SESAME Low-level RF Commissioning

November 2–8, 2016

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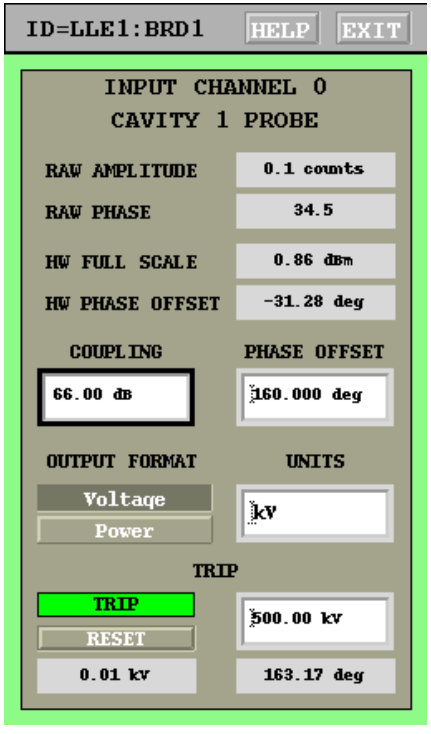
November 8, 2016

Outline

LLRF9/500 Setup

- Set up LLRF9 (LLE1) to run two stations;
  - Two cavity probe signals (500 MHz);
  - Two cavity forward signals (500 MHz);
  - Two cavity reflected signals (500 MHz);
  - Two drive outputs (500 MHz);
  - Interlock input (24 V, DC supply bypass for now).
- Galil DMC-2123 motion controller;
- To be done: vacuum gauges, triggers, additional RF monitors.

Signal Levels And Calibrations



- Iterative process, start from safe attenuations, 20 dB on drive;
- Procedure:
  - Tune cavity on resonance;
  - Adjust FWD coupling to match SSA;
  - Use R_s to calculate the probe level;
  - Detune as far as possible, calibrate reflected;
  - Calculate full-scale levels for all channels, adjust attenuation.
- Drive attenuation set to reach 50 W from drive amplifier at full LLRF9 output;
- Measured 41/48 W for stations 1/2.

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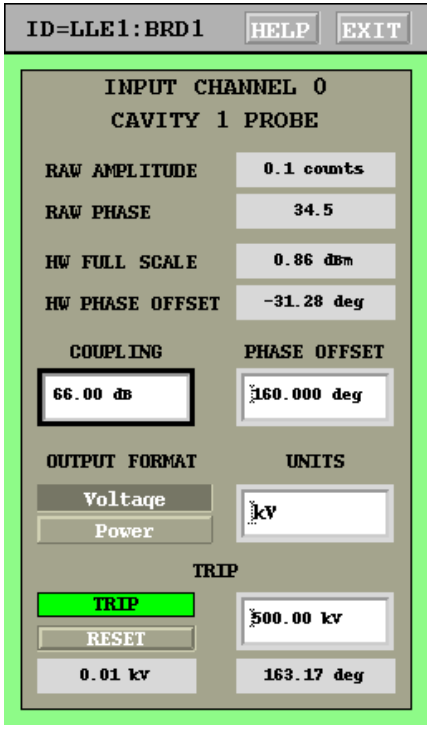

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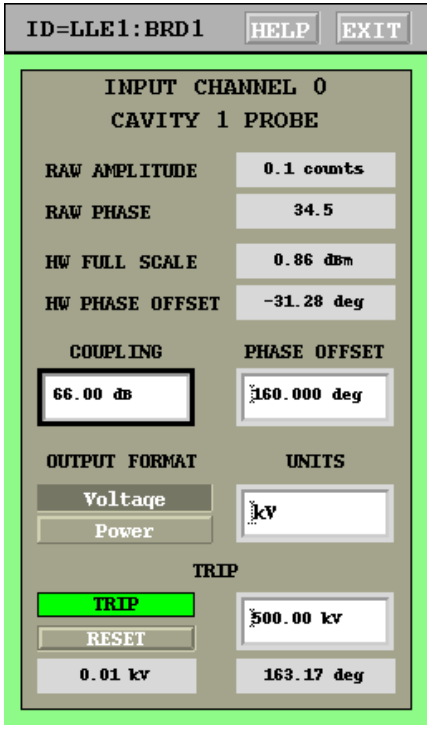

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Motion Control

- Use custom Dimtel StreamDevice driver for Galil DMC-21X3;
- Standard problem with closed-loop controllers:
  - We need velocity control;
  - Galil loop is designed for position control;
  - Velocity control is an afterthought, implemented by integrating velocity to generate setpoint position;
  - If the motor is slower, than desired (due to mechanical load), position error accumulates;
  - Setting velocity to 0 does not stop motion!!!
- Used velocity feedforward (FV) to directly control torque, set KP/KI/KD to 0.

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Outline

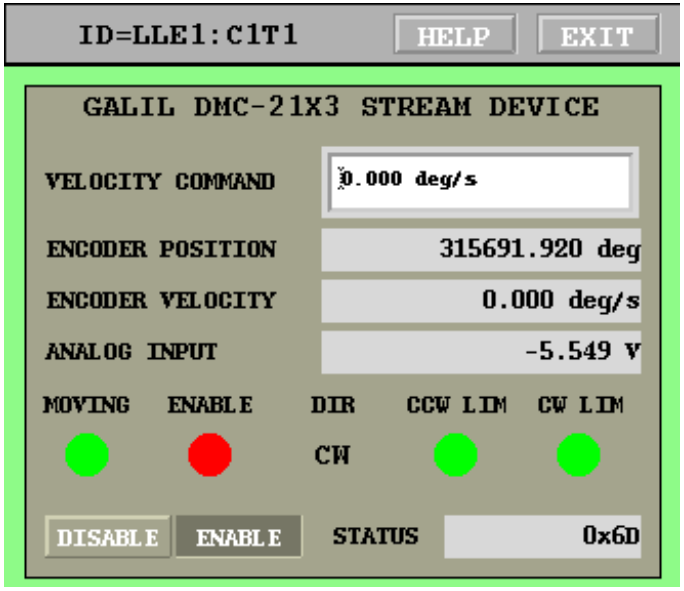
Hardware Setup

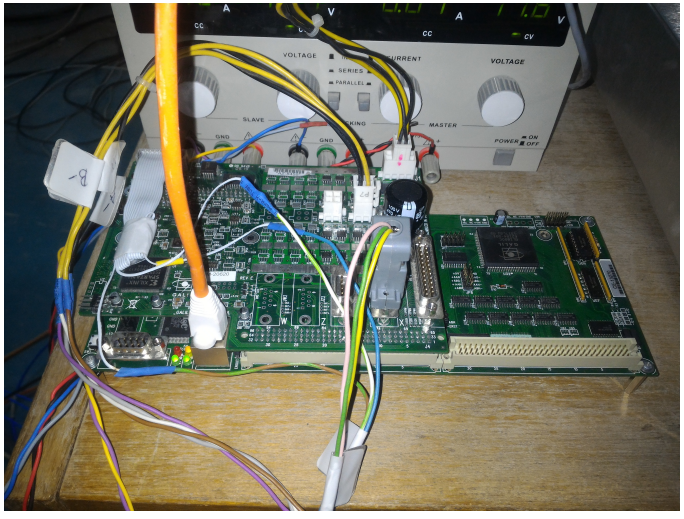
- LLRF9 (LLE3) in temporary configuration;
  - One cavity probe signal (500 MHz);
  - One cavity forward signal (500 MHz);
  - One cavity reflected signal (500 MHz);
  - One drive output (500 MHz);
  - Interlock input (24 V, DC supply bypass for now);
  - Trigger input (2.8 V).
- Galil DMC-2183 motion controller with SDM-20620 (Micro Stepper Motor Drive).

Motion Control

- Same device driver as in the storage ring;
- Open loop control;
- Need to limit maximum velocity, since steppers can slip and stop moving at high velocities;
- One residual issue:
  - Sometimes Galil controller stops the motor;
  - Happens when moving long distances (fully detuned to resonance);
  - Not seen in the lab during driver development (DMC-2133);
  - Possibly some driver setting (SPM mode?).

Motion Control (Continued)

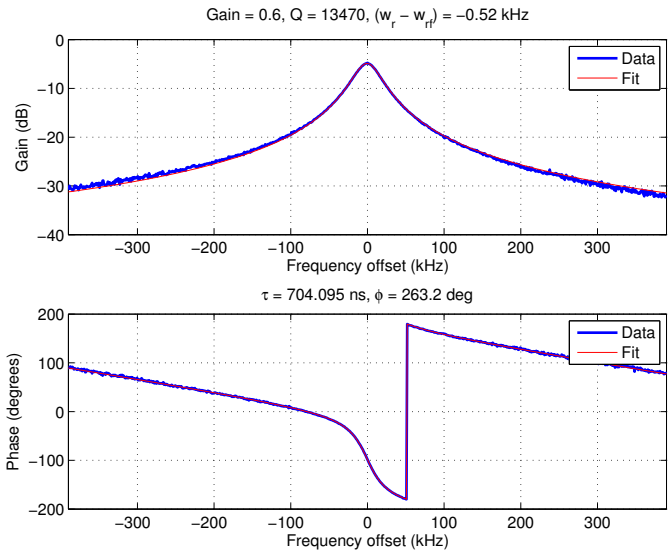




- Two controls: enable/disable and velocity setpoint;
- Driver supports readback of position and velocity;
- In the booster DCM-21X3 determines position by counting stepper pulses;
- No velocity readback in the booster;
- Status bits:
  - Moving
  - Enabled
  - Direction
  - Limit switches

Outline

Cavity 2: Open Loop Transfer Function



- Measured using integrated network analyzer;
- November 2: cavity 2 tuned on resonance;
- $Q_l = 13470 \rightarrow \beta = 2.1$;
- November 7: after some operation,
- Delay dropped from 704 to 595 ns — removed long cable at the output of drive amplifier;
- $Q_l = 14350 \rightarrow \beta = 1.9$???

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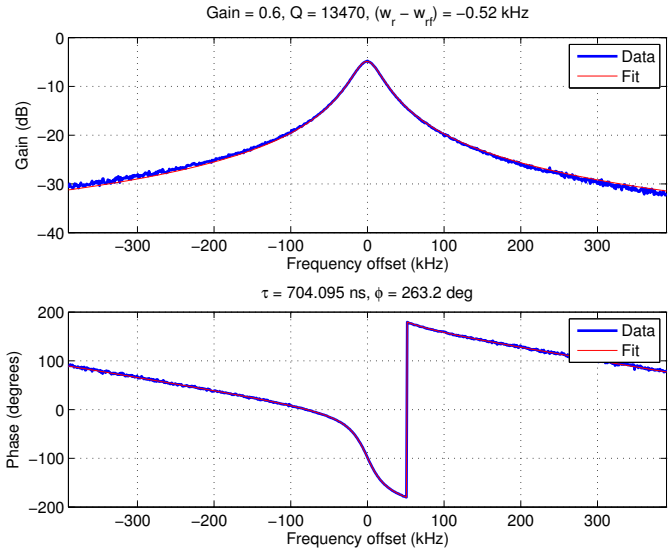

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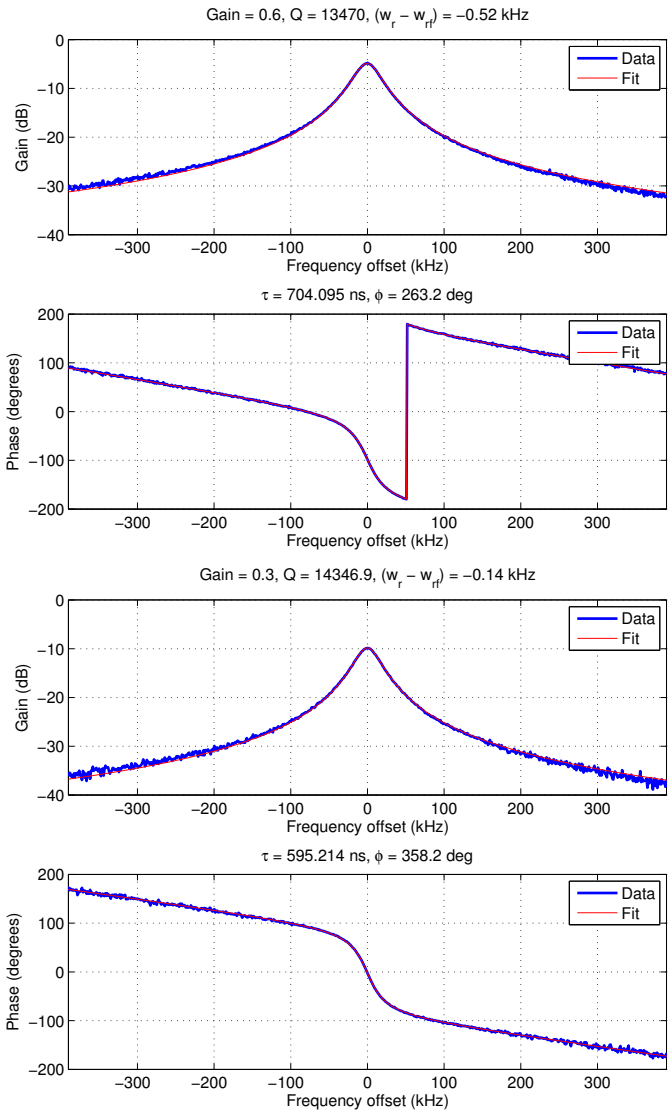

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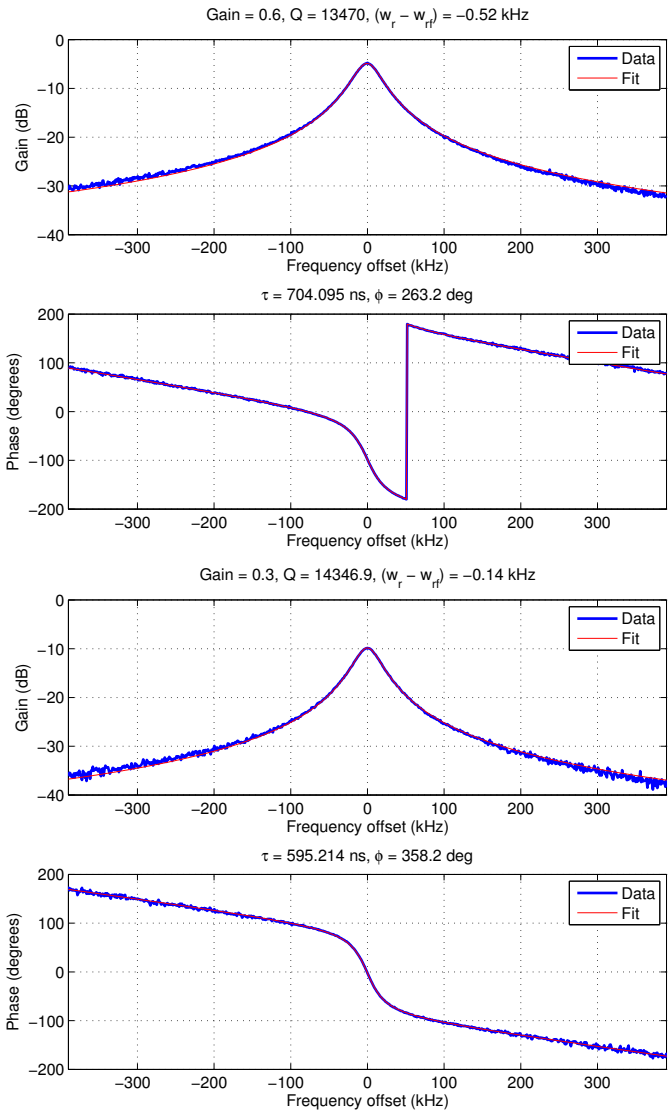

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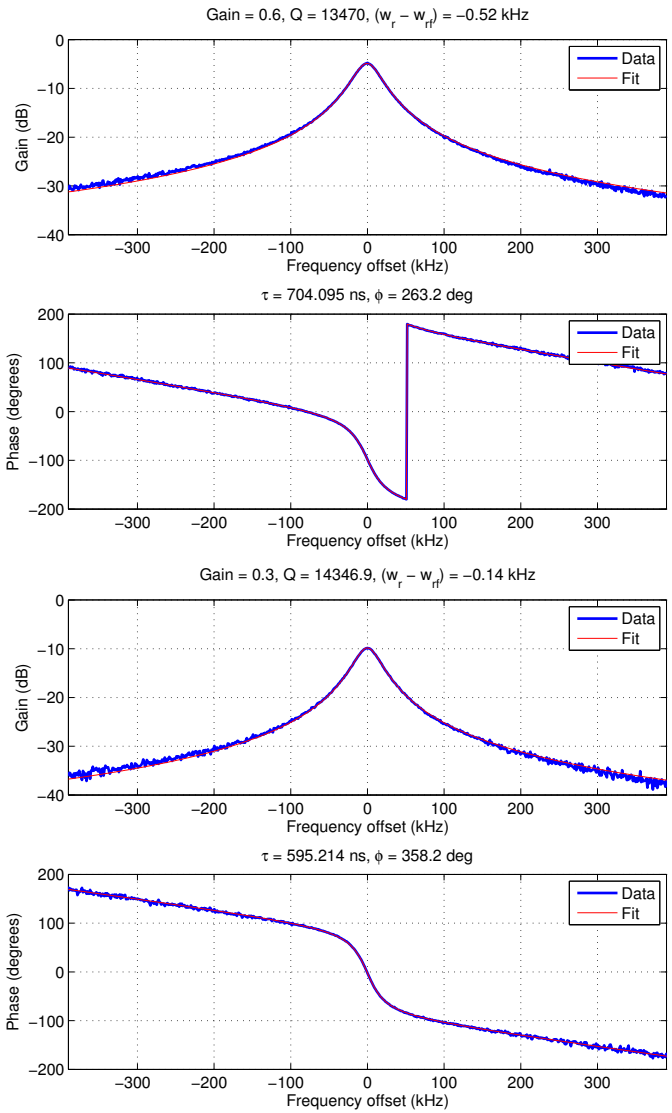

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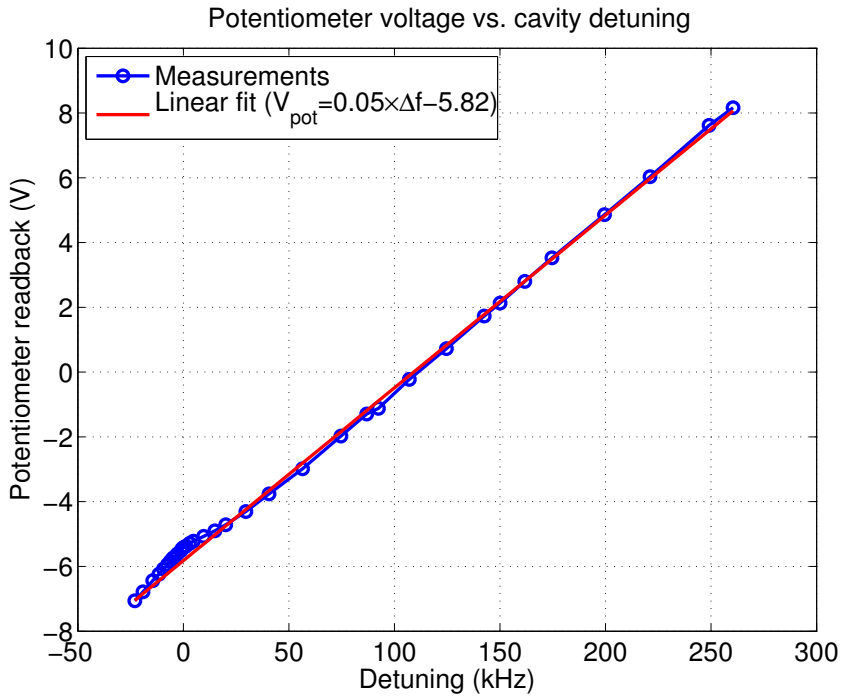
Tuning Scan

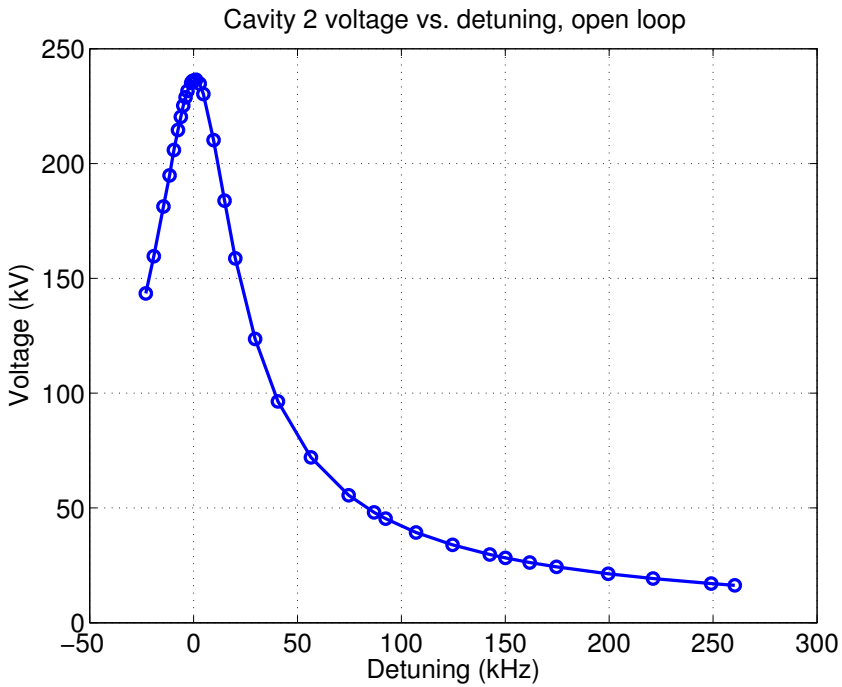
- Run the station in open loop, fixed setpoint;
- Move the cavity from limit switch to limit switch;
- At multiple points record:
  - Probe voltage and phase;
  - Forward and reflected power and phase;
  - LLRF9 output power meter;
  - Tuner potentiometer;
  - Open-loop transfer function.
- A lot of interesting plots!

Tuner Position Potentiometer vs. Detuning



- Nearly linear;
- A deviation near zero detuning is caused by wall heating;
- Slope should be consistent, offset shifts with temperature.

Cavity Voltage vs. Detuning



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- Zooming in we see an interesting effect — peak voltage is around 650 Hz;
- Cavity response fitting offset?

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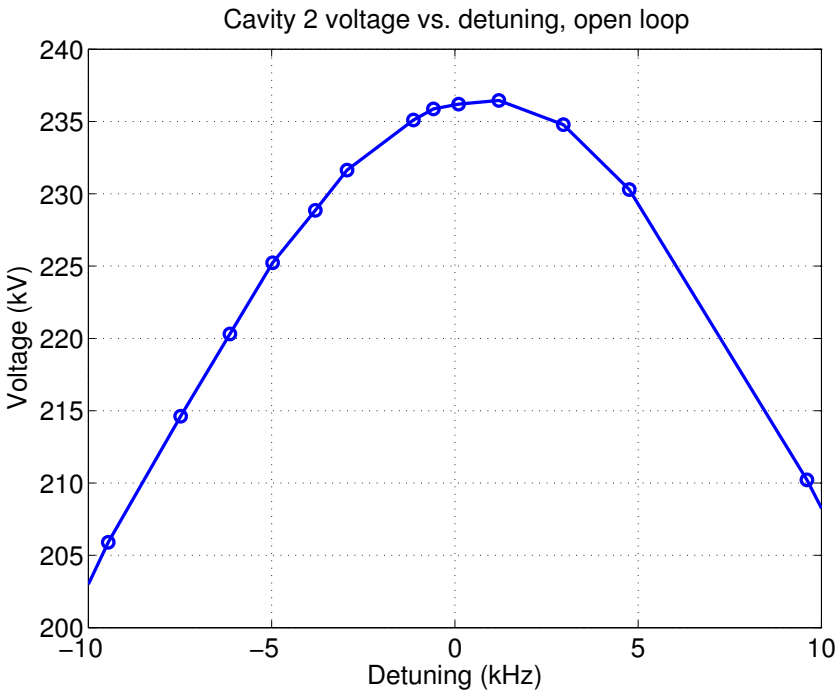

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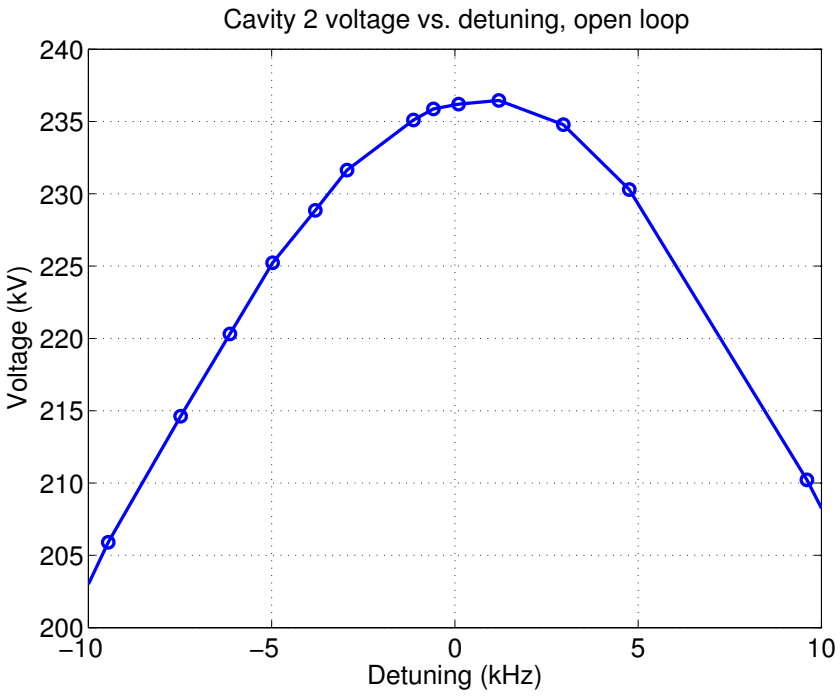

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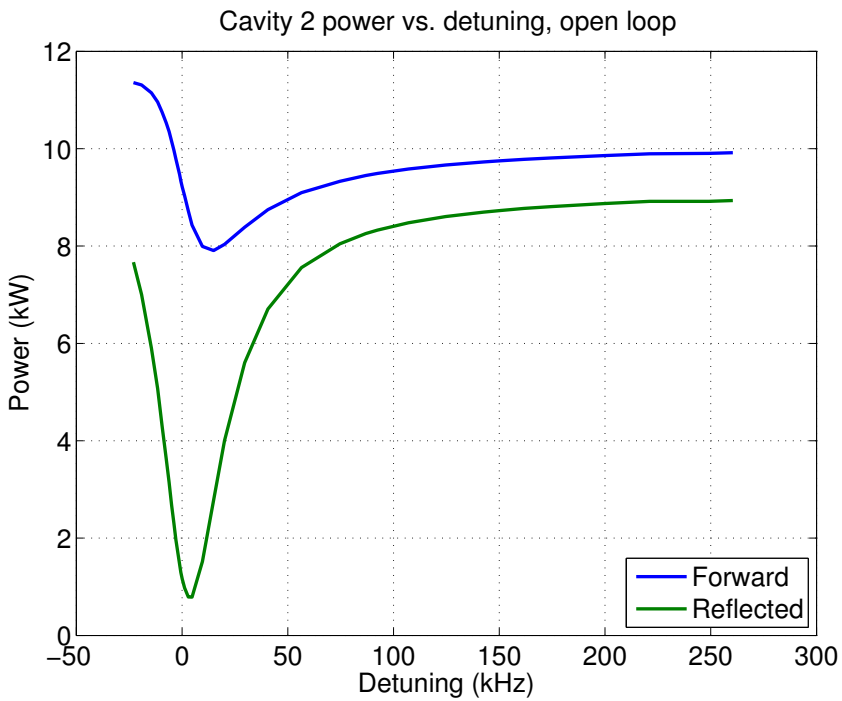

- Reflected power minimum near 0;
- Forward power reading changes due to finite directivity of couplers;
- Drive level is constant;
- Peak field and minimum reflected are offset;
- Offset minimum of reflected power is expected, directivity again.

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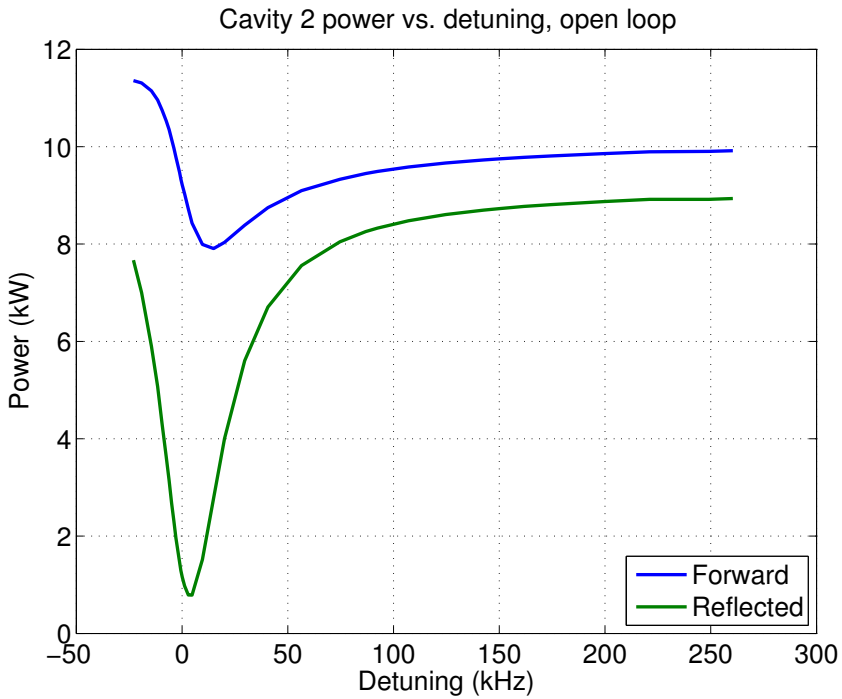

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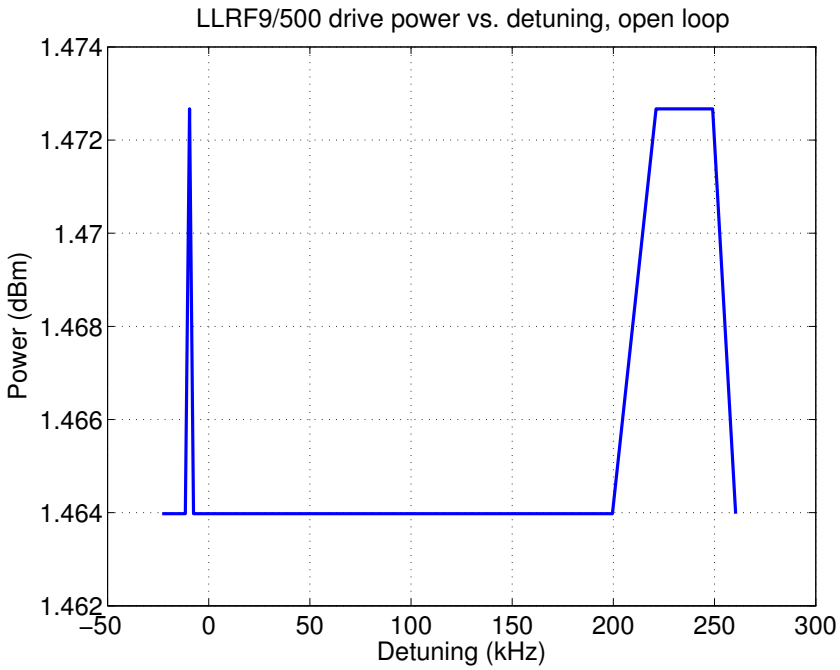

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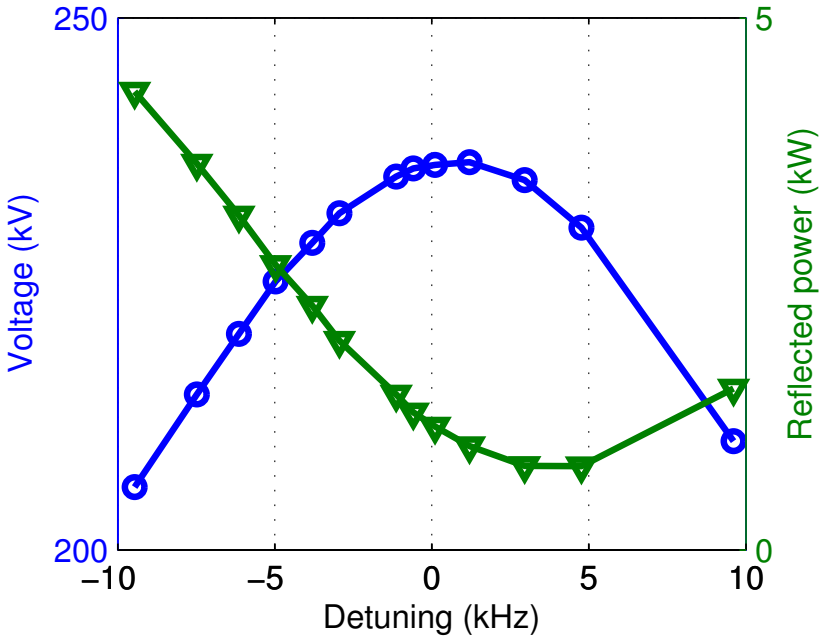

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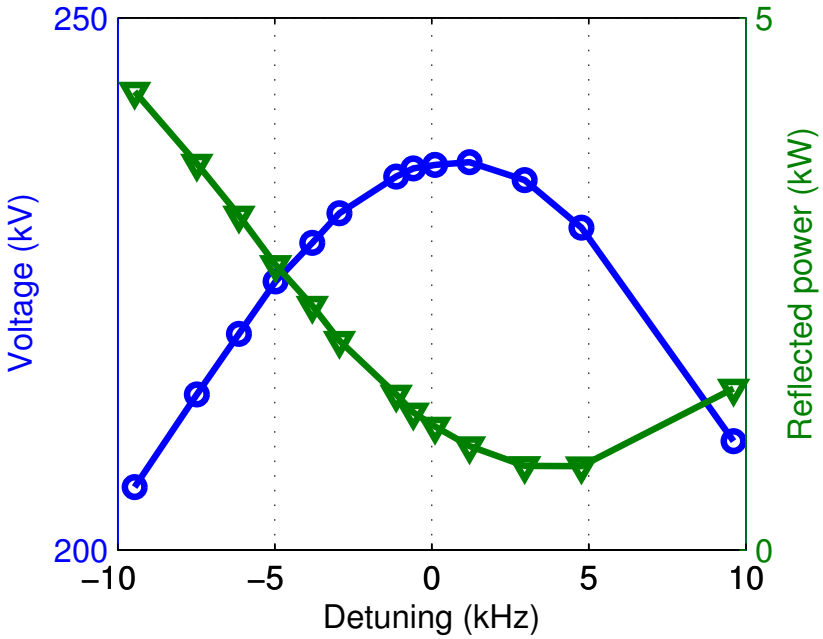

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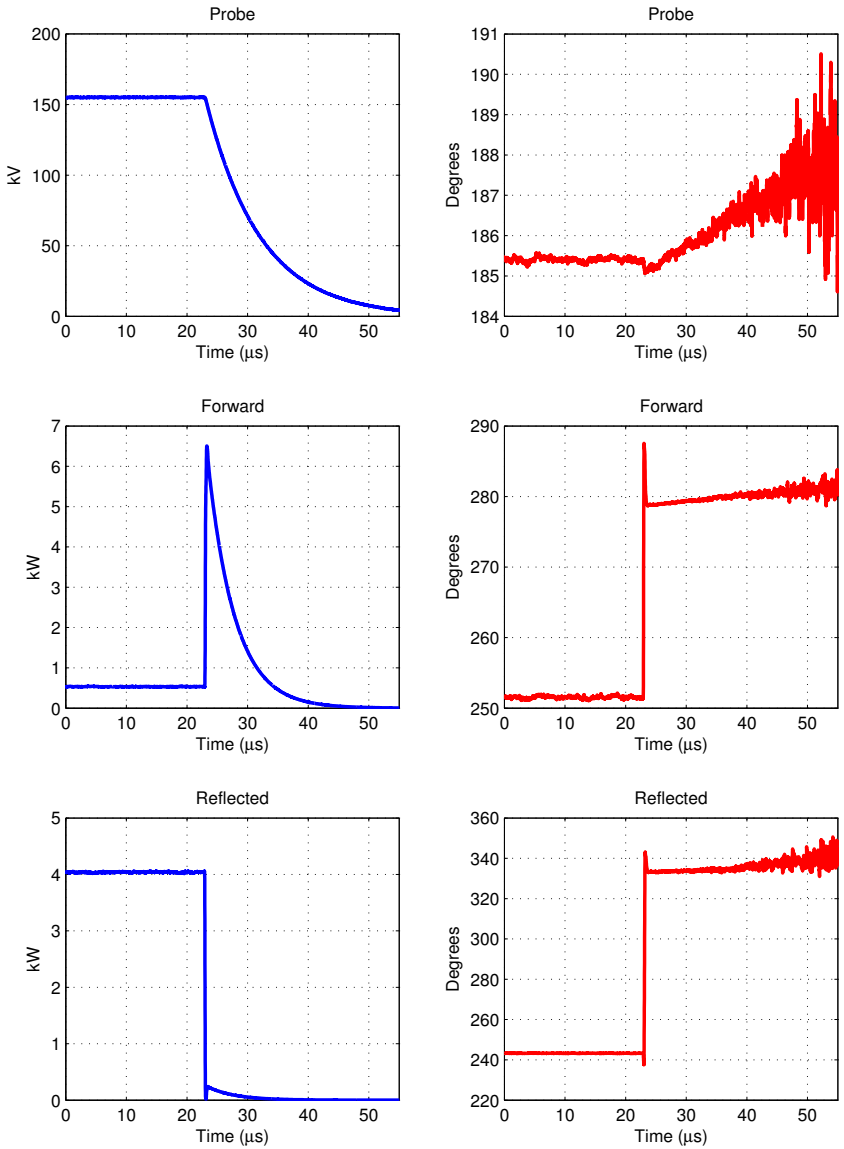

- Step drive to 0;
- Natural cavity response;
- Can extract quality factor and detuning;
- At the same tuning point collected 20 transfer function measurements;
- Roughly 300 Hz offset between frequency and time domain.

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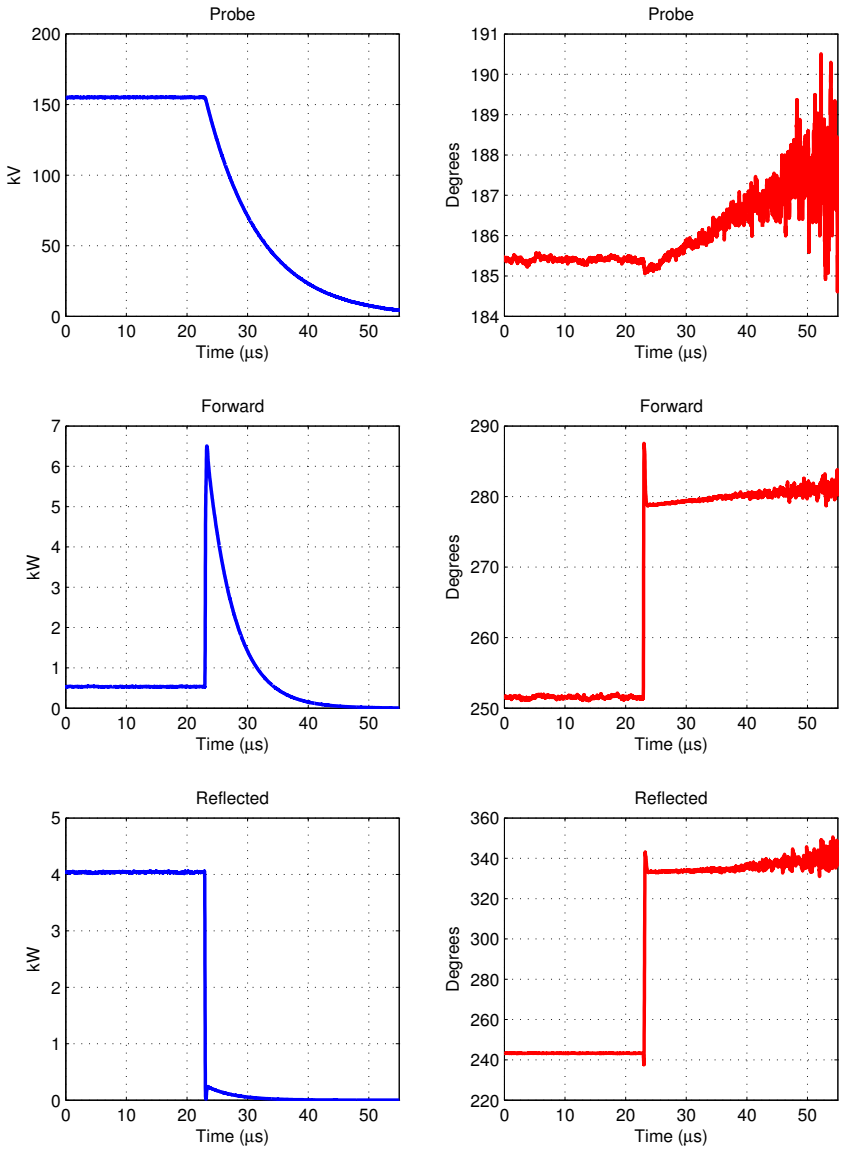

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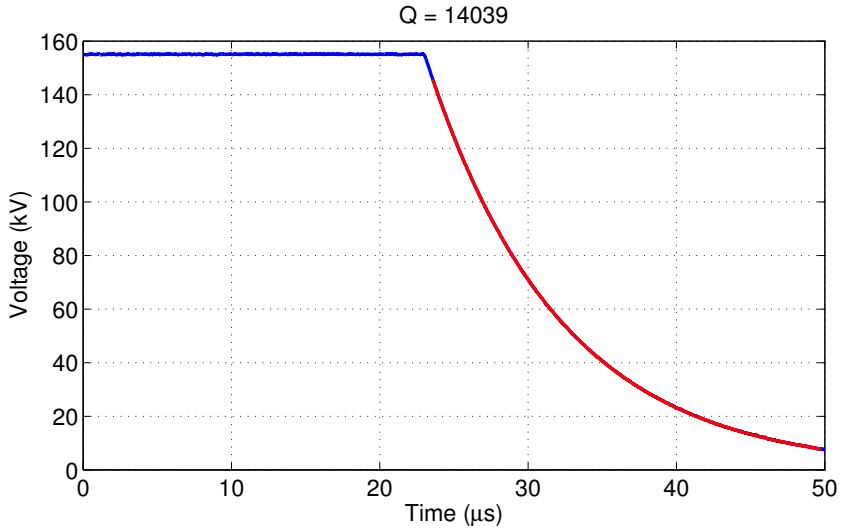

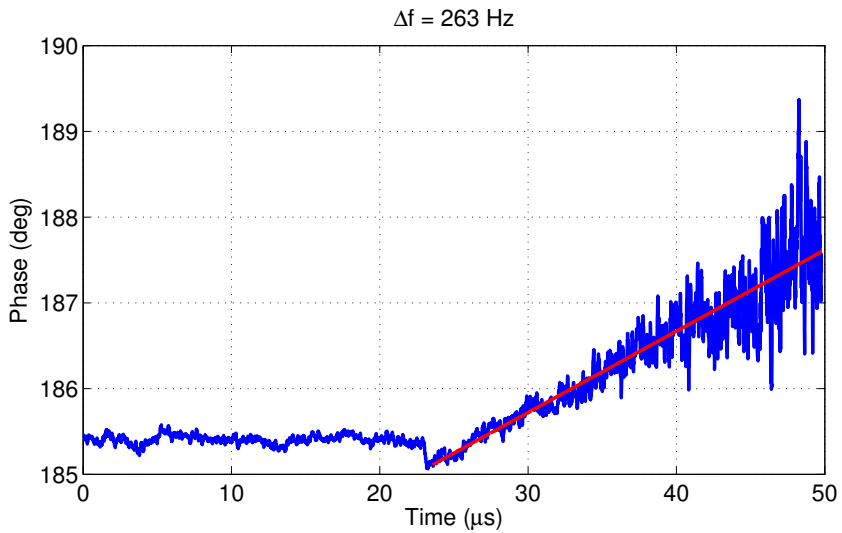

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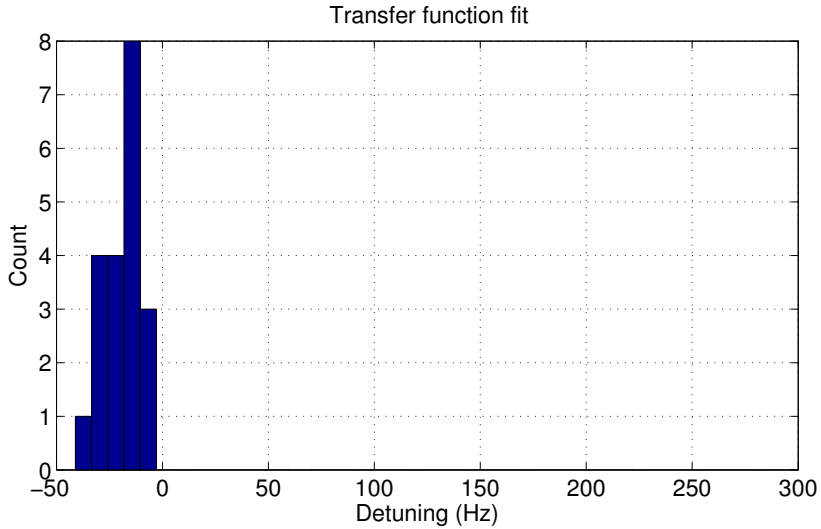

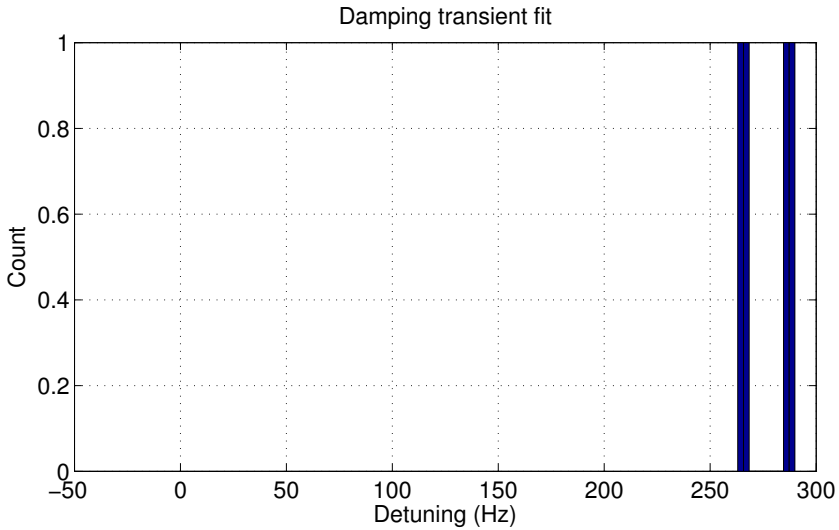

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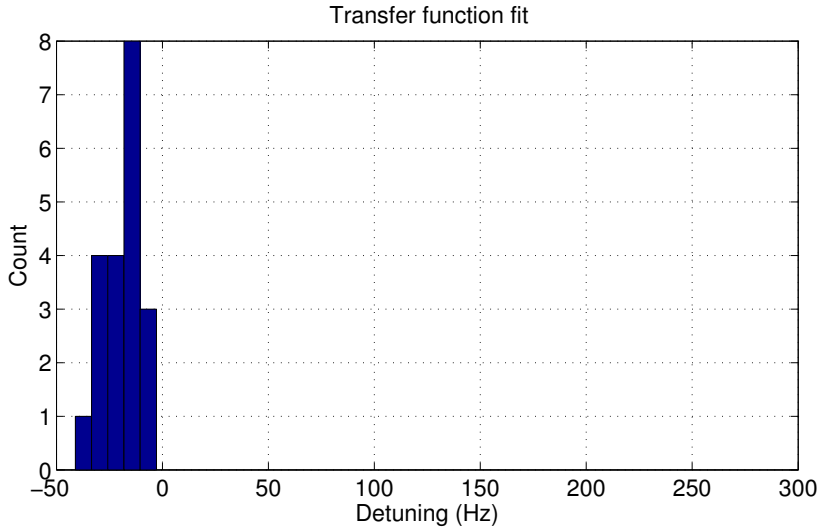

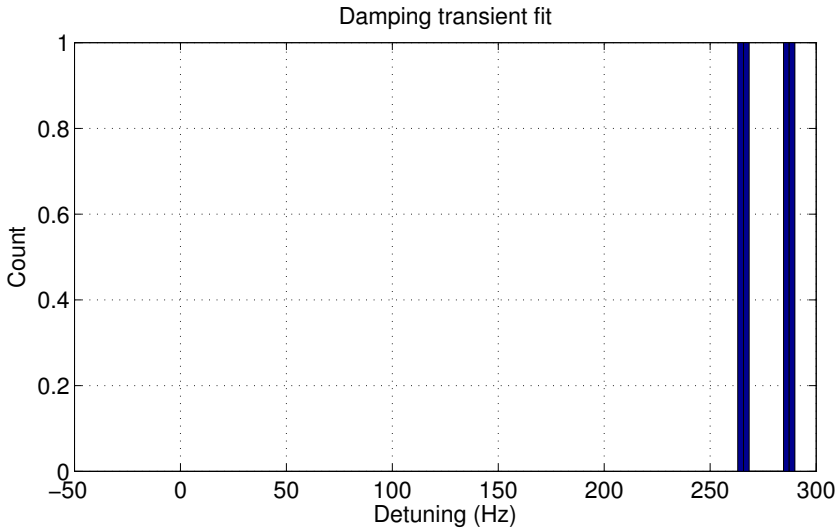

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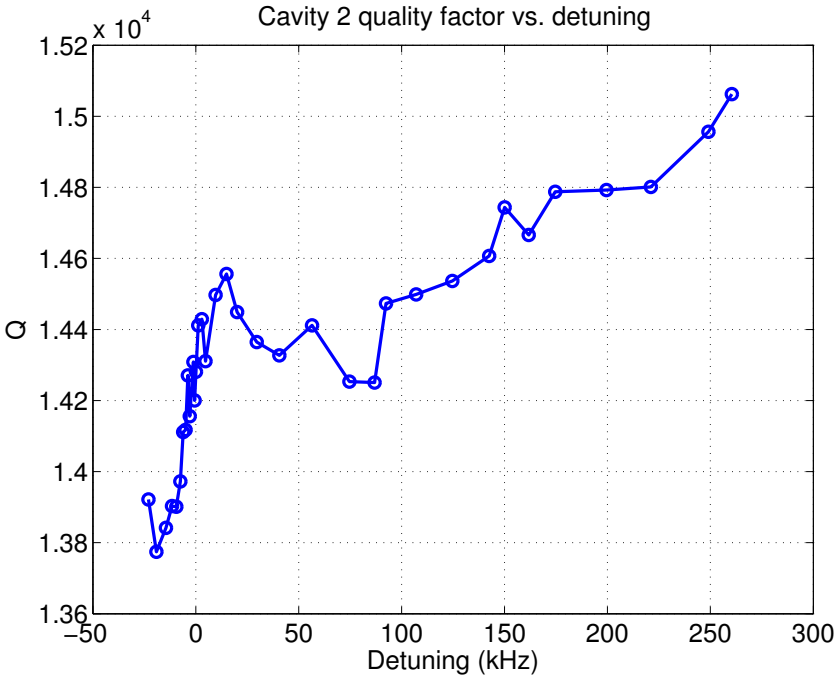

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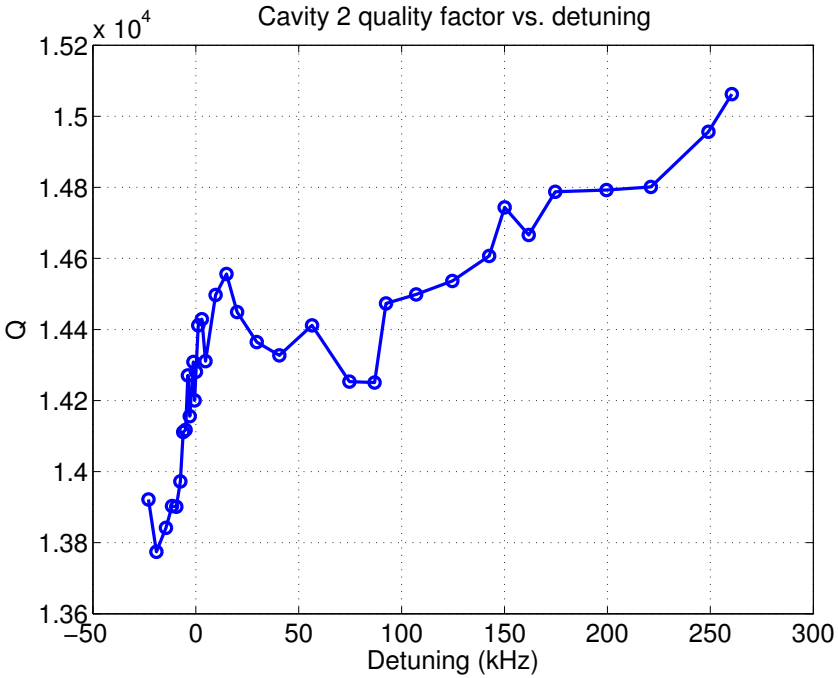

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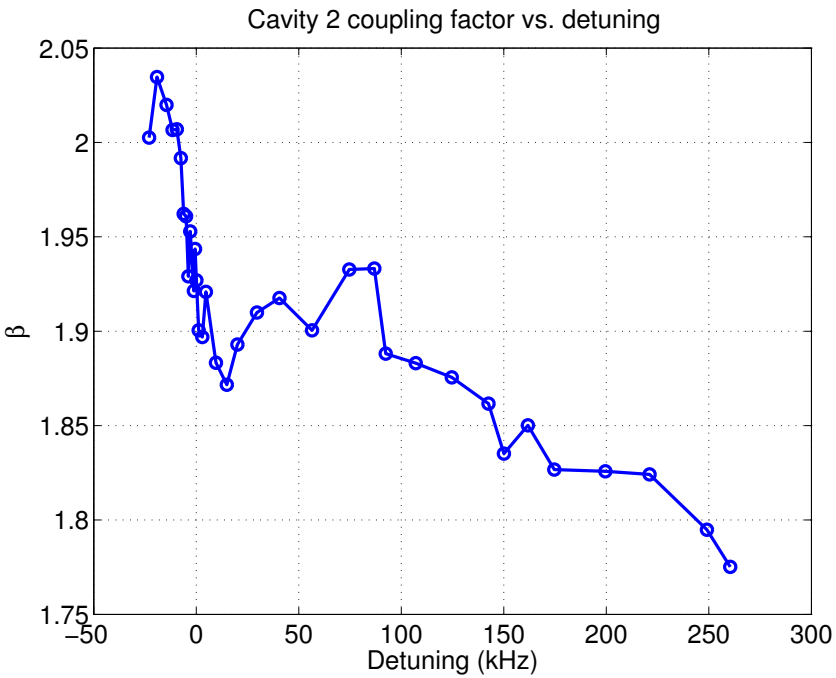

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Transfer Functions and Fits

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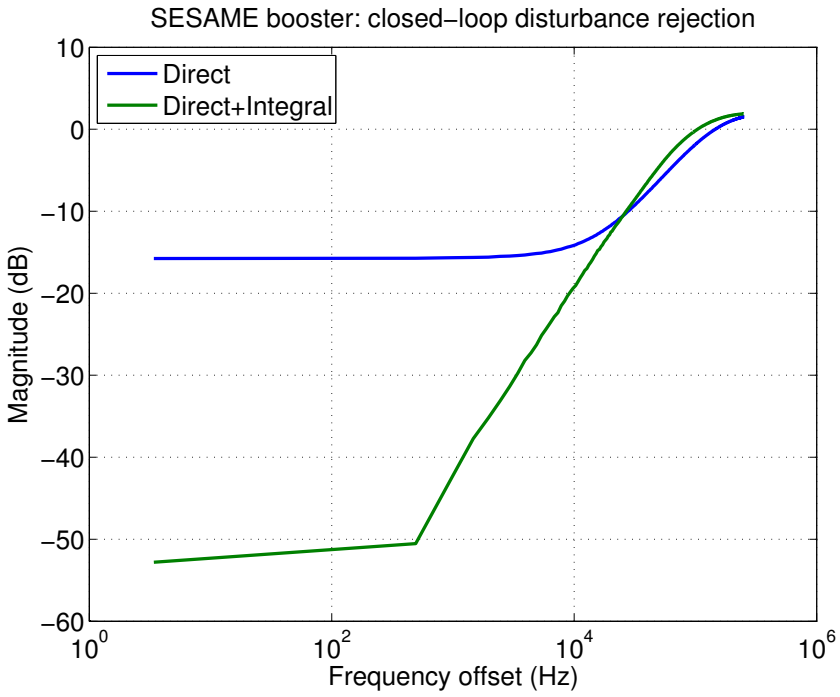

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- Around 16 dB proportional rejection;
- Loop gain of 5.1;
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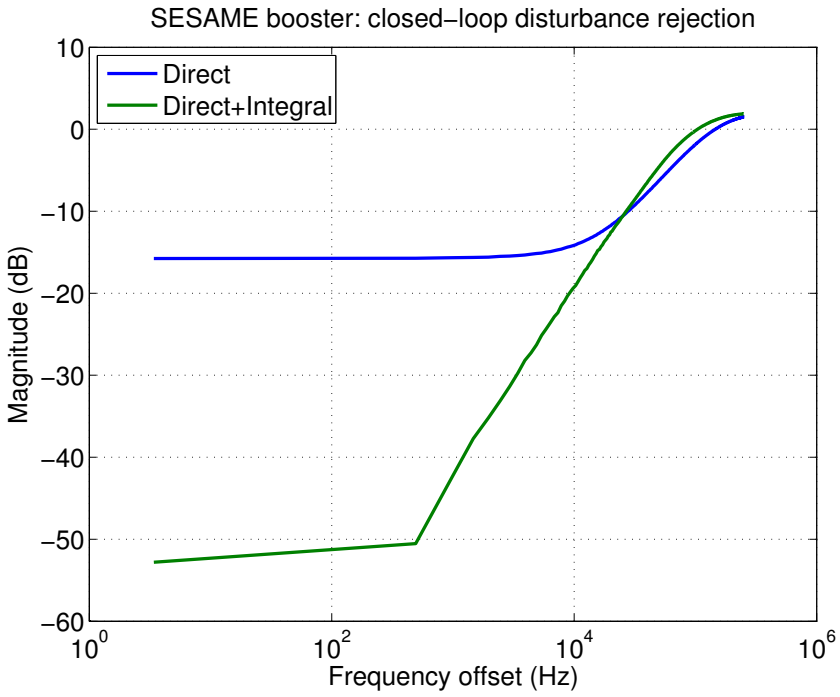

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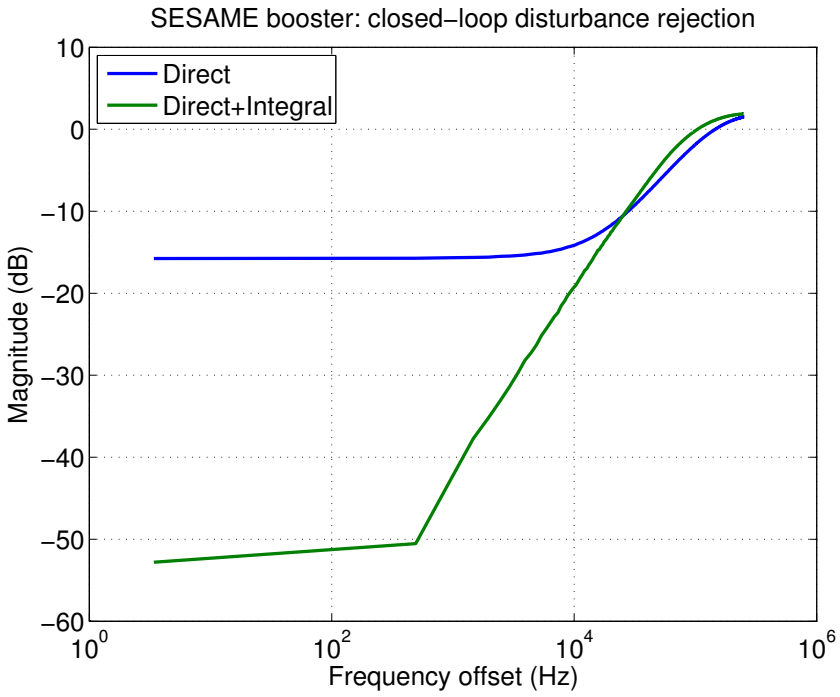

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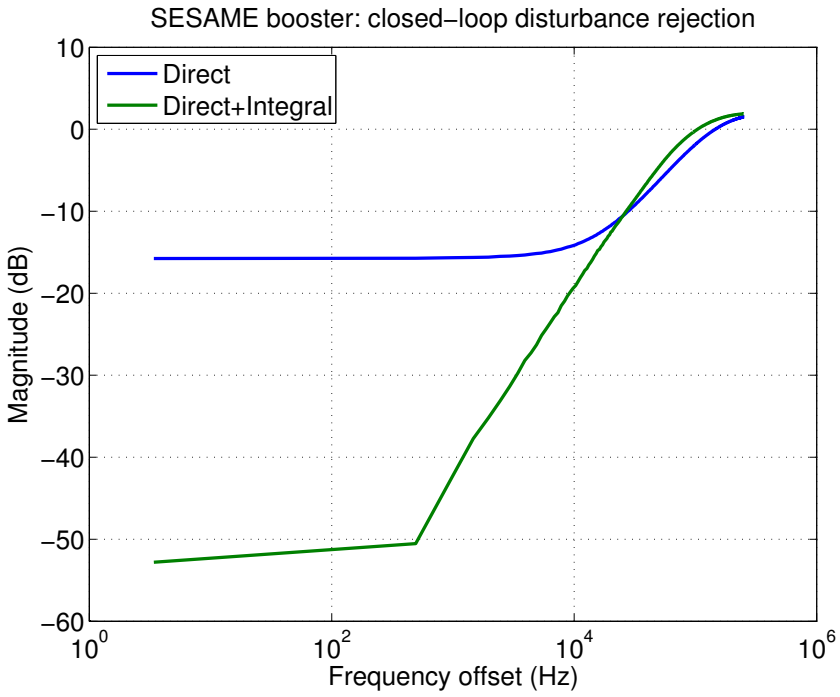

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Summary

- Successfully operated two storage ring and one booster stations;
- Calibrations are preliminary, better values with beam;
- Booster setup needs permanent home.