

# Positron Ring Measurements

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# Outline

## 1 System overview

- Introduction
- Front and Back End
- Specification highlights
- Operating experience

## 2 Measurements

- Experimental Setup: Vertical
- Experimental Setup: Longitudinal
- Vertical Feedback Operation
- Grow/damps
- Longitudinal Studies
- Observations

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# iGp Highlights



- A 500+ MHz processing channel.
- Finite Impulse Response (FIR) bunch-by-bunch filtering for feedback.
- Control and diagnostics via EPICS soft IOC on Linux.
- External triggers, fiducial synchronization, low-speed ADCs/DACs, general-purpose digital I/O.

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# Front/Back-end Unit



- 1.5 GHz front-end detection frequency.
- 2-cycle comb generator.
- 1 GHz back-end frequency.
- Integrated control via iGp GPIO:
  - Front and back-end LO phase shifters;
  - Front and back-end attenuators.

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# iGp Specifications

- Design goals:
  - Reliability;
  - Maintainability;
  - Ease of use;
  - Diagnostics.
- FPGA based processing:
  - Flexible;
  - Field upgradable.

## Specifications

Bunch spacing  $\geq 1.9$  ns

Harmonic number 64–5120

ADC resolution 8 bits

DAC resolution 12 bits

Feedback filter 16-tap FIR

Downsampling 1-32

DAQ memory 8 MB

Digital GPIO 32 channels

Slow analog I/O 8 channels

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# Installed Units and Tests

- iGp is installed or has been tested in the following machines:
  - DAΦNE (LNF-INFN): four systems, transverse feedback;
  - Photon Factory (KEK): one system, longitudinal feedback;
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# Vertical Feedback Configuration

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- BPM signals applied directly to difference hybrids;
- $\Delta Y$  is connected to the front-end input;
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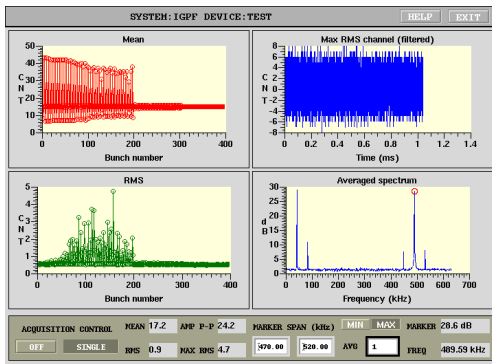
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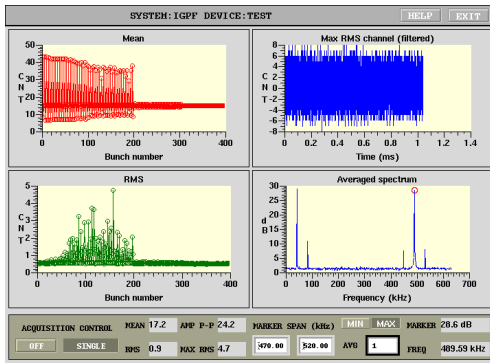
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# Waveform Panel



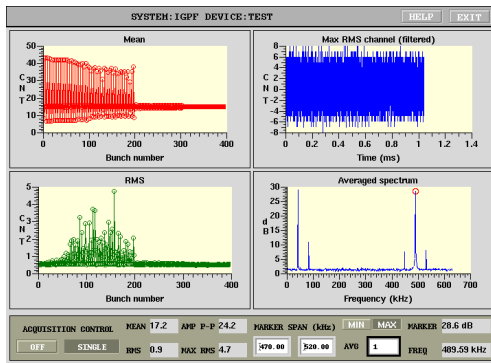
- Updates at 1 Hz
- Uses data from all bunches over many turns.
- Four waveforms:
  - Mean;
  - RMS;
  - Bunch with largest RMS;
  - Averaged spectrum of all bunches.

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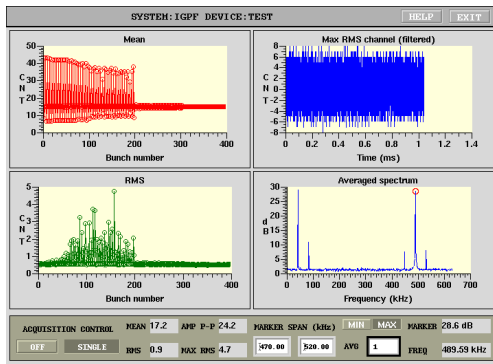
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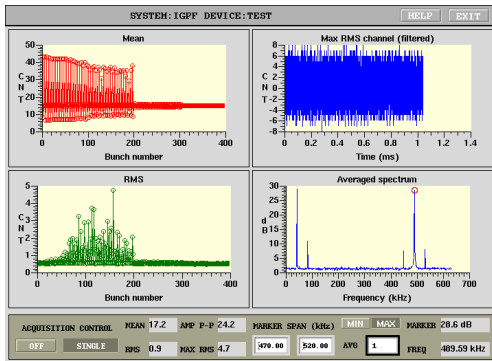
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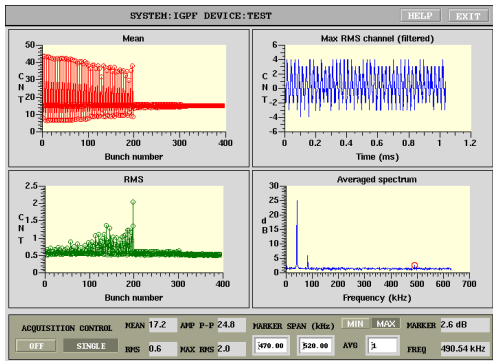


# Feedback in Action



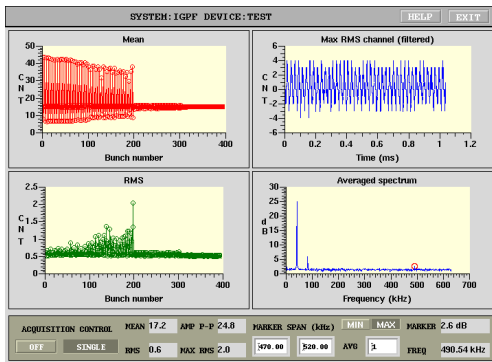
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- When feedback is turned on, vertical motion is suppressed to the noise floor;
- Significant longitudinal oscillation component.

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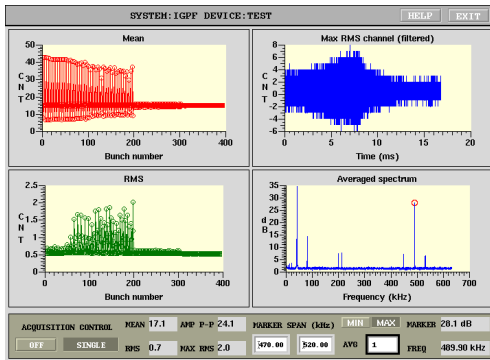
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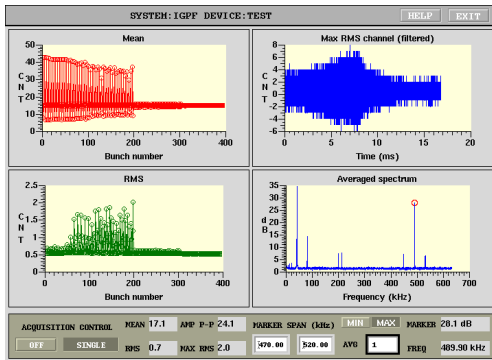
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# Grow/damp Waveforms



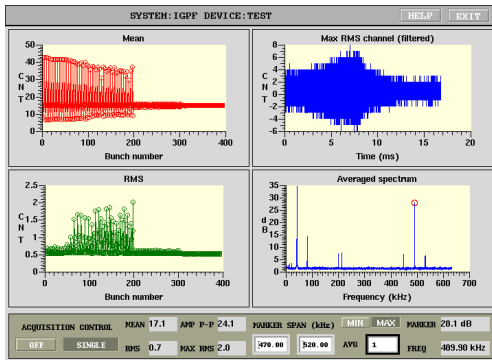
- Can also configure the system for grow/damp measurements;
- Results are immediately seen on the waveform panel;
- Data can then be read out for further analysis.

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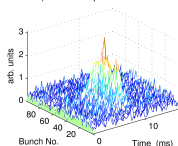
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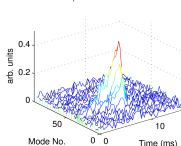
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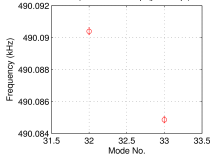
a) Osc. Envelopes in Time Domain



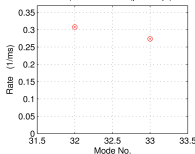
b) Evolution of Modes



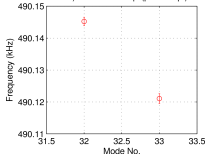
c) Oscillation freqs (pre-brkpt)



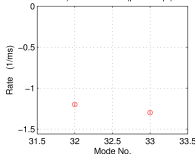
d) Growth Rates (pre-brkpt)



e) Oscillation freqs (post-brkpt)



f) Growth Rates (post-brkpt)



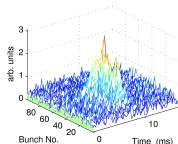
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- 50 bunches filled;
- Several eigenmodes are unstable: 32 and 33;
- Growth rates of  $0.27\text{--}0.3\text{ ms}^{-1}$ ;
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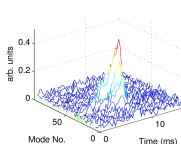


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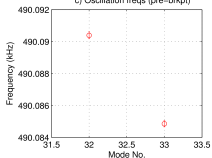
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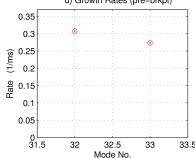
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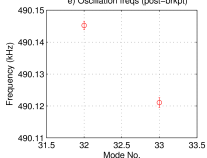
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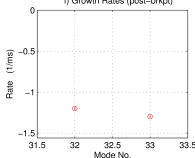
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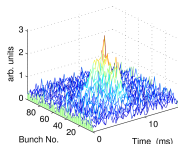


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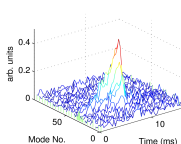
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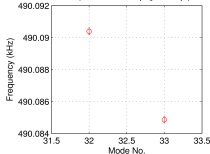
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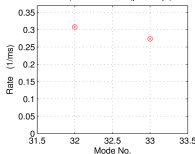
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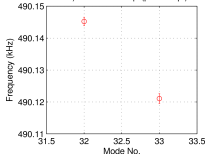
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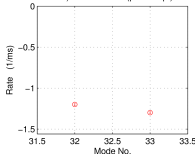
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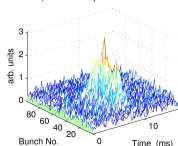


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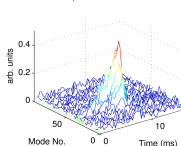
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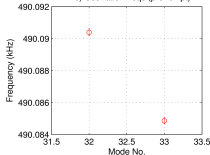
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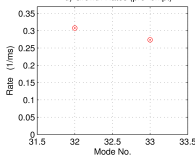
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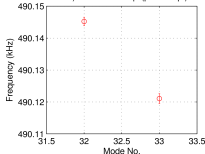
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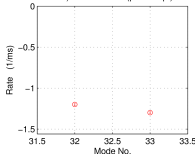
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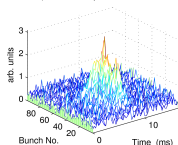


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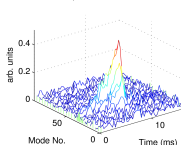
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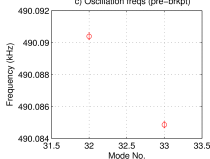
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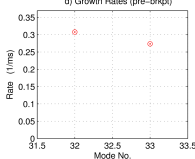
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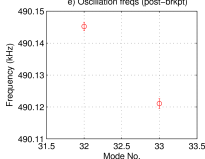
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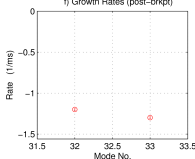
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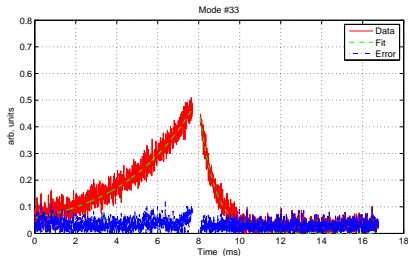
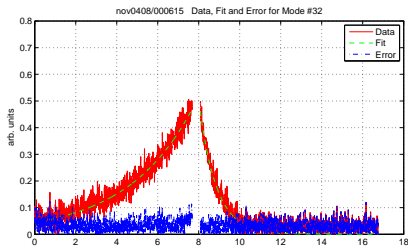
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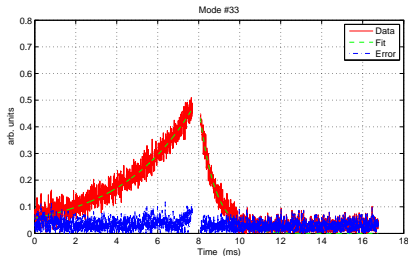
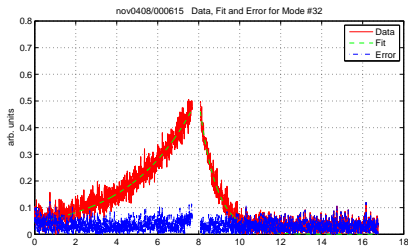
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At Fs: G1= 47.0329, G2= 0, Ph1= -83.9861, Ph2= 0, Brkpt= 10200, Calib= 1.

# Growth and Damping Transients



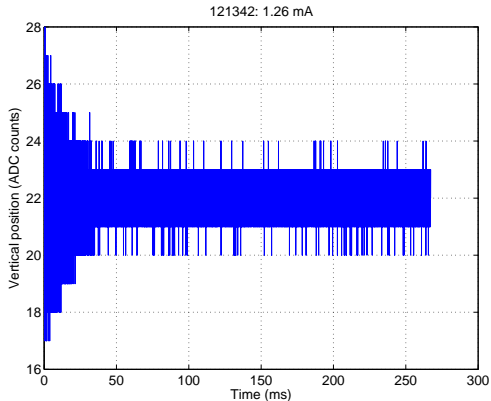
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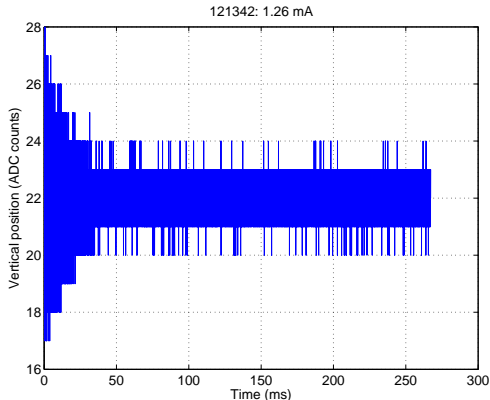
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# Single-bunch Damping



- Single-bunch measurement;
- Use feedback to excite the bunch, then record natural decay;
- Big change in damping with beam current.

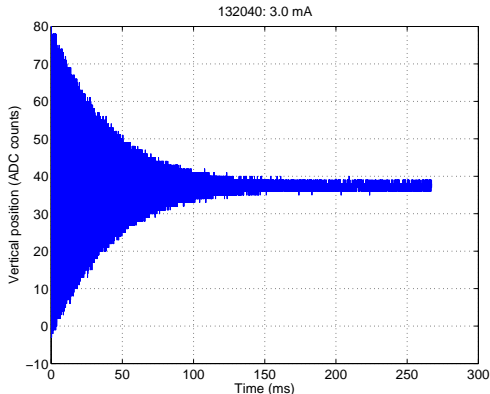
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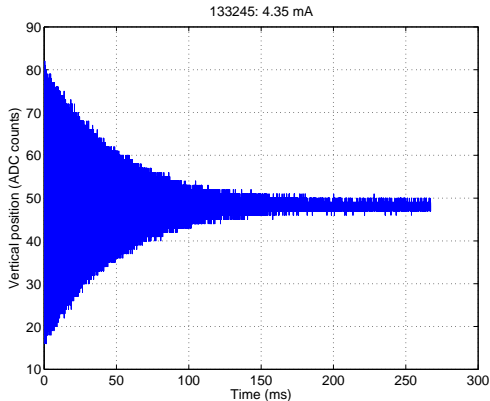


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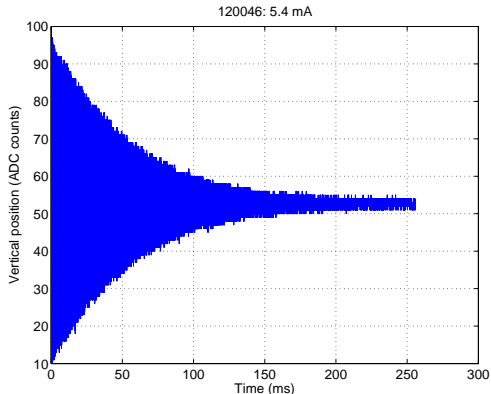
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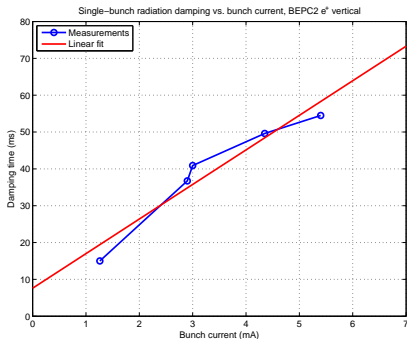
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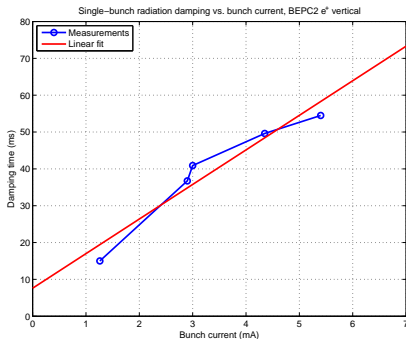
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# Damping Rate vs. Bunch Current



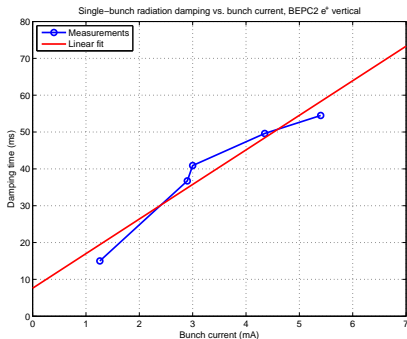
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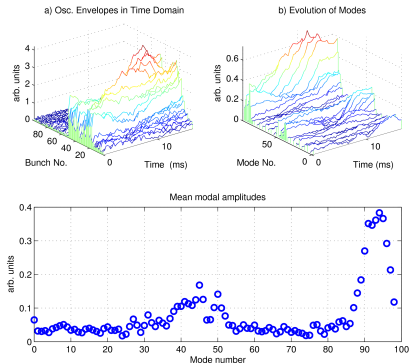


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# Outline

- 1 System overview
  - Introduction
  - Front and Back End
  - Specification highlights
  - Operating experience
- 2 **Measurements**
  - Experimental Setup: Vertical
  - Experimental Setup: Longitudinal
  - Vertical Feedback Operation
  - Grow/damps
  - **Longitudinal Studies**
  - Observations

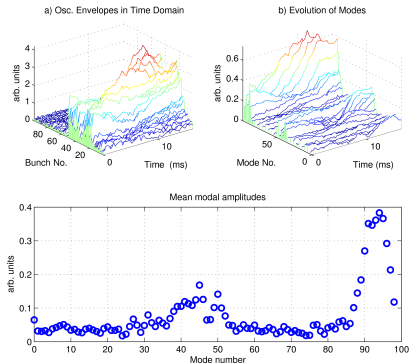
# Longitudinal Modal Analysis



- Closed-loop record;
- Analyze longitudinal motion;
- Active eigenmodes -8 to -4.

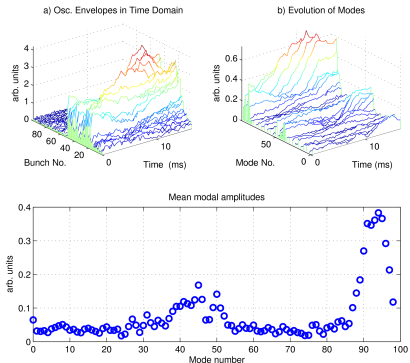


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# Observations

- Clearly see vertical and horizontal instabilities in the positron ring;
- In the vertical plane single-bunch damping changes with bunch current;
- Vertically the instabilities are most likely driven by an HOM, not resistive wall or electron cloud;
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- Further study should focus on:
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