Look at the track hit efficiency and dE/dx of the BaBar drift chamber

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thanks to Giulietto Felici, Giuseppe Finocchiaro, Marcello Piccolo

SuperB general meeting, La Biodola 31 May 2010

What has triggered the investigation

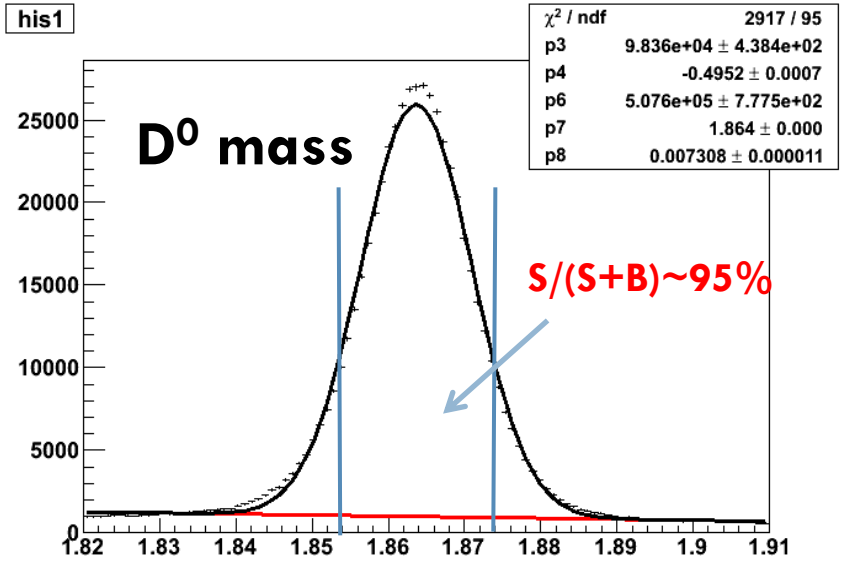
- In FastSim we want to implement reliable PID selectors built from the basic ingredients: dE/dx (DCH+SVT), DIRC, TOF, etc.
  - It requires a sufficiently precise description of each ingredient
- Use Babar data to study the performance of dE/dx and tune a realistic simulation of Babar and SuperB (the latter with possible modifications)
  - Observed some interesting features in the DCH hits distribution. Work still in progress.

Selection of pions, kaons and dimuons samples in Babar data

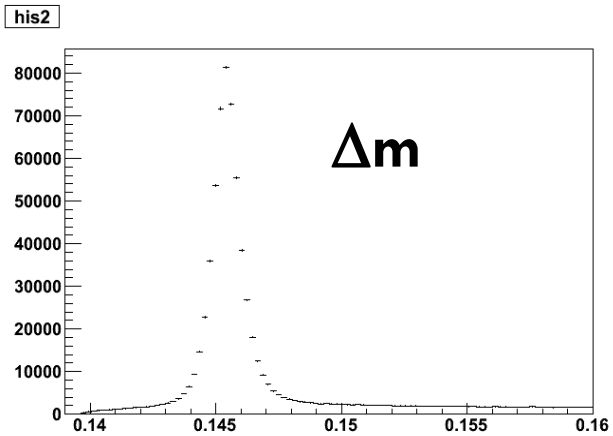
- Selection of $D^{*+} \rightarrow D^0\pi^+$, $D^0 \rightarrow K^-\pi^+$ (+ c.c.)

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

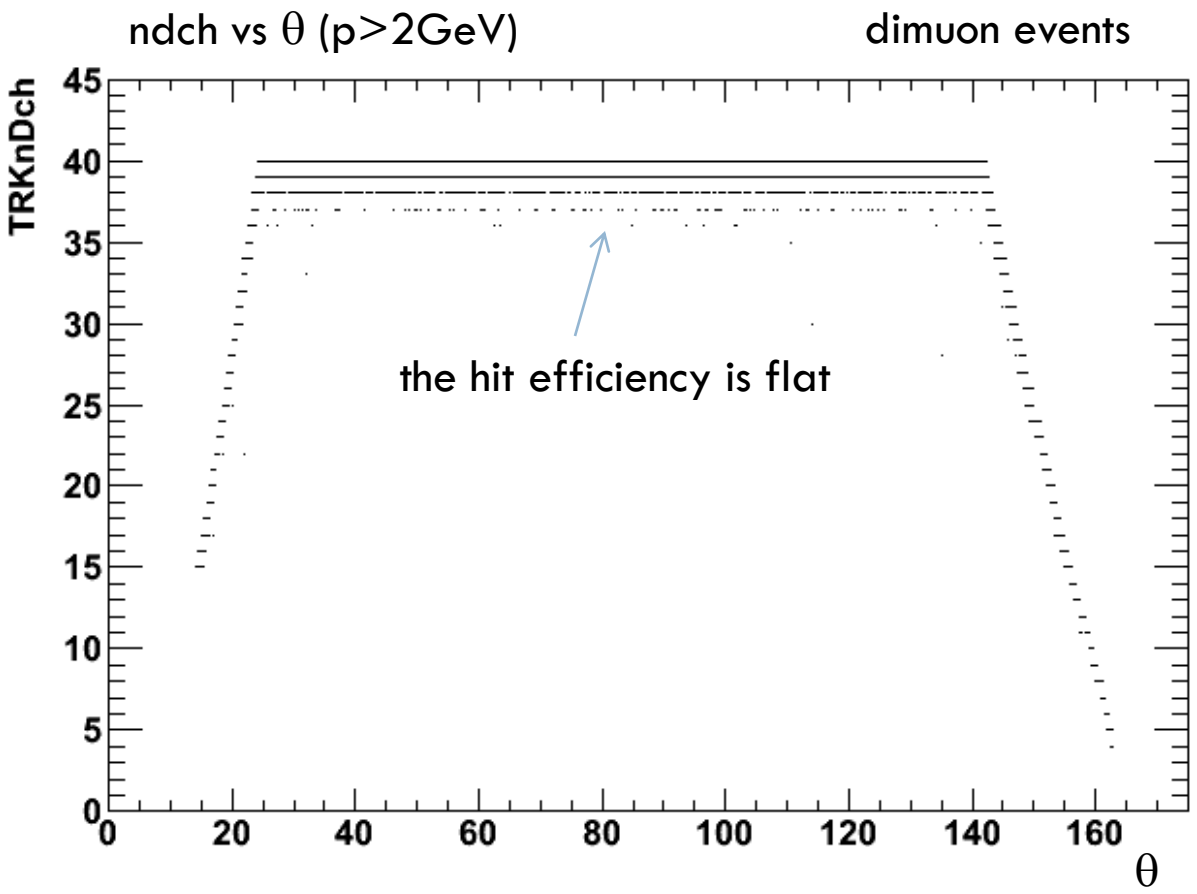
$144.45 < \Delta m < 146.45$ MeV



- Selection of dimuons events
  - provided by the PID group
  - nTrk/evt = 2



DCH hits vs polar angle in FastSim

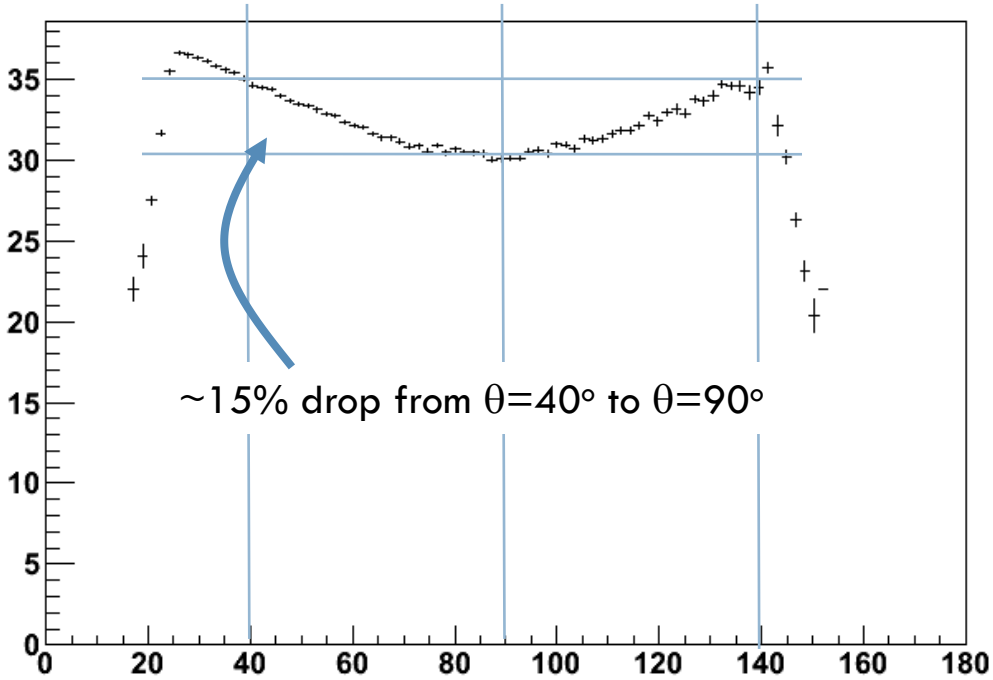


DCH hits vs polar angle in BaBar

(Run6)

pions from $D^{*+} \rightarrow D^0\pi^+$, $D^0 \rightarrow K^-\pi^+$

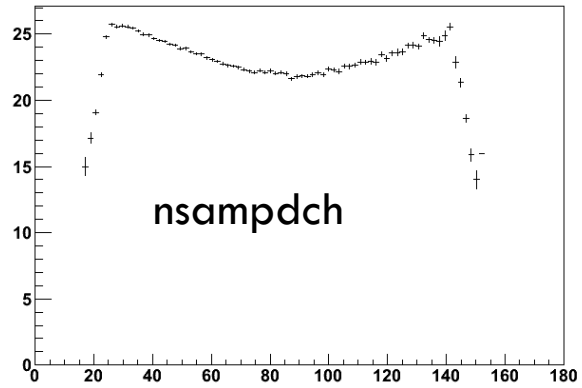
ndch vs θ (p in [1.9,2.1]) **(pions with p>2 GeV)**



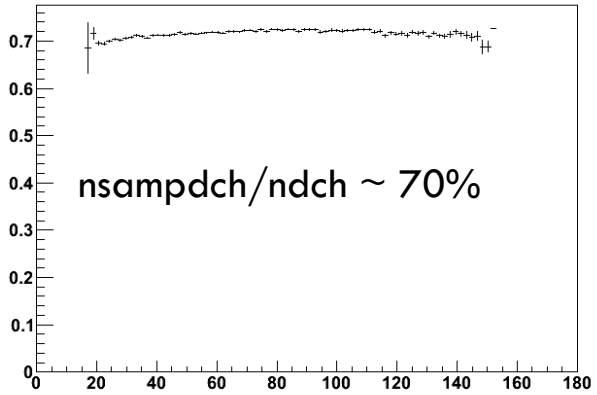
Is the pattern mainly caused by 'hit confusion' in pat. rec. due to the track multiplicity of the event? → next slide

#hits used to evaluate dE/dx

nsampdch vs θ (p in [1.9,2.1])

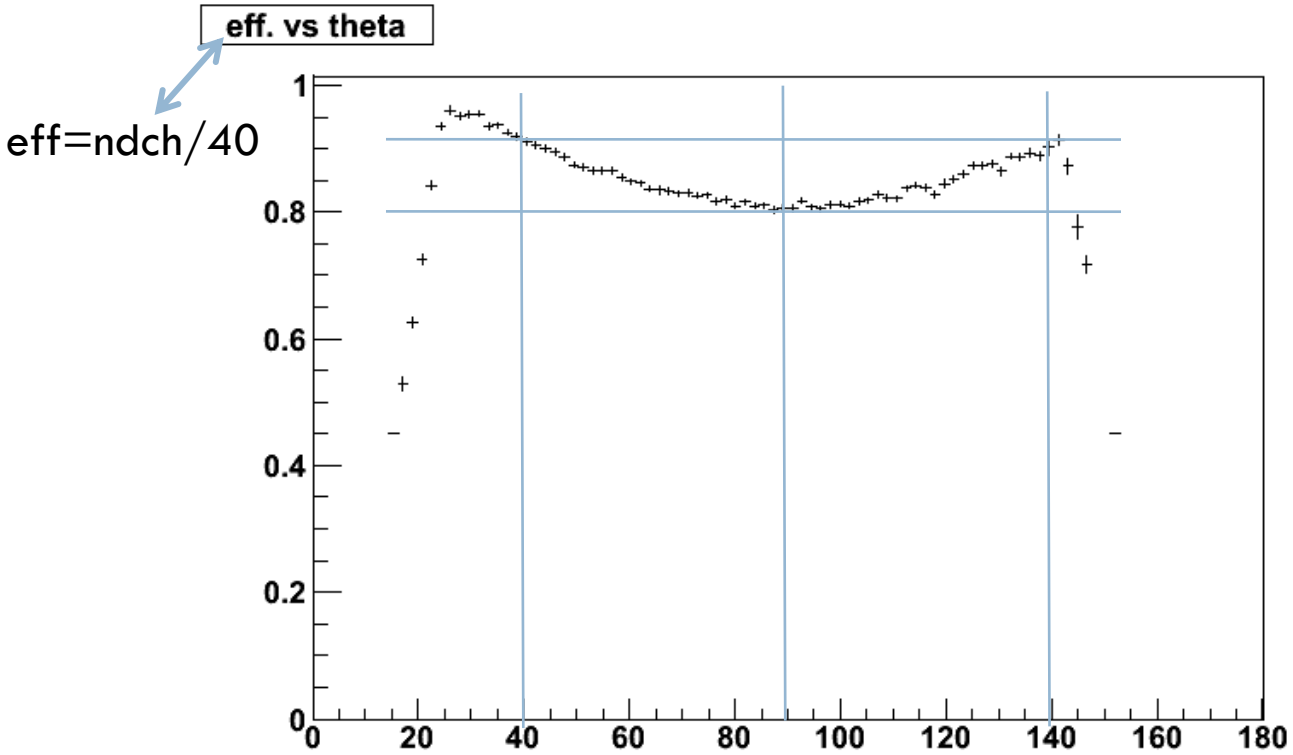


nsampdch/ndch vs θ (p in [1.9,2.1])



DCH hits vs polar angle in BaBar

dimuons events (nTracks/event = 2)



The pattern is still there even when the hit confusion is expected to be negligible

Note: the absolute efficiency is slightly increased (at θ=90°: 80% in dimuons, 75% in D*)

DCH hits vs polar angle in BaBar

dimuons events (nTracks/event = 2)

Consider a model where $dp = \lambda\, dx$

dp=prob. that the track generates a visible hit in a path length *dx*

➔ $\varepsilon = 1 - e^{-\lambda x}$

expressing λ in terms of eff at θ=90° (ε_1) and adding a global eff on top of it (ε_0):

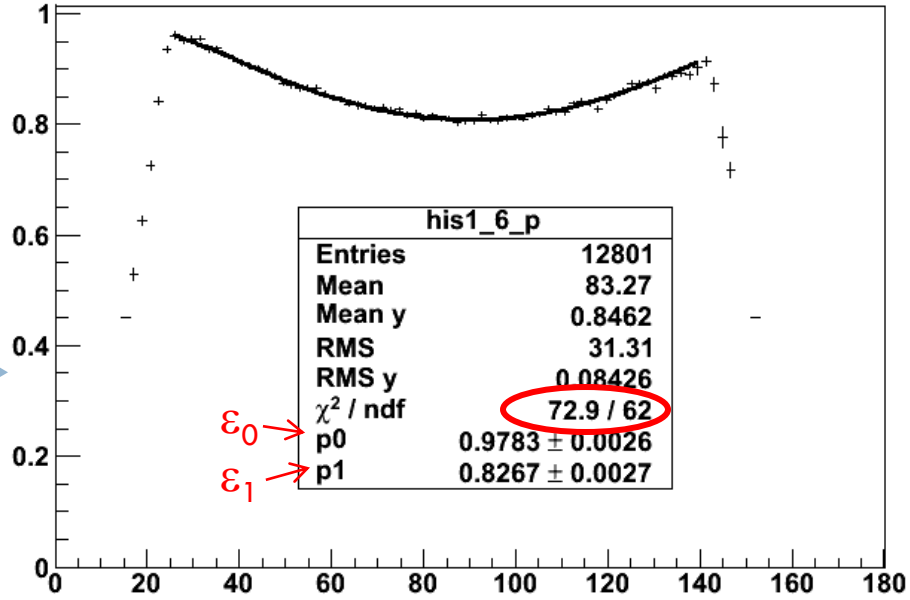
$$eff = \varepsilon_0 (1 - (1 - \varepsilon_1)^{x/h})$$

h=cell height (1.19cm)

this "threshold model" describes the data very well

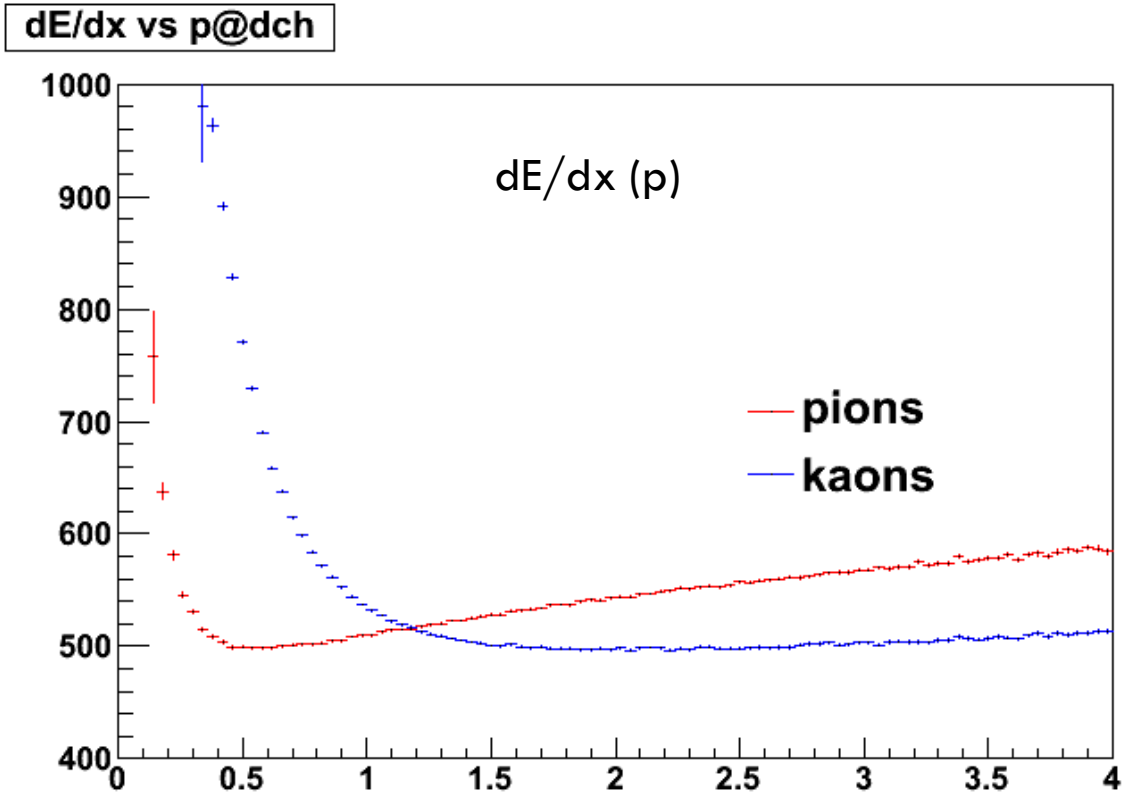
Can we check the correlation with the amount of charge in the cell?

eff. vs theta eff = ndch/40



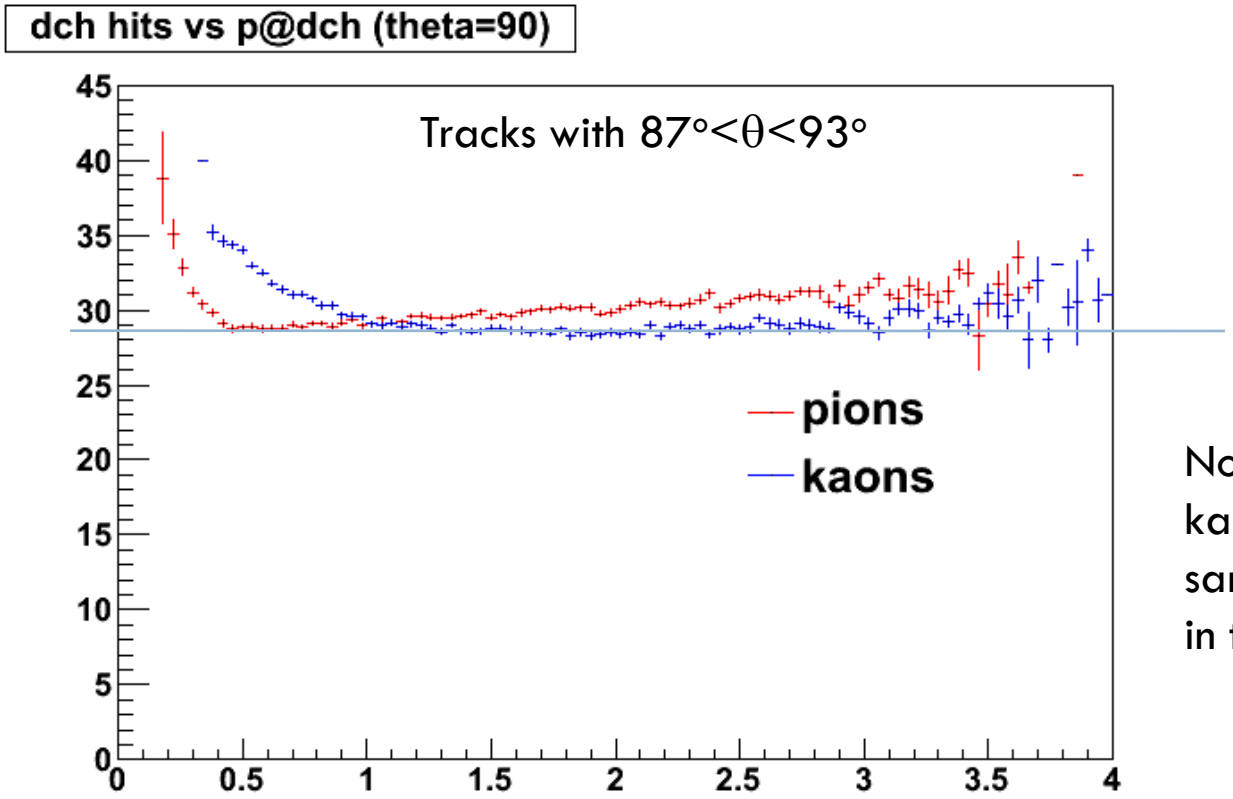
Correlation with the amount of ionization

Use π and K from $D^{*+} \rightarrow D^0\pi^+$, $D^0 \rightarrow K^-\pi^+$ to check if there is a correlation between the hit efficiency and the amount of ionization



Correlation with the amount of ionization

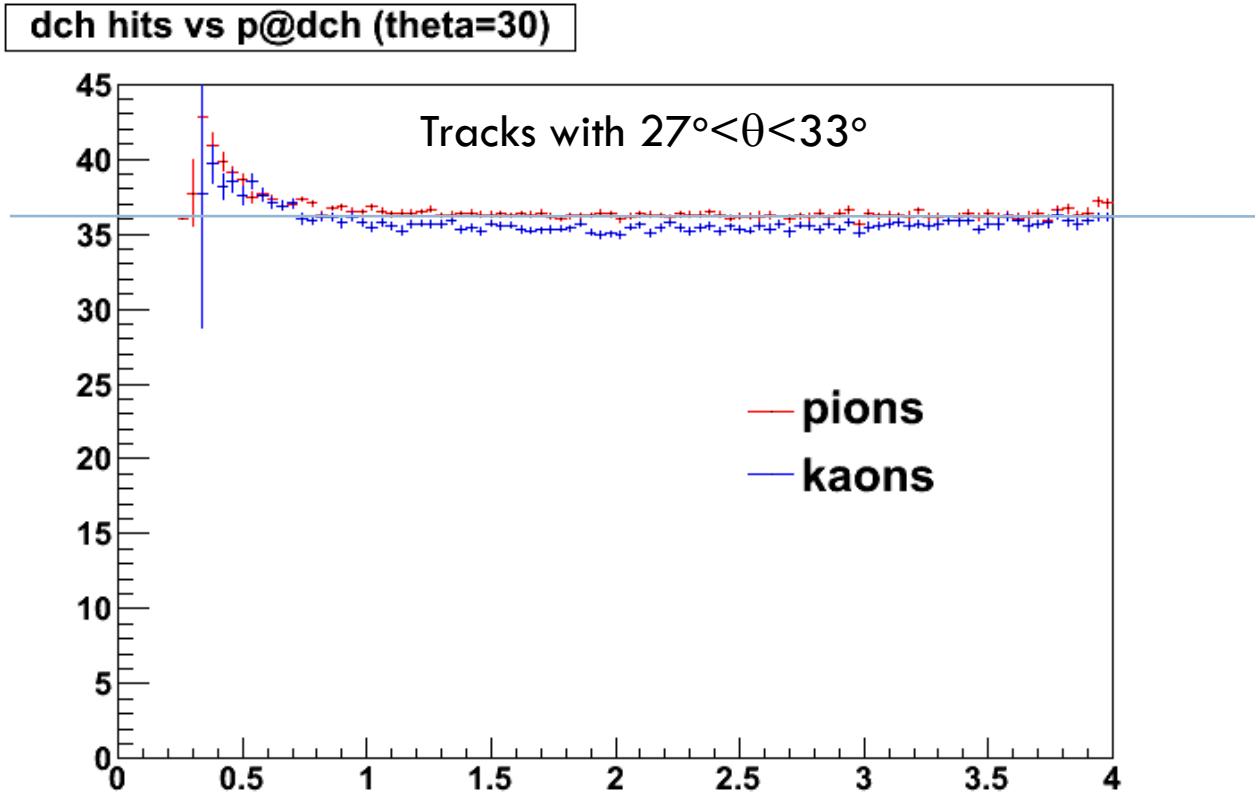
At θ=90° there is a clear correlation between #hits and charge



Note: pions and kaons have the same path length in the cell

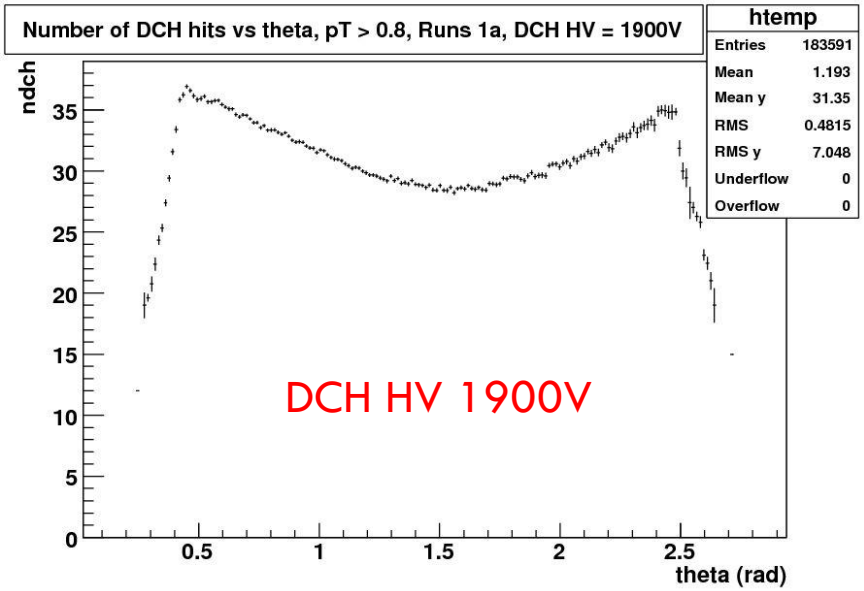
Correlation with the amount of ionization

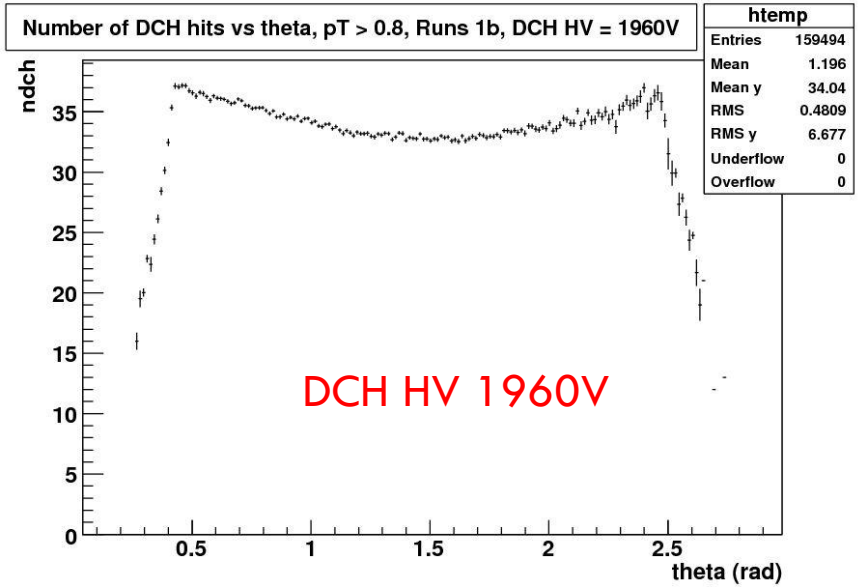
At θ=30° a saturation effect is visible



Correlation with the amount of ionization

Another check: the efficiency increases with the DCH HV

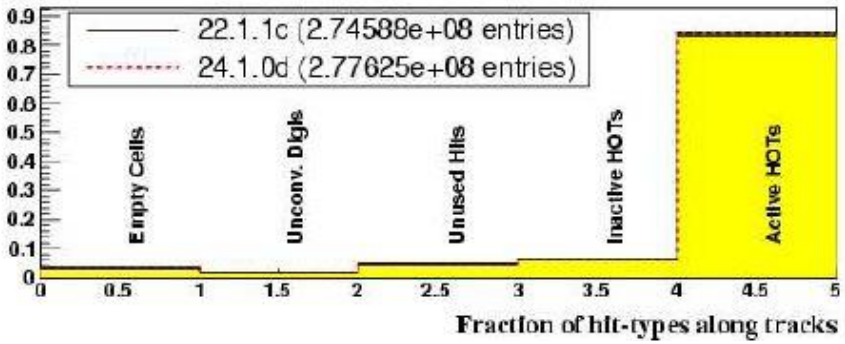


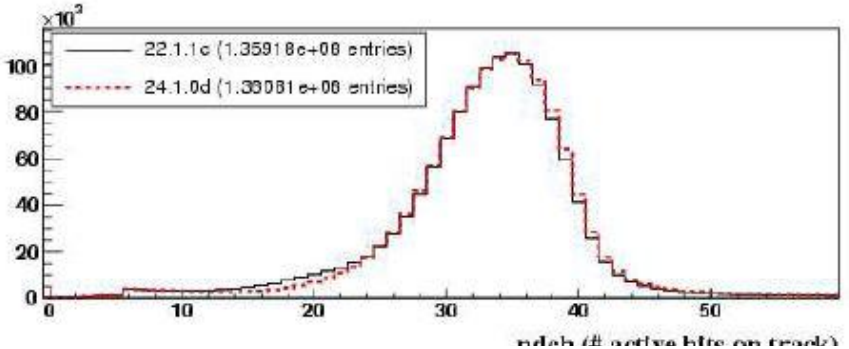


plots by A.Telnov

Hit types along the track

Hit types along the track





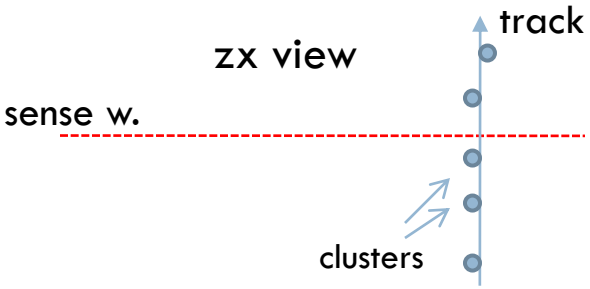
From a slide of I. Ofte, BaBar CM Dec. 2007

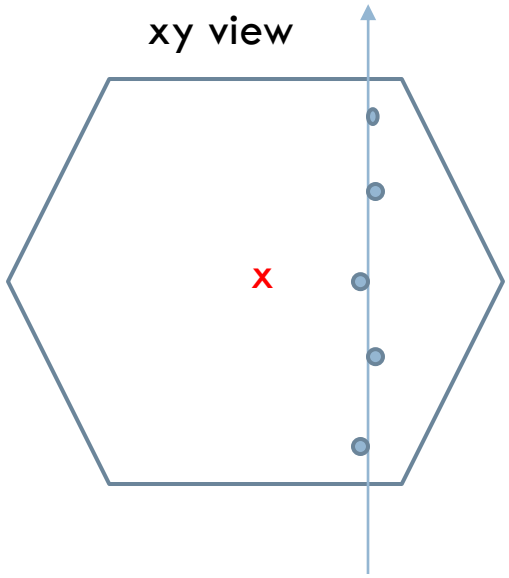
The datasample and selection cuts are not specified

- Active HOTs: ~85%
- Inactive HOTs: ~6%
- Unused Hits: ~5%
- Unconv. digis: ~1%
- Empty cells: ~3-4%

Hypothesis

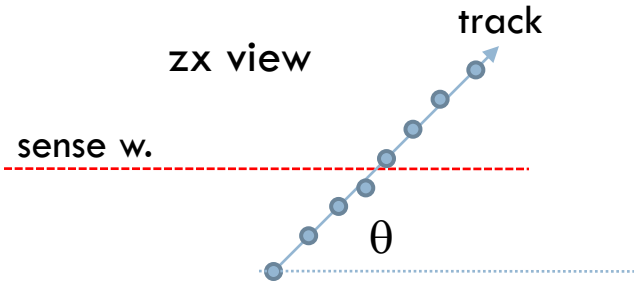
hypothesis suggested by Giuseppe: effect related to the probability of losing the hits closest to the wire? (time displacement of cell hits)

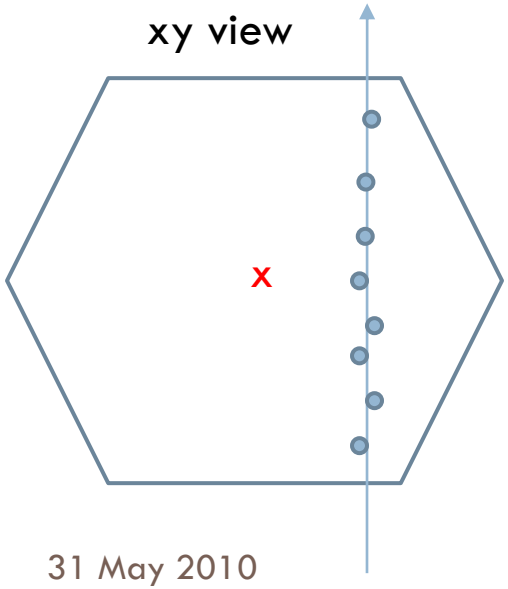




from Babar NIM:

To reduce the time jitter in the signal arrival and at the same time maintain a good signal-to-noise ratio, the signal threshold was set at about 2.5 primary electrons.





Use of Babar data to tune the drift chamber dE/dx in FastSim

dE/dx simulation in FastSim

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

- $\sigma(\langle dE/dx \rangle_{hit})$ 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:

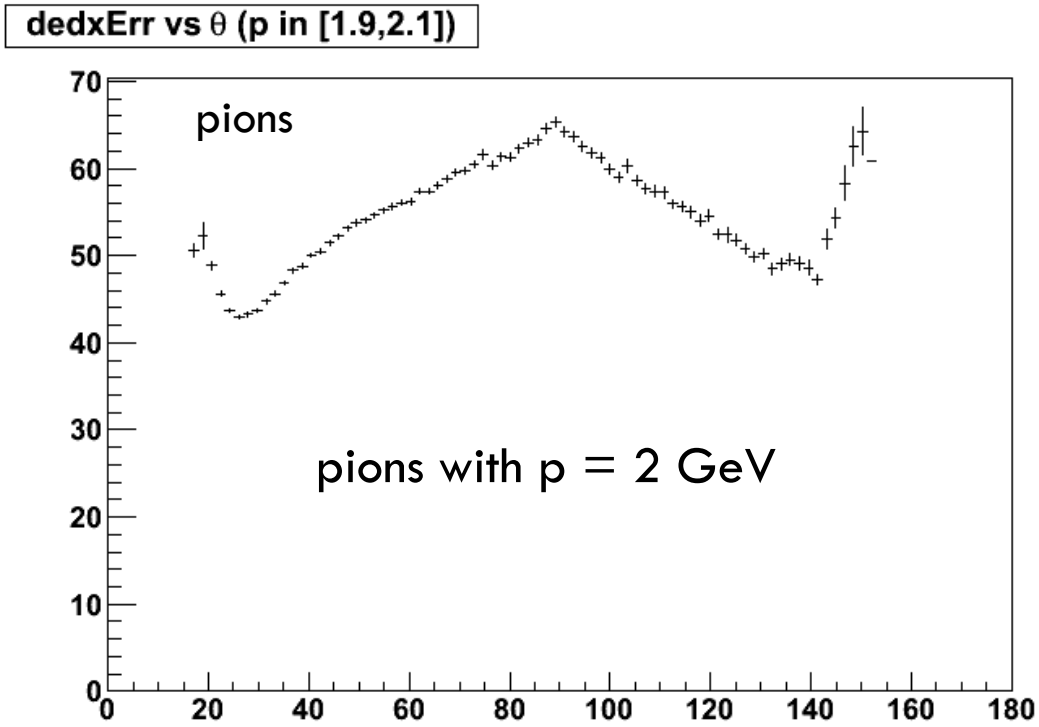
α = so that the K-π separation is consistent with plots in Babar BAD1500
$\beta = 1$
$\gamma = -0.5$

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

goal: determine α, β and γ from Babar data

σ(dE/dx) vs θ (pions)

First, I use σ(dE/dx) vs θ to measure γ :



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

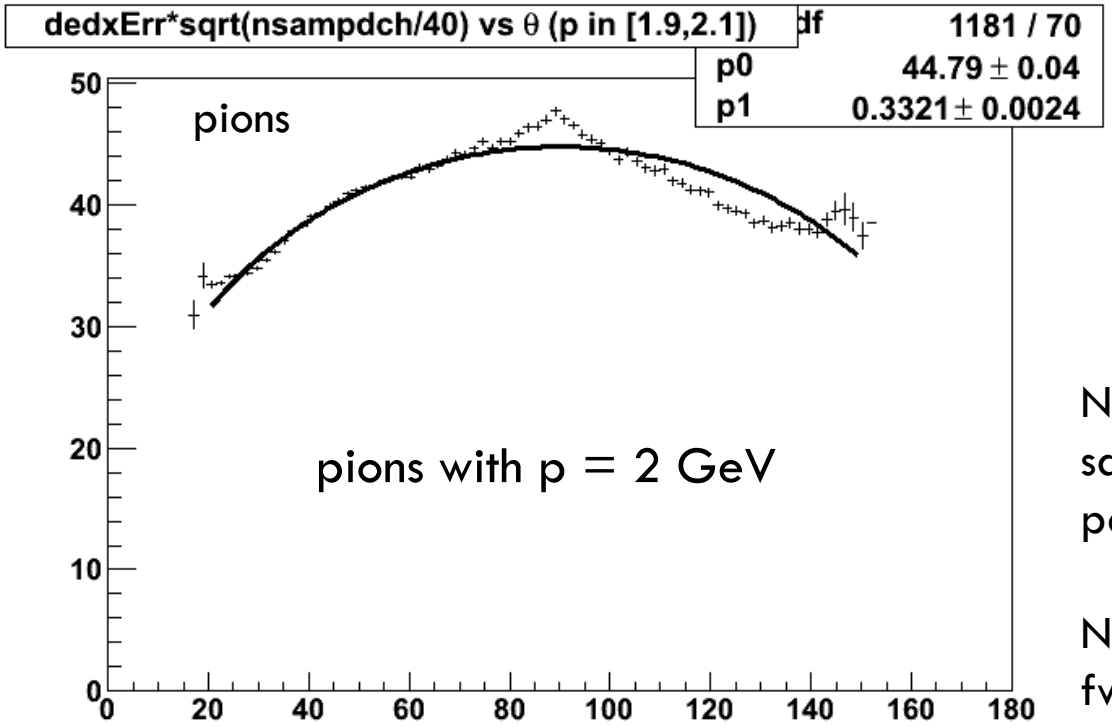
dx~h/sin(θ)
h=cell height

But before I rescale the distribution by sqrt(N_hit), **assuming that the error scales as 1/sqrt(N_hit)**

The result in the next slide

σ(dE/dx) vs θ (pions)

$$f(\theta) = p0(\sin\theta)^{p1}$$



p1 = - γ

➔ γ = -0.33
(it was set to -0.5)

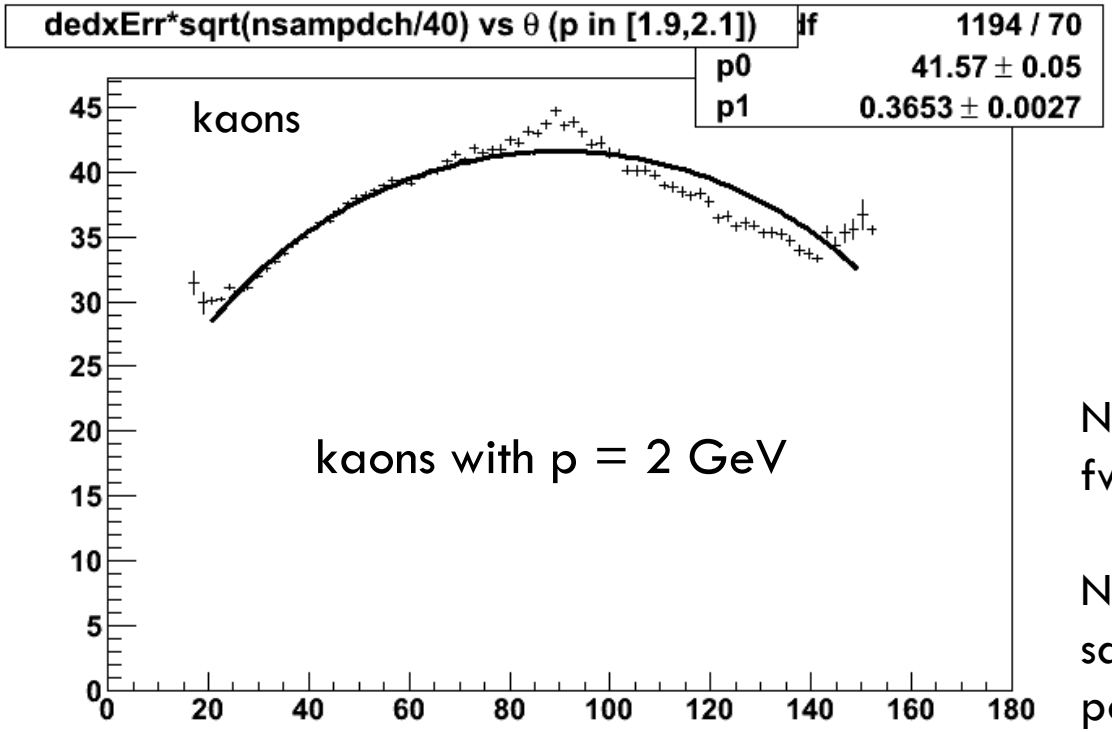
Note 1: the normalization by sqrt(N_hit) has *almost* removed the peaks in the fwd/bwd regions

Note 2: the distribution is significantly fwd-bwd asymmetric

σ(dE/dx) vs θ (kaons)

the same for kaons: good agreement with pions

$$f(\theta) = p0(\sin\theta)^{p1}$$



$\longleftrightarrow$ p1 = - γ

➔ γ = -0.37
(it was set to -0.5)

Note 1: the distribution is significantly fwd-bwd asymmetric

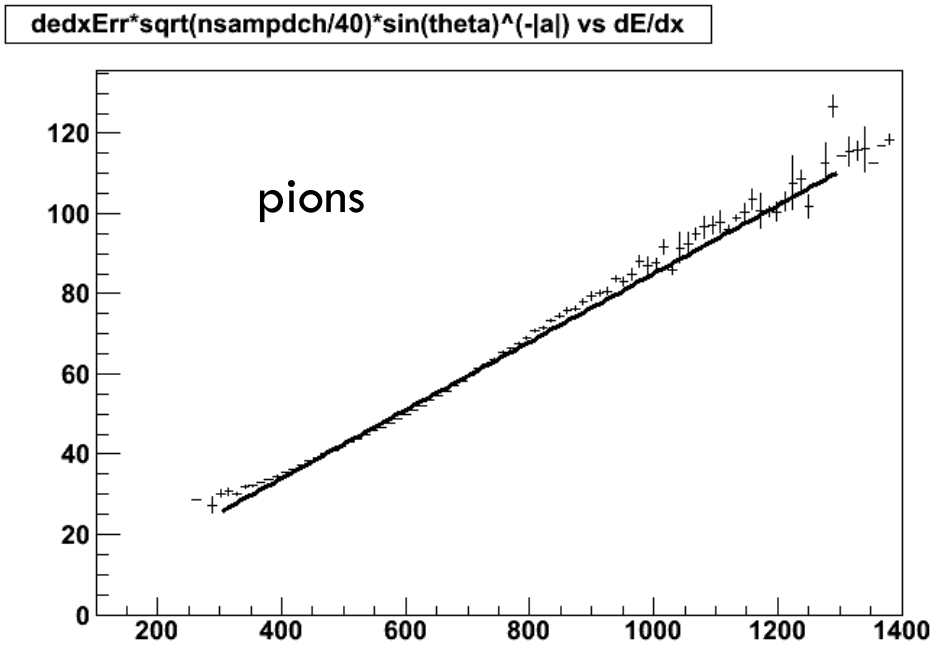
Note 2: the normalization by sqrt(N_hit) has *almost* removed the peaks in the fwd/bwd regions

σ(dE/dx) vs dE/dx (pions)

Then I "measure" α and β:

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

I take σ(dE/dx) vs dE/dx after having normalized σ(dE/dx) by sqrt(N_hit)/dx$^{\gamma}$



Not a real fit: I consider y(x)=par0*x and find the value of par0 that 'fits' reasonably well. If such value exists, then it means that α=par0 and β=1 is a reasonable assumption

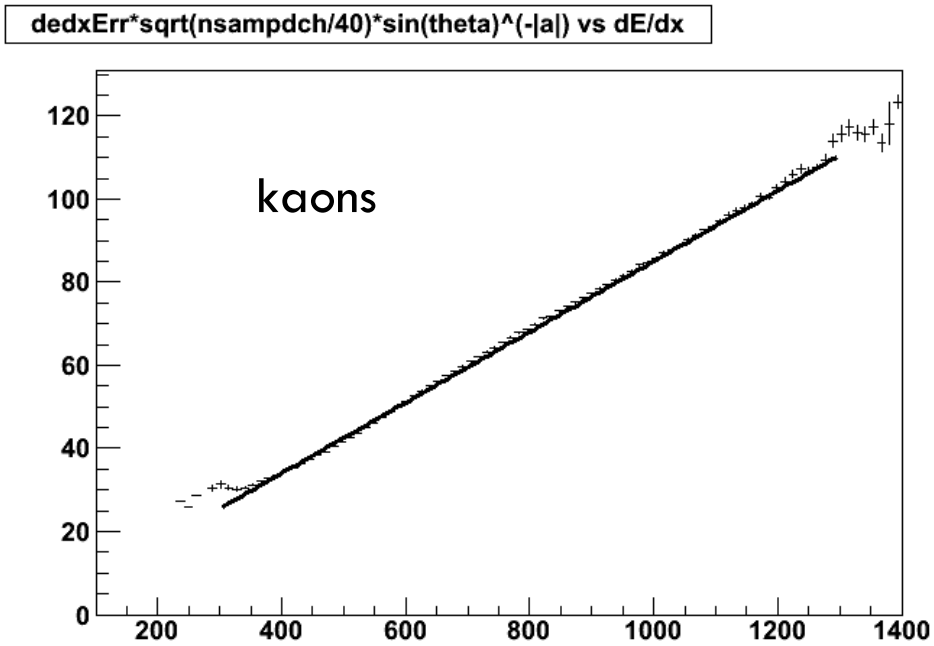
In the plot on the left:
α=0.085
β=1

σ(dE/dx) vs dE/dx (kaons)

same for kaons

In the plot below:
α=0.085
β=1

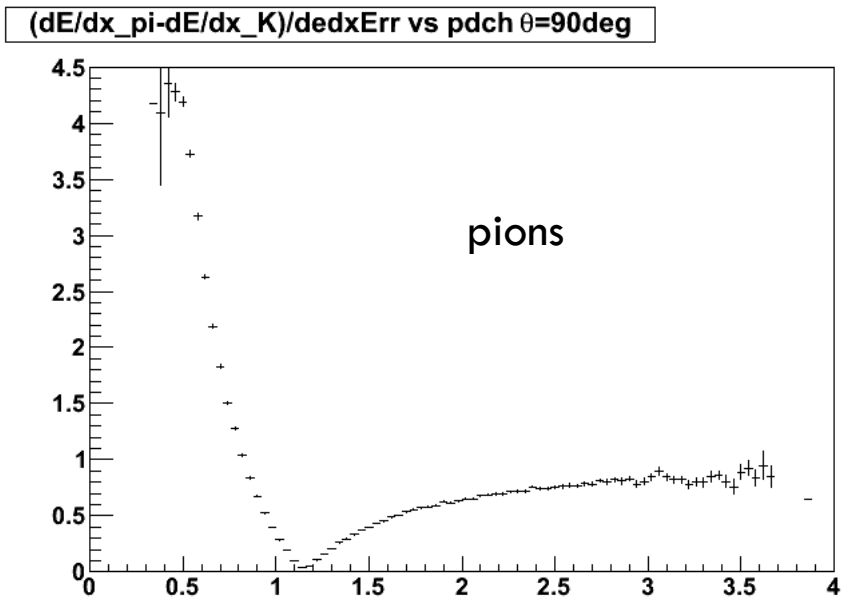
$$\sigma\left(\frac{dE}{dx}\right) = \alpha\left(\frac{dE}{dx}\right)^{\beta} dx^{\gamma}$$

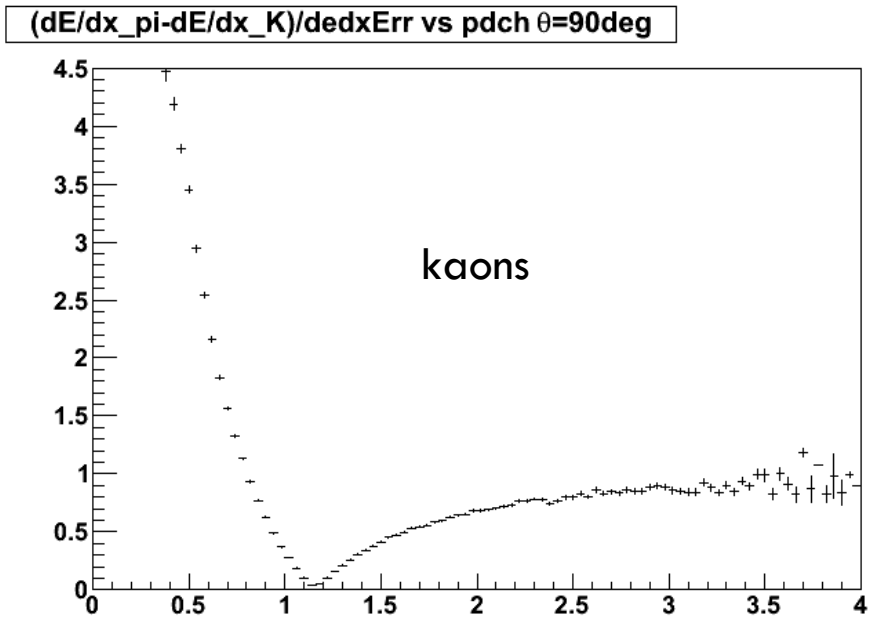


good agreement between pions and kaons

Kaon-pion separation with dE/dx

$\theta = 90°$

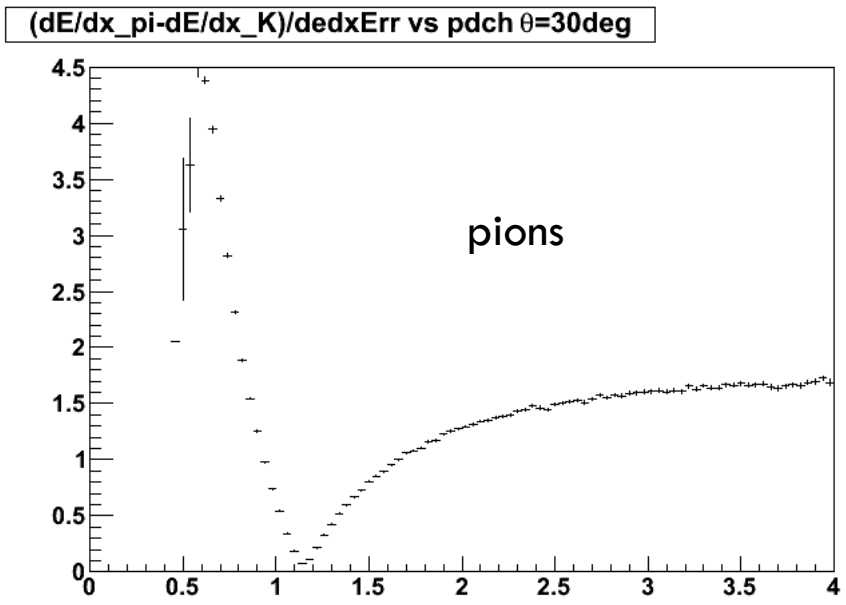


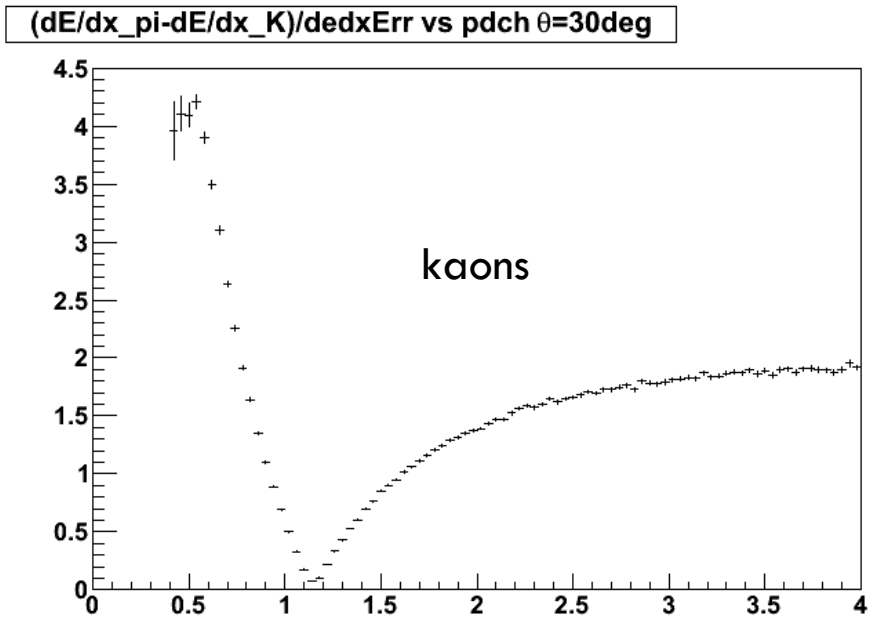


separation = [dE/dx_(exp pion)-dE/dx_(exp kaon)]/σ(dE/dx)

Kaon-pion separation with dE/dx

$\theta = 30°$

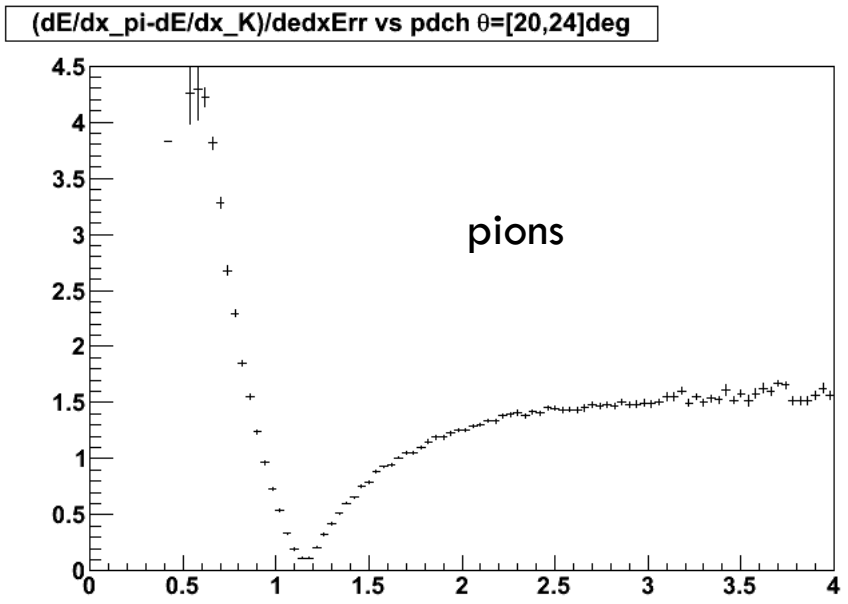


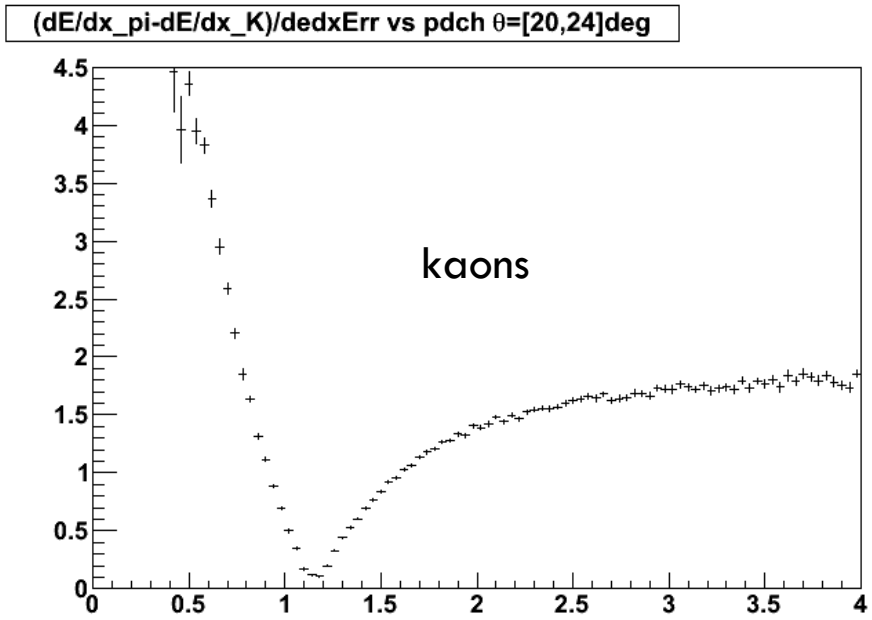


separation = [dE/dx_(exp pion)-dE/dx_(exp kaon)]/σ(dE/dx)

Kaon-pion separation with dE/dx

θ in [20°,24°] (region not covered by DIRC)





separation = [dE/dx_(exp pion)-dE/dx_(exp kaon)]/σ(dE/dx)

Summary

- Interesting feature of nDCH hits vs theta observed in Babar data
  - now implemented in FastSim for the Babar config.
  - should we adopt the same for the baseline SuperB configuration?
- Used the Babar data to tune the Babar drift chamber dE/dx in FastSim
  - should we adopt the same parameters for the baseline SuperB configuration?

Further discussion at the FastSim session tomorrow at 16:00

backup

p vs theta (pions)