SHMS Heavy Gas Cerenkov Detector
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Above ~ 3 GeV/c, hadron species cannot be reliably distinguished by time of flight over the 2.6 m baseline planned for the SHMS detector stack, and so information from Cerenkov detectors becomes increasingly relevant. An aerogel Cerenkov detector with $n = 1.02$ will provide $\pi^{\pm}/K^{\pm}$ discrimination only up to 2.4 GeV/c. Beyond this momentum, a gaseous Cerenkov detector is required. Based on the excellent operational experience at JLab and elsewhere, we propose to construct a threshold Cerenkov using the heavy perfluorocarbon (PFC) gas C_4F_{10} as a radiator. This gas has an index of refraction of 1.00143 at standard temperature and pressure, and so can be used here over a wide range of incident particle momenta.

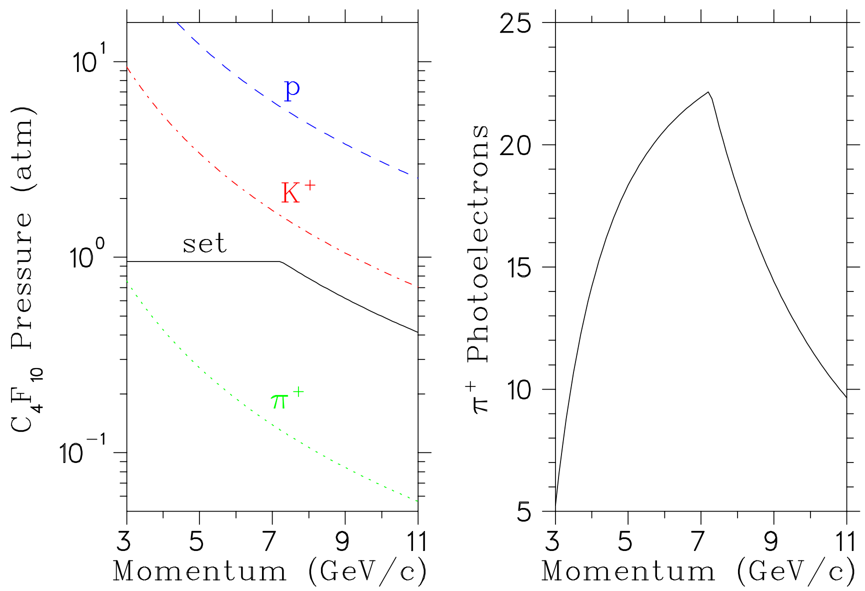

Figure 1: Left: Threshold C_4F_{10} pressure required for Cerenkov light generation from the particles indicated. The solid curve indicates the operating pressure planned for the detector. Right: Number of photoelectrons anticipated for the detector, taking into account the transmittance, reflectivity, and quantum efficiency functions of the detector components.

The solid curve in the left panel of Figure 1 indicates the gas pressure we propose to use at each SHMS central momentum setting. It is expected that the detector gas pressure will be remotely controlled from the counting room as the spectrometer momentum is changed. We assume 0.95 atm pressure from 3.4 GeV/c to 7.0 GeV/c, and sub-atmospheric pressure at higher momenta. The gap between the 'set' and 'K^+' curves above 7 GeV/c takes into account the $\pm 10\%$ momentum bite of the SHMS, and a possible 0.1 atm error in the setting of the gas pressure regulator. We do not anticipate the detector being used for π^+/K^+ separation at momenta below 3.4 GeV/c.

Figure 2 shows a schematic design for the heavy gas Cerenkov. The enclosure is a cylinder of nonmagnetic stainless steel, with the PMTS located outside, viewing through a 1 cm thick UV-grade fused silica window. This allows for better isolation of the pressurized cavity, and allows one to maintain proper PMT-mirror optical alignment should the PMT require servicing. Because of the compact SHMS beam envelope, only two mirrors and photomultipliers are required, so they should be of the highest possible quality. As a reference design, we have selected the Photonis[1] XP4508B 5" photomultiplier tube. This is similar to the PMT

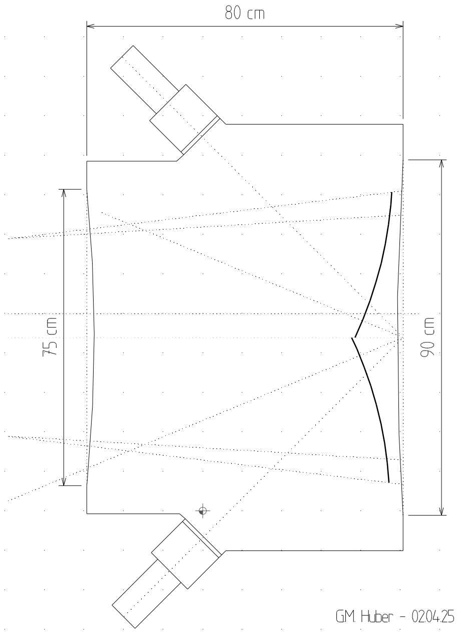

Figure 2: Schematic design for the SHMS heavy gas Cerenkov detector.

currently used in Hall B, except that it has a flat face of fused silica, which allows for flush mating with the quartz window. A custom-design voltage divider with boosted voltage between the photocathode and the first dynode will be used to provide optimum focussing of the photoelectrons, and so minimize losses within the dynode chain. To minimize abberations, the mirrors should be thin glass, which can be structurally reinforced outside of the beam envelope. Protected aluminum mirror coatings with $> 90\%$ reflectivity down to 200 nm are commercially available [2]. We propose to use $0.020''$ titanium for the particle entrance and exit windows, which is the same material used on the G0 spectrometer.

C_4F_{10} is very expensive, and so a recovery system is required. C_4F_{10} has excellent UV transmission characteristics (97%@170 nm) provided it is kept pure. A filter and cold trap may be desirable additions to the gas recovery system, to maintain the required gas purity. Both oxygen and water absorb strongly below 200 nm, and should be kept below 0.1%. Residual nitrogen has an effect on the refractive index, and should be kept constant and below $< 1\%$.

The right panel of Figure 1 indicates the number of photoelectrons expected from π^+ for a 70 cm radiator length. The C_4F_{10} transmission, mirror reflectivity, quartz transmittance, and PMT spectral characteristics, as well as possible optical mis-alignment, were all taken into account. The resulting π^+ detection inefficiency, assuming that an offline cut is placed at < 1.5 p.e. to eliminate knock-on events, is less than 0.1% for all momenta between 3.4 and 11.0 GeV/c.

In conclusion, a heavy gas Cerenkov detector, utilizing a C_4F_{10} radiator with variable pressure between 0.4 and 0.95 atm, appears to be a practical way to obtain reliable π^+/K^+ separation within the SHMS.

References

[1] Photonis Imaging Systems, www.photonis.com.

[2] Lambda/Ten Optics, 7A Stuart Road, Chelmsford, MA 01824.