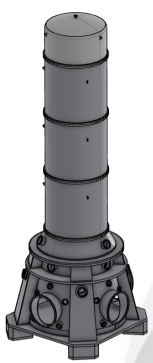
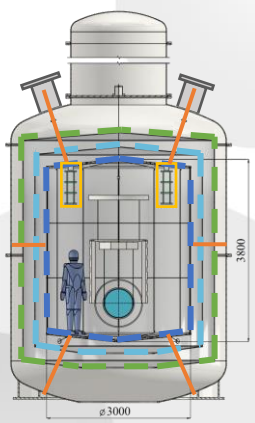
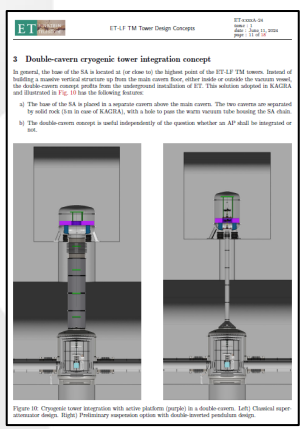
ET-ISB Fall Workshop on ET-LF TM Tower Integration Concepts

Status of cryogenic tower integration

IJCLab's Statement on ET






ET-LF TM Tower Design Concepts

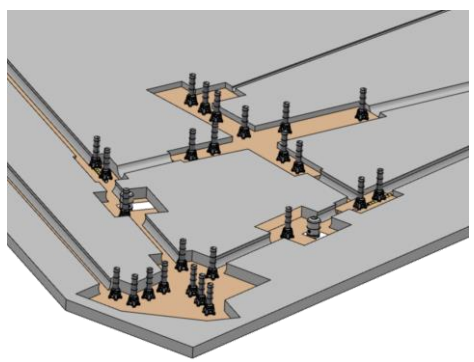
3 Double-cavern cryogenic tower integration concept

In general, the base of the SA is located at (or close to) the highest point of the ET-LF TM towers. Instead of building a massive vertical structure up from the main cavern floor, either inside or outside the vacuum vessel, the double-cavern concept profits from the underground installation of ET. This solution adopted in KAGRA and illustrated in Fig. 10 has the following features:

a) The base of the SA is placed in a separate cavern above the main cavern. The two caverns are separated by solid rock (3 m in case of KAGRA), with a hole to pass the warm vacuum tube housing the SA chain.

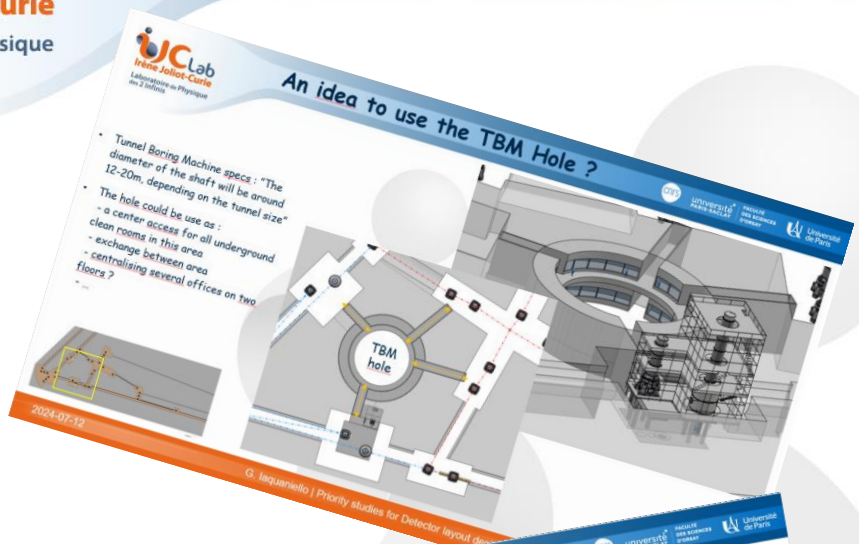
b) The double-cavern concept is useful independently of the question whether an AP shall be integrated or not.

Figure 10: Cryogenic tower integration with active platform (purple) in a double-cavern. Left: Classical superattenuator design. Right: Preliminary suspension option with double-inverted pendulum design.



Nov. '22 — Apr. '23 — Nov. '23 — Jan. '24 — Mar. '24 — Oct. '24

Detector Layout



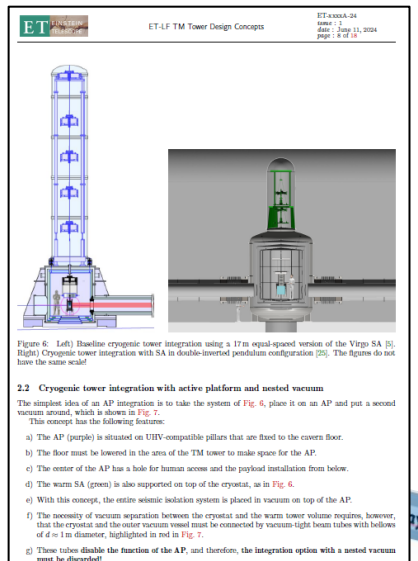

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Figure 6: Left) Baseline cryogenic tower integration using a 17 m equal-spaced version of the Virgo SA [5]. Right) Cryogenic tower integration with SA in double-inverted pendulum configuration [25]. The figures do not have the same scale!

2.2 Cryogenic tower integration with active platform and nested vacuum

The simplest idea of an AP integration is to take the system of Fig. 6, place it on an AP and put a second vacuum around, which is shown in Fig. 7.
This concept has the following features:

a) The AP (purple) is situated on UHV-compatible pillars that are fixed to the cavern floor.

b) The floor must be lowered in the area of the TM tower to make space for the AP.

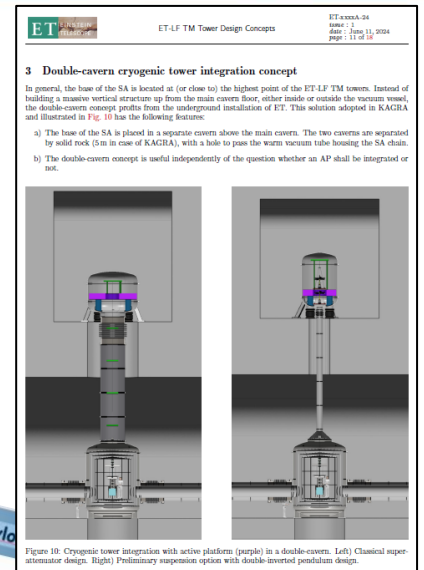
c) The center of the AP has a hole for human access and the payload installation from below.

d) The warm SA (green) is also supported on top of the cryostat, as in Fig. 6.

e) With this concept, the entire seismic isolation system is placed in vacuum on top of the AP.

f) The necessity of vacuum separation between the cryostat and the warm tower volume requires, however, that the cryostat and the outer vacuum vessel must be connected by vacuum-tight beam tubes with bellows of $d \approx 1$ m diameter, highlighted in red in Fig. 7.

g) These tubes **disable the function of the AP**, and therefore, **the integration option with a nested vacuum must be discarded!**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3 Double-cavern cryogenic tower integration concept

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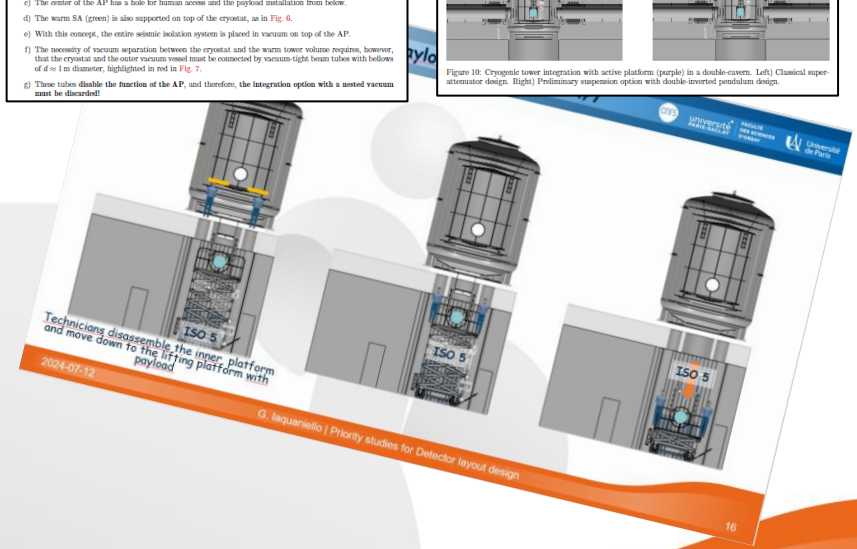
b) The double-cavern concept is useful independently of the question whether an AP shall be integrated or not.

Figure 10: Cryogenic tower integration with active platform (purple) in a double-cavern. Left) Classical super-attenuator design. Right) Preliminary suspension option with double-inverted pendulum design.

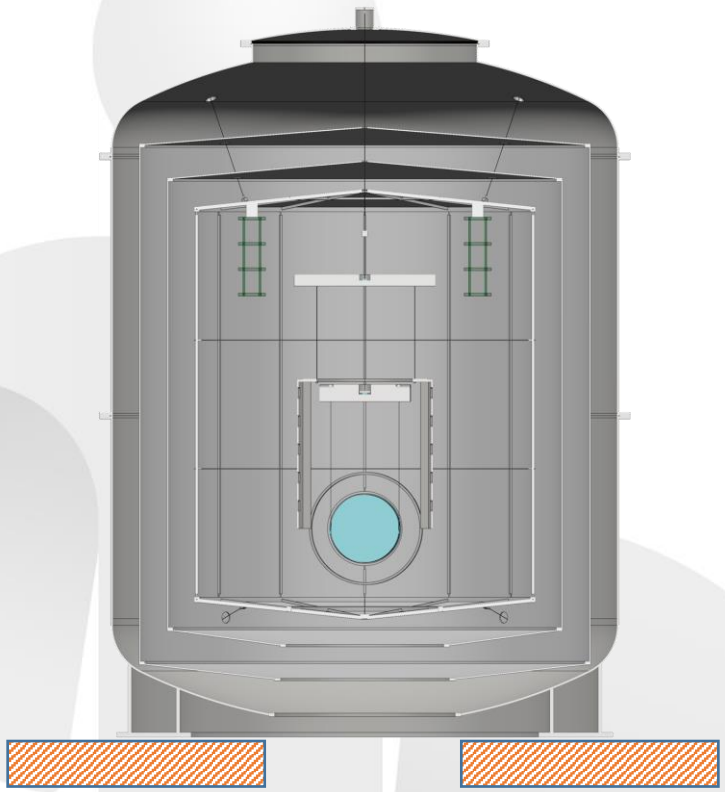


Chamber

Welding standard

Vacuum standard

Buckling Coeffiscient



Height

Dimensions

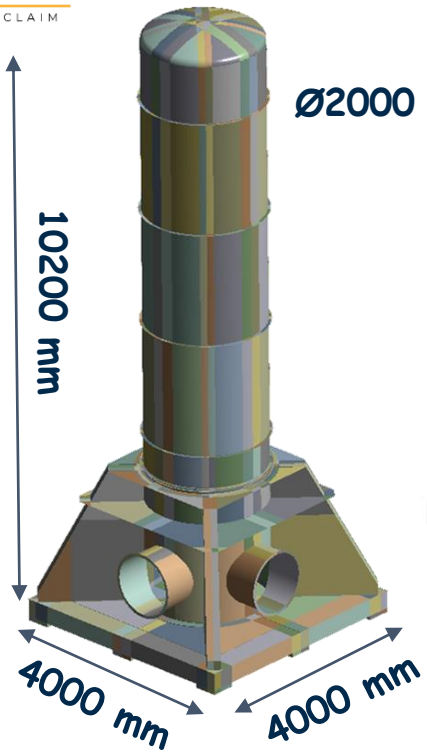
Weight

Access

Towers

VIRGO's tower

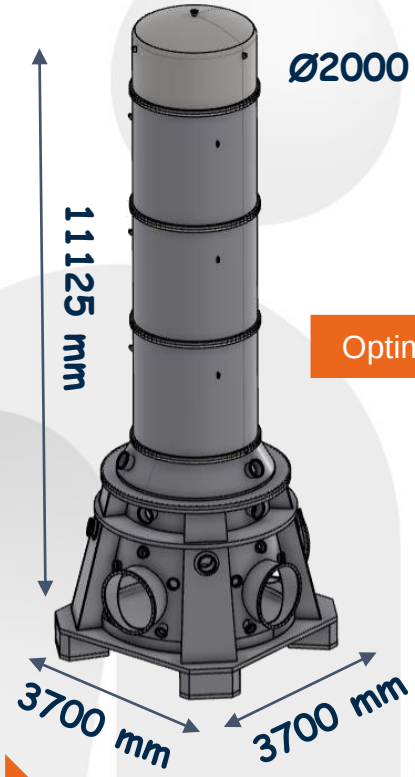
Ansys SPACECLAIM



1st Mode: 20,8 Hz
Mass: 20,9 T

Decrease frequencies

Einstein Telescope's tower (E.G.O.)

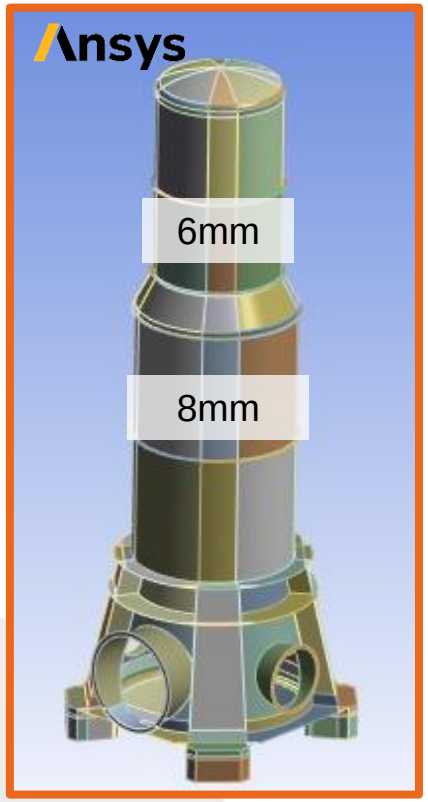


1st Mode: 17,3 Hz
Mass: 24,2 T

Optimisation ET

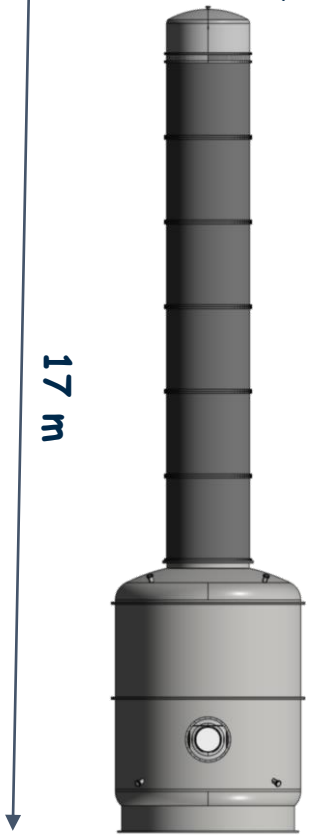
Increasing frequencies

Optimisation



1st Mode: 25,6 Hz / +8,3Hz
Mass: 23,4 T / -0,8T

Conservative Cryostat



1st Mode: ? Hz
Mass: ~40 T

Chamber

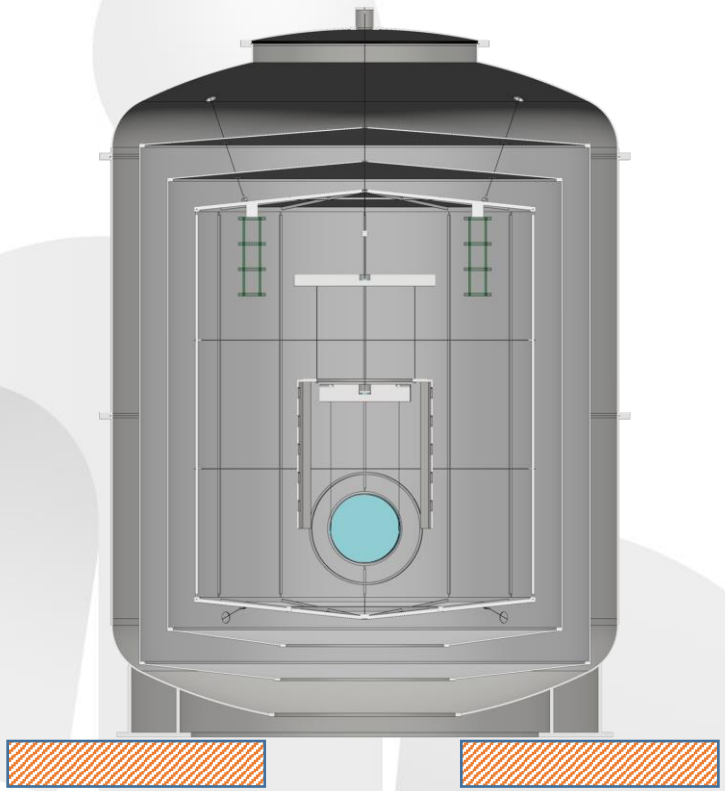
- **Base Height** already define in overleaf document : 6m
- Upper tube's height define betweeb 12 < l < 17m => but we need to simulate it if it's feasible
- Footprint's **dimensions**' too : 5x5m squared
- Maximum towers' **weight** need to be define with civil engineering according **stability** requirements
- **Access** to the tower for payload maintenance would be from the **bottom** until we are able to find a viable solution for lateral access
- To reach a **vacuum** of 10^{-10} mbar we need to adopt Ultra High Vacuum standard (Helicoflex, Copper joint, …)
- We are an international collaboration : which standard we are using for simulation ?
  For example, according to the french CODAP (Construction code for unfiredpressure vessels) the charge multiplier for linear **buckling** need to be more than 3
- Which **welding** standard to be imposed on manufacturers

Internal interfaces

Thermal Shields

Cryo pipe

Heat Link



Active Noise Mitigation

Mirror suspension

Temporary Platform

Internal interfaces

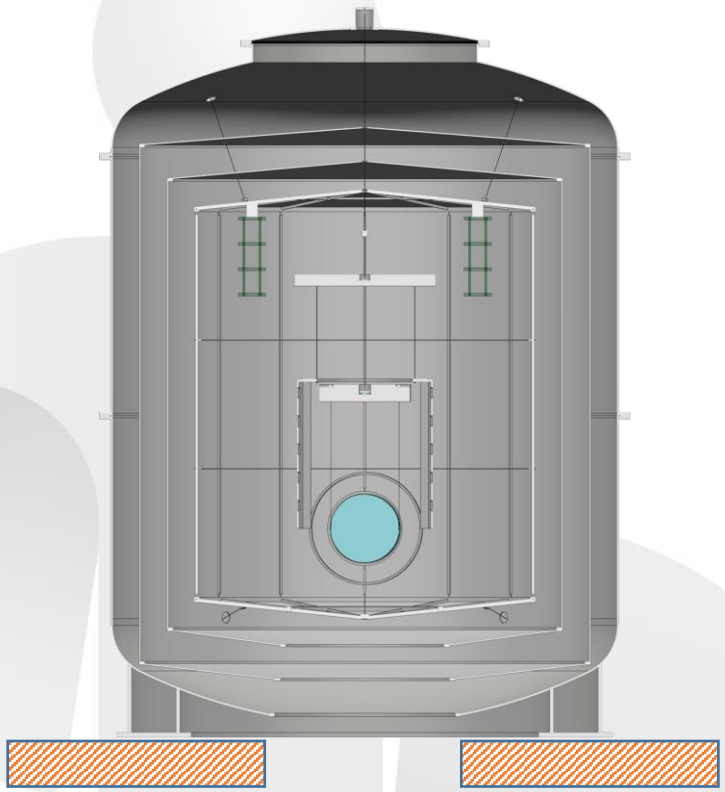
- **Thermal shields** need to be support with a support structure and damped with a solution to design
- Need to define **cryo** pipe into the chamber (how many ? Diameter ? I/O position ? …)
- Same work for **heat link**
- Waiting to know if there'll be an **Active Noise Mitigation** in or out the chamber which may change drastically the chamber shape and/or dimensions
- Following the choice of the cavern, single or double, we are waiting to know which solution will be chose for mirror suspension to define interaction with the chamber : inverted pendulum, super attenuator, …

Vacuum

Tube

Outgassing

Viewports



Pumping

Valve

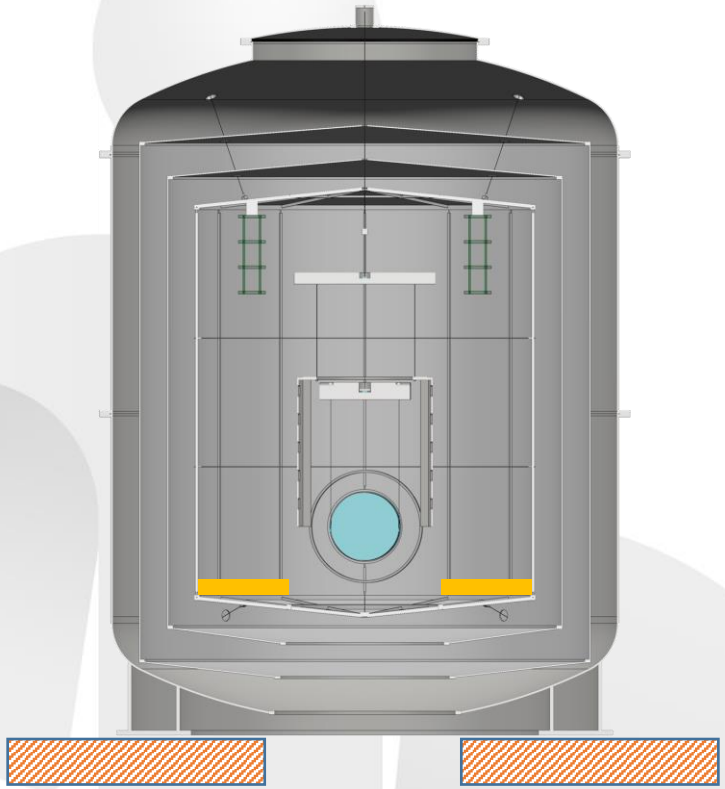
Baffle

Vacuum

Vacuum

- **Tube**'s diameter is already chose : Ø1000 mm
- We need a study on **outgassing** to determine how long would it be and if it's possible underground ?
- How many pump needed to reach 10^{-11} mbar ?
- How many **viewports** needed on each tower ? Diameters and positions of them ?
  Especially on the cryostat, each viewport means modifications on each thermal shields so we need to define its quickly.
  Each additional viewport, especially if it is facing the frame of one of the heat shields, will result in new structural simulations
- Positions and number of **valve** we will need across interferometers arms for budget definition : there are very expensive, especially for XHV so these is a significant cost for the budget
- Baffles positions and size of it to work on space need for maintenance process into the inner shield

Payload maintenance



Dust

Access

Maintenance operator

Platform

Installation

Payload maintenance

- To prevent dust during maintenance, we will use internal **laminar flow**

  We had a presentation on laminar flow study during the maintenance of payload, in May, by Perugia's team : need more information on implementation of laminar flow ceiling system into the chamber

- We need to define how many **technicians** will be involved into maintenance, and how to define access ?

  Some people in the collaboration talked about robot to do the job in the future ?

- If the **maintenance operator** will be human, we need to design a temporary platform to build on each payload maintenance operation into the inner shield

- We need to think on the **installation's** process on how to remove and to put back the mirror

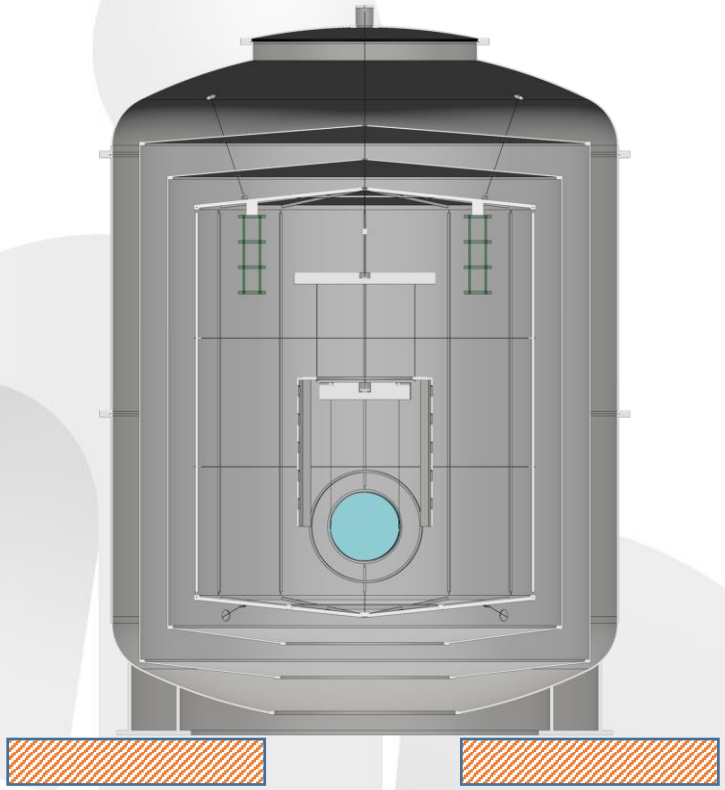
Chamber's manutention

Scaffolding

Transport

Lifting tools

Translation tools



Technicians

Personal Protection

Installation

Position

Chamber's manutention

- Determine the **transportation** process to impose to manufacturers
- Think about the path from the surface to the installation at its final destination
- The **position** is already define in the overleaf document : $-0.5m \leq \Delta x \leq 0.5m$
- Think about precise **alignment** process' of an object larger than 30T
- If needed during instrument's life, we need to think on how to move / align it with scaffolding ?
- Work with civil engineers to define the **transport / translation tools** along the arms, to install each heavy components

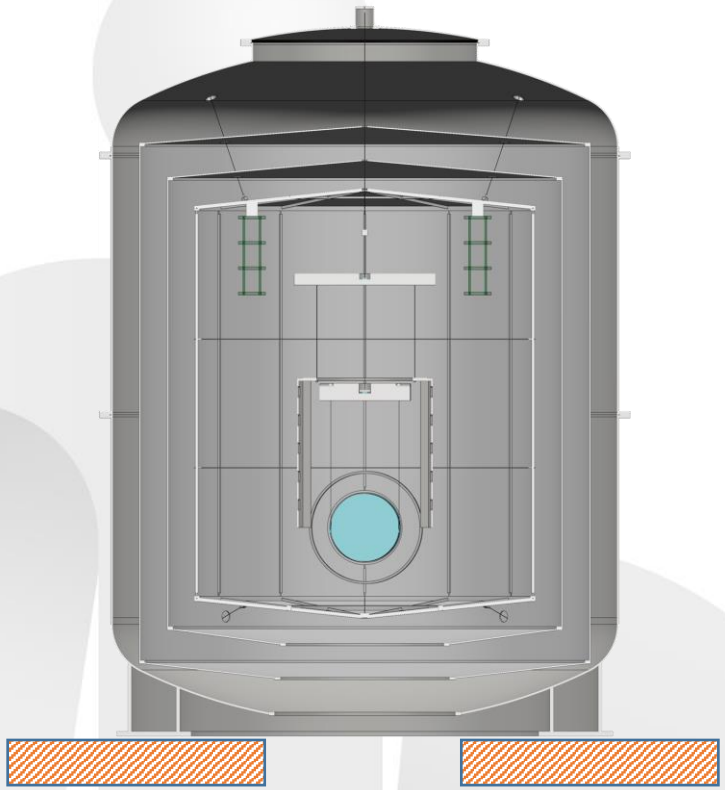
External disturbances to take into account

Electro - Magnetic

Magnetic

Lifting tools

Humidity



Acoustic

Seismic

Airflow

Thanks for your attention

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