

DE LA RECHERCHE À L'INDUSTRIE



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CRITICAL DESIGN REVIEW #1 FOR MEDIUM BETA CAVITY CRYOMODULES

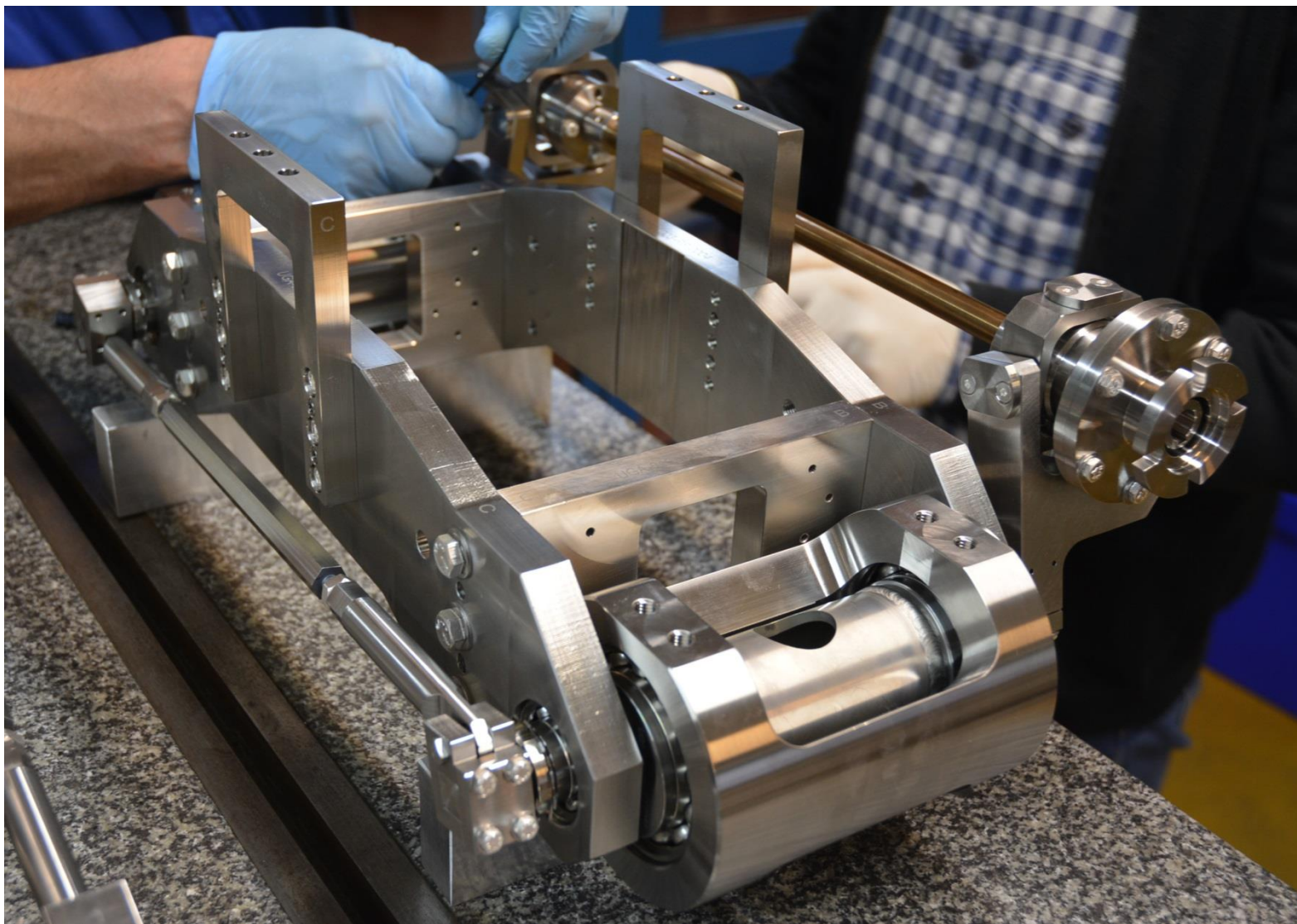
3-4 APRIL 2017

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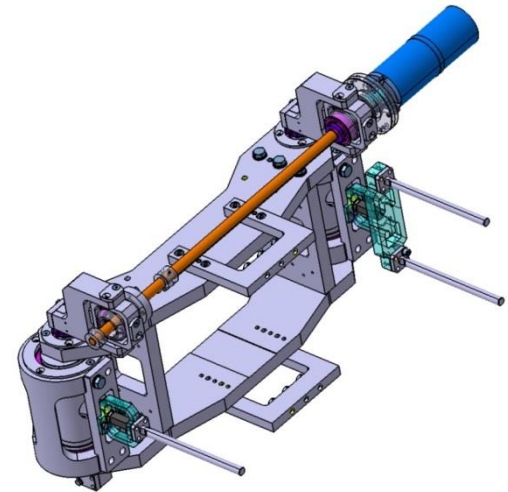
COLD TUNING SYSTEMS

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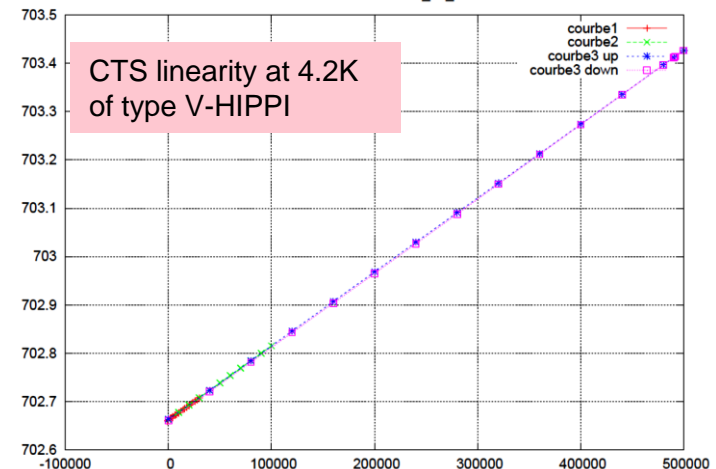
GUILLAUME DEVANZ



- Saclay V type adapted for ESS cavities
- +/- 3 mm range
- using only positive stroke
 - MB range = 650 kHz
 - HB range = 590 kHz
- Theroretical resolution ~1Hz
- 1+1 piezo symmetrical arrangement
- Cold motor and planetary gearbox (1/100e)
- Piezo support has a stiffness 10 times higher than the cavity \Rightarrow piezo preload at 2K is independant of the cavity springback force
- Good linearity due to high stiffness, proven on many previous Saclay designs (Soleil, Super-3HC, TTF/X-FEL,HIPPI)



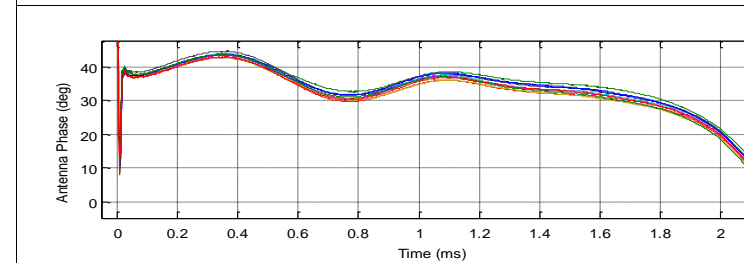
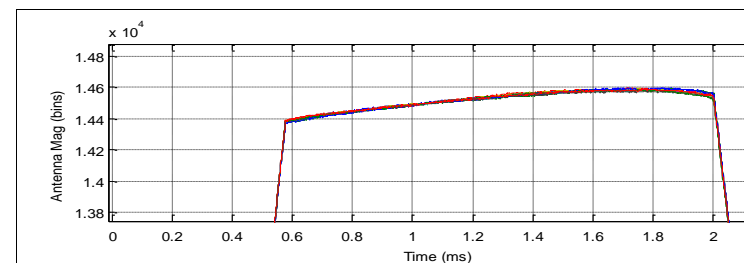
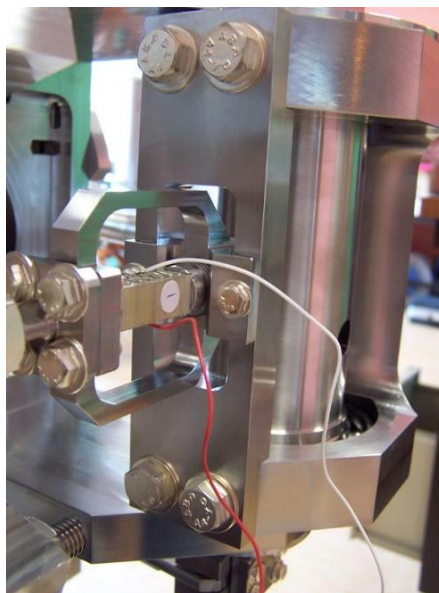
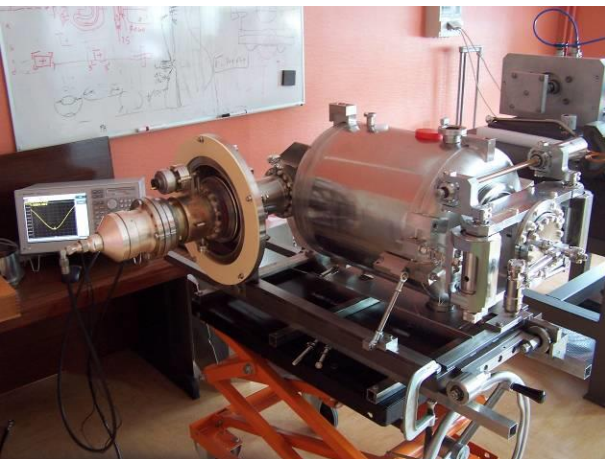
SLHC cavB T=4.2K 15_09



Design based on experience with SACLAY-V tuners:

Performance with a single piezo with beta 0.47 5-cell 704 MHz has been proven

- >1kHz piezo tuning static tuning range achieved
- Test cavity with static LFD of -650 Hz at testing gradient
- LFD compensation achieved for 2ms, 50Hz
- Large margin on the piezo voltage : used $\frac{1}{4}$ of the range



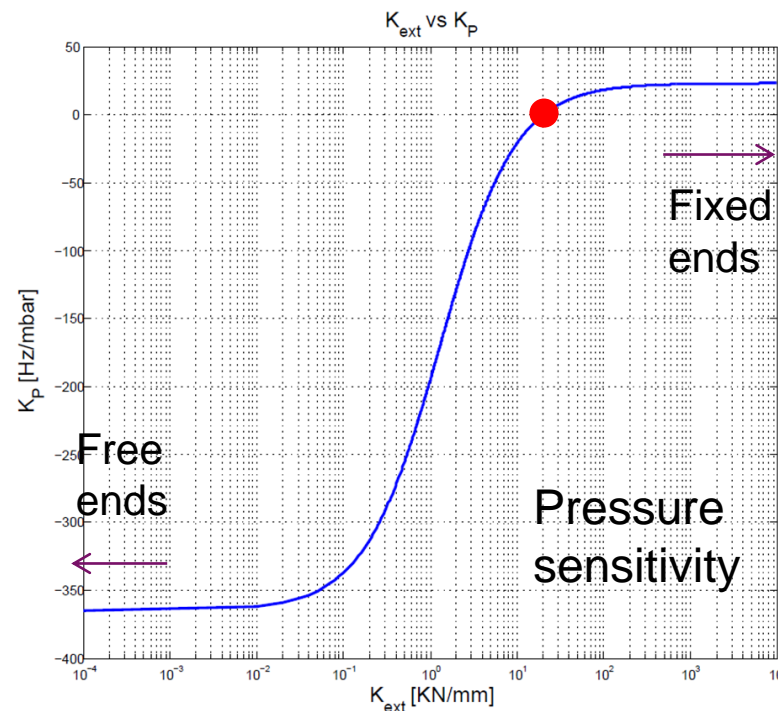
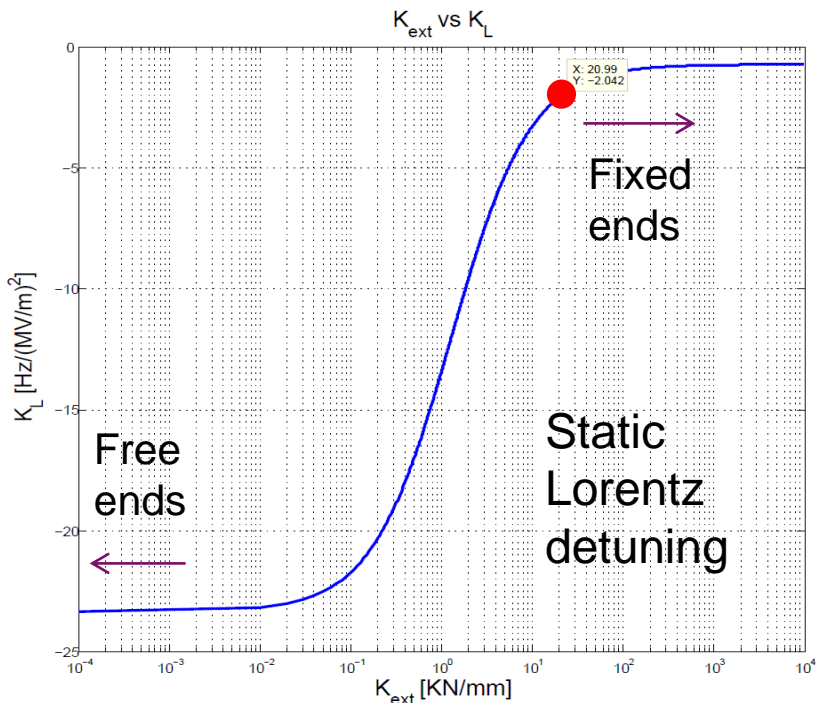
- All design parameters are based on Saclay U-Lund beta 0.67 and Saclay beta 0.86 cavities RF/mechanical properties
- Stiffness
 - He vessel and tuner combined in series
 - Assumption for the tank stiffness 75kN/mm
 - Aim for the tuner 30 kN/mm
 - combined external stiffness goal is $k_{\text{ext}} = 21 \text{ kN/mm}$
- Piezo range assuming $k_{\text{ext}} = 21 \text{ kN/mm}$:

	Medium	High
K_L , static [Hz/(MV/m) ²]	-2.04	-1.3
Eacc [MV/m]	16.7	20
Static LFD [Hz]	-570	-520

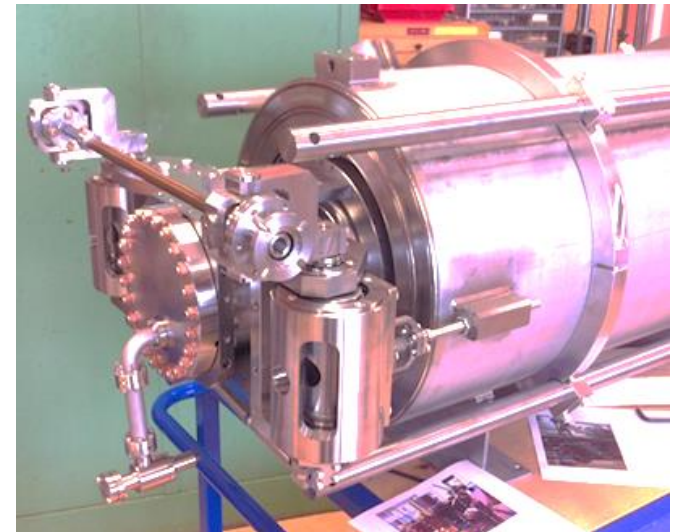
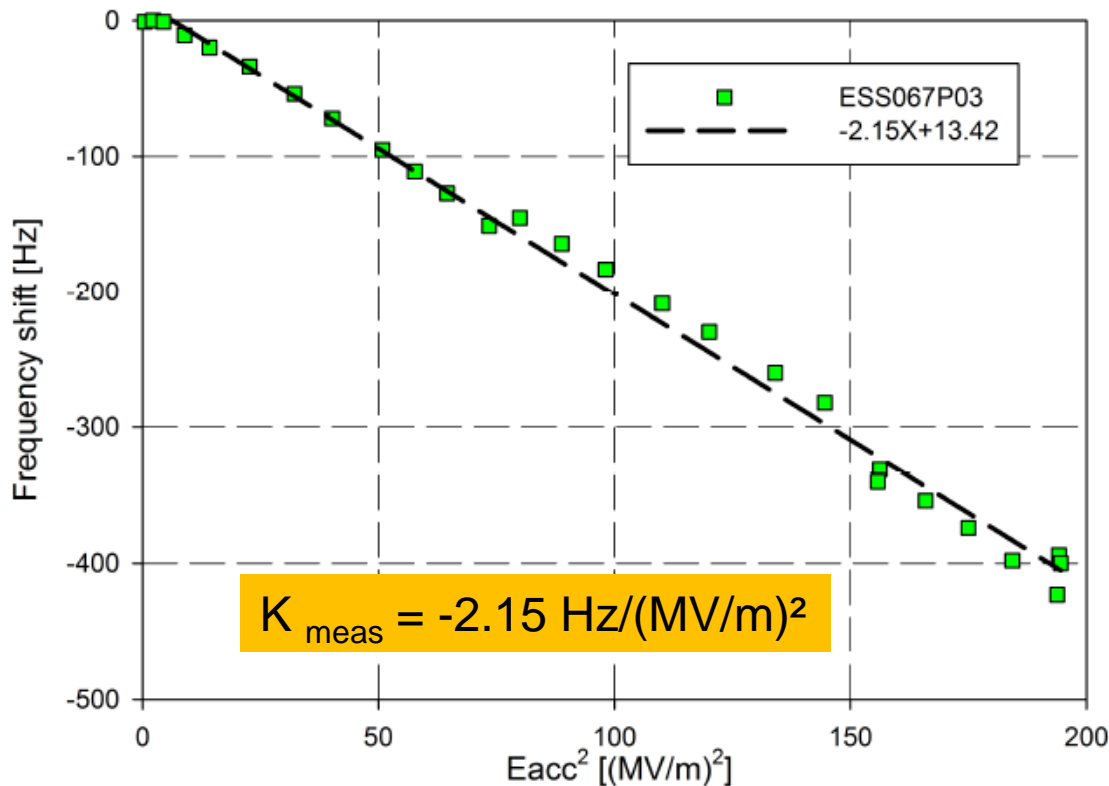
→ most demanding cavity for piezo is Medium beta due to higher Lorentz force detuning.

Previous generation of Saclay-V tuner reached

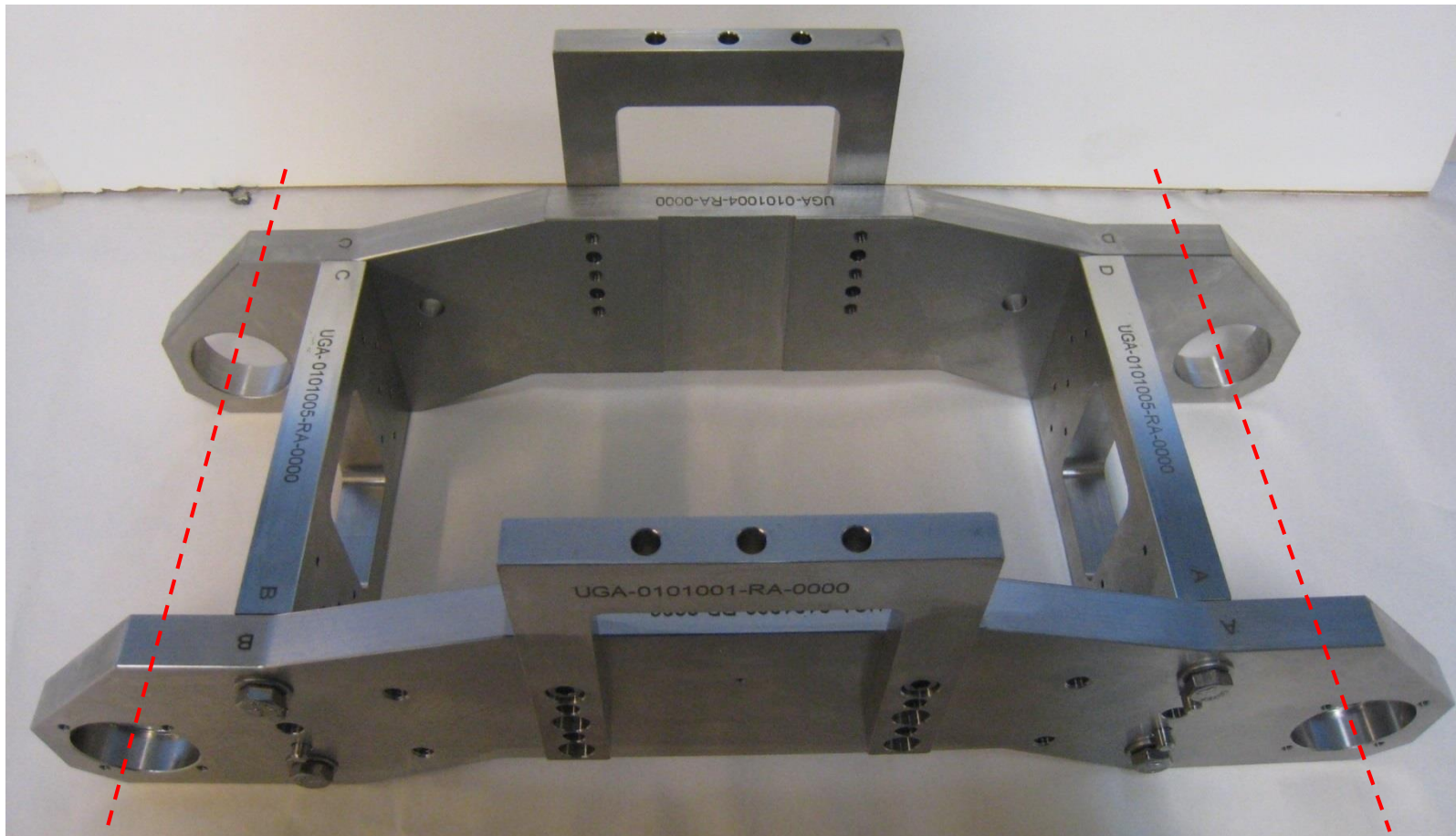
Cavity wall thickness (mm)	4
Tuning sensitivity (kHz/mm)	215
Stiffness (kN/mm)	1.3
K_L static Lorentz coefficient (Hz/(MV/m) ²) (fixed ends)	-0.74
K_L static Lorentz coefficient (Hz/(MV/m) ²)	-23.4
K_L static Lorentz coefficient (Hz/(MV/m) ²) for $K_{ext}=21$ kN/mm (●)	-2.04



Validation of the tuner stiffness efficiency for keeping LFD coefficient at low on beta 0.67 CW test at 2 K. Result is compatible with design value of $K_L = -2.04 \text{ Hz}/(\text{MV}/\text{m})^2$



- No motor nor gear box during test
- Reverse orientation of tuner arms dictated by the vertical test supporting system

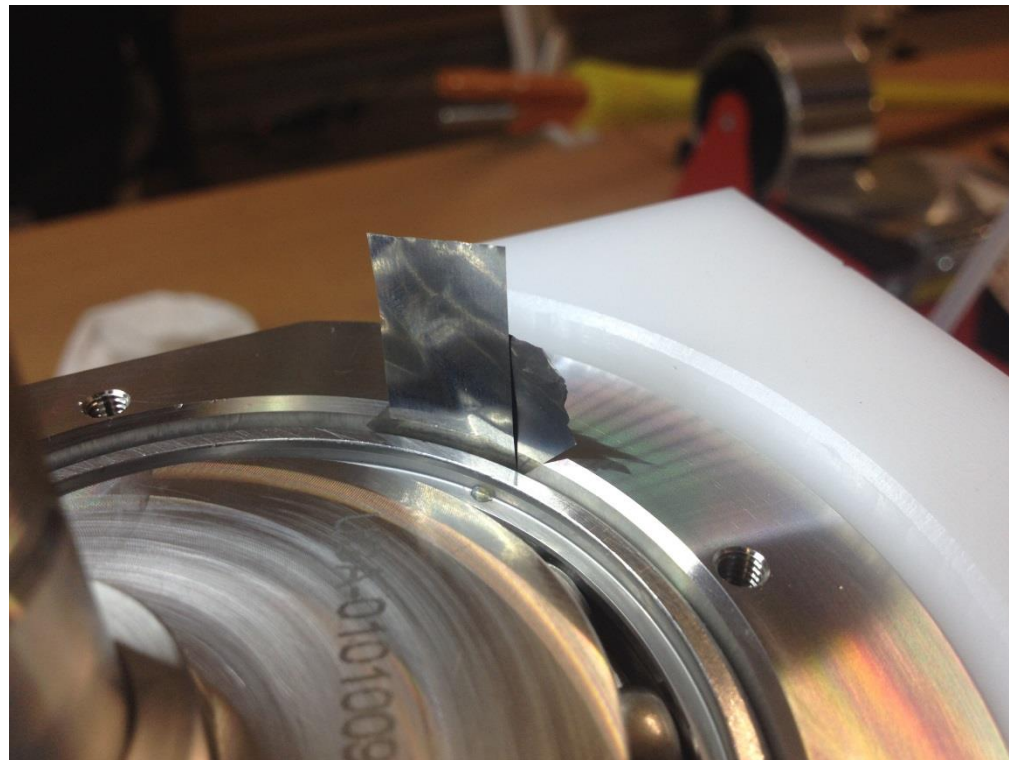


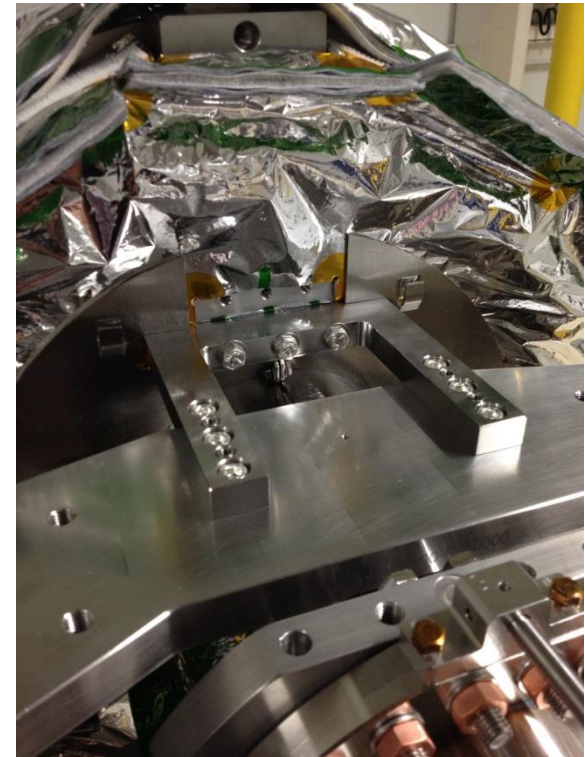
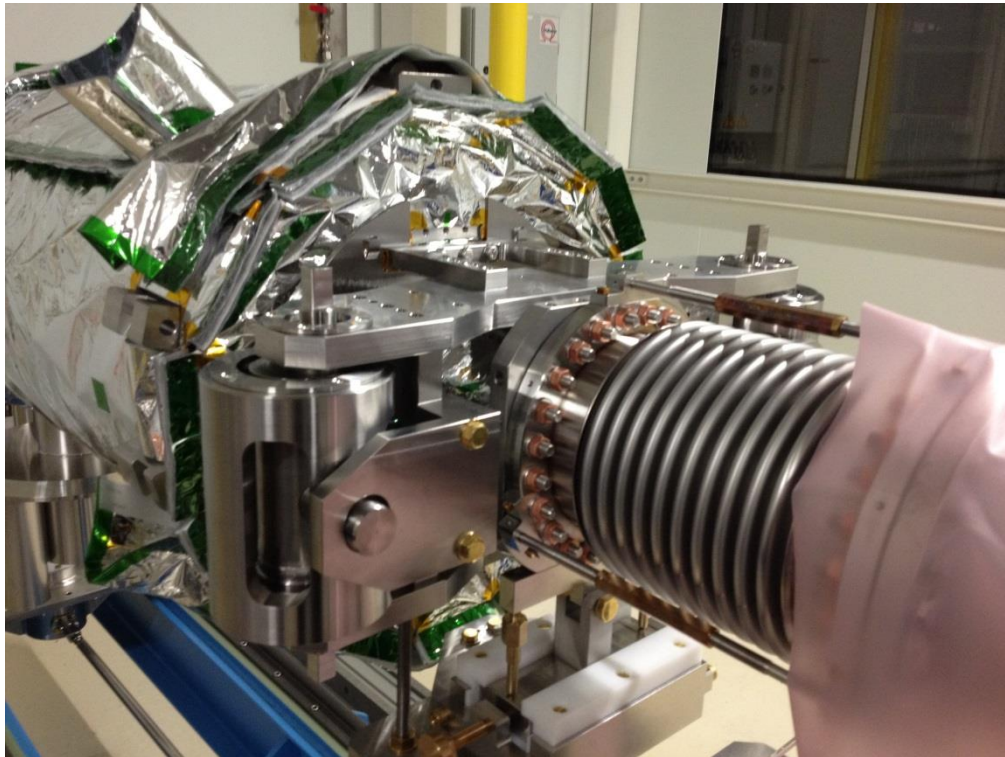
- This frame is assembled around the beam pipe, once the cavity string is sealed and outside of the clean room.
- Required alignment of bearing holes of eccentric shafts is ensured by repeatable accurate assembly (pins, precision machining pairing marks on parts)
- Dedicated tools for assembly

Detailed measurements on one of the ECCTD tuners of mechanical play between bearings and shaft or bore :

maximum observed play shows excellent manufacturing skills :

- Between bearing and shaft : 20 μm (left)
- between bearing casing and bore is 40 μm (right)



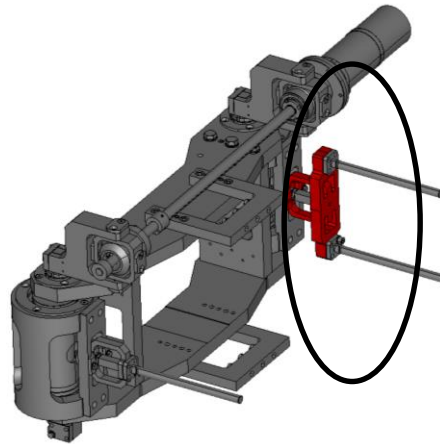


1. Tuners are partially disassembled (6 subassemblies)
2. Frame is rebuilt around the cavity beam tube. Reproducibility of geometry is obtained thanks to alignment pins
3. Dedicated tooling makes assembly accurate and fast

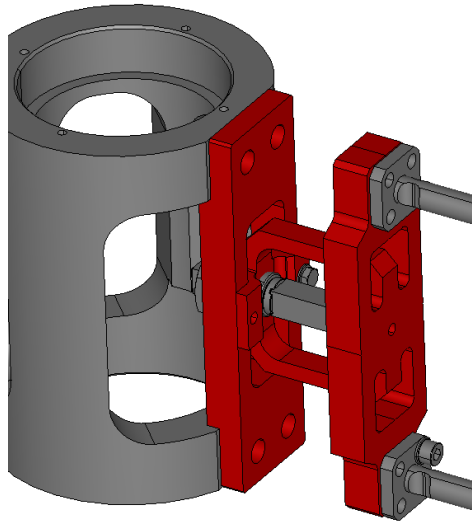
Case of 2 piezos installed symmetrically on each side of the cavity:
 Each side of the tuner deals with an equivalent half of the cavity, so half of its stiffness.
 For each frame, we aim at a stiffness of $10 \times K_{cav} / 2$: the mandatory piezo preload is conserved independantly of the tuner position

	medium beta	High beta
Theoretical cavity stiffness K_{cav} (kN/mm)	1.3	2.82
Maximum cavity stiffness for design (kN/mm)	1.6	3.3 (3.54 measured on most stiff 0.86 prototype)
Maximum force applied to frame (kN) assuming 3mm tuner range	2.4	5.0
Piezo frame stiffness required (kN/mm)	6.45	14.1

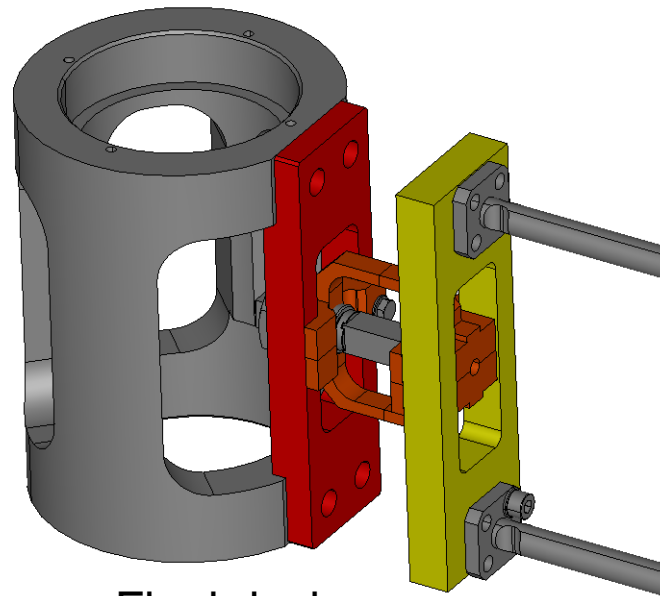
- The high beta cavity sets the parameters for the stiffness of frames and auxillary parts
- A single design can be used for both medium and high beta



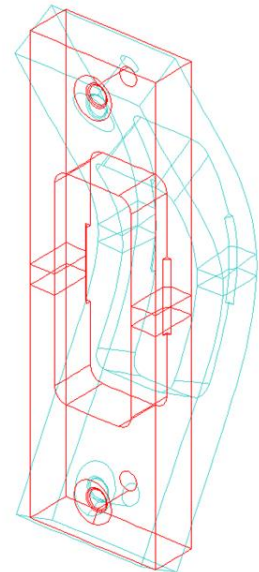
- Cost reduction
 - Less material
 - Less machining
- Improved stiffness



Preliminary design



Final design

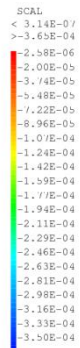
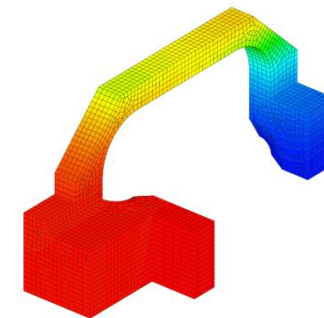
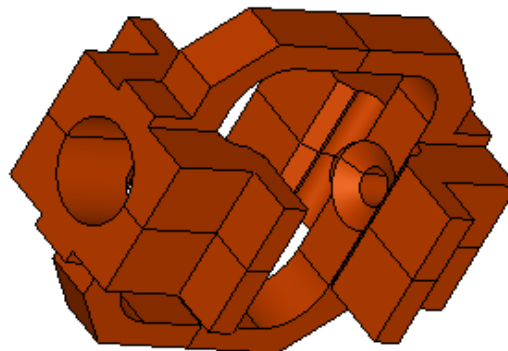
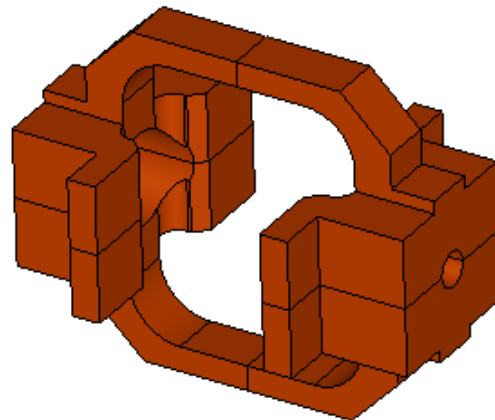
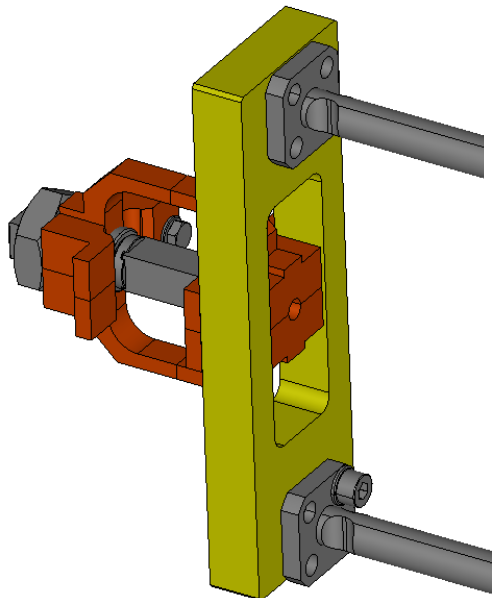


Symmetrical design of the piezo frame

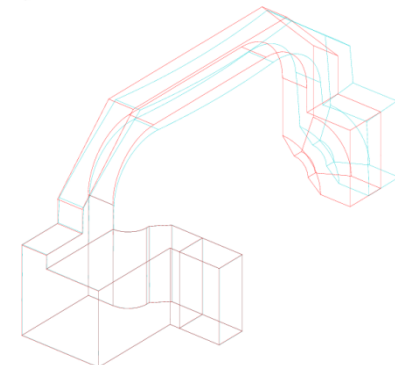
Higher stiffness of 14.7
kN/mm

-> single design for MB and
HB

Symmetrical frame design
helps reducing difference
between left and right
piezo frames

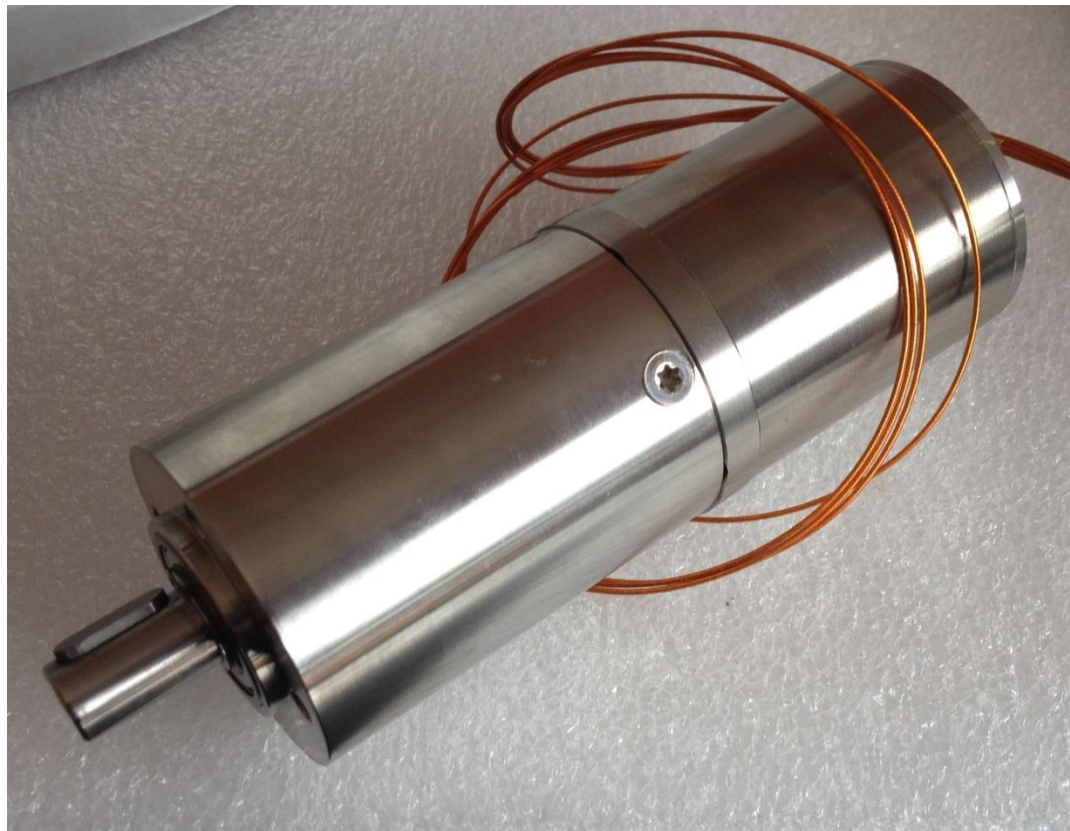


displacmt_1





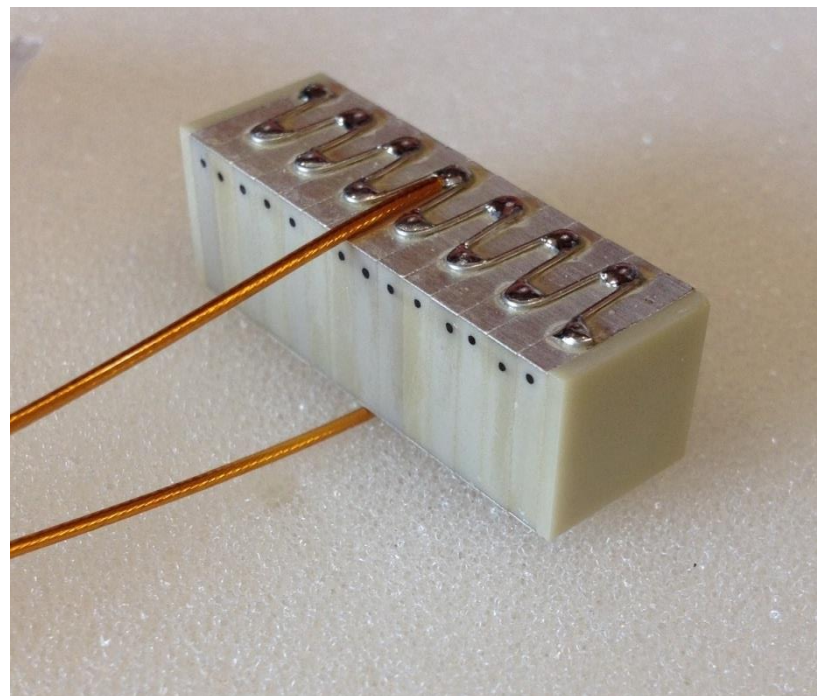
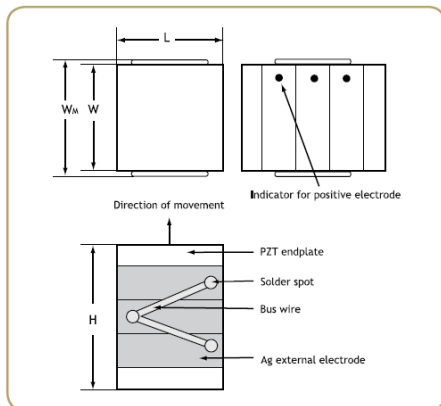
PHYTRON motor
Planetary gear box
1/100 ratio



length	30mm
Max. voltage	200 V
RT stroke	46 μm
RT capacitance (typ.)	5500 μF
4K stroke	~ 0.1 *RT stroke
Blocking force	4200 N

- Noliac piezo stack NAC 2022-H30
- Custom cable (AWG 26)
 - Rad. Resistant Insulator material : extruded polyimide
 - Length 200 mm up to connector

STACKED MULTILAYER ACTUATORS
Typical outline of stacked plates



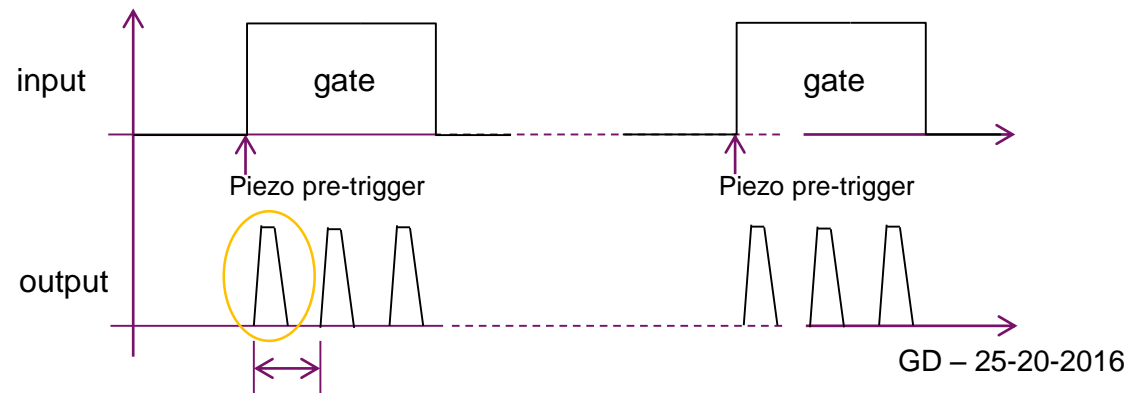
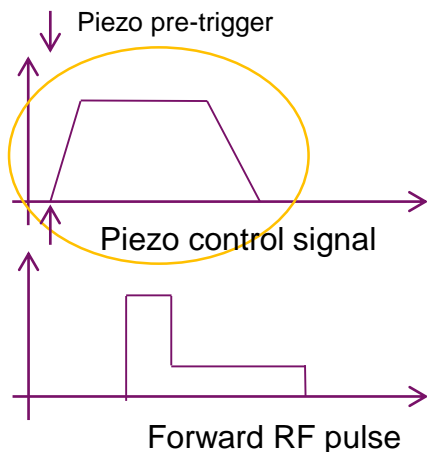
Amplifiers for M-ECCTD : Noliac NDR 6220

- Compact, single channel
- covers the full voltage range of piezo stacks (unipolar mode up to 300V)
- high power 55 W



Piezo signal generation for ECCTD (EPICS+ signal generator):

1. arbitrary mode
2. single or burst of trapezoidal pulses



User adjustable burst period

G. Devanz CEA-Saclay

Procured in 2016 for ECCTDs :

- 8+1 tuners manufactured in 2016 (4 for each ECCTD),
- 8+1 Phytron cryogenic motors with planetary gear boxes
- 20 piezo
- 4+1 piezo amplifiers

Serial procurement in 2017:

Call for tender for serial production of mechanical assemblies launched in march 2017

Order for Phytron motors placed in feb. 2017

Testing configuration of piezo for LFD compensation in ECCTDs is flexible:

- Amplifiers have enough power to drive two piezos in parallel
→ 2 piezo/cavity configuration with a single control voltage
- Routing can be performed on the fly using an amps-to-piezo patchbay
- All cavities can be mechanically excited simultaneously or independantly in order to check the parasitic mechanical excitation of cavity n piezos on cavity m RF frequency

Validation of piezo choice/use is expected after ECCTD testing, ordering will follow (short lead times)