# Overview of HK calibration

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# Outline

- Status of Calibration WG
- Overview of current design of HK calibration
- Plan for prototyping and R&D
- List of talks in the calibration session

# Status of HK Calib WG

- We collected ideas for HK calibrations and wrote up a document 'Conceptual Design' of HK calib
  - Available for HK WGs: http://www-sk.icrr.u-tokyo.ac.jp/indico/categoryDisplay.py?categId=69
    - Note: this is for HK WGs. Not for public.
  - This document compiles ideas for HK calibs, including items specific for HK and improvement from SK

- Planning to do R&Ds and prototyping to test the ideas for calib system (hardware)
- Establish "real" design for HK calibrations based on inputs from Physics WGs and results of R&Ds prototyping.

# Outline of the document

- Inner detector calibration
  - Photo-sensor calibration
  - Water property calibration
- "Higher level" calibration
  - Energy calibration, etc
  - Outer detector calibration
  - Calibration-source deployment system

Many of them were already discussed in the previous HK meetings.

This talk flashes the contents of the document.

# Goal of HK calibration

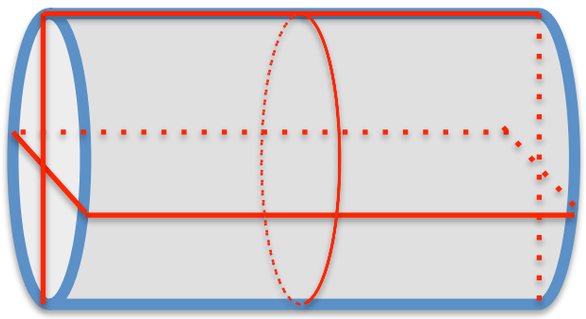
- Need to set goals to design the HK calibrations.
- Physics sensitivity studies are in progress, and requirements from physics to HK calibration are not clear yet.

- We assume/set the goals for now:
  - **HK will explore all physics topics that SK has done so far**
  - **HK needs to be calibrated to achieve SK (SK-II) level detector performance**

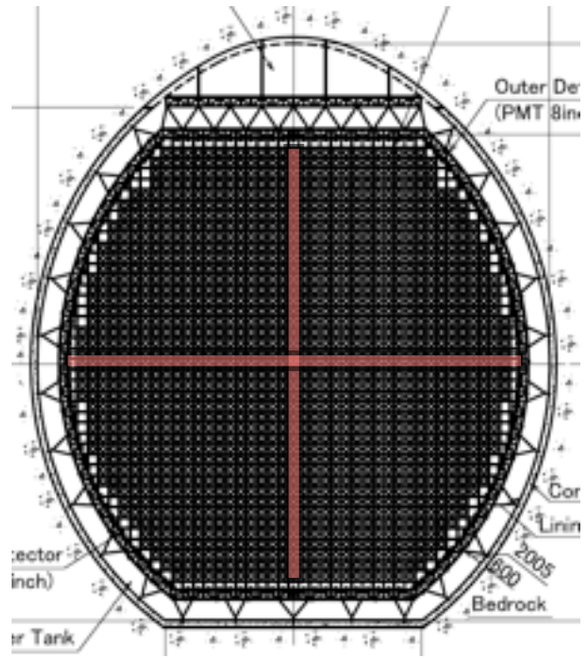
# Photo-sensor calibration

- Strategy to calibrate ~99k photo-sensors with three steps:
  - Pre-calibration
    - A fraction of photo-sensors (~5% of all photo-sensors) will be calibrated prior to the installation.
  - Post-installation calibration
    - Gain tuning, photo-detection efficiency, timing, ...
    - Calibrate photo-sensors *in-situ* after installation referencing to the pre-calibrated photo-sensors.
  - Detector monitoring
    - Monitor the stability of detector continuously for lifetime of the experiment.
- Characterization of photo-sensor
  - *Ex-situ* measurements (at a lab)
    - QE, angular dependence of photo-sensor response
  - See Hiro-san's talk for details

: 'pre-calibrated PMT' location



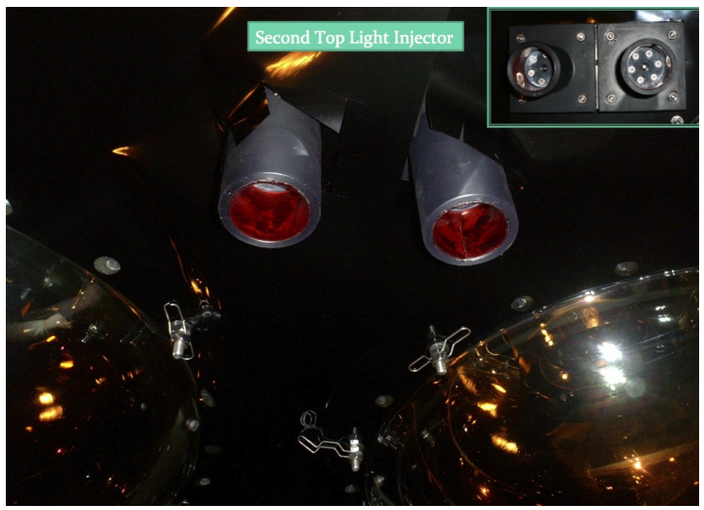
Segmentation wall

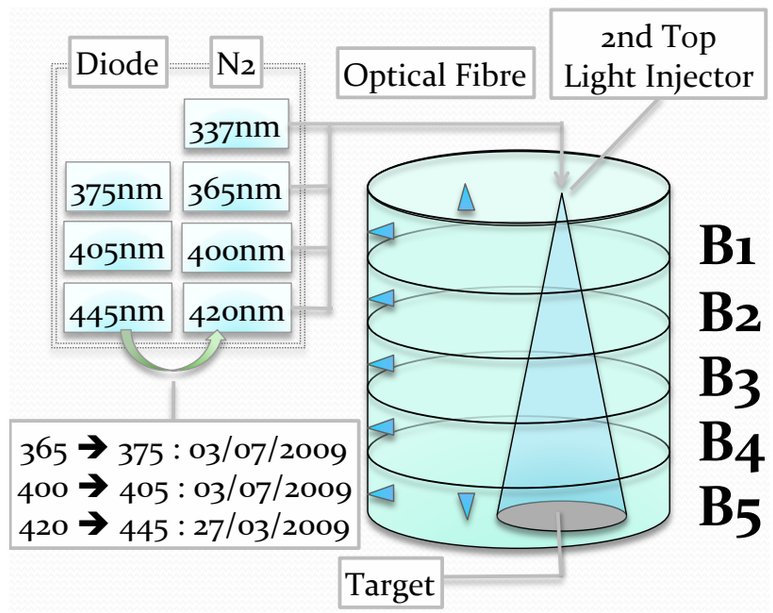


# Water property & reflectivity

- Water property
  - Scattering, attenuation, absorption
  - The same idea as SK: use several wavelengths of light
  - Calibration/measurement in each compartment
- Reflectivity of detector material
  - PMT glass, black sheet, tyvek
  - *Ex-situ* measurements would help for better understanding
  - Additional *in-situ* measurement after installed

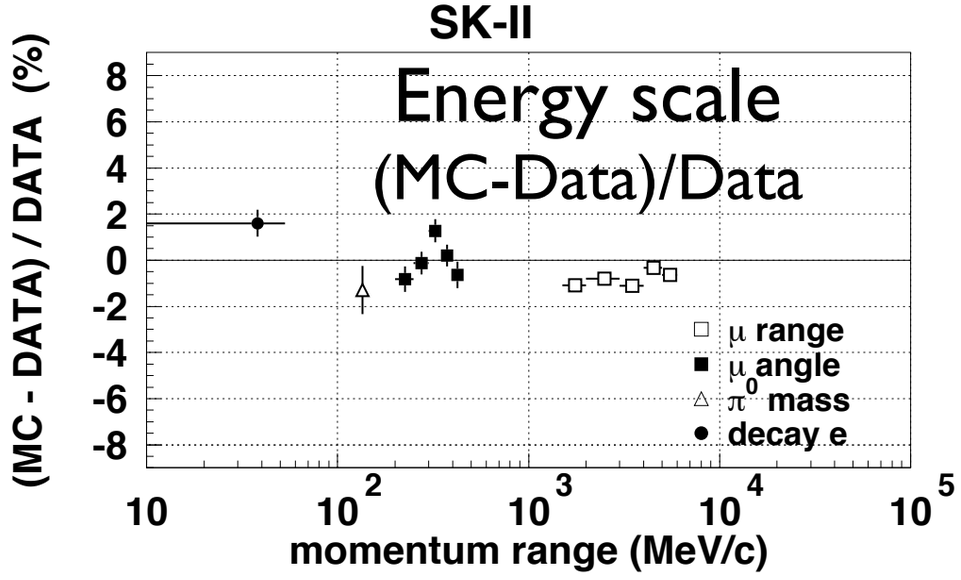
SK light injection system for water calib



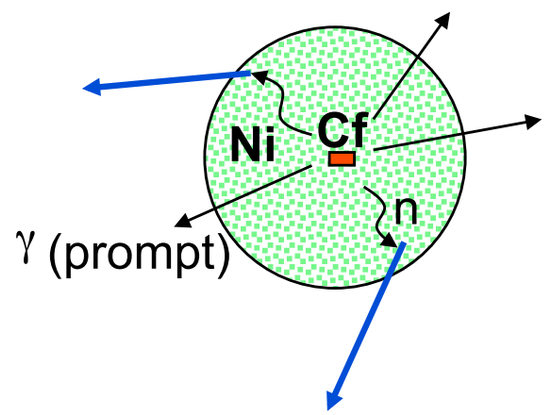
# “Higher level” calibration

- Energy calibration, for example.
- Need to design the calibrations for each targeted physics topics
  - Man-made (low energy) and natural calibration sources (high energy)
    - Especially low energy calibration since there is no natural source




- Considering the calibration sources used in SK for HK calibration
  - LINAC, DT generator, “Nickel” source
- Possible new calibration sources
  - ‘Fission-triggered’ Nickel source, $^{16}N$, etc
  - See Szymon and Koshio-san’s talk for details
- Revisit the calib sources consideration based on Physics WGs inputs

“Nickel source”
(Cf-Ni: $^{58}Ni(n,\gamma)^{59}Ni$)



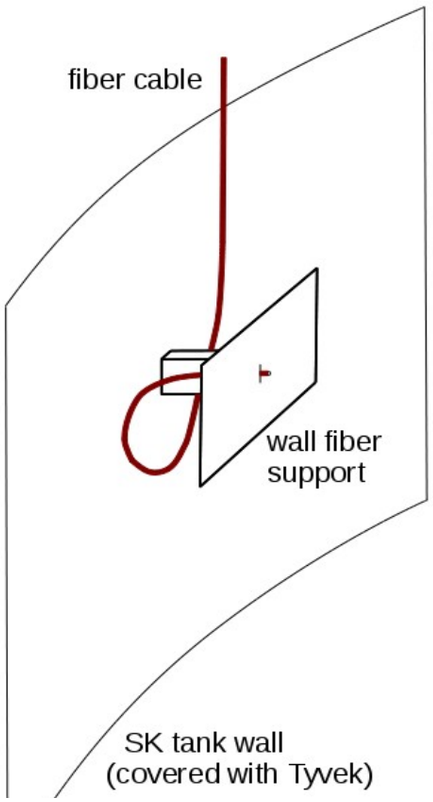
# Calib-source deployment system

- Automated / remote-controlled calib system
  - Need to calibrate 10 compartments
  - Handle multiple calib sources & switch the sources w/o turning off photo-sensor HV
- Ability to deploy the calib sources at sophisticated location in the detector volume
  - Cover asymmetric detector geometry (unlike SK)
  - Used for photo-sensor calibration and 'higher level' calibration
  - A couple of ideas (SNO, Borexino, KamLAND, Daya Bay style)
    - → need to test with prototyping
- A system to measure the calib-source position
- See Szymon's talk for details

# Outer detector calib

- The same ideas as SK: calibrate photo-sensors using light sources, cosmic-rays, and dark noise
- Inter-calibration between ID and OD for timing
- New ideas and possible improvement from SK
- See Shige-san's talk for details

# SK OD light injection system




# Items for R&Ds & prototype

- Photo-sensor characterization underwater
  - Will collaborate with Photo-sensor WG
  - → See Hiro-san's talk

- Calibration source deployment system
  - Includes a system to measure the calib-source position
    - red light + underwater camera
  - → See Szymon's talk

- New calibration sources
  - "New" compared to SK calibration
    - ex. fission-triggered 'Nickel' source, neutron generator, etc
  - → See Koshio-san's talk

# Designing HK calib

- To design the HK calib, many items needs to be determined:
  - Calibration sources (man-made, natural sources)
  - Method to deploy the calibration sources
  - Precision (goal of the calibration)
- SK calibration methods/techniques should work in HK, but making a simple copy of SK calib may be difficult (ex. LINAC), and may need/want something new calibration for HK physics goals
- ➜ Collaboration with Physics WGs are indispensable.

# Summary

- Conceptual Design Document (v1) on HK calib available for HK WGs.
  - Feedback are very welcome
- R&Ds and prototyping are being planned
- Will establish HK calibrations based on inputs from Physics WGs, Photo-sensor WG, and the results of R&Ds
- ➜ Collaboration with Physics WGs and Photo-sensor WG are indispensable.

- Talks in the calibration session:
  - Outer Detector calibration [S. Matsuno]
  - PMT testing facility [H. A. Tanaka]
  - Source deployment system [S. Manecki]
  - New calibration sources [Y. Koshio]