DQW Tuner Mockup Test

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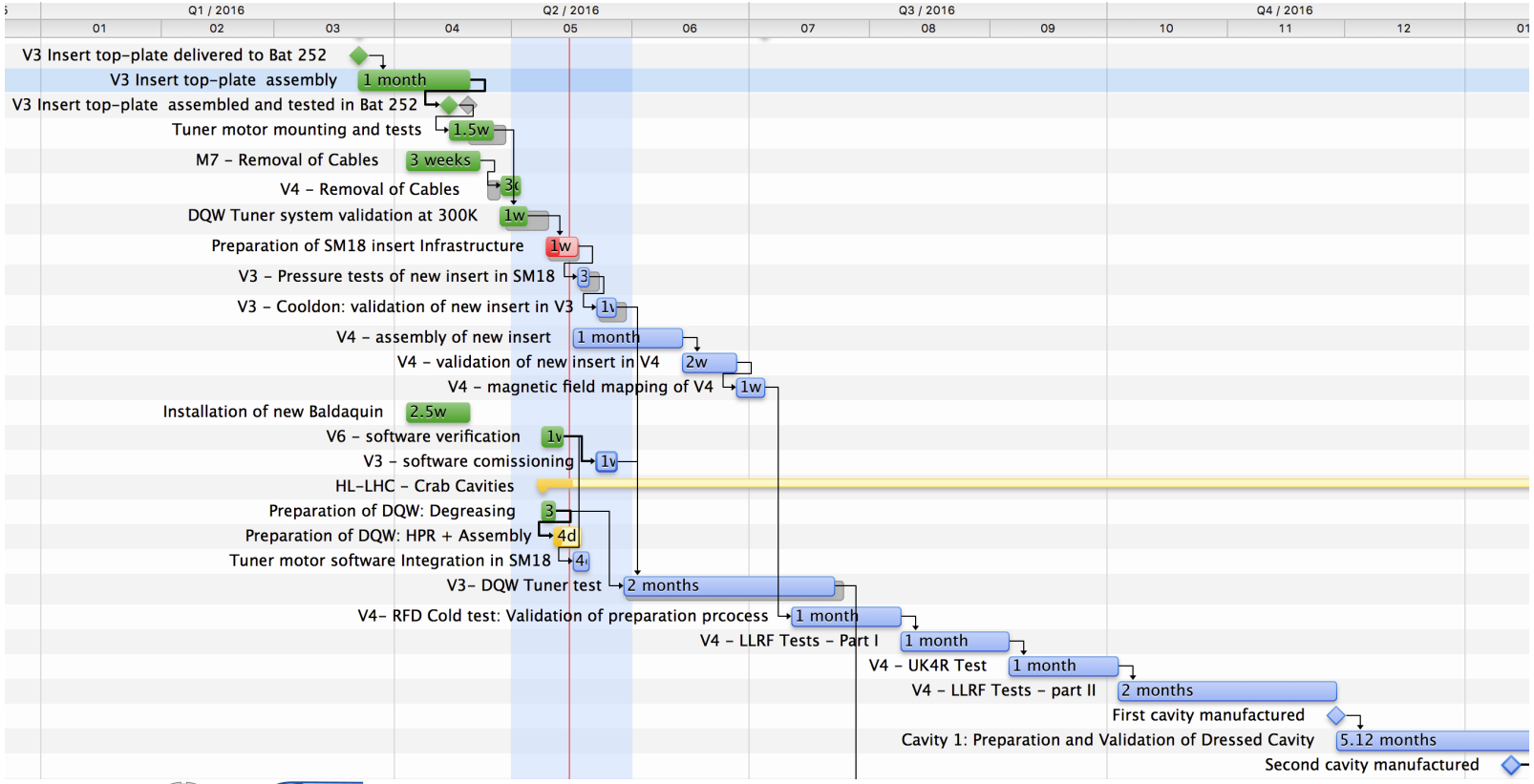
Joint LARP CM26/Hi-Lumi Meeting SLAC 18-21 May 2016

Planning Overview

- **Recent preparations:**
  - Setup of DQW tuner test in parallel with validation of new insert.
  - 2 month test period reserved for DQW tuner test.
  - Preparation of V4 proceeding in parallel (for LLRF setup).

Planning Overview



DQW Slow Tuner Test

Warm:

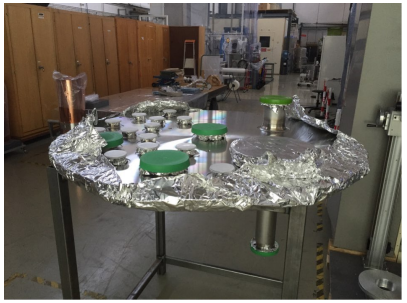
- Step resolution and speed tests of the motor at warm w/o cavity using potentiometers and LVDTs (Kurt's team).
- Backlash characterization (expected post SM18).

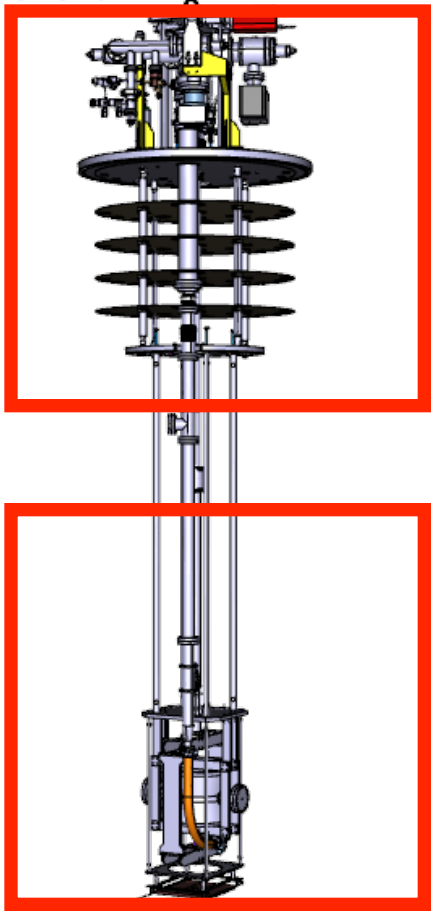
Cold:

- Cool down procedures (disengaging tuner frame and motor).
- Feedback loop and frequency resolution at 2 K (200 kHz required).
- Driving modes and motor routines testing (ramping).

SM18_V3 Insert for Cryo Test

- **Preparation of insert divided into 2 parts:**
  - Assembly of and validation of top plate.
  - Assembly of cavity and tuner system.
- **Cavity mounted horizontally new V3 insert.**





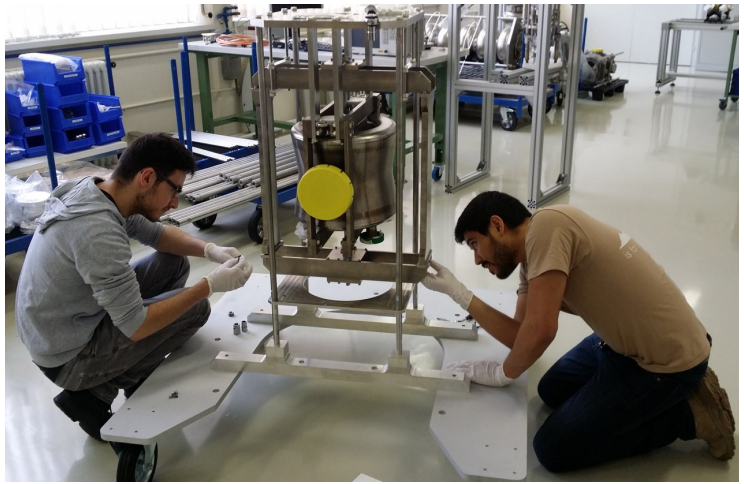
Top Plate Assembly

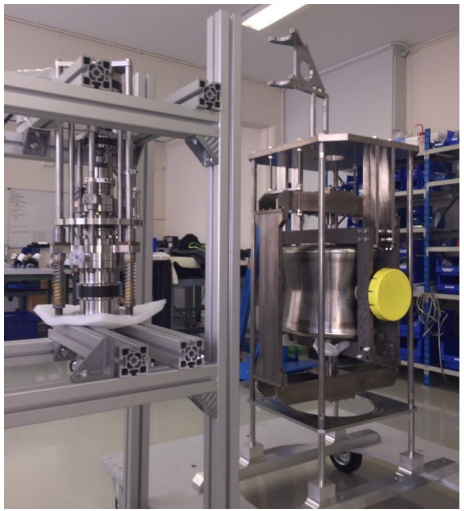
Top-plate received: Week 11
Transferred to assembly area in 252-R-10 and assembly started immediately.

Top-plate assembled and tuner motor installation done in parallel.

Cavity and Tuner Frame

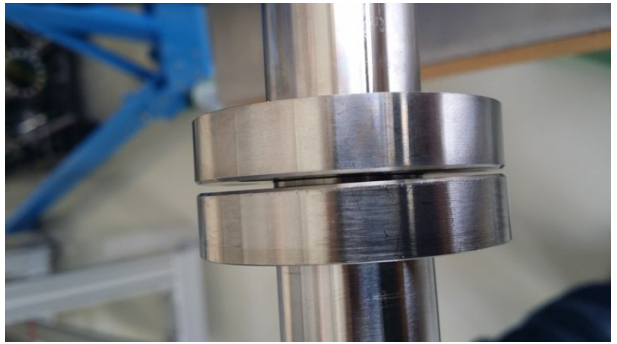
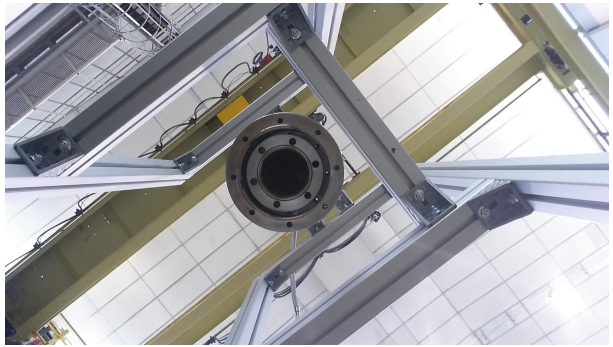
- **Dry assembly done in 252-R-10:**
  - Cavity assembly in insert structure finish in wk 8.
- **Currently: Cavity preparation for cold test.**
  - Demounted, degreased, HPR'ed, to be assembled in the cleanroom.





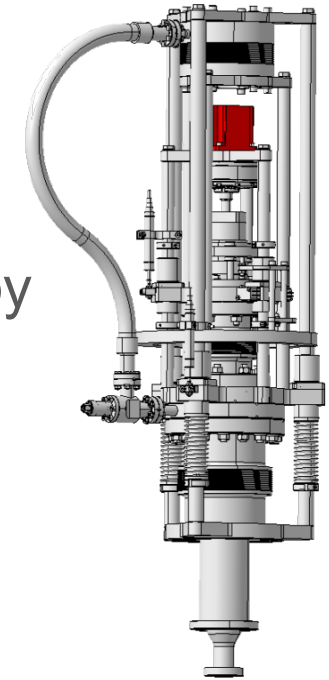
Tuner Systems

- Some mechanical issues found during assembly. Resolved with designer & workshop.


Tuner Systems

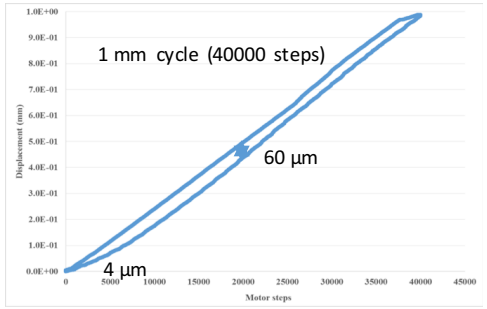
- **Tuner control system:**
  - Based on prototype defined by Kurt Artoos & developed by Luca Arnaudon
  - PLC based: Developed and implemented by Pablo Fernandez Lopez
    - Compatible with existing SM18 sowftware infrastructure

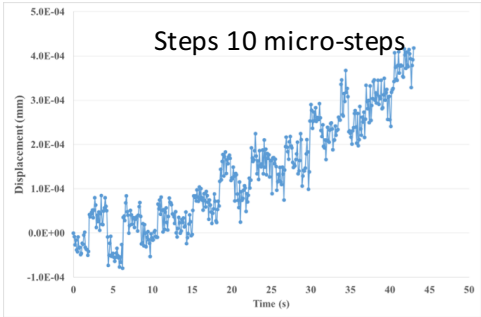


Motor System at 300K

- **Linear motor prototype tested without load**

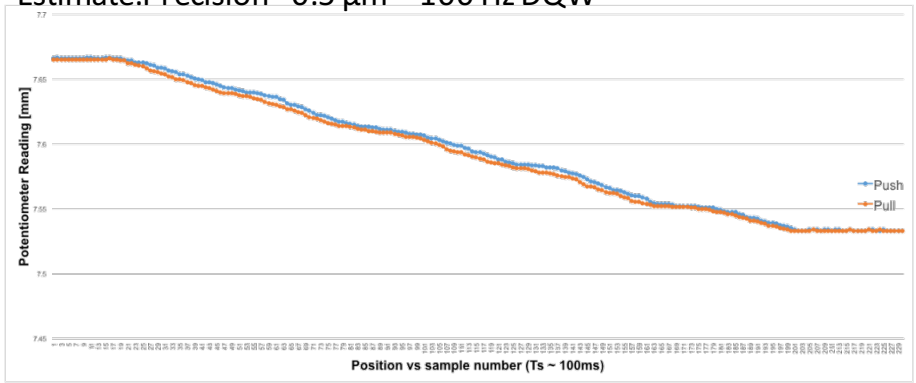
Fully assembled and tested with 400 microsteps (with LVDT)





Estimate:Precision ~0.5 µm ~ 100 Hz DQW

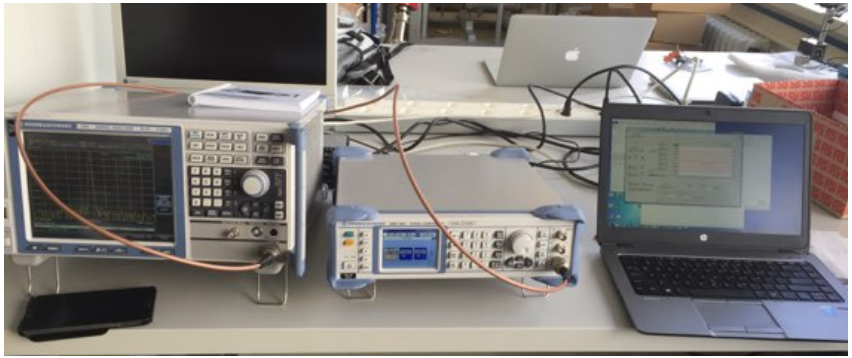
Measurement **E. Gallay**

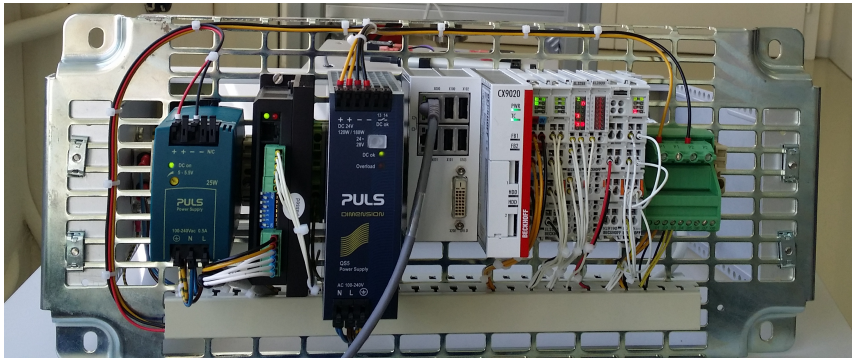


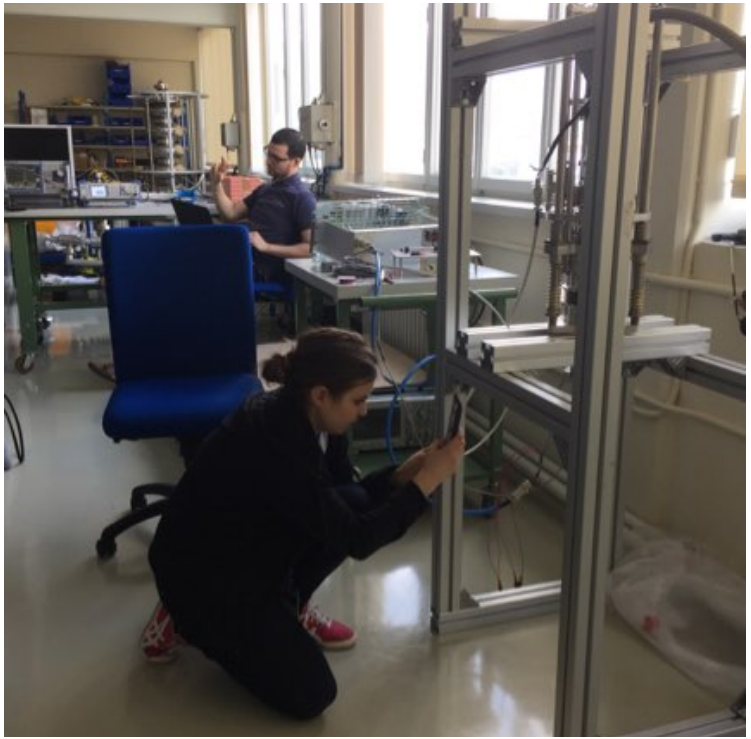
- **Retested with PLC.**

Cycle length: 0.131mm
Largest deviation: 6.8um
=> scales to 52um for 1mm cycle

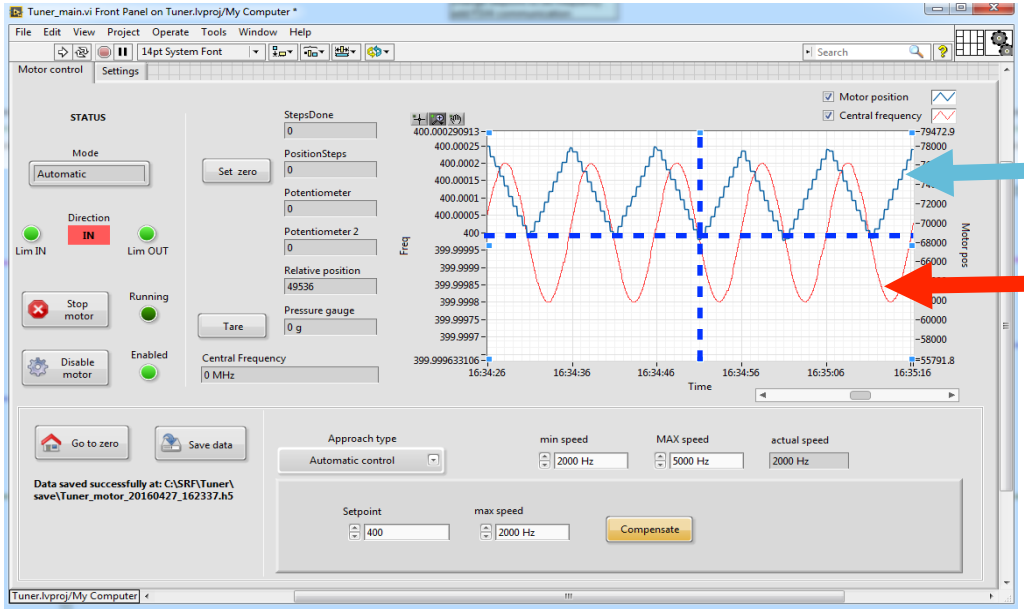
Testing the Tuner Systems





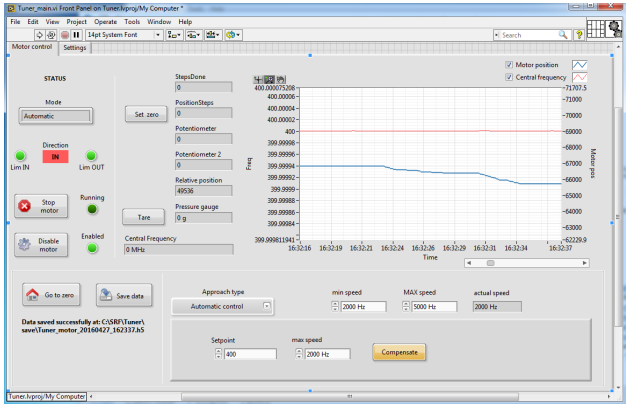


First Test of Tuner Control Loop: 27/04/2016



Tuner Motor Drive

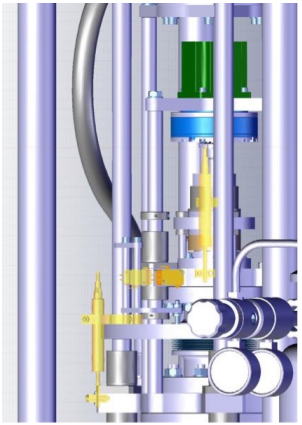
Frequency Modulation



In steady-state with feedback not fully closed, we see integration of noise => drift. This should not be an issue for the cavity with fully closed loop.

Notes from the Warm Test

- **Motor system and bearings re-checked after non-conformities:**
  - No issues found.
- **Calibration of strain gauge is done.**
- **Software:**
  - Full set of monitoring instrumentation implemented.
  - Control software integrated into SM18 LabView structure.
  - Measurement data integrated into SM18 data structure.

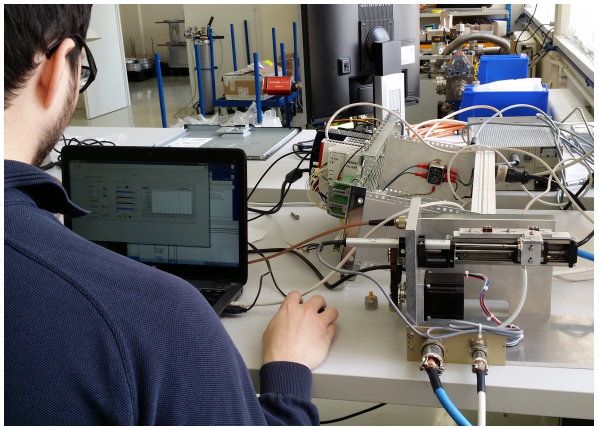


Notes from the Warm Test

- **Position Range:**
  - Elastic range =0.5 mm/plate => max motor range =1 mm.
  - For ‘Push mode: Load offset assumed to be ~0.2 mm.
- **Protection of cavity from tuner:**
  - Software interlock on position : tested and functional.
  - Hardware interlock on position: tested and validated.

System Protection

- **Software interlocks:**
  - Redundant and set after first manual operation.
    - Closed loop target frequency inside range.
    - Limit displacement of the potentiometers…
- **Hardware interlocks:**
  - Limit switches.
  - Potentiometers.
  - Strain gauge.
  - Frequency measurement.



DQW Tuner Test Plan

1. **Setup at Warm:**

   At 300K, disengage motor => assembly (bellows) to be free.

2. **Cool down to 2K:**

   Monitoring of position potentiometers, correlated with pressure & temperature

   May need He pressure in cavity to avoid mechanical stress on tuner system.

3. **Test cavity without tuner engaged.**
4. **Set of limit switches & engage motor.**
5. **Tuner Test in Manual mode => no FBL.**
   1. 'Push' phase of testing: with defined motor load offset (0.2mm).
   2. Cycle measurement (push and release in increasing step blocks) => measure range, and backlash.
   3. Backlash measurements with coarser step size on the stepper motor.
   4. Frequency measurements: Test sensitivity/ precision.
6. **Tuner Test: Auto mode => with FB.**
   1. Commissioning of feedback mechanism => verify that follows a frequency change.

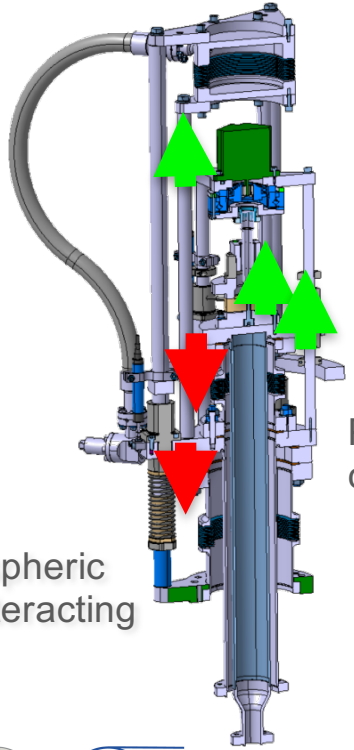
   Variation from PLL on/off, Frequency modulation, & Lorentz Force detuning.

   2. FB sensitivity/precision at holding a set point.
7. **Repeat step 5 for the pull phase.**
8. **Repeat across zero strain point.**
9. **Access results before next steps.**

Notes for Cooldown

- **Tuner concentric push-pull tubes :**
  - Requirement: Should not exceed 50 MPa on cavity from tuner rods.
- **Cooldown (ΔT= several K):**
  - Fast cool down => differential contraction in mm range => pressure on cavity => risk of plastification.
- **Mitigation:**
  - Uncouple the two tubes during cool down
    - By removing the coupling between Harmonic Drive and Roller screw
    - By shifting/removing the mechanical end stops + end switches.
  - **Result: Reduces effective push on cavity (to sub 0.055 mm) => pressure seen by cavity during cooldown: 32 MPa**
    - **This is below the 50MPa limit**

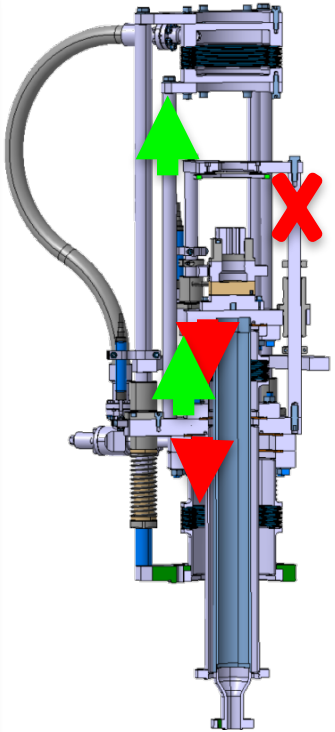
Protection for Cooldown



Pressure compensation.

Arrows – atmospheric pressure, counteracting vacuum forces.

Motor uncoupled during a cool down



Break a connection between inner and outer tube.

Pressure compensation is not working like before:

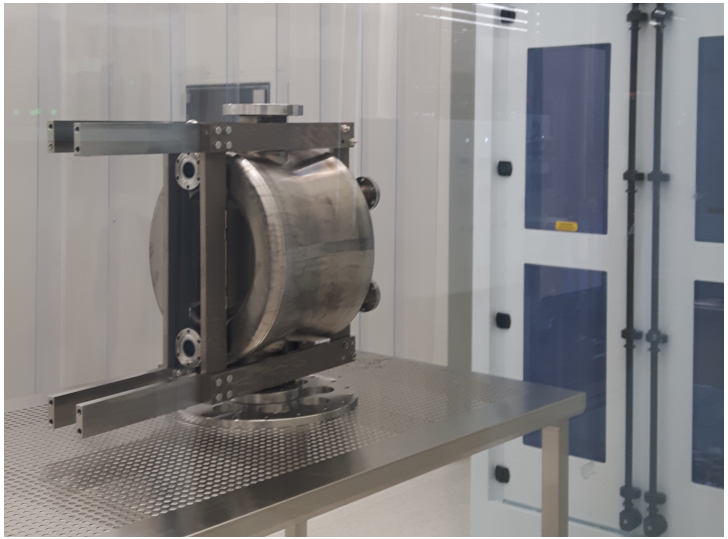
These forces go to the cavity (44 Kg).

As for 18/05/2016

- **Top plate at the SM18**
  - In standby waiting for the insert support to be freed.
  - V3 will go to validation with 2.8 bar g w/o motor on week 20.

As for 18/05/2016

- **The cavity at the SM18 cleanroom**
  - 30 h HPR, currently drying for assembly.
  - Assembly of tuner frame and fixing the plungers will follow.



HiLumi
HL-LHC PROJECT

Thanks.

LARP CERN