Low-level RF Test at ANKA

LLRF9 demo on June 24, 2014

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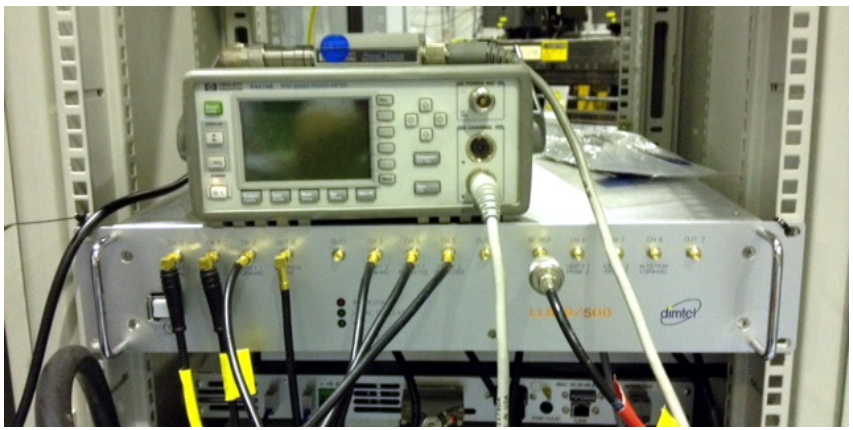
September 10, 2014

Outline

LLRF9 System



- A single 2U chassis for one- and two-cavity RF control;
- 9 input RF channels, 4 RF outputs;
- Tuner motor control via RS-485;
- External interlock daisy-chain;
- Two external trigger inputs.

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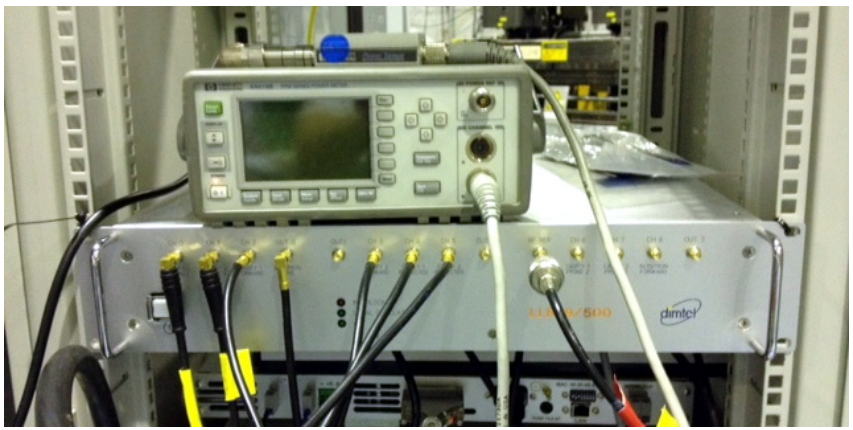

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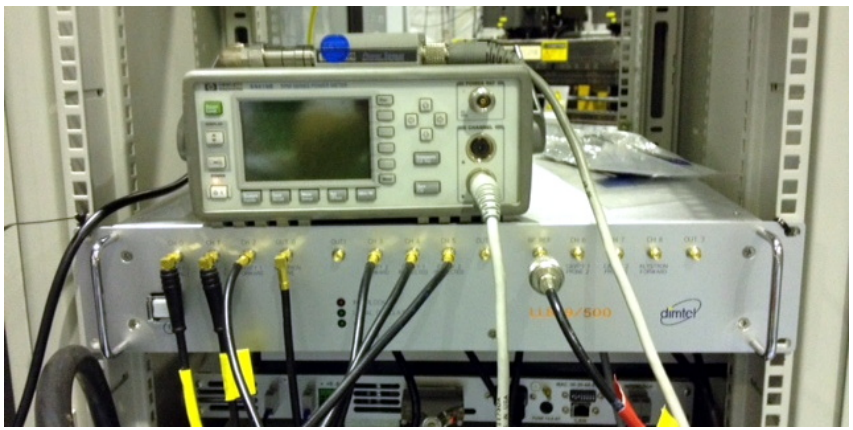

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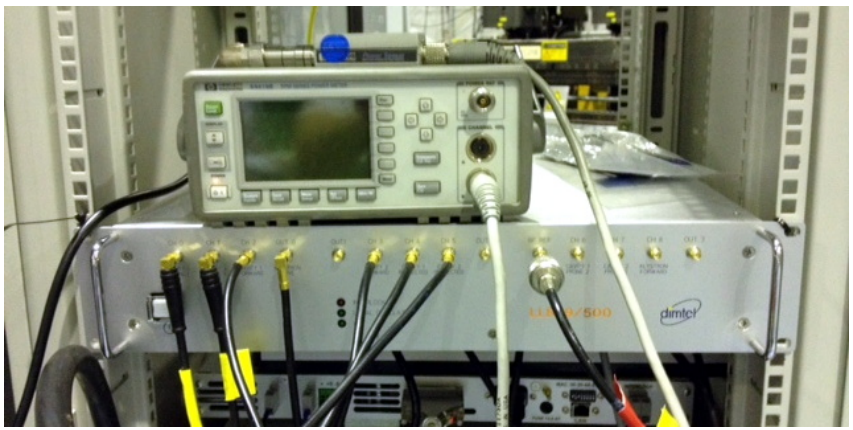

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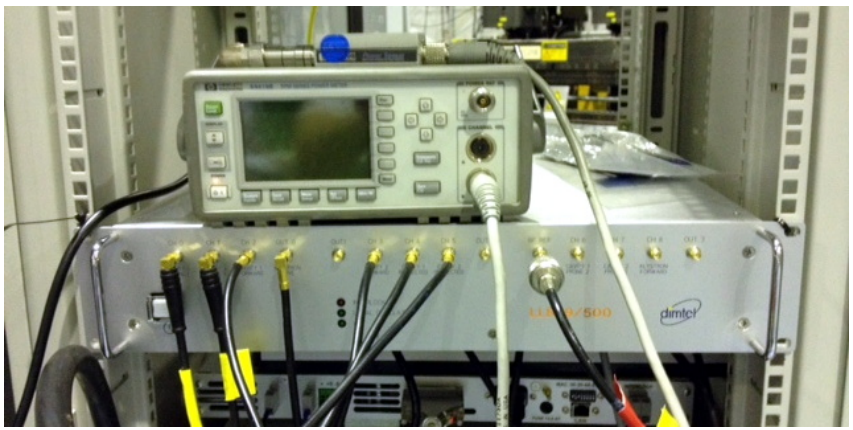

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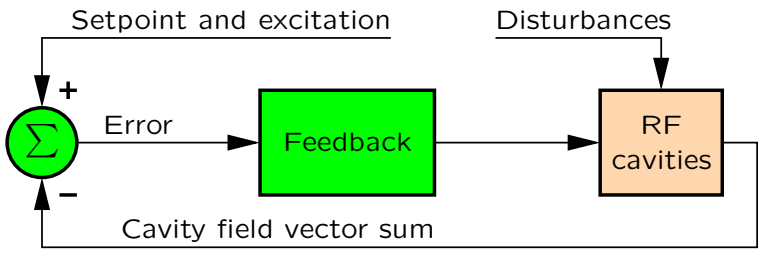
ANKA Demo Setup

- Set up LLRF9 to run one station, minimum number of connected channels:
  - Two cavity probe signals (500 MHz);
  - Two cavity forward signals (500 MHz);
  - Two cavity reflected signals (500 MHz);
  - Drive output (500 MHz);
  - Interlock input (TTL).
- Used EPICS2ACS interface to control cavity tuning;
- Started unpacking hardware at 13:50, ready for injection at 21:00;
- Could not reach full beam current due to excessive RF drive attenuation (set for 90 kW max), out of time for additional test.

Closed Loop Transfer Function



- Measured from setpoint to the error signal;
- Quantifies closed-loop disturbance rejection vs. frequency offset from f_{RF};
- Transfer function with beam;
- Proportional and integrator loops produce high rejection at low frequencies;
- Magnitude on log-log scale (ELSA data).

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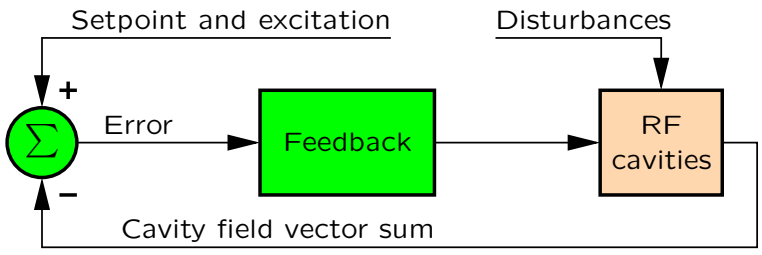

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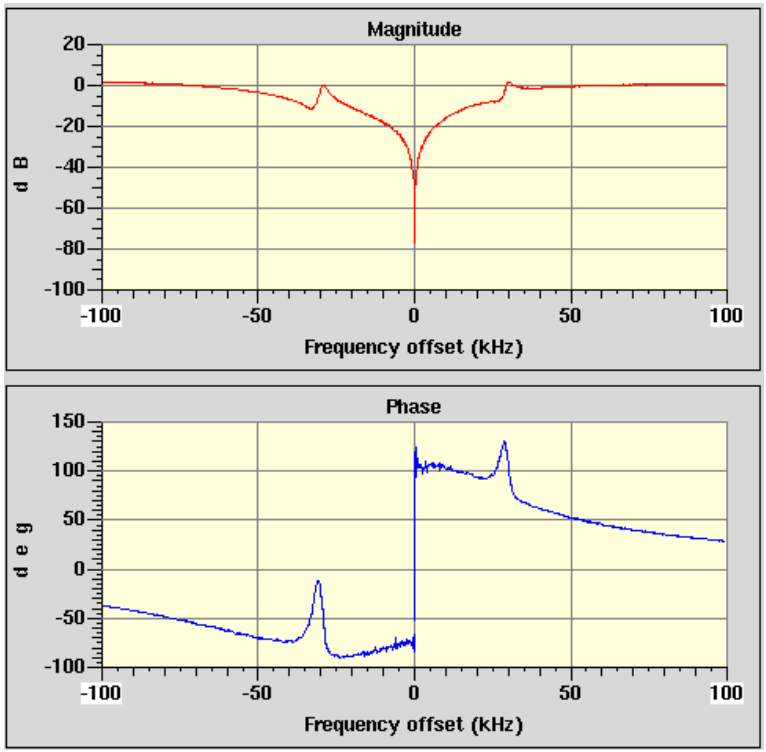

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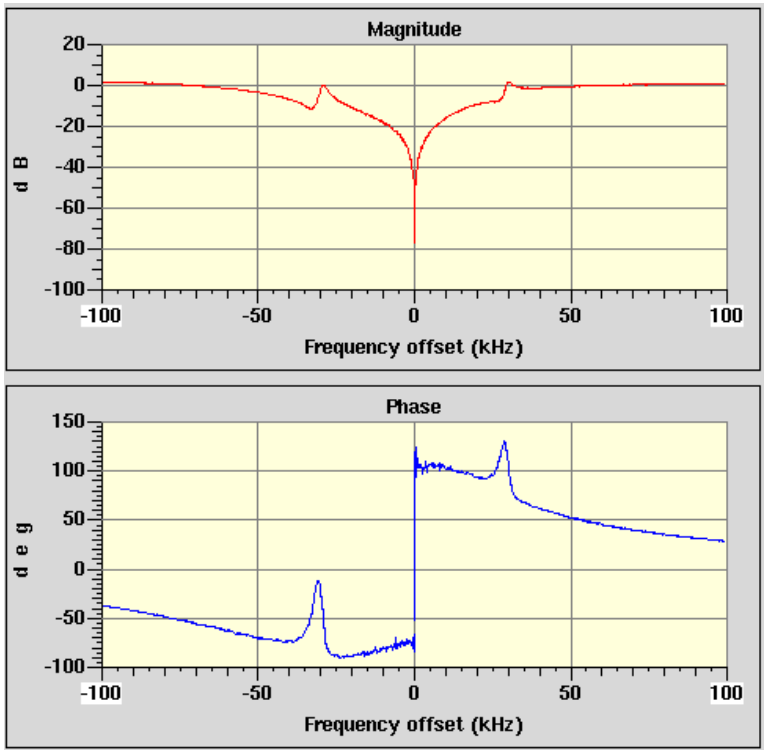

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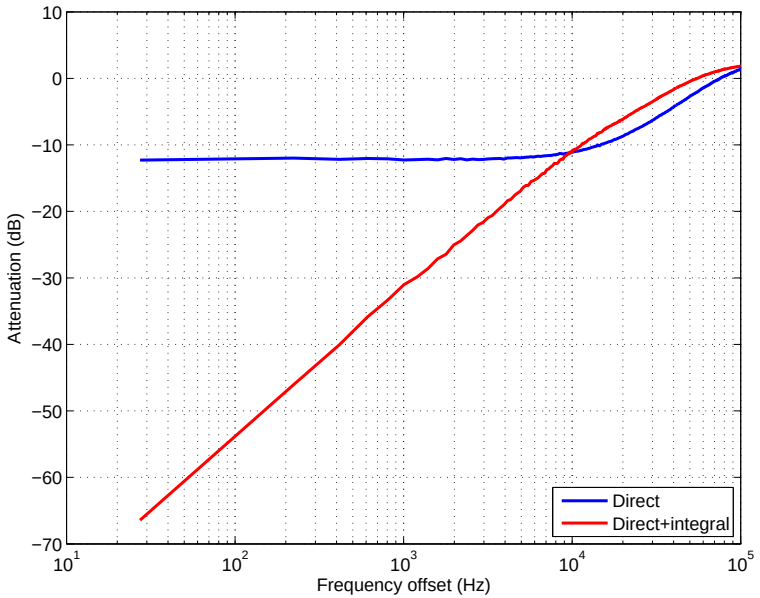

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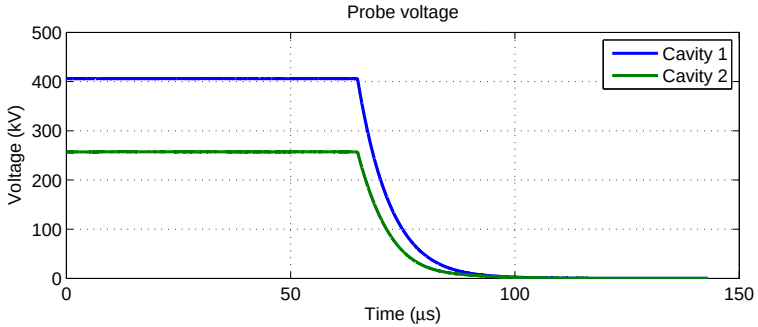
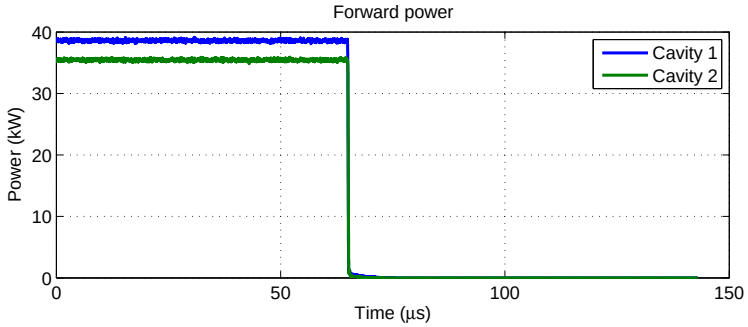
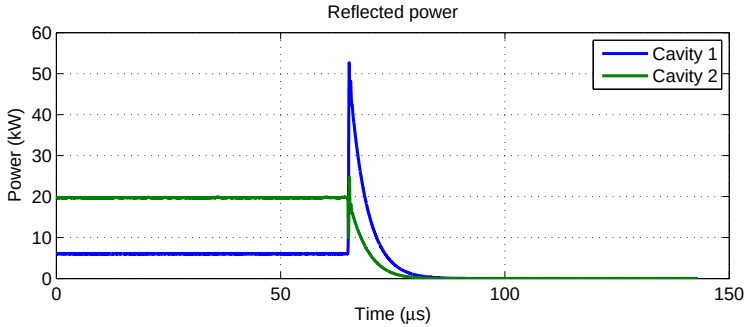
Interlock Trip







- Manually detuned cavity 2 to increase reflected power;
- Trip point set to 20 kW;
- When reflected power exceeds the threshold, RF drive is turned off within 100 ns;
- Cavity field decays consistent with the loaded Q;
- Stored energy shows up in reflected power transients.

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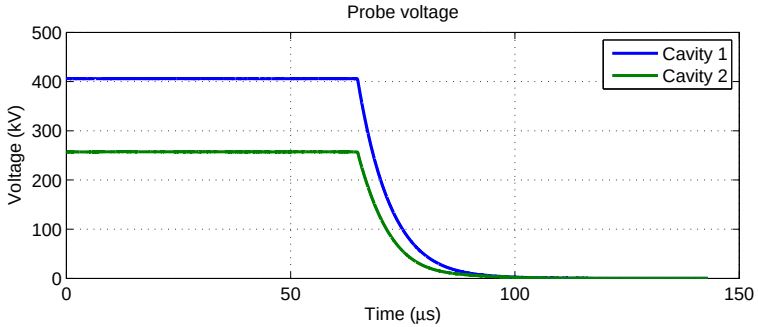

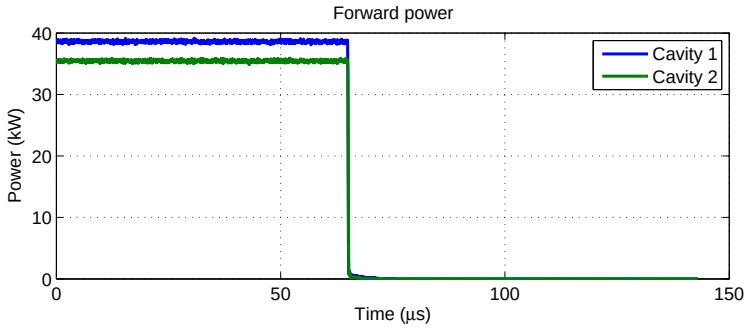

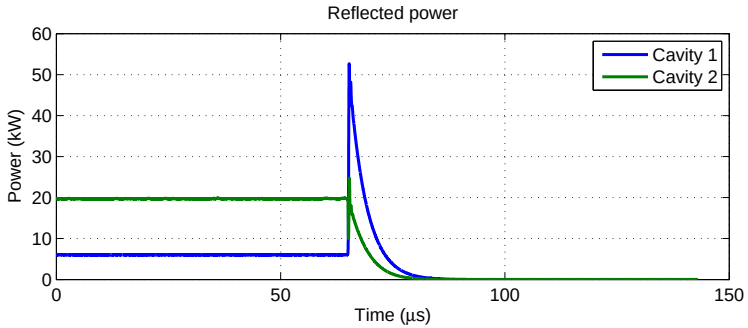

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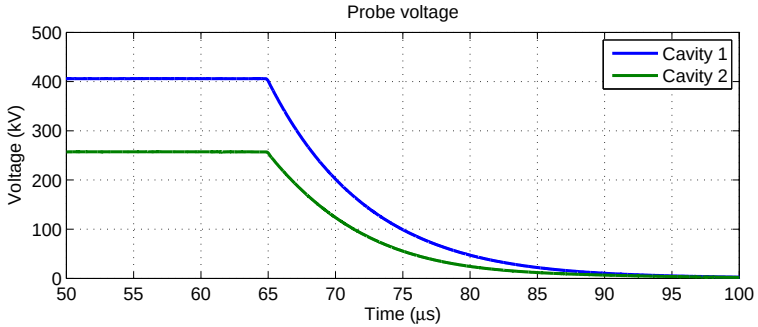

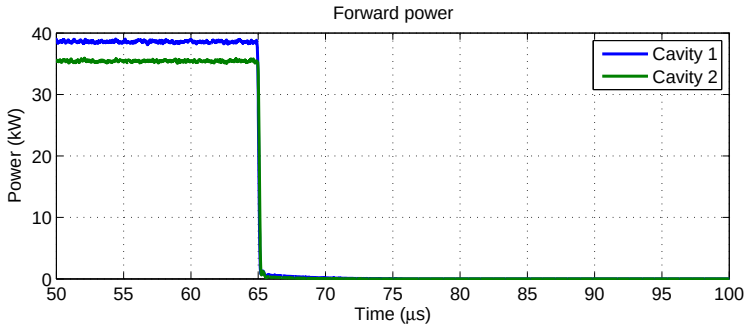

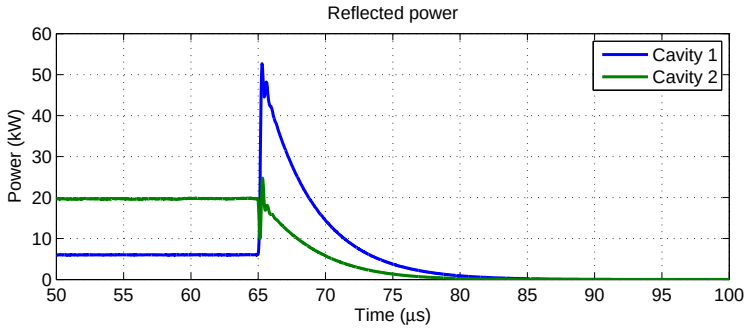

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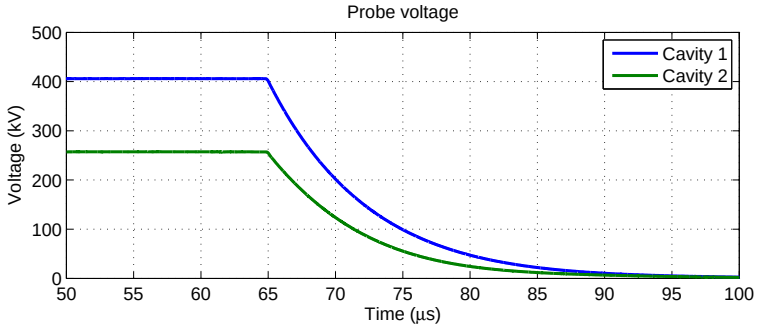

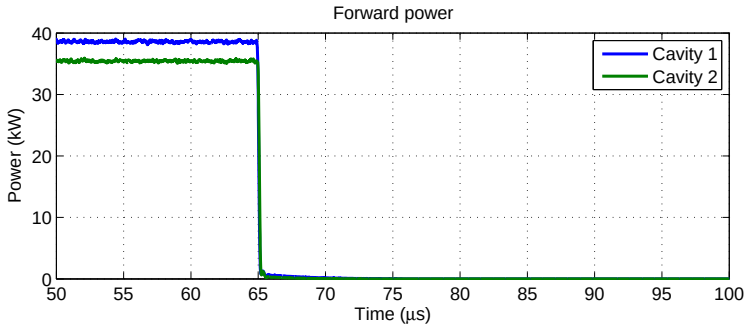

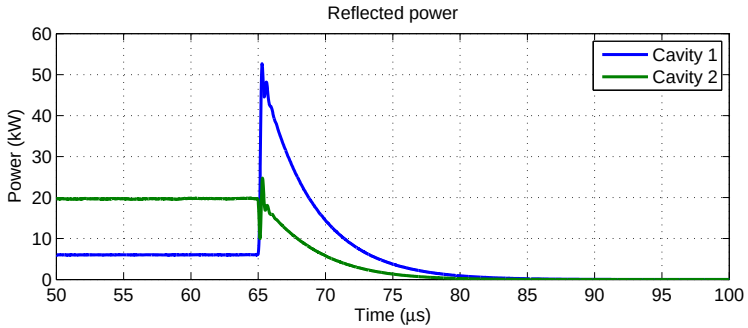

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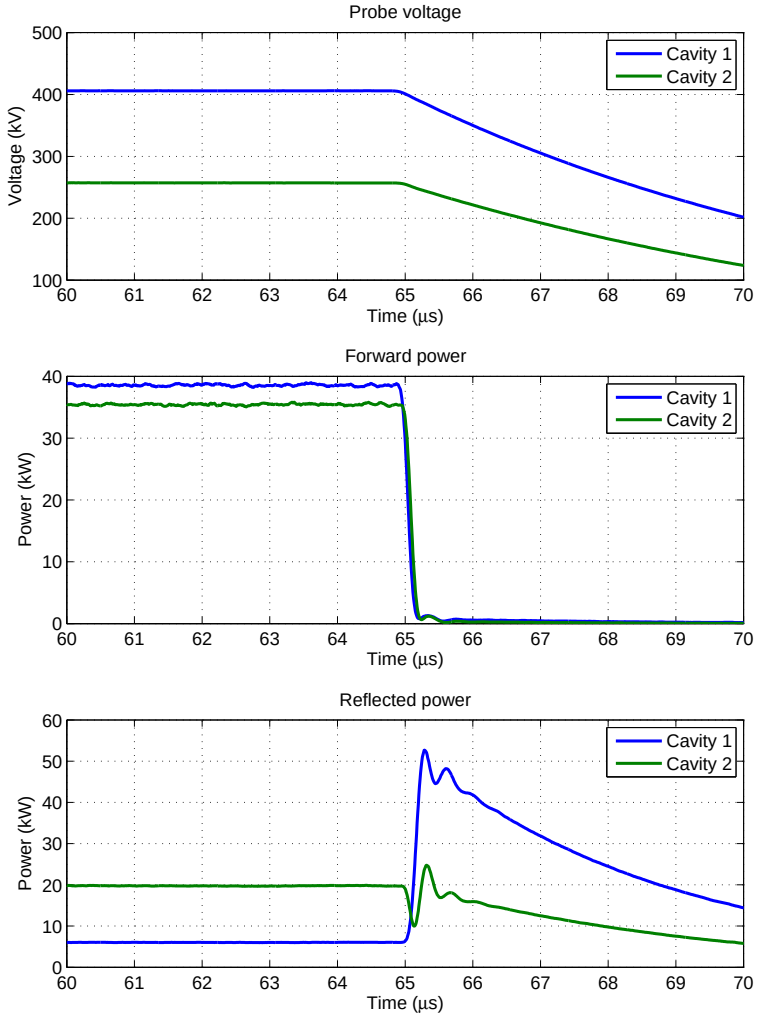

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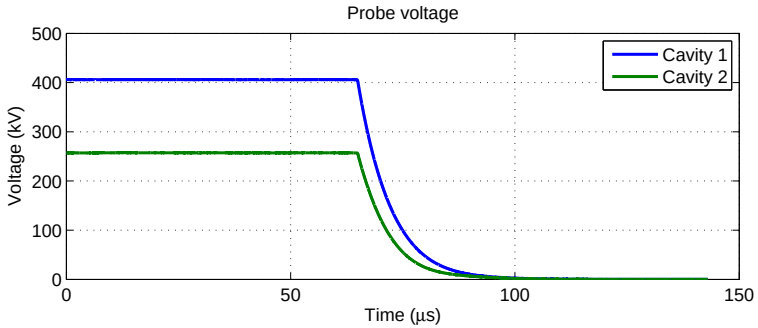

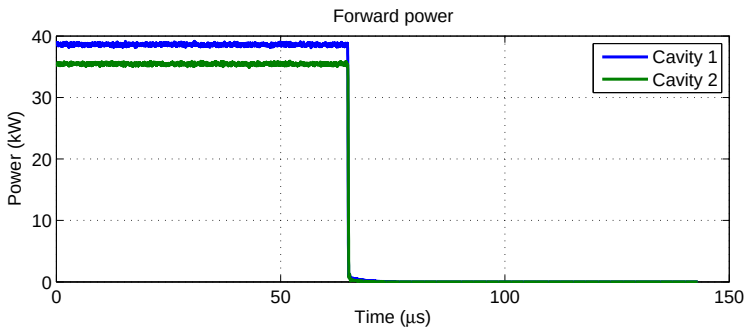

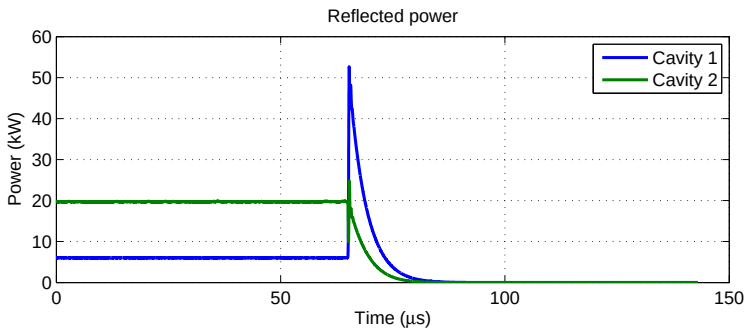

- Can fit field decay transients to extract detuning and Q;
- Envelope fits reasonably well;
- Error indicates this is not just second order decay, more complicated dynamics at play.

Parameter	Cav. 1	Cav. 2
Detuning, kHz	-3.8	-29.4
Loaded Q	11375	10630

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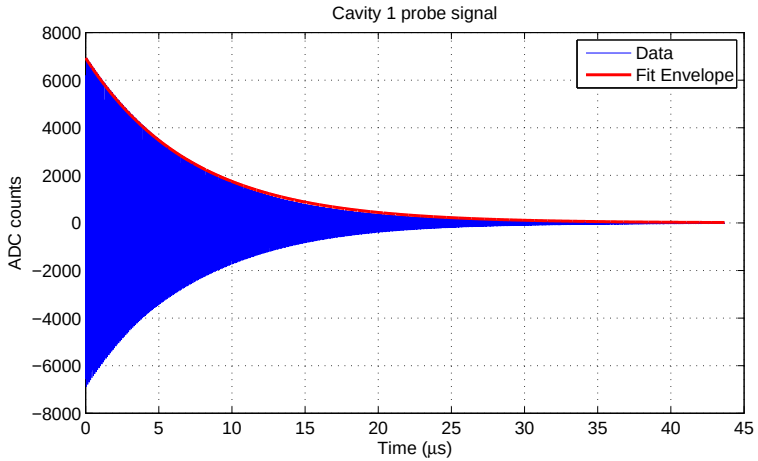

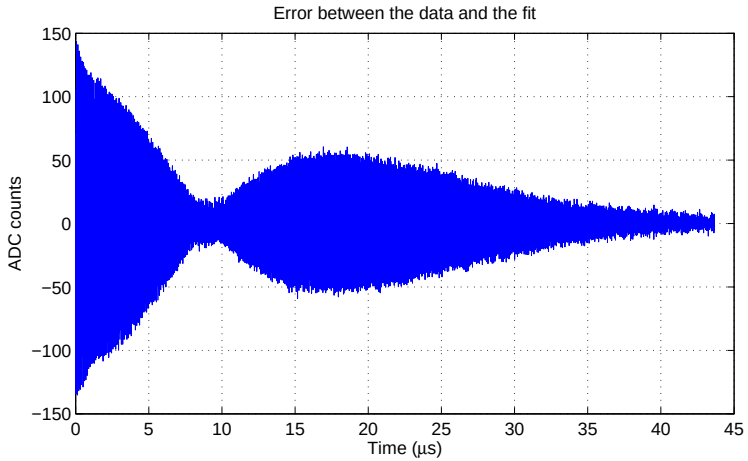

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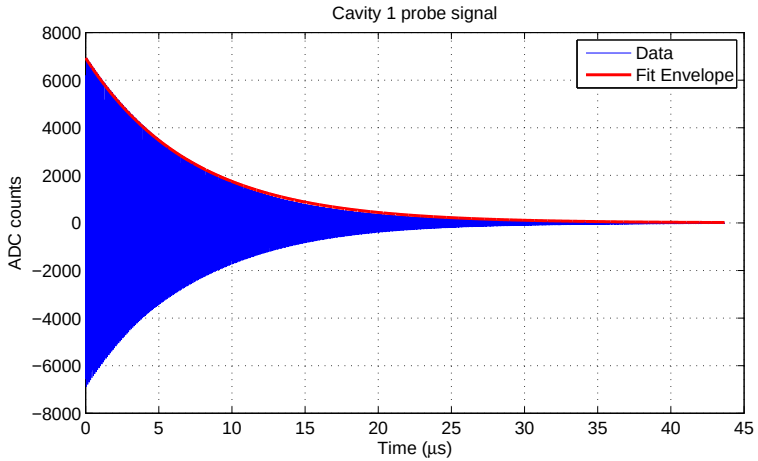

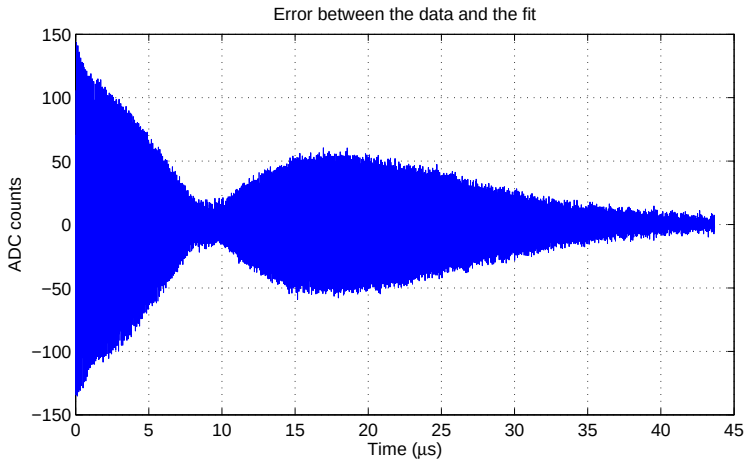

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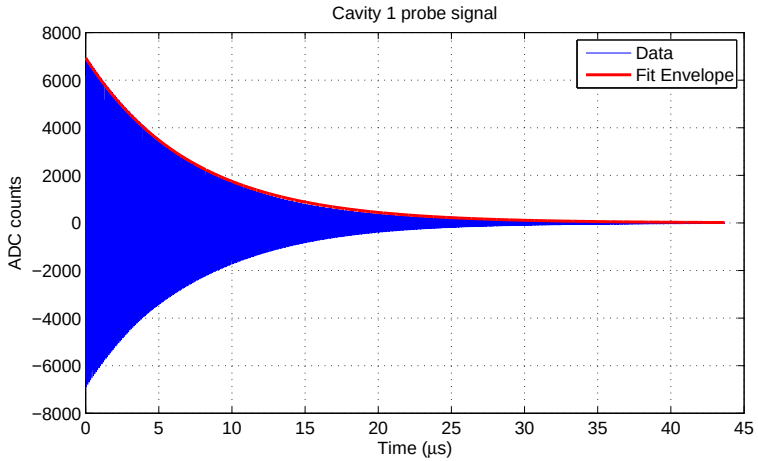

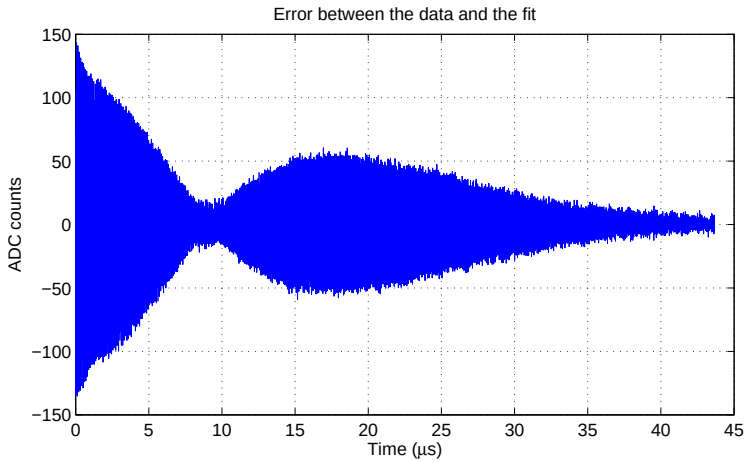

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- Demonstrated powerful user interface tools necessary for fast station configuration;
- Tested cavity voltage adjustment during energy ramping (used a Matlab script to track the energy);
- Showed high rejection of disturbances, good tuner loop response with low reflected power;
- Demonstrated that LLRF9 can be commissioned quickly in a real accelerator environment.

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