

New Libera Hadron

Matjaz Znidarcic, Libera Workshop, May 2015, Solkan

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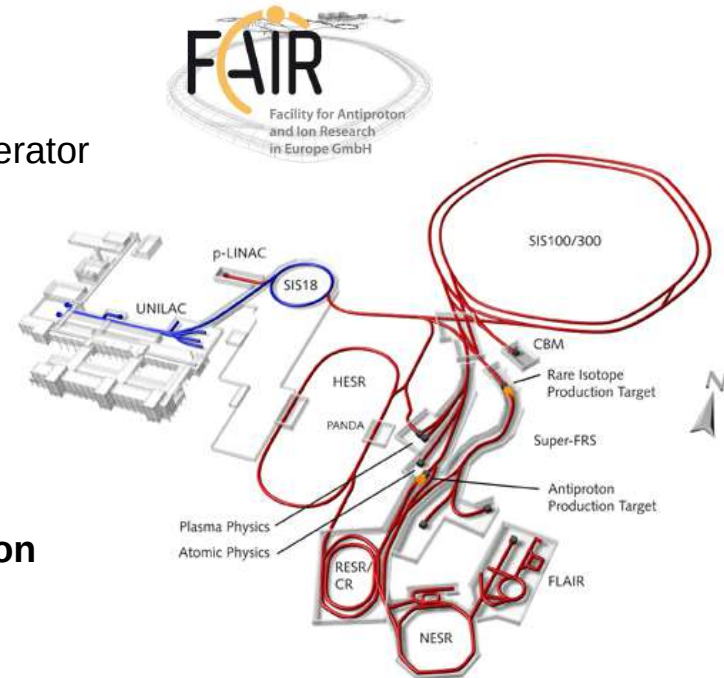
Requirements

Meet the special requirements of FAIR project – SIS 100 accelerator

- **Long acceleration cycles**
- **Low charges**
- **Huge signal dynamics**

Meet the requirements of latest hadron circular machines

- **High bunch repetition rates**
- **Short acceleration cycles with high frequency variation**



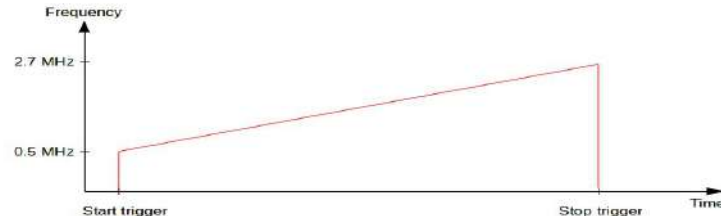
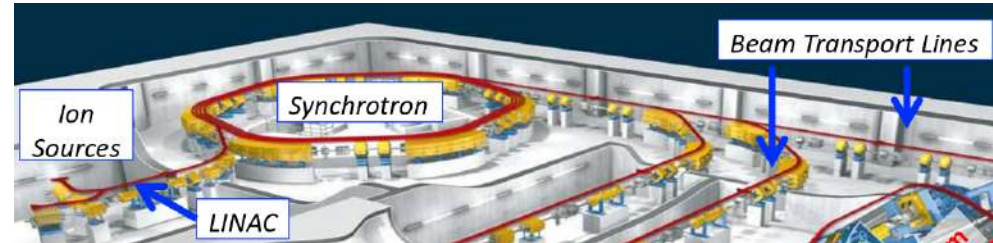
Typical operation cycle

Injection - acceleration - extraction

- **Bunch repetition rate: kHz to few MHz**
- **Bunch length: several ns (after injection) down to some ns (at extraction)**
- **Cycle duration: up to several seconds**

Libera Hadron

- **Start event**
- **Raw ADC data storing**
- **Bunch-by-bunch detection, position calculation and data storing**
- **Stop event**

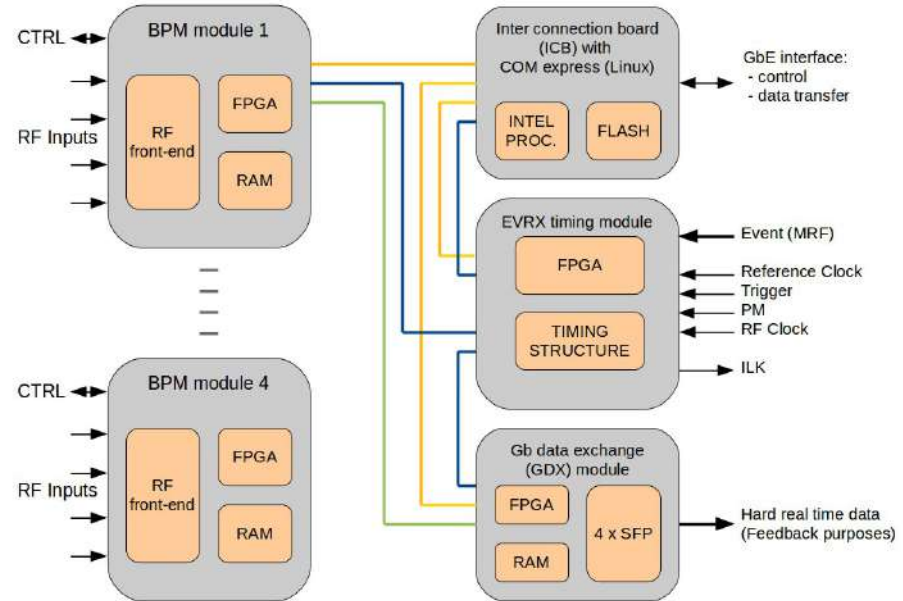
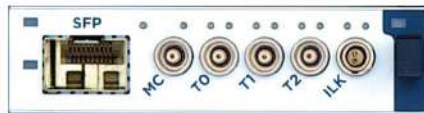


Libera Hadron

- ICB – COM Express with Intel processor
- Up to four BPMs
- Timing module (EVRX)
- GDX module
- Optional slots



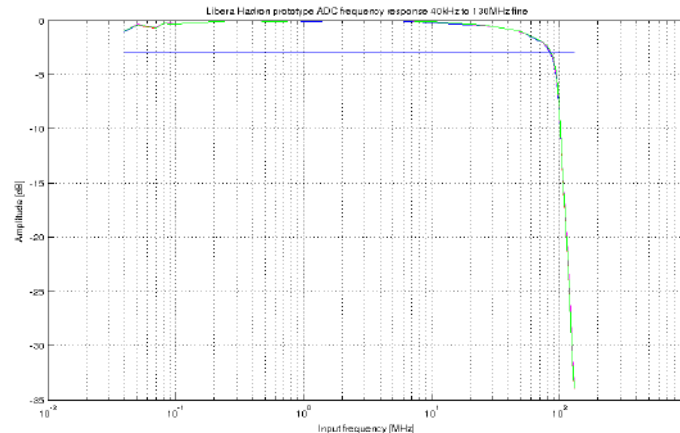
www.i-tech.si



- Control, data transfer
- LVDS link
- Clock and timing

BPM Acquisition module

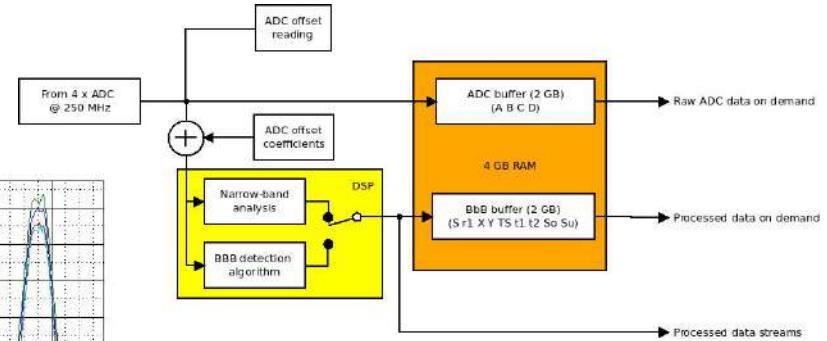
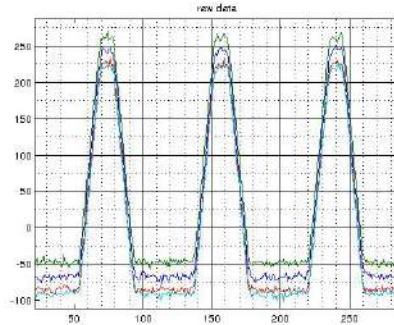
- Virtex 6 SX
- 250 MHz sampling rate
- 16 bit ADC converter from Analog Devices
- 4 equal low noise RF chain
- Customer specific
 - Filtering
 - Dynamic range
 - Gain
- GSI FAIR filter requirements
 - 40 kHz – 55 MHz (flat response)
 - -20 dB @ 125 MHz



Data processing

Start event – Postmortem event or Stop event

- **ADC offset correction**
- **Bunch-by-bunch detection algorithm**
- **Narrow-band analysis**
- **Data storing - streaming**



Data	Type/Amount
Broadband data on demand (ADC data @ 250 MHz sampling rate)	~ 270 M samples (> 1 second of data), 4 channels
Bunch-by-bunch data on demand	~ 200 M samples (> 66 seconds of data @ 1 MHz bunch repetition rate)
Slow data stream (@ ~10 S/s)	Slow data stream available to the control system
Fast data stream (@ ~10 kS/s)	Fast data stream available to the GDX module slot (on demand to the control system)

Data processing and bunch detection

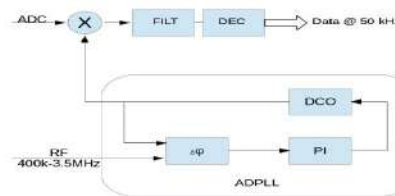
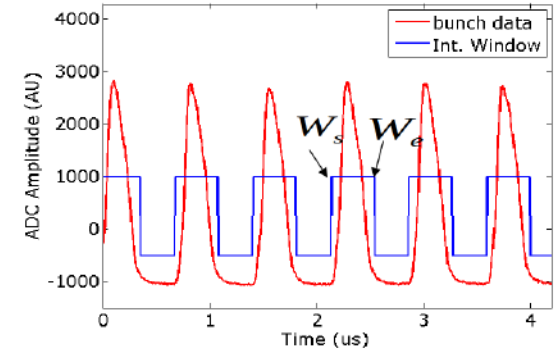
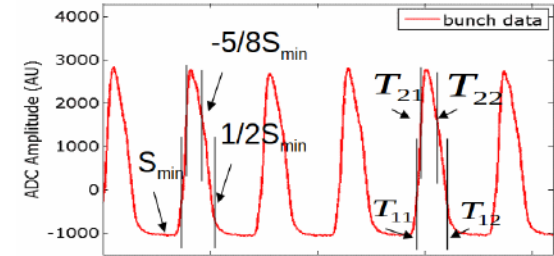
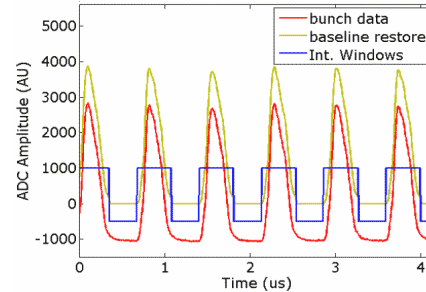
- Shoe-box and Capacitive pickups
- Diagonal or orthogonal installation

- **Bunch-by-bunch algorithm**

- Bunch detection
- Processing window calculation
- Baseline restorer (*Shoe-box)
- Energy calculation
- Position calculation
- Output data rate = Bunch-by-bunch (varying)

- **Narrow band analysis (low charges)**

- SDR receiver
- I & Q calculation
- Position calculation
- Output data rate = 50 kHz (fixed)



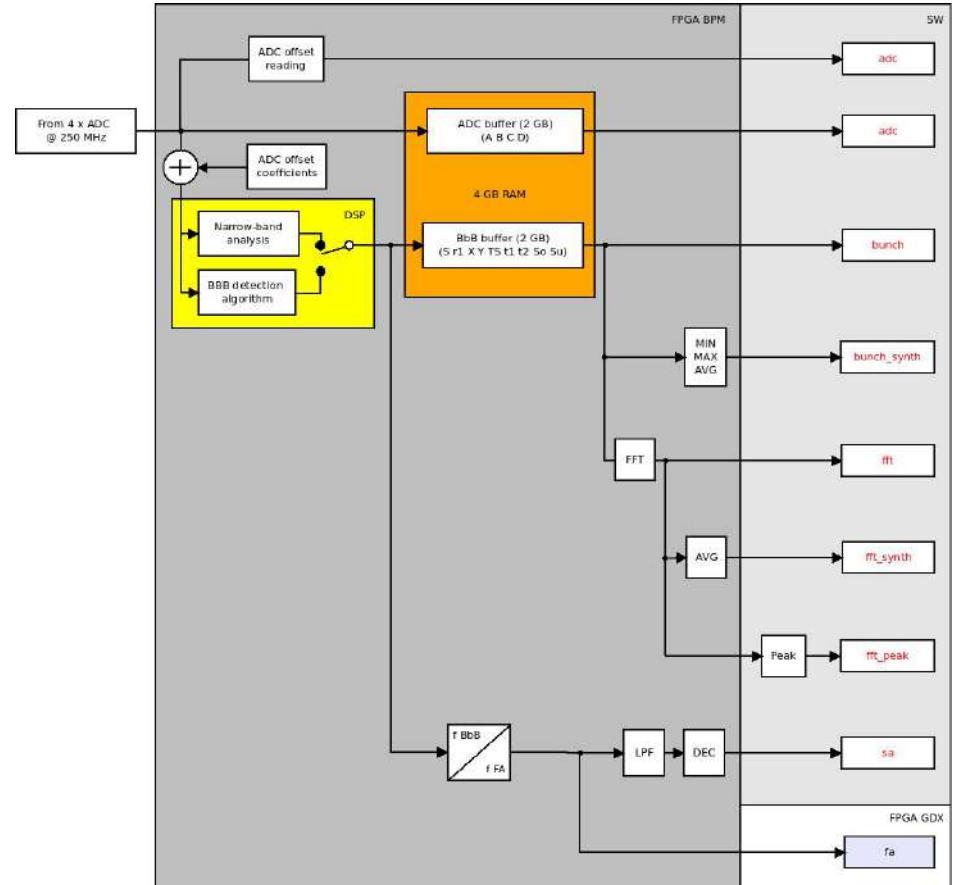
Data Paths

Data on demand

- **Raw ADC data (270 MSamples)**
- **Bunch-by-bunch (200 MSamples)**
- Synthetic bunch-by-bunch
- FFT
- Synthetic FFT
- FFT peak

Stream

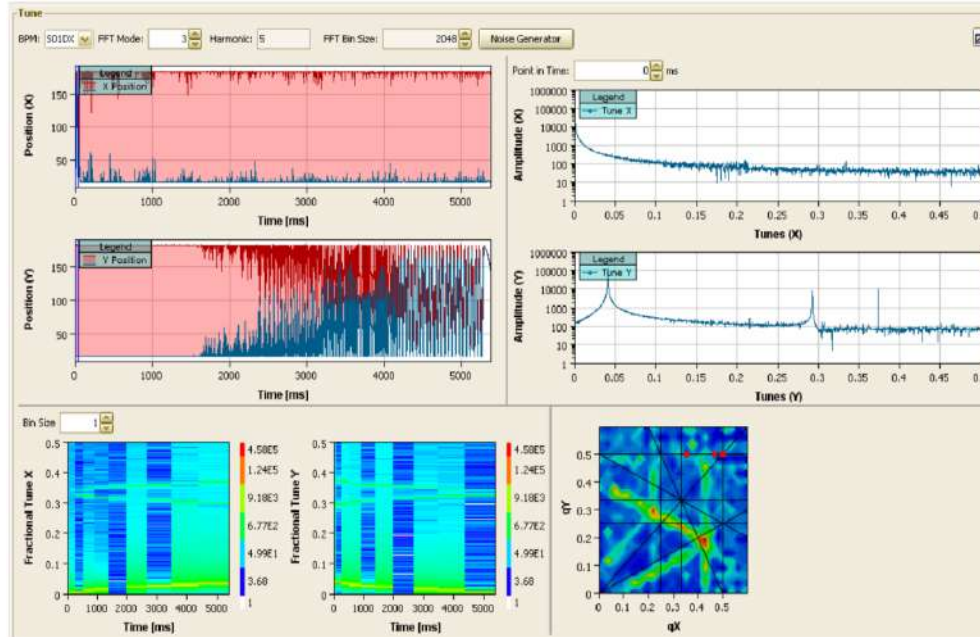
- **GDX fast data**
- **Slow data**



Data Acquisition

X & Y position envelope vs. time/bunches.
Obtained using `bunch_synth (ts, te, n)`

Color coded FFT waterfall diagram vs. time.
Obtained using `FFT_synth (ts, te, n)`



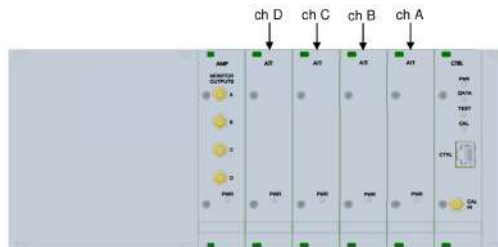
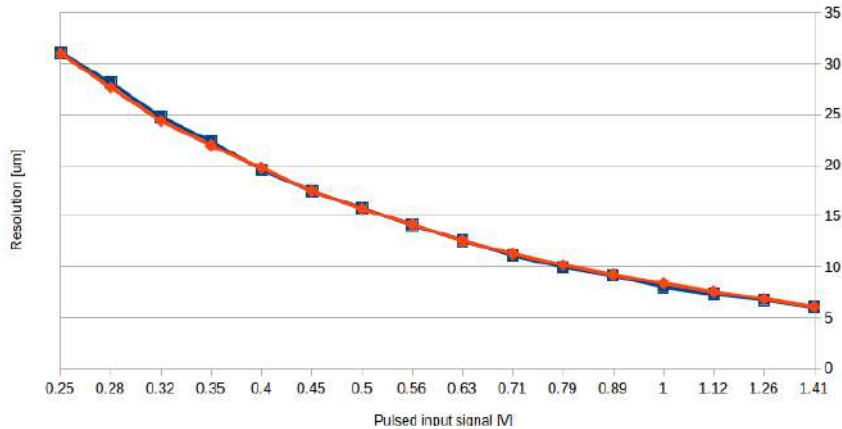
X & Y FFT plot corresponding to specific point in time. Obtained using `FFT(ts, n=1)`

Tune point (X,Y) for a specific point in time. Obtained using `FFT_peak (ts)`

Performances – GSI FAIR version

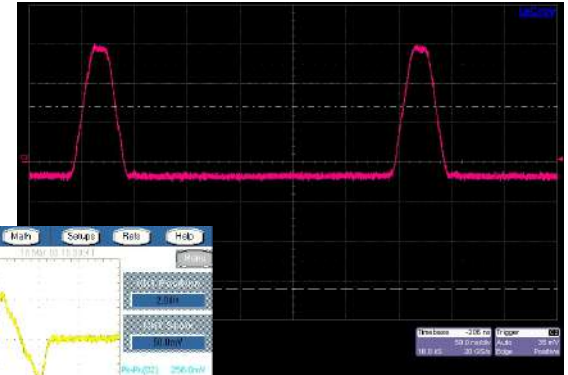
Shoe-box sensor

Position resolution measurement (Bunch by Bunch)



Input signal

- **Vp = 1.4 V**
- **Kx = Ky = 100 mm**
- **Pulse FWHM = 30 ns**
- **Xrms, Yrms = ~ 5 µm**



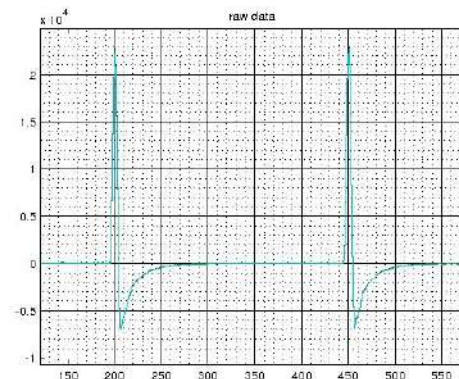
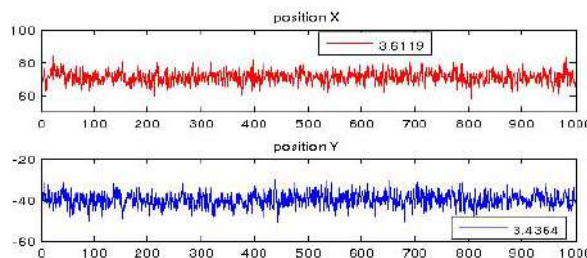
TSINGHUA university

200 MeV Proton Synchrotron

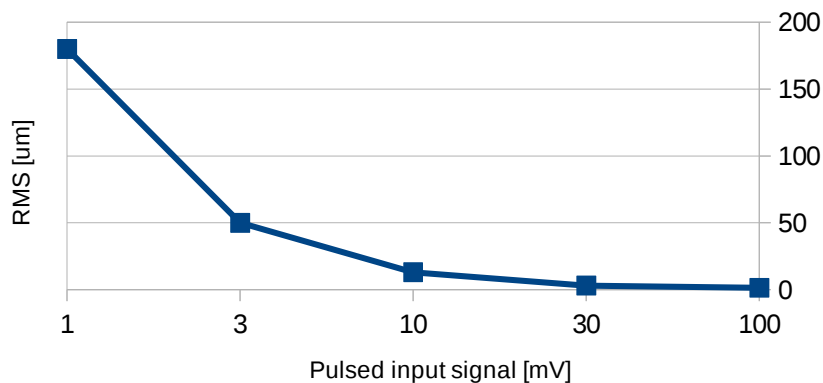
- Button pickup
- Bunch frequency 1.3 - 6.3 MHz
- Single bunch

Input signal

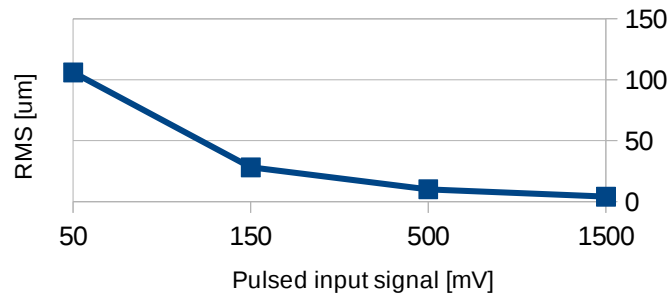
- $V_p = 1 \text{ mV} - 1.5 \text{ V}$
- $K_x = K_y = 50 \text{ mm}$



Position RMS measurement - FWHM=270 ns

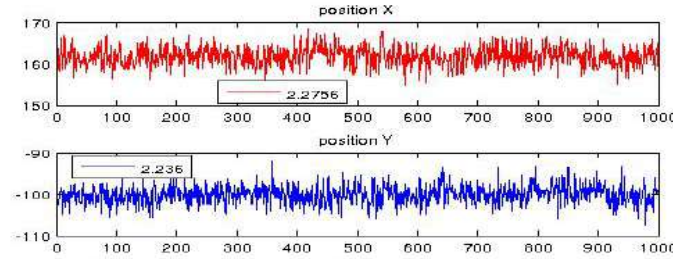


Position RMS measurement - FWHM=20 ns

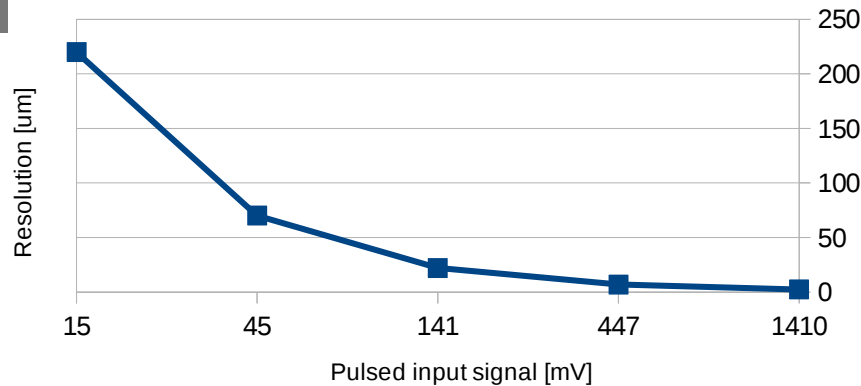


KHIMA – Korea Heavy Ion Medical Accelerator

- Shoe-box sensor
- 0.4 - 3 MHz
- Single bunch

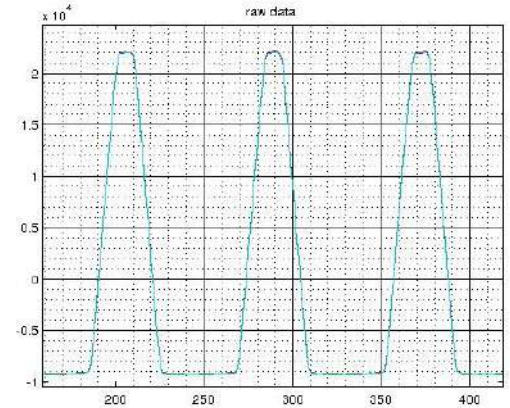


Position resolution measurement (Bunch by Bunch)



Input signal

- **Vp = 1.4 V**
- **Kx = Ky = 100 mm**
- **Pulse FWHM = 80 ns**
- **Xrms, Yrms = ~ 2 µm**



What is next?

Developments, guidelines, challenges ...

- **FAIR**
 - Orbit feedback
 - White Rabbit module implementation
- **Libera Spark HR**
 - Medical accelerators, machines with less demands in terms of data storing and post processing...

