

TOP counter @N-lab

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for the Belle II TOP group

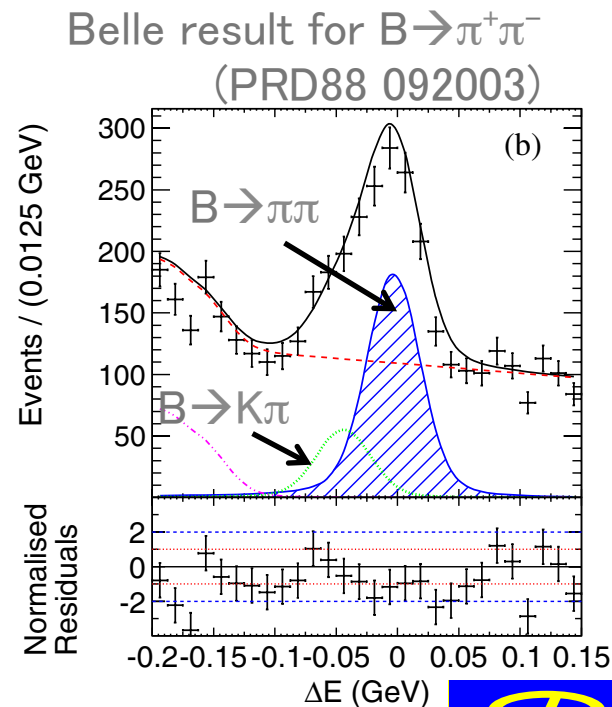
17th Dec, 2015

N-lab introduction



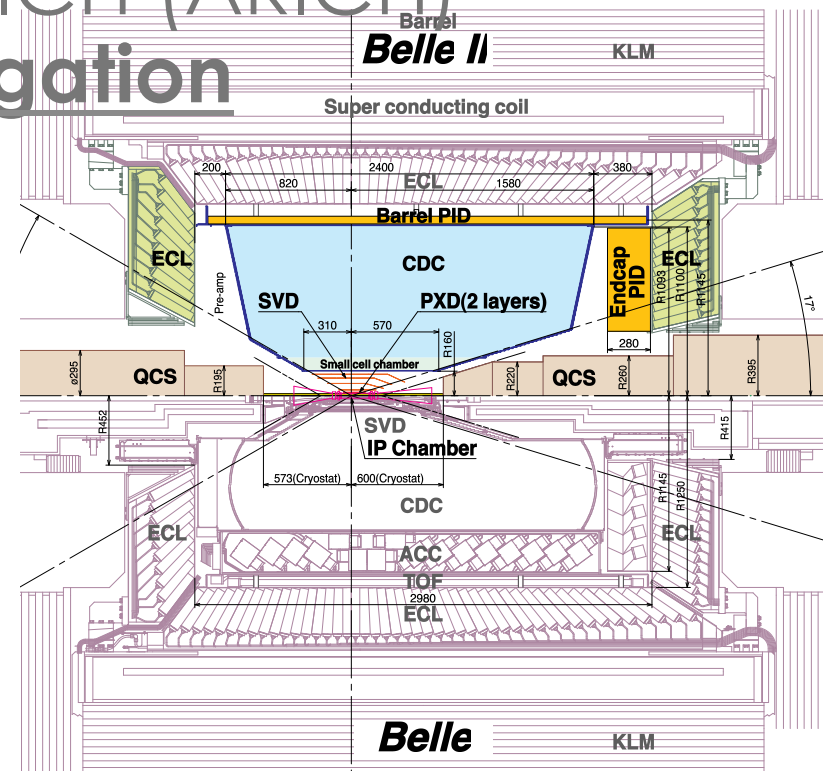
Particle Identification @Belle II

- PID is an essential part for precision measurement in Belle II
 - $B \rightarrow \pi\pi$ / $B \rightarrow K\pi$
 - $B \rightarrow \rho\gamma \rightarrow \pi\pi\gamma$ / $B \rightarrow K^*\gamma \rightarrow K\pi\gamma$
- Improvement of K/π separation for high momentum region was critical.



PID Upgrade

- Time Of Flight (TOF)
 - + Aerogel Cherenkov Counter (ACC)
 - endcap : Aerogel RICH (ARICH)
 - barrel : Time Of Propagation counter (TOP)
- TOP counter
 - novel type of **Ring Imaging Cherenkov** detector with quartz radiator and fast photo sensor



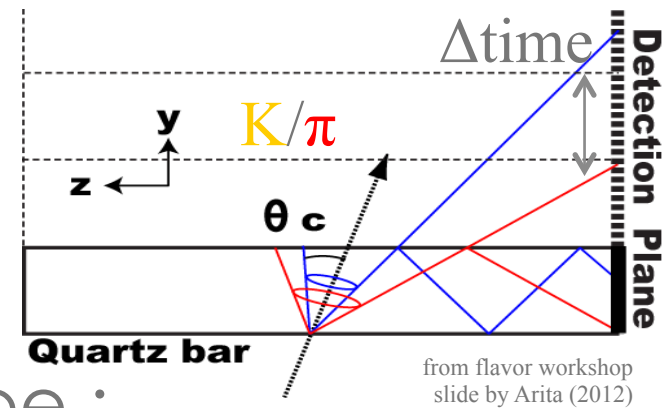
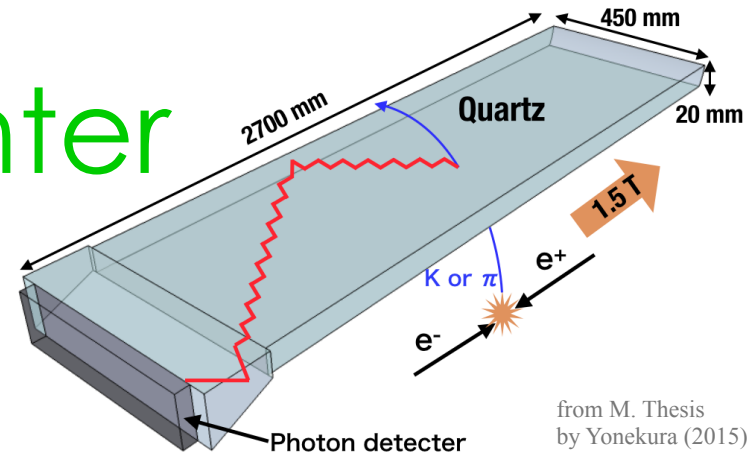
TOP counter

□ concept

- reconstruct ring image of Cherenkov radiation with timing information

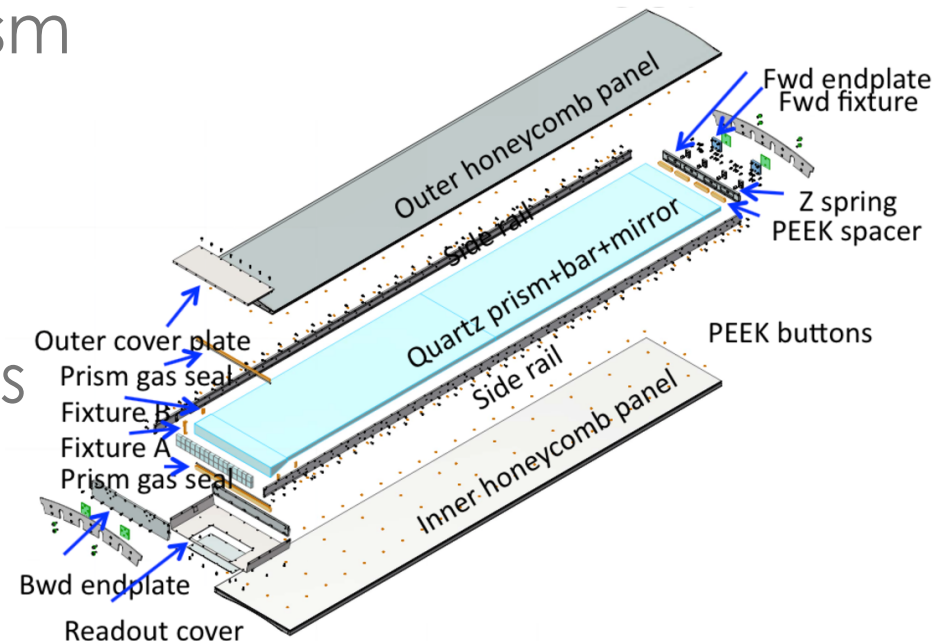
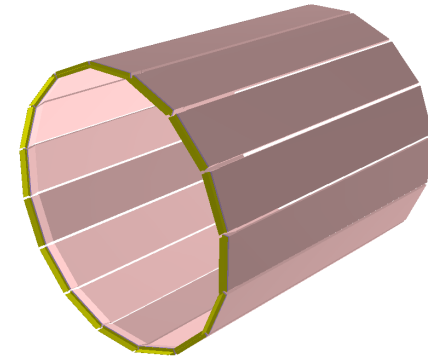
□ advantages

- threshold type \rightarrow RICH type : improvement on PID performance
- compact : more space for CDC
- smaller amount of materials



Detector overview

- barrel structure with 16 modules
- module components
 - quartz bars (2 pieces/module)
 - focusing mirror, prism
 - photo sensors (MCP-PMT)
 - quartz-bar box
 - readout electronics
 - and many more...



quartz radiator

- consisting of 2 quartz bars, focusing mirror and prism
 - roughness $< 5\text{\AA}$
 - reflectance $> 99.9\%$
 - transmittance $> 98.5\%/m$
- assembly in the clean room @KEK
 - acceptance test
 - alignment and gluing

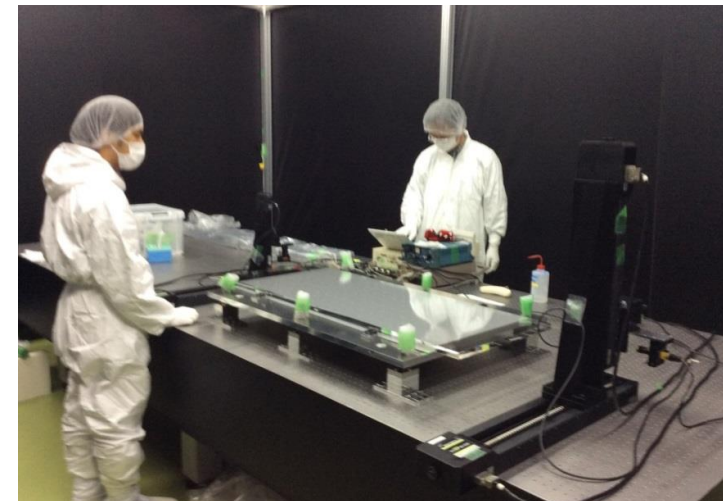
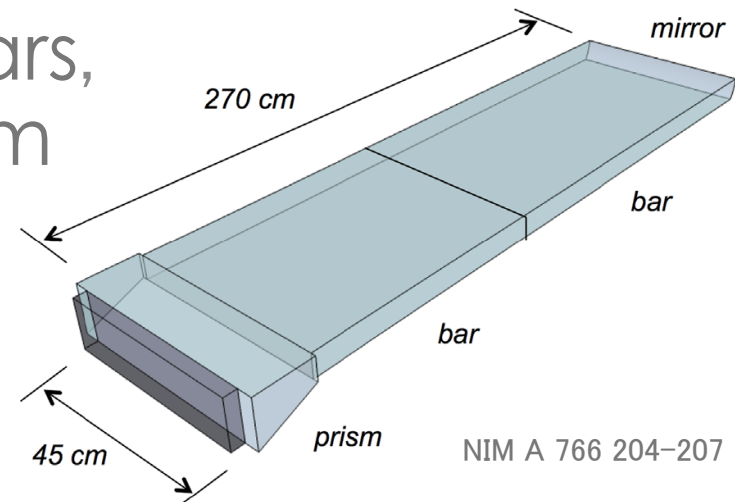
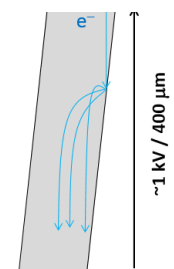
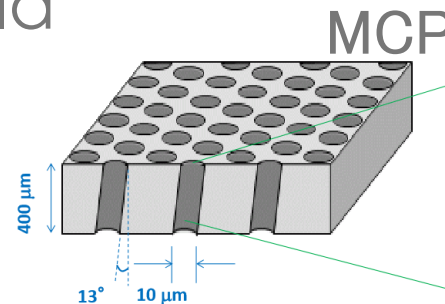
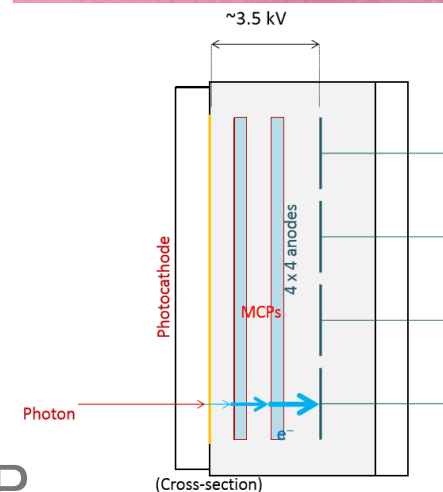
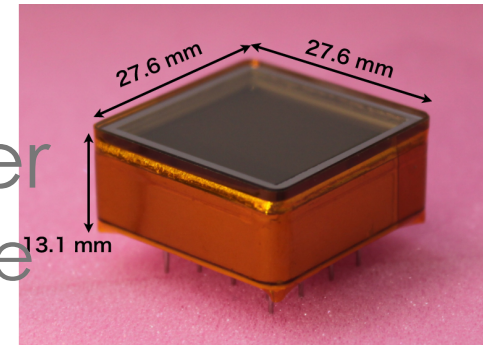


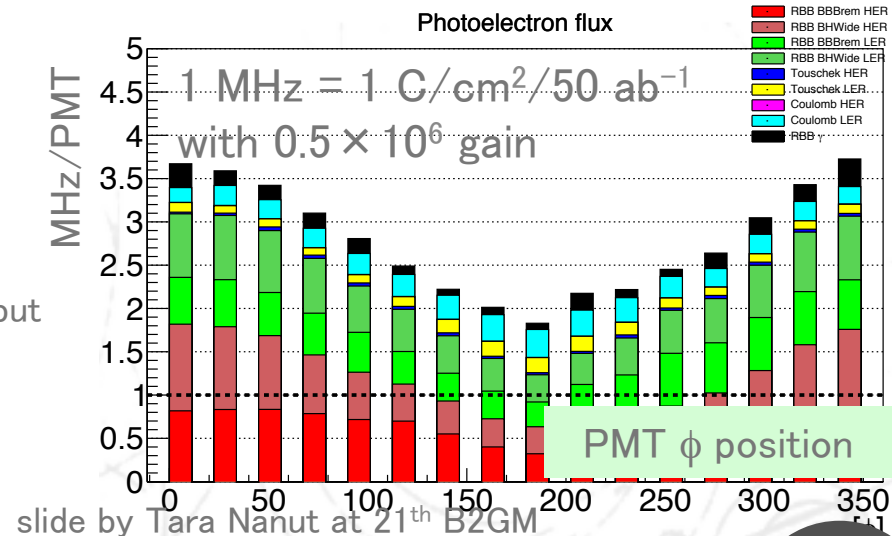
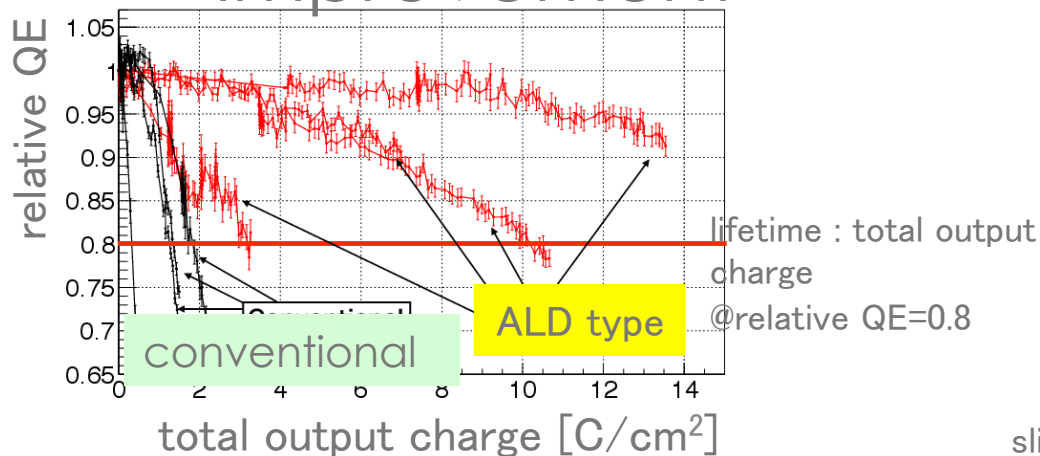
photo sensor : MCP-PMT

- key point to realize TOP counter
 - two layers of Micro Channel Plate
 - < 50 ps timing resolution for a single photon
 - available in magnetic field
- various R&D items
 - gain and timing resolution
 - operation in 1.5 T field
 - radiation tolerance
 - lifetime



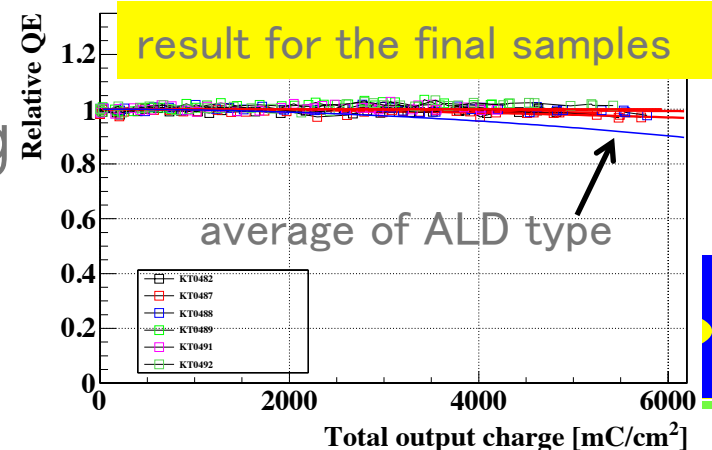
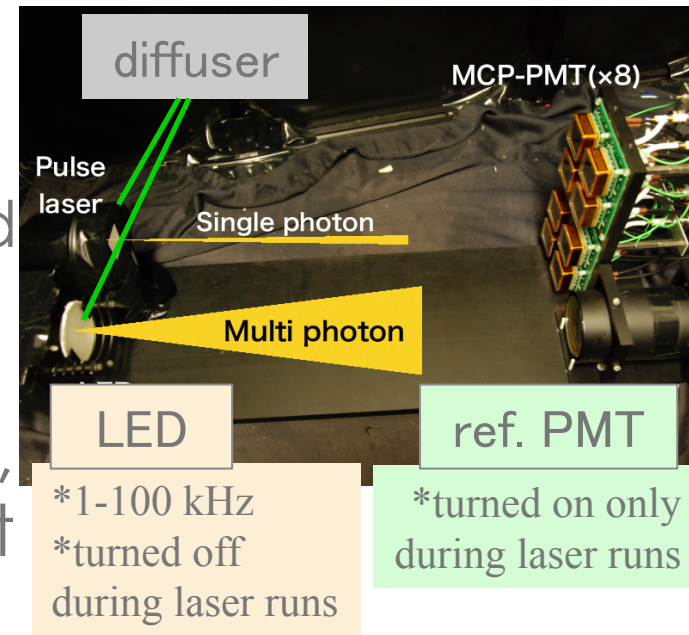
Lifetime improvement

- possible QE degradation due beam background in Belle II environment
 - ion feedback
 - neutral gasses
- We have worked on R&D for lifetime improvement



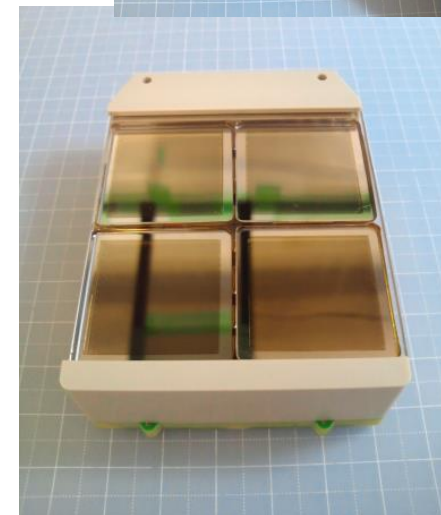
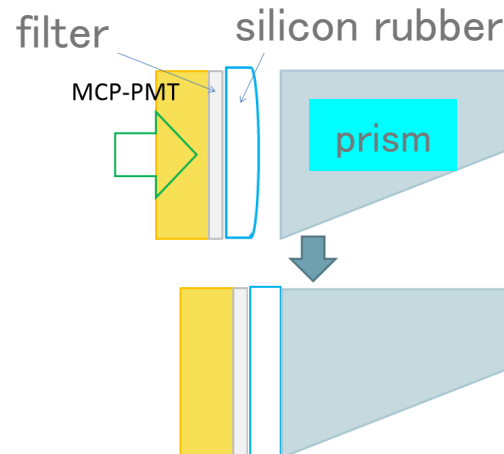
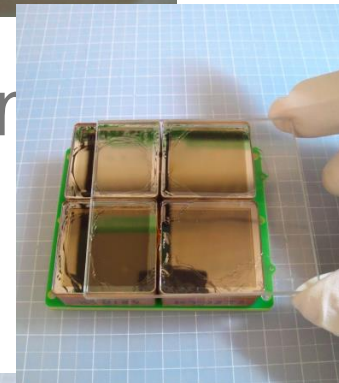
lifetime improvement

- lifetime measurement
 - LED to give loads to PMTs and laser to monitor their relative QE
- various samples were tested, and significant improvement was confirmed with certain method
- mass production is on going
 - to be installed in the last modules



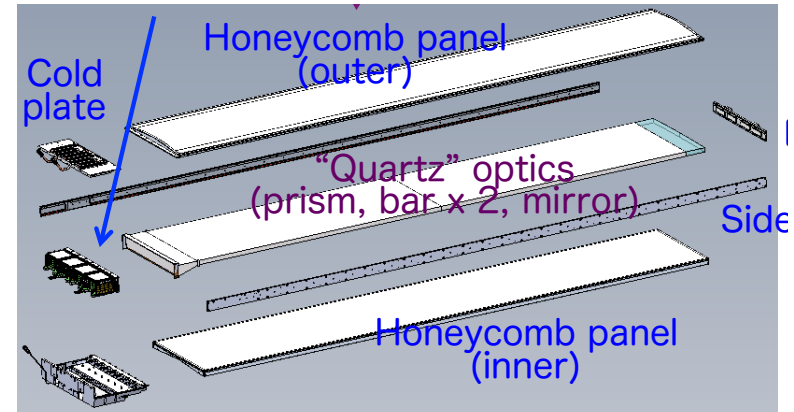
PMT module

- conventional-type PMTs need to be replaced
→ replacement should be considered in installing PMTs
- optical contact with silicon rubber
 - no bubble with small force
 - PMTs should be detachable



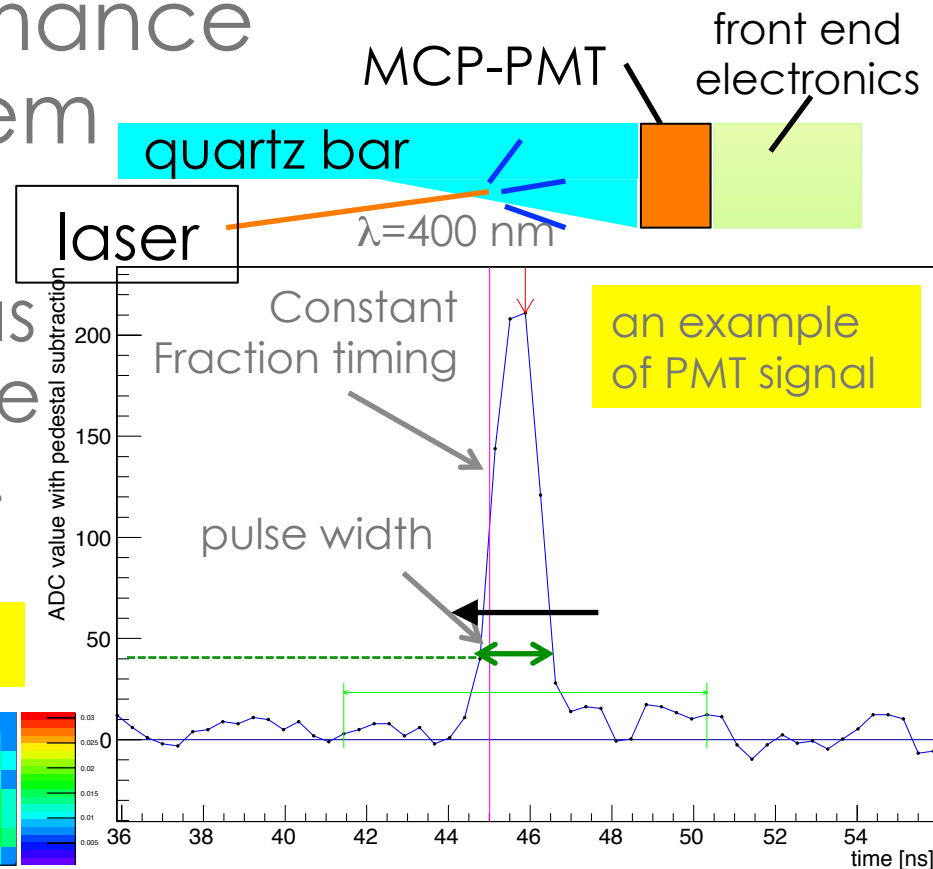
mechanics

- Quartz Bar Box (QBB)
 - hold quartz bars with light material
 - sag should be $< 0.5\text{mm}$
 - aluminum honeycomb panel + strong back in handling a single module



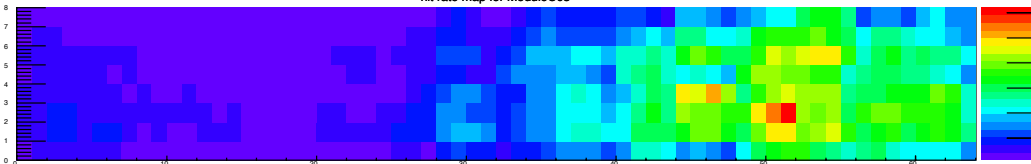
module test

- We have tested assembled modules to confirm performance as integrated system
- using laser system
- Laser response was observed for all the readout channels.



hit map in laser data (512ch/module)

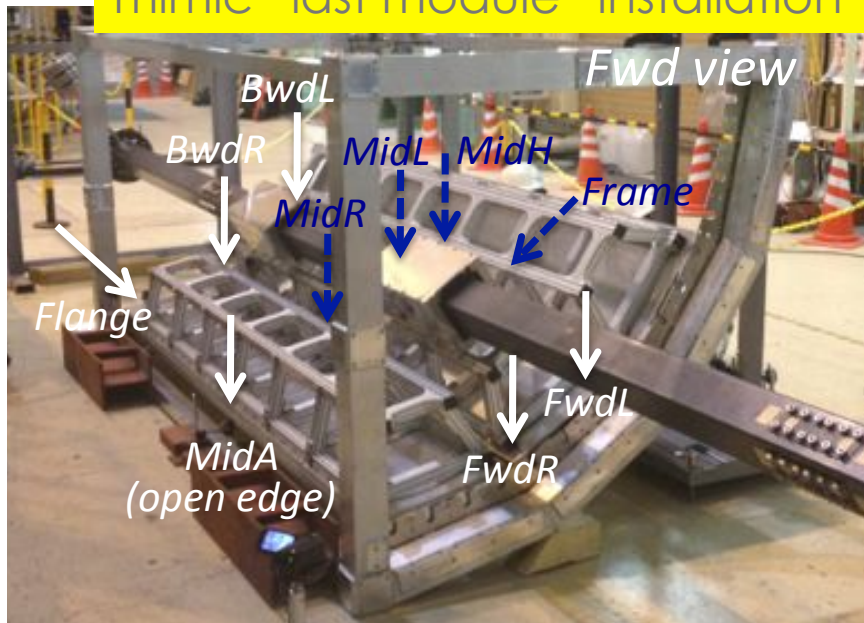
hit rate map for ModuleC03



module installation

- Procedures of module transportation and installation are confirmed with dummy modules

mimic "last module" installation



dummy modules installed at the real Belle detector

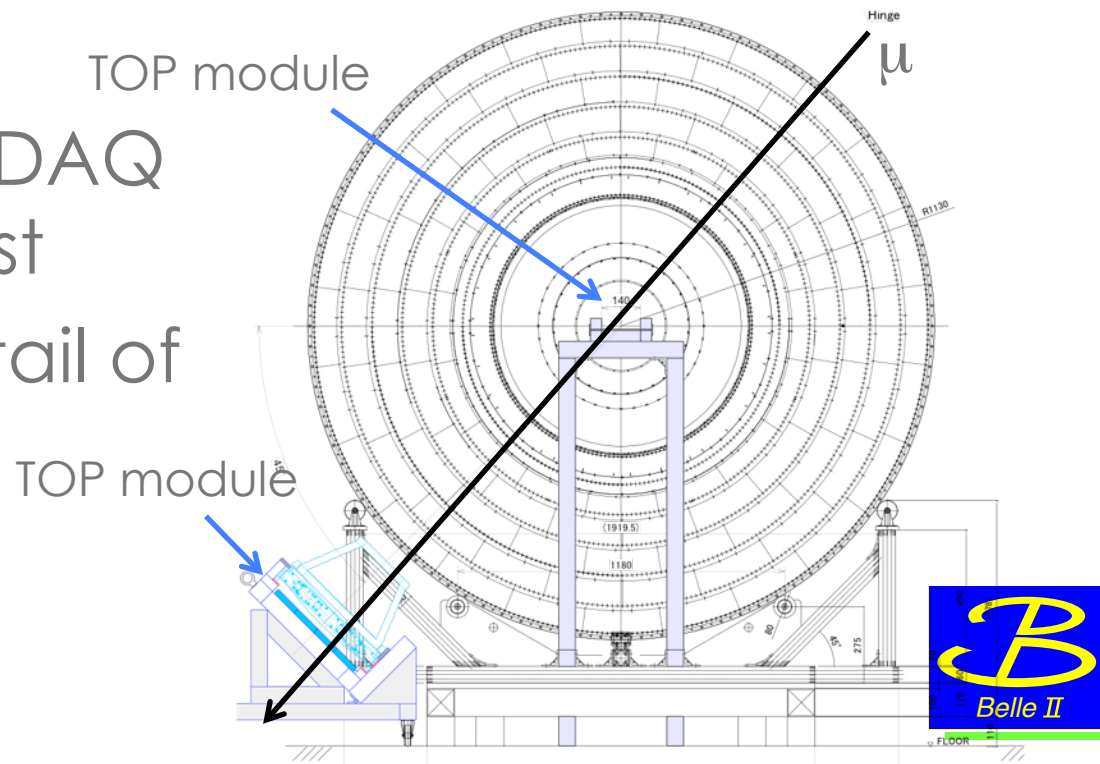


module test plan

- performance test with Belle II CDC (central drift chamber) as a tracking device

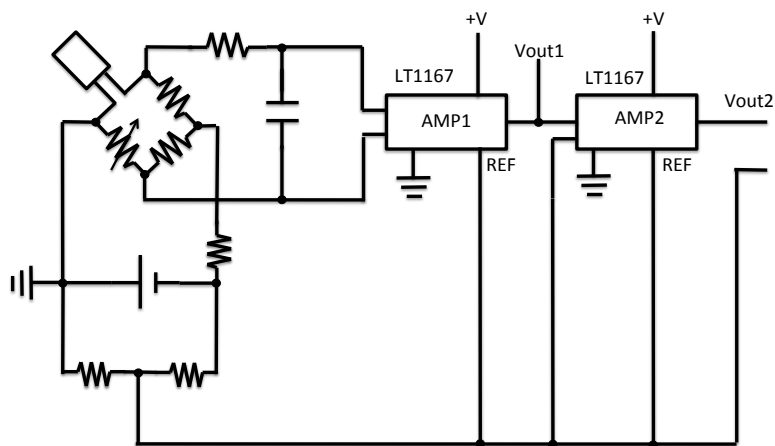
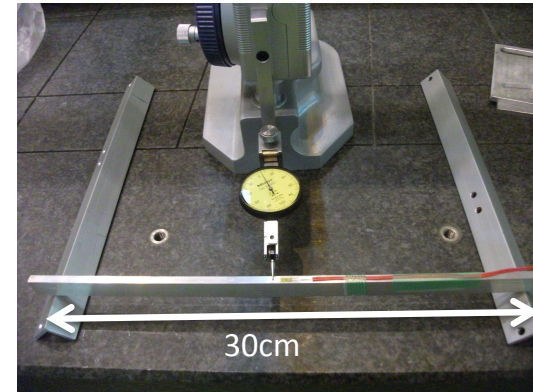
- also works as DAQ integration test

- discussing detail of design and going to start construction



students' activities

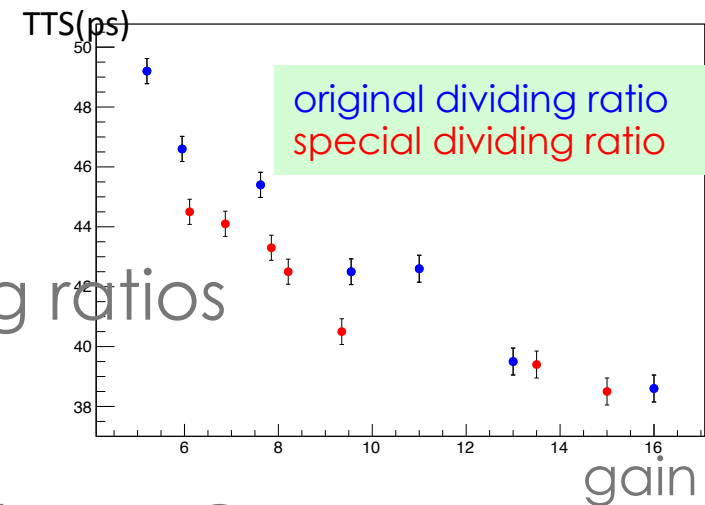
- development of strain gauge
- monitoring sage of TOP module during installation



photon detector R&D

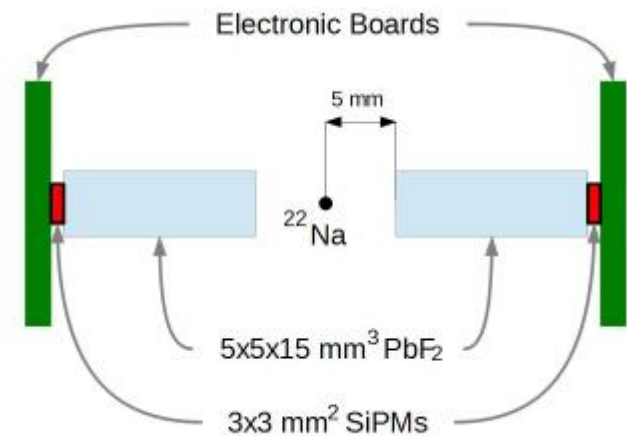
□ MCP-PMT performance study

- optimization of HV dividing ratios
- lower gain keeping TTS
→ longer lifetime



□ development of Cherenkov TOF-PET

- application of excellent single photon TTS
- new MPPC by Hamamatsu (not MCP-PMT)
- collaboration with the Ljubljana group



summary

- Nagoya group is intensively working for the TOP counter construction
 - module construction, structure design, development of photo sensors, preparation of installation, performance test...
- Production of all the modules and their installation is scheduled to finish by the end of next April