Tests of MaPMT and electronics for Forward RICH

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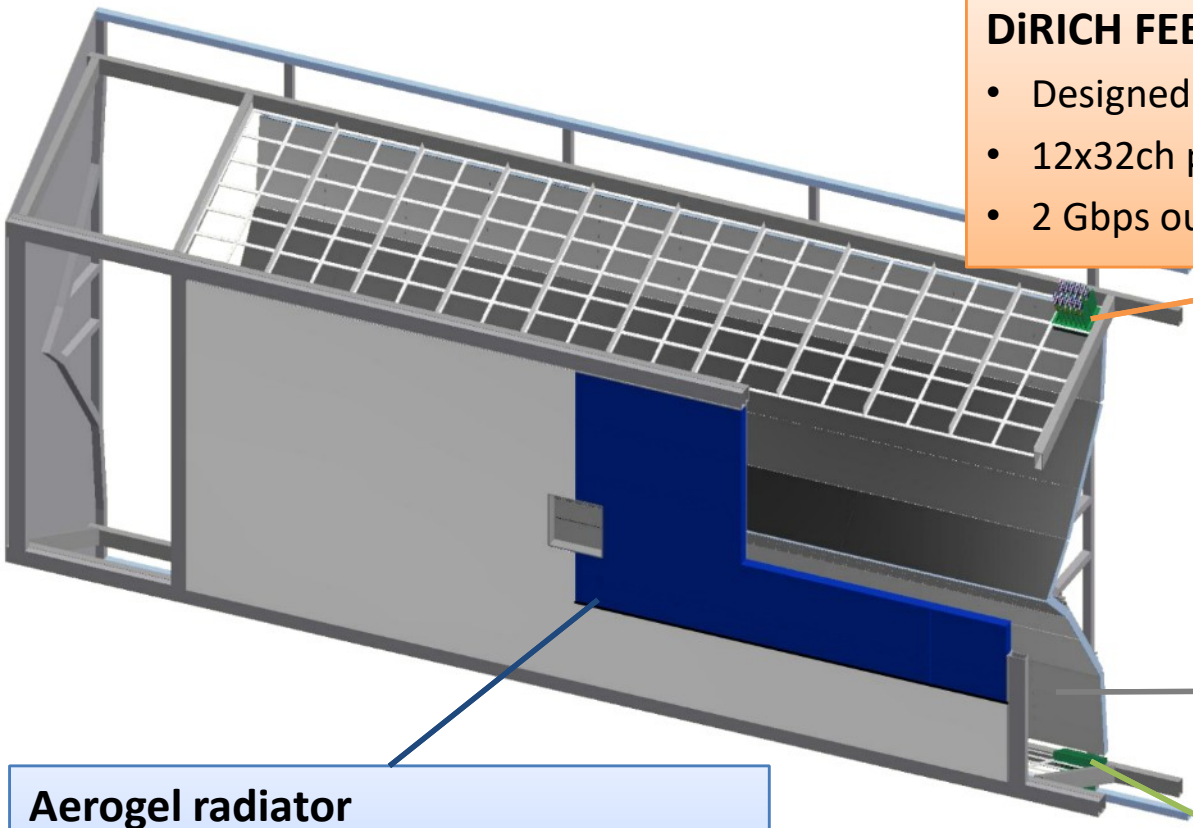
PANDA Forward RICH baseline design



DiRICH FEE (GSI)

- Designed for H12700 readout
- 12x32ch preamp+disc+TDC
- 2 Gbps output link

Mirrors

- 2 mm float glass
- Al+SiO_2 coating

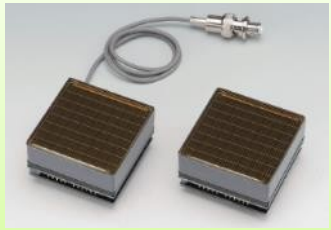
Aerogel radiator

- Focusing 2- or 3-layer aerogel
- n≈1.05
- 40 mm thick

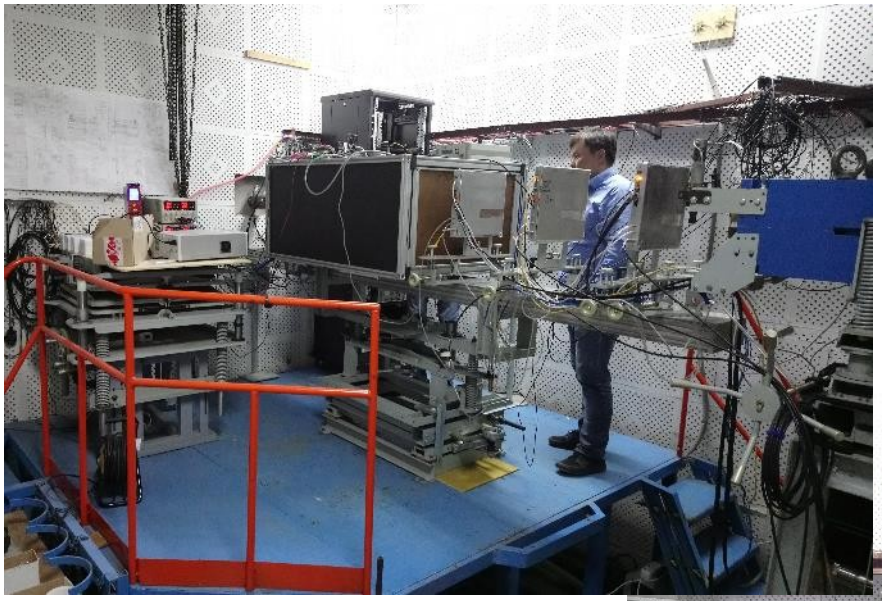
Photon Detector

H12700 MaPMTs (Hamamatsu)

- flat panel
- 8x8 anode pixels of 6mm size

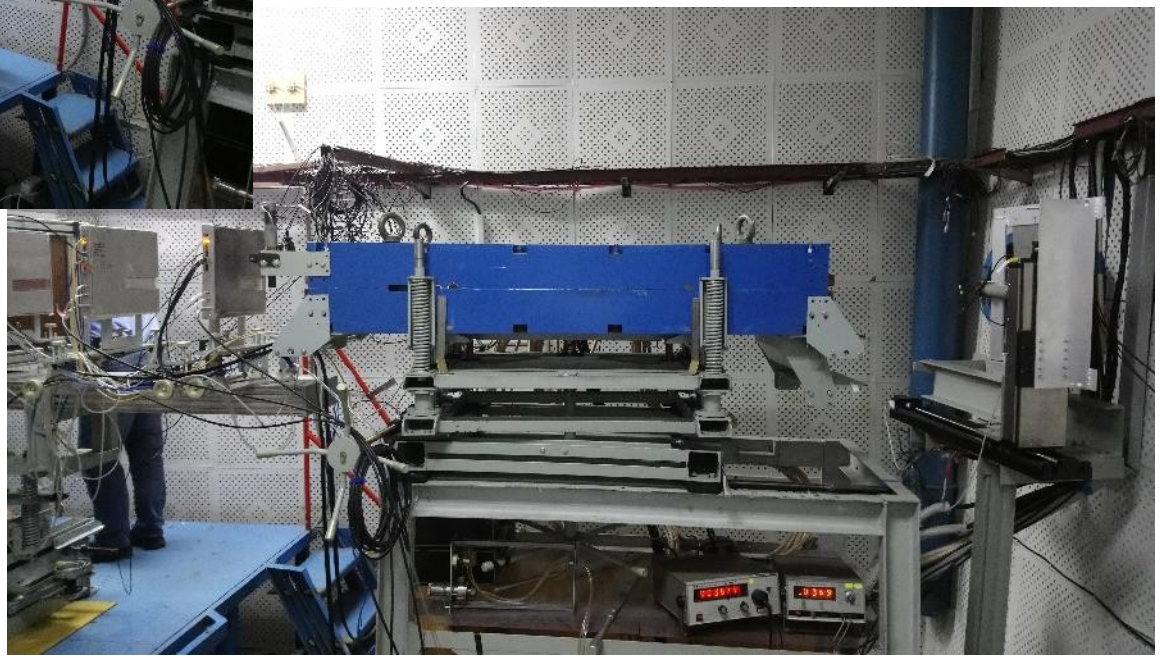


Test beam in June 2019

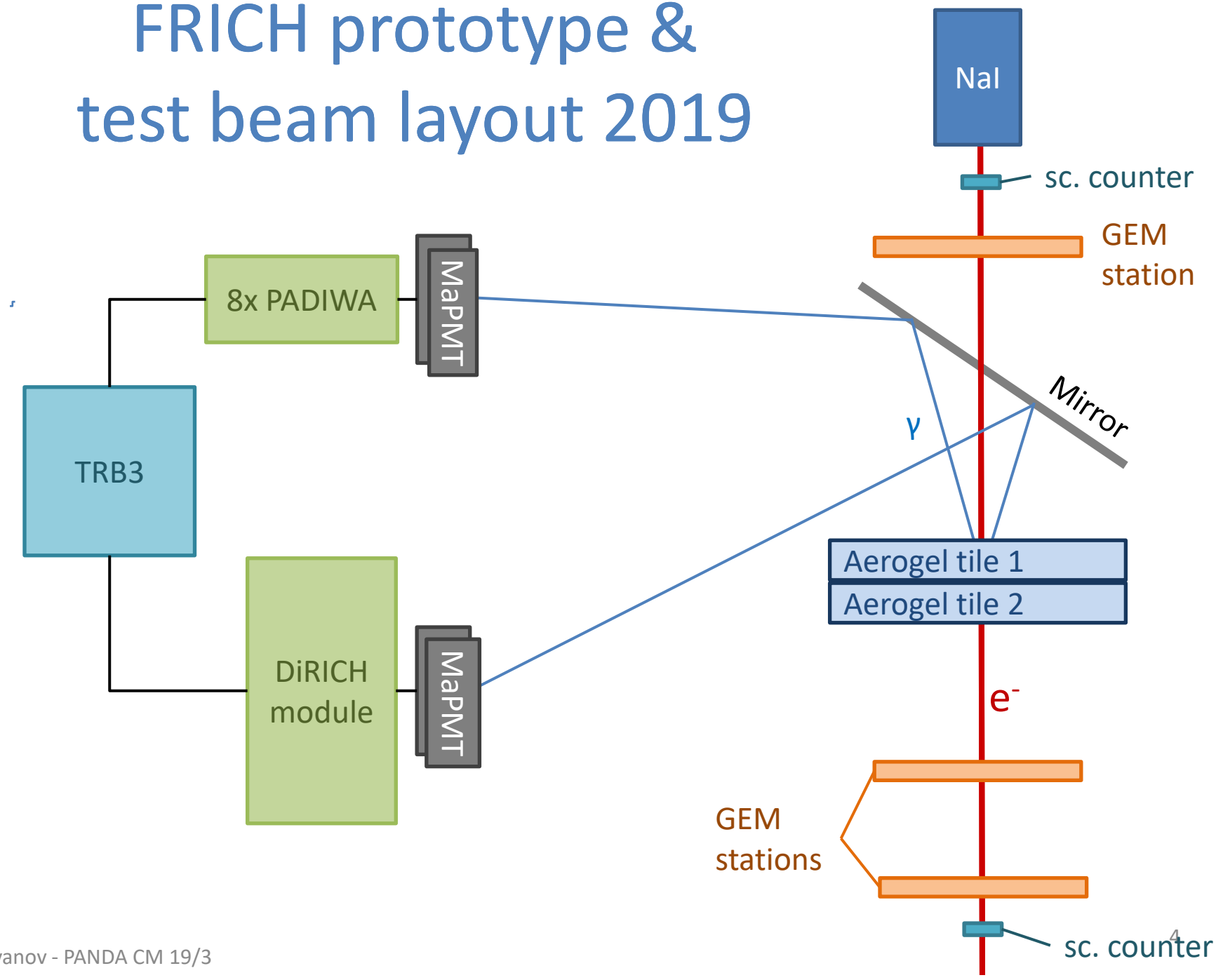


Electron and gamma test beam facility at BINP VEPP-4M accelerator

- 3 GeV electrons
- 2 scintillation counters for triggering
- 3 GEM tracker stations with 70-200 um resolution
- NaI calorimeter

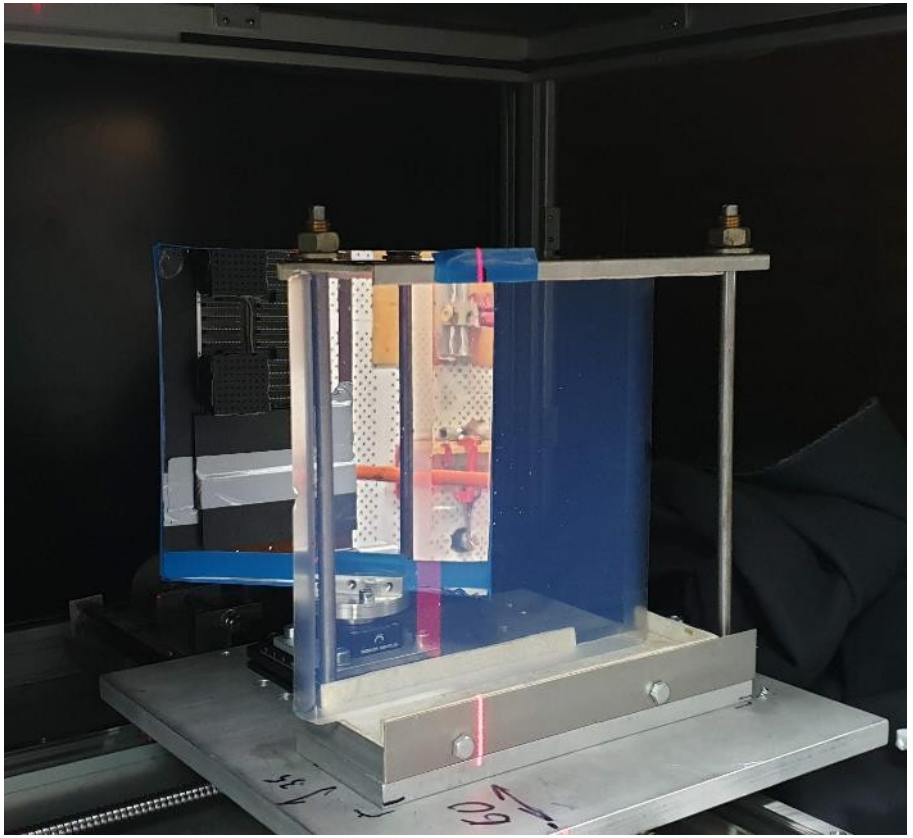


FRICH prototype & test beam layout 2019



Forward RICH prototype
June 2019

4 MaPMTs readout in half by PADIWA (128 ch) and DiRICH (128 ch)



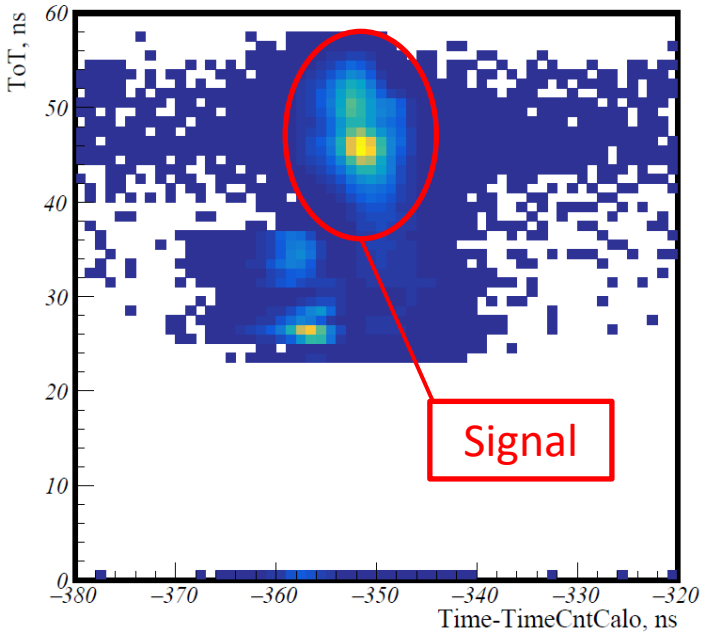
Aerogel sample with a flat mirror installed at 45° w.r.t. the PD and aerogel.

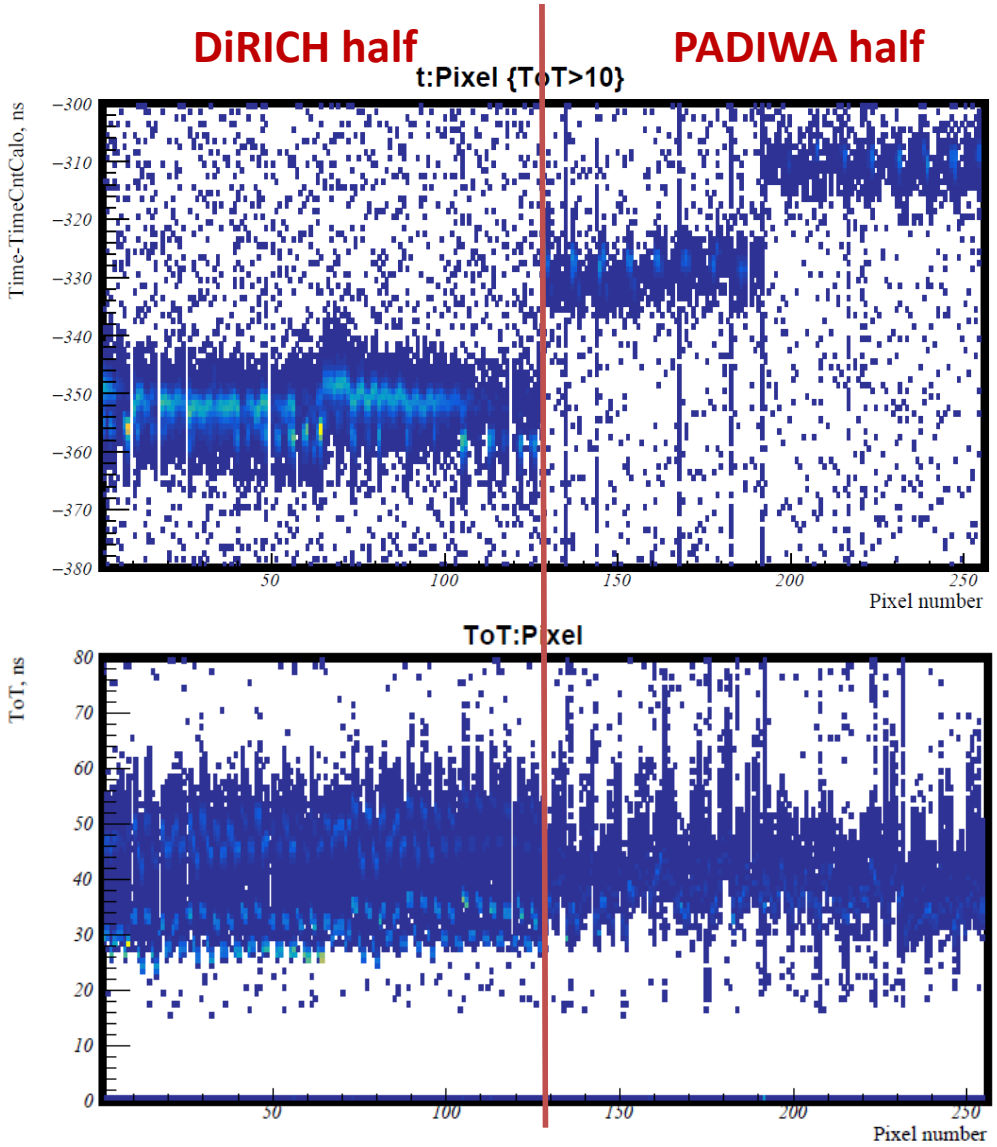
Time and ToT vs channel

test beam 2019

Timing is measured w.r.t. a scint. counter (~few ns resolution)

ToT vs Timing for DiRICH channels

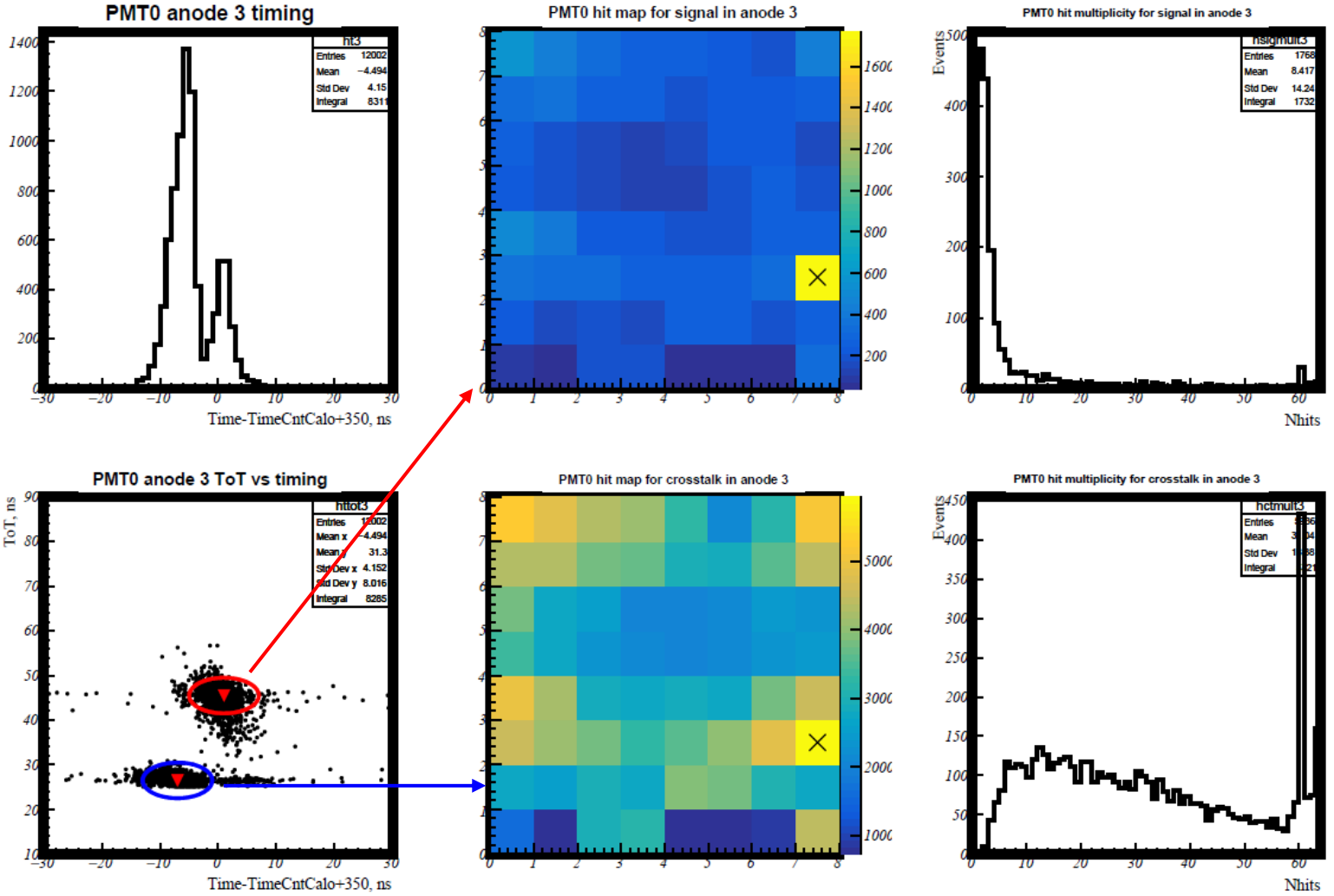




Cross talk issue in 2019

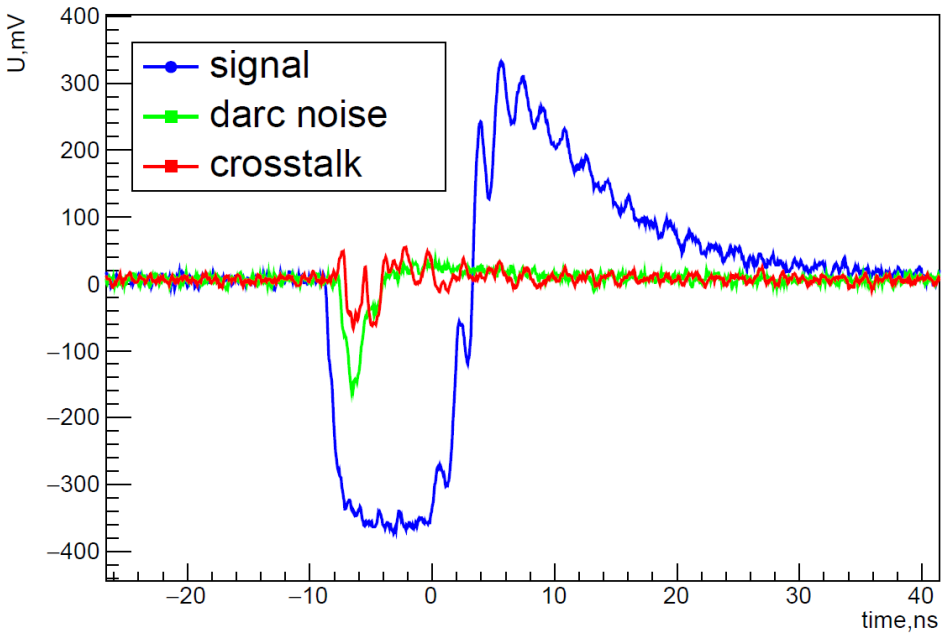
Signal coming later in time and have higher ToT

Crosstalk coming earlier in time and have lower ToT



Signal and crosstalk averaged waveforms

Pulsed illumination from a laser



- Light source: PiLas PiL051x, 510nm, Δt<140 ps
- Oscilloscope: Keysight MSOX6004A, 6 GHz BW with differential active probe N2752A, 6 GHz BW
- Signal viewed directly on illuminated anode, CT viewed on a distant anode
- All anodes connected to PADIWA

- Signal amplitude is ~20p.e.
- CT amplitude is about 2% of signal
- CT negative swing is delayed by a few ns w.r.t. signal at the same voltage level.

Test beam 2019 results

Performance averaged on the DiRICH channels only

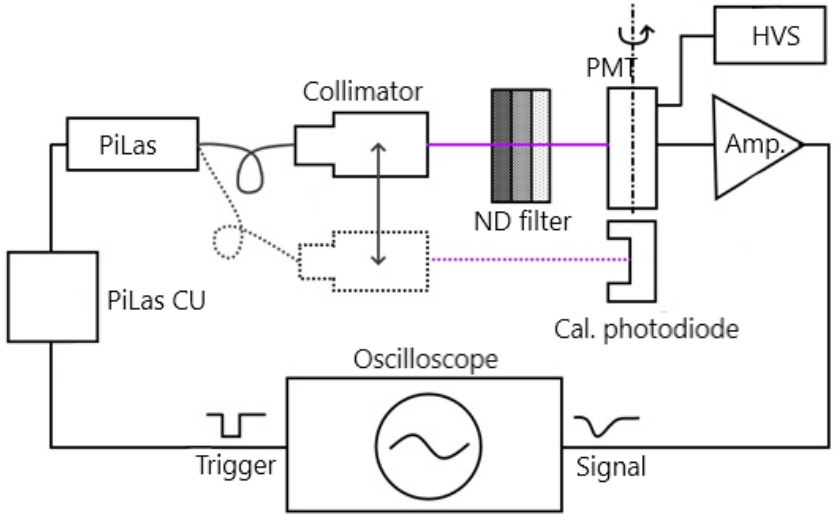
Radiator	Parameter	Test beam 2019	Calculation
Stack of 2 layers 2 cm, n=1.0526 + 2 cm, n=1.0500	N_{pe}	22	39
	R, mm	201	199
	σ_{1pe}(R), mm	3.31	3.08
Stack of 2 layers 2 cm, n=1.0538 + 2 cm, n=1.0511	N_{pe}	21	40
	R, mm	203	201
	$\sigma_{1p.e.}$(R), mm	3.25	3.11
Single layer 2 cm, n=1.0538	N_{pe}	15	26
	R, mm	204	201
	σ_{1pe}(R), mm	3.24	3.17

1.8 times less

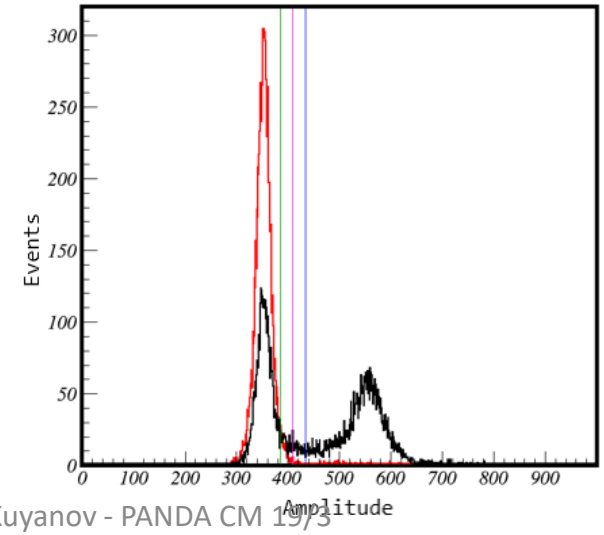
Effects in the calculation: aerogel chromaticity, Rayleigh scattering, radiator thickness, pixel size, 80% efficiency factor (reflectance, light loss at aerogel surface).

Effects left out of the calculation: tracking resolution, multiple scattering, anode charge sharing, aerogel inhomogeneity, FEE efficiency, non-gaussian shape of dN_{pe}/dR.

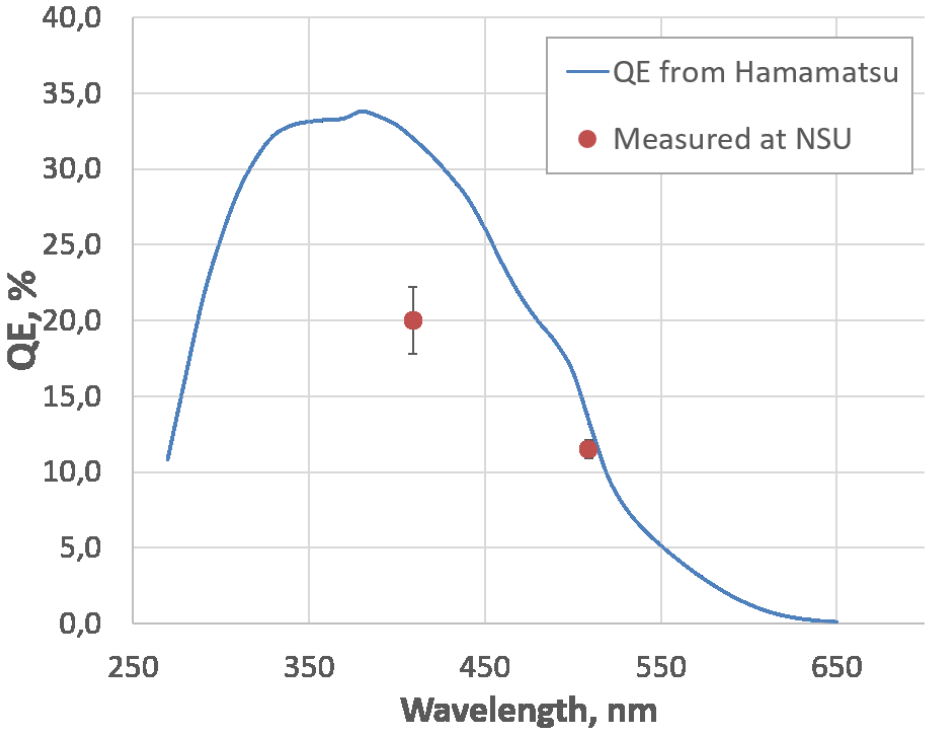
Absolute QE of MaPMT H12700



Charge amplitude spectrum

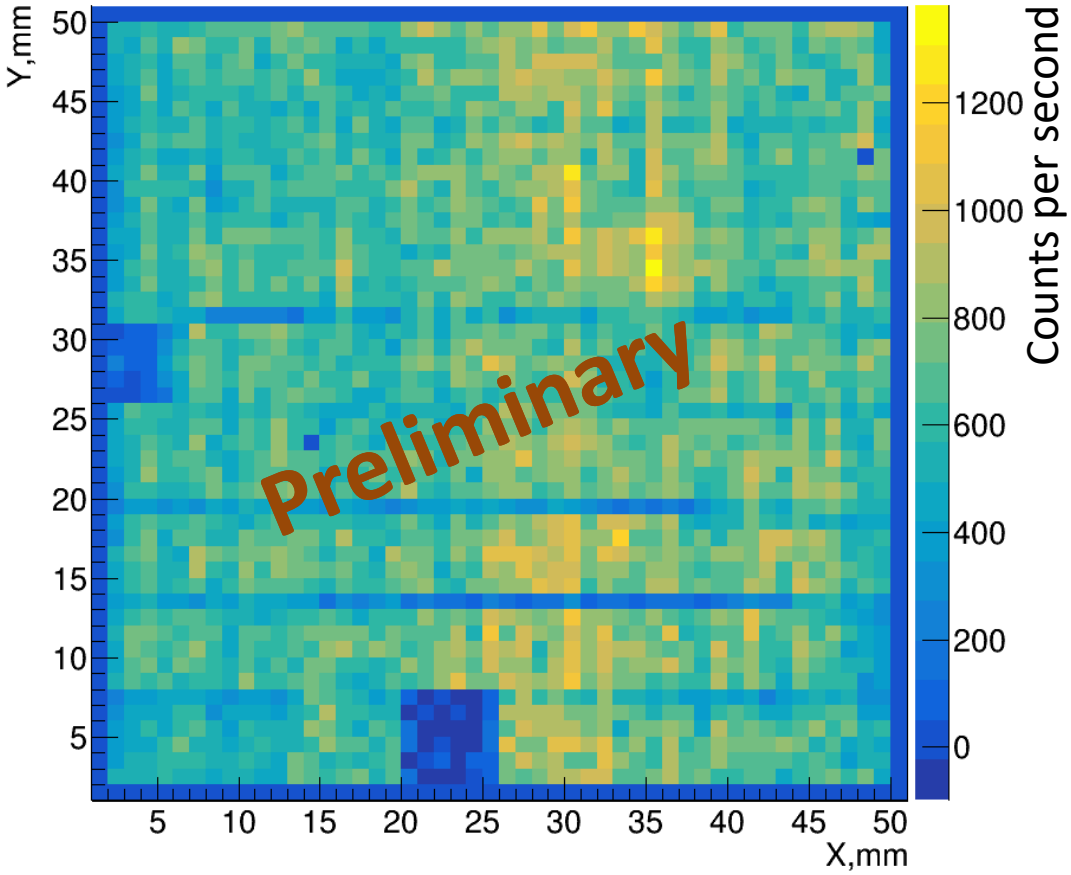


$$QE = \frac{N_{p.e.}}{N_\gamma} \qquad N_{p.e.} = -\ln \frac{N_0^{signal}}{N_0^{noise}}$$



To do: MaPMT QE is to be scanned on wavelength and area

MaPMT H12700 efficiency uniformity first scan



- Light source: PiLas PiL051x, 510nm, Δt<140 ps
- PADIWA readout
- Laser spot size ~0.5mm
- Scan pitch 1mm
- Positioning accuracy 20µm
- Counts of illuminated pixels are shown

Conclusion and outlook

- Forward RICH prototype with 4 MaPMTs and DiRICH & PADIWA & TRB3 readout was assembled and tested with the electron test beam at BINP in June 2019
- Low number of photoelectrons observed in test beam points to lower MAPMT QE than expected
- First measurement of MAPMT QE with a laser showed 1.6x lower QE for 409 nm than in the datasheet
- First MAPMT efficiency uniformity scan with a pulsed laser illumination was carried out
- Scan using continuous illumination from a monochromator is to be carried out