Cryogenic System for Superconducting Final Focus Magnets (SCFFM) at ATF-2

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OUTLINE

- Proposed cooling scheme for SCFFM for 4K Connection Box
- ✓ Vibration control
- ✓ Heat load estimation
- Set up plan for the cryostat in the ATF-2
- Proposed schedule for construction plan
- 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 ATF2!! and can be consistent with BNL's magnet cooling design.

Proposed the cryogenics system at KEK

- Cooling scheme @ ATF2
  - We propose to construct

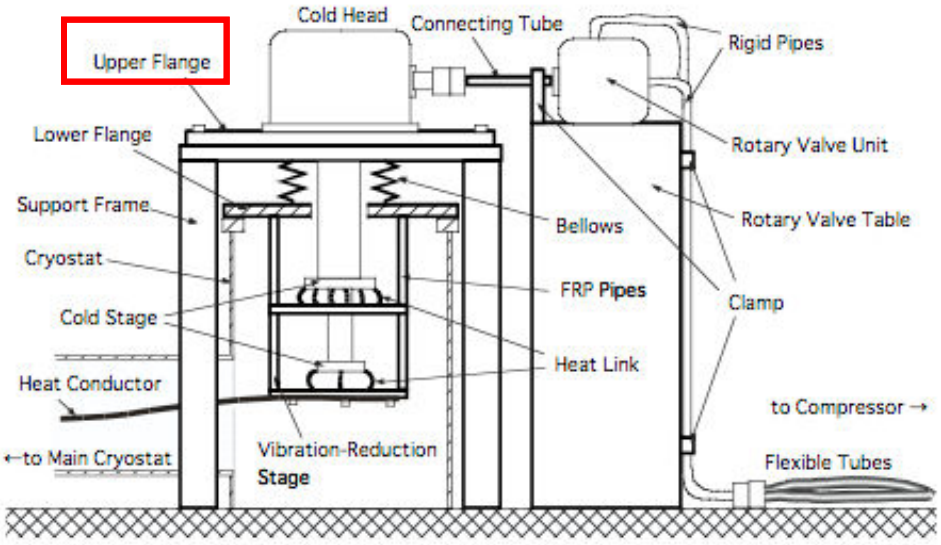
"A re-condensation cooling type" with low vibration Cryo-coolers.

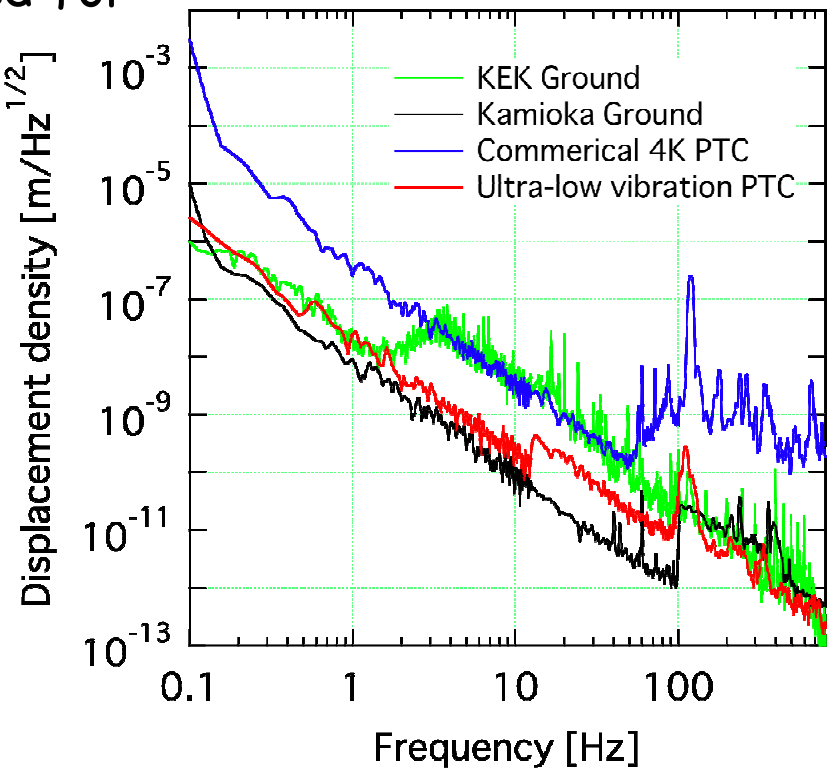
  - Vibration Control -> Mixture of LCGT scheme & SCGR scheme

A R&D work of low vibration cryogenics system have just started in Cryogenics Science Center as a basic research for this kind of project.

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.

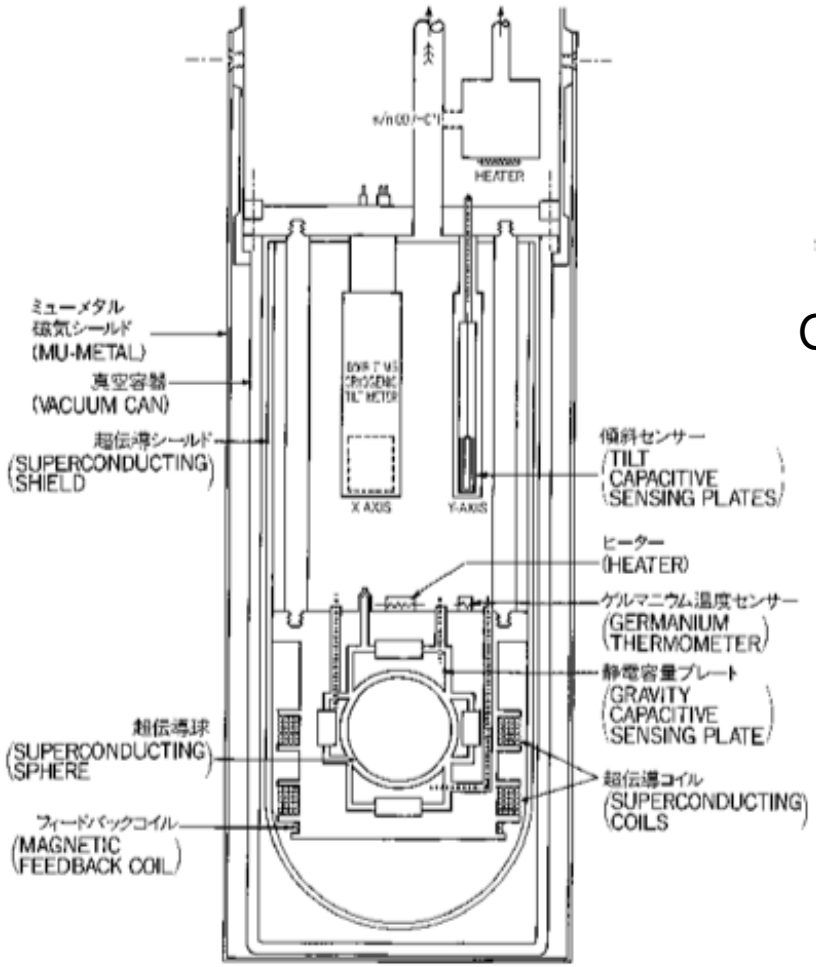
Example of Superconducting Gravimeter

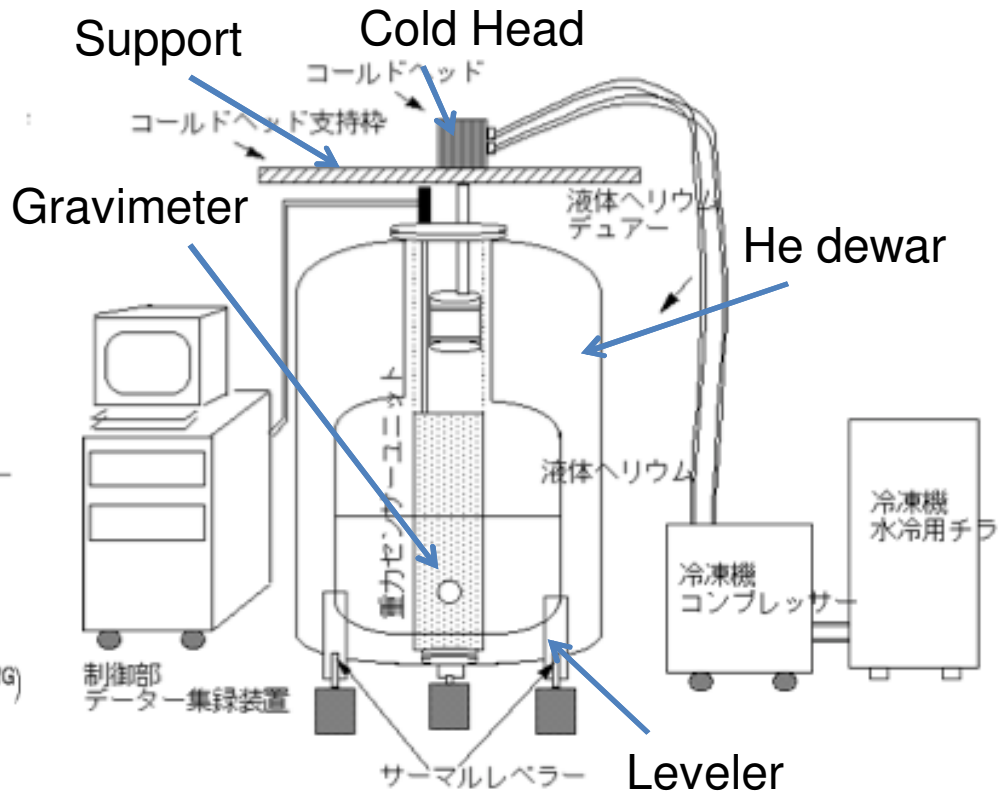
Restrain boiling type by using cooler

(Baby sitter, re-condensation, thermo siphon)

Sensitivity

$$\frac{\Delta g}{g} \approx 10^{-12}$$





Cooling scheme for 4K connection box at ATF2

Heat loads by Current leads into 4K level
300A x 4 leads (0.6 W, 0.15W/lead) by HTC conductor
20A x 10 leads (Total 0.56 W, 0.056W/lead) by Low RRR Cu

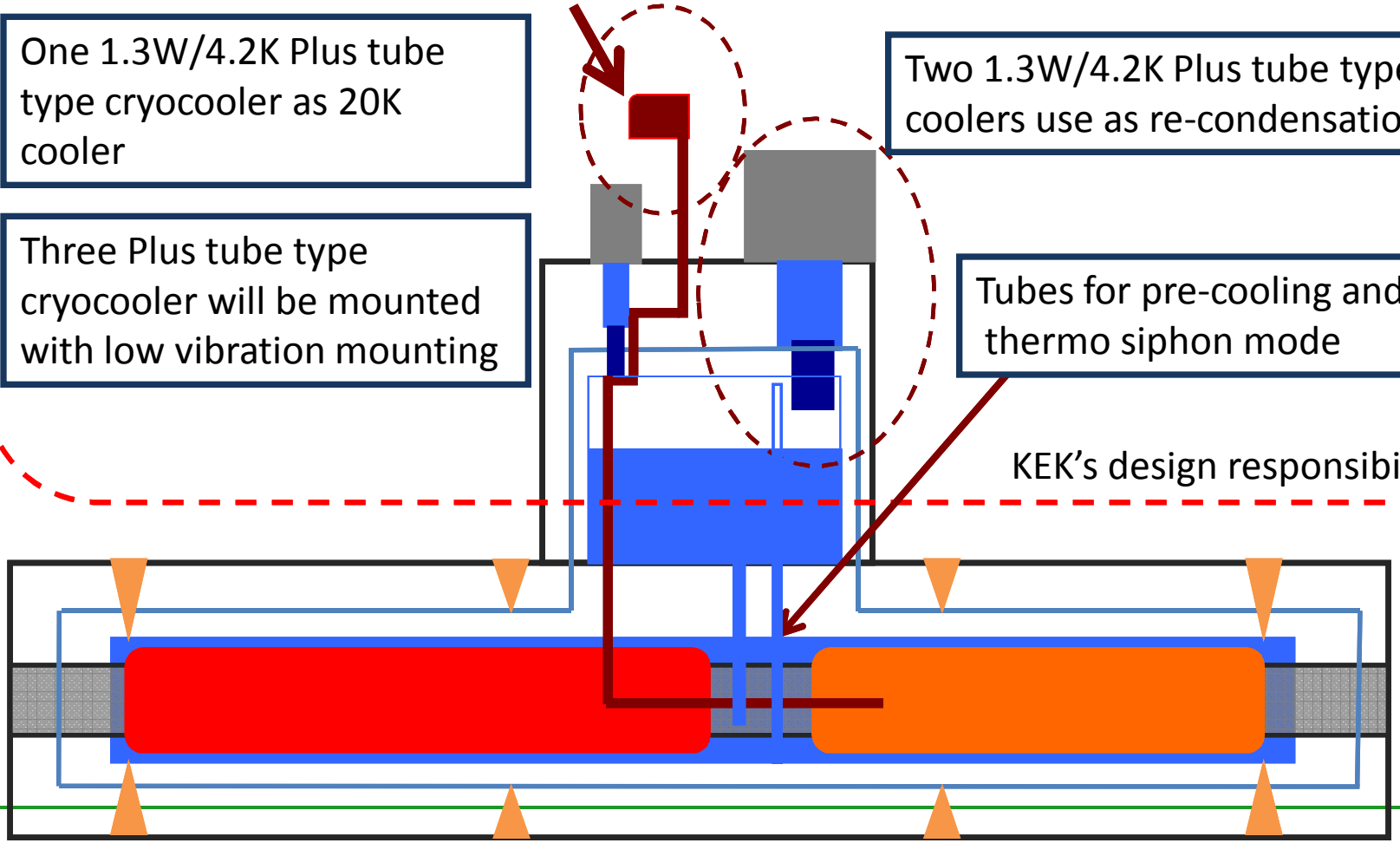
One 1.3W/4.2K Plus tube type cryocooler as 20K cooler

Three Plus tube type cryocooler will be mounted with low vibration mounting

Two 1.3W/4.2K Plus tube type cryo-coolers use as re-condensation cooler

Tubes for pre-cooling and thermo siphon mode

KEK's design responsibility



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  "A re-condensation cooling type" with low vibration Cryo-coolers.
  - Vibration Control -> Mixture of LCGT scheme & SCGR scheme

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Estimated heat loads at 4K connection box

		Heat Loads (W)		
		300K->77K	77K->20K	20K(77K)->4.2K
	Element			
Puls Tube No.1	Current Leads	50.0	4.70	1.04
Puls Tube No.2 &3	Radiation	3.2	0.00	0.11
	GFRP Support	5.0	0.00	0.10
	Electrical leads	5.0	0.00	0.10
		13.2	0.00	1.35
Puls Tube No.1		57.6	15.0	
Puls Tube No2+No.3		72.0		2.4
		58.8		1.1

One 1.3W/4.2K Plus tube type cryocooler as 20K cooler

Two 1.3W/4.2K Plus tube type cryo-coolers use for re-condensation coolers

Enough for radiation cooing

< 1.5~2.4 W by magnets Not enough

Cooling performance for magnet cryostat

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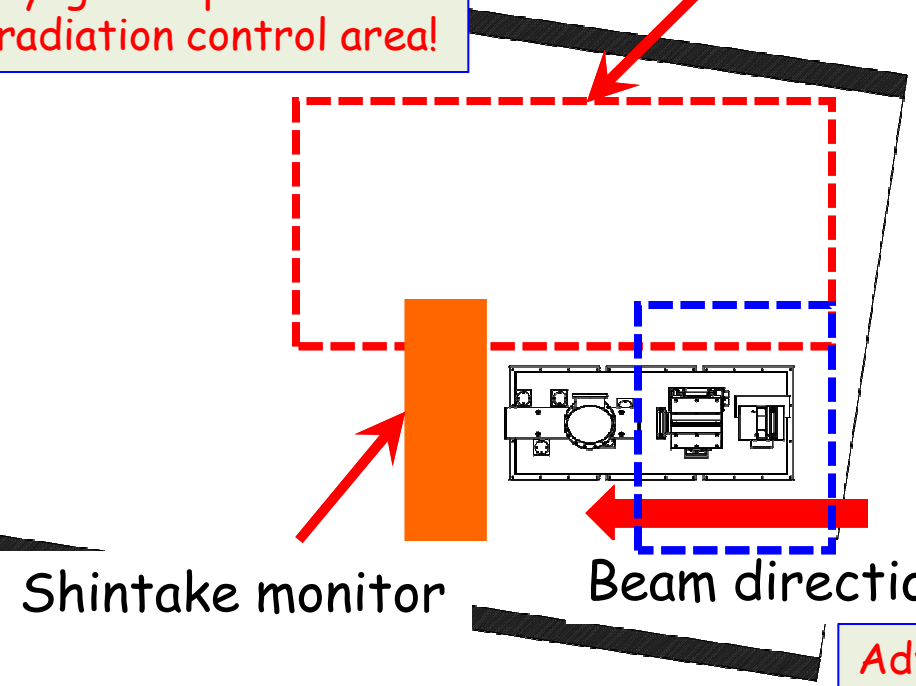
Proposed set up plan in the tunnel at ATF2

For working and walking space

This is good solution at ATF2!

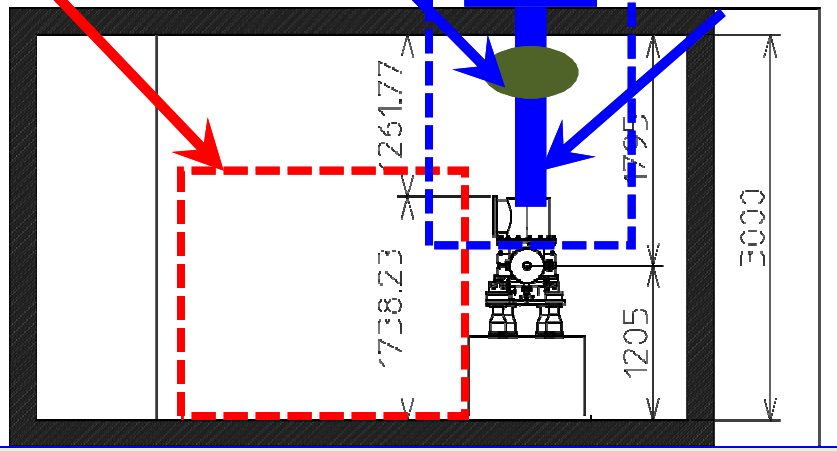
ryogenics part
radiation control area!



4K connection box

Bellows part

connect



Advantage Two.
Huge of mass of shield block will be attached with the BOX, and it will be reduced mechanical reson

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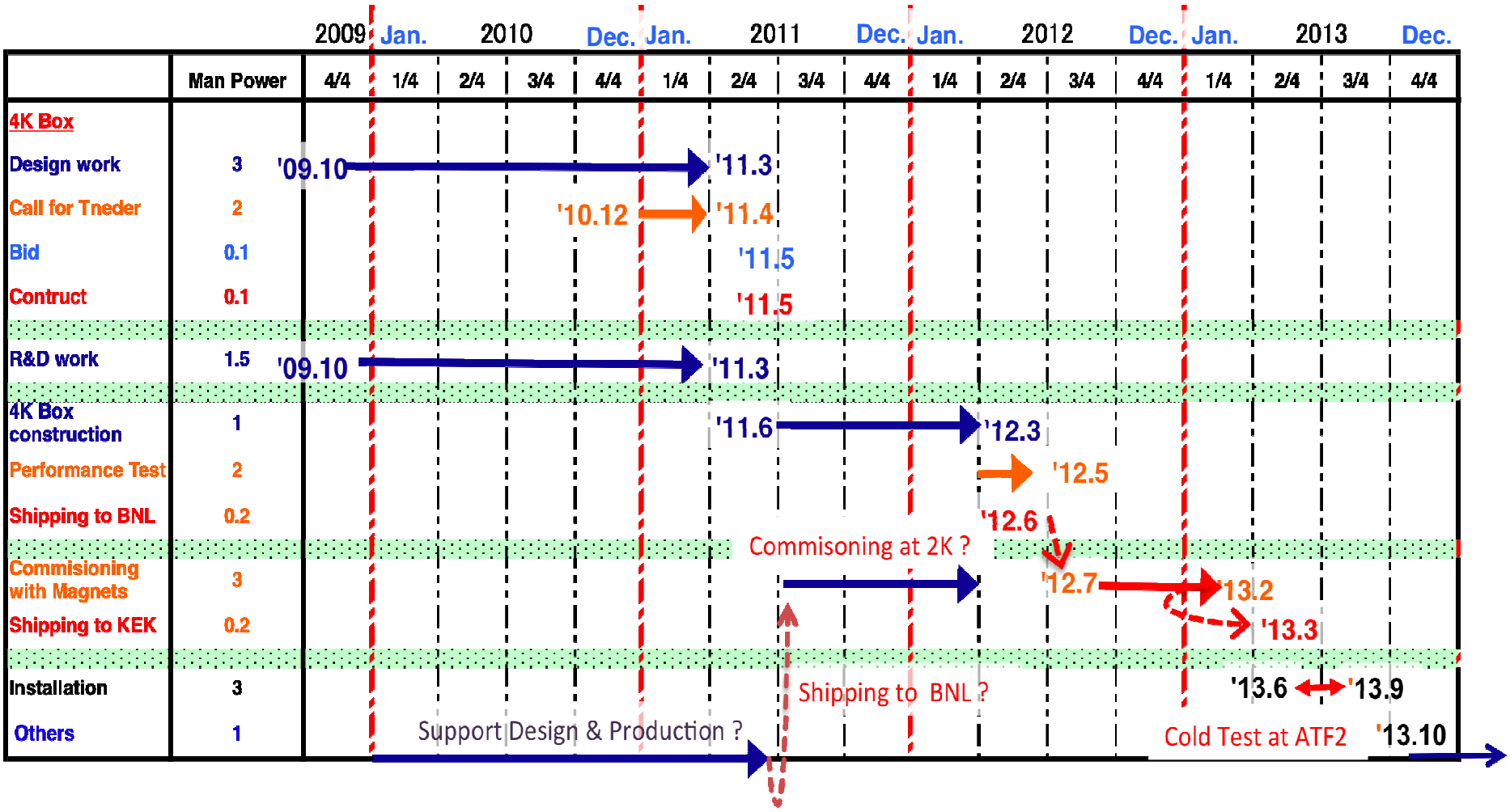
Proposed Schedule (Construction & Installation)



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Summary

- Re-condensation cooling system @ ATF2 are proposed by KEK.
- R&D work for low vibration cryogenics have been accepted in Cryogenics Science Center as a basic research.
- 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.
- Final goal for the ready to operation in ATF-2 is the end of October 2013.

Open to Discussion

- R&D?
- Other part for Contributions?
- Support system?
- Vibration?
- Etc?

Appendix

Design work for 4K box at KEK

- Structure of Current Leads
  For B1 & B3 magnets -> HTC + L.R^3.Cu lead
  For left five magnets -> hybrid conductor type like LHC sc-corrector magnet

- Cryo-coolers -> Plus tube cryocooler
- Cooling scheme -> Re-condensation cryogenic system

Mixture of LCGT scheme & SCGR scheme

Estimated Heat load by Current Leads-Case 1

			Heat Loads (W)		
			300K->77K	77K->20K	20K->4.2K
Element	Multipole	Max. I			
Description		Scenario			
	Bn or An	(A)			
Main Quadrupole	B2	275	27.5	2.57	0.24
Dipole Cor.	B1	20	2.0	0.19	0.12
Skew-Dipole Cor.	A1	20	2.0	0.19	0.12
Main Sextupol	B3	125	12.5	1.17	0.20
Skew-Sext. Cor.	A3	20	2.0	0.19	0.12
Quad. Cor.	B2	20	2.0	0.19	0.12
Skew-Quad. Cor.	A2	20	2.0	0.19	0.12
			50.0	4.67	1.04

Set-up: consists of L.R^3. Cu & HTC
300K->77K leads: Low-R^3 Cu
77K->20K leads: Low-R^3 Cu
20K-> 4K leads: HTC

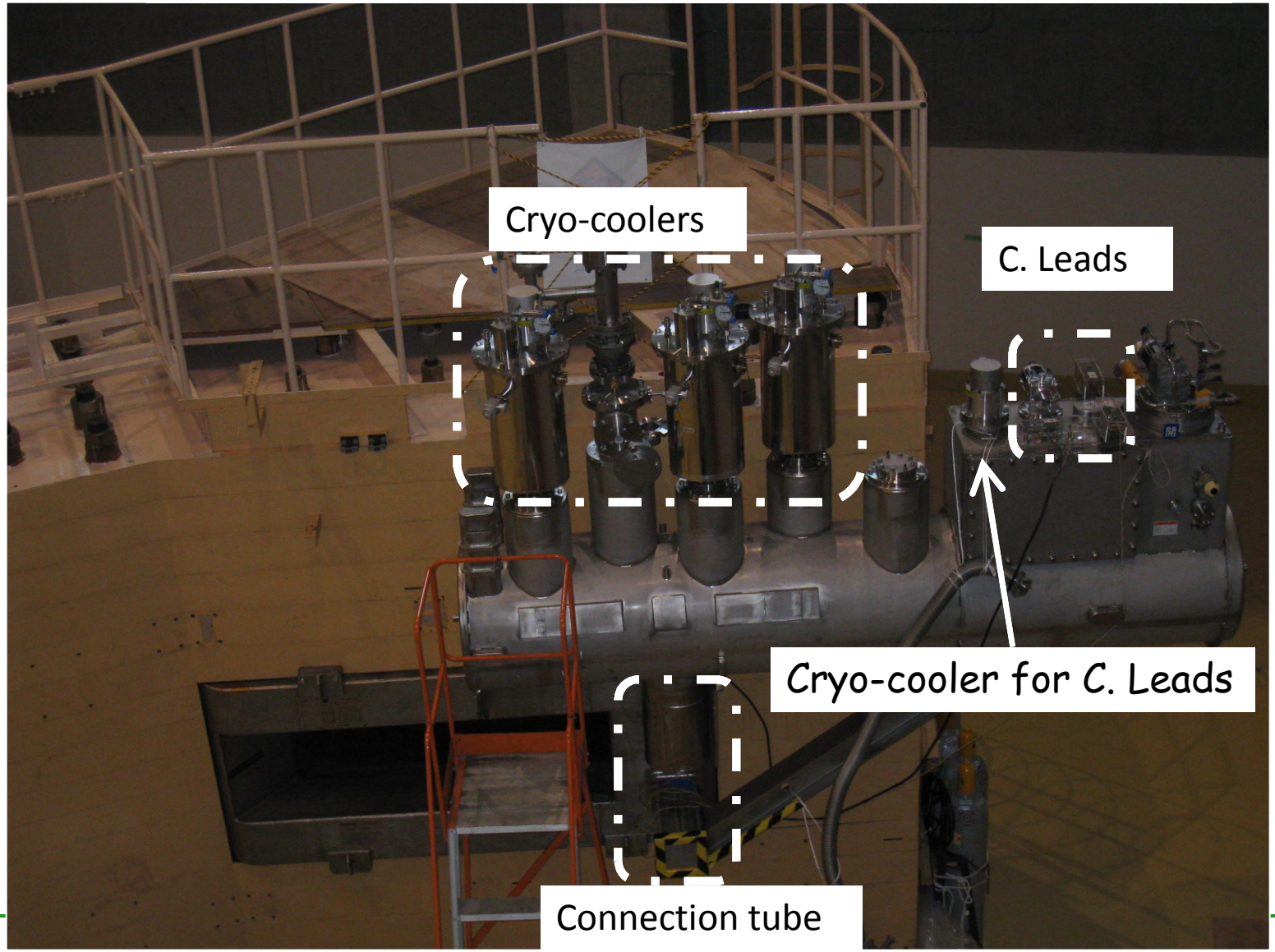
300K->77K calculation was based on Wiedemann-Franz law.
Roughly ~50W/kA

Estimated Heat load by Current Leads-Case 2

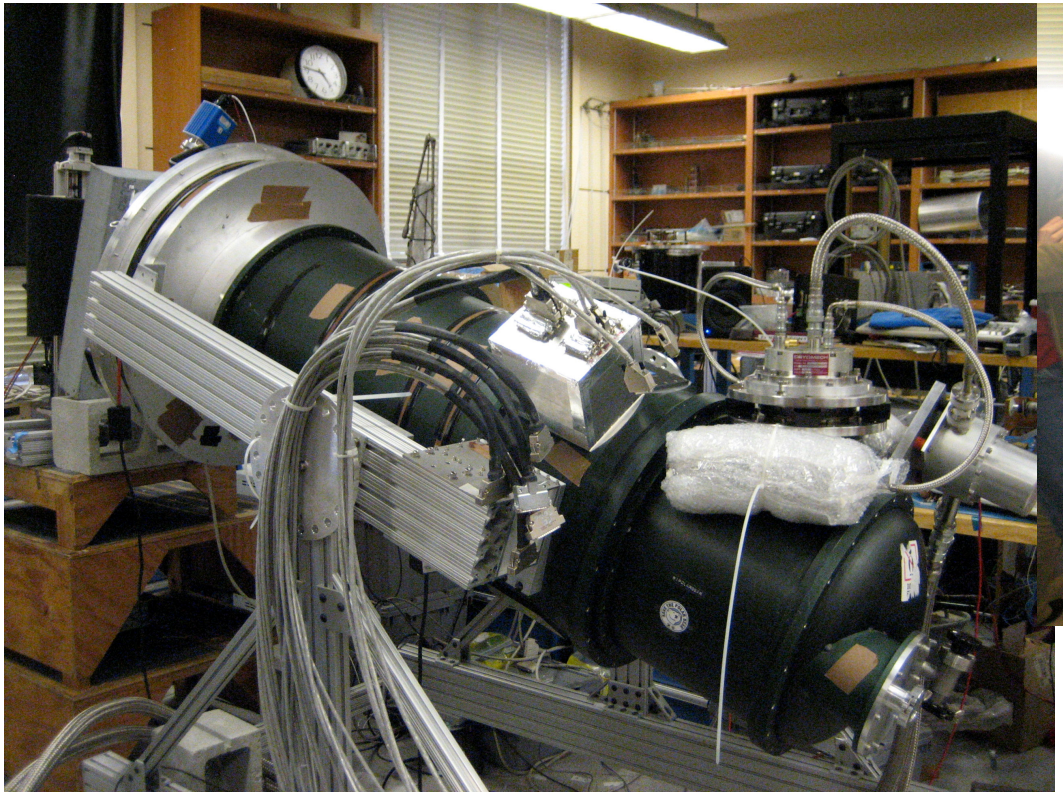
			Heat Loads (W)		
			300K->77K	77K->20K	20K->4K
Element	Multipole	Max. I			
Description		Scenario			
	Bn or An	(A)			
Main Quadrupole	B2	275	27.5	2.57	0.24
Dipole Cor.	B1	20	1.7	0.19	0.11
Skew-Dipole Cor.	A1	20	1.7	0.19	0.11
Main Sextupol	B3	125	12.5	1.17	0.20
Skew-Sext. Cor.	A3	20	1.7	0.19	0.11
Quad. Cor.	B2	20	1.7	0.19	0.11
Skew-Quad. Cor.	A2	20	1.7	0.19	0.11
			48.3	4.67	1.01

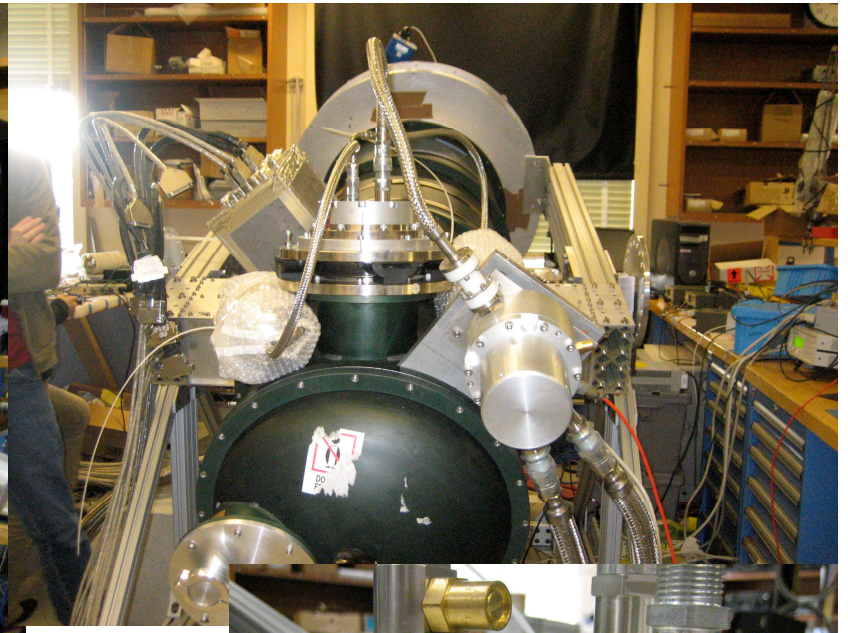
Set-up: consists of hybrid Cu
300K->77K leads: hybrid Cu
77K-> 20K leads: hybrid Cu
20K-> 4K leads: hybrid Cu
(Except B1 and B3 leads)

Example of Connection Box with Cryocooler and C. Leads at SKS



Example of the cryostat with CRYOMECH PT





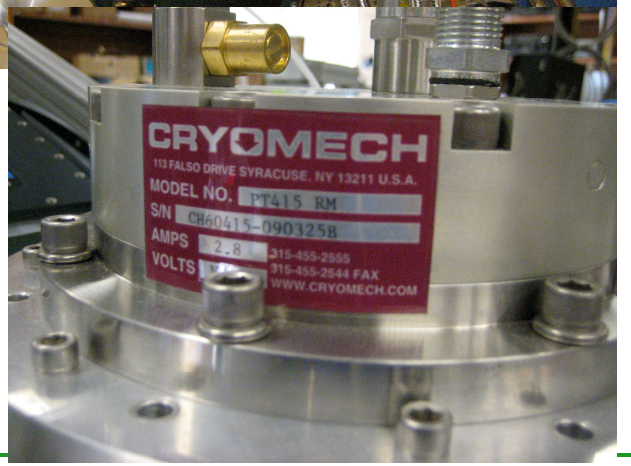
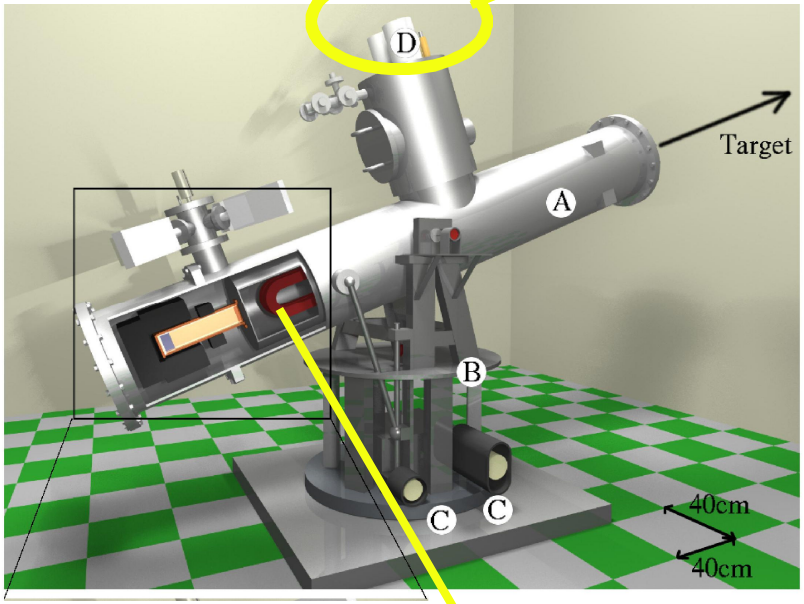
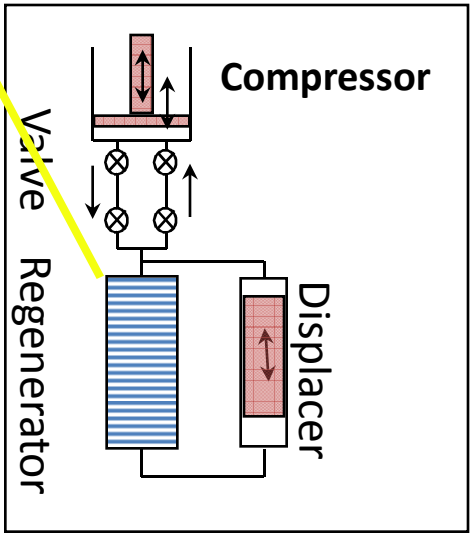


Photo: Polar Bear Experiment system by UCB

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).