dE/dx in Babar data and fastsim

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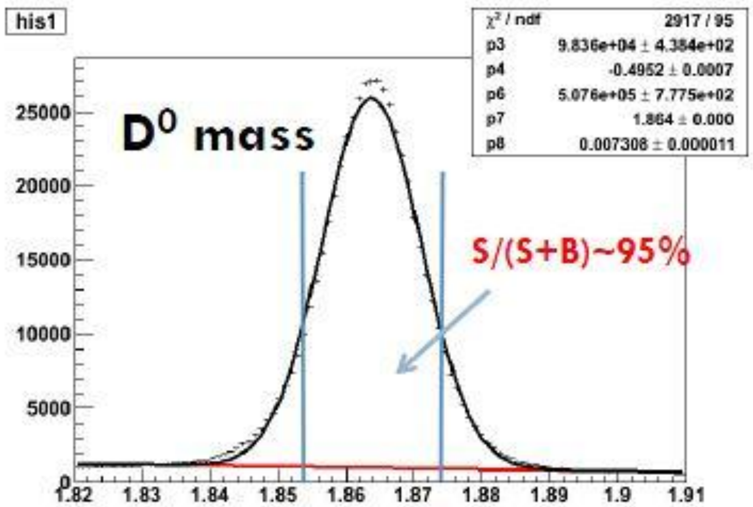
Selection of pions, kaons and dimuons samples in Babar data

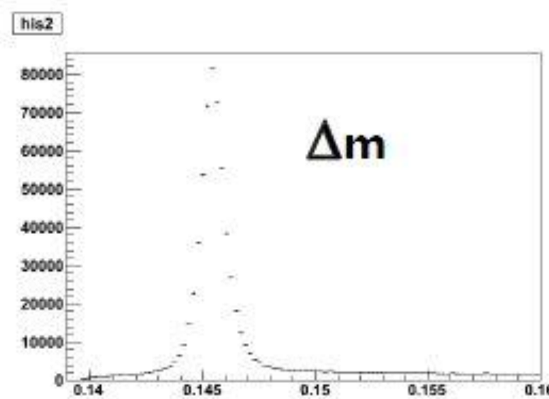
- Selection of $D^{*+} \rightarrow D^0\pi^+$, $D^0 \rightarrow K^-\pi^+$ (+ c.c.)

$|mD^0 - \langle mD^0 \rangle| < 1.5\ \sigma$

$144.45 < \Delta m < 146.45$ MeV

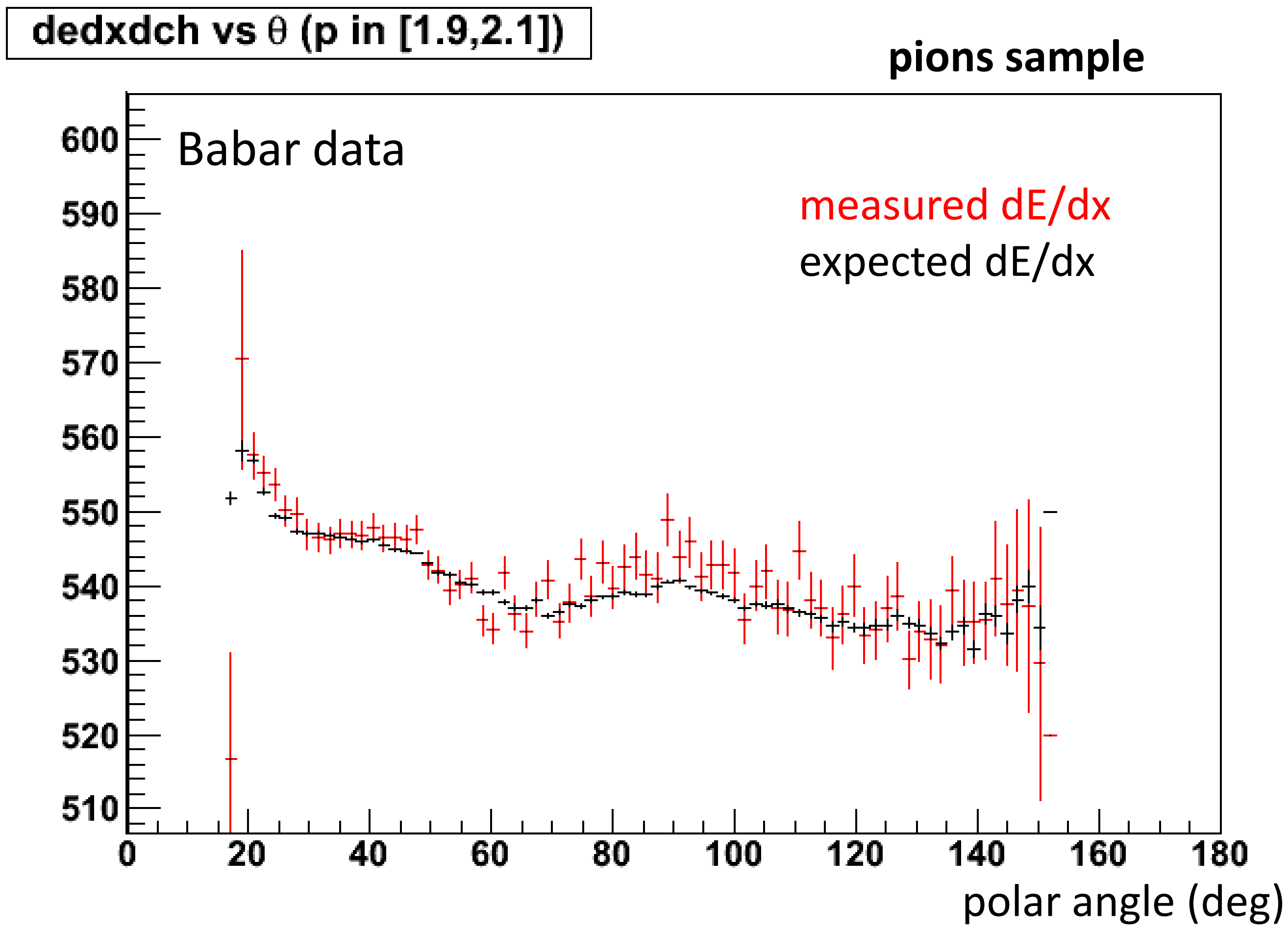
see also
http://agenda.infn.it/getFile.py/access?contribId=57&sessionId=3&resId=0&materialId=slides&confId=2262





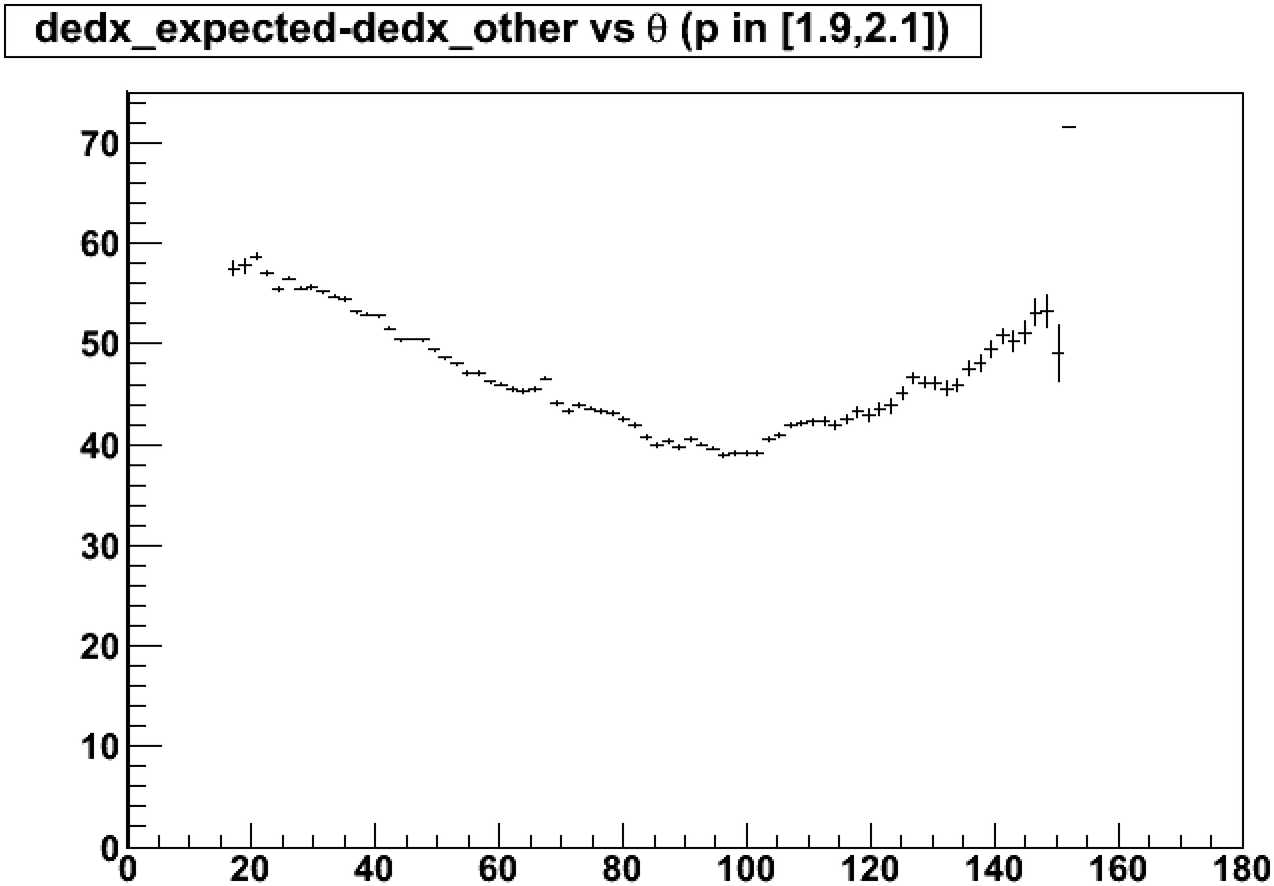
Babar PID ntuples, RUN6 data

Babar data: <dE/dx> and dE/dx_expected(pion) vs polar angle for 2GeV pions



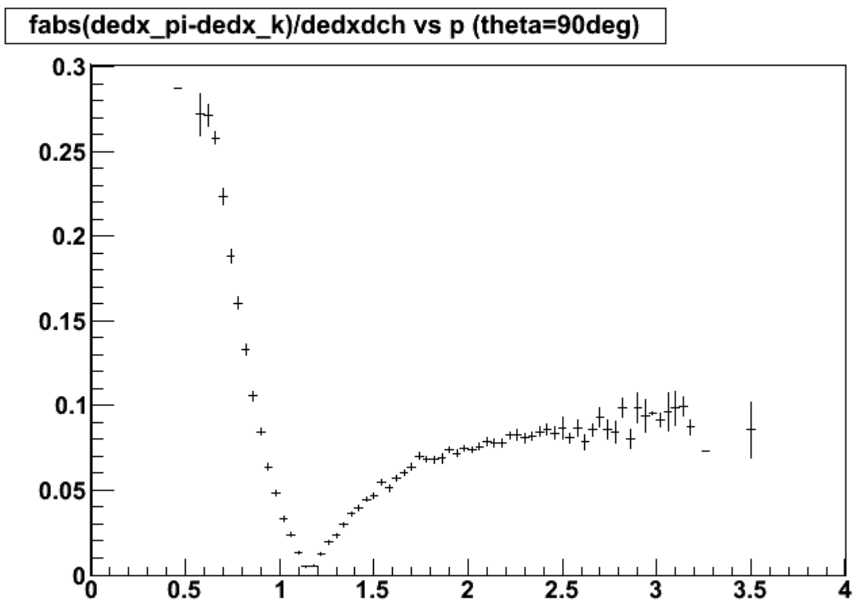
The **mean value** of the measured dE/dx for 2GeV pions is **not** constant in polar angle.
The expected dE/dx follows the same pattern.

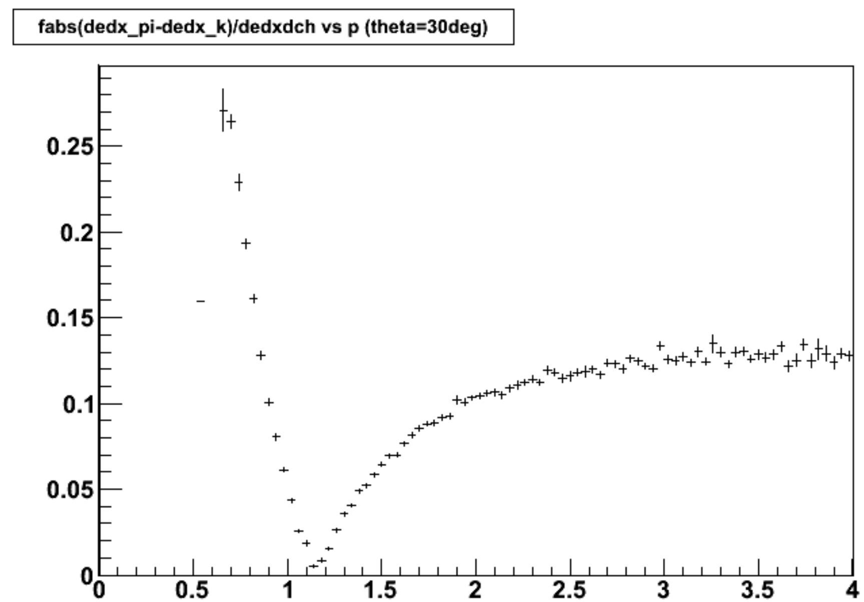
Babar data: dE/dx_expected(pion)-dE/dx_expected(kaon) vs polar angle for 2GeV pions



dE/dx_expected(pion)-dE/dx_expected(kaon) for p=2GeV.
The distribution is **not** constant over the polar angle
In FastSim the distribution is constant

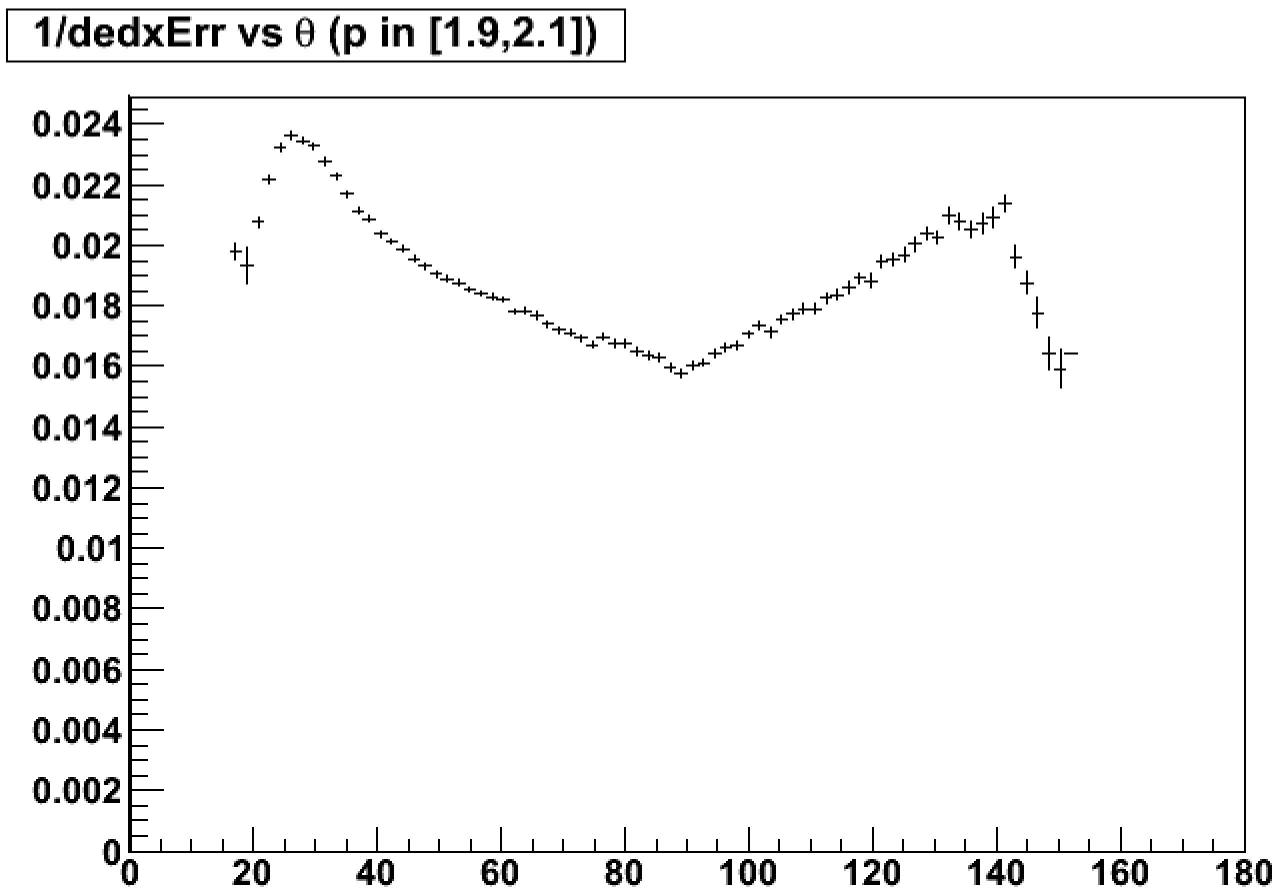
Babar data: 'relative' pi/K separation vs p





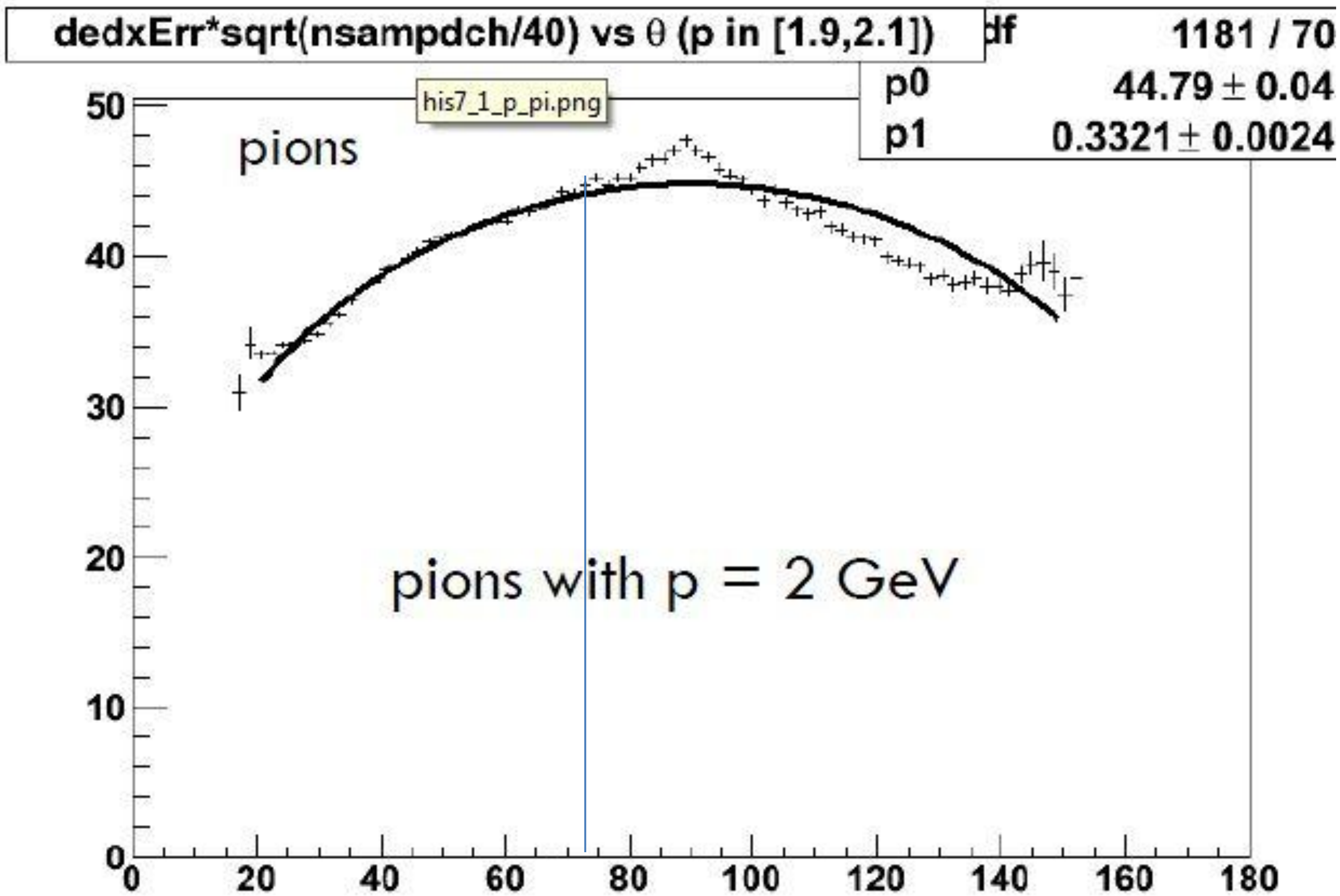
|dE/dx_expected(pion)-dE/dx_expected(kaon)|/dEdx vs p for θ=90^o and θ=30^o

Babar data: 1/(dEdx error) vs polar angle



1/dEdx_error vs polar angle for 2GeV pions

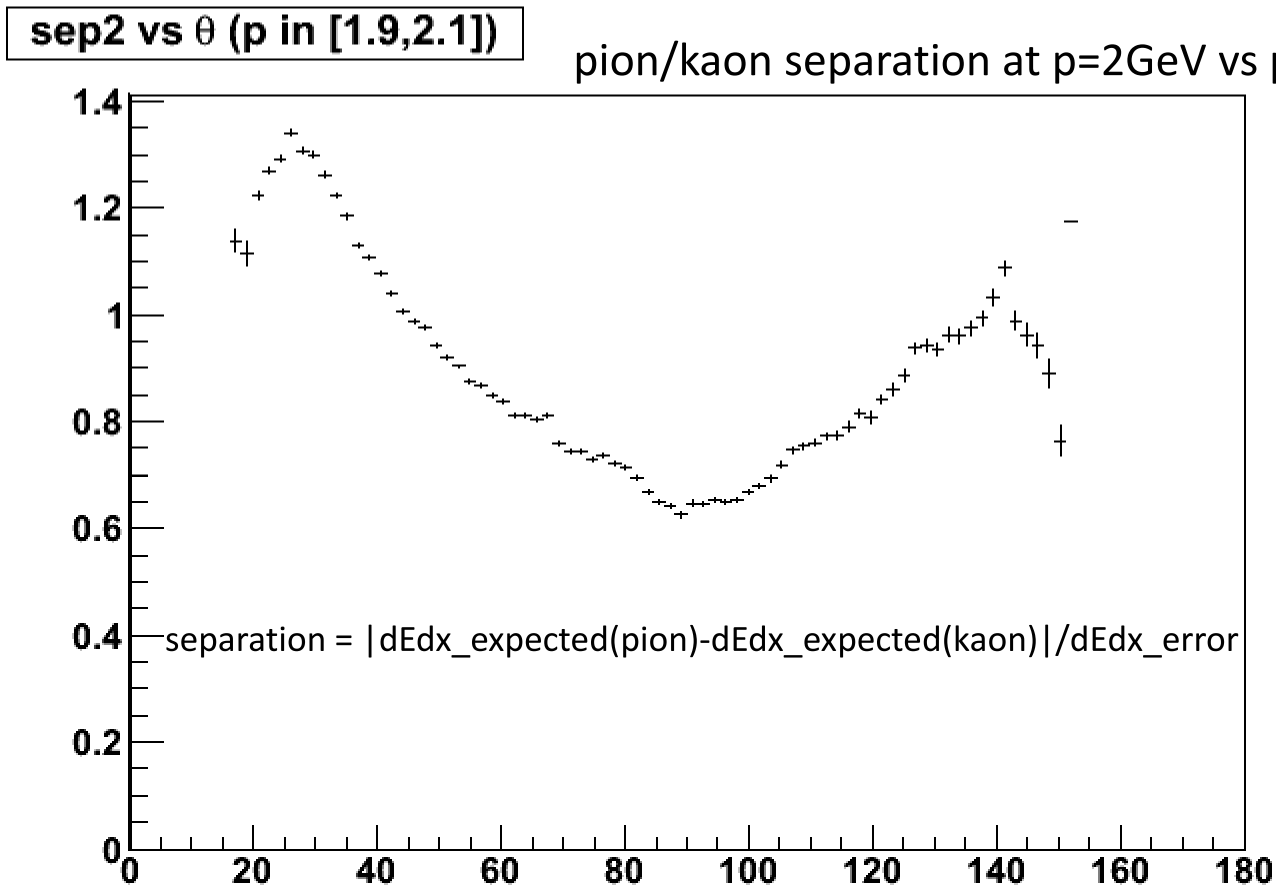
Babar data: modelization of dE/dx error vs polar angle



dEdx_error*sqrt(nsampDch) vs polar angle for 2GeV pions.
The function fits well the distribution between θ=30 and 70. At θ=90 the fit function underestimates the error. Note the asymmetry between fwd and bwd directions

Babar data: pion/kaon separation at p=2GeV vs polar angle

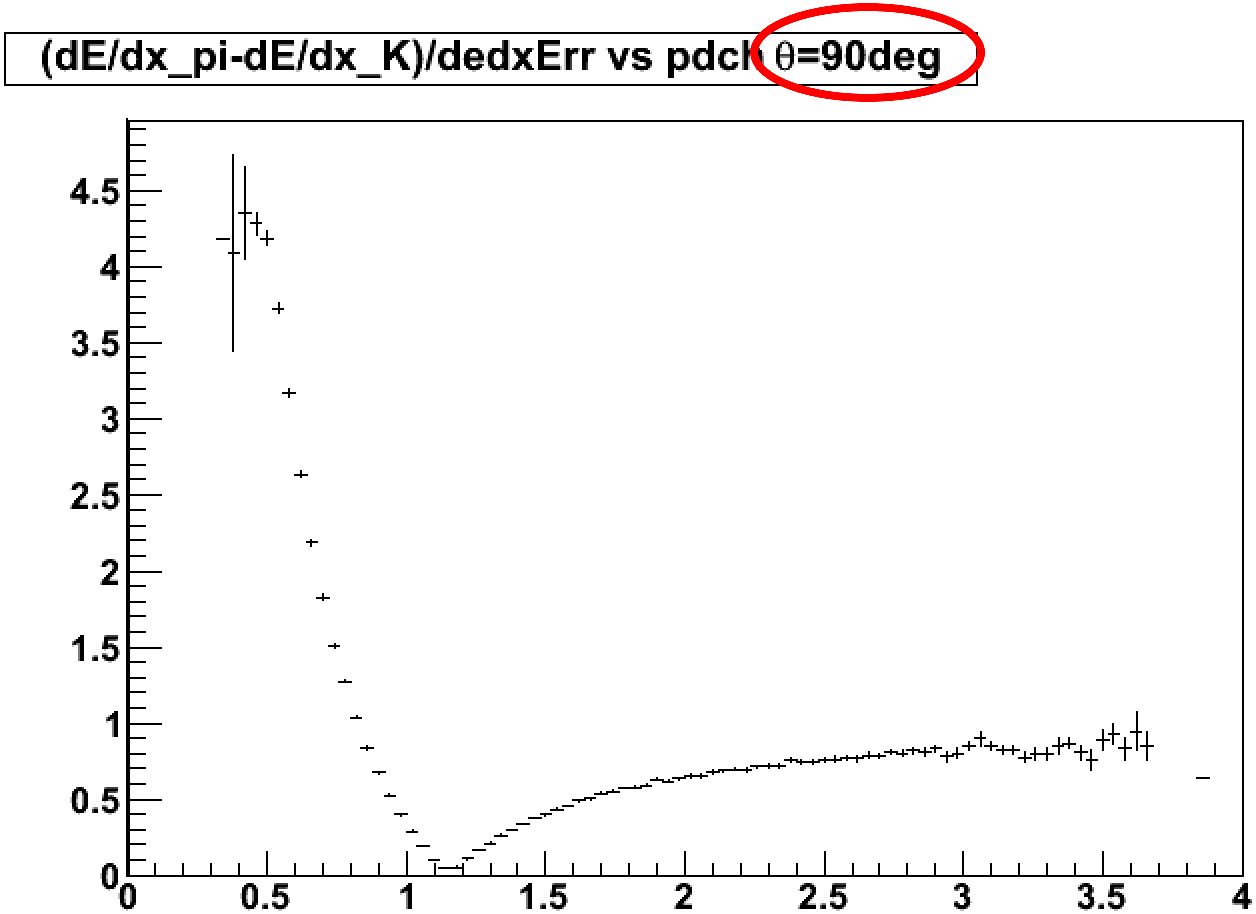
pion/kaon separation at p=2GeV vs polar angle



2GeV pions
from Babar data

The separation at θ=30 is twice the separation at θ=90.
The peaked shape is the result of two contributions: (dEdx_exp(pion)-dEdx_exp(kaons)) and 1/dEdx_error, both showing the same peaked pattern (sl. 4 and sl. 7)

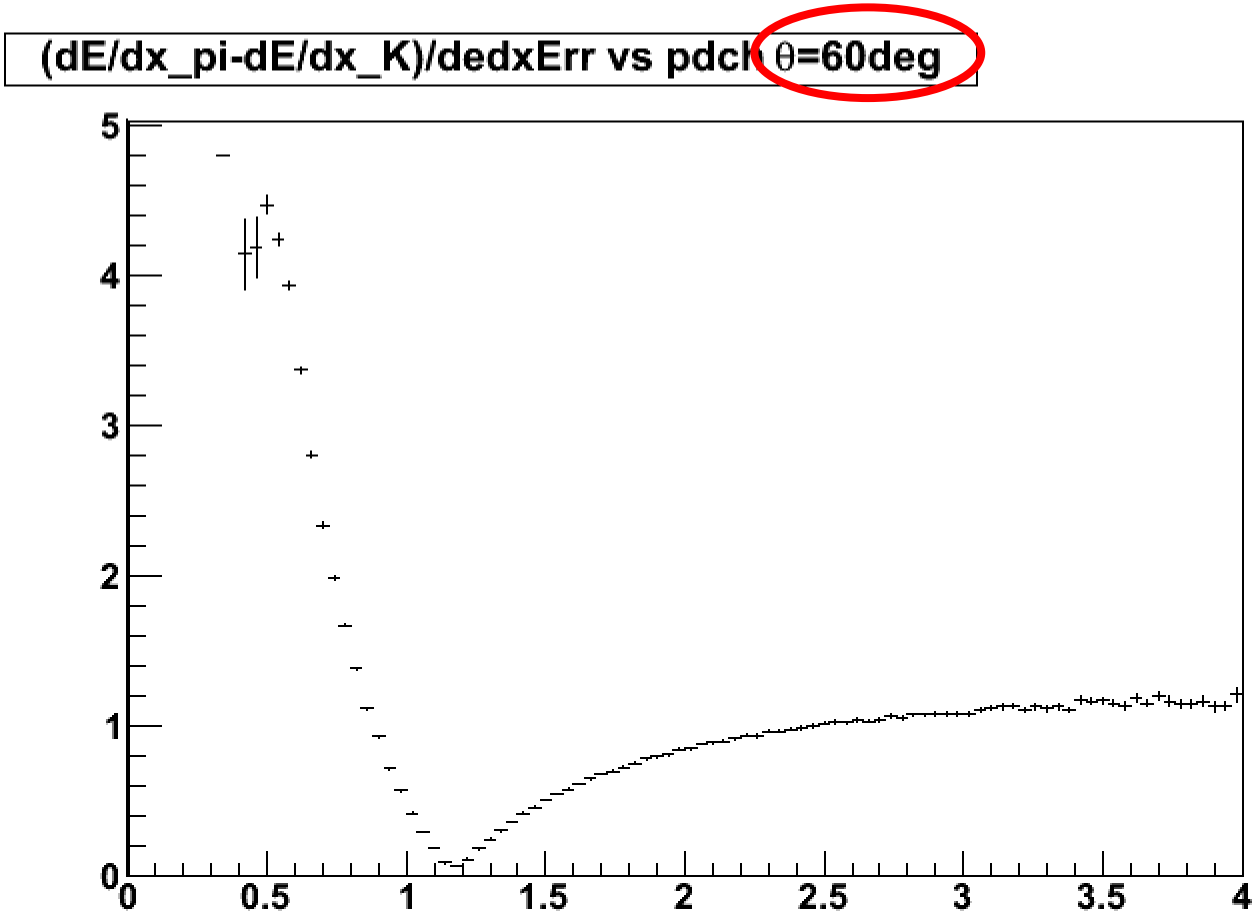
Babar data: pi/K separation at θ=90^o



pions from
Babar data

separation = |dEdx_expected(pion)-dEdx_expected(kaon)|/dEdx_error

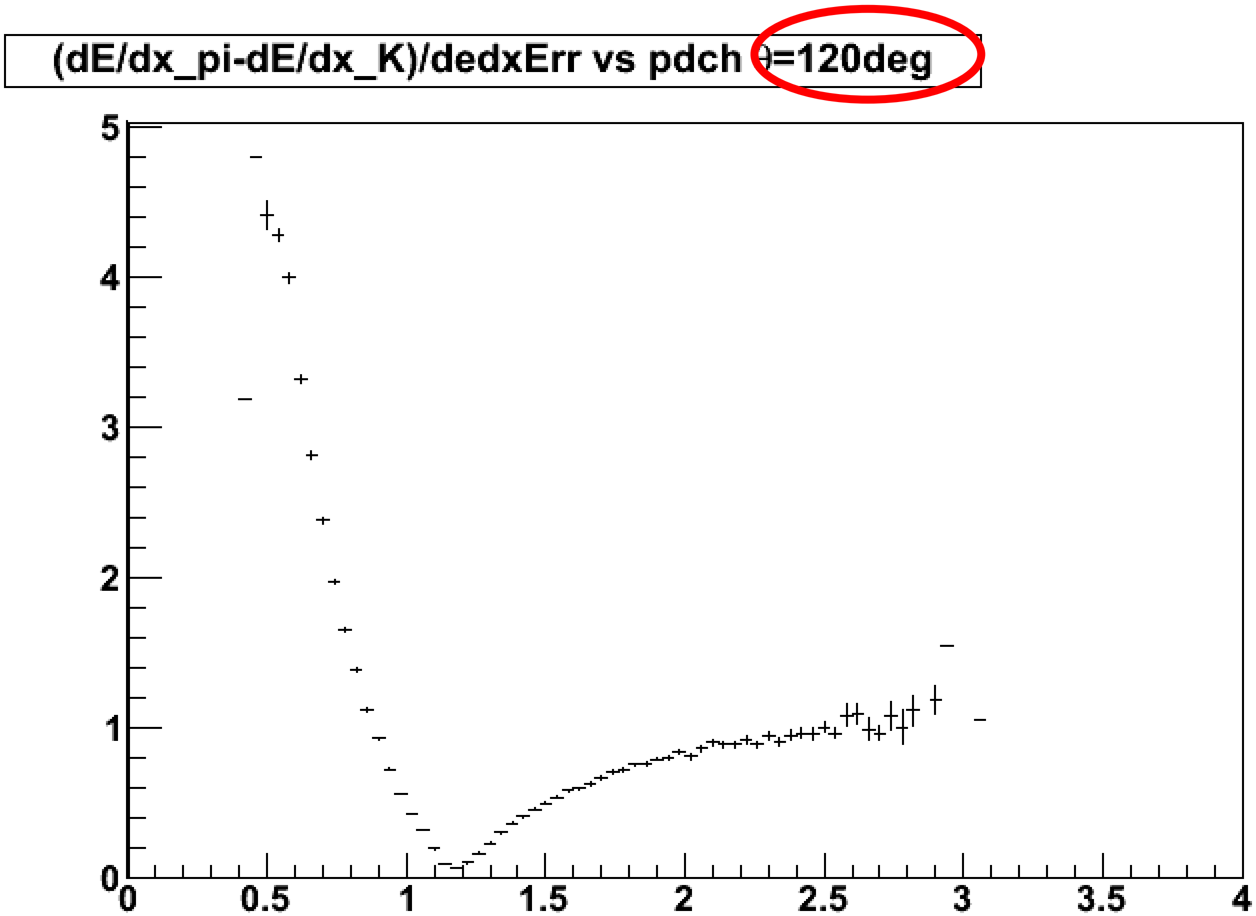
Babar data: pi/K separation at θ=60^o



pions from
Babar data

separation = |dEdx_expected(pion)-dEdx_expected(kaon)|/dEdx_error

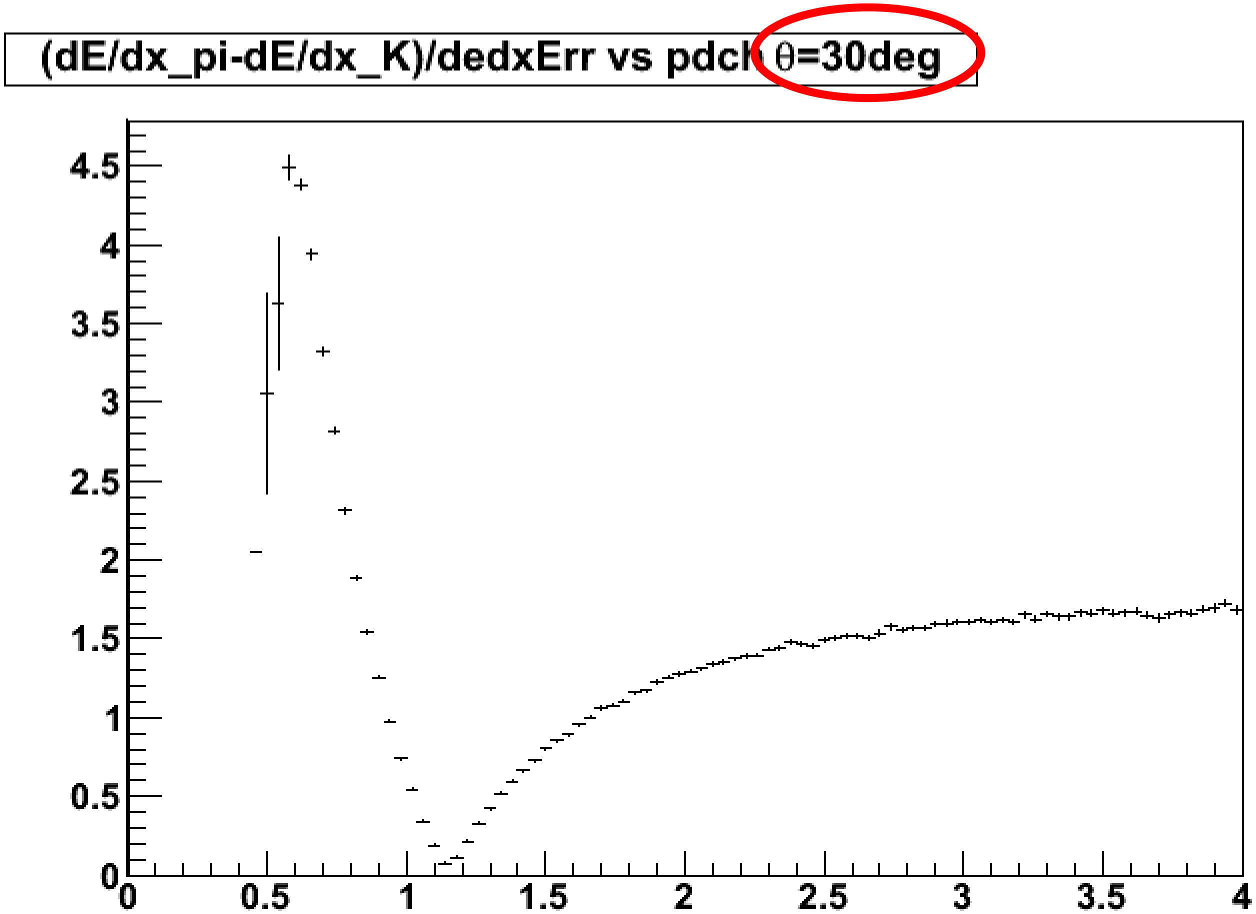
Babar data: pi/K separation at θ=120^o



pions from Babar data

separation = |dEdx_expected(pion)-dEdx_expected(kaon)|/dEdx_error

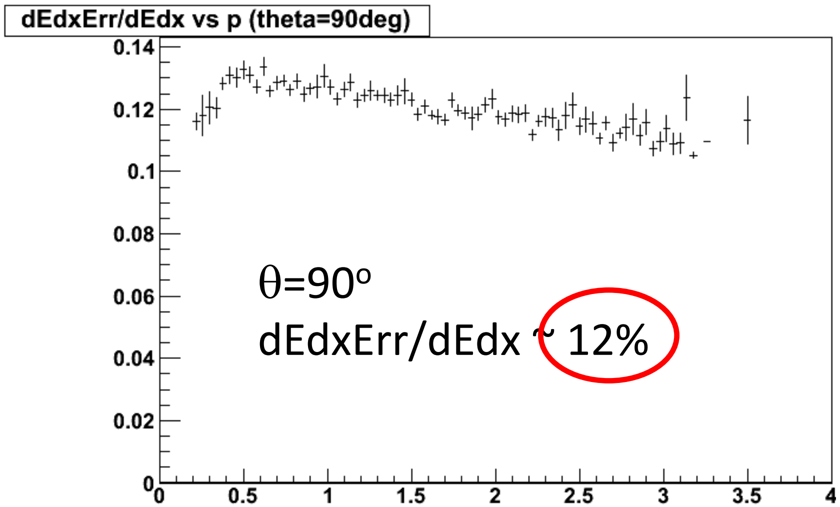
Babar data: pi/K separation at θ=30^o

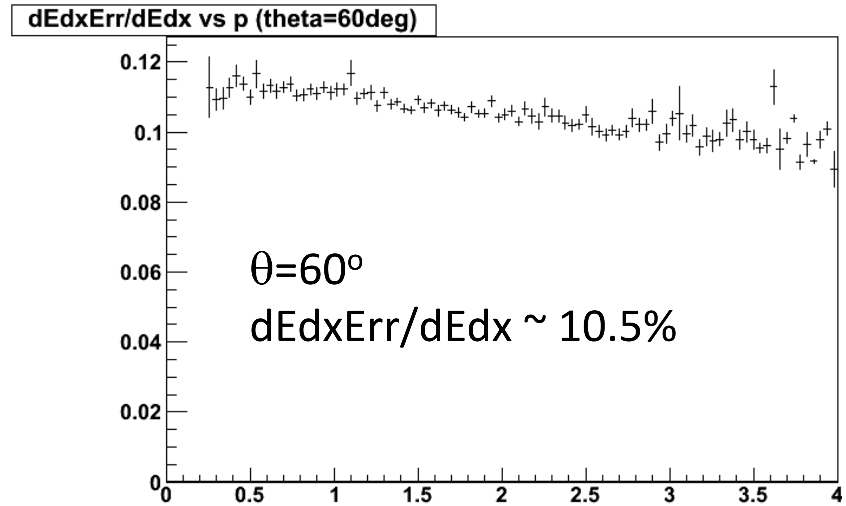


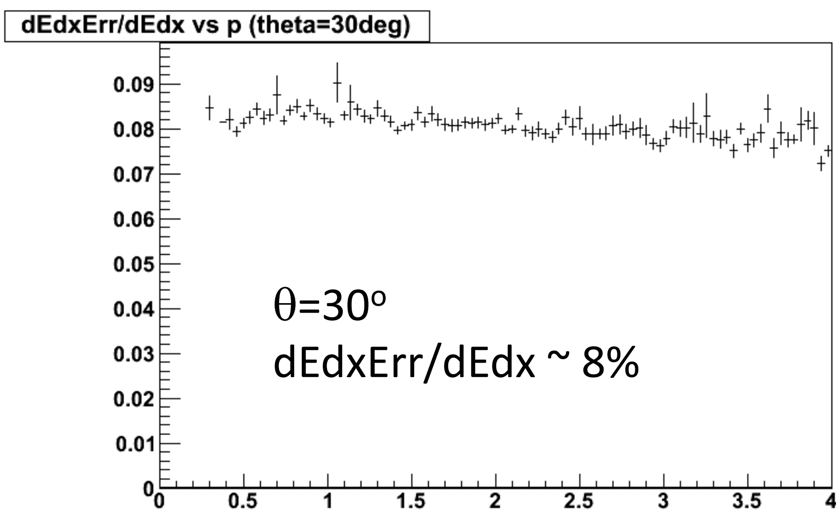
pions from Babar data

separation = |dEdx_expected(pion)-dEdx_expected(kaon)|/dEdx_error

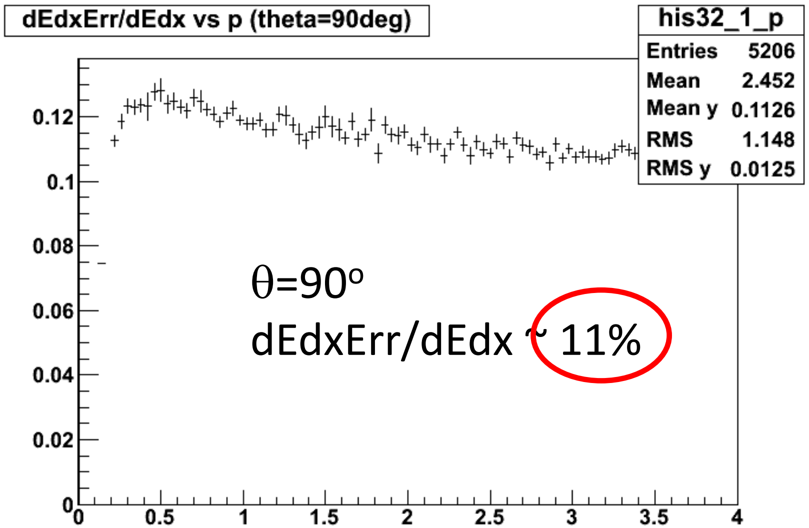
Babar data: dEdxErr/dEdx for pions

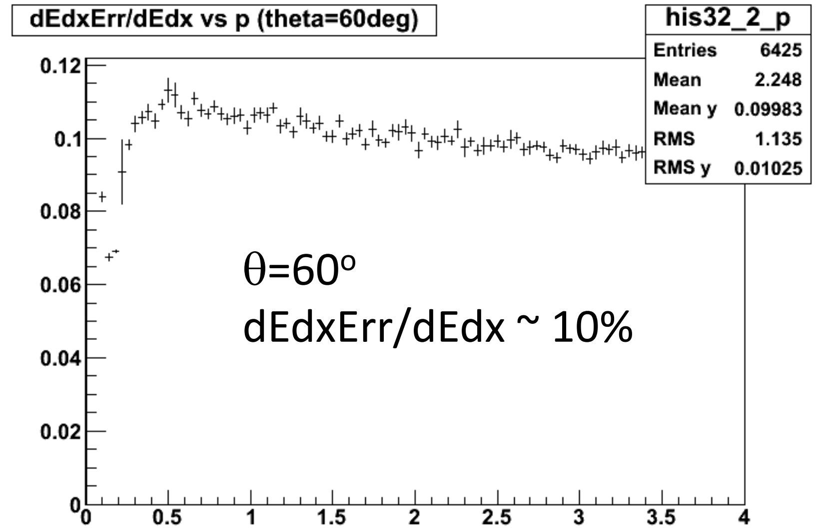


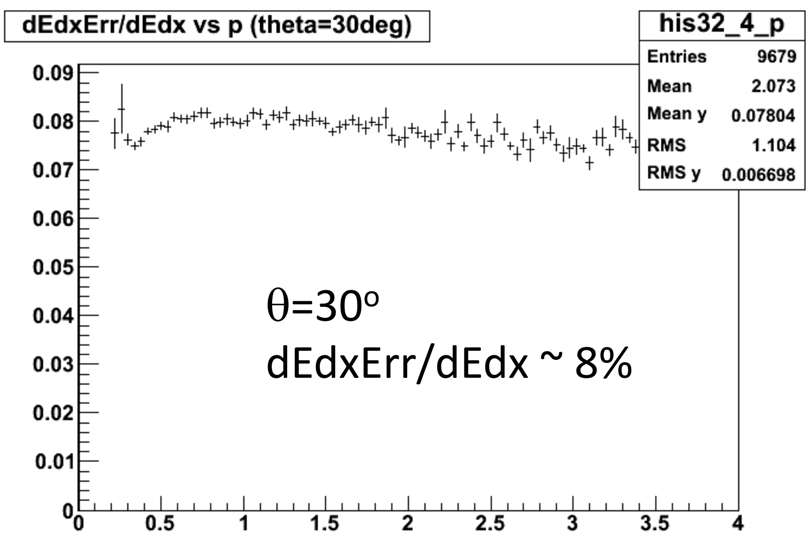




Babar data: dEdxErr/dEdx for **muons**







dE/dx simulation in FastSim

- $\langle dE/dx \rangle_{hit}$ is computed with the Bethe Bloch function and then smeared according to $\sigma(\langle dE/dx \rangle_{hit})$

(Gaussian smearing)

- $\sigma(\langle dE/dx \rangle_{hit})$ is parameterized as

$$\sigma\left(\frac{dE}{dx}\right) = \alpha\left(\frac{dE}{dx}\right)^{\beta} dx^{\gamma}$$

where α, β, γ parameters are chosen as:

$\alpha =$ tuned on Babar data

$\beta = 1$

$\gamma =$ tuned on Babar data

step 1:determine γ

tuned according to fit in sl. 8

step 2:determine α

tuned according to Babar K/pi separation

- $\langle dE/dx \rangle_{track}$ is measured as a 'random' truncated average of $\langle dE/dx \rangle_{hits}$

If the trunc_frac =70% then 30% of $\langle dE/dx \rangle_{hits}$ are removed randomly. $\langle dE/dx \rangle_{track}$ is the weighted mean of the remaining 70%. $\sigma^2 \langle dE/dx \rangle_{track}$ is computed as the variance of the weighted average.

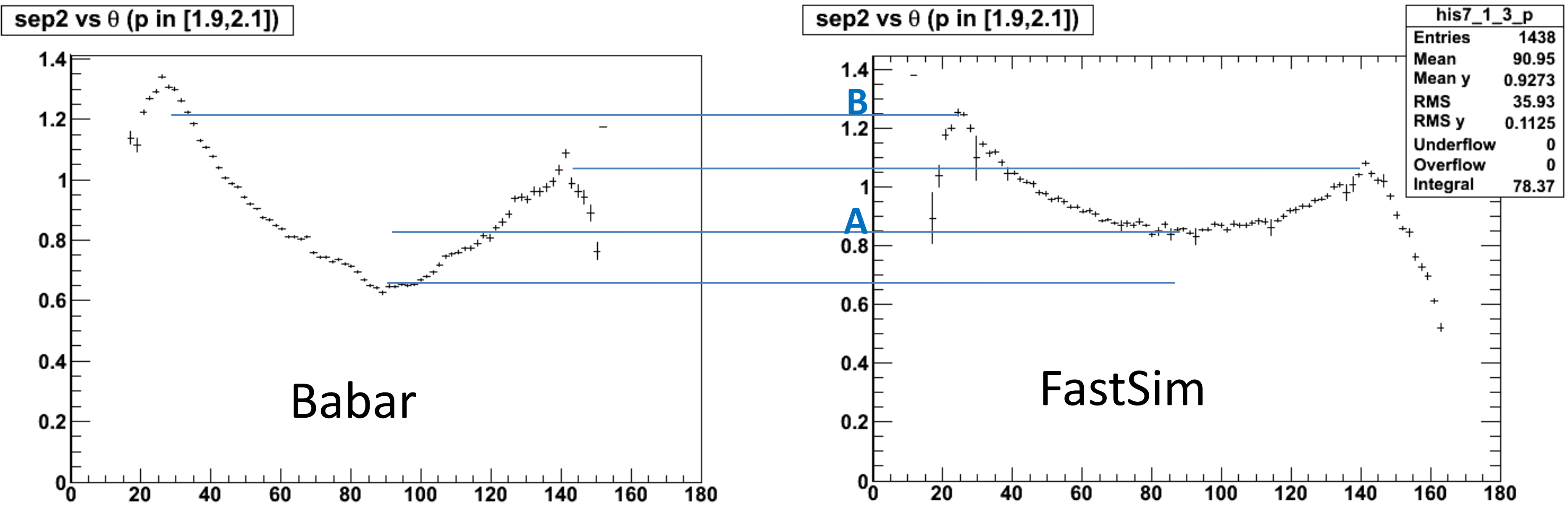
dE/dx simulation in fastsim

- characteristics
  - expected dE/dx value from Bethe Bloch function
  - measured dE/dx from Gaussian smearing around the expected value
    - sigma (error) parameterized as in previous slide
  - no real truncation, but ‘random truncation’ that reduces # of samples but does not change the Gaussian shape
  - parameters tuned to match the dE/dx K/pi separation in Babar
- advantages
  - no calibrations needed when DCH parameters are changed
    - dE/dx measurement given by Gaussian distributions with known mean and sigma
  - definition of PID selectors fast and painless
- disadvantages
  - some limitations in realism arising from simplified approach

- Alternative approach
  - use a Landau-like distribution for the dE/dx measurement of single hits and apply real truncation
  - this approach was also considered 2 years ago but was discarded based on overall balance of advantages/disadvantages

pi/K separation Babar vs fastsim

Comparison of Babar and fastsim samples of 2GeV pions



The parameter γ affects the range (B-A)/B. The fit in slide 8 underestimates the actual range of pi/K separation vs polar angle in Babar data for two reasons:

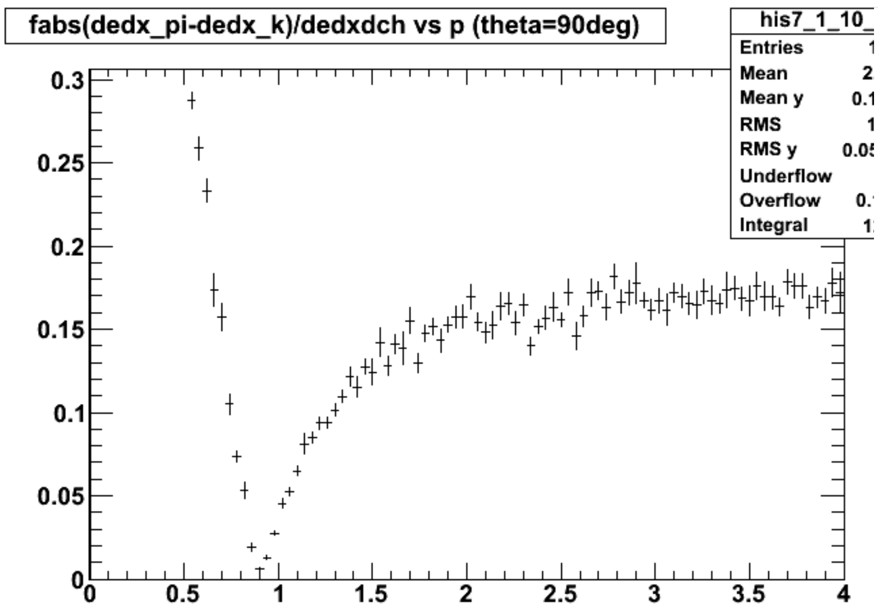
a) peak at $\theta=90^o$ in the distribution of Babar dEdxErr vs θ (slide 8)

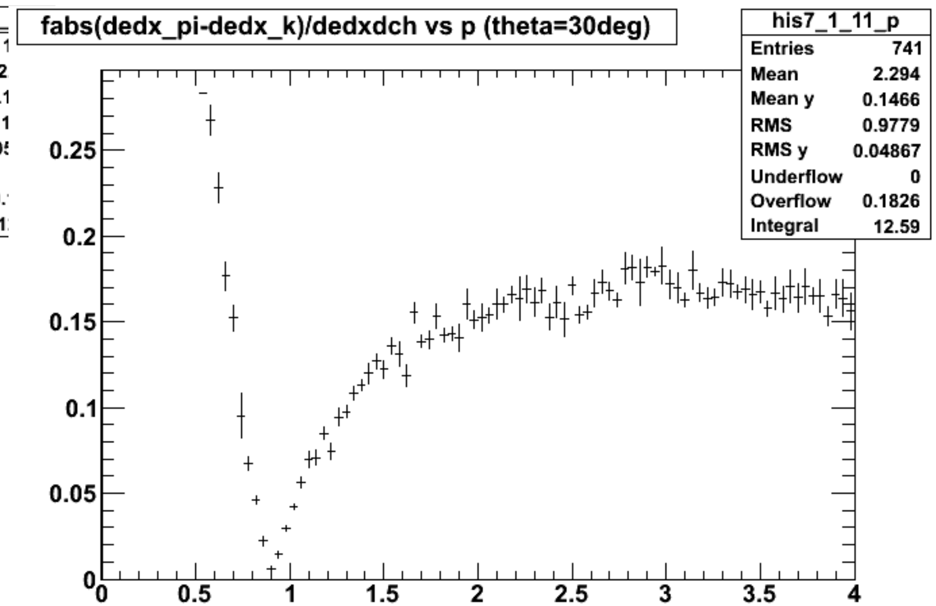
b) |dE/dx_expected(pion)-dE/dx_expected(kaon)| vs θ is also peaked at $\theta=30^o,140^o$ (slide 4)

The parameter α was chosen to give an overall reasonable matching given γ

fastsim: ‘relative’ pi/K separation vs p

(to be compared with the distribution in Babar data, sl. 5)



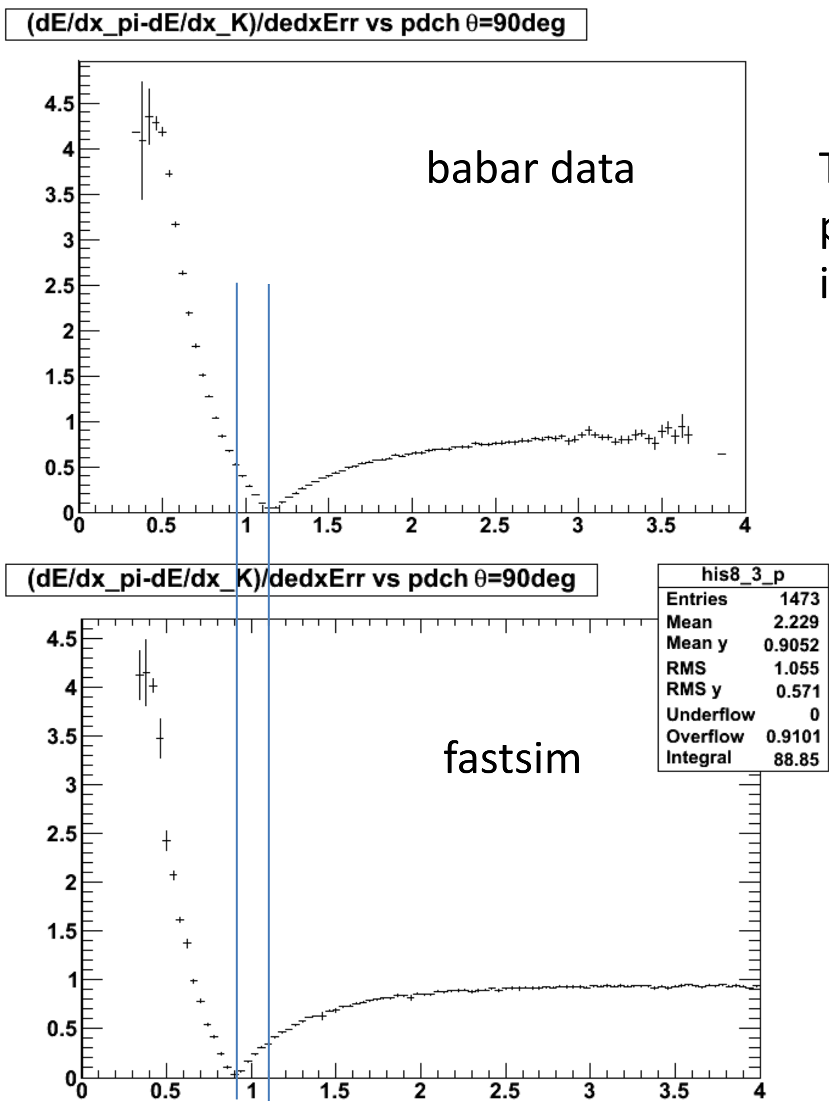


|dE/dx_expected(pion)-dE/dx_expected(kaon)|/dEdx vs p for $\theta=90^o$ and $\theta=30^o$

This quantity depends only on the Bethe-Bloch function used by FastSim (i.e., not on the way the dE/dx *error* is modeled)

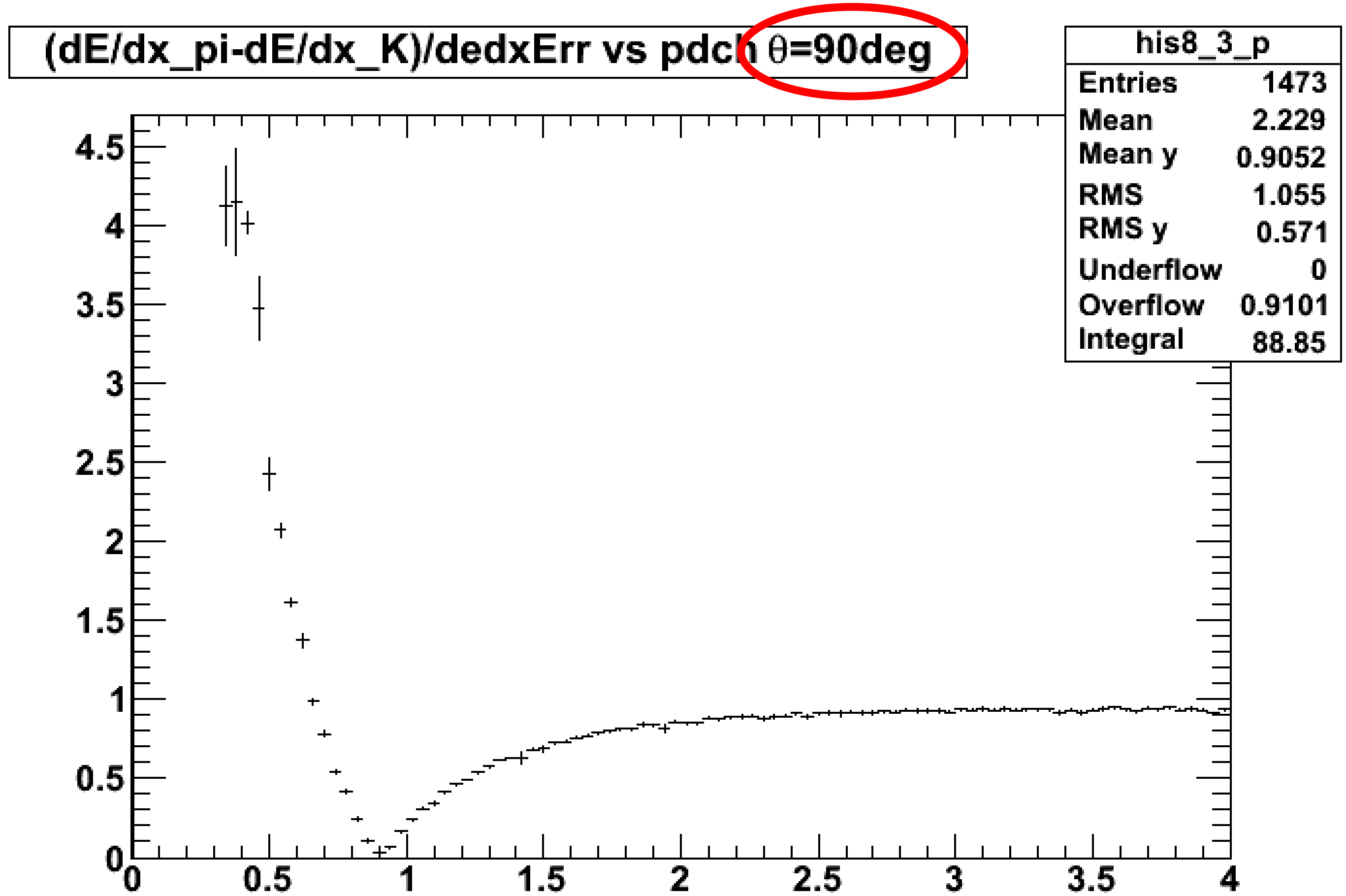
The relative separation is smaller in Babar compared to fastsim. *Therefore if the dEdx error in Babar and fastsim are set to be the same, the pi/K separation in Babar will be smaller than in FastSim*

pi/K separation Babar vs fastsim



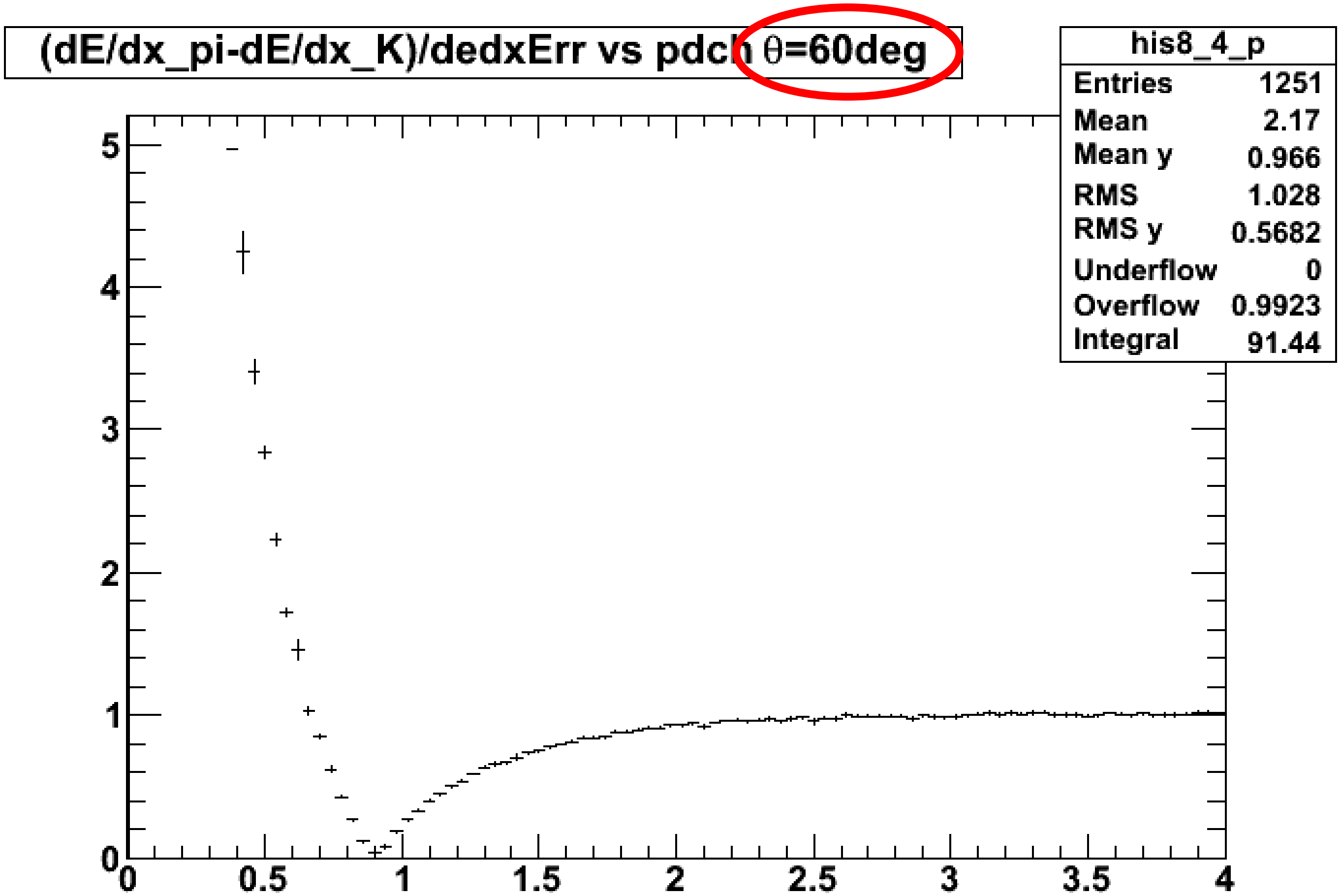
The point of zero K/pi separation is at p=1.15 GeV in Babar and at p=0.90 GeV in fastsim.

fastsim: pi/K separation at θ=90^o



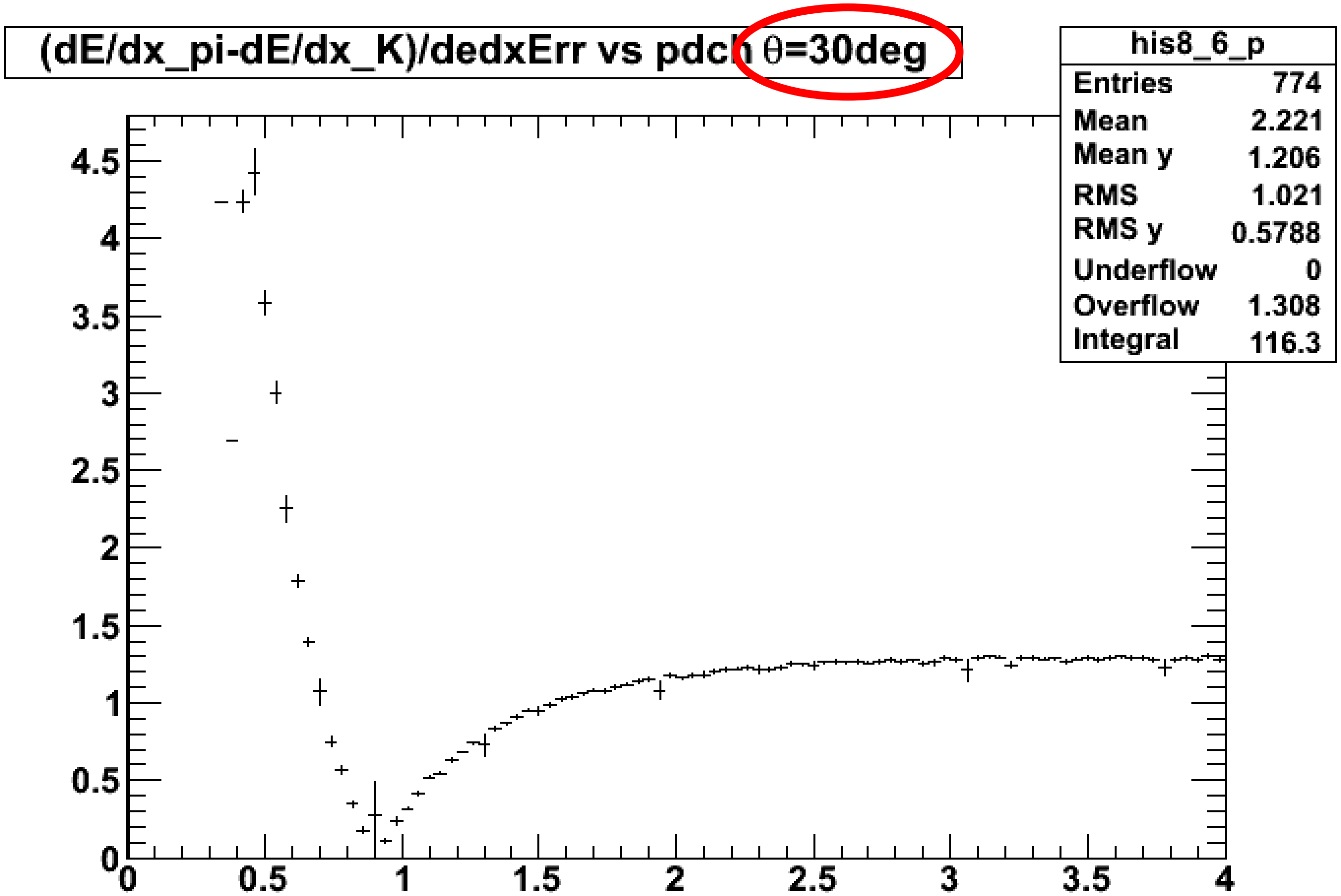
separation = |dEdx_expected(pion)-dEdx_expected(kaon)|/dEdx_error

fastsim: pi/K separation at θ=60°



separation = |dEdx_expected(pion)-dEdx_expected(kaon)|/dEdx_error

fastsim: pi/K separation at $\theta=30^o$



separation = |dEdx_expected(pion)-dEdx_expected(kaon)|/dEdx_error

Main differences between the Babar and fastsim outputs

- |dEdx_expected(pion)-dEdx_expected(kaon)|/dEdx in Babar and fastsim (slides 5 and 17)
- dE/dx error vs polar angle in Babar (slide 7)
  - the model function proportional to (pathlength)$^{\gamma}$ is a simple approximation of the Babar distribution.
  - On the other hand it wouldn't make much sense to try to reproduce in fastsim the exact pattern observed in Babar data
- The momentum at which dE/dx(pion)=dE/dx(kaon) differs by about 200MeV/c between Babar and fastsim (slide 19)

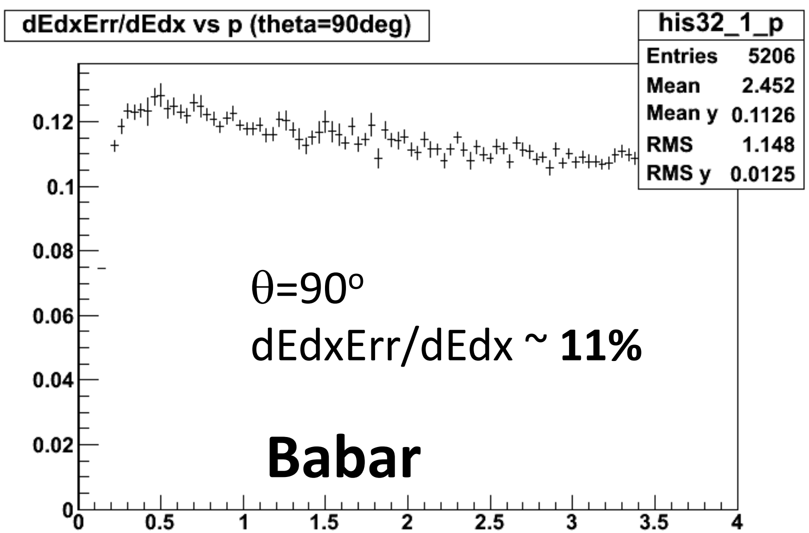
- The first two points (especially the first one) above imply that with the current dE/dx simulation it's not possible to tune fastsim to match both the Babar dE/dx relative uncertainty and the Babar K/pi separation
  - one explanation could be the fact that in Babar <dE/dx> is the most probable value (real truncation) while in fastsim it's the mean value (sl. 15-16)
  - the main figure of merit to tune fastsim is the particles separation

Jean-Francois proposal

http://agenda.infn.it/getFile.py/access?contribId=271&sessionId=31&resId=1&materialId=slides&confId=4441 (sl. 12)

dEdx resolution vs p ($\theta=90^o$)

muons sample

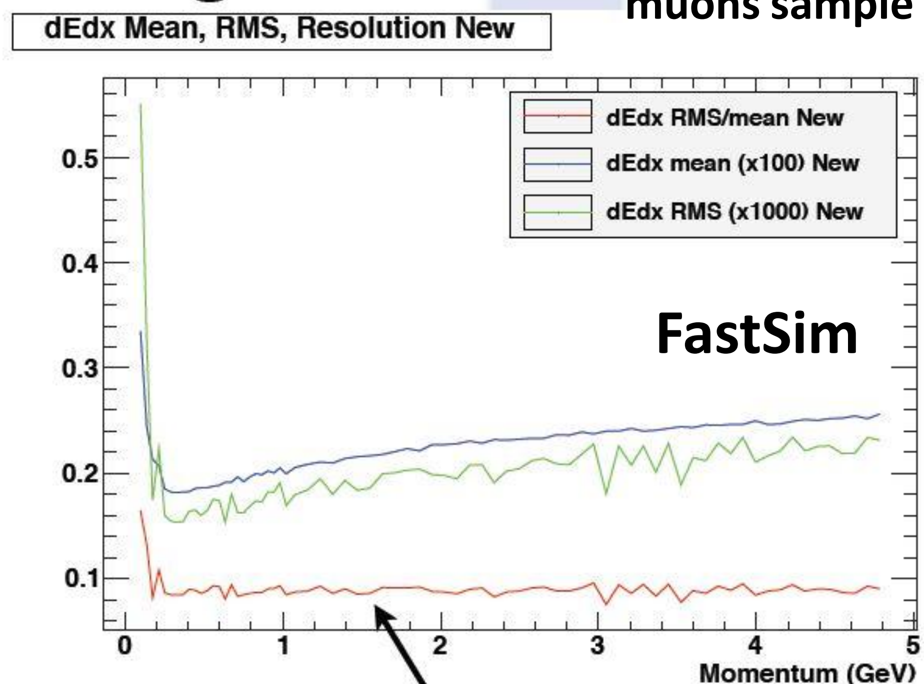


$\theta=90^o$

dEdxErr/dEdx ~ **11%**

Babar

muons sample



FastSim

$\theta=90^o$

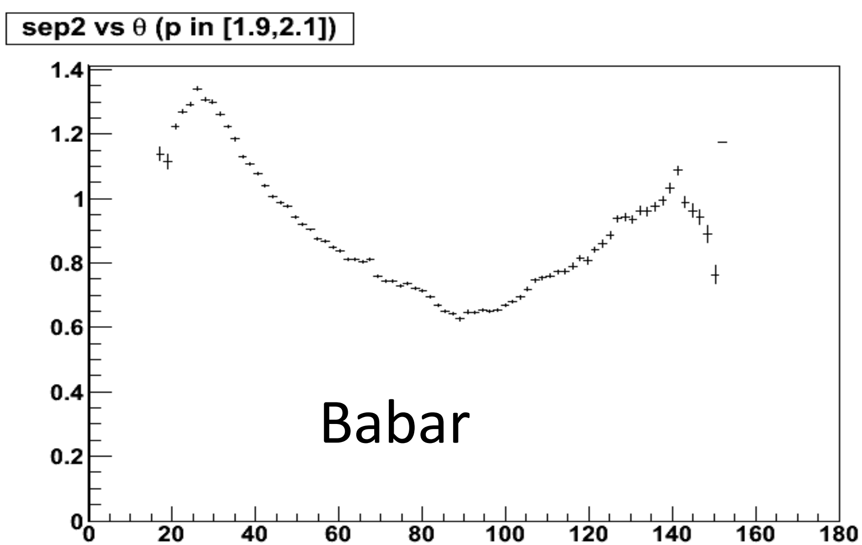
dEdxErr/dEdx ~ **7.5%**

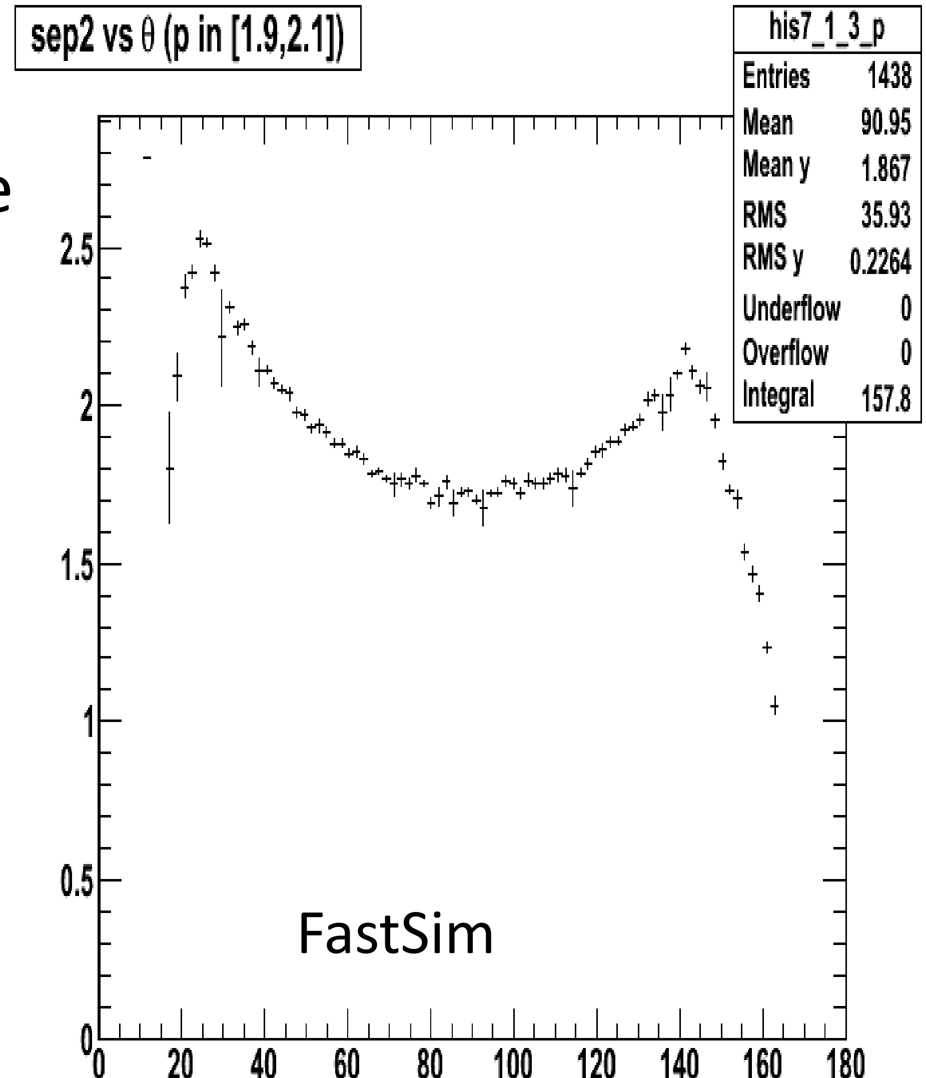
dEdx resolution underestimated

Jean-Francois proposal

(sl. 12)

pi/K separation vs polar angle

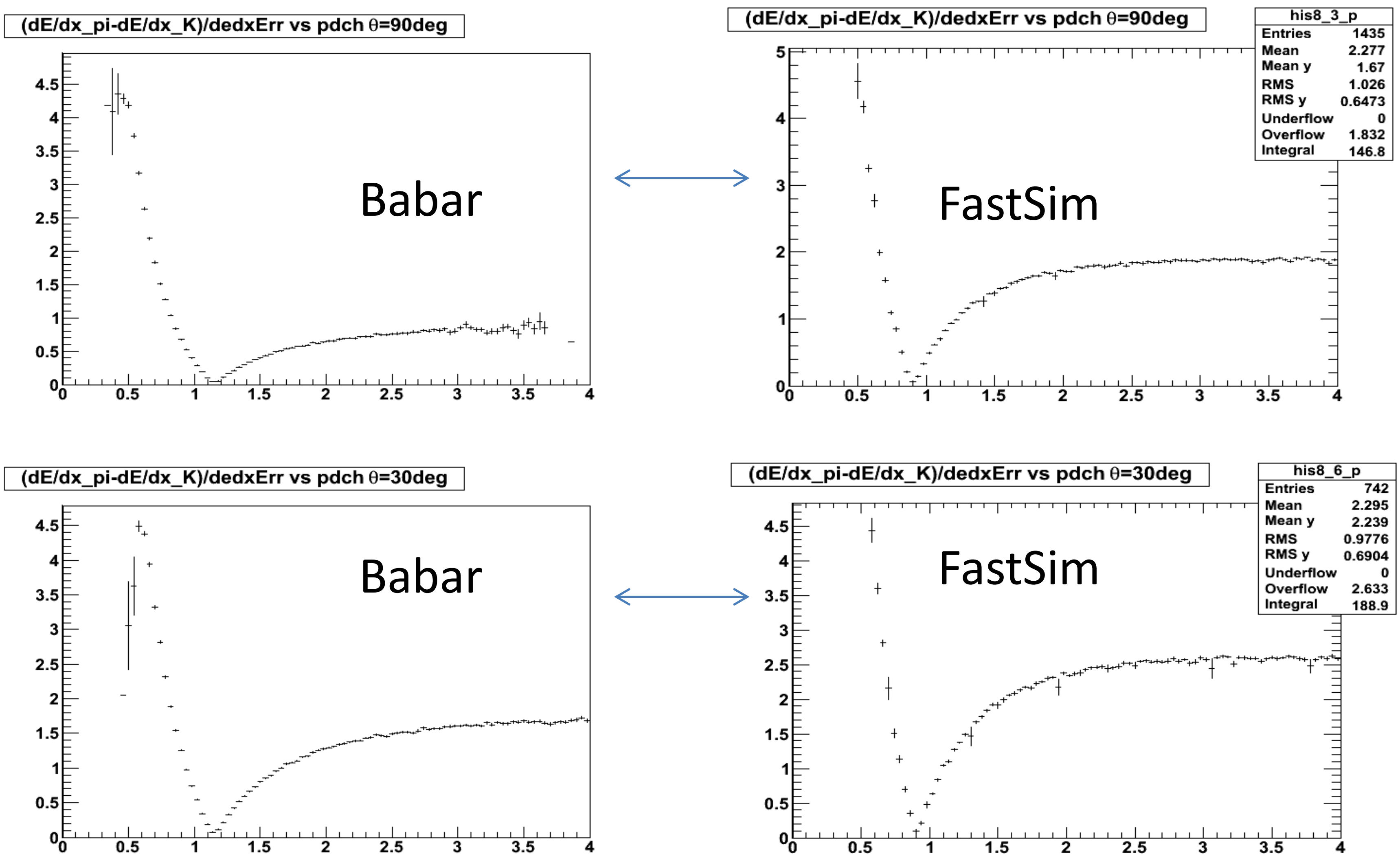




pi/K separation strongly overestimated

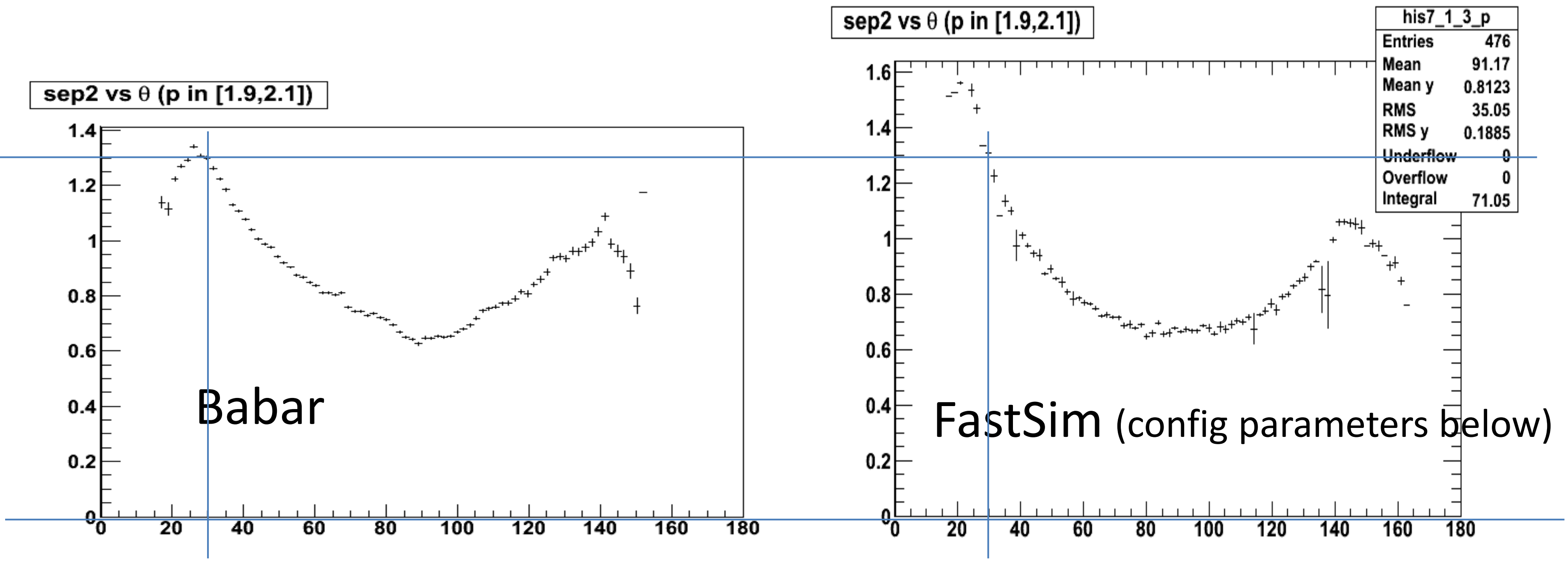
Jean-Francois proposal

pi/K separation vs p. Babar vs FastSim



pi/K separation strongly overestimated

Alternative set of fastsim parameters (I)



α=0.00237 (note: to be compared with 0.00154→dE/dx resolution increases)

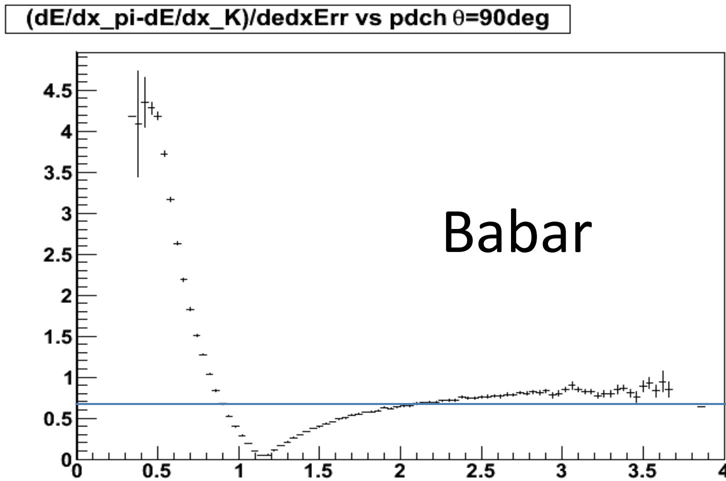
β=1

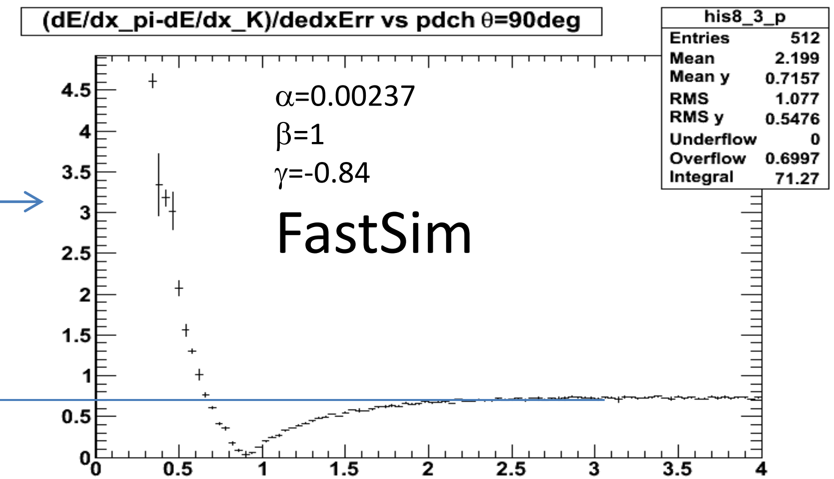
γ=-0.84

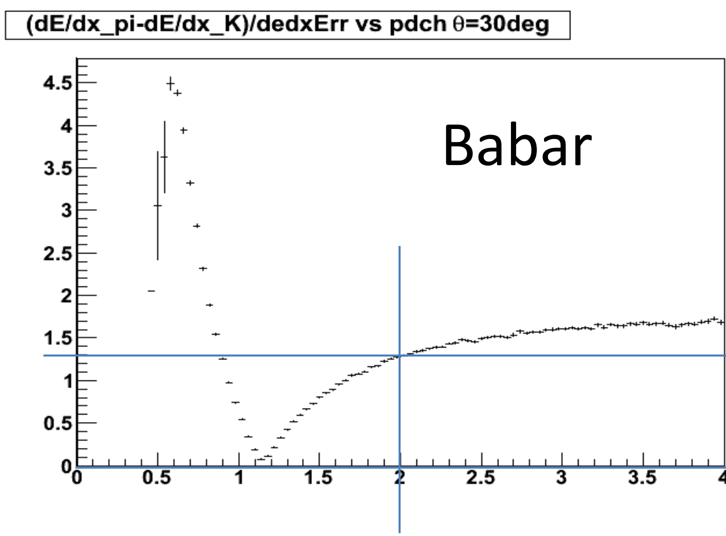
(note: β slightly <1 might improve the agreement further)

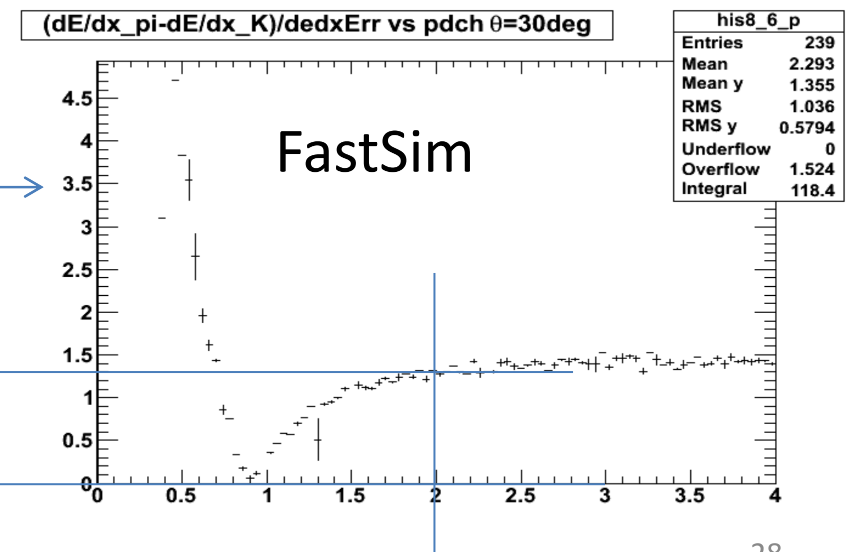
Alternative set of fastsim parameters (II)

pi/K separation vs p. Babar vs FastSim









BACKUP

dEdxErr/dEdx fastsim pions