TRIUMF

ISAC Current Monitor System Operations Manual

	Name	Signature	Date
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History of Changes

Revision Number	Date	Description of Changes

1. PURPOSE AND SCOPE

The purpose of this document is to serve as the operations manual for the ISAC Current Monitor System (ICMS). The functionality of the individual monitors is described in separate documents (see section 3).

2. OVERVIEW

The ISAC Current Monitor System contains one intercepting current monitor in the MEBT beam line (MEBT:CHOPSLIT), and two non-intercepting current monitors (NIMs) in the SEBT beam line (post-accelerator). The ISAC Current Monitor System, in compliance with the ISAC-II Safety Report, allows the delivery of approved ion beams with energies greater than 5 MeV/u into the ISAC-II Experimental Hall to intensities within license limits.

3. REFERENCED DOCUMENTS

The following referenced documents are available on TRIUMF DocuShare:

- ISAC-II Safety Report: Document-561
- TRI-DN-08-22 (The MEBT chopper as ISAC-II intercepting current monitor): Document-18468
- ISAC Current Monitor System Specifications: Document-21010
- ISAC Operators' Manual: Document-6995
- Calibration, Inspection and Testing Index: Document-9745
- ISAC Safety revision for the incorporation of the "non-intercepting monitors (NIMs) OK signal" (J. Drozdoff, draft)

4. REQUIRED READING

This document is required reading for:

1. ISAC Operators
2. ISAC High-Energy Beam Delivery Physicist(s)
3. ISAC High-Energy Facility Coordinator

5. RESPONSIBILITIES

5.1 Overall Responsibility

The overall responsibility for the ISAC Current Monitor System lies with the Accelerator Division Head.

5.2 Specific Responsibility

The ISAC Current Monitor System is the responsibility of the ISAC High-Energy Facility Coordinator.

6. ISAC Current Monitor System Description

6.1 EPICS Interface

The ICMS uses EPICS for its graphical user interface (see Figure **1**). The interface is accessible from the main ISAC EPICS menu by left-clicking "Beam Modes" and selecting "ISAC2 Current Monitoring System".

The user interface contains the following fields / buttons:

1. Beam Properties Requested
   - 1.1. **A**: the mass of the accelerated isotope (default value is 0)
   - 1.2. **Q**: the charge of the isotope at MEBT:FC9 (default value is 0)
   - 1.3. **E**: the ion beam energy after ISAC-II acceleration (default value is 0)
   - 1.4. **SC Cavities On**: the number of superconducting cavities turned on to obtain the desired ion beam energy **E** (default value is 0)
2. Allowable Limits
   - 2.1. $\mathbf{E_{max}}$: the maximum ion beam energy deliverable as per the Safety Review Completion Document (default value is 0)
   - 2.2. $\mathbf{I_{max}}$: the maximum current deliverable as per the Safety Review Completion Document expressed in particle amperes (default value is 0)
   - 2.3. $\mathbf{I_2} = \mathbf{I_{max}} \cdot \mathbf{Q}$: the maximum current deliverable calculated by EPICS in electrical amperes (default value is 0)

3. Chopper Mode selection button (‘11’ or ‘11+5’): The selected mode is displayed to the right of the button (default mode is 11MHz)
4. Accept button: temporarily stores the fields from 1-3 above, denies write access to the same fields, and starts a 300 second timer
5. Reset button: resets all fields from 1-3 above to their default values
6. MEBT:FC9
   - 6.1. Readback current: EPICS variable MEBT:FC9:SCALECUR
   - 6.2. Gain selector buttons and readback of the selected gain
   - 6.3. Lock button: locks the MEBT:FC9 gain and calculates **R** (see definition in section 6.2)
   - 6.4. Unlock button: unlocks the MEBT:FC9 gain and resets **R**
   - 6.5. **R** calculation readback
   - 6.6. Conditions required in order to Lock (includes a MEBT:FC9 call-up button)
7. MEBT Chopper Slit
   - 7.1. Readback current: EPICS variable MEBT:CHOPSLIT: RDCUR
   - 7.2. Gain selector buttons and readback of the selected gain
   - 7.3. Lock button: locks the MEBT:CHOPSLIT gain and calculates $\mathbf{T_1}$ (see definition in section 6.2), where $\mathbf{T_1}$ is the MEBT Chopper Slit trip limit
   - 7.4. Unlock button: unlocks the MEBT:CHOPSLIT gain and resets $\mathbf{T_1}$
   - 7.5. $\mathbf{T_1}$ calculation readback
   - 7.6. Conditions required in order to Lock (includes a MEBT:CHOPSLIT call-up button)
   - 7.7. Trip Status indicator light
   - 7.8. Trip Value readback
8. NIM1
   - 8.1. Readback signal: EPICS variable SEBT:NIM10: RDCUR
   - 8.2. Gain selector buttons and readback of the selected gain
   - 8.3. Lock button: locks the NIM1 gain and calculates $\mathbf{T_2}$ (see definition in section 6.2), where $\mathbf{T_2}$ is the NIM1 trip limit
   - 8.4. Unlock button: unlocks the NIM1 gain and resets $\mathbf{T_2}$
   - 8.5. $\mathbf{T_2}$ calculation readback
   - 8.6. Conditions required in order to Lock (includes a SEBT:NIM10 call-up button)
   - 8.7. Trip status indicator light
   - 8.8. Trip Value readback

9. NIM2
   9.1. Readback signal: EPICS variable SEBT:NIM18: RDCUR
   9.2. Gain selector buttons and readback of the selected gain
   9.3. Lock button: locks the NIM2 gain and calculates $\mathbf{T_3}$ (see definition in section 6.2), where $\mathbf{T_3}$ is the NIM2 trip limit
   9.4. Unlock button: unlocks the NIM2 gain and resets $\mathbf{T_3}$
   9.5. $\mathbf{T_3}$ calculation readback
   9.6. Conditions required in order to Lock (includes SEBT:NIM18 call-up button)
   9.7. Trip status indicator light
   9.8. Trip Value readback
10. Engage Request button: removes write access to the unlock buttons, displays the SEBT:BB20 (Beam Blocker) EPICS panel, and sends a GO signal to the Safety System . The Engage Request active is indicated by a green dot on the left side of the button. The Engage Status active is indicated by a green rectangular light on the right side of the button.
11. Disengage Request button: allows write access to the unlock buttons, removes the SEBT:BB20 (Beam Blocker) EPICS panel, and removes the GO signal to the Safety System. The Disengage Request active is indicated by a black dot on the left side of the button. The Disengage Status active is indicated by a green rectangular light on the right side of the button.
12. Conditions required in order to Engage the system

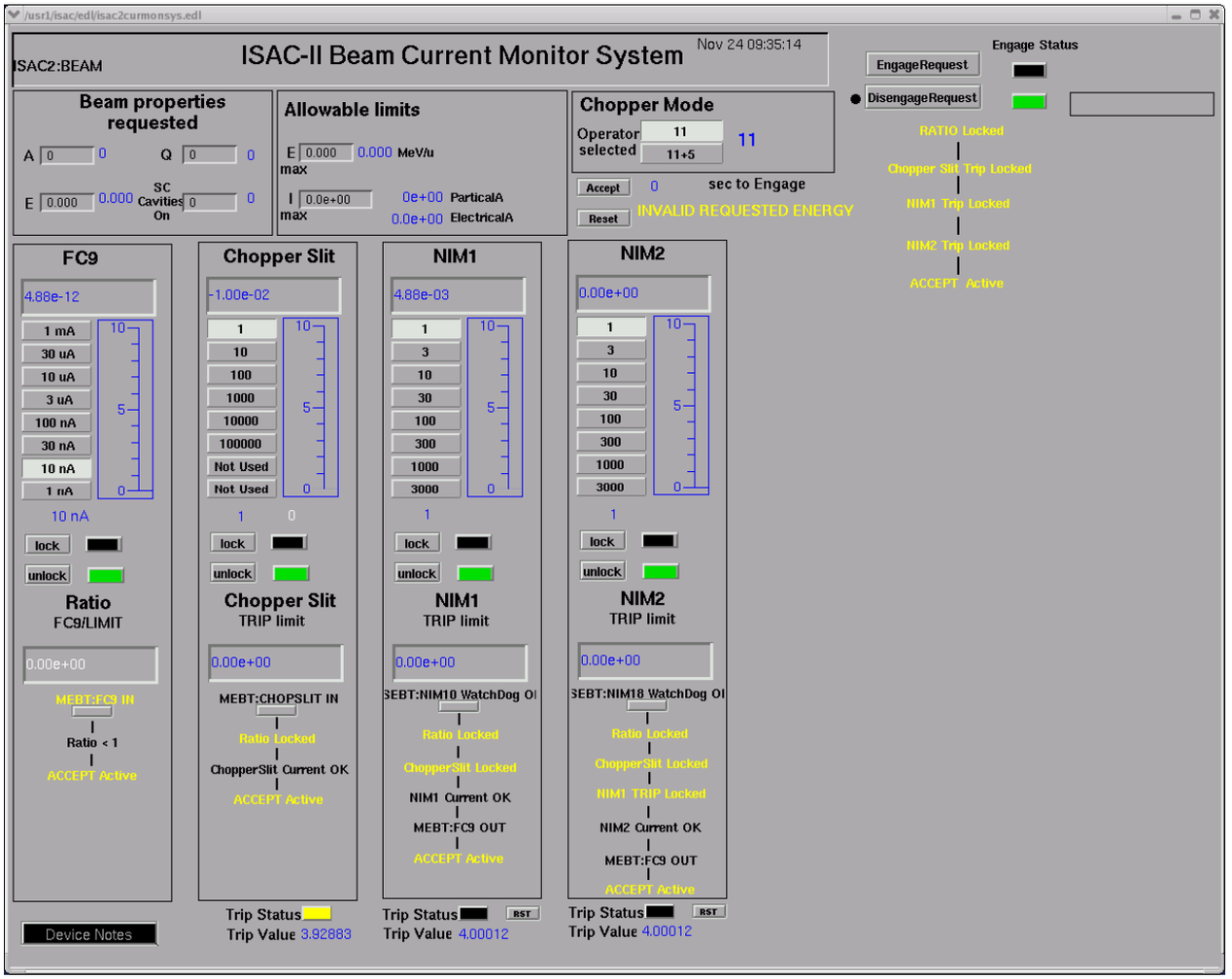

Figure 1. ISAC Current Monitor System EPICS interface. The picture shows the system disengaged and all the fields set to their default values.

6.2 Ratio and Trip Limit Definitions

The ratio (**R**) and the trip limits for all three monitors are defined as follows:

1. **R** is the ratio between the current measured on MEBT:FC9 (**F**) and the maximum approved current measured in electrical amperes ($\mathbf{I_2}$). **R** is calculated as follows:

$$R = \frac{F}{I_2}$$

2. $\mathbf{T_1}$ is the MEBT Chopper Slit trip limit. **P** is defined as the current measured on MEBT:CHOPSLIT. $\mathbf{T_1}$ is calculated as follows:

$$T_1 = \frac{P \cdot 0.8}{R}$$

3. $\mathbf{T_2}$ is the NIM1 trip limit. $\mathbf{N_1}$ is defined as the voltage readback of SEBT:NIM10. $\mathbf{T_2}$ is calculated as follows:

$$T_2 = \frac{N_1 \cdot 0.8}{R}$$

4. $\mathbf{T_3}$ is the NIM2 trip limit. $\mathbf{N_2}$ is defined as the voltage readback of SEBT:NIM18. $\mathbf{T_3}$ is calculated as follows:

$$T_3 = \frac{N_2 \cdot 0.8}{R}$$

The trip limit formulas above ensure that the Current Monitor System will trip if the beam current increases above 80% (0.8 factor) of the maximum allowable limit.

6.3 System Hardware

The GO signal to safety is provided by two control boxes, one for the chopper slit (see Figure 2) and one for the two NIMs (see Figure 3). Both control boxes have led indicators on the front panel that display the status; a green led indicates a proper functional status, while a red led indicates a trip status of the relative component.

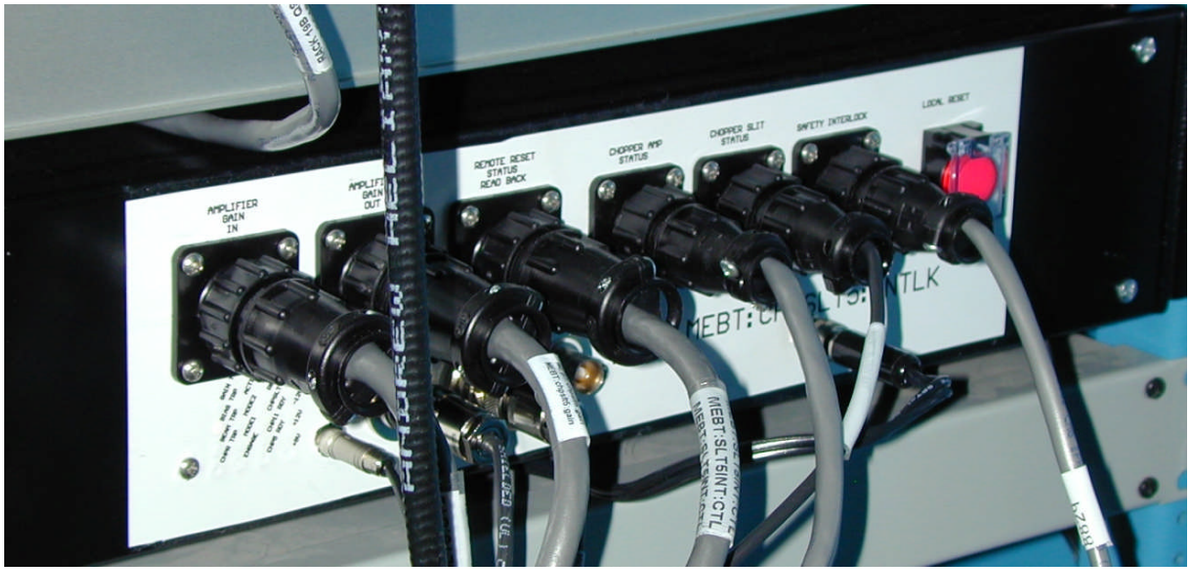

Figure 2. MEBT Chopper Slit control box. Location: Rack 18B, North Mezzanine, ISAC-I Experimental Hall.

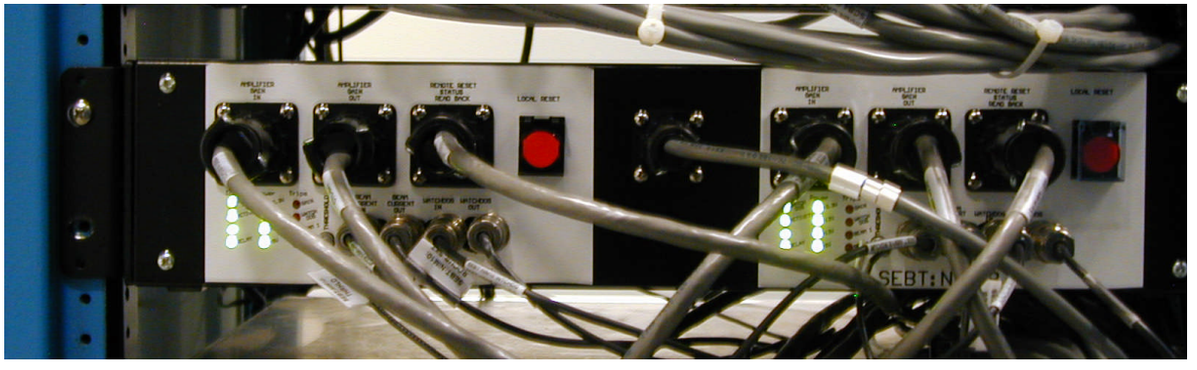

Figure 3. SEBT Non-Intercepting Monitors control box. Location: Row 1, Rack 7, ISAC-II Power Supply Room.

7. ISAC Current Monitor System Setup Instructions

The ISAC Current Monitor System only needs to be used if beam needs to be delivered past SEBT:BB20.

1. Select the appropriate beam mode(s) using existing procedures.

2. Press the **Disengage Request** button and the **Reset** button. All fields will be set to default values.

3. Insert SEBT:FC20.

4. Enter the appropriate data into all "Beam Properties Requested" fields (the mass **A**, the charge **Q** at MEBT:FC9, the energy **E** in MeV/u after the ISAC-II superconducting linac, and the number of **SC Cavities On**).

5. Enter the appropriate data into all "Allowable Limits" fields (the maximum energy $\mathbf{E_{max}}$ in MeV/u, and the maximum current $\mathbf{I_{max}}$ in particle nA for the accelerated beam as per the Safety Review Completion Document). EPICS then calculates and displays the maximum current limit $\mathbf{I_2}$ in electrical nA.

6. Select the appropriate chopper mode: 11Mhz (default) or 11MHz + 5MHz.

7. Press the **Accept** button. A 5 minute (300 second) timer will begin. The following steps must be completed within 5 minutes. If 5 minutes elapses before the system is Engaged the above input fields will be reset to their default values. If this happens, start again at step 2.

8. Stop the beam on MEBT:FC9 and adjust the Faraday cup gain as required.

9. Press the MEBT:FC9 **Lock** button. Write access to the gain selection menu will be removed, and the ratio **R** will be calculated. *Note that **R** must be less than 1. If it is not, you will be unable to lock MEBT:FC9 since the amount of beam measured on MEBT:FC9 is greater than the maximum approved current.*

10. Insert the MEBT Chopper Slit (MEBT:CHOPSLIT) monitor. Set the Chopper Slit gain so that a healthy signal can be read and the "Chopper Slit Current OK" condition is satisfied. *This condition ensures that the monitor gain setting is greater than the trip limit* $\boldsymbol{T_1}$. Press the Chopper Slit **Lock** button.

11. Remove MEBT:FC9 and stop the beam on SEBT:FC20.

12. Set the NIM1 gain so that a healthy signal can be read on the monitor and the "NIM1 Current OK" condition is satisfied. *This condition ensures that the NIM1 gain setting is greater than the trip limit* $\boldsymbol{T_2}$. Press the NIM1 **Lock** button.

13. Set the NIM2 gain so that a healthy signal can be read on the monitor and the "NIM2 Current OK" condition is satisfied. *This condition ensures that the NIM2 gain setting is greater than the trip limit* $\boldsymbol{T_3}$. Press the NIM2 **Lock** button.

14. Press the **Engage Request** button. Wait 10 seconds. If the request is accepted, the SEBT:BB20 EPICS device page will be displayed (see Figure 4) and a GO signal will be supplied to the Safety System. The 5 minute timer will stop counting.

15. On the SEBT:BB20 device page press the **Request** button to obtain the safety enable for running beam to the ISAC-II Experimental Hall and press the **Request** button to obtain the SEBT:BB20 safety enable. The beam blocker can now be removed.

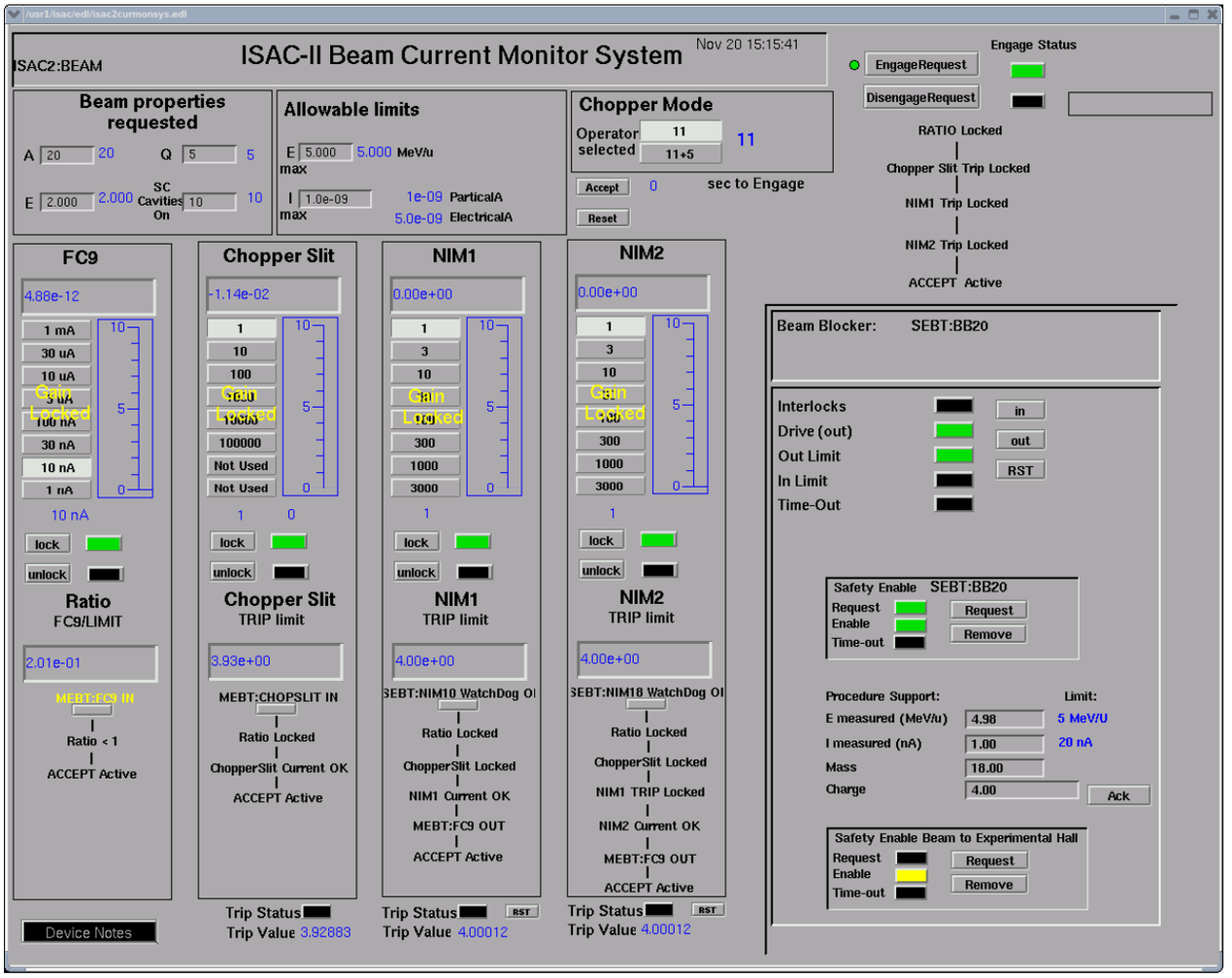

Figure 4. ISAC Current Monitor System EPICS interface after engaging the system.

8. Trip Events

A trip event is caused by the removal of the GO signal from one of the ISAC Current Monitor System control units ("NIM'S OKAY" and "CHOPPER OKAY" LEDs on the ISAC Safety System Display – See Figure 5). If a trip occurs, the safety enable for SEBT:BB20 will be lost and the Beam Blocker will fall in. Depending on which source is delivering beam through the superconducting linac (determined using the ISAC Beam Modes), the appropriate Safety Faraday cups will be driven in (IOS:FC3 and IOS:FC6 when running from OLIS; ITW:FC5, ITE:FC7 and IMS:FC3 when running from ITW or ITE).

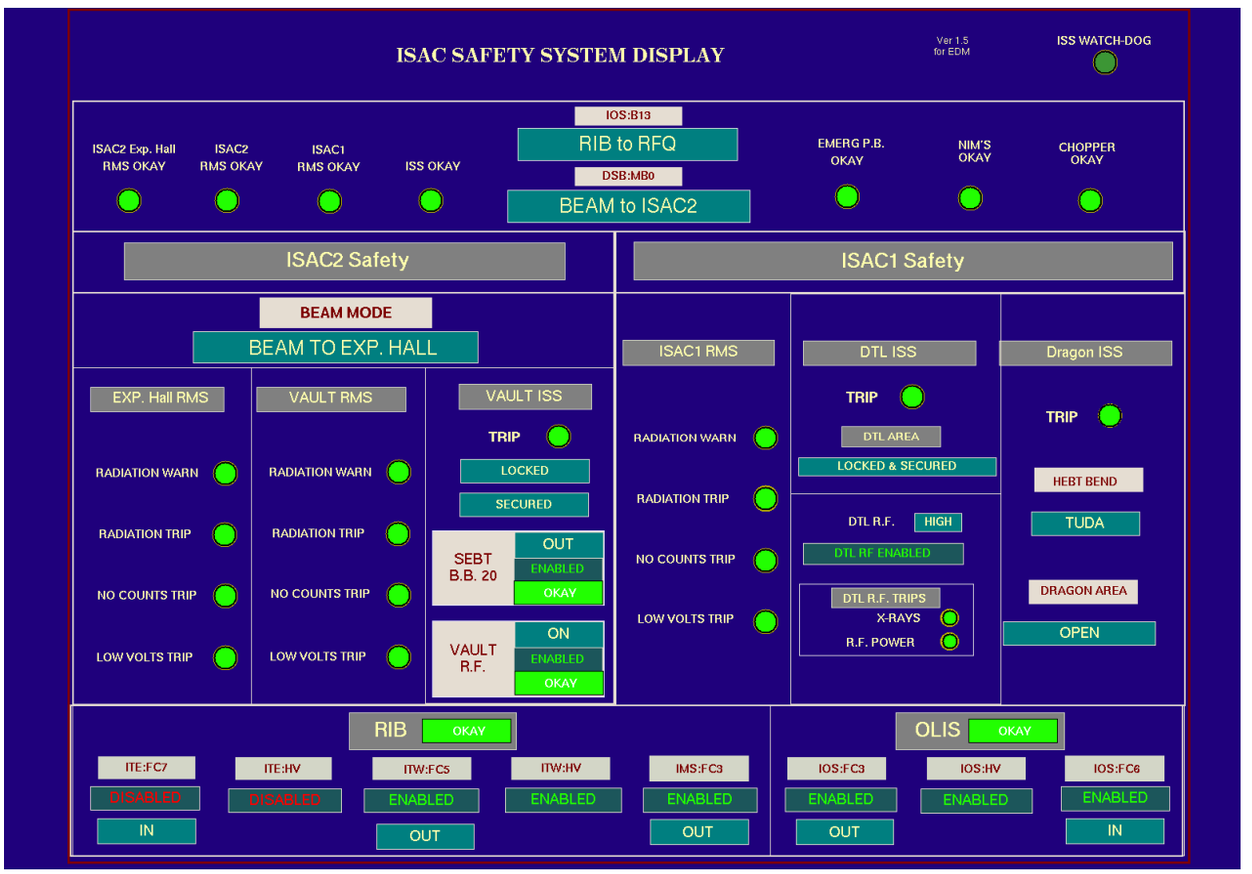

Figure 5. ISAC Safety System Display.

On a trip condition the Current Monitor System will disengage. All settings will remain unchanged and the source of the trip will be displayed. Once the source of the trip is identified and cleared, the Engage Request button can be

pressed. SEBT:BB20 can be removed after the two Safety Enable signals are requested (see section 7, step 15).

A trip will be triggered by any of the following events:

1. **P** is greater than $\mathbf{T_1}$ for more than 5 seconds
2. $\mathbf{N_1}$ is greater than $\mathbf{T_2}$ for more than 5 seconds
3. $\mathbf{N_2}$ is greater than $\mathbf{T_3}$ for more than 5 seconds
4. MEBT Chopper Slit is not at its 'In' limit
5. MEBT Chopper Slit bias is 'Not OK'
6. MEBT Chopper is Not OK (for either 11 or 11+5) for more than 2 seconds
7. NIM1 watchdog is Not OK for more than 2 seconds
8. NIM2 watchdog is Not OK for more than 2 seconds
9. Any amplifier gain 'Lock' OK signal is lost
10. 'Engage' OK signal is lost
11. Disengage Request button is pressed

9. Operator Confirmation

When the ‘Engage Request’ is active a beam properties confirmation window (Figure 6) pops up on the ISAC Control Room Alarm Handler console at the start of each shift. This pop-up window is accompanied by an alarm in the ‘Controls Event Handler’ (Figure 7).

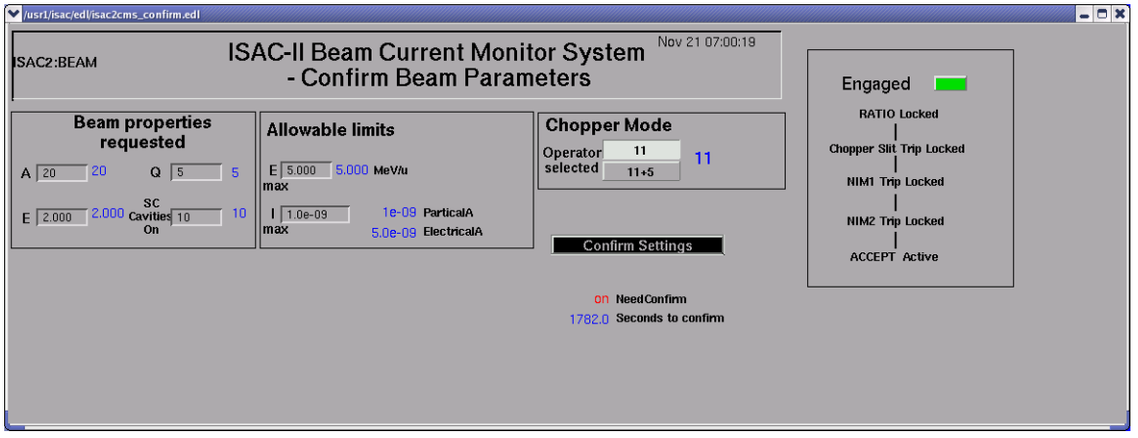

Figure 6. The ‘ISAC-II Beam Current Monitor System – Confirm Beam Parameters’ pop-up window.

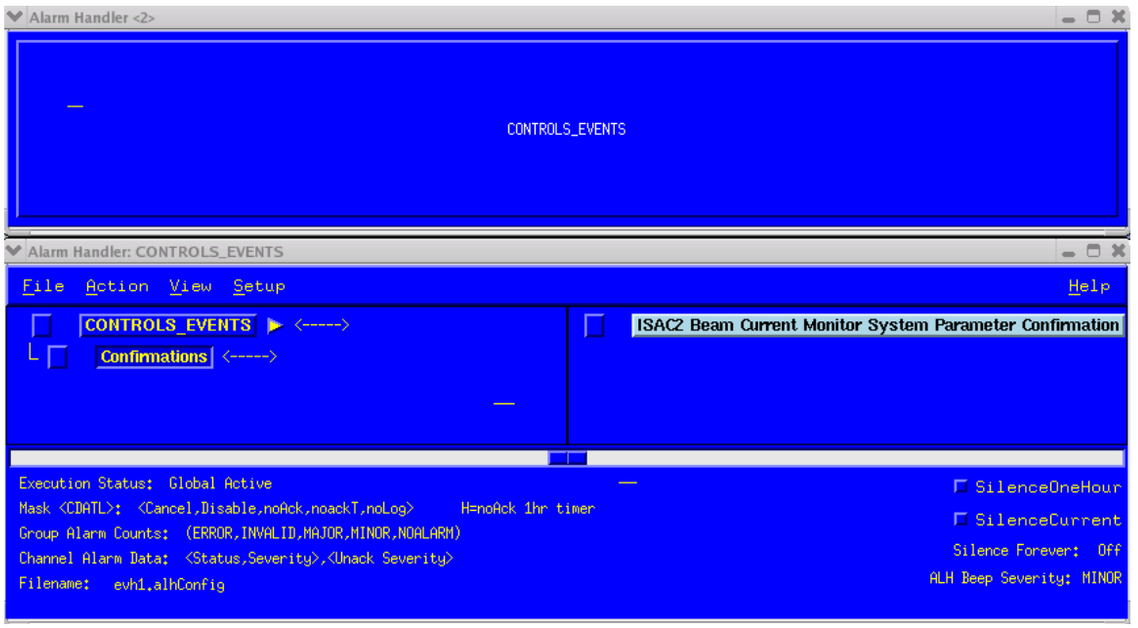

Figure 7. The ‘Controls Event Handler’.

After reviewing the beam parameters and confirming that they are correct, the on-duty ISAC Operator must press the ‘Confirm Settings’ button. The Operator is prompted to Login using his/her trmail user name and password. After entering a comment (required) the Operator must press the ‘Apply Confirm’ button, this action triggers an automatic entry to be inserted in the ISAC Elog and the confirmation window to close. If the confirmation succeeds the Elog entry summary is:”ISAC2 CMS Start of Shift Confirmation SUCCEEDED”. If the confirmation is not done within 30 minutes the Elog entry summary is:”ISAC2 CMS Start of Shift Confirmation FAILED”. Once the confirmation process is completed the Operator can clear the ‘Controls Event Handler’ alarm.

When the ‘Disengage Request’ is active, the beam parameters confirmation pop-up window is disabled.