

Performance Evaluation of 50-cm Photodetectors for Hyper-Kamiokande

Jun 2014 Neutrino 2014 at the GSU on Boston University's Charles River Campus

M.Kuze, M.Ishitsuka (Titech), Y.Hayato, S.Nakayama, Y.Nishimura, H.Tanaka, M.Shiozawa (ICRR), Y.Suda, H.Aihara, M.Yokoyama (Univ. of Tokyo), S.Hirota, M.Jiang, A.Minamino, T.Nakaya (Kyoto University), Y.Kawai, T.Ohmura, M.Suzuki (HPK), A.Taketa (ERI)

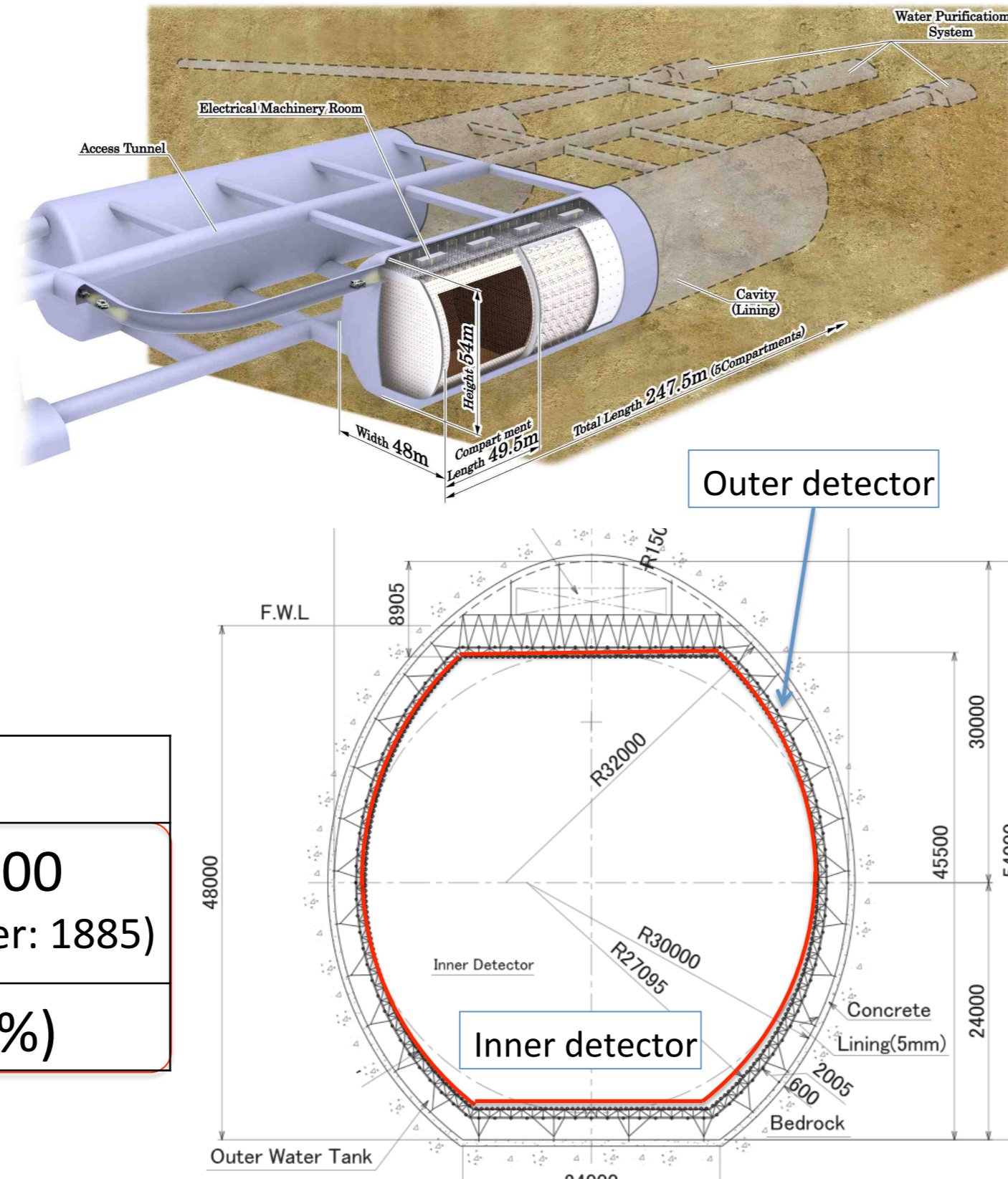
Yuji Okajima (Tokyo Institute of Technology)

Hyper-Kamiokande

- A future plan of ν experiments with 1 M-ton water Cherenkov detector.
- High sensitivity with much statistics because of the large size.

Purpose of use

- Accelerator, solar, and atmospheric neutrino measurement.
- Proton decay search
- Study about Astro-particle physics (Measurement of supernova neutrino etc.)
- etc.



Volume	0.99 M-ton
Number of photodetectors	Inner: ~99000 Outer: ~25000 (Super-Kamiokande: Inner: 11146 Outer: 1885)
Coverage	20 % (Super-Kamiokande: 40%)

Required to develop new photodetectors with better performance and lower cost than Super-Kamiokande (SK) PMT
(As a countermeasure for the cost of large number of photodetector and performance decrement from the small coverage)

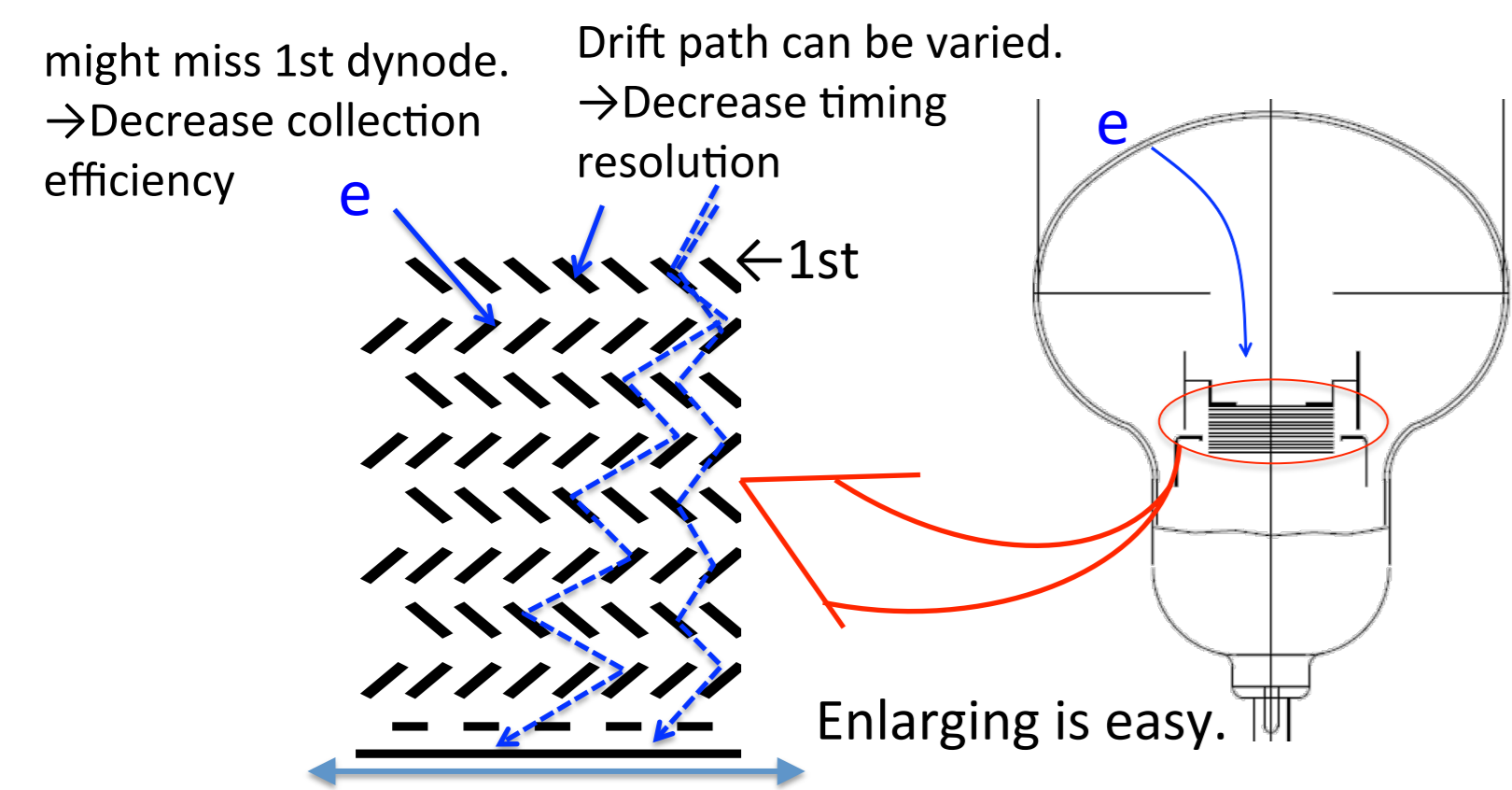
Photodetectors for Hyper-Kamiokande

There are 3 candidates for photodetectors of Hyper-Kamiokande. 50 cm ϕ Box and Line type PMT and Hybrid Photodetector (HPD) are under development.

The photodetectors below have higher QE (30%) than SK PMT (22%)

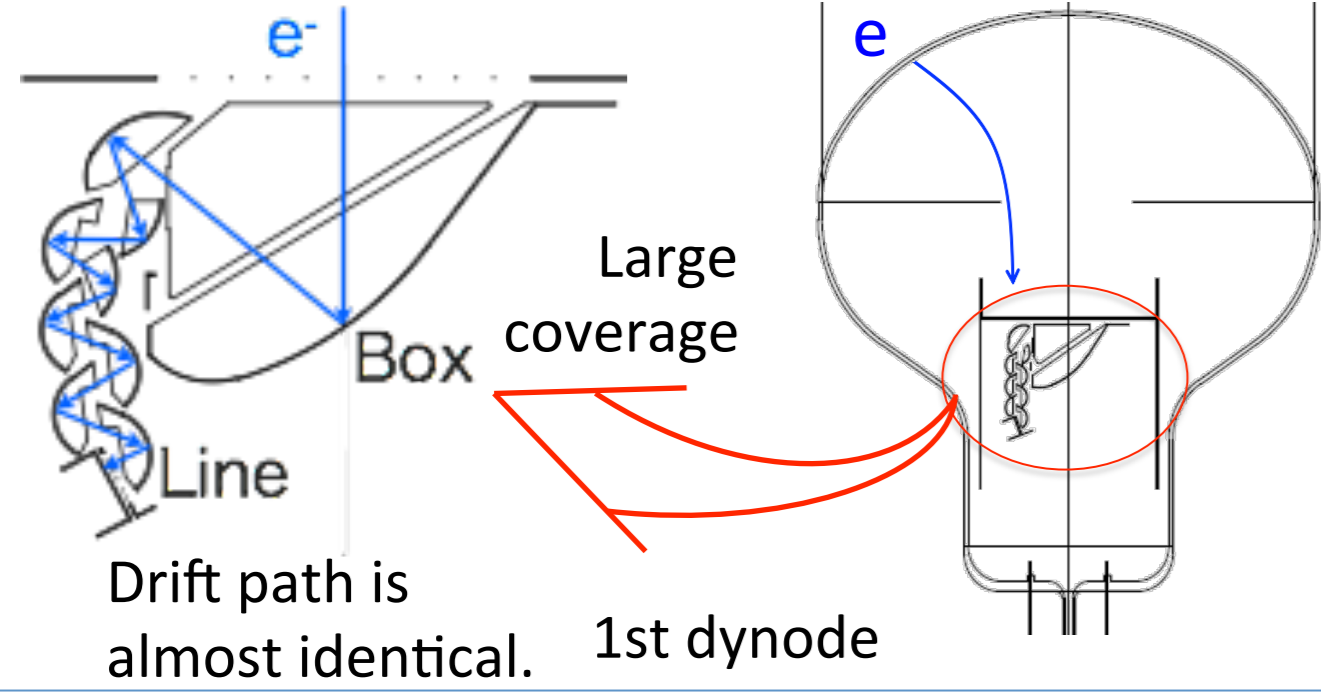
Venetian blind type PMT(Super-K)

- Used in Super-K for 18 years and the performance is established and reliable.
- The high QE prototype has been already made.



Box and line type PMT (New for 50 cm ϕ)

- PMT with different type dynode

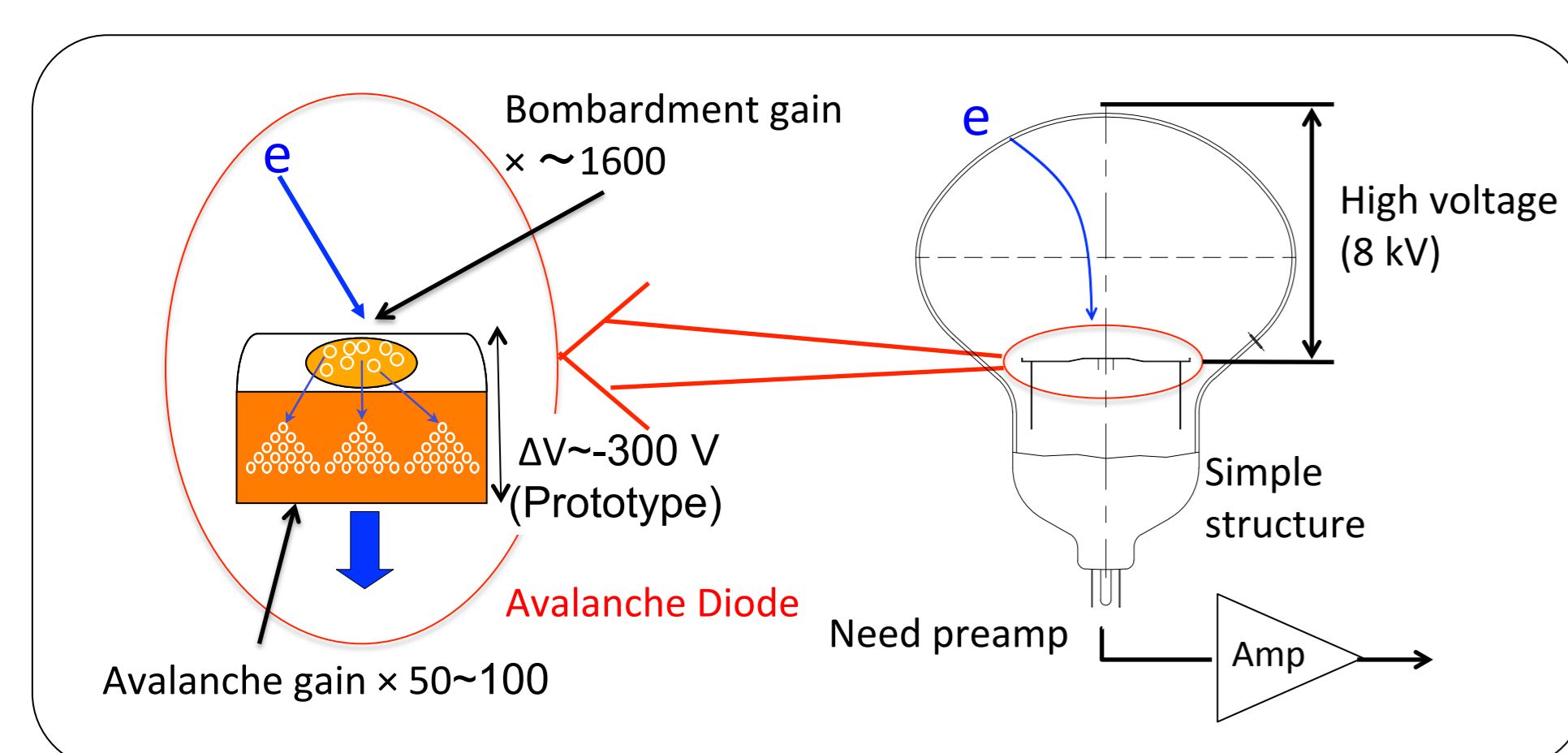


Feature

- High collection efficiency by box shape 1st dynode
- Fast time response by linear focused dynode

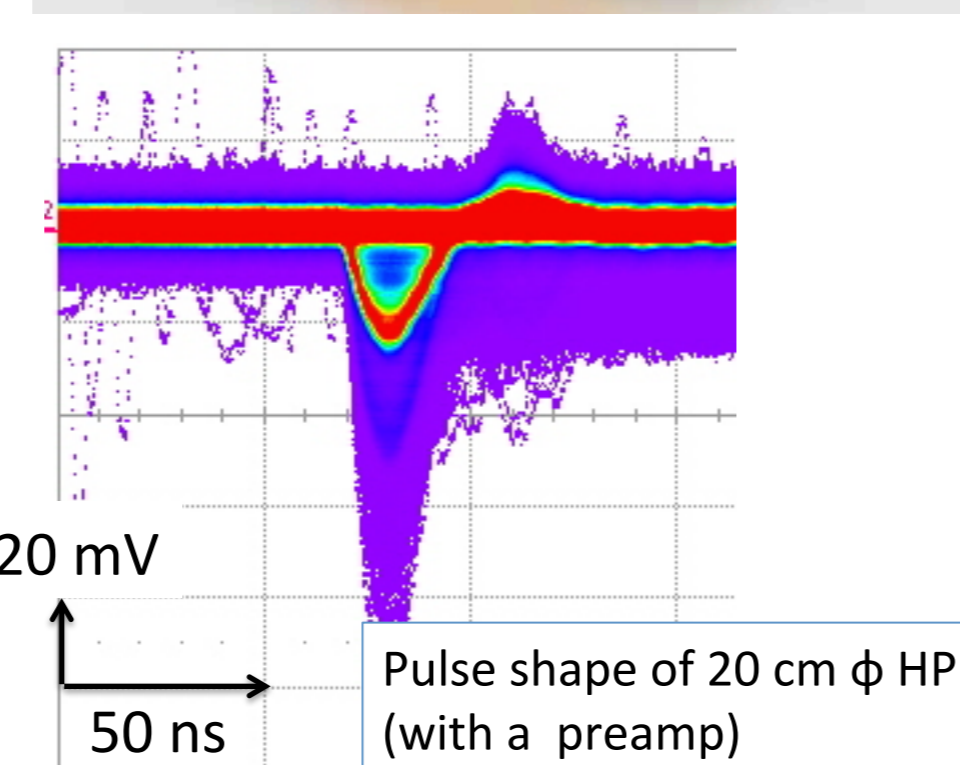
Hybrid Photo Detector (HPD)

Photodetector with avalanche diode instead of dynode



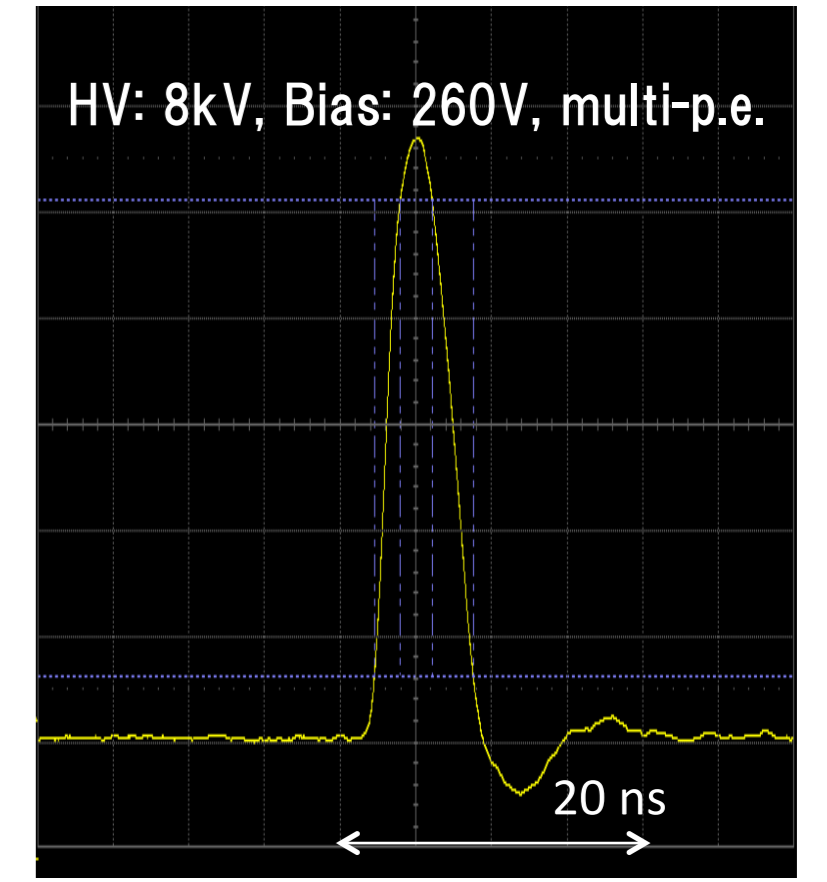
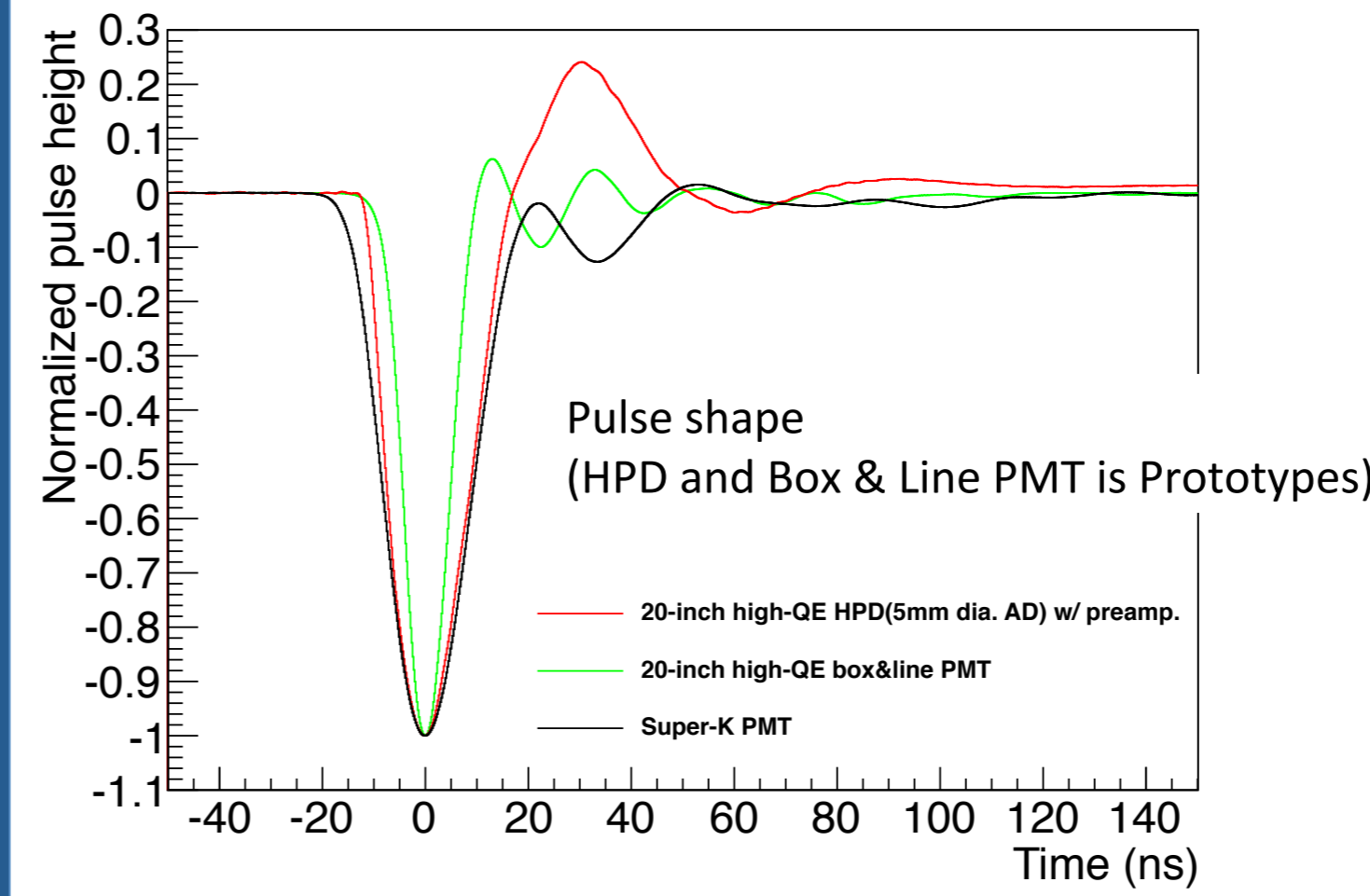
Feature

- Simple structure and low cost
- The HV is higher than PMT
- Good signal resolution



Performance

We evaluated some basic performance of the prototype of 50 cm ϕ HPD with 5mm ϕ Avalanche Diode (AD) and preamp, and Box & Line PMT (20 mm ϕ AD in the final design HPD)

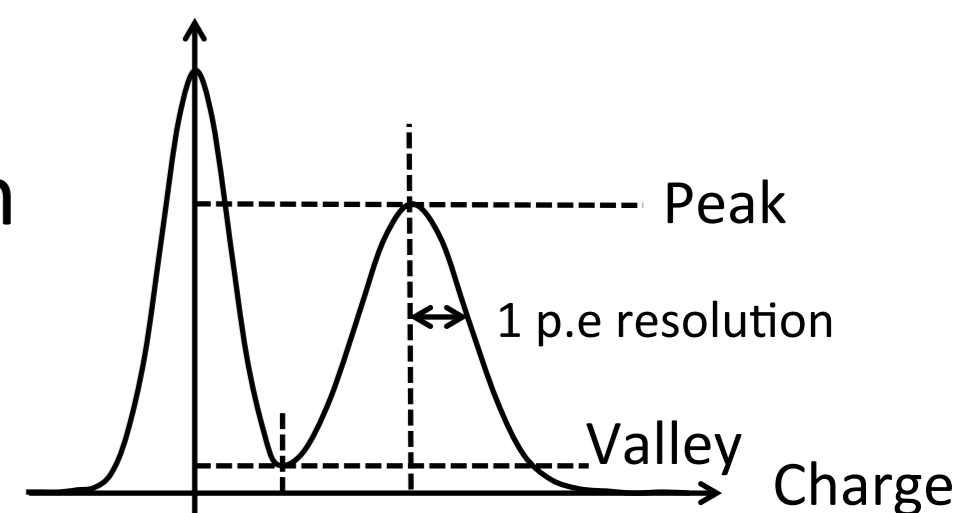


20 cm ϕ HPD w/o preamp
 rise time: 1.7 ns, fall time: 2.7 ns

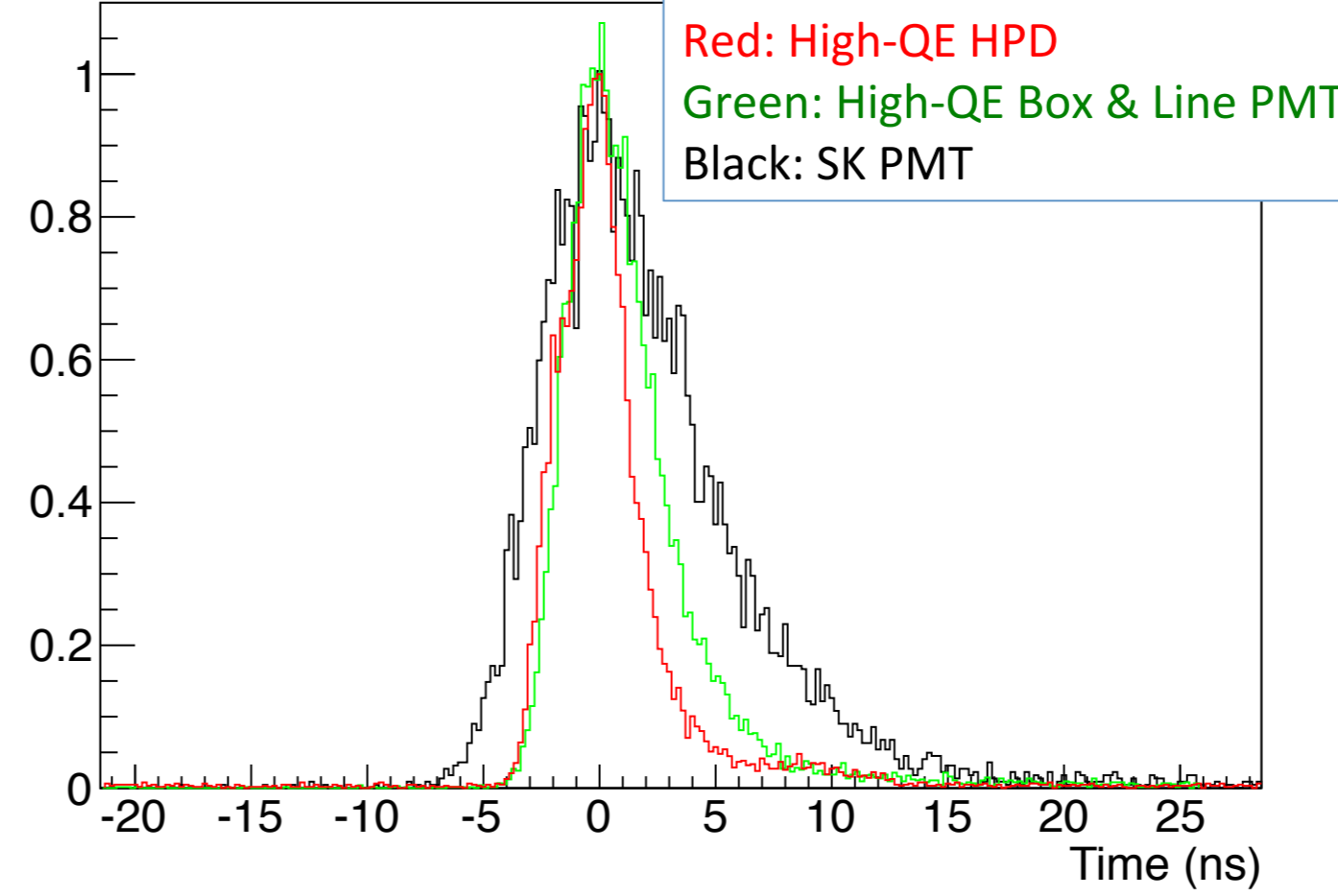
HPD and Box & Line PMT have faster response than that of Super-K PMT.

Pulse width	HPD (w/ amp)	Box & Line PMT	SK PMT
Rise Time	7.4 ns	6.2 ns	10.6 ns
Fall time	11.5 ns	6.3 ns	13.1 ns
Pulse Width	25.5 ns	16.7 ns	31.4 ns

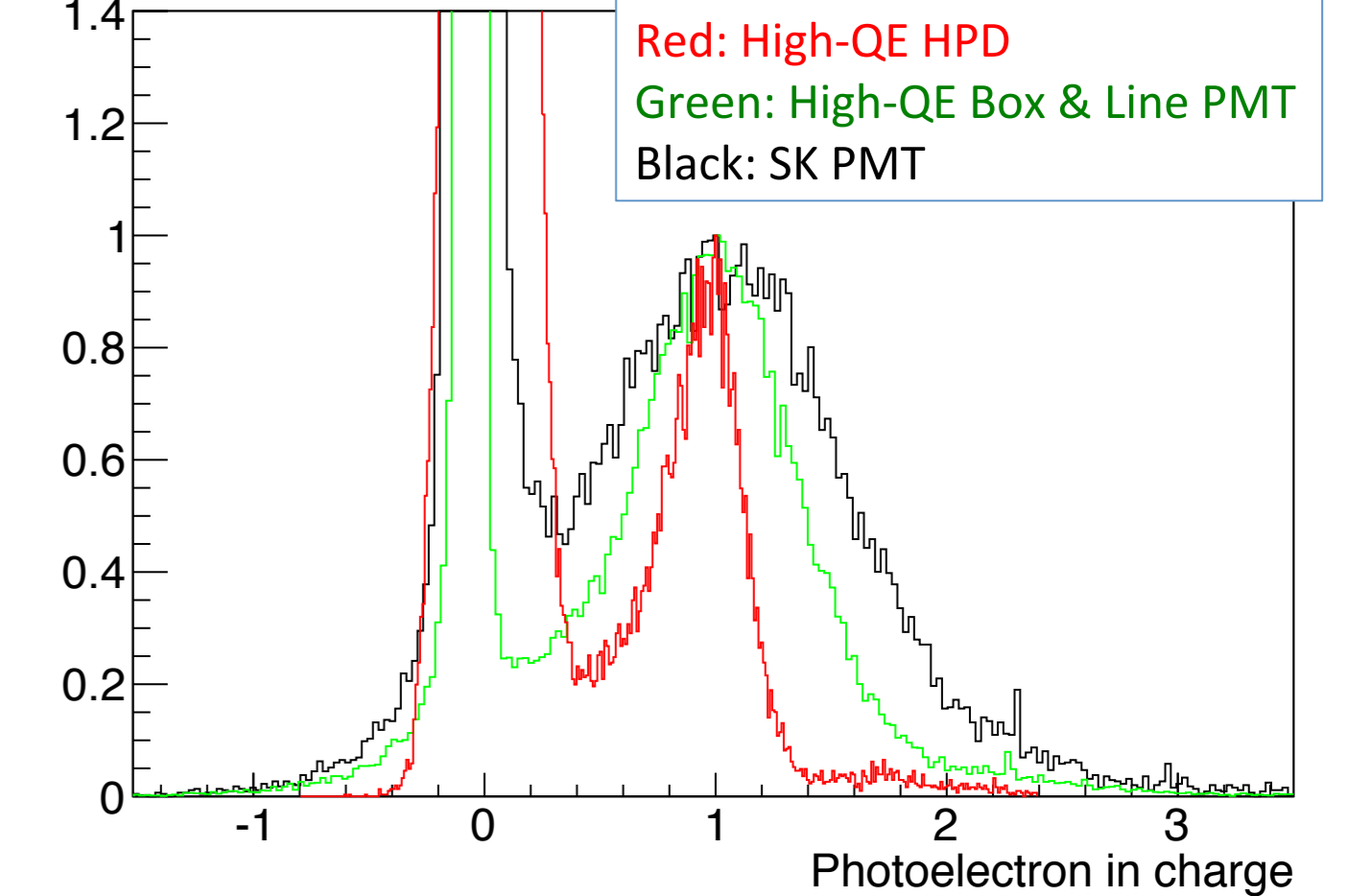
Box & Line PMT and HPD have better 1p.e resolution and timing resolution.



Transit Time Spread (TTS)



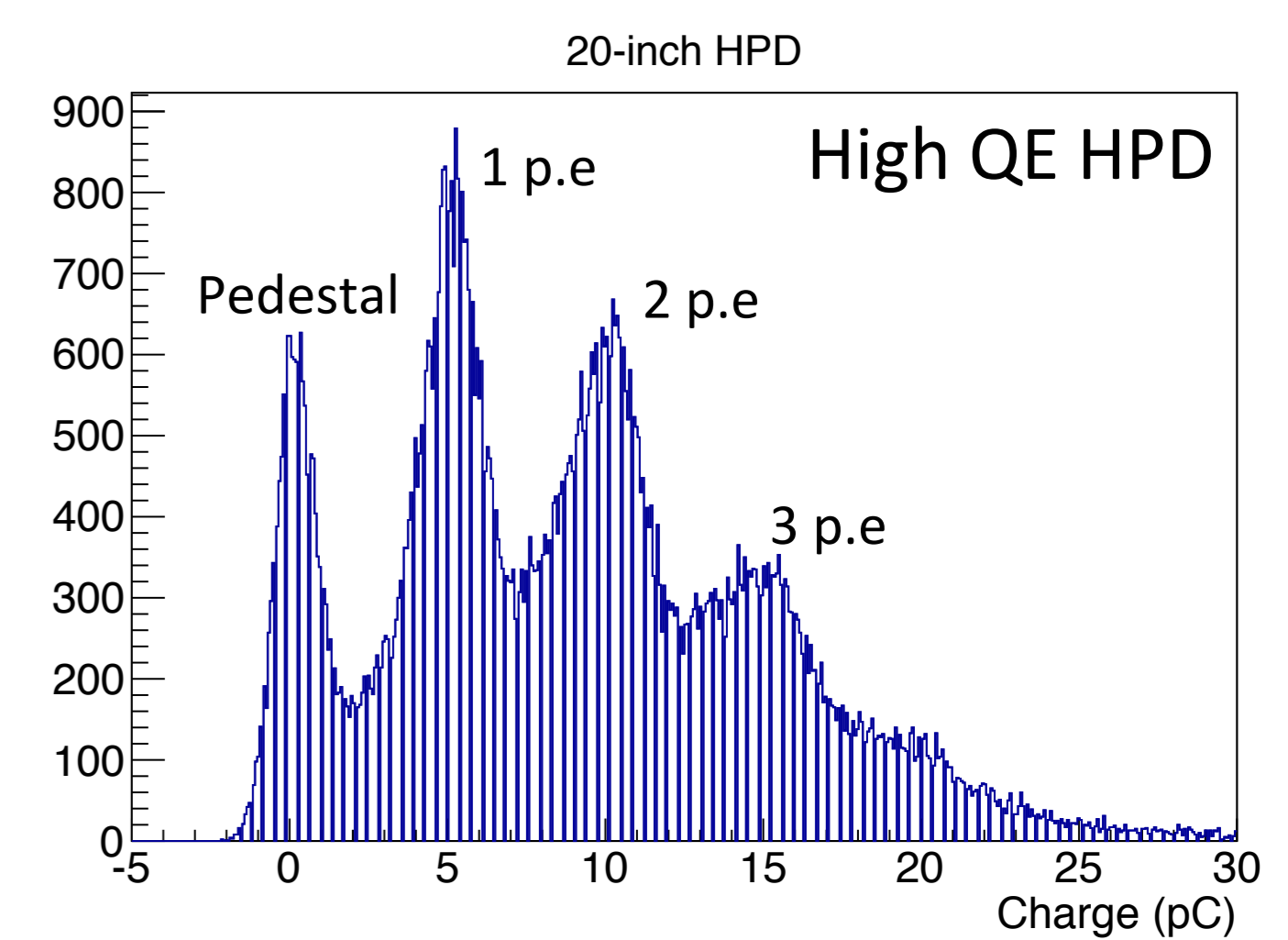
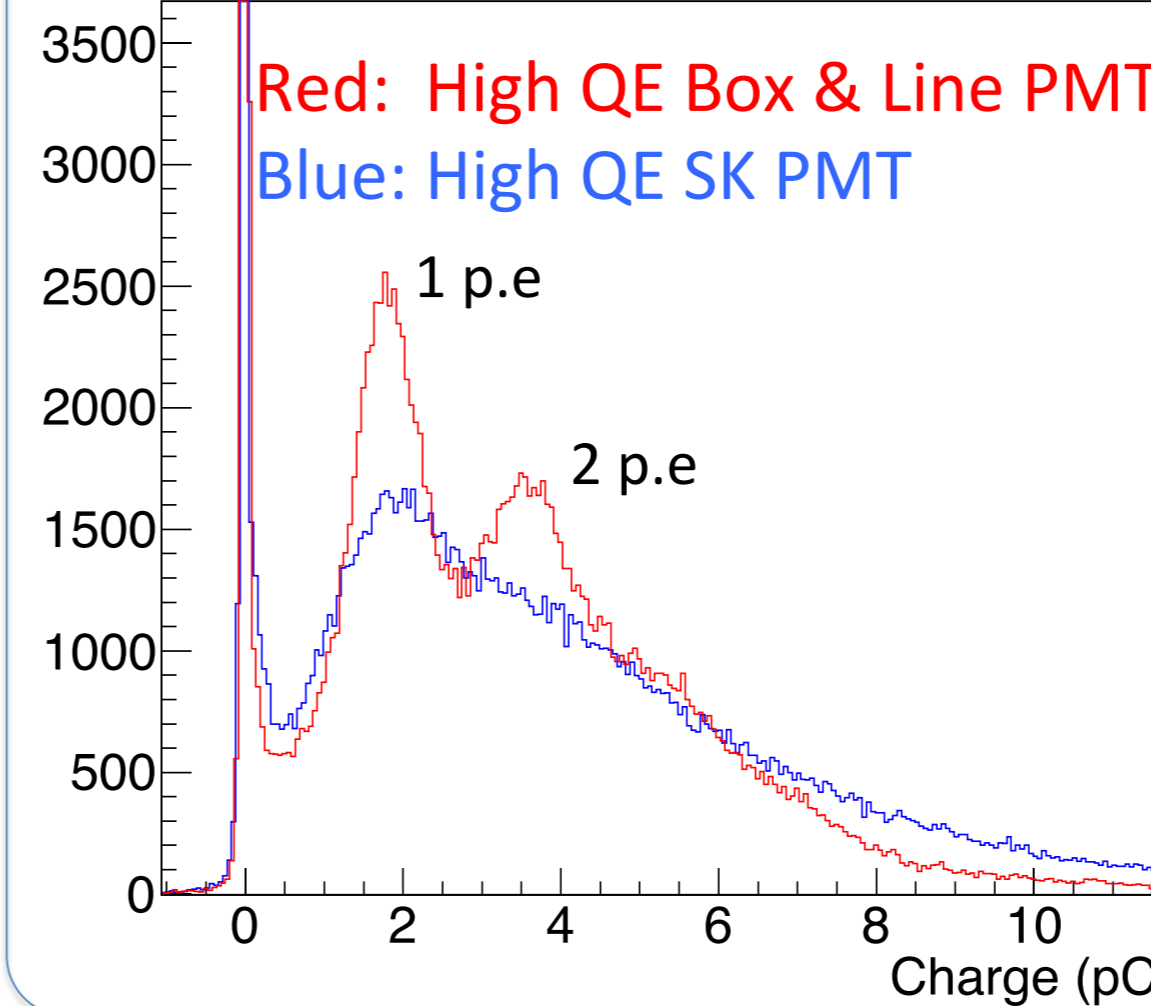
1p.e Distribution



	HPD (w/ preamp)	B&L PMT	SK PMT
1 p.e resolution (σ/μ)	16%	35%	53%
Peak/valley	3.9	4.3	2.2
FWHM of TTS (measured)	3.4 ns	4.1 ns	7.3 ns
FWHM of TTS (calculated)	0.75 ns (w/o preamp)	2.7 ns	5.5 ns

The timing resolution of HPD becomes worse in the preamplifier (From the intrinsic resolution)

Multi-p.e. distribution



Multi photoelectron peaks can be identified in HPD and Box & Line PMT

Conclusion

- We are developing new 50-cm ϕ photodetectors
 - Evaluation first performance of these prototypes
 - Better performance (pulse shape, timing resolution, 1 p.e resolution) of new photodetectors was confirmed than the Super-K PMT.
- New preamplifier for 20 mm ϕ avalanche diode is under development to improve the performance
- Box & Line PMT is ready for a test in water tank that will start in summer 2014
- We will evaluate 50 cm ϕ photodetectors performance in more detail
 - Gain dependence on temperature and magnetic field, after pulse noise, uniformity of gain and efficiency and so on