

FETS PERSONNEL & MACHINE INTERLOCK SYSTEMS

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Abstract

The Front End Test Stand (FETS) [1] is a high energy pulsed proton driver that aims to produce a perfectly chopped 50 Hz, 60 mA, 2 ms H^- beam. FETS consists of a Penning Ion source, Low Energy Beam Transport (LEBT), 4 m long bolted construction 324 MHz four vane Radio Frequency Quadrupole (RFQ). The H^- Beam will be perfectly chopped so that bunches of particles can be trapped and accelerated with very low loss into a circular accelerator. To protect personnel from X-ray radiation along with prompt neutrons & gamma radiation, a concrete block-house has been built around the facility and a personnel interlock and search system developed.

This paper discusses the mechanical and electrical systems used to ensure personnel safety via the Personnel Protection System (PPS) and machine safety by use of a Programmable Logic Controller, (PLC), used as the Machine Interlock Systems.

INTRODUCTION

With the anticipated acceleration of the particle beam Bremsstrahlung electromagnetic radiation will significantly increase, being produced by the RFQ, beam line and dump. A protective concrete block-house has been built around the beamline.

Figure 1 illustrates the layout of the FETS block-house and the two entrances.

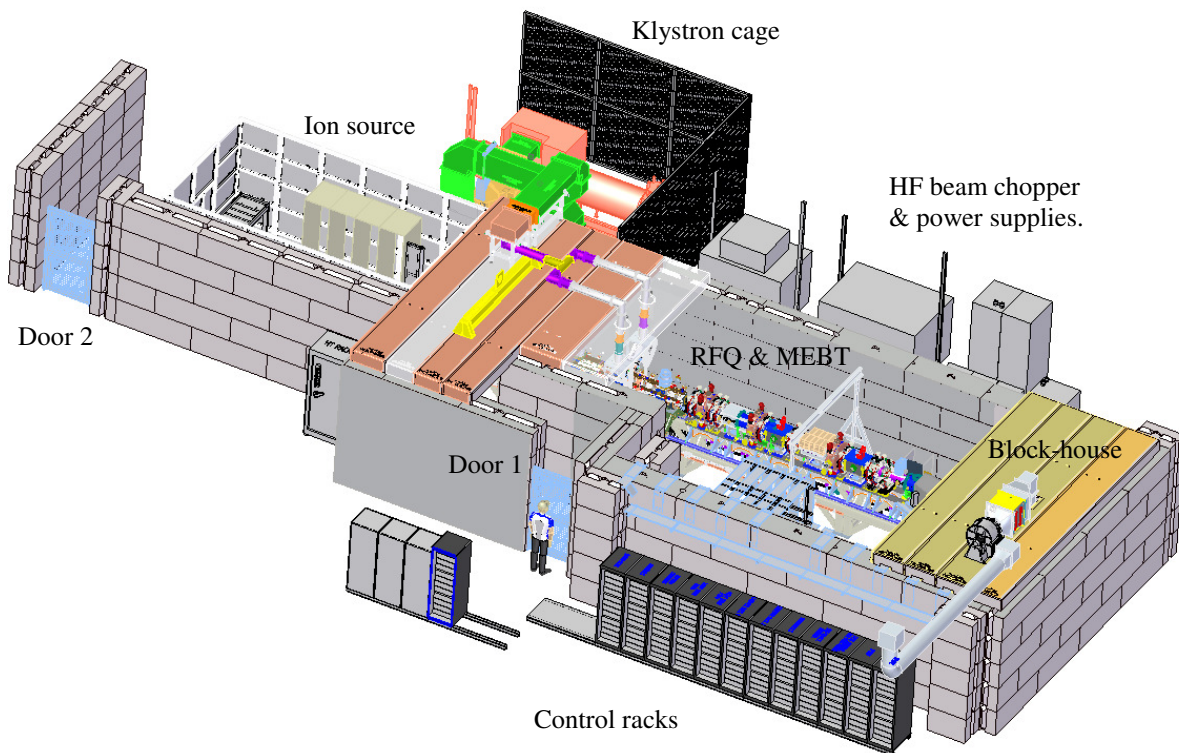


Figure 1: Fets protective concrete block-house.

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BLOCKHOUSE DOORS



Figure 2: Ion source entrance.

Entrance into the FETS block-house is via two doors. Above the doors are system status warning lamps.

Figure 2 shows the door at the ion source end of the block-house. The door closure is monitored by two completely independent safety interlock systems.

A mechanical safety interlock tongue switch, has a dual key mounted on the door, these are inserted into the switch body when closed. A magnetically actuated non-contact safety switch provides the second independent interlock.

At the bottom of the door an emergency break-out panel is fitted with a ceramic break-tube door latch. In the event of an emergency, a person could escape from the inside through the locked door.

In Figure 2, on the inside wall can be seen two push buttons which form part of the PPS. The red mushroom button on the yellow back-box is a Beam Off Button, (BOB).

With the successful completion of a search for personnel within the block-house, the LED lighting circuits change from a white (natural) light to a dark blue light to signify that following a time-delay the machine will become active. Pressing any of these BOB buttons will trip the PPS system preventing the generation of a beam.

The white push button lower down the wall, is one of seven pneumatic delay electrical switches used to implement the search. As a search of the facility is being made

the operator pushes this button to confirm that they have visited that position.

When the door is closed a permanent magnet catch holds the door closed. Once the FETS block-house has been searched and cleared of personnel and subsequently locked, a unique mechanical safety Castell [2] key is released.

PERSONNEL PROTECTION SYSTEM

Hazard producing equipment is controlled by two means; a mechanical, (Castell trapped key interlock), and an electrical circuit. The electrical circuit consists of two separately wired independent electrical contacts, (dual guard line).



Figure 3: Mechanical "Castell" trapped key exchange interlock.

Situated by the main entrance to the block-house is a 5 lock key-exchange mechanism. All doors have a unique key which become trapped in the mechanism. When the block-house is securely locked and all the red keys are inserted and rotated, a locking cam is allowed to releasing the five Brass keys on the right of Figure 3. These are then removed and taken to unlock and enable hazard producing equipment.

In addition to mechanically enabling the 'hazard producing equipment' a second electrical interlock also controls the operation of the 'hazard producing equipment'.



Figure 4: PPS control chassis front panel.

A 4U 19" PPS control chassis contains the relays and timers associated with the FETS Personnel Interlocks. Figure 4, shows the PPS control chassis front panel. The block-house doors have their closed states illuminating green status Light Emitting Diodes, (LEDs). Internal escape route doors are monitored for their closure but these are not locked. Provision is made for three external systems to also be polled for safe conditions. If any of these indicate a hazardous condition, then both the dual guard-line interlocks

become open circuit, shutting down all hazard producing equipment.

To initiate a search of the block-house, the red ‘Search’ button is pressed, a (7 minute) timer is started and the yellow “Searching” LED illuminates. During this time period the operator walks around the block-house pushing all seven search confirmation push buttons. On completion of the timely search of the block-house, a red “Searched” LED illuminates.

The operator can then press the black “Complete” button which will enable the guard-line 1 and guard-line 2 interlocks. Down the right hand side of the panel shown in Figure 2 are relay status red LEDs which confirm that guard-line relays have changed state.

These two independent relay contact closures are integrated into the hazard producing equipment control systems. In addition, a 2U timing interlock chassis, (figure 5), can be interposed, this inhibits the propagation of timing signals to the equipment and regenerates the guard-line relays. A key-switch on the front panel allows this timing inhibit to be over-riden to allow setting up of the equipment.



Figure 5: PPS timing interlock chassis panel.

The status of the two guard-lines are shown by green LEDs and the interlocked timing signals shown by yellow LEDs.

MACHINE INTERLOCK SYSTEM

FETS has numerous separated systems which must be operational and dependant on each-other, in order to prevent damage or a dangerous condition arising.



Figure 6: Machine interlock and control status panel.

In order to display satisfactory conditions, a simple row of green LEDs reflect a logical ‘AND’ function being performed by the PLC logic. When fully programmed it is anticipated that all 12 green LEDs will be illuminated to allow the accelerator to operate. Beneath each of the green individual LEDs are two smaller yellow LEDs. These give an indication of some logical relationship required to bring on the active condition. (For example for a magnet power supply to be turned on, both its water flow & temperature sensors must be combined together).

When the required support systems are operational and the ‘AND’ function is ‘Go’ (all green LEDs on) the PLC energises the “Machine Interlocks Ready” indicator along with two separate relays. (Figure 6, top left green indicator on bottom panel). An overall “Enable” key-switch allows managerial control of the beam line, the machine cannot be operated unless ‘permission’ is given by inserting the key and turning it. A second key-switch switches between “Ion Source Test” and “Beam”. “Ion source test” enables timing signals to be applied to make the Penning source operate but with the platform earthed to prevent beam in the LEBT.

FETS is energised by lifting a protective plastic lid over a small black push button. Pressing this button will enable the timing signals to the Penning ion source extraction voltage power supply on the energised HT platform and an H-Beam is produced. A large red mushroom push button is used to turn the system off.

NEXT STEPS

The FETS accelerator is scheduled to be commissioned with beam in summer 2019.

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