PID in the FastSim

Réunion SuperB-LAL
28 septembre 2009

Nicolas Arnaud, Leonid Burmistrov,
Alejandro Perez, Achille Stocchi

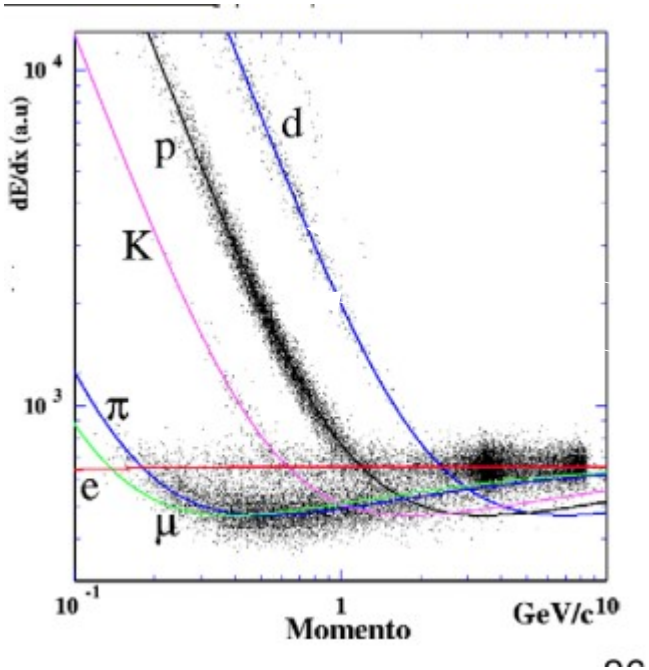
INTRODUCTION: PID systems in SuperB detector
DRC, DCH, TOF, SVT

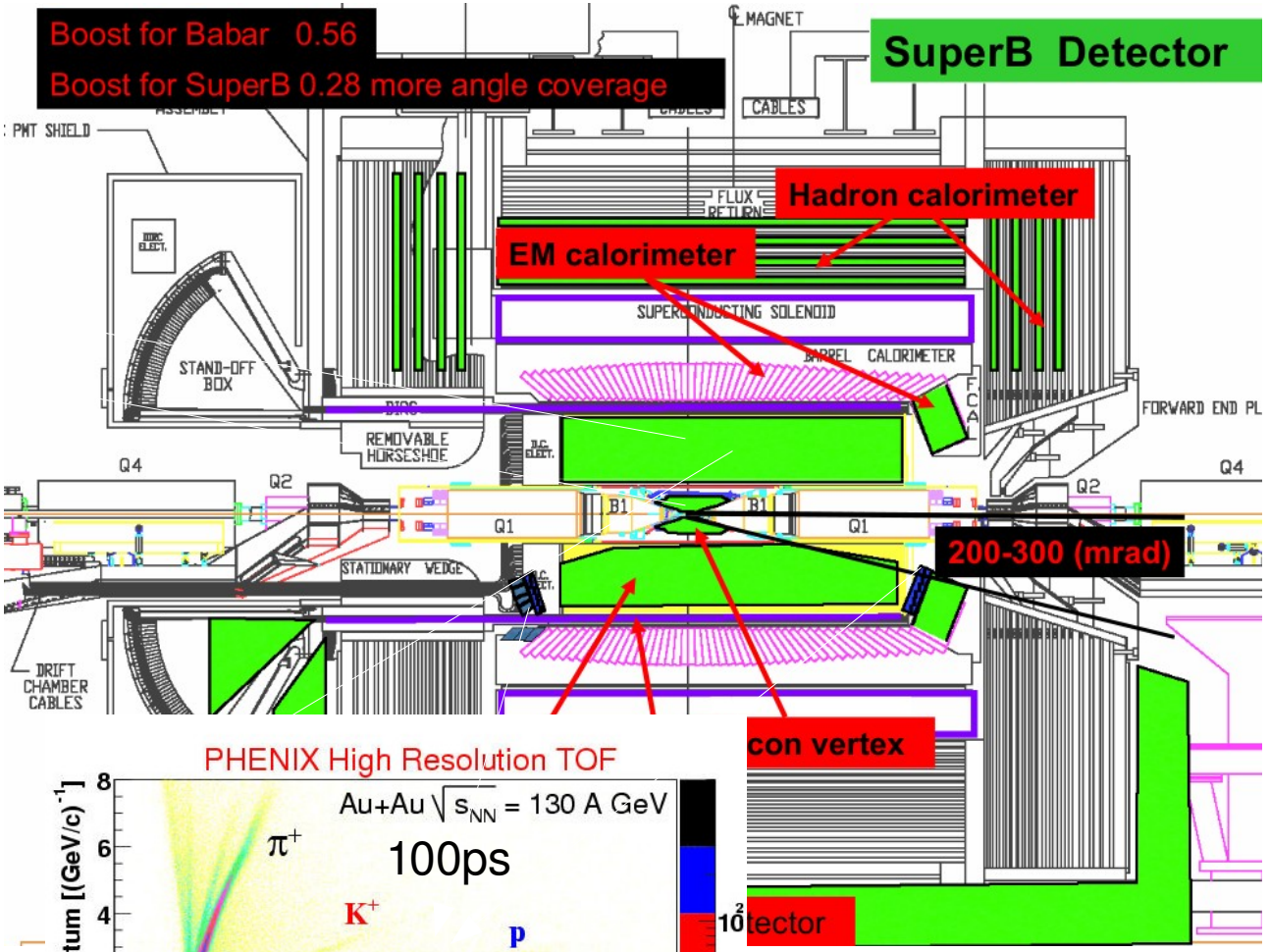
Our responsabilities :

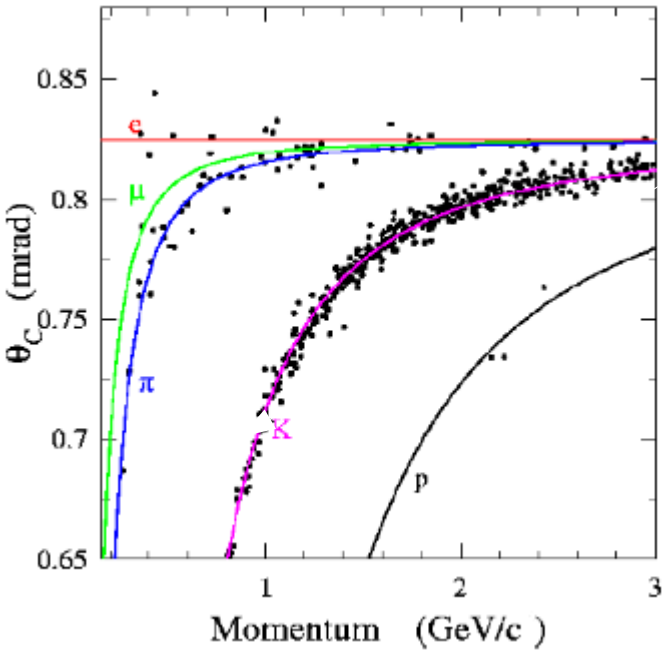
Implementation of TOF in FastSim

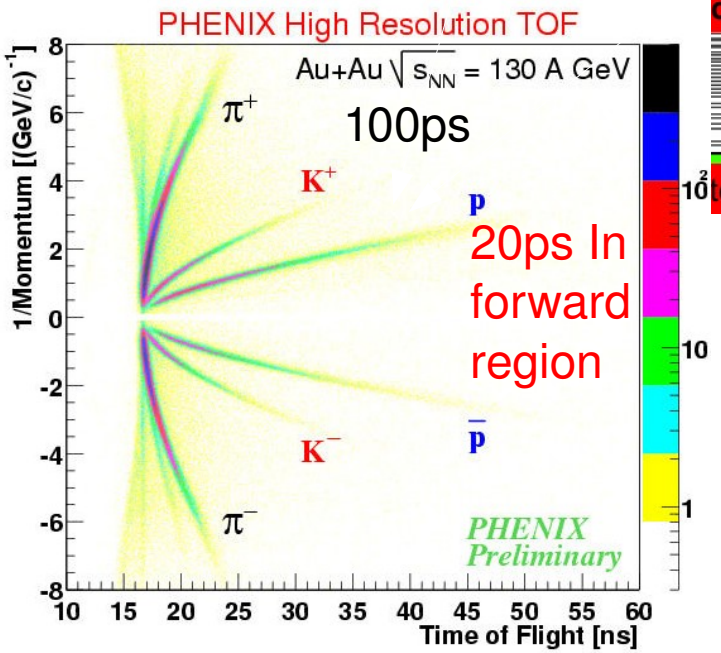
Provide PID “selectors” in FastSim

PID systems in SuperB detector
DRC, DCH, SVT, TOF







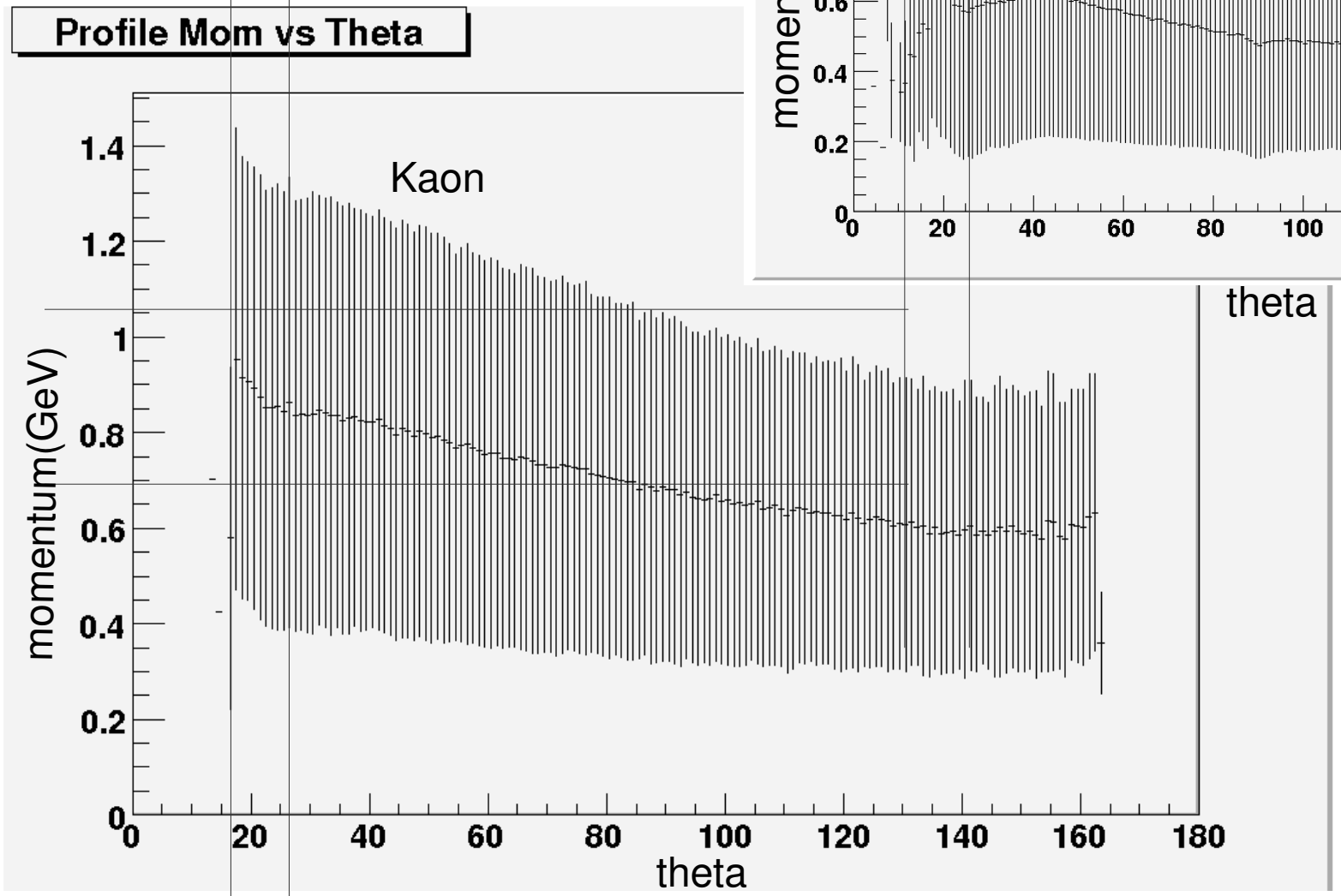


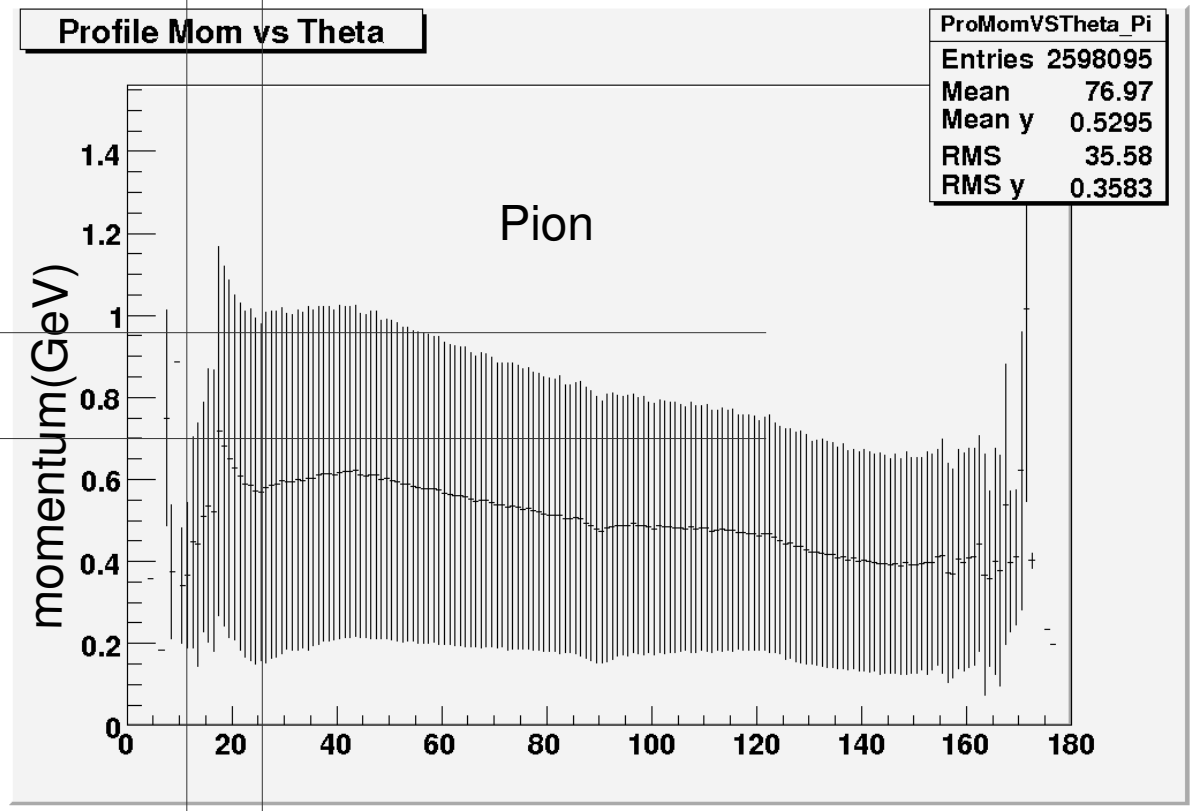
B->K pi

Babar
Mom_Max ~4.3GeV

SuperB
Mom_Max ~ 3.3GeV

Truth much


Profile Mom vs Theta
Kaon
momentum(GeV)
theta
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
20
40
60
80
100
120
140
160
180


Profile Mom vs Theta
ProMomVSTheta_Pi
Entries 2598095
Mean 76.97
Mean y 0.5295
RMS 35.58
RMS y 0.3583
Pion
momentum(GeV)
theta
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
20
40
60
80
100
120
140
160
180

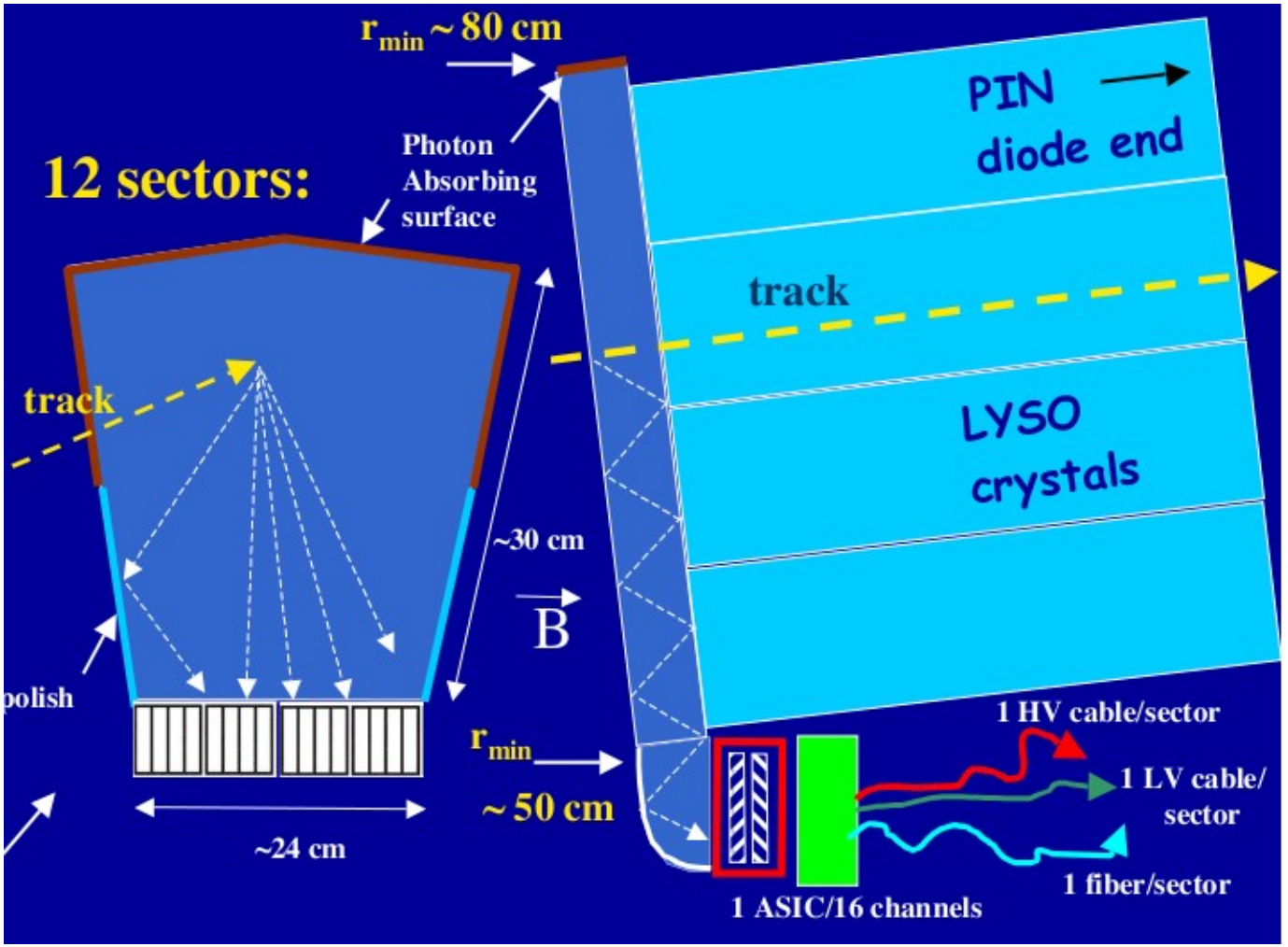
The TOF system : some details

$$\Delta t \approx \frac{Lc}{2p^2}\left(m_1^2 - m_2^2\right)$$

L ~ 2 meters

P_{max} ~ 3.2 GeV/c

DIRC-like" Forward TOF detector, Vavra



Pre-shower detector

1.5 – 2.0 cm thick

One possibility: glued to FWD EMC

Theta coverage from 16 to 25.5 deg

Very small number of electronic channels

Background from low energy neutrons

Length of the tracks have to be very well measured

TOF in FastSim

Check if TOF detector was hit

If so, time measurements = true (Geant) time smeared by a Gaussian distribution with given error.

Rad. Length ~10%
Same as DIRC (Cerenkov PID detector for barrel) detector

No Background photons

Number of signal photons is Poisson-like distributed, with 2 photons in average + 1 photon (numbers to be changed when full simulation available)

To calculate the expected time for a given particle hypothesis, the length of the track L_{track} has to be determined as

$T_{exp} = L_{track} / beta / c$

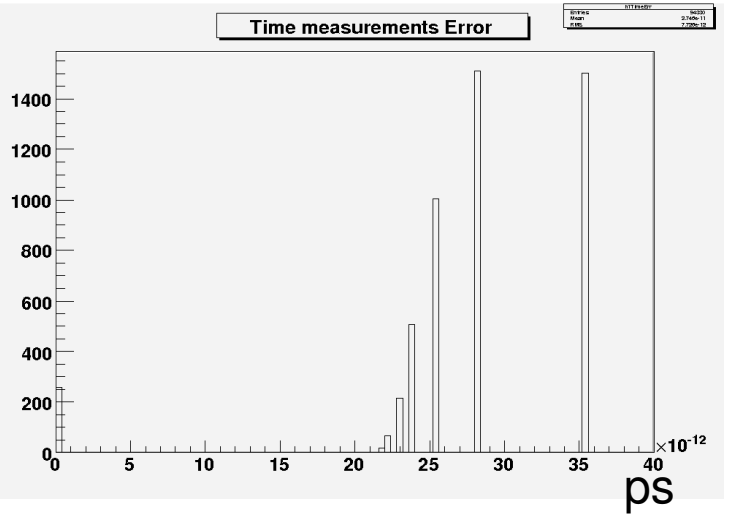
Uncertainty due to beta measurements gives additional error about 10ps

Uncertainty due to L_{track} measurements has to be studied.

Full simulation of the TOF detector to be done

Resolution formula

Error on time measurements in FastSim



Time resolution formula

$$\sigma(t) = \sqrt{\frac{\sigma_{sci.}^2 + \sigma_l^2 + \sigma_{TTS}^2}{N_{eff.}} + \sigma_{elect.}^2}$$

Obviously not Divided by N_{eff}

σ_{sci} = contribution of the light flash

σ_l = variation of the travel time due to
i) different point impact
ii) emission angle of the photons

} detector

$\sigma_{sci.} \sim 0$

$\sigma_l \sim 0$

Quarz for Cherenkov light
(NIM A 440 (2000) 124)

σ_{TTS} = photoelectron transit time spread (TTS)

} PM

MCP-PMT or SiPM

$\sigma_{TTS} \sim (30-40)\,ps$

N_{eff} = number of primary photoelectrons

} PM+detector

σ_{elec} = spread time due to the electronics

} electronics

Initial implementation of PID “selectors” in FastSim

We use BaBar run6-r24c PID tables to create new truth based table selector

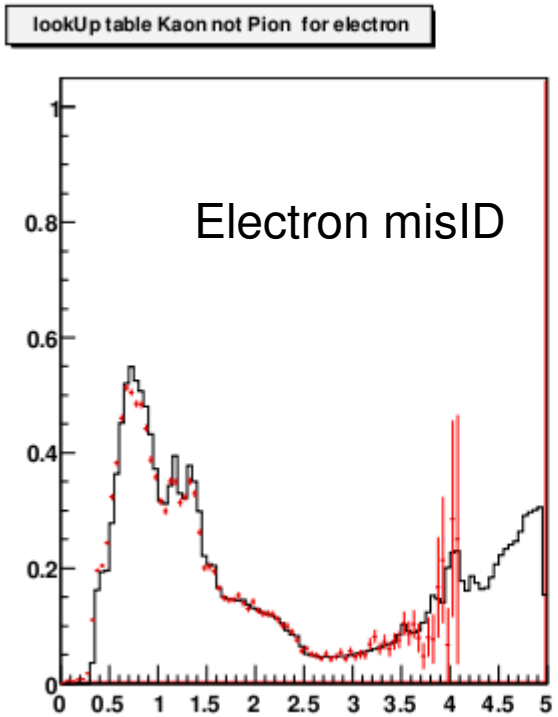
Example of the table. For a given bin on theta 25.0°>theta>15.6°
and 60 equal size bins of momentum 4.96> mom>0.289

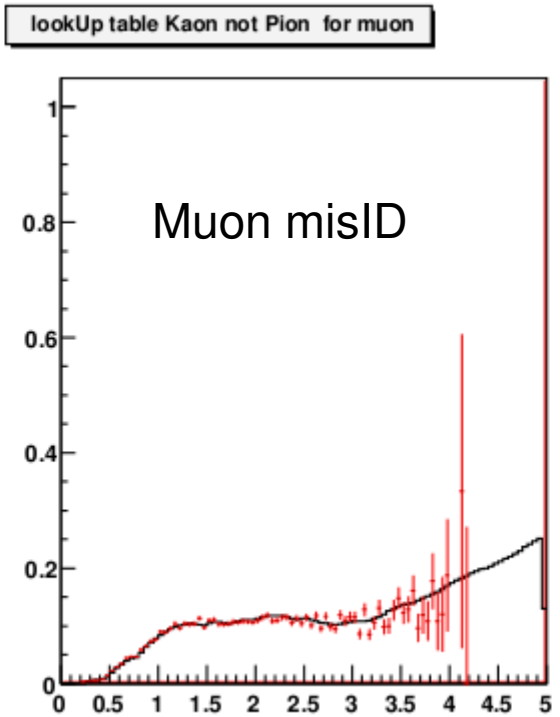
ANGLE 15.6 25.0
MOMENTUM 60 0.289583 4.96042

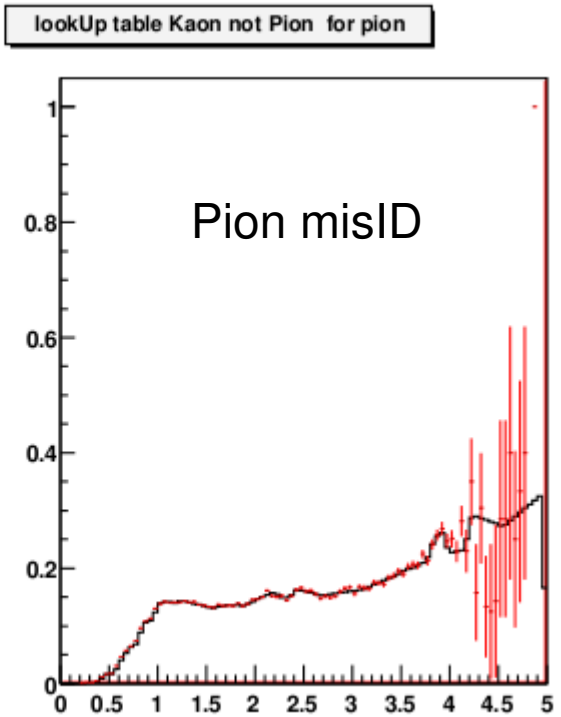
mom	e	mu	pi	K	pron
DATA					
0.289583	0	0.00243576	0.00188678	0.541667	0
0.36875	0	0.00345289	0.00267467	0.767857	0
0.447917	0	0.00447002	0.00941918	0.991999	0.0072548
0.527083	0	0.0255947	0.00952798	0.973379	0
.....					
.....					
.....					
END					

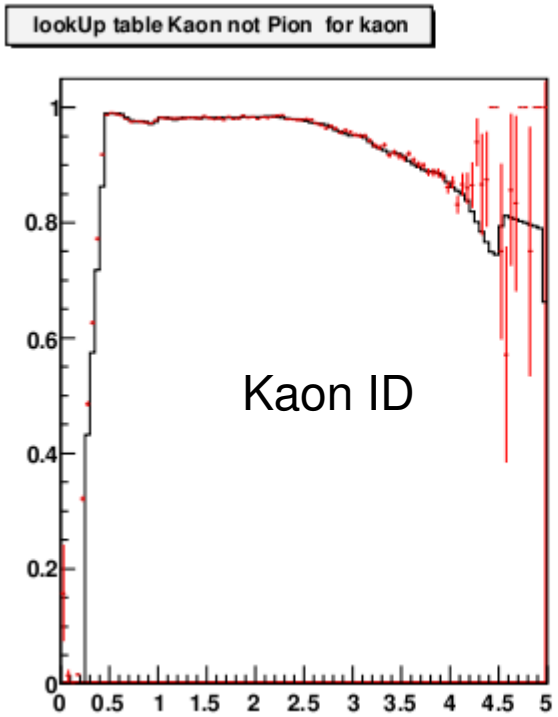
- In one file any number of the theta bins can be used
- Bin size for momentum is constant
- Selectors are nested (..tight, loose...)
- table path is given by tcl file
- Bit map for PID selectors is available
- Description information available in the superB wiki page

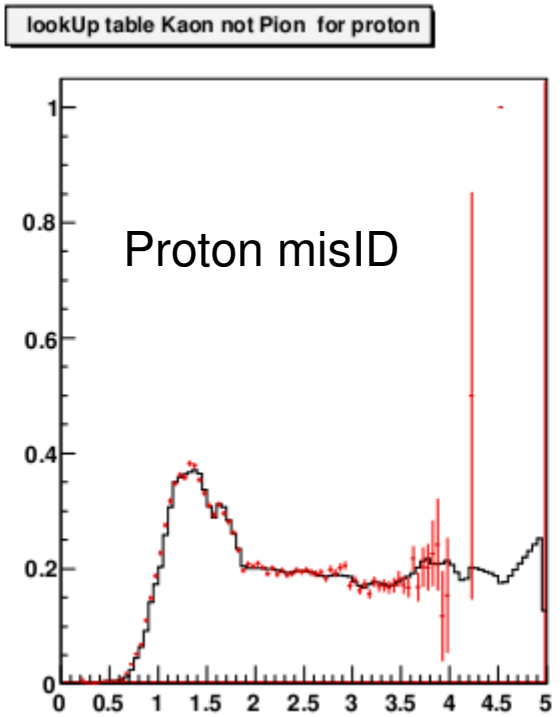
Example of table-based Kaon selector

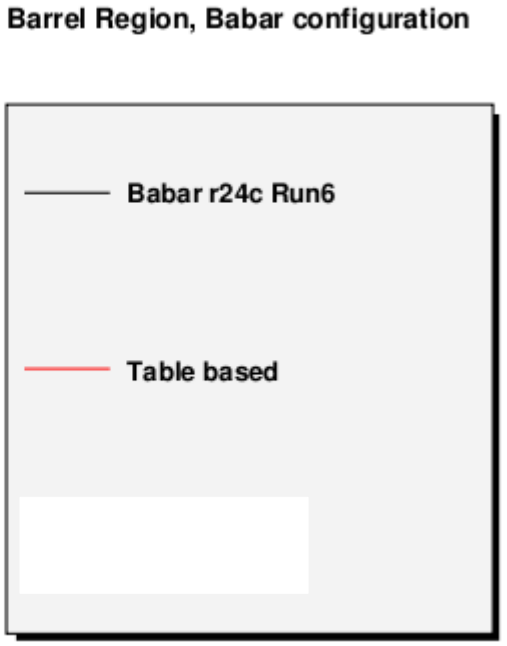












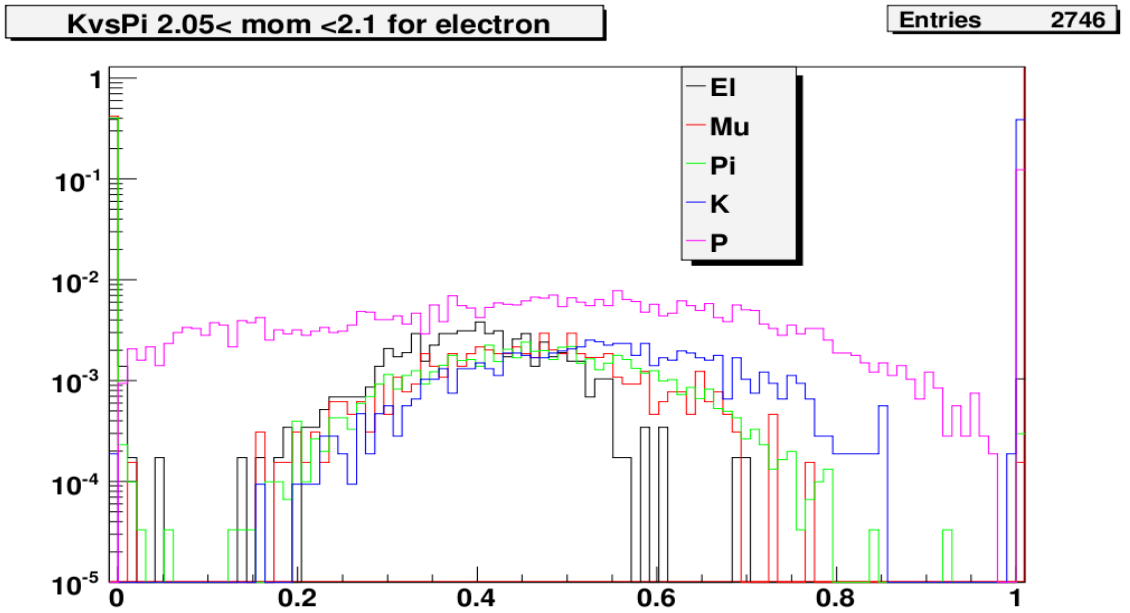
More realistic selectors based on likelihood ratios

Based on 6 inputs

1) Number of Cerenkov photons (DRC) efficient for low momentum, barrel region
2) Cerenkov angle (DRC) efficient for high momentum, barrel region
3) dE/dx measurements from (DCH)
4) dE/dx measurements from (SVT) not yet implemented in FastSim
5) time measurements from (TOF) , FWD region (30 ps)
6) time measurements from (bwd-EMC) , bwd region (100ps) not yet implemented in FastSim

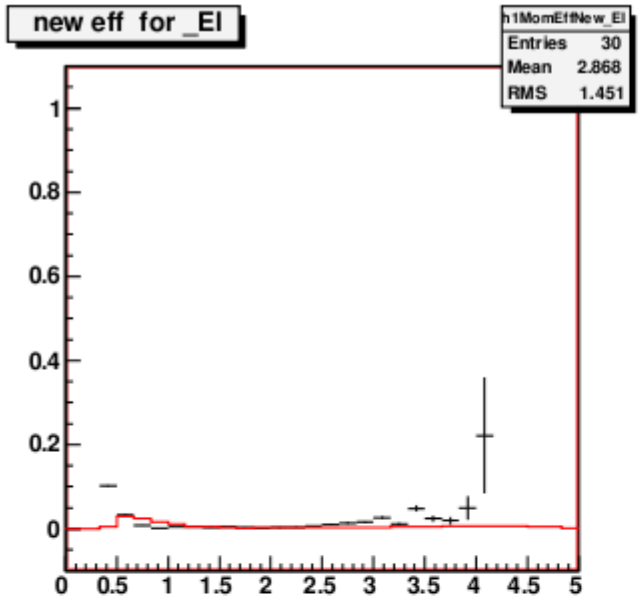
Lh_Kaon = Lh_DRC_Kaon x Lh_DCH_Kaon x Lh_TOF_Kaon

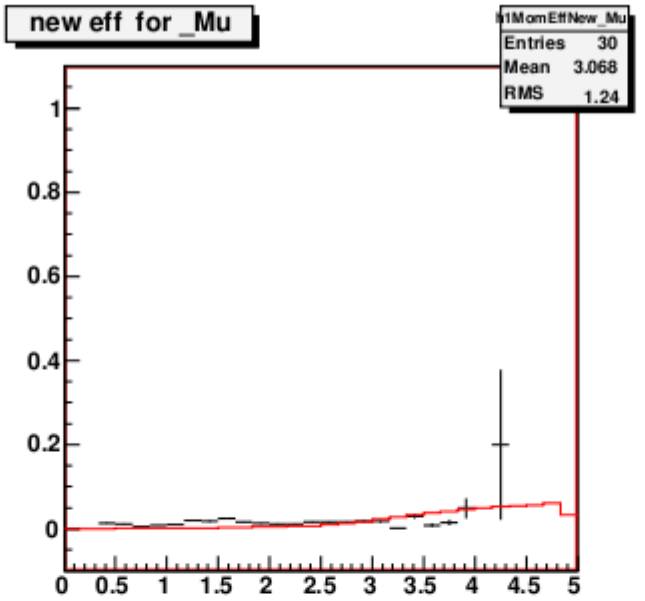
Main Kaon/pion separation variable is LhratioKvsPi = Lh_Kaon/(Lh_Kaon + Lh_pion)

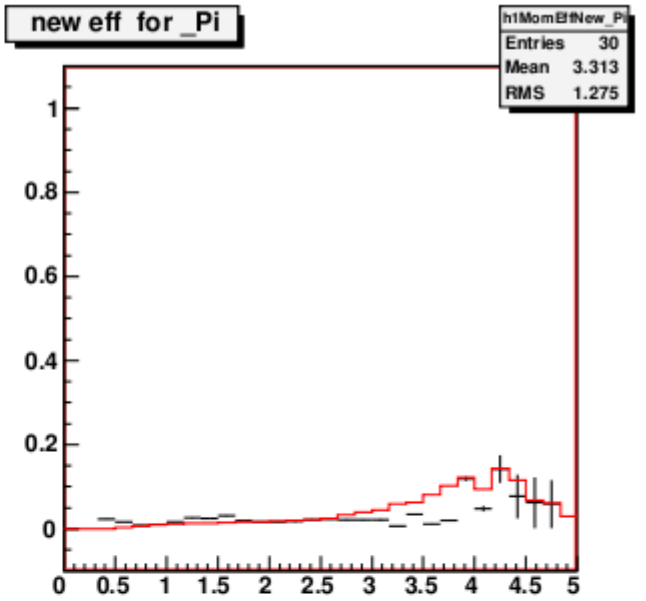


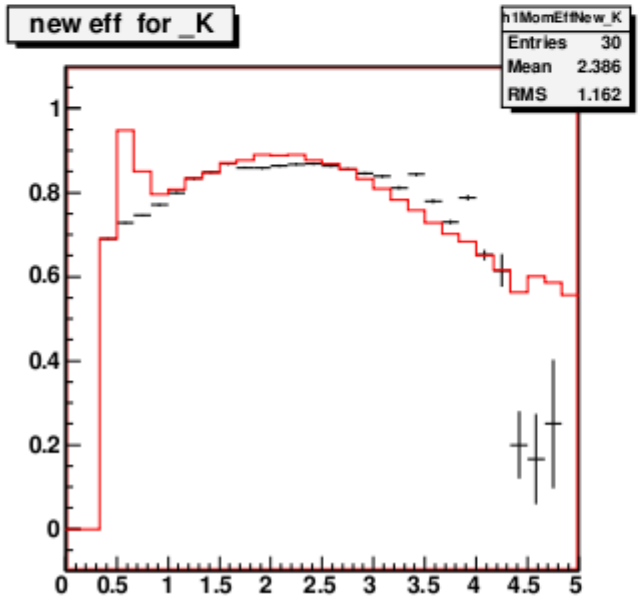
Another discriminant variable is LhratioKvsElectron. Optimizing 2D-cuts vs. momentum we get:

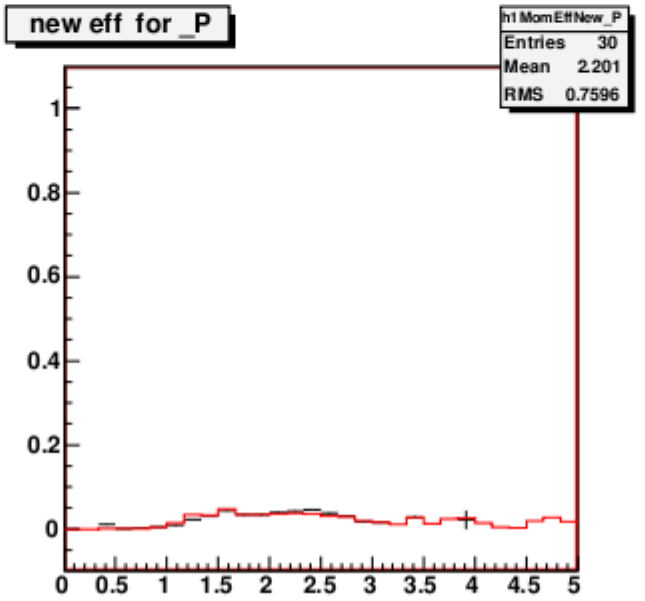
FastSim Kaon tight selector vs corresponding Babar Table selector











We need to improve these results. Work is going on..

Conclusion

TOF implemented in Fastsim

Table based and likelihood selectors are implemented and tested

Improvements still to be done by taking in to account FWD region of the PID system.

Realistic Geant4 simulation of the TOF detector needed.
This job started in collaboration with Kiev Taras Shevchenko National University.