

Proximity focusing RICH with TOF capabilities

Peter Krizan for the Belle Aerogel RICH Group ¹

Faculty of Mathematics and Physics, University of Ljubljana, and J. Stefan Institute,
Ljubljana, Slovenia

E-mail: `peter.krizan@ijs.si`

Abstract. A proximity focusing RICH with aerogel radiator has been studied to extend the hadron identification capabilities in the forward region of the Belle spectrometer. Such a proximity focusing RICH counter is also a very fast detector if a micro-channel plate (MCP) PMT is used as the photon detector. With its excellent timing properties, the same device could also serve as a time-of-flight counter and thus supplement other identification methods. A prototype of this novel device using BURLE 85011 64-anode, microchannel plate PMT, was tested on the bench and in the test beam at KEK. A good separation of pions and protons was observed in the test beam data with a time-of-flight resolution of about 35 ps (rms) for Cherenkov photons produced in the PMT window.

1. Introduction

A proximity focusing RICH with aerogel radiator (Fig. 1) has been studied to extend the hadron identification capabilities in the forward region of the Belle spectrometer [1]. To further improve its performance, a novel technique was developed where multiple aerogel layers of different refractive indices are combined in such a way that the Cherenkov ring images from individual layers overlap on the photon detector plane. In this innovative approach, the uncertainty in the Cherenkov angle measurement from the radiator thickness is greatly reduced [2, 3].

Such a proximity focusing RICH counter is also a very fast detector, in particular if a micro-channel plate (MCP) PMT is used as the photon detector. With its excellent timing properties, the same device could also serve as a time-of-flight counter and thus supplement other identification methods. Cherenkov photons emitted in the radiator medium as well as in the entrance window of the PMT can be used for the time-of-flight measurement (Fig. 1). This allows to positively identify also particles with momenta below the Cherenkov threshold in the aerogel radiator (≈ 1.5 GeV/ c for kaons and ≈ 3 GeV/ c for protons). Consequently, a good separation of kaons and protons would be possible in this region as well.

While we have already discussed the performance of the BURLE 85011 MCP PMT [4], a multichannel device with 8x8 channels and 6 mm \times 6 mm large pads, as the detector of Cherenkov photons in a RICH counter [5], the present paper describes measurements and results obtained with a modified configuration in which we have registered both the hit position and its time in the same π^2 beam at KEK.

¹ A collaboration of: Chiba University, Toho University (Funabashi), KEK (Tsukuba), J. Stefan Institute (Ljubljana), University of Ljubljana, University of Maribor, Nagoya University, Tokyo University of Science (Noda), and Tokyo Metropolitan University

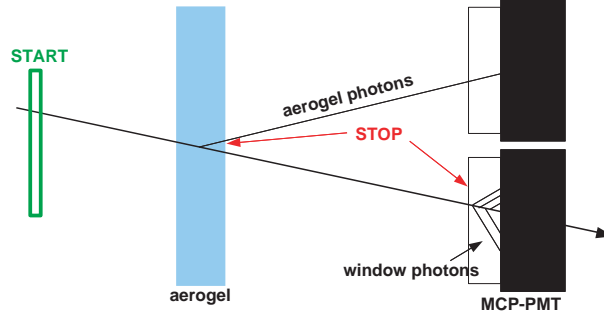


Figure 1. Schematic view of a combined RICH and TOF counter.

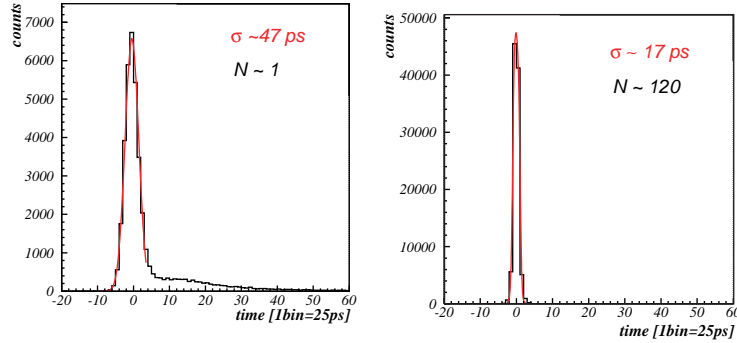


Figure 2. Single photon (left) and multiple photon (right) TDC distributions obtained by the laser pulse illumination.

2. The bench test

Timing properties of BURLE 85011 MCP PMT were first measured on the bench. The PMT was mounted in the dark box and illuminated by short light pulses from a picosecond laser (PLP-02-SLDH-041) with the repetition rate of 1 kHz. The light was guided from the laser into the box by an optical fiber; its intensity was controlled by filters between the end of the fiber and PMT. The signal from the PMT was first amplified and then split by a resistor network into two branches; one was fed to the charge sensitive ADC while the other was discriminated and used as a stop signal for a CAMAC TDC module. As a start signal for the TDC, the trigger signal from the laser was used.

The TDC distributions, corrected with ADC values for the time-walk, are shown in Fig. 2 for single and multiple photon signals. The time resolution for the prompt peak of the single photon distribution is 47 ps, while for pulses with a large number of photons the resolution is better than 20 ps. Note that the expected number of Cherenkov photons emitted by a minimum ionizing particle in the PMT window is 12, such that from the measured dependence of time resolution as a function of the pulse intensity we deduce that the expected time resolution is 30 ps.

3. The beam test

In the beam test set-up, similar to the layout of Fig. 1, charged particle track parameters were measured by two multi-wire proportional chambers [5]. The hits on the photon detector provided the stop for the time-of-flight measurement, and the start was provided by another MCP PMT (Hamamatsu R3890) 65 cm upstream. The distributions of hits, depending on their time of flight for Cherenkov photons from aerogel, is plotted in Fig. 3a. Fitting this distribution with

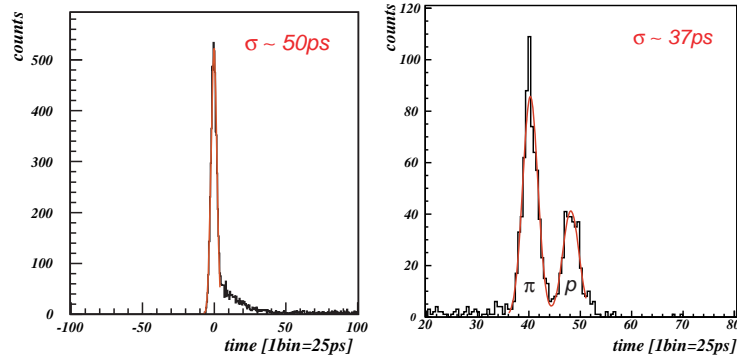


Figure 3. The distribution of the time of flight as measured by single Cherenkov photons from the aerogel radiator (left) and by Cherenkov photons from the PMT window, shown for 2 GeV/c pions and protons (right).

a Gaussian function yields a standard deviation of about 50 ps. For 10 detected hits per track this would correspond to a time-of-flight resolution of 20 ps.

An excellent resolution is also found from the distribution over time of flight as determined by the Cherenkov photons from the PMT window. As can be seen in Fig. 3b, the standard deviation of the distribution for pions is 37 ps. We can also see that pions are clearly separated from protons even in this very compact set-up with a very short flight path. In the Belle spectrometer, where the typical flight path is about 2 m, the measured performance would correspond to a 6σ separation between pions and kaons at 2 GeV/c, and a 3.5σ separation between protons and kaons at 4 GeV/c.

4. Conclusion

In the present study we have investigated time of flight capabilities of a proximity focusing RICH with aerogel radiator and a fast micro-channel plate PMT photon detector. Such a device could also serve as a time-of-flight counter and thus supplement other identification methods, in particular for low momentum tracks. A prototype of this novel device using BURLE 85011 64-anode, microchannel plate PMT, was tested on the bench and in the test beam at KEK. Cherenkov photons emitted in the radiator medium (aerogel) as well as in the entrance window of the PMT were used for the time-of-flight measurement. Resolutions of ≈ 50 ps for single photons from the aerogel radiator and ≈ 35 ps for multiple photon pulses from the PMT window were measured. A good separation of pions and protons was observed in the test beam data.

References

- [1] T. Matsumoto et al., Nucl. Instr. and Meth. A 518 (2004) 582.
- [2] T. Iijima, S. Korpar et al., Nucl. Instr. and Meth. A 548 (2005) 383.
- [3] P. Krizán, S. Korpar, T. Iijima, Nucl. Instr. and Meth. A 565 (2006) 457.
- [4] BURLE 85011 data sheet: <http://www.burle.com/cgi-bin/byteserver.pl/pdf/85011-501.pdf>
- [5] P. Krizán et al., Nucl. Instr. and Meth. A 567 (2006) 124.