Mechanical Design of Multi-PMTs for IWCD

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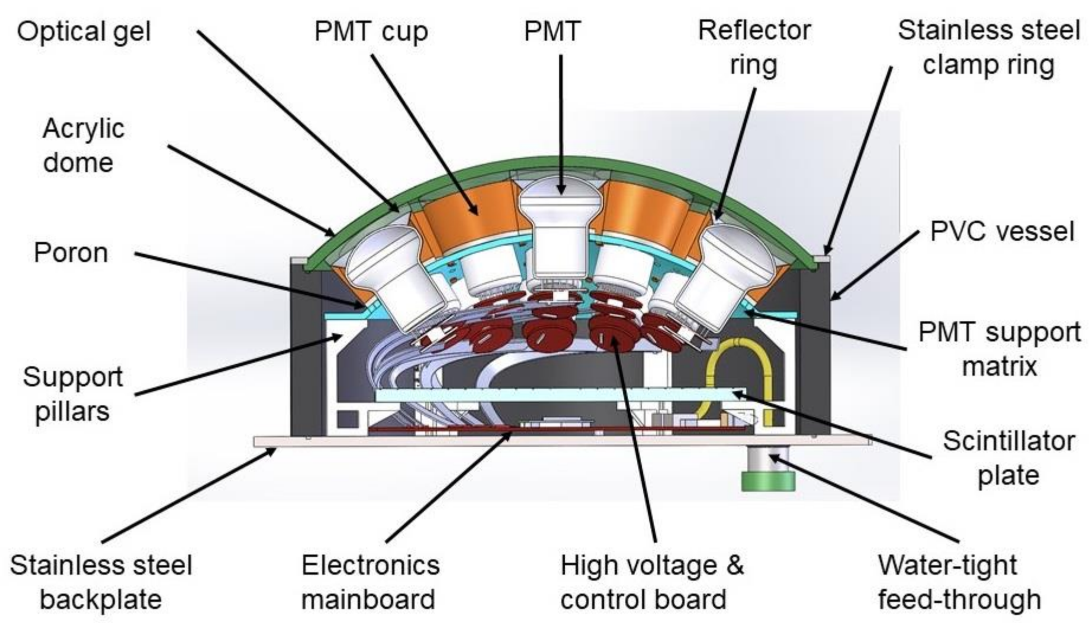
Introduction

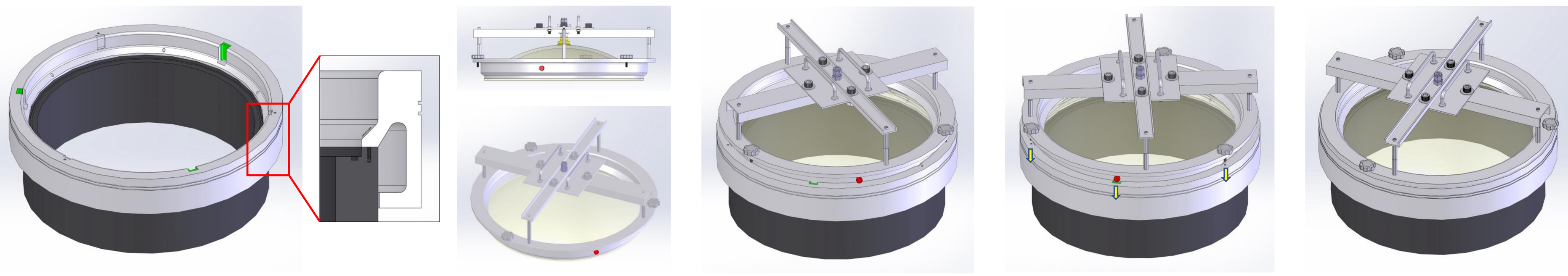
Approximately 500 multi-PMTs (mPMTs) will be used as the photosensors for the Intermediate Water Cherenkov Detector (IWCD), a new near detector for the approved Hyper-Kamiokande experiment that will be built by 2025. The IWCD mPMT design has nineteen 3" PMTs enclosed in a water-tight pressure vessel, along with the associated electronics. The 3" PMTs provide excellent spatial imaging of the neutrino-induced Cherenkov light ring. This poster will focus on the mechanical design of the mPMT vessel. In particular, design of acrylic dome, use of optical gel to couple the dome to the PMTs, assembly procedures of dome and PMT unit (including the necessary jigs / fixtures), design of water-tight feed-through & plans for testing and results from several mPMT prototypes.

The mechanical design of mPMT module should satisfy the following requirements:

- The mPMT vessel must be water-tight to 30m water depth
- The mPMT vessel must not seriously degrade the quality of ultra-pure or Gd-doped water. Also, the mPMT vessel must not be seriously weakened by the ultra-pure or Gd-doped water
- The mPMT vessel should have a lifetime of 20 years
- The mPMT mechanical design should be reasonably simple to manufacture and assemble. It should be possible to maintain production rate of 1 mPMT vessel per day with ≈3-4 technicians



UV transparent acrylic dome & its assembly

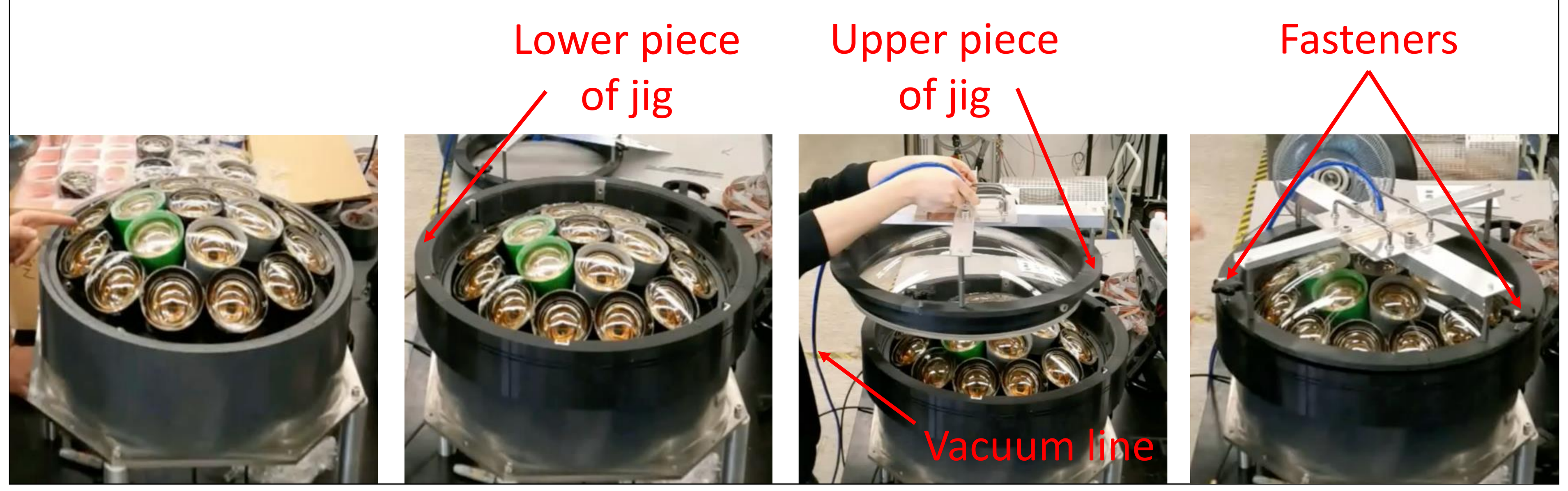


[1] [2] [3] [4] [5]

- UV transparent acrylic material is chosen for the dome. To sustain the water pressure, 15mm thick acrylic sheet is considered. Hollow spherical segment (dome shape) is used to maximize coverage area for the PMTs.
- For the dome assembly, a jig is designed. Assembly procedure is as follows-

1. Place the lower piece of jig on the outer rim of vessel - Fig. [1]
2. Grip the dome in upper piece of jig by using vacuum gripping technique
3. Place the upper piece of jig on the lower one and allow rotation of the upper jig using rollers (red) - Fig. [3]
4. When the rollers align with the guide rails (green) on the lower jig, upper jig assembly slides downward – Fig. [4]
5. Three fasteners are used to accurately lower the dome furthermore - Fig. [5]
6. Once the dome is accurately placed, vacuum grip is released and jig is detached

- Some of the actual assembly images are shown below:

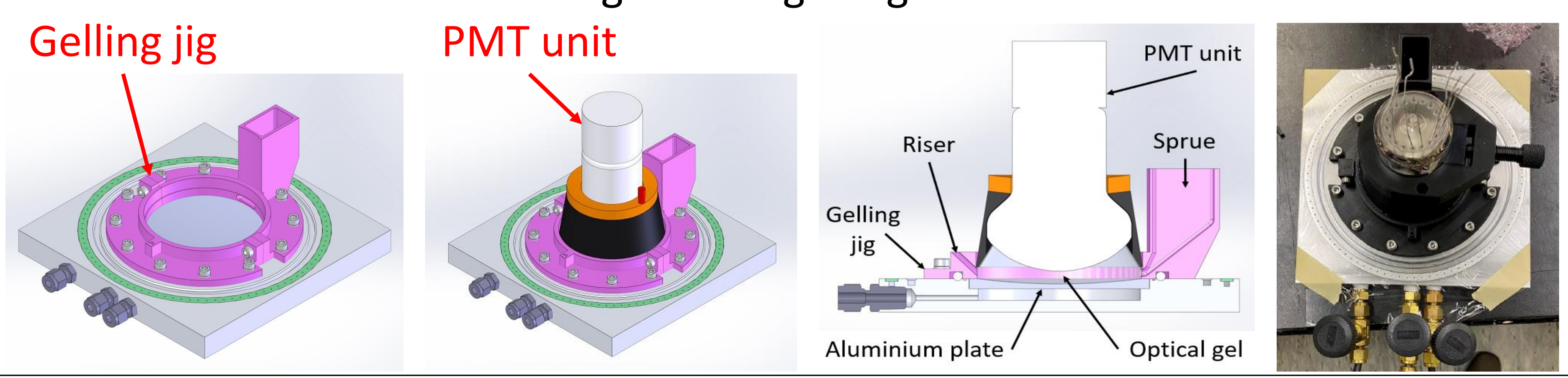


Use of optical gel to couple the dome to the PMTs

- An optical gel is used as a coupling between the PMTs and the acrylic dome on the front of the module. Newest prototypes use Wacker Elastosil 604 optical gel
- PMT unit consists of PMT, poron, PMT cup, reflector ring & optical gel
- A jig is designed for the gel application on PMT unit
- Assembly procedure of the PMT unit is as follows:

1. PMT is inserted into 3D printed cup
2. Reflector ring is inserted and glued into cup
3. PMT unit assembly is placed in mould which is closed and tightened
4. Gel is inserted into the mould using gelling jig
5. After gel sets, mould is disassembled

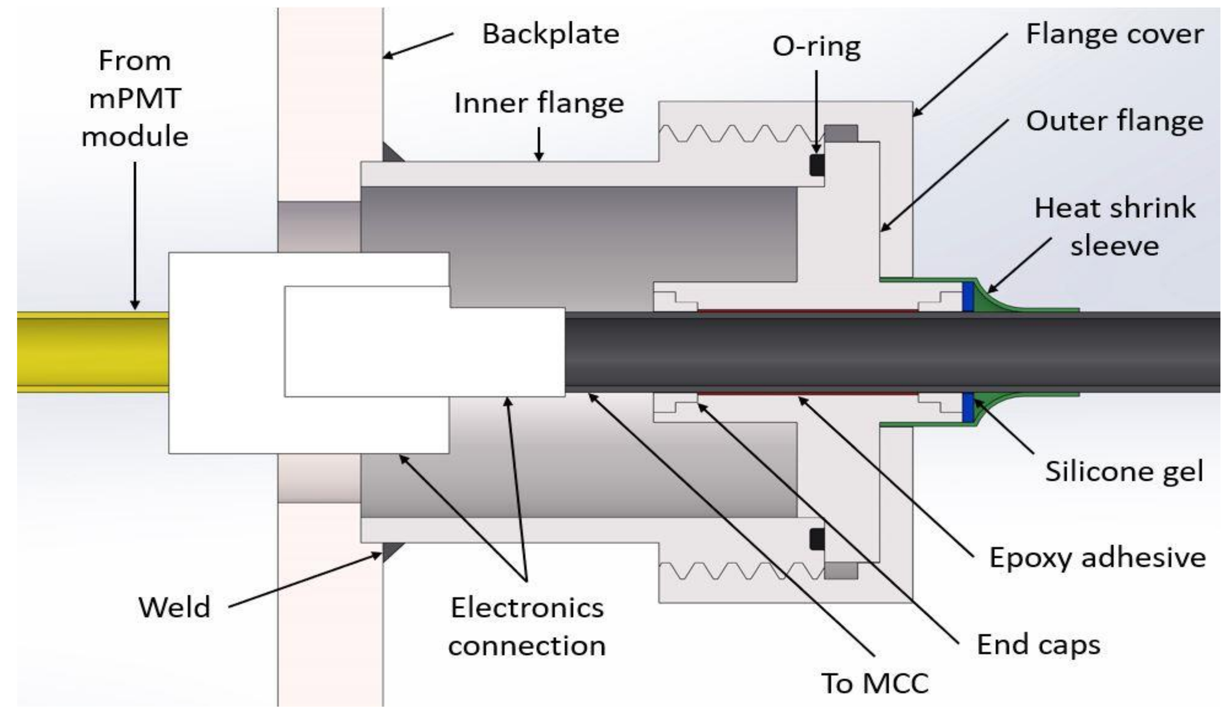
- Model view and Actual image of the gelling is shown below:



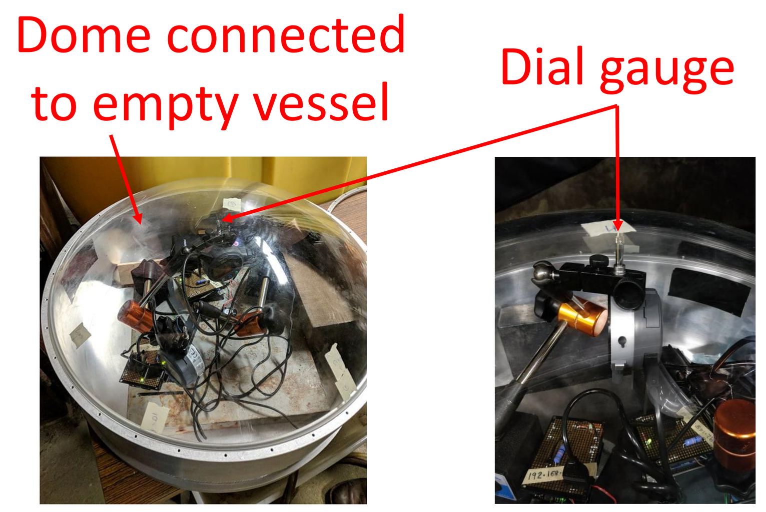
Design and testing of feed-through connector

- Design of feed-through connector has been completed
- The design of the connector provides waterproof feed-through, also allowing easy detachment in case of maintenance
- Feed-through design is split into two sections; one consists of Inner flange which is fixed (welded to back plate of mPMT Module), while second consists of Outer flange assembly and Flange cover which is detachable
- As per the operational and transportation phases of the experiment, following tests will be performed on the connector-

1. Hydrostatic pressure test [up to 1 MPa]
2. Cyclic pressure test [0.8 MPa – 1.2 MPa]
3. Tension (pull) test [222 N]
4. Immersion (soak) test [17 °C & 50 °C]
5. Temperature variation test [0 °C & 50 °C]

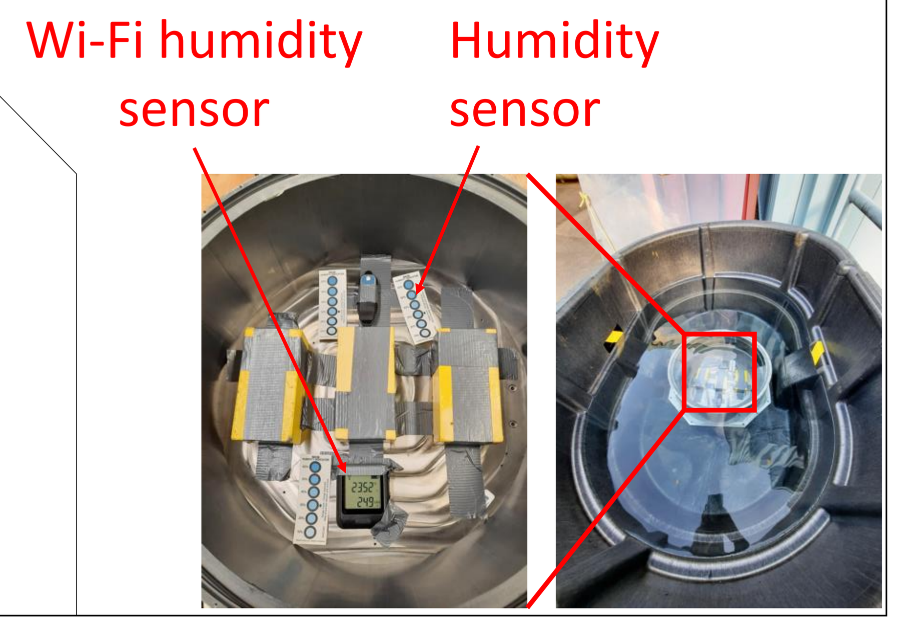


Results from mPMT prototypes



- Pressure test of acrylic dome up-to 0.8MPa has been carried out to measure deflection
- Use of dial gauge to record the deflection readings over the period of time
- Max. 2.6mm deflection observed at 0.8MPa pressure

- Conducting 5 month immersion test of fully assembled mPMT to check water diffusion through acrylic dome
- Wi-Fi enabled humidity sensor installed inside the mPMT vessel to continuously monitor humidity



Summary

- Mechanical design of mPMT vessel is complete. Design modifications of jigs & fixtures and fine-tuning assembly procedure is in progress
- Testing of the mPMT vessel for various conditions is being carried out. Initial test results on the mPMT prototypes are promising
- In contact with companies & machine shops for mass production of mPMTs for IWCD

An Intermediate Water Cherenkov Detector for Hyper-Kamiokande Using the NuPRISM Concept (by Dr. Mark Hartz)
https://indico.cern.ch/event/981823/contributions/4295370/

Electronics for Multi-PMTs for the IWCD at Hyper-Kamiokande (by Marcin Ziembicki)
https://indico.cern.ch/event/981823/contributions/4295249/