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MCP-PMT quantum efficiency monitoring and operation status of the TOP counter at the Belle II experiment

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The BelleII experiment is a high luminosity electron and positron collider experiment at SuperKEKB in Japan. In this experiment, we aim to measure B-decay precisely and search for effects from New Physics. We started physics data taking with the whole detector system in March 2019. The Time-of-propagation (TOP) counter is a detector for particle identification in the barrel region of the BelleII detector. It consists of a quartz radiator and high timing resolution photodetector, and it can identify K^\pm and π^\pm from the arrival time and hit position of Cherenkov light.

Micro-Channel-Plate Photomultiplier(MCP-PMT) is the photodetector for the TOP counter; it measures photon timing with a resolution of 30 ps; it gives excellent particle identification performance. One of the issues for the TOP counter is the lifetime of the photocathode of MCP-PMTs. The quantum efficiency (QE) will decrease by the accumulated output charge of MCP-PMTs due to the outgassing from MCPs. We have worked to improve the lifetime of the photocathode and installed three types, Conventional type, Atomic Layer Deposition (ALD) type, and Life-extended ALD type, in the TOP counter. The lifetime of the conventional MCP-PMT is 1.1 C/cm^2 on average, and we are planning to replace it with the Life-extended ALD type that has the longest lifetime during the long shutdown that starts in 2022 summer.

We have developed monitoring tools for MCP-PMTs and measured the gain, output charge, and QE of MCP-PMTs during physics data taking. First, we measured the gain, and it changed about 10% during physics data taking due to the characteristics of ALD that applied to MCP for a longer lifetime. To make the output charge of MCP-PMTs smaller, we are operating with relatively low gain. Due to this, threshold efficiency will decrease during physics data taking. We increased the high voltage for MCP-PMTs during physics data taking, considering gain decrease and output charge to keep efficiency. Second, we measured the output charge of MCP-PMTs. (Figure1) These are small enough compared to their lifetime, and we expect that there is almost no QE degradation in all MCP-PMTs. Finally, we measured the QE degradation considering the threshold efficiency drop during the physics data taking. (Figure2) As a result, we found a more considerable QE degradation than expected in 5% of MCP-PMTs. We think this degradation is a problem of the MCP-PMT production, noise from the read-out system, etc.

We will present the MCP-PMT status and the operation status of the TOP counter at the BelleII experiment.

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