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# Behavior of 144ch HAPDs for the Belle II Aerogel RICH in the magnetic field

Various B-meson decay modes include charged kaons and pions in the final state. Therefore it is essential for the Belle II detector to identify them with a high accuracy. To fulfill this in a wide momentum range, the Aerogel Ring Imaging Cherenkov detector (ARICH) counter will be installed as PID device in the endcap region of the Belle II detector.
The target performance of the ARICH counter is to separate kaons from pions at a 4¥$sigma$ significance in momentum range up to about 3.5GeV/c.
ARICH is a proximity focusing RICH detector employing aerogel as a Cherenkov photon radiator and a newly developed 144 channel multi-anode Hybrid Avalanche Photon Detector (HAPD) as a position sensitive detection of Cherenkov photons.

HAPD consists of a vacuum tube with a photo-cathode and four Avalanche Photo-Diode (APD) chips. In an HAPD, the photoelectrons emitted from the photo-cathode are accelerated under a high electric field, which is provided by a high voltage of 7kV applied between the photo-cathode and the APD chip, and hit the APD. The signal is further multiplied by the avalanche in the APD.

Since HAPDs are used in a 1.5T magnetic field in the Belle II detector, we have tested 520 HAPDs from the mass production in the magnetic field using the FANTASQUE magnet at KEK. During the tests, we observed that in most of HAPDs anomalously large pulses (compared to the single photon signal) are generated when operated in a magnetic field.

The main adverse effect of these large pulses is the induction of a short dead time of the readout electronics after each pulse. Because the frequency of the large pulses varies greatly from tube to tube, we decided not to use HAPDs with the fraction of dead time higher than 2%. Initially about 23% of HAPDs (114) were rejected by this criterion.

We performed several studies to understand the mechanism generating large pulses.
Using a simple simulation it was demonstrated that in a magnetic field an electron avalanche can form on the ceramic sidewall of HAPD (so-called surface flashover), possibly resulting in a discharge. In addition, it was found that re-doing getter activation (which improves vacuum quality in the tube) reduces the rate of pulses drastically, resulting in a negligible fractions of dead time for all initially problematic samples. While this clearly shows that large pulses are related to the vacuum quality in the tube, finding the mechanism behind is challenged by an observation that the frequency of large pulses also strongly, and in a puzzling way, depends on the APD bias voltage.

In this presentation, we show the details of the anomalous behavior of HAPDs in the magnetic field and discuss the studies to cope with it.

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