Report of Beam test results for TOP counter

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We have been carrying out R&Ds on a newly invented particle identification detector named as a Time-Of-Propagation counter; a kind of ring-imaging Cherenkov counter similar to Babar/DIRC, in the aim to upgrade the Belle spectrometer. It comprises a long crystal-bar functioned as a Cherenkov radiator and light propagation material, and a butterfly-shaped mirror attached at a bar-end which focuses lights onto the photon detectors. The TOP counter detects Cherenkov photons in terms of their horizontal emission-angle Φ and time of propagation TOP by multi-anode single-photon sensitive photo-multiplier tubes with anode-width of 1mm and transit-time spread of σ_{TTS}=70-80ps.

We carried out the beam-test experiment at π2-line of KEK-PS for 20 shift by the end of November 2001. In this experiment, we have focused on the two following issues: (1) The study of crystal-bar's polishing accuracy on the TOP resolution, and (2) the examination of a further simplified TOP counter.

TOP resolution

The achieved TOP resolution are plotted by open symbols in Figure.2 as a function of the path-length(L_{path}) along the propagation trajectory. In this measurement, the expected TOP resolution of $\sigma_{TOP} \leq$ 100ps is attained at $L <$ 1m, while it is two to three times worse than the anticipated one at $L >$ 2m. Detail examination of the quartz-bar, insufficient polishing accuracy that fails to meet our demand. A newly qualified quartz-bar is prepared and replaced with the old one. The closed symbols in Figure 3 are the TOP resolution obtained using the new quartz-bar. Improvement of the polishing accuracy certainly results in the expected TOP resolution, which has improved from $\sigma_{TOP} \sim$ 300ps to 150ps at L=2m. This is equivalent to the single-photon Cherenkov-angle resolution of $\sigma_{\theta_c} = 10.6$mrad.

Further simplified TOP counter

TOP counter is very compact compared to DIRC. We propose a further simplified version of TOP-counter, which comprises only a crystal-bar and photon detectors. It does not need the butterfly-shaped focusing mirror. When the mirror is simply removed, the TOP principle does not function well since Φ vs TOP relation cannot be uniquely extracted among many possible solutions. But we have noticed that by enlarging the width of the crystal-bar will solve this relation. We have beam-tested the prototype new counter with a bar size of $1,000\text{mm}^L \times 200\text{mm}^W \times 20\text{mm}^H$. The measured Φ vs. TOP relation and TOP resolution were obtained as expected.

It can be concluded that from these Beam-test results we have comfirmed the basic performance of the TOP-counter. And, developing a photon collection method over an expected sufficient amount is the next R&D issue waiting for our attention.

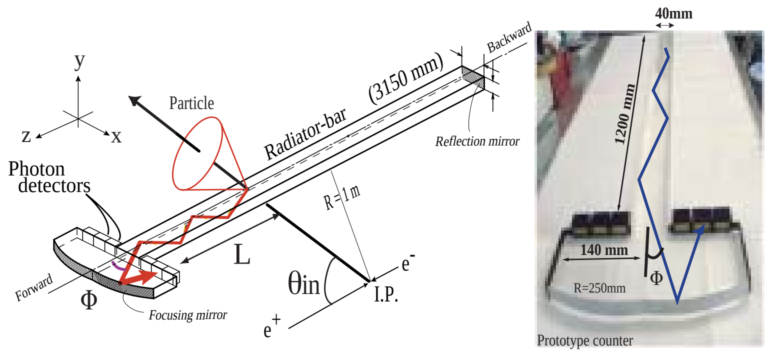

図 1: A schematic drawing of the TOP-counter(left) and the photograph of a prototype counter (right). The prototype has a bar of $1,200\text{mm}^L \times 40\text{mm}^W \times 20\text{mm}^H$ size, a focusing-mirror with a curvature of $R = 250$mm, and 6PMTs(R5900-U-L16) as photo-detectors. Backward going photons are reflected by a mirror attached at the other bar-end and detected by the PMTs with later coming TOP than the forward going photons.

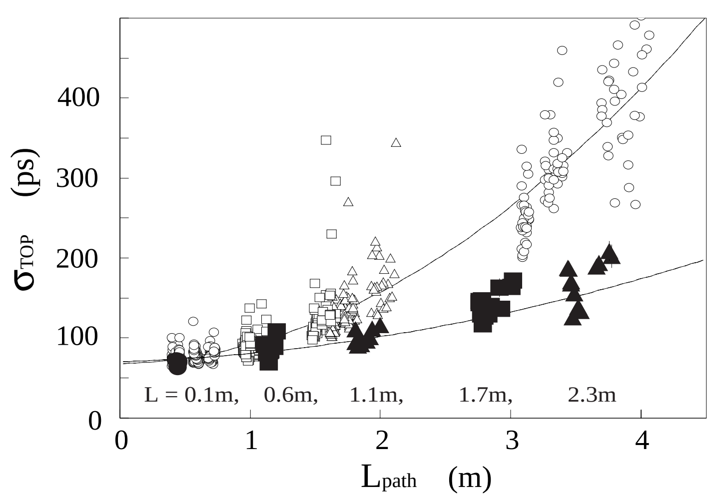

図 2: TOP resolution attained by the beam-tests for TOP-counter with the butterfly-shaped focusing-mirror. Open symbols are obtained by the insufficiently polished quartz-bar, while the closed ones by the newly prepared bar. Horizontal axis is the path-length along to the propagation trajectory.