Integrated Gigasample Processor

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Dimtel, Inc., San Jose, CA, USA

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Outline

1. System overview
   - Introduction
   - Operating experience
2. Features
   - Specification highlights
   - Architecture
   - Important features
   - Front and Back End
3. User Interface
   - Controls
   - Diagnostics
4. Measurement Examples
   - Photon Factory
   - DAΦNE

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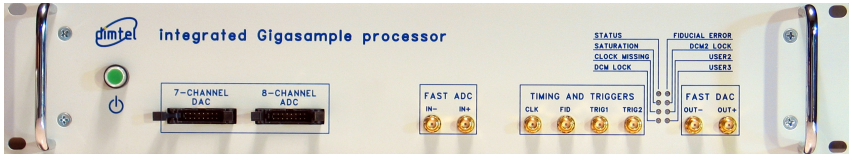
iGp Highlights



- 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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What's Inside

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Installed Units and Tests

- iGp is installed or has been tested in the following machines:
  - DAΦNE: four systems, transverse feedback;
  - Advanced Light Source: one system, longitudinal feedback;
  - Photon Factory (KEK): one system, longitudinal feedback.
- Gproto tests:
  - PEP-II transverse feedback;
  - KEKB transverse feedback;
  - ATF damping ring longitudinal feedback;
  - DAΦNE transverse feedback;
  - PEP-II bunch-by-bunch luminosity monitor.

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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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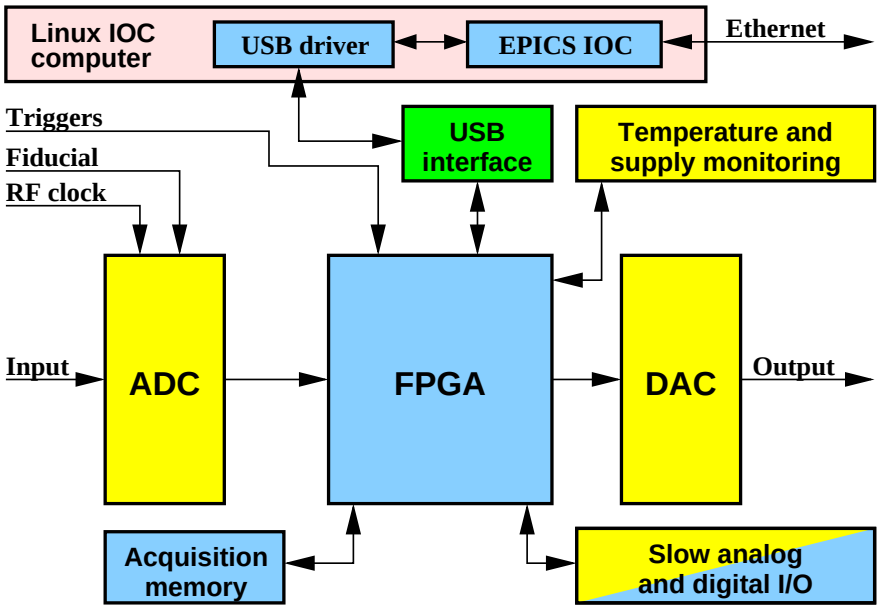
System Block Diagram



- Real-time processing in the FPGA.
- Low-rate ($\leq$ 10 Hz) diagnostics via USB.
- 8 MB memory:
  - Data acquisition in normal operation;
  - Can be used for grow/damps, other diagnostics;
  - Internal or external data acquisition triggers.

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Important Features

- ADC and DAC timing adjustment with 10 ps step size.
  - Eliminates the need for mechanical delay lines.
- High bandwidth
  - 1.26 GHz input bandwidth;
  - 200-300 ps output rise and fall times.
- Self-test program for verifying system health.
  - Generated report can be compared to factory results using "diff".
- User-friendly IOC setup program
  - With a series of windows leads the user through network setup, date/time setting, and IOC name.
- DAC test pattern generator.

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Front/Back-end Unit

- 2U 19" rackmount chassis, just like the iGp.
- 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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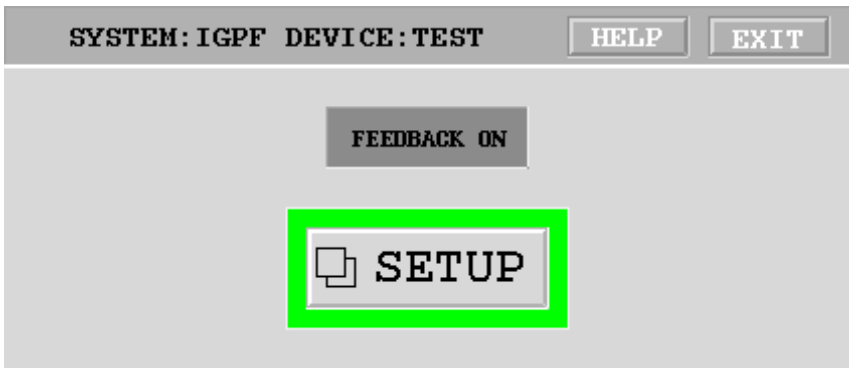
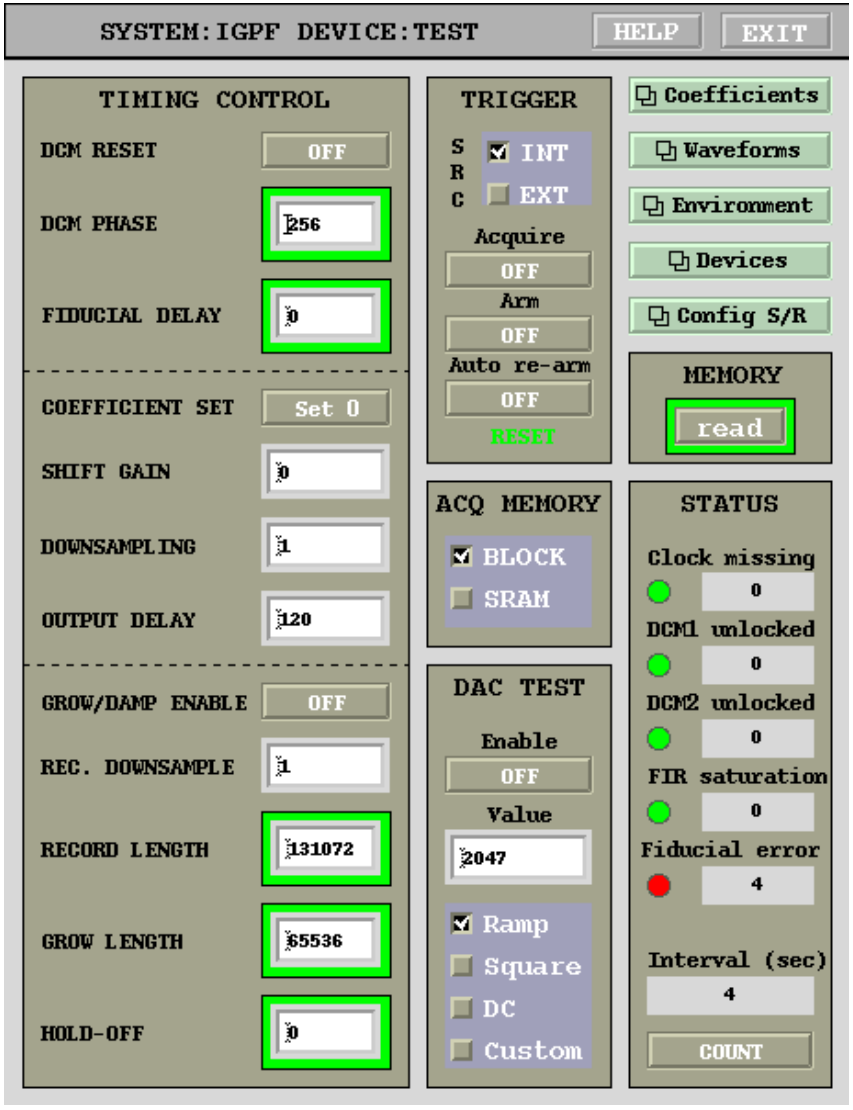
Top-Level Panel



- Top-level panel is kept very simple on purpose.
- One control: feedback on/off.
- Error summary:
  - Green - no errors;
  - Yellow - warning (saturation);
  - Red - error.

Control Panel



- Controls:
  - Timing;
  - Feedback;
  - Data acquisition;
- Status:
  - RF clock;
  - FPGA DCMs (digital clock managers);
  - Saturation;
  - Fiducial.

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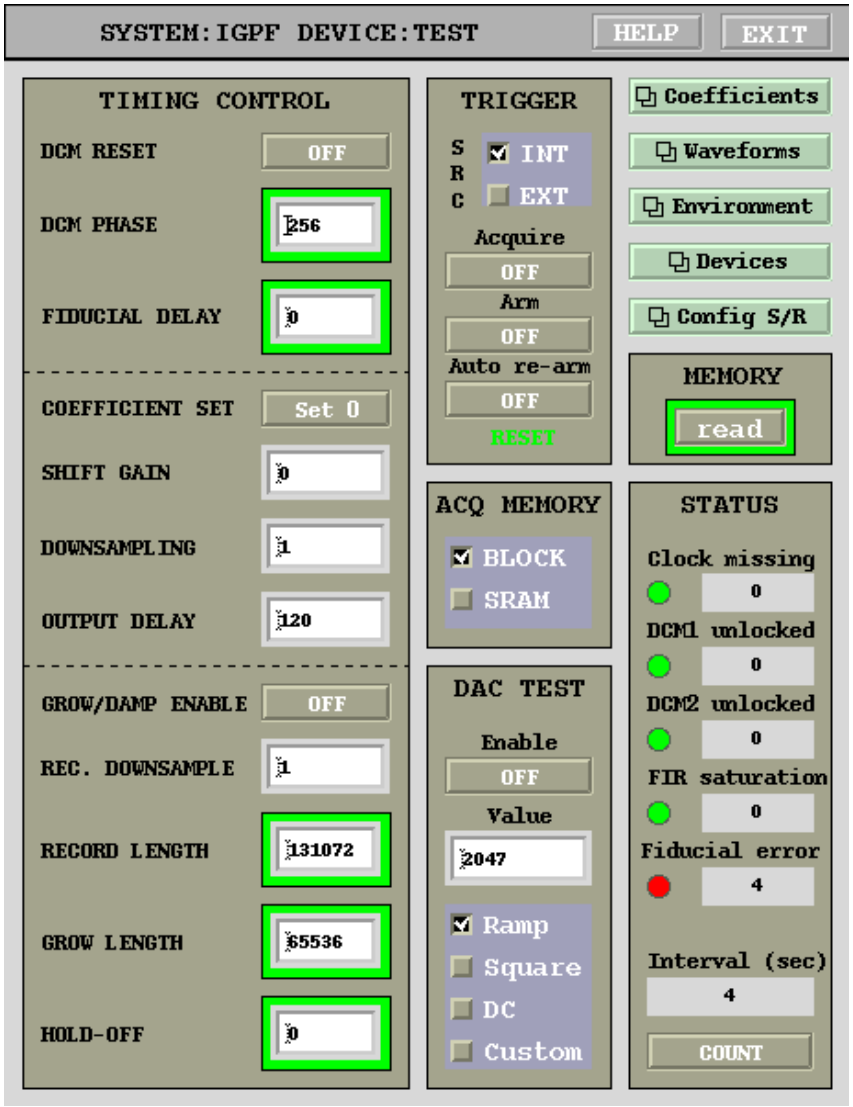
Control Panel



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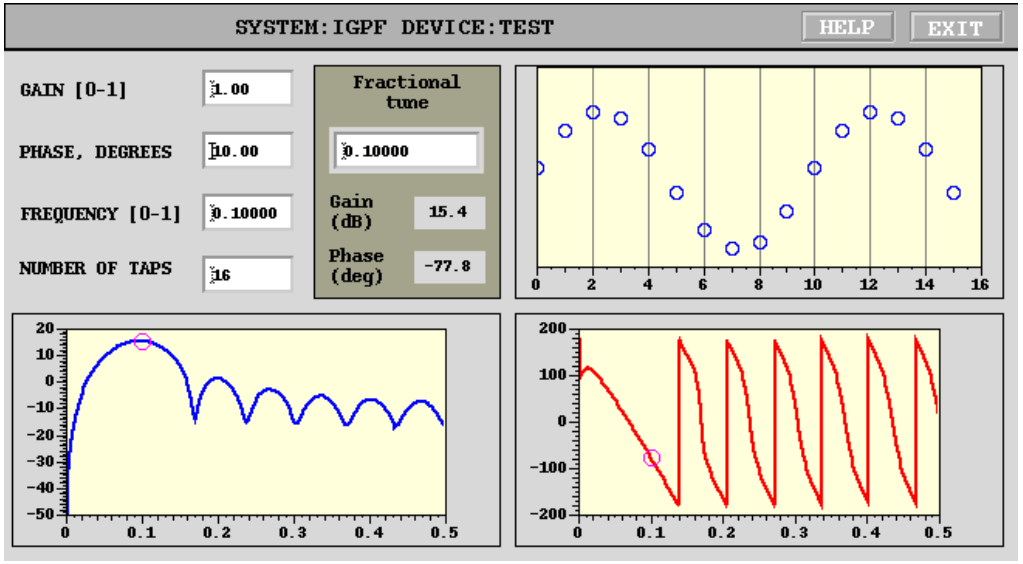
Coefficient Generator



- Integrated filter generator and analyzer.
- Computes frequency response.
- Gain and phase readout at the tune frequency.
- Filter tuning made easy.

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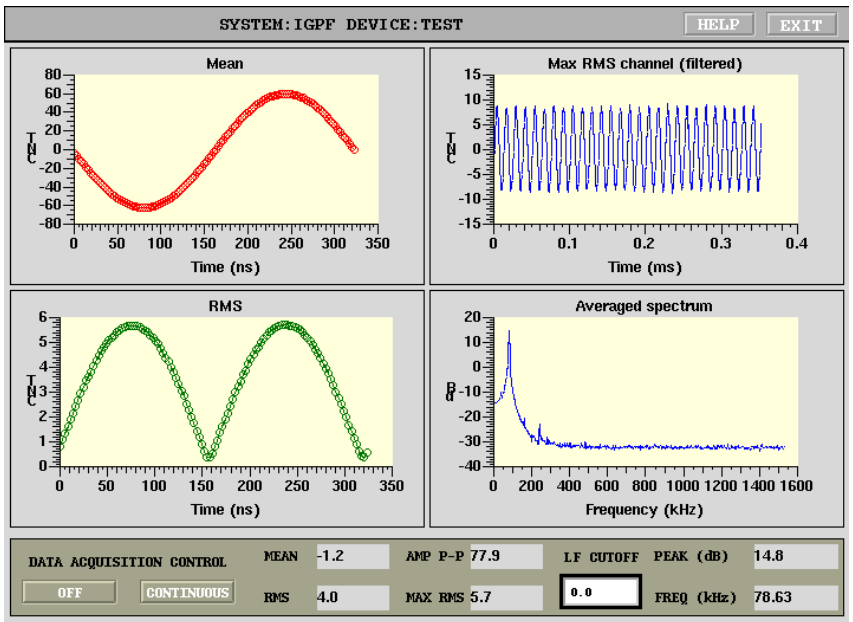
Waveform Display



- From bunch data matrix to vectors:
  - Bunch-by-bunch mean and RMS;
  - Time record of the most unstable bunch;
  - Averaged spectrum.
- From vectors to scalars for stripcharting:
  - Mean;
  - Overall and maximum RMS;
  - Peak-to-peak amplitude;
  - Spectral peak frequency and magnitude.

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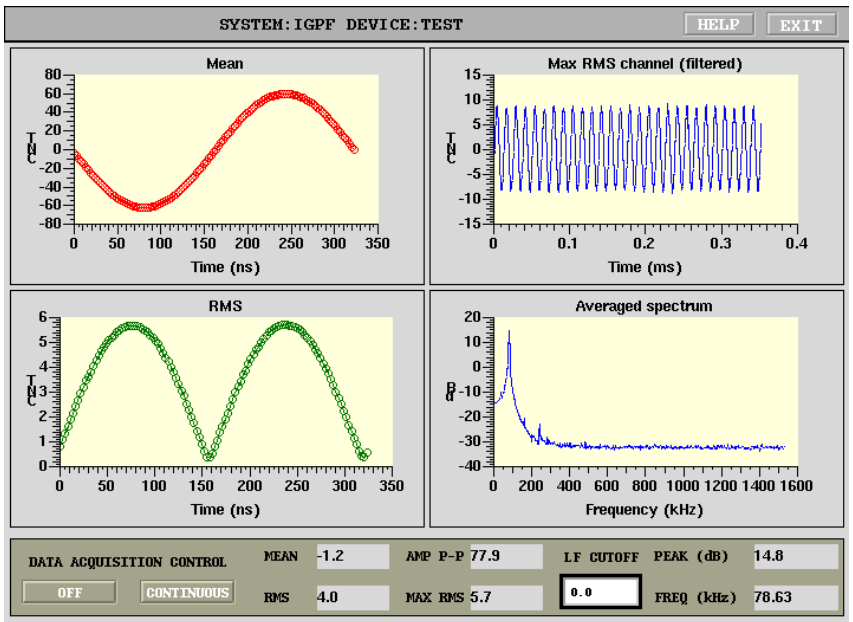

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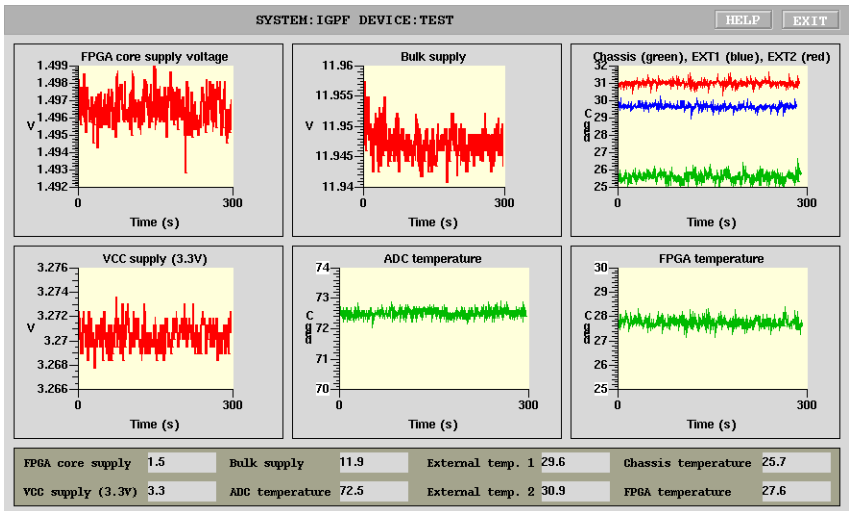
System Health



- Built-in monitoring of supply voltages and system temperatures.
- Voltages:
  - FPGA core;
  - Global 3.3 V;
  - Bulk supply (12 V).
- Temperatures:
  - ADC;
  - FPGA;
  - Board temperature;
  - ECL clock delays.

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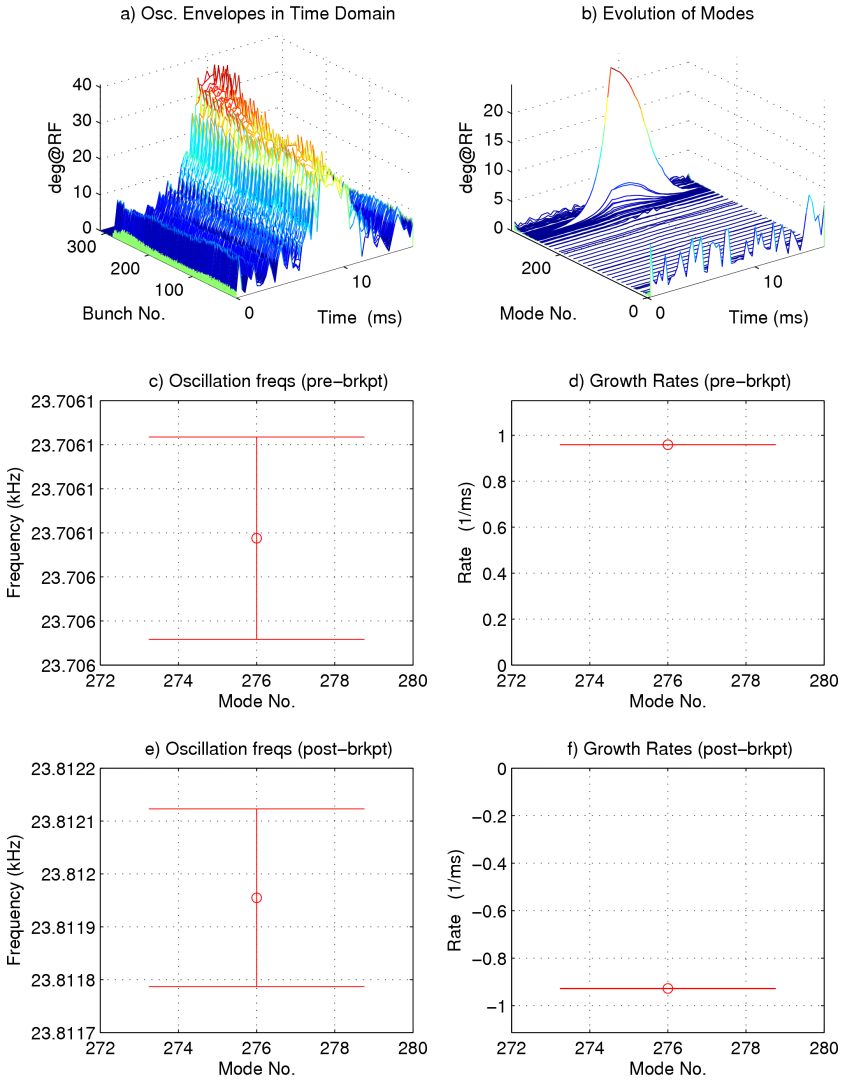
Photon Factory Longitudinal Grow/Damp



PF:jun3007/215154: Io= 200mA, Dsamp= 1, ShifGain= 0, Nbun= 312,
At Fs: G1= 0.10338, G2= 0.1723, Ph1= 65.515, Ph2= 65.5215, Brkpt= 20000, Calib= 1.

- A test as a longitudinal feedback.
- 500.1 MHz RF, 312 bunches.
- Growth and damping rates of 1 ms^{-1}.

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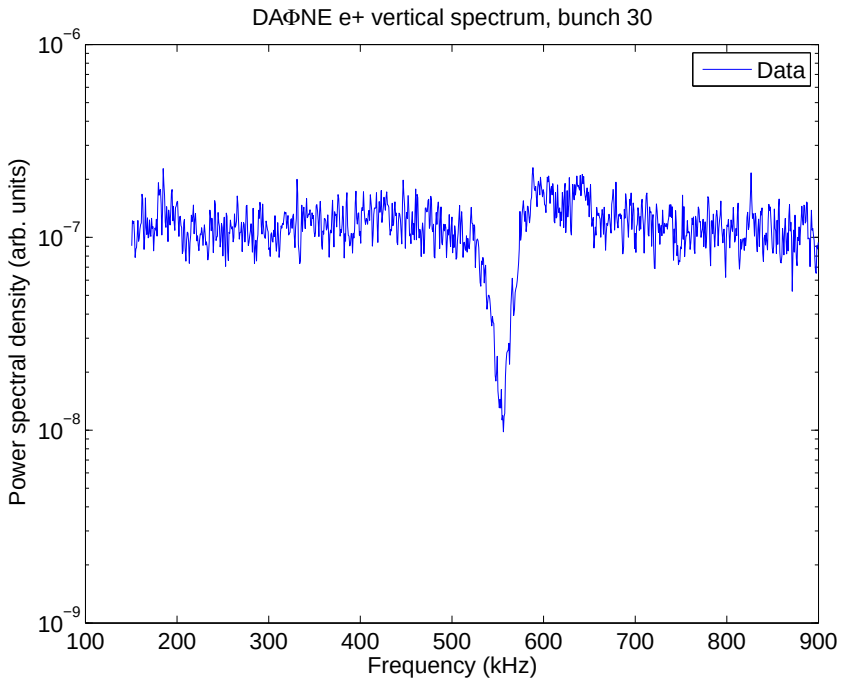
DAΦNE Steady-state Recording



- Vertical feedback in the positron ring.
- 368 MHz, 120 bunches.
- Bunch spectrum shows a notch due to feedback action.
- Fit the spectrum using the feedback/beam model.
- Extract bunch-by-bunch tunes.
- Completely parasitic!

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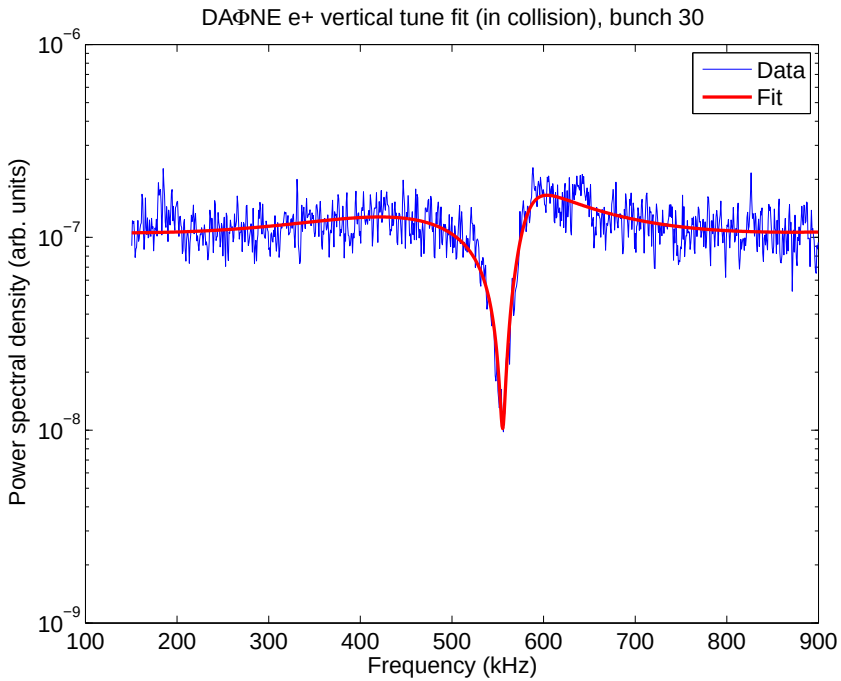

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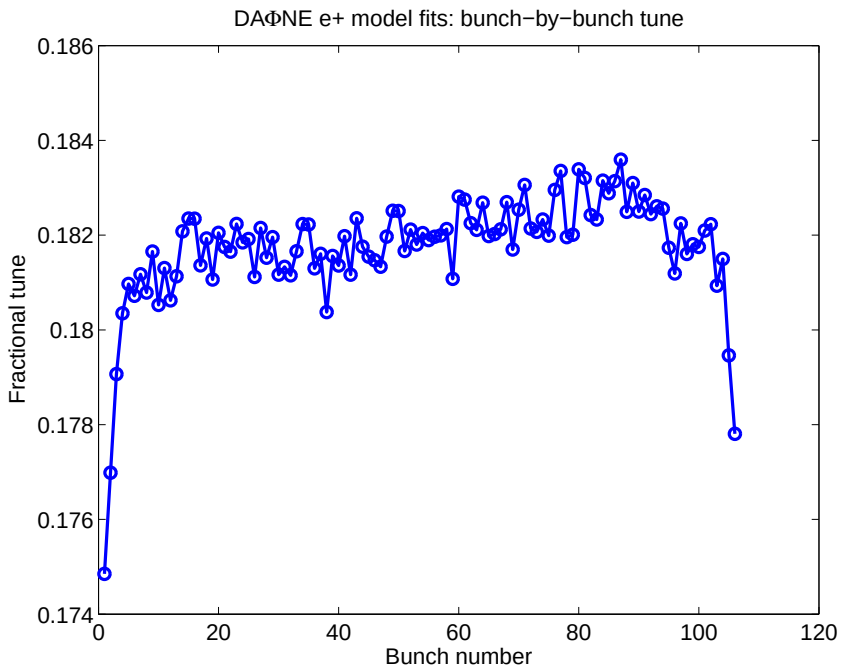

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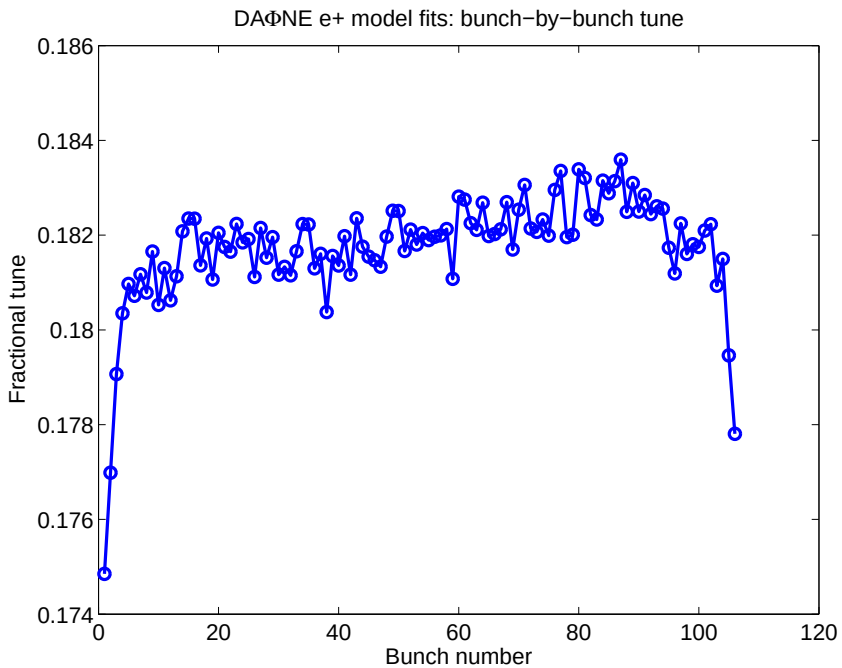

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- Integrated tools make for extremely simple system configuration and maintenance.
- Powerful diagnostics provide real-time stability and performance tracking.
- Direct interface to sophisticated Matlab analysis tools for machine studies.

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