NW-LARP-DQW#2 Cavity + HOM Coupler Cod Test Report

Date: October 16, 2017

Introduction

The bare cavity of NW-LARP-DQW#2 was cold tested in September 2017 at Jlab by HyeKyoung Park, who was joined remotely by Qiong Wu and Silvia Verdu-Andres. The cold test ended with the cavity quenched at a deflecting voltage of 5.3 MV, both CW and pulsed mode. The cavity was MP conditioned for ~1.5hr at low field (0.16-0.2MV), and less than 30 min for the rest of the zones (see Silvia's ppt on DQW#2 bare cold test results). Low field Q0 of the cavity reached 8.53e9.

After the bare cavity test, the cavity had one blank flange opened in the cleanroom to install the HOM coupler on the FPC side. The coupler went through a light BCP of 15-20 um on the RF surfaces below the cavity-mating flange, and a light removal on the rest of the RF surfaces. The coupler was also ultrasonically cleaned after the BCP. The cavity and the HOM coupler was assembled, leak checked, and kept under vacuum in the first two weeks of October.

The HOM coupler was cold tested with NW-LARP-DQW#1 in May, 2017 with a maximum deflecting voltage of 2.8 MV. The coupler was not BCPed after fabrication at CERN for the first cold test. The goal for this second cold test is to reach higher field after the chemistry treatment.

Preparation for the cold test

The cavity assembly was found mounted to the center of the frame, which will cause the HOM coupler exceeded the top plate outer diameter limit. The cavity assembly was shifted to the side of the frame.

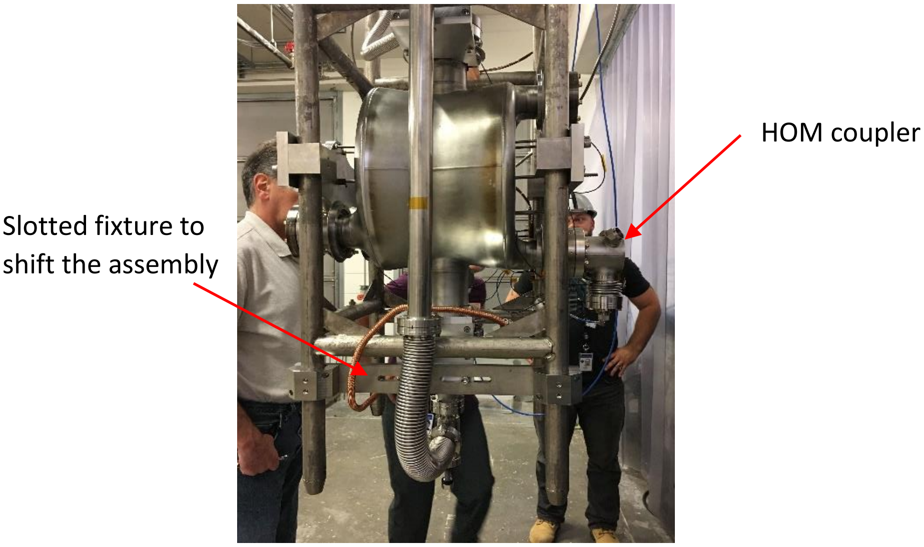

Figure 1: HOM coupler installed interfering with loading into the Dewar.

The assembly was shifted to the left of Figure 1 through the slotted panel. The cavity was assembled onto the frame with the HOM coupler on the same side of the Dewar cable channel (slotted baffle side), see Figure 2. The cap of the HOM coupler missed the cable channel by ~5 mm after the shift.

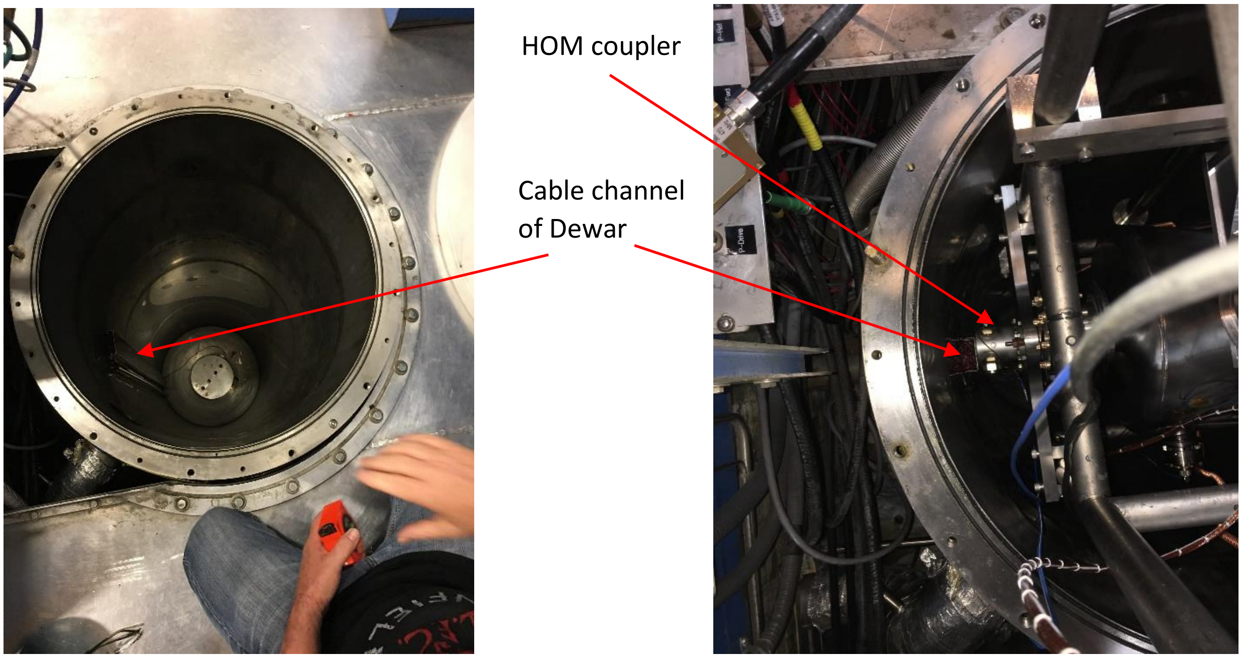

Figure 2: The HOM cap barely missed the cable channel fixed inside of the Dewar by ~5 mm.

The threaded rods connecting both stiffening plates and the cavity center plates are not well attached. The rods on both sides can be easily moved after threaded into the cavity, with the FPC side worse than the other. The 2 of the helicoils put into the tuner fixture (bean shape) are damaged, and the rods has to go into another threaded hole, see Figure 3.

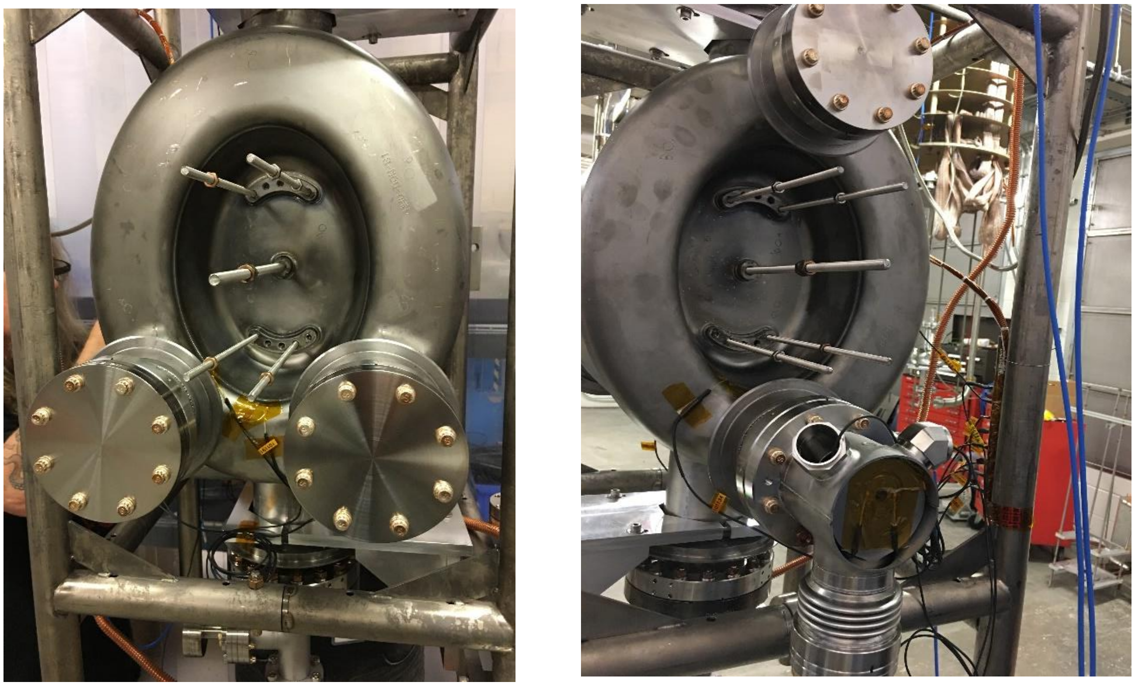

Figure 3: 2 Stiffening rods has to be moved to another hole due to helicoil damage. The threads are damaged as well.

Thermal sensors are well attached at BNL defined locations before cool down, see Figure 4 for locations of 8 thermal sensors. Unfortunately, no signal was detected from sensor #5 since cool down.

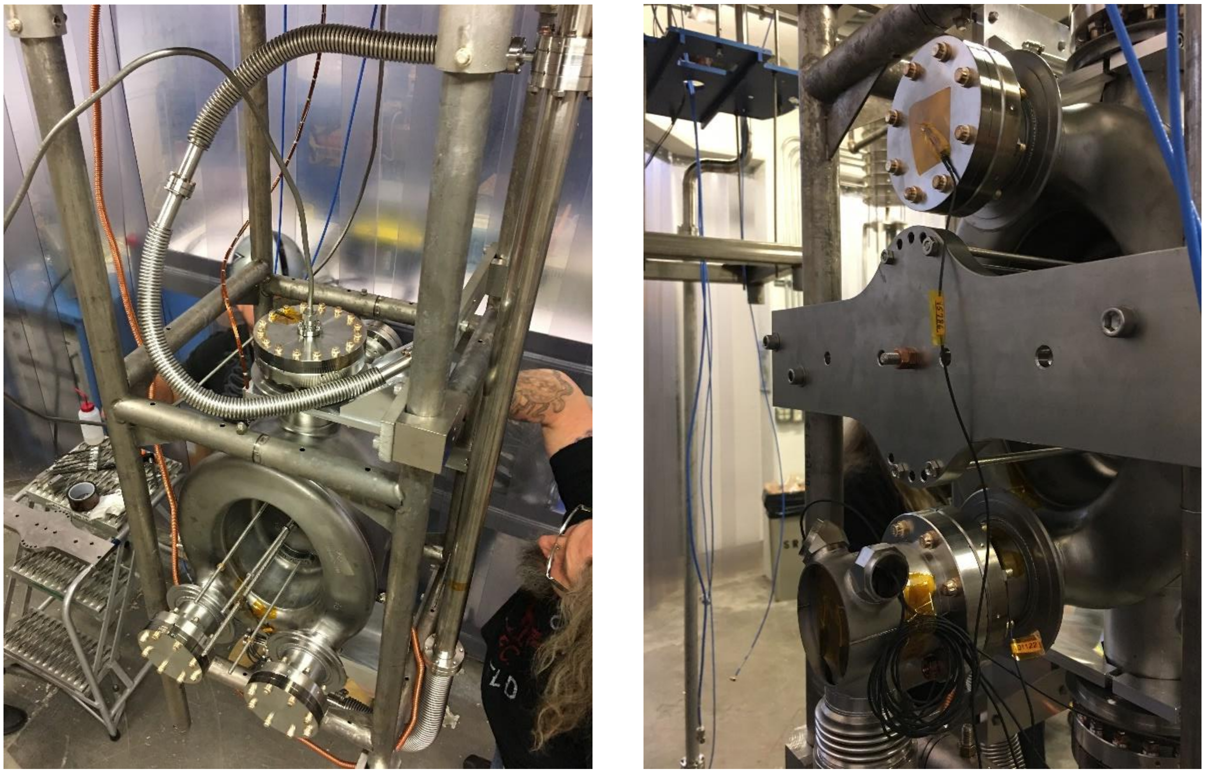

Figure 4: 8 thermal sensor locations.

The thermal sensors are attached with the following configuration:

Sensor #	Label #	Location
1	95786	FPC blank flange
2	95793	vacuum pipe, top flange
3	101122	HOM gasket
4	101134	HOM high B field
5	101190	highest peak field region
6	101191	2HOM side inner conductor blend
7	117102	HOM coupler cooling hole
8	118939	HOM coupler cooling hole

Conditioning

The MP conditioning starting at 4K and went on at 2K. The multipacting zones are same as bare cavity. 0.15-0.2 MV is a very hard MP zone. We put 75 W incident power max to condition through through pulse mode. The first condition through took ~4 hours of different kinds of settings. After the first break through, the cavity still falls back into this hard zone, but can be conditioned < 10 min under pulsing.

The soft zones are easy to condition and not coming back after the first break through. We found even very low field MP zones at 0.065-0.088 MV, and high field MP zones 1.8-2.3 MV.

Measurements

1. High Power RF at 2K

The cavity reached 3.6 MV in CW mode, and 4.12 MV in pulse mode during the high power test at 1.98 K. The peak electric field at quench is 39 MV/m, and the peak magnetic field is 76 mT. Both are on the cavity. The field on the HOM coupler is always lower than the peak fields on the cavity.

The quality factors are measured as shown below:

Q0 at low field	9e9
Q0 at 3.4 MV (operation)	6.5e9
Q0 at 3.6 MV (quench)	6.3e9
Qext_fpc	1.8e9
Qext_PU	1.28e12
Qext_HOM	3.83e10

The radiation is below 1mR/hr at quench.

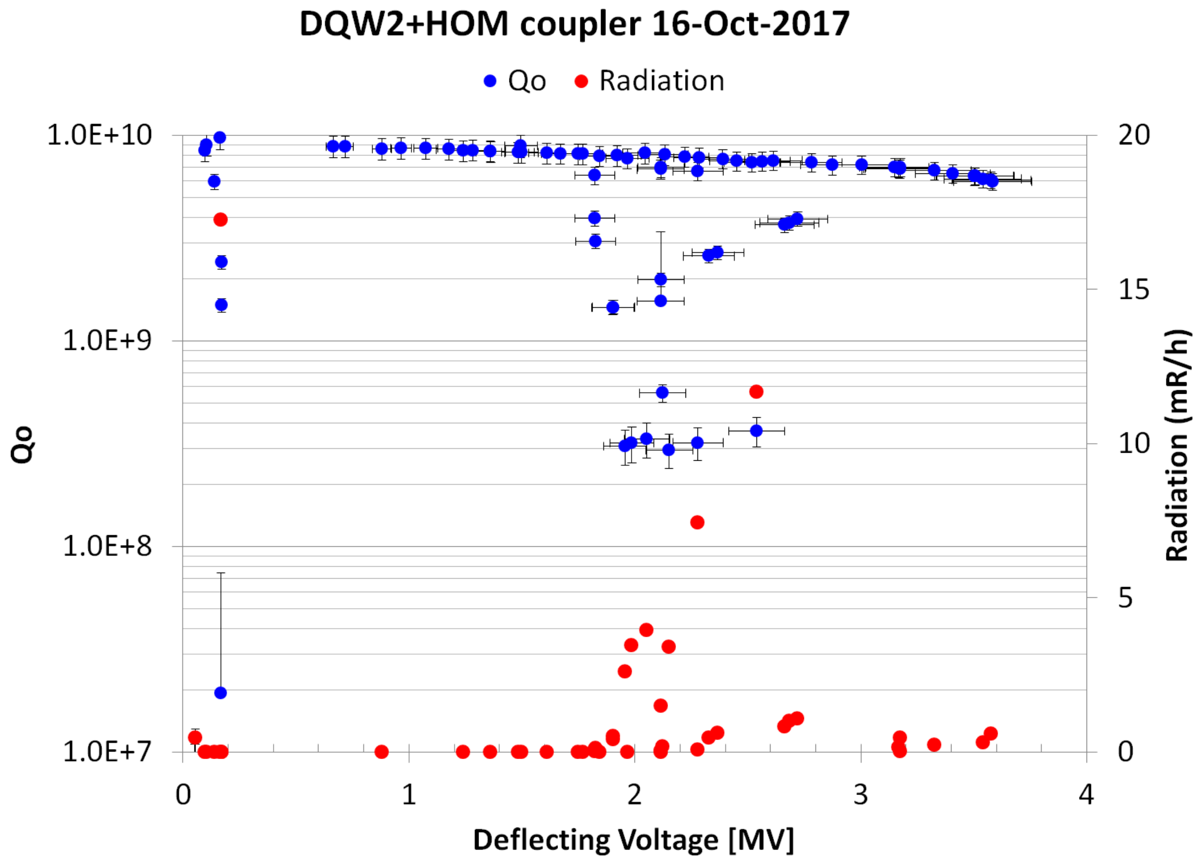

Figure 5: Cavity reached 3.6 MV maximum and quenched in CW mode.

The Lorentz detuning factor measured for this cavity is -491Hz/(MV^2). LD factor data are in Figure 6.

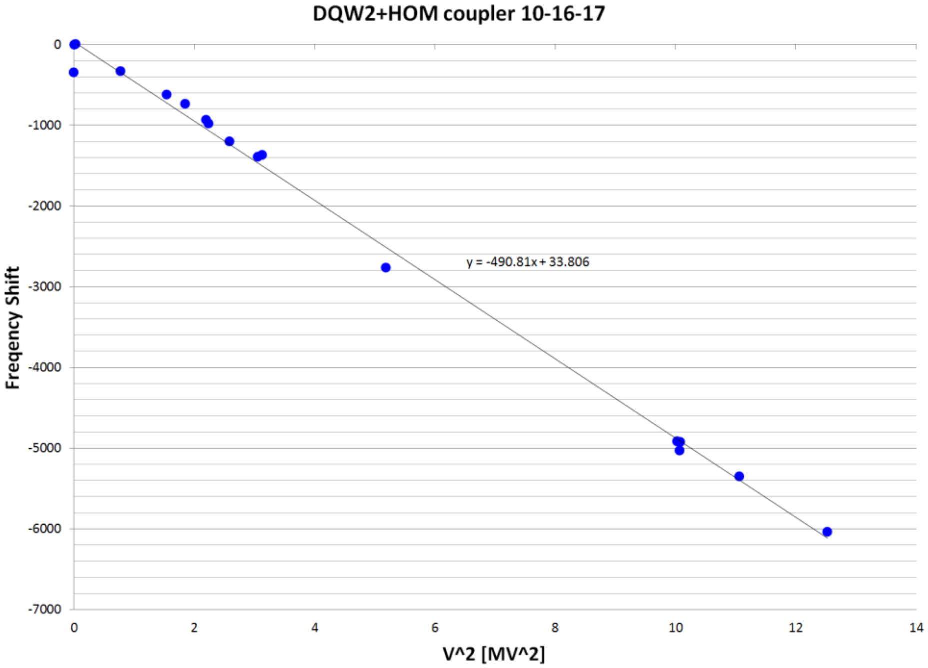

Figure 6: Lorentz detuning factor measurement at 1.98K

The Lorentz Detuning factor data in Figure 6 has eliminated the points during multipacting conditioning. The elimination criteria is radiation, Q0 degradation, and Dewar pressure spikes.

Comparing to the PoP cavity at 202Hz/(MV^2), the large Lorentz detuning shows that the stiffening plate is poorly attached. This is comparable with the bare cavity test of DQW#1 at 449Hz/(MV^2), which used the same stiffening system.

The temperature sensor showed thermal activities near the HOM coupler. Among the 8 sensors, the one attached to the center of the two HOM coupler ports (#5), did not give a signal to the read out device. The sensors attached to the FPC flange on the top (#2) had very large fluctuations comparing to other 6 sensors that had recorded signals, see Figure 7 for sensor layout and temperature data.

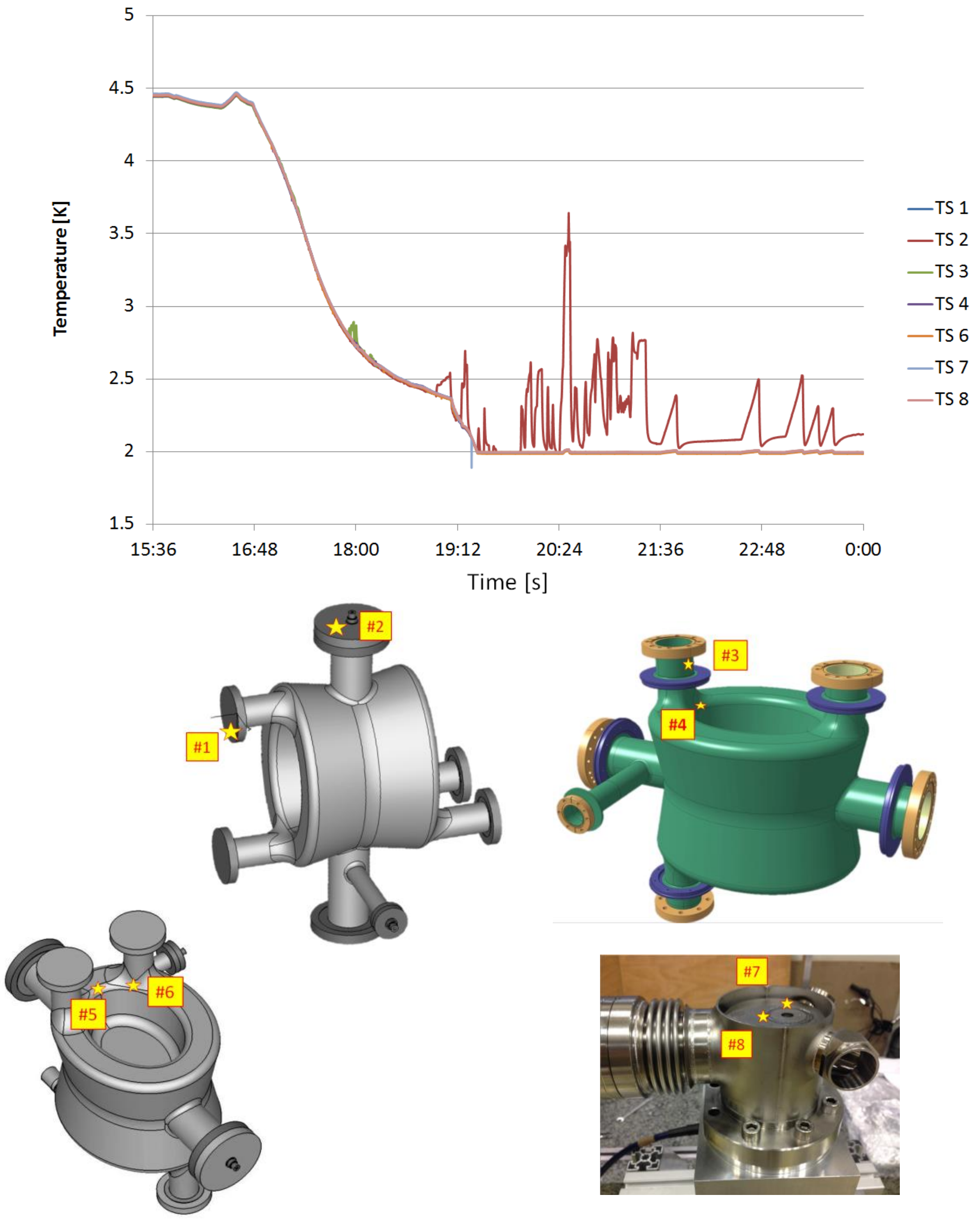

Figure 7: Signals from all thermal sensors during cold test.

The temperature data with the high power RF activities are shown in Figure 8.

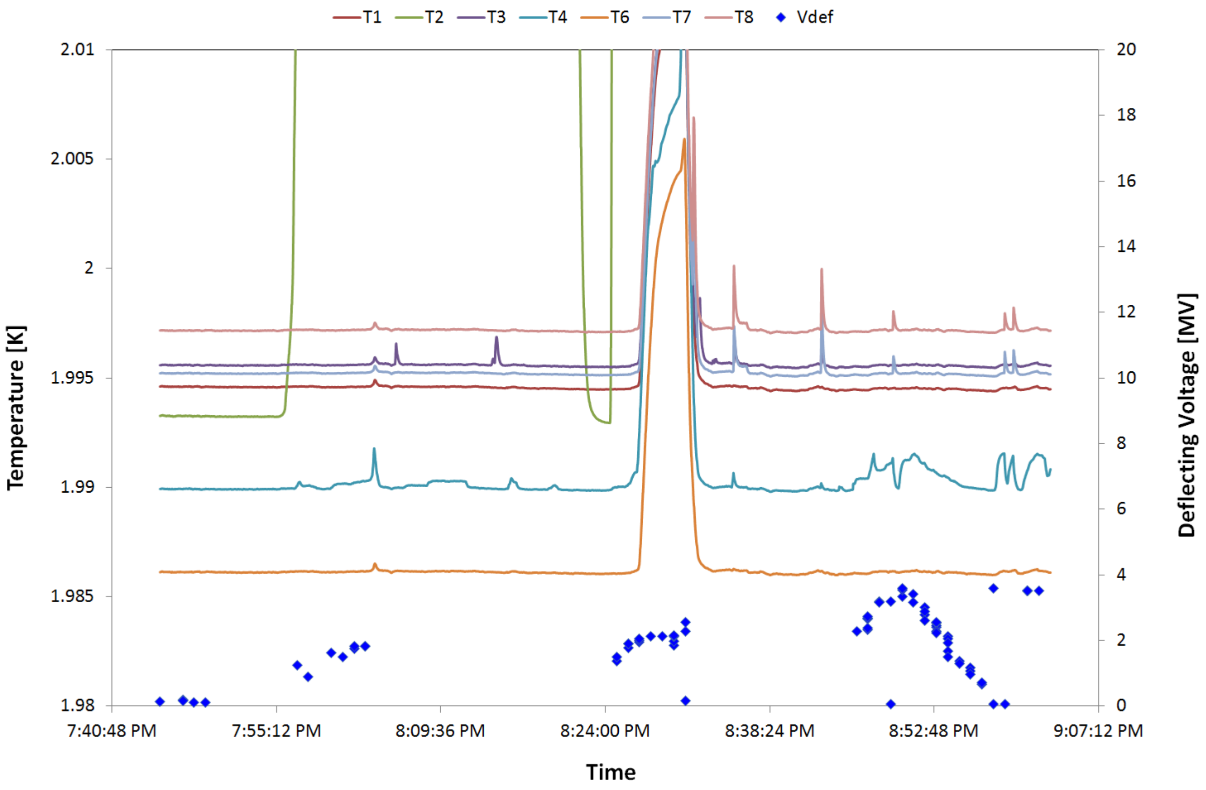

Figure 8: Temperature signal with deflecting voltage.

2. HOM measurement with network analyzer at 2K

HOM were measured at 2K using a network analyzer with the following setup: scanning with 100MHz span from 500MHz to 2GHz, using 20001 number of points, 5kHz IF bandwidth, 5dBm power; and then zoom into each mode with reduced number of points and IF bandwidth. The results are plotted in Fig. 9, with numbers listed on Table 1. Please note here we listed all the HOMs we simulated, some of them cannot be damped using 1 HOM coupler configuration, which means they have high quality factor with 1 HOM, and normally cannot be measured using FPC/1 HOM ports combination.

The HOM measurement of the NW-LARP-DQW#1 with the same HOM filter in May, 2017 at JLab showed only 1 mode with Q higher than 10^6, while this measurement showed 14 modes. One possible reason is that the previous measurement used wider frequency span and high Q modes are easier to be missed, another possibility is that the previous measurement used FPC/PU port combination and lots of HOM cannot be measured. (will confirm with Jamie). In order to understand the fabrication error induced HOM frequency shift, we plotted the frequency differences of HOMs in these two measurements in Fig. 10. The ~570MHz mode's frequency is away by 1.1%, and all the other HOMs are within 0.2%.

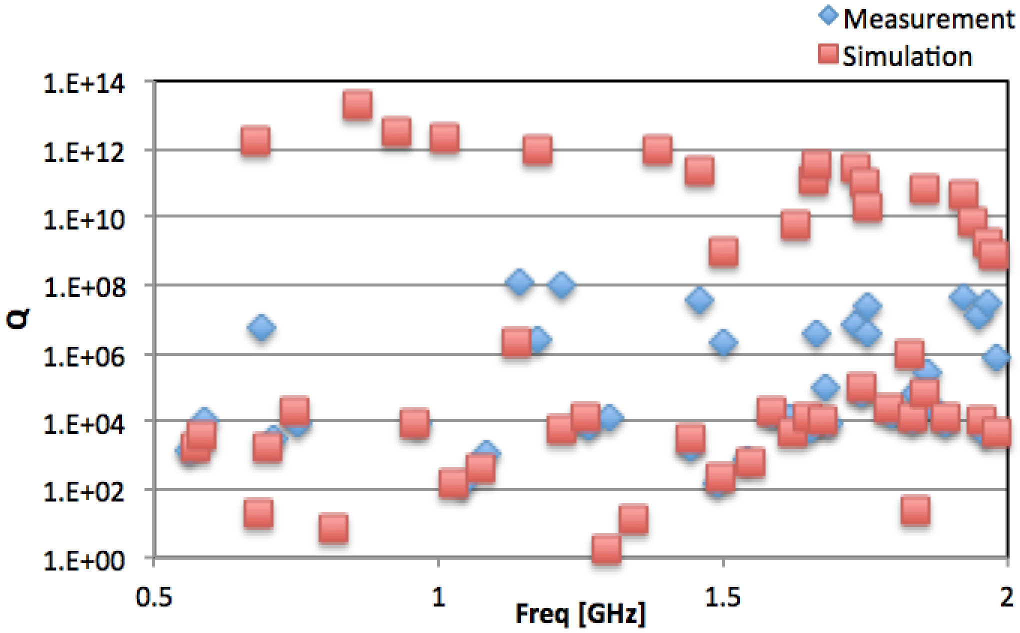

Figure 9: Simulated and measured quality factor of HOMs.

Table 1: Simulated and measured quality factor of HOMs.

Measured at 2K			Simulation	
Freq [GHz]	Q		Freq [GHz]	Q
0.56294	1318		5.7099E+08	1821.821595
0.58761	10535		5.8416E+08	4084.709125
0.68622	6032400		6.7704E+08	1.58E+12
			6.8465E+08	19.66738577
0.70758	3332		7.0117E+08	1768.660833
0.75087	9321		7.4626E+08	1.78E+04
			8.1398E+08	6.929545791
			8.5459E+08	1.94E+13
			9.2734E+08	3.41E+12
0.96278	8514		9.5888E+08	9575.488771
			1.0087E+09	2.24E+12
1.04325	161		1.0271E+09	152.3335932
1.08238	1061		1.0722E+09	413.317082
1.13959	1.30E+08		1.1377E+09	1.95E+06
1.17432	2504300		1.1714E+09	8.99E+11
1.21724	1.10E+08		1.2157E+09	6209.073215
1.26044	6570		1.2600E+09	1.42E+04
1.29845	13961		1.2951E+09	1.70965291

			1.3436E+09	12.62946967
			1.3850E+09	8.54E+11
1.44192	1773		1.4400E+09	2900.218773
1.45945	36334000		1.4555E+09	2.10E+11
1.48891	144		1.4948E+09	210.1392289
1.50009	1934200		1.5001E+09	8.55E+08
1.54307	690		1.5489E+09	657.9960695
1.58318	17070		1.5838E+09	1.84E+04
1.61843	12865		1.6198E+09	5085.224774
			1.6256E+09	6.29E+09
1.65405	5865	smooth on	1.6484E+09	1.41E+04
1.66454	3867400		1.6607E+09	1.14E+11
1.6795	104850		1.6628E+09	3.22E+11
1.68377	8232		1.6751E+09	1.00E+04
1.73476	7435000		1.7319E+09	2.87E+11
1.74356	62719		1.7406E+09	9.71E+04
1.75268	24582000		1.7490E+09	9.67E+10
1.75558	4218100		1.7543E+09	1.97E+10
1.7969	16308		1.7891E+09	2.52E+04
			1.8274E+09	9.68E+05
1.83291	10258		1.8317E+09	1.33E+04
1.83828	66533		1.8403E+09	25.28099114
1.85966	287240		1.8537E+09	6.46E+10
1.86459	31809		1.8560E+09	6.85E+04
1.89059	9161	smooth on	1.8889E+09	1.44E+04
1.92209	4.50E+07		1.9206E+09	4.46E+10
1.94712	1.20E+07		1.9404E+09	7.57E+09
1.95655	4828		1.9523E+09	1.03E+04
1.9627	2.80E+07		1.9620E+09	1.58E+09
1.98084	8.09E+05		1.9762E+09	8.13E+08
			1.9776E+09	4376.888066

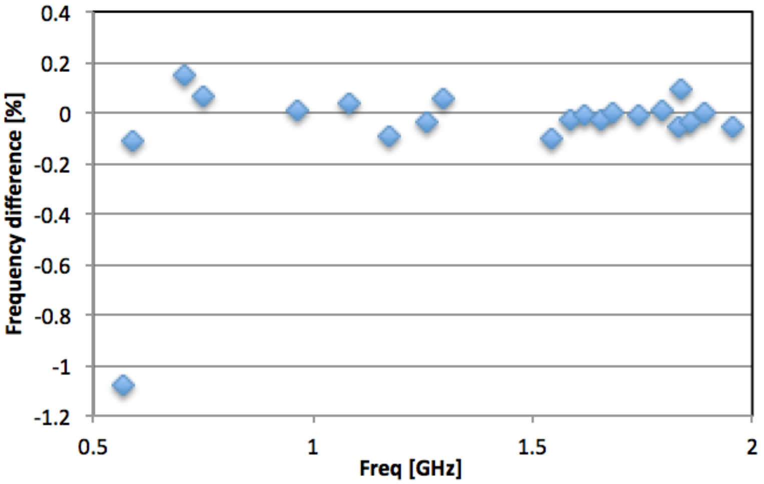

Figure 10: frequency difference in two cryogenic measurements with different cavities.

Discussion:

The very high peak from the thermal sensors is probably from cryogenic system fluctuation due to the LCLS-II cryomodule testing. Similar fluctuations can be observed from Figure 7 after 10:30pm when we have completed all measurements and stopped all RF activities.

Compare to the other sensors attached to the high RF field region, signal from sensor #4 showed relatively the most active temperature change during the entire testing. This sensor is located at the highest RF field on HOM port vicinity.

HyeKyoung Park will check the thermal sensors after the cavity is pulled out from the dewar.