RF and Instability Studies in SESAME

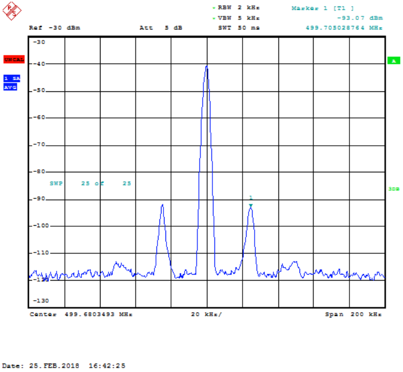
Preliminary Results

D. Teytelman, et.al.

Dimtel, Inc., San Jose, CA, USA

February 28, 2018

Sunday — Spectrum Analyzer Studies



- BPM sum signal;
- Synchrotron sidebands around the RF:
  - Roughly -50 dBc (≈ 1°;);
  - Driven by RF phase/amplitude noise.
- Dipole motion suppressed by exciting longitudinal quadrupole oscillations with RF phase modulation;
- 10 dB reduction of mode 0;
- Mode -23, bursting, many synchrotron harmonics.

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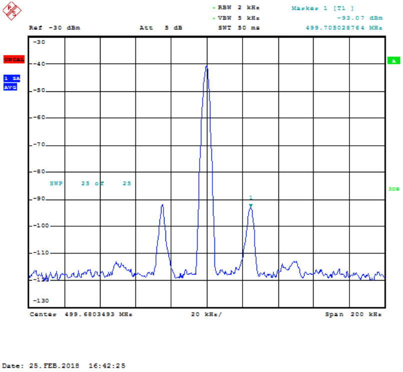

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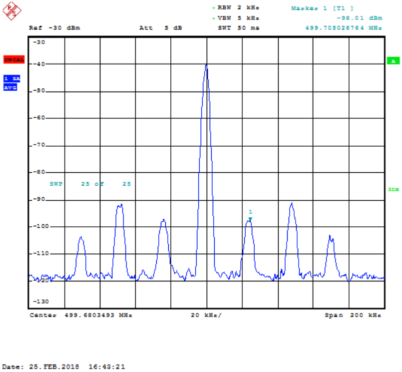

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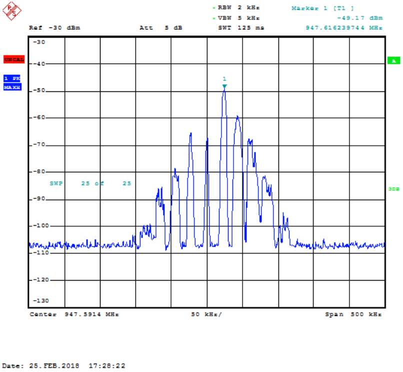

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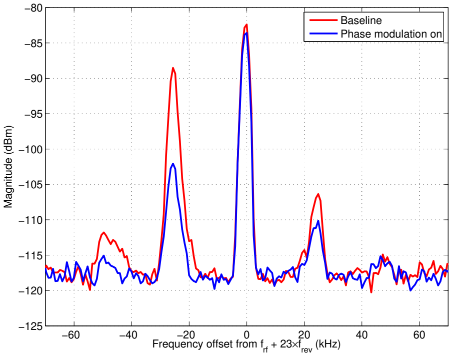
Unstable Mode Suppression With Quadrupole Modulation



- Mode -23 observed at $f_{\mathrm{rf}} + 23 f_{\mathrm{rev}}$;
- 13 dB suppression;
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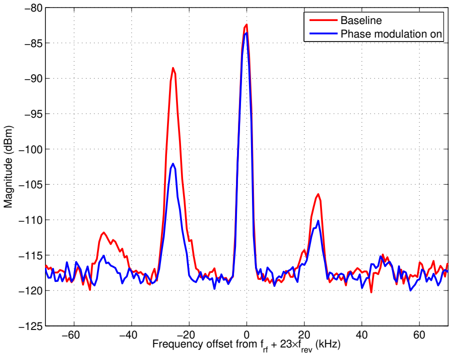

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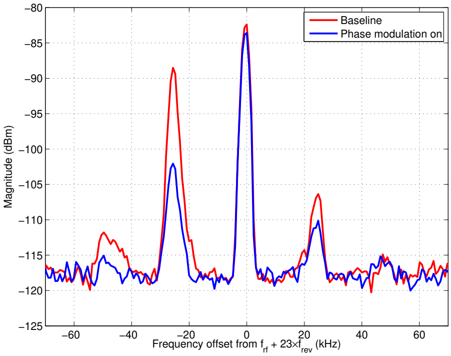

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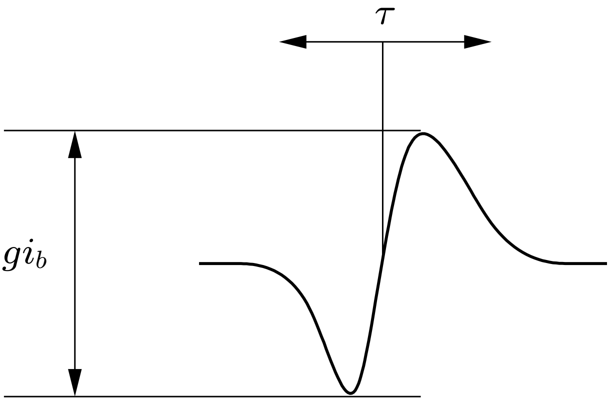

- Sum signal derived from 2/4 BPM buttons;
- Sampled at the zero crossing;
- Sensitivity is proportional to slope, bunch current.

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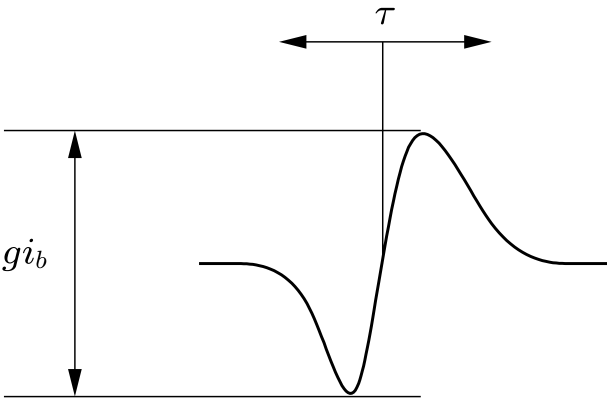

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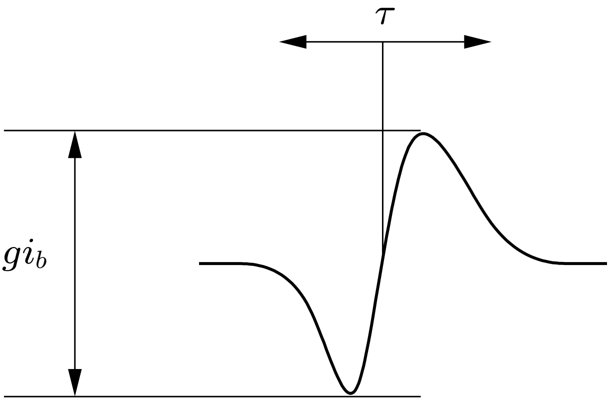

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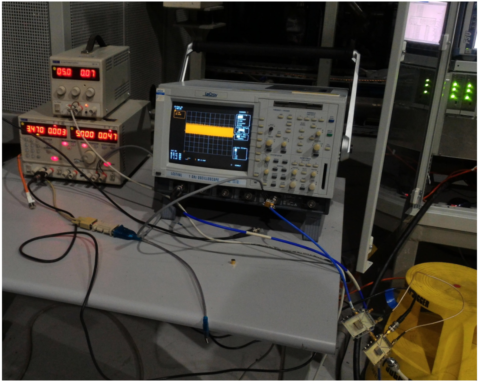

- Sum signal derived from 2 buttons (B and D);
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- RS-232 readout (2 MS data set in 6 minutes).

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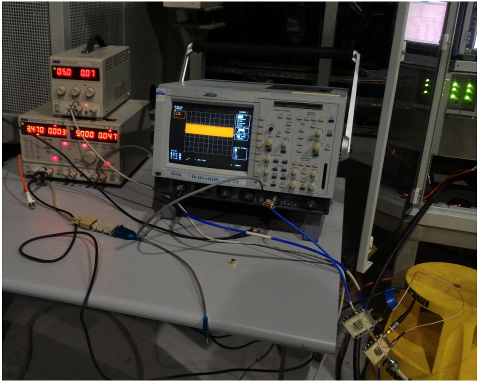

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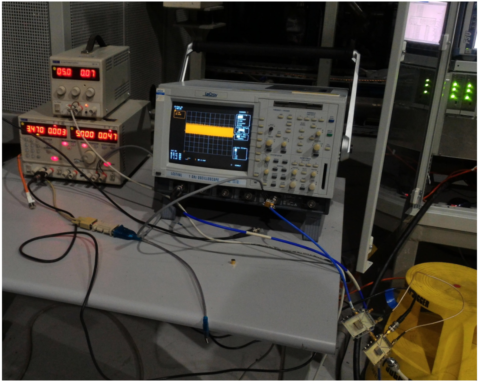

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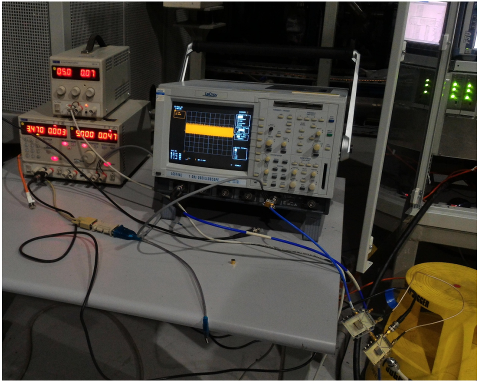

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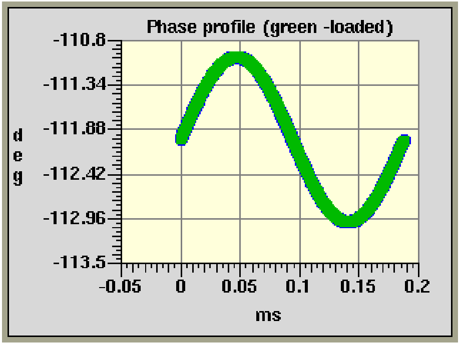

- Apply 1° of phase modulation at 5.3 kHz via one RF station;
- Beam is a follower at that frequency, expect 0.25° amplitude of motion at that frequency
- Averaged spectrum of all bunches clearly shows the calibration signal;
- As well as synchrotron motion at 25 kHz;
- And LeCroy spur at 32.7 kHz.

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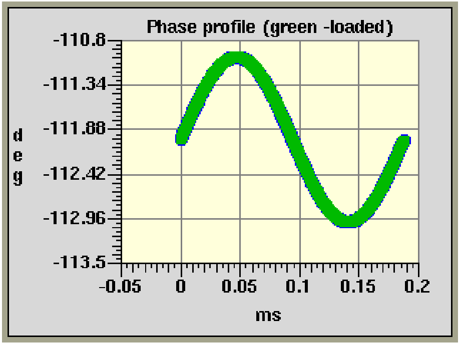

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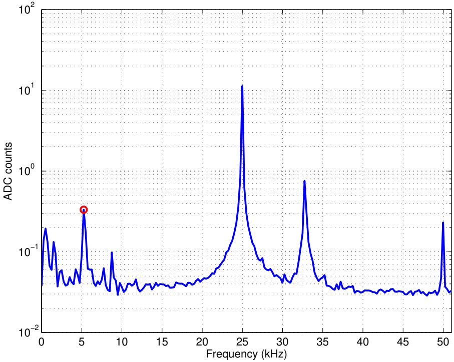

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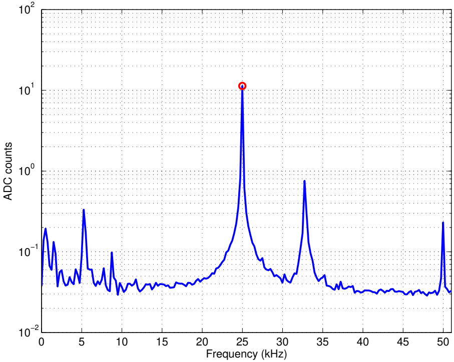

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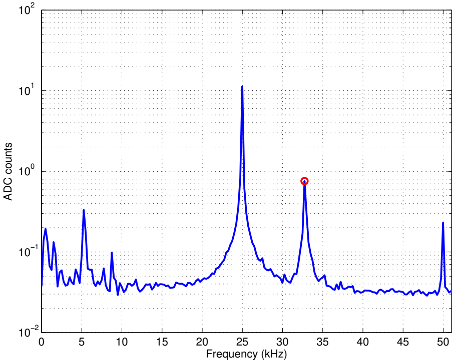

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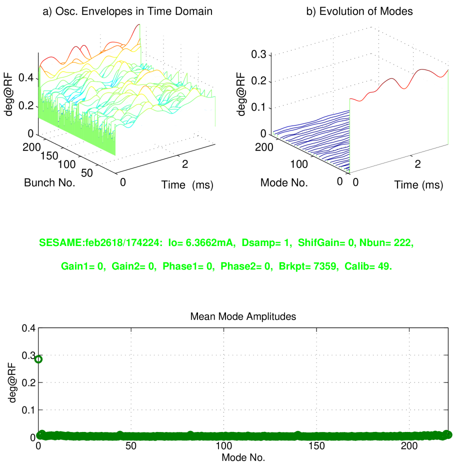

- Filtering bunch signals around 5.3 kHz and performing modal analysis;
- Calibration factor of 49 counts/mA/°;
- Reference signal amplitude over 19 measurements;
- +27/−21% maximum errors;
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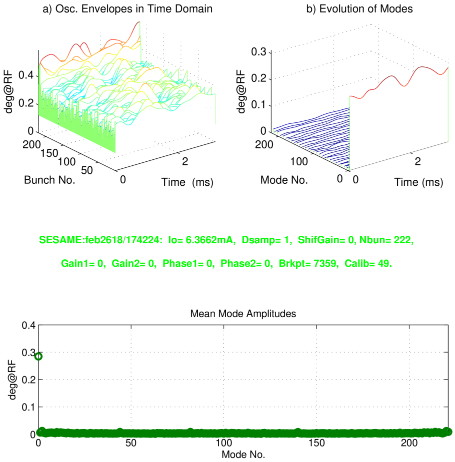

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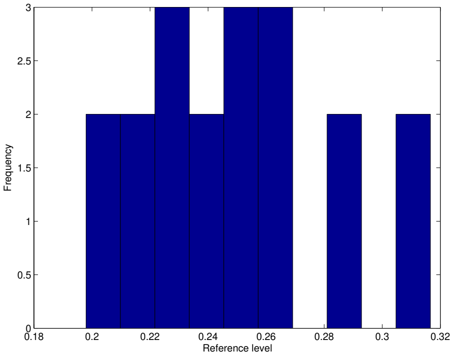

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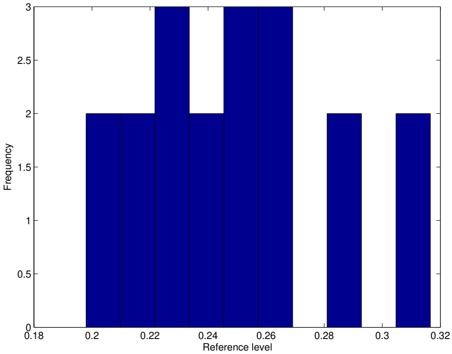

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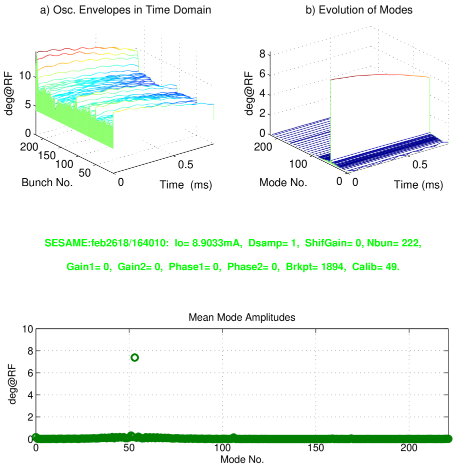

- Low current (9 mA);
- Large mode 53 (L9) oscillation;
- Multiple modes, beating at 30 mA;
- Modes 53, 106, 169;
- Spectrum has multiple synchrotron harmonics, frequency resolution is too coarse to determine if these are intra-bunch modes or generated by non-linearities.

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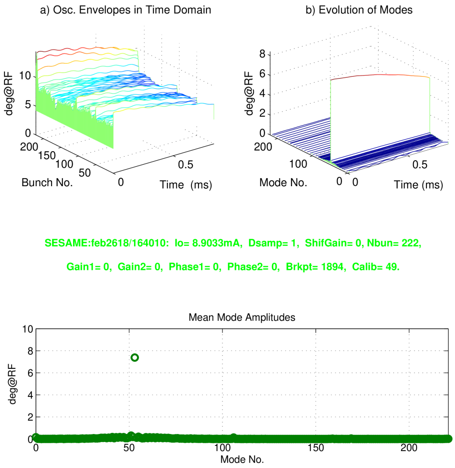

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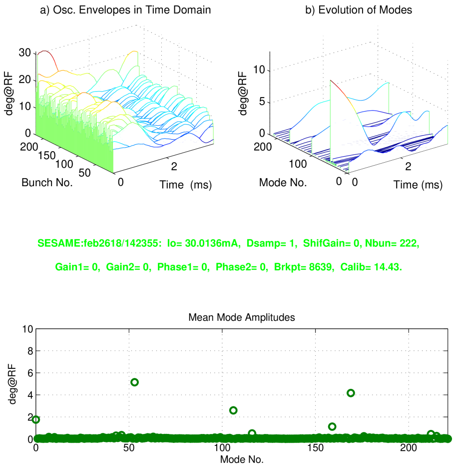

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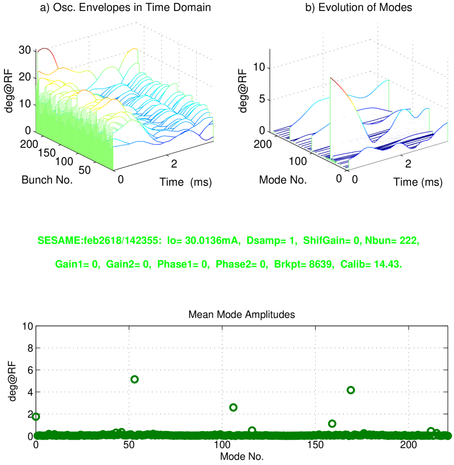

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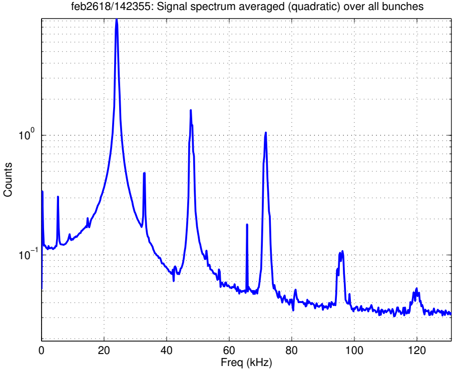

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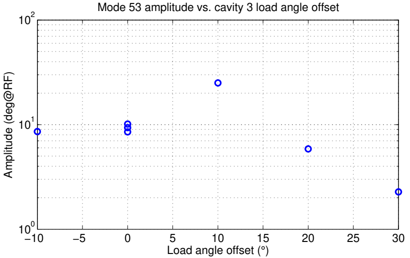

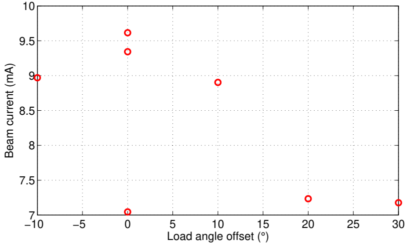

- Scan load angle offsets to identify the cavity driving mode 53;
- Response in cavities 3 (strong) and 4 (mild);
- Clear effect for positive LAO;
- Since detuning due to beam loading is small here, can convert loading angle offset to detuning;
- Lost current when the HOM crossed the synchrotron sideband (-7 to -14 kHz detuning);
- At zero LAO oscillation returned.

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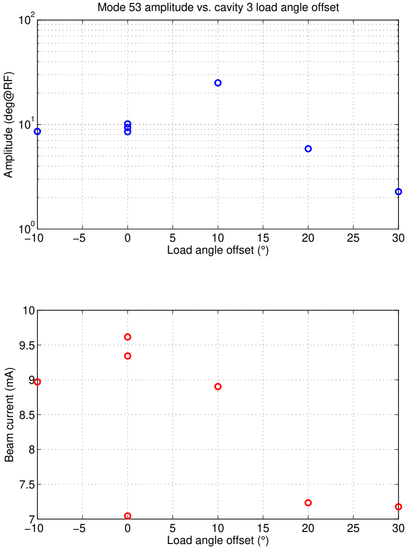

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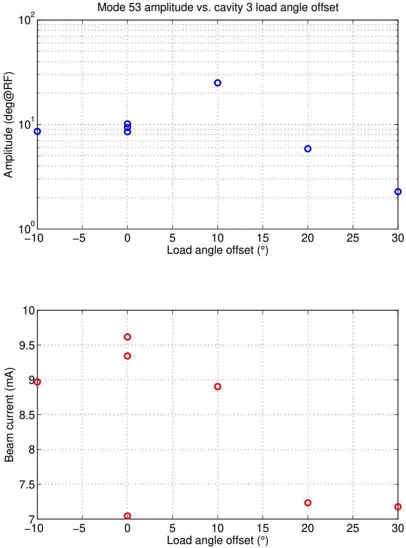

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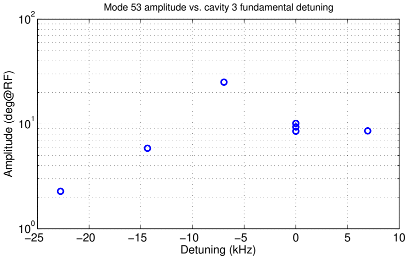

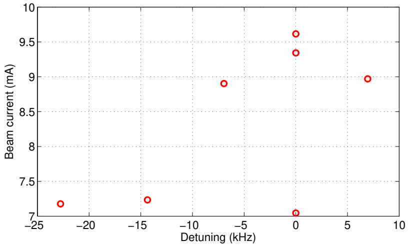

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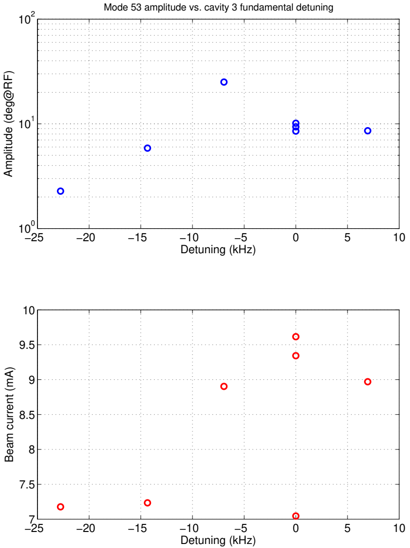

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Developments on Tuesday

- Worked on achieving higher beam currents;
- Started from injecting a uniform fill pattern, very smooth injection, reached 171 mA, lost due to the RF loop stability;
- After a quick adjustment went to 214 mA, again lost due to RF stability;
- Retuned and optimized all 4 stations, reached 258 mA, lost beam due to a vacuum trip;
- Next focused on ramping to 2.5 GeV. Filled to 110 mA;
- Observed large longitudinal mode 0 oscillation (6degree amplitude);
- Some parasitic tuning after the hand-off to beamline reduced that to 0.5°.

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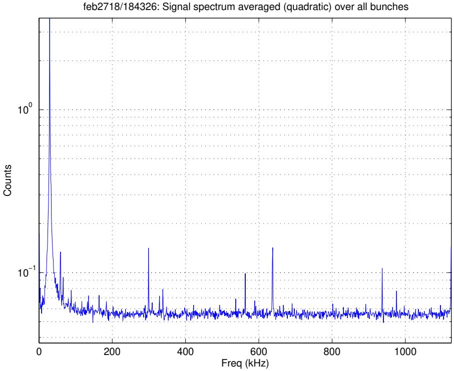
Stable Beam at 2.5 GeV



- Filled to 110 mA, ramped;
- Observed large mode 0 motion, no HOMs;
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- Residual level around 0.5°.

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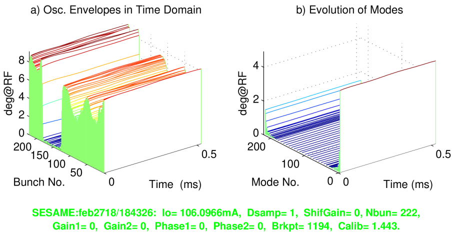

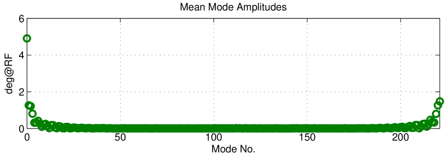

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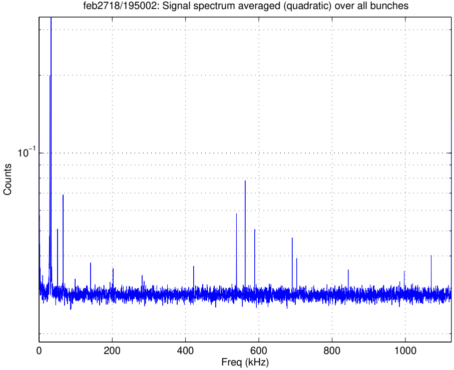

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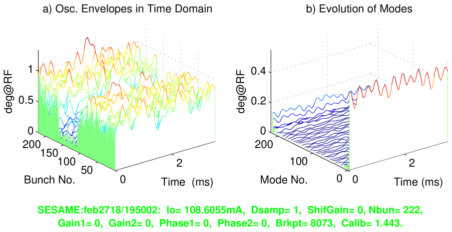
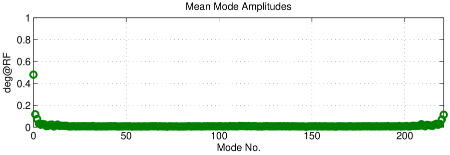
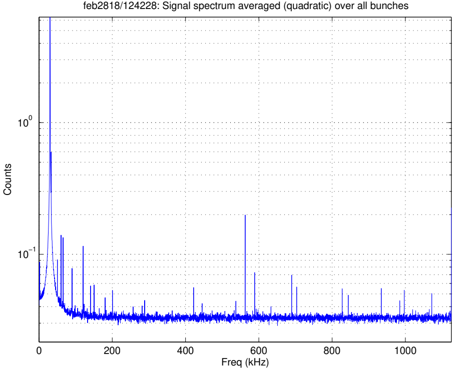




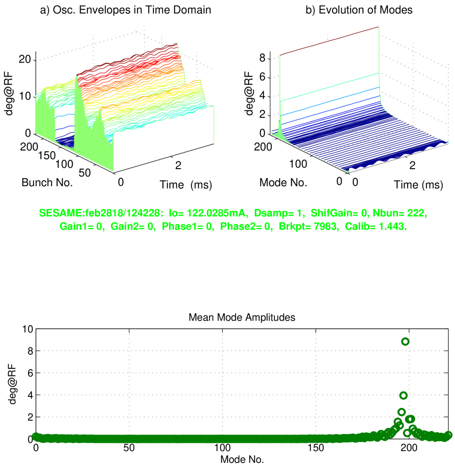
- Filled to 110 mA, ramped;
- Observed large mode 0 motion, no HOMs;
- Adjusted LLRF loops to reduce mode 0 motion (integral gain increased from 0.02 to 0.025);
- Residual level around 0.5°.

Stable Beam at 2.5 GeV



- Developments this morning — improved LLRF setup, filled to 123 mA, ramped;
- Large motion at mode -24;
- Residual mode 0 level around 0.2° (1.1 ps).

Stable Beam at 2.5 GeV



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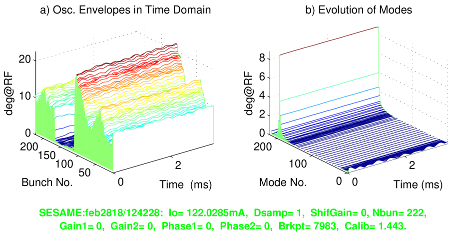

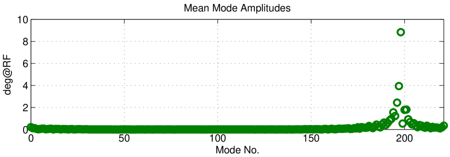

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Summary

- Observed large longitudinal motion driven by cavity HOMs;
- Cavity temperature tuning is tricky — too many modes move at once, need to identify the worst drivers;
- Improvised monitor is very helpful, though limited;
- LLRF feedback loops need to be tuned to achieve voltage stability and Robinson stability simultaneously at all beam loading conditions;
- Plan to focus on optimizing cavity temperatures to achieve stable beam at 2.5 GeV.

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