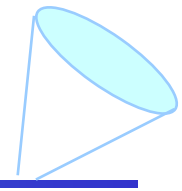
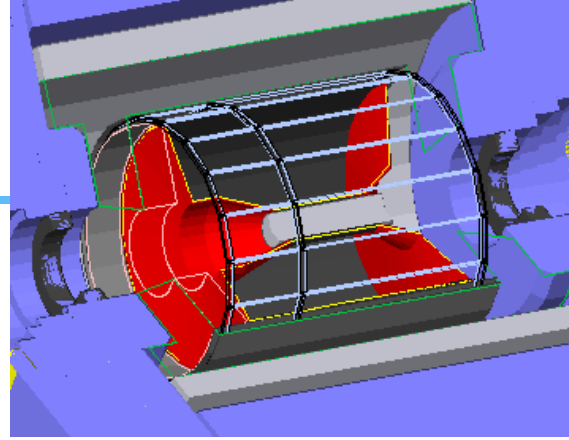
TOP counter R&D

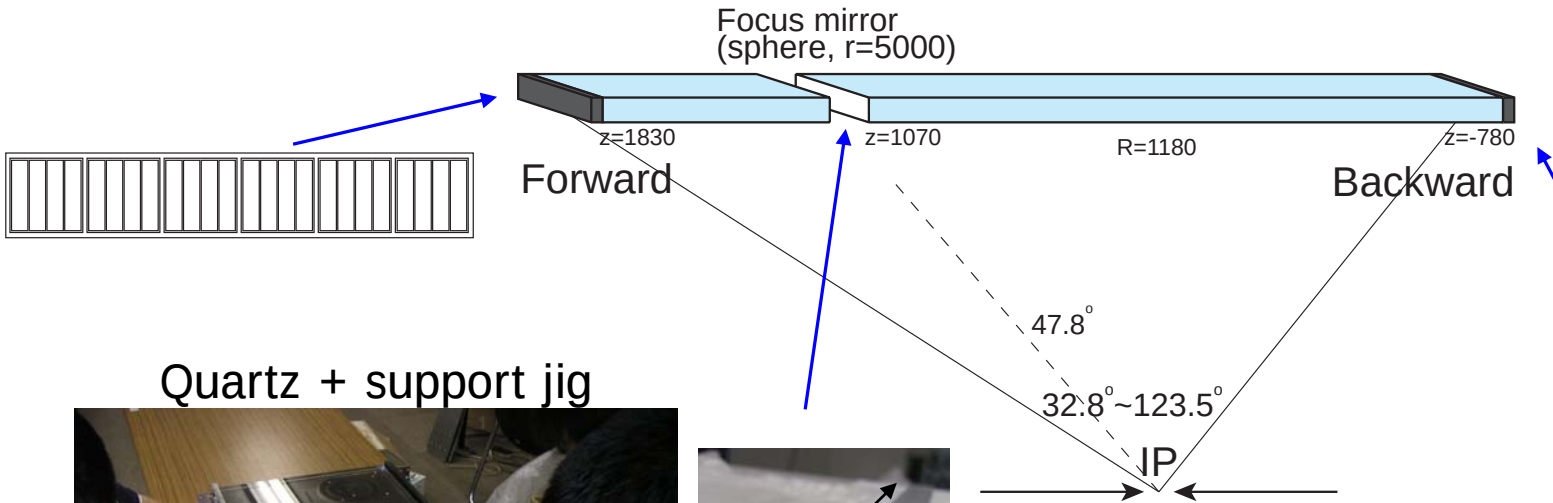
2008/12/11 K.Inami



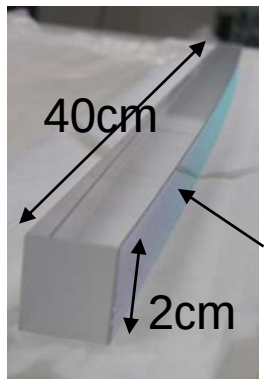
TOP counter

- Quartz radiator + mirror
- MCP-PMT (square shape, 4ch)





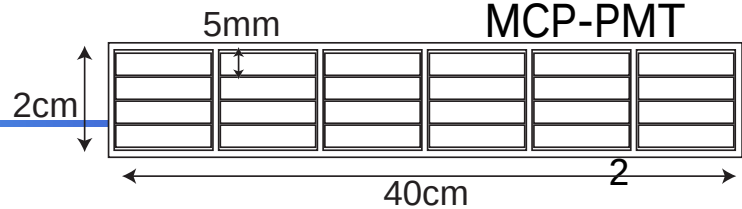
Quartz + support jig



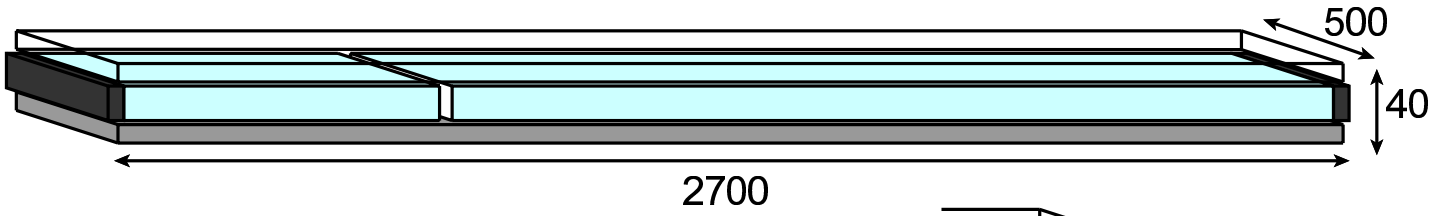
mirror (R=5 m)

Focusing mirror

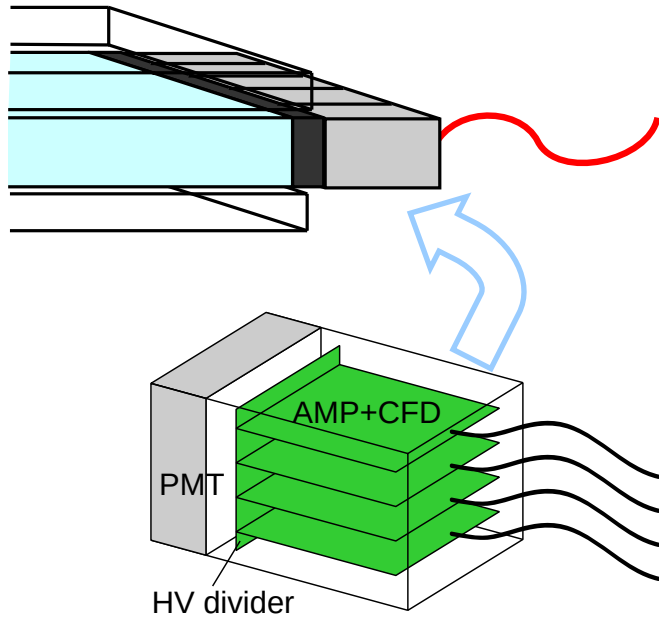
MCP-PMT



TOP module

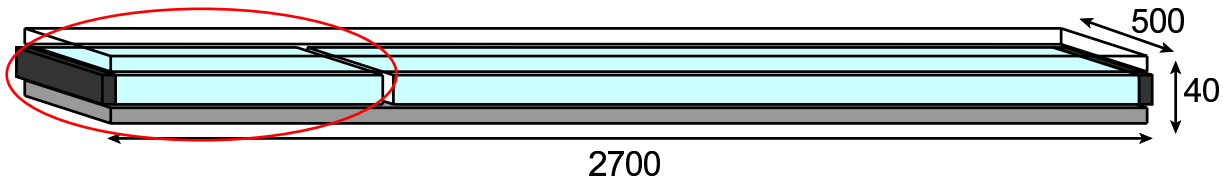


- A module supporting quartz and PMT
  - Quartz radiator
    - Support by aluminum honeycomb box
      - Black box
  - MCP-PMT
    - Assemble with front-end elec.
    - Connect elec. part to honeycomb
      - Not glue PMT with quartz
- Prototype construction
  - 1st step) quartz 1m (forward, backward part)
    - Beam test in June
  - 2nd step) quartz 2m + focus mirror
    - Beam test from this week

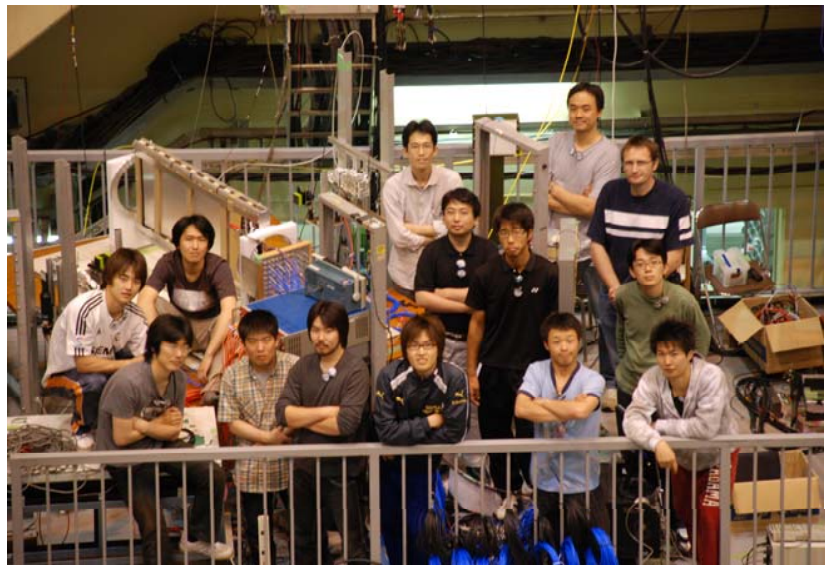


Previous beam test

- At Fuji test beam line in June
- Prototype of forward part



  - Using real size quartz and MCP-PMT
    - MCP-PMT: Multi-alkali p.c., C.E.=60%
- Check
  - Ring image
  - Number of photons
  - Time resolution



Beam test set up

TOP counter
Quartz bar(915 × 400 × 20mm)

Timing counter
10mmf quartz + MCP-PMT
σ_{t0} < 15ps

MWPC 1

MWPC 2

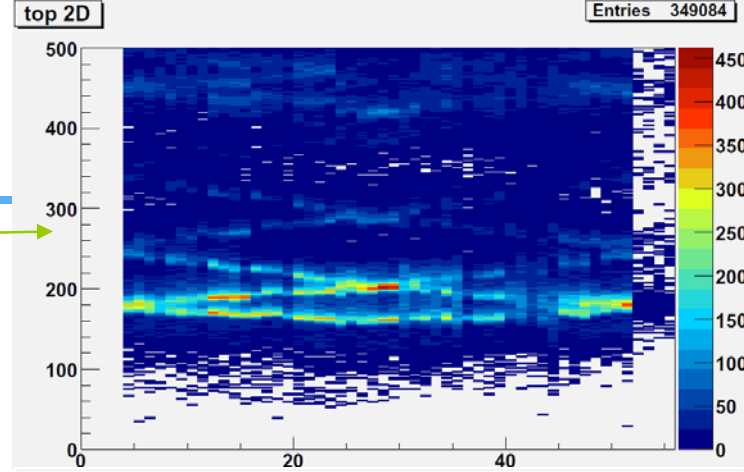
Trigger counter

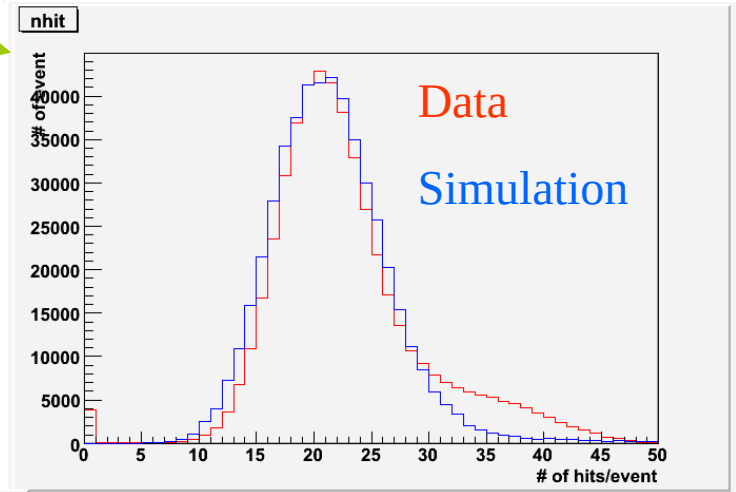
MCP-PMT (56ch)

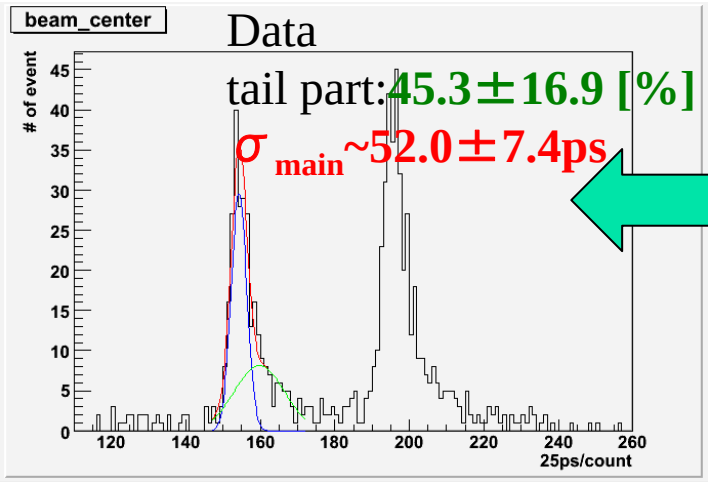
Lead glass + Finemesh PMT
used as the trigger counter

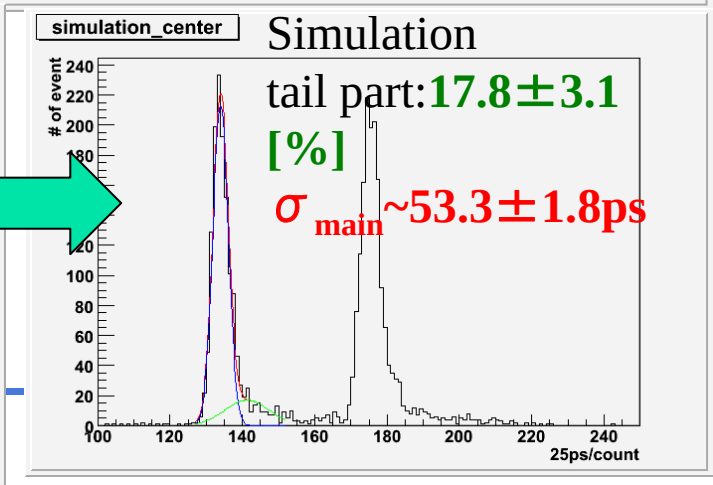
Beam test results

- Ring Image
  - Similar with Simulation
- Number of photons
  - N~20; as expected
    - Tail due to EM shower in triggers
- Time resolution
  - Main part; expected time resolution
  - Rate of tail seems large.
    - Not in MCP-PMT and readout



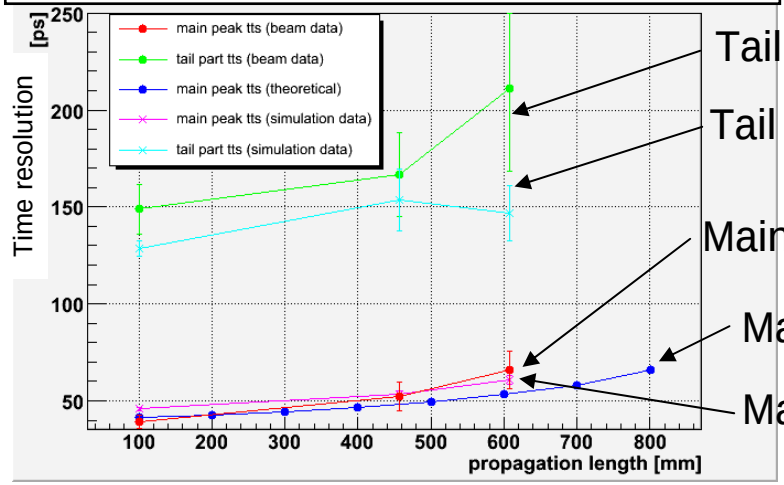






Beam test results

Time resolution vs. propagation length



Tail part for beam data (green)

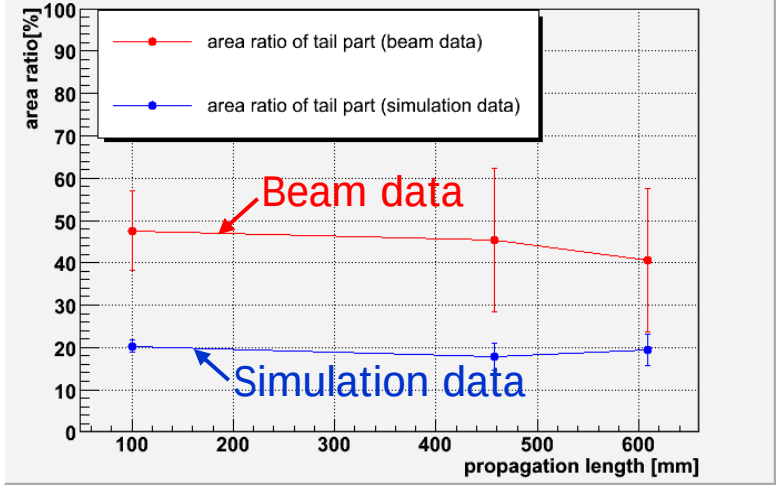
Tail part for simulation (light blue)

Main peak for beam data (red)

Main peak for theoretical exp. (blue)

Main peak for simulation data (pink)

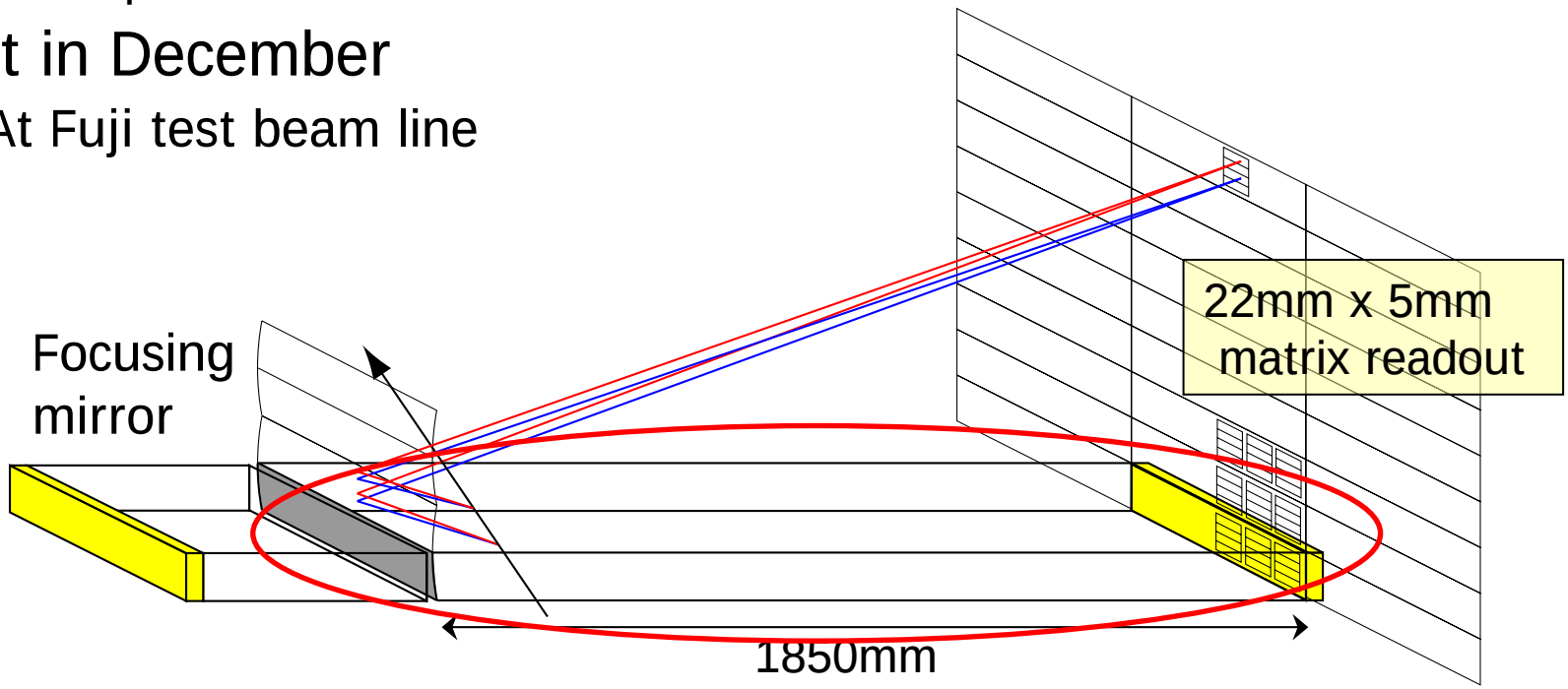
Area ratio vs. propagation length



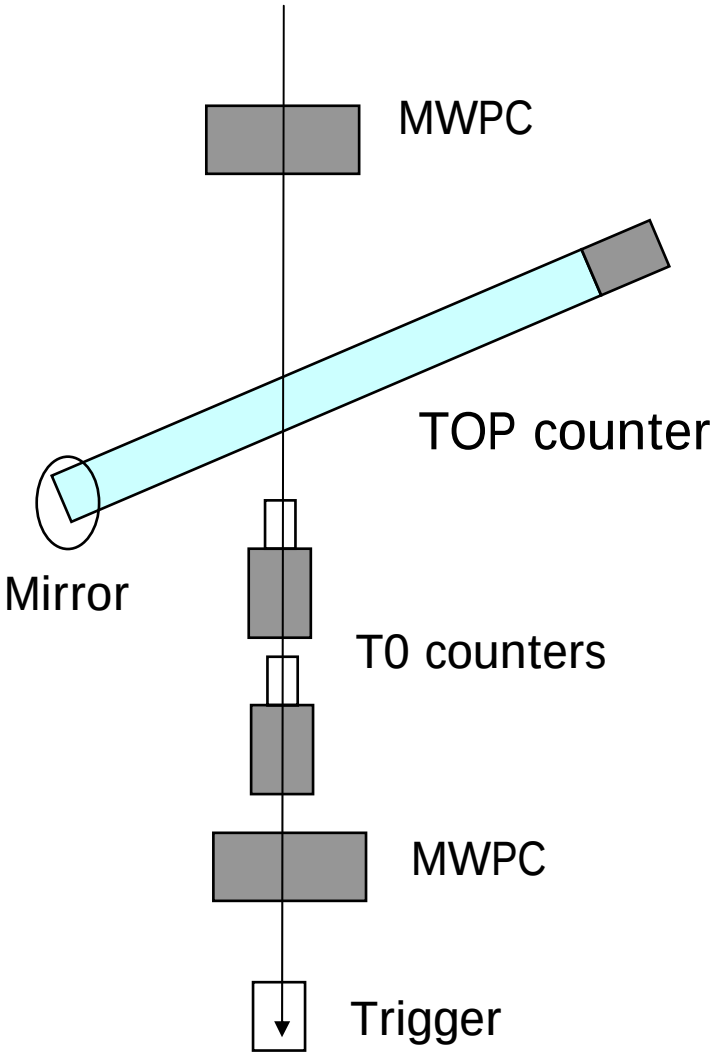
- Time resolution; OK
- Area ratio of tail part to main part
  - Large tail in beam data
  - Need to confirm the reason
    - Cross-talk, propagation?
    - Beam spread?

Next beam test

- Ring image with focusing TOP
  - Quartz ~2m long
  - Focusing mirror
  - MCP-PMT
  - Check focusing property
    - Improvement of time resolution
- Test in December
  - At Fuji test beam line



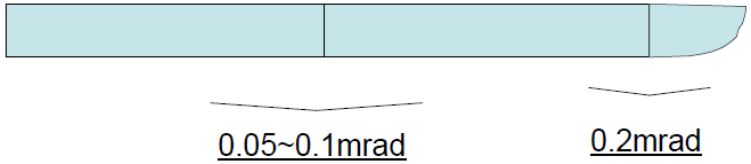
Setup



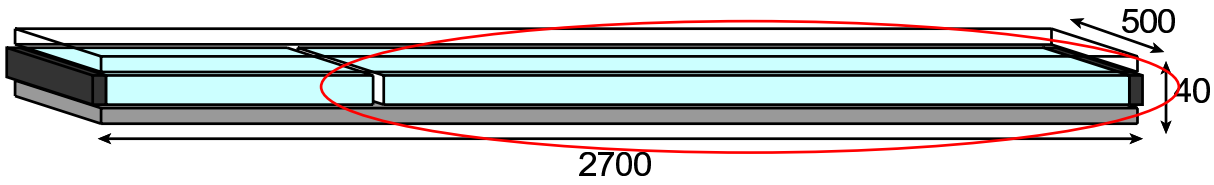
- Trigger counters
  - 1 scintillation counter
  - Timing counters
    - TOF counter with MCP-PMT
      - <10ps resolution
- TOP counter
  - Slide and rotate
- Tracking system
  - MWPC

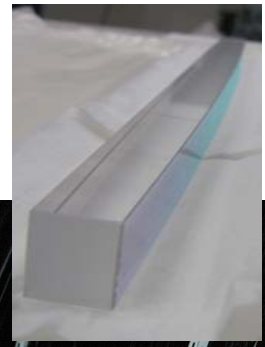
Focusing TOP development

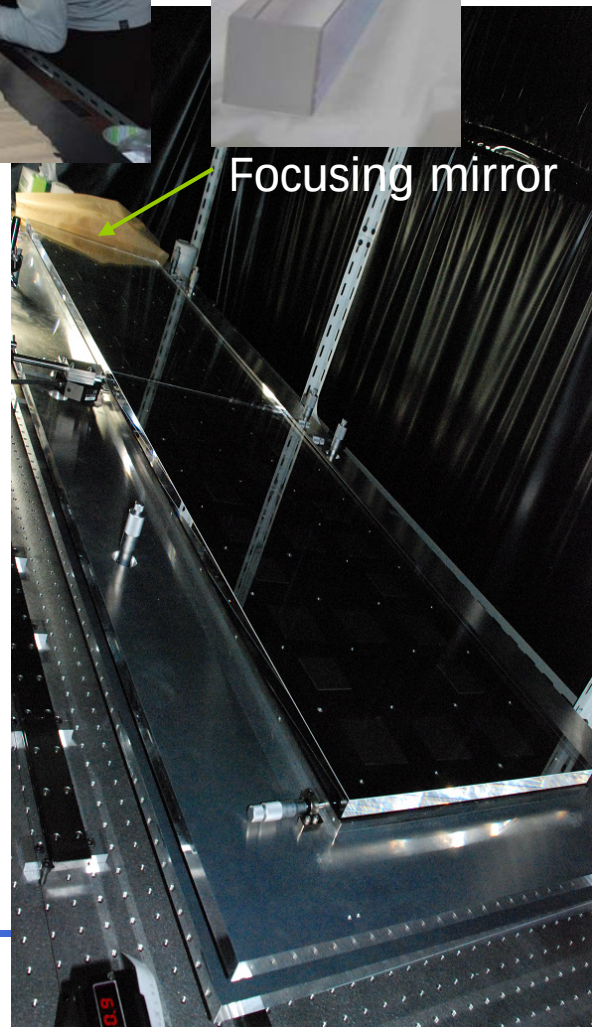
- Quartz radiator
  - Size; 91.5 x 40 x 2 cm^3 x2
  - Focusing mirror
  - Glued
    - UV cure type (NOA63)
    - Flatness; ~0.2mrad
      - Laser depth meter
      - Laser reflection at mirror



  - Aluminum honeycomb structure

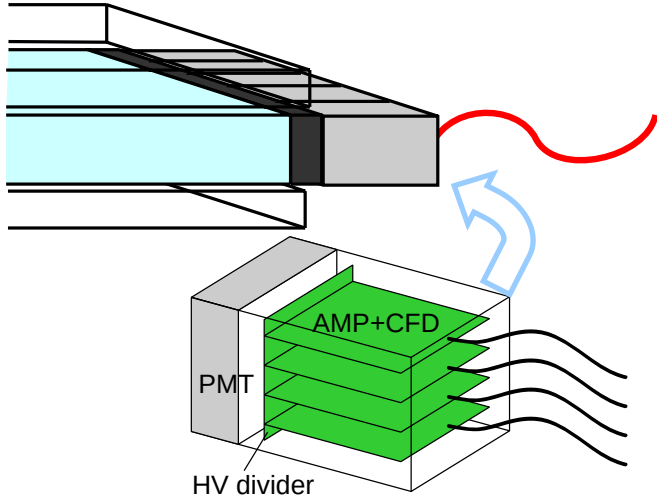




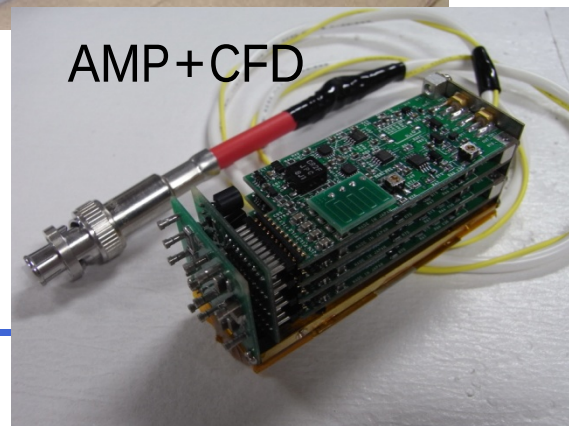


Focusing TOP development (2)

- MCP-PMT
  - Almost same as previous one
  - Multi-alkali photo-cathode
    - 11 PMTs without Al protection
  - PMT box
    - New AMP + CFD board
      - TTS<40ps with MCP-PMT
    - Backup; AMP + NIM discriminator
      - Same as previous beam test



- Readout by CAMAC TDC,ADC
  - Same as previous

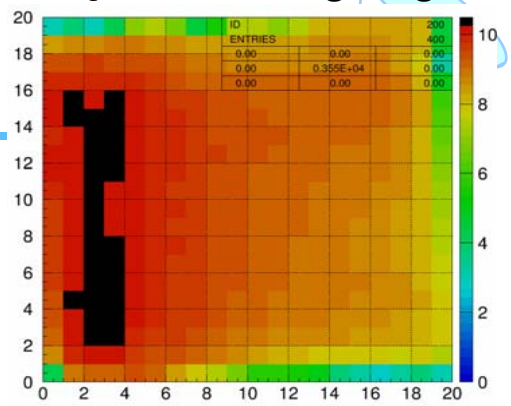


MCP-PMT R&D

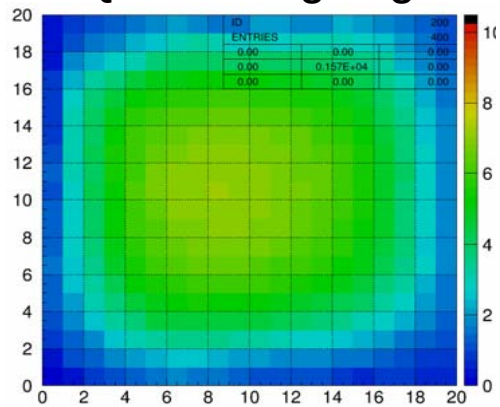
- Lifetime test
  - Multi-alkali p.c. with Al protection
  - With square-shape MCP-PMT
  - → Short lifetime, position dependence

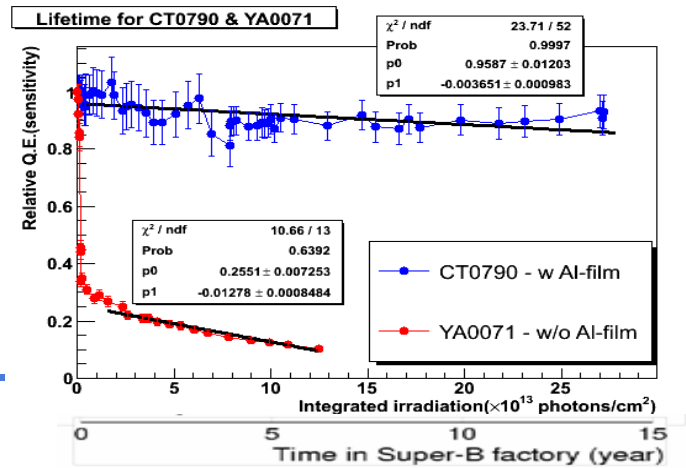
- Difference with round-shape PMT
  - Enough lifetime (>10 super-B year)
  - Need to confirm the difference
    - Internal structure
    - Material difference?
  - Need to confirm the lifetime of round-shape MCP-PMT

QE before aging



QE after aging





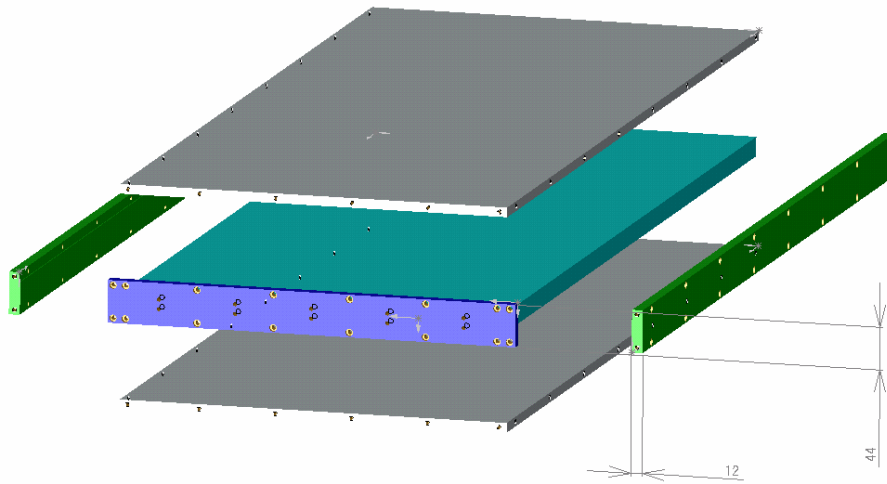
Summary

- Previous beam test in June
  - Prototype for forward part
  - Good ring image, number of photons (~20photons)
  - Good time resolution of 40~60ps. However, there is a unknown large tail.
    - Cross-talk or fluctuation of the propagation?
- Next beam test with focusing TOP prototype
  - Beam test from this week at Fuji beam line
  - Confirm chromatic effects
    - Time resolution degradation due to chromatic dispersion
    - Functionality of focusing scheme
- Photon-detector is key point.
  - Need to establish production and lifetime

Quartz radiator

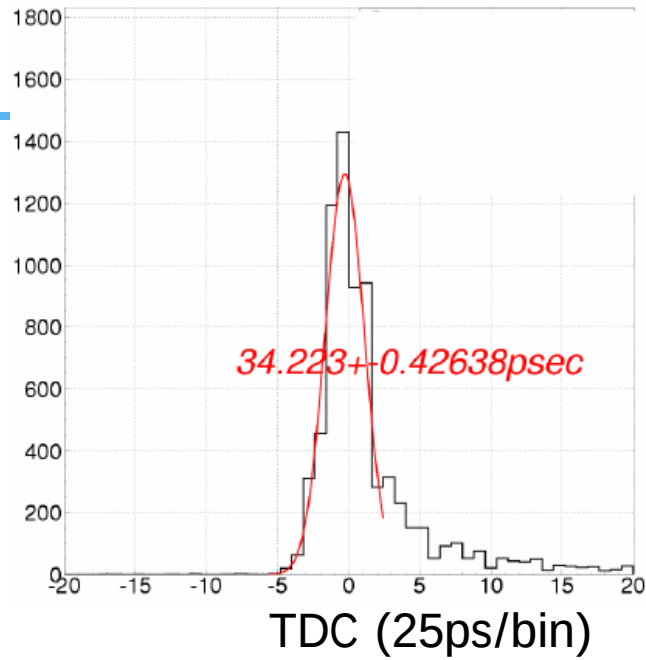
- Size; 915 x 400 x 20 mm
- Flatness; <2μm
- Roughness; <0.5nm
  - By Okamoto optics work, inc.

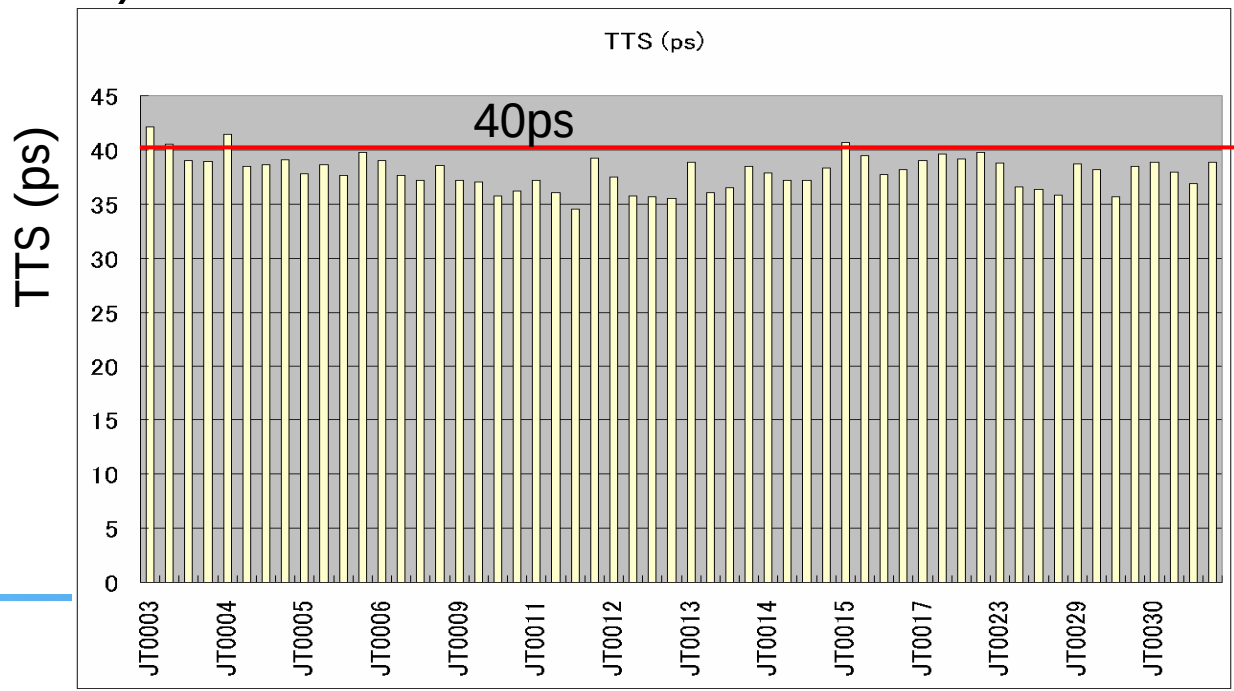
- Support by Aluminum honeycomb panel
  - 1cm thickness
  - With plungers
    - Keep quartz in air
    - ~1kg/plunger on honeycomb
    - ~2.5kg/plunger on side panel



PMT performance (TTS)

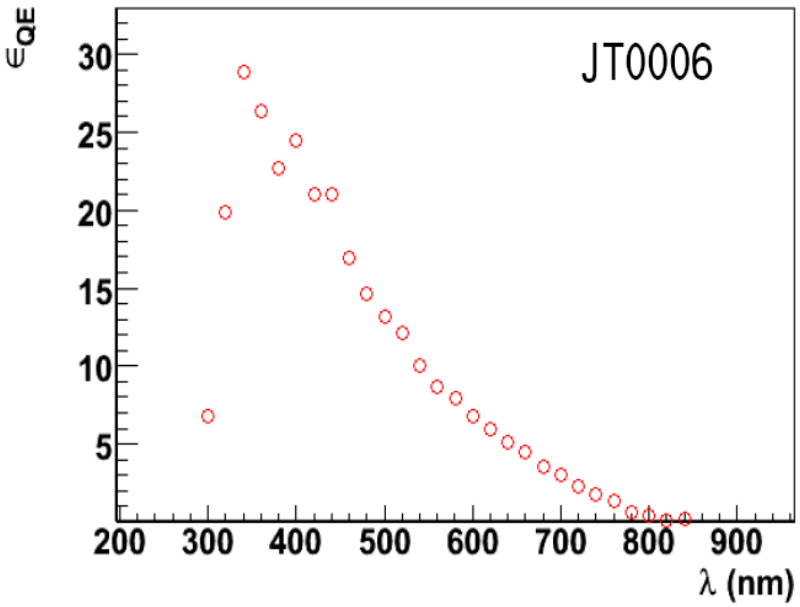
- Test with pulse laser
  - single photon level
- Readout
  - PMT base
    - HV divider, AMP
  - LED (Philips, 350MHz)
  - CAMAC TDC (25ps/bin)
- Result
  - 35~40ps
  - Stable

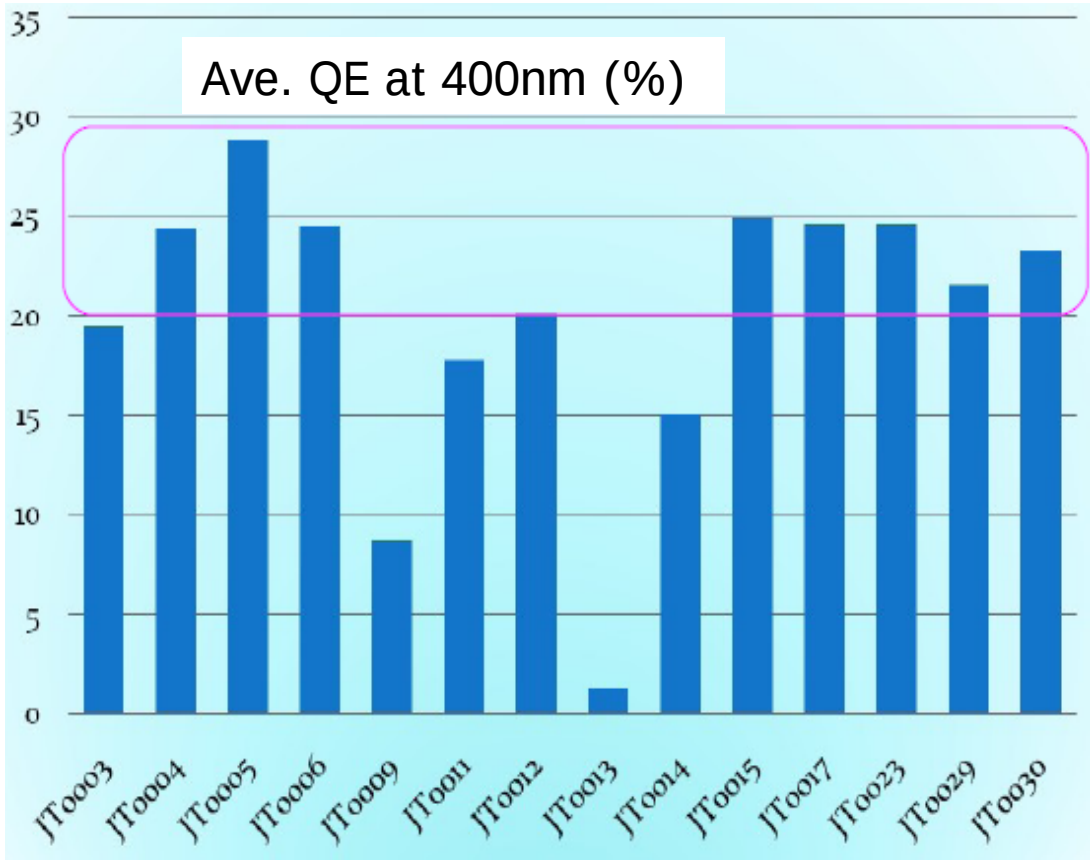




PMT performance (QE)

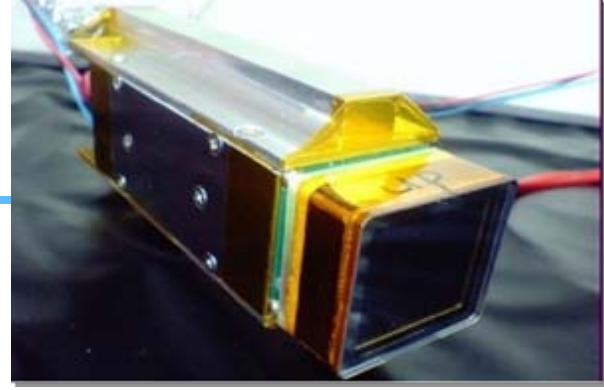
- Measure by monochrometer



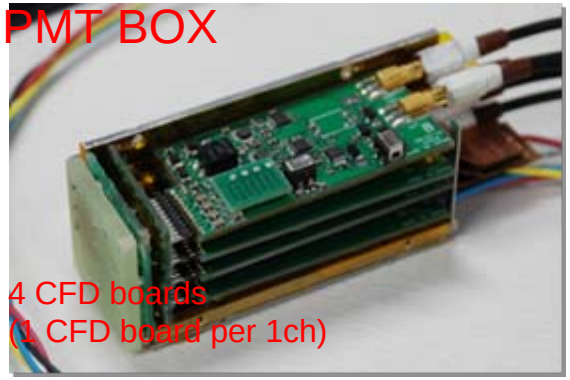


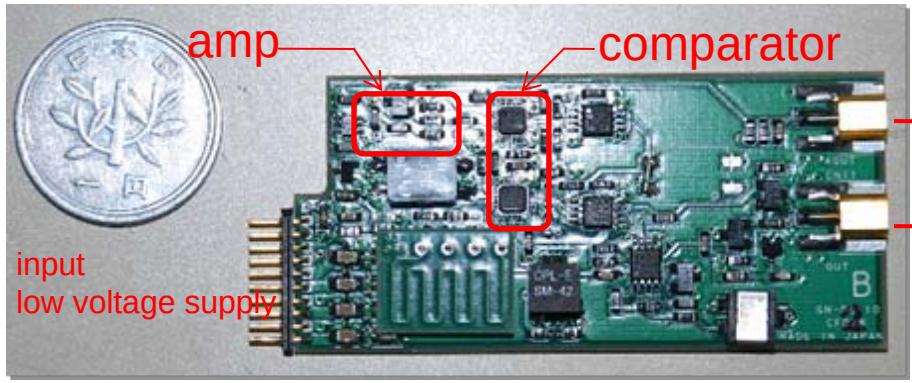
- Result
  - Typical QE distribution
    - Multi-alkali p.c.
  - Enough QE
    - Some of them are bad. Need to improve.

CFD and PMT box



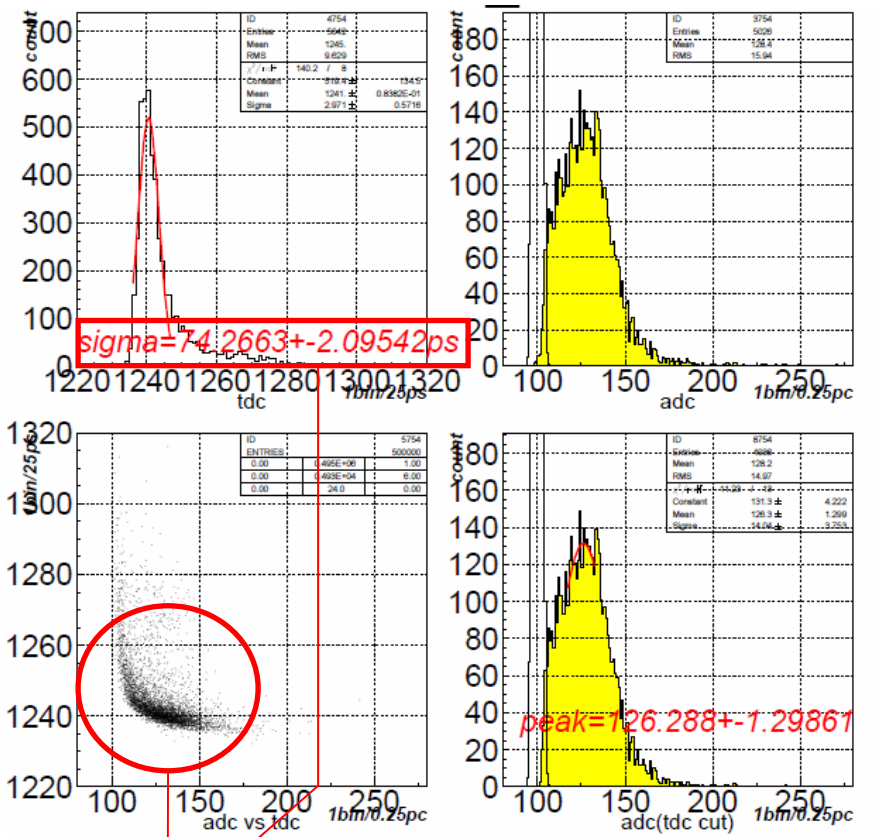
- HV divider + AMP + Discriminator
- Smaller size
  - $29mm^{W} \rightarrow 28mm^{W}$
- Prototype
  - Fast AMP (MMIC, 1GHz, x20)
  - Fast comparator (180ps propagation)
  - CFD with pattern delay
- Performance
  - Test pulse
    - ~5ps resolution
  - MCP-PMT
    - σ<40ps
    - Working well





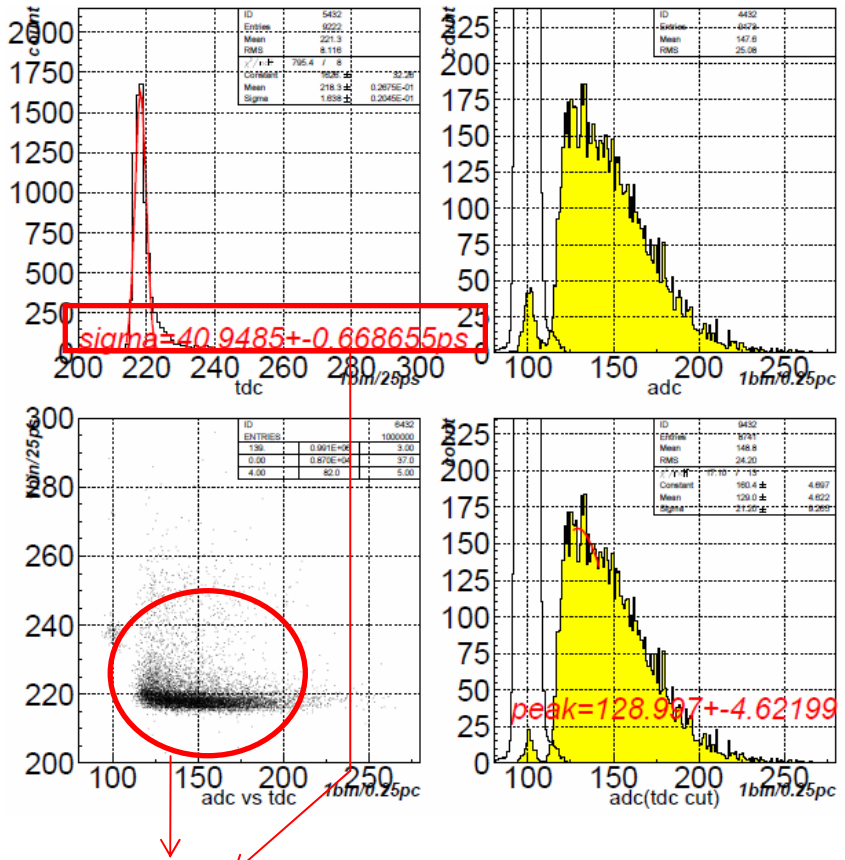
Performance with CFD

setup for reference



time walk
→need to be corrected

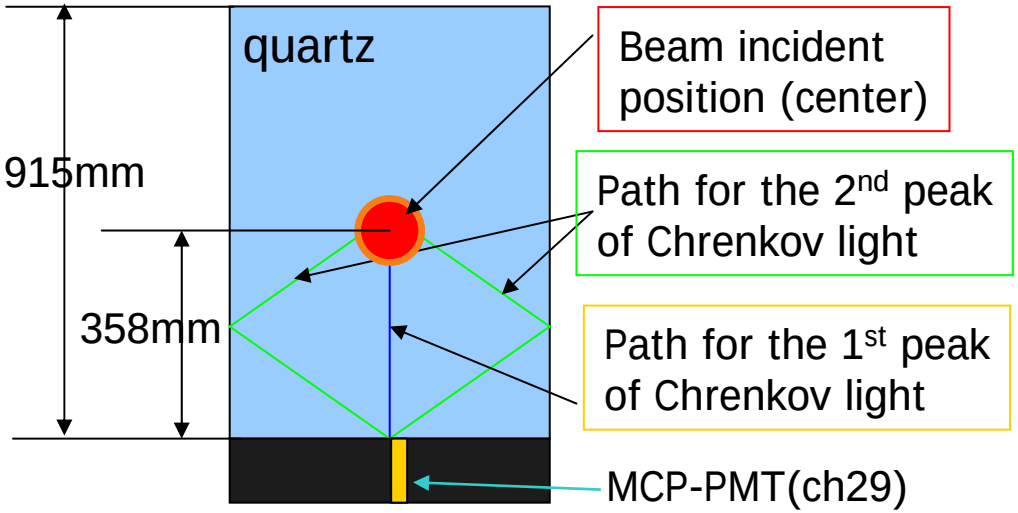
setup for confirming CFD ability

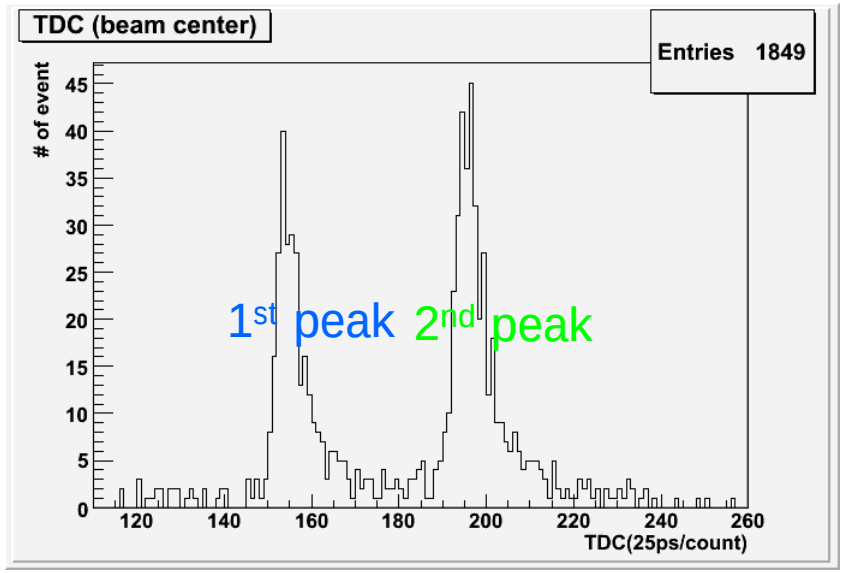


CFD works well!
It doesn't need ADC information.

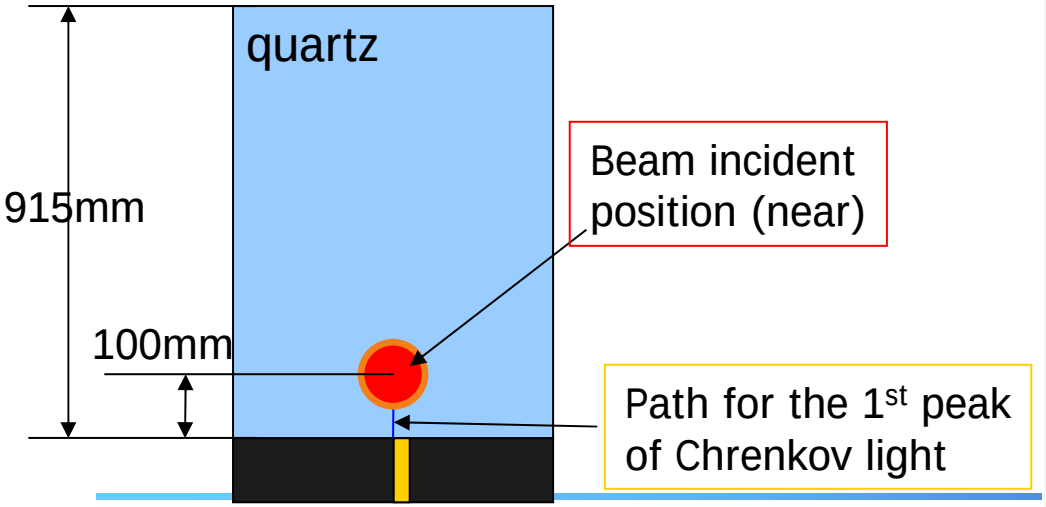
Beam test results

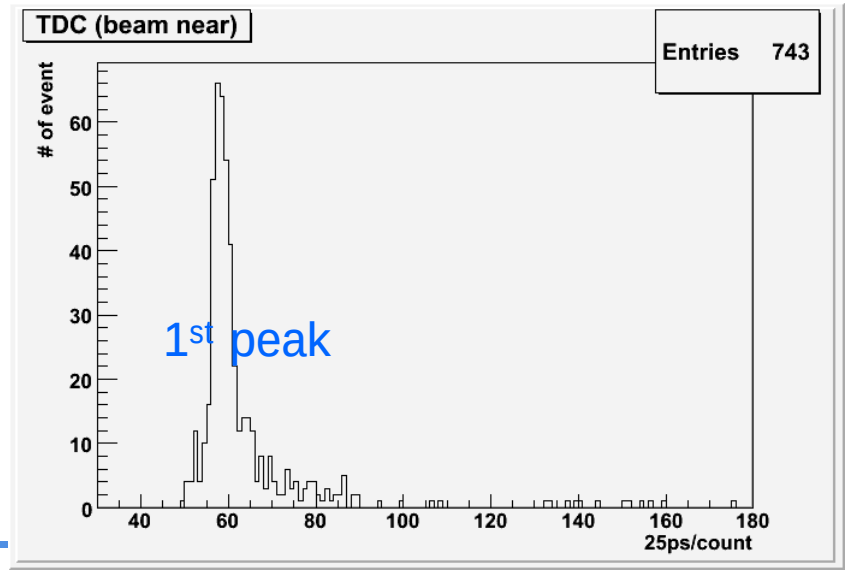
Beam incidence condition center





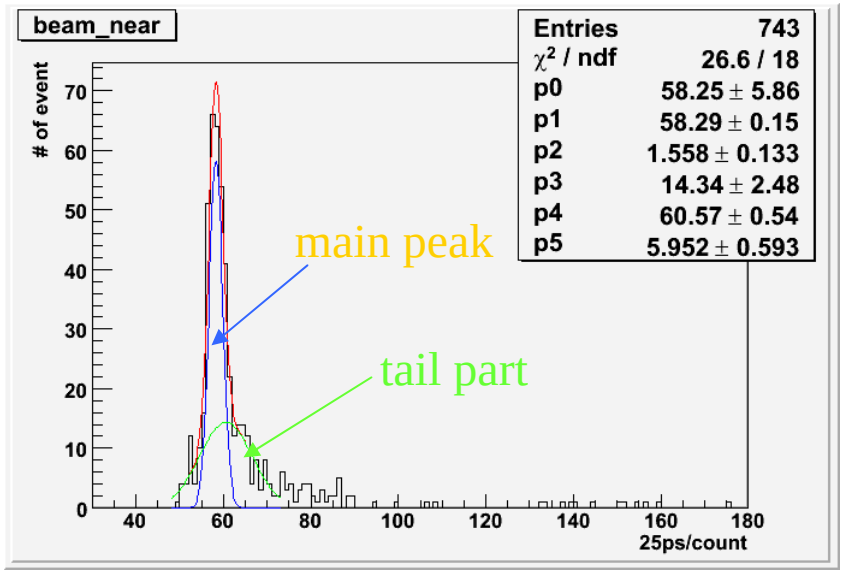
Beam incidence condition near





TDC distribution (near)

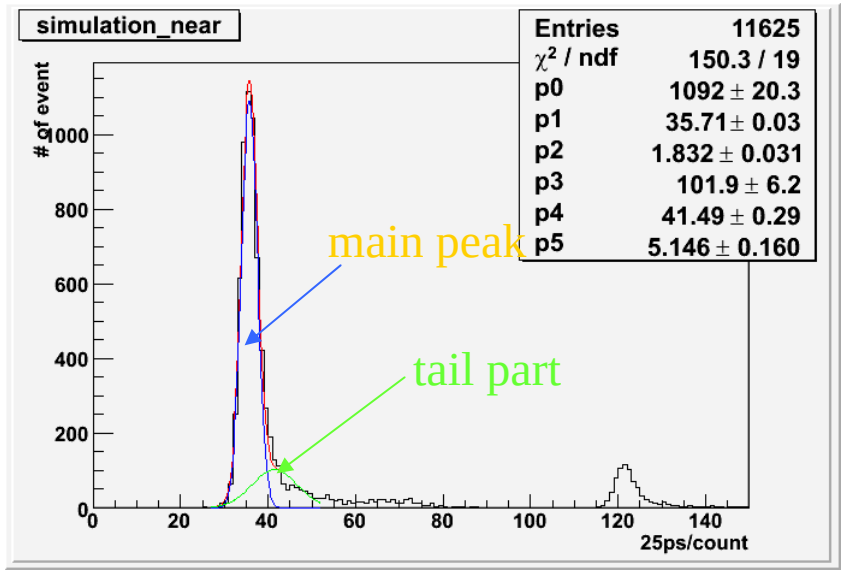
ch29 TDC (beam data)



area ratio of tail part : **47.5±9.4 [%]**

$\sigma_{\text{main peak}}$ **～38.9±3.4ps**

ch29 TDC (simulation data)

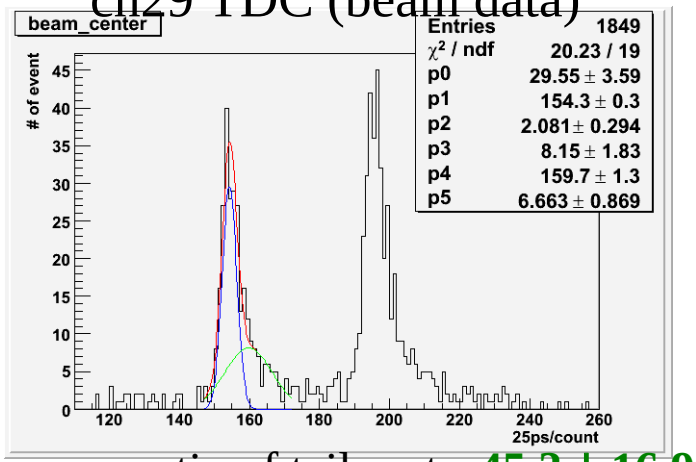


area ratio of tail part : **20.3±1.4 [%]**

$\sigma_{\text{main peak}}$ **～45.8±0.8ps**

TDC distribution (center)

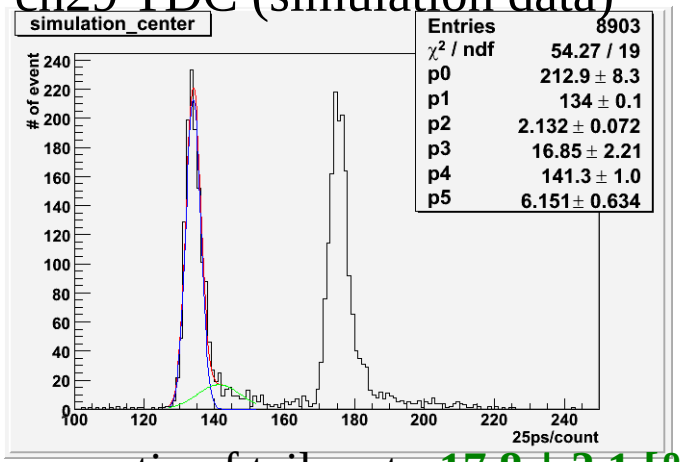
ch29 TDC (beam data)



area ratio of tail part : **45.3±16.9 [%]**

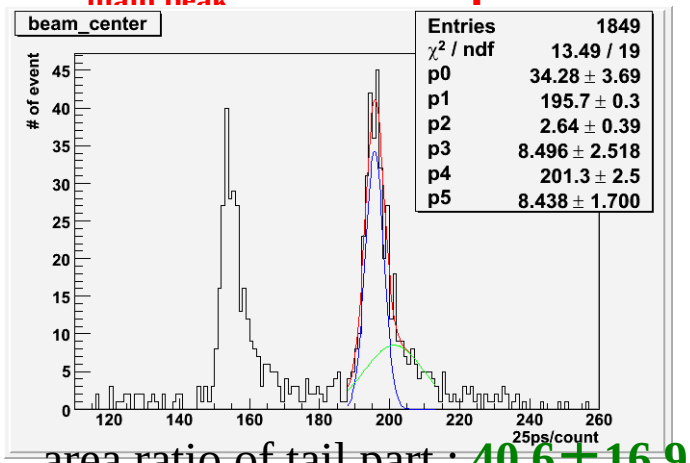
$\sigma_{\text{main peak}}$ **~52.0±7.4ps**

ch29 TDC (simulation data)



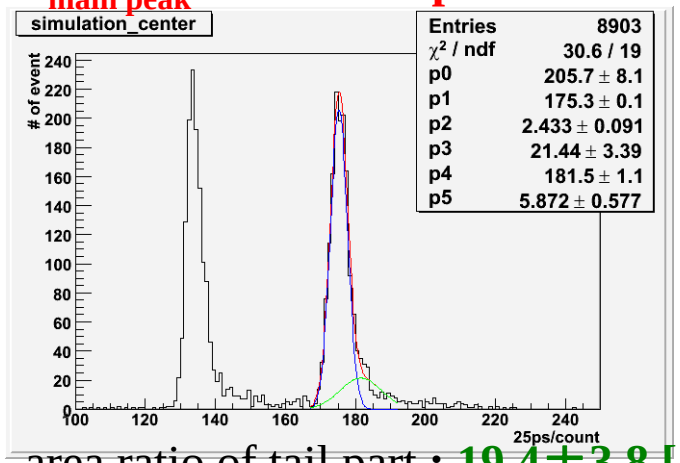
area ratio of tail part : **17.8±3.1 [%]**

$\sigma_{\text{main peak}}$ **~53.3±1.8ps**



area ratio of tail part : **40.6±16.9 [%]**

$\sigma_{\text{main peak}}$ **~66.0±9.8ps**



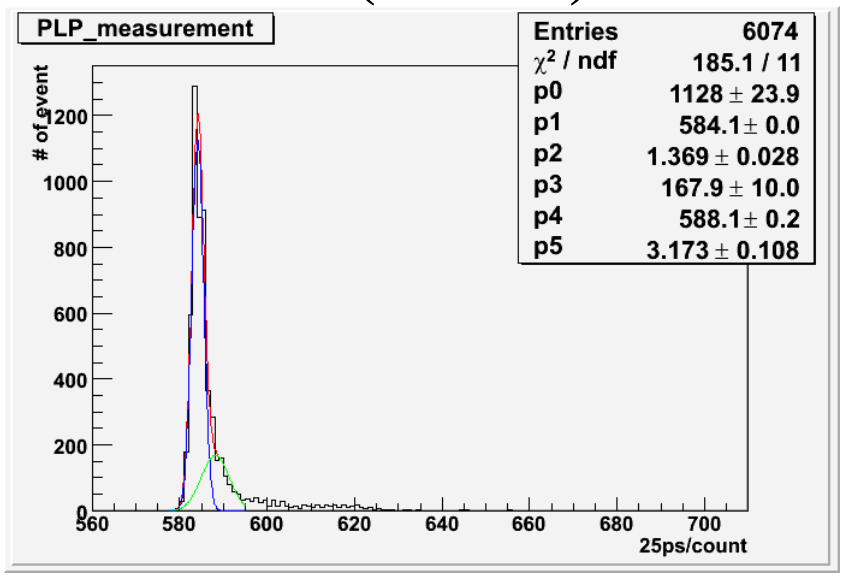
area ratio of tail part : **19.4±3.8 [%]**

$\sigma_{\text{main peak}}$ **~60.8±2.3ps**

TDC distribution with pulse laser

- Measure the TTS of MCP-PMT
  - With same readout electronics used at the beam test
  - With Pico-sec Light Pulsar (400nm)

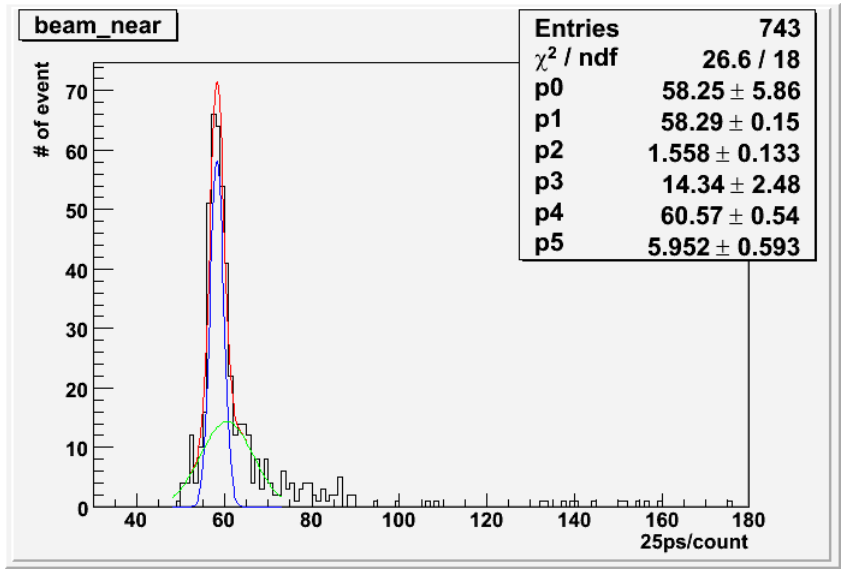
ch29 TDC (PLP data)



area ratio of tail part : **25.3±1.8 [%]**

$\sigma_{\text{main peak}}$ **~34.2±0.7ps**

ch29 TDC (beam data)



area ratio of tail part : **47.5±9.4 [%]**

$\sigma_{\text{main peak}}$ **~38.9±3.4ps**