Overview of WCTE mechanical systems

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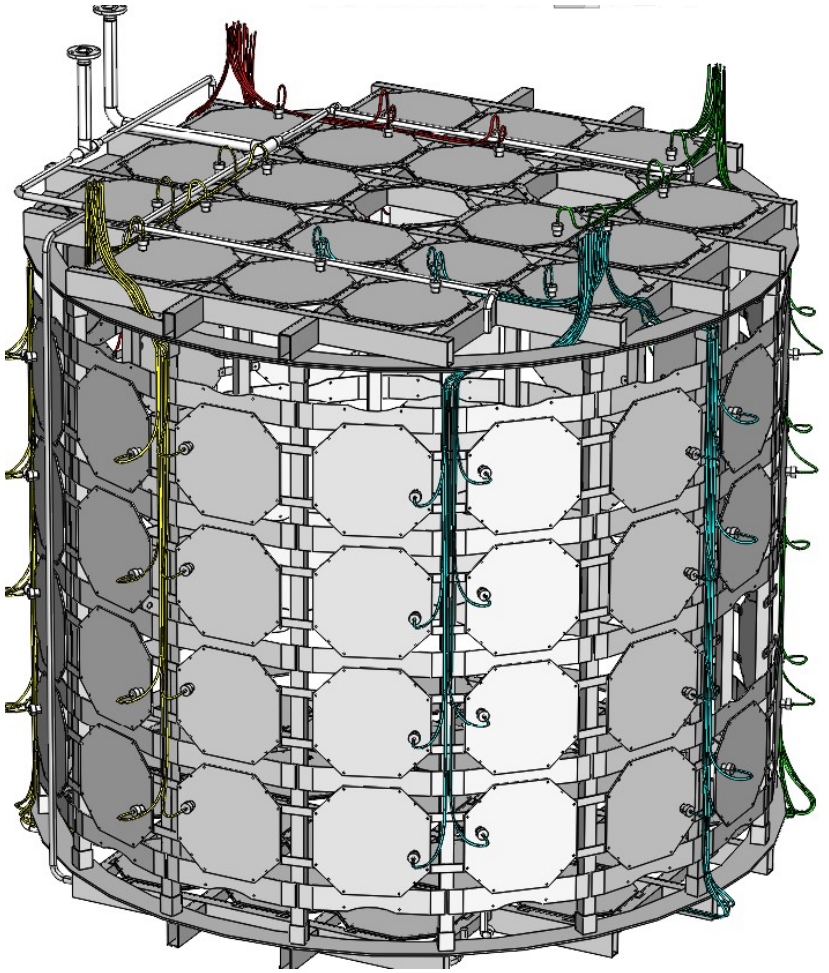
on behalf of the WCTE mechanical WG
2022/07/19

Current status

Design of mechanical systems of WCTE is well advanced with good progress since the last CM.
Specially, in the integration with other features of the detector (water system, photogrammetry, mPMT connector...) *[Ganesh] [Alejandro]*

Drafted an updated assembly *[Kshitija]* procedure and estimated the space requirements for the whole WCTE at the assembly area

Working on the CDS prototype at Imperial *[Oliver]*



Space requirements at assembly area

Updated preliminary assembly procedure requires more space than previous estimate

Working on further requirements for mPMT testing at the assembly facility

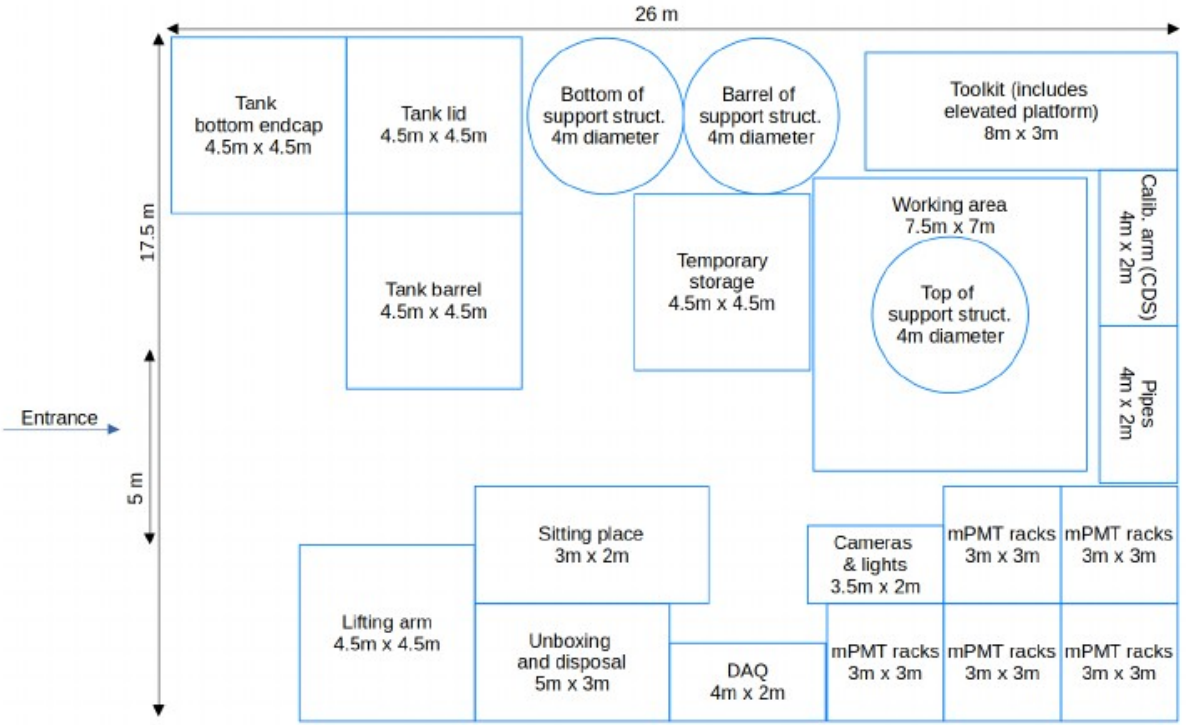
Several assembly procedures are possible depending on the available space at assembly and experimental areas

Space Requirements

The space required for the storage and assembly of all the WCTE components.

Note that the tank will be directly assembled in the T9 area and thus, only storage space would be needed for the tank in case there is no sufficient storage space for it at T9. Here, we assume the case where the tank has to be stored in the assembly hall.

- An area of 26 m x 17.5 m = 455 m^2 *(to be optimized depending on the available spaces)*
- Height of at least 10 m
- Access to crane with maximum load of at least 30 ton
- Entrance of at least 5 m wide and 6 m in height with access for truck to load and unload the detector components.



WCTE Assembly and Installation

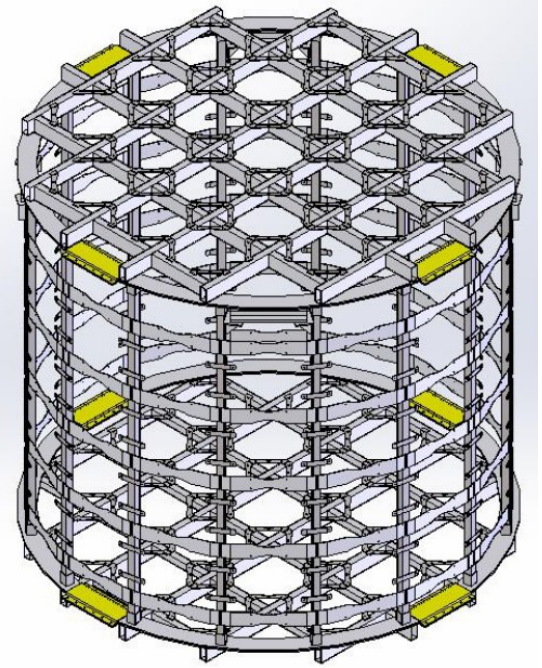
The WCTE tank and mPMT support structure will be delivered at CERN from Spain in six major parts:

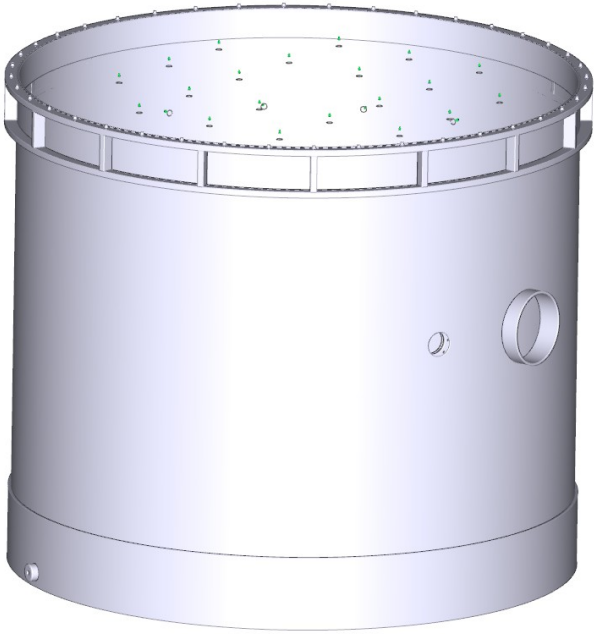
- **Bottom endcap of the mPMT support structure**
- **Top endcap of the mPMT support structure**
- **Barrel of the mPMT support structure**
- **Tank**
- **Base of tank (or already welded to the tank)**
- **Lid of tank**

No welding is foreseen to assemble these components, but preferably another method such as clamps.

In the assembly area, the full detector will be instrumented with PMTs and the rest of necessary components: lights, cameras, water pipes, calibration arm (CDS) and cabling.

If possible, it would be very useful to perform a check of the detector before moving to the T9 experimental area. Still trying to define how to do it safely.





Next steps

Finalize design (and update all dependencies, including TDR) based on July low momentum beam studies

→ Do we need rails *[Erik on Friday]* to operate in both beams?

Start to work closer with CERN to define the final assembly and installation procedure

→ Feasible, safe, efficient

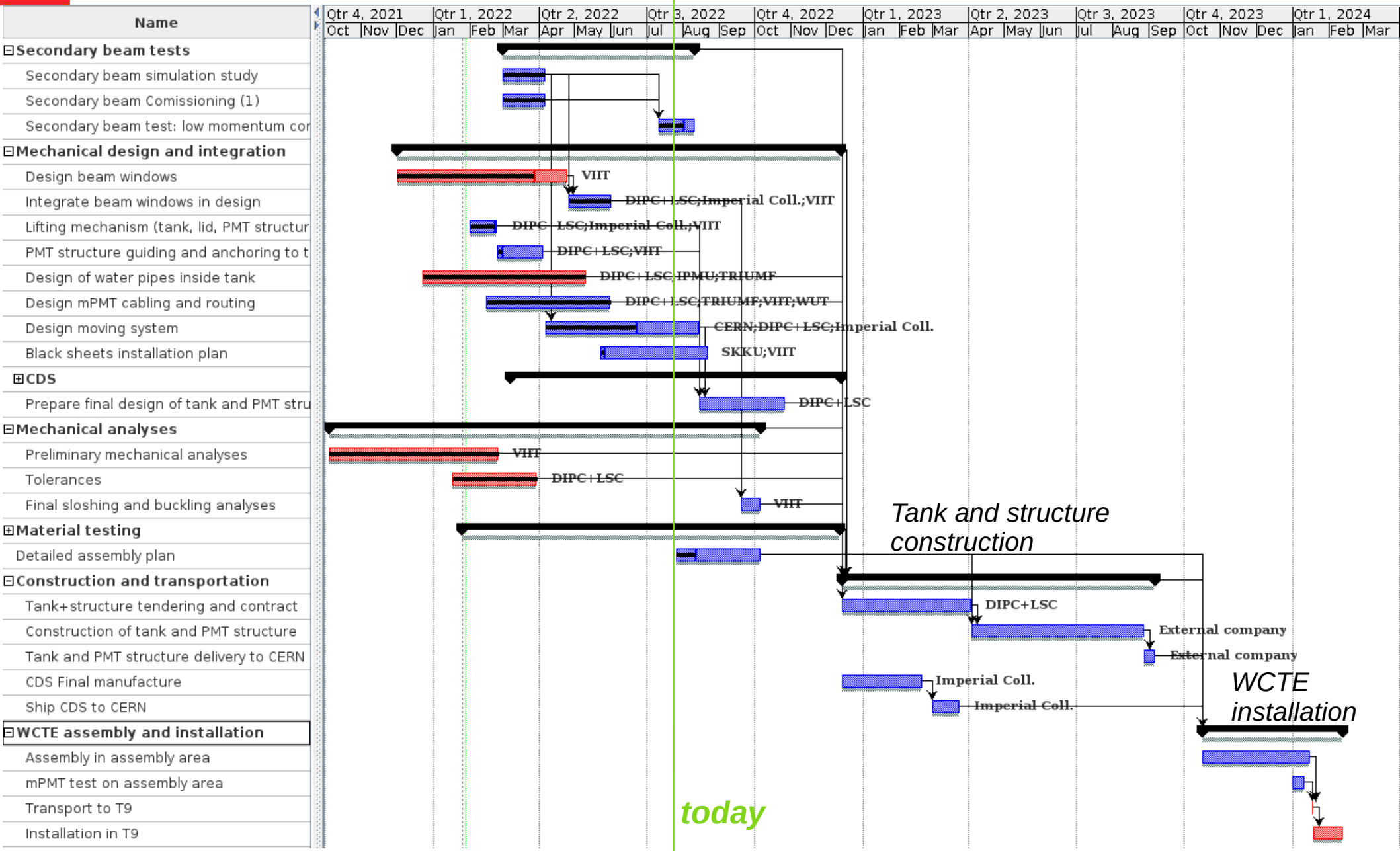
→ Exchange of information is slowly starting

Address design and installation related remaining issues *[Jorge]*

Exploring (with the electronics group) ways of how to test mPMTs once mounted on the structure in the assembly area

- Major open questions: light tighten the instrumented detector and cooling during mPMT test (no water)

Updated schedule and plan



Mechanical talks at this meeting

Tuesday

	Tank and support structure design and analysis *160/1-009, CERN*	*Saurabh Patil* 14:37 - 14:57
15:00	**Assembly and installation (including Black sheets and tertiary beam window)** *160/1-009, CERN*	*Kshitija Satao* 14:57 - 15:15
	Waterproof feedthrough and Soak tests *160/1-009, CERN*	*Ganesh Pawar et al.* 15:15 - 15:30
	CDS and mechanical *160/1-009, CERN*	*Oliver Jeremy* 15:30 - 15:45
16:00		
	Pipes, cameras, lights, integration and latest design *160/1-009, CERN*	*Alejandro Taboada et al.* 16:05 - 16:20
	Construction Schedule *160/1-009, CERN*	*Jorge Pelegrin* 16:20 - 16:35

Friday

	Rails and moving system *160/1-009, CERN*	*Erik Richards* 14:00 – 14:12

And all the rest

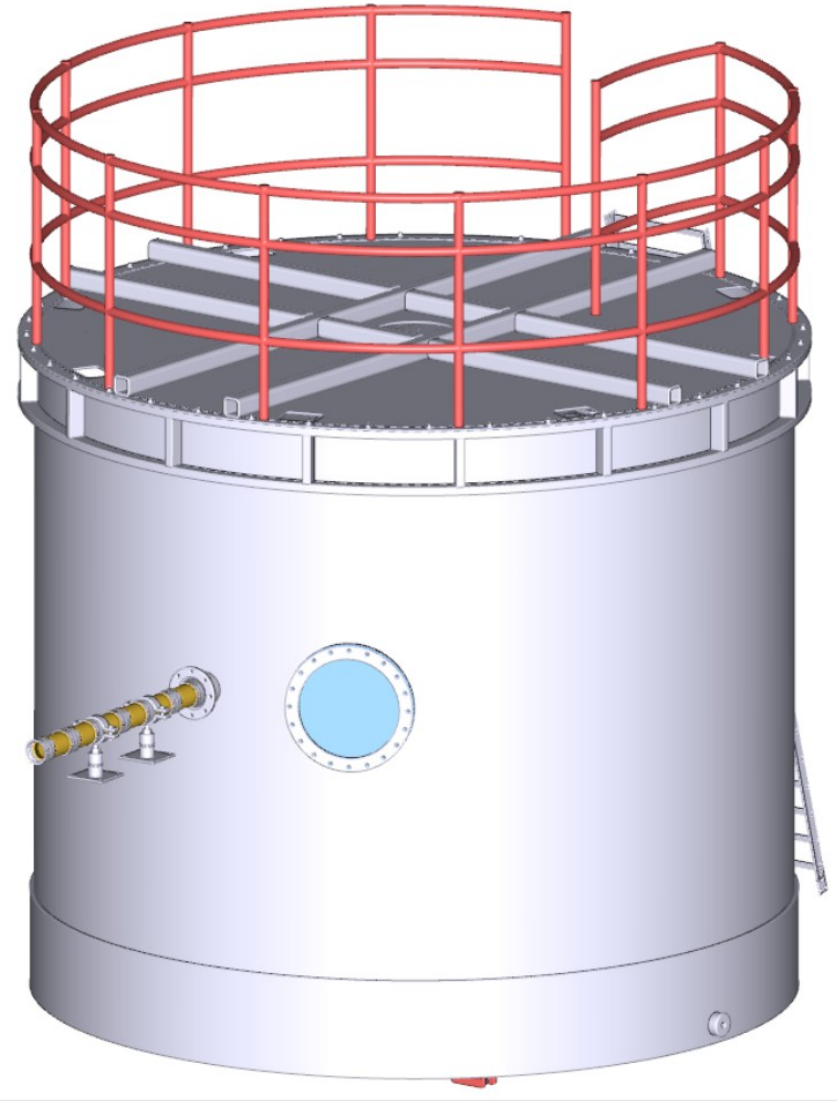
Introduction: latest design

Cylindrical tank of 4 m diameter and 3.5 m height

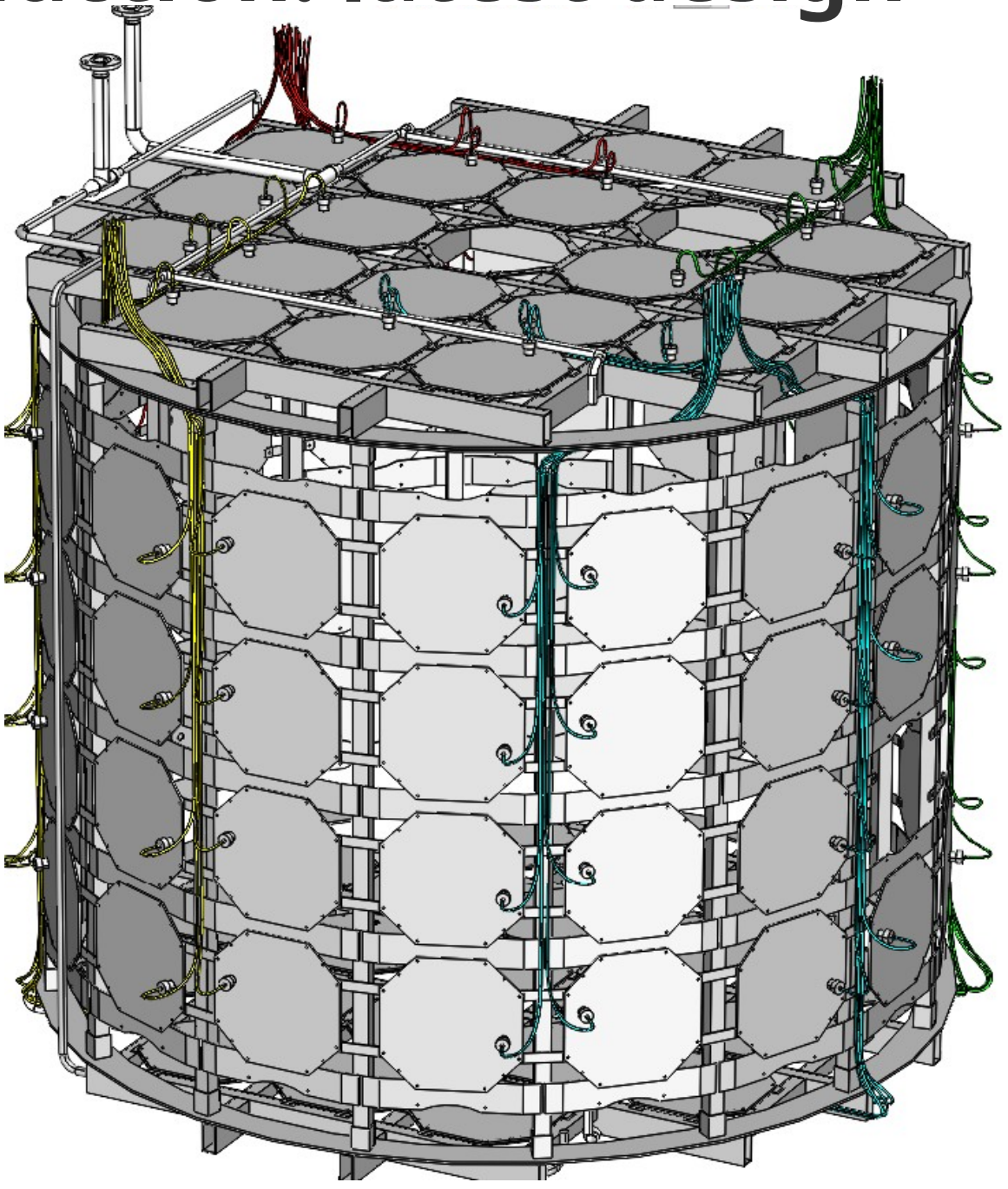
Made from SS-304 and smaller pieces made from other materials
All compatible with ultra-pure and Gd-loaded water

Two windows for both secondary and tertiary beam configurations

Water pipes and cables come out through the tank lid



Introduction: latest design

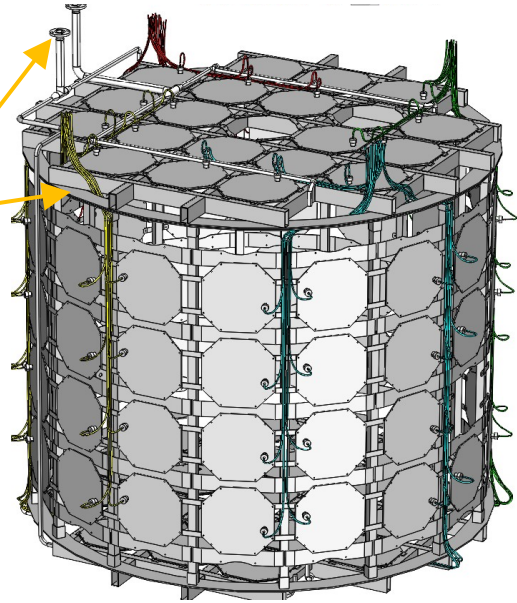


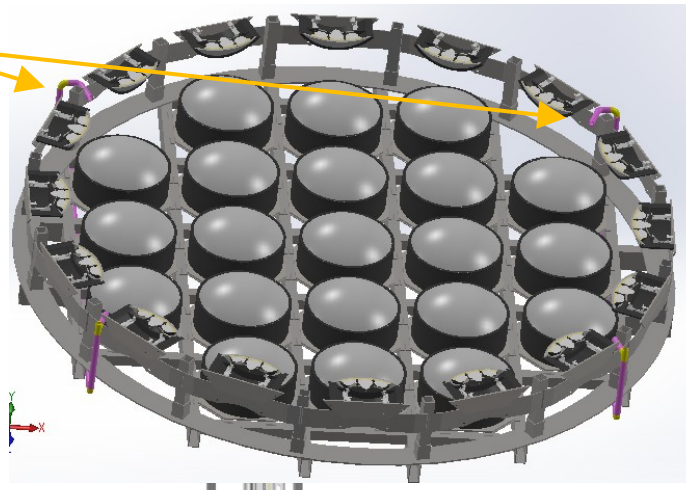
Introduction: latest design

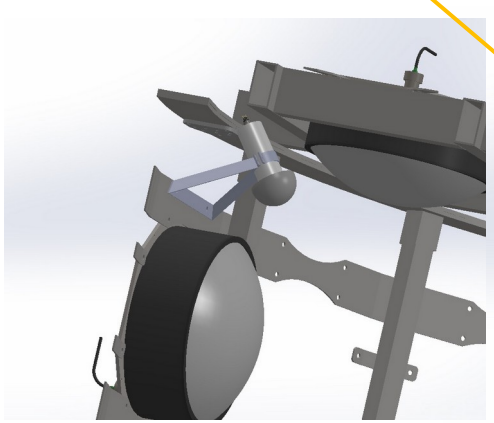
Instrumented with 102 mPMTs:
- cables in 4 bundles routed along the columns of the mPMT support structure

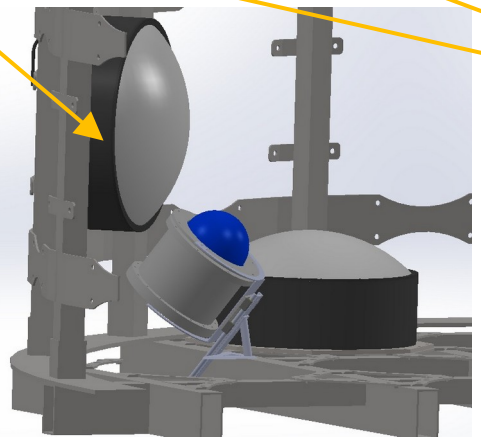
Water pipes:
- Single entry point for inwards flow and ramified into four inlets
- Single entry point for outwards flow and ramified into four outlets
- Additional pipe to the bottom for pumping out the water when draining the tank

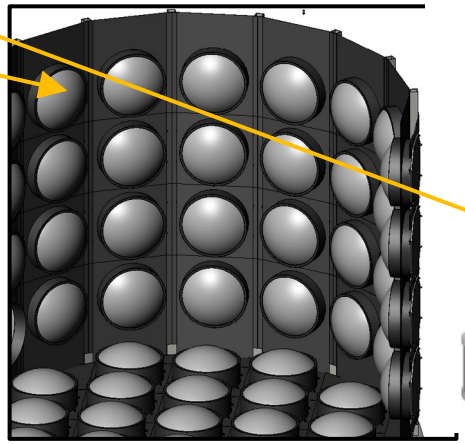
Other instrumentation:
- Cameras and lights for photogrammetry calibration
- Black sheets surrounding mPMTs, cameras and lights
- Central Deployment System (CDS)

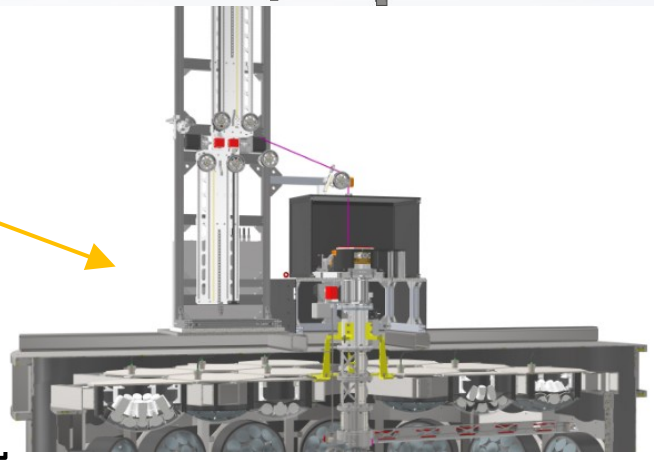






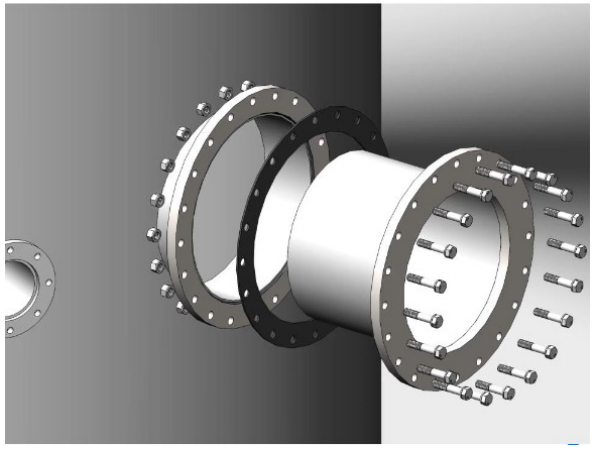


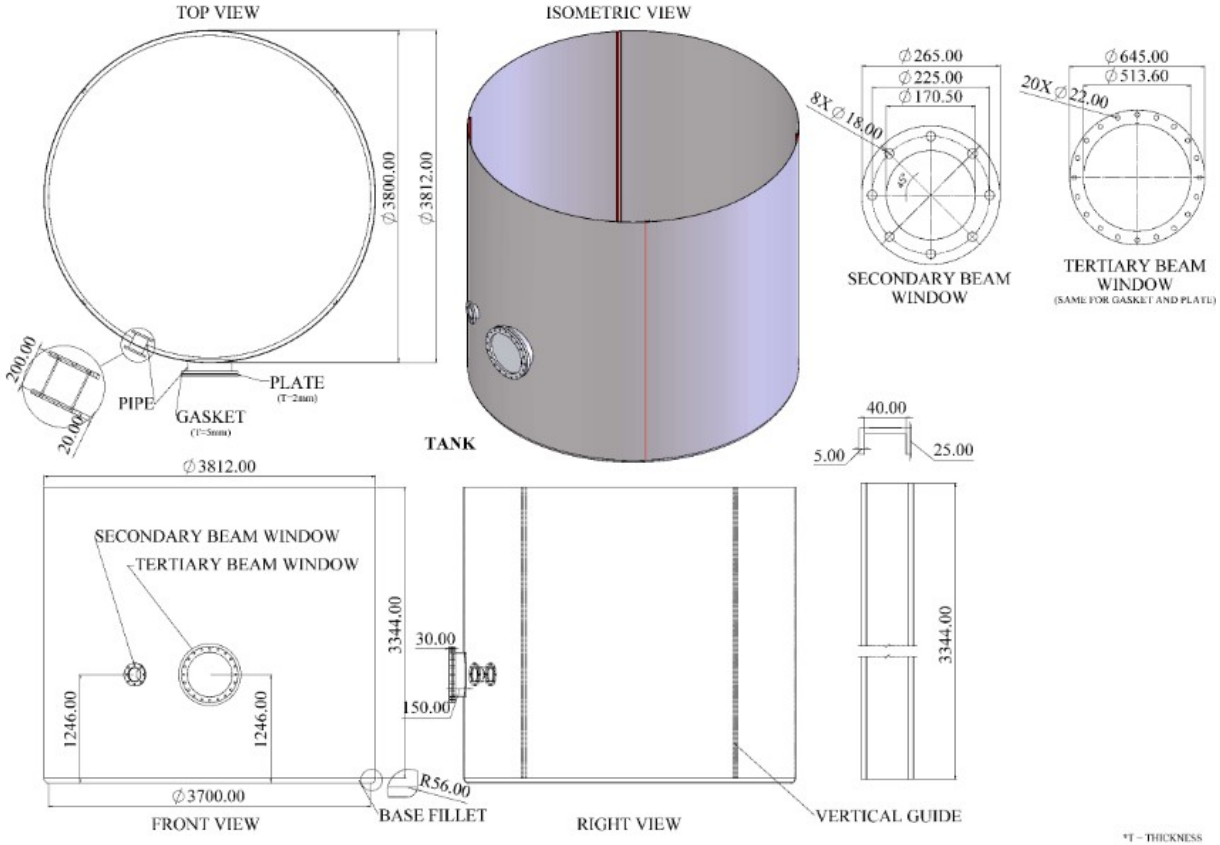




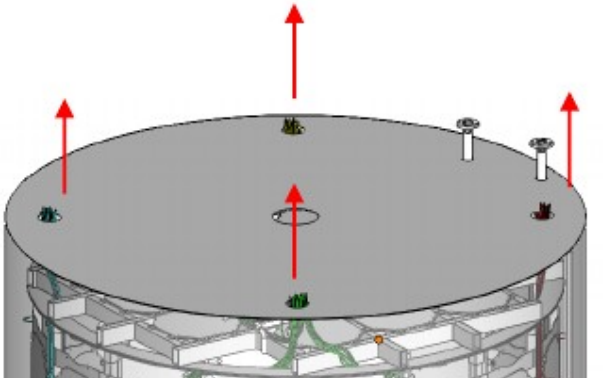
Tank (barrel)

- SS-304, 3800mm diameter and a wall thickness of 6mm
- edge having a radius of curvature of 56mm to avoid high stresses at sharp edge between the barrel and the bottom plate
- The secondary and the tertiary beam windows are at a height of 1246mm from the bottom
- Physics and mechanical studies for beam windows being finalized

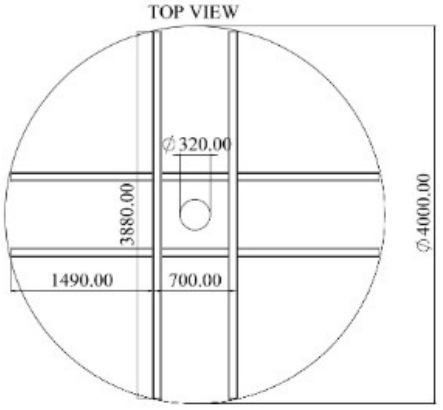


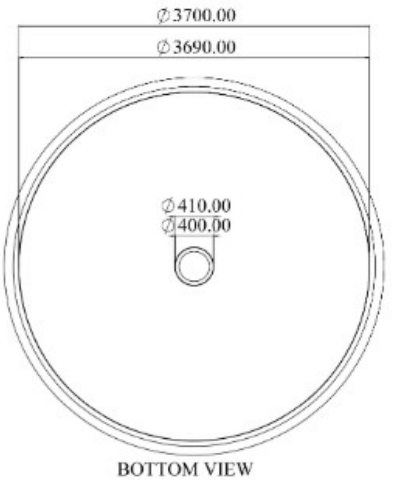


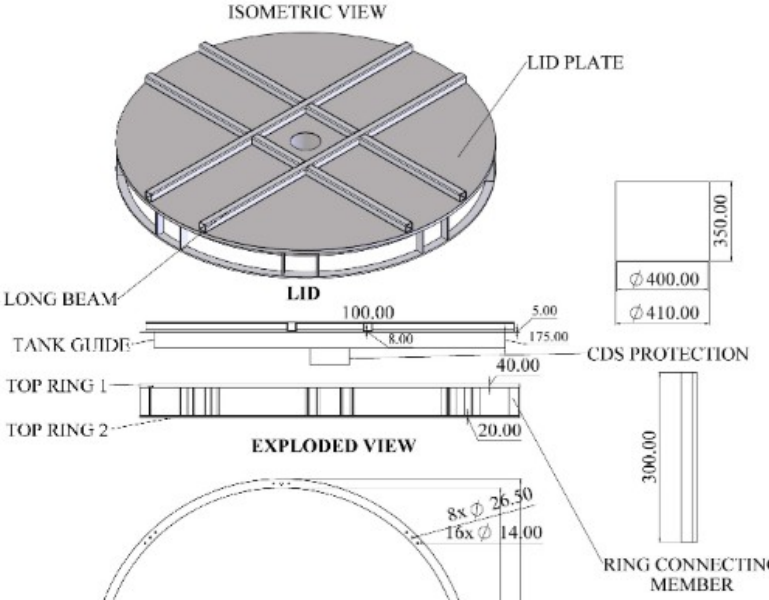
Tank Lid

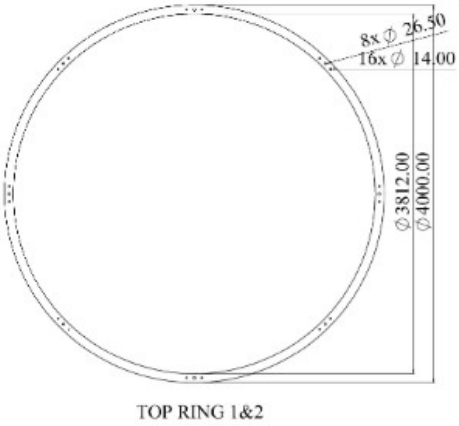


- SS-304. The plate is 5mm thick and reinforced with cross beams of 8mm thick. This is enough to prevent bending due to 300kg of CDS weight and two persons
- The lid plate has a hole of 320 mm diameter for insertion of CDS (Central Deployment System) into the tank. A 350mm long hollow pipe protects the CDS from accidental impacts
- Two additional holes for water pipes
- Four additional holes for cables
- A 175mm high cylinder with an i.d. of 3690mm and an o.d. of 3700mm at the bottom of the tank lid plate acts as a tank guide
- Top ring 1 and top ring 2 are attached to each other through 8 ring connecting members of 300mm length using bolts



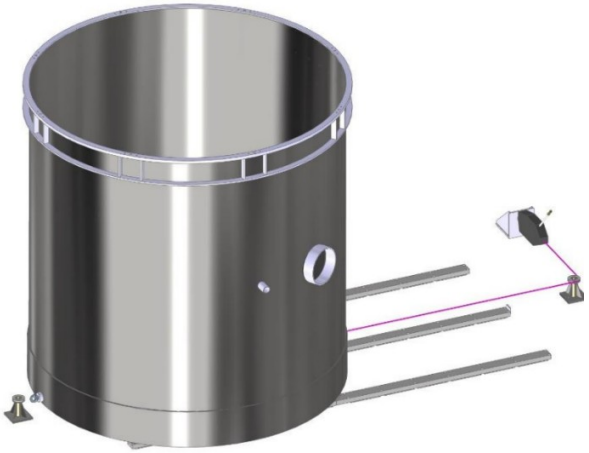


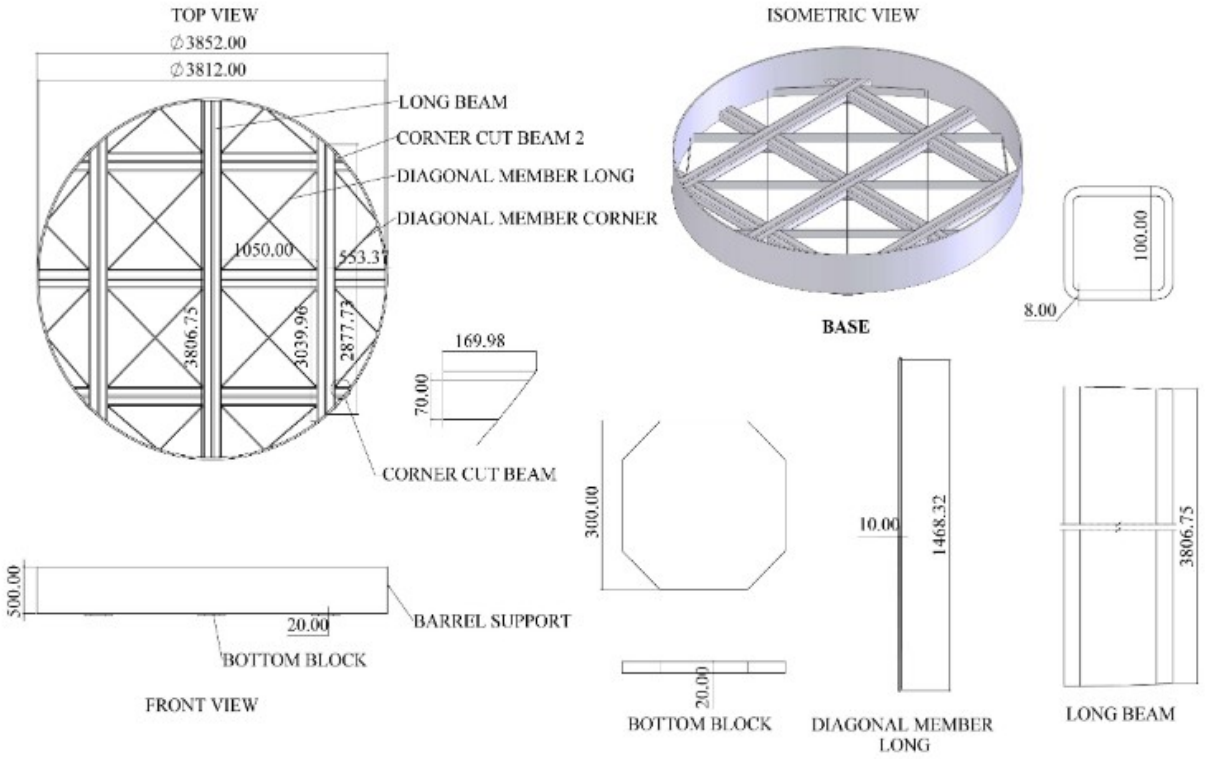




Tank Base

- The tank is placed on a base to facilitate its movement between the secondary and tertiary beams
- It consists of a matrix of members which have two 100mm x 100mm square pipes with a wall thickness of 8mm and further strengthened by diagonal members made of solid strips with a cross-section of 100mm x 10mm
- The cylindrical barrel support surrounding the matrix is made of a strip which is 500mm wide and 20mm thick
- Octagonal bottom blocks are provided at the nine junctions of the central matrix.
  Rollers are fixed to these blocks for transport of the tank between both beam





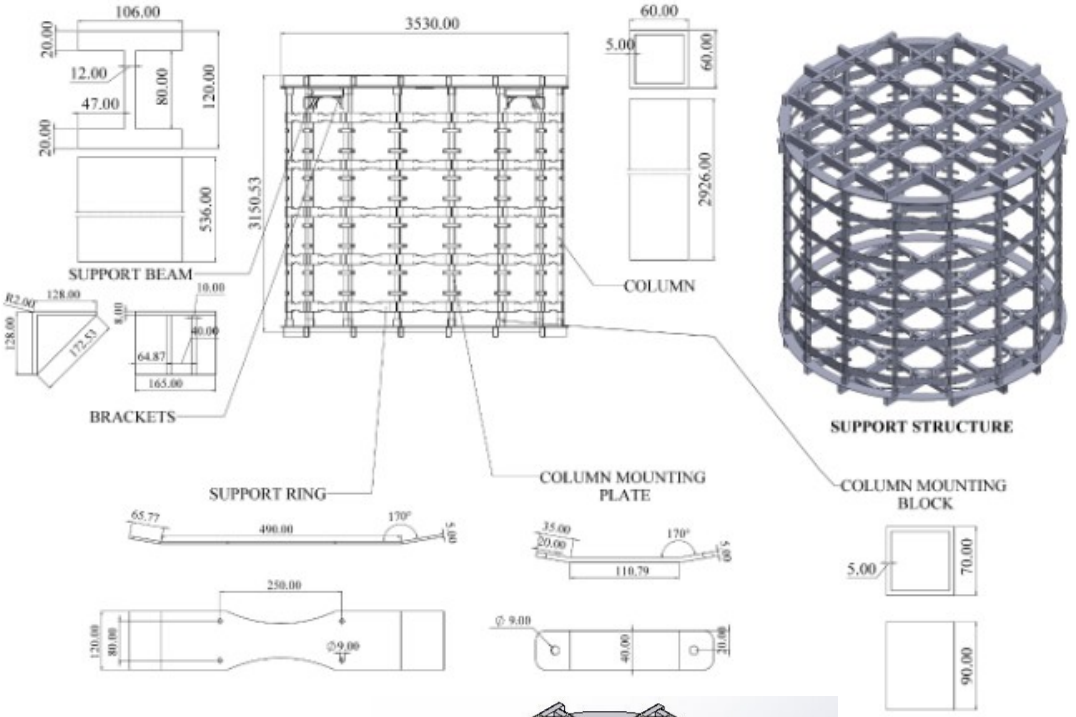
mPMT Support Structure

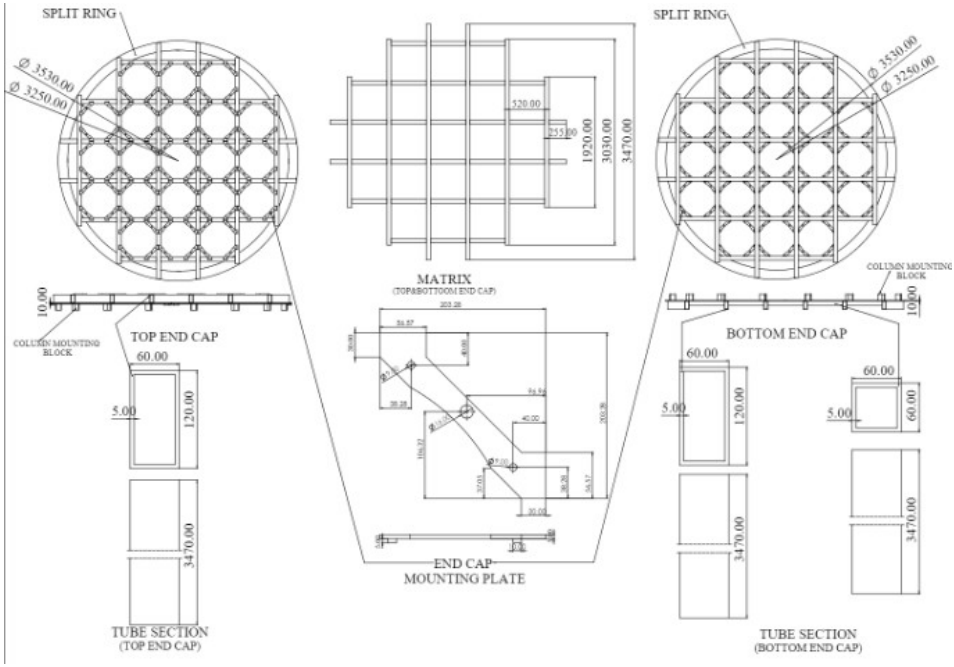
This will be delivered into three parts, barrel and top and bottom end caps and finally assembled and instrumented at CERN

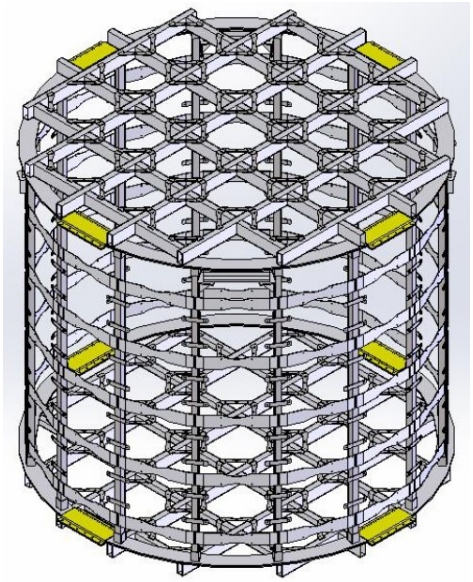
- SS304 to arrange the mPMTs inside the tank
- The bottom end cap consists of a 280mm wide and 10mm thick ring and mounted on a matrix of rectangular pipes of 120mmx60mmx5mm and 60mmx60mmx5mm
- The top end cap is similar to the bottom end cap except that all the pipes of the matrix have rectangular cross-section of 120mmx60mmx5mm
- End cap mounting plates are welded on top of the matrix for mounting the mPMTs from the top

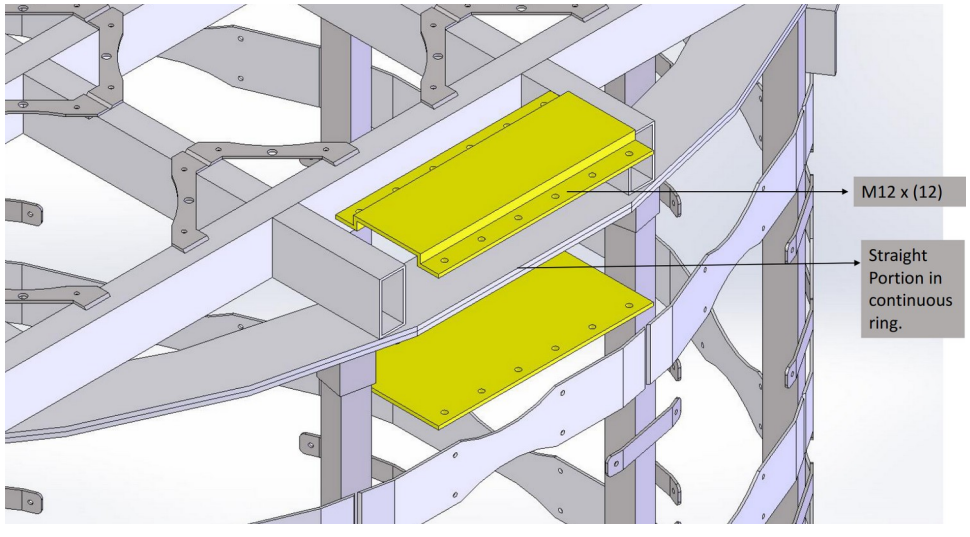
- The barrel has columns made of square pipes with a cross-section of 60mmx60mmx5mm and are connected to the top and bottom end caps by inserting them
- The columns are linked by support ring elements made of 5mm thick. The support ring and the column mounting plates are used to mount the mPMTs on the barrel.
- Four support I-beams are mounted on brackets symmetrically just below the top end cap.

mPMT Support Structure



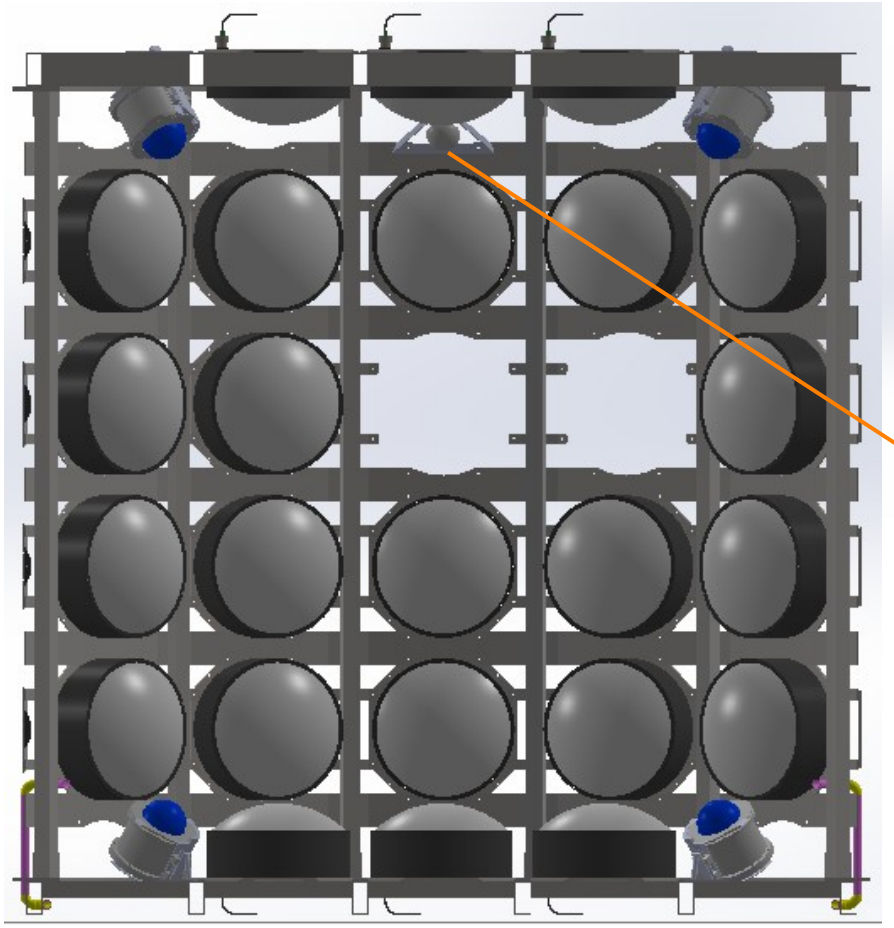




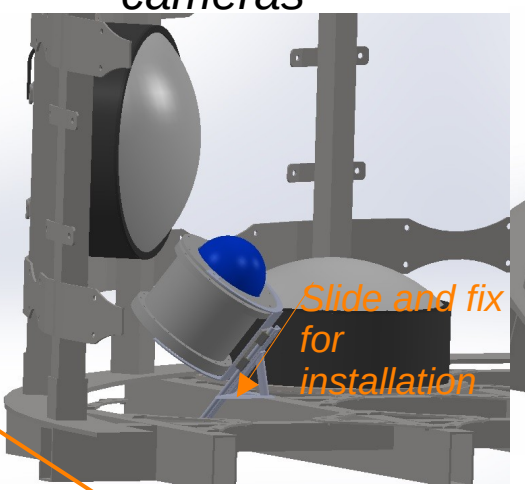


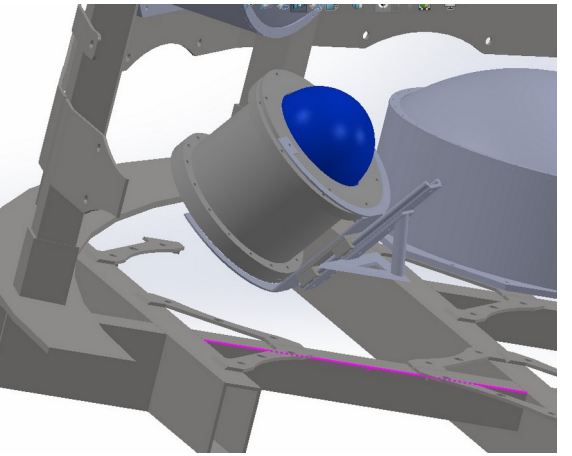
Other design features

Photogrammetry systems
Layout with 8 cameras in the corners is preferred

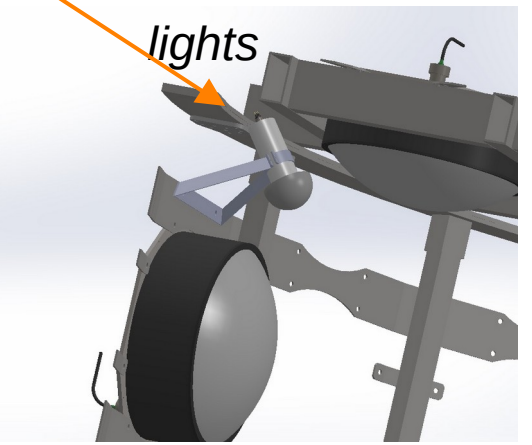


cameras



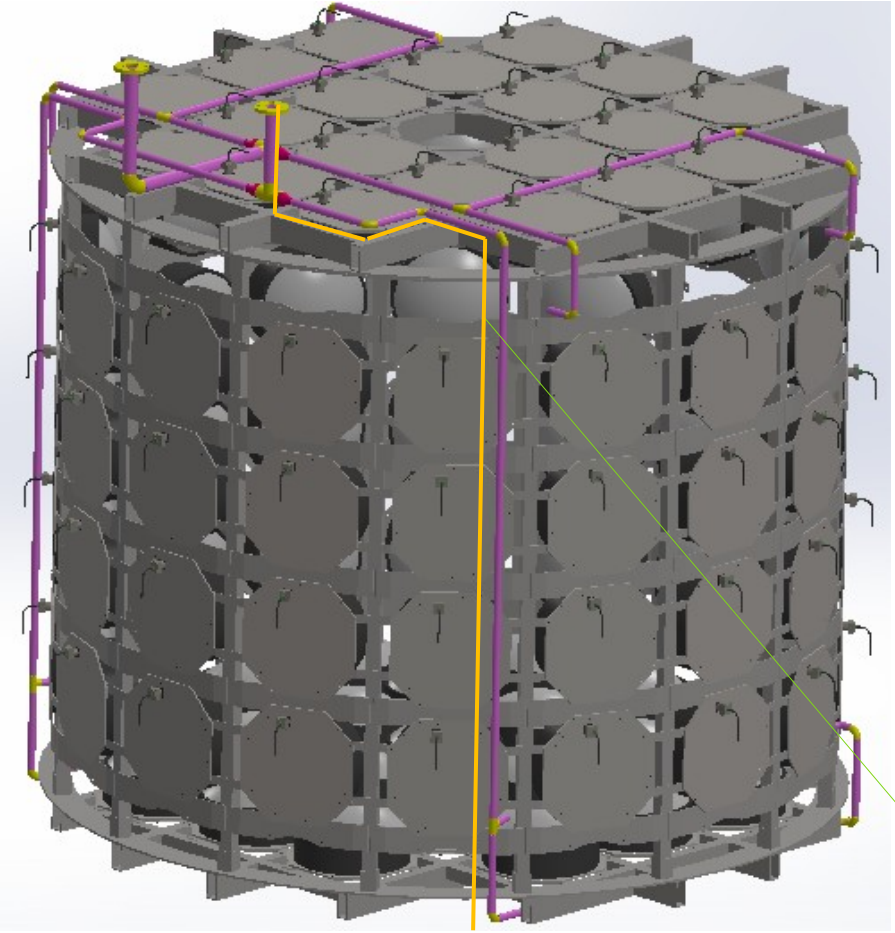


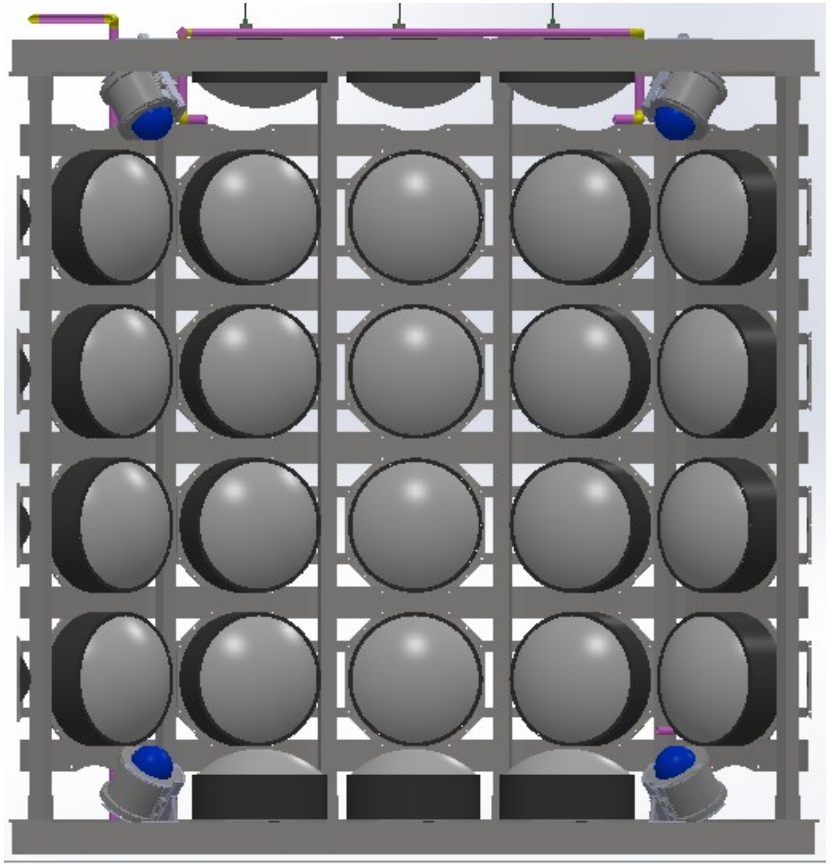
lights



Other design features

Water pipes

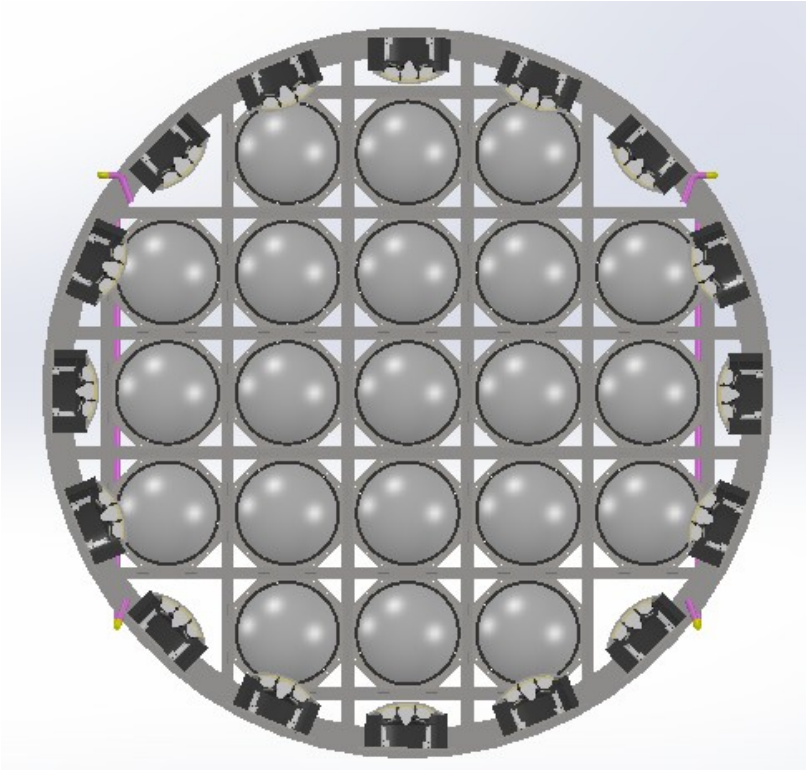


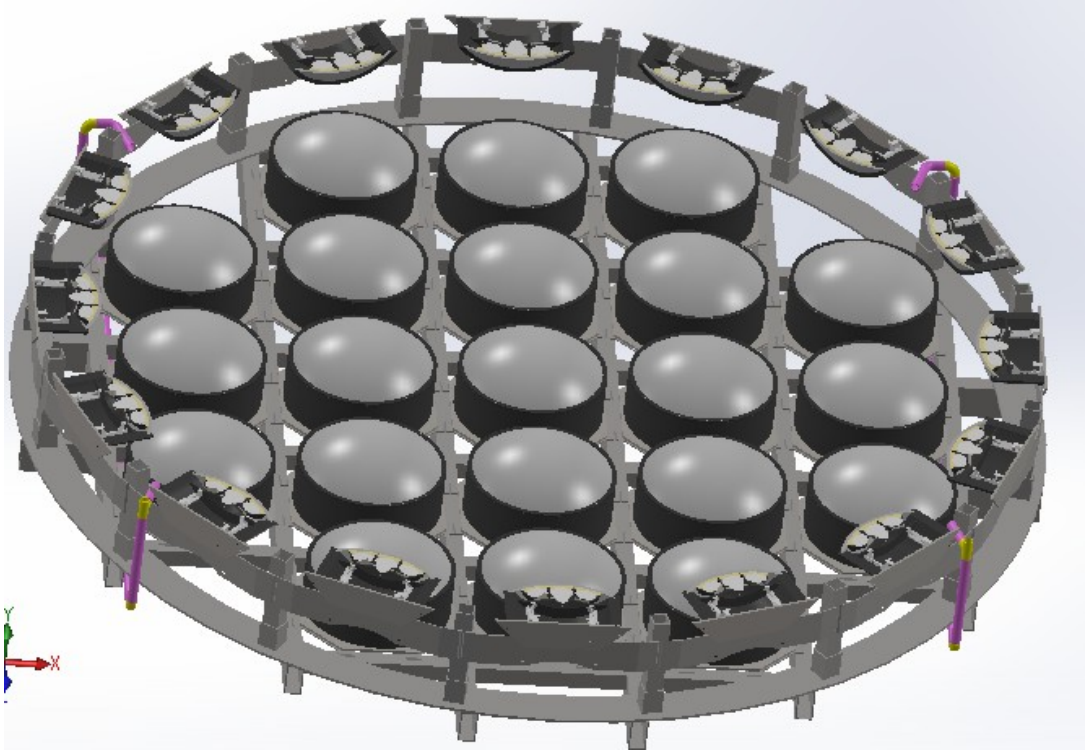


For draining the tank, we will add another pipe to the bottom of the tank to pump out as much water as possible

Other design features

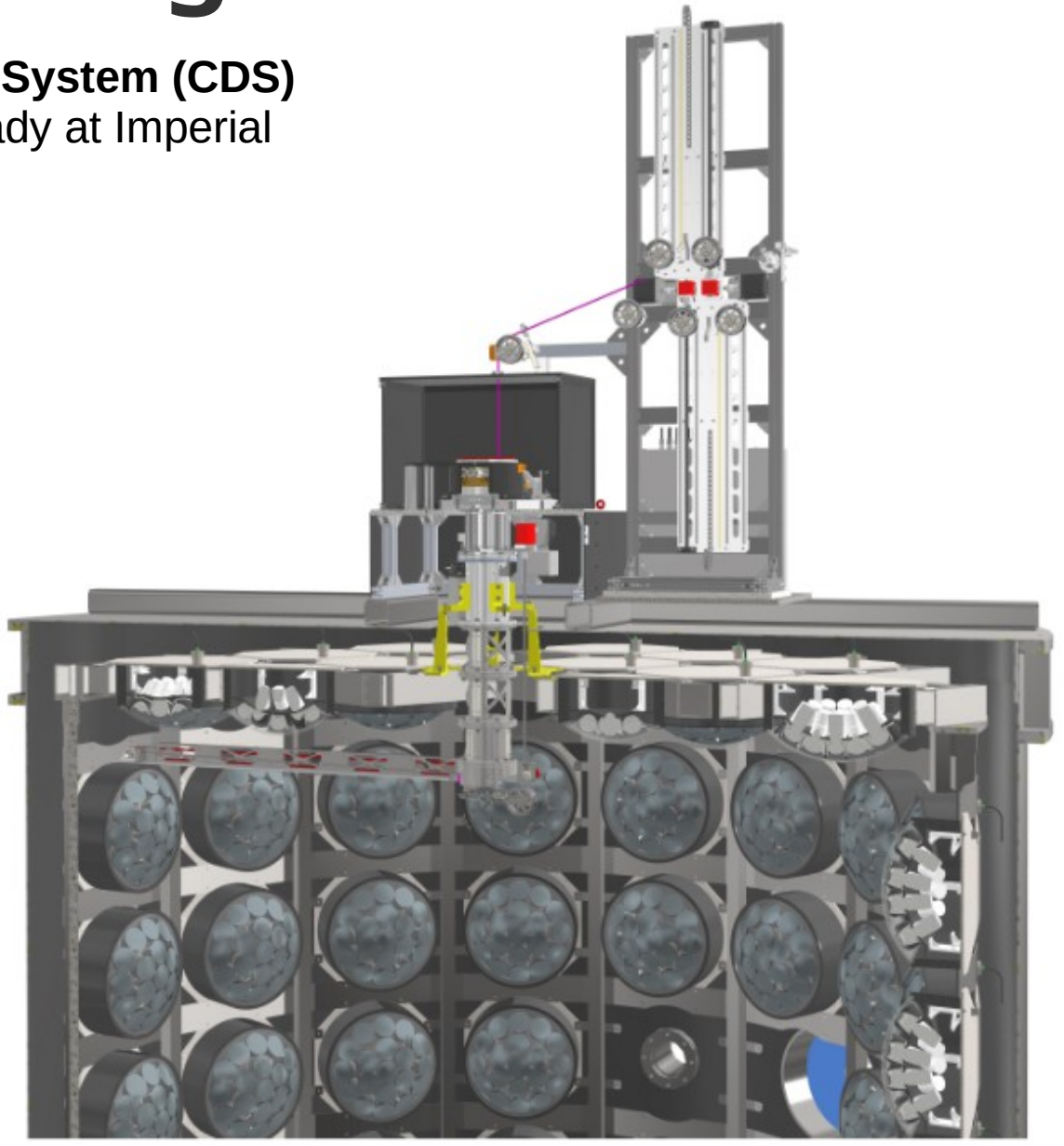
Water pipes
Slight modification of the outlet direction





Other design features

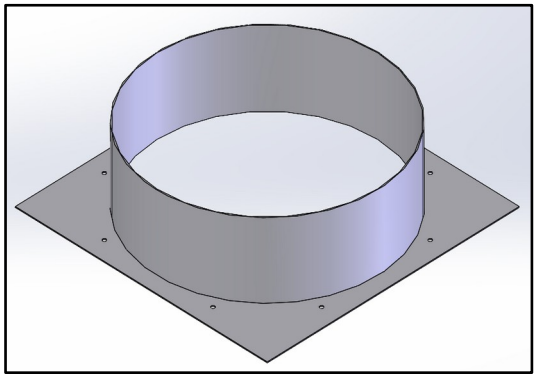
Central Deployment System (CDS)
Working prototype ready at Imperial

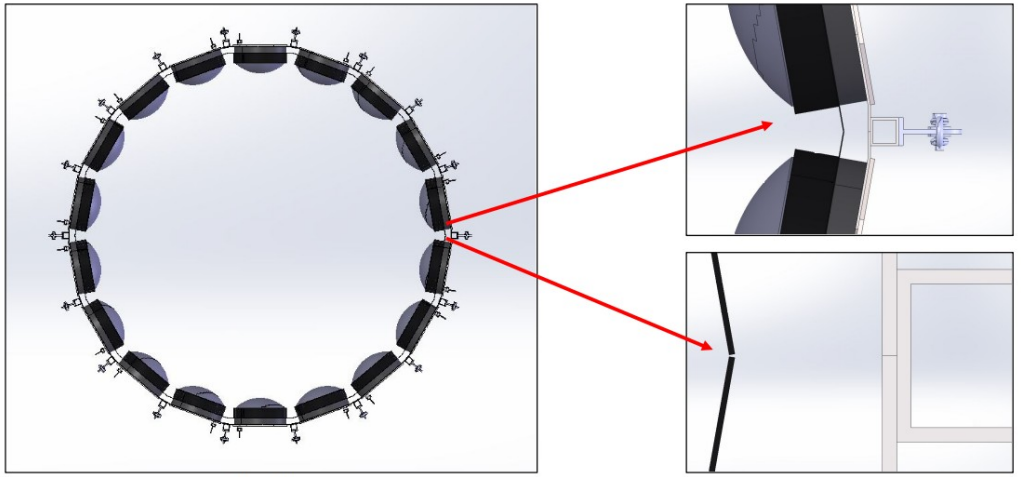


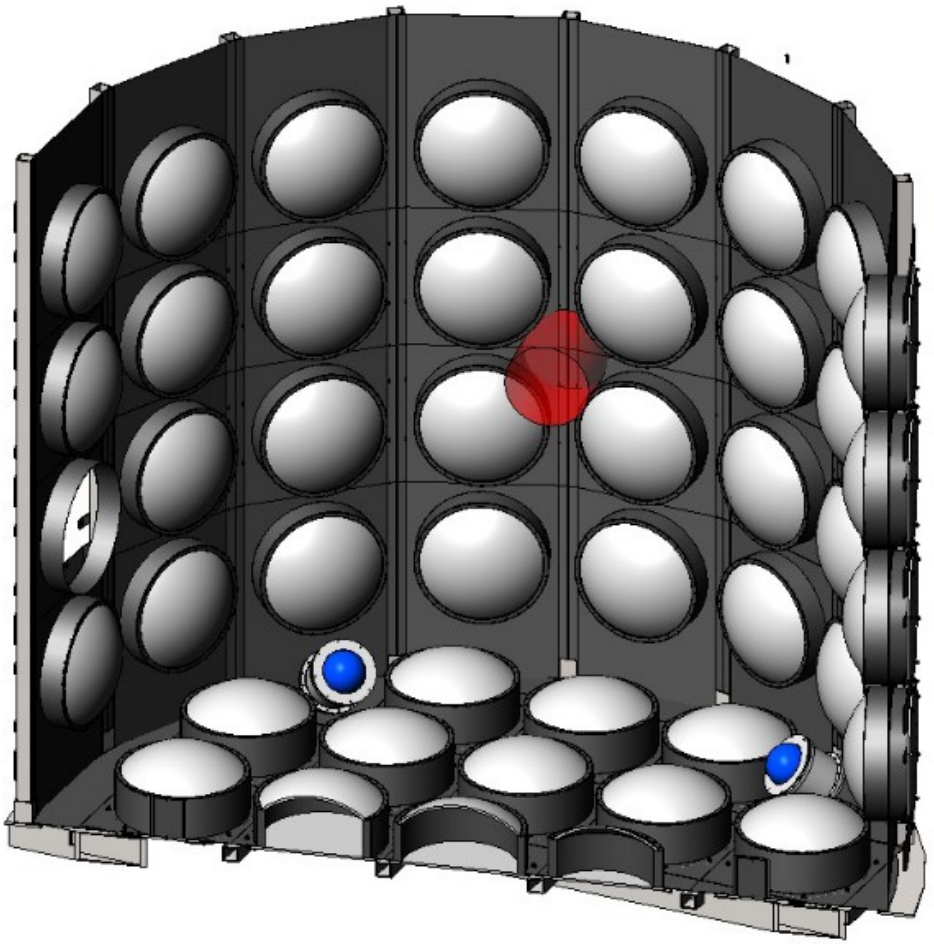
Other design features

Black sheets
Basic design and concept in place
Soak tests ongoing

Material: PTFE
Thickness: 2mm

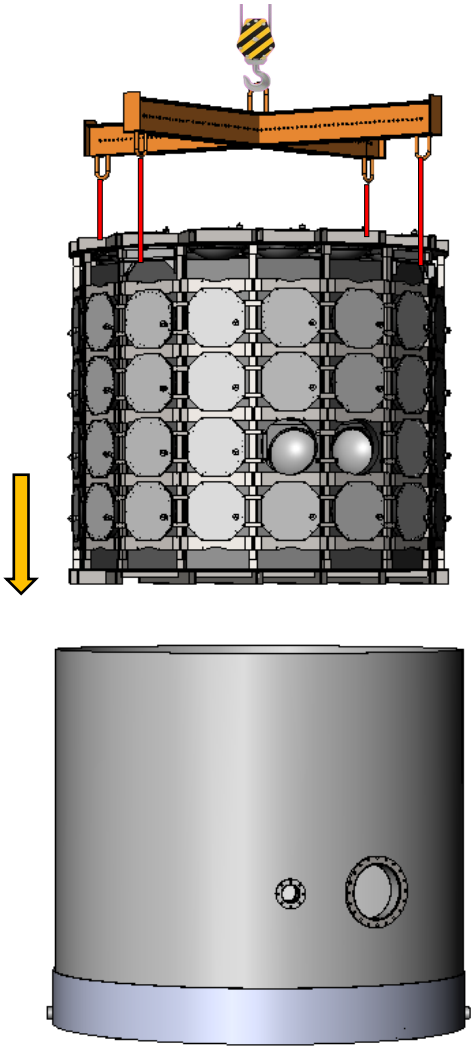




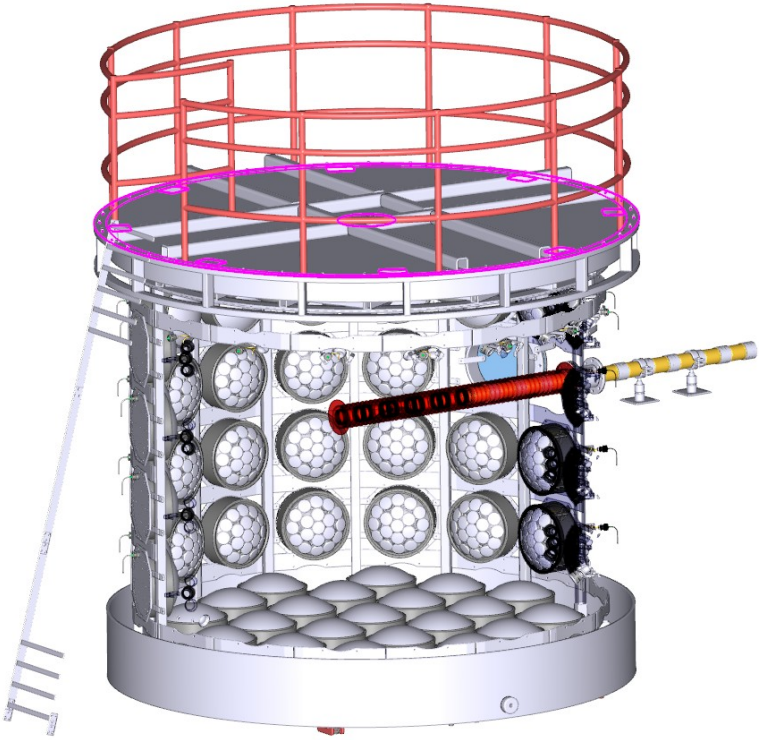


Remaining design items

Rails to insert the mPMT structure into the tank (ongoing)



Identify suitable hose for inserting tertiary beam into the tank



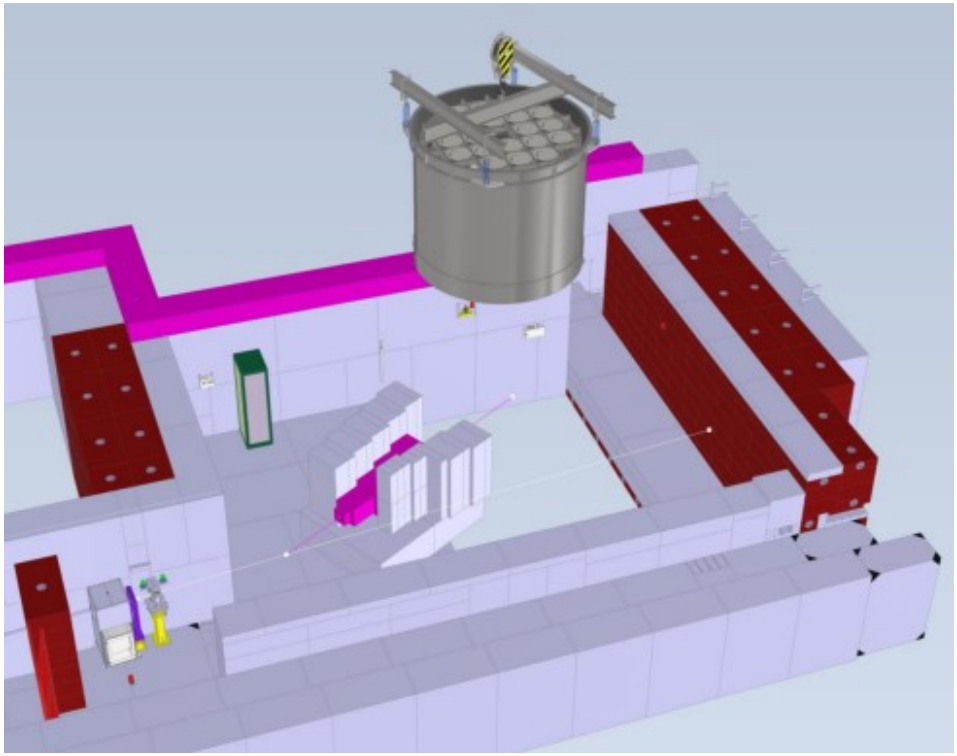
Handling and Assembly

Once all the components arrive to the assembly area by truck, they will be handled by a spreader beam operated by crane at the assembly facility

Trying to identify solutions for avoiding tilt of tank and structure when lifting

Therefore, the assembly are must have large entrance and crane access

Further, for assembly elevated platforms and/or scissor lifts will be needed



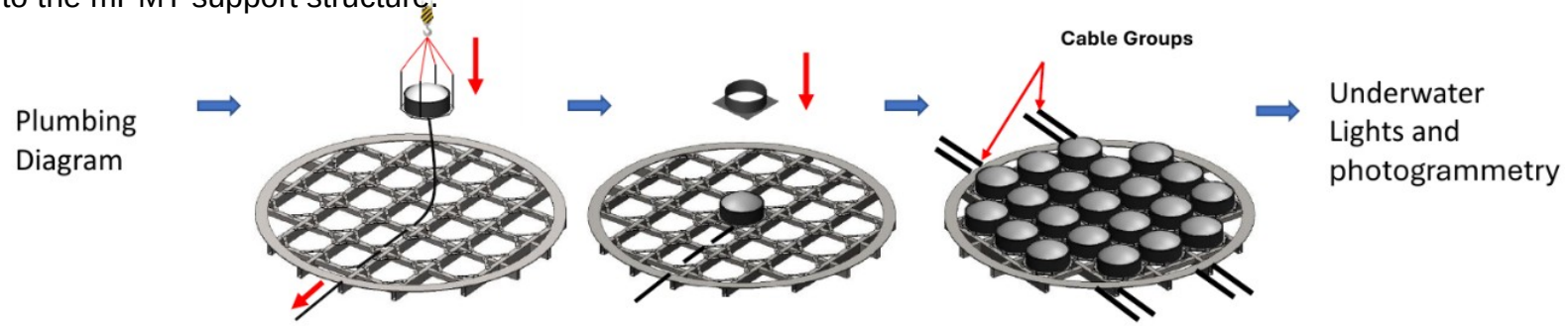
Assembly

1. Bottom End Cap of mPMT Support Structure

Instrument the bottom end cap of the mPMT support structure.

- Fix all the water pipes
- Place PMTs near its final position
- Pull the feedthrough cable from underneath the end cap
- Lower the PMT, place the blacksheet on it and fix both using bolts

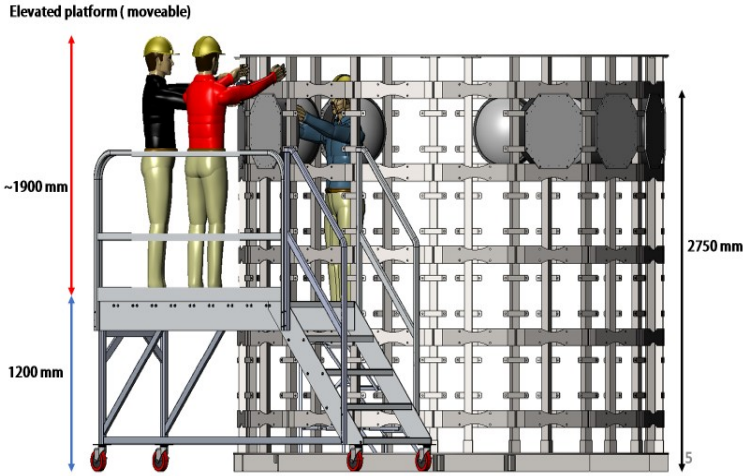
Once all mPMTs of a cable group are fixed, the cables will be tied and secured and the underwater cameras and lights will be attached to the mPMT support structure.



2. Barrel of mPMT Support Structure

Independently, instrument the barrel of the mPMT support structure.

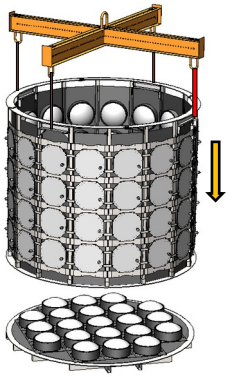
- Place and fix the mPMT at its place for the first two rows of the barrel
- Clip the cables temporarily
- Using an elevated platform or scissor lift, mount mPMTs on the top two rows
- Tie and secure the cables according to the layout



Assembly

3. Assembly of Bottom End Cap and Barrel of mPMT Support Structure

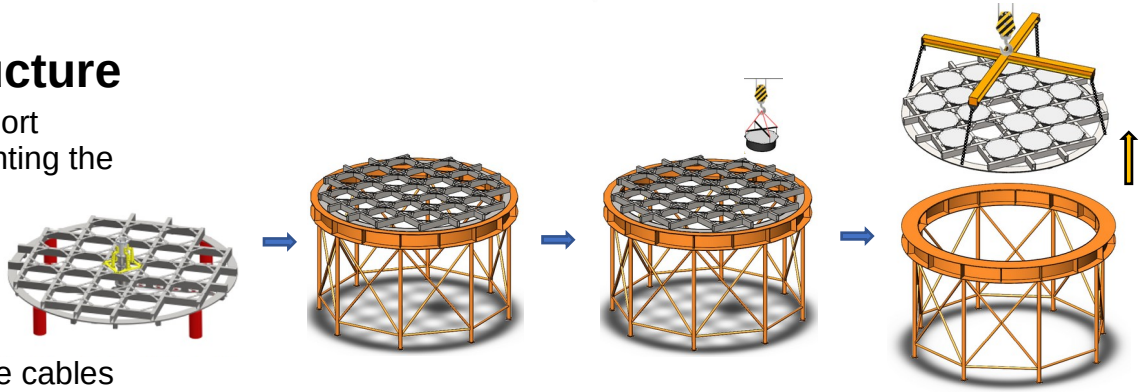
Lift and align the barrel of the mPMT support structure with the bottom end cap.
Lower and fix the barrel will be lowered and fixed to the bottom end cap using clamp fixtures.



4. Top End Cap of mPMT Support Structure

For the instrumentation of the top end cap of the mPMT support structure, this will be placed on an elevated platform for mounting the PMT and CDS.

- Place and assemble the CDS
- Lower and fix the PMTs in their place
- Mount the blacksheets and fix them to the PMTs



Once all mPMTs of a cable group are fixed, tie and secure the cables and attach the underwater cameras and lights to the structure.

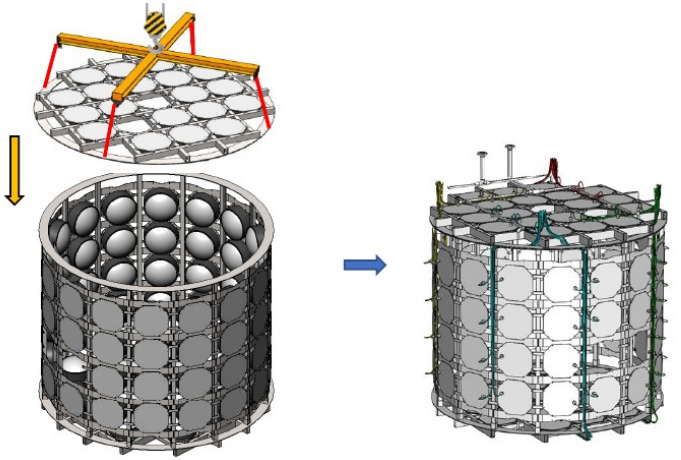
5. Assembly of Top End Cap and Barrel of mPMT support structure

Lift and align the top end cap of the mPMT support structure with the rest (bottom end cap and barrel) of the mPMT support structure.

Using an elevated platform or scissor lift to access the top end cap, join both rings using clamp fixtures.

Once all the structure is assembled, install the remaining water pipes.

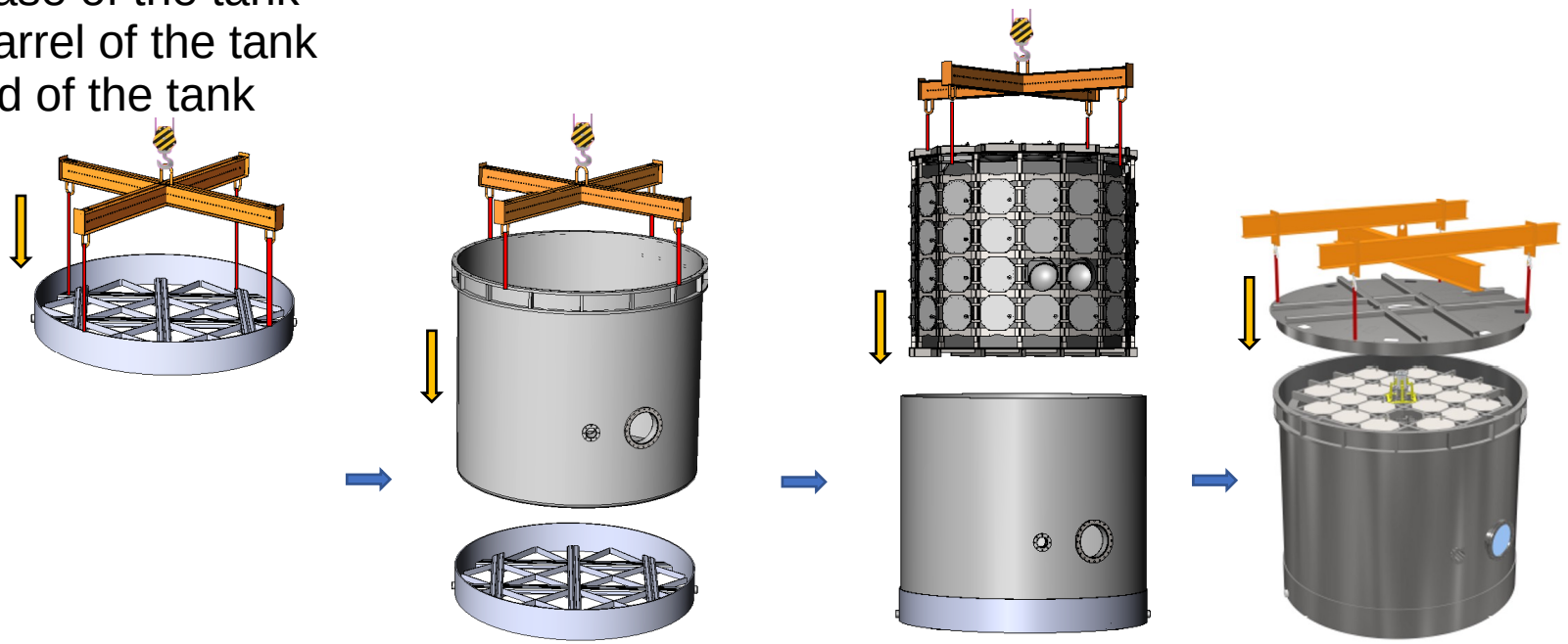
Tie the bottom end cap cables to the barrel column and secure all the cable groups on the top end cap



Transport to T9 area and final assembly

It is not safe to lift the tank with the mPMT structure inside

After the work is done in the assembly area we will need to transport to T9 and separately
- Fully instrumented mPMT support structure
- Base of the tank
- Barrel of the tank
- Lid of the tank



- Fix the base of the tank to the rails in the T9 area.
- Move the tank into the T9 area; align it correctly with respect to the base and place on it.
- Lift the structure assembly and place it inside the tank.
- Place the lid on the top of the tank.

Transport to T9 area and final assembly

It is not safe to lift the tank with the mPMT structure inside

After the work is done in the assembly area we will need to transport to T9 and separately
- Fully instrumented mPMT support structure
- Base of the tank
- Barrel of the tank
- Lid of the tank

Special care must be taken to transport the fully instrumented mPMT structure from the assembly are to T9

The safest way to transport these large pieces would be to load them into a truck with a crane and then unload them at the T9 area
Extra protection packaging may be needed for the transport of the instrumented mPMT structure
This depends on the distance between assembly and T9 halls

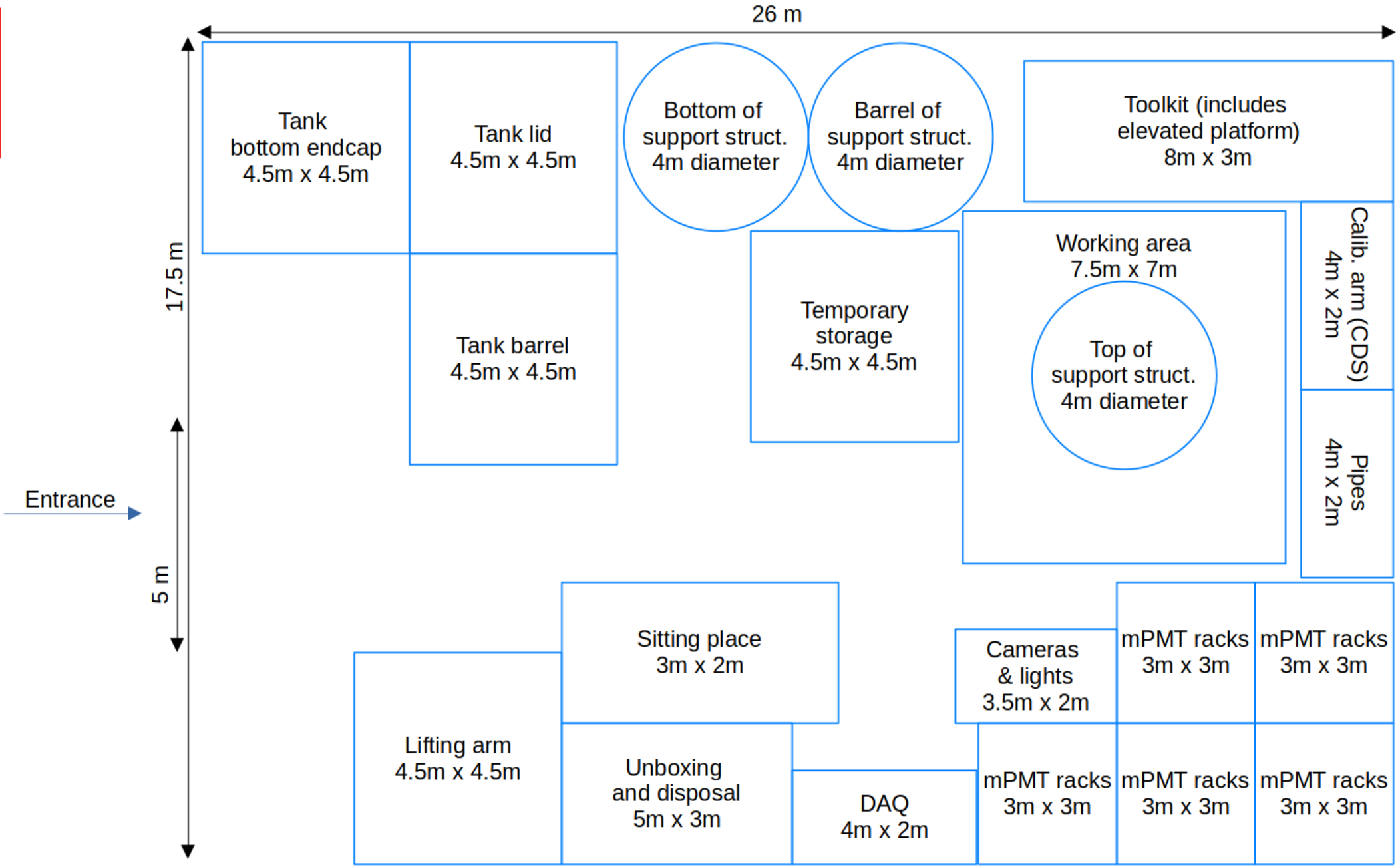
Additionally, since the base, lid and barrel of the tank will not be used in the assembly area, they could be stored elsewhere or even at T9 if sufficient space is available.
From that point we are flexible and we can do whichever is better in terms of space available and, ease and safety of handling.

Requirements for the Assembly Area *(space)*

The space required for the storage and assembly of all the WCTE components.

Note that the tank will be directly assembled in the T9 area and thus, only storage space would be needed for the tank in case there is no sufficient storage space for it at T9. Here, we assume the case where the tank has to be stored in the assembly hall.

- An area of 26 m x 17.5 m = 455 m^2 *(to be optimized depending on the available spaces)*
- Height of at least 10 m
- Access to crane with maximum load of at least 30 ton
- Entrance of at least 5 m wide and 6 m in height with access for truck to load and unload the detector components.


26 m
17.5 m
5 m
Entrance
Tank
bottom endcap
4.5m x 4.5m
Tank lid
4.5m x 4.5m
Tank barrel
4.5m x 4.5m
Bottom of
support struct.
4m diameter
Barrel of
support struct.
4m diameter
Toolkit (includes
elevated platform)
8m x 3m
Temporary
storage
4.5m x 4.5m
Working area
7.5m x 7m
Top of
support struct.
4m diameter
Calib. arm (CDS)
4m x 2m
Pipes
4m x 2m
Sitting place
3m x 2m
Lifting arm
4.5m x 4.5m
Unboxing
and disposal
5m x 3m
DAQ
4m x 2m
Cameras
& lights
3.5m x 2m
mPMT racks
3m x 3m
mPMT racks
3m x 3m
mPMT racks
3m x 3m
mPMT racks
3m x 3m
mPMT racks
3m x 3m

Timeline detail