OPEN XAL STATUS REPORT 2017

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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 (Open XAL also ships with a suite of general purpose accelerator applications). This paper discusses progress in beam dynamics simulation, interaction with control system and software organization. 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] positions itself as a generic open source software platform for accelerator physics. The core Open XAL source is written in the Java programming language but is accessible via scripting. Initially developed by Spallation Neutron Source (SNS) at ORNL [3], it is used world-wide by different accelerator labs including: China Spallation Neutron Source (CSNS) in Dongguan, China, European Spallation Source (ESS) in Lund, Sweden with the collaboration of COSYLAB, Ljubljana, Slovenia, Spiral2 program at the Grand Accélérateur National d'Ions Lourds (GANIL) in Caen, France, and SNS in Oak Ridge, TN.

Many other institutions, such as Facility for Rare Ion Beams (FRIB) at Michigan State University in Lansing, MI and TRIUMF in Vancouver, Canada, have contributed to it.

SITE SPECIFIC STATUSES

Significant work on this project continues at the various sites with following details:

CSNS

The linac commissioning will be accomplished in the middle of 2017. The old XAL is still being used for linac commissioning. However, Open XAL is installed and tested in the new control room and migration is pending.

ESS

ESS continued to work on Open XAL to integrate it in its systems, to expand the capabilities of the model and to re-engineer the GUI creation process.

EPICSv4 is now available as a plugin in the site.ess.devel.pvaccess branch. The implementation was fully backward compatible with EPICSv3 and essentially transparent for the user.

The communication mechanism creates a connection with both protocols and selects the version that responds. The drawback is that if an EPICSv3 and an EPICSv4 channel with the same name exist on the same network, behavior of the connection is not deterministic.

Open XAL is now fully integrated with the Role Base Access Control. Every application can be authenticated on the RBAC server receiving the token associated with the role of the user. ESS is considering, in the future, connecting this authentication mechanism with the Access Control of EPICS in order to have a unified interface to control the roles of the users and operators.

A technique based on Lie transform methods is under evaluation as a possible extension of the model for the non-linear dynamics. The application of this technique is to simulate the non-linear effect of the space charge in an iterative self-consistent algorithm [4], or to evaluate the effect of external non-linear forces on the beam [5].

The current process of creating Graphical User Interfaces for Open XAL applications requires a significant amount of boilerplate code causing a loss in productivity. A new approach is under development [6] using software tools that allows the user to visually design the flow of data and events between the various elements of the applications (widgets and models), automatically generating the application code. The developer only has to write accelerator physics code, for which template classes and methods have already been produced. The software tools are programming language agnostic, allowing the generation of the application code in different pluggable programming language: Java/Swing, JavaFX, HTML5/Javascript, etc., thus enabling Open XAL applications to stay up to date with the latest programming language fashion. The current target language is JavaFX. Figure 1 shows the interface used in the new Open XAL model browser.

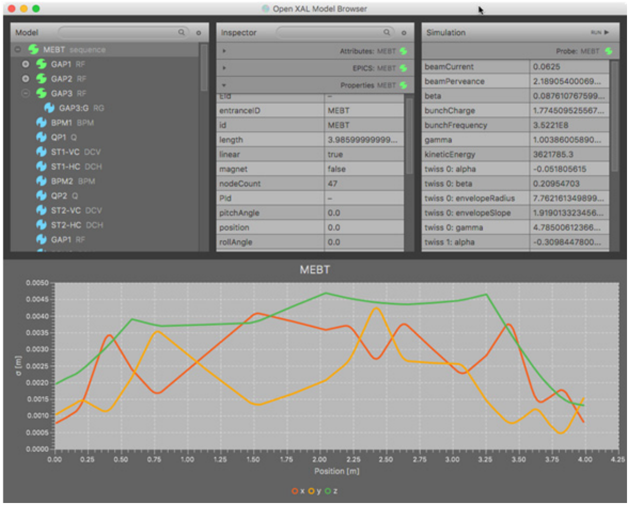

Figure 1: New GUI for Open XAL [6].

SNS

Open XAL remains the main physics application toolkit for SNS control room. As the Beam Test Facility (BTF) was commissioned in fall 2016, Open XAL also became the main tool for scanning 6-D phase space [7].

The emittance analysis application, initially designed for analyzing data taken by a slit-harp system, was modified to analyze data points with uneven spatial distributions given by the slit-slit scanning system at BTF. Fig. 2 demonstrates Gaussian smoothing of experimental data obtained by continuously moving actuators (thus the data points are not taken on a regular grid) for a 2-D scan.

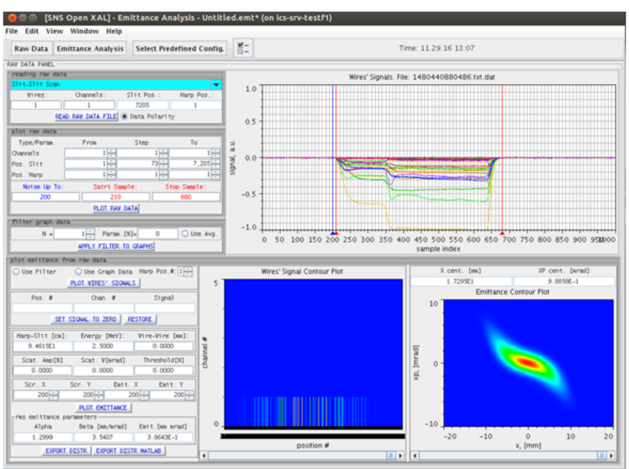

Figure 2: Emittance analysis application for BTF.

The SNS control room is relying on Linux-based consoles for operations. Open XAL is running on the same consoles. Owing to the obsolescence of the Swing GUI toolkit (default GUI for Open XAL), it is necessary to consider replacements of GUI packages. At SNS, migration to a browser-based approach is currently under consideration and a pilot application is being developed.

The mechanism for RF acceleration has been significantly enhanced within the online model [8]. RF cavity structures are now modelled as composite aggregations of independent RF gaps. Thus, a cavity maintains attributes of the superstructure while the gaps express their particular properties. In particular, each gap now maintains a complement of four transit-time factor functions and their derivatives (independent of other gaps and the parent cavity). The full set of transit-time factor functions describes any profile including asymmetric and offset fields. A thin-lens model is still employed for acceleration; however, it is necessary to generalize the method to suit the full field model. The new approach employs a Hamiltonian based upon Laplace transform theory. So far, the new acceleration model produces similar results to the previous model for the SNS warm linac. However, for the SNS super-conducting linac, the new model shows significant differences, namely a reduction in overall energy. These differences can be attributed to better representation of field asymmetries and subsequent phase slip not possible with the previous model.

Since SNS also is developing a particle in cell (PIC) code PyORBIT [9], benchmarking of Open XAL online model against PyORBIT is a routine procedure [10]. Usually it requires additional effort to create identical setups for simulations with these two codes. To simplify this situation, a new interfacing module between Open XAL framework and PyORBIT code is under consideration.

FUTURE PLANS

As of today, Open XAL represents mature production-ready software. It provides a broad framework covering everything needed for accelerator control. Our goal was to produce a generic tool that would allow for easy interaction with the existing infrastructure of different facilities. Due to the uniqueness of every accelerator project this goal is hard to achieve. Thus, a modular approach that cleanly decouples different parts of the framework is essential.

Setup and GUI

The current setup that heavily relies on XML files is somewhat inconvenient and should be revised. It is relatively hard to setup an accelerator environment without knowledge of Open XAL internals. The GUI layer is, unfortunately, tightly integrated into many applications thus making these application platform and facility specific. Recent independent efforts at ESS and SNS regarding new GUI prove that this is becoming an issue that slows down future development. It's important to merge these efforts, so the whole collaboration will benefit. Also, many applications are bound to specific setup files, which limits their usefulness for other sites.

Documentation and Scripting Support

The Open XAL documentation is scarce. This makes learning Open XAL difficult for a newcomer without having experts on-hand.

The current trends in computer science and software engineering makes Java fluency rare among post-graduate students. Scripting languages (most notably Python or its JVM variant Jython) are becoming more popular among college graduates. Open XAL has always supported Jython and JRuby, but they were used for standalone scripts that are hard to re-use or integrate into the framework. Providing consistent support for different flavors of JVM-based scripting is also important for attracting new users, enabling students with no prior programming knowledge, and to begin using Open XAL without the steep learning curve of Java.

Applications

Some applications are site specific and address very particular problems. However, there are many generic applications that address general accelerator problems across facilities. A good example is the Scan1D application.

Creating a common interface to storage system and implementing it in all generic applications, instead of using custom or text based file formats, can greatly increase reusability of such applications. For example, at SNS, some applications store data in relational database, others store data in custom XML files and some in text files. Gluing two applications together frequently requires a lot of routine error-prone programming of input/output interaction.

Support of a common data format that is readable by scientific software will also simplify Open XAL for scientists that are not programmers.

Lack of a headless operation mode for a generic application prohibits using the application for complicated scenarios including scripted repetitive tasks. Thus, all actions accessible via GUI should be also available in headless mode.

Online Model

The online model is the very crucial part of Open XAL. Yet every large accelerator is unique and requires some tweaking or even completely different approach. This causes forking of Open XAL code and implementing a site-specific online model that cannot be easily used by others. Implementing a seamless interface between online model and the rest of the framework would allow pluggable online models for different XAL installations. The same interface should be able to serve as a proxy for third-party codes, simplifying benchmarking between different accelerator codes.

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