DEVICE AND ACCELERATOR MODELLING RELATIONAL DATABASE*

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Abstract

We describe an integrated relational database for beamline element configuration data and online accelerator modeling, for LCLS.

BACKGROUND

The Linac Coherent Light Source (LCLS) is an electron accelerator and coherent X-ray laser being developed at SLAC to study phenomena in the 1.5 - 15 Ångstrom, 1-230 femtosecond realm. Since LCLS will be a user facility, and is being developed within a tight timeframe, we used a systemic infrastructure approach to share resources across technical and operational activities. This paper describes the foundational project for this approach.

PROBLEM

In the past, there was either no master list of accelerator devices or else the tools used, such as spreadsheets, were not flexible and robust enough for large scale configuration control. Therefore different groups maintained device information pertinent for themselves in various spreadsheets and files. Configuration changes, such as device data for cabling, metrology, or power conversion, had to be incorporated manually into these disparate spreadsheets and files. This resulted in unsynchronized and inconsistent data.

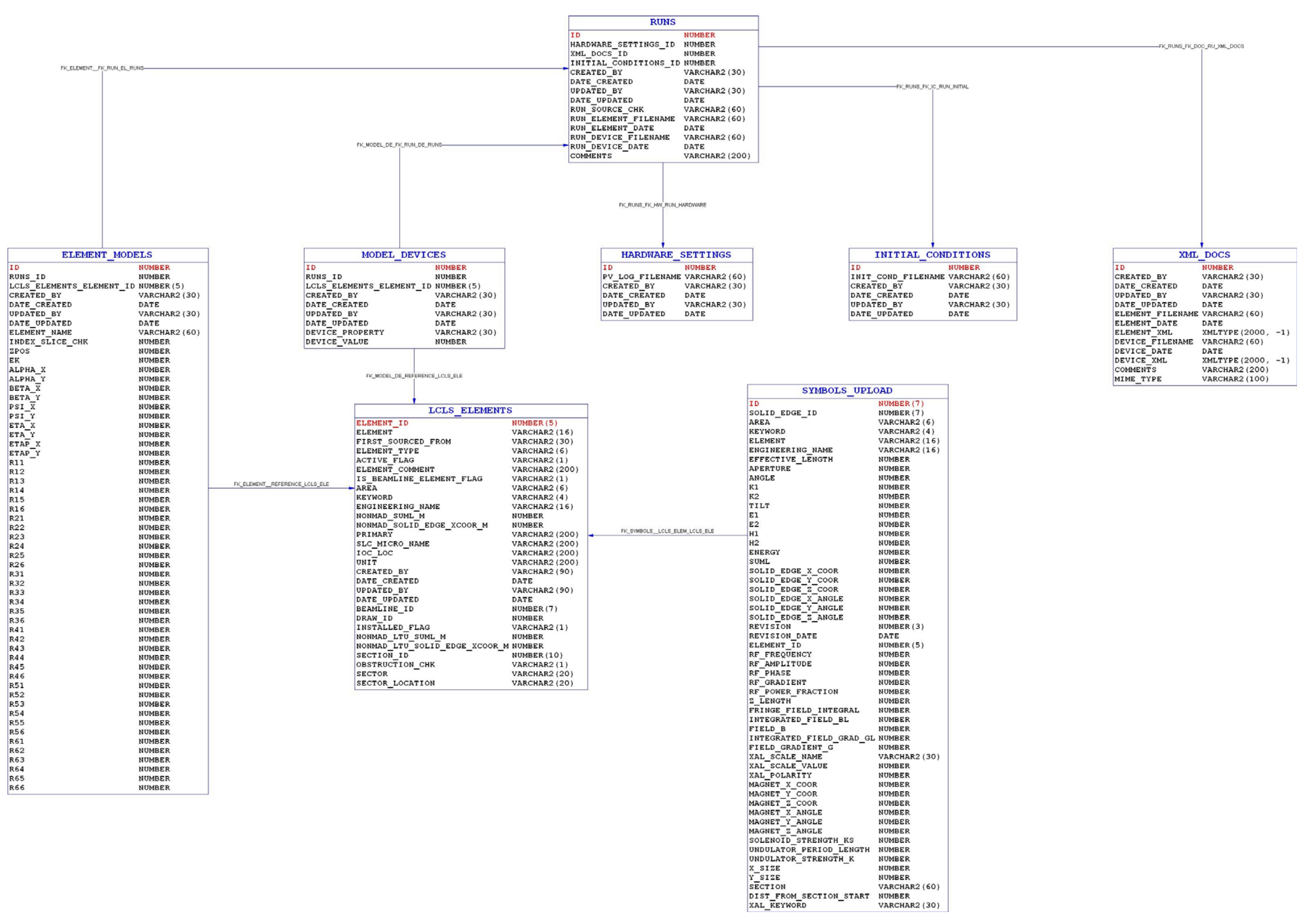

Figure 1: The LCLS Accelerator Model Subschema Entity-Relationship Diagram.

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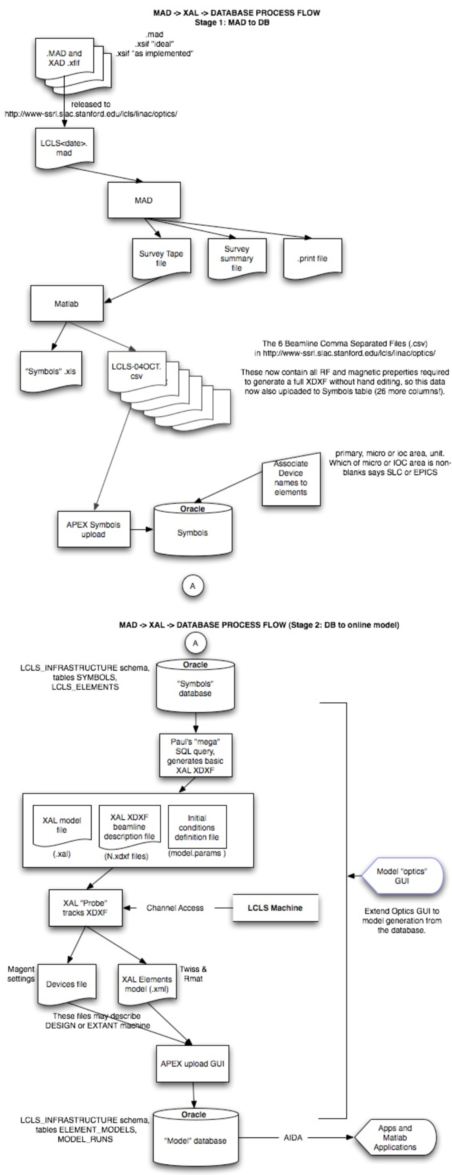

Figure 2: Shows the process of creating the device database and online model. In stage 1, the MAD design deck is loaded into the database; In stage 2, that database is used to derive and track an online model, whose Twiss and R-mats are then available from the database also.

DEVICE DATABASE SOLUTION

For LCLS, we have implemented a master list of devices in an Oracle database. This device database serves as the backbone of a device-centric architecture, integrating both engineering and physics work processes, as well as legacy databases already in use at SLAC. Device model, EPICS device front-end configuration, cabling, survey, calibration, power conversion, maintenance and problem tracking – are each included as a schema in a single Oracle instance [1]. The accelerator device modeling databases are further described below.

MODEL DATABASES

There are two logical subschema for accelerator modeling; first, the device database, being derived from MAD [2] includes the design model. This device database is used as source input to derive a second, online, model of the as-installed beamline devices, using real beam readings. Figure 1 shows the subschema for offline (MAD), and online (XAL) model data. Figure 2 shows the process of loading the MAD model to update the device database (stage 1), and then automatically deriving, tracking, and loading, an online model back into the database (stage 2).

Offline MAD Model and Device Database

Since the conceptual accelerator model is based on the beam line optics output from MAD, a database to store the different versions of the MAD deck was an important starting point for the device database.

Additional functions were built into the database, such as to compare versions of the MAD deck. The physicists, the engineers, and the controls group often refer to the same accelerator device by different alias names, different coordinate systems, and different units of measurement. Therefore, similarly to how a phone directory for people streamlines organizational work, this devices directory stores or joins key attributes for devices, in order for cross-functional groups to quickly translate MAD symbol names to control system (EPICS or SLC) device names, and coordinates. Database triggers orchestrate how the data are placed in the device database so that the newest version from the MAD deck is used. We used Oracle's Application Express interface (APEX), which works together with the database triggers, to provide a uniform view of MAD and non-MAD devices in one editable report. From the device database, one is able to select information stored for each device in the legacy cabling database, power supplies database, or inventory database, etc.

Online Accelerator Model Database

An automated facility for online model generation creates an XAL [3] online model beamline description file using a long but stable database query. The resulting model is then tracked by an XAL "probe", and results are loaded back into the database. As such, both the design or extant machine model, of the present and all previous model runs are available. These models can be inspected or used by applications, and are linked to the relevant element configurations. An interactive modeling application program [4] can be used by a control room user to manage this whole process, see Figure 3.

Controls software, optimization applications and feedback, use the AIDA (Accelerator Independent Data Access) [5] programming interface to acquire static element data and model parameters such as Twiss parameters and transfer matrices from the relevant database schemas. Native XAL applications can use the database derived XAL input file.

RESULTS AND CONCLUSION

A unified device and model database was a significant expenditure, but has proved to be successful for predictability and repeatability of machine commissioning experiments.

FUTURE PLANS

Presently, we are implementing a staged release system of four database instances; Development, Quality Assurance, Production and Backup. More broadly, we are working towards a single "enterprise" database used to manage all aspects of static device and operational data; that is, everything other than the online control device data handled by EPICS.

ACKNOWLEDGEMENTS

As an infrastructure project, the database is the product of cooperation among many departments. Thanks in particular to power conversion, metrology, and controls EPICS teams for their commitment to a true reference database, and to Dr Hamid Shoaee, Controls Dept Head, for vision and investment.

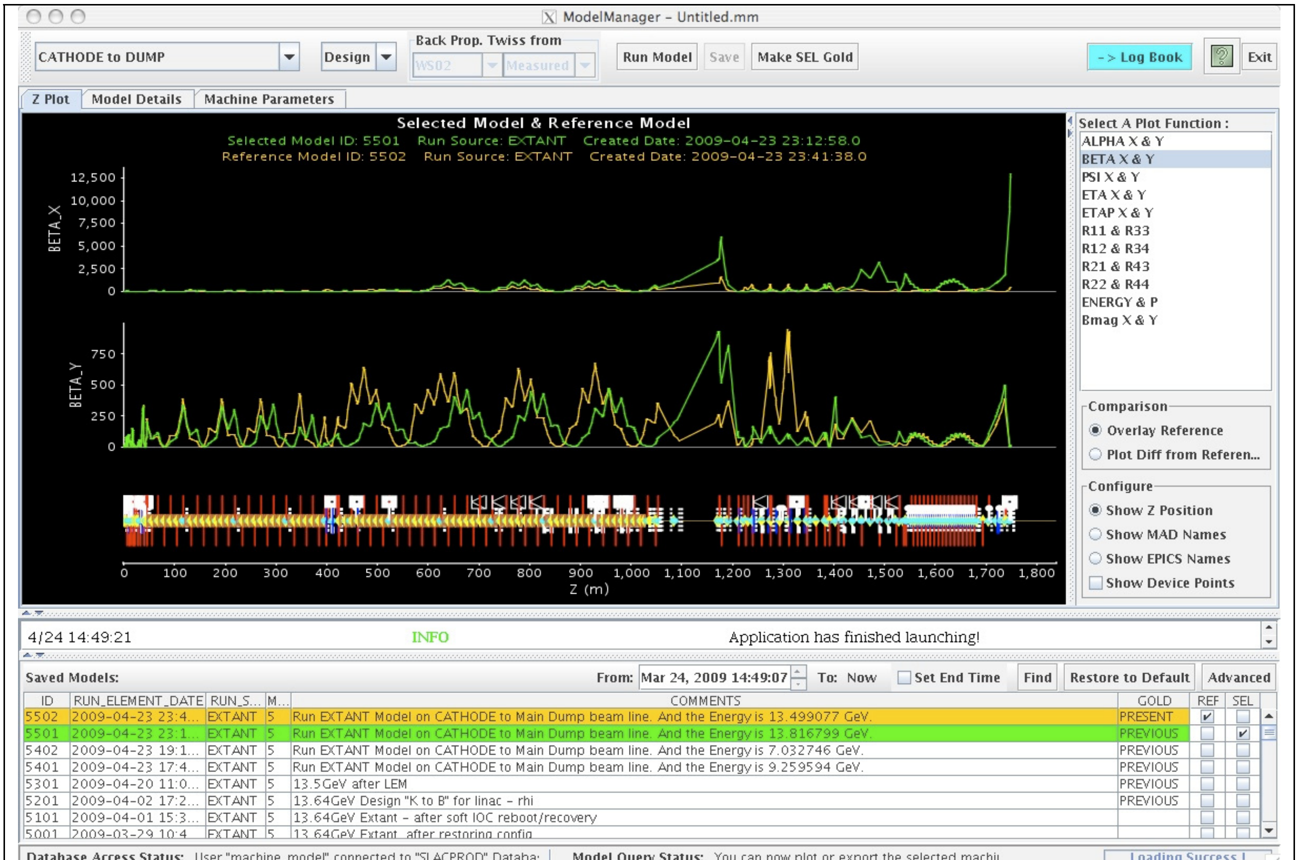

Figure 3: This screenshot shows the Model Manager program, which helps a physicist to generate the XAL lattice model of a beamline of the LCLS from the database, track it given extant optics conditions (such as magnet fields and gradients), and load the results back into the database. They may also inspect any past model (see bottom pane), or set one in particular as the "GOLD" model – the one model run output dataset that all applications to use by default.

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