

Bunch-by-bunch Feedback Commissioning in SSRF

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June 19, 2019

Installation

Activity Summary

Performance Comparison

Diagnostic Measurements

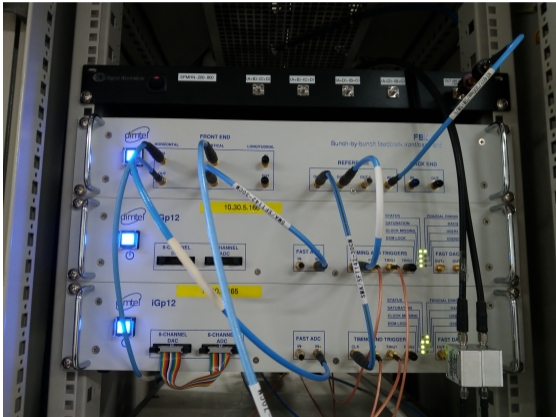
Grow/Damp Measurements

Injection Transients

Single Bunch Tune Tracking

Bunch Cleaning

Summary



- ▶ Two baseband processors (iGp12):
 - ▶ Dual plane, X and Y;
 - ▶ Vertical.
- ▶ Inputs: RF reference, fiducial $\times 2$, 4 buttons;
- ▶ Custom hybrid network;
- ▶ Outputs: Power amplifier drive to two kickers, used resistive ZFRSC-42 splitters.

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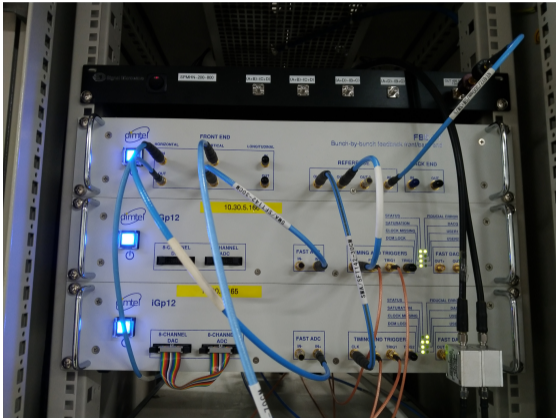
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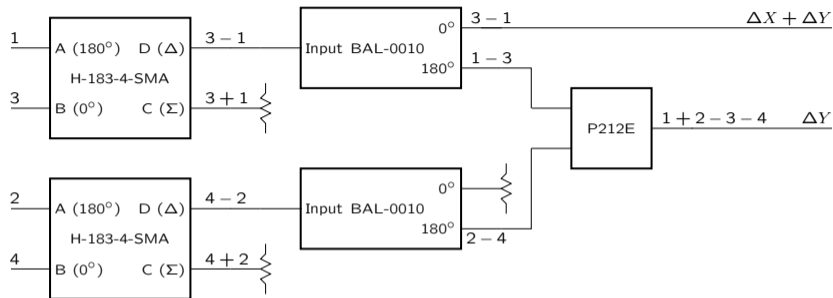
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- Grow/Damp Measurements
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BPM Hybrid Network



- ▶ Improved setup to derive vertical and diagonal signals from a single pickup;
- ▶ Driven by the available components;
- ▶ Weinschel 980-2K delay lines on all inputs;
- ▶ Good balance for 2/4 pair, significant gain error for 1/3, need to be investigated.

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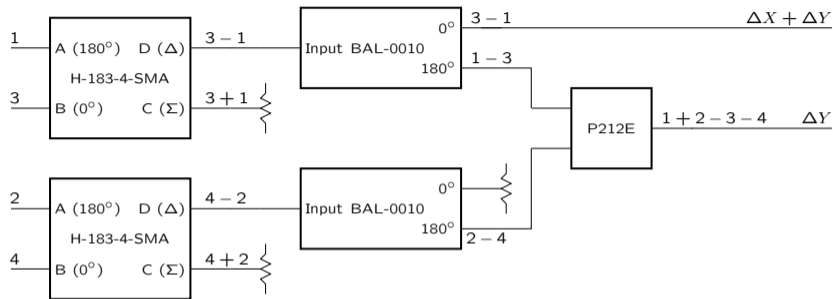
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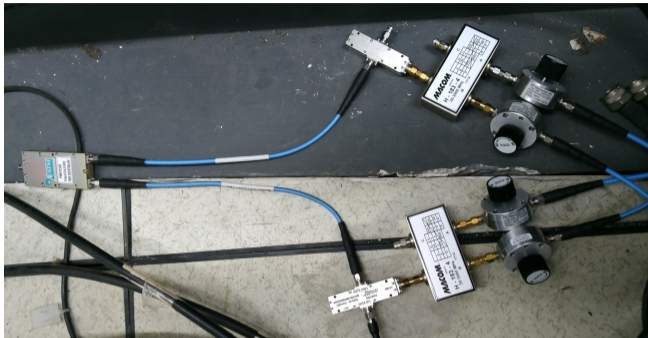
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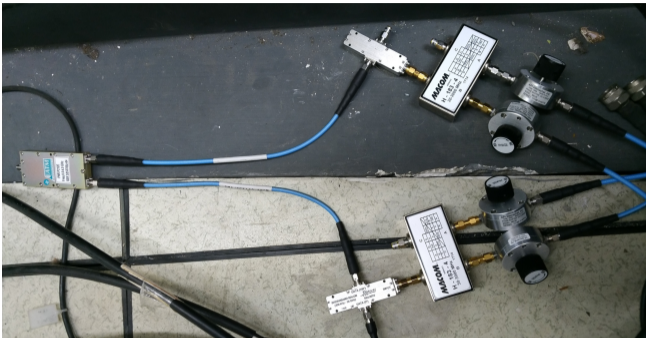
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Day by Day Summary

▶ Monday (2019-06-17):

- ▶ Updated the systems to the latest FPGA and IOC code;
- ▶ Discussed and planned the overall setup;
- ▶ Designed custom hybrid layout;
- ▶ Parasitically connected the hybrid, observed the beam.

▶ Tuesday(2019-06-18):

- ▶ Installed the hardware in the rack above power amplifiers (left the old system unperturbed);
- ▶ Single bunch: timed and phased the system, designed the FIR filter;
- ▶ Went through a round of hands-on training;
- ▶ Continued with multibunch studies:
 - ▶ Performance check at full current;
 - ▶ Feedback filter optimization;
 - ▶ Grow/damp measurements;
 - ▶ Injection transients with and without feedback.
 - ▶ Performance comparison to the existing SPring-8 setup;
 - ▶ Bunch cleaning;
 - ▶ Single bunch tune tracking.

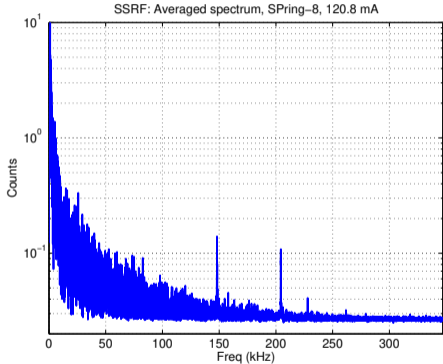
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Comparing SPring-8 and iGp12



- ▶ At 120 mA took data with the original SPring-8 setup, then switched to iGp12;
- ▶ SPring-8: averaged bunch spectra show X and Y lines;
- ▶ iGp12: signals suppressed to the noise floor;
- ▶ Horizontal:
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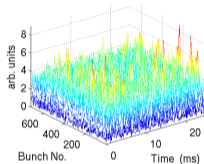
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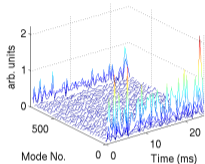
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Comparing SPring-8 and iGp12

a) Osc. Envelopes in Time Domain

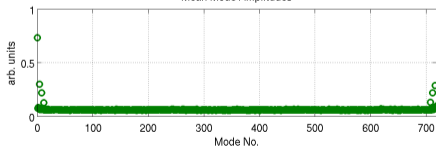


b) Evolution of Modes



SSRF:jun1819/184759: Io= 119.3921mA, Dsamp= 1, ShifGain= 2, Nbun= 720,
At v: G1= 3.1857, G2= 0.00033988, Ph1= 40.3135, Ph2= -38.051, Brkpt= 17310, Calib= 1.

Mean Mode Amplitudes



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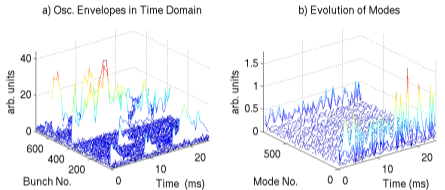
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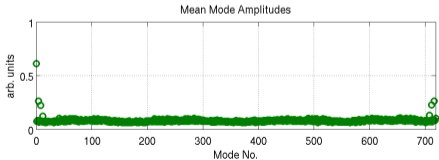
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Comparing SPring-8 and iGp12



SSRF: jun1819/183742: Io= 120.0675mA, Dsamp= 1, ShifGain= 2, Nbnun= 720,
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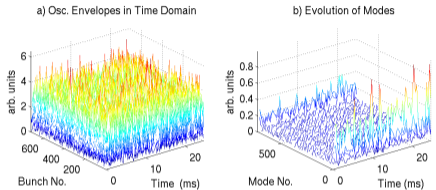
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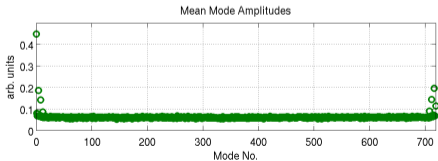
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Comparing SPring-8 and iGp12



SSRF: jun1819/184759: Io= 119.3921mA, Dsamp= 1, ShifGain= 2, Nbn= 720.
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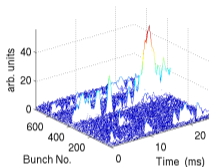
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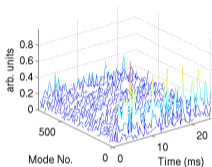
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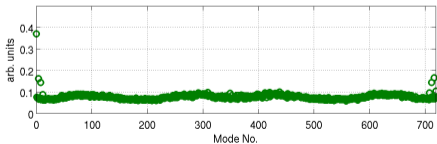


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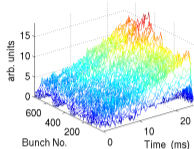
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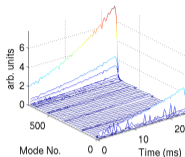
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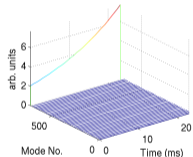
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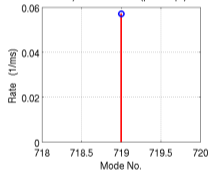
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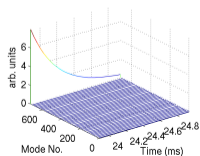
c) Exp. Fit to Modes (pre-brkpt)



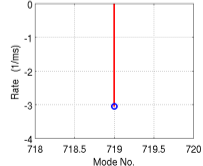
d) Growth Rates (pre-brkpt)



e) Exp. Fit to Modes (post-brkpt)



f) Growth Rates (post-brkpt)



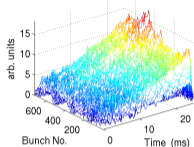
SSRF:jun1819/192107: Io= 245.4669mA, Dsamp= 1, ShifGain= 3, Nbn= 720,
At v: G1= 6.3714, G2= 0.00067976, Ph1= 40.3135, Ph2= -38.051, Brkpt= 16574, Calib= 1.

- ▶ **Standard fill pattern, 245 mA total current;**
- ▶ Relatively slow growth of mode 719 (-1), typical resistive wall instability;
- ▶ Growth rate of 0.057 ms^{-1} , damping rate of -3.0 ms^{-1} ;
- ▶ Nicely exponential transients.

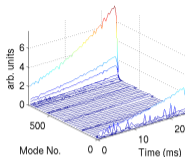
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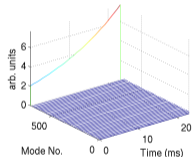
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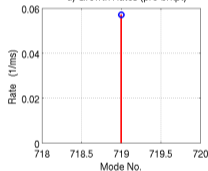
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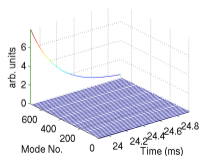
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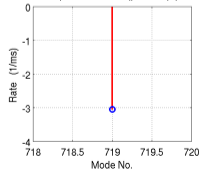
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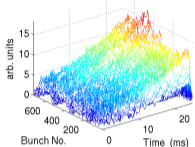
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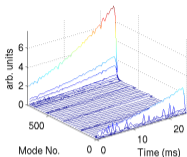
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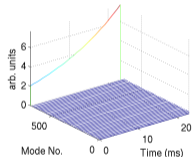
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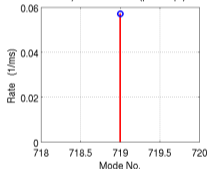
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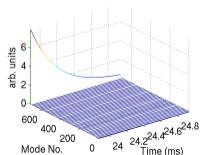
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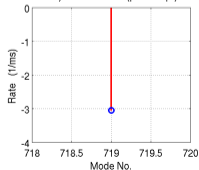
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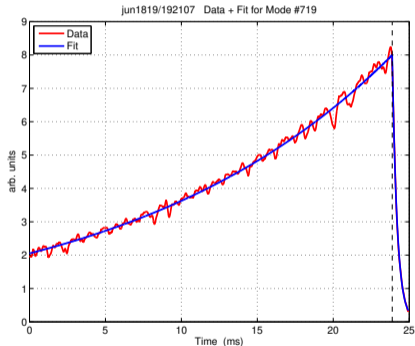
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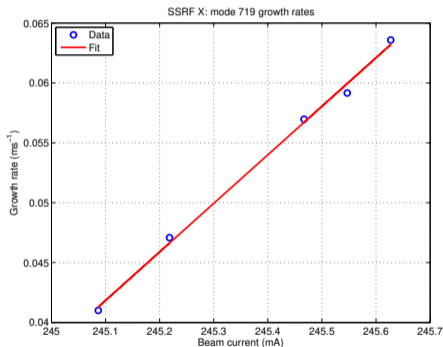
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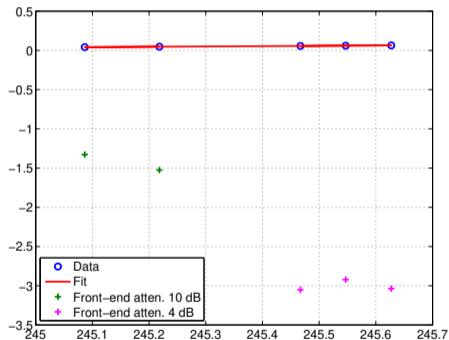
Growth Rates vs. Beam Current



- ▶ Nicely linear behavior, very small span of currents;
- ▶ Show the damping rates as well;
- ▶ Very fast damping, scales linearly with gain.

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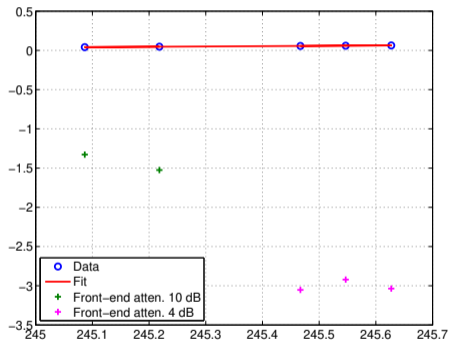
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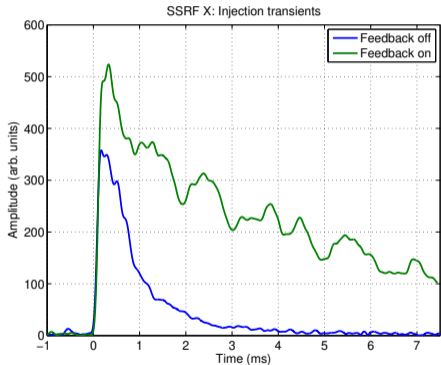
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Injection Transients



- ▶ **Fast transient damping with feedback;**
- ▶ Lower peak amplitude;
- ▶ Comparison with SPring-8 transient;
- ▶ Some bunches have beating behavior;
- ▶ And some are completely out of control.

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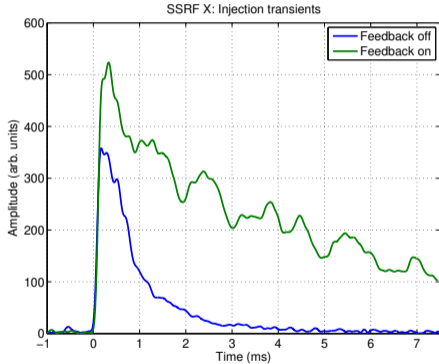
Injection Transients

Single Bunch Tune Tracking

Bunch Cleaning

Summary

Injection Transients



- ▶ Fast transient damping with feedback;
- ▶ Lower peak amplitude;
- ▶ Comparison with SPring-8 transient;
- ▶ Some bunches have beating behavior;
- ▶ And some are completely out of control.

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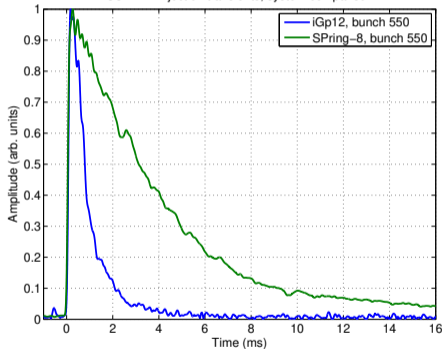
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SSRF X: Injection transients, system comparison

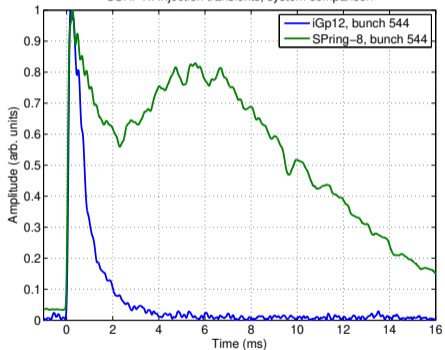


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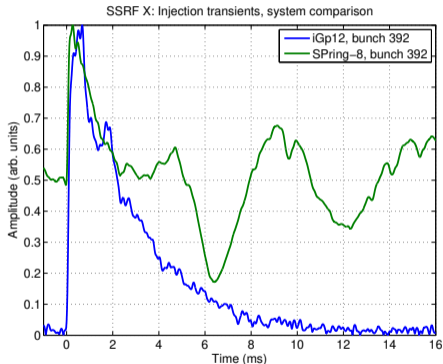
Injection Transients

SSRF X: Injection transients, system comparison



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Injection Transients



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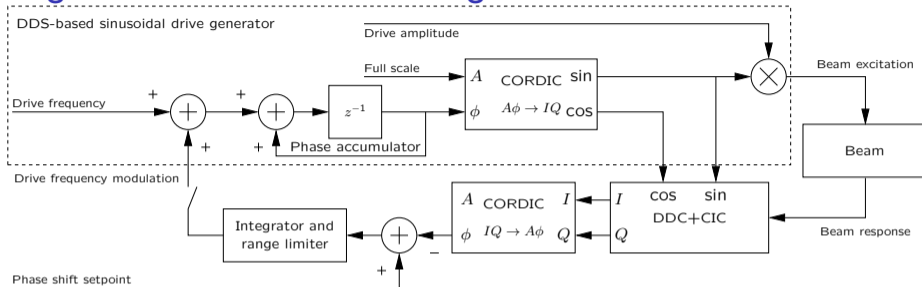
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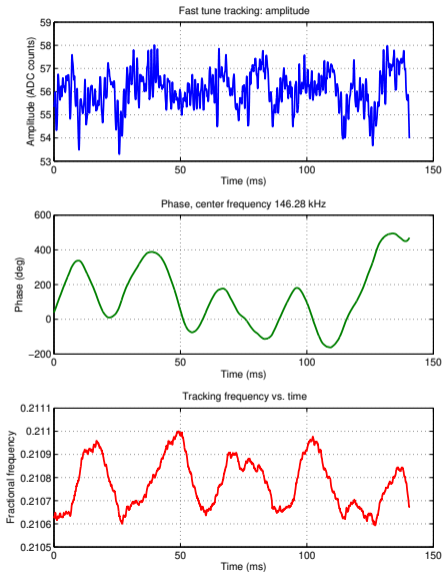
Single Bunch Phase Tracking



- ▶ A single bunch is excited with a sinusoidal excitation at low amplitude (20–40 μm);
- ▶ Response is detected relative to the excitation to determine the phase shift
- ▶ In closed loop, phase tracker adjusts the excitation frequency to maintain the correct phase shift value;
- ▶ Adjustable integration time, tracking range, loop gain.

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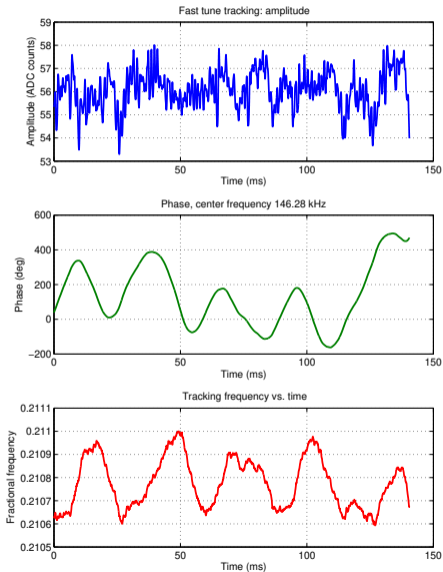
Fast Phase Tracking



- ▶ Decimation factor in phase tracker controls tracking bandwidth;
- ▶ 200 turns decimation, 3.5 kHz feedback rate;
- ▶ Roughly 150 Hz closed loop tracking bandwidth;
- ▶ No clear periodic pattern over 140 ms.

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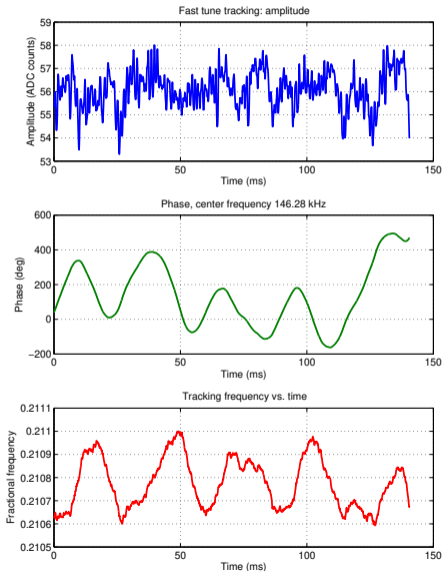
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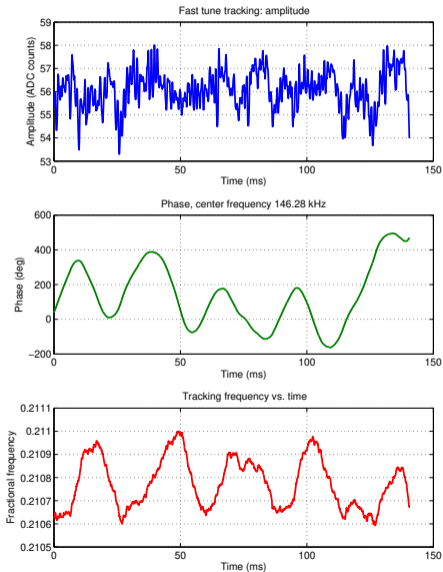
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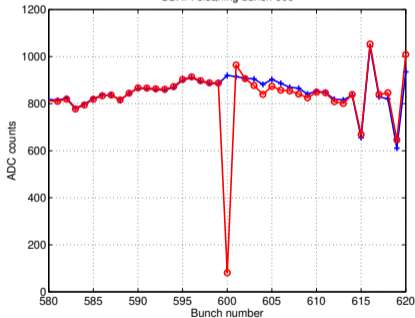
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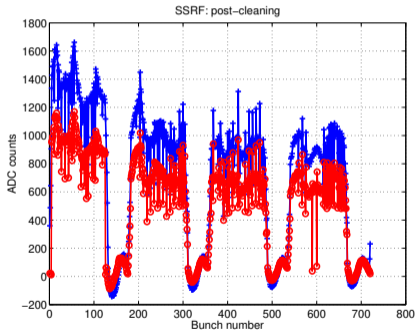
SSRF: cleaning bunch 600



- ▶ **Cleaned out bunch 600;**
- ▶ Many buckets cleaned;
- ▶ Around the first train;
- ▶ Middle of the fourth train;
- ▶ End of the fill.

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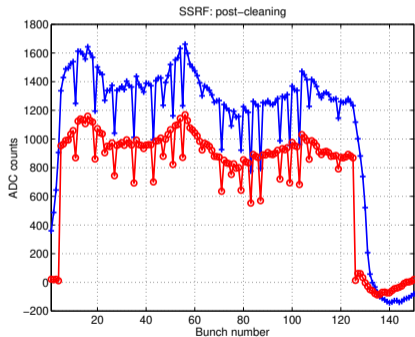
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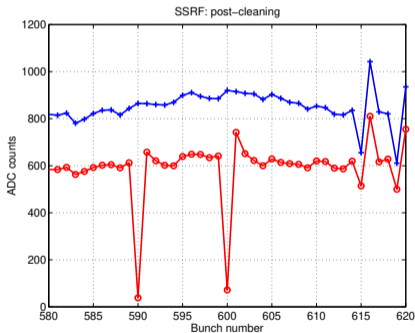
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To Do List

- ▶ **Switch to a high-quality RF reference;**
- ▶ Investigate button signal mismatch (1 and 3);
- ▶ Check power amplifier drive levels, adjust as needed;
- ▶ Modal scan to fully characterize impedances in X and Y;
- ▶ Redesign dual band filter generator not to require toolboxes;
- ▶ Post-mortem acquisition setup;
- ▶ Additional training.

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Summary

- ▶ **Successfully commissioned Dimtel bunch-by-bunch feedback in SSRF;**
- ▶ Looks quite solid, need some operational experience to judge stability of this configuration;
- ▶ Better master oscillator reference is critical!!!
- ▶ Many diagnostics to be explored — program for the next visit?

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