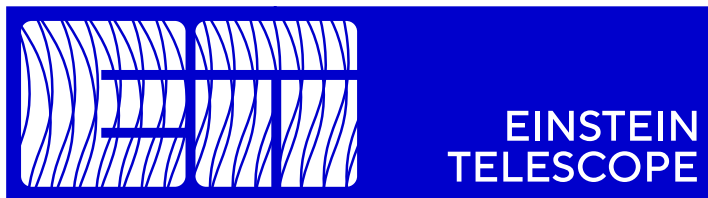


General Mechanical Structure Cryostat

Van Long Hoang

Elba, 29/09/2025

III Workshop on ET-LF TM Tower Integration



SAPIENZA
UNIVERSITÀ DI ROMA



Compulsory requirements:

- Horizontal division for installation and transportation purposes
- Radiation shielding
- Highly thermally conductive material for the shields
- **Cooling down of the shields**
- Clean air flow system on the Payload
- Safety issues

Numerical Constraints

Vacuum Chamber requirements:

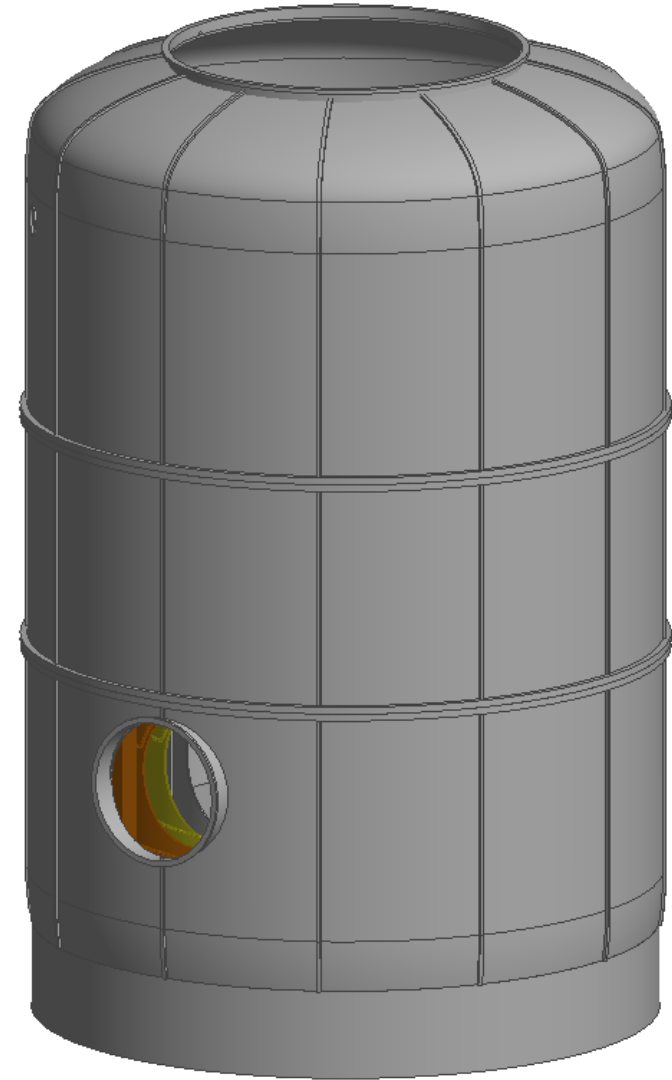
- Ext $\varnothing = 4.5$ m
- Height = 6.5 m

Payload requirements:

- $\varnothing$ bulk = 1 m
- Optical Axis Height = 2.5 m (wrt ground)

Clean room aperture below cryostat

- $\varnothing = 3$ m



Cryostat main components

Vacuum Chamber

Material

Stainless Steel

Dimensions

External Diameter ≈ 4.5 m

Height ≈ 6.5 m

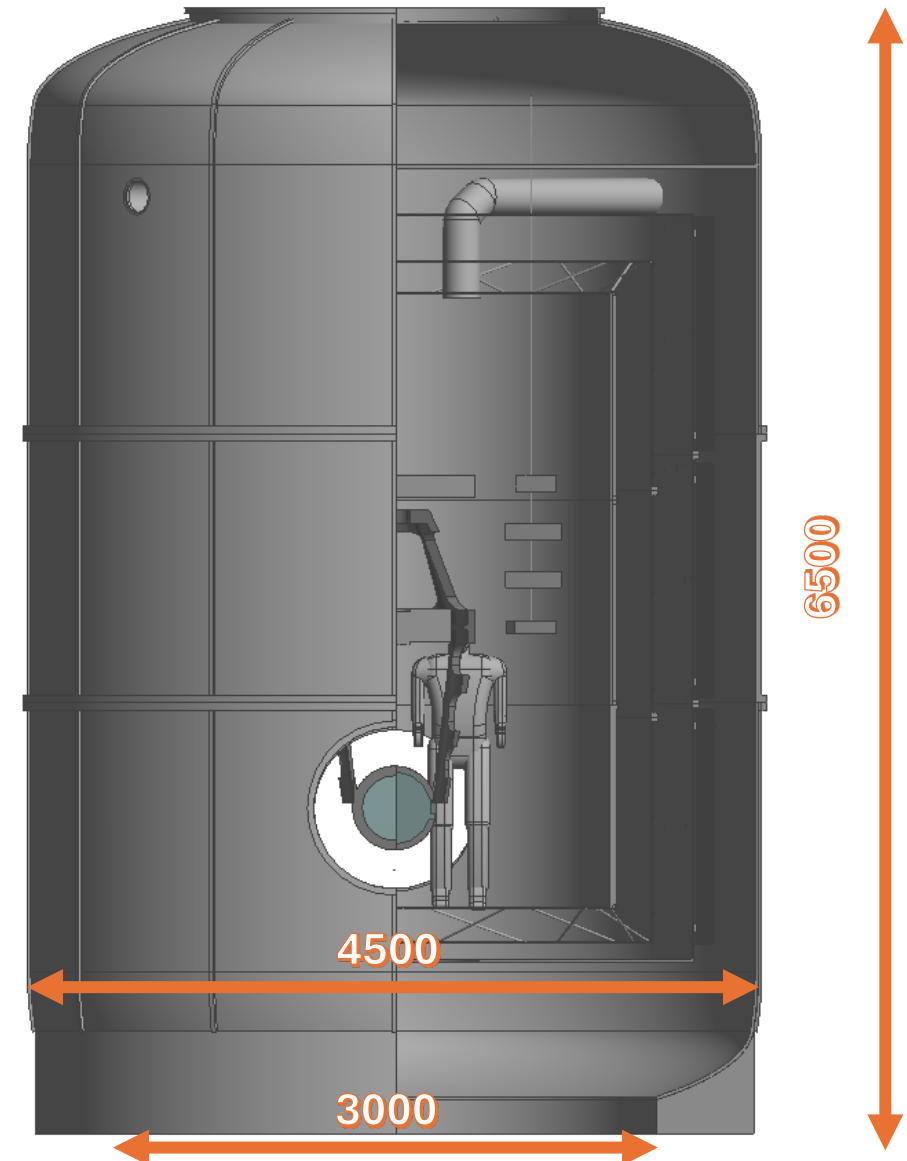
How many horizontal divisions?

Bottom Access

Diameter ≈ 3 m

Interface flange to be defined (ca. 1.6 m)

Vacuum Separation from upper warm tower, but vacuum is shared between all shields



Cryostat main components

Outer Thermal Shield - OTS

Material

High thermal conductive Aluminum (e.g. Al6063, 1000 series)

Dimensions

External Diameter ≈ 3.7 m

Height ≈ 4.5 m

Physical properties

How many horizontal divisions?

Stiffeners

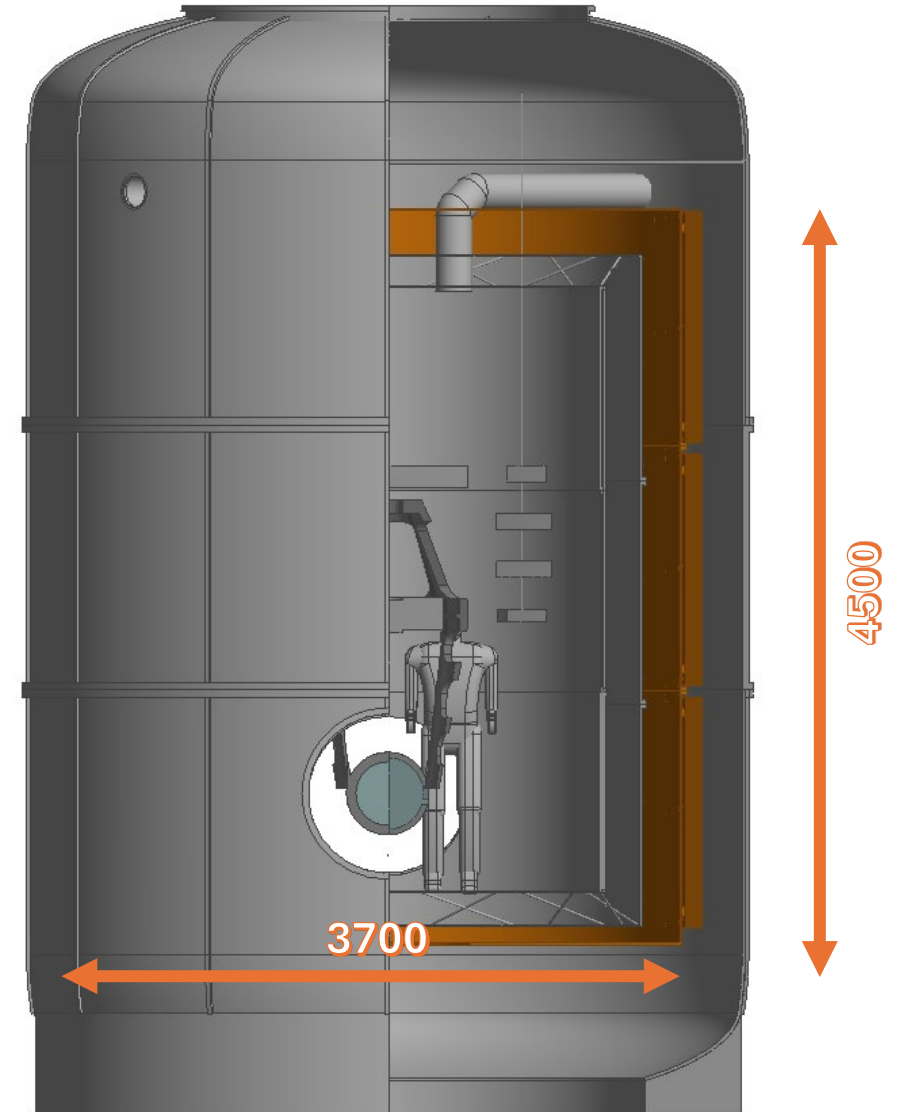
Arm Pipe

Bottom access

Target Temperature 80 K

Compulsory Radiation shielding

Helium Gas Exchange



Cryostat main components

Inner Thermal Shield - ITS

Material

High thermal conductive Aluminum (i.e. Al6063, 1000 series)

Dimensions

External Diameter ≈ 3.2 m

Height ≈ 4.2 m

Physical properties

How many horizontal divisions?

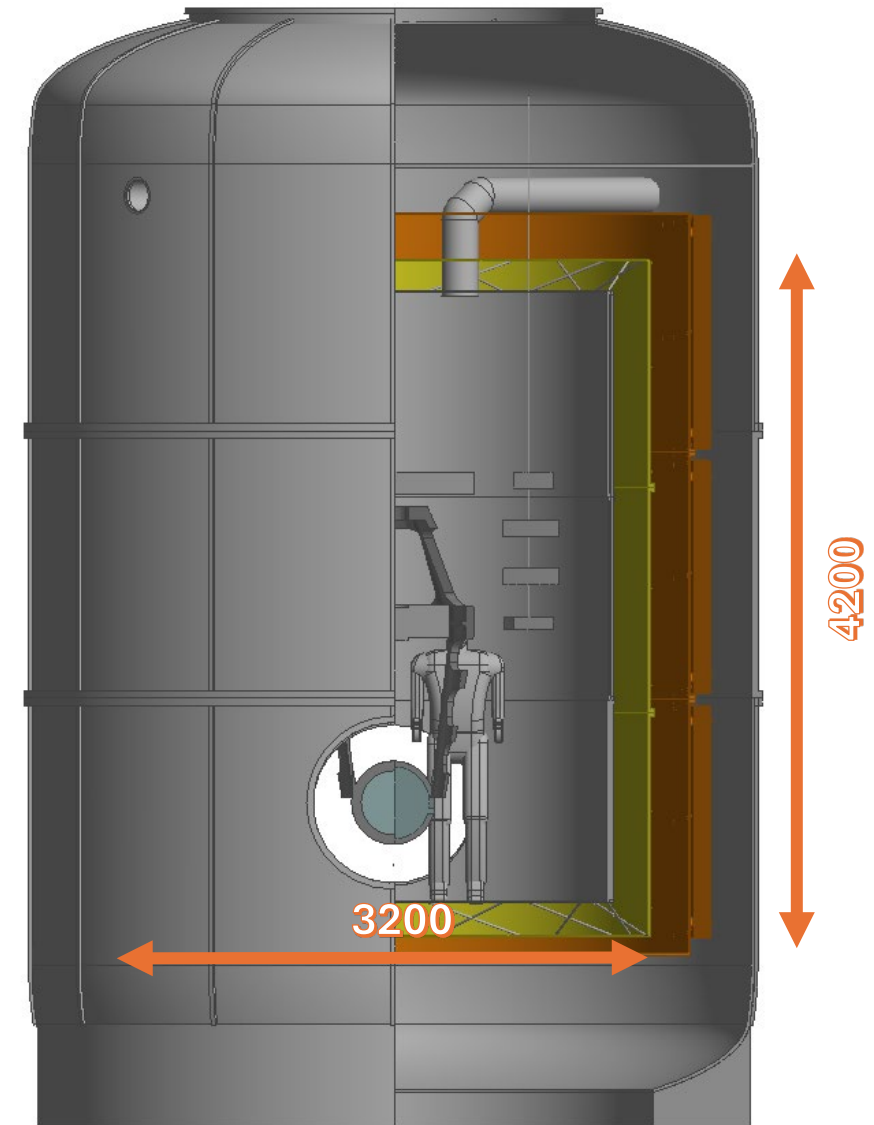
Stiffeners

Arm Pipe

Bottom access

Target Temperature 5 K

Helium Gas Exchange



Cryostat main components

Internal Inner Thermal Shield - IITS

Material

High thermal conductive Aluminum (i.e. Al6063, 1000 series)

Dimensions

External Diameter ≈ 2.7 m

Height ≈ 3.8 m

Physical properties

How many hor. Divisions?

Stiffeners

Arm Pipe

Bottom access

Target Temperature 2 K

Helium II

Payload and Beam Axis

>850 mm workspace around

Height from ground

2.5 m (Locally)

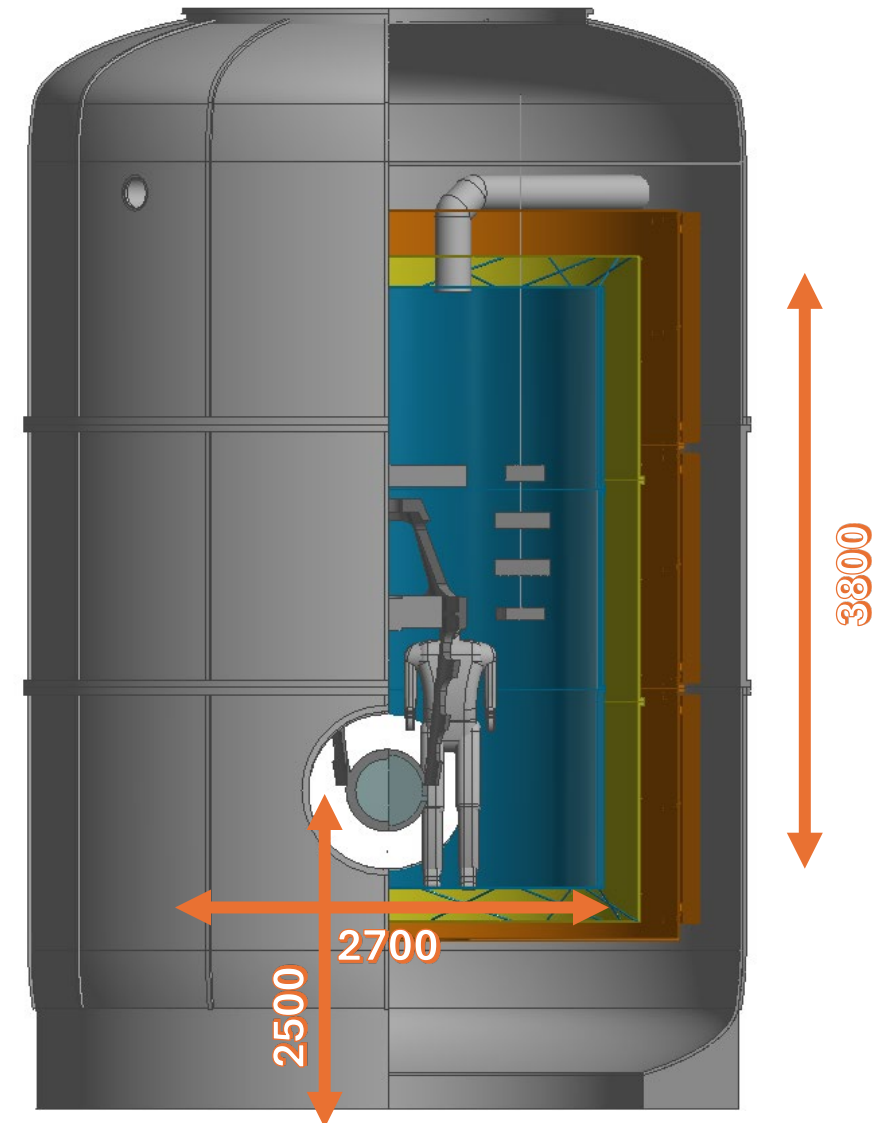
1.3 m in general

Height from IITS base ? TBD

Last iteration from 2nd ET-ISB

Workshop on ET-LF TM Tower

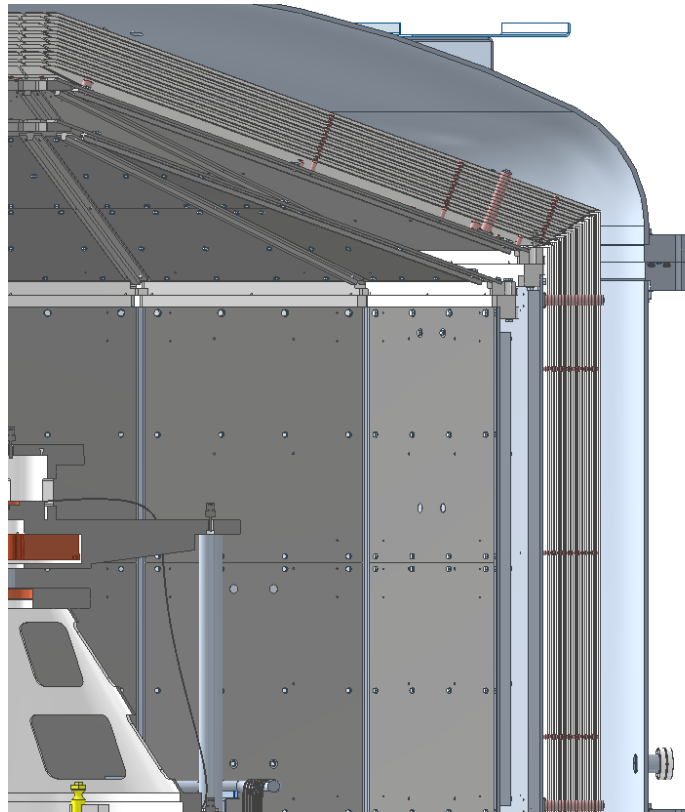
Integration ET-0094A-25



OTS faces VC at room temperature, so a radiation shield must be considered

MLI (Multi Layer Insulation) blankets proved to release particles (KAGRA), resulting in frosting on optical windows.

New proposed radiation shielding by ARC-ETCRYO in Rome : RML (Rigid Multi Layer)



C75 in ARC-ETCRYO Rome

RML - Rigid Multi Layer

To be implemented in ARC

Thin (up to 0.3 mm of Aluminum) layers kept in place by a non-conductive system

Easier to be applied on Polygonal surface

Takes into account tie-rods

To consider thermal input through various holes

In case of layered thermal shields (this proposal will be explained in next slides), RML on bottom surface must be designed

Shape

Circular or Polygonal

Number of horizontal Divisions

2 or more

Stiffeners

On VC-OTS-ITS-IITS

Material

Al6063 (ARC-ETCRYO)

Cabling Management

Electrical wires

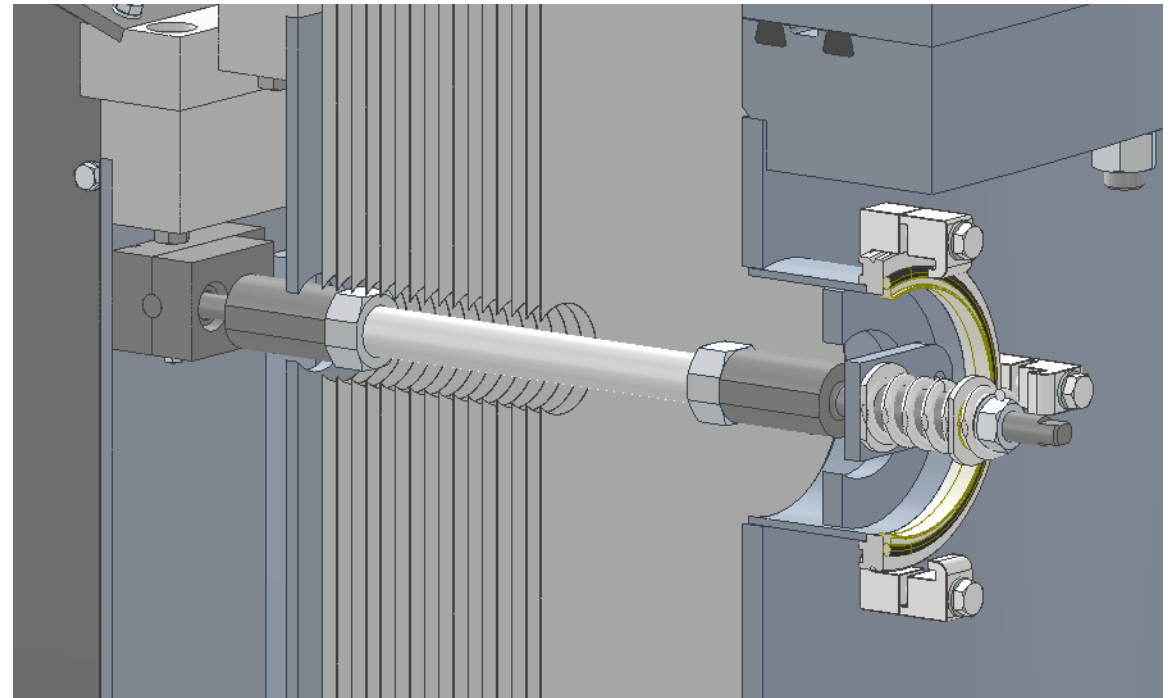
Hole Management

Cables – suspension wires

Tie Rods

Anchor thermal shields to VC, for stabilization and modes control

Material: G10 + stainless steel



Tie Rods in ARC

Thermal shields supports must be chosen taking into account: operability inside IITS, thermal inputs, modal analysis.

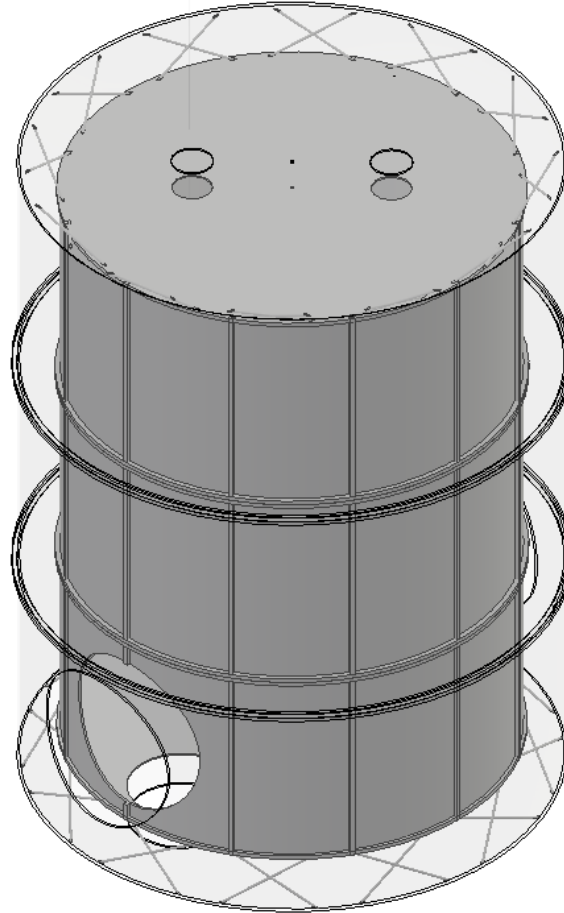
Beam Supported

Presented by Iaquaniello
ET-0055B-24

Top and bottom rods for
all thermal shields

Easy implementation for
RML

Material and sizing to be
defined

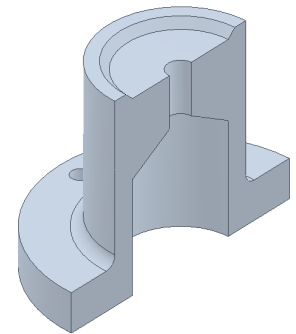
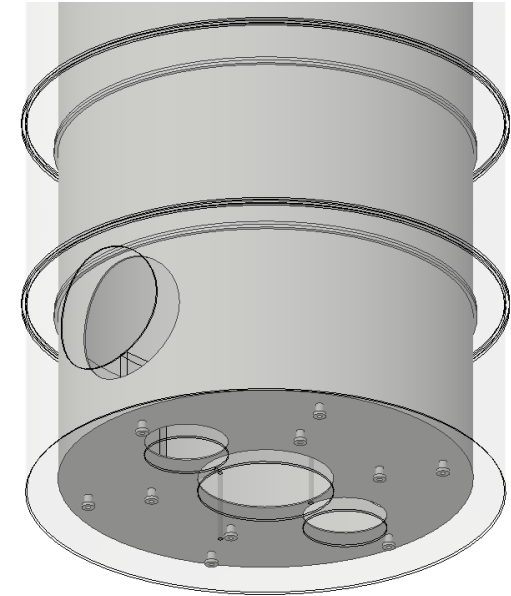


Layed

Will be used in C75

Must be take into account:

- Thermal input
→ insulating material
 - Weight loads
 - Bottom radiation shielding
 - Hard implementation of RML
-
- Material and sizing to be defined



Example of support in ARC

To consider different phases of helium between OTS, ITS and IITS due to different target temperatures → different cooling architectures.

Since thermal shields are divided in horizontal sections, continuity between helium channels must be guaranteed (i.e. indium flanges)

Proposal: Intrinsic in structure

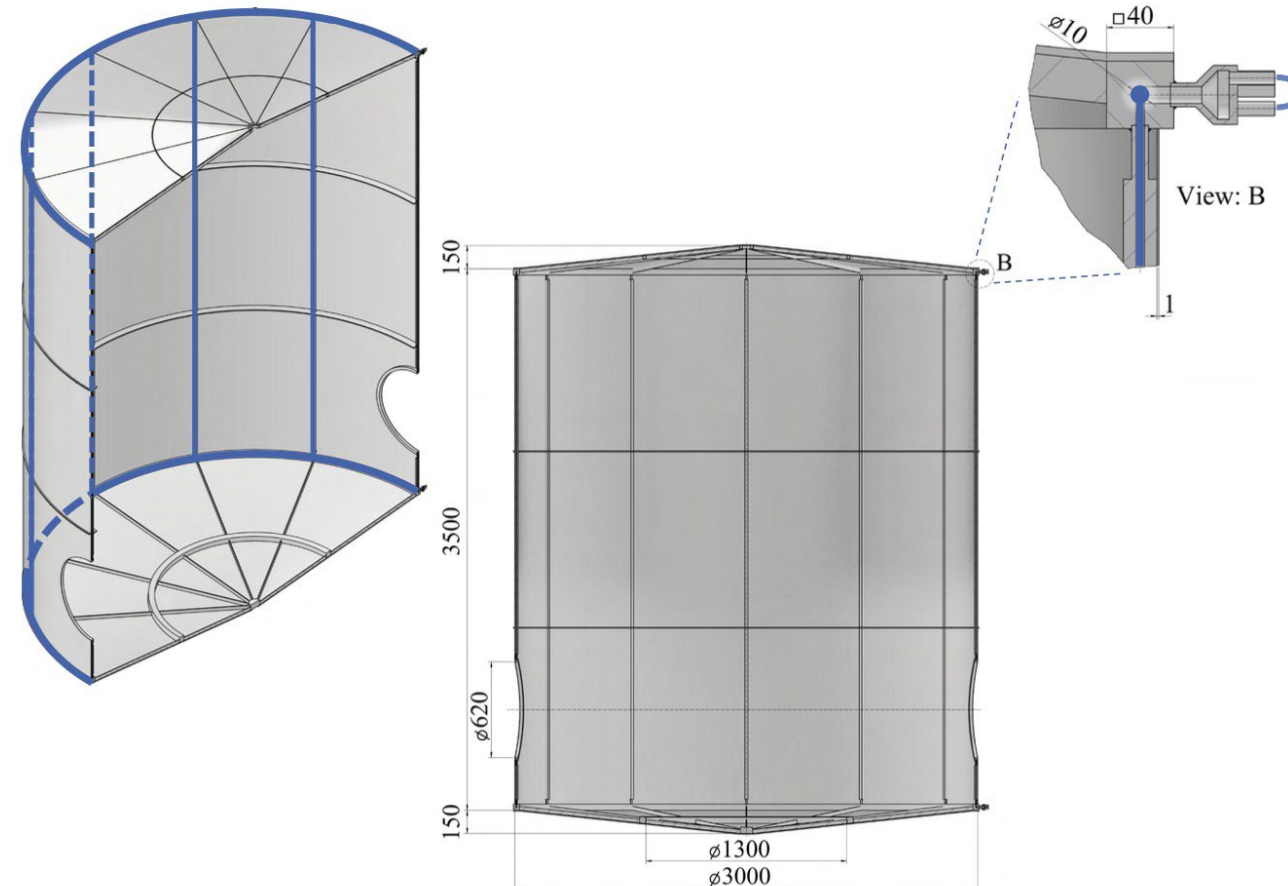
Aluminum structure with hollow profile, already simulated

To be defined:

- Number of vertical paths
 - Vertical paths is good for Newtonian noise
 - Multiple vertical path means multiple passages on horizontal sections

EXAMPLE

On the right as presented by L Busch, G Iaquaniello, P Rosier, M Stamm and S Grohmann ET 0297A -23



Clean air vents

Clean air flow must be operative inside IITS prevent dirt/particles to deposit on the mirror. Direction and flow must be defined. During opening of VC, there must be slight overpressure.

Flow of clean air from above, in a vertical or angular manner (to be analyzed)

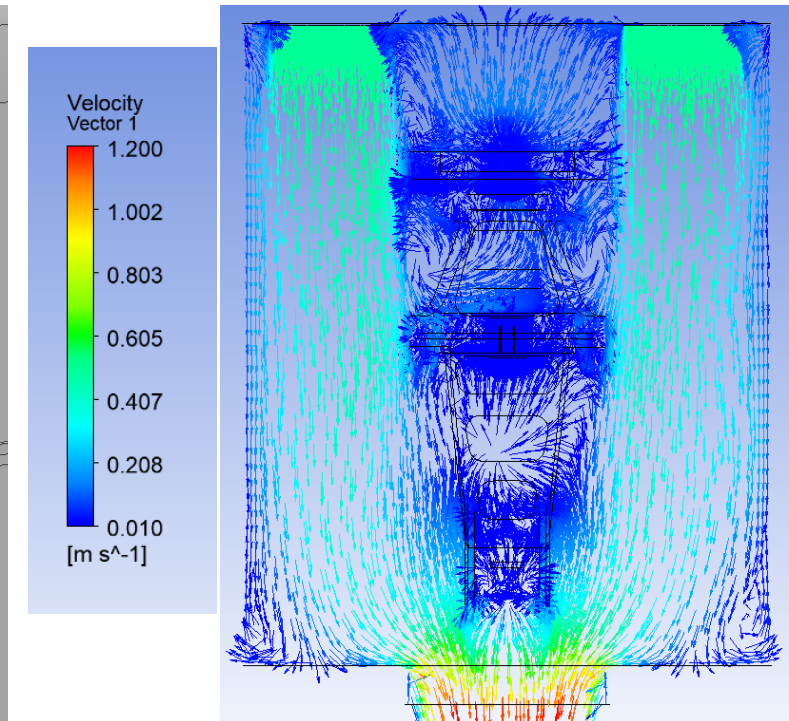
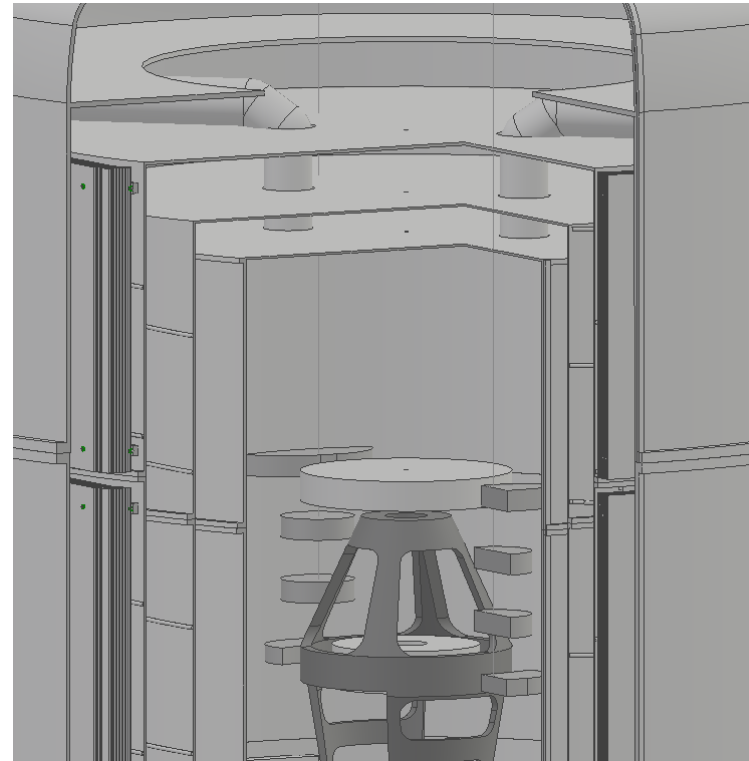
Whole payload is impinged by the clean air

Clean air exits from the payload hole on the bottom or from other air vents.

Air must not be trapped between main thermal shields, so exhaust holes might be necessary.

To consider variety and abundance of metal parts encountered by the flow

To consider wise design of pipe in between the shields



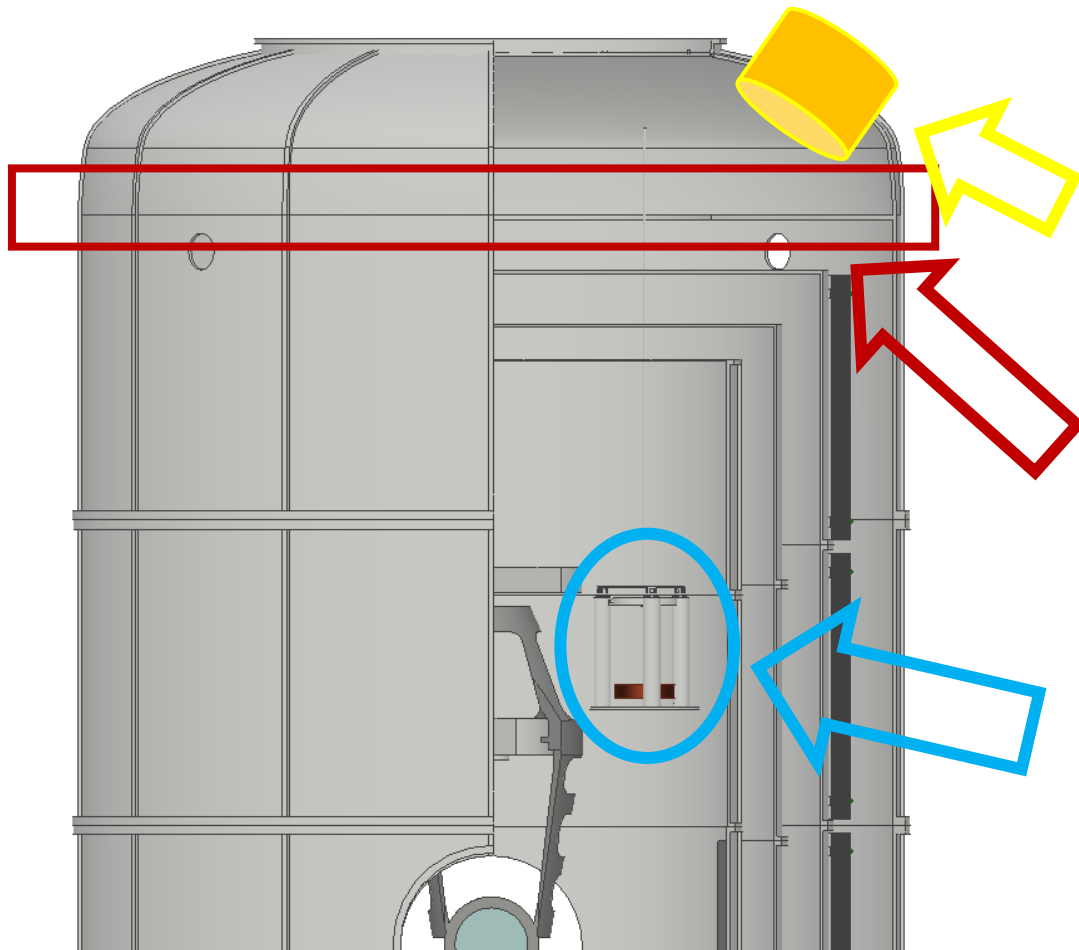
Courtesy of Marco Orsini

The requirements standard ISO 4 are at least:

- 150 ACH
- 0.45 m/s (average) (range: $0.3 \text{ m/s} \leq v \leq 0.56 \text{ m/s}$)

Room Temperature Roof

Solid plane, at room temperature and fixed to the VC, on which various elements, that must reach the payload, are fixed to



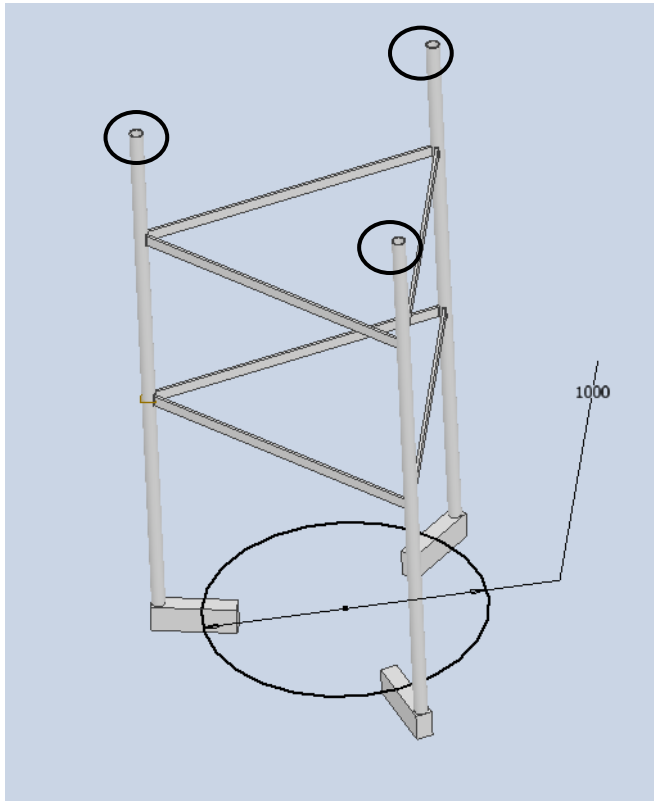
Dimensions and position to be defined

Handling aperture flanges on the dome

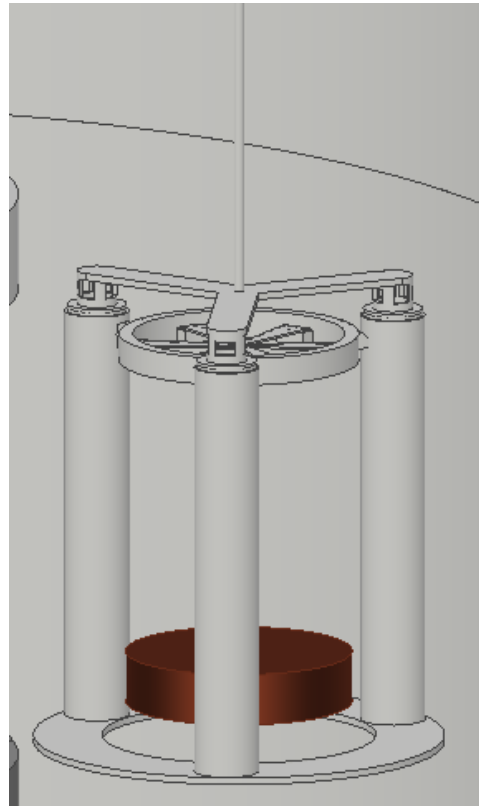
Anti-failure system and mounting system for the payload can be mounted on the separating roof

HLVIS Heat links Vibration Isolation System can also be mounted here

Solid plane, at room temperature and fixed to the VC, on which various elements, that must reach the payload, are fixed to



Just a first concept
Structural TBD



CuBe blades can be
used here TBD

- An antifailure system for payload suspension is needed

It can be integrated in the mounting system, but this choice impacts on the structural stiffness required to all the thermal shields and finally also constraining the thermal behaviour.

--> We are developing the concept of a structure hanging from the RTR

- KAGRA developed a HLVIS (Heat Link Vibration Isolation System) to reduce the impact of thermal shields modes (ca. 12-16 Hz). In our case we need to also cut the LF seismic background.

--> We are developing a compact LF attenuation system (already mentioned in the PBS)

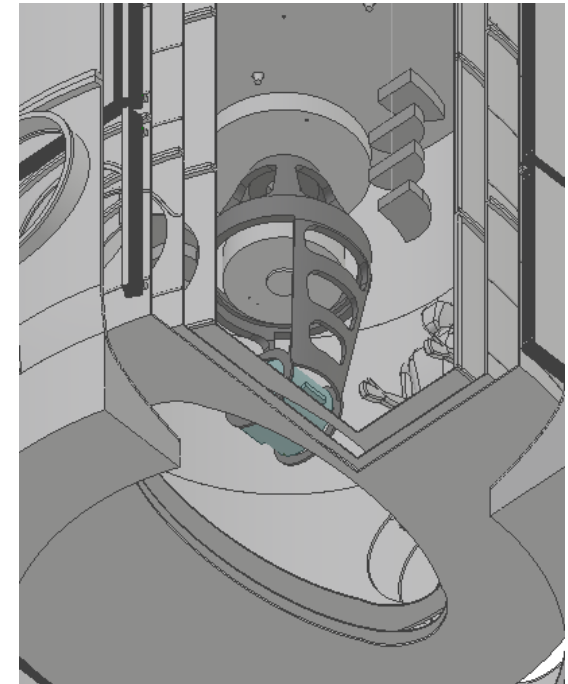
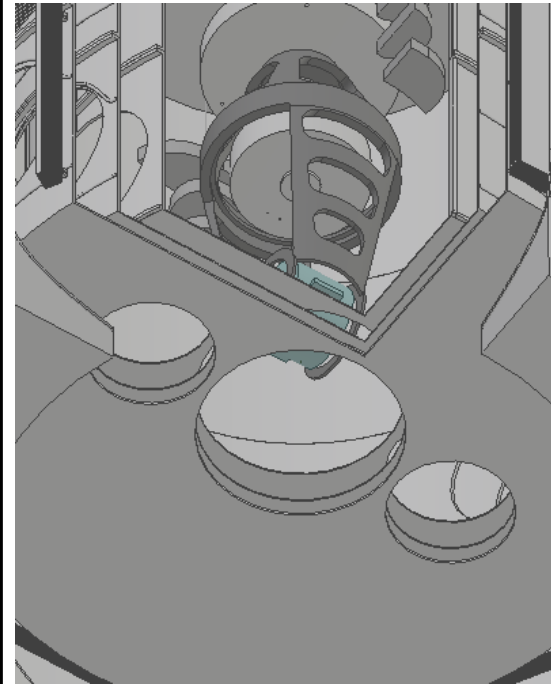
In case of emergency, one must be able to pull the body out (lost of consciousness) from the IITS. Usual man footprint is 60 cm. What about unconscious man?

Proposals

- Manholes (collateral to Payload entrance hole)
- Only one elliptical payload hole (with auxiliary walkable floor sections)

During interferometer operation, holes must be closed. During maintenance/assembly safety must be ensured (no falling), but one's unconscious body has to be able to pass through.

Can you add a platform on top of the holes?



More on next presentation by Philipp Rosier

- Main numerical requirements are set (cryostat diameter, optical axis height wrt ground)

There are many open topics to be discussed:

- Number of horizontal division of the cryostat and the shields;
 - Balance between ease of transportation and ease of installation;
- Radiation shielding is necessary.
 - RML solution will be studied in ARC-ETCRYO;
- Clean air system inside the cryostat must be designed.
 - Air vents from the top seems the best solution
- Shields supports
 - Shields must support the payload weight + operators
- Shields cooling
 - Cooling must take into account vibration and noises
- Room Temperature Roof
- Safety issues