CRAB cavity tuning system SPS and LHC

K. Artoos

16/12/2021

Tuning principle, Range

Range in Spec ± 150 kHz (LHC) (± push/pull)

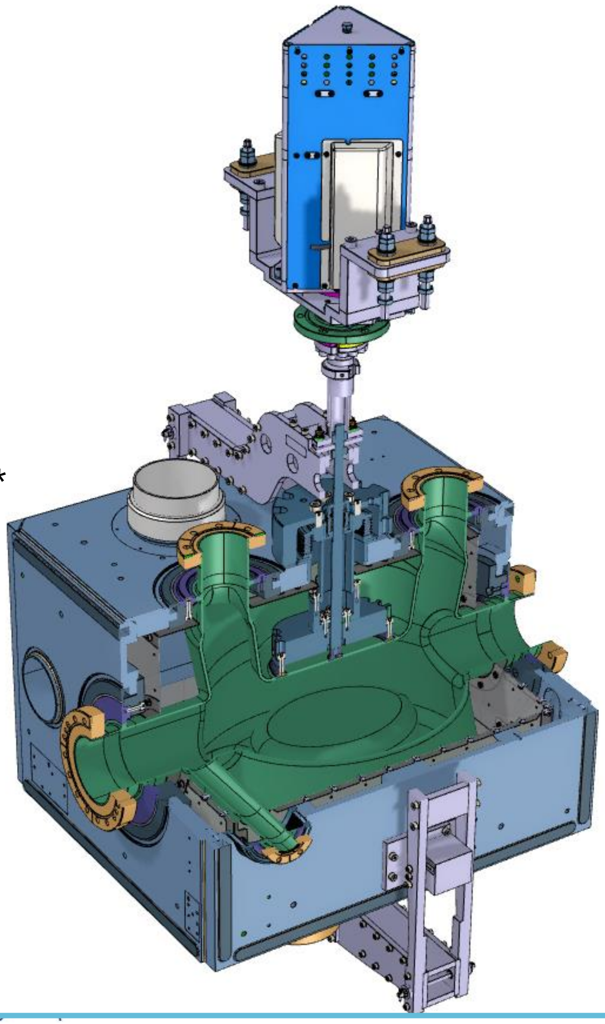
FINE TUNING PRINCIPLE

Symmetric actuation through tuner frame and concentric tubes. Actuator outside cryostat and floating

DQW
318 kHz/mm*
S. Verdú Andrés

Tuning range
± 509 kHz
±1.6 mm*
elastic range at 2 K
Max. force:
± 3.8 kN

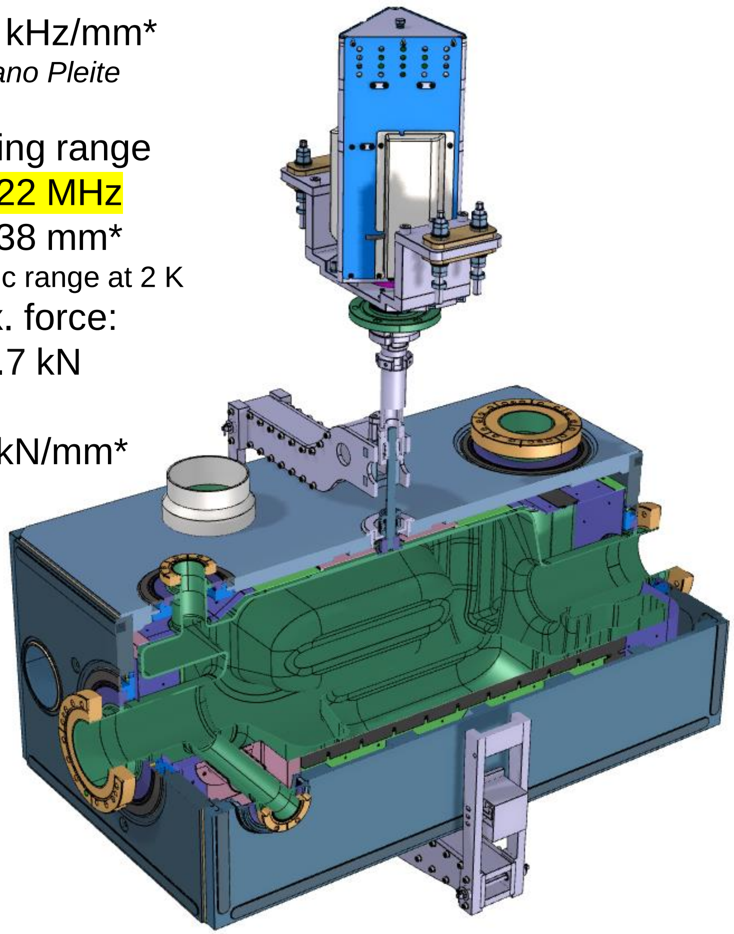
2.2-2.4 kN/mm*



RFD
512 kHz/mm*
E. Cano Pleite

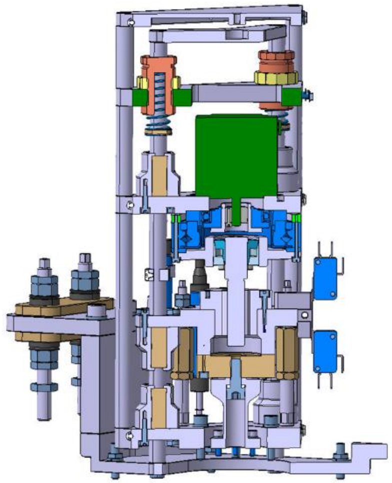
Tuning range
± 1.22 MHz
± 2.38 mm*
elastic range at 2 K
Max. force:
± 6.7 kN

2.8 kN/mm*



*Measured as tuner stroke or Δ distance between 2 plates

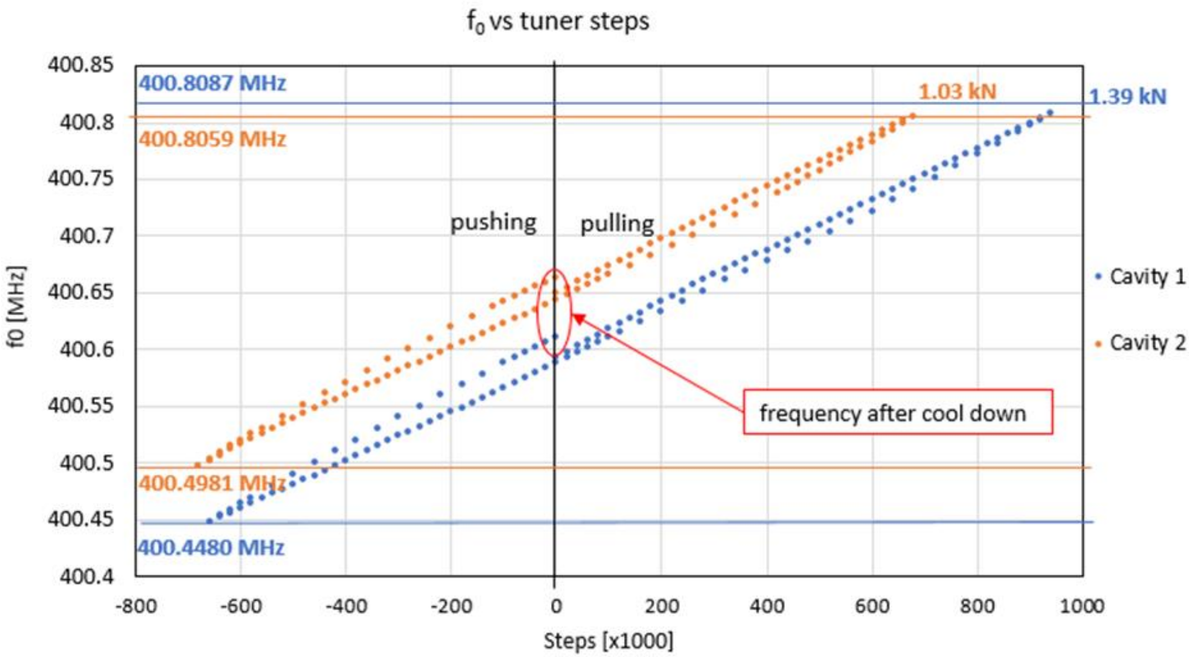
Linear drive set-up, Resolution, speed



EDMS 1994455 *SPS DQW Tuner documentation*

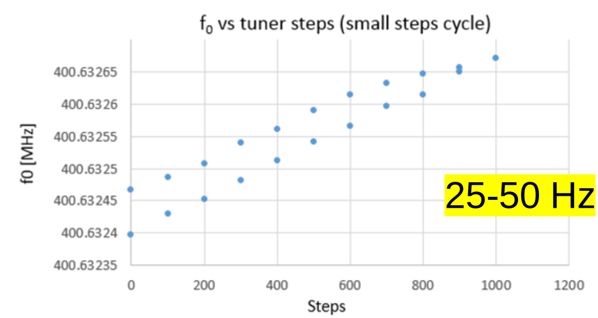
Motor: **1.3 Nm Bipolar Nema 23 (1.8°)**
HD: HFUS-20-100-2SO, **ratio i:0.01**
Roller screw Rollvis RV 12 x **1 mm lead**

Ratio Motor displacement/cavity deformation: 1.5
System stiffness: 1.6 kN/mm



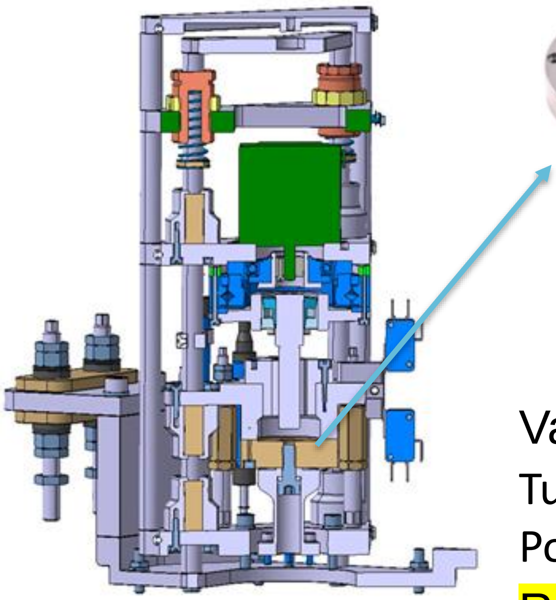
DQW:
Measured at 2 K (SM18)
0.23 Hz/ step resolution
Driver 8000 microsteps

Maximum tuning speed:
2000 steps/ second,
because not ramped



Hysteresis present

Instrumentation



Load cell Kistler 5 kN (DQW, RFD 10 kN))
4576A55C1 class 0.1

Variables Timber:

Tuner force: ACF.POW.C% :SG_RAW in N

Position: ACF.TUNER.C%:Position in steps

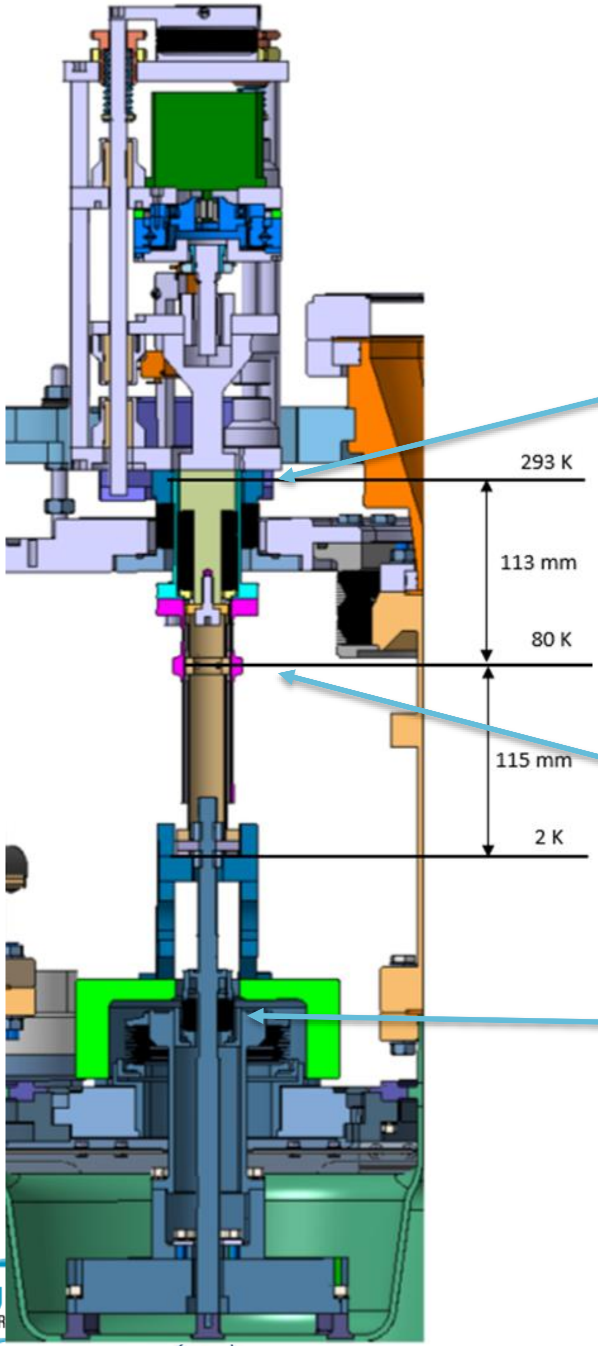
Remark about zeroing position

Potentiometer Megatron RC13-25 M no longer used, resolution not good
Plan is to replace this by resolver with conditioner

Interlock tuner DQW SPS : limit switches, Load cell at ± 2 kN

Request: function to move to zero load position when T He tank > 100K

Tuner (load cell) possible perturbations “Drift”



Feedthrough bellow: sensitive to pressure (atm)
1% change atm >> ~ 3N *

Temperature gradient, change will change tuner load

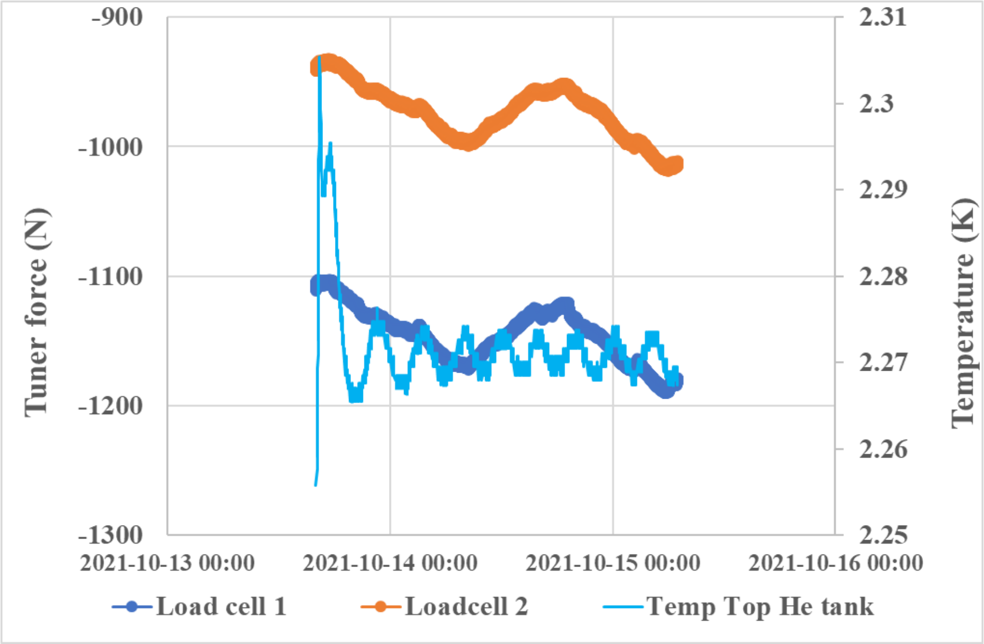
Thermalisation temperature not measured, refer to FPC thermalisation

He Tank feedthrough + cavity surface
Sensitive to He tank pressure (and temperature when saturated liquid)
1 mbar >~3 N*

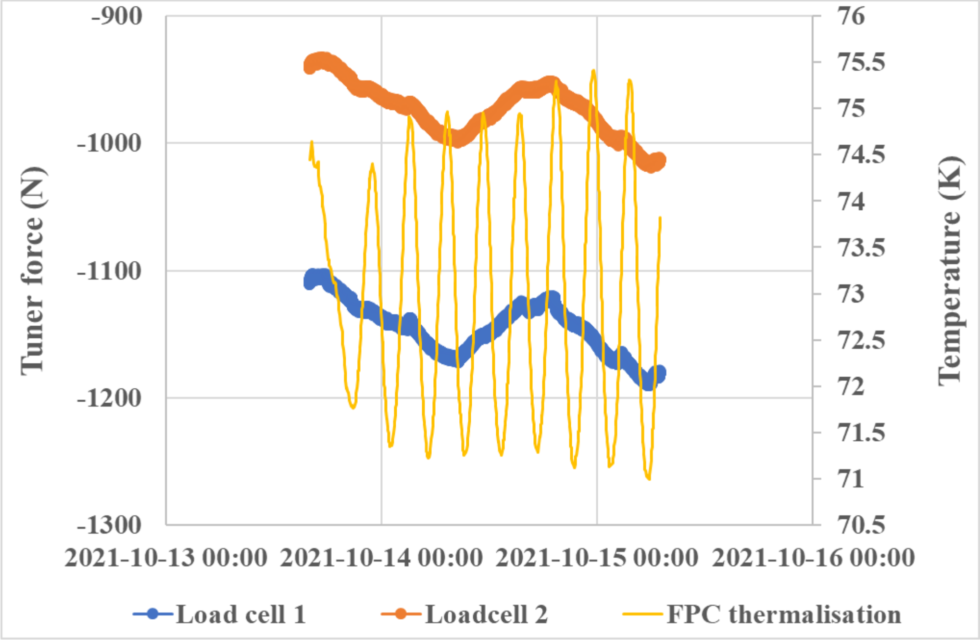
* Rough estimate

Cavities at 2 K, no tuner changes

Temp He tank
So also pressure



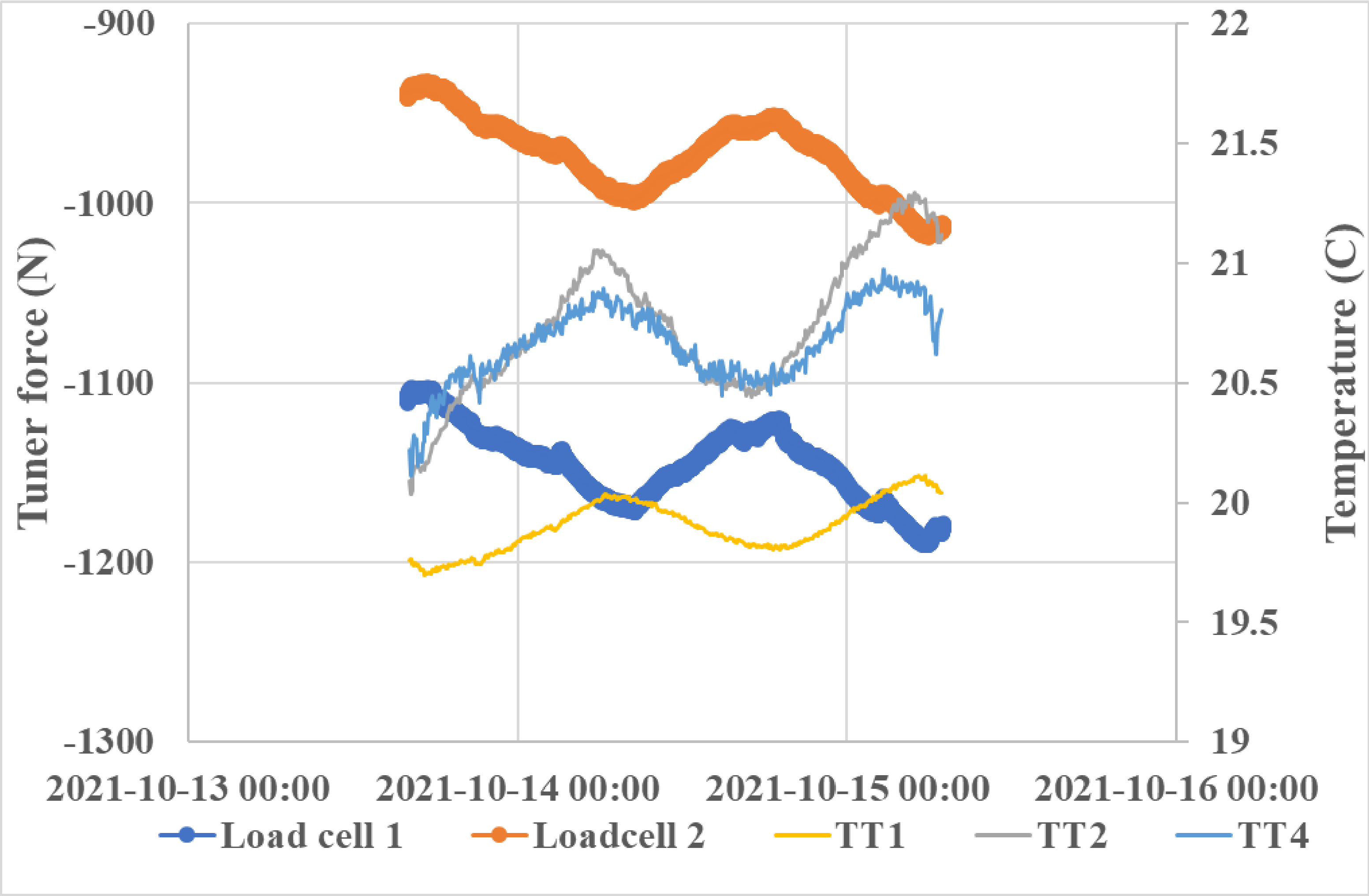
Temp
Thermalisation
FPC



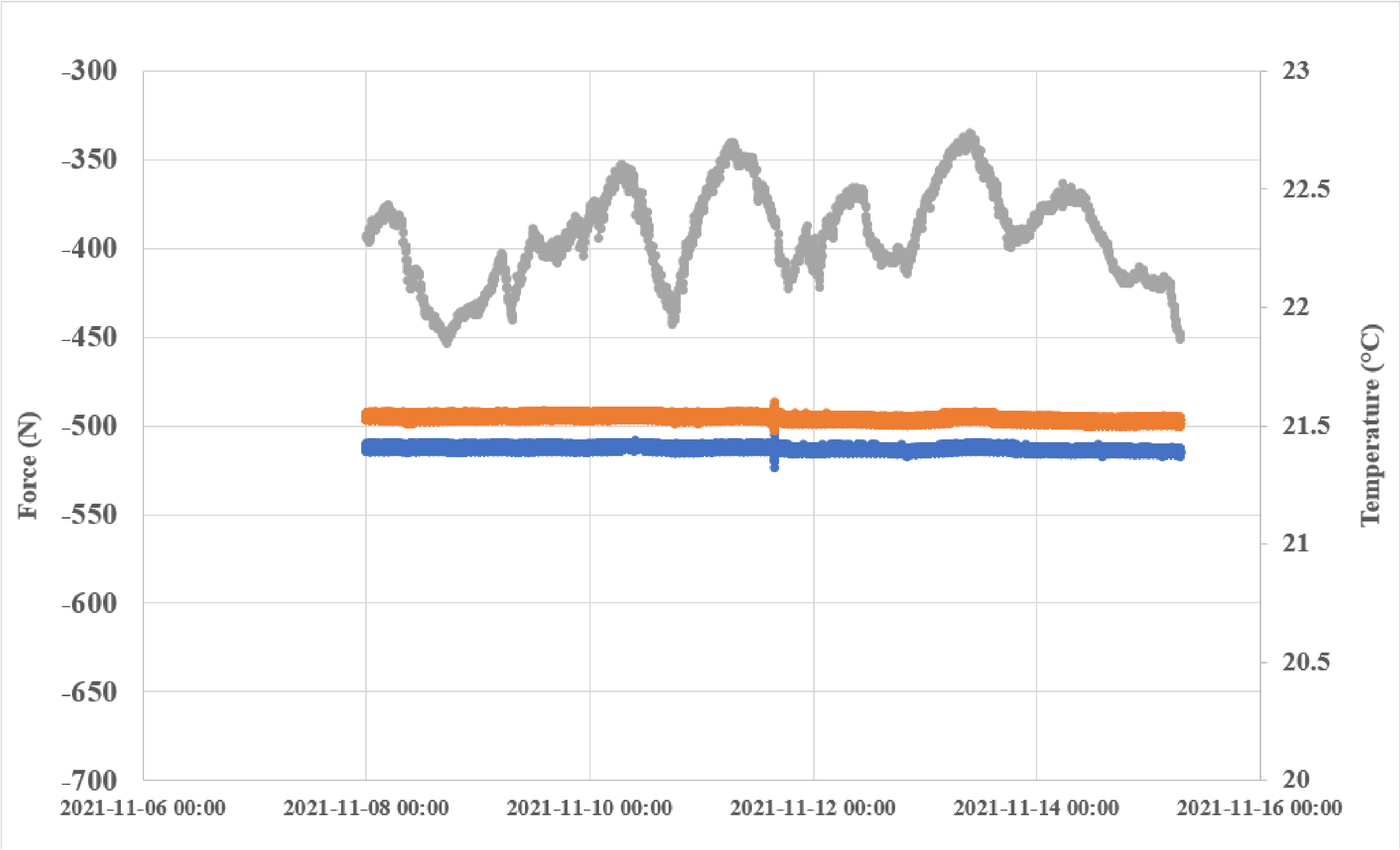
2nd ripple frequency fits with cryo cycle?

Cavities at 2 K, no tuner changes

Temperature tunnel



CM stable at room temperature

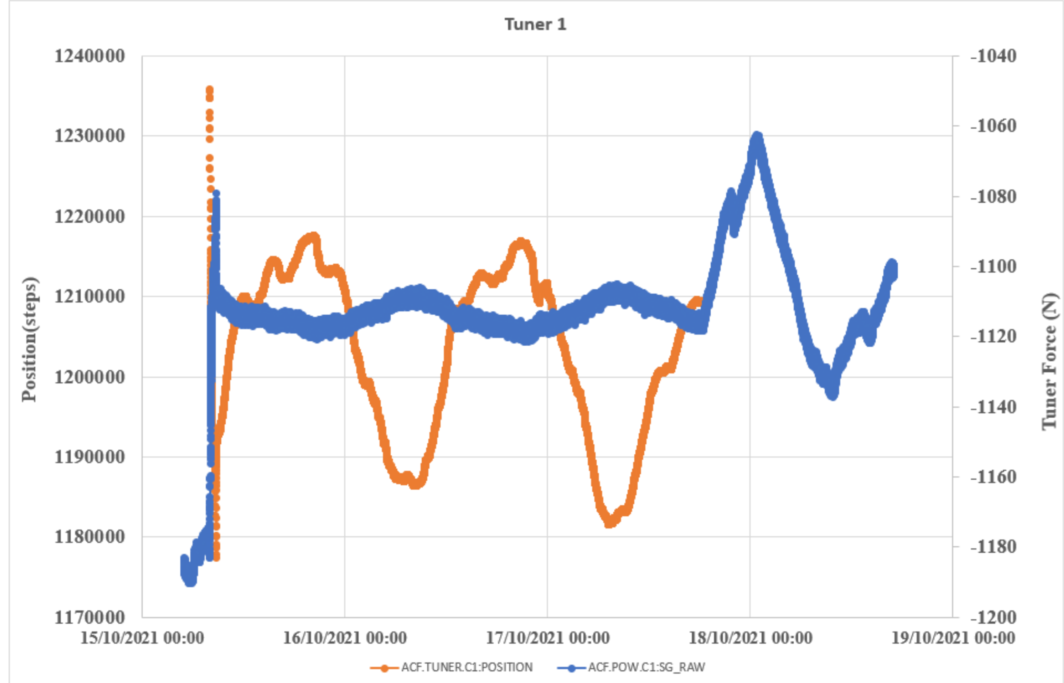


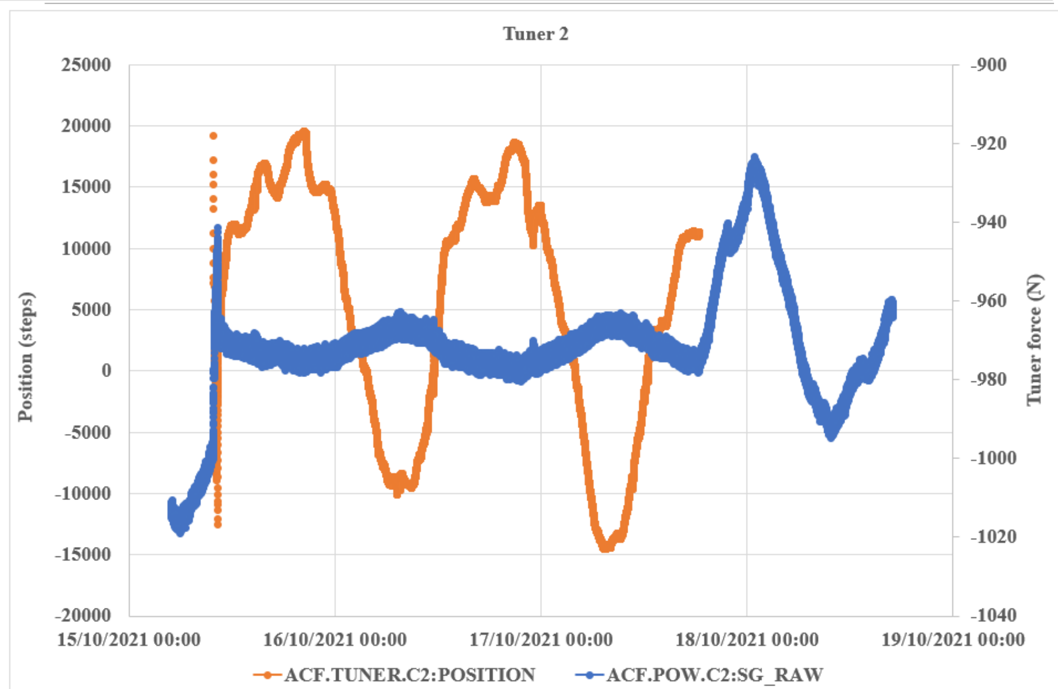
Check T influence on load cell + cables
No thermal gradient inside CM means no change of tuner force with tunnel temperature

15-18 October

? Feedback with tuner
? Input

Comment: Orange curve are steps sent to the tuner. If no steps are sent there are no points stored in timber. So there was clearly a loop running.





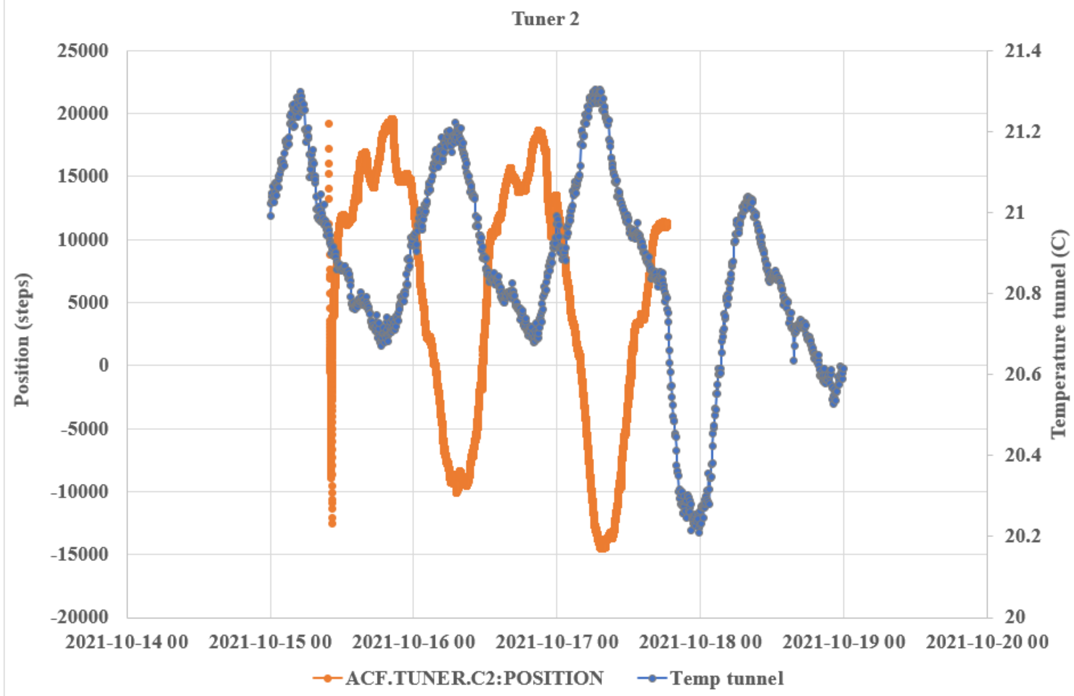
15-18 October

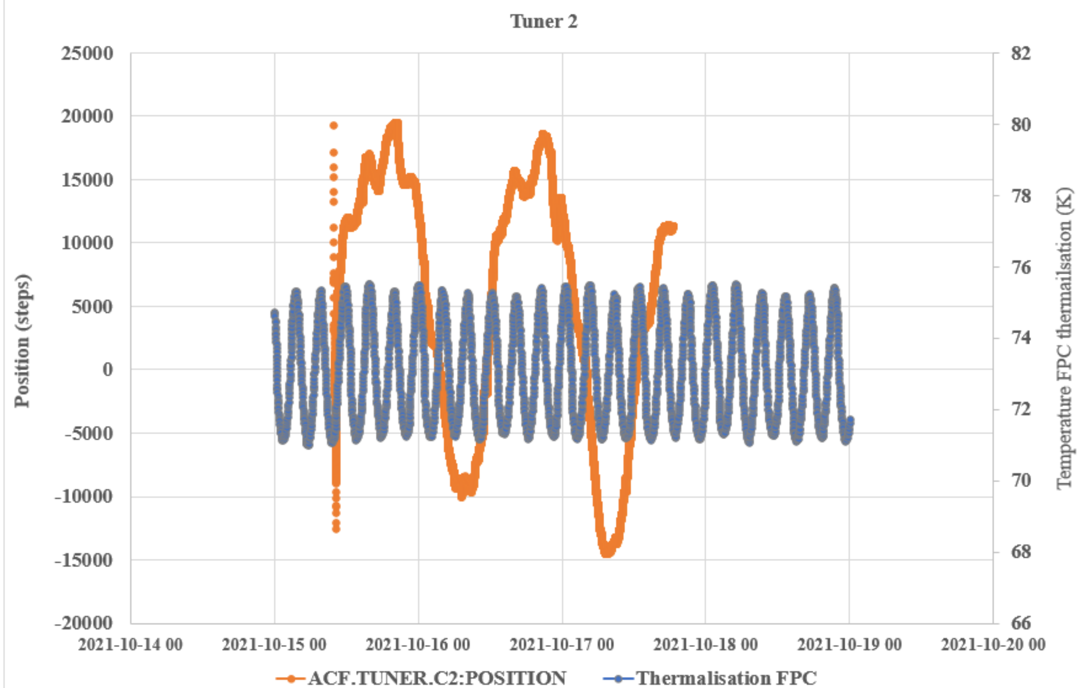
Influence tunnel temperature

+ indications cryo cycle on temperature tunnel

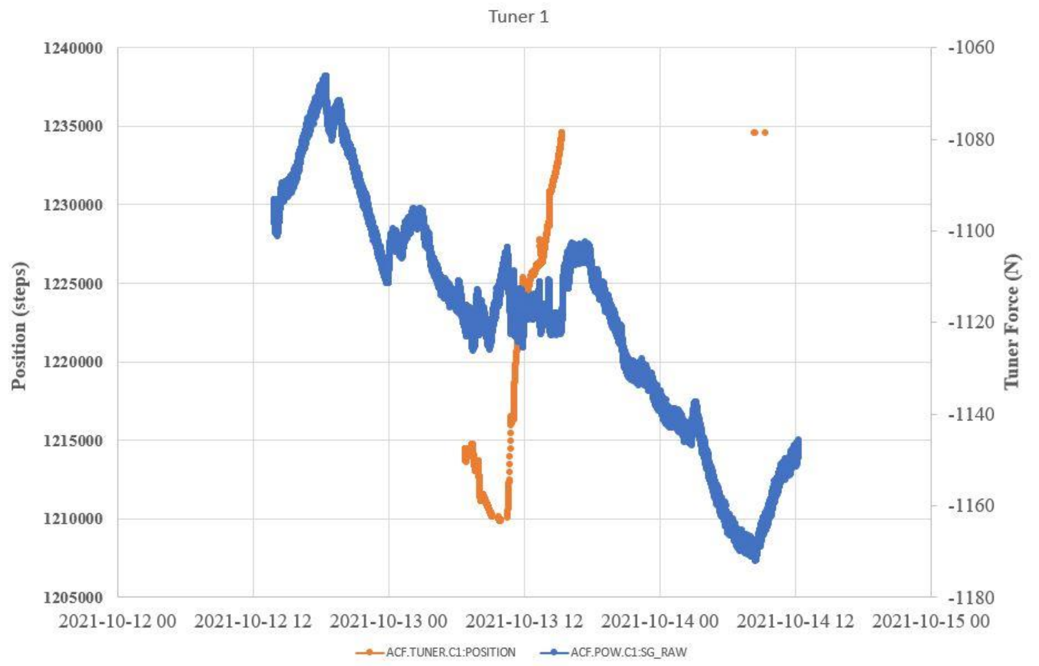
Influence thermalisation temperature

What was the input of the FB control ? Frequency, Power 2 K cryo?
This would indicate that the frequency drift is related to tuner drift and hence temperature drift

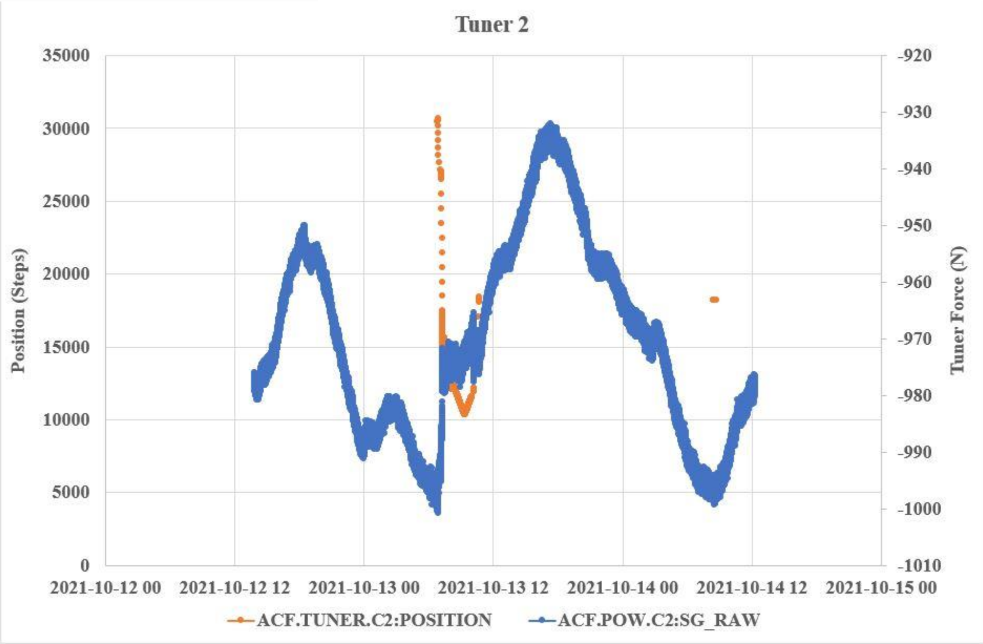




MD

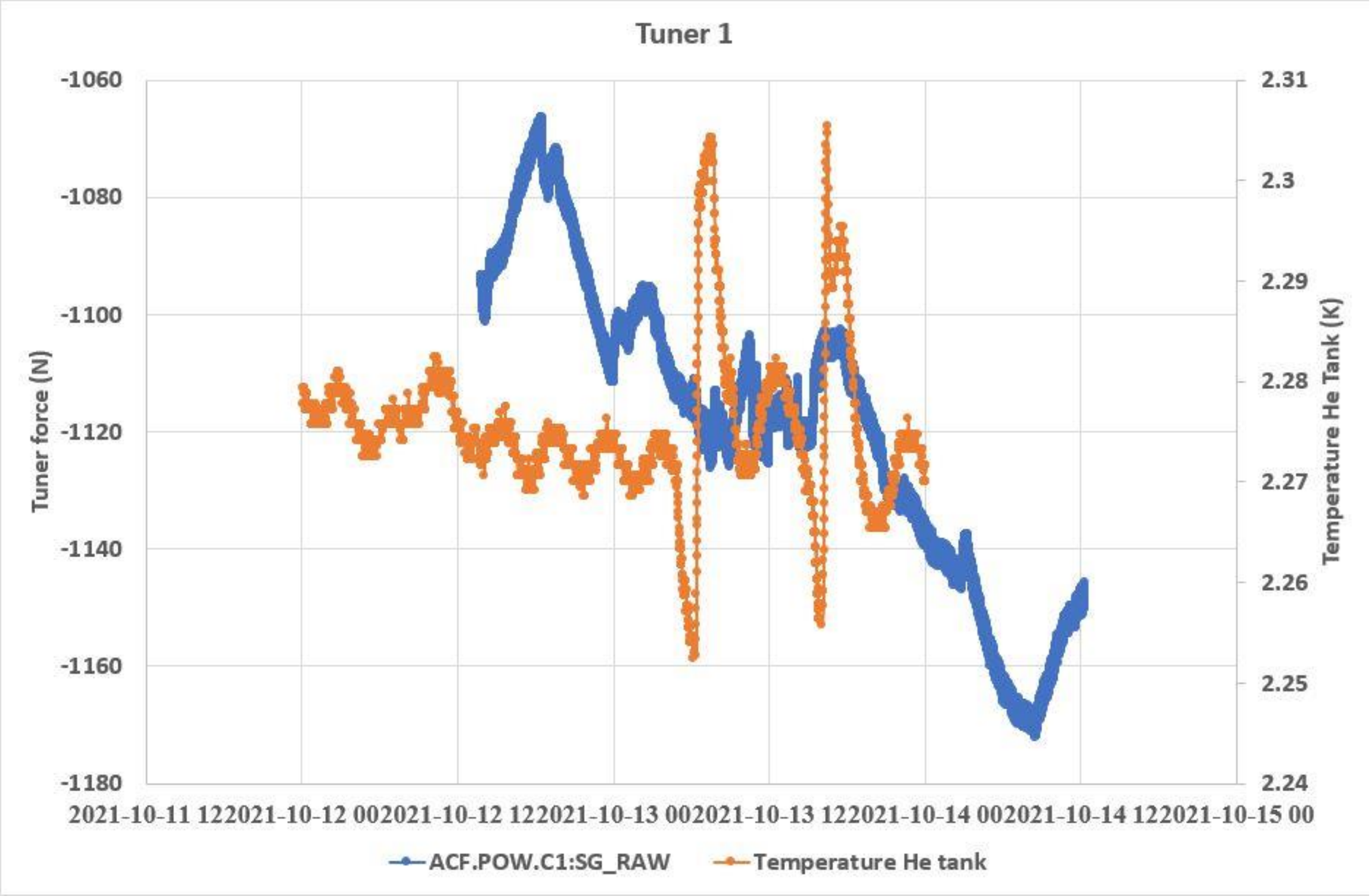


Tuner 1
Position (steps)
Tuner Force (N)
1240000
1235000
1230000
1225000
1220000
1215000
1210000
1205000
-1060
-1080
-1100
-1120
-1140
-1160
-1180
2021-10-12 00
2021-10-12 12
2021-10-13 00
2021-10-13 12
2021-10-14 00
2021-10-14 12
2021-10-15 00
ACF.TUNER.C1:POSITION
ACF.POW.C1:SG_RAW



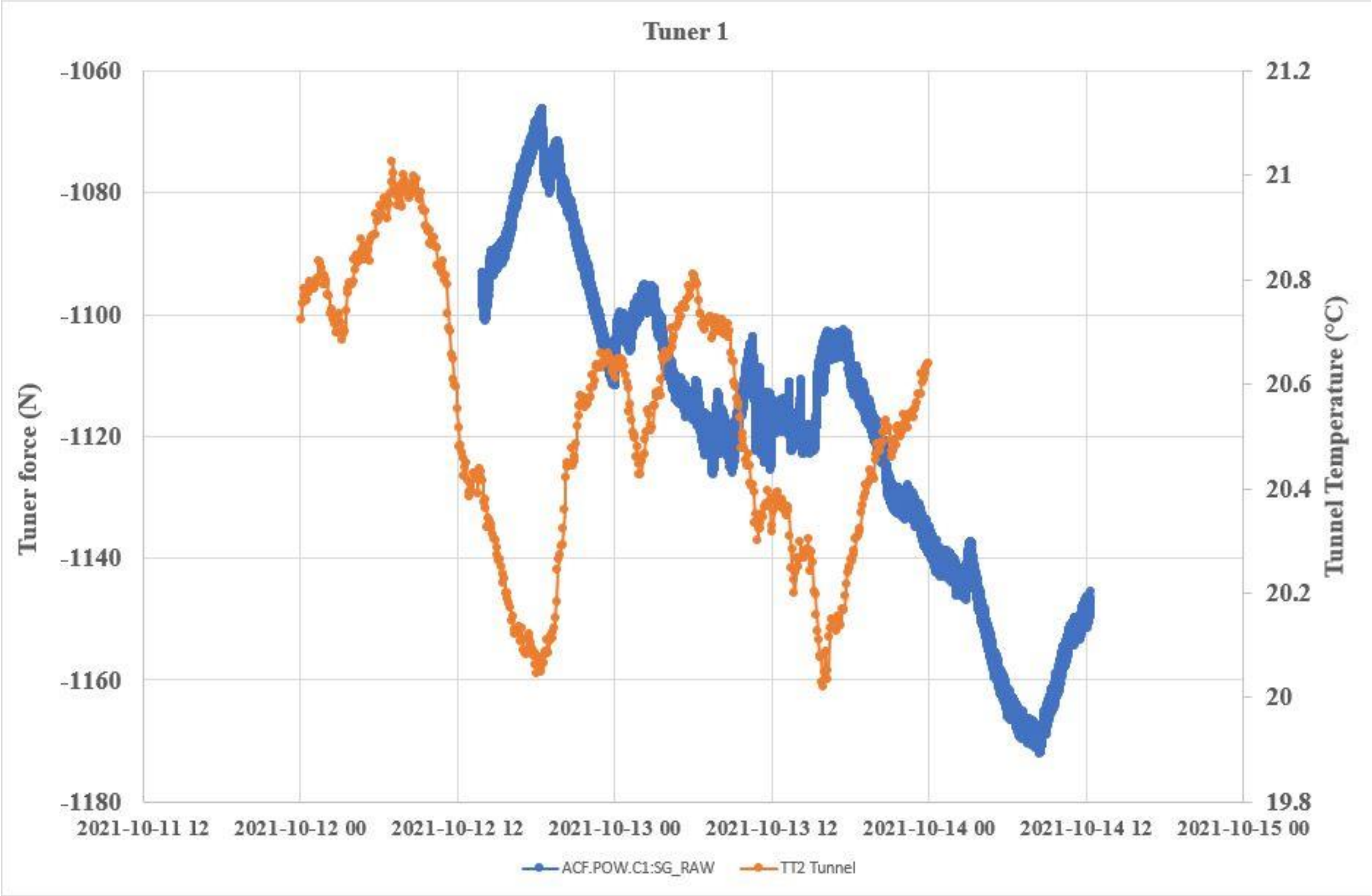
Tuner 2
Position (Steps)
Tuner Force (N)
35000
30000
25000
20000
15000
10000
5000
0
-920
-930
-940
-950
-960
-970
-980
-990
-1000
-1010
2021-10-12 00
2021-10-12 12
2021-10-13 00
2021-10-13 12
2021-10-14 00
2021-10-14 12
2021-10-15 00
ACF.TUNER.C2:POSITION
ACF.POW.C2:SG_RAW

MD

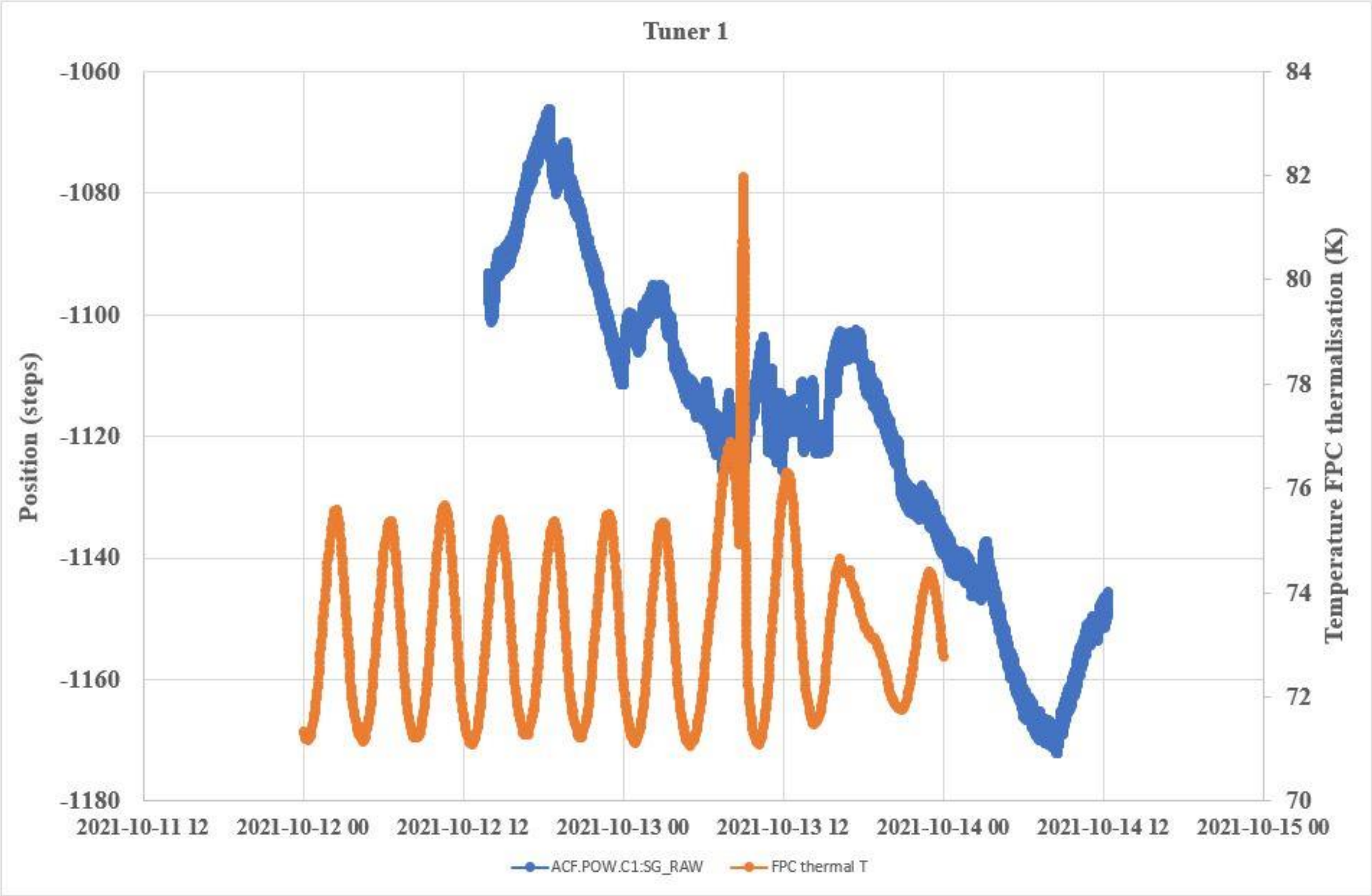


Temperature Cavity

MD



Tunnel temperature


Tuner 1
-1060
-1080
-1100
-1120
-1140
-1160
-1180
Position (steps)
84
82
80
78
76
74
72
70
Temperature FPC thermalisation (K)
2021-10-11 12
2021-10-12 00
2021-10-12 12
2021-10-13 00
2021-10-13 12
2021-10-14 00
2021-10-14 12
2021-10-15 00
ACF.POW.C1:SG_RAW
FPC thermal T

Conclusions

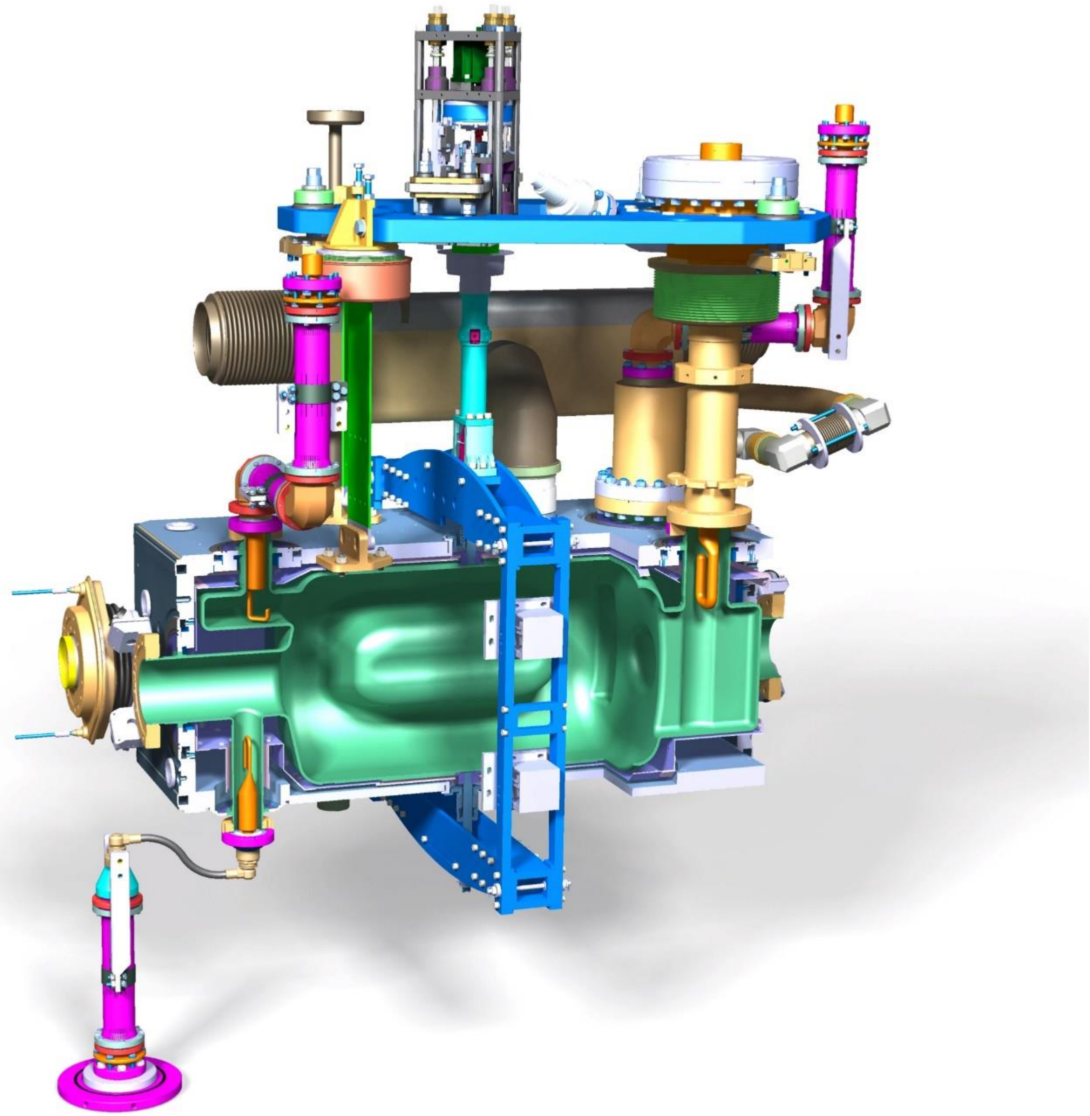
- Drift seen on tuner load cells, possibly related to observed frequency drift of cavity, can be attributed to tunnel temperature and to a lesser extend to the 2 K cryo cycle.
- Some of the 2 K cryo cycle is found back in the tunnel temperature.
- Drift can be compensated with the tuner as demonstrated on 15th to 18th October
- Requests to implement in Tuner control: back to zero > 100 K, tuner speed ramp

Thank you for your attention!

HiLumi
HL-LHC PROJECT

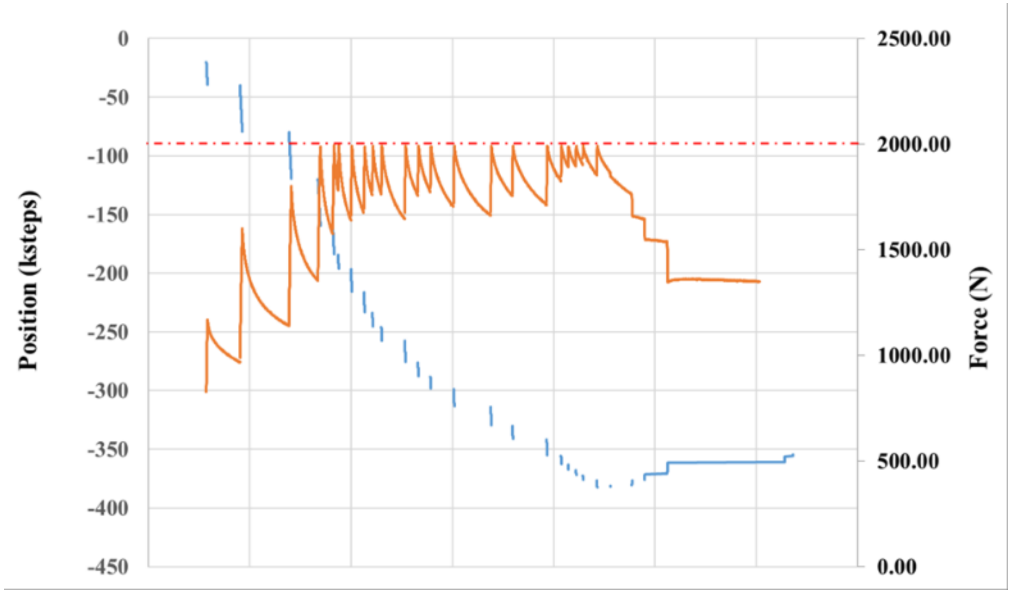
Spare slides

Reminder functioning tuner



Reminder end of Run1 DQW SPS 2018

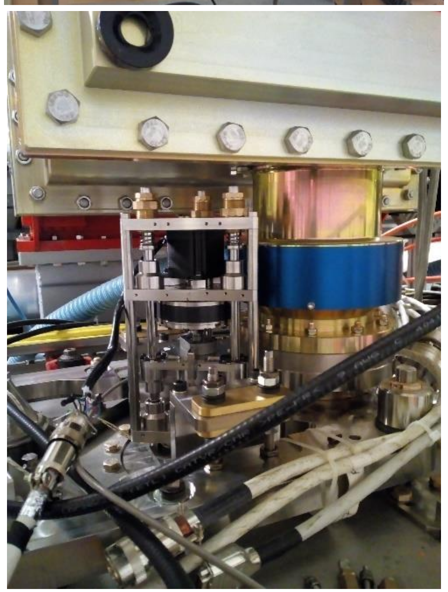
- Sudden increase of stiffness 2-3 October after thermal cycle
- no real blockage
- One motor-gear coupling started slipping 19/10
- Tuner heaters broken + wires damaged
- Possible ice formation



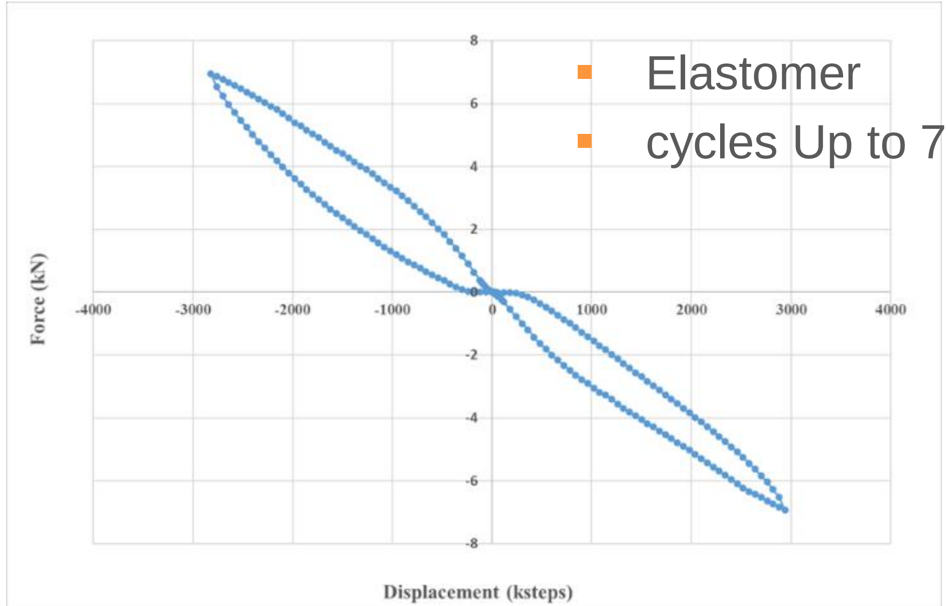
Important observations:

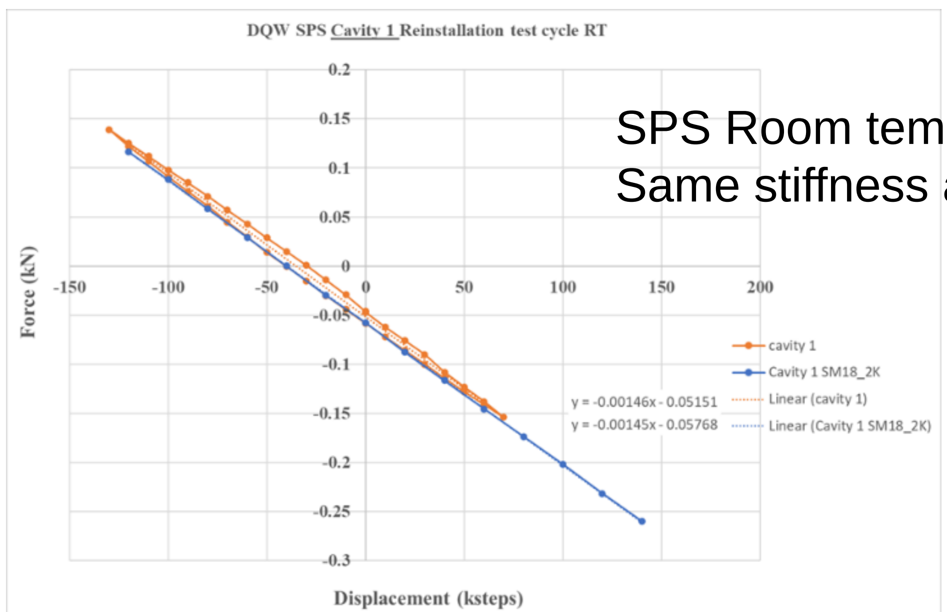
- Very hard to dismount motor in-situ or to replace the heater
- Impossible to retighten the coupling without full actuator disassembly
- No access to set limit switches and hard stop
- Potentiometer not needed

Testing



- Elastomer
- cycles Up to 7 kN

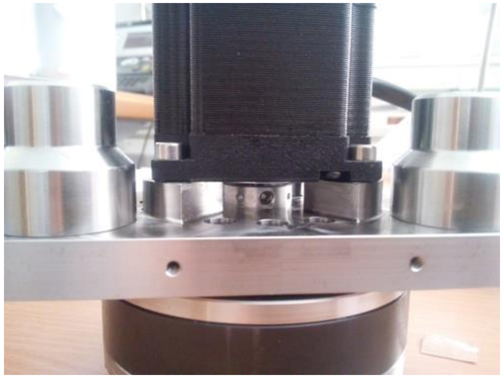


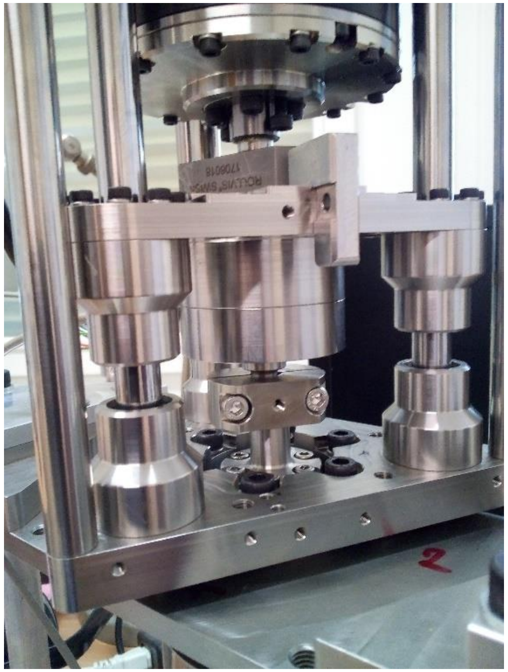


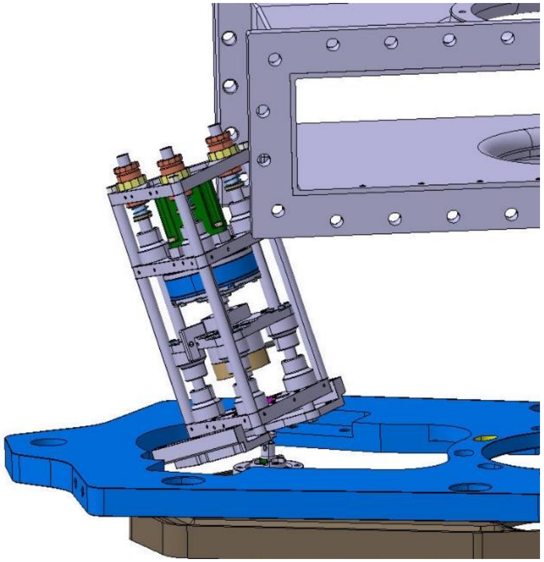
SPS Room temperature
Same stiffness as SM18

SPS DQW and RFD Upgrade

- D-type slip-free Oldham coupling with set screw
- Introduction connection clamp
- Creation more space
- Lowered actuator height







- Removed potentiometers
- Moved limit switches to front
- Only 1 hard stop in front