Libera

Libera Single Pass E

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- **Operation**
- **Features**
- **Data Paths**
- **CS integration**
- **Performances**
- **Conclusion**

Why Libera Single Pass E ?

To meet the special requirements of KEK Linac

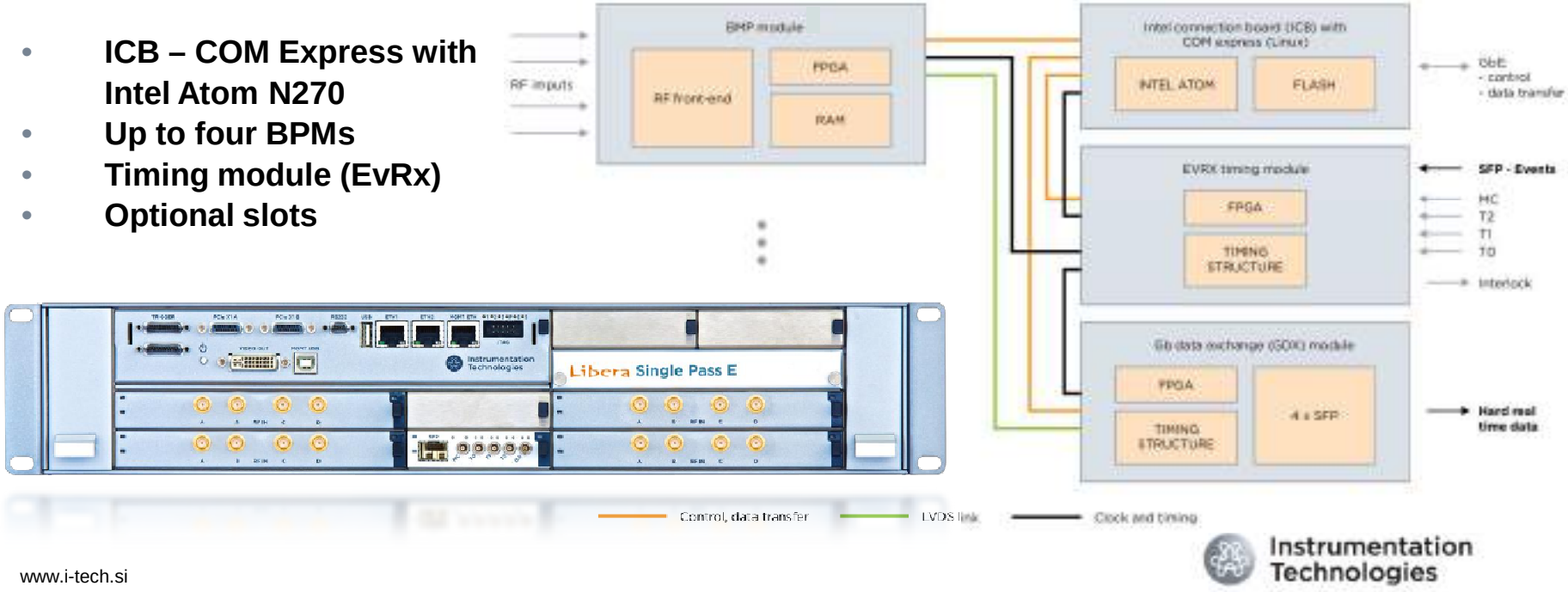
- **Better position measurements performances**
- **Individual processing of two 96 ns spaced bunches**
- **Linear and 3rd order Polynomial position calculation**
- **Capability of receiving externally generated events**
  - EvRx event receiver (MRF event generator)
  - EPICS real time event receiver

To meet the requirements of latest linear machines

- **Requirements for better performances**
- **Latest technology**
- **More flexibility**
- **More processing power**

Libera Single Pass E hardware architecture

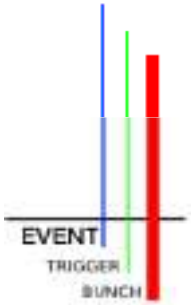
- **ICB – COM Express with Intel Atom N270**
- **Up to four BPMs**
- **Timing module (EvRx)**
- **Optional slots**

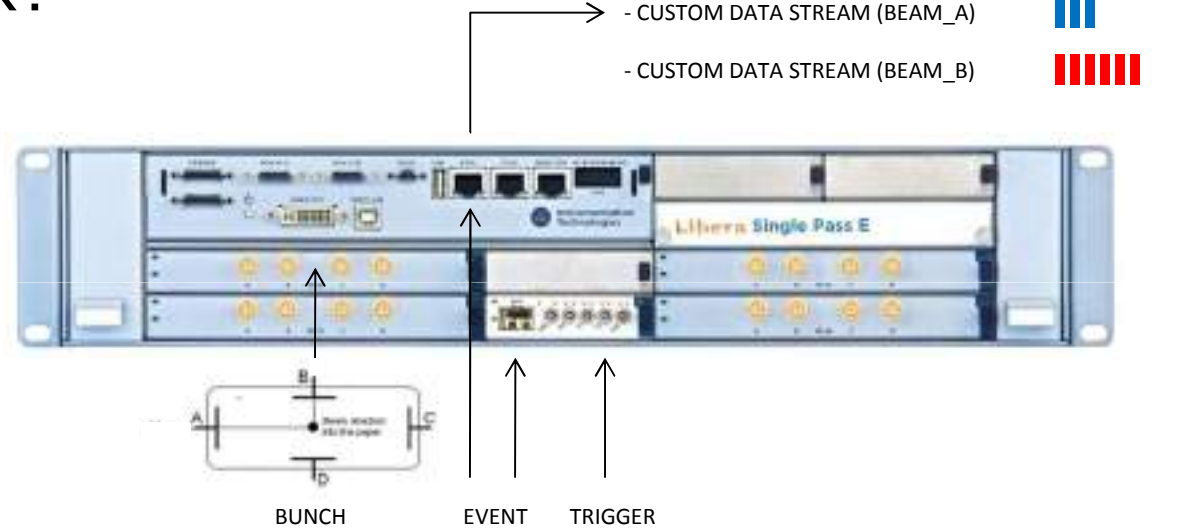


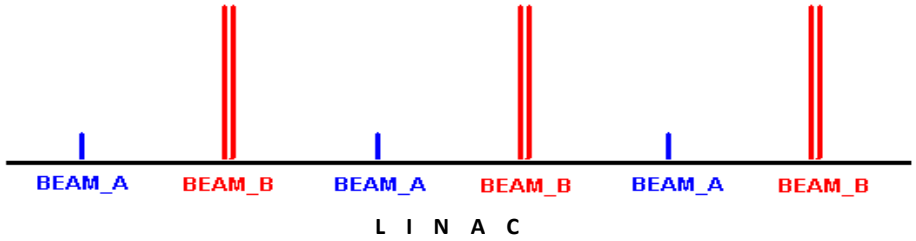
Instrumentation Technologies

How does it work?

- **Signal sequence**



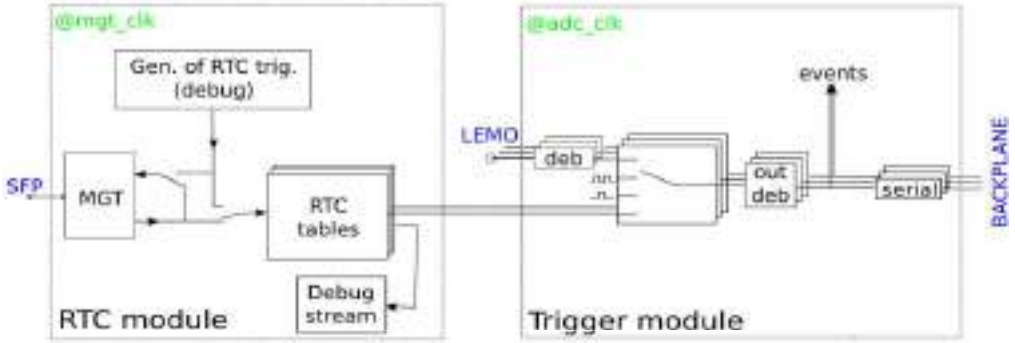




Instrumentation Technologies

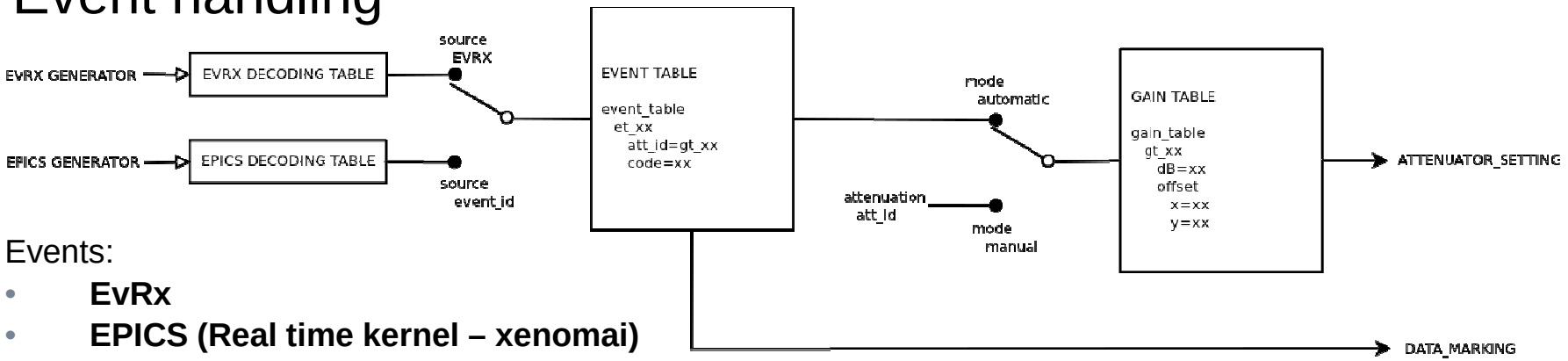
EvRx – Timing module

- **Clock generator – up to 160 MHz**
- **KEK case**
  - **Event frequency 114 MHz**
  - **10 different event codes**
- **Decoding tables**
- **External HW trigger source**
- **Interlock output**



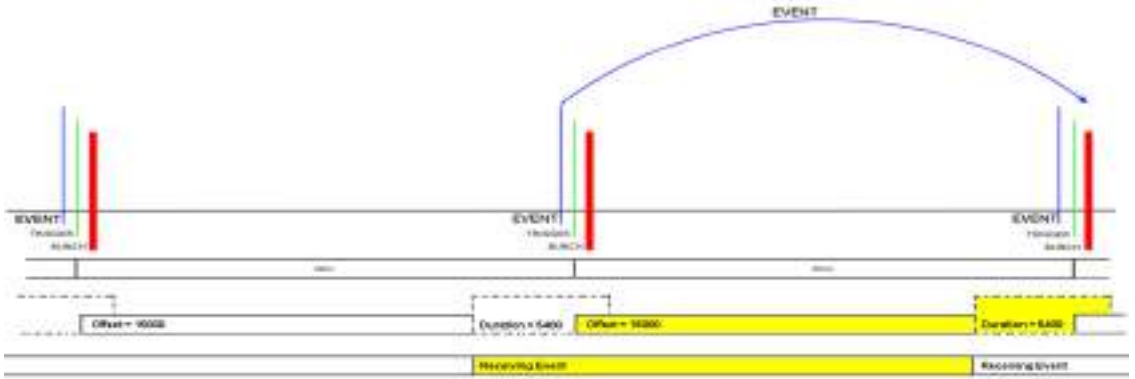
Instrumentation Technologies

Event handling



Events:

- **EvRx**
- **EPICS (Real time kernel – xenomai)**



Instrumentation Technologies

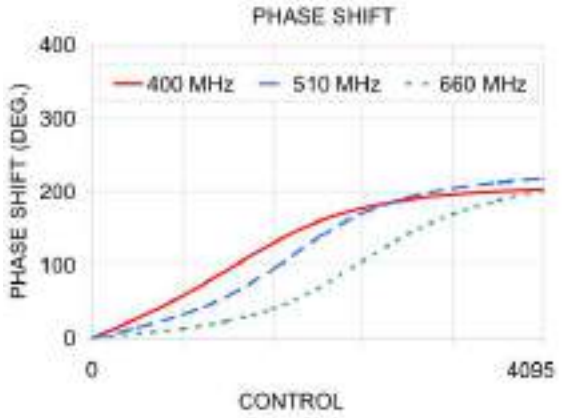
BPM Acquisition module

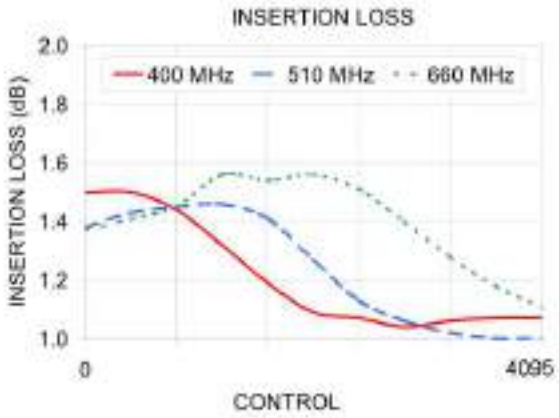
- **Virtex 5 SX**
- **Up to 160 MHz sampling rate**
- **4 equal low noise RF chain**
  - **31 dB variable attenuation**
  - **Internal analog phase calibration**
- **Customer specific**
  - **Filtering**
  - **Sampling frequency**
  - **Dynamic range**

Phase alignment

Good results can be achieved only with phase aligned signals, up to 70% better position resolution

- **Manually - software controlled (12 bit DAC) phase shifter for each RF chain**
  - High stability
  - 0° ~ 200° (Approximately 30 cm cable mismatch)

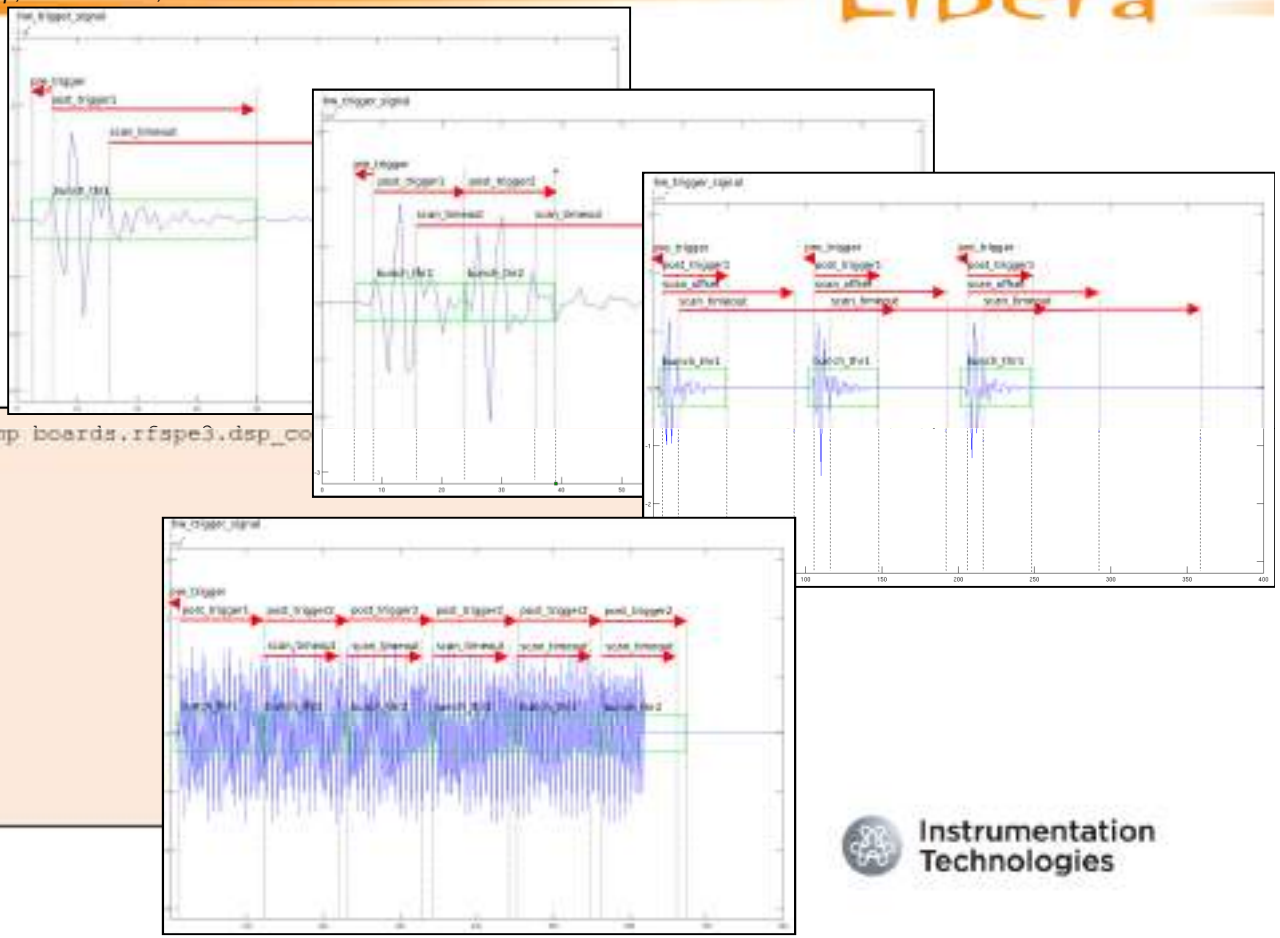




Instrumentation Technologies

Data processing

- **Single bunch to continuous-wave**



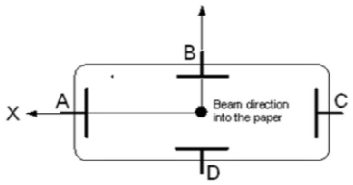
```
root@ubuntu-libera:~# libera-ireg dump boards.rfspe3.dsp_co
enable=true
num_of_bunches=2
bunch_thr1=3000
bunch_thr2=3000
pre_trigger=3
post_trigger1=12
post_trigger2=17
scan_offset=0
scan_timeout=1000
data_averaging=1
pickup_orientation=orthogonal
calculation_method=linear
insert_zeros=false
reset_counters
```


Instrumentation Technologies

Position calculation

The options for each plane coefficients Kx and Ky are the following:
i(x) j(x) = 00, 01, 02, 03, 10, 11, 12, 13, 20, 21, 22, 23, 30, 31, 32, 33

- **Orthogonal pickup positioning**
  - **Linear calculation**
  - **Polynomial calculation** →



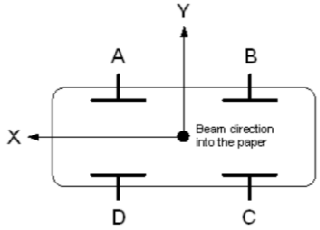
$$X = X_{OFFSET} + \sum_{ij=0}^{3} K_{Xij} \left(\frac{(V_A' - V_C')}{(V_A' + V_C')} \right)^i * \left(\frac{(V_B' - V_D')}{(V_B' + V_D')} \right)^j$$

$$Y = Y_{OFFSET} + \sum_{ij=0}^{3} K_{Yii} \left(\frac{(V_A' - V_C')}{(V_A' + V_C')} \right)^i * \left(\frac{(V_B' - V_D')}{(V_B' + V_D')} \right)^j$$

- **Diagonal pickup positioning**
  - **Linear calculation** →
  - **Polynomial calculation**

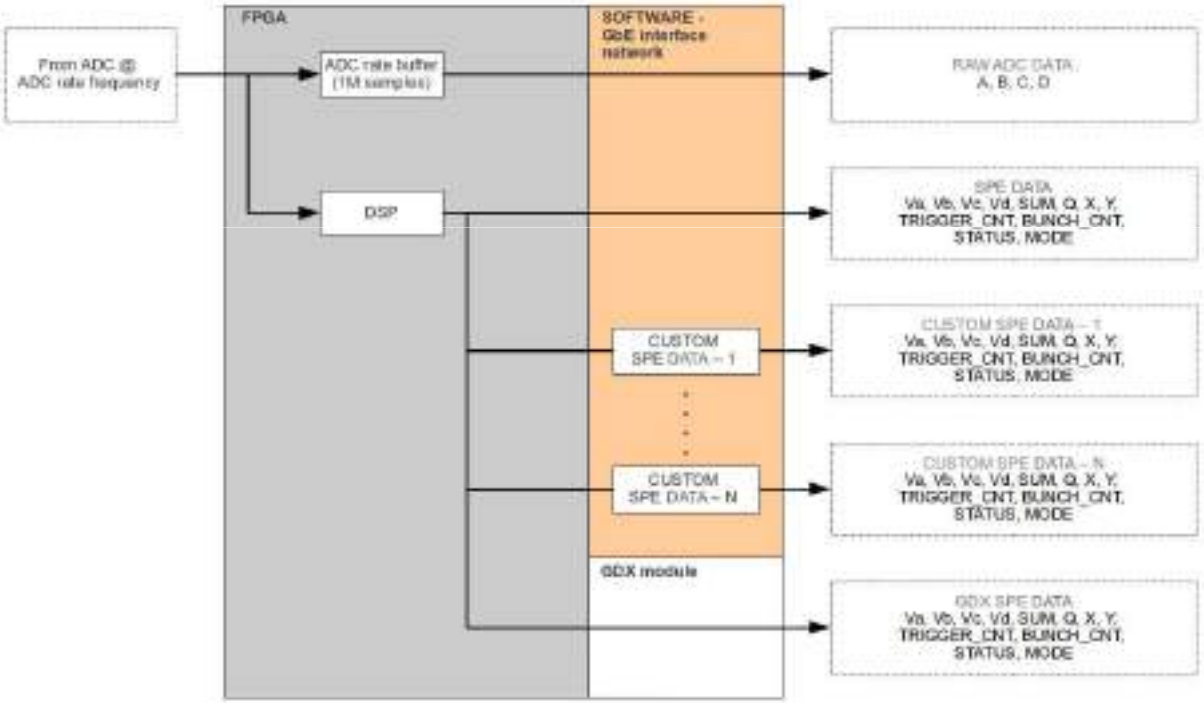
$$X = K_X \frac{((V_A' + V_D') - (V_B' + V_C'))}{(V_A' + V_B' + V_C' + V_D')} - X_{OFFSET}$$

$$Y = K_Y \frac{((V_A' + V_B') - (V_C' + V_D'))}{(V_A' + V_B' + V_C' + V_D')} - Y_{OFFSET}$$



Instrumentation Technologies

Data Paths

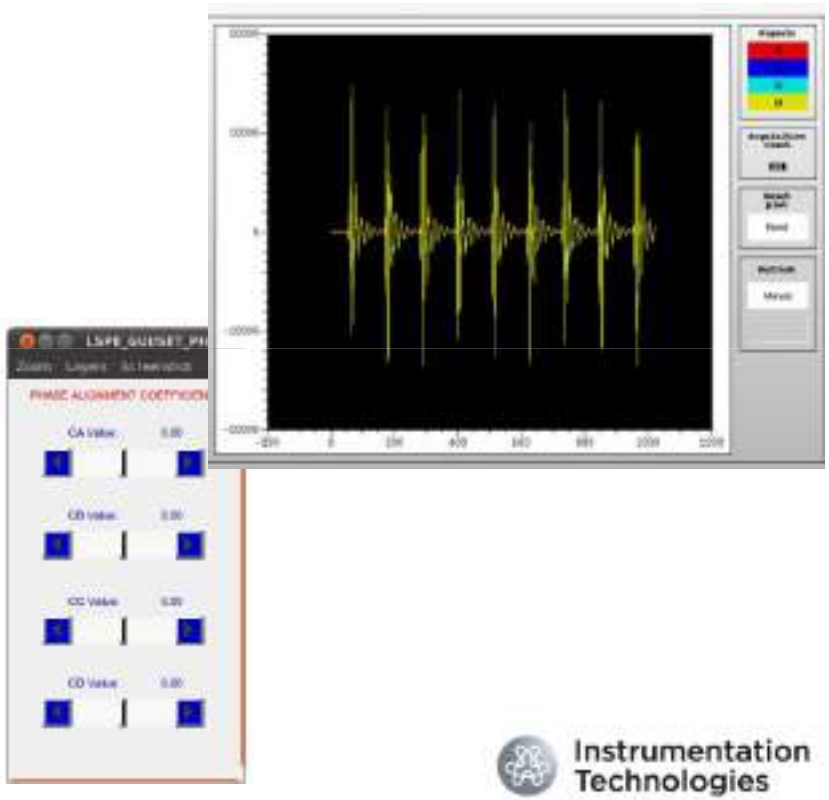


Instrumentation Technologies

Control System Integration

Integration options through Libera BASE

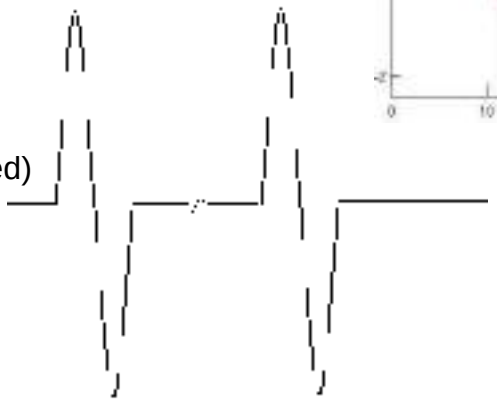
- **EPICS driver**
  - CSS
  - EDM
- **Libera IREG**
  - Matlab
  - Lab VIEW
- **Tango driver (development)**

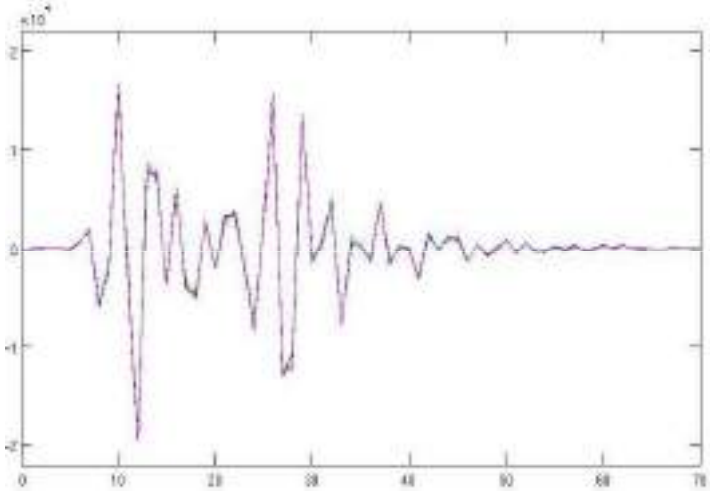


Libera Single Pass E - KEK version

Individual processing and auto detection of two consecutive bunches. Charge detection over event generator.

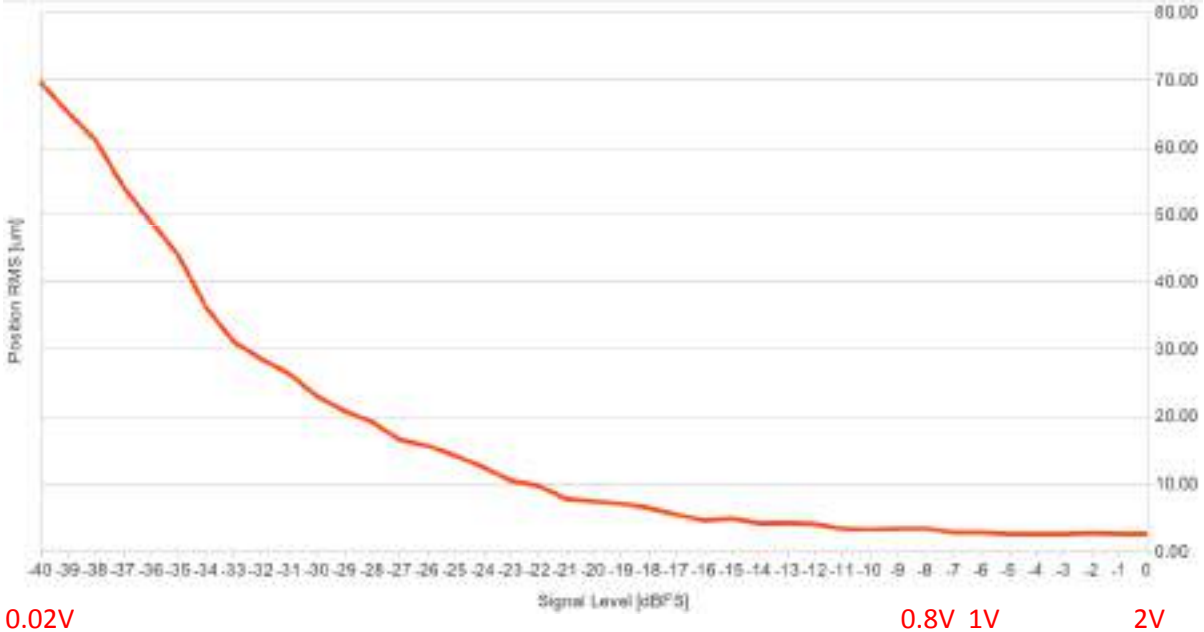
- **RF board**
  - Sampling frequency: 160 MHz
  - Filtering: 522 MHz
- **Input Signal**
  - Repetition frequency: 50 Hz
  - Possible beam combinations
    - Single bunch
    - Double bunch (96 ns spaced)
    - Charge 0.1 nC
    - Charge 4 nC
    - Charge 5 nC
    - Charge 10 nC





Instrumentation Technologies

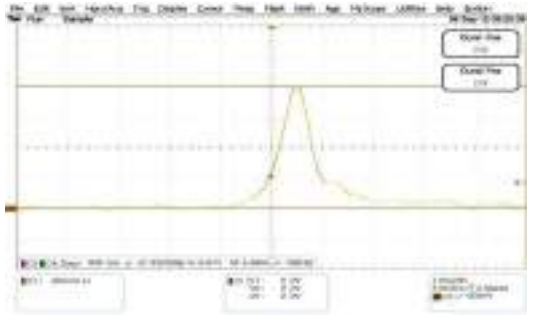
Performances – KEK version



0.02V 0.8V 1V 2V

Input signal = 2V peak

- **Xrms, Yrms = ~ 2.5 µm**

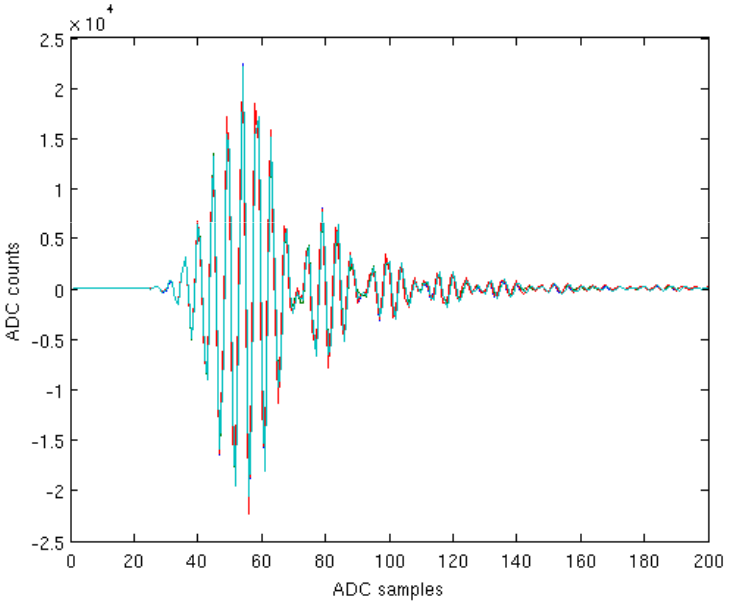


Instrumentation Technologies

Libera Single Pass E – Standard single bunch version

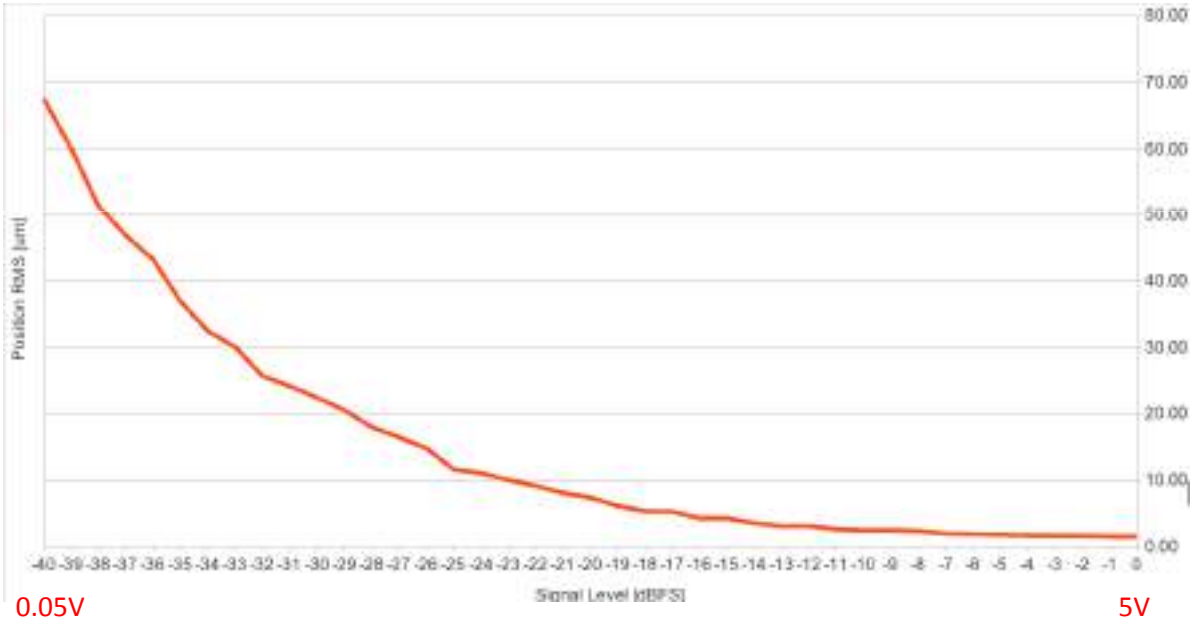
Individual processing and auto detection of single bunch signals

- **RF board**
  - Sampling frequency: 155 MHz
  - Filtering: 500 MHz
- **Input Signal**
  - Repetition frequency: up to 1 kHz
  - 40 dB dynamic range



Instrumentation Technologies

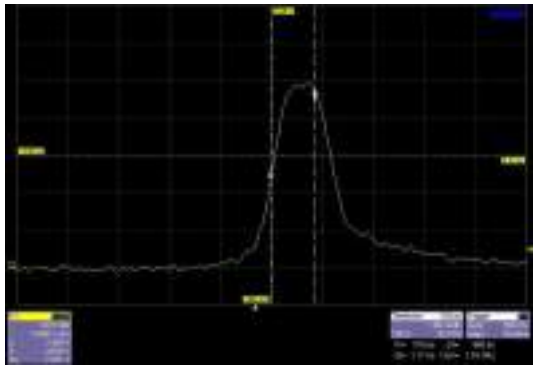
Performances – Standard version



0.05V 5V

Input signal = 5V peak

- **Xrms, Yrms = < 1.5 µm**

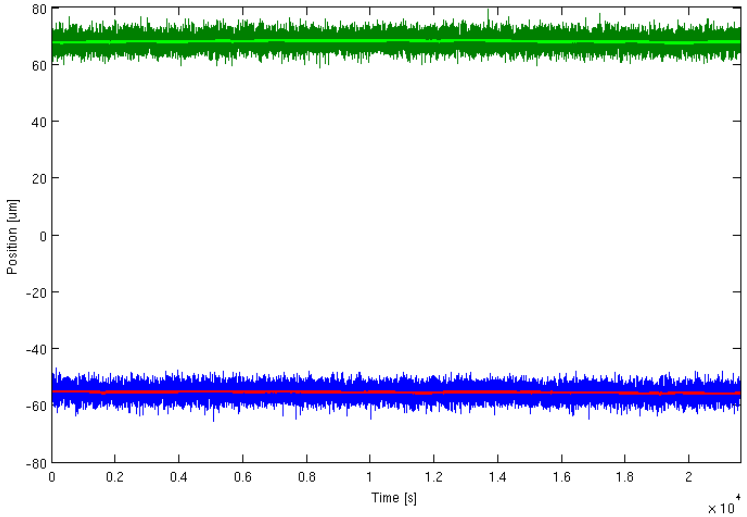


Instrumentation Technologies

Temperature Stability

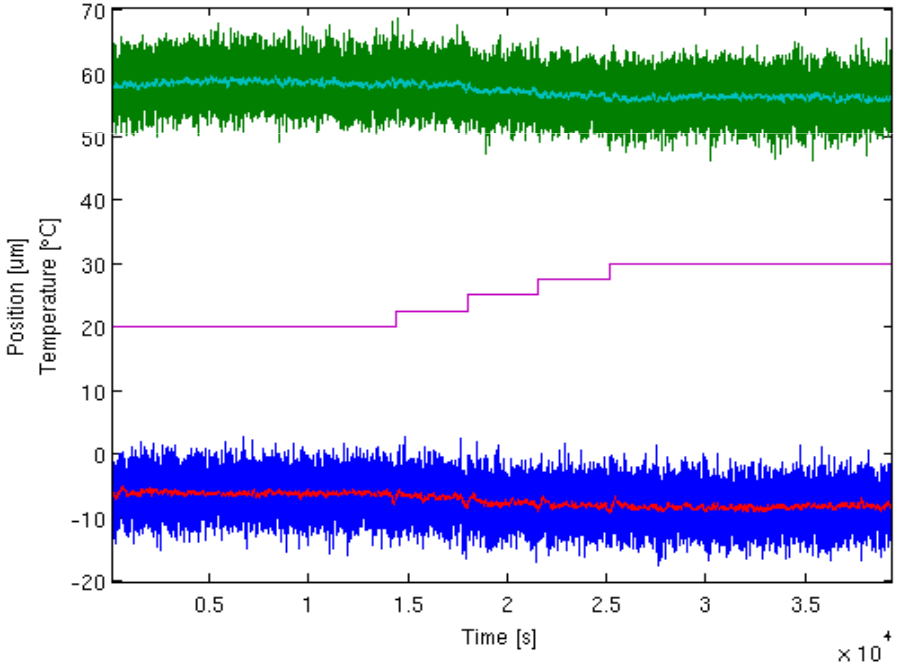
Long-term test

- **Temperature 25℃**
- **Duration 6h**
- **Negligible position drift**



Long-term test

- **Temperature change 20℃ - 30℃**
- **Duration 11h**
- **X position drift = 2.5 um**
- **Y position drift = 2.9 um**



What is next?

Next developments, guidelines, challenges …

- **Control system integration**
  - Tango Driver
- **High frequency FELs**
  - Down conversion
- **ERL machines**
  - High frequency machines (1.3 GHz, 1.5 GHz …)
  - Measurement of accelerated – decelerated beam