DEVELOPMENT OF COMMISSIONING SOFTWARE SYSTEM FOR J-PARC LINAC

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Abstract

Beam commissioning of J-PARC LINAC has been performed since November 2006. A commissioning software system consisting of software frameworks and database has been developed. We overview the system and describe each component, showing interrelation and data flow among the components, with emphasis on how to compare device data and models. We show commissioning applications developed for the LINAC commissioning.

DESIGN PRINCIPLES

We have designed our commissioning software system based on the following principles. Various parameters for commissioning, such as EPICS record names, model parameters, lattice geometry, unit conversion parameters, and calibration parameters should be controlled in a central database as a single data source, which should provide common data to commissioning tools which require them. Seamless data I/O between software components and comparison between modelling and device data should be as quick and easy as possible.

COMMISSIONING SOFTWARE SYSTEM

Fig. 1 shows a schematic layout of the commissioning software tools and their connection to database and the control system. Each component is connected to each other via network (solid lines). Interfaces of accelerator devices such as magnet power supplies, RF systems, beam monitors are controlled with EPICS servers called IOC's (Input Output Controllers). High Level Applications (HLA's) control and monitor devices via EPICS channel access. A unit conversion EPICS server for magnet power supplies helps control devices in comparison to models. A save-and-restore database and archivers save device parameters through channel access. Commissioning DB stores key parameters for control and models, and calibration. Tools to generate input files for above components (dashed lines) have been developed.

Commissioning DB

A relational database called Commissioning DB has been developed as a central storage of the commissioning information both for control system and simulations. The following information is stored in the database.

- EPICS record names and their relation to devices
- Lattice geometry of devices and device parameters for each beam mode
- Parameters for unit conversion functions.

These data, strongly related to each other, must be flexibly sorted, selected and arranged for each commissioning software tool. Relational database has an advantage for this purpose because a logical table (a "view") can be created with any combination and format of the data. While keeping the arrangement functions, maintenance of data is relatively simple since each set of data can be maintained in individual tables depending on different updating periods and different data sources.

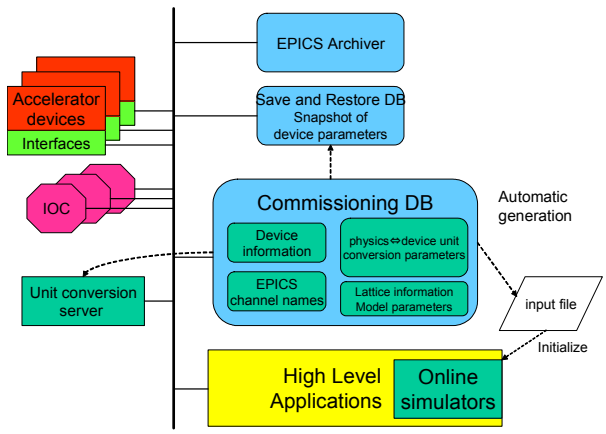

Fig. 1: A layout of commissioning software system.

Save and Restore DB

We utilize a Java application SCORE in XAL framework [1]. It has been customized for J-PARC to use PostgreSQL, and to deal with special set channels which require "strobe" signals to actually set the parameters to devices. The SCORE can save snapshots of channel values, and fetch a past set of parameters and compare with online values, and set them to devices. We use SCORE for monitors, magnets, and RF system at LINAC.

Archivers

Achivers have been developed to save device information for long term for offline analysis and investigation of device problems. Two kinds of the archivers have been developed for LINAC. The archiver for scaler data and the arvhiver for waveform data. The archiver for scalar data collects non-waveform data with a float value of scalar EPICS data and save them directly into a relational database (PostgreSQL). It collects most of LINAC channels of about a few 10 thousands. The data

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collection is done in two ways; a) monitoring method (by event notification by IOC's when channel values are changed, for data which rarely varies; b) polling method at a predefined period (typically a few seconds). The database server can display serves also trend graphs in specified time ranges in Web. The waveform archiver collects waveform data and saves them as binary files. The file format is defined as JWF (J-PARC Waveform Format).

Unit Conversion Server

In HLA's, it is efficient to set and read parameters in physical units, instead of device units for quick comparison of accelerator devices to models. For this purpose, a online unit conversion EPICS server has been developed [3] for magnet power supplies based on an EPICS server developed for SNS [7]. It creates physical "set" and "monitor" records in connection to corresponding device records inside IOC's. Conversion between physical (magnetic field) and device (current) values are calculated using third order polynomial functions in divided ranges in device parameters, so that inverse equations can be analytically solved. Reading, writing, and event notification of physical records are supported. The server has been working stably for at least a few months with 700 channels of LINAC quadrupole, dipole, and steering magnets successfully.

Software Frameworks

We have developed commissioning applications in JCE (J-PARC Commissioning Environment) [2] and Java. JCE has been developed for quick development of device control and commissioning applications in SAD script language. JCE interpreter codes have been built in pure Java carefully to keep easy maintenance capability and extensibility. With JCE, seamless programming is possible in any combinations of device control, online model calculations with GUI. Java applications utilize XAL Java library [1]. XAL is a high level application framework developed at SNS, with EPICS control, the XAL online model, and database interface, with many commissioning applications. JCE is linked with XAL and can utilize XAL functions. Our programming strategy is to write in Java for tools whose methods and algorithm have been established. For those with procedures which are under development or urgent needs for commissioning are mostly written in JCE.

Online Models

The XAL online model has been adopted and extended for J-PARC. Since TRACE3D has been used in LINAC, detailed comparison of the two codes has been performed which results in excellent agreements of simulation and understanding of both codes [6]. The difference in transverse and longitudinal beta functions is within order of 0.1%. Fringe field of quarupole magnets has been implemented based on the TRACE3D permanent quadrupole element. Emittance growth effects in RF gaps have been added based on Trace3D method.

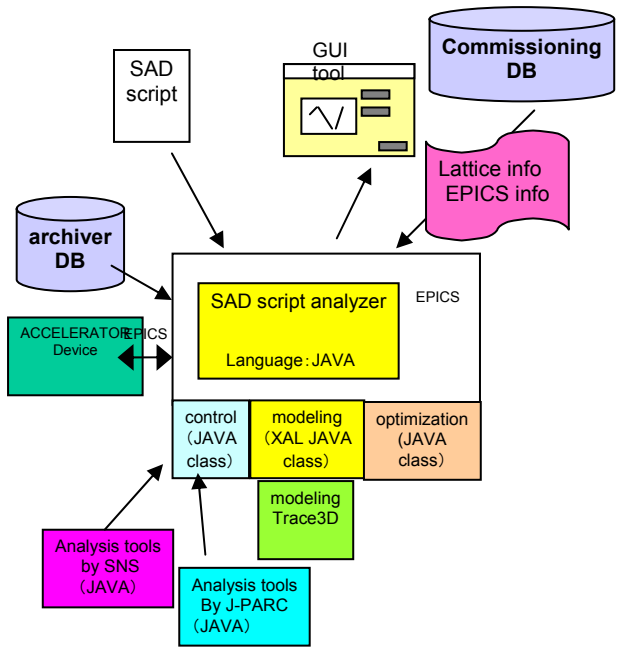

Fig. 2: A schematic view of JCE.

APPLICATIONS FOR LINAC

Following applications have been developed and applied in the LINAC commissioning. Configuration files with the lattice geometry, EPICS records, and device parameters are generated from the Commissioning DB.

- RF tuning application (Fig. 3)
  RF amplitude and phase of a cavity are scanned, and beam energy at downstream is measured with a pair of fast current transformer (FCT's). By fitting data with models, an optimum set point is determined.
- Beam based alignment application (Fig. 4)
  This scans magnet field of a quadruple magnet and an upstream steering magnet, and measures beam positions at the quadrupole magnet and at a downstream position. Then, it determines the offset of the beam position monitor at the quadruple magnet with the beam based alignment technique.
- Transverse matching application (Fig. 5).
  The r.m.s. widths of beam profiles with wire scanners are read through EPICS and an optimum quadrupole magnet setting in a matched condition is calculated with the model. The resulting field setting is applied to quadrupole magnets via EPICS.
- Simulator of beam envelopes and orbits (Fig 6).
  It can fetch online magnet field values as model input parameters. This function is useful to confirm applied field settings.
- Monitor display applications for beam position monitors, current monitors, beam loss monitors.

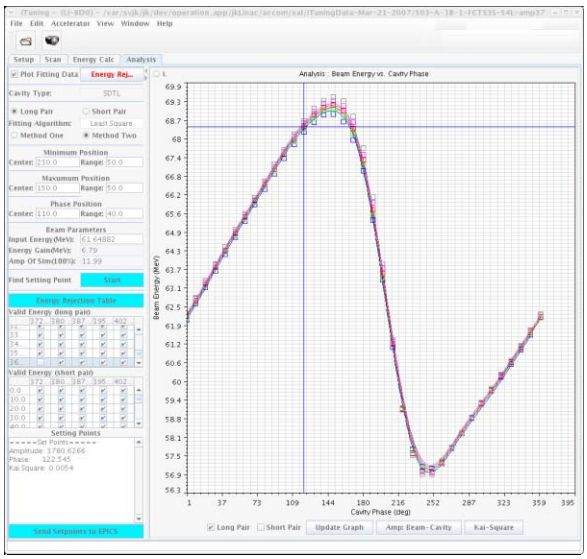

Fig. 3: RF tuning application with SDTL.

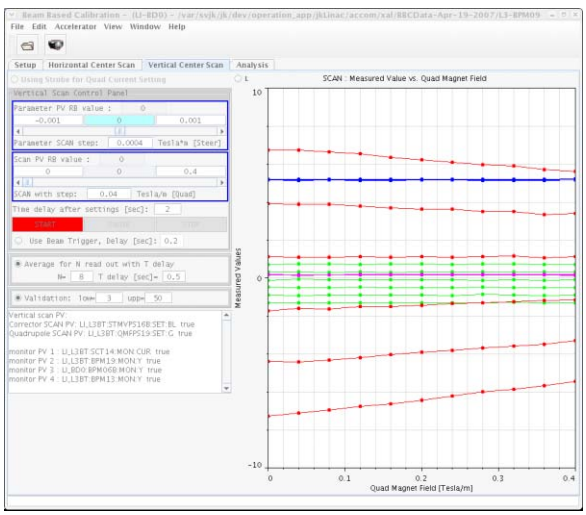

Fig. 4: Beam based alignment application at MEBT1.

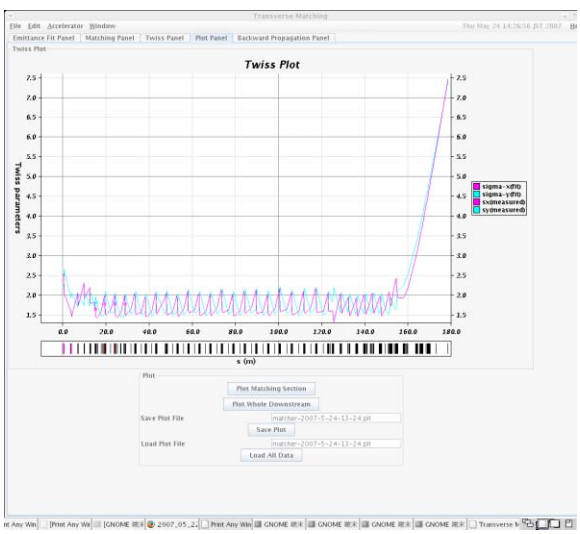

Fig. 5: Transverse matching application.

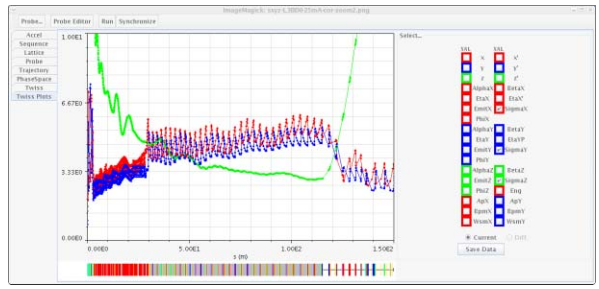

Fig. 6: An online model tool for envelope and orbit.

CONCLUSIONS

We have developed commissioning software system in connection with Commissioning DB, Save and Restore DB, archivers and Unit Conversion Server. JCE has been developed as a script interpreter for quick development of beam commissioning software. Applications have been developed in Java and JCE and utilized successfully in the beam commissioning.

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