Libera

Single Pass Solutions for Hadron and Electron Machines

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General Requirements for Instrumentation

- Capability of processing Various Beam Flavors
  - **Single bunch**
  - **Train of uniform bunches**
  - **Train of various bunch patterns**
  - **CW operation**
- Dynamic range
  - **Operation with high/low charges**
- Capability of building Fast Feedback / Feed Forward loops
- Integration into the Machine Control System

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Required Performances

- Electron Linear Machines
  - **Position resolution (Single Bunch) < 5 um**
- Hadron Linear Machines
  - **Phase resolution < 1 °**
  - **Position resolution < 100 µm**
- Temperature Stability
  - **Negligible position drifts at stable and variable temperature**

Parameter	LANSCE LINAC	pLINAC (GSI)	Spiral 2 LINAC
Bunch repetition rate	201.25 MHz	325.224 MHz	88.0505 MHz
Input power range	50 dB	60 dB	40 dB
Position resolution	100 um	100 um	±10/±100 um
Phase resolution	0.25 deg	1 deg	±0.5 deg

Libera Single Pass H - Libera Brilliance Single Pass

FERMI@Elettra, IHEP, NSRL, NSRRC, KEK Linac, ESRF, BESSY, MAX LAB, SPRING 8,TARLA, CANADIAN LIGHTSOURCE, BNL ERL, BNL NSLS 1, AUSTRALIAN SYNCHROTRON, LANL, FRIB, GSI FAIR P-Linac …

- Stripline and Button Pickups

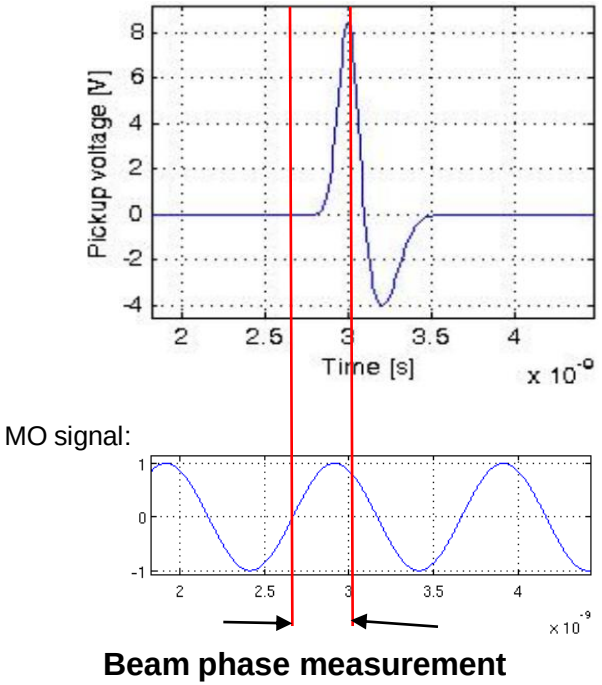
- Linear Hadron Machines
  - **Beam position monitor**
  - **Beam phase measurement**
  - **Beam charge measurement**

- Field of FEL Machines
  - **Beam position monitor in LINACs**
  - **Beam charge measurement**
- Synchrotron Light Sources
  - **Injection efficiency measurements**
  - **Beam position monitor applications in LINACs and transfer lines**
- ERL Machines
  - **Beam position and charge monitor**

Libera Single Pass H

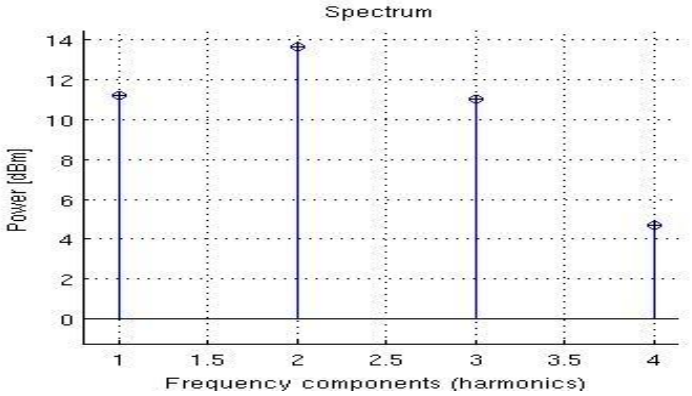
- Intel Dual Core
- RF Acquisition Modules
- Fast Acquisition Module
- Timing Module
- Optional Slots

Beam Phase Measurements Basics



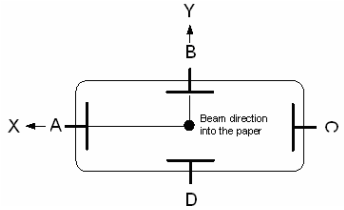
Beam phase measurement

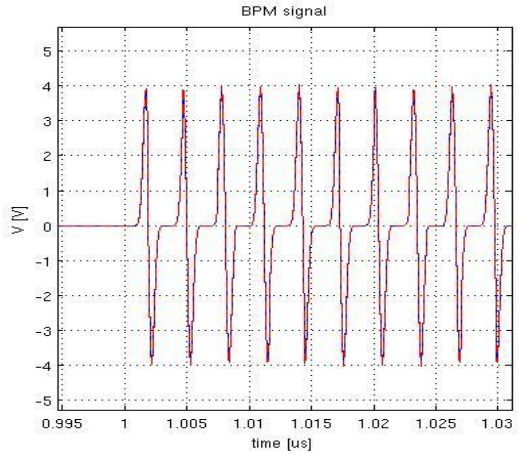
- The periodical nature of the input signal concentrates the power at few frequency components.
- The phase relation between the bunch signal and the Master Oscillator signal is used for the time of arrival measurement.

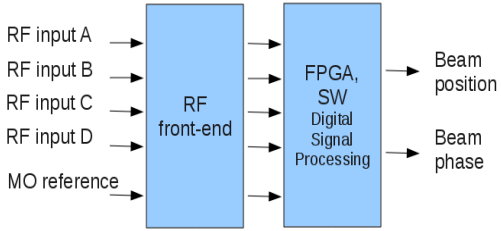


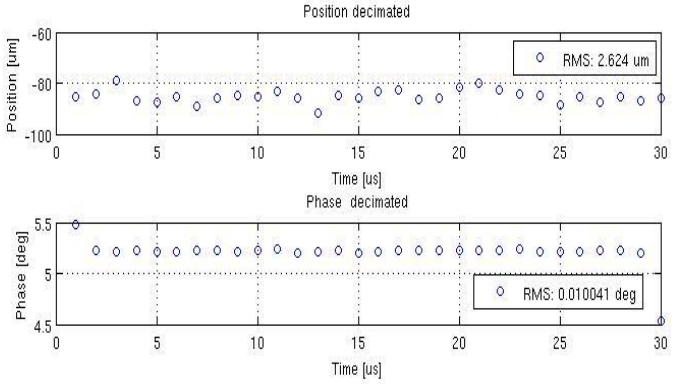
How does it work?

- Train of pulses and reference signal
- The beam position and phase stream is provided at a decimated rate. (e.g. 1 MHz)









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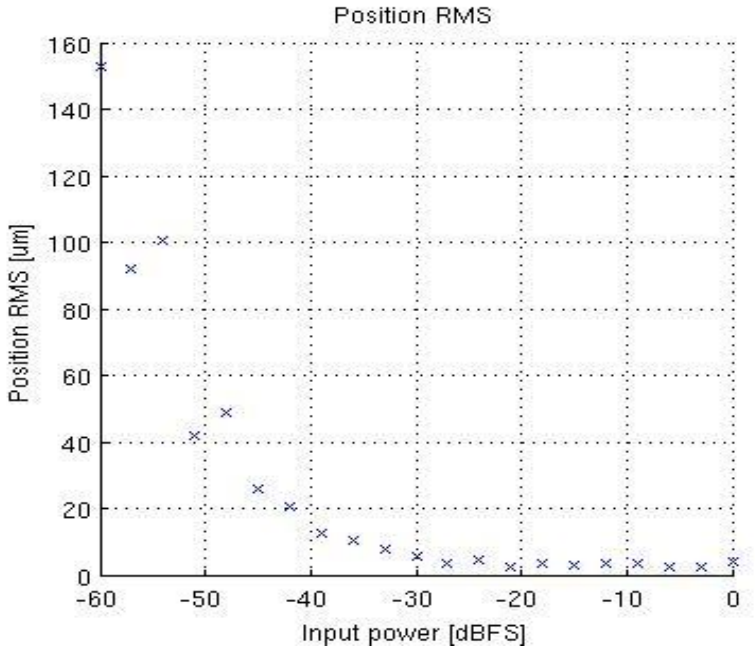
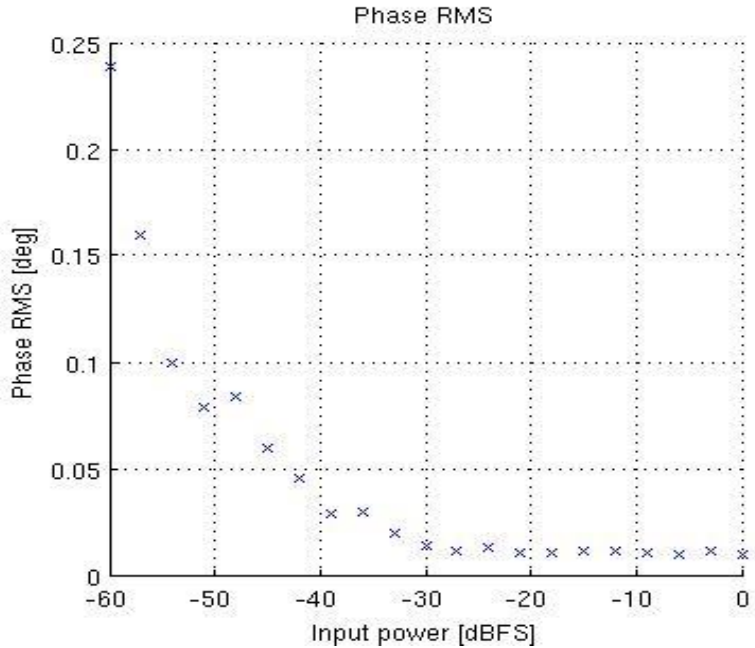
Laboratory Measurements

Measured position and phase uncertainty in the range of 60 dB at 650 MHz (the GSI pLINAC example).

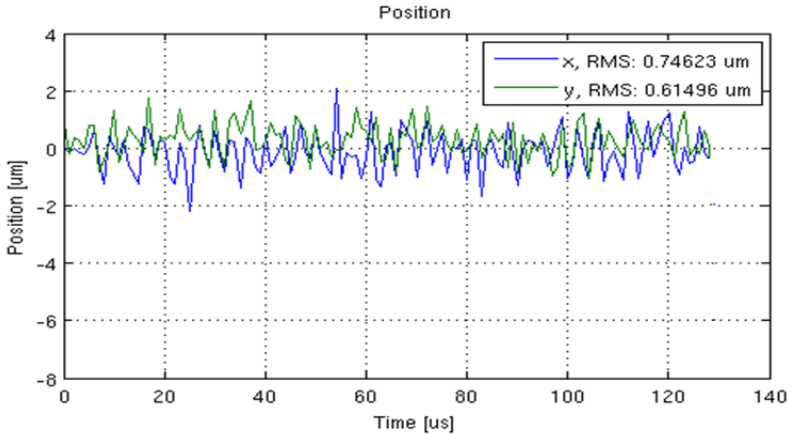
(0 dBFS corresponds to ±4V input.)

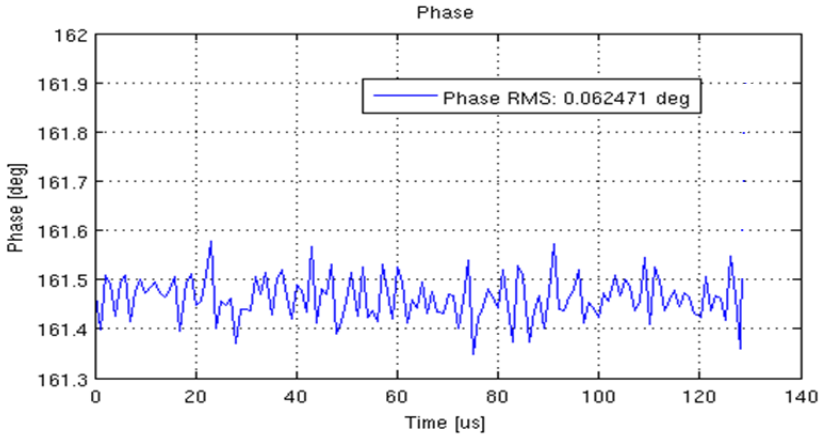




Measurements at CIEMAT

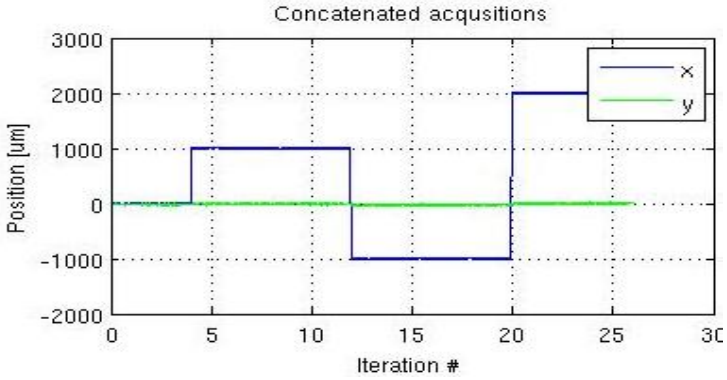
- 175 MHz bunch repetition rate
- Measurement of the second frequency harmonic
- Input signal -40 dBm
- 120 µs long acquisition, 1MHz data rate,



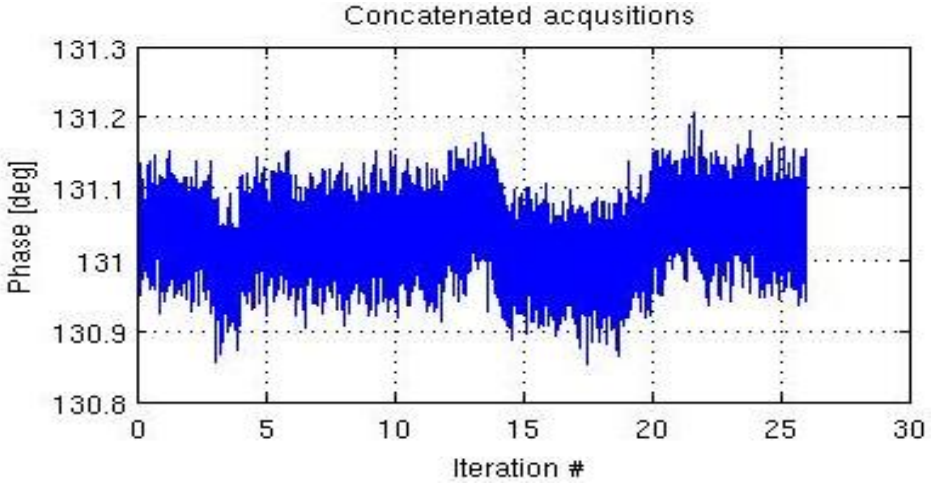


Phase / Position Measurements

- 175 MHz bunch repetition rate, wire movements +1, -1 +2 mm



- Negligible impact on phase measurement



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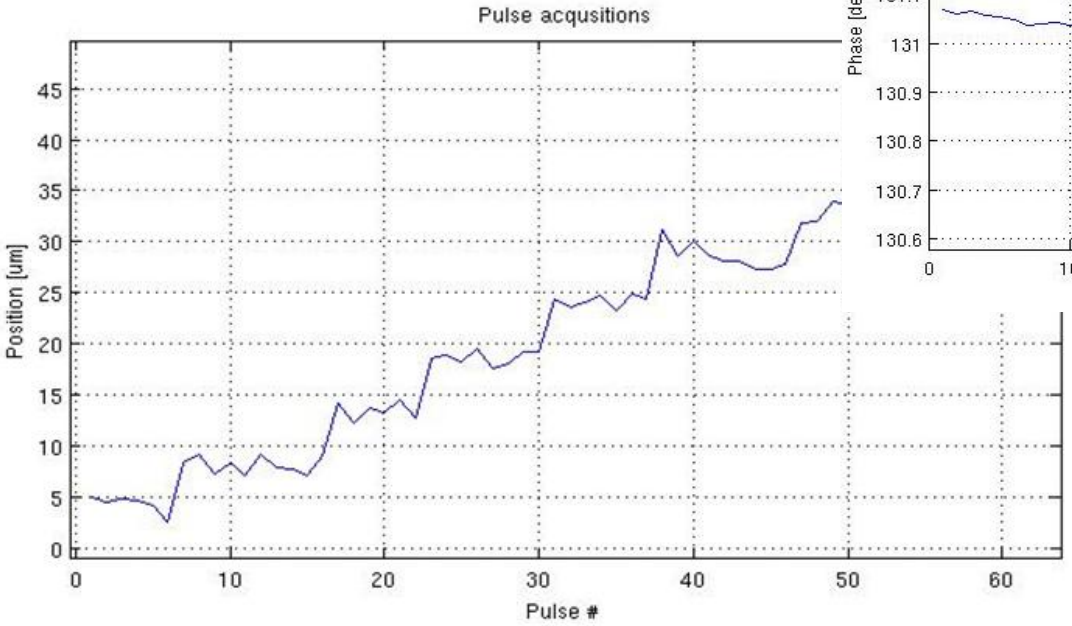
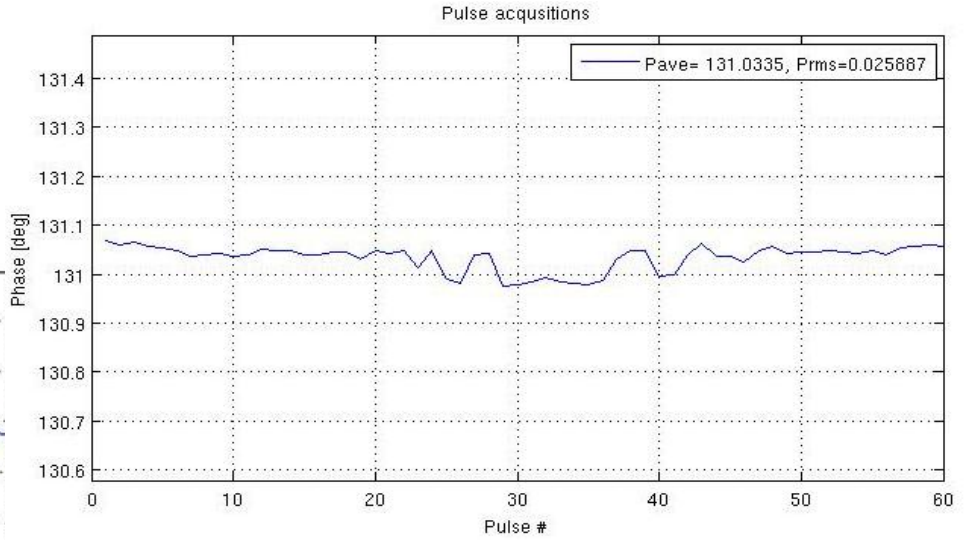
Phase / Position Shifting

- Wire movements 5 µm
- Phase shifting test





No. of phase delay bullets	Measurement 1 [deg]	Measurement 2 [deg]
0	131.089	131.097
1	122.190	122.201
2	114.350	114.380
1	122.540	122.620
0	130.410	130.710

Libera Brilliance Single Pass

- Built on the broadly used Libera HW Architecture A
- Experience and support from the Libera Community

- **All-In-One**
  - Analog Signal Processing
  - Digitalization
  - Digital Signal Processing
  - Fast GbE Interface

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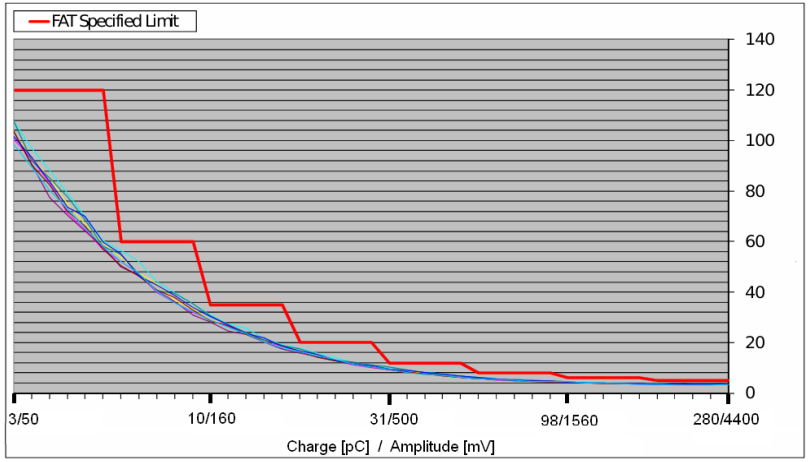

Performance Specifications (Single Bunch)

Estim.Charge [pC]	Measured Peak [mV]	Libera Level Setting	ADC Counts (± 1000)	Required position RMS (µm)	Typical position RMS (µm)
280	4400	-10	15000	5	3
98	1560	-19	15000	6	4
31	500	-29	15000	12	9
10	160	-31	7000	35	33

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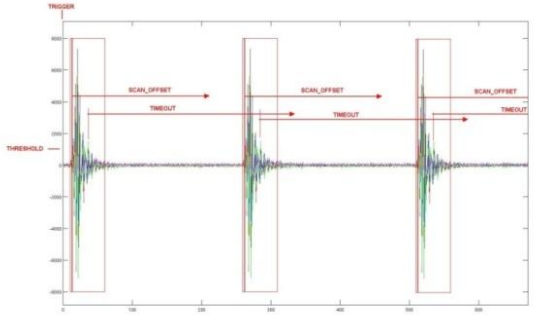
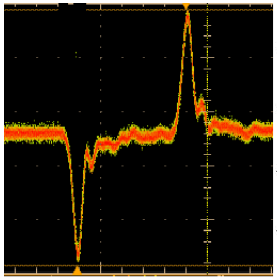
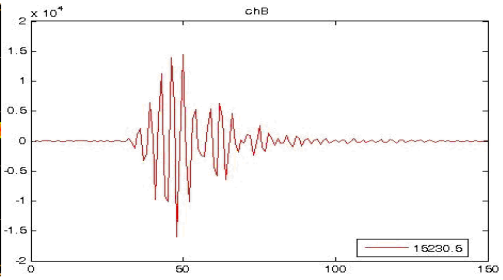
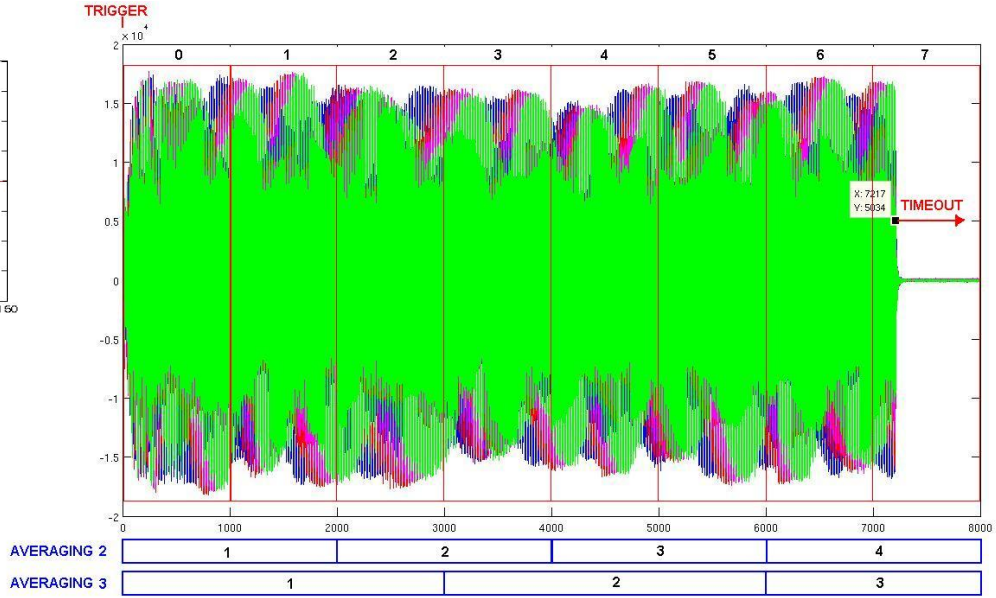


How does it work?

- Time Domain Data Processing



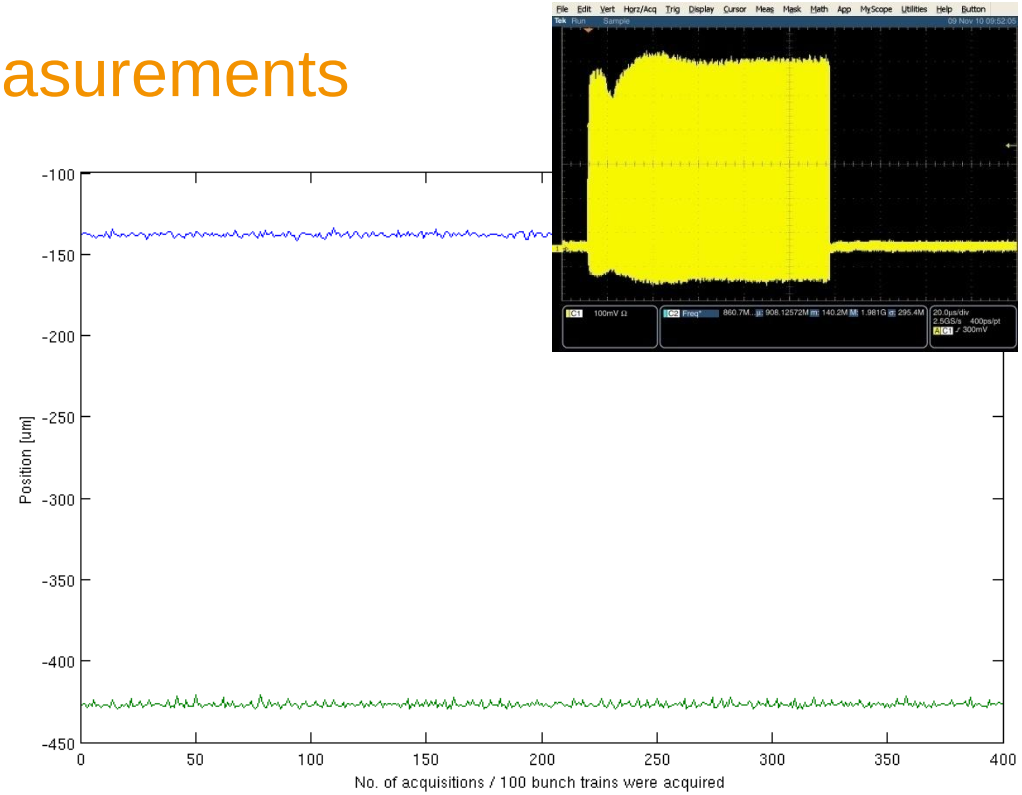




Bunch Train Position Measurements

- BNL ERL, TARLA…

- Single bunch, Bunch train, CW
- Input signal
  - Macropulse frequency: 10 Hz
  - Micropulse frequency: 9.38 MHz
  - Macropulse length: 1000 bunches
- Position resolution
  - Xrms = 1.23 µm
  - Yrms = 1.66 µm



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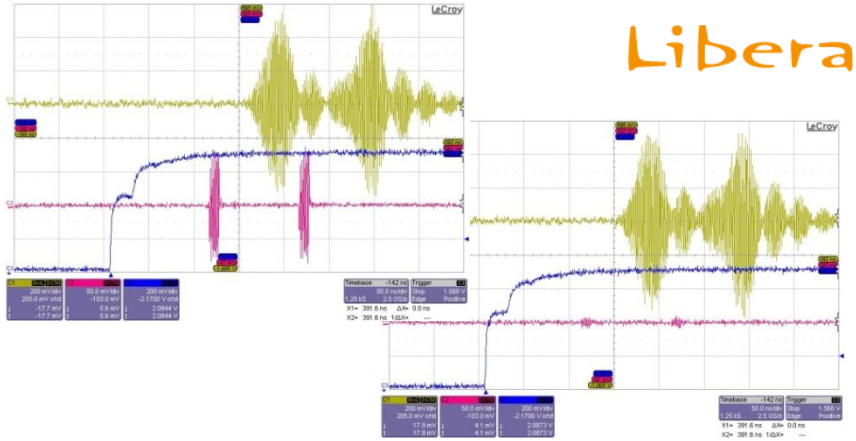
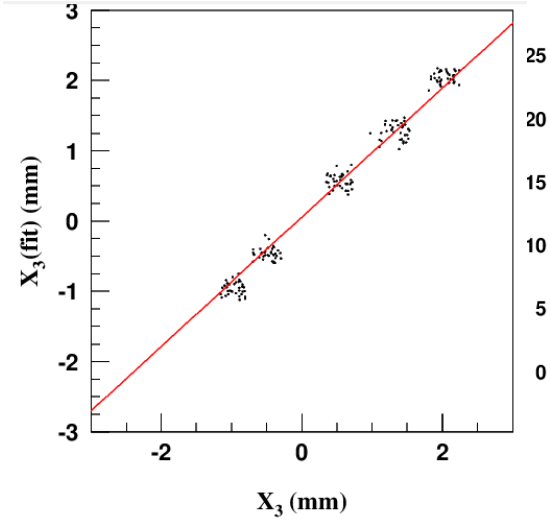
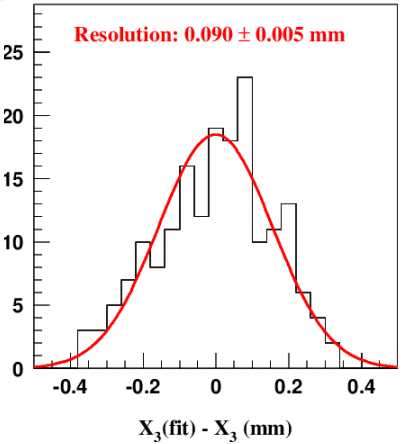
Special Beam Flavors

- KEK Linac…
- Input signal
  - Repetition frequency: 50 Hz
  - Possible beam combinations
    - 1 bunch
    - 2 bunch (96 ns spaced)
    - 0.1 nC
    - 1 nC
    - 10 nC
- EPICS controlled gain
- Single bunch position resolution: ~ 10 µm
- On beam measurements: ~ 90 µm







Instrumentation Technologies

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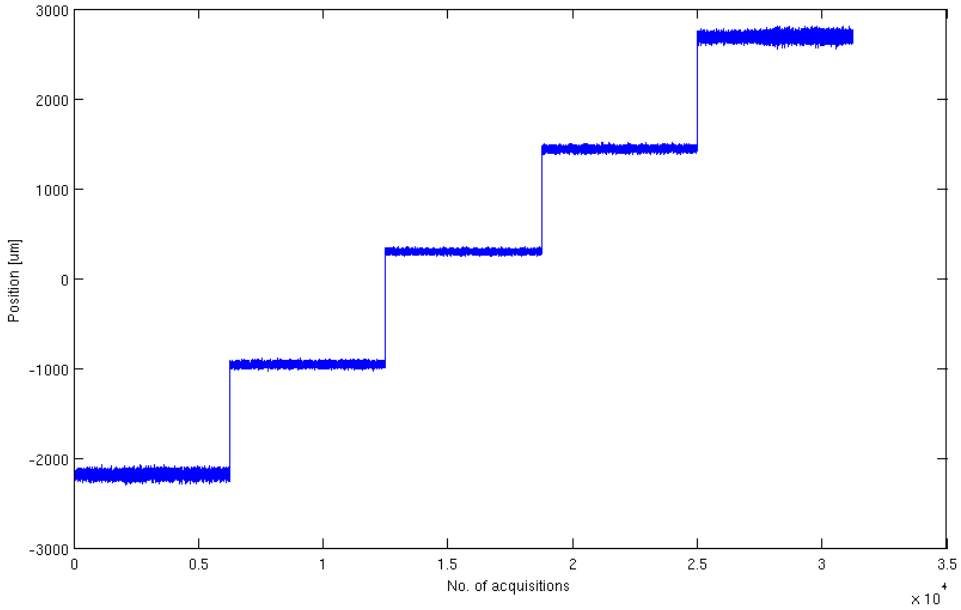
High-frequency Bunch Signals

- IHEP for KIPT Linac, LNLS transfer lines..

- External DWC module
- Input signal
  - Macropulse frequency: 625 Hz
  - Micropulse frequency: 2856 MHz
  - Macropulse length: 3μs
- Position resolution: ~ 3 μm



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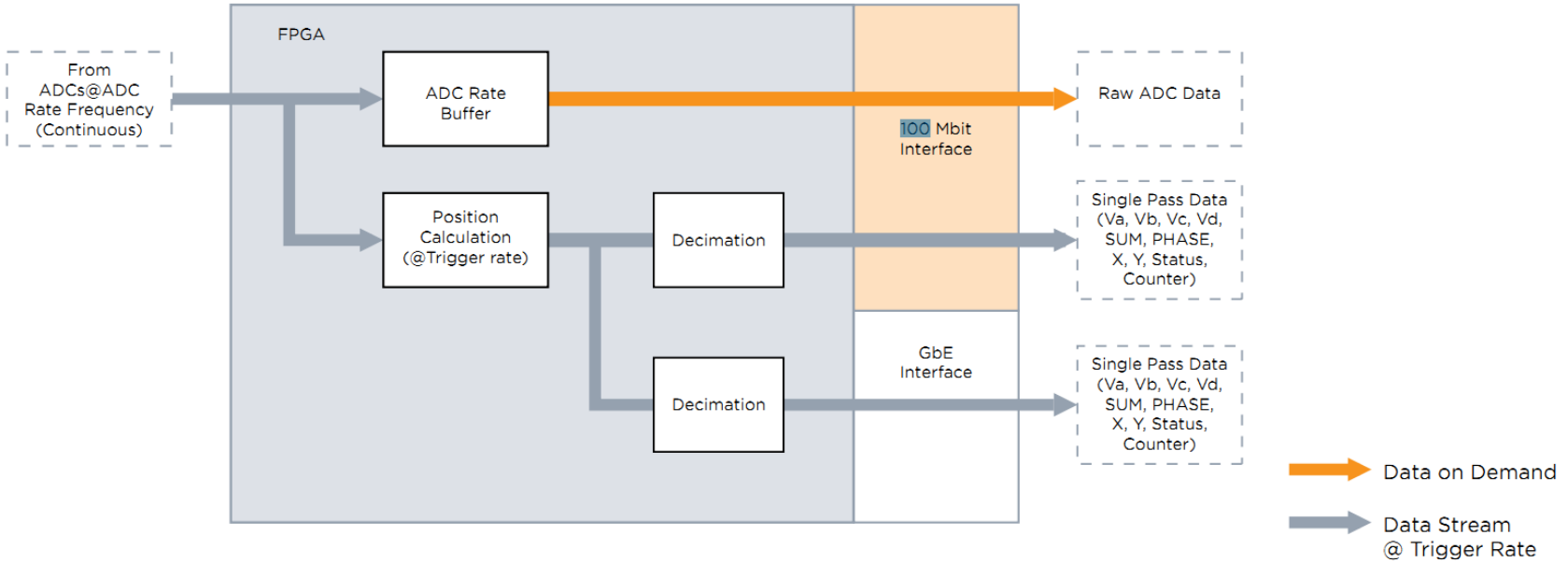
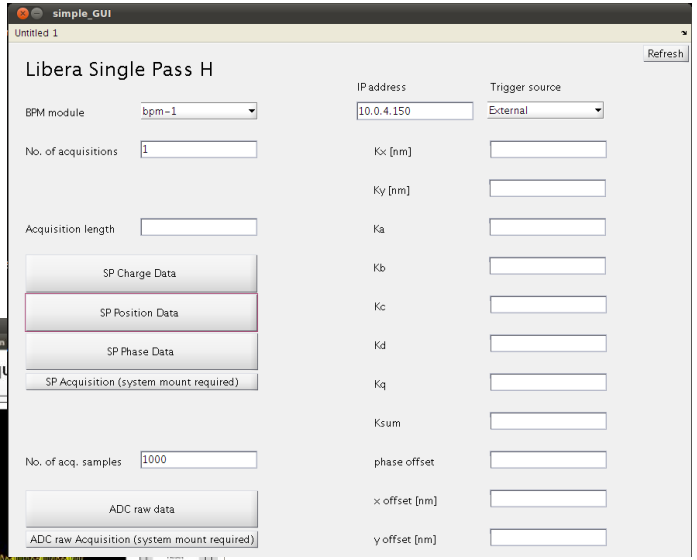
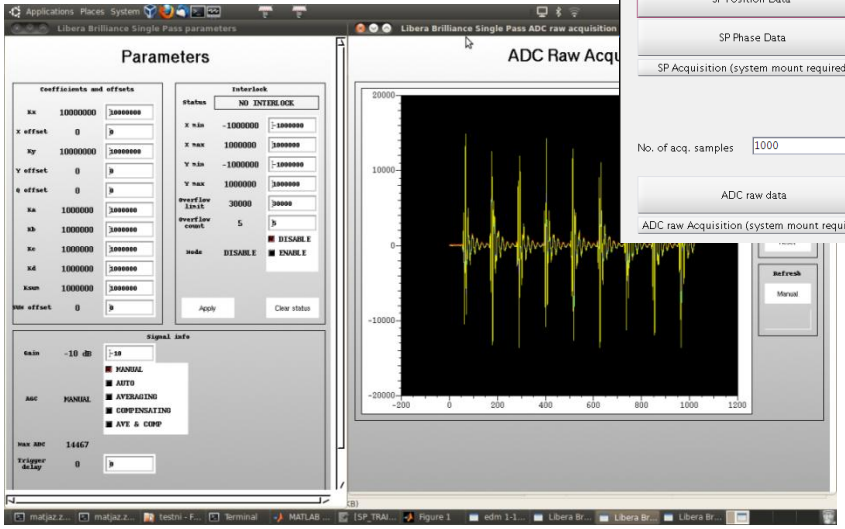
Default Single Pass Data Paths



Control System Integration

- Integration options through CSPI or LIBERA BASE
  - EPICS driver
  - Generic server
  - TANGO driver
  - Matlab
  - Lab VIEW
  - Custom





Working On

- Single Pass solutions for higher bunching frequencies
  - High frequency FELs
  - Higher repetition rates (kHz)
  - ERL machines (1,3 – 1,5 GHz)

- Different event receiving modules