LLRF9 Beam Tests

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March 18, 2021

Day 1: Monday

- Spend a few hours in the morning figuring out tuner issue in cavity D;
- Mechanical issue found and resolved after an access;
- Tested the station state machine;
- Injected beam, tuned feedback loops;
- One beam loss event at 200 mA due to the user error;
- Reduced integral gain and easily reached 500 mA;
- Dumped the beam and reinjected from scratch in the “hands-off” mode.

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Day 2: Tuesday

- Started at 8 AM from capturing some data with SRF1 at 500 mA;
- Moved to LLRF9;
- Injected to 500 mA in 100 mA steps, captured characterization data at each step;
- Upon completing all the measurements we transitioned to the 7 nm lattice;
- Captured data at 100 and 500 mA;
- Two runs in top-up mode, 1.5 and 2 hours.

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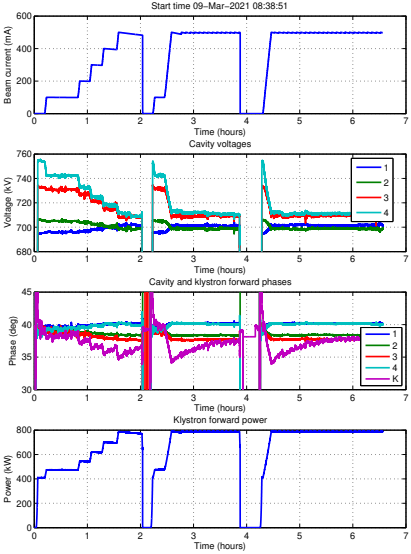

- Stripcharts sampling at 2 SPS:
  - Beam current;
  - Cavity voltages and phases;
  - Klystron forward power and phase.
- Full day 2 AP;
- The first top-up run;
- The second top-up run;
- Station voltage is 2820 ± 1.2 kV.

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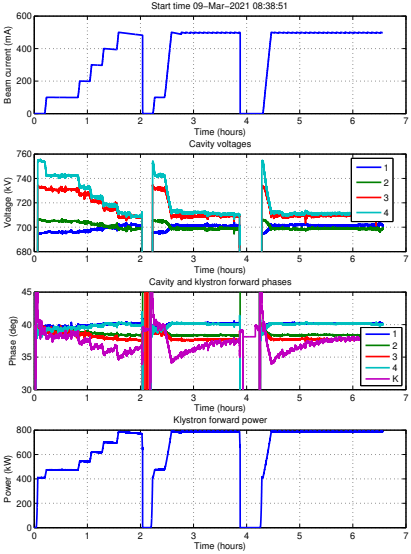

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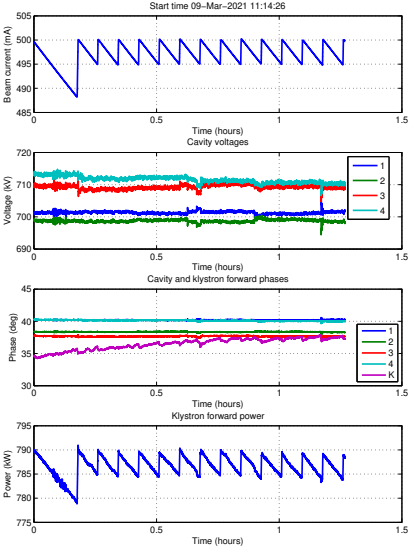

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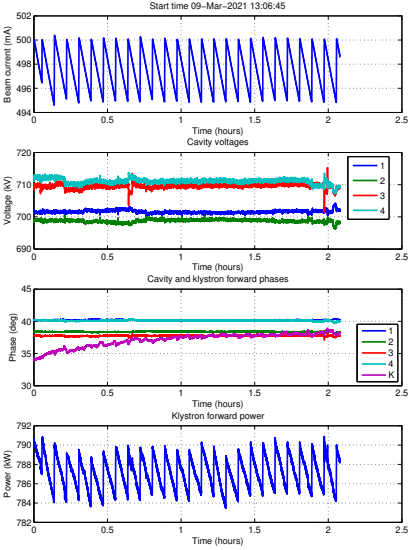

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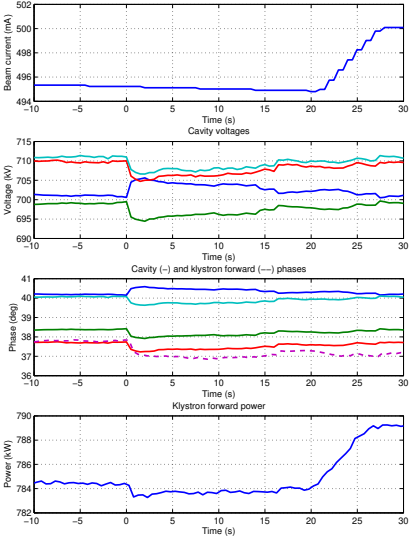
Glitches Observed During the AP



- Cavity 1 amplitude and phase jump, 0.7% and 0.3°.
- Cavity 2 responds in a mirror fashion to keep the vector sum fixed;
- Cavities 3 and 4 follow 2;
- Suggests cavity 1 probe signal insertion loss change;
- A few more glitches, now cavity 3;
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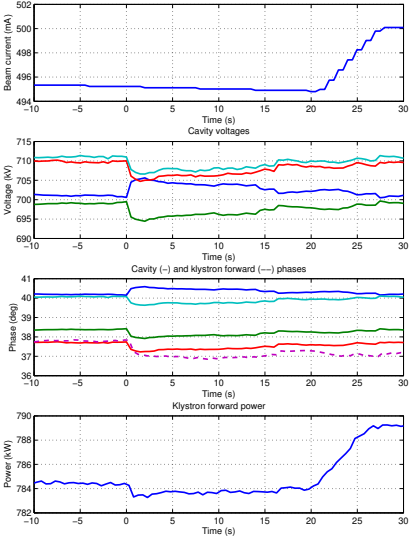

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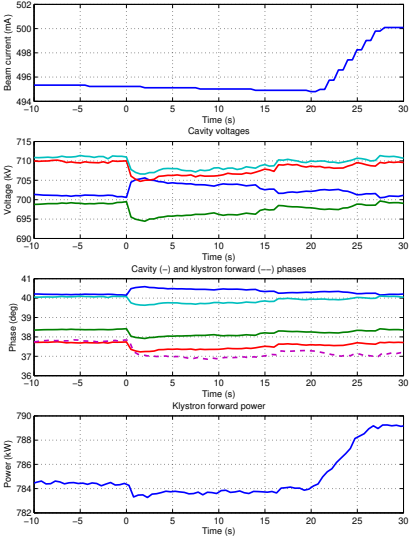

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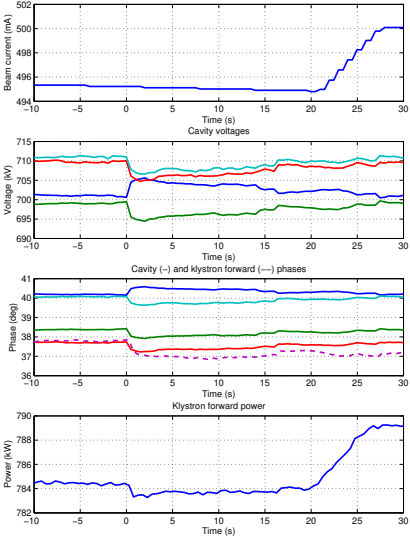

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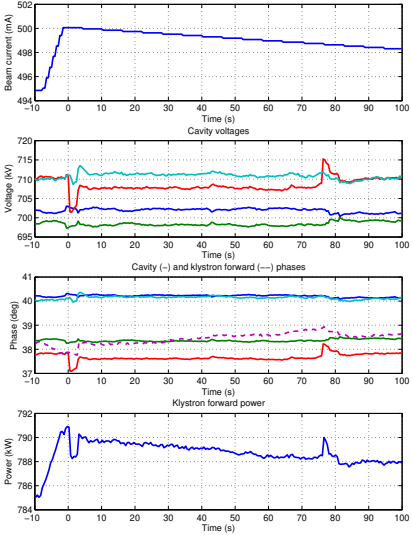

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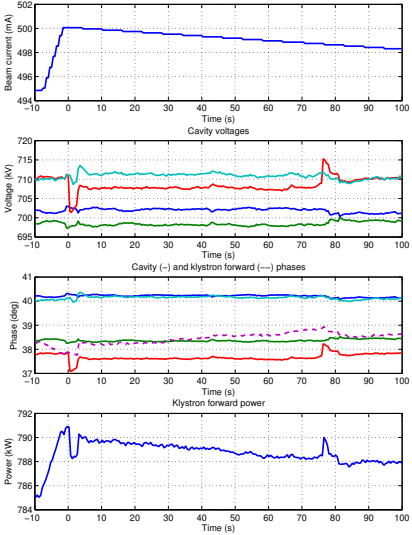

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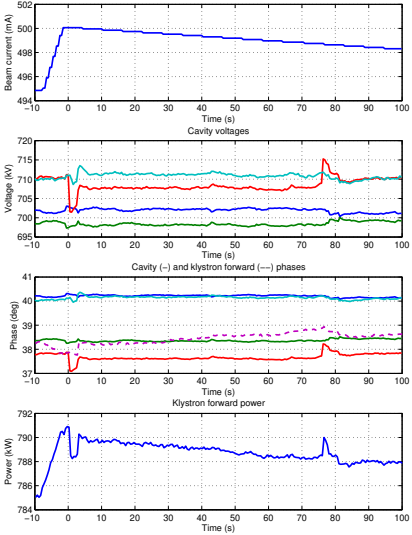

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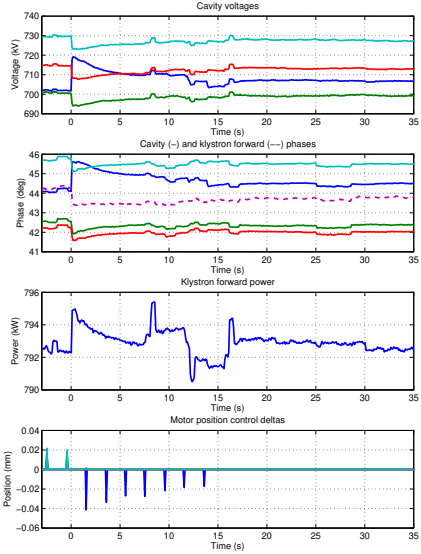

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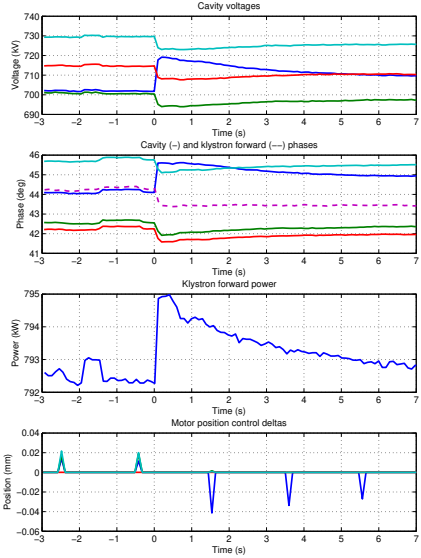

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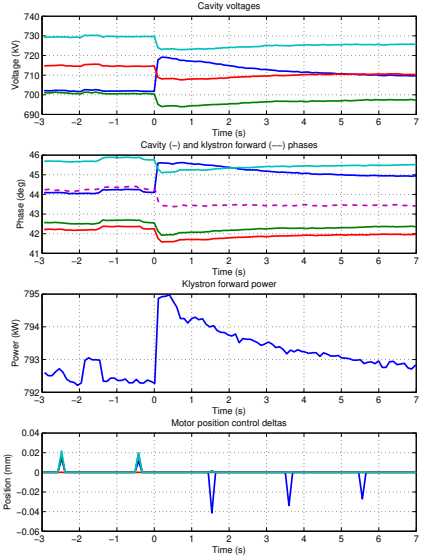

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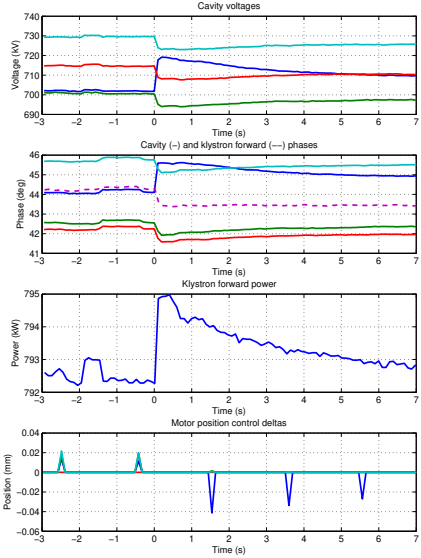

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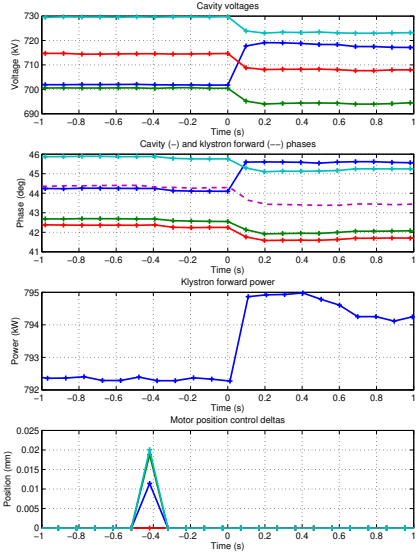

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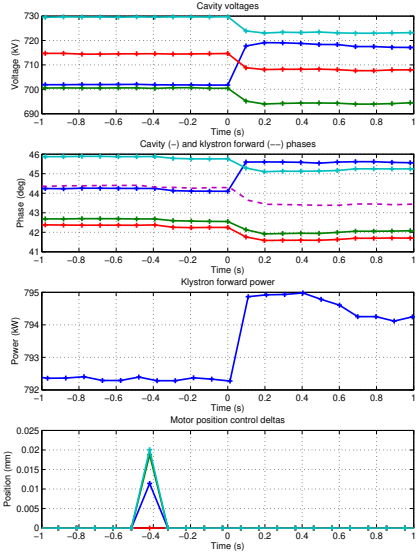

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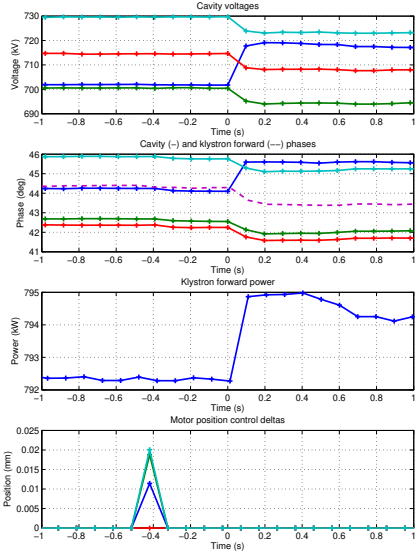

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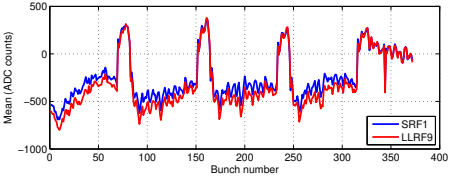
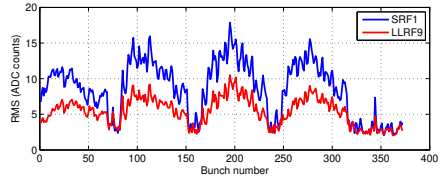
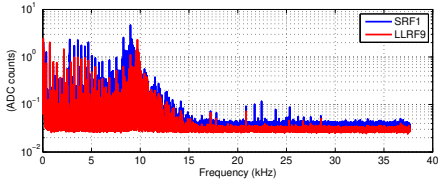
Bunch-by-bunch Signals and Spectra







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- Station phase is slightly different for LLRF9;
- May affect front-end sensitivity;
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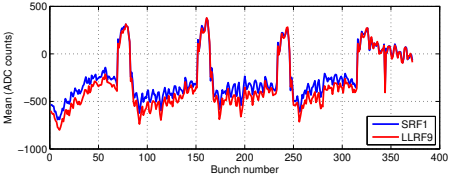

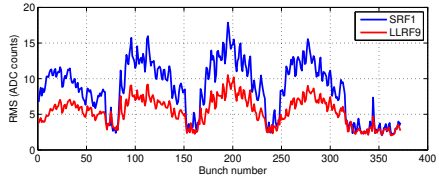

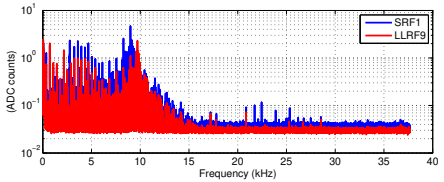

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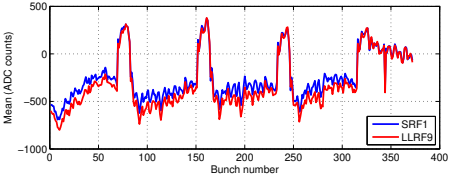

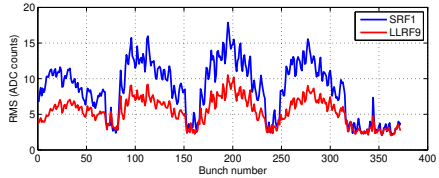

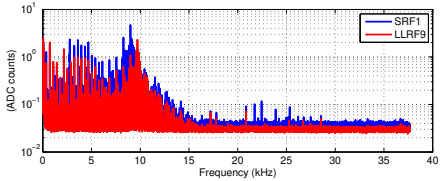

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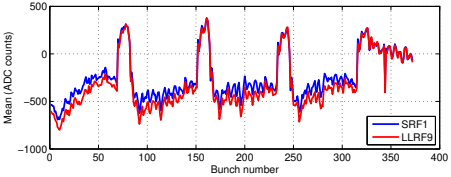

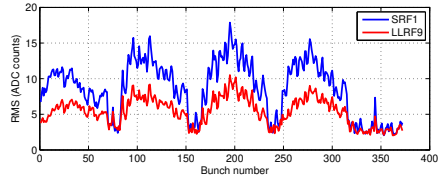

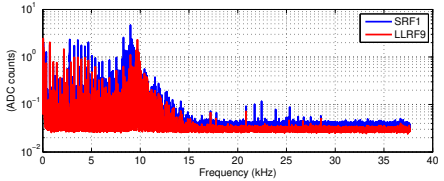

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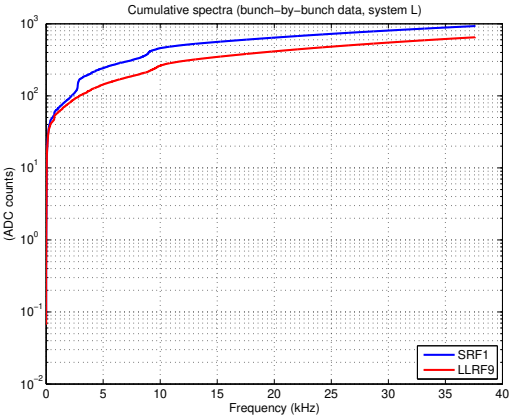
- Station phase is slightly different for LLRF9;
- May affect front-end sensitivity;
- See dramatic reduction in the RMS.

Cumulative Spectra



- Clear difference between the cumulative spectra;
- Some difference at 360 Hz;
- A big difference around 2.7 kHz;
- Smaller increase around the synchrotron frequency as well.

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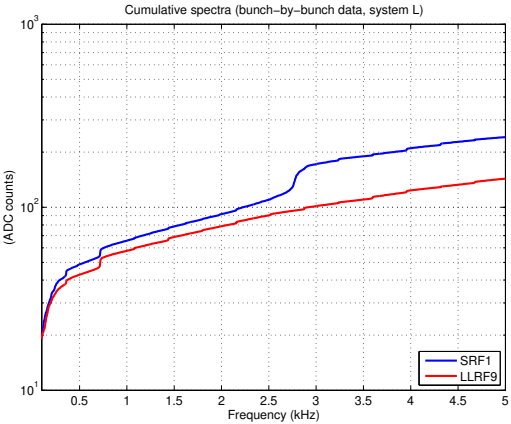

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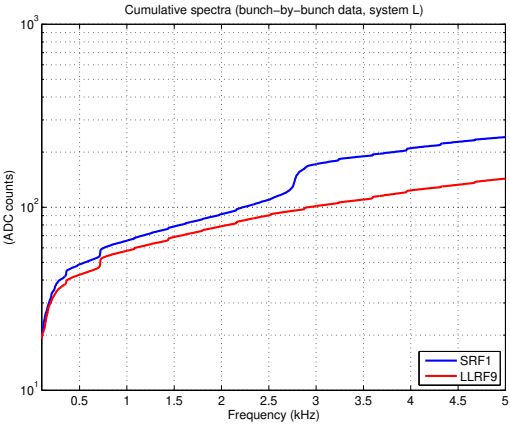

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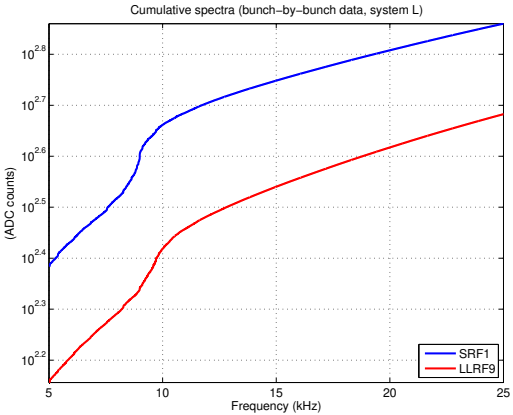

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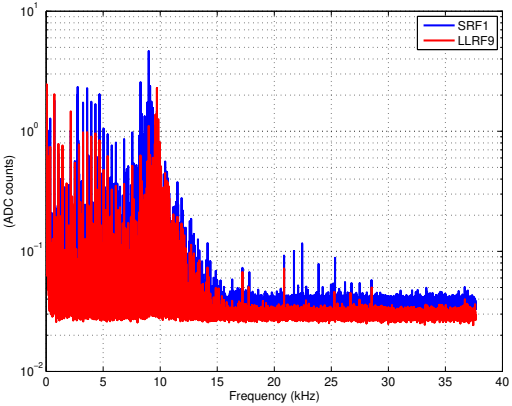
Detailed Spectra



- Broadband noise floor is lower;
- The line at 360 Hz is halved;
- 2.7 kHz is completely absent;
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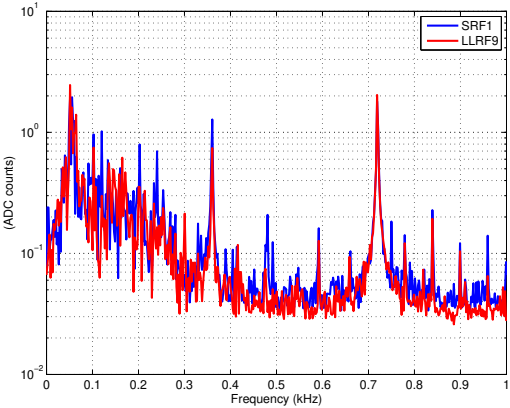

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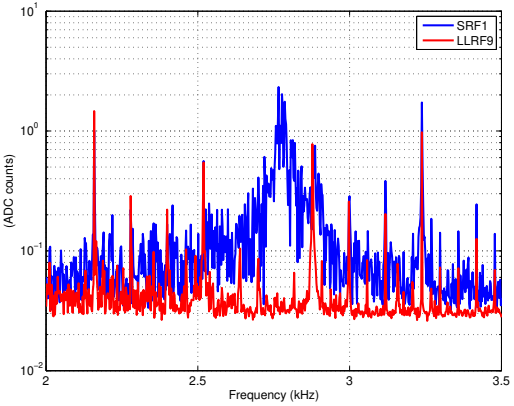

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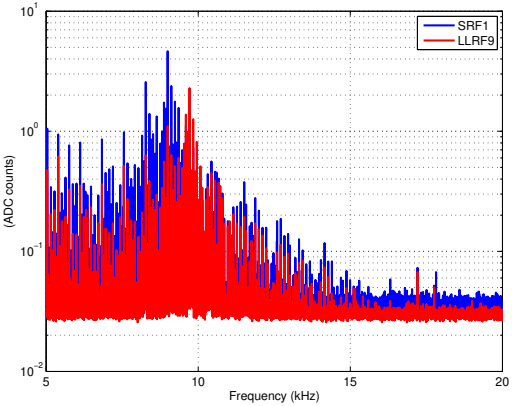

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Summary

- Very smooth commissioning for the full beam currents;
- Good stability margins, short-term operation experience suggests this is a fairly robust configuration;
- Field stability is comparable to the old station at offsets above 10 Hz, more stable below;
- Feedback configuration can be further optimized;
- EPICS vector sum control is designed and ready for integration.

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