FRIB Lattice-Model Service for Commissioning and Operation

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Introduction

The Facility for Rare Isotope Beams (FRIB) uses a superconducting linear accelerator designed to accelerate all stable ions to energies greater than 200 MeV/u with beam power on target up to 400 kW. [1] This driver accelerator must be highly configurable in order to accommodate a broad range of ion species and charge states. In order meet these requirements for energy and power on target, accelerator beam simulation software will be important to facilitate accelerator configuration and optimization. Management of beam simulation data will be critical for efficient commissioning and reproducible operation of the FRIB driver accelerator.

The FRIB Lattice-Model Service (LMS) has been designed to allow for easy organization and retrieval of beam simulation data. The primary software used for the FRIB driver accelerator design is IMPACT, and therefore the LMS initially supports IMPACT simulation data. However, its flexible data model allows it to be easily extended to support additional types of simulation data. Accelerator simulation data can be divided into two parts: the Lattice and the Model.

[1] Jie Wei, D. Arenius, N. Bultman, F. Casagrande, C. Compton, K. Davidson, et al., "Progress toward the Facility for Rare Isotope Beams," *Proc. NA-PAC'13*, Pasadena, CA, USA, Sept . 2013, paper FRYBA3.

Data Model

Lattice

The Lattice consists of the position and orientation of the accelerator elements along with any information needed to fully define the particles trajectory through the accelerator. This includes the element types and any type specific configuration parameters. As well as, the initial beam conditions including the particle species and initial change state.

Model

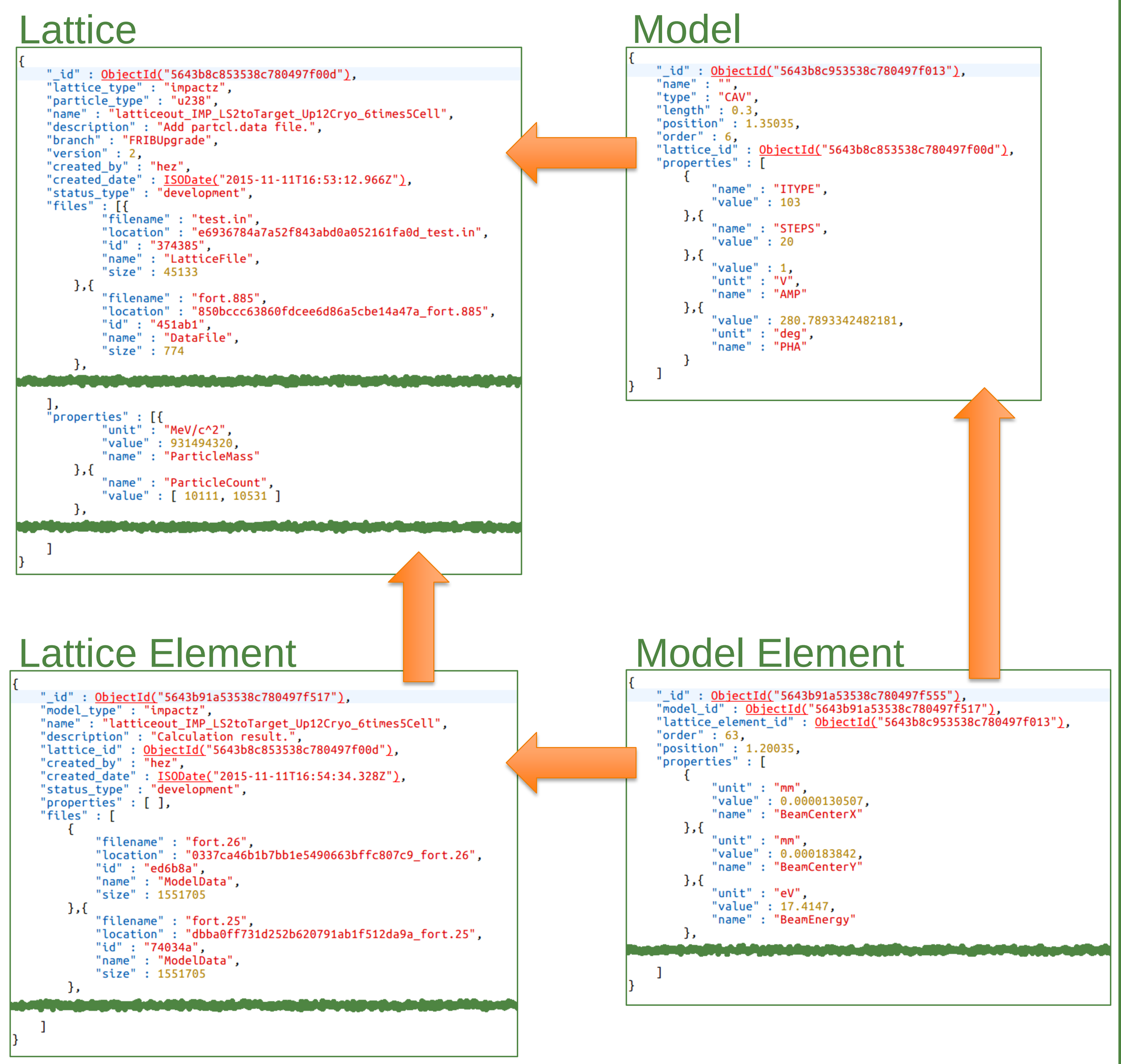
The Model is the complete result of executing the beam simulation software with a Lattice as input. The exact content of the Model is specific to each type of beam simulation software. In general the Model includes the following beam parameters at multiple locations along the accelerator: size, position, divergence and energy.

Design

The overall architecture is adopted from a similar Lattice-Model Service in use at NSCL II. [2] The most significant change from original architecture is the switch from a traditional relational database to a document-oriented database.

The document-oriented database provides a flexible system for storing information and is well suited for storage of beam simulation data. The original relational database scheme was designed to store objects with related arbitrary properties. Through the use of a document-oriented database, more information is now being stored, while the implementation has been greatly simplified. Furthermore, this data model can be more easily extended to support future requirements.

[2] G. Shen, et al., "NSLS II Middlelayer Services", *Proc. of ICALEPCS'13*, San Francisco, CA, USA, Oct. 2013, paper MOPPC155.

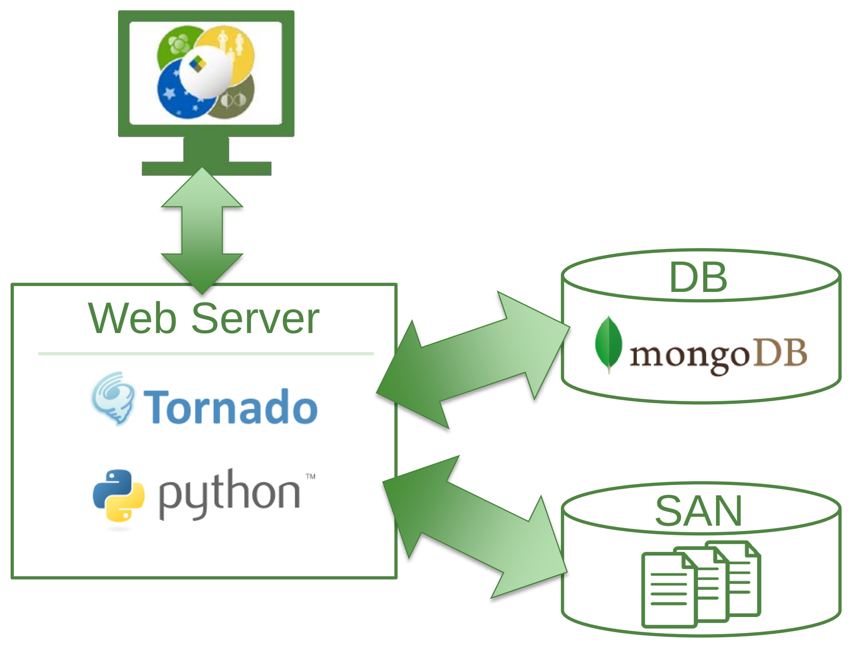


The figure above illustrates the relation between documents and provides an example of the information that is stored in the database. A Lattice contains multiple elements, typically these elements represent accelerator devices. Similarly, a Model contains multiple elements corresponding to results from a Lattice Element.

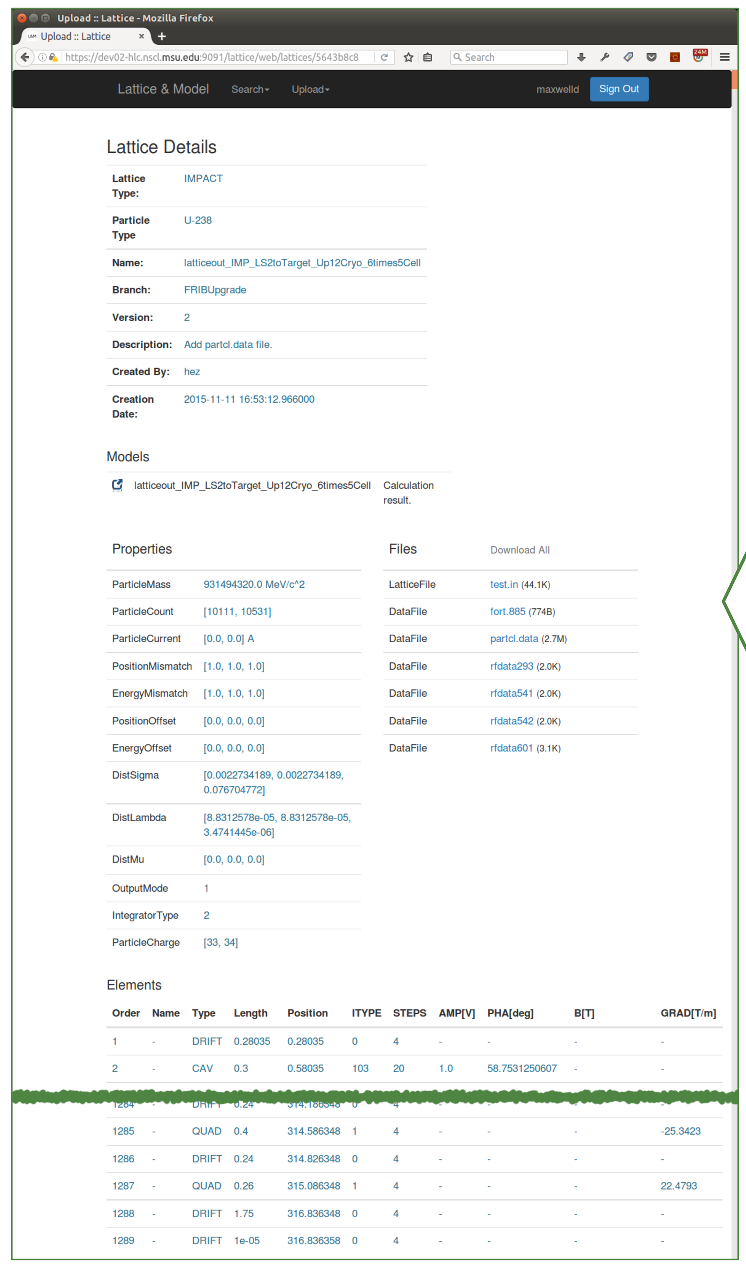
Architecture

The Lattice-Model Service (LMS) is implemented in Python using the Tornado web framework. The use of Python allows for the reuse of existing libraries for reading IMPACT input and result data files. In addition, Python has excellent support for numeric processing, text processing and web applications. Tornado includes a high performance web server which supports modern generator-based asynchronous programming. However, the standard Tornado text template engine was found to be insufficient in this case and instead the more powerful Jinja2 text template engine was used.

The MongoDB document-oriented database is used as it provides excellent performance and integration with Tornado through the use of the Motor client. Motor provides a high performance asynchronous library for interacting with MongoDB.



Web Interface

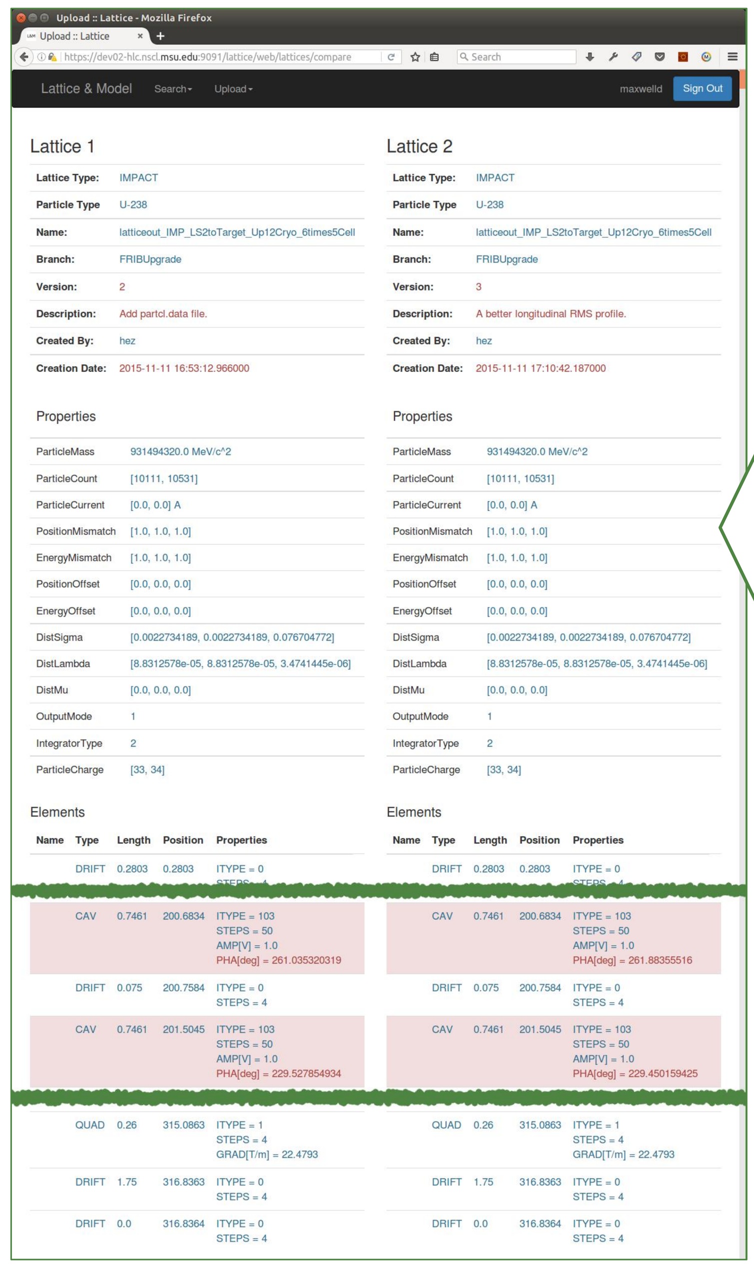


To facilitate convenient access to the simulation data a web interface is provided to users for both submitting new data and for retrieval of existing data. When simulation data is submitted to the LMS the raw data is processed and properties are automatically extracted. In addition, the user can specify a name, description and other metadata to identify and organize the data.

A detailed view of the Lattice data includes its name, description, properties and other metadata. The list of original data files is shown on the right and these files are available to the user for download. The Lattice Elements are displayed at the bottom of the screen in tabular format.

A detailed view of the Model data includes its name, description and other metadata. The original data files are available to the user for download. Model Element data is displayed in a plot at the bottom of the screen. Multiple properties can be easily plotted simultaneously. In this example, the beam position X, position Y and energy are shown.

Lattice and Model Comparison



An important feature of the LMS is the ability to directly compare Lattice and Model data in order to find the specific differences.

The Lattice comparison view indicates the differences clearly by marking them in red. The comparison includes name, description, properties and other metadata. Lattice Elements are shown at the bottom of the screen. In this example the RF Cavity phase is shown as containing differences.

The Model comparison view indicates the differences in the name, description, properties and other metadata by marking differences in red. The Model Element data is easily compared by displaying the data on the same plot. In this example the beam position X for both Models is shown.

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