The Diamond Light Source Control System Interface to the Libera Electron Beam Position Monitors

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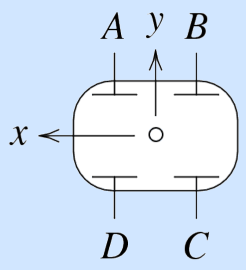
LIBERA SYSTEM OVERVIEW



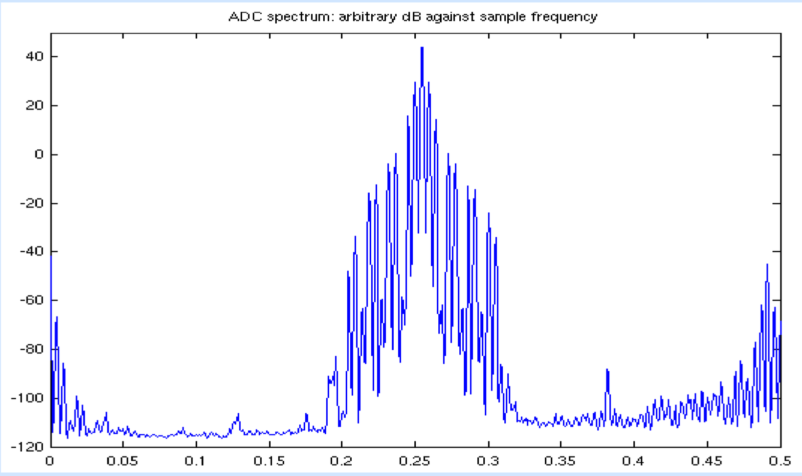
$$x = K_X \frac{A-B-C+D}{A+B+C+D} + X_0$$

$$y = K_Y \frac{A+B-C-D}{A+B+C+D} + Y_0$$

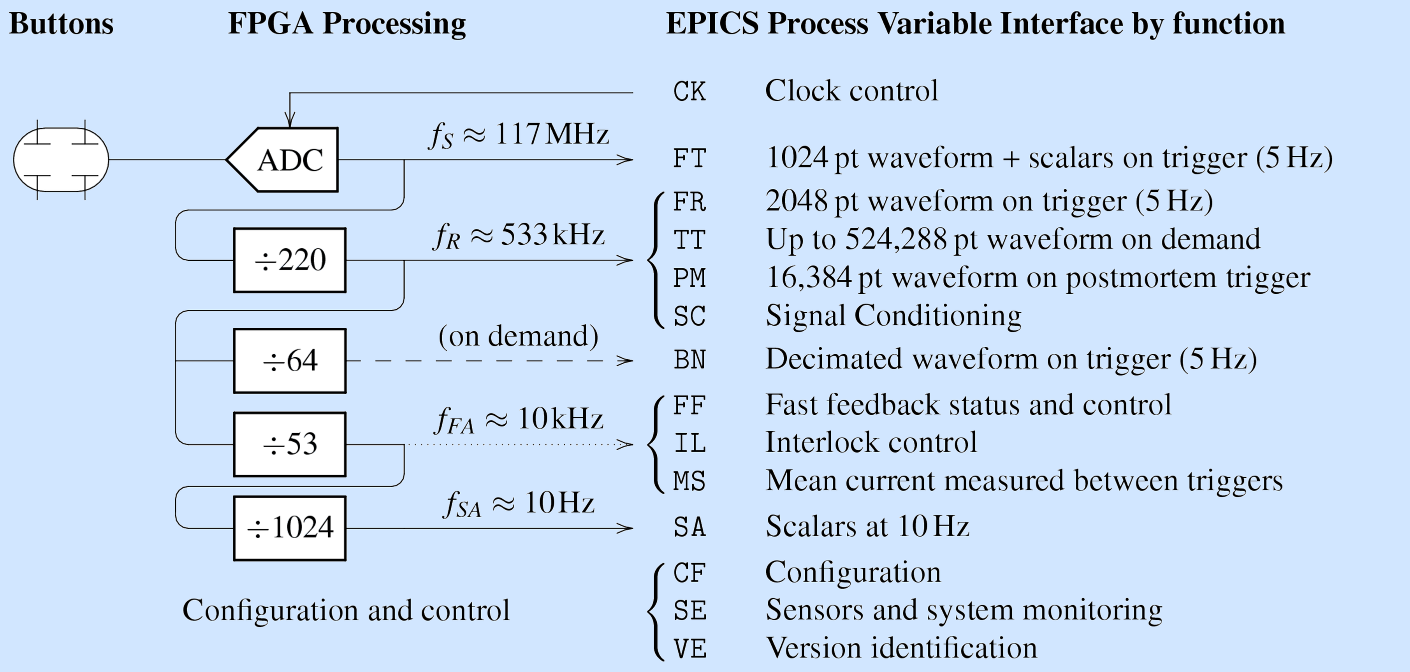
$$I = K_I \cdot (A+B+C+D)/G$$

Signals from the electron beam are picked up by four buttons (A, B, C, D) and are used to calculate the beam position x, y and the beam current I.

- Calibration factors K_x, K_Y are determined by button geometry.
- Offsets X_0, Y_0 are measured by beam based alignment.
- Current scale K_I is dynamically calibrated against the DCCT.
- G is the currently configured RF board gain.

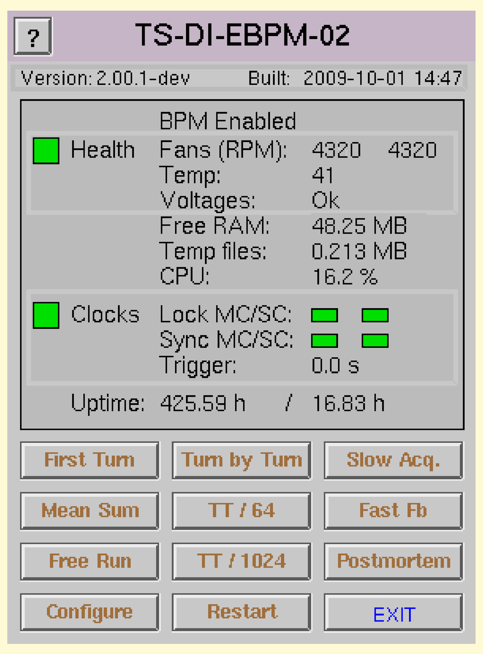


The raw button RF signal is bandpass filtered to f_{RF}±5MHz, digitally sampled at f_S≈220/936 f_{RF}, then processed in the Libera FPGA. This figure shows the spectrum of the signal captured by the ADC.

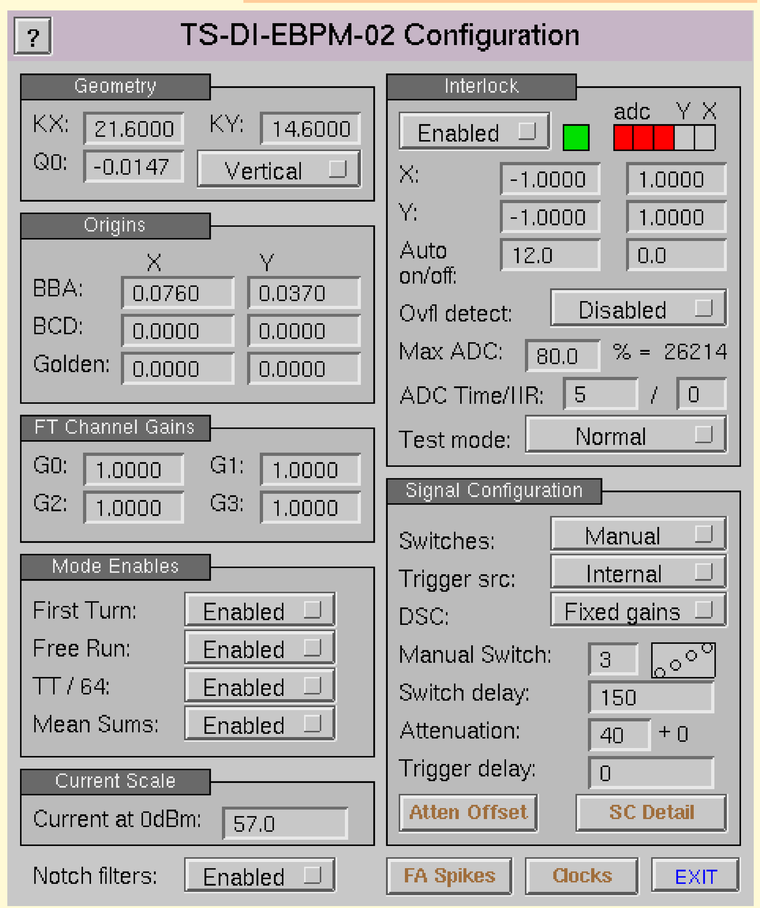


SYSTEM SOFTWARE

Individual overview screen for each Libera, shows health and status, together with links to more detailed displays.



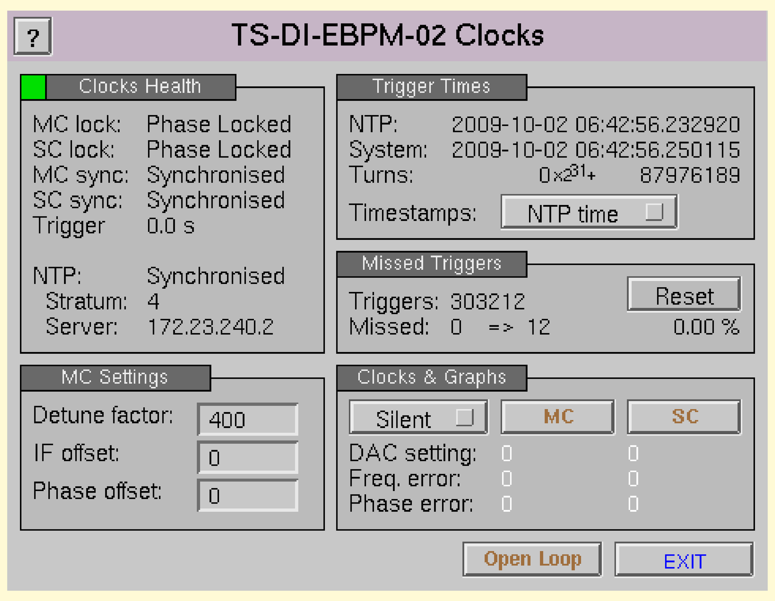
Configuration (CF)



This screen shows a number of configuration settings for Libera, including scaling factors, position offsets, interlock configuration, rotating crossbar switch and attenuator control together with a number of other options.

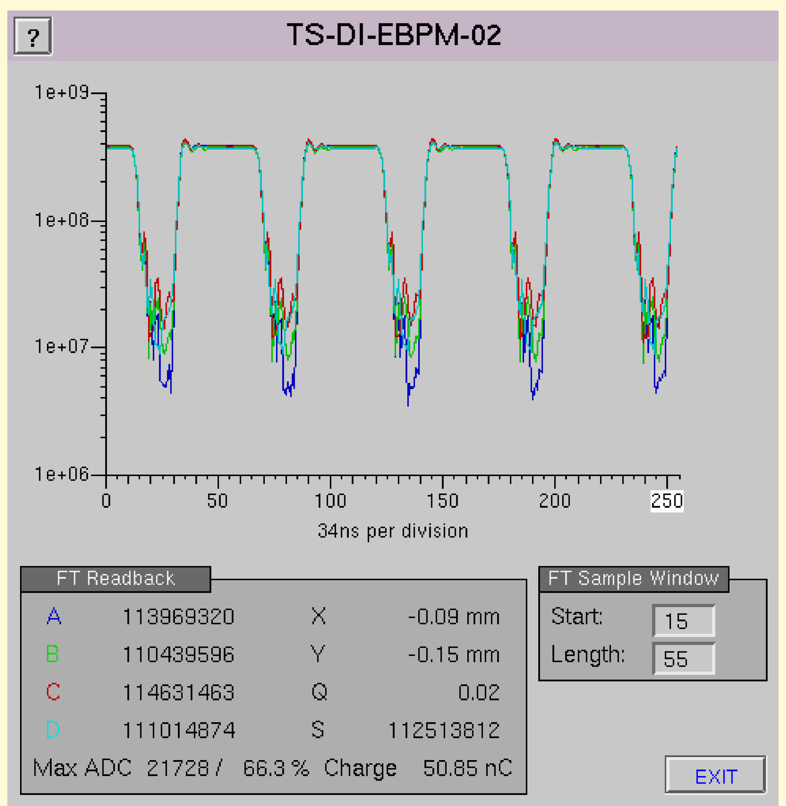
Clock Control (CK)

The clock PLL is controlled and monitored via this screen which also shows PVs for managing timestamps and clock synchronisation.



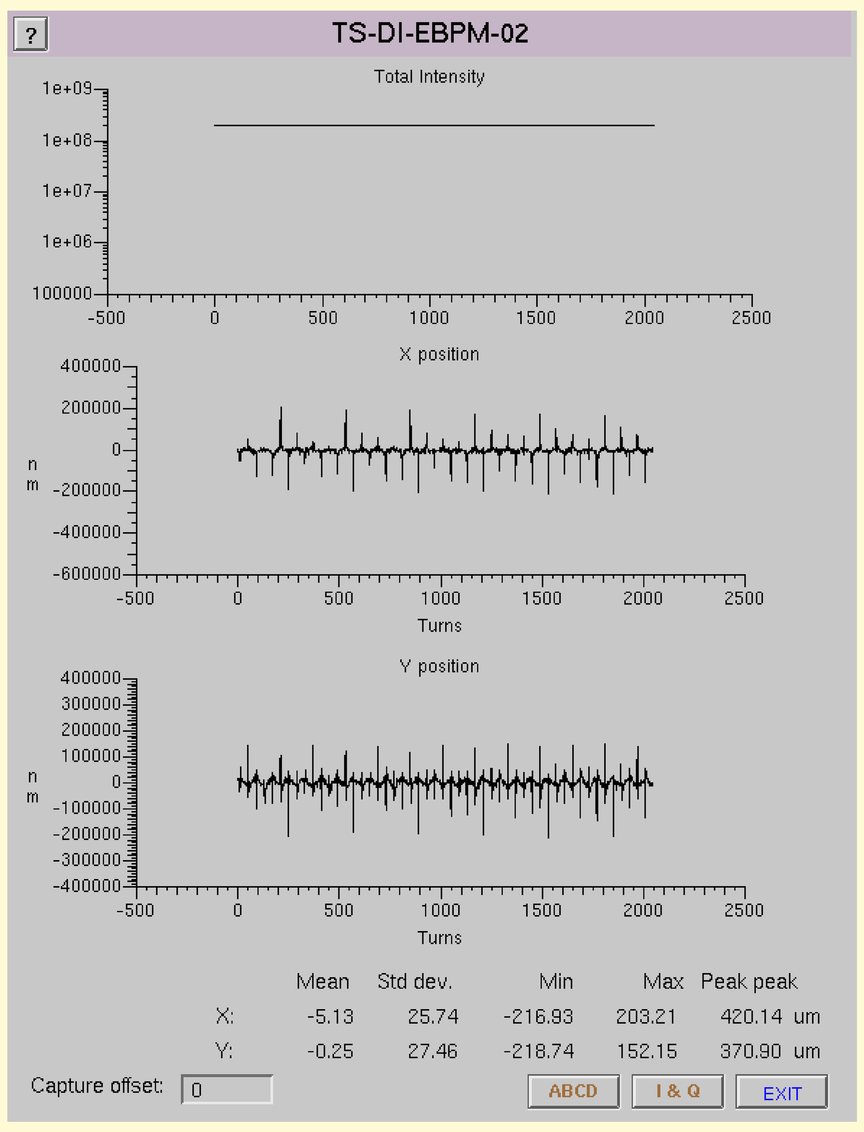
ADC data (FT)

On this screen the ADC sampled waveform is shown frequency shifted to DC. The envelope of the fill pattern is visible, convolved with the RF bandpass filter. From these waveforms "first turn" positions are calculated.

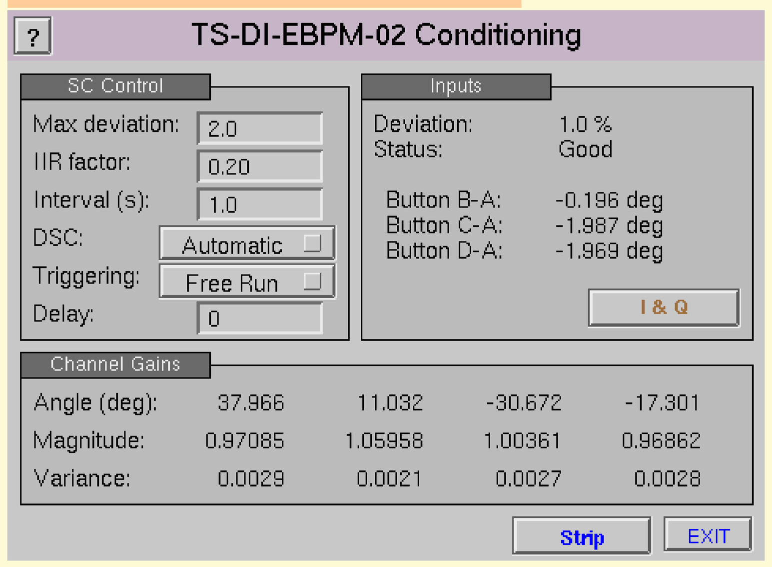


Turn By Turn (TT)

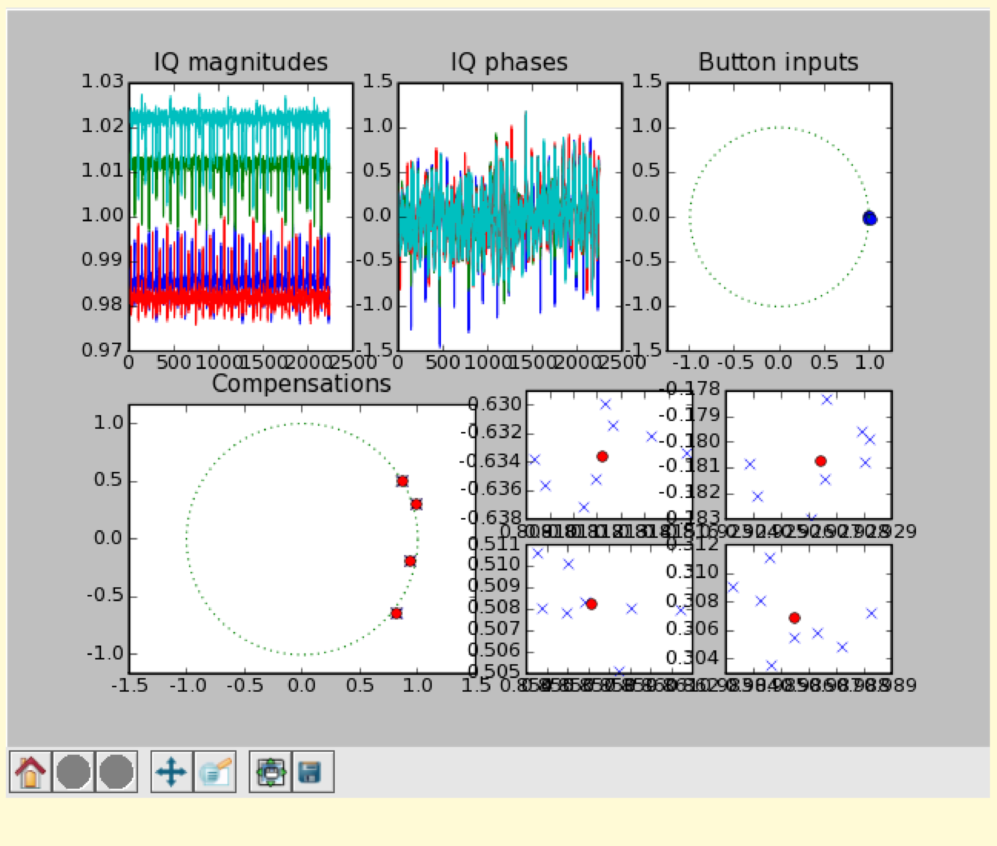
Turn by turn data, captured on trigger, showing spikes from switching transients. During machine physics investigations the switching is disabled to avoid these spikes.



Signal Conditioning (SC)

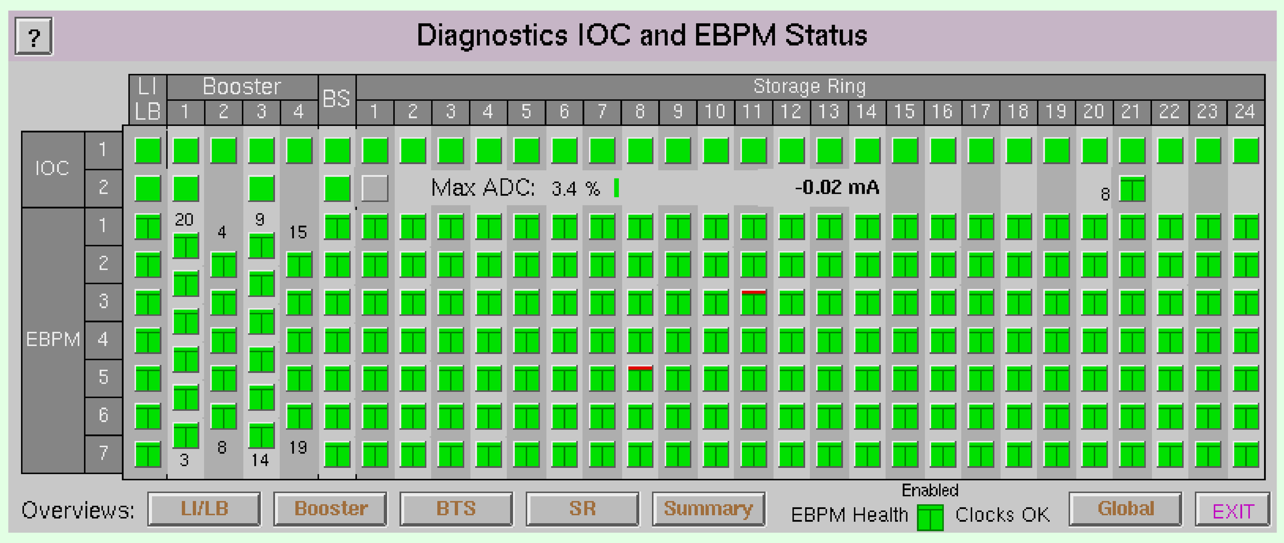


Signal conditioning is managed through the screen above, and the figure below shows its operation. Because the cable lengths are matched, the four button inputs are in phase, but the individual channel gains are distributed over ±30° or so and ±5%. We still see switching spikes in the magnitude data, but much smaller than they would be if not compensated.

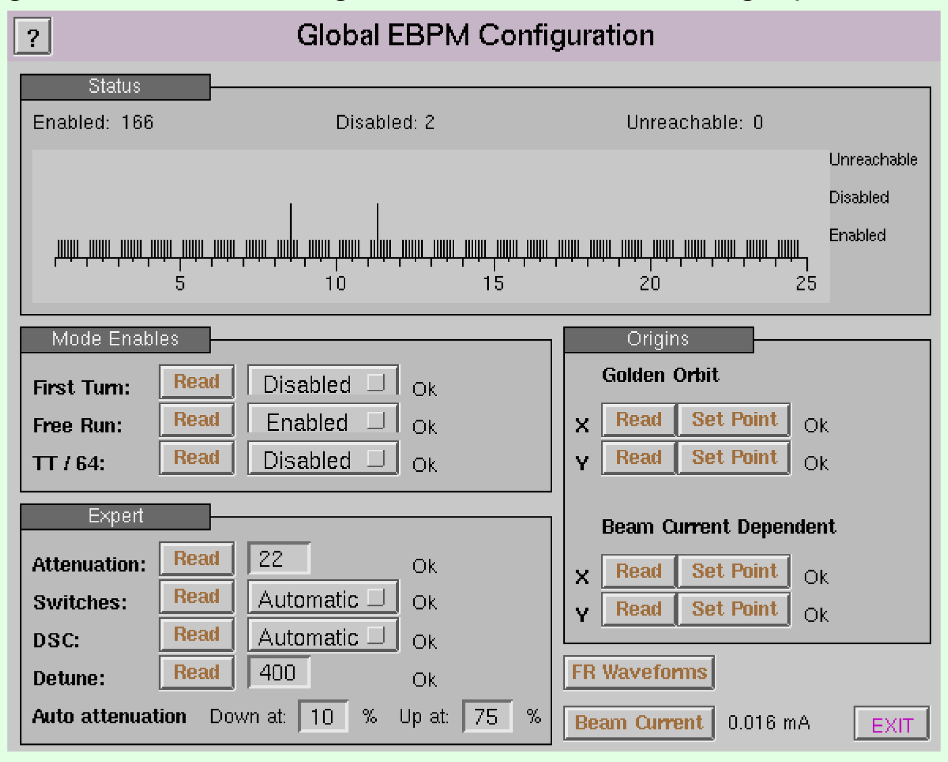


SYSTEM INTEGRATION

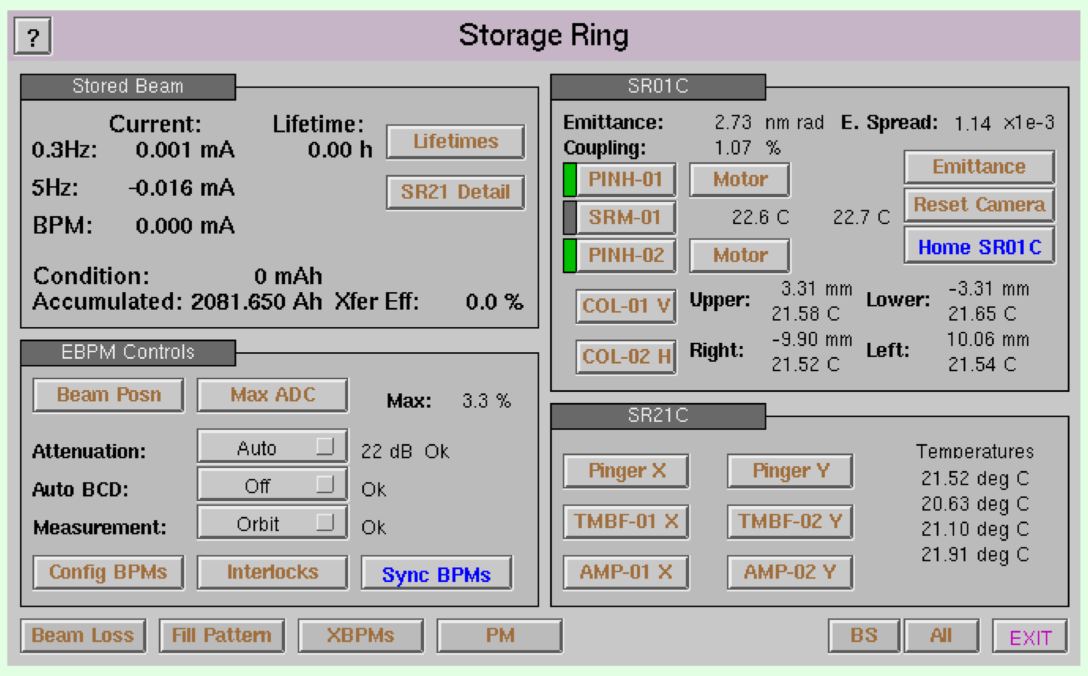
This controls Overview screen shows the status of all Libera EBPMs in the machine, as well as the status of all other Diagnostics IOCs. Any Libera can be selected for a more detailed view of the associated status, configuration and data.



More detailed overview of the functions provided by the Concentrator. Shows waveform with aggregate status of all Liberas, together with controls to automatically manage gains and other settings on all Liberas from a single place.

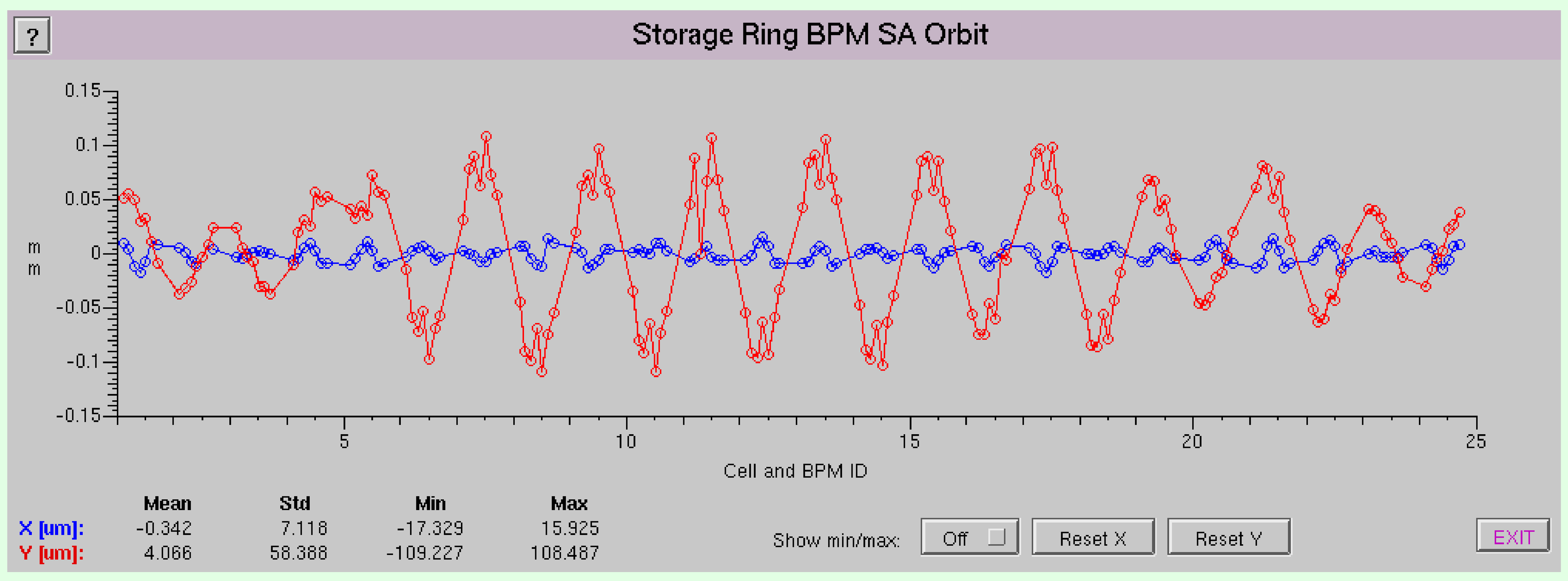


This display aggregates all the important Diagnostics controls for the storage ring including a number of global Libera options provided by the concentrator, for example the measurement mode controls the clock detune and turns the RF crossbar switch rotation on or off.

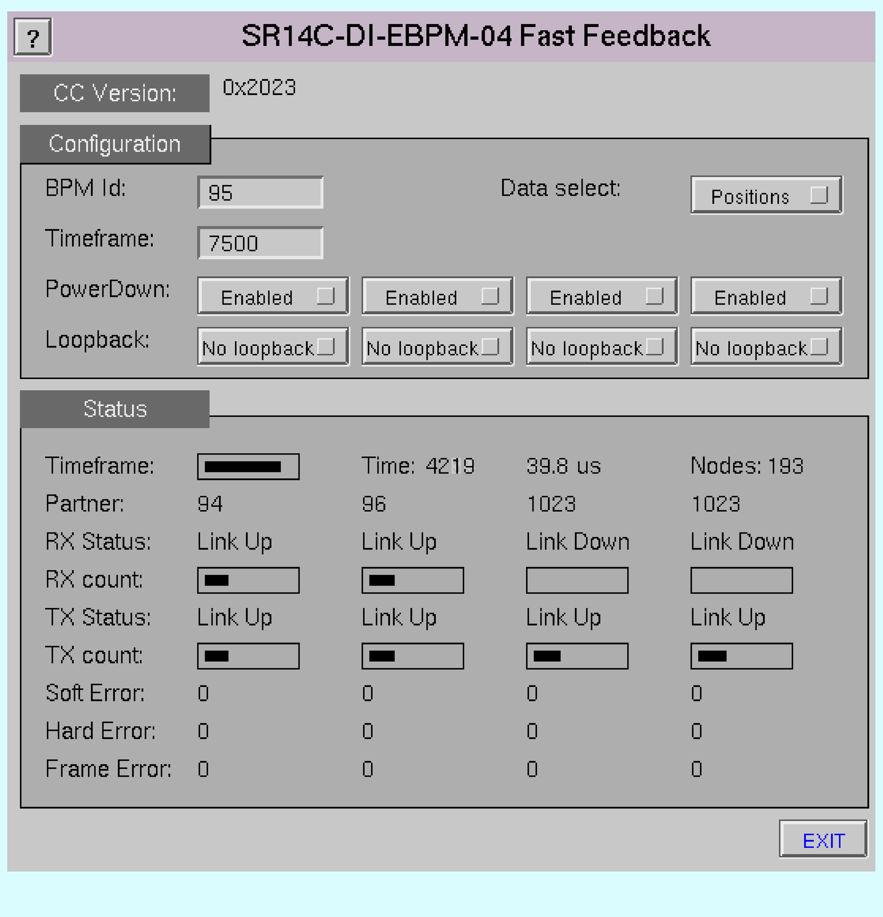


Slow Acquisition (SA)

Global view of beam position before orbit correction, updated every 100ms. During fast feedback the orbit deviation is well under a micron, here we see the uncorrected orbit during machine startup.

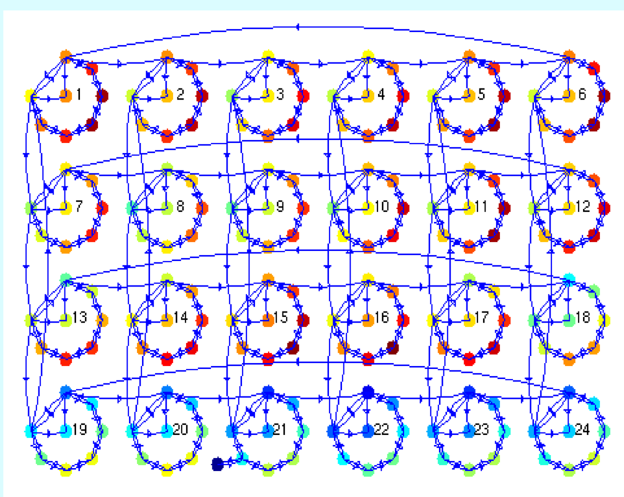


Fast Feedback (FF)



Fast feedback network. The figure below shows the topology of the fast feedback network with 7 Liberas in each cell connected in a circle, and the entire storage ring connected as a 6x4 torus. Nodes are coloured by the time taken for communicate to complete (up to 42μs).

The screen to the left shows the fast feedback links on an individual Libera; these are compiled to form the figure below.



Postmortem (PM)

The postmortem data is automatically archived from all Liberas each time a postmortem trigger is generated. This particular postmortem shows a machine protection trip generated by the Libera position interlock: one EBPM jumped in position (due to a cabling fault), forcing a fast feedback response from the rest of the system, which then exposed a bug in the fast feedback network as the entire beam was driven away from nominal position. Other beam trips have their characteristic postmortem signatures.