A Proposal of cryogenics system for the SC FD quad at ATF2

N. KIMURA, A. Yamamoto, T. Tomaru, K. Tsuchiya, and T. Tauchi (KEK)

Outline

- Infrastructures at ATF2
- Proposal for cryogenics system by KEK
  (Additional components)
- Summary

Infrastructures at ATF2

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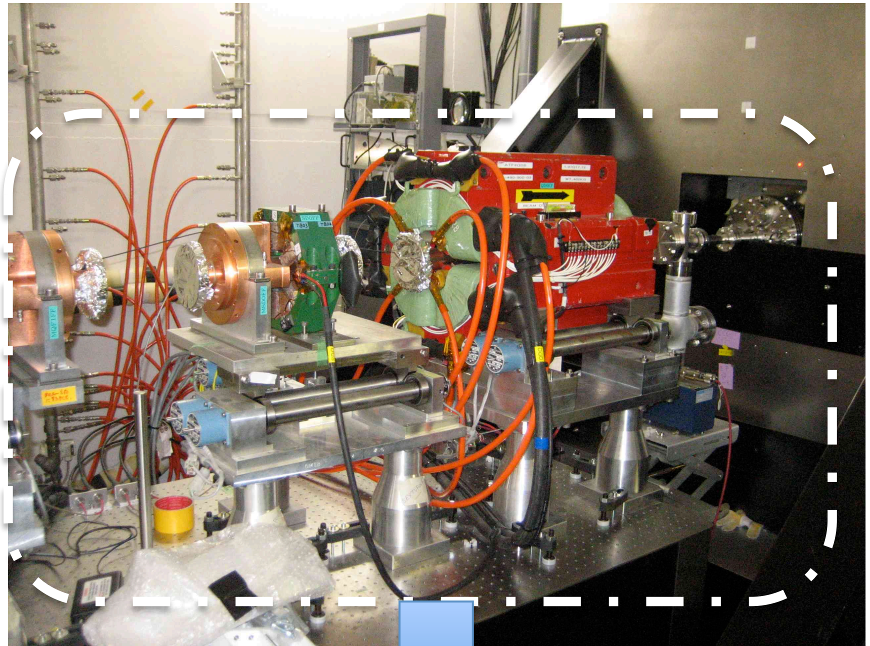
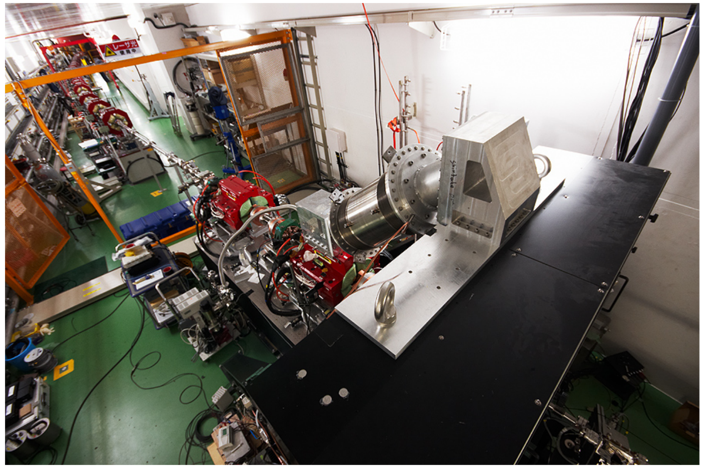
LHe supply	Very limited
(supplied only by dewar, from Cryogenics Science Center)	
Cryogenics facility	None
Space for Liquefier around ATF	??
GHe recovery line	Yes
Human resource for cryogenics operation	None
Power supplies for SC magnets	None

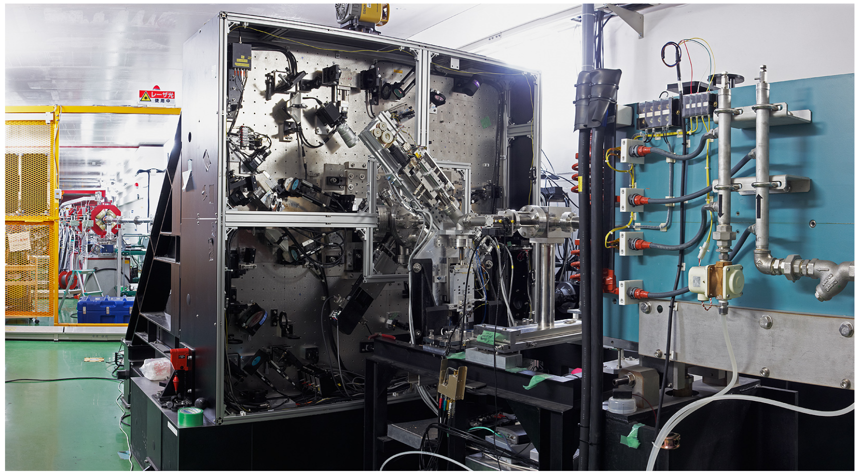
We would like to propose our plan which can be operated under limited infrastructures at ATF!! and can be consistent with BNL's magnet cooling design.

Environment for SC-FF @ATF2



Replace for SC-FF magnets





Proposal for cryogenics system at KEK

- Solution of cooling scheme @ ATF2
  - Re-condensation cooling type with low vibration Cryo-coolers.
  - It may be better than conducting cooling type for respecting BNL design.
- However, design of heat load should be reduced, hopefully, lower than 1 W (Max 2W)!
- Total heat load in the current design/plan by BNL ~15 W may not be handled/accepted at the current ATF2 environment.

Proposal for cryogenics system (cont.)

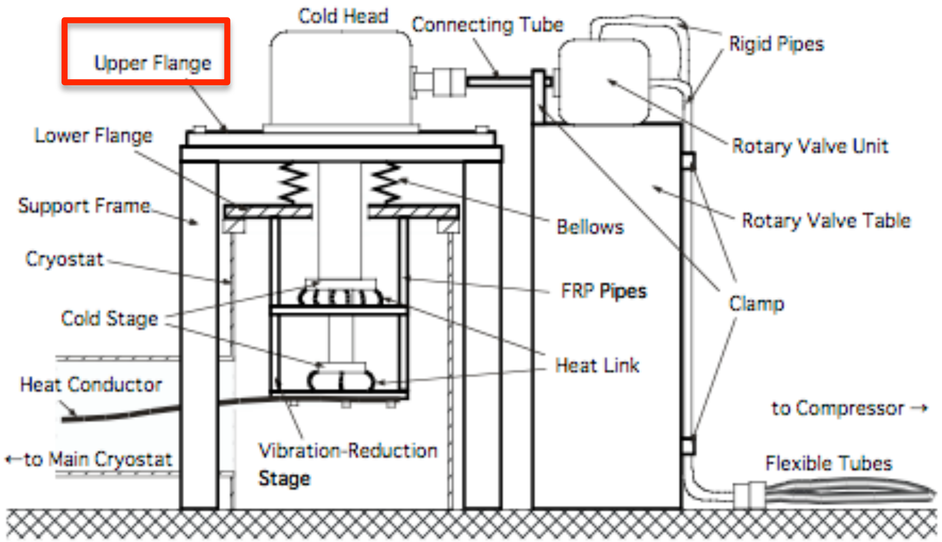
- In addition, we propose/suggest to install a laser interferometer or equivalent system into the cryostat for vibration measurement of SC coil.

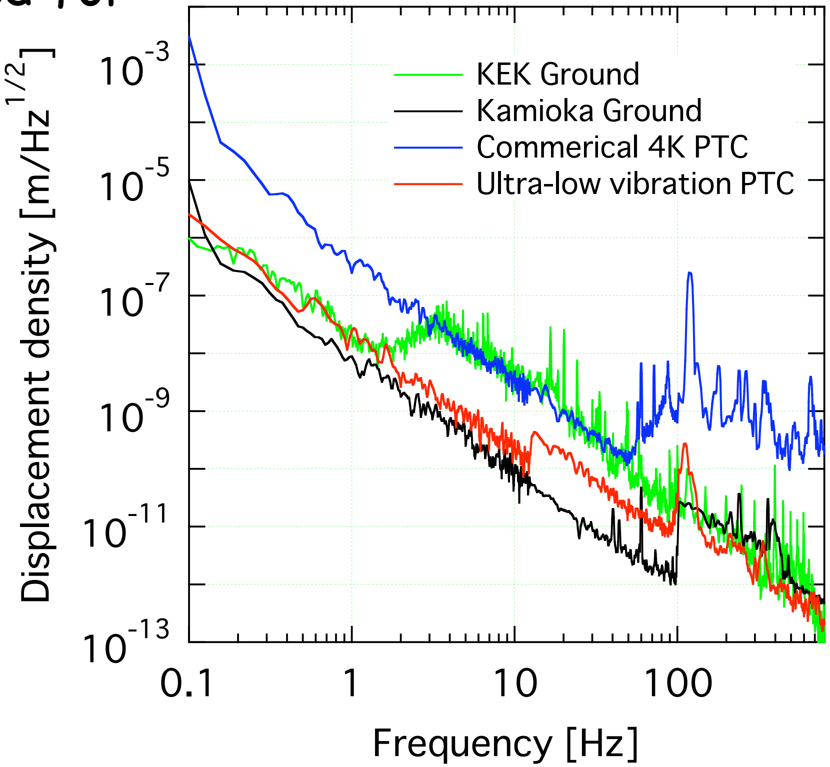
- The relation between rigidity of support and vibration is not clarified yet. We would like to discuss the relation with BNL.

- It is important to reduce total heat load lower than 1 W (except for the current leads) !

Example of Ultra-low Vibration
Pulse tube cryo-cooler system at KEK

This system was originally developed for gravitational wave detector.





Vibration level of the system was **almost the same as that in Kamiokamine.**

Vibration level is ~1nm@1Hz (Bin width~0.01)

When the cryo-cooler uses as a re-condensation cooler, do not need vibration reduction stage in above figure.

Point is separated Rotary valve from cold-head.

By courtesy of Dr. T. Tomaru (KEK)

This system was presented at ICC13.

Re-condensation type

HTC Current leads
300A x 4 pairs (1.6 W)
100A x 10 pairs (1 W)

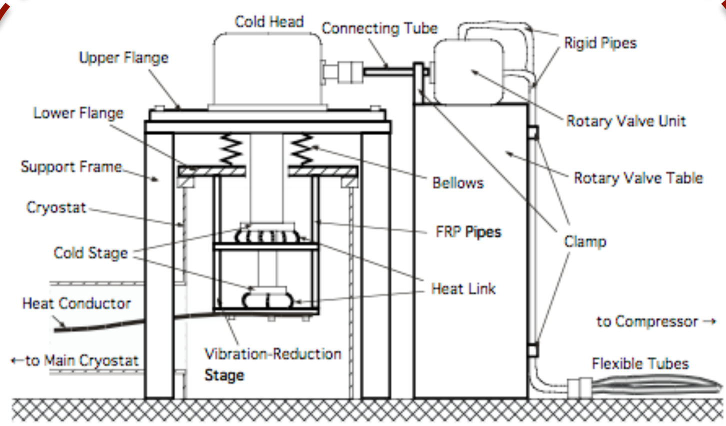
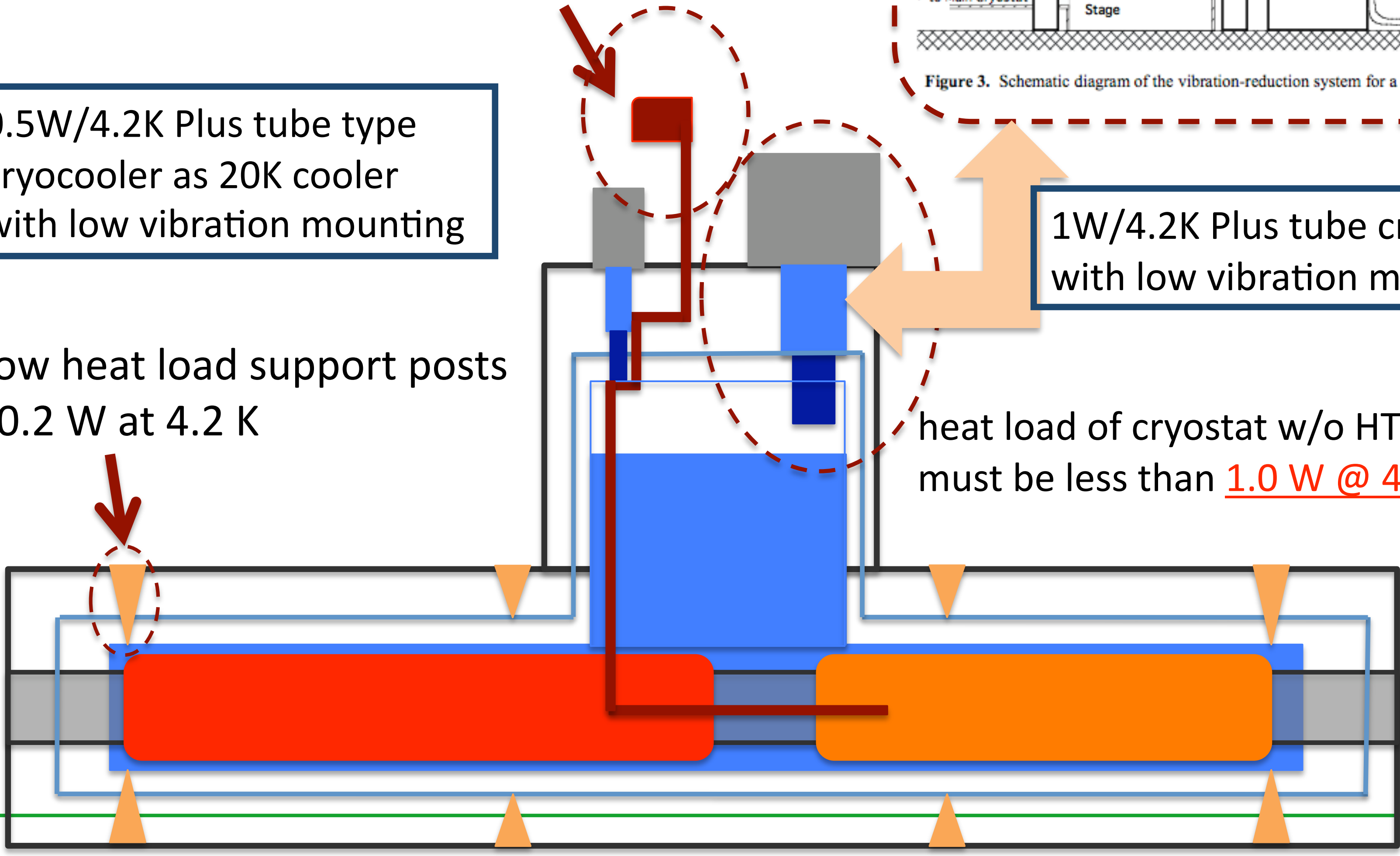


Figure 3. Schematic diagram of the vibration-reduction system for a 4K PT cryocooler.

0.5W/4.2K Plus tube type cryocooler as 20K cooler with low vibration mounting

1W/4.2K Plus tube cryocooler with low vibration mounting

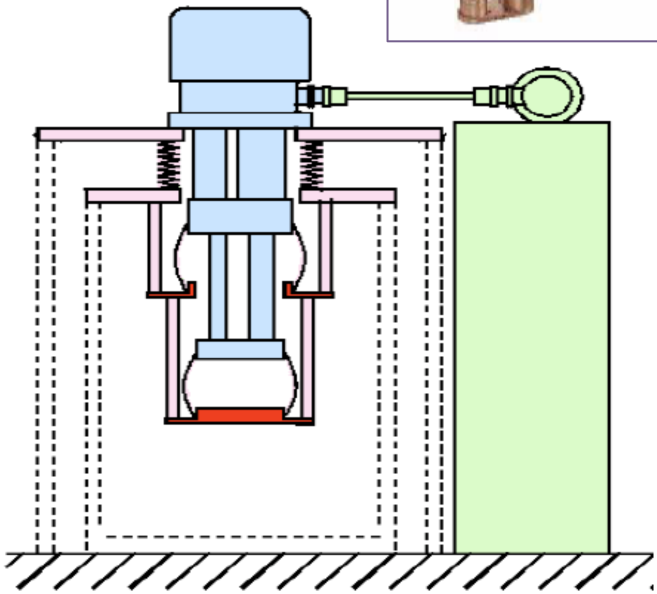
Low heat load support posts
<0.2 W at 4.2 K



heat load of cryostat w/o HTC CL must be less than <u>1.0 W @ 4.2 K</u>

Example of Pulse tube cryo-cooler

Model :*SRP-052A*
Commercialized by SHI Ltd.
Specification : 0.5W@4.2K / 20W@45K with a 7kWcompressor
Standard System Configuration of SRP-052A, without connecting tube
Advantage : • Valve Unit Separated from Cold Head
Easy for Maintenance, Short Down Time • Flexibility for Vibration Reduction Presented



Ultra-low Vibration Pulse tube cryo-cooler was developed with collaboration of KEK and SHI.

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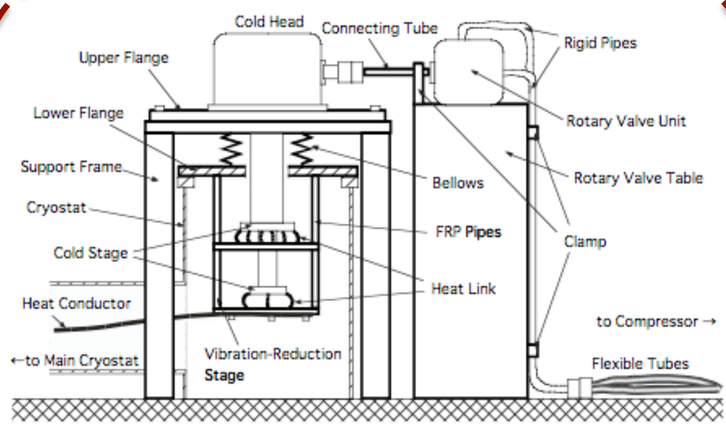

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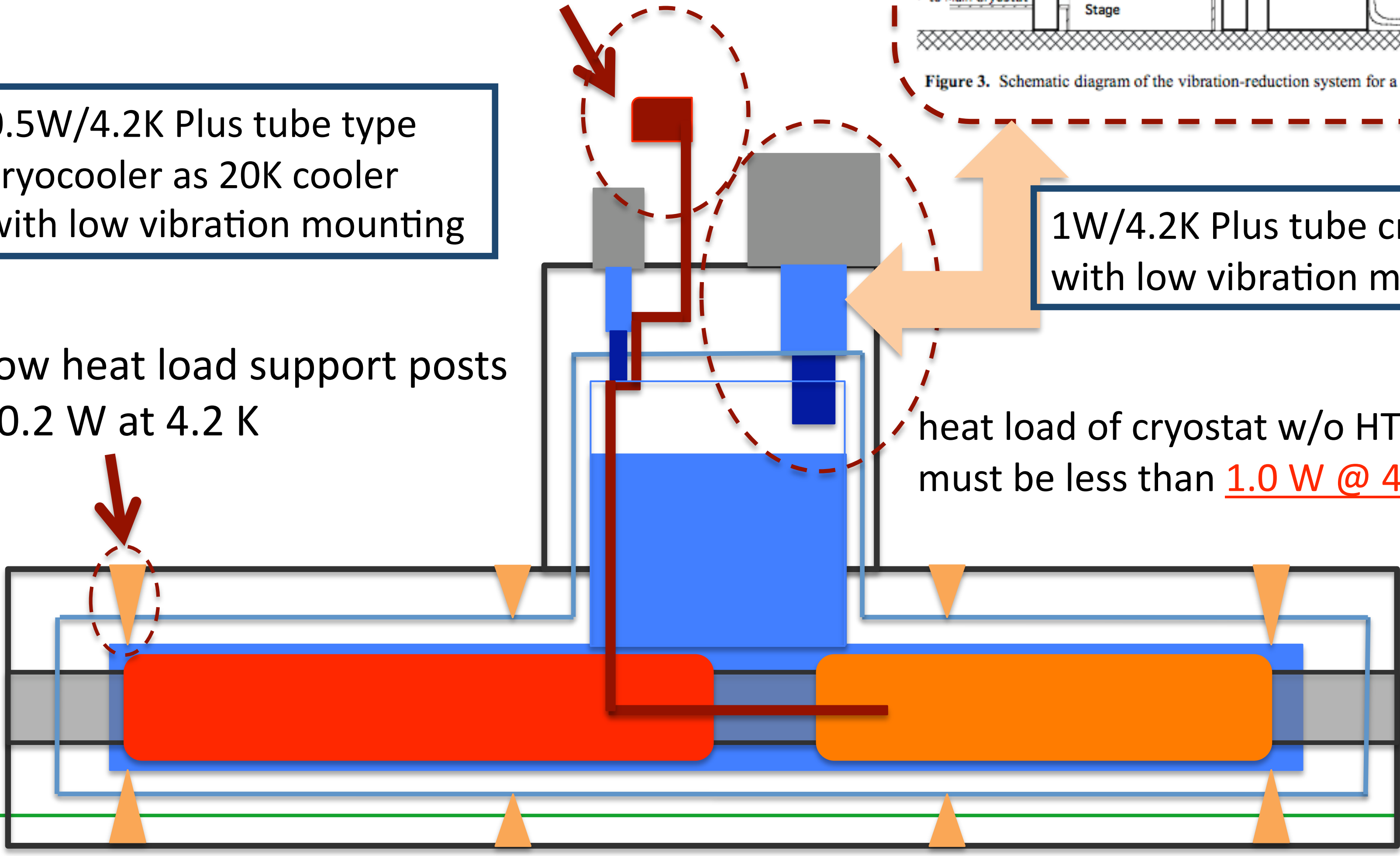

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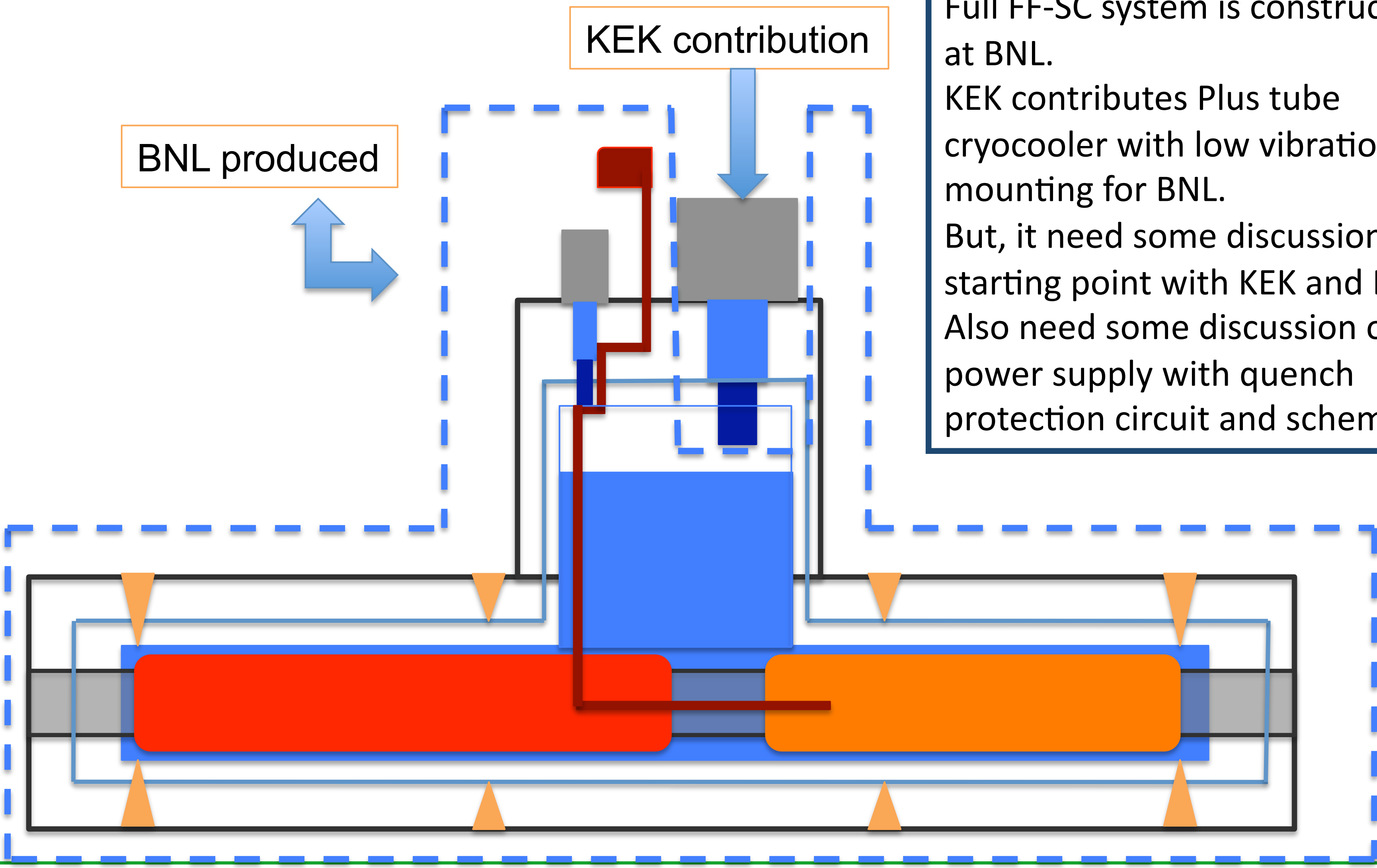
Proposal of Re-condensation type by KEK



Full FF-SC system is constructed at BNL.
KEK contributes Plus tube cryocooler with low vibration mounting for BNL.
But, it need some discussion of starting point with KEK and BNL.
Also need some discussion of power supply with quench protection circuit and scheme.

Summary

- Re condensation cooling system @ ATF2

  are proposed by KEK. It requires revising design (of support posts) for SC magnet thermal design to reduce total heat load lower than 1 W, with a possible balance with the low vibration requirement.
- For better understanding of vibration level on surface of SC magnet, we hope to extend discussion with BNL magnet group to find an optimum solution to reduce total heat load and to satisfy the low vibration requirement.
- For reducing vibration level lower than 50 nm, we may contribute to the low vibration cryocooler system design to be adaptable to the BNL magnet design in cooperation to the design study for the magnet support system and the thermal load.
- We would like to to extend discussion with BNL to find possibility of testing FF-SC magnet @ ATF2 .
- We also would like to discuss quality of Power supply for the magnet, and quench protection design.

Theme of Discussion

- Revising design (of support posts) for SC magnet thermal design
- Optimum solution to reduce total heat load and to satisfy the low vibration requirement
- The BNL magnet design in cooperation to the design study for the magnet support system and the thermal load
- Find possibility of testing FF-SC magnet @ ATF2
- Quality of Power supply and quench protection design

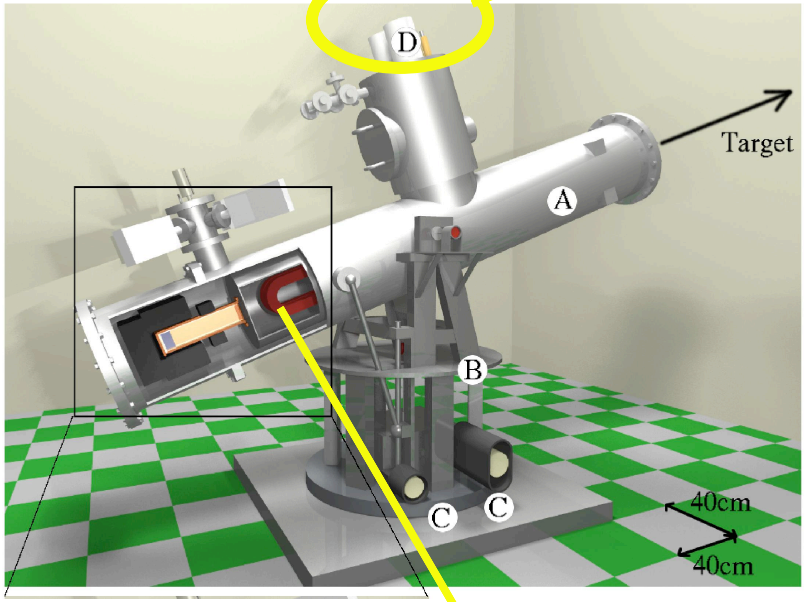
Appendex

Cryogen-Free Superconducting Magnet by using Cryo-Cooler

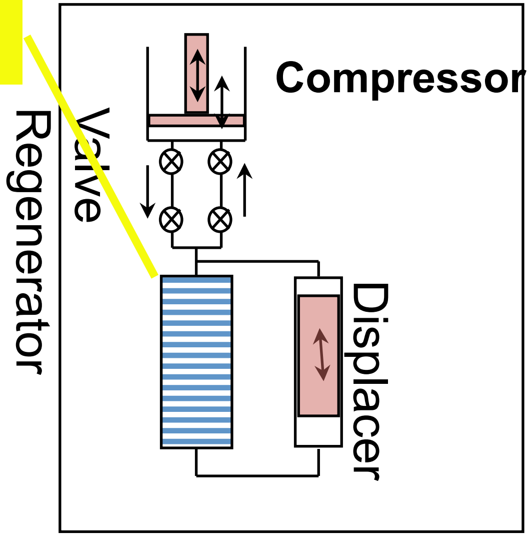
- Cryo-cooler Technology has been progressed,
- A medium-scale superconducting magnet with a heat load of ~ a few W may be cooled by using Cryo-coolers.
- It may help the magnet operation in fully automatic mode with “operational shift-free”.

Superconducting Magnet for Solar Axion Search @ ICEPP U-Tokyo

Cryo-cooler

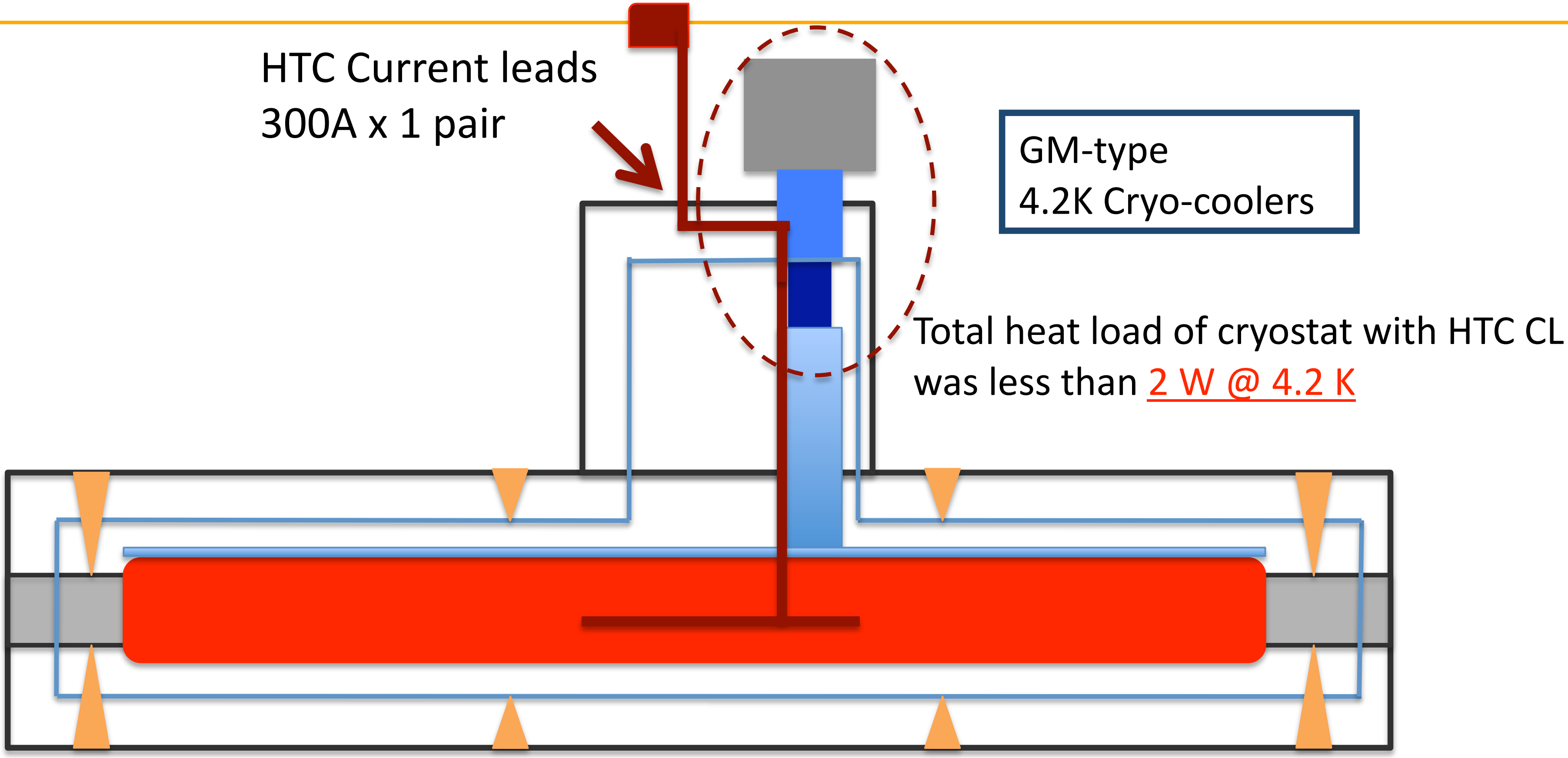


Race Track Coils
(5 T x 2m)



- Dipole field of 10 T•m
- Cooled by using cryo-coolers (2 W at 4.2 K).

Example of Conduction cooling type magnet at KEK

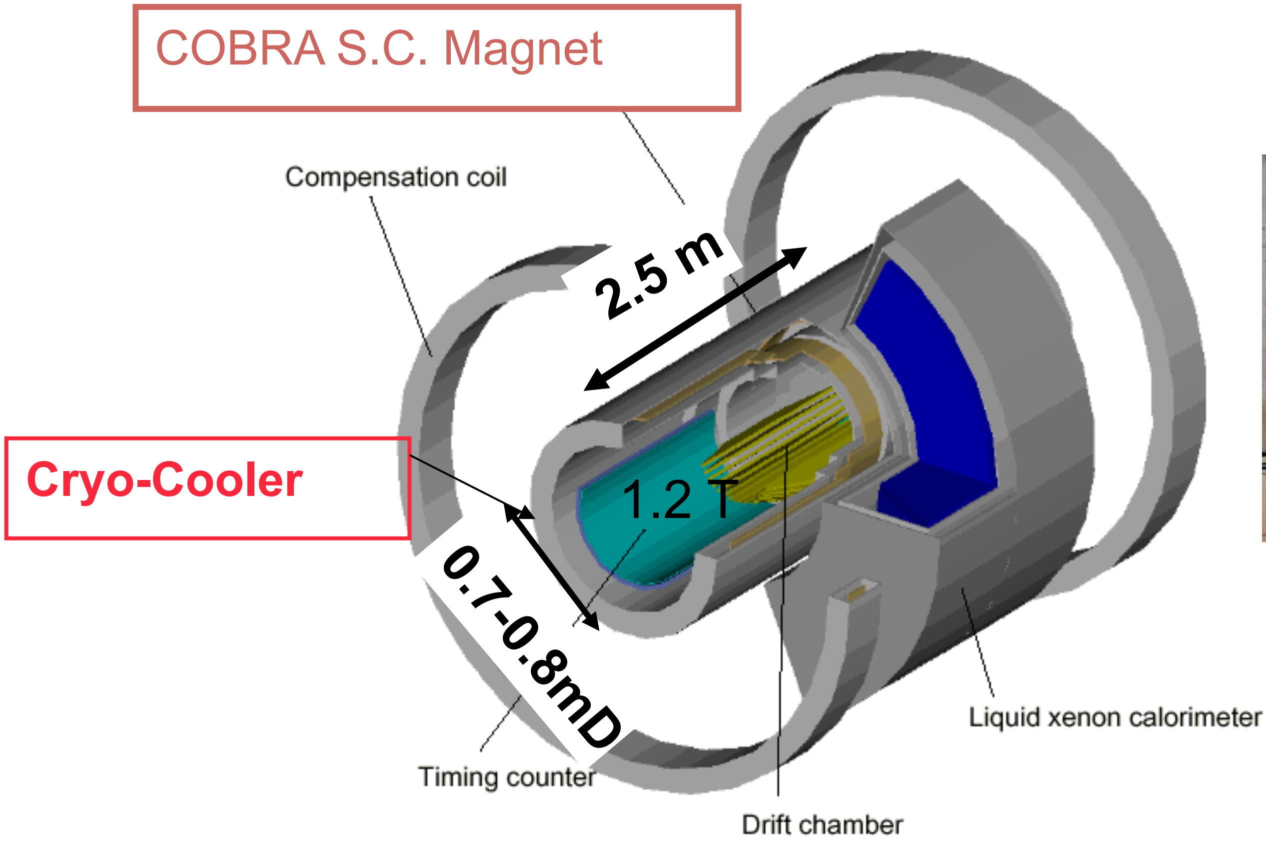


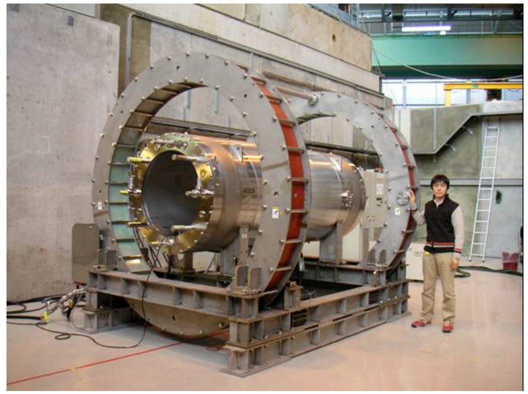
The magnet were made for
Axion search project.

Coil type: Race truck type
Coil number: 2
Coil length: ~2.1m
Coil mass: ~135kg/coil
Center field: 5 T
Nominal current:336 A

Superconducting Magnet

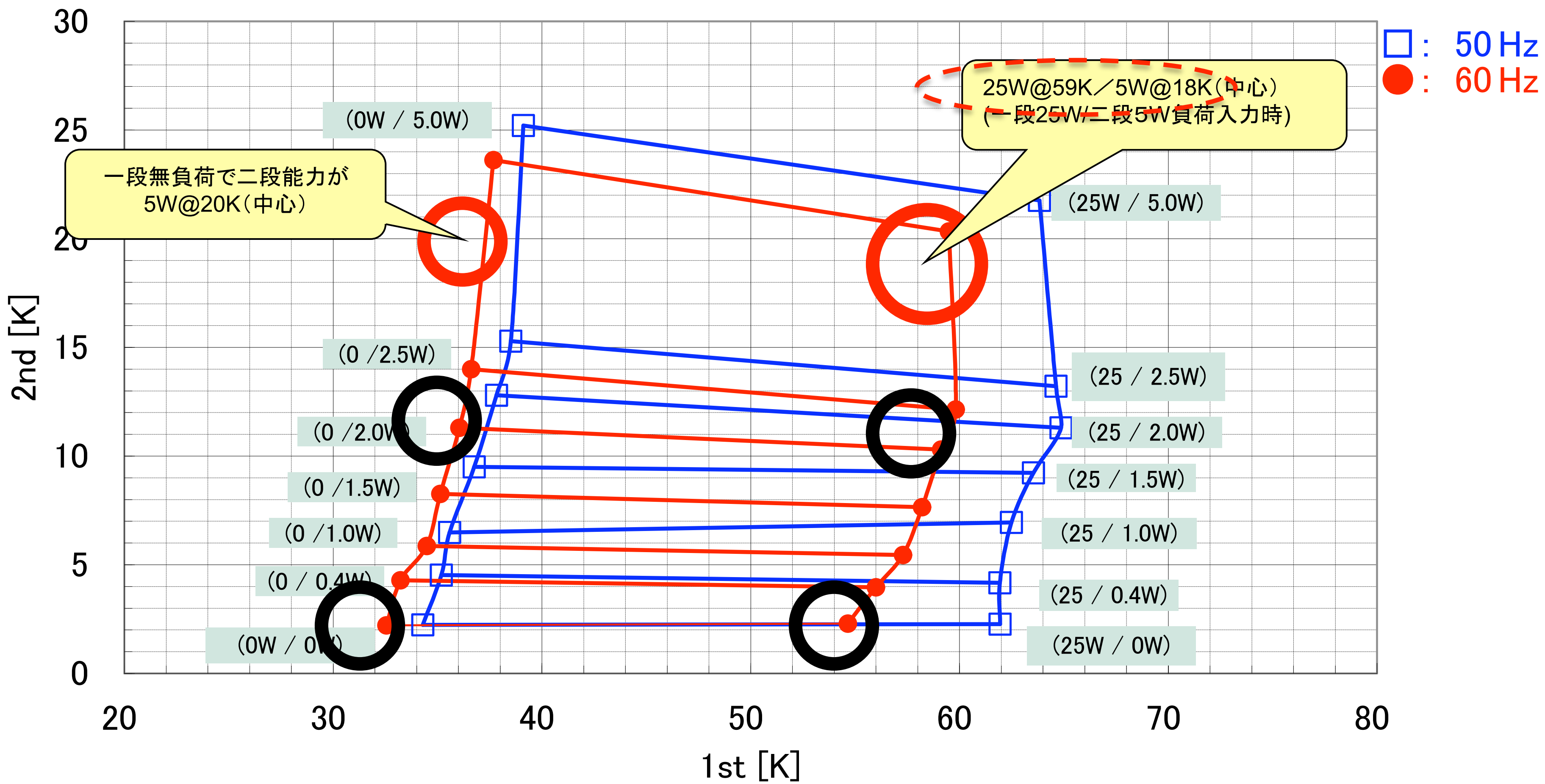
For the MUEGAMMA (MEG) @PSI





Simulation of cooling power at 20K using 0.5W@4K Pulse tube

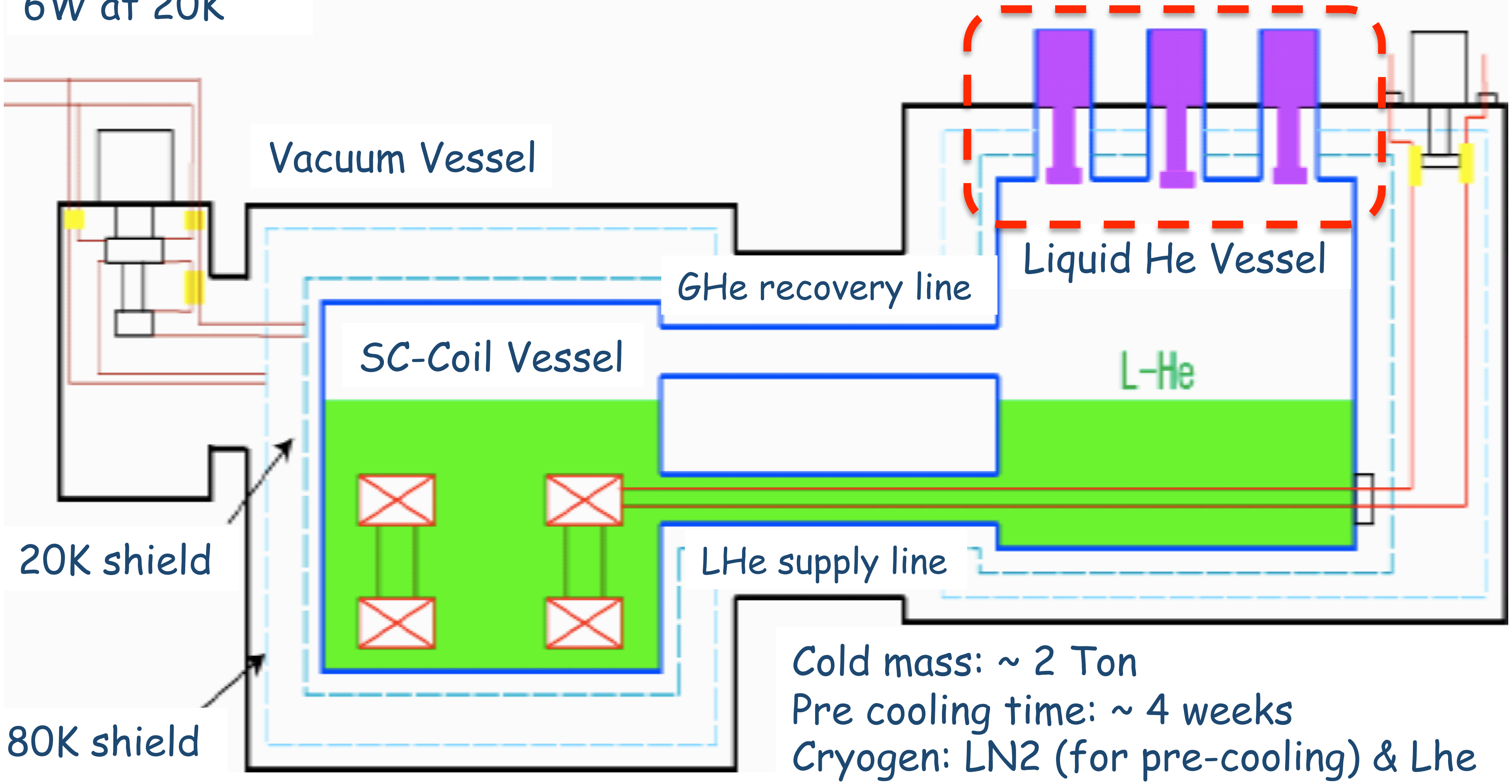
25W@59K(1st)/5W@18K(2nd)



Cryo-coolers for radiation shields

60W at 80K
6W at 20K

Re-condensation Cryo-coolers
(GM-JT type, 5W at 4.2K x3)



Cold mass: ~ 2 Ton
Pre cooling time: ~ 4 weeks
Cryogen: LN2 (for pre-cooling) & Lhe
Current feeds by HTC current leads

An example of semi cryogen free system
SKS Cryogenics system at KEK

Comparison table

	Re-condensation Cooling	Conduction Cooling
Consistent of BNL's magnet design	Very near But need some of modifications	Far way
Operation	easy	Very easy
Needs LHe for pre-cooling?	Yes	None
Needs GHe recovery line?	Yes	None
Needs permission of operation by local government?	Yes, but not difficult	None
How many coolers?	2 (1 for HTC CL)	2 (1 for HTC CL)
Human resources for operation	Few	Very few