TUNER DEVELOPMENT AT CEA-SACLAY

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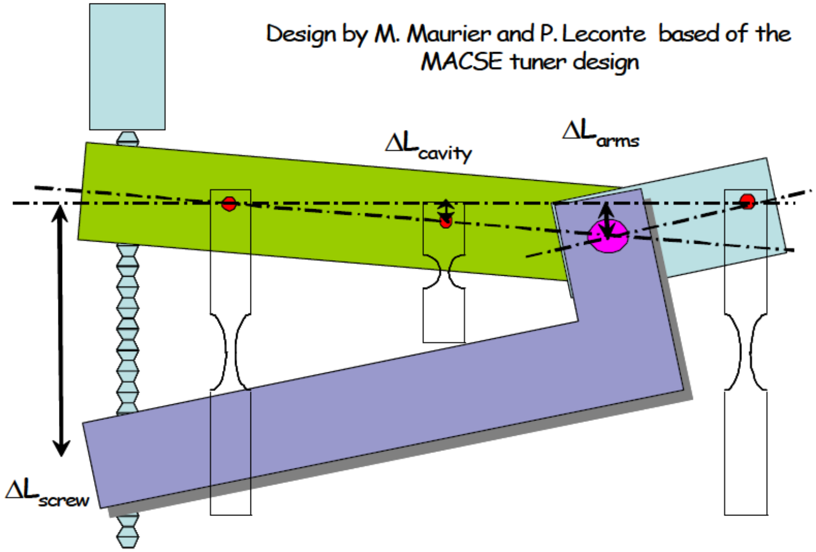
MACSE - TTF

Cold tuning system design started at Saclay for the MACSE cryomodules, 1.5 GHz CW e- linac (3-cells and 5-cells cavities) : need for cold tuner, operating in LHe.

Followed in the early 90's by the TTF (Saclay-I) with an asymmetric, simplified lever arm design

Mechanical Principle of Present TTF Tuner



- Double lever system ratio ~1:17
- Stepping motor with harmonic drive gear box
- Screw-nut system : lubricant treatment (balzers Balinit C coating) for working at cold and in vacuum
- ΔZ = +- 5 mm and Δf = +- 2.6 MHz
- Theoretical resolution : δz = 1.5 nm !

P. Bosland

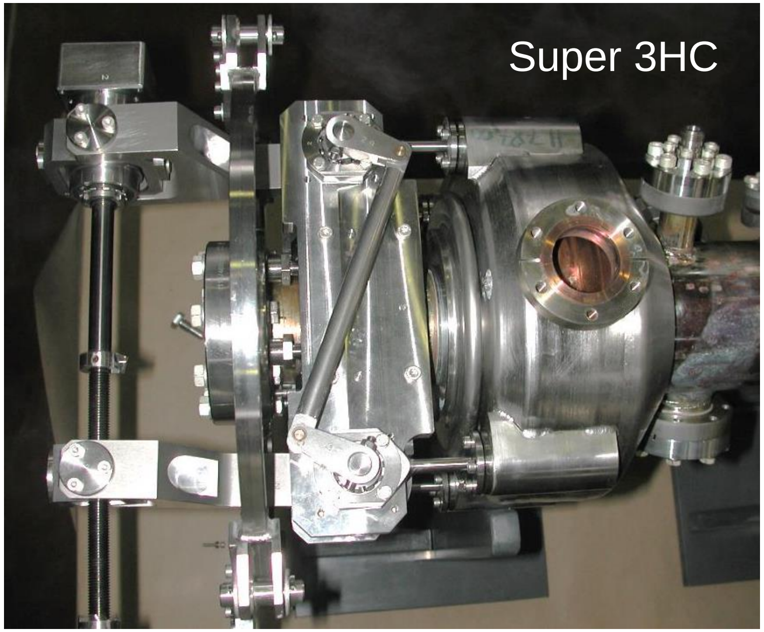
Addition of piezo actuators by DESY, operated since the beginning of TTF, basis of the XFEL tuner

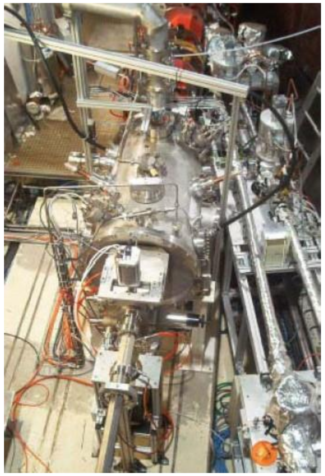
SYNCHROTRON CAVITY TUNERS

- Then SOLEIL cavities (352 MHz) : symmetric dual lever arms prompted by the tuning range and dimensions

- Elettra Trieste and PSI-SLS Super3-HC cryomodules dual single-cell 1.5 GHz, scaled down version of Soleil tuner. Total of 4 tuners in operation since 2003

Heavy use of tuner on circular machines, full range operation on a daily basis





PIEZO TUNER R&D

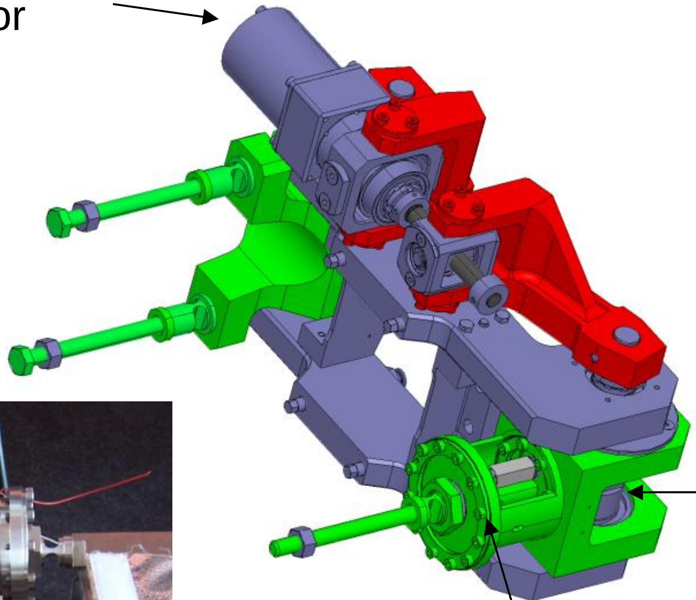
In the 6th European Framework Program, a new cold tuner implemented with fast piezoelectric actuators has been developed (CARE/SRF) based on the experience gained from the former cold tuner designs. This new tuner should meet the needs for Lorentz forces or microphonics compensation on the 9-cell elliptical cavities used in the future linear collider (ILC) or Free Electron Laser linacs

Design choices

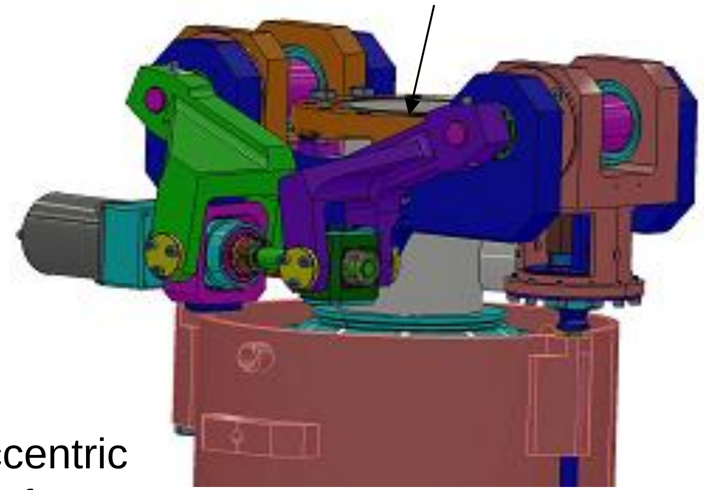
- Excentric rods transfer rotation into displacement like Saclay SR cavities tuners
- Achieve a stiffness at least 10x the stiffness of the cavity
- Remove the neutral point from the tuning range to suppress backlash : equivalent to choose to only lengthen the cavity. The room temperature frequency must be shifted accordingly
- Always use increasing forces to tune the cavity to higher frequency (for both slow tuner and piezo parts)
- Tune the cavity to operation frequency at cold by using a fraction of the positive tuning range
- Use the cavity reaction force to preload the PZTs (aiming at $F_{preload}$ > 500 N). No other adjustment
- Typical fast tuning range +1kHz to compensate for the LFD i.e. 3 micrometers cavity lengthening

SACLAY-II 2004-2006

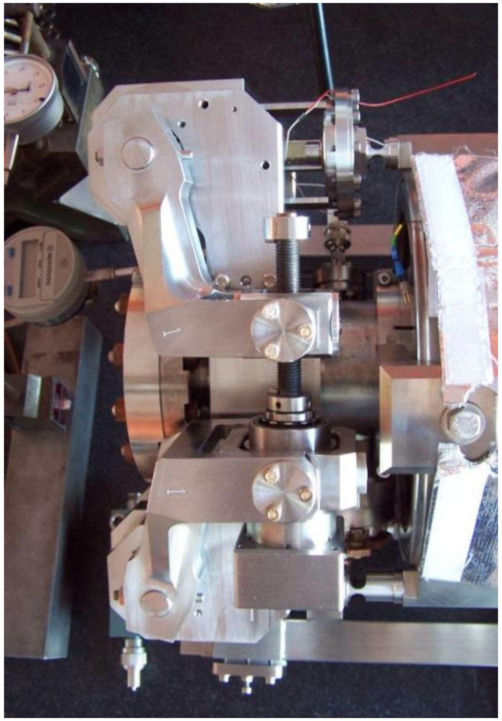
Stepper motor



Cavity flange

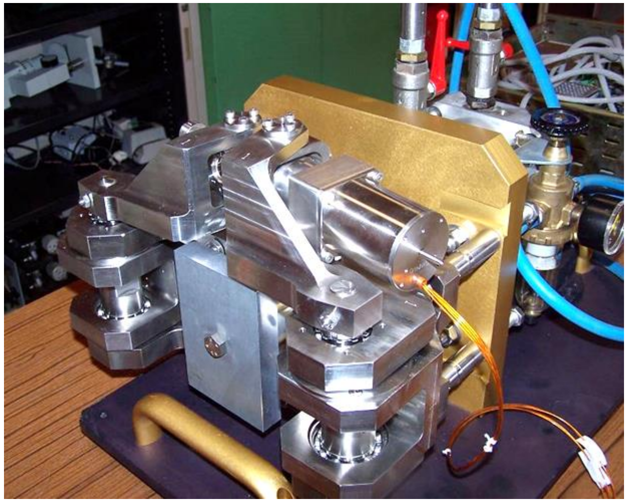


Eccentric shaft



Dual piezo support

Stiff tuner (meas. 35kN/mm)

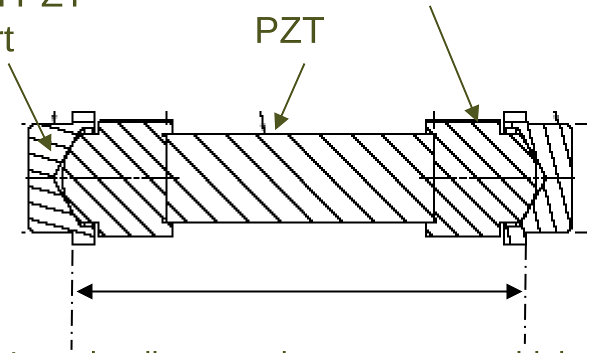


SACLAY-II PIEZO SUPPORT

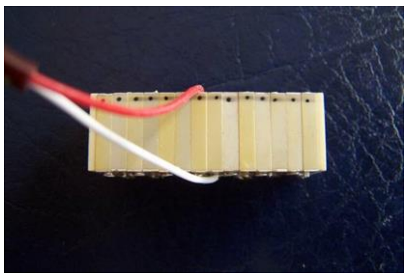
We were worried about damaging piezos

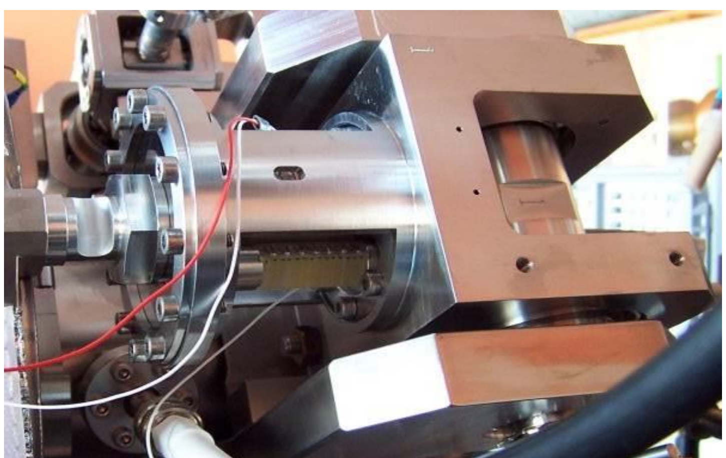
- due to shear and bending forces
- due to insufficient preload

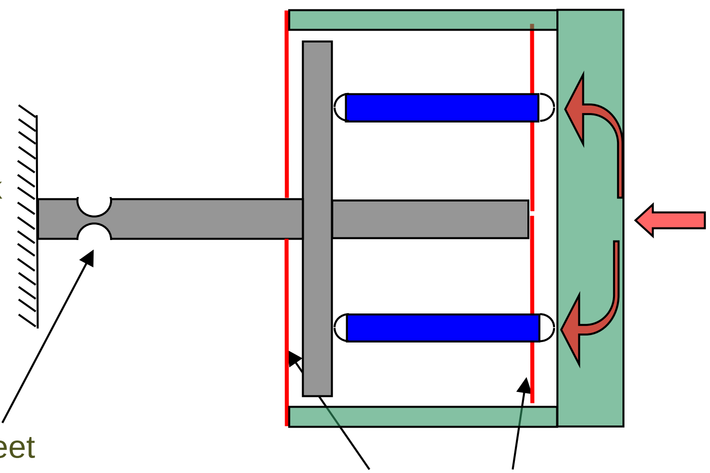
2 piezos were considered as safer than one…



Length adjustment by accurate machining
51 mm (+0.005, -0)





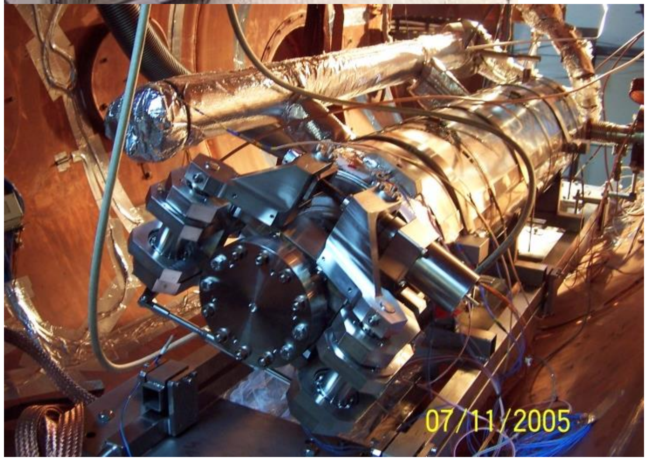


Flexible feet

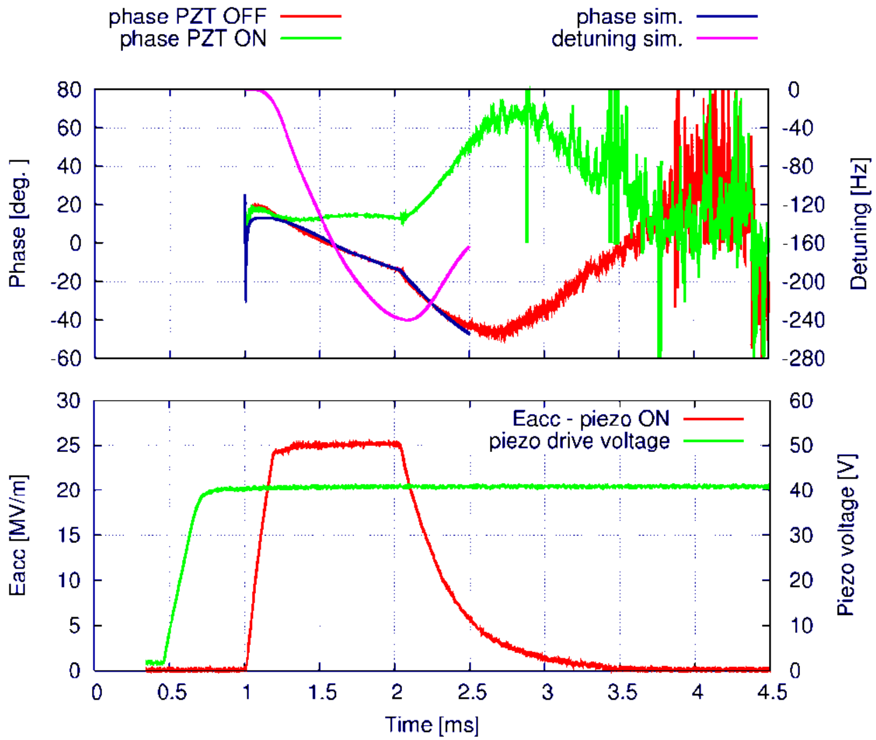
transverse motion is generated by excentric rods

2 stainless steel membranes

No transverse stress on the PZTs



Tested on C45 DESY 9-cell in CryHoLab.
Pulse operation at E_{acc} = 25 MV/m

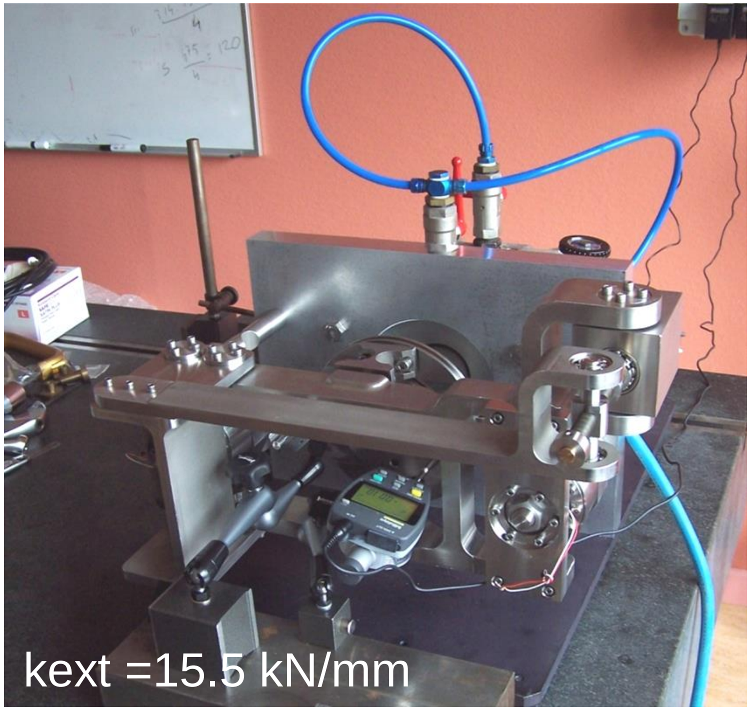


- LFD compensation achieved (20Hz estimated residual detuning)
- But difficult to have both piezo loaded correctly simultaneously in the same support

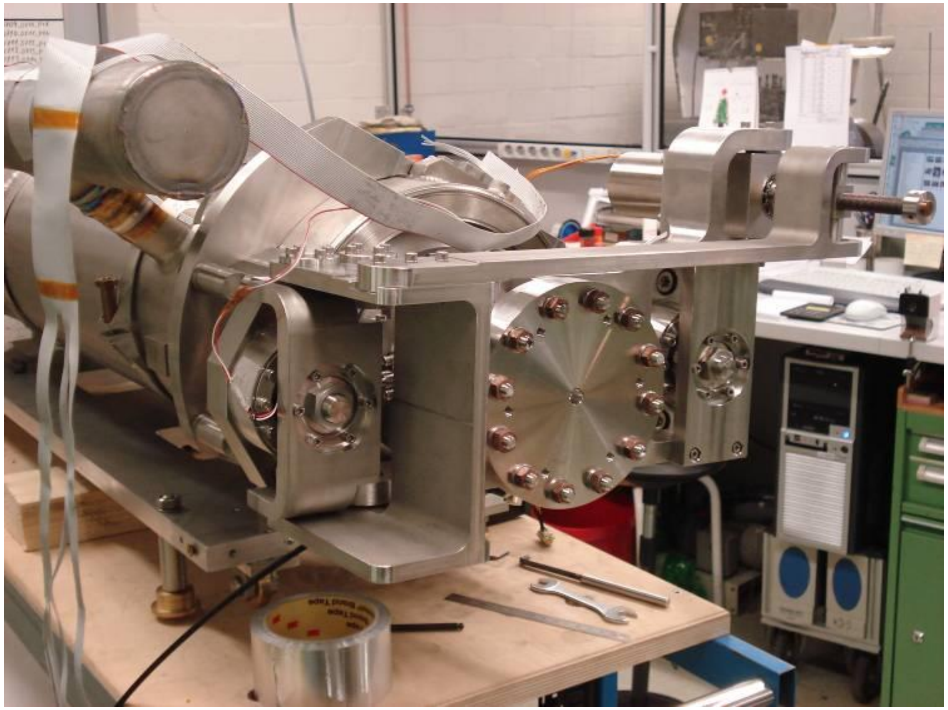
SACLAY-IV 2006 2007

- for 1.3 GHz 9-cell cavities
- asymmetrical , with simpler structural parts to reduce cost (like Saclay-I, TTF and XFEL tuner) aiming at reducing the cost
- Still 2 piezos this time not in the same support but one on each side of the flange
- The piezo support was also using stainless steel membranes to prevent shear forces (coaxial design) -> still expensive

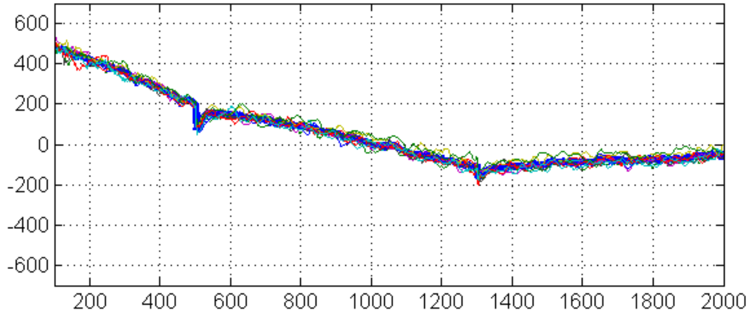
Stiffness measurement on pneumatic jack



Preparation for the pulsed test in Chechia @ DESY (2007)



SACLAY-IV LFD COMPENSATION IN CHECHIA

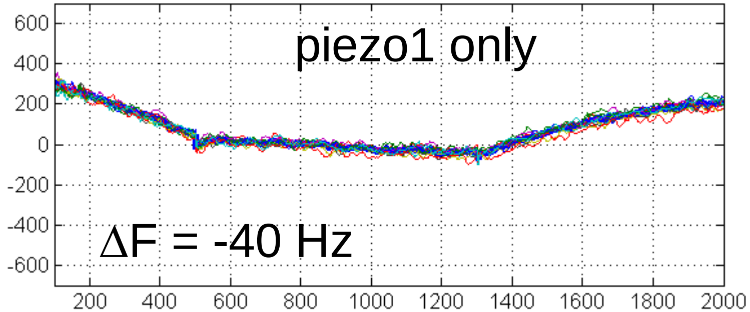


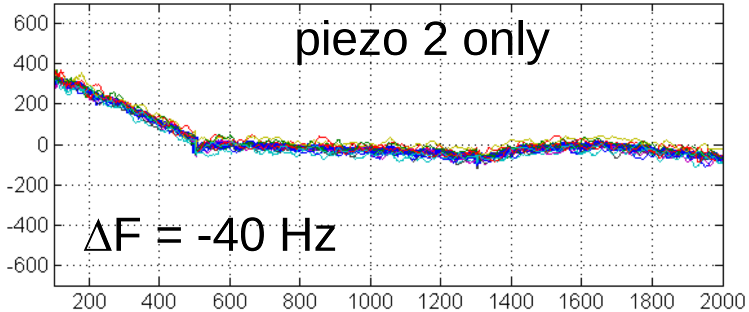
compensation OFF

ΔF = -300 Hz

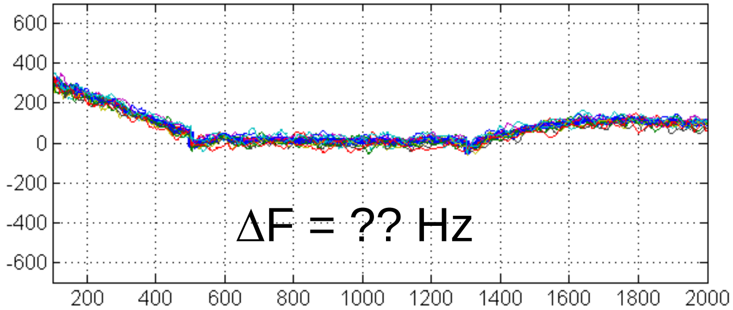
25 MV/m in Chechia (w/ L. Lilje)

compensation ON





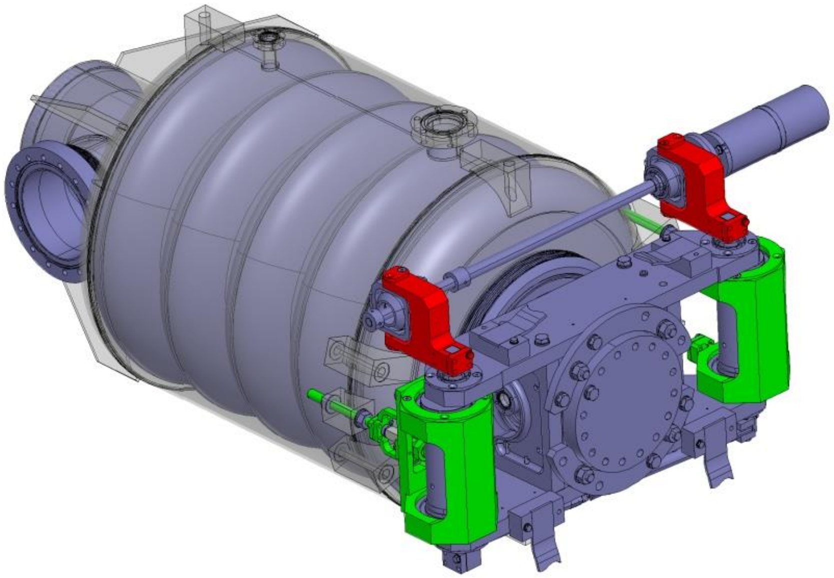
Both piezos

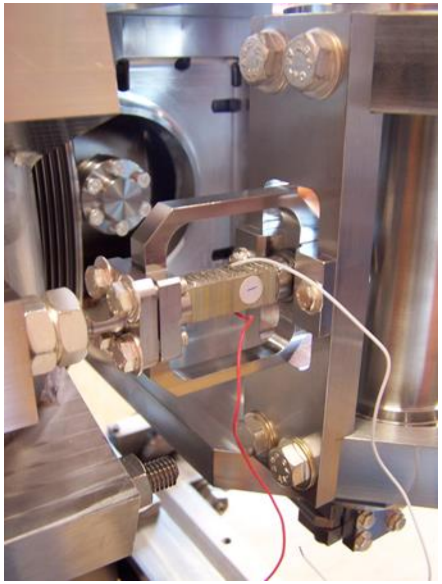


Good performance for piezo LFD compensation

Drawbacks: cost of the piezo supports, relying on the cavity springback force is not very practical

TUNERS FOR PROTONS – SACLAY-V



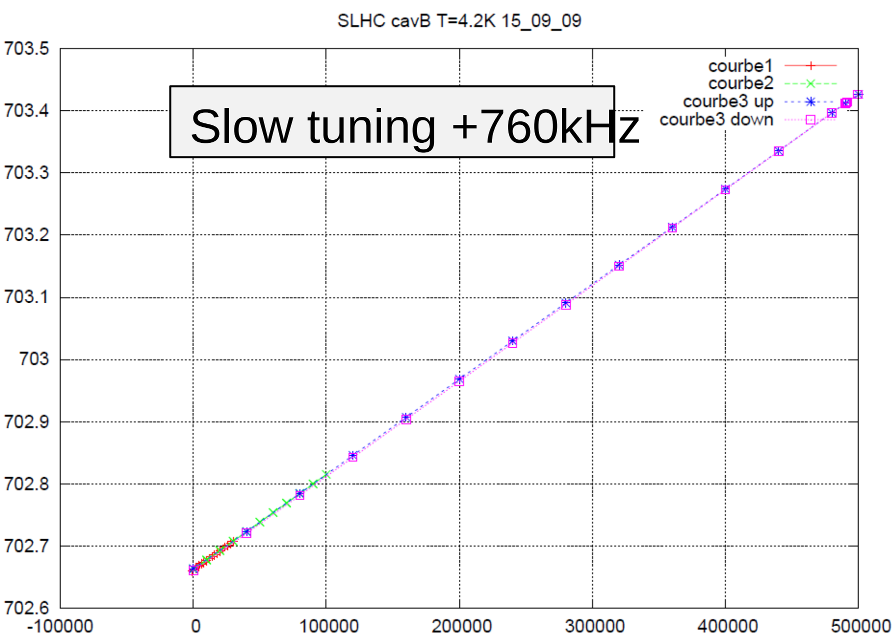


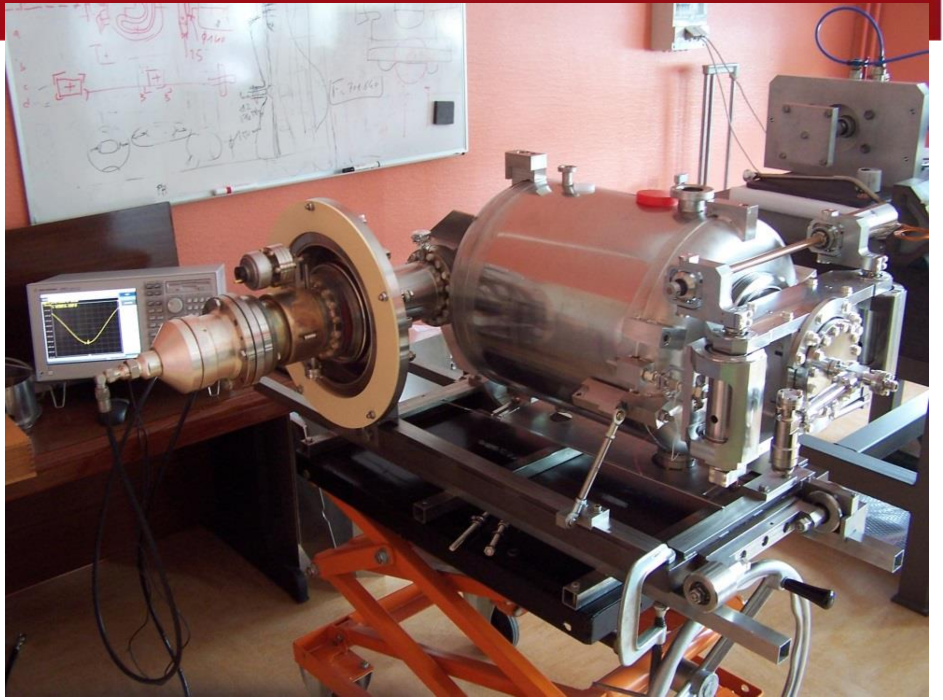
- Try to simplify the machining of the parts of a Saclay II type,
- Simplify assembly/disassembly
- Design a piezo frame which enables preload of piezo and make it independent of the cavity springback force
- Use a single piezo first

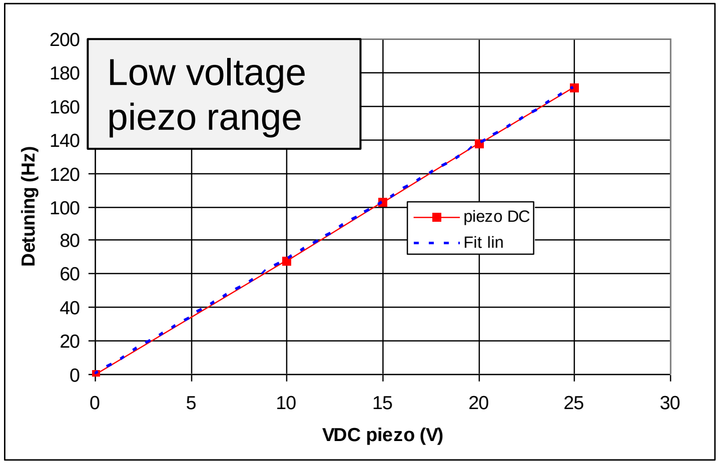
- does not take space on the beam line
- planetary gear box for reliability
- possible symmetric slow tuning +/- 2.5 mm

STATIC CARACTERISTICS

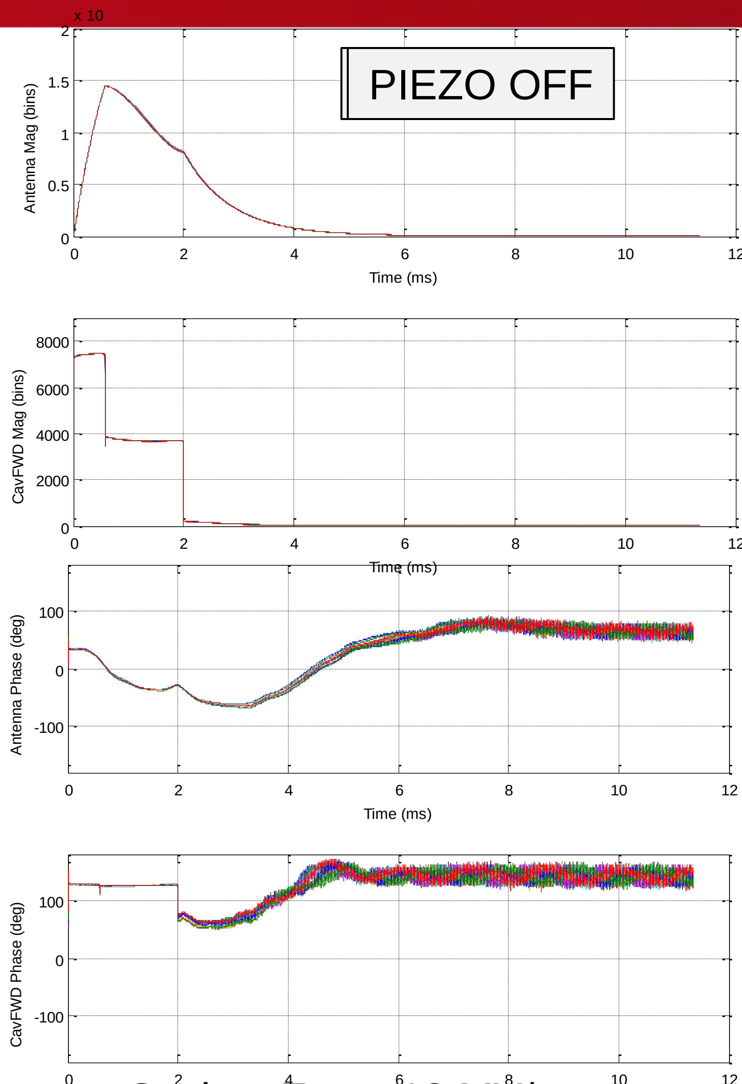
Testing on the CARE-HIPPI
704 MHz β= 0.47 5-cell cavity
K_L = -3.8 Hz/(MV/m)²

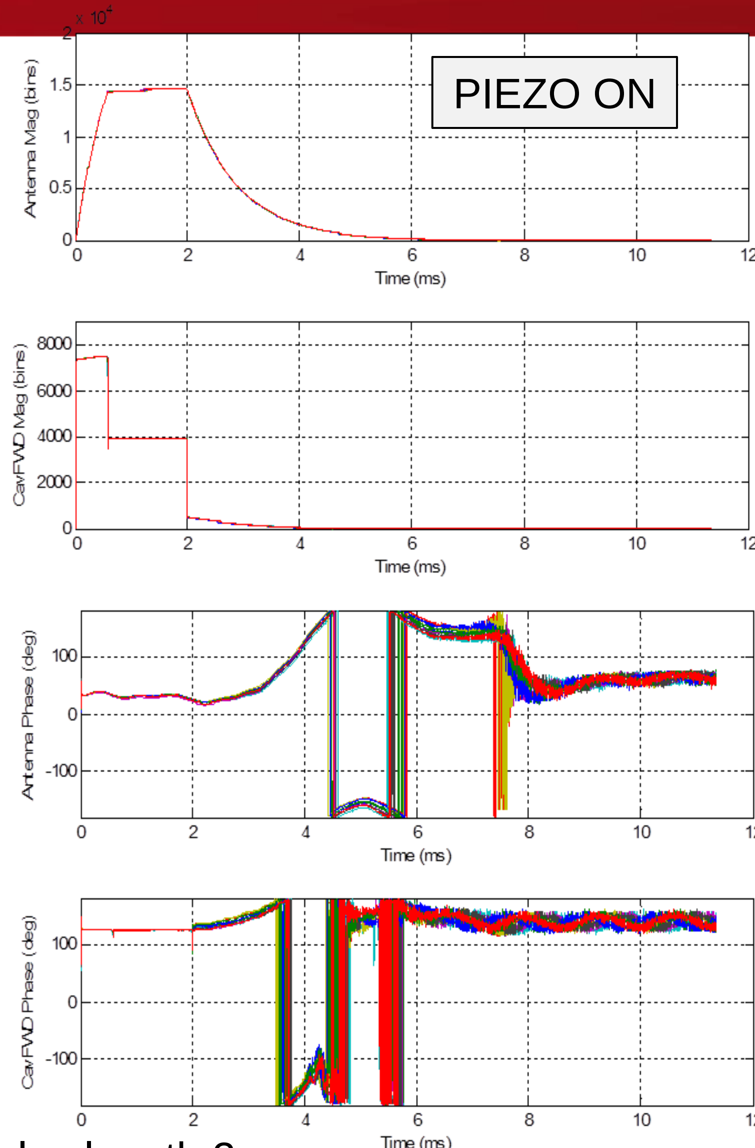






LFD COMPENSATION RESULTS

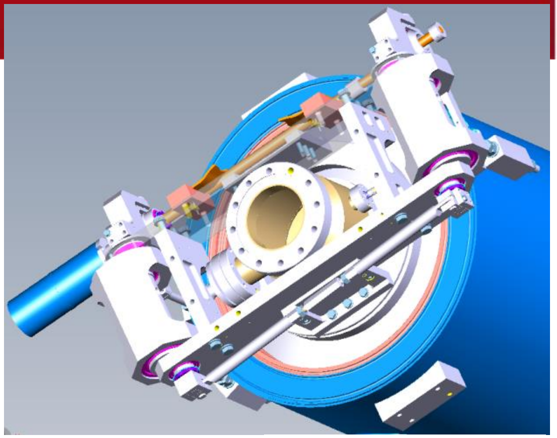




Cavity : Eacc=13 MV/m

RF: Repetition frequency = 50Hz, pulse length 2ms

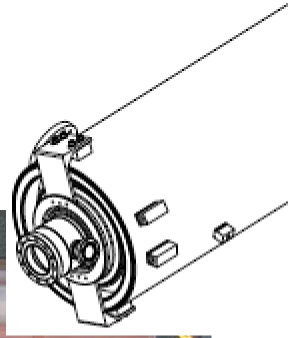
SACLAY-V SPL TUNER

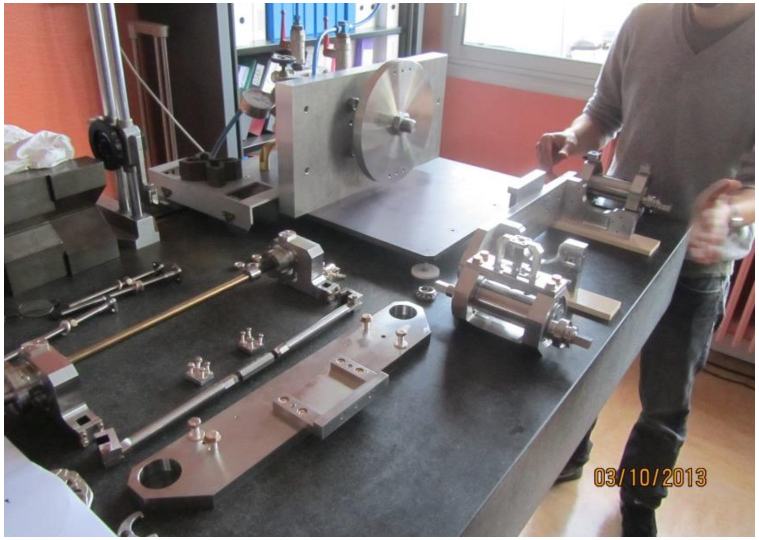


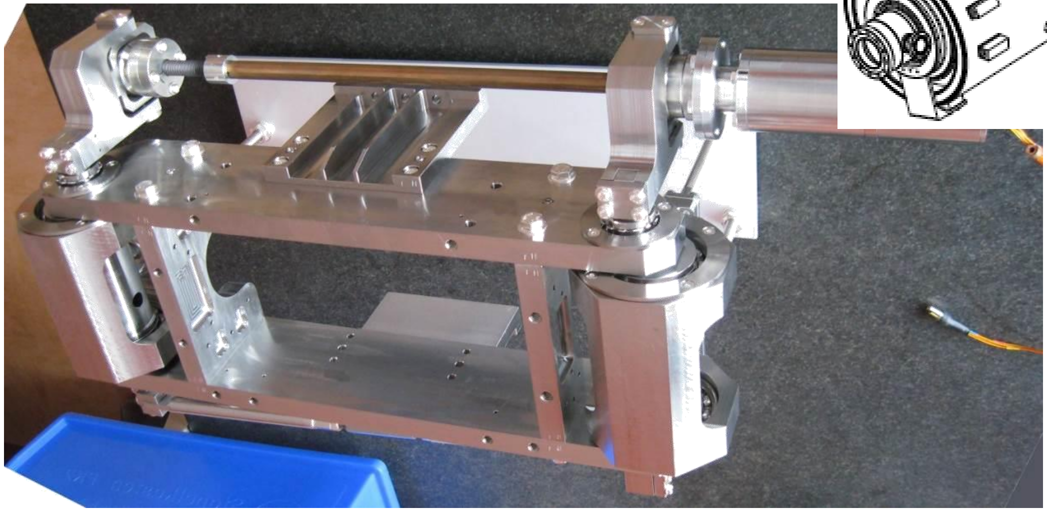
SPL tuner design is SACLAY-V of the previous type with minor modifications:

- Tuner installation on an already assembled cavity string requires:
    - compatibility with cavity clamping tools
    - Two stage assembly (pre-assembly can be done in advance, final assembly only on the cavity)
    - Attachment on beam pipe rather than on the cavity flange

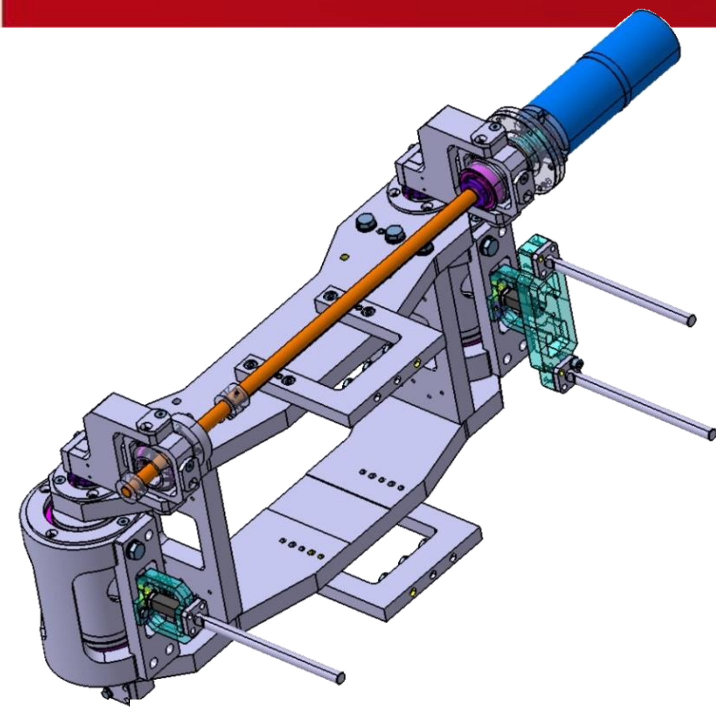
- More space for HOM dampers



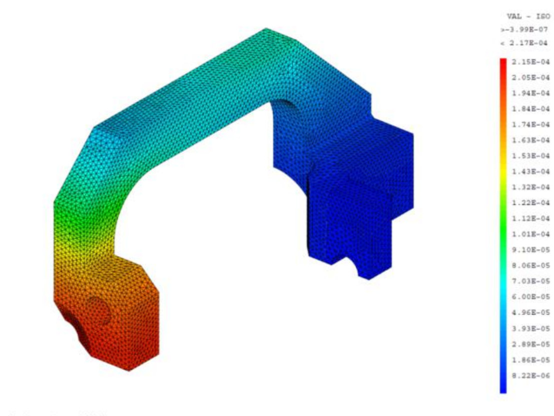


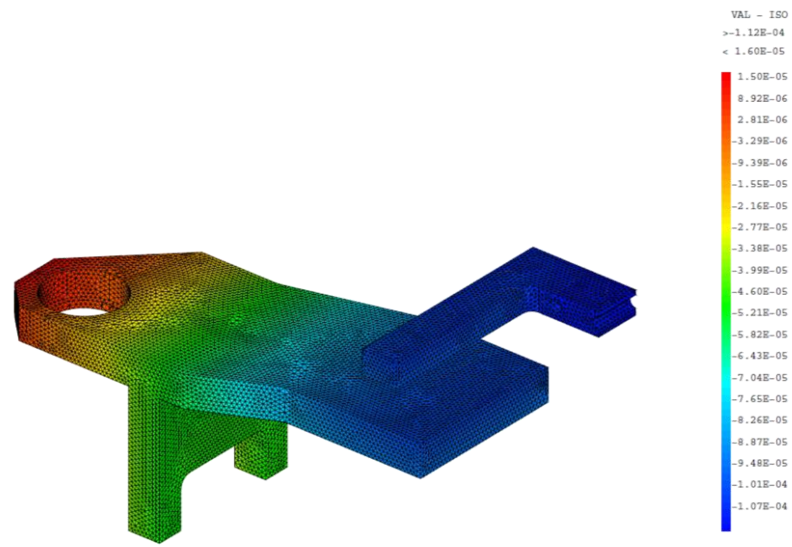


SACLAY-V ESS TUNER



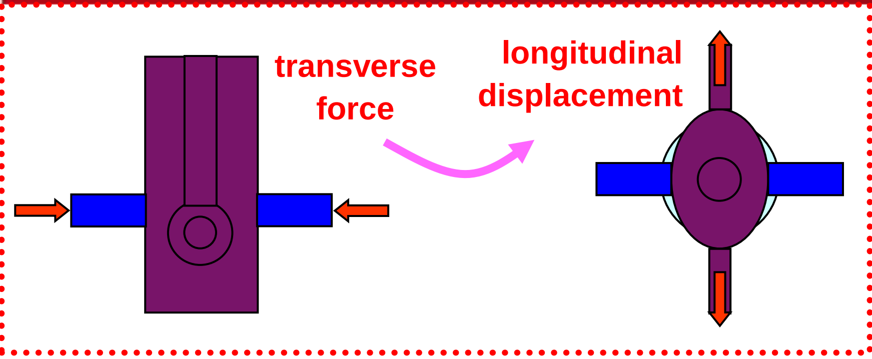
- Saclay V SPL type adapted for ESS cavities
- +/- 3 mm range
- using only positive stroke MB theor. range = 650 kHz, HB range = 590 kHz
- 1+1 piezo for redundancy
- Cold motor and planetary gearbox (1/100e)
- Piezo support has a stiffness 10 times higher than the cavity ⇨ piezo preload at 2K is independent of the cavity springback force



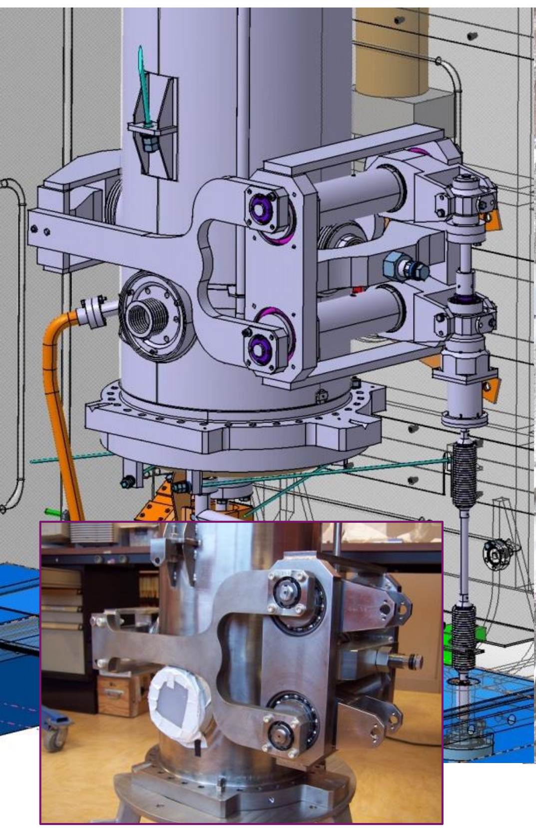


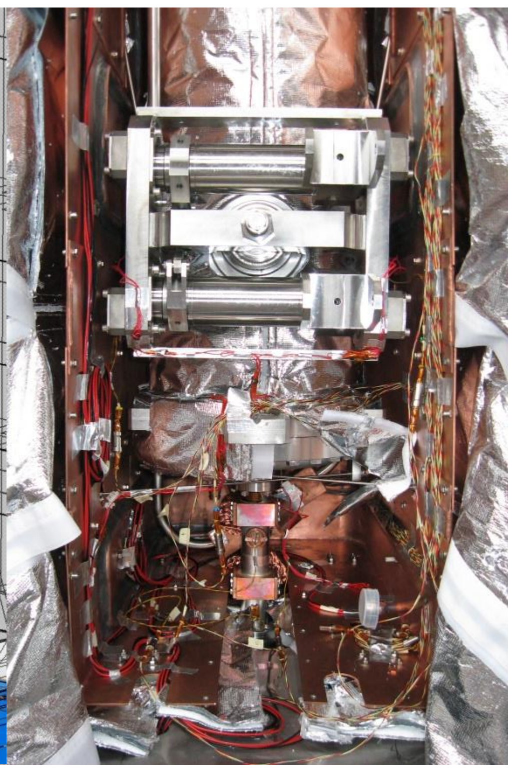
FROM RESEARCH TO INDUSTRY

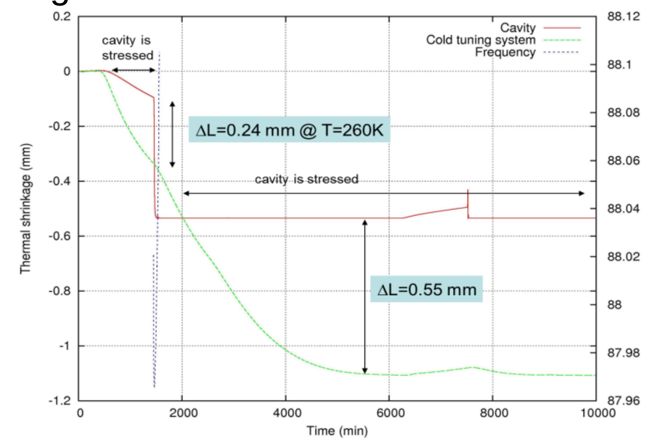
DEUTERON LINACS – SPIRAL2



- Transverse lever tuner
- Squishes the cavity
- Saves longitudinal space
- Motor is outside the vacuum vessel
- Disengagement system added after preseries cryomodule test in 2008: QWR experienced plastic deformation during cooldown







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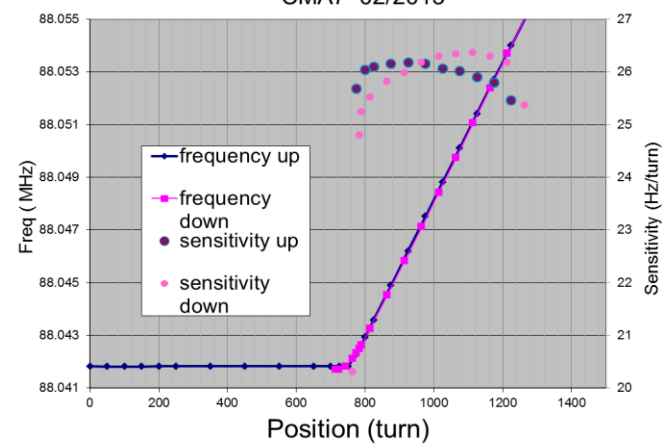
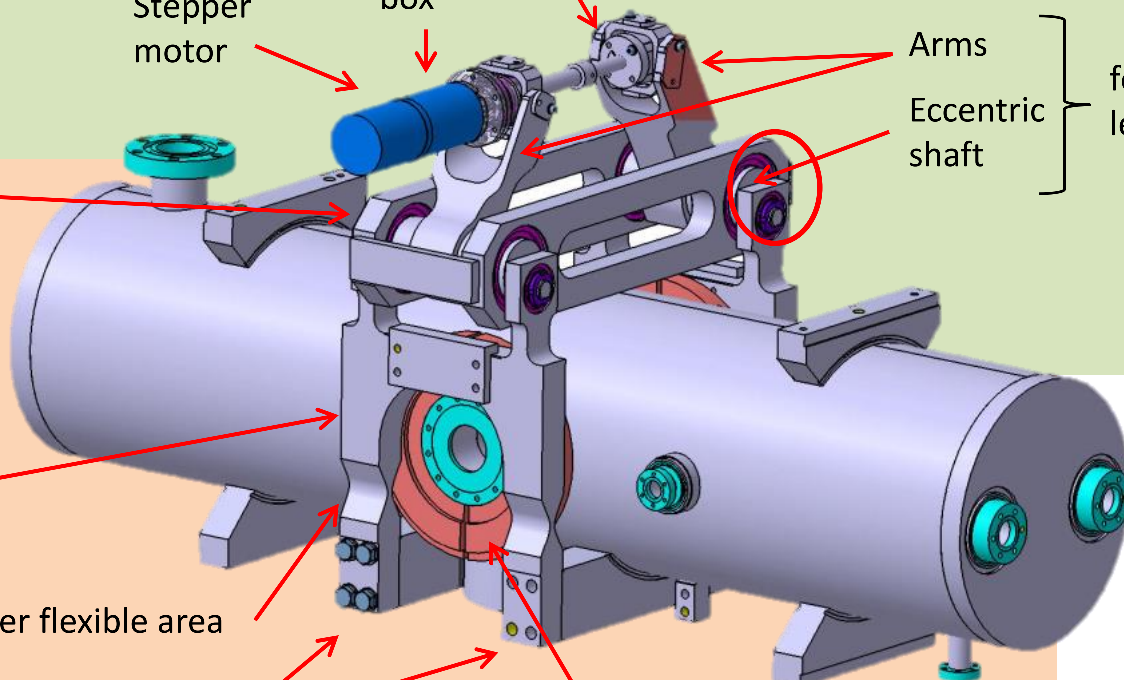
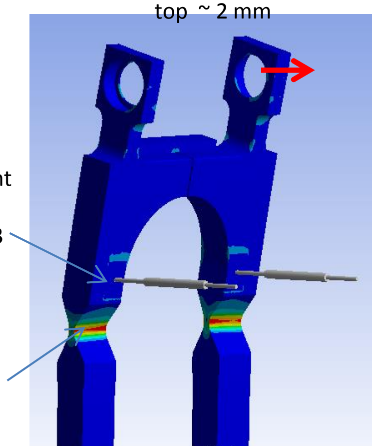


IFMIF LIPAC

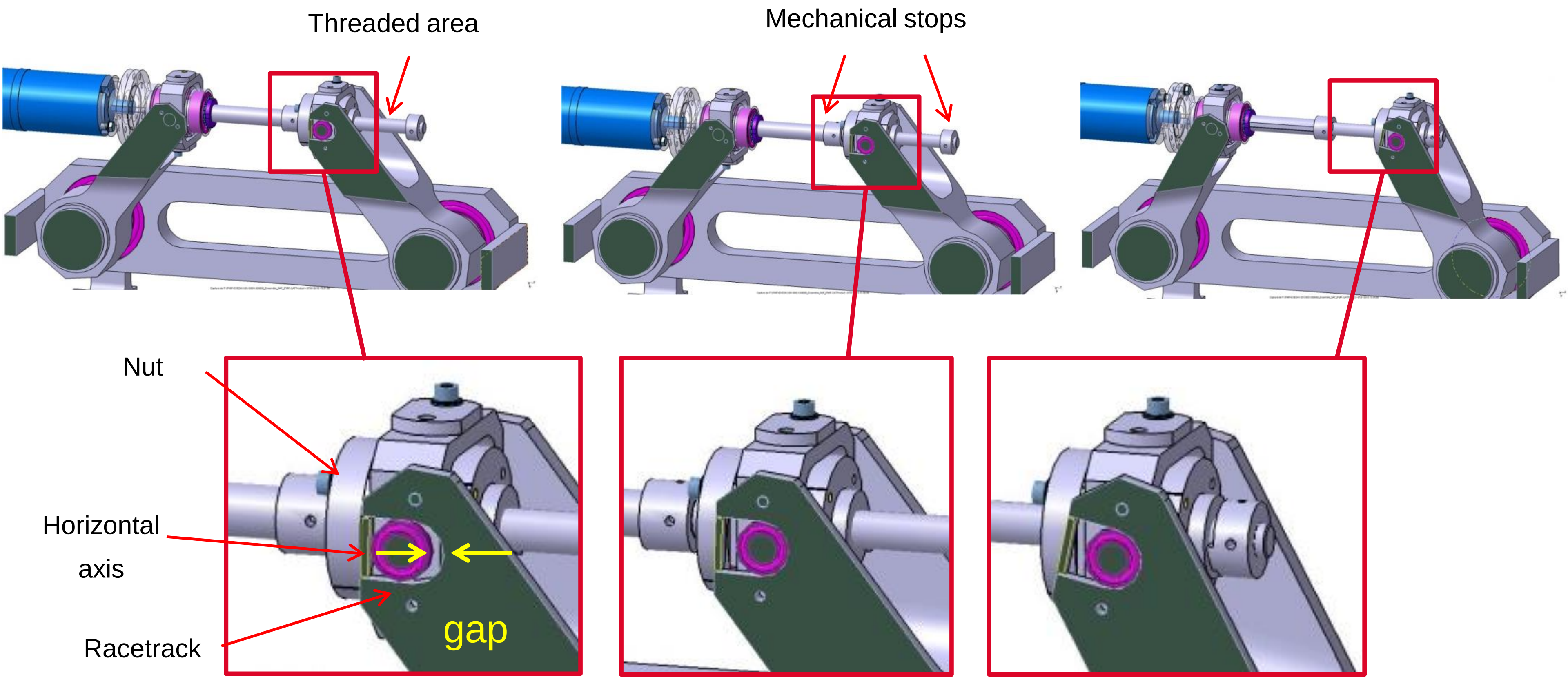


F=8kN on beam ports
F=250N on the main screw



IFMIF LIPAC – DISENGAGEMENT SYSTEM

- The horizontal axis of the universal joint is sliding in a racetrack hole
- The mecanism is covered and secured by a cap (not seen in cut views)



Released position — Engagement point — Cavity fully compressed

Thank you for your attention

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