Test of a Time-Of-Propagation (TOP) Counter for the Belle II and LEPS Experiments

Spokesperson: Toru Iijima
Professor, Kobayashi-Maskawa Institute, Nagoya University
Email: iijima@hepl.phys.nagoya-u.ac.jp

Collaborators: Kenji Inami, Associate Professor, Nagoya Univ.
Kazuhito Suzuki, Assistant Professor, Nagoya Univ.
Yasuyuki Horii, Assistant Professor, Nagoya Univ.
Kodai Matsuoka, Researcher, Nagoya Univ.
Yoshinobu Arita, Graduate student (D1), Nagoya Univ.
Naoto Kiribe, Graduate student (M1), Nagoya Univ.
Shigeki Hirose, Graduate student (M1), Nagoya Univ.

Takashi Nakano, Professor, RCNP, Osaka Univ.
Shuhei Ajimura, Associate Professor, RCNP, Osaka Univ.
Yorihito Sugaya, Assistant Professor, RCNP, Osaka Univ.
Masayuki Niiyama, Assistant Professor, Kyoto Univ.

Requested beam running time: 60 shifts (3 weeks) in total

Requirements for the beam condition, equipments etc.:

- Photon beam of 2.4 GeV at the tagging rate of >100KHz
- 1.5mm thick Pb converter to produce e^+e^-
- LEPS forward spectrometer to analyze the e^+e^- tracks
- Room to assemble the TOP counter prototype
- A stand for the TOP counter prototype
- 19” racks for readout electronics
- Wired LAN, Wireless LAN

Summary of Proposal

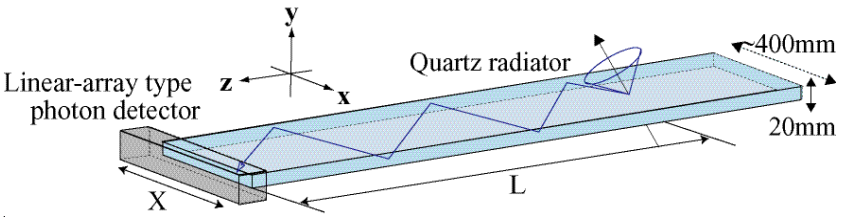
We would like to carry out tests of a Time-Of-Propagation (TOP) counter using abundantly produced electron-positrons by the LEPS photon beam. The TOP counter is a newly developed particle identification detector, which utilizes total internal reflection of Cherenkov photons produced in an accurately polished quartz bar. By measuring the time of arrivals for each Cherenkov photon with precision better than 50ps, good hadron identification can be made with relatively compact design. In this test experiment, we will bring a Belle II prototype detector in the LEPS spectrometer, and aim at proofing its principle; measuring number of photoelectrons and resolution etc. with various incident conditions. The experiment will be performed by physicists from Belle II and LEPS. Outputs of this test experiment would be of benefit not only for Belle II, but also for LEPS and LEPS2 experiments. We would like to request 60 shifts (about 3 weeks in total) of running time, preferably divided into two or three periods, to allow step-by-step improvement of the detector system.

Detailed description of proposed research

Objectives and impacts of the experiment

We propose to carry out the beam test of TOP counter and obtain the data to evaluate the performance. TOP counter have been studied to utilize as particle identification (PID) detector at the Belle-II experiment. It is also applicable to other experiment as a high-precision velocity measurement system. Therefore, outputs of this test experiment would be of benefit not only for Belle-II, but also for LEPS and LEPS2 experiments.

To extend the physics reach at the Belle-II experiment, that plans to start from 2015, we would like to improve the K/pi separation capability of the spectrometer by upgrading the particle identification (PID) system. In the barrel region of the spectrometer, the present time-of-flight and aerogel Cherenkov counters are replaced with a Time-Of-Propagation (TOP) counter, whose conceptual overview is shown in Figure.



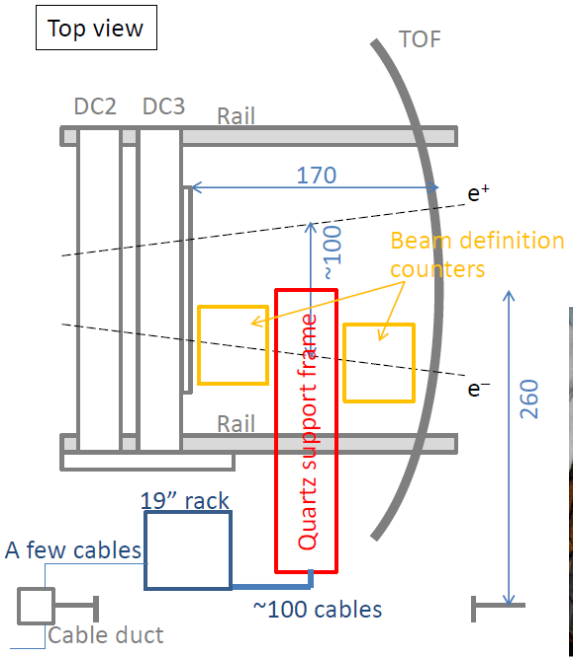
In this counter the time of propagation of the Cherenkov photons internally reflected inside a quartz radiator is measured. The Cherenkov image is reconstructed from the 3-dimensional information provided by two coordinates (x, y) and precise timing, which is determined by micro-channel plate (MCP) PMTs at the end surfaces of the quartz bar.

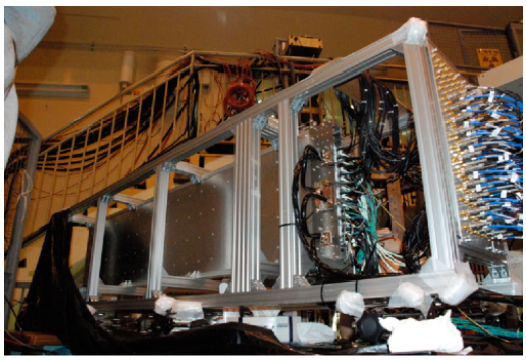
In this proposed beam test, we want to demonstrate the performance of TOP counter prototype. We want to confirm that the ring image, number of detected Cherenkov photons and the time resolution for the ring image reflected by a focusing mirror is consistent with the prediction by the simulation program. In the previous test, we found a small amount of background photons in the time distribution under signal peaks. We will take data for several incident conditions to check the behavior of background photons.

Experimental method and apparatus

We propose to use LEPS beam line and perform the test with LEPS detectors to obtain

the information of trigger, tracking and timing. The proposed setup is shown in Figure.





We have produced a prototype TOP counter (see picture) to check the demonstrated overall timing performance. The prototype consists of 1830 x 400 x 20 mm^3 quartz radiator with a spherical focusing mirror (5m radius) and the 14 MCP-PMT array. The signal from MCP-PMT will be read out by compact CFD electronics and TDC.

We will measure the Cherenkov photons generated by the incident electrons. The momentum and position is measured by LEPS detector.

Estimation of the beam time requested

We would like to request 60 shifts (about 3 weeks in total) of running time, preferably divided into two or three periods, to allow step-by-step improvement of the detector system.

Considering the beam intensity obtained by the previous experiment, we can obtain enough data for a few hours running for a limited trigger region (~1cm). We want to take data sets for several incident conditions, by changing the angle and position, to check the performance for whole coverage region. We want to take for 10 conditions. Including the setup change, we need about 4 hours for each condition. Then, we also want to take data with background hits or multiple particle hits with e^+ and e^-.

Therefore, we request the run time of a week including setup and detector tuning, for one detector configuration.

Experimental schedule

As a first step to operate the TOP counter with LEPS detector, we want to have a beam time in April 2012 (about 20 shifts). Then in June and July, whenever some gaps between LEPS physics runs become available, we would like to have beam time again to test the detector with new MCP-PMTs and readout electronics.

Equipment provided by the experimental group

We provide the following items for the beam test;
- TOP counter
- Scintillation counters for beam definition and local trigger
- Readout electronics and cables
- DAQ, HV system
- Support frame