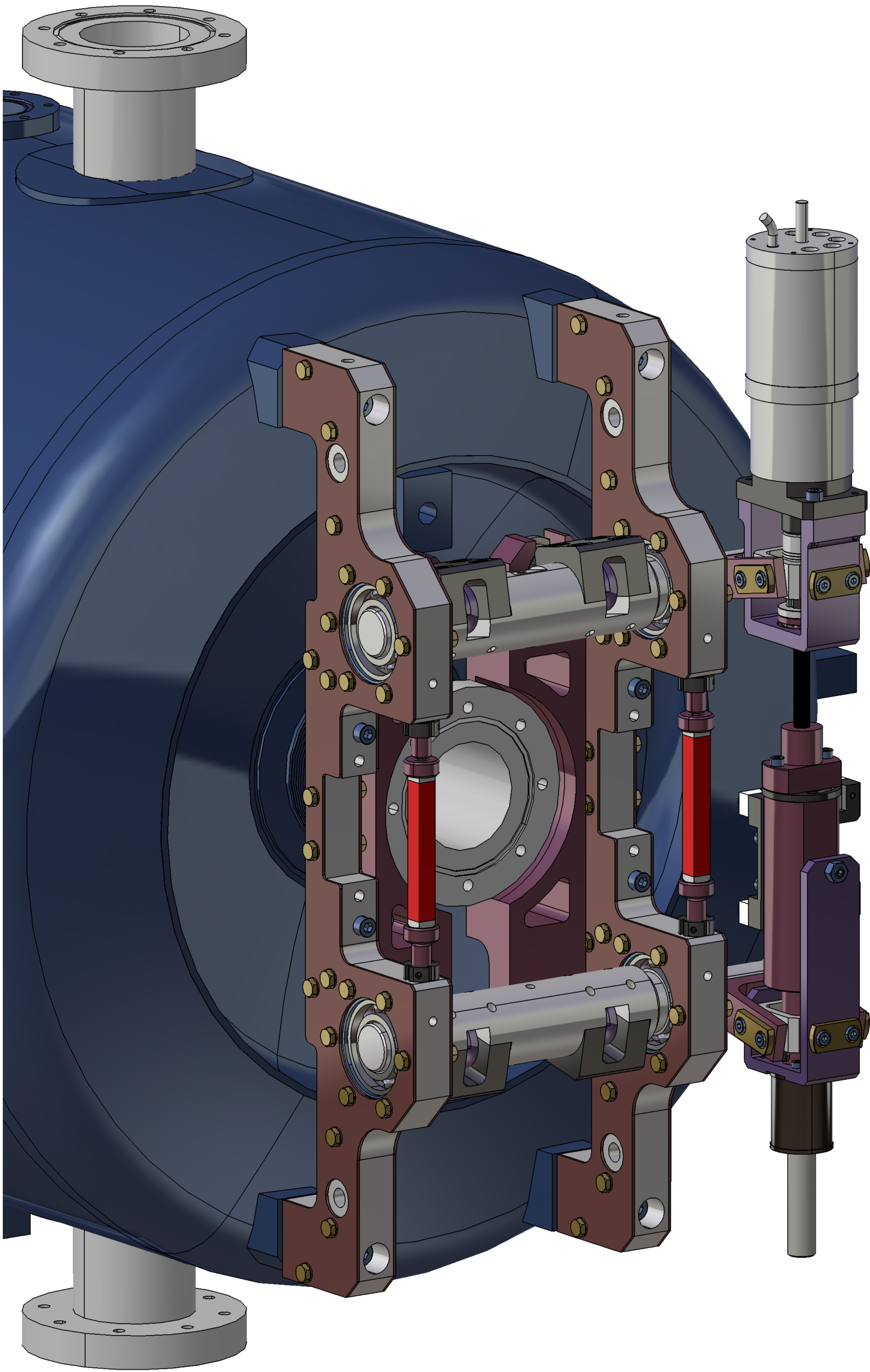


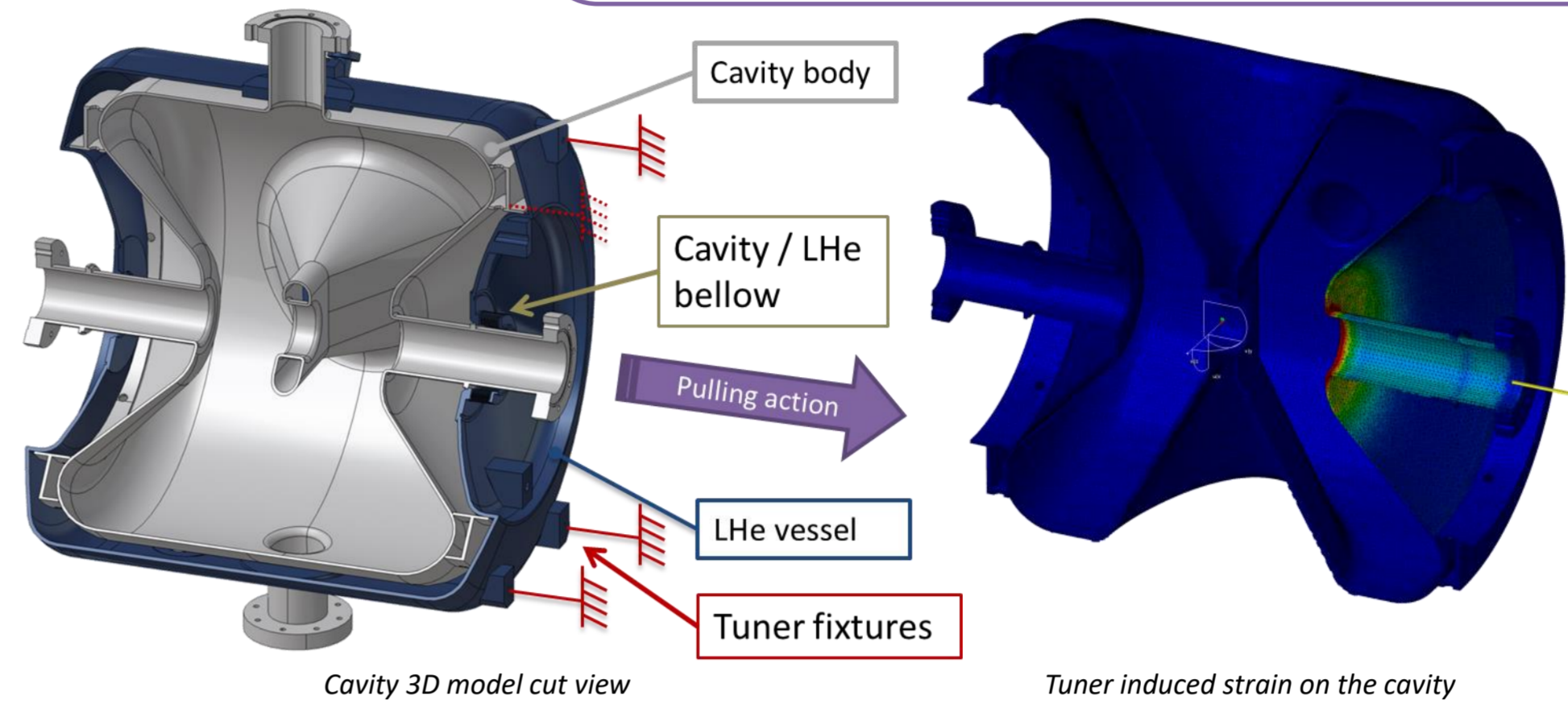


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In the framework of the MINERVA construction (MYRRHA Isotopes productionN coupling the linEar acceleRator to the Versatile proton target fAcility), a fully equipped prototype cryomodule is being developed. In order to control the resonance frequency of the cavities during operation, a deformation tuner has been studied. The kinematic model is based on a double lever system coupled with a screw nut linear actuator. The motion is generated by a stepper motor and two piezoelectric actuators working at low temperatures within the thermal insulation vacuum of the cryomodule. Key parameter of this work is the high tuning speed which is required to fulfil the fault tolerance strategy. This paper reports the design study and first tests of the built tuners at room temperature and in vertical cryostat configuration.

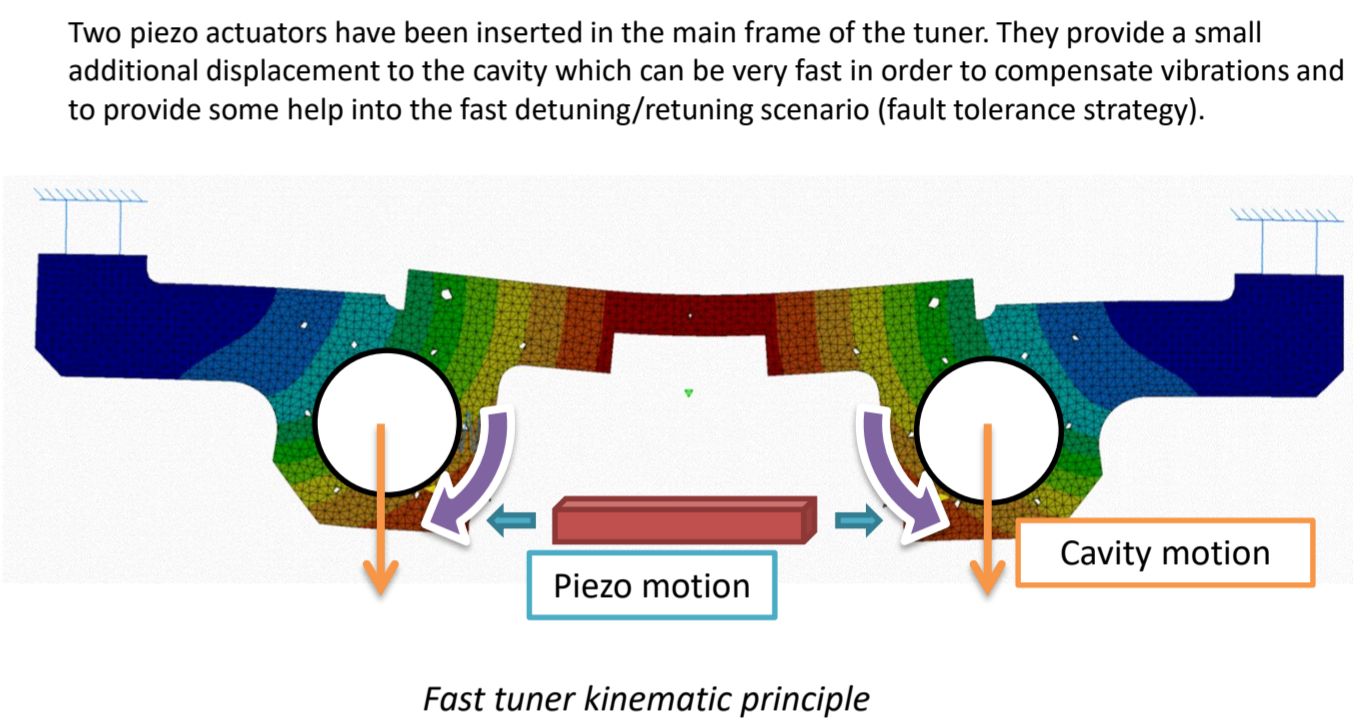
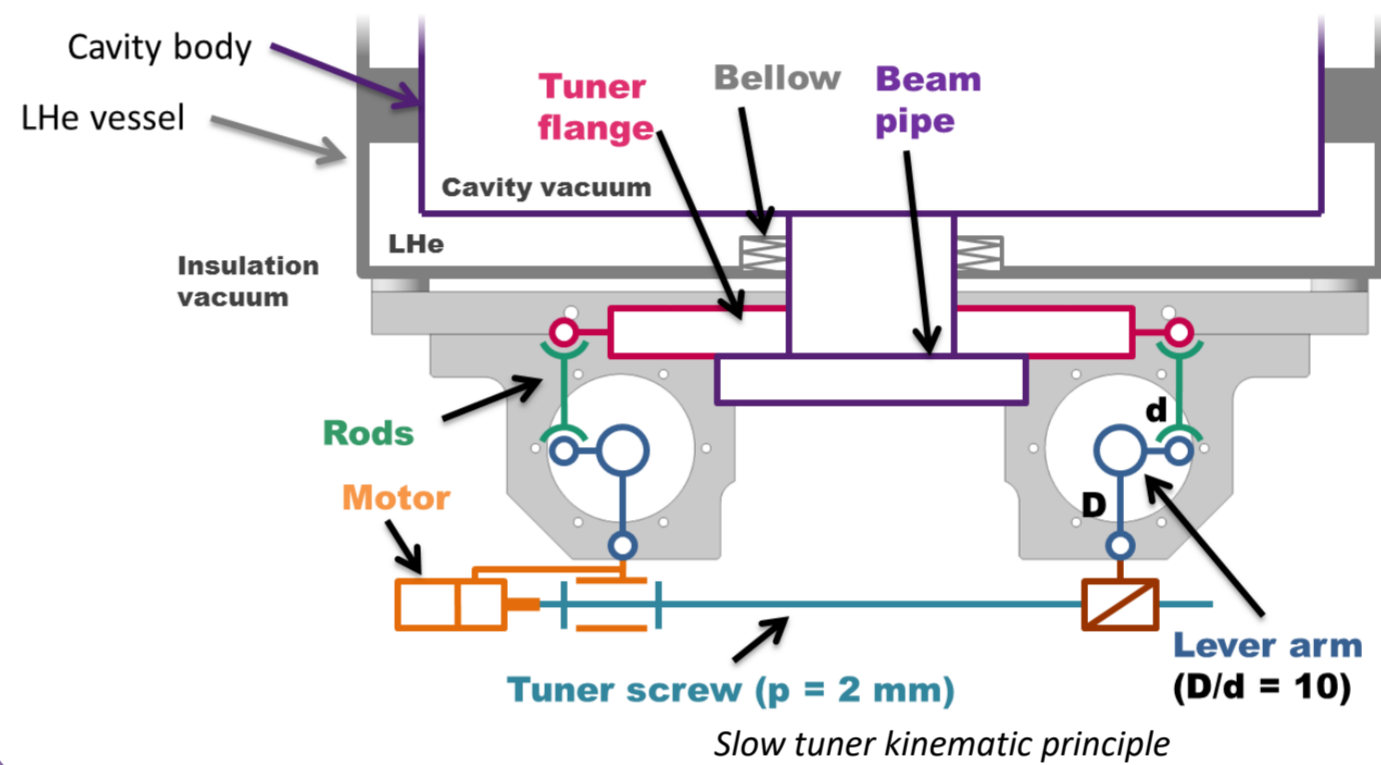


Active tuning concept

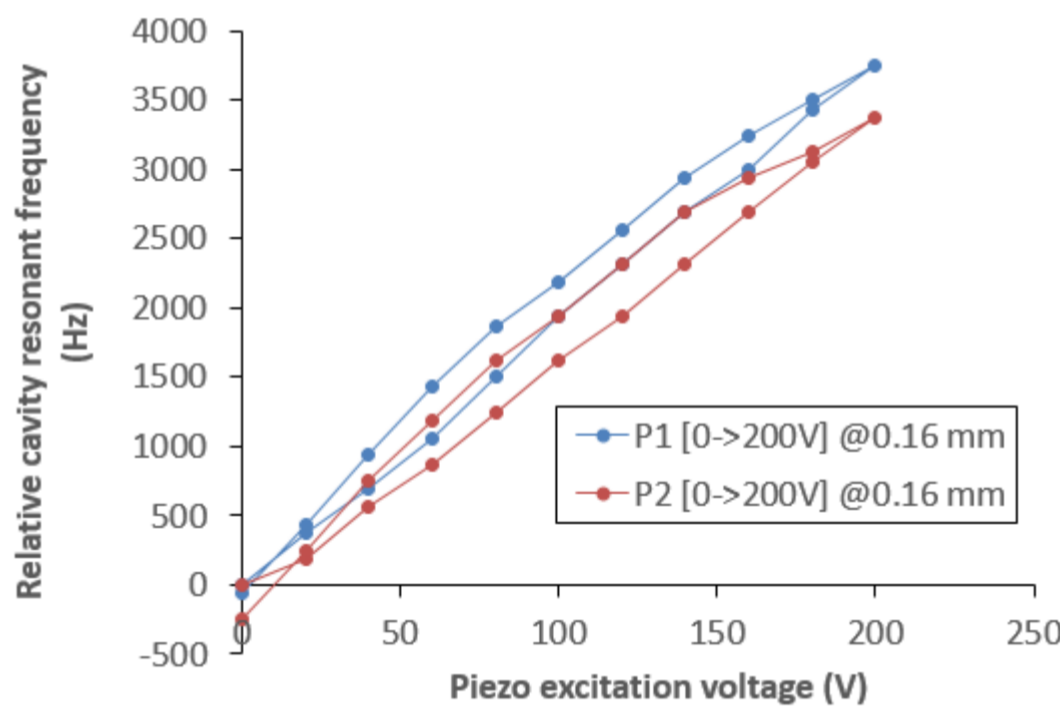
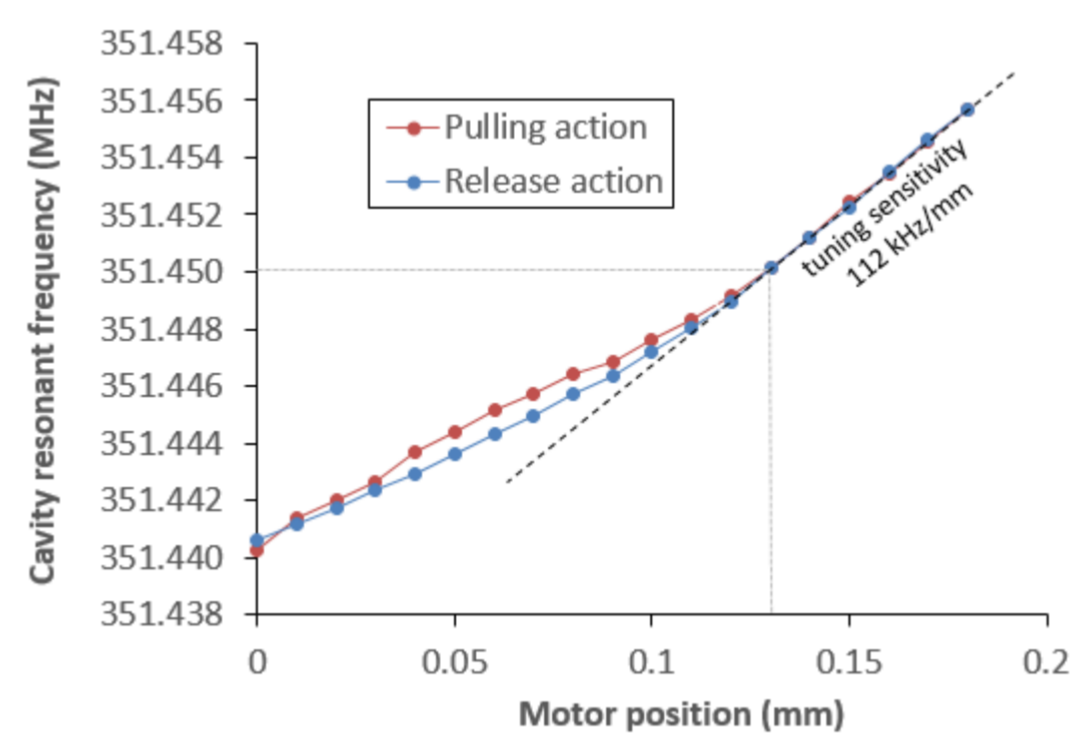


| Cavity/tuner parameters | Unit | Value |
|-------------------------|----------|--------|
| Frequency sensitivity | kHz/mm | 180 |
| Stress sensitivity | MPa/mm | 367 |
| Stiffness | kN/mm | 15 |
| Cavity bandwidth | Hz | 160 |
| Motor resolution | Step/rev | 200 |
| Gearhead ratio | | 6.25:1 |
| Roller screw pitch | mm | 2 |
| Lever arm ratio | | 20 |
| Displacement resolution | µm/step | 0.08 |
| Frequency resolution | Hz/step | < 14.5 |

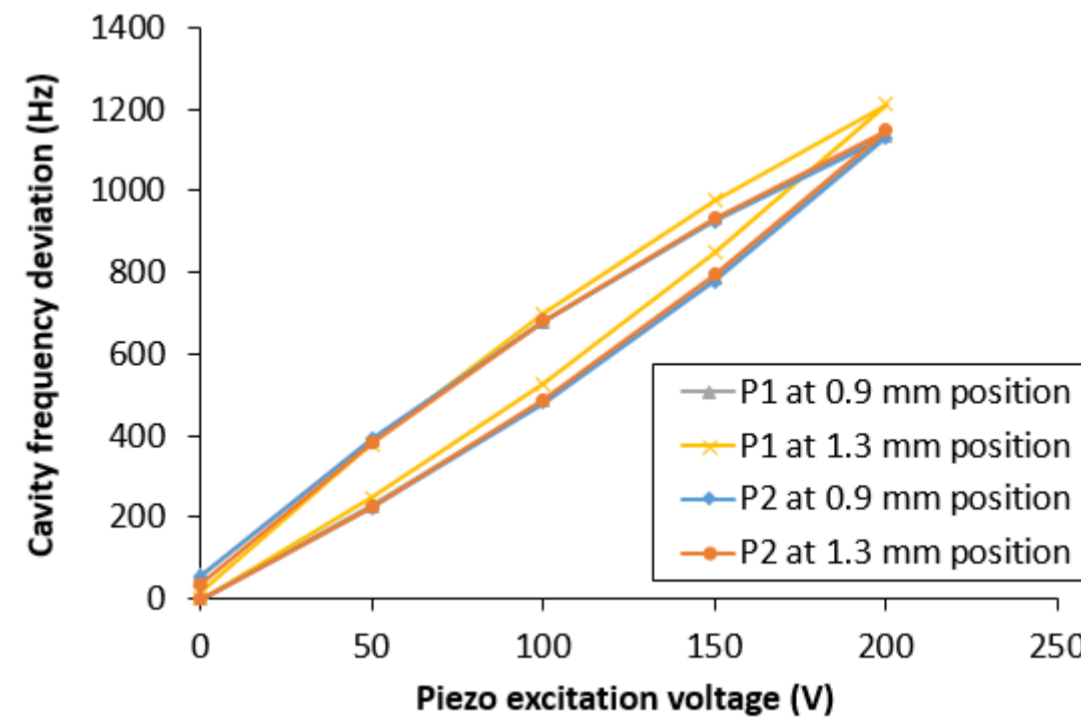
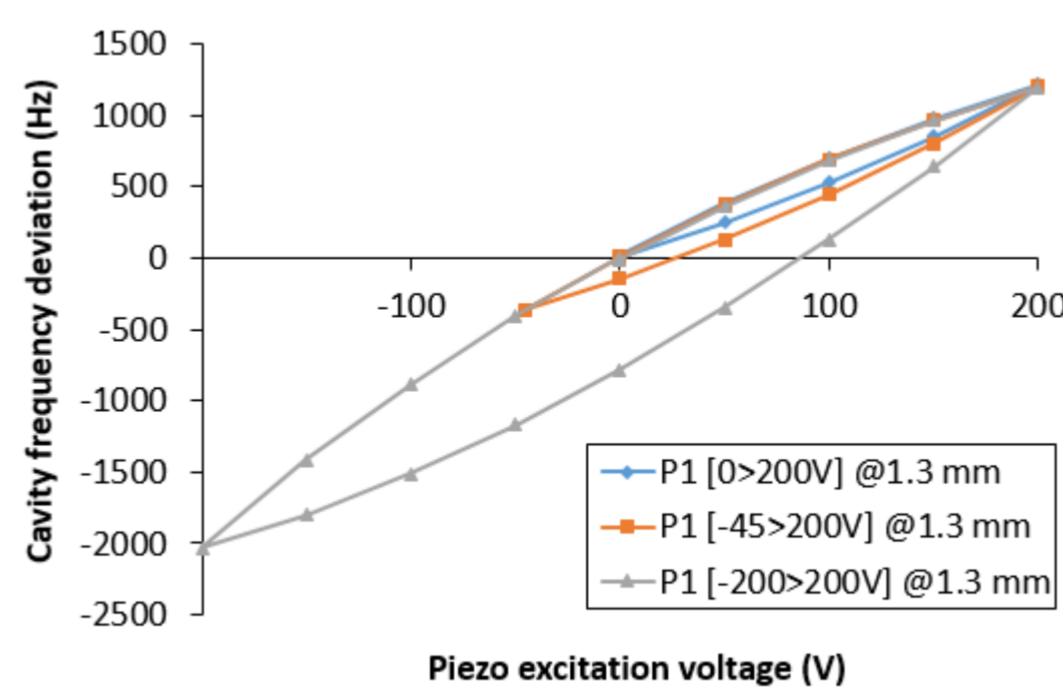
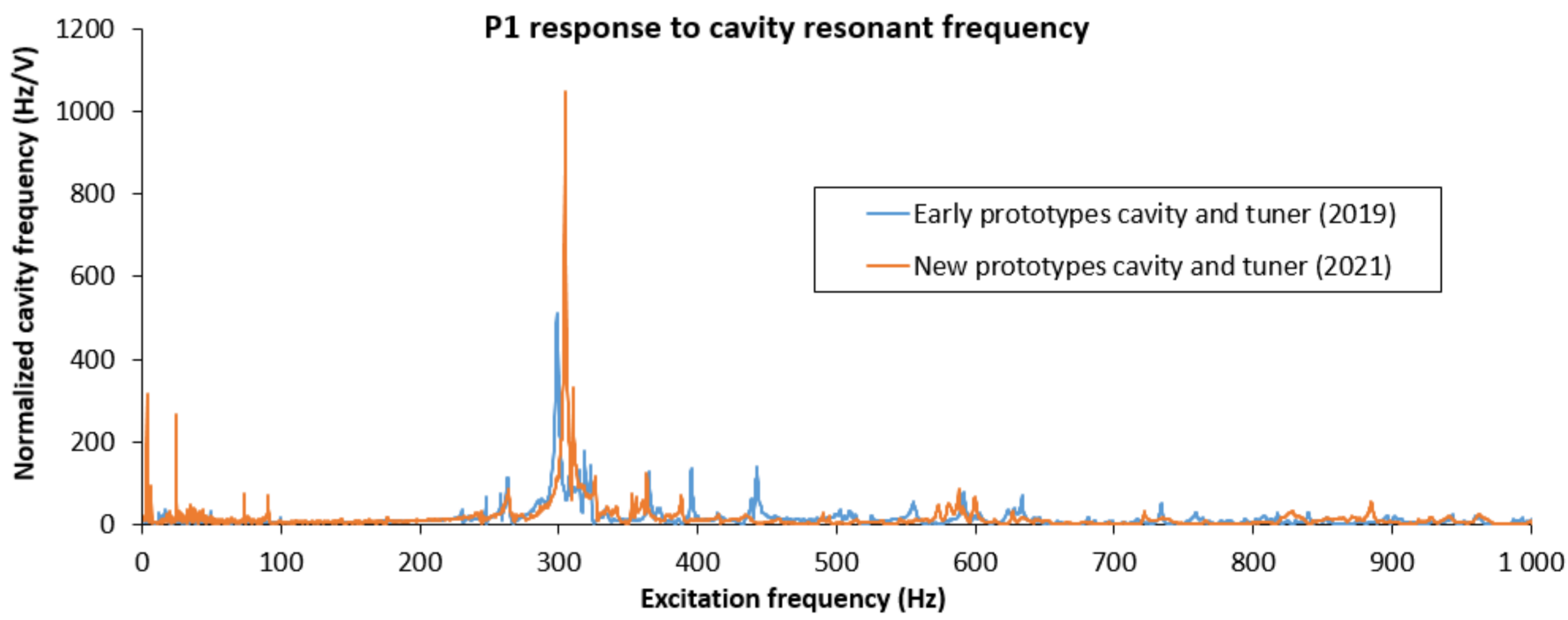
The tuner is mounted on the liquid helium vessel which is welded on the cavity body (rigid connection). Then it pulls the cavity beam pipe flange along the beam axis. Maximum force applied is 13.1 kN and corresponds to a deformation of 0.87 mm and a frequency shift of 158 kHz. The mechanical system is composed of several elements: a roller screw system driven by a stepper motor acts on a double lever arm mechanism to provide a significantly reduced displacement of the cavity flange. Additional information on the cryomodule integration of the tuner and cavity can be found on MOP098 H. Saugnac.



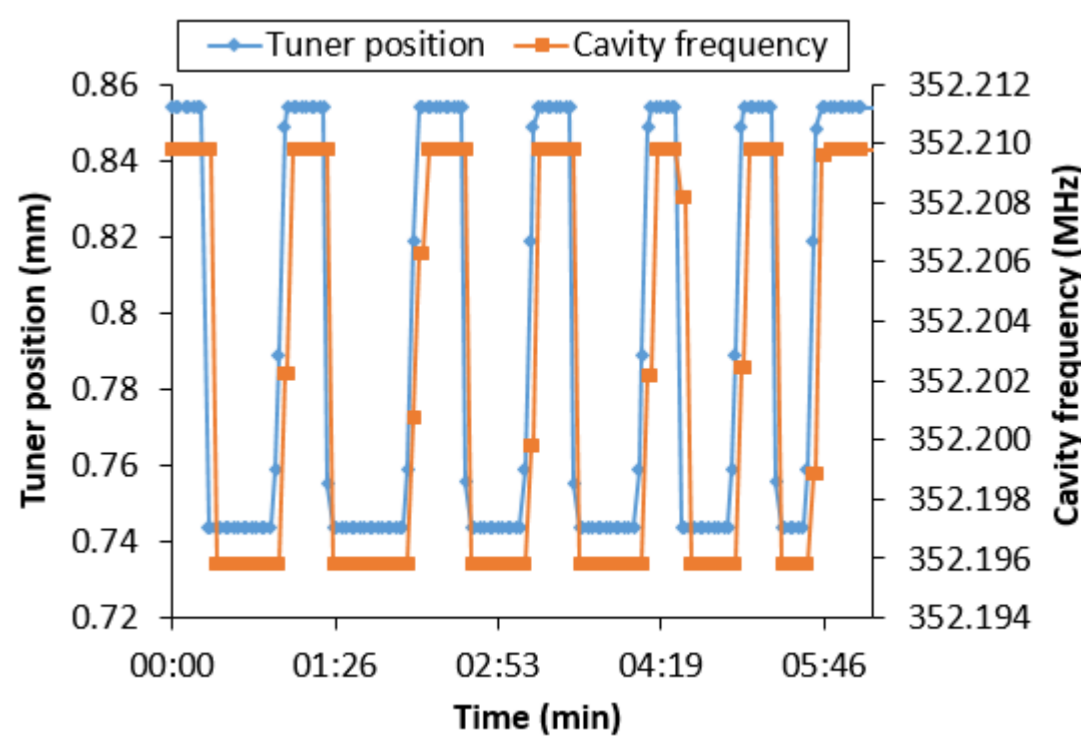
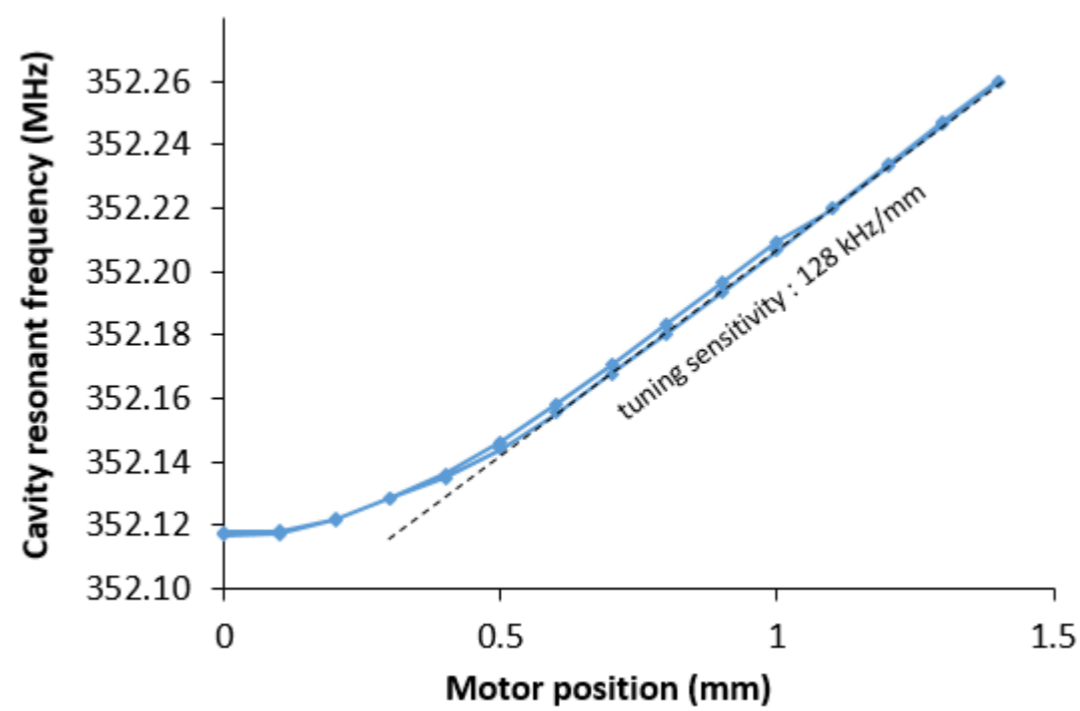
Slow tuner tests (at 300K)



Fast tuner tests (at 2K)



Slow tuner tests (at 2K)



Actuators specifications

- Motor :**
- Manufactured by Phyttron
 - Nominal speed : 100 rev/min
 - Max speed : 600 rev/min
 - Overall dimensions (øxL): ø57 x 119 mm
 - Weight : 1.7 kg
 - Nominal current : 1.2 A
 - Planetary gear head with 6.25:1 ratio
 - Radiation tolerant up to 10⁶ J/kg
 - Vacuum and cryogenics compatible



- Piezos :**
- Manufactured by CTS (Noliac)
 - Dimensions : 72x40x10 mm
 - Capacitance : 13.9 µF (at 300 K)
 - Stroke : 115.5 µF (at 300 K; 0 to 200 V)
 - Blocking force : 4200 N
 - Max voltage : 200 V

