A CONTROL SYSTEM OF THE SLOW-EXTRACTION BEAM LINES IN THE J-PARC PROJECT

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Abstract

Japan Proton Accelerator Research Complex (J-PARC) project is now under construction at Tokai-mura by High Energy Accelerator Research Organization (KEK) and Japan Atomic Energy Research Institute (JAERI). J-PARC 50 GeV Proton Synchrotron (PS) aims at providing 50 GeV proton beam with the intensity of 15 μA. An experimental hall for particle and nuclear physics (NP-hall) is designed to handle intense slow-extraction proton beam and provide kaons, pions, and other secondary particles for multi-purpose physics use.

The control system for the primary and secondary beam lines is designed to operate magnets on the beam lines, monitor the intensity and profile of beams, and control many kinds of equipments.

The present article reports the basic policy and design of the control system for the slow-extraction beam lines.

SLOW-EXTRACTION BEAM LINES AND NP-HALL

Figure 1 shows a schematic drawing of slow-extraction beam lines and NP-hall [1], and Table 1 shows a summary of the slow-extraction proton beam. Proton beams accelerated up to 50 GeV by 50 GeV-PS are extracted to NP-hall through beam switching yard during the extraction period of 0.7 sec in the accelerator operation cycle of 3.4 sec. Protons focused on the production target (T1) [2] generate secondary particles such as kaons, pions, and so on, which are transported to the experimental targets through secondary beam lines and used for physics experiments. After hitting the production target, protons are transported to the beam dump [3] and absorbed safely.

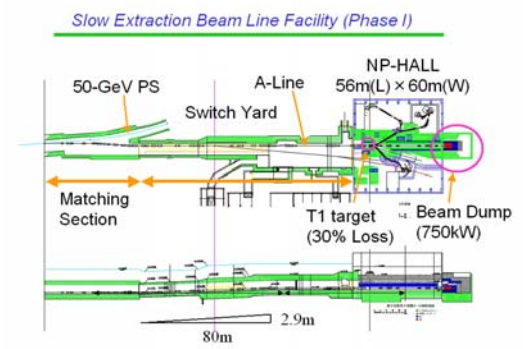

Figure 1: Schematic drawing of slow-extraction beam lines and NP-hall (Phase 1)

Table 1: Specifications of the slow-extraction beam

Beam energy	50 GeV
Beam intensity	3.0×10^{14} p/cycle
Beam power	750 kW
Extraction period	0.7 sec
Operation cycle	3.42 sec

POLICY OF THE CONTROL SYSTEM

The followings are our policy on designing the control system of slow-extraction beam lines and NP-hall;

- The construction group of slow-extraction beam lines and NP-hall has responsibility for the operation of beam lines and equipments.
- Since the operation of primary beam lines are strongly related to that of secondary beam lines and experiments themselves, the control system must be located in the experimental hall.

These policies lead to the local control system in NP-hall. Quality of beam and safety of the beam line operation can be achieved by close communication with the central control system.

Relationship with the central control system can be summarized as follows;

- The local control system issues the permission of the beam extraction to the accelerator central control.
- The local control system issue the permission of the accelerator operation by which 50GeV-PS can start the beam acceleration.
- The local control system provides the permission of the beam extraction and related information of the beam line status to the accelerator central control.
- The accelerator central control provides information of operation status of equipments related to the beam extraction.
- The accelerator central control provides timing information for the equipments of beam line elements.
- The accelerator central control must issue the interrupt signals when it suspends the beam extraction without precaution.

The local control system is based on these policies.

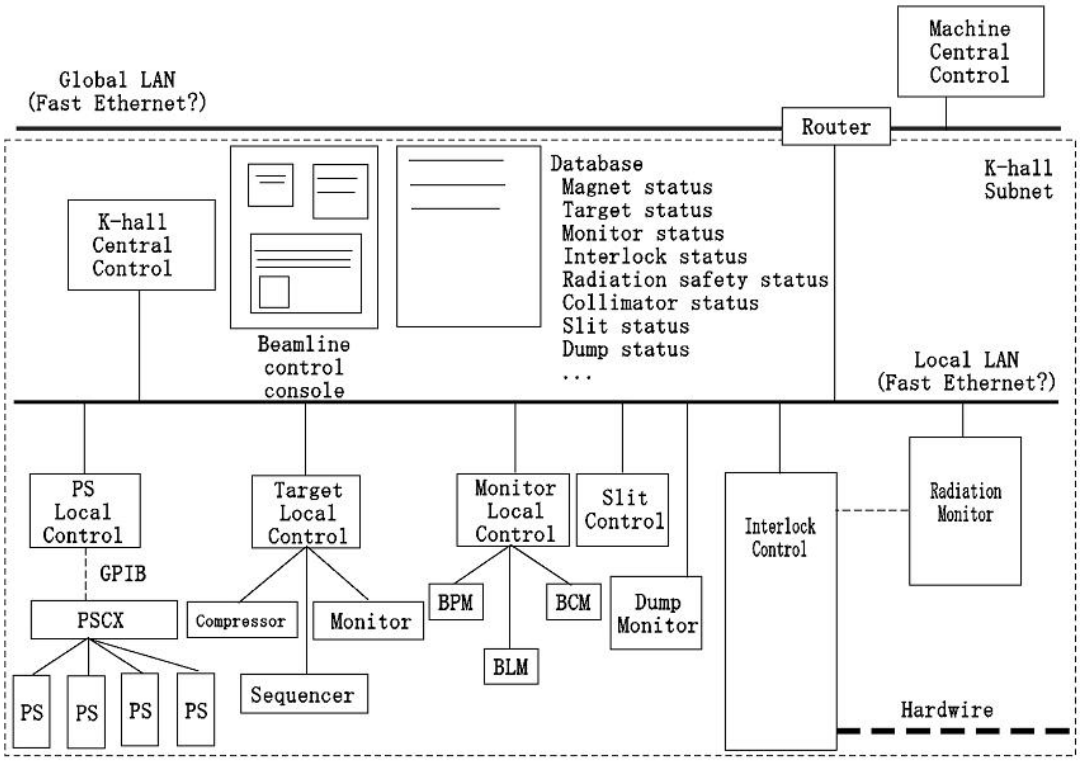

Figure 2: A schematic drawing of the local control system for the slow-extraction beam lines and NP-hall.

GENERAL LAYOUT

Figure 2 illustrates the schematic drawing of the local control system for the slow-extraction beam lines and NP-hall. The readout electronics will be installed in the local control room and near the production target (T1) and the beam dump. All the electronics and input output controller (IOC) for EPICS are connected each other by the local Ethernet whose access is limited to the common users. Each component may be tested during the installation by the their own data taking system, although all the components should be connected to EPICS framework in the final stage.

Beam monitors

The beam current monitor (BCM) and the beam profile monitors (BPRM) are used to monitor the current intensity and profile of the slow-extraction beam [4]. Beam loss monitors will also be installed to monitor the unexpected large beam loss in the beam line [4]. Signals of beam monitors are transferred to the readout electronics outside the radiation shield, and data are presented on the display in the local control room by EPICS [5]. Some of readout electronics related to the interlock system must issue the interrupt signal to protect the serious damage to beam line equipments. VME-based readout electronics, which can issue the interrupt signals to the safety control system, are now under preparation. Total number of BCM and BPRM could be 4 and 16, respectively. That of BLM could be 100-200.

Beam line magnets and power supplies

Beam line magnets and its power supply for the primary and secondary beam lines are installed before the construction. Since we are going to bring the existing magnets and power supplies in the KEK 12GeV-PS to Tokai site, the control system of the magnet power supply for the slow-extraction beam lines and NP-hall can be easily configured without major modification. However, the existing magnet control system [6] must have connection with EPICS framework, so the SQL-based database will be necessary. EPICS-MySQL software device driver is now under discussion with online-electronics group in KEK.

Equipment control and monitoring

The primary target (T1) is one of the most important equipments in NP-hall since it is highly activated by the irradiation of the primary proton beam. The target driver for moving, rotating, and monitoring its status (temperature, rotation speed, water flow, etc.) must have connection with programmable logic controller (PLC) with network device, and can communicate with EPICS.

Collimator and beam dump are also important items for the stable operation of the proton beam. Temperature of collimators and the beam dump core made of copper must be constantly monitored with thermocouple devices. Total number of thermocouple device could be 1000-2000 channels.

Basically, these devices are monitored each extraction period. The signal multiplexer with GPIB interface are now under consideration since EPICS can easily handle

GPIB-Ethernet gateway. Software device driver must be developed and tested in near future.

Safety control

Some of beam line equipments must issue the interrupt signals to stop the operation of the accelerator when an accident would occur during the stable operation. The safety system of J-PARC are comprised of the personal protection system (PPS) and the machine protection system (MPS). Both of PPS and MPS must issue the interrupt signals directly without computers and software. Table 2 shows the typical elements of PPS and MPS units in the slow-extraction beam lines and NP-hall.

PPS is designed to guarantee the protection of personnel safety. Items of PPS are doors in the beam line tunnels, bending magnets which can control the beam angle, personal keys, and so on. J-PARC PPS requires to duplicate all the monitors and cables connected to PPS equipments.

MPS is designed to guarantee the protection of equipments in the beam lines. Items of MPS are beam loss monitors, collimators, beam dump, target, vacuum, cooling water, and so on.

The signals from PPS and MPS equipments are transferred to the local control room, and the logic diagram of the operation status is configured in PLC modules. The interrupt signals are connected to the accelerator central control by duplicate hardwires.

Table 2: MPS/PPS units in beam lines and NP-hall

Element	MPS/PPS	# of items
Extracted beam intensity	M	1
Septum magnet	MP	1
SY-magnets	M	All
Beam plug	P	2
BLM	M	All
SY bending magnet	P	8
Production target (T1)	MP	1
Collimators	M	2
Beam dump	M	1
SY, NP vacuum	M	9
SY, NP air conditioner	P	2
Personal keys	P	65
Doors, shields	P	15
Cooling water	P	3
Emergency	P	10

Control Software, timing, and network

As described above, J-PARC accelerator control group decided to use EPICS for the accelerator control. In the local control room, most of the electronics and drivers will be installed and the operators manage the GUI interface on the console display. The console display may be in different places, using network. Some of basic information during the accelerator and beam lines will be displayed on the web.

Monitored data will be saved to the local storage devices, such as HDD and DLT. It is recommended that the accelerator central control also stores all the data including the slow-extraction facility.

Timing information related to the accelerator operation will be provided by the accelerator central control through the optical fibers [7]. At least, the beginning of the accelerator cycle, the start and stop signals of the beam extraction must be provided to make triggers for the data acquisition.

SUMMARY AND FUTURE PROSPECTS

The control system of the slow-extraction beam lines and NP-hall is presented. Some of electronics modules and software will be tested in near future.

REFERENCES

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[6] Y. Suzuki et al., in this proceeding.
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