Beam-test result of Tile-TOF counter

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We have been studying on a very-high-resolution time-of-flight (TOF) counter. The point of this TOF counter is to use Cerenkov lights radiated in a crystal block. The design of the test counter is shown in Figure 1. Charged particles go through the quartz block and the photo-detector. For a practical use, this counter will set as tiles. So, we call it "Tile-TOF counter". To improve the time resolution, we implement the following feature: (1) To reduce the time spread of the internal reflecting photons, a small size radiator is used. (2) Instead of scintillation light, Cerenkov light is used because the emission time is negligibly small. (3) The high-resolution photo-tube whose transit-time-spread (TTS) is $\sigma_{\rm TTS} = 50 \sim 100$ ps for a single photo-electron is used. Such a photo-tube gives good performance, even though the number of Cerenkov photons are much smaller ($100 \sim 200$ photo-electrons) compared to scintillation lights. In a simulation study, the expected time resolution is less than 10 ps.

We carried out a beam-test at the π2-line of the KEK-PS at December 2002. We tested with two type of photo-multiplier-tubes, L16-PMT(HPK R5900U-00-L16) and MCP-PMT (HPK R3809U-50-25X). The purpose of the beam-test is to confirm the performance. To evaluate the time resolution, we put two counters of the same along the beam direction and measure residual of the detected time between the up-stream and the down-stream counters.

The L16-PMT is the metal-packaged line-focus-type PMT with 16 channel anode. The TTS for each channel is $\sigma_{\rm TTS} \sim 75$ ps for a single photo-electron. One advantage of the L16 is that the required time resolution for each channel is not so severe because we can use the 16 time measurements. For the L16-PMT, the number of detected photo-electrons is ~ 120 in total and the obtained time resolution is ~ 30 ps for each channel. By averaging over the 16 channels, the total time resolution of $\sigma_{\rm L16} = 12.1$ ps is obtained.

The MCP-PMT is the single-anode PMT equipped with two micro-channel-plates, whose TTS is $\sigma_{\rm TTS} \sim 50$ ps for a single photo-electron. For the MCP-PMT, the number of detected photo-electrons is $150 \sim 200$ and the obtained resolution is $\sigma_{\rm MCP} = 10.6$ ps, as shown in Figure 2.

In this beam-test, we have obtained 10.6 ps resolution and confirmed that our idea is correct in principle. For both types, we obtain the number of detected photo-electrons as we expected. However, the time resolution is a little worse than expectation. The time fluctuation in the readout electronics, which is $\sigma_{\rm elec} \sim 9$ ps, is identified as the reason. Therefore, improvement of the readout system is the next issue.

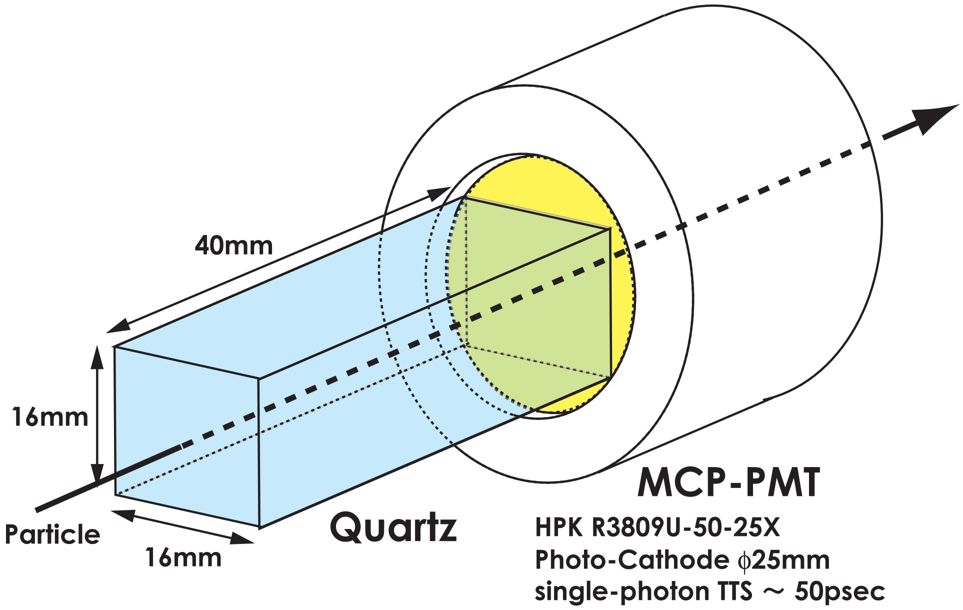

Figure 1: Tile-TOF counter with MCP photo-tube.

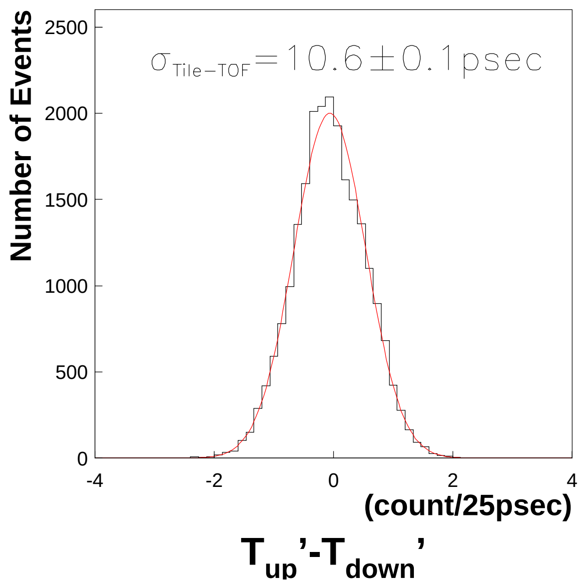

Figure 2: TDC residual distribution between the up-stream and down-stream counters for MCP type.