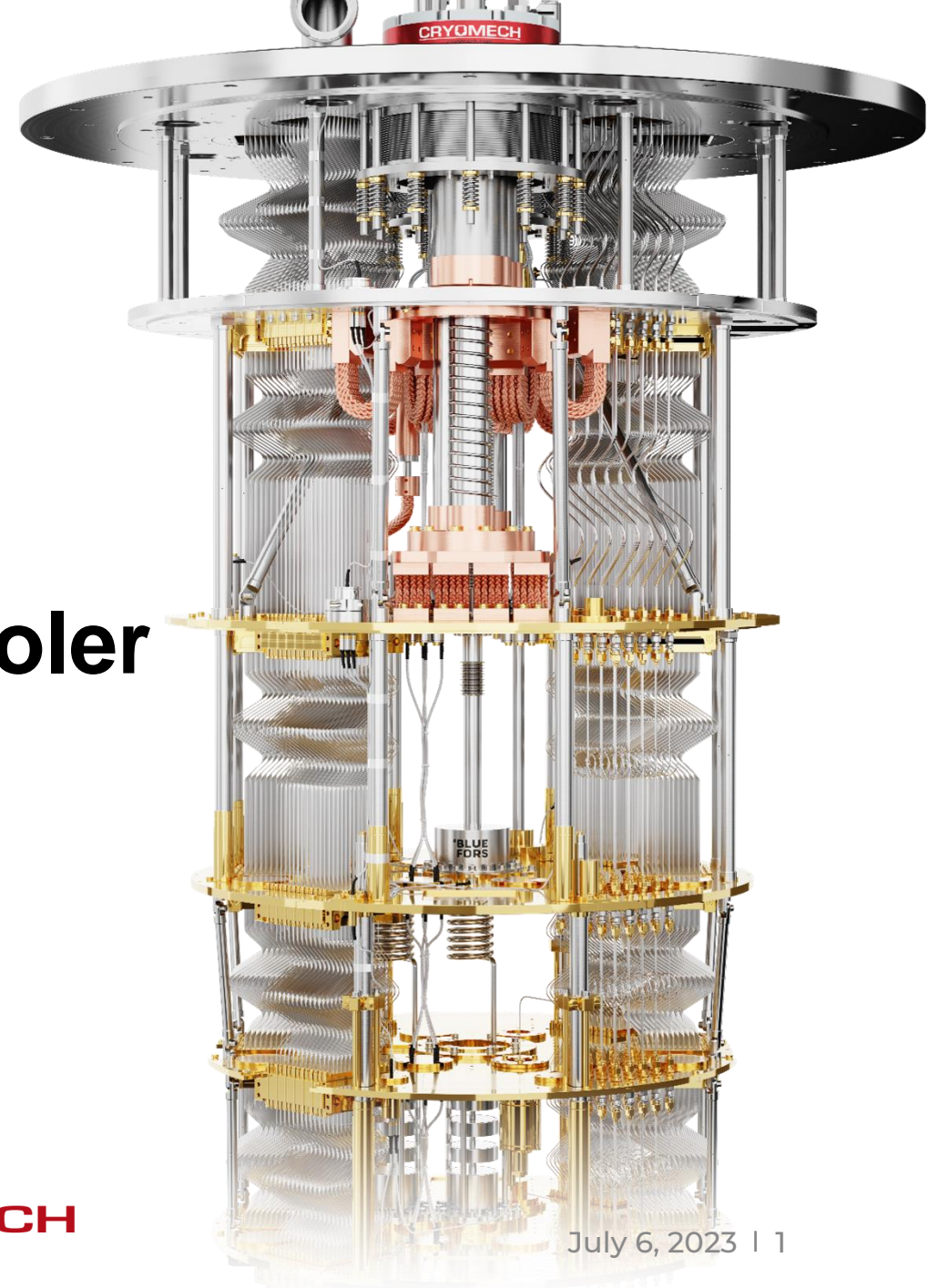


**BLUE
FORS**

Development of a **5 W/4.2 K** two-stage pulse tube cryocooler

Xihuan Hao, Brent Zerkle, Joe Cosco and Rich Dausman

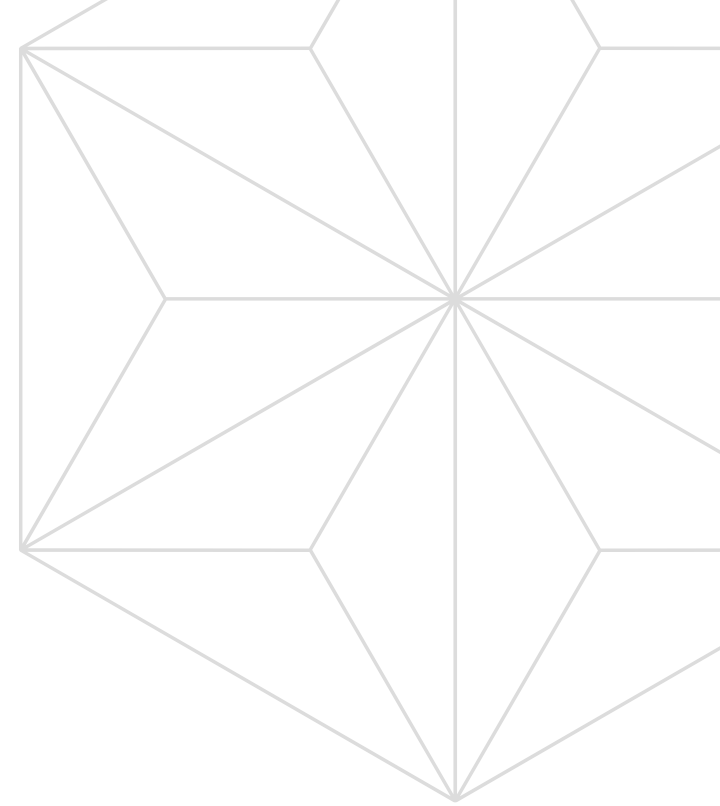
Cool for Progress.



July 6, 2023 | 1

Table of Contents

- Introduction
- System Design
- Performance and Discussion
 - ❖ Cold Head Cooling Capacity
 - ❖ Cold Head Cool-down Speed
 - ❖ Regenerator Intermediate Cooling Capacity
- Summary



°BLUEFORS

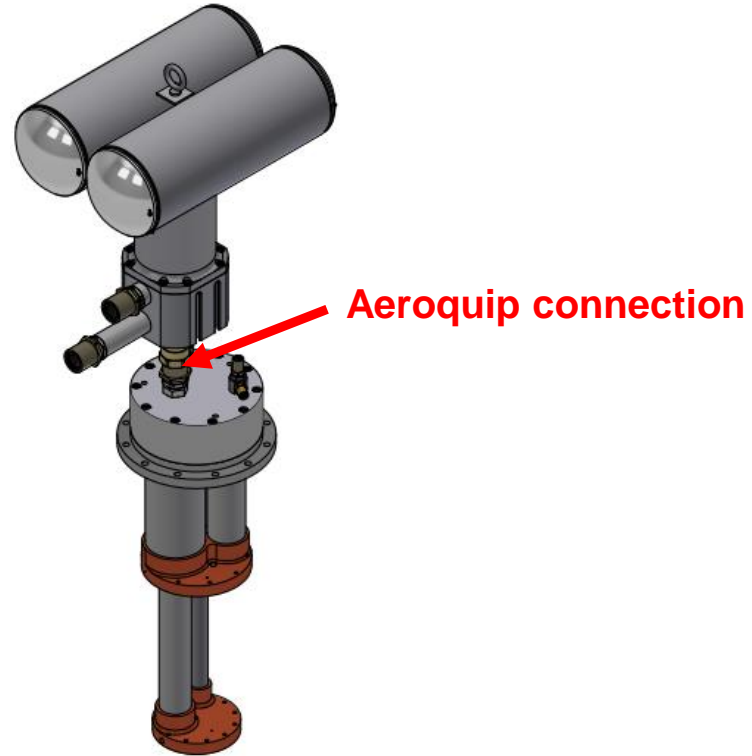
1. Introduction

- Bluefors Cryocooler Technologies has been continuously improving the cooling capacities and energy efficiencies of its 4.2 K two-stage pulse tube cryocoolers. The 2.7 W at 4.2 K two-stage pulse tube cryocooler (Model PT425) was developed and introduced by Cryomech, Inc. in 2021, which, at the time, was the largest, commercially available, 4 K pulse tube cryocooler.
- Our newest model, the **PT450**, has been successfully developed, providing a minimum of 5.0 W at 4.2 K on the 2nd stage with 65 W at 45 K on the 1st stage simultaneously, operating on either 60 or 50 Hz power.
- The PT450 answers the market's need for the continuing development of large cryogen-free dilution refrigerators, superconducting magnets, helium liquefiers and other applications requiring large cooling capacities at 4 K.

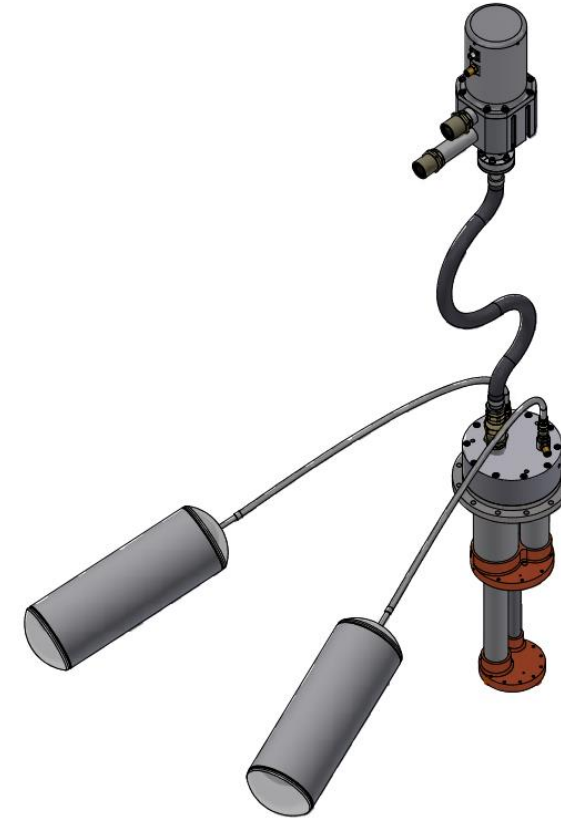
Cool for Progress.

°BLUEFORS

2. System Design



Integrated Motor (Model PT450)

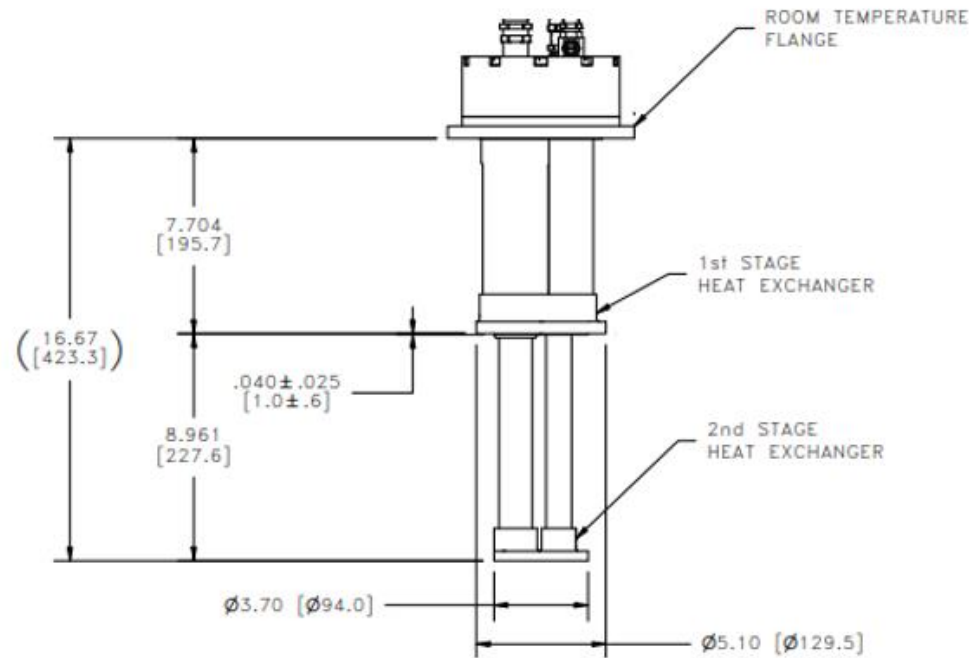


Remote Motor (Model PT450-RM)

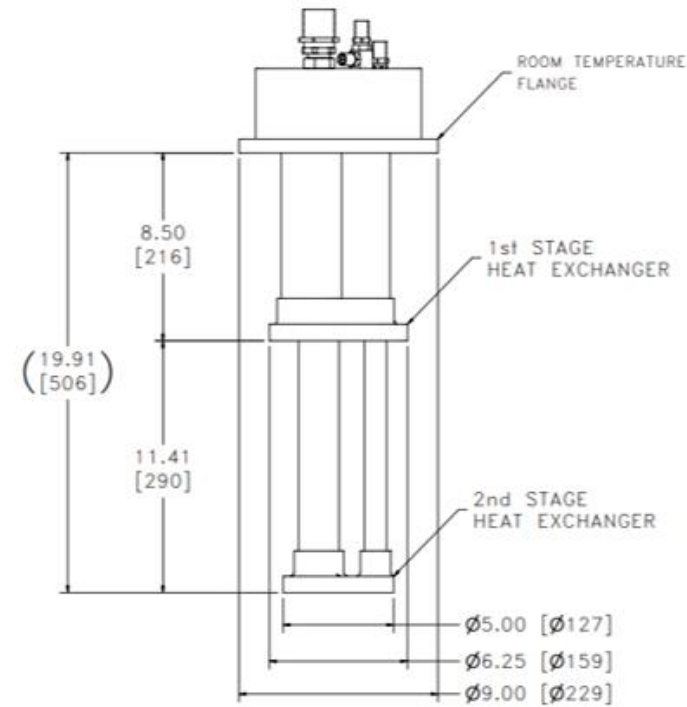
Figure 1. Images of PT450 and PT450-RM pulse tube cryocoolers.

°BLUEFORS

2. System Design



PT425-RM



PT450-RM

Figure 2. Outline dimensions of the PT425-RM and the PT450-RM pulse tube cryocoolers.

°BLUEFORS

3. Performance and Discussion

3.1 Cold Head Cooling Capacity

PT450 Specification (minimal guaranteed):

- Cooling capacity: 5.0 W @ 4.2 K with 65 W @ 45 K
- No-load base temperature: ≤ 2.80 K

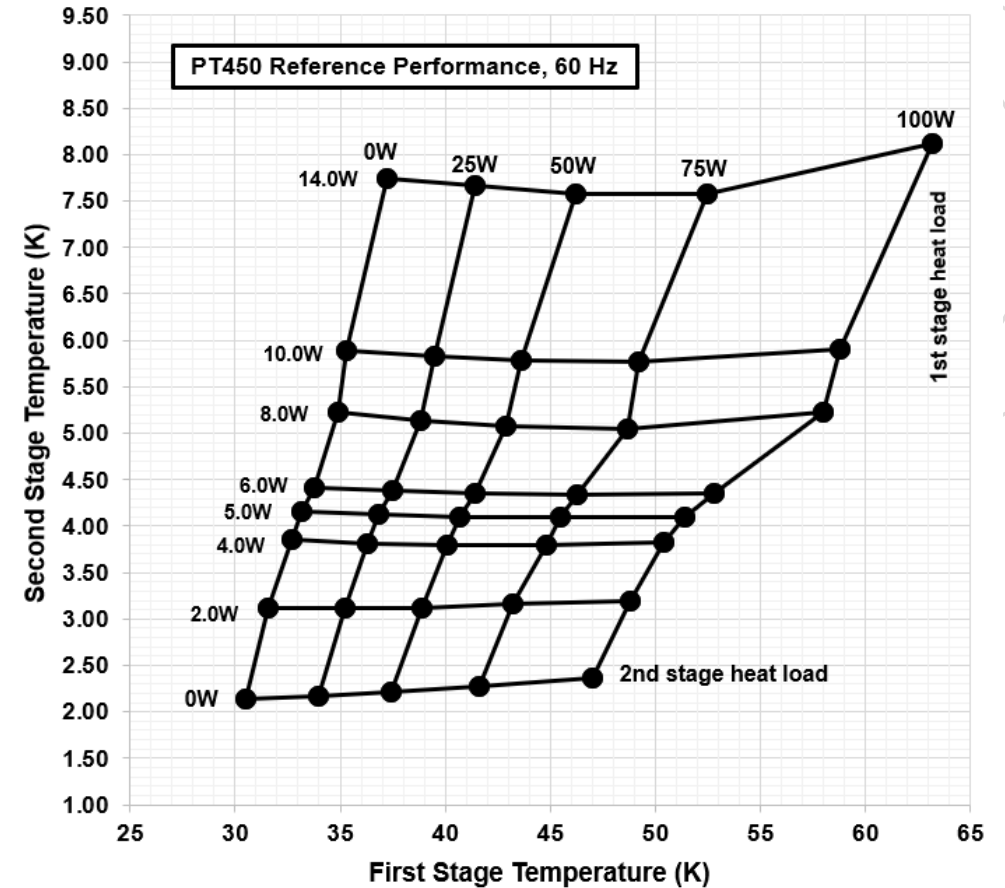


Figure 3. Typical cooling capacity curve of the PT450 pulse tube cryocooler.

3. Performance and Discussion

3.1 Cold Head Cooling Capacity

PT450-RM Specification (minimal guaranteed):

- Cooling capacity: 4.5 W @ 4.2 K with 60 W @ 45 K
- No-load base temperature: ≤ 2.80 K

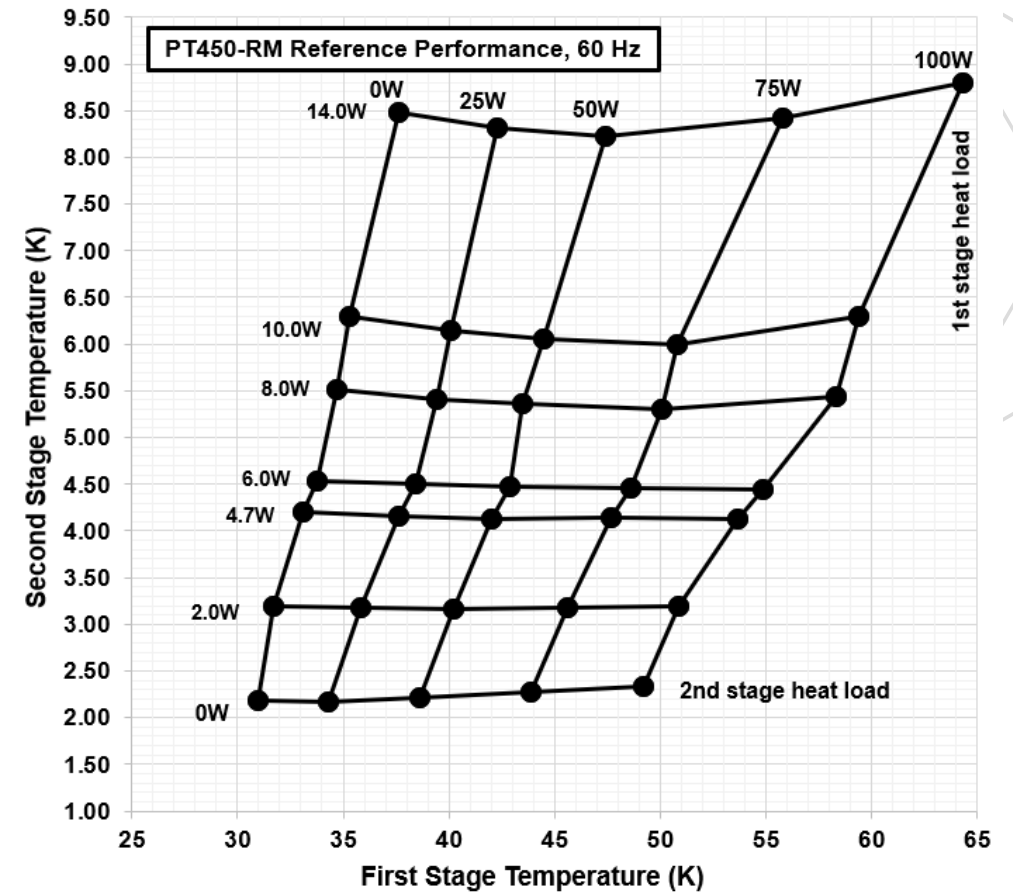


Figure 4. Typical cooling capacity curve of the PT450-RM pulse tube cryocooler.

°BLUEFORS

3.2 Cold Head Cool-down Speed

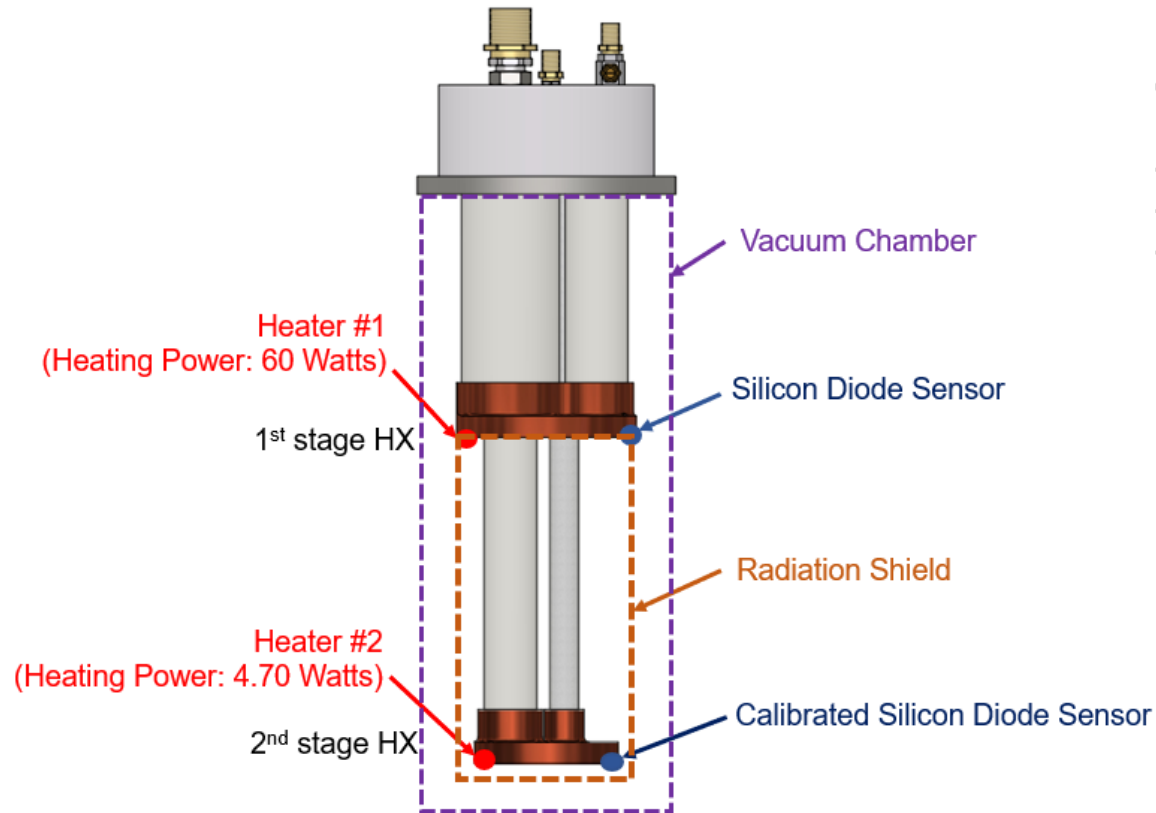


Figure 5. Schematic diagram of the experimental setup of PT450-RM cool-down speed test.

°BLUEFORS

3.2 Cold Head Cool-down Speed

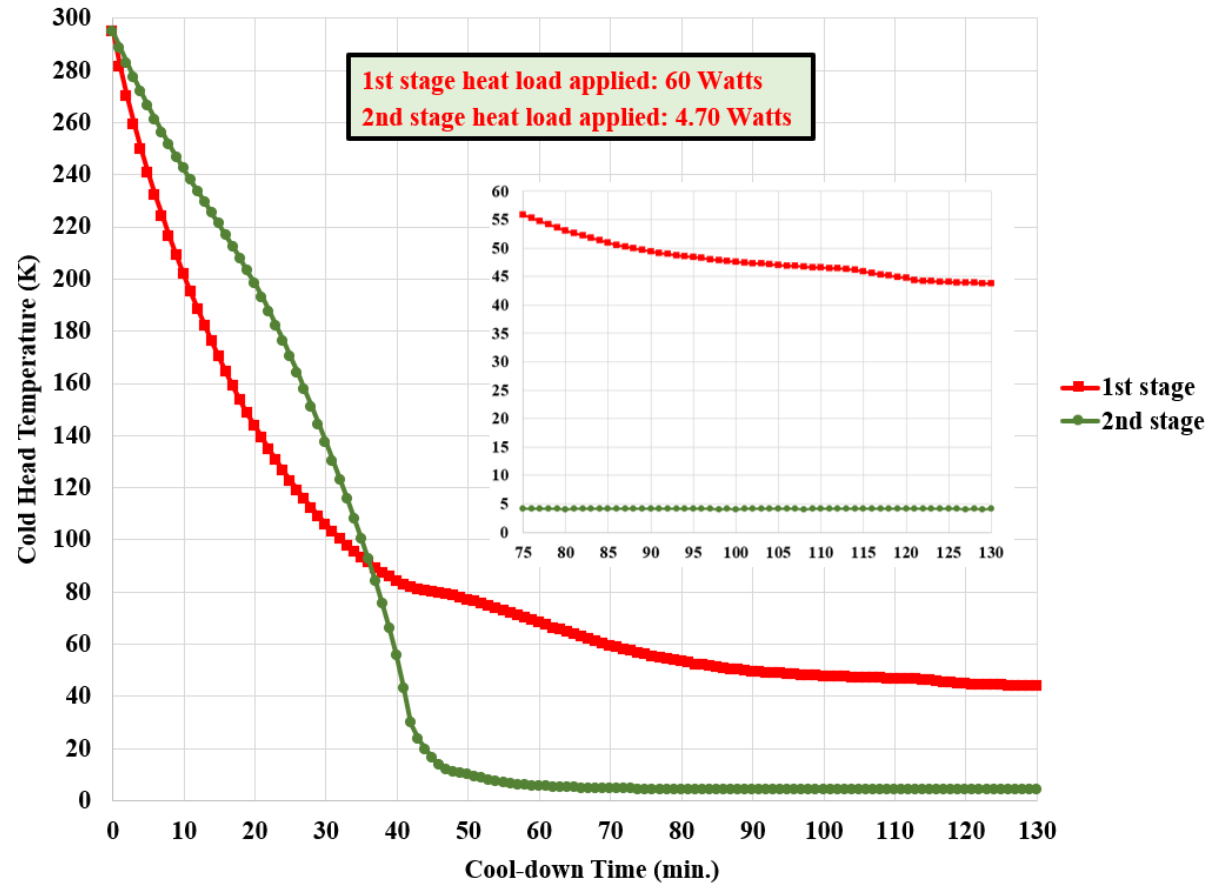


Figure 6. Cool-down curves of a PT450-RM cryocooler (60 Hz).

- With heat loads of **60 Watts** and **4.70 Watts** applied to the 1st stage and 2nd stage simultaneously, it takes about **115 min.** for the 1st stage to reach 45 K and about **75 min.** for the 2nd stage to reach 4.2 K.

°BLUEFORS

3.3 Regenerator Intermediate Cooling Capacity

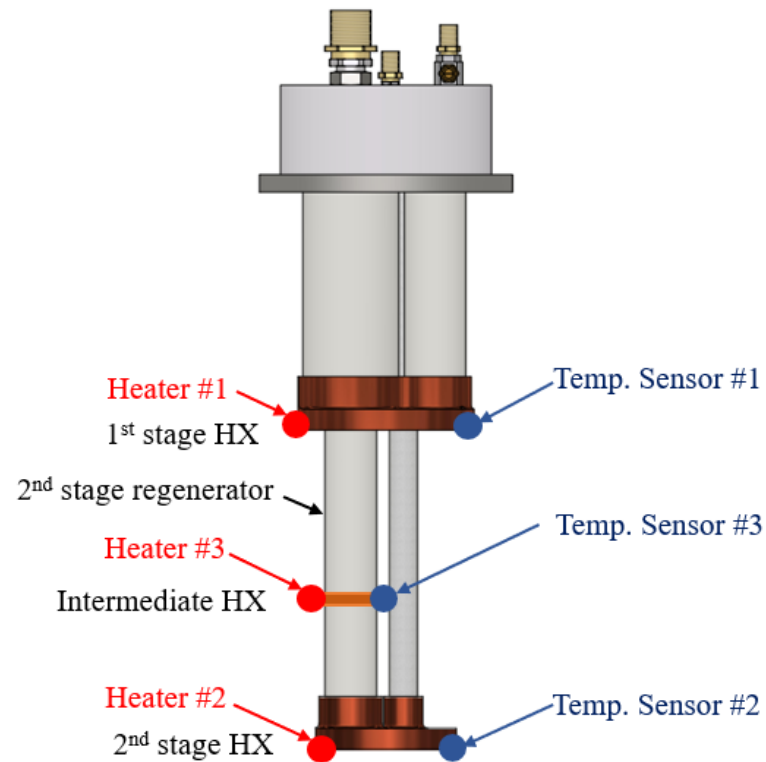


Figure 7. Schematic for extraction of the intermediate cooling from the 2nd stage regenerator.

- In pulse tube cryocoolers, excess cooling, due to regenerator inefficiencies, can provide distributed cooling along the regenerator, or intermediate cooling at a certain location on the regenerator.
- Testing has been conducted on an experimental PT450-RM. The actual cooling capacity is 5.18 W at 4.2 K on the 2nd stage with 70.5 W at 45 K on the 1st stage simultaneously on 60 Hz power.
- During the testing, the 1st and 2nd stage temperatures are maintained at **45 K** and **4.2 K**. Heat loads ranging from 0 W to 6.0 W were applied to the intermediate HX.

3.3 Regenerator Intermediate Cooling Capacity

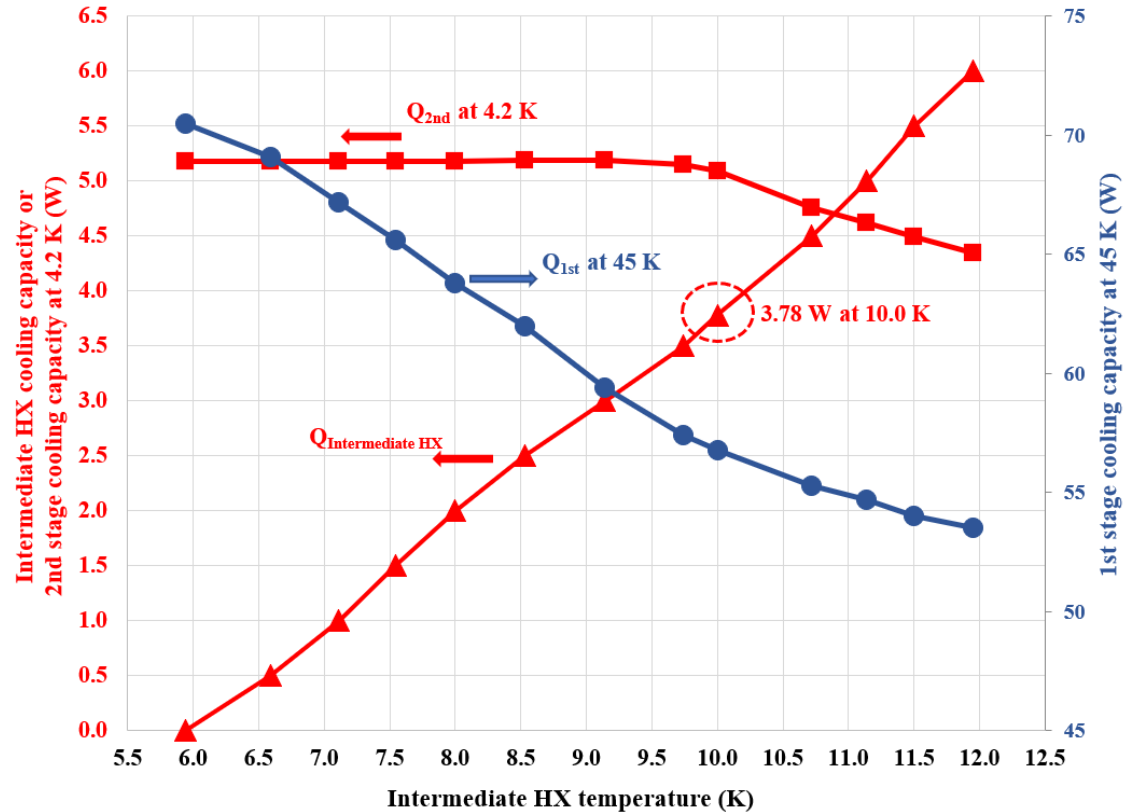


Figure 8. Cooling capacity of intermediate HX with the 1st stage at 45 K and 2nd stage at 4.2 K.

The intermediate HX can provide 3.78 W at 10 K without affecting the 2nd stage cooling capacity at 4.2 K!

°BLUEFORS

4. Summary

- A high cooling capacity 4.2 K two-stage pulse tube cryocooler (**Model PT450**) has been developed at Bluefors Cryocooler Technologies. The PT450 cryocooler provides a minimally guaranteed 5.0 W at 4.2 K on the 2nd stage with 65 W at 45 K on the 1st stage simultaneously, operating on either 60 or 50 Hz power.
- In addition, a new helium compressor (**Cryomech CP3000-Series**) has also been developed to provide sufficient helium flow for the PT450 and other large cooling capacity cryocoolers. The CP3000-Series is the largest commercially available helium compressor for the Gifford-McMahon cryocooler and G-M type pulse tube cryocooler market.
- As part of its development, the PT450 cryocooler is going through consistency tests to ensure reliable performance.

Cool for Progress.

°BLUEFORS

Acknowledgement



Cool for Progress.

**BLUE
FORS**

Thank you!

Cool for Progress.

[BLUEFORS.COM](https://bluefors.com) [CRYOMECH.COM](https://cryomech.com)

July 6, 2023 | 14

