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Disc DIRC Endcap-Cherenkov Detector for PANDA @ FAIR

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

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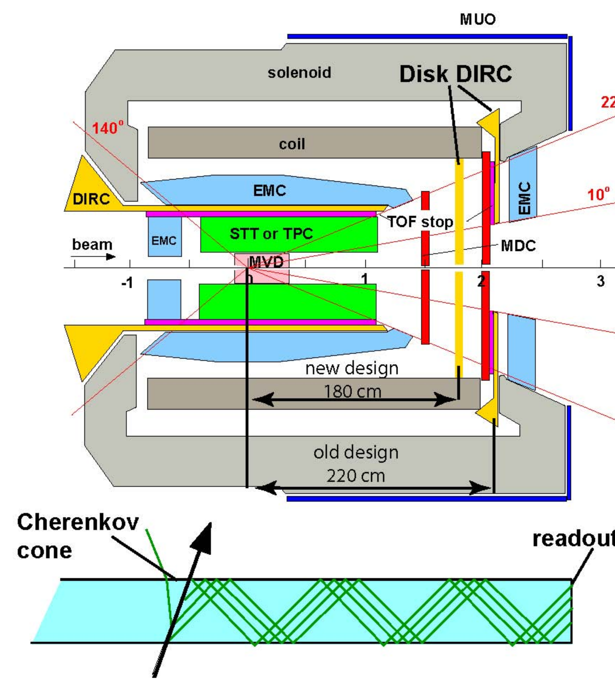
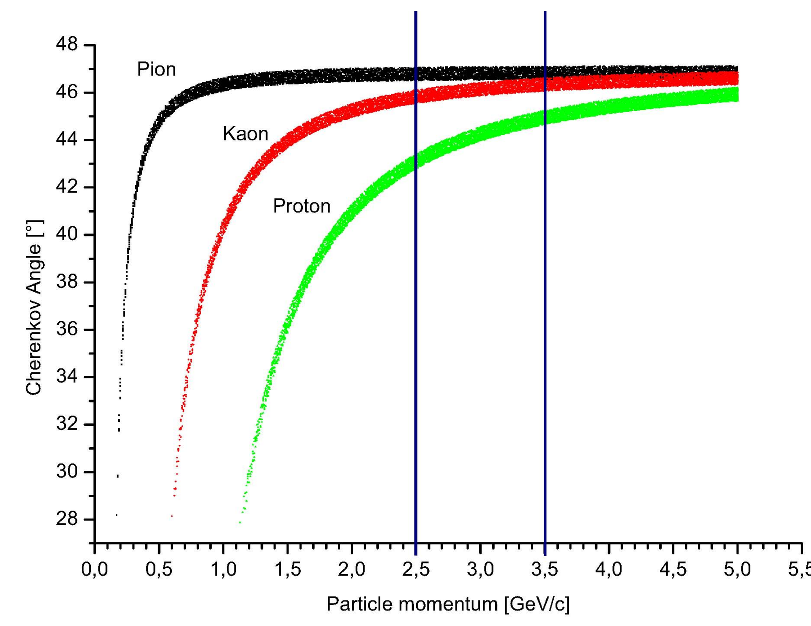
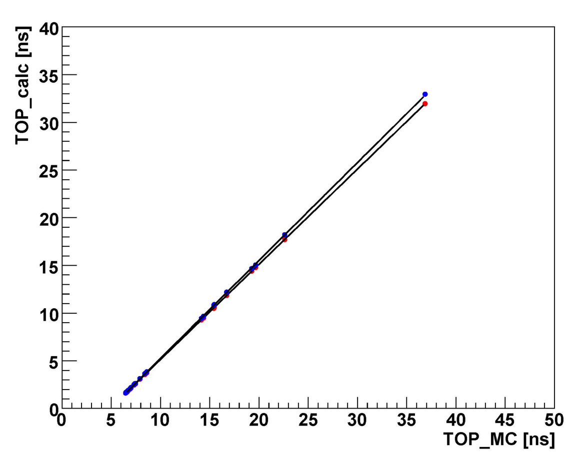
The Disc DIRC (detection of internally reflected Cherenkov light) detector is a fused silica solid radiator with a readout, sensitive for single photons. Intending to separate π-κ up to 4 GeV/c, PANDA provides two possible radiator positions.
A particle passing the radiator creates Cherenkov light, which is propagated by internal reflection to the rim area. To avoid broad distributions, dispersion correction is necessary.
Two possible designs are investigated.



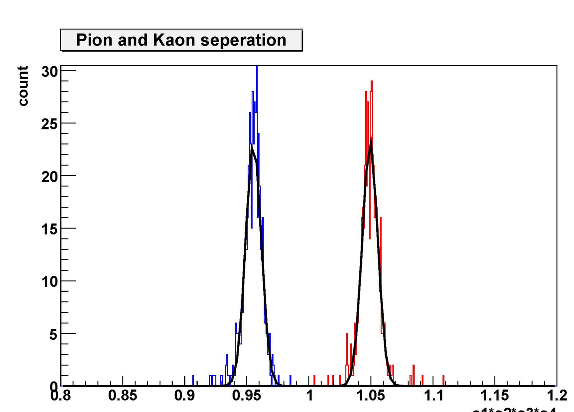


Dispersion (even in the limited range of visible light 400-700 nm) leads to an overlapping of the distributions. For fused silica radiators, the separation of π and κ up to a momentum of 2.5GeV/c is easily feasible. At momentum ranges above 3.5GeV/c the separation becomes quite hard. In our two designs a separation of above 4GeV/c is obtained by dispersion corrections.

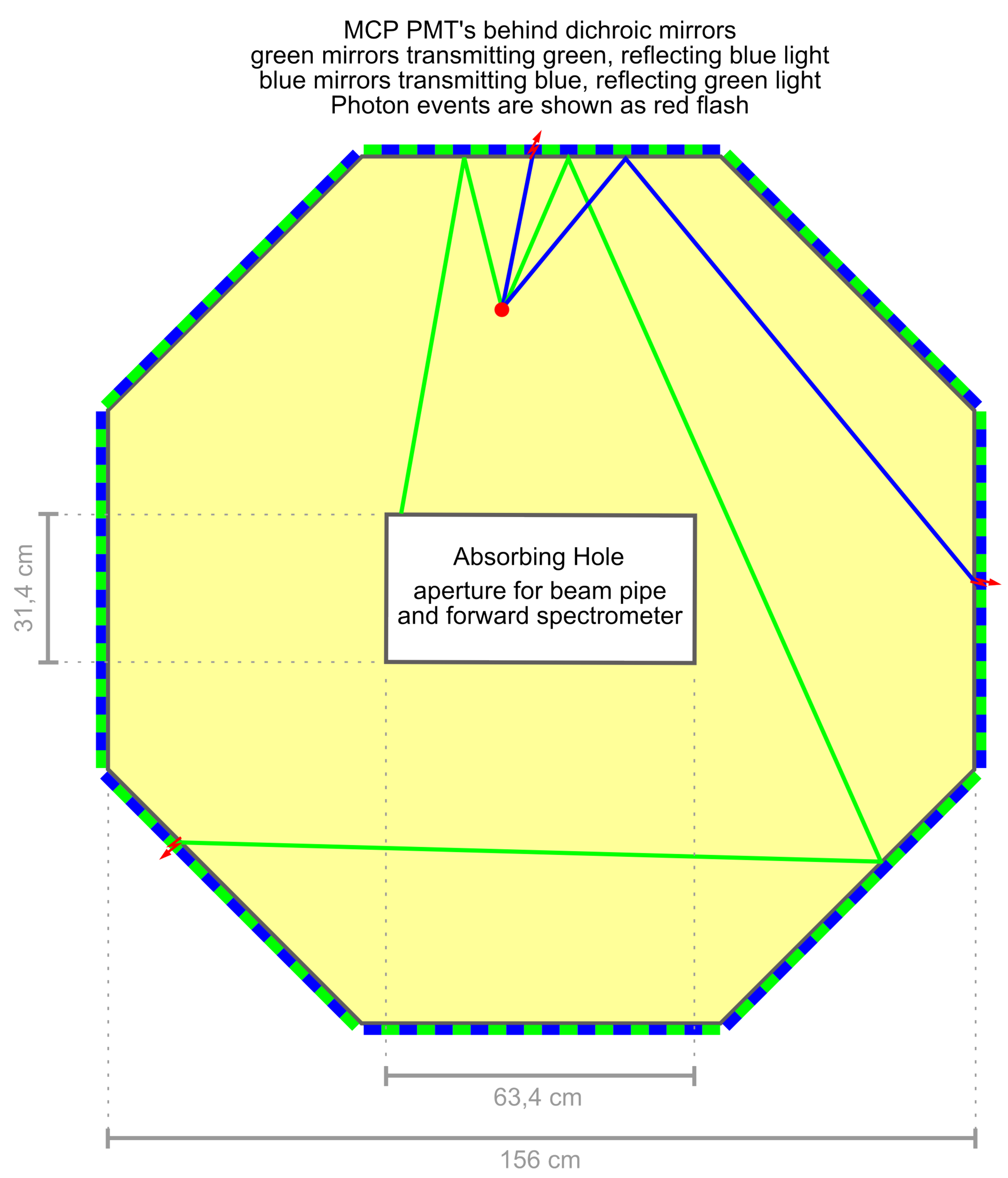
Time of Propagation (ToP) design

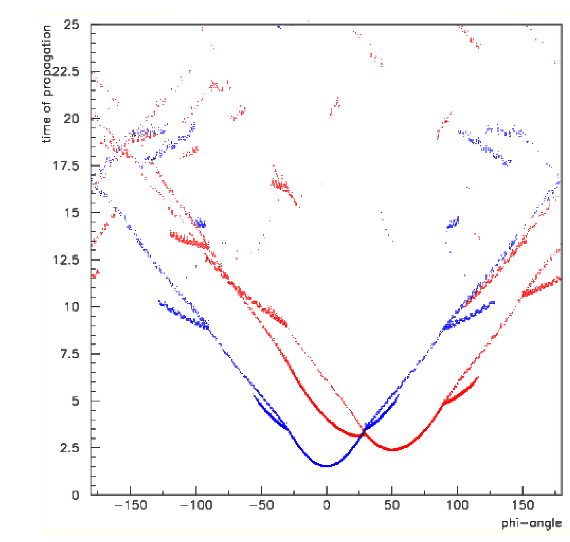


The measured ToP for each particle is compared with an analytically calculated ToP using the two assumptions that the particle is either a pion or a kaon. The slope S_i of these values in the measured versus calculated ToP plane is sufficient to extract the right particle hypothesis. An external start time T_0 is not required for this detector.

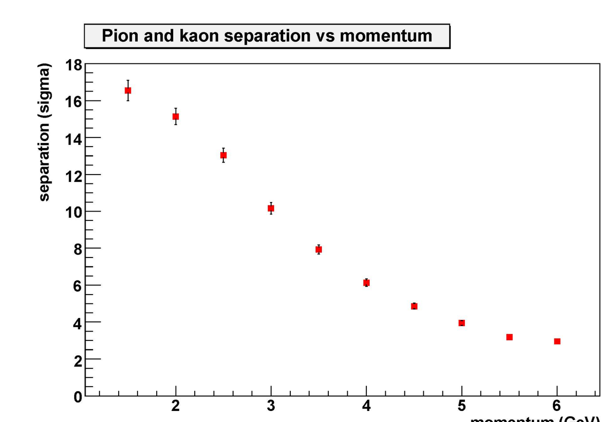


If the product of the above mentioned slopes for the two hypotheses (pion and kaon) and for each of the two wavelengths ranges from the different mirror types S1*S2*S3*S4 is smaller (larger) than 1, the particle is positively identified as a kaon (pion).





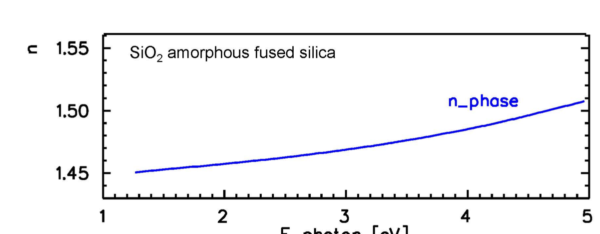
Hit pattern of two particles penetrating the disc at different positions. The time of incident is the same. The photons of the different particles can easily be distinguished.

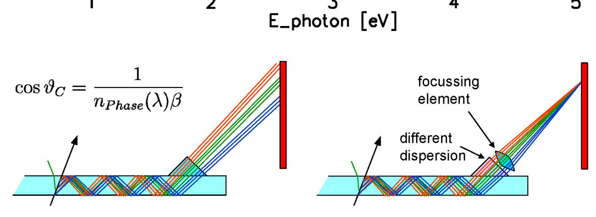


Separation power of the ToP Disc DIRC vs. the momentum is calculated as $\sigma_{sep} = \frac{|m_i - m_j|}{(\sigma_i + \sigma_j)/2}$, resulting in 2.3% miss identification at 4σ. A time resolution of 50ps is assumed.

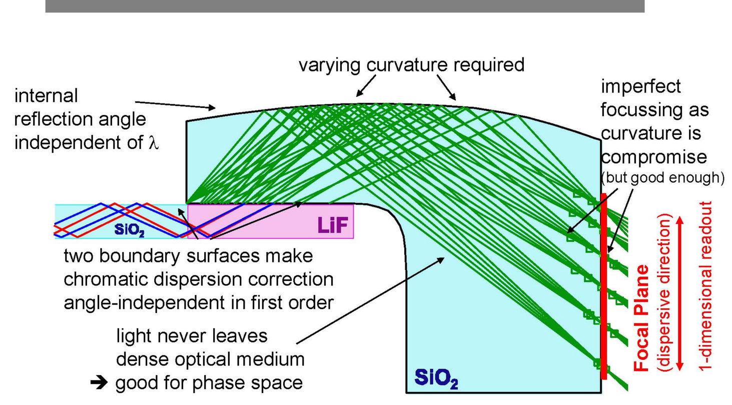
ToP Endcap Disc DIRC. The disc is of octagonal shape with a rectangular hole. The acceptance range is 5° to 22° in one direction and 10° to 22° in the other. Each side is equipped with 120 dichroic mirrors, separating at a wavelength of 500nm. Behind each mirror is a single photon readout by MCP-PMTs.
The penetrating particle creates Cherenkov photons. The photons are propagated through the disc by total reflection. As soon as they reach the rim of the disc, interaction with the mirrors occurs. Depending on the wavelength, with the probability of 0.5 they are reflected towards the next mirror. In case they are not reflected but transmitted, the time of the photon with the now defined color range is measured by the MCP. Using the above mentioned slope analysis method, it is possible to extract the particle type from the measured ToP without knowing the penetration time of the particle.

Focussing Light guide design

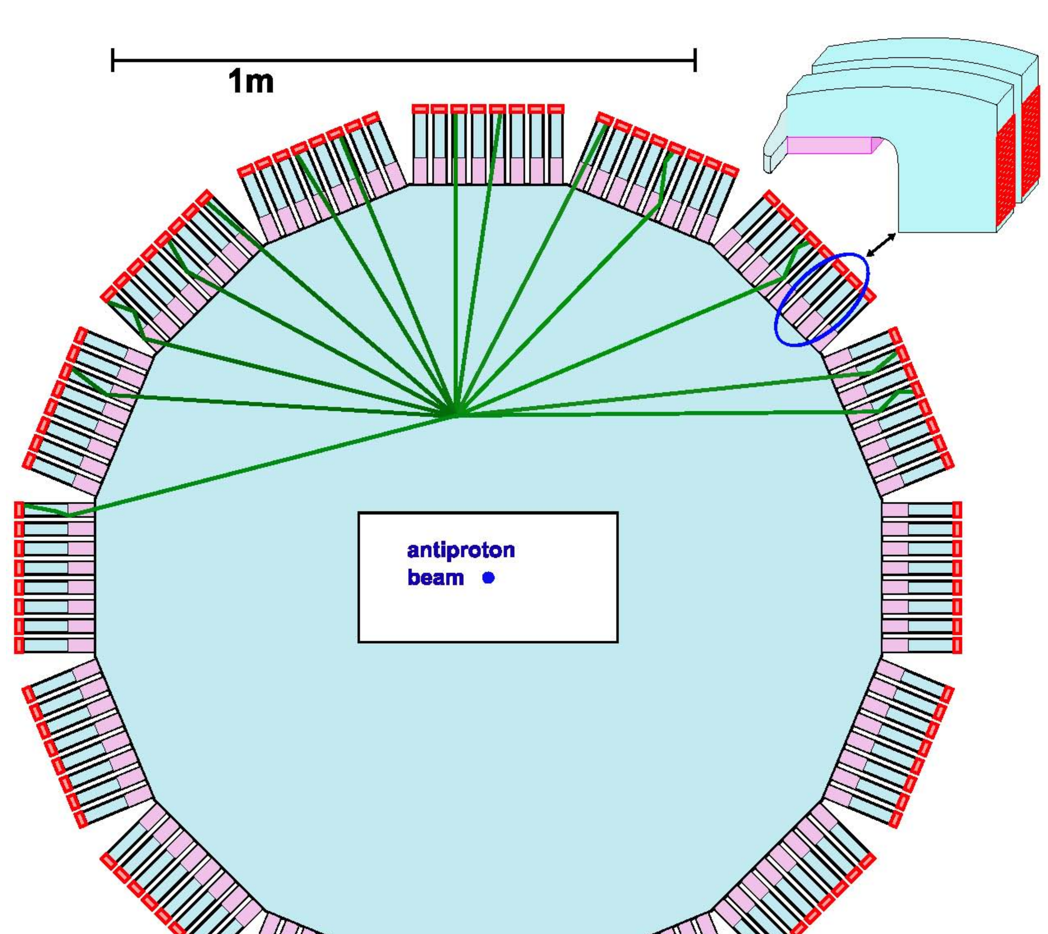


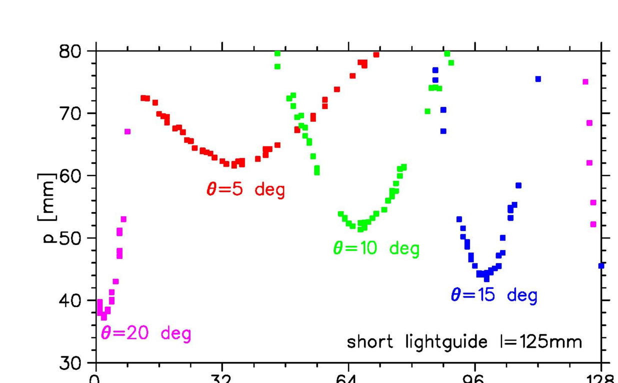


In a dispersive medium Cherenkov light has parallel light paths of colour-dependent angle. A prism element corrects the angle before a focussing element converts angle information into position information.

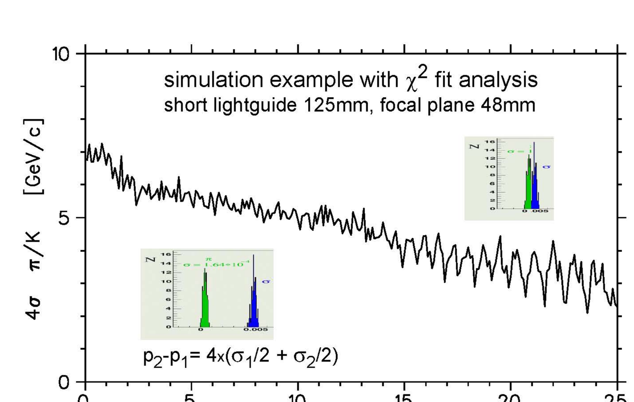


LiF with its special refractive index is the first step in dispersion correction. It is followed by a focussing correction due to the SiO_2 light guides.





Hit Pattern of the focal plane. 1 dimensional readout for a number of particles vs. the light guide number of incident.



Separation power of the Focussing Disc DIRC vs. the angle of incident is calculated with $\sigma_{sep} = \frac{|m_i - m_j|}{(\sigma_i + \sigma_j)/2}$, resulting in 2.3% miss identification at 4σ

Focussing Light guide Endcap Disc DIRC. The disc is of hexadekagonal shape with a rectangular hole. The acceptance range is 5° to 22° in one direction and 10° to 22° in the other. Each side is equipped with a LiF bar leading the photons to fused silica light guides. In total 96 light guides are red out by 4608 single photon readout channels (PMTs) on their focal plane.
The penetrating particle creates Cherenkov photons. The photons are propagated through the disc by total reflection. As the photons hit the LiF part of the disc, the first step of the dispersion correction is automatically achieved by the abnormal index of refraction of this material. Leaving the LiF to the fused silica light guides, the photons are now focused to a focal readout plane. By measuring the readout position, the Cherenkov angle can be reconstructed. This directly leads to the π-κ separation.