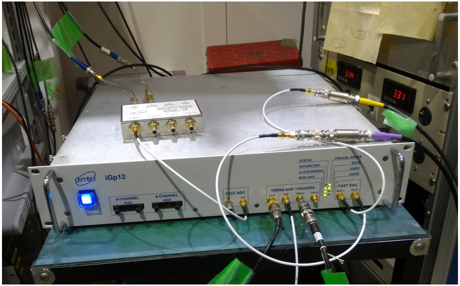
Bunch-by-bunch Feedback Demo in UVSOR

D. Teytelman[1], et. al.

Dimtel, Inc., San Jose, CA, USA

December 4, 2017

Hardware Setup



- Final configuration with two amplifiers driving diagonal striplines;
- Used two diagonal buttons in a hybrid network (BPMH-20-2G) to generate signal with both X and Y sensitivity;
- Closed feedback loops in both X and Y using a single processor;
- Direct sampling of the hybrid output by the ADC.

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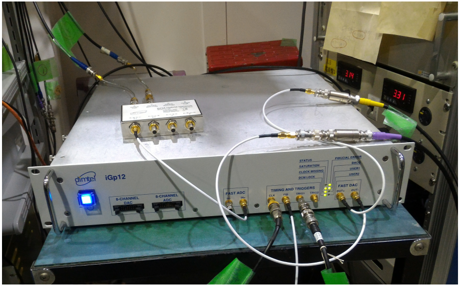

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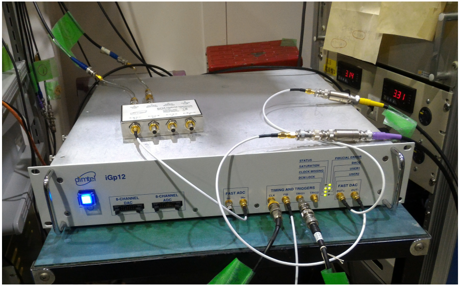

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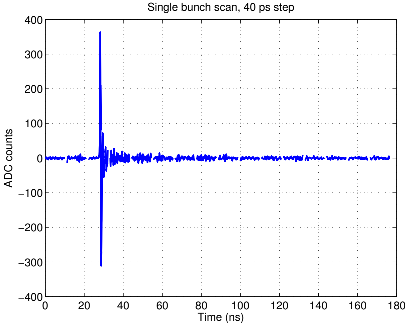
ADC Signals and Timing



- Single bunch in the ring;
- ADC clock delay scan (40 ps);
- Capture mean and RMS over N turns for each bunch;
- Some ringing after the bunch;
- Zooming in — normal BPM signal (difference of two buttons);
- Fine scan to find optimal timing (6030 ps);
- Sensitivity to longitudinal motion is reduced at the peaks — RMS nulls.

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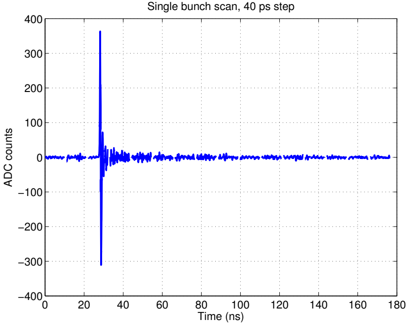

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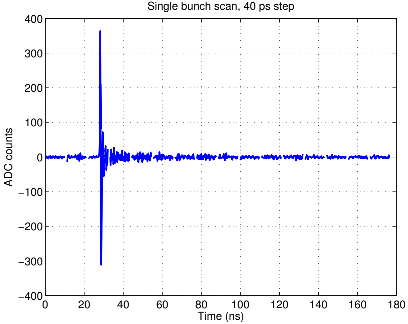

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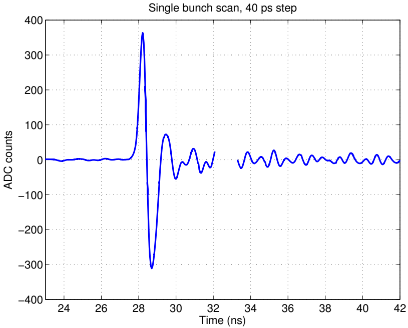

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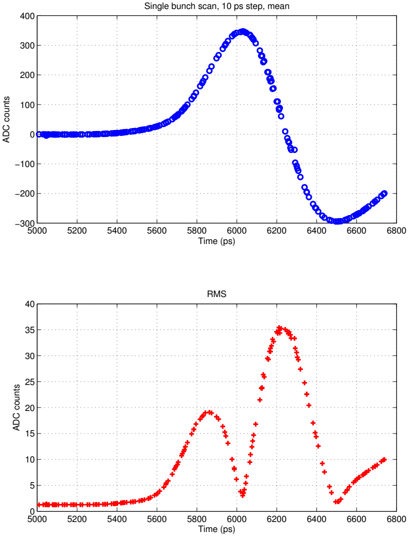

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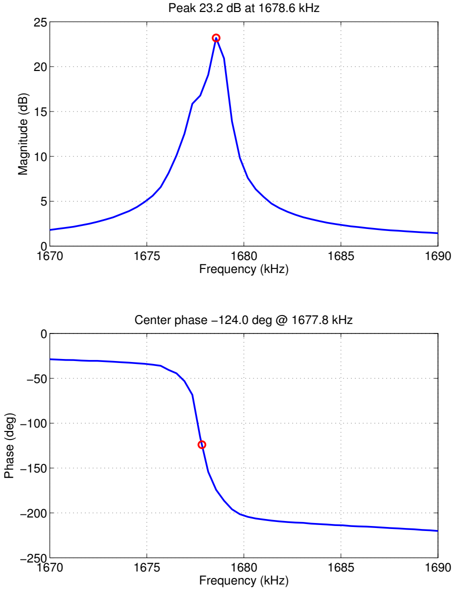

- Single bunch beam transfer function measurement(horizontal);
- Performed using narrowband receiver (I and Q), stepping excitation frequency;
- Relatively slow measurement, affected by tune jitter;
- Same measurement in the vertical plane

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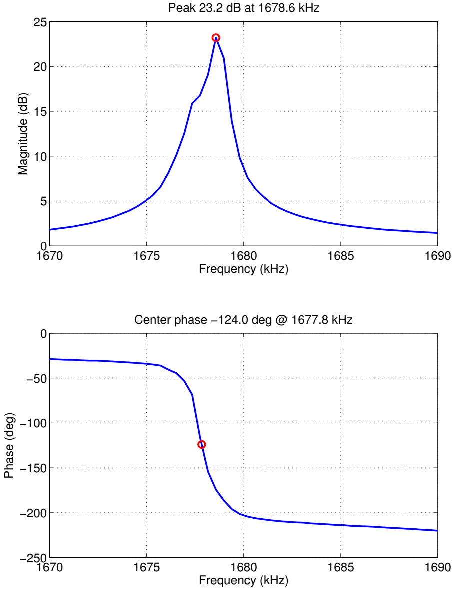

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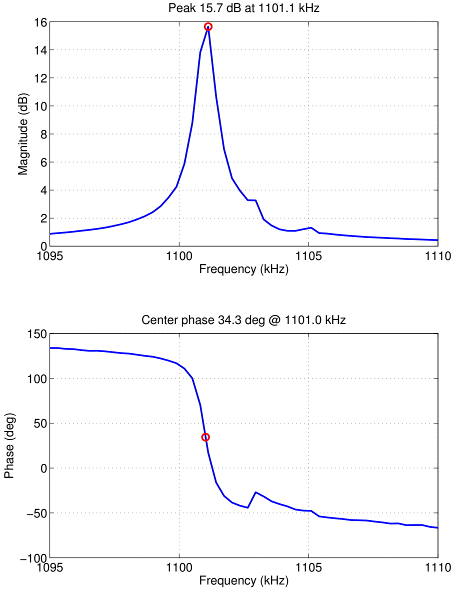

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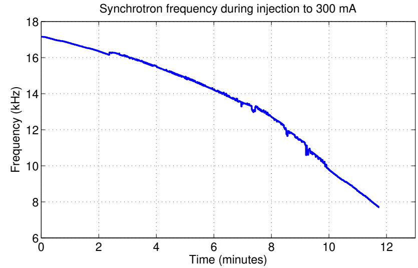
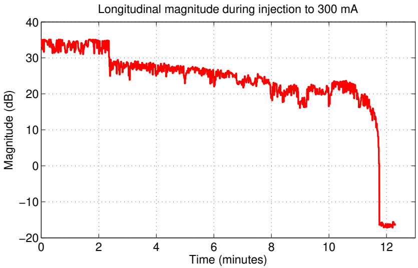
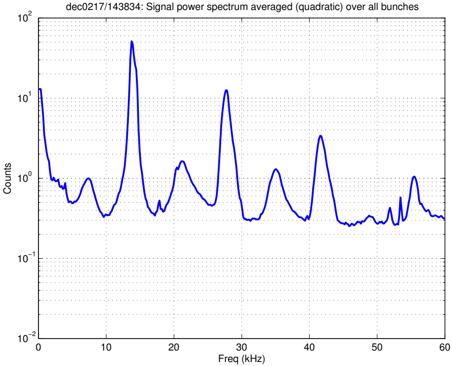
Longitudinal Stability





- Synchrotron frequency and amplitude during injection to 300 mA;
- Frequency drops as higher harmonic voltage is developed;
- Near the end of the record beam stabilizes and the frequency reading is lost.

Longitudinal Oscillation Spectra



- Longitudinal motion (8 bunches):
  - Large at 197 mA, 13.8 kHz;
  - Stable at 300 mA, 7.8 kHz;
  - Curious line at 20 kHz.

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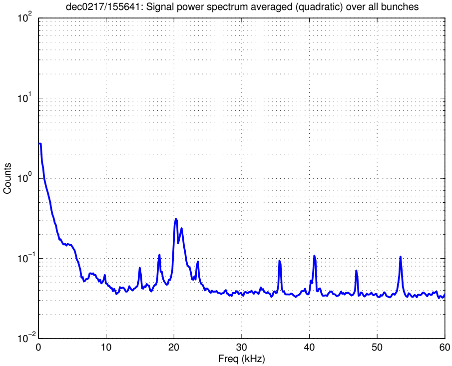

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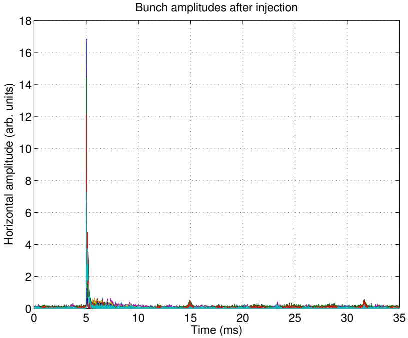

- 300 mA in top-up mode;
- Synchronized to injection trigger, start point 4.9 ms before injection;
- Same plot, zoomed in;
- Horizontal signal damps quickly;
- Fitted damping time 140 µs;
- Longitudinal damping is slower, around 1.5 ms;
- After injection bunches oscillate at 20 kHz as if harmonic voltage was not present.

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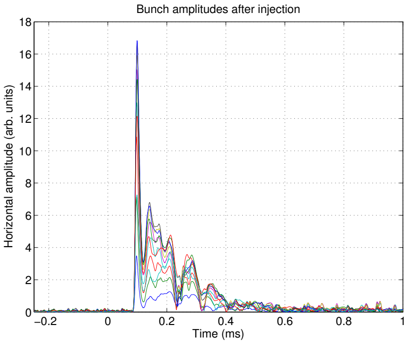

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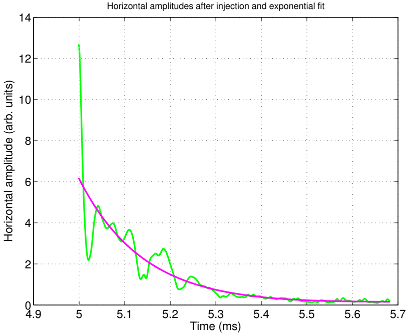

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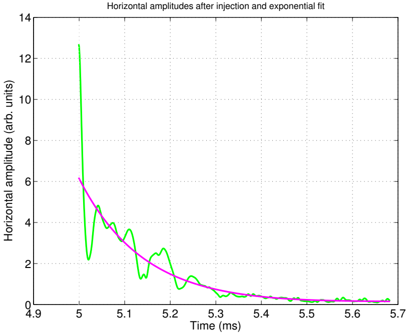

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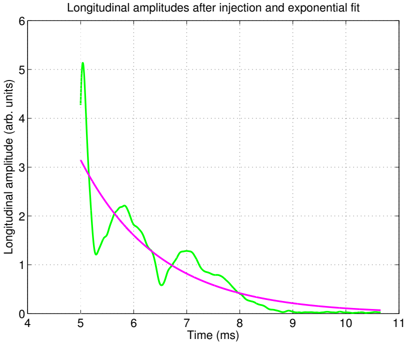

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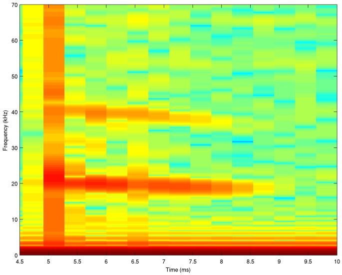

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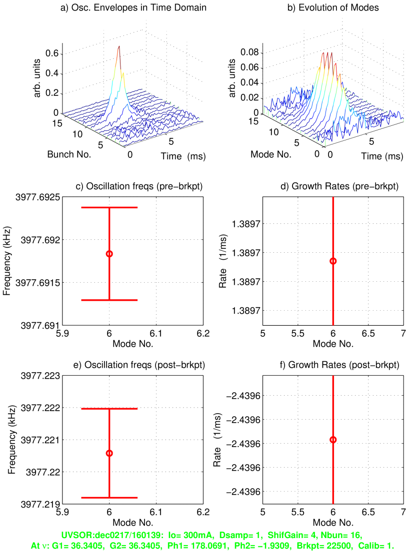
Positive Feedback Grow/Damp Measurement



- Beam is stable — use positive feedback to excite growth;
- Positive feedback on for 4 ms;
- Broad modal spectrum peaking around mode 6 mostly reflects fill pattern and feedback gain;
- Fitting growth and damping rates, nice exponential fits;
- Reduced negative feedback gain in half, slower damping, as expected.

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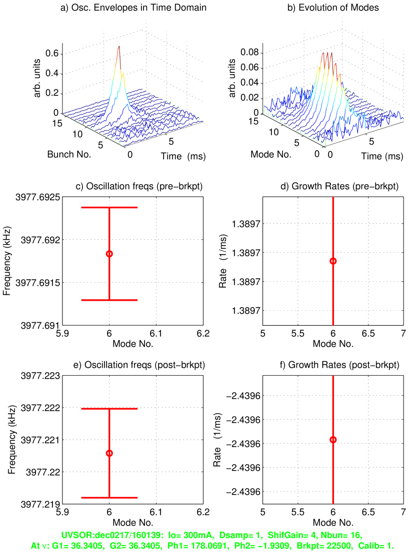

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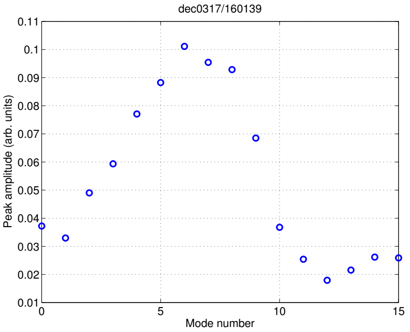

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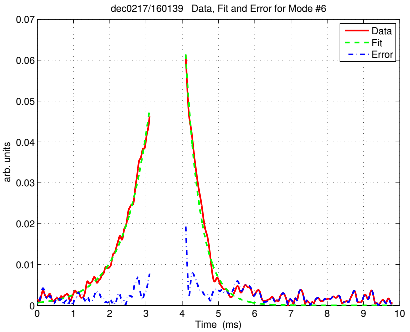

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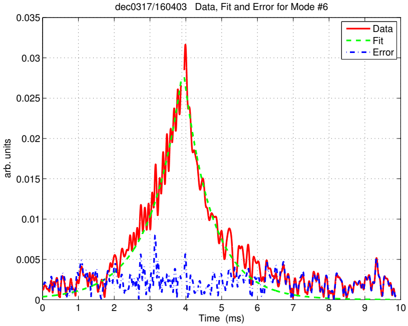

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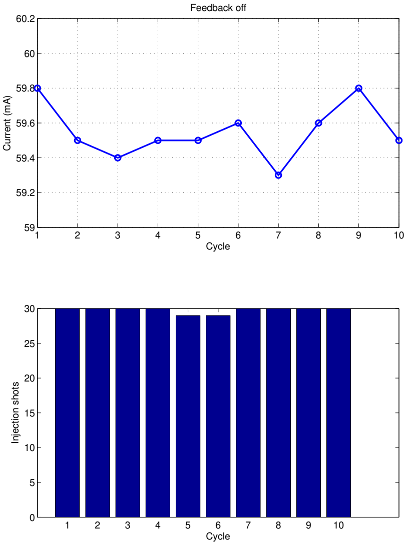
Feedback and Single Bunch Injection



- Spent some time trying to optimize injection process for higher single bunch current;
- Clear effect of feedback operation is seen in top-up tests at 60 mA;
- With feedback off, 29–30 injection shots are needed and stored current fluctuates;
- With feedback on, need 15 shots on average, constant 59.9 mA;
- More work needed to understand injection limitations better.

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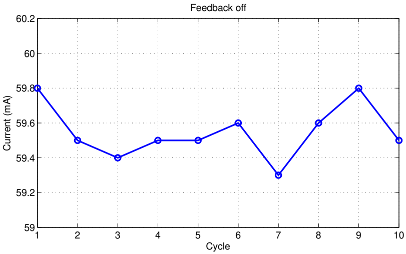

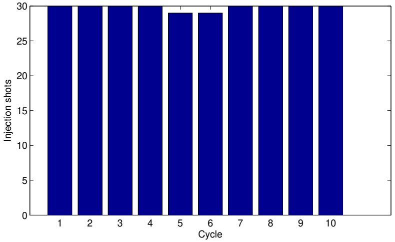

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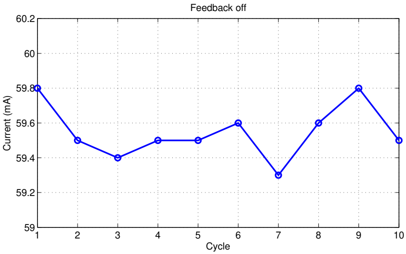

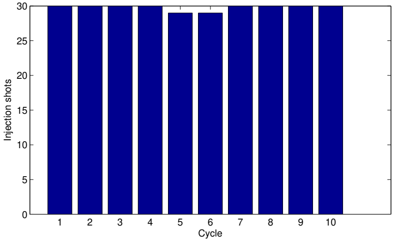

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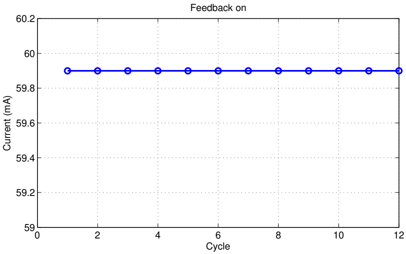

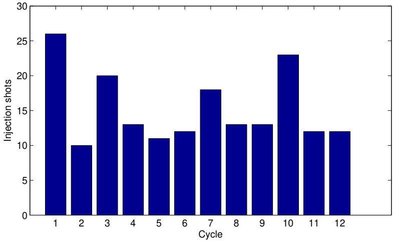

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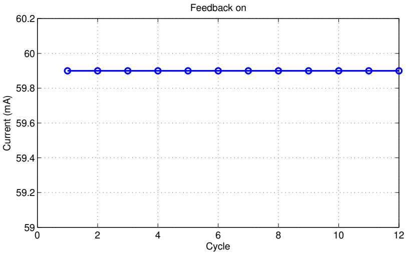

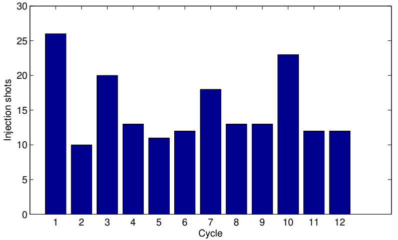

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- Performed a number of beam diagnostic measurements;
- At 60 mA feedback clearly improves injection efficiency during top-up operation;
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