New PID detector - TOP counter - for Belle II experiment

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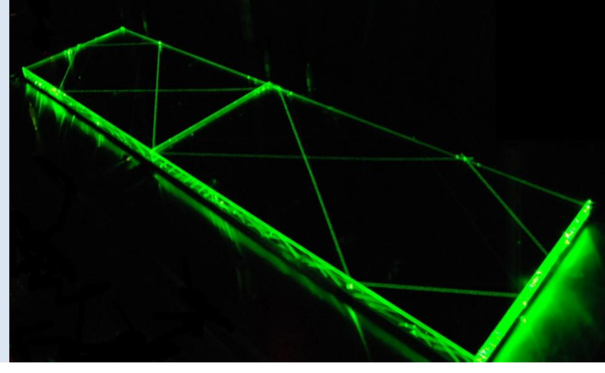
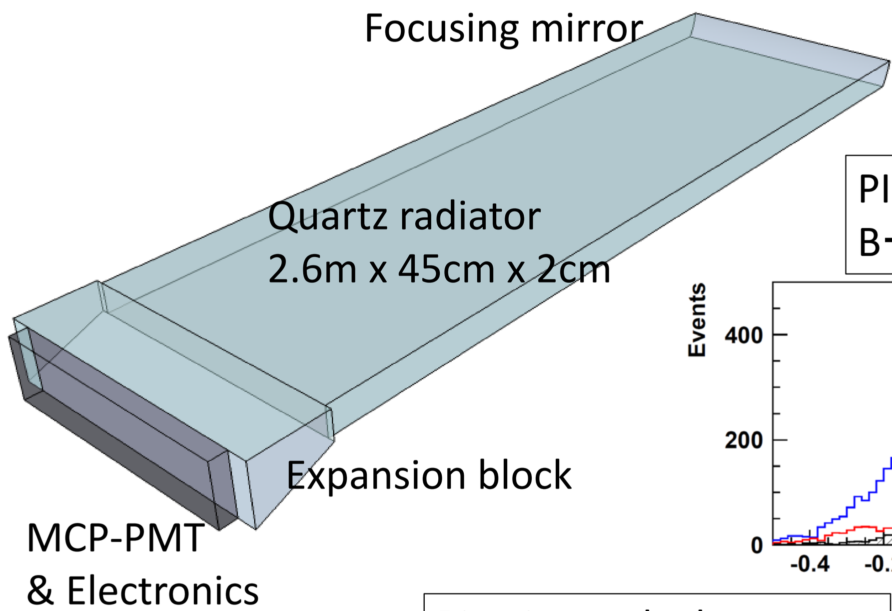
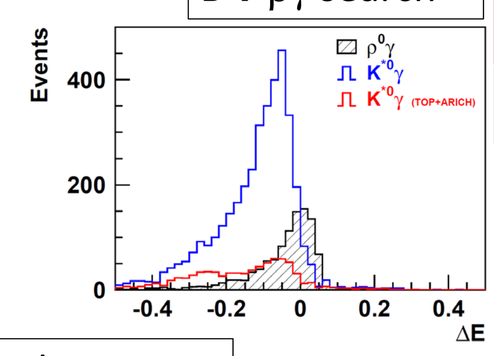
for Belle-II PID group



Abstract: We have been developing a Cherenkov ring-imaging counter as a barrel particle identification device of Belle II detector for super B-factory at KEK. Recently, we have started the module production with 2.7m long quartz radiator, honeycomb panel box, MCP-PMTs and the fast electronics. In the performance tests, we evaluate the number of detected photons, time resolution and the related performance for each component. In this presentation, we show the overview of TOP counter, test results, module production status and prospects.

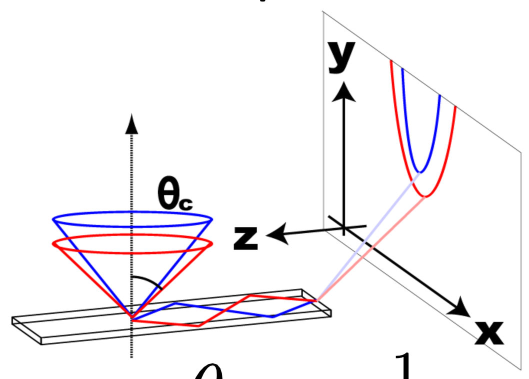
New ring imaging Cherenkov detector, named "TOP counter" will be used for K/π particle identification in Belle-II barrel region, which measures the time-of-flight and time-of-propagation of internal reflected photons. TOP counter consists of the quartz radiators, a focusing mirror and an image expansion block, in order to correct for chromaticity and increase the number of effective detected photons.





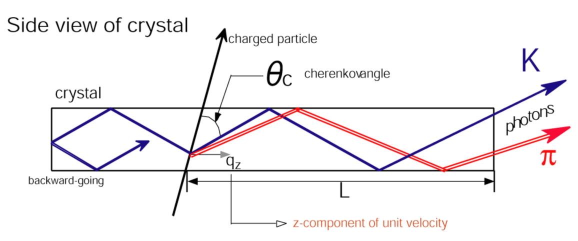
Target PID performance

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



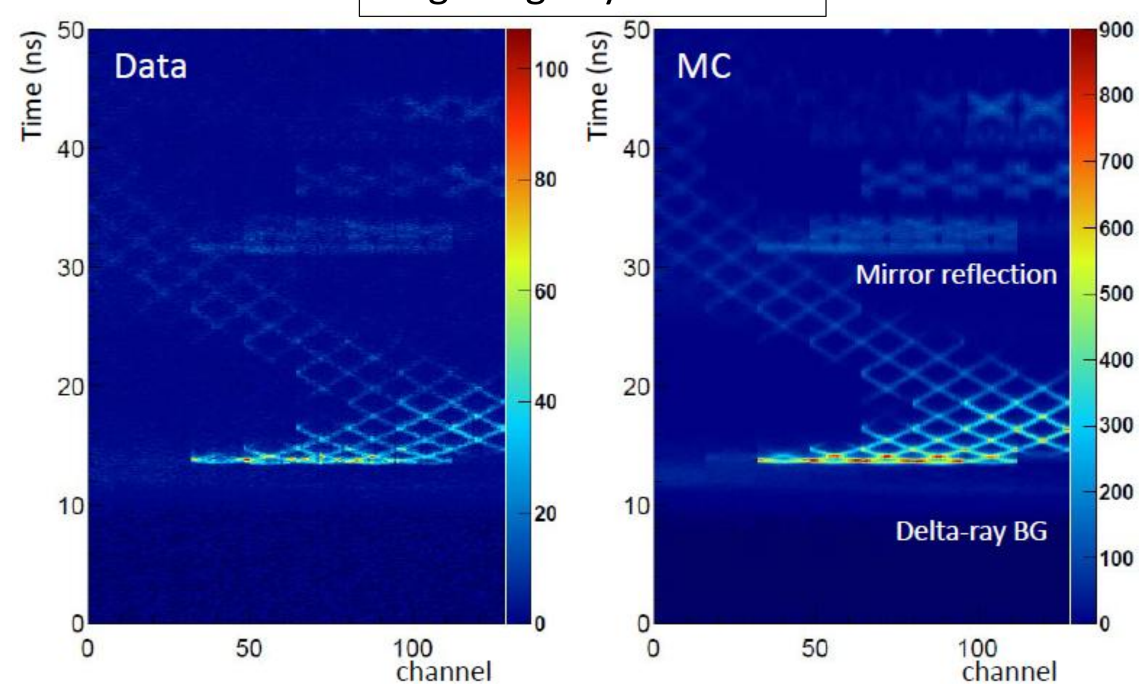
$$cos\theta_c = \frac{1}{n\beta}$$

(θc : Cherenkov angle)

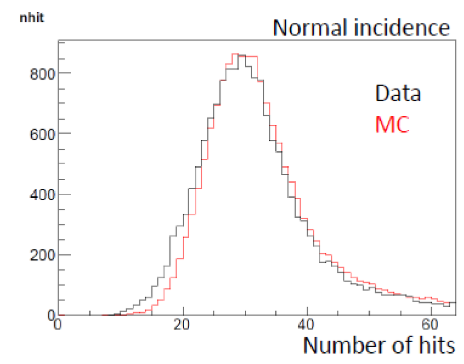


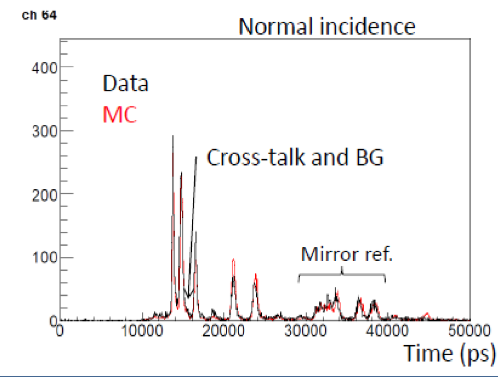
Cherenkov photons are emitted in the quartz bar, and propagate to the MCP-PMT. Cherenkov ring image is reconstructed not only by x-y position but also with time information. TOP counter utilizes the time-of-flight information additively. So, TOP counter requires a good time resolution, less than an order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

Ring image by beam test



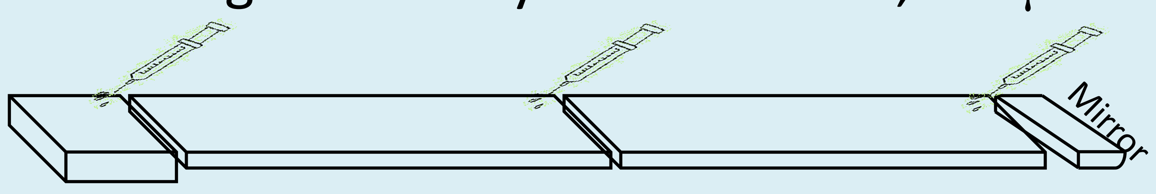
Particle ID is performed using likelihood calculation using complicated ring image. Beam test data is obtained as expected, enough number of photons and precise time resolution

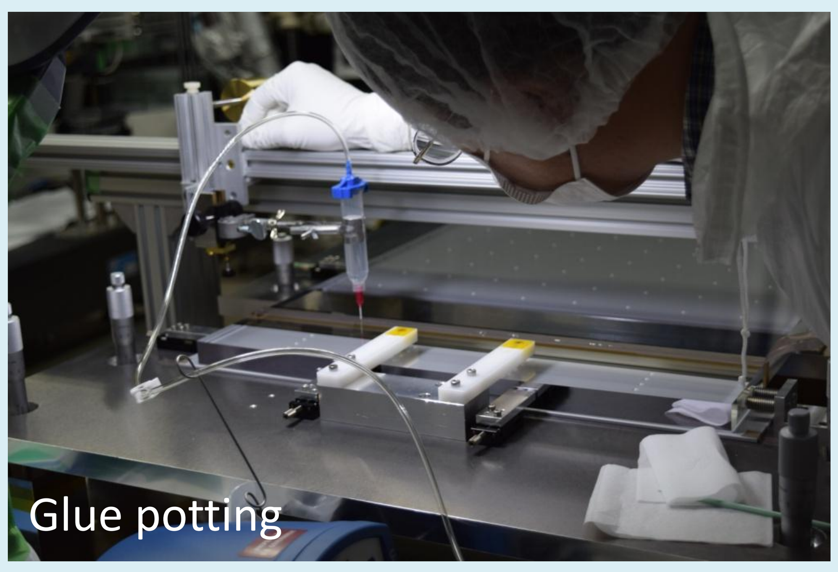


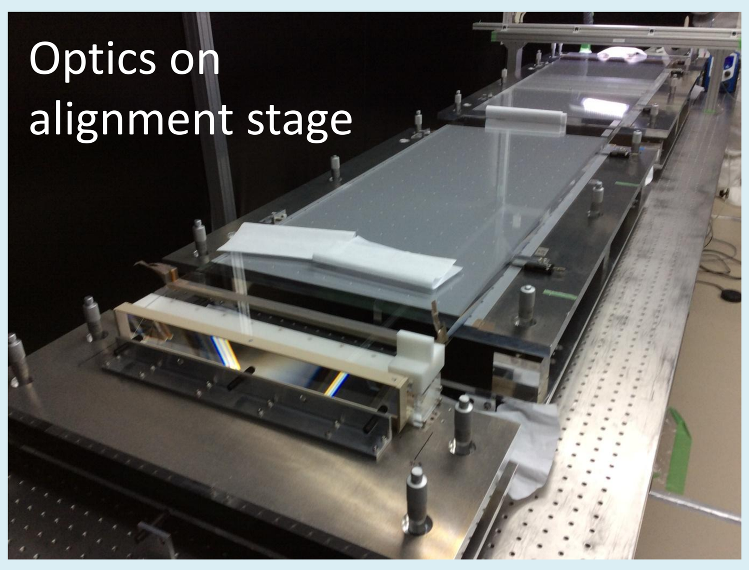


Quartz radiator

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 ~0.02mrad, ~10μm by EPOTEK301-2.

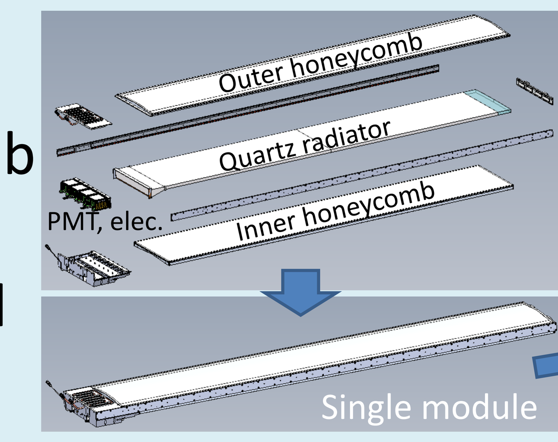


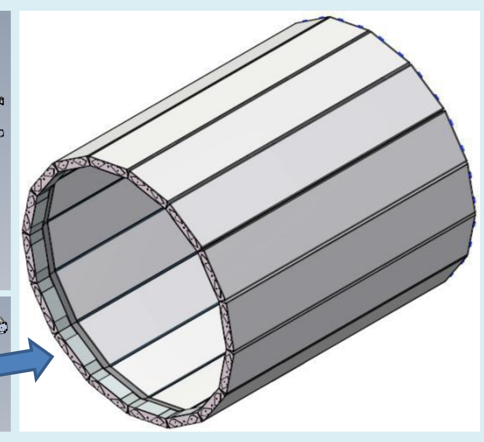

Glue potting

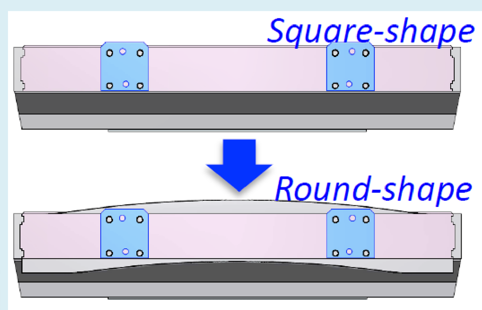

Optics on alignment stage

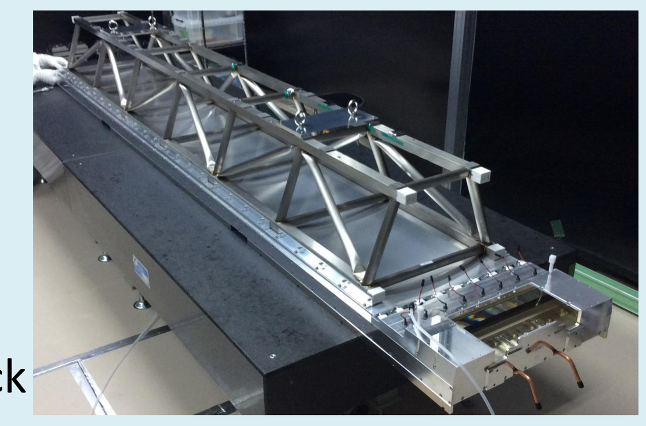
Mechanics

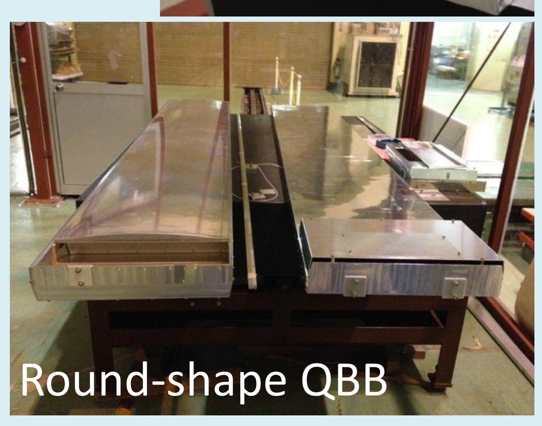
Radiator is supported by honeycomb panel and buttons with the flatness of ~40μm. The stiffness is improved by the round shaped honeycomb and the barrel connection.
During the production, "strong back" is attached to the quartz-bar-box (QBB) to keep the flatness.

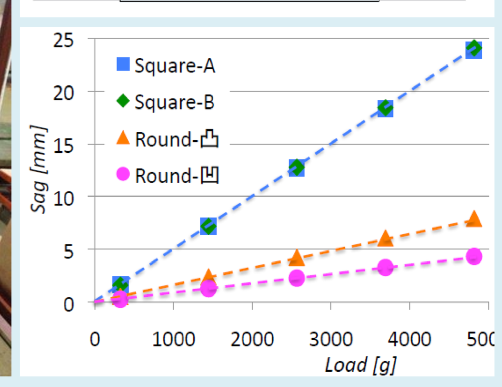






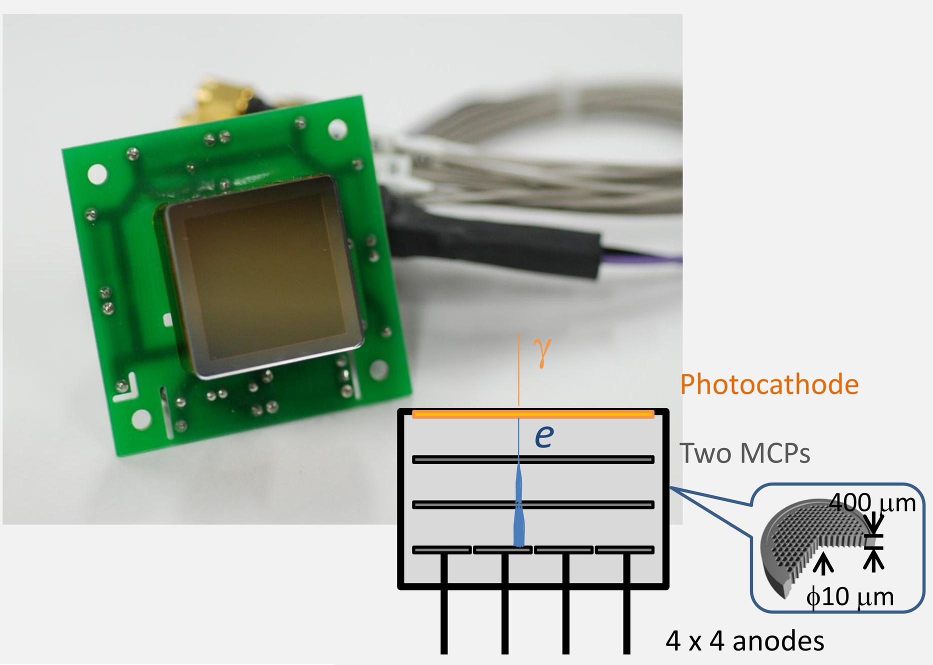

QBB with strong back

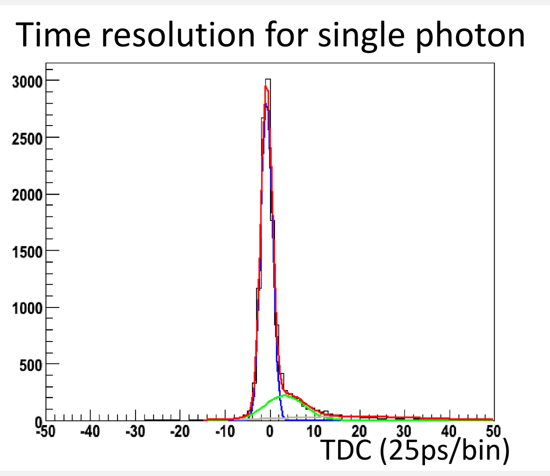

Round-shape QBB

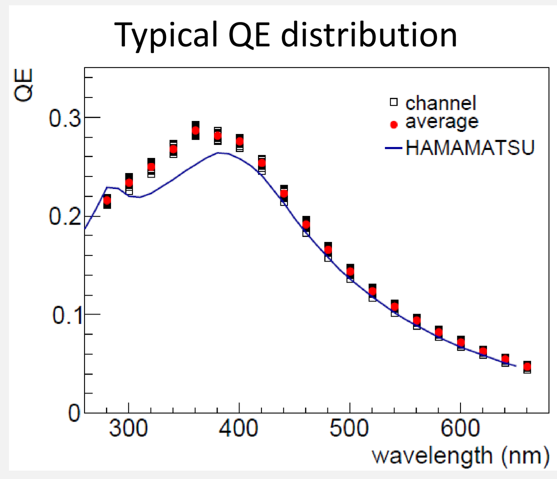


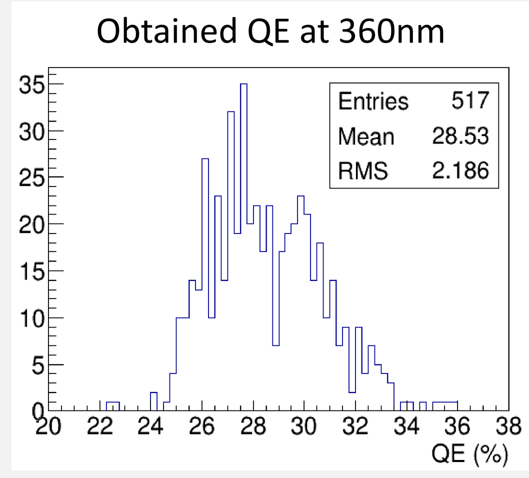
MCP (Micro-Channel-Plate) PMT

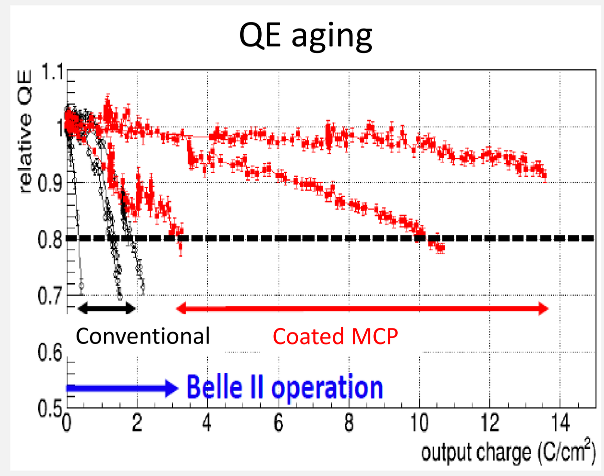
MCP-PMTs work for single photon detection even under a 1.5T magnetic field, with a TTS of <40ps. Enhanced photocathode has been adopted to increase the number of detected photons. Mass production for Belle II has been performed with the stable performance of TTS<40ps and QE~28.5%. Lifetime was improved by adopting coated MCP.





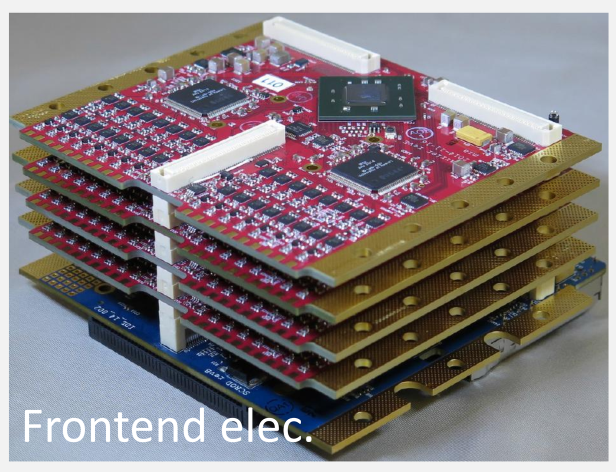


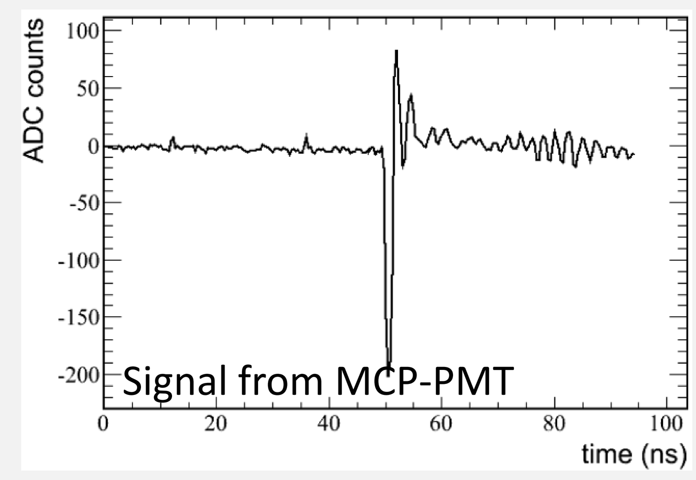




Electronics

The PMT signal is read out by a newly developed ASIC, "IRS", with GHz analog bandwidth, high-performance waveform recording, to achieve pico-second level timing measurement. Prototypes are developed and shows the performance as expected; time resolution with PMT is ~50ps. Final model is in mass production.

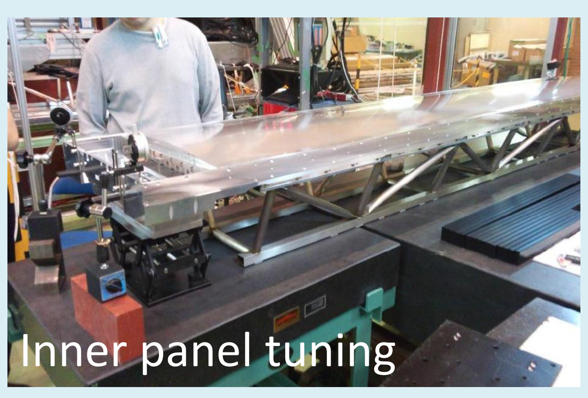

Frontend elec.



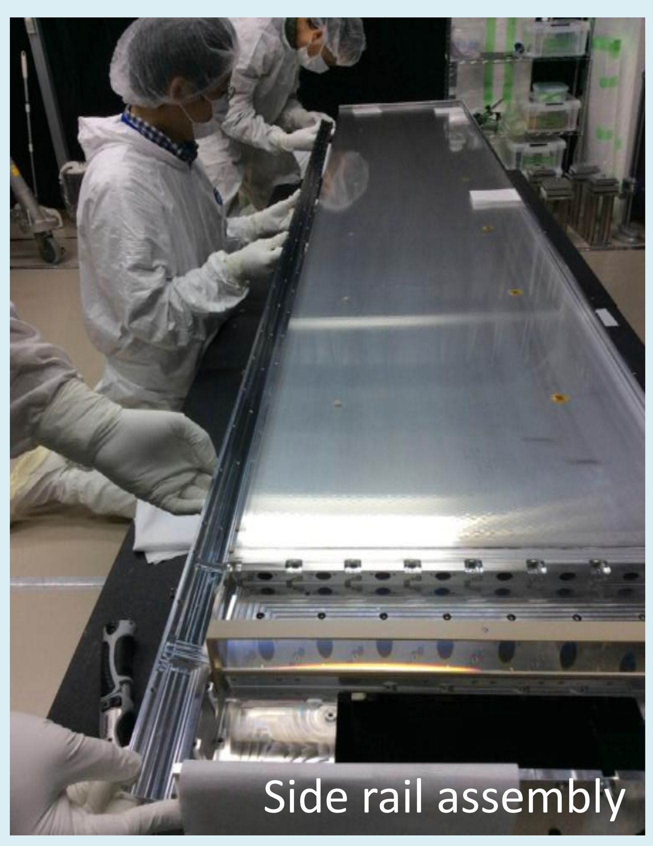
Signal from MCP-PMT

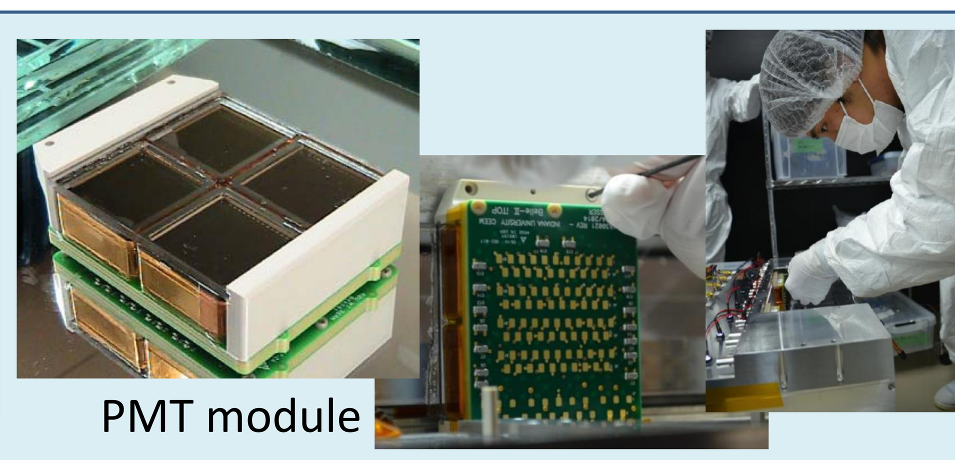
TOP module production

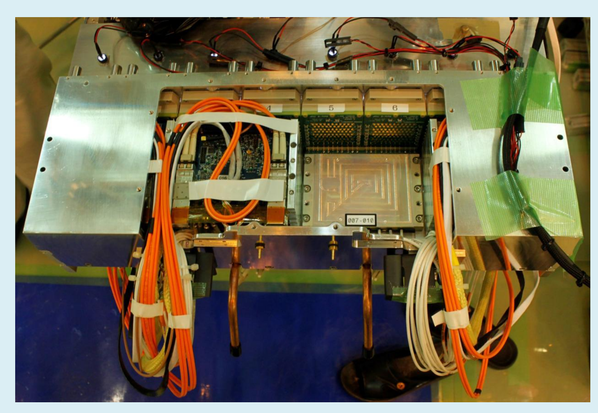
Finally, module production has been started from Dec. 2014, following the practice of 4 prototypes. After optics gluing and honeycomb/ button preparation, we lift up the optics from the glue stage to honeycomb, then assemble QBB, PMT modules and frontend electronics. Currently, the production goes successfully, although we update the procedure step by step. We could produce ~2.5weeks per module and plan to finish/install all modules by the end of JFY2015.


Inner panel tuning


Quartz lifting on QBB


Side rail assembly


PMT module


PMT module and frontend elec. in QBB