

Hyper-Kamiokande

Hyper-Kamiokande (Hyper-K) is a large water Cherenkov detector planned at Kamioka, Japan. It allows more sensitive research into many neutrino physics topics as an extension of Super-Kamiokande (Super-K). The candidate site is about **8 km south** of Super-K **under 648 m** of rock. The fiducial volume of Hyper-K is **25 times larger** than that of Super-K. We are considering a **possible upgrade of photodetectors** as well.

► Details in arXiv:1109.3262 [hep-ex] (15 Sep 2011) "Letter of Intent : The Hyper-Kamiokande Experiment - Detector Design and Physics Potential -"

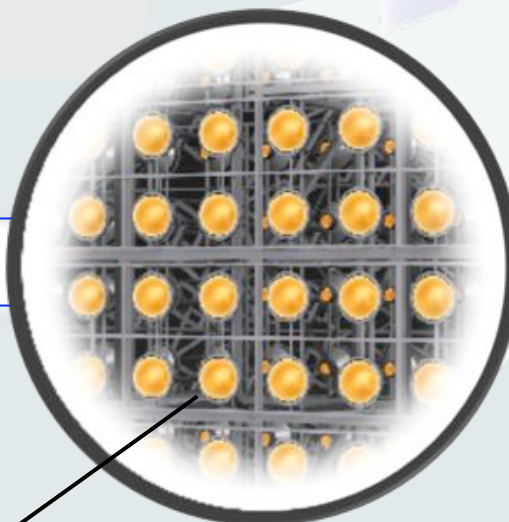
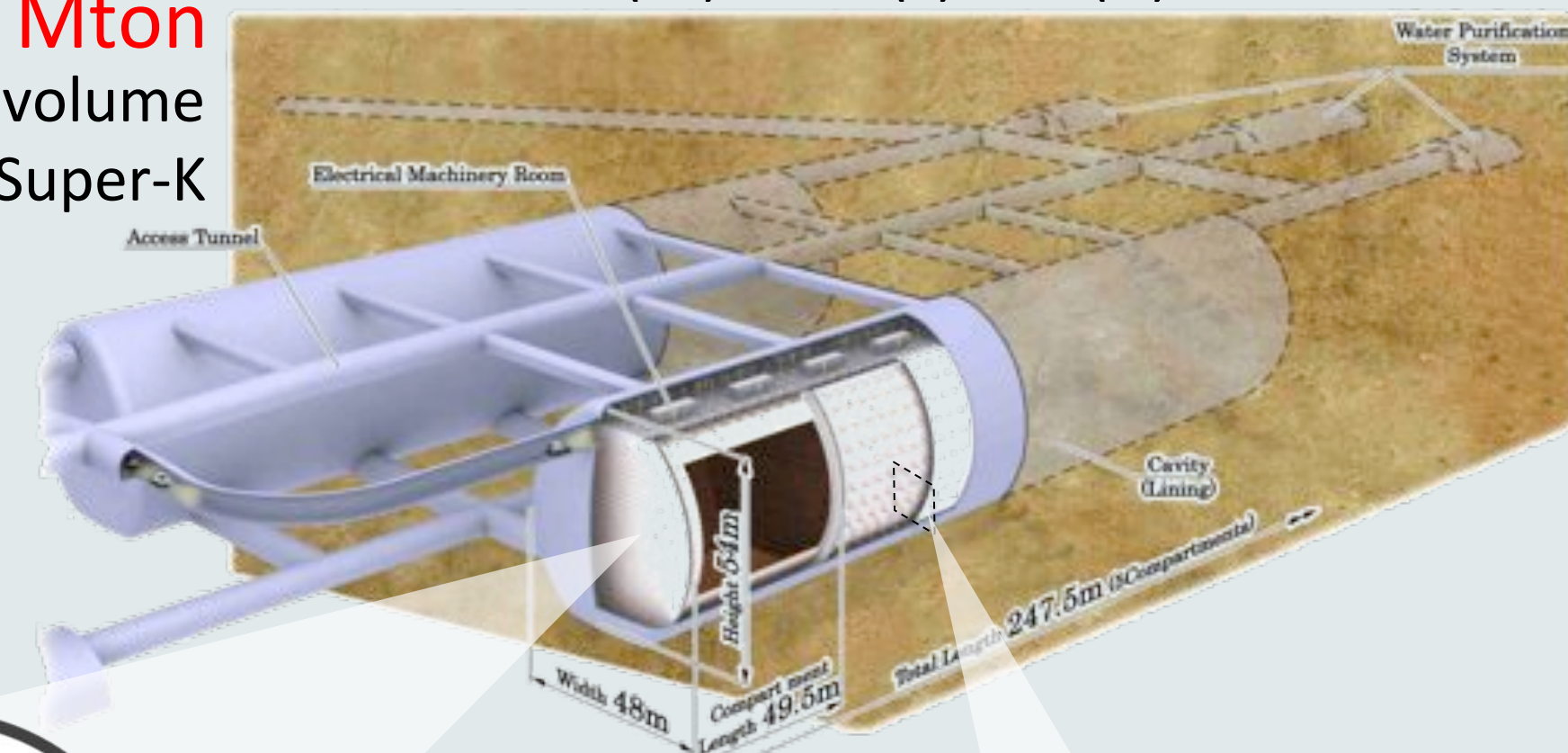
Super-Kamiokande
(since 1995)
0.0225 (0.05) Mton
39.3m ϕ \times 41.4m



Fiducial (total) mass
0.56 (0.99) Mton
 \times 25 (20) volume
of Super-K

Design of Hyper-Kamiokande

48(W) \times 250(L) \times 54(H) m³ \times 2 tanks



The detector consists of inner and outer compartments.

Photodetector

Base design assumes the same photo-multiplier tubes (PMTs) as used in Super-K.

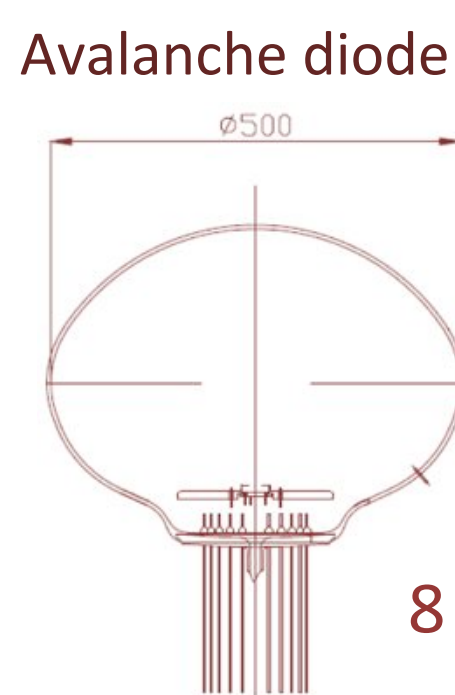
Candidate photodetectors

- Selected by
- Better performance
 - Reliability
 - Low cost

20-inch HPD will be developed within a few years.

Fewer photodetectors, smaller size and photon-collecting reflectors may be considered to reduce cost.

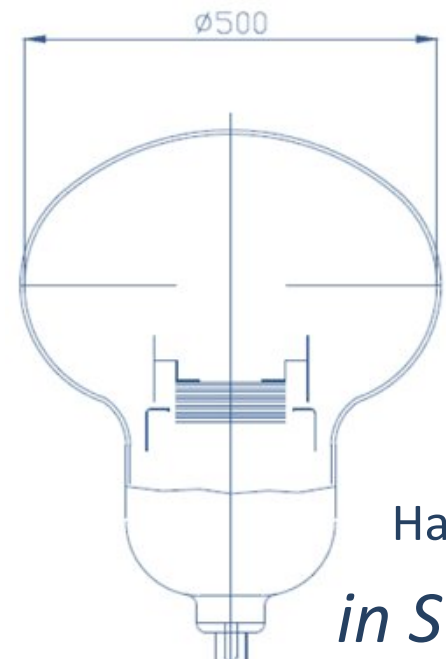
Hybrid-PhotoDetector (HPD)



8 or 13 inch HPD is under testing

PMT

Dynode : Venetian-blind type

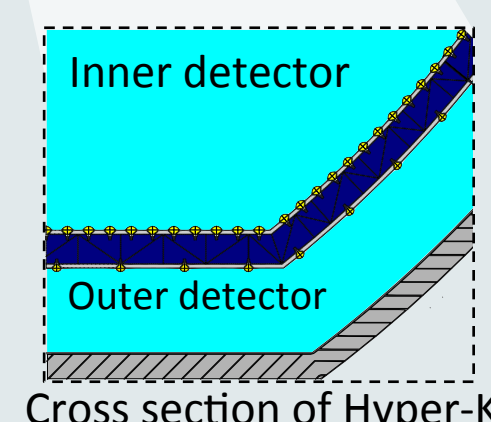


R3600
Hamamatsu
in Super-K

Another PMT with a different type of dynode is also a possible candidate that has a faster response time.

The number of photodetectors

	Hyper-K	Super-K
Inner detector (for ν detection)	99,000 (20-inch)	11,129 (20-inch)
Outer detector (for cosmic-ray veto)	25,000 (8-inch)	1,885 (8-inch)
Photo-coverage	20%	40% [†]
QE (quantum efficiency)	~30%	22%



[†]) Except SK III period

Higher QE is expected in Hyper-K.

► To choose the best photodetector for Hyper-K a proof test is planned in a water tank at Kamioka.

Hybrid-PhotoDetector (HPD)

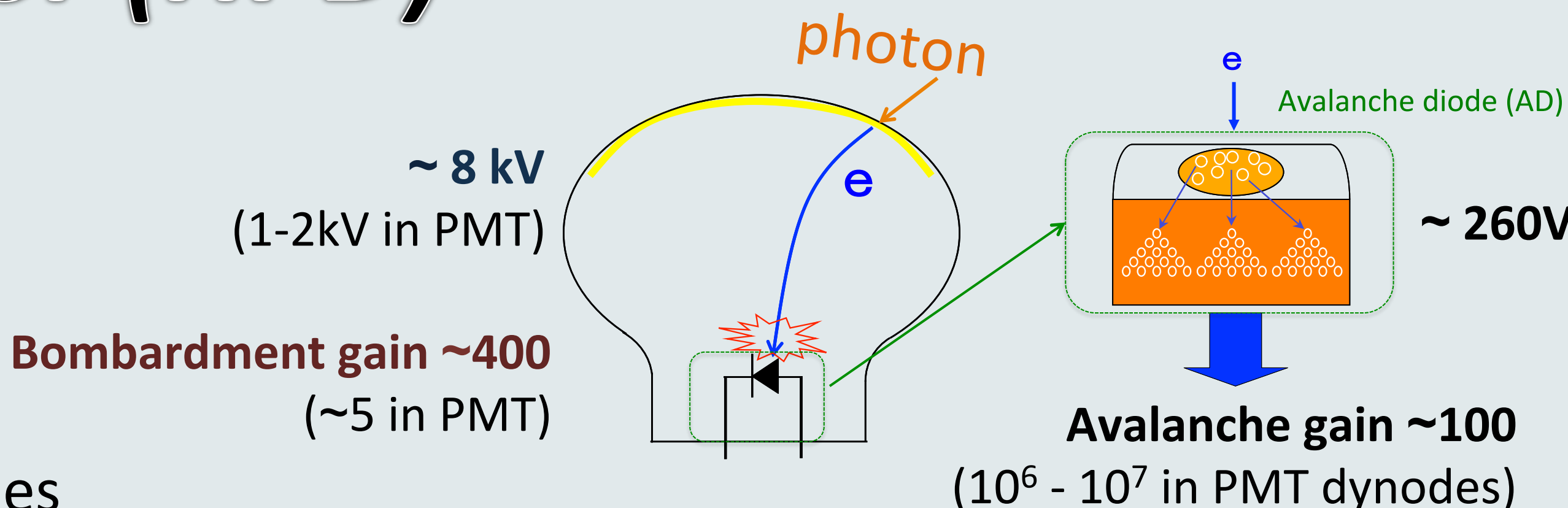
- A new type of a photodetector with an avalanche diode instead of metal dynodes -

High performance

- Timing uniformity and fast response
- Gain uniformity
- Better S/N ratio

Low cost

- Simple structure without metal dynodes



Difficulties

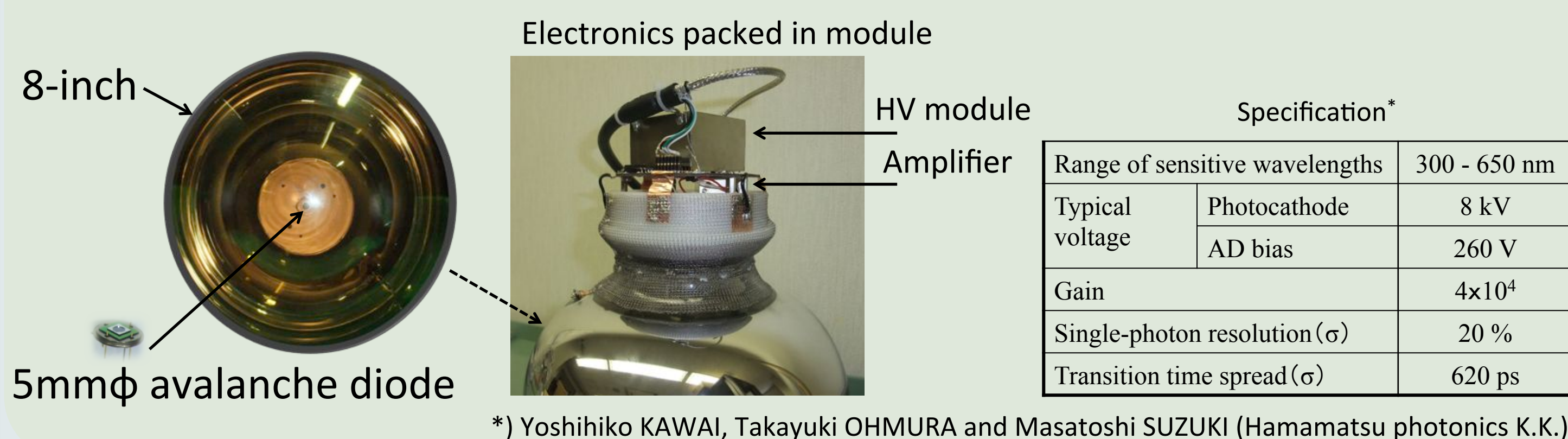
- High voltage and amplifier
- Dark current of avalanche diode
- Thermal dependence
- No prior experience using

Viability for practical use in Hyper-K must be confirmed.

8-inch HPD

- For the first proof test -

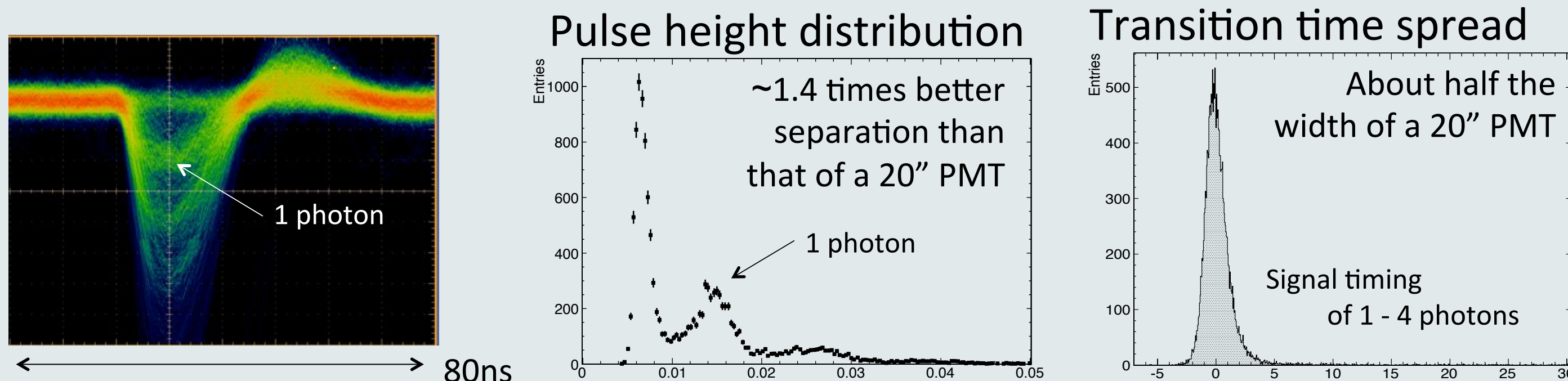
► 8-inch HPD was developed by Hamamatsu photonics*.



*) Yoshihiko KAWAI, Takayuki OHMURA and Masatoshi SUZUKI (Hamamatsu photonics K.K.)

► We started a measurement of its performance.

A prototype of 8-inch HPD (Preliminary check by oscilloscope)

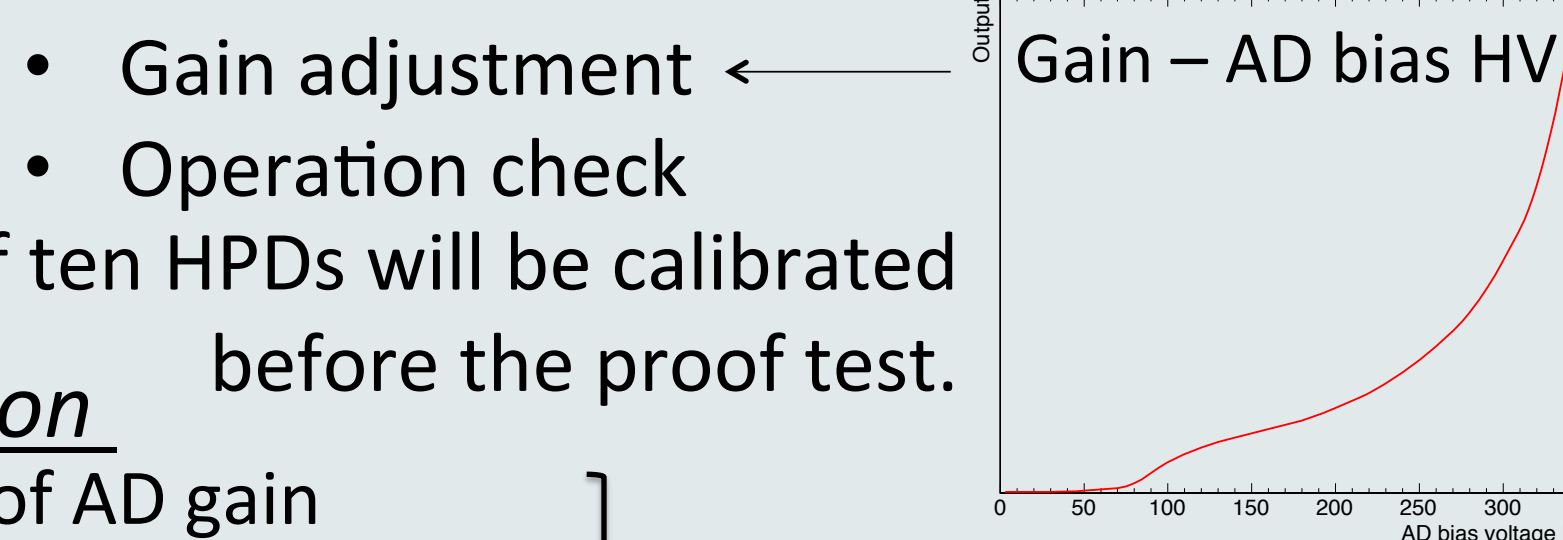


► Factors such as cable length, DAQ electronics and temperature are different from the actual setup of the proof test.

► Calibration of ten 8-inch HPDs before the test in water

Calibration for the proof test

Start from
summer 2012



Gain adjustment
Operation check
Eight of ten HPDs will be calibrated before the proof test.

Characteristic evaluation

- Thermal dependence of AD gain
- Linearity, saturation and rate tolerance
- S/N ratio by HV and temperature
- Cross talk between HPDs, cables or boards and light leak from HPD
- Stability and aging effect
- Uniformity of timing and gain

Correction, optimization

Detailed performance and a long-term stability of two HPDs will be evaluated.

Test plan in 200-ton water tank

► A 200-ton water tank,

loaded with *Gadolinium* (0.2%), was constructed at Kamioka mine by neutron tagging experiment,

EGADS (Evaluating Gadolinium's Action on Detector Systems). It is an evaluation test for **GADZOOKS!** (Gadolinium Antineutrino Detector Zealously Outperforming Old Kamiokande Super!)

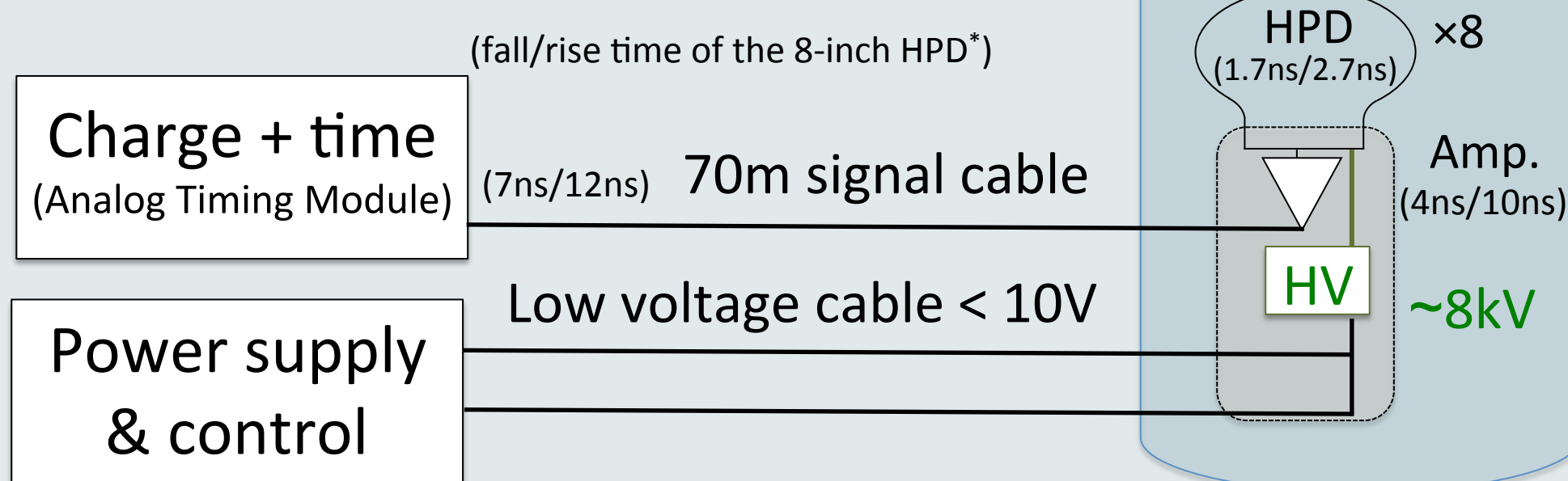
The tank is equipped with **240 20-inch PMTs** and its installation will be completed in 2012.

► **Photo-detector evaluation test**

It is allowed to replace several PMTs with candidate photodetectors. In 2012 eight 8-inch HPDs will be installed in the tank alongside 20-inch PMTs. We evaluate the performance of the candidate compared to that of the 20-inch PMT.

► **Setup of 8"HPD test in EGADS**

Planned in 2012 -



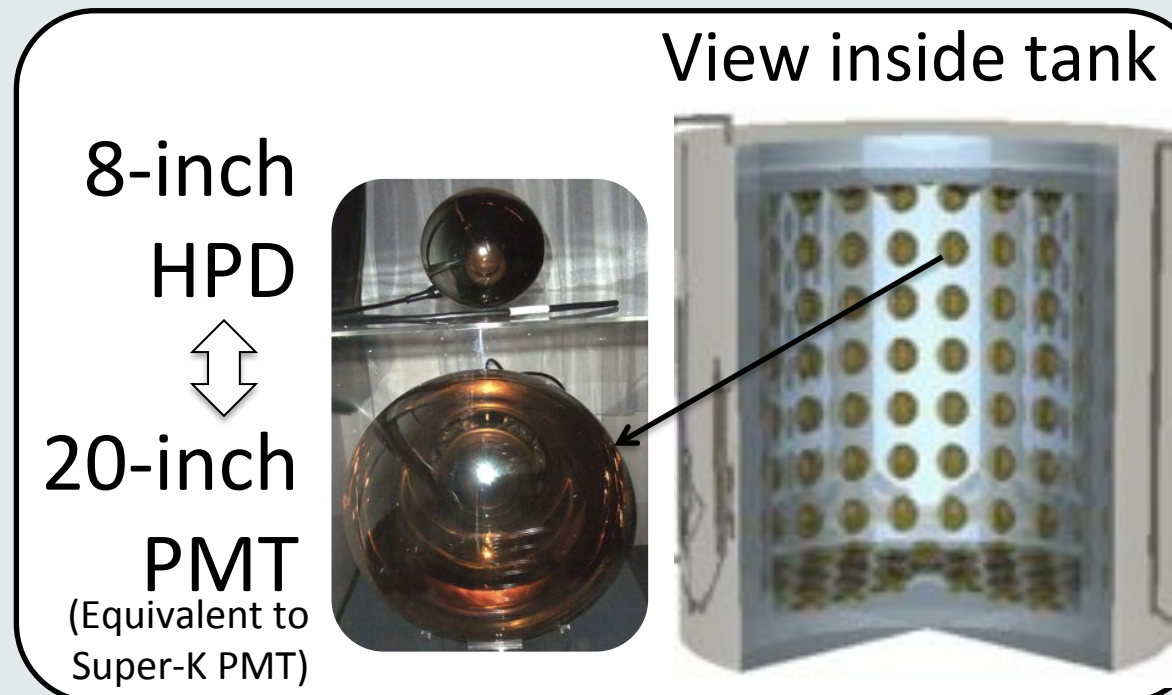
A safety operation under ~8kV HV should be established.

► **Possibility to use HPD in Hyper-K**

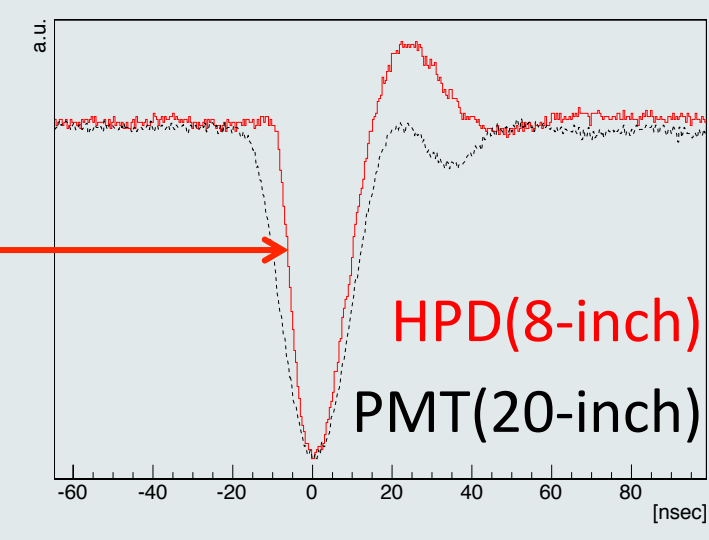
A measured trigger rate and resolutions in this test will give a possible energy threshold and a realistic sensitivity of Hyper-K using HPD. The safety and stability of operation in water will also be observed. Development of a 20-inch HPD will proceed based on this proof test.



~ 7 m



Signal is shaped by amplifier so that HPD has a similar shape to PMT for the EGADS test.



To use the same DAQ for both PMT and HPD

Schedule

Photo-detector performance measurements have started.

The first proof test to measure water Cherenkov light is planned using 8-inch HPDs in 2012, as well as larger photodetectors with 20-inch diameter later within several years.

Tentative R&D time scale of the photodetector measurement

	July	Aug	Sep	Oct	Nov	Dec	2013	2014	2015	2016
In box	Setup	Calibration	Precise performance / Stability					20-inch PDs		
In tank		Preparation	Installation	Calibration / Measurement				Test other photodetectors		

Open Hyper-K meeting will be held on 22-23 August, where more details are presented.