HB650 Cryomodule - Design Status

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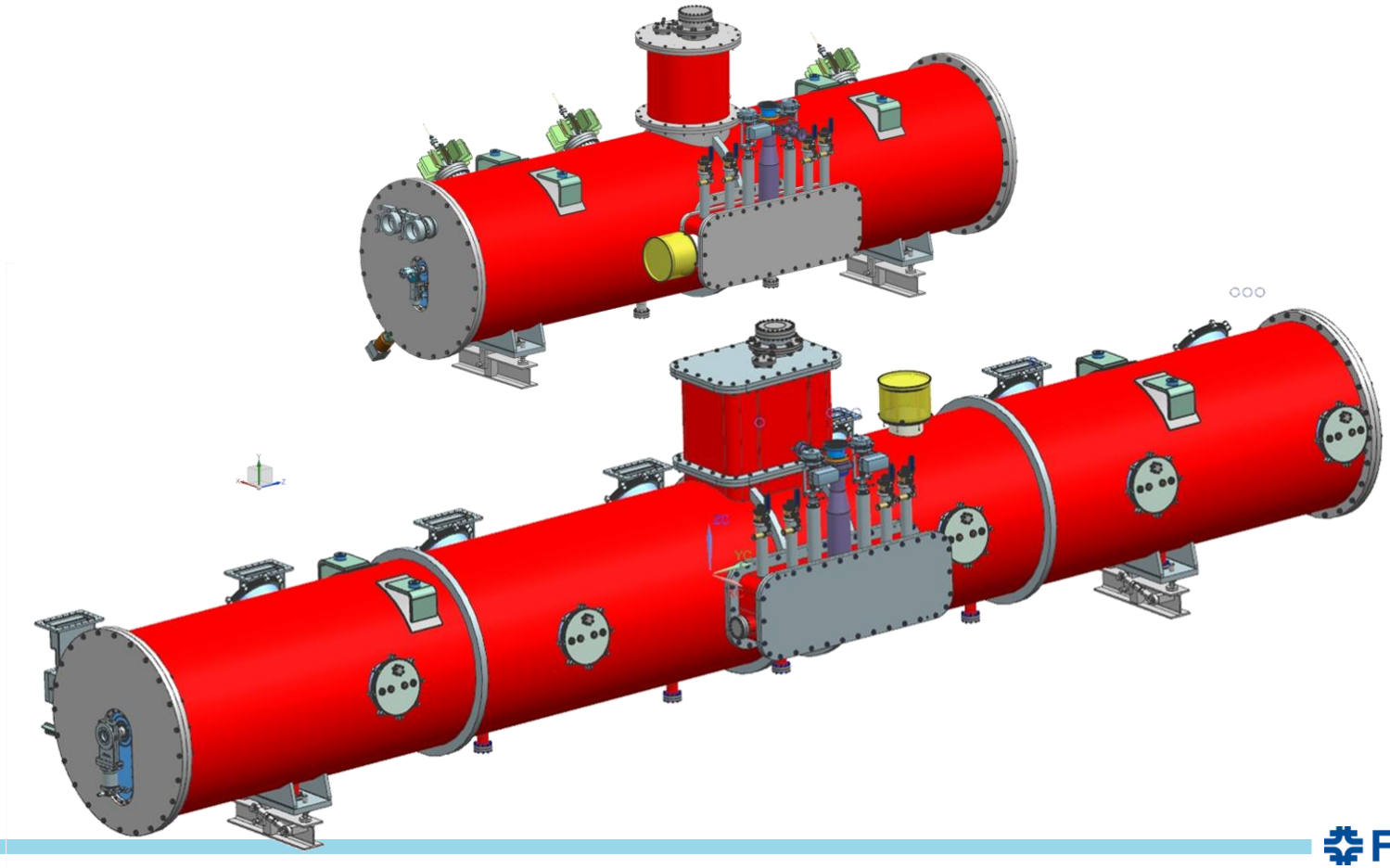
Layout

1. Description of the HB650 cryomodule
2. Beam line
3. Pipe sizing
4. Assembly process
5. Instrumentation

1. Description of the cryomodule

The design of the HB650 cryomodule is based on SSR1 cryomodule.

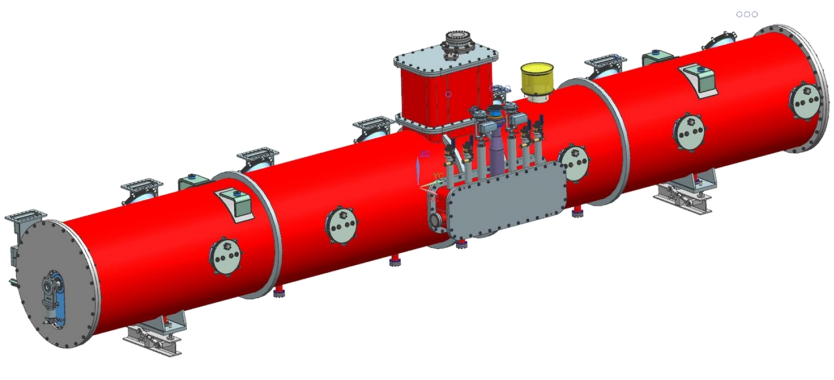
- Minimize the design cost
- Use of similar tooling and procedures

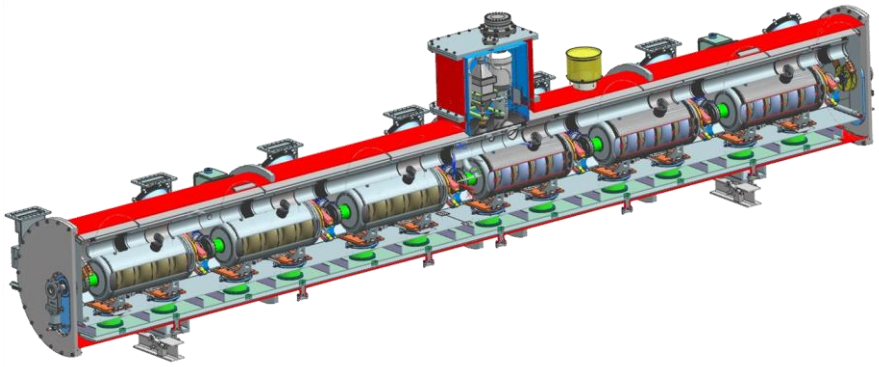


1. Description of the cryomodule

1.1 Arrangement

- Vacuum vessel : 9.7 m long and around 1.5 m high compared to the beam axis
- Thermal shield at 35-50 K
- 4 K line used as thermal intercept & to cool down the cold-mass
- 4 Bayonets, 2 Cryogenic valves & an heat exchanger
- 6 Cavities, tuners & couplers
- A magnetic shield around each cavity

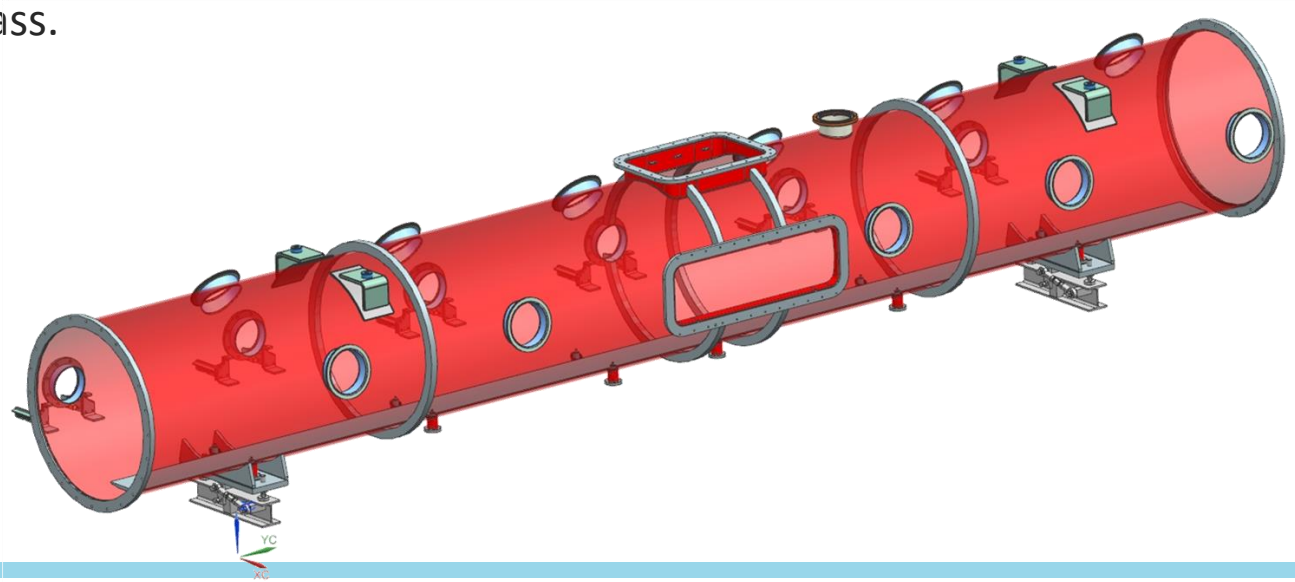




1. Description of the cryomodule

1.2 Vacuum vessel

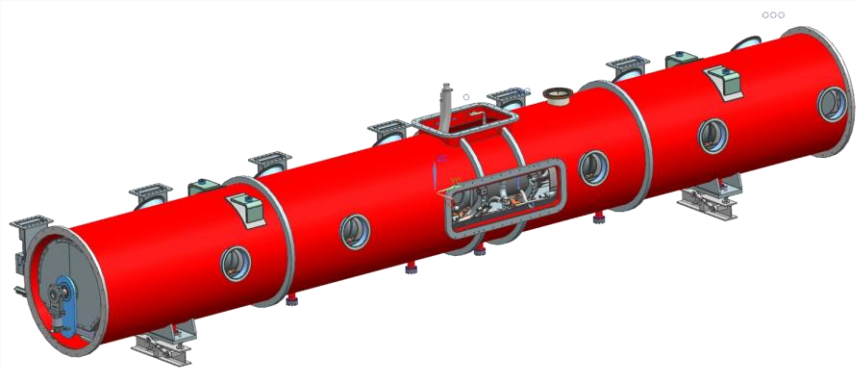
- Some analytical calculations have been done to size this vessel.
- Relief analysis has been done.
- FEA need to be done in order to be sure about the locations of the supports post and the lifting lugs.
- The vacuum vessel is composed of 11 tuner ports which are used also for the instrumentation.
- The bottom of the vessel is flat in order to order to make easier the insertion of the cold-mass.

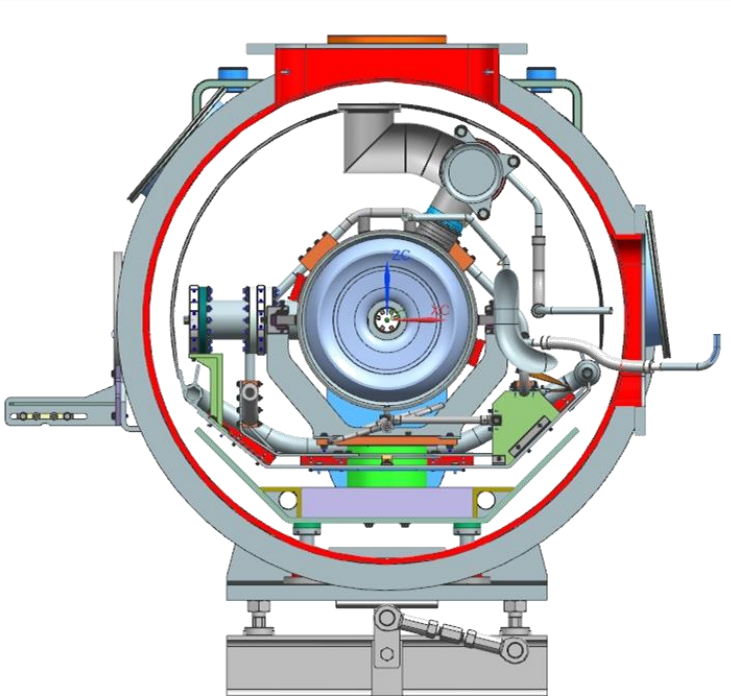


1. Description of the cryomodule

1.3 Validation of design concept

HB650 cryomodule is based on a strong-back at room temperature. Calculations have been done in order to warrant that the strong-back will be still warm after the cool down of the cryomodule.

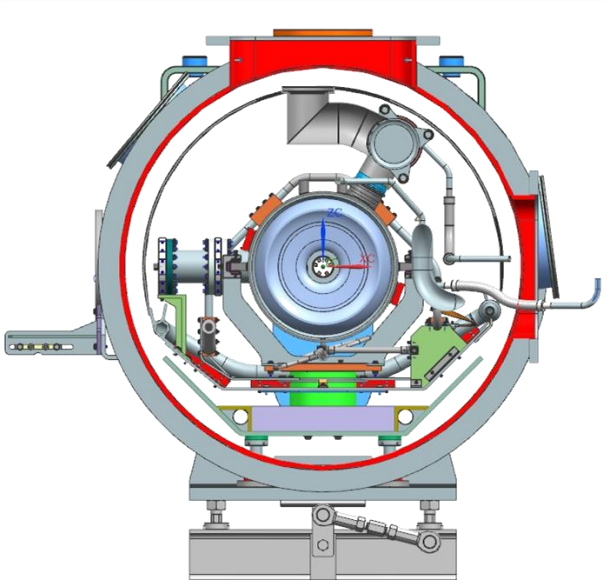


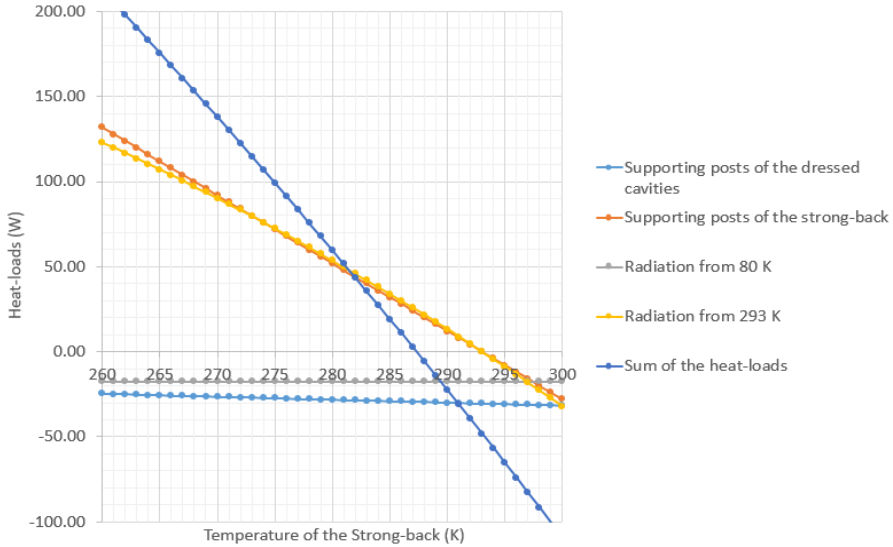


1. Description of the cryomodule

1.3 Validation of design concept

All the heat-loads applied on the strong-back can be estimated analytically according to the temperature of the strong-back. Then applying the 1st law of thermodynamics, the equilibrium temperature can be calculated.





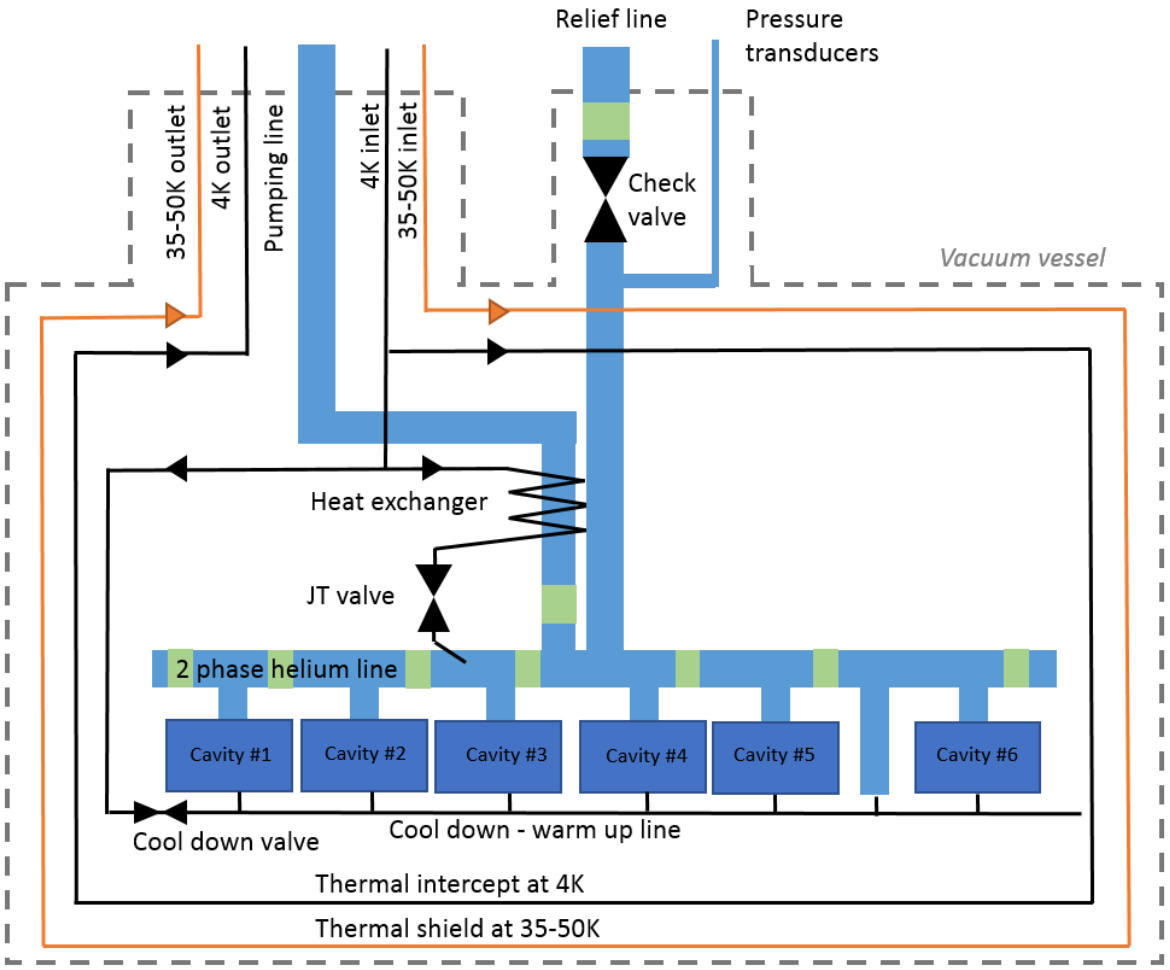
T equilibrium : 286 K
Max vertical displacement : 2 µm

This variation of temperature is not an issue for the alignment.

Fermilab

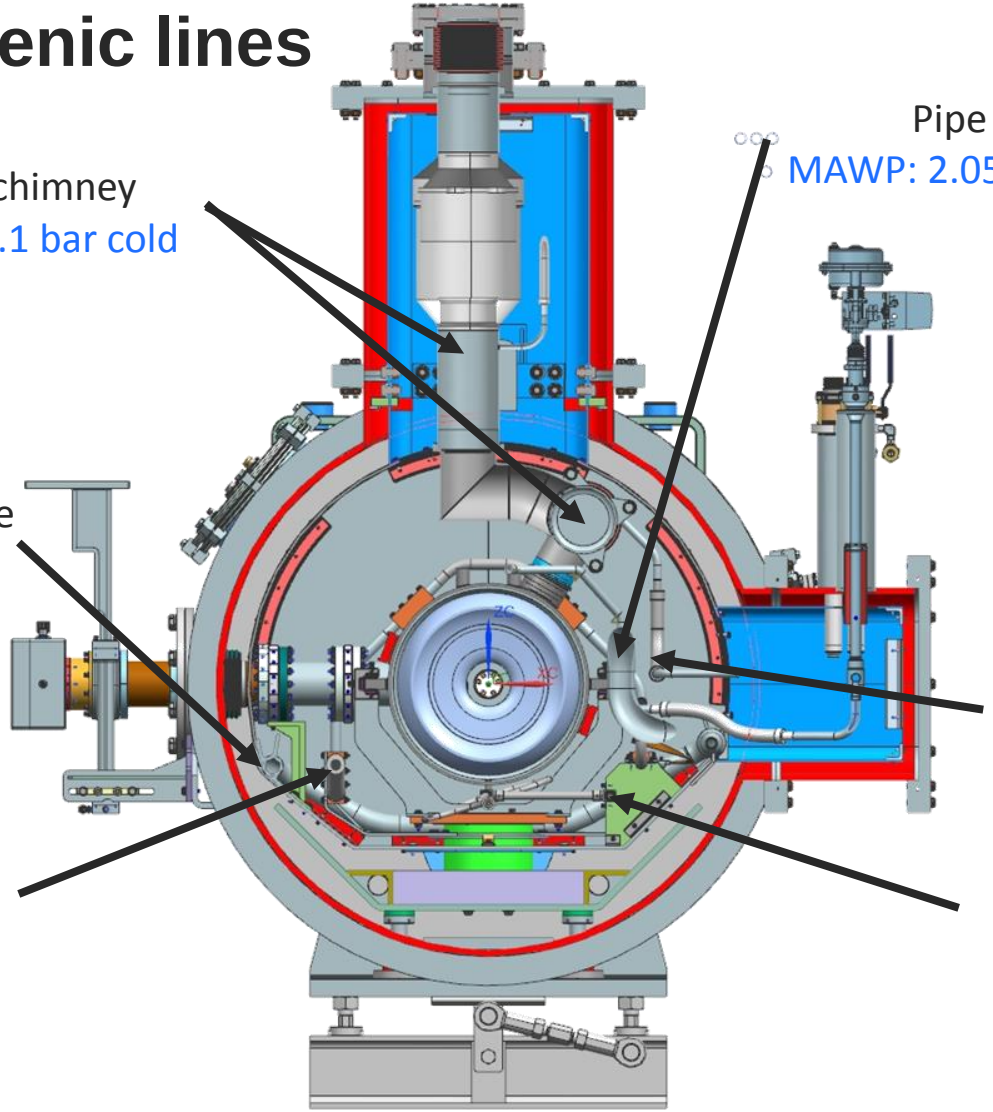
1. Description of the cryomodule

1.4 Layout of the cryomodule



1. Description of the cryomodule

1.5 Cryogenic lines



Pipe G - 2 phase He & chimney
MAWP: 2.05 bar warm, 4.1 bar cold

Pipe B - Pumping line
MAWP: 2.05 bar warm, 4.1 bar cold

Pipe E & F - 35-55 K line
MAWP: 20 bar

Pipe A - 2.2 K supply
MAWP: 20 bar

Pipe C & D - 4.5 K line
MAWP: 20 bar

Pipe H - Cool down / warm up line
MAWP: 20 bar

1. Description of the cryomodule

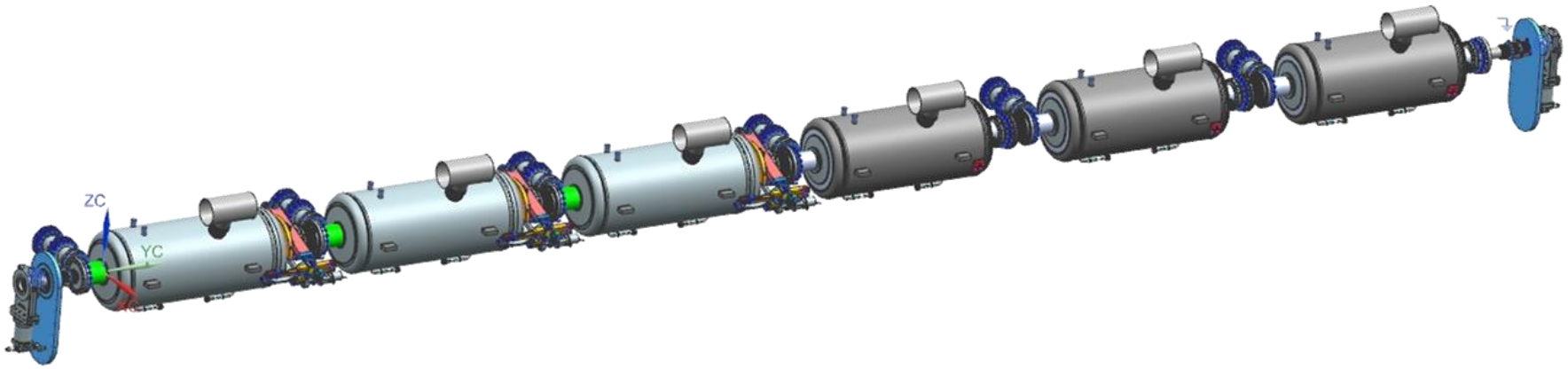
1.6 Heat loads

	Each unit (W)			#	Total (W)		
	35-50 K	4 K	2 K		35-50 K	4 K	2 K
Input coupler static	3.30	0.60	0.15	6	19.8	3.6	0.9
Input coupler dynamic	7.4	1.1	0.66	6	44.6	6.7	4.0
Cavity dynamic load			22.00	6			132.0
Support post	1.7	0.9	0.04	12	20.8	10.9	0.5
Thermal shield	50.5		2.2	1	50.5		2.2
Conduction relief line	1.0		0.3	1	1.0		0.3
Conduction beam line	0.9	0.04	2.E-04	2	1.7	0.1	5E-04

	35-50 K	4 K	2 K
Total static	93.9	14.6	3.9
Total dynamic	44.6	6.7	136.0
Total static + dynamic	138.5	21.3	139.9

2. Beam line

The string is composed of three 0.92 cavities and three 0.9 cavities. The length and the flange of these 2 cavities being different it is necessary to design several of bellow assemblies.



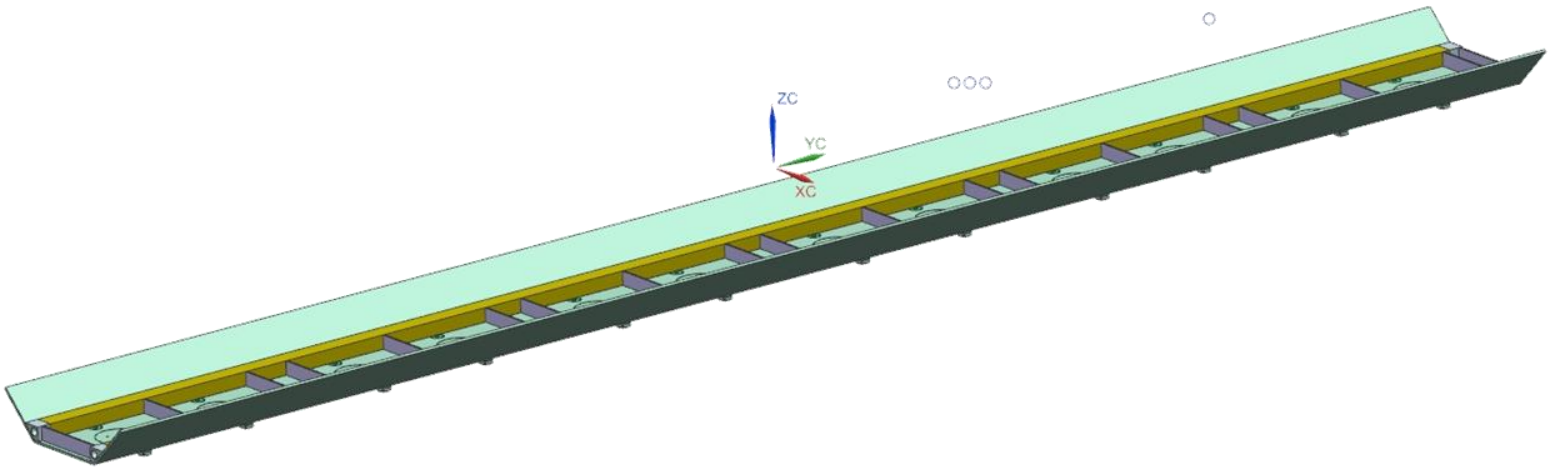
3. Pipe sizing

Calculations have been done in order to demonstrate that all the pipes of HB650 cryomodule have been designed per venting requirements.

	Needed diameter for the chimney of the dressed cavity	Needed diameter for the 2-phase helium pipe	Needed diameter for the relief line
Loss of insulating vacuum	40.8 mm	92.0 mm	100.6 mm
Cavity vacuum loss	43.6 mm	106.8 mm	106.8 mm
Considered diameter	93.5 mm	146.8 mm	122.8 mm

4. Assembly process

All the cryogenic lines have been pre-designed based on an assembly process, but the design stage is not over yet. Simulations, and several parts need to be designed including the beam line.



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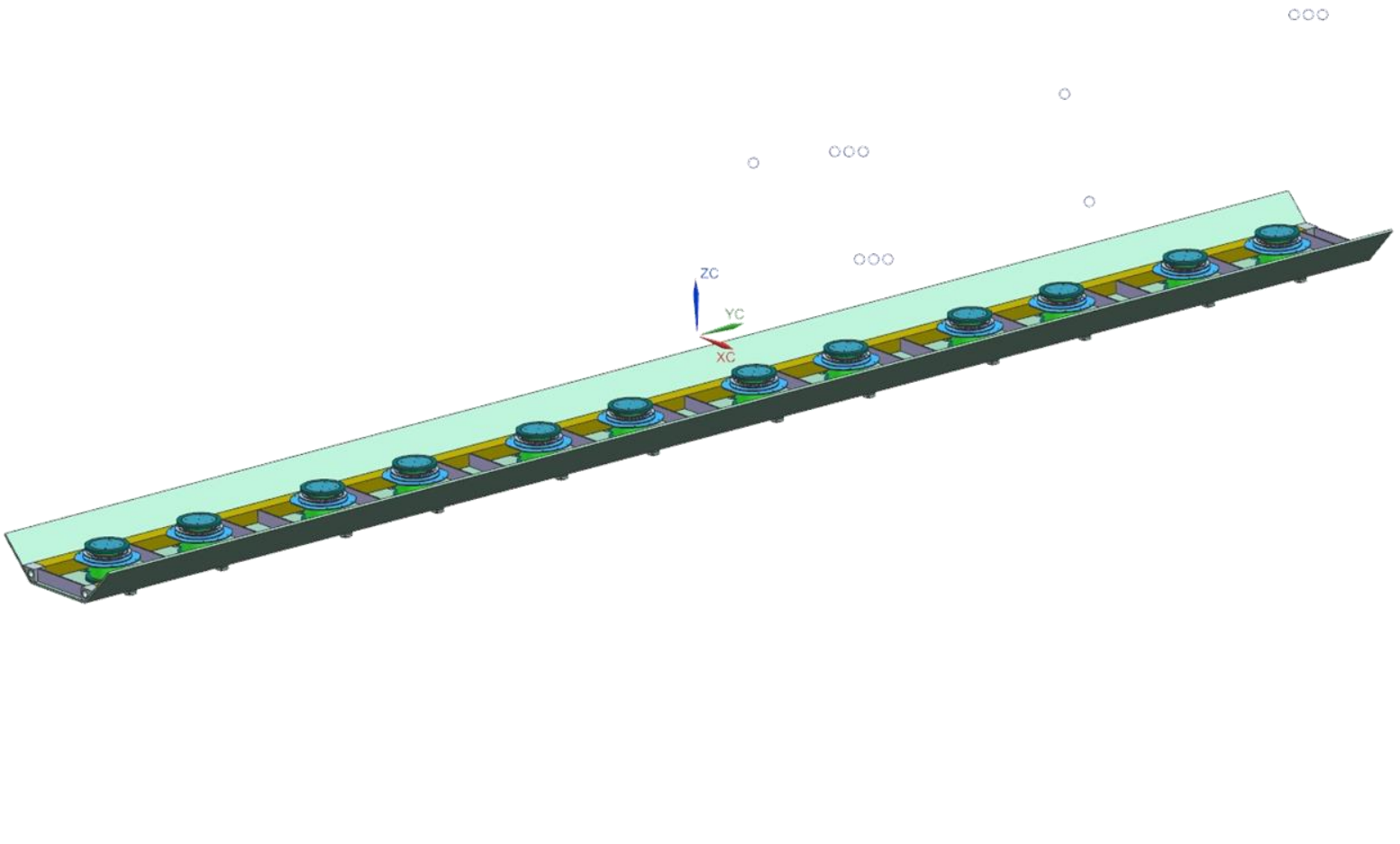

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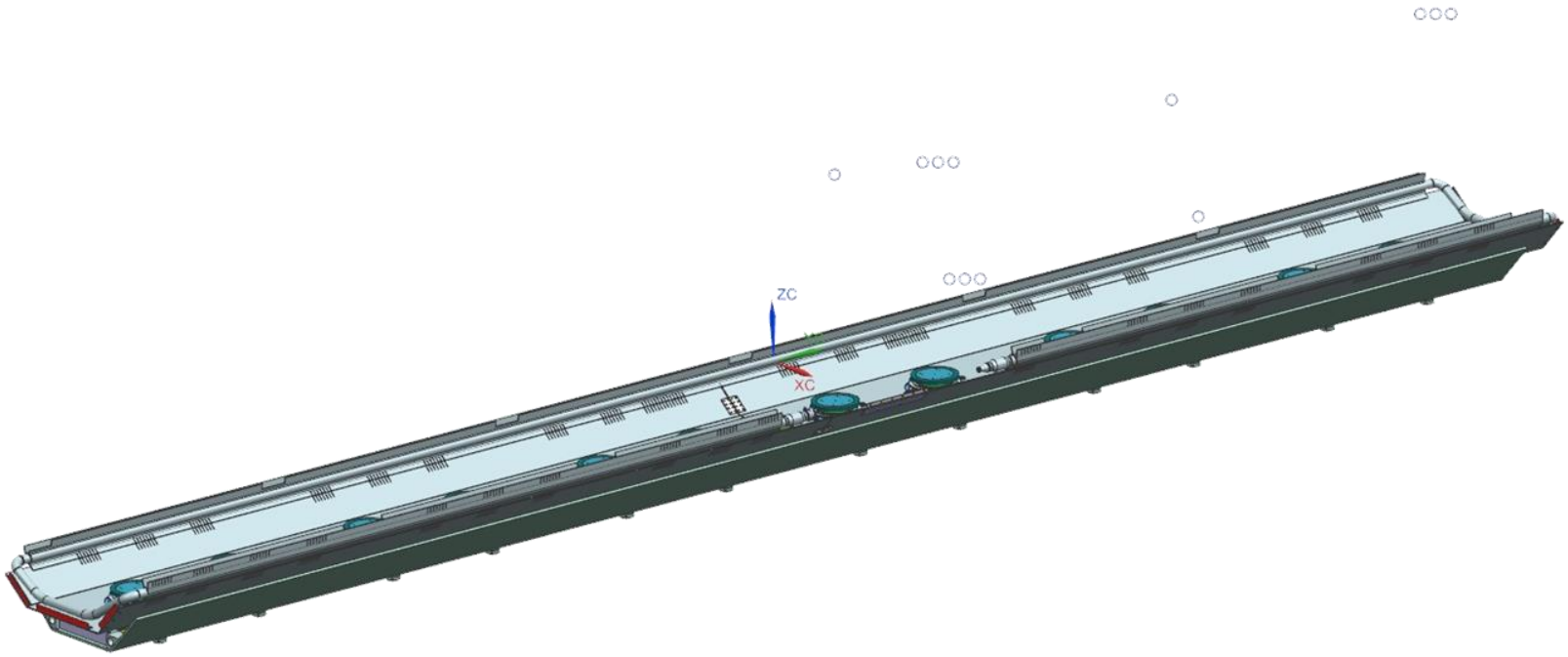

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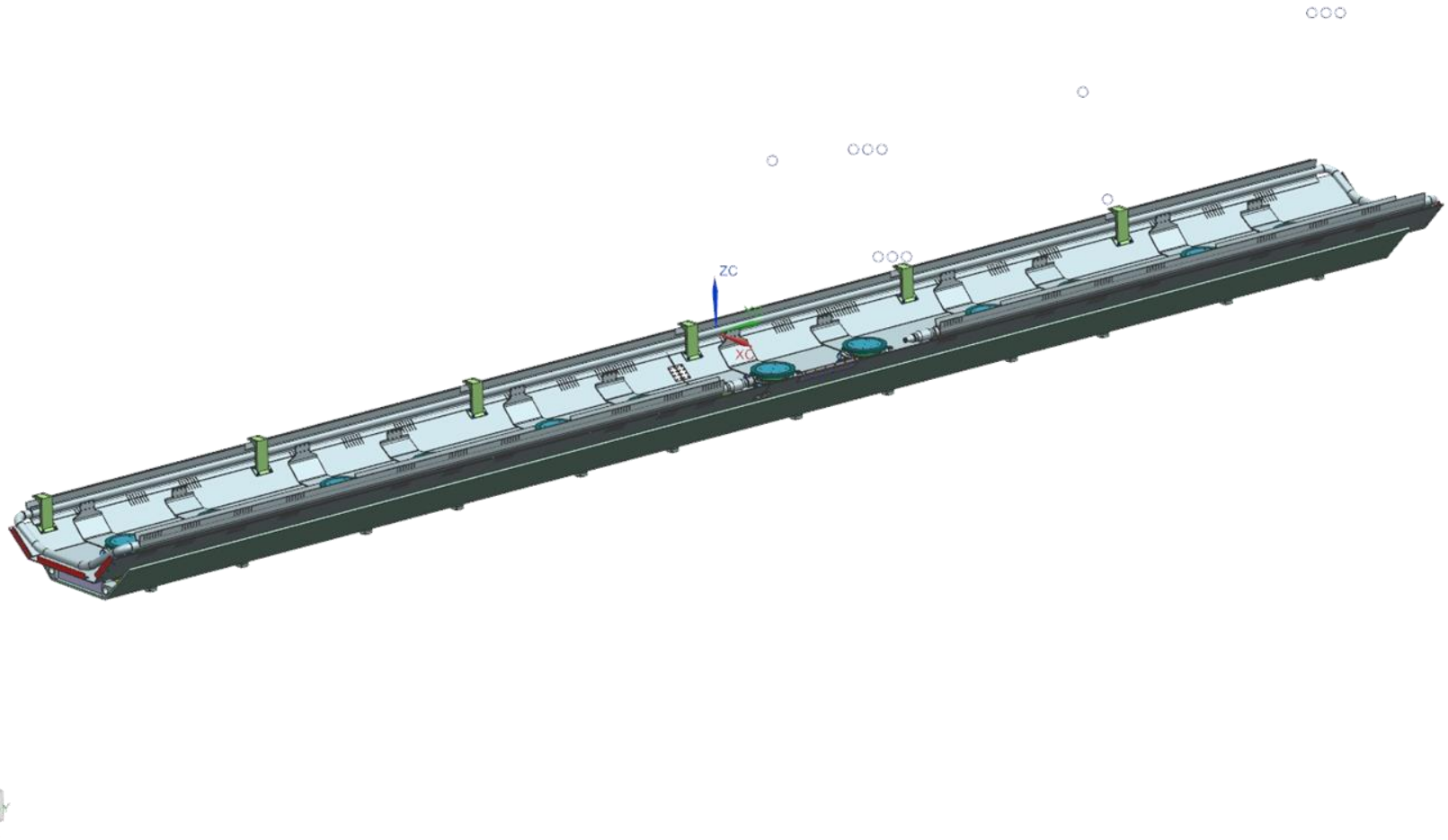

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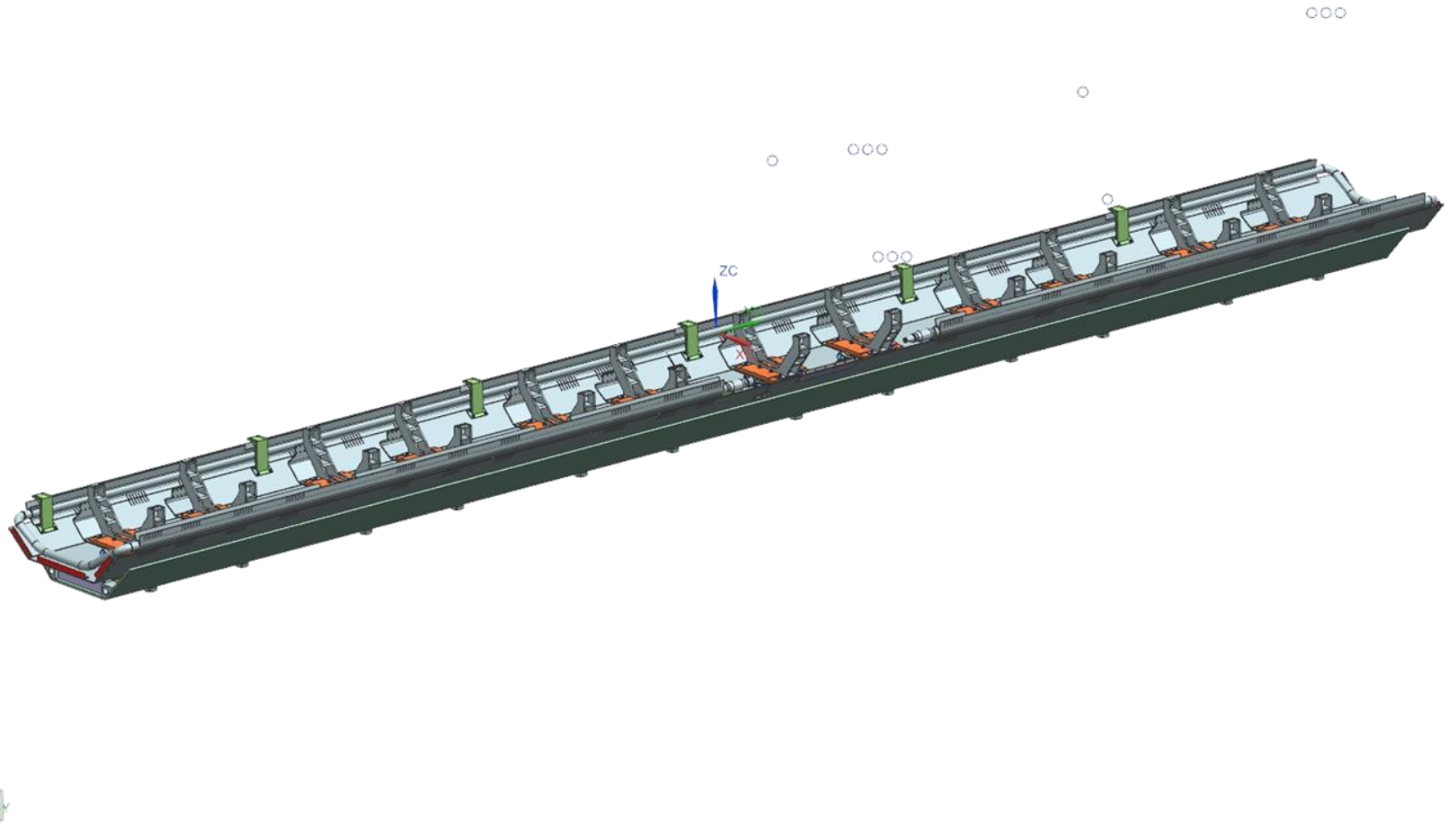

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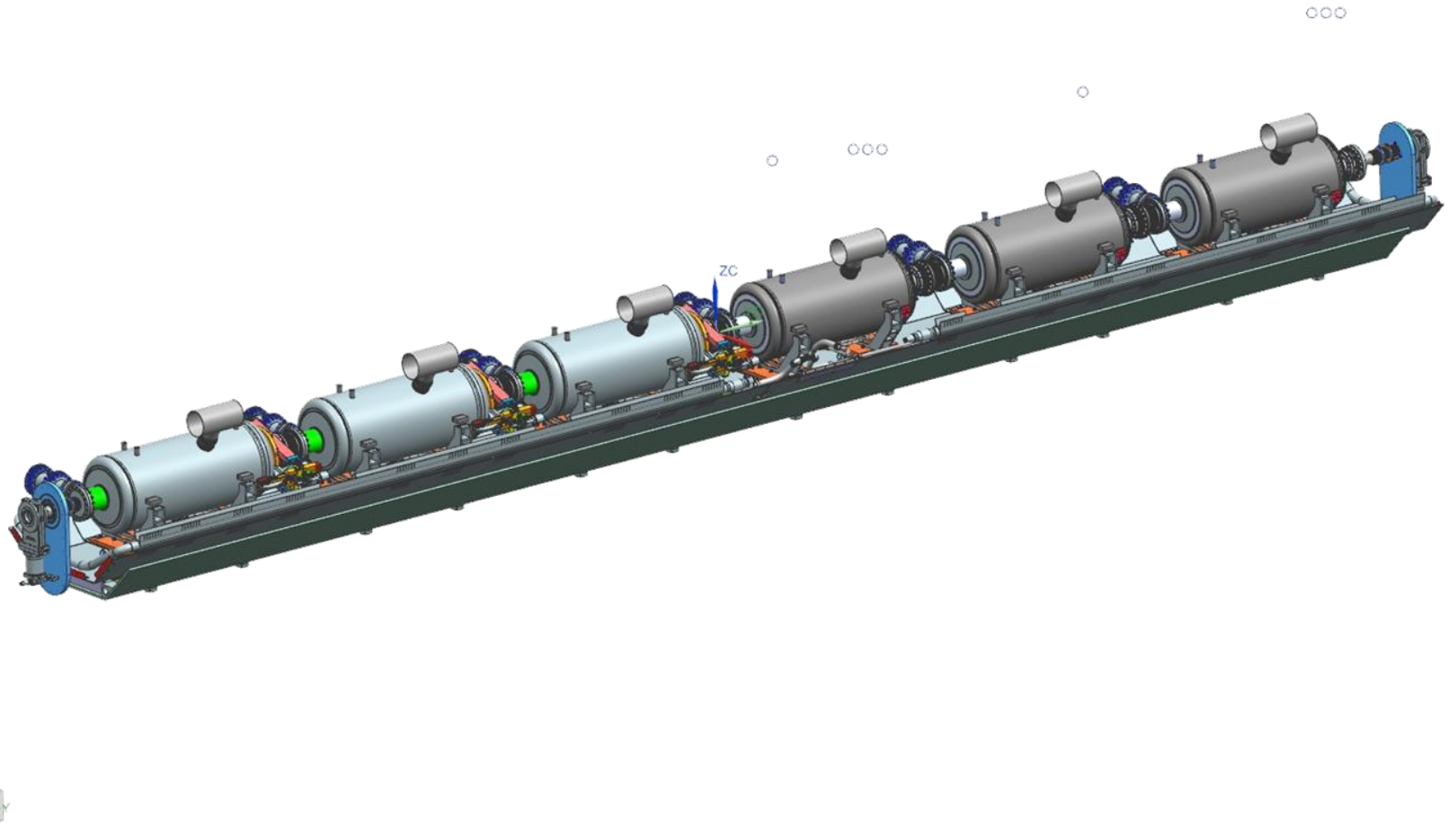

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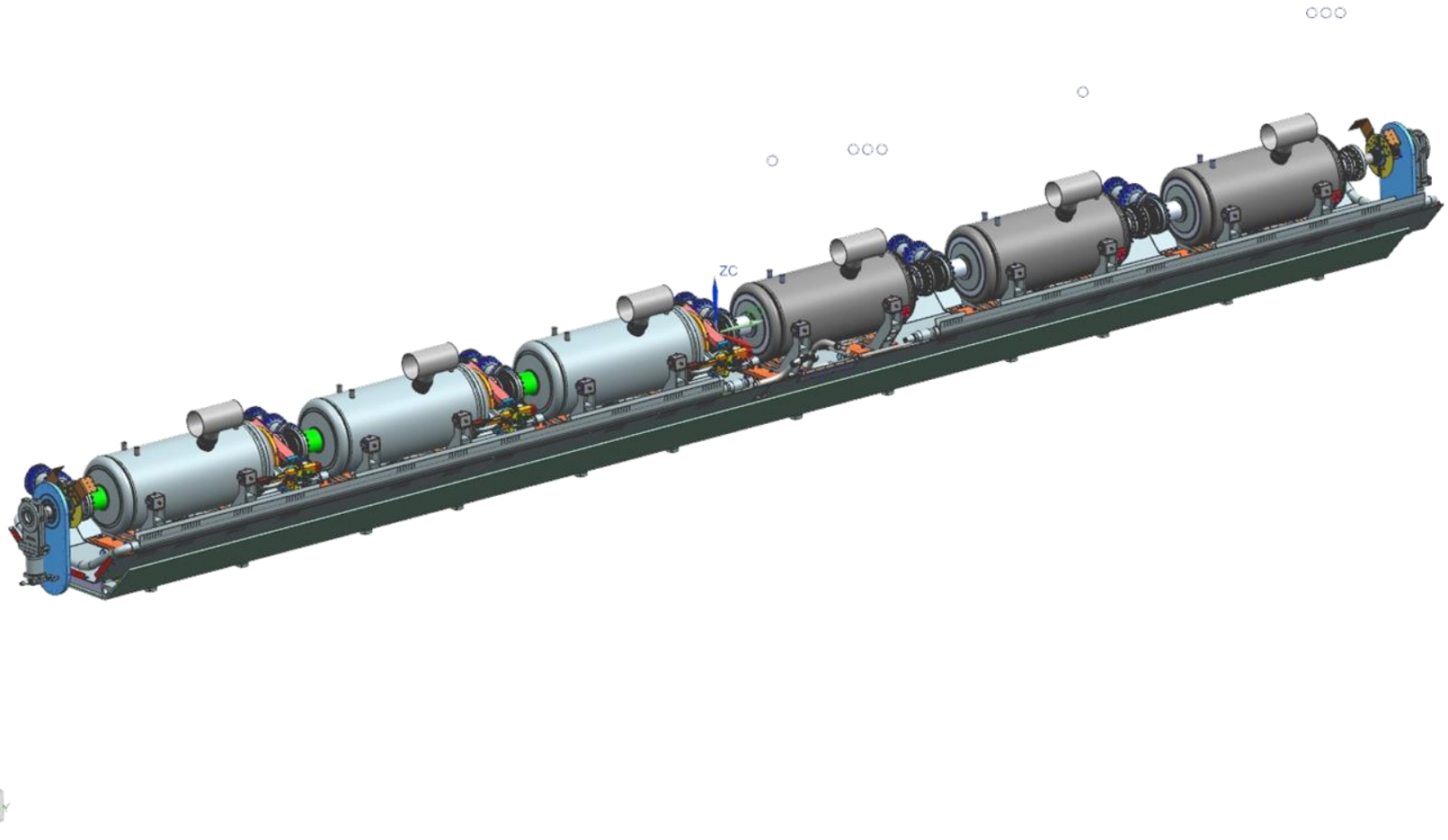

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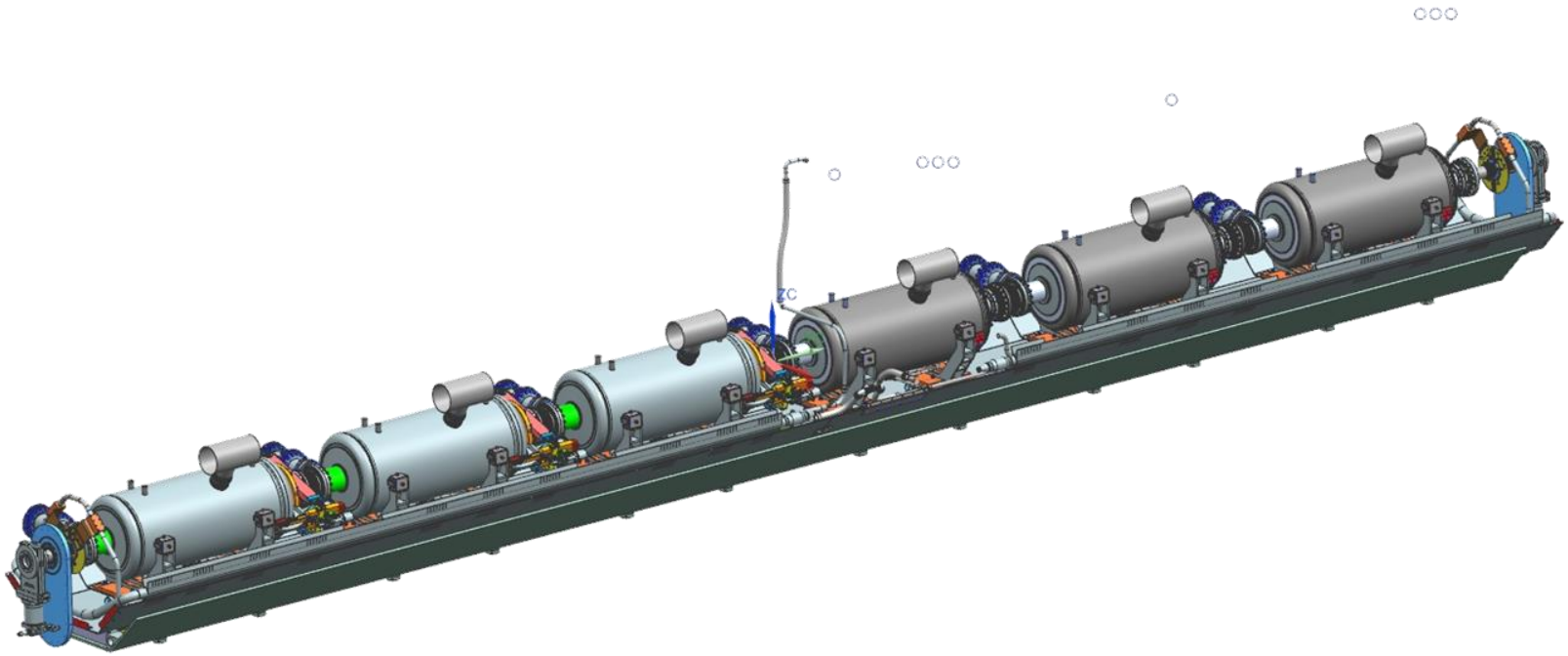

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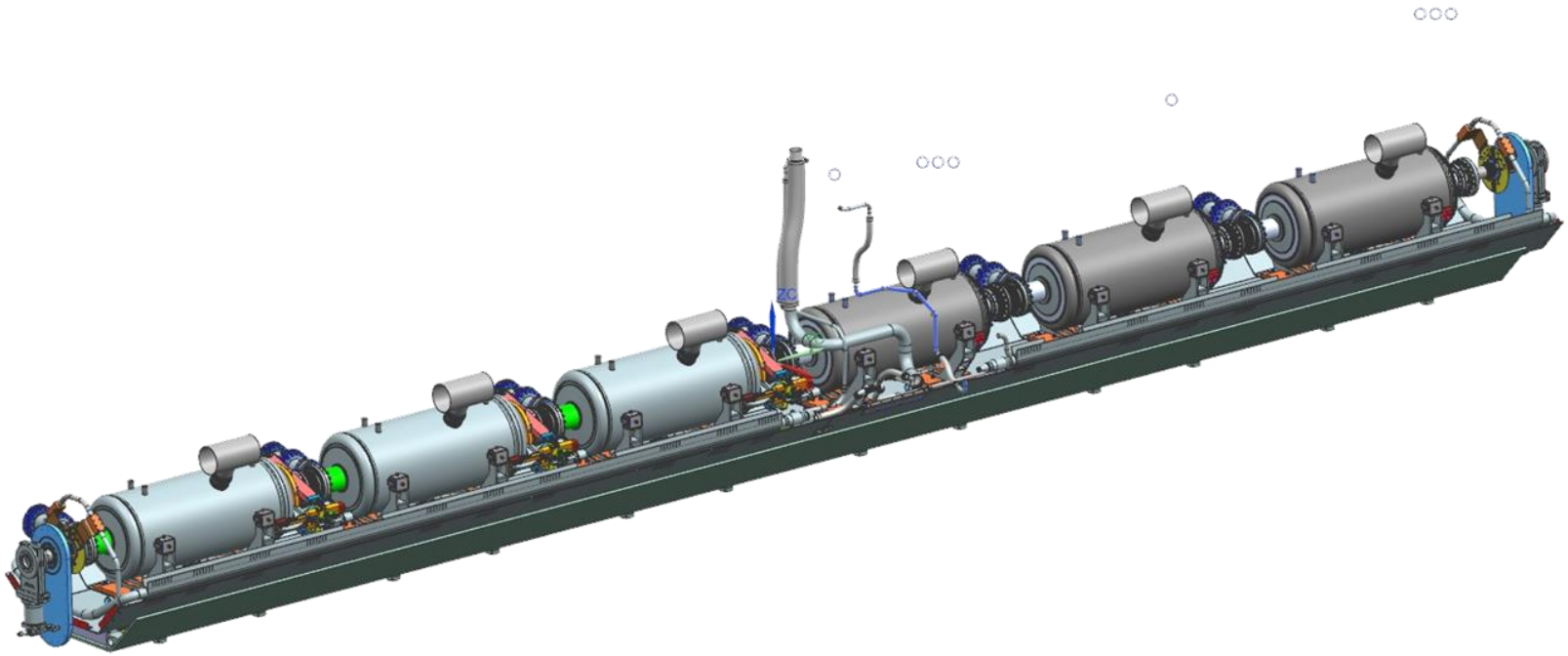

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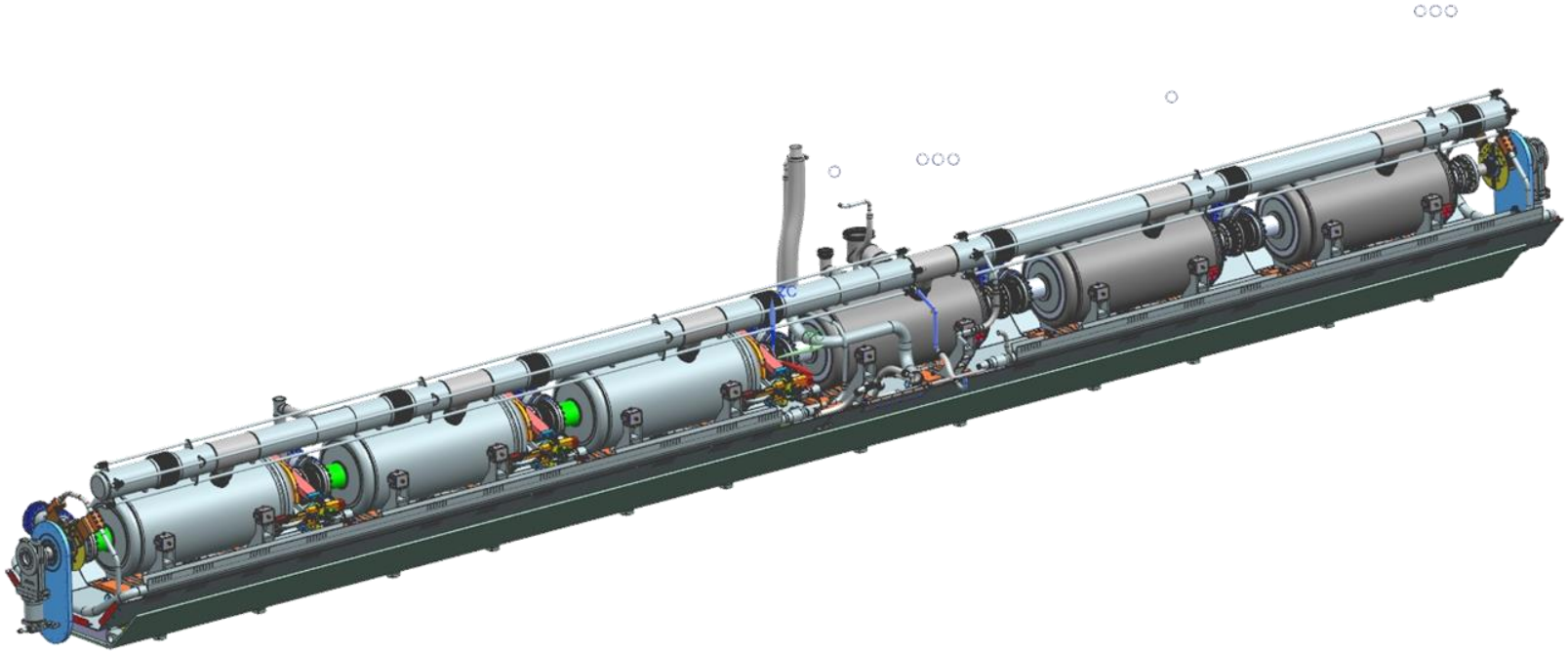

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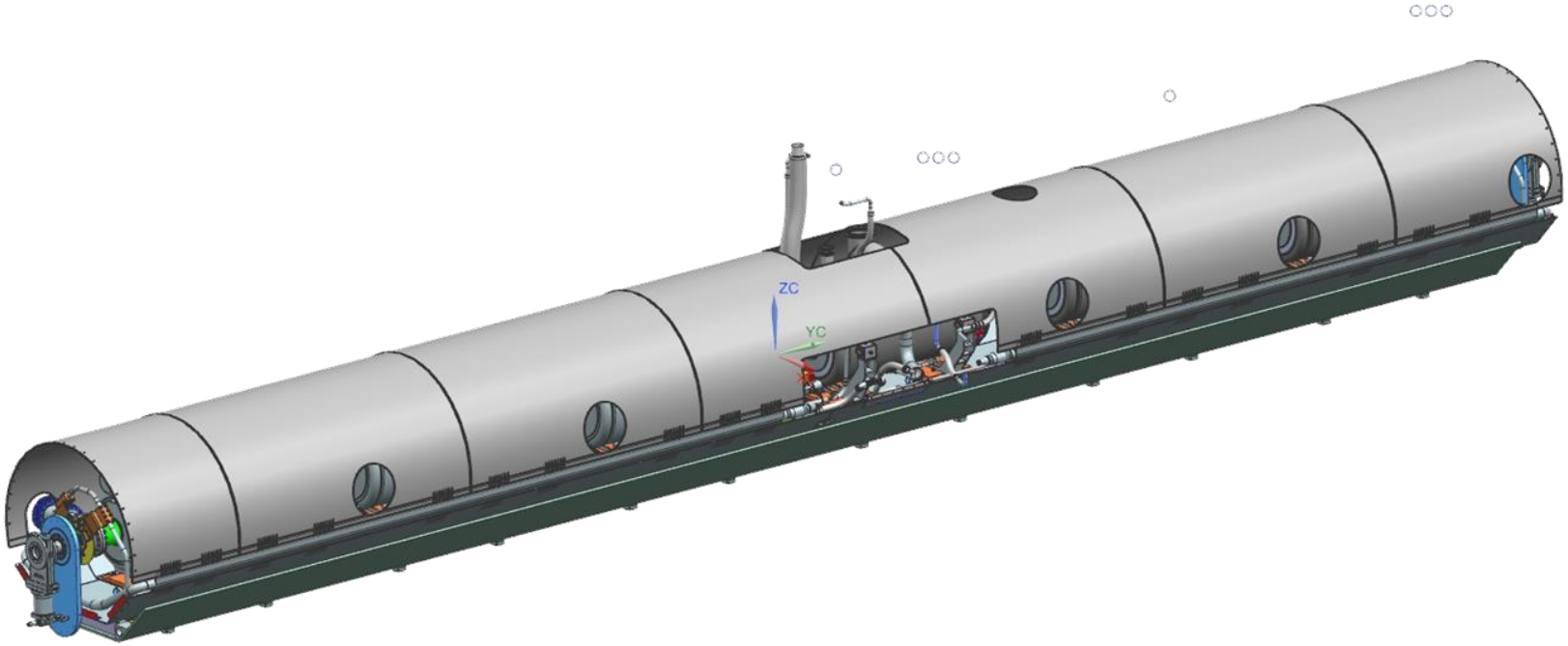

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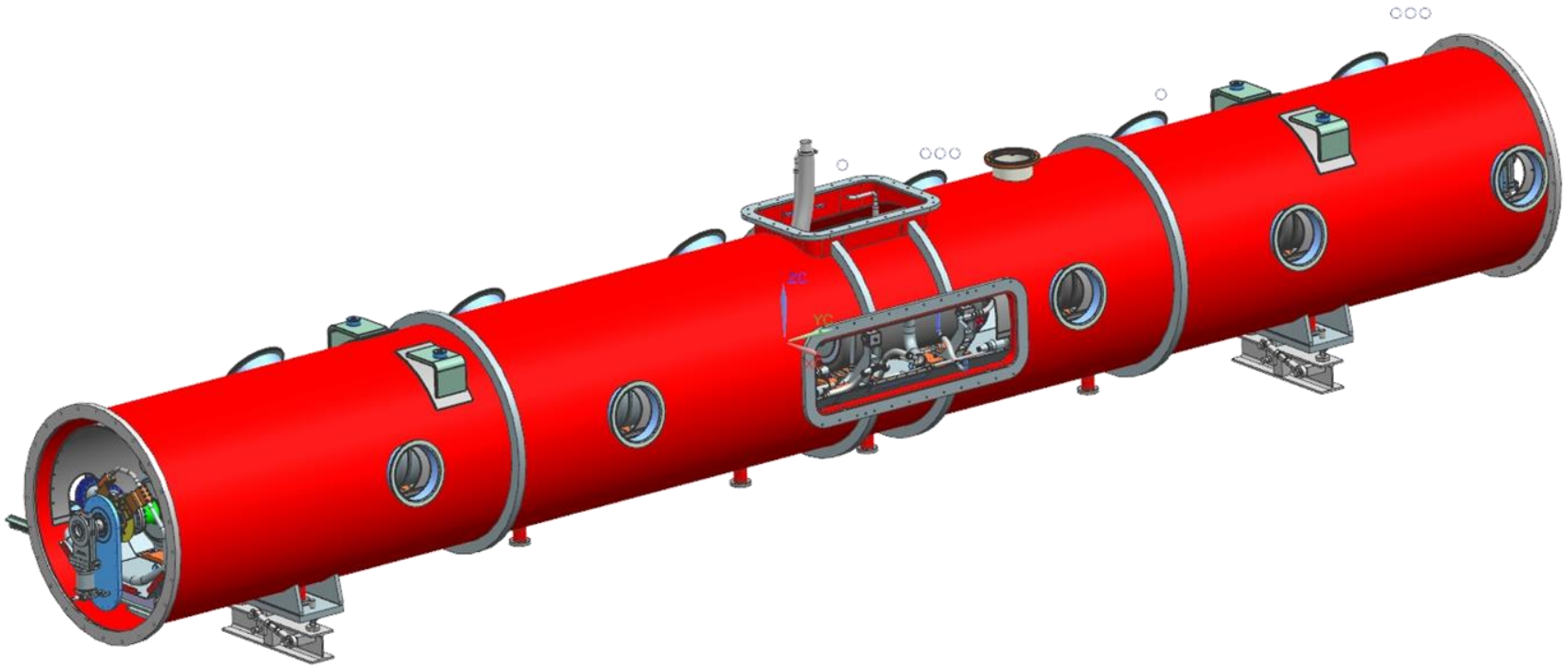

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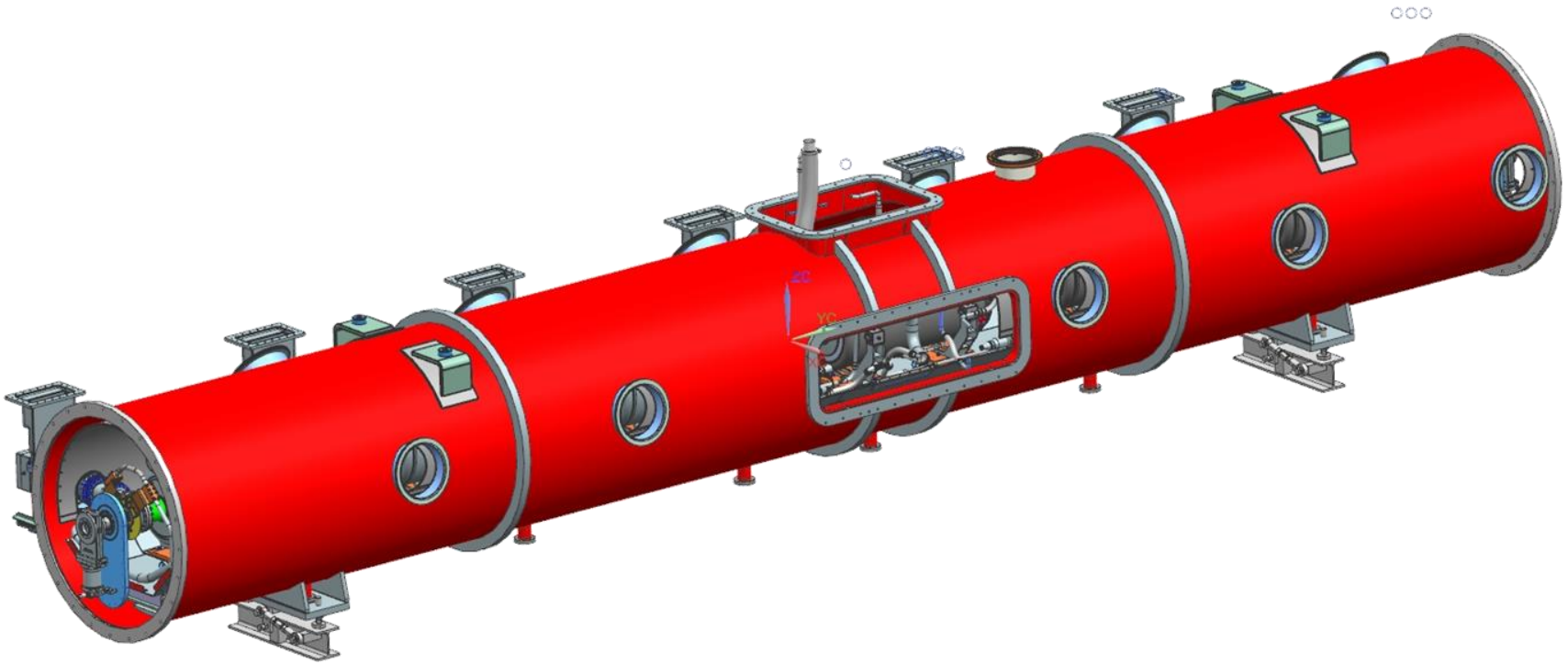

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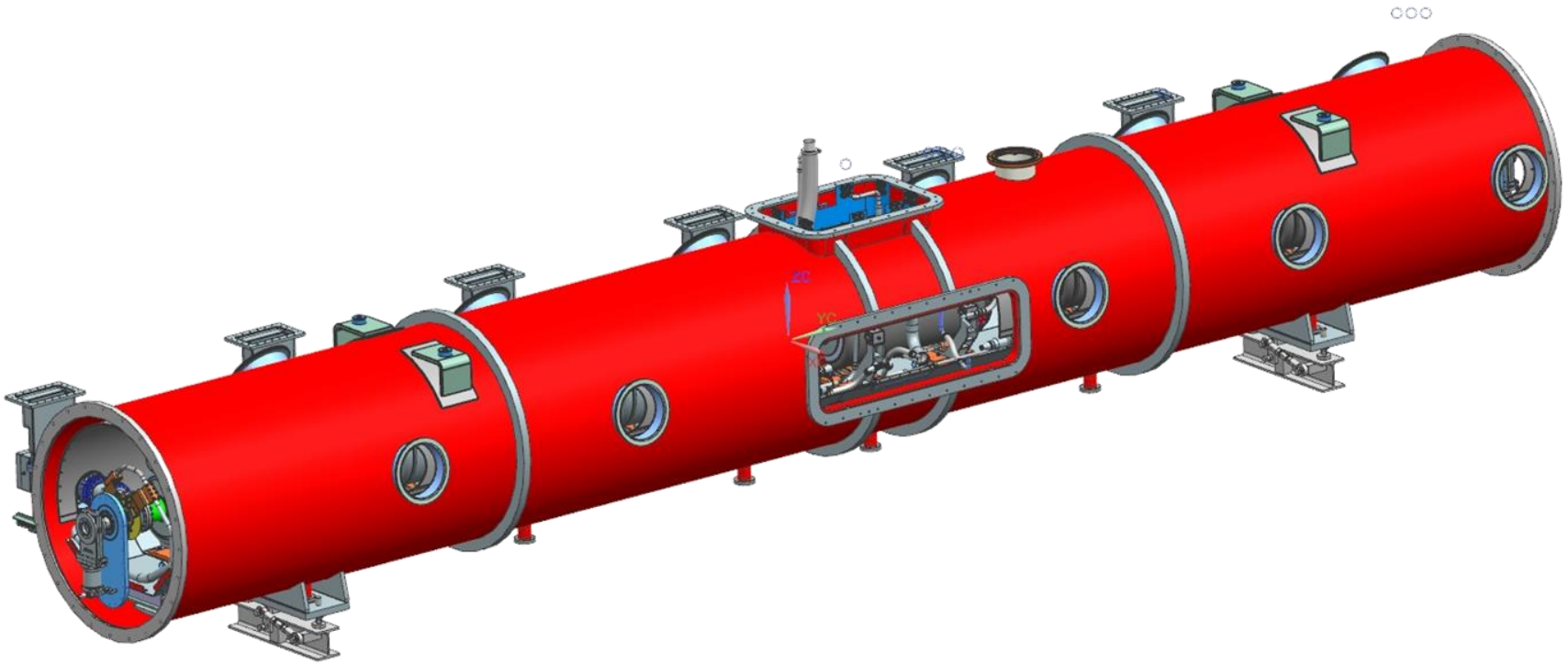

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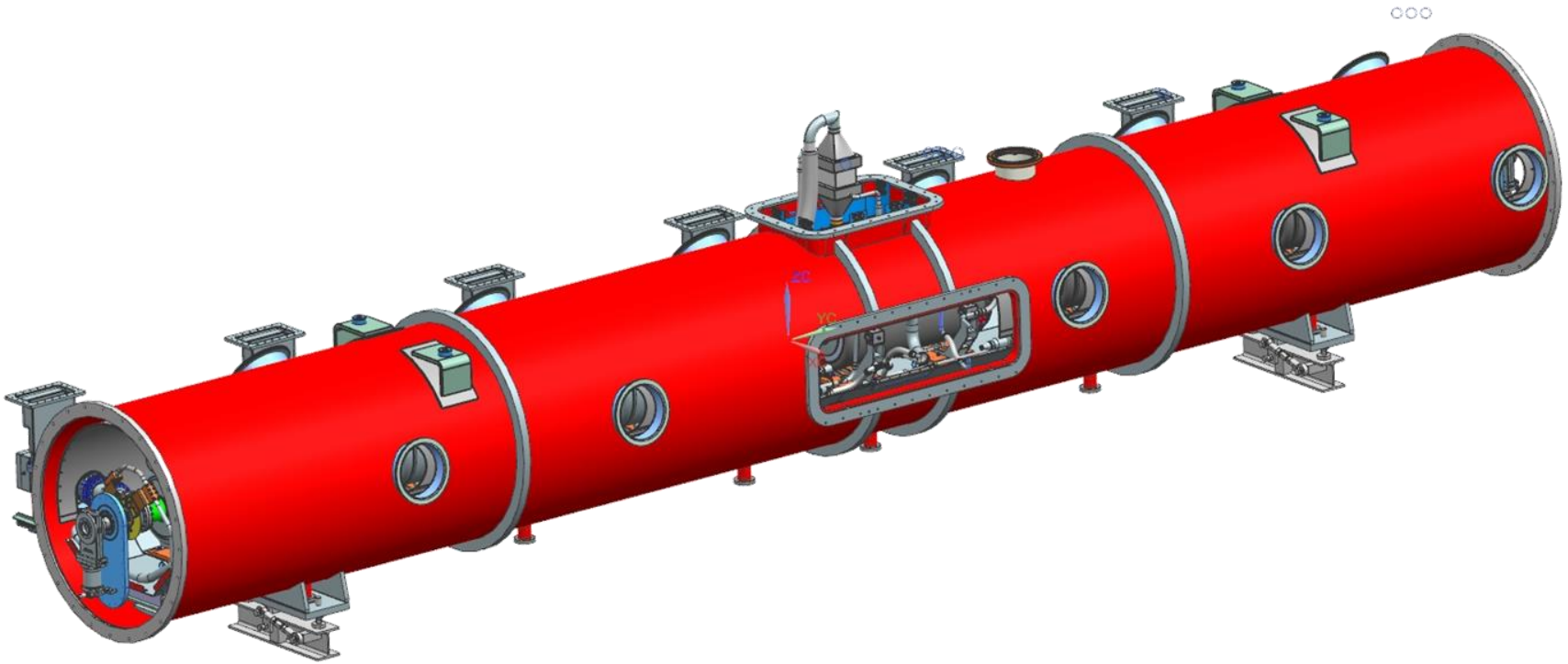

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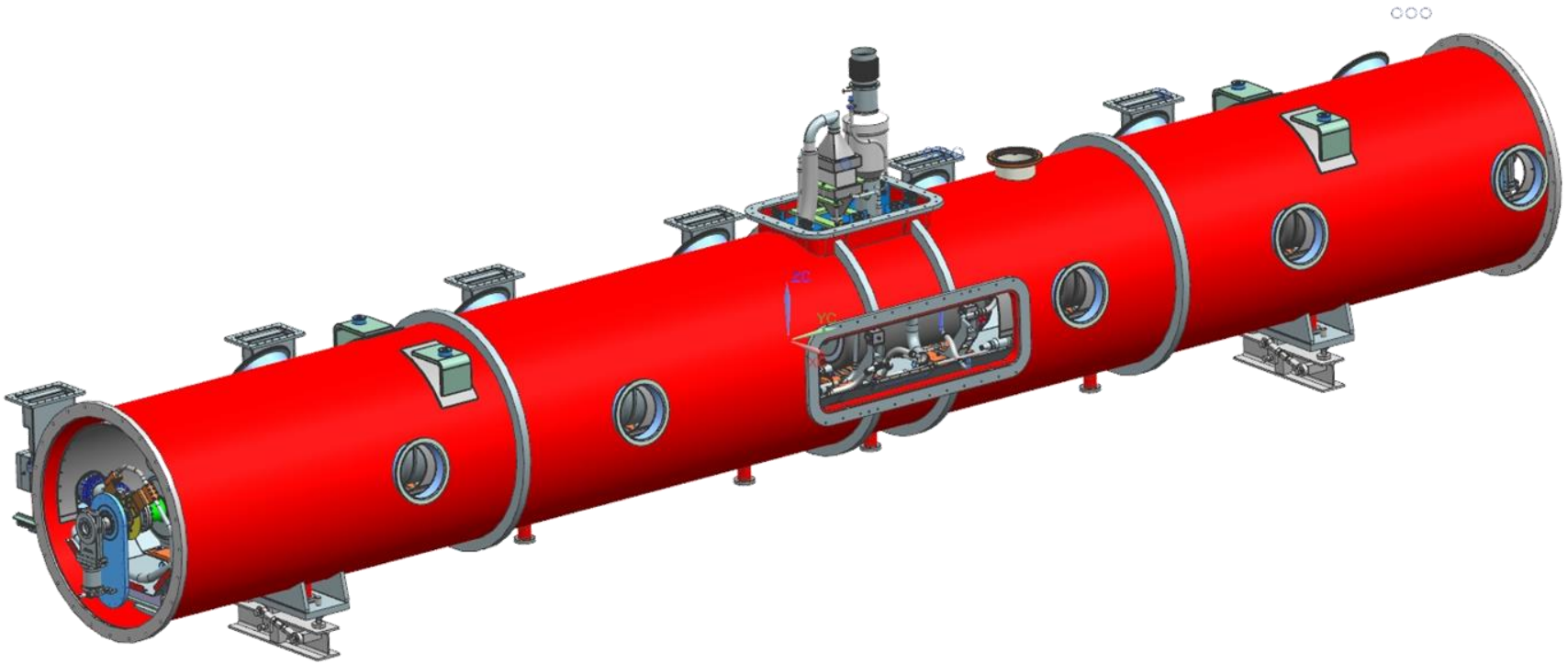

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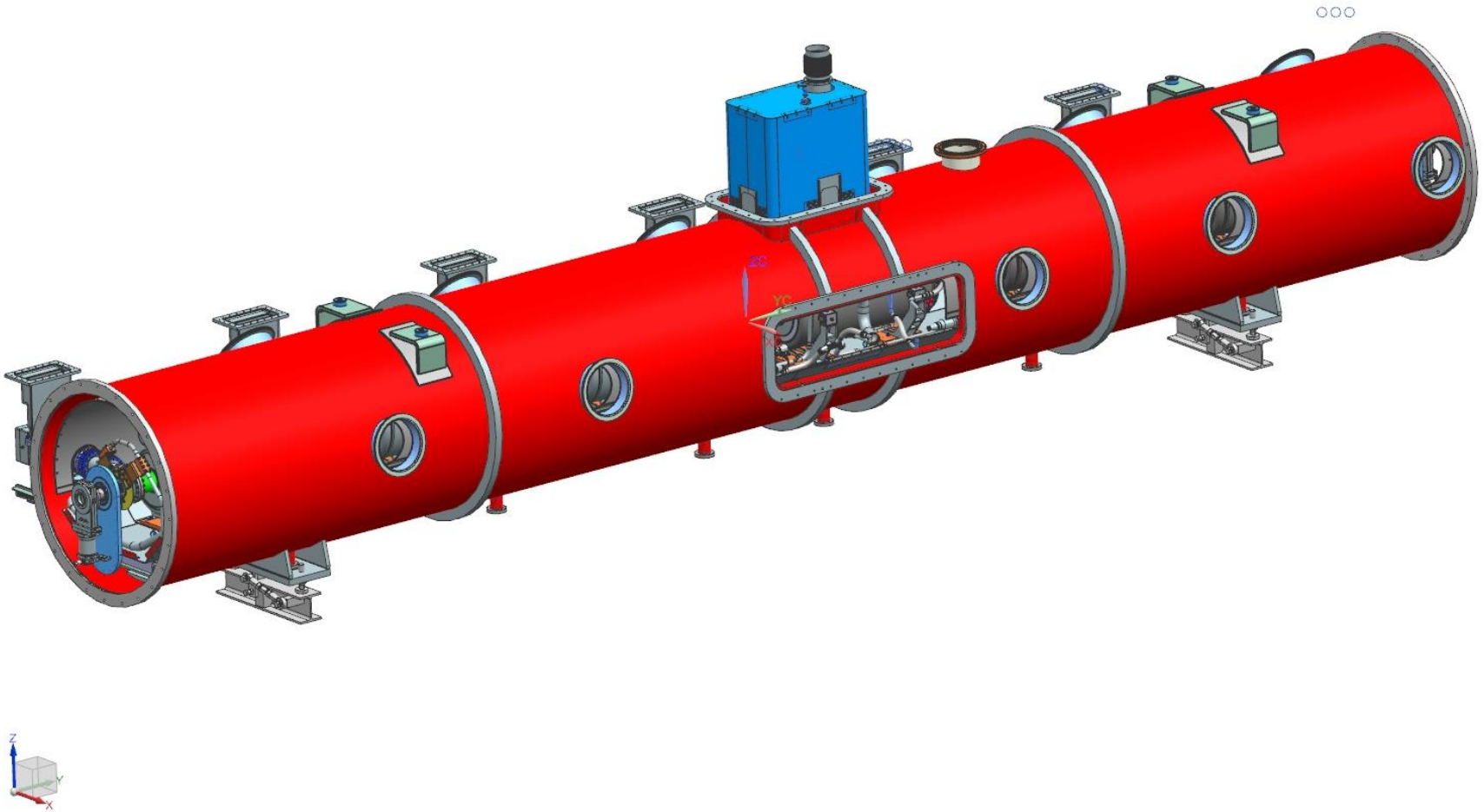

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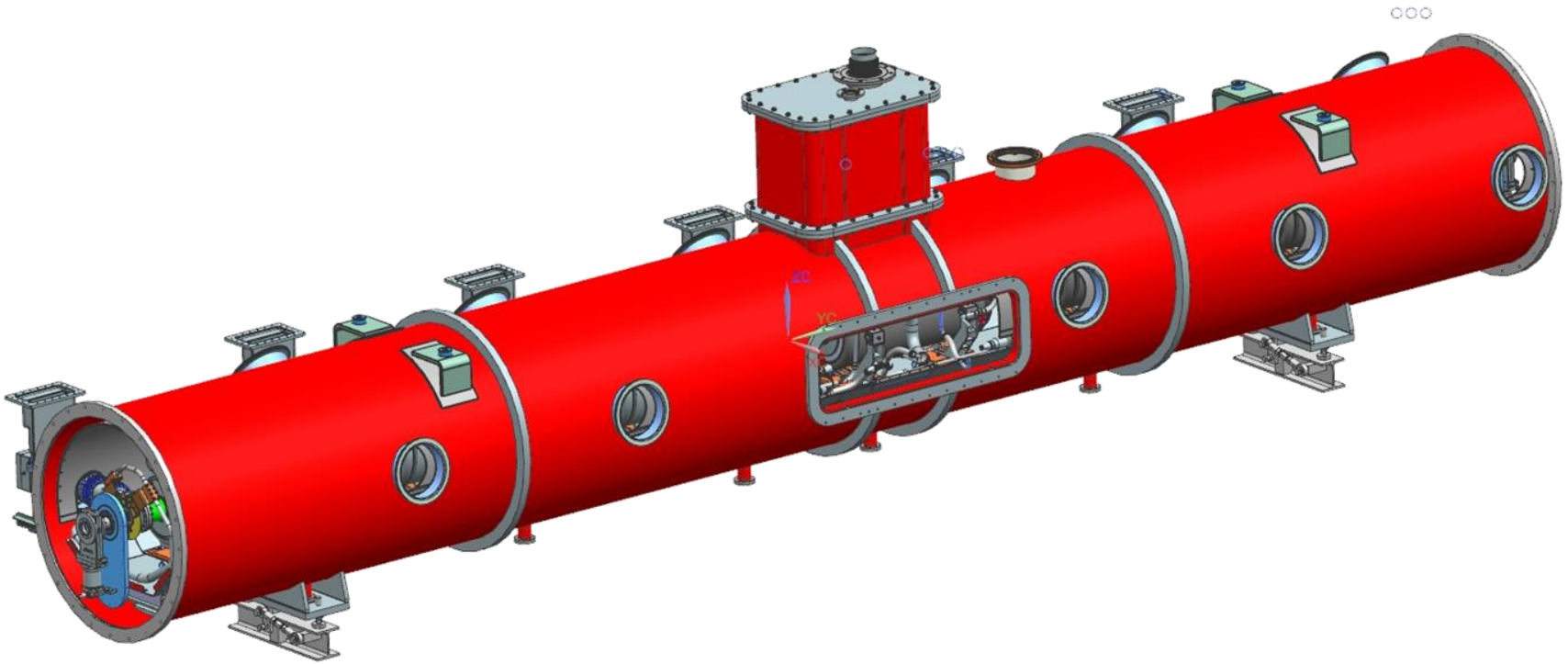

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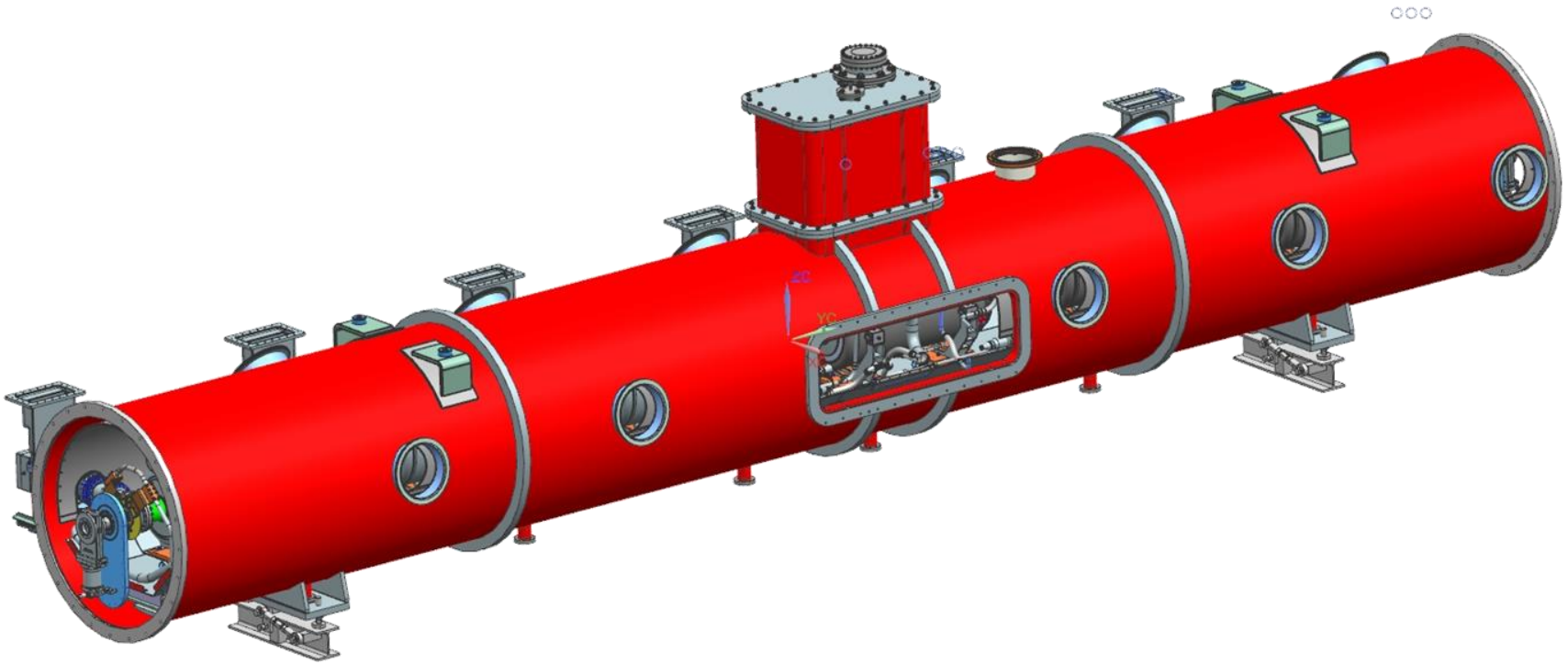

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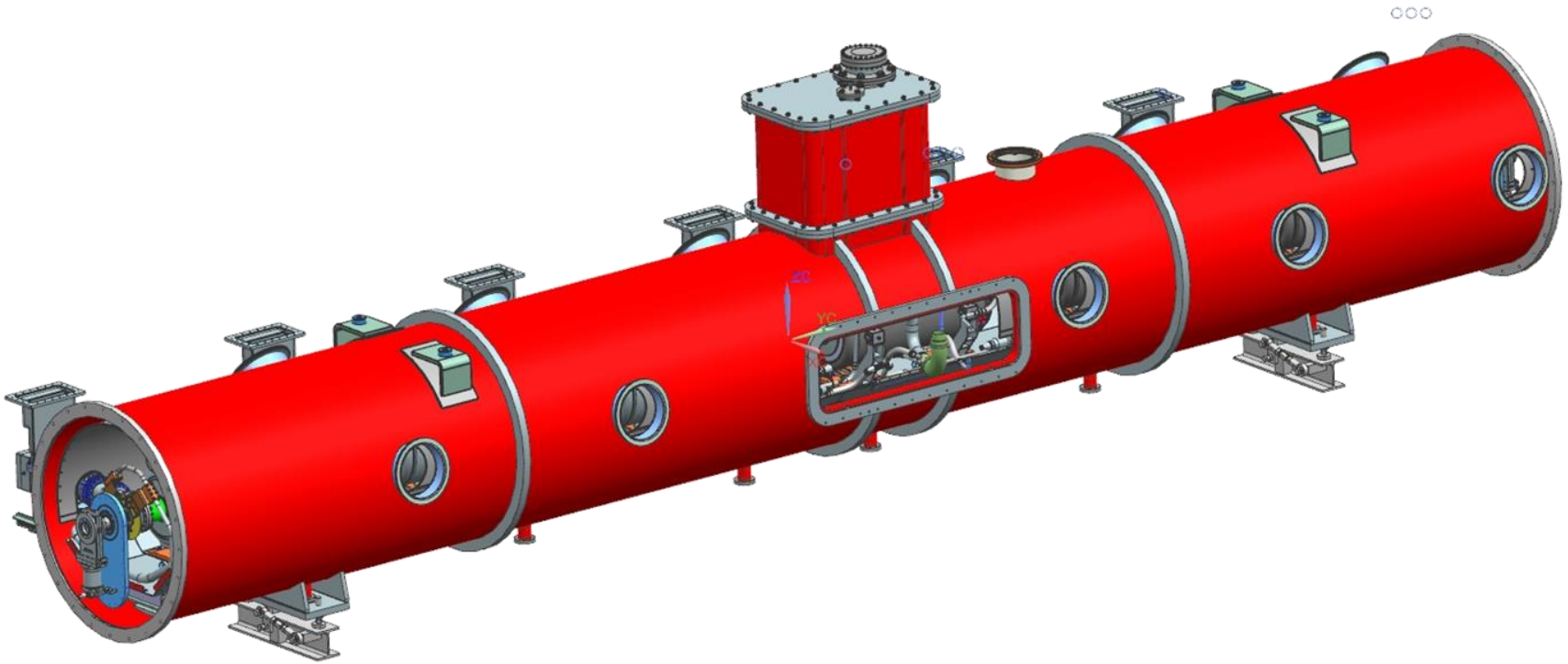

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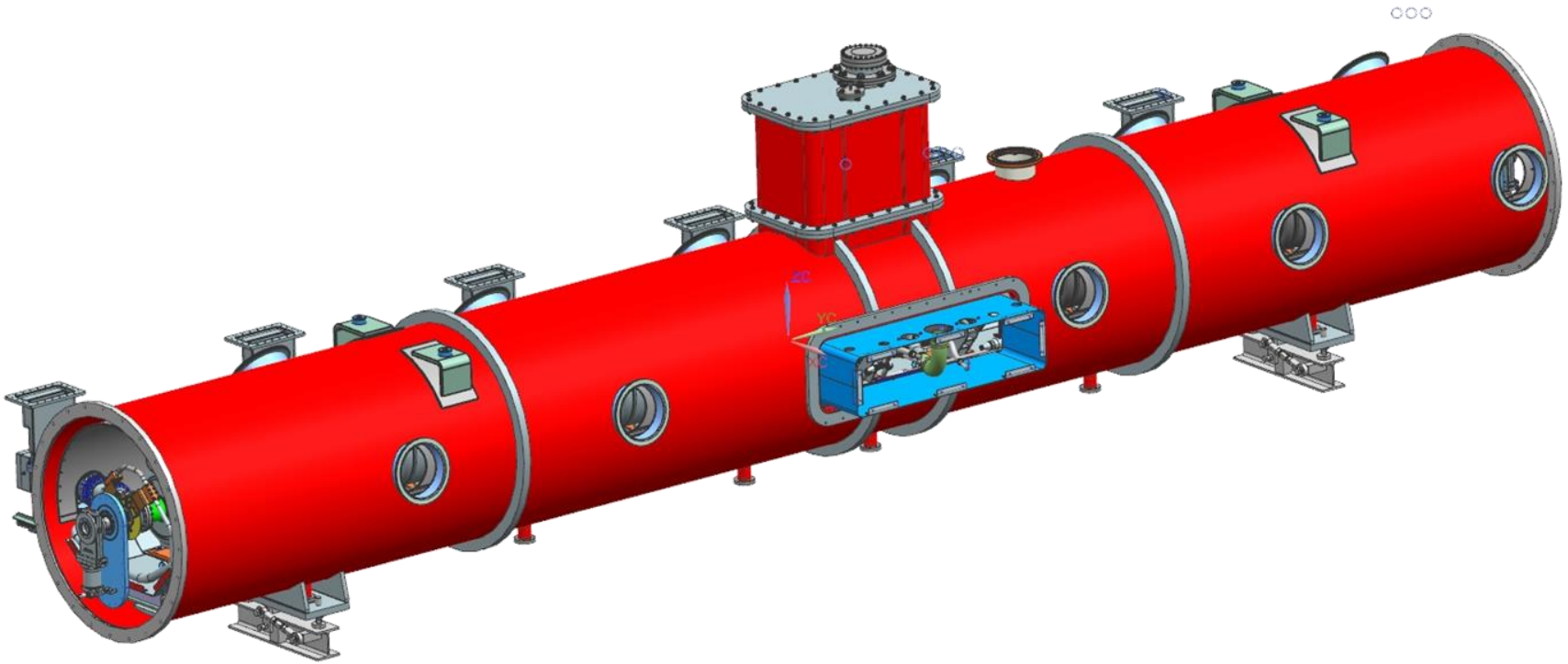

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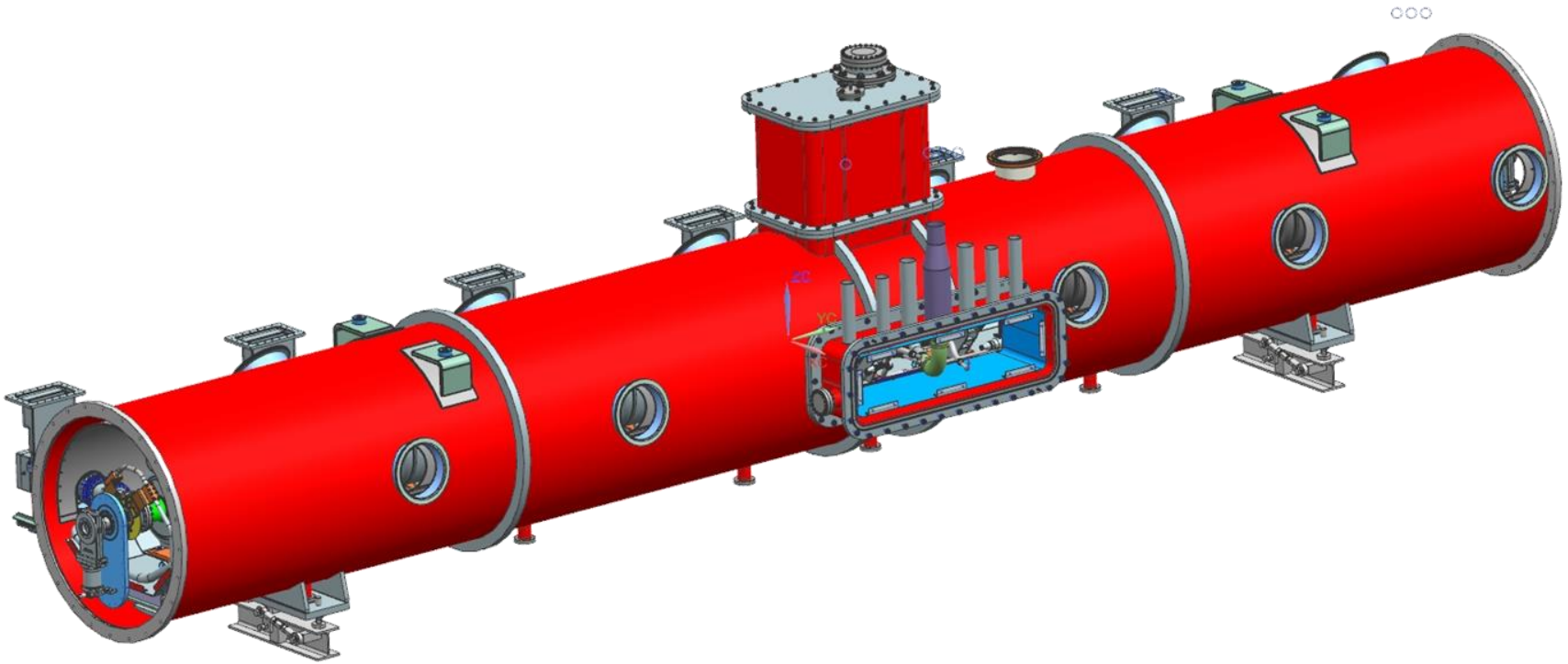

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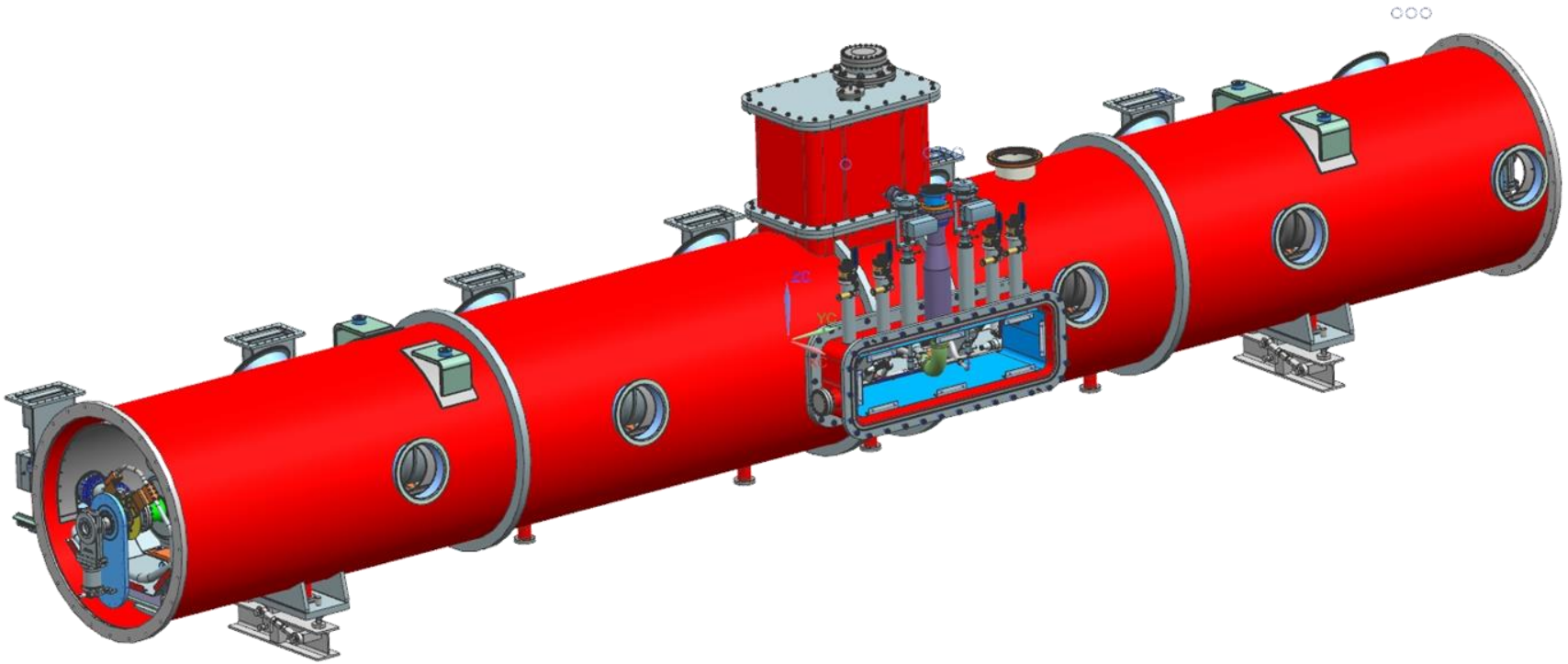

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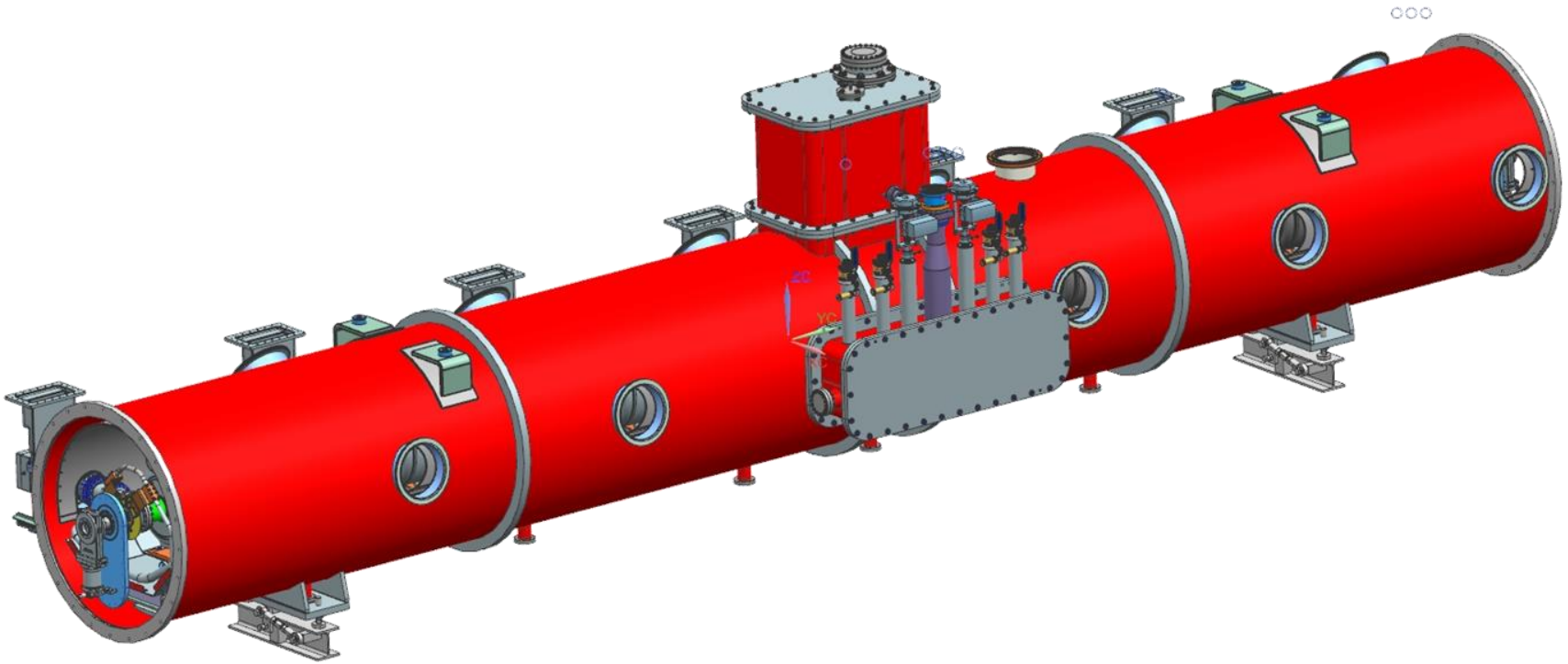

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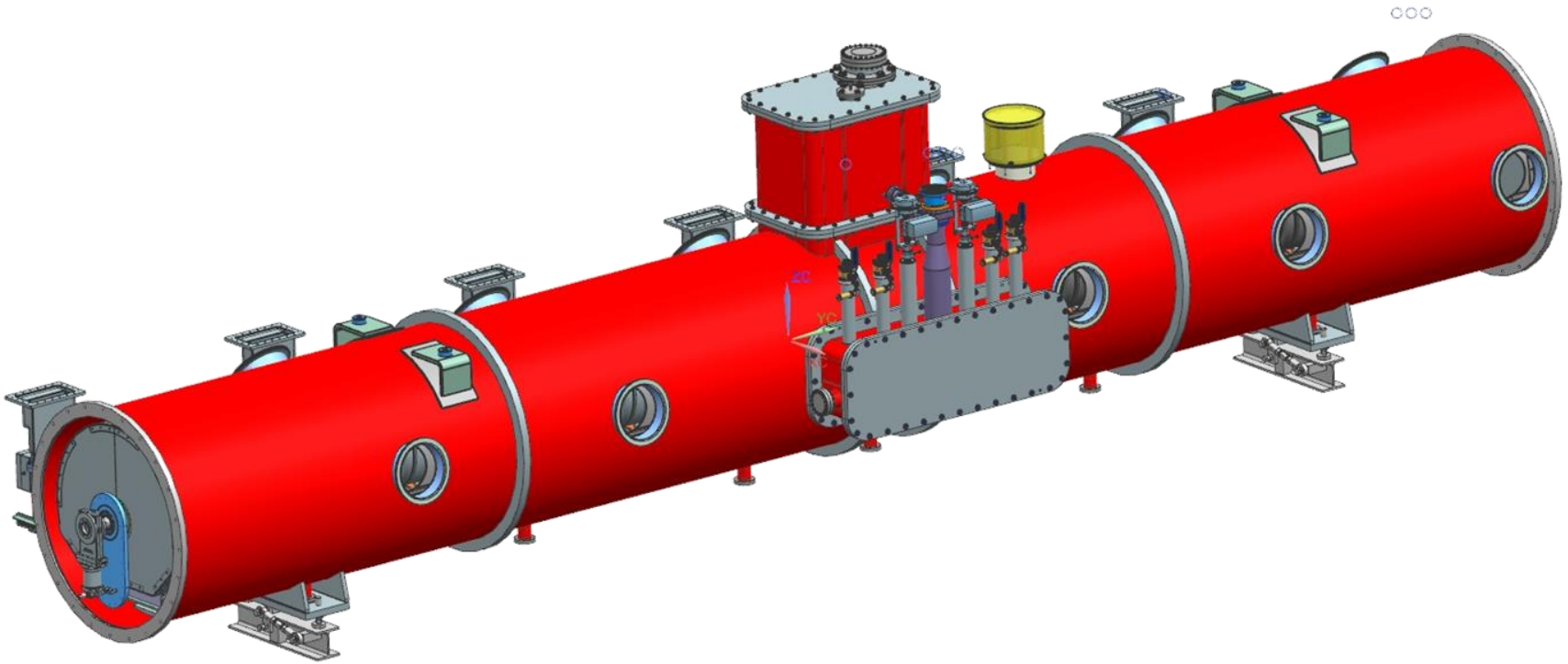

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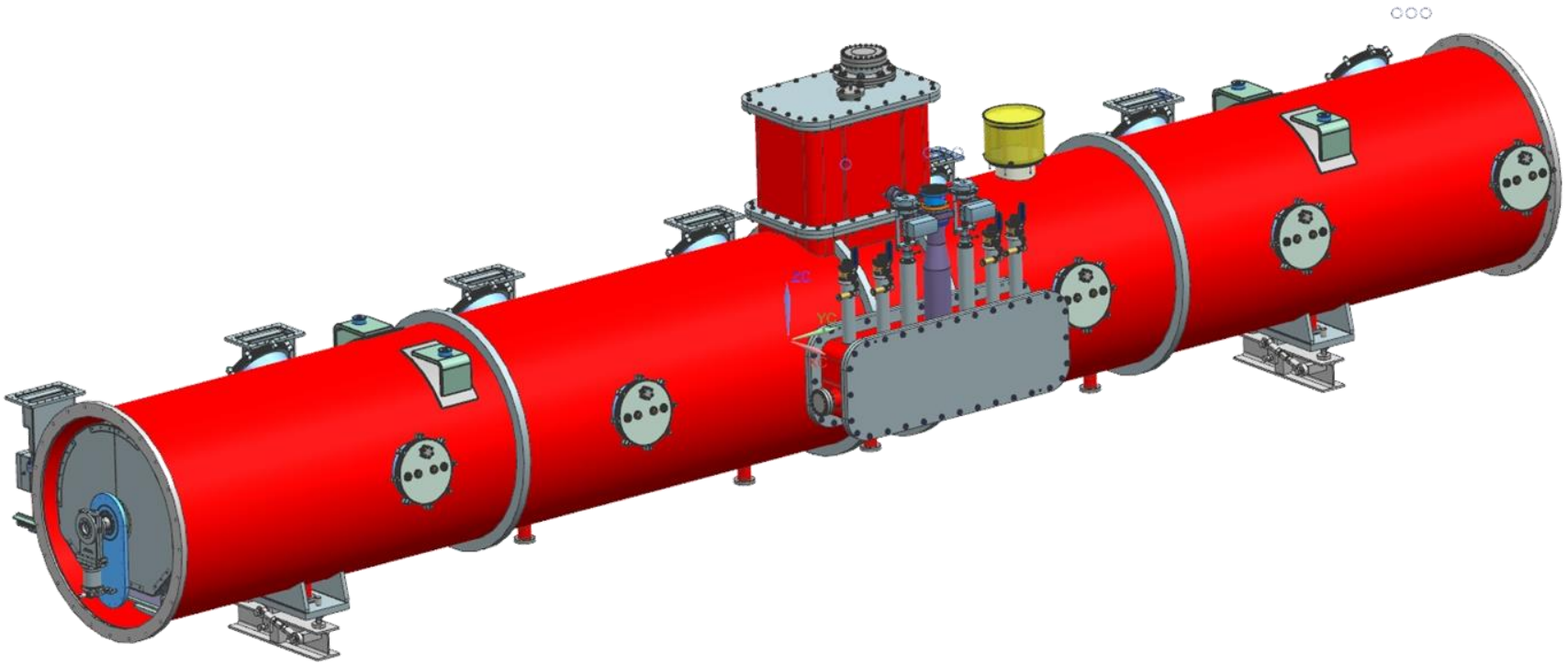

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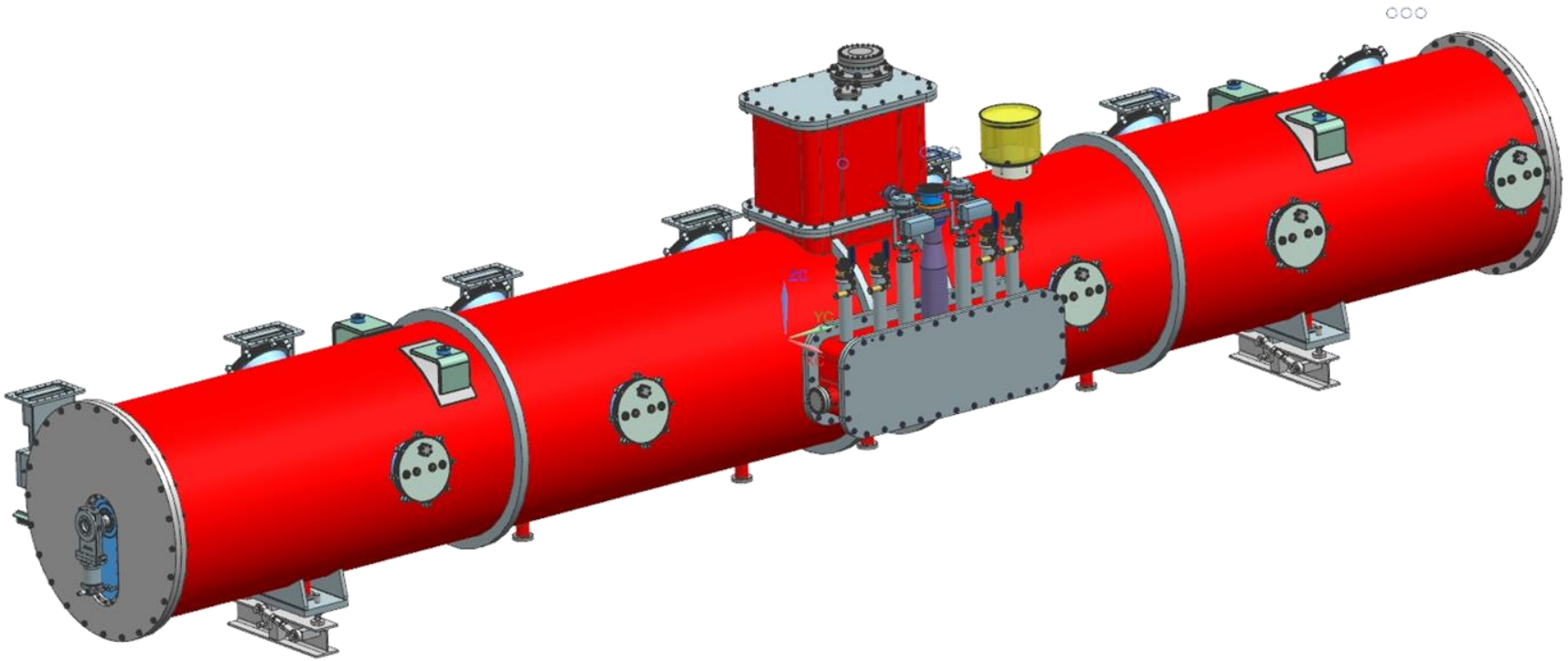

5. Instrumentation

- The instrumentation will be very similar to what has been done on SSR1 cryomodule.
- Having two ports for each tuner it is possible to split the instrumentation in order to have more room to do these connections.
- On the top of the cryomodule, two pressure transducers will read the pressure in side the two phase helium pipe.