

# HyperK OD system underwater test

1. Waterproof: Underwater connection
2. Waterproof: PMT
3. Waterproof: Feedthrough
4. Connector issues
5. Other tests
5. Summary

**Karen Hayrapetyan, Francesca Di Lodovico, Teppei Katori, Phil Litchfield, Paul Solar**  
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# 1. List of requirements

It follows ID requirements

## Requirement

Item	Criteria
Waterproof	No water leak during applying water pressure $>0.8\text{MPa}$ and $>2\text{days}$
Radon Emanation	$\ll 10\text{mBq/connection}$
Corrosion Tolerance	$<10\%$ water transparency degradation in 3-months soaking
HV Stability	$<1\text{uV}$ , $1\text{uA}$ fluctuation before and after applying $1\text{MPa}$ water pressure when connected to $6\text{M}\Omega$ dummy load with $2.5\text{kV}$ .
Frequency Stability	$<1\%$ difference before and after applying $1\text{MPa}$ water pressure for $1\text{Vpp}$ sinusoid of $[0.1, 100]\text{MHz}$
Signal continuity	Continuous after $1\text{MPa}$ water pressurization
HV tolerance	$2.5\text{kV}$ tolerance after $1\text{MPa}$ water pressurization
Low-gas-pressure Tolerance	No HV trip by degassing the connectors from $1\text{atm}$ to $20\text{Pa}$ .

ID requirements

Test	Criteria	Status
Waterproof: Underwater connection	No water leak with $\sim 1\text{MPa}$ water pressure and $>2\text{days}$	Working
Waterproof: PMT	Stable PMT running with $\sim 1\text{MPa}$ water pressure and $>2\text{days}$	Done 
Waterproof: Feedthrough	No water leak with $\sim 1\text{MPa}$ water pressure and $>2\text{days}$	Working
Signal stability	Stable PMT running with underwater connection and feedthrough with $\sim 1\text{MPa}$ water pressure and $>2\text{days}$	
Low gas pressure tolerance	No HV trip at $2\text{kV}$ at $1\text{kPa}$	

# 1. Waterproof: Underwater connection

## Underwater connector → SHV connection

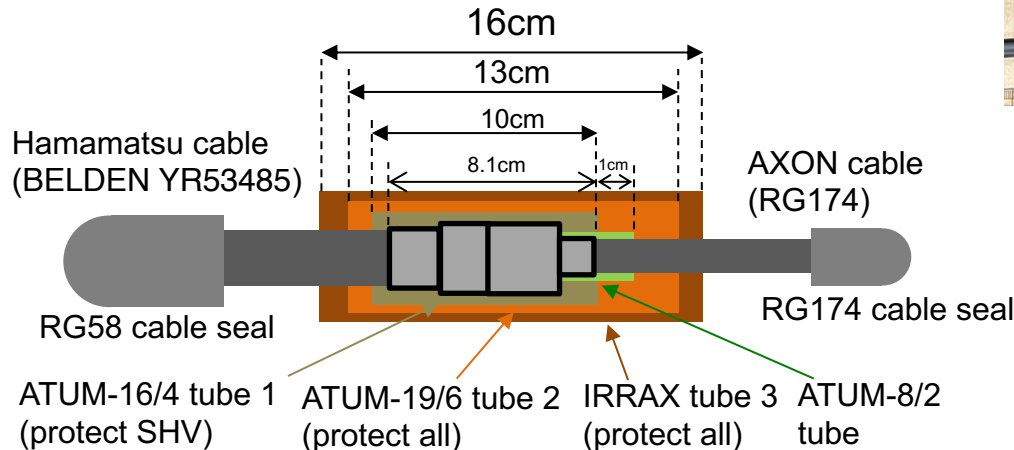
- OD originally planned to use underwater connectors from AXON. The new plan is SHV connection.

## Goal

- Protect the SHV connection from water by shrink tubes
- no gap between cable outer jacket and shrink tube

## OD underwater connection

- Based on ID underwater connection design
- 3 layers of shrink tubes
- Shrink tube 1&2 protect connectors from water
- Shrink tube 3 adds mechanical strength
- We focus tube 1&2 for underwater connection test



BELDEN or  
RG58 (PMT)



RG174  
(electronics  
vessel)

## ID underwater connection

BNC + SHV



1st	
Over BNC	Raychem ATUM-16/4-70mm
Over SHV + Over RG174	Raychem ATUM-16/4-100mm + Raychem ATUM-8/2-10mm x2
2nd	
145mm-exposed	Raychem ATUM-19/6-0-185mm
3rd	
Over 2nd	IRRAX SLEEVE PS 7/25-225mm

2024/09/25

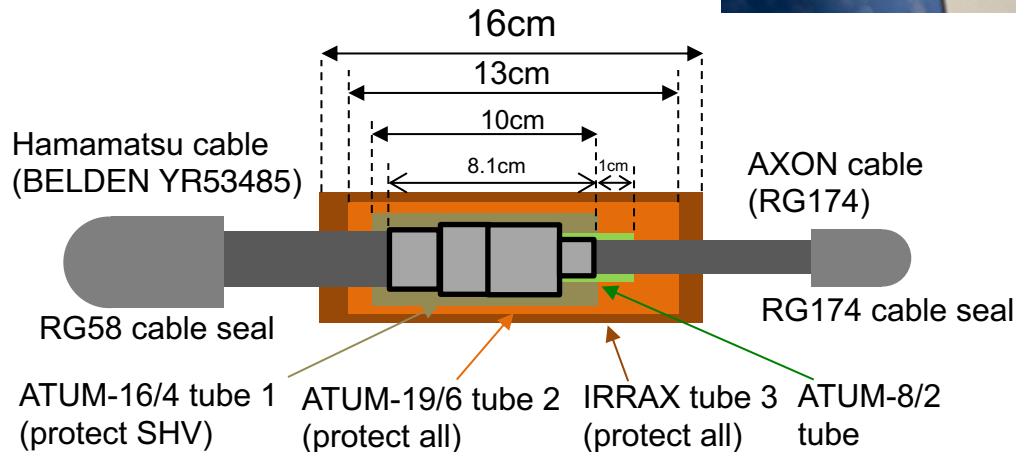
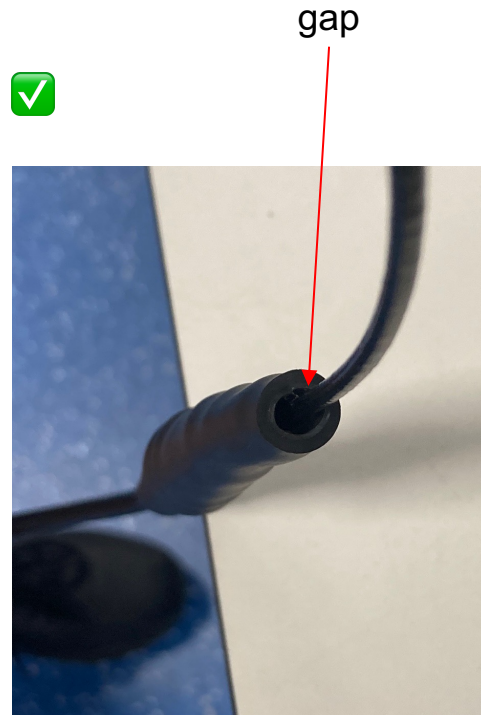
# 1. Waterproof: Underwater connection

## OD underwater connection design 1

- ATUM-8/2 tube on the thin RG174 cable
- ATUM-16/4 tube 1 covers SHV connection ✓
- ATUM-19/6 tube 2 cannot cover all ✗

Tube 1 and 2 make a gap in RG174 side, because ATUM-19/6 tube 2 cannot shrink to 2.54mm (RG174 cable)

New design use a smaller tube 2



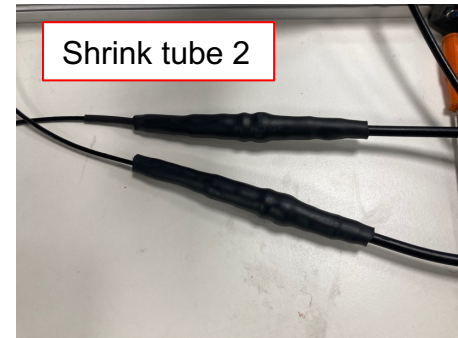
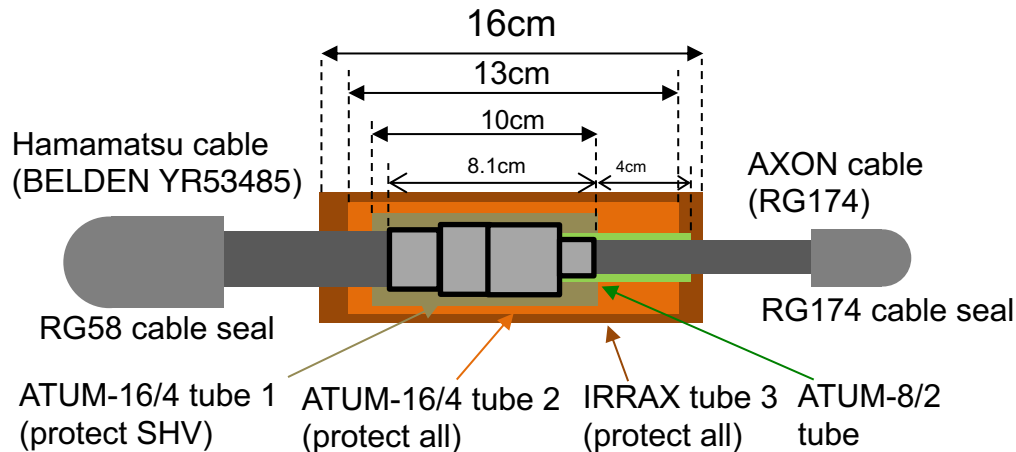
# 1. Waterproof: Underwater connection

## OD underwater connection design 2

- ATUM-8/2 tube on the thin RG174 cable
- ATUM-16/4 tube 1 covers SHV connection
- ATUM-16/4 tube 2 cannot cover all

Again, ATUM-16/4 tube 2 cannot shrink enough to RG174 diameter.

New design require longer ATUM-8/2 so that tube 2 and ATUM-8/2 can contact





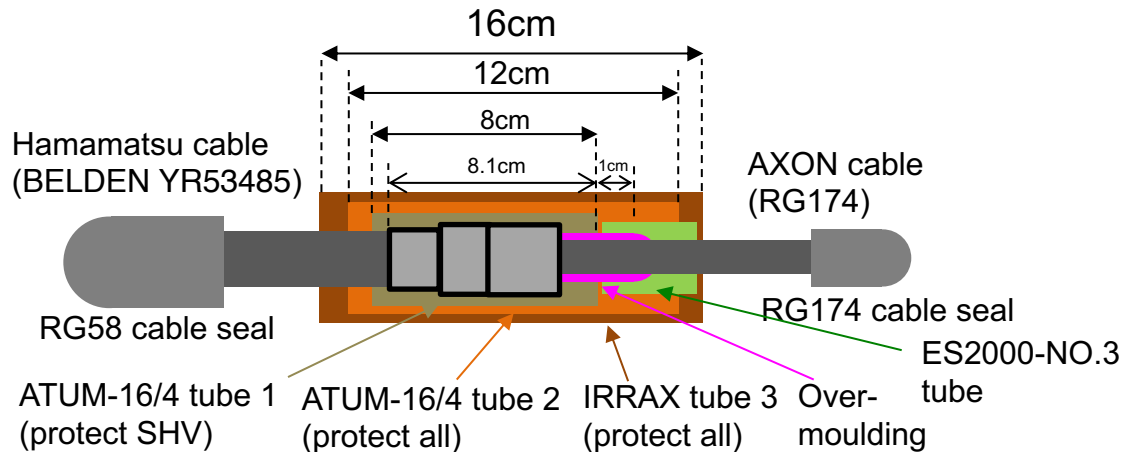
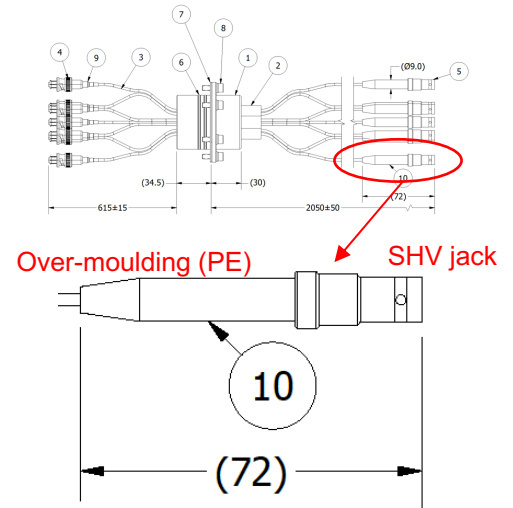
# 1. Waterproof: Underwater connection

## OD feedthrough design change

- New design uses waterproof over-moulding for the RG174 cable
- Similar over-moulding is used inside of the underwater connector  
→ watertight with pressure,

## OD underwater connection design 3

- ES2000-NO.3 to cover part of over-moulding
- ATUM-16/4 tube 1 covers SHV connection and part of over-moulding
- ATUM-16/4 tube 2 covers all and part of additional tube
- IIRAX tube 3 cover all



Over-moulding of RG174 (w/ SMB connectors)

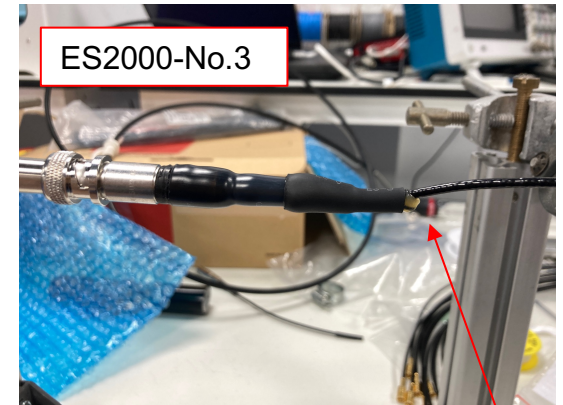
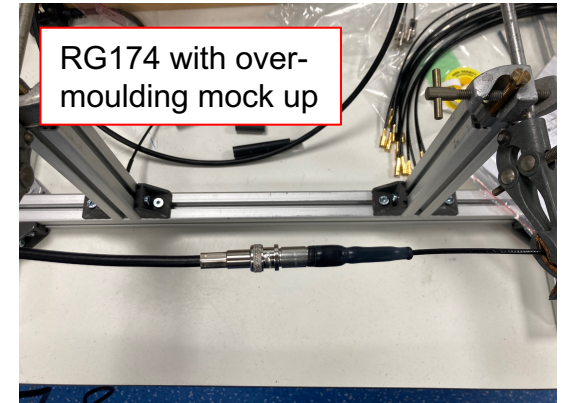
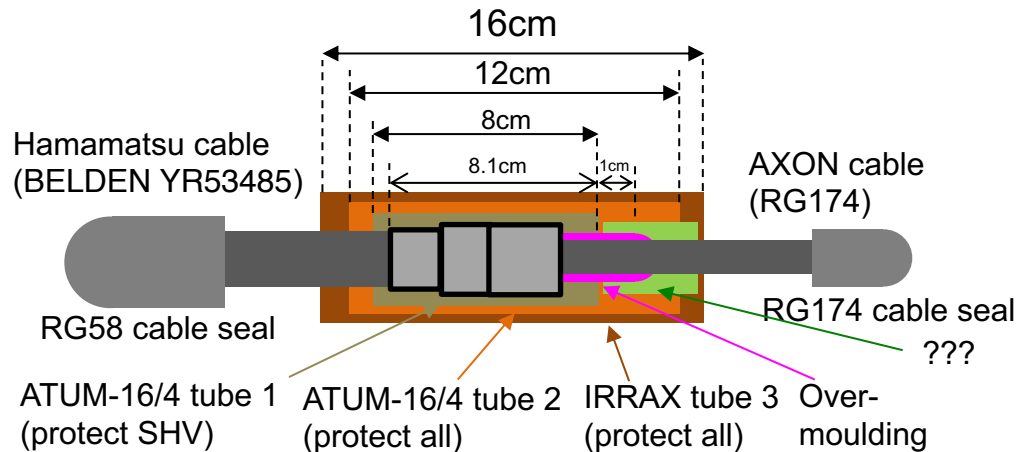
# 1. Waterproof: Underwater connection

## OD underwater connection design 3

- ES2000-NO.3 to cover part of over-moulding ⚠️
- ATUM-16/4 tube 1 covers SHV connection and part of over-moulding ✅
- ATUM-16/4 tube 2 covers all and part of additional tube ✅

ES2000-No.3 doesn't look like water-pressure tight  
→ we need to test with water pressure

We may search other mastics for this purpose



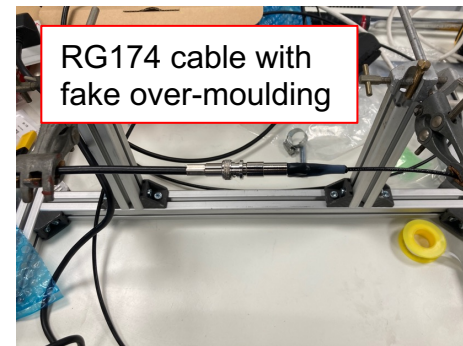
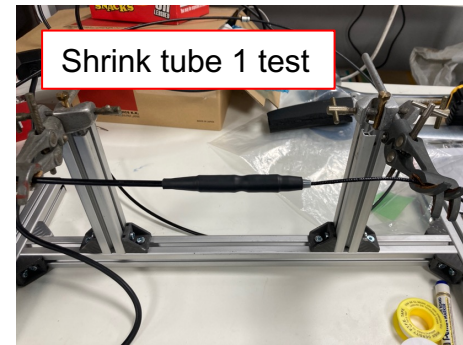
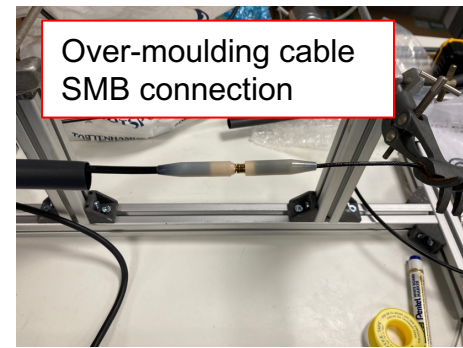
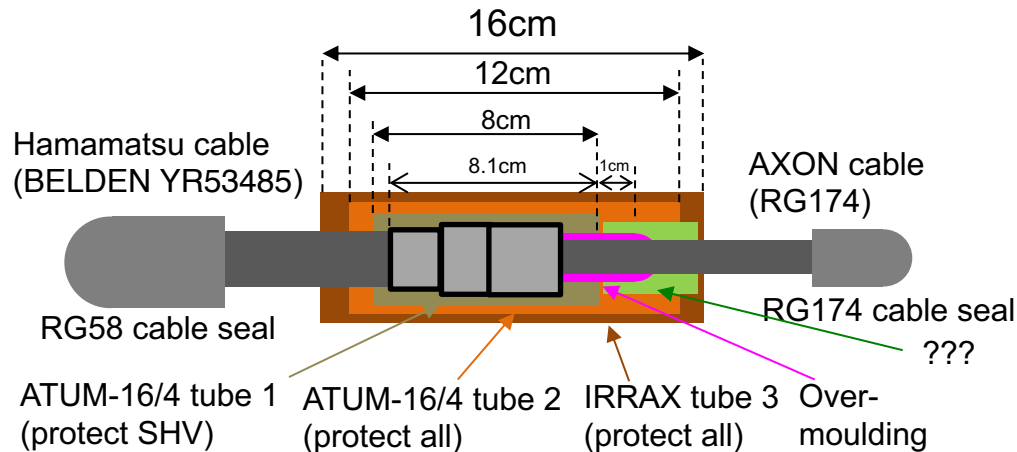
# 1. Waterproof: Underwater connection

## Plan

- We don't have RG174 terminated with SHV jack with over-moulding
- We do have RG174 terminated with SMB connectors over-moulded

1. We tested adhesivity of ATUM 16/4 tube and PE over-moulding
2. We add shrink tube to imitate the over-moulding of RG174 terminated with SHV jack, we use this to design underwater connection

The new feed-through will have RG174 terminated with SHV jack with over-moulding (3 months)

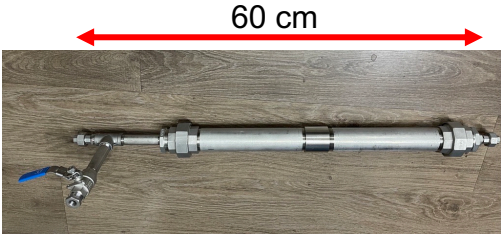




# 2. Waterproof: PMT

## Two pressure vessel (10 bar rated)

- Small vessel to test small things (underwater cable connection, etc)
- Large vessel to test larger things (PMTs)



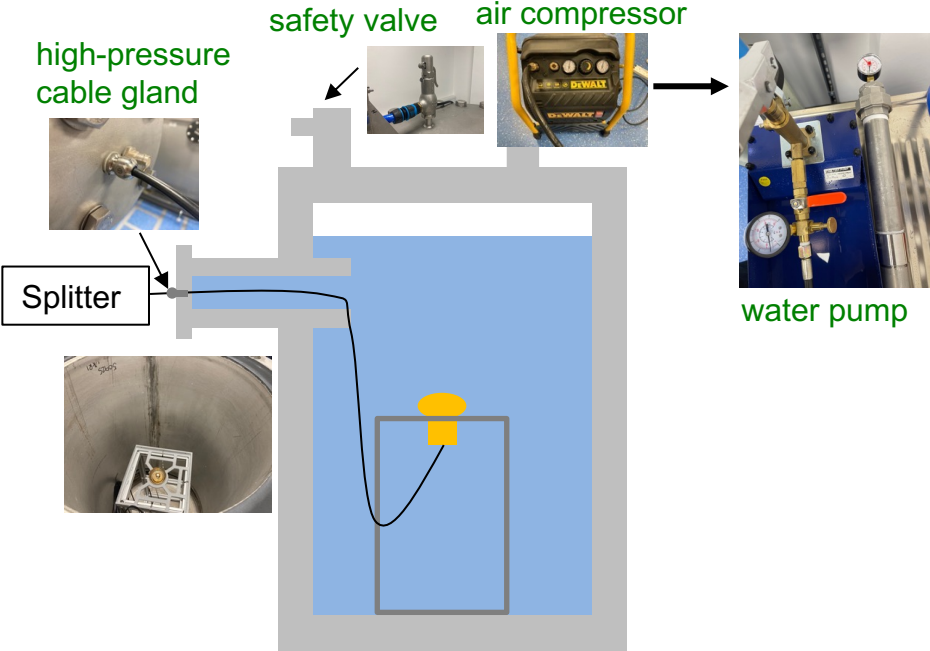
Small pressure vessel

## Hamamatsu 3-inch PMT with pressure

- Tested in 10 bar water with air pressure
  - Tested in 10 bar water with water pressure
  - PMT ran continuously more than 2 days
- It passed underwater test ✓



Large pressure vessel



## FD2 mPMT test (Beda)

- Air pressure may affect the measurement by gassing to the system
- Water pressure is better to use

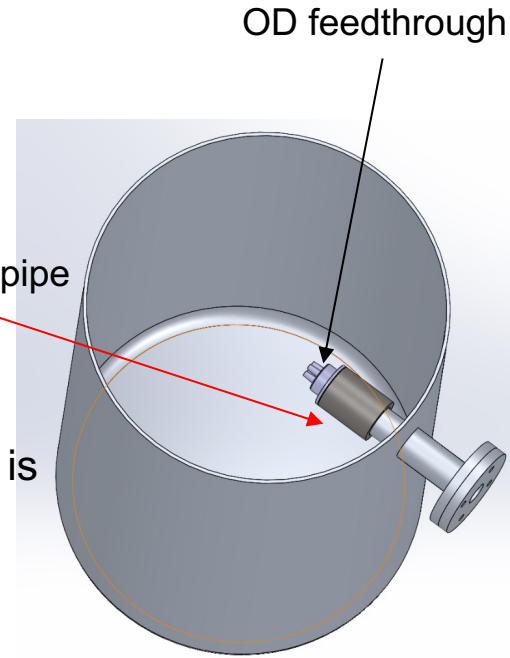
# 3. Waterproof: Feedthrough

## OD feedthrough with pressure

- AXON OD feedthrough doesn't fit to our flange
- High-pressure pipe and flange was ordered, received

## Plan

1. Pressure test of the new flange
2. Pressure test with the OD feed-through (below). AXON OD feedthrough has underwater SMB connectors to both end (new design is SHV). We use this, then seal the other end with cable sealer.
3. Repeat without underwater connectors, but heat shrink on SMB connectors with over-moulding
4. Repeat these with the new feedthrough with SHV connectors (3 months)



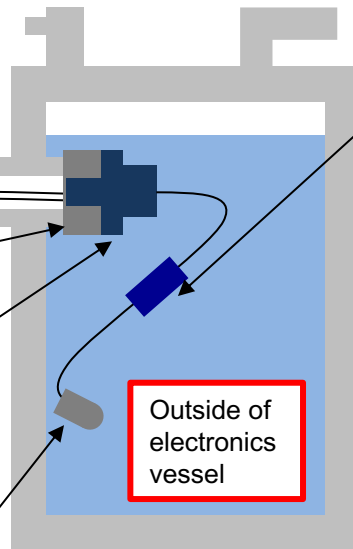
High-pressure pipe and flange



AXON feedthrough



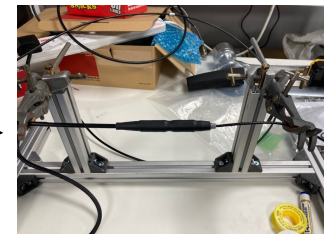
Inside of electronics vessel



Outside of electronics vessel

Heat shrink cable sealer

- (2) AXON underwater connector (SMB)
- ↓
- (3) SMB over-moulding with heat shrink



## 4. HK OD PMT underwater connection study: Connectors

We need correct connectors for the testing

### SHV plug connectors for Hamamatsu 3-inch PMT

- To-Conne custom made connectors
- Ordered

### SHV plug connectors for NNVT 3-inch PMT

- We received the part number (AXON)
- Will ask quotes from AXON

### SHV jack connectors for AXON OD feedthrough

- We received the part number (SLK)
- Waiting quote

It is difficult to proceed signal testing with the same SHV connectors with HyperK in 2 months

### New issue: feed-through

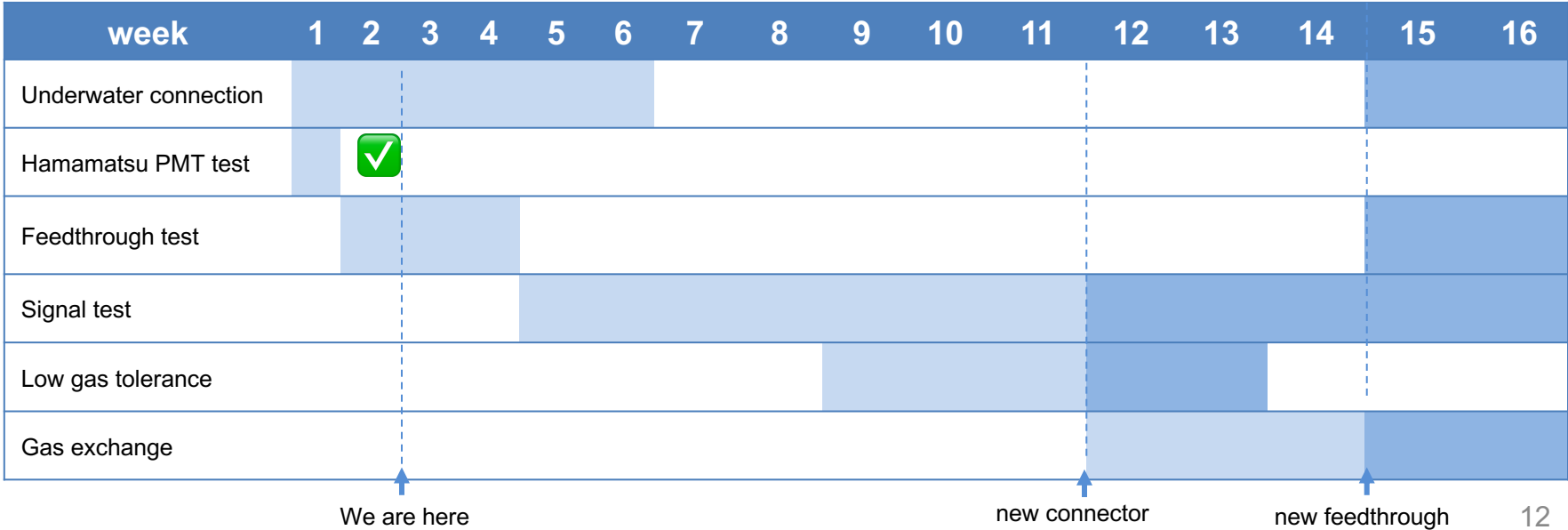
- We don't have any RG174 cables terminated with SHV with PE over-moulding. We need the new OD feedthrough for realistic underwater connection test, LT=3 months.

BNC	Inner Detector
Plug	To-Conne BNCP-58A-K
Jack	To-Conne BNCJ-58A
SHV	
Plug	To-Conne SHVP-174H2
Jack	To-Conne SHVJ-174H2
SHV	Outer Detector
Plug	To-Conne SHVP-YR53485 (HPK)
Plug	AXON CON860768A (NNVT)
Jack	SLK 5SHF11S-A02-100 (AXON)

# 5. HK OD PMT underwater connection study: Summary

- 1. Waterproof: underwater connection test (~4 weeks)
  - R&D is ongoing, we have a plan to proceed
- 2. Waterproof: Hamamatsu PMT test (~1 weeks) - Done
- 3. Waterproof: feedthrough test (~3 weeks)
  - Testing the AXON OD feedthrough in the vessel
- 4. Signal stability test
  - We will proceed to this after (1), (2), (3)
- 5. Low gas tolerance test
  - Tests will start soon, vacuum pump is investigated
- 6. Gas exchange test
  - Tests will start after (4), with new set up

We need the new OD feedthrough for realistic underwater connection test



# Backup



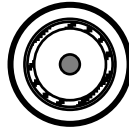
# 1. Waterproof: Underwater connection

## 3-inch Hamamatsu PMT cable - BELDEN YR53485 OD feedthrough cable - RG174A/U

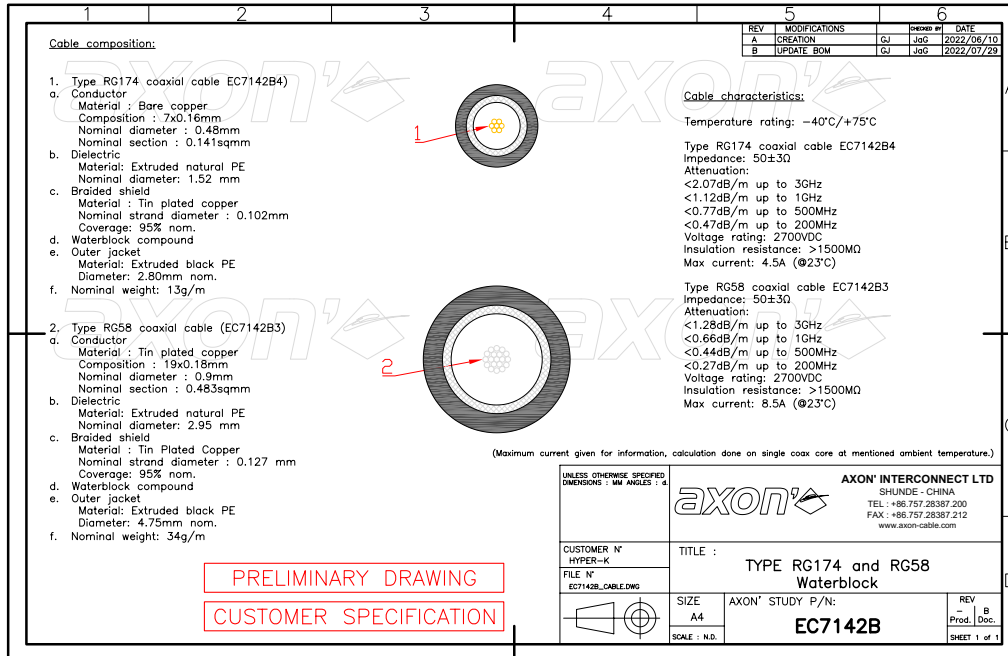
Conductor: BC, 0.48mm $\phi$   
Dielectric: Extruded natural PE, 1.52mm $\phi$   
Braided shield: TPC w/ water block compound  
Outer jacket: Extruded black PE, 2.80mm $\phi$



Conductor: CCS, 1.02mm $\phi$   
Dielectric: PE, 3.71mm $\phi$   
Braided shield: TC, w/ PE grease  
Tape: Al/Poly/Al  
Outer jacket: HDPE, 6.15mm $\phi$



AP-ENG01-AN03-A



Preliminary Technical  
Data Sheet

11-05-2008 Rev. 1

YR53485

**I. Description:**

RG-58 Type Coaxial Cable, PE Insulation, HDPE Jacket

**II. Electrical Characteristics:**

Nom. Impedance: 50 Ohms  
Nom. Inductance: 0.08 Micro-H/ft.  
Nom. Capacitance Conductor to Shield: 30.8 pF/ft.  
Nom. Velocity of Propagation: 66%  
Nom. Delay: 1.54 ns/ft.  
Nom. Conductor DC Resistance at 20 Degrees C: 16 Ohms/1000 ft.  
Nom. Shield DC Resistance at 20 Degrees C: 2.1 Ohms/1000 ft.  
Max. Operating Voltage: 1750 Vrms

MHz	dB/100 ft.
1	0.4
10	1.2
50	2.8
100	4.1
200	6.0
400	8.8
700	12.0
900	13.8
1000	14.5

**III. Physical Characteristics:**

Operating Temperature Rating: -55 to +80 Degrees C  
Nom. Bulk Cable Weight: 35 lbs/1000 ft.  
Min. Bending Radius (install): 2.5"  
Max. Recommended Pulling Tension: 74 lbs

Conductor  
AWG: 18  
Stranding: Solid  
Material: Copper-Covered Steel  
Nom. Diameter: .040"

Dielectric  
Material: PE  
Nom. Diameter: .146"

Shield  
First Layer  
Type: Braided  
Material: Tinned Copper  
Nom. Percent Coverage: 95%  
Flooding Compound: PE Grease (Between Shield Layers)

Second Layer  
Type: Tape  
Material: Aluminum/Poly/Aluminum  
Nom. Percent Coverage: 100%

Jacket  
Material: HDPE  
Nom. Diameter: .242"  
RoHS Compliant: Yes

# 3. Waterproof: Feedthrough

## New OD feedthrough

- Underwater connection is replaced with SHV connectors
- Over-mouldings are applied on the SHV jack connectors

