

## R&D on the extension of the MCP-PMT lifetime

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A Micro-Channel-Plate PMT (MCP-PMT) has an excellent time resolution. A disadvantage of the MCP-PMT is a short photocathode lifetime, which means a drop of the quantum efficiency (QE) of the photocathode. It is a major issue for applications to detectors at high intensity experiments, such as the Belle II TOP detector. In the first part of the presentation, we talk about the improvement we made so far. Improvement of the lifetime was made by suppressing the residual gas. By applying an atomic layer deposition technique on the MCPs, we improved the lifetime by an order of magnitude; The average lifetime of eight samples was measured to be  $10.4 C/cm^2$ . We succeeded in improving the lifetime by applying the further residual gas reduction processes; The lifetime of eight samples was measured to be longer than  $13.6 C/cm^2$ . These results will be shown in detail in this presentation.

In the second part of the presentation, we talk about further lifetime improvement. We first need to understand the mechanism of the photocathode deterioration. We studied the residual gas by analyzing after-pulses caused by feed-backed ions. We can identify the ion species from the timing of the after-pulse. We studied the correlation between the lifetime and appearance of ion species. To investigate the effect of the other ions and neutral gas, which were blocked by an aluminum layer applied on the MCP, we also measure the lifetime of samples without the aluminum layer. These results will also be presented.

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