

# IMPLEMENTATION OF WEB-BASED OPERATIONAL LOG SYSTEM AT RIBF

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## Abstract

The electronic operational log is utilized in many accelerator facilities. It records relevant parameters and automatically specified actions performed by accelerator operators and stores them in a dedicated database. The Zope-based operational log system (Zlog) developed by the High Energy Accelerator Research Organization (KEK) has been utilized for the RIKEN Radioactive Isotope Beam Factory (RIBF) control system. Using the Web application of the Zlog, the information on the accelerator operation is represented on the Web browsers as character strings in a table. However, the character strings in the HTML table displayed on the Web browser consist of many lines, and in the case of Zlog, become complicated, because many parameters are altered during the RIBF operation. Therefore, an improved user interface should be introduced. To that end, we have developed a new Web-based operational log system for the RIBF control system that can provide operational logs with a variety of rich graphical user interface (GUI) components. The developed RIBF operational log system consists of a log monitor server, Web-application-based user interface, and PostgreSQL-based database. In addition, various types of user interface have been implemented for the equipment, such as the electromagnet power supply. Since 2013, this operational log system has functioned without experiencing serious problems, monitoring approximately 3,000 points of the Experimental Physics and Industrial Control System (EPICS) record.

## INTRODUCTION

The RIKEN Radioactive Isotope Beam Factory (RIBF) accelerator facility consists of five cyclotrons, including a superconducting ring cyclotron, and two linear accelerators [1]. In the RIBF, we constructed a distributed control system based on the Experimental Physics and Industrial Control System (EPICS) for electromagnet power supplies, beam diagnostic instruments, vacuum control systems, and so on [2]. The electronic log system for recording daily accelerator operation during beam tuning, which is a control-system application, is called an operational log system. Operational log systems are widely used in place of paper-based logbooks at large accelerator facilities. In 2004, Zlog was developed by the High Energy Accelerator Research Organization (KEK) as a Web-based operational log system for EPICS-based system [3]. Since then, Zlog has been introduced not only at KEKB [4] and J-PARC [5], but also at RIBF [6].

Hereafter, we will report the operational experience of

Zlog at RIBF after brief introduction of the Zlog system. Subsequently, we will introduce a new operation log system, which has rich user interface components suitable for various device types and is more effective for accelerator operation in RIBF.

## ZLOG SYSTEM

Zlog is based on Zope [7], which is an object-oriented Web application framework, and consists of Web applications and a log monitor server written in Python. The operation record can be manually input through the Zlog Web application. In addition, when the EPICS record value is changed, a log can be automatically inserted using the caMonitor program, with Zlog acting as an event-driven log monitor server using the Zlog Python-CA interface [8]. The inserted logs are stored and managed in a PostgreSQL-based database. The Zlog database has a table structure with “operations,” “comments,” “related\_group,” and other columns, besides the standard “id” and “timestamp” columns. The Zlog system chart given in Ref. [3] is illustrated again in Fig. 1, and a screenshot of the Zlog display on the Web browser is shown in Fig. 2.

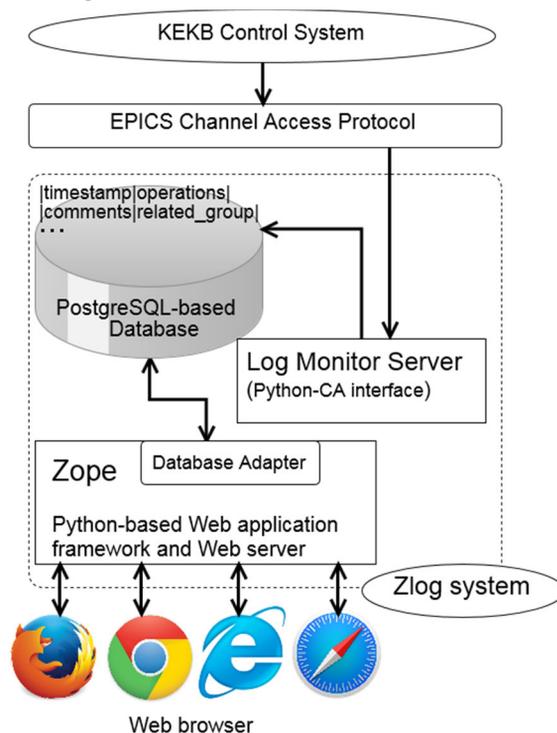


Figure 1: System chart of the Zlog system.

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Figure 2: Screen capture of the Zlog user interface displayed on a Web browser (Firefox). This installation is for the RIBF control system.

At RIBF, the automatically inserted operation logs triggered by the log monitor server of Zlog have been used more frequently than the manually input operation logs. Nearly all the electromagnet power supplies are operated during beam tuning at RIBF. For example, when the beam intensity decreased slightly as a result of a complicated procedure of optimizing many electromagnet power supplies, the detailed operational history of the power supplies was necessary in order to determine the cause and recover the best beam conditions during beam tuning. In such an event, operators can restore the parameters of the power supplies by using Zlog. It has also a comment-writing function; however, a wiki-based system [9] and paper-based logbooks are mainly used for comment-writing and pasting important images. Therefore, comment-writing to Zlog is not a considerable task.

On the other hand, various kinds of user interface functions, which are absent in Zlog, were required for realizing efficient operations in case of the RIBF accelerator operation. This may be attributed to the complexity of the HTML-based display of Zlog when displaying a history of equipment to be frequently controlled. This can be attributed to the use of a significant number of character strings. For example, about 600 electromagnet power supplies are operated until the beam tuning for each beam service is completed. Therefore, we developed a new Web-based operational log system that can handle various user interfaces and is more suited to the RIBF operation. In addition, the Beam Status History log system was also developed.

## OPERATIONAL LOG SYSTEM AT RIBF

### Specifications

The newly developed RIBF operational log system consists of a log monitor server, Web-applications, and PostgreSQL-based database. The system was developed according to the following specifications. The interface of the RIBF operational log is unified with that of the Web-based system currently in use at RIBF. By using a log

monitor server like Zlog, the operational log is automatically stored in the PostgreSQL-based database, wherein the EPICS record value acts as a trigger. In the new RIBF operational log system, the table structure for storing the log has been made compatible with Zlog. Hence, the Zlog user interface can also access the database of the new RIBF operational log system.

### System Behavior

In this system, more than 3,000 EPICS records are monitored. The log monitor server is written in the C programming language and acquires the operational logs from the EPICS Input/Output Controllers (IOCs) on an event-driven basis. The system chart of the RIBF operational log system is shown in Fig. 3. The log monitor server process with the caMonitor, whose functions can be event-driven through a channel access protocol, utilizes the following steps to store an operational log in the database:

1. Using the EPICS process variable (PV) management system [10], EPICS records are obtained and a list of monitoring with caMonitor is prepared.
2. When an event occurs due to a change in a value of EPICS record, the caMonitor program creates a character string with a comma-separated line determined by the changed value and the EPICS record. For example, if the AR2\_Q01 electromagnet power supply sets the DAC to 29.076 via “psld\_nio:AR2\_Q01:DacCnv” as the EPICS record, then “psld\_nio, AR2\_Q01, DacCnv, 29.076,” is created as a character string.
3. At the RIBF accelerator facility, beams can be served simultaneously for an experiment using a beam accelerated by an azimuthal varying field (AVF) cyclotron, which uses a linac- (RILAC) accelerated beam and a RIKEN Ring Cyclotron (RRC)/RIBF beam. The experiment type is recognized by the operational log system based on the EPICS record.
4. The operation is classified automatically based on a part of the EPICS record. The major classifications are AVF, RIBF, and RILAC, which are based on the accelerator used for the experiment. The minor classification is the type of equipment, such as vacuum and electromagnet power supply.

The character string with a comma-separated line created by the log monitor server is placed in the “operation” column while the operation type is placed in the “related\_group” column; these data are stored in the database together with a timestamp.

In the case of Zlog, when registering an EPICS record in the log monitor server, it is necessary to write the code in Python. On the other hand, the list file, which is created by the EPICS PV management system, is simply passed as an argument to the log monitor server when the RIBF operational log is used.

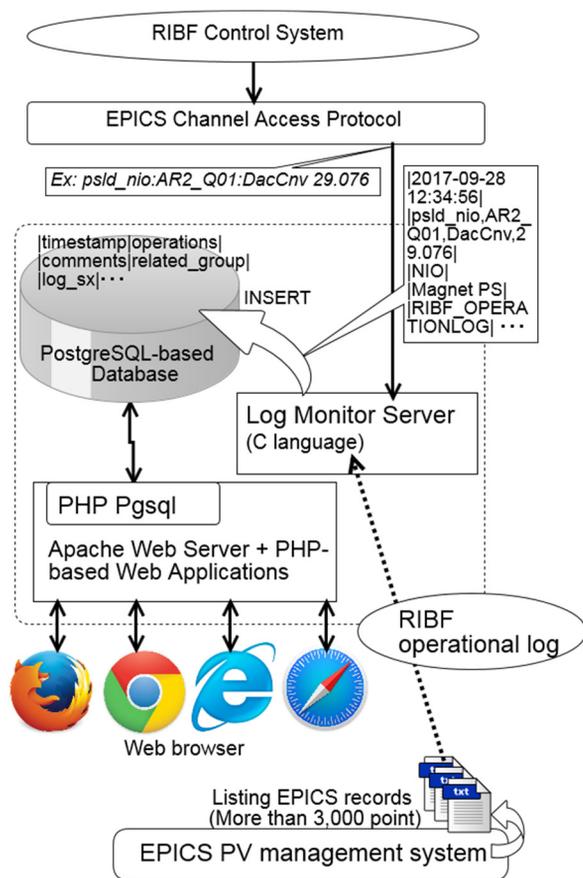


Figure 3: System chart of the new RIBF operational log system consisting of a log monitor server, Web-applications, and PostgreSQL-based database.

## USER INTERFACES FOR RIBF OPERATIONAL LOG SYSTEM

### Outline

The stored operation log can be accessed through the Web application developed by using PHP. For development of the user interface, Bootstrap [11] ver. 2.3.2 was used as a front-end HTML/CSS/JavaScript framework. The key feature of this system is that a separate user interface is prepared for each operational log type depending on the equipment. Several examples of user interfaces for different items of equipment are described below.

### Electromagnet Power Supply

In the RIBF control system, the EPICS record format of the electromagnet power supply is standardized, having the form of `psld_XX:YY:ZZ`. Here, `XX` is the type of controller, `YY` is the name of the electromagnet excited by the power supply, and `ZZ` indicates an action to the power supply. Therefore, a comma-separated character string with the setting digital-to-analog converter (DAC) values and EPICS record is stored in “operations” column of the database. The Web application obtains data from the database based on time range and the classification.

These data are then reconfigured for each electromagnet power supply and displayed in an HTML format.

Figure 4 shows a screenshot of the user interface for electromagnet power supplies displayed on the Web browser. The maximum and minimum DAC values for each 10-min periods, are displayed as “199-201.5” in the case of DAC values of `A_Q32` electromagnet power supply, as shown in Fig. 4. When the hypertext link “199-201.5” is clicked, all the operational logs performed during the specified 10 minutes are displayed as shown in the bottom-right corner of Fig. 4).

It is possible to use the EPICS record to retrieve past operations corresponding to the set value of the electromagnet power supply. Further, the user interface also lists the last operated DAC values for all the electromagnet power supplies in order from the upstream of the beam course. This function allows easy comparison of past parameters of the electromagnet power supplies with the current parameters, if the DAC is operated. These data can also be displayed as a chart.

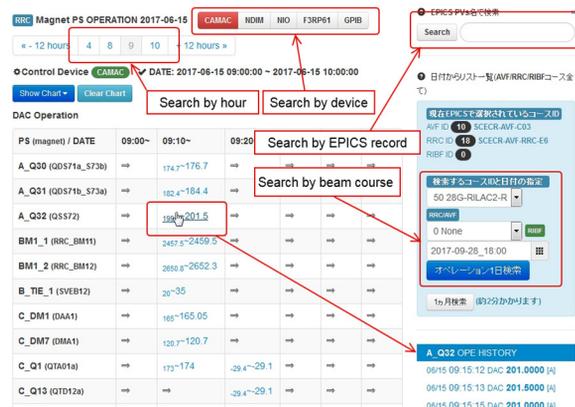


Figure 4: Screenshot of the user interface for electromagnet power supply. Various search functions are provided.

### Beam Diagnostics

The developed operation log system is designed to display both the operational log and the measured data as an image file in the case of the wire scanner (beam profile monitor). Consequently, past images of wire scanners can be compared with present ones at any time during beam tuning (Fig. 5). The user interface also provides a search function by using the EPICS record function.

In addition to the wire scanner device, the open/close status of the Faraday cups, which measure the beam intensity and are also used as beam stoppers, is also monitored. Thus, the status change from open to close (or close to open) is also displayed on the Web application of the RIBF operational log system. In addition, Faraday cup operation monitoring is closely related to estimating the beam service time because the insertion of Faraday cups stops beam delivery. Therefore, we implement another dedicated system in the case of Faraday cup operation, as described in the next section.

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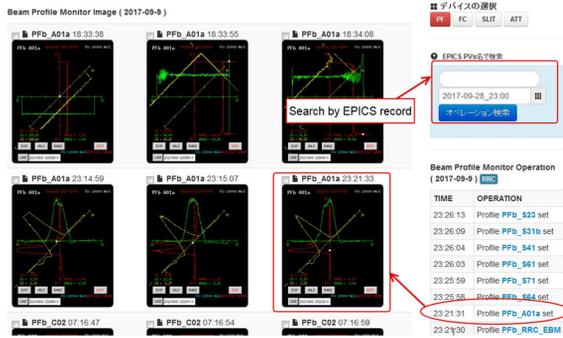


Figure 5: Screenshot of user interface for wire scanner. It is also possible to acquire measurement data of the beam position as an image file simultaneously to the operational log.

## ADDITIONAL DEDICATED OPERATIONAL LOG SYSTEM

### Motivation for Visualization of Beam Service Time

At RIBF, Zlog is used to obtain the open/close logs of the Faraday cup for measurement of the beam service time as well as paper-based log notebook. Beam availability is one of the important indices that indicates the research productivity of accelerator facilities. It is defined as the ratio of the actual to the scheduled beam service time. In the past, the beam availability was calculated based on information recorded by operators in Zlog and paper-based logbooks. However, it is cumbersome for an operator to accurately log and count stop time during beam service interruptions. That is, when beam service interruption occurs due to hardware troubles of the accelerators, fixing the problem and resuming the beam service again as soon as possible is of utmost importance. Thus, it is difficult to expect the operators who encounter hardware trouble to log the exact time at which the event occurred as accurately as the electronic log system does. Therefore, we implemented a dedicated operational log system, which is independent from the RIBF operational log, for keeping track of the beam service time [12].

### Beam Status History

We term the log system that records the beam service history for users as “Beam Status History.” At RIBF, the Faraday cup acts as the beam stopper; the insertion of the Faraday cup on the beam path stops the beam supply to the user. Therefore, the insertion status of the Faraday cup is used as an event trigger with caMonitor. The Beam Status History is implemented with the EPICS IOC, and the beam stop time and the total beam service time are automatically measured. The name of the Faraday cup that is first inserted for each beam service interruption is also shown.

## User Interface

When the beam stops, the operators input the stoppage reason in a comment form through the Web application of Beam Status History. The user interfaces are provided by Web applications using Asynchronous JavaScript and XML (Ajax) technology. In this system, Ajax is used to display the beam on/off status and the real-time table of the beam service time (Fig. 6).

From the perspective of the accelerator operator, Beam Status History is a system that provides a more detailed RIBF operational log for the Faraday cup. Similar to the RIBF operational log system, Beam Status History was developed based on the same concept as Zlog, which consists of an EPICS-based log monitor server, database, and Web applications.

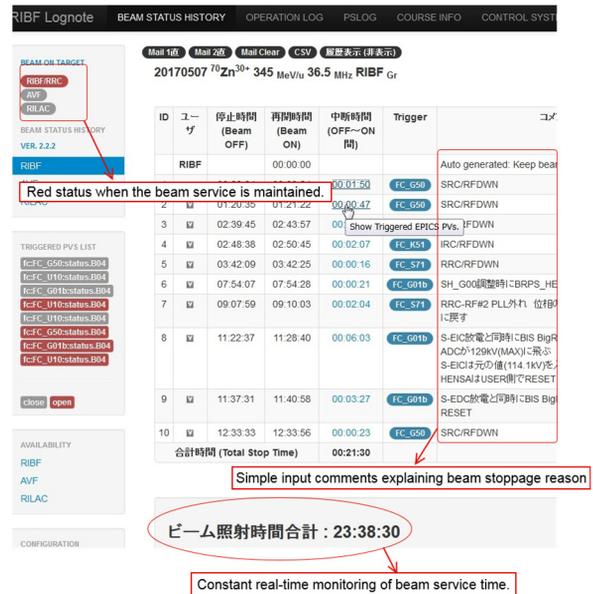


Figure 6: Screenshot of user interface for Beam Status History. The accelerator operator can always check the beam service time using this system.

## CONCLUSION

We developed a new RIBF operational log system that caters to the requirements of the RIBF accelerator operators. For implementing the electronic log at RIBF, automatic operation recording during the whole accelerator operation is a requirement. In order to provide various user interfaces for the operational log, the RIBF operational log system was developed as a Zlog-compatible tool, because Zlog has been implemented previously at RIBF. In the case of problems during beam tuning in particular, the proposed system is useful for analyzing the operation, such as the electromagnet power supplies operation and the electron resonance ion source operation. Moreover, new systems such as the beam interlock system [13] have been added to the RIBF control system; therefore, their user interfaces for the operational log will be developed in the same way in the future.

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