

RTPC Operations Manual

Jiwan Poudel¹, Nathan Baltzell, Stephen Bueltmann, Eric Christy, Nathan Dzubenski, Carlos Gayoso, Mohammad Hattawy, Narbe Kalantarians, Sebastian Kuhn, Aruni Nadeeshani, David Payette, Madhusudhan Pokhrel
(The BONuS12 Experimental Group)

RTPC Operations Manual v2.0

February 23, 2020

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.

¹jpoud001@odu.edu

Contents

1	RTPC Overview	1
2	Information For Shift Takers	4
2.1	Shift Taker Responsibilities	4
2.2	Updating the Logbook	5
2.3	Hall B Alarm Handler	5
2.4	Contacting the RTPC system Experts	6
2.5	Monitoring the BONuS/RTPC sub-systems	8
2.5.1	Monitoring the BONuS12 Gas system	9
2.5.2	Monitoring and Control of the RTPC HV system	10
2.5.3	Monitoring the RTPC LV system	11
2.5.4	Monitoring the Hit Occupancy	11
3	Information For RTPC Subsystem Experts	12
3.1	Subsystem Expert Responsibilities	12
3.2	Hot Checkout	12
3.3	On-Call Responsibilities	13
3.4	BONuS Gas system	14
3.5	RTPC System HV setting	17
3.6	Monitoring and Control of LV	20
3.7	Monitoring BONuS Interlocks and the RTPC System Performances	21
3.8	Monitoring and Control of the DMS	22
3.9	Maintenance of the RTPC System	23
3.10	Pedestal Run and configuration test	23
4	RTPC Authorized Personnel	25
5	References	25
A	Appendix: GAS System	26

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 and 2. 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 $r=80$ mm. Helium gas is used in the buffer, and mixture of He (80%) and CO₂ (20%) is used in the active space. The gas system for the BONuS12 experiment is shown in figure 3.

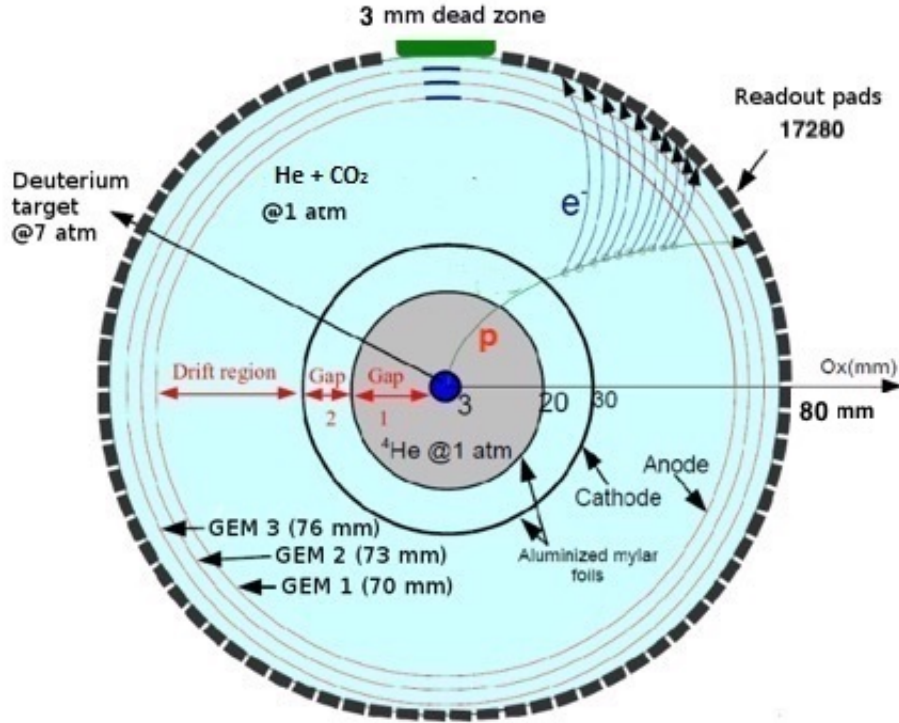


Figure 1: Schematics of cross-section of BONuS12 RTPC and a proton track

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.

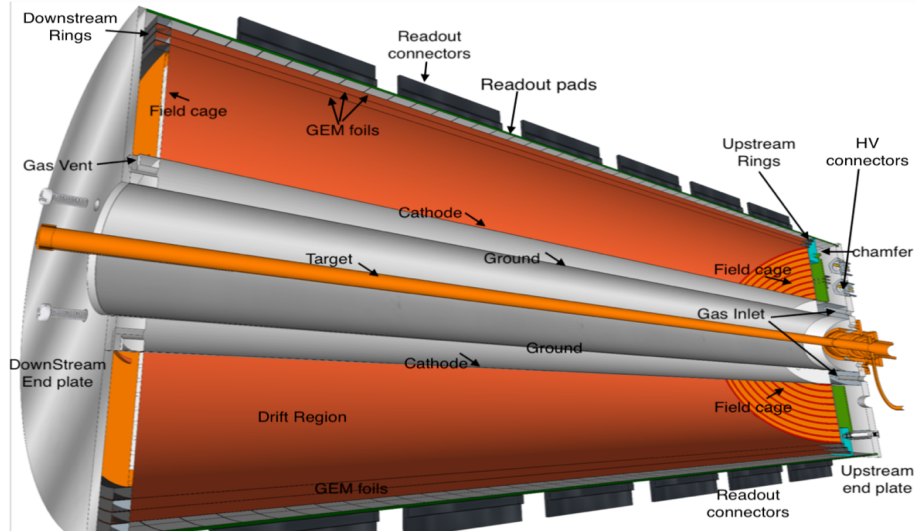


Figure 2: Longitudinal cross-sectional of BONuS12 RTPC

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 1. 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 $4\text{ mm} \times 2.75\text{ mm}$ 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.

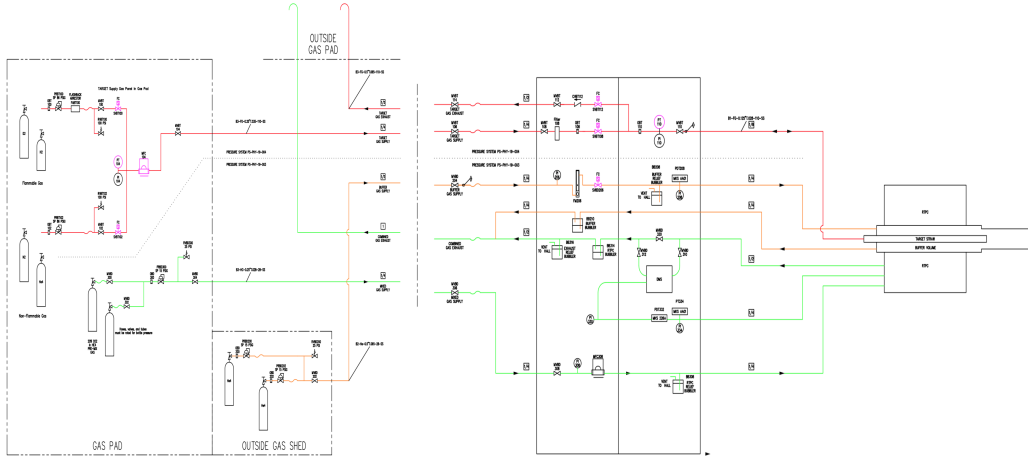


Figure 3: BONuS12 Gas System

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 4. Zero suppression and Pedestal subtraction are implemented in FEUs for the BONuS12 experiment.

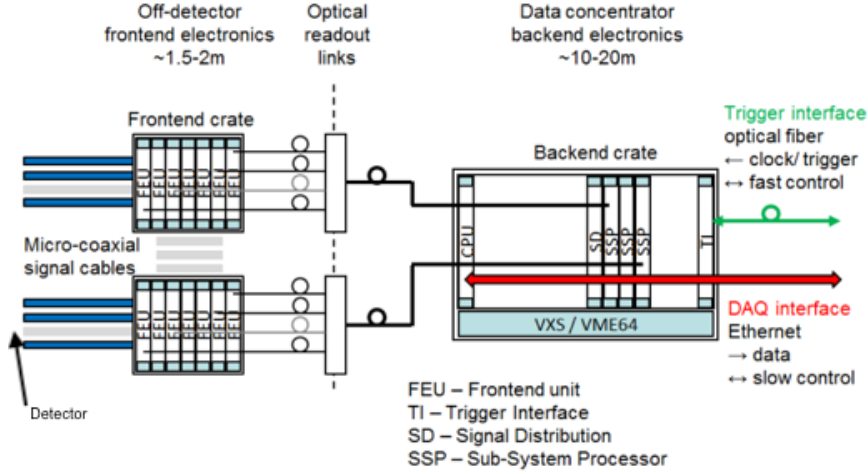


Figure 4: Schematics of Data Acquisition Electronics for the RTPC

2 Information For Shift Takers

2.1 Shift Taker Responsibilities

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 BONuS/RTPC sub-systems (sub-section 2.5)
 - (a) Monitoring the RTPC Gas system (sub-section 2.5.1)
 - (b) Turning ON and OFF the HV of the RTPC detector using HV Control Interface (sub-section 2.5.2)
 - (c) Monitoring LV of FEUs in RTPC readout electronics (sub-section 2.5.3)
 - (d) Monitoring the hit occupancy scalers of the system (sub-section 2.5.4)

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), details can be seen in figure 5. 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 following guidance on alarms 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 the RTPC. These channels can be reset either through the RTPC HV control screens. These channels should be reset only after ensuring that whatever condition caused the trip (any interlocks) 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.

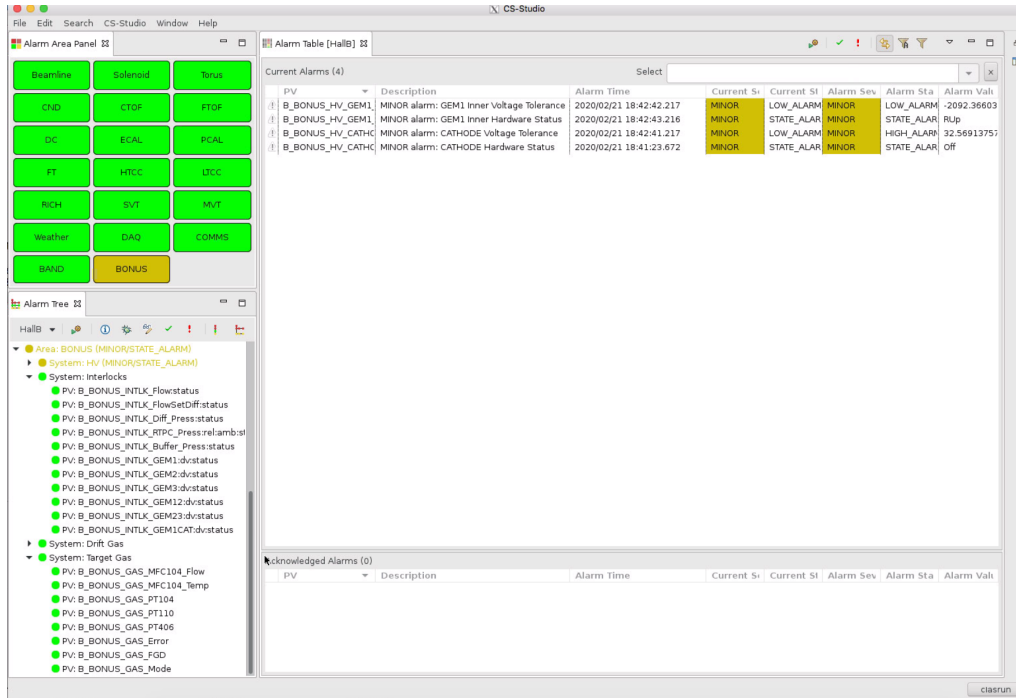


Figure 5: Alarm handler in counting house

There is also alarm for the BONUS target (pressurised deuterium gas ~ 65 psig). Overpressure or underpressure of the target gas provides alarm. For the target alarm, contact the RTPC/BONUS on-call expert. RTPC expert purges the target gas daily being in counting house, so acknowledge the target alarms during purging, except it is an alarm for the 'error'.

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 get advice on how to proceed or to address the problem. The RTPC on-call phone number is **757-329-4844**.

Only the 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 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.

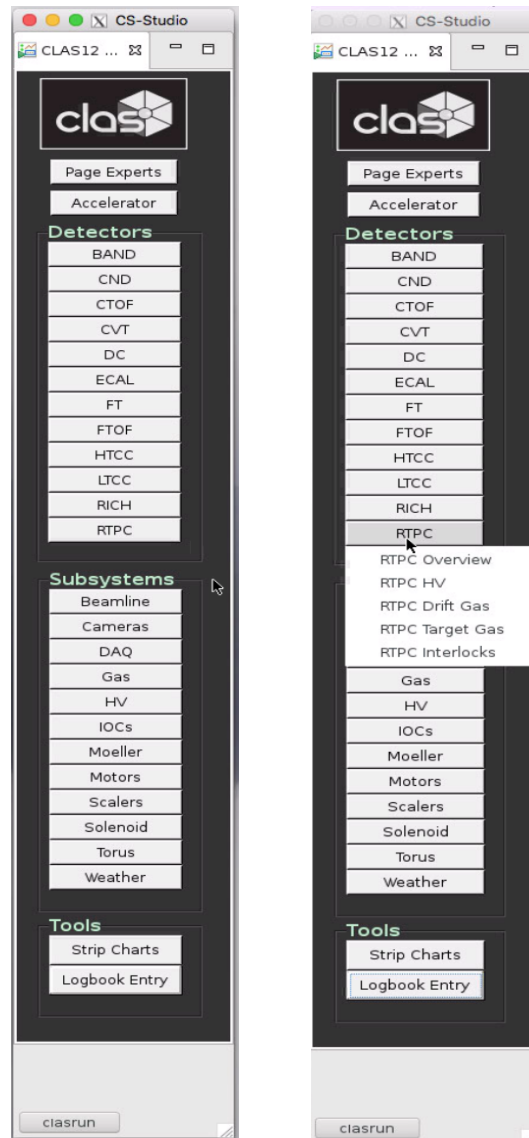


Figure 6: CS-Studio for the slow controls of the CLAS12 (left: general, right: RTPC options)

2.5 Monitoring the BONuS/RTPC sub-systems

RTPC Overview (BONuS Overview) is under “RTPC” of the detector sub-systems in the CLAS12 CS-Studio as shown in figure 6. CS- Studio is obtained using the command `clascss` in the Linux terminal of counting house computers. Along with the RTPC Overview, other sub-menus (RTPC HV, RTPC Drift gas, target gas and Interlocks) are also under “RTPC” menu. BONuS sub-system GUI are obtained either clicking these sub-menus or from clicking link in the Overview screen shown in figure 7.

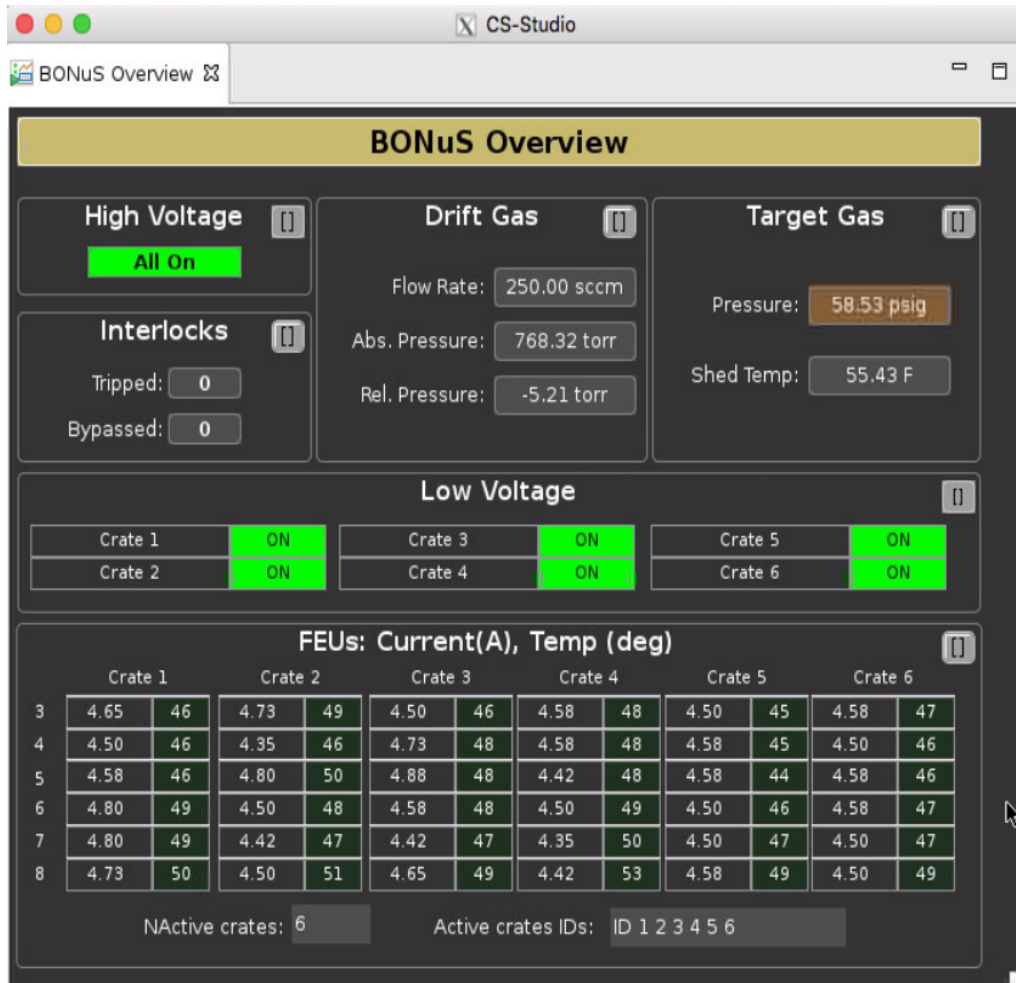


Figure 7: BONuS/RTPC Overview GUI

2.5.1 Monitoring the BONuS12 Gas system

There are two separate gas flow lines to the RTPC detector. Helium gas is flowing in the buffer region, and pre-mixed gas [He (80%) and CO₂ (20%)] is flowing in the drift region of the RTPC.

Clicking on the “RTPC Gas” menu under RTPC options, we get BONuS Gas Monitoring Interface as shown in figure 8. Flow rate of gas and the pressure inside the RTPC should be within a specified limit. If it crosses the limits, alarm will be activated along with the RTPC HV interlocks. So, monitoring of this is required for the uninterrupted and better performance of the RTPC.

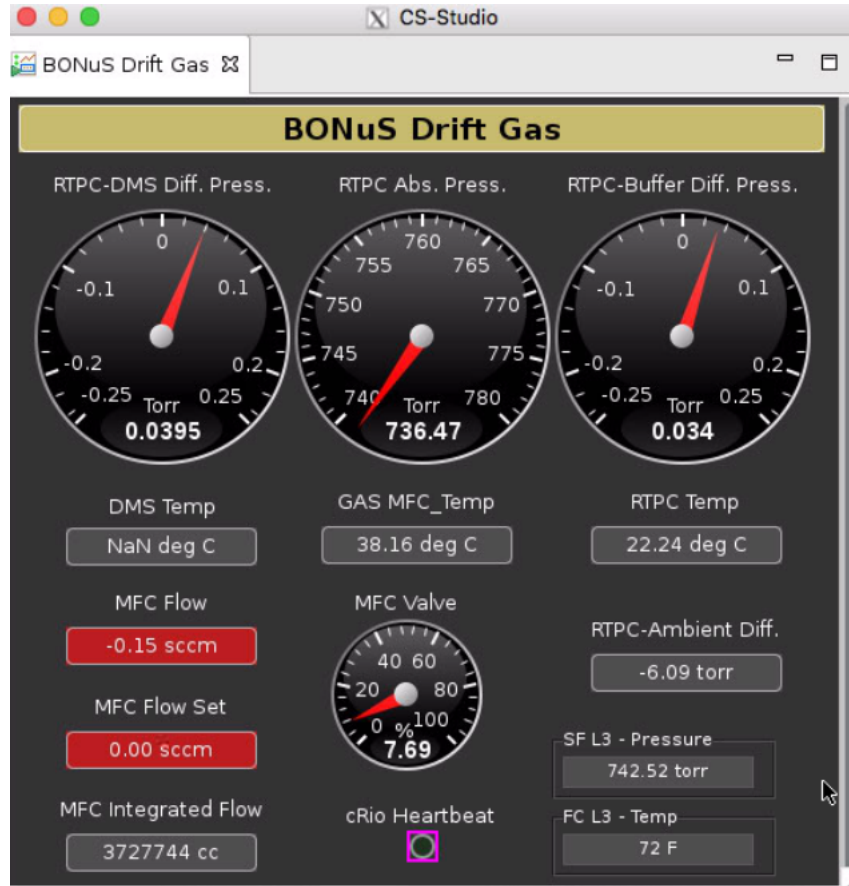


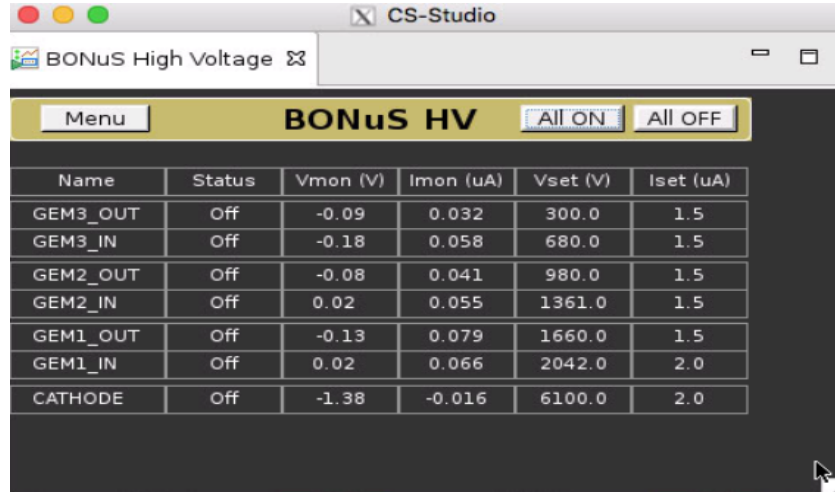
Figure 8: RTPC Gas Monitoring Interface

2.5.2 Monitoring and Control of the RTPC HV system

Novice GUI shows the status of the GEMs and cathode HV of the RTPC, but doesn't show the turn ON and OFF option for the individual channel. There are "All ON" and "All OFF" bottom on top (and also under menu option) to turn all channels ON/OFF. HV powering sequence is within the "All ON" bottom, so clicking it starts powering on sequence from Cathode to the GEM3 Out. It takes about 1 minutes to see the "ramping up" status in all the channels. "All OFF" doesn't have powering down sequence, so all the channels starts ramping down at once when "All OFF" is clicked.

If any channel trips or kills during ramping up or down, wait until all the channels show "OFF" status to turn them back "ON" . If any channel shows "kill" status, there is no need to clear it individually. Clicking "All ON" will clear the "kill", and start the turning on sequence from 'Cathode to GEM3'. But, wait until Vmon shows $\sim 0V$ in all the channels before clicking "All ON".

Note: If "All ON" doesn't start ramping up channels but only cleared the killed channel, please relick the "All ON" after about 1 minutes. Also, if you click "All ON" before all the channels show 'OFF' status, you will probably get 'output failure' alarm which can be cleared with the help of an RTPC expert. Furthermore, if any interlock is active which can be seen as 'Tripped' in the RTPC overview GUI (figure 7), HV can not be turned ON. To clear the interlock, help of an RTPC expert is required.



Name	Status	Vmon (V)	Imon (uA)	Vset (V)	Iset (uA)
GEM3_OUT	Off	-0.09	0.032	300.0	1.5
GEM3_IN	Off	-0.18	0.058	680.0	1.5
GEM2_OUT	Off	-0.08	0.041	980.0	1.5
GEM2_IN	Off	0.02	0.055	1361.0	1.5
GEM1_OUT	Off	-0.13	0.079	1660.0	1.5
GEM1_IN	Off	0.02	0.066	2042.0	2.0
CATHODE	Off	-1.38	-0.016	6100.0	2.0

Figure 9: RTPC HV control Interface for Novice

2.5.3 Monitoring the RTPC LV system

Low voltage is applied to the Front End electronics of the RTPC data acquisition. RTPC and FMT share the common power supply to the Front End Units (FEUs). Low Voltage (LV) power supply is monitored from the RTPC Overview GUI as shown in figure 7. When there is an issue with LV, both RTPC and FMT are affected. Low voltage power cycle could be done safely by experts, as it can activate the interlock for both RTPC and FMT HV with some delay.

2.5.4 Monitoring the Hit Occupancy

Hit occupancy of the RTPC detector looks like as shown in figure 10. Comparison of the monitoring plot with the attached picture is required. If the monitoring looks completely different than the attached one, please inform the Run-cordinator or the RTPC expert on call.

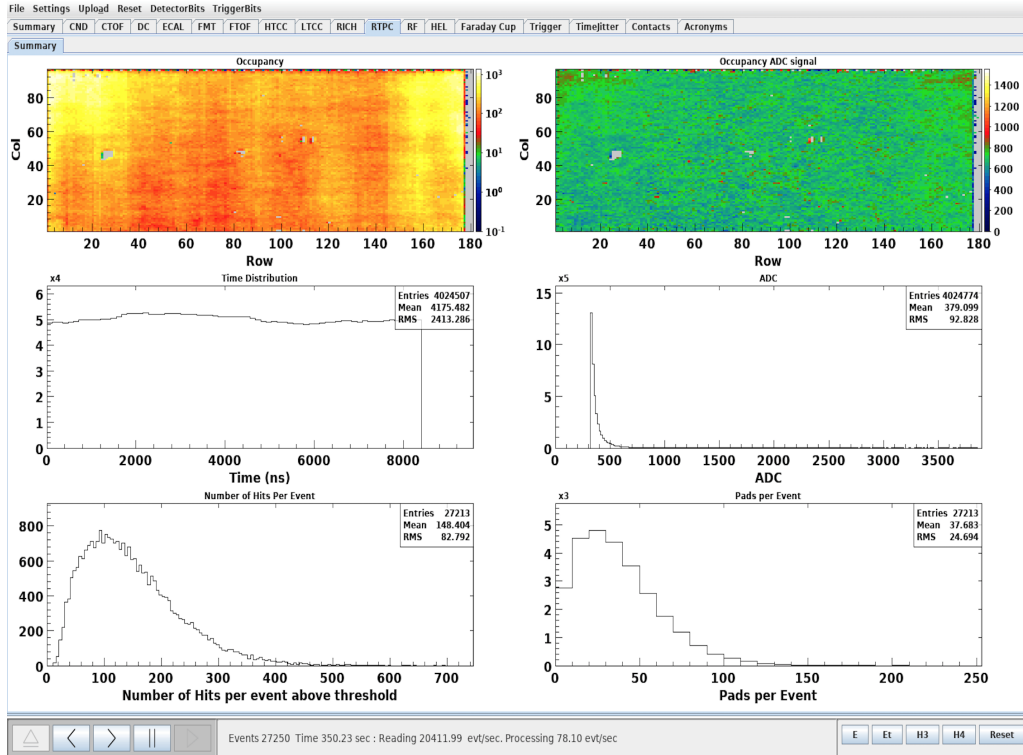


Figure 10: Occupancy monitoring of the RTPC

3 Information For RTPC Subsystem Experts

3.1 Subsystem Expert Responsibilities

The RTPC system expert have following responsibilities:

1. Complete hot checkout sign-off before the start of the rg-f run period (sub-section [3.2](#))
2. Respond to calls on the on-call phone to resolve issues with the BONuS/RTPC during data taking (sub-section [3.3](#))
3. Monitoring and control of the BONuS gas system (sub-section [3.4](#))
4. Adjust the system HV settings (sub-section [3.5](#))
5. Monitoring and control of low voltage (sub-section [3.6](#))
6. Monitoring BONuS Interlocks and the RTPC system performances (sub-section [3.7](#))
7. Make repairs to the hardware during maintenance periods (sub-section [3.9](#))
8. Perform pedestal run for data taking (sub-section [3.10](#))

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 check-out is an online checklist for each subsystem that includes a sign-off for all hardware elements of the system (e.g. HV, LV, gas). Before the RG-F run period, the hot checkout of the RTPC (BONuS) sub-system should be performed which includes the verification that the detector is operational, and the Slow Controls system for the Gas, HV and LV is functioning. Figure [11](#) shows the expansion of the Hot Chekout list for the RTPC (BONuS), including different sub-system of the Hall B.

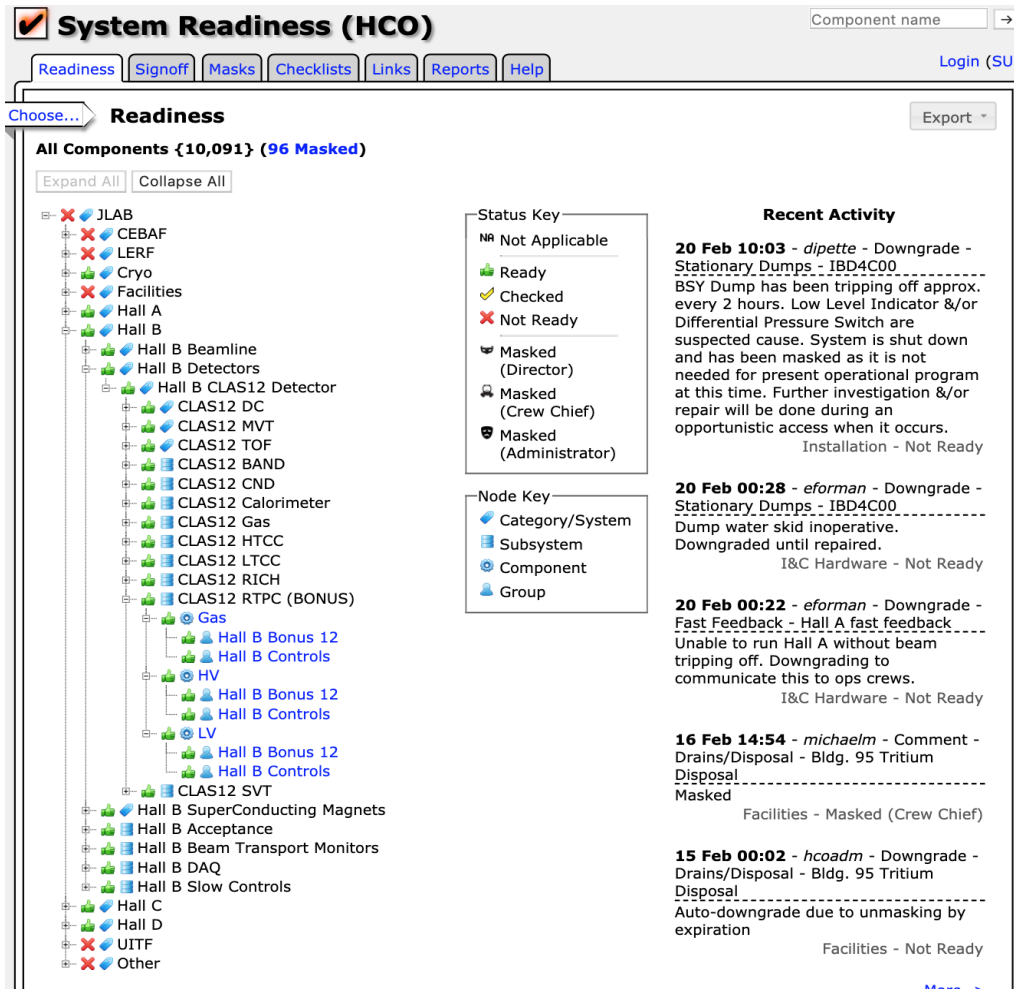


Figure 11: Hot-checkout List of Hall B

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 **757-329-4844**.

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 share all issues that they cannot resolve with the RTPC subsystem group periodically and help to make practical decisions regarding which problems that 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.

3.4 BONuS Gas system

BONuS gas sytem is divided into two categories: i) Drift gas and ii) Target gas. Both of these gas sub-system have separate EPICS GUI monitoring as shown in figure 8 and figure 12. Details of the different parameters used in these GUI is found in the document attached in the Appendix (page 26).

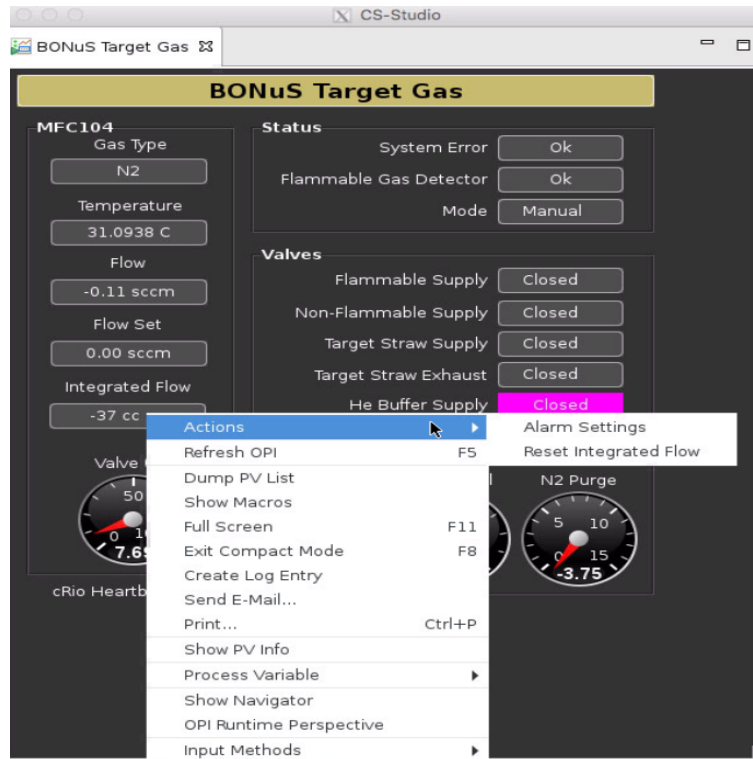


Figure 12: Target gas monitoring GUI

In both the monitoring, expert also cannot change current value of any variables, except integrated flow. When you right click on the integrated flow, you will have options as shown in figure 12. Click on: action-; Reset intergrated flow to reset the total gas consumption after using a bottle of drift/target gas. Alarm can be activated to get alert for changing the gas bottles.

All the gas controls is performed from a windows pc at counting house (first computer on the right jafter entering into Hall B counting house). Use your Jlab username and password to open the pc, and enter GUI.vi in the search option at the bottom of the desktop. When you click on GUI.vi, it will open a Lab-view window as shown in figure 13 or 14. Control on the BONuS drift gas is detailed in the Appendix (page 26).

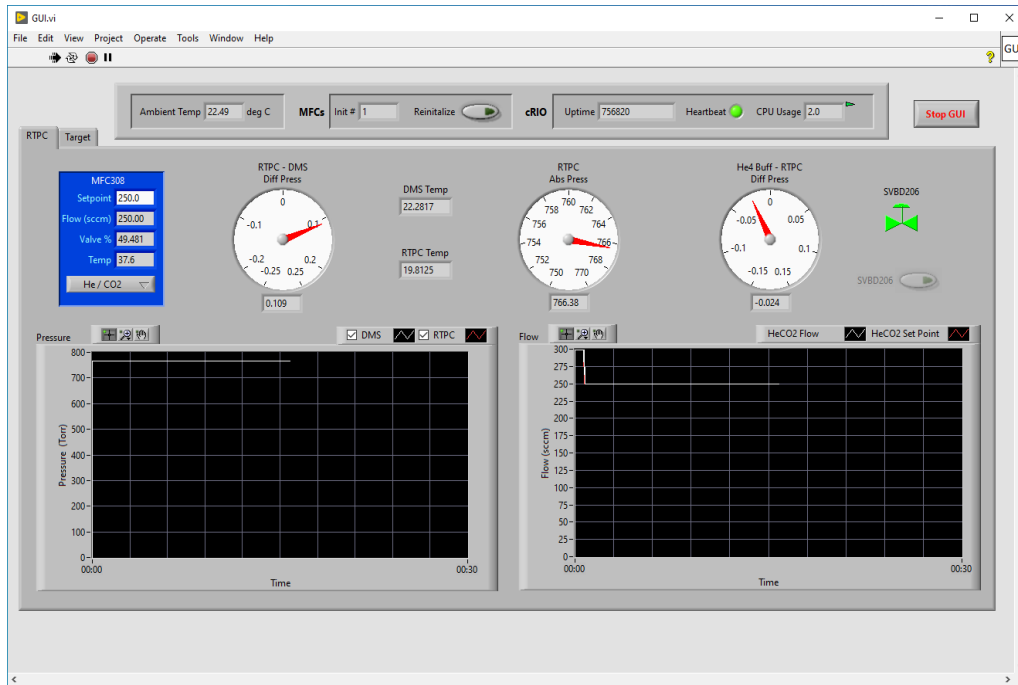


Figure 13: RTPC gas control from Lab-view Interface

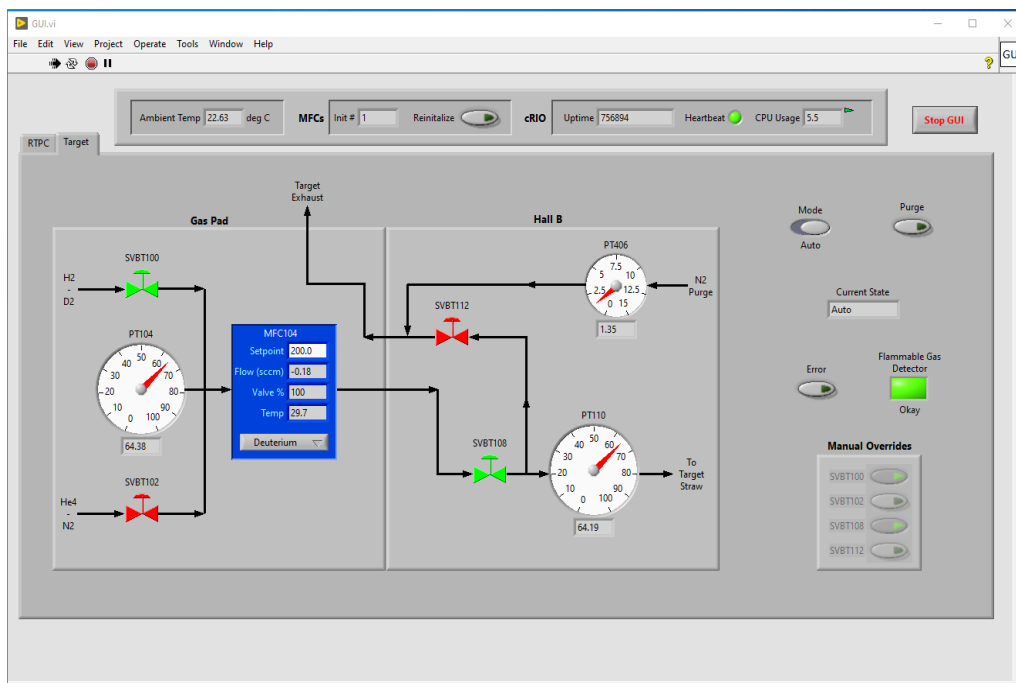


Figure 14: Target gas control from Lab-view Interface

Details of BONuS target gas control is explained in [Target Manual](#), so please look at that document before starting to control the target gas.

There is also BONuS HV interlock related with both gas system (2 related to target gas and 5 related to drift gas as shown in figure 15), so please make sure that which interlock will be active before using the gas controls. Mostly bypass the target related interlock before purging the target gas. Please, don't bypass any interlock during the data taking. If it's absolutely necessary to bypass any, inform all the RTPC expert group and also put log-entry in [HBRTPC](#).

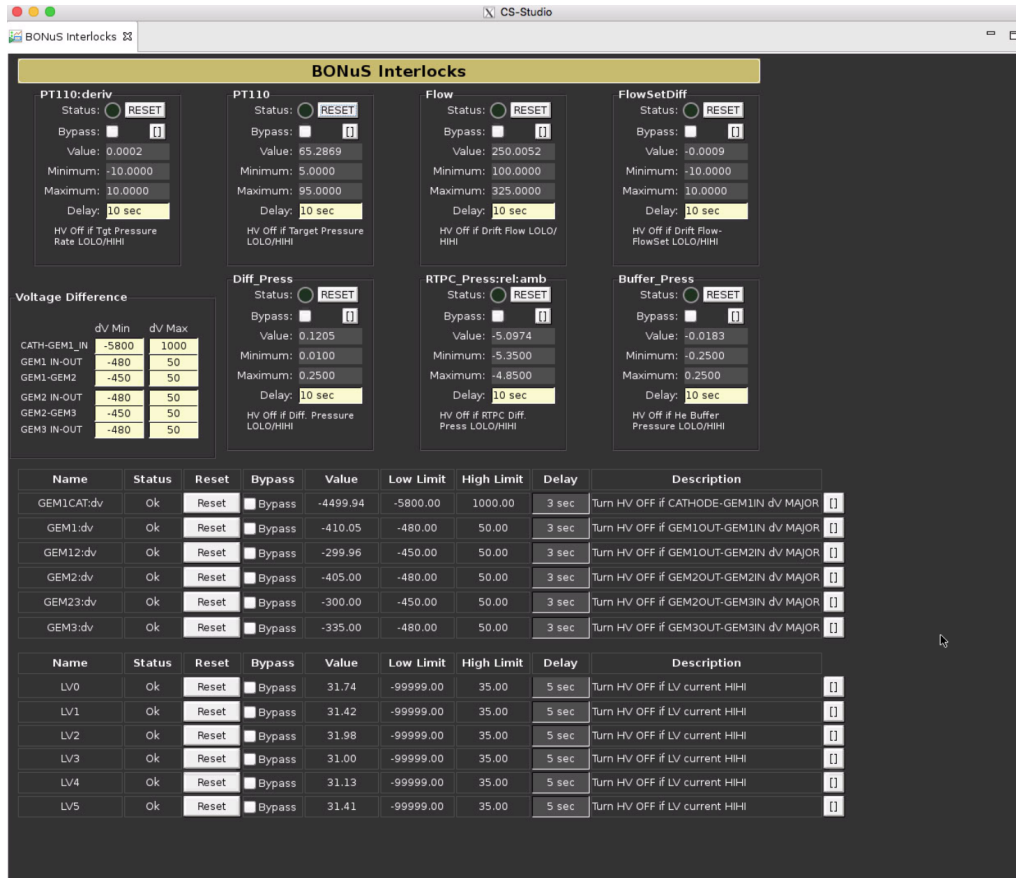


Figure 15: RTPC interlocks

3.5 RTPC System HV setting

Expert Interface has access to change several parameters in the RTPC HV control. Along with the “All HV ON” and “All HV OFF” from menu, individual channel can be controlled. This interface also has control over voltage setting, trip current setting, trip delay setting and also the setting for the ramping rate. Voltage and current limit for each channel can be set directly from the interface by typing new values in the respective boxes of ‘Vset’ and ‘Iset’ as shown in figure 16. This interface also shows the HV sequence timing for ramping up high voltage included in “All HV On” for both Novice and Expert mode.

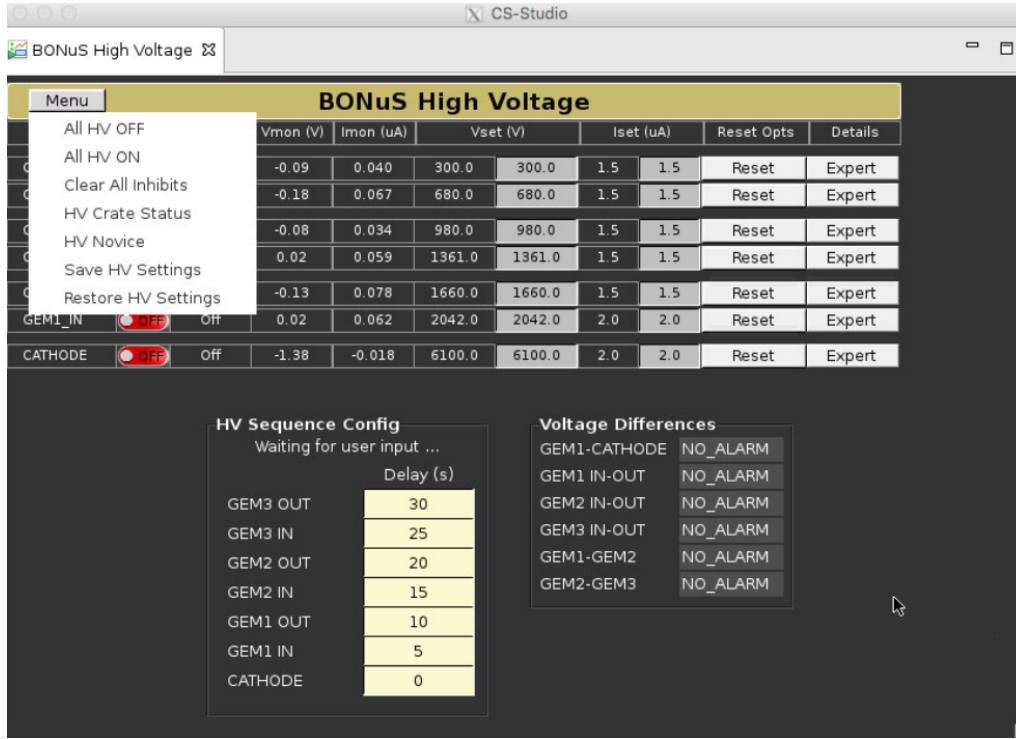


Figure 16: RTPC Expert HV control Interface

There is no need to clear any error on channels while using “All HV On” as clear is embedded within it. However, while using individual channels “Clear All Inhibits” is used to clear any errors occurred in any channels. Clearing the error on channels can be done by clicking on “Reset→clear” on that channel.

Different HV setting for RTPC related with different runs (Production, cosmic) are saved which could be restored by clicking “Restore HV Setting” on the menu. This helps to reduce errors of typing numbers in the GUI and also restore the previous setting after change.

Ramping rate and the trip time can not be set from this interface. To change these, click on the expert on the particular channel which gives a new window as shown in figure 17. In this expert screen, ramping rate and trip time are inside controls box (Lower left) which can be changed typing new number in the corresponding box. Both ramping up and down rate will

be set for all the GEM-related channels when changed in one of them. For cathode, these are independent of GEM channels.

MPOD HV Channel - hvbonus2

Output Index: 1 Output Name: U0 Output Group: 0

Module

Module Index	1	Description	"iseg, E08C2, 08, 7300757, 04.73"		Clear
Aux. Temp 0	27.00	HW Limit Current	101.94	Ramp Speed Current	2.000
Aux. Voltage 0	23.98	HW Limit Voltage	101.97	Ramp Speed Voltage	0.500
Aux. Voltage 1	4.96				

Status: 0x90EE Event Status: 0x0 Event Ch Status: 0x0

Status

Output On	On	Status	0x800180
Output Inhibit	no inhibit	Ramp Up	not increasing
Min Sense Voltage	no failure	Ramp Down	not decreasing
Max Sense Voltage	no failure	Enable Kill	not active
Max Terminal Voltage	no failure	Emergency Off	not active
Max Current	no failure	Fine Adjustment	active
Max Temperature	no failure	Constant Voltage	not active
Max Power	no failure	Voltage Bounds	Exceeded
Timeout	no failure	Current Bounds	Ok
Constant Current Mode	not active	Voltage Control	not active
Switch	1 On		

Output Super. Behavior

0x1040

- Min Sense Voltage
- Max Sense Voltage
- Max Terminal Voltage
- Max Current
- Max Temperature
- Max Power
- Inhibit
- Timeout

0=ignore, 1=ramp down, 2=emergency off, 3=module emergency off

Controls

Switch: **On**

Current	1.50E0 uA	1.50E-6 A	
Voltage	300.00 V	300.00	
Supervision	0x1040	0x1040	
Voltage Ramp Up Rate	-15.00 V/s	-15.00 V/s	
Voltage Ramp Down Rate	-15.00 V/s	-15.00 V	
Current Ramp Up Rate	0.000060 A/s	0.000060 A/s	
Current Ramp Down Rate	0.000060 A/s	0.00006 A/s	
Trip Time Max Current	0.00 ms	500 ms	
Config Current	0.00	Config Voltage	-3000.00
		Config Terminal Voltage	-3000.00

Measured

Current	-5.87E-2 uA
Voltage	-300.00 V
Terminal Voltage	-300.00 V
Temperature	27

Figure 17: HV channel control for experts

If the Mpod crate has issues, ‘output failure’, ‘input failure’ or ‘crate status’ alarms will appear. If so, use “HV Crate Status” under menu of figure 16 to get the crate status GUI. This GUI shown in figure 18 allows users to remotely reboot (ON/OFF) the crate to clear all the errors. This is only done, if there is issue with both the power supply modules or as a last resort to fix unknown issue related to the power supply.

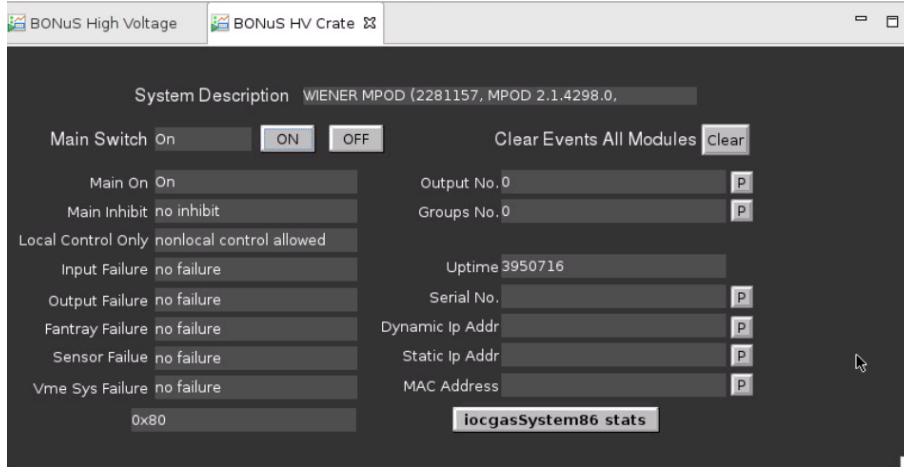


Figure 18: RTPC HV crate status

3.6 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 as well as all the crates at once, but before doing so it needs to figure out which FEU has issue and which cart it belongs to. Turning All OFF and On of LV can be done from the RTPC overview GUI (fig. 7). But to turn OFF/ON individual crate, LV controls GUI (as shown in figure 19) is needed which is obtained by clicking on the “parenthesis→LV control” near the Low Voltage in the RTPC overview GUI (fig. 7).

#	Description	Pw	Vmon	Imon	Status	Vset (V)		Iset (A)		Vmax (V)		Up (V/s)		Down (V/s)		CFG	Itrip (A)	
0	Crate 1	ON	4.499 V	26.914 A	ON	4.500	4.500	50.0	50.0	16.0	16.0	100	100	100	100	<input type="checkbox"/>	60.0	60.0
1	Crate 2	ON	4.497 V	26.609 A	ON	4.500	4.500	50.0	50.0	16.0	16.0	100	100	100	100	<input type="checkbox"/>	60.0	60.0
2	Crate 3	ON	4.500 V	26.852 A	ON	4.500	4.500	50.0	50.0	16.0	16.0	100	100	100	100	<input type="checkbox"/>	60.0	60.0
3	Crate 4	ON	4.502 V	25.938 A	ON	4.500	4.500	50.0	50.0	16.0	16.0	100	100	100	100	<input type="checkbox"/>	60.0	60.0
4	Crate 5	ON	4.500 V	26.148 A	ON	4.500	4.500	50.0	50.0	16.0	16.0	100	100	100	100	<input type="checkbox"/>	60.0	60.0
5	Crate 6	ON	4.500 V	26.484 A	ON	4.500	4.500	50.0	50.0	16.0	16.0	100	100	100	100	<input type="checkbox"/>	60.0	60.0

Figure 19: LV controls on EPICS Interface

Note: RTPC HV and FMT HV interlocks might be active during power cycle of the LV for FEUs if it takes longer to power up FEUs. Currently, delay setting is 5sec. We can set max delay of 10 sec. To go higher than this, Saclay group should be consulted.

3.7 Monitoring BONuS Interlocks and the RTPC System Performances

BONuS interlock for High voltage are related with target gas, drift gas, LV and GEM biasing voltages as shown in figure 15. The minimum and maximum value at the interlock setting could not be set from Interlock GUI. These maximum and minimum values are actually set from the Alarm setting of particular PVs in the respective sub-system GUI. One example is shown in figure 20 for the MFC flow rate of drift gas, which is obtained by double clicking the PV value on Drift gas GUI as shown in figure 8. Setting LOLO and HIHI in the alarm setting also set the max and min of Interlock.

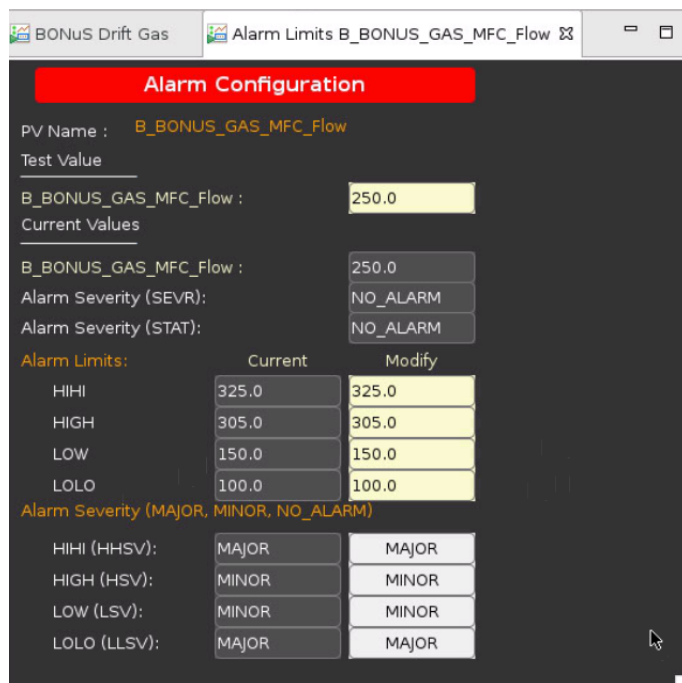


Figure 20: Alarm Limit settings

Monitoring the strip charts of all the PVs periodically and also uploading them in **HBRTPC** is crucial. Adjusting the parameters accordingly for the better performance of the RTPC is an important task of the RTPC experts.

3.8 Monitoring and Control of the DMS

DMS is run from dedicated vncserver on clondaq4:1 (DMS_BONUS). To access the vncserver follow the following steps:

- i) From Hall network (from any clonpc computers):

vncviewer clondaq4:1 -RemoteResize=0 -Shared

- ii) From personal computer with hallgateway following steps should be completed:

ssh -Y username@login.jlab.org
ssh -Y username@hallgw


```
ssh -Y clasrun@clonsl2
vncviewer clondaq4:1 -RemoteResize=0 -Shared
```

Being in the vncserver, dms daq computer is accessed using 'ssh -Y daq@bonusdms'. High voltage supply GUI is opened using command 'sudo CAENGECO2020'.

3.9 Maintenance of the RTPC System

RTPC experts are also responsible for any change/maintenance of the RTPC system. Mostly the high voltage and the gas panel and control could be the issue. After the decision of the RTPC experts, maintenance of the RTPC sub-system is performed either accessing the hall or from the counting house. Every maintenance should be logged in [HBLOG](#) and [HBRTPC](#) logbook.

3.10 Pedestal Run and configuration test

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 constraints, configuration 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 correctly.

To take pedestals, go to `~/mvt/Codascript/` directory from any clon-machines in the counting house and use the following command in terminal:

```
MvtRunBatchCol_HR PEDRUN ./mvt2crates_bonus 500
DEBUG
```

Before entering the command, make sure that nothing is running on mvt1 and mvt2 crates. Mostly, no data taking nor even prestart is running from CODA.

The above command open up two new windows (one for mvt1 and other for mvt2) and takes the pedestal of our electronics using 'mvt2crates_bonus.cnf' configuration file for FEUs, produced pedestal file and ZS threshold file to be used in the data taking. But, the above command doesn't take number of

samples mentioned in config file, but takes fixed 16 samples for the pedestal run. During pedestal run with the above command, events are collected with 50KHz internal trigger.

There are chain of processes included in this command which takes pedestal data, analyze the data for average pedestal and noise, perform common mode noise rejection, calculate zero suppression ADC values for all channels based on provided threshold value and the noise, modifies threshold and put mask to individual channels mentioned in MvtMask.txt file, creates the pedestal file and final threshold file for FEUs, and also creates and transfers the final configuration file of the mvt1 and mvt2 to the destination for the CODA run.

During pedestal run main window and two new windows are running. After completion, main window shows pedestal run is done. But new xterm windows should be closed manually. If pedestal run is running for 15 minutes and still not finished, please contact expert.

Note: If you have any issues taking pedestal in mvt1 or mvt2 crates for BONuS, please contact [Jiwan Poudel](#). As we have large window of 80 samples and also sparse readout, we are not using MvtRunBatchCol to take pedestals.

If you didn't see pedestal noise plot, use the following command:

xmgrace -p GraceNoise_mvt1.par -autoscale y filename

Filename should have .ace extension.

[Note: For the cosmic test with mvt1, mvt2 (BONuS) and mvt3 (FMT) crates in the hall, two master configurations are available: mvt123_ctof_cnd_ts and MVT123.CTOF_CND. While running mvt123_ctof_cnd.ts configuration, data files are saved in /work/bonus/ with name tag bonustest_. And, running MVT123.CTOF_CND config, data files are saved to the directory as it is run with PROD66 configuration and later sent to tape. The name of the directory would be mvt123 in /cache/. Furthermore, there are two other configurations: mvt1_er and mvt2_er to test the mvt1 and mvt2 separately. In all the configurations, trigger used for the cosmic test at Hall is /CTOF_HTCC/ctof.ts_cosmic.trg.]

4 RTPC Authorized Personnel

Table 1: Authorized personnel for RTPC

sn	Name	phone	email
1	On Call Expert	757-329-4844	—
2	Bueltmann, Stephen	757-232-5368	sbuelتما@odu.edu
3	Christy, Eric	—	christy@jlab.org
4	Hattawy, Mohammad	423-596-8352	hattawy@jlab.org
5	Kuhn, Sebastian	757-639-6640	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/>

A Appendix: GAS System

The BONuS12 RTPC, DMS and target gas panel (v.0.4)

Carlos A. Ayerbe Gayoso^{*1}, Nathan Dzbenksi^{†2}, George Jacobs^{‡3}, Robert Miller^{§3}, and
Narbe Kalantarians^{¶4}

¹The College of William and Mary, Williamsburg, Va 23187

²Old Dominion University, Norfolk, Va 23529

³Jefferson Lab, Newport News, Va 23606

⁴Virginia Union University, Richmond, Va 23220

September 8, 2019

Abstract

Instructions manual of the gas panel to distribute and control the gas supply, target, drift and buffer region, for the BONuS12 Radial Time Projection Chamber (RTPC) and Drift Monitor System (DMS). The manual includes step by step procedure to initialize and stop the system and a description of safety points in the system.

1 Introduction

The BONuS12 RTPC consists of a 40 cm long cylindrical chamber conformed by different concentric regions. At the center there is a target straw of 3 mm radius filled with Deuterium or Hydrogen at pressure of 7 atm. Next, there is a buffer region, filled with ^4He at 1 atm, to minimize the effect of Møller electrons. This region is surrounded by an aluminized mylar foil cylinder of 20 mm radius connected to the ground. Two volumes surround the buffer, standoff and drift region. These volumes are separated by another cylindrical aluminized mylar foil of 30 mm radius, acting as a cathode. Then, a set of three GEM cylindrical foils will amplify the electron signal produced by the ionization of the gas in the drift region. The first GEM, with a radius of 70 mm, acts as the anode of the chamber, producing a radial electric field perpendicular to the beam. The second and third GEM foils have a radius of 73 and 76 mm respectively. Finally, a cylindrical printed circuit board with ≈ 18000 sensor pads collects the charged amplified by the GEMs. The whole chamber will be inserted in a solenoid which will produce a magnetic field parallel to the beam. Figure 1 shows a transverse scheme of the RTPC showing the different regions and the ionization process.

The Drift-gas Monitoring System (DMS) is essentially a drift chamber designed to measure the drift-velocity of electrons in the drift-gas mixture. It does this by detecting β electrons radiated by two ^{90}Sr sources in coincidence with ionization electrons that those β 's create (see Fig.2). Each β must travel straight up through the hole in the skeleton of the DMS into the drift gas, create an ionization electron in the sensitive region, and be detected at the opposite end by an scintillator-photomultiplier tube combination. The ionization electrons that are created in that sensitive region are forced to move toward the anode via the electric field created by the cathode-anode combination and the field shaping electrodes that ensure the field is uniform in between. By knowing the distance between the sources and the arrival time of ionization electrons at the anode, we can calculate the drift velocity of those electrons. That drift velocity along with readings from attached pressure and temperature sensors, will tell us a bit more about the gas mixture changes and its effect on the velocity.

The construction of the DMS consists of the skeleton, electronics, and sources. The skeleton is made of six detachable Delrin sides held together by screws and maintains its air-tightness by way of rubber gaskets. The cathode, anode, and field-shaping electrodes are made of conducting metals. Those together with the photomultiplier tubes all rely on a high-voltage power supply. Finally the sources are Eckert & Ziegler ^{90}Sr sources that will be housed in a plastic and attached to the DMS in a light-tight manner.

^{*}Corresponding author: gayoso@jlab.org

[†]ndzbe001@odu.edu

[‡]jacobs@jlab.org

[§]rmiller@jlab.org

[¶]narbe@jlab.org

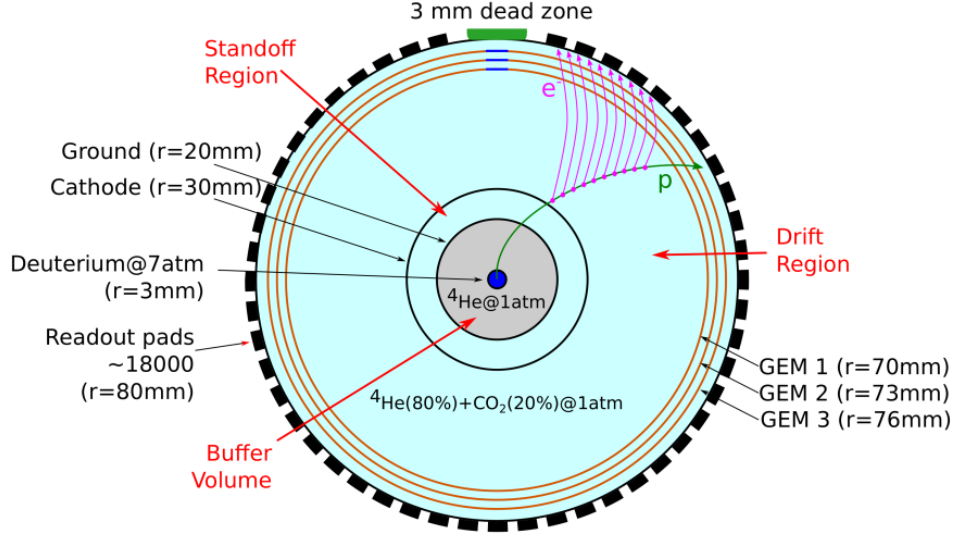


Figure 1: Cross section scheme of the BONuS12 RTPC, showing the concentric gas volume regions and its corresponding gas composition. The regions indicated in red are the volumes gas supply by the gas panel.

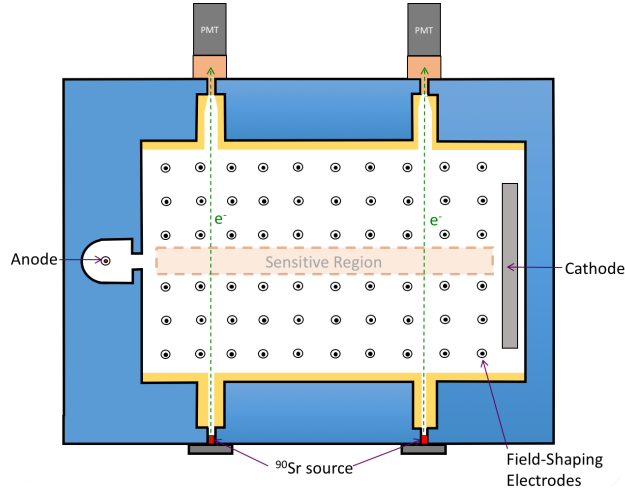


Figure 2: Drift Monitor System concept. (From N. Dzubenski)

The gas panel described in this note is designed to supply a pre-mixed gas, 20% CO₂ in He, to the standoff and drift volumes of the RTPC, the DMS, He to the buffer volume and the different gases to be uses in the target.

2 Description and construction of the Gas Panel

2.1 Gas Line Runs and Connections

There are pre-existing lines running from the target gas pad to the hall that are available. These lines terminate at the downstream end of the space frame. These lines can be diverted to the upstream location or new lines can be run that terminate at the upstream end of the space frame. The RTPC gas is supplied in high pressure, 2000 psi, pre-mix cylinders of 20% CO₂ in He, containing 220 SCF (approx. 6200 liters). Two cylinders will be connected at the same time in order to keep the same gas proportion during the experiment time¹. Pressure regulators reduce the gas supply pressure to 15 psi for the mass flow controller. Flow limiting orifices limit gas flow in case of component failure.

¹provider cannot guarantee the same gas proportion from bottle to bottle

2.2 Description of the gas panel

2.2.1 Target System

2.2.2 RTPC System

The RTPC gas panel contains the gas system sensors, valves and controls for the pre-mix (standoff and drift volume) and He for the buffer volume.

The pre-mix gas flow pressure is controlled by a Mass Flow Control (MFC) MFC308 and is monitored by a pressure gauge PI308 at the inlet of the MFC. The He gas to the buffer volume is controlled by the manual flowmeter FM206.

The gas panel could be isolated from the gas supply closing the valves MVBD304 (pre-mix gas) and the flowmeter FM206 (He supply) (see figure 3).

The MFC flows gas to the RTPC then to the DMS. The gas flow can be bypass the DMS manually, operating the valves MVBD310, MVBD320 and MVBD312 (as is explained in section 3.3).

The mineral oil filled bubblers, for the RTPC, DMS and Buffer, act as a check valve to prevent backflow of air into the system while maintaining the desired detector pressure and providing a visual indication of gas flow.

3 Use of the gas system

3.1 Controls and Instrumentation

A National Instruments cRio is used to control the MFC308 and read back the gas system flow and pressure signals. These signals are available on EPICS:

- RTPC Gas Flow (MFC308)
- RTPC Absolute Pressure (PT334)
- DMS-RTPC Differential Pressure (PDT332)
- Buffer Differential Pressure (PDT208)

The MFC is regulated via the gas system GUI located at Gas shed, L3 space frame. The EPICS readouts are available from any computer where EPICS can read out.

3.2 Gas System Initial Start-up

The RTPC and DMS must be purged of normal air the first time to be used². Read the whole list of steps below, before start the procedure since they are not strictly sequential. **DO NOT TURN ON THE HV UNTIL THE PROCEDURE IS COMPLETED.**

1. Verify all gas system components, gas lines, RTPC detector and DMS volume are connected as shown in the gas system P&I diagram (fig.3, fig.4 and fig. 5).
2. Verify proper valve lineup for start up in the following order:
 - (a) Close or check closed MVBD304 and MVBD202³.
 - (b) Open or check open MVBD306, MVBD308, MVBD204, MVBD310 and MVBD312.
 - (c) Close the flow meter valve on FM206.
 - (d) Open the gas cylinder valves and set the pressure regulators to 15 psi.
 - (e) Open MVBD304 and MVBD202.
3. Set the flows on MFC308 (via epics) and FM206.
4. Purge the detector and DMS volumes at 100 sccm to 250 sccm for ~90 min.
5. Once the purge is complete, reduce the detector and DMS flows for data taking.
6. Turn on HV.

²it includes when any of the vessels are open to the atmosphere, besides the exhaust connections from the bubblers

³at the gas shed

3.3 Flow and Pressure Controls

Increase or decrease of gas flow or pressure is done as follows:

- **Detector gas flow control:** Adjust the set point of MFC308 (from the gas system GUI) to increase or decrease gas flow.
- **He buffer gas flow control:** Adjust manually FM206 control valve to increase or decrease flow
- **RTPC gas volume pressure control:** To increase pressure, add oil to the RTPC exhaust gas bubbler. To decrease pressure, remove oil from the bubbler.
- **He buffer pressure control:** To increase pressure, add oil to the buffer exhaust gas bubbler. To decrease pressure, remove oil from the bubbler

To add or remove oil from the bubbler, just unthread the glass jar from the lid.

3.3.1 RTPC and DMS supply

Regulate the flow through the MFC as needed via the gas system GUI. From the DMS, the gas returns to the gas panel and is conducted to the RTPC. The pressure between the DMS and the RTPC is monitored via EPICS by PDT332 and PT334 with an extra line between the RTPC, the DMS and the panel.

3.3.2 Bypass DMS

In case of direct supply to the RTPC bypassing the DMS (the gas flow is not stopped), the procedure is as follows:

- open MVBD320
- close MVBD310 and MVBD312

RTPC pressure is still monitored with PDT332 since the monitor line between the RTPC and the DMS is not isolated.

3.4 Gas System Shut Down

To shut down and isolate the gas system perform the following actions;

- Close the gas cylinder valves
- Close MVBD304, MVBD202, MVBD306, and MVBD204.

4 Hazards

Portions of the gas system, as shown in figure 4 are considered a pressure system and must satisfy all safety regulations indicated by JLab ES&H. Portions of the gas panel NOT considered a pressure system, after the following components:

- immediately after the flow-meter FM206.
- after MFC308

The RTPC and the DMS are not considered pressurized vessels as pressure is limited by the oil filled bubblers. The gases to be used are not flammable, so not further consideration is needed.

Although the gas exhaust is conducted to the atmosphere outside the hall, any possible gas leak in the system would not cause a Oxygen Deficiency Hazard (ODH) Risk.

5 Monitoring and Archiving of Drift Gas System

The necessary mass flow rate, differential pressure, and temperature readings for the BONuS12 drift gas system will both be incorporated in the the standard CLAS12 monitoring scheme and archived via EPICS. The associated controllers and sensors will be streamed in to the same cRIO framework that is used for all of the detectors and their auxiliary systems. This information being archived will be useful for analysis and calibration purposes in that it will help in understanding how the RTPC was performing during data taking.

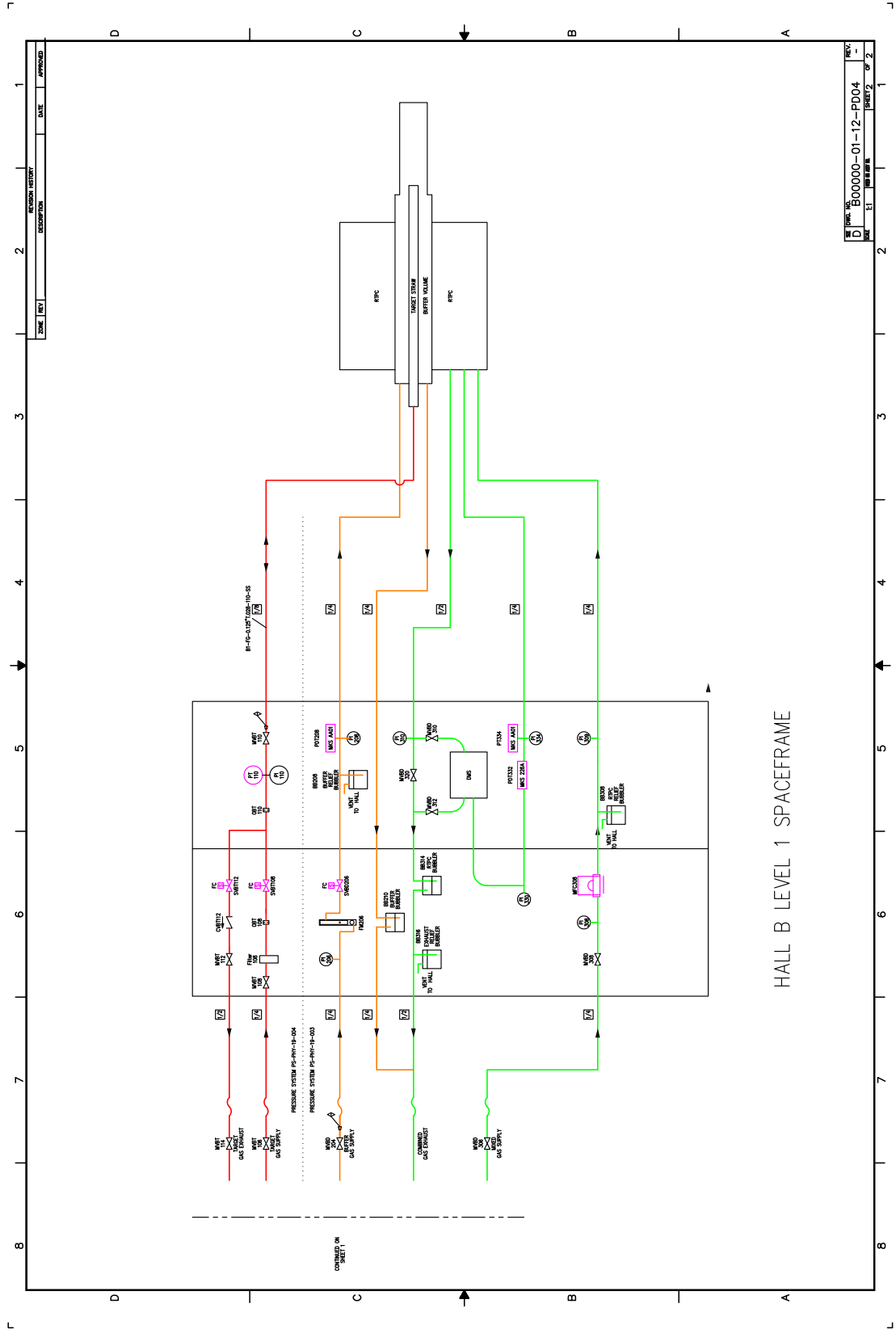


Figure 4: CAD scheme of the complete RTPC, DMS and target gas system designed by R. Miller.

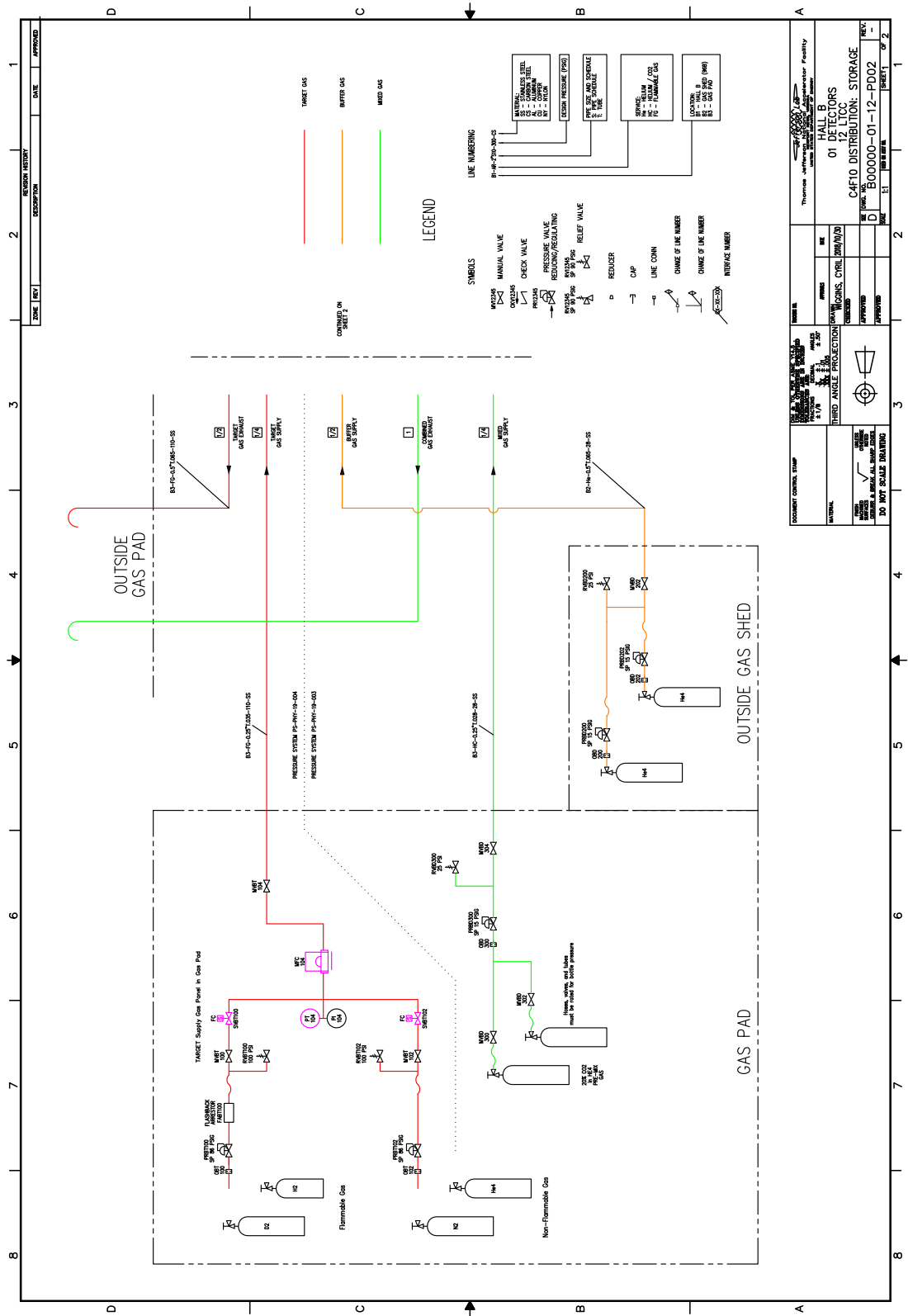


Figure 5: CAD scheme of the gas supply system. Draw by R. Miller.