

TUCAN

TRIUMF Ultra Cold
Advanced
Neutron source

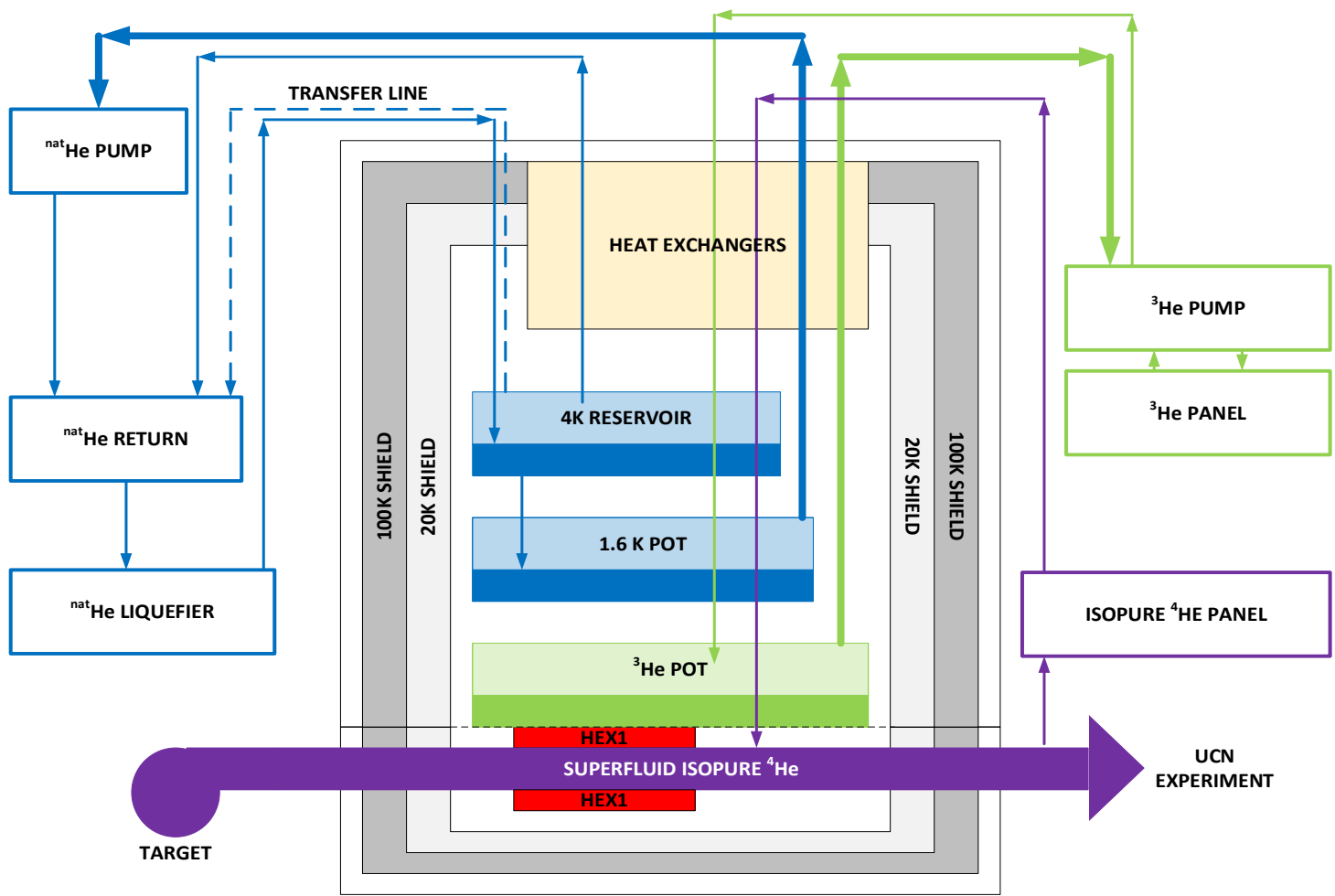
Cryogenic systems for the TUCAN source

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On behalf of the TUCAN collaboration

nEDM2023 - The 5th Workshop on Searches for a Neutron Electric Dipole Moment
November 7th, 2023

Keeping 27 liters of isopure Helium-4 at ~1.1K under 10-Watt heat load

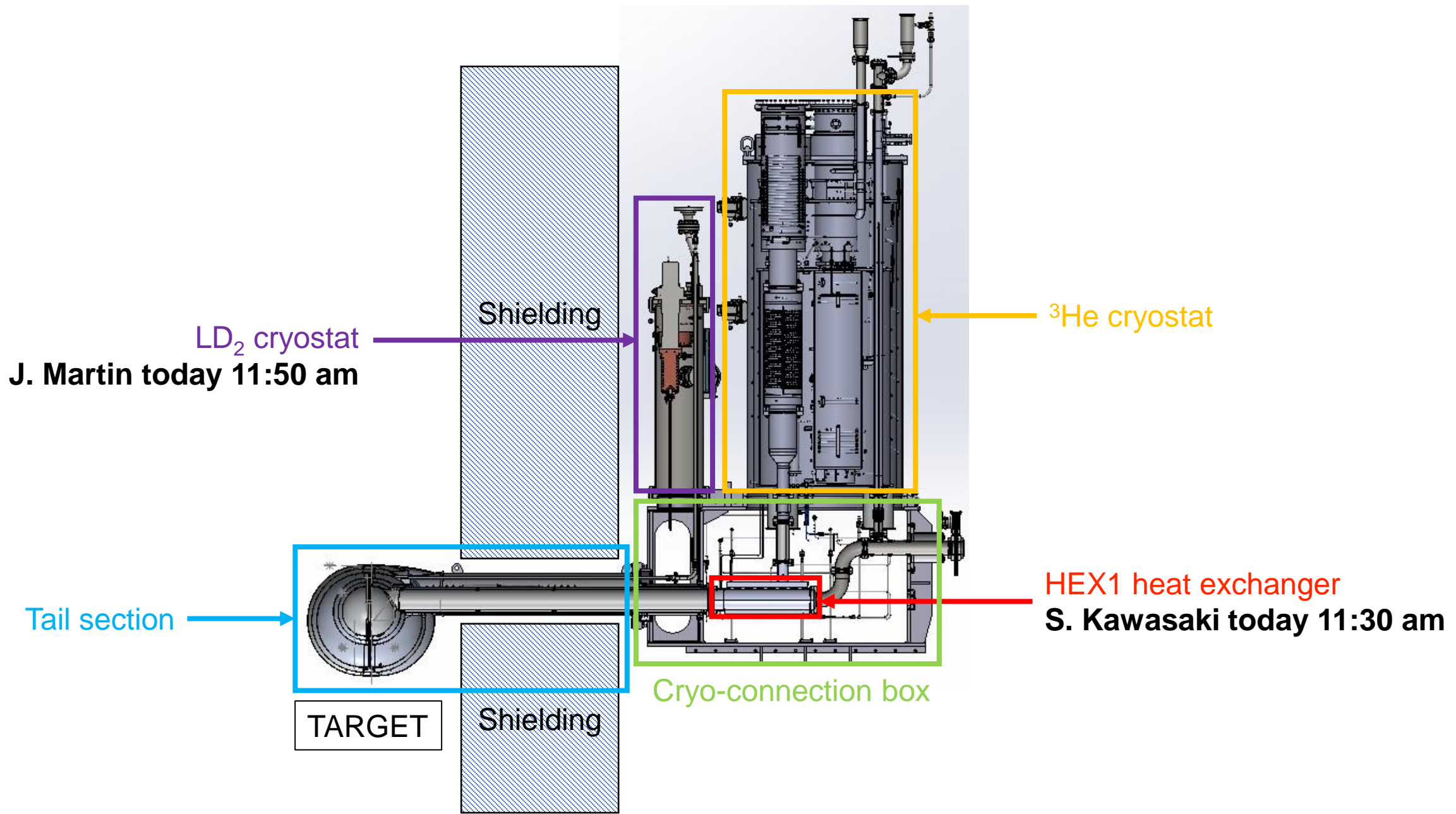


Three gases:

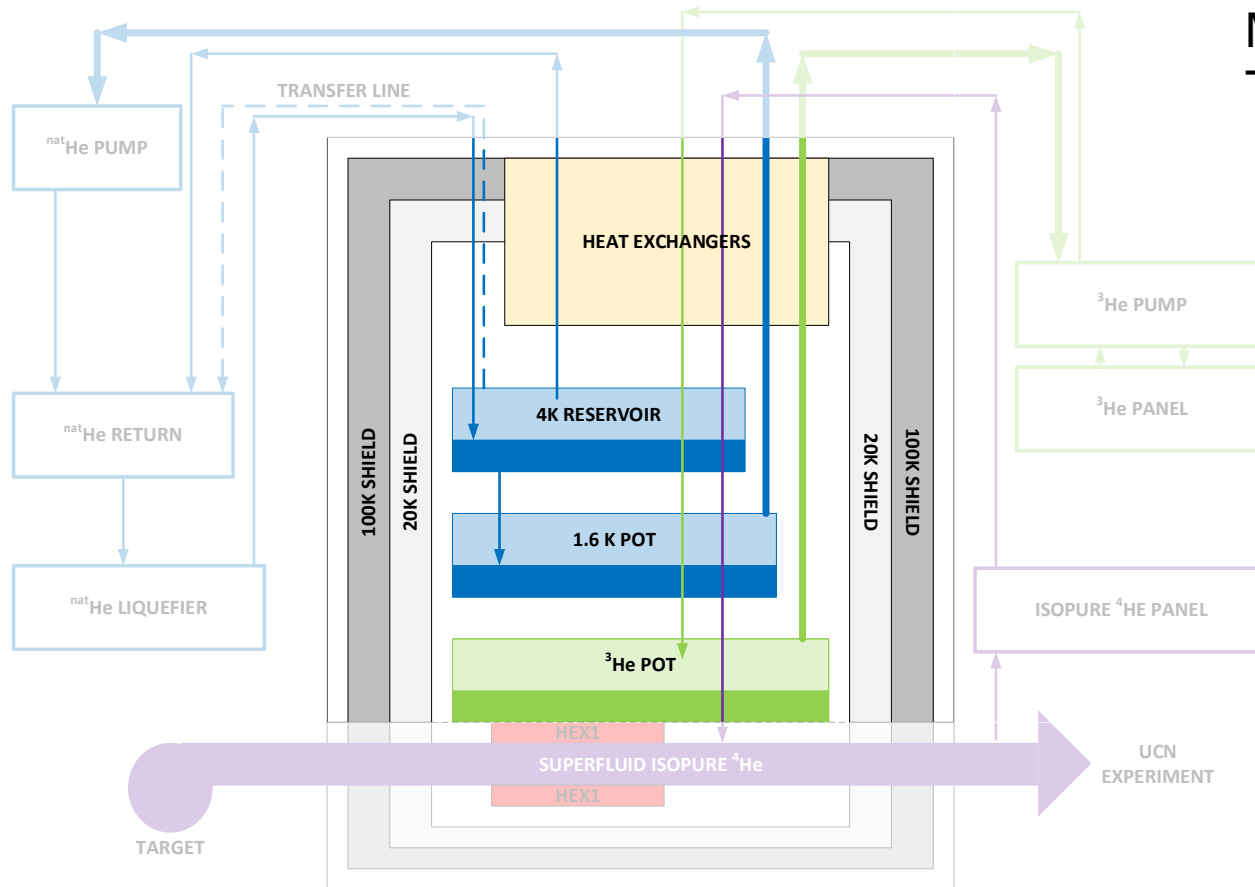
- Natural Helium
- Helium-3
- Isopure Helium-4

This challenge implies state-of-the-art:

- Cryostat
- ^{nat}He liquefier
- Liquid ^{nat}He transfer line
- Cryostat
- Heat exchanger
- Pump
- ^3He and ^4He gas handling
- ...



The Helium-3 cryostat



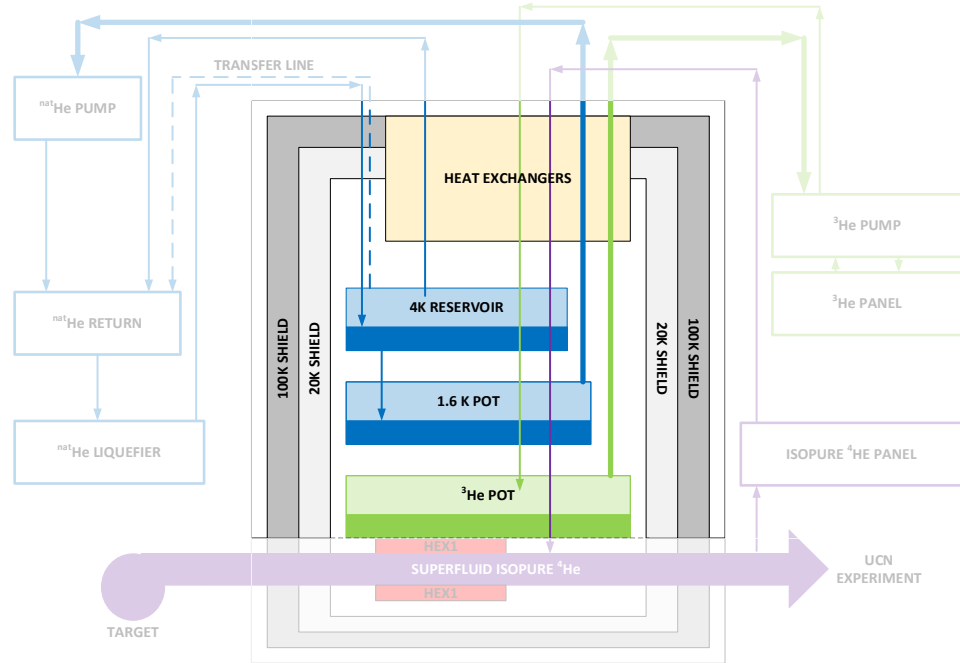
Made by [JECC Torisha](#) in Japan
 Tested at KEK in 2020 and shipped to TRIUMF



KEK Test

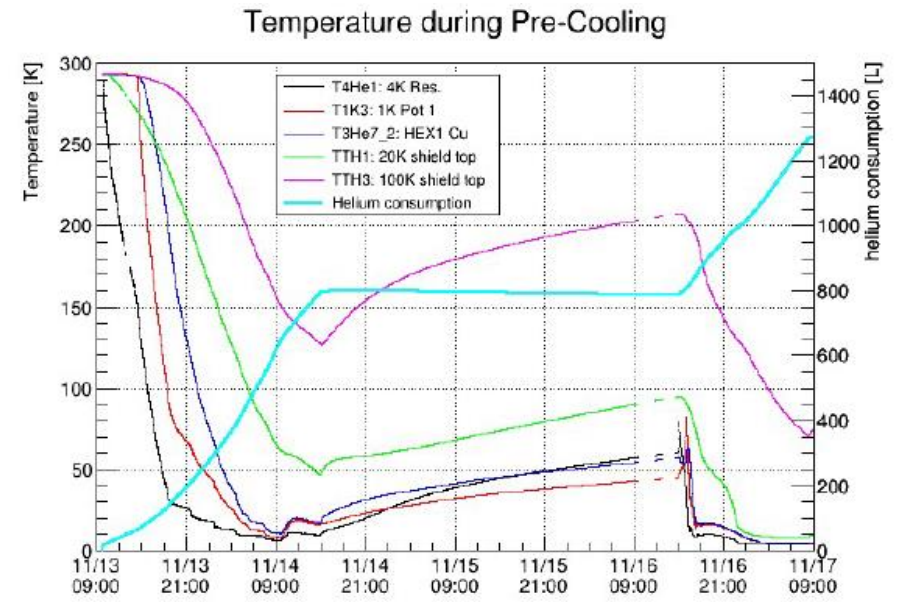
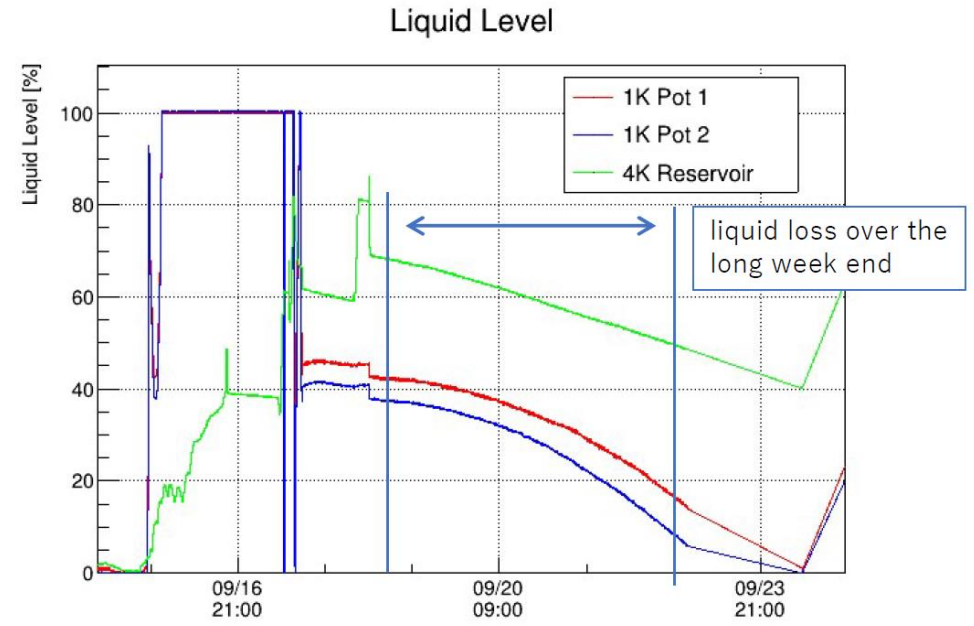
Initial tests were performed at KEK in 2021

2 days and 1000L of liquid Helium to start filling the 4K reservoir



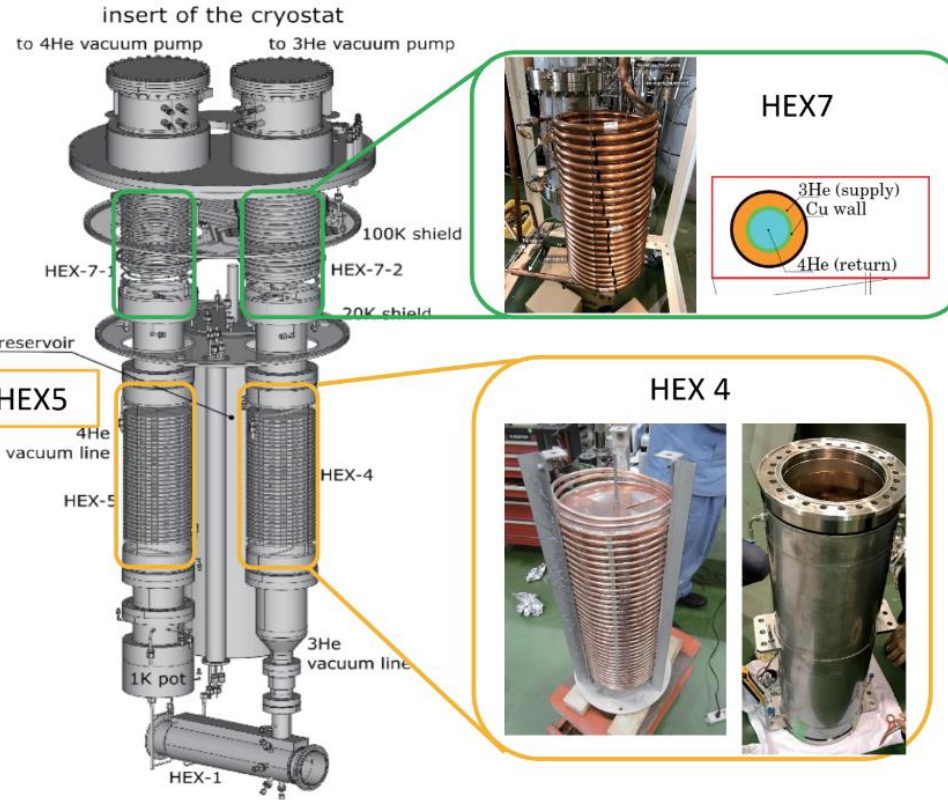
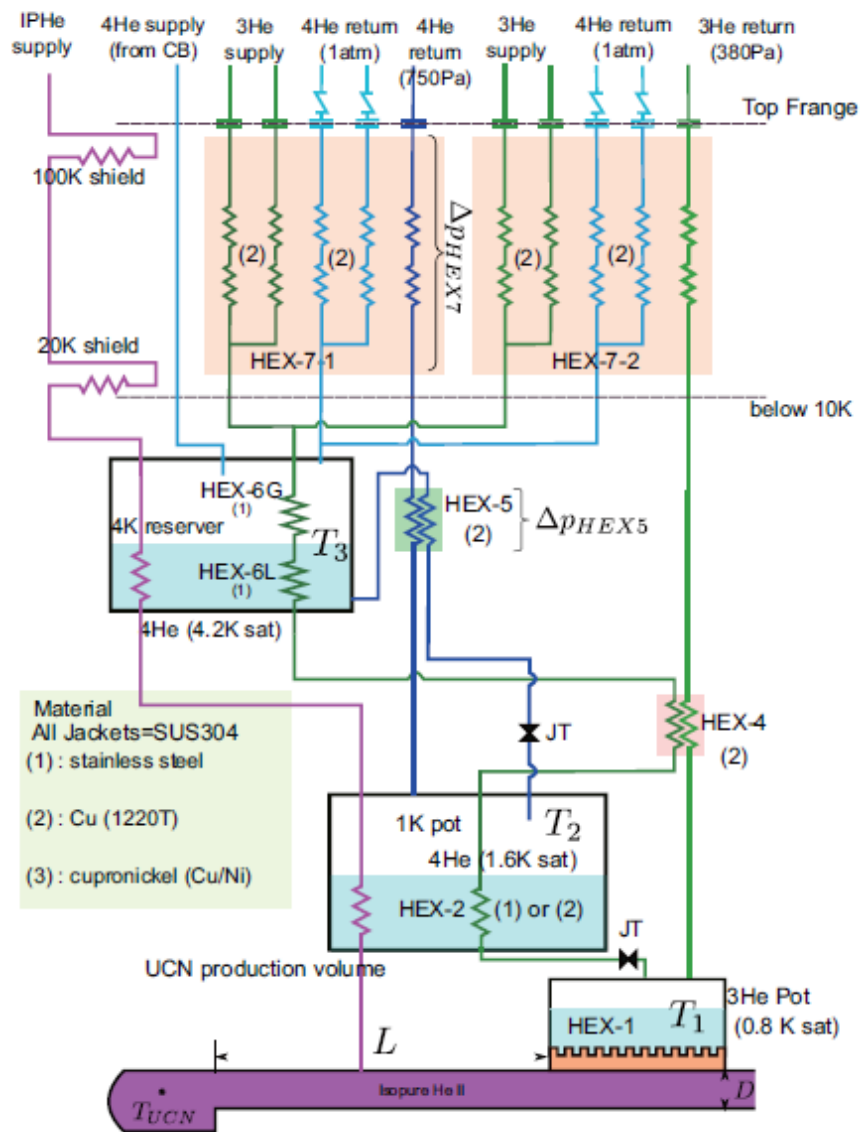
Static heat load:

- 4K pot : 600 mW
- 1.6K pot 50 mW
- ³He pot : 5 mW



KEK Test

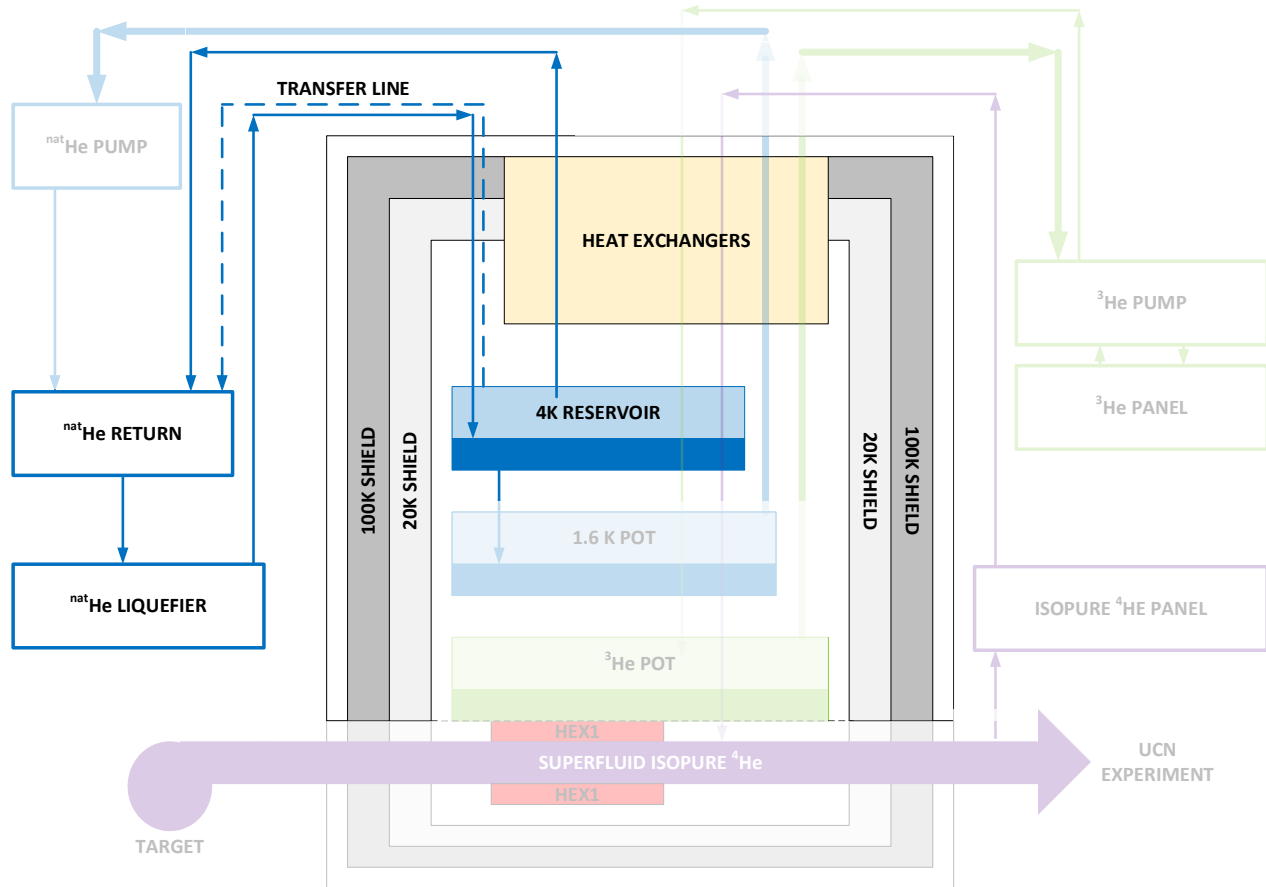
Conceptual flow diagram



Position	design value	measured value
After HEX7	10 K	< 10 K
after 4K reservoir	4.2 K	4.4 K
After HEX5 (⁴ He line)	2.8 K	3.3 K
After HEX4 (³ He line)	2.8 K	3.2 K
1K pot	1.6 K	3.1 K
³ He pot	0.8 K	3.0 K

This tests with ^{nat}He in ³He system and limited pumping speed concluded the different heat exchanger work as designed.

4K reservoir filling test

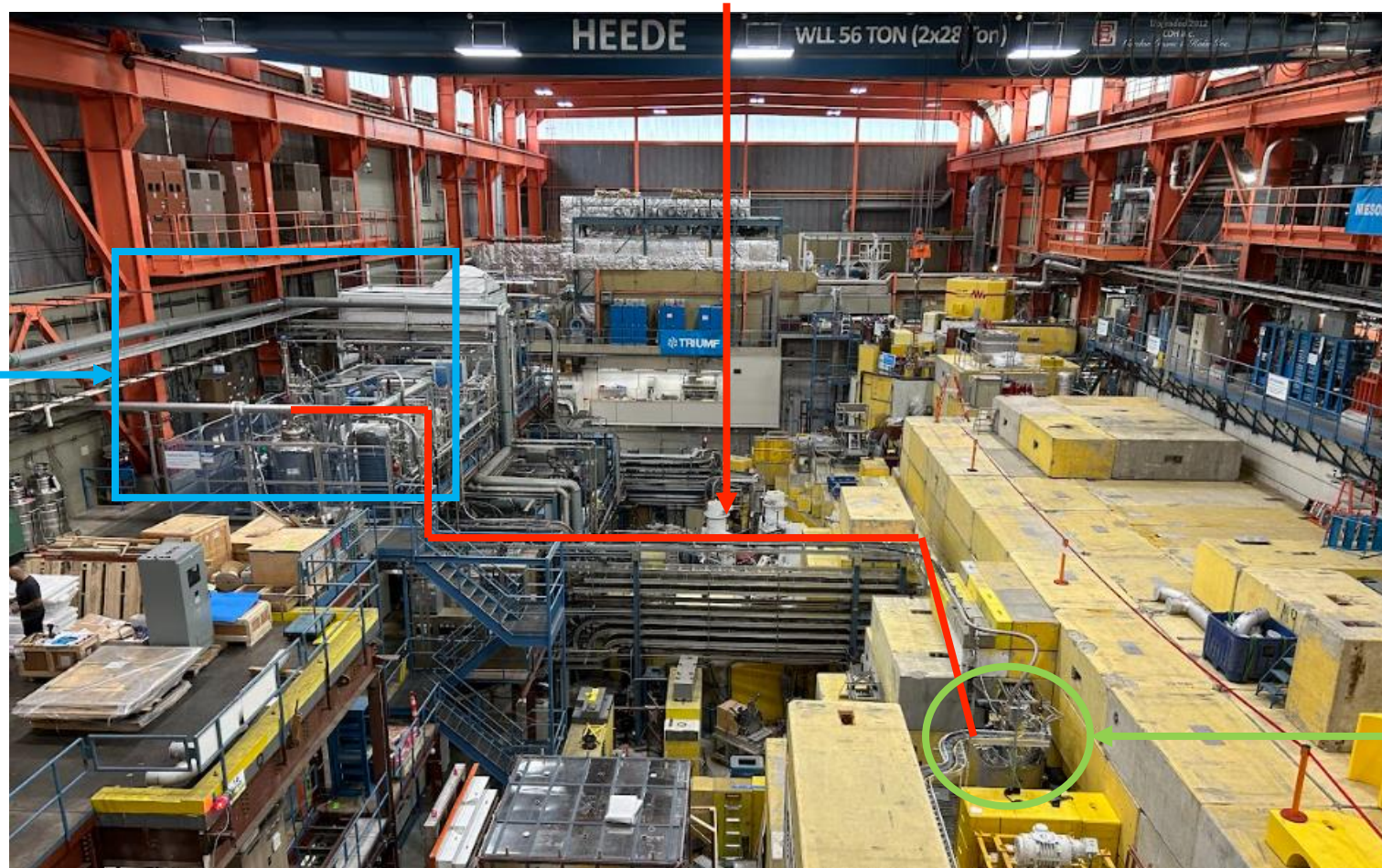


We performed initial test of the cryostat in combination with the helium liquefier and return, and the transfer line.

4K reservoir filling test

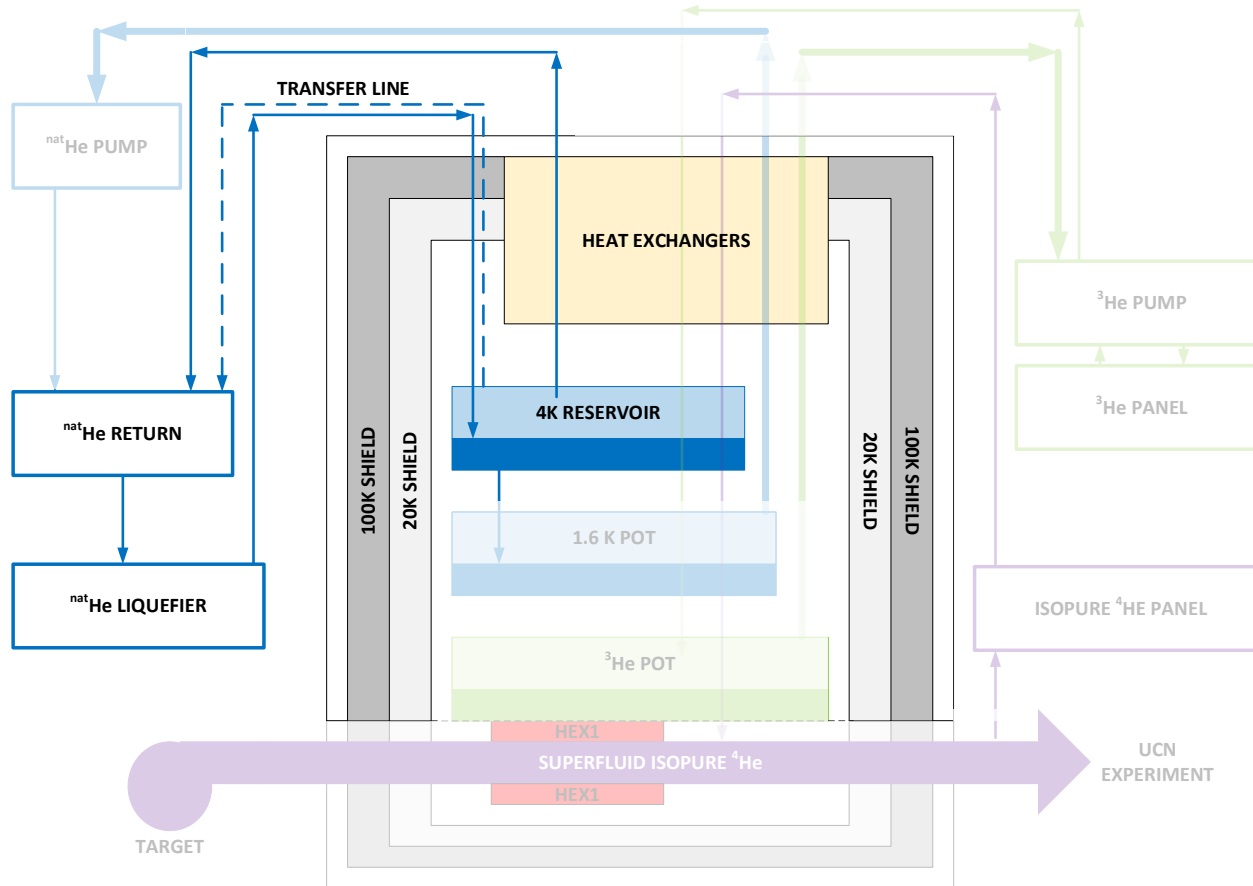
33 m long transfer line, self cooled by gas return, 3.6 W heat input

^{nat}He liquefier (44 L/h)
and return



Cryostat

4K reservoir filling test

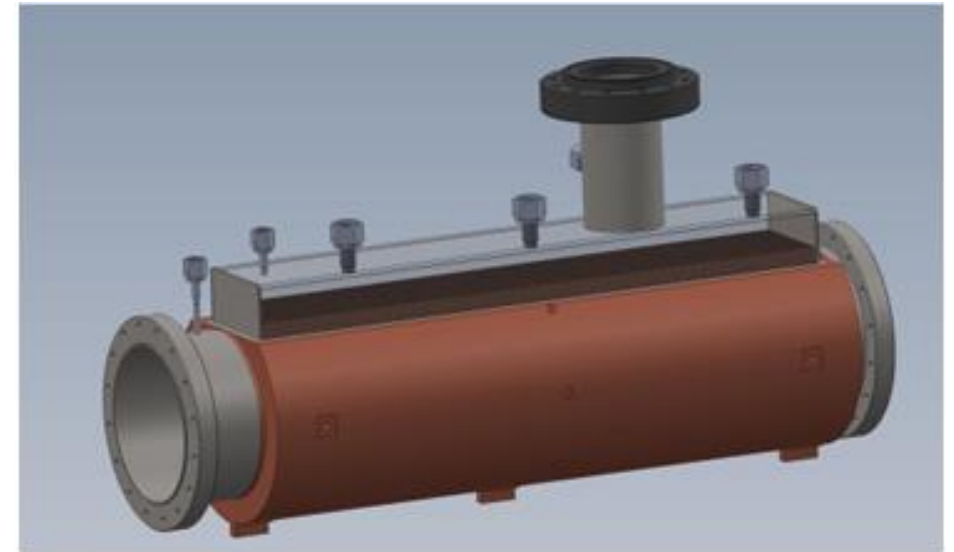
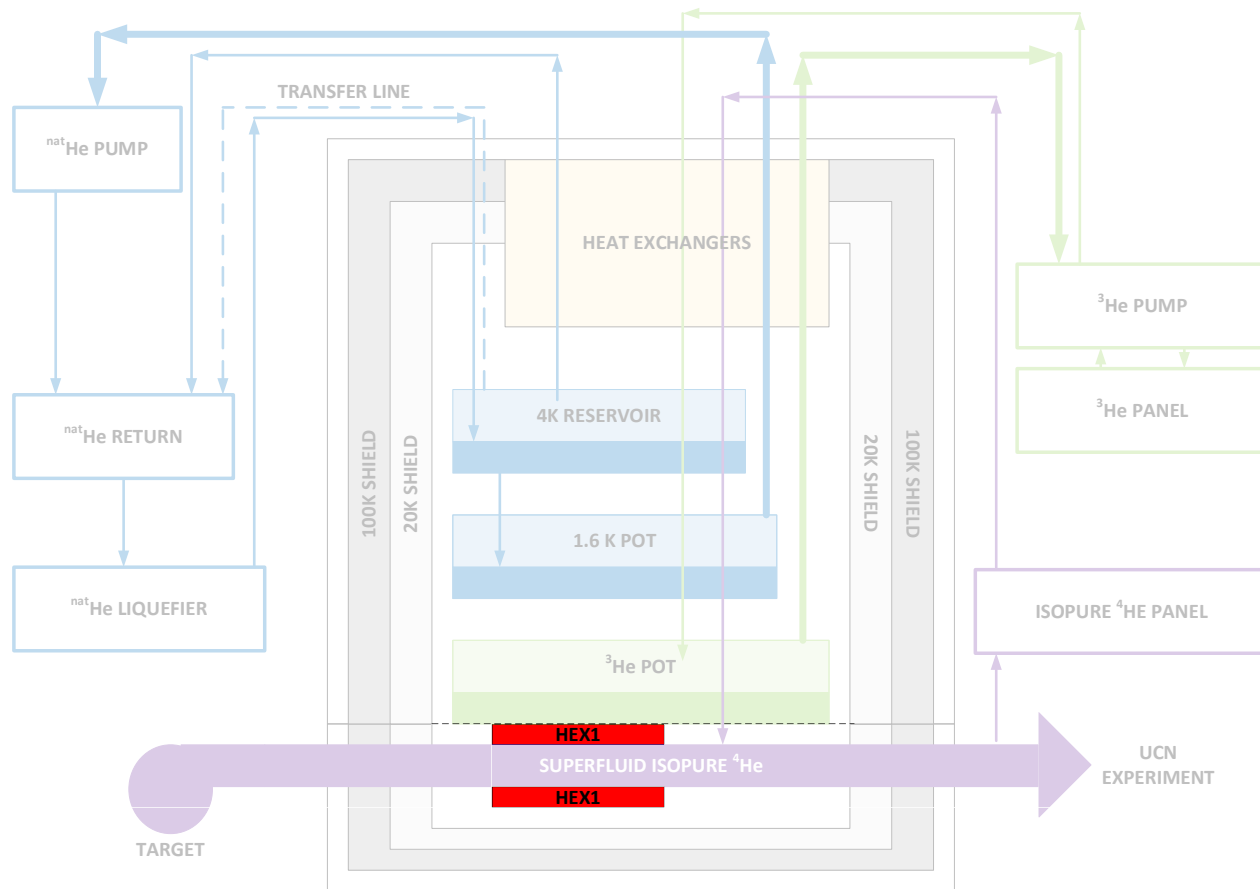


Main results:

- 7h and 92.9 L of liquid helium needed to cooldown the transfer line and start transferring liquid helium into the cryostat.
- 2h45 to fill the 4K pot up to 80%.
- No cold leak.

S. Stargardter

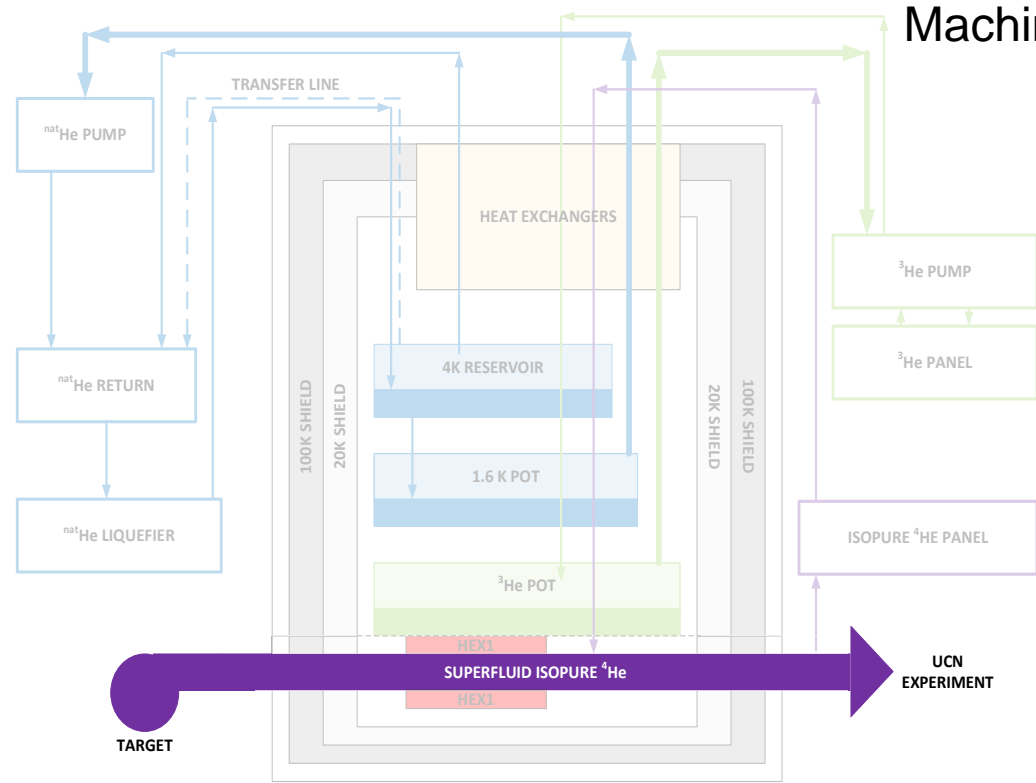
The heat exchanger HEX1



Dedicated talk by Shinsuke Kawasaki today at 11:40 am

The tail section

Machined, thin-walled Al domes to minimize neutron absorption and heat load

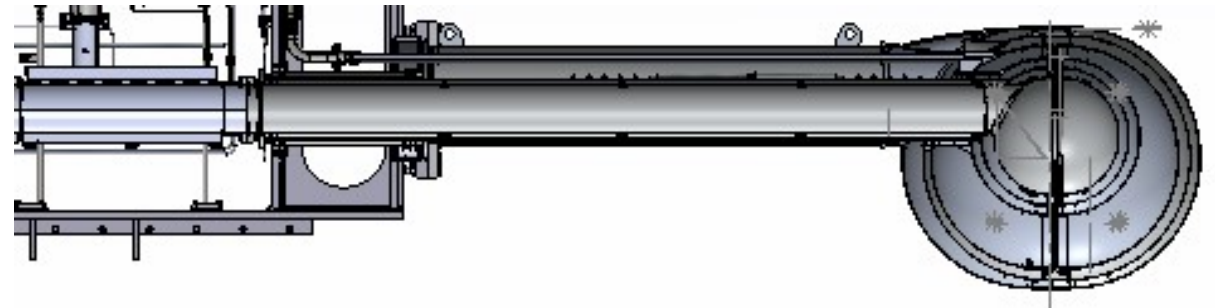
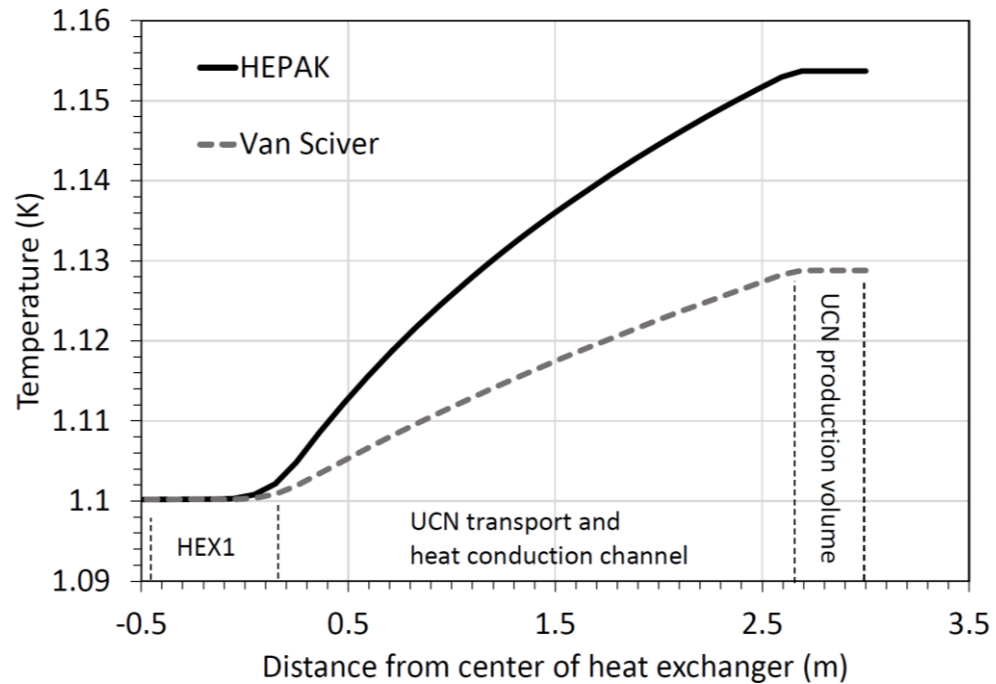


UCN-reflective NiP coating: Measured UCN storage lifetime at LANL in 2021
Superfluid-tight: extensive leak checking completed

The tail section is currently under construction at TRIUMF workshop to be installed by April 2024.

Superfluid ^4He thermal conductivity

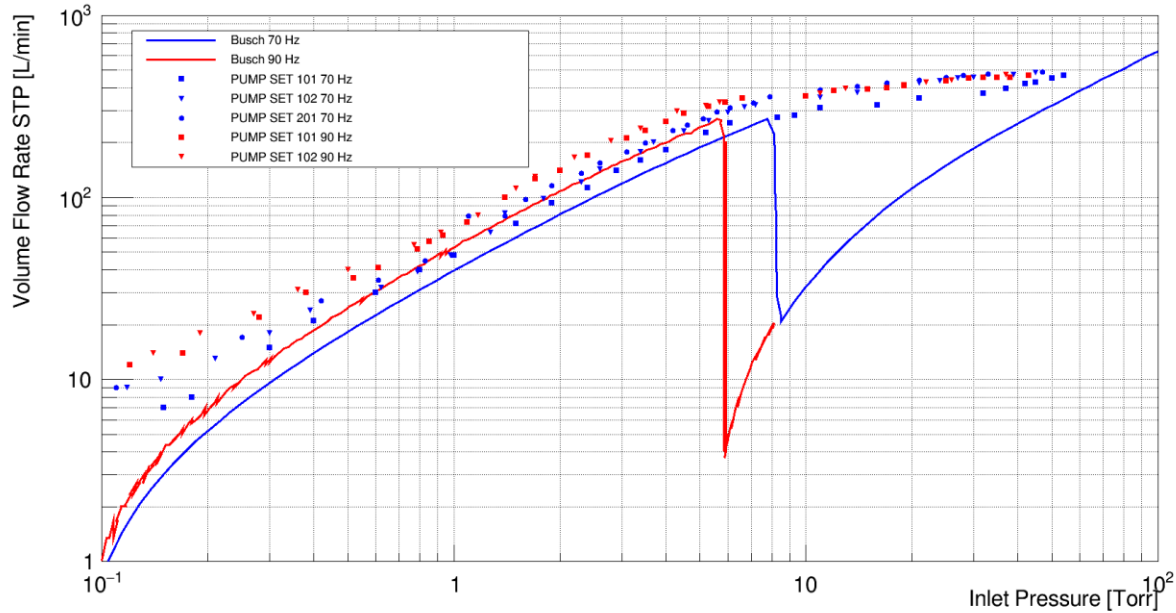
HEPAK and Van Sciver models predict different temperature profile for the Isopure helium.



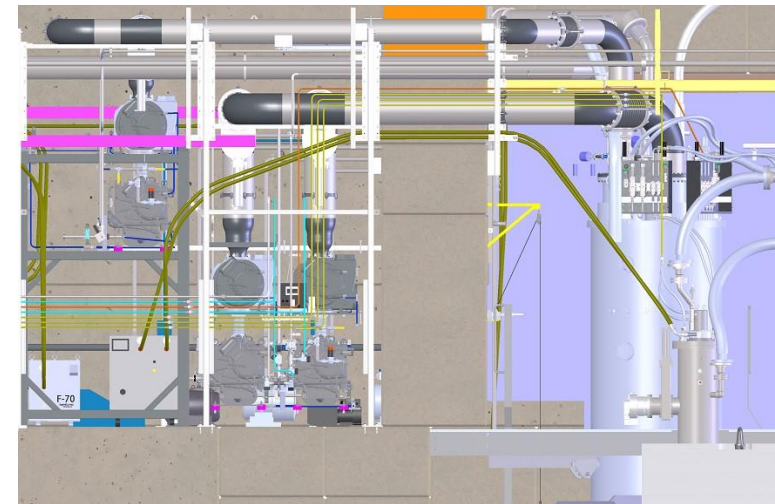
Measurement of temperature in superfluid ^4He will be performed.

³He cryostat pumping

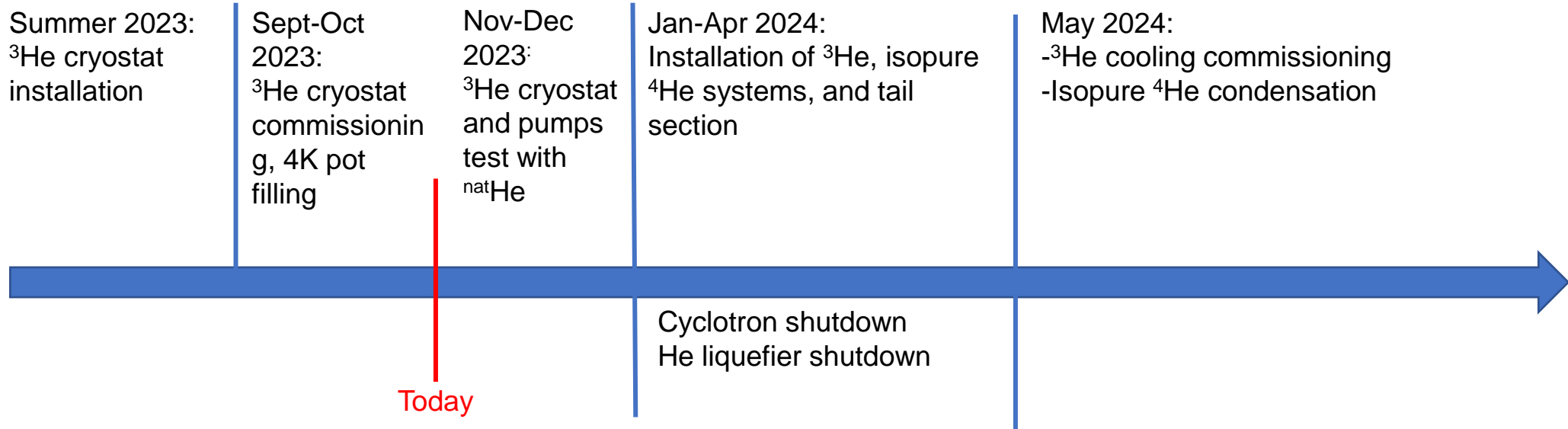
Busch pump sets ⁴He Mass Flow Performance



- Cryostat pumping is done by three sets of Busch Panda and Cobra (2500 m³/h). One for ^{nat}He in the 1.6 K pot and two for ³He in the 0.8 K pot.
- First test done with ^{nat}He showed performances better than manufacturer estimations.
- Piping between pumps and cryostat currently being installed. Test of the full assembly to start next month.



Timeline:

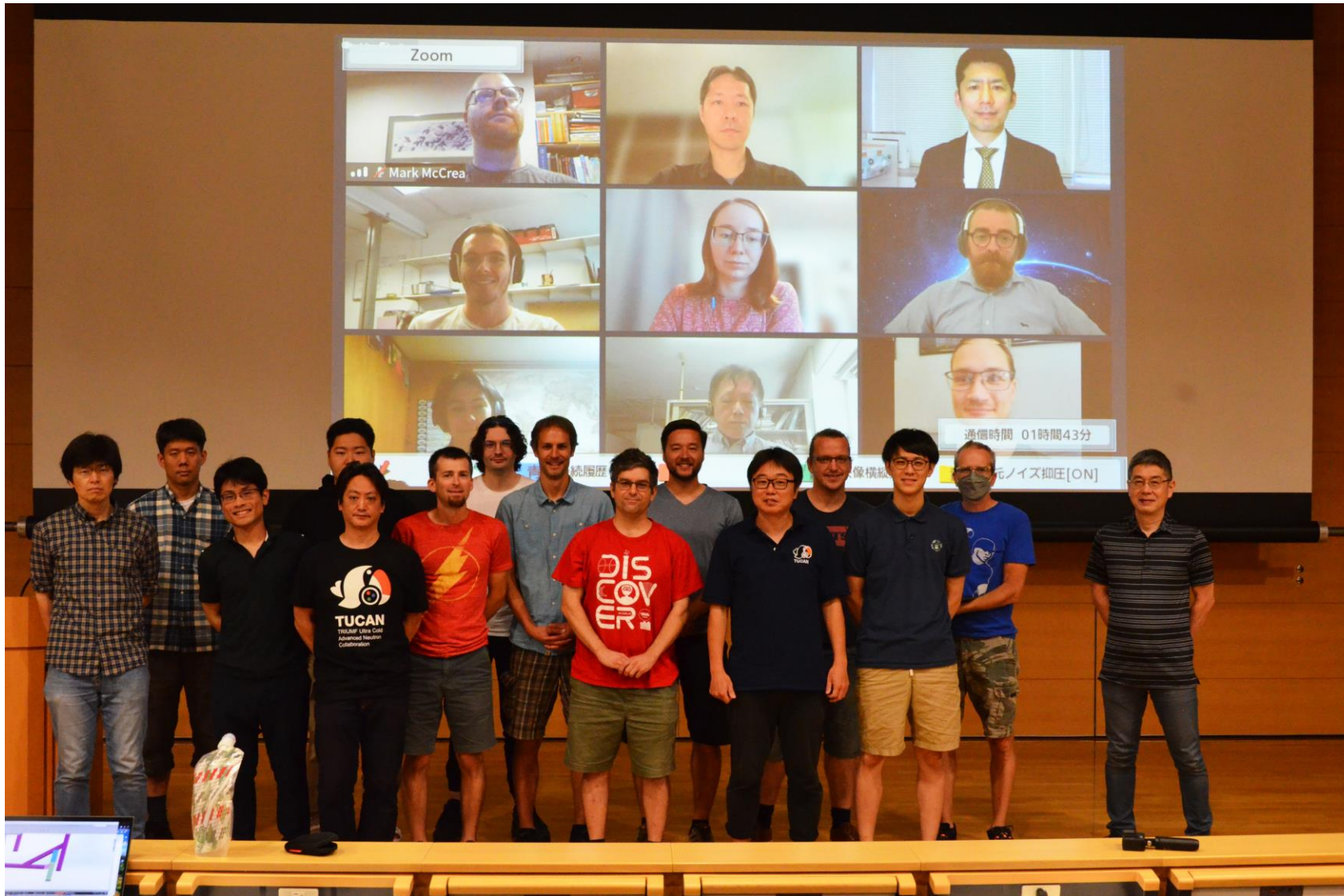




CONCLUSION

- First commissioning of the cryostat, $^{\text{nat}}\text{He}$ liquefier and transfer line showed good performance.
- Busch pumps show better performance than expected.
- Test of cryostat and pumps together to be performed with $^{\text{nat}}\text{He}$ in the coming month.
- Installation of the tail section, ^3He and isopure ^4He systems will take place by April 2024.
- Full cryogenic systems commissioning and isopure ^4He condensation next summer.

THANK YOU



TUCAN collaboration meeting. August 2023. KEK Tsukuba, Japan