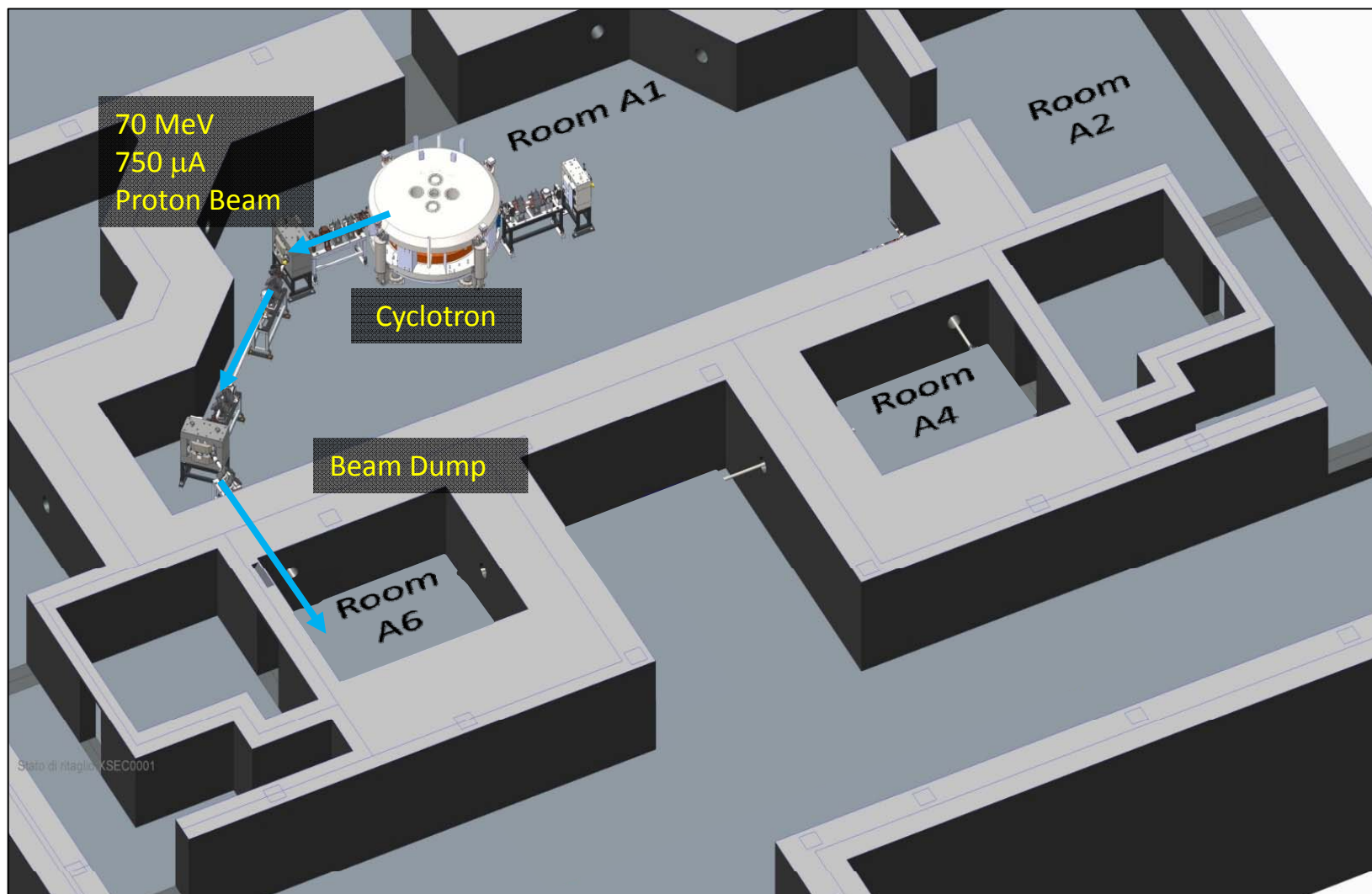


THE TEMPORARY SAFETY SYSTEM (TSS) STRUCTURE

CARLO RONCOLATO

SPES SAFETY TECHNICAL ADVISORY COMMITTEE
23/07/2015- INFN LNL - LEGNARO (PD), ITALY

SITE ACCEPTANCE TEST LAYOUT



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SAFETY PROCEDURES



- To prevent people to get a radiation dose higher than the limits given by the law from **accidental exposure** in **controlled areas**.
- This system does not provide any protection against any possible **activated radiating components** which will be controlled by **administrative procedures**.
- Prior to allowing proton beam, all the Level -1 must be **cleared of personnel**. **Permission to beam** in the transfer line, cyclotron and beam dump will be granted only if: all the **doors are closed**, all the **monitors** in the critical places are measuring values **below a certain threshold**.



- There are two source of risk of potential shock hazard in the SPES facility at this phase. One is form the **HV platform** of the **Cyclotron Ion Source**, operating at 40kV and located below the Cyclotron itself. And another is from the **HV Power Supplies** located in the **Power Bay Area**. Two locked cabinets can be open only when the HV is shut down, accordingly to the Control Access System.



- The building is delivered equipped with the standard preventions for the fire detection and extinction, accordingly to the **Fire Safety Permit**.

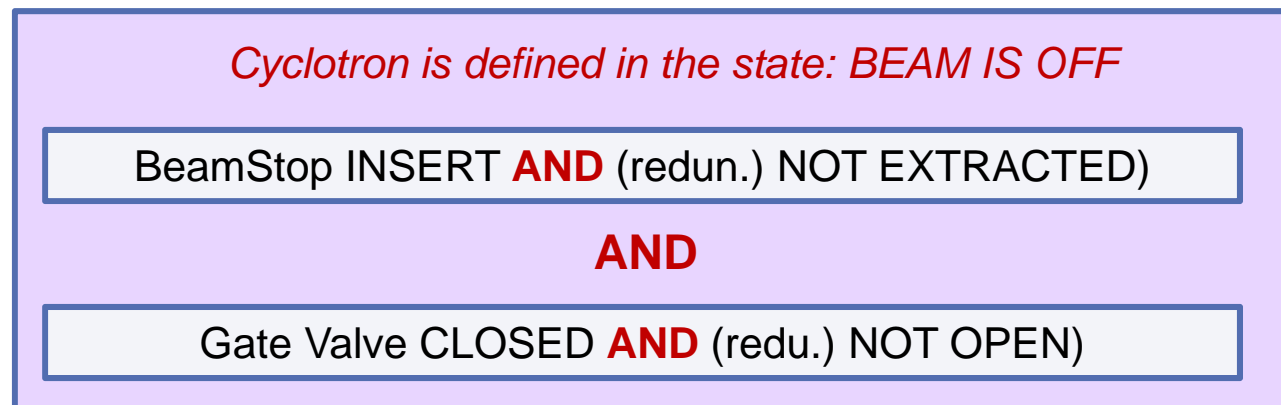
HW CHOICES: REDUNDANCY AND DIVERSITY

The system has a number of inputs and produces an output. The output shall be redundant and diverse.

- **Redundancy** will be achieved by having **two independent lines** for every signal.
- **Diversity** means that any action will be applied to **two different parts** of the system.

In other words, each action results in two redundant outputs (four signals in total).

2 redundancy and diverse conditions to produce an output

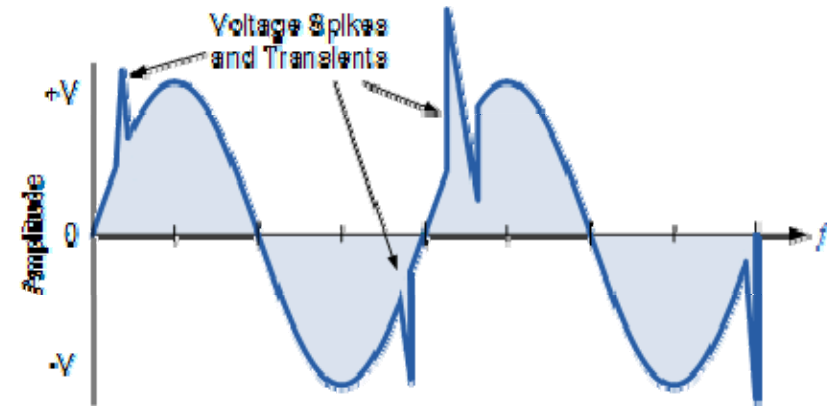


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FAIL SAFE RECLOSURE ACTIONS

*circuit breaker to preventing electrical overloads from passing through a circuit, circuit breaker can automatically "**reclose**" the circuit and restore normal power transmission*

The Cyclotron may be deactivated by the TSS, but never re-activated.



This means that in case of failure, **malfunctioning**, or any detection of **inconsistency in the redundancy** the TSS will perform an action. **This action can not be reset without manual intervention.**

For example, the PSS detects an unauthorized state in one of the switches of the door of the A1 bunker. The Cyclotron will be immediately switched off. If the switch comes back to an authorized state, the PSS has to be reset by an external intervention (for example from the operator's interface).

Other actions, like pressing an emergency button, need the same intervention.

SCOPES

- **Controlling** the exposition of personnel in controlled areas.
- **Prohibiting** the access when the beam is delivered.
- **Organizing** an access strategy to the areas after/before the beam delivery.
- **Generation** of the acoustic and light warnings to describe the machine status.
- **Preventing** an accidental rupture of the beam line.
- **Limiting** the radioactive gas species emissions to the external environment.

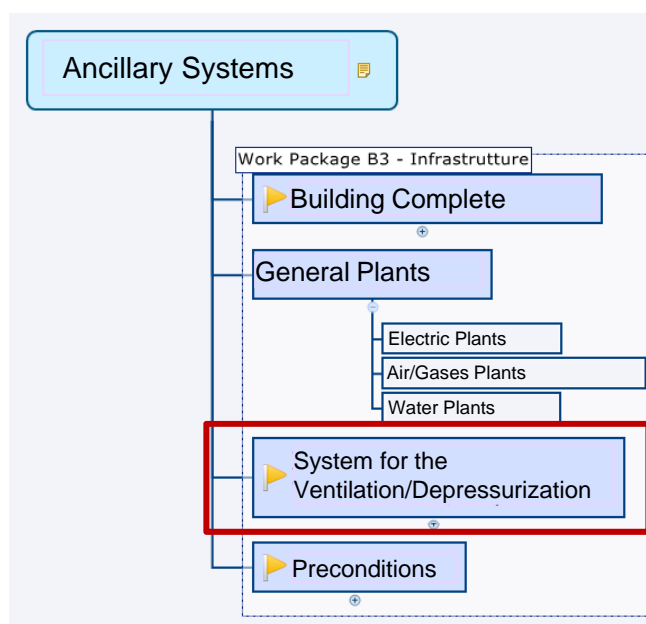
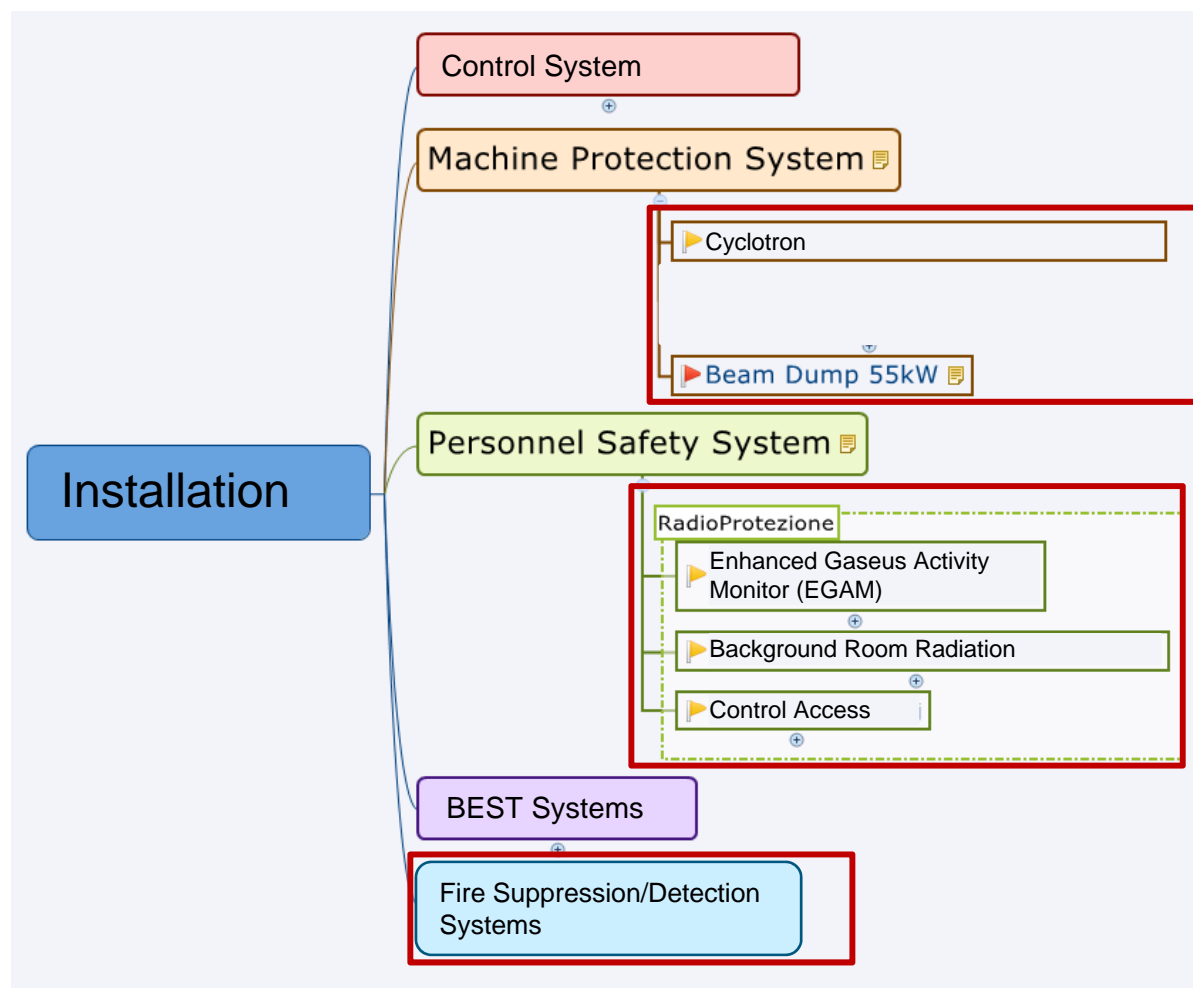
Personnel Protection System (PPS)

1. System for the measurements of the **Background Room Radiation**
2. System for the **Ventilation/Depressurization** (Room A1 and A6)
3. **Personnel Control Access System** for the Level -1.

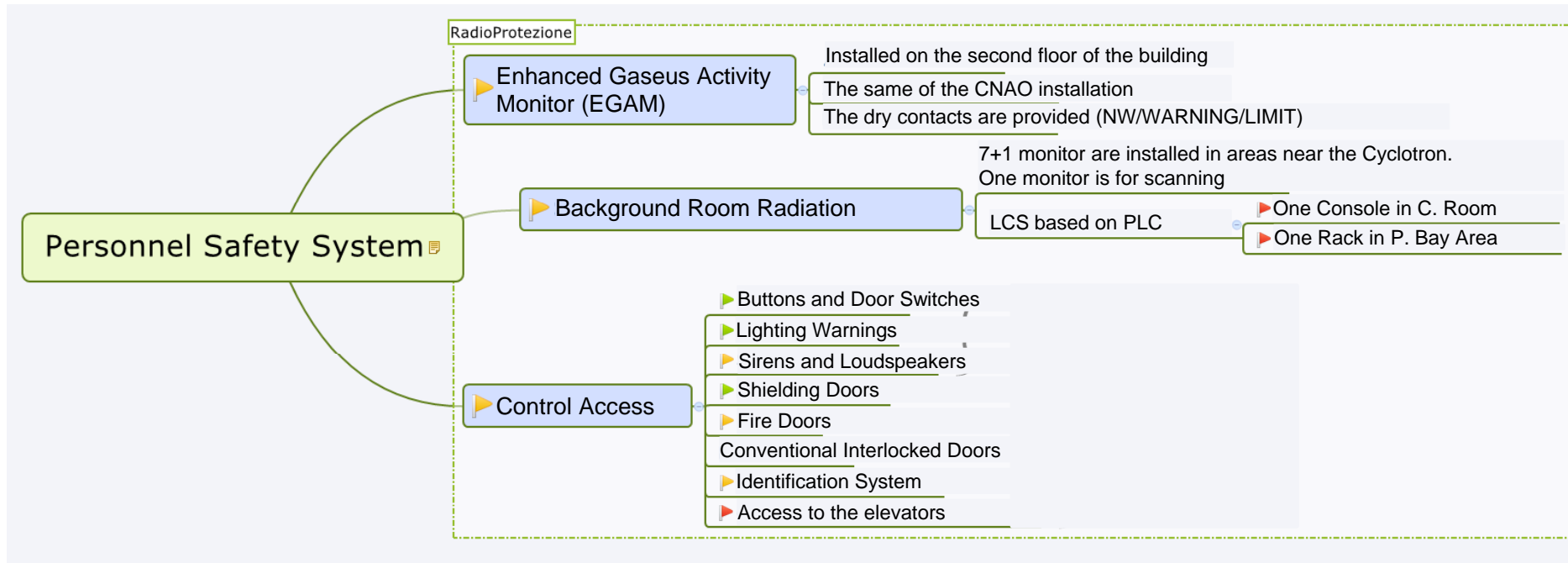
Machine Protection System (MPS)

4. MPS for the **Cyclotron**
5. MPS for the **Beam Dump**
6. Enhanced Gaseous Activity Monitor **EGAM**.

SUB-SYSTEMS INVOLVED



Apart from the previous listed systems, additional ancillary system must be installed.

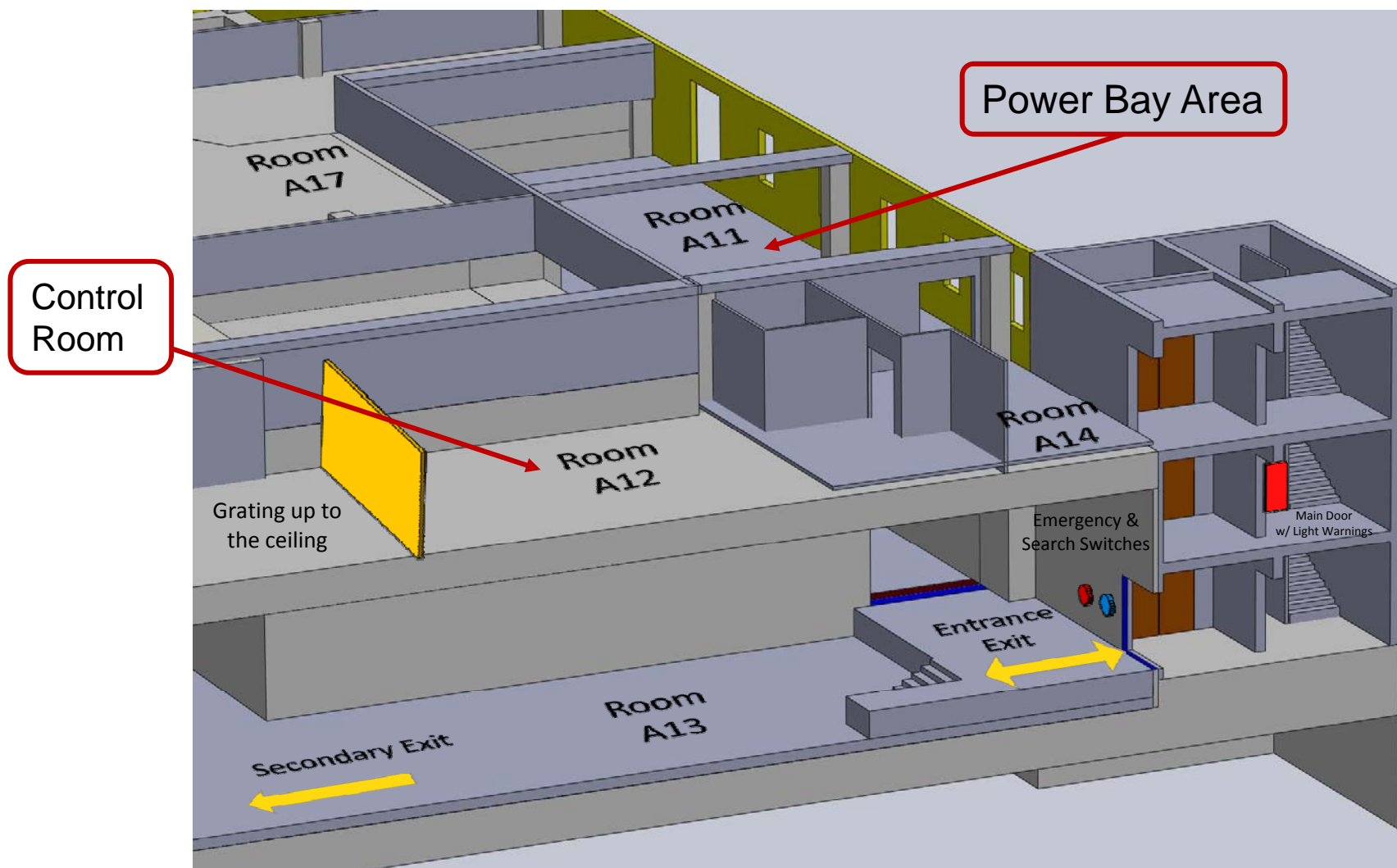


The Control Room is the only place where personnel is admitted when the beam is delivered. (First Guess)

All the other areas are locked with grates and padlocks

After a measuring campaign performed by the Radiation Protection Group some areas could be open to personnel.

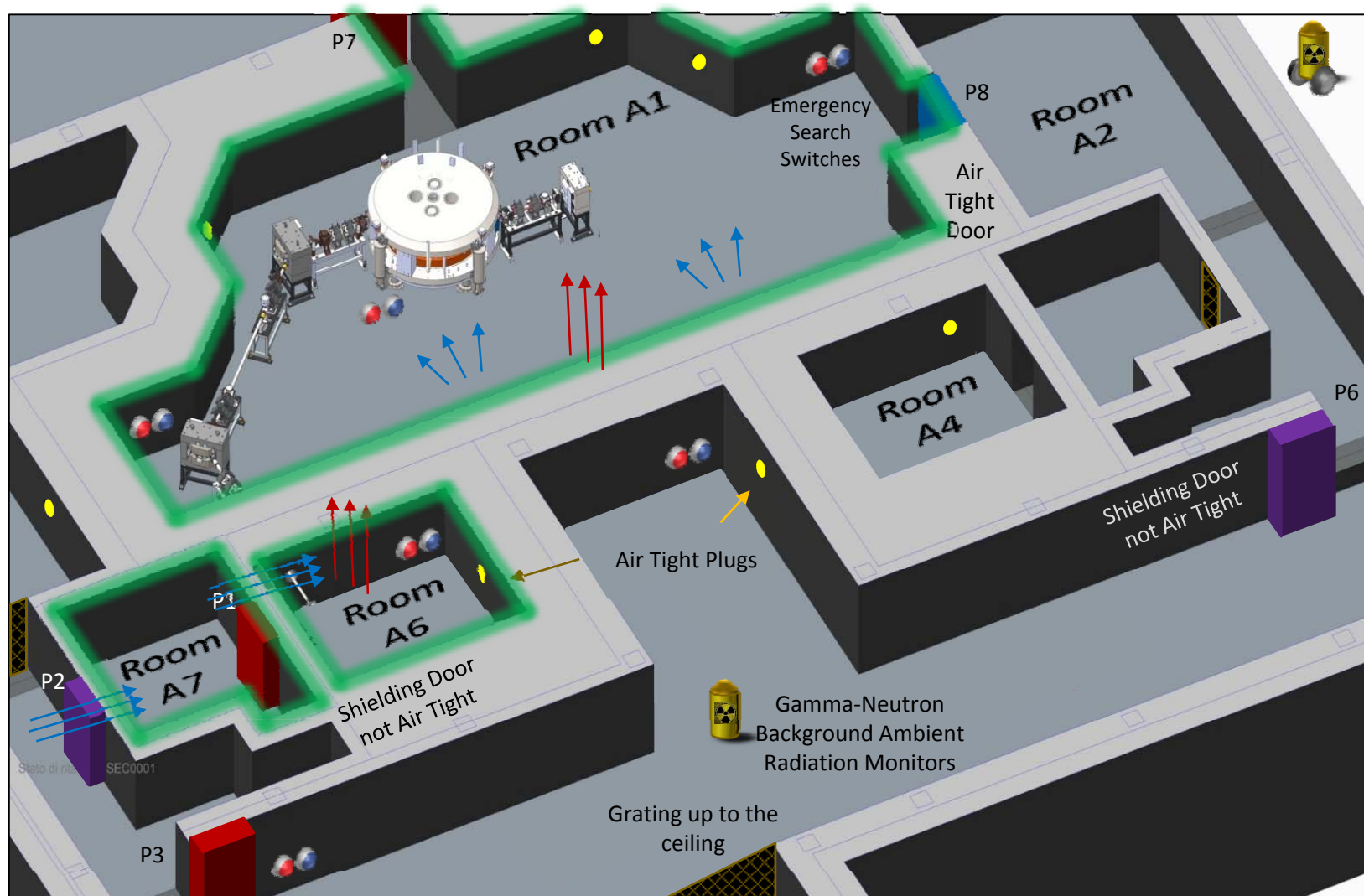
CONTROL ACCESS SYSTEM LAYOUT (1/2)



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CONTROL ACCESS SYSTEM LAYOUT

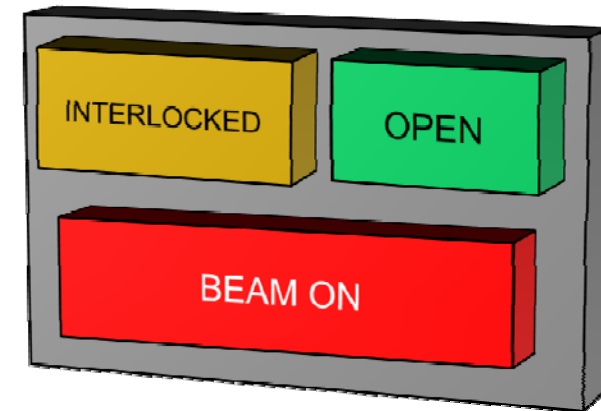


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CONTROL ACCESS FEATURES

- Light Warnings are above the main entrance (NORD Side) and secondary exit (SOUTH Side)
- Sound Warnings during Search and when is terminated.
- Access:
 - Below 1MeV: only Authorized Personnel
 - Above 1MeV: only Rad. Prot. Personnel
- Emergency “Beam Off” Buttons are places at the Level -1. An additional button is also in console. These buttons will be latching.
- Three different areas can be interlocked at Level -1
- Elevator is inhibited in INTERLOCKED state and BEAM ON state.



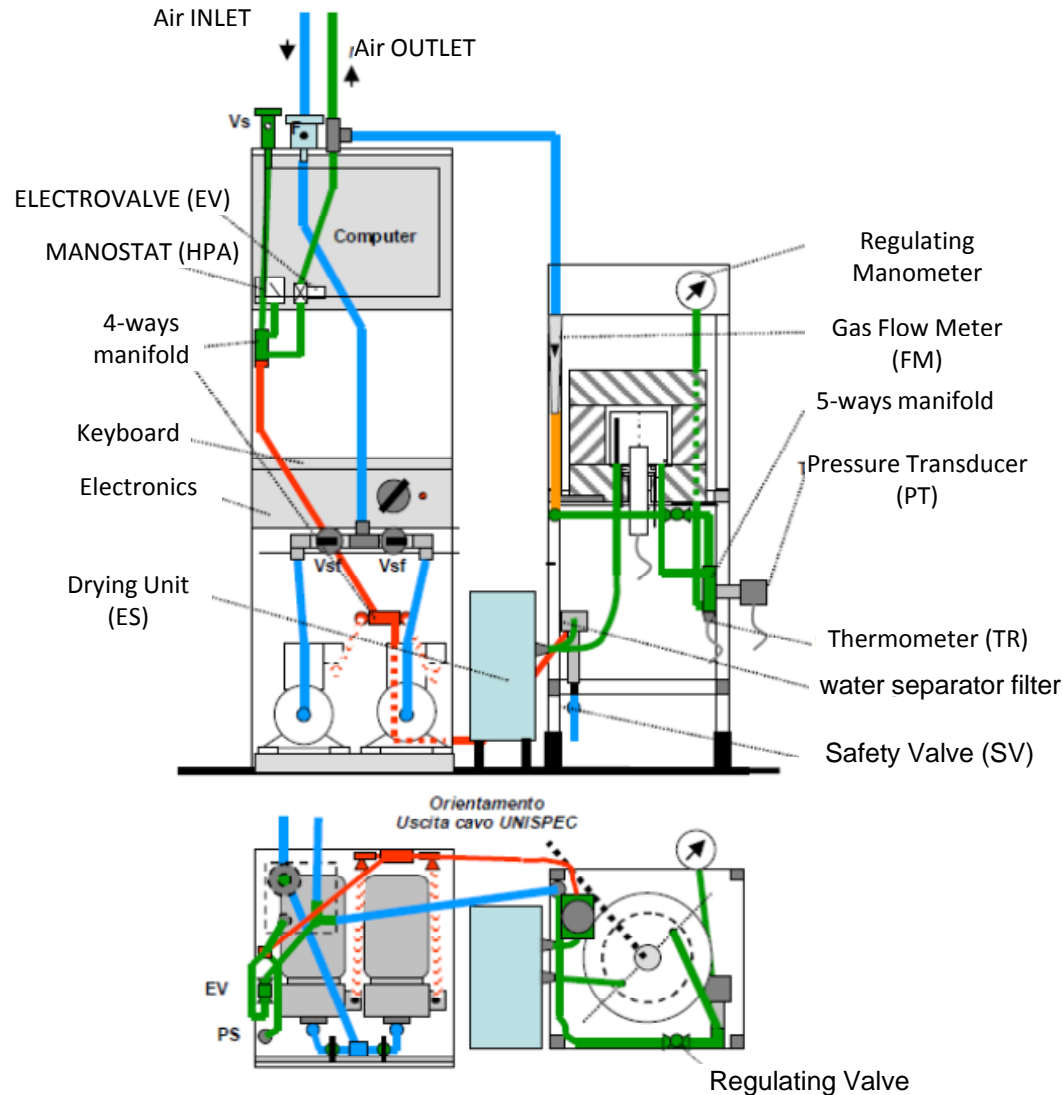
Indication	Meaning
BEAM ON	Beam ON
INTERLOCKED	Level -1 cleared of people and doors closed
OPEN	Door unlocked/no search

Doors are equipped with two switches: one switch has closed contacts when the door is closed. The other has open contacts when the door is closed.

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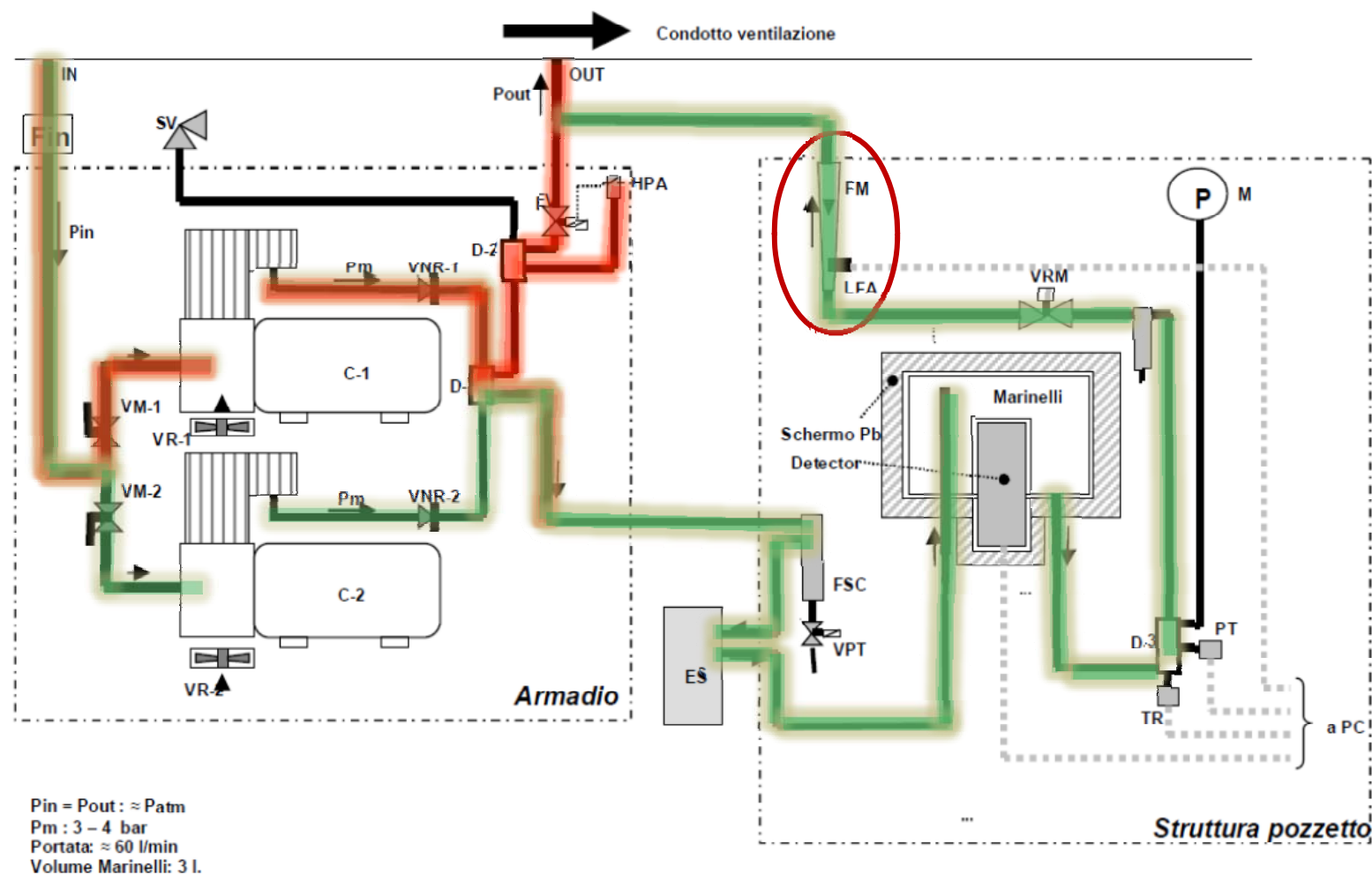
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ENHANCED GASEUS ACTIVITY MONITOR (EGAM) (1/3)



- Filtered inlet
- two compressors (one on standby) The pressure range is operating between 0.3 and 0.4 MPa (3-4 bar).
- A Marinelli Cell (3 lt) with a NaI (TI) detector, housed within a lead screen (detector and its electronics are both shielded)
- Pressure is an input for the measurement, while temperature is simply recorded.
- Between 8 and 11 sec to fill the chamber.

ENHANCED GASEUS ACTIVITY MONITOR (EGAM) (2/3)



ENHANCED GASEUS ACTIVITY MONITOR (EGAM) (3/3)

EVENT ONE: GAS CIRCUIT ERROR

List of Alarms:

- Low Pressure
- High Pressure Compressors
- High Pressure Marinelli
- Low Pressure Marinelli

Sensors:

Reed Sensor on FM
Manostat (HPA)
Pressure Transducer (PR)
Pressure Transducer (PR)

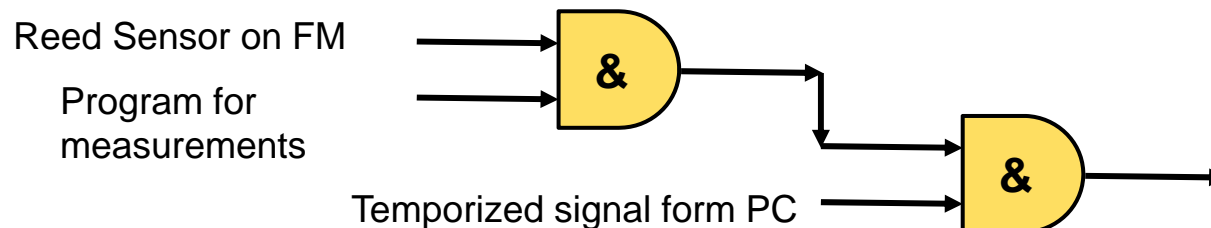
EVENT TWO: PROGRAM/MEASUREMENTS ERROR

List of Alarms:

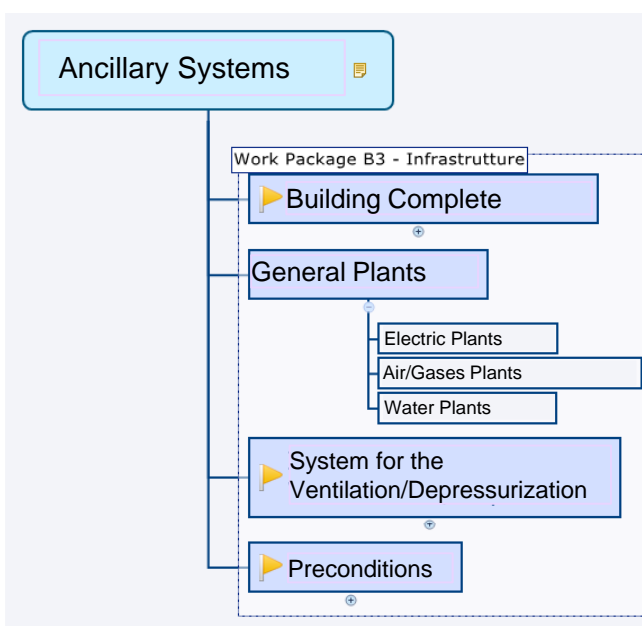
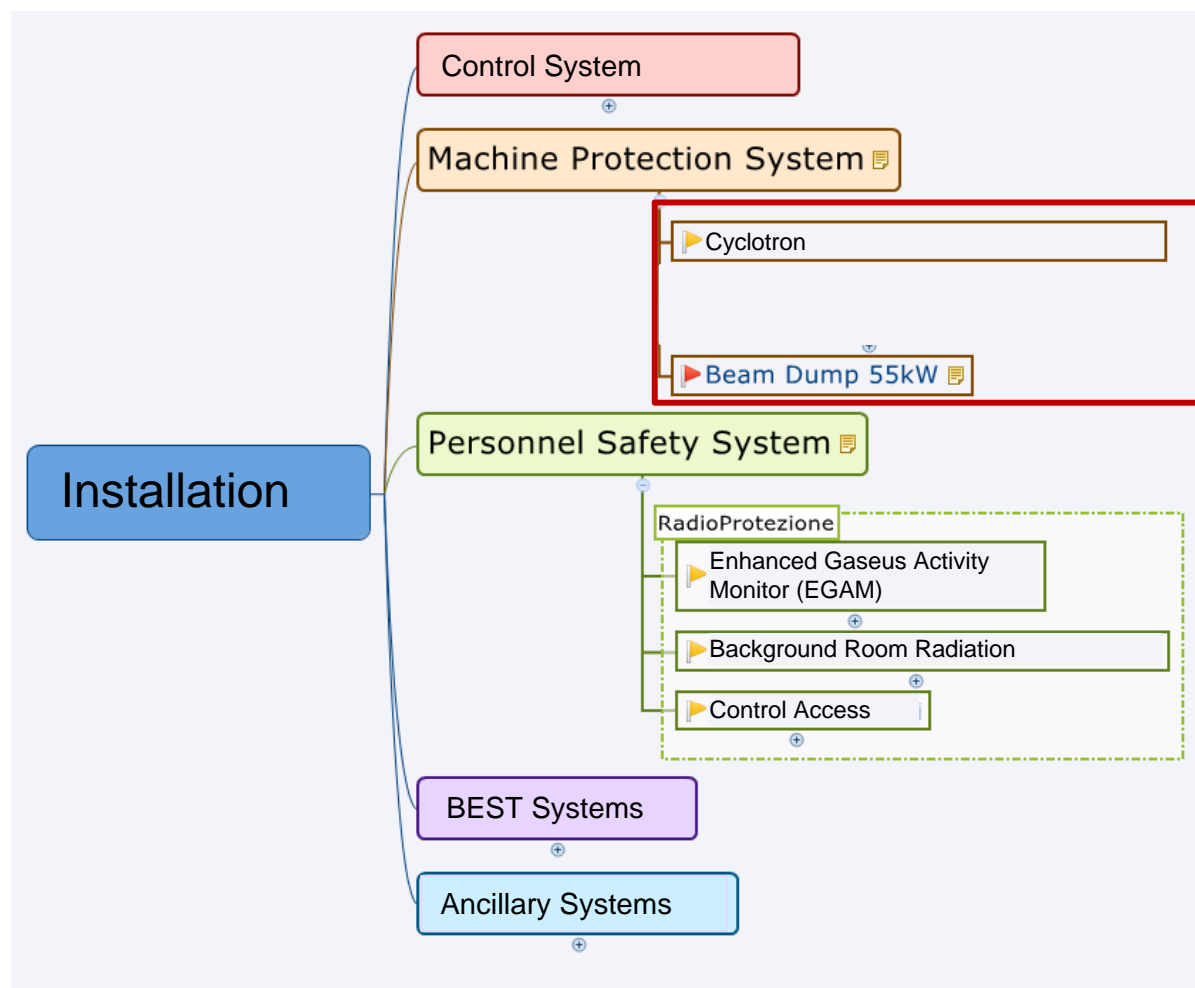
- No Counting Rate in measurements
- Computer is not running

Sensors:

Program for measurements
Temporized signal form PC



SUB-SYSTEMS INVOLVED



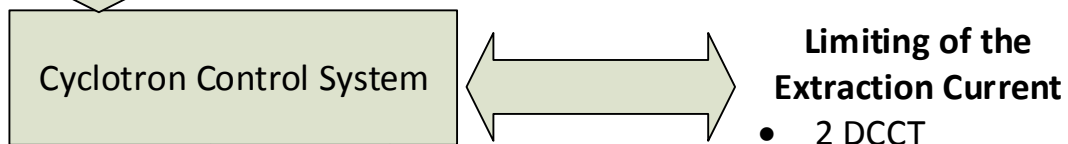
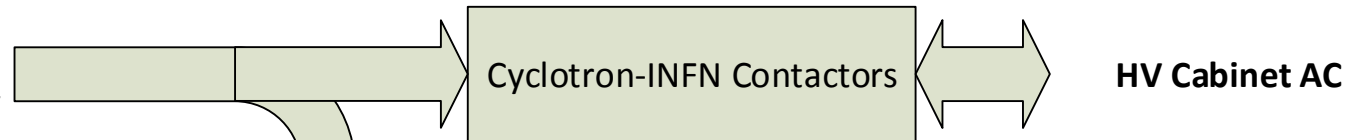
Apart from the previous listed systems, additional ancillary system must be installed.

MPS OF CYCLOTRON

Access Control System

Permissions

- Generated by a Search
- Revoked by Emergency «Beam Off» Buttons (1 in the console)



Ion Source

- Beam Stop Position
- Gate Valve Position
- BIAS HV
- Inflections Electrodes

Beam Extraction SIDE 1

- Extraction Probe Position
- Gate Valve Position

Beam Extraction SIDE 2

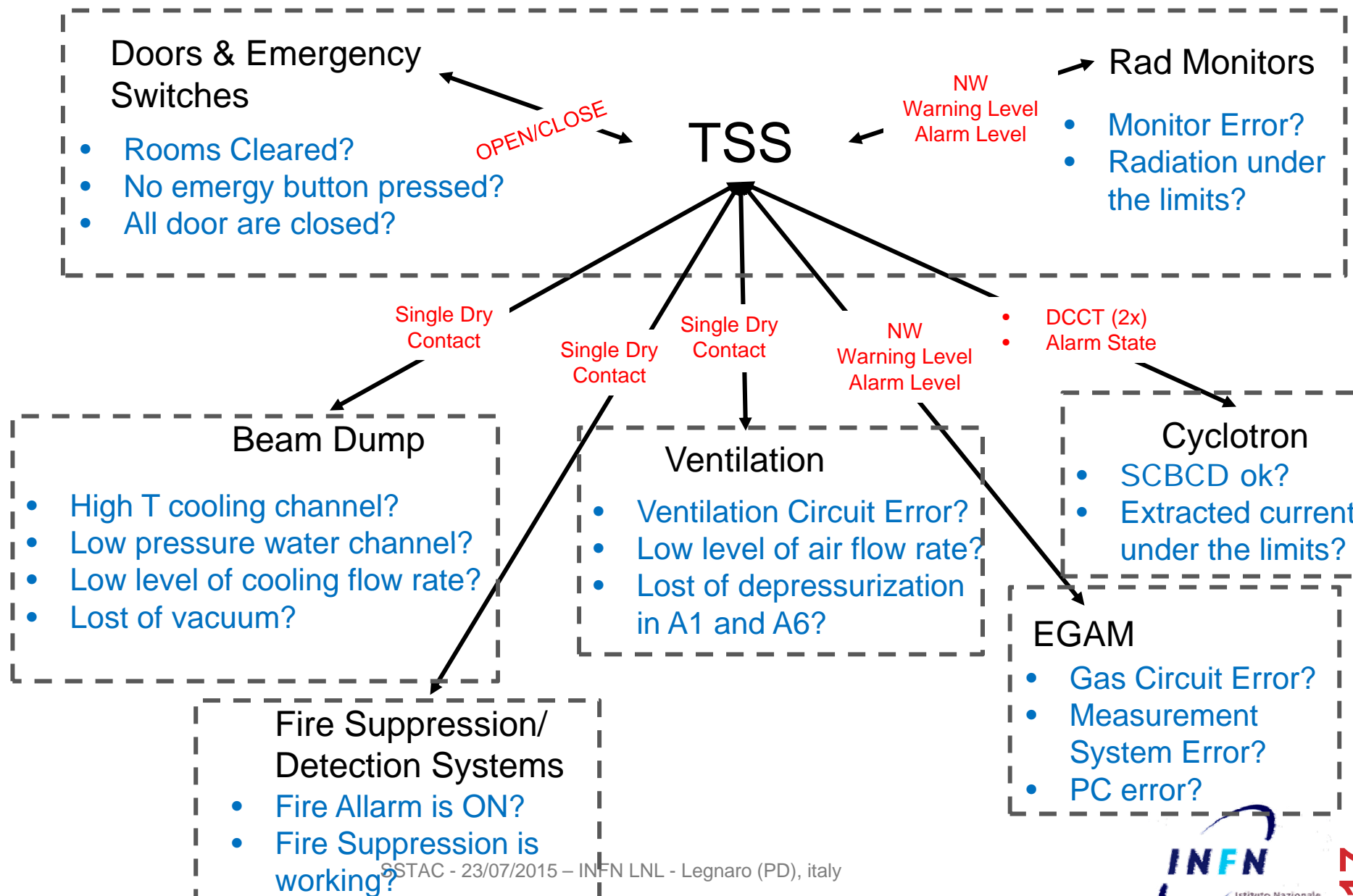
- Extraction Probe Position
- Gate Valve Position

SCBCD x9

System
Critical
Beam
Control
Device

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CHAIN OF CONTROLS



SUMMARY (1/2)

Three main sources of risk typical of accelerator machines.
Radiation Hazard Exposure, Shock Hazard, Fire Risk. Several sub-systems:

1. System for the measurements of the Background Room Radiation
2. System for the Ventilation/Depressurization (Room A1 and A6)
3. Personnel Control Access System for the Level -1.
4. MPS for the Cyclotron
5. MPS for the Beam Dump
6. Enhanced Gaseous Activity Monitor EGAM.
7. Fire Suppression/Detection Systems

HW Choices: Redundancy and Diversity. Two different conditions with double check.

SUMMARY (2/2)

FAIL SAFE Reclosure Actions. *The Cyclotron may be deactivated by the TSS automatically, but can re-activated only manually.*

Acces Strategy presented. *One entrance, two exits, doors, switches, lightings warnings, monitors, etc...*

Enhanced Gaseus Activity Monitor (EGAM). Features, sensors, error detection and interventions.

Cyclotron connections with TSS. Contactors Rack (Digital Logic based on dry contacts) for SCBCD, in addition to two analog current signals from DCCTs. Triggering the alarms from the current measurements is in charge of INFN.

Chain of Control. Many subsystems involved. Control access and radiation monitors are hardwired. Other subsystems gives a single signals.