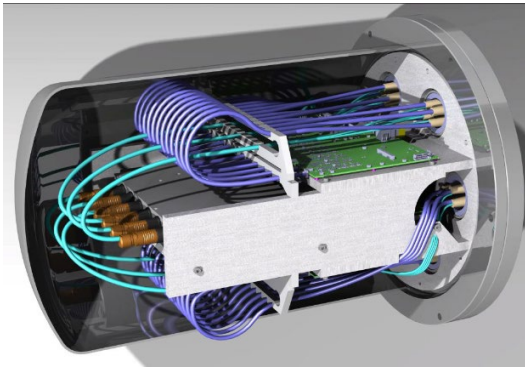
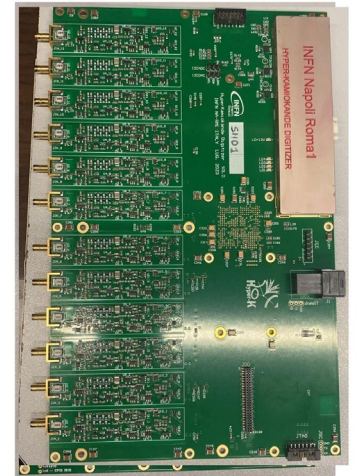


WP3 : Electronics in JENNIFER2

L. Lavitola – INFN



Digitizer V3 Bottom 



Electronics in JENNIFER2 WP3

Design and testing of low noise front-end electronics for large area photodetectors and of underwater electronics. Two proposals of a low noise front-end electronics for large area photodetectors from JENNIFER2 members, together with two more from other Hyper-K members have been reviewed by the collaboration. One of the two JENNIFER2 proposal was successful. It is currently being finalized for mass production and construction for the experiment. Furthermore, the data processing module for the underwater electronics and the supporting structure containing the LV-HV-front-end boards are currently under prototyping for mass production and are under responsibility of JENNIFER2 members.

- Milestone 3.1 (month 30) Report on low noise front-end and underwater electronics requirement and design
- Deliverable 3.3(month 48) Final report on low noise front-end and underwater electronics
- From JENNIFER2 Periodic Technical Report - 1/4/2019-31/5/2023

Underwater electronics vessels

Underwater system (France, Italy, Japan, Korea, Poland, Spain, Switzerland, UK)

Front-end digitizers  (OD:  )

On-board calibrator 

Data Processing Board  

Timing/Synchronization  

HV, LV power supplies  (CAEN)

Pressure tolerant cases 

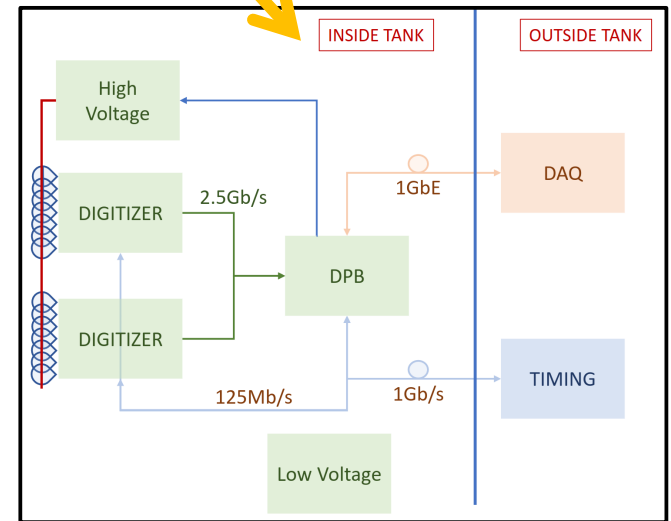
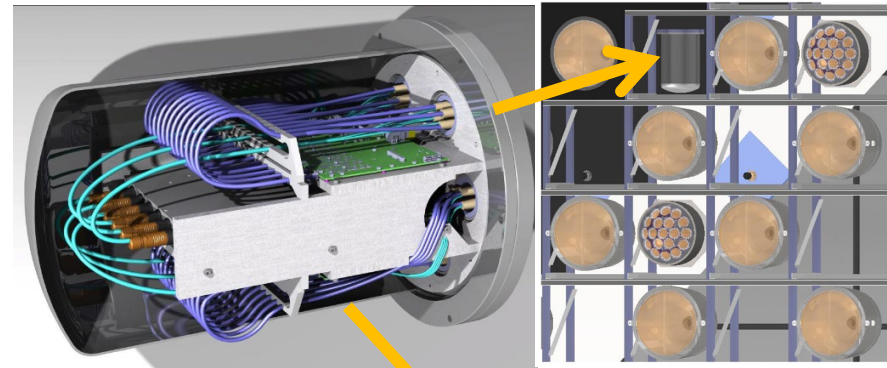
Cables, feedthroughs, optical fibres (shared)

Out-of-water system

DAQ 









Timing/Clock gener.& distrib. 

Infrastructure (huts, air conditioning, cable trays,...) 

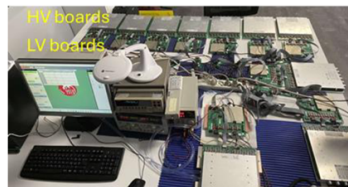


Status of procurement and production

Status of procurement and production

- Some of the components (takes long to produce) were already ordered or in the procurement process.
 - LV and HV boards Delivery starts soon. 
 - Underwater vessel Started procurement. 
 - Long lead-time components Procurement on track.  
(FPGA, special chips, optical modules)
- Calibration system preparation has been started.
 - Signal switchers were produced. 
 - Calibration system is under preparation. 
- Timing system preparation is on track.  
- Mass production of the other modules will start in early 2025.

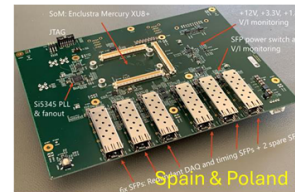
LV & HV
(Switzerland)



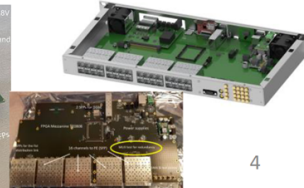
Digitizer
(Italy)



Data processing Board
(Spain & Poland)

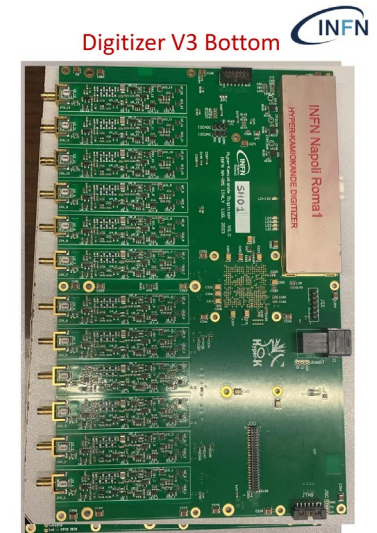
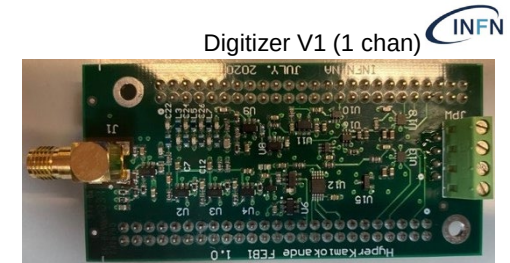


Timing system
(France & Italy)



Digitizer project status

- R&D, single channel schematic and prototype (V1). Collaboration review
- **Design selected by the Collaboration Oct. 2022**
- First board prototypes (V2) delivered on Feb. 2023
- Second generation (V3) delivered on Oct. 2023
- **Validation tests underway** in test benches at INFN, Kamioka, CERN to speed up the process
- Prototypes are needed for validation, development, VST
- Optimise prototype re-spin schedule
- Early “critical” (i.e. with long delivery lead time) **components procurement underway**
- Preparation for mass production (early next year)



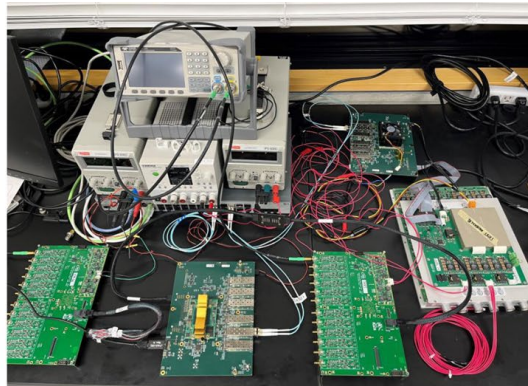
Electronic System: VST at CERN and Kamioka

- System integration tests and VST are on going at CERN and Kamioka
- All system interfaces are being tested
- Vessel assembly procedure under development
- Facility to put underwater fully assembled vessels (up to ten simultaneously)
- Confirmed already to meet most of the requirements
- R&D on track to start assembly at CERN in 2025

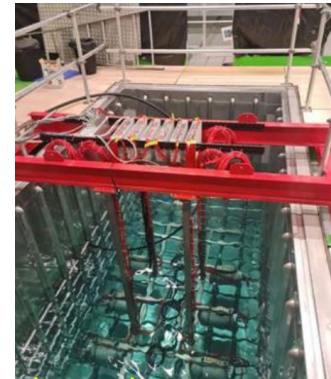
VST at CERN



VST at Kamioka

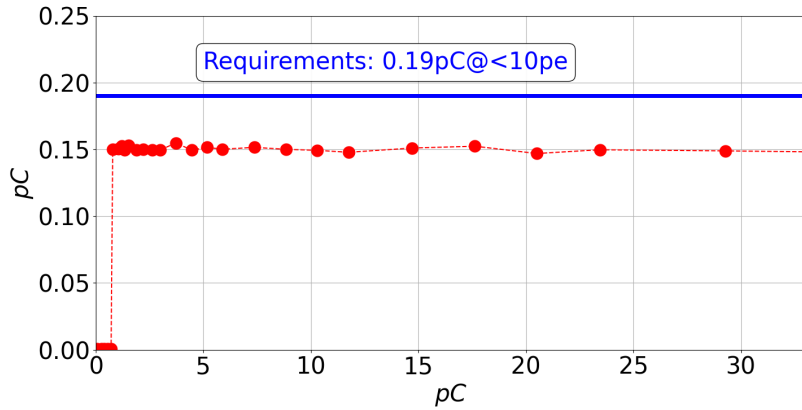


Underwater test at CERN

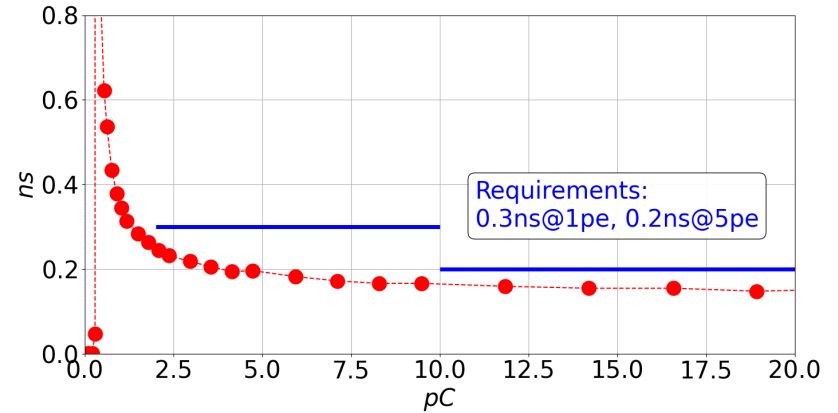


HK Digitizer performances

Charge resolution



Time resolution



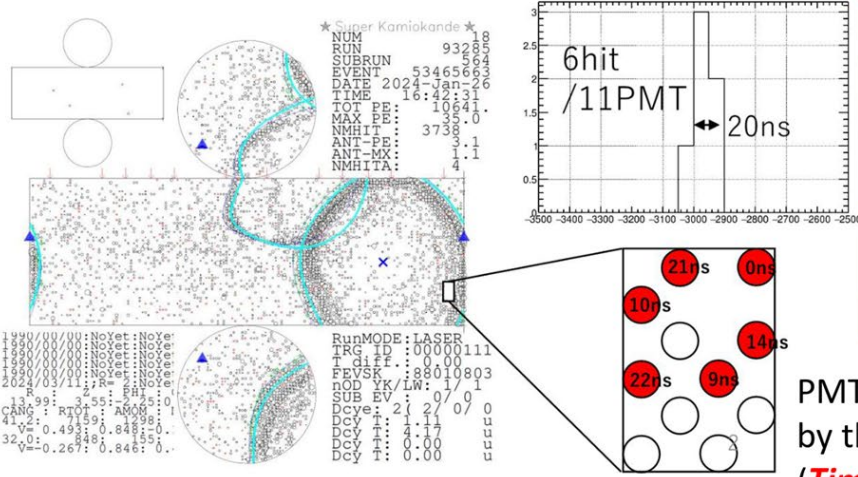
Both charge and time resolutions are well within the requirements

HK Digitizer tested in Super-Kamiokande

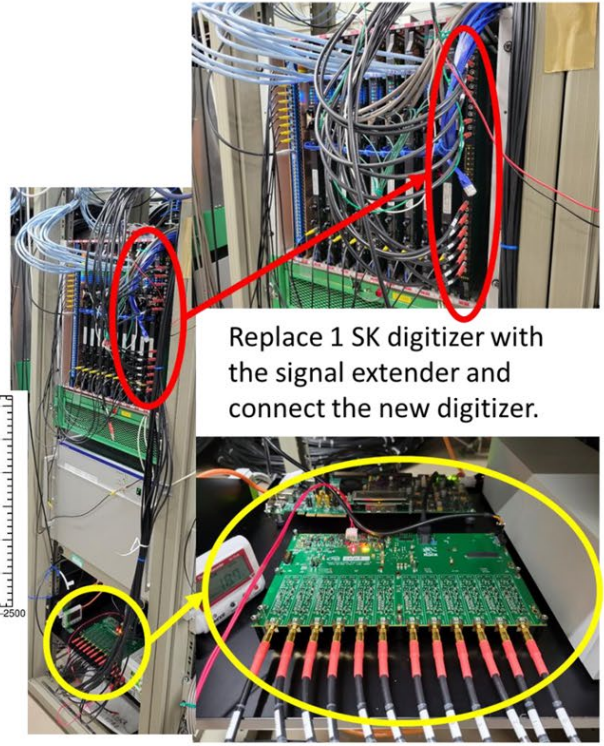
Digitizer performance check
(Stand alone, before assembly)

Collected SK & HK PMT data using
the HK digitizer.

Atmospheric neutrino candidate events
were recorded using the HK electronics.



PMT hits observed
by the SK electronics



Replace 1 SK digitizer with
the signal extender and
connect the new digitizer.

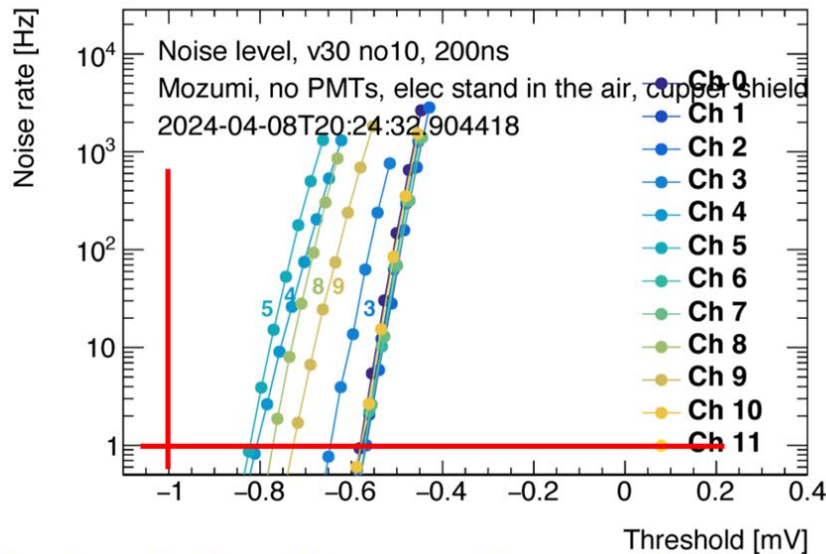
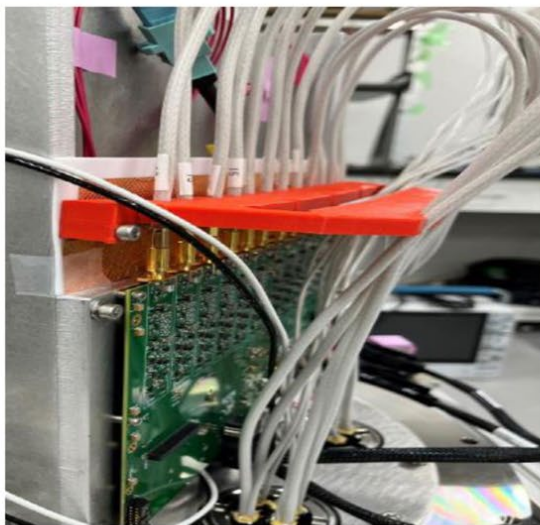
PMT hits observed
by the HK electronics.
*(Timing adjustment is very rough.
No calibrations are applied.)*

Integration test → Design modification

7. Check no “noticeable” signal interference exists.

We found noisier channels in one side of the digitizer.

Placed a PTFE sheet with copper tape between the LVPS and the digitizer as a (tentative) noise shield.

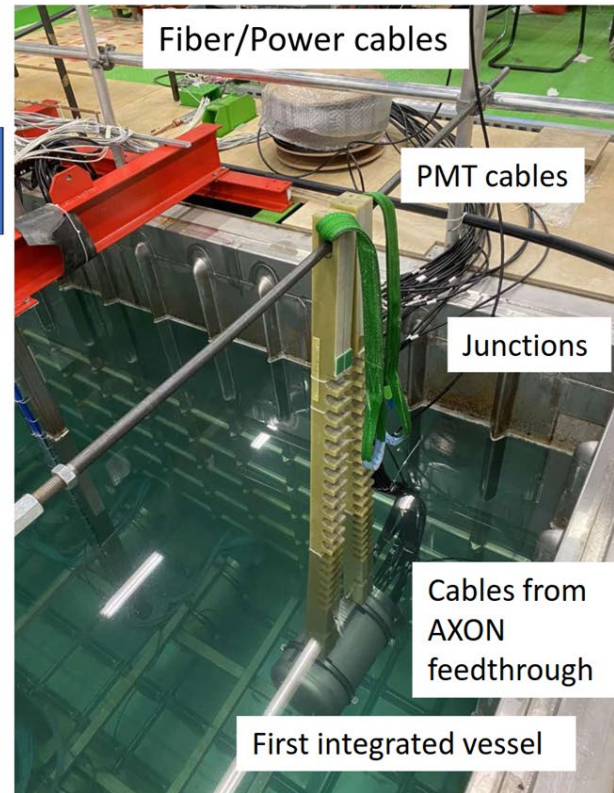
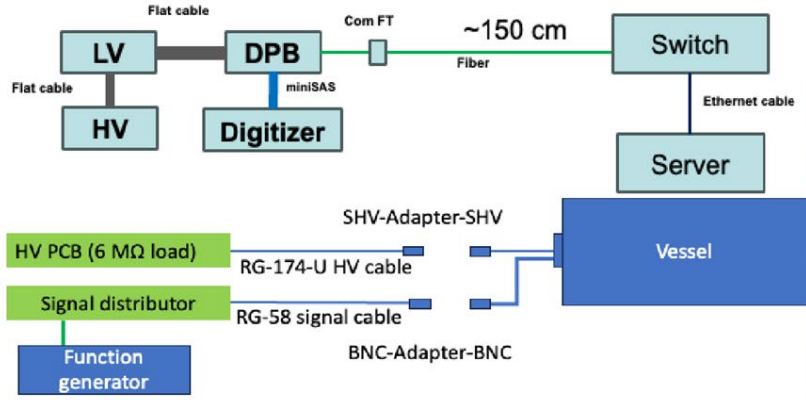


Still there are visible noises but satisfies the requirement.

Studying to suppress noises further (negligible level). 10

Underwater test at CERN

Fully assembled underwater module is in the water for tests since February.



- Feb. 8 Assembled the board on the stand
- Feb. 15 Immersed the vessel in the water.
(Water temperature is 16 C).
- Feb. 20 HV board switched ON at nominal power
i.e. 6 MΩ load at 2500 V
(kept running until March 15)
- Mar. 15 Water temperature was set to 14 C.
- Mar. 17 Powering on the digitizer boards.
- Mar. 25 Powering on all the boards
(LV/HV/DPB/Digitizers)

Underwater Units Quality Assessment: pressure test

Each of the HK Underwater Unit (UU) needs to be tested at a pressure of 10 bar in water after the assembly of the electronic components is completed:

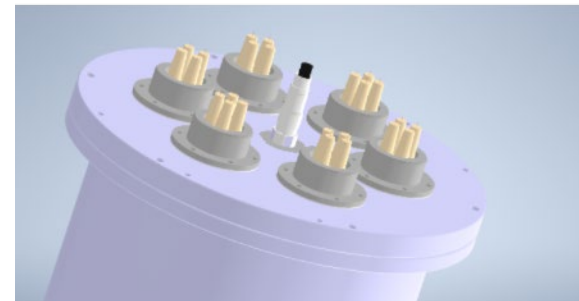
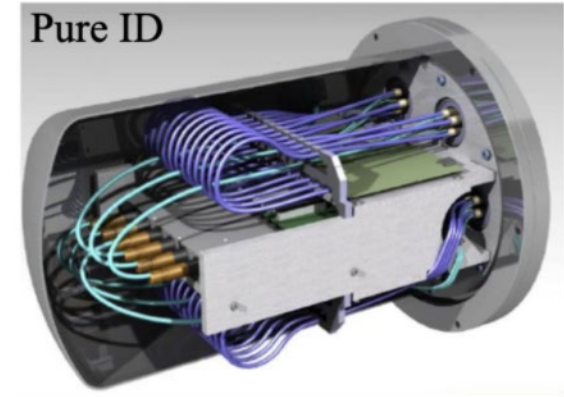
- mandatory to guarantee the absence of leaks
- test of the UU in realistic environmental condition

Each underwater units will be equipped with :

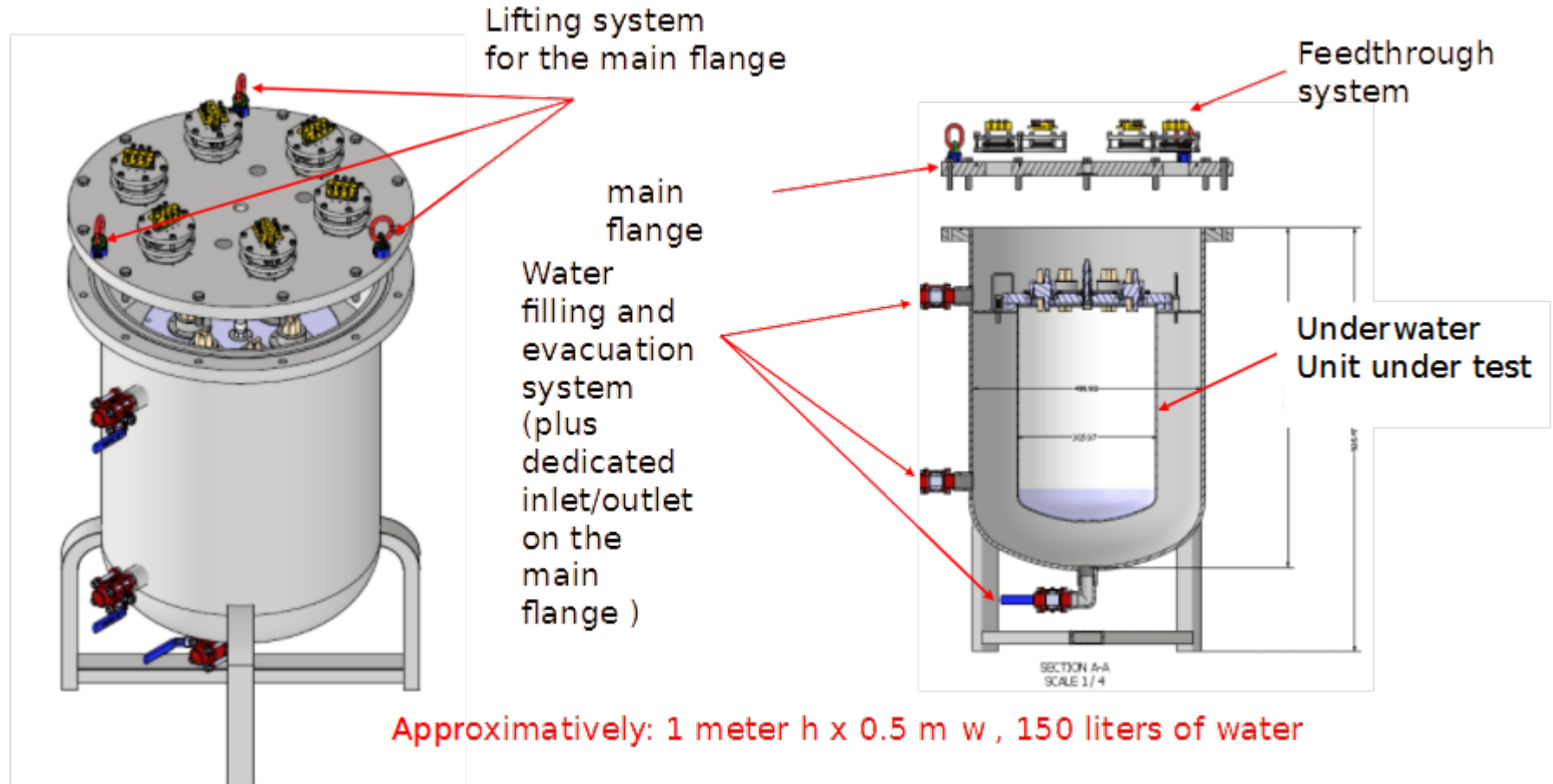
- 6 dedicated feedthroughs for HV and signal
- 1 dedicated feedthrough for LV and communication via optical fiber

The 6 feedthroughs, hosting 4 cables each, will come with 5 meters of cable with a Diameter of 10.1mm, bending radius of 80.8mm (x8 of diameter) made of Hard black polyethylene and equipped with BNC on RG58 and SHV or SMB on RG174

The Cable end is not sealed, thus can not be exposed to 10 bar pressure that may propagate inside the UU under test

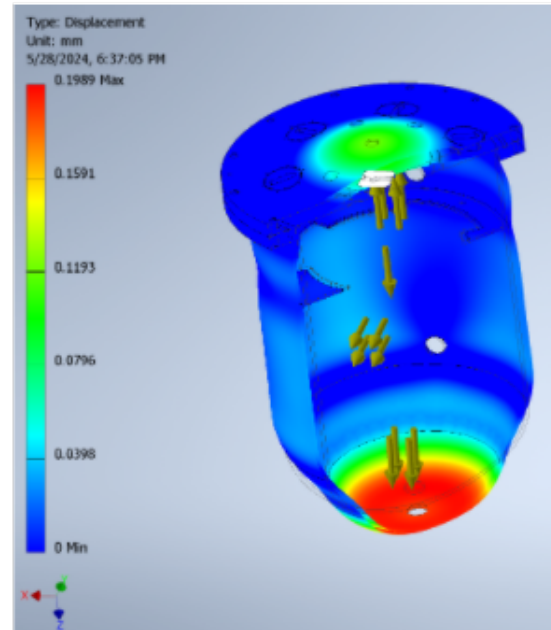
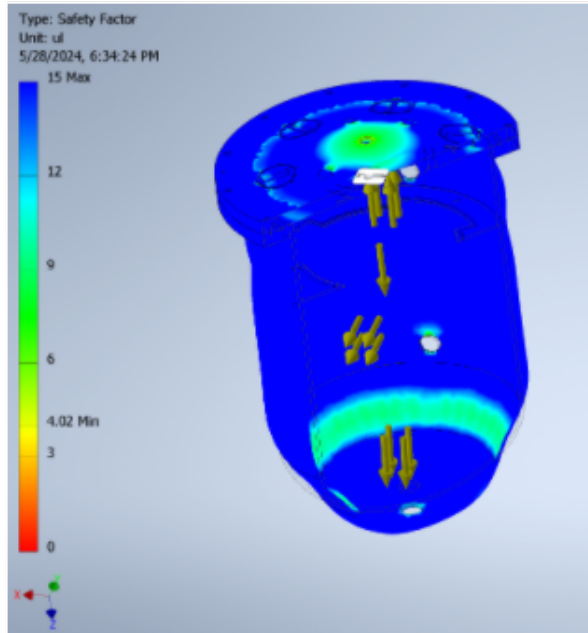


Underwater Units Quality Assessment: pressure test proposal



Underwater Units Quality Assessment: pressure test proposal

FEM analysis of the simplified pressure test bench vessel ongoing



Test results at 15 Bar
Safety factor ~ 4
Maximum displacement 0.19 mm

Preliminary results are fine, more details will be included and the stress analysis will be repeated. Full structure in stainless steel. Extra room left in case of further services are needed.

Long term schedule

← Jennifer2 → Jennifer3 →

Calendar year / items	2024				2025				2026		
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q
Module assembly @ CERN & Transport to Kamioka								Assembly & transport			
Digitizer	Component procurement				Production & transport						
	Calibration system prep.				Test (QA) & Calibration						
Data processing board					Production & delivery						
	Test system prep.				Test (QA)						
LV & HV module	Production										
	Test system prep.		Test (QA)								
Underwater vessel	procurement and production										
Electronics stand					Production						
Underwater PMT cables with feedthrough and connectors (A)					Procurement (Tender)		Production & transport				<i>Min. lead time: 7 months from contract</i>
Feedthrough with power + fiber cables & breakout fibers production (B C)					Procurement (Tender)		Production & transport				
Long underwater fiber + power cables with connector production (D)					Procurement (Tender)		Production & transport				
Shared items					Procurement (Tender)		Production & transport				