# Proposal to Modify the Personnel Safety System Methods for Terminating Beam

## Objective

The objective of this note is to propose another means for terminating the beam from the source that does not require turning off the gun high voltage except when necessary. The proposed method in this note to “safe” the downstream segments of the accelerator will be to withdraw PSS permissive to the electron gun laser system that is the source of the polarized electrons.

## Background

The CEBAF Personnel Safety System (PSS) is designed to ensure that personnel are not exposed to prompt radiation exceeding the CEBAF administrative limits. This is accomplished by maintaining "exclusion" areas for accelerator operations. Exclusion areas are designed to maximize the amount of shielding and distance between personnel and beam operations. The exclusion states for an area are Beam Permit and Power Permit. Access areas are areas that have no prompt radiation hazard, but where access is tightly controlled. The access states for an area are Restricted Access, Sweep, and Controlled Access.

The system design is based upon two complimentary principals:

1.) Keep the hazard away from people. This is done by the use of “critical devices” which prevent beam from entering an occupied area. These critical devices are backed up by a fast response Beam Current Monitoring (BCM) system that will reach back and shut off beam if it detects current in improper paths.

2.) Keep People away from the hazard. If an exclusion area is violated, such as if a tunnel entrance door is opened, the interlock system will immediately shut off the beam and any other device which could present a prompt ionizing radiation hazard.

Currently the PSS shuts off the beam using the following methods:

* Opening the Gun HVPS AC contactor
* Removing the Gun HVPS safety interlock permit
* Shorting the Gun HVPS DC output
* Removing the Polarized Source permit
* Kicking the 130kV beam on to a safe aperture device

In addition to shutting off the main beam source, removing the Gun HVPS eliminates possible field emission current. The field emission current can take on the same trajectory as the high power full current electron beam. However, the field emission current from the gun is on the order of a few picoamps. All downstream critical devices are capable of handling this amount of current.

**Applicability for Gun High Voltage greater than 200kV**

In the above analysis it was assumed that the field emission current is at most on the order of a few nano-amps. For gun HV in excess of 500kV the field emission current can be as high as a few micro amps. The above procedure will provide adequate protection. Studies are still underway to determine what is an acceptable amount of field emission current for normal dc gun operation for polarized sources, however, the desire is to eliminate as much field emission current as possible to within at most the nano-amp range.

At present it is okay for the PSS system to turn off the gun high voltage to prevent beam from propagating towards an access area. As DC electron gun technology improves and higher voltage guns become the norm, repeated shutting down of the gun high voltage becomes more detrimental. As the operating voltage for a DC gun increases, the time required for conditioning increases as well. For a 500kV gun, it could take well over half a day or longer to “condition” the gun to its operating voltage.

## Requirements for the new Injector segment Power Permit state

In this report our focus is only in PSS faults that drop the Injector segment from Beam Permit to Power Permit. At present, when the Injector segment is in the Power Permit mode, the Gun HVPS does not have PSS permissive and hence personnel are unable to turn on the Gun high voltage power supply (HVPS).

Our proposal is to change the PSS logic such that the gun HVPS remains on under Power Permit conditions for the Injector segment. The only time the Gun HVPS should lose PSS permissive is under conditions that will drop the Injector Segment to Restricted Access such as opening of access doors, any hatch opened, elevator door opened, Run/Safe crash switch, Top Stop Crash Switch, and SSI interface chassis “Chain Intact” fault. The proposal for ensuring that no beam is propagated while the Injector segment is in Power Permit is to insert the laser shutter for the four halls and take away laser shutter permissive. The Laser shutter permissive would be activated only when the Injector segment is in Beam Permit.

We review the different PSS configurations that allow beam operation with downstream access conditions. With each scenario is a recommended course of action that should allow the gun high voltage to remain on due to PSS faults that drop the Injector segment to Power Permit. There are conditions that require the gun high voltage to turn off; for completeness, those conditions are listed also.

* The PSS logic for the gun HVPS must provide a PSS permissive to the HVPS during Injector Power Permit.
* The laser shutters must insert and remain inserted while the injector segment is in Power Permit (no laser shutter permissive).
* Laser shutter permissive allowed only for Injector Beam Permit.
* SSG must have the ability to perform functionality test on laser shutter system for certification.
* SSG must have full access and control of laser shutter system. This will be considered a critical device and if there are any changes to the laser shutter system hardware the functionality must be recertified.

## Beam Delivery States and Hazards

Below are different PSS scenarios for beam delivery that requires protection of workers downstream from upstream beam permissive states.

### 1. The Injector segment is an access area (No beam):

**PSS State(s):**

Injector segment is in Controlled Access, Sweep, or Restricted Access.

**Mitigation**:

The Gun HVPS is always off when the Injector segment is an access area.

**Proposed actions:**

No change

### 2. The Injector segment is an exclusion area (Beam destination - 500keV spectrometer dump):

**PSS State(s):**

* The Injector segment only is in Beam Permit

**Mitigations:**

* Critical devices are configured for the desired beam destination
* A CARM at the Injector gate monitors radiation levels

**Proposed Actions:**

Injector segment

Access faults, crash faults, or failure of any critical device in the Injector segment:

* The Injector segment drops to Restricted Access
* The Gun HVPS turns off

Non-access or non-emergency faults in the Injector segment:

* The Injector segment drops to Power Permit
* The laser system output is interrupted to prevent propagation of high intensity photoelectrons
* Gun HVPS remains on

Other segments - no action

### 3. The Injector segment is an exclusion area. (Beam destination - beyond the Injector segment.

**PSS State:**

* The Injector segment is in Beam Permit.
* Additional segments are in Beam Permit.

**Mitigation:**

* Critical devices are configured for the desired beam destination

**Proposed Actions:**

Injector segment

Access faults, crash faults, or failure of any critical device in the Injector segment:

* The Injector segment drops to Restricted Access
* The Gun HVPS turns off

Non-access or non-emergency faults in the Injector segment:

* The Injector segment drops to Power Permit
* The laser system output is interrupted
* A3 and A4 are inserted
* Gun HVPS remains on

Other segments in exclusion mode

Access faults, crash faults, failure of a critical device in another segment:

* The effected segment drops to Restricted Access
* The Injector segment drops to Power Permit
* The laser system output is interrupted
* A3 and A4 are inserted
* Gun HVPS remains on

Non-access or non-emergency faults in another segment:

* The effected segment drops to Power Permit
* The Injector segment drops to Power Permit
* The laser system output is interrupted
* A3 and A4 are inserted
* Gun HVPS remains on