BEAM COMMISSIONING SOFTWARE AND DATABASE FOR J-PARC LINAC

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Abstract

A beam commissioning software system based on a relational database (RDB) has been developed for the J-PARC LINAC. We developed two high-level software frameworks, JCE [1] and XAL [2]. JCE (Java Commissioning Environment) based on a scripting language SAD script has been developed in Java with device control, monitoring, online modelling and data analysis functions. XAL has been developed initially by SNS and further developed and customized for J-PARC. A commissioning database system has been developed to configure commonly these two frameworks, for model geometry, EPICS device control [3], and calibration parameters. A server for unit conversion of magnet power supplies has also been developed for the commissioning software [4]. Commissioning applications for RF tuning, transverse matching, orbit correction, beam-based calibration have been developed as key commissioning tools and successfully applied for beam tuning. We report on the status of development for the commissioning software system.

SYSTEM OVERVIEW

The layout of the commissioning software system is shown in Fig. 1. The system consists of Commissioning DB (CODB), Save and Restore DB (SRDB), Unit Conversion Server (UCS), and High Level Applications (HLA's). The commissioning software system is connected with the control systems consisting of devices and IOC's through EPICS channel access. Commissioning stores static parameters for device controls and models necessary for beam commissioning; lattice geometry, EPICS channel names, unit conversion functions, and monitor calibration parameters. Save and Restore database save most of important device parameters in EPICS channels with functions to restore parameters to some device channels. Unit conversion server [1] helps user to control and monitor devices in terms of physics EPICS channel instead of device EPICS records in IOC's. This is necessary to map device parameters directly to the online model to understand current situation of the beam lines. Utilizing these environments, high level applications run to control devices and analyze data from devices. After data analysis, device calibration parameters are corrected and improved. These parameters are saved with to CODB as a new set of lattice data. Commissioning DB is also updated when monitor calibration parameters or lattice geometry are modified.

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HIGH LEVEL APPLICATION FRAMEWORKS

Two frameworks for high level applications have been developed, Java Commissioning Environment (JCE) [1] and XAL [2]. Most of functions are shared in the both environments. It is up to user to choose which framework to develop an application.

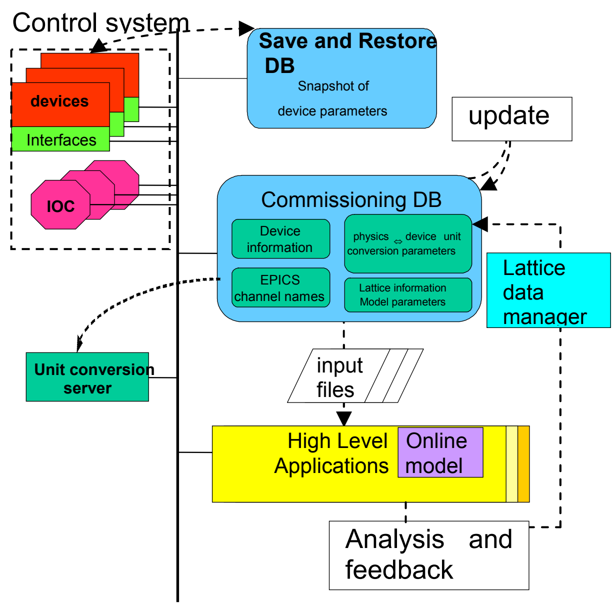

Figure 1: Interrelation of components in the commissioning software system.

Java Commissioning Environment (JCE)

JCE has been developed to fulfil user requirement to write commissioning applications in SAD scripting language for LINAC. Original SAD [5] developed in KEK was implemented in FORTRAN with complex coding. For efficient maintenance and extension of functions, we have implemented a new SAD script interpreter JCE in Java. SAD scripting language is basically Mathematica language with list operations and mathematics functions. JCE has XAL online simulator, and device control and monitoring function in EPICS chancel access with JCA/CAJ library [3]. JCE has many graphics components for GUI application. The advantage of JCE is quick development and debugging capability of applications without compilation. We have developed monitor display applications, a magnet field setting application, a wire scanner control application, and transverse matching application. These applications are initialized either with XAL input files, or their own CSV files, automatically generated from CODB.

XAL

XAL is developed in SNS [2]. In J-PARC, an automatic generation scheme of XAL input files has been developed. A special requirement for J-PARC is to use both Trace3D and XAL as online models. For this purpose, detailed comparisons between the two models are made and fine tuning for agreement up to a few 10th percent levels has been achieved. For this purpose, modifications for model parameters must be made. Also, a customization for database interface functions for PostgreSQL [5] was made.

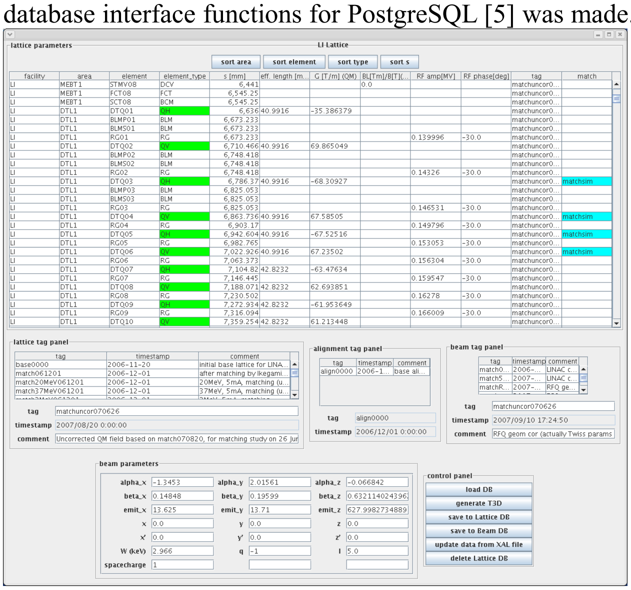

Figure 2: Lattice data manager.

COMMISSIONING DB

CODB is used for lattice data management, and to maintain monitor calibration data and unit conversion functions and automatic generation of input files for applications. PostgreSQL [6] is adopted as RDBMS.

Lattice Data Manager

Lattice data sets for quadrupole, dipole magnets, and RF gaps together with beam condition parameters are saved as a history in the Commissioning database. Each data set is tagged with a comment. The lattice data is separated into static data and dynamic data. Geometry belongs to static data, and magnetic field and RF amplitude and phases belongs to dynamic data. They are store in separated tables in the RDB. Each lattice data is made by constructing a logical table (view) from the two tables. XAL input files and CSV files for other applications such as magnetic field setting tool are generated from the lattice table.

We design magnet and RF parameters from a model (either Trace3D or XAL). The designed set of parameters is stored in the DB. In beam studies, corrections of parameters are applied. The corrected set of parameters is saved in the DB with new tags so that this set of parameters can be used as an input for models. From each set of parameters, XAL and Trace3D input files can be generated. The GUI tool for managing the lattice DB is shown in Fig. 2.

Database Management

Monitor calibration parameters, and device positions are frequently updated during beam test. We use a Web server tool, phpPgAdmin [7], to maintain these data. This has a function to import and export CSV files to/from a database table. Typically modifications of parameters and regeneration of input files for applications can be done within an hour. Further improvements of table structures to improve maintenance efficiency are going to be made.

SAVE AND RESTORE DATABASE

Save and Restore Database is useful to take a snapshot of device parameters and save in the database. The saved data set can be restored to the devices any time. We used SCORE applications in XAL and developed database in PostgreSQL. There is no relation to the online model. A few functions which are missing in SCORE are required during the commissioning. Some of the parameters (e.g. RF) should be saved periodically, while taking snapshots by users tends to being forgotten. Some of the parameters are convenient if directly read from high level applications (e.g. magnetic field). To resolve these problems, utilizing pvlogger tool in XAL has been tested.

BEAM COMMISSIONING APPLICATIONS

In this section, we describe key commissioning applications.

RF Phase Scan Application (iTuning)

In proton LINAC, fine tuning of amplitude and phase of each RF is essential for efficient beam acceleration and good beam quality. An application for this purse, iTuning, has been developed in XAL. For tuning of a RF source, a pair of FCT's (Fast Current Transformers) is used for beam energy measurement at the exit of the cavity. The application scans RF amplitude and phase and measures FCT phases, then calculates beam energies and fit the obtained curves with a model and determines the setting point of the RF source. The time and manpower for the tuning has been remarkably improved by this application.

Transverse Matching Application (matcher)

Transverse matching correction is essential to improve transverse beam quality and suppress beam loss. We use wire scanners to measure beam profiles and singlet quadrupole magnets to tune beam profiles. An application for wire scanner control and profile measurements [], and a transverse matching application [10] havee been developed in JCE. The latter is shown in Fig. 3. The curved shown are measured and predicted beam envelopes. Mismatch factor of less than 5% was achieved.

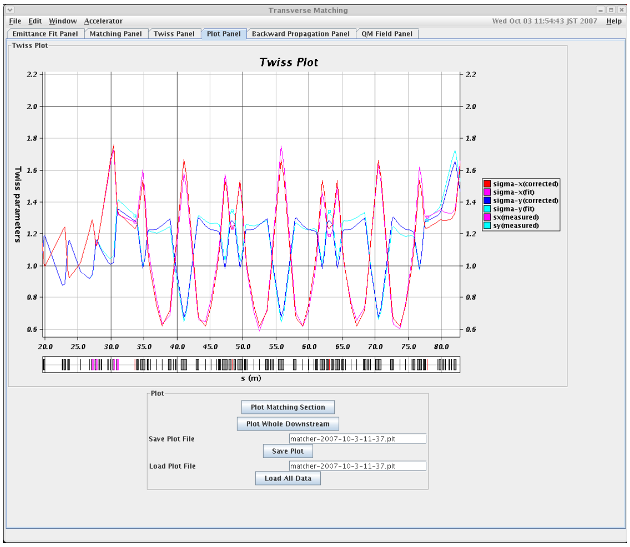

Figure 3: Transverse matching application.

Beam Based Correction Application

Before orbit correction, beam based alignment is applied to tune beam directions to pass through the field center of the quadruple magnets. An application for this alignment (BBC) has been developed in XAL [11]. The application scans a quadrupole magnet and an upstream steering dipole magnet and measures beam positions with beam position monitors, and determine the steering magnet setting and an offset of the beam position monitor.

Orbit Correction Application

We utilizes OrbitCorrection application in XAL for orbit corrections. For this purpose, physics records in *BL* are created for steering dipole magnets in the Unit Conversion Server. Orbit correction works well with model prediction and resulting deviation of orbit is less than 1mm.

Beam Energy Analyzing Application

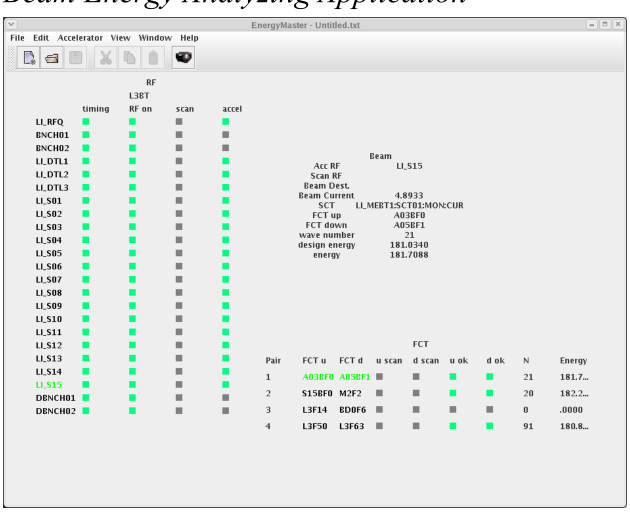

Figure 4: Energy analysis application.

There are many FCT pairs in LINAC to measure beam energy. However, each FCT pair can measure phase differences only within 360 degrees and there is no way to determine absolute beam energy without knowledge of other information. For this purpose, energy analyzer application (EnergyMaster) has been developed in XAL as shown in Fig. 4. The application integrates and analyzes information of beam destination, timing system, RF conditions and chooses proper a FCT pair and calculates absolute beam energy.

CONCLUSIONS AND PROSPECTS

We have developed a commissioning software system for J-PARC LINAC. The system is maintained by the CODB which provides common environments for applications. JCE and XAL have been developed for application frameworks. The system works efficiently for beam commissioning and achieved designed beam energy of 181MeV and beam transportation to RCS. Further efficient maintenance scheme for CODB and utilization of SRDB will be developed.

REFERENCES

[1] H. Ikeda and H. Sako, *et al*, "Development of a SAD script interpreter with Java", 2nd Annual Meeting of Particle Accelerator Society of Japan, 2005, Tosu, Japan; H. Ikeda and H. Sako *et al*, "Development of a script interpreter for beam commissioning of J-PARC LINAC", 4th Annual Meeting of Particle Accelerator Society of Japan, 2007, Wako, Japan.

[2] J. Galambos, *et al*, "XAL application programming framework", Proceedings of ICALEPCS 2003, Gyeongju, Korea.

[3] http://www.aps.anl.gov/epics/; http://jca.cosylab.com/

[4] H. Sako, "Unit conversion channel access server for J-PARC LINAC", 4th Annual Meeting of Particle Accelerator Society of Japan, 2007, Wako, Japan.

[5] K.Oide and H.Koiso, "Anomalous equilibrium emittance due to chromaticity in electron storage rings", Phys. Rev. **E49,** 4474 (1994).

[6] http://www.postgresql.org/

[7] http://phpppgadmin.sourceforge.net/index.php/

[8] G. Shen, *et al*, "RF amplitude and phase tuning of J-PARC SDTL", PAC'07, Albuquerque, USA; G. Shen, *et al*, "Tuning of RF amplitude and phase of J-PARC DTL and SDTL", 4th Annual Meeting of Particle Accelerator Society of Japan, 2007, Wako, Japan.

[9] H. Akikawa, *et al*, "Profile measurement and transverse matching in J-PARC LINAC", PAC'07, Albuquerque, USA.

[10] H. Sako, *et al*, "Transverse matching in J-PARC LINAC commissioning", 4th Annual Meeting of Particle Accelerator Society of Japan, 2007, Wako, Japan.

[11] G. Shen, *et al*, "Beam based alignment of J-PARC LINAC", 4th Annual Meeting of Particle Accelerator Society of Japan, 2007, Wako, Japan.

[12] C. Allen, *et al*, "XAL online model enhancements for J-PARC commissioning and operation", PAC'07, Albuquerque, USA.