Research Result Presentation Meeting of the ICRR Inter-University Research Program 2023

Brief report on

2022i-A-005 *carried over to 2023* + **2023i-A-003** 200.000 + 170.000 ¥

[supporting our works on Super-Kamiokande I – VII]

2022i-B-001 *carried over to 2023* 500.000 ¥

[supporting our contributions to the built of the Hyper-Kamiokande project]

they are follow-ups of two similar ICRR-IURP 2019 projects (the HK one had D. Bravo as IP), and another two sets ICRR-IURP 2020 and ICRR-IURP 2021

and hopefully predecessors of the two new ICRR-IURP 2024 projects just submitted (the SK one has N. Ospina as IP)

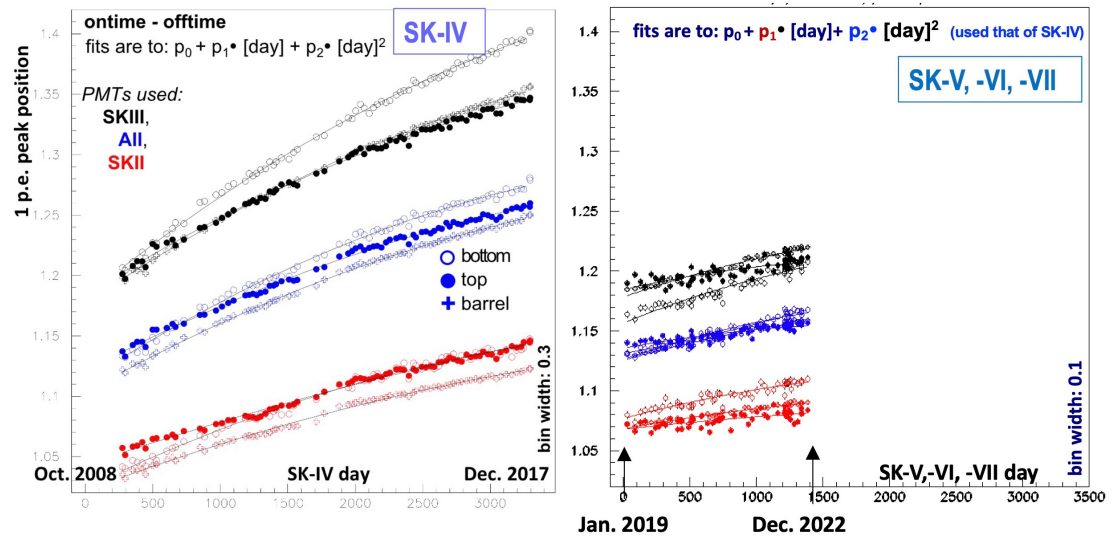
February 21st 2024, online presentation

L. Labarga (University Autonoma Madrid, UAM)

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

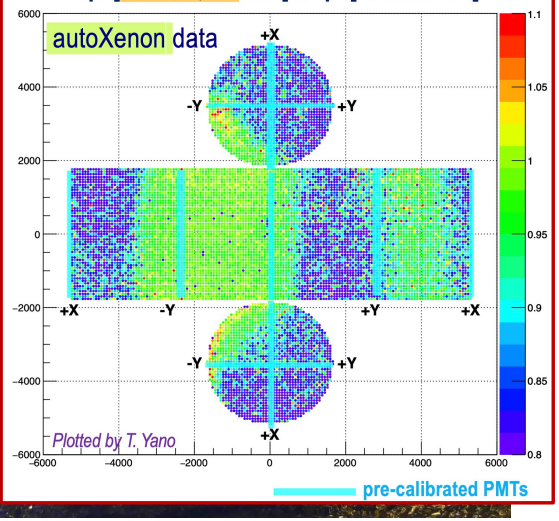
(1pe[coils #1, #2 OFF] / 1pe[all coils ON]) – 1

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

Changes in efficiency for light collection

[<qisk>$(pmt_N)_{run\ i}$ / <qisk>$(pmt_N)_{run\ i-1}$]

1pe[coils #1, #2 OFF] / 1pe[all coils ON]



ICRR-IURP 2019: local travelling

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

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

Radio-purity campaign for SuperK-Gd @ Canfranc Underground Laboratory

Table 5. Summary of $Gd_2(SO_4)_3 \cdot 8H_2O$ assay results by HPGe detectors. The sample identifier is coded as follows: YYMM##, where YYMM is the year and month of production and ## refers to the batch number produced within that month. The measurements of each radioactive chain are separated into the early part of the chain (E) and the late part of the chain (L). The isotopes identified are the longest lived within each sub-chain, and the activities are estimated assuming secular equilibrium (eq.) within each sub-chain.

Sample	Laboratory	Detector/method	Activity (mBq/kg, 95% CL)										
			^{238}U chain		^{232}Th chain		^{235}U chain		^{40}K	^{138}La	^{176}Lu	^{134}Cs	^{137}Cs
			E, ^{238}U eq.	L, ^{226}Ra eq.	E, ^{228}Ra eq.	L, ^{228}Th eq.	E, ^{235}U eq.	L, ^{227}Ac eq.					
		SK-Gd Req. →	<5	<0.5	<0.05	<0.05	<30	<30	–	–	–	–	–
17090X	LSC	Asterix	<8.4	<0.21	<0.30	<0.30	<0.42	<1.6	<1.0	<0.14	0.13±0.03	<0.07	<0.13
180702	LSC	Asterix	<4.3	<0.12	<0.22	<0.21	<0.3	<1.1	<0.5	0.13±0.04	0.24±0.03	<0.07	<0.08
180703	LSC	Asterix	<6.3	<0.24	<0.44	<0.38	<0.3	<1.1	<0.5	<0.14	0.22±0.03	<0.07	<0.07
190302	LSC	Asterix	<6.7	<0.32	<0.35	<0.29	<0.42	<0.92	<1.6	0.26±0.1	<0.21	<0.09	<0.09
190303	LSC	Asterix	<5.9	<0.3	<0.44	<0.29	<0.39	<0.81	<1.5	0.45±0.09	0.16±0.12	<0.08	<0.09
190304	LSC	Asterix	<7.7	<0.42	<0.55	<0.36	<0.52	<1.22	<2.1	0.40±0.11	<0.21	<0.13	<0.14
190502	Boulby	Belmont	<5.4	<0.49	<0.95	<0.48	<0.36	<1.7	<2.8	<0.28	0.49±0.08	–	<0.10
190502	Kamioka	Lab-C Ge	<25.0	<0.75	<0.52	<0.36	<9	7.9±0.8	<1.63	<0.37	0.68±0.18	<0.16	<0.22
190604	Boulby	Belmont	<9.80	<0.47	<0.61	<0.50	<0.45	<2.33	<2.45	<0.21	0.97±0.11	–	<0.08
190604	Kamioka	Lab-C Ge	<26.9	<0.68	<0.55	<0.33	<4.6	<1.2	<2.02	<0.36	1.43±0.19	<0.19	<0.34
190606	Boulby	Merrybent	<13.1	<0.84	<0.79	<0.63	<0.37	2.6±0.6	<3.27	<0.29	1.23±0.16	–	<0.13
190606	Kamioka	Lab-C Ge	<17.3	<1.36	<0.91	<0.94	<8.3	2.6±1.3	<3.20	<0.26	0.74±0.29	<0.39	<0.50
190606	Kamioka	Lab-C Ge, Ra Disk	–	<0.31	<0.82	<0.48	–	–	–	–	–	–	–
190607	LSC	GeOroel	<5.0	<0.30	<0.79	<0.42	<0.30	<0.96	<1.59	<0.18	<0.13	<0.12	<0.09
190608	LSC	Asterix	<6.2	<0.53	<0.43	<0.35	<0.40	<0.88	<1.50	<0.14	<0.25	<0.08	<0.09
190608	Kamioka	Lab-C Ge	<23.2	<1.06	<1.38	<0.80	<4.3	<1.8	<2.15	<0.49	<0.51	<0.21	<0.30
190608	Kamioka	Lab-C Ge, Ra Disk	–	<0.63	<0.52	<0.61	–	–	–	–	–	–	–
190702	LSC	GeOroel	<7.7	<0.45	<1.11	<0.50	<0.37	2.4±0.9	<1.5	<0.20	0.23±0.13	<0.12	<0.11
190702	Kamioka	Lab-C Ge	<12.0	<0.63	<1.08	<0.33	<3.4	<1.6	<1.99	<0.28	0.28±0.12	<0.17	<0.28
190703	LSC	Asterix	<5.9	<0.35	<0.51	<0.50	<0.45	1.8±1.0	<1.7	<0.20	0.51±0.13	<0.10	<0.10
190704	Boulby	Belmont	<9.8	<0.44	<0.66	<0.75	<0.29	<1.39	<2.01	<0.25	<0.18	–	<0.10
190706	Boulby	Belmont	<9.5	<0.45	<0.66	0.53±0.12	<0.28	<1.32	<2.09	<0.25	<0.25	–	<0.13
190706	Kamioka	Lab-C Ge	<9.4	<0.69	<0.50	<0.86	<2.26	<1.10	<1.9	<0.29	<0.19	<0.19	<0.26
190801	LSC	GeAnayet	<20	<0.92	<1.5	<0.77	<0.80	<1.17	<1.44	<0.18	2.7±0.2	<0.23	<0.18
190803	LSC	Asterix	<4.9	<0.31	0.39±0.21	0.55±0.22	<0.36	<0.74	<1.4	<0.09	3.5±0.1	<0.08	<0.07
190804	Boulby	Belmont	<11	<0.46	0.67±0.21	<0.67	<0.38	<1.98	<2.57	<0.20	4.60±0.24	–	<0.10
190805	LSC	GeOroel	<6.5	<0.52	0.53±0.44	0.57±0.40	<0.44	<0.98	<1.18	<0.10	9.44±0.10	<0.10	<0.09
190806	Boulby	Merrybent	<8.09	<0.43	0.49±0.11	1.27±0.13	<0.26	<1.23	<1.78	<0.14	9.35±0.22	–	<0.07
190901	LSC	Asterix	<6	<0.30	0.42±0.27	0.37±0.27	<0.46	<1.20	<1.47	<0.15	4.85±0.12	<0.10	<0.13
190902	Boulby	Belmont	<5.52	<0.26	0.53±0.10	0.63±0.09	<0.33	<1.22	<1.32	<0.10	8.78±0.18	–	<0.05
190903	LSC	Asterix	<6.2	<0.37	0.59±0.28	0.35±0.28	<0.54	<1.7	<1.5	<0.14	4.9±0.1	<0.10	<0.09
190905	Kamioka	Lab-C Ge	<8.6	<0.21	0.72±0.20	0.70±0.16	<5.2	<1.1	<1.57	<0.09	6.6±0.2	<0.09	<0.13
190905	Kamioka	Lab-C Ge, Ra Disk	–	<0.29	0.58±0.25	<0.39	–	–	–	–	–	–	–
200101	Kamioka	Lab-C Ge	<6.80	<0.35	0.98±0.18	1.00±0.15	8.24±1.68	<0.54	<0.95	<0.08	6.25±0.17	<0.18	<0.13
200103	Kamioka	Lab-C Ge	<8.46	0.51±0.12	1.42±0.25	0.84±0.17	<2.11	<0.88	<1.43	<0.12	0.18±0.07	<0.13	<0.16
200104	Kamioka	Lab-C Ge	<8.39	<0.36	1.48±0.24	0.84±0.18	<3.45	<0.95	<1.02	<0.08	<0.28	<0.23	<0.11

(a) (b) (c)

Fig. 4. (a) ULBS laboratory in Hall C of LSC, (b) a $Gd_2(SO_4)_3$ sample inside the GeOroel shield, and (c) a $Gd_2(SO_4)_3 \cdot 8H_2O$ sample inside the Asterix shield.

J. Pérez, PhD thesis 2017

measurement techniques

JOURNAL ARTICLE ACCEPTED MANUSCRIPT

Gadolinium concentration measurement with an atomic absorption spectrophotometer

Ll Marti ✉, L Labarga

Progress of Theoretical and Experimental Physics, ptae022, https://doi.org/10.1093/ptep/ptae022

Published: 10 February 2024

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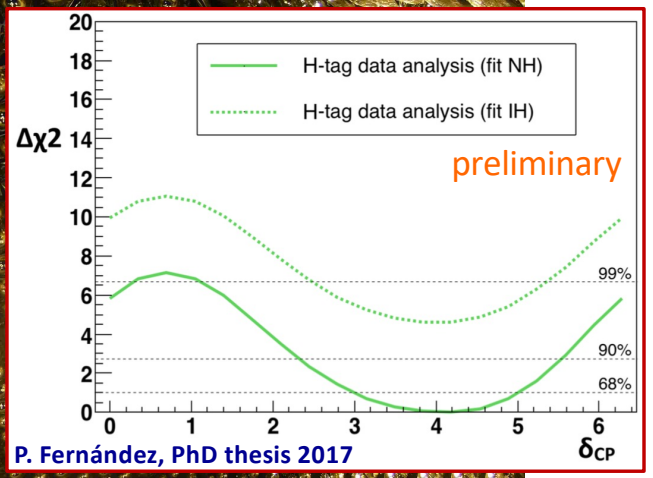
ICRR-IUR 2023: pub. fees

ICRR-IUR 2021: Shipping SK-Gd T1.5 Gd samples to Canfranc for radio-purity investigations

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

neutron - tagging in oscillation analyses



arXiv > hep-ex > arXiv:2311.05105

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High Energy Physics – Experiment

[Submitted on 9 Nov 2023]

Atmospheric neutrino oscillation analysis with neutron tagging and an expanded fiducial volume in Super-Kamiokande I-V

Super-Kamiokande Collaboration: T. Wester, K. Abe, C. Bronner, Y. Hayato, K. Hiraide, K. Hosokawa, K. Ieki, M. Ikeda, J. Kameda, Y. Kanemura, R. Kaneshima, Y. Kashiwagi, Y. Kataoka, S. Miki, S. Mine, M. Miura, S. Moriyama, Y. Nakano, M. Nakahata, S. Nakayama, Y. Noguchi, K. Sato, H. Sekiya, H.

Search for the Diffuse Supernova Neutrino Background

The Astrophysical Journal Letters, 951:L27 (8pp), 2023 July 10 https://doi.org/10.3847/2041-8213/acdc9e

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OPEN ACCESS

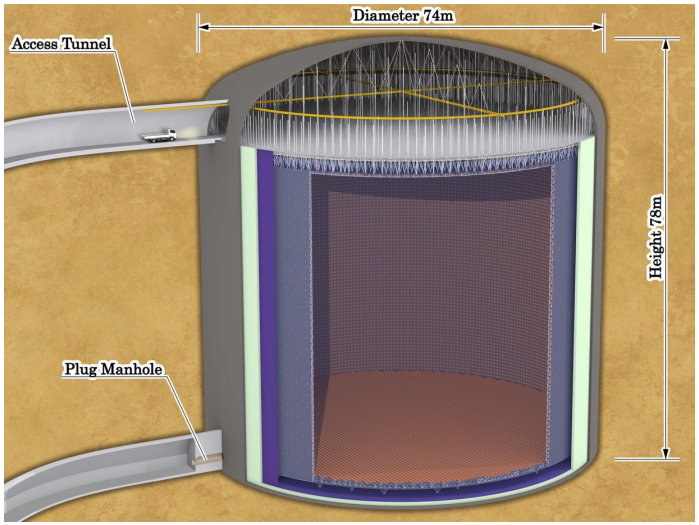
Search for Astrophysical Electron Antineutrinos in Super-Kamiokande with 0.01% Gadolinium-loaded Water

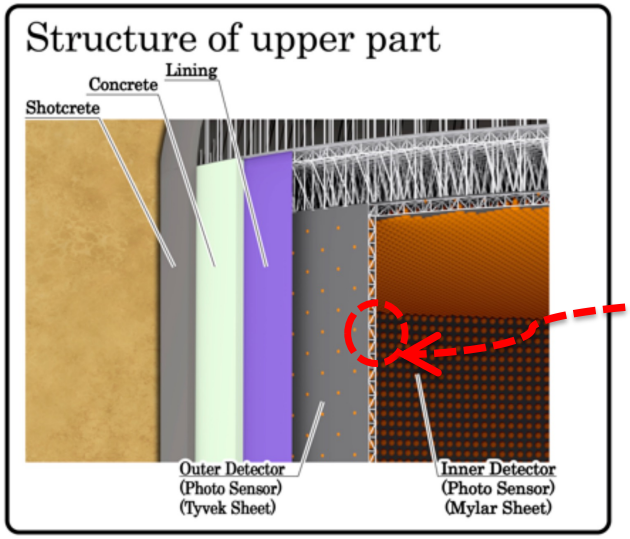
M. Harada[1], K. Abe[2,3], C. Bronner[2], Y. Hayato[2,3], K. Hiraide[2,3], K. Hosokawa[2], K. Ieki[2,3], M. Ikeda[2,3], J. Kameda[2,3], Y. Kanemura[2], R. Kaneshima[2], Y. Kashiwagi[2], Y. Kataoka[2,3], S. Miki[2], S. Mine[2,4], M. Miura[2,3], S. Moriyama[2,3]

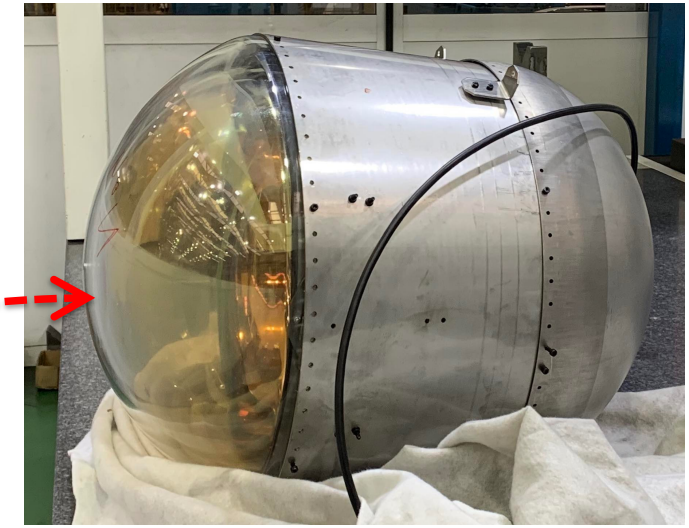
ICRR-IURP 2023: local travelling

UAM research/works in Hyper-Kamiokande: two highlights at a glance

basic in HK are the photo detection system units







- fantastic PMT R12860-HQE
- problem with chain reaction after accidental implosion of one PMT: the case of SK
- need new implosion mitigation cover (SK: 40 m, HK: 70 m). Careful dessign needed: efficiency, noise, safety etc.
- **UAM worked very hard to make them a reality**

ICRR-IURP 2019: Finite Element Modeling of its design of an acrylic window without flange
ICRR-IURP 2020: Acquisition of HK PMTs with no vacuum for mechanical tests; research traveling inside Japan
ICRR-IURP 2021: Acquisition of HK flanged acrylic windows for the final test program of the sp-cover

UAM research/works in Hyper-Kamiokande: two highlights at a glance

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

L. Labarga (UAM), HK-calib premeeting, HK CM February 2024
20240206

We are working on an auto-flashing light calibration system for Hyper-Kamiokande, similar to the auto-Xenon system in Super-Kamiokande, that running in auto-calibration mode monitors the evolution with time of many aspects of the performance of the HK Inner Detector:

- Light transmission through water at different parts of the water tank
- Relative light collection efficiency of every ID PMT
- Status of every ID PMT at any time
- Identify changes in the gains of the ID PMTs (joint analysis with the so-called “Nickel calibration” data)
- Top-Bottom detector asymmetries in light transmission
- others

ICRR-IURP 2023: optical material for viability studies

Summary

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

A05, A03: supporting our works on Super-Kamiokande I – VII

B01: supporting our contributions to the built of the Hyper-Kamiokande project

ICRR-IURP is an extremely useful program; it is helping very much UAM in its research with SK and HK by funding

- 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 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-Kamiokand
- ….

Thank you very much ICRR for your Science and your support !