A FESA DAQ for Fast Current Transformer in SIS18

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Abstract

This contribution presents the development of the data acquisition (DAQ) system for the readout of fast beam current transformers (FCT) as installed in the GSI synchrotron SIS18 and as foreseen in several FAIR ring accelerators. Fast current transformers are reliable devices that offer a large analogue bandwidth and can therefore monitor bunch structures with high resolution. At appropriate sampling rates continuous measurements throughout repeated machine cycles lead to a large amount of raw data. The analysis of those raw data may range from simple bunch parameter calculations to complex longitudinal phase space reconstructions. Consequently, a new DAQ system must be carefully designed to allow for flexible acquisition modes or to allow for data reduction methods in special applications. The aims of the development are discussed and the status of the new DAQ is presented..

Phase space tomography in SIS 18

Test system for tomography analysis

The phase space is derived from a set of longitudinal bunch profiles as illustrated in Fig.1. The SIS18 analysis was implemented using Mathematica software and the CERN tomography code [1]. This graphical user interface (GUI) allows to preview the raw data, define all necessary cuts and analysis parameters and to visualize the reconstructed longitudinal phase space.

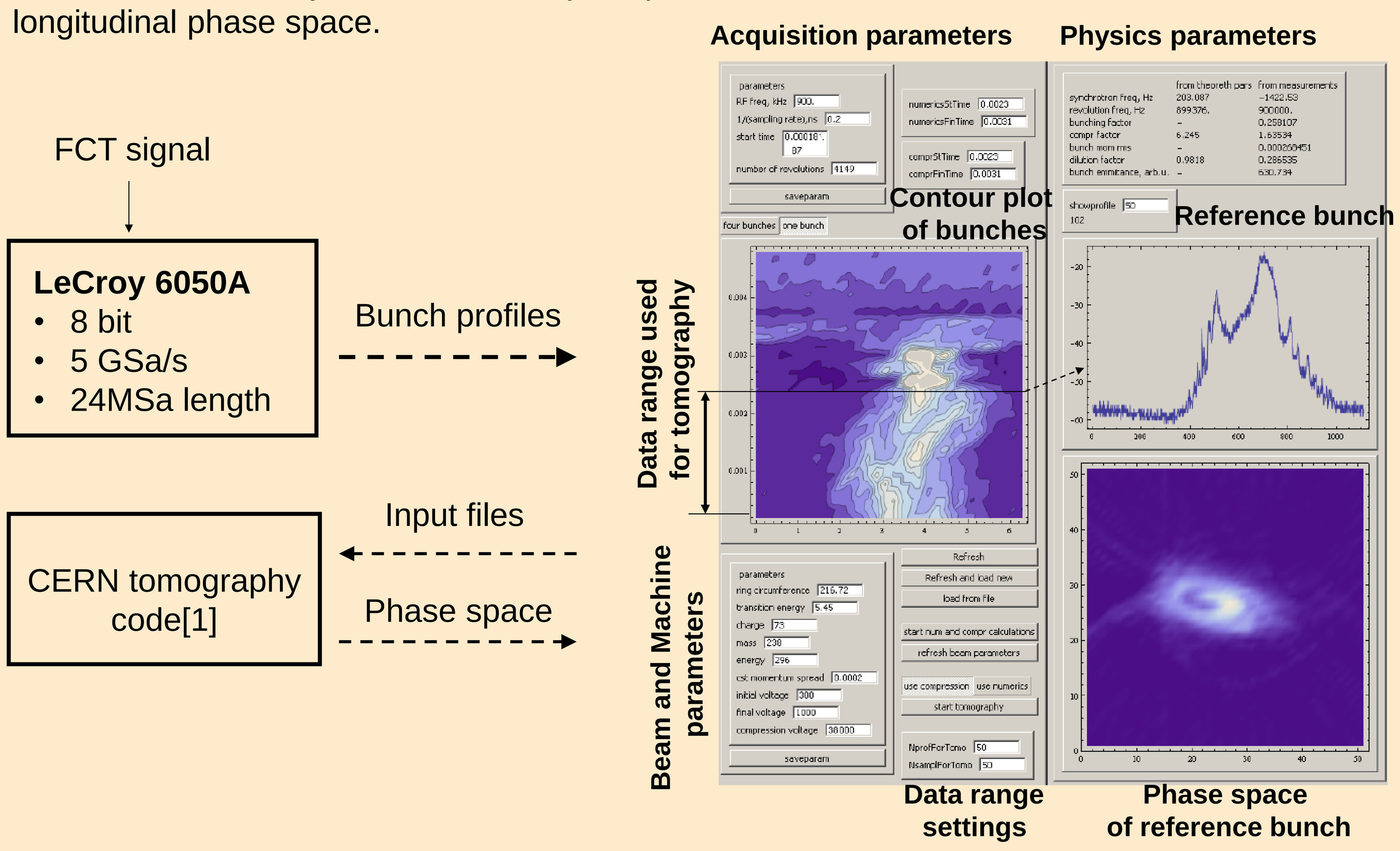


Fig. 1. Tomography diagnostics scheme in the SIS 18.

Measurement results

A typical SIS18 synchrotron cycle at GSI consists of injection plateau, acceleration ramp, plateau at top energy and fast or slow extraction. Particles are injected at a kinetic energy of 11.4 MeV/u from a linear accelerator. Applying slowly increasing RF voltage at a harmonic number h=4, four bunches are formed and afterwards accelerated up to the maximum possible energy of 1 GeV/u.
For the test measurements the fast bunch compression scheme at top energy was used.

Main parameters during test measurements:

Ion	U73+
RF harmonic during acceleration	h=4
Top energy	295 MeV/u
Recapture time	6 ms
Compression amplitude	38 kV
RF harmonic during compression	h=1

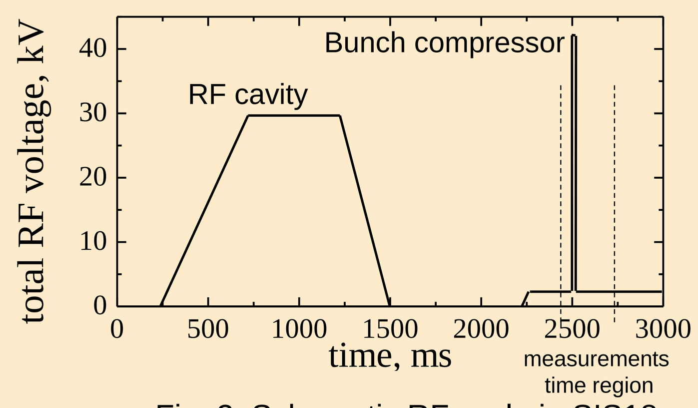


Fig. 2. Schematic RF cycle in SIS18 with bunch compression

The performance of the available measurement devices was also tested.

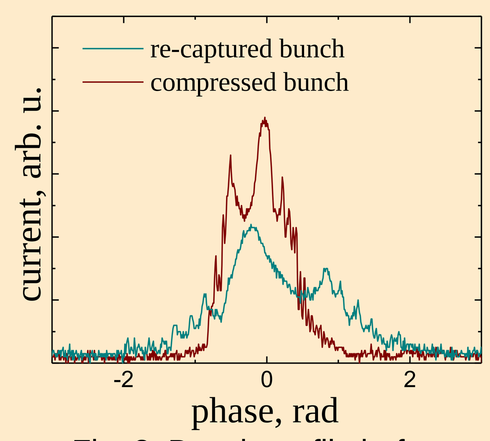


Fig. 3. Bunch profile before and after compression

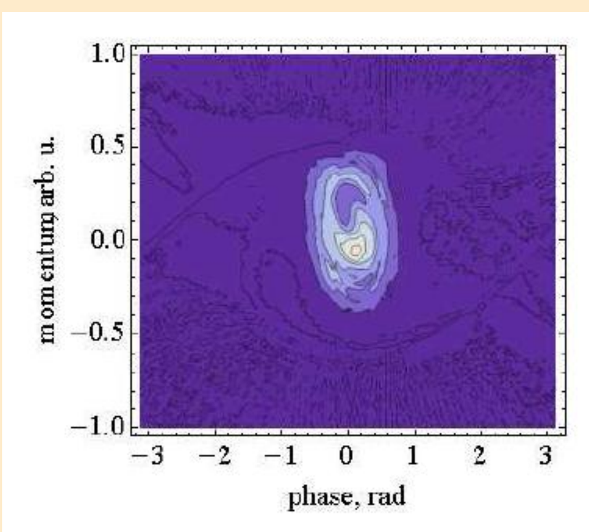


Fig. 4. Reconstructed phase space of the compressed bunch

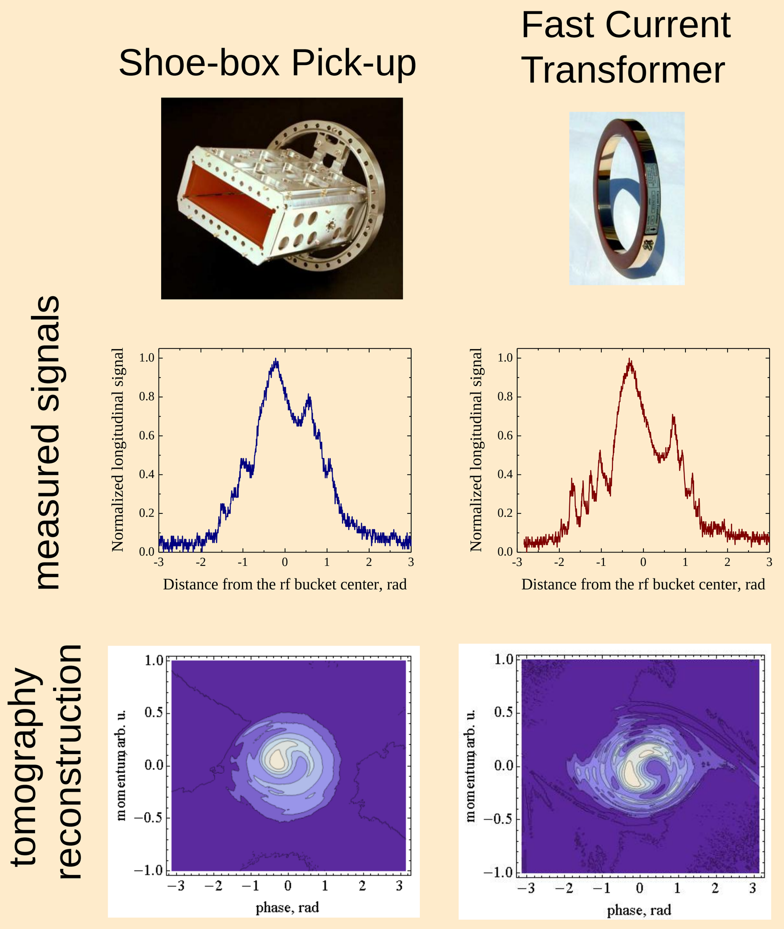
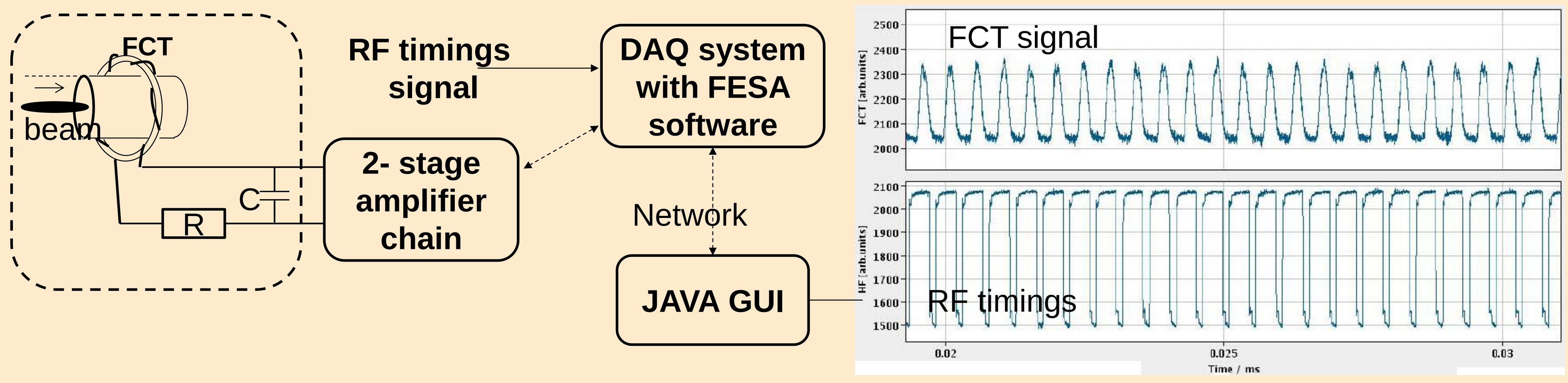


Fig. 5. Comparison of the data from the wide band FCT and position pick-up

The machine cycles of the future FAIR rings include a number of RF manipulations: RF capture, fast compression, merging, batch compression. Tomography reconstruction will serve as a tool to test the performance of these processes.

Present developments of the FESA based DAQ

Layout of DAQ system



The SIS18 is equipped with a wide-band FCT (FCT-260-50:1-LD-H from Bergoz) with an upper bandwidth of 650 MHz. The FCT signal is directly fed to a 20 dB amplifier at the output. In a second stage, a variable-gain Femto DUPVA-1-60 amplifier matches the signal level to the ADC input range in the electronics room. The amplifier gain was controlled by a 32 channel Struck IO board. A FESA (Front End Software Architecture) [2] class on the front-end CPU controls amplifier stage, reads out the ADC module and stores the data. FESA has been developed by CERN and has been chosen as standard for beam instrumentation DAQ systems for FAIR. The FCT signal is recorded by a 4 channel Struck SIS3350 ADC with 500 MHz maximum sampling frequency, 12 bit resolution, and 1 GByte on board memory. The ADC is capable to do acquisition in multi-event mode.

Test of the multi-event mode

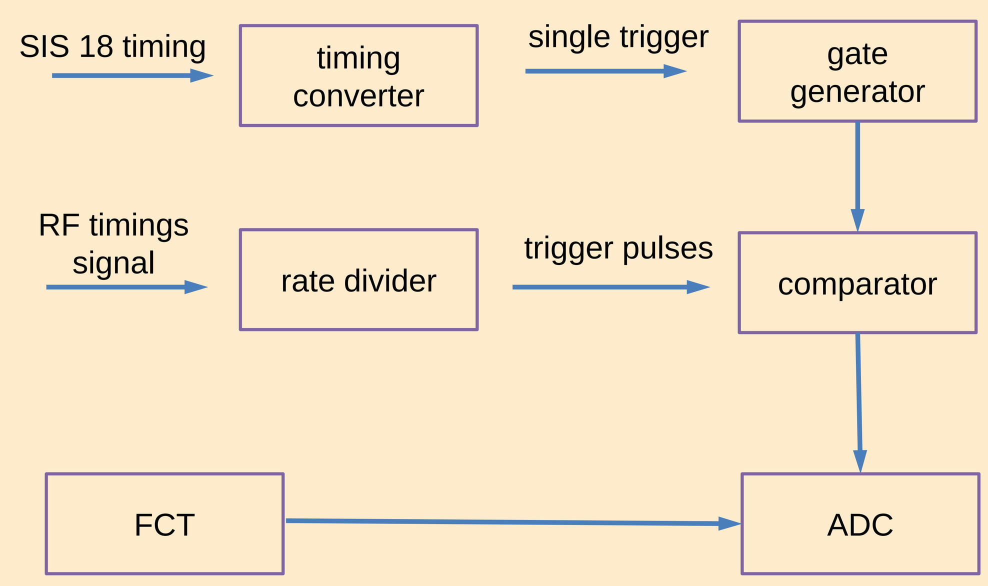


Fig.6. Schematic hardware setup for multi-events measurements

Triggering system is realized presently using NIM logic. Thus, some parameters could be changed only manually. A single board electronics which can be controlled remotely via the FESA class has been developed.

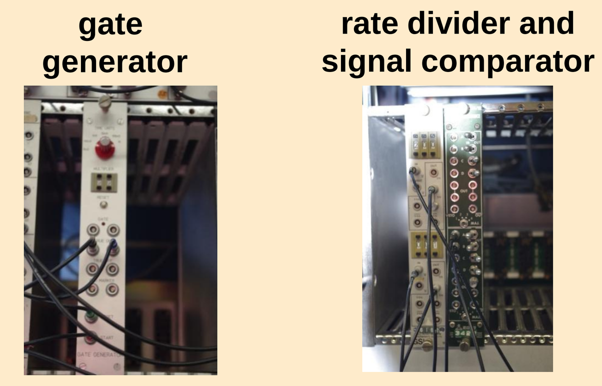


Fig. 7. NIM modules used for multi-triggering

The FESA class switches the ADC to the multi-event acquisition mode. The number of events and the acquisition length for each event are user defined acquisition parameters controlled via the JAVA based GUI. The raw data can be previewed as “mountain range” plot.

Main parameters during test measurements:

Ion	U73+
RF harmonic during acceleration	h=4
Top energy	350 MeV/u

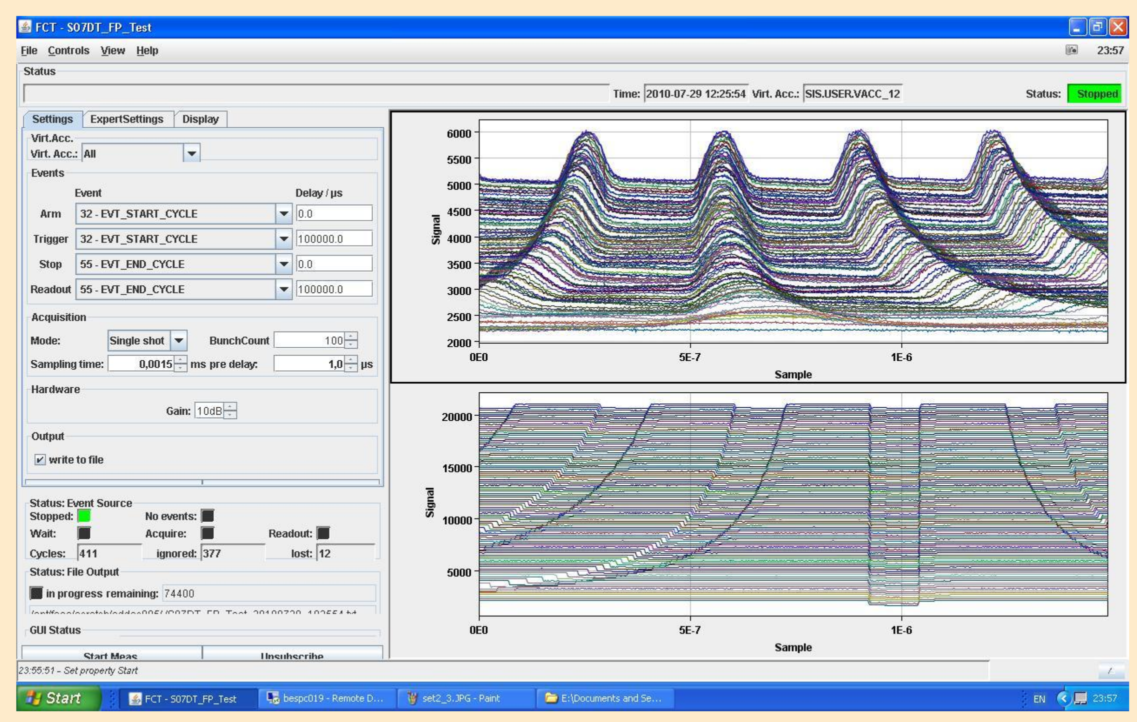


Fig. 8. Beam profiles and RF reference timing measured during acceleration. The time between two consecutive events is 3000 revolutions. The vertical axis represents the time in arbitrary units along the machine cycle.

Example of an immediate application

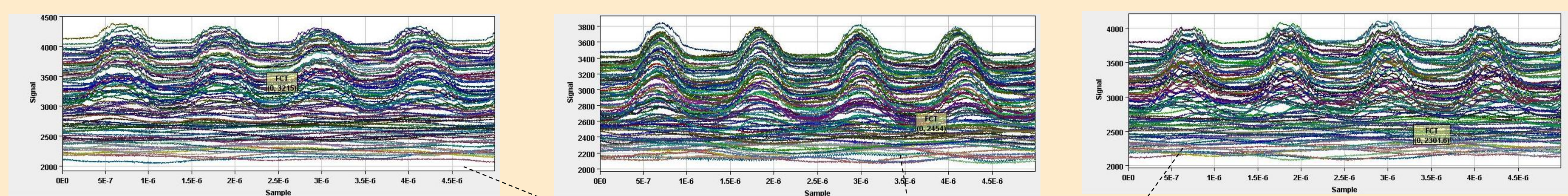


Fig. 9. Mountain range plot of bunches during RF capture at different RF frequencies

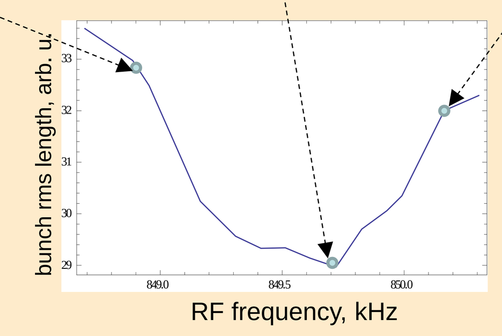


Fig. 10. Bunch length after RF capture at different RF frequencies

By measuring the bunch length at the end of RF capture, the optimal RF frequency can be obtained.

Summary and outlook

The new DAQ system is based on FESA and has been built with two aims in mind, routine machine tuning and dedicated beam physics experiments. The initial development phase was concluded by successful test measurements in SIS18. In the next phase, the analysis on the DAQ system will be enhanced in order to provide online trending plots of basic parameters such as bunch length or bunch position with respect to the RF timing. This includes also measurement of the synchrotron frequency derived by the bunch position oscillation. Successful implementations of the tomographical algorithms on the Graphics Processing Units are well known worldwide. On a GPU a speedup of 1-2 orders can be achieved in comparison to a CPU. Based on previous experience with the SIS18 tomography software one can expect analysis times of a few seconds in typical applications. This, it is also planned to develop a FESA based longitudinal tomography software on a dedicated PC equipped with a GPU.

References

[1] S. Hancock, P. Knaus, M. Lindroos, Tomographic measurements of longitudinal phase space density, European Particle Accelerator Conference, Stockholm, Sweden, 1998.

[2] T. Hoffmann, M. Schwickert, G. Jansa, FESA at FAIR – the front-end software architecture, PCaPAC 2008