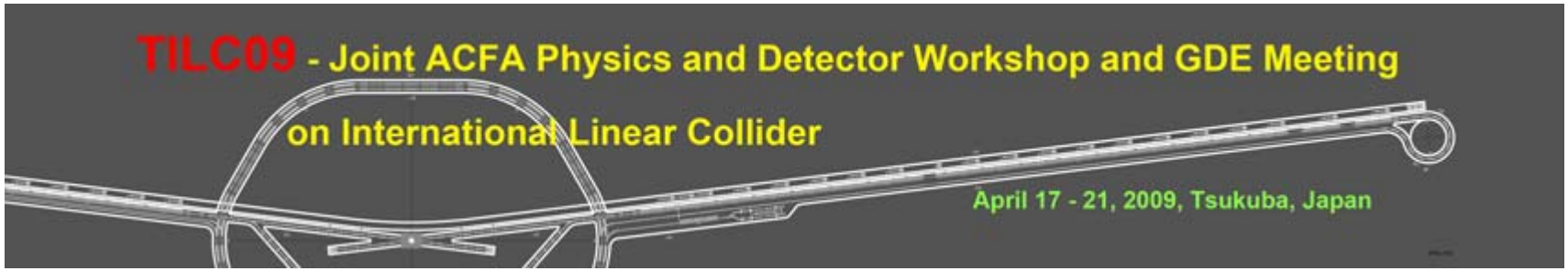


# Qualification Tests for the ILC Blade-Tuner

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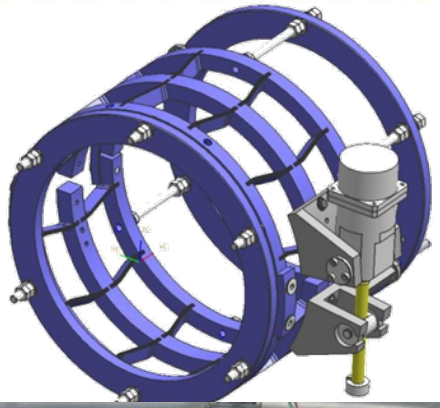
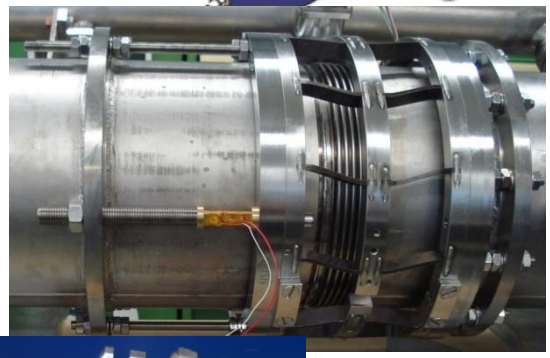
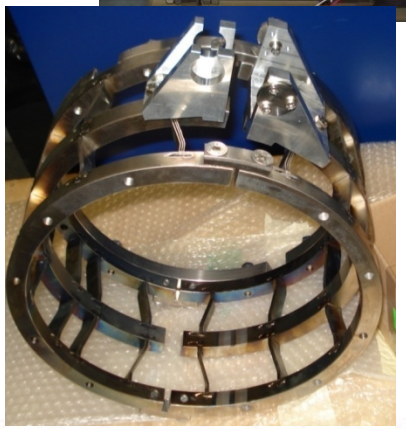
# Resuming

## Status of the Blade Tuner development:

- “Slim” design prototype with piezo realized from the original *SuperStructures* tuner. Manufactured and intensively cold tested at CHECHIA (DESY) and HoBiCaT (BESSY) searching for limits and performances
- From the experience gained, a “revised” Blade Tuner was designed. Guidelines: titanium, stiffness, strength, piezo action and further simplification.
- New design tuners manufactured in a small series of 8 units, 2 more are under production.







# Qualification Strategy

Threefold strategy:

- Room temperature facility using single cell cavities at LASA:
  - Acceptance test after manufacturing
  - Measure of tuning range (limited) with a calibrated load

- Cold test in horizontal cryostat, Continuous Wave (CW) scenario:
  - Hobicat facility at BESSY available, hopefully tests done by June.
  - Active and positive collaboration with BESSY group is on-going these topics

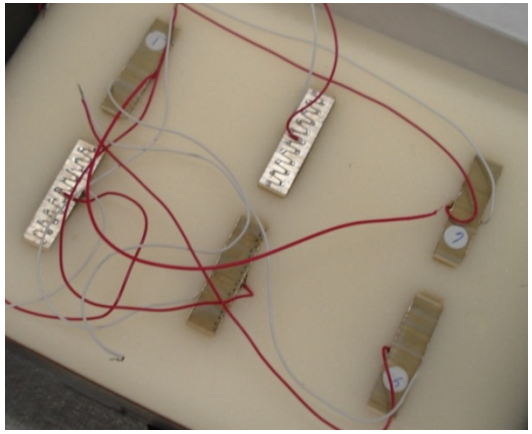
- Final cold test in horizontal cryostat, ILC pulsed scenario:
  - No time slots available for CHECHIA at DESY, used for prototype tests.
  - Facility available at FNAL, 2 units already shipped and pulsed cold test before summer.

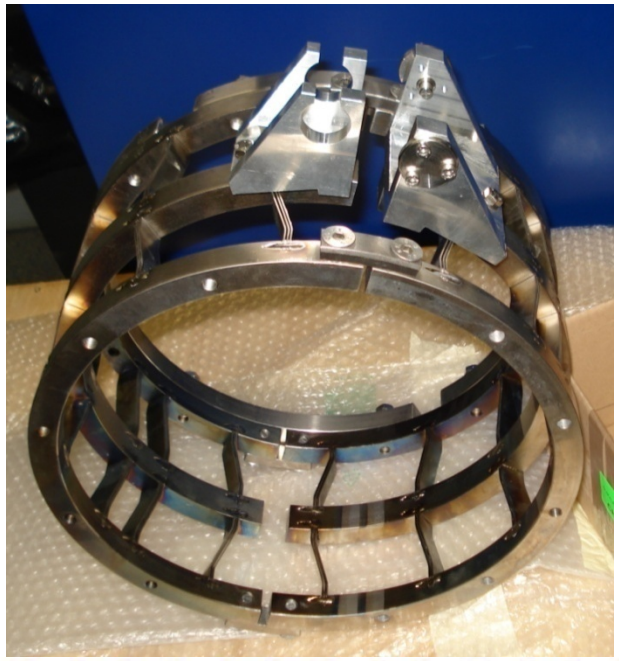
# Manufacturing

Important installations to come in short times:

- Cryomodule 2 (CM2) of **ILCTA** facility at New Muon Lab, FNAL, US: 8 units
- **S1-Global** facility at KEK, Japan: 2 units

**ILC-HiGrade** of EU FP7 is also on the way: 24 units



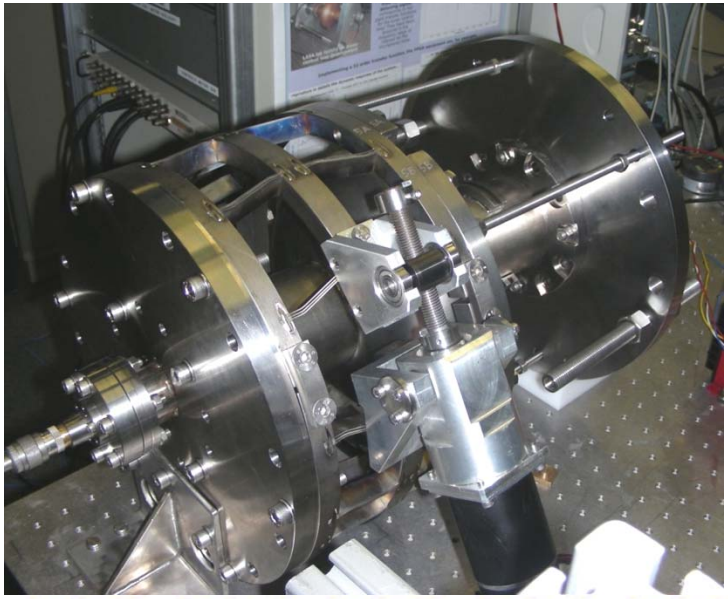


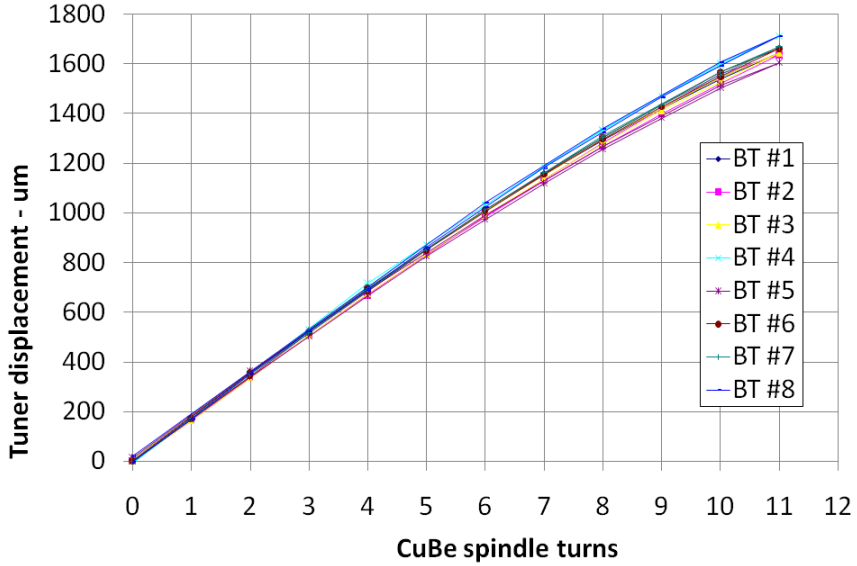
# Room Temperature Qualification

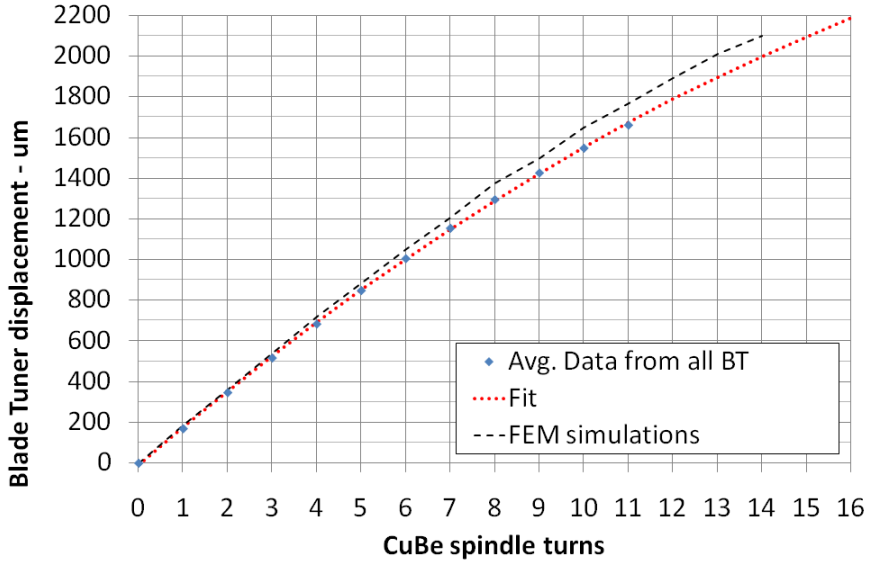
Devoted single-cell facility in use. The tuner acts on an external load with calibrated stiffness.

Results meet expectations in terms of **homogeneity** and **predictions** (in within 5 %)

Tuning range measured up to 11 motor spindle turns, no risk of plastic deformations





# CW cold tests overview

CW and PLL (Phase Locked Loop) facility represents an unique opportunity to deeply understand the performances of each component of the tuning system.

Issues to be addressed by cold tests:

1. **Tuning** : tuning measurements over different ranges and cycles
2. **Dynamic detuning** : cavity detuning response to piezo actions
3. **Sticking and backlash** : investigation on eventual non-idealities in cavity constraints at sub-micrometer scale
4. **Mechanical** : Proper modes, resonances and group delay in the assembly structure
5. **CW behavior** : Active and passive microphonics compensation

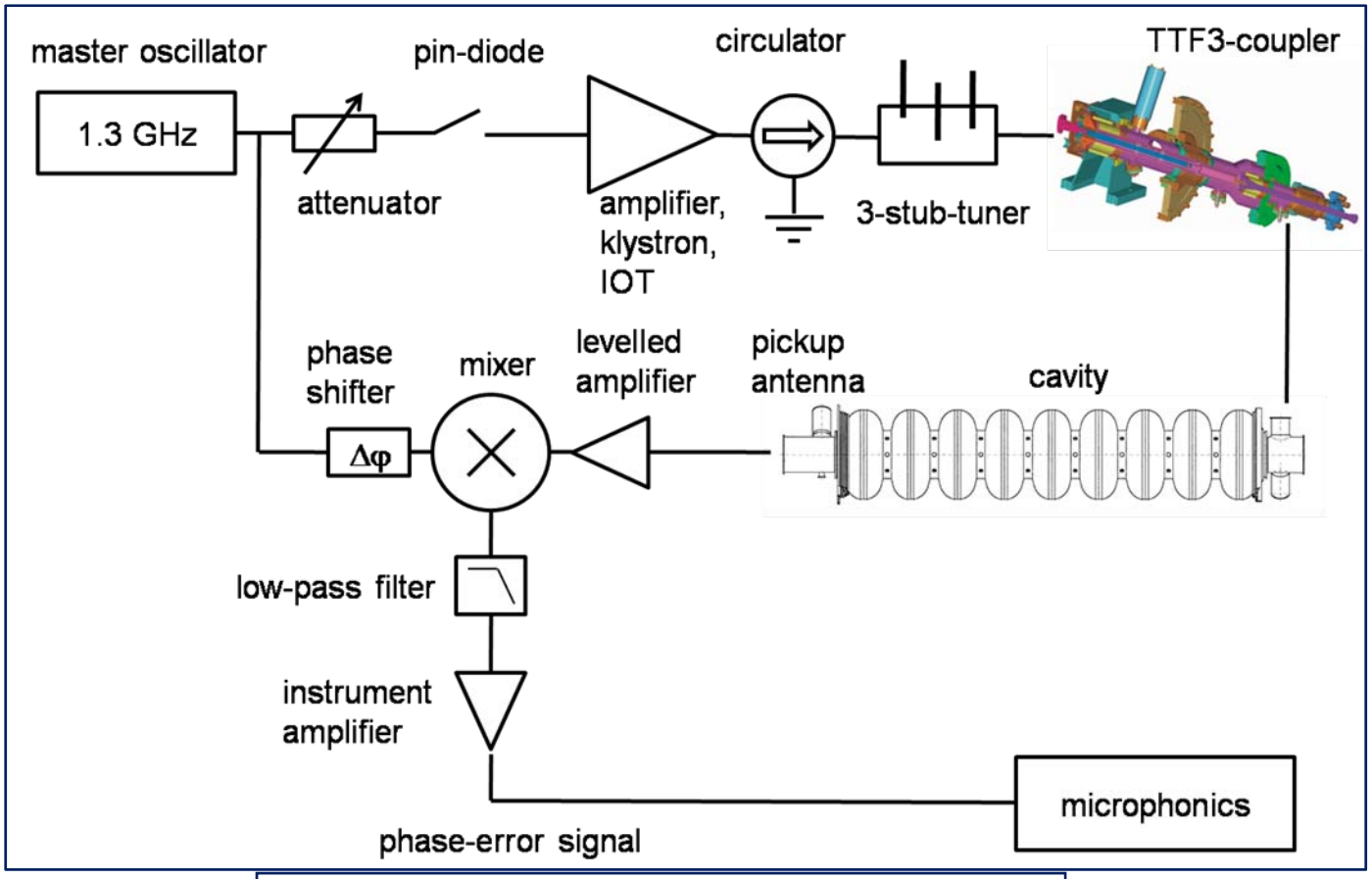
# Setup for the cold test @ BESSY

Main parameters for the incoming ILC Blade Tuner cold test :

- **Cavity / tank:**
  - Z86 cavity with modified He tank, reduced pad distance and central bellow.
  - A devoted tuner to tank interface has been realized
- **Tuner assembly**:
  - *Drive unit*: Phytron stepper motor + HD gear, the reference choice.
  - *Treatments*: XFEL “recipe”, Lamcoat + Balinit for HD splines and screw/nut.
  - *Piezo*: two 40 mm length stacks from Noliac
- **Facility equipment**:
  - *Stepper motor driver*: half-step mode available, 1 A set as maximum current.
  - *Lock-in amplifier*: for Transfer Function measurements
  - *Piezo driver*
  - *Phase Locked Loop …*

# The Phase Locked Loop

Phase Locked Loop at HoBiCaT:

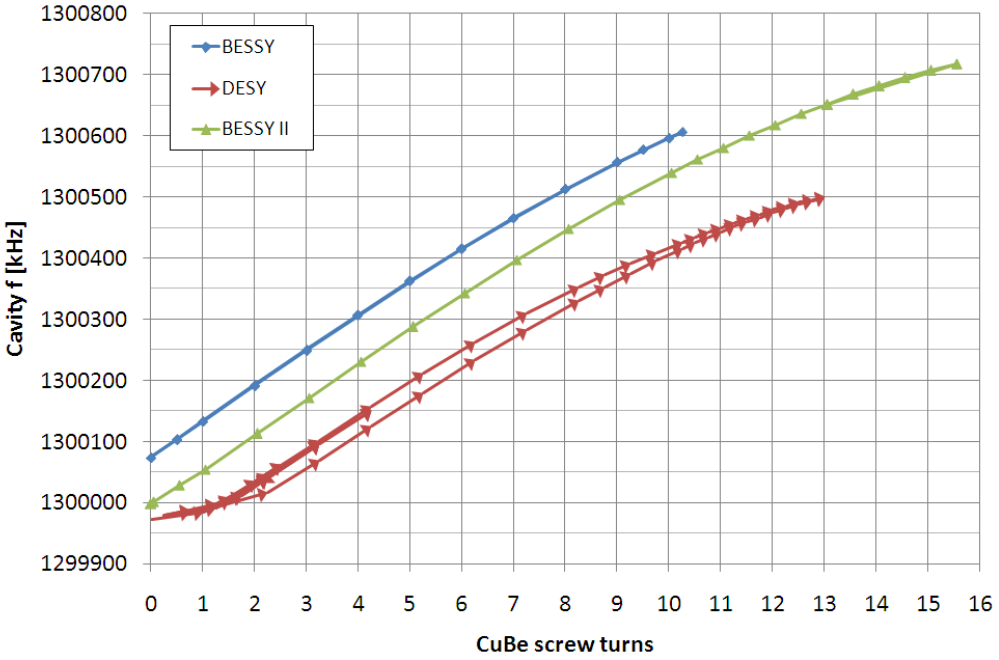



O. Kugeler, ERL07, Daresbury, May 21-25 2007

# 1. Tuning

Cavity frequency is locked by PLL, stepper motor drive unit is energized. Tuning range and sensitivity (Hz/step) are measured.

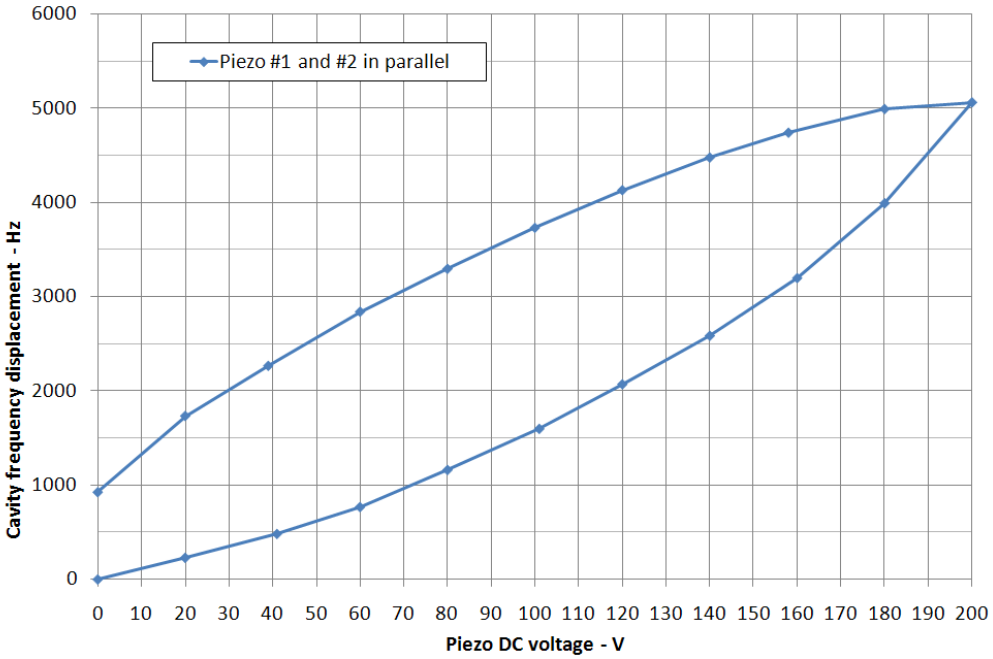
- **Qualification Tests**:
  - *Full range*: 3 - 5 subsequent complete cycles.
  - *Bandwidth-level range*: span of 1 ksteps around the nominal working point (1.3 GHz or half-way of the full span).
  - *Minimum range*: span of 10 steps around the working point iterated by automated routine.
- **Expectations**:
  - 600 kHz full tuning range
  - 1.5 Hz/step (half-step) minimum resolution
  - Negligible hysteresis and piezo unloading effect
- **Experience with prototype:**
  - Expectations met after cycling.



# 2. Dynamic detuning

Cavity is locked by PLL and tuned to the nominal working point, piezo are energized. Tuning range and sensitivity (Hz/V) are measured.

- **Qualification Tests** :
  - *LFD compensation*: cavity detuning response (phase error signal) to an half-sin piezo pulse with ILC timing scheme, each piezo alone and together.
  - *Piezo DC tuning range*: cavity detuning response (phase error signal) to a DC voltage applied to each piezo as well as both in parallel.
- **Expectations**:
  - At least 1 kHz dynamic or 2 kHz static piezo detuning as required by ILC RDR.
  - No deviation from piezo nominal hysteresis curve.
- **Experience with prototype:**
  - Extremely positive, expectations met with significant margin: 5 kHz static piezo detuning!

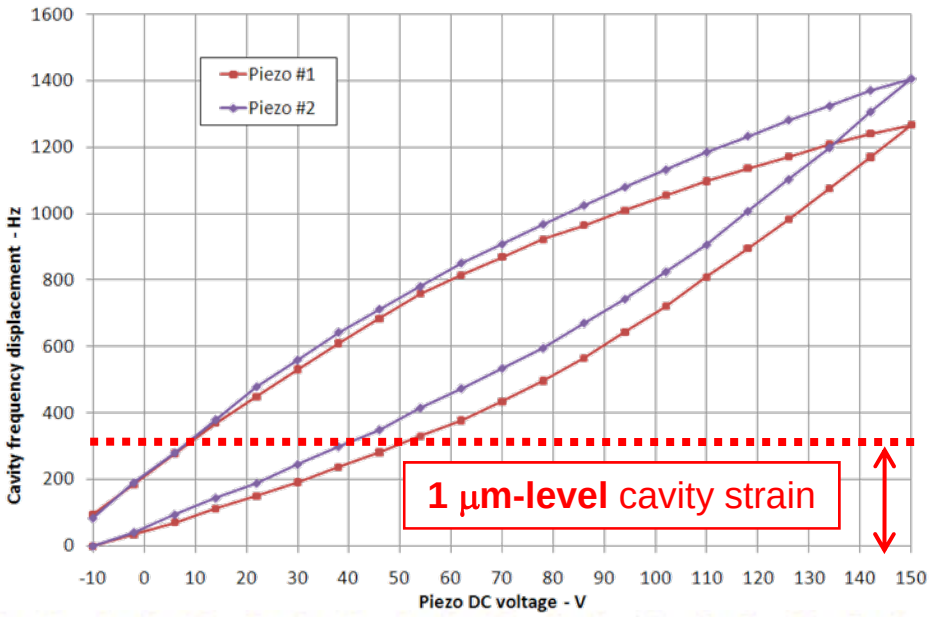


# 3. Sticking, backlash and small scale issues

Cavity is locked by PLL and tuned to the nominal working point, both drive unit and piezo are used to investigate sub-micrometer scale behavior.

- **Qualification Tests** :
  - *Motor driven*: span of 10 steps around the working point, moving by single steps and iterated by automated routine. 1 step ~ 10 nm cavity displacement.
  - *Piezo driven*: sinusoidal signal with low frequency (10 Hz) and amplitude applied to each piezo independently. 100 mV ~ 3 nm cavity displacement.
- **Experience with prototype:**
  - Positive. No deviation from ideality in piezo behavior.
  - The backlash introduced by planetary gear has been observed

The Cry3 support scheme with Ti pad sliding on rolling needles will be installed for horizontal cryostat cold test.

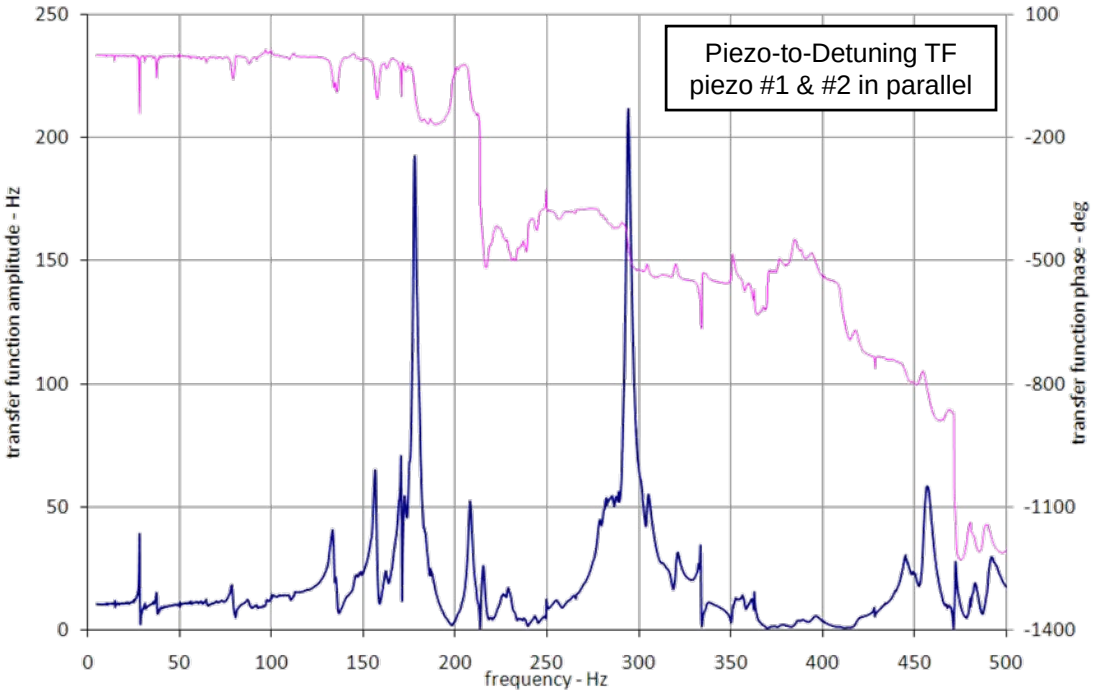


# 4. Mechanical analyses

PLL and piezo actuator / sensor duality allow unique analyses of the assembly dynamic response

- **Qualification Tests**:
  - *Piezo-to-Detuning and Piezo-to-Piezo Harmonic Transfer Functions:* main modes concurring to the final assembly dynamic response can be identified, together with group delay and piezo coupling to the cavity.
- **Experience with prototype:**
  - Very detailed and repetitive TF acquired.

Analytical simulation can be performed making use of TF data as, for instance, the response of the system to an arbitrary piezo pulse!



# Measurements overview

A detailed schedule for each experimental measurement is currently under finalization in view of cold tests. In particular, among other:

- **Dynamic detuning:**
  - A *single half-sin pulse* will be used: 1.25 ms time length, 10 Hz rep. rate, amplitude as high as allowed by PLL dynamic range (max piezo voltage if possible) .
  - The error signal of the calibrated PLL will be acquired by a triggered oscilloscope, then cavity detuning can be easily reconstructed.
  - The achievable dynamic detuning will be assumed to be the maximum $\Delta f$ obtained in a flat-top equivalent time window (1 ms).
- **Sticking and backlash investigation**:
  - During minimum range measurements the motor drive unit will iteratively perform several tuning cycles, each *direction inversion* will highlight the amount of backlash.
  - For piezo driven small scale measurements an *harmonic modulated signal* will be fed to piezo in order to perform a locked measurement with the lock-in amplifier.
- **Mechanical analyses**:
  - In framework of time constraints, each measurement to be performed at the nominal working point (small tuning range, piezo action) will be repeated in different working points over the tuning range. This will allow to evaluate the *effect of compressive pre-load* on tuning parameters.