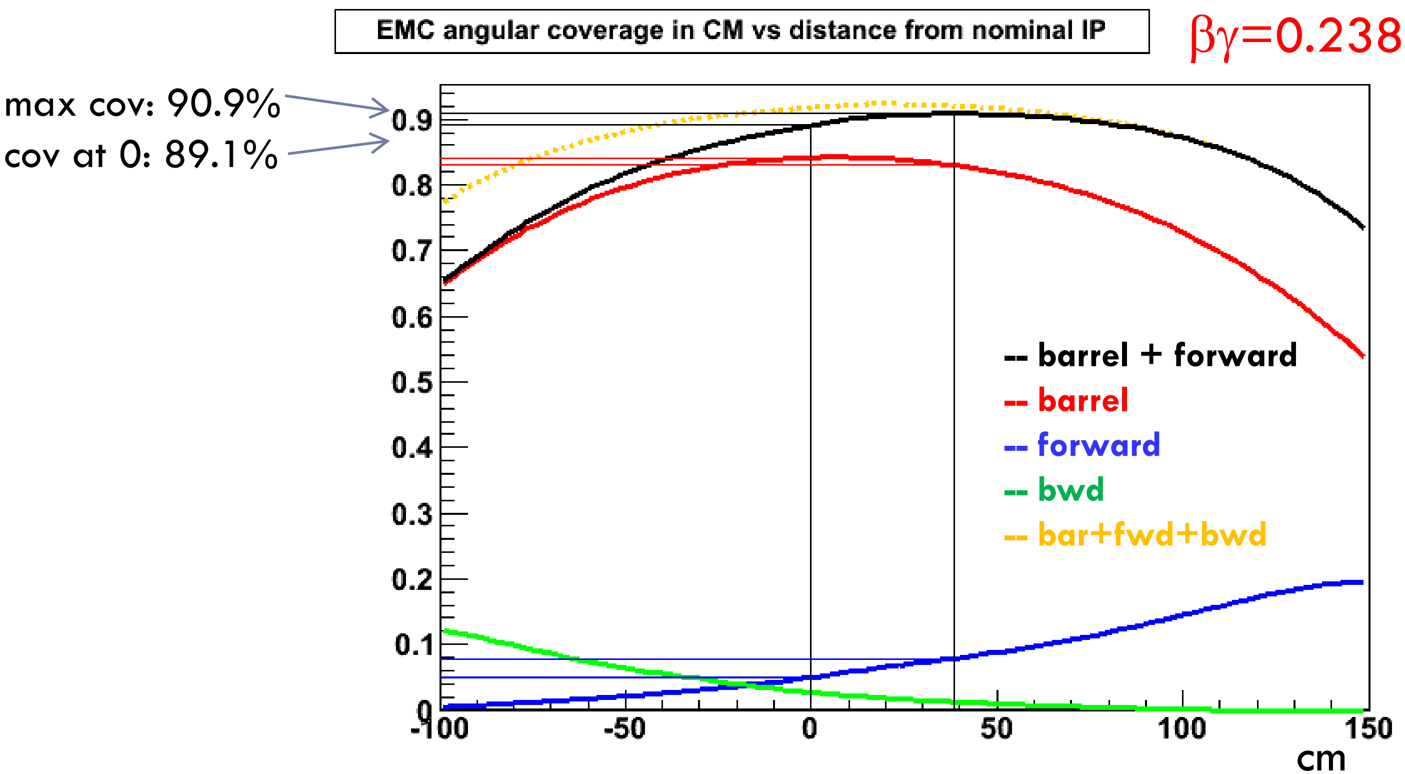
cov at 0: 89.1%



θ in lab frame constrained to be within the baseline SVT coverage [0.3,π-0.3]rad

EMC coverage vs IP position

Inclusion of backward EMC coverage

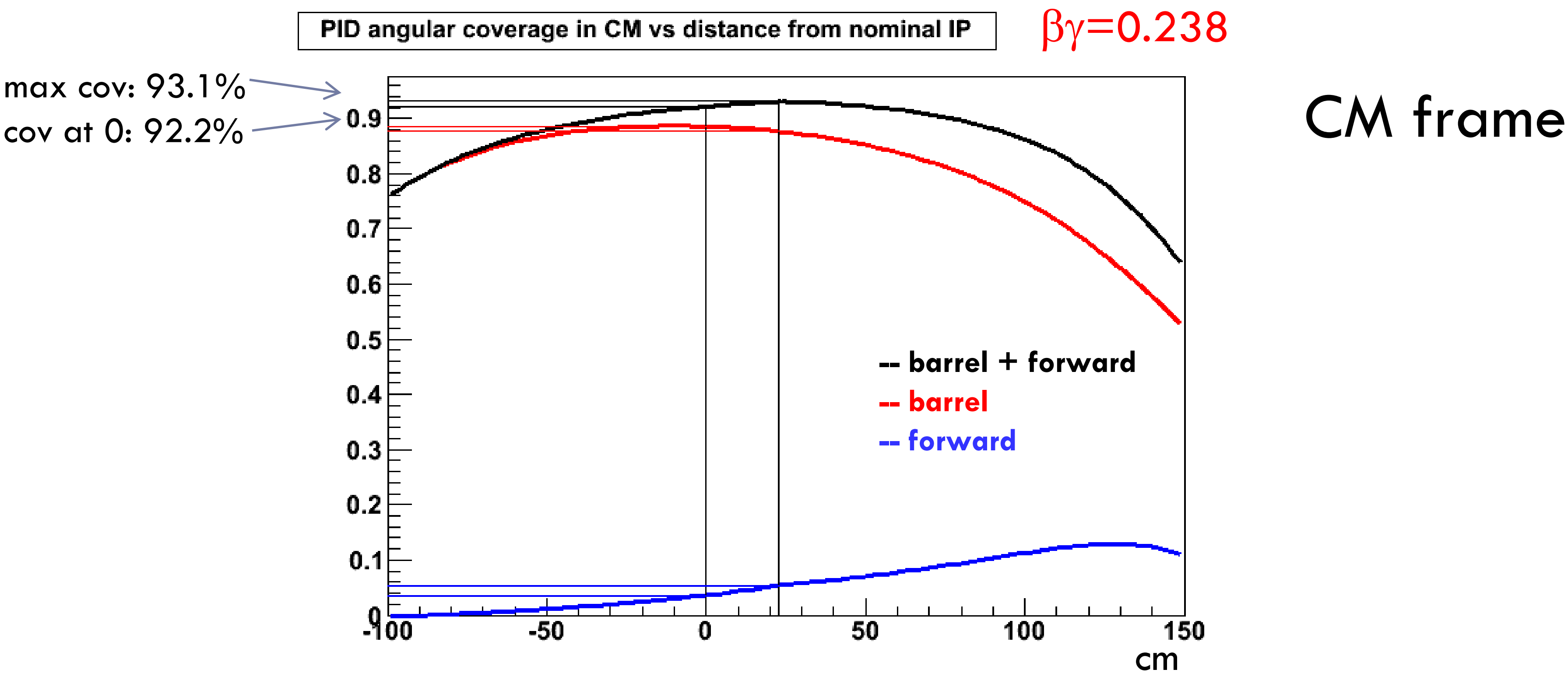


CM frame

θ in lab frame constrained to be within the baseline SVT coverage [0.3,π-0.3]rad

FDIRC+TOF coverage vs IP position

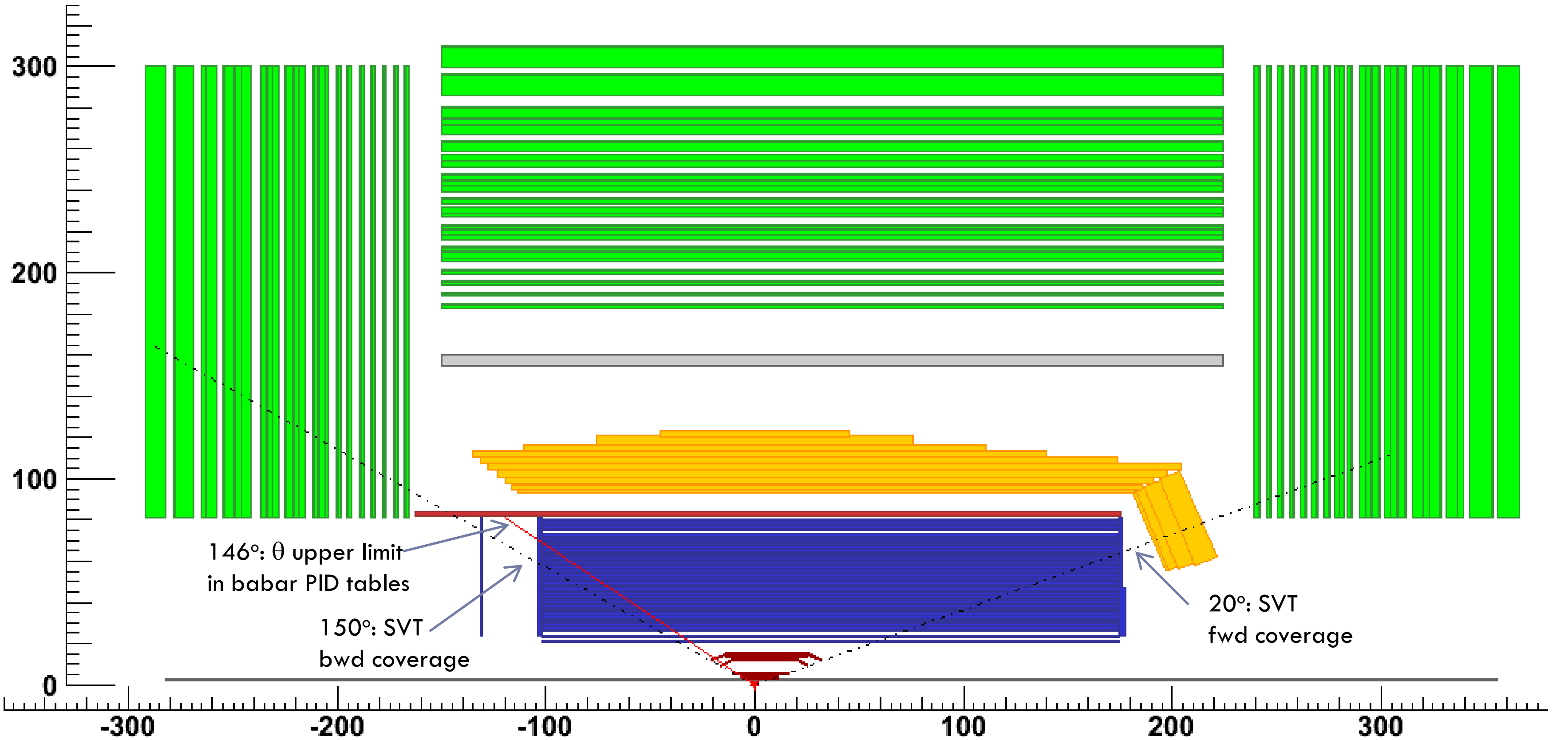
Angular coverage of FDIRC+TOF in CM as a function of the IP position w.r.t. the nominal (= BaBar) position



θ in lab frame constrained to be within the baseline SVT coverage [0.3,π-0.3]rad
Plots without this constraint in backup

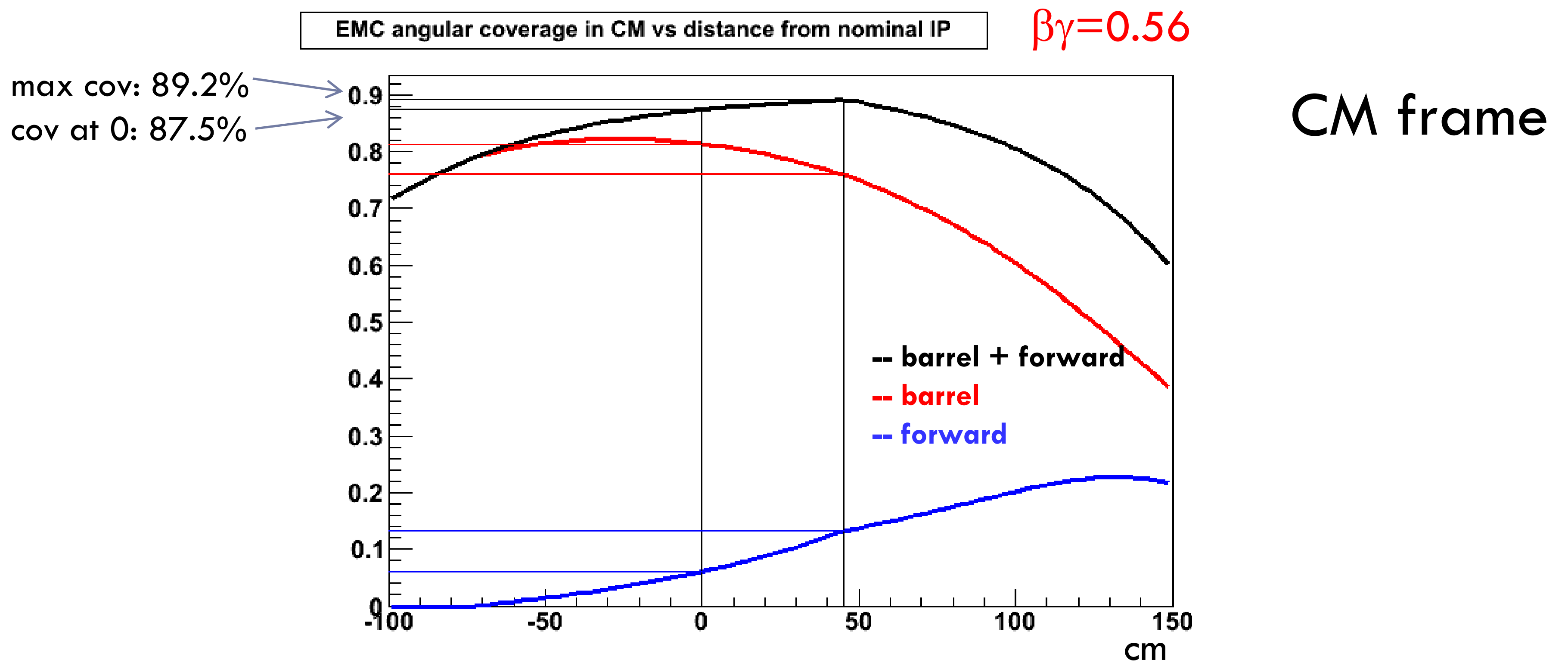
BaBar configuration

Babar SVT angular acceptance: [20,150]deg



EMC coverage vs IP position - Babar

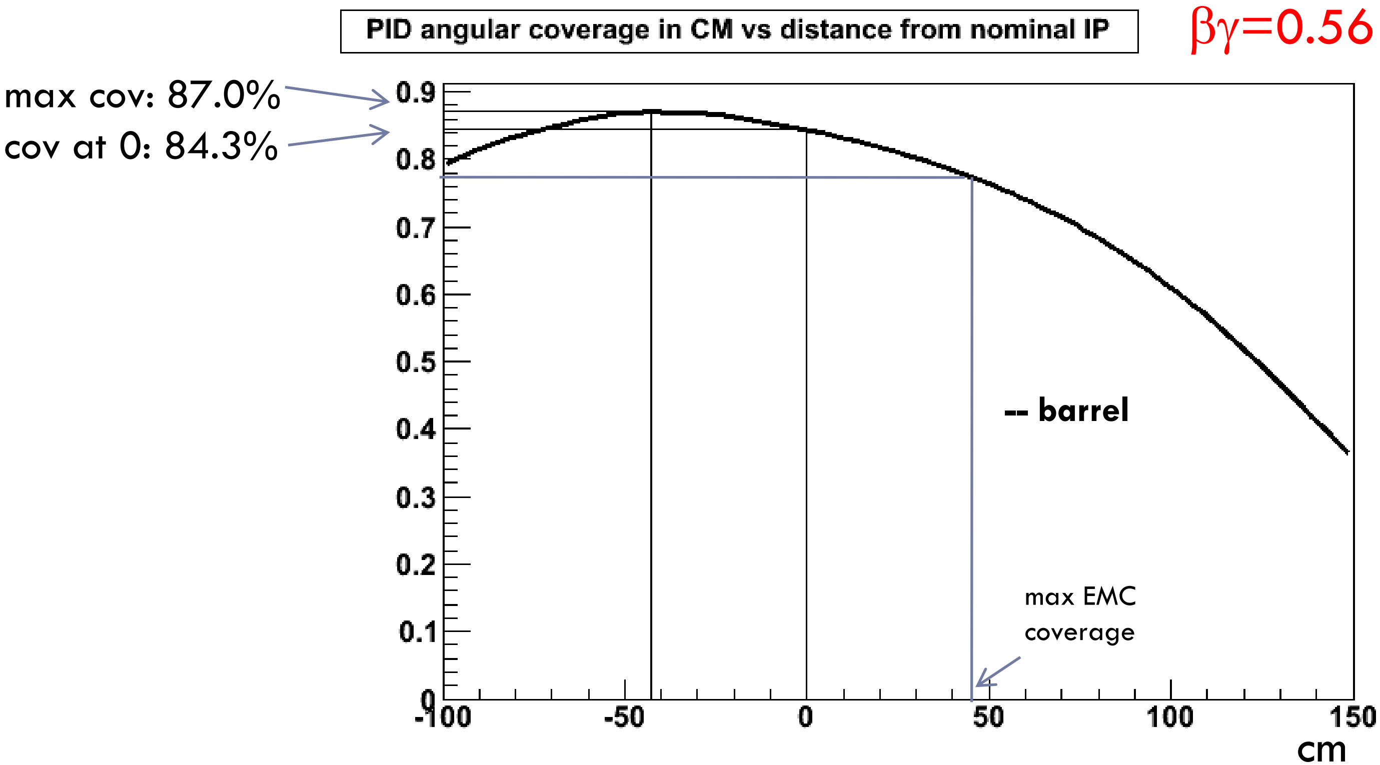
EMC angular coverage in CM as a function of the IP position w.r.t. the nominal position



θ in lab frame constrained to be within the SVT coverage [0.35,π-0.52]rad

DIRC coverage vs IP position - Babar

DIRC angular coverage in CM as a function of the IP position w.r.t. the nominal position



CM frame

θ in lab frame constrained to be between 20° (=0.35rad, SVT fwd coverage) and 146° (upper limit of Babar kaon PID tables)