DCH performance vs endcap shape and position

Matteo Rama
Giuseppe Finocchiaro
LNF
10 October 2012

Goals

- Evaluate the DCH performance as a function of the shape and position of the endcaps
  - p resolution
  - K/π separation using dE/dx
  - B→D*K reco. efficiency, ΔE

- All studies shown in these slides have been produced using FastSim V0.3.2

Configurations

common features:

- 10 superlayers, 4 layers each: A A S_+ S_- S_+ S_- S_+ S_- A A
  - |stereo angle| ≈ 0.06 rad
  - inner wall radius: 26.5 cm
  - outer wall radius: 80.3 cm
  - sense wires r_{min} : 28.6 cm
  - sense wires r_{max} : 78.0 cm
- hit spatial resolution: babar-like
- hit efficiency vs polar angle: babar-like (babar-like: tuned on babar data)
- σ(dE/dx) modelization: babar-like
  - $\sigma\left(\frac{dE}{dx}\right) = \alpha \left|\frac{dE}{dx}\right|^{\beta} dx^{\gamma}$ α, β, γ tuned on babar data

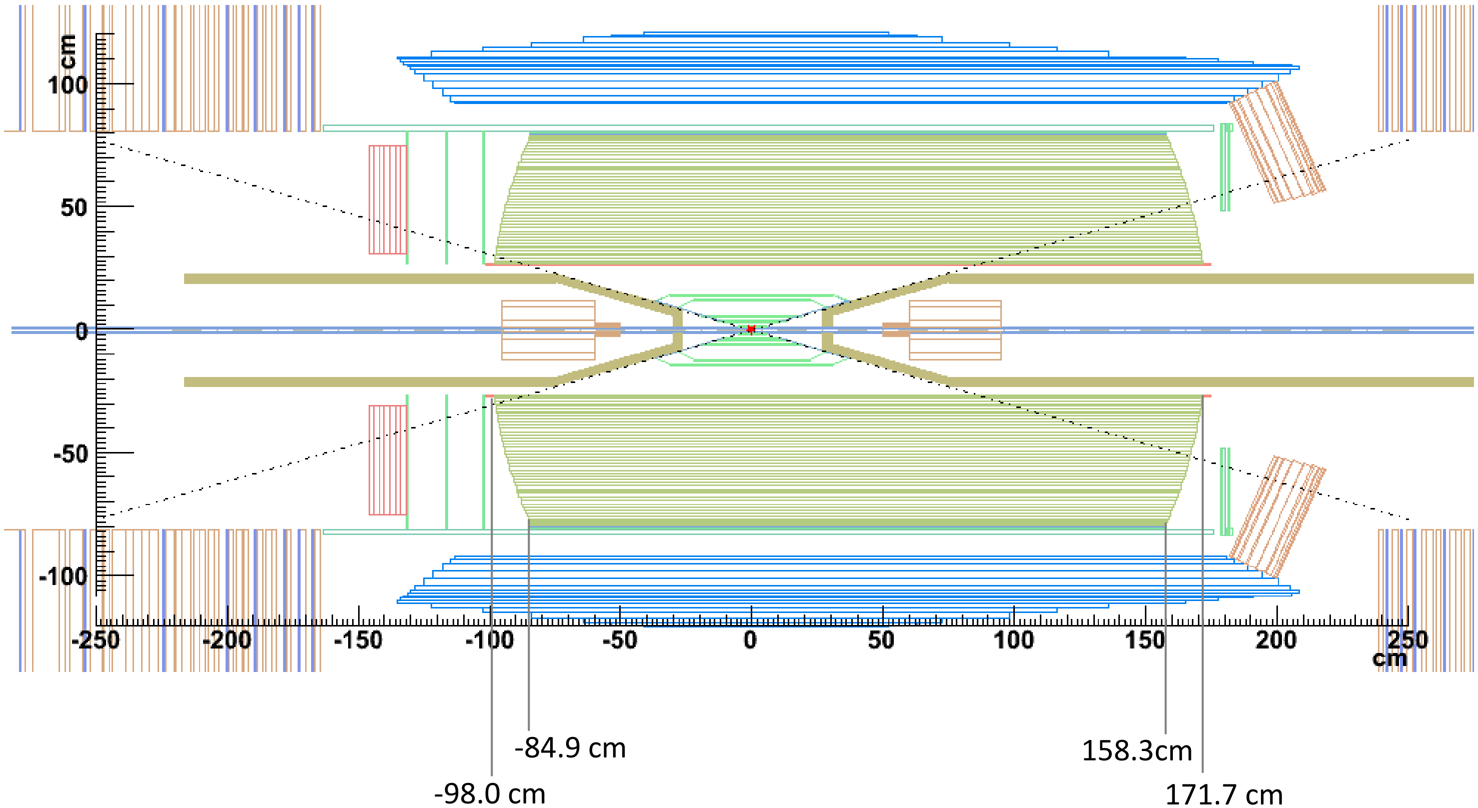
distinguishing features

- shape and position of endcaps
  - concave/convex
  - varying position along z

FastSim configurations based on drawings provided by S. Lauciani (see backup slides)

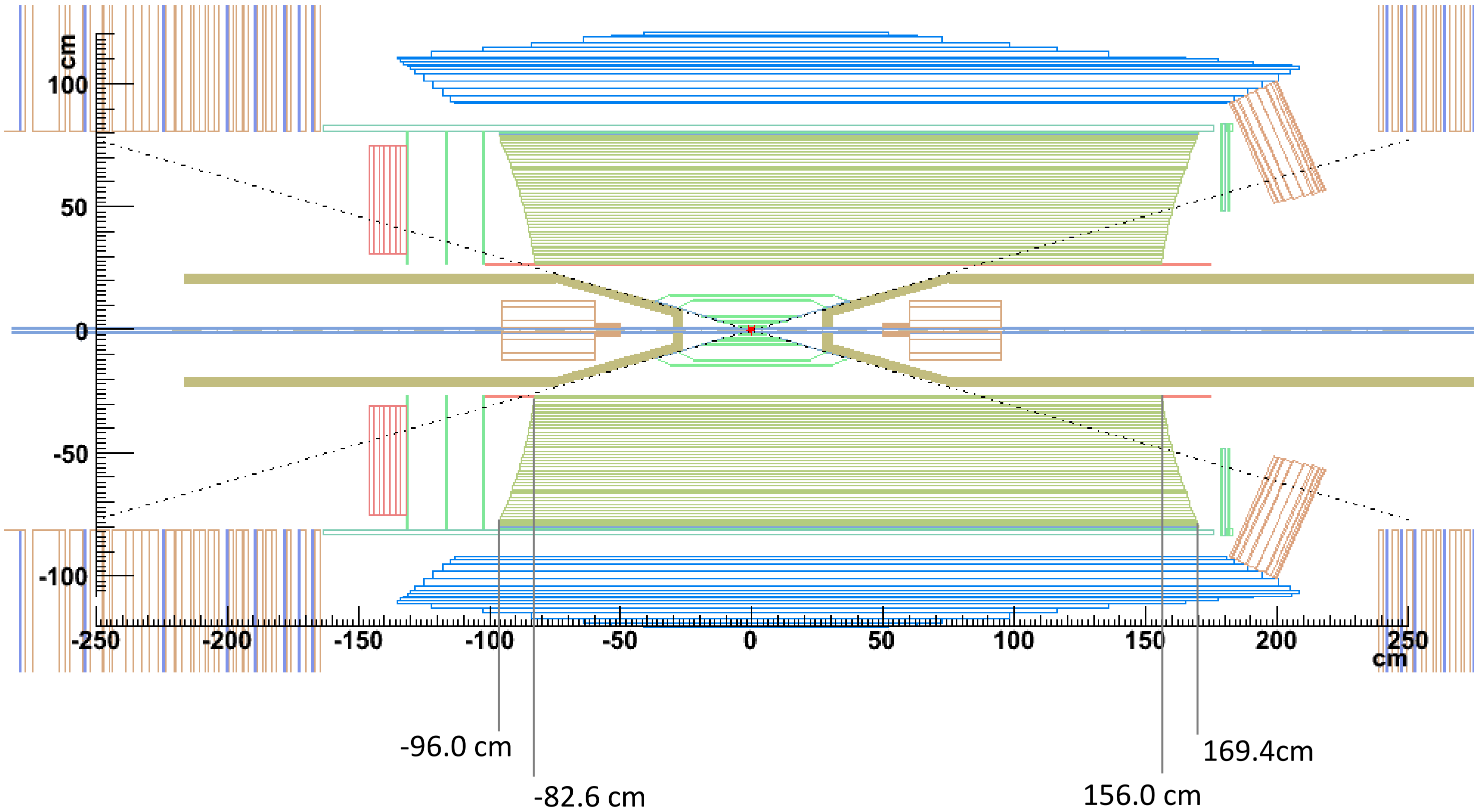
Option 1

x-z layout in fastsim



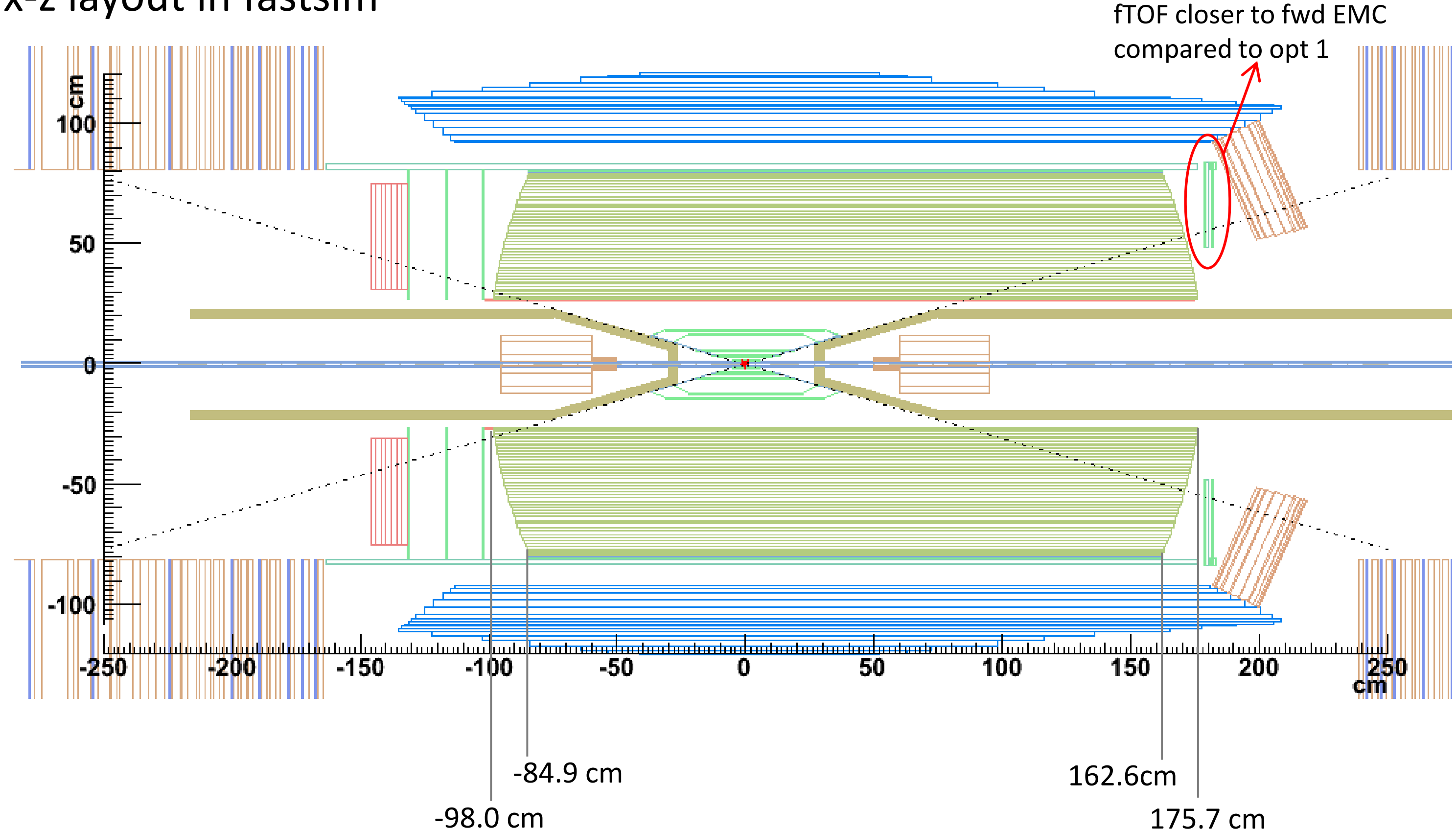
Option 2

x-z layout in fastsim



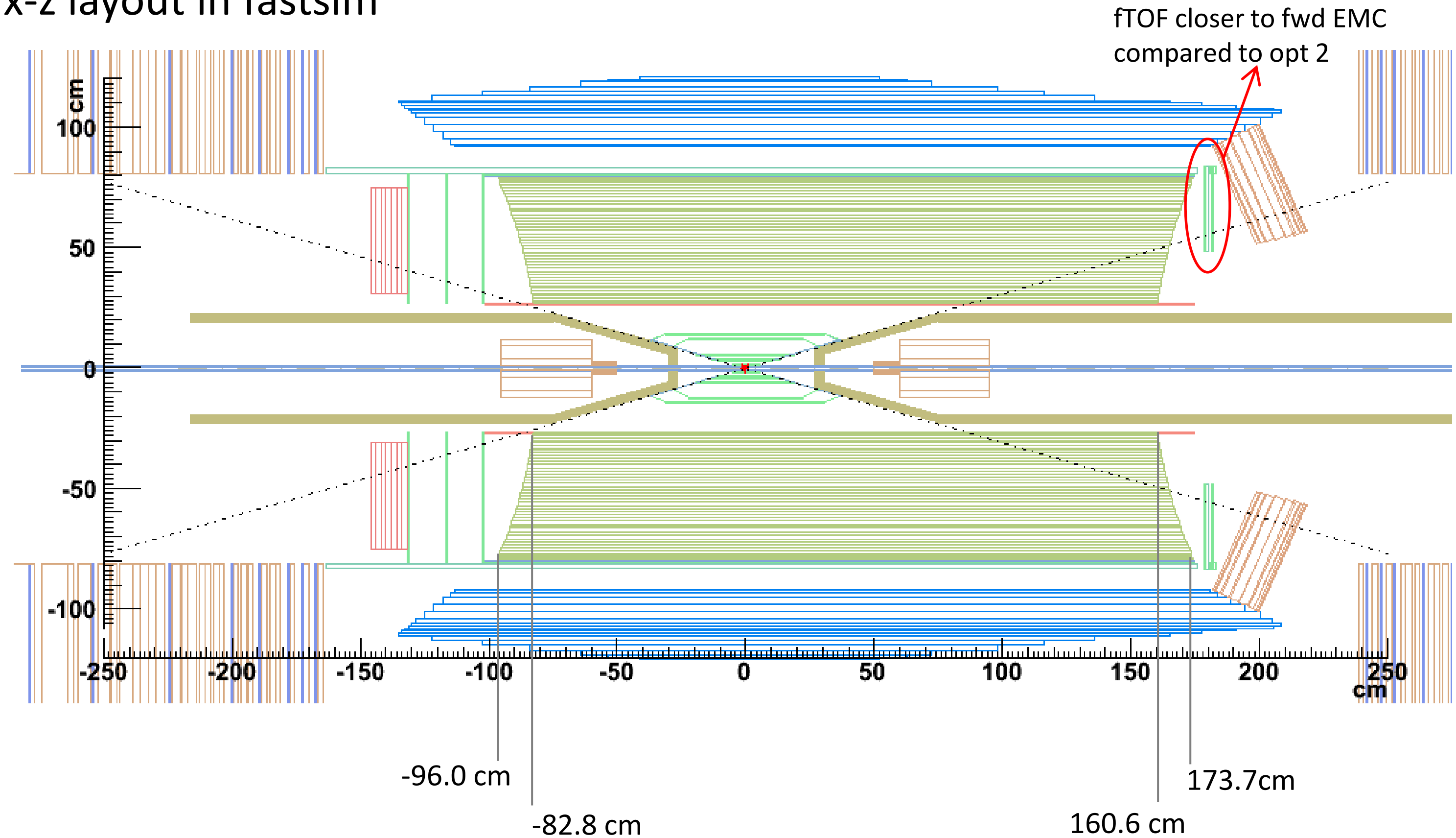
Option 3

x-z layout in fastsim



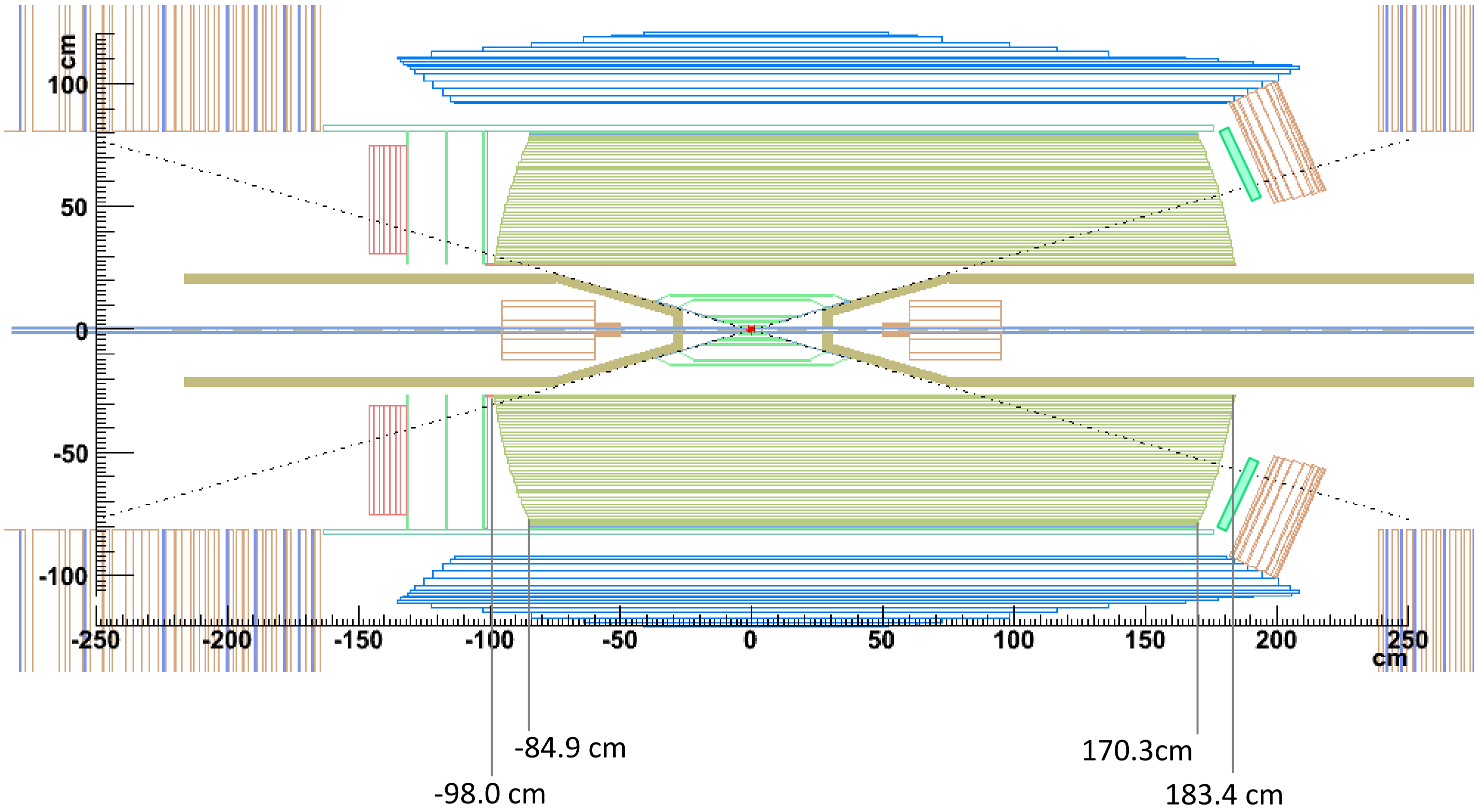
Option 4

x-z layout in fastsim



Option 5

x-z layout in fastsim

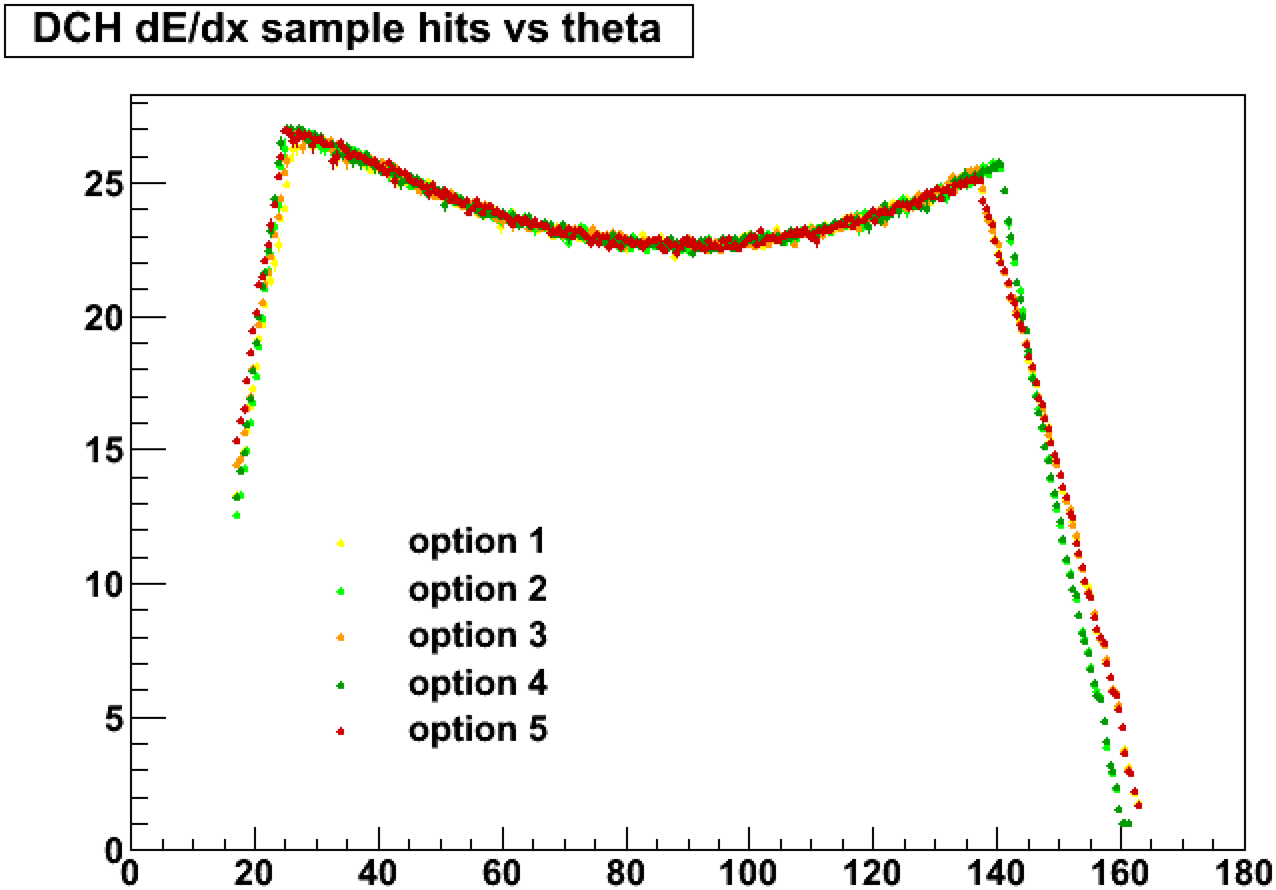


Part I
validation with p = 4 GeV/c single particles

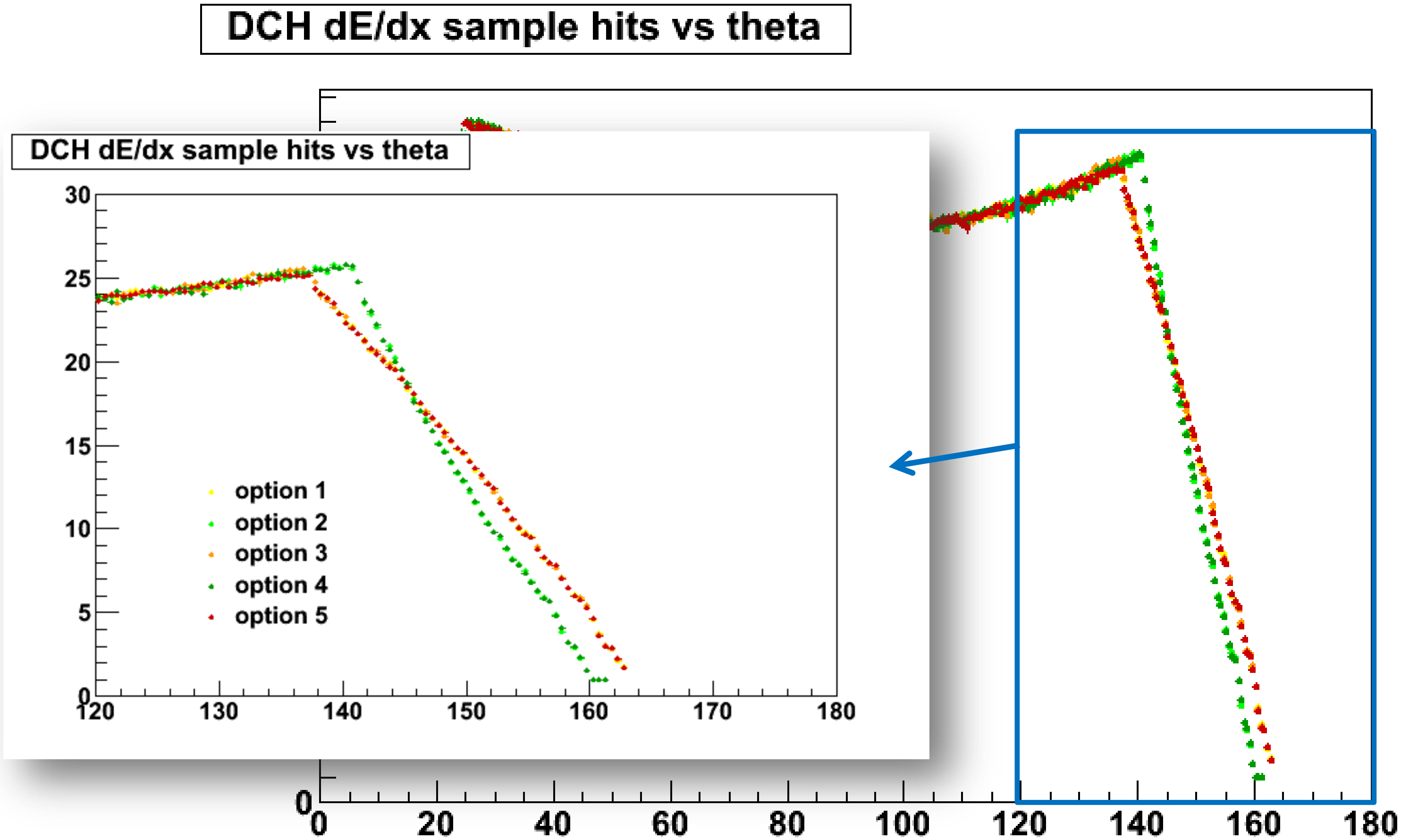
single particles generated with:

- p = 4 GeV/c
- dP/ dcosθ = const   [θ = polar angle]
- cosθ in [0.3,π-0.3] rad   [SVT angular acceptance]
- 50k events for each configuration

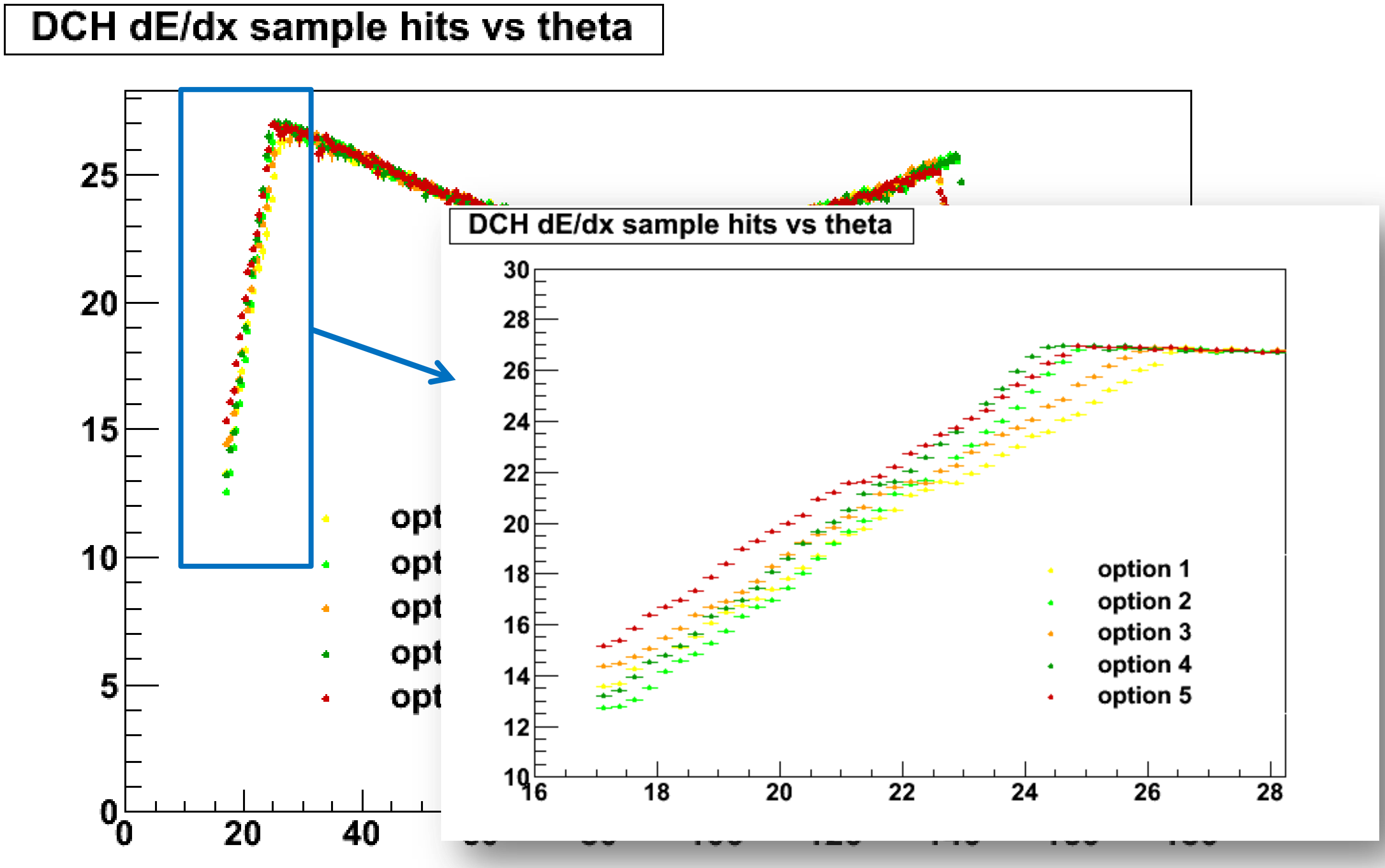
single π^+, p = 4GeV/c, flat cosθ



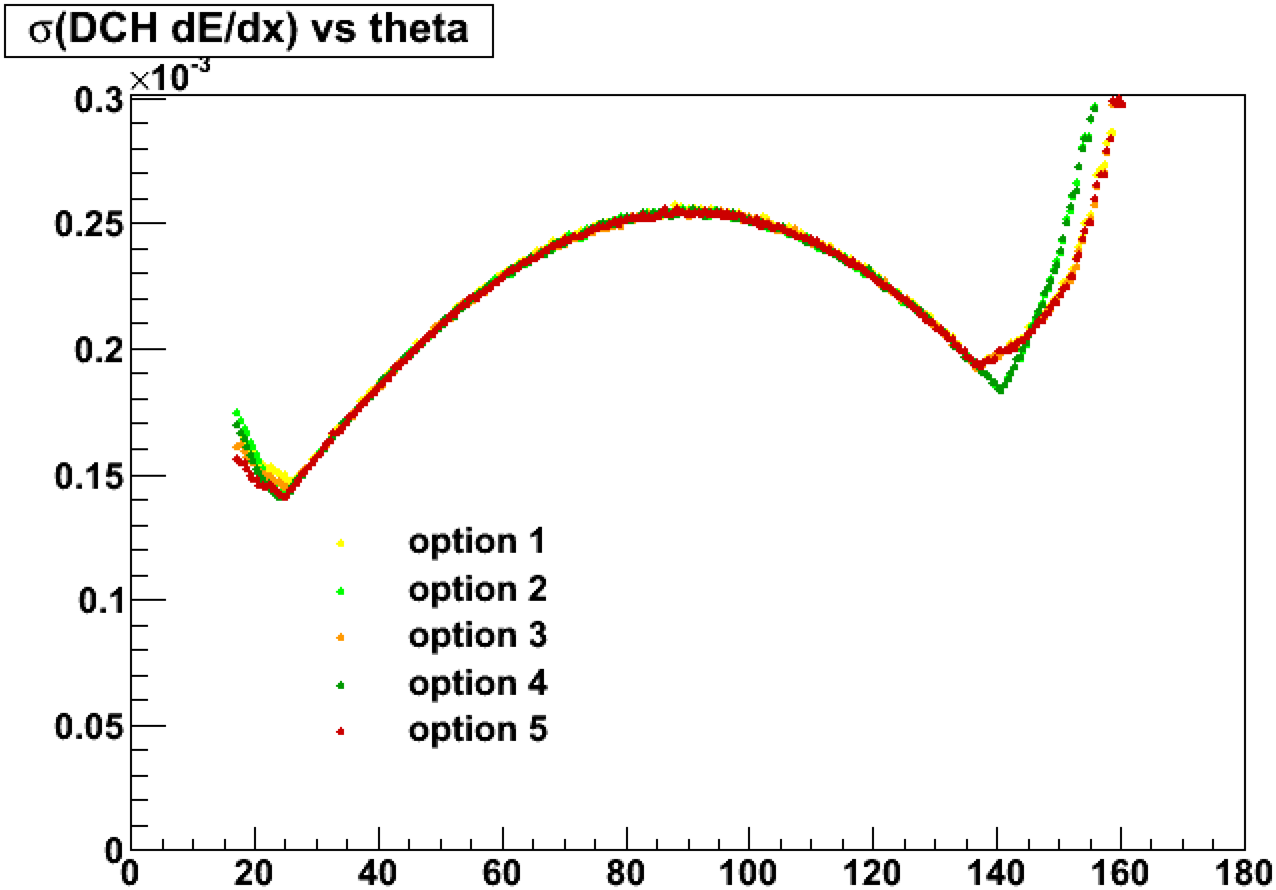
single π^+, p = 4GeV/c, flat cosθ



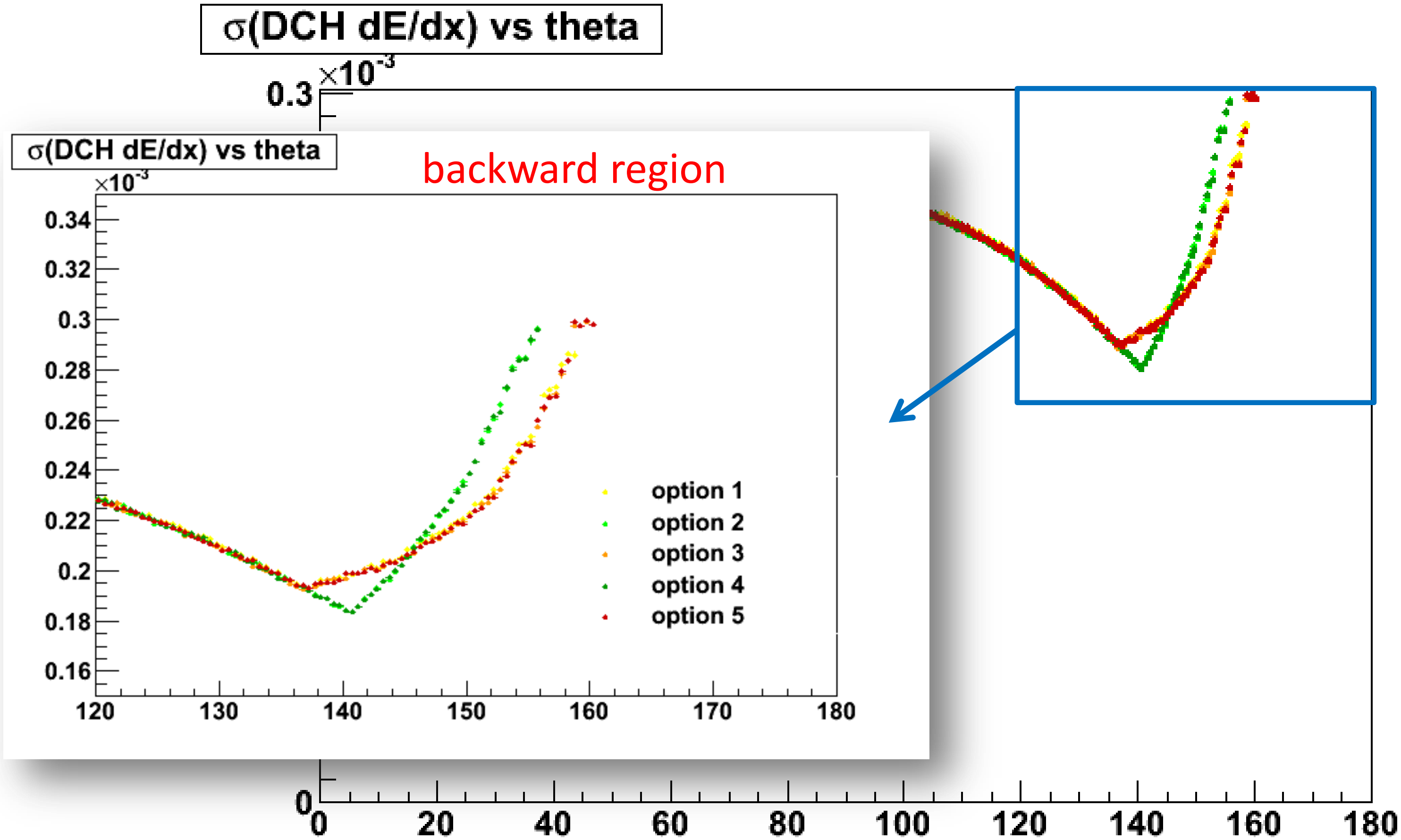
single π^+, p = 4GeV/c, flat cosθ



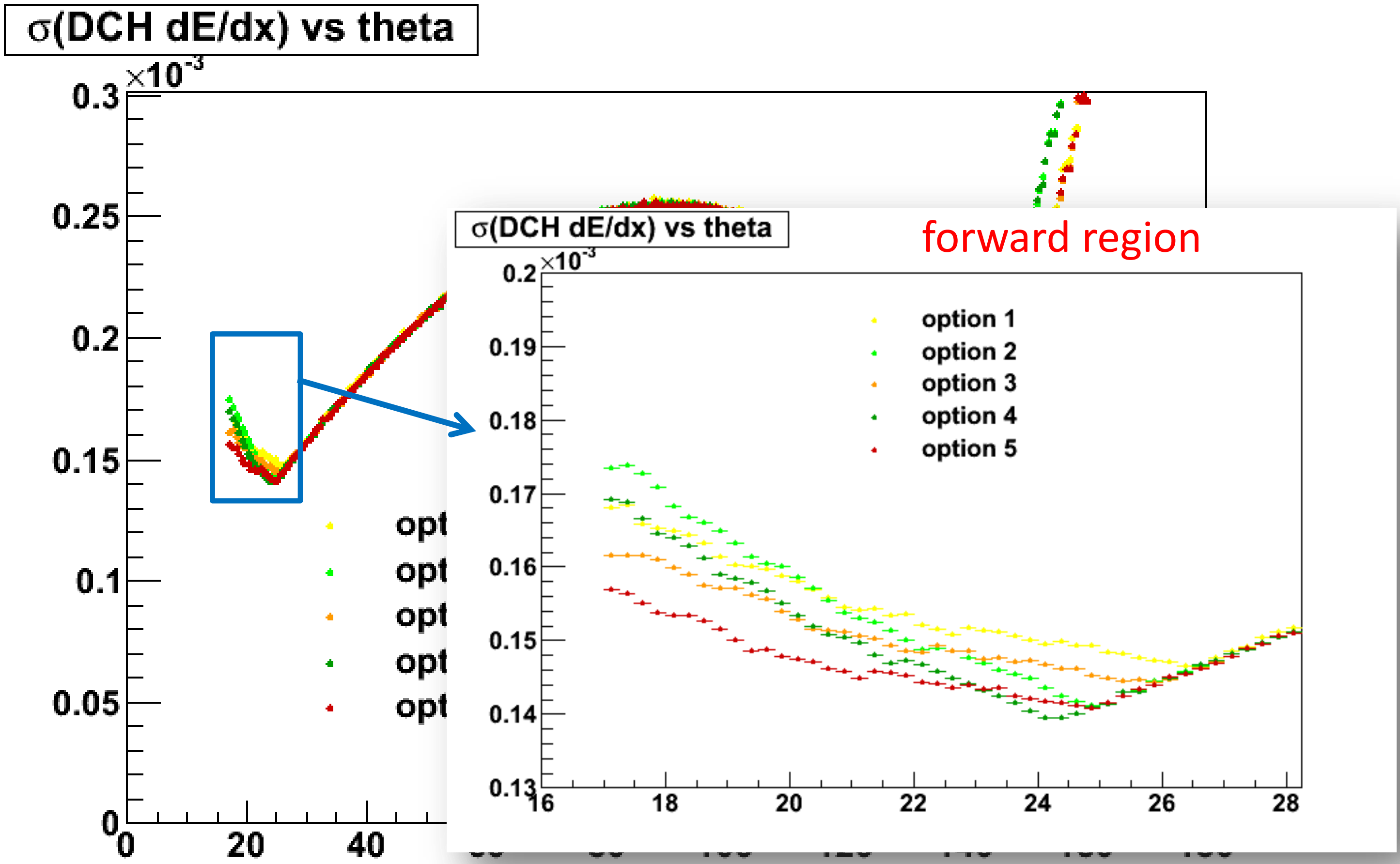
single π^+, p = 4GeV/c, flat cosθ



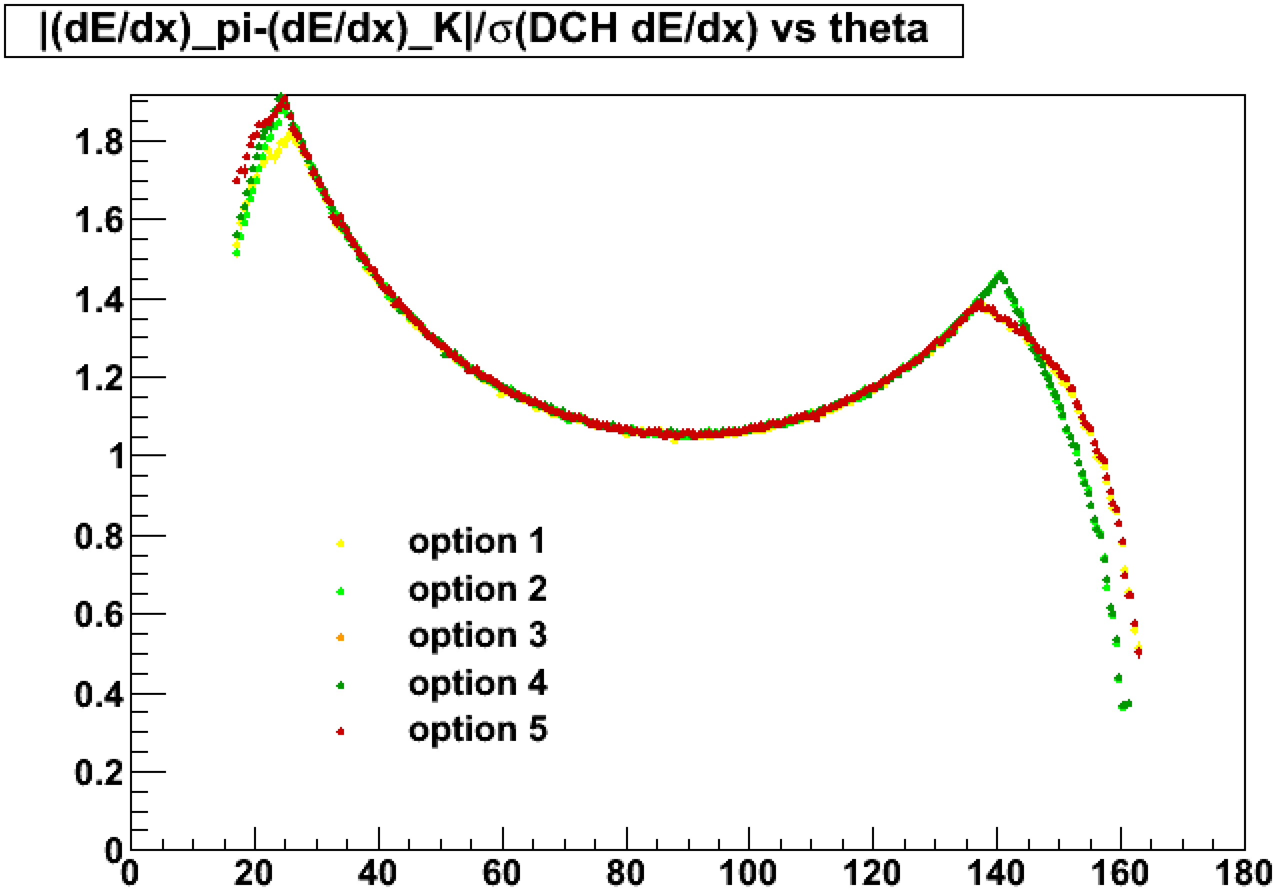
single π^+, p = 4GeV/c, flat cosθ



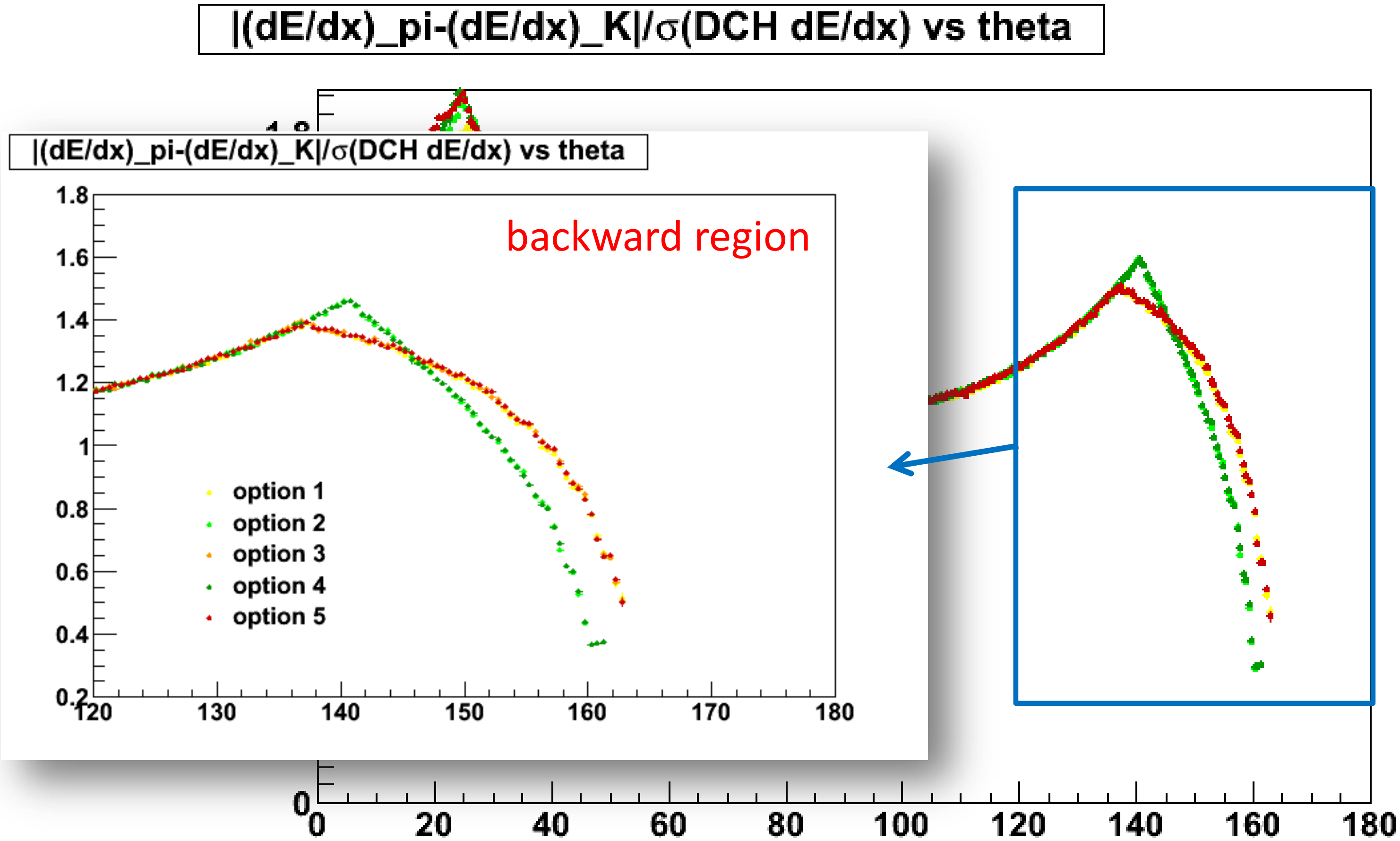
single π^+, p = 4GeV/c, flat cosθ



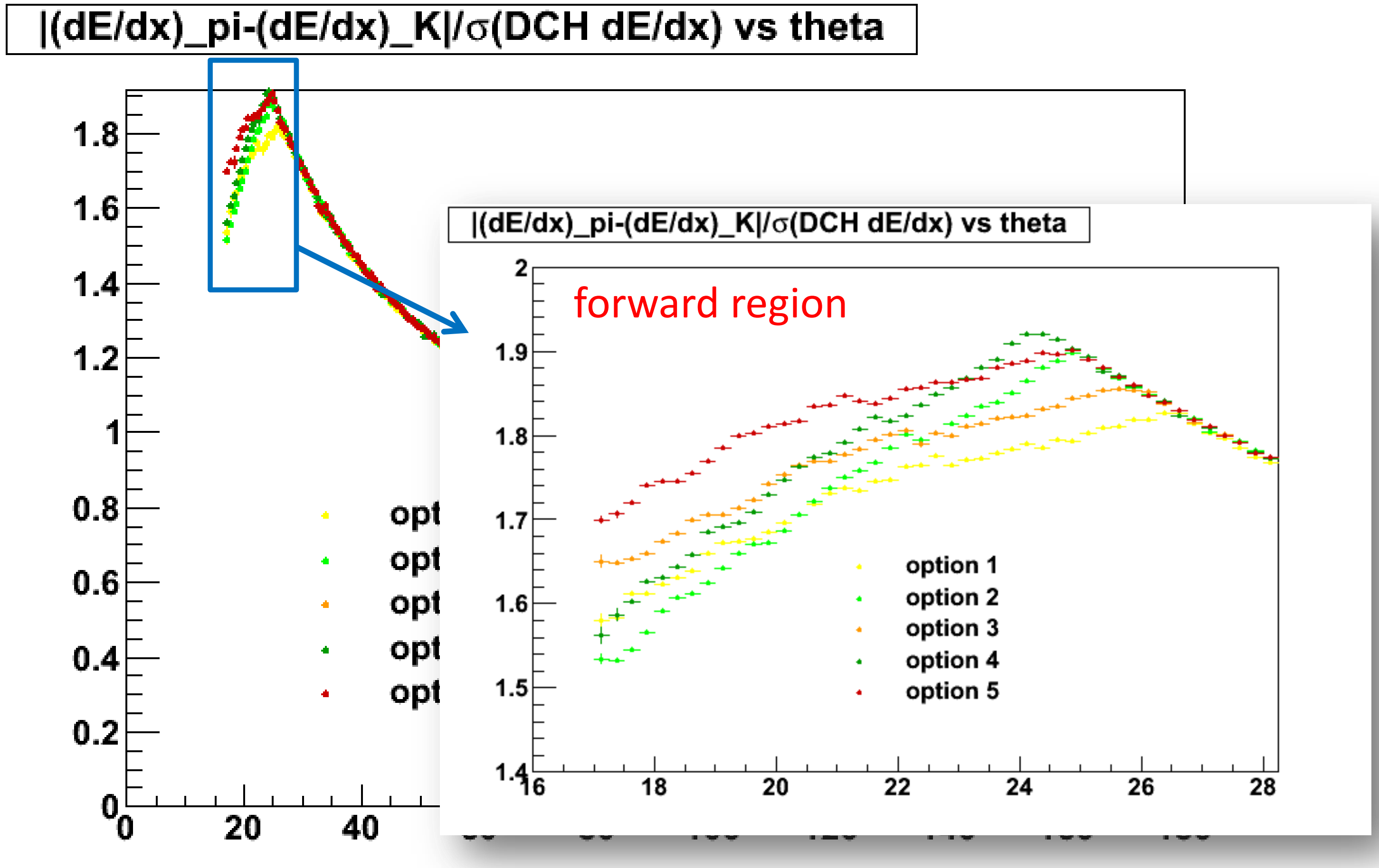
single π^+, p = 4GeV/c, flat cosθ



single π^+, p = 4GeV/c, flat cosθ



single π^+, p = 4GeV/c, flat cosθ



Part II

single particles (π^+) with flat p and cosθ distributions

single particles generated with:

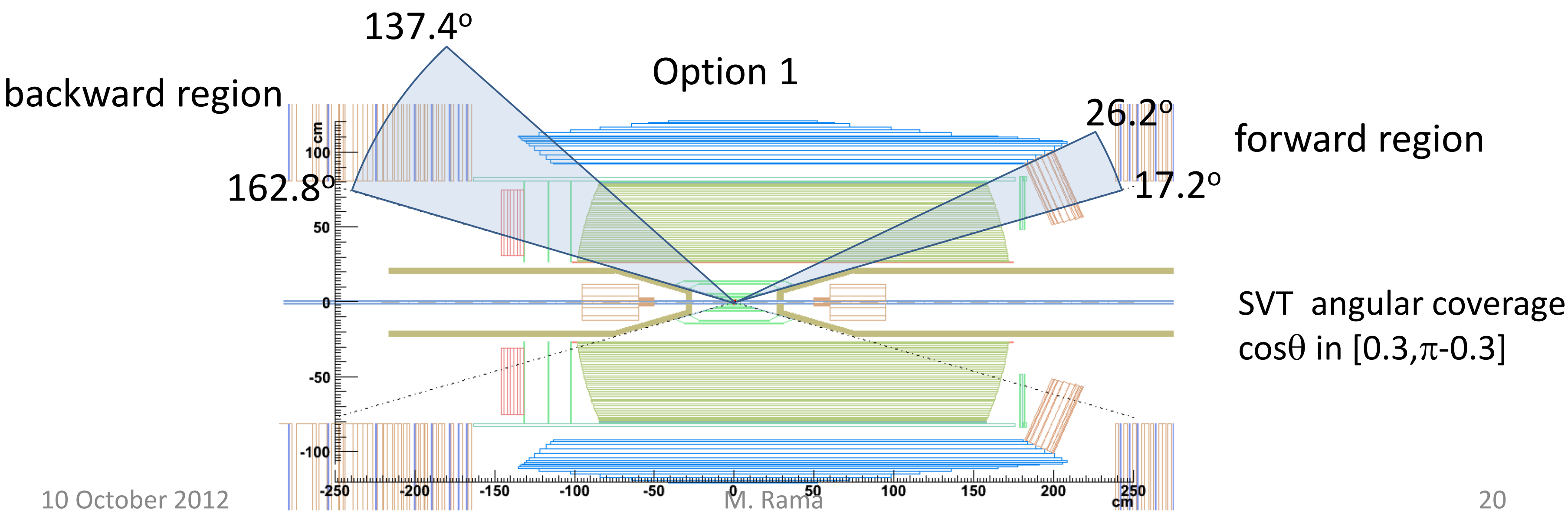
- p in [0.1, 4.0] GeV/c
- dP/ dcosθ = const   [θ = polar angle]
- θ in [0.30,0.46] rad   [DCH forward region]   or
  θ in [2.40,π-0.30] rad   [DCH backward region]
- 200k events for each configuration

Part II

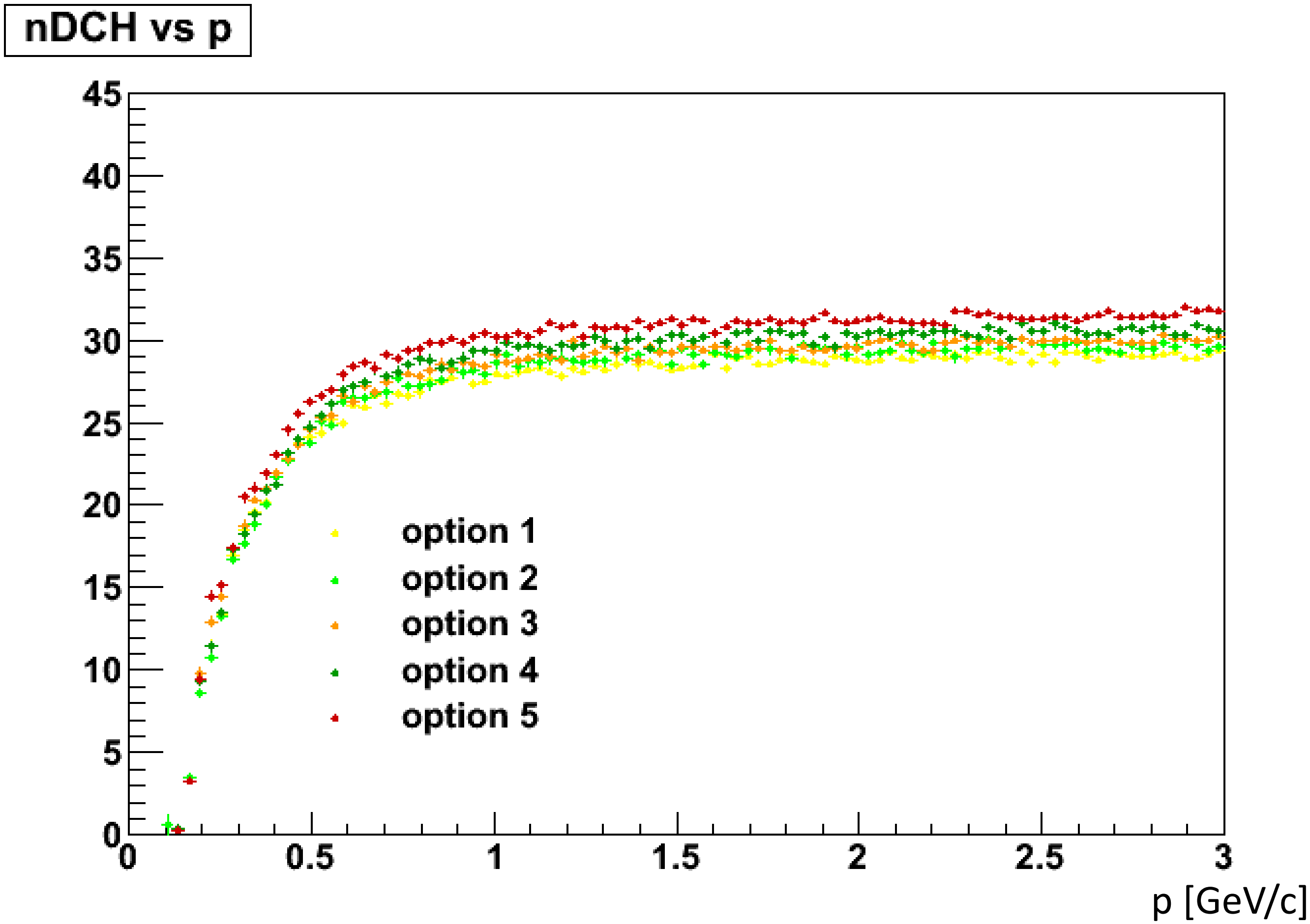
single particles (π^+) with flat p and cosθ distributions

single particles generated with:

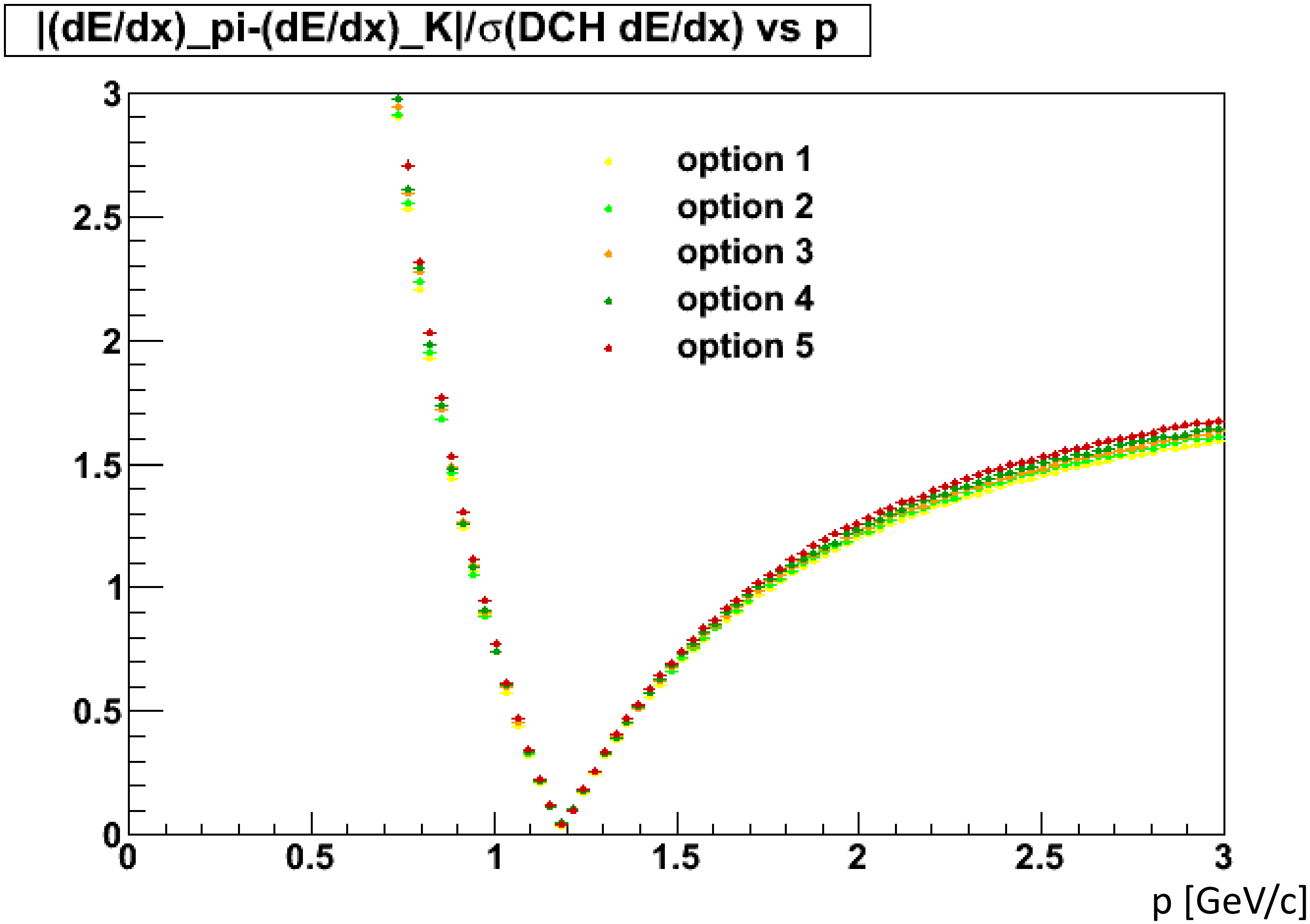
- p in [0.1, 4.0] GeV/c
- dP/ dcosθ = const [θ = polar angle]
- θ in [0.30,0.46] rad [DCH forward region] or
  θ in [2.40,π-0.30] rad [DCH backward region]
- 200k events for each configuration



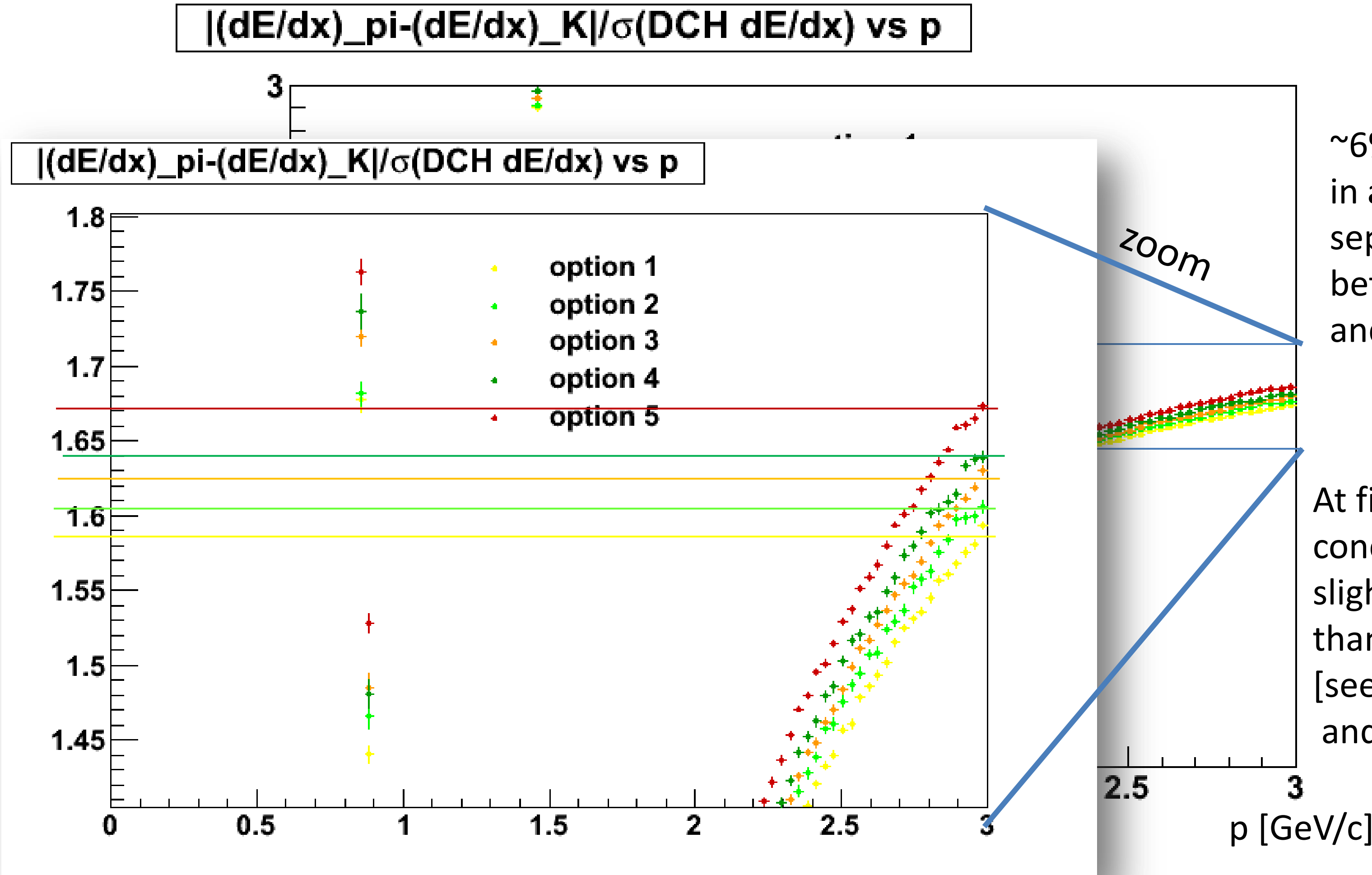
forward region



forward region



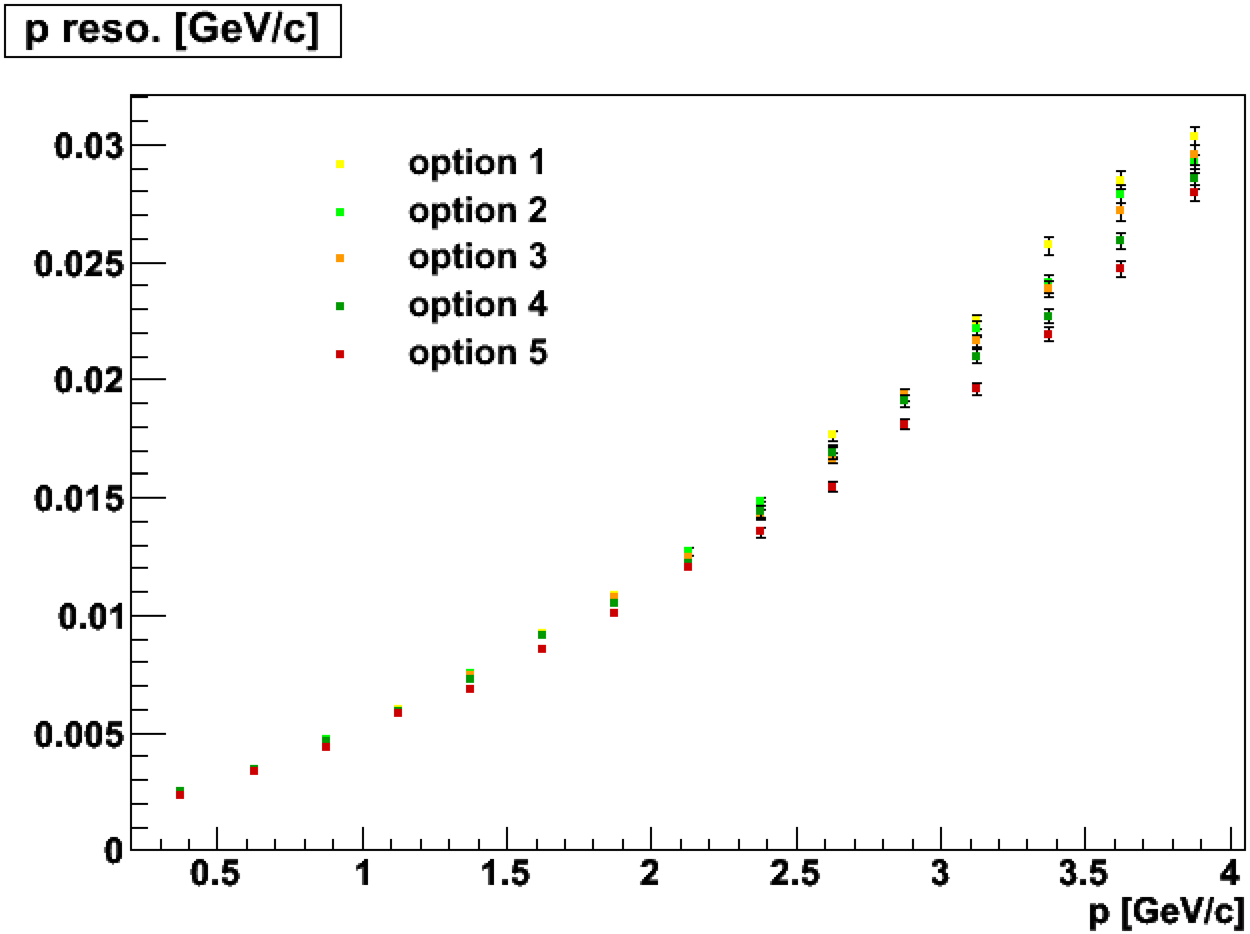
forward region



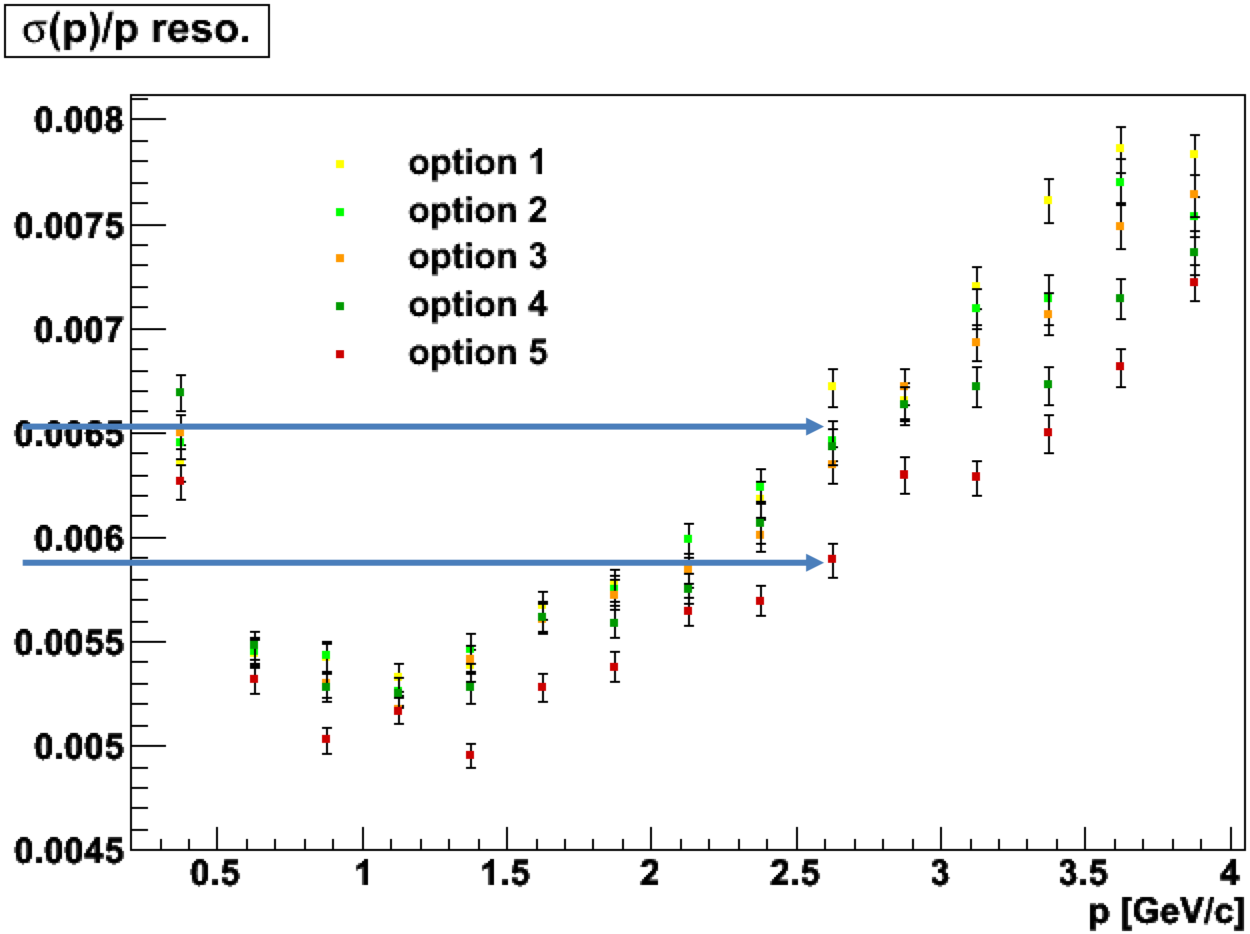
~6% difference in average K/π separation between opt 1 and opt 5

At fixed z length, concave config slightly better (~1.3%) than convex config. [see opt2 vs opt1 and opt4 vs opt3]

forward region



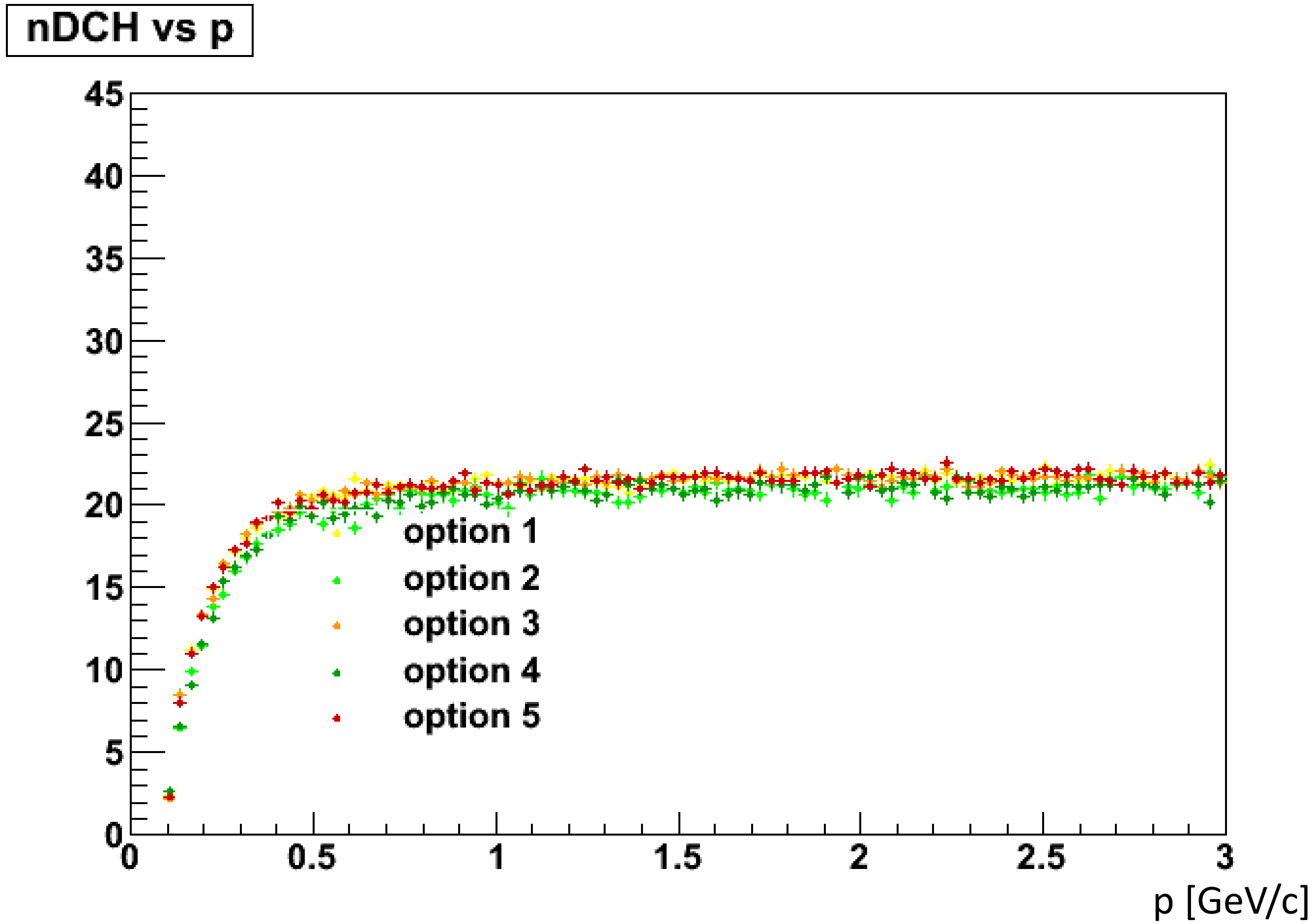
forward region



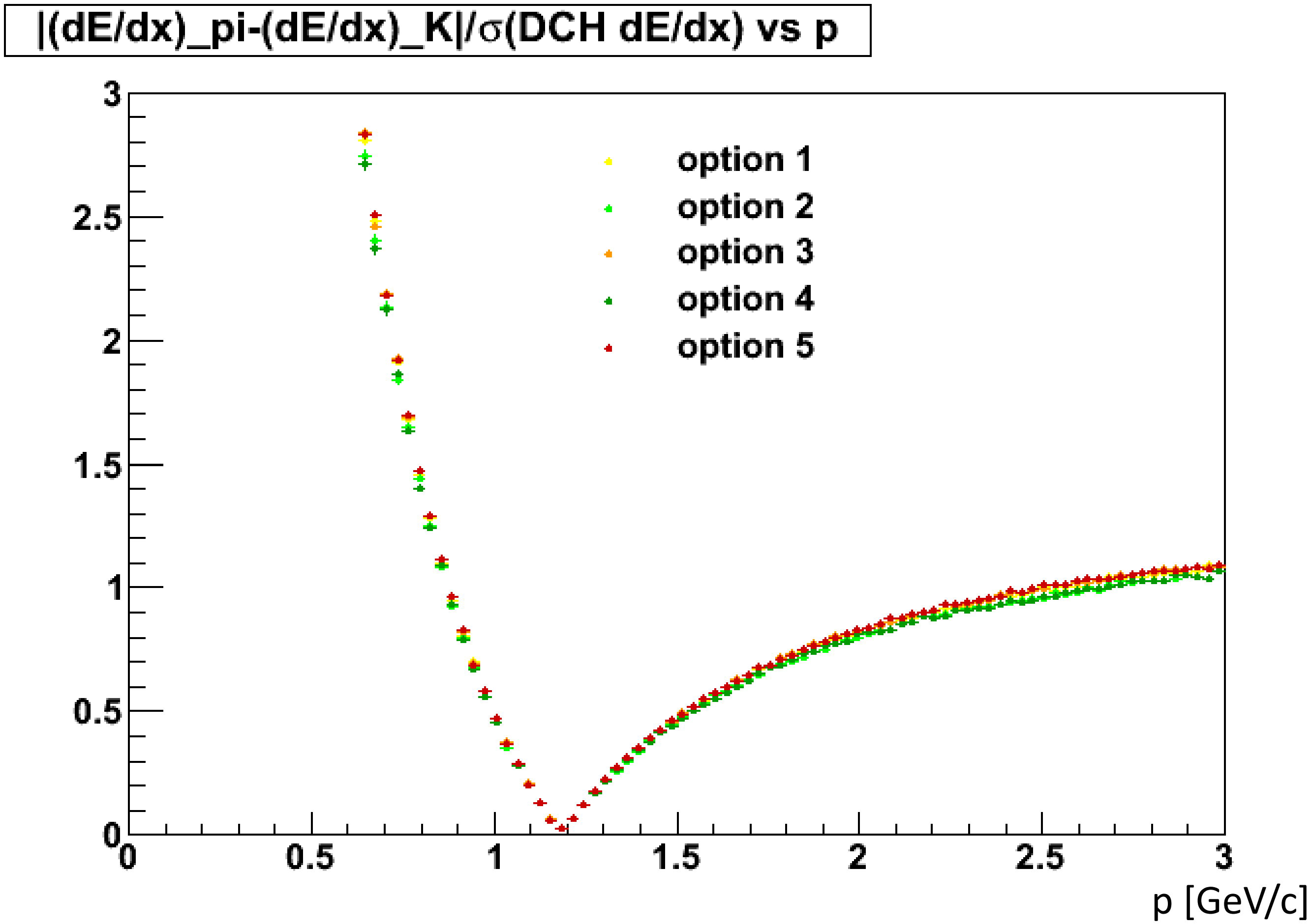
≈10% σ(p)/p relative variation over different configs.

At fixed z length, concave and convex configs shows similar performance within the stat uncertainty.

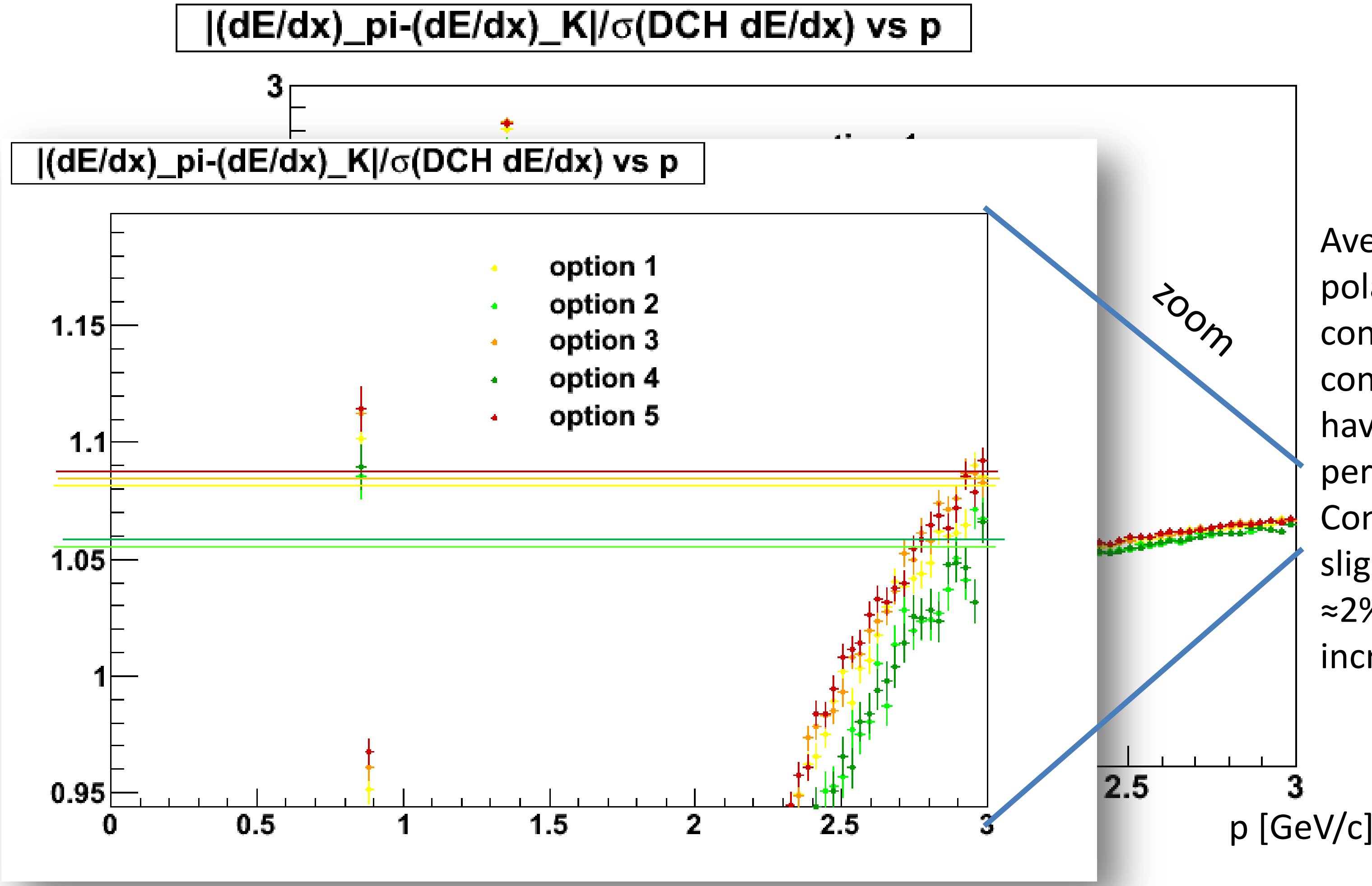
backward region



backward region

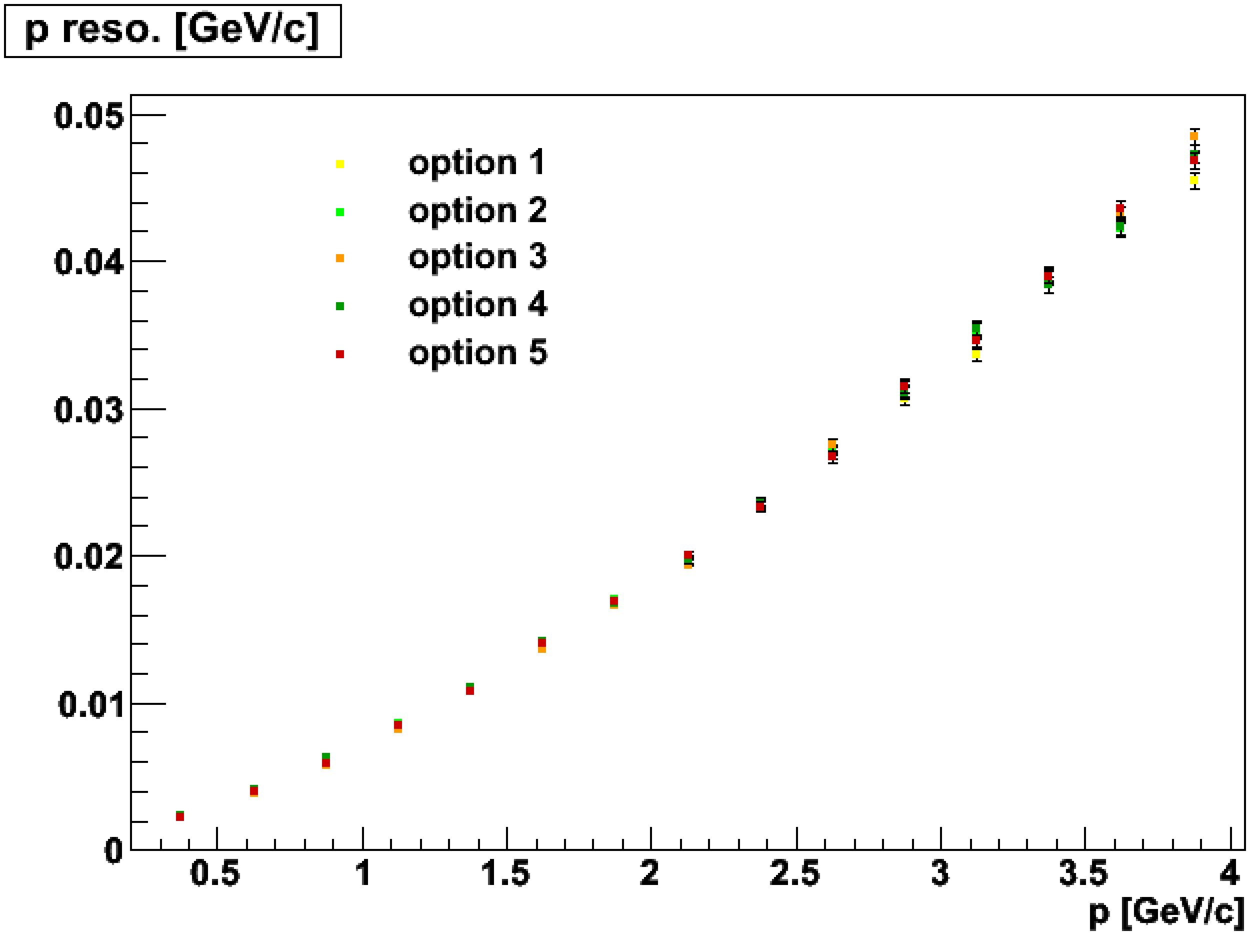


backward region

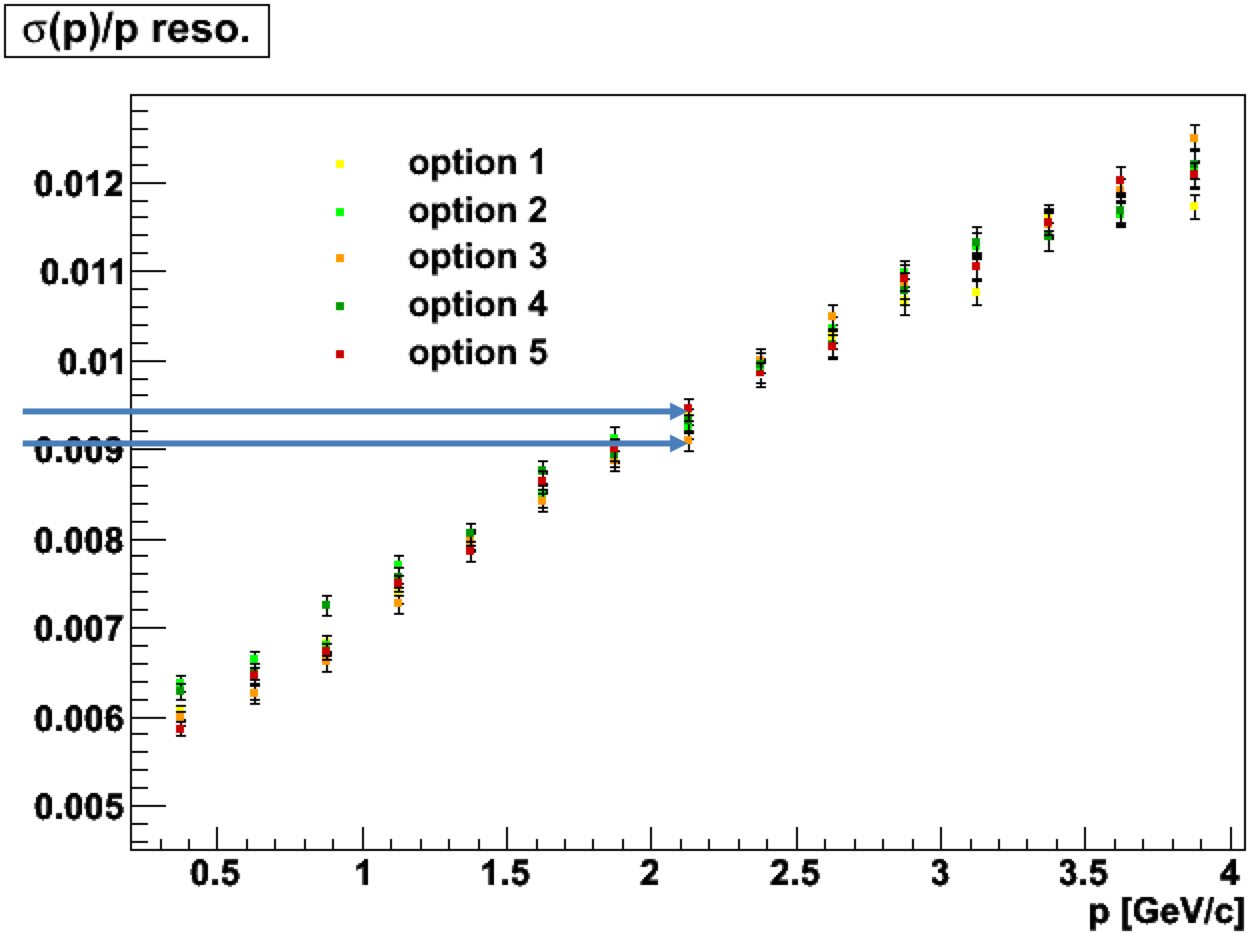


Averaged over the polar angle, the concave and convex configs have similar performance. Convex configs slightly better: ≈2% separation increase

backward region



backward region



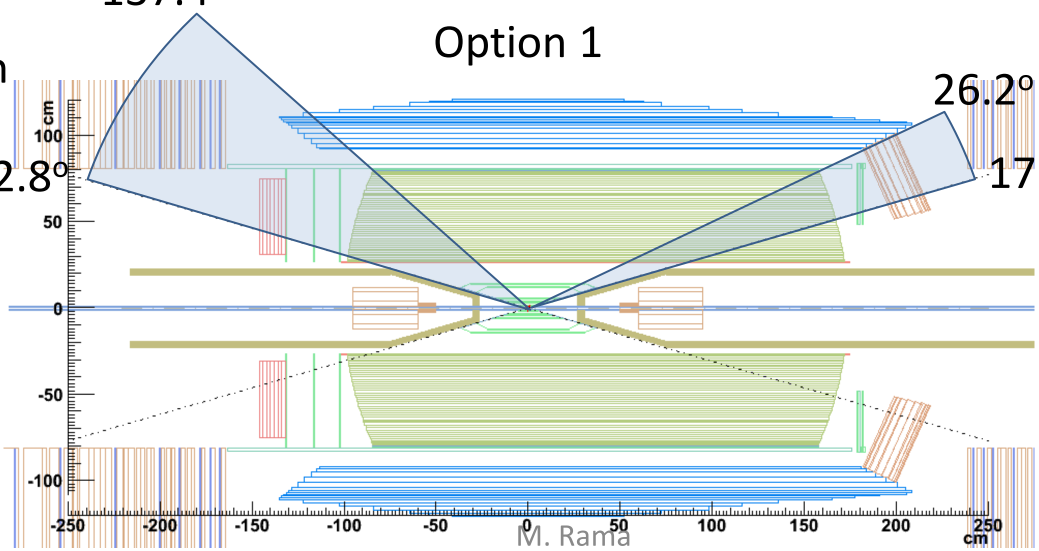
Integrated over the whole bwd region, p resolutions are similar within a ≈4% relative variation.

Part III

$$B^0 \to D^{*-}K^+, D^{*-} \to \overline{D}^0 K^-, \overline{D}^0 \to K^+\pi^-$$

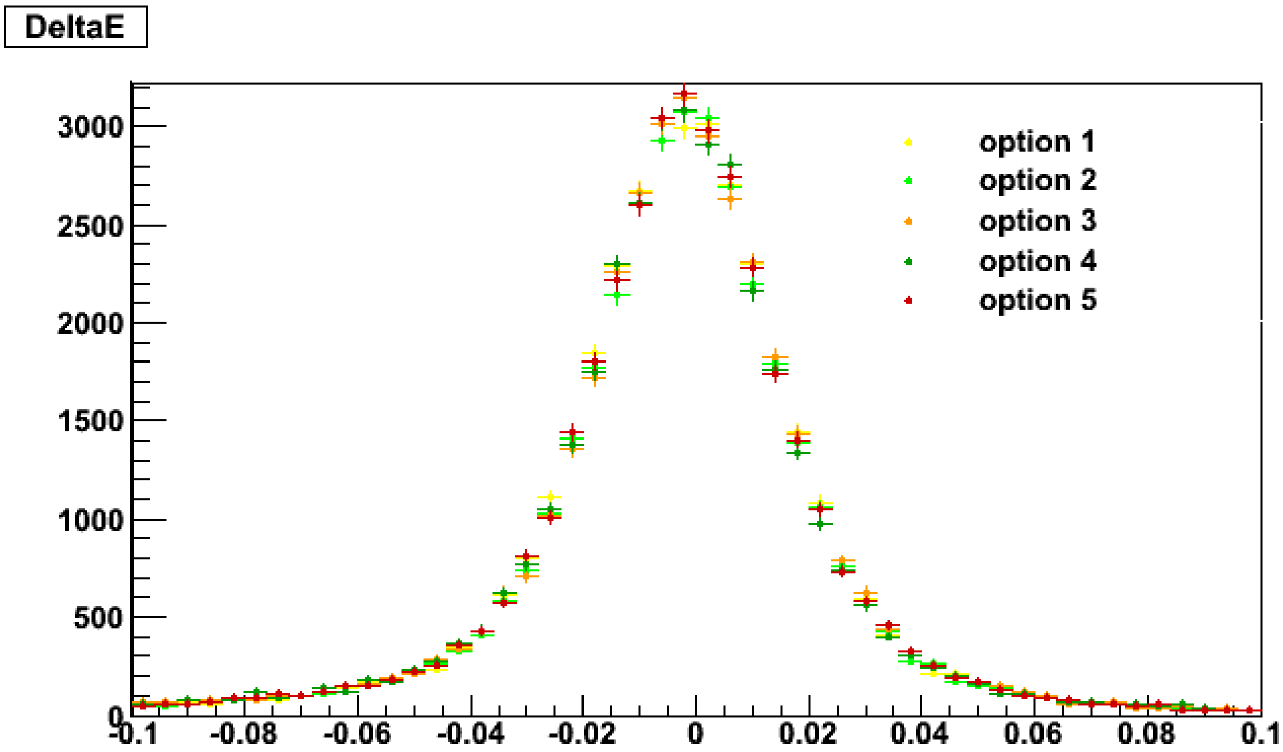
5x10[4] B→D*K signal events for each configuration

- truth matching required



ΔE reconstruction

$B^0 \to D^{*-}K^+, D^{*-} \to \overline{D}^0 K^-, \overline{D}^0 \to K^+\pi^-$

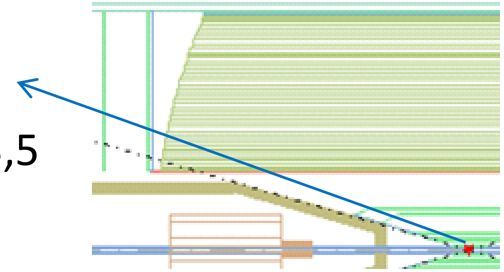


reconstruction efficiency of B→D*K

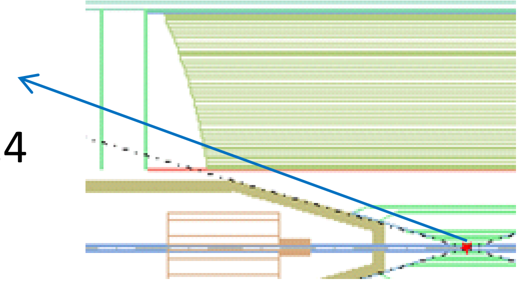
DCH configuration	B→D*K reco efficiency [%] (|ΔE|<50 MeV ~2.5σ)
option 1	65.4 ± 0.2
option 2	64.4 ± 0.2
option 3	65.1 ± 0.2
option 4	64.6 ± 0.2
option 5	65.3 ± 0.2

The (tiny) differences are driven by the backward region: eff[opt1,3,5] > eff[opt 2,4]

options 1,3,5

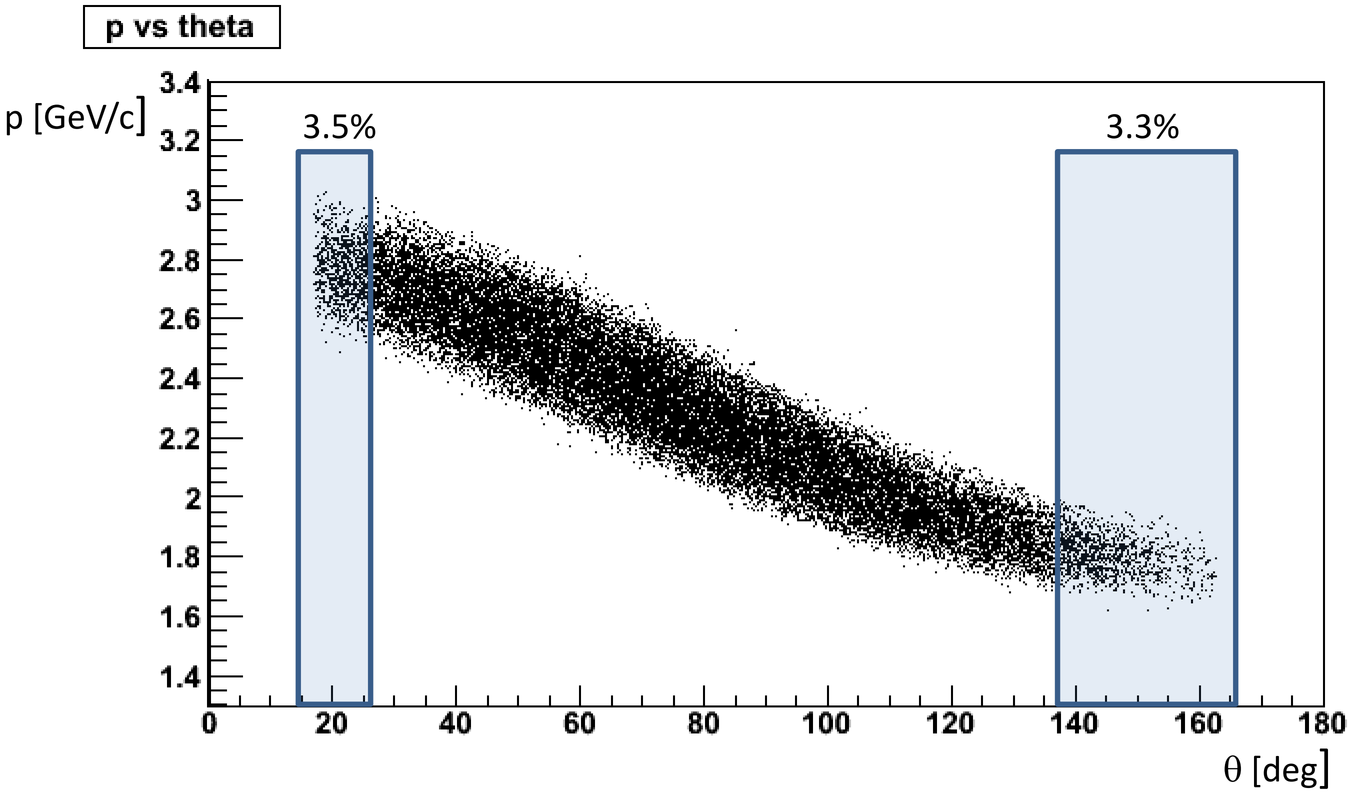


options 2,4



Options 1, 2 and 3 have the same efficiency within ≈0.2%

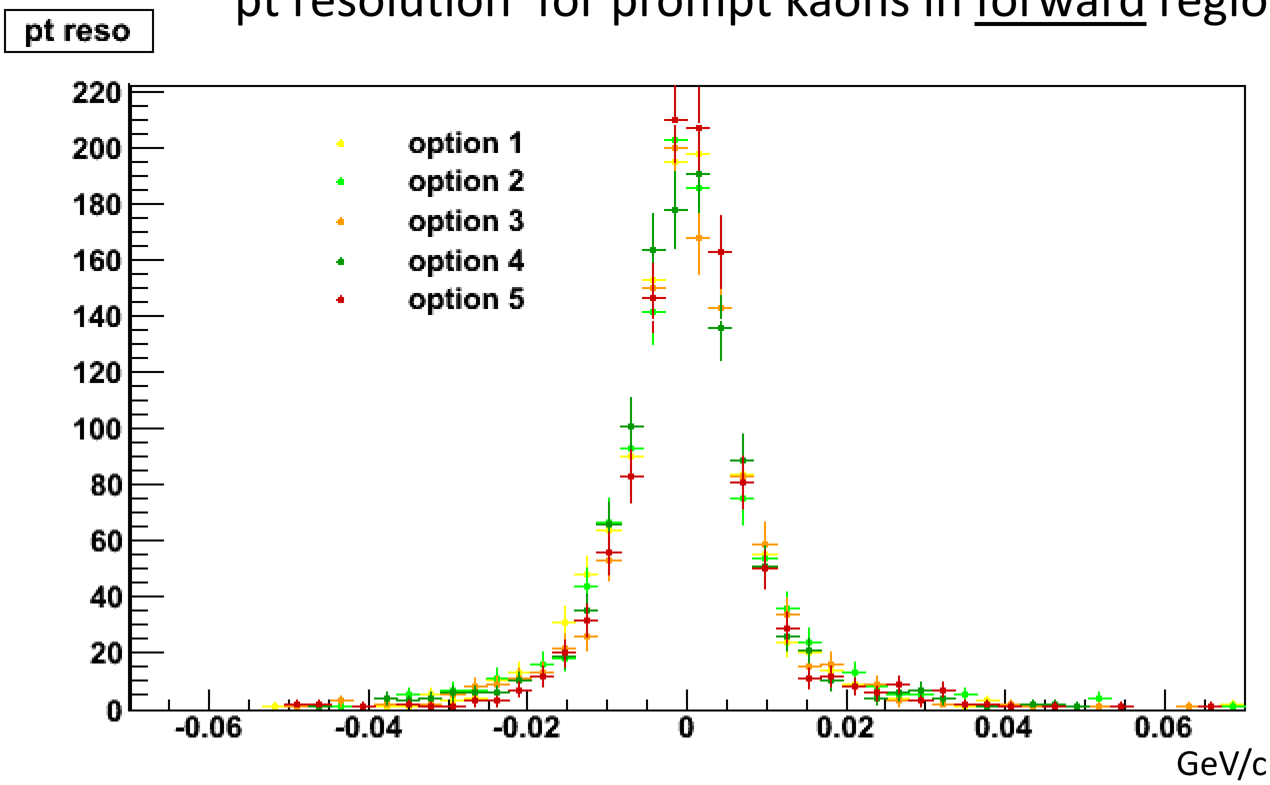
p vs θ distribution of prompt kaons (B→D*K)



selected samples
forward region: 1213 (3.5%)
barrel region: 32242 (93.2%)
backward region: 1157 (3.3%)

forward region

pt resolution for prompt kaons in forward region



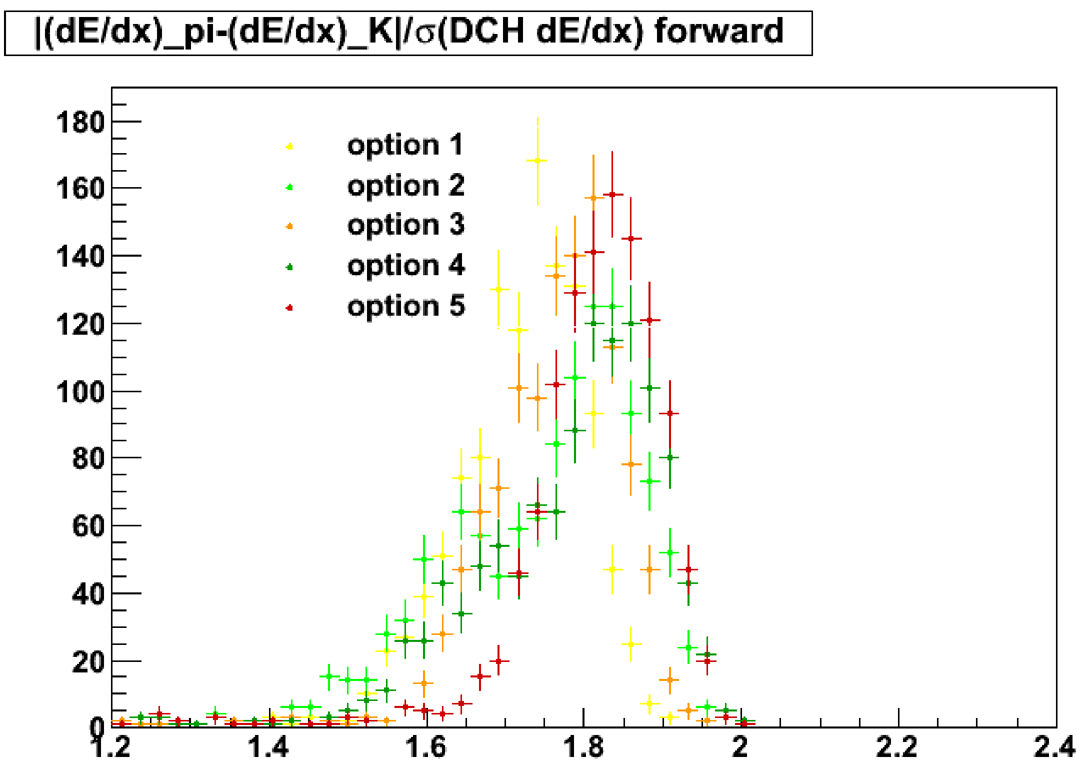
Option 5 is visibly better.
Differences in opt1-4 are not evident.

forward region

$$K/\pi\ separation \equiv \frac{|(dE/dx)_\pi - (dE/dx)_K|}{\sigma(dE/dx)}$$

$(dE/dx)_h$ = expected dE/dx in the ***h*** hypothesis

$\sigma(dE/dx)$ = dE/dx measurement error



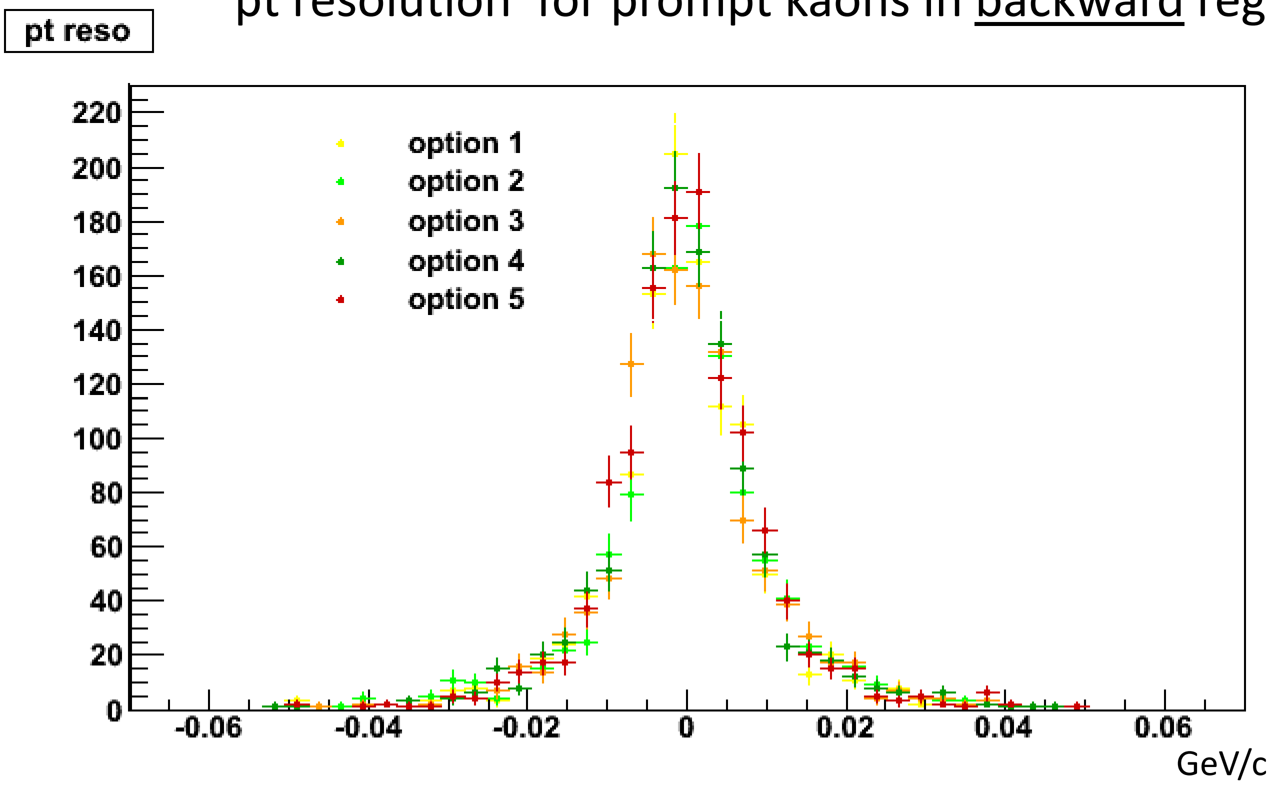
config	$\mu \pm RMS/\sqrt{N}$
1	1.723 ± 0.002
2	1.751 ± 0.003
3	1.767 ± 0.003
4	1.787 ± 0.003
5	1.822 ± 0.003

The pattern *sep1<sep2<sep3<sep4<sep5* is visible. Differences are tiny.

At fixed z length, concave config slightly better (≈1%) than convex config. [see opt2 vs opt1 and opt4 vs opt3]

backward region

pt resolution for prompt kaons in backward region

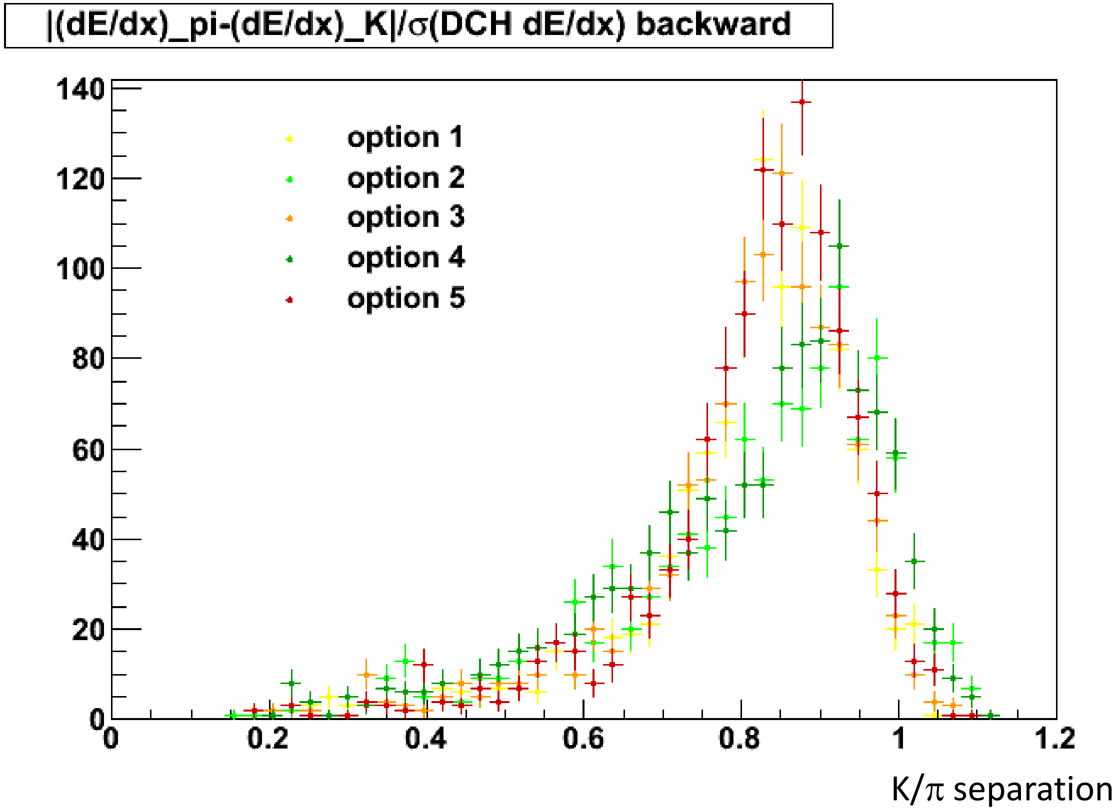


backward region

$$K/\pi\ separation\ \equiv \frac{|(dE/dx)_\pi - (dE/dx)_K|}{\sigma(dE/dx)}$$

$(dE/dx)_h$ = expected dE/dx in the ***h*** hypothesis

$\sigma(dE/dx)$ = dE/dx measurement error



config	$\mu \pm RMS/\sqrt{N}$
1	0.801 ± 0.004
2	0.812 ± 0.005
3	0.802 ± 0.004
4	0.808 ± 0.005
5	0.816 ± 0.004

Average K/π separations consistent within ≈ 0.5%

Conclusions

- 5 options for the DCH endcaps have been compared. They differ in shape and z position.
- Differences in performance are generally small, as expected.
- Forward region
  - K/π separation: At fixed z position, the concave shape shows slightly better performance (≈1% relative gain).
  - p resolution: ≈10% $\sigma(p)/p$ variation over different configs. Consistent with previous estimates of ~1% per cm of DCH length[1]. At fixed z length, concave and convex configs shows similar performance within the stat uncertainty (2-3%).
  - B→D*K: Possible differences in absolute (relative) reco efficiency due to track reconstruction and ΔE resolution are below 0.2% (0.3%) among different configs.
- Backward region
  - K/π separation: Using single particles generated with flat cosθ and p distributions, and averaging over the bwd region, the convex configuration shows slightly better performance (≈2%). Using prompt kaons from B->D*K, concave and convex configurations are consistent within 0.5%.
  - p resolution: Integrated over the whole bwd region, p resolutions are equal within a ≈4% relative uncertainty.
  - B->D*K: convex configuration shows slightly larger B→D*K reco efficiency: 0.8% (1.2%) absolute (relative) efficiency gain.

[1] http://agenda.infn.it/getFile.py/access?contribId=74&sessionId=11&resId=0&materialId=slides&confId=2902

[2] http://agenda.infn.it/getFile.py/access?contribId=133&sessionId=19&resId=0&materialId=slides&confId=1165

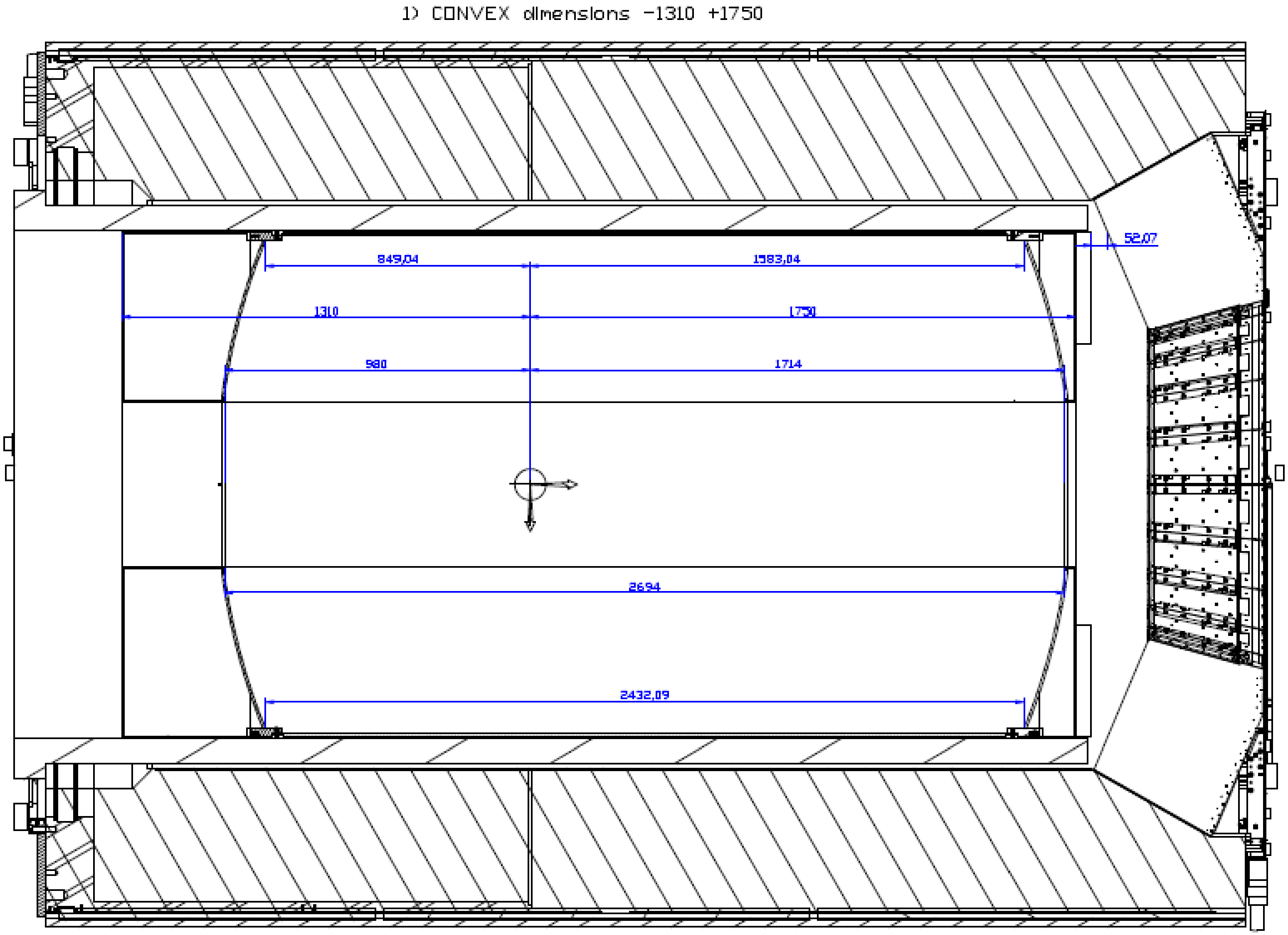
convex vs concave shape summary

Summary of results concerning the comparison between the concave and convex shapes with a given length (i.e., option1 vs option2 or option3 vs option4)

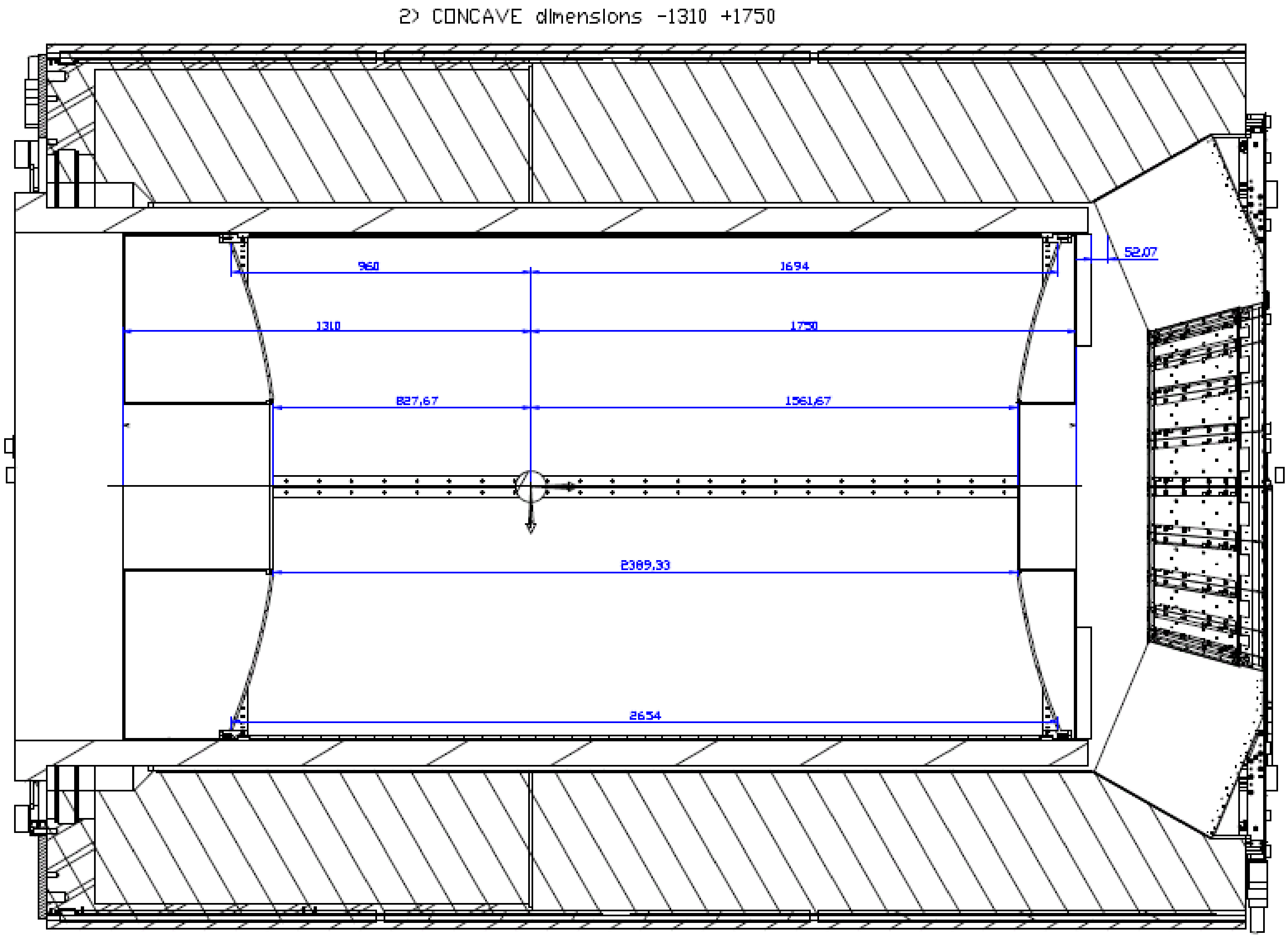
	forward region	backward region
K/π separation	concave +1% w.r.t. convex	With single particles (flat cosθ): convex +2% w.r.t. concave With prompt K from B→D*K: same separation within 0.5%. (*)
σ(p)/p	same resolution within 2-3% relative uncertainty (stat limited)	same resolution within ≈4% relative uncertainty (stat limited)
B->D*K reco. eff.	same reco. eff. within 0.3% relative uncertainty (stat limited)	convex +1.2% relative increase w.r.t. concave

(*) The K/π separation depends on both the polar angle (see for example slide 17) and p. Therefore, results for particle samples with different polar angle and p distributions can vary.

backup

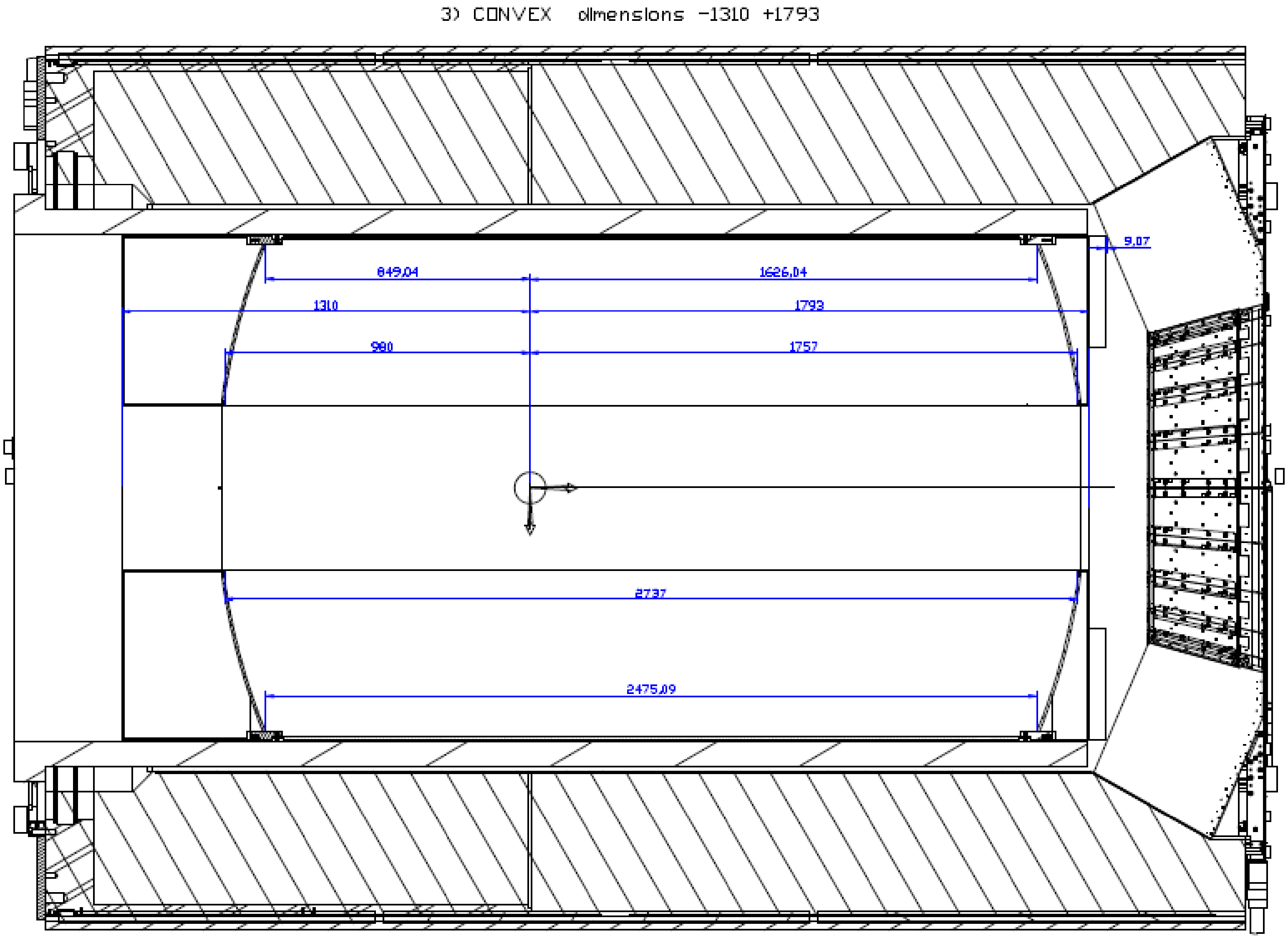


Drawing from Stefano Lauciani, LNF



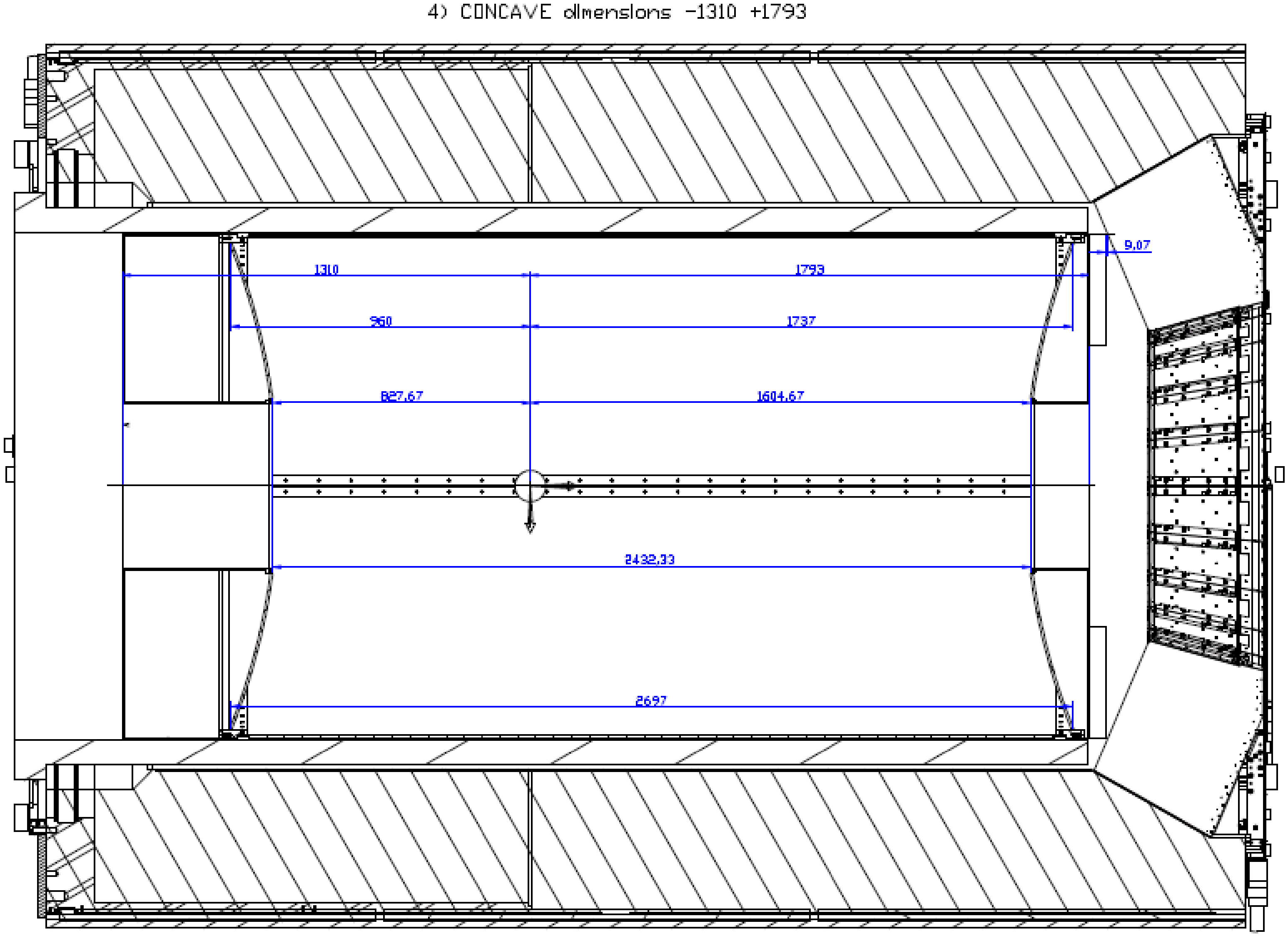
210 mm

Drawing from Stefano Lauciani, LNF

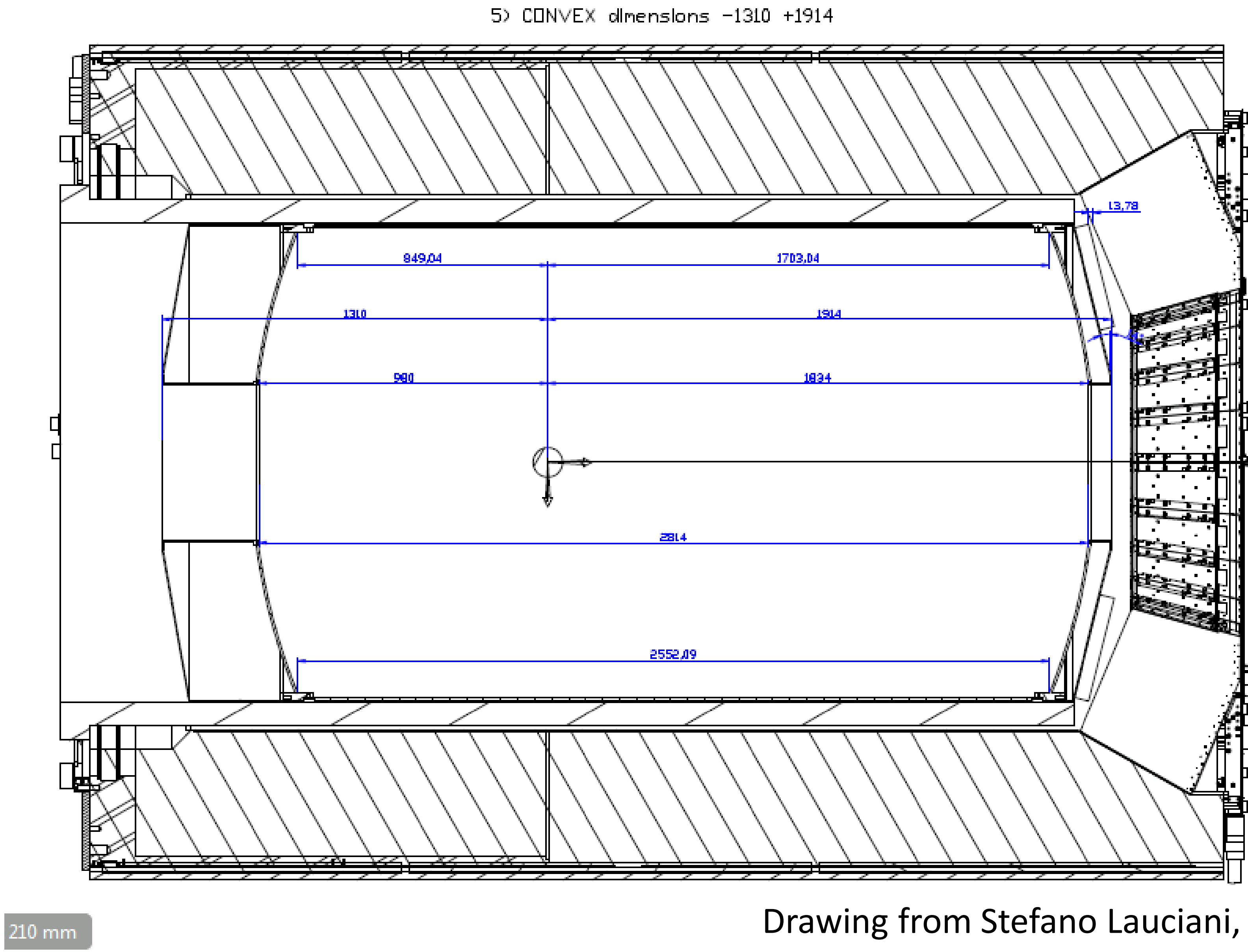


: 210 mm

Drawing from Stefano Lauciani, LNF



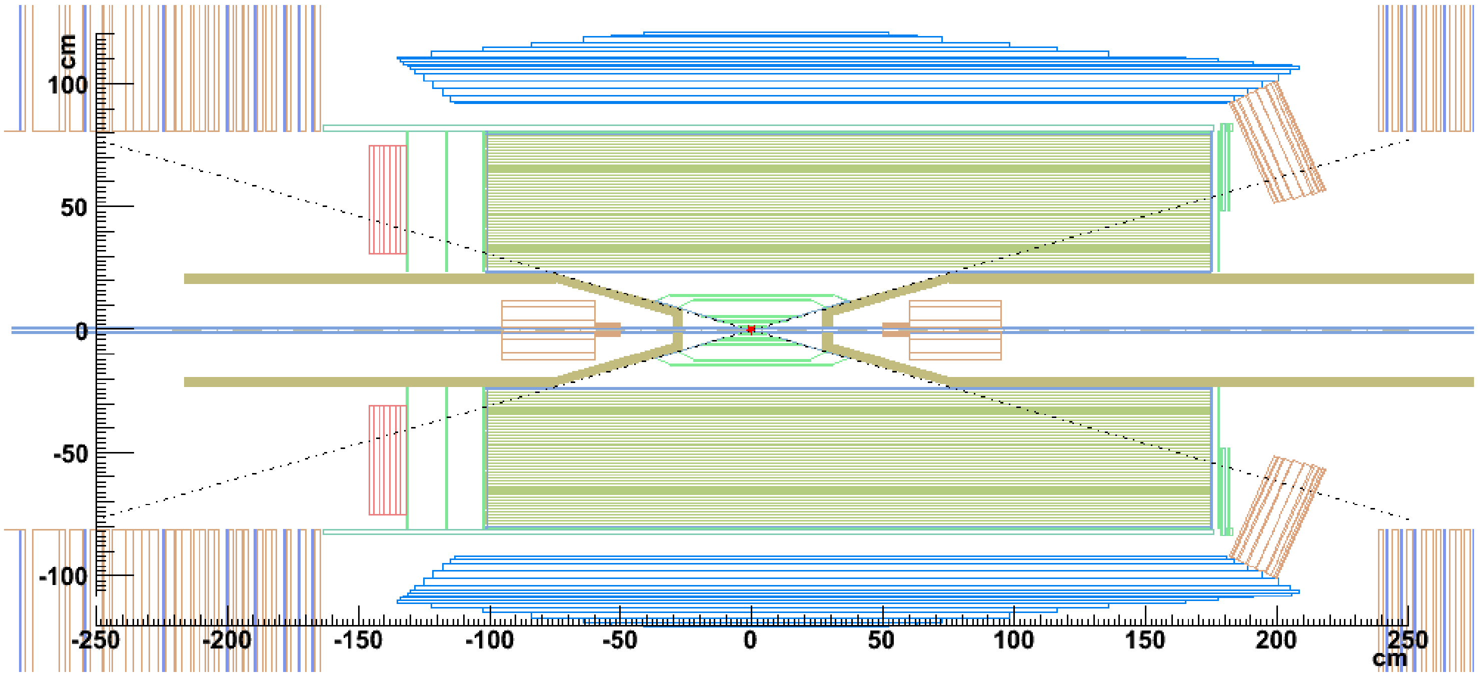
Drawing from Stefano Lauciani, LNF



Drawing from Stefano Lauciani, LNF

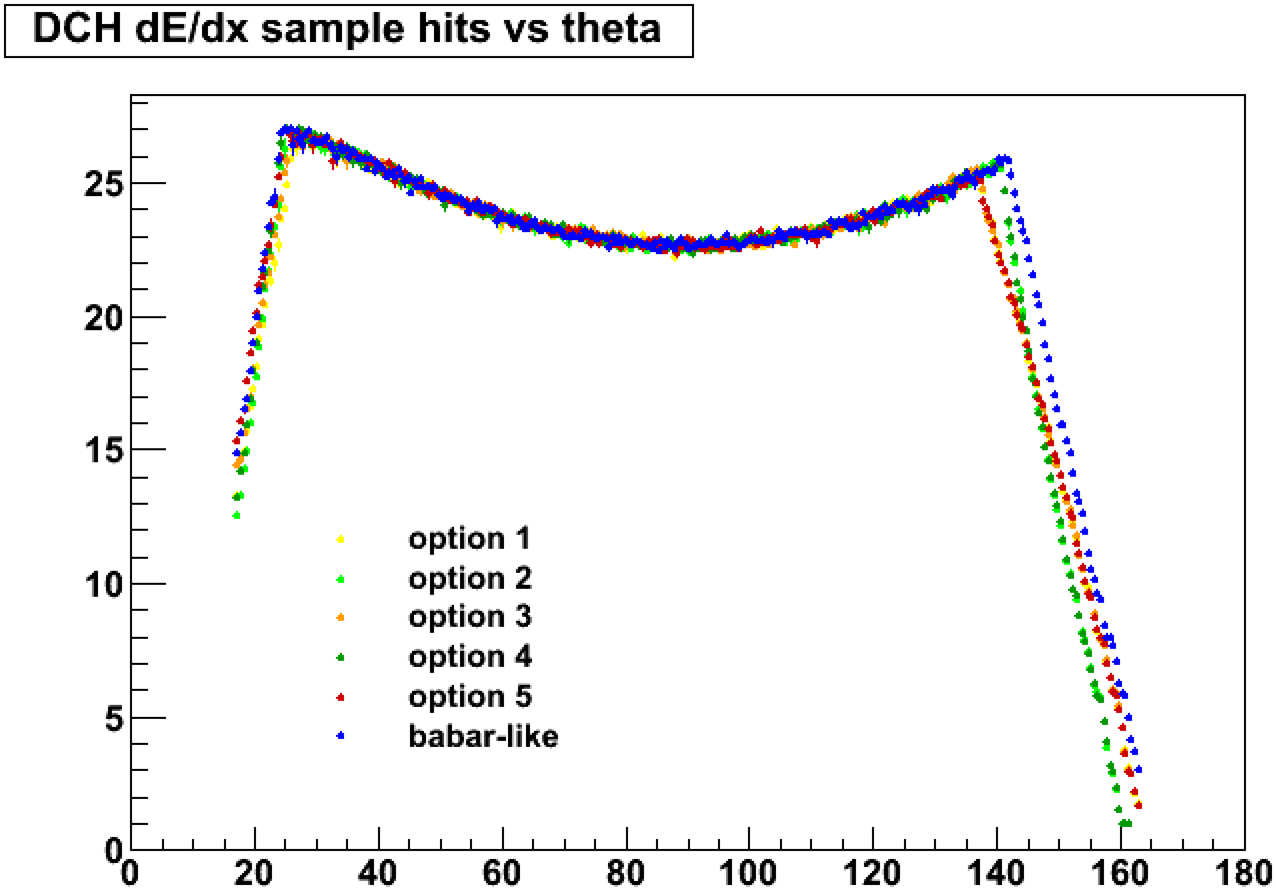
Option 6

x-z layout in fastsim

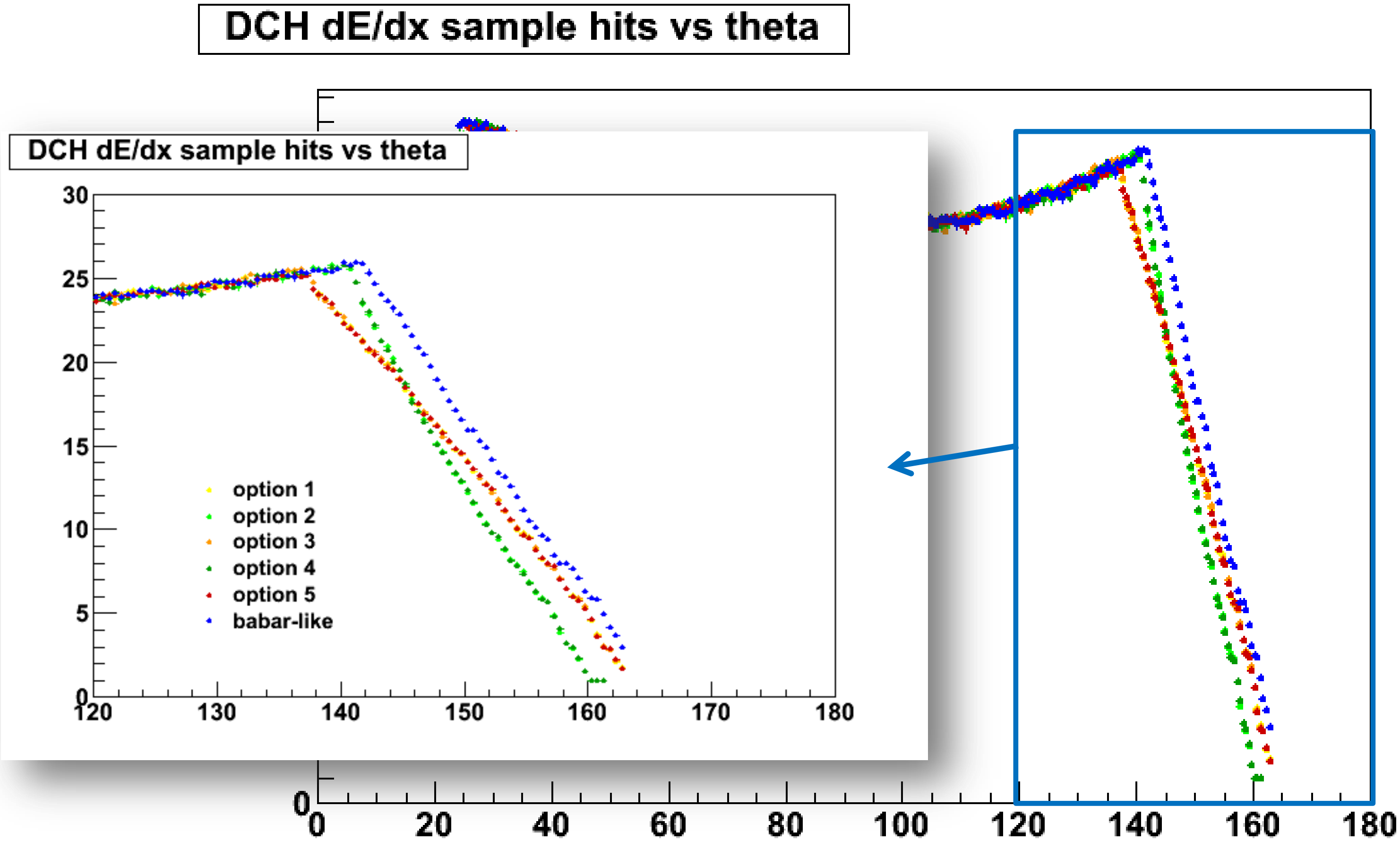


old SuperB (babar-like) configuration

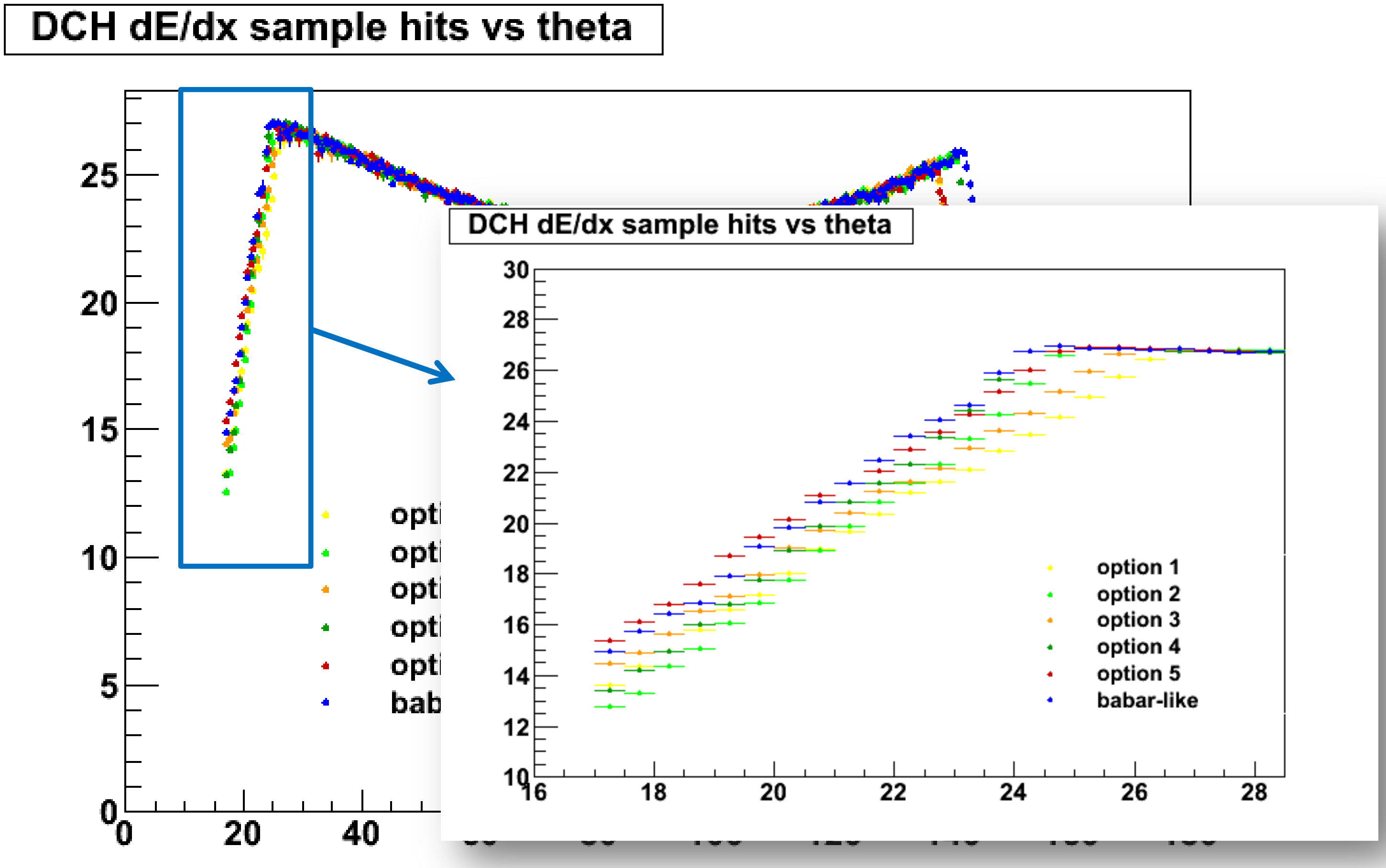
single π^+, p=4GeV/c, flat cosθ



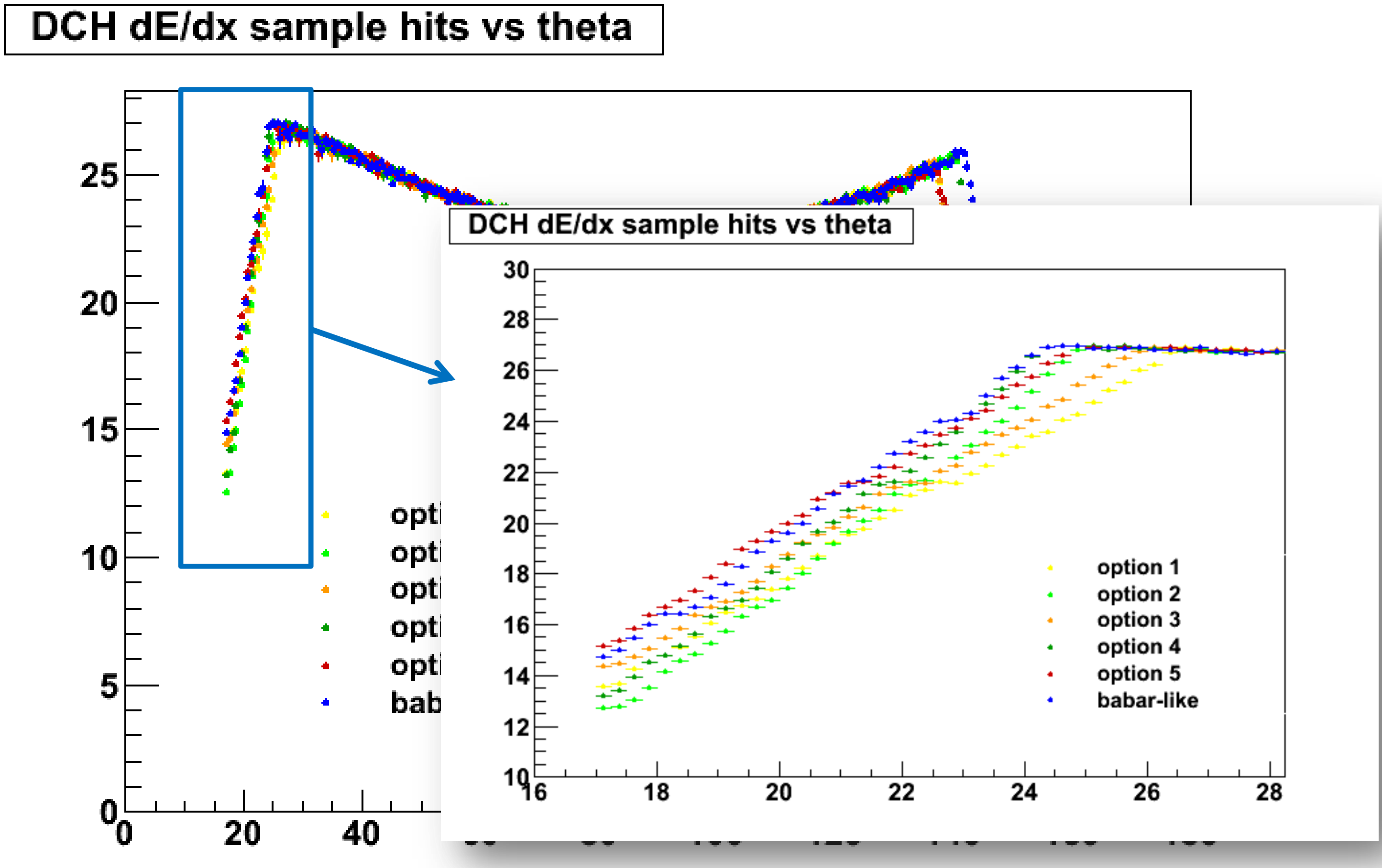
single π^+, p=4GeV/c, flat cosθ



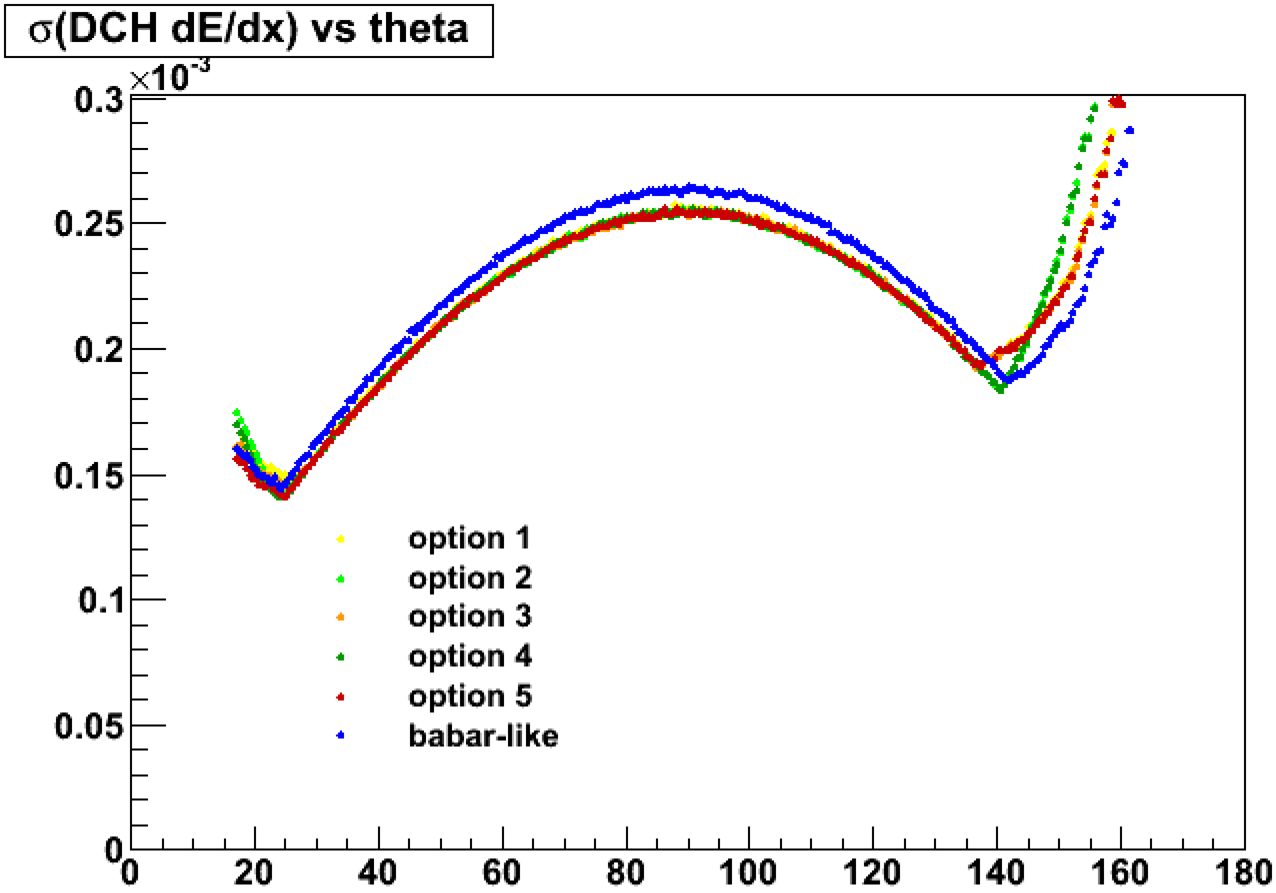
single π^+, p=4GeV/c, flat cosθ



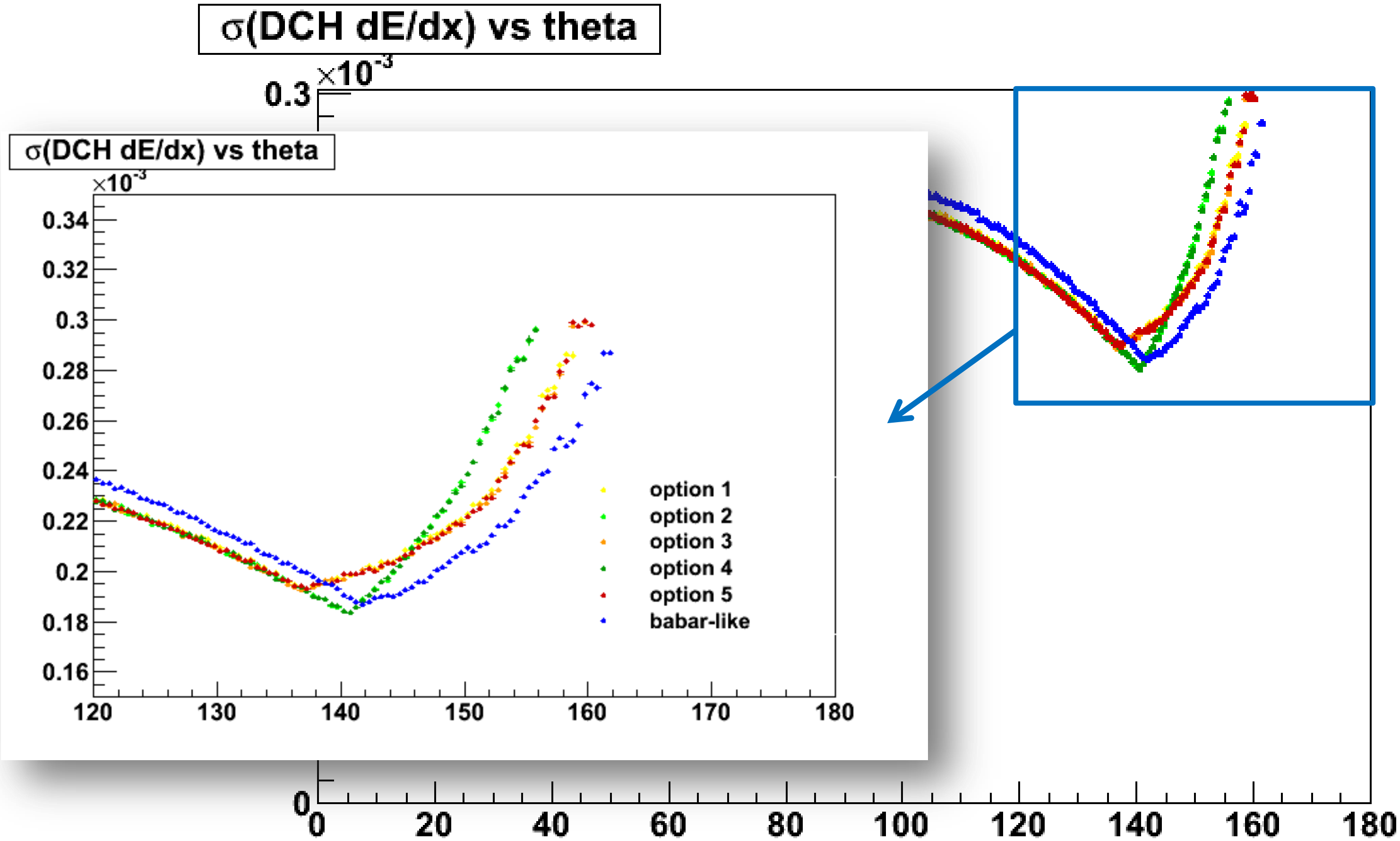
single π^+, p=4GeV/c, flat cosθ



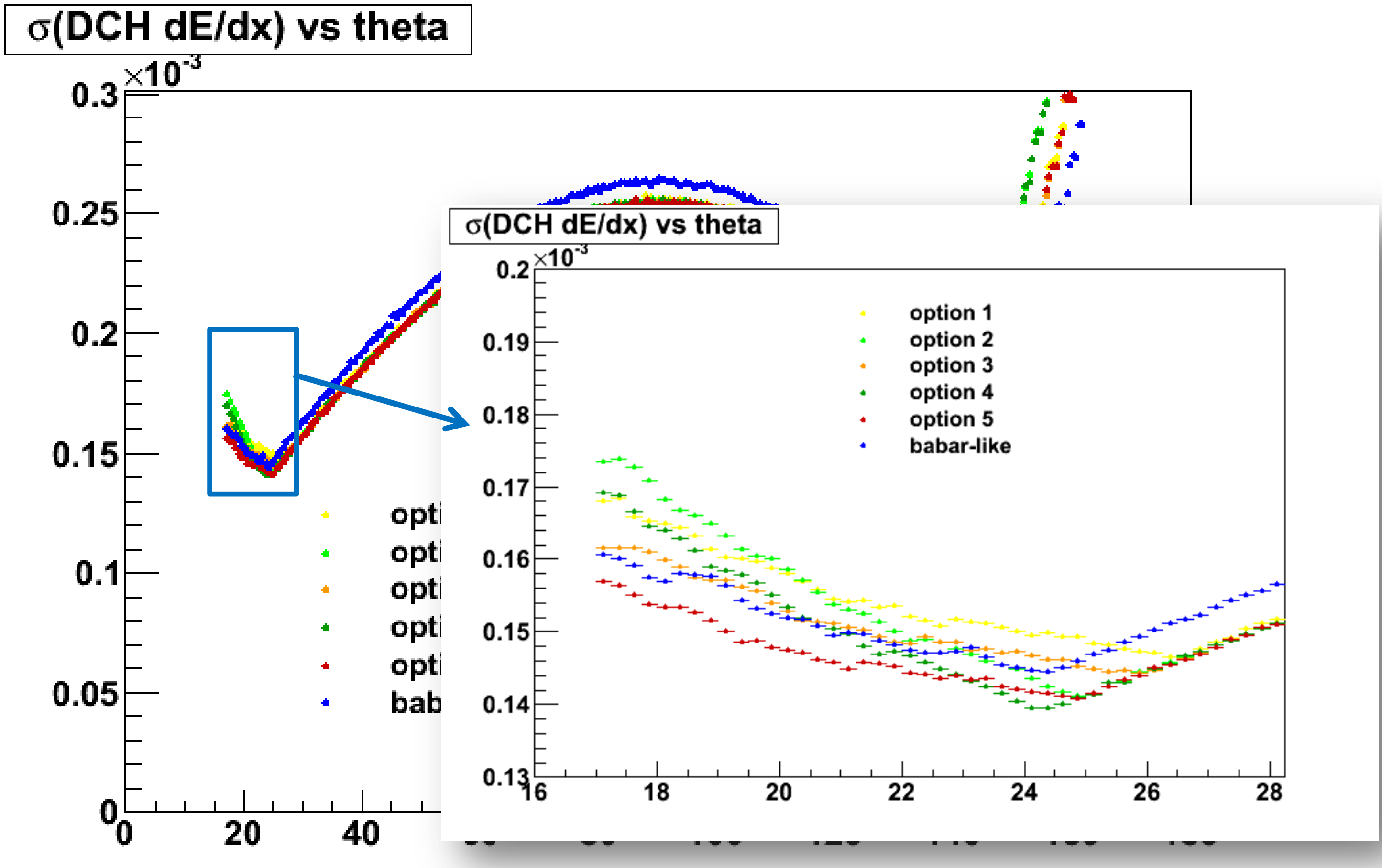
single π^+, p=4GeV/c, flat cosθ



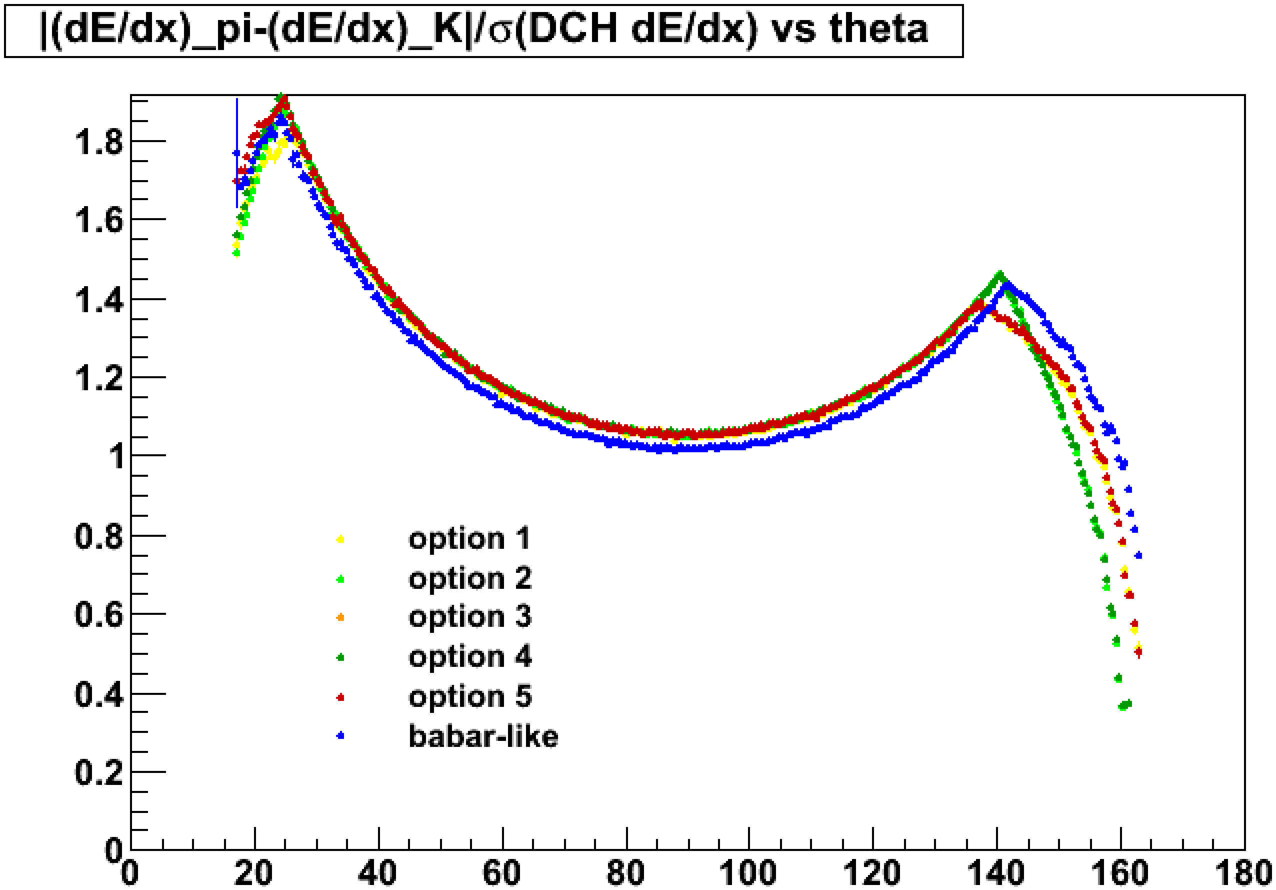
single π^+, p=4GeV/c, flat cosθ



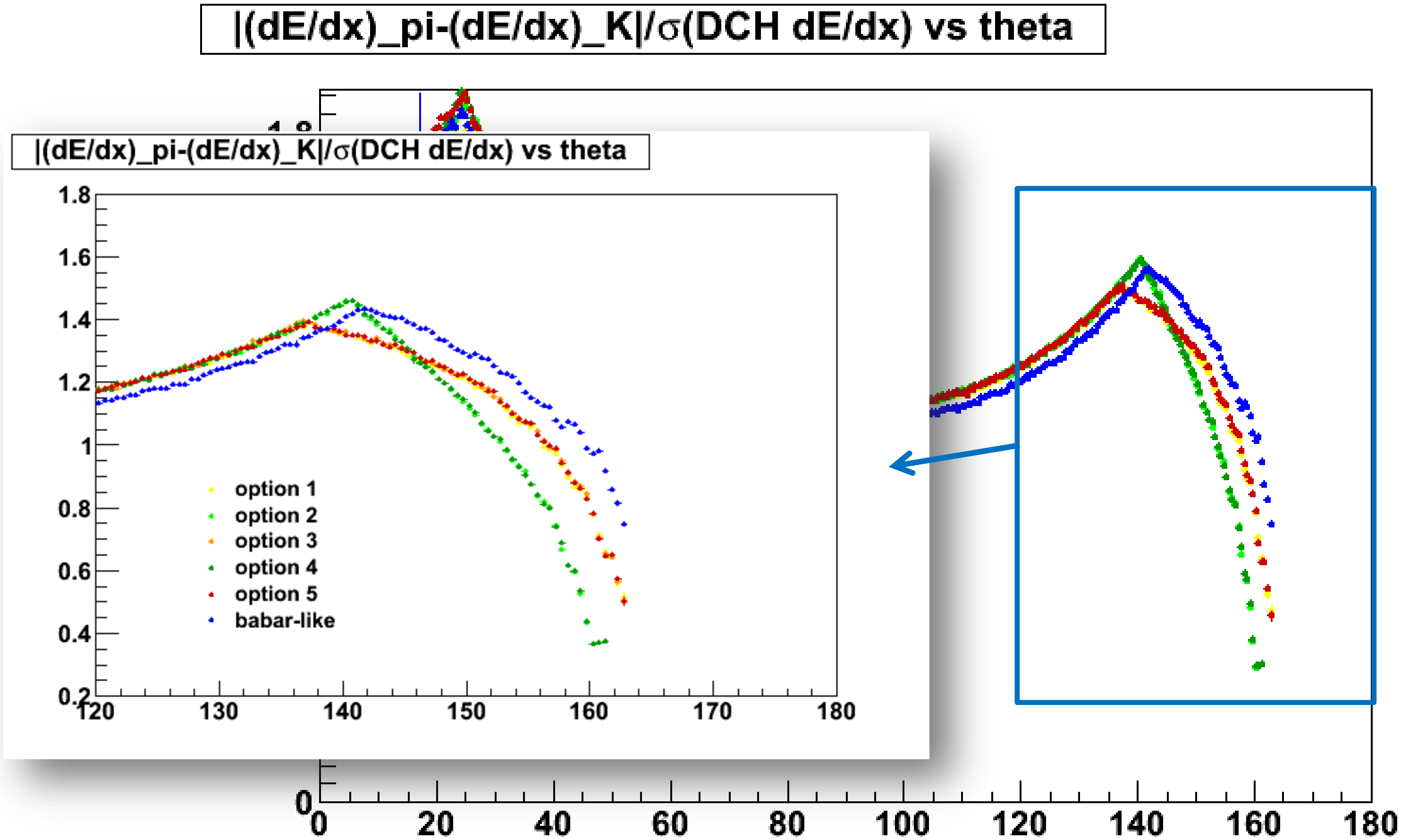
single π^+, p=4GeV/c, flat cosθ



single π^+, p=4GeV/c, flat cosθ



single π^+, p=4GeV/c, flat cosθ



single π^+, p=4GeV/c, flat cosθ