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Upgrade of the spoke test cavity station - PIP II †

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INTRODUCTION

Originally the spoke test cavity cryostat was designed to test exclusively SSR1 cavities [1] [2]. The goal of this upgrade is to extend this capability to SSR2 cavities, and to the low and high beta 650 MHz cavities. Each cavity is tested with its coupler and tuner, and is supported in the same way as it will be inside the cryomodule.

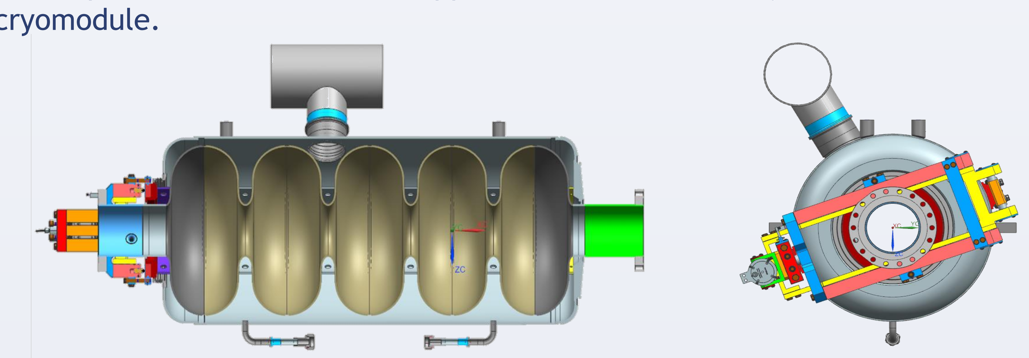
Fig. 1. Cross section of the high beta 650 MHz dressed cavity with its tuner

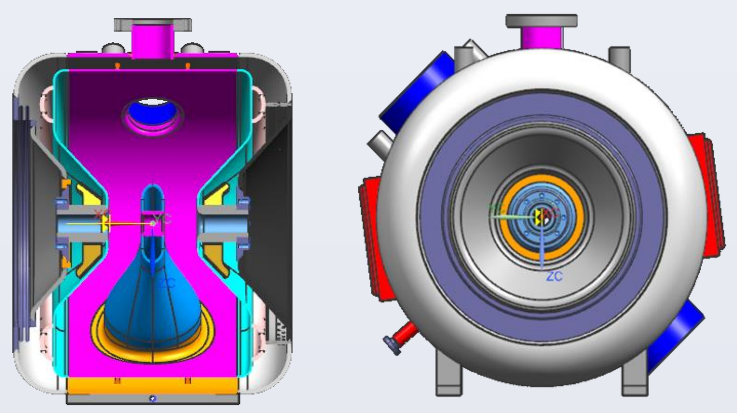
Fig. 2. Cross section of the SSR1 cavity

Due to the fact that SSR2 cavity has a diameter 2” bigger than SSR1 cavity [4], and the high beta 650 MHz cavity [5] have a chimney making an angle with the vertical axis and a length around 55” compared to 39.5” for the length of the existing vacuum vessel, an upgrade of the test station is necessary.

In order to reduce the cost and the time of the project, it has been decided to re-use the components of the existing test station as much as possible and also to minimize the number of components to disassemble. Therefore, it has been decided that the top part of the cryogenic components including the heat exchanger designed for a maximum flow rate of 1.25 g/s should not be changed. Another important constraint was the room available inside the test station:

- The vacuum vessel and thermal shield can be extended but we still want to be able to have access on both ends of the vessel.
- The design needs to consider an assembly process matching with the room available.

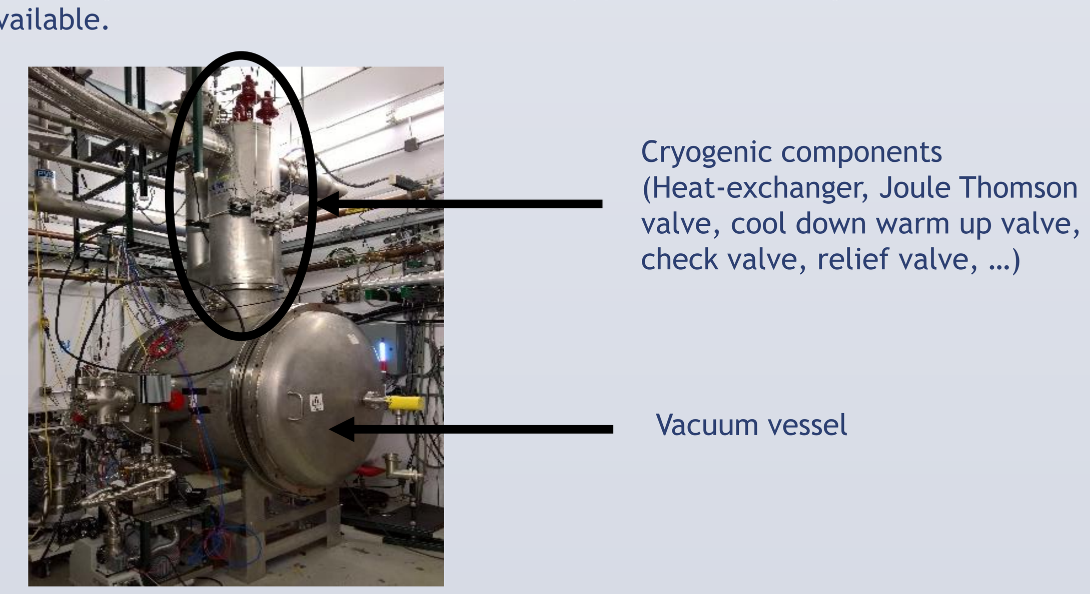

Fig. 3. Existing test station [3]

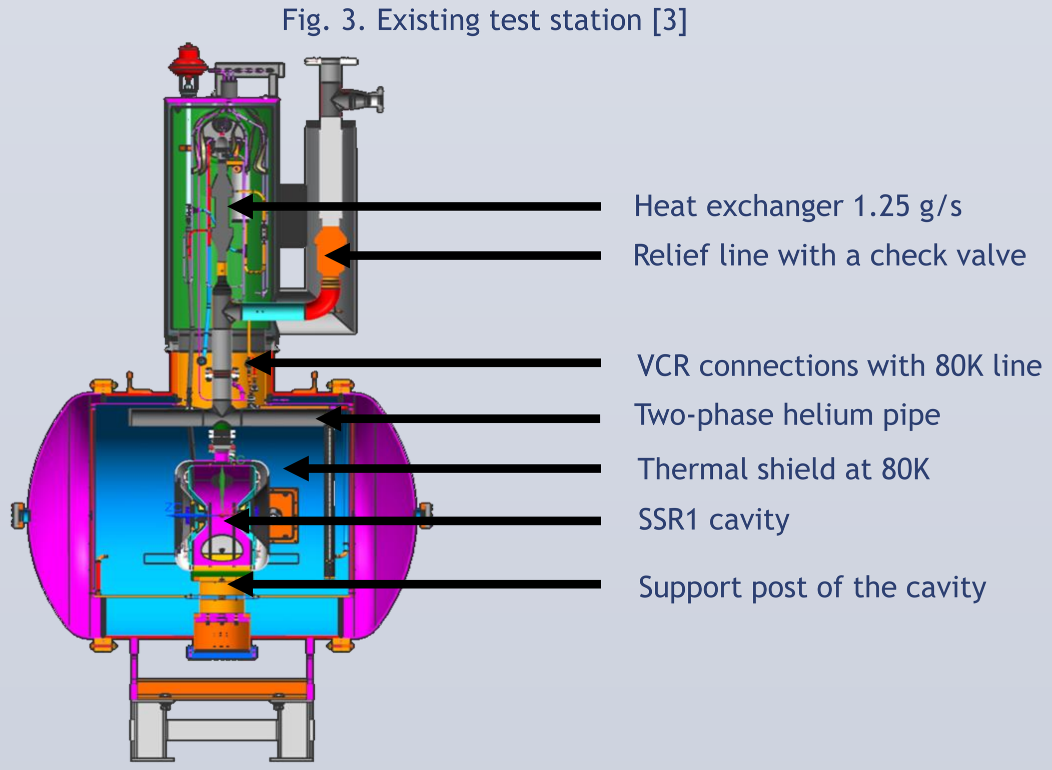

Fig. 4. Cross section of the existing test station

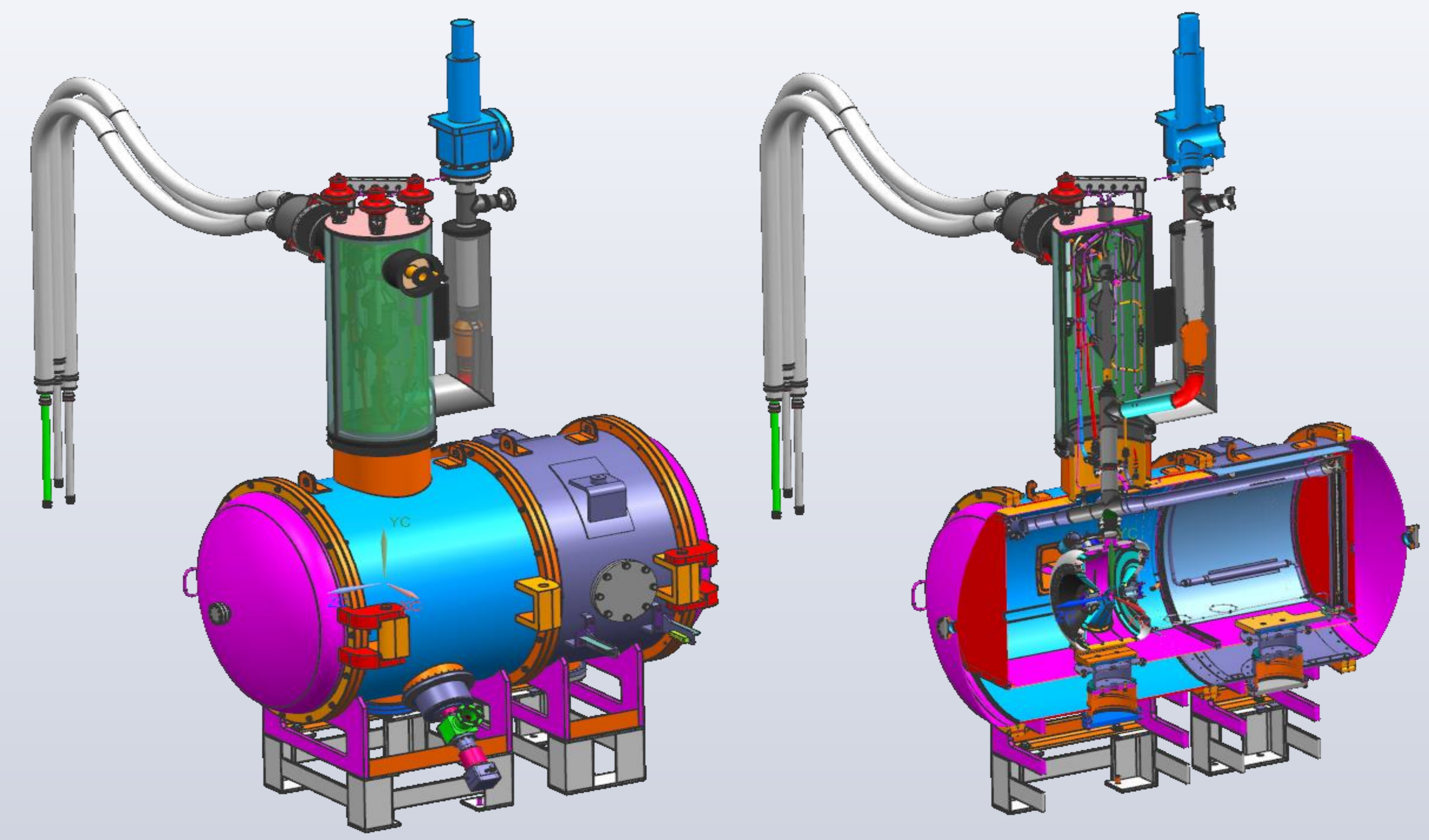
Fig. 5. New test station - SSR1 configuration

MECHANICAL DESIGN

The vacuum vessel, the magnetic shield and the thermal shield of the existing STC have been extended. The vacuum vessel’s extension is 30” long. It also has been decided to add a support post on this extension in order to support the 650 MHz cavities due to their length. Moreover, the height of this support post has been reduced by 1.9” in order to fit SRR2 cavity inside the test station.

Two-phase helium pipe design

In order to fit the high beta and low beta 650 MHz cavity inside the thermal shield it has been necessary to re-design the two-phase pipe:

- Its length has been increased in order to let the helium container at one end.
- A removable interface has been designed in order to make the connection with the cavity.

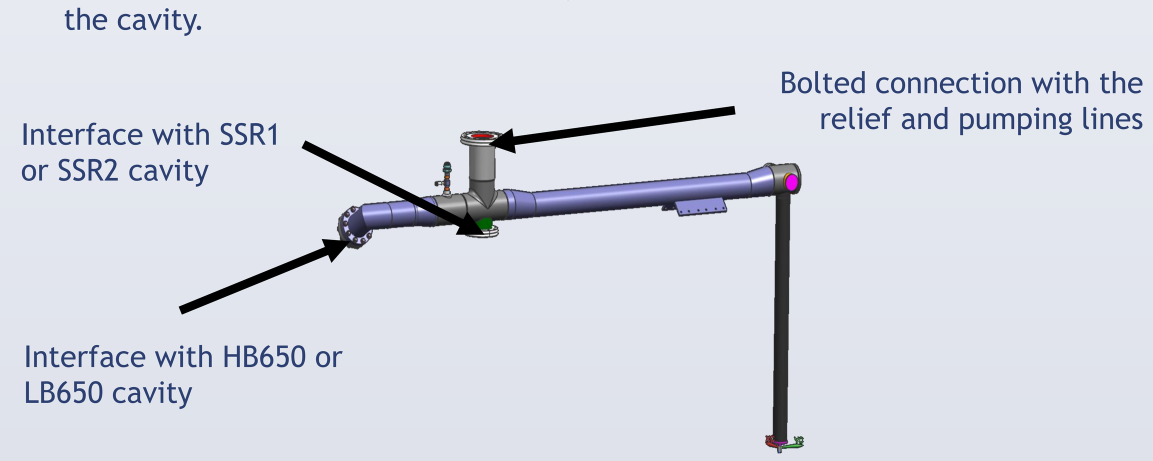

Fig. 6. Modification of the two-phase helium pipe

High beta 650 MHz configuration

In order to test high or low beta 650 MHz cavities, an aluminum plate will be set on the two support posts inside the vacuum vessel. On one side, the plate will be directly bolted to the support and on the other side the plate will be able to slide via two Teflon plates. Outside the vessel, the cavity including the cold part of the coupler, the cool down - warm up line and the interface with the two-phase helium pipe will be set on an aluminum structure which will slide inside the vessel thanks to a rail and adjustable wheels. Finally, the cavity will be inserted inside the vacuum vessel.

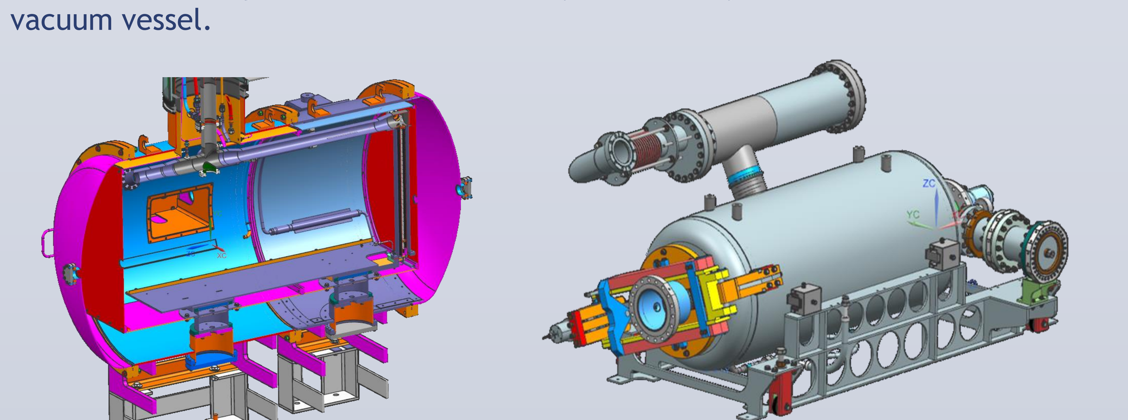
Fig. 7. High beta 650 MHz cavity on its insertion tooling

The high beta 650 MHz cavity fits perfectly inside the thermal shield. The main difficult part was to design the interface between the cavity and the two-phase helium pipe. Calculations have been done in order to estimate what will be the displacement during the cool-down between these two elements in order to design properly the bellows.

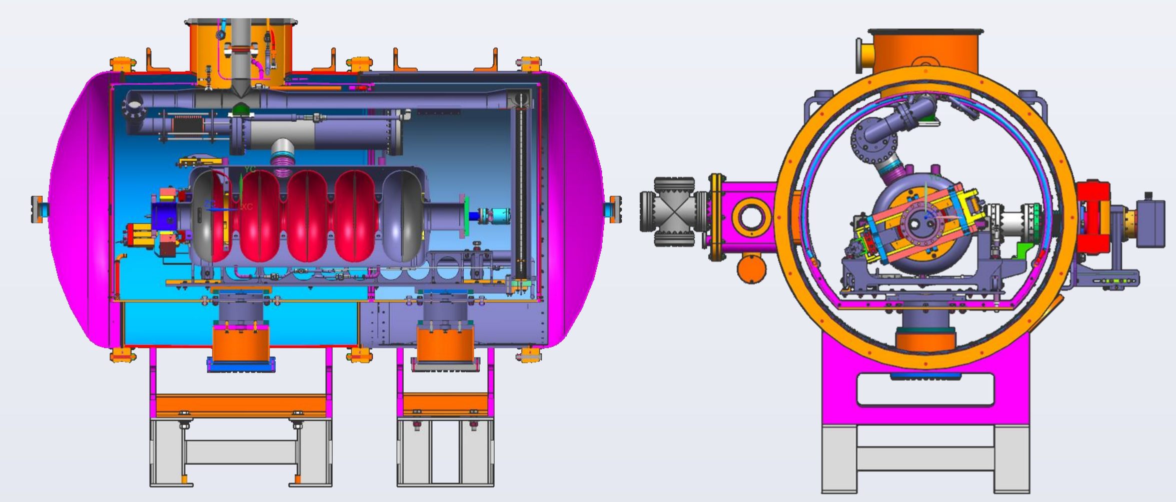
Fig. 8. New test station - HB650 configuration

CRYOGENIC DESIGN

Due to the fact that the high and low beta 650 MHz cavities have a chimney making an angle with the vertical axis contrary to SSR1 and SSR2 cavities, it has been necessary to design a dedicated interface. The 80K line with a design pressure of 80 psi will be cooled by using liquid nitrogen. The two-phase helium pipe and the cool down - warm up line will be cooled up to 2K with liquid helium considering a design pressure of 59.5 psi.

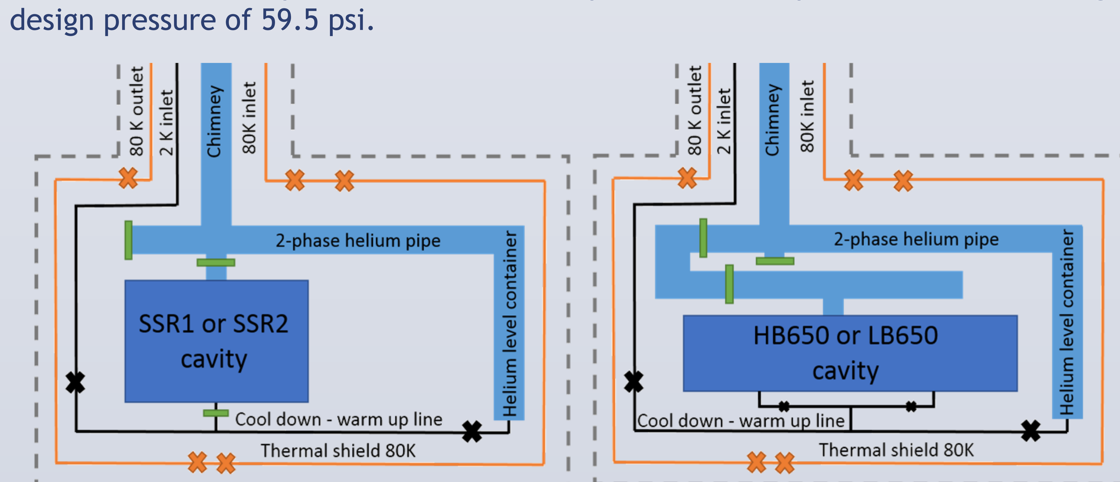

Fig. 9. Schematic of the cryogenic lines

Heat loads

The vessel and the thermal shield being longer, and the two support posts shorter, the heat loads are more important and the helium mass flow should be close to 1.24 g/s. This value is close to the maximum flow of the exchanger: 1.25g/s. Nevertheless, we should have some margin considering that the heat loads on the 2K stage have been slightly over-estimated due to the fact between one supporting post and the 2K stage there will be some Teflon. In this way, the thermal contact won’t be perfect, and the heat loads should be lower.

	Existing test station	New test station
Heat loads on 80K stage (W)	16.3	23.9
Heat loads on 2K stage in static (W)	1.30	4.6
Heat loads on 2K stage in dynamic (W)	24.0	24.0
Latent heat of helium (J/g)	23.0	23.0
Helium mass flow (g/s)	1.10	1.24

Fig. 10. Heat loads of the existing and new test station

Thermal shield design

The new thermal shield will be cooled actively at 80K by expanding the existing lines. The interface will be done with flexible tubes and VCR connections in order to easily connect the two thermal shields.

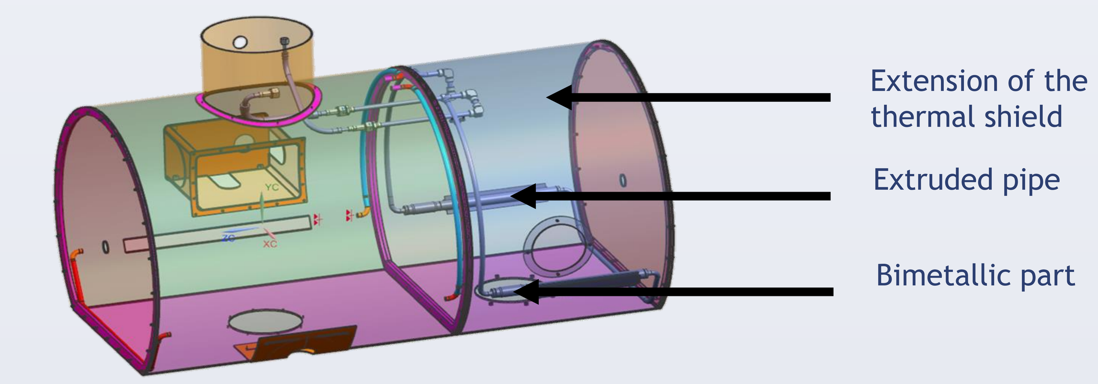

Fig. 11. Thermal shield

ASSEMBLY PROCESS

The upgrade of this new test station has been done in a way to avoid any welds inside the existing vacuum vessel. Therefore, it was not necessary to disassemble many components and to remove the MLI around the existing pipes. The assembly process will be the following:

- The cryogenic lines will be disconnected including the two-phase helium pipe, the cool down - warm up line and the 80K line.
- The existing thermal shield will be supported by temporary supports.
- Due to design constraint, the only solution to remove the existing cavity support post will be to cut it.
- The new two-phase helium line and the new cavity support post will be set up.
- The new vacuum vessel, the magnetic shield, the thermal shield and support post will be connected to the existing station.

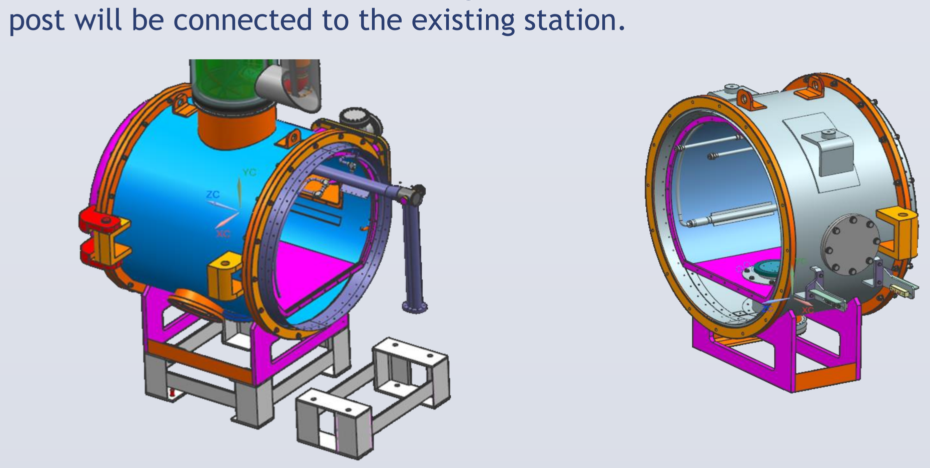
Fig. 12. Installation of the new test station

CONCLUSION

The main challenge of this upgrade was to be able to fit the high beta 650 MHz cavity inside the thermal shield with regards to the room available. For this, the cavity will slide inside the vessel thanks to a structure on wheels and guided by a rail. As it was the case for SSR1 cavity, we will qualify the high beta 650 MHz cavities in “cryomodule” conditions by testing the tuner and the coupler together. By changing the plate on the cavity support post, we will be able to test and qualify all the cavities needed for PIP-II. Therefore, we will have more flexibility and adaptability to follow the project schedule.

The design of this test station is now completed and the procurement is in process. The schedule is to upgrade this test station early 2018 and to start to qualify the high beta 650 MHz cavities.

REFERENCES

[1] A. Hocker, et al., “RF tests of dressed 325 MHz Single-Spoke Resonators at 2K”, LINAC 2014.

[2] A. Sukhanov, et al., “Result of cold tests of the Fermilab SSR1 cavities”, LINAC 2014.

[3] M. Chen, et al., “Project X Superconducting Spoke Resonator Test Cryostat 2 K Conversion”, AIP Conf. Proc. 1573, 790 (2014).

[4] L. Ristori, et al., “Development and performance of 325 MHz Single Spoke Resonators for project X”, SRF 2013.

[5] I.V. Gonin, et al., “650 MHz elliptical superconducting RF cavities for PIP-II project”, LINAC 2016.

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