Requirements for the PANDA Cherenkov detectors

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1 Objective

This write-up aims at determination of the momentum range, in which π/K/p discrimination by means of Cherenkov detectors is required at PANDA. This range is determined by: $i)$ studying the kinematics of a set of selected processes involving charged kaons in the final state and $ii)$ imposing a demand of a feasibility to positively identify all kaons.

2 Detectors

Three Cherenkov detectors covering different ranges of polar angle in the laboratory frame are foreseen for PANDA:

Barrel DIRC for $\theta \in (22^\circ, 140^\circ)$,

End cap DIRC for $\theta \in (5^\circ, 22^\circ)$,

Forward RICH for $\theta \in (0^\circ, 10^\circ)$.

3 Lower momentum limit

The lower limits of the π/K and K/p discrimination through the Cherenkov detectors are determined by the capabilities of the time of flight and energy loss detectors which are supposed to ensure particle identification at lower momenta. The ToF technique is most powerful in the forward region, where particles traverse the distance of about 7 m between the start and stop counters. Assuming a time resolution of 100 ps and a 1% momentum resolution and equal fluxes of each particle kind we obtain a scatter plot of squared invariant mass *versus* momentum as shown in fig. 1. As seen in the figure, the ToF technique provides good π/K separation up to ~ 2 GeV/c and good K/p separation up to ~ 4.5 GeV/c.

As for the Barrel and End cap regions, it is rather certain that the ToF resolution will be worse here due to a much shorter distance and - presumably - worse time resolution of the detectors

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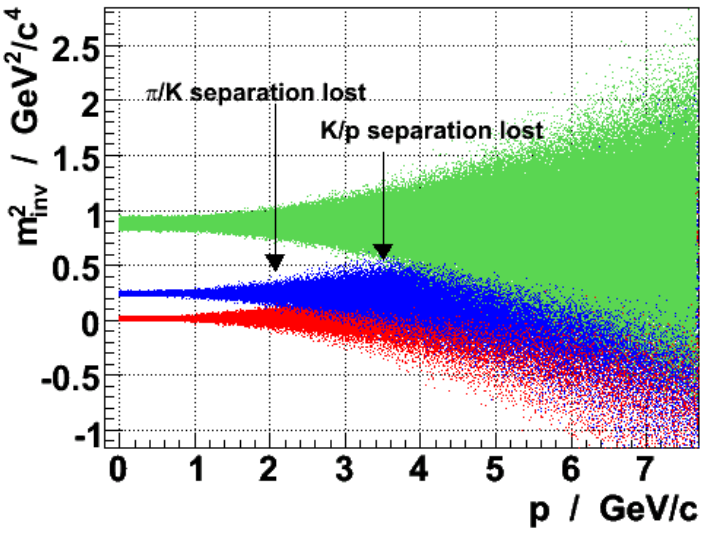

Figure 1: Reconstructed square of invariant mass *versus* momentum for pions, kaons and protons in the forward region (for details see text).

involved. This means, that the lower momentum limit for the correspoding Cherenkov detectors must be set much lower than for the forward region, possibly as low as 1-1.5 GeV/c.

For completeness it should be added that the energy loss measurement provides π/K discrimination only up to approximately $p = 0.7$ GeV/c and K/p discrimination up to $p = 1.0$ GeV/c as depicted in fig. 2 showing the STAR data[1].

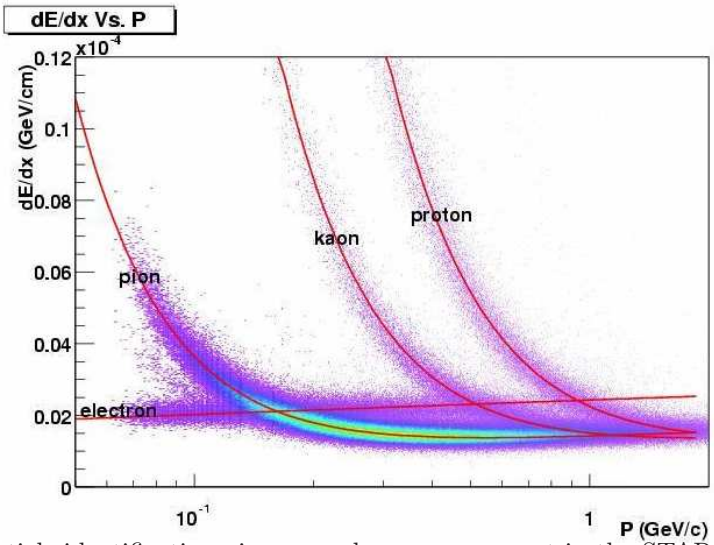

Figure 2: Particle identification via energy loss measurement in the STAR experiment.

[1]limits and figure taken from the lecture *Analysis Techniques in HEP* by Claude A. Pruneau.

4 Upper momentum limit

In order to determine the upper momentum limit, up to which PANDA requires π/K/p discrimination, kinematics of several processes were simulated. The choice of reactions must be done very carefully, the main criterion being a presence of fast kaons in the final states. Partly, the reactions were selected from the benchmark reaction list of the Techical Progress Report (TPR), partly they were extracted from the *Physics Case* chapter of the TPR. Considered processes are listed below:

1. $\bar{p}\,p \;\rightarrow\; D^{+}D^{-} \;\rightarrow\; 2K\,4\pi$ at $p_b = 15.0$ GeV/c
2. $\bar{p}\,p \;\rightarrow\; D^{*+}D^{*-} \;\rightarrow\; 2K\,4\pi$ at $p_b = 15.0$ GeV/c
3. $\bar{p}\,p \;\rightarrow\; \gamma\,K^{+}K^{-}$ at $p_b = 15.0$ GeV/c
4. $\bar{p}\,p \;\rightarrow\; \gamma\,\phi \;\rightarrow\; \gamma\,K^{+}K^{-}$ at $p_b = 15.0$ GeV/c

Samples of 10 000 events were generated for each of the above processes assuming phase-space distributions (package Pluto++). Occupancy of the $\theta_{LAB} - p_{LAB}$ space for each process is shown in fig. 3. Black lines indicate limits of angular acceptances of the individual Cherenkov detectors.

Fig. 4 shows, that practically the whole part of the $\theta_{LAB} - p_{LAB}$ plot below the 2–body kinematical limit is filled with the events of the investigated reactions. This region is not "background–free" - a substantial background of pions (produced directly or originating from decays of heavier particles) will cover the whole region as well.

5 Summary

In order to provide π/K/p discrimination in **full acceptance** for the four investigated processes, K mesons need to be positively identified up to the following momentum limits p_{max}:

for the Barrel DIRC p_{max} changes smoothly between 7 GeV/c at $\theta = 22^{\circ}$ and less than 1 GeV/c at $\theta = 140^{\circ}$,

for the End cap DIRC p_{max} changes smoothly between 14.5 GeV/c at $\theta = 4^{\circ}$ and 7 GeV/c at $\theta = 22^{\circ}$,

for the Forward RICH p_{max} changes smoothly between 15.5 GeV/c at $\theta = 0^{\circ}$ and 12.5 GeV/c at $\theta = 10^{\circ}$.

It should be stressed here, that the presented limits were determined by imposing a demand that 100% of kaons originating from the investigated processes are to be positively identified.

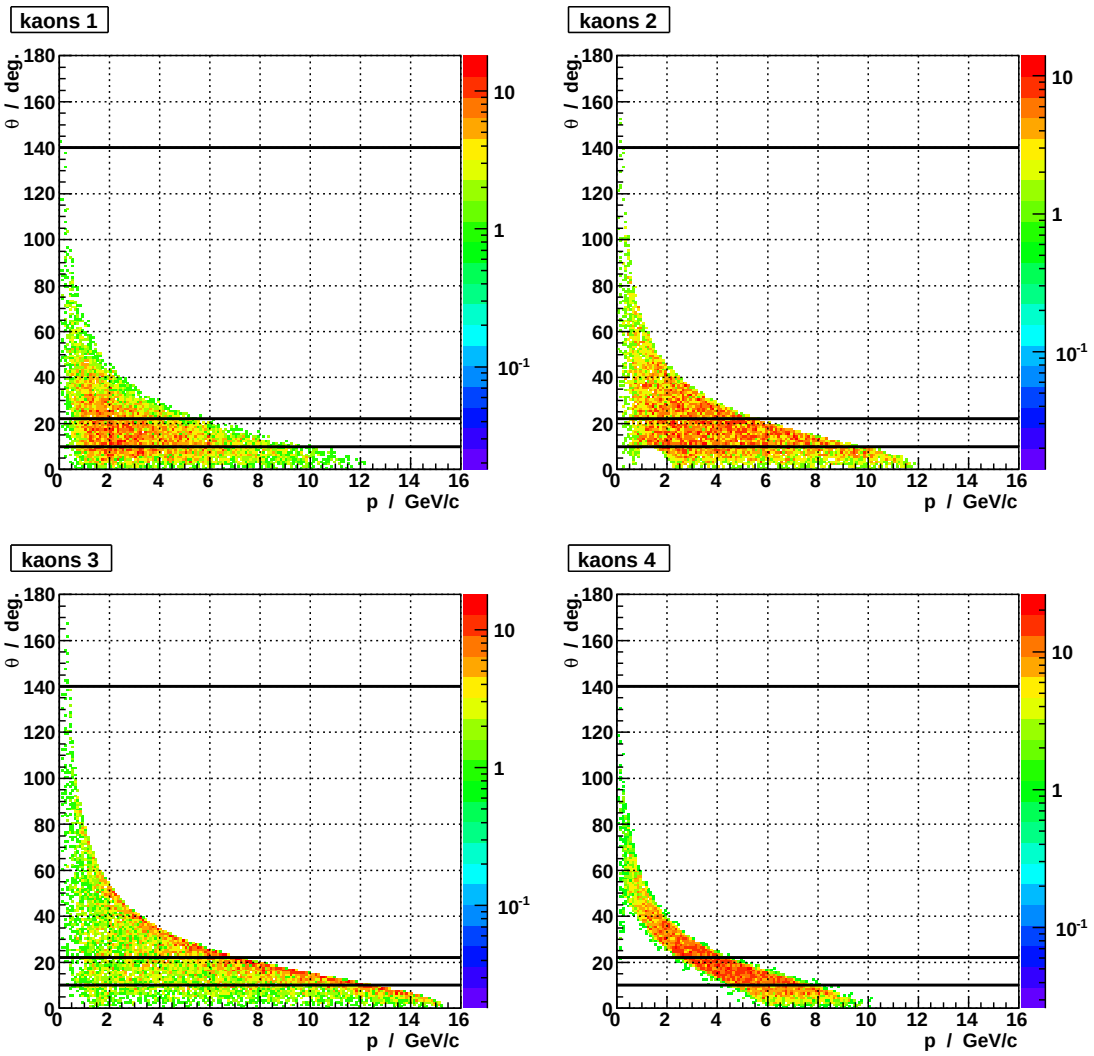

Figure 3: Scatter plots of polar angle (LAB) versus momentum for kaons stemming from the investigated reactons.

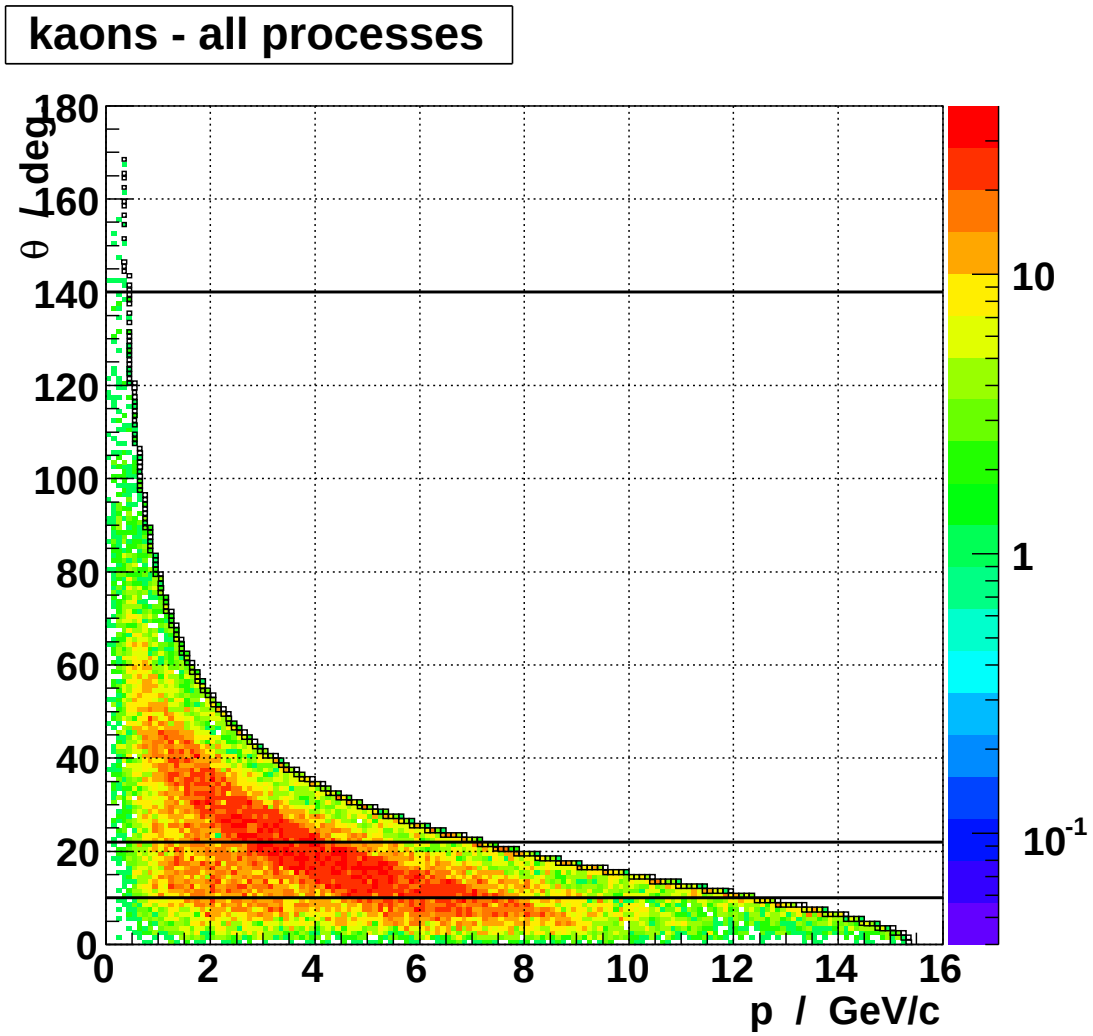

Figure 4: Sum of the spectra displayed in fig. 3. Black boxes indicate the 2-body kinematics (2 kaons in the final state).