

# UPGRADE OF ACCELERATOR RADIATION SAFETY SYSTEM FOR SPRING-8

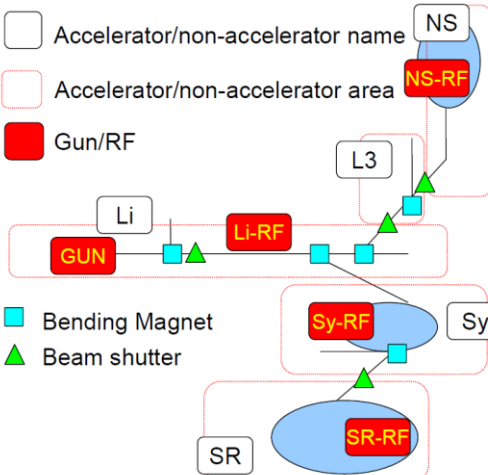
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**Abstract:** An accelerator radiation safety system (accelerator safety interlock system) to protect persons from radiation hazard induced by electron beams and synchrotron radiation has been operating over a decade in SPRING-8. The accelerator safety interlock system for SPRING-8 is based on the operation mode control system. The operation mode control system became complicated because the number of "operation mode" has increased according to SPRING-8 upgrades. Therefore we are planning to construct new accelerator safety interlock system. We will report the status of the current safety interlock system and the conceptual design of the new one. This upgrade is scheduled for the summer of 2010.

## Purpose:

The most important function of an accelerator safety interlock system is to manage accessible criteria of radiation controlled areas for accelerators and permissions of fundamental acceleration devices which are GUN and RF. An accelerator safety interlock system is keeping watch on the condition of access control equipments for the machine area, the radiation monitor and other safety instruments.

To control the electron beam, permissions of four RF and one GUN are managed by the accelerator safety interlock system for SPRING-8.



Spring-8 Accelerator Components

## Spring-8 Accelerator:

SPRING-8 consists of five access controlled areas which are four accelerator areas and one non-accelerator one. The accelerator areas are Linac (Li), injection booster Synchrotron (Sy), Storage Ring (SR) and NewSUBARU storage ring (NS), and the non-accelerator area is L3 beam-transport (L3). These areas are connected by beam transport lines, and basically divided by each electron beam shutters (no electron shutter available between Li and Sy). The beam transportation route is determined by bending magnets. The beam acceleration has achieved by one electron gun (GUN) and four acceleration RF (RF) which are Li-RF, Sy-RF, SR-RF and NS-RF.

## Current Interlock System:

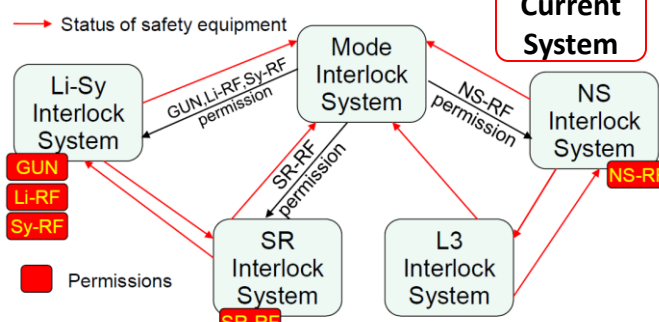
- Features**
- Programmable Logic Controller (PLC) based system.
  - Based on Operation Mode and accelerator (area) system.
  - Some areas communicate each other (see red line)
  - Some permissions are managed by one system (see red square).
  - Some areas are managed by one system (e.g. Li-Sy system)

## Operation mode(MODE)

- Manage combination of some areas
- Appropriate MODE is required for accelerator operation.
- MODE transition procedure is fixed (see Fig.).

## ISSUES

- Complex system → Hard maintenance and modification
- Lower extensibility



Schematic view of Current Accelerator Safety Interlock System

Interlock System	Covered Area	Related Permission
Mode	-	GUN, Li-RF, Sy-RF, SR-RF, NS-RF
Li-Sy	Li, Sy	GUN, Li-RF, Sy-RF, SR-RF
L3	L3	GUN, NS-RF
SR	SR	GUN, SR-RF, Sy-RF
NS	NS	GUN, NS-RF

Covered area and related permission of Current Accelerator Safety Interlock System

## The List of mode and their combinations(part)

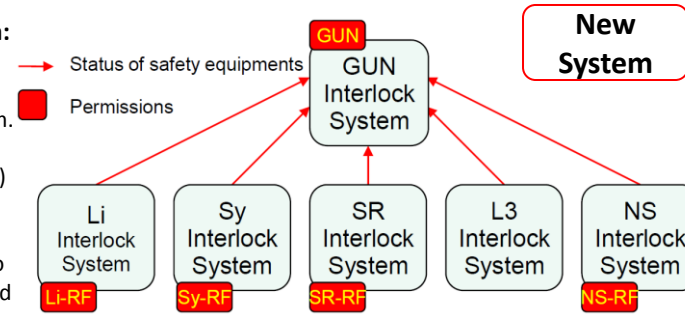
- READY Mode
- L2 Mode
- L3 Mode
- Sy-injection Mode
- SR-injection Mode
- Topup Mode
- SR-storage Mode
- NS-injection Mode
- NS-storage Mode
- Sy• NSinjection Mode
- SR• NSi-njection Mode
- Topup• NS-injection Mode
- L2, Sy-storage Mode
- L2, Sy-storage, SR-storage Mode
- L2, Sy-storage, NS-storage Mode
- L2, Sy-storage, SR-storage, NS-storage Mode
- Sy-injection, SR-storage, NS-storage Mode
- Topup, NS-storage Mode
- NS-injection, Sy-storage, SR-storage Mode
- SR-storage, NS-storage Mode

Covered area and related permission of Current Accelerator Safety Interlock System (Red region shows Mode with portion injection)

## Updated Interlock System: Features

- Programmable Logic Controller (PLC) based system.
- Consist of GUN interlock system and accelerator (area) interlock system.
- One way communication from area interlock system to GUN interlock system(see Red line) and any other communication is unavailable.
- Independent permission management
- Independent area management

- Efficient expansion of accelerator components.
  - Improvement of maintenance
- Construction**
- GUN interlock system newly constructed.
  - New modules for safety system will be installed.
    - Shutter permission controller module
    - Bending magnet controller module
    - Search status monitoring module
  - To achieve an independence of accelerator (area) safety interlock systems.
  - Additional Accelerator components
    - Beam shutter
    - Li-Sy: newly added
    - L3-L4(NS): additional



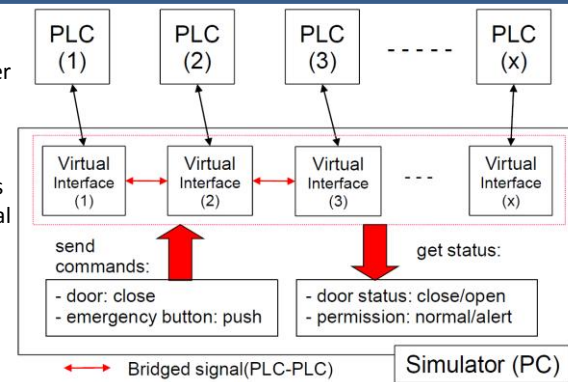
Schematic view of New Accelerator Safety Interlock System

Interlock System	Covered Area	Related Permission
Gun	-	GUN
Li	Li	GUN, Li-RF
Sy	Sy	GUN, Sy-RF
L3	L3	GUN
SR	SR	GUN, SR-RF
NS	NS	GUN, NS-RF

Covered area and related permission of New Accelerator Safety Interlock System (Covered areas and related permissions is independently managed by each interlock systems)

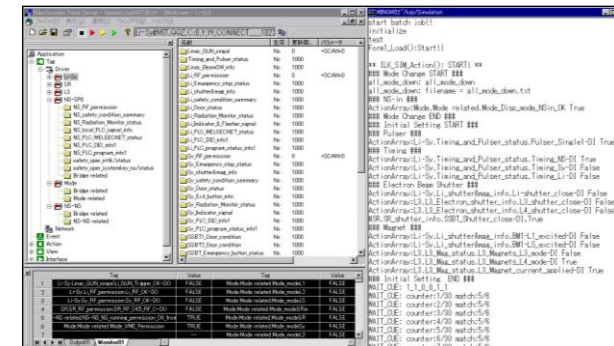
## Simulation System

- Powerful tool for interlock ladder software check
- Individual operation
- Based on PLC and PC (Windows)
- Manage combination of several systems
- Programmatically control PLC signal (set/monitor)



## Schematic view of simulator operation

- Ladder software for checking is installed each PLCs
- PLC calculates output signal
- **PLC Input signal:** programmatically controlled by simulator PC via virtual interface.
- **PLC output signal:** monitored by simulator PLC
- All status of PLC and command can be logged occasionally



## Simulator display

- **Left window:** shows virtual interface. Upper sub-windows show all PLC systems(LEFT) and their signals. Lower sub-window shows signal status of PLCs
- **Right window:** shows command sequence and simulation results.

## SUMMARY

The design of the new accelerator safety interlock system is reported. The new system considers that the independency of accelerator safety interlock systems is important and will achieve an efficient expansion of accelerator area components.

The construction is scheduled for August 2010 and will be ready for the user operation at the end of September. The new accelerator safety interlock system will be ready to connect an additional accelerator area, XFEL.