HIGH POWER PULSED TESTS OF A BETA=0.5 5-CELL 704 MHZ SUPERCONDUCTING CAVITY

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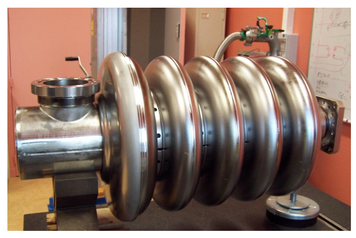
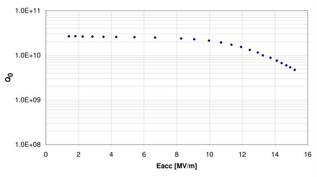
A β = 0.5 5-cell 704 MHz cavity was developed in the framework of European R&D programs on high intensity pulsed proton injectors. Medium beta elliptical cavities are known to be sensitive to Lorentz detuning, which can become difficult to deal with in pulsed operation. The cavity was optimized to reduce the Lorentz detuning by means of two series of rings welded around the irises, and equipped with a piezo tuning system. In order to test the cavity in pulsed mode, a power coupler with 1 MW capability was connected to the cavity.

We report here on the fully equipped cavity tests at 1.8 K carried out in the horizontal cryostat Cryholab at Saclay to study its RF and mechanical behavior in pulsed mode, mostly with 2 ms pulses at a 50 Hz repetition rate. The compensation of Lorentz force detuning has been achieved at an accelerating gradient of 13 MV/m (44 MV/m peak surface electric field).

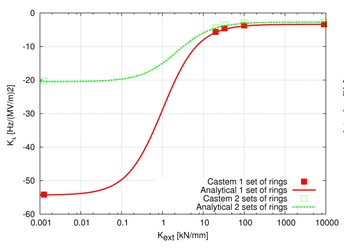
CAVITY PARAMETERS	
RF frequency	704 MHz
Cavity geometrical beta	0.47
Optimal beta	0.52
Bpk/Eacc [mT/(MV/m)]	5.59
Epk/Eacc	3.36
G [Ohm]	161
r/Q [Ohms]	173
Repetition frequency	50 Hz
RF pulse length	2 ms
Number of stiffening rings sets	2
Stiffness (kN/mm)	2.25
Static KL (Hz/(MV/M)^2)	-3.8 (meas.)
Tuning sensistivity (kHz/mm)	300

β = 0.5 704 MHz cavity

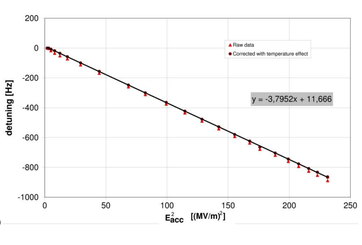




Test of cavity at 1.8 K in vertical cryostat

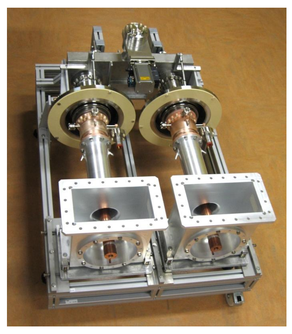


Optimised K_L

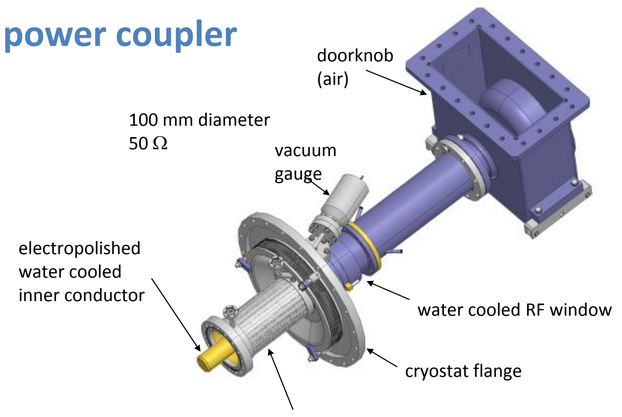


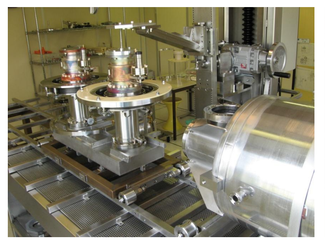
K_L measurement in vertical cryostat

1MW, 10% duty cycle power coupler

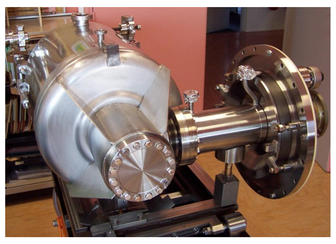


Conditioned on the room temperature test stand up to 1.2 MW (2ms, 50Hz pulses)

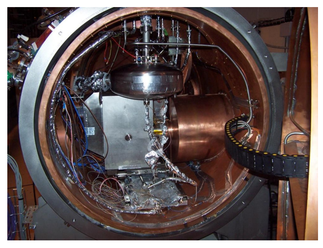




Coupler transfer from coupling waveguide to the cavity in the clean room

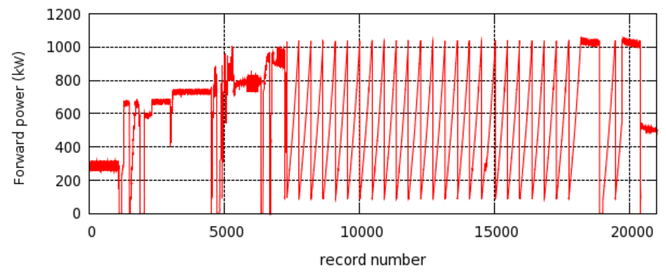


Full assembly

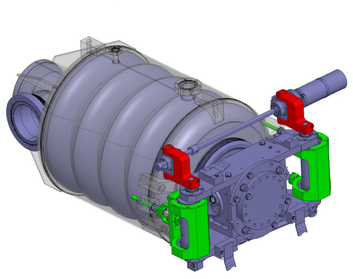


Installed in cryolab with magnetic and thermal shields

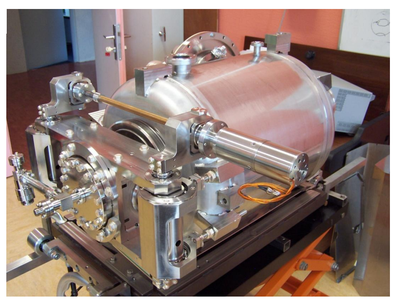
Conditioning of one coupler connected to the cavity at 4.5 K in full reflection at nominal 10% duty cycle

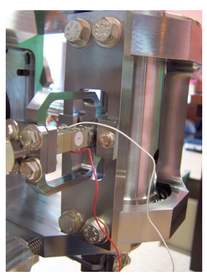


Saclay V piezo tuner



- Planetary gear box (3 stages)
- Single NOLIAC 30 mm piezo actuator to compensate for Lorentz Force Detuning (Max voltage 200 V)
- Slow tuner with symmetric action
- Stiffness measured on the tuner pneumatic jack = 35 kN/mm

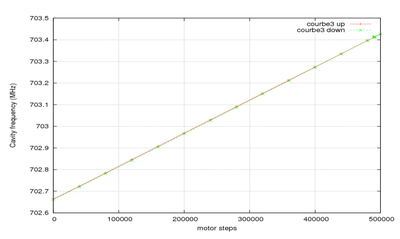


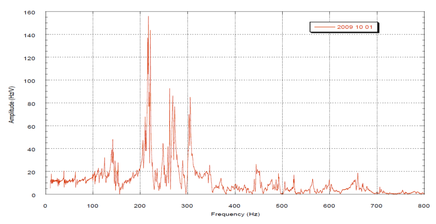


- Single piezo
- Piezo frame ensures
  - adjustable preload
  - makes preload independent of cavity spring-back force which varies with tuning position

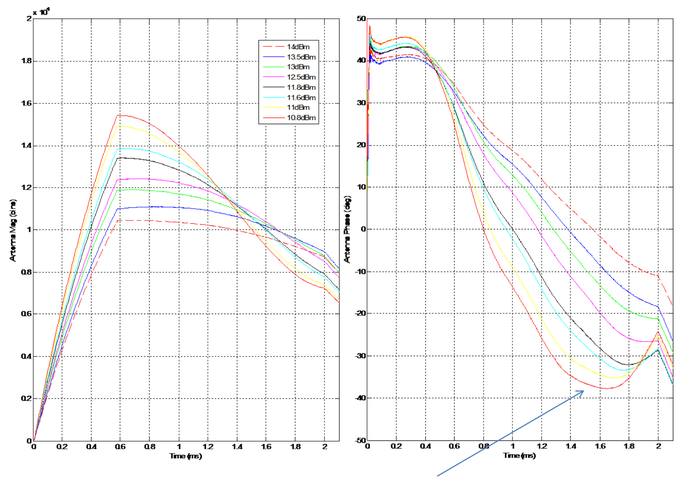
Measurements in horizontal cryostat

- very good linearity
- positive tuning range 760 kHz
- corresponds to 2.5 mm elongation of the cavity (theor. amplitude is +2.7 mm, tuner deforms by 0.16 mm due to cavity spring-back force at full extension
- piezo voltage to cavity detuning transfer function



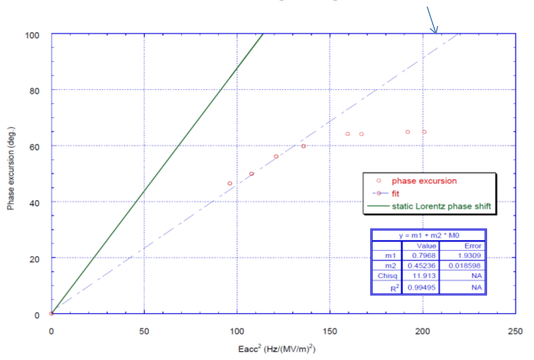


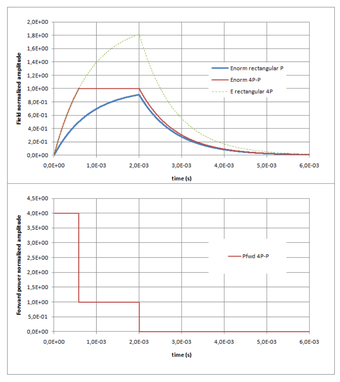
Lorentz force detuning in pulsed mode



- Eacc between 9.8 and 14.3 MV/m (measured at the end of filling time)
- Fixed RF source frequency
- Flat top of 1.4 ms simulated with 4P-P scheme

Saturation of LFD for higher gradients

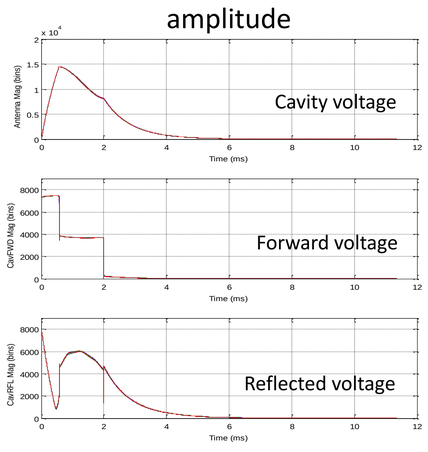




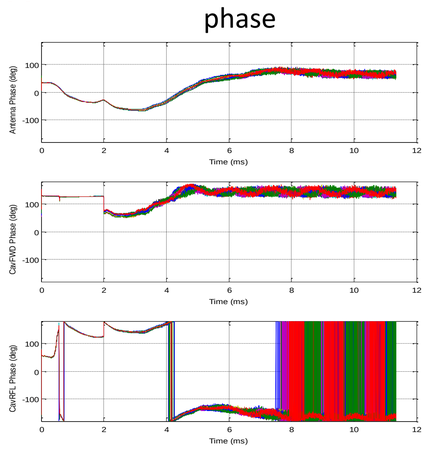
Lorentz force compensation with Saclay V piezo tuner

Piezo OFF

amplitude



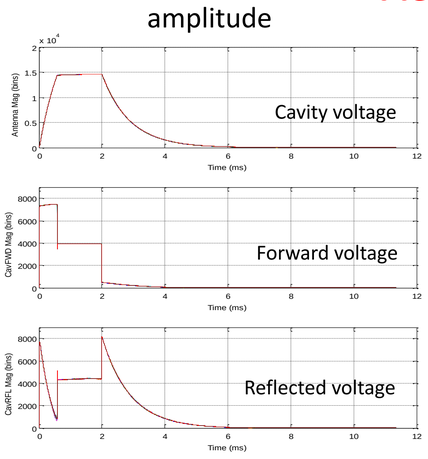
phase



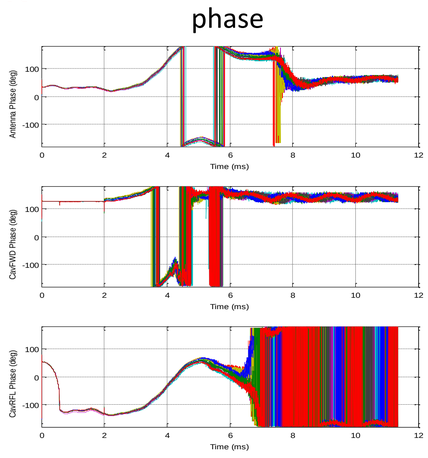
Eacc=13 MV/m
repetition frequency = 50Hz
RF pulse length = 2ms

Piezo ON

amplitude

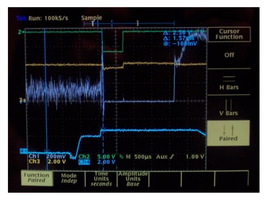


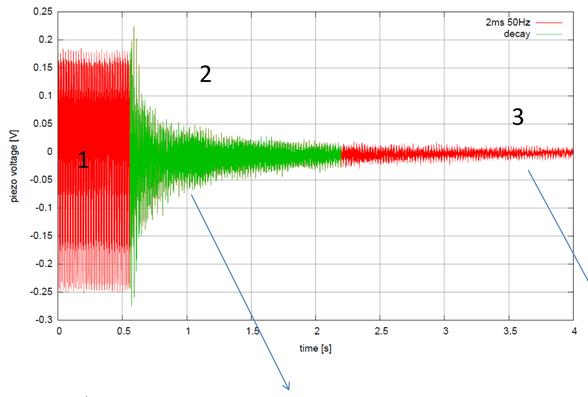
phase



LFD Compensation achieved setting manually signal generators driving the piezo actuator. The piezo drive signal starts 940 µs before the RF pulse (amplitude is 60 V)

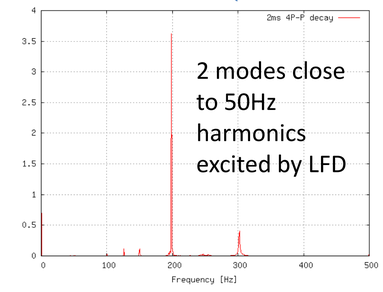
LFD effect on Vcav at 13 MV/m		
compensation	OFF	ON
Amplitude variation (%)	45	1.4
Peak-to peak phase excursion (deg)	50	16





Piezo used as a sensor:

1. Cavity pulsed at 50 Hz, 2ms into mechanical steady state
2. RF is switched off : free oscillation of mechanical modes excited by LFD
3. After mode damping, environemental vibration



2 modes close to 50Hz harmonics excited by LFD