Accelerated Lifetime Test of the SRF Cavity Tuner/Dressed Cavity System for the LCLS II He Project

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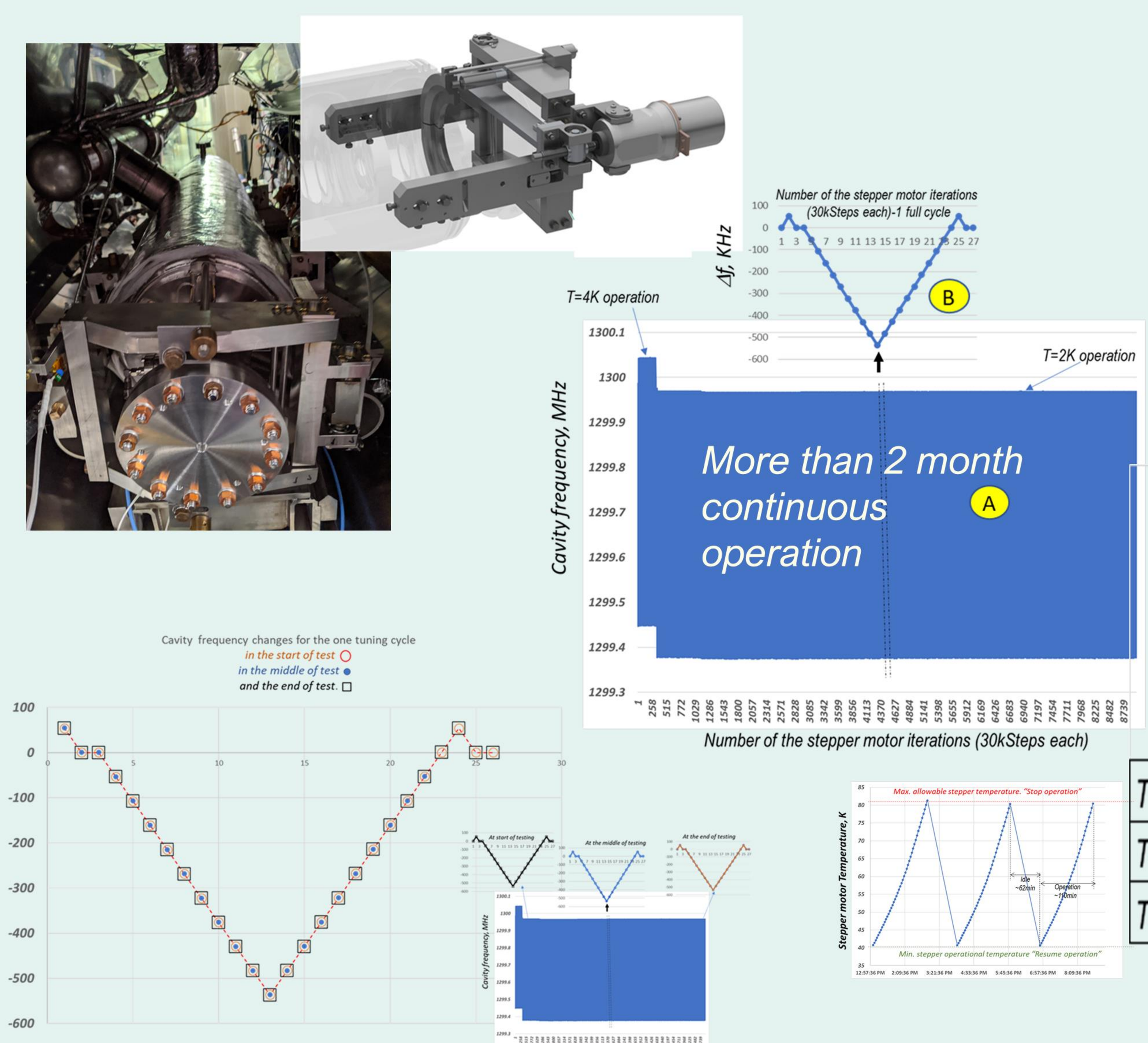
The off-frequency detune method is being considered for application in the LCLS-II-HE superconducting linac to produce multi-energy electron beams for supporting multiple undulator lines simultaneously. Design of the tuner has been changed to deliver roughly 3 times larger frequency tuning range. Working requirements for off-frequency operation (OFO) state that cavities be tuned at least twice a month. This specification requires the in-crease of the tuner longevity by 30 times compared with LCLS-II demands. Accelerated longevity tests of the LCLS-II HE dressed cavity with tuner were conducted at FNAL's HTS. Detail analysis of wearing and impacts on performances of the tuner's piezo and stepper motor actuators will be presented. Additionally, results of longevity testing of the dressed cavity bellow, when cooled down to 2 K and compressed by 2.6 mm for roughly 2000 cycles, will be presented.

Tuner System for Off Frequency Operation (OFO)
Major differences from LCLS II specs:

- **Tuner range extended up to 800kHz**
- **Longevity of tuner operation increase ~20 times**

Accelerated longevity test of the LCLS II HE tuner(stepper & piezo actuators, & bellow/cavity system at FNAL's HTS facility)



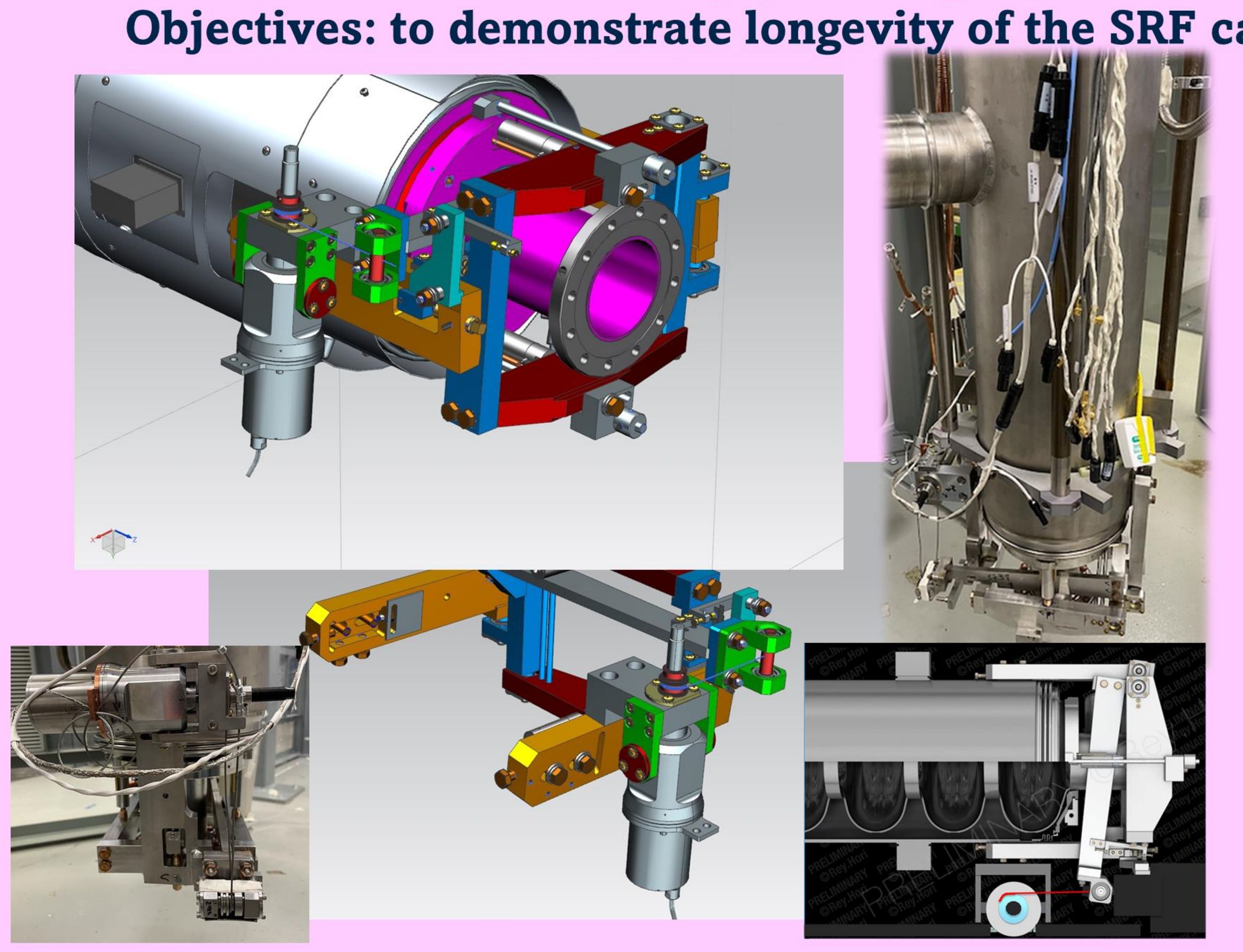
Specification for longevity of the stepper and piezo actuators.

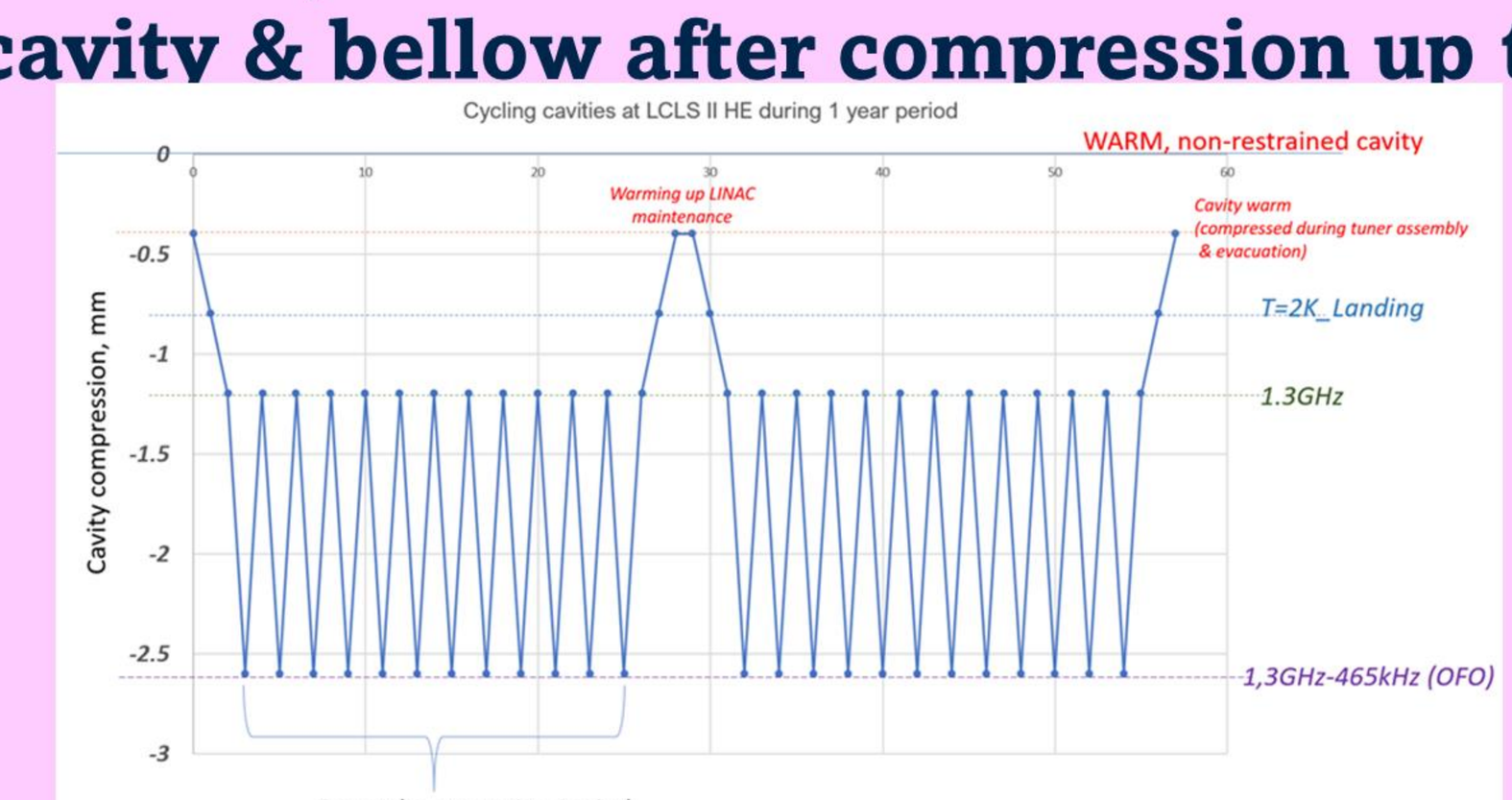
	LCSI II	LCLS II HE
Frequency tuning required for 95% of the cavities to bring to 1.3GHz after cooldown to T=2K, **[kHz]**	200	200
Stroke/compression required to tune cavities to 1.3GHz after cooling down to T=2K, **[mm]**	0.67	0.67
Forces on the shaft/nut system to tune 95% of cavities to f=1.3GHz, **[N]**	260	260
Forces on the piezo actuator to tune 95% of cavities to f=1.3GHz, **[kN]**	2.6	2.6
Forces on the shaft/nut system to tune 95% of cavities to OFO f=1.3GHz-465kHz, **[N]**	N/A	710
Forces on the piezo actuator to tune 95% of cavities to OFO f=1.3GHz-465kHz, **[kN]**	N/A	6
Longevity of the actuator/Number of the motor steps to tune cavity from 1.3GHz to "safe" position before warm-up (twice a year) during 20 years, **[MSteps]**	10	10
Longevity of the actuator/Number of the motor steps to tune cavity from 1.3GHz to "1,3GHz-465kHz" and back 20 times a year during 20 years, **[MSteps]**	N/A	210
Longevity for 20 years operation, **[Msteps]**	10	**220**
Overall stroke of traveling nut on the shaft for 20 years of operation, **[m]**	1.0	22
Overall stroke/cavity compression for 20 years of operation, **[m]**	0.03	0.7

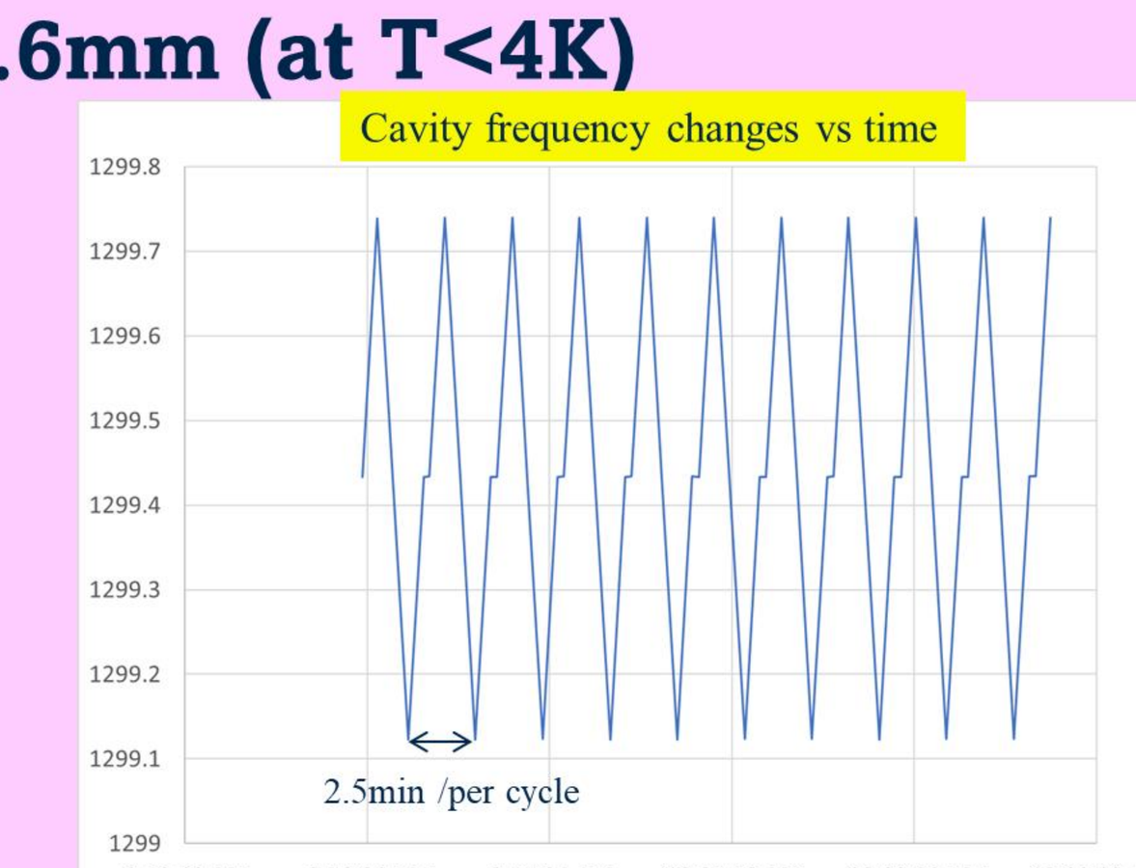
Summary of the HTS Accelerated Test.

	Number of the cycles (660kSteps each cycle)	Accumulated number of steps by stepper motor, [Msteps]	Accumulated cavity re-tuning, [MHz]	Accumulated stroke/travel of the nut on the shaft, [m]	Accumulated stroke= compressions of the cavity, [m]
T=4K	226	150	270	15	0.47
T=2K	400	264	475	26	0.8
Total	626	**414**	745	41	1.3

Test at VTS with modified Fast-Slow Tuner system with dressed LCLS II cavity (submerged into LHe &T=2K).
Objectives: to demonstrate longevity of the SRF cavity & bellow after compression up to 2.6mm (at T<4K)





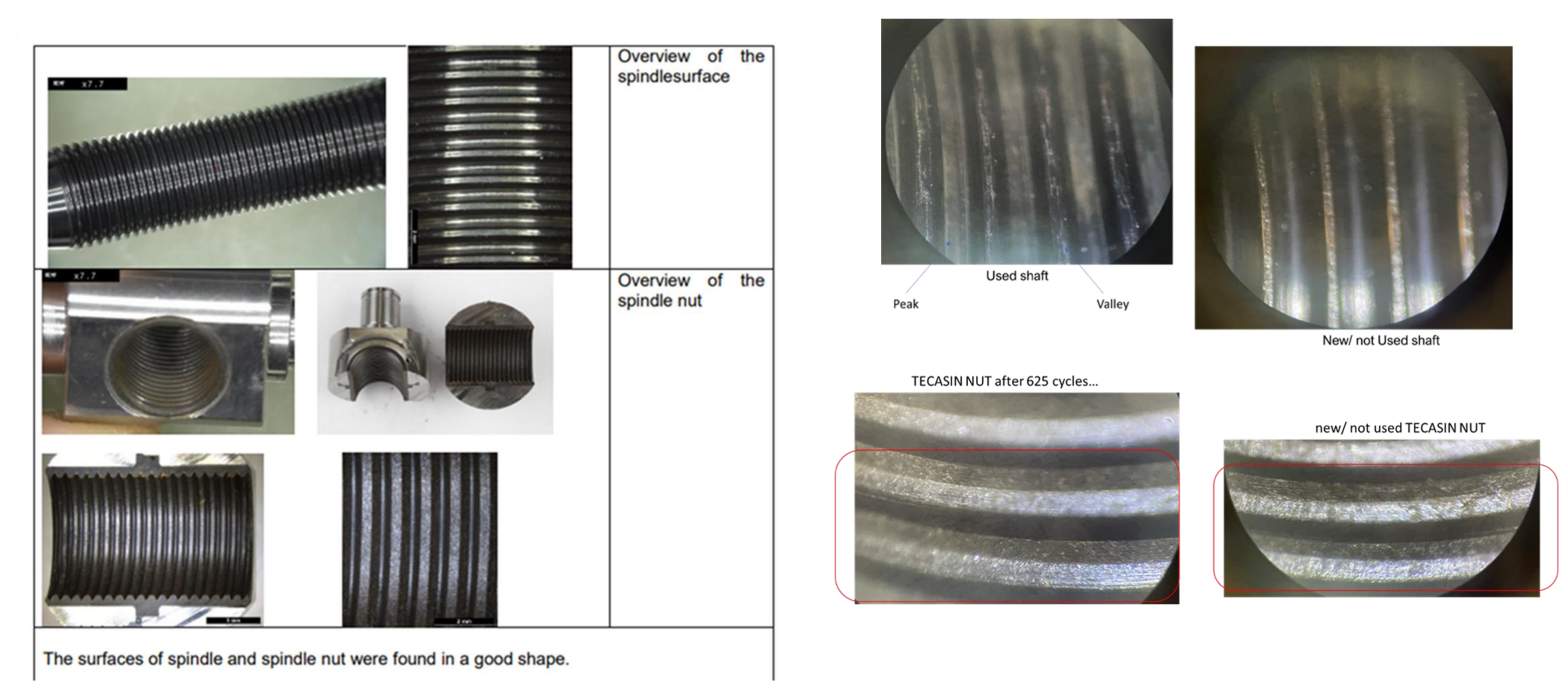


At VTS three cool-down warm up cycles:
(1) 130 + (2) 270 + (3) 640 =1040 cycles
after each cycle visual inspection of the bellow & pressure test have been conducted – to confirm integrity of SRF cavity and bellow.

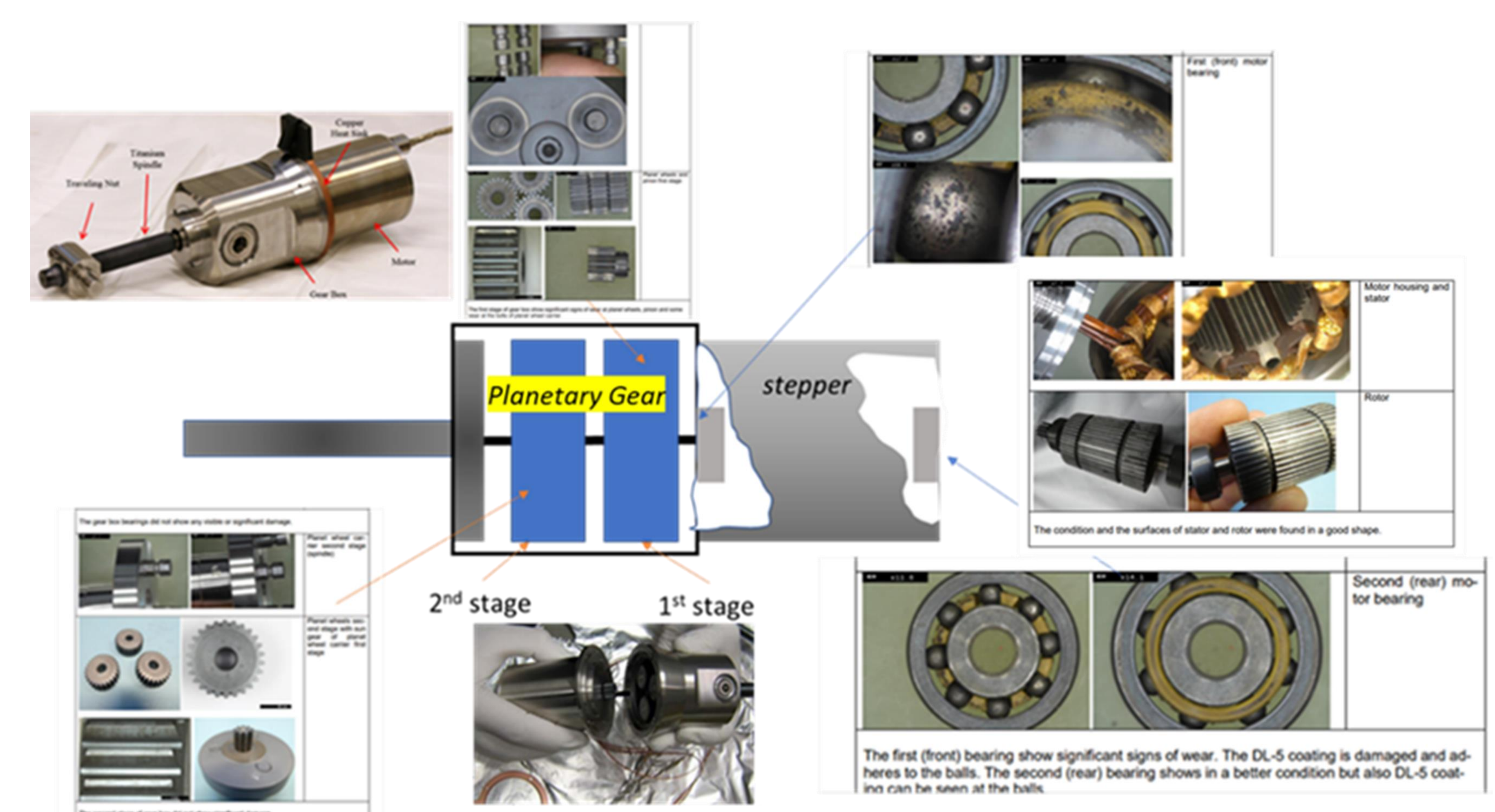
Dressed cavity & bellow withstand without any failure of 1660 (~8 lifetime) cycles up to 2.6mm compression.

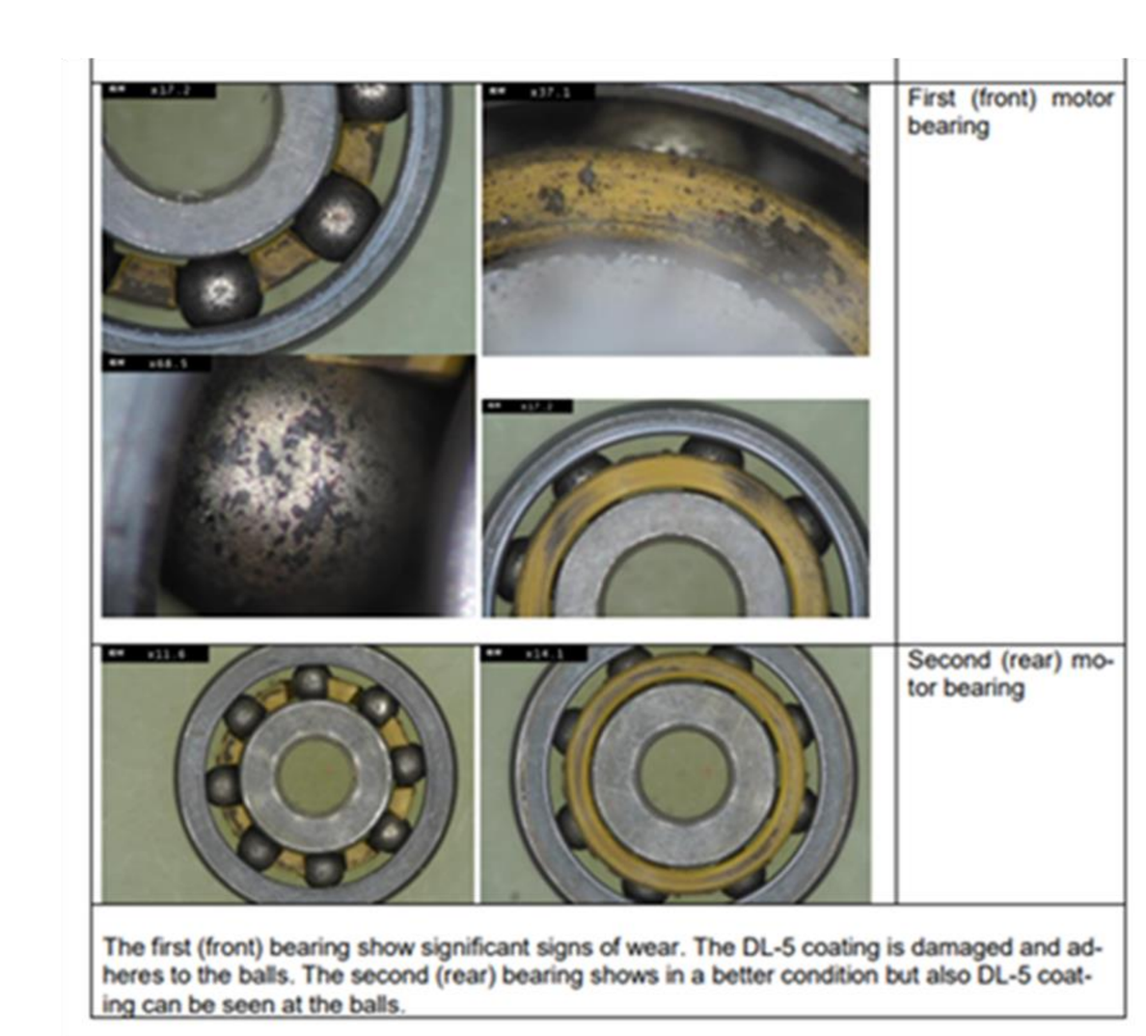
Phytron stepper actuator investigation after longevity studies *
**Major studies performed by Phytron team at vendor facility*

Step 1. Visual Inspection at FNAL & Phytron site after 2-month test



Step 2. Investigation at Phytron site after 2-month test





Summary of the Accelerated Lifetime Test of Phytron Stepper Motor Actuator.

Stepper motor actuator has been tested at cryogenic temperature and insulated vacuum during 2-month continuous operation. Accumulated number of steps was ~414 MSteps that is 2 times longer than estimated longevity for LCLS II HE (and in ~40 times longer that LCLS II longevity specifications). We do not observe any degradations of stepper actuator performances. Additional investigation of the stepper actuator by vendor (Phytron ,INC) show wearing of some components of actuator but not significant to impact overall performance of actuator.

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