

Research Result Presentation Meeting of the ICRR Inter-University Research Program 2024

Brief report on

2024i-B-002 300.000 ¥

An auto-flashing system in Hyper-Kamiokande for monitoring the detector evolution with time

[supporting UAM's contributions to the built of the Hyper-K project]

It is a follow-up of two similar ICRR-IURP 2019 projects (the HK one had D. Bravo as IP), another two sets (HK, SK) each year ICRR-IURP-2020, -2021 and -2022, one "SK" ICRR-IURP-2023,

and it is funded in parallel to another ICRR-IURP 2024 ("SK" one) with N. Ospina as IP

January 29th 2025, online presentation
L. Labarga (University Autonoma Madrid, UAM)

A UAM responsibility in the Super-Kamiokande running is the detector monitoring and calibration with both, the so-called **auto-Xenon system** and the “**Nickel**” calibration

- The **auto-Xenon system** provides a continuous ~ 0.15 Hz flash from a scintillator ball located at the center of the detector feed with the light from a Xenon lamp in the outside above the tank.
- The “**Nickel**” is a **monthly calibration** measuring the few MeV emitted after the capture by either Ni or Gd nuclei, of neutrons released in the spontaneous fission of a ^{252}Cf source inside a Ni ball (≈ 18 cm \varnothing) that is temporarily deployed for the purpose also in the center of the detector.

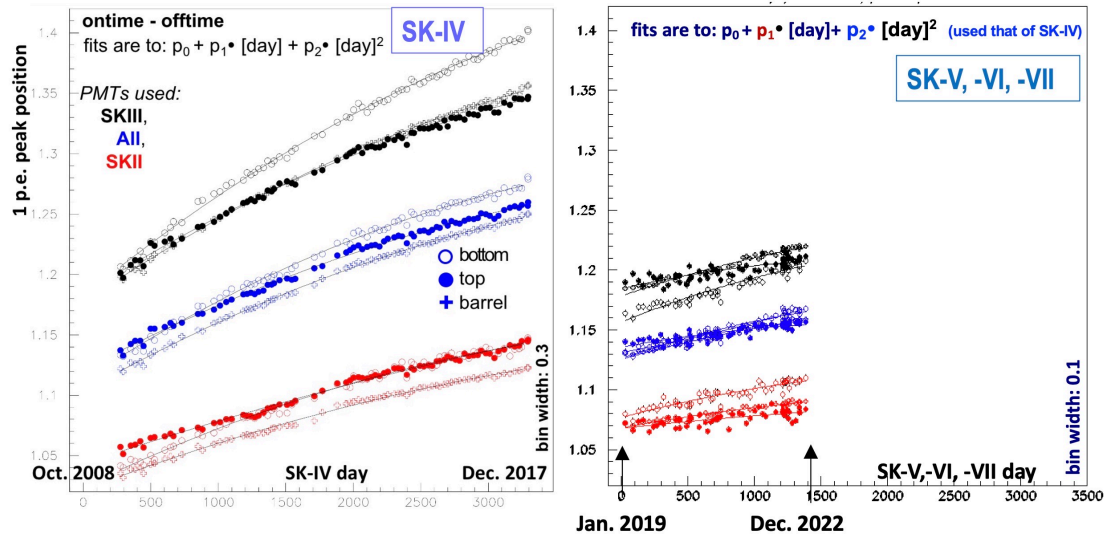
That “tandem” has revealed to be of most importance in the understanding of the SK running;

- ✓ establishment of a **gain evolution different with time**, by $> 15\%$ in some cases, of the **SK-ID 20” PMTs**. Time dependent corrections are implemented for all data samples.
- ✓ measurement of the daily evolution of the **Top-Bottom Asymetry in light collection TBA[t]**. This variable is key to ensure a proper reflection of the impact of detector conditions in the MC generation of basically all relevant samples.
- ✓ provide almost **instant analyses** and **first conclusions** of the data **when major incidents occur in Super-Kamiokande**. Paradigmatic have been the SK situations after the recent geomagnetic coils’ failures, repairs, further failures, etc. The auto-Xenon data did provide precise pictures of the collection efficiencies variations along the whole detector due to those incidents.

UAM research in Super-K: some highlights at a glance

calibrations, detector evolution, etc.

PMT gain increase with time: evolution of Nickel's 1 p.e. peak position for PMT groups



Changes in PMT gains

behavior of fitted 1-photo-electron peak

Nickel data

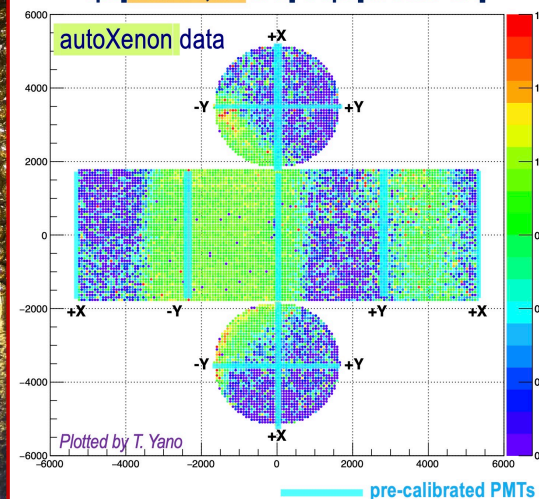
$(1\text{pe}[\text{coils \#1, \#2 OFF}] / 1\text{pe}[\text{all coils ON}]) - 1$

	ALL PMTs	SK-2 PMTs	SK-3 PMTs
TOP	$-5.0 \pm 0.1 \%$	$-6.8 \pm 0.1 \%$	$-4.0 \pm 0.1 \%$
BOT	$-6.2 \pm 0.1 \%$	$-7.6 \pm 0.1 \%$	$-4.8 \pm 0.2 \%$
BAR	$-2.7 \pm 0.1 \%$	$-3.4 \pm 0.1 \%$	$-2.1 \pm 0.2 \%$

Changes in efficiency for light collection

$[\langle \text{qisk} \rangle (\text{pmt}_N)_{\text{run } i} / \langle \text{qisk} \rangle (\text{pmt}_N)_{\text{run } i-1}]$

$1\text{pe}[\text{coils \#1, \#2 OFF}] / 1\text{pe}[\text{all coils ON}]$



ICRR-IURP 2019: local travelling
ICRR-IURP 2020, 2022, 2023: materials for
improvement of autoXenon system

It is crystal clear to us the **need of a similar system in Hyper-Kamiokande for a similar purpose**

The **UAM** has initiated **yet another** important but simple **hardware contribution** to the **HK** project: An **auto-flashing system** in the Far Detector for monitoring the detector evolution with time with a similar philosophy as the one in SK.

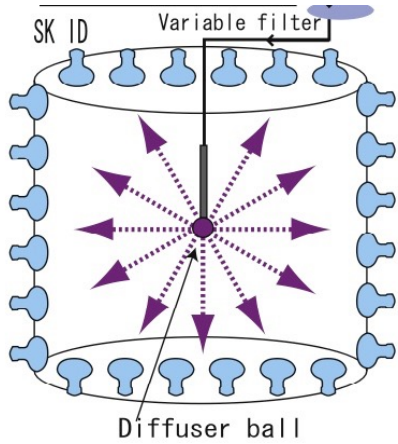
As in SK, this system will provide almost instant information about the status of the HK detector:

- Light transmission through water at different parts of the water tank
- Light collection efficiency of every ID PMT
- Status of every ID PMT at any time
- Identify changes in the gains of the ID PMTs.
- Top-Bottom detector asymmetries in light transmission
- others

The system is therefore of maximum interest for the optimum running of HK

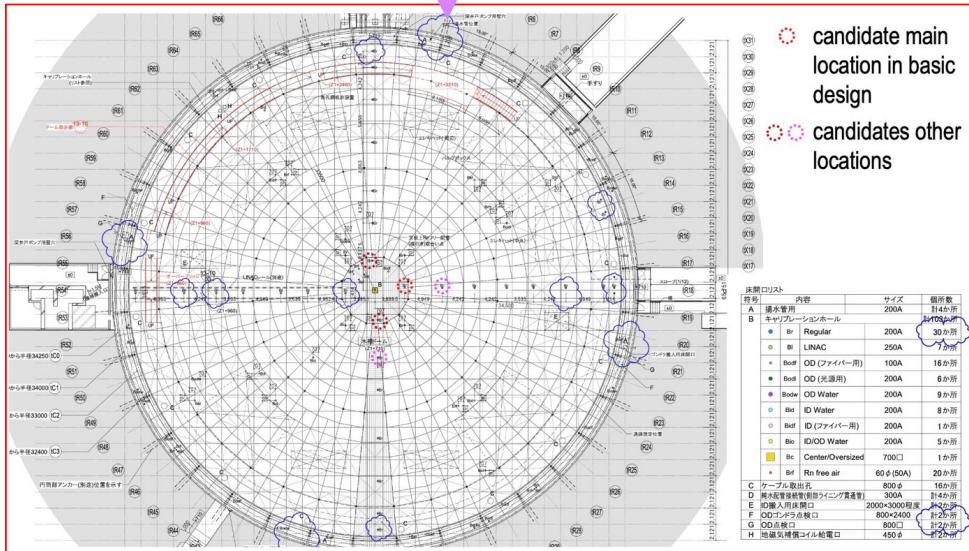
It is the main subject of this and some of the previous UAM's ICRR-IURP projects

The design is "a la SK"



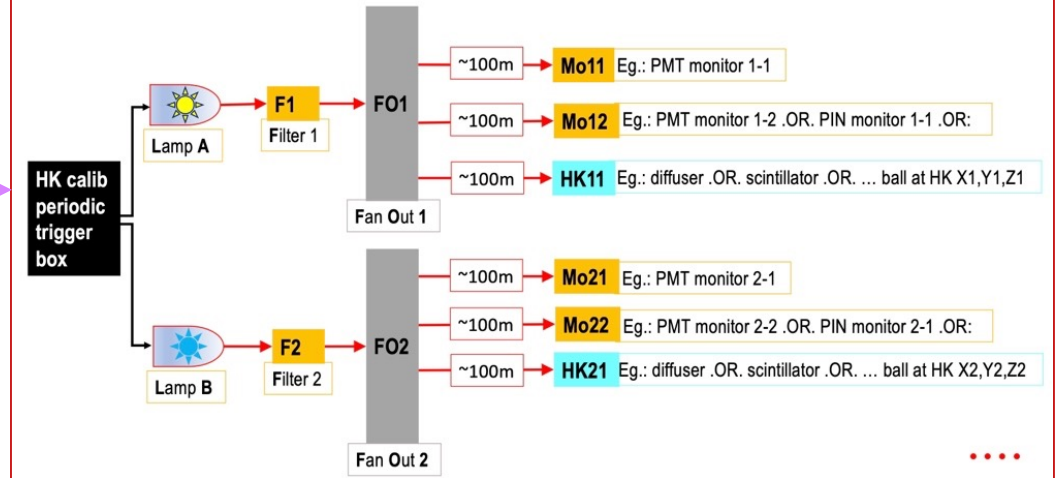
With additions after the SK experience: 4 balls

- 2 scintillator using Xe lamps → wide range λ
- 2 balls, using UK's multi- λ LED HK system → low and high λ ranges for absorption and scattering control



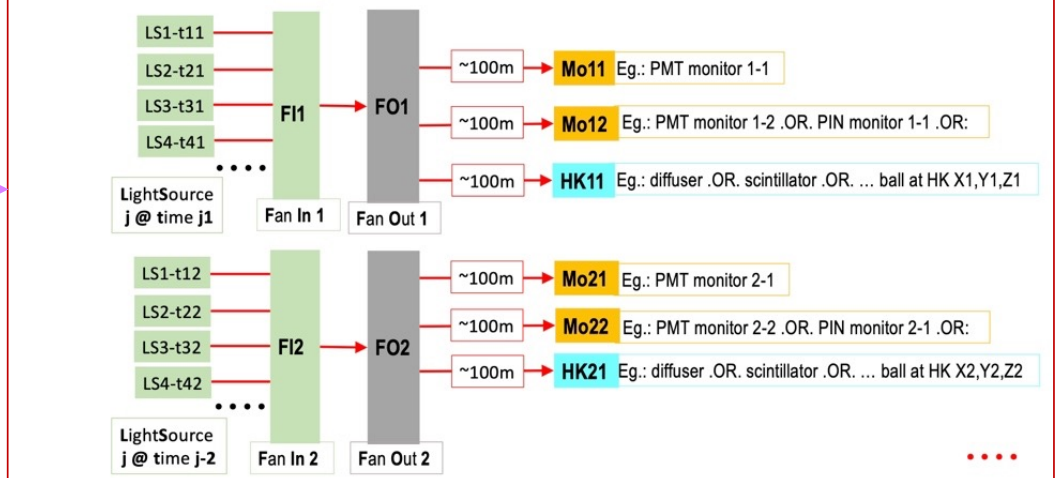
Using different lamps

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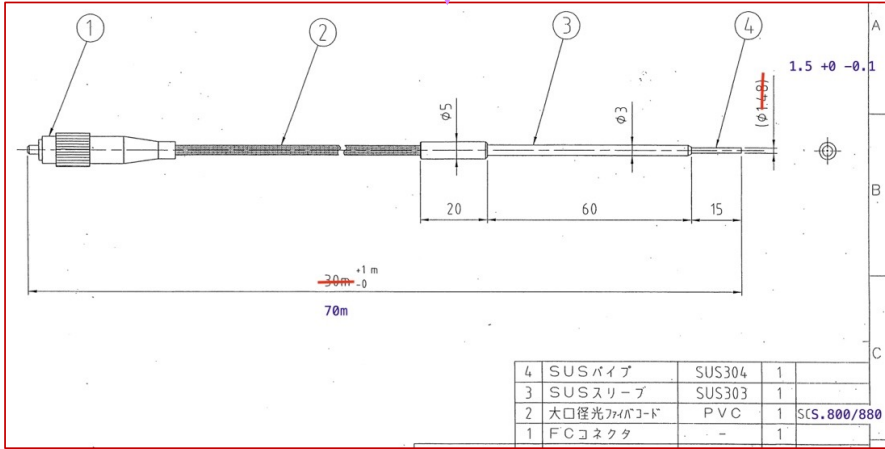


Using UK's LED multiwavelength device

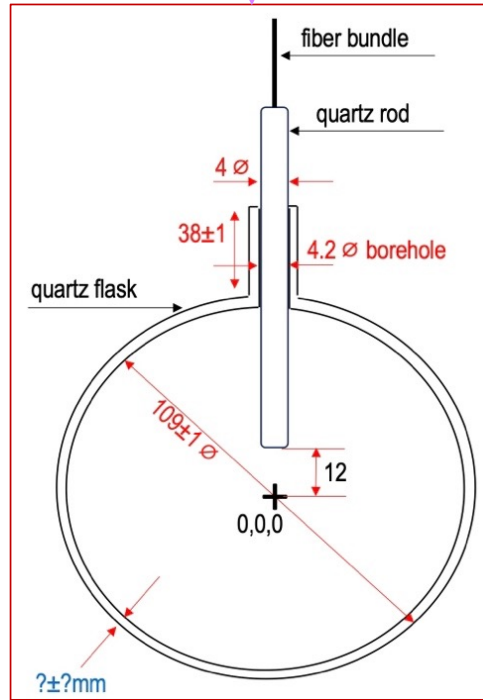
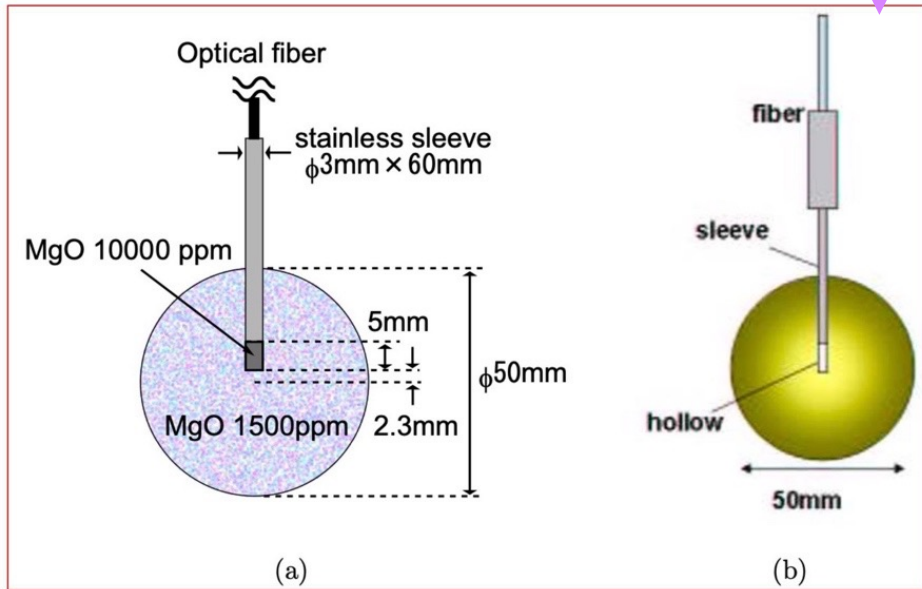
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Most components are commercial, exceptions are:



- ✓ Fiber coupling to ball ←
- ✓ Scintillator ball ← from SK experience, OK
- ✓ UK's multi- λ LED HK system ← from UK colleagues, OK
- ❖ High isotropy diffuser ball ← Promising results by SNO-LS phase colleagues, but further R&D is needed

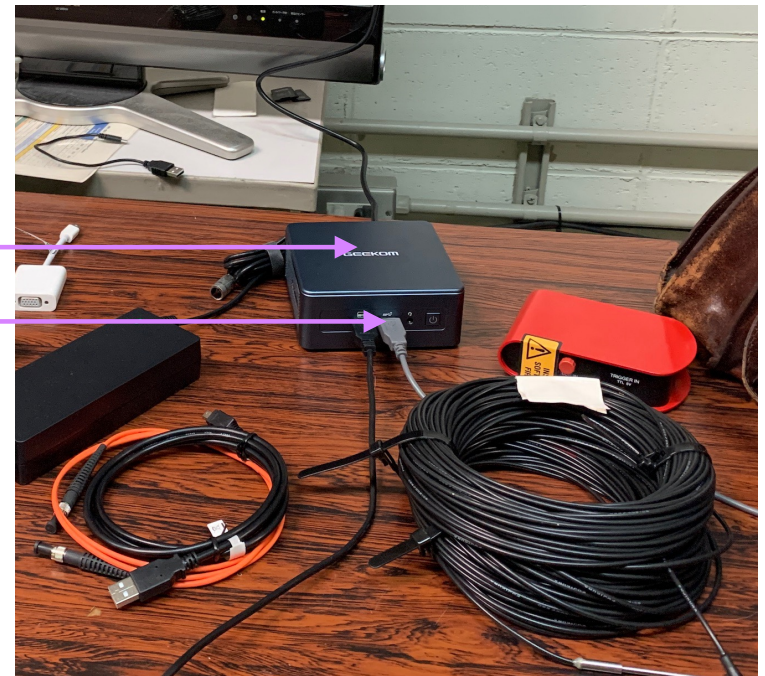
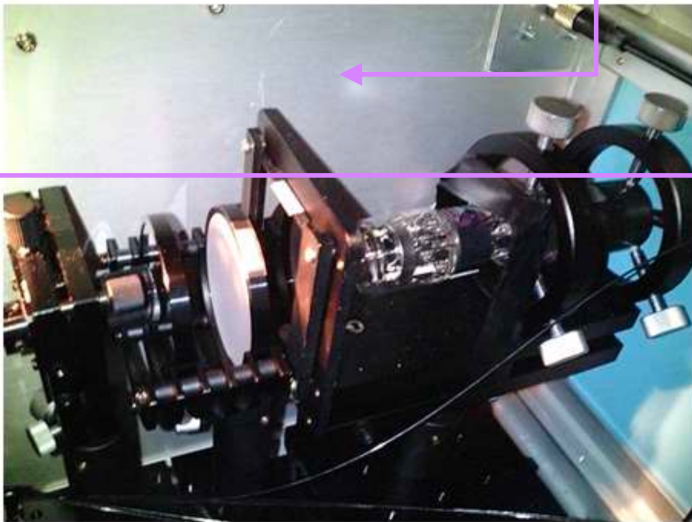


Global schedule:

We aim to have the complete system built and commissioned (optics) at the end of FY2026, to be implemented into the HK DAQ, and mounted in the tank when conditions permit.

A feeling of the evolution of the hardware status

- 2022FY-ICRR-IURP *2 x 35 m. optical fiber with connectors and misc.*
- Carry over funds for HK from 2022FY-ICRR-IURP + 2023FY-ICRR-IURP: *CCS200 spectrophotometer + misc. parts*, Hamamatsu's *Power Supply C9727-01* for 1 PMT monitor
- UAM group money: *GEEKOM Mini PC IT13, NUC 13 i9-13900H* for controlling CCS200
- Got this FJ2024: *300.000 ¥* misc. optical components (filters for ranges of λ , fan-in/fan-out, other)
- Requested further Spanish funding for scintillator + diffuser balls, monitor PMTs, other
- To request at ICRR-IURP program for the following years
- Others ...



Summary

UAM has been granted with ICRR-IURP projects since the start of the program back in 2019 :

A05, A03: for our works on Super-Kamiokande I – VIII

B01, B03: for our contributions to the built of the Hyper-Kamiokande

ICRR-IURP is an extremely useful program; it is helping very much UAM in its research:

- Research trips inside Japan
- Materials for upgrade and current auto-Xenon system for Super-Kamiokande
- Finite Element Modeling of its design of an acrylic window without flange
- Acquisition of HK PMTs with no vacuum for mechanical tests
- Acquisition of HK flanged acrylic windows for the final test program of the original sp-cover
- Logistics transport of SK-Gd T1.5 Gd samples to Canfranc lab. for RI investigations
- **optical material for studies of viability of an auto-Xenon like system for Hyper-Kamiokande**
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Thank you very much ICRR for your Science and your support !