

OPEN XAL STATUS REPORT 2022

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Abstract

The Open XAL accelerator physics software platform has been developed through international collaboration among several facilities since 2010. The goal of the collaboration is to establish Open XAL as a multi-purpose software platform supporting a broad range of tool and application development in accelerator physics and high-level control (Open XAL also ships with a suite of general-purpose accelerator applications). This paper discusses progress in beam dynamics simulation and updated application framework along with new generic accelerator physics applications. We present the status of the project at each participating facility and a roadmap for continued development.

SNS STATUS

The Spallation Neutron Source (SNS) continues to use Open XAL as the main control room accelerator physics tool. The SNS switched to the latest Java 17 LTE release in Control Room. Several new features were implemented for linac tuning and emittance measurements in the ring.

Scaling Magnets in Superconducting Linac

One routine operational task in the SNS is to rescale the magnetic fields in the ring and transport lines after changing the final beam energy in the linac. Until recently, this task was performed with the Open XAL Energy Manager application. Since Energy Manager has a complicated logic and interface, it has been replaced by an addition to the Superconducting Linac (SCL) Tuner Wizard. The new addition to SCL Wizard measures the final beam energy in the linac and rescales the downstream magnetic fields accordingly. A screenshot of the magnet scaling addition is shown in Fig. 1. On the left panel, there are new buttons for initialization and setting new values, and a list of all beam transport lines after the SCL. The user can calculate the scaling coefficients for H- ions or protons (the SNS beam is composed of H- before the stripping foil in the ring, then protons after the foil) by using the functionality of the top right panel. The user can also choose particular beam lines and magnets for scaling. The red color is a warning sign that some of the power supplies in the sequence will not be able to set the calculated field.

Cavity Failure Test in SCL

The Cavity Failure Test addition to the SCL Tuner Wizard application (Fig. 2) demonstrates an automated retuning procedure of the SCL in the case of the failure of one of the SCL cavities. Before starting this part of the SCL Wizard,

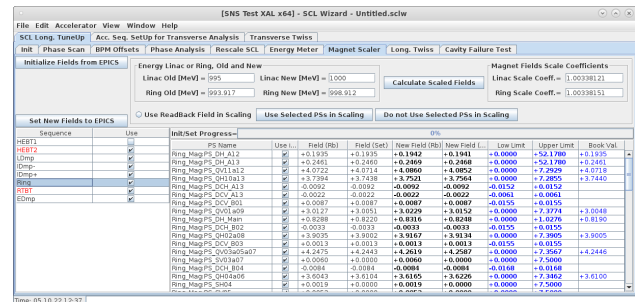


Figure 1: Magnet scaling part of the SCL Tuner Wizard Open XAL application.

the user should define which cavity should be monitored, save and prepare Amplitude Feed Forward waveforms for the downstream cavities that will be used in the correction, and define the goal for a detuning parameter for the failing cavity. The algorithm and successful results of using this test are described in [1]. The Cavity Failure Test addition is not intended to be used during SNS production: this type of cavity failure is not critical to the SNS availability metrics and is handled by operators with thorough documentation of the circumstances of the event.

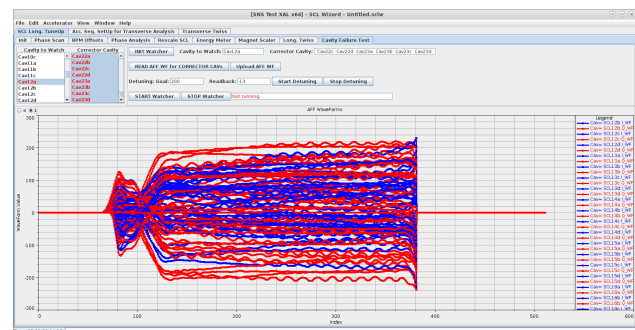


Figure 2: Cavity Failure Test Addition to SCL Tuner Wizard.

4D Emittance Measurement in SNS Ring

A critical component of efforts to produce an approximately self-consistent beam [2] in the SNS ring is to measure the four-dimensional (4D) beam emittance [3] during accumulation. The 4D emittance can be reconstructed from at least four horizontal, vertical, and diagonal wire-scanner measurements with different transfer matrices connecting the wire-scanner and reconstruction locations [4]. An Open XAL application has been developed to carry out this measurement using four wire-scanners in the ring-target beam transport (RTBT) section of the SNS.

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The first task of the application is to optimize the lattice optics for the reconstruction. Control of the phase advances between each wire-scanner is limited: there are two power supplies associated with the quadrupoles in the wire-scanner region — one controls quadrupoles {QH18, QH20, QH22, QH24} and the other controls quadrupoles {QV19, QV21, QV23, QV25}. The application allows the user to control the horizontal and vertical phase advances at the final wire-scanner by varying the strengths of these quadrupoles while ensuring that the beam size is kept small in the wire-scanner region and at the spallation target.

The second task of the application is to perform the reconstruction in the control room. Transfer matrices and beam sizes are extracted from data files containing the measured beam profiles and the PVLoggerID from the time of the measurement. The 2D projections of the reconstructed covariance ellipsoid are displayed along with the measurement lines. Measurements can be grouped to compute the emittances as a function of time during accumulation. Figure 3 shows the application GUI after performing a multi-optics reconstruction of a production beam.

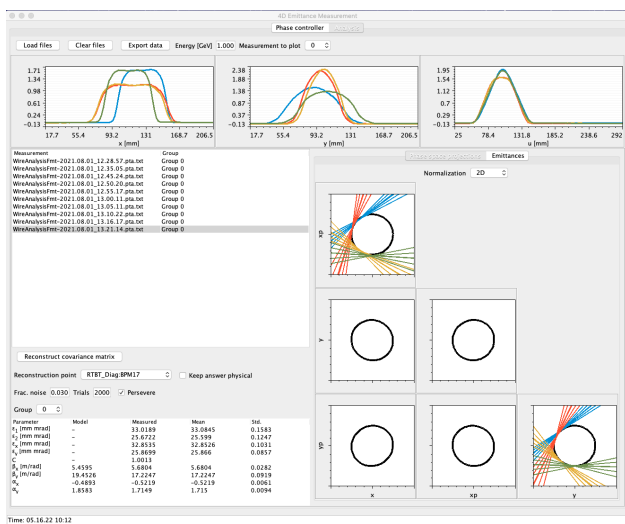


Figure 3: Emittance measurement application.

ESS STATUS

Since our last report [5], the main efforts at ESS have been to improve the code quality and prepare the applications needed for the next stages of beam commissioning, which include the RFQ, MEBT, and the first DTL tank. It is the first time we have used Open XAL to control quadrupole magnets and RF cavities at ESS.

Online Model

We continued extending the Open XAL online model to match the specific requirements of the ESS Linac.

A new solver was implemented, called Synchronous-Tracker, which computes the synchronous phase in the RF cavities. This feature is useful when cavities are described using field maps or multiple RF gaps.

The model was updated to include links between readback and setpoint PVs. There is also a new method to set a value to a PV and wait for the readback to match the setpoint within a tolerance. This was found to be quite useful, for example, for scanning the LEBT Iris, which has a rather slow stepping motor.

Finally, since the electromagnets at ESS are controlled by setting a current value, not a field value, we included an option to define a conversion factor between field and current so that we can set the current from the Open XAL model. This means that the virtual accelerator now also creates current PVs, which is useful for testing applications.

Transverse Matching Script

In the last commissioning, we tested the first version of the transverse matching application. It is a Python script that uses widgets to control and analyze the wire scanners in the MEBT section. To keep the application as simple as possible, only the step size and start/stop positions for the scans are configurable by the user. The script launches the selected wire scanners simultaneously and saves the data in a HDF5 file. The file can be loaded in the same application, which performs a Gaussian fit on the profiles and displays the measured sigmas against the default or live optics in the linac. One can then search for initial beam envelope parameters such that the difference between the model and measured beam sizes at the wire positions is minimized. Figure 4 shows an example of the analysis of data acquired from 3 wires compared to the machine optics (design or live) and fitted initial beam parameters.



Figure 4: Example of data acquired from 3 wires compared to the set optics and fitted initial beam parameters.

Accelerator Simulator

After the commissioning of the ion source and the LEBT, we realized that the LEBT Application [6] was very useful. We developed a new application, called Accelerator Simulator, that generalizes the LEBT application for any section of

the linac. It allows us to perform simulations using *design* or *live* settings, and to display measurements from diagnostics.

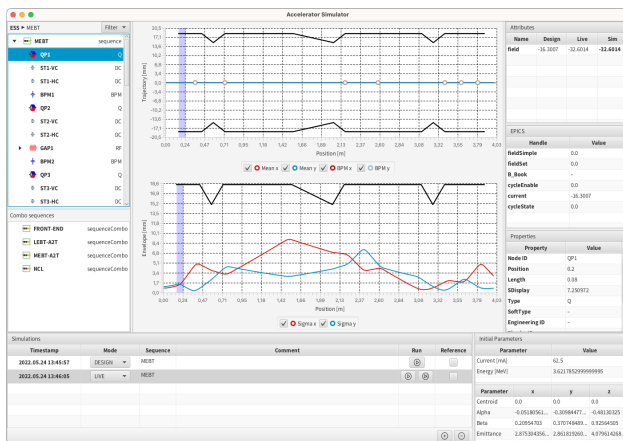


Figure 5: Screenshot of the Accelerator Simulation application.

Figure 5 shows a screenshot of the Accelerator Simulator application. On the left panel, the user can select sequences and elements. On the right panel, the settings of the elements are shown, both design values and live parameters. Finally on the bottom part, the user can define simulations and modify the initial parameters.

Logbook Integration

In Sept. 2021, we switched our logbook server at ESS from ELOG [7] to Olog [8], but both servers coexisted during some time. To make it possible to write post entries in any logbook, a new logbook extension was developed. The extension looks for service providers implementing the logbook service, which can be included as plugins. Two plugins are available now, one for Olog and one for ELOG. The extension supports more than one plugin at the same time.

The FxApplication extension was also upgraded to use this new logbook extension. A screenshot of the new entry dialog is shown on Fig. 6.

Scanner Application

Scanner application continues to be one of the most used applications during ESS commissioning. A generic multi-dimensional scanner has many use cases. The application has received numerous minor fixes and improvements. HDF5 output is now standard and has been reworked to more closely resemble the Nexus formatting we intend to use at ESS. CSV export was added. The aforementioned set and verify readback functionality is now used by this application. We changed the scan order to “sawtooth style” which is important for elements that can trip the machine if changed too rapidly, e.g., solenoids. We added an option to include a reversed scan as well as a one-by-one scan, which, instead of scanning all combinations of the selected parameter space, scans one parameter at a time while keeping the other parameters at their reference values.

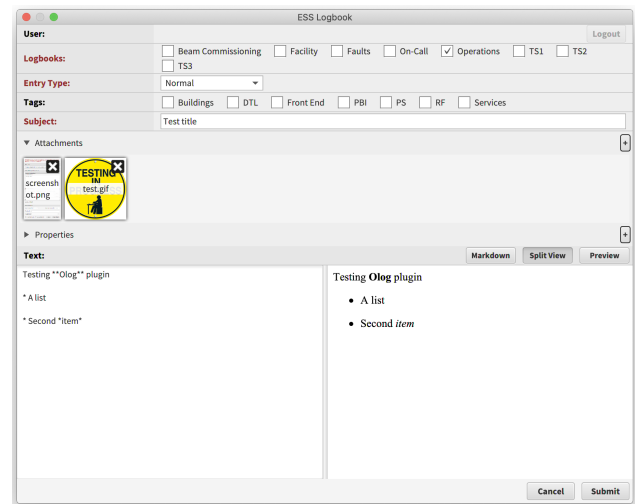


Figure 6: Dialog to post a new entry in Olog from Open XAL JavaFX applications.

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