Elettra Sincrotrone Trieste

Superconducting devices and cryogenics in Elettra & Elettra 2.0

Outline:

- Elettra Sincrotrone Trieste Cryogenic Team
- Superconducting devices in Elettra
- Main cryogenic issues faced
- New Superconducting devices foreseen for Elettra 2.0
- Summary

Elettra Sincrotrone Trieste Cryogenic Team

- The team is composed by 4 persons: F.Lauro, D.Millo, M.Modica, P.Zupancich.

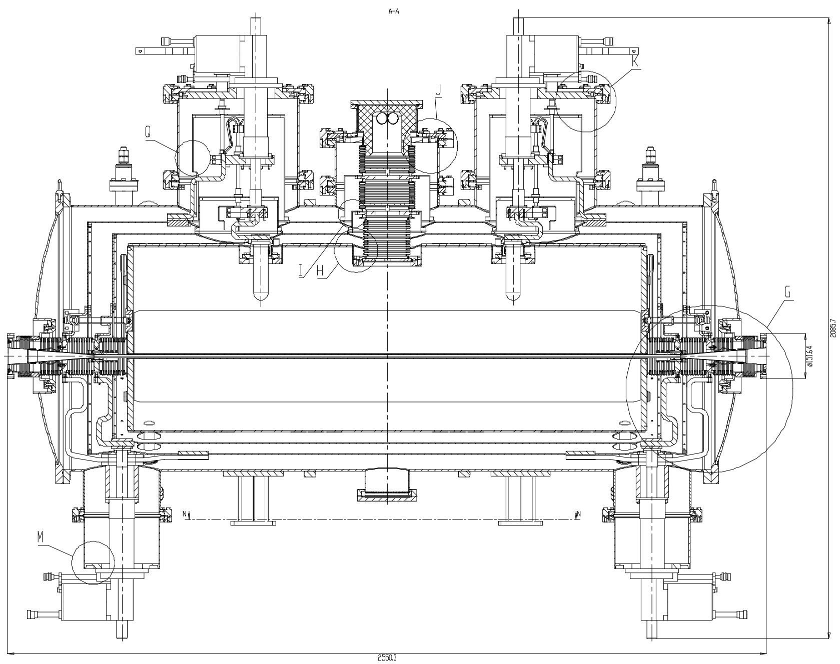
- F.Lauro, D.Millo and P.Zupancich are employed since long time in Elettra and they have experience with the Elettra cryogenic devices.

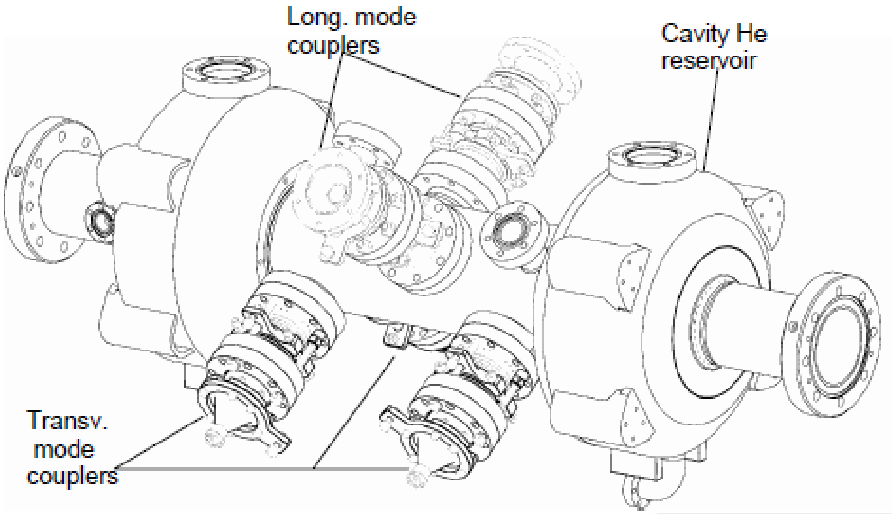
- I Joined Elettra Sincrotrone Trieste in June 2021, after 20 years spent in cryogenic & SC lab of ASG Superconductors S.p.a. as responsible of field engineers and cryogenic lab.

Superconducting devices in Elettra

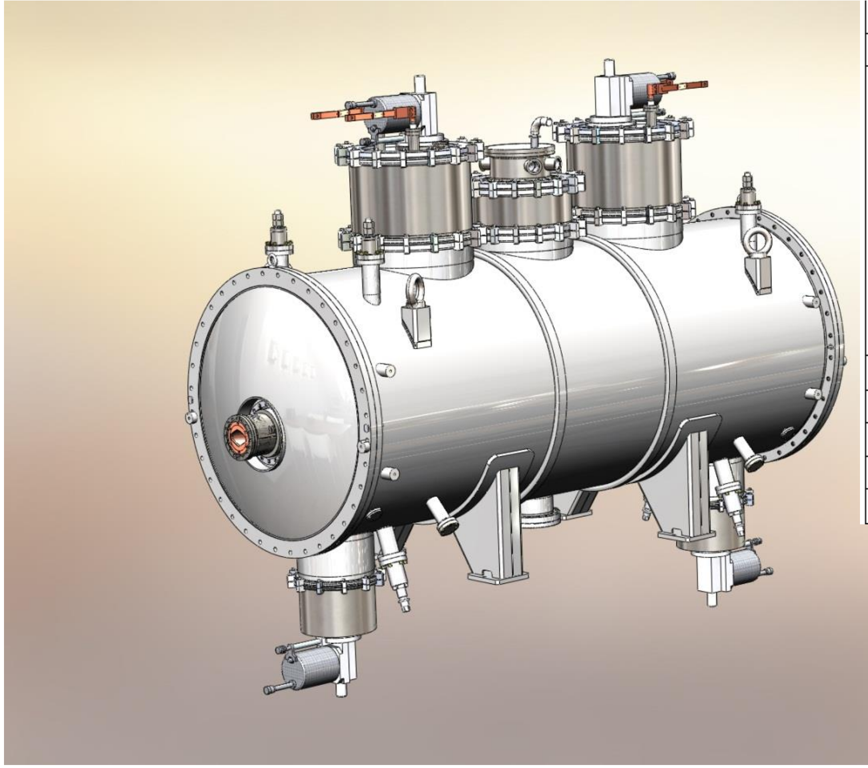
Currently Elettra Sinctrone Trieste has 2 SC system:

- 3.5T SC Wiggler
- 3HC SC Cavity





3.5T SC Wiggler



Field direction	Vertical
Field structure	¼ -3/4, 1, -1, …..1, -3/4, 1/4
Main poles	
magnetic field	3.5 T
number of poles	45
¾poles	
magnetic field	2.7 T
number of poles	2
¼poles	
magnetic field	0.9 T
number of poles	2
Transverse field homogeneity	$\Delta B/B < 5*10^{-3}$ at $x=\pm 1$ cm
Pole gap	16.5 mm
Period length	64 mm
Stored energy	240 kJ
Working temperature	4.2 K

The SC Wiggler has been designed and built by B.I.N.P.(Novosibirsk) and installed in Elettra in 2003, then refurbished in 2013 and 2017.

3.5T SC Wiggler

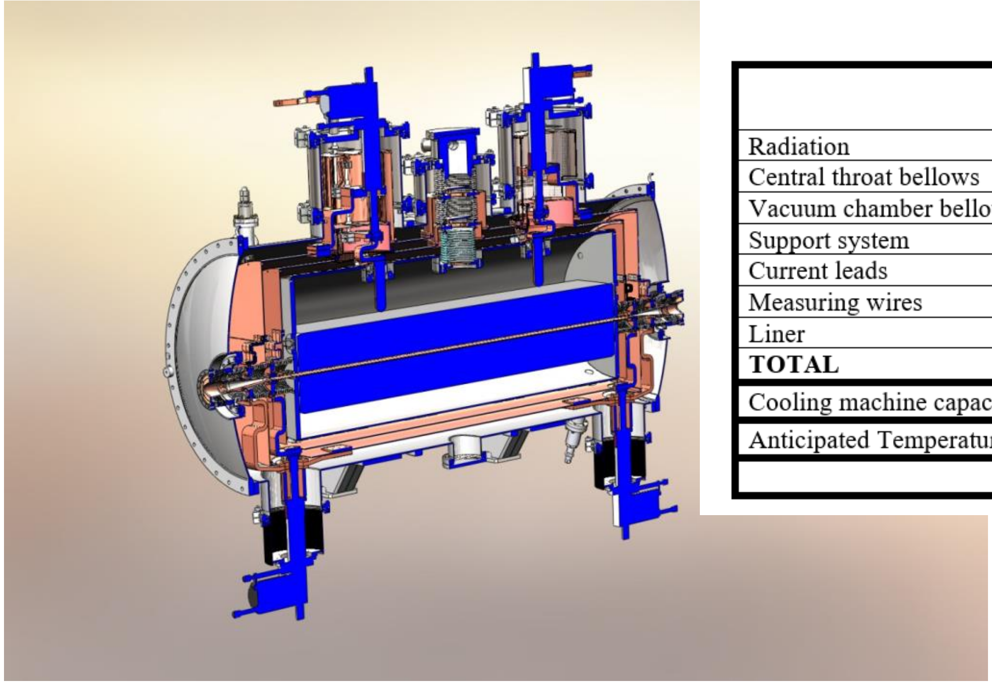
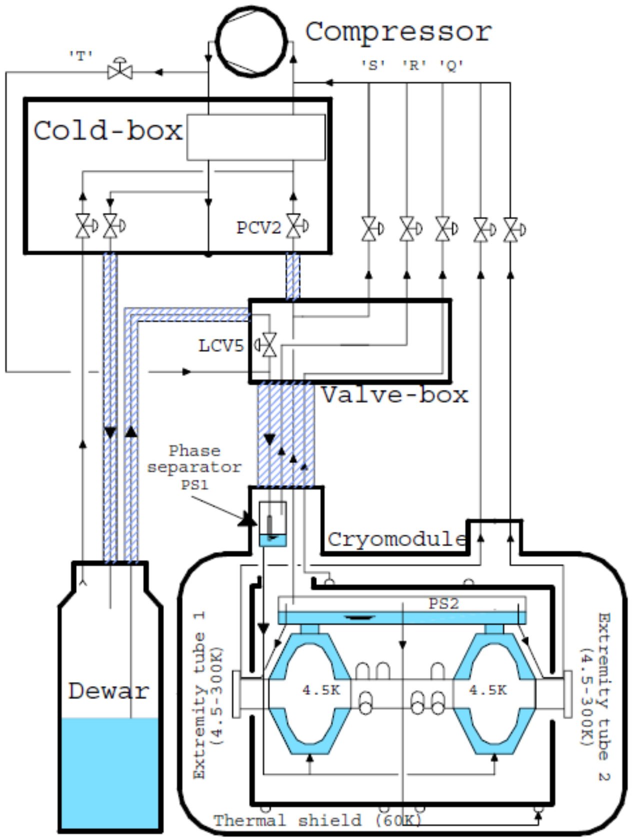


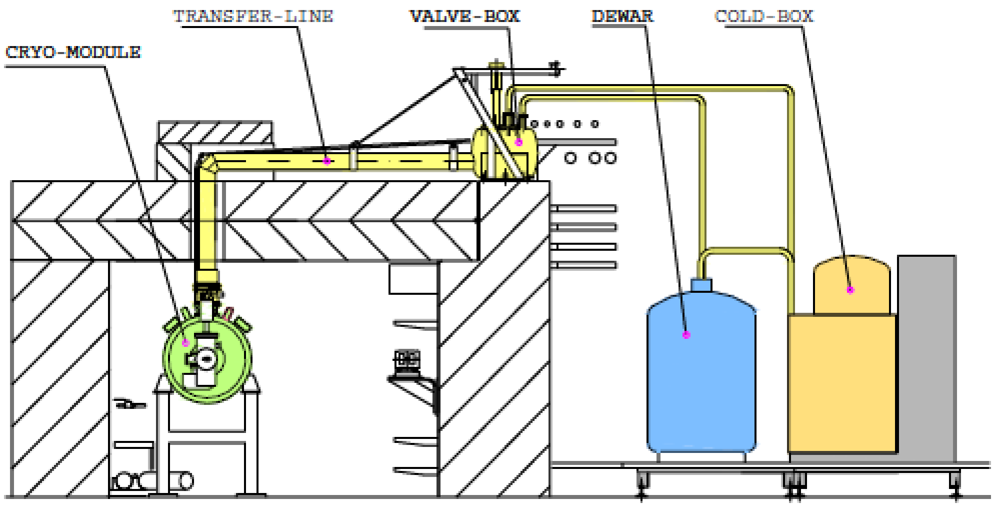
Table 3 Heat in-leak estimation

	First 60K shield screen, Watt	Second 20K shield screen, Watt	LHe tank 4.2K, Watt
Radiation	11.4	0.16	0.0001
Central throat bellows	2.5	0.22	0.06
Vacuum chamber bellows	5.5	0.18	0.04
Support system	0.55	0.1	0.01
Current leads	110	0	0.6
Measuring wires	1.6	0.1	0.01
Liner	0	10 (image currents)	0.2
TOTAL	**131.55**	**10.76**	**0.9201**
Cooling machine capacity	**210**	**25**	**2**
Anticipated Temperature, K	**<50**	**12.7**	**4**

- ❖ It is a zero boil off magnet with working temperature @ 3,9K
- ❖ It is foreseen an extraordianary maintentance to swap from Leybold cold heads to Sumitomo cold head, for obsolescence (2023)

3HC SC cavity





The cryomoudule is equipped with Air Liquide Helial 1000 refrigerator and Kaeser compressor

3HC SC cavity: Air Liquide Helial 1000

3HC thermal loads

Components	Load	Comments
2 RF cells	22 W	Directly in LHe bath
2 L-couplers	3 W	Cooled by conduction
4 T-couplers	8.5 W	Cooled by conduction
2 Extremity tubes	0.2 W	With 2×0.05 g/s cold GHe
Cryomodule static losses	5.1 W	With 0.071 g/s cold GHe in thermal shield (60 K)
Cryo-lines	6.5 W	Assuming 0.5 W/m load
Total refrigeration power at 4.5 K: 45.3 W		
Total warm GHe return: 0.171 g/s → 5.2 l/h of liquefaction		

Cryogenic performances Helial 1000

Performances	Guaranteed	Design	Measures
Liquefaction mode without LN2 precooling with LN2 precooling	**32,61 l/h** **63 l/h**	**34,2 l/h** **66 l/h**	
Mixed mode (refrigeration + liquefaction)	**107** W and **7,6** l/h	**112** W and **8** l/h	

In mixed mode we have:

- 58% of operating margin in refrigeration
- 32% of operating margin in liquefaction

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Main cryogenic issues faced

3 main iussues have been faced:

- ❖ Turbine low efficency (cold box)
- ❖ Warm helium return lines valves (cryomodule)
- ❖ Air contamination (compressor)

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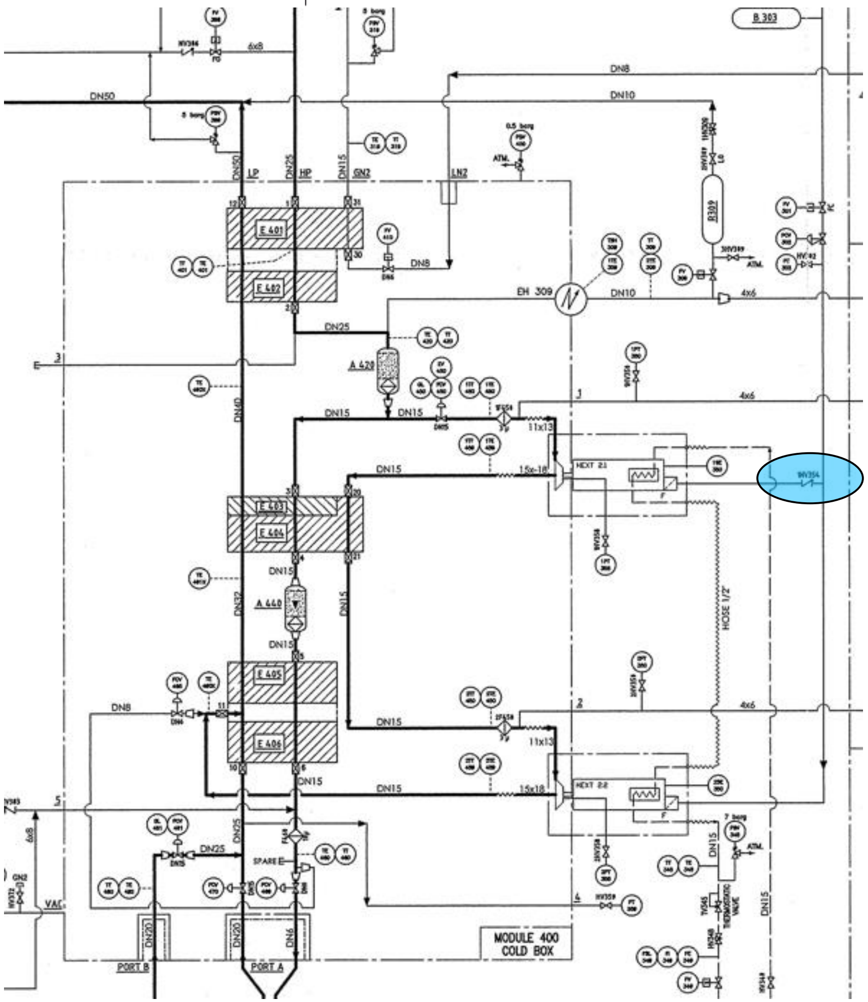
Turbine low efficency



The power refrigeration and the liquefaction rate decreased and it was not enough to keep the required helium level in the cryomodule.
We observed air condensation on the turbine and abnormal behaviour of the pressure in the turbine helium line.

- Internal Leak in check valve 1nv354

<u>Thanks Christian Geiselhart(PSI),</u>
we understood the problem and solve it, only chaninging the valve.(easy to do but difficult to understand!!!)

CERTIFIED MANAGEMENT SYSTEM CQY CERTIQUALITY UNI EN ISO 9001:2015 UNI ISO 45001:2018

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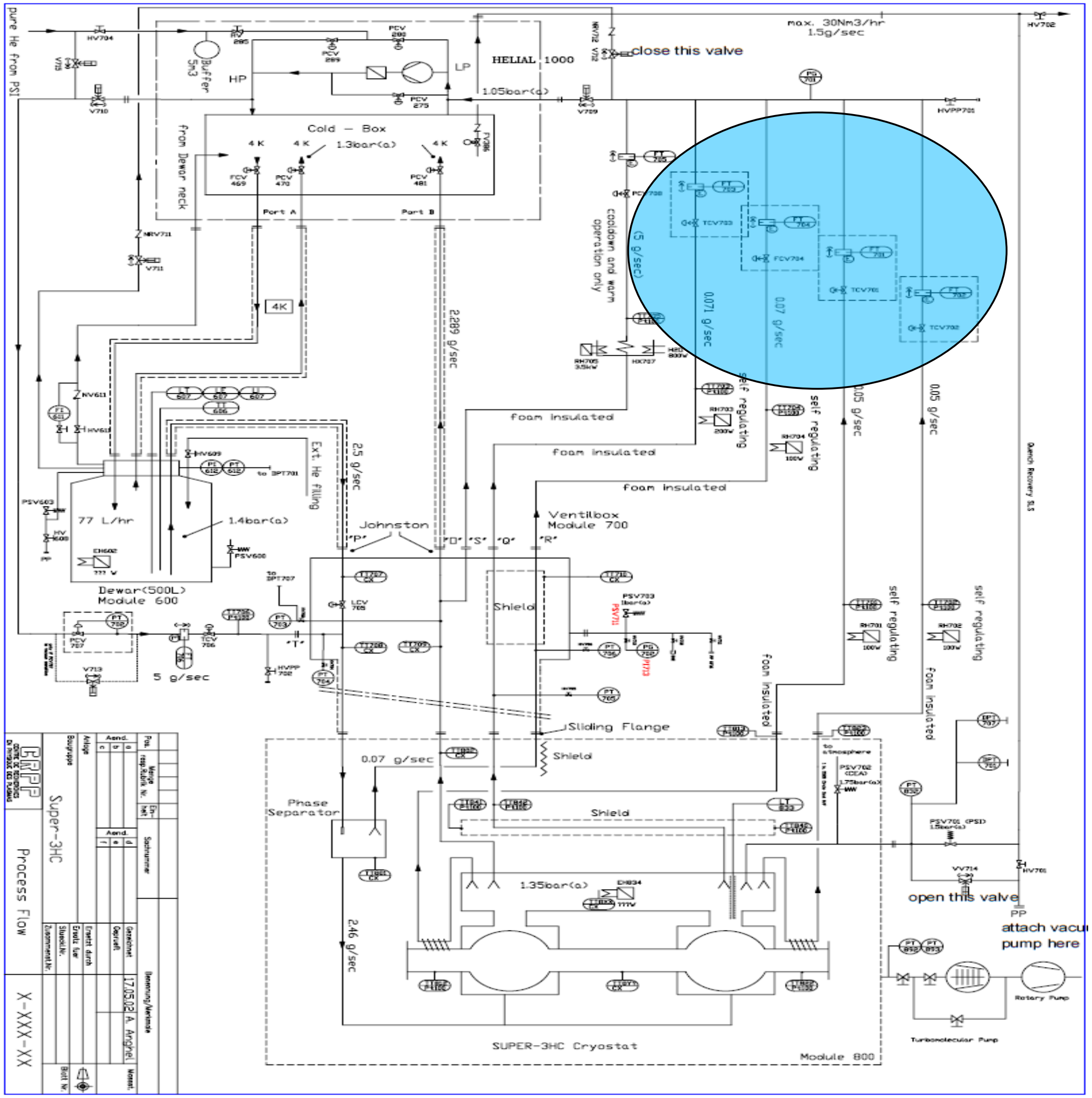
Warm helium return valve control

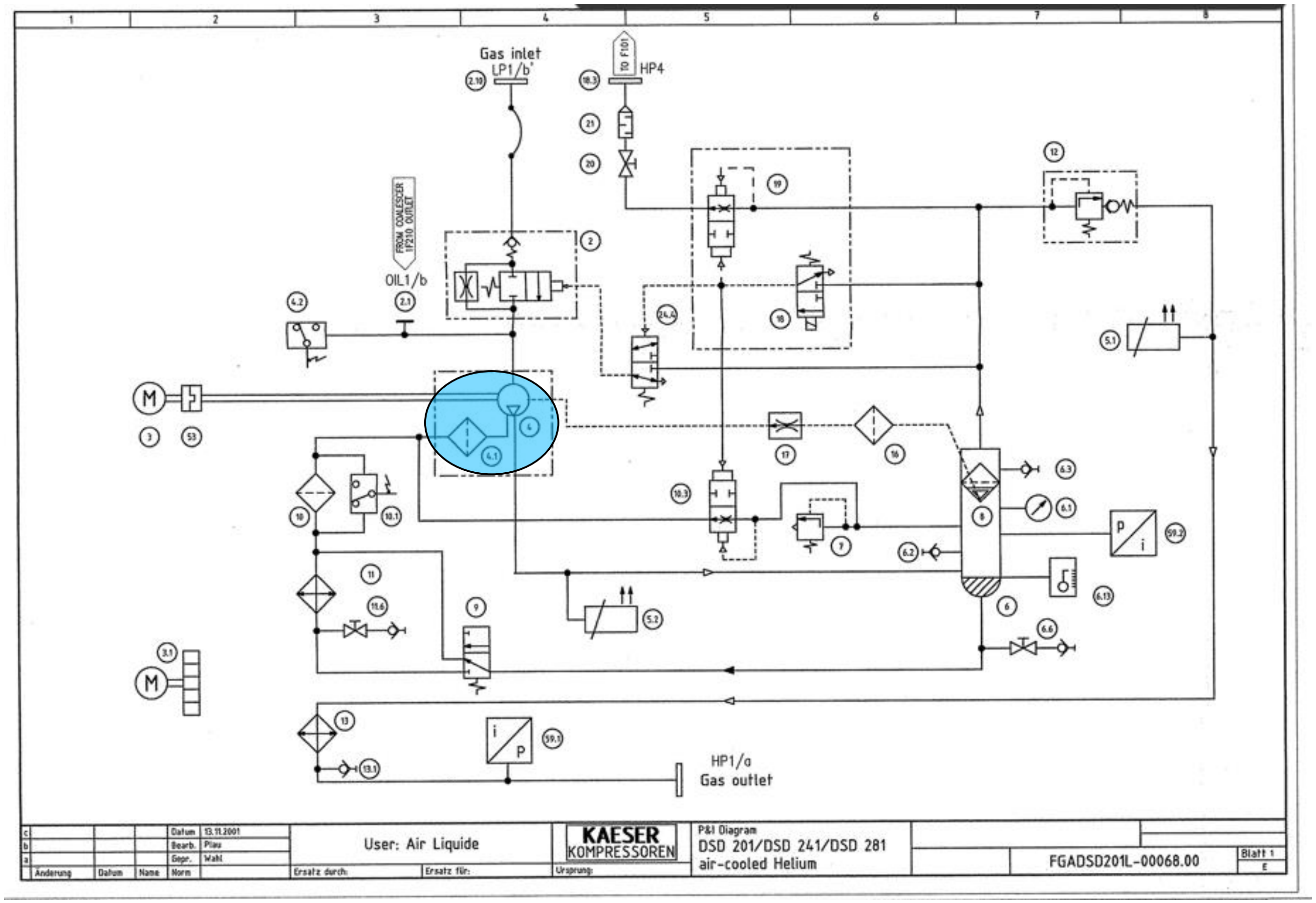


Remote control of valves did not work properly, we found the valve fully open with ice in the piping the He buffer in overpressure(13,5bar) and the dewar empty. The System stopped the cold box for major failure.

Now we are controlling the valves in manual mode and next shutdown we will install a bypass line with a manual valve .We already changed one valve with a new one (cold box cold; cavity warm.)

Air contamination

Air contamintation in the compressor. In particualr it has been found a leak in between the screw group and the motor. It has been necessary to change not oly the gasket, but also all the filtering system in ORS. (2019)



Future of Helial 1000

- Now even if with some home made adjustment, the system is working properly: the liquefaction rate is 33 L/h.

- During the darktime for the commissiong of Elettra 2.0 it is foreseen an upgrade of the control system and a major maintenance/replacement of all the warm valves.

- It is planned to modify the neck of the dewar in order to be able to take some LHe.

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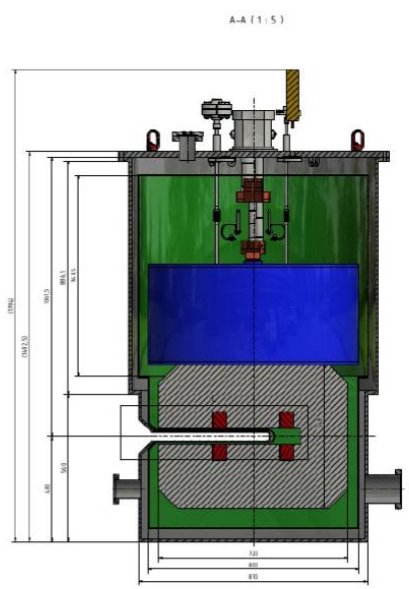
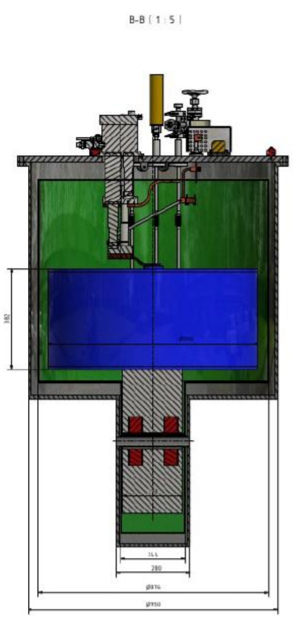
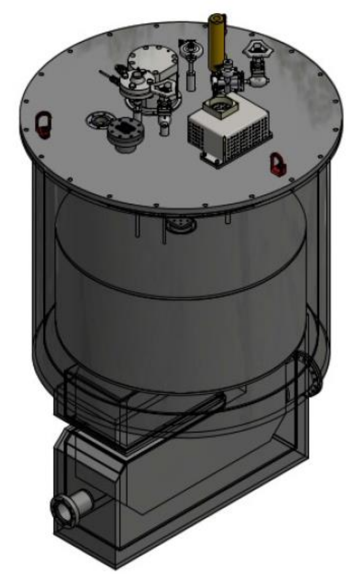
Elettra 2.0 SC devices: Superbends

In the Elettra 2.0 project , it is foreseen to install 3 Supebends magnet in 2026 (the delivery for the SAT will be in 2025)

The cooling system probablily will be a He tank with cryohead(s). The system is conduction cooled (the expected working temperature is between 3,5K and 4K). The vacuum vessel will be C shaped in order to install the SB in the ring without touching the beam line.







Elettra 2.0 SC devices: crab cavities

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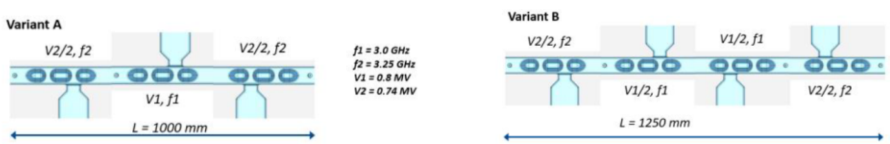
It is foreseen to install 3 or 4 deflecting cavity inserted in 1 cryomodule

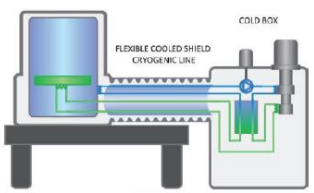
Crab cavity : Cryogenic loads

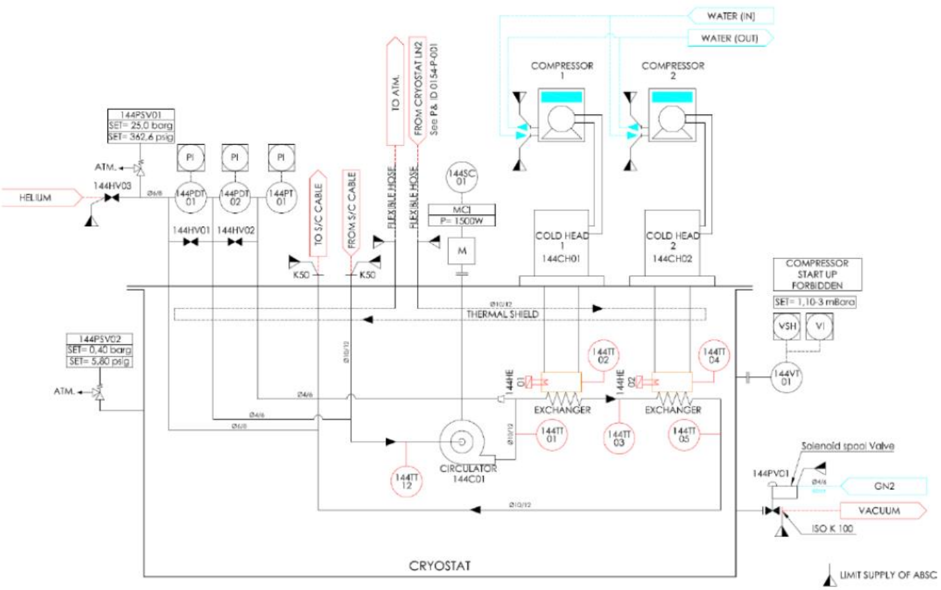


Temperature Operating	Total Cryogenic Loss (A/B), W		
	Nb	Nitrogen-doped Nb	Nb_3Sn
2 K	0.7 / **1.2**	0.3 / 0.6	N/A
4 K	5.2 / **9.0**	N/A	0.6 / **0.7**

thermal load@60K[W]	
thermal shield	3
tie rod	1
cabling and sensors	0,1
tot.	**4,1**

Due to the low thermal load a possible way to cool it is usign a **remote cooling helium system** or usigin the extra refrigeration power from the helial1000.





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Summary

- The cryogenic Elettra team has been presented
- We talk about the main cryogenic problems faced and how we solved it
- The current and future cryogenic devices of Elettra 2.0 have been showed

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Thank you for your attention!

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