track and B reconstrction vs DCH length

M. Rama, SuperB general meeting
14 December 2010

Outline

Goal: evaluate the impact of the drift chamber length on B reconstruction.
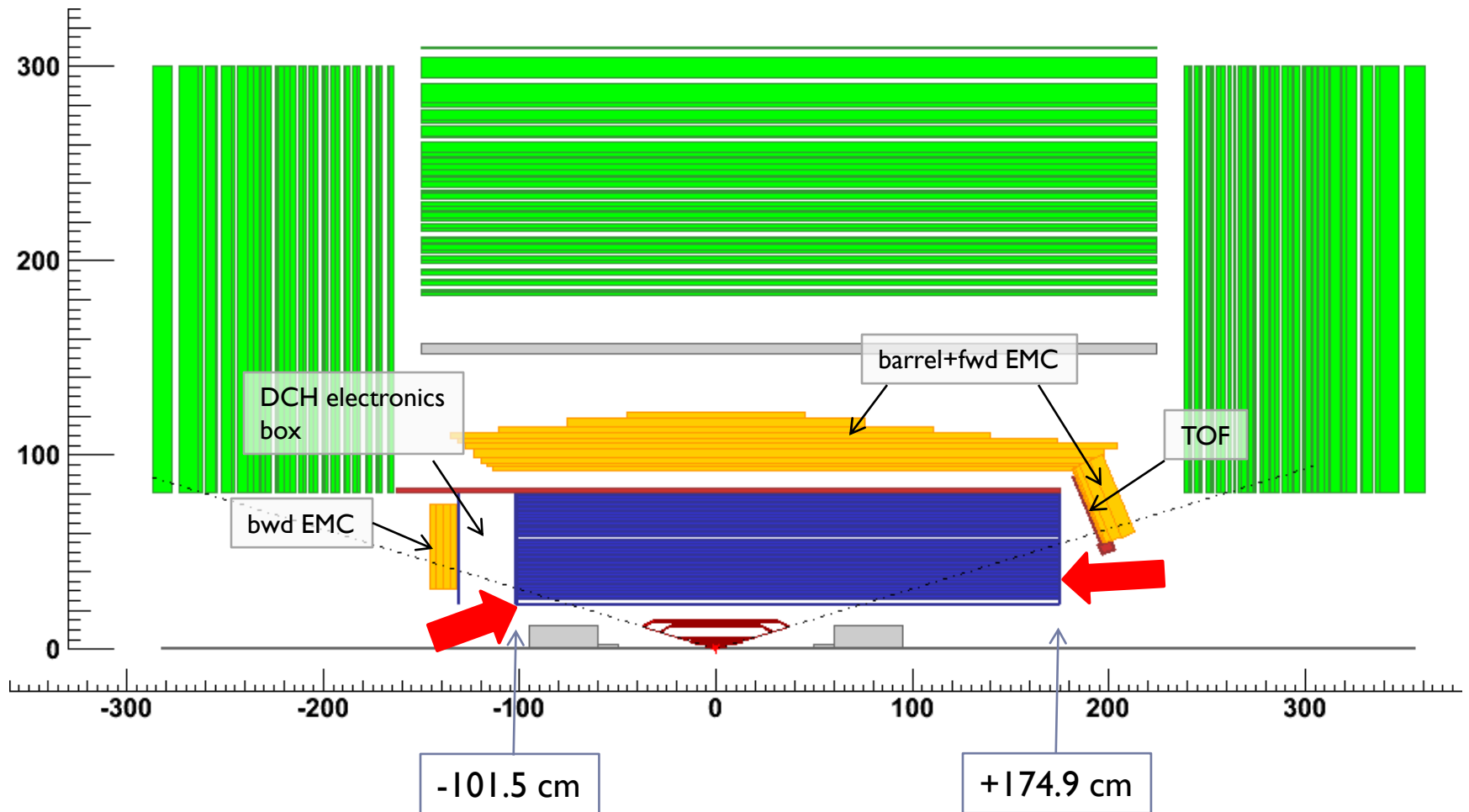It's an update of a previous study (general SuperB meeting at LNF, Dec 2009)

4 DCH configurations:

⊕ baseline
⊕ 20cm shorter in the forward region (FARICH case)
⊕ 20cm longer in the backward region (no bwd EMC)
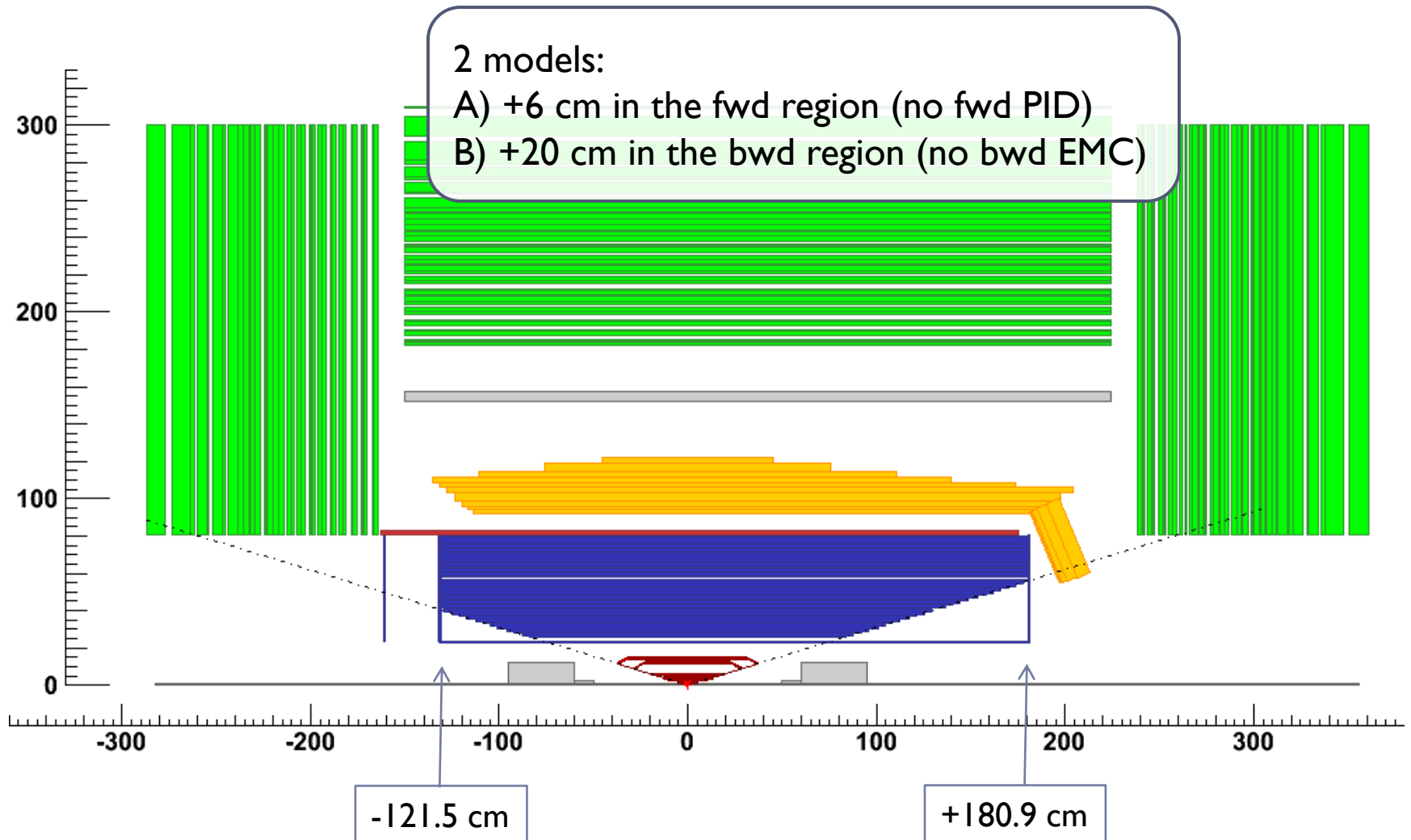⊕ 6cm longer in forward region (no fwd PID)

Simulated events:

FastSim V0.2.5 patched
4x100k single pions
4x100k $B^0 \to \pi^+ \pi^-$ events
4x100k $B^0 \to D^* K$ events

machine background not included

baseline DCH
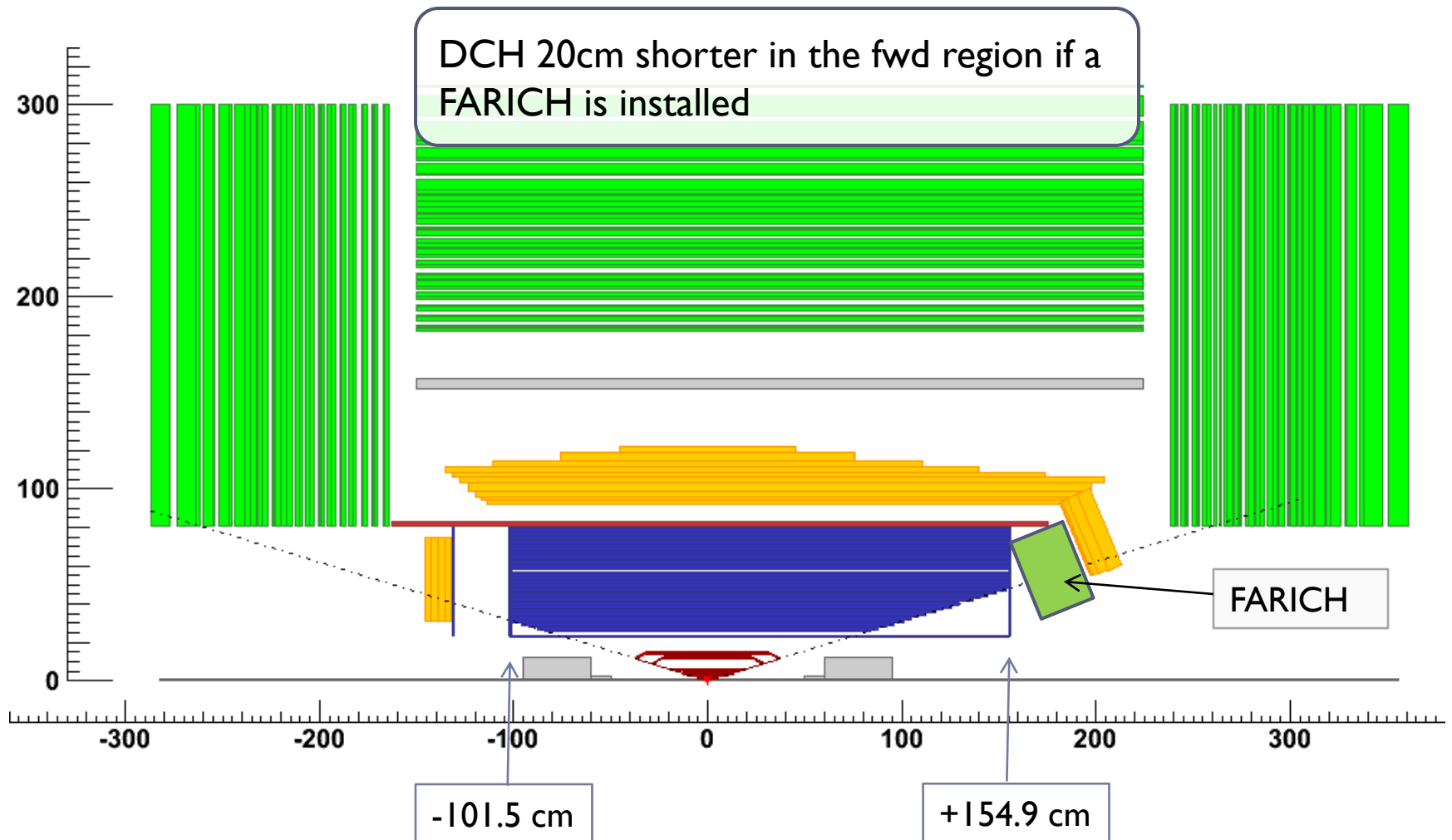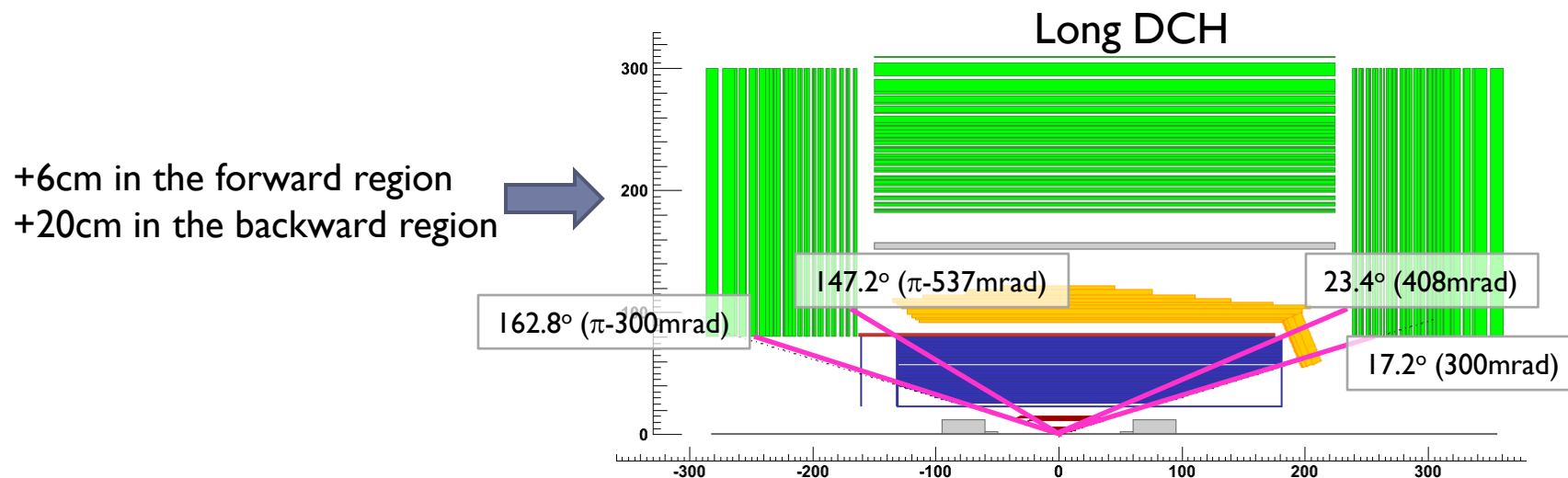
Long DCH

2 models:
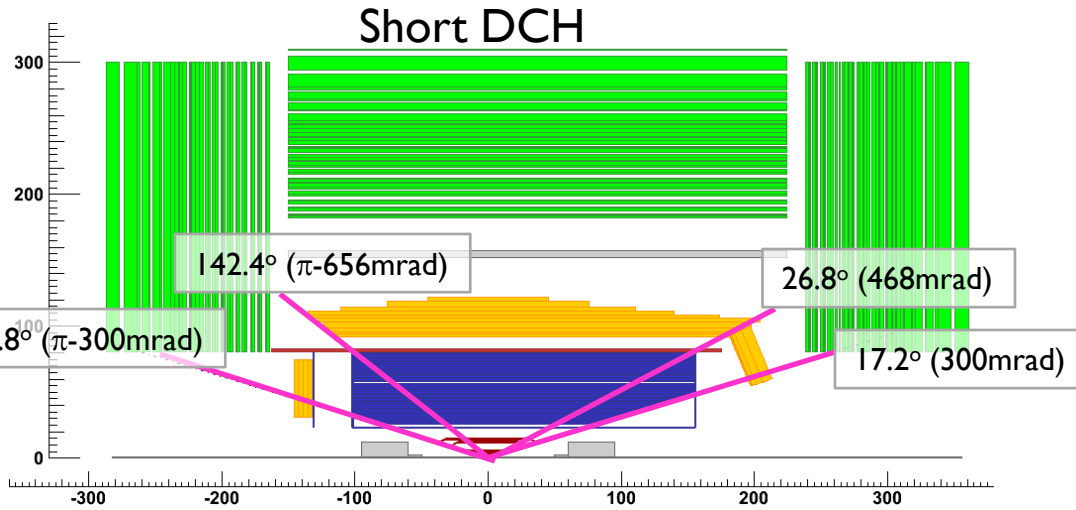A) +6 cm in the fwd region (no fwd PID)
B) +20 cm in the bwd region (no bwd EMC)

-121.5 cm

+180.9 cm

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Short DCH

DCH 20cm shorter in the fwd region if a FARICH is installed

FARICH

-101.5 cm

+154.9 cm

Angles useful to interpret the patterns in next slides

baseline

142.4° (π-656mrad)

24.1° (420mrad)

162.8° (π-300mrad)

17.2° (300mrad)

Long DCH

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

147.2° (π-537mrad)

23.4° (408mrad)

162.8° (π-300mrad)

17.2° (300mrad)

Angles (II)

Short DCH

162.8° (π-300mrad)

142.4° (π-656mrad)

26.8° (468mrad)

17.2° (300mrad)
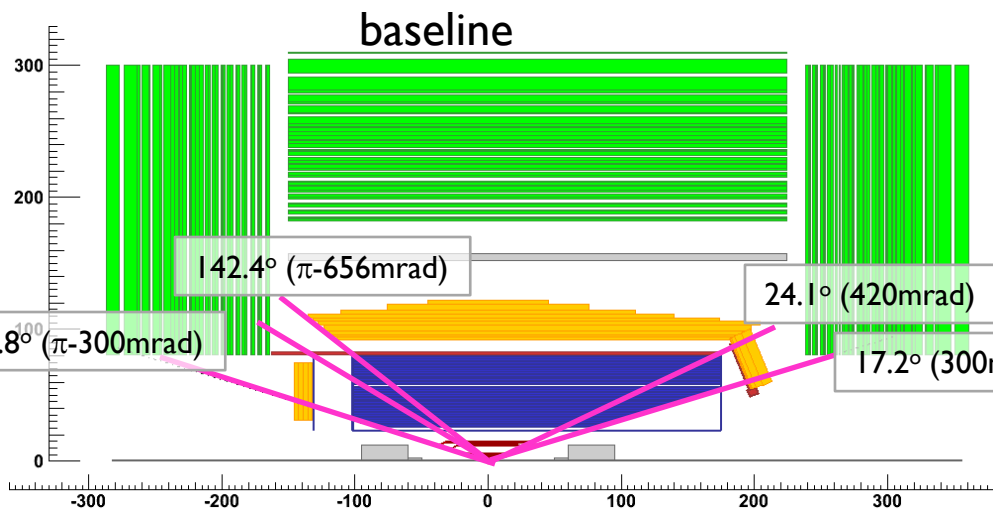
drift chamber hits as a function of the polar angle
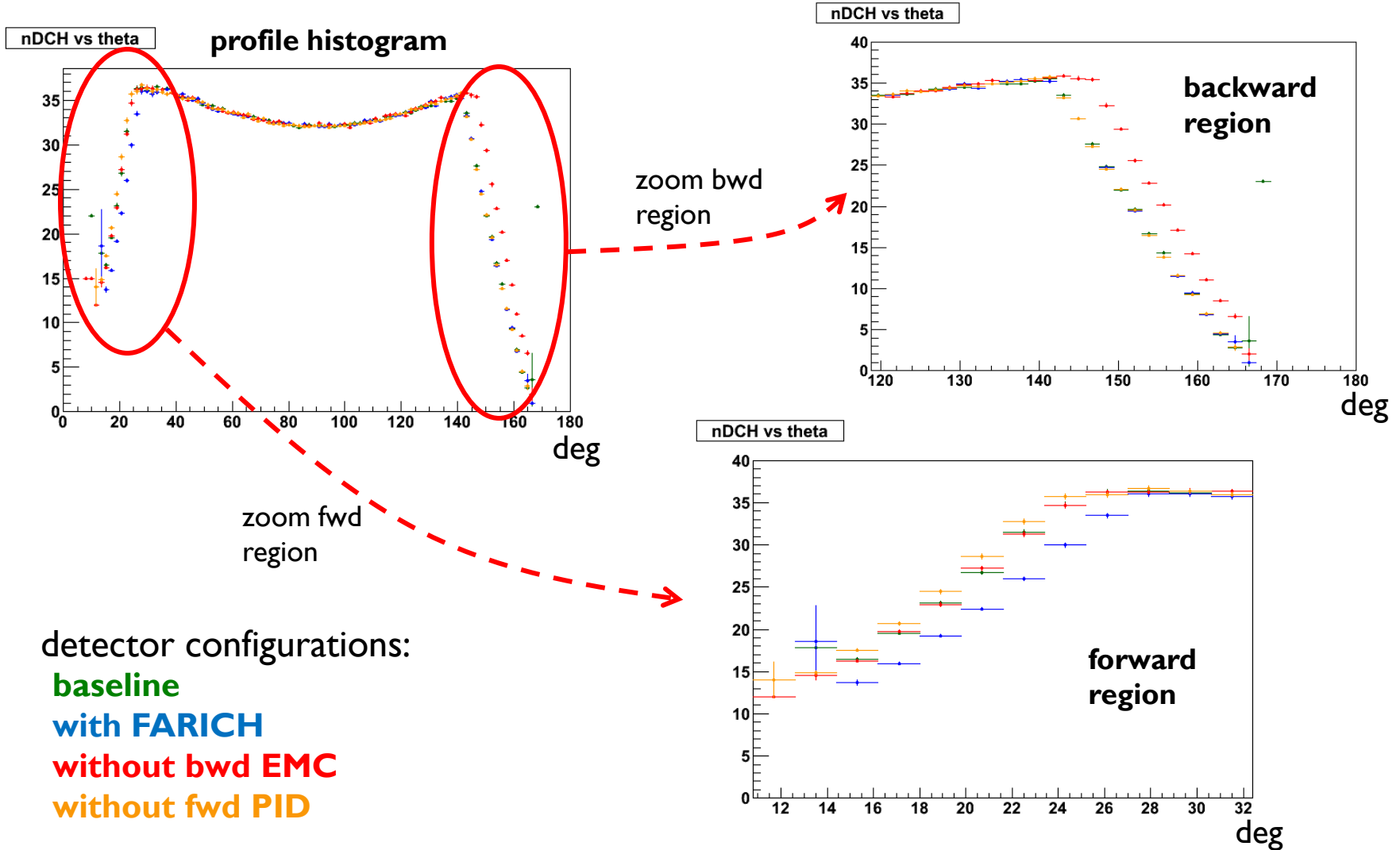
nDCH vs theta

profile histogram

nDCH vs theta

backward region

zoom bwd region

deg

deg

nDCH vs theta

zoom fwd region

forward region

deg

detector configurations:
 baseline
 with FARICH
 without bwd EMC
 without fwd PID

single particles:
p resolution at θ=23°

Note: the stat errors are smaller than the squares size

σp/p

baseline
with FARICH
without bwd EMC
without fwd PID

p (GeV)

σp (GeV)

baseline
with FARICH
without bwd EMC
without fwd PID

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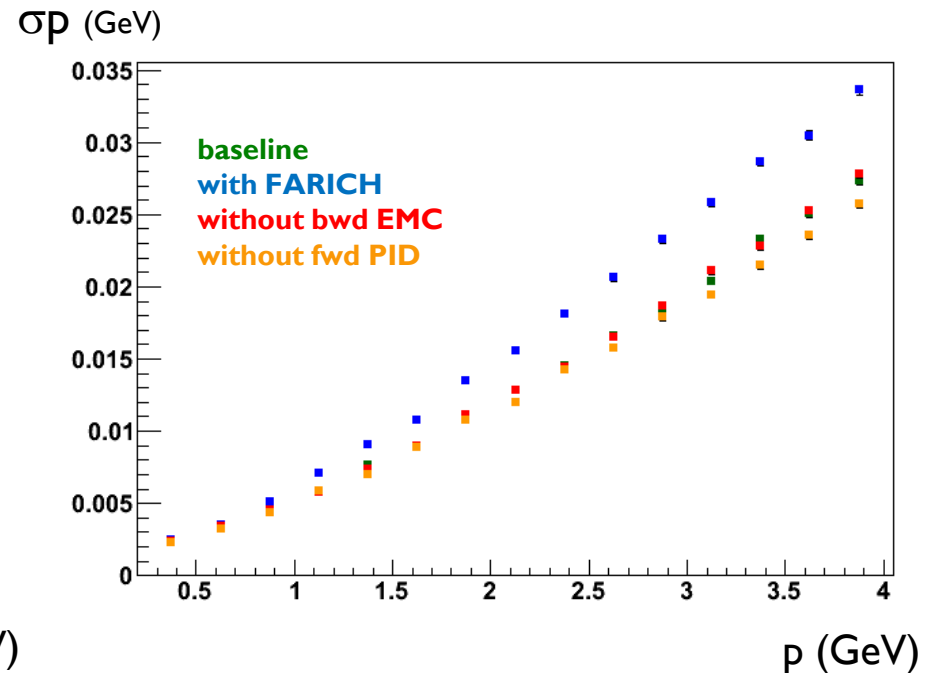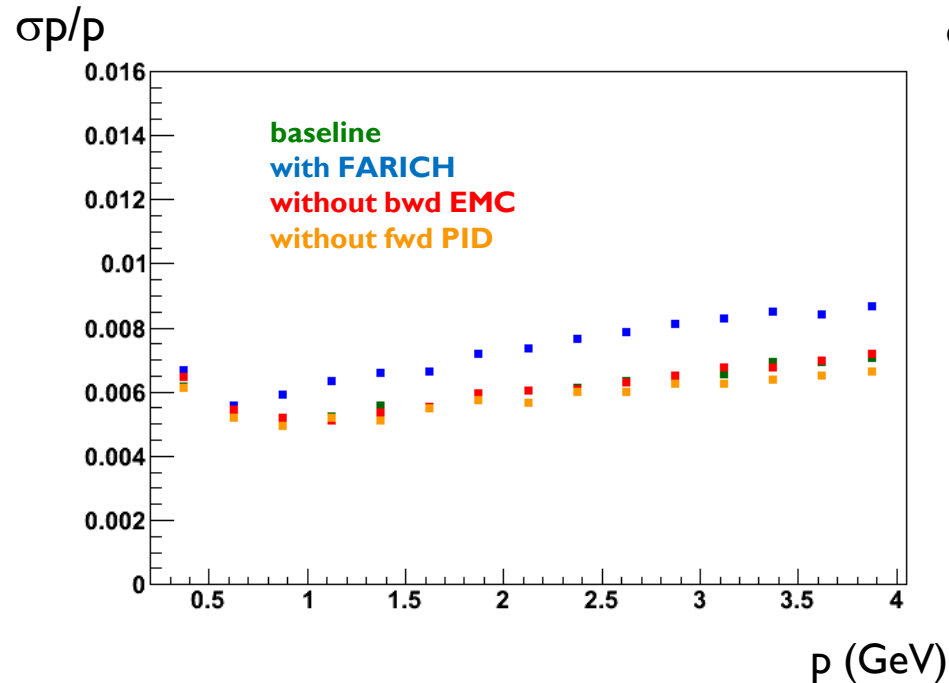
p resolution in Short DCH worsens by ~20% in fwd region (for θ=23°)
negligible effect in Long DCH vs. Masked DCH

single particles:
p resolution at θ=150°

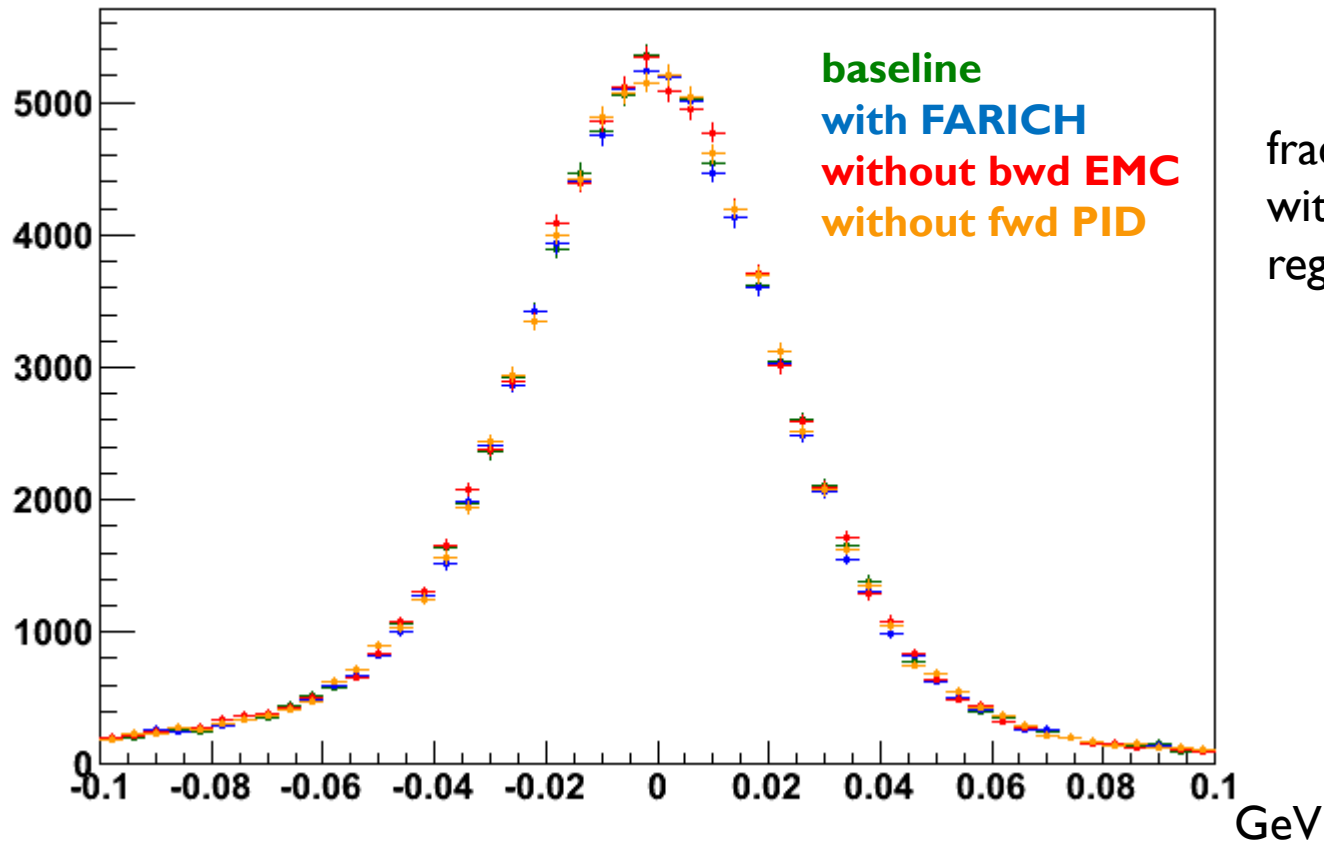Note: the stat errors are smaller than the squares size

σp/p

baseline
with FARICH
without bwd EMC
without fwd PID

p (GeV)

σp (GeV)

baseline
with FARICH
without bwd EMC
without fwd PID

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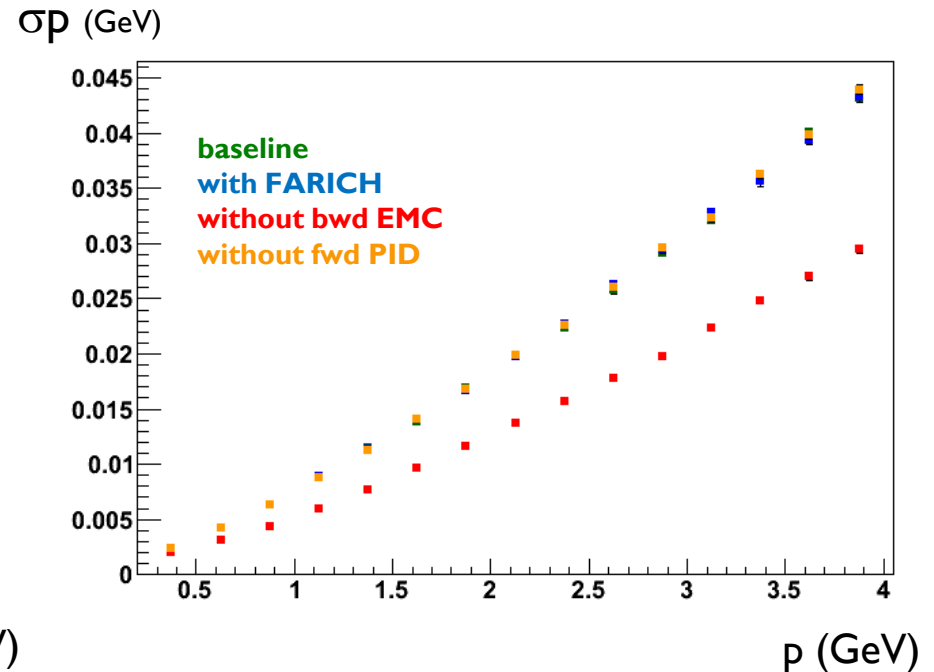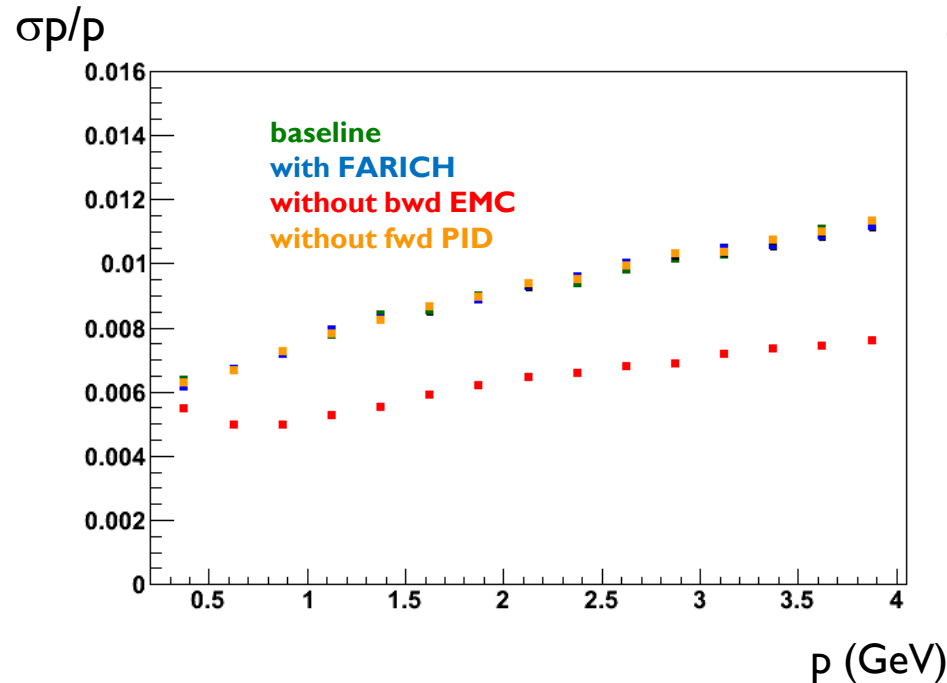
p resolution in Long DCH improves by ~30% in bwd region (for θ=150°)

Effect on B➔π⁺π⁻ reconstruction

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

DeltaE

baseline
with FARICH
without bwd EMC
without fwd PID

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

GeV

the effect on the overall ΔE distribution is hardly visible

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

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?

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

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

If $\sigma(p_1) \rightarrow 1.2\ \sigma(p_1)$ 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%: $\sigma(\Delta E) \rightarrow \sim 1.01\ \sigma(\Delta E)$
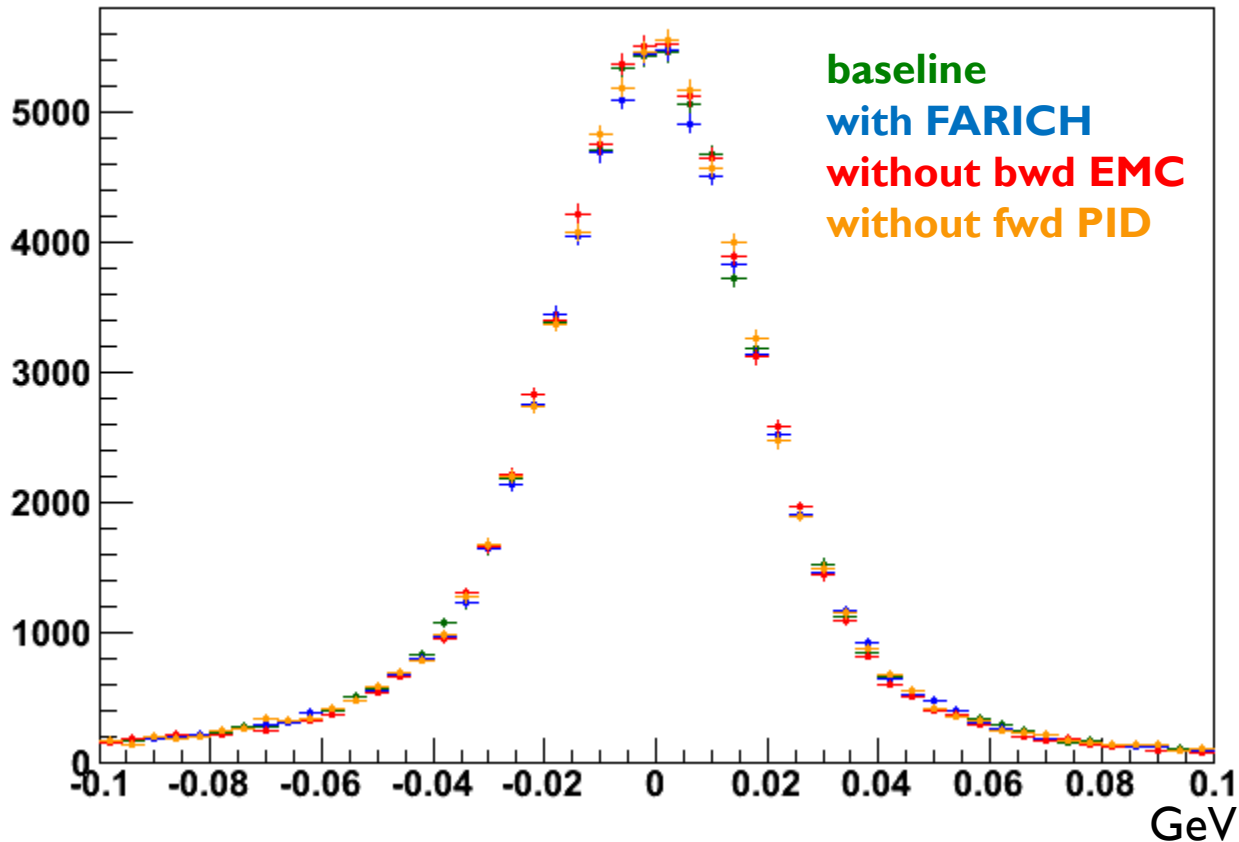
Assuming a Gaussian distribution for ΔE, a $\pm 2.5\sigma$ window correspond to a 2.5/1.01=2.475σ cut. The efficiency loss in this case would be ~0.1%. Due to the tails the loss is larger, but it remains ≤1%. **Consistent with what observed.**

Effect on B⁰→D*⁻K⁺ reconstruction

$B^0 \rightarrow D^{*-}K^+, D^{*-} \rightarrow D^0\pi^-, D^0 \rightarrow K\pi$ no selection cuts applied, just MC truth matching

DeltaE

baseline
with **FARICH**
without bwd **EMC**
without fwd **PID**

the effect on the overall ΔE distribution is hardly visible

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

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

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Conclusions

These results confirm the previous study

- significant improvement of p resolution in bwd region with long DCH (no bwd EMC)

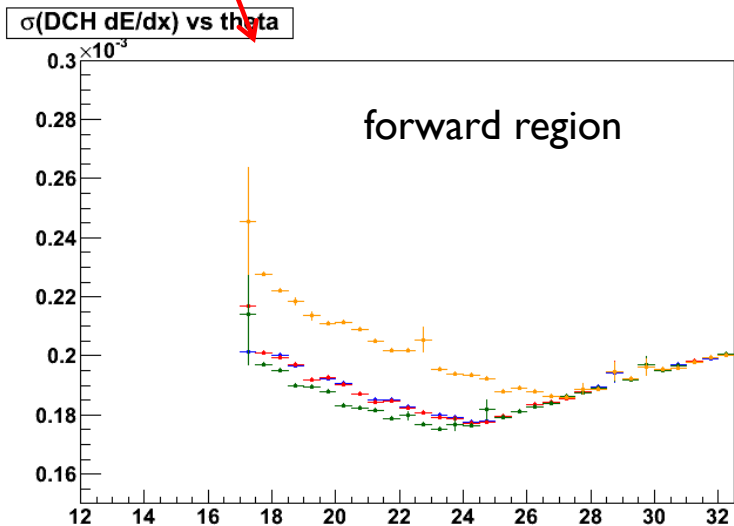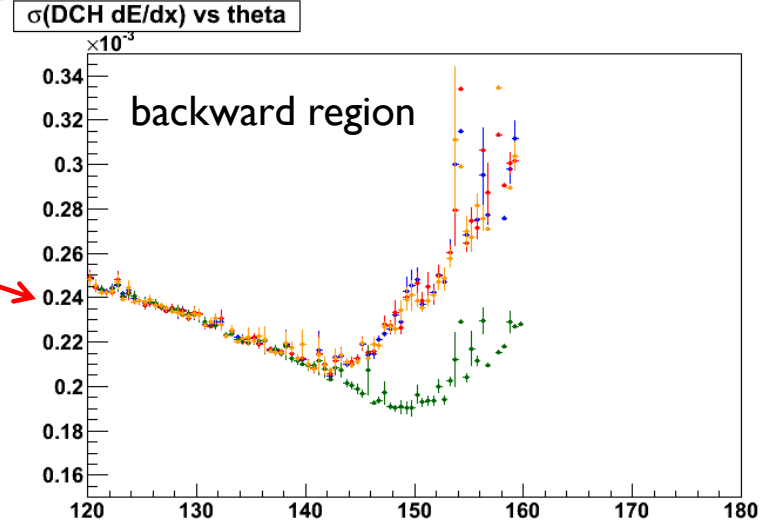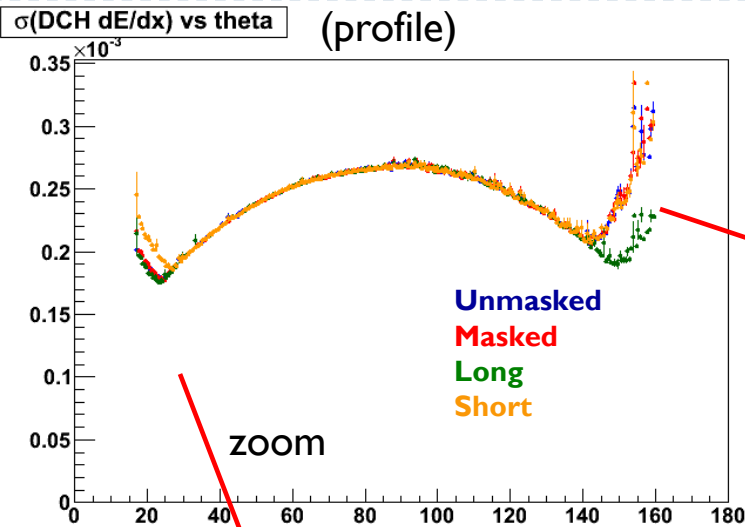- significant worsening of p resolution in fwd region with short DCH (FARICH)

BUT

- the overall impact on B reconstruction is small (modes considered: B→ππ, B→D*K). The variation of the selection efficiency for a 2.5σ ΔE selection window is ≤1%.

backup

tracks from B→ππ:
σ(DCH dE/dx) vs polar angle

σ(DCH dE/dx) vs theta (profile)

Unmasked
Masked
Long
Short

zoom

σ(DCH dE/dx) vs theta

backward region

zoom

σ(DCH dE/dx) vs theta

forward region
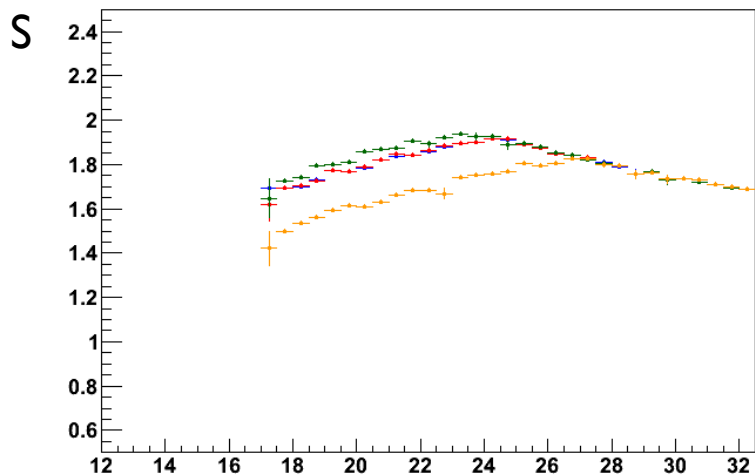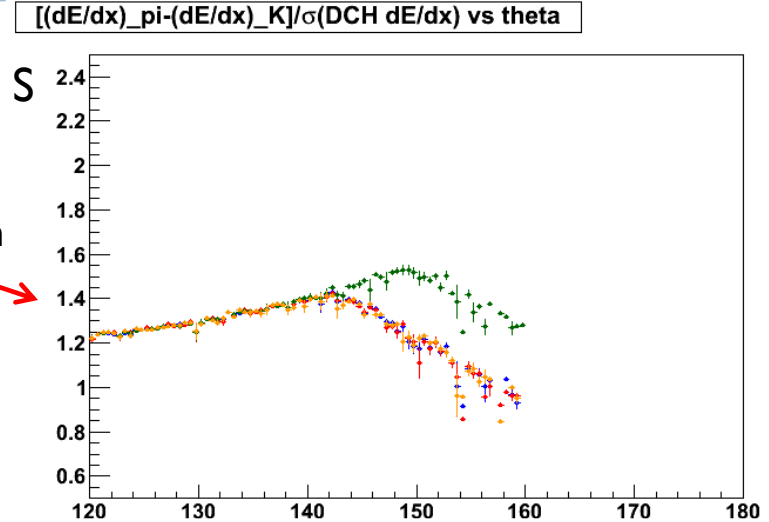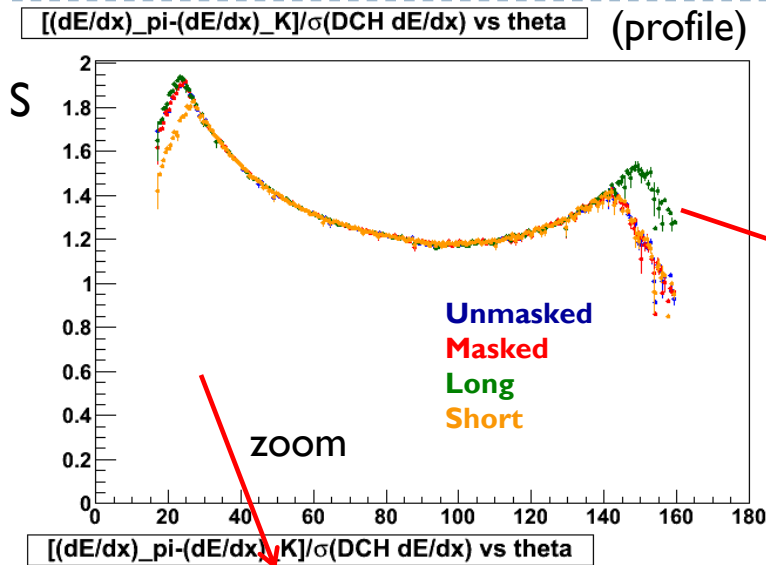
Note: the spread of the dE/dx measurement of the single hit is parameterized as:

$$\sigma(dE/dx) = a_1 (dE/dx)^{a_2} dl^{a_3}$$

$a_2 = 1$
$a_3 = -0.5$

a_1 (and also a2) is tuned to resemble the dE/dx π/K separation measured in Babar data (sl. 9)

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

[(dE/dx)_pi-(dE/dx)_K]/σ(DCH dE/dx) vs theta (profile)

Unmasked
Masked
Long
Short

zoom

[(dE/dx)_pi-(dE/dx)_K]/σ(DCH dE/dx) vs theta

[(dE/dx)_pi-(dE/dx)_K]/σ(DCH dE/dx) vs theta

zoom

$S=[\text{Expected\_dE/dx}(pi)-\text{Expected\_dE/dx}(K))]/\sigma(dE/dx)$

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)

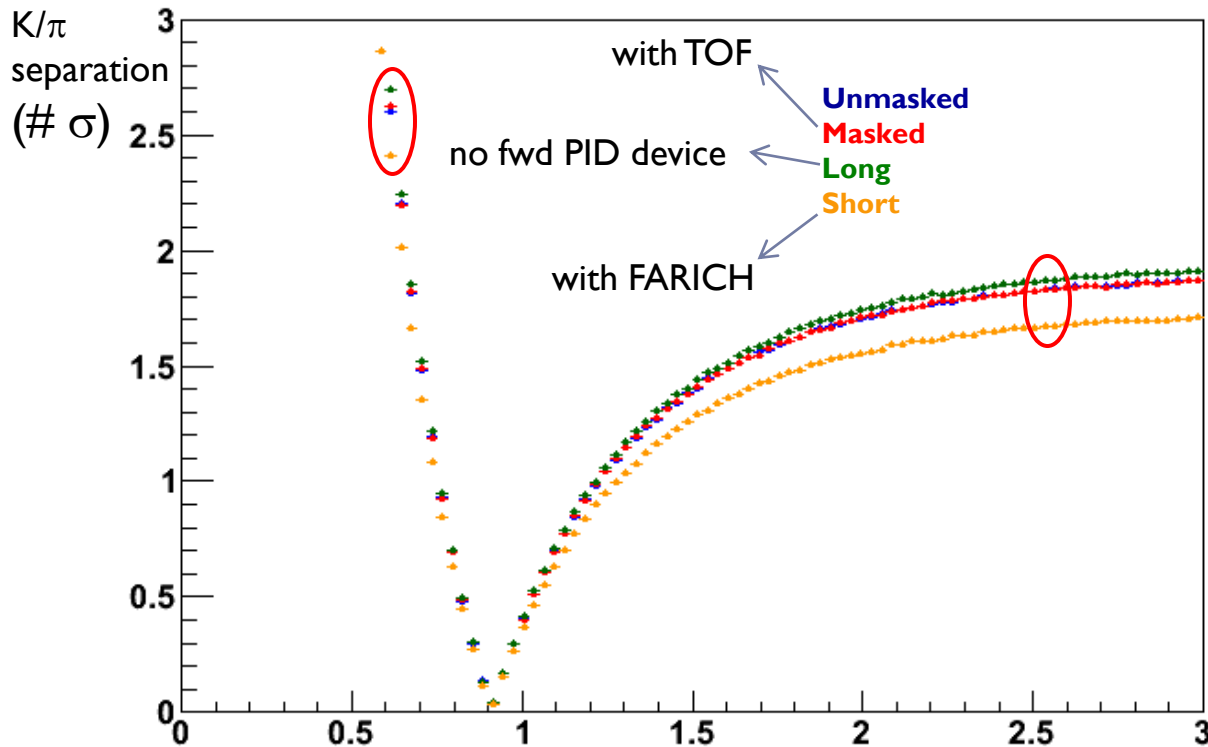## Short DCH w.r.t. Masked:
- 3.6% of tracks fall in the fwd region, where the dE/dx separation decreases by ~0.2σ

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

|(dE/dx)_pi-(dE/dx)_K|/σ(DCH dE/dx) vs p

K/π separation (# σ)

with TOF
Unmasked
Masked
Long
Short
no fwd PID device
with FARICH

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°

|(dE/dx)_pi-(dE/dx)_K|/σ(DCH dE/dx) vs p

K/π separation (# σ)

Unmasked
Masked
Long
Short

with bwd EMC

no bwd EMC

no bwd EMC ('Long')

~0.4σ difference @2.5GeV
~0.3σ difference @0.6GeV

with bwd EMC
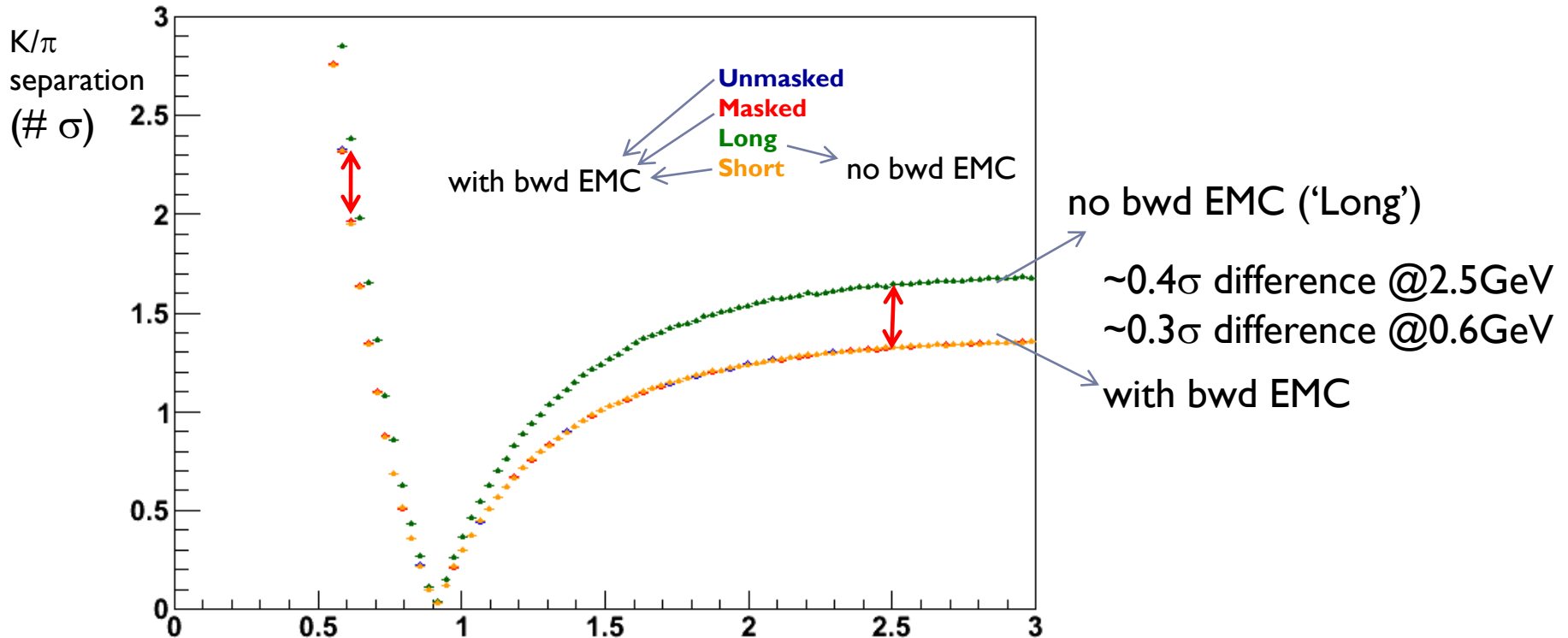
Summary

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→$\pi\pi$, B→D*K) ➔ Impact on B reconstruction (reco. efficiency, ΔE resolution) is very small

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

dE/dx BaBar vs fastsim
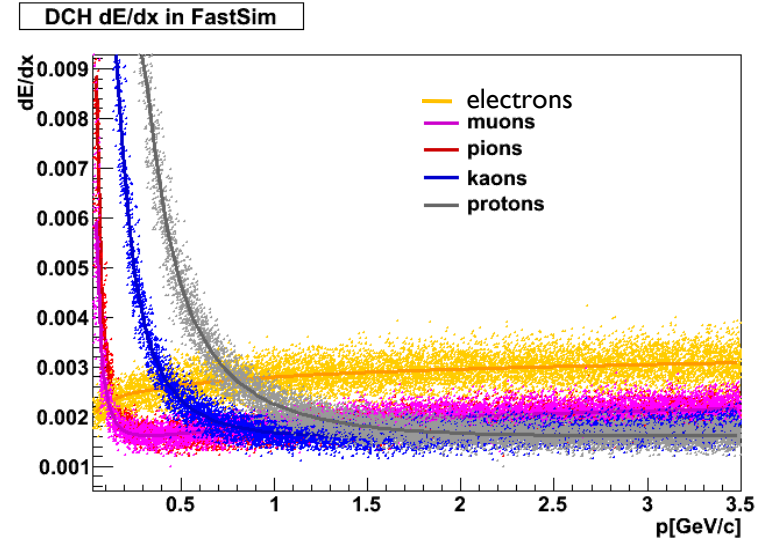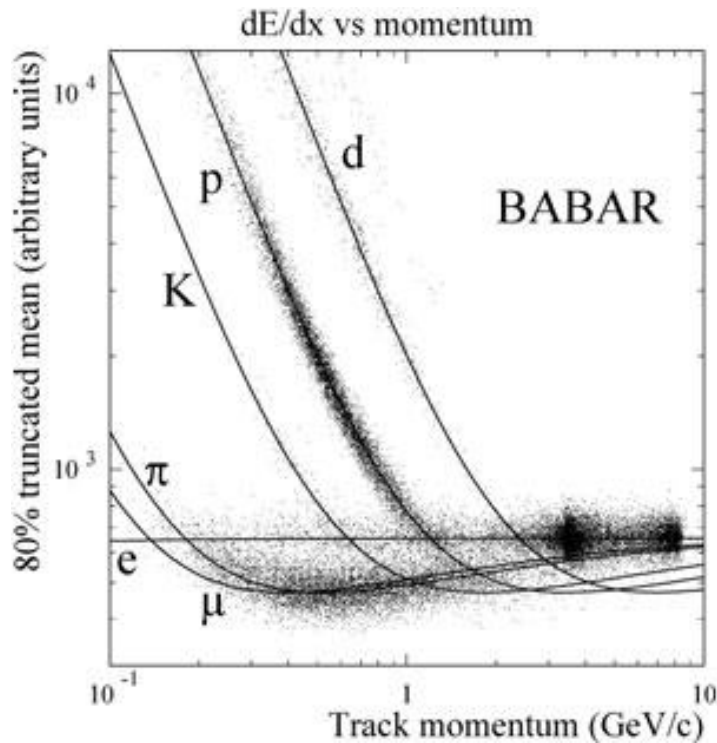
muons→protons: reasonable
electrons: need work