Performance evaluation of the electron identification system for the J-PARC E16 experiment

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The J-PARC E16 experiment[1)] is proposed for measuring the spectral modification of vector mesons in nucleus. Here, we detect electron-positron pairs generated in ϕ meson decays, produced in pA reactions. It is crucial for a successful measurement to separate electrons from huge hadronic backgrounds, especially pions, which are a primary component of those.

For the electron identification, we adopt two-stage detectors comprising hadron blind detectors (HBDs) and lead-glass electro-magnetic calorimeters (LGs). The HBD is a gas-type Cherenkov detector with a CF_4 radiator.[2)] Emitted Cherenkov photons are converted into electrons at a CsI photocathode, and these electrons are amplified by a gas-electron multiplier (GEM).[3)] The LG is a calorimeter sensitive to EM showers generated by an incident particle in lead-glass. The high-energy electrons generate large showers compared with pions; therefore, the LG is able to distinguish electrons from pions based on the quantity of Cherenkov photons emitted by the showers.

Both detectors were developed independently, and their performances were evaluated separately.[4,5)] If particle detection by one detector affects another detector, the combined performance of the system possibly becomes worse than expected from the individual performances. For example, an incident pion may produce knock-on electrons in the CF_4 radiator of the HBD, one of which may have sufficient energy to produce EM showers in the LG, which is installed behind the HBD. These effects are expected to be small; however, experimental validation is necessary.

We performed a beam test for a total performance evaluation of the HBD and LG in the commissioning run of the E16 spectrometer at the high-momentum beamline at J-PARC. As shown in Fig. 1, we constructed a novel setup, which covered the forward acceptance of the E16 spectrometer. The responses of the HBD and the LG were examined for pions, identified by the triple coincidence of scintillation counters and two gas Cherenkov detectors (GCs) positioned in front of the HBD. The primary beam intensity was typically 1×10^9 protons/spill suitable for the readout system of this measurement. We adopted one carbon and two copper targets, whose total thickness was 0.2% interaction length. This was the same configuration as the E16 experiment.

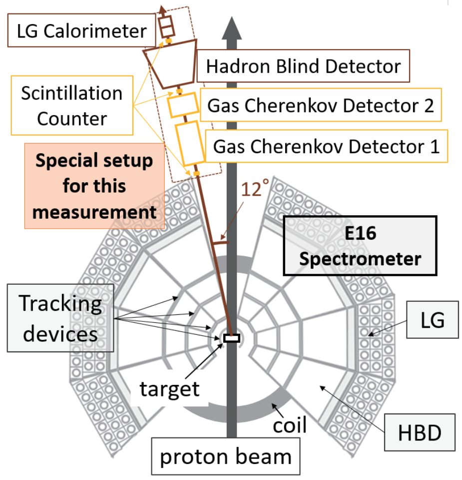

Fig. 1. Experimental setup for evaluating the overall performance of the electron identification system.

The HBD and LG distinguished electrons from pions by applying a threshold to the number of detected photons. We measured the threshold dependence of three quantities: single rejection power of the HBD (SR_{HBD}), that of the LG (SR_{LG}), and total rejection power of the HBD and the LG (TR). Here, the rejection power was defined as the number of total events divided by that of misidentified events. If the correlation between the detectors is negligible, the product of SR_{HBD} and SR_{LG} is expected to be consistent with TR. At the threshold, which will be used in the future experiment, the values of SR_{HBD} and SR_{LG} were determined to be 49 ± 44 and 3.6 ± 0.1, respectively; therefore, the product of these values was 178 ± 16. Compared with the product, the measured value of TR was 174 ± 29. These two values were consistent within their statistical uncertainties; therefore, we concluded that the HBD and LG independently work for pions.

In the coming beamtime in February and June 2021, we plan to study and evaluate the performance minutely with the E16 spectrometer, in terms of rate capability and the response depending on an incident angle and momentum of incoming particles.

References
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