Instability Studies in CESR-TA

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March 18, 2009

Outline

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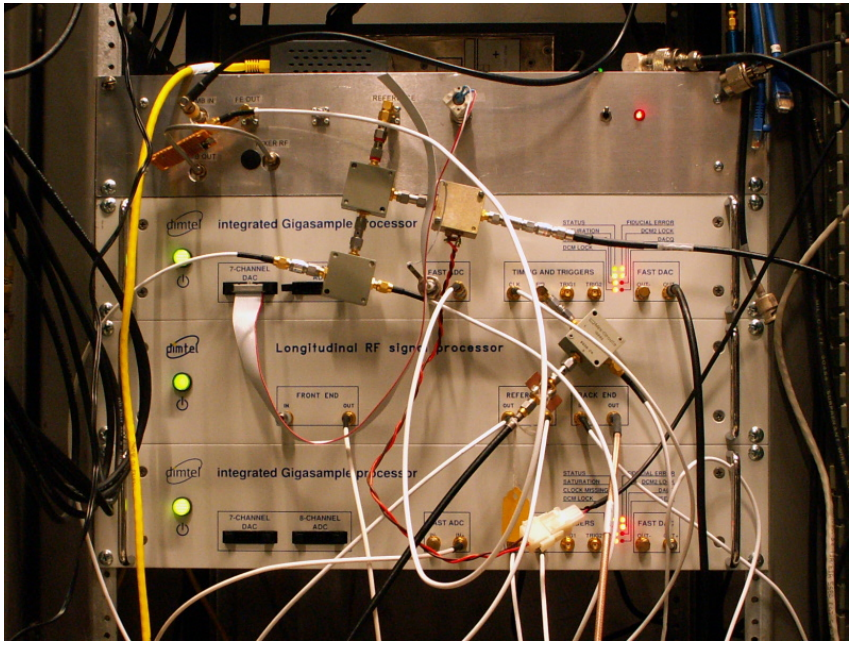
Hardware setup



- Two iGp processors for longitudinal and vertical feedback;
- FBE-500L longitudinal front/back-end;
- Transverse front-end prototype;
- A lot of external hardware for RF amplification and distribution, fiducial distribution, external filtering.

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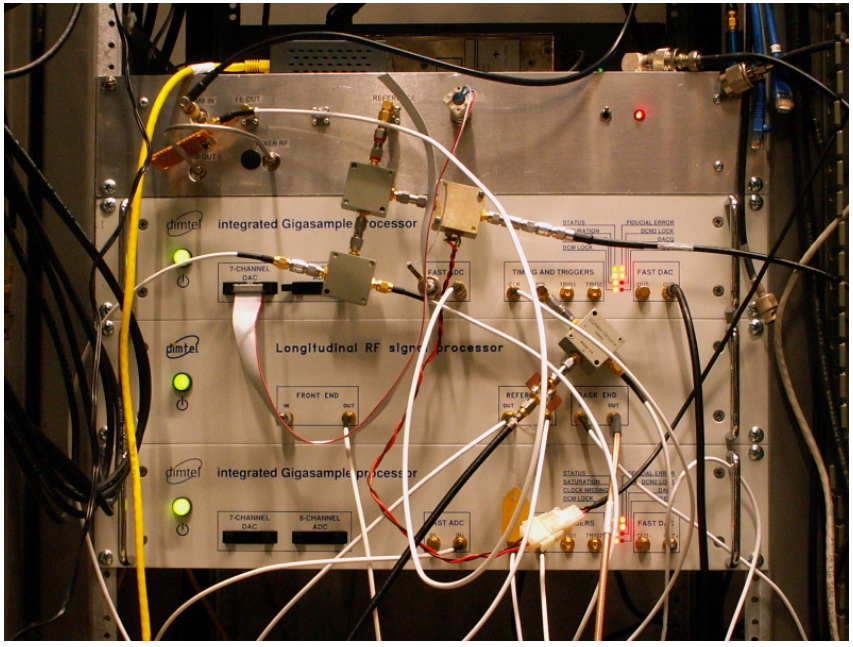

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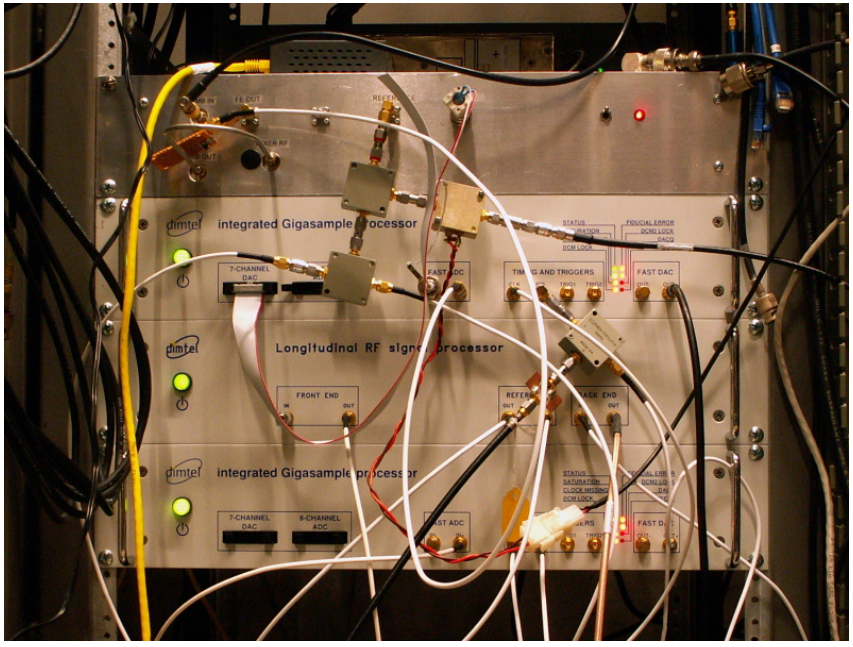

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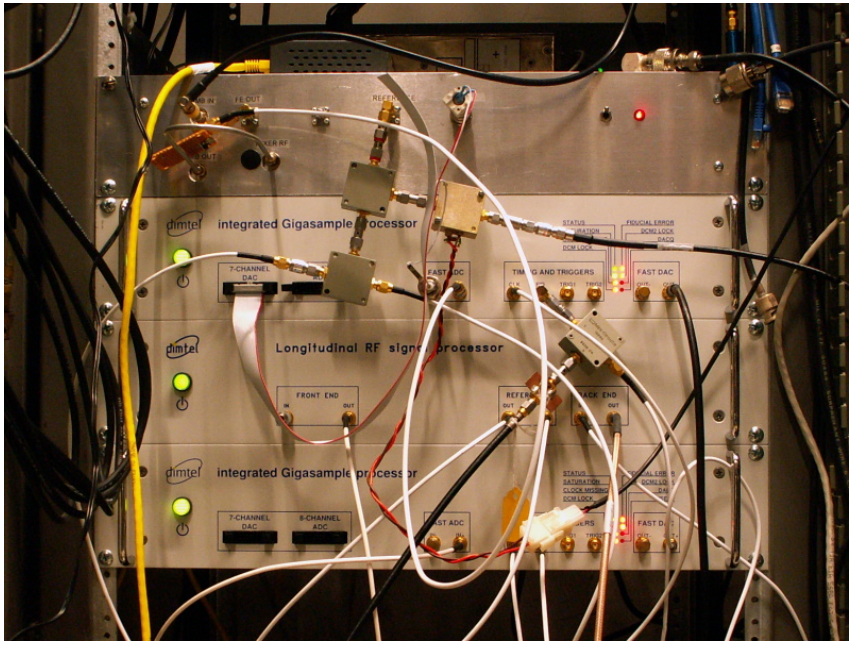

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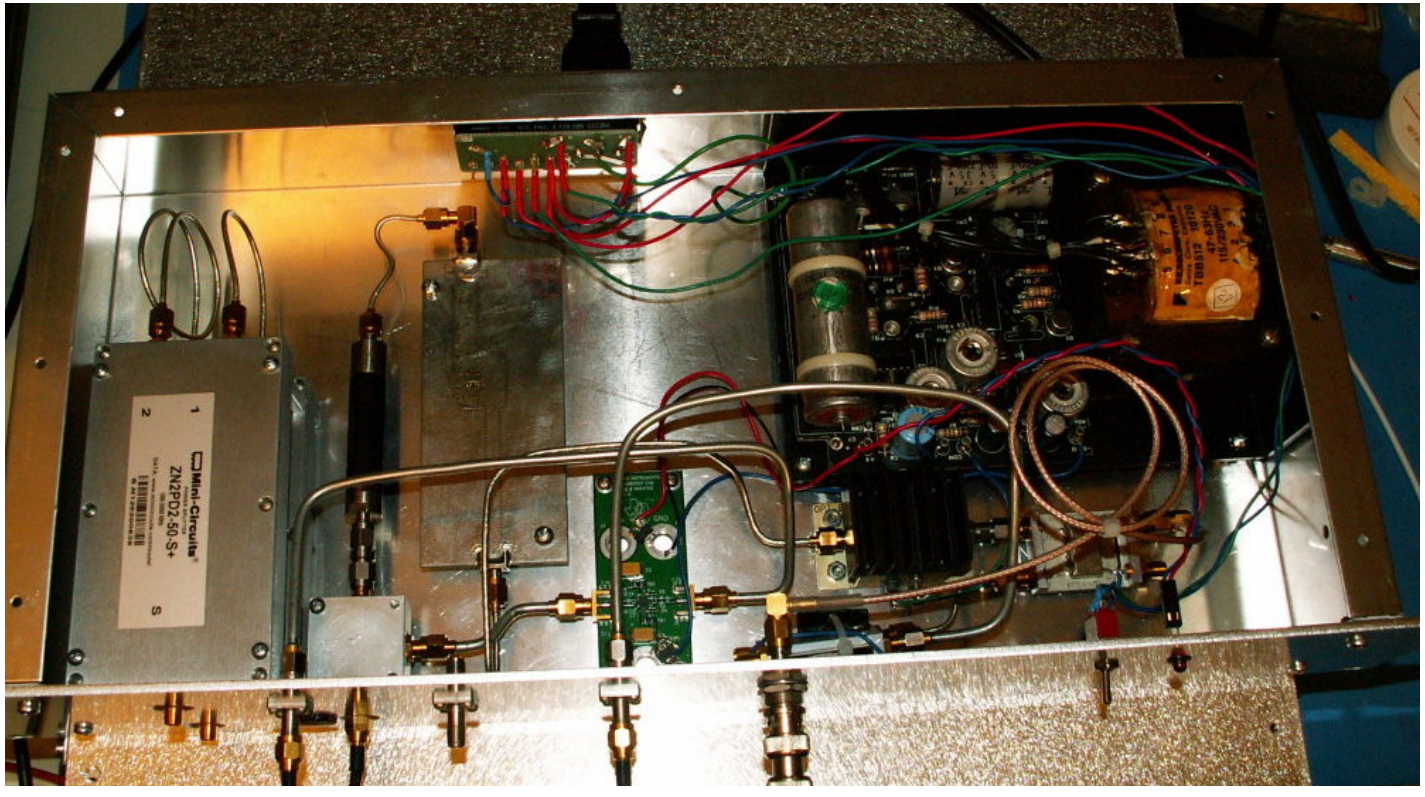
Front-End Prototype



- Phase shifting at 500 MHz;
- SRD 3× multiplier;
- Two-cycle comb generator;
- 14 dB of baseband gain;
- External padding & filtering.

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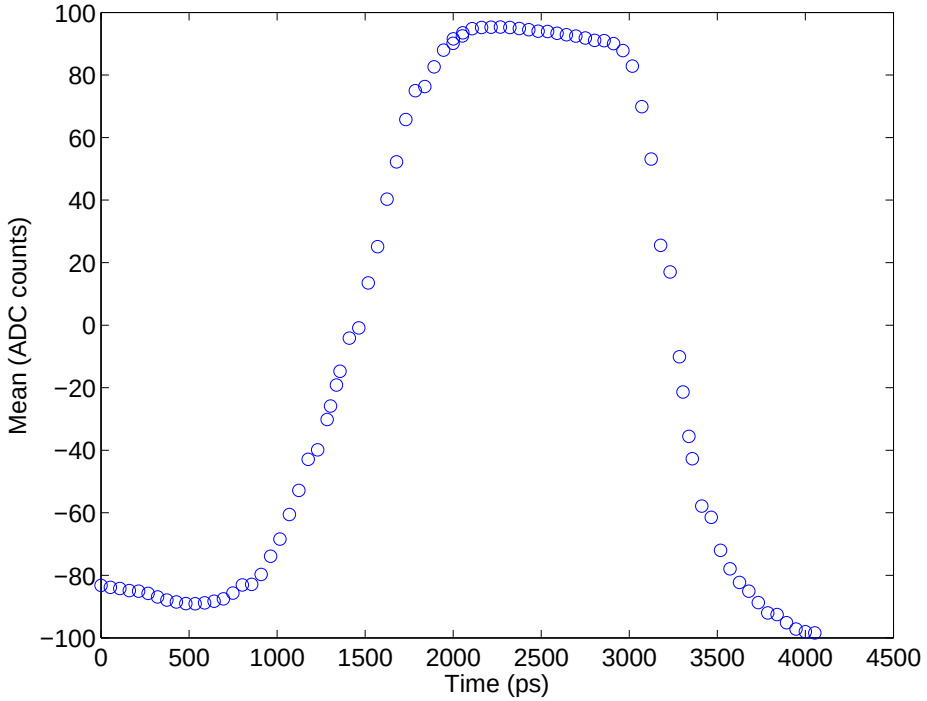
Transverse Front-End Timing Sweep



- Set up for amplitude detection;
- Sweep ADC sampling clock and capture mean value;
- Reasonable response a bit longer than expected (360 MHz low-pass);
- RMS sweeps are more reliable.

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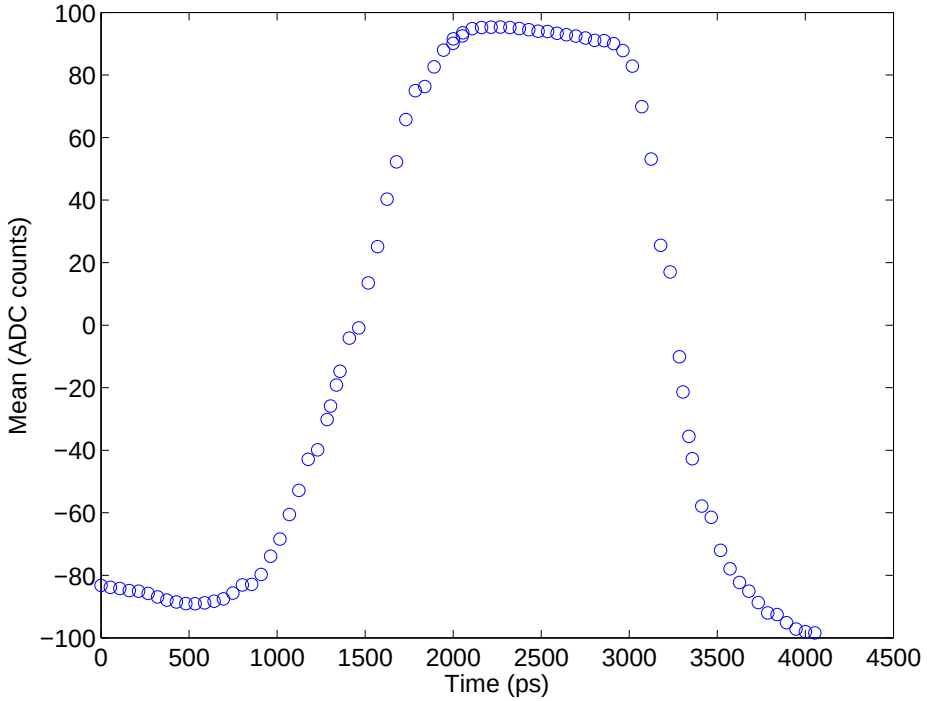

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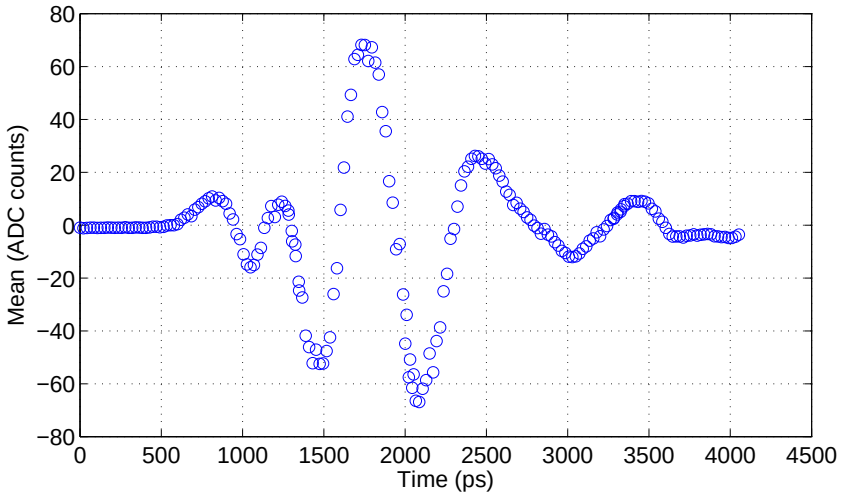
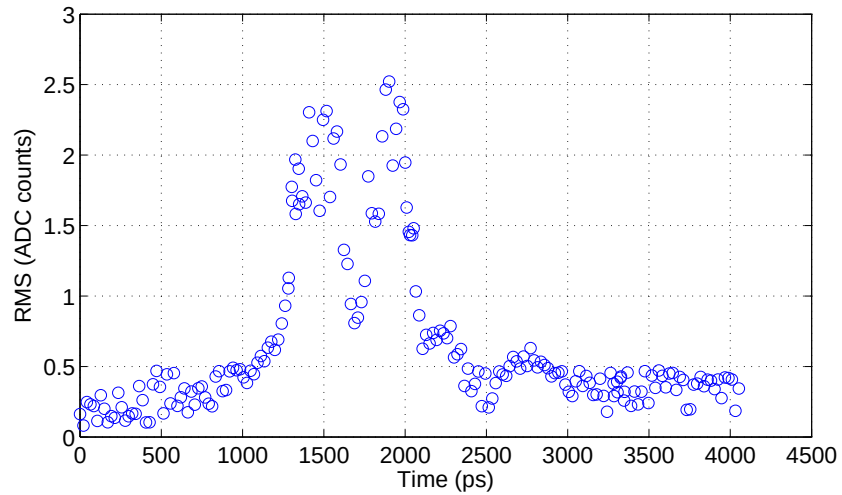
Transverse Timing Without Front-End





- Excited the beam through the back-end;
- Measured both mean and RMS;
- Fine timing into difference hybrids could be improved somewhat;
- Front-end calibration is 80 counts/mA/mm (12μm LSB at 1 mA).

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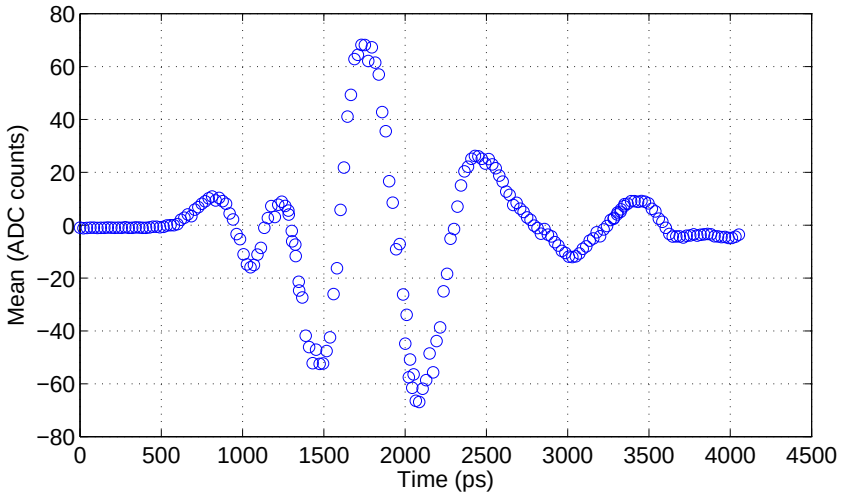

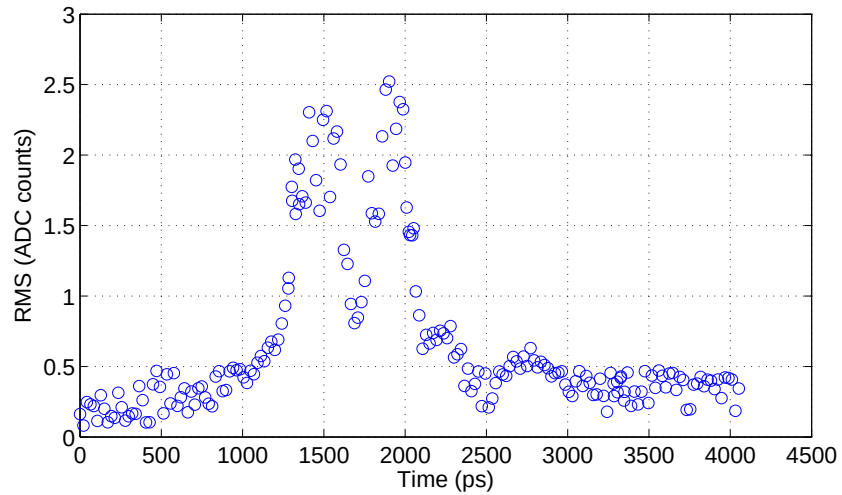

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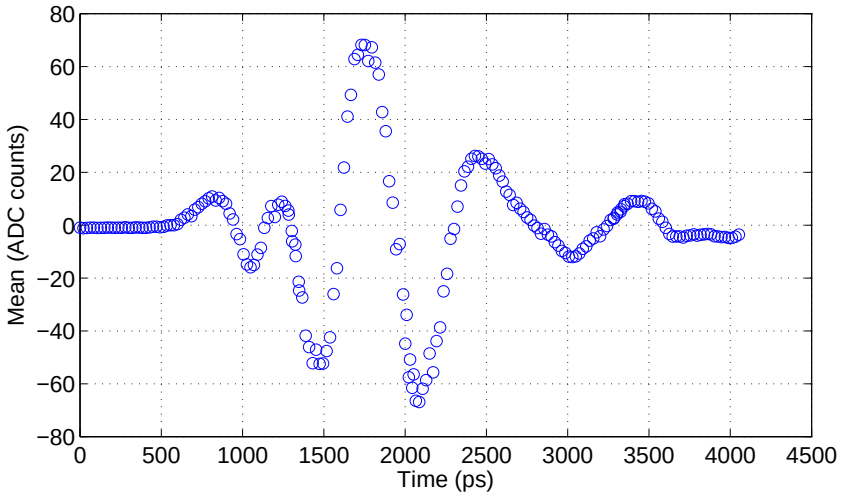

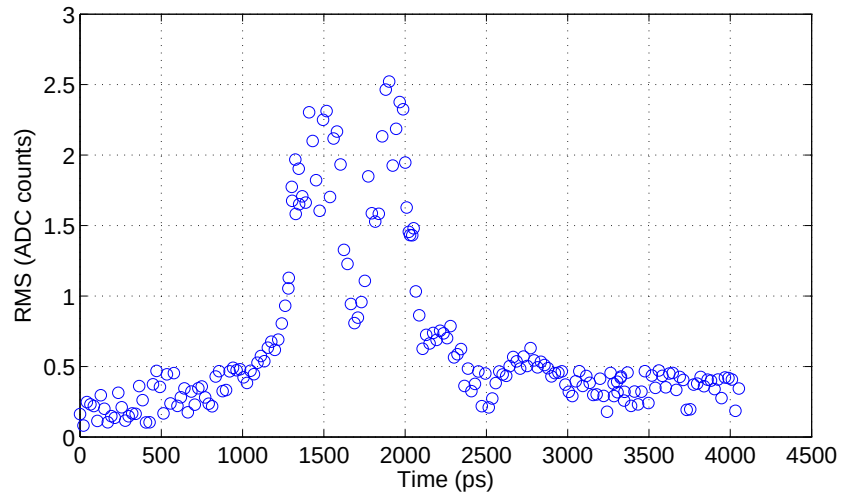

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Longitudinal Setup and Observations

- Longitudinal feedback setup took most of the first day;
- Different RF source and cables - all timing had to be redone;
- Higher energy than in January - beam was less responsive;
- Demonstrated single-bunch positive/negative feedback;
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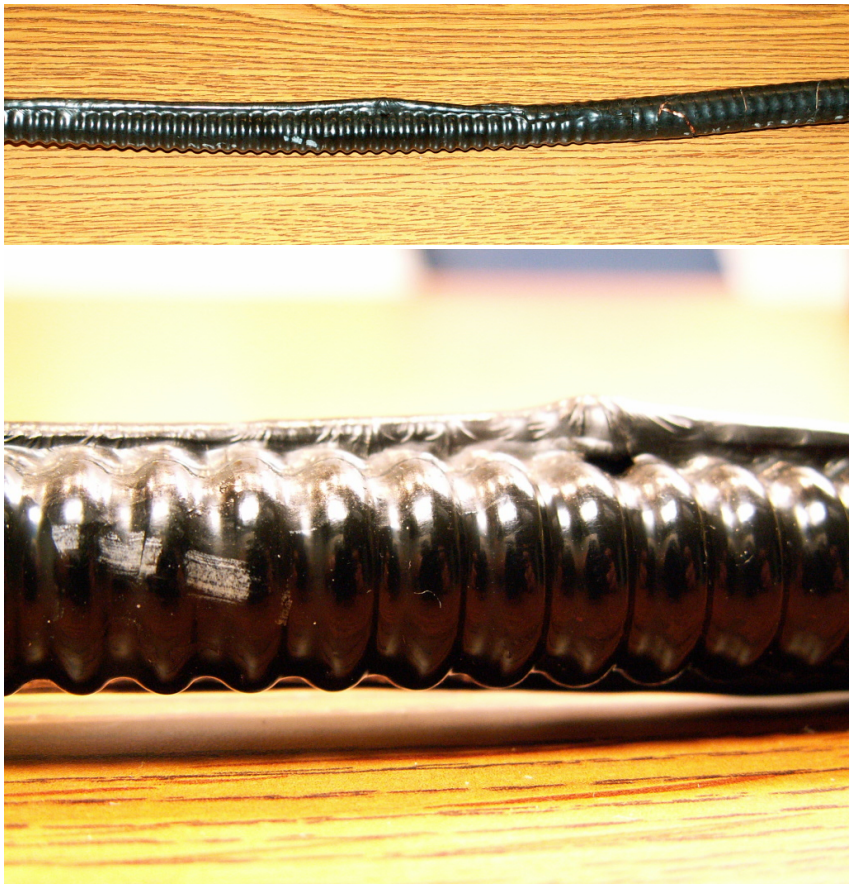
Back-end gain

- In January we observed lower back-end gain than expected (12 dB low);
- On Thursday (3/12) one of three cables between the power splitter and the kicker was found to be damaged;
- Back-end gain after cable replacement increased significantly, roughly 10–20 dB.

Back-end gain



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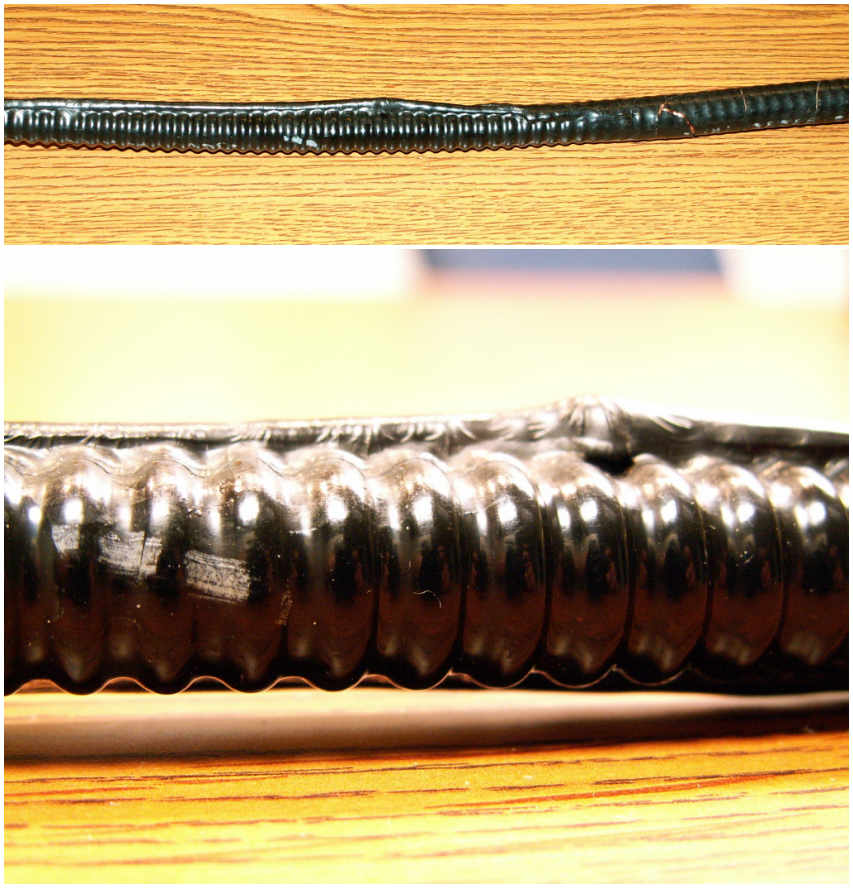

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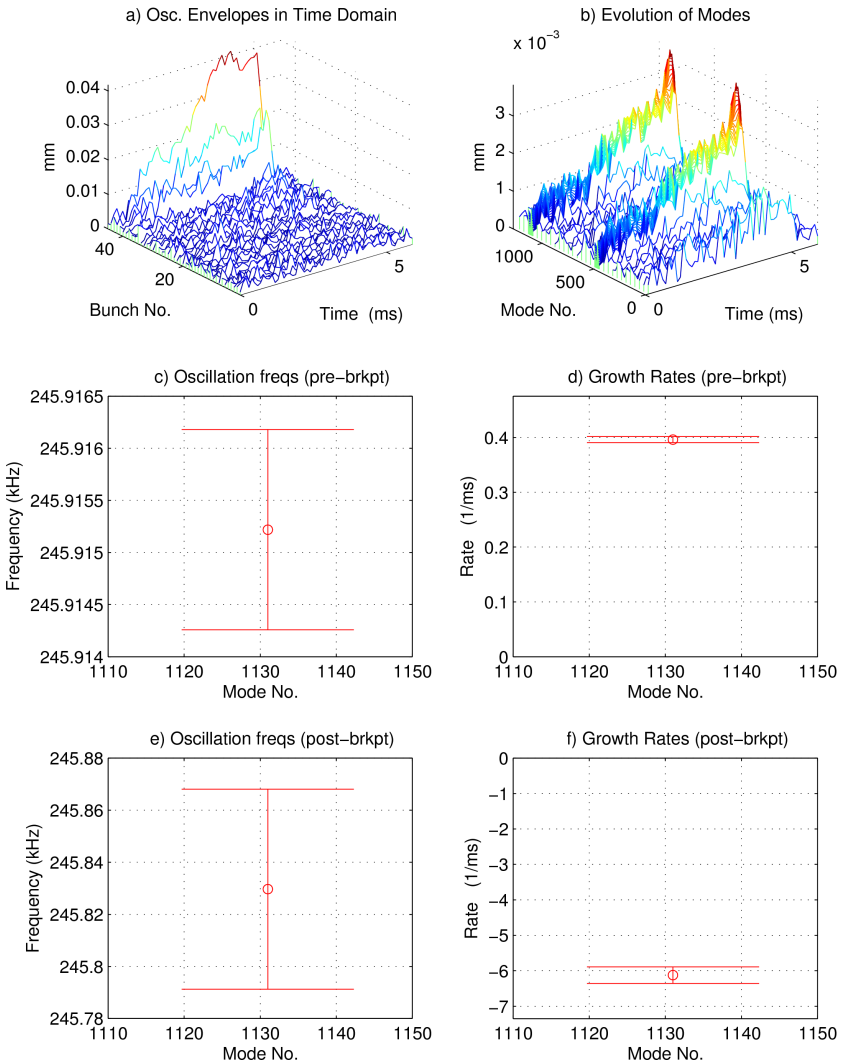
Grow/Damp Measurement



CESR TA:mar1109/164558: Io= 47mA, Dsamp= 1, ShifGain= 5, Nbun= 45,
At Fs: G1= 102.0631, G2= 0, Ph1= −64.687, Ph2= 0, Brkpt= 1965, Calib= 80.4.

- 45 bunches filled to 47 mA;
- Fairly uneven current distribution;
- Activity in the tail of the train;
- Modes around -151 (1130) are unstable;
- Great feedback damping.

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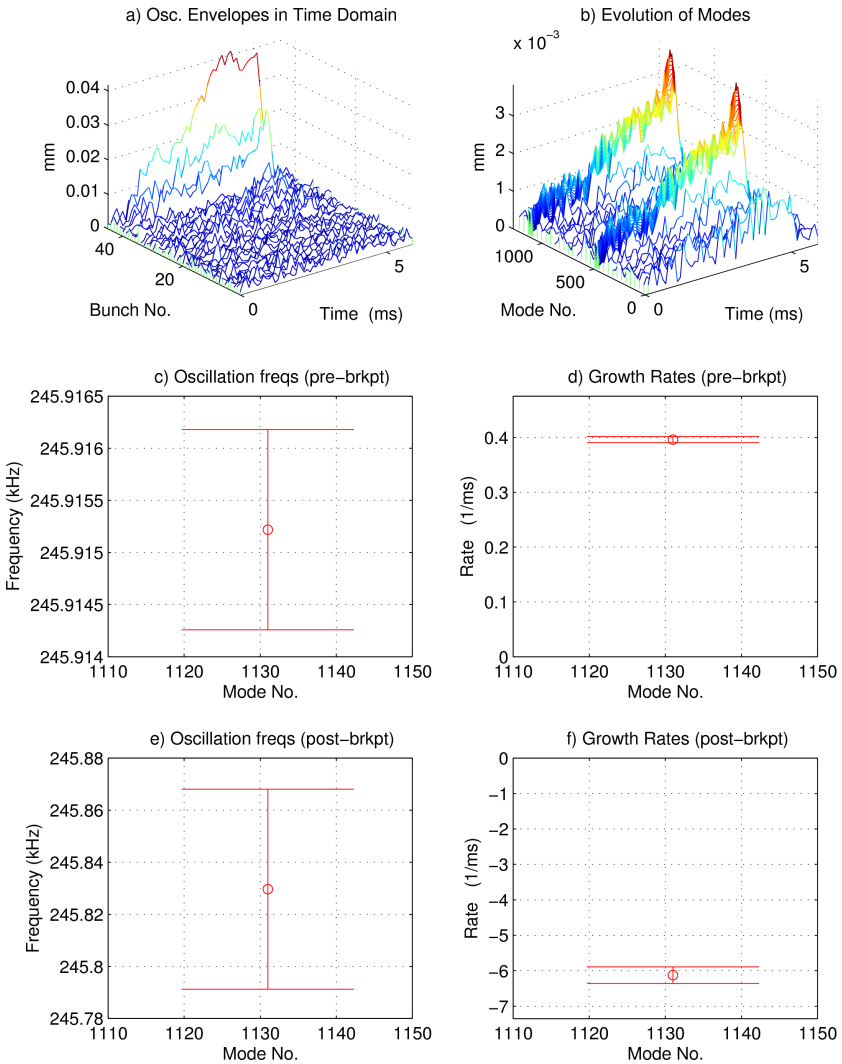

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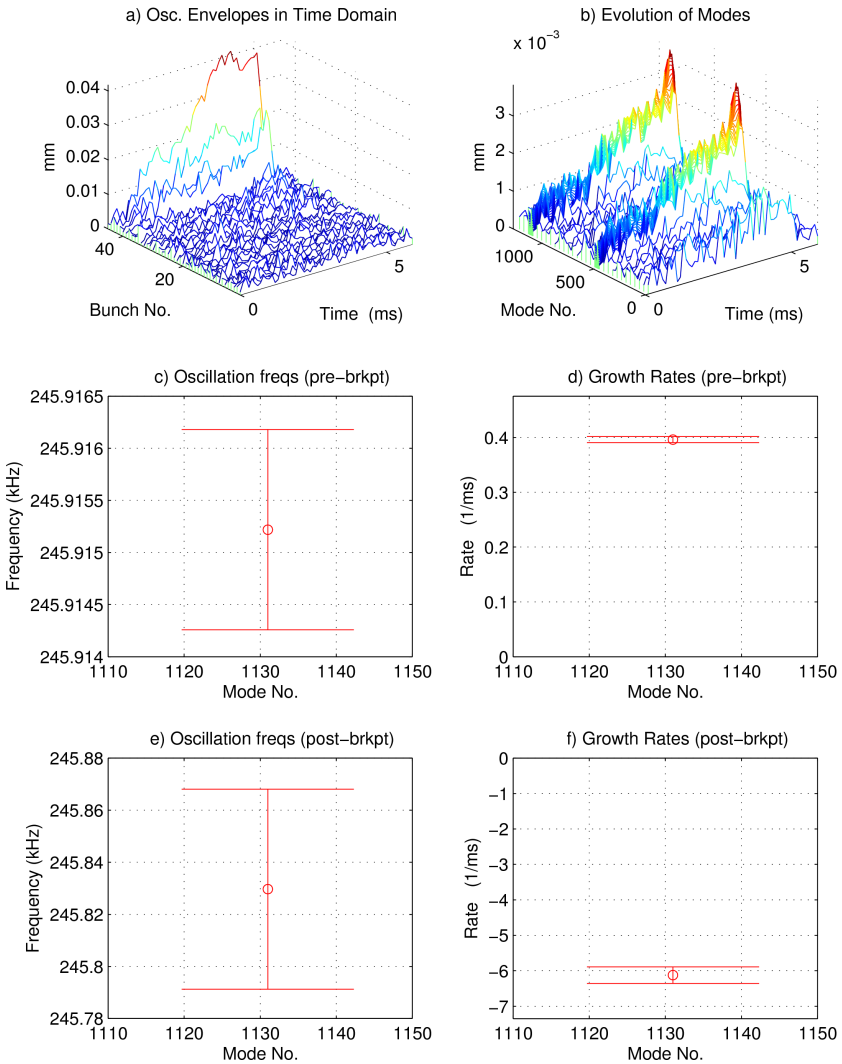

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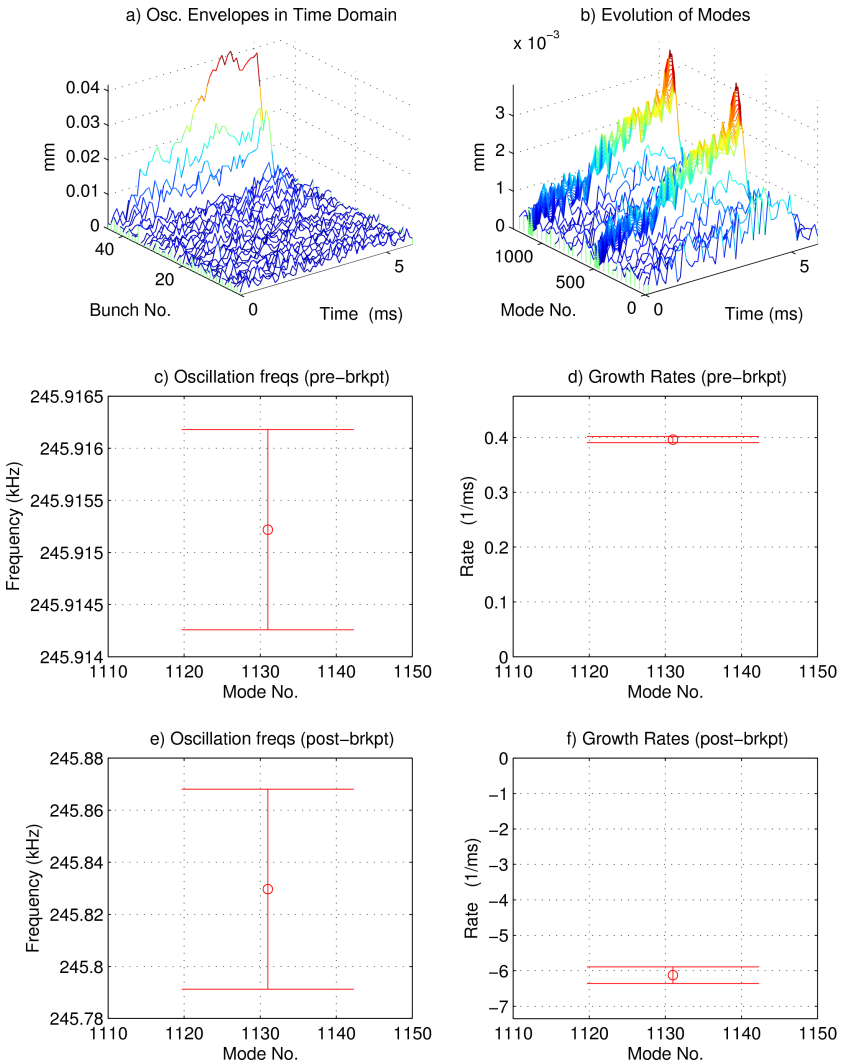

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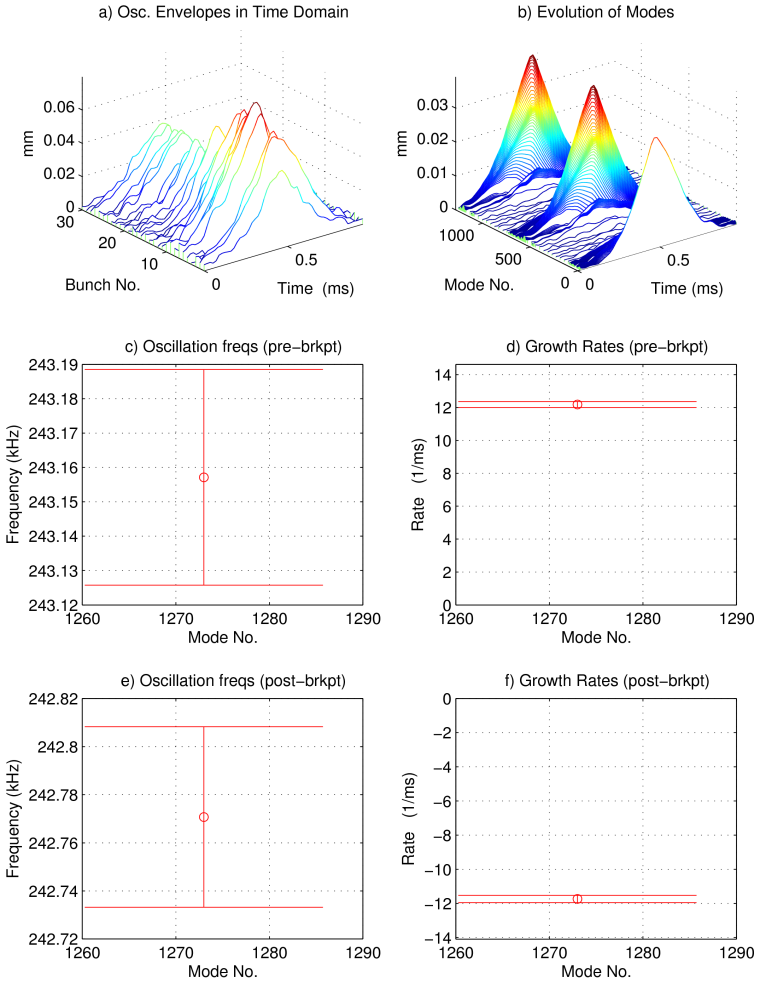

CESR TA:mar1309/141821: Io= 24.8mA, Dsamp= 1, ShifGain= 5, Nbun= 30,
At Fs: G1= 102.1006, G2= 102.1006, Ph1= −27.4997, Ph2= 152.5003, Brkpt= 245, Calib= 80.4.

- Drive/damp measurements around 20-24 mA;
- With the front-end - very high gain;
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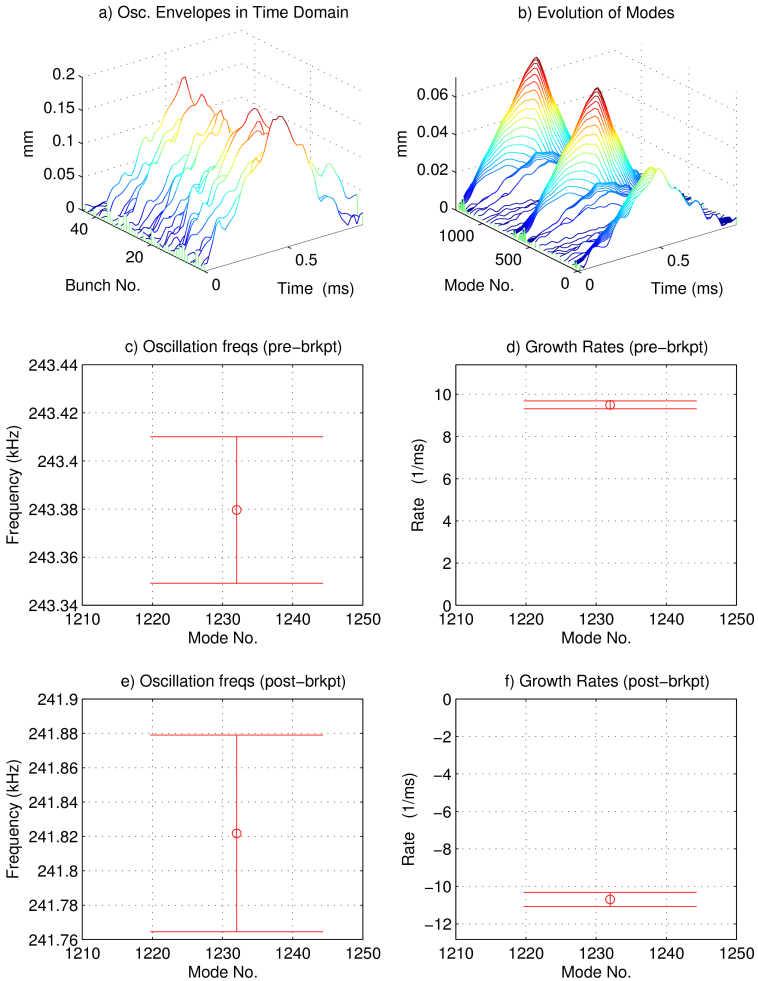

CESR TA:mar1209/230523: Io= 21.3mA, Dsamp= 1, ShifGain= 5, Nbun= 45,
At Fs: G1= 208.5848, G2= 208.5848, Ph1= −31.6783, Ph2= 148.3217, Brkpt= 240, Calib= 80.4.

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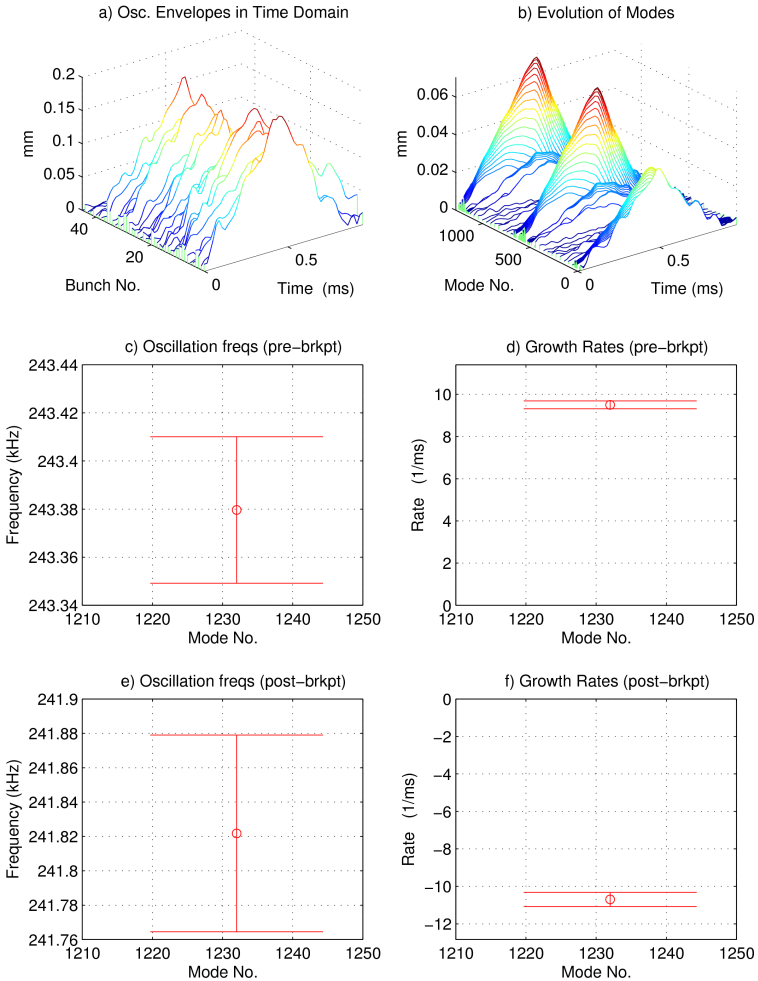

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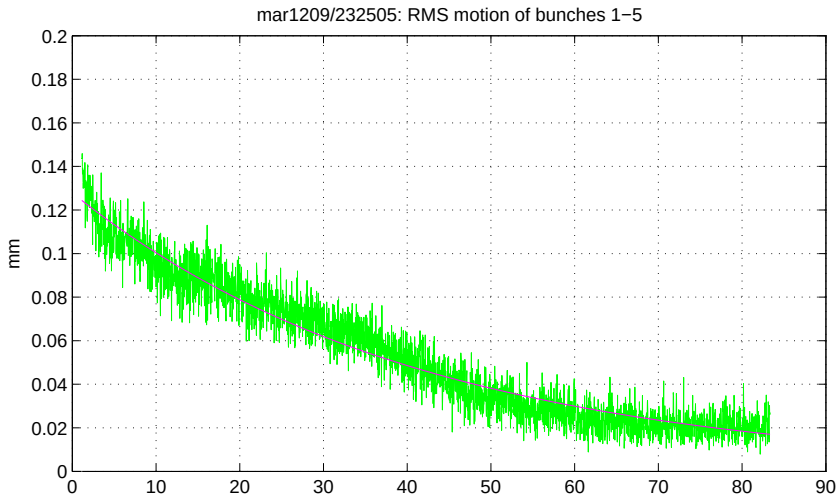

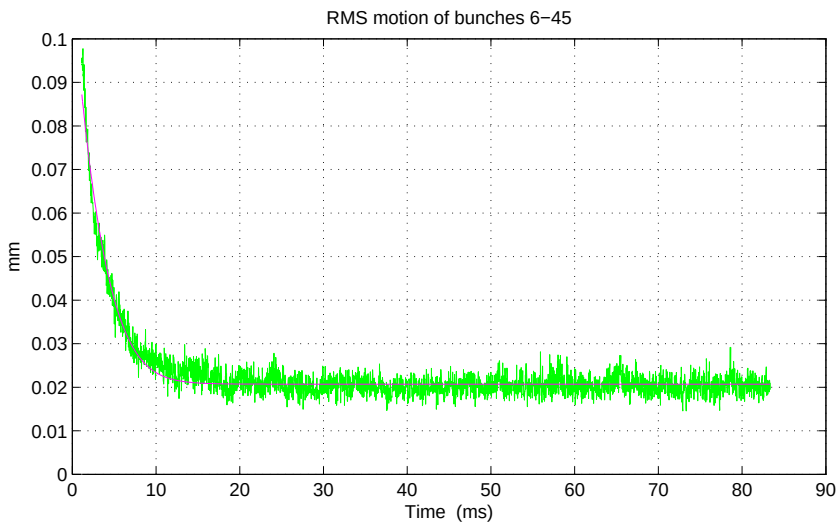

- 45 bunches filled to 21 mA;
- Positive feedback to excite motion;
- Record open-loop decay;
- 41 ms damping time for the first 5 bunches;
- 4.3 ms damping time for the next 40 bunches.

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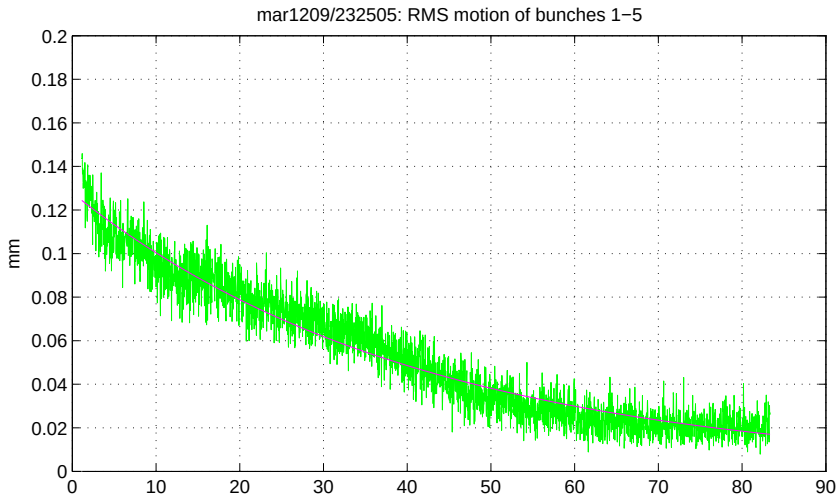

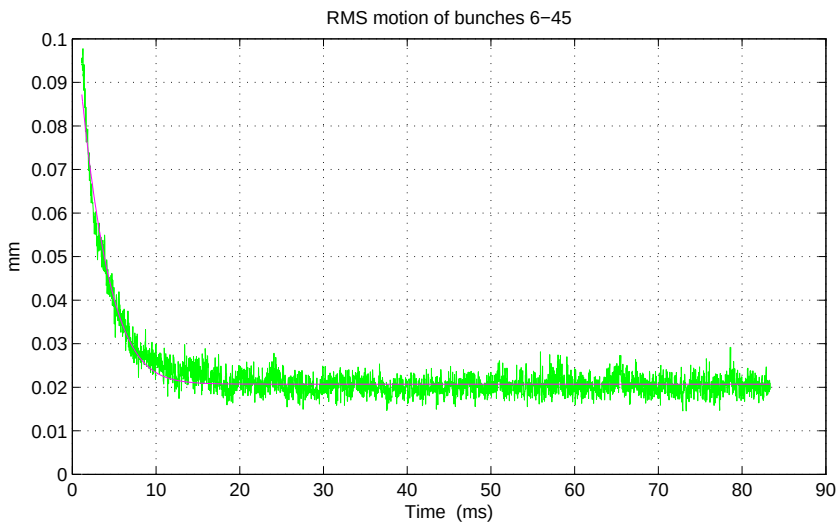

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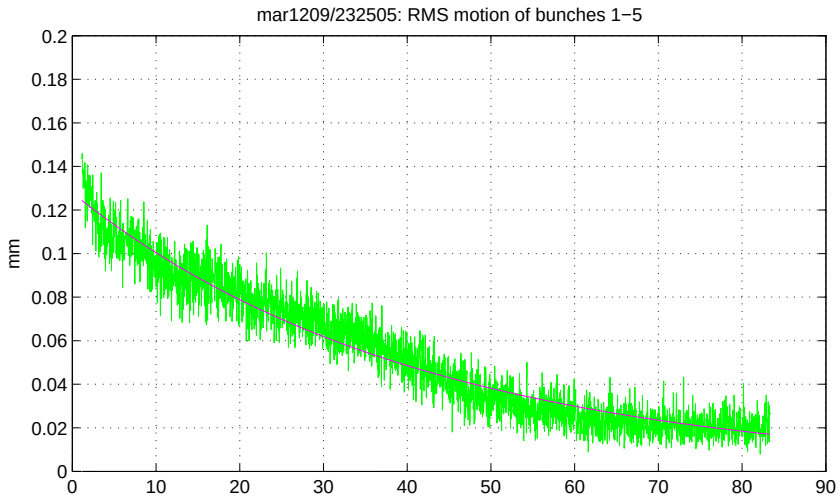

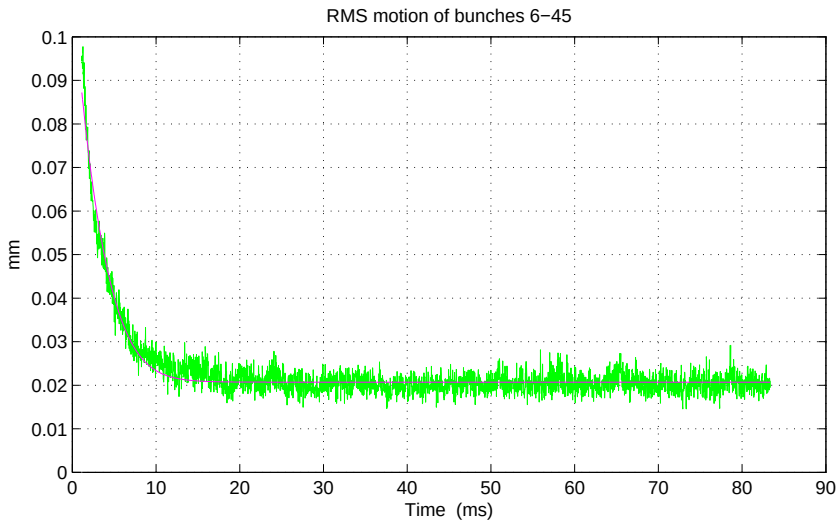

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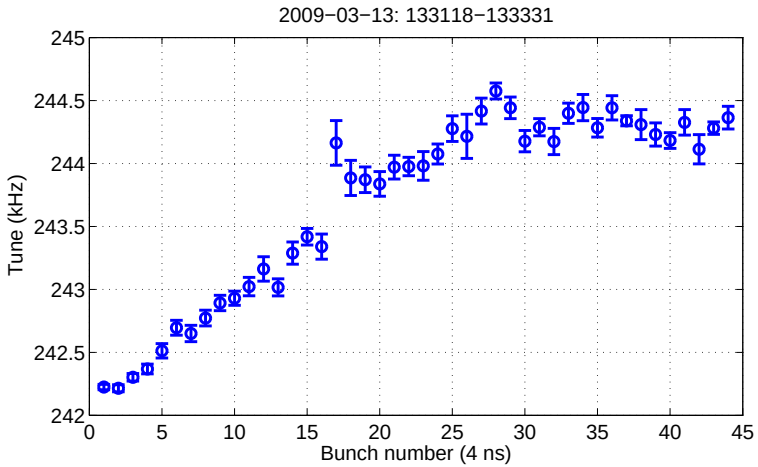
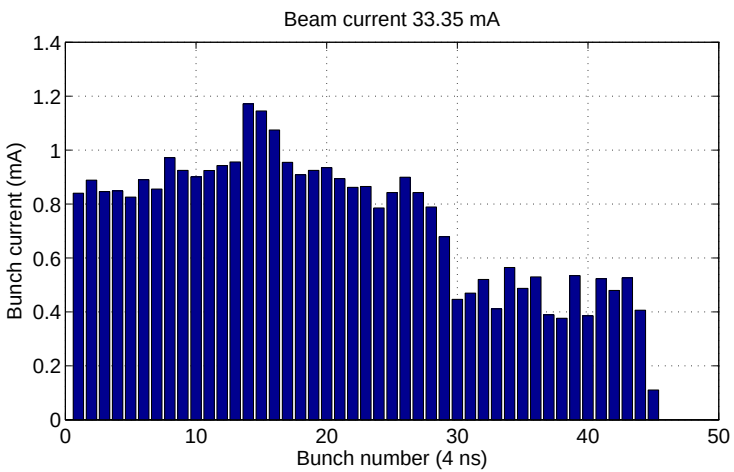
Measuring Bunch-by-bunch Tunes





- To get reasonably clean spectra needed to average 8+ measurements - 6548 turns per bunch in each;
- Measurements are basically repeatable;
- Used bunch cleaning mode to remove the last 15 bunches;
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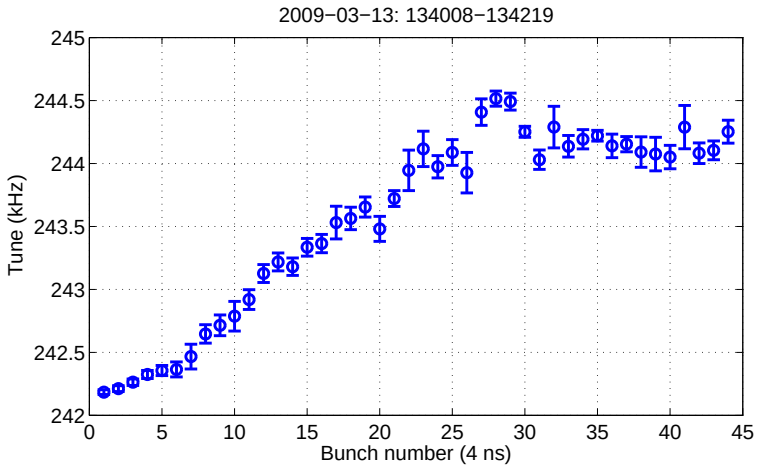

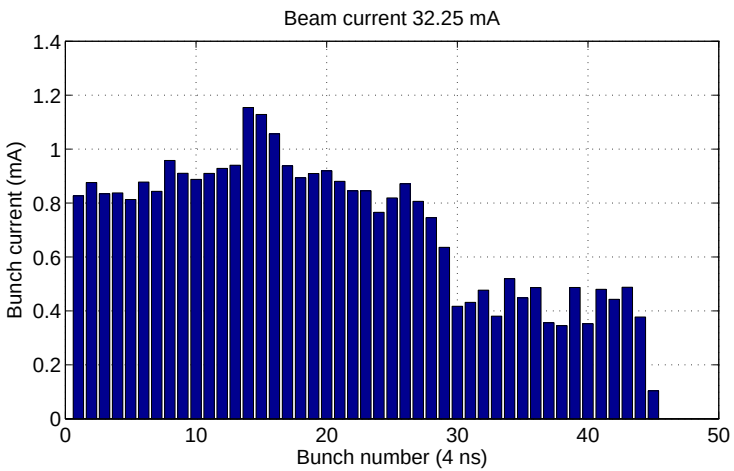

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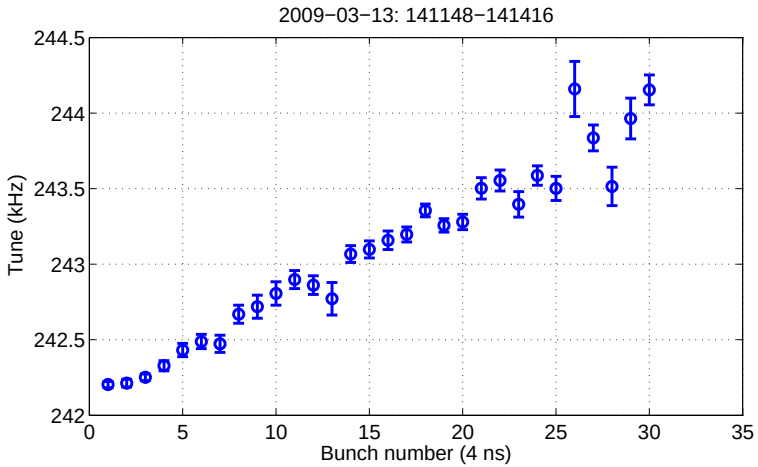

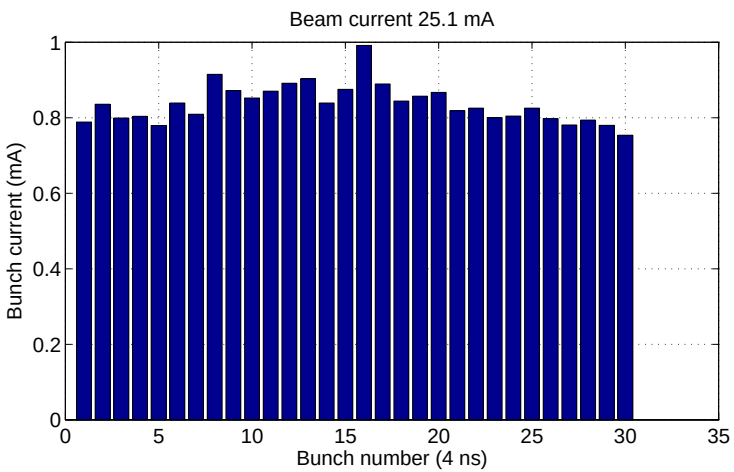

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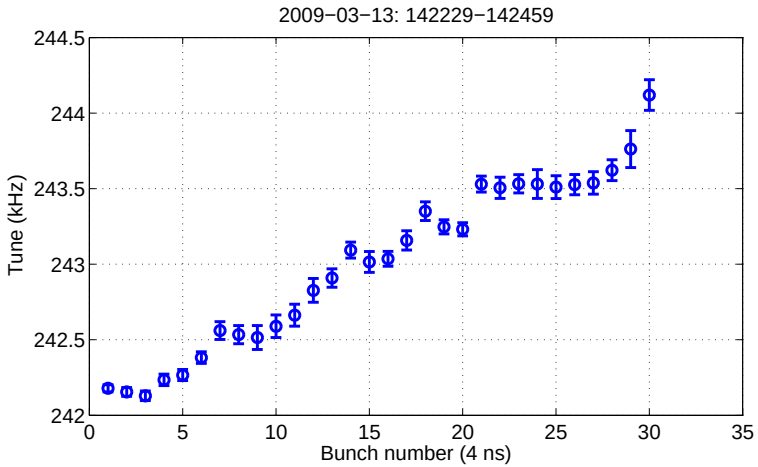

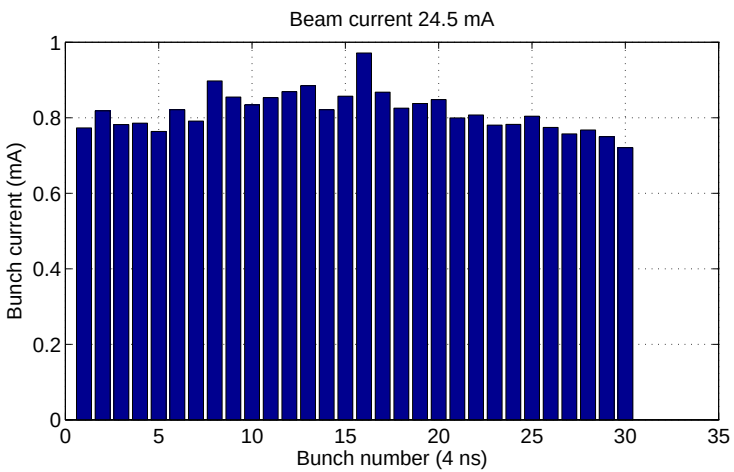

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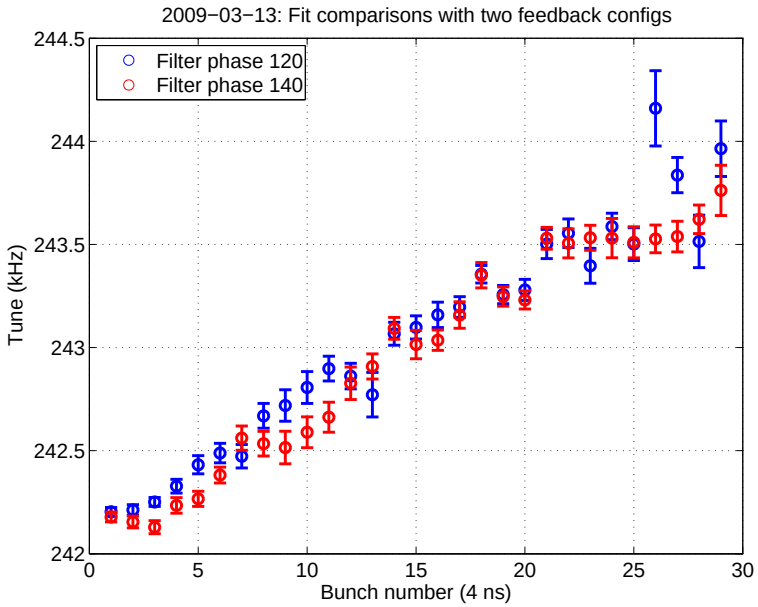

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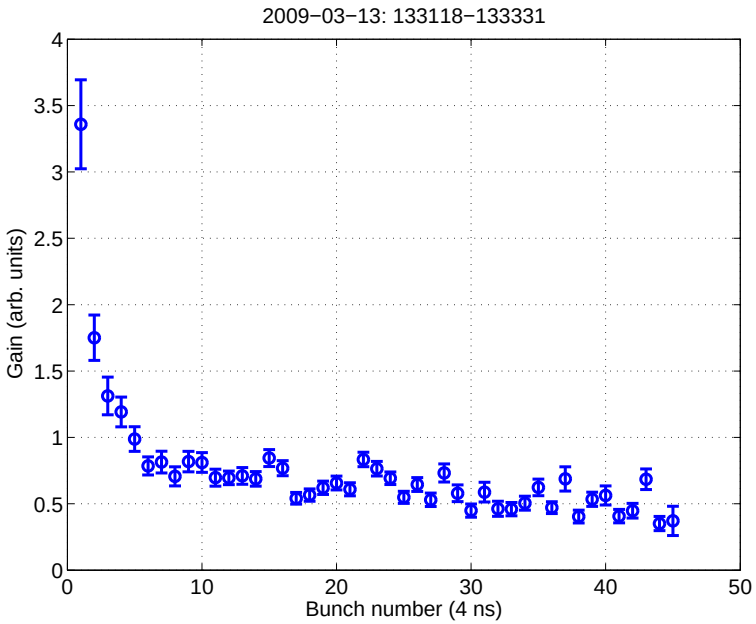
Notch Fitting Data: Loop Gain



- Notch fitting has 5 parameters:
  - loop gain;
  - pickup to kicker phase advance;
  - resonant frequency;
  - growth rate;
  - noise amplitude.
- Interesting drop in gain...

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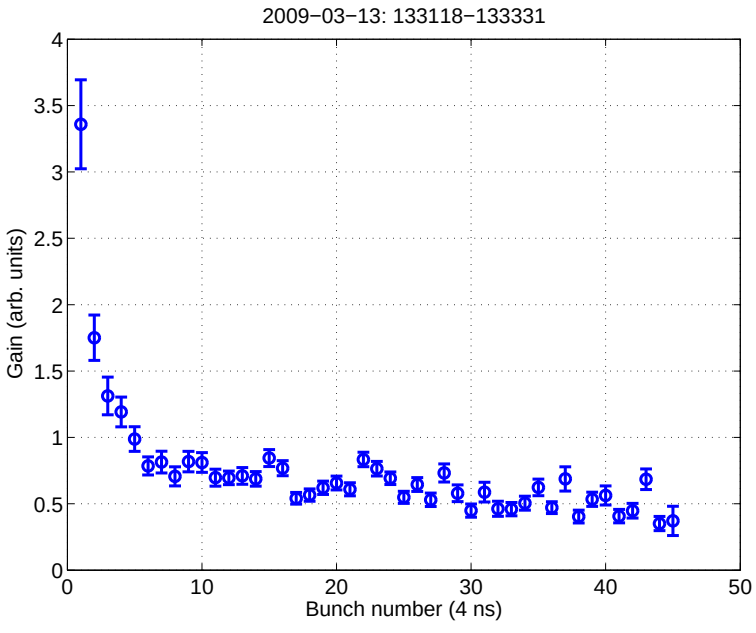

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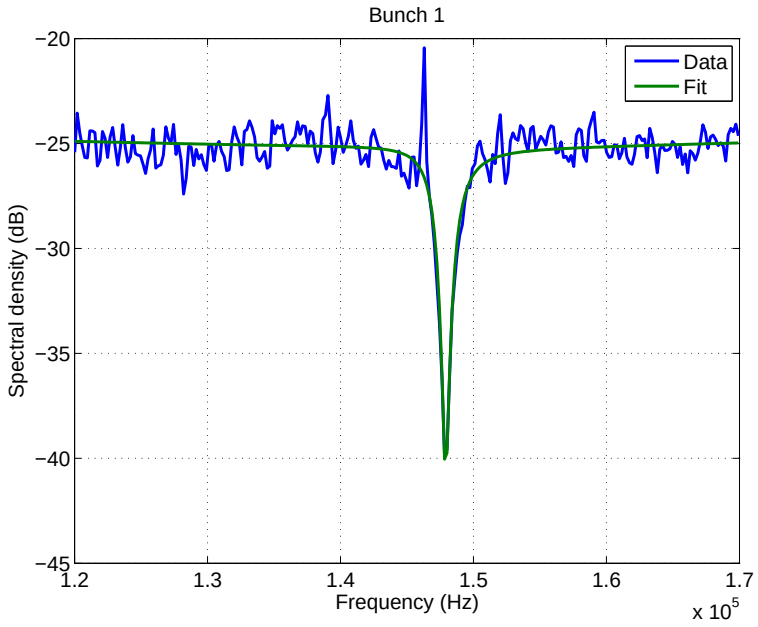
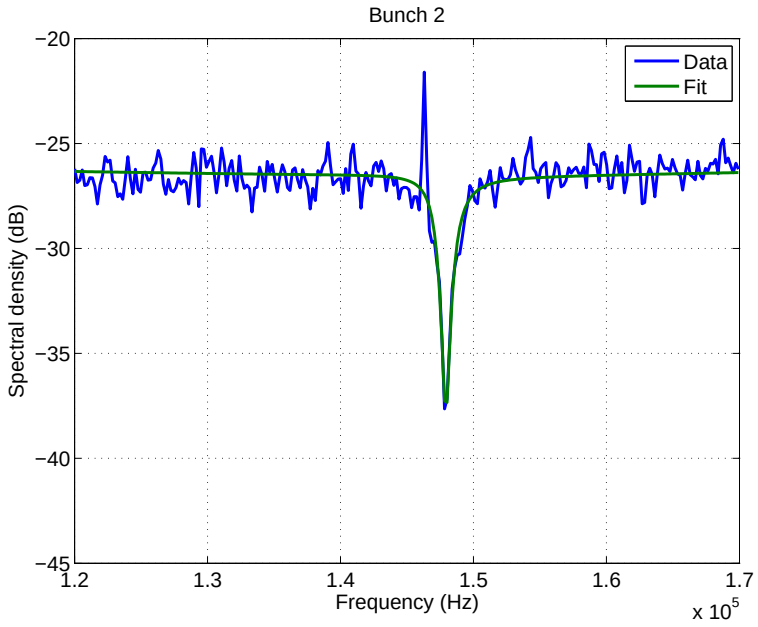
  - loop gain;
  - pickup to kicker phase advance;
  - resonant frequency;
  - growth rate;
  - noise amplitude.
- Interesting drop in gain...

Notch Fitting Data: Loop Gain (Continued)



- Bunch 1 shows nice deep notch;
- Shallower notch for bunch 2;
- Long kicker response couples bunches;
- Noise from bunch 1 is impressed on 2, 3, possibly 4;
- Observed that turning on feedback on all bunches (1:89) obliterated the notches.

Notch Fitting Data: Loop Gain (Continued)



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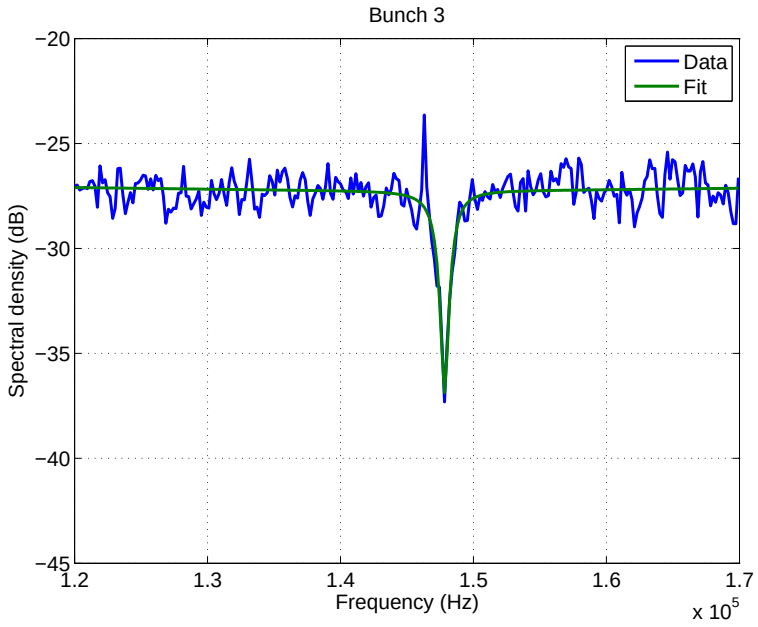

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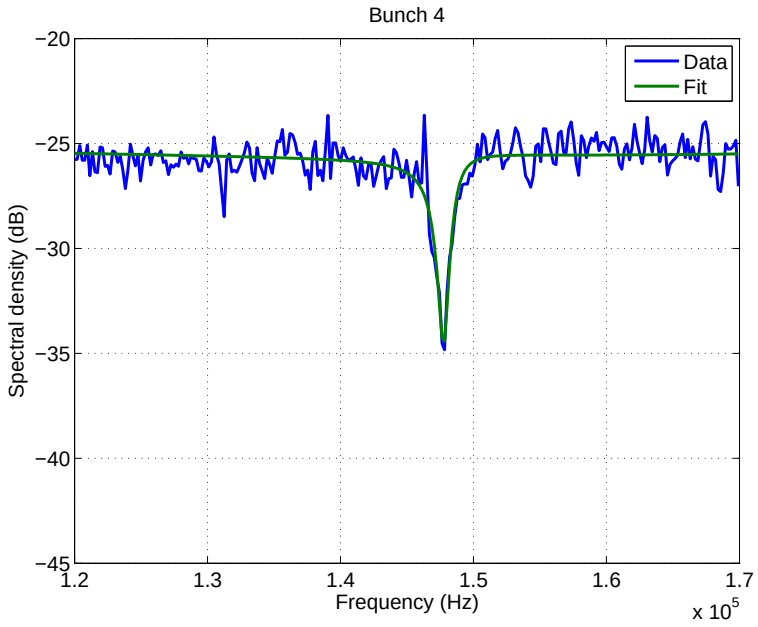

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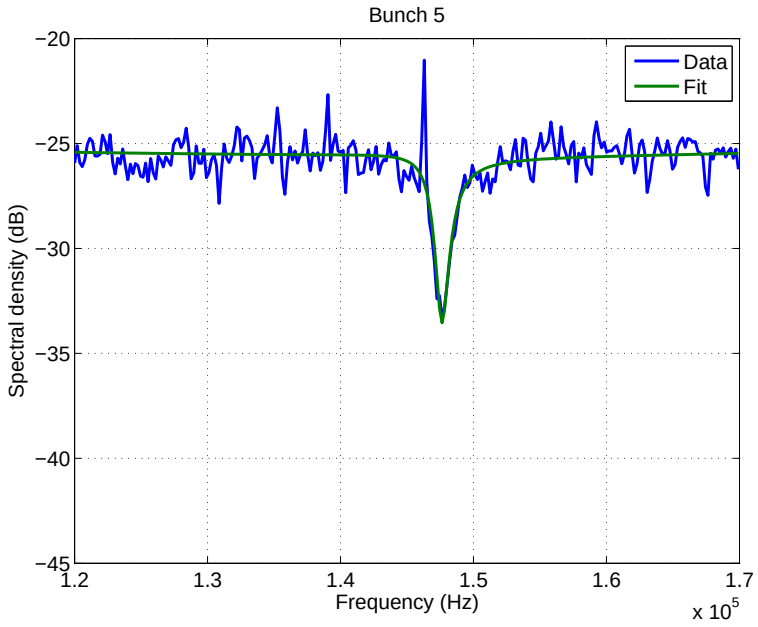

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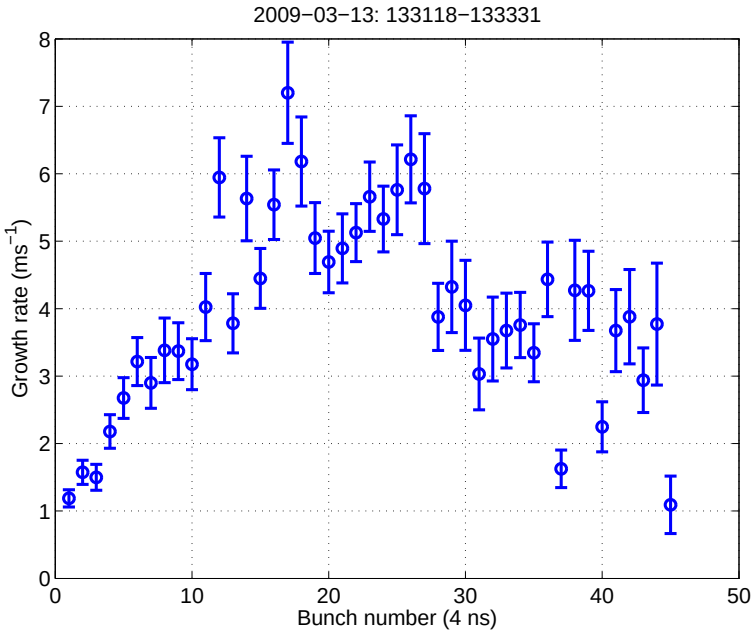
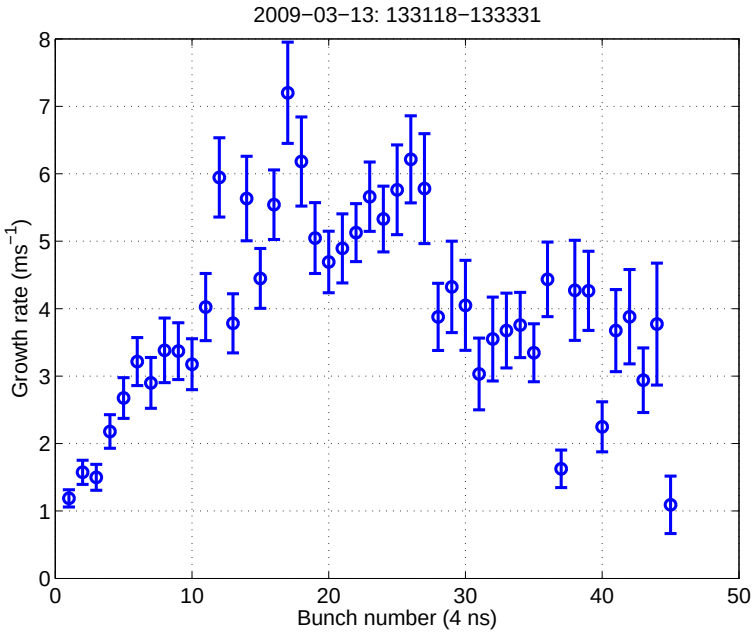
Notch Fitting Data: Growth Rate



- Not clear if the rising growth rate is real;
- Some of this is due to the bunch-to-bunch coupling in the feedback loop;
- Some - from instability coupling mechanisms.

Notch Fitting Data: Growth Rate



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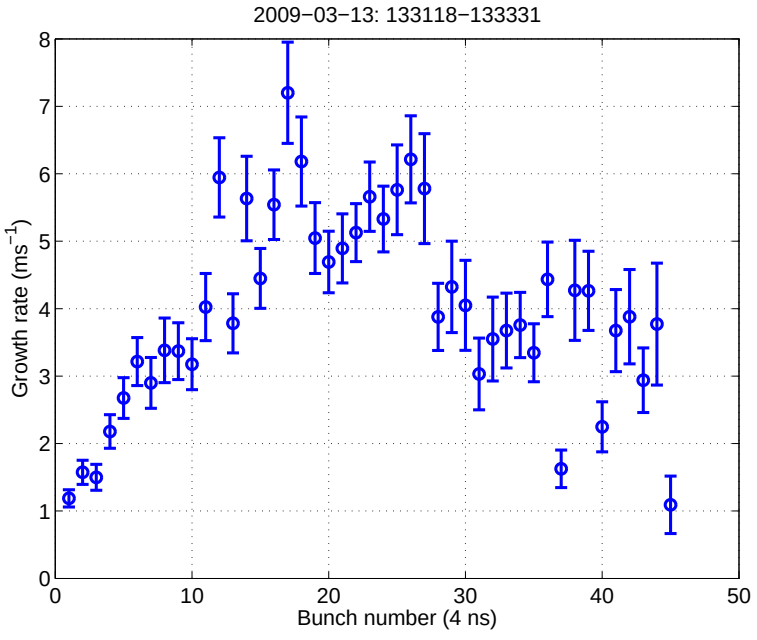

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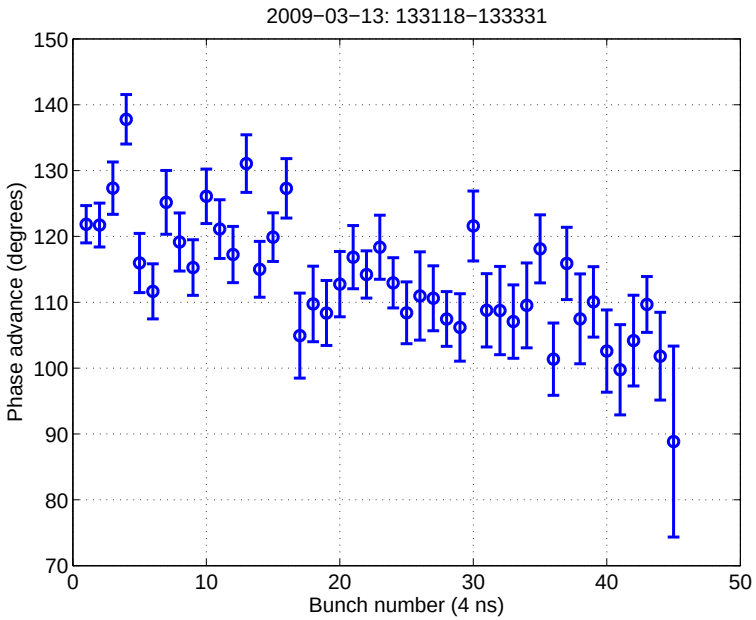
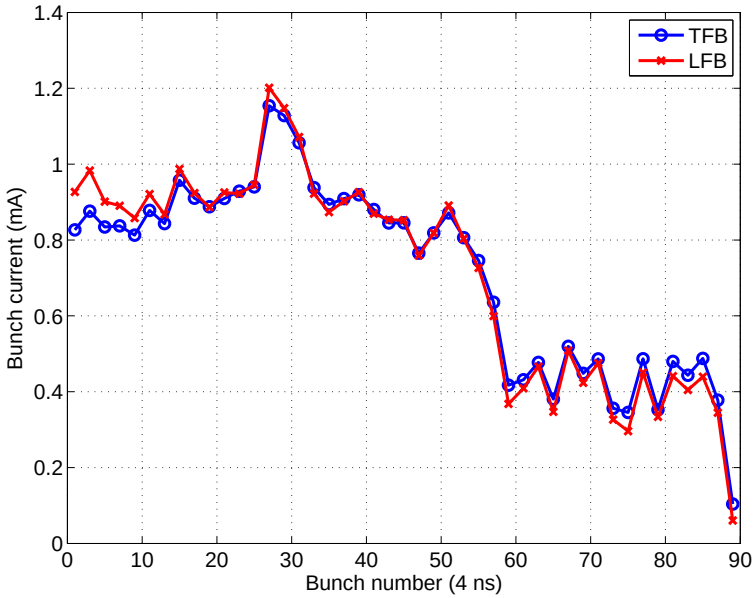
Notch Fitting Data: Phase Advance



- I would expect to see no shift from bunch to bunch.

Bunch-by-bunch Currents Comparison



- Data acquired with both TFB and LFB;
- LFB data is processed to extract low-frequency modulation that reflects bunch-by-bunch currents;
- Reasonable agreement between the two methods.

Summary

- Demonstrated vertical feedback for positron beams;
- Significant damping margins;
- Bunch-by-bunch tune measurement is feasible;
- iGp can be operated with direct sampling;
- Replacing damaged cable in the longitudinal system improved the back-end gain.

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