Mechanical Q factor measurement

Main flow:

1. Excite a resonance at f_0
2. Measure its decay time constant τ

(3. Obtain Q factor using $Q = \pi f_0 \tau$)

4. Repeat 1-3 for all the measurable resonances

What we need:

Q factors *with* & *without damping* at lower frequency (below 20 Hz).

in order to know whether all the resonances,
which can disturb the lock-acquisition, are damped enough by active controls.

Requirement for damping is set to following:
1/e decay time constant < 1 min

Ref. https://gwdoc.icrr.u-tokyo.ac.jp/cgi-bin/private/DocDB/ShowDocument?docid=6285
https://gwdoc.icrr.u-tokyo.ac.jp/cgi-bin/private/DocDB/ShowDocument?docid=4155

Preparation:

1. Measure forced transfer functions
   in order to know which the appropriate actuator is.

2. Calculate eigen-mode-shapes & their resonant frequencies
   using 3D-rigid-body model.

3. Implement damping filters
   in order to complete this measurement smoothly.

Measurement (for the time being)**:**

1. Open “dv” for watching oscillation of related DoFs.

2. Open 2 windows of “diaggui” for excitation & for measurement.

3. Set excitation amplitude, frequency, and time duration
   in diaggui for excitation.

4. Input excitation signals and
   after confirming the resonance is excited enough by looking at dv,
   turn off the excitation then start measurement of the decay signal.

5. Fit the measured data by following formula:

$$f(t) = A\exp\left(-\frac{t}{\tau_e}\right)\sin\left(2\pi f_0 t\right) + x_0,$$

When it was difficult to excite only one resonant mode and a beating signal is measured, the signals can be fitted by a double decay sine wave function:

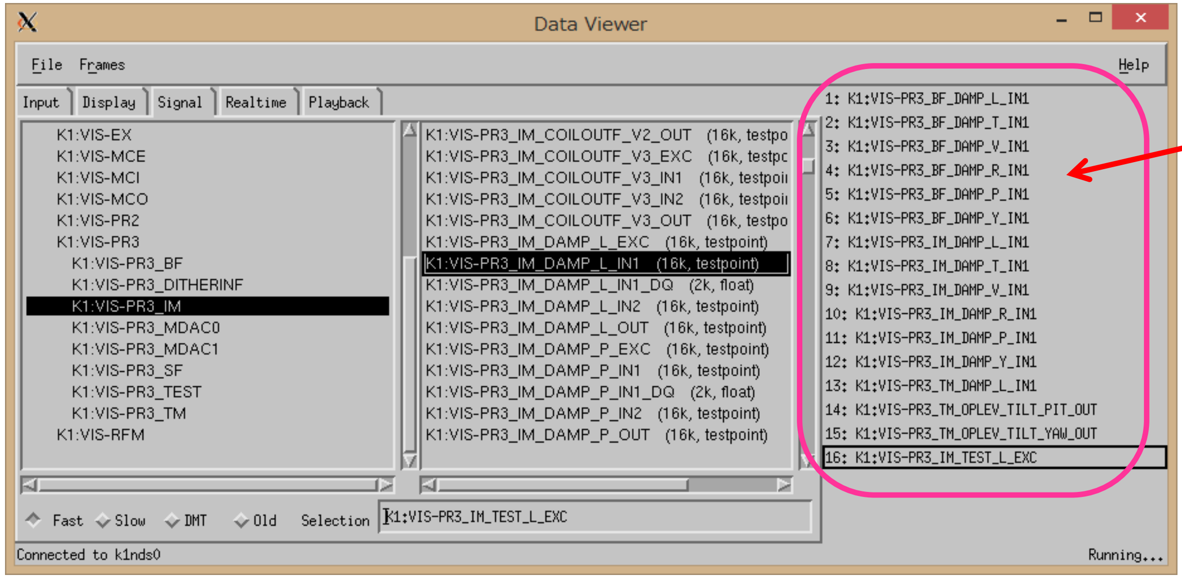
$$f(t) = A_1\exp\left(-\frac{t}{\tau_{e,1}}\right)\sin\left(2\pi f_1 t\right) + A_2\exp\left(-\frac{t}{\tau_{e,2}}\right)\sin\left(2\pi f_2 t\right) + x_0$$

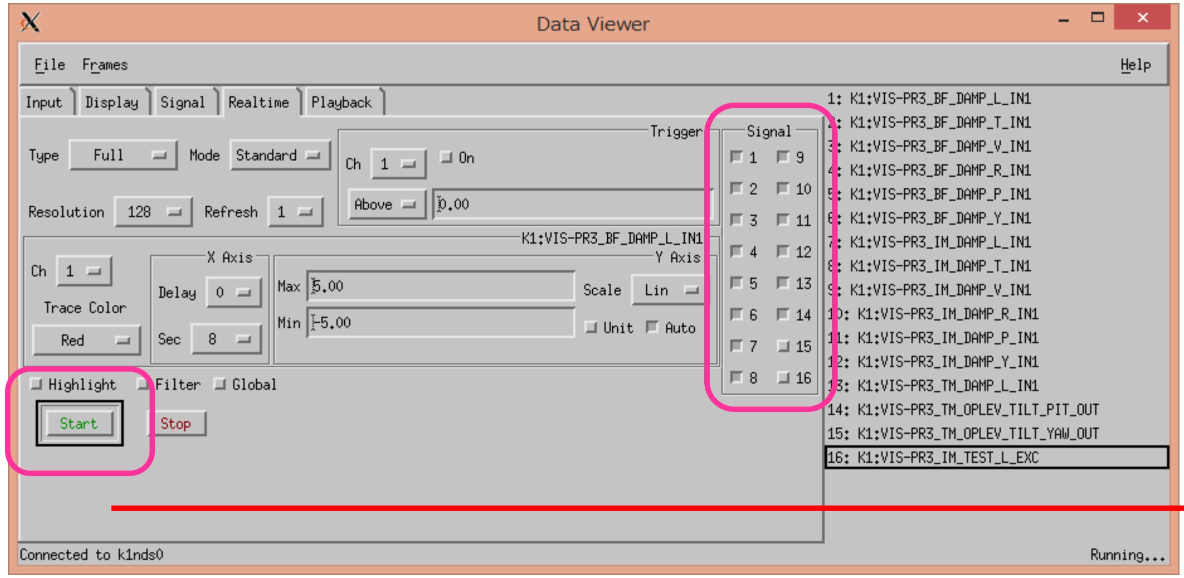
Photos:

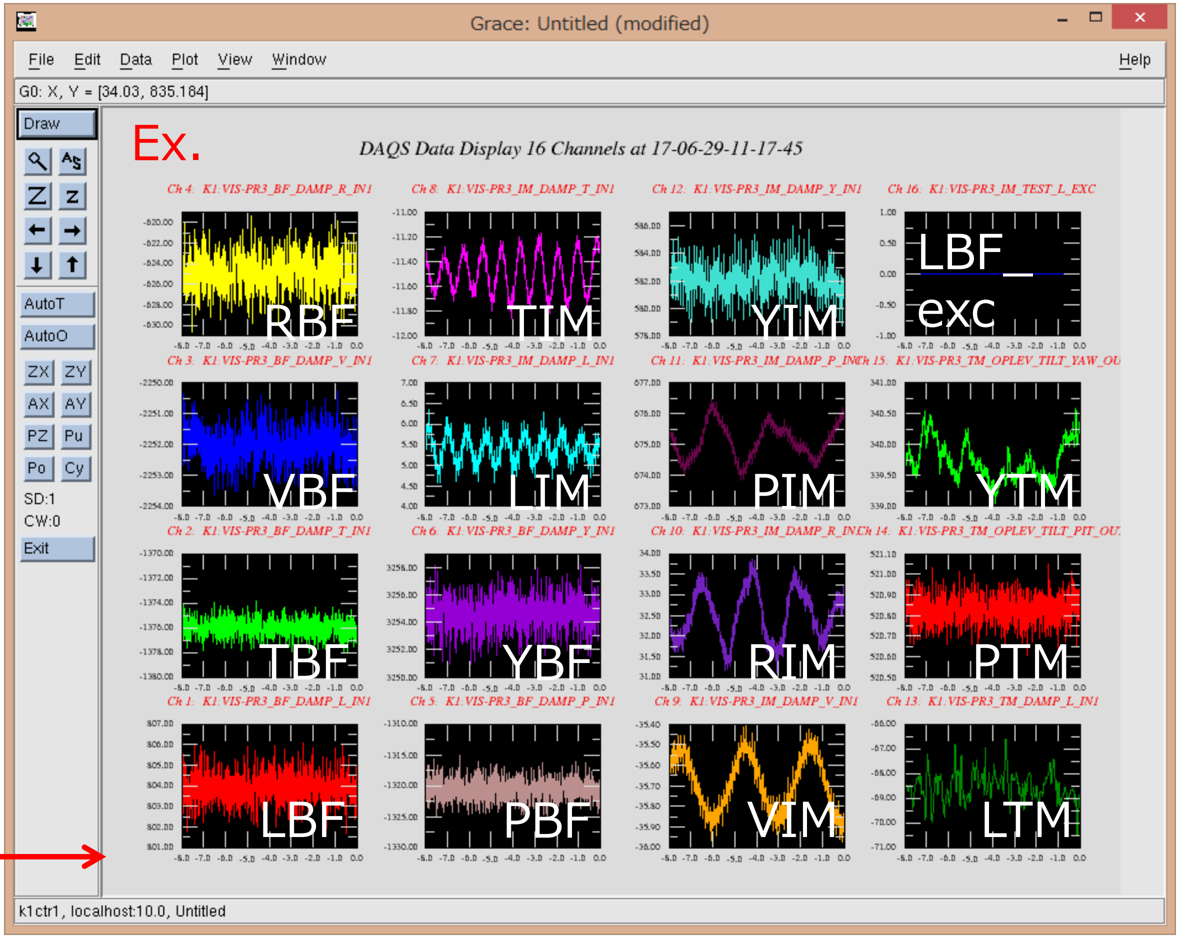
1. Open “dv” for watching oscillation of related DoFs.

Step1: $ dataviewer & (or $ dv &)

Step2: Add channel names which you want to measure.

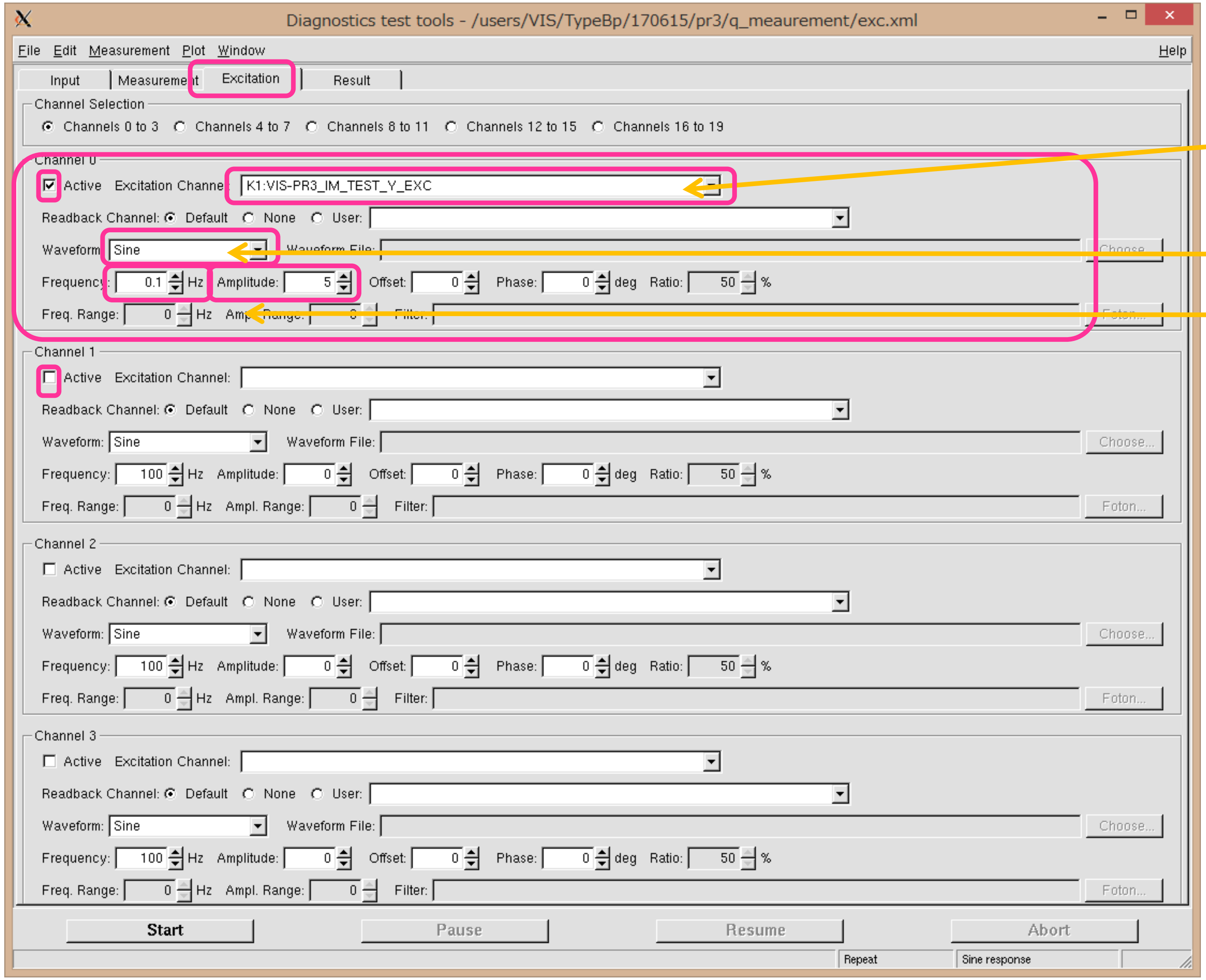






Photos:

2. Open a window of “diaggui” for excitation.



Input channel names which you want to excite.

Set a shape of excitation signal

Set a excitation frequency & amplitude

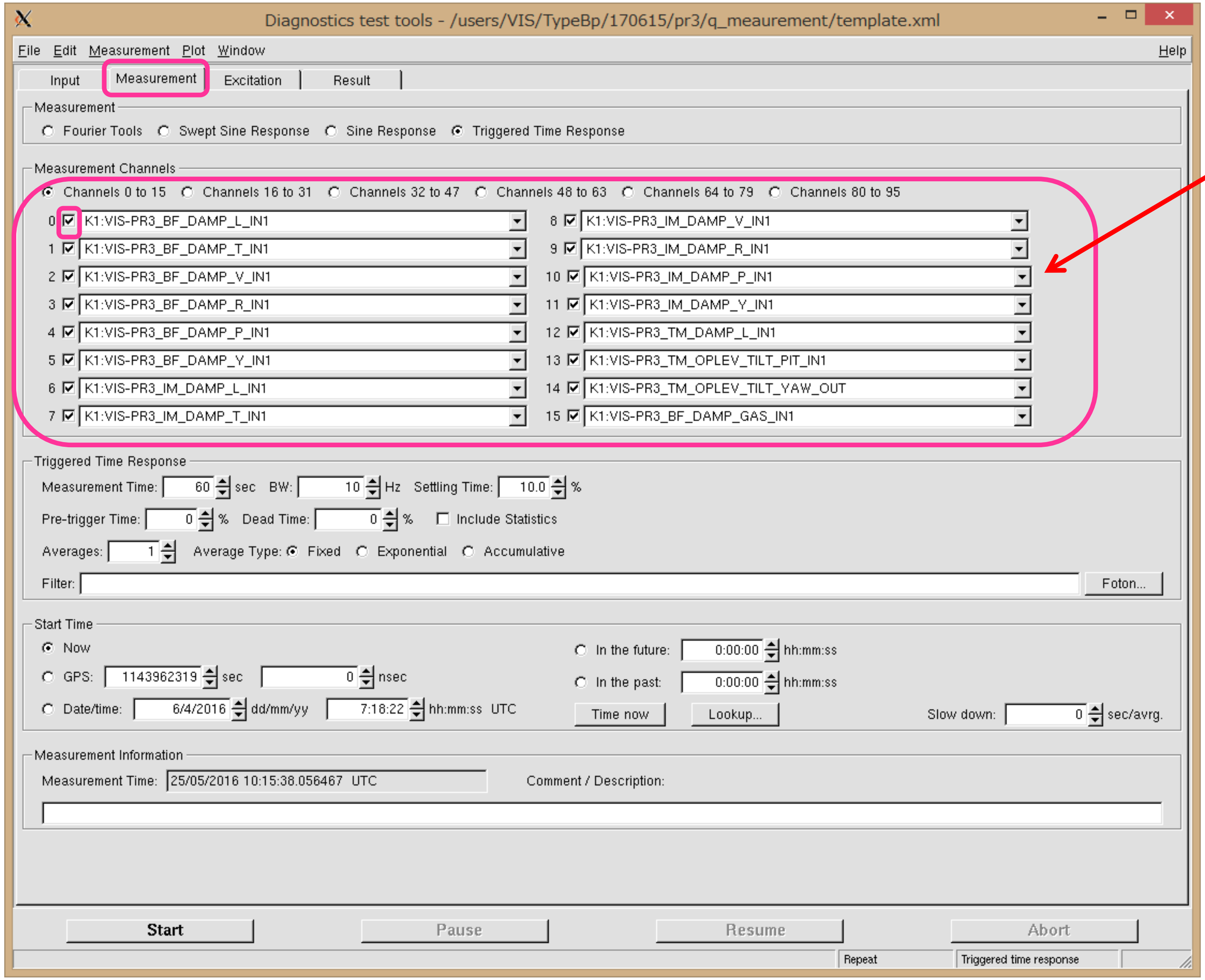
Ref:

Step1: $ diaggui &

Step2: open following fie in the application.
/users/VIS/TypeBp/170615/q_measurement/pr3/exc.xml

Photos:

2. Open another window of "diaggui" for measurement



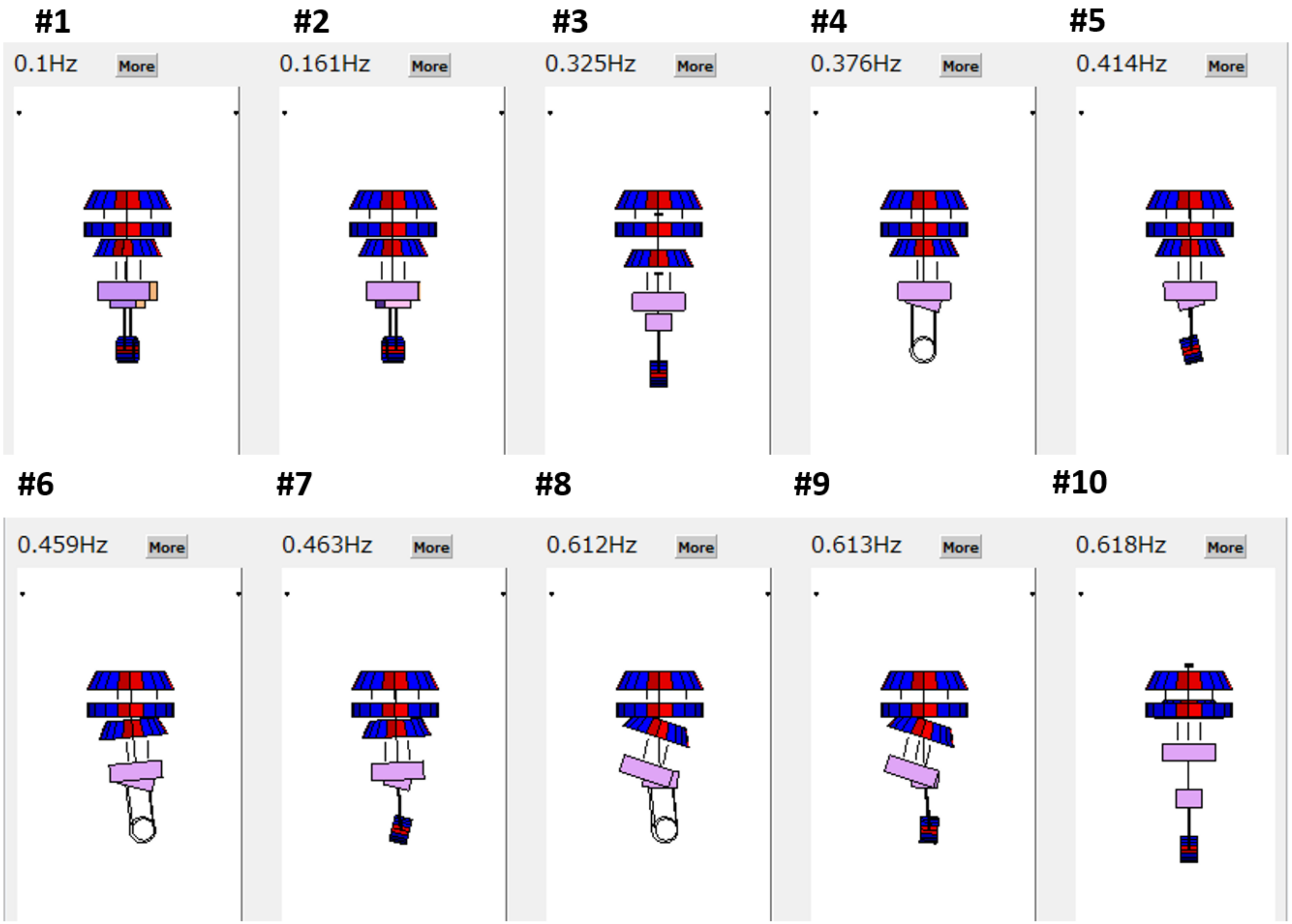
Input channel names which you want to measure.

Ref:

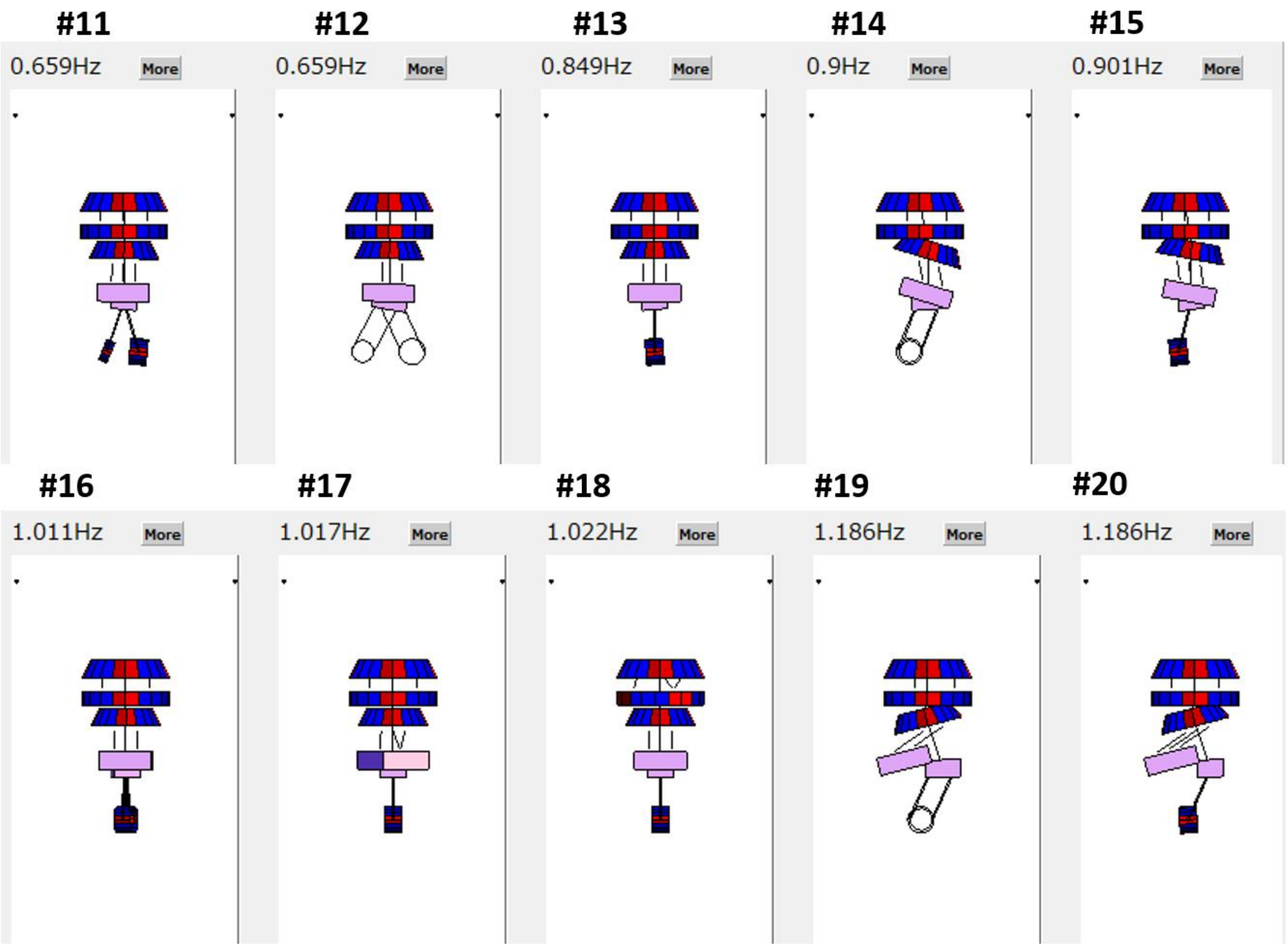
Step1: $ diaggui &

Step2: open following fie in the application.
/users/VIS/TypeBp/170615/q_measurement/pr3/template.xml

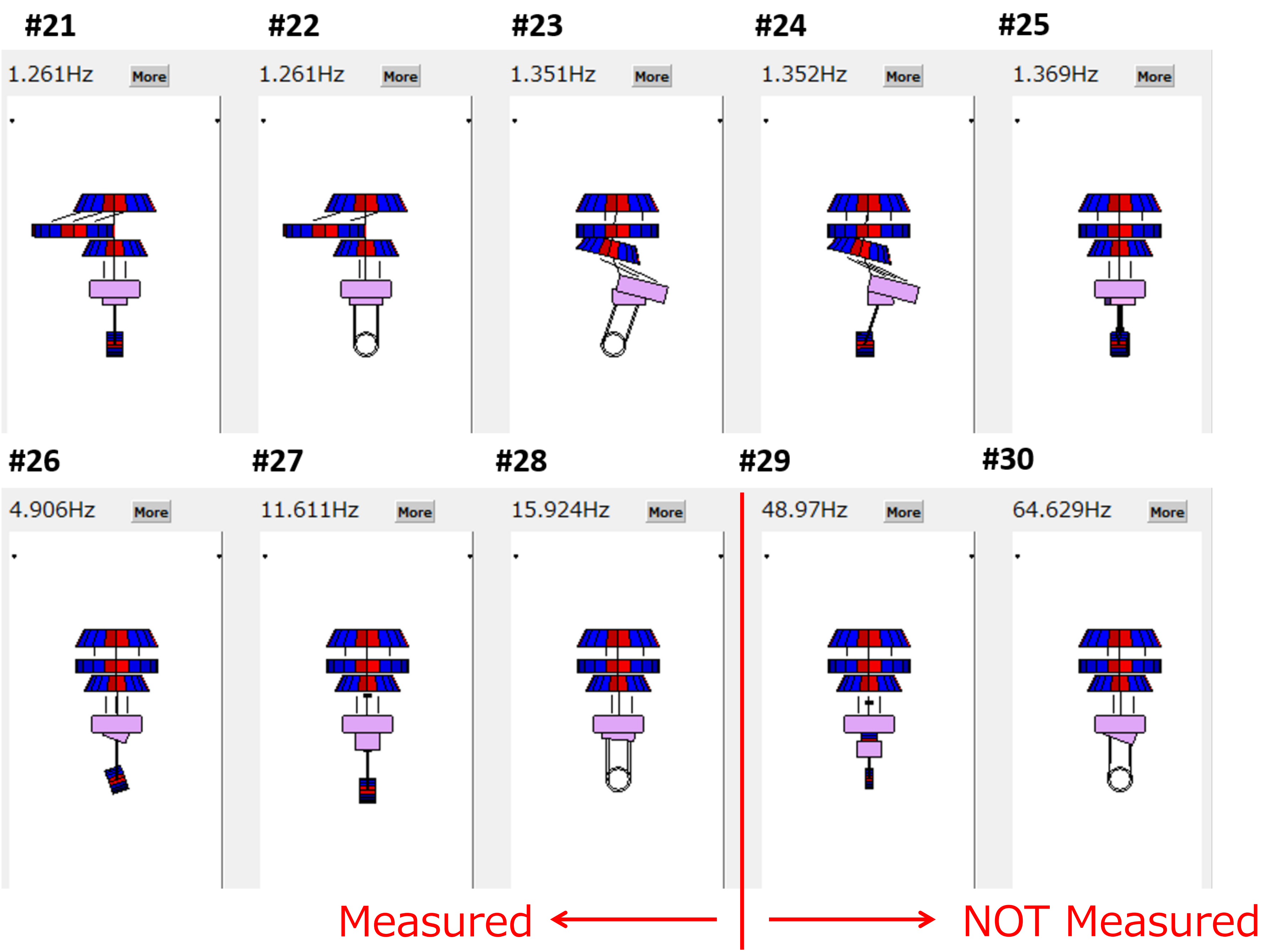
Ex. PR3 SAS (Type-Bp):



#1
0.1Hz
More
#2
0.161Hz
More
#3
0.325Hz
More
#4
0.376Hz
More
#5
0.414Hz
More
#6
0.459Hz
More
#7
0.463Hz
More
#8
0.612Hz
More
#9
0.613Hz
More
#10
0.618Hz
More

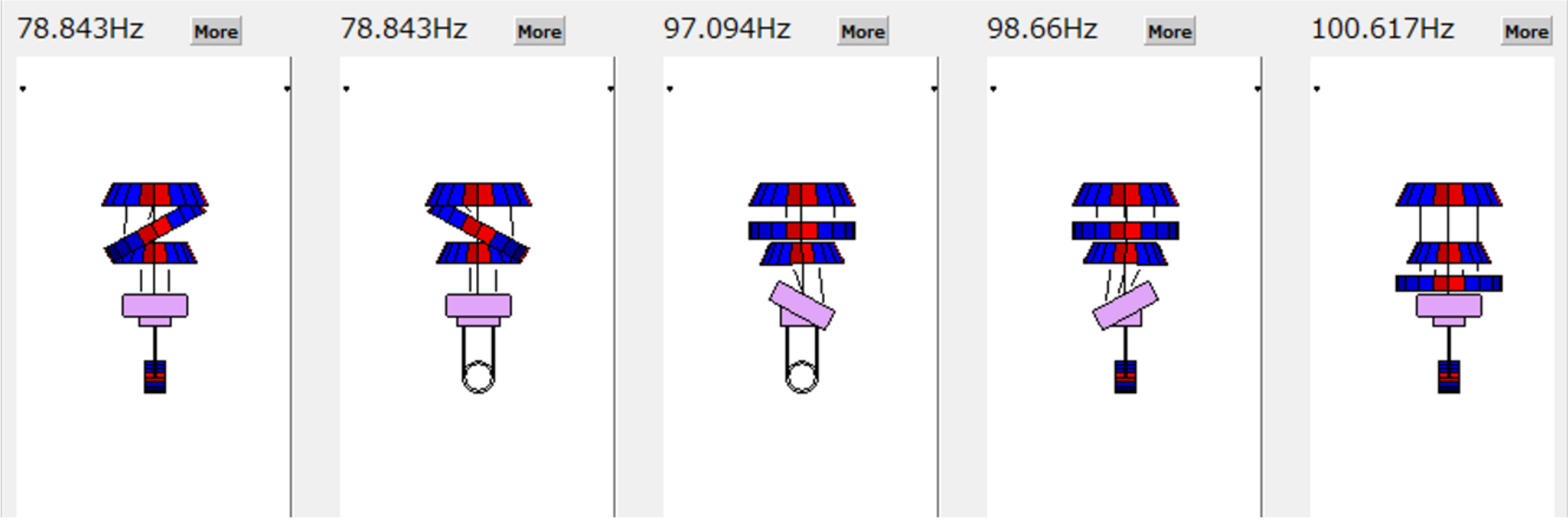


#11
0.659Hz
More
#12
0.659Hz
More
#13
0.849Hz
More
#14
0.9Hz
More
#15
0.901Hz
More
#16
1.011Hz
More
#17
1.017Hz
More
#18
1.022Hz
More
#19
1.186Hz
More
#20
1.186Hz
More

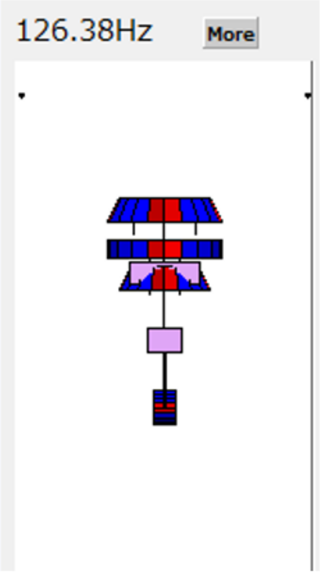

#21
1.261Hz
More
#22
1.261Hz
More
#23
1.351Hz
More
#24
1.352Hz
More
#25
1.369Hz
More
#26
4.906Hz
More
#27
11.611Hz
More
#28
15.924Hz
More
#29
48.97Hz
More
#30
64.629Hz
More
Measured
NOT Measured

NOT Measured

#31 #32 #33 #34 #35

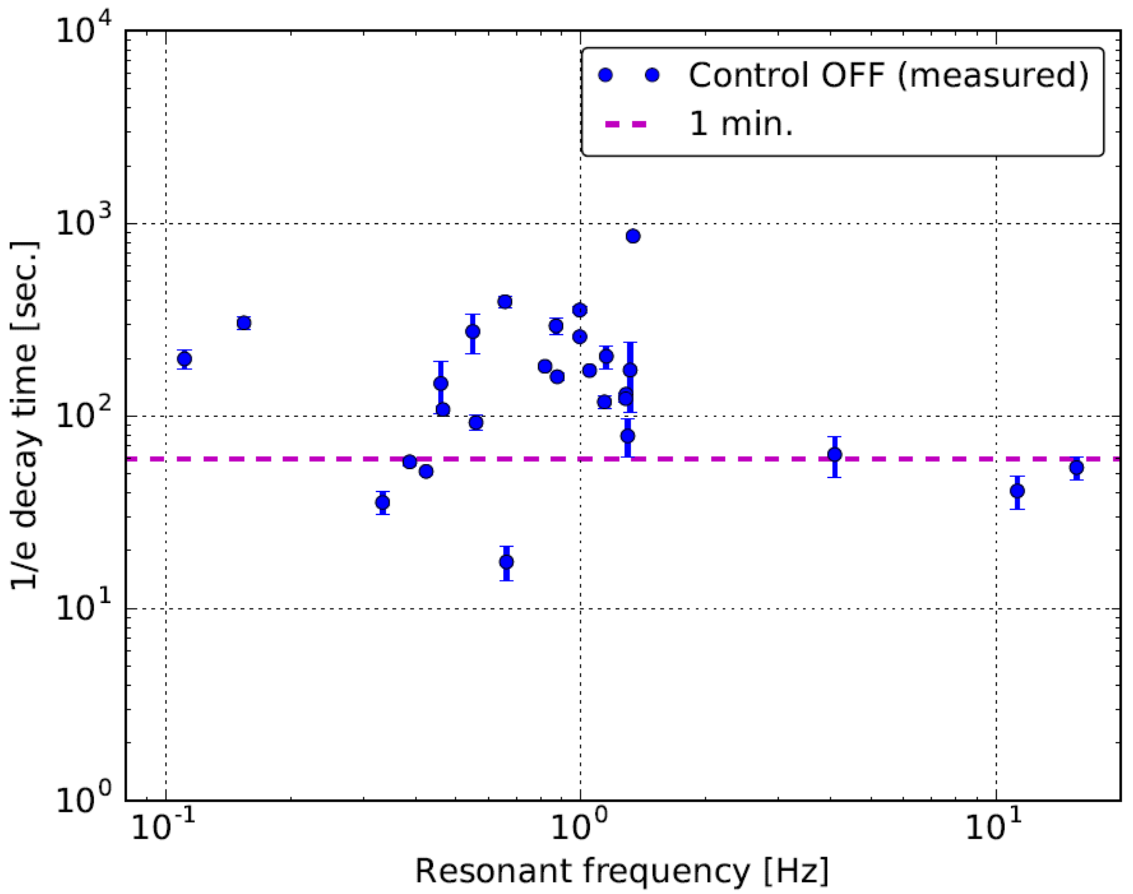


#36

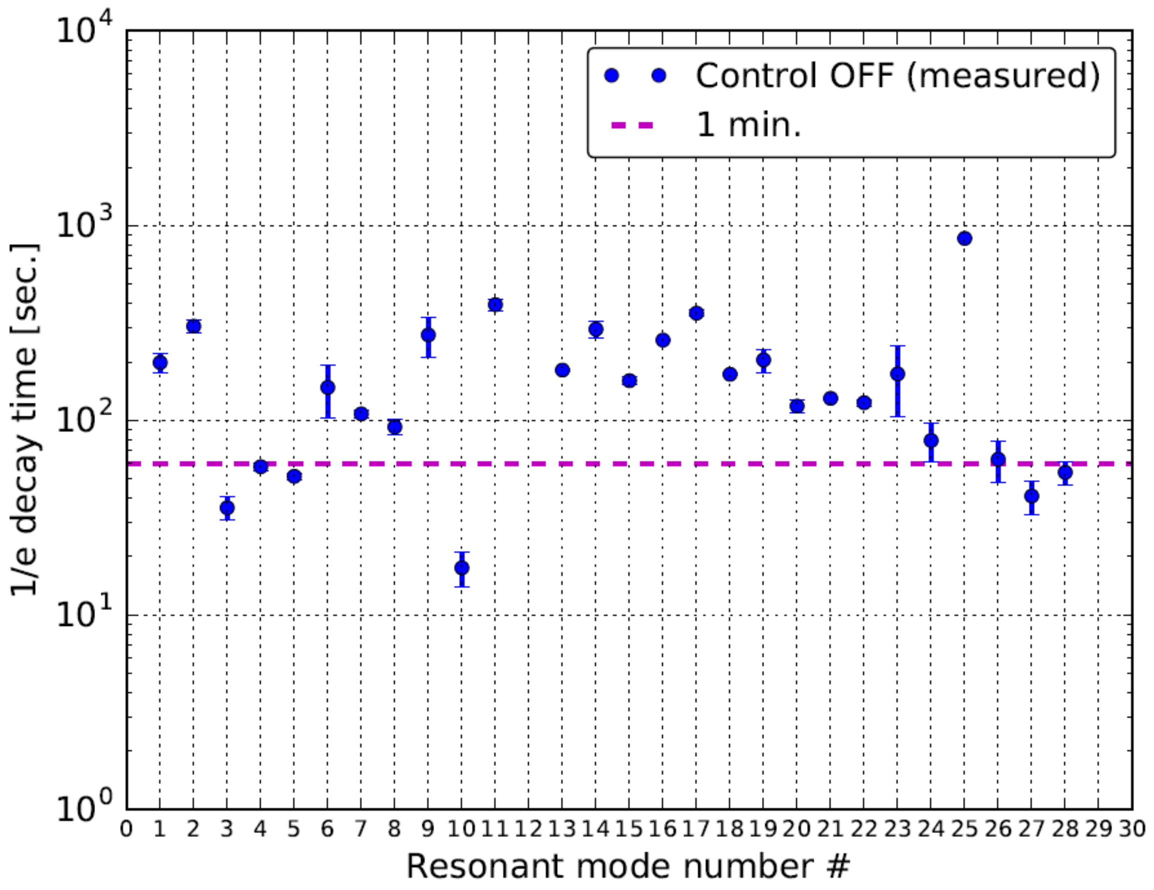


Since these higher-resonant-frequency-modes are so difficult to be excited and also the decay time constants of these modes are expected originally smaller. Thus we do not take care of them for the time being.

Result:



Control OFF (measured)
1 min.
1/e decay time [sec.]
Resonant frequency [Hz]



Control OFF (measured)
1 min.
1/e decay time [sec.]
Resonant mode number #

You can automate the above method more: