

LLRF9 in SPEAR3

First Day

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Dimtel, Inc., San Jose, CA, USA

January 28, 2021

Setup

Channel
Calibrations

Strip Tool
Data

Cavity
Probe
Spectrum

Summary

Current Status

- ▶ **Unit installed and powered;**
- ▶ On the network Tuesday morning;
- ▶ Master oscillator reference level adjusted Tuesday afternoon;
- ▶ Coupling factors adjusted Wednesday to match RF readouts;
- ▶ Temporarily modified top-level IOC code to calculate the vector sum of 4 cavities instead of 2.

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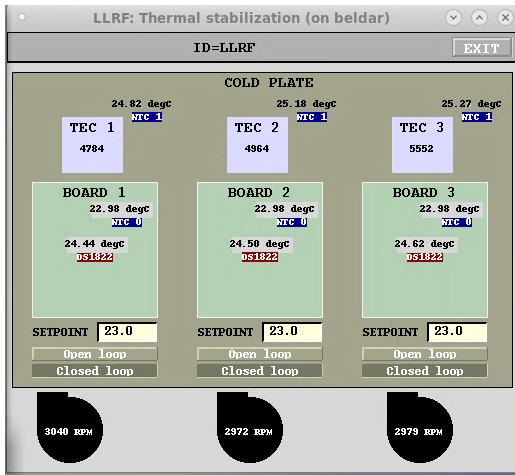
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Some Panels

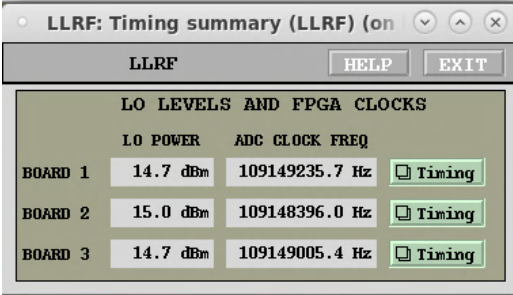


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Some Panels



The screenshot shows a software window titled "LLRF: Timing summary (LLRF) (on)". The window has a title bar with a dropdown arrow, an up arrow, and a close button. Below the title bar is a header bar with the text "LLRF" and two buttons: "HELP" and "EXIT". The main content area is titled "LO LEVELS AND FPGA CLOCKS" and contains a table with three columns: "BOARD", "LO POWER", and "ADC CLOCK FREQ". Each row represents a board and includes a "Timing" button.

	LO POWER	ADC CLOCK FREQ	
BOARD 1	14.7 dBm	109149235.7 Hz	<input type="checkbox"/> Timing
BOARD 2	15.0 dBm	109148396.0 Hz	<input type="checkbox"/> Timing
BOARD 3	14.7 dBm	109149005.4 Hz	<input type="checkbox"/> Timing

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Some Panels

LLRF: Scalar monitors (LLRF:BRD1) (on bel: [dropdown] [up] [down] [close])

ID=LLRF:BRD1 [HELP] [EXIT]

RAN DDC READBACKS

SLAVE MASTER Error/2 [copy]

DDC CHANNEL

	ADC 0	ADC 1	ADC 2	ADC 3	DIAG
I	4280.9	1180.1	4583.5	5106.7	0.0
Q	-2955.0	5104.6	-2204.9	4323.2	0.0
AMP	5201.0	5239.3	5086.3	6690.9	0.0
PHASE	34.6	-77.0	25.7	-40.3	-0.0

LLRF: Scalar monitors (LLRF:BRD2) (on bel: [dropdown] [up] [down] [close])

ID=LLRF:BRD2 [HELP] [EXIT]

RAN DDC READBACKS

SLAVE MASTER Drive [copy]

DDC CHANNEL

	ADC 0	ADC 1	ADC 2	ADC 3	DIAG
I	3224.8	-5311.4	5723.2	4080.2	0.0
Q	4225.2	255.1	447.6	5475.9	0.0
AMP	5315.2	5317.5	5740.7	6828.9	0.0
PHASE	-52.6	-177.3	-4.5	-53.3	-0.0

LLRF: Scalar monitors (LLRF:BRD3) (on bel: [dropdown] [up] [down] [close])

ID=LLRF:BRD3 [HELP] [EXIT]

RAN DDC READBACKS

SLAVE MASTER Drive [copy]

DDC CHANNEL

	ADC 0	ADC 1	ADC 2	ADC 3	DIAG
I	-650.5	2780.0	5689.3	-1713.1	0.0
Q	-5513.7	-4207.0	-402.7	-6165.1	0.0
AMP	5552.0	5042.5	5703.5	6398.7	0.0
PHASE	96.7	56.5	4.0	105.5	-0.0

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LLRF: All Channels (LLRF) (on beldar)

LLRF HELP EXIT

ALL CHANNELS

CAVITY 1 PROBE	673.86 kv	18.39 deg	<input type="checkbox"/> Channel
CAVITY 2 PROBE	715.32 kv	19.81 deg	<input type="checkbox"/> Channel
KLYSTRON FWD	776.53 kw	-9.20 deg	<input type="checkbox"/> Channel
CAVITY 3 PROBE	714.35 kv	21.79 deg	<input type="checkbox"/> Channel
CAVITY 4 PROBE	739.76 kv	14.46 deg	<input type="checkbox"/> Channel
CAVITY 1 FWD	175.48 kw	14.13 deg	<input type="checkbox"/> Channel
CAVITY 2 FWD	208.77 kw	10.34 deg	<input type="checkbox"/> Channel
CAVITY 3 FWD	210.66 kw	16.38 deg	<input type="checkbox"/> Channel
CAVITY 4 FWD	213.40 kw	7.81 deg	<input type="checkbox"/> Channel

Raw I/Q: board 1 Raw I/Q: board 2 Raw I/Q: board 3

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Channel Setup Panels

The image displays five LLRF Channel Setup Panels, each for a different channel. Each panel contains the following information:

- Channel ID:** LLRF: Channel 0, 1, 2, 0, 1 (from left to right).
- Probe/Cavity:** CAVITY 1 PROBE, CAVITY 2 PROBE, KLYSTRON FND, CAVITY 3 PROBE, CAVITY 4 PROBE.
- Raw Data:** RAW AMPLITUDE and RAW PHASE.
- Hardware Settings:** HW FULL SCALE and HW PHASE OFFSET.
- Control Settings:** COUPLING and PHASE OFFSET (with input fields).
- Output Format:** Voltage and Power buttons.
- TRIP:** TRIP (green button) and RESET (grey button) buttons, with associated values.

Channel	Raw Amp	Raw Phase	HW Full Scale	HW Phase Offset	Coupling	Phase Offset	TRIP	RESET
Channel 0 (Cavity 1 Probe)	5182.7	74.1	0.47	5.53	70.05	-62.000	300.00	671.23
Channel 1 (Cavity 2 Probe)	5222.2	-37.2	0.73	-60.06	70.18	316.000	300.00	712.38
Channel 2 (Klystron FND)	5066.4	64.6	0.48	-46.64	82.56	-28.500	300.00	776.47
Channel 0 (Cavity 3 Probe)	5318.0	0.4	0.35	-159.67	70.48	-179.200	300.00	714.72
Channel 1 (Cavity 4 Probe)	5386.4	-124.0	0.67	135.68	70.46	2.000	300.00	742.29

Channel	Raw Amp	Raw Phase	HW Full Scale	HW Phase Offset	Coupling	Phase Offset	TRIP	RESET
Channel 2 (Cavity 1 FND)	5720.0	47.5	0.23	142.09	35.30	-176.000	300.00	174.21
Channel 0 (Cavity 2 FND)	5530.6	-10.1	0.55	-85.46	36.02	304.000	300.00	207.13
Channel 1 (Cavity 3 FND)	5019.2	-50.3	0.84	-150.23	36.61	-144.400	300.00	208.72
Channel 2 (Cavity 4 FND)	5686.6	-102.7	0.44	-145.71	56.00	-105.000	300.00	212.14

Setup

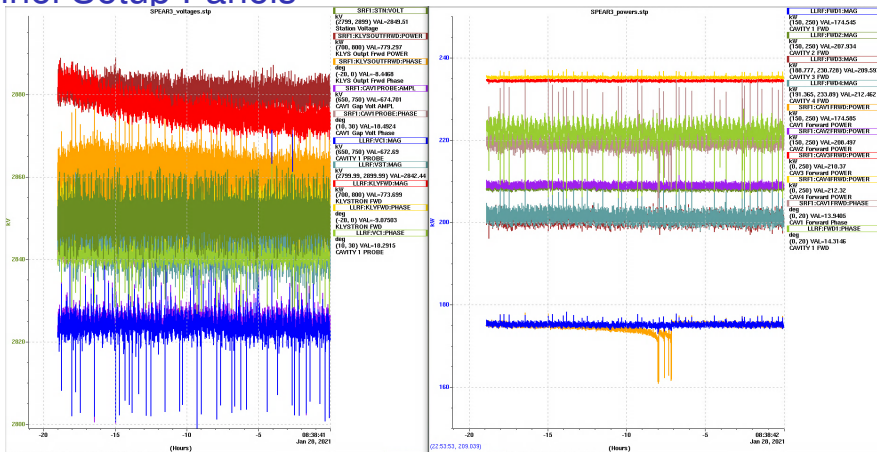
Channel Calibrations

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Cavity Probe Spectrum

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Channel Setup Panels



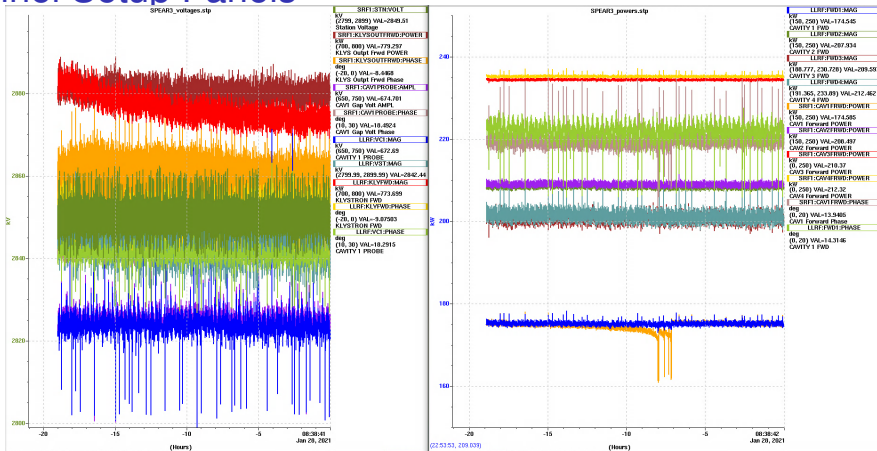
- ▶ Ran two strip tools for roughly 20 hours;
- ▶ The first StripTool: capturing forward power for all cavities, cavity 1 phases;
- ▶ The second StripTool: capturing station voltage, klystron forward, cavity 1 voltage and phase.

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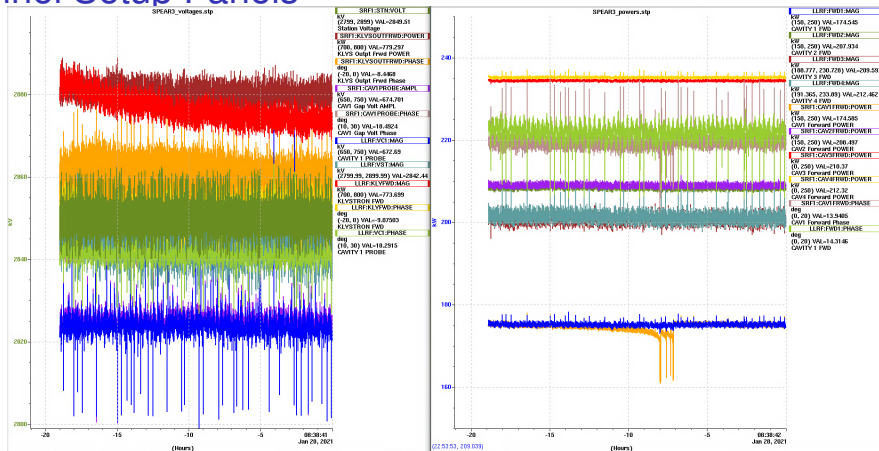
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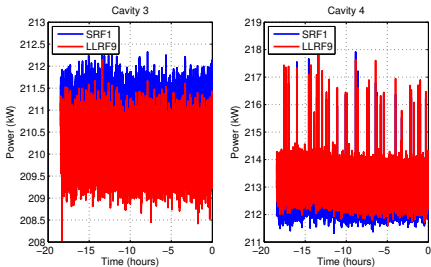
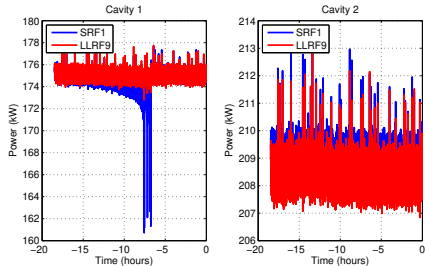
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Forward Power Signals



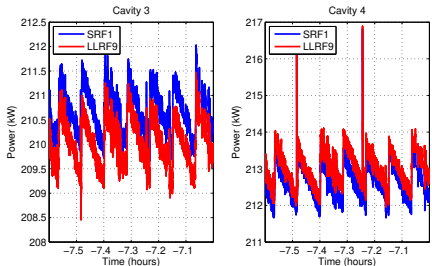
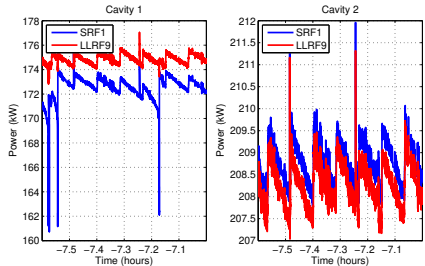
- ▶ Several interesting points:
 - ▶ Common glitches in cavities 1, 2, and 4;
 - ▶ Readout drops in cavity 1 (SRF1 only) between -10 and -5 hours;
 - ▶ Near absence of glitches in cavity 3.
- ▶ Zooming in;
- ▶ Periodic pattern — top-up?
- ▶ Zooming in again.

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Forward Power Signals



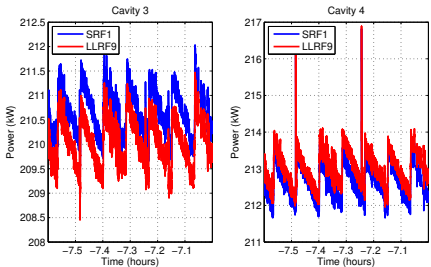
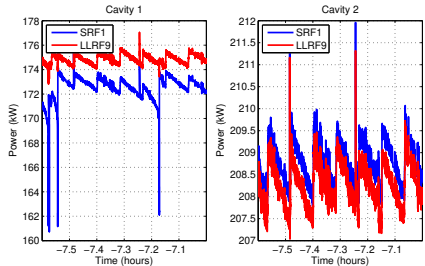
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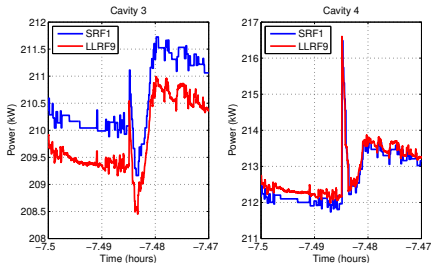
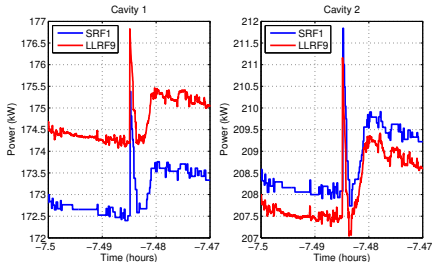
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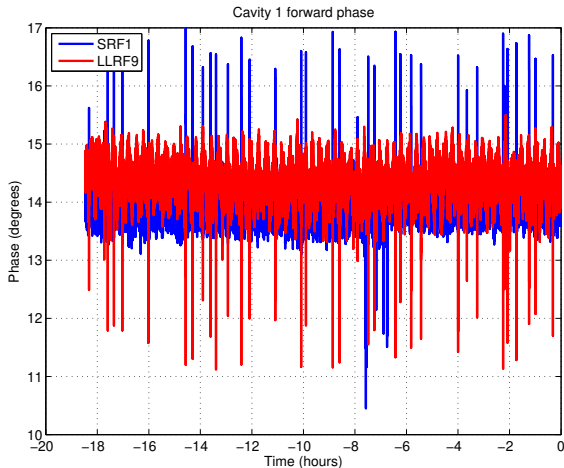
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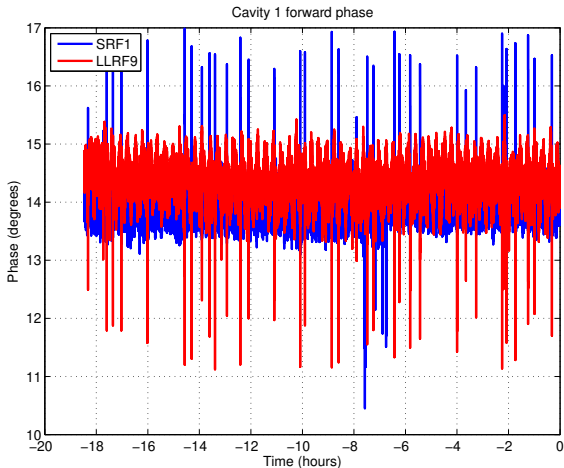
Forward Phase Signals



- ▶ Glitches show up in phase as well;
- ▶ Those seen in both systems are real, unique to SRF1 — readout/connector problems;
- ▶ Zooming in;
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- ▶ SRF1 and LLRF9 have opposing conventions of phase...

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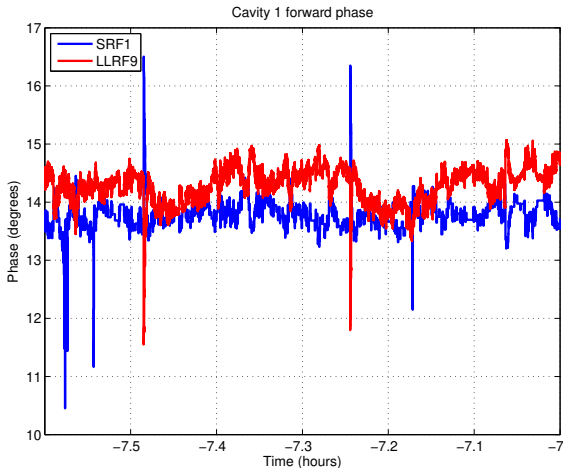
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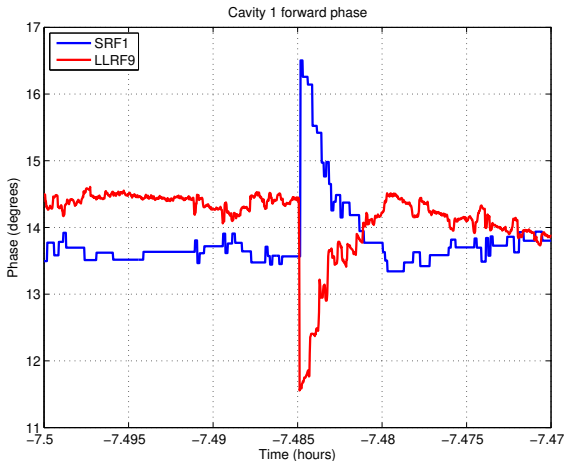
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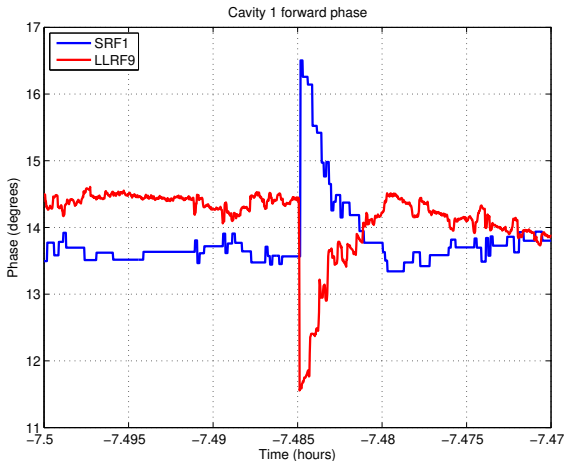
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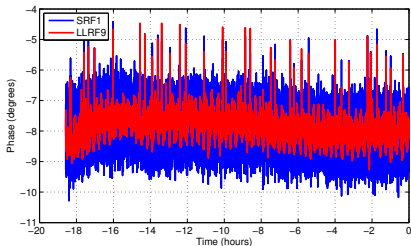
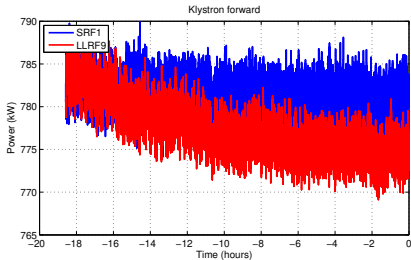
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Klystron Forward Signals



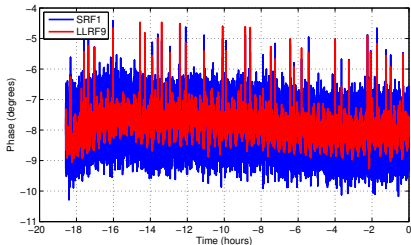
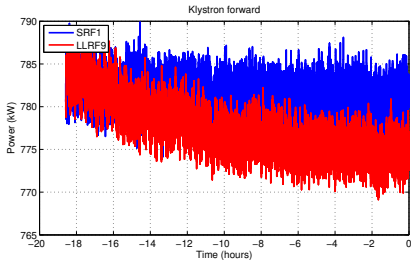
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- ▶ Will monitor over the next few days;
- ▶ Zooming in;
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- ▶ Phase from LLRF9 is inverted and matched to SRF1 in average sense;
- ▶ Glitches in phase — tuner motion with deadband?

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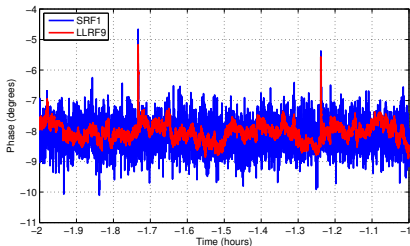
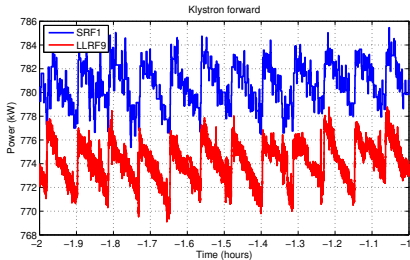
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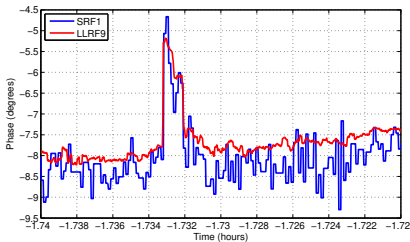
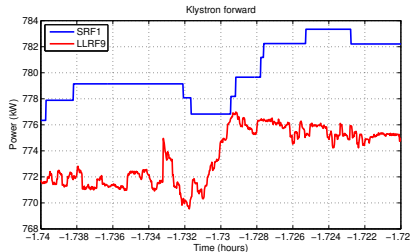
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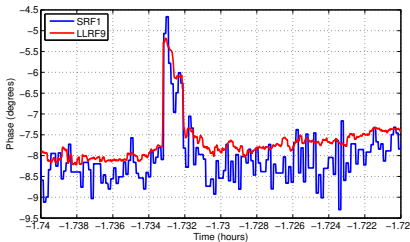
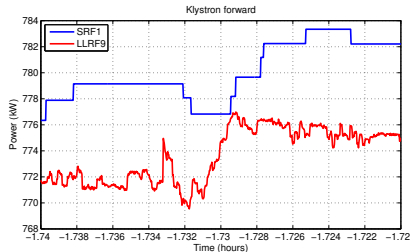
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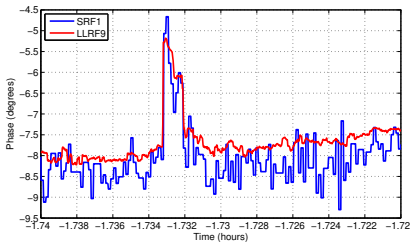
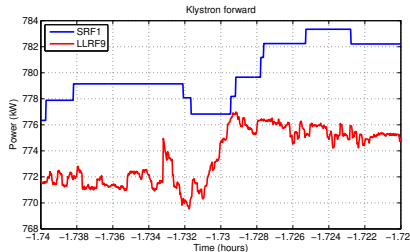
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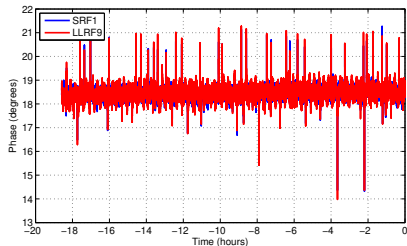
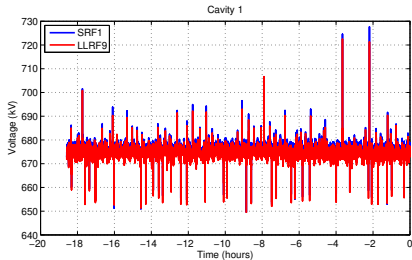
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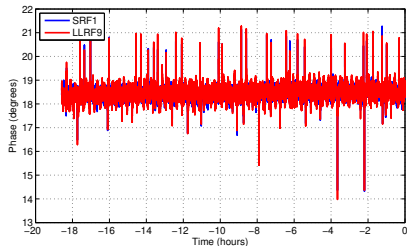
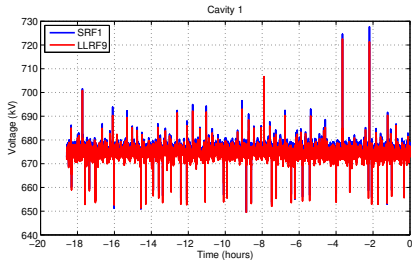
Cavity Probe



- ▶ Reasonable agreement;
- ▶ Sigmas 1.68 and 1.7 for SRF1 and LLRF9 respectively;
- ▶ Zooming in we see higher resolution and lower latency of LLRF9 readings.

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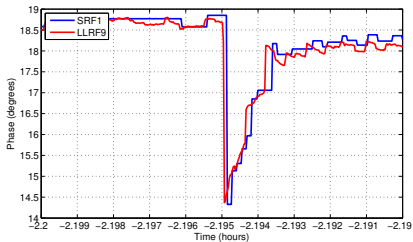
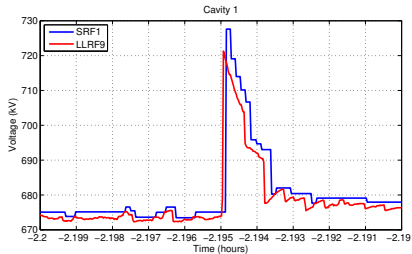
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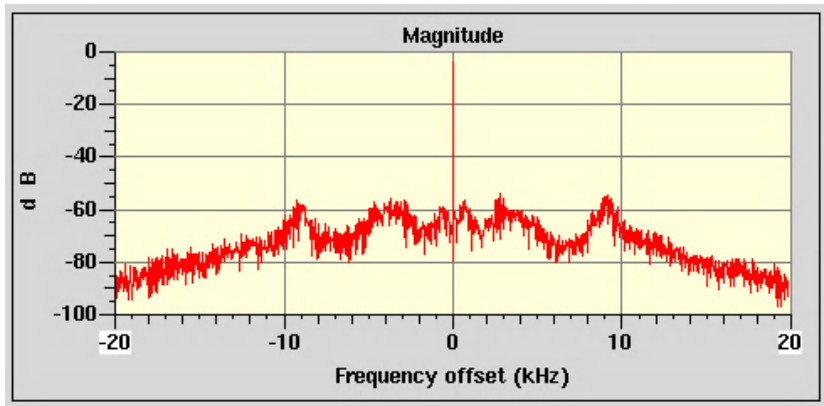
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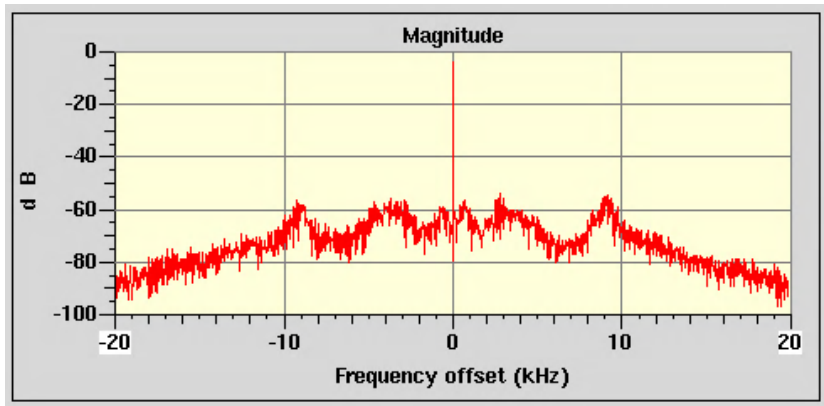
Cavity Probe



- ▶ Cavity 2 spectrum captured by the internal spectrum analyzer;
- ▶ 9 kHz synchrotron peak is visible.

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Summary

- ▶ **LLRF9 demo unit is in place;**
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 - ▶ Top-level panel;
 - ▶ Tuner loop;
 - ▶ Interlock testing;
 - ▶ Installing Matlab tools and checking their operation;
 - ▶ Driving the klystron.

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