

Overview of the Photodetector Development

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for the Hyper-K Photodetector (HK-PD) WG

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Many options ...

□ Sensors

- HPD, PMT w/ box-line dynodes, PMT w/ venetian blind dynodes, ...
- High QE, Normal QE
- 20-inch, 12-inch, 11-inch, 8-inch, ...

□ Light collection

- No light collectors, WLS plates, Winston cones, ...

□ Protective cases

- All acrylic, Acrylic+Stainless, ...
- w/ passive magnetic shielding (such as mu-metal wire cages) ?

Should be chosen primarily by physics requirements

Cost, quality control in mass production, and production/assembly period are also very important for the choice

Overall R&D status

- 8" HPD prototypes under evaluation
 - Showing good basic performances
 - Long-term proof test in a 200-ton water tank from this summer

- First prototypes of 20" HPD and new 20" PMT (with box-line dynodes) coming in a few months
 - Planning to test them in the 200-ton water tank next year

- High-QE 20" photocathode
 - Test production done (SK type PMT) and starting evaluation

Overall R&D status (cont'd)

- PMT R&D in the U.S. is progressing
 - Testing of Hamamatsu HQE 12" PMTs has been completed (paper published)
 - ADIT/ETL are producing 11" PMTs

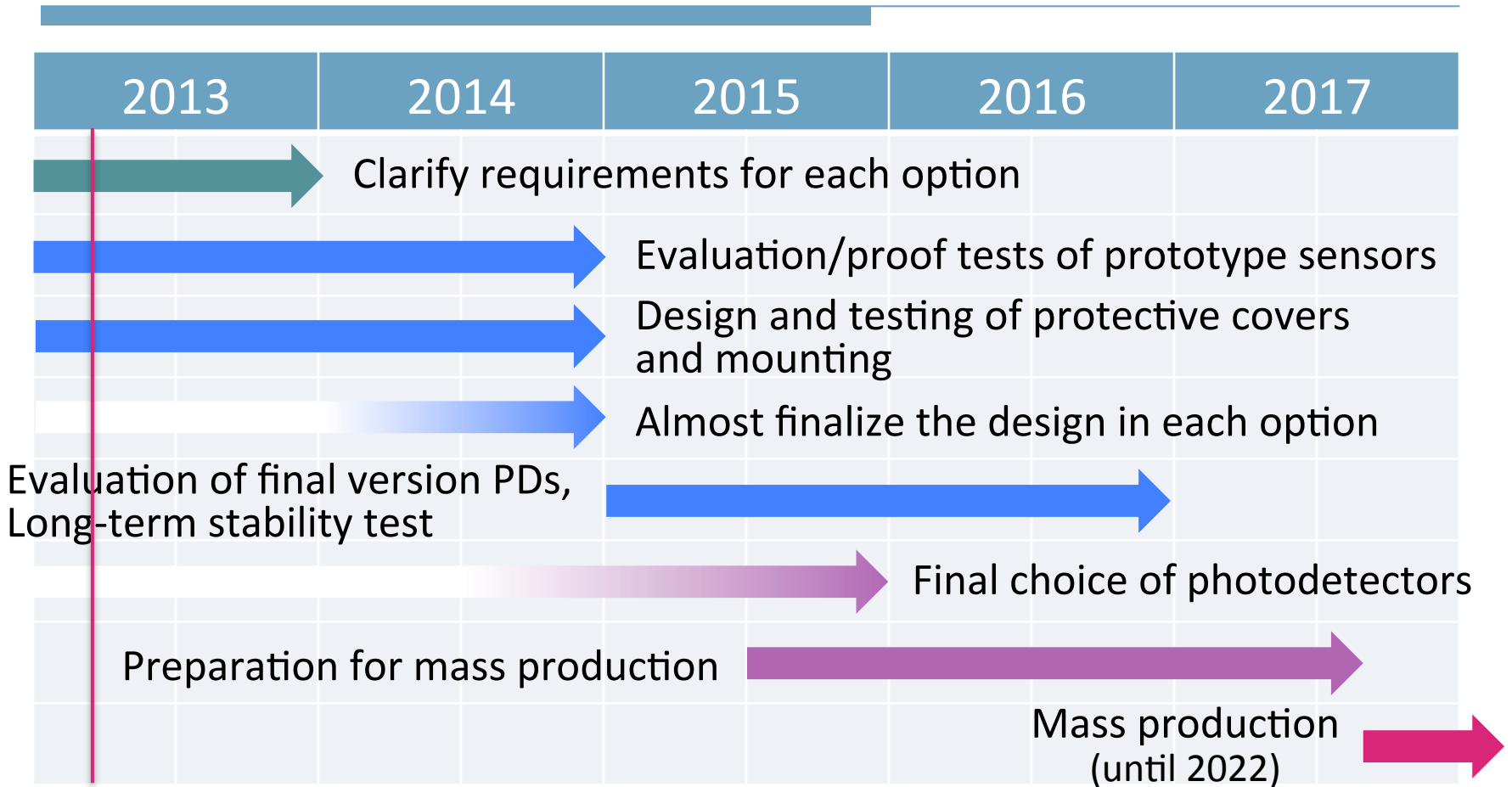
- Various light collection options are being studied
 - Wavelength shifter + dichroic mirror
 - Acrylic Fresnel lens

- Just started designing protective covers for sensors and mounting structures

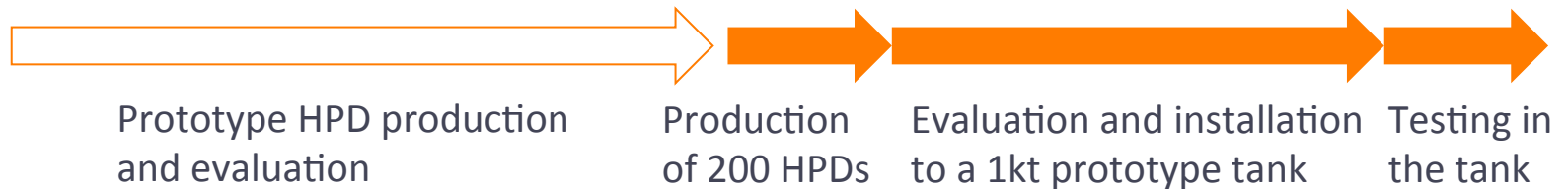
Requirements on PDs from physics

- It's difficult to find a general requirement (or threshold) on each specification of photodetectors
 - Efficiency(CE/QE), TTS, acceptance, dark rate, ...
- A practical way may be to check physics sensitivities by HK simulations with measured/assumed PD performances for each option
- Collaborative work with software WG, physics WG, and calibration WG is indispensable
 - Must be started now

Plan / Schedule



If our proposal to a grant-in-Aid (submitted in March) is approved.



Plan (near-term)

- Continue each R&D work
 - 8" HPDs and HQE 20" PMTs in a 200-ton tank
 - 20" HPDs and new 20" PMTs coming soon
 - Light collector studies (simulations/measurements)

- Start physics sensitivity checks for each PD option
 - Need to summarize specifications as inputs to simulation

- The next-step planning for each option
 - Test some options in the 200-ton tank ?
 - Detailed performance check in the TRIUMF/US facilities ?

- Write a photodetector R&D document (next page)

Documentation

- We will make an internal document first.
 - Gathering descriptions on past/present studies
 - The global R&D plan and to-do items
 - First version by the end of September
 - Expected to be updated accordingly as new results come

- Then, we will produce a public document.
 - As for studies not specifically for Hyper-K, we may need description on possible applications to Hyper-K in addition to references to relevant papers/documents.

Table of Contents for the internal document

Under discussion in HK-PD WG

1. Introduction
2. Candidate photodetectors
present 20" PMTs / HPDs / new 20" PMTs / others
3. PD optical and electronic characteristics
4. PD mechanical characteristics
5. Light collection enhancement
6. (Physics sensitivity comparison)
7. Protective cases
8. Support structures
9. Cost estimation
10. Discussion and Plan

Talks in this session

- Status and plan for photodetector tests in a 200-ton tank
Nishimura (ICRR)
- Performance evaluation and pre-installation calibrations of prototype photodetectors
Hirota (Kyoto)
- Enhanced light collection with a wavelength shifter trap
Retiere (TRIUMF)
- R&D of light collection system using acrylic lens
Ikeda (Kyoto)
- Using fast photosensors in the next generation water Cherenkov neutrino detectors
Sanchez (Iowa State U.)

Supplement

HK-PD WG members (28 persons)

- Nakayama^C
- Nishimura^C
- Konaka
- Smy
- Nakaya
- Yokoyama
- Suda
- Huang
- Ikeda
- Hirota
- Kudenko
- Haga
- Ling
- Iijima
- Kametani
- Retiere
- Mine
- Tateishi
- Itow
- De Perio
- Kuze
- Maricic
- Svoboda
- Bergevin
- Taketa
- Ishitsuka
- Okajima
- Hide Tanaka

Task of the Hyper-K Photodetector (HK-PD) WG

- Develop the photodetector assemblies which meet the required performance and cost for the Hyper-K detector
 - Photo-detectors are the key component of a water Cherenkov detector.
 - The fraction of the photodetector cost is significant ($\sim 1/3$ of the total construction cost in the current estimation).

Hyper-K photodetectors in the baseline design

(in LOI)

□ Inner detector

- 99,000 20-inch ϕ PMTs
- 20% photo-coverage (= SK-II)
- Hamamatsu R3600 PMTs (used in SK)
 - Known to satisfy basic requirements
 - Operated for more than 16 years in SK.
Long-term stability are well understood.
- Acrylic and FRP protective cases.

□ Outer detector

- 25,000 8-inch ϕ PMTs

Requirements for Hyper-K photodetectors

- We don't have an accurate grasp of all requirements yet.
- Specification of 20-inch PMT (R3600) must be a reference.
 - QE : 22% @ $\lambda=390\text{nm}$
 - Gain : 10^7
 - Dark rate : 4.5kHz @0.25p.e. threshold
 - Transit time spread : 2.2nsec (1σ) for 1p.e. signals
 - Pressure tolerance : 6kg/cm²
- Requirements should depend on physics targets and Hyper-K configuration (number of compartments, Gd, ...).
- **We first have to clarify the requirements for each photo-detector option**
 - Possibly based on Hyper-K simulation studies.