Measurement of photoelectron yield in a hadron blind detector for the J-PARC E16 experiment

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A hadron blind detector (HBD) has been developed for the J-PARC E16 experiment.[1)] The E16 experiment aims to detect the in-medium modification of a ϕ meson in a nucleus via the $\phi \to e^+e^-$ decay. The HBD identifies the positrons and electrons by converting the emitted Čerenkov photons in CF_4 into photoelectrons with a CsI photocathode. The converted photoelectrons are amplified by a triple gas electron multiplier (GEM)[2)] stack to obtain a signal on readout pads. The CsI photocathode is evaporated on the surface of the top GEM of the stack. We perform the measurement in the momentum region (up to 4 GeV/c) where only positrons and electrons can emit Čerenkov photons in the HBD. Although almost all of the ionization electrons emitted from charged particles are removed by applying reversed drift-field before the triple-GEM section, a huge amount of such charged particles would contaminate the HBD signal. Therefore, the detection yield of the photoelectrons is the most significant value required to discriminate the Čerenkov photons at the trigger level.

The detection yield of the photoelectrons depends on the quantum efficiency of the CsI photocathode and photoelectron collection efficiency. The collection efficiency is defined as the ratio of the number of photoelectrons that are collected and subsequently amplified by the GEMs to the number of photoelectrons produced at the CsI photocathode. The collection efficiency is, therefore, supposed to depend on the electric field at the surface of the CsI photocathode, whose strength is determined by the size and pitch of the GEM holes.

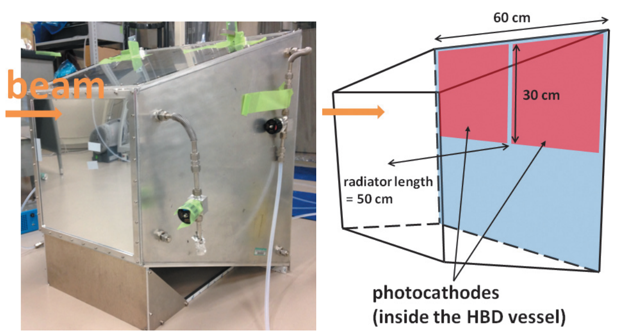

Fig. 1. Photograph (left) and schematic view (right) of the HBD prototype.

To evaluate the pitch dependence of the detection yield of the photoelectrons, we produced a prototype HBD with two types of GEMs: type-A has the hole and pitch sizes of 55 µm and 140 µm, respectively, while type-B has the pitch size of 110 µm with the same hole size. The length of the Čerenkov radiator is 50 cm, and the size of the photocathode is 60 cm × 60 cm, which is divided into four parts with size 30 cm × 30 cm, as shown in Fig. 1. For the prototype, one 30 cm × 30 cm type-A photocathode and one 30 cm × 30 cm type-B photocathode were prepared.

Using the prototype HBD, we performed a beam test with a 1.0 GeV/c positron beam at the Research Center for Electron Photon Science, Tohoku University. Figure 2 shows the obtained charge distribution, where we observed ~7.6 mean photoelectrons with type-A and ~10.7 with type-B.

Because we confirmed that these photocathodes have almost the same quantum efficiency, the difference in the detection yield of the photoelectrons is attributed to the difference in the photoelectron collection efficiency. Based on this result, which fulfills the experimental requirement with type-B GEMs, we have decided to adopt type-B GEMs as the E16 HBD. This is the first result of the HBD made in Japan with large (30 cm × 30 cm) GEMs.

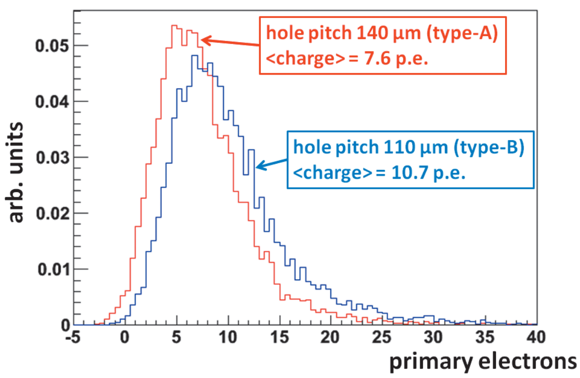

Fig. 2. Charge distribution of two different photocathodes.

References
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2) F. Sauli: Nucl. Instr. and Meth. A **386** (1997) 531

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