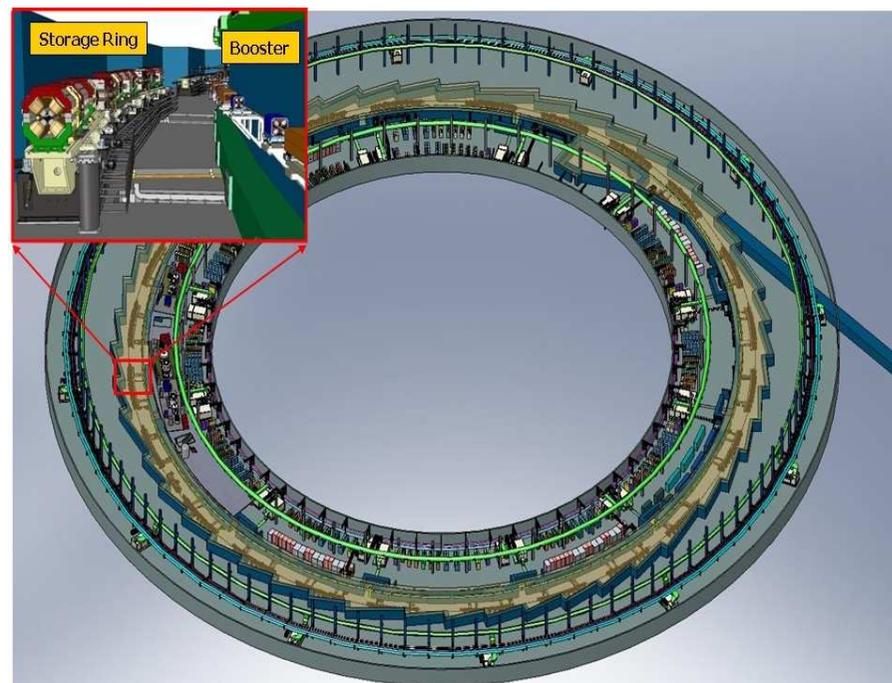


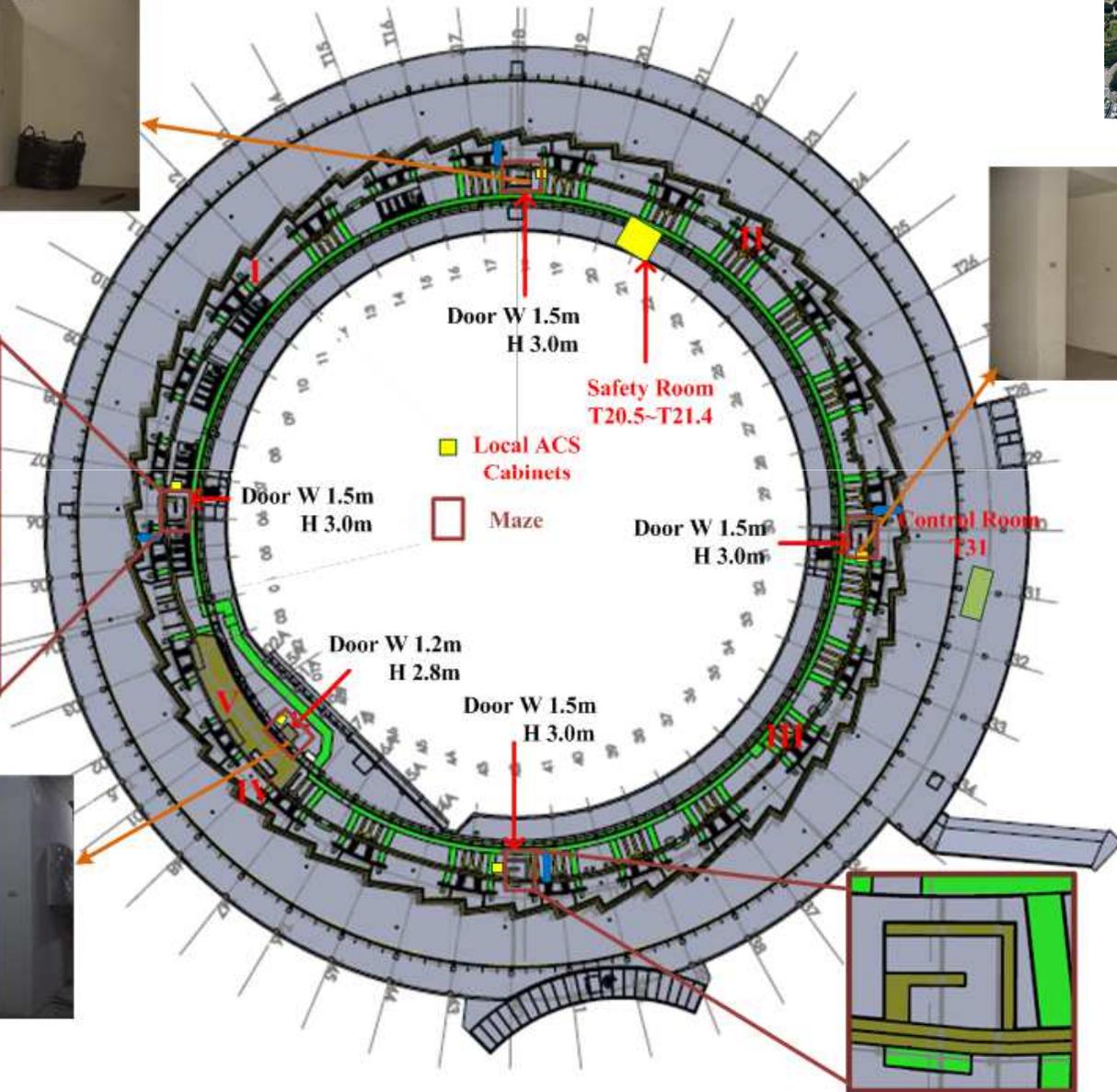
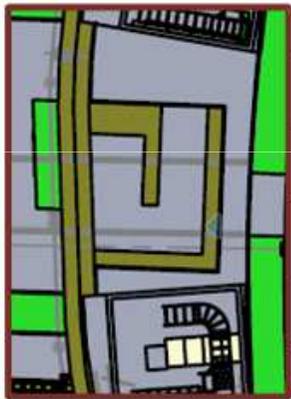
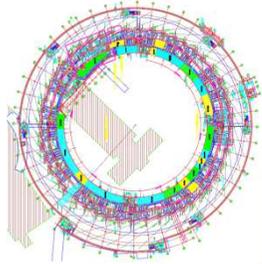
The Design of Radiation Safety Access Control System (ACS) for Taiwan Photon Source

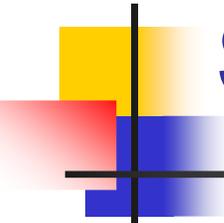
Parameters	TPS
Beam energy (GeV)	3.0
Stored beam current (mA)	500
Circumference (m)	518
Emittance	< 2 nm-rad
Design dose limit (mSv/y)	1

Chien-Rong Chen
Radiation & Operation
Safety Division, NSRRC
Email: ccr@nsrrc.org.tw
May 10, 2013



The Diagram & Mazes for TPS



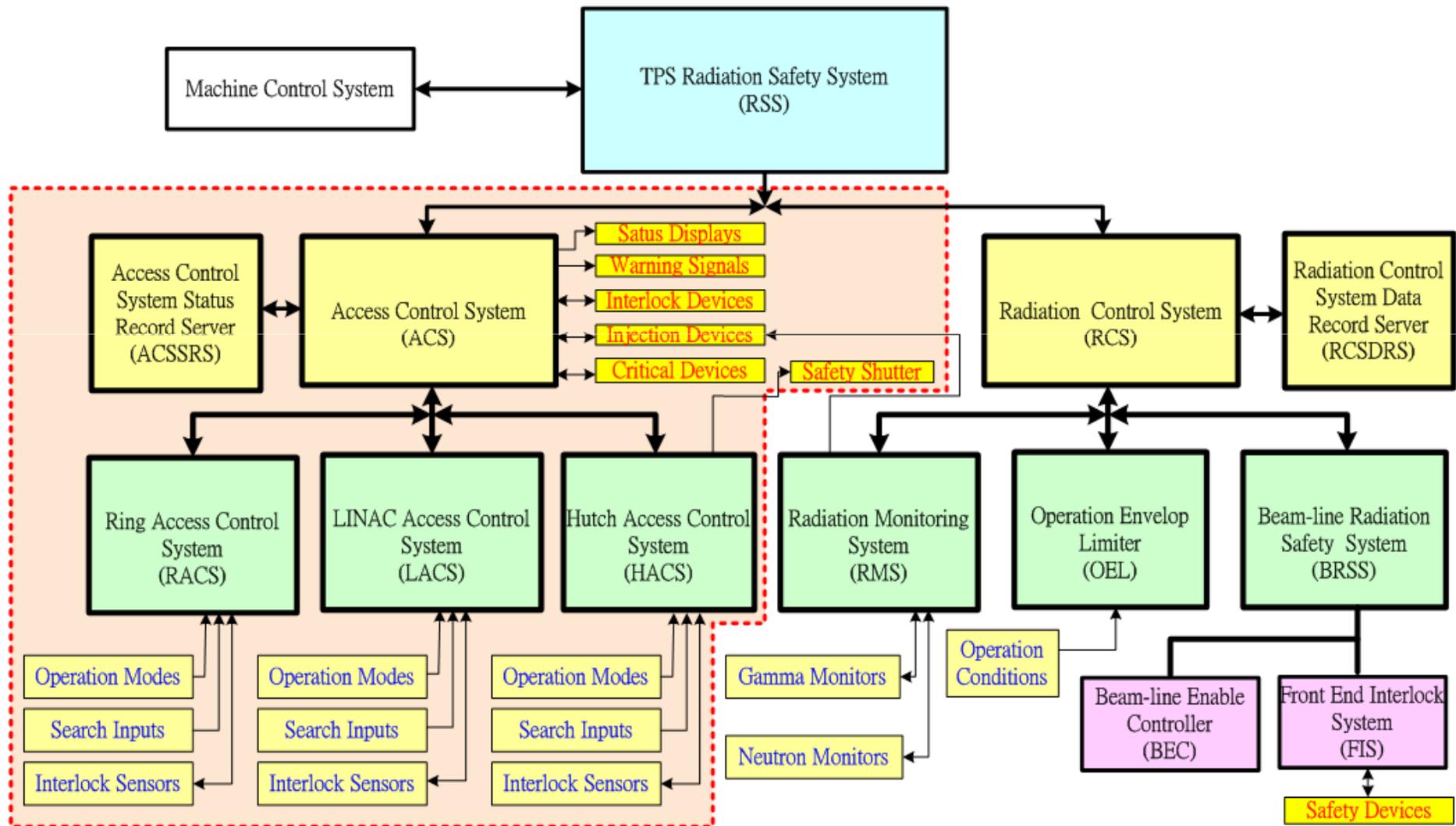


The Design of Radiation Safety ACS for TPS

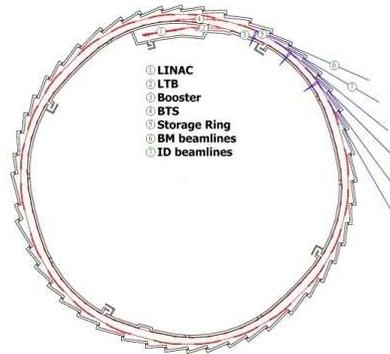
Contents:

- The structure of Radiation Safety System
- The layout of ACS
- The design function, guidelines & specification of ACS
- Requirements about the use of PLC
- Operation modes & controlled area of ACS
- Interlock logic & flow graph of ACS
- The Interlock devices of RSS (ACS & RCS)
- Search procedure of ACS
- Findings and discussion

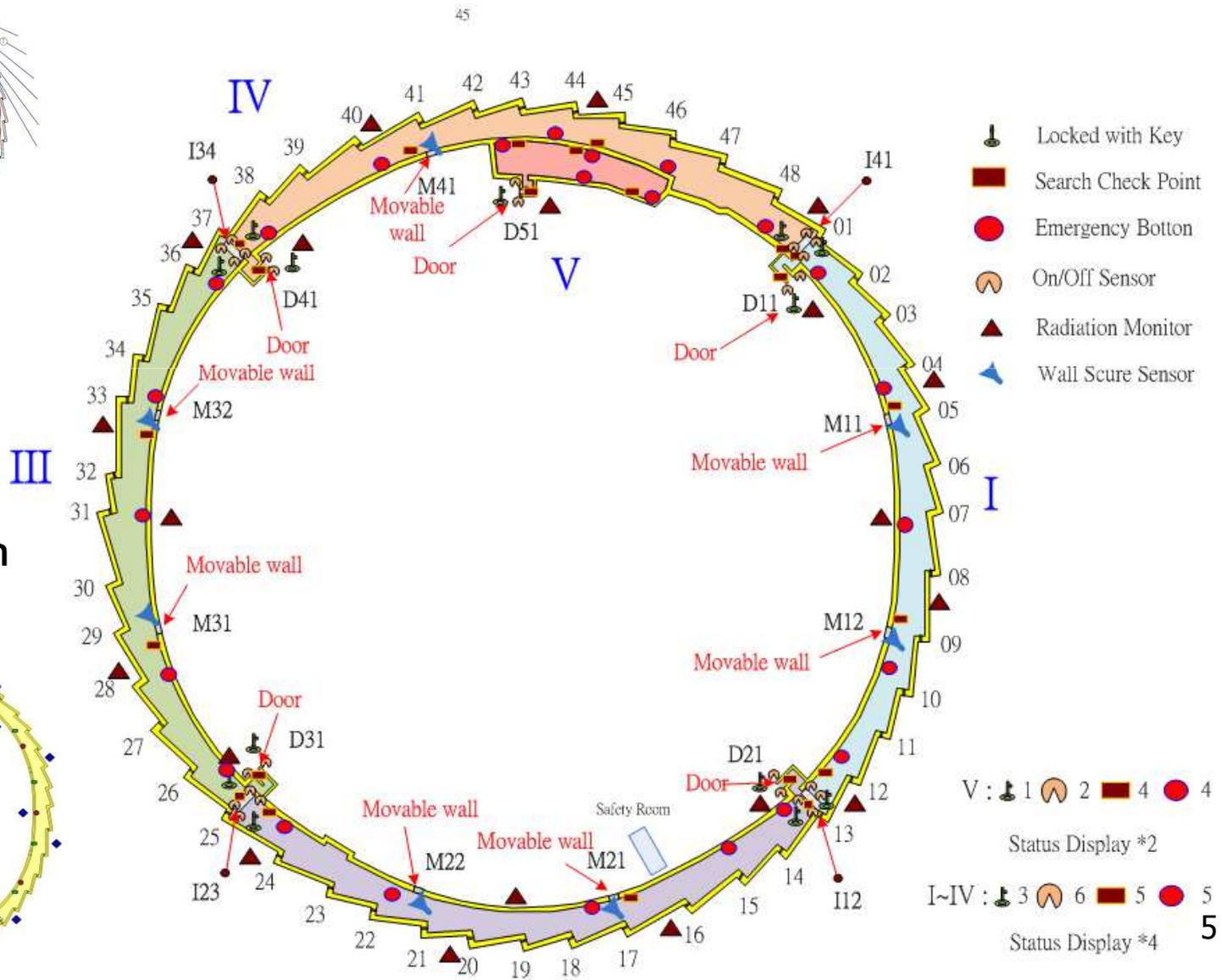
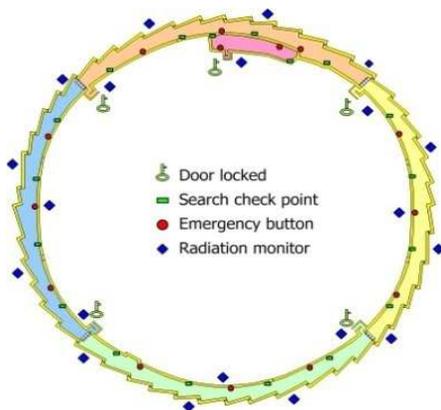
The Structure of Radiation Safety System and its Sub-systems



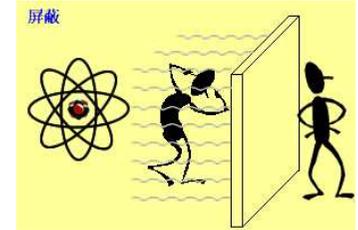
The Layout of Access Control System



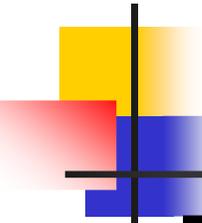
The prohibited area is divided into five exclusion regions.



Design Function of ACS for TPS



- Sub-system of Radiation Safety System.
- Prevent or control personnel access to and stay at high radiation areas due to prompt radiation.
- Addition to personnel safety protection, interlock system is used for machine (or equipment) protection.
- In design phase, the arrangement of shielding must be included.
- Inherited and upgraded from current TLS system.
- Conventions in most facilities and recommendations of ANSI N43.1 standards entitled “Radiation Safety for the Design and Operation of Particle Accelerators” [2011] are followed.



Design Guidelines for ACS

■ **Reliability**

It should provide the required protection, while subject to all foreseeable aging and environmental conditions at the accelerator facility. These conditions may include weather extremes, high electromagnetic fields, high radiation fields, earthquakes, and the cumulative effects of aging on components, such as corrosion, dirt, and normal wear.

■ **Redundancy**

The ACS is duplicated throughout (input devices, wiring, logic function, outputs), and is periodically tested to ensure that both 'guard-lines' are operating correctly.

■ **Independence**

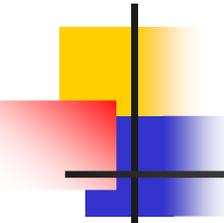
Each safety interlock must function independently of any other safety interlocks

■ **Testable**

Before commission, the system or sub-system shall be checked and assured to meet the requirements. Pre-test and on line test is necessary.

■ **Fail-Safe**

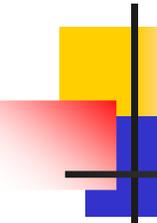
In case of failure, the ACS shall maintain a safe condition.



The Specification of ACS

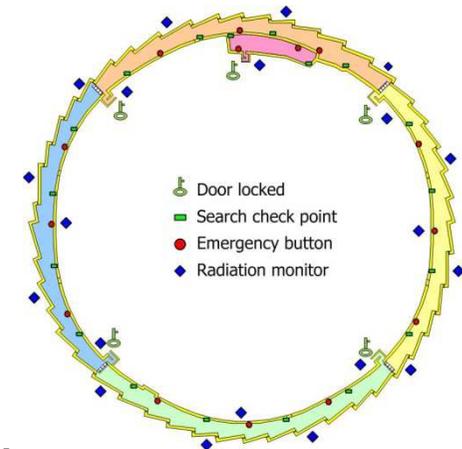
- When the restricted area is unsealed or ACS is failed, beam must be off and machine must be shut down.
- All entrances into high radiation areas or rooms must have interlocks.
- To control the access to High Radiation Area, the keys and combination are used.
- Each safety interlock shall be on a dedicated circuit to operate independently of all other safety interlocks.
- The caution, labels and warning devices around high radiation areas must be installed.
- When safety interlock system has been tripped, to resume operation of the accelerator will allowed only after the causing of the interrupt has been corrected and reset by manual.

Requirements about the use of PLC



- Qualified and safety-rated PLC systems shall be used.
- The system shall be completely isolated from other networks, including the World Wide Web.
- The revision or upgrade should be controlled and secured.
- The redundancy requirements about hardware and software should be achieved.
- The both normal and abnormal operations will be considered.
- A sufficient UPS system shall be provided. The measures to watch program fails shall be taken.

Operation modes and Controlled Area of ACS



According to the accelerator operating condition, Accelerator access control status can be divided into three states.

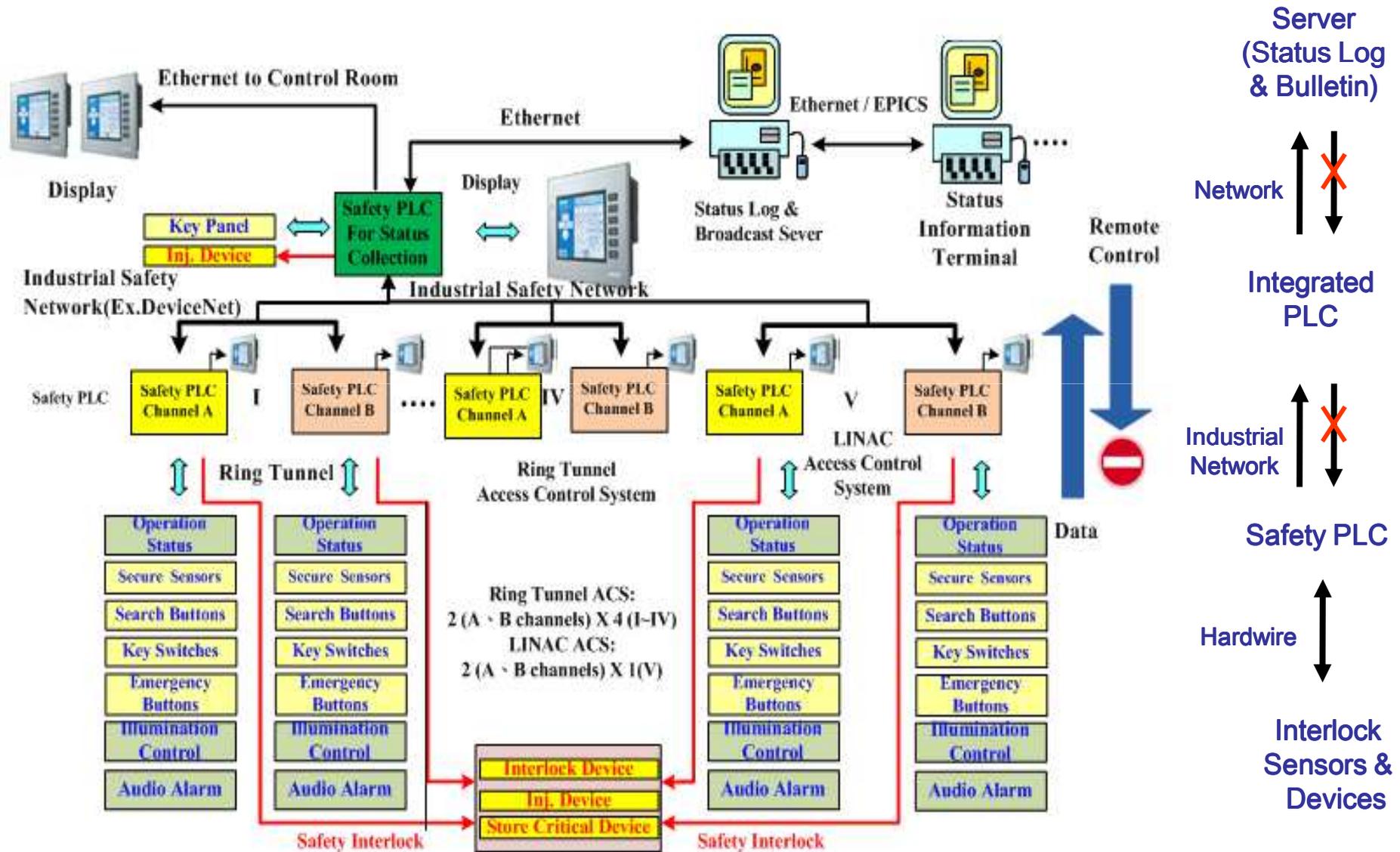
- Controlled entry/Shut down (Green light) ●
- Limited entry/ Patrol inspection (Yellow light) ●
- Prohibited entry/ In operation (Red light) ●



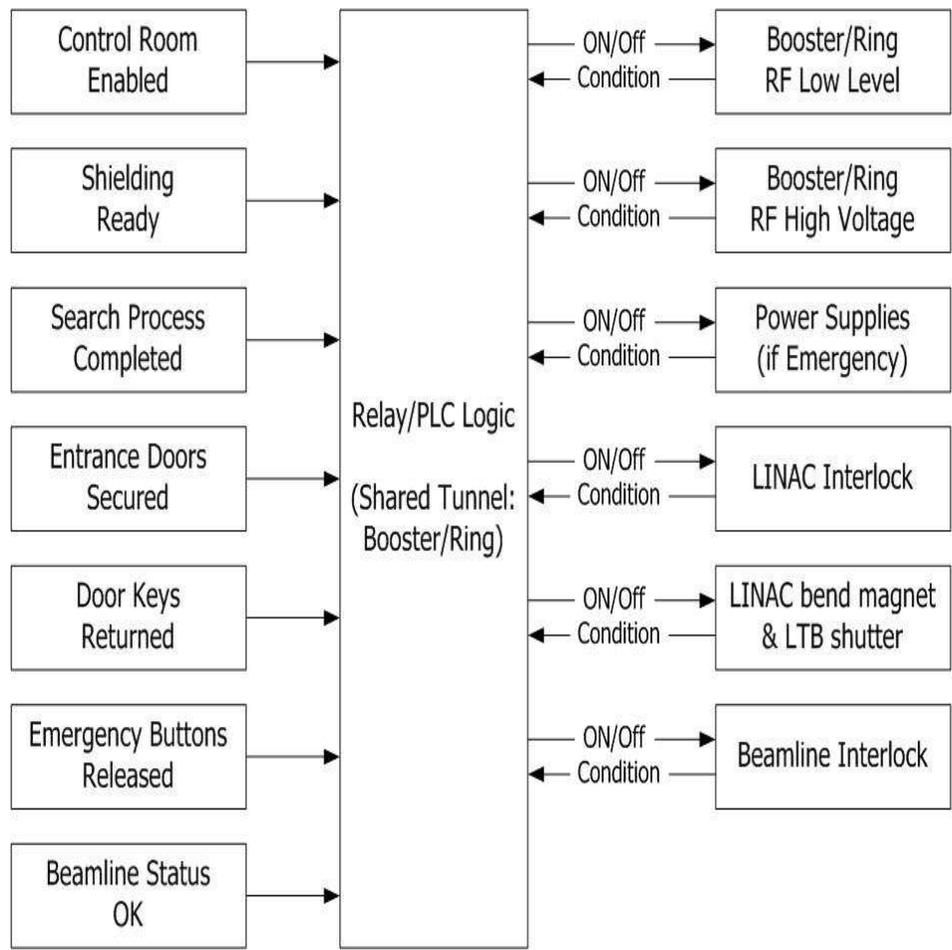
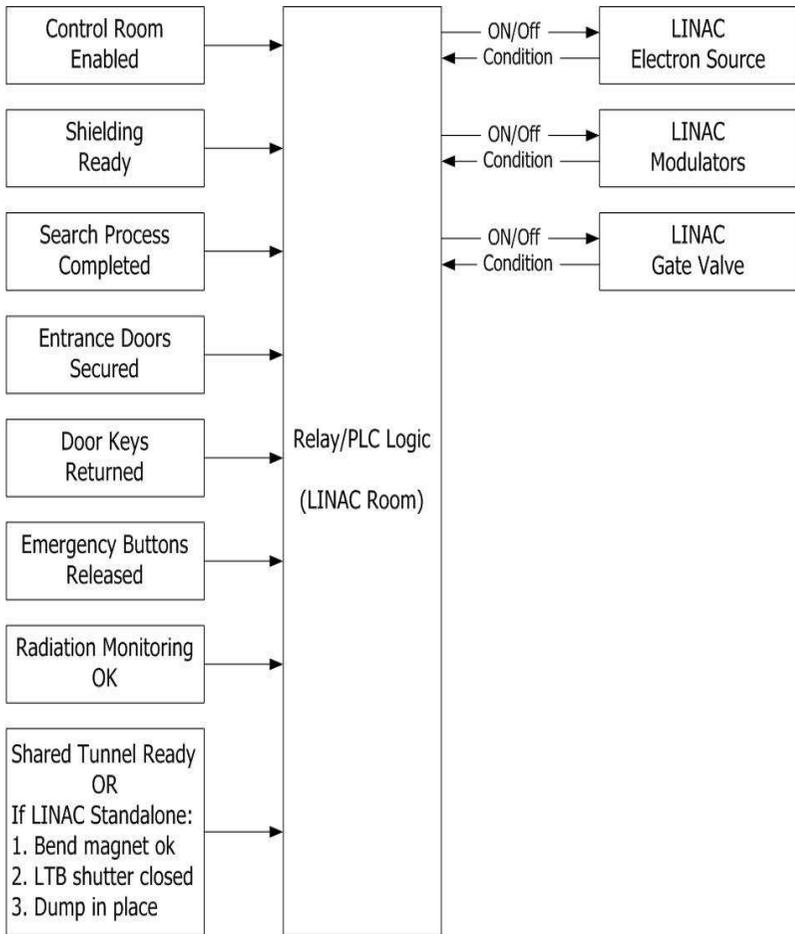
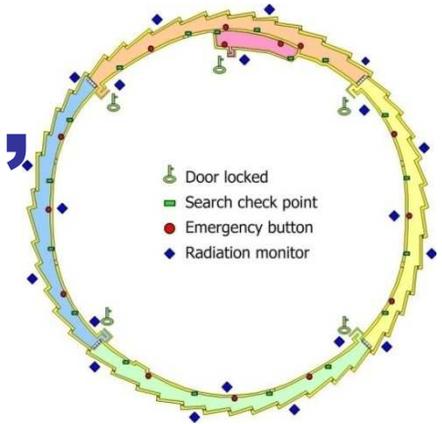
The TPS radiation controlled area will be divided into several regions with different levels of access authorizations: free, restricted, prohibited area.

- Machine off / no prompt radiation / free access area.
- Machine on / high prompt radiation / personnel exclusion / prohibited area
- Intermediate controlled access state between the 2 conditions above / restricted, area

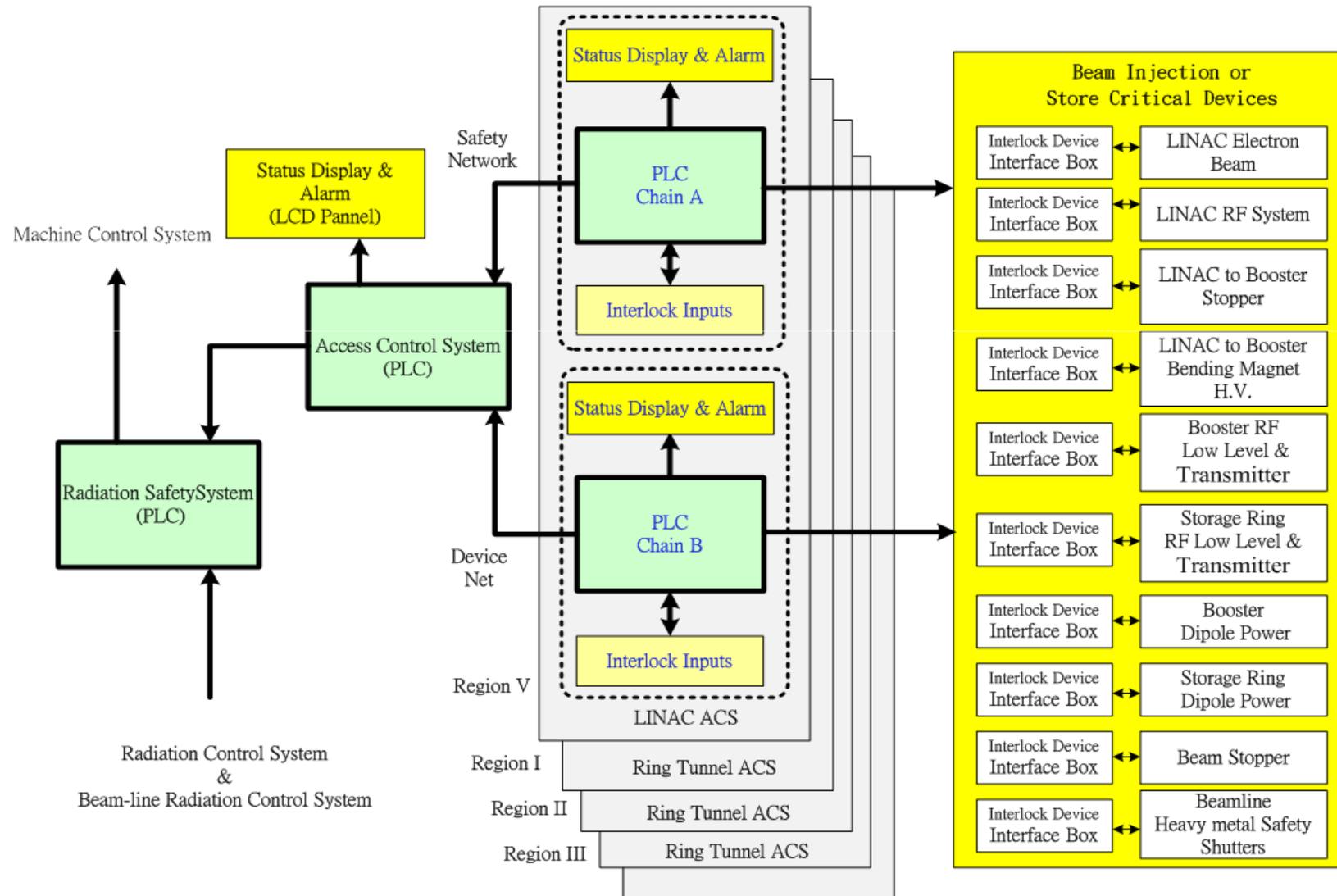
The Safety Network of ACS



ACS Interlock Logic of LINAC, Booster/Storage Ring



Flow Graph of Radiation Safety ACS



Interlock Devices for ACS & RCS

- ★ **LINAC :**
- ★ LINAC Electron Beam X 2
- ★ LINAC RF System X2
- ★ LTB Dipole
- ★ LTB Beam Stopper



Beam Inhibiting or Terminate Device



Critical or Injection Device

- ★ **Booster/Ring Tunnel :**
- ★ RF system (1 for Booster 4 for Storage)
- ★ Dipole Power Supply

- ★ **Beamline Interlock :**
- ★ Heavy Metal Shutter X48 (7 for 1st stage)

Beamline Branch Shutter

Radiation Monitor X12

(Input) Safety and Operation Envelopes :

Hall Probe or Dipole Setting

Beam Status (ex. Beam stored > 150mA for Top-up)

Beam Current

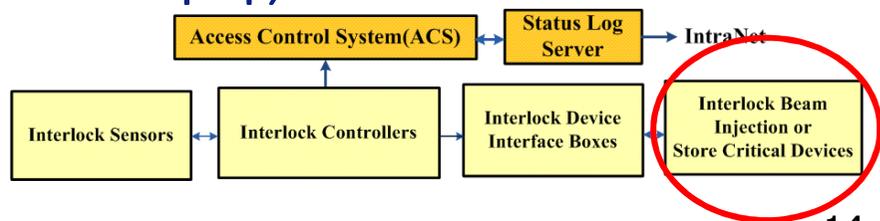
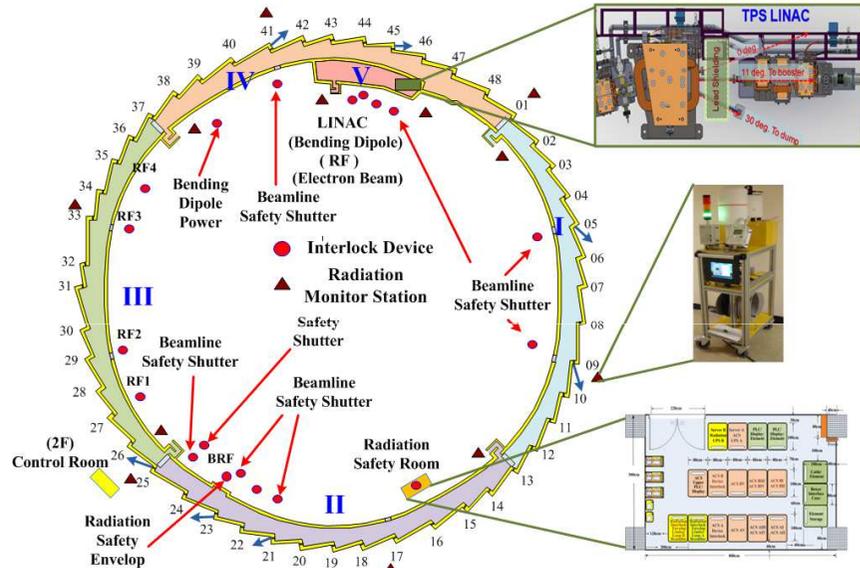
Injection Efficiency

Injection Enable Signal

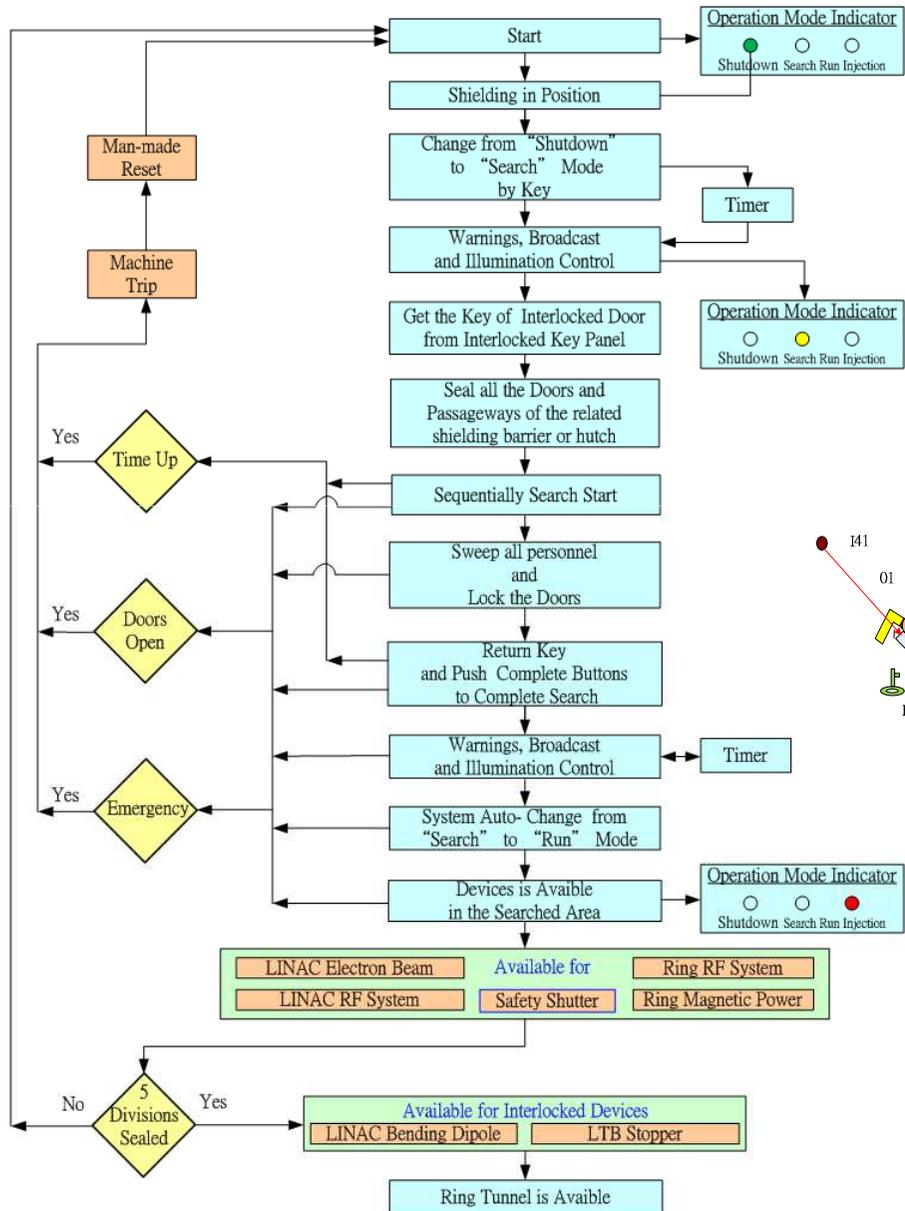
Interlocked doors/gates, Door Keys

Emergency off. Forced In/Out

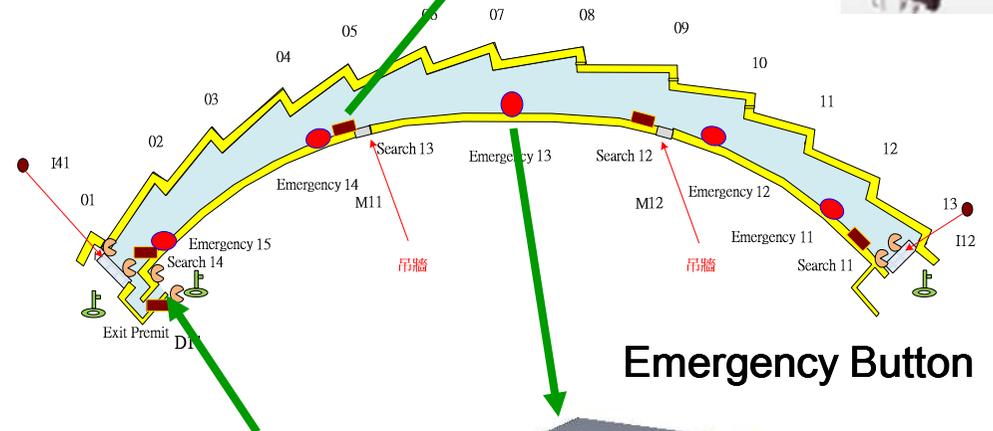
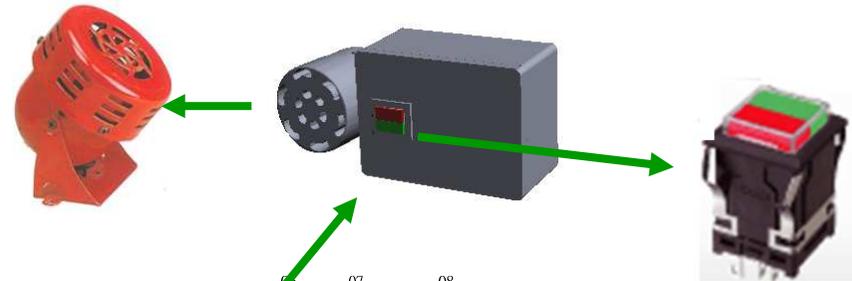
The Distribution of Interlock Devices



Search Procedure for each Controlled Zone in Tunnel



Search Button & Alarm



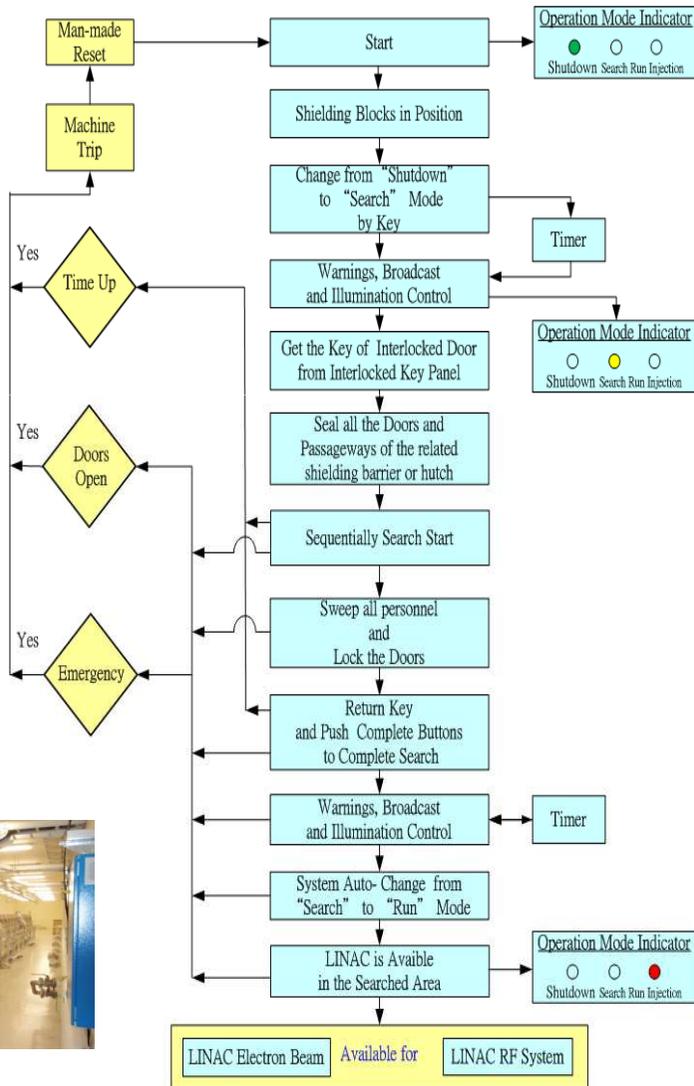
Emergency Button



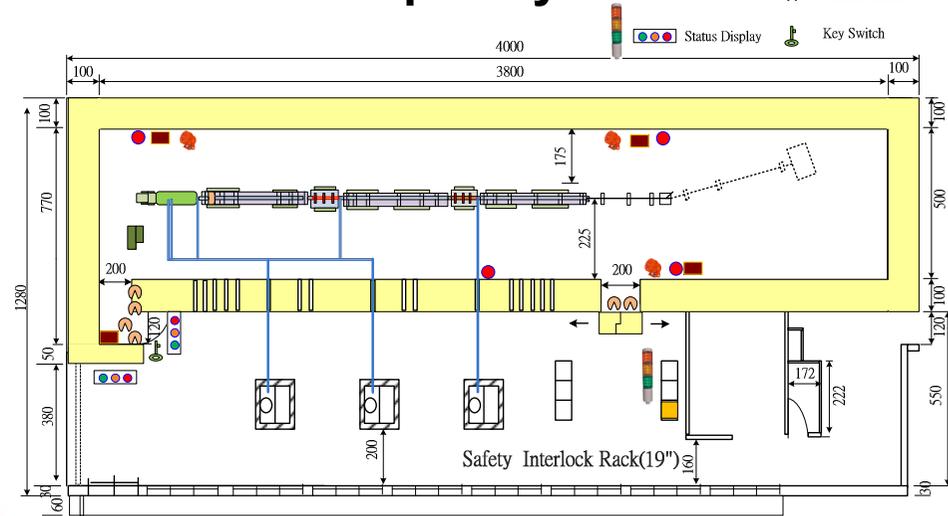
Warning lights



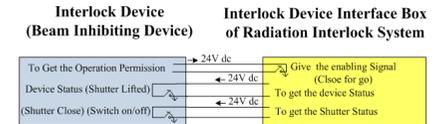
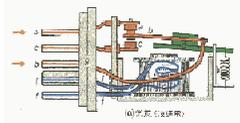
The Search Procedure for LINAC Controlled Zone



LINAC temporary test site



Findings and Discussion of Implementation(1)



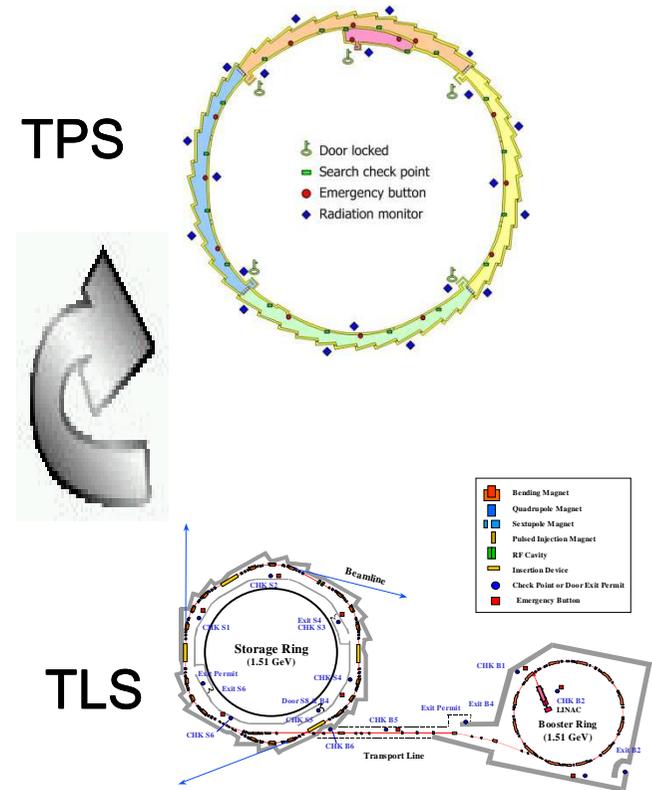
1. The interface specification between the elements and devices in system is very important and shall be kept the same definition. The ACS in TPS uses analog signals as inputs and outputs between the devices. The signal level is the voltage level, 0 or 24Vdc.
2. The voltage drop and signals attenuation about the ACS must be concerned especially for a huge ring since the most relay, sensors and elements have their own lower limit of excitation.
3. The definition and practical about the fail-safe is quite different between the industrial control safety and radiation safety. In the industrial control safety, the fail-safe means the backup for the control system only. However, in our radiation safety ACS, fail-safe is duplicated, parallel and double checks throughout whole system.
4. At TPS, the 518 m circular shared tunnel is divided into four sub-regions. **To segment large area into small pieces saves the time to recover the failed local device and search process.** The effect of time-saving also depends on the operation schedule. **For long cycle operation, the division gives little benefit.**

Findings and Discussion of Implementation(2)

5. After pressing the search button, a local alarm audio will sound in few ten seconds. This makes a good warn to person who stay in that area.
6. All controls, instruments, and readouts must be clearly identified and functional on the accelerator control console. (Human Factors Engineering)
7. General safety not related to radiation shall be considered in the design and operational stages. What to be considered are high voltage, RF power, and dark current on vacuum piping.
8. Property of material radioation-resistance must be considered in the wiring and components installed in high radiation field. The radiation-induced degradation might cause device failure or system incorrect-action.



TPS will be opened to users in 2015. The commissioning of radiation safety ACS of TPS is planned to be in the end of this year. The ACS will be ready to provide the function of radiation protection from the very beginning of the system pre-operation testing.



Thank you for your attention.

