Cryogenic System for Superconducting Final Focus Magnets* at ATF-2

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*SCFFM: Superconducting Final Focus Magnets
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

- Infrastructures at ATF2
  - 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

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
  - “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.
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 cryocoolers use as re-condensation cooler

Tubes for pre-cooling and thermo siphon mode

 KEK’s design responsibility

Cryogenics Science Center/KEK
(Nobuhiro KIMURA –16/Dec./2009 at ATF2 TB meeting )
Example of Connection Box with Cryocooler and C. Leads at SKS

Cryogenics Science Center/KEK (Nobuhiro KIMURA –16/Dec./2009 at ATF2 TB meeting)
Example of Ultra-low Vibration  
Pulse tube cryo-cooler system for LCGT 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)

\[ \frac{\Delta g}{g} \approx 10^{-12} \]
Proposed the cryogenics system at KEK

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## Estimated heat loads at 4K connection box

<table>
<thead>
<tr>
<th>Heat Loads (W)</th>
<th>300K→77K</th>
<th>77K→20K</th>
<th>20K(77K)→4.2K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Puls Tube No.1</td>
<td>Current Leads</td>
<td>50.0</td>
<td>4.70</td>
</tr>
<tr>
<td>Puls Tube No.2 &amp; 3</td>
<td>Radiation</td>
<td>3.2</td>
<td>0.00</td>
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<tr>
<td></td>
<td>GFRP Support</td>
<td>5.0</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Electrical leads</td>
<td>5.0</td>
<td>0.00</td>
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</tbody>
</table>

- **Puls Tube No.1**: One 1.3W/4.2K Plus tube type cryocooler as 20K cooler
- **Puls Tube No.2 & 3**: Two 1.3W/4.2K Plus tube type cryocoolers use for re-condensation coolers

- **Cooling performance for magnet cryostat**: ~1.5 W From magnets
- **Enough cooling power for radiation shield**: 58.8

### Cooling performance summary
- **Estimated heat loads**
  - 50.0 W for 300K→77K
  - 4.70 W for 77K→20K
  - 1.04 W for 20K(77K)→4.2K

- **Radial heat load**
  - 3.2 W for Puls Tube No.1
  - 0.0 W for Puls Tube No.2 & 3

- **Heat load for GFRP support**
  - 5.0 W for Puls Tube No.1
  - 0.0 W for Puls Tube No.2 & 3

- **Heat load for electrical leads**
  - 5.0 W for Puls Tube No.1
  - 0.0 W for Puls Tube No.2 & 3

- **Total heat load**
  - 72.0 W for Puls Tube No2+No.3
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Advantage one. Easy maintenance of cryogenics part due to the outside of radiation control area!

For working and walking space

This is good solution at ATF2!

Advantage Two. It easy to supply Lhe for pre-cooling and recovery after quench.

Advantage Three. To adopt the BOX with huge of mass of shield block, it will be reduced mechanical resonances.
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Proposed Schedule (Construction & Installation)

Cryogenics Science Center/KEK
(Nobuhiro KIMURA – 16/Dec./2009 at ATF2 TB meeting)
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Summary

• Re-condensation cooling system @ ATF2 are proposed by KEK.
• 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.
• R&D work for low vibration cryogenics have been accepted in Cryogenics Science Center as a basic research.
• 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
Superconducting Magnet for Solar Axion Search @ ICEPP U-Tokyo

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