A Gas Supply System for the HADES-RICH Detector ◇

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A ring imaging Cherenkov detector (RICH) is used for identification of e^+e^- pairs in the dilepton spectrometer HADES [1]. The efficiency for electron identification is essentially determined by the discrimination power between Cherenkov rings and image patterns originating from particle background or electronics noise. This discrimination is strongly related to the number of Cherenkov photons $N_{det}^{Ph} \approx N_0 \cdot Z^2 \cdot \Delta d \cdot \sin^2 \Theta_C$ detected in one ring [2], where the characteristic figure of merit N_0 contains all relevant optical and electronics properties. The radiator length Δd of the HADES RICH varies from 36 cm ($\theta_{e^\pm} = 18°$) to 65 cm ($\theta_{e^\pm} = 85°$). For highly relativistic ($\beta = 1$) leptons (Z = 1) and a gaseous C_4F_{10} radiator, the Cherenkov angle $cos(\Theta_C(\lambda)) = (n(\lambda))^{-1}$ is fixed to $\Theta_C \approx 3.2^o$. The sensitivity of the gaseous photon detector is limited by the solid CsI photocathode [1] and the transmission cutoffs of detector gas (CH_4) and window (CaF_2) to the VUV wavelength region 146 nm $< \lambda <$ 210 nm. Both, radiator and photon detector are operated at atmospheric pressure. Taking optimum parameter values for all components yields a figure of merit $N_0 \approx 110$ and a corresponding number of detected photoelectrons $10 < N_{det}^{Ph} < 18$.

In the wavelength region of interest water vapor and oxygen exhibit strong absorption bands around $\lambda \simeq 160$ nm. In order to minimize the contamination content originating from leaks and from outgasing of detector surfaces the gas in the radiator and detector volumes ($\simeq$ 700 ltr. and 500 ltr., resp.) has to be exchanged and repurified once per hour. For this purpose we have developed a dedicated gas purification and supply system (layout see Fig. 1). It consists basically of two independent parts, a methane and a C_4F_{10} branch. Both parts are connected through a pressure control system, which guarantees a difference $\Delta P < 2hPa$ between the two volumina and protects the fragile CaF_2 window in between from mechanical stress overload.

For the methane branch, an open system is realized using high gas quality (4.5) from the supplier and an additional purification stage with molecular sieve. An open system was not possible for the radiator gas, since C_4F_{10} is rather expensive and available only in standard industrial quality (2.7). Due to the particular properties of C_4F_{10} (boiling point T = -2 C°, vapor pressure p = 2268 hPa (T=20 C°)) we have constructed a closed recirculation system with several purification stages and an additional liquefaction to fill, purify and recover the radiator material.

Liquid C_4F_{10} from a 7 ltr. reservoir (25) is vaporized at room temperature and flushed into the system (30) through purification cartridges filled with several types of molecular sieve. Returning gas from the radiator chamber is pushed by a membrane compressor (3) to a second purification station before it is liquefied in a -25°C heat exchanger at 2000 hPa. At this stage gaseous impurities with lower boiling point are separated and blown away (14 - 16). The liquid is then returned by a gear pump (22) to the higher pressure value of the reservoir. A constant flow (43, 17) of additional N_2 (quality 5.0) through the liquefaction part avoids condensation of radiator gas at unpleasant places and helps to get rid of residual contaminations.

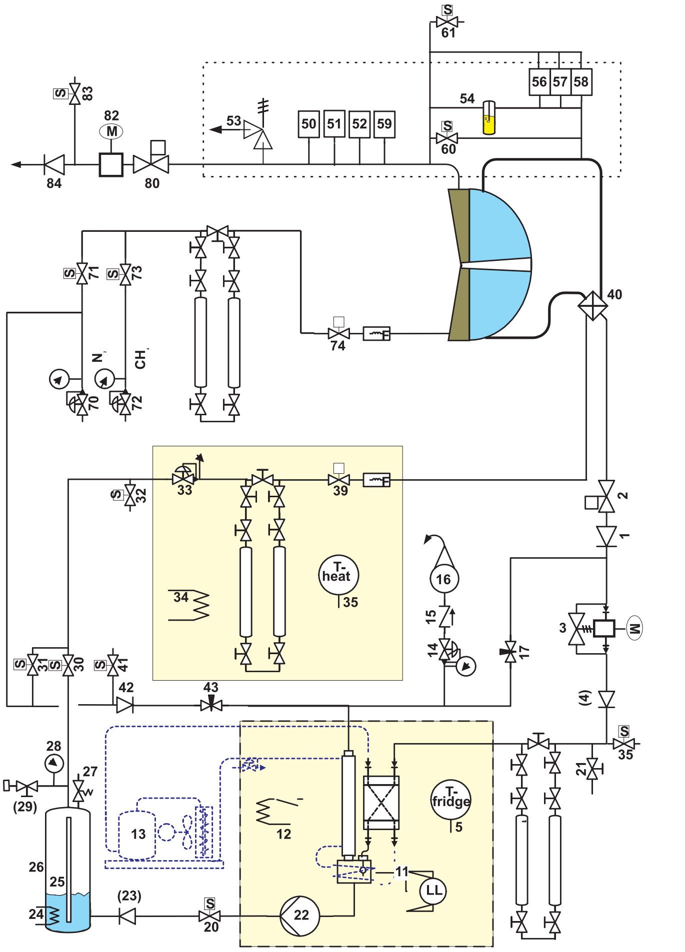

Fig. 1: Schematic layout and piping diagram of the HADES RICH gas system.

All components of the system are controlled by a modular programmable logic unit (Phytec IGAS-Station) using 6 digital and 7 analog input channels and 18 digital and 4 analog output channels [3]. The system allows stable operation with oscillation amplitudes of pressure differences below 0.2 hPa. A three level security system consisting of a software module, an electronic circuitry and a mechanical stage is included to protect the 400μm thin forward wall of the radiator from underpressure and to avoid damage to the CaF_2 window by sudden malfunctions or power failures. The system was successfully operated during ten weeks of commissioning runs with the HADES detector and demonstrated the expected performance.

References

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