SC Cavity Dynamic Detuning Modeling

(M. Doleans)

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Thanks to people: Ricky Campisi
Jean Delayen
Kirk Davis
Steve Smee
Mark Champion
Sang-ho Kim

Motivations:

- To have a global picture of Lorentz detuning in SCRF

→ Dynamic detuning : - From Lorentz forces in pulsed operation
- From piezo action

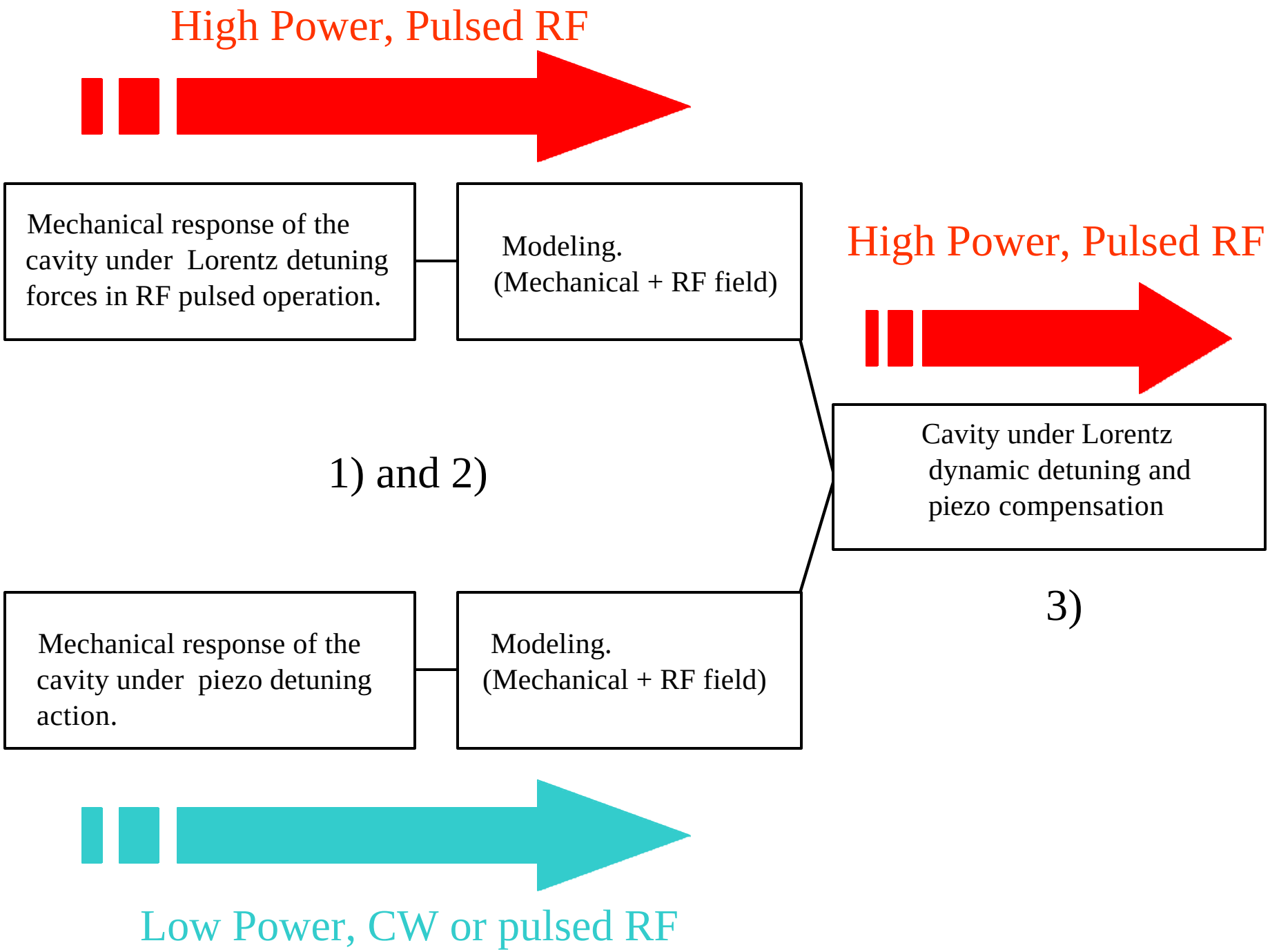
→ Behavior of the cavity field under dynamic detuning

2) To have a proper modeling

→ Modeling of the cavity mechanical response under: - Lorentz forces excitation
- Piezo excitation

→ Modeling of the cavity field evolution during dynamic detuning

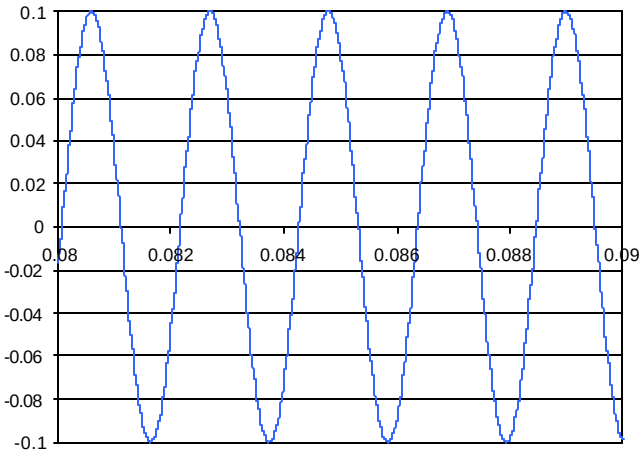
3) Find an adequate piezo excitation form to compensate the Lorentz detuning during beam pulse


High Power, Pulsed RF
Mechanical response of the cavity under Lorentz detuning forces in RF pulsed operation.
Modeling. (Mechanical + RF field)
High Power, Pulsed RF
1) and 2)
Cavity under Lorentz dynamic detuning and piezo compensation
3)
Mechanical response of the cavity under piezo detuning action.
Modeling. (Mechanical + RF field)
Low Power, CW or pulsed RF

Modeling of the field behavior for a cavity under sinusoidal detuning.

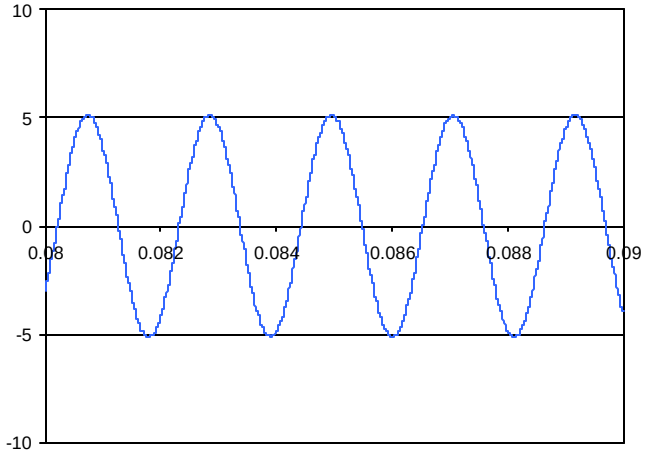
(Behavior in steady state)

Sinusoidal detuning



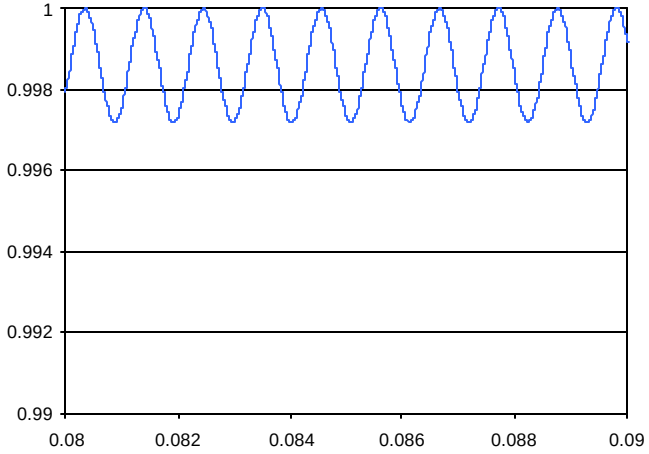
time (s)

cavity voltage phase (deg)



time (s)

cavity voltage amplitude (normalized)



time (s)

Amplitude of the detuning expressed in fraction of cavity half-bandwidth.

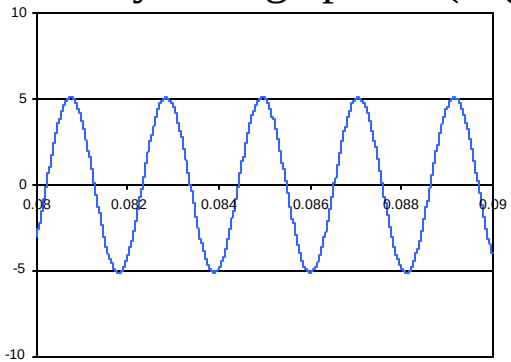
1 half-bandwitdh for SNS medium beta cavity ~ 1Khz

Amplitude of detuning : +/-100Hz
Frequency of detuning : 500Hz

View in polar plot

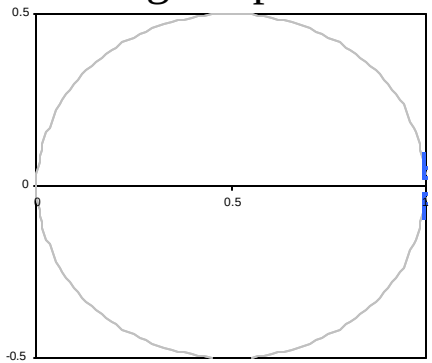
(Frequency of detuning : 500Hz)

cavity voltage phase (deg)



time (s)

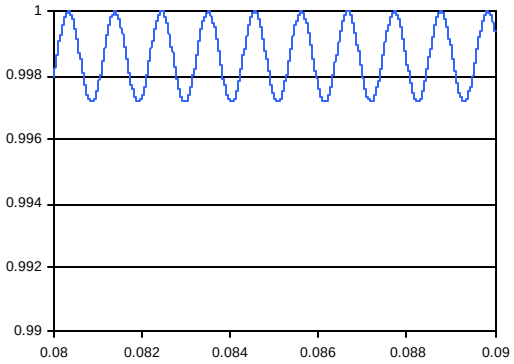
Voltage in polar view



Im

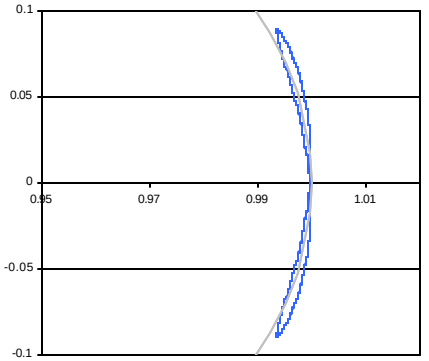
Re

cavity amplitude (normalized)



time (s)

Voltage in polar view



Im

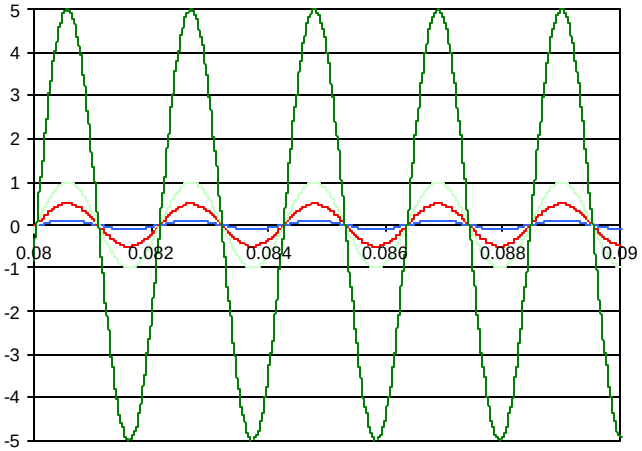
Re

The behavior of the field of a cavity under dynamic detuning is more complicated than in the static case

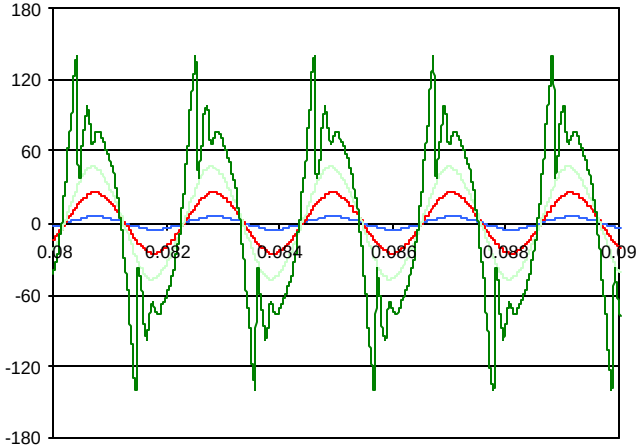
Modeling of the field behavior for a cavity under sinusoidal detuning, and different amplitudes of detuning

(Frequency of detuning : 500Hz)

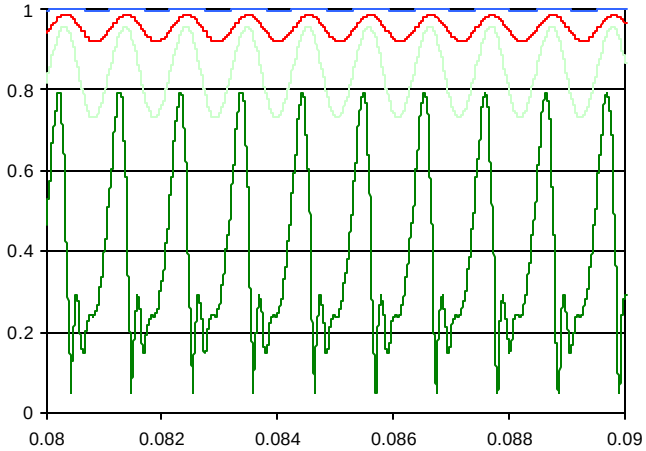
Sinusoidal detuning



cavity voltage phase (deg)



cavity amplitude (normalized)



Curve description, amplitude of the detuning

Blue: +/-100Hz

red: +/-500Hz

Light_green: +/-1000Hz

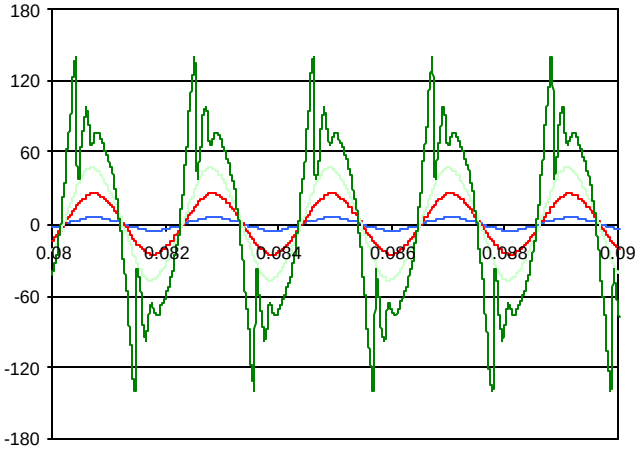
Dark_green: +/-5000Hz

For large amplitude of dynamic detuning the field behavior can take complicated shape

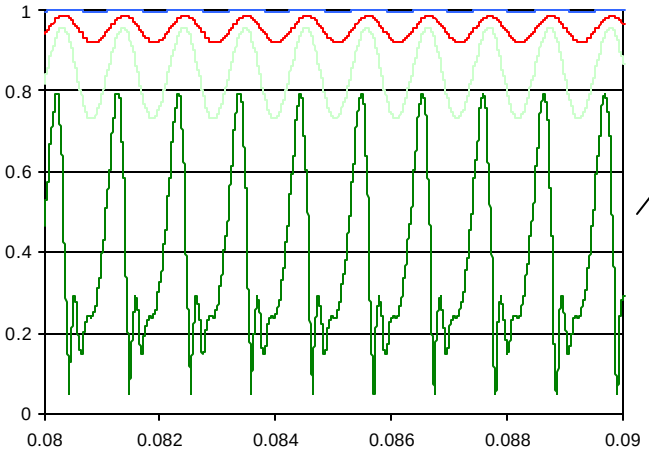
View in polar plot

(Frequency of detuning : 500Hz)

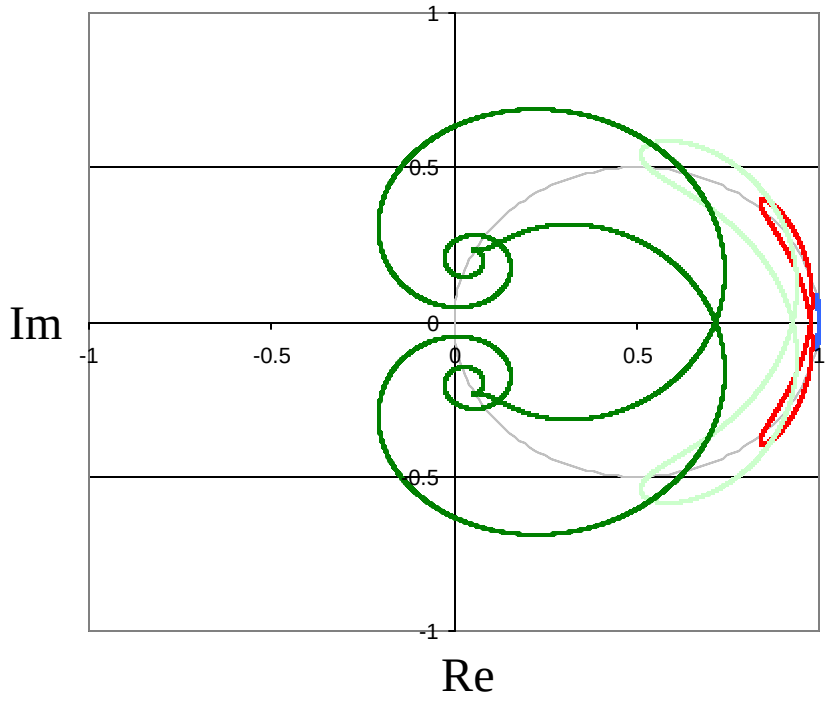
cavity voltage phase (deg)



cavity amplitude (normalized)



Voltage in polar view



Curve description, amplitude of the detuning

Blue: +/-100Hz

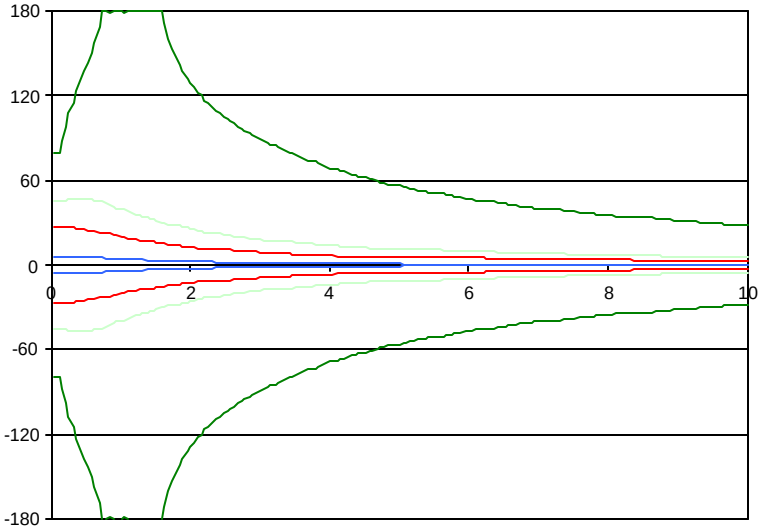
red: +/-500Hz

Light_green: +/-1000Hz

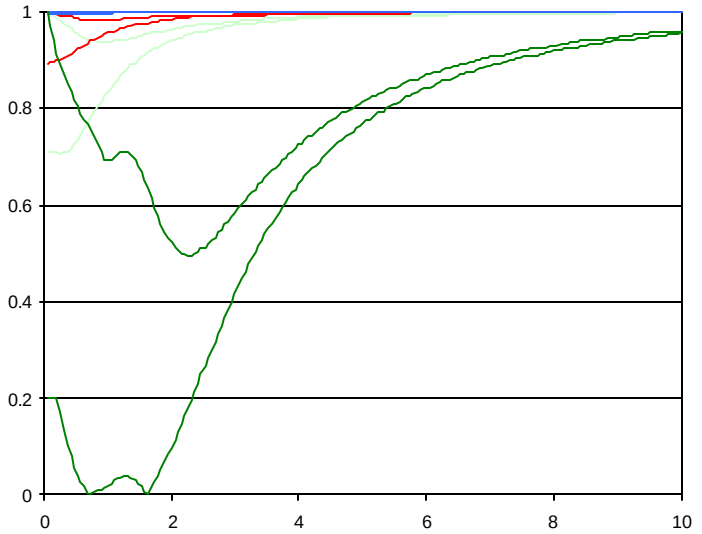
Dark_green: +/-5000Hz

Dependence on the frequency of the detuning

Max. and min. of the cavity voltage phase (deg)



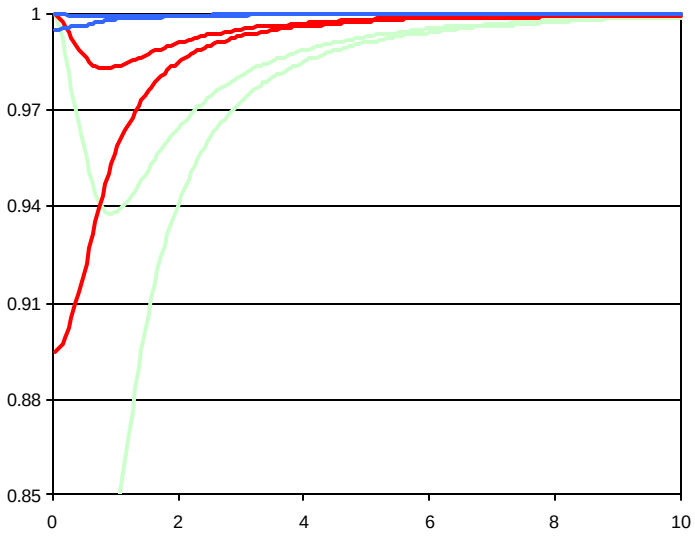
Max. and min. of the cavity voltage amplitude



Frequency of the detuning in fraction of the cavity Half-bandwidth.

The field can not follow very fast detuning compare to the cavity half bandwidth.

Max. and min. of the cavity voltage amplitude



Curve description, amplitude of the detuning

Blue: +/-100Hz

red: +/-500Hz

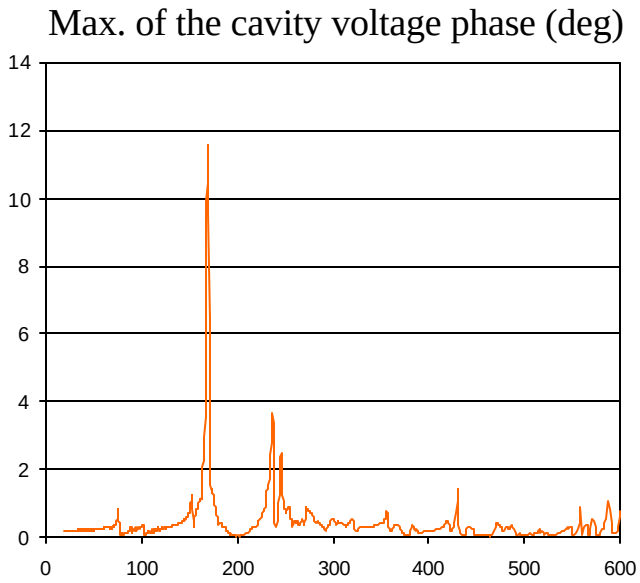
Light_green: +/-1000Hz

Dark_green: +/-5000Hz

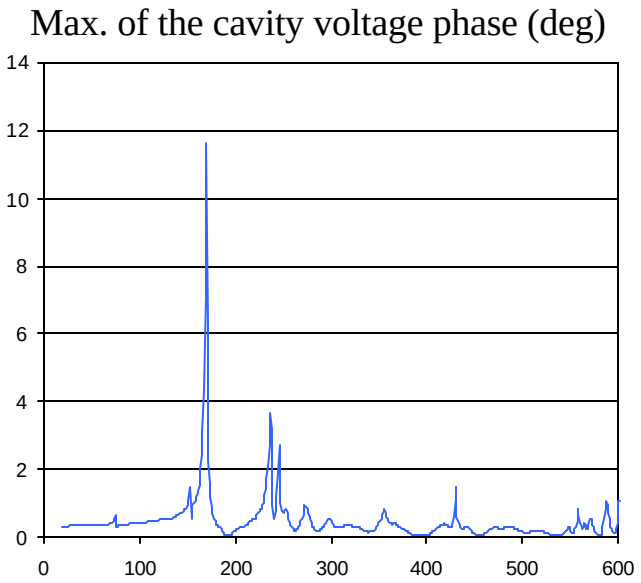
Modeling of the cavity mechanical response under sinusoidal piezo excitation

Cavity operated in
Low power CW
Open loop
Under sinusoidal piezo excitation,
fixed amplitude (~10mV)

modeling
Orthogonal set of mechanical modes
2nd order differential equation for each



Measured spectrum,
(Cavity number2)

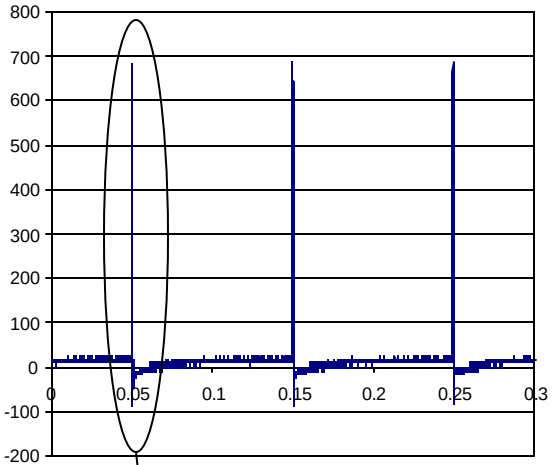


Modeled spectrum,
(20 modes)

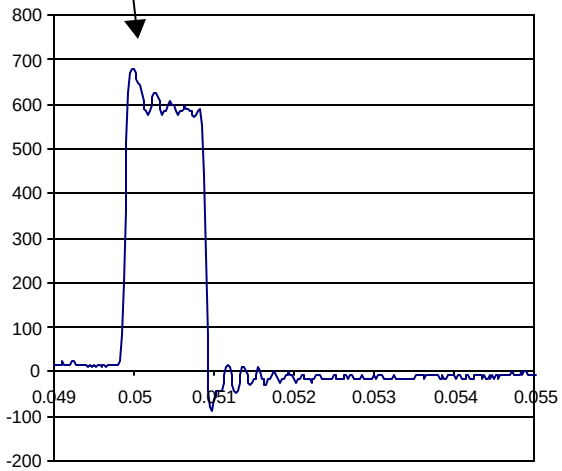
The model seems sufficient to represent the mechanical spectrum

Modeling of the cavity mechanical response under “square” piezo excitation

Square piezo excitation form, 600mV peak



time (s)

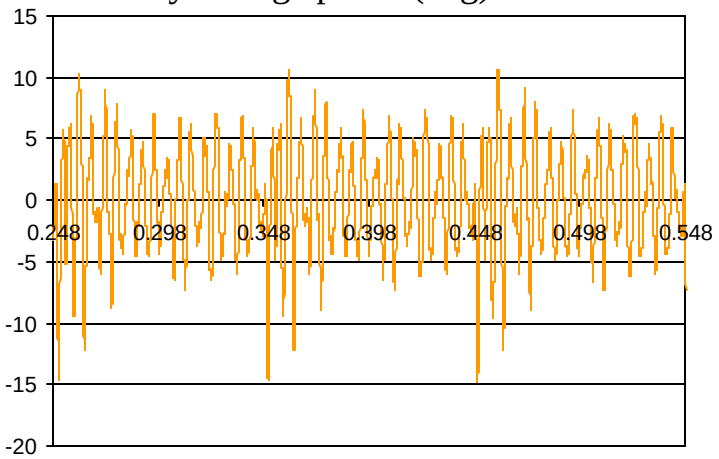


time (s)

Measured phase

(Cavity number2)

Cavity voltage phase (deg)

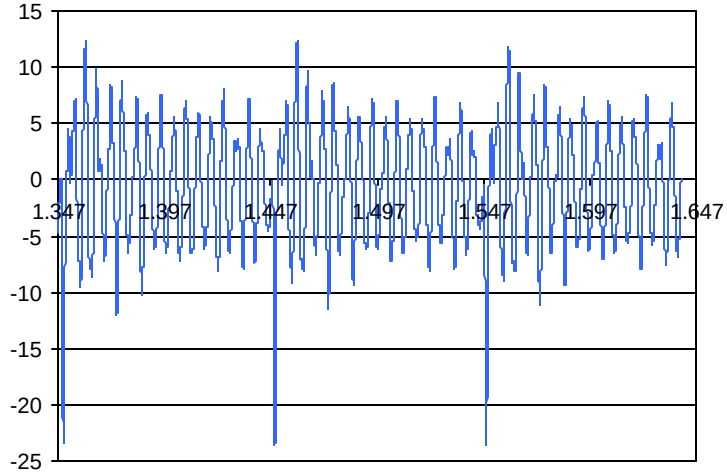


time (s)

Modeled phase

(20 modes)

Cavity voltage phase (deg)

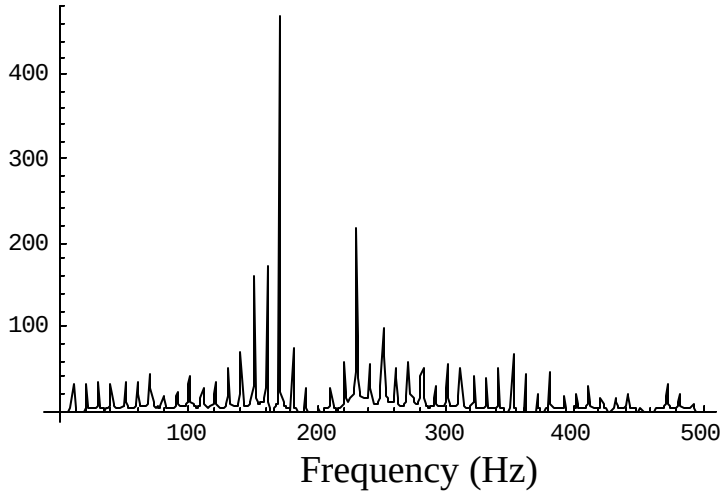


time (s)

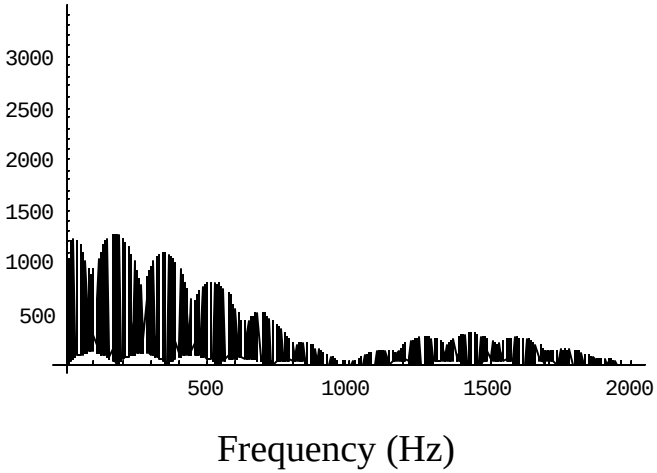
Non linearity between the piezo excitation and the induced amplitude of the detuning have been observed in the meaured data and should be included in the modeling

Modeling of the cavity mechanical response under “square” piezo excitation

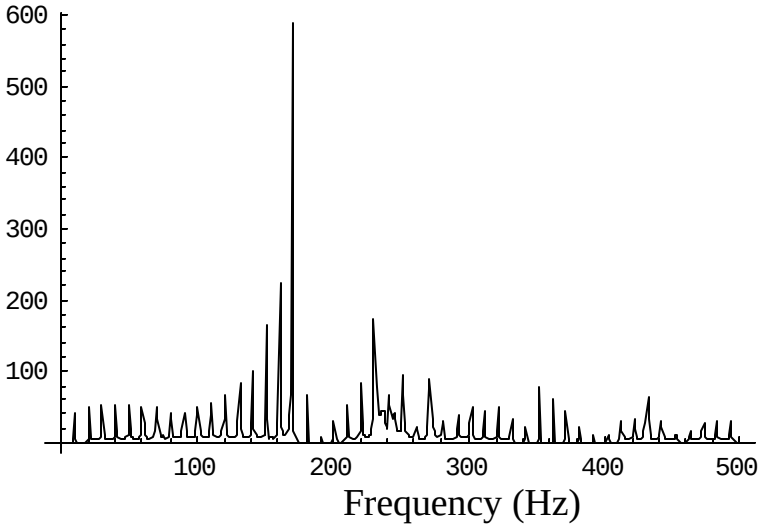
FFT of Measured phase (Cavity number2)



FFT of the square piezo excitation



FFT of Modeled phase (20 modes)



Procedure seems reasonable and further efforts are needed.

Further studies:

- Continue data processing and confirm modeling procedure

2) Repeat the procedure for Lorentz detuning excitation

3) Find an adequate piezo excitation form to compensate the Lorentz detuning during beam pulse