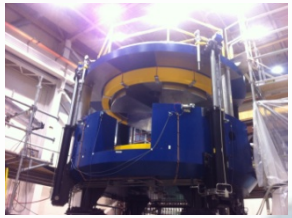
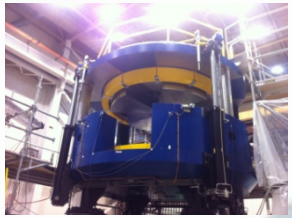


WORKING GROUP #5
THE CYCOLTRON

SAFETY ASPECTS OF THE COMMISSIONING AND SAT

JULY 23TH 2015
SSTAC MEETING LNL

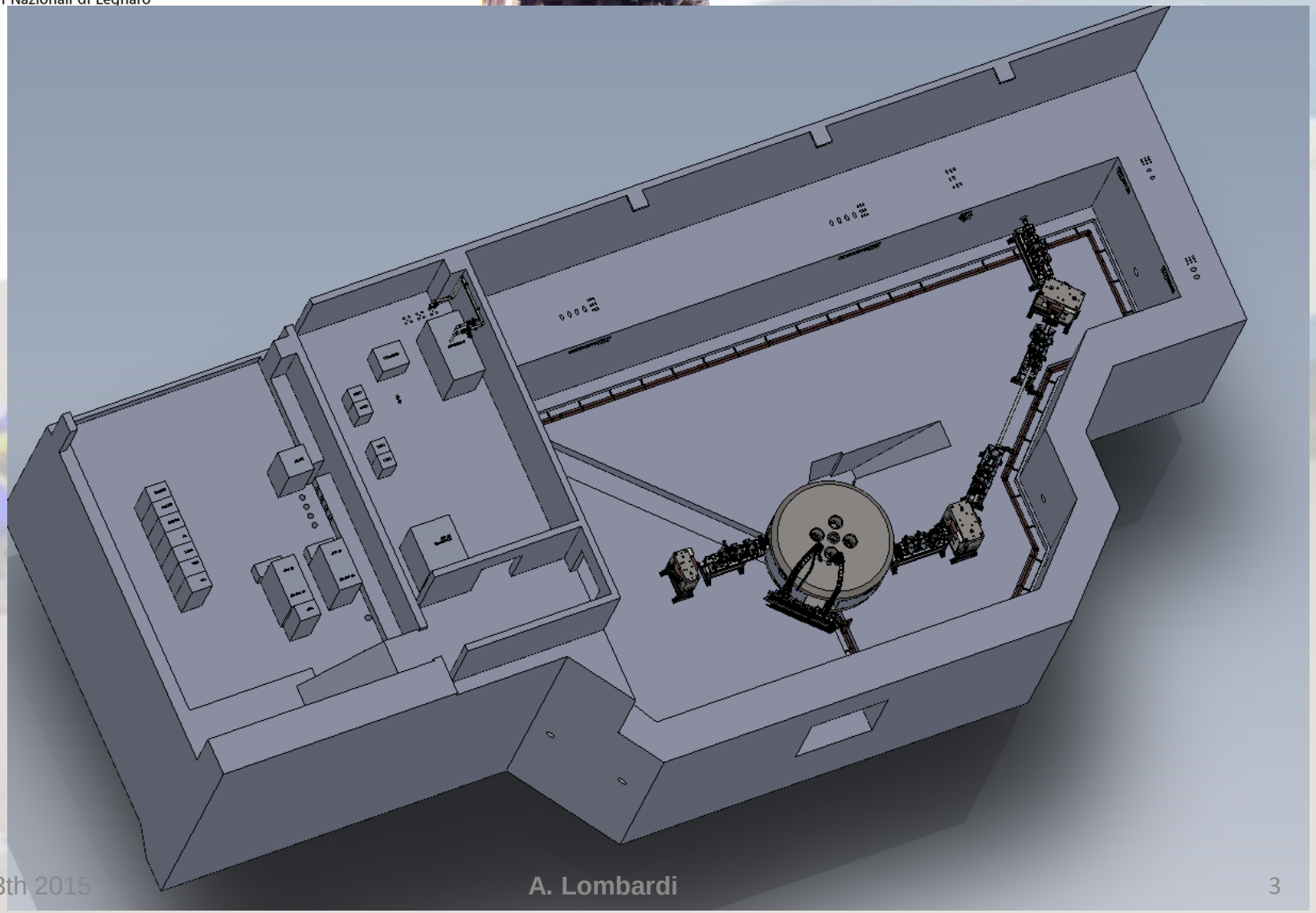
INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro



SPES exotic beams for science

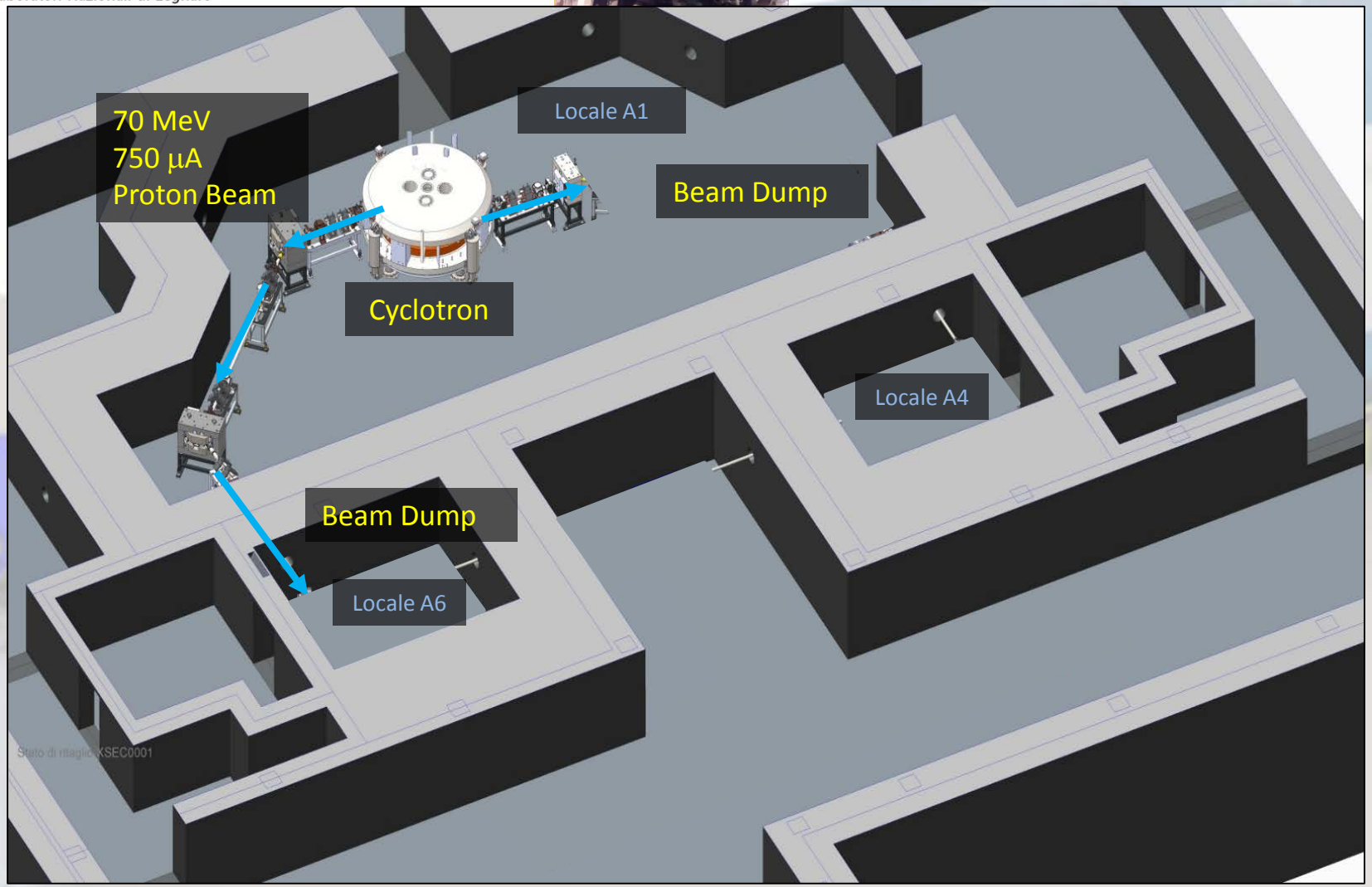
INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro

SPES exotic beams for science



INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro

SPES exotic beams for science



Access Control System

ACS

By INFN

Radiation Control System

RCS

By INFN

- Doors' interlocks and/or violation
- Radiation monitoring interlocks
- Presence detection
- Malfunctioning detection
- Alarm system (s)
- Fire detection system
- ....

- Consensus
- Interlocks
- Interrupts

Machine Control System

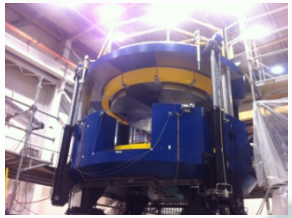
MCS

Actions

- Stop beam
  - Fast
  - Slow
- Inhibit operation
- Permit operation
- Safety devices actuation

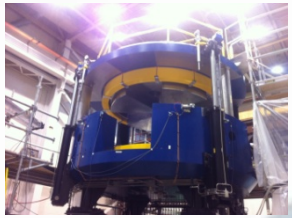
Safety devices

- Beam stoppers
- Operation interlocks
- Mechanical inhibition devices
- Machine protection devices



Commissioning phases of the Cyclotron

1. Source and injection line (20 kV extraction)
2. RF resonators
3. Beam Acceleration
   1. Up to 1 MeV
   2. Up to maximum energy (70 MeV)
4. Extraction
   1. Single port
   2. Double port
5. Beam Transport to target
   1. low power
   2. High power



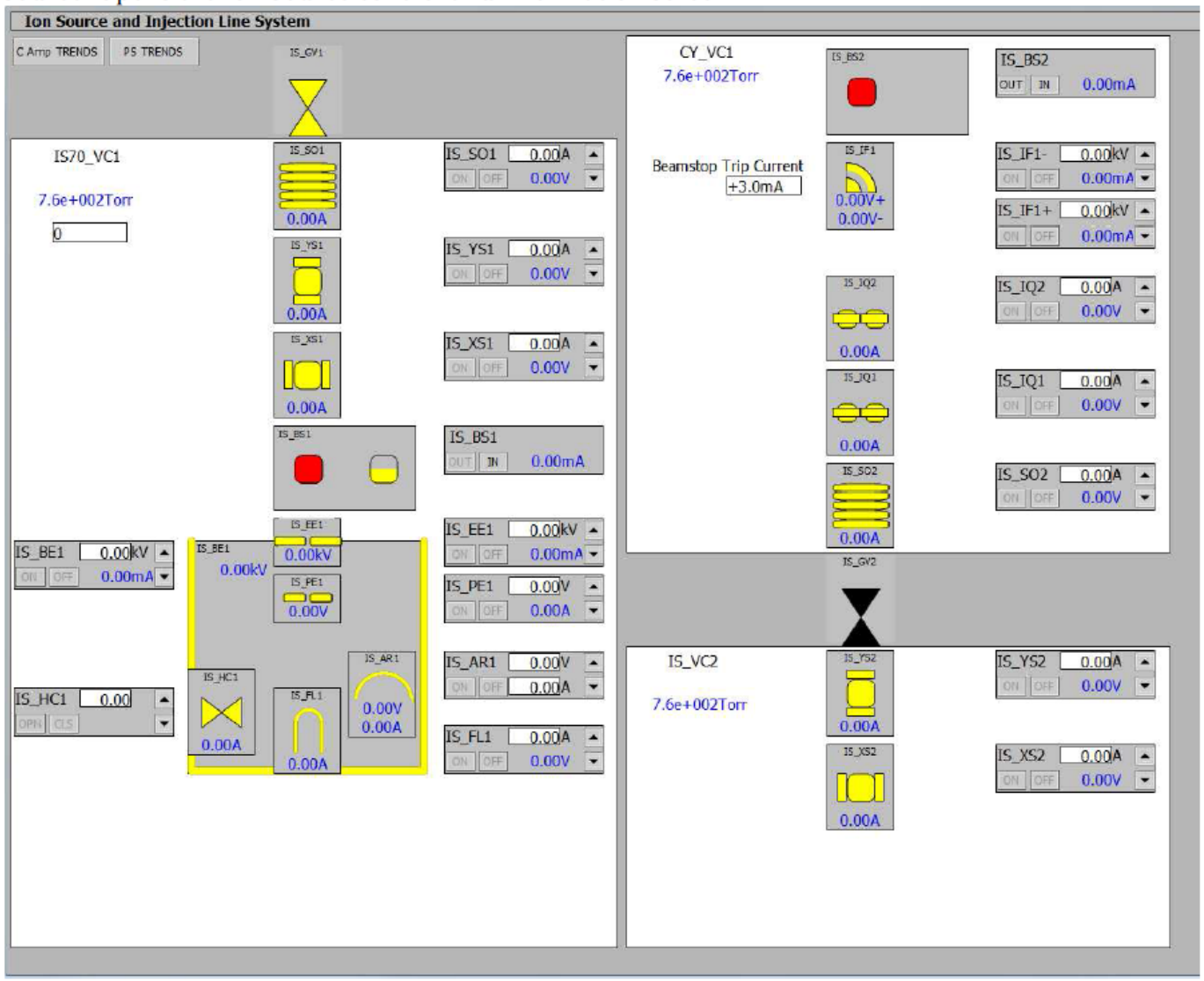
The high voltages associated with the ion source system and the inflectors are located in the following places;

1. High voltage cabinet (all HV power supplies and a rack biased at source voltage)
2. High voltage duct (cabling that is biased at ion source voltage)
3. Cyclotron pit (ion source)
4. Inside cyclotron magnet (inflectors)

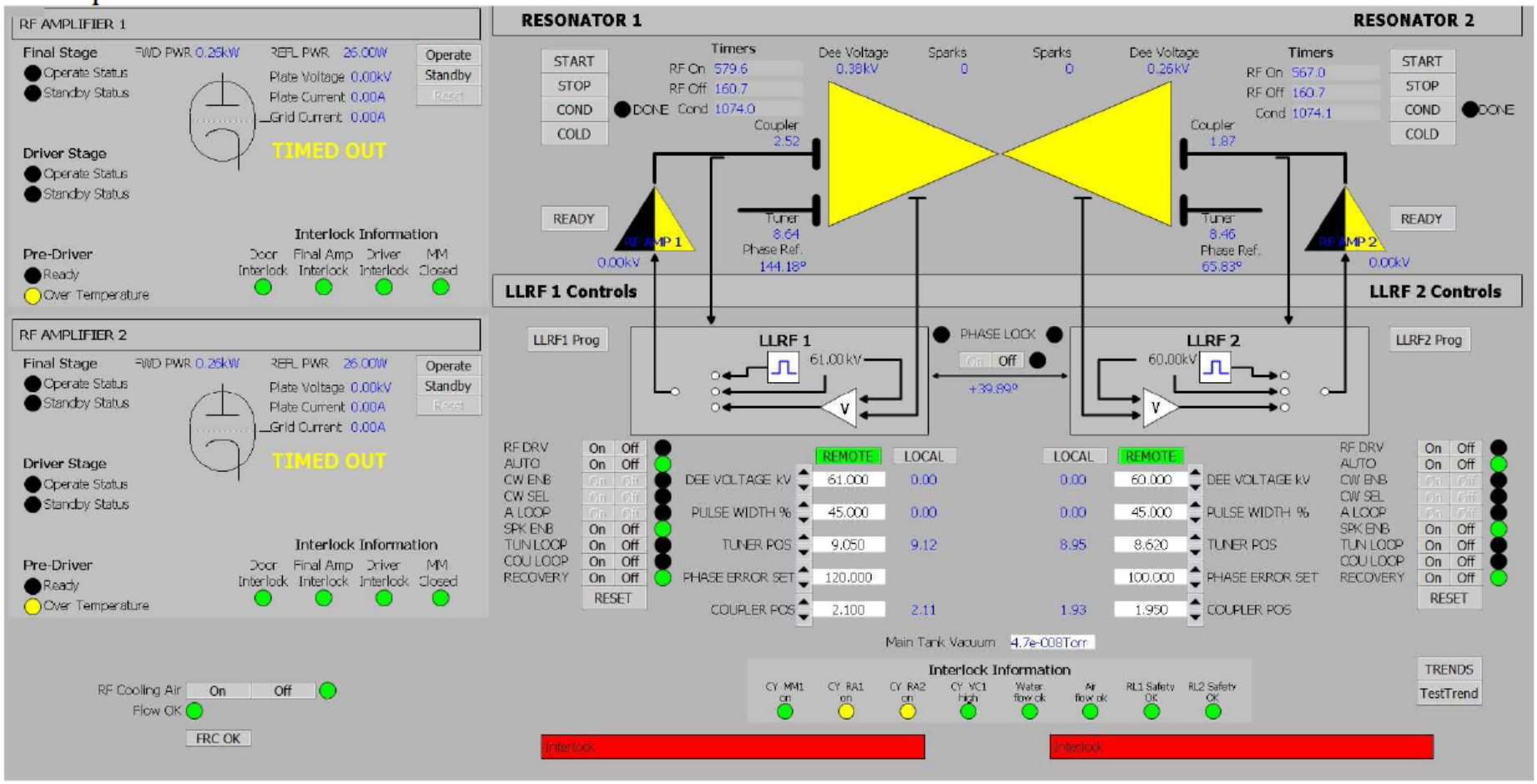
Mnemomics	Description
HV_DL1	HV Cabinet Door Lock and Switch 1 (Front)
HV_DL2	HV Cabinet Door Lock and Switch 2 (Rear)
VT_DL1	Pit Door Lock and Switch (high voltage enclosure at the cyclotron)
MM_LS1	Main Magnet Closed Limit Switch
HV_MD1	Manual Power Disconnect
HV_AK1	Main AC Contactor
HV_HK1_BE	Bias HV Relay
HV_HK2_IF+	Inflector + Output HV Relay
HV_HK3_IF-	Inflector - Output HV Relay
HV_HK4_EE	Extractor Output HV Relay

TABLE 1 HV SAFETY DEVICES

Source: Opens the Ion Source control and information screen.

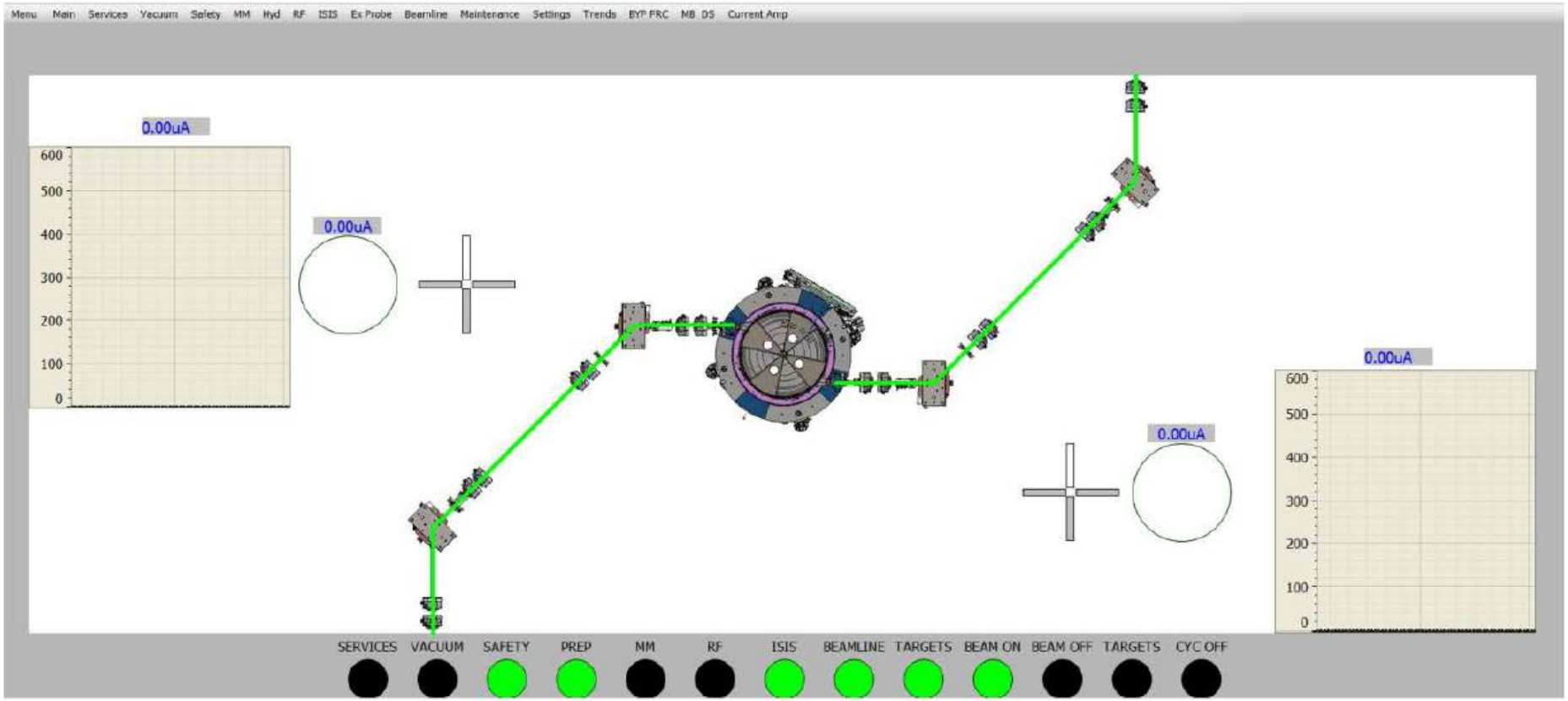


RF: Opens the RF control and information screen.

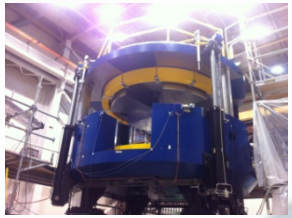


More information can be found in [DN8] DN700_36_341 RF Controls – in progress

Main Overview Screen:



The main overview screen is an overview of the current status of all cyclotron processes. It provides quick access to additional screens for detailed information regarding a specific process.



Beam Diagnostic Devices

- Four sectors
- Collimator
- Beam transformer
- Wire scanner

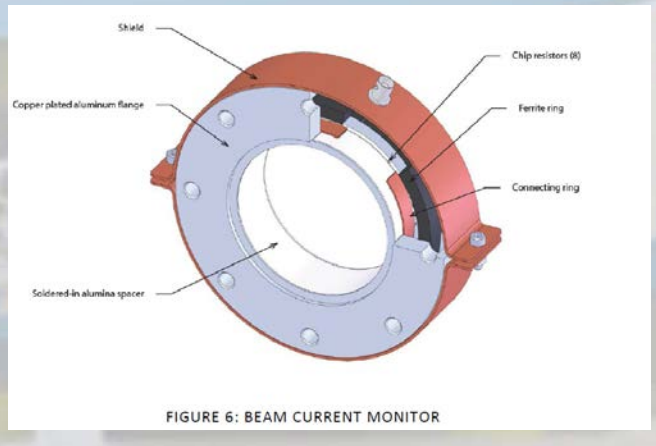
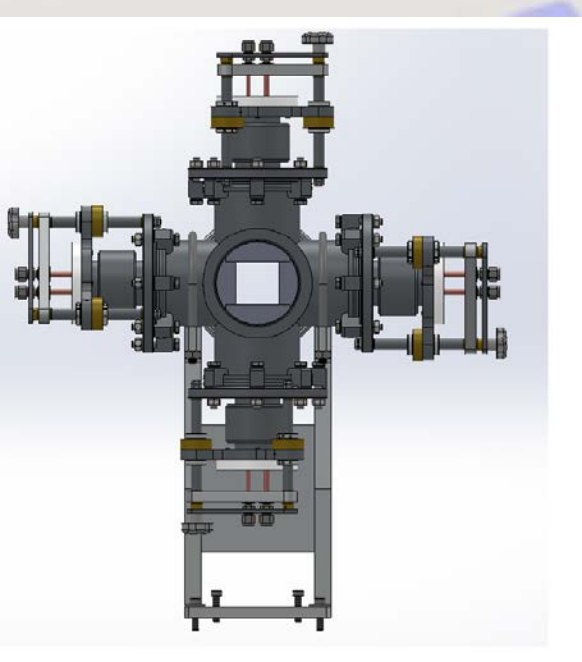
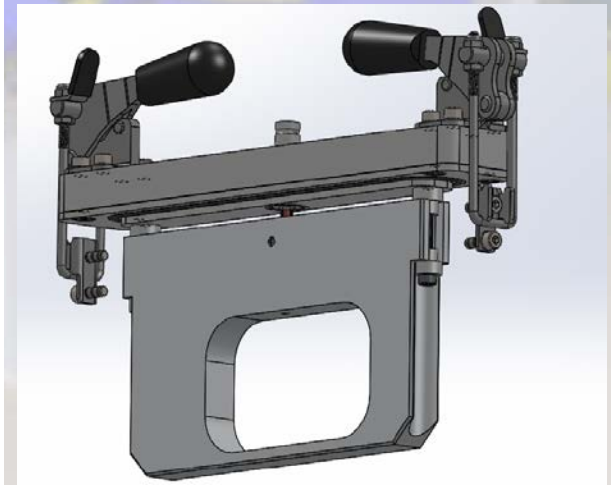
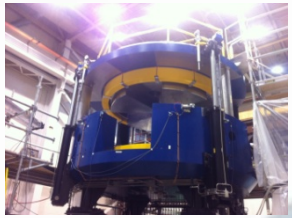


FIGURE 6: BEAM CURRENT MONITOR





INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro



SPES exotic beams for science

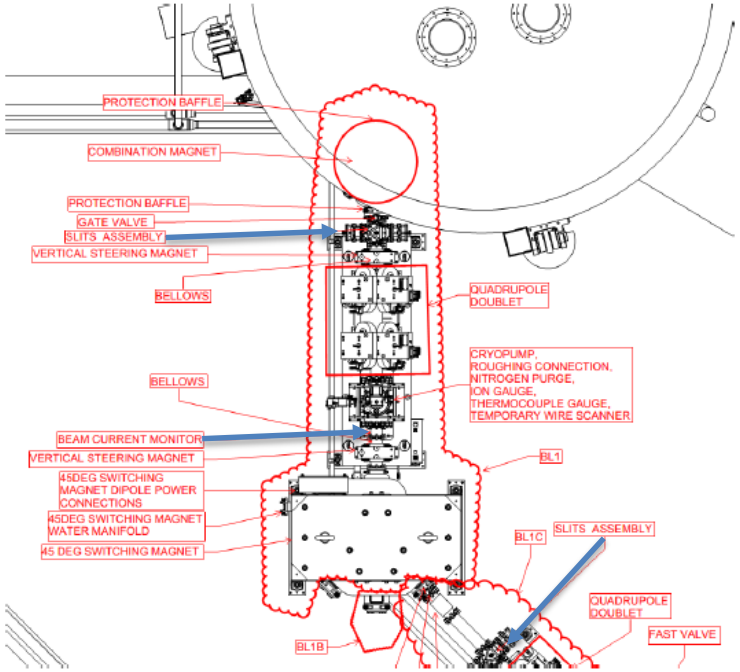


FIGURE 1: BEAMLINE BL1

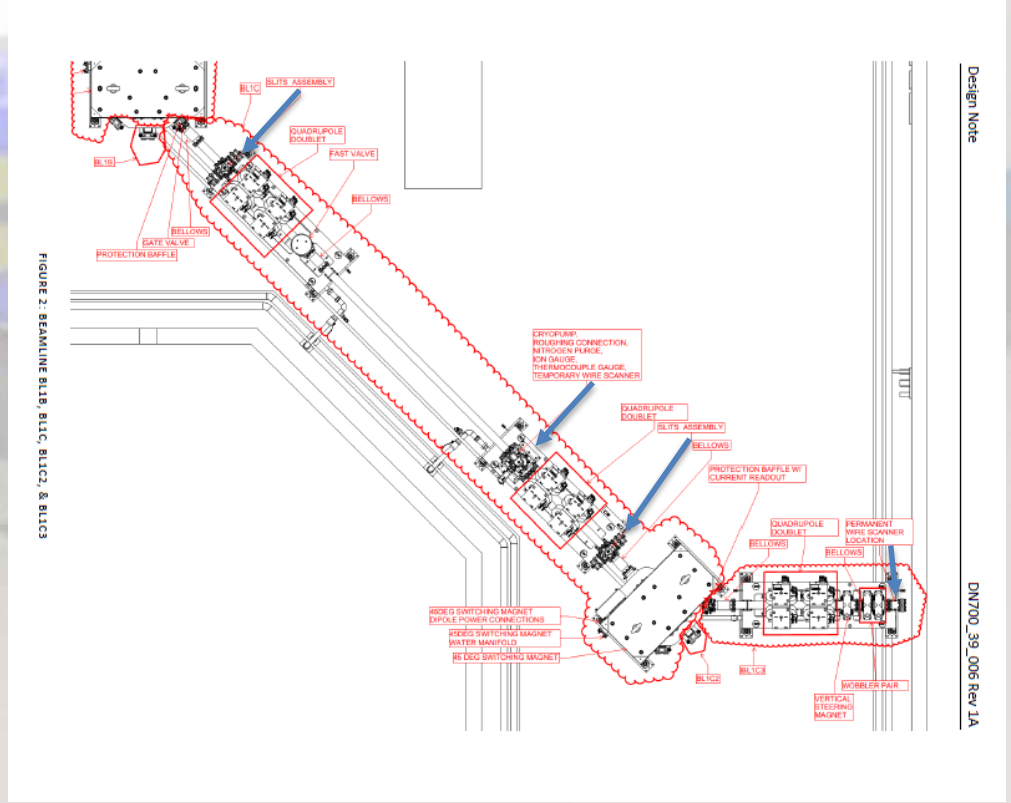


FIGURE 2: BEAMLINE BL1B, BL1C, BL1C2, & BL1C3

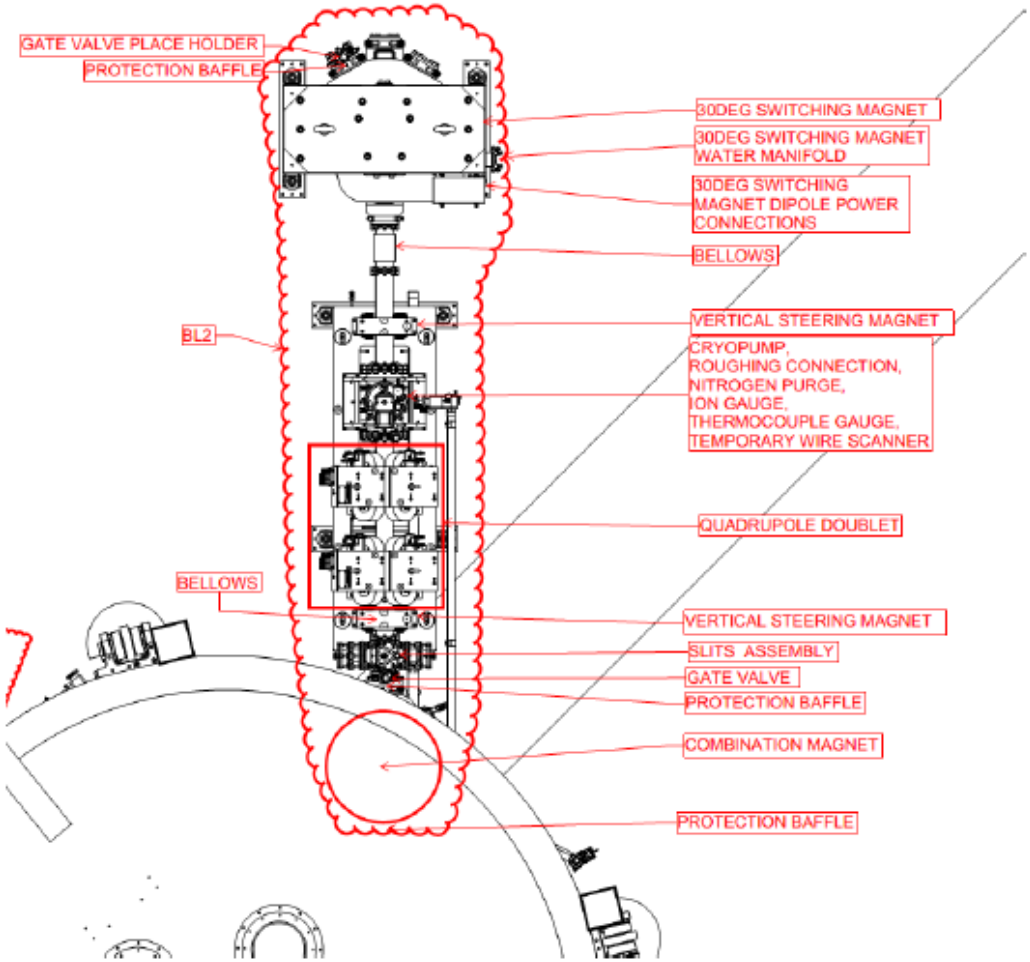
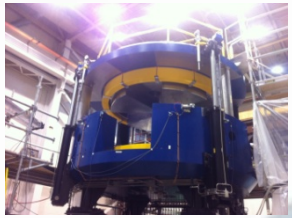


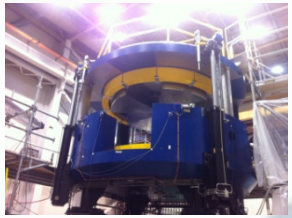
FIGURE 3: BEAMLINE BL2



Activity time schedule for the Commissioning and the SAT

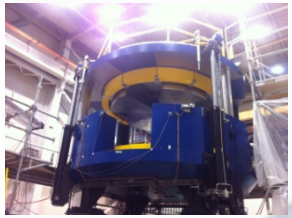
- Safety System Commissioning 17/08- 14/09
- Source Commissioning 21/09- 30/09
- RF Commissioning 24/09- 22/10
- Beam Commissioning
  - Injection 26/10- 3/11
  - Acceleration without extraction 26/11- 14/12
  - Extraction and Beam Line 1 tuning 15/12- 12/01/16
  - Extraction and Beam Line 2 tuning 21/01- 26/01
  - Dual beam extraction 05/02- 08/02
  - Operation and Commissioning LNL-BEST 09/02- 03/03

This schedule needs to be fine-tuned with the INFN activities.

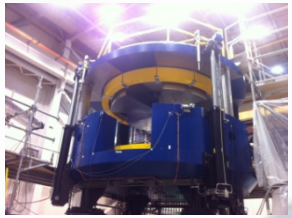


Requirements; summary of

1. Any malfunction of the SRS will safely shutdown beam operation or prevent beam operation.
2. Any access trip or activation of an Emergency Stop Button (EStop) will safely shutdown beam operation thru the use of hardwired interlocks.
3. All SRS must be made using failsafe principles: any hardware component malfunction will safely shutdown beam operation or prevent beam operation. THIS MUST BE SIGNED OFF BY BEST
4. The system must provide diagnostic information with respect to malfunctions
5. All critical elements of the system must be separated and isolated with respect to other systems.



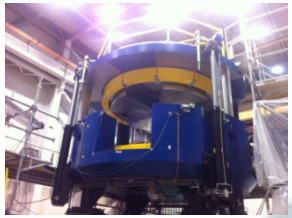
6. Blocking of the beam, where possible, must take place at least in two different ways.
    - Beam stoppers must be failsafe and fail in and latch
    - The type and material used must stop the entire beam
    - The material integrity must be guaranteed
7. Audible and visual alarms: malfunctioning has to be seen by the system
8. The safety system must be guaranteed to be unaffected by the loss of PC supervision
9. The system shall use directly connected components and circuits (door interlocks, EStop, and other components that directly shut off the cyclotron
10. Safety cabling must be run in metal conduit
11. Keys; set for accelerator ON
12. Switch off time less than 100 milliseconds *contract* @ *50* µsec)
13. Current Intensity Limiter: failsafe, able to control current distribution to two beamlines at fixed values (250µA to bunker 1 and 500µA to bunker 2)



3 Cyclotron Device Reaction Time

- **ISIS Beamstop:** ~500 milliseconds to in limit after safety enable is removed
- **Inflector HV relays:** failsafe; ~70 milliseconds after safety enable is removed
- **Ion Source Bias HV relay:** failsafe; ~70 milliseconds after safety enable is removed
- **ISIS Gate Valve:** 2 seconds after safety enable is removed
- RF: **LLRF Circuit:** ~60 µsec after enable is removed, second circuit is ~6.5 milliseconds

INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro



SPES exotic beams for science

1.1 Cyclotron Safety Critical Beam Control Devices

- **I**on **S**ource and **I**njection **S**ystem (**ISIS**) **Beamstop:** a water-cooled copper disc (diameter of 44.5 mm and thickness of 6.5 mm) located 10 mm downstream of the ion source
- **Inflector HV relays:** 2 High Voltage relays that grounds the inflector electrodes and their power supplies. These are considered as one device for redundancy and are failsafe devices.
- **Ion Source Bias HV relay:** High Voltage relay that grounds the inflector electrode and its power supply and is a failsafe device.
- **ISIS Gate Valve:** located in the injection line. When closed this completely blocks the injection line and low energy beam cannot enter the cyclotron.

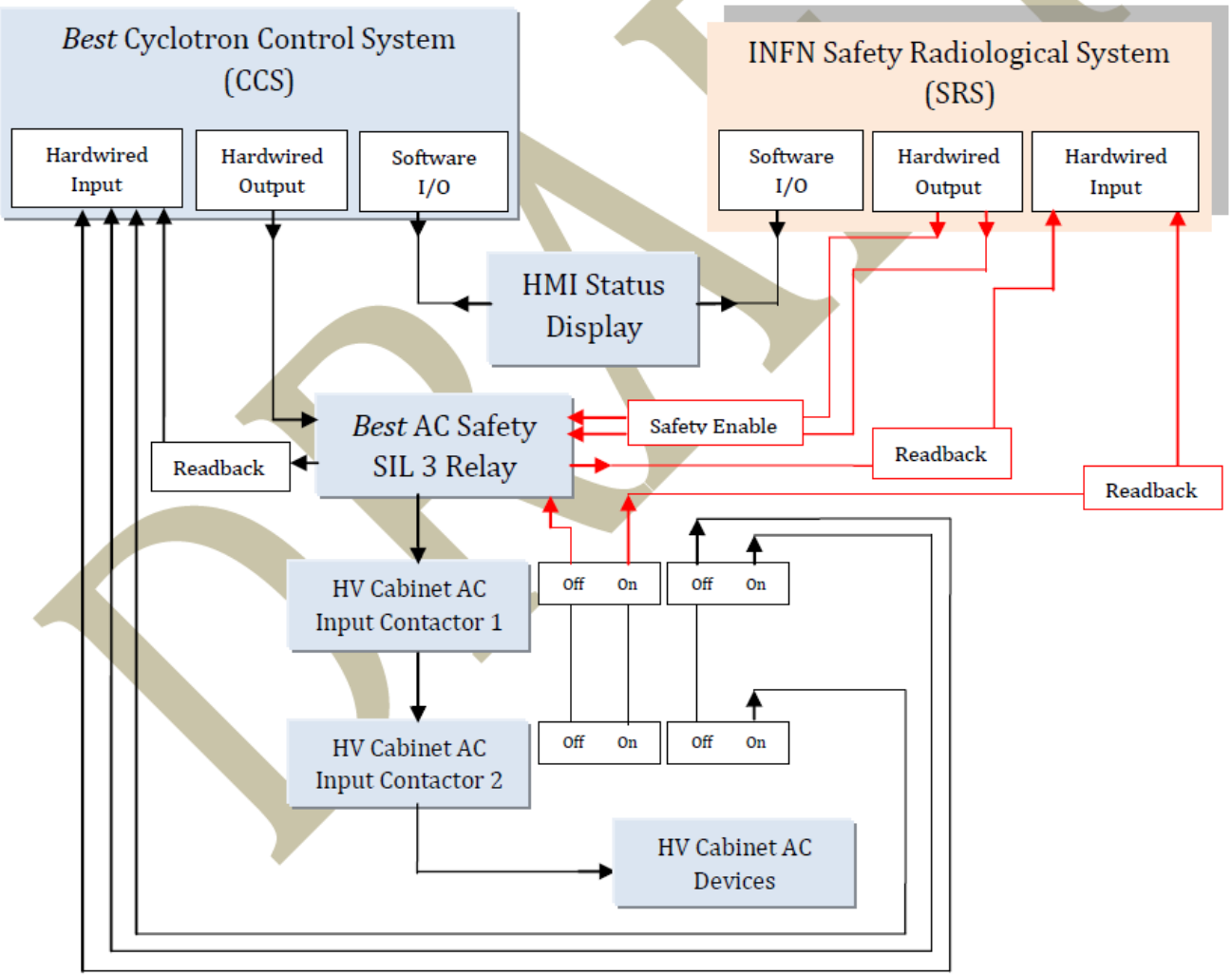
1.2 Beamline Safety Critical Beam Control Devices for side 1

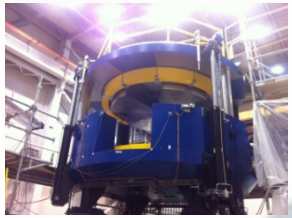
- **Extraction Probe 1**
- **Extraction Probe 1 Gate Valve**

1.3 Beamline Safety Critical Beam Control Devices for side 2

- **Extraction Probe 2**
- **Extraction Probe 2 Gate Valve**

Best - INFN Interface Schematic for HV Safety SIL3





Magnet Field mapping