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Introduction

4K GM cryocooler has been widely used for cooling superconducting magnets, such as, magnets in MRI systems. 4K GM cryocoolers with magnetic regenerator materials are inevitably exposed to the magnetic field. The cooling capacity of 4K GM cryocoolers will be affected by specific heat variation of magnetic regenerator materials under magnetic fields. The experimental investigation of the cooling capacity of SHI commercial 1W 4K GM cryocoolers in magnetic fields was carried out from the viewpoint of magnetic regenerator materials (HoCu₂ only or HoCu₂/Gd₂O₂S(GOS) hybrid). SHI type RDK-408D3 cold head using HoCu₂/GOS hybrid magnetic regenerator materials can keep at about 4.2 K up to 2.0 T magnetic fields.

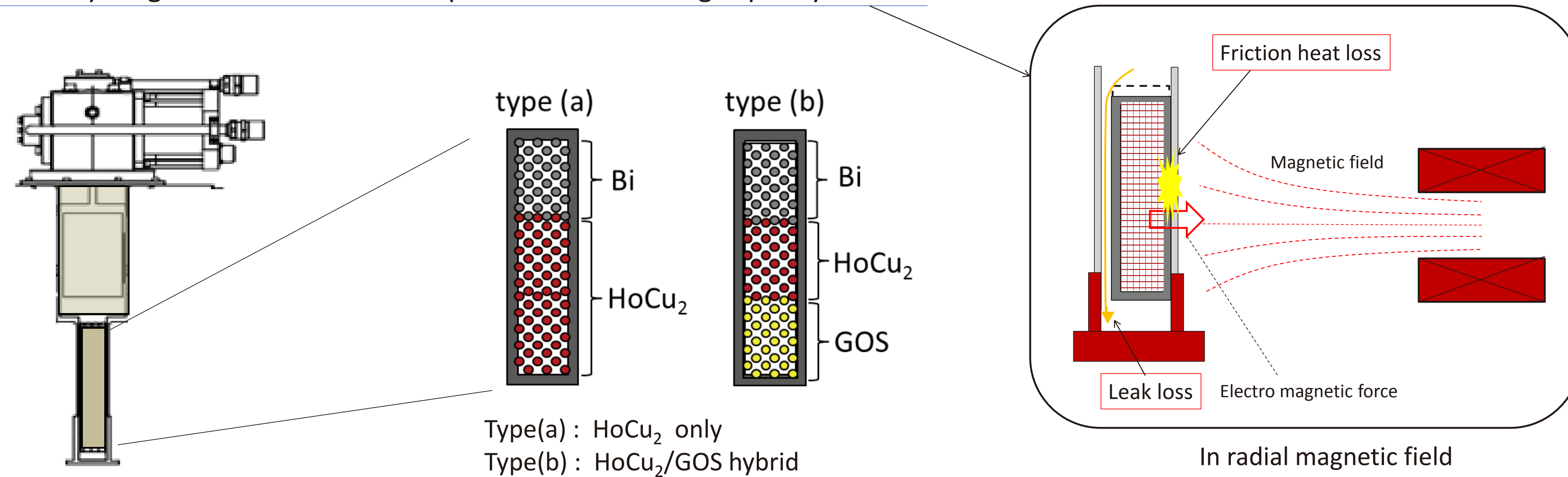
Conclusion

- ❖ By using HoCu₂/GOS hybrid regenerator, the cooling capacity of an SHI 1W 4K GM cryocooler can be kept under a magnetic field up to 2.0 T. (about 4.2 K with heat load of 1.0 W at 2nd stage in 2.0 T magnetic field)
- ❖ The magnetic regenerator material GOS is necessary for maintaining the second stage below helium boiling temperature, 4.2 K, up to 2.0 T.
- ❖ In magnetic field below 0.5 T, the dependence of magnetic field direction dependence on cooling capacity performance is not observed.
- ❖ It is considered that the amount of magnetic noise caused with operated cryocooler will be lower by using HoCu₂/GOS hybrid regenerator.

The purpose of experiment

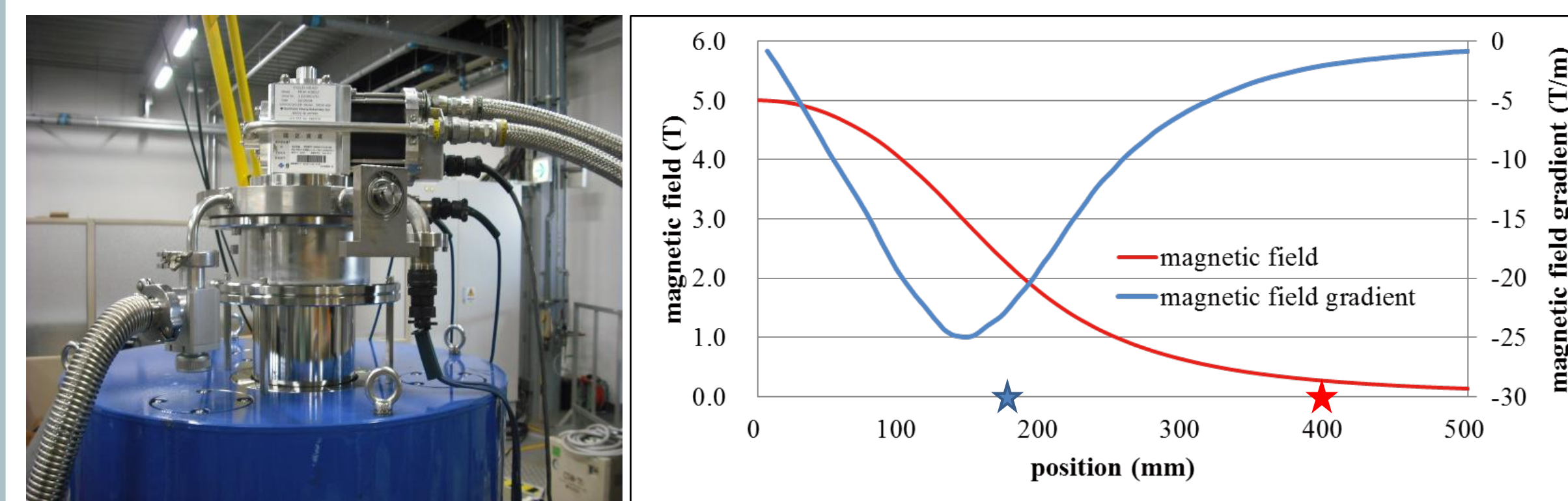
To verify the cooling capacities of SHI commercial 1W 4K GM cryocoolers in magnetic fields (Focused on the effect of magnetic regenerator materials, HoCu₂ only or HoCu₂/GOS hybrid)

To study magnetic field direction dependence on cooling capacity



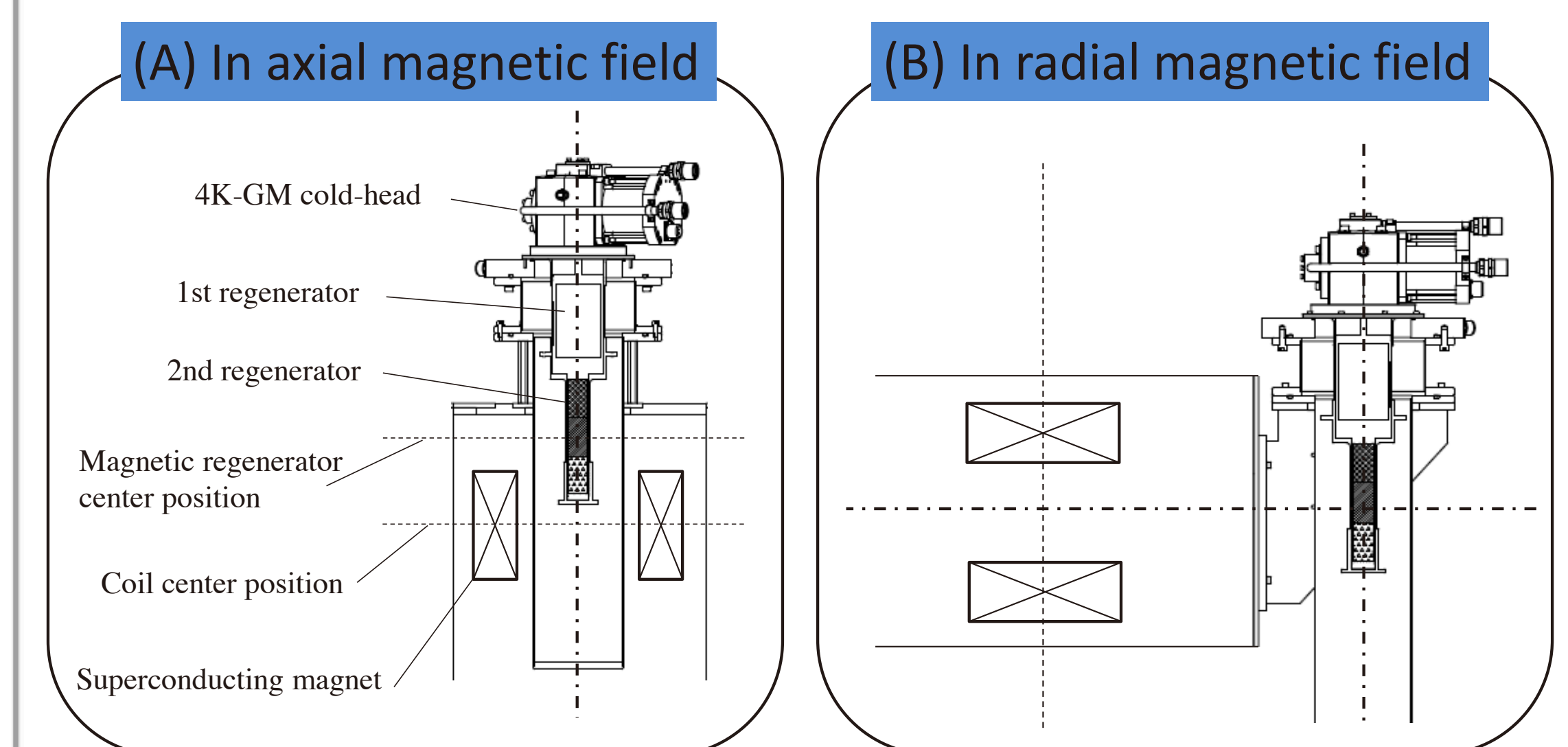
Experimental System

The source of magnetic fields



In both configurations, the magnetic regenerators are exposed to magnetic fields with magnetic field gradients.

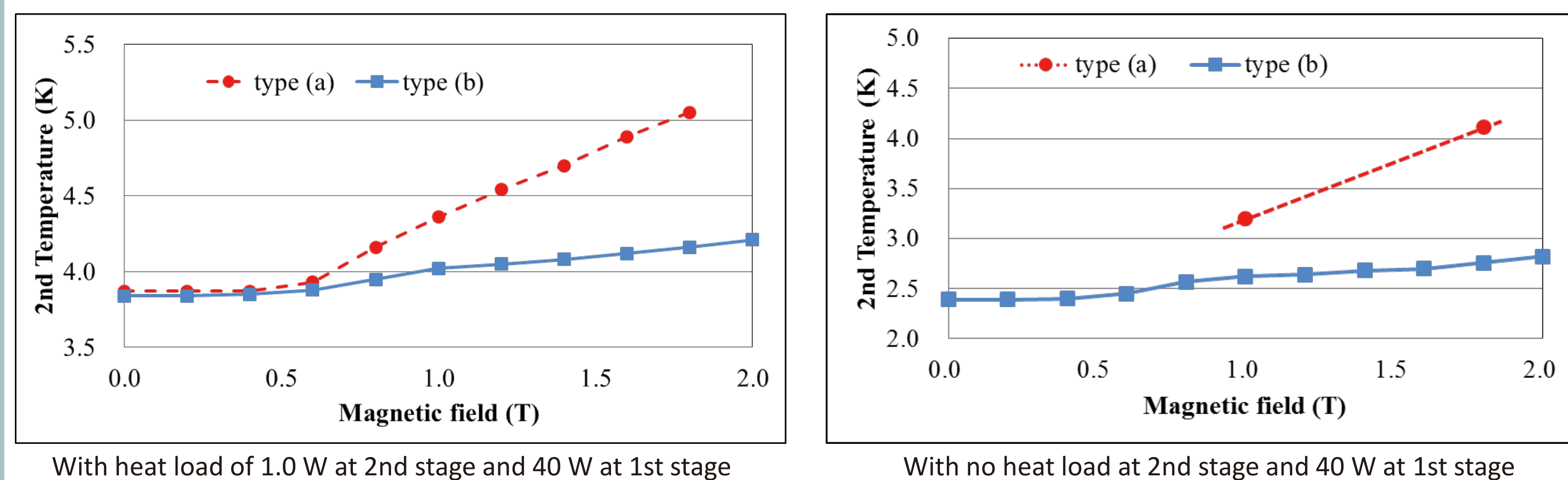
Experimental configurations



In configuration (A), up to 2.0 T at the position of HoCu₂ layer center
 In configuration (B), up to 0.45 T

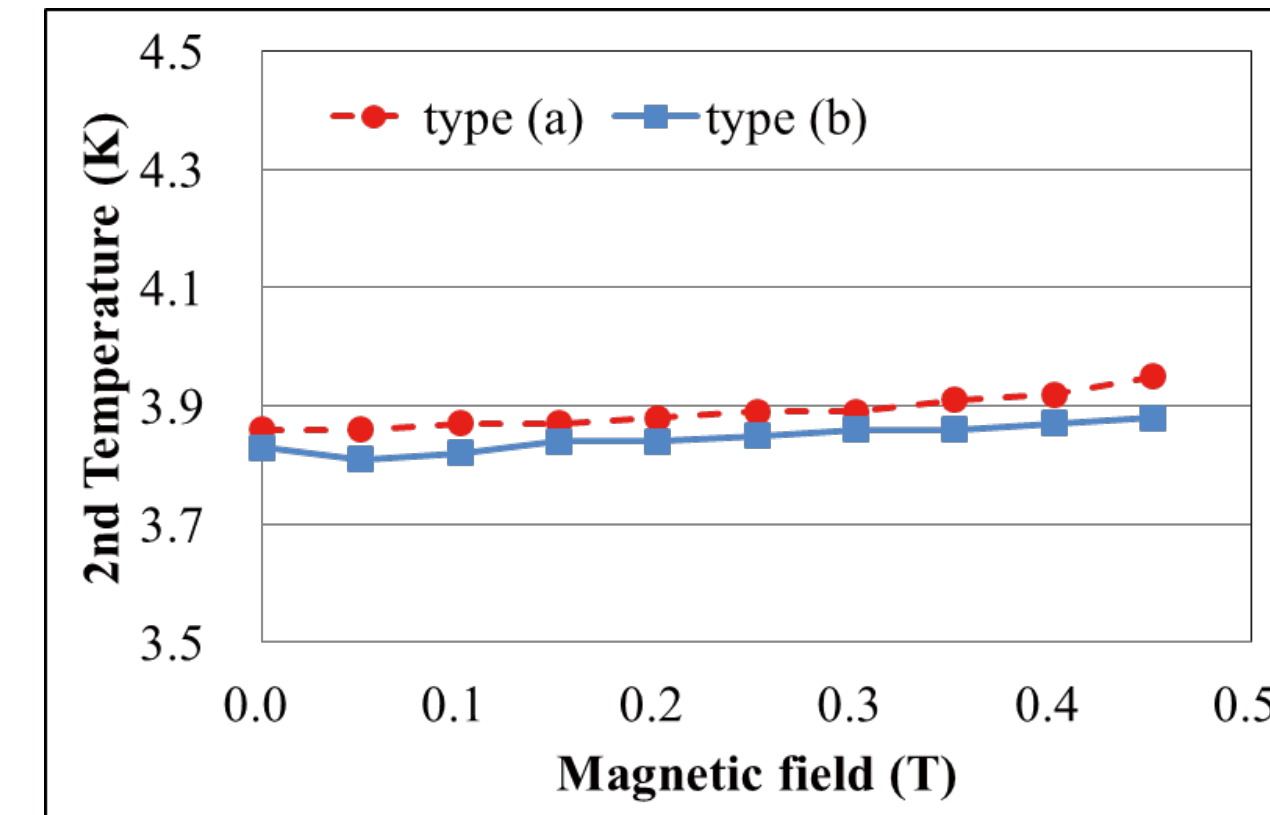
Experimental results

In axial magnetic field



No obvious reduction of cooling capacity is observed for both types in magnetic fields below 0.6 T. In magnetic fields above 0.8 T, for type (a), the cooling capacity reduces as magnetic field increases, no remarkable reduction of cooling capacity is observed for type (b). For type (a), the cooling capacity cannot maintain below helium boiling temperature even without heat load at the second stage.

In radial magnetic field

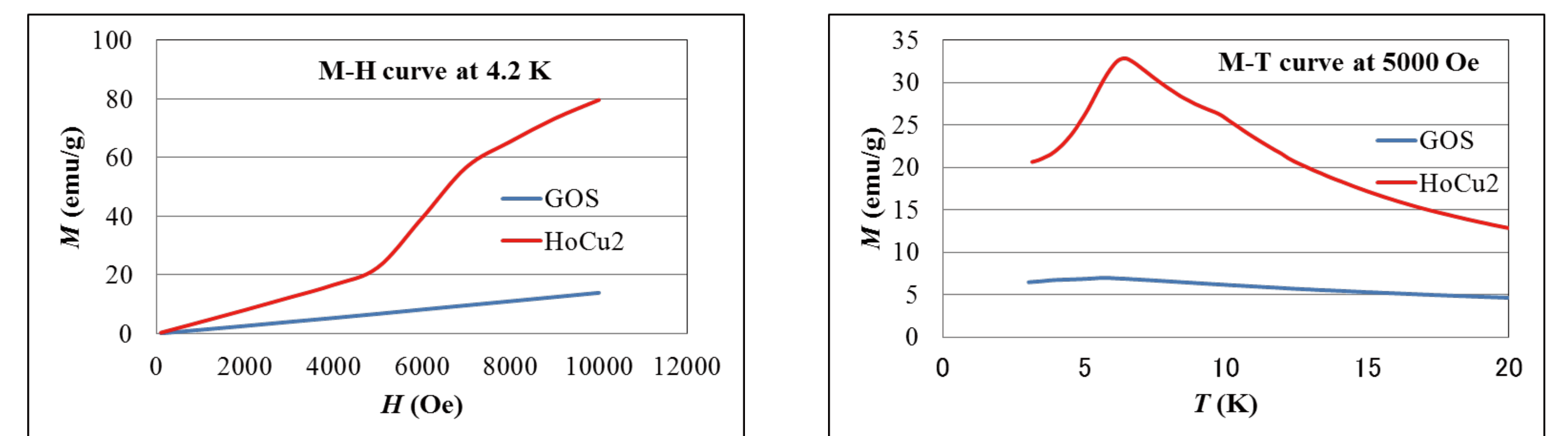


In magnetic field below 0.5 T, the cooling capacities of both types can be kept (consistent with the result of axial magnetic field). No obvious increase in friction heat loss and leak loss in magnetic field below 0.5 T.

Discussion of AC magnetic noise

When the cold head is operated, the primary factors of AC magnetic noise are

The moving magnetic regenerator with magnetism fluctuates in external magnetic fields. The magnetism fluctuation of magnetic regenerator caused by an operated cold head.



In typical temperature and magnetic field, M, dM/dH and dM/dT of GOS are less than those of HoCu₂. By using HoCu₂/GOS hybrid magnetic regenerator, it is expected that AC magnetic noise will be reduced.