K / π separation with DIRC-like TOF detector

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Outline

- Likelihood ratio method for K/π separation. Calibration
- Time separation. Effects contibuting to the time resolution smearing (Leonid presentation)
- Simple and illustrative analysis
- More refined analysis and preliminary results

Likelihood method. Calibration

$$Likelihood = \prod e^{(-\chi_i^2)} \qquad \chi^2 = \left(\frac{time.measured - expected}{RMS}\right)^2$$

i corresponds to the PMT channel and this is to describe all photons collected in one PMT

Example for kaons: We generate kaons and gather following data to the calibration table

Ch_id	T	RMS	P	Theta	m
0	7.995nsec	0.0799792nsec	4000 Mev/c	20 deg	494 MeV
1	7.99026nsec	0.0429357nsec	4000 Mev/c	20 deg	494 MeV
2	7.98498nsec	0.0376411nsec	4000 Mev/c	20 deg	494 MeV
3	7.98164nsec	0.040736nsec	4000 Mev/c	20 deg	494 MeV
4	7.97613nsec	0.0424979nsec	4000 Mev/c	20 deg	494 MeV
5	7.97503nsec	0.04022nsec	4000 Mev/c	20 deg	494 MeV
6	7.97526nsec	0.0441045nsec	4000 Mev/c	20 deg	494 MeV

....

Ch_id is the ID of PMT

For a pion we follow the same calibration procedure

Time separation.

$$\chi^2 = \left(\frac{time - expected}{RMS}\right)^2$$

time is the time between bunch crossing and single photon registration in the photomultiplier

Effects that contribute to the RMS

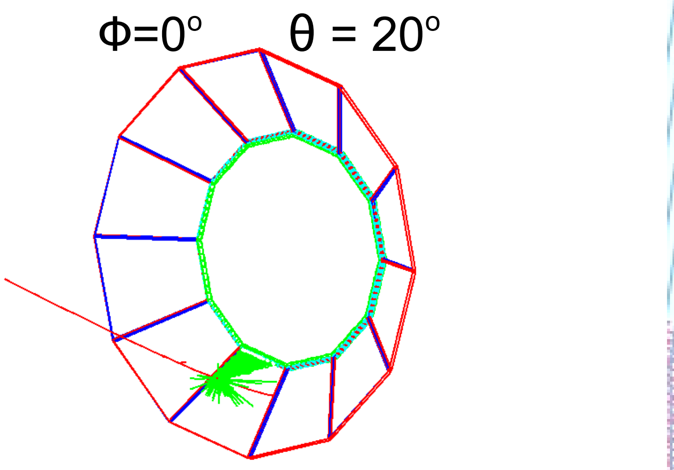
- TTS
- T_0
- Electronics
- Quantum efficiency
- Protective foil

Simple model, demonstration of the method

First steps using likelihood method

- All the effects are taken into account smearing time distributions by Gaussian with width σ
- The quantum efficiency is taken into account by accepting one photon every 10^{th} photon produced by one particle

We generated at the same Phi and theta angles

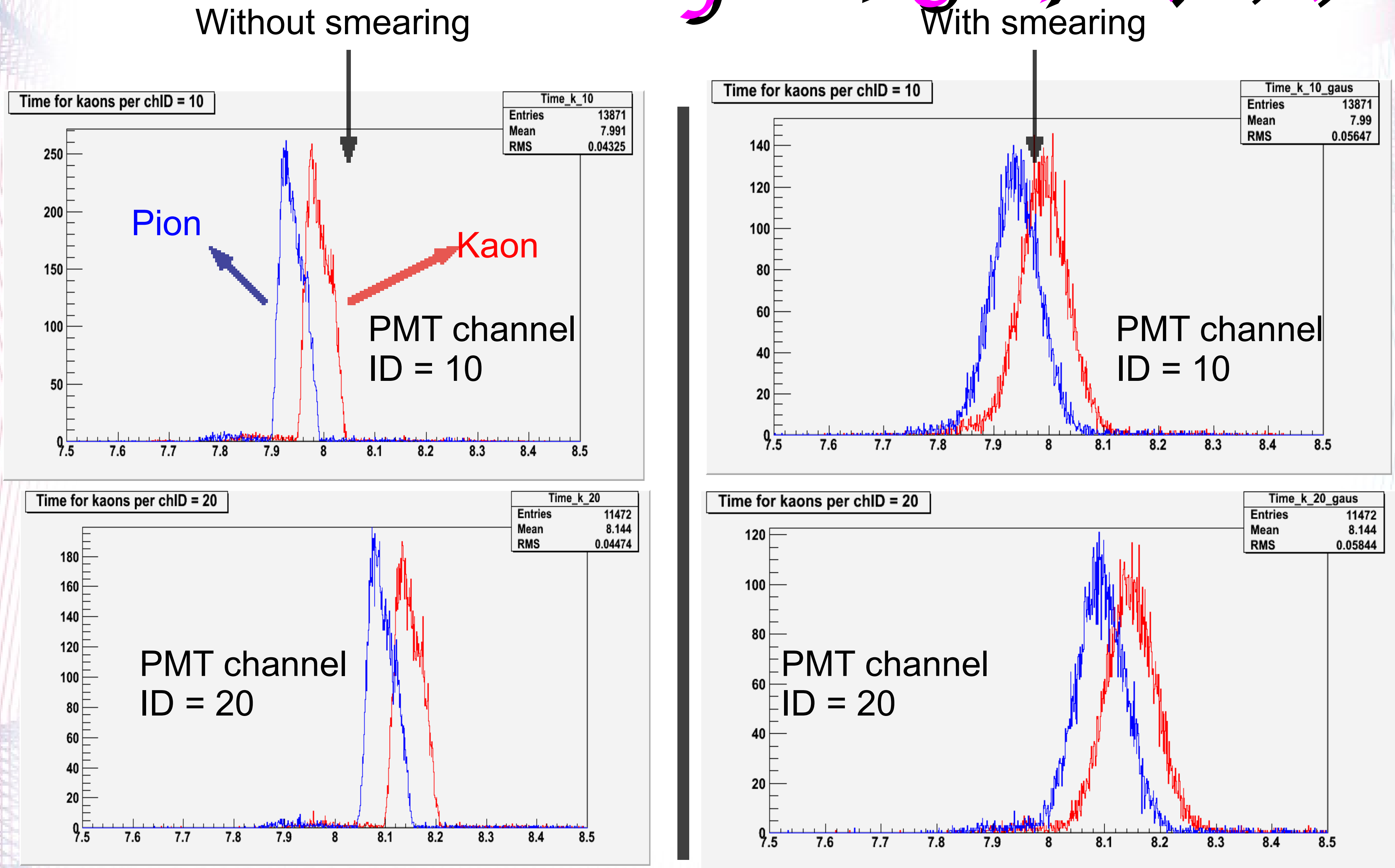


$$Likelihood.ratio = \frac{likelihood(K)}{likelihood(K) + likelihood(\pi)}$$

Likelihood ratio → 1 —> K

Likelihood ratio → 0 —> π

Time distribution for 4 GeV/c (K,π)



At the time $t = 0$ the particle is emitted the interaction point

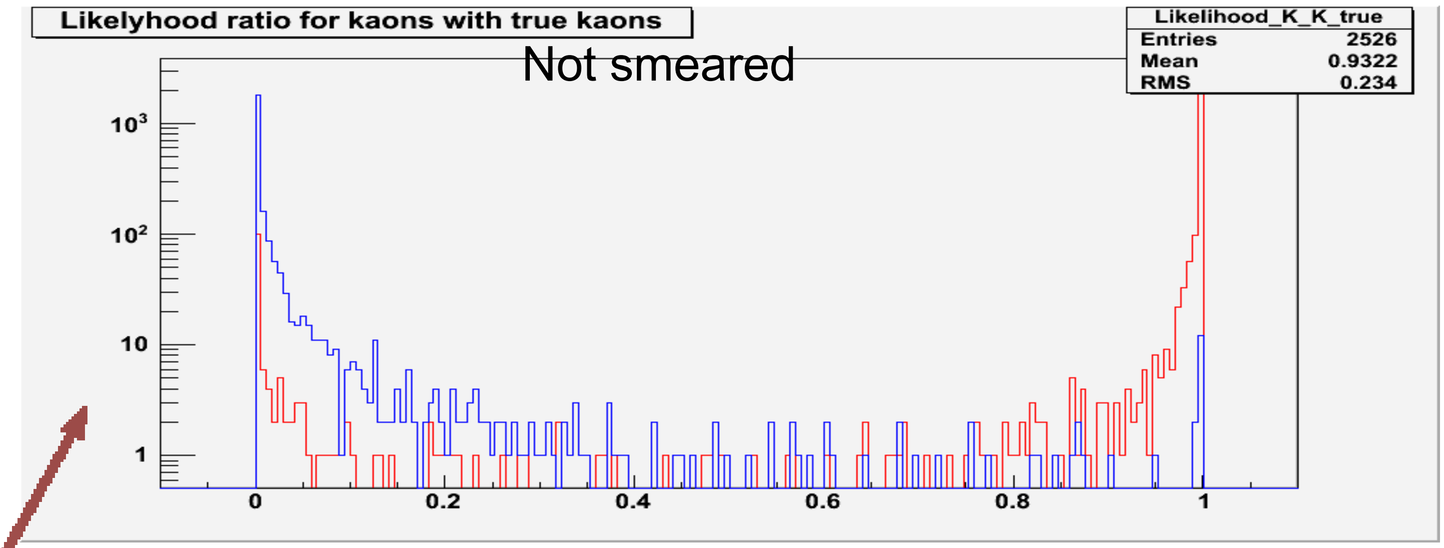
Likelihood ratio, 4GeV/c

$$Likelihood.ratio = \frac{likelihood(K)}{likelihood(K) + likelihood(\pi)}$$

$T_K - T_\pi = 46ps$

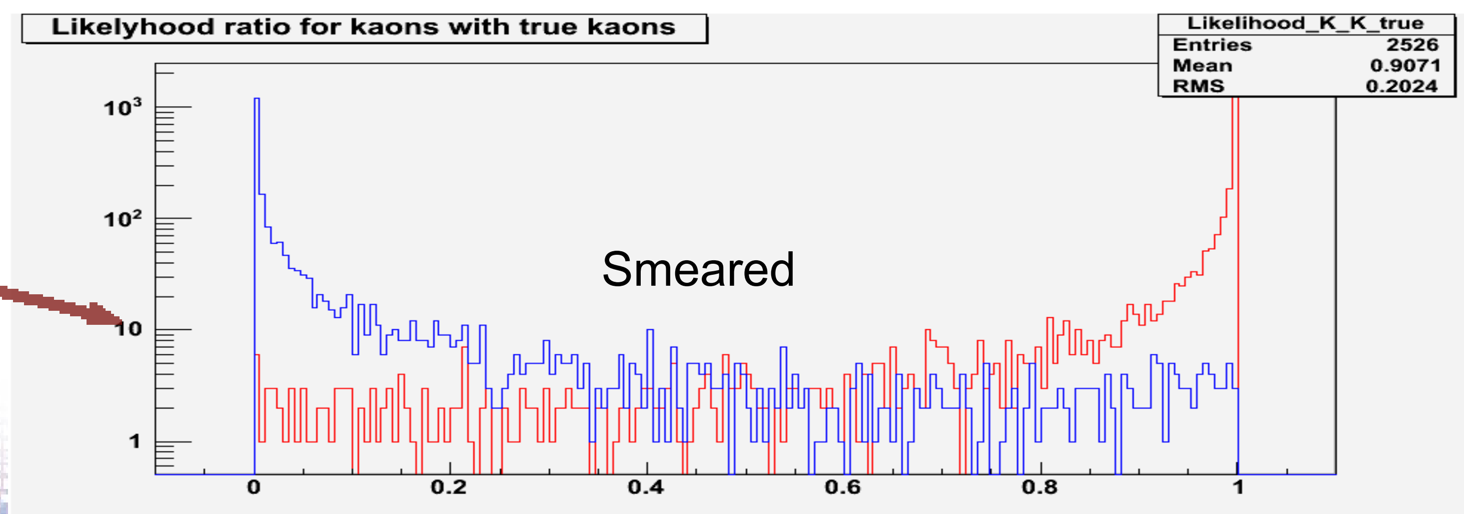
$\sigma_{total} = 24,6ps$

2σ separation

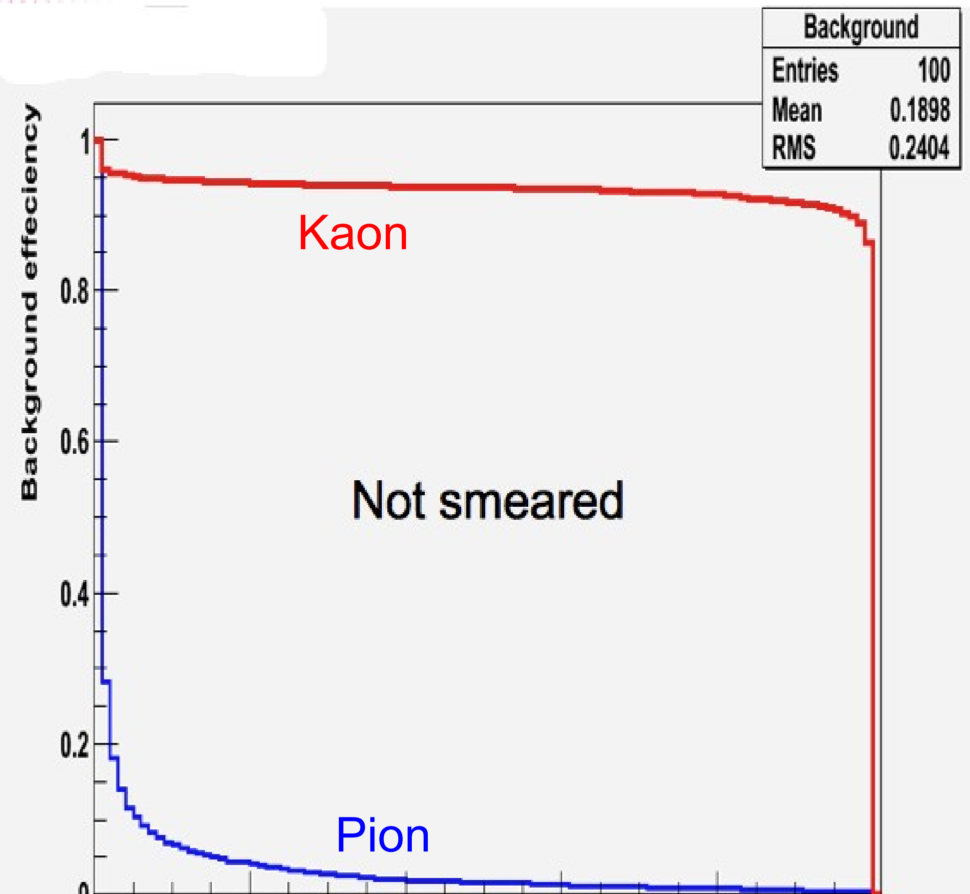


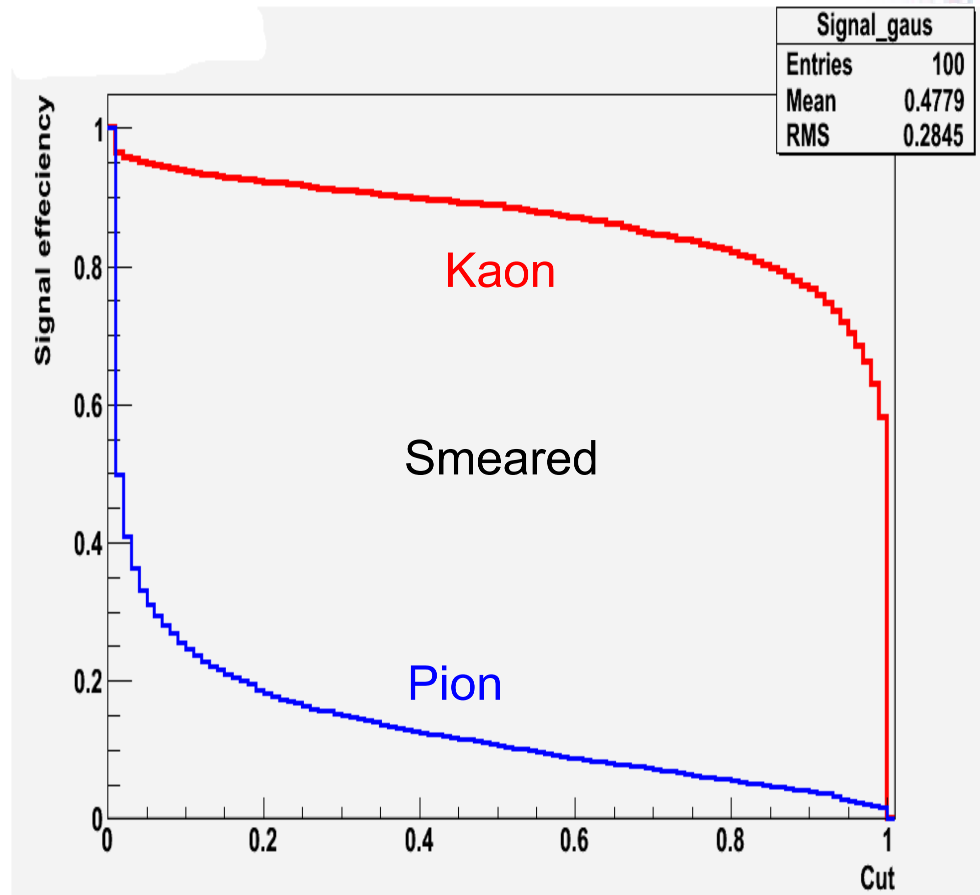
$N_{pe} \sim 7.9$

Log scale



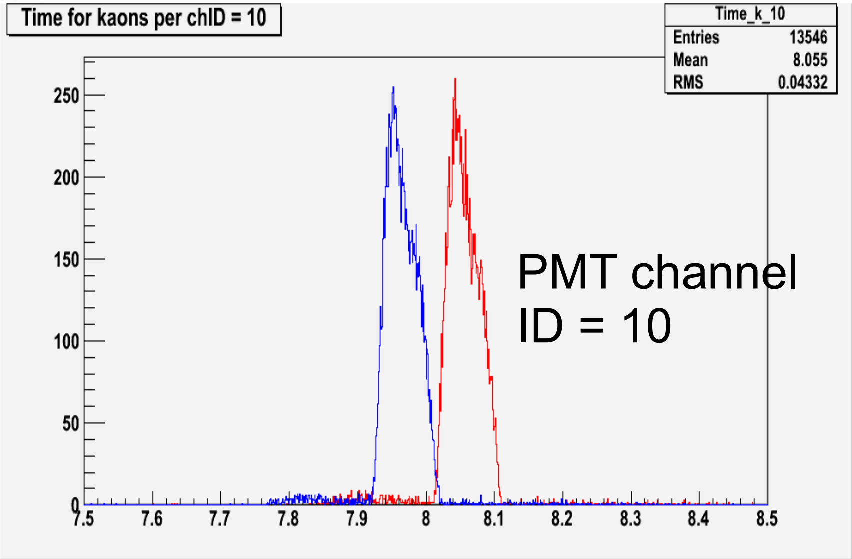
Effeciency as a function of cut on the Likelihood ratio (4GeV/c)

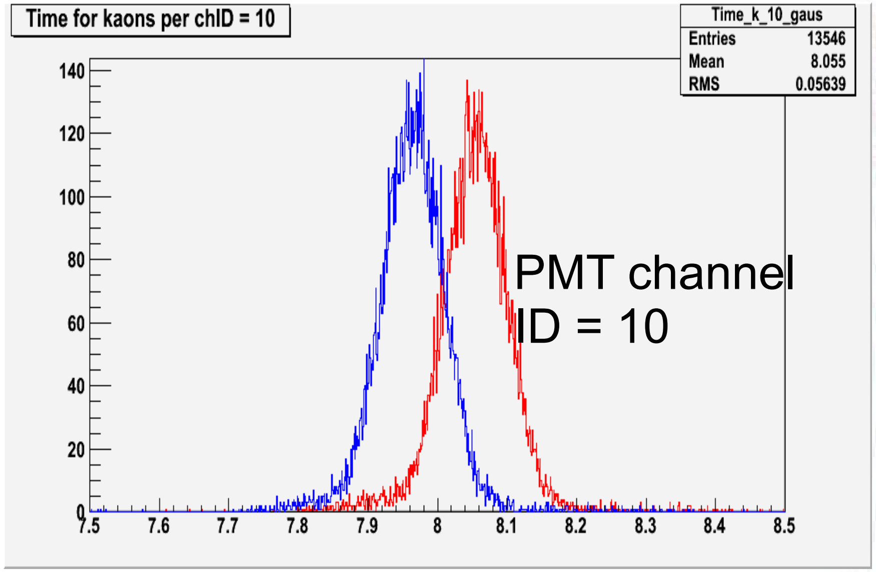


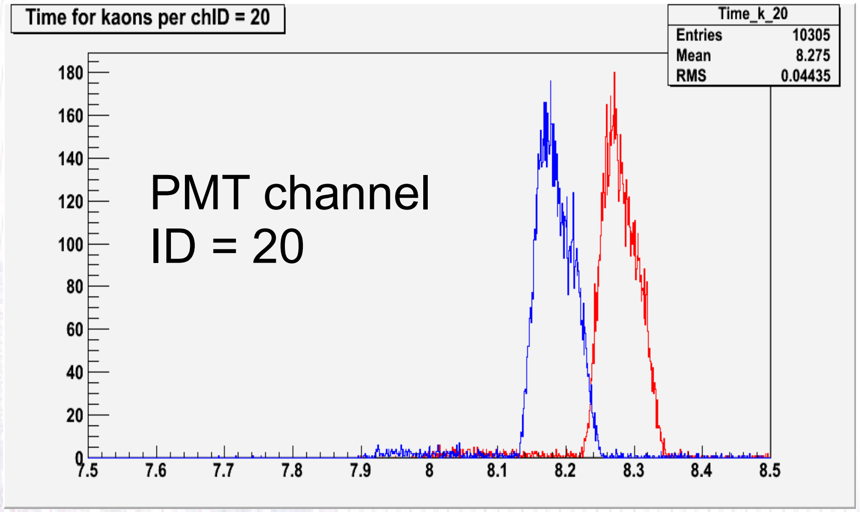


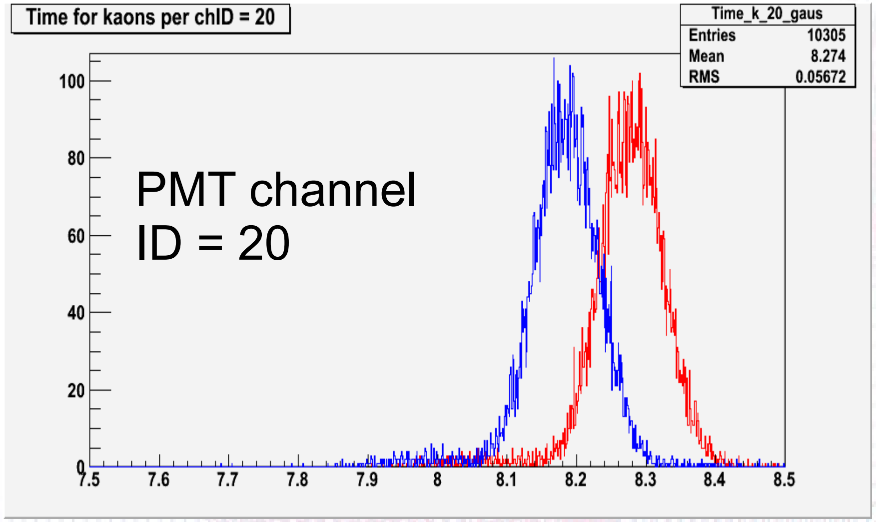
We generate only pions and kaons and now we consider pions as a background for kaon identification

Time distribution for 3 GeV/c (K,π)







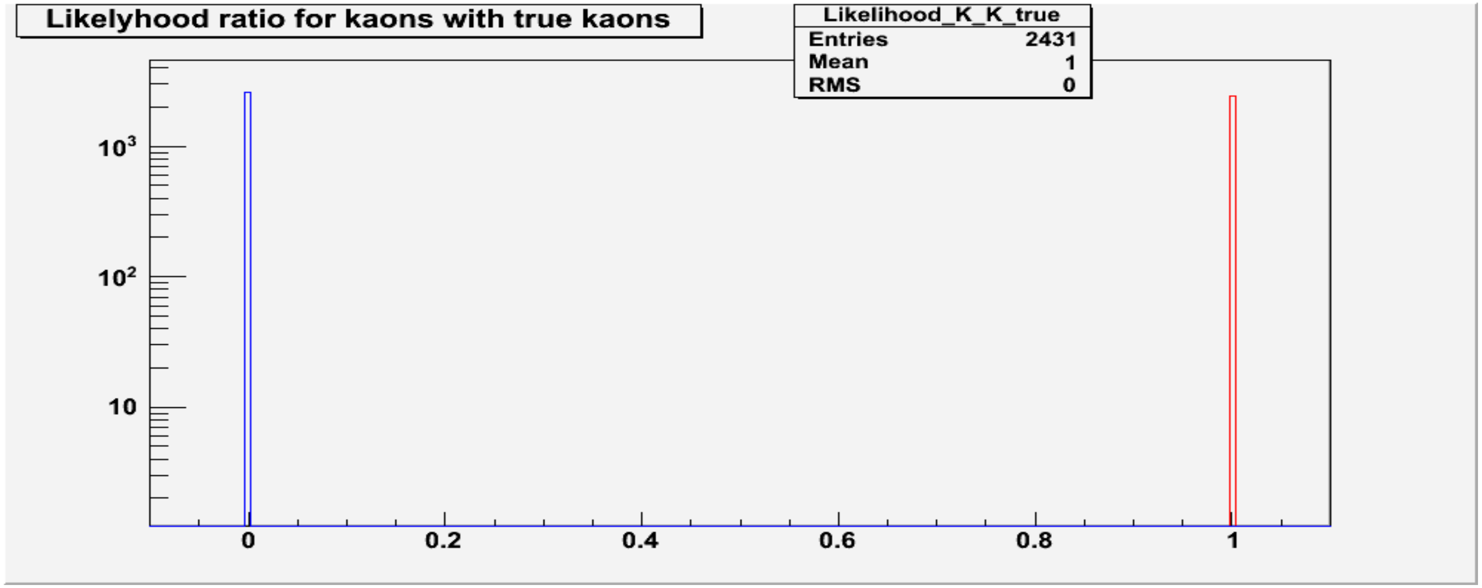


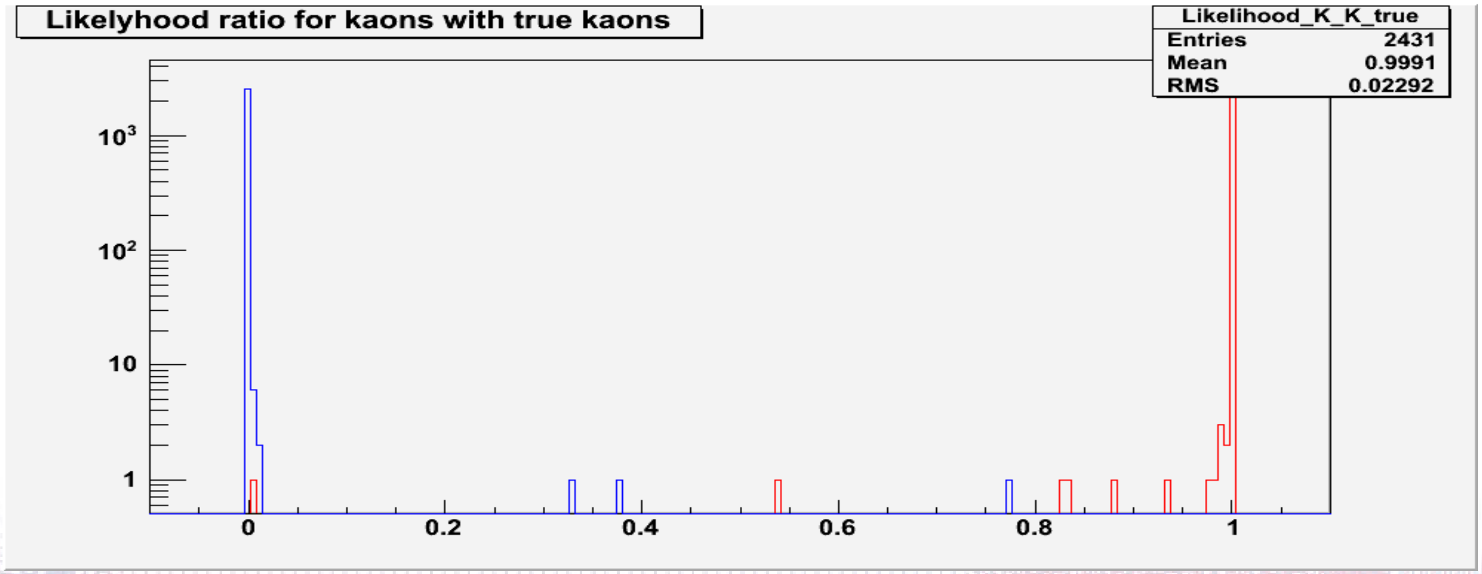
Likelihood ratio, 3GeV/c

$T_K - T_\pi$=83ps

σ_{total} = 24,8ps

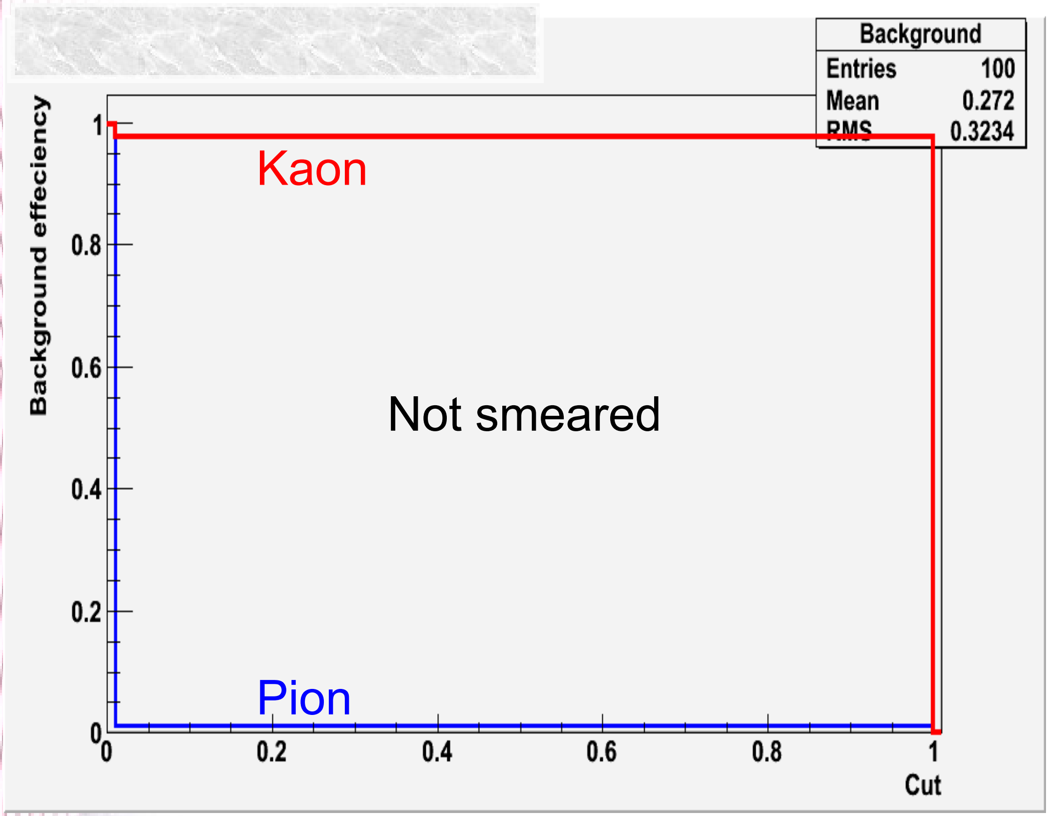
3σ separation

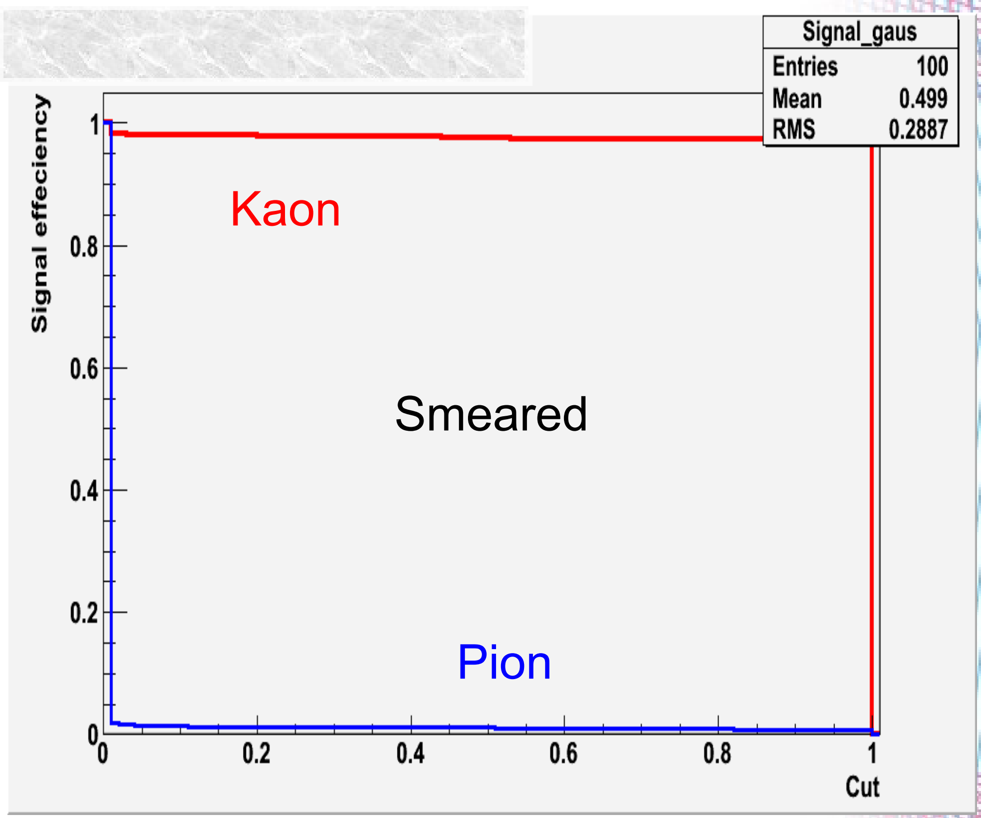




N_{pe}~7.5

Efficiency 3 GeV/c





Now we also consider pions as a background for kaon identification

Torwars a more complete analysis

Now we scan 1000 points in a 3-dimensional parameter space:

- P = [0.7, 0.8, 0.9, 1, 1.5, 2, 2.5, 3, 3.5, 4] GeV/c
- θ = [16, 17, 18, 19, 20, 21, 22, 23, 24, 25] degrees
- φ = [0, 3, 6, 9, 12, 15, 18, 21, 24, 27] degrees

- Quantum effeciency os GaAsp was simulated
- Every channel has $\sigma_{electronics} = 10$ psec
- Every photoelectron has $\sigma_{TTS} = 35$ psec

If there were two indissociable e^- in one channel we took an average time between them

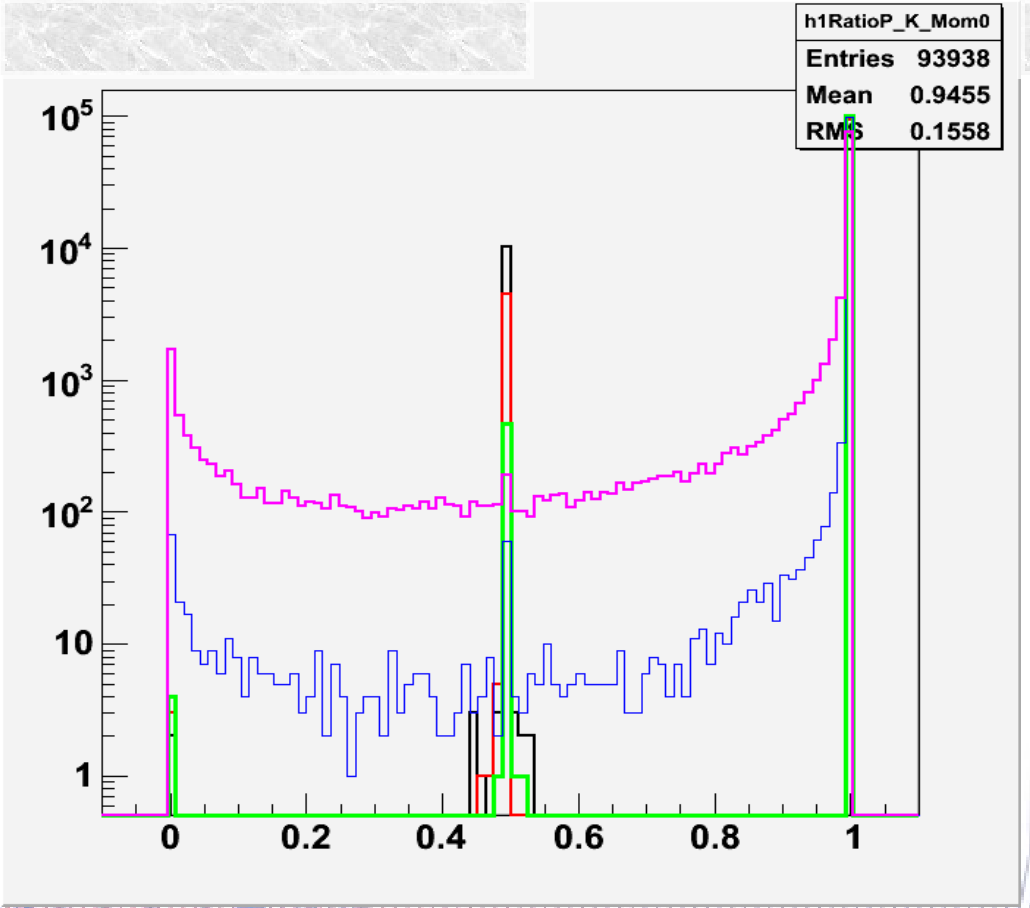
- T_0 was generated the same for every track

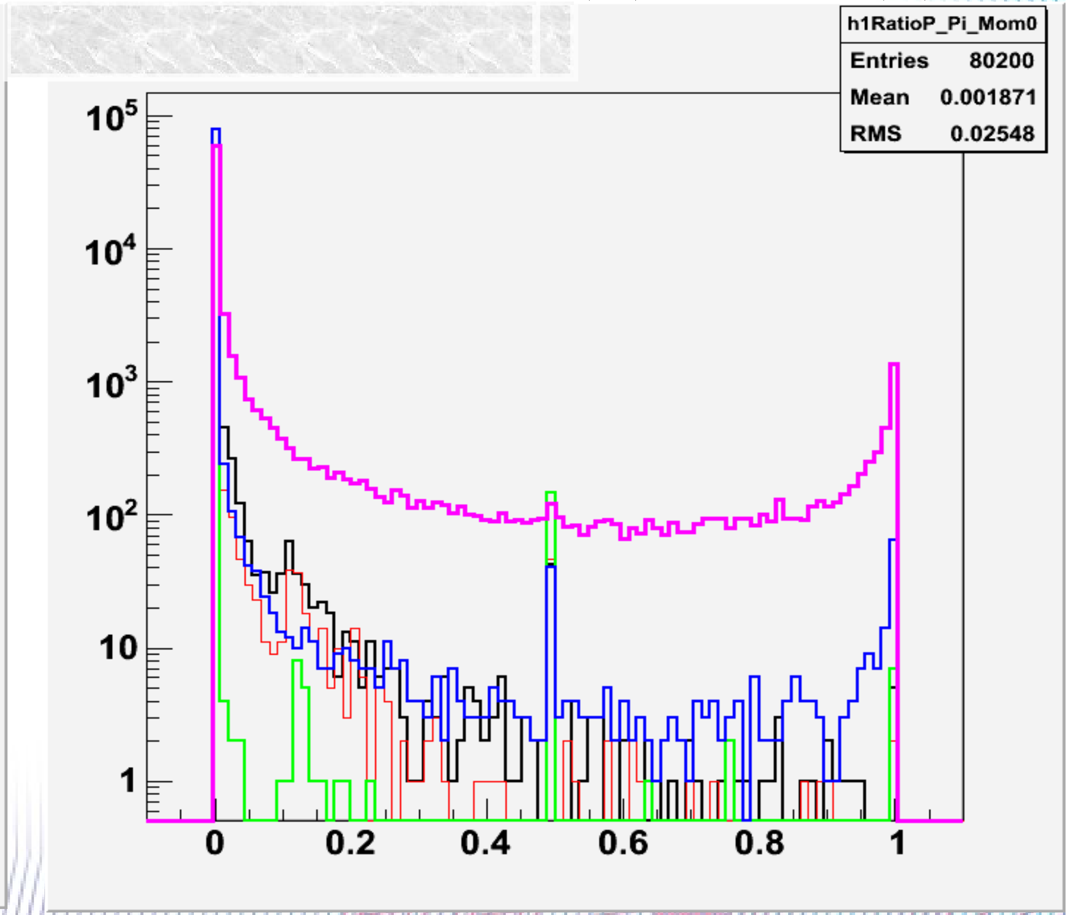
Likelihood for K and π vs momentum

Colors correspondance: **700 MeV/c**, **900 MeV/c**, **1500 MeV/c**, **2500 MeV/c**, **3500 MeV/c**

$$Likelihood.ratio = \frac{likelihood(K)}{likelihood(K) + likelihood(\pi)}$$

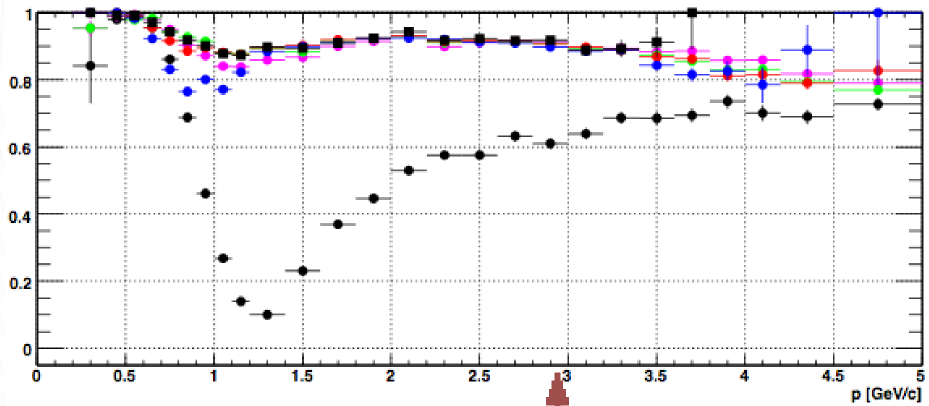
$$Likelihood.ratio = \frac{likelihood(\pi)}{likelihood(K) + likelihood(\pi)}$$



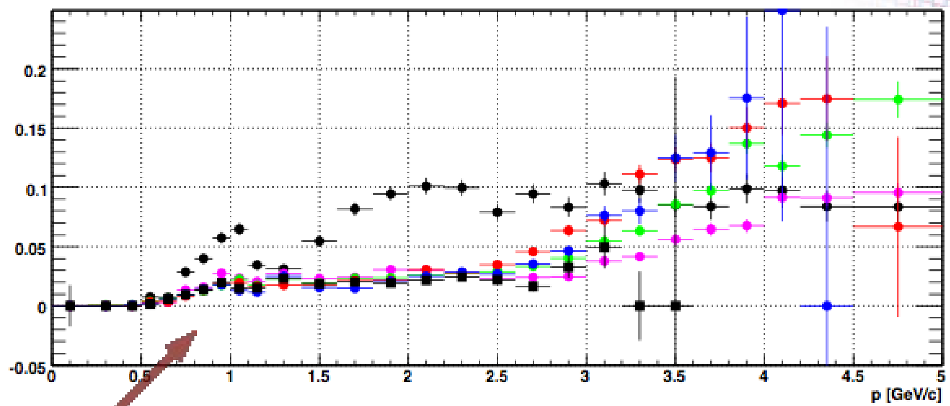


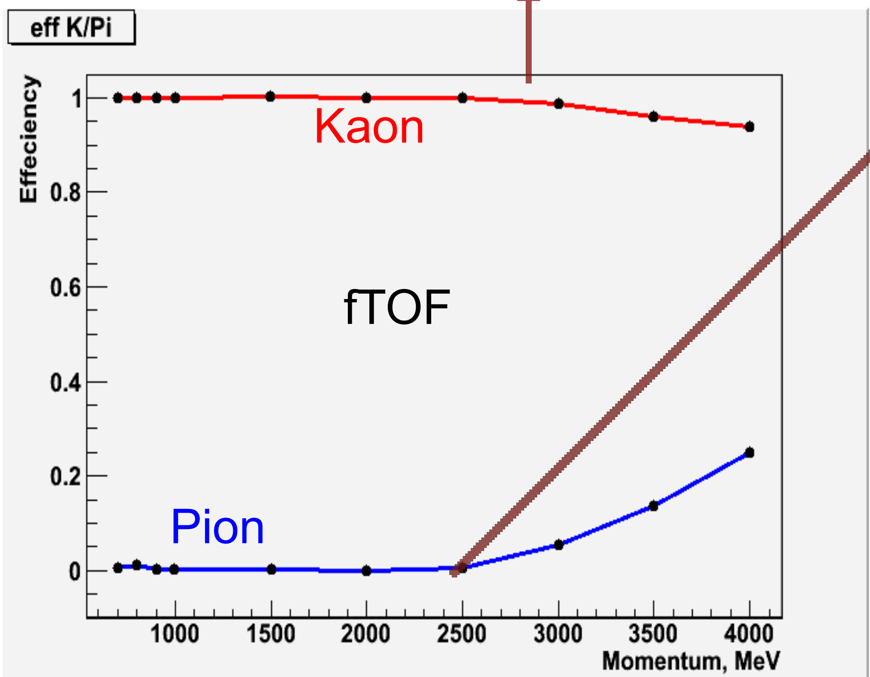
Comparing fTOF performances with dE/dx loose cut

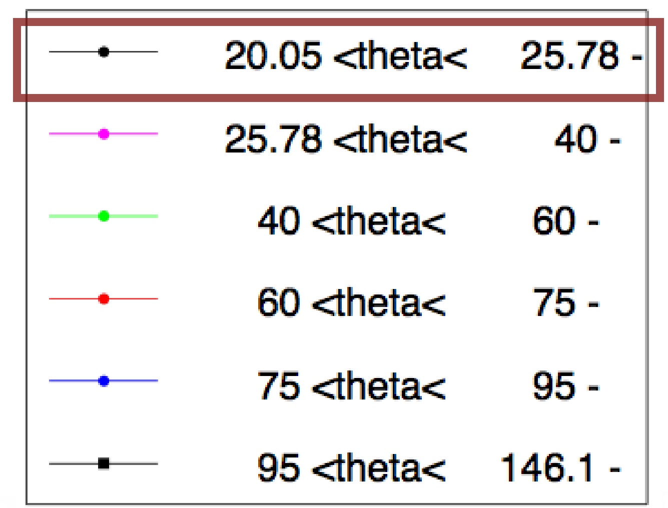
Kaon loose for kaon, BaBar



Kaon loose for pion, BaBar



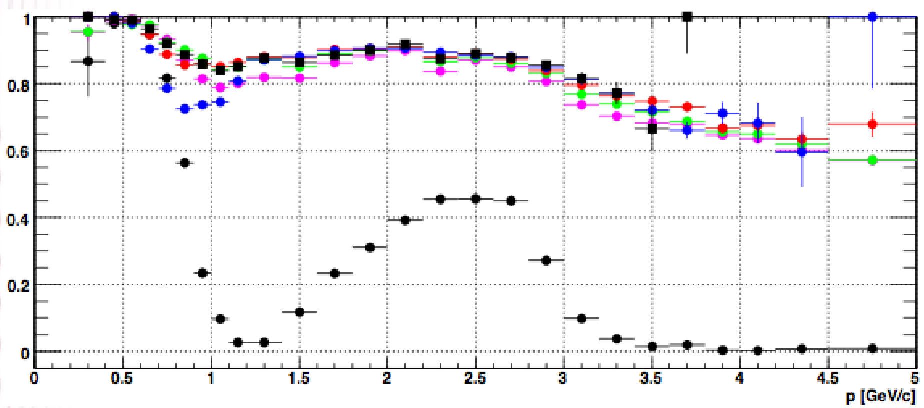




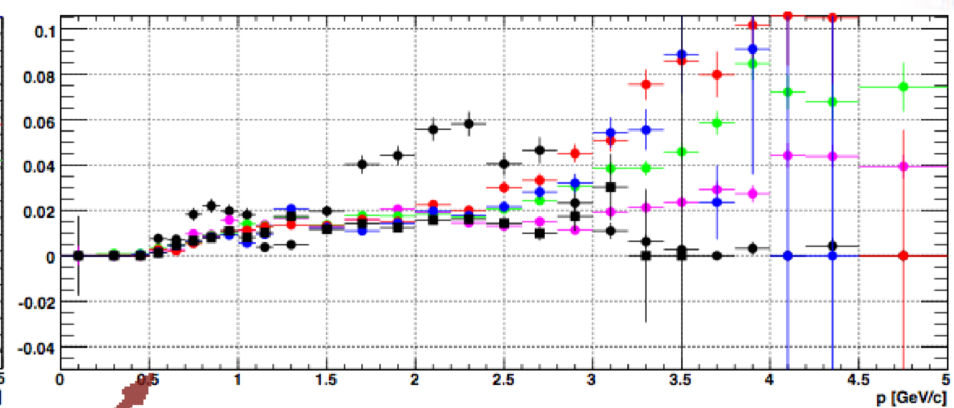
The cut on likelihood: likelihood > 0.1

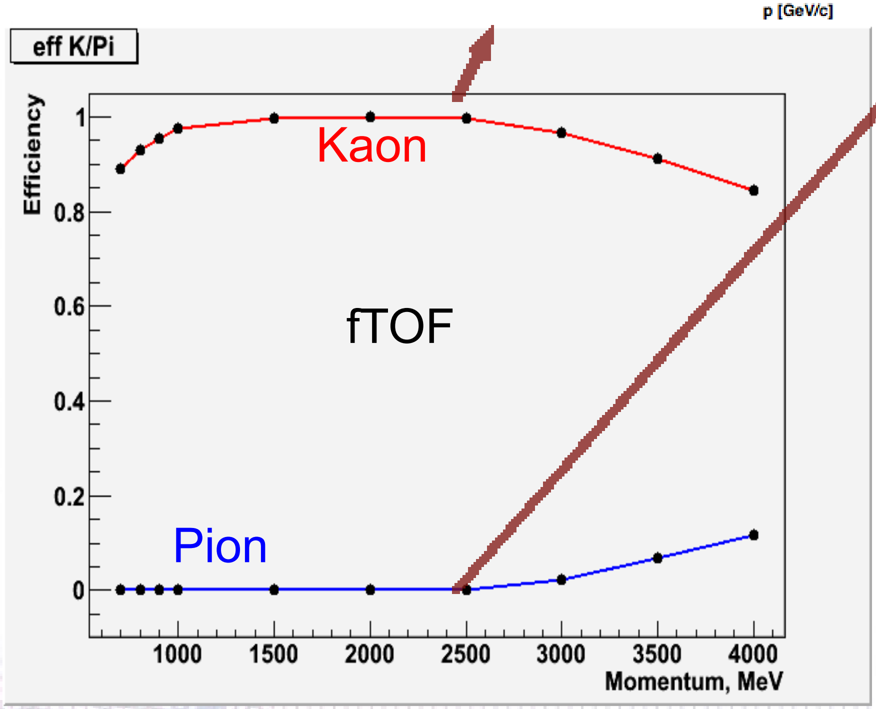
Comparing fTOF performances with dE/dx tough cut

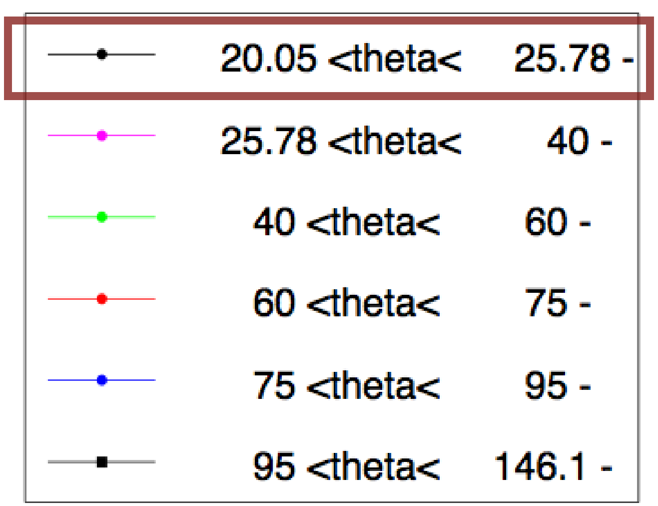
Kaon tight for kaon, Babar



Kaon tight for pion, BaBar







The cut on likelihood: likelihood > 0.6

Conclusions

- Very good K/pion separation can be reached with TOF device improving very significatly the PID from Babar.

- Caveat (work in progress)
  The results shown do not include
  - sigma track and sigma detector coupling to the bar
  - backgrounds and delta electrons