Research Result Presentation Meeting of the ICRR Inter-University Research Program 2020

Brief report on

A05: Data Taking, Calibrations, Measurements and Analysis with Super-Kamiokande and SuperK-Gd

200.000 ¥

B01: Development and testing of cost-effective, high-performance Photo-Detector anti-implosion covers for Hyper-Kamiokande

500.000 ¥

which are follow-ups of two similar ICRR-IURP 2019 projects (the HK one had D. Bravo as IP)

and hopefully predecessors of the two new ICRR-IURP 2021 projects just submitted

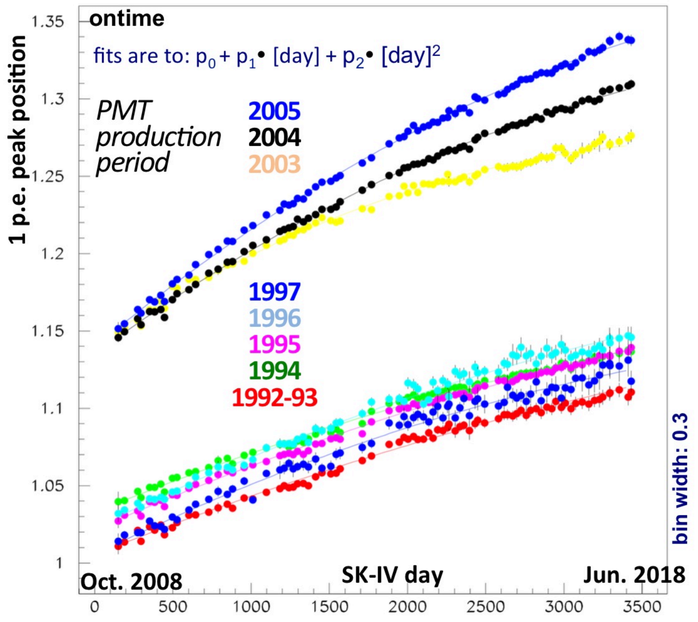
February 8th 2021

L. Labarga (University Autonoma Madrid, UAM)

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

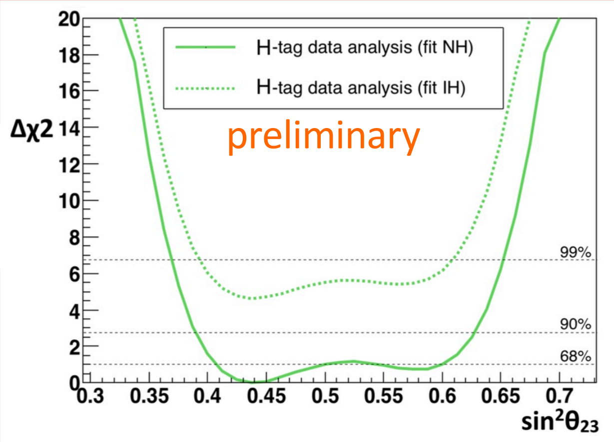
PMT-gain variation with time at different PMT groups

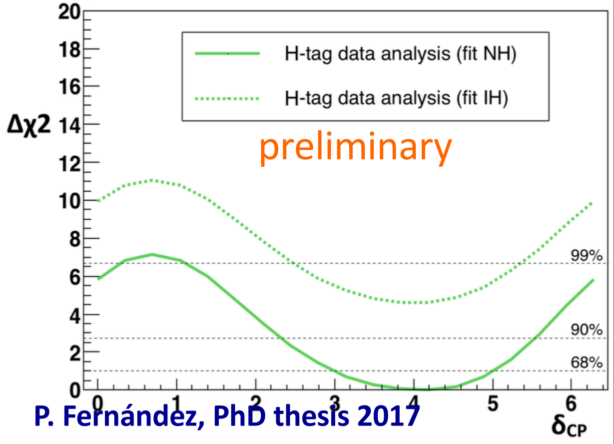
Nickel SK-IV data: gain [fitted 1 p.e. peak] vs. time



calibrations, detector evolution, etc.

neutron-tag in oscillation analyses





P. Fernández, PhD thesis 2017

local travelling funded with ICRR-IURP 2019, ICRR-IURP 2020 was planned to use also for it, but COVID came ….

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

(Units are mBq/Kg; limits are at 95% CL)

CHAIN	MAIN SUBCHAIN ISOTOPE	GOX-1510-D-001	GSF-1701-D-003	GSF-1705-D-001	GSF-1711-D-171111B	GSF-1711-D-171111A	GSF-1703-A-702142	GSF-1703 B- (RGD-OSF-005)	GOX-1603-B-237	GOX-1603-B-239	GOX-1603-B-236	GSF-1604-B-1	GSF-1611-B-003	GSF-1703-B-(RGD-OSF-005)	GSF-1703-B-(RGD-OSF-005)-b	GSF-1707-B-007	GSF-1604-C-160303	GSF-1707-B-007	GSF-1710-C-170901	GSF-1710-C-170902	GSF-1710-C-170903
^{238}U	^{238}U	1672 ± 122	< 45	< 11	< 52	< 168	< 13	< 13	< 68	< 130	< 36	< 25	< 13	< 10	< 19	< 10	< 20	< 10	< 9.7	< 12	< 11
	^{226}Ra	< 2.8	0.4 ± 0.2	4.3 ± 0.6	< 1.1	2.0 ± 1.4	0.7 ± 0.4	< 0.34	< 0.9	< 1.0	< 1.4	< 0.6	< 0.3	< 0.31	< 0.54	< 0.18	< 0.64	< 0.18	< 0.19	< 0.21	< 0.21
^{232}Th	^{228}Ra	259 ± 6	28.5 ± 1.1	12.2 ± 1.0	300 ± 7	778 ± 39	< 0.39	< 0.39	< 2.7	< 2.3	< 1.4	< 0.7	< 0.3	< 0.30	< 0.74	< 0.21	< 0.67	< 0.21	< 0.24	< 0.26	< 0.30
	^{228}Th	124 ± 3	6.3 ± 0.5	2.5 ± 0.4	31 ± 2	70 ± 3	1.7 ± 0.4	< 0.28	< 2.5	< 1.4	< 0.8	0.9±0.3	< 0.4	< 0.33	< 0.43	< 0.26	0.5 ± 0.2	< 0.26	< 0.28	< 0.31	< 0.30
^{235}U	^{235}U	28.7 ± 1.5	< 1.5	< 1.0	< 3	< 4	< 1.3	< 0.77	< 1.6	< 0.8	< 1.0	< 3.1	< 0.6	< 0.69	< 0.82	< 0.3	< 0.7	< 0.3	< 0.35	< 0.41	< 0.42
	^{227}Ac / ^{227}Th	< 14	< 5.5	3.4 ± 1.4	31 ± 5	46 ± 9	< 3.1	< 2.3	< 4.3	-	-	< 6.1	< 1.9	< 1.8	< 2.0	< 1.2	< 2.3	< 1.2	< 1.7	< 1.4	< 1.6
	^{40}K	21 ± 6	< 1.0	< 1.8	27 ± 3	57 ± 4	< 8.2	< 3.2	< 4.6	< 5.3	< 3.4	< 2.1	< 1.8	< 1.5	< 2.5	< 0.9	< 1.6	< 0.9	< 0.8	< 1.0	< 0.7
	^{138}La	< 3.2	< 0.25	< 0.36	< 2.4	< 2.4	< 0.29	< 0.29	< 0.6	< 0.7	< 0.7	< 0.5	< 0.3	< 0.29	< 0.31	< 0.20	< 0.3	< 0.20	< 0.09	< 0.05	< 0.14
	^{176}Lu	5.9 ± 0.4	26.5 ± 0.8	6.1 ± 0.4	< 1.2	4.3 ± 0.6	2.6 ± 0.3	< 0.29	< 0.8	< 0.7	< 1.6	0.4±0.3	0.4±0.1	< 0.46	< 0.41	0.4±0.1	< 0.4	0.8 ± 0.1	0.13± 0.03	0.11± 0.04	< 0.14
	^{134}Cs	-	-	-	-	-	-	-	< 0.24	< 0.4	< 0.23	< 0.24	< 0.09	< 0.09	-	< 0.06	< 0.1	< 0.06	< 0.08	< 0.06	< 0.07
	^{137}Cs	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	< 0.3	< 0.34	< 0.30	< 0.24	< 0.16	< 0.12	-	< 0.12	< 0.1	< 0.12	< 0.13	< 0.10	< 0.11

J. Pérez, PhD thesis 2017

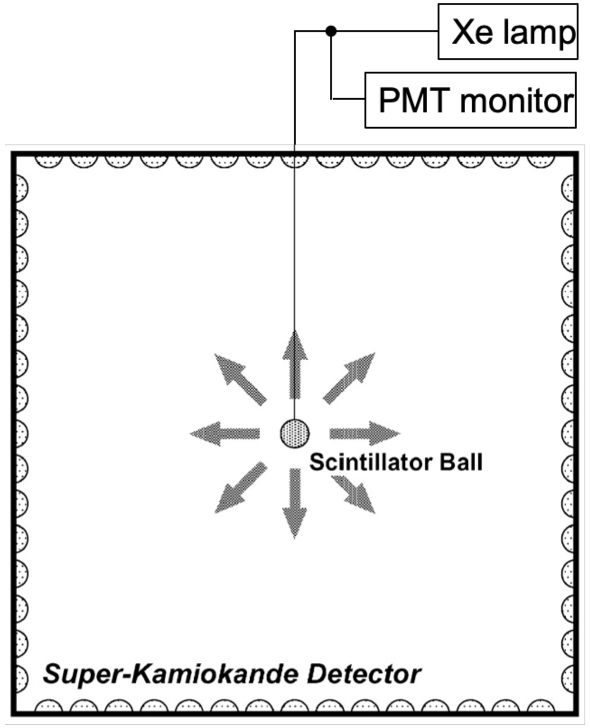
Excellent $Gd_2(SO_4)_3$ achieved, within specifications within experimental limits; Now preparing for mass production screening.

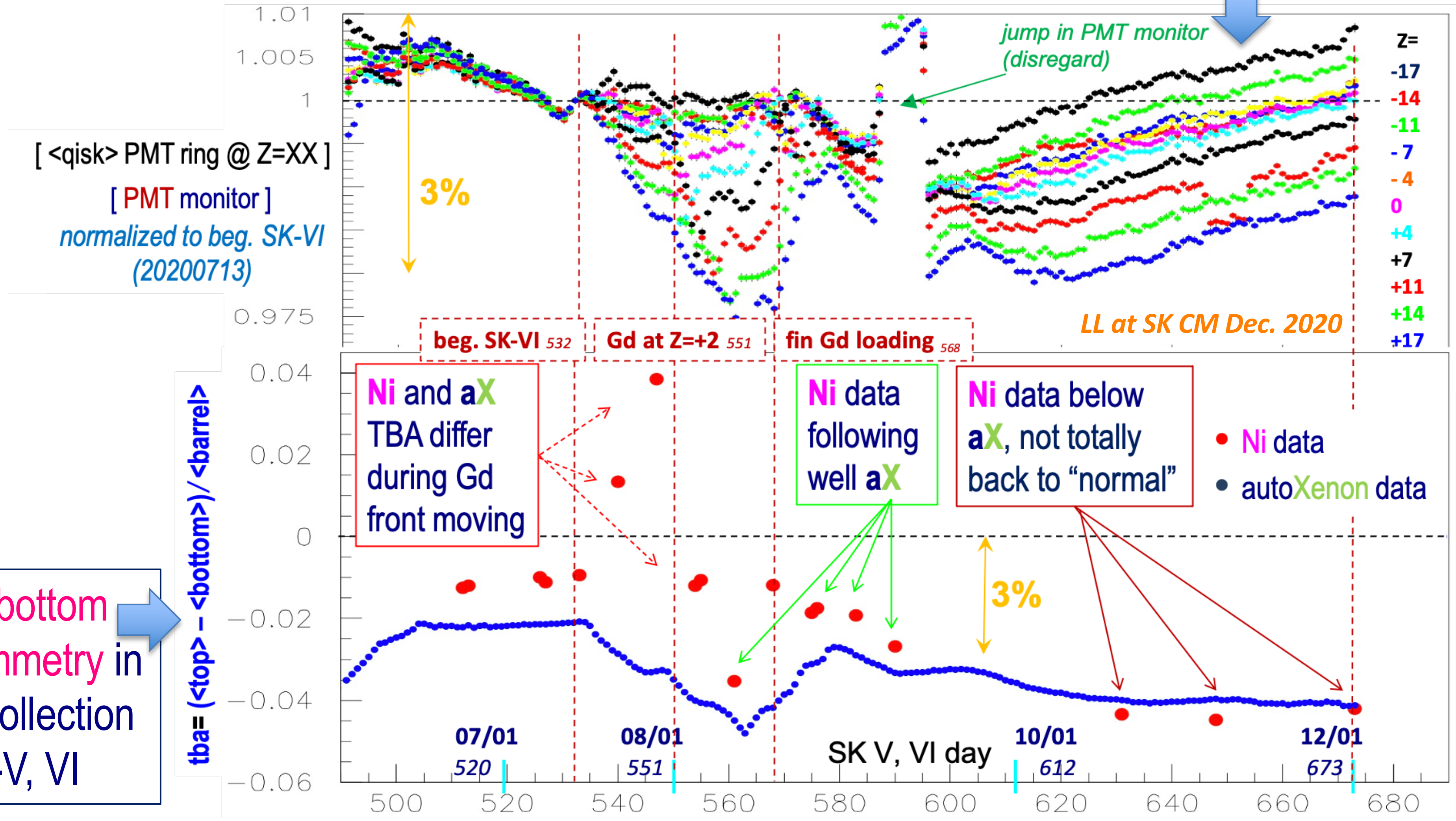
Name of Samples analyzed
[MATerial*-date-**C**ompany-lot]

***GSF:** $Gd_2(SO_4)_3$ **GOX:** Gd_2O_3

autoXenon system (~0.08 Hz) and Cf-Nickel *few MeV* γ_s (~every month) as means to monitor the performance of the detector

evolution of transparency at different detector heights (Z)



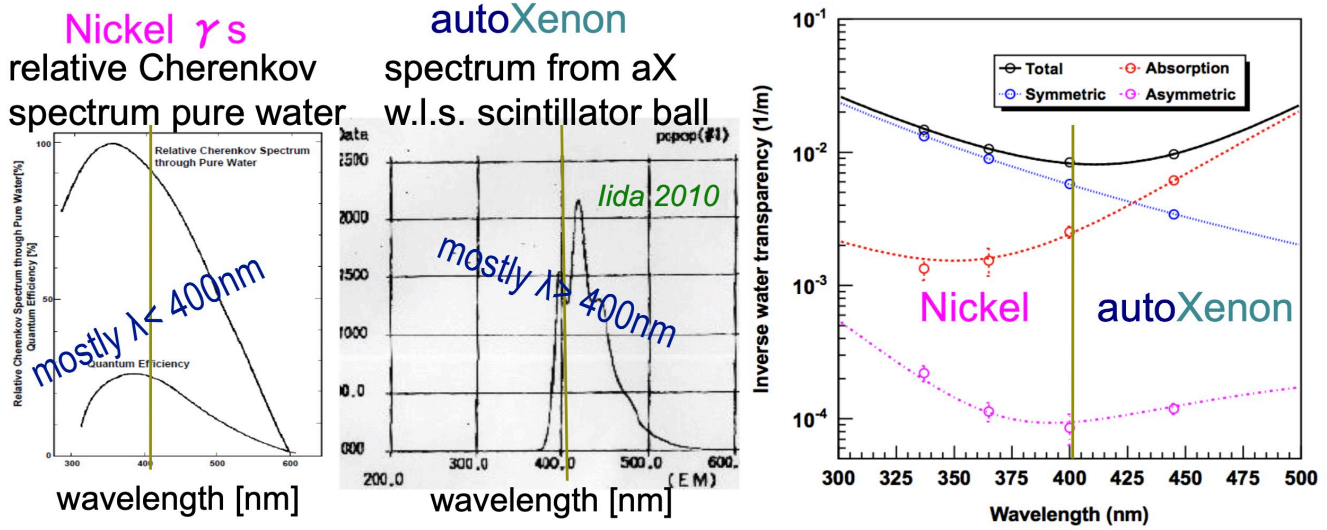


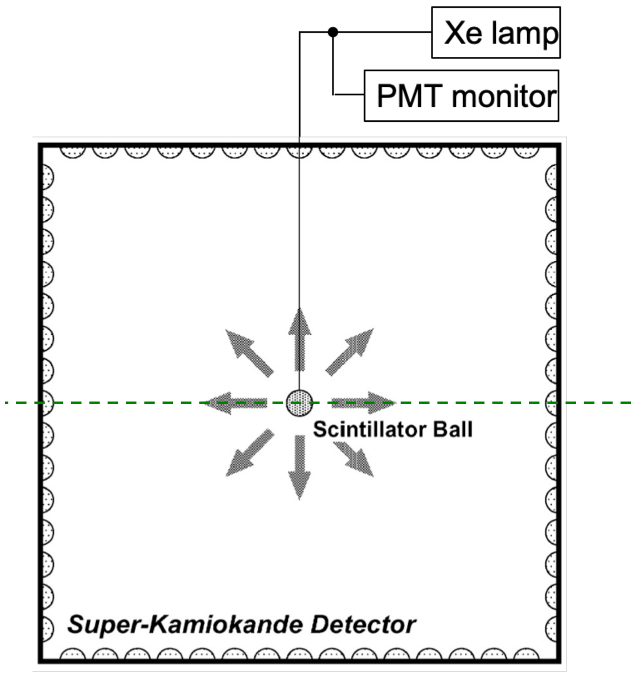
top – bottom [a]symmetry in light collection in SK-V, VI

→ very powerful system

→ for instance, the differences Ni vs. aX TBA during Gd loading might indicate a difference in light transmission at different wavelengths (also observed qualitatively with the Korean laser system) → try to improve with ICRR-IURP 2020

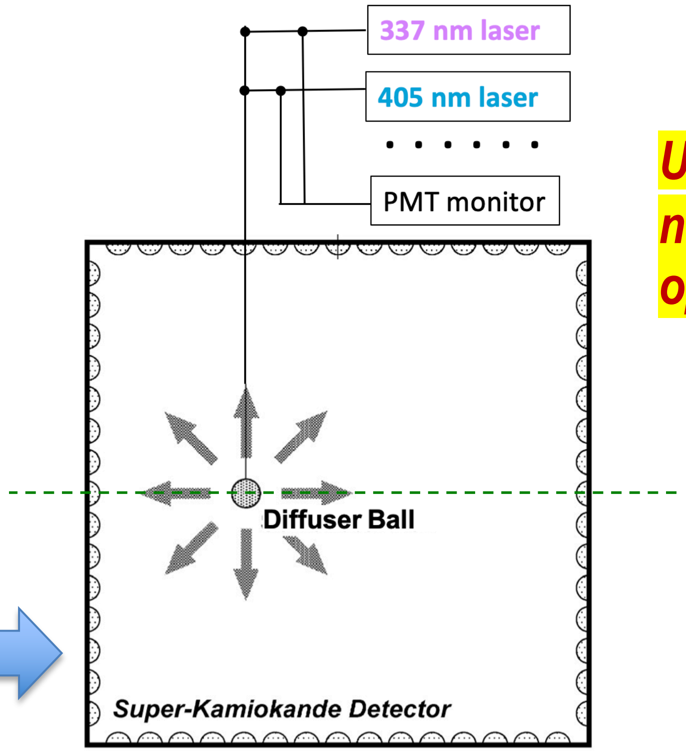
a note about emission spectra and water parameters





Study light transmission globally also vs. wavelength:

Add to the current auto-Xenon system, another one with emission of fixed wavelength lights

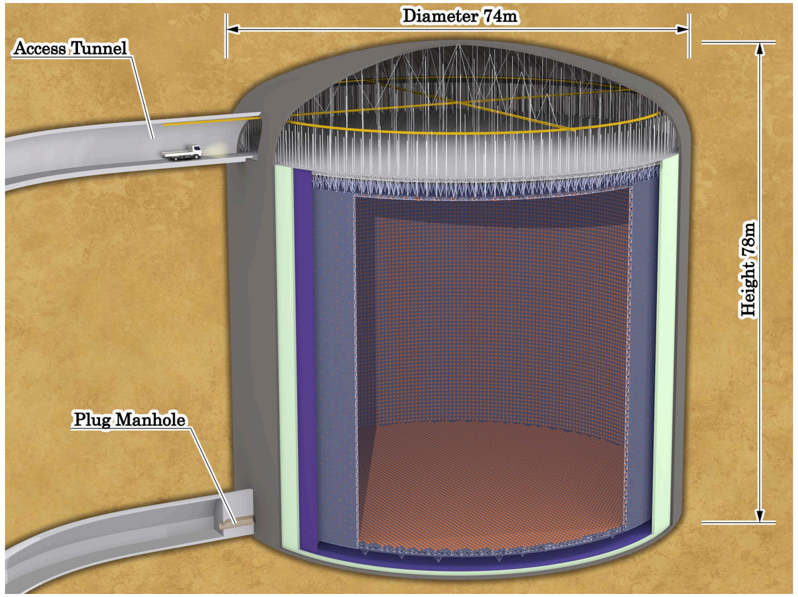


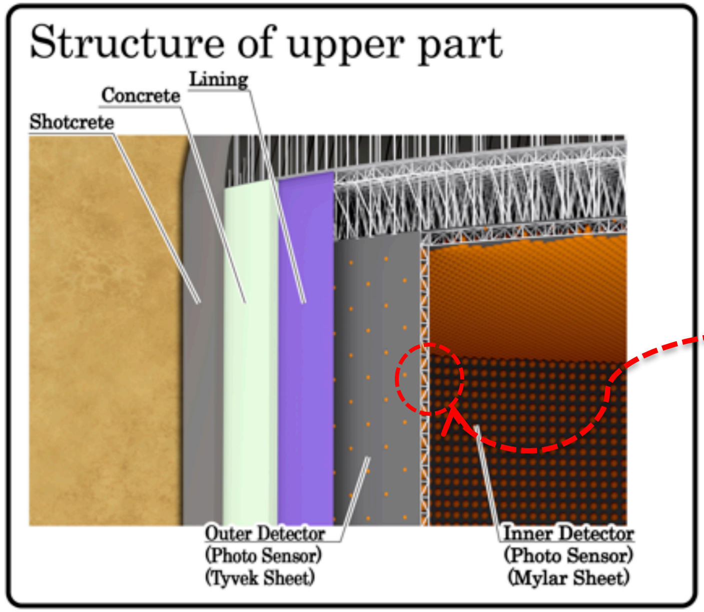
Use ICRR-IURP 2020 for it; not cheap, start with the optical fiber system

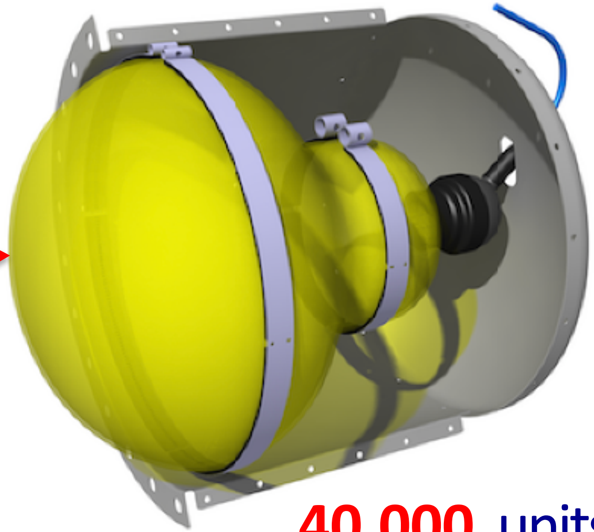
UAM research/works in Hyper-Kamiokande: two highlights

- building a strong Spanish participation in the experiment: already 7 groups
- identifying relevant parts of the experiment for suitable contributions by Spain: see next

basic in HK are the photo detection system units

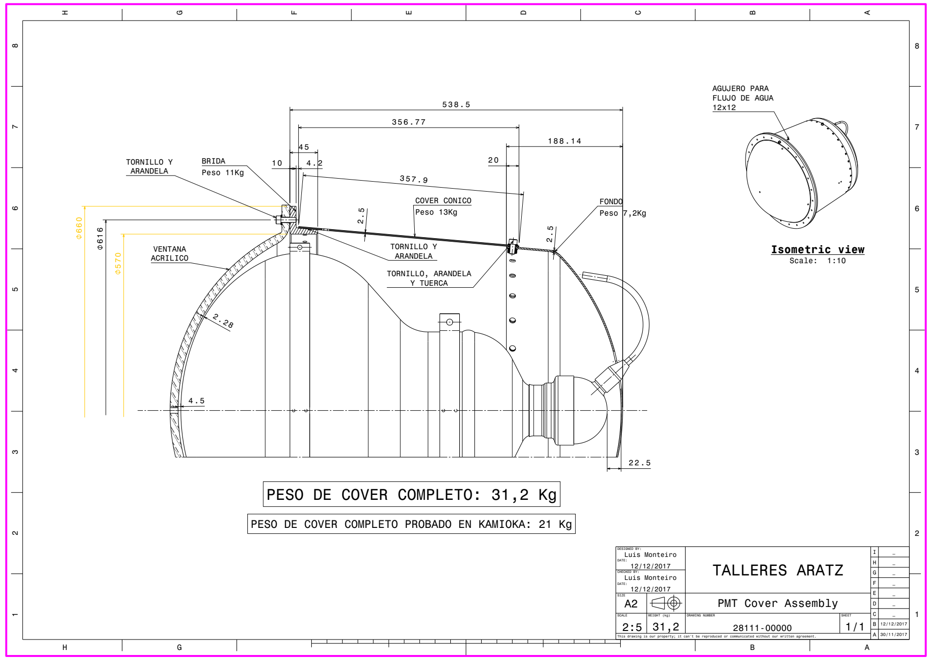






40.000 units at most

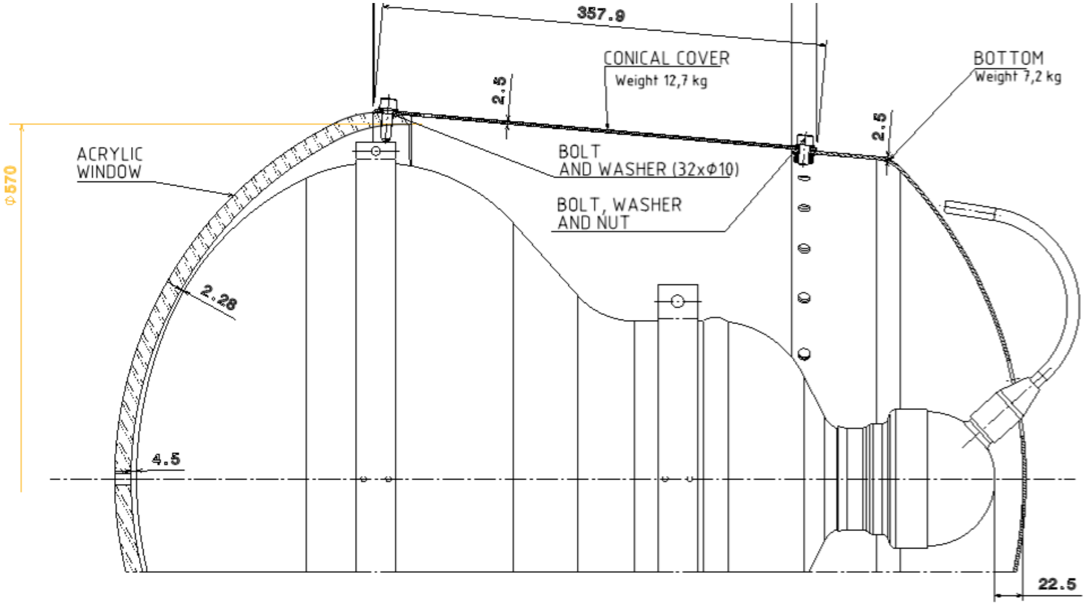
- fantastic PMT R12860-HQE
- problem with chain reaction after accidental implosion of one PMT: the case of SK
- need new implosion mitigation cover (SK: 40 m, HK: 70 m)
- careful dessign needed: efficiency, noise, safety etc.
- **UAM + LSC + are working hard in making them a reality**



V2.2 successfully tested both hydrostatically and with induced implosion

https://drive.google.com/file/d/1N1BrW75O4Z1MKmGp2FawtnDGa3nBOugk/view

Proposing for Hyper-Kamiokande:



V3: probably the simplest, most robust, and cheapest approach

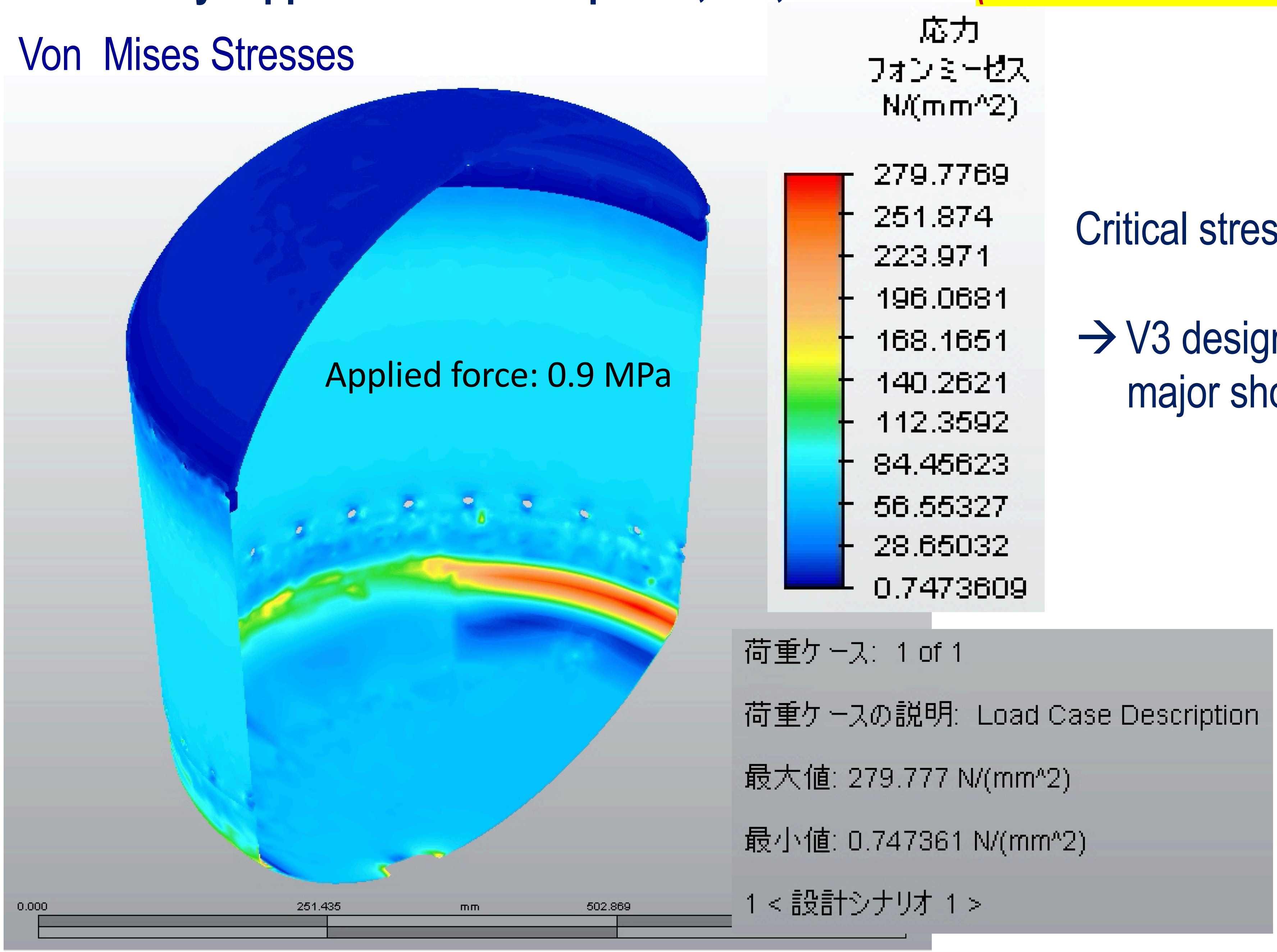
- flangeless acrylic domes
- Attachments by rivets

but keep/improve current version V2.2 (→ **V2.3**) as alive backup

Calculations by Nippon Marine Enterprises, Ltd, 201908

(funded with ICRR-IURP 2019, D. Bravo, UAM)

Von Mises Stresses

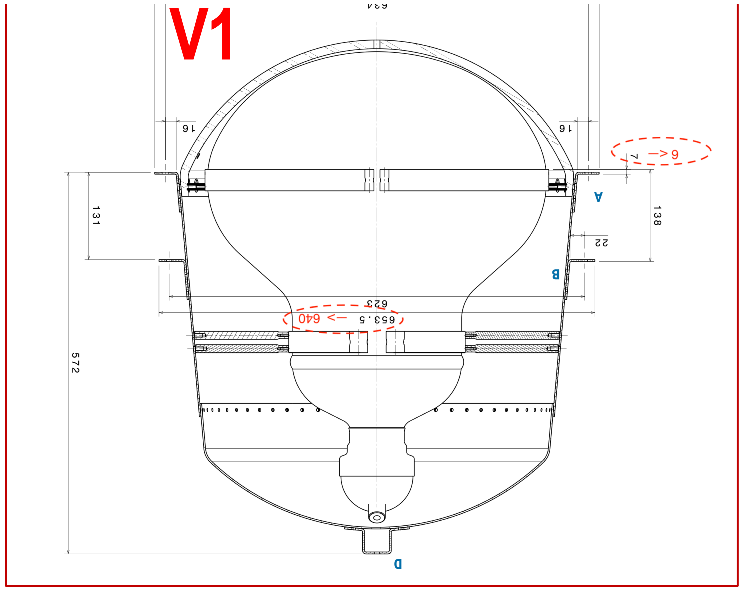


Critical stress: ~500 N/mm^2

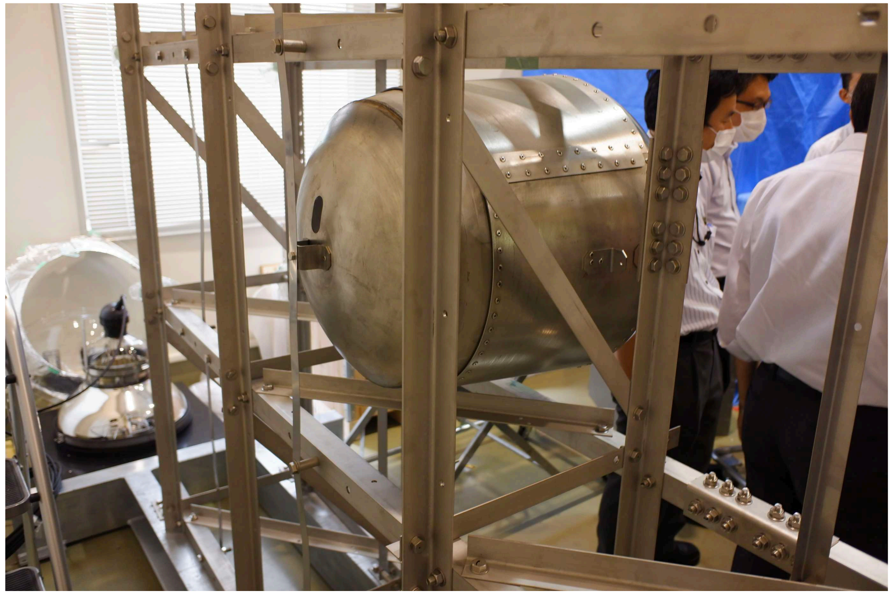
→ V3 design does not show any major show-stopper

Attachment Cover-to-Structure

V1

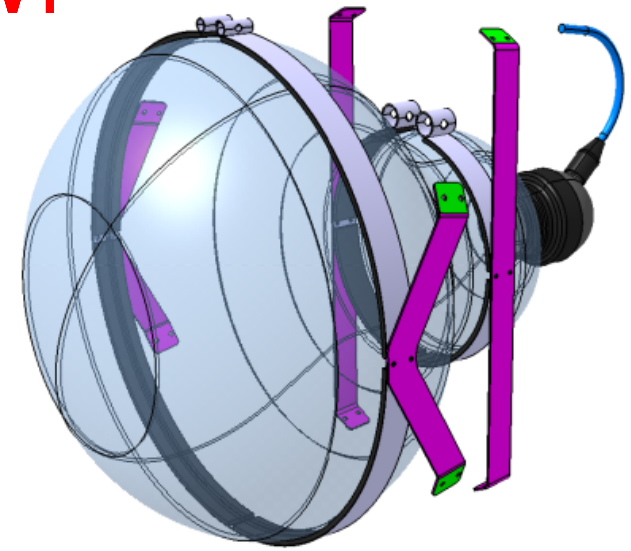


unit of sp-cover in place in Kashiwa HK mockup structure for testing



Attachment PMT-to-Cover

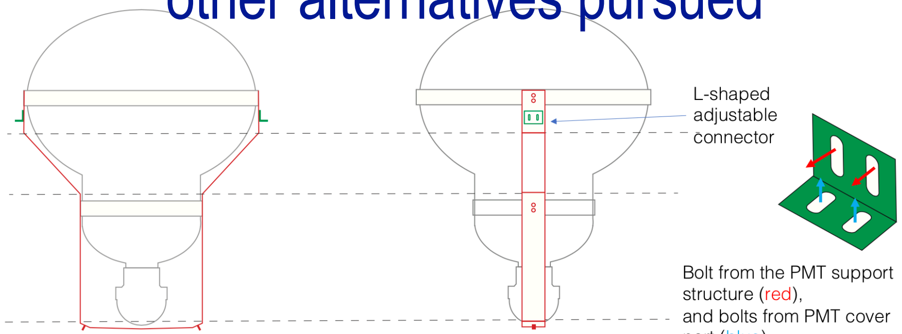
V1



2 HK PMT no vacuum for testing attach. system purchased with ICRR-IURP 2020

Update of an idea of PMT connection method (J.K. Sep.16)

other alternatives pursued

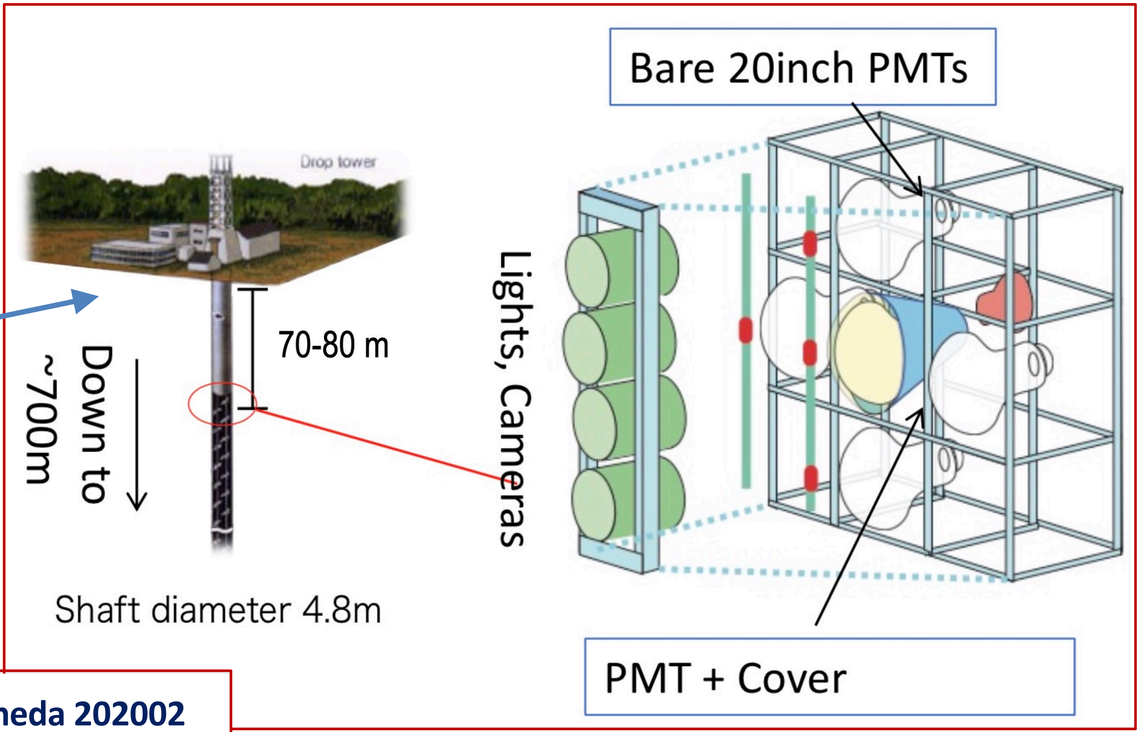


Bolt from the PMT support structure (red), and bolts from PMT cover port (blue). Long holes to adjust the uncertainties.

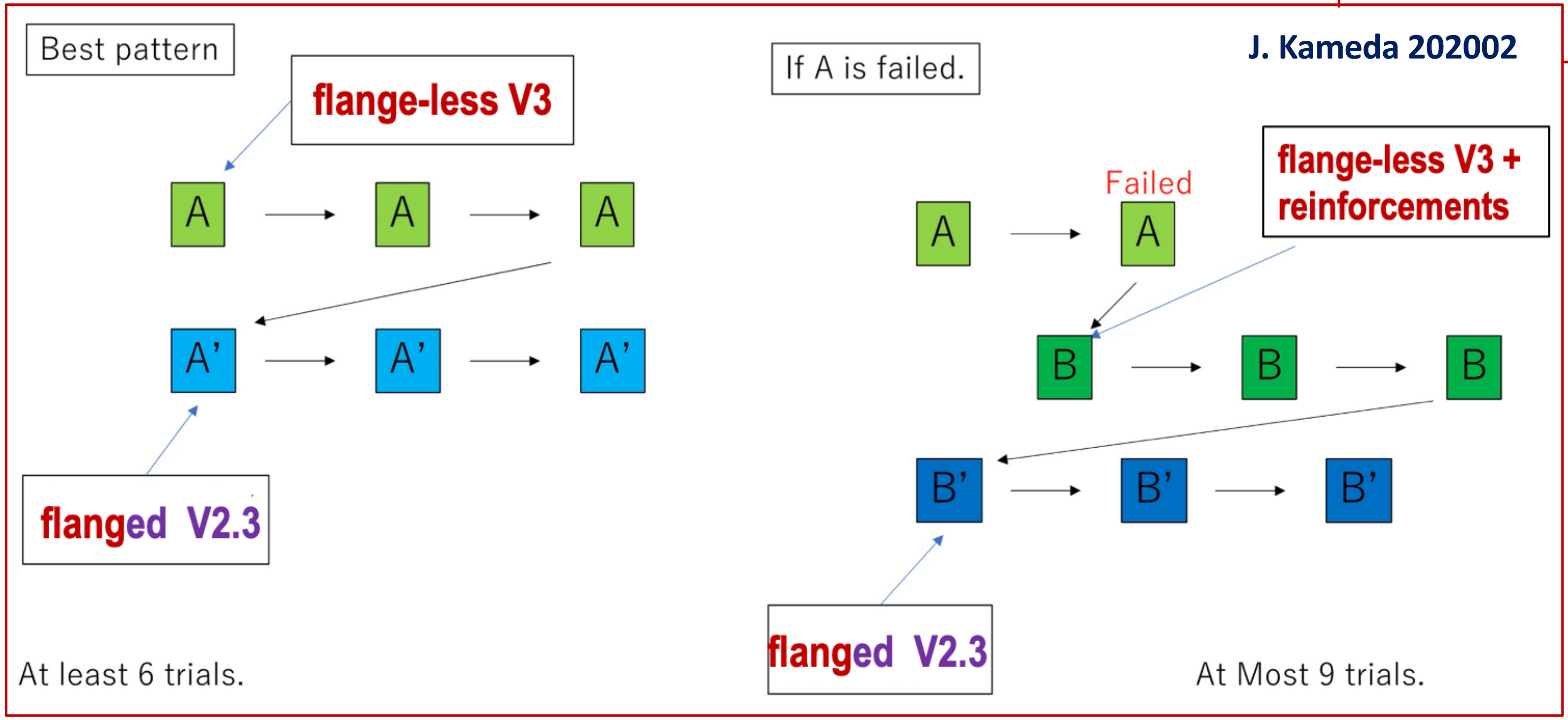
- Made by a stainless steel band in a uni-structure.
- Big radius / small radius PMT bands are both connected to the structure.
- The structure is connected to PMT cover by L-shaped adjustable connectors (front side) and bolts (backside). Four points in total.

The **final test program to formally propose the cover design to the Collaboration**:

- a set of hydrostatic pressure test in Spain
- a set of implosion induced tests at depth at former *Japan Microgravity Center* facility in Hokkaido



pattern approach for both @hydrostatic and @implosion tests:



Many parts, items, etc. needed.

The flanged acrylic windows will be as those at [HK pmt + cover] now in SK, made by Kuraray, no further R&D needed.

Four flanged acrylic domes are needed for the tests; used ICRR-IURP 2020 to purchase them

Summary

UAM has been granted with two ICRR-IURP 2020 projects:

A05: Data Taking, Calibrations, Measurements and Analysis with Super-Kamiokande and SuperK-Gd
B01: Development and testing of cost-effective, high-performance Photo-Detector anti-implosion covers for Hyper-Kamiokande

they are follow-ups of two similar ICRR-IURP 2019 projects (the HK one had D. Bravo as IP)
… and hopefully predecessors of the two new ICRR-IURP 2021 projects just submitted

ICRR-IURP is an extremely useful program.
It has helped UAM very much in its research around SK and HK by funding

- Research trips inside Japan
- Preparations of a new auto-monitoring 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
- ….

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