Particle identification with Proximty focusing RICH: Maximum likelihood technique

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Motivation

Particle identification up to 4 GeV/c is necessary.

$\pi - K$ difference in the Cherenkov angle at 4 GeV/c:
for aerogel tile n=1.05, thickness t=2 cm

Particle	θ_c @ 4GeV/c	Single photon σ_{θ_c} @ 4GeV/c	N_{det}
π	308 mrad	13 mrad	5.8
K	285 mrad	13 mrad	5.8

Overall Cherenkov angle resolution per track is

$\sigma_{\theta_c}(\mathrm{track}) = \frac{\sigma_{\theta_c}}{\sqrt{N_{det}}} = 5.4$ mrad

with N_{det} equal to the average number (5.8 in this case).

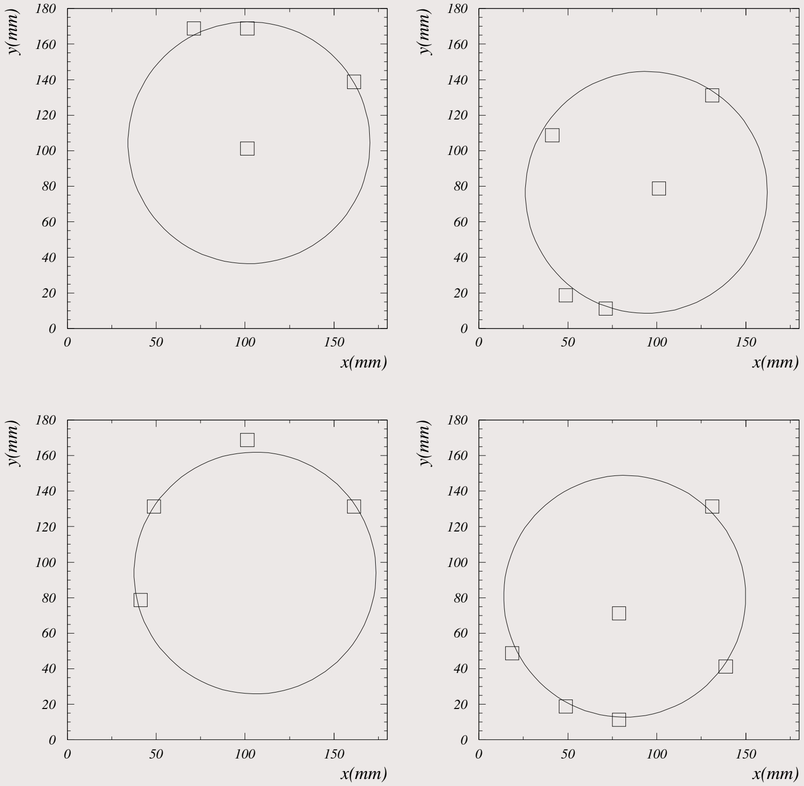
With the achieved resolution, a safe 4σ separation should be obtained.

However, the number of detected photons is Poisson distributed, and the PID capabilities have to be evaluated more carefully.

This will remain so even if we achieve the target, and detect around 10 photons, and in particular for lower momenta.

Construction of the Likelihood function

For each charged track calculate probabilities for different particle hypotheses hyp e,μ,π,K,p, background



Background level is low, most of the background photons come from scattered photons in the aerogel radiator.

The probability density for a particular hit i:

$$\boxed{p^{hyp}(\theta_i) = N_{det} S(\theta_i, \theta^{hyp}) + N_{bgr} B(\theta_i)}$$

Signal: $S^{hyp}(\theta_i) = \frac{1}{\sqrt{2\pi}\sigma_i} e^{\frac{(\theta_i - \theta^{hyp})^2}{2\sigma_i^2}}$ Background (flat): $B(\theta_i) = B_0 \theta_i$

Normalisation to expected number of photons: $\int\limits_{\theta_0}^{\theta_1} p^{hyp}(\theta) d\theta = N_{det} + N_{bgr} = n_e$

Poissonian nature of the process: $\frac{(n_e)^n}{n!} e^{-n_e}$

Construction of extended likelihood function

$$\boxed{L^{hyp} = \frac{(n_e)^n}{n!} e^{-n_e} \cdot \prod_i^n p^{hyp}(\theta_i)}$$

Normalisation: $\lambda^{hyp} = \frac{L^{hyp}}{\sum\limits_k L^k}$, where $k = e, \mu, \pi, K, p, background$

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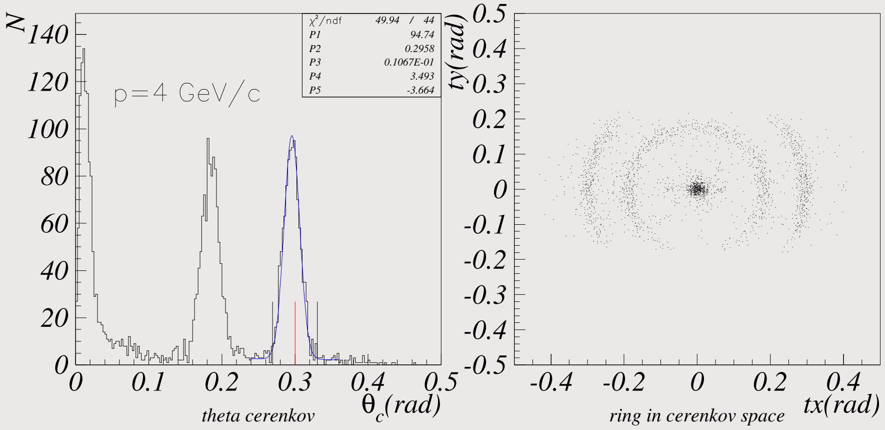
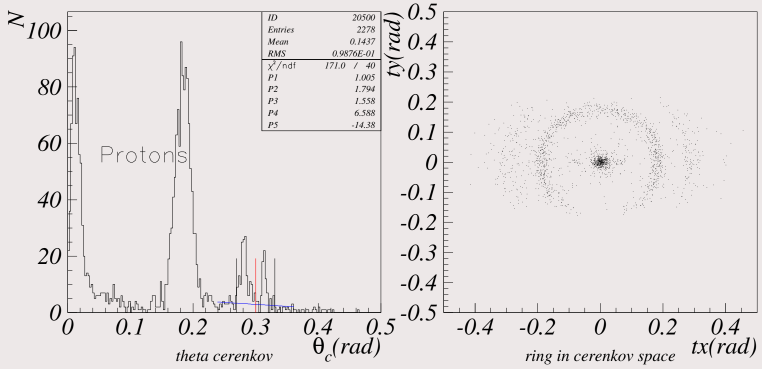
Separation Capabilities Example

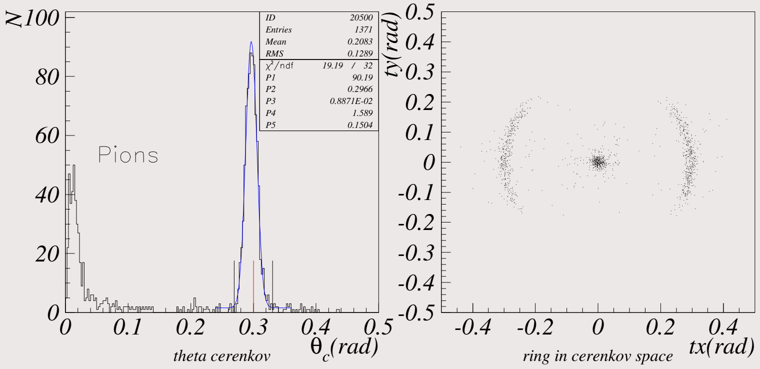
2002 TestBeam Run 163 sample (particles: π and proton),

beam momentum p=4 GeV/c, aerogel n=1.05 t=2 cm, $\varepsilon_{geo} < 0.30$



Selection criteria: $L^{proton} > L^{\pi}$ $L^{\pi} > L^{proton}$

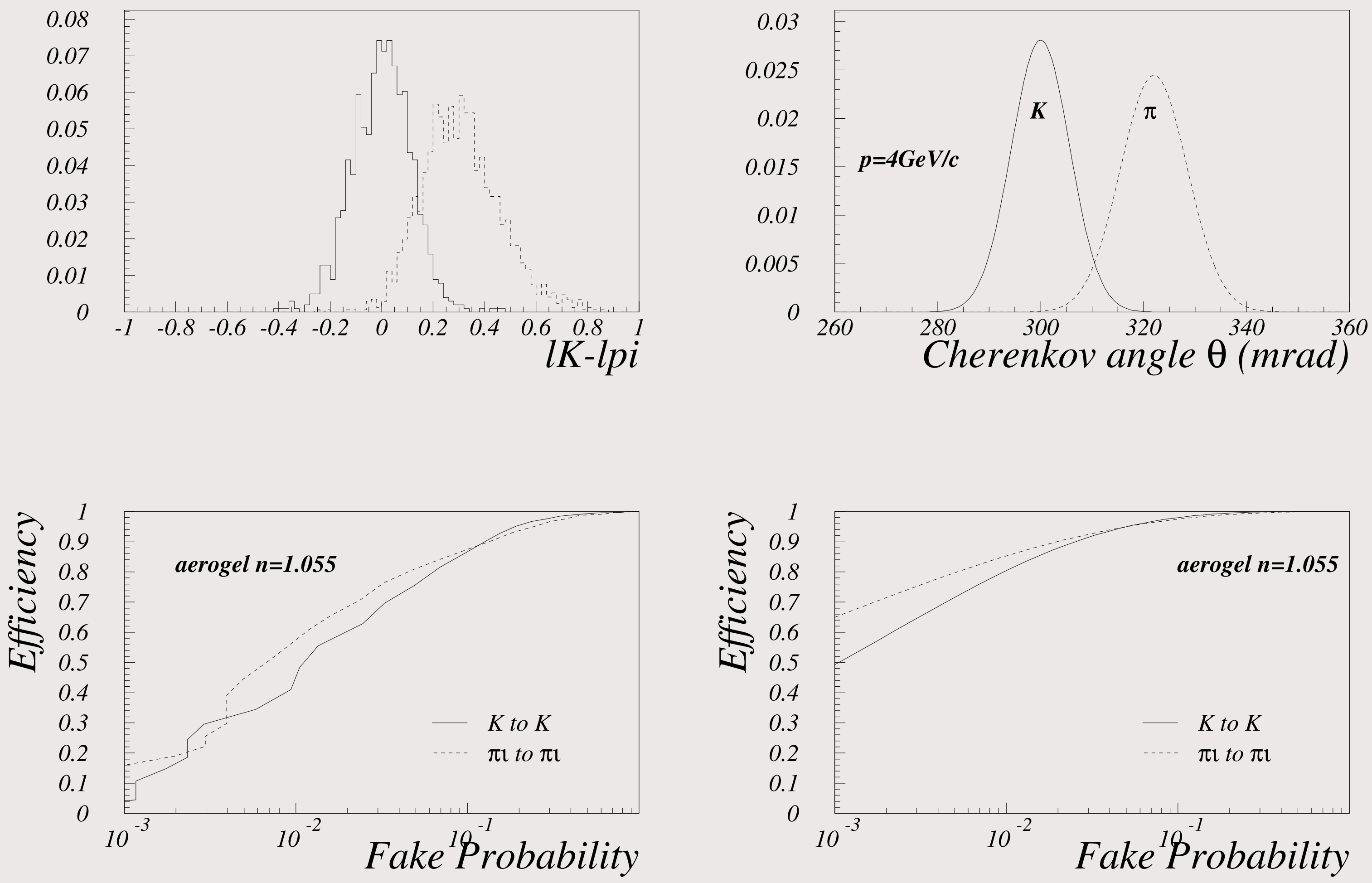




RICH1 with much larger acceptance would of course give much better results, but there is unfortunately no equivalent run on the RICH1 side - in the π, p run a dual radiator was used, and for such a case the algorithm is still being adapted.

Efficiency vs. fake probability n=1.055

Compare π at 4 GeV/c and π at 1 GeV/c (same behaviour as Kaons @ 3.8 GeV/c)



Conclusions

- The standard likelihood method for particle identification with a RICH has been adopted for the recorded data
- Efficiencies are in agreement with expectations
- Next: dual radiator case
- + many more, under study

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