Modification of the HADES-RICH Geometry for Measurements at FAIR Energies ◇

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The HADES experiment at GSI, Darmstadt, was designed to measure rare e^+e^--decays of light vector mesons up to 3.5 GeV in elementary reactions and up to 2 AGeV in heavy ion collisions. It is planned to use HADES with higher beam energies ($\sim$ 8 AGeV) at the new FAIR facility. Experiments at higher beam energies are characterised by an increase of particle multiplicities per event and reaction kinematics with a more pronounced emission of faster particles to forward polar angles. Due to the currently used radiator geometry, the RICH performance and its $e^\pm$/hadron discrimination capability is expected to suffer from three effects:

1. Photon background from pion induced Cherenkov light due to an increase of average particle momenta.
2. Lower average detection efficiency for $e^\pm$ due to the more forward oriented emission, i.e to polar angles with short radiator lengths.
3. Larger hit background in the photon detector originating from γ and charged reaction products due to the increase of particle multiplicities per event, in particular for heavy collision systems.

Since the RICH is used as an online trigger device for events with $e^\pm$ content, the magnitude of these effects has a considerable impact on the HADES performance.

A rearrangement of the mechanically coupled Target - RICH system accompanied by a moderate (few cm) upstream shift with respect to the magnetic field and the innermost drift chambers may help. The prohibitive costs for a new mirror and photon detector rule out a complete RICH redesign. Therefore, we have studied 3 new scenarios, in which only the radiator is modified :

- Use of different radiator gases
- Extension of radiator length
- Upstream shift of photon detector

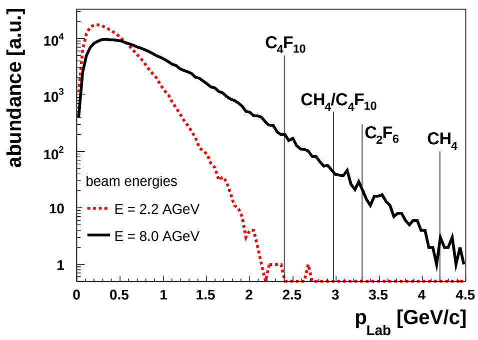

Fig. 1: Pion momentum distributions for thermal ω - decays at various projectile energies. The Cherenkov thresholds are shown for 4 radiator gases.

All combinations were systematically investigated using the standard HADES software packages (PLUTO++, HGEANT, and HYDRA) for event generation, particle transport, and detector signal analysis, respectively, with experimentally verified detector parameters and unchanged ring search algorithms [1]. The simulations were performed for the decay channels $\omega \rightarrow e^+e^-$ and $\omega \rightarrow \pi^+\pi^-\pi^0$ of ω mesons emitted from a thermally equilibrated source with temperatures of 72 MeV, 85 MeV, 108 MeV, and 125 MeV and for a more realistic scenario with UrQMD based C + C collisions at $E_{beam} = 8.0\,$AGeV.

With $C_4F_{10}/CH_4(1:1)$ or C_2F_6 as radiator gas the fraction of pions generating Cherenkov photons is reasonably small up to $E_{beam} = 8.0\,$AGeV (see Fig. 1). For heavier hadrons (kaons, protons etc.) the detector stays blind. Since for pions the ring radii ($\overline{R} \simeq 8 \pm 3mm$) and number of primary photons per ring ($\overline{N_{phot}} \simeq 6 \pm 3$) are considerably smaller than for electrons, they can be separated and suppressed.

A radiator vessel extension of 150 mm leads to an increase of Cherenkov photons an hence of the number of firing pads per ring, especially at forward polar angles. Therefore the ring recognition quality is improved, in spite of the the poorer optical quality of ring image.

Inside the vessel, the photon detector is shifted upstream with respect to the target by 50 mm to reduce the background from direct γ and charged particle hits.

Fig. 2 shows that the combination of all modifications leads to an increase of the single $e^\pm$ detection efficiencies in the ρ/ω mass region as compared to the current setup.

From this we conclude that forthcoming experiments with HADES at FAIR energies are possible and that small modifications may lead to an improved RICH performance already at current SIS beam energies.

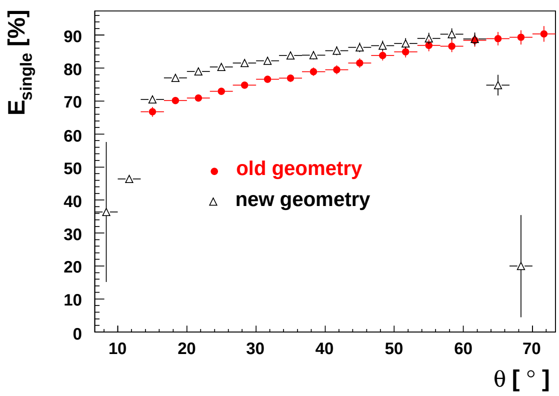

Fig. 2: Expected single $e^\pm$ detection efficiencies for $\rho \rightarrow e^+e^-$ decays in C + C collisions at $E_{kin} = 8.0\,$AGeV for the standard and a modified geometry (see text). The events were generated by UrQMD simulations.

References

[1] M. Weber, diploma thesis, TU München, 2007

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