# RTPC Operations Manual

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**Abstract**

This document provides an overview of the Radial Time Projection Chamber (RTPC) system and serves as an Operations Manual for the detector. Instructions are provided for shift takers related to the basic steps of operating and monitoring the HV controls, monitoring the detector system and responding to alarms, and knowing when to contact the on-call personnel. More complete details are also provided for RTPC system experts regarding the channel mapping to the readout electronics, the cable connections and routing in Hall B, LV controls, and detector servicing. This document also provides references to the available RTPC documentation and a list of personnel authorized to perform RTPC system repairs and to modify system settings.

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# Contents

# 1 RTPC Overview

The CLAS12 Radial Time Projection Chamber (RTPC) is a cylindrical gaseous detector of radius 8 cm used in the BONuS12 experiment. This detector is made up of three layers of 40 cm long concentric GEM (Gaseous Electron Multiplier) cylinders as shown in figure 1. The detector has two separate cylindrical volume: buffer volume extending from target wall (at radius r=3 mm from beamline) to the ground foil of the detector (at r =20 mm), and active volume extending from ground foil to the padboard at r = 80mm. Helium gas is used in the buffer, and mixture of He (80%) and CO2 (20%) is used in the active space.

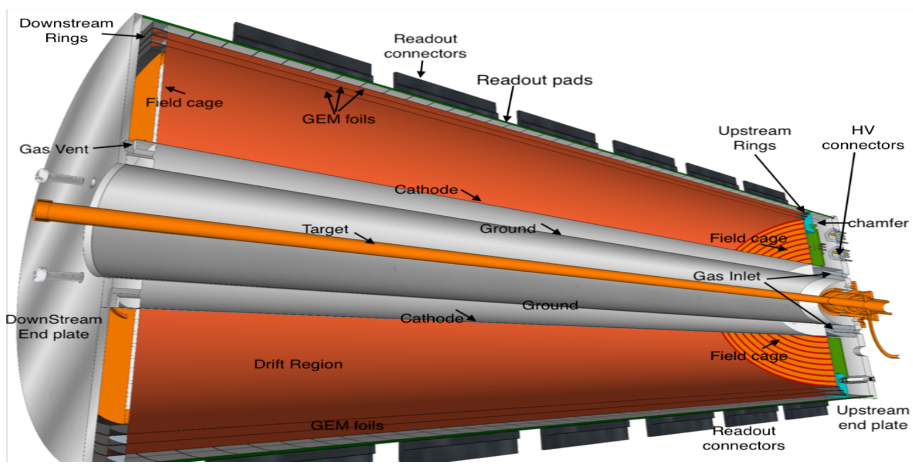


Figure 1: Cross-sectional view of BONuS12 RTPC

There are 7 high voltage channels to power up RTPC up to 7000V, but the current limit for the HV is extremely low. One high voltage channel is used for the cathode foil and the 6 others are connected to the GEMs. The end caps are powered via the inner most GEM foil and the cathode.

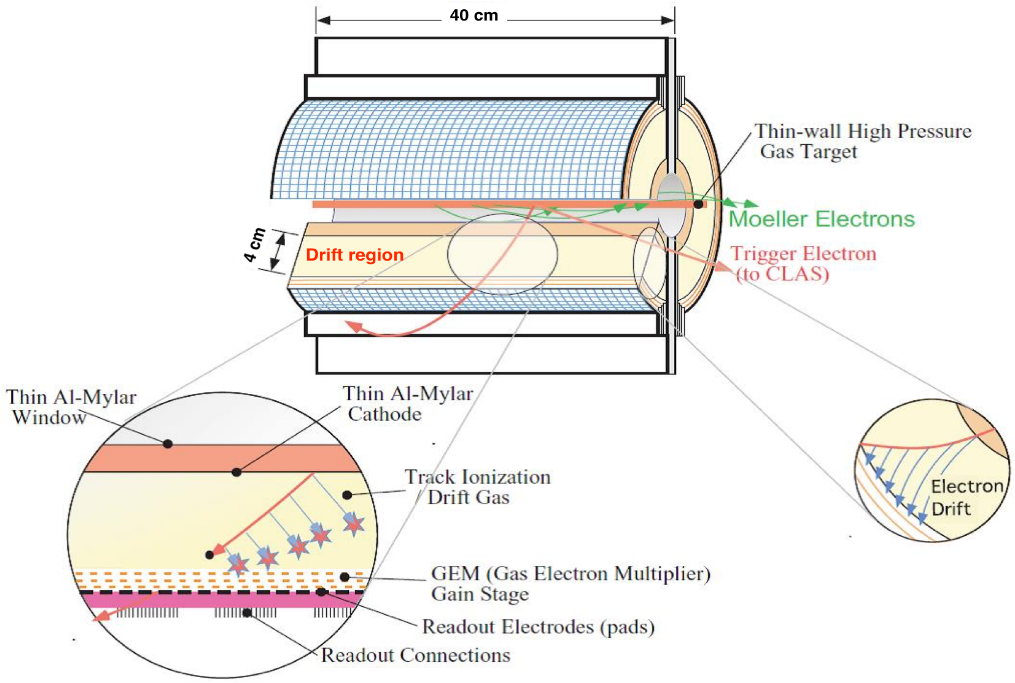


Figure 2: Schematics of BONuS12 RTPC and a proton track

When a proton traverses through the gas in the drift region of RTPC, atoms along its path are ionized which liberate electrons as shown in figure 2. An electric field maintained in the drift region drives these electrons toward GEMs. Avalanche occurs when electron passes through GEM because of the high electric field established between the two sides of each GEM. Three GEM foils are utilized to produce a large number of electrons which are collected from the readout board at the outer layer. The RTPC readout board comprises of a pattern of 4 mm$\times$2.75 mm conductive pads around the cylindrical detector. Electric signals obtained out of the readout board are used to project the position of the proton at particular time. In order to reconstruct a complete track of proton, we have 17280 readout pads around the RTPC and the DREAM based DAQ system is used to collect the signals from the pads.

The DAQ system of RTPC consists of DREAM (Dead-timeless Readout Electronics Asic for Micromegas) chips developed by SACLAY group, primarily for the Micromegas detector of Hall B at Jefferson Lab. We replace the Micromegas detector by the RTPC detector in BONuS12, but would like to use the compact ASIC, DREAM. Each DREAM chip has 64 channels and each channel has integrated amplifier, filter, shaper, discriminator, and 512 cell analog circular buffer. So, signal from 64 readout pads are easily processed by a DREAM which are also sampled and temporarily stored in its buffer. Eight such chips are hosted by a FEU (Front End Unit), which is also supplemented by Flash-ADCs so as to get digitized data out from the FEU. Data are transferred from FEU to backend-unit using optical links as shown in figure 3. Zero suppression and Pedestal subtraction are implemented in FEUs for the BONuS12 experiment.

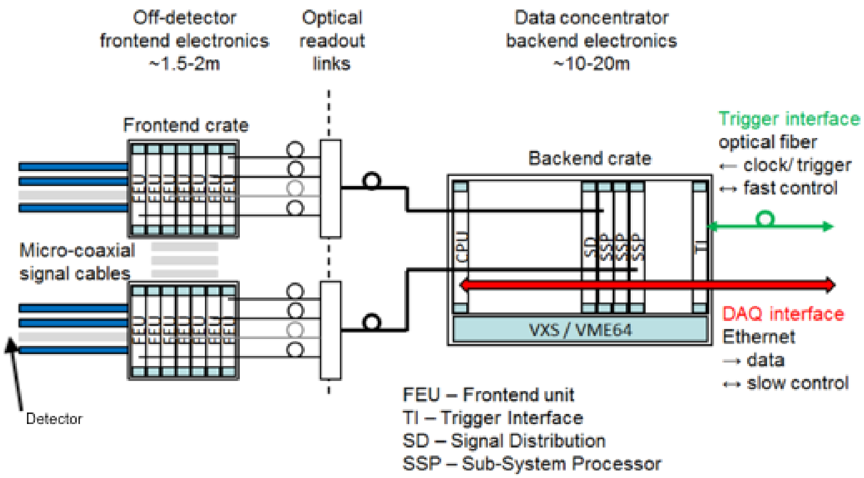


Figure 3: Schematics of Data Acquisition Electronics for the RTPC

# 2 Information For Shift Takers

## 2.1 Shift Taker Resposibilities

The shift takers in the counting house have following responsibilities with regard to RTPC system:

1. Updating the Hall B Electronic Logbook with records of system conditions (sub-section 2.2 )

2. Responding to RTPC system alarms for the Hall B Alarm handler (sub-section 2.3)

3. Contacting RTPC system on-call personnel (sub-section 2.4)

4. Monitoring the flow rate and pressure of gas on RTPC Gas interface (sub-section 2.5)

5. Turning ON and OFF the HV of the RTPC detector using HV Control Interface (sub-section 2.6 )

6. Monitoring LV of FEUs in RTPC readout electronics (sub-section 2.7)

7. Monitoring the hit occupancy scalers of the system (sub-section 2.8)

## 2.2 Updating the Logbook

The electronic logbook is set up to run on a specified terminal in the Hall B Counting House. Shift takers are responsible for keeping the records of the monitoring of RTPC sub-systems (Gas, HV, LV in RTPC Overview) and occupancy. Shift takers are also responsible for keeping an up-to-date and accurate record of any problems or issues concerning the RTPC system. For any questions regarding the logbook, its usage, or on what is considered to be a logbook worthy entry, consult the Leader or Run Coordinator.

Note the shift worker should follow all posted or communicated instructions about entering RTPC monitoring histograms or scaler information into the e-log. This is typically done (at least) once per run as directed on the shift checklist.

## 2.3 Hall B Alarm Handler

The BEAST alarm handler system running in the Counting House monitors the entire Hall B Slow Controls system. This includes the HV and low voltage (LV) systems, gas systems, torus and solenoid controls, subsystem environment controls (e.g. temperature, humidity), and pulser calibration systems (among several others). The system runs on a dedicated terminal in the Counting House. One of the main responsibilities of the shift worker is to respond to alarms from this system, either by taking corrective action or by contacting the appropriate on-call personnel. Instructions and details on the alarm handler for Hall B are given in Ref. [1].

For the RTPC system there are three elements that are monitored by the alarm handler. The first is the HV system. Any time a channel trips off an alarm will sound. Trip in one channel turn off the HV to all the channels in RTPC. These channels can be reset either through the alarm handler or through the RTPC HV control screens. These channels should be reset only after ensuring that whatever condition caused the trip (e.g. bad beam conditions) has been addressed. The second RTPC element monitored by the alarm handler is the gas supply to the RTPC. An overpressure or underpressure condition at any monitored point in the system will cause the HV power supply to trip off. These conditions are not expected to occur during normal operation of the RTPC gas supply. If such an alarm condition occurs, the RTPC on-call expert should be contacted to investigate and restore the system. ?? gas bottle change??

### 2.4 Contacting the RTPC system Experts

As a general rule, shift takers should spend no more than 10 to 15 minutes attempting to solve any problem that arises with the RTPC system. At that point they should contact the assigned RTPC on-call expert either to provide advice on how to proceed or to address the problem. The RTPC on-call phone number is ??.

Only RTPC system experts are authorized to make changes to the RTPC parameter settings, to work on the hardware or electronics, or to modify the DAQ system software. This division between shift taker responsibilities and expert responsibilities is essential to maintain in order to protect and safeguard the equipment, to ensure data collection is as efficient as possible, and to minimize down time. If the shift worker has any questions regarding how to proceed when an issue arises, the shift leader should be consulted.

### 2.5 Monitoring the Gas Flow

There are two separate gas flow lines to the RTPC detector. Helium gas is flowing in the buffer region, and mixture of He (80%) and CO2 (20%) is flowing in the drift region from pre-mixed bottle. EPICS Gas monitoring interface could be obtained from the"RTPC" botton on the CS-Studio for the slow controls of the CLAS12 detector sub-system. It is also located under "Gas" subsystem option with the name "RTPC". CS- Studio can be obtained by using command 'clascss' in the terminal of counting house computers. General CS-Studio for the slow control of the CLAS12 detector is on the left of Figure 4, while the right is showing the RTPC menus as well.

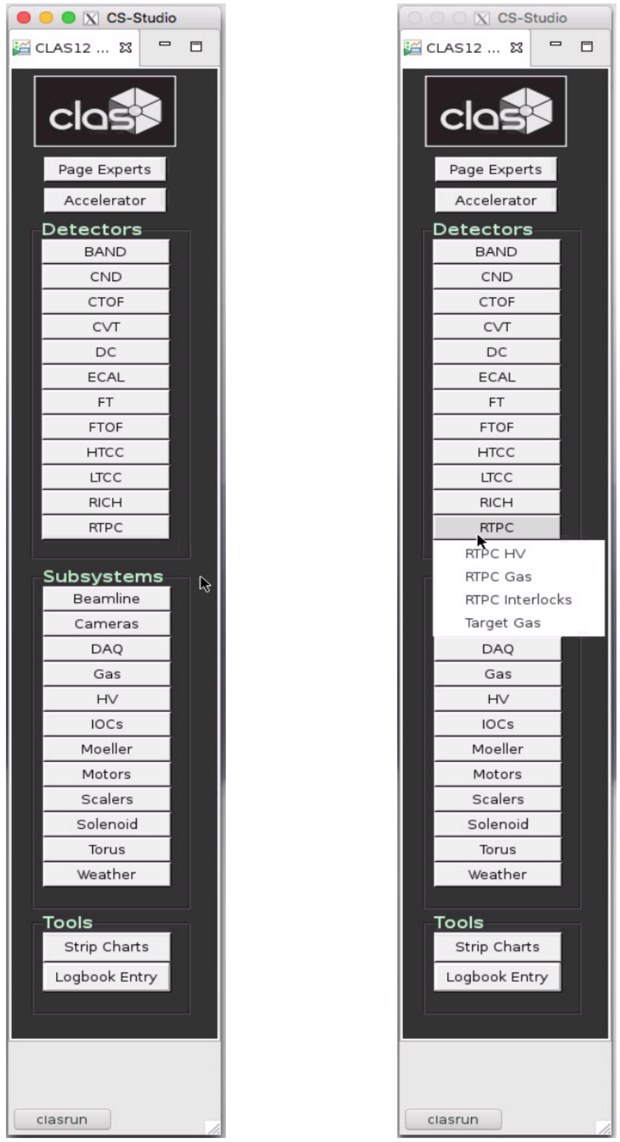


Figure 4: CS-Studio for the slow controls of the CLAS12 (left: general, right: RTPC options)

Clicking on the "RTPC Gas" menu under RTPC options, we get BONuS Gas Monitoring Interface as shown in figure 5. Flow rate of gas and the pressure inside the RTPC should be within a specified limit. If it croses the limits, alarm will be activated along with the RTPC HV interlocks. So, monitoring of this is required for the uninterrupted and better perfomance of the RTPC. Except the monitoring, the MFC integrated flow should be reseted after the use of new gas bottle of HeCO2 mixture.

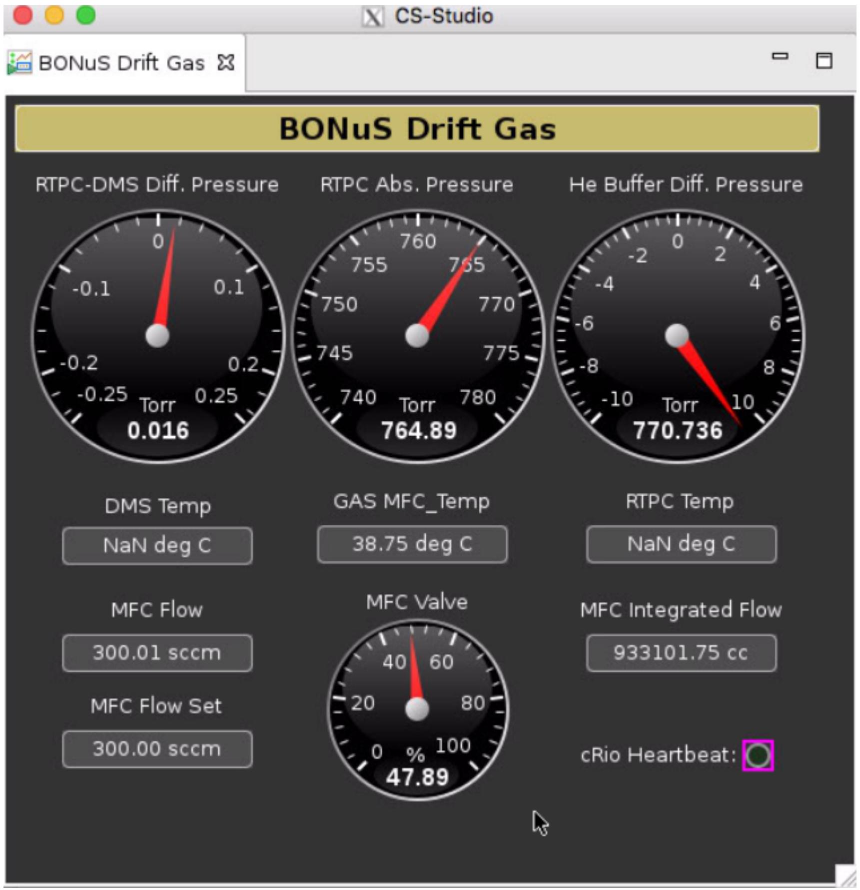


Figure 5: RTPC Gas Monitoring Interface

## 2.6 HV Monitoring and Control

(There will some changes in the GUI for novice users)

Novice users can visualize the status of HV on each GEM and cathode, but don't have access to to turn ON and OFF the individual channel. There will be a global ON/OFF bottom on top (which is now "All HV ON" and "All HV OFF" under menu). Clear all inhibits and HV powering sequence as well as delay to ON each channel are incorporated within "All HV ON". All the channels turn OFF at once by "All HV OFF".

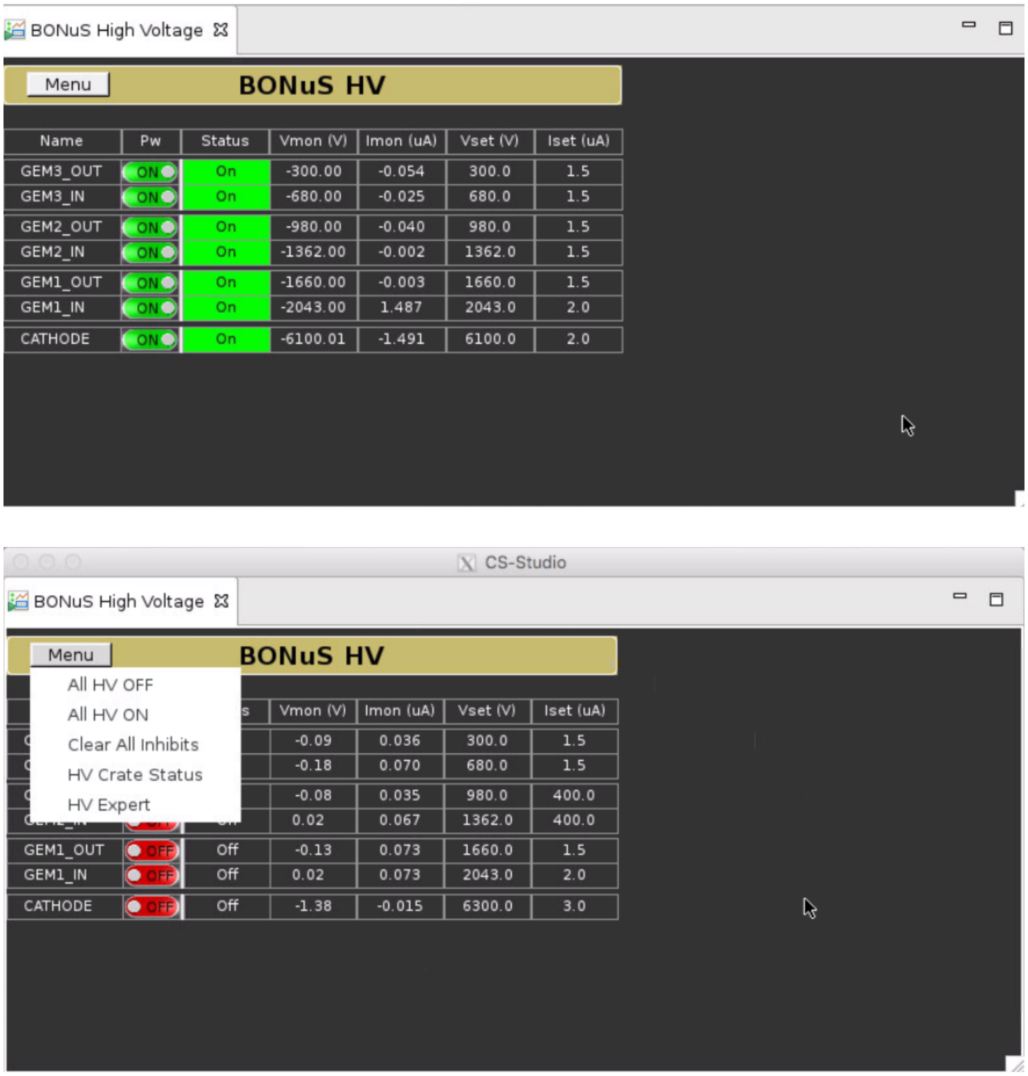


Figure 6: RTPC HV control Interface for Novice

## 2.7 LV Monitoring

## 2.8 Monitoring Hit Occupancy

# 3 Information For RTPC Subsystem Experts

## 3.1 Subsystem Expert Resposibilities

The RTPC system expert have following responsibilities:

1. Complete hot checkout sign-off before the start of each run period (sub-section 3.2 )
2. Respond to calls on the on-call phone to resolve issues with the RTPC system during data taking (sub-section 3.3)
3. Take HV gain calibration runs and adjust the system HV settings (sub-section 3.4)
4. Monitoring and control of low voltage (sub-section 3.5)
5. Monitoring RTPC system performances (sub-section 3.6)
6. Make repairs to the hardware during maintenance periods (sub-section 3.7)
7. Perform Configuration Test and take pedestal run for data taking (sub-section 3.8)

## 3.2 Hot Checkout

Prior to the start of each beam running period, each subsystem Group Leader is responsible to review the components of their systems to be sure that they are fully operational. This review is referred to as hot checkout. The hot checkout is an online checklist for each subsystem that includes a sign-off for all hardware elements of the system (e.g. HV, LV, detectors, gas). For the RTPC system, the hot checkout includes verification that the detector is operational, that the Slow Controls system for the Gas, HV and LV is functioning, and that the DAQ system can fully communicate with the readout electronics.

## 3.3 On-Call Responsibilities

Each subsystem Group Leader will organize a list of on-call experts who will take responsibility for carrying a cell phone to allow 24 hour access to experts who can address any problems that arise during a beam running period. The phone numbers of all subsystem experts are posted on the run page [2]. Any problems that cannot be quickly solved by the shift workers, where quickly amounts to 10 to 15 minutes, should result in a call to the relevant expert cell phone. The RTPC on-call phone number is ??.

The on-call experts can often diagnose problems over the telephone, but there are times when they will have to go to the Counting House to more fully address an issue. One of the important responsibilities of the on-call experts is to make practical decisions regarding which problems require access to Hall B for immediate attention and which can be delayed to periods when the accelerator is down or other work is scheduled in the hall.

Note: It is the responsibility of the RTPC on-call expert to review all issues that they cannot resolve with the RTPC subsystem Group Leader as soon as it is reasonable.

## 3.4 System HV setting

Expert Interface has access to HV control of individual channel in RTPC, along with "All HV ON" and "All HV OFF". Along with ON/OFF, this interface also has control over voltage setting, trip current setting, trip delay setting and also the setting of ramping rate. This interface also allows users to reset the powering delay for each channel while using "All HV ON".

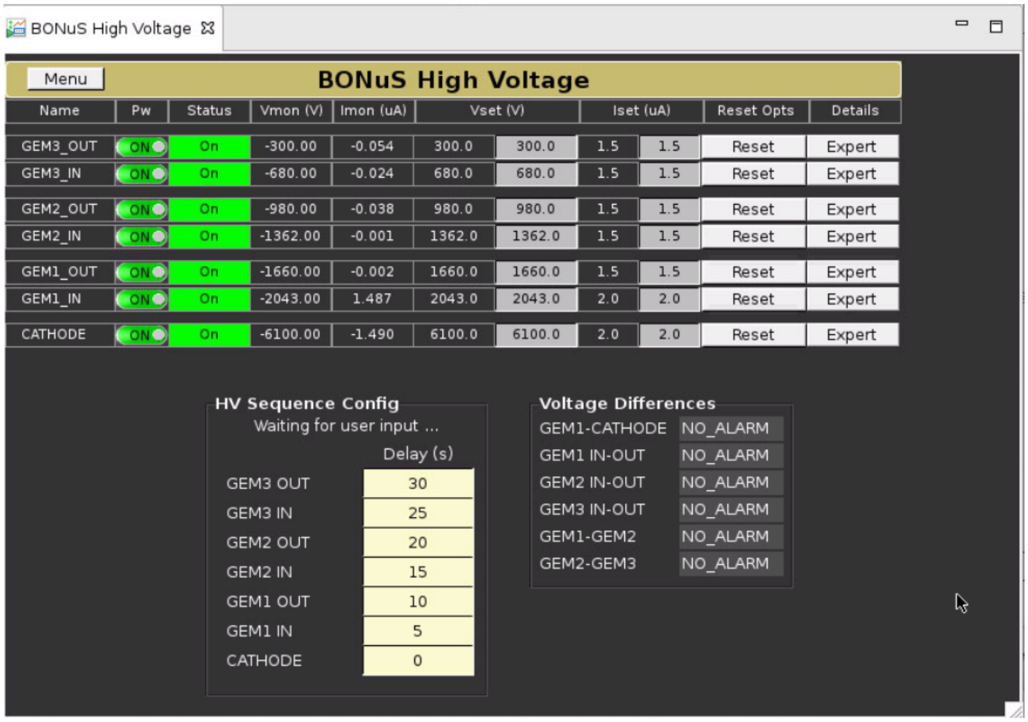


Figure 7: RTPC HV control Interface for Expert

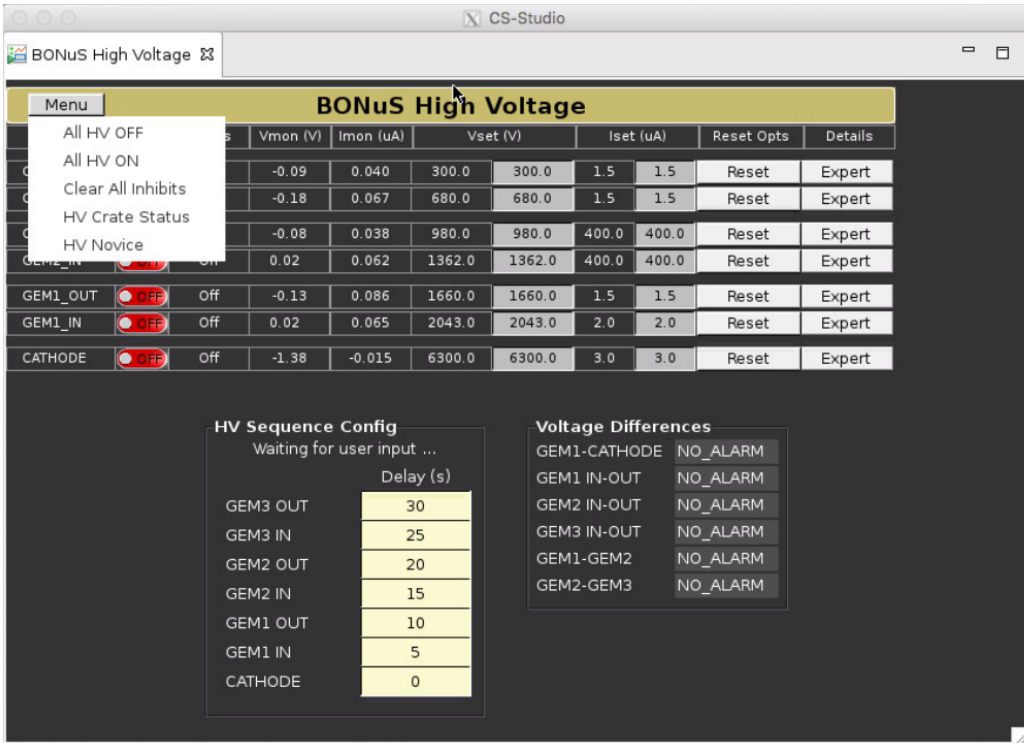


Figure 8: RTPC Expert HV control Interface

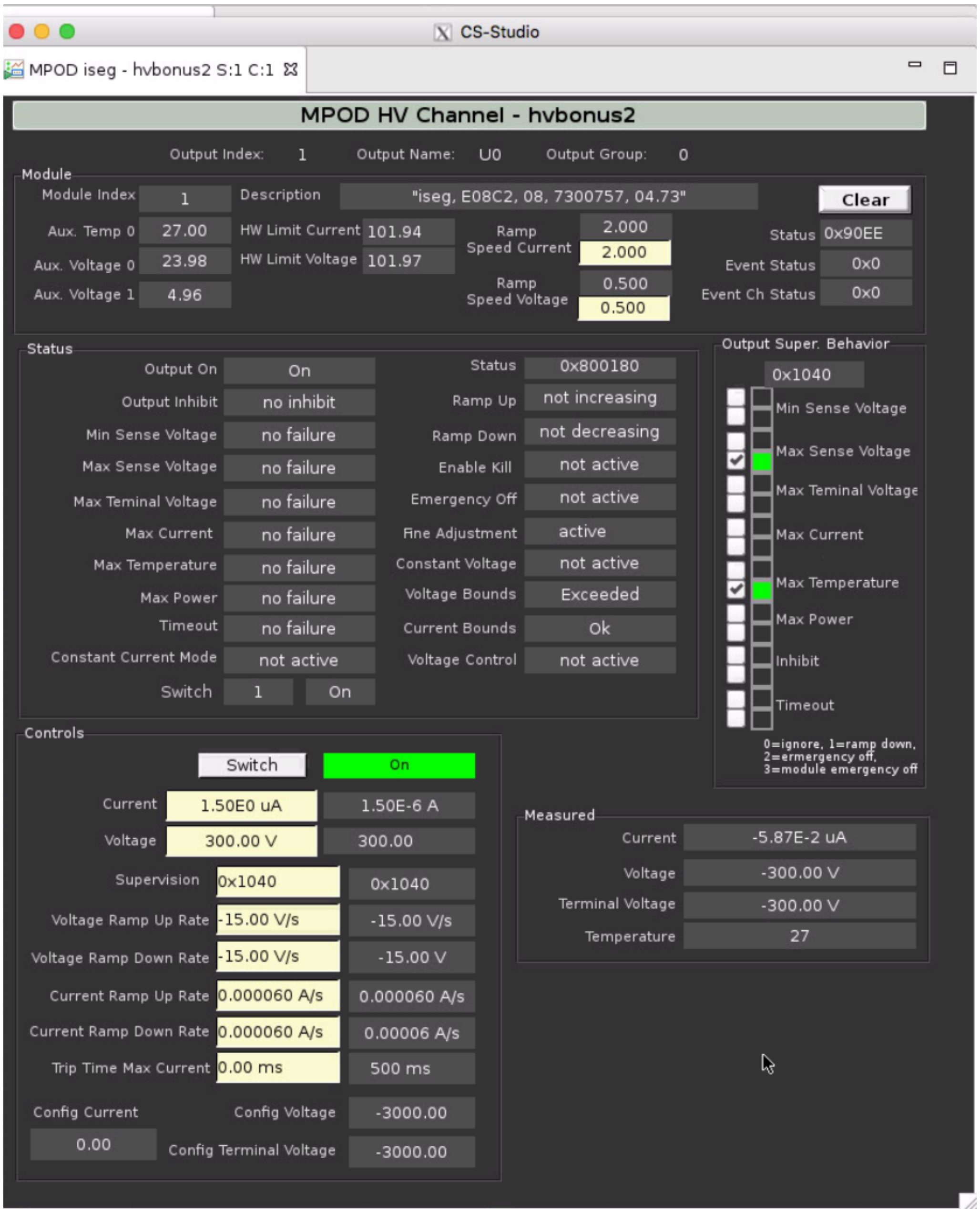


Figure 9: HV channel control for experts

If the Mpod crate has issues, figure 10 allows users to remotely reboot the crate. This is only done, if there is issue with whole supply module or as a last resort to fix unknown issue related to power supply.

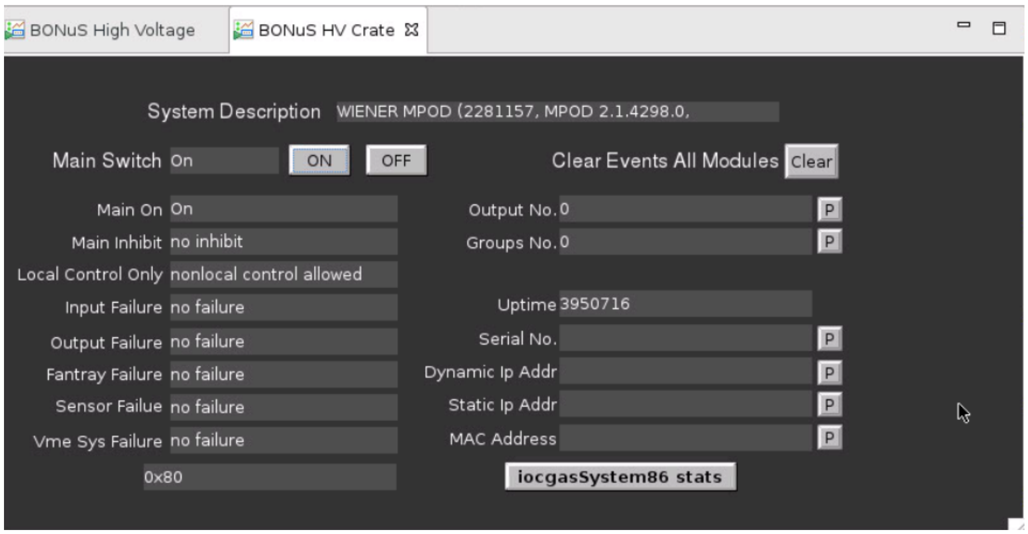


Figure 10: RTPC HV crate status

## 3.5 Monitoring and Control of LV

Low voltage is applied to the FEUs for the Readout of the RTPC detector. There are six crates for the total 48 FEUs, with 8 FEUs in each crate. Among 8 FEUs in each crate, 6 are used by RTPC and one by FMT. If there is any communication errors related with FEUs, LV might need to turn ON and OFF. While doing this, both FMT and RTPC are affected. Each individual crate can be turned On and OFF, but before doing so it needs to figure out which FEU has issue and which cart it belongs to. (Details will be updated soon, after getting link to RTPC menu from MVT. Slow control group is working on it).

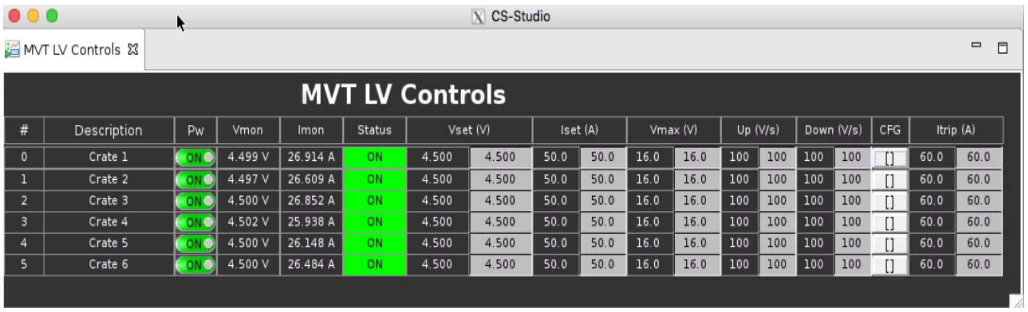


Figure 11: LV controls on EPICS Interface

## 3.6 Monitoring RTPC System Performances


Figure 12: RTPC interlocks

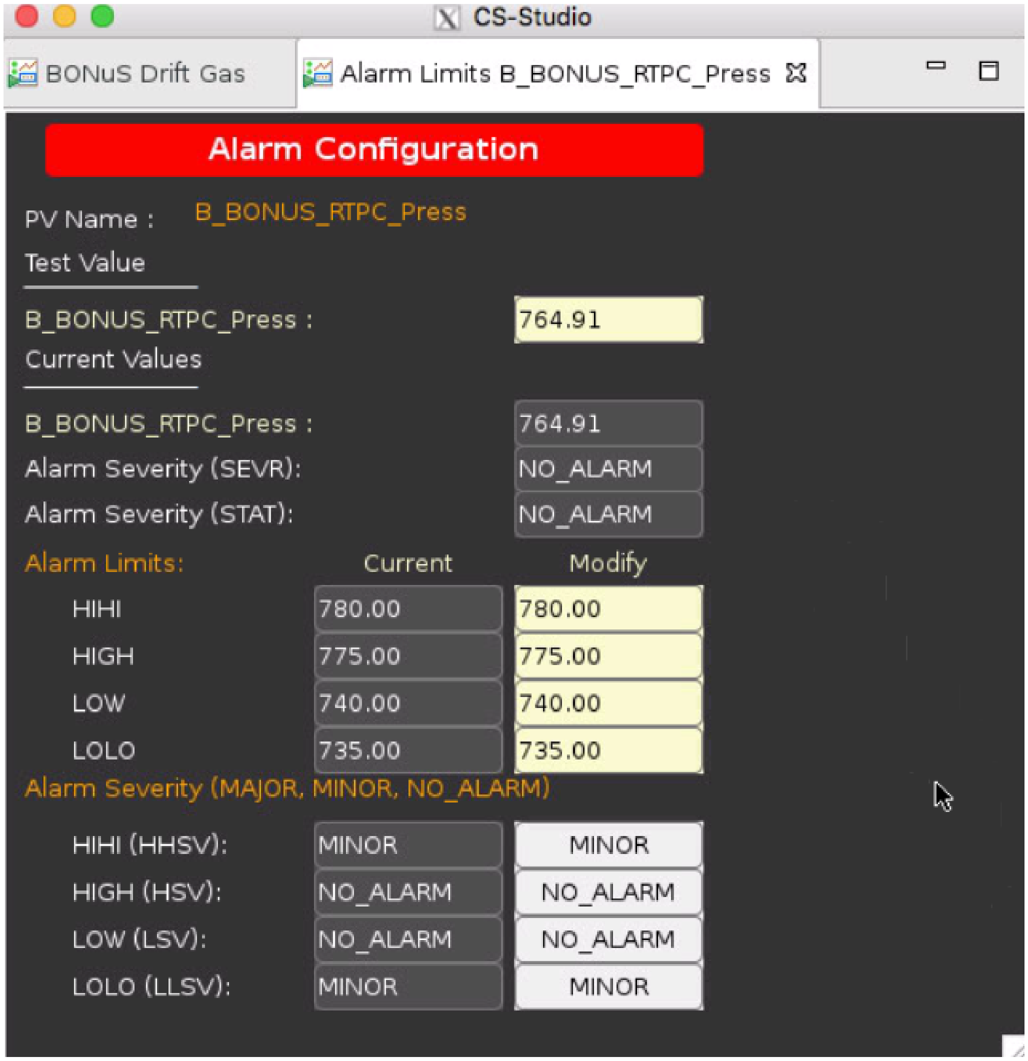


Figure 13: Alarm Limit settings

## 3.7 Maintainance of the RTPC System

## 3.8 Configuration Test and Pedestal Run

RTPC data are collected by FEU and only the ADC samples above threshold (specified by BONuS group) are written in output. Common mode noise rejection and pedestal subtraction is also performed by FEU containing DREAM chips. To apply those constains, configuation of the RTPC DAQ should have access to pedestal file and the threshold files. So, the first step is to take pedestals of the our system. After powering up both FEU and BEU, we need to be sure that our DAQ system is synchronised and working corretly. For the test, go to ∼/mvt/Codascript/ directory and use the command in terminal:

**Mvt_ConfigTest -c ped.cnf**

If you can reach to the option to quit (pressing 'shift+q'), everything is fine. If the config test ends before reaching to quit option, there might be some issues.

If you encounter a config test failure, reboot the rocs and try the config test again. If the problem still persist, turn OFF and ON the LV on FEUs from EPICS LV control iterface as shown in figure 11. After rebooting the FEUs, try config test again.

Note: If the last resort also fails, please contact the RTPC contact person, to contact to Irakli Mandjavidze (email: irakli.mandjavidze@cea.fr).

If the configuration test susceeded, pedestal run should be taken using following command:

**MvtRunBatchCol PEDRUN ./ped.cnf 500 DEBUG**

This command takes the pedestal of our electronics using 'ped.cnf' configuration file for FEUs, produced pedestal file and ZS threshold file to be used in the data taking.

# 4 RTPC Authorized Personnel

Table 1: Authorized personnel for RTPC

| sn | Name | phone | email |
|---|---|---|---|
| 1 | Bueltmann, Stephen | — | sbueltma@odu.edu |
| 2 | Christy, Eric | — | christy@jlab.org |
| 3 | Hattawy, Mohammad | — | hattawy@jlab.org |
| 4 | Kuhn, Sebastian | — | skuhn@odu.edu |

## 5 References

[1] Hall B Alarm Handler https://clasweb.jlab.org/wiki/index.php/Slow_Control_Alarms

[2] Hall B Run information Page https://www.jlab.org/Hall-B/run-web/