Beam-test result of Tile-TOF counter (T547)

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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 Cherenkov lights radiated in a crystal block. 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, Cherenkov light is used because the emission time is negligibly small. (3) The high-resolution photo-tube whose transit-time-spread (TTS) is $\sigma_{\rm TTS} = 30 \sim 50$ ps for a single photo-electron is used. Such a photo-tube gives good performance, even though the number of Cherenkov photons are much smaller ($100 \sim 200$ photo-electrons) compared to scintillation lights.

We carried out a beam-test at the π2-line of the KEK-PS at February 2004. The purpose of the beam-test is to confirm the performance compared to the expectation from the detector simulation. We measured the number of detected photons and the time resolution depending on the incident position and angle.

The photograph of test counter is shown in Figure 1(left). The test counter consists of the quartz radiator and Micro-Channel-Plate (MCP) PMT. The size of quartz bar is $12.6 \times 12.6 \times 300$ mm. Charged particles go across the quartz bar.

The performance of MCP-PMT is evaluated by the single photon radiation using the laser pulser. The time resolution is about 50 ps, the quantum efficiency is about $20\% \times 0.4$ and the collection efficiency is about 50%. The performance have been monitored by laser periodically during the beam-test.

The setup is shown in Figure 1(right). The test counters are located between the tracking chambers. The event is triggered by the outer scintillation counters, whose size is 3×3 cm. The gas Cherenkov counter is set at up-stream to select the proton and pion. In order to get a large number of events, the +3 GeV/c beam is used.

To evaluate the time resolution, we put two same counters along the beam direction and measured the residual of detected time between the up-stream and down-stream counters. Figure 2 shows the result of the number of detected photons and the time resolution depending on the incident angle. The incident position is the middle of quartz bar, 150 mm distance from MCP-PMT. The simulation result is also plotted in the figure. We confirm that the simulation can express the behavior of the measured result at some level. The difference between the data and simulation is found out to be due to the degradation of the PMT gain because of the high hit rate at the experiment.

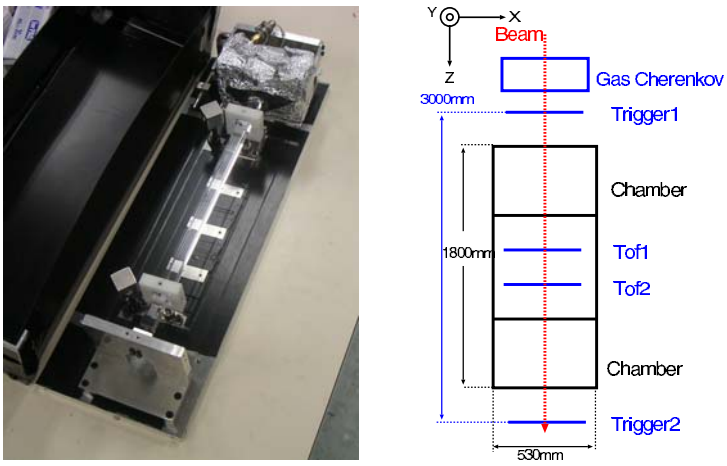

Figure 1: Tile-TOF counter (left) and setup along the beam line (right). The size of quartz radiator is 12.6 × 12.6 × 300 mm. MCP-PMT is placed at the end of quartz bar.

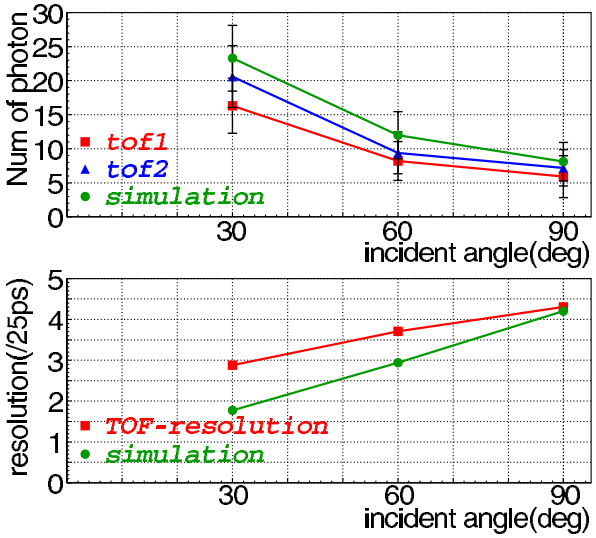

Figure 2: Number of detected photons (top) and time resolution (bottom) as a function of incident angle, compared to the expectation of the detector simulation. Red and blue lines show the data and green lines show the simulation result.