

# S1-G Cryomodule Thermal Tests

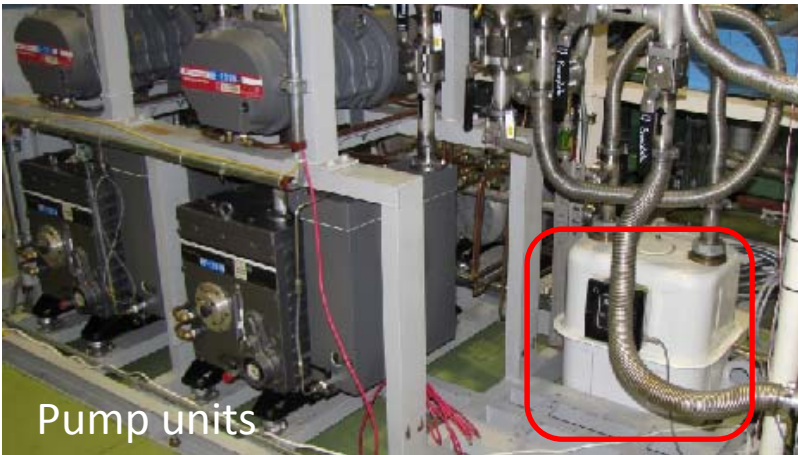
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# Measurements of thermal characteristics of Module A and C

- Heat load
  - Measurement of mass flow rate of evaporated 2K LHe
  - Static heat load of Module A and C
  - Dynamic heat load of DESY, FNAL and KEK cavities at 31.5 MV/m
- Temperature profile
  - Temperature measurement by Cernox, PtCo and CC.
  - Temperature profiles of the components at static and dynamic operating conditions
- Position change of cavities and GRP during cold test
  - Positions of KEK cavities by Wire Position Monitor (WPM)
  - Positions and deformations of GRPs of Module A and C by WPM and strain gauges
  - Positions of GRP of Module A by Laser Position Monitors

# Heat load measurements

- Mass flow rate of evaporated 2K LHe is measured by the volume flow meter at room temperature and atmosphere pressure after the pump units.
  - The precision of the measurement is in the range of 0.2 W from the STF experiment .
- Static heat load measurement of Module A and C
  - The static heat load of Module A and C is measured at the same time, not separated.
- Dynamic heat load measurement of DESY, FNAL and KEK cavities at 31.5 MV/m
  - Dynamic heat load of each cavity, separately.
  - Heat load of each cavity in the detune condition, separately
  - Dynamic heat load of eight cavities, all together.
  - For these measurements, the cryogenic system need to be a stable condition thermally. For one parameter change, it takes two hours for the system to be stable.



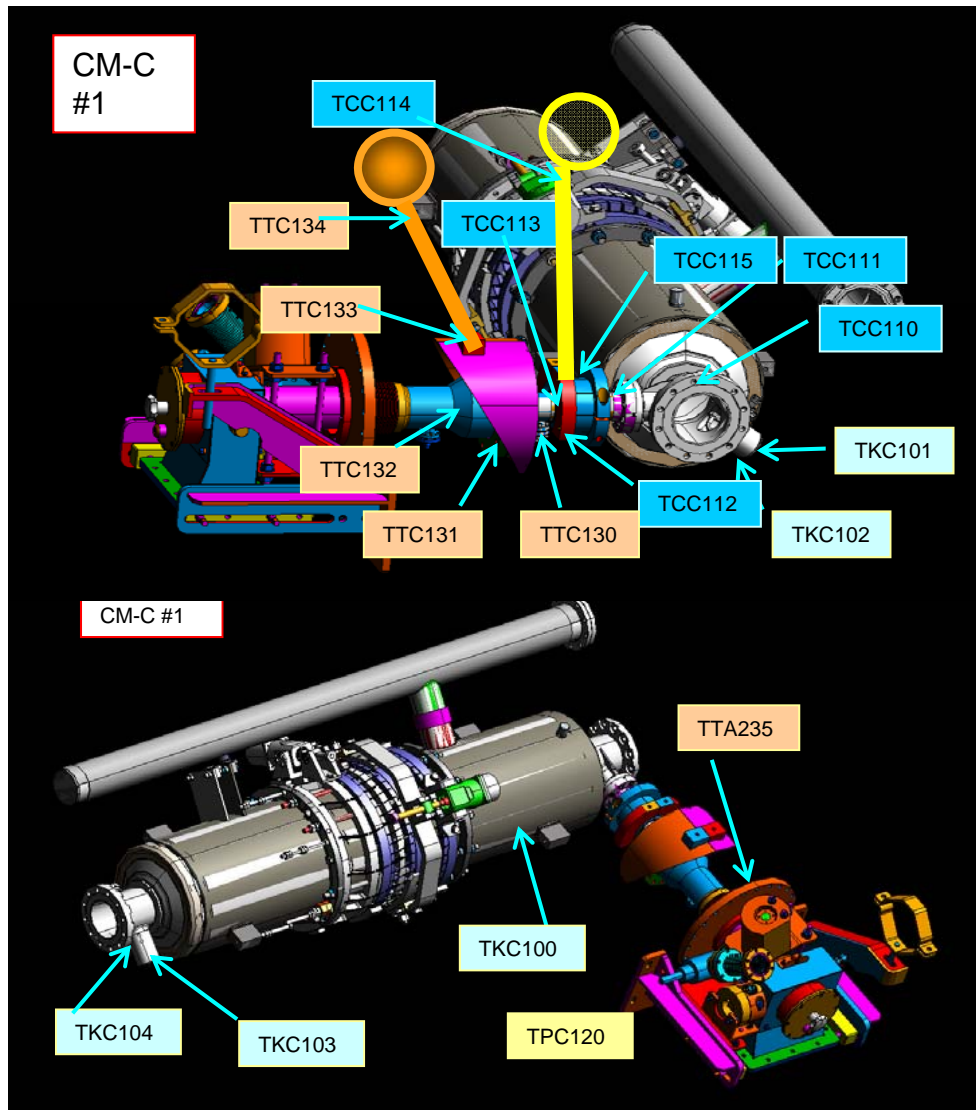
Pump units

Volume flow meter

# Temperature profiles of the components

- Temperature profiles of the components are performed in parallel with the heat load measurements.
- The measured temperature profiles are compared with thermal calculation results of the components.
- Temperature sensors:
  - Cernox (2K – 100K) : 82
  - PtCo (2K – 300K) : 72
  - CC thermocouple (70K – 300K) : 66

# Temperature sensors on cavity jacket and input coupler



Tag No	Position of measurement			
TKC100	Helium Vessel			
TKC101	HOM coupler in the input coupler side-top			
TKC102	HOM coupler in the input coupler side-bottom			
TKC103	HOM coupler in the non-input coupler side-top			
TKC104	HOM coupler in the non-input coupler side-bottom			
TKC105	Piezo			
TCC110	Connection area of input coupler with beam pipe			
TCC111	5K thermal intercept of input coupler (beam pipe side)			
TCC112	5K thermal intercept of input coupler (body)			
TCC113	5K thermal intercept of input coupler (warm coupler side)			
TCC114	5K thermal intercept of input coupler (cooling pipe side)			
TTC115	5K thermal intercept of input coupler (intercept side)			
TPC120	Helium Vessel			
TTC130	80K thermal intercept of input coupler (beam pipe side)			
TTC131	80K thermal intercept of input coupler (body)			
TTC132	80K thermal intercept of input coupler (vacuum vessel side)			
TTC133	80K thermal intercept brade of input coupler (coupler side)			
TTC134	80K thermal intercept brade of input coupler (cooling pipe side)			
TTC135	Input coupler (room temperature and in the vacuum vessel)			

Cernox:12, PtCo: 1, CC: 6

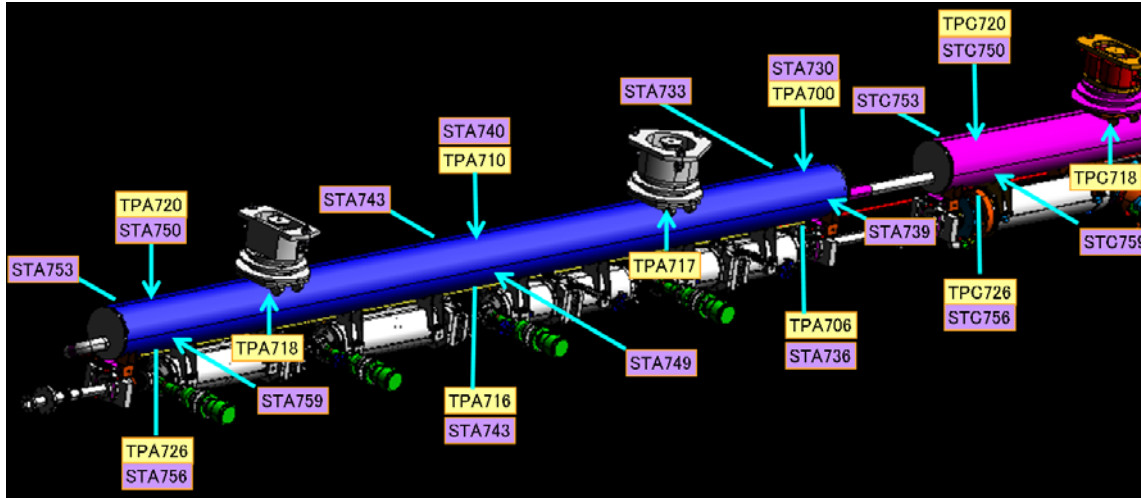
Cavity vessel= 2

Input coupler= 12 (including thermal intercepts)

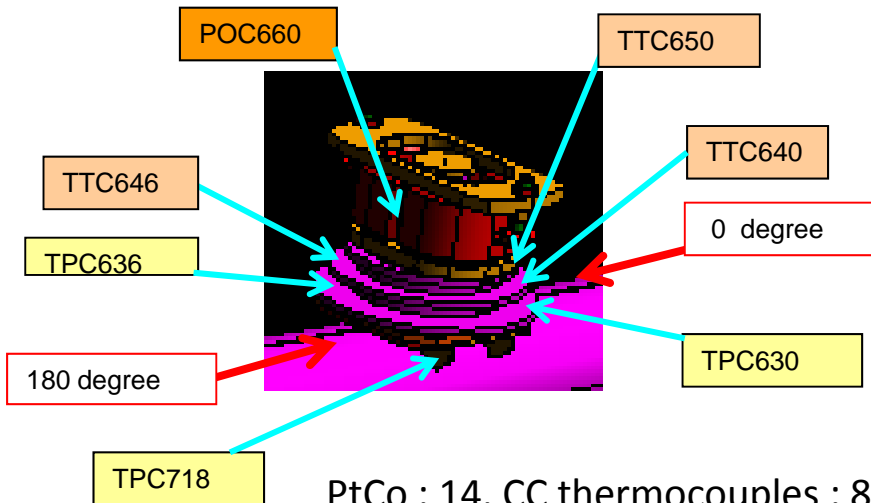
HOM coupler= 4

Piezo= 1

# Temperature sensors on GRP and support posts



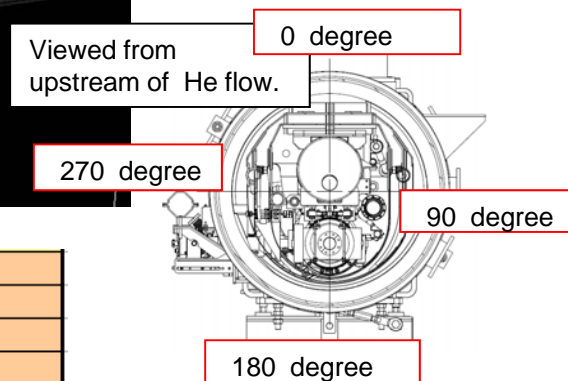
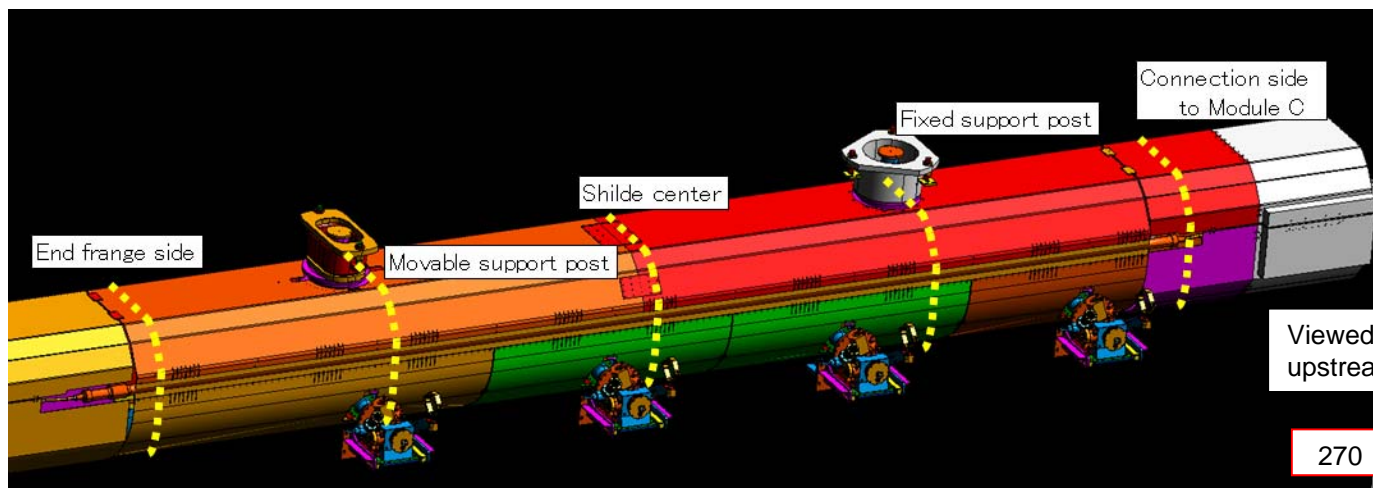
Tag No	Position of measurement
TPA700	Upstream-top (Module-A connection side)
TPA706	Upstream-bottom
TPA10	Center-top
TPA16	Center-bottom
TPA17	Connection area between S.P and GRP
TPA18	Connection area between S.P and GRP
TPA20	Downstream-top (end flange side)
TPA26	Downstream-bottom
TPA27	Connection area to the fixed support post
TPA28	Connection area to the movable support post
STA730	0 degree in the side of Upstream
STA733	90 degree in the side of Upstream
STA736	180 degree in the side of Upstream
STA739	270 degree in the side of Upstream
STA740	0 degree in the center
STA743	90 degree in the center
STA746	180 degree in the center
STA749	270 degree in the center
STA750	0 degree in the side of end flange
STA753	90 degree in the side of end flange
STA756	180 degree in the side of end flange
STA759	270 degree in the side of end flange



PtCo : 14, CC thermocouples : 8  
 GRP= 10  
 Support Post= 6  
 Strain gauge: 12

Tag No	Position of measurement
TPC630	5K thermal intercept at the 0 degree
TPC636	5K anchor at the 180 degree
TTC640	80K thermal intercept at the 0 degree
TTC646	80K thermal intercept at the 180 degree
TTC650	Room temperature area
POC660	Support structure

# Temperature sensors on thermal shields



Tag No	Position of measurement
TPC510	0 degree in the side of module-C
TPC513	90 degree in the side of module-C
TPC516	180 degree in the side of module-C
TPC519	270 degree in the side of module-C
TPC523	90 degree at fixed support post
TPC526	180 degree at fixed support post
TPC529	270 degree at fixed support post
TPC530	0 degree at shield center
TPC533	90 degree at shield center
TPC536	180 degree at shield center
TPC539	270 degree at shield center
TPC543	90 degree at movable support post
TPC546	180 degree at movable support post
TPC549	270 degree at movable support post
TPC550	0 degree in the side of end flange
TPC553	90 degree in the side of end flange
TPC556	180 degree in the side of end flange
TPC559	270 degree in the side of end flange

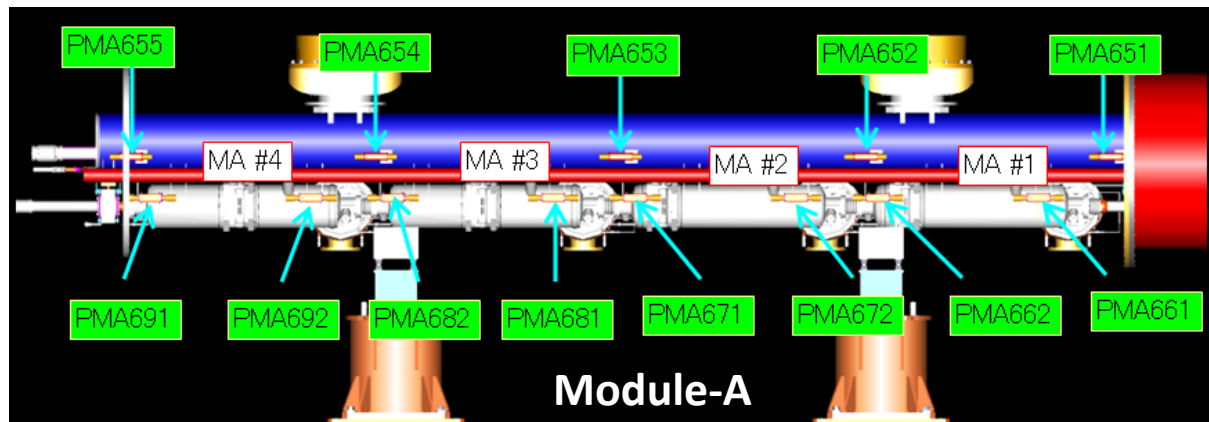
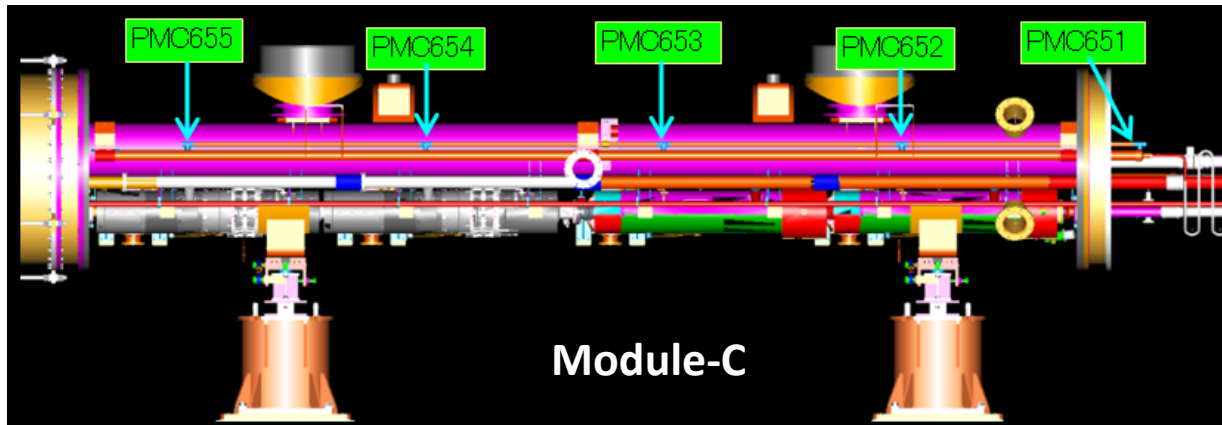
TTC810	0 degree in the side of module-C
TTC813	90 degree in the side of module-C
TTC816	180 degree in the side of module-C
TTC819	270 degree in the side of module-C
TTC830	0 degree in the center
TTC833	90 degree in the center
TTC836	180 degree in the center
TTC839	270 degree in the center
TTC850	0 degree in the side of end flange
TTC853	90 degree in the side of end flange
TTC856	180 degree in the side of end flange
TTC859	270 degree in the side of end flange

5K shield  
PtCo : 18  
80K shield  
CC : 12

# Position measurement of cavities and GRP

## Measurement of position of cavities and GRP by WPM

- Module-C
  - 5 WPMs are assembled on the GRP.
- Module-A
  - 5 WPMs on the GRP and 2 WPMs for each cavity are assembled. In total, 13 WPMs.



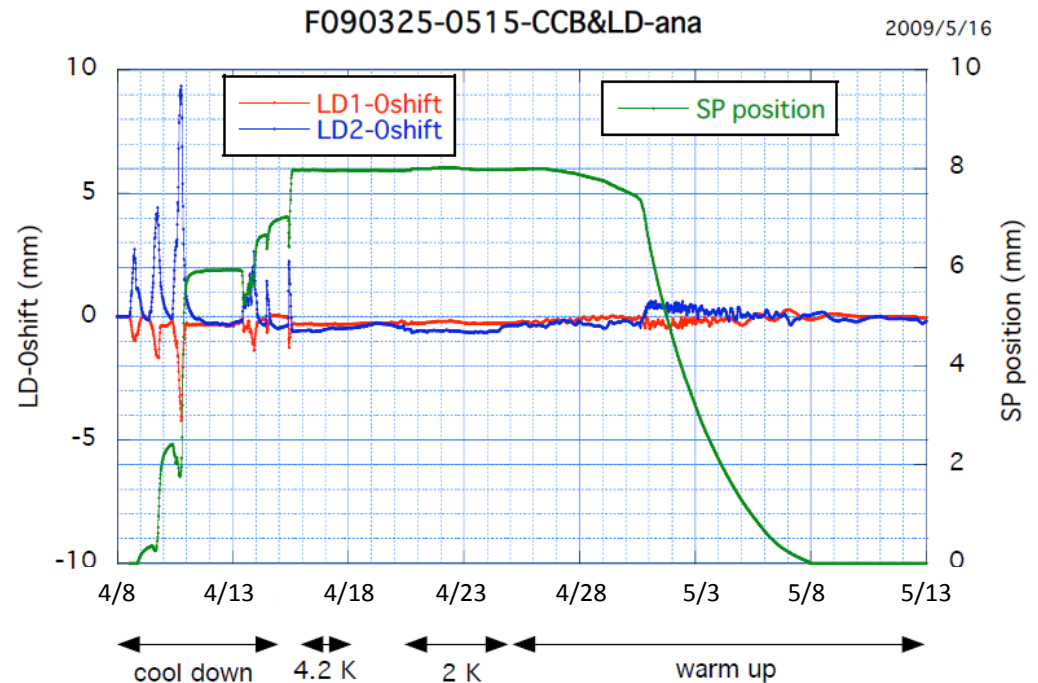
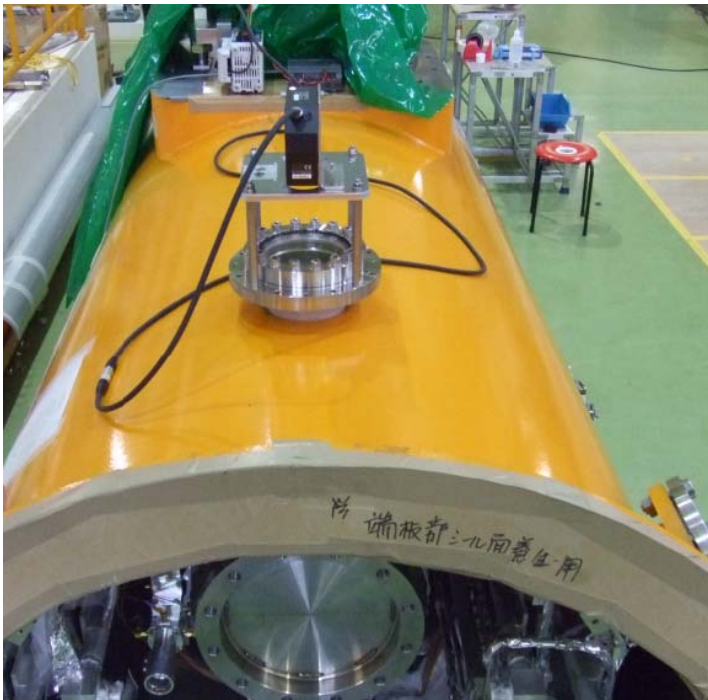


# Measurement by laser position monitor

The laser position monitors were applied for measuring the change in the GRP shape while cooling Module-B. The monitors showed good precision for the long operation.

3 laser position monitors will be used for measuring the GRP positions of Module-A during the cold test before summer shut-down.

- For this measurement, the thermal radiation shields need to have holes to introduce laser to the GRP.



Laser position monitors for measuring the GRP positions of Module-B and measured results

# Summary

- As the thermal tests of S1-G cryomodule, the following measurements are planned;
  - Static and dynamic heat loads of cavities and modules
    - Volume flow meters
  - Temperature profile of the components
    - 220 thermal sensors
  - Position and deformation of GRPs and KEK cavities
    - 18 WPMs
    - 3 Laser position monitors
    - 24 strain gauges
- The required period of these measurements is 4 weeks.