Software Applications for SPring-8 Accelerator Operations

M. Takao*
SPring-8, Mikazuki, Sayo-gun, Hyogo 679-5198, Japan

Abstract

Various software applications have been developed for SPring-8 accelerator operations. The effectiveness of these software tools in the operation of SPring-8 accelerator complex is reported.

1 INTRODUCTION

The SPring-8 (Super Photon Ring 8-GeV) is a dedicated synchrotron radiation facility with an 8-GeV third generation light source storage ring (SR), which has been in operation since 1997. At present, 44 beamlines have been constructed and in use, 25 of which are for insertion device (ID) and the others for synchrotron radiation by bending magnet. The injector consists of a 1-GeV linac and 8-GeV booster synchrotron. The linac is shared with another 1.5-GeV synchrotron radiation storage ring, NewSUBARU (NS), whose injection energy is 1-GeV.

In 2002, scheduled user beam time was 4148 hours and beam availability was 95.4 %. Beam availability for users is one of the most important performance parameters of the SPring-8 storage ring operation. To make beam availability as high as possible, we continuously improve both hardware and software operation tools. In this paper we report higher level software applications to smoothly operate the complicated accelerator complex.

2 FRAMEWORK OF SPRING-8 CONTROL SYSTEM

The SPring-8 accelerator complex from linac to beamlines, including the NS storage ring, is controlled in terms of the unified software framework [1, 2, 3]. The SPring-8 control system consists of engineering work stations, VMEbus systems and an optical fiber network system [1]. The remote procedure call is used for the communication between machine control applications over the network. The operation history and the equipment parameters are stored on a database by relational database management system, Sybase.

The SPring-8 control system heavily depends on the database system [4]. All operation parameters of equipments are stored on the database, and logged data are collected periodically and stored. Logged data are handled in uniform way, so we can easily access them with the same procedure. Functions accessing the data are prepared by the control group, and hence user applications can easily manage the logged data.

Since the SPring-8 control system is developed under the basic concept of transparent, a non-expert programmer can easily build higher level integrated applications for accelerator operations. The higher level application can control an equipment by sending a character command message to lower level control software. The command is a character string as the English like syntax, for instance, “put/sr_mag_ps_b/1234.5A”. Furthermore the accessibility to database also assists in-house staff to develop software applications for accelerator operations.

3 HIGHER LEVEL OPERATION SOFTWARE APPLICATIONS

Corresponding to the complicated accelerator structure, there are many operation modes, *i.e.* linac only, booster synchrotron injection, SR injection, NS injection, and so on. Both SPring-8 SR and NS have been in operation, we should daily change operation mode. The switching process of operation mode takes a few tens minutes, and hence in some case a mis-operation results in no little time loss. We then developed operation softwares so as to prevent mis-operations.

Higher level operation software applications for each component of accelerator complex consist of a control panel and a status monitoring panel for beam operation. The task of the control panel is to execute a sequence of operation process, and that of the monitoring panel is to check the ready status of machine for beam injection. The latter panel permits to turn on beam switch after the condition for beam injection is fulfilled.

Figure 1 is an example of the control panel which is the top panel for linac control. There are similar control panels for SPring-8 SR, booster synchrotron, and NS. Main func-

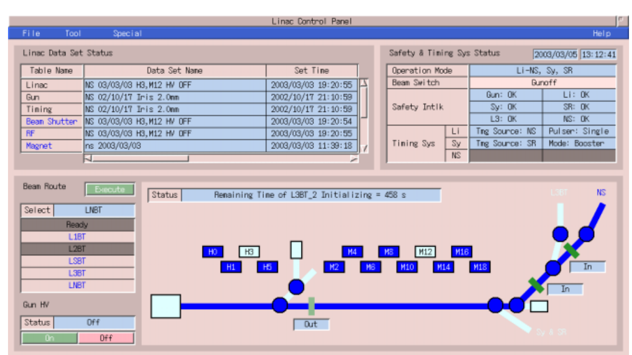


Figure 1: Linac control panel.

tions of linac control panel is as follows.

- Setting operation parameters to all equipments of

* takao@spring8.or.jp

linac.

- Saving operation parameters of equipments on database.
- Switching beam route through linac.
- Turning on (off) high voltage of electron gun.

For example, in the switching procedure to NS injection the following procedures are executed sequentially:

1. Changing the mode of the switching magnet to NS injection.
2. Changing the timing source of linac to NS.
3. Setting the gun pulser to 1 ns width.
4. Notifying an operator of changing the operation mode to NS injection.
5. Degaussing the switching magnet.
6. Opening the beam shutter at the beam transport line to NS.
7. Setting operation parameters to equipments of linac.

For the sake of radiation safety, in NS injection mode the pulse width of gun should be 1 nsec and the timing signal has to come from NS. Similarly, the beam shutter opening and the excitation of the switching magnet are permitted only in NS injection mode. If one makes a mistake in beam route switching procedure, radiation safety interlock acts on. Top panel of linac control automatically executes the above switching sequence.

At the Spring-8 SR the status monitoring panel for beam operation checks ready condition for beam injection, that is shown in Fig. 2. Each row in the panel corresponds to labeled equipment groups. When an equipment group becomes ready for beam injection, the button color of the row becomes blue. After all rows turn blue, the inhibition of beam switch is released.

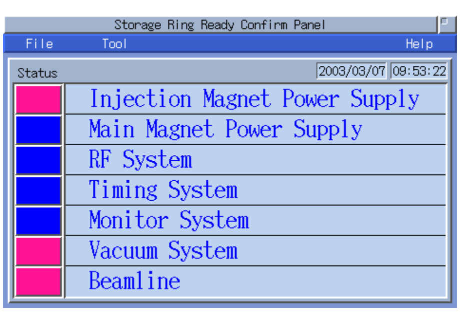


Figure 2: SPring-8 storage ring ready status panel for beam injection.

Detailed information on an equipment group can be obtained by the sub-panel opened by clicking the row. Figure

Figure 3: Half part of beamline ready status panel.

3 is the half part of the sub-panel for beamline ready status monitoring panel. At present, during beam injection of SPring-8 SR, the main beam shutters for beamlines should be closed and the ID gaps also have to be fully opened. The beamline ready status monitoring sub-panel checks these conditions for beam injection.

4 BEAM LOSS ANALYSIS SOFTWARE TOOL

For the purpose of minimizing downtime of user beam, it is urgently needed to recover the machine from faults. The SPring-8 SR has two kinds of interlock systems: one provides radiation safety protection, and the other protects the ring components from damage by synchrotron radiation. We have developed a software tool to judge the origin of beam loss among many faults appearing at the time of beam loss, which is shown in Fig. 4.

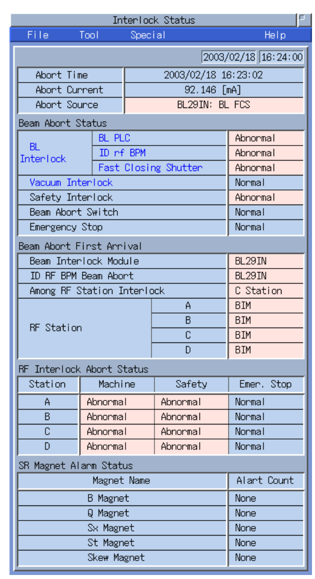


Figure 4: Beam loss analysis panel.

There are provided the beam interlock by beam position monitors (BPM) placed specially for ID beamline, which protects beamline components from the damage of intense synchrotron radiation from ID when electron beam orbit excursion occurs. If a beam interlock acts on, the stored beam is aborted by switching off RF power. At the time beam loss occurred, hence the BPM beam interlock always issues beam abort request. The beam interlock module (BIM), that forwards the abort requests to RF system, detects which signal comes first. However, the BIM is not aware of beam loss by interlock signals not going through BIM, such as faults of RF system itself or radiation safety interlock signal directly going to RF system. Low level controllers of RF system observe whether RF switch is turned off by an external signal or not. Gathering informations on beam interlock, beam loss analysis panel decides the origin of beam loss. In the case displayed in Fig. 4, the failure of the fast closing shutter at ID beamline 29 (BL29IN) causes the beam loss.

5 SOFTWARE LIMITS FOR BEAM INJECTIONS

The maximum stored current of the SPring-8 storage ring in user beam is restricted to 100 mA by radiation safety. This limit is secured by the hardwired interlock of beam current monitor. We use a software limit to stop beam injection just before the stored current interlock, which results in loss of stored beam, works on.

The integrated injection charge to NS for one shift is also severely restricted by the radiation safety and hence there is provided a hardwired interlock for the beam injection to NS. For the sake of operation convenience, we prepare a software tool limiting the integrated injection charge, whose display is shown in Figure 5.

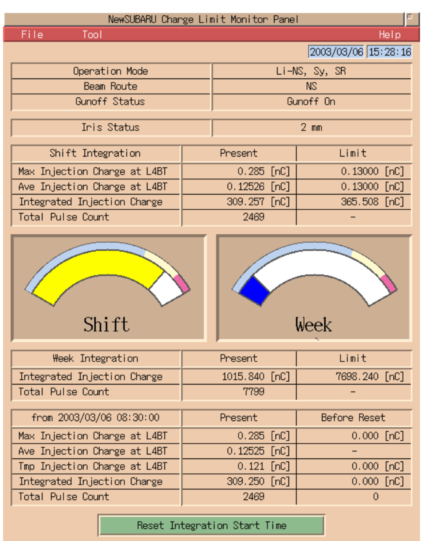
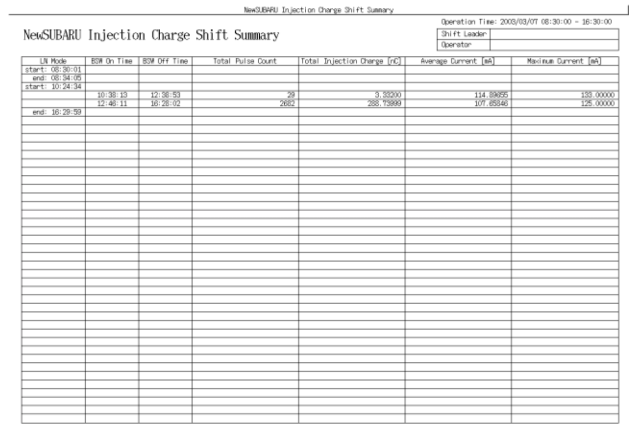


Figure 5: NewSUBARU injection charge limit panel.

Recording the statistics of the beam injection is another important task of NS injection charge limit panel, since the frequent beam injection to NS is in progress. NS injection charge limit panel summarize operation statistics for one shift, whose printing out is given in Fig. 6. For one shift, the start and end times of NS injection mode, the beam switch on time, the total number of the injected pulses, the total, average and maximum injected charge are all recorded.



NewSUBARU Injection Charge Shift Summary

NewSUBARU Injection Charge Shift Summary

Operation Time: 2003/03/07 08:30:00 - 16:30:00

Shift Leader	
Operator	

LN Mode	BSW On Time	BSW Off Time	Total Pulse Count	Total Injection Charge [nC]	Average Current [mA]	Maximum Current [mA]
start: 08:30:01						
end: 08:34:05						
start: 10:24:34						
	10:38:13	12:38:53	29	3.33200	114.89855	133.00000
	12:46:11	16:28:02	2682	288.73999	107.65846	125.00000
end: 16:29:59						

Figure 6: Operation statistics for NewSUBARU beam injection.

6 CONCLUSIONS

The software applications described here are little part of operation tools developed at Spring-8. Due to high flexisibility and extendability of the SPring-8 control systems, many software applications for accelerator operations are developed by in-house staff. These integrated software tools contributes to stable operation of SPring-8 accelerator complex with high beam availability for users.

It is planed to put the top-up operation to user beam in near future of SPring-8 SR. It is necessary for top-up operation to control SPring-8 accelerator complex with more tight connection between injector and SR, and hence the more integrated software tools will be needed. The unified control system of the SPring-8 accelerator complex makes possible to develop such an integrated software applications for the operation.

I would like to thank all members of linac group, ring accelerator group, control group and opertion group.

7 REFERENCES

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