

# Japan and Europe Network for Neutrino and Intensity Frontier Experimental Research

# Towards Hyper-Kamiokande

WP3 report

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12 December 2022, Mid Term Review



# Towards Hyper-Kamiokande

## Objectives:

- Test a Gd-doped water Cherenkov using the existing Super-Kamiokande detector
- Accurate optical calibration of a large tank Cherenkov detector.
- Design the Outer Detector for the Hyper-Kamiokande experiment.
- Design specific low-threshold, low-noise, large dynamics front-end electronics.
- Develop realistic simulation of the Hyper-Kamiokande detector.



# Online Meetings and Shifts so far

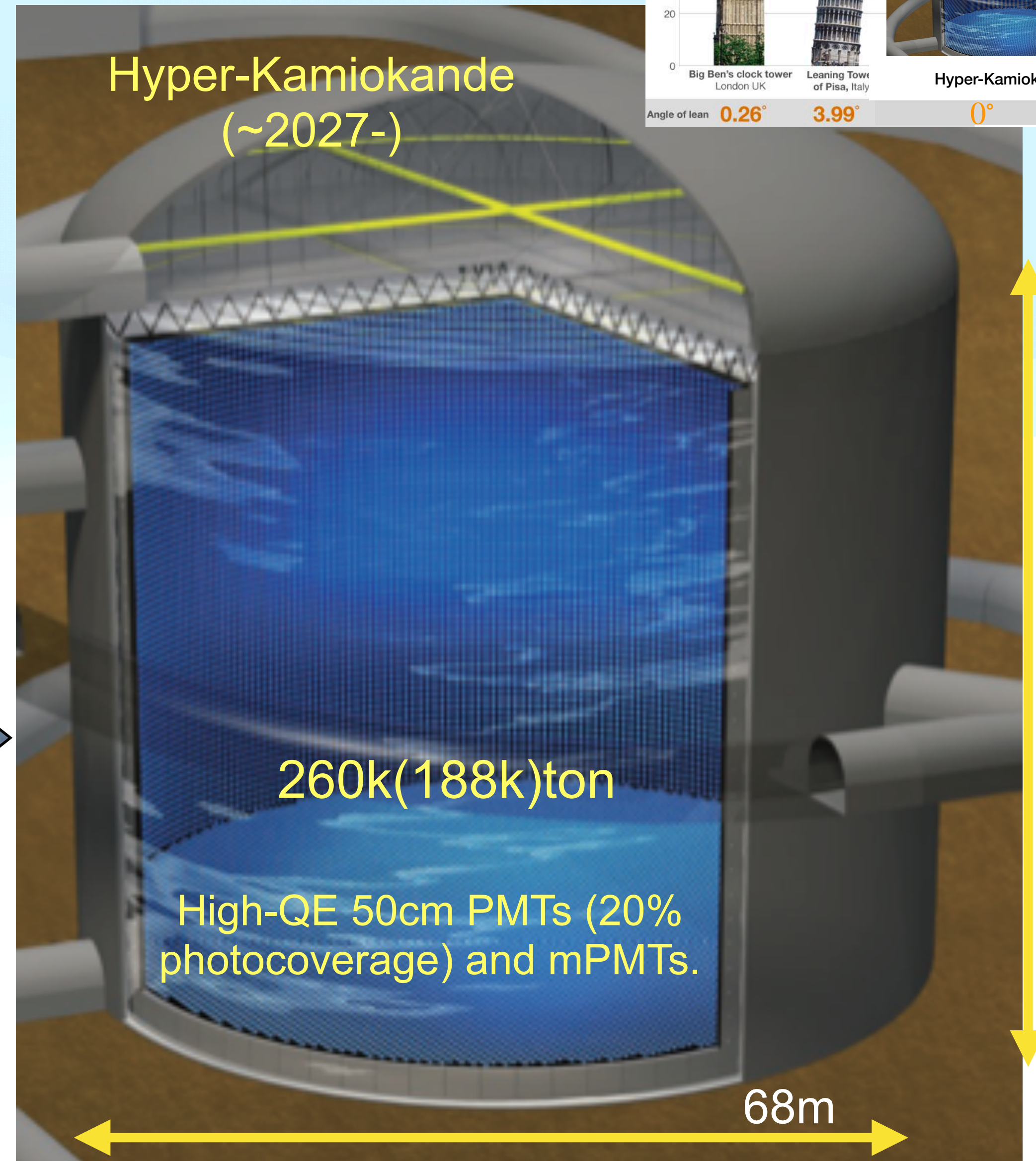
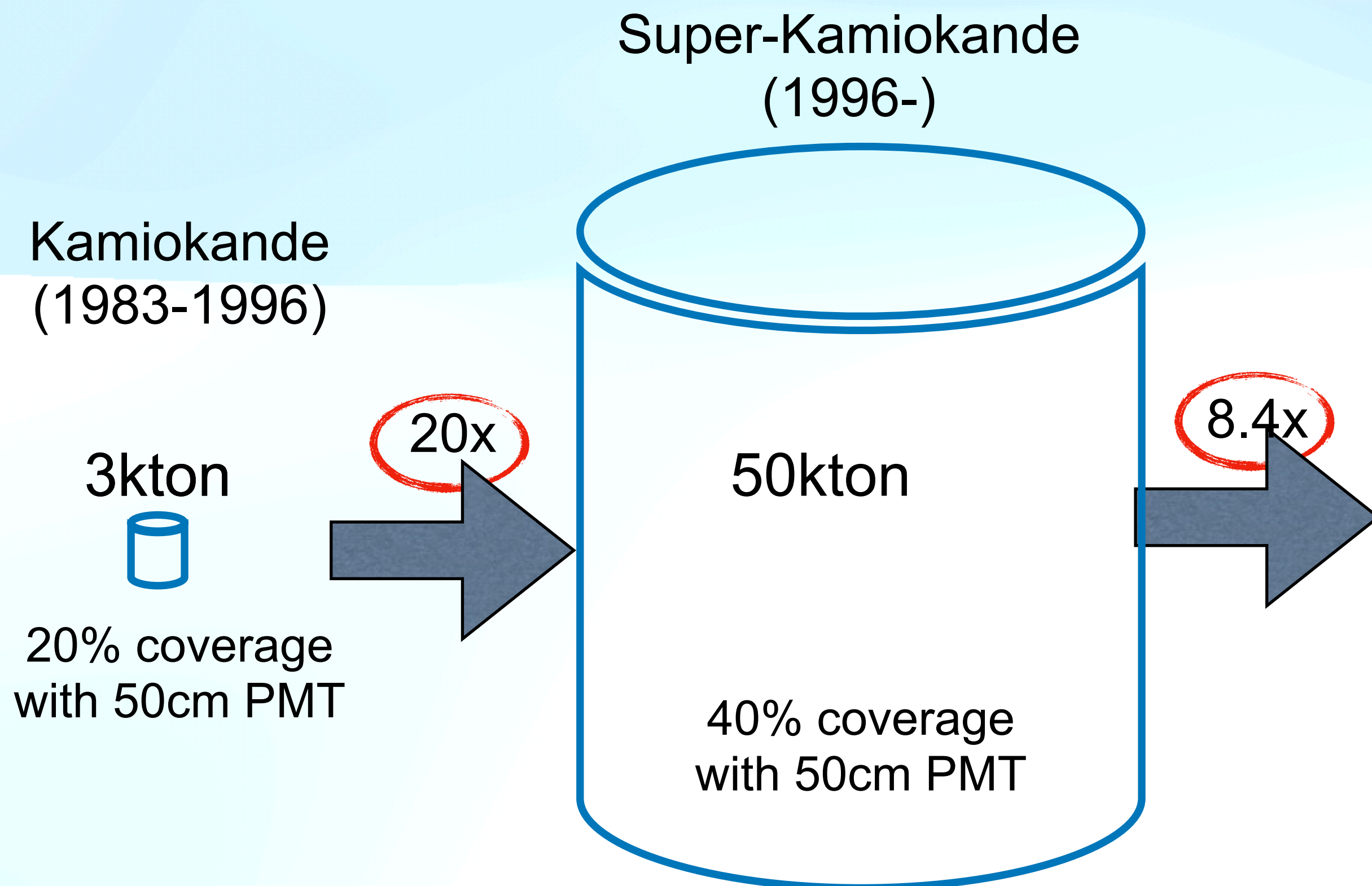
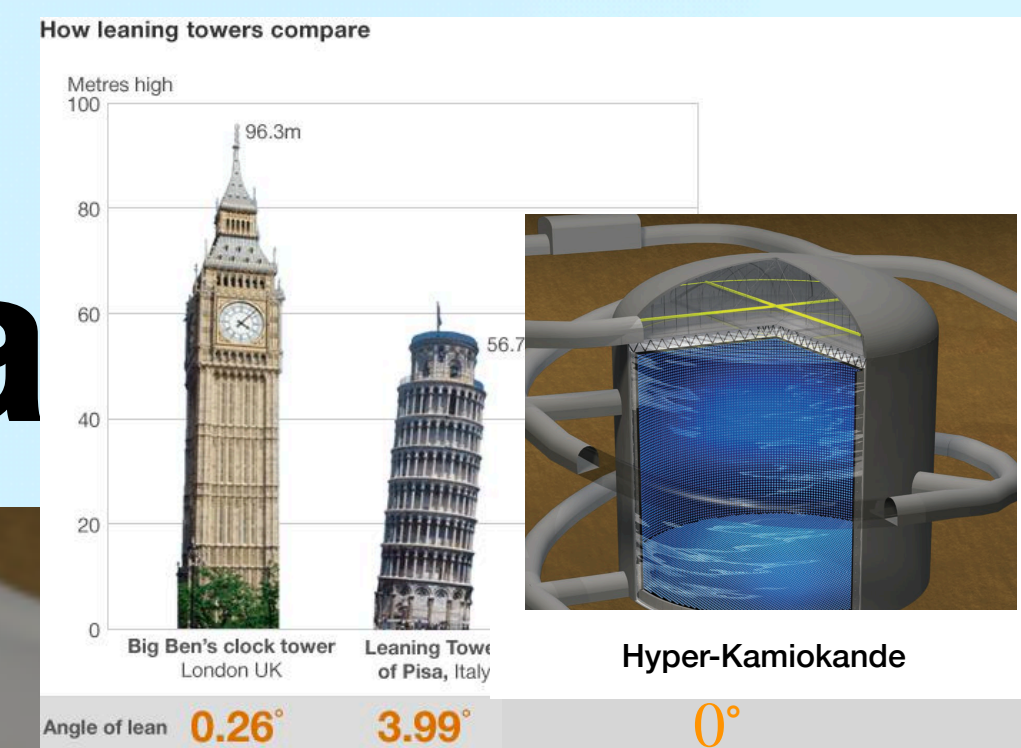


- Zoom meetings so far.
- Only a few people travelled for specific work.
- Shifts all online.
- The situation is changing and collaboration meetings are moving to be in person as well as people are traveling again for work in Japan.

26 November 2022 during HK CM

# Status of the Hyper-K Cavern Excava

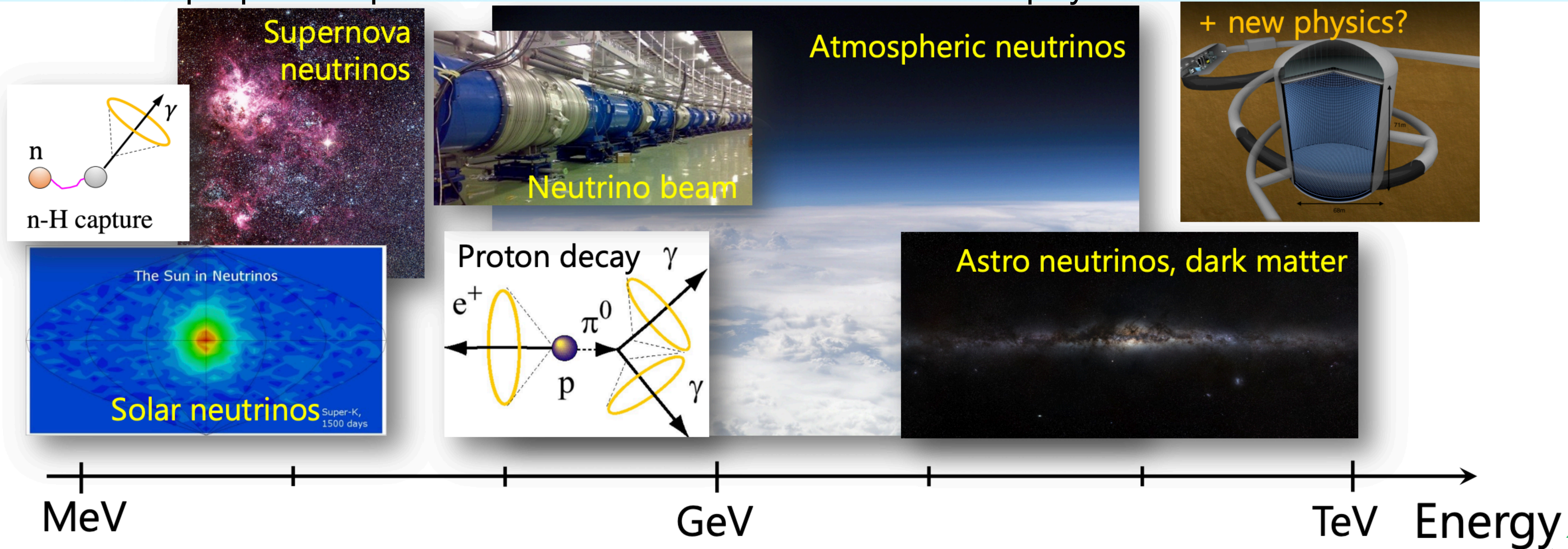
## Nucleon Decay Experiment Neutrino Detection Experiment



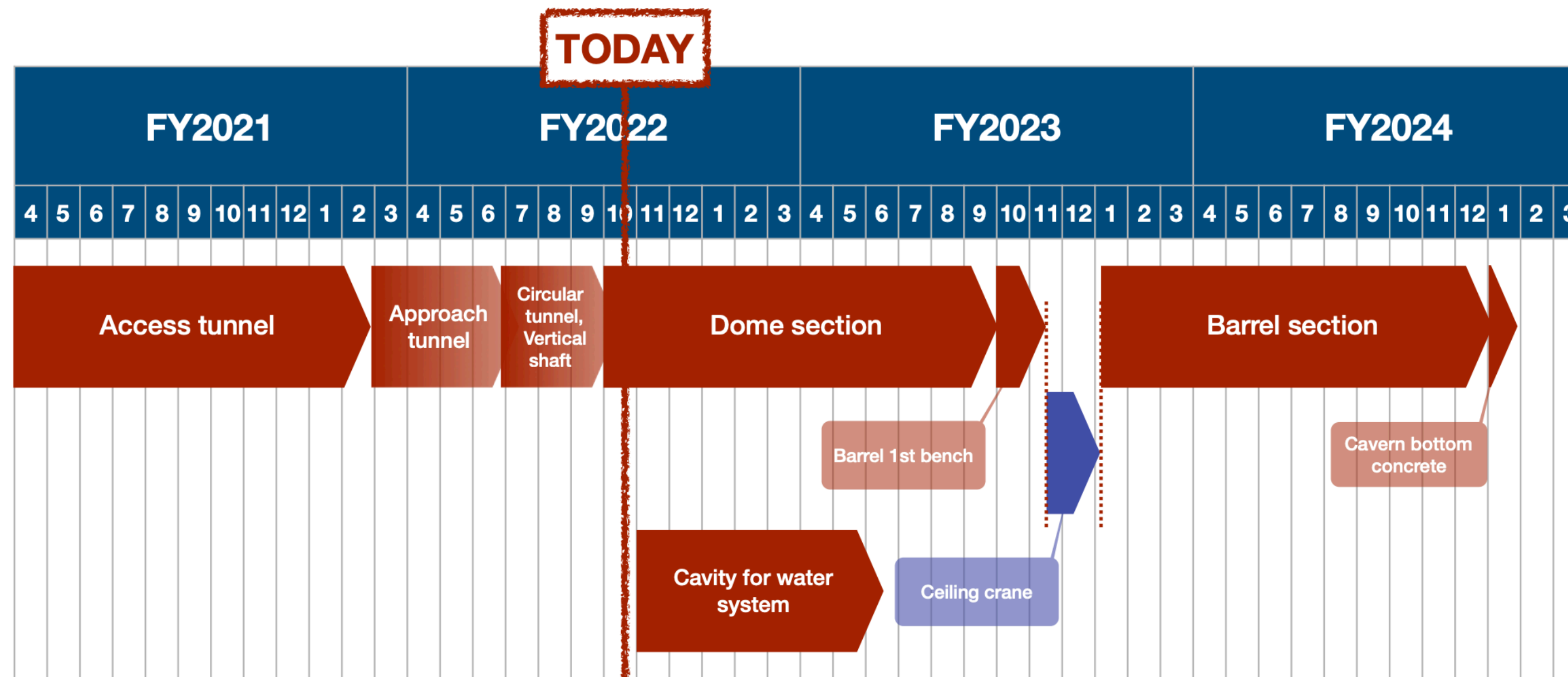
*Unprecedented scale of underground cavern*

# Hyper-Kamiokande Physics

- “Multi-purpose experiment” sensitive to different neutrino physics.



# Status of the Hyper-K Cavern Excavation

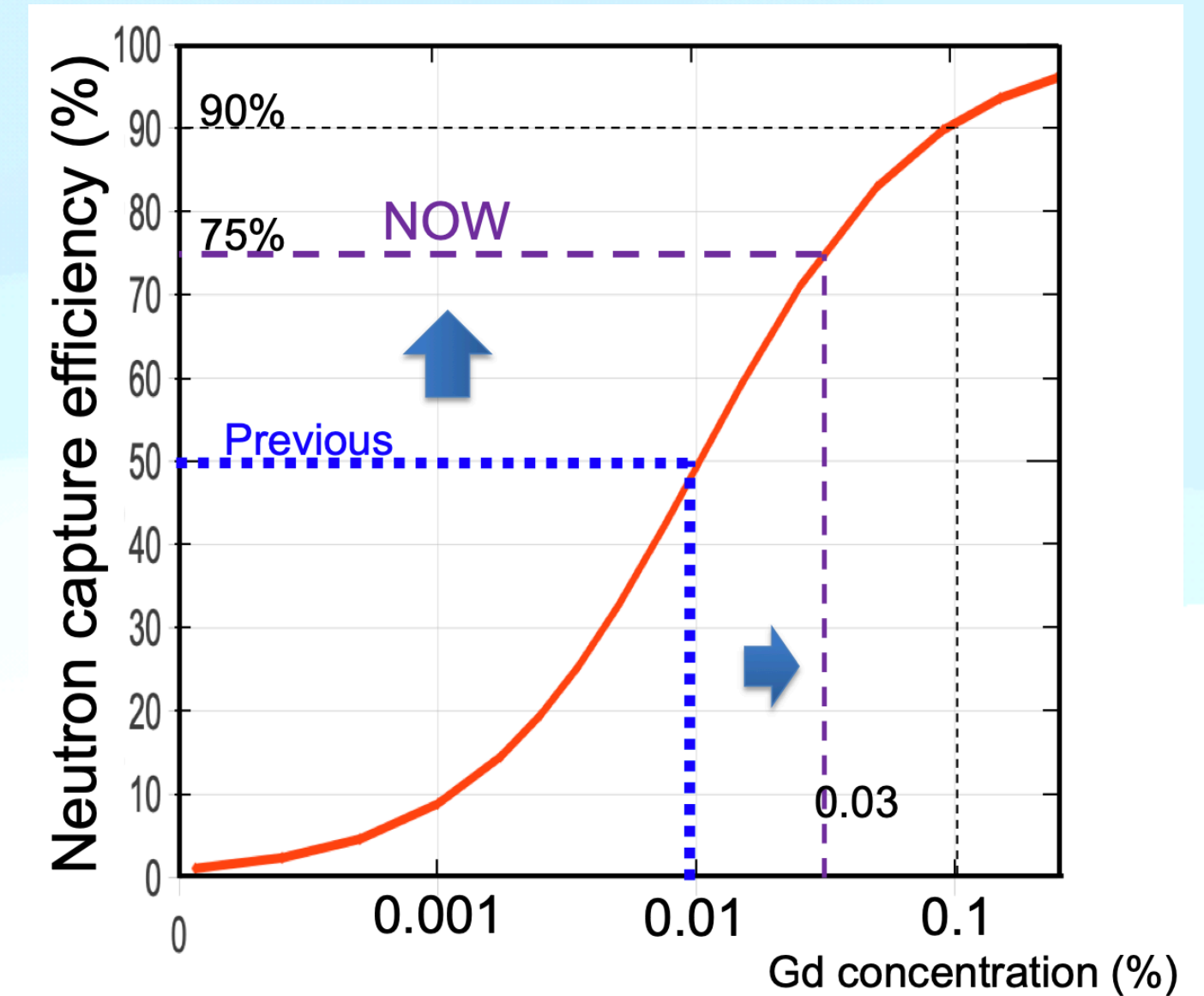
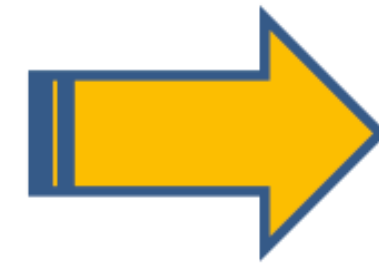


- The cavern excavation time extended for ~2 months (w.r.t. the original timeline) Mainly due to a large number of rock supports at the dome section and an increase of the dome height (excavation volume)
- Facility group believes that there is room to shorten the barrel excavation time to keep the original timeline and do delay in the start of the tank lining construction

# Task 3.1: Study of a gadolinium-doped water Cherenkov detector [INFN,NCBJ,King's,RAL,U-Tokyo]

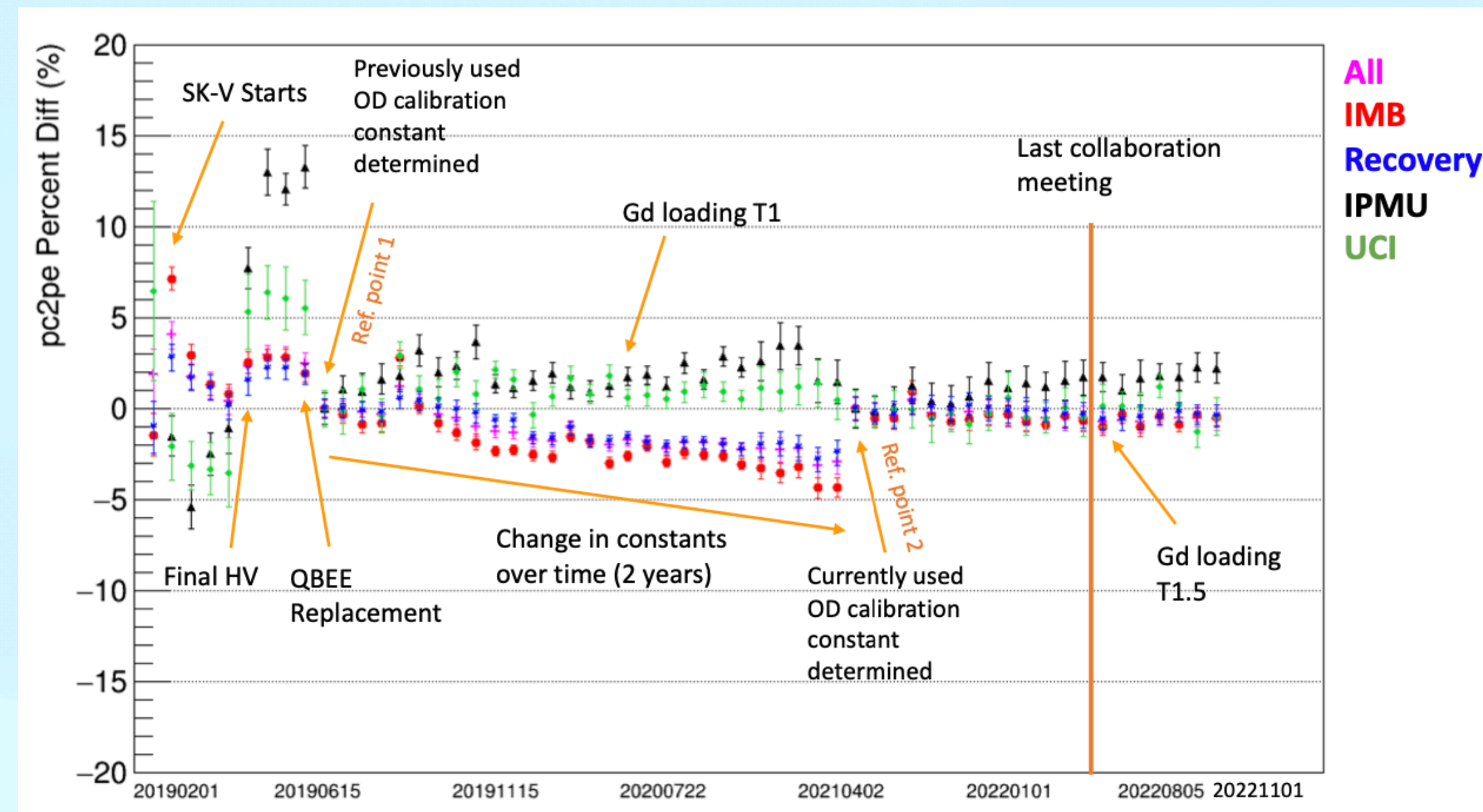
- Super-Kamiokande detector status

**Successfully loaded 26tons of  $Gd_2(SO_4)_3 \cdot 8H_2O$**

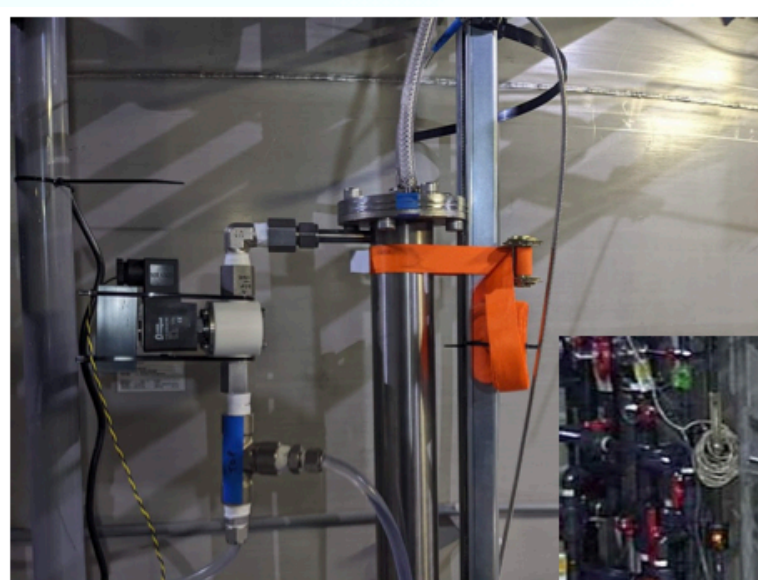
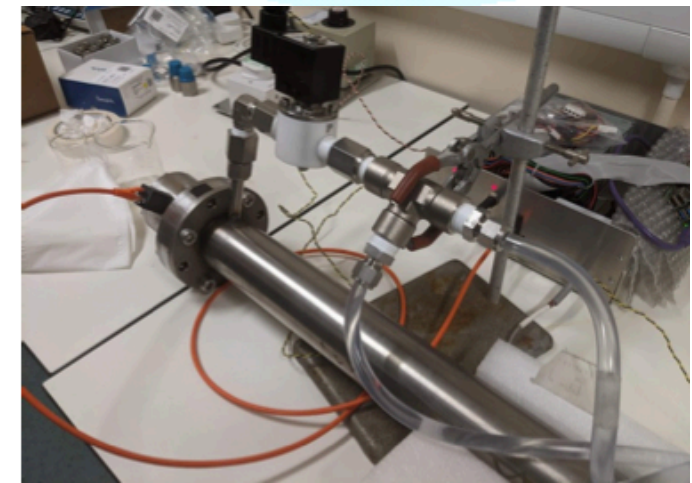
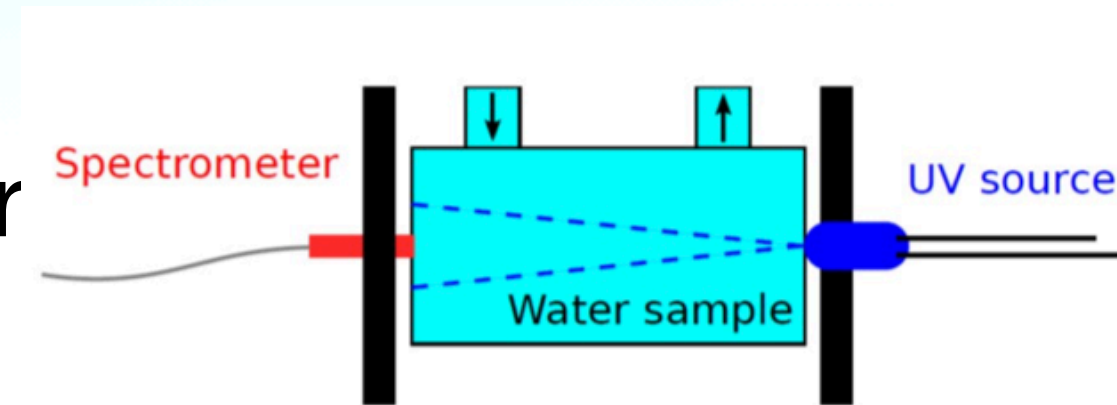


- Objectives: Test a Gd-doped water Cherenkov using the existing Super-Kamiokande detector
- Deliverable and Milestones: decision of the feasibility of the UV system to measure Gd concentration in Super-Kamiokande (month 30).

- OD charge calibration constants



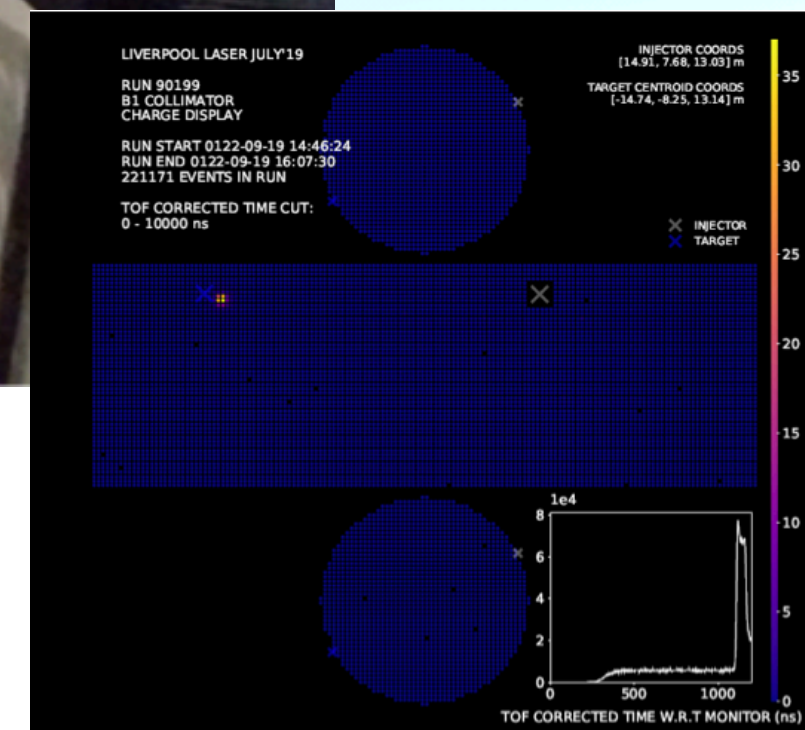
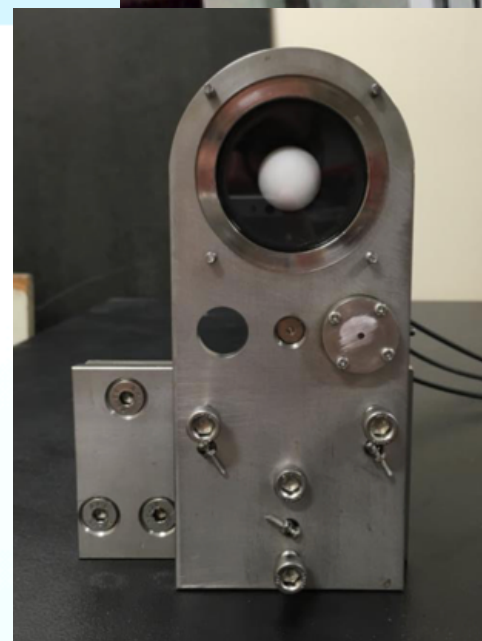
- Gadolinium Absorbance Detector (GAD), EGADS installation.
- GAD was shipped in June with GAD team following soon after
- Currently it is taking data and it is commissioned.



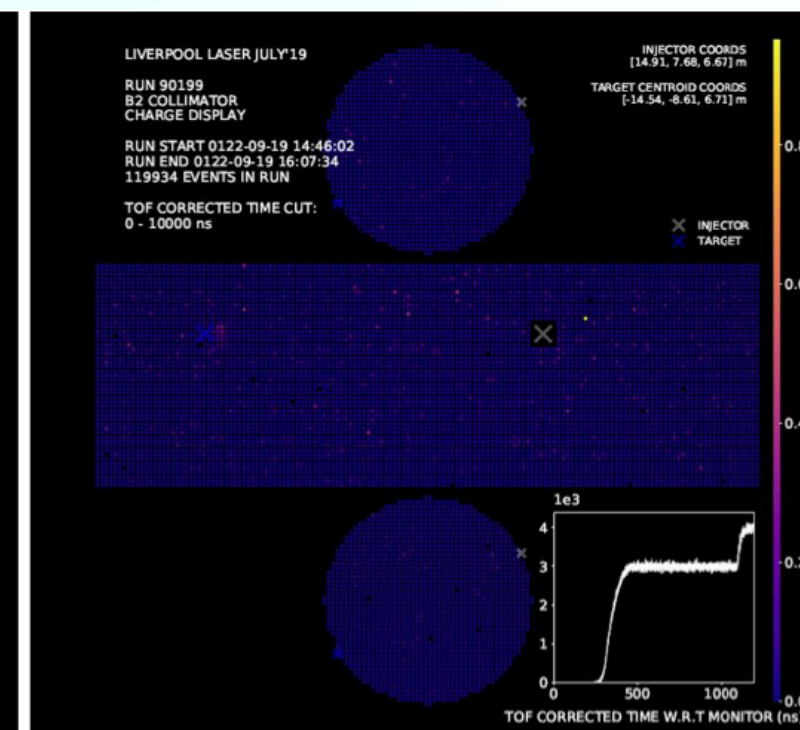


# Task 3.2: Development of a calibration system for a water Cherenkov detector [ INFN, QMUL, RAL, U-Tokyo ]

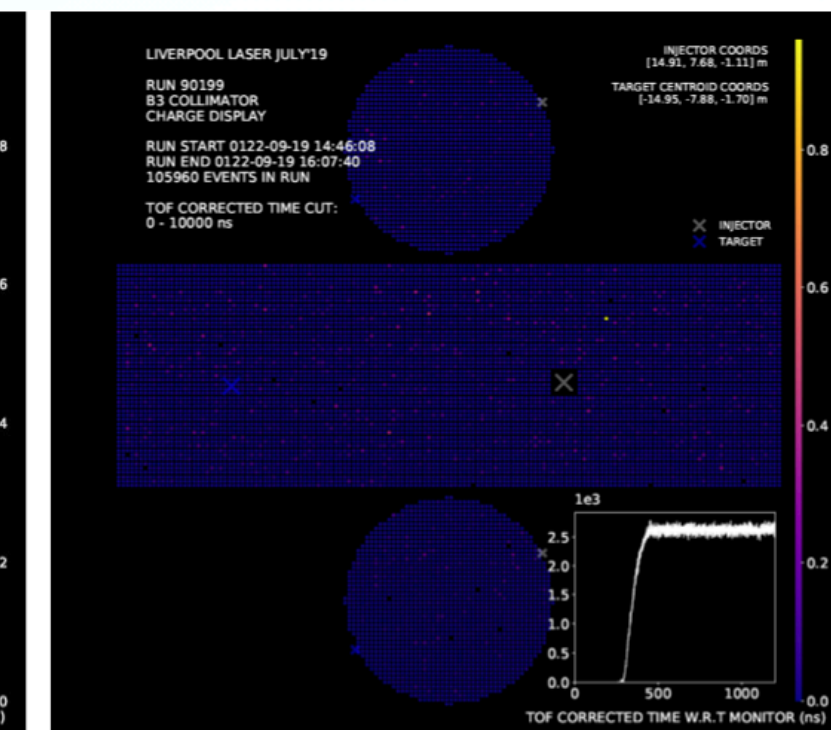
- Objectives: Accurate optical calibration of a large tank Cherenkov detector
- Deliverable and Milestones: data taking and analysis of the light pulse calibration prototype after the first year of data taking (month 24).



B1 Clear Spot



B2 Faint Spot (~5-10%)

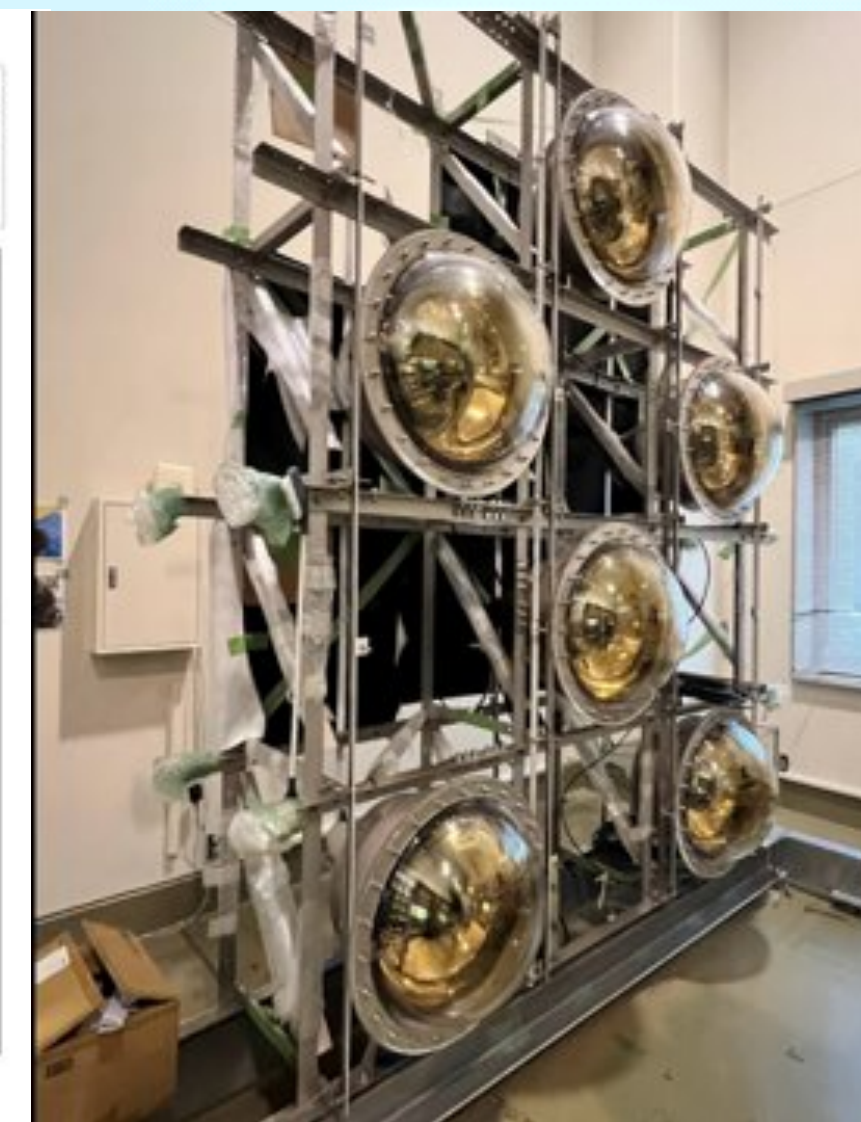
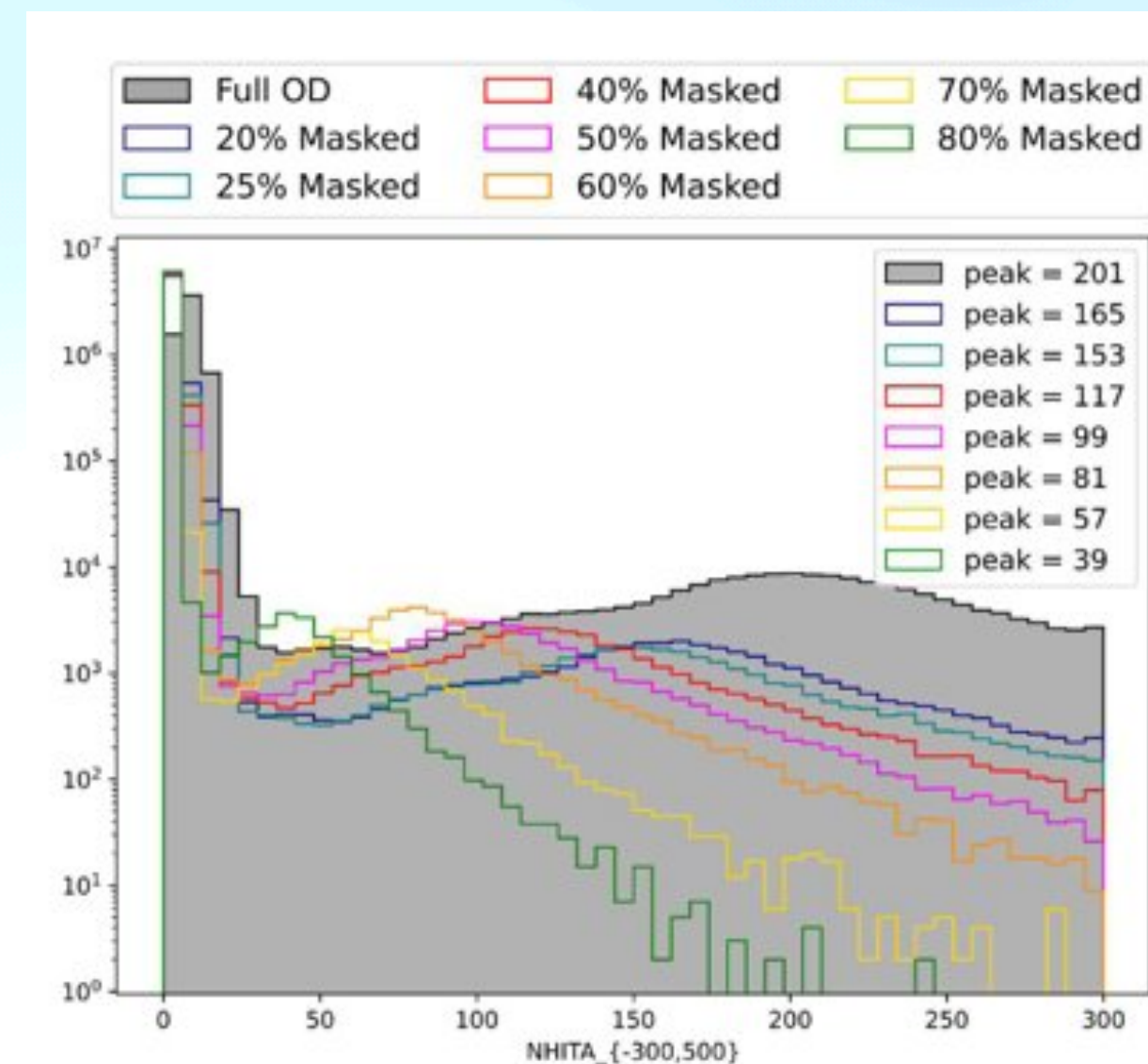


B3,4,5 No Spot Visible

- We were able to work on the UKLI hardware for the first time since 2019
- Diffusers and LEDs working well
- Unfortunately collimators B3-5 have failed and B2 is not in good shape
- Were unable to replace monitor PMT but we will do at the next visit

# Task 3.3: Hyper-Kamiokande Outer Detector [King's, U-Tokyo]

- Objectives: Design the Outer Detector for the Hyper-Kamiokande experiment.
- Deliverables and Milestones: Technical note on the proposed Outer Detector system (month 36)
- Physics driven optimization of number of PMTs based on Super-K scaling
- PMT testing almost complete: both PMT models passed recent pressure tests up to 10bar
- Materials testing underway



# Task 3.3: Hyper-Kamiokande Outer Detector [King's, U-Tokyo]

- WLS plate measurement setup (Baby-K) commissioned
- Good progress on PMT QA design, possible storage and testing locations near Kamioka under discussion.
- Many discussions on 'Integration', installation procedures for units and Tyvek are evolving
- A technical note was already provided to the Hyper-K review committee. Currently being updated.

2 warehouses + small office space in one place  
(for OD/mPMT/electronics storage + OD assembling?)

Warehouse #1 (~24m x ~18m = ~432m<sup>2</sup>)



Warehouse #2 (~13m x ~9m = ~117m<sup>2</sup>)



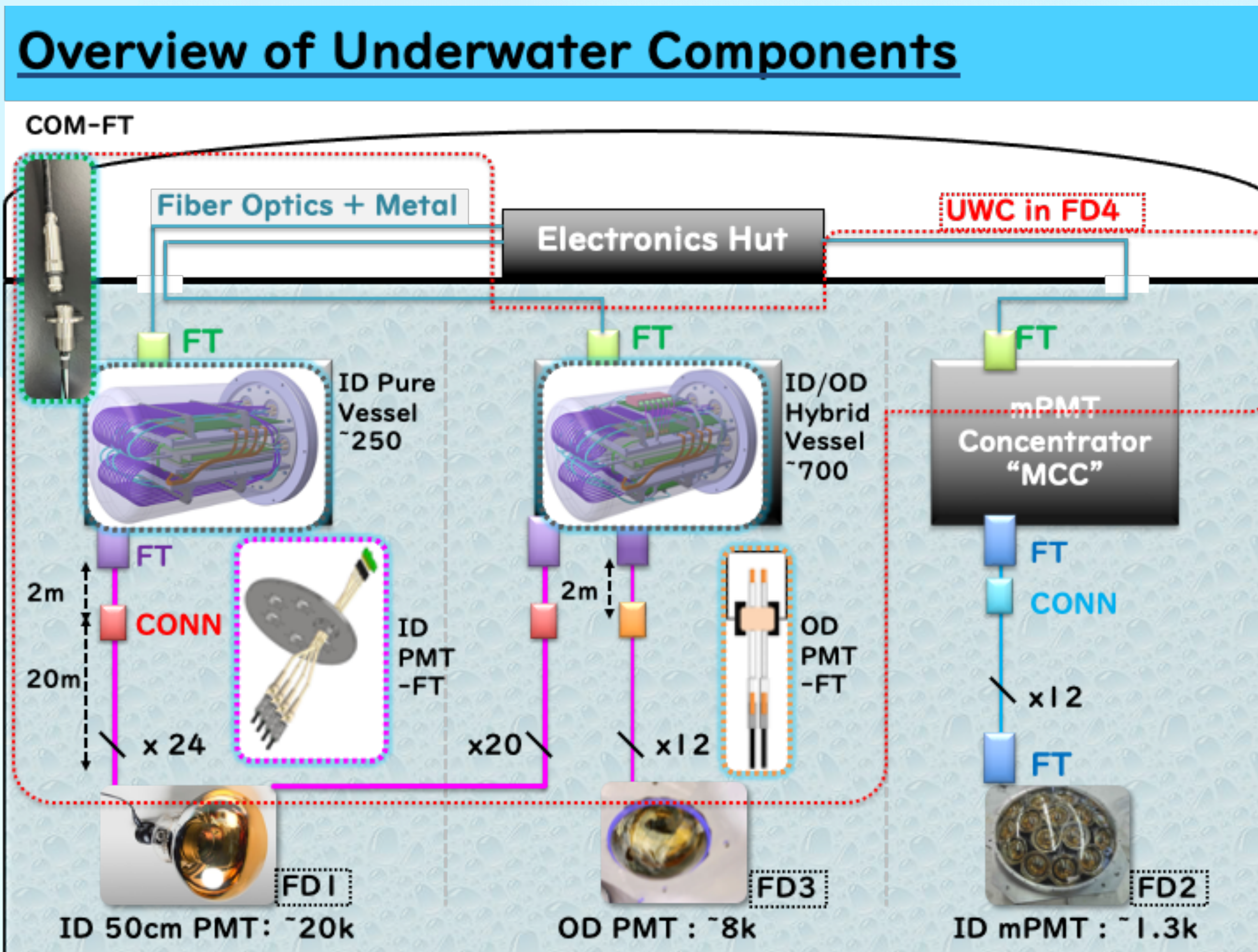
Small office space (under refurbishment)

- Larger room (~4m x ~5m, need to confirm)
- Smaller room
- Kitchen
- Toilet

There is tap water outside the warehouse #1

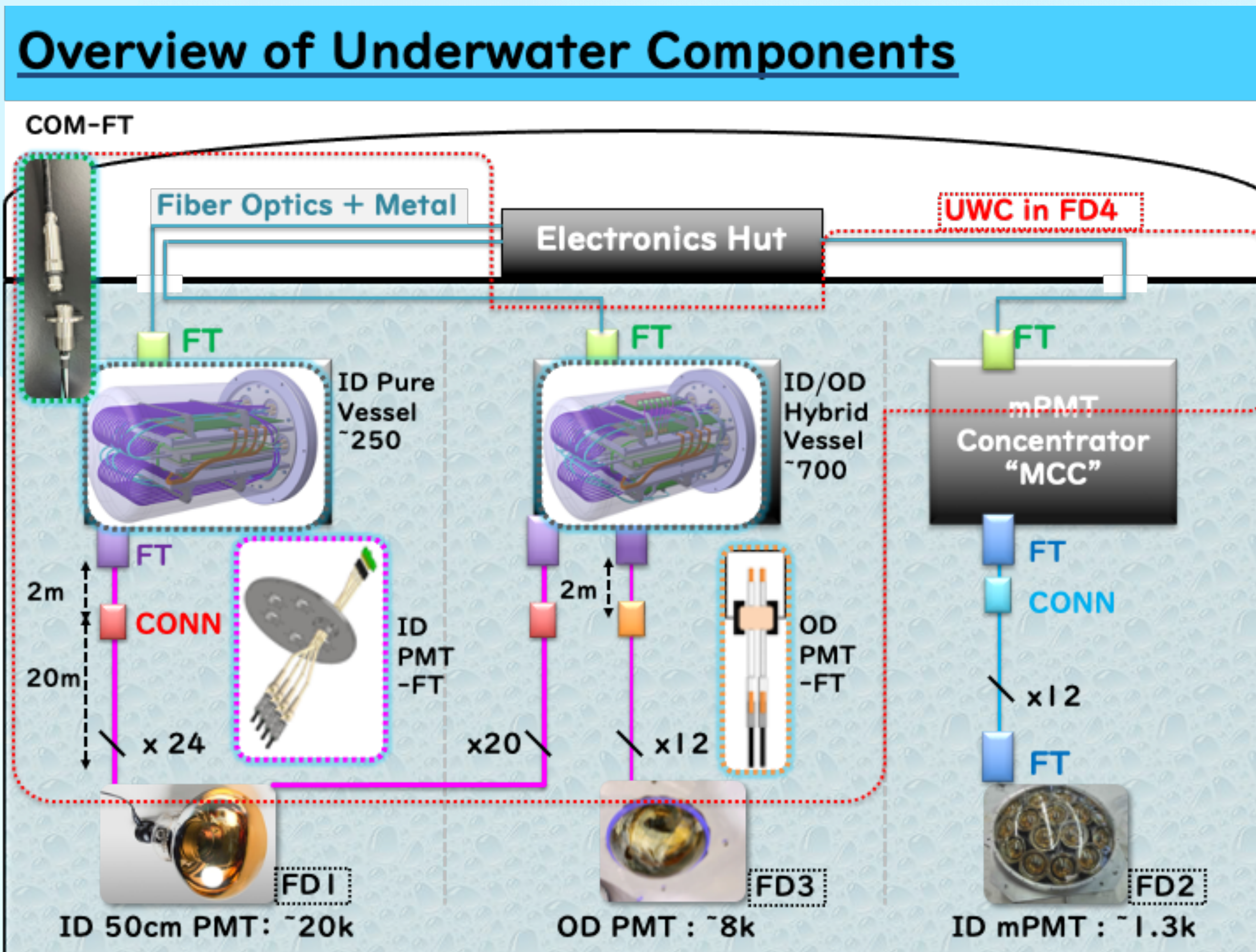
- 3.1km from Jikken-Tou
- Same owner as the field, not officially reserved too.
- 2 warehouses maybe suitable for storage of OD/mPMT/electronics (see next page)
- Larger room in office space maybe appropriate for OD PMT+WLS assembling.

# Task 3.4: Design of a low noise front end electronics for large area photodetectors [NCBJ, UGE, CAEN, U-Tokyo]



- Objectives: Design specific low-threshold, low-noise, large dynamics front-end electronics. => Design and testing of underwater electronics.
- The Hyper-K electronics is in water. It was finalised during the pandemic.
- The electronics front end components as well as the underwater components as been studied during the pandemic.
- The electronics will be assembled inside “vessels” that will be attached to the tank frame before filling the tank with water..
- The future work is for delivering the underwater components.

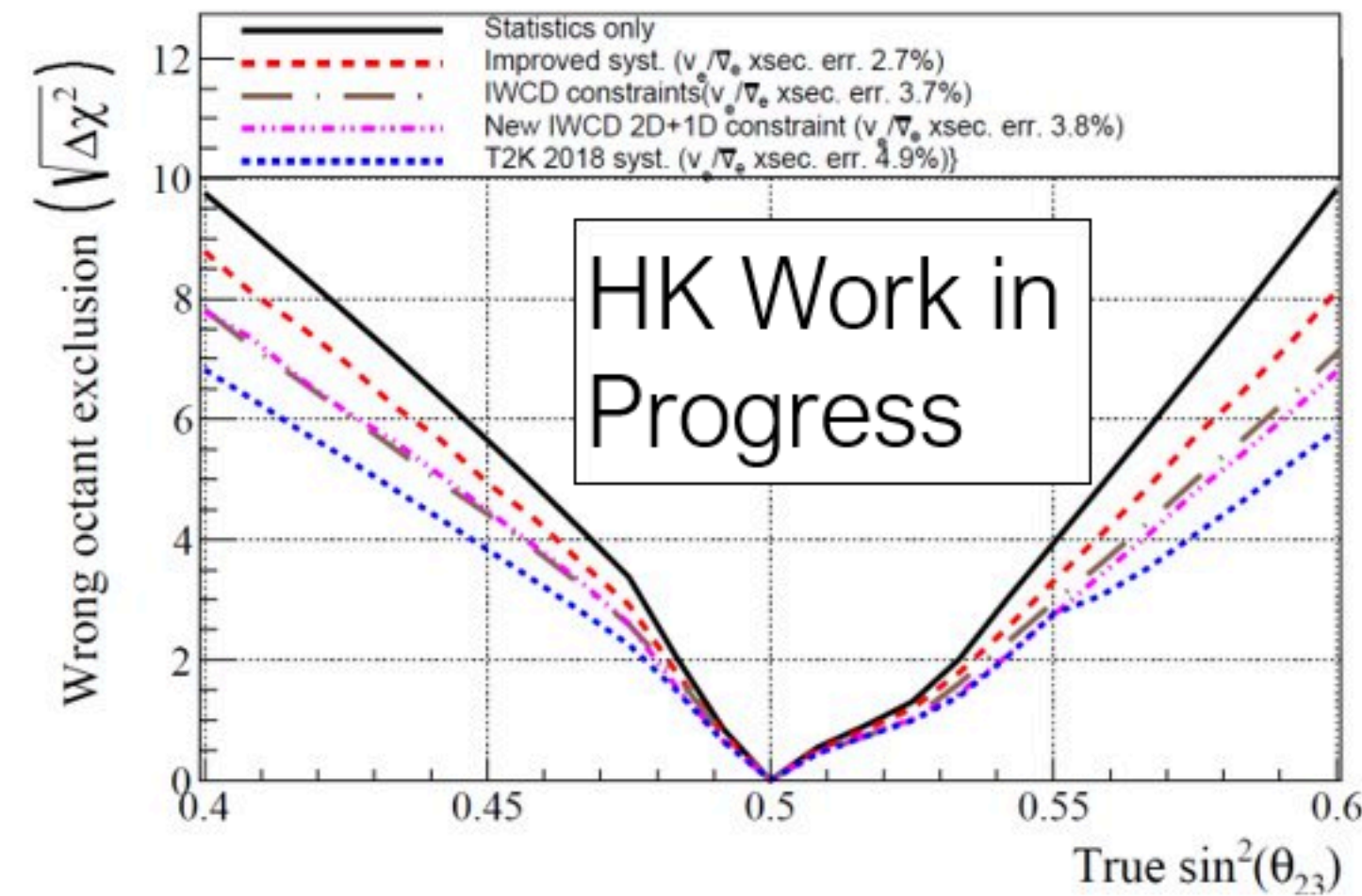
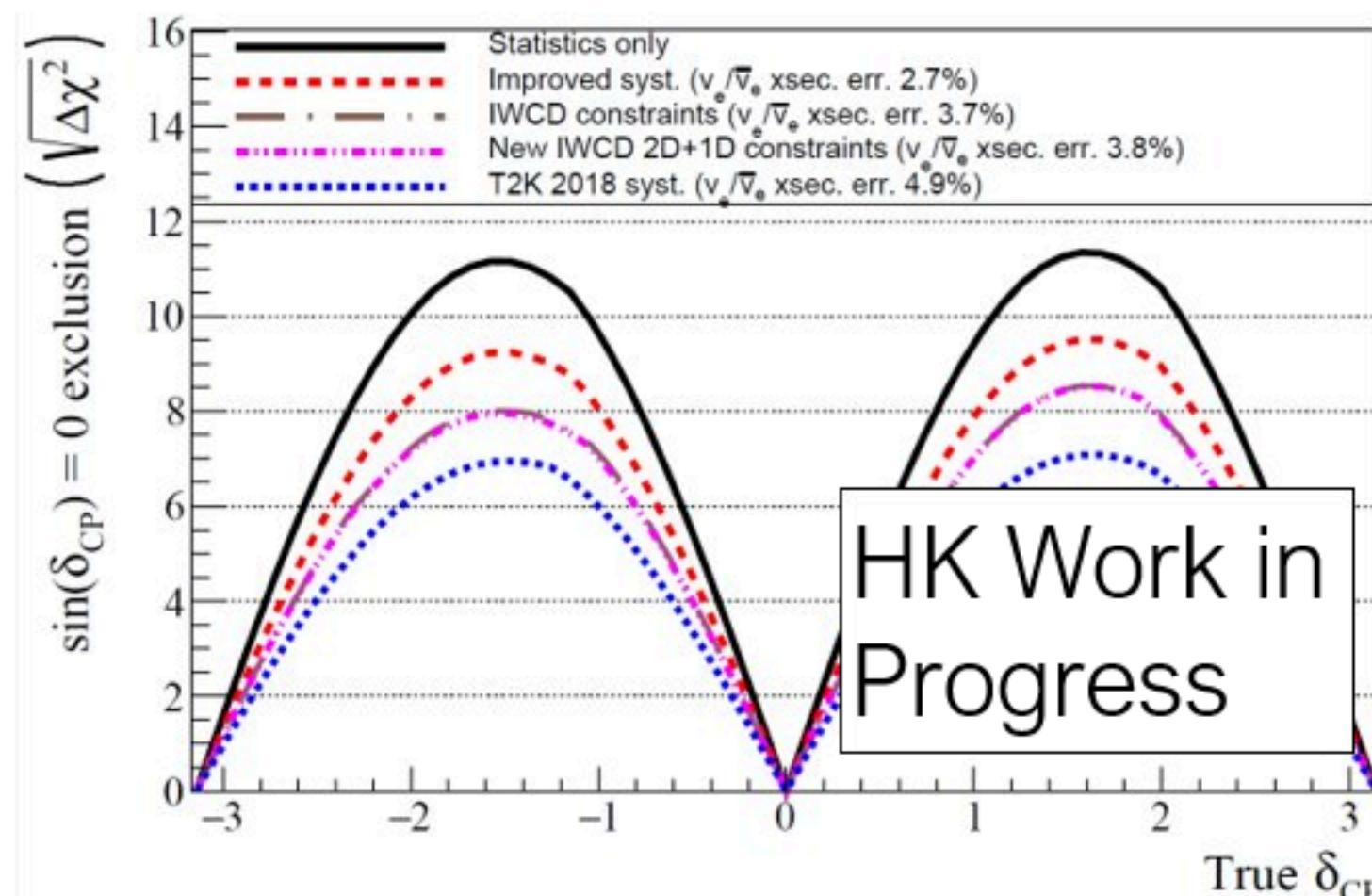
# Task 3.4: Design of a low noise front end electronics for large area photodetectors [NCBJ, UGE, CAEN, U-Tokyo]



- Objectives: Design specific low-threshold, low-noise, large dynamics front-end electronics. => Design and testing of underwater electronics.
- Deliverables and Milestones:
  - data processing module for the underwater electronics of the far detector
  - underwater equipment and supporting structure containing the LV and HV front-end readout boards.

# Task 3.5: Hyper-Kamiokande simulation [INFN, King's, RAL, U-Tokyo]

- Objectives: Develop realistic simulation of the Hyper-Kamiokande detector.
- Deliverables and Milestones: simulation data analysis with the final photosensor configuration (month 48)
- Current status:
  - OD simulated in the Hyper-K geometry.
  - Work on understanding detector systematics has started.
  - HK Software framework created. First Monte Carlo productions using this framework are planned for later this year.
  - Sequential long-baseline oscillation analysis completed including intermediated detector and empirical neutrino interaction uncertainties.
  - Studied effect of oscillations on neutrinos from 10kpc supernova (20 solar mass, Nakazato model)



# Status of secondments

Institution	WP3 done (months)	WP3 planned	WP3 % done
INFN	8.5	21.0	40.6%
DESY		0.0	
OEAW-HEPHY		0.0	
IFJ-PAN		0.0	
UKP		0.0	
JSI		0.0	
METU		0.0	
TAU		0.0	
LAL-CNRS		0.0	
CEA		0.0	
IFAE		0.0	
UNIGE	0.2	4.0	4.2%
NCBJ	0.6	5.0	12.0%
KCL (Qmul)	0.4	30.0	1.4%
UKRI	4.3	23.0	18.6%
CAEN	0.0	2.0	0.0%
FBK		0.0	
Total	14.0	85.0	16.5%

- The pandemic affected the number of trips to Japan which were noticeably reduced.
- The transfer from QMUL to King's affected King's (and associated UK institutions).
- Now that the restrictions to go to Japan are much less, there is a plan of future work for the JENNIFER2 members.
- In particular PhD students, who never saw the experiment, are the first in line to go to Japan in the next months.