ISBN: 978-3-95450-184-7 doi:10.18429/JACoW-IPAC2018-THPAK069

OPEN XAL STATUS REPORT 2018

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Abstract

The Open XAL accelerator physics software platform is being developed through an 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, new RF models, and updated application framework along with new generic accelerator physics applications. We present the current status of the project, a roadmap for continued development and an overview of the project status at each participating facility.

INTRODUCTION

Open XAL [1,2] is a generic open source software platform for accelerator physics. Open XAL is written mainly in the Java programming language but is accessible via any JVM based scripting language. It is used world-wide by different accelerator labs including: China Spallation Neutron Source (CSNS) in Dongguan, China; European Spallation Source ERIC (ESS) in Lund, Sweden; Spiral2 program at the Grand Accélérateur National d'Ions Lourds (GANIL) in Caen, France; and SNS in Oak Ridge, TN, USA.

We will discuss developments since the IPAC'17 conference [3]. Open XAL collaboration came up with various site-specific applications and general improvements of simulation techniques in online model.

ESS

At ESS, main efforts have been put in improving the site specific online model (JELS) and in the development of applications required for the first stages of the accelerator commissioning.

Online Model

The machine description is now imported from the official lattice repository, which uses the TraceWin [4] format, and the SMF xml files are generated accordingly.

Regarding the online model, several improvements were made. The main change was to modify all transfer maps so that the calculations were done in the laboratory frame of reference, which is the reference system used by Open XAL. Previously all matrices were calculated in the beam reference frame.

The RF field map element was optimized ~30% in speed by using a first order integrator. A similar approach was followed to create two new elements, used for the solenoids in the LEBT, in which it is possible to import a field map described in Cartesian coordinates (ESSMagFieldMap3D) or in the longitudinal and radial components (ESSSolFieldMap), the later assuming cylindrical symmetry.

A new technique to treat the field map with a Hamiltonian model is under investigation and it is discussed in [5].

A new DTL tank element was introduced and it uses the same definition for the Transit Time Factor as TraceWin. This allows to set the RF phase of the first gap and the algorithm calculates the phase of all the subsequent gaps, just like in the DTL tank element provided in Open XAL core.

All new elements were benchmarked against TraceWin, as well as the full accelerator lattice, and results were in very good agreement. For more details, see [6].

Applications

The ESS logbook was integrated in Open XAL so that applications can post new entries from a dialog or generate automatic messages. A new framework for physics applications is being developed based on JavaFX and JacpFX [7] and it is planned to port all new applications once the framework is ready. For the moment a version that adds a tool bar with the same functionality as the Swing version and also the e-Log posting capability and a link to the User documentation Wiki is already being used. An expansion of the FxApplication framework, as it is called, is expected to be released later this year.

An Open XAL configurator application was released. This is a simple tool to configure some of the Open XAL settings, as the default optics, logbook server address, and the status of the authentication system RBAC.

For commissioning a LEBT viewer application was created. In this application the trajectory and envelope along the LEBT and the commissioning tank are displayed together with readings from diagnostics (see Fig. 1). From the application it is possible to manipulate some of the magnets and power supplies from the source and LEBT and it is also possible to perform a simple matching based on diagnostics readings (from profile and emittance monitors). A more detailed description of this application can be found in [8].

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Figure 1: LEBT application GUI interface. On the top the Menu Bar is created from the FxApplication class. The plots show the trajectory (top chart) and envelope (bottom chart) together with NPM readings. On the bottom of the application panel there are 4 tabs: beam input parameters, input values for the LEBT magnets, LEBT diagnostics display and input values for Ion Source magnets and power supplies.

The Scanner application allows a multidimensional scan of any number of variables. A new widget has been developed to quickly select multiple channels to read or write to. As for other applications the data are stored in XML files afterwards. It is possible to scan only a sub-set of the channel ranges by analytical formulas that accept most common mathematical operations with x_1, x_2, x_3, … as aliases for the writeable channels. Configuration such as time delay between data acquisitions and multiple acquisitions at each scan point have been added. There is little analysis of the data included, so the user is for now expected to rather have their external scripts or similar which reads the XML file and do their own analysis. An example of how a LEBT corrector scan could look like is shown in Fig. 2, using the Virtual Accelerator to set up the virtual EPICS server.

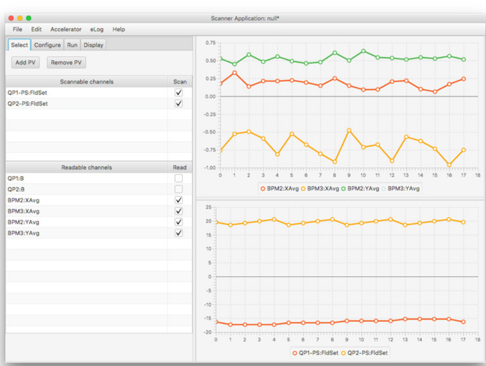

Figure 2: Scanner application GUI interface. On the top the Menu Bar is created from the FxApplication class. The scanned PVs are selected from the left panel and displayed on the right. On top is the reading from the BPMs and on bottom the scanned magnetic fields.

All relevant applications for the Ion Source and LEBT have been recently tested in the Control Room, with successful results. The tests were intended to verify the system configuration and the communication with the controls racks but disconnected from the accelerator hardware.

For the next commissioning step a trajectory correction application is under development. Two correction methods are included so far: a 1-to-1 and a SVD correction. The matrices used can be extracted from the machine model or can be measured. It is possible to define machine blocks where a subset of the machine BPMs and steerers are selected and are independent of the XML file sequences definitions. The overall trajectory can be corrected to the BPM zeros or to a predefined reference trajectory. To complement this application a Trajectory Display Application was also developed. A screen shot of both applications is shown in Figs. 3 and 4.

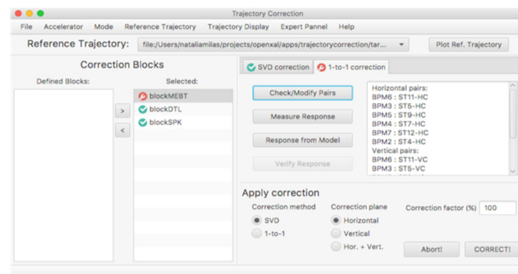

Figure 3: Trajectory Correction application GUI interface.

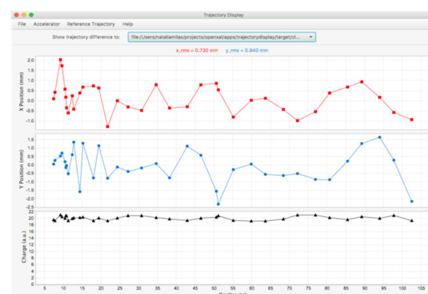

Figure 4: Trajectory Display application GUI interface.

SNS

At SNS, we are gradually updating software infrastructure used for building and deploying Open XAL in the SNS Control Room. We currently assessing replacements for the Ant build system and plan to make a final decision within a year. The Open XAL tutorial is also work in progress. Several linac tuning applications were improved.

Warm Linac Tuner Wizard

Initially, the goal of the tuning procedure for the normal conduction linac was setting the design parameters of the warm linac RF cavities, because the beam acceleration in the long RF structures of the Drift Tube and Coupled Cavity Linacs is defined by the longitudinal positions of the RF gaps. Then it was found that empirical corrections of the amplitudes and phases of the cavities can reduce beam loss and improve operational stability of cavities. The modified Open XAL application is now capable of scanning the whole warm linac after these empirical corrections and to record the existing response from the Beam Position Monitors that also measuring the arrival time of the bunch center as a phase parameter. The results

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of the scans can be reproduced later even after repairs related to the cavities RF systems or the RF signal distribution line electronics. Usually, the deviations of the empirical tuning results from the design values are not big. They are on the level of a few degrees in phases and a few percent in the cavity amplitudes.

Figure 5 shows a screenshot of the application with several cavity scans.

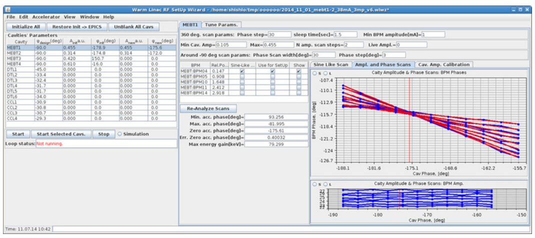

Figure 5: Warm Linac Tuner Wizard, cavities scans.

SCL Tuner Wizard

The SCL Tuner Wizard has been used for several years now. The recent improvement added more automation to the tuning process reducing the needed attention from the operator. Now the application can recognize the unsuccessful phase scan of the cavity, and it repeats the scans until reaching satisfactory results. At this moment the count of unsuccessful scans is set to three. Also, the application will not start the scan process if the cavity is not at the requested amplitude which was a frequent event in the past. The SCL Tuner Wizard now has a part to perform an automatic beam recovery experiment in the case of one cavity fault. This application should recognize a cavity failure, detune this cavity, perform the automated fast superconducting linac retuning keeping the same final energy, and restore the production beam. The time needed to perform these actions is an important parameter for future Accelerator Driven Systems.

GANIL

For alignment in the beam lines of the SPIRAL2 facility, a new application based on Open XAL has been created. The user selects the correctors and the beam position diagnostics. The program calculates the corrections to apply for centring the beam. This is done by solving the following matrix system [9].

$$C = -(A^t A)^{-1} A^t M^{-1}$$

Where C is the vector of n corrections to be applied, A is the matrix of the correctors effects on the beam position on the diagnostics, M is the vector of m measures on the beam diagnostics.

Reducing misalignment of the beam is equivalent to minimization of

$$x^2 = \sum_{i=1}^{m} \left[\sum_{j=1}^{n} A_{ij}\, C_j + M_i \right]^2$$

Each Monitor has a weight W_i to moderate its influence, if needed, so the final system to solve is:

$$x^2 = \sum_{i=1}^{m} (W_i \left[\sum_{j=1}^{n} A_{ij}\, C_j + M_i \right]^2) + \sum_{j=1}^{n} (Cj)^2$$

The A matrix is obtained by computing the effect of correctors on monitors, using the first order transfer map of the Open XAL online model for magnets with the Calculation Engine.

This application has been tested with success (1 to 4 iterations) on LEBT lines and is still in progress. The GUI is shown in Fig. 6.

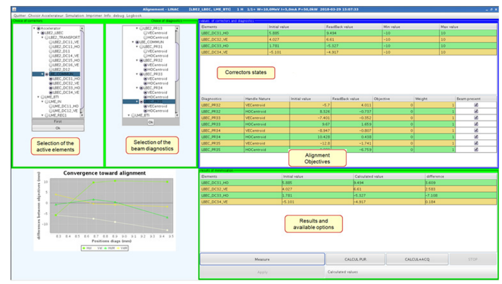

Figure 6: Alignment application for Spiral2 Lines.

CSNS

CSNS has made great progress in the past year. The first bunch of protons bombarded on the tungsten target on August 28, 2017. The average beam power has achieved more than 20 kW with the repetition rate of 25 Hz which means the parameter of the average beam power has met the acceptance goal (10 kW) of the CSNS project.

We modified the online model by adding fringe field of quadrupole for our RCS ring. From the measured betatron tunes and response matrix, it shows that the calculation value with the modified model agreed with the experiment well. The application of orbit correction for RCS ring was developed based on the orbit correction application available in Open XAL and successfully used in our RCS commissioning. We choose 20 orbits, which correspond to 20 different energy points respectively. So, we need to correct twenty tracks with the energy from 80 MeV to 1.6 GeV.

FUTURE PLANS

During the last year Open XAL collaboration mainly focused on creation of site-specific applications and looking for a replacement of existing GUI framework. A plethora of different applications that were made is a good evidence that the framework continues to be a modern and useful tool for accelerator-based facilities. We also observed significant fragmentation of code base between different institutions. Thus, we will need to concentrate on merging of our efforts to ensure that online models are easily interchangeable. We will also continue implementing the Open XAL development plans outlined in [3].

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ACKNOWLEDGMENT

This manuscript has been authored by UT-Battelle, LLC, under Contract No. DE-AC0500OR22725 with the U.S. Department of Energy. This research was supported by the DOE Office of Science, Basic Energy Science, and Scientific User Facilities. The United States Government retains and the publisher, by accepting the article for publication, acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this manuscript, or allow others to do so, for the United States Government purposes. The Department of Energy will provide public access to these results of federally sponsored research in accordance with the DOE Public Access Plan (`http://energy.gov/downloads/doe-public-access-plan`).

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