Design of the PID counter for charmed baryon spectroscopy experiment at J-PARC

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We have proposed a charmed baryon spectroscopy experiment via the (π^-, D^{*-}) reaction at the J-PARC high-momentum beam line. Pion beams of 20 GeV/c are used with a momentum resolution of 0.1%. Charmed baryon states are measured by means of the missing mass spectroscopy with a resolution of10 MeV/c by reconstructing scattered D^{*-} from its decay chain of $D^{*-} \to \bar{D}^0\pi^- \to K^+\pi^-\pi^-$. Because the multi-particle productions including kaons and pions are much larger than the signals, particle identification (PID) is of importance to keep the background level in the charmed baryon spectrum low. In order to identify the D^{*-} decay pions and kaons which have a wide momentum range of $2 - 16$ GeV/c, we plan to use a Ring Imaging Cherenkov (RICH) counter. Aerogel and C_4F_{10} gas whose refractive indices of 1.04 and 1.00137 are used for the radiators, respectively.

PID performance of the designed RICH counter is evaluated by using the GEANT4-based simulation. The yield of Cherenkov photons from the aerogel were measured by using an electron beam of $\sim$ 700 MeV/c at the Research Center for Electron Photon Science (ELPH). The results were used to tune an optical parameter of the aerogel. Photomultiplier tubes (PMTs) with a photon window transparent for ultra-violet light or multi-pixel photon counters (MPPCs) are assumed as photo-sensors placed, where the typical quantum efficiencies of them are taken into account. In the case of MPPC, the performance due to its high dark current is also estimated in the simulation. An opening angle of a Cherenkov light cone (θ) is determined as follows. The direction of the each emitted photon are calculated from center of each radiator and detected position at the photo-detection plane. The distribution of the Cherenkov angle is obtained as the angle of the emitted photon directions along the momentum direction of scattered particle. Then, the Cherenkov angle is obtained as the average of the distribution of the Chernekov angle. The accuracy of the Cherenkov angle is related to the number of detected photons. For satisfying the required angular resolution of 9.6 mrad, the thickness of the radiators for obtaining the enough number of photons is determined to be 6.0 cm and 150 cm, respectively. Figure 1 shows the conceptual design of the RICH counter. The particle identification is performed by using the Cherenkov angle. The estimated PID efficiency and the wrong particle identification ratio were found to be 99% and 1%, respectively. Contribution by particle misidentification is increased to be only 6% of the background level expected in the ideal case of perfect particle identification. It is low enough to keep the high-sensitivity for the charmed baryon spectroscopy. Therefore, the conceptual design of the PID counter has been finished.

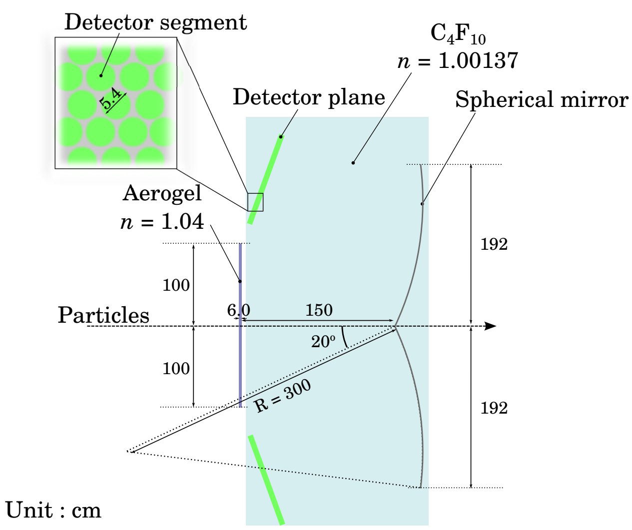

Figure 1: Conceptual design of the PID counter