INTEGRATION OF INDEPENDENT RADIATION MONITORING SYSTEM WITH MAIN ACCELERATOR CONTROL

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Abstract

The radiation monitoring system of J-PARC was constructed as a part of safety facilities. It is isolated, and has been operated independently from the main accelerator control.

In 2013, integration of the radiation monitoring system with the main accelerator control was discussed. In order not to affect to the original safety system, standard TCP/IP network connections and accesses to the central database are not allowed. During 2013-2014, we added new hardware to the existing systems, and developed device-level data-link layers to enable one-way data transfer to the accelerator control system.

In 2014, radiation monitoring data can be supervised from the accelerator control system. We understand that this is a significant improvement to realize safer operation of J-PARC accelerators and experimental facilities.

INTRODUCTION

An accelerator facility is always associated by related facilities. For example, safety facilities (a personal protection system, a radiation safety system, etc.), utilities (water cooling system, electricity distribution facility, etc.), and so on. In J-PARC accelerator complex, the radiation safety system was constructed by non-accelerator group, and had been operated independently. It has an isolated network, dedicated terminals for data view and history retrieve. Behind the fact, there exists a strong policy: "safety systems must be independent".

In J-PARC, the radiation monitoring system is a part of the safety system. When accelerator operators and/or staff members wanted to know radiation levels of monitoring posts, they had to visit the radiation safety office. Checking of radiation monitoring data from the central control room was not possible.

SCHEME FOR DATA-SHARING

J-PARC Accelerator Complex

J-PARC (Japan Proton Accelerator Research Complex) is a high-intensity proton accelerator complex. It consists of three accelerators: a) 400-MeV linac (LI), b) 3-GeV Rapid Cycling Synchrotron (RCS), and 30-GeV Main Ring (MR). Addition to them, there are three experimental facilities: d) Material and Life Science Experimental Facility (MLF), e) Neutrino Experimental Facility (NU), and f) Hadron Experimental Facility (HD). J-PARC was constructed and has been operated jointly between two institutes: JAEA and KEK [1,2].

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Accident of Hadron Experimental Facility

On May 23, 2013, we had a serious accident at the Hadron Experimental Facility. Radioactive materials were released out of the radiation controlled area. The dose level was estimated less than 0.17 uSv on the site boundary closest to the Hadron Experimental Facility. Moreover, 102 workers were exposed by uncontrolled radioactive materials. Out of them, 34 persons were found to receive radiation dose in the range of 0.1-1.7mSv, all below the legal limit [3,4].

A team of third-party experts (the External Expert Panel) was established in order to review and inspect the accident. In August, 2013, the official report, including preventive measures against recurrence of similar accidents, was submitted to the Nuclear Regulation Authority of Japan [5]. It reflects the recommendations of the Panel. In the report, lack of sharing of radiation monitoring information was pointed out.

Policies and Plans for Implementations

We discussed a method to enable sharing of radiation monitoring data between the radiation monitoring system and the accelerator control system. In order to keep the independency of the safety system, TCP/IP network connections are not allowed. In addition, accesses to the central database of the safety system are prohibited, to avoid increases of system loads. We accepted above policies as same as before.

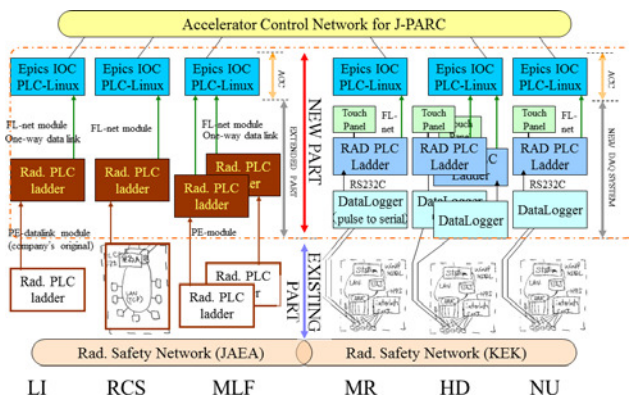

Figure 1: Overview of the data-sharing scheme.

We investigated the existing radiation monitoring systems. Our idea is that data-links to the device-level layers are possible without influences on the original safety system. The overview of the implementation scheme is shown in Figure 1.

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Key issues are:

- For JAEA (LI, RCS and MLF), an extension of the existing PLC-based front-end system is considered. A dedicated data-link (PE data-link) is used to export monitoring data to the extended part.
- For KEK (MR, NU and HD), the existing system is a CAMAC-based DAQ system. Introducing new DAQ system is considered. Raw pulse signals to CAMAC are divided and are fed into the new DAQ system.
- Between the accelerator control and above two new systems, another data-link layer, FL-net, is used for one-way data transfer. Here FL-net is a device-level communication network defined by a Japanese consortium [6]. This layer is significant to guarantee independency of the safety system as before.
- A PLC-type EPICS IOC, which is a standard of J-PARC MR control [7,8], is used to receive shared-data of radiation monitors. In total, there are six EPICS IOCs, each corresponds to one of accelerators and experimental facilities.

IMPLEMENTATIONS

Figure 2 shows implementation details of both JAEA and KEK cases. For JAEA, the extended part was developed by the company which is in charge of the existing system. For KEK, new DAQ system was developed under a collaboration of us (accelerator staff) and radiation safety staff. It consists of: (a) "Data Logger", a commercial product which converts pulse signals to periodical serial string outputs, (b) "RAD PLC Ladder", accepts serial inputs, calculate radiation monitoring levels, and generate alarm I/O signals (HIHG and HIHI levels), and (c) "Touch panel", enables to configure the DAQ parameters and to view monitoring data on-site.

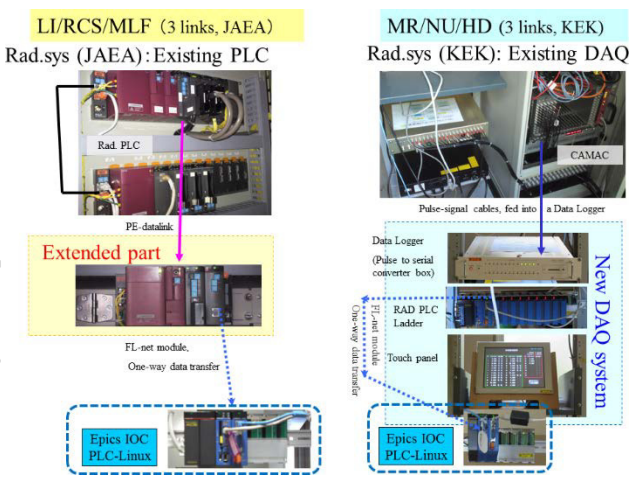

Figure 2: Implementations at JAEA and KEK.

In fact, operation of J-PARC had been suspended for seven month due to the accident. Beam operation restarted in December, 2013 [9]. During the month followed by the suspended term, we proceeded the implementation one by one, as show in Figure 3. In October, 2014, alarm threshold values for MR and NU are in a test phase. The implementation for HD is just on-going phase, and to be completed in November, 2014.

	LI	RCS	MLF	MR	NU	HD
Implementation	Dec. 13	Jan.14	Feb.14	Jun.14	May.14	On going
Monitoring data	○ OK	○ OK	○ OK	○	○	Not yet
Alarm data	○ OK	○ OK	○ OK	△ (In test)	△ (In test)	Not yet

Figure 3: Rough history of implementations.

OPERATION EXPERIENCES

Demonstration of Radiation Monitoring by Accelerator Control

Figure 4 demonstrates 2-shift (~16 hours) trends of gas monitors on June 20, 2014. A standard EPICS tool, StripTool, is used. It shows behaviour of radiative gas levels correspond to the beam operation. In addition, data of two different sites, MR and NU, are merged in a single graph seamlessly.

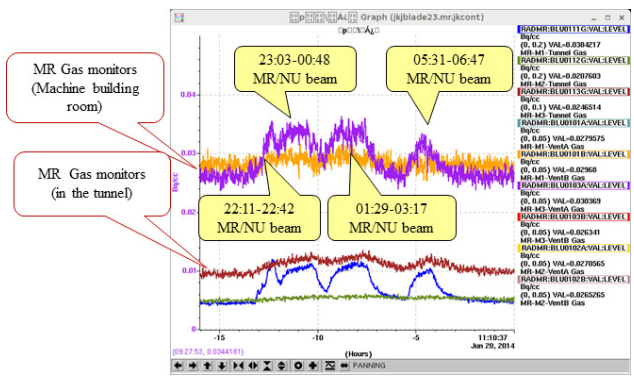

Figure 4: Demonstration of monitoring radiation data using an accelerator control tool.

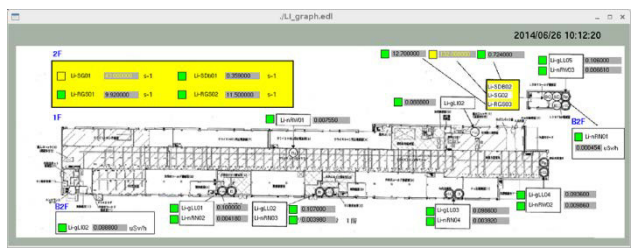

Figure 5: Map-style alarm-level indications for J-PARC LI.

Figure 5 is a map-style screen for the linac accelerator. Alarm levels, HIGH in yellow and HIHI in red, would be shown with color indications. Figure 5 is the screenshot on June 26, 2014, a few hours after accelerators stop, accordingly radiative gasses were still in the machine ventilation room at the "2F" floor level.

In fact, this screen was requested by accelerator operators. They need to identify the alarm location(s) as soon

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tool, edm, is essential to develop this screen in a very short term (roughly a week).

Available Terminals

Before the accident, only a few dedicated terminals in the radiation safety office were available to check radiation monitoring information. Now all the terminals of the accelerator control can be used. Total number could be about 50 in the central control room. Additional pieces of terminals are also available in accelerator's local rooms and in experimental facilities.

CONCLUSION

We integrated the radiation monitoring system, which was constructed and has been operated independently, into the main accelerator control. Operators and commissioning staff members can check radiation monitoring data much easier than before. This work improve safety of J-PARC accelerators against possible damages using high intensity proton beams.

We thank the radiation safety staff members and accelerator operators of J-PARC, for their positive collaborations and discussions. Their contributions are indispensable to the present work.

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