RTPC Operations Manual

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(The BONuS12 Experimental Group)

RTPC Operations Manual v1.2

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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 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 = 80mm. 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.

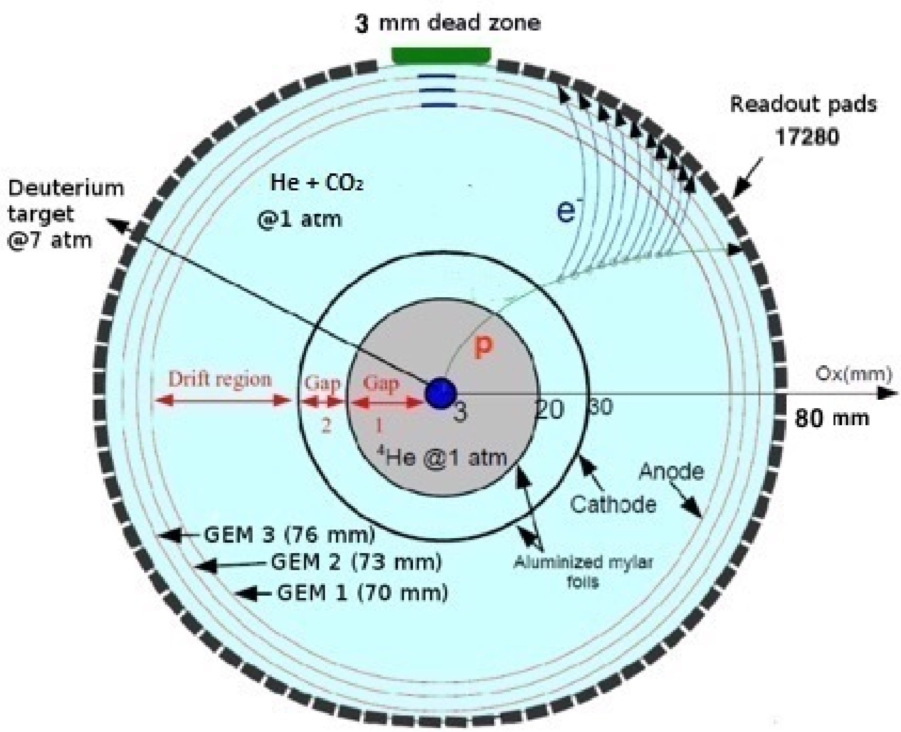

Figure 1: Schematics of cross-section of BONuS12 RTPC and a proton track

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.

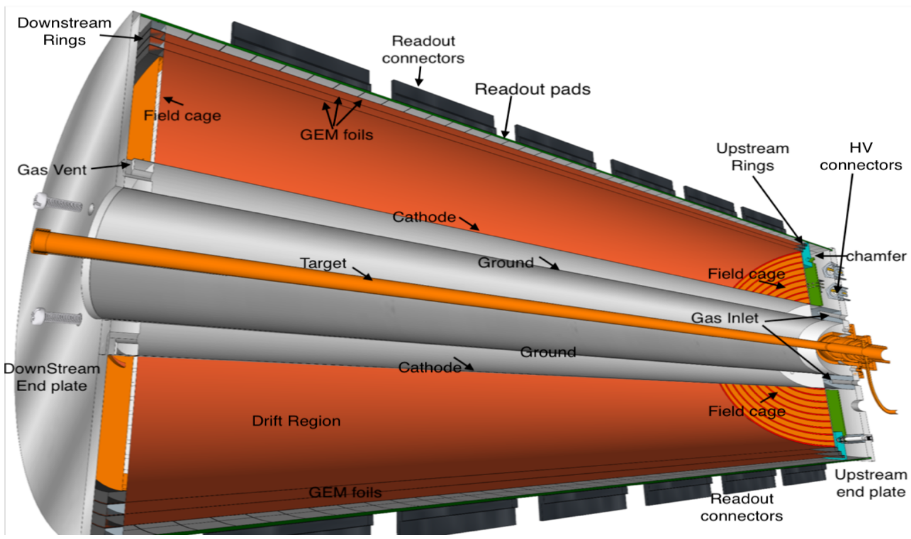

Figure 2: Longitudinal cross-sectional of BONuS12 RTPC

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 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.

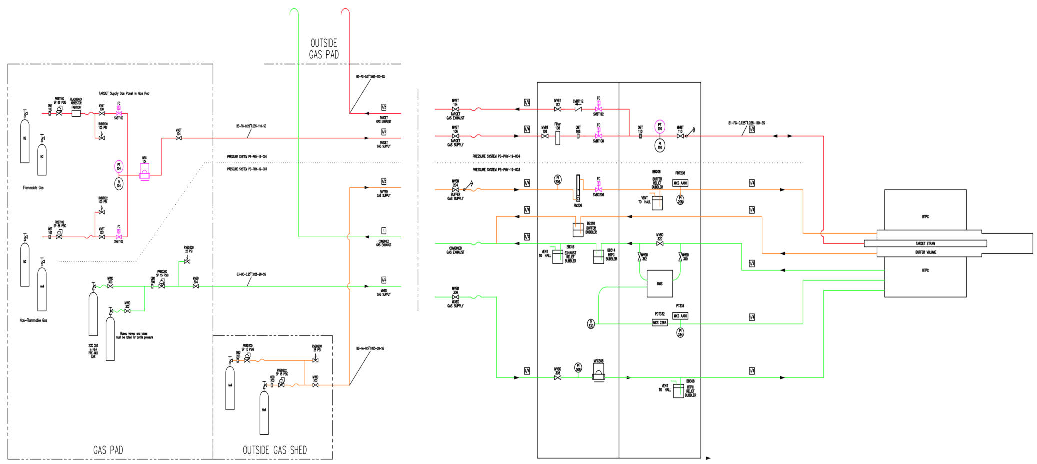

Figure 3: BONuS12 Gas System

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.

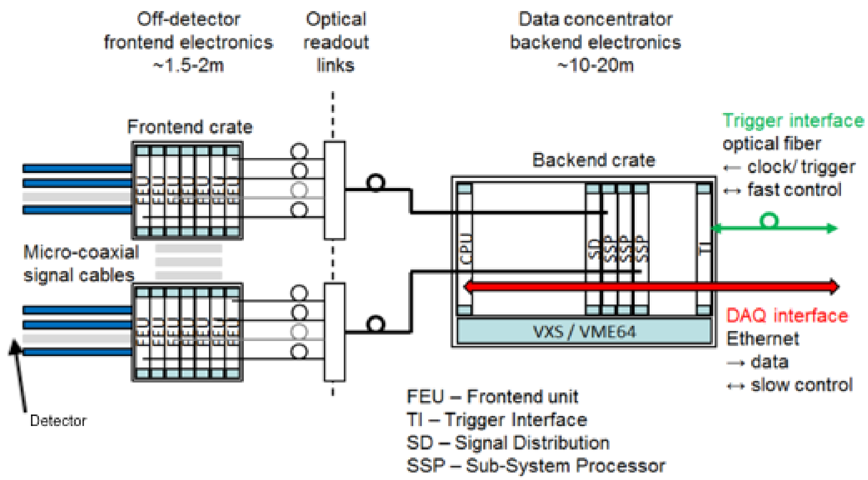

Figure 4: Schematics of Data Acquisition Electronics for the RTPC

2 Information For Shift Takers

2.1 Shift Taker 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 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). 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.

There is also alarm for the BONuS target (pressurised deuterium gas ∼80 psig). Overpressure or underpressure of the target gas provides alarm. For the target alarm, contact the RTPC/BONuS on-call expert.

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.

2.5 Monitoring the BONuS/RTPC sub-systems

EPICS Gas monitoring interface could be obtained from theRTPC 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 5, while the right is showing the RTPC menus as well.

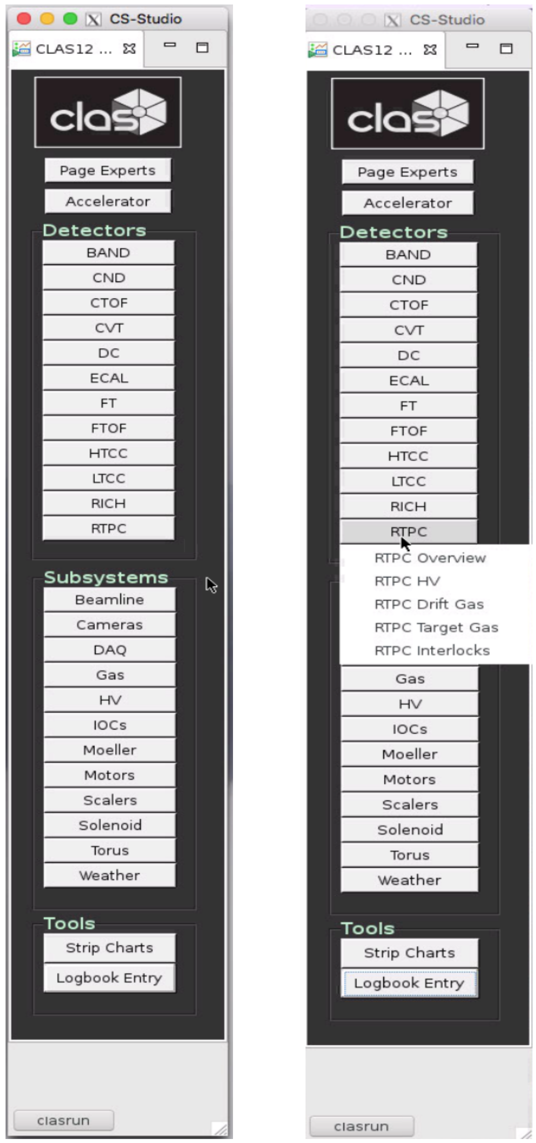

Figure 5: CS-Studio for the slow controls of the CLAS12 (left: general, right: RTPC options)

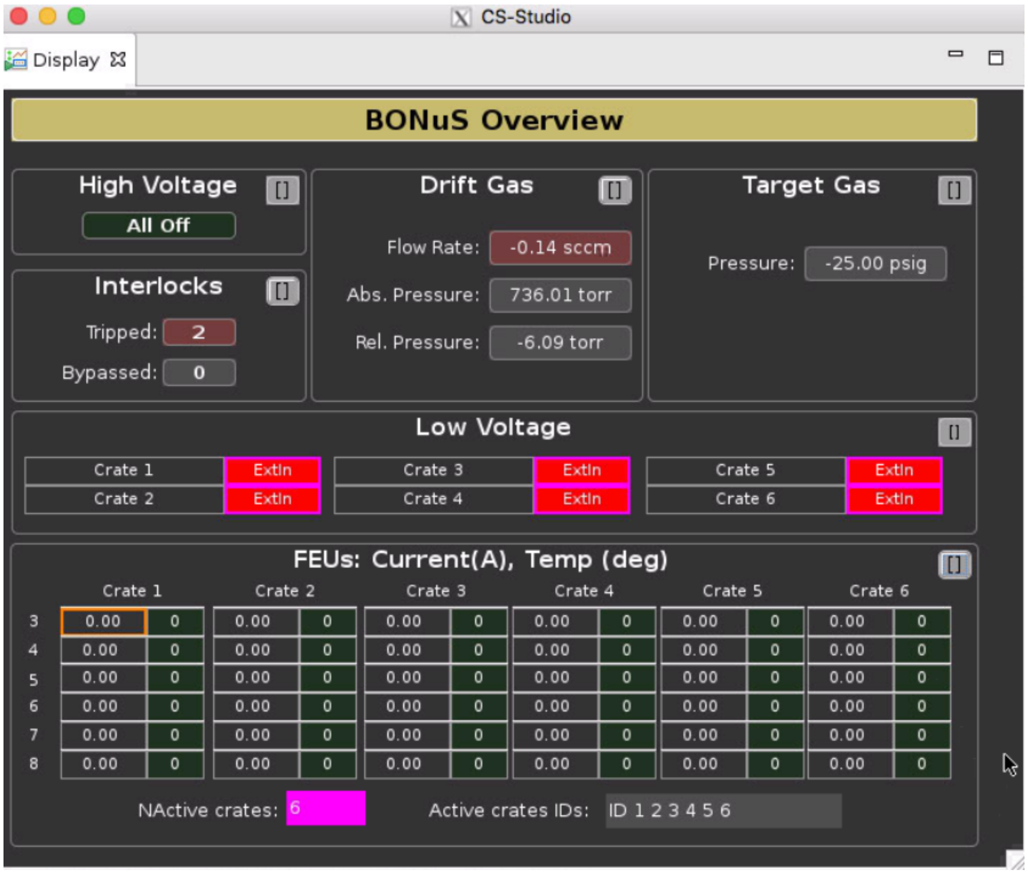

Figure 6: RTPC overview showing LV system monitoring

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 mixture of He (80%) and CO2 (20%) is flowing in the drift region from pre-mixed bottle.

Clicking on the "RTPC Gas" menu under RTPC options, we get BONuS Gas Monitoring Interface as shown in figure 7. 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.

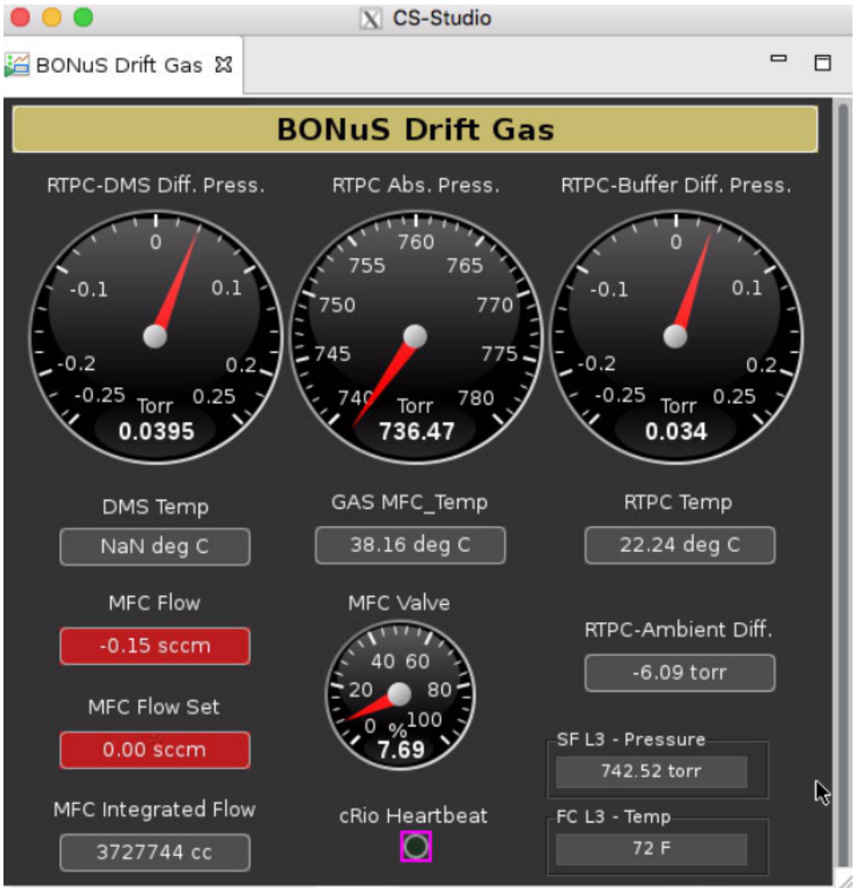

Figure 7: RTPC Gas Monitoring Interface

2.5.2 Monitoring and Control of the RTPC HV system

Novice users can visualize the status of HV on each GEM and cathode in the RTPC HV GUI, but don't have access to to turn ON and OFF the individual channel. There are "All ON" and "All OFF" bottom on top (and also under menu option) to turn on and off all channels. HV powering sequence is within "All ON" bottom so it starts powering up starting from Cathode to the GEM3 Out. I takes about 1 minutes to see all of them ramping up. Status of each channel is visulized on the GUI. There is no powering down sequence, so all the channels starts ramping down at once by "All OFF".

If any channel trips or kills, wait until all the channels show 'off' status to turn them ON.

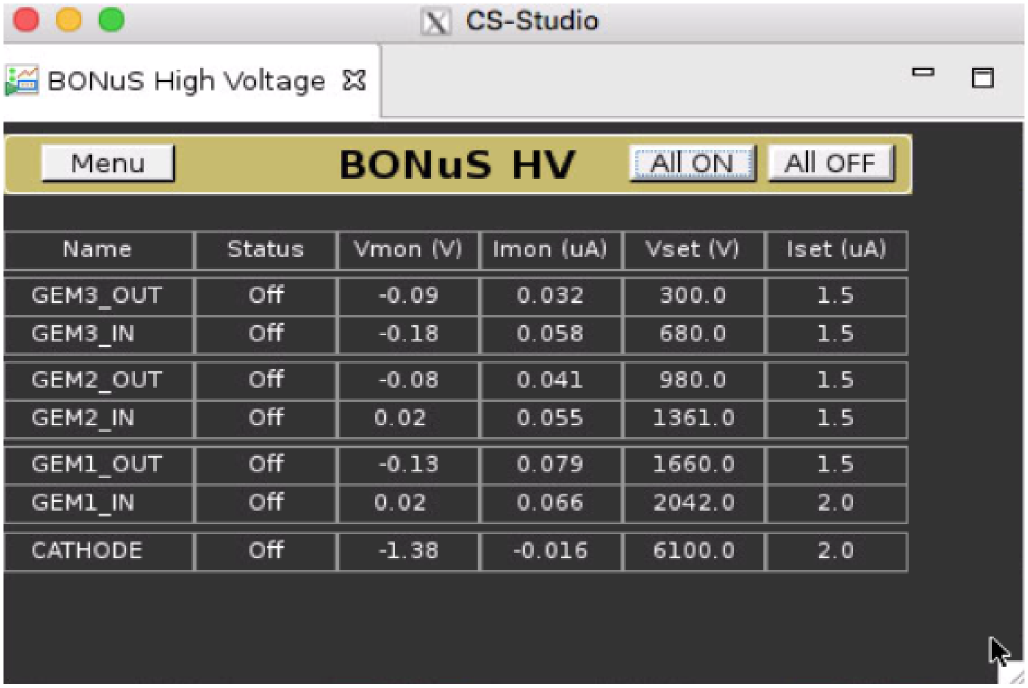

Figure 8: RTPC HV control Interface for Novice

2.5.3 Monitoring the RTPC LV system

Low LV monitoring is in Figure 6.

2.5.4 Monitoring the Hit Occupancy

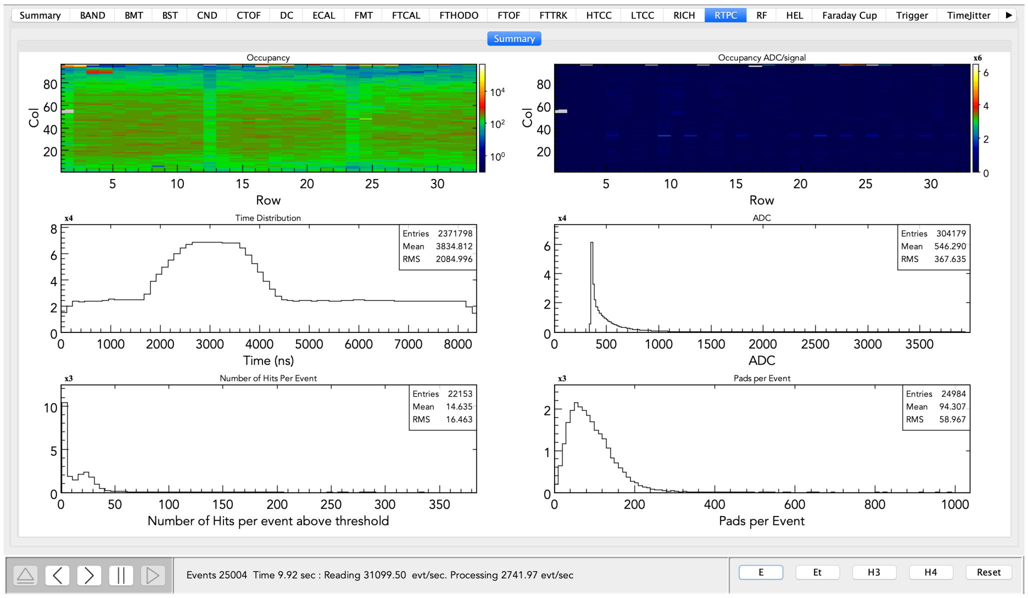

Figure 9: Occupancy monitoring of the RTPC

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. Monitoring and control of the RTPC gas system (sub-section 3.4)
4. Take HV gain calibration runs and adjust the system HV settings (sub-section 3.5)
5. Monitoring and control of low voltage (sub-section 3.6)

6. Monitoring and control of the DMS (sub-section 3.7)

7. Monitoring RTPC system performances (sub-section 3.8)

8. Make repairs to the hardware during maintenance periods (sub-section 3.9)

9. Perform Configuration Test and take 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 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 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 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 BONuS12 Gas system

3.5 RTPC 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".

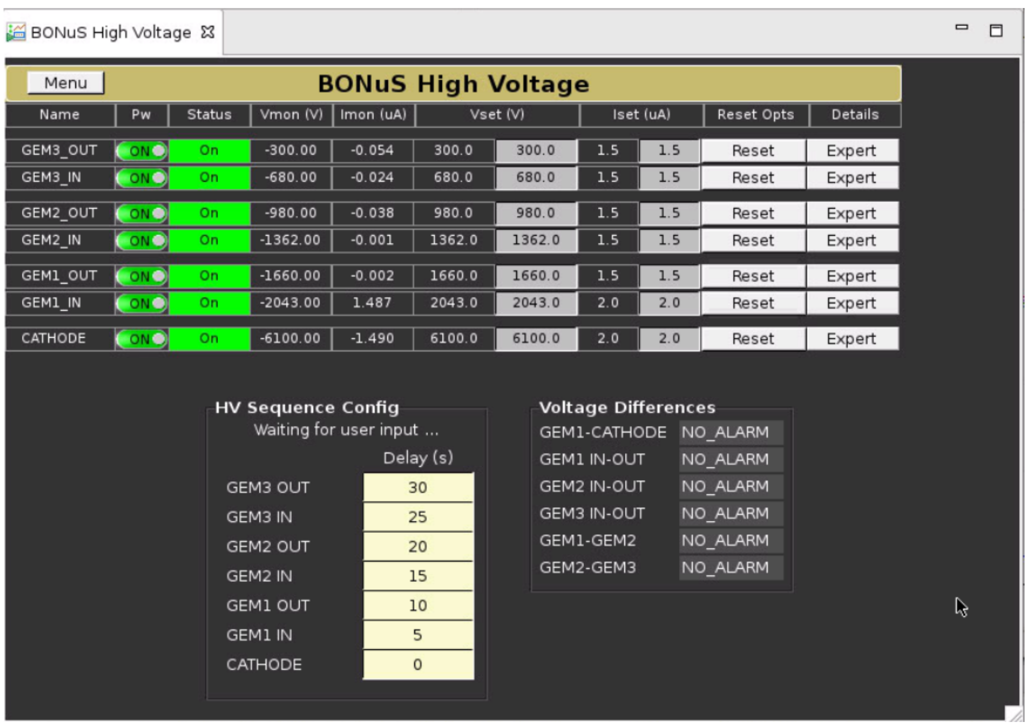

Figure 10: RTPC HV control Interface for Expert

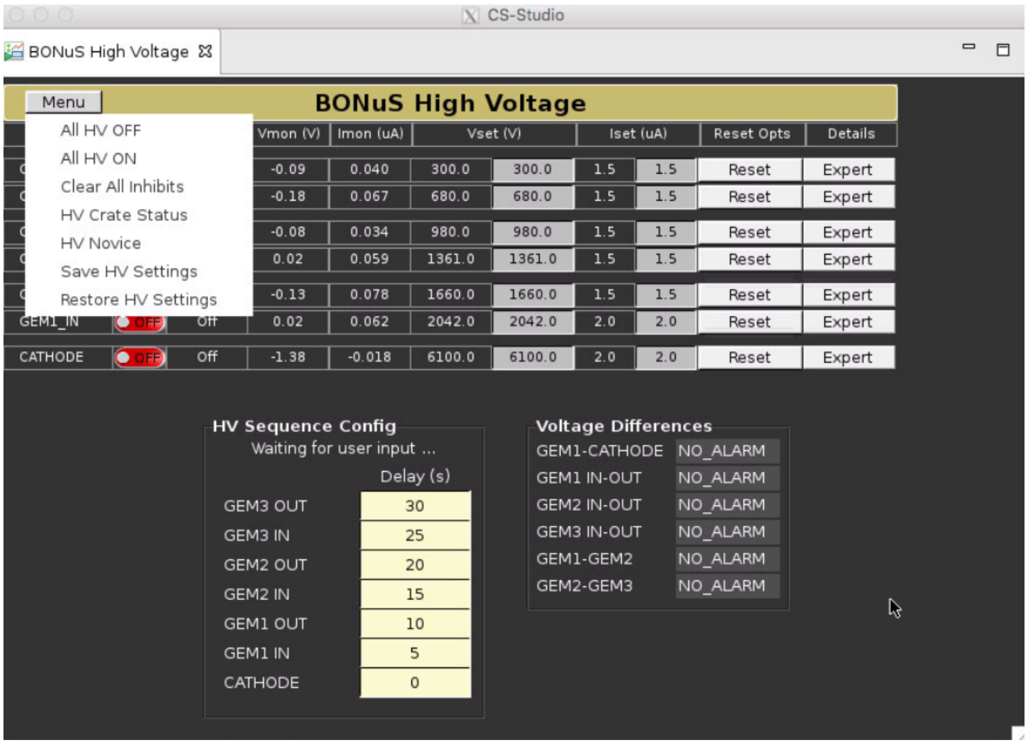

Figure 11: RTPC Expert HV control Interface

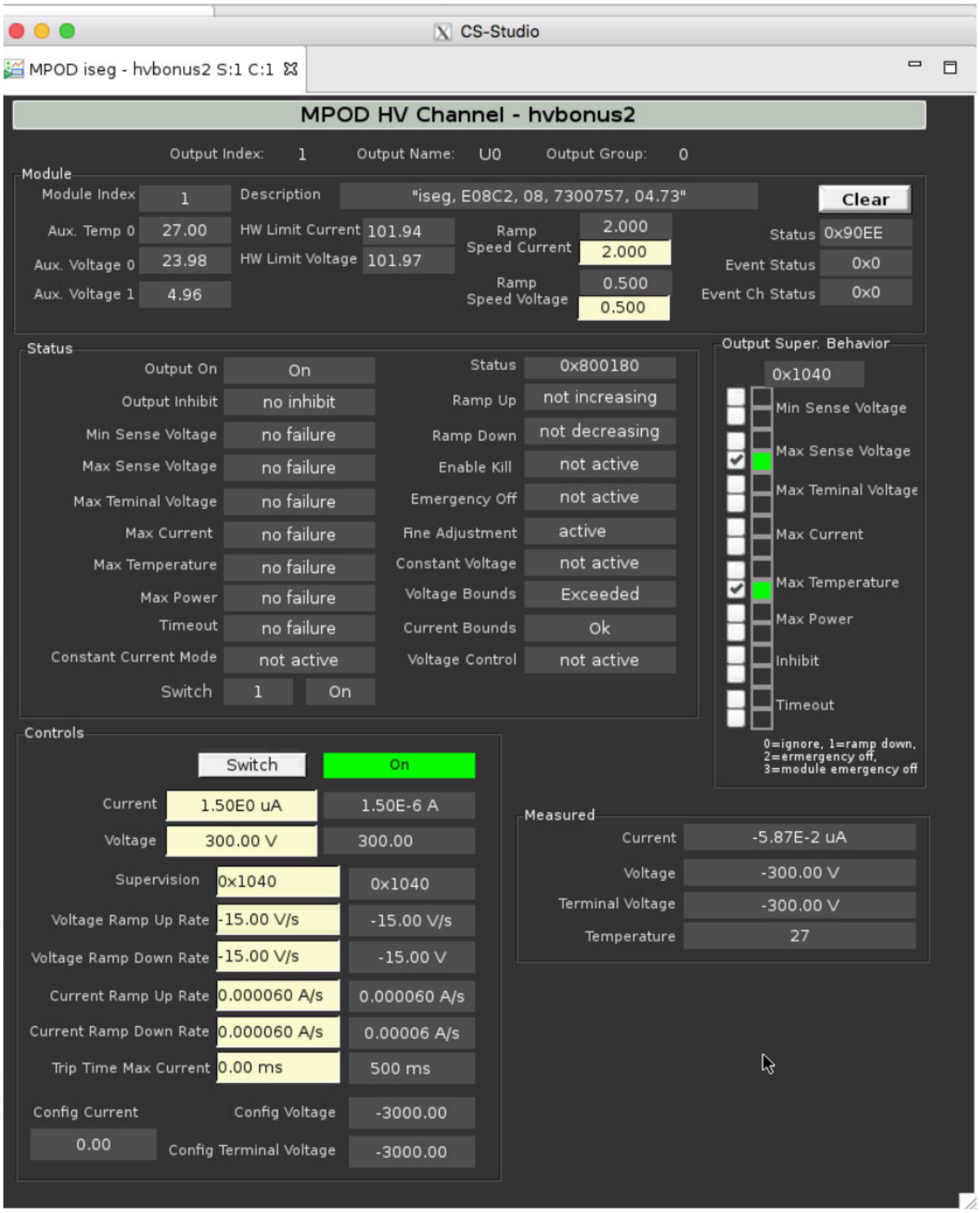

Figure 12: HV channel control for experts

If the Mpod crate has issues, figure 13 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.

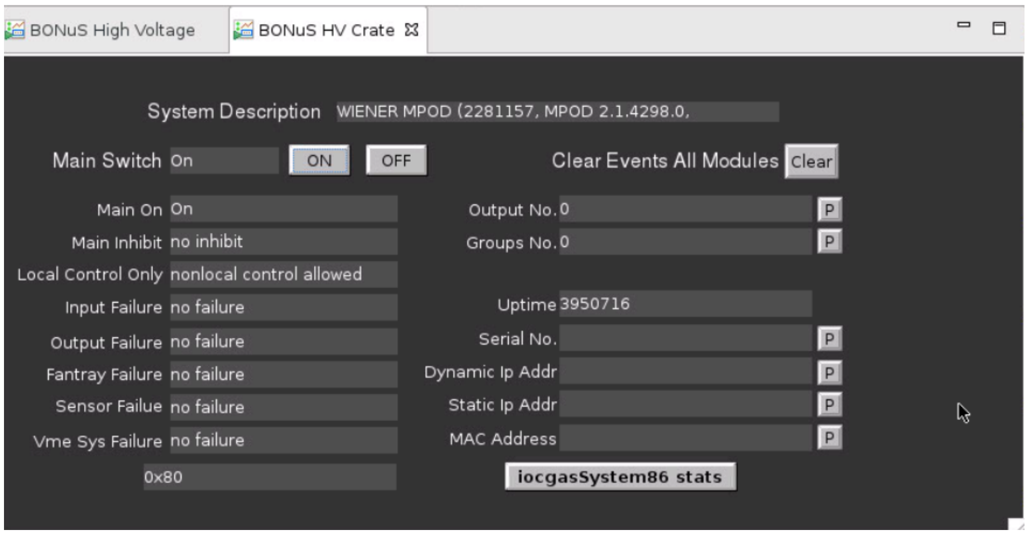

Figure 13: RTPC HV crate status

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, 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).

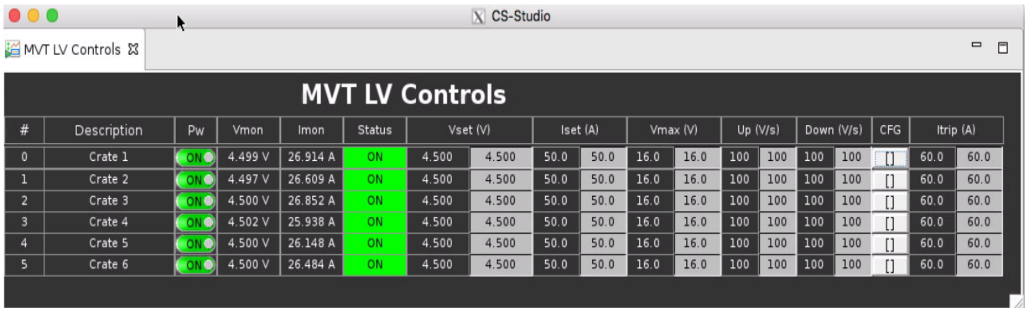

Figure 14: LV controls on EPICS Interface

3.7 Monitoring and Control of the DMS

To access DMS DAQ computer:

From Hall network: ssh -Y daq@bonusdms

From outside the Hall network:

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

After getting to DMS DAQ computer, we will get to daq@daq

3.8 Monitoring RTPC System Performances

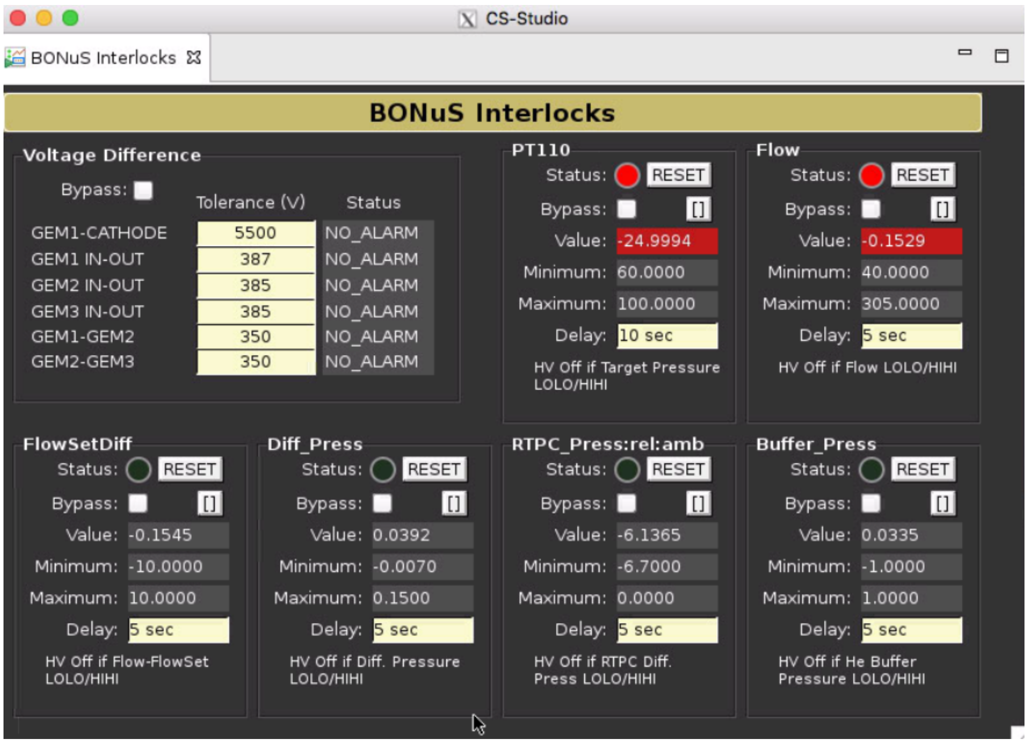

Figure 15: RTPC interlocks

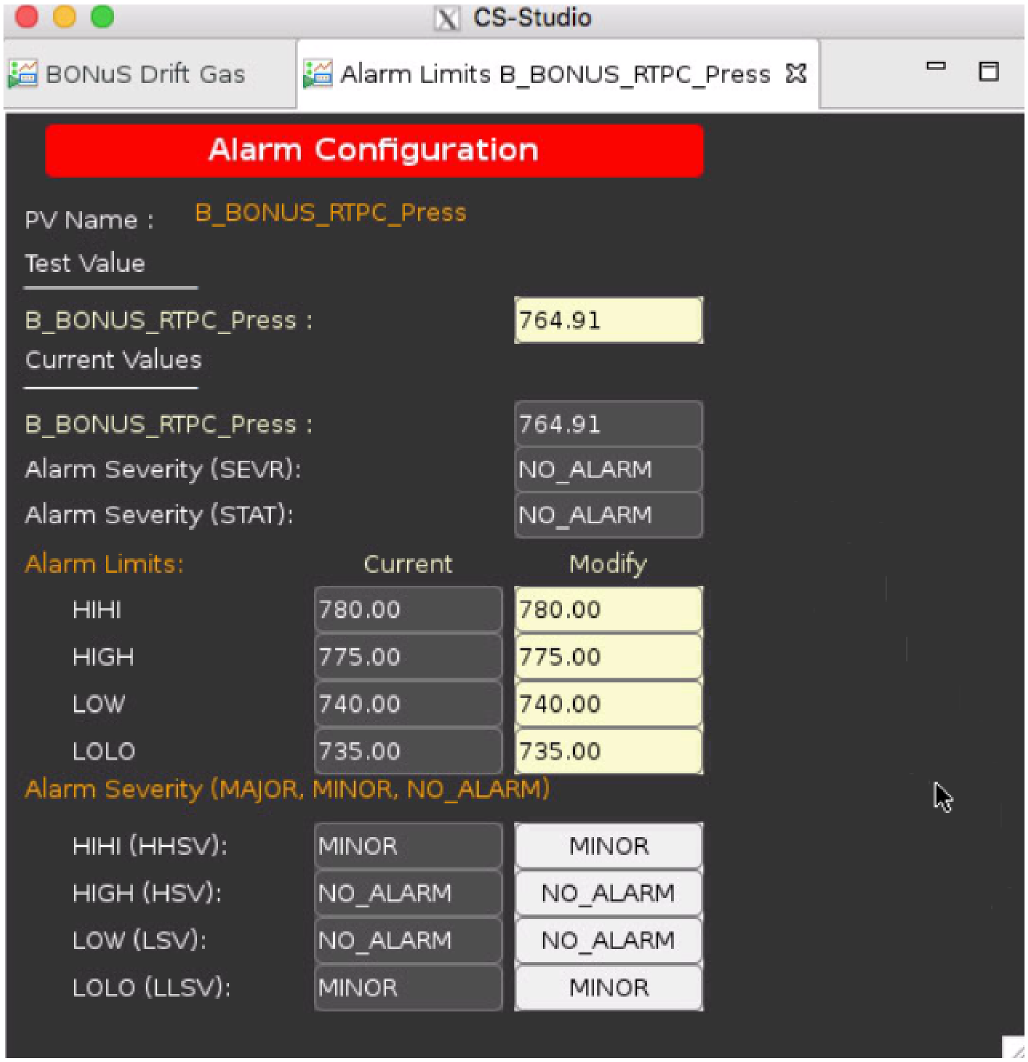

Figure 16: Alarm Limit settings

3.9 Maintainance of the RTPC System

3.10 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 14. 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	On Call Expert	757-329-4844	—
2	Bueltmann, Stephen	757-232-5368	sbueltma@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 RPTC, DMS and target gas panel (v.0.4)

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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 proceadure 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 ^{4}He 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 $\approx$ 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.

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¶narbe@jlab.org

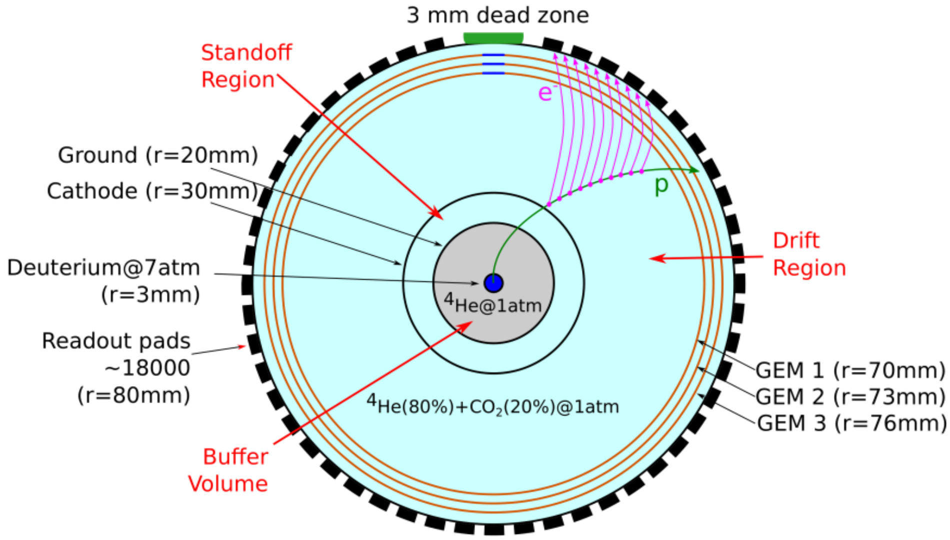

Figure 1: Cross section scheme of the BONuS12 RTPC, showing the concentric gas volume regions and its corresponding gas composition. The regions indicated in red are the volumes gas supply by the gas panel.

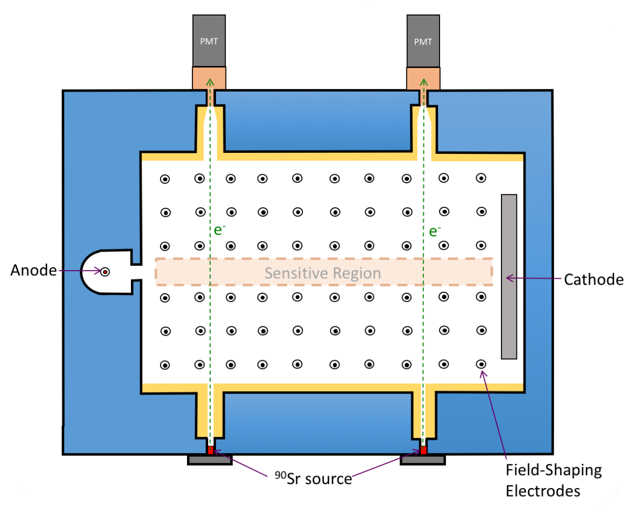

Figure 2: Drift Monitor System concept. (From N. Dzbenski)

The gas panel described in this note is designed to supply a pre-mixed gas, 20% CO_2 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% CO_2 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 time[1]. 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.

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

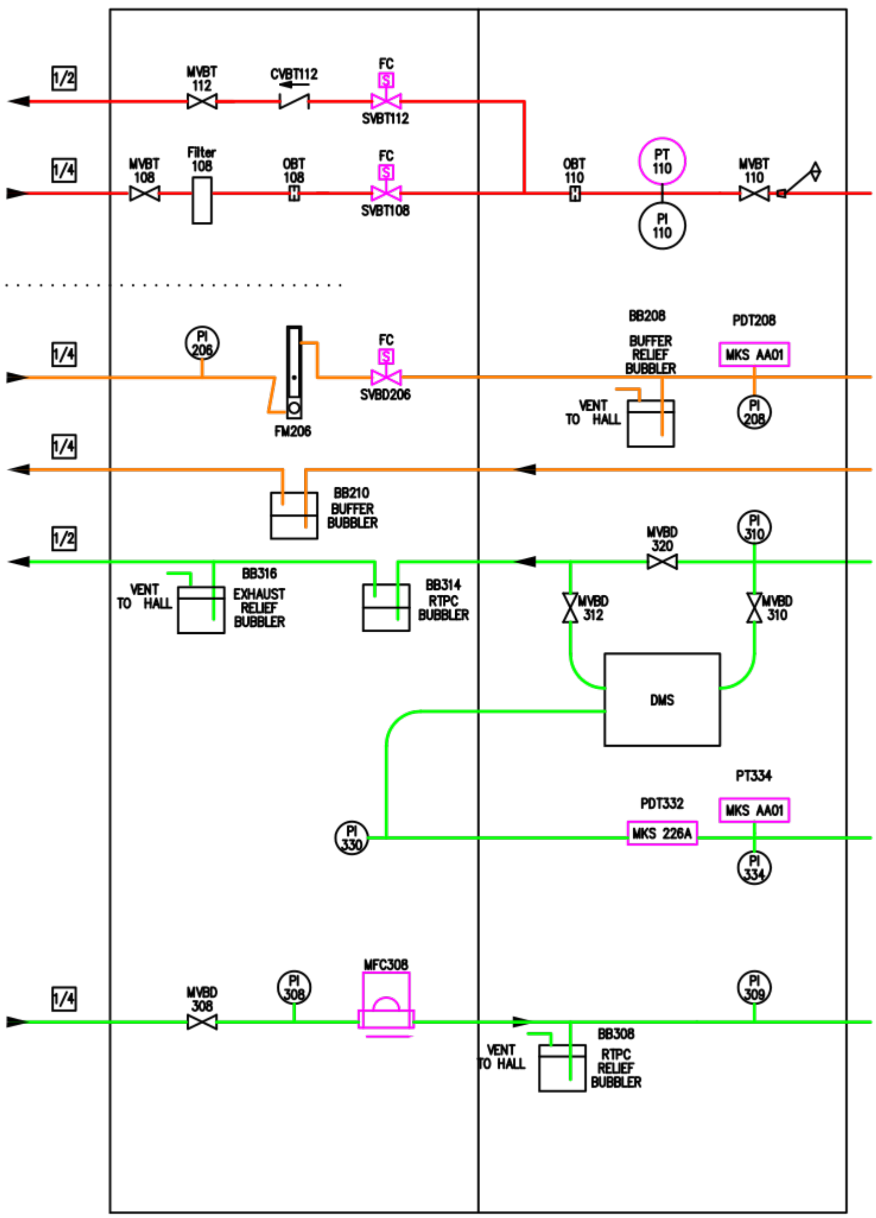

Figure 3: CAD concept of the gas panel designed by R. Miller. The green lines indicate the pre-mix gas pipes. The orange lines indicate the He system. The red lines indicate the target system. The scheme shows the DMS which will be located near the panel. A complete scheme of the system is shown in fig. 4

The ^{4}He buffer gas is supplied in high pressure, 3000 psi, cylinders each containing 220 SCF. Pressure regulators reduce the gas supply pressure to 15 psi for the manual flow meter with valve. Flow limiting orifices limit gas flow in case of component failure. Gas for the ^{4}He buffer volume is supplied from the Legacy Hall B He gas distribution system. The ^{4}He gas cylinders are located at the Hall B Gas Shed, Bldg. 96B.

It is required one volume exchange per hour for the drift/standoff volume and for the buffer volume. For the drift/standoff volume it is estimated a flow rate 150 sccm, thus 1 bottle will last 692 hours or 29 days. Making use of two bottles simultaneously, the time is doubled. For the buffer volume, the estimated flow rate is 20 sccm, therefore 1 bottle will last 5191 hours or 216 days.

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 used[2]. 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 MVBD202[3].
   (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.

[2]it includes when any of the vessels are open to the atmosphere, besides the exhaust connections from the bubblers
[3]at 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.

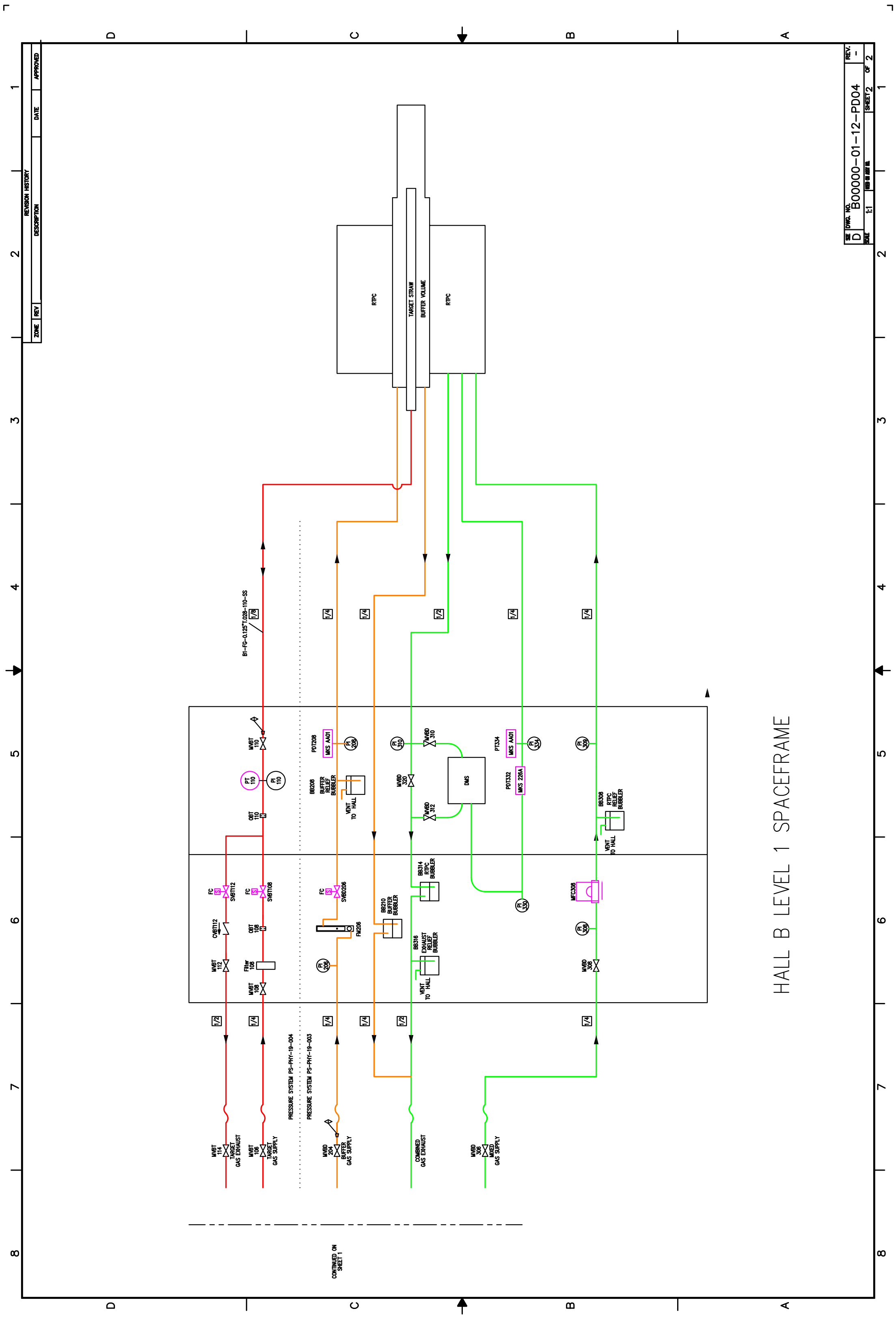

Figure 4: CAD scheme of the complete RTPC, DMS and target gas system designed by R. Miller.

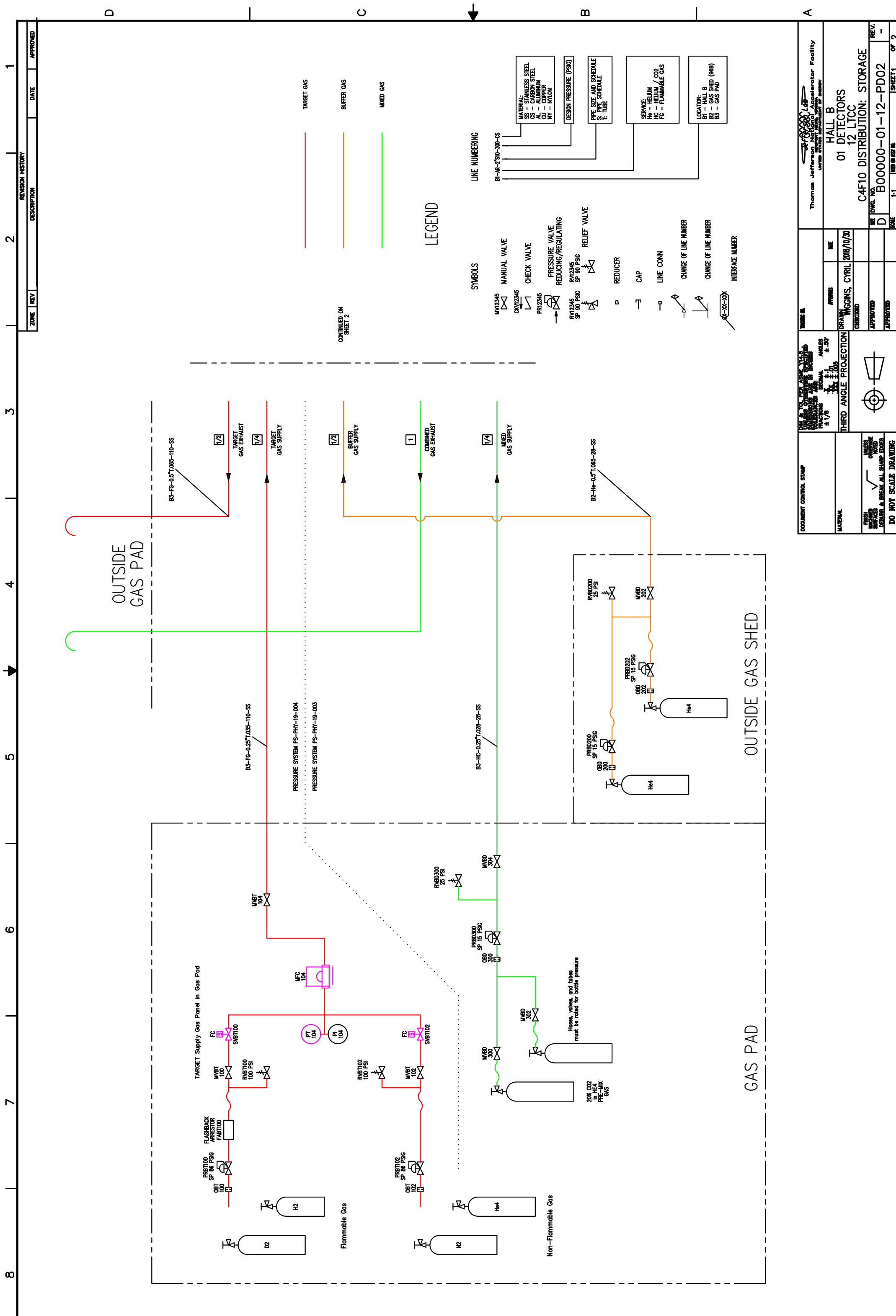

Figure 5: CAD scheme of the gas supply system. Draw by R. Miller.