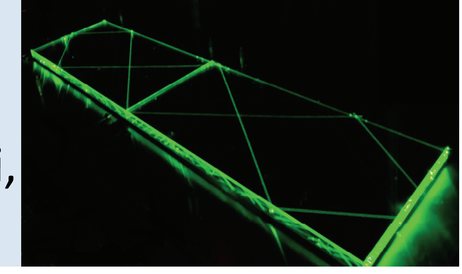
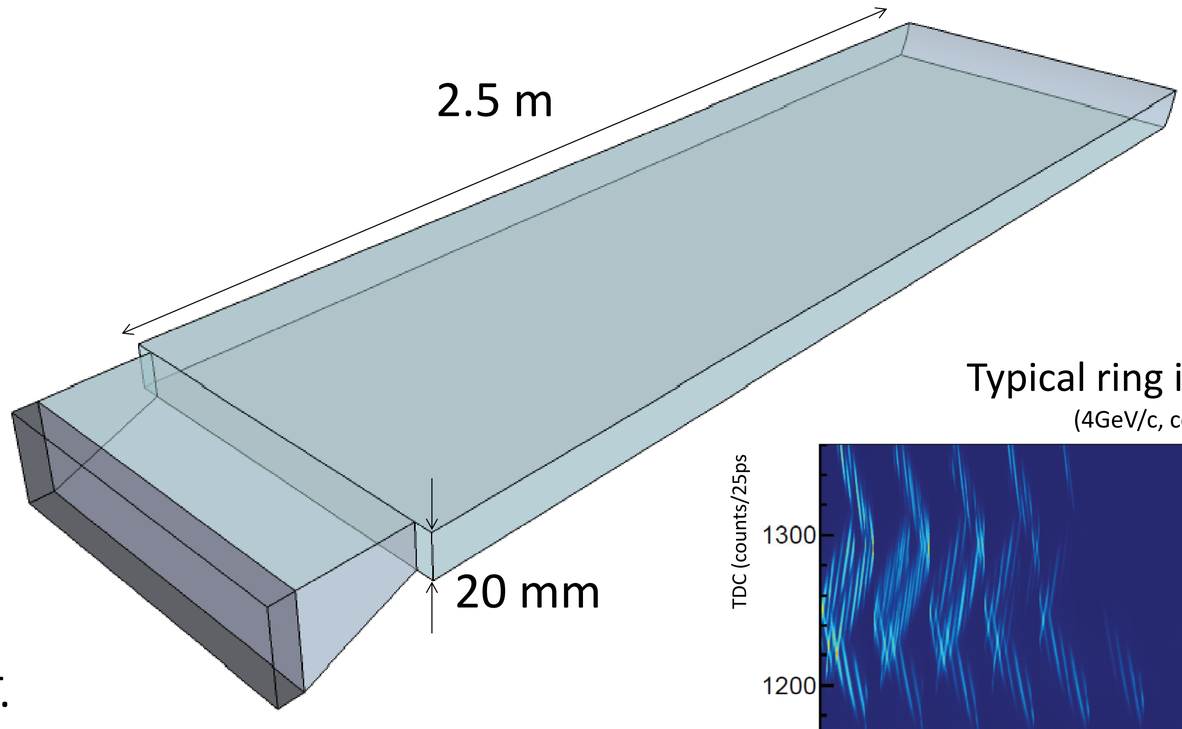
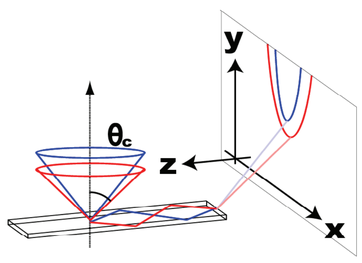
TOP counter for Belle-II experiment

Belle-II B-PID group (Nagoya university, University of Hawaii, University of Cincinnati, Pacific Northwest National Laboratory, Jozef Stefan Institute and KEK)



Ring imaging Cherenkov detector is to be used for K/π particle identification in Belle-II by measuring the time-of-flight and time-of-propagation of Cherenkov photons.
The current design utilizes a focusing mirror and an image expansion block, in order to correct for chromaticity and increase the number of effective detected photons.

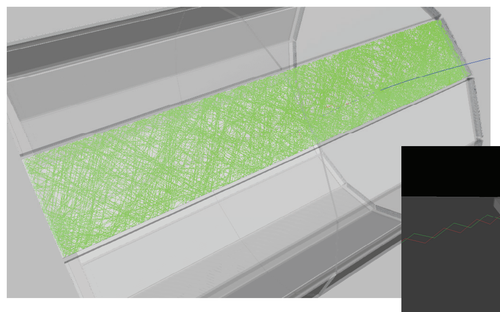


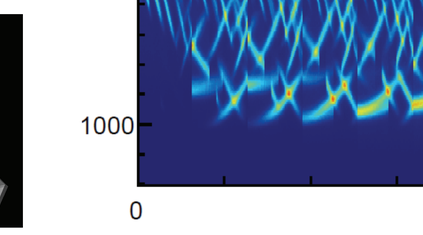


$$cos\theta_c = \frac{1}{n\beta}$$

(θc : Cherenkov angle)

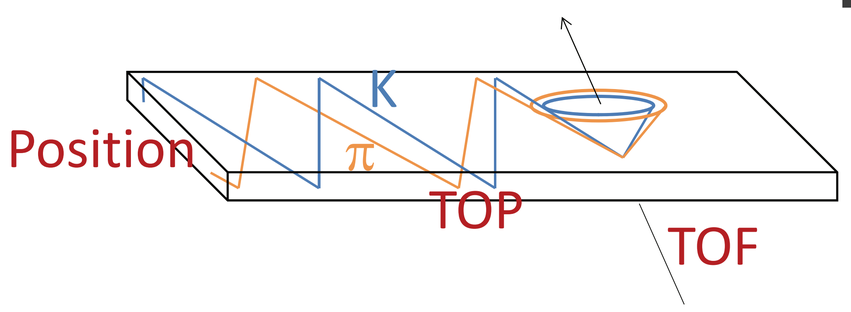
Cherenkov photons are emitted in the quartz bar, and propagate to the MCP-PMT. The Cherenkov ring image is reconstructed not only by x-y position but also with time information. TOP counter also uses the time-of-flight. Therefore, the TOP counter requires a good time resolution less than an order of 100ps for single photon detection.





Typical ring image
(4GeV/c, cosθ=0.5)

TOF, TOP and position at the PMTs are different between K and π of the same momentum.

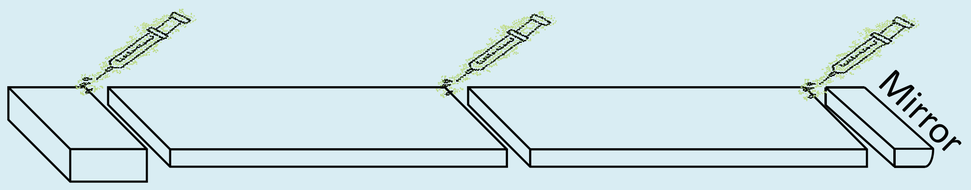


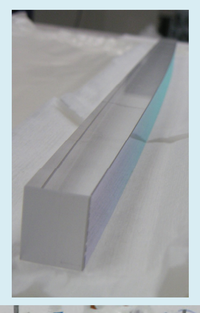
Target PID performance

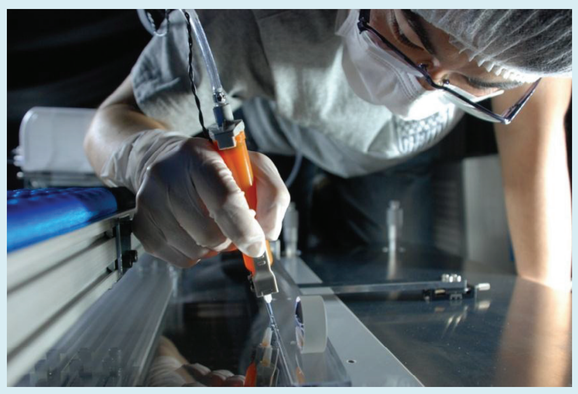
π/K separation	Belle (ACC+TOF)	New PID (TOP counter)
Efficiency	90%	97%
Fake rate	11%	2%

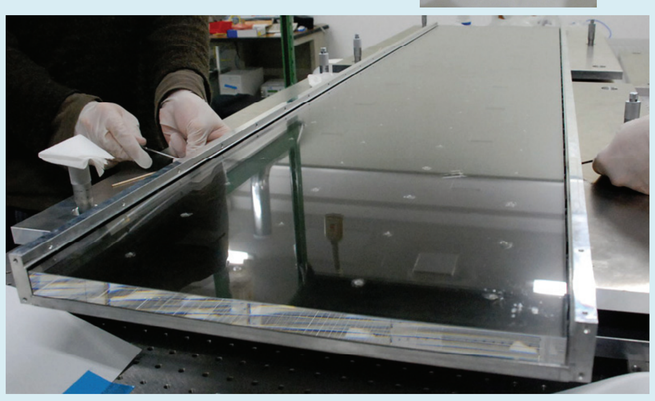
Quartz bar

The Cherenkov radiator is made of high quality quartz with a polishing accuracy of 2λ flatness and 5Å surface roughness. Two quartz bars, a focusing mirror and an image expansion block are glued with an angle accuracy of ~2mrad.



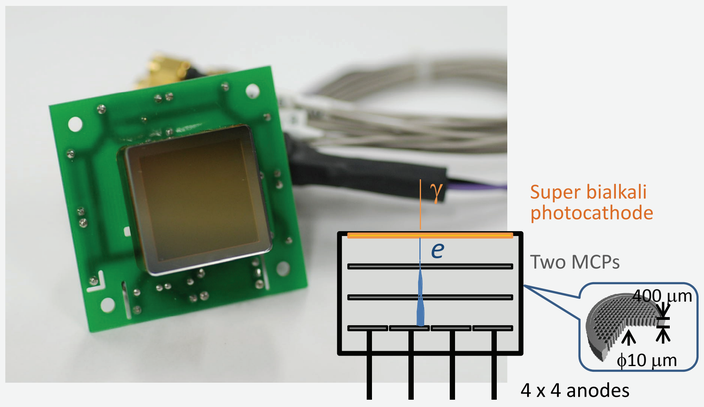


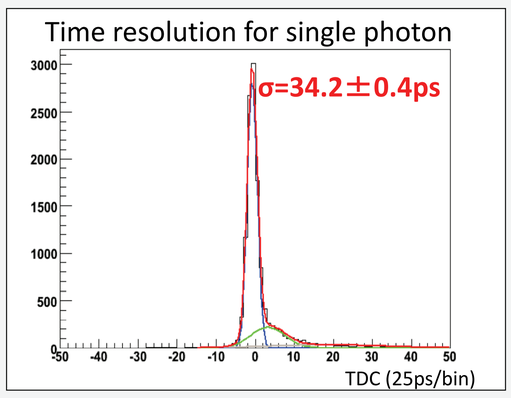


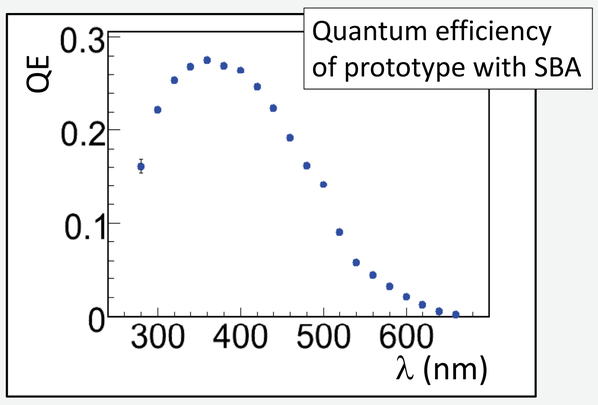


MCP (Micro-Channel-Plate) PMT

MCP-PMTs work for single photon detection even under a 1.5T magnetic field, with a TTS of <40ps. Super bialkali (SBA) photocathodes have been recently adopted to increase the number of detected photons.

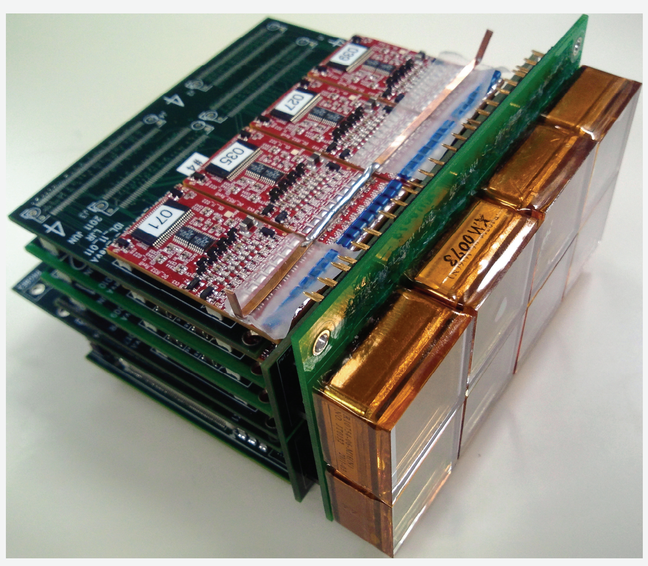


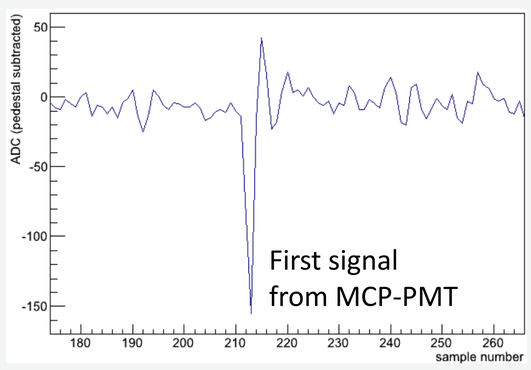


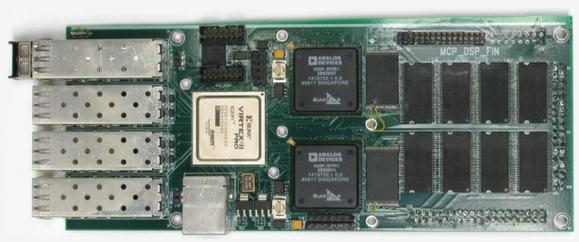


Waveform sampling ASIC

The PMT signal is read out by a newly developed ASIC, “BLAB”, with low-power GHz analog bandwidth, high-performance waveform recording, to achieve pico-second level timing measurement. A prototype has been developed and performs as expected.

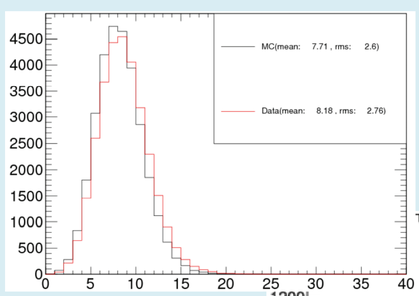






Reconstruction

A prototype counter has been constructed and the performance measured. The ring images are compared with the MC simulation outputs. The number of detected photons and the time resolution agree well with the expectation.
Prototype reconstruction software reproduces the complicated ring image to calculate PDFs with reasonable speed.



Number of detected photons over 8 MCP-PMTs

TDC distribution for the center of MCP-PMT