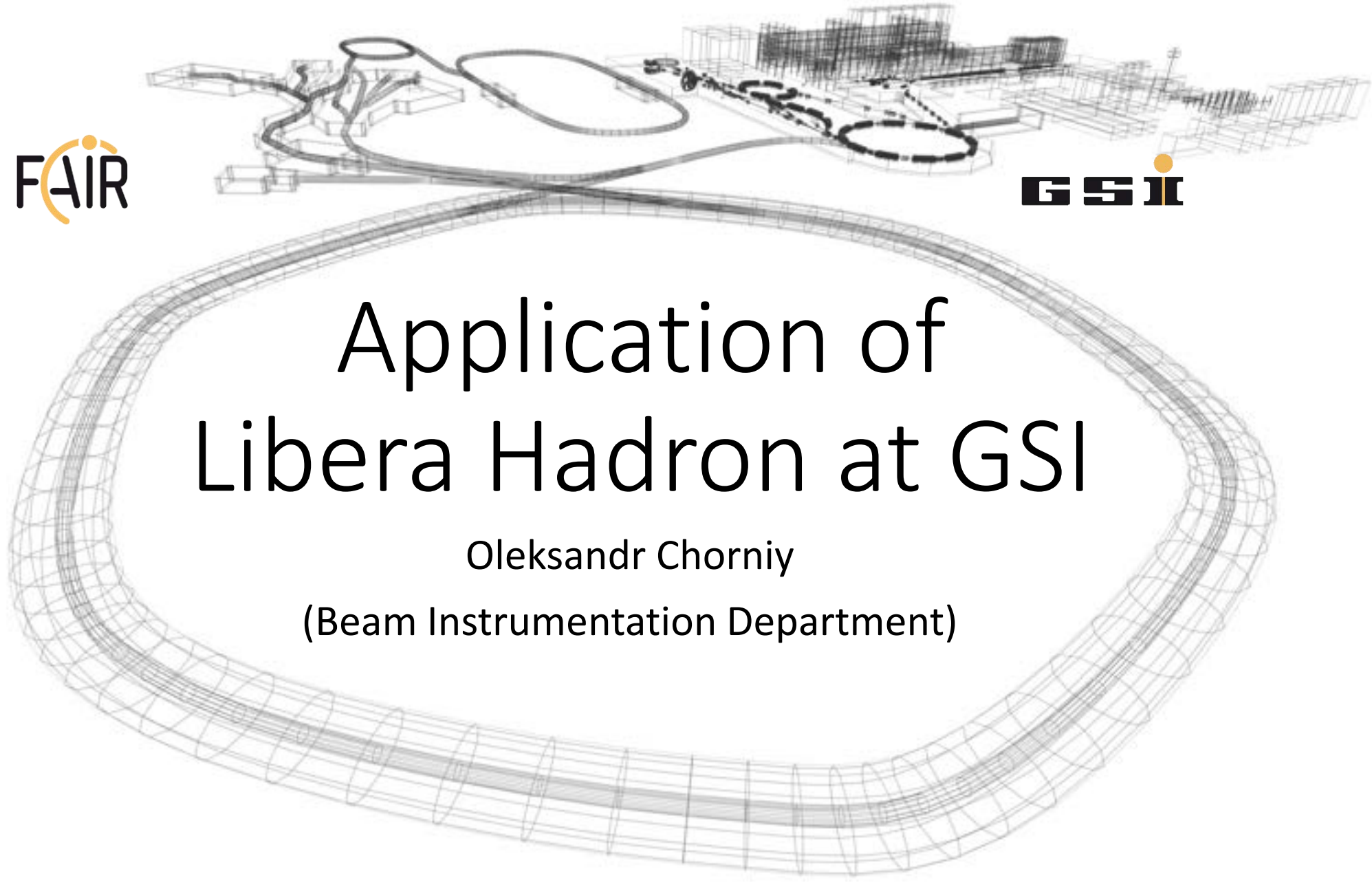


Application of Libera Hadron at GSI

Oleksandr Chorniy

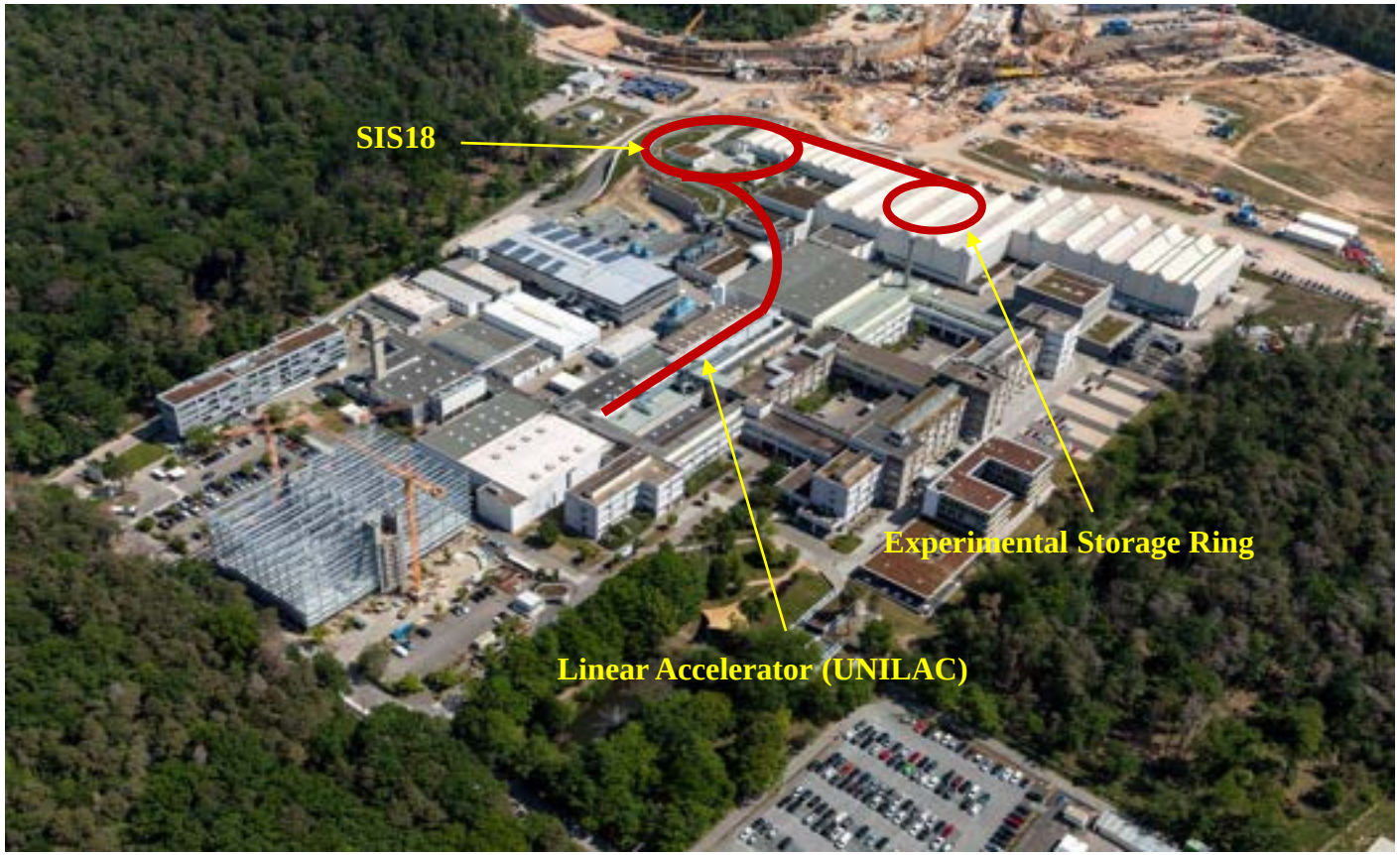
(Beam Instrumentation Department)

GSI Helmholtz Centre for Heavy Ion Research

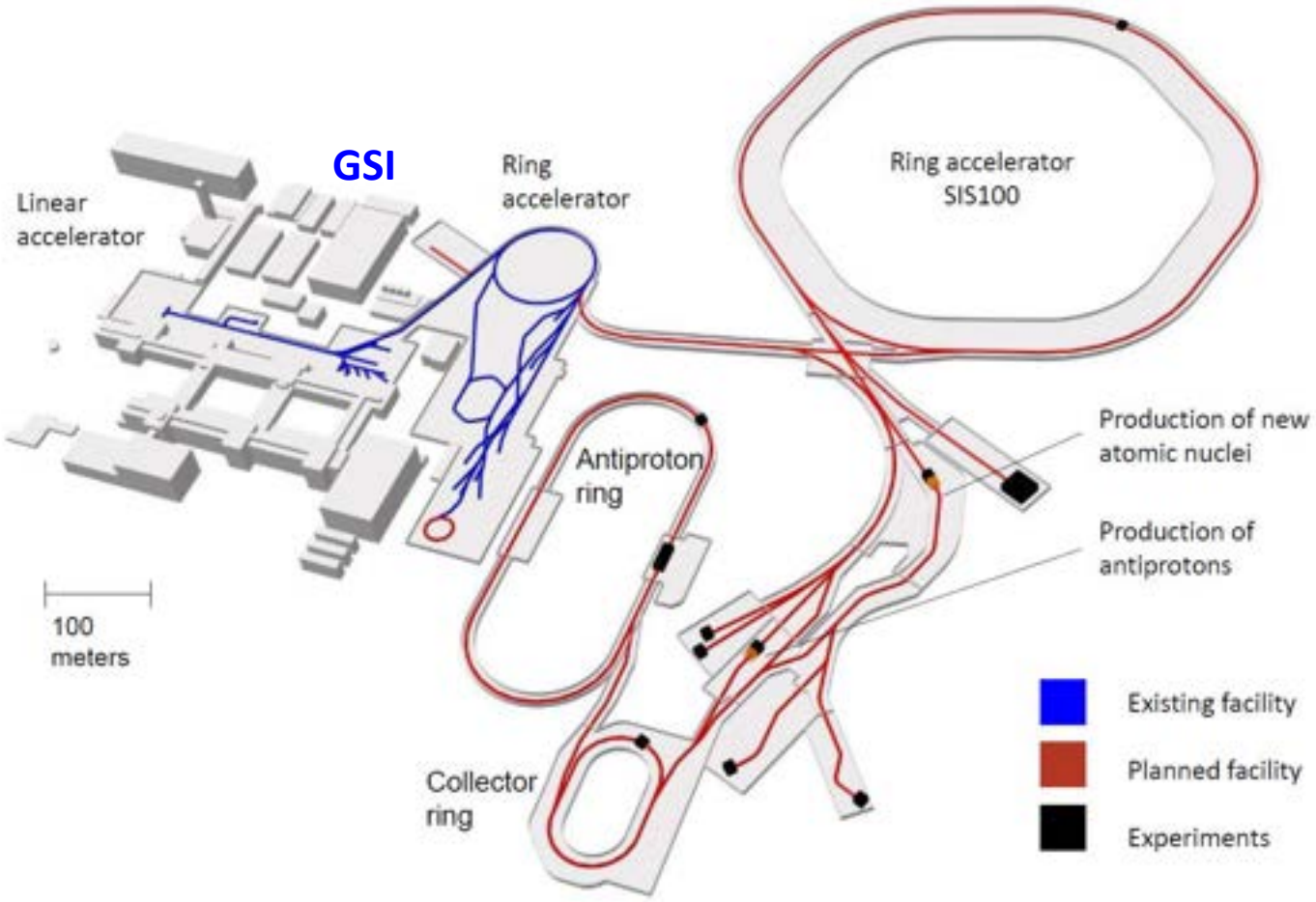
Location of GSI on the map

GSI facility

FAIR facility



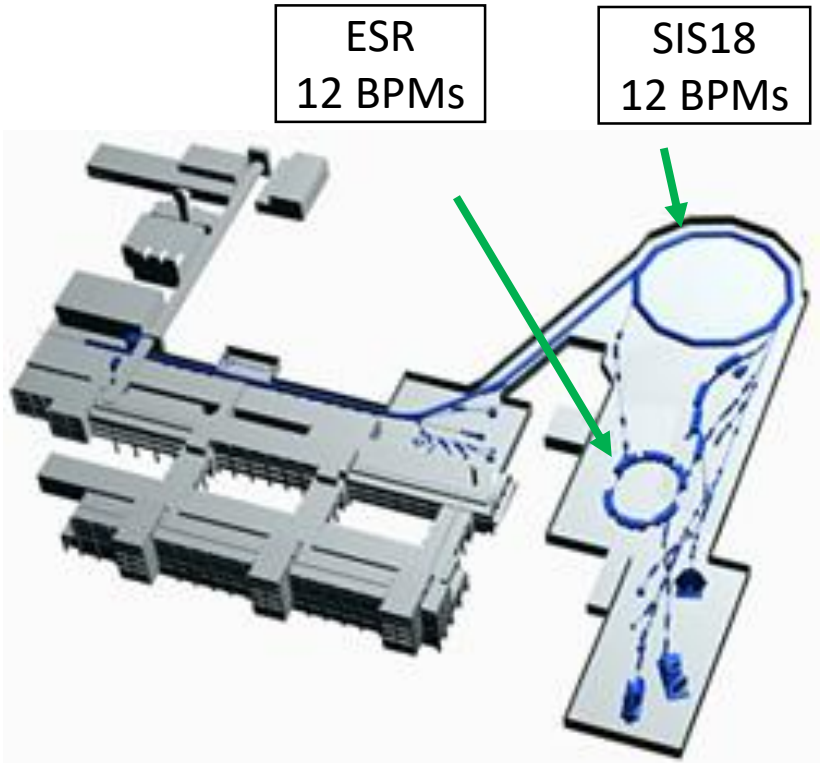
FAIR (Facility for Antiproton and Ion Research)



Aerial view of GSI and FAIR, May 2022

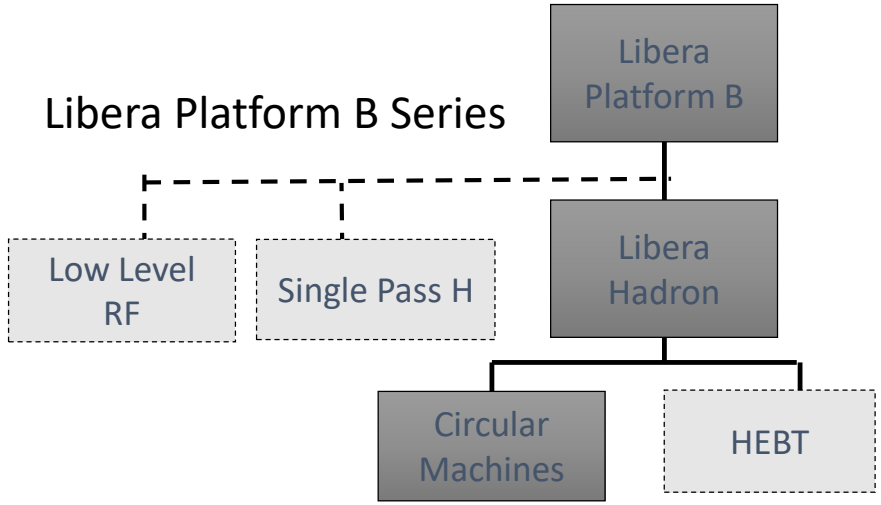
photographer D. Fehrenz

Upgrade of GSI BPM System

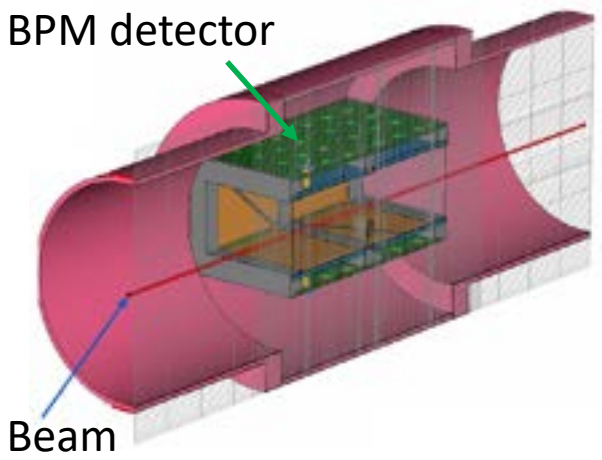


In the **SIS18** synchrotron the beam is accelerated to high energies (1GeV/u for U) and goes to experimental areas or **ESR**

In the **ESR** the beam is used for experiments or accelerated/decelerated /accumulated and distributed over experimental areas



- 19“, 2U, 310mm depth
- mTCA based
- FTRN slot (FAIR Timing Receiver Network)
- Acts as FEC (Front End Computer)
- Up to 4 ADC boards
- I/O for pre-amplifier control



Libera Hadron

Libera Hadron for FAIR

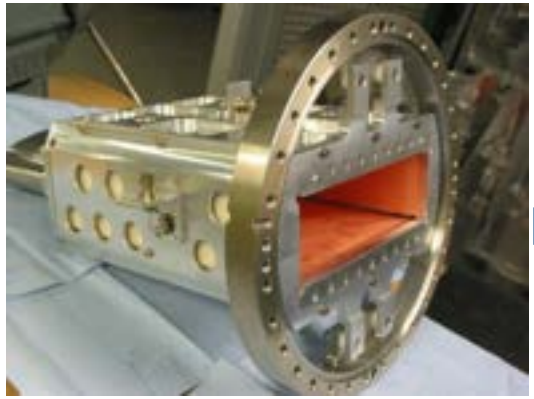
Delivery for FAIR in 2018

FAIR Ring BPM test bench installation

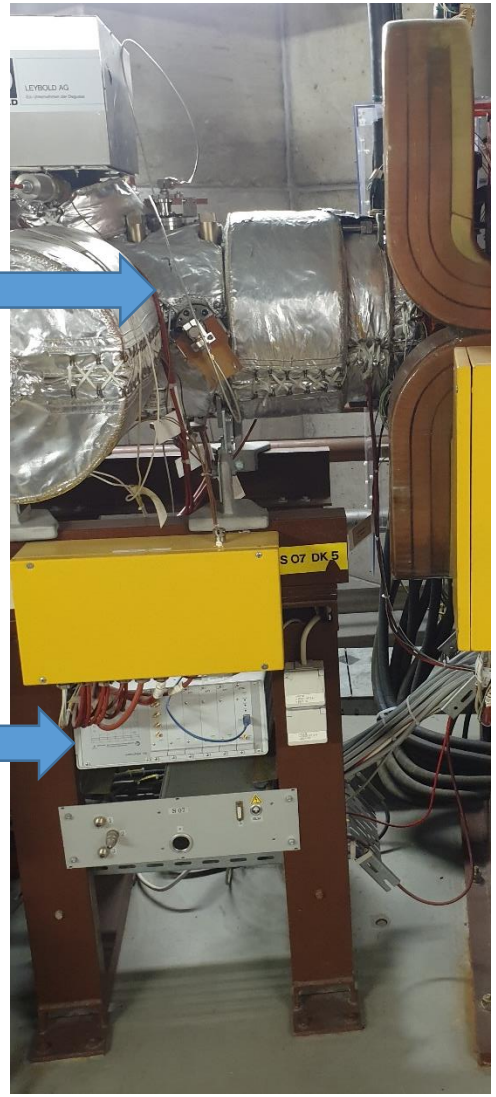
Libera Hadron for SIS-18 and BPM Hardware

Three Liberas (for twelve SIS18 BPMs) in Electronic room

SIS18 Shoe-box BPM



SIS18 tunnel (BPM location)



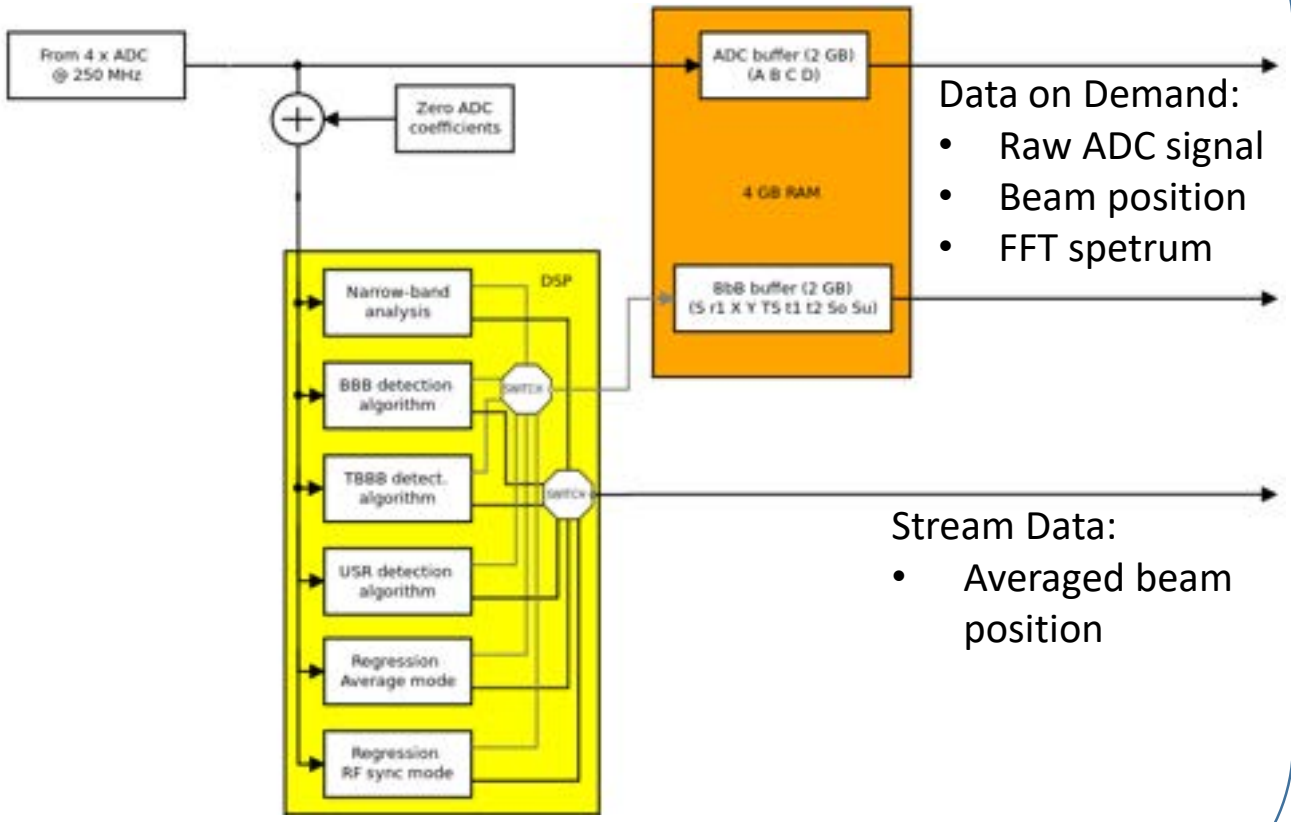
Amplifier 110
(I-Tech)

Zoomed picture of one Libera

Long signal and Amp control cables

Frontend Controller for Libera Hadron

Libera Hadron ADC board FPGA



Data on Demand:

- Raw ADC signal
- Beam position
- FFT spetrum

Stream Data:

- Averaged beam position

Single BPM Software Controller

Acquisition of On-demand data

- Short chunks (1MB) of On-demand data
  - in realtime regime with 5Hz rate during acceleration cycle
  - at specificied trigger events (2-10 events) during acceleration cycle
- Large amount of On-demand data (1Gb) at the end of acceleration cycle

Buffering of Stream DATA

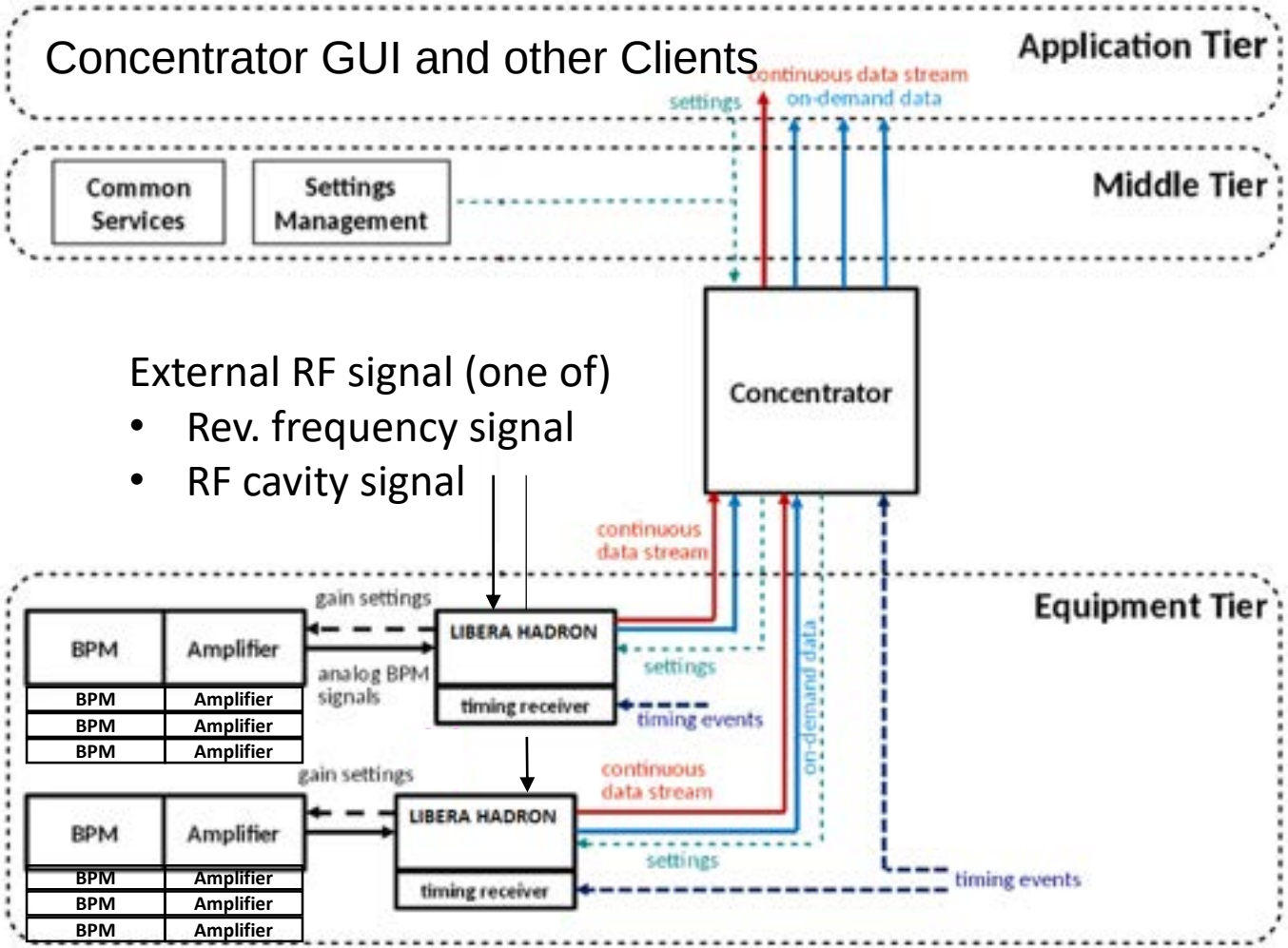
Acquisition Settings:

- Choise of position calculation algorithm for Stream and On-demand independently
- Position calculation algorithm parameters
- Trigger settings

Amplifier Control (Gain Set, Calibration procedure)

BPM Concentrator

Topology of BPM system at GSI

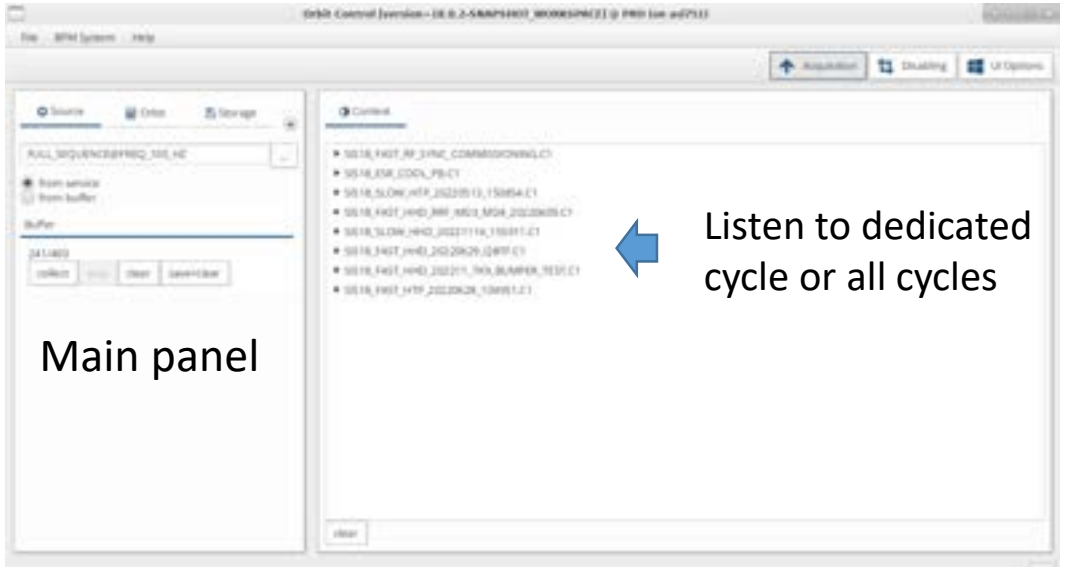


Some features of Concentrator

- Concentrator performs the aggregation, common postprocessing of data from all BPMs per machine
- Concentrator is the single point of access to the BPM system for all operational clients
- Buffering of the Stream Data from all Liberas. Stream acquisition is independent from on-demand acquisition
- Realtime orbit at different decimations (1, 10, 25, 100, 1000 S/second) and at specific timing events
- All on-demand data are provided in parallel, i.e. no switching between on-demand Acquisition Regimes (Positions, Raw, Spectra, etc.) is required
- Amplifier Gain switching between different machine cycles and along a single machine cycle

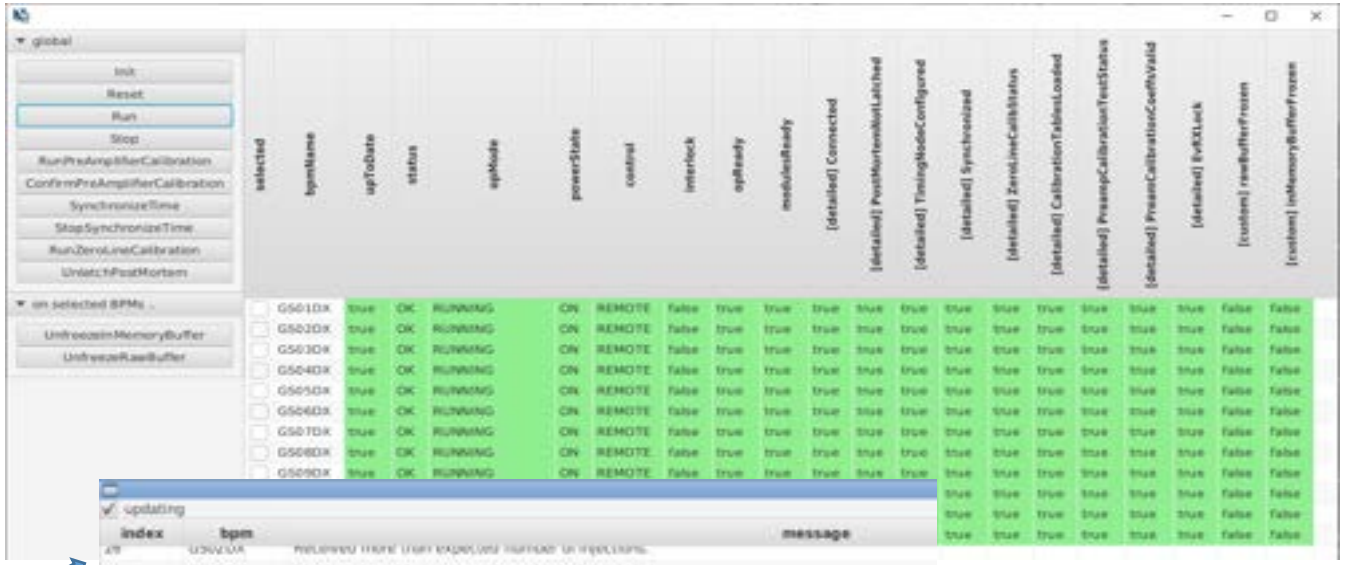
BPM Controller and Concentrator are developed by Cosylab

Concentrator GUI



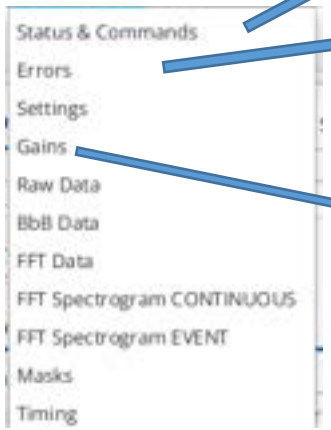
Main panel

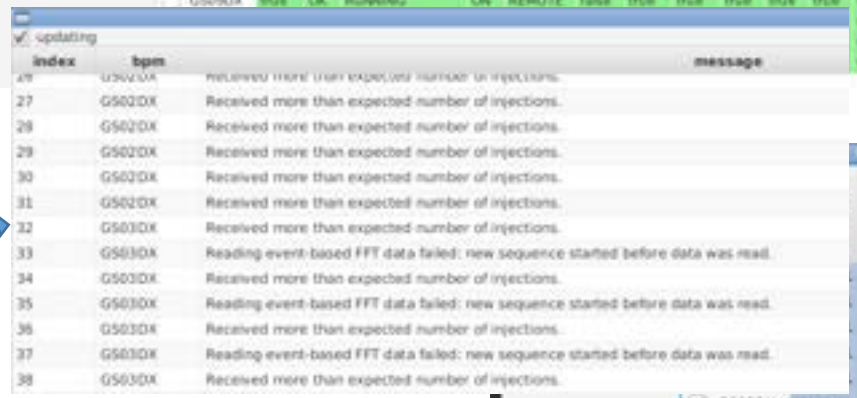
Listen to dedicated cycle or all cycles

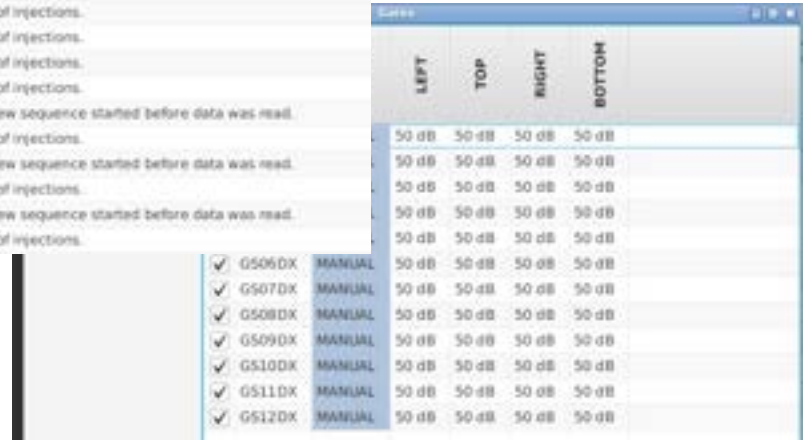


Subscription to the different types of stream data

Available functionalies





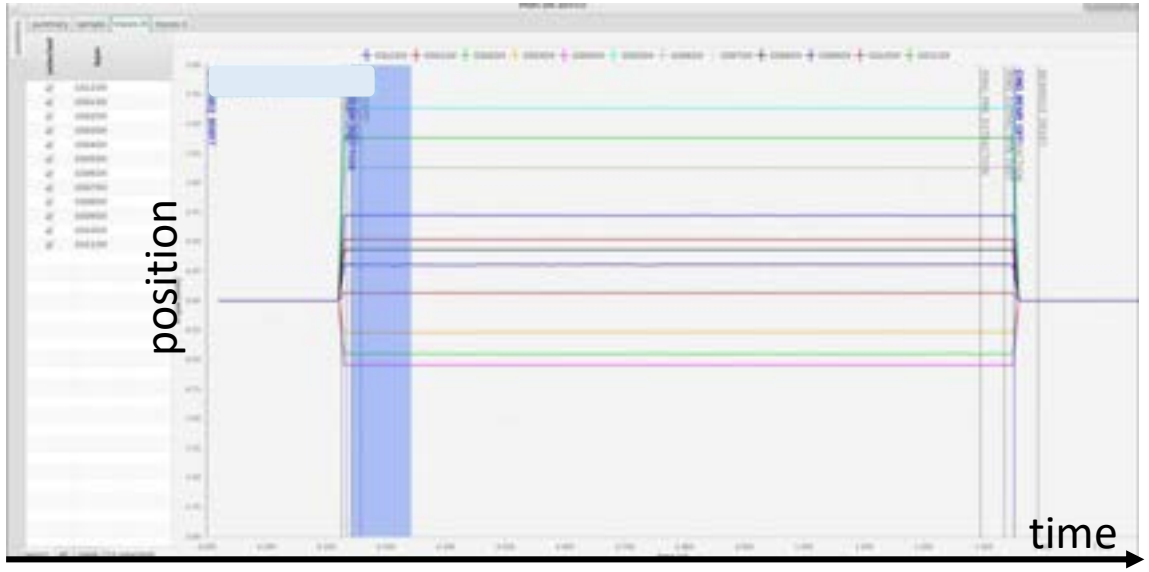


BPM Concentrator GUI has been developed by Kajetan Fuchsberger@KaiFox GmbH

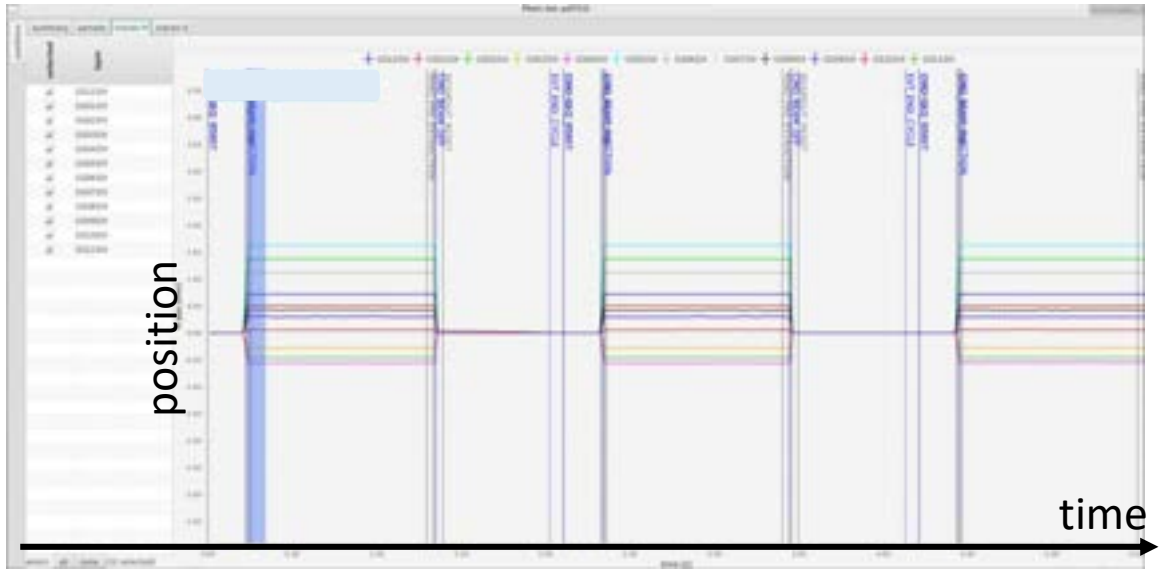
Beam Position Stream Acquisitions

Beam position evolution from all BPMs in Traces view:

- Cycle-to-cycle update
- Free running mode 1 Hz update



Orbit view



Beam Position Stream Measurements

Evolution during 4 s cycle in SIS18.

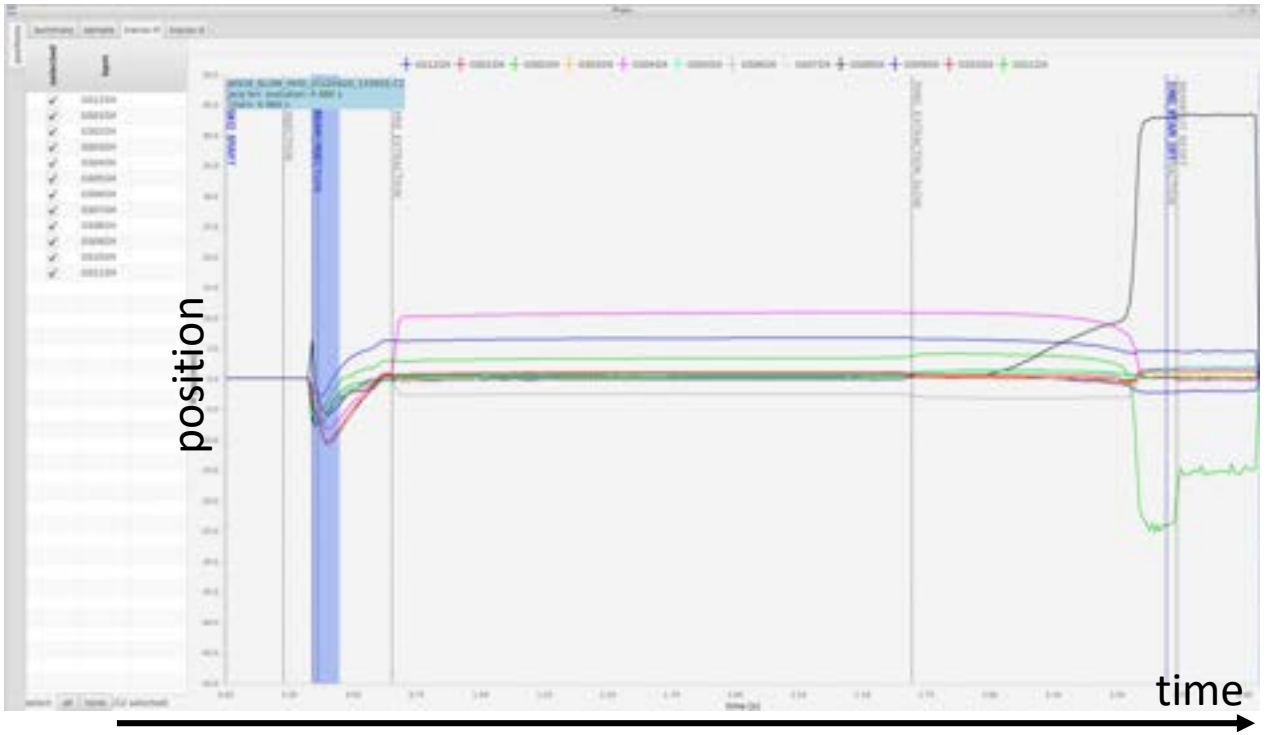
Plot is updated once in the end of every cycle.

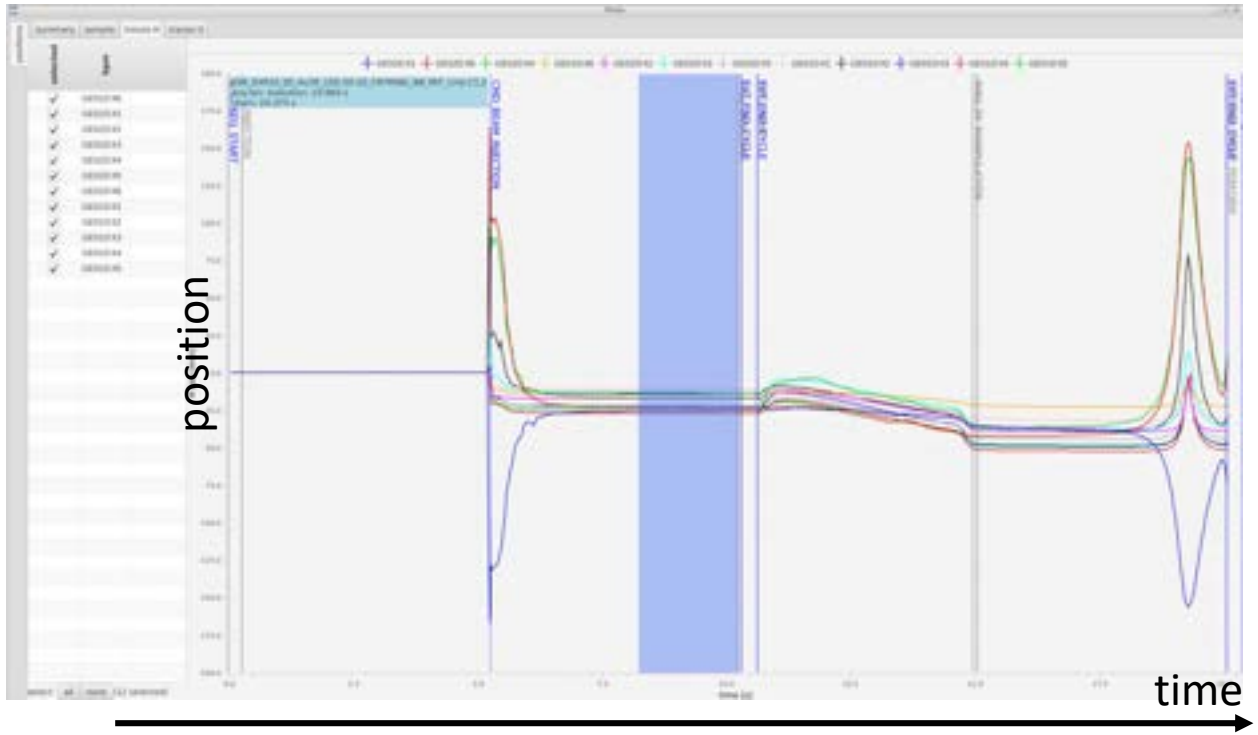
Decimation 10ms

Evolution during 20 s cycle in ESR:

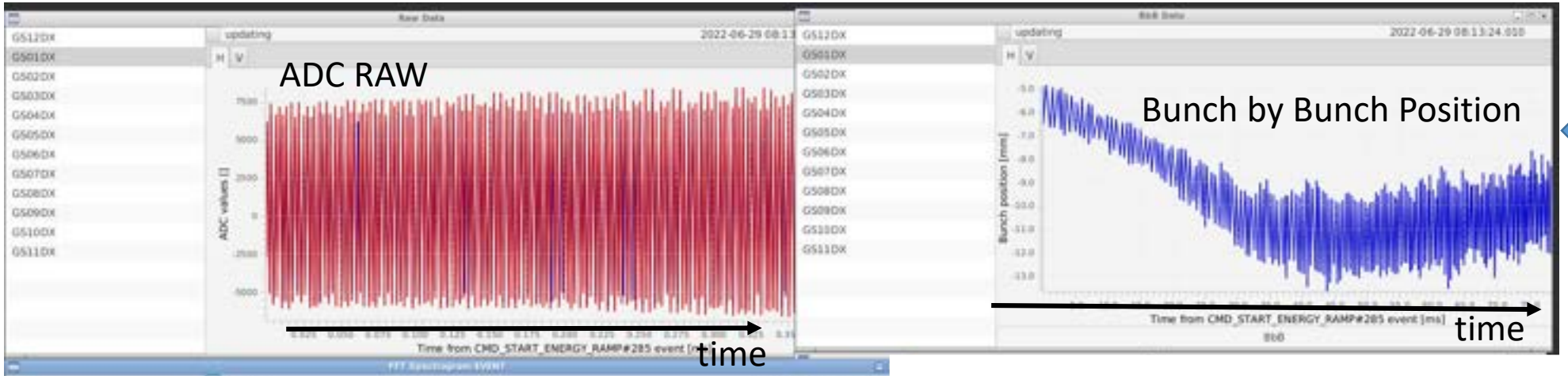
Plot is updated every second with new data every second

Decimation 100 ms

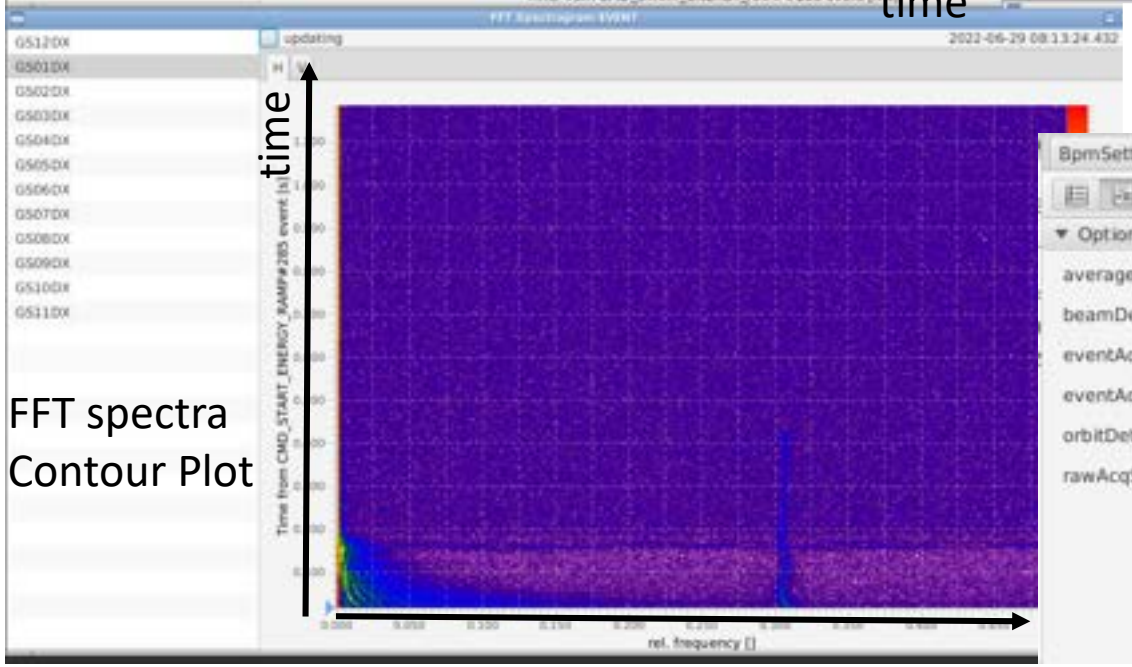




Ondemand Data and Acquisition settings

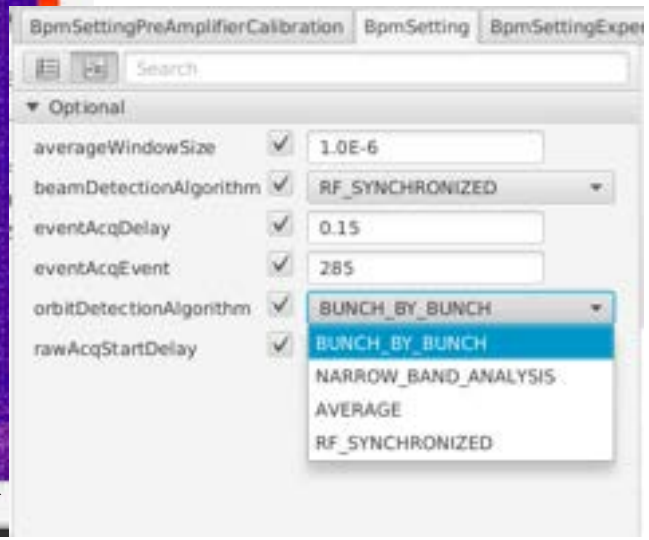


SIS 18 measurements example

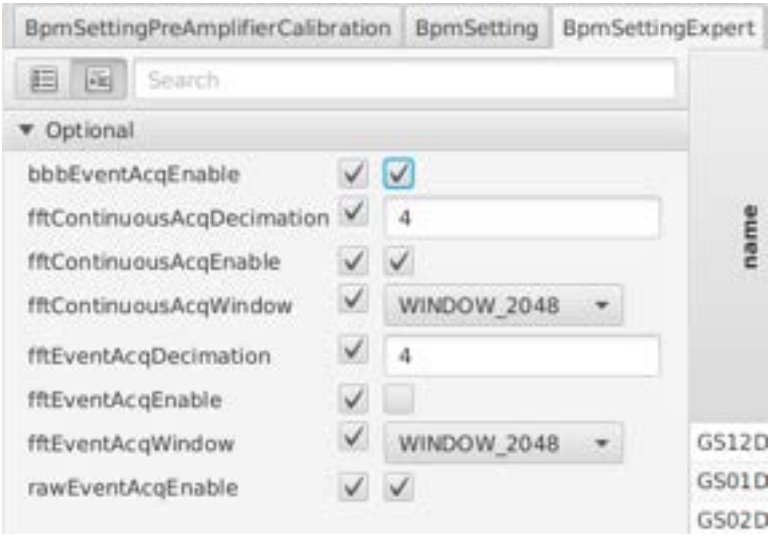


FFT spectra Contour Plot

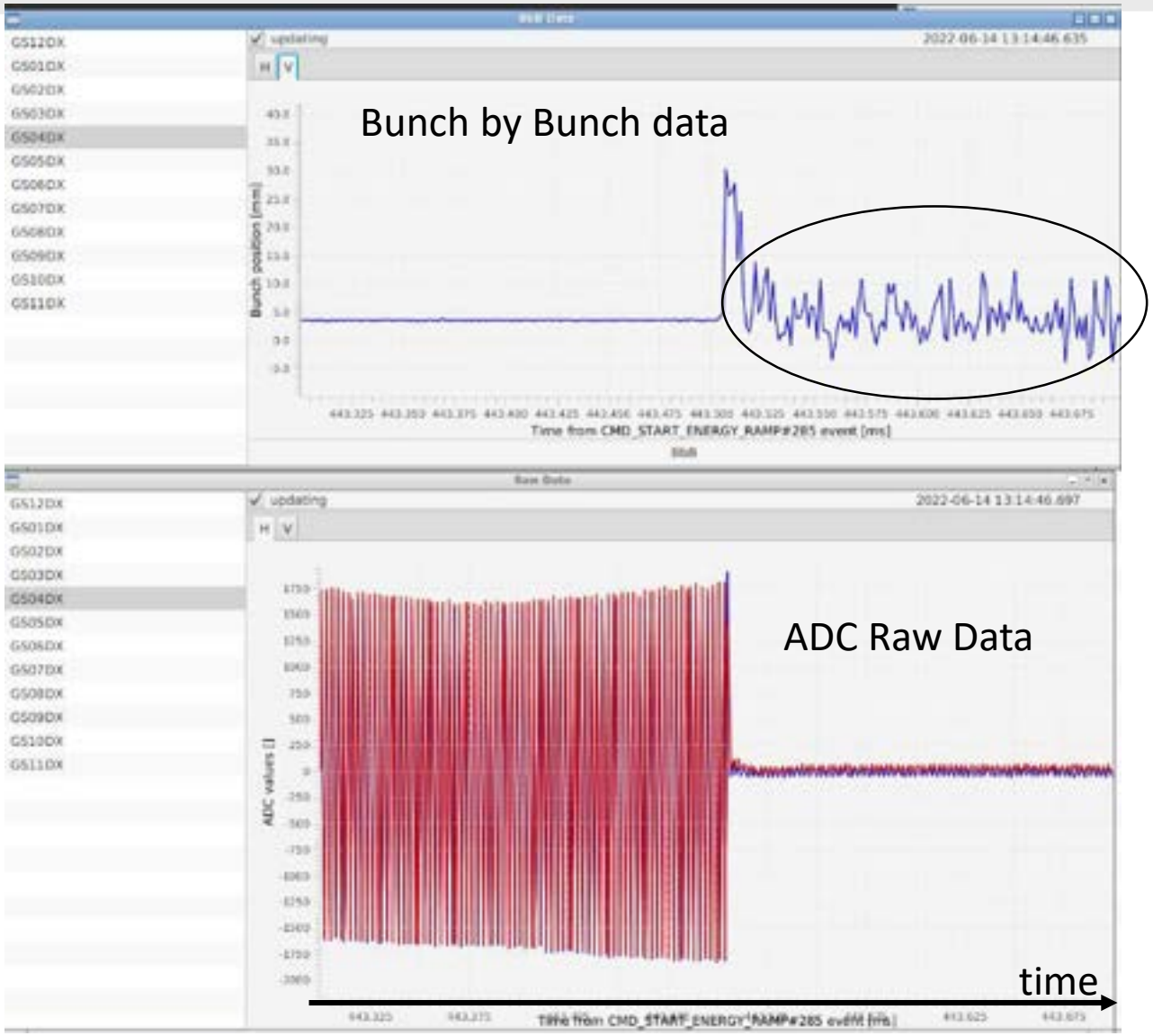
Settings



Expert Settings



SIS18 Mesurements at fast extraction



There is no beam but „position“ are still shown.
It is not a bug, it is feature of the algorithm - it always produce position.
Next todo -> using error estimates in position data to identify coasting beam regions

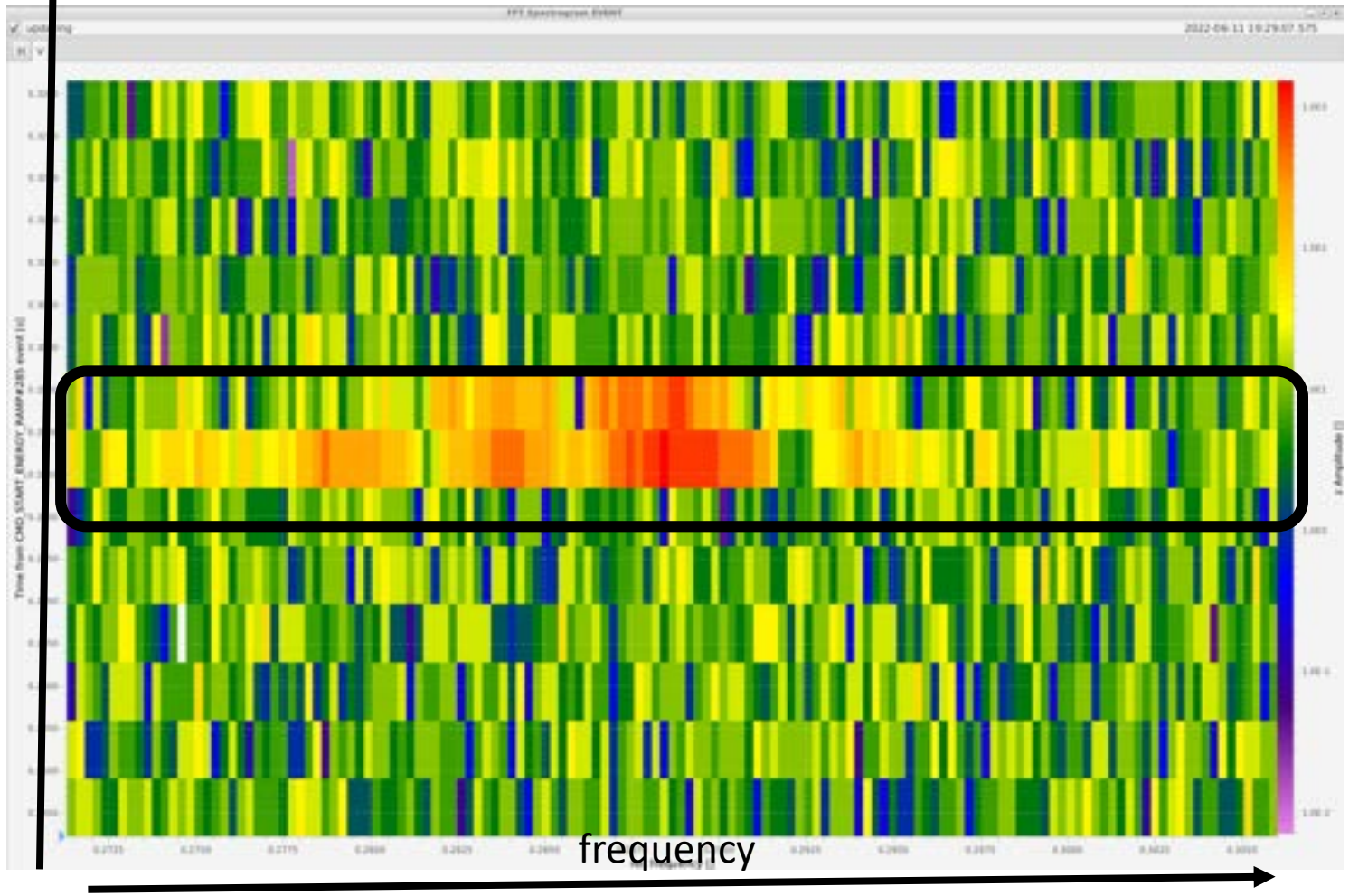
Ability to acquire all types of data simultaneously will be important during future comissioning phases.

Now it is also used during machine experiments…

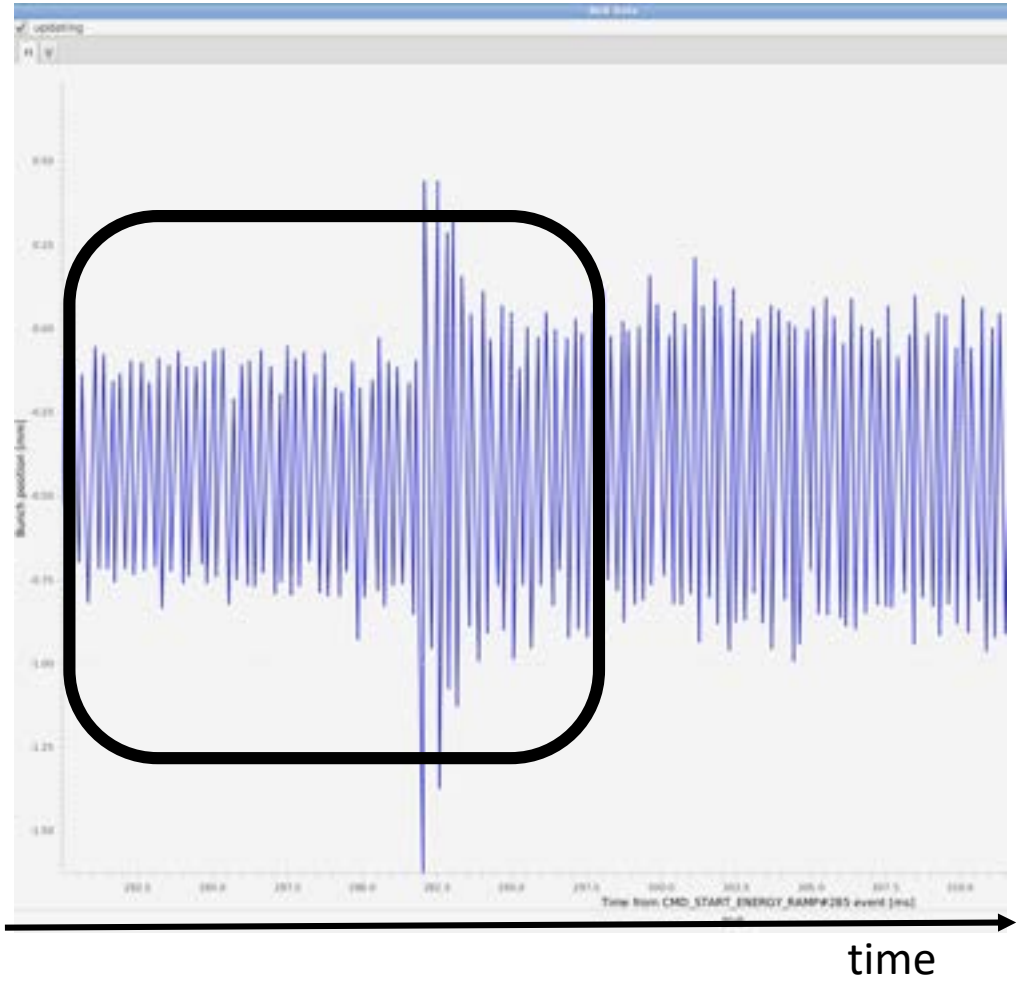
SIS18 Mesurements with transversal „kick“

… for example to identify the „Kick“ location

Zoomed view of FFT contour plot (width is 0.03 a.u.)

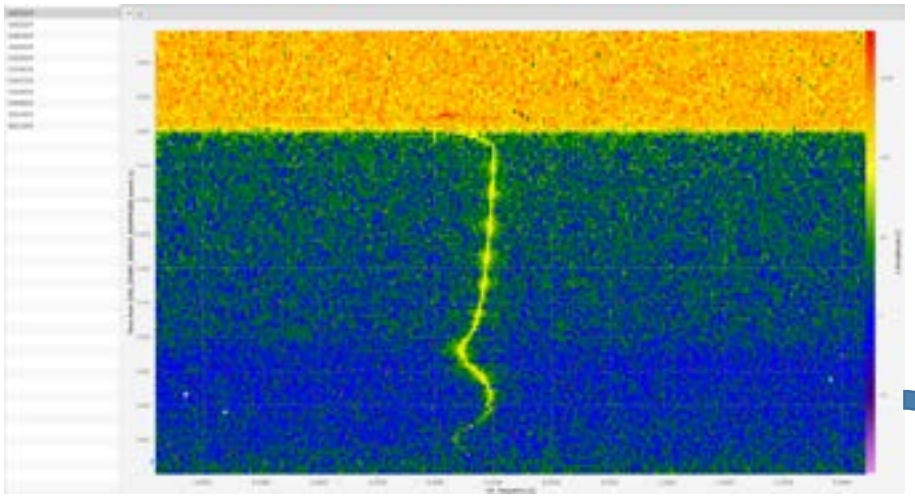


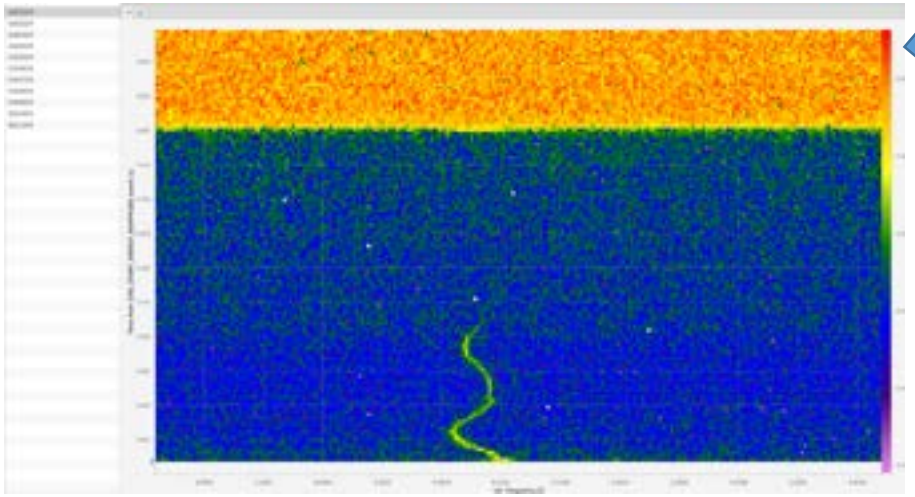
Bunch by bunch position data.

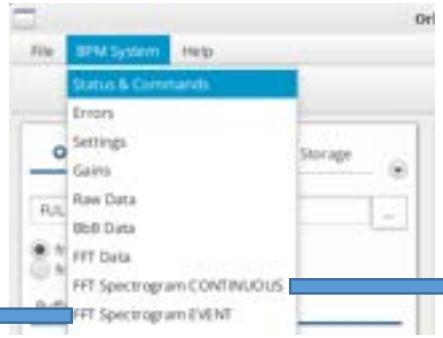


Position FFT spetra: Event and Continuous

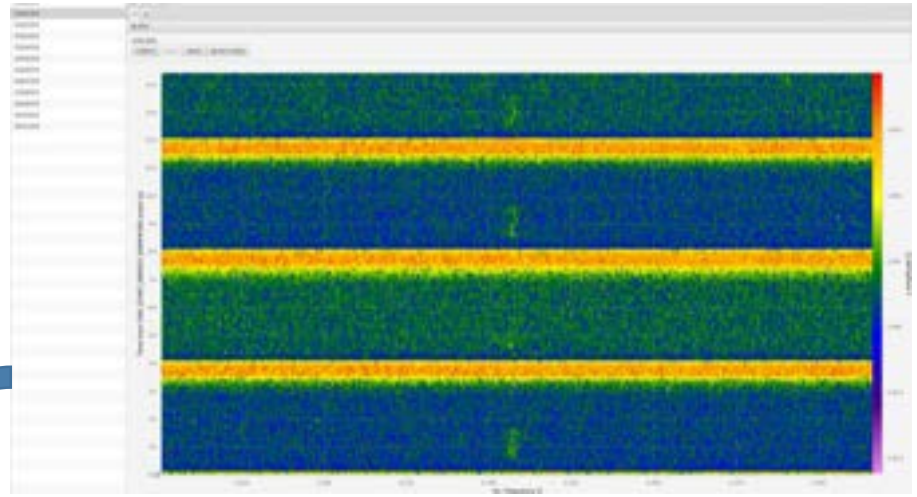
Trigger on a given event: contour FFT Plot is updated/refreshed in the end of every cycle.

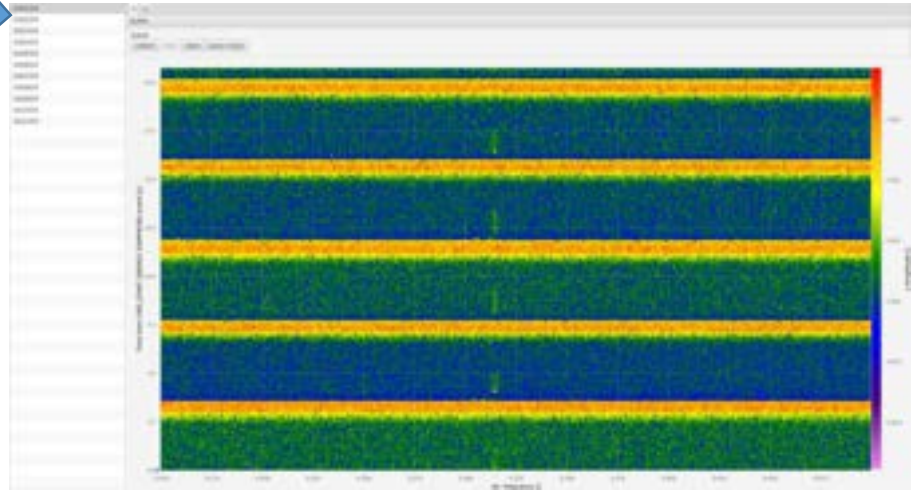






Continuous update: contour FFT Plot is updated every second with new data added to plot





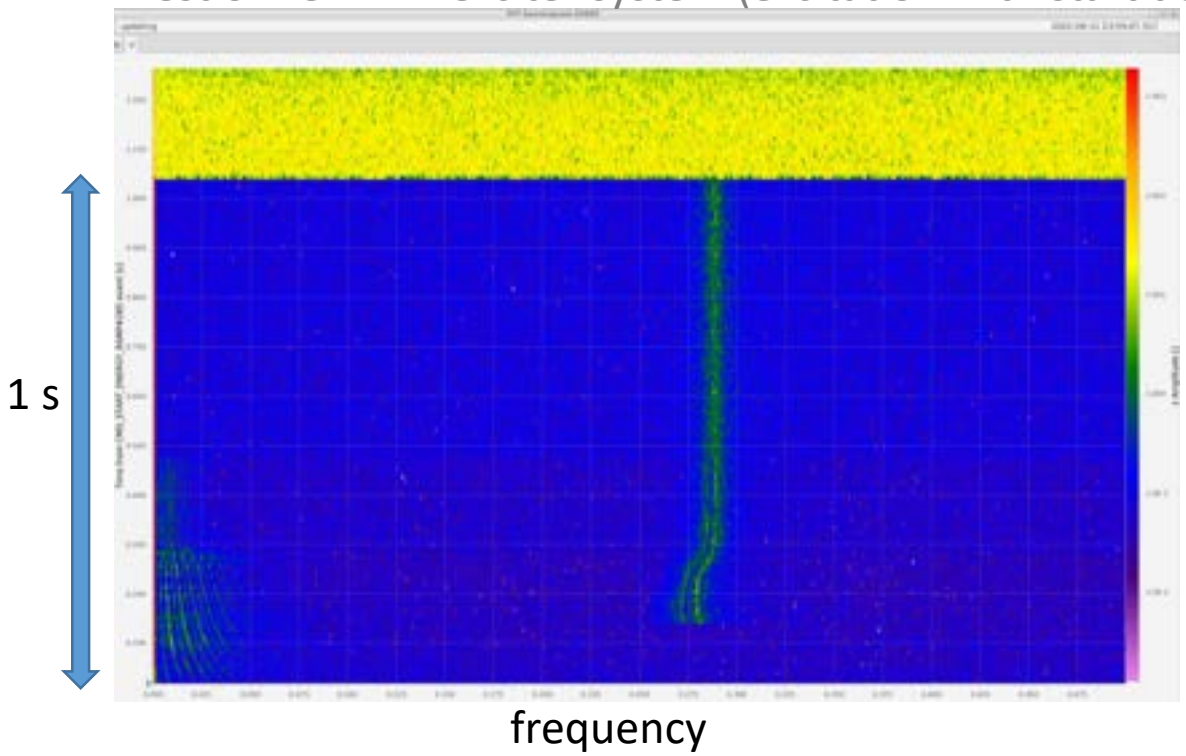
Both modes can be activated at the same time

Tune measurements in SIS18 and ESR

Tune measurements during short acceleration cycle in SIS18.

Contour FFT Plot is updated/refreshed in the end of every cycle. Decimation 1 ms

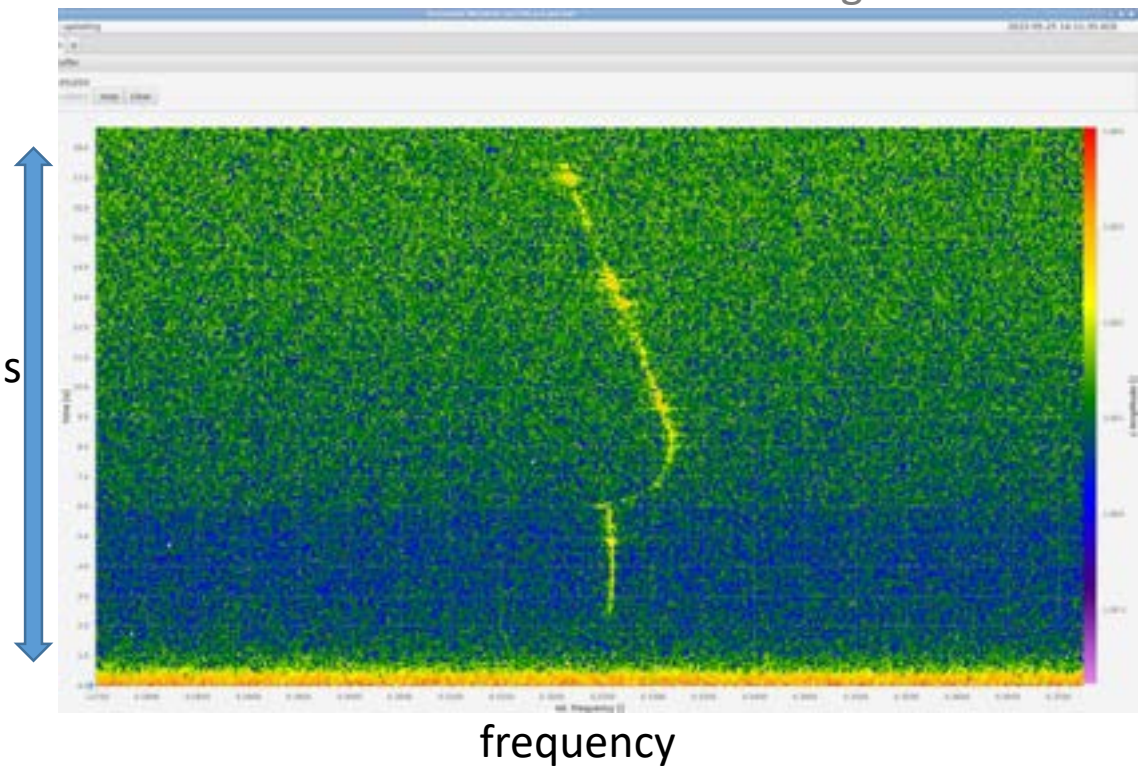
Test of new BTF exciter system (excitation with start delay)



Tune measurements during long deceleration cycle in ESR.

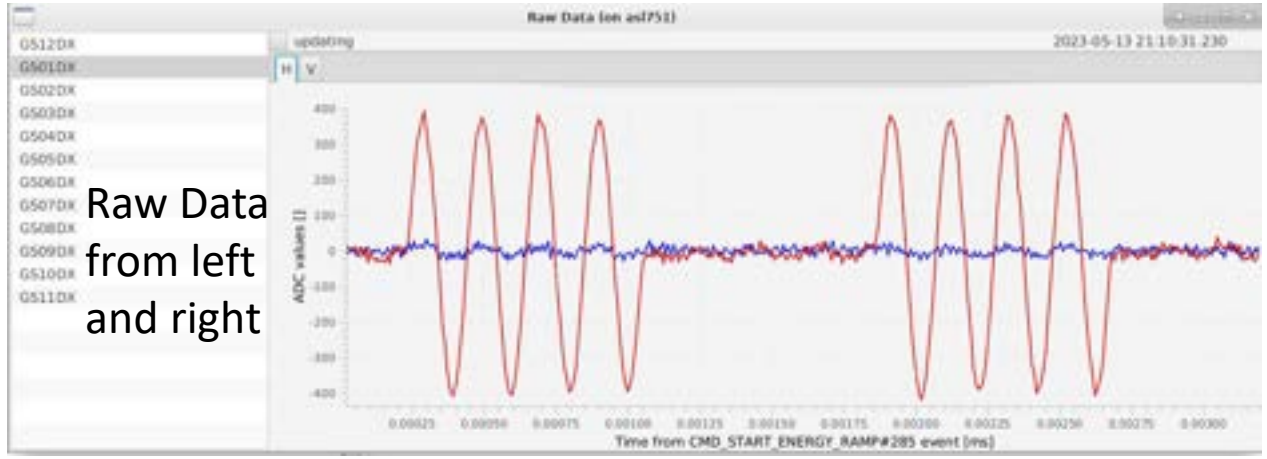
Contour FFT Plot is updated every second with new data added to plot. Decimation 200 ms

First ESR tune measurements during decelaration

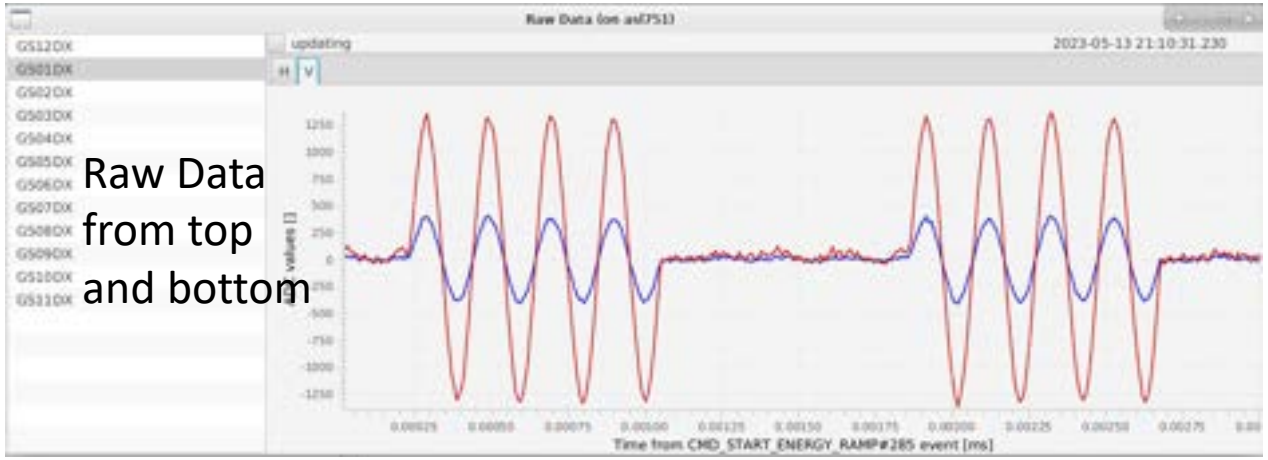


Maintenance mode

- Switch for internal signal generator of HPA110 (before was used only for calibration)
- Gain per BPM single plate (right,left,top,bottm) can be set



Raw Data from left and right



Raw Data from top and bottom

Corresponding Orbit view

Improvements on Libera Hadron

position

$$X = a\frac{U_l - U_r}{U_l + U_r}$$

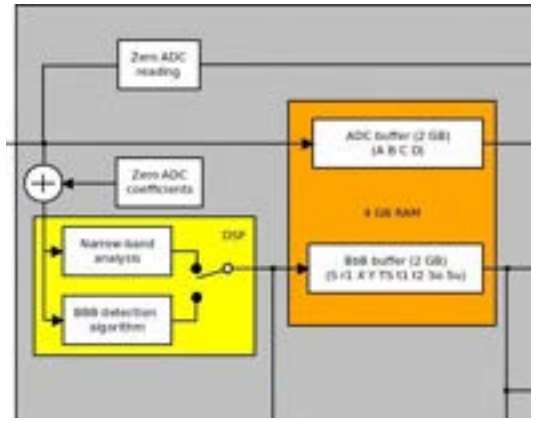
Bunch signal integration

$$U = \sum S_i$$

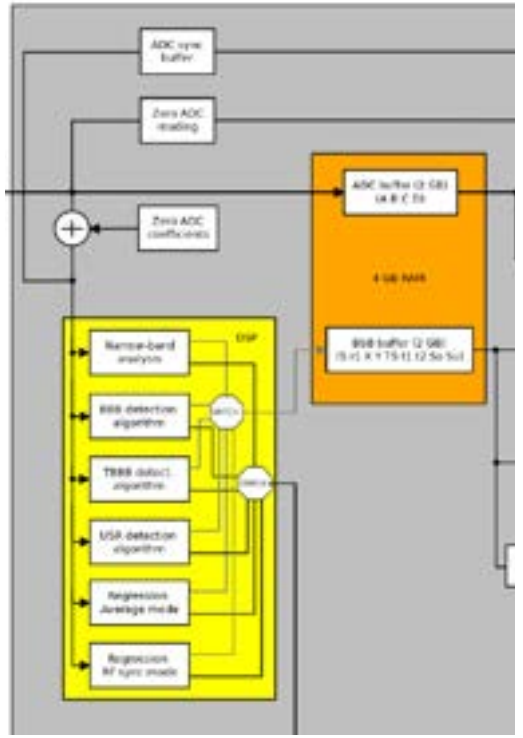
Root-sum-square

$$U = \sqrt{\sum {S_i}^2}$$

algorithms in 2018



algorithms in 2021



Original methods

Narrowband -> Acqusition windows provided by external RF (cavity) + Heterodyne

BBB -> Acqusition windows detected using threshold + Bunch signal integration

New methods

tBBB-> Acqusition windows provided by external RF (cavity) + Bunch signal integration

Regression sync -> Acqusition windows by external RF (revolution) + **Root-sum-square**

Regression async -> Acqusition windows length set by user + **Root-sum-square**

DIGITAL PROCESSING OF PICK-UP SIGNALS FOR POSITION AND TUNE DETERMINATION,
R. Singh, A. Reiter, P. Kowina and P. Forck, Proceedings of IBIC2015

Summary and plans

Team

Electronics and functionality tests
GSI: K. Lang, A. Reiter, R. Singh,
W. Kaufmann, P. Kowina

Libera Controller Design
GSI: O. Chorniy

Concentrator Design and GUI
KaiFox GmbH: K. Fuchsberger

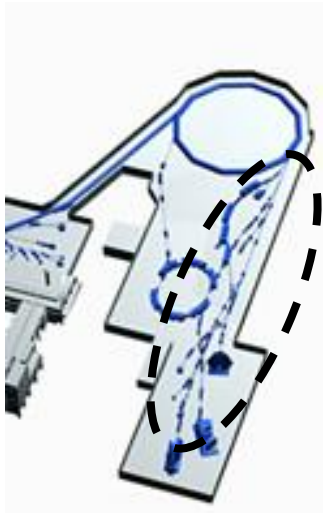
Software Controllers implementation
Cosylab: R. Hari, A. Debenjak,
M. Matiz,…

Techn. Support and work on FPGA
I-Tech: D. Tinta,
A. Bardorfer, M. Znidarcic,…

Improvements in BPM system after upgrade:

- Realtime orbit notification
- Parallel aquisition of all type of data
- Free running modes for all type of data
- Tune measurements at very low intensities
- Amp. Gain separately for each cycle

Next: Bring HEBT Liberas in operation with beam



HEBT Liberas test stand

- Software Controllers ready
- Concentrator GUI next task