GRP/cavity movement during cool down

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KEK

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Objective and history of this study

- Objective: to understand the alignment characteristics of the present cryostat
  and to answer the following question,
  " Is it possible to satisfy the required alignment tolerances for the SC cavity ? "

- History: From the early stage of the STF cryomodule development, we have tried the measurement of the GRP/cavity movement during the cool down many times by using WPM, however, we could not succeeded to obtain the reliable results.

  Last year, we have performed the comparative measurement of GRP movement in a STF-cryomodule by three kinds of methods, using laser displacement sensor (LDS), optical telescope, and WPM.

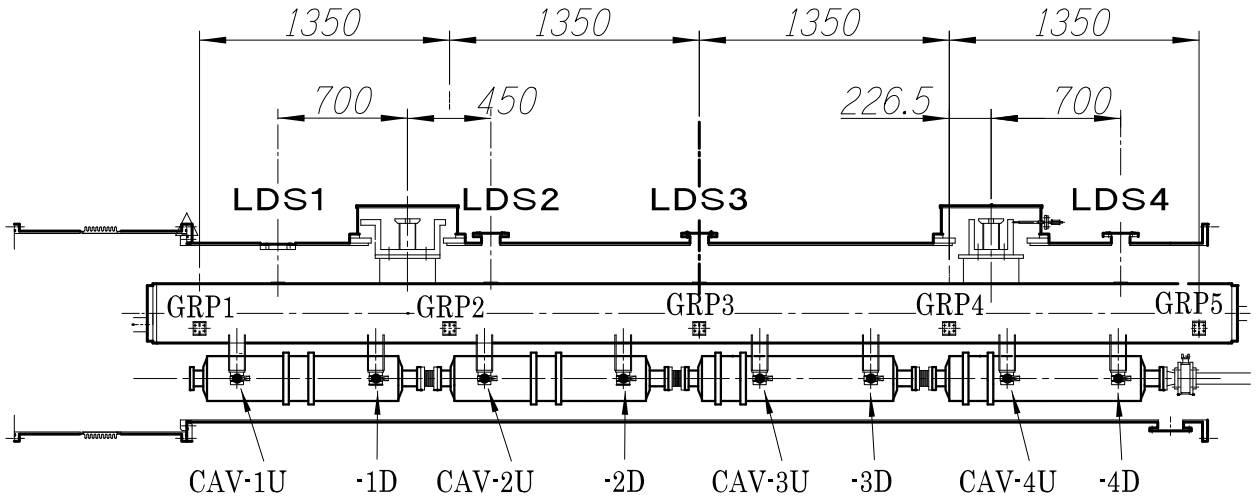
  This year, we have measured the GRP movement during the period of the 1st S1G experiment by using four LDS.

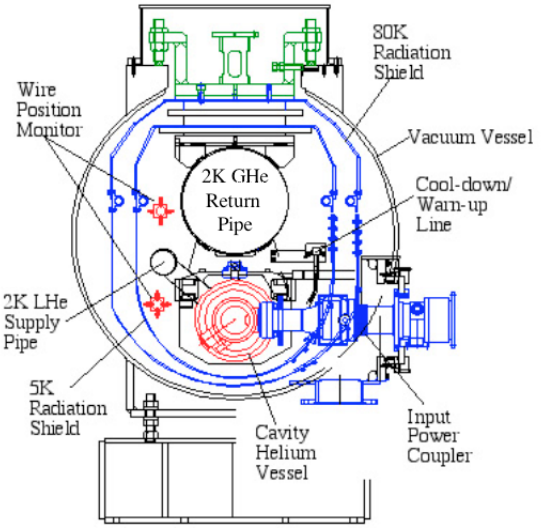
Measurement and set up for S1G experiment

Laser displacement sensors:

- four sensors; LDS1, LDS2, LDS3 and LDS4
- distance change (ΔY) between GRP and Vac vessel
- sampling time; 1 sec

Wire Position Monitors: 5 monitors for GRP, ΔX and ΔY
8 monitors for four cavities, ΔX and ΔY

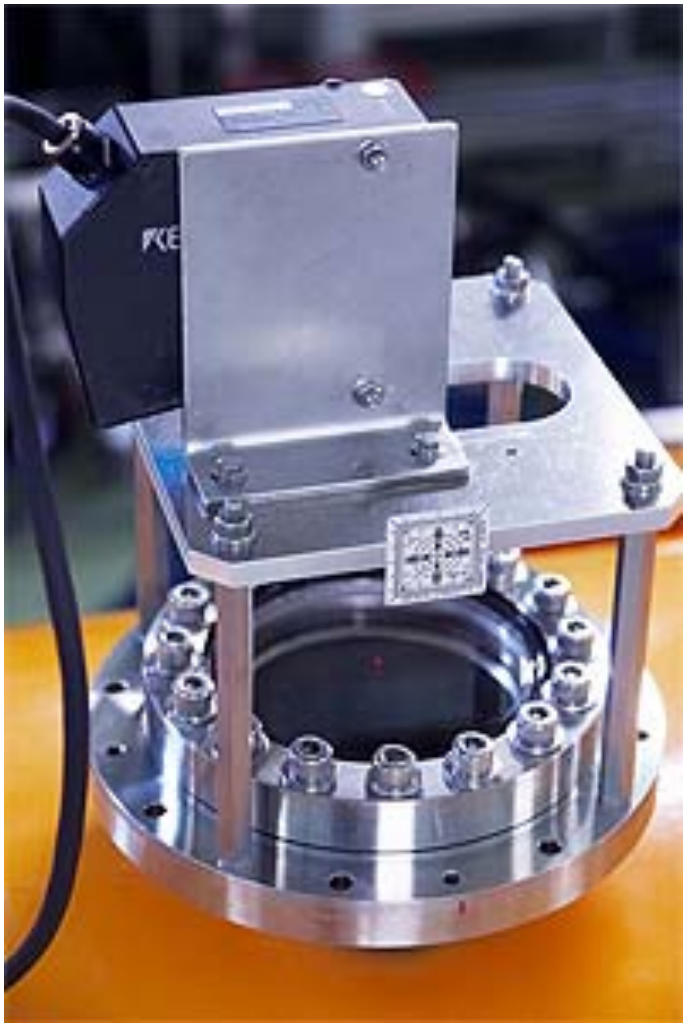




8 temperature monitors on GRP: front, center, rear part
top, bottom top, bottom top, bottom

S1G cryomodule

Laser displacement sensor



Keyence LK-G series laser displacement sensor specification

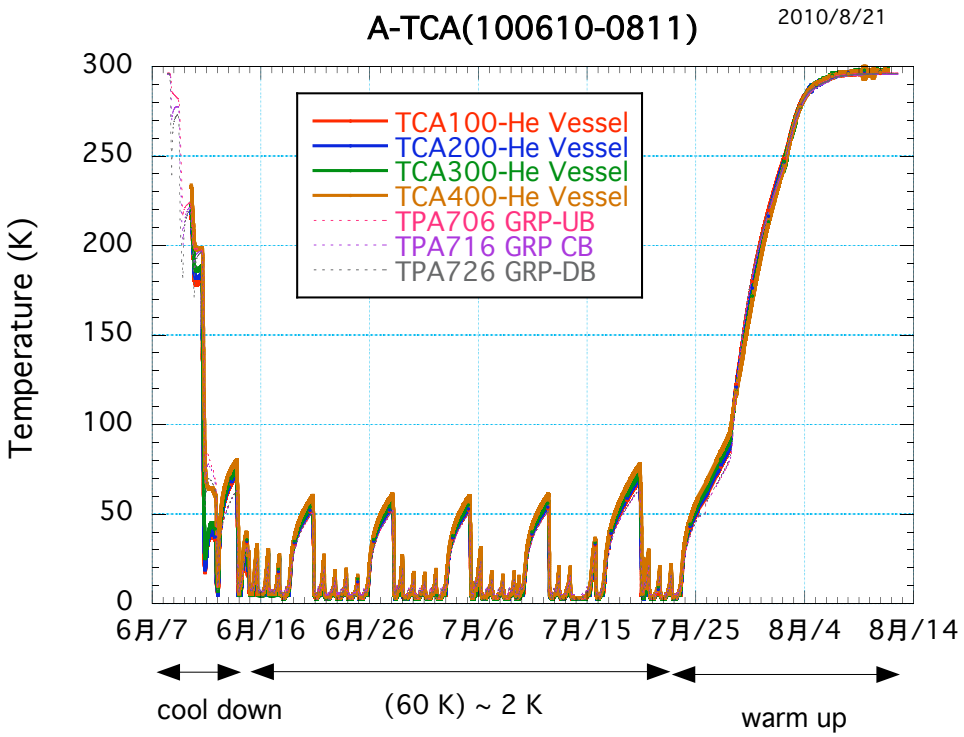
measuring range:	400 ± 100 mm
resolution:	2 μm
linearity:	± 0.05 % of F.S.
spot dia.:	approx. 290 μm

Cooling method

- June 8 to 11 : GHe (~80K), mass flow rate = ~1.5 g/sec
- From June 12: LHe

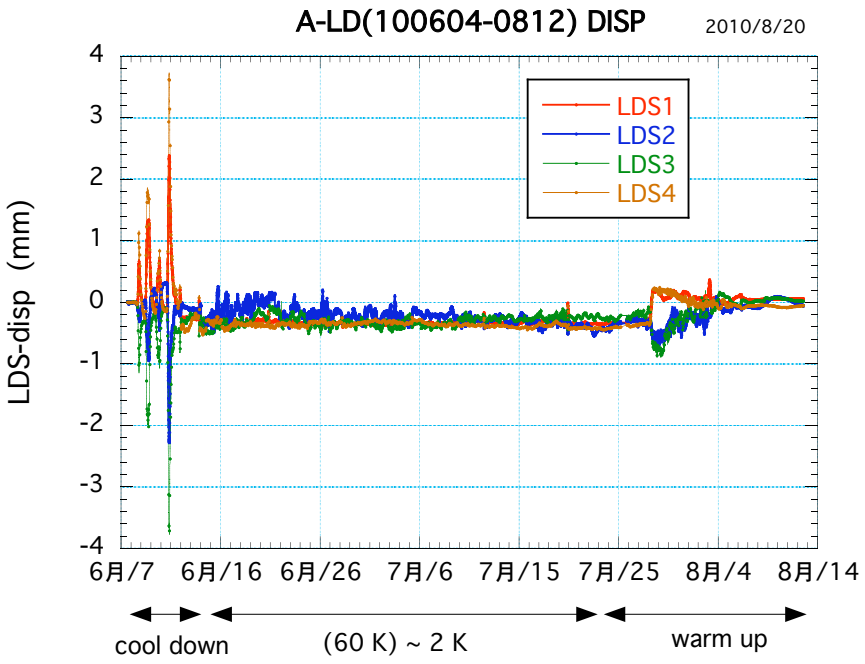
  at 4.2 K mass flow rate = ~0.35 g/s

  at 2 K mass flow rate = ~0.4 g/s
- Feature of this cool down: system was operated only in the daytime (intermittent cooling)

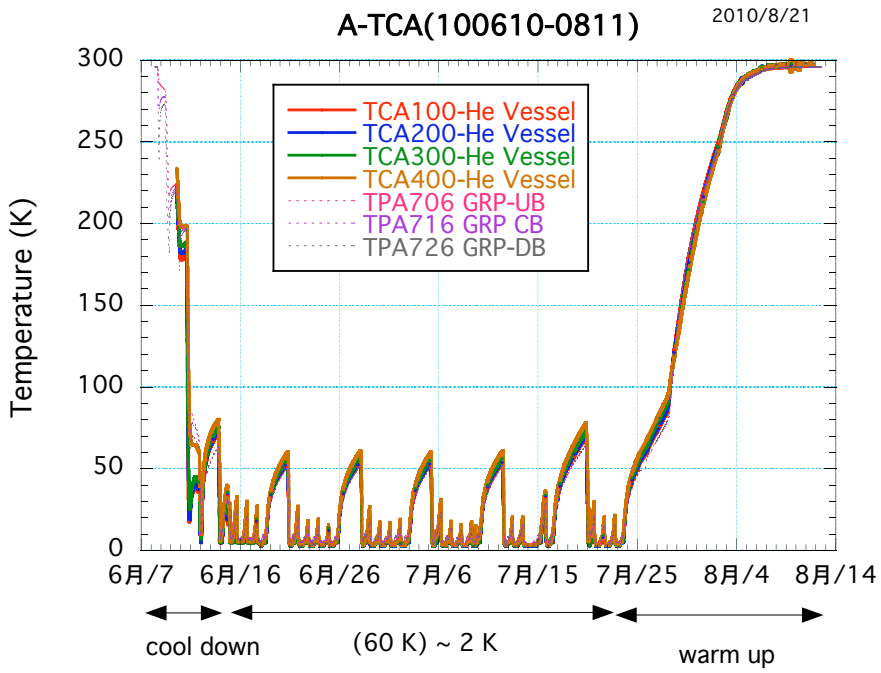


LDS signal and temperature during whole period

LDS signal

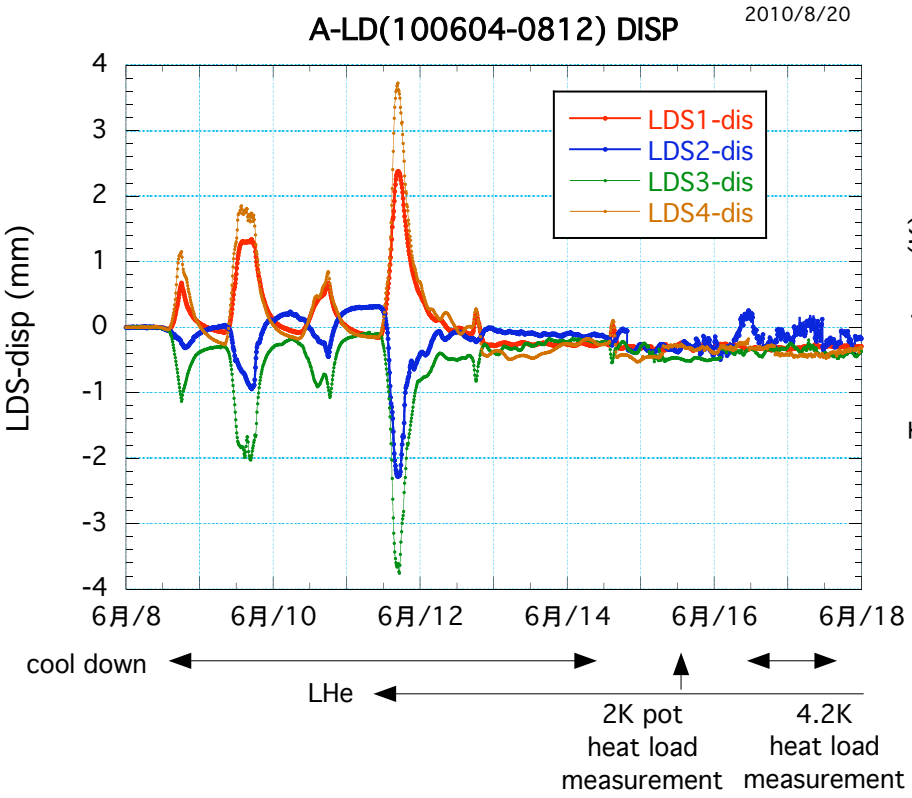


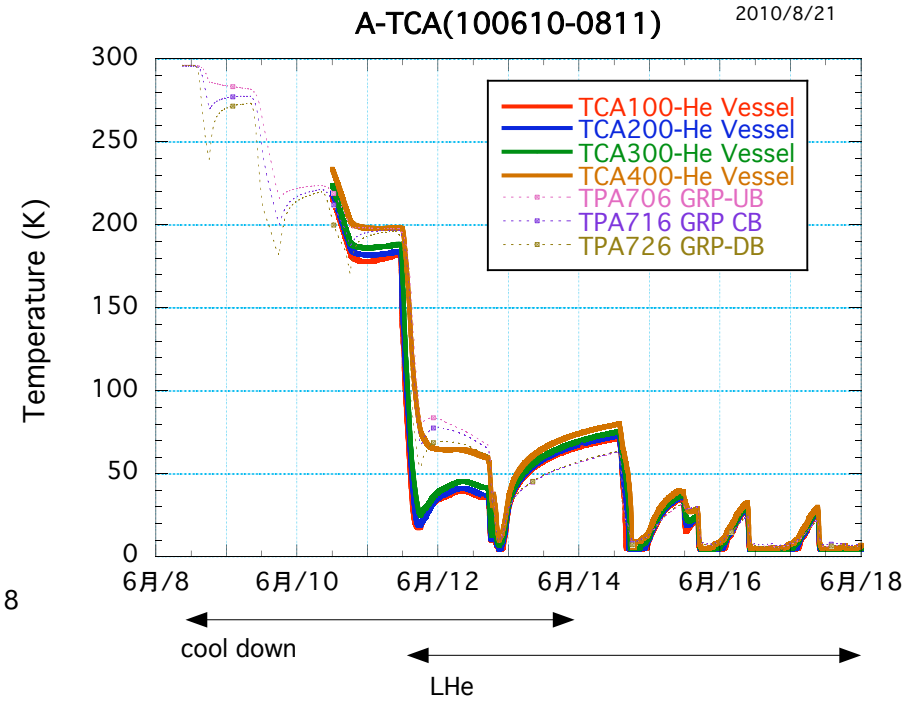
He vessel and GRP temp



During cool down and warm up period,
large movement of GRP is observed.

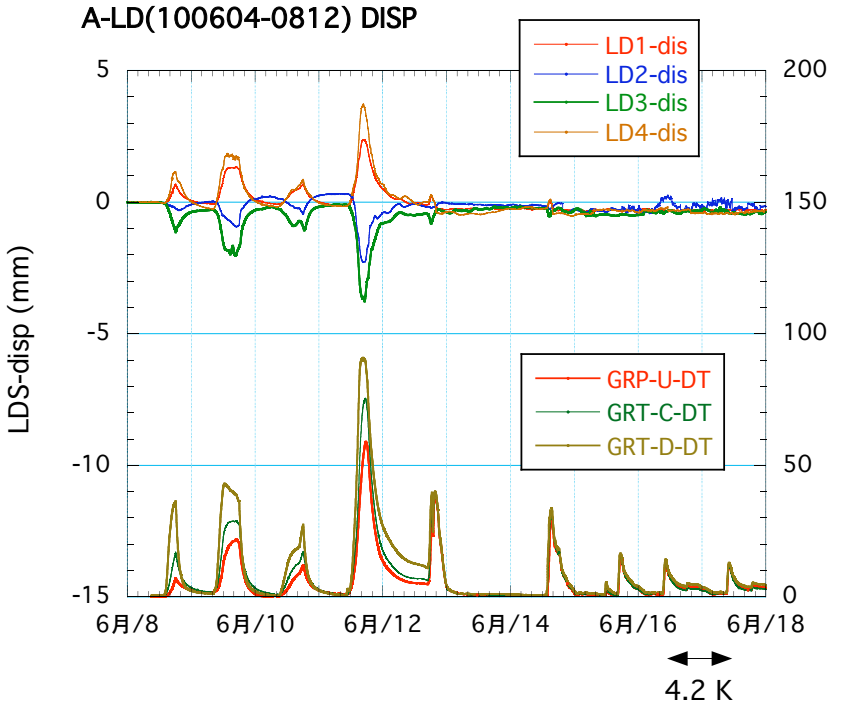
During cool down period (June 8 ~June 14) (1)

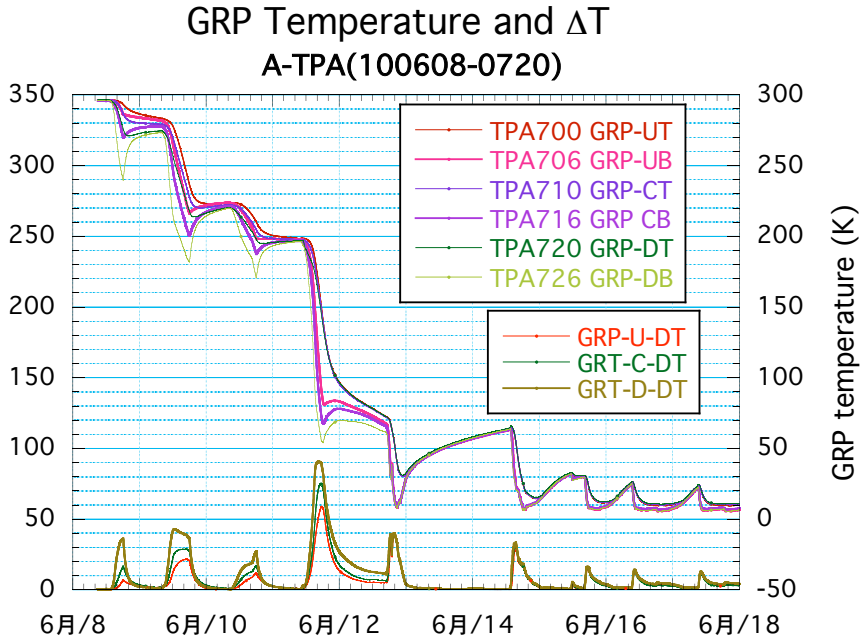




This figure means that a banana-shape vertical deflection of the GRP occurred, as INFN-DESY group had reported previously.

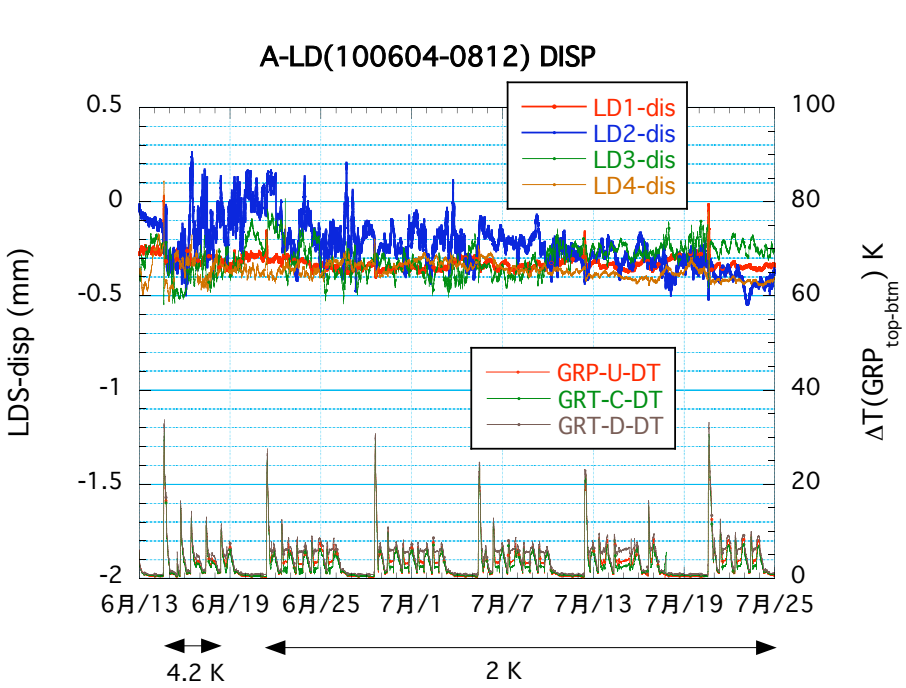
During cool down period (June 8 ~14) (2)

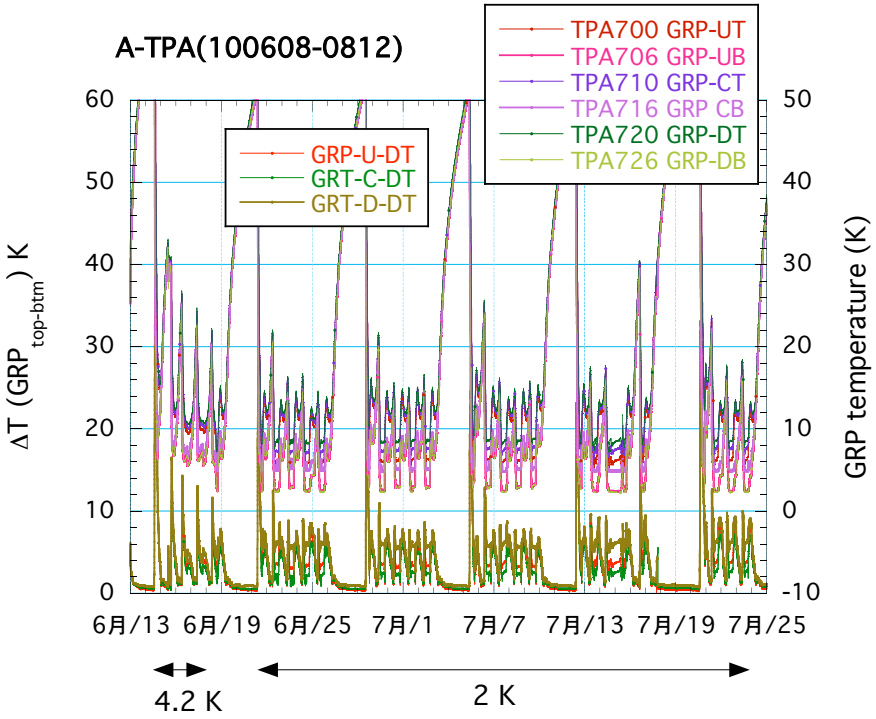




The temperature difference between top and bottom of the GRP
shows clear correlation with LDS signal, when the temperature is higher than ~60 K.

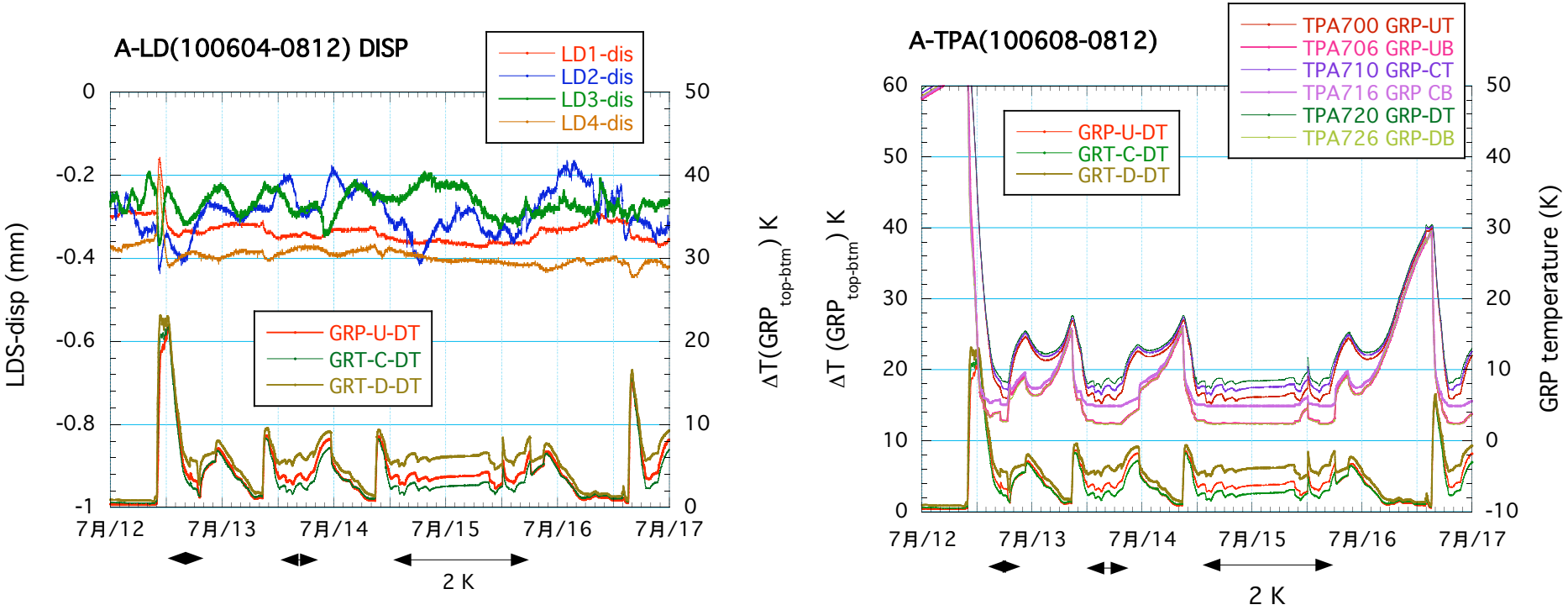
During cold state (June 13 ~July 25) (1)





LDS2 and 3 showed relatively large fluctuation compared to LDS1 and 4.
However, the average displacement of the GRP was about -0.3 mm.
This value agreed well with the amount of thermal contraction of the support post.

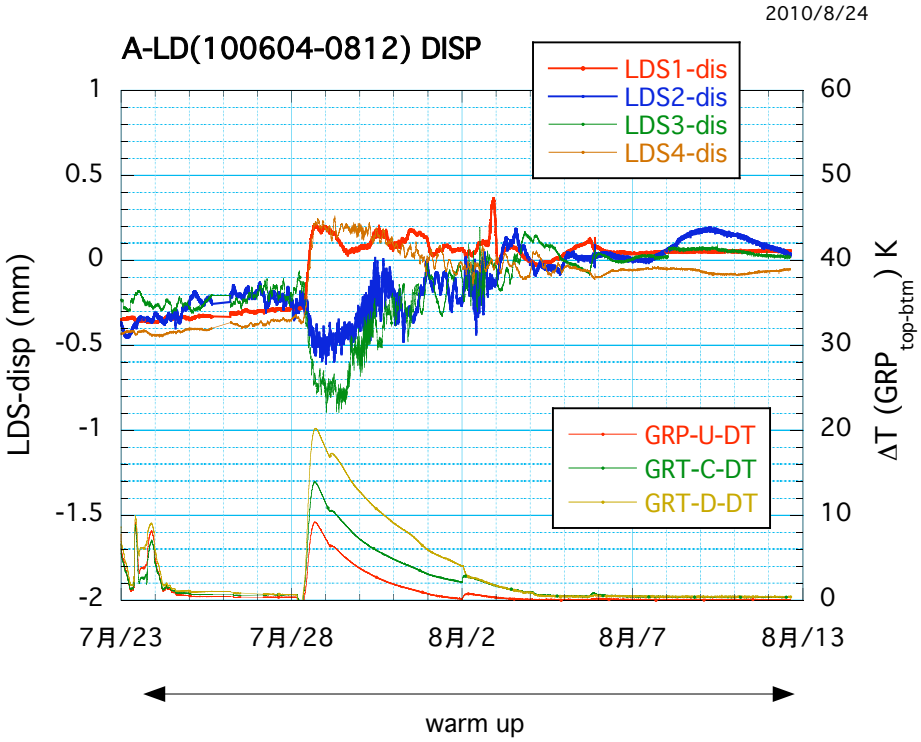
During cold state (July 13 ~July 17) (2)

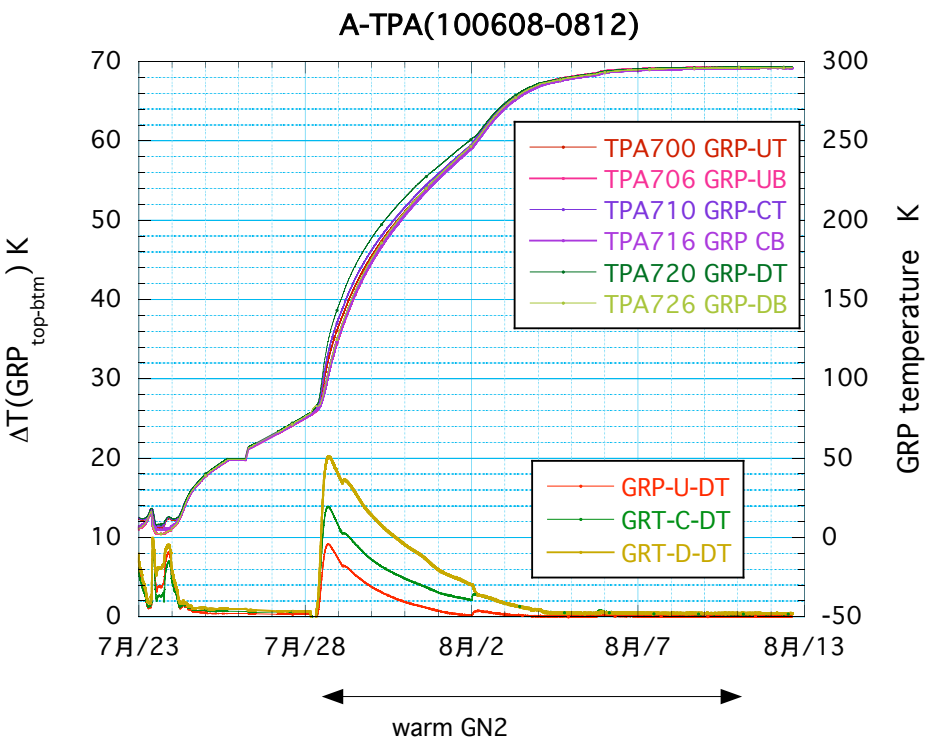


From 12:00 July 14, the system was kept at 2 K about 24 hours, however, the signals of LDS did not become stable.

The fluctuations of LDS2 and LDS3 are more prominent than others. The reason is not clear yet ?

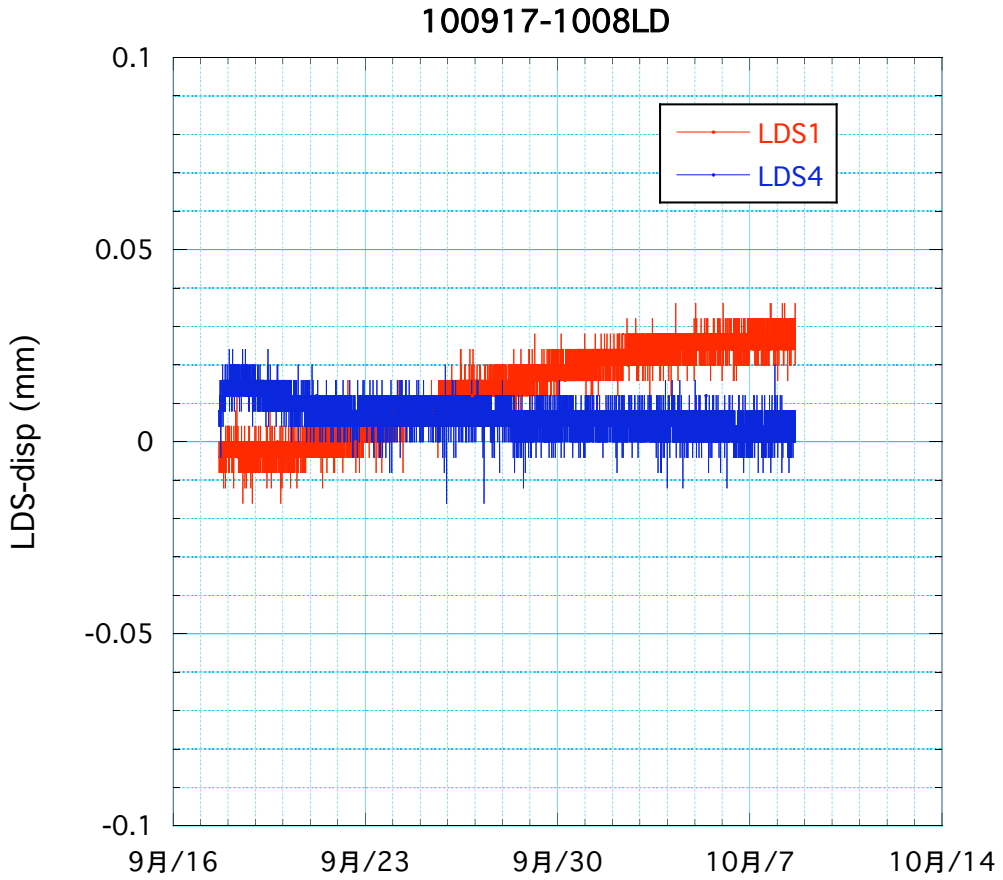
During warm up period (July 23 ~ Aug 13) (1)





When warm gas was supplied to GRP at about 80 K, relatively large temperature difference was occurred, and this caused the deflection of GRP.

Stability check of the LDS



Summary

- Rather large vertical movement (max 3.7 mm) was observed at the end parts of GRP during the cool down period.
  This movement could be reduced by taking appropriate cooling method.

- Summary of the GRP movement

	before cooling	2 K	after warm up
GRP front (LD1)	0	-0.35 mm	0.05 mm
GRP support post (LD2)	0	-0.30 mm	0.10 mm
GRP center (LD3)	0	-0.25 mm	0.03 mm
GRP rear (LD4)	0	-0.40 mm	-0.05 mm

  * expected thermal contraction of the support post is about 0.25 mm

- The deflection of GRP must be due to the temperature difference between top and bottom of GRP. A calculation with FEM code well explained the amount of the deflection during cool down.

- During the cold state, an unexpected movement (amplitude; ~±0.1 mm) of the GRP was observed. The reason of this movement (or fluctuation) is not clear now.