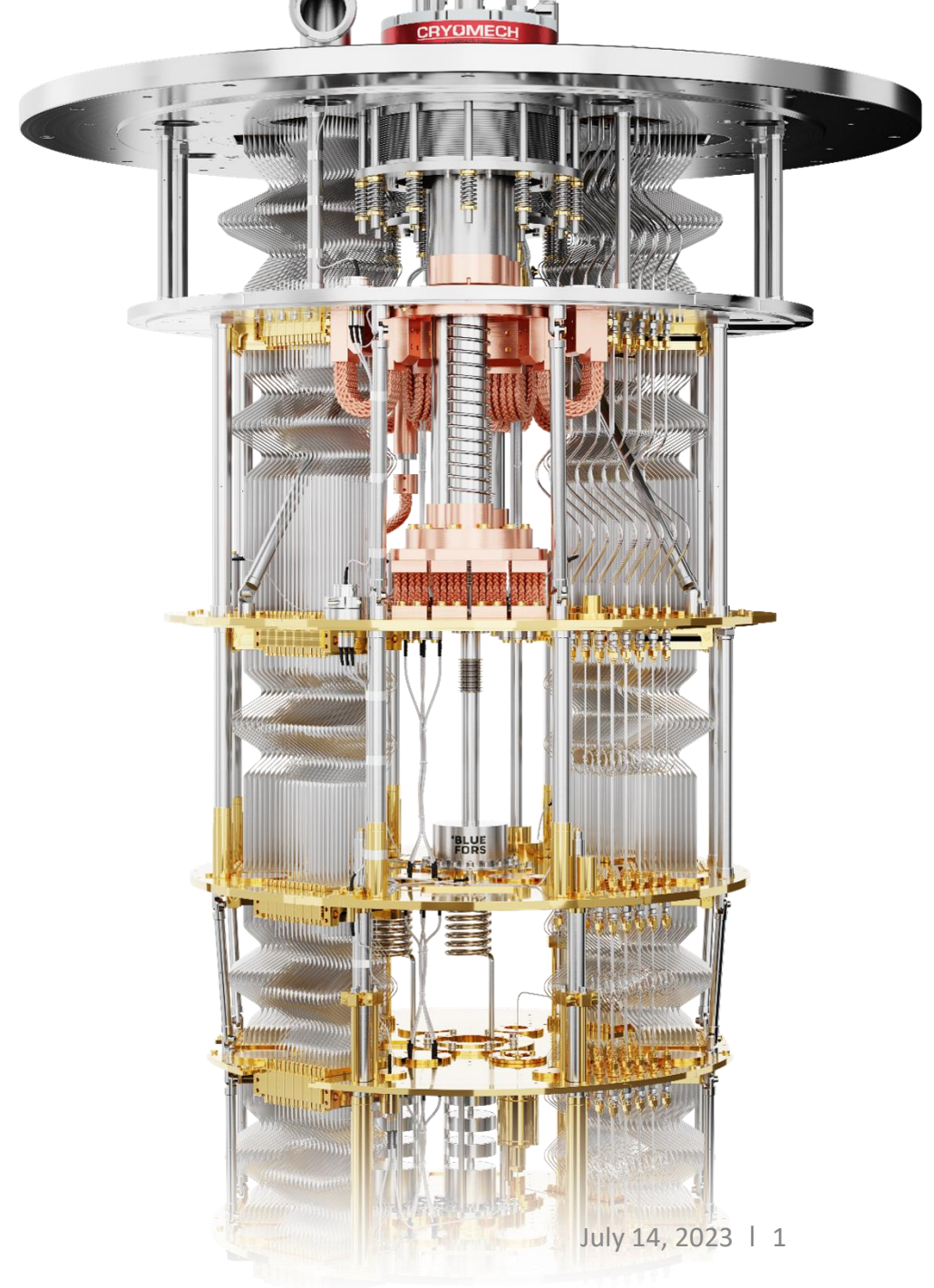




An Efficient, Low Vibration Reliquefier for NMR Applications

Tim Hanrahan, Graham Harrington
Bluefors Cryocooler Technologies

Cool for Progress.

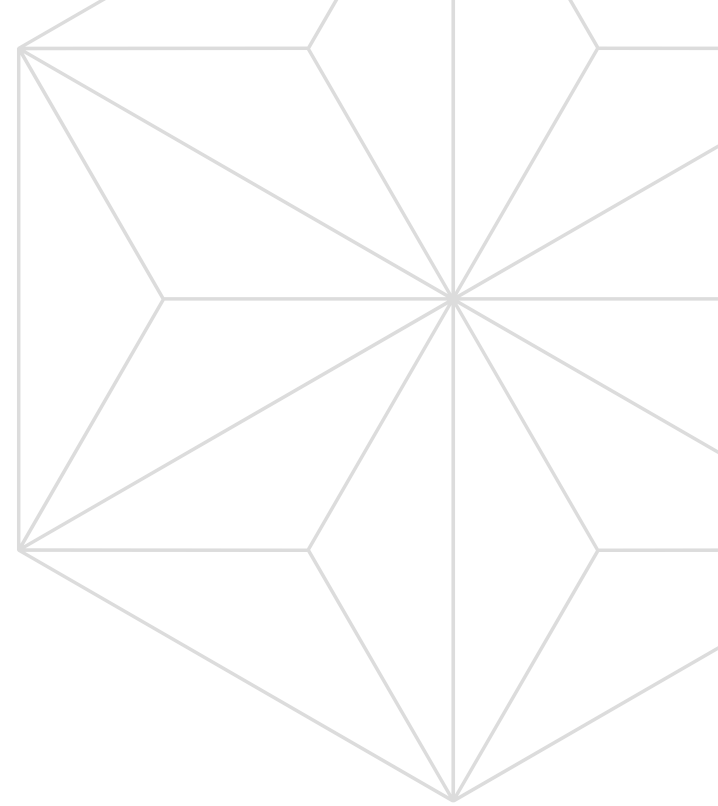


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Outline

- Background
- Vibration Reduction Tests
- Cooling Performance Tests
- Results from NMR Spectrometer Test
- Future Work and conclusions

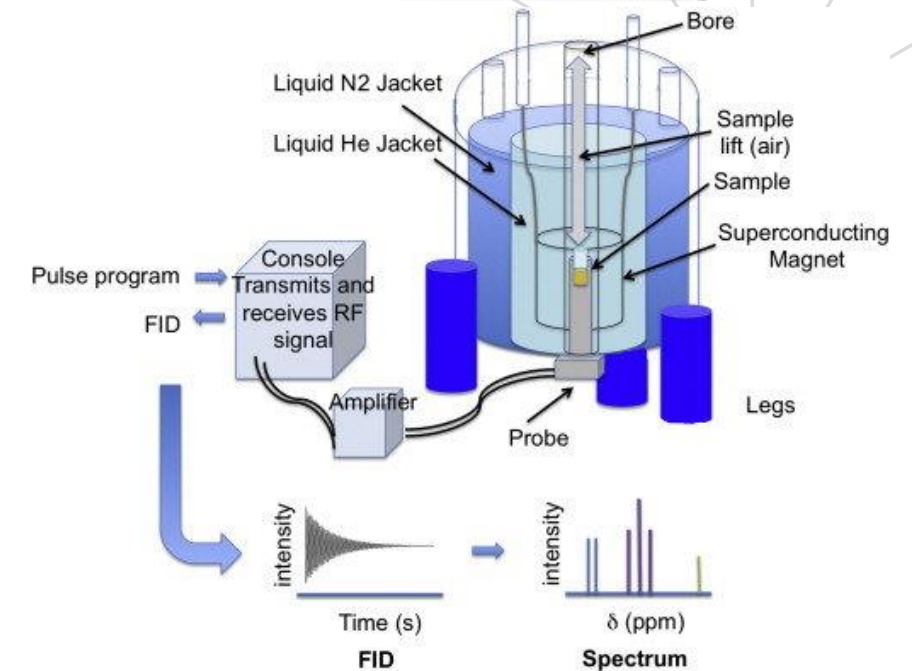
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Background – NMR Spectrometry

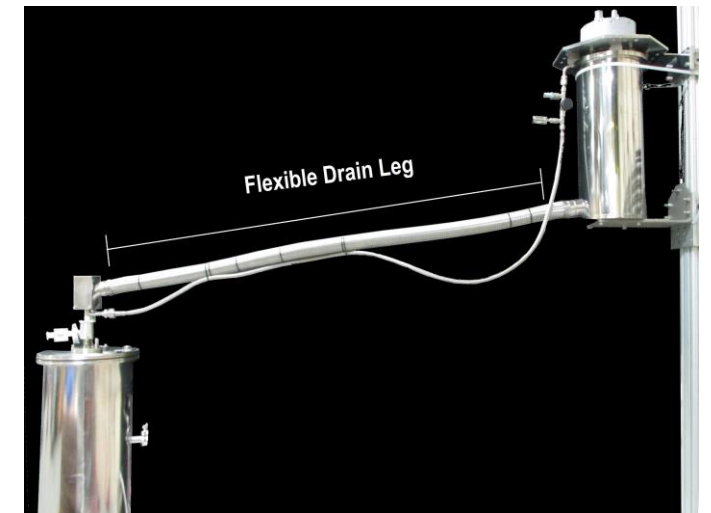
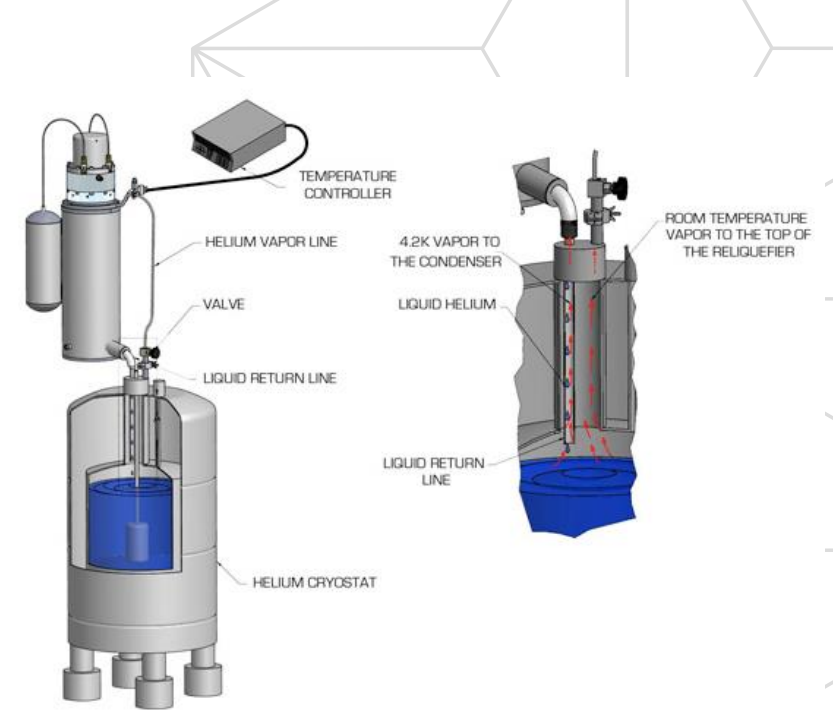
- Sensitive analytical tool used for imaging chemical and biological samples.
- Extremely sensitive to mechanical vibration.
 - Mounted on pneumatic dampers to isolate room vibration
- Low Helium boiloff on the order of 0.5 L/day or less depending on operating conditions
- The challenge: provide a small, low-cost helium recovery unit for labs with 1 or 2 systems



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Background – Helium Reliquefiers

- Closed cycle units designed to turn a wet cryostat into a dry cryostat
- Ideal for labs with 1 or 2 cryostats
- Helium liquefaction rates of 10-25 L/day
- Helium recondensing rates of 0.5 – 1.3 W
- Previously have designed low vibration reliquefiers for STM and MEG applications



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Test Setup – Vibration Isolation

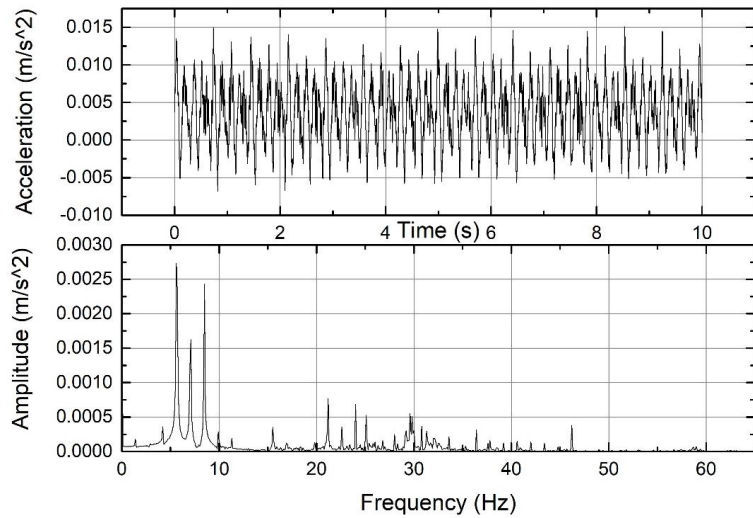
- Measured acceleration in 3 axes with a Wilcoxon 731A seismic accelerometer
- Test setup placed on isolated slab in our manufacturing facility
- Measured background vibration prior to each test for comparison



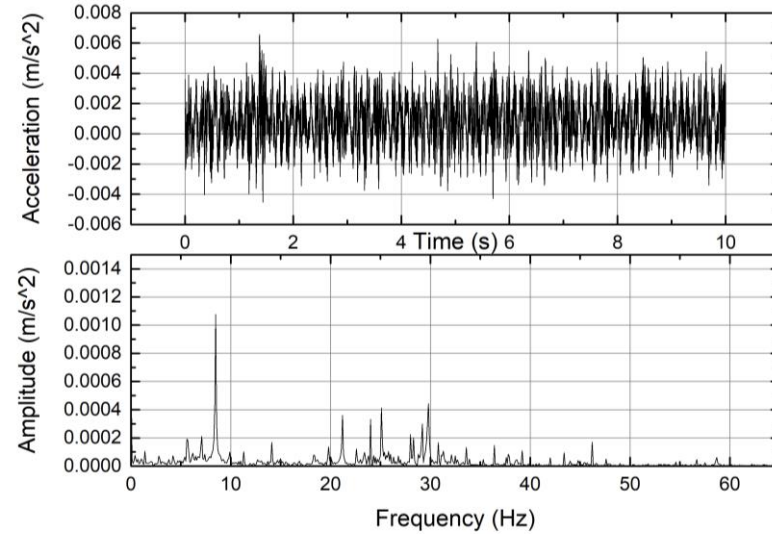
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Initial Results

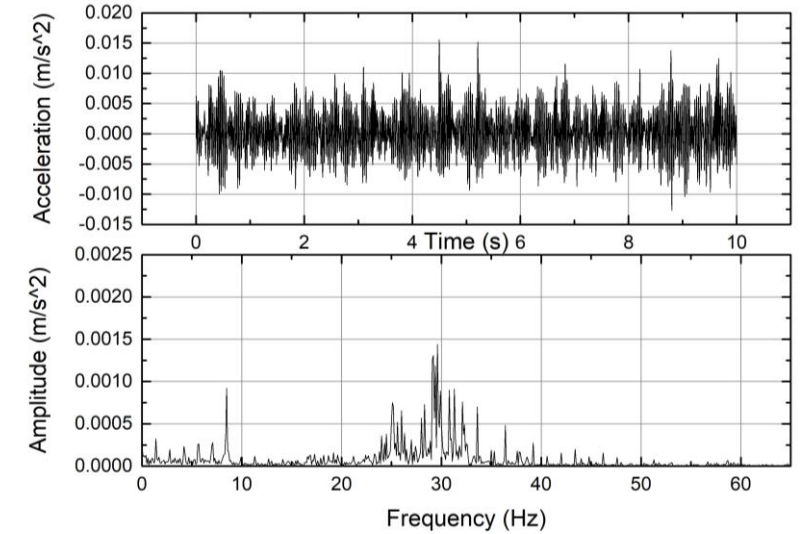
X-direction



Y-direction



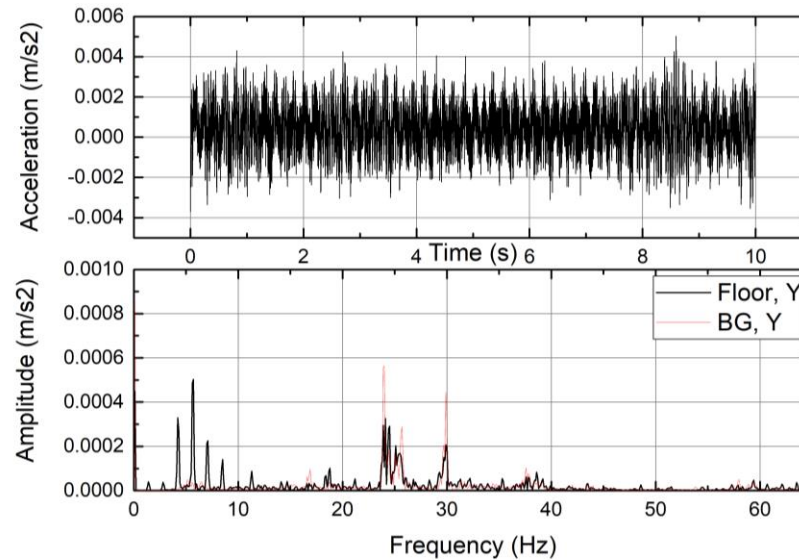
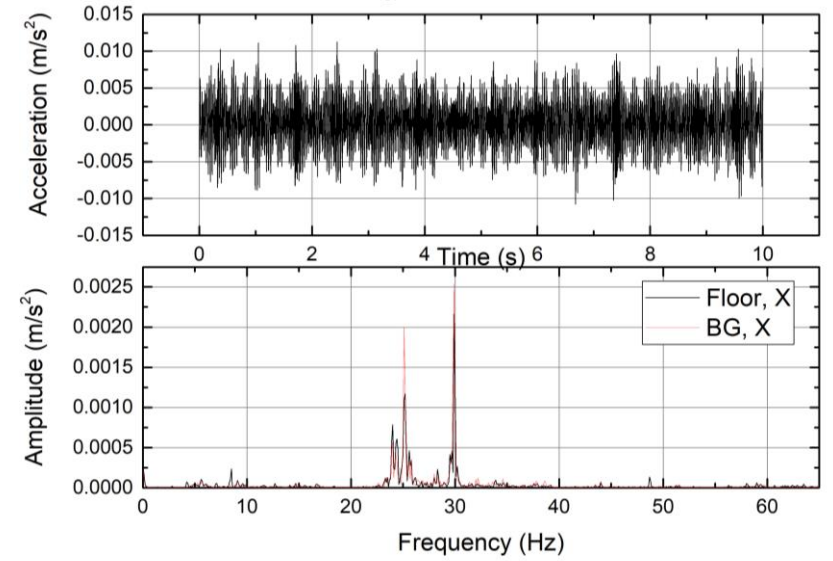
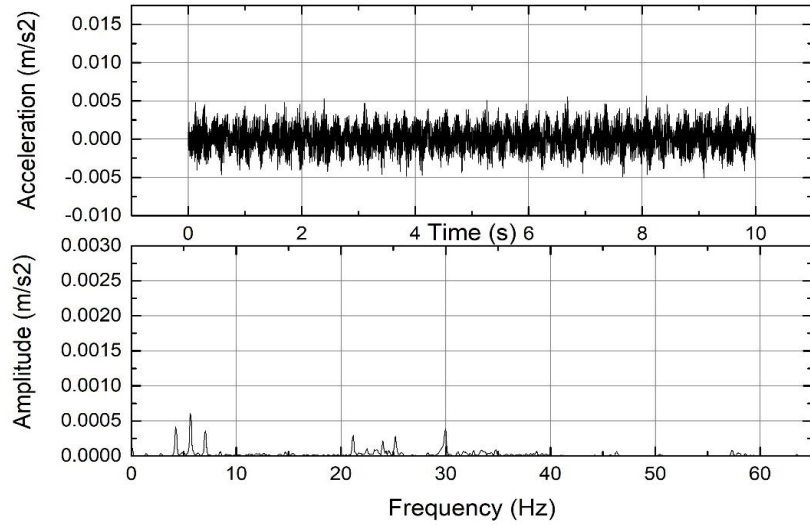
Z-direction



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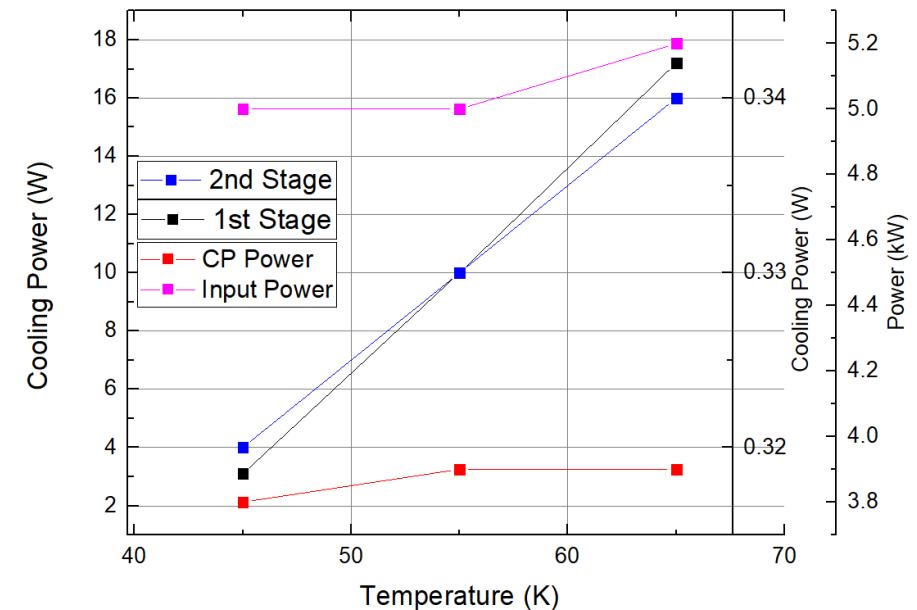
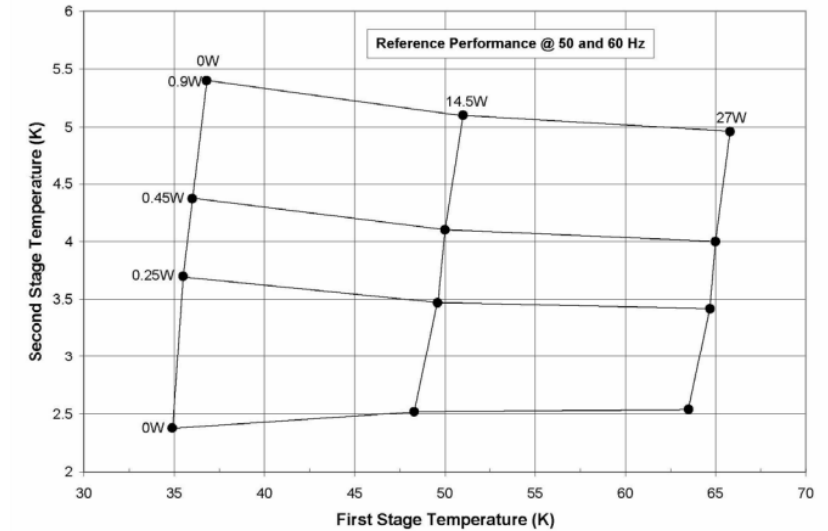
Vibration Improvements



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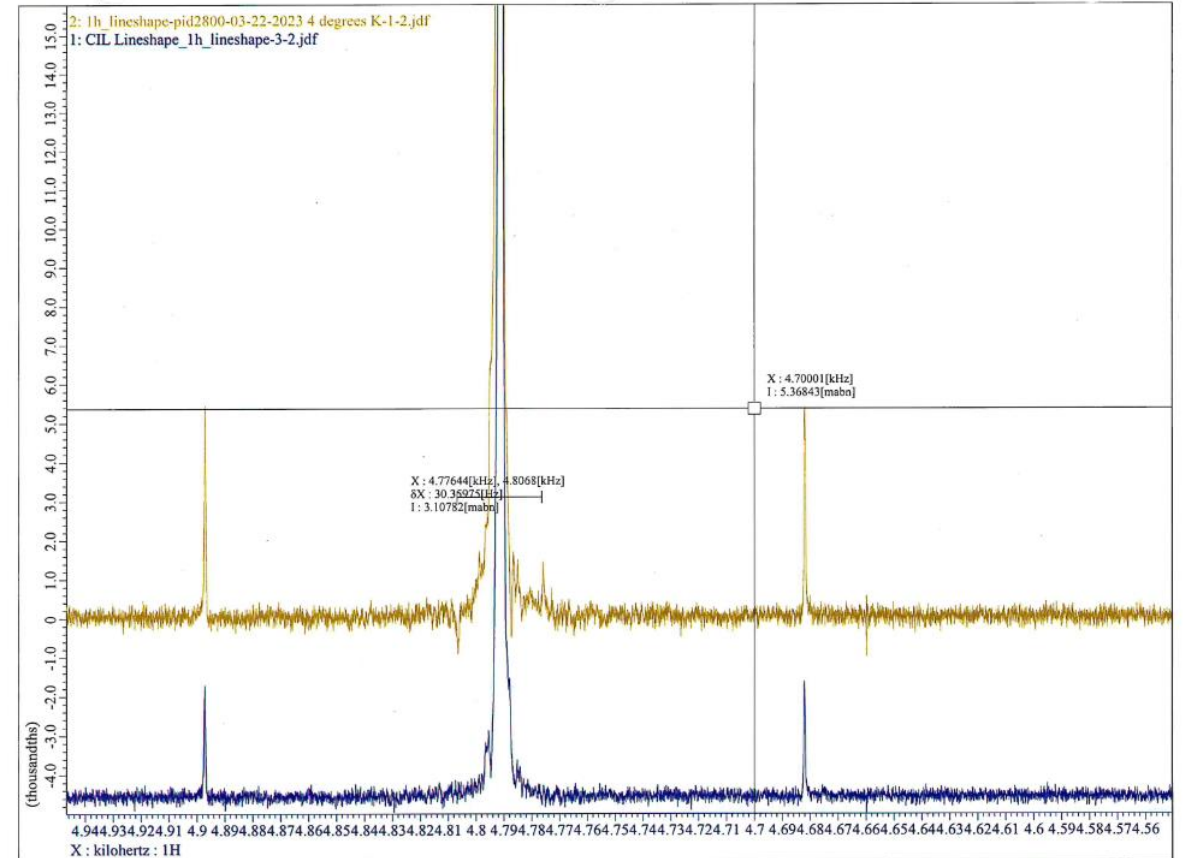
Cooling Performance

- Tested the cooling performance of PT405-RM with
 - CPA2850 (5 kW)
 - CP103 (3 kW)
 - CPA286i (inverter compressor).
- Liquefaction capacity with CPA2850
 - 1.45 L/day from room temperature gas
 - 4.3 L/day from Lhe boiloff
- We were not able to liquefy helium with CP103 compressor due to low 1st stage cooling power
 - Measured cooling performance: 0.2W at 4.2K with 9.7W at 65K



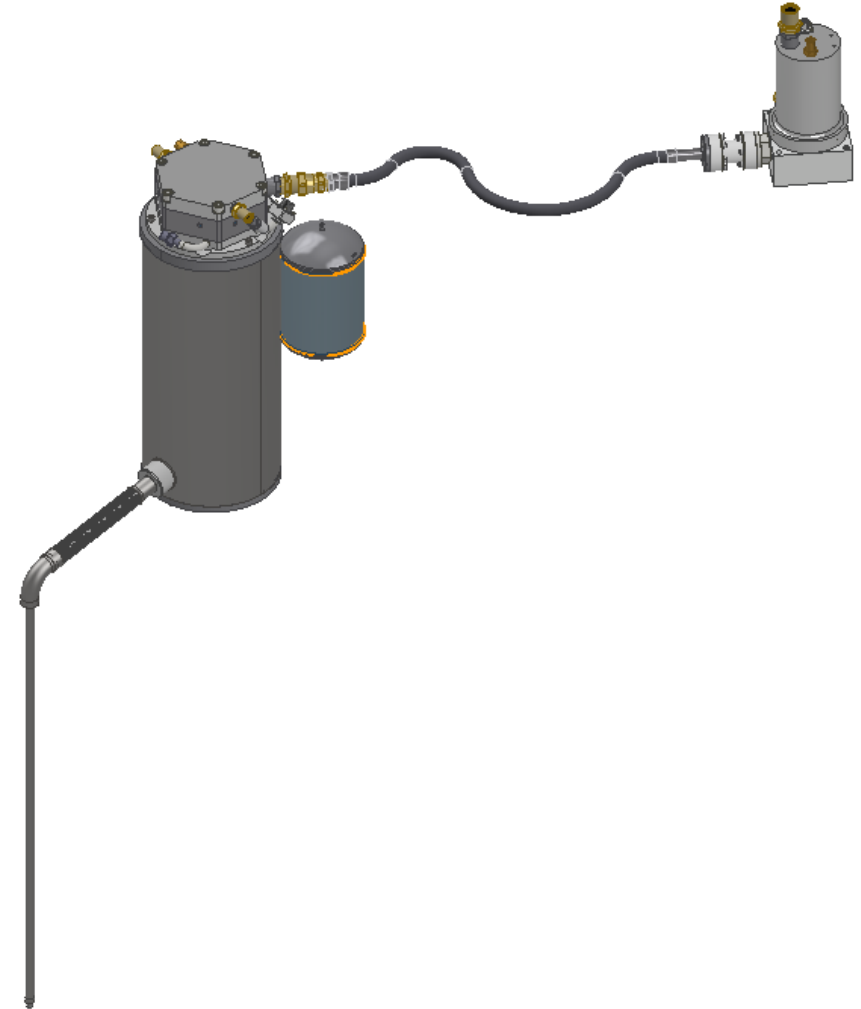
NMR Spectrometer Test

- The prototype was installed in a 600 MHz NMR spectrometer and operated for 2 months without loss of helium.
- We measured a variety of liquid samples and did not detect the cryocooler vibration in the sample spectra.



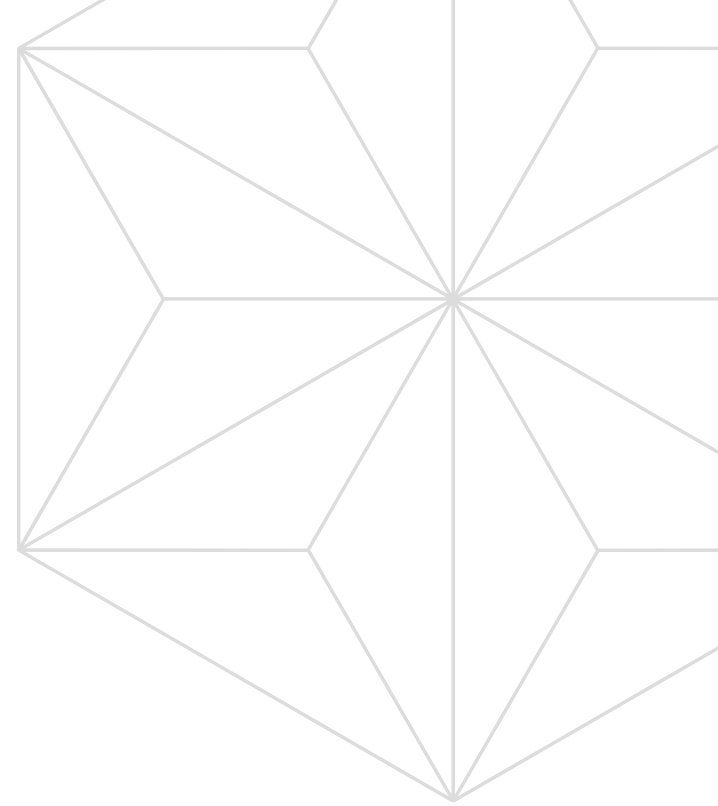
Final Prototype Design

- Reduced overall height of unit by ~10 inches
 - Remote reservoir volumes
 - Horizontal bellows on drain leg
- Redesigned heat internal heat exchangers to improve efficiency
- Redesigned internal structure of reliquefier cryostat to reduce losses



Future Work

- In the process of building the final prototype for testing
- Retest new prototype and compare with previous results
 - Does the vibration change with bellows orientation?
 - Does the redesign affect the cooling performance
- Optimize cryocooler and reliquefier to operate with CP103 compressor
- Retest system in more NMR spectrometers
 - 600 MHz NMR with cryoprobe -> Most sensitive current applications



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Thank you!

Thanks to the Cryomech team and our collaborators for help with building and testing the system!

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