TUL-DMCS research

Magnetostrictive tuner
Control system

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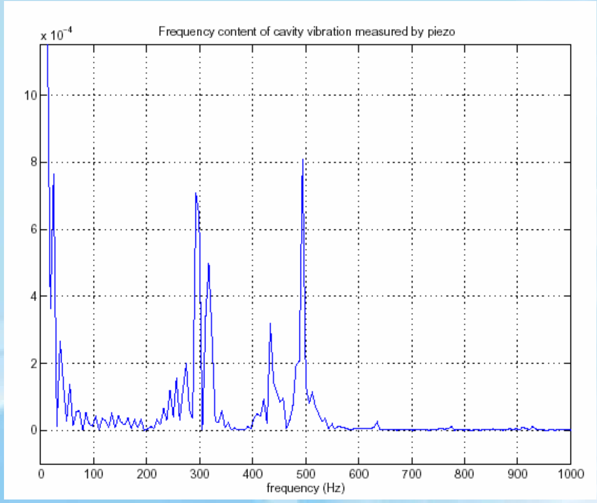
Hamburg 01.IV.2005

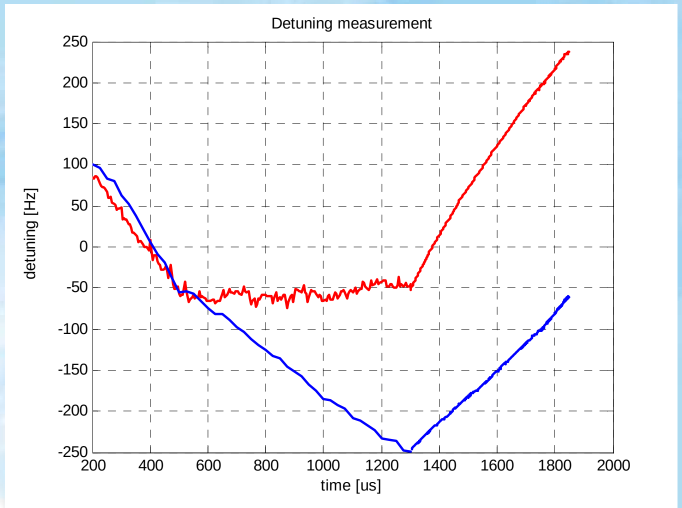
Outline

- **Curent Results**
- **System identification**
- **Magnetostrictive tuner test**

Current results (1/2)



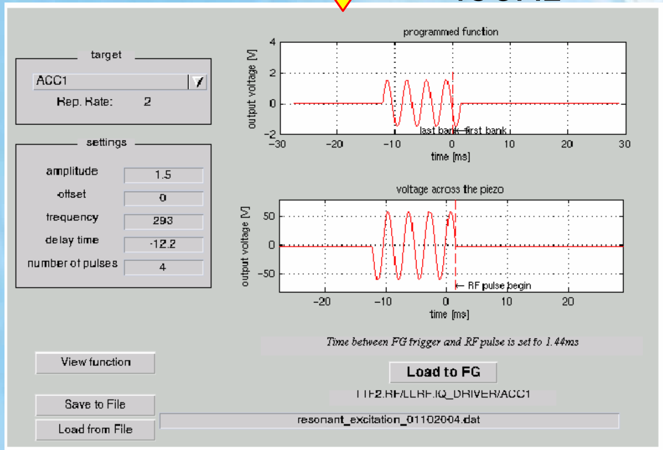
Frequency content of cavity vibration



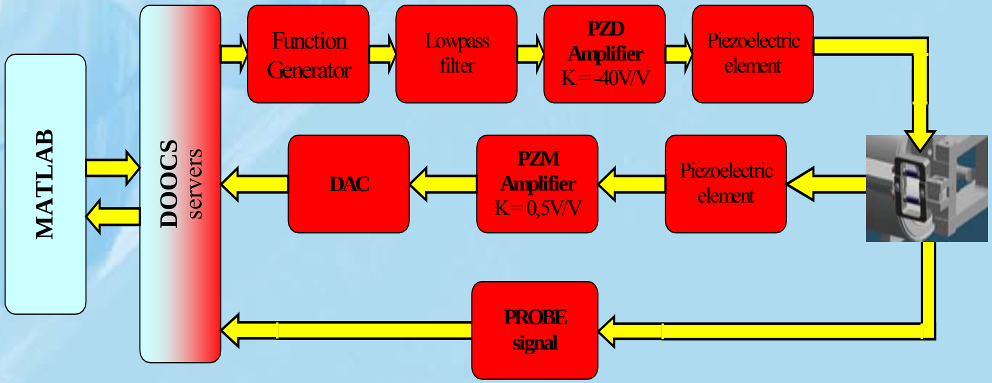
Detuning only 30Hz during flat top (20MV/m)
Without compensation detuning is 200Hz

Resonance frequencies

291Hz
325Hz
496Hz

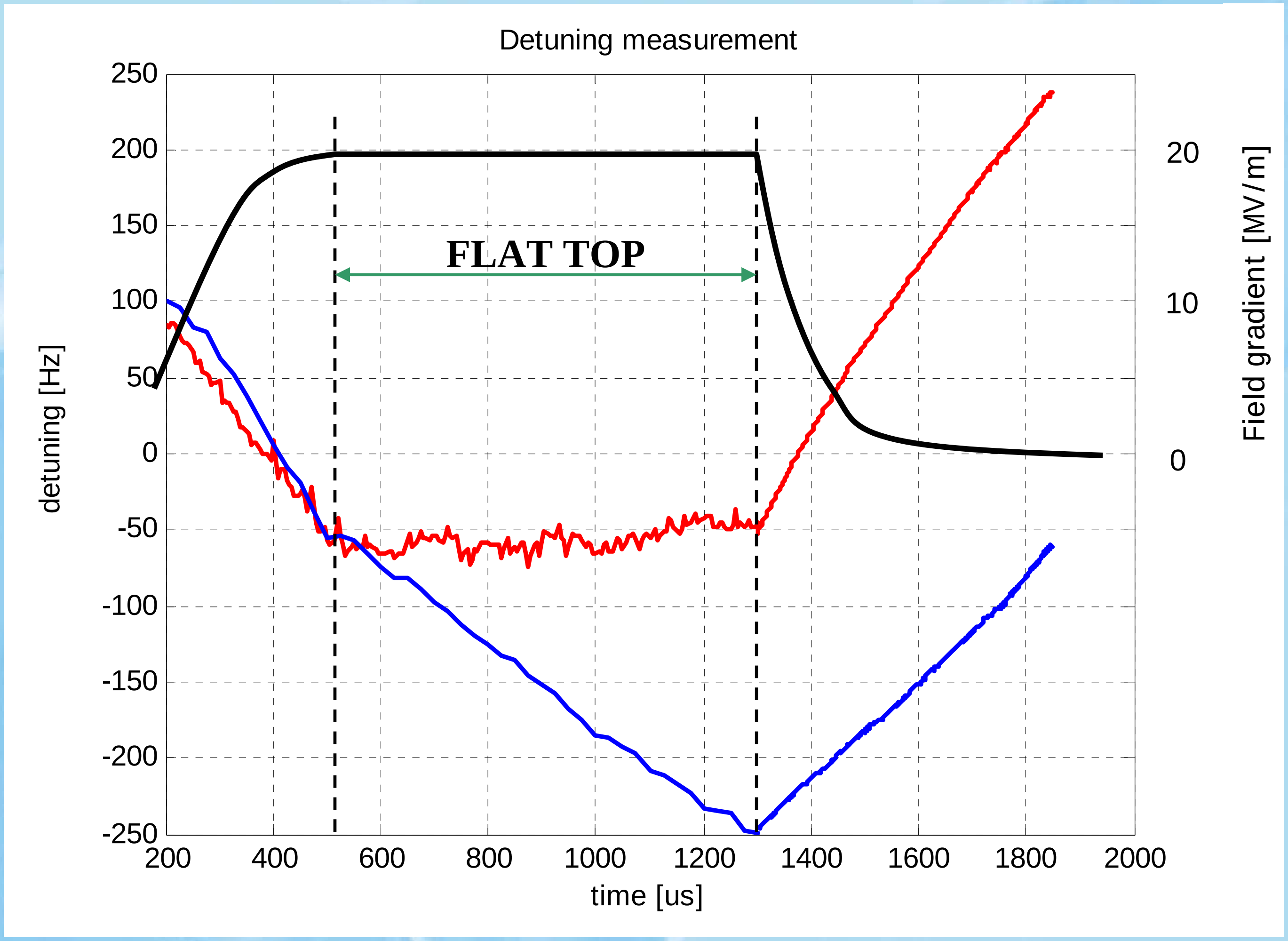


MATLAB application



Control system for piezoelement (ACC1, cav5)

Current results (2/2)



After compensation, the detuning (red curve) is only 30Hz during flat top for field gradient 20MV/m (black curve). Resonance excitation method was used.

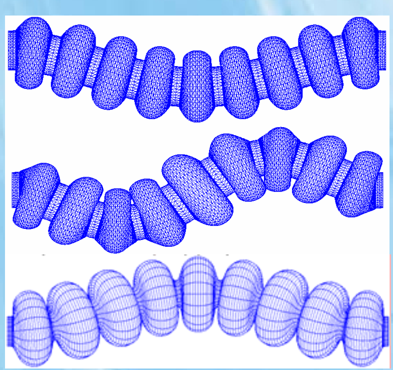
Without compensation detuning is 200Hz (blue curve)

Control System

Each cavity is **different**
as a consequence each cavity needs a different (dedicated) control system settings.

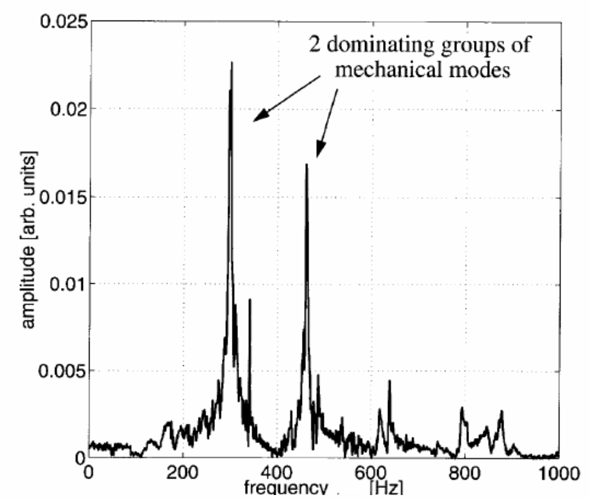
Fast automatic system identification procedure is needed for proper starting and operation point.

Adaptive feed-forward algorithm will be used

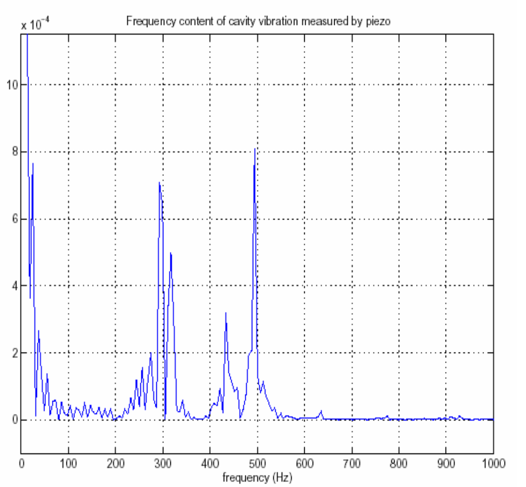


PhD thesis of H. Gassot

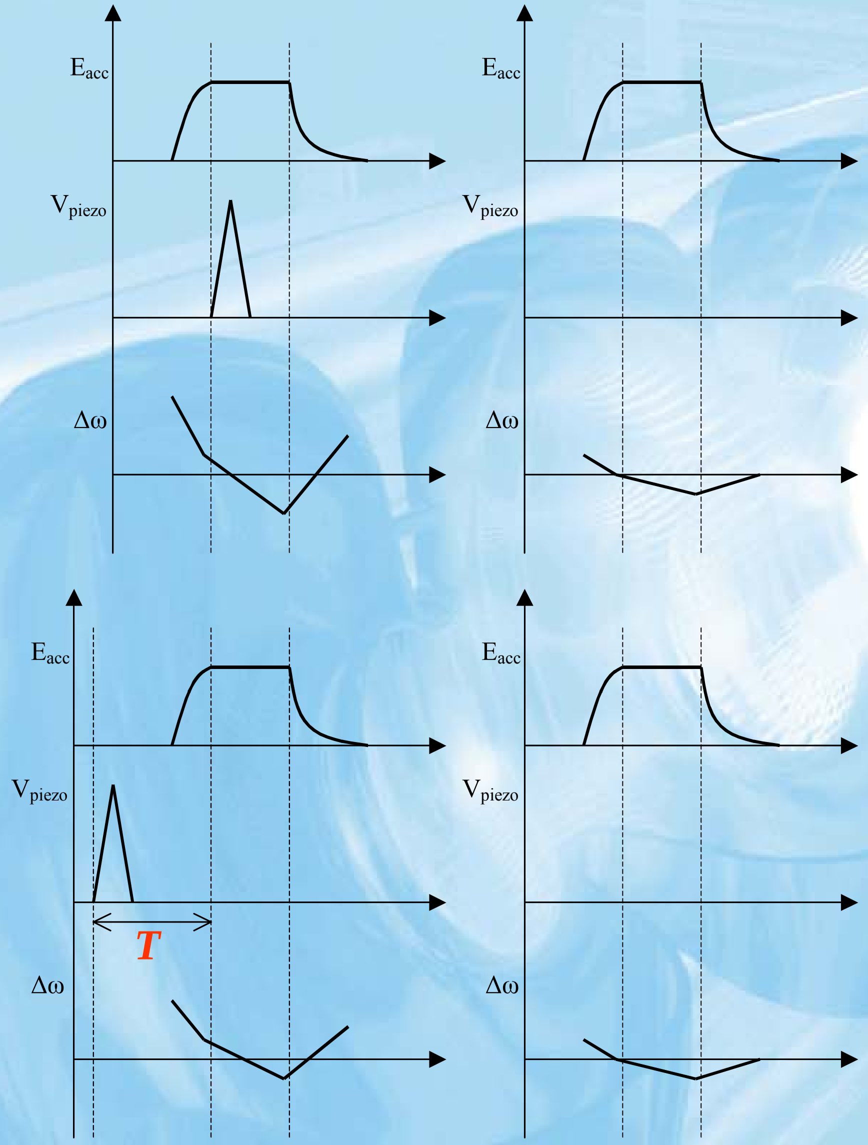
Results from FEM mechanical simulations (H. Gassot)



Results from experiment in ACC1/Cav5

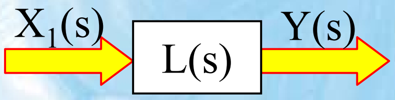


System identification



Let's assume that system is linear

Detuning caused by the piezoelement might be calculated as a difference between detuning caused by RF field with piezo action and RF field only.

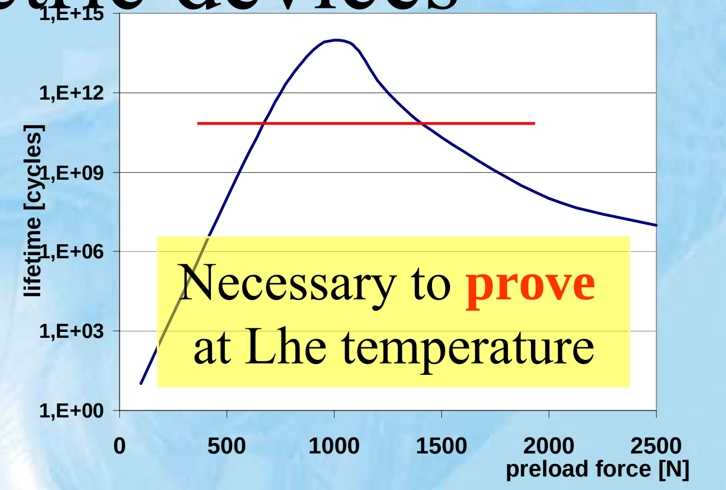


Detuning is measured using forward power and probe signal. Forward power last only 1,3 ms, therefore there is need to shift piezo pulse versus RF field by *T* and perform next measurement.

To eliminate microphonics and other noises there is need to average data from several measurements

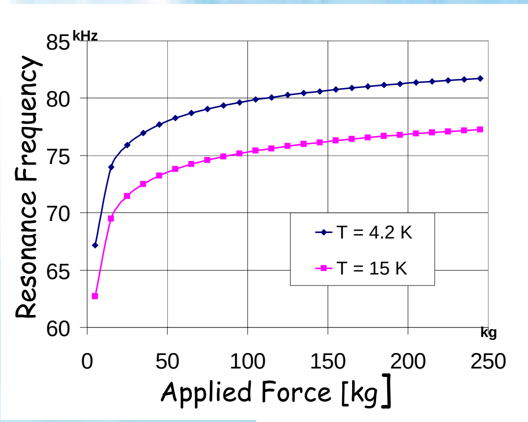
Test will be performed soon

Problems with piezoelectric devices



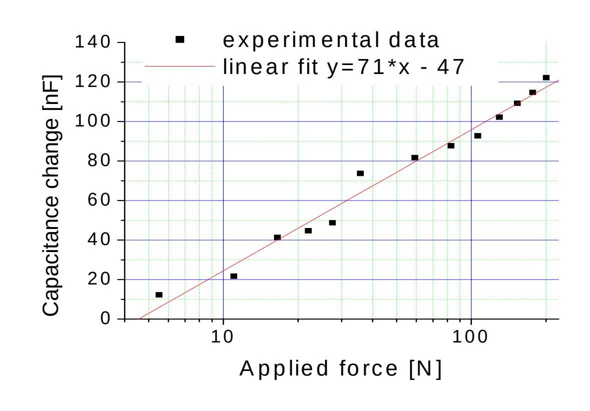
The lifetime of the piezo element depends on preload force

Till now, the preload force was calculated and/or assumed but never measured



Four new methods of the static force measurement at 1.8÷4 Kelvin are proposed:

1. Resonance position on the impedance curve
2. Capacitance change
3. Strain gauge sensor (metal)
4. Piezoresistive sensor (semiconductor crystal)

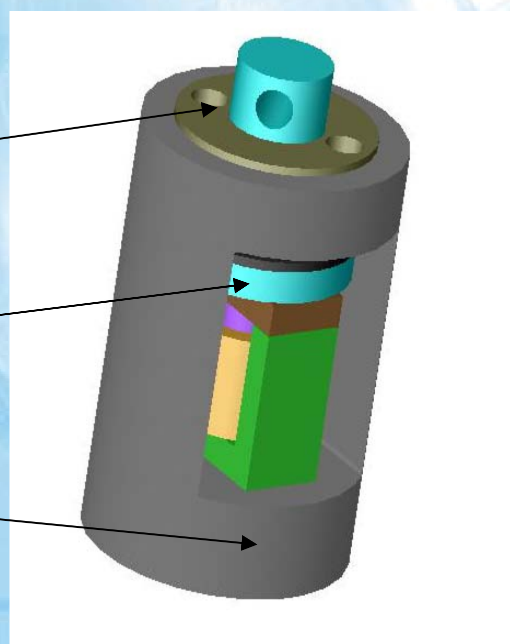


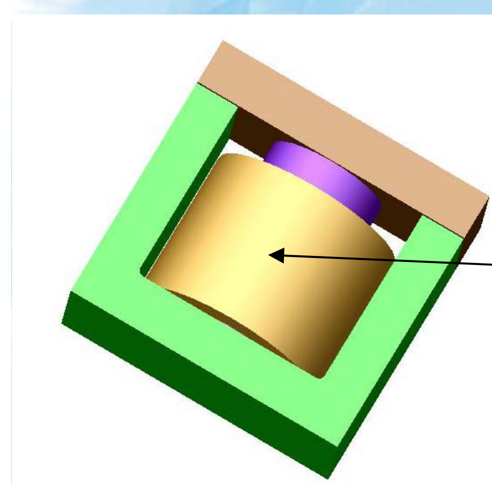
Magnetostrictive tuner conception

Magnetostrictive elements:

- might have a higher lifetime,
- are immune to shortcuts,
- generate less heat,
- might have higher tolerance for preload change than piezo

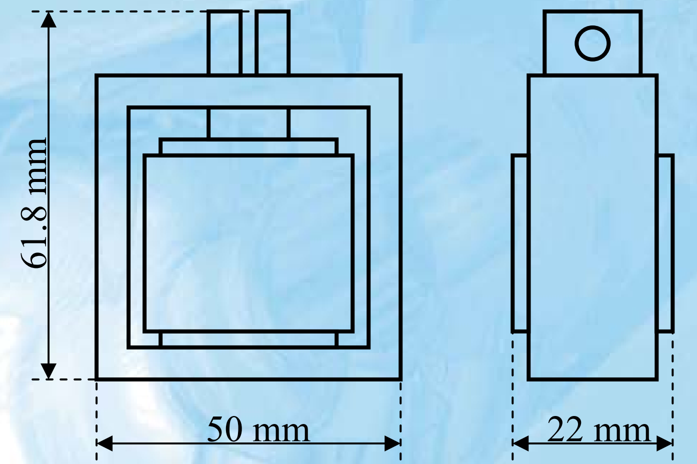
Magnetostrictive tuner is an option and must be fully compatibly with existing fixture for piezoelement

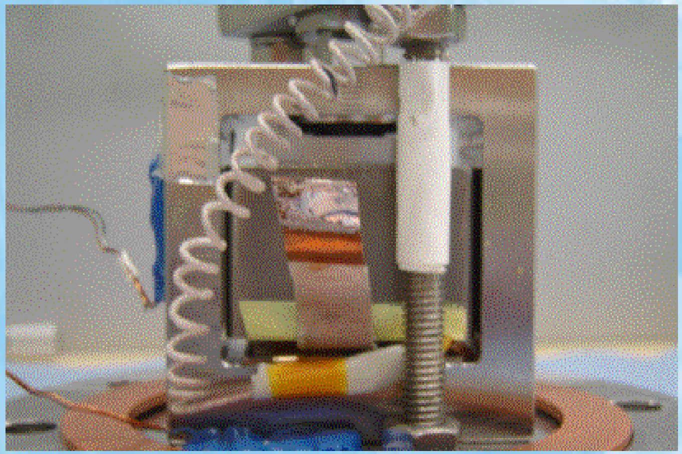


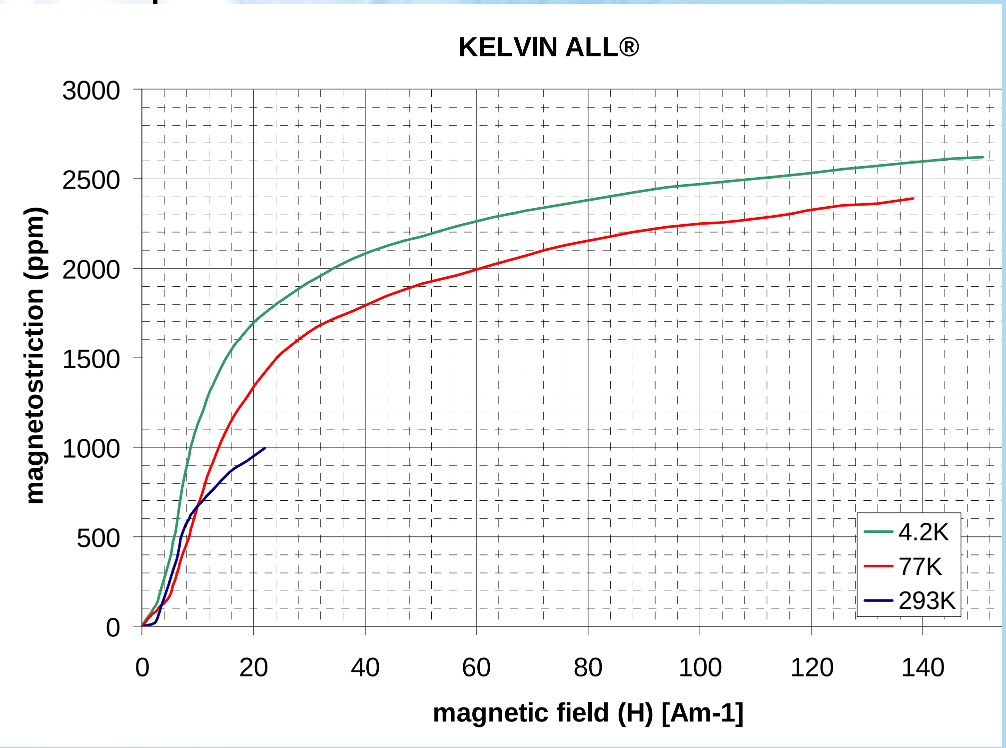


Magnetostrictive tuner specifications

Parameter	Specification
Dimensions:	61.8 mm High x 50 mm Wide x 22 mm Deep
Stroke:	20 µm (preload 1500N)
Resolution:	better than 0.2 µm
Slew rate:	0.15 µm/ µsec
Operating Temp:	2.1 K
Load:	3 kN
Stray magnetic field:	< 25mG at 30 mm from actuator
Pulse Length:	1.6 ms
Repetition Rate:	60 per second
Heat Load to 2.1 K:	< 0.1 W
Lifetime:	5 x 10^{10} Cycles





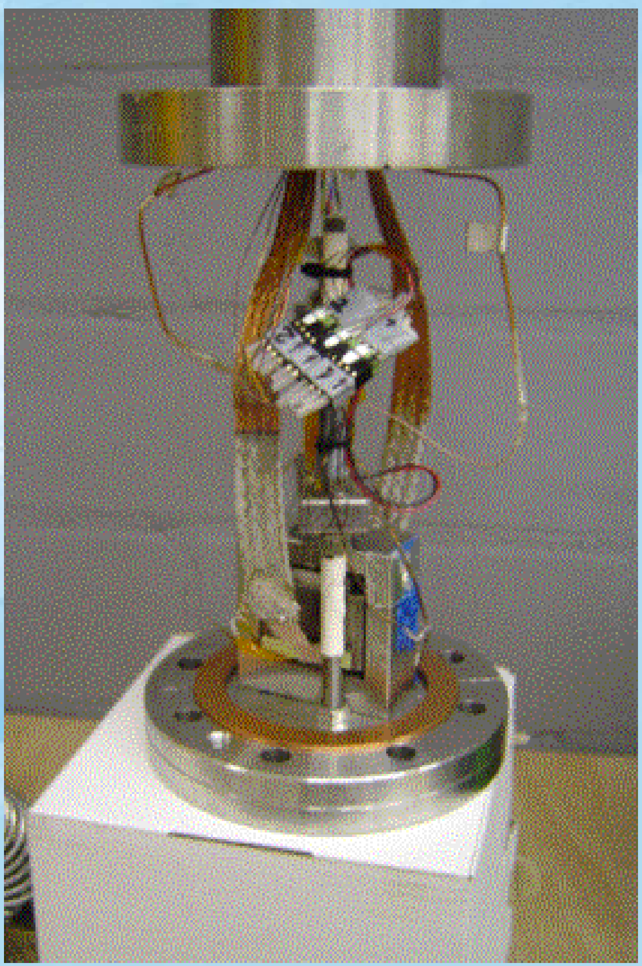


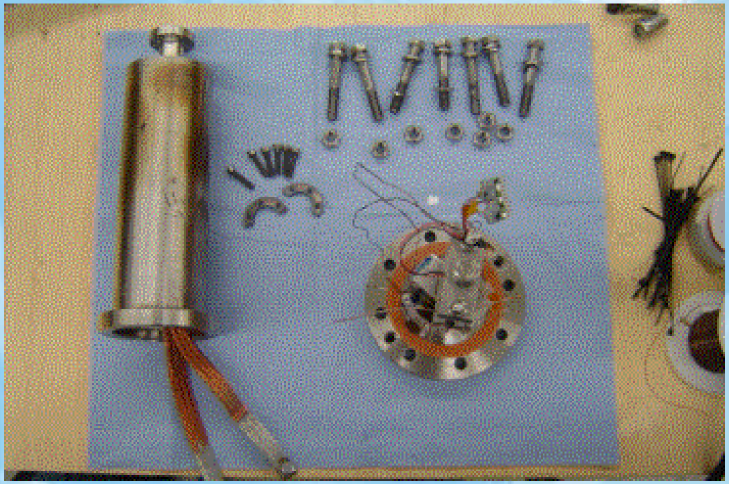
Magnetostrictive tuner performance (1/2)

Current test

Experiment goals

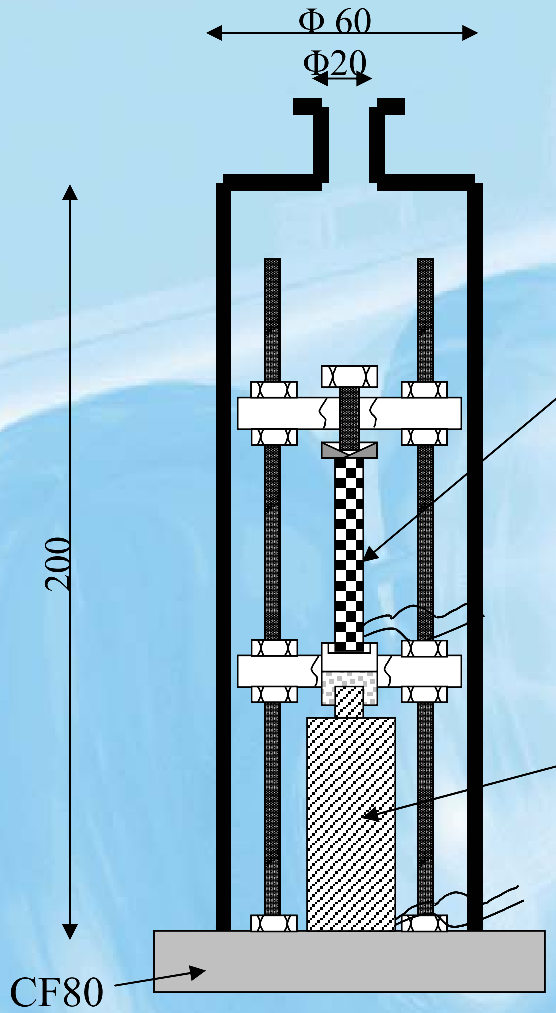
- **Run tuner at low temperature**,
- Transfer function from magnetostrictive element to piezoelectric one
- Transfer function from piezoelectric element to magnetostrictive one
- Characterize magnetostrictive tuner vs. NOLIAC piezo stack
  (similar experiment with two piezostacks was done)
  - stroke vs applied current
  - maximal frequency
- Heat dissipation (temperature rise)





Magnetostrictive tuner performance (2/2)

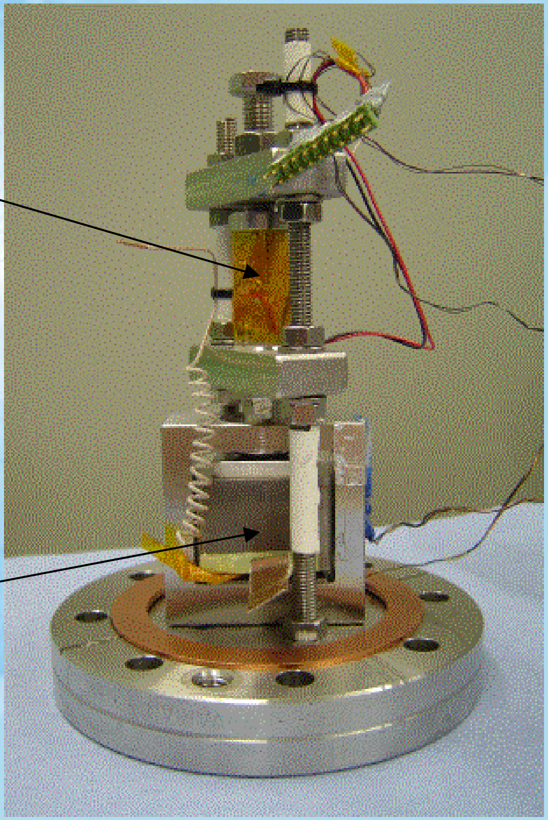
Current test



Schematic view

piezoelement
(sensor)

Magnetostrictive
element
(actuator)



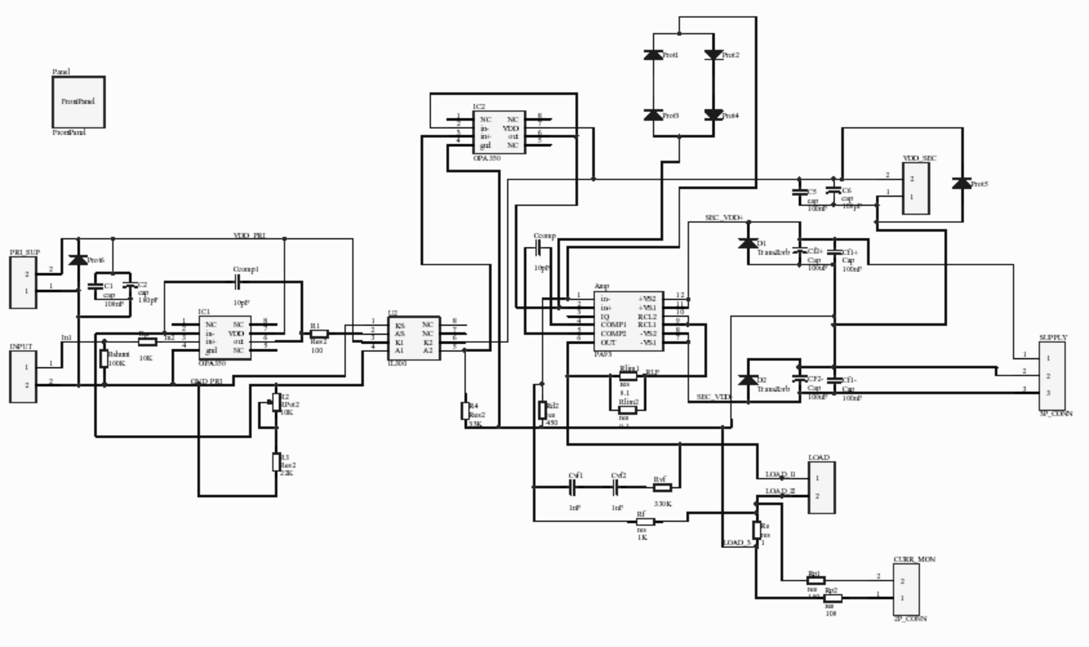
Prepared fixture

This experiment is already done (end of Nov.)

Power Transconductance Amplifier

Technical Specifications:

- Maximum output current amplitude – 8 A
- Maximum pulse duration – 2.3 ms
- Maximum repetition frequency – 20 Hz
- Amplification – 3.33 A/V



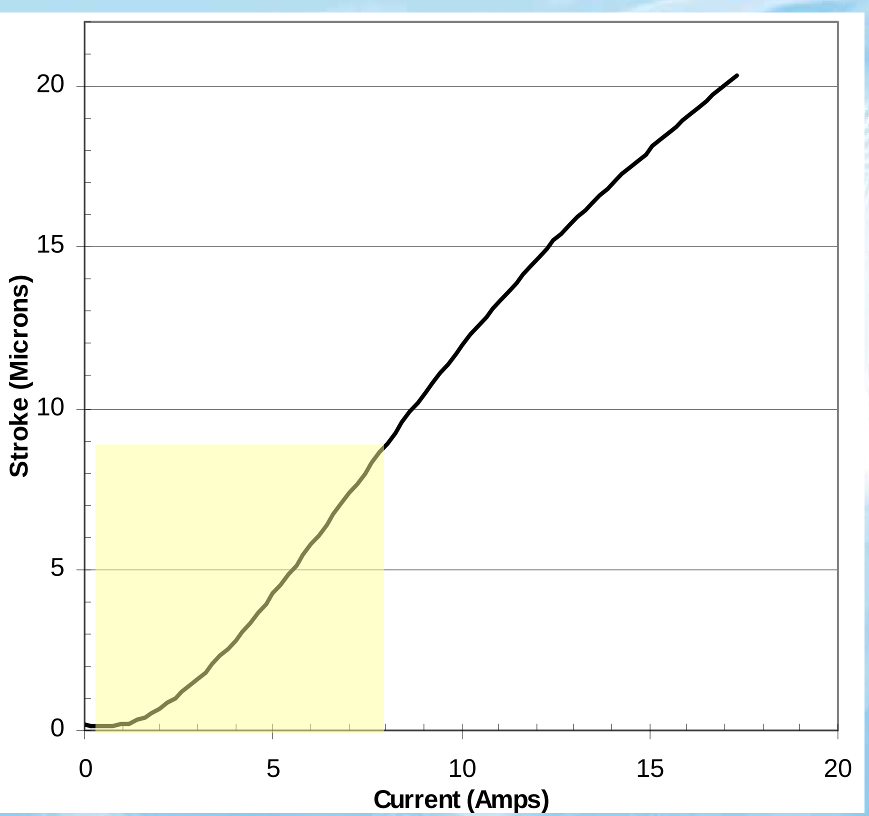
PTA based on PA93 APEX Power Operational Amplifier

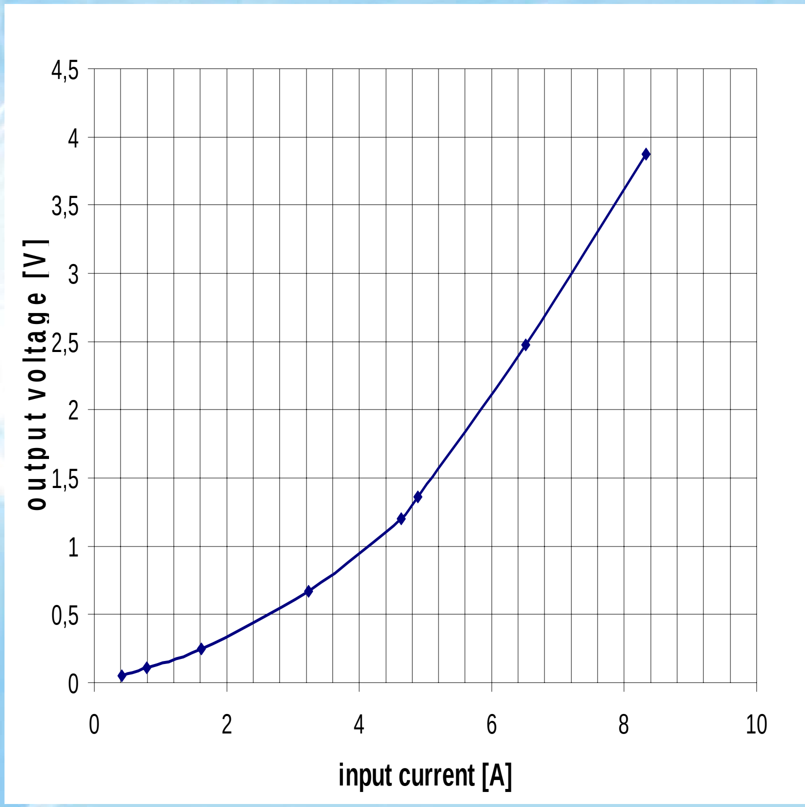
PWM amplifier is under investigation

Schematic of amplifier (designed by G. Jablonski, DMCS-TUL)

Results

Magnetostrictive tuner successfully works at 4K





Precise calibration is needed

Future test with magnetostrictive rods

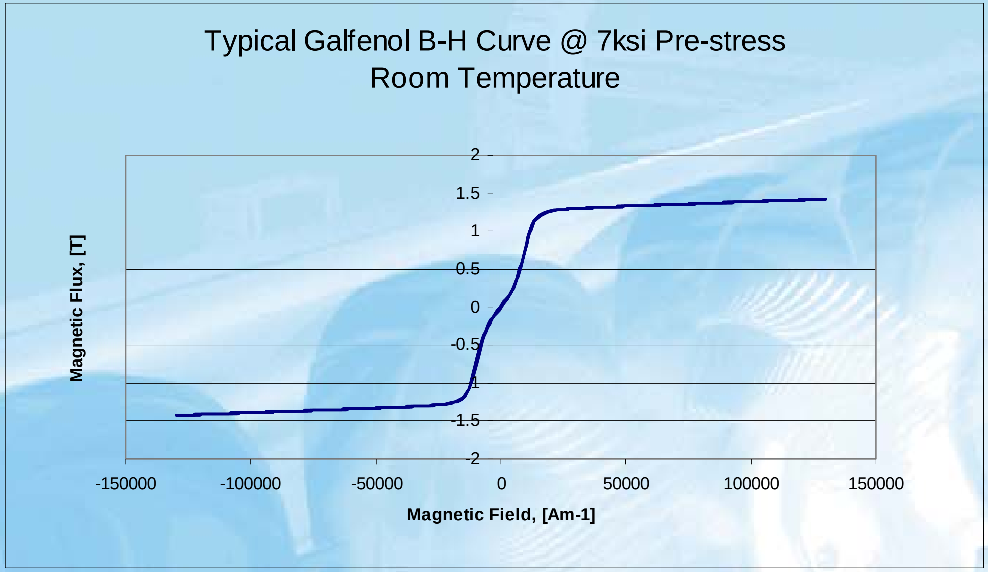
- Two new magnetostrictive rods from **ETREMA** was ordered. They are made of GalFeNOL (6x6x20mm).

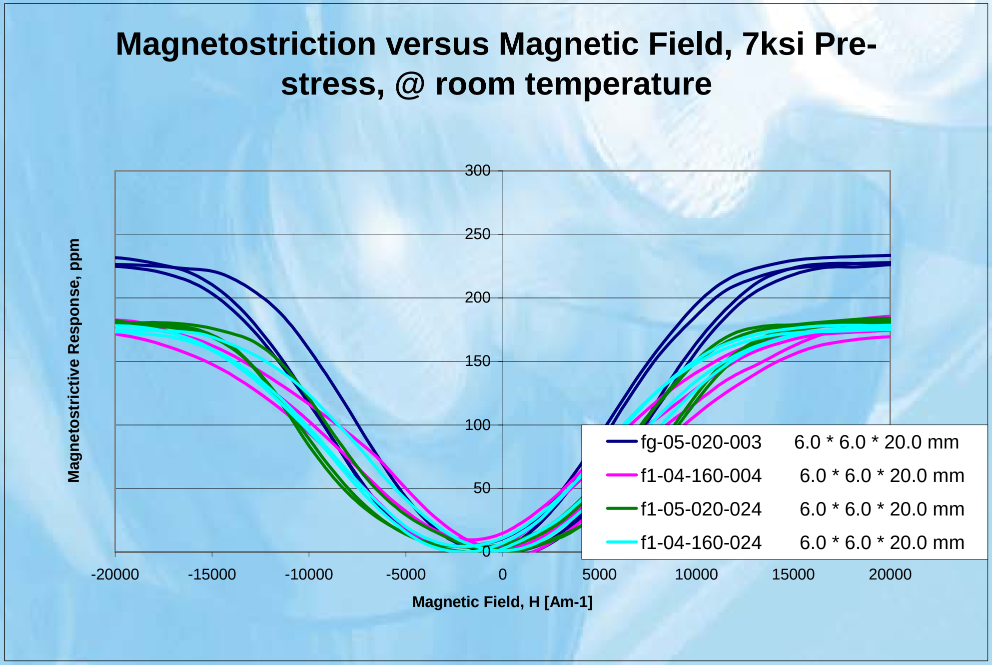
- We would like to perform a characterization of all 3 rods (or more if we acquire) similar to the piezo one, including:
  - Displacement measurement versus magnetic field applied to device for different preload settings (i.e. 0N, 1kN, 2kN, 3kN),
  - Max. stroke,
  - Dynamics of motion,
  - Heat generation – coil is made of Nb_3Sn,
  - Magnetic field distribution (if possible)

NOTE: Proper cryostat is in IPN, Orsay and need only small modifications.

The possibility to perform proper test in Poland (Wroclaw) is considered.

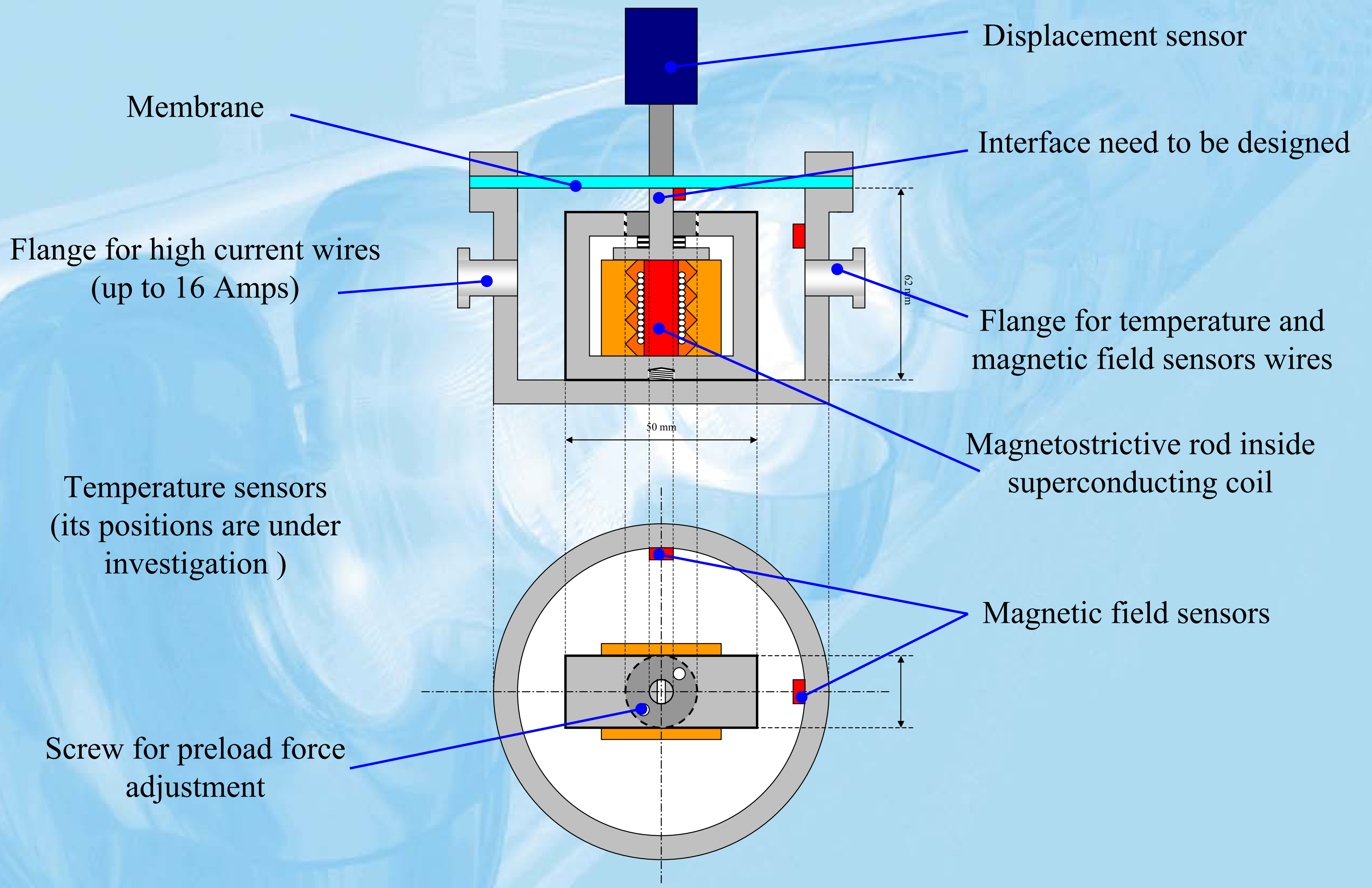
ETREMA Rods





Dimensions: 6x6x20mm
Material: GalFeNOL

Future test with magnetostrictive rods



Conclusions

Lorentz force compensation for field up to 35MV/m based on piezoelectric devices was successfully demonstrated.

A lot of problems are solved so far i.e. neutral point, force measurement at 2K, etc, but there are plenty difficulties, which need to be worked out.

There is need to automate the parameter finding process.

Magnetostrictive tuner **works** at cryogenic temperatures. Detailed characterization of different magnetostrictive rods is necessary.

LLRF design:

Stefan Simrock, Alexander Brandt, Mariusz Grecki,

http://tesla.desy.de/~abrandt

http://tesla.desy.de/~simrock

LLRF model:

Ryszard Romaniuk

http://tesla.desy.de/~elhep

Tuner control design:

Przemek Sekalski, Lutz Lilje

http://tesla.desy.de/~sekalski