Forward Time-of-Flight System Operations Manual

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Abstract

This document provides an overview of the CLAS12 Forward Time-of-Flight (FTOF) System and serves as an Operations Manual for the detector. Instructions are provided for shift workers 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 FTOF system experts regarding the channel mapping to the readout electronics, the cable connections and routing in Hall B, higher-order high voltage system operations, and detector servicing. This document also provides references to the available FTOF documentation and a list of personnel authorized to perform FTOF system repairs and to modify system settings.

Contents

1 FTOF Overview

The Forward Time-of-Flight (FTOF) system is a major component of the CLAS12 Forward Detector that is used to measure the flight time of charged particles emerging from beam-related interactions in the target. The average path length from the target to the FTOF counters is roughly 6 - 7 m. The system requirements include excellent timing resolution for particle identification and good segmentation to provide for flexible triggering options. The system specifications call for an average time resolution of σ_{TOF}=80 ps at the more forward angles of CLAS12 ($\theta < 35°$) and 150 ps at larger angles ($\theta > 35°$). The system must also be capable of operating in a high-rate environment. At the nominal CLAS12 operating luminosity of 1×10^{35} cm^{-2}s^{-1}, the average rate per scintillation counter approaches 1 MHz.

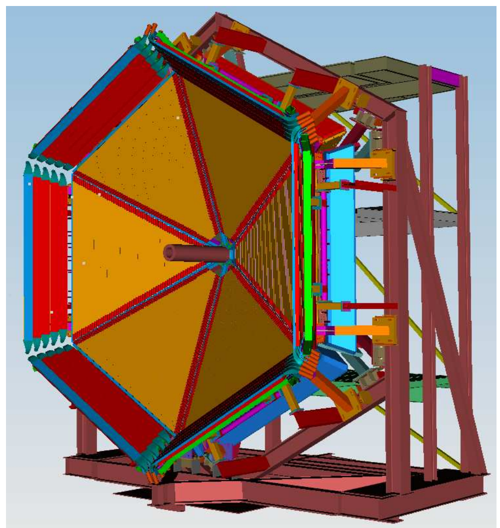

Figure 1: View of the FTOF counters for CLAS12 highlighting the location of the panel-1 and panel-2 counters. The panel-1b counter arrays are shown in orange and the panel-2 counter arrays, mounted around the perimeter of the Forward Carriage, are shown in red. The panel-1a counter arrays are mounted immediately downstream of the panel-1b arrays, and are not visible in this picture. The Forward Carriage is roughly 10 m in diameter.

The CLAS12 spectrometer in the forward direction is built around a six-coil superconducting toroidal magnet that divides the active detection area into six 60°-wide azimuthal regions called sectors. In each of the six sectors of the CLAS12 Forward Detector, the FTOF system is comprised of three arrays of counters, referred to as panels, named panel-1a, panel-1b, and panel-2. Each panel consists of a set of rectangular scintillators with a PMT on each end. Panel-1 includes the sets of counters located at forward angles (roughly 5° to 35°) (where two panels are necessary to meet the 80 ps average time resolution requirement) and panel-2 includes the sets of counters at larger angles (roughly 35° to 45°). The positioning and attachment of the FTOF detector arrays on the Forward Carriage of CLAS12 are shown in Fig. 1. Each of the six panel-1a arrays contains 23 counters, each of the six panel-1b arrays contains 62 counters, and each of the six panel-2 arrays contains 5 counters.

Fig. 2 shows the sector naming and identifier conventions for the FTOF system, as well as the definitions of the left and right sides of each sector. A summary of the FTOF technical parameters is given in Table 1.

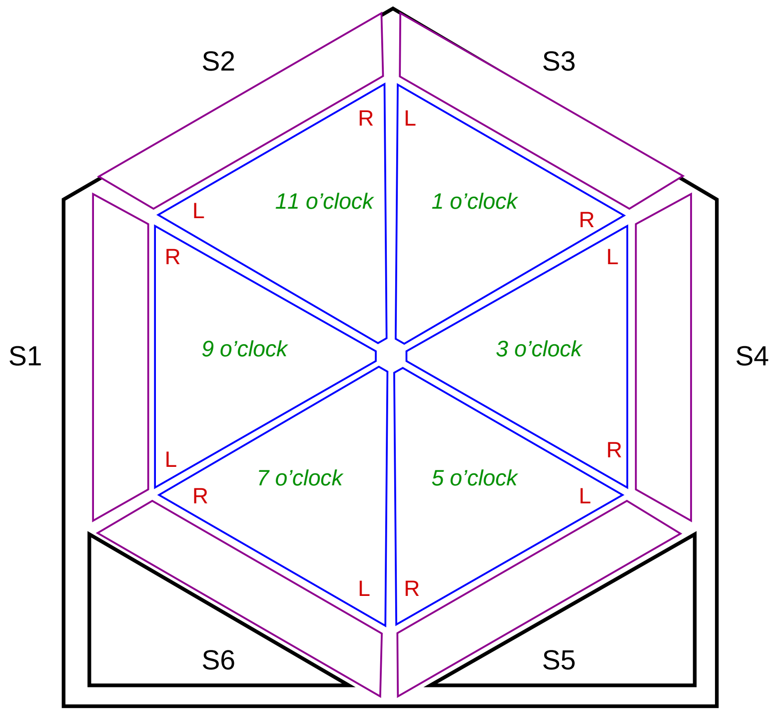

Figure 2: Schematic view of the Hall B Forward Carriage looking downstream along the electron beamline showing the sector naming convention, the definitions of the left (L) and right (R) sides of each sector, and the clock position identifier. The electron beam goes into the page such that S1 is on beam left and S4 is on beam right.

A block diagram of the readout electronics for one counter of the FTOF system is shown in Fig. 3. The PMT anode outputs are connected to JLab VME leading edge discriminators and CAEN VME TDCs. Both high resolution TDCs (25 ps LSB CAEN 1290A) and lower resolution TDCs (100 ps LSB CAEN 1190A) are employed, where the lower resolution TDCs are associated with the longer counters at large polar angles for panel-1a, panel-1b, and panel-2. The PMT dynode outputs are connected to JLab 250 MHz VME flash ADCs.

The electronics for each sector are located behind the detectors on the three levels of the Forward Carriage as follows:

- FTOF S1: FC Level 2 South
- FTOF S2: FC Level 3 South
- FTOF S3: FC Level 3 North
- FTOF S4: FC Level 2 North
- FTOF S5: FC Level 1 North
- FTOF S6: FC Level 1 South

Note that "South" refers to beam left and "North" to beam right (closer to the Pie Tower). Fig. 4 shows the rack locations for the FTOF VME electronics and signal cable patch panels.

The high voltage (HV) power supplies for each FTOF sector are either CAEN 1527LC

Parameter	Design Value
Panel-1a	
Angular Coverage	$\theta = 5° \rightarrow 35°$, $\phi: 50\%$ at $5° \rightarrow 85\%$ at $35°$
Counter Dimensions	$L = 32.3$ cm $\rightarrow 376.1$ cm, $w \times h = 15$ cm $\times$ 5 cm
Scintillator Material	BC-408
PMTs	EMI 9954A, Philips P2262
Design Resolution	90 ps $\rightarrow$ 160 ps
Panel-1b	
Angular Coverage	$\theta = 5° \rightarrow 35°$, $\phi: 50\%$ at $5° \rightarrow 85\%$ at $35°$
Counter Dimensions	$L = 17.3$ cm $\rightarrow 407.9$ cm, $w \times h = 6$ cm $\times$ 6 cm
Scintillator Material	BC-404 (#1 $\rightarrow$ #31), BC-408 (#32 $\rightarrow$ #62)
PMTs	Hamamatsu R9779
Design Resolution	60 ps $\rightarrow$ 110 ps
Panel-2	
Angular Coverage	$\theta = 35° \rightarrow 45°$, $\phi: 85\%$ at $35° \rightarrow 95\%$ at $45°$
Counter Dimensions	$L = 371.3$ cm $\rightarrow 426.1$ cm, $w \times h = 22$ cm $\times$ 5 cm
Scintillator Material	BC-408
PMTs	Photonis XP4312B, EMI 4312KB
Design Resolution	145 ps $\rightarrow$ 160 ps

Table 1: Table of parameters for the scintillation bars, PMTs, and counters for the FTOF panel-1a, panel-1b, and panel-2 arrays.

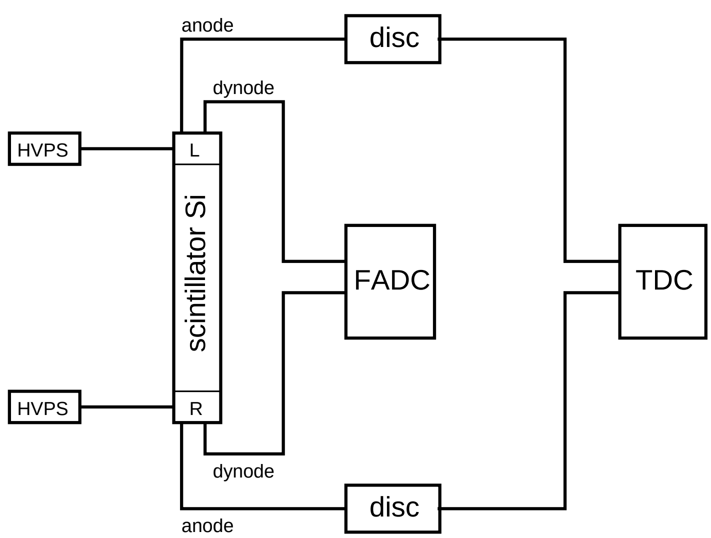

Figure 3: Block diagram for the FTOF system showing the layout of the readout electronics and HV connections for a single representative counter.

mainframes or CAEN 4527 mainframes outfitted with negative polarity 24-channel A1535N modules. The HV mainframes that power the FTOF system are actually shared between the FTOF and the PCAL. The FTOF boards occupy slots #0 to #7 of each mainframe and the PCAL boards occupy slots #8 to #15 of each mainframe. The supplies are named HVFTOFn, n=1→6 (i.e. HVFTOF1 → HVFTOF6). Fig. 4 shows the locations of the HV mainframes for each of the FTOF sectors on the Forward Carriage.

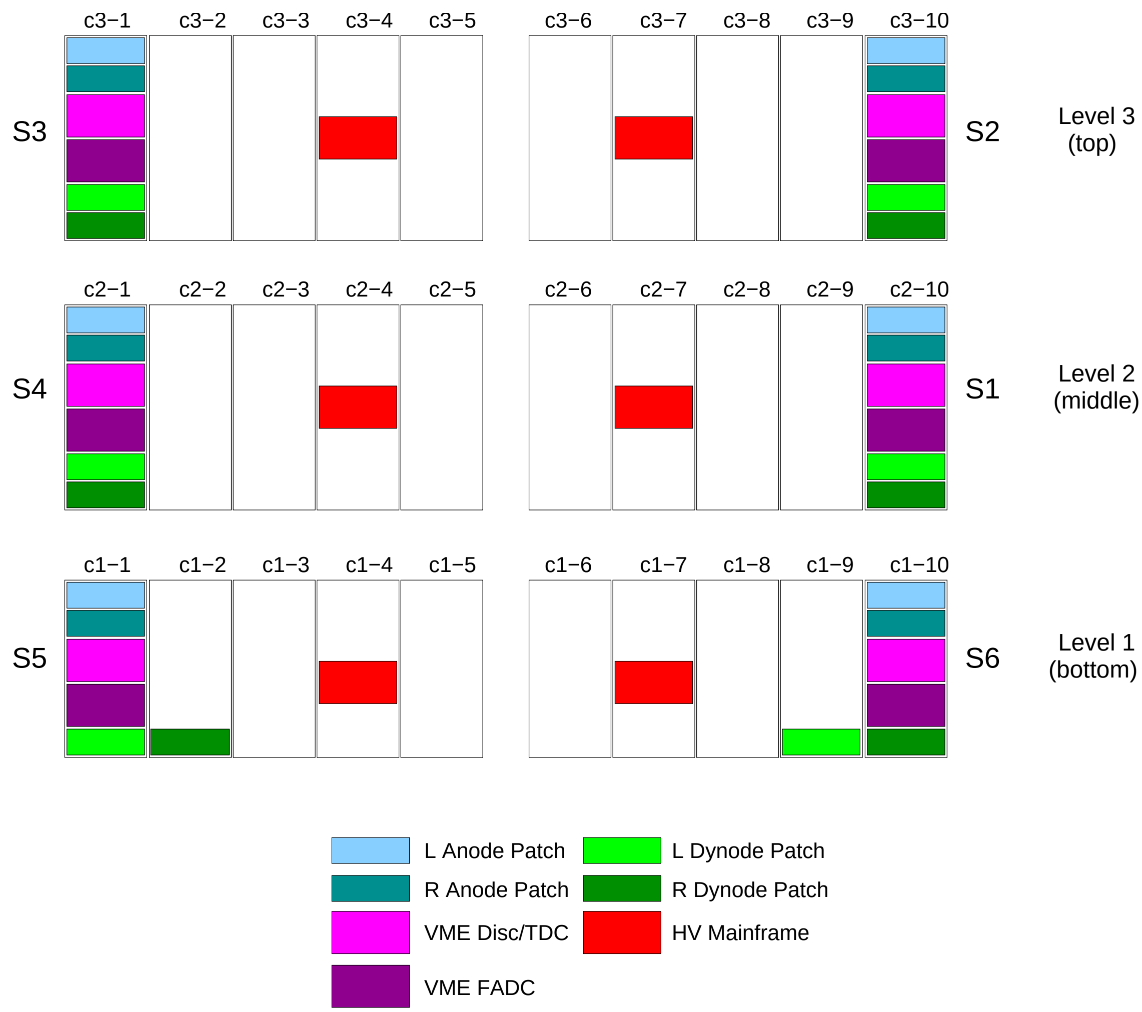

Figure 4: Forward Carriage layout of the FTOF VME electronics, signal cable patch panels, and HV power supplies in the electronics racks on each of the three levels. The rack names on each level (c1, c2, and c3) are numbered 1 through 10. This view is looking upstream. Note: The racks on Level 1 are 180 cm tall and those for Levels 2 and 3 are 210 cm. For this reason, the dynode patch panels are split into two neighboring racks on Level 1.

2 Information for Shift Workers

2.1 Shift Worker Responsibilities

The shift worker in the Hall B Counting House has five responsibilities with regard to the FTOF system:

1. Updating the Hall B electronic logbook with records of problems or system conditions (see Section 2.1.1)
2. Contacting FTOF system on-call personnel for any problems that are discovered (see Section 2.1.2)
3. Responding to FTOF system alarms from the Hall B alarm handler (see Section 2.1.3)
4. Turning on or off the high voltage for the FTOF system using the HV control interface (see Section 2.2)
5. Monitoring the hit occupancy scalers for the system (see Section 2.3)

2.1.1 Updating the Logbook

The electronic logbook (or e-log) [1] is set up to run on a specified terminal in the Hall B Counting House. Shift workers are responsible for keeping an up-to-date and accurate record of any problems or issues concerning the FTOF system. For any questions regarding the logbook, its usage, or on what is considered to be a "logbook worthy" entry, consult the assigned shift leader.

Note the shift worker should follow all posted or communicated instructions about entering FTOF monitoring histograms or scaler information into the e-log. This is typically done (at least) once per 8-hour shift as directed on the shift checklist.

2.1.2 Contacting FTOF System Personnel

As a general rule, shift workers should spend no more than 10 to 15 minutes attempting to solve any problem that arises with the FTOF system. At that point they should contact the assigned FTOF on-call expert either to provide advice on how to proceed or to address the problem. The FTOF on-call phone number is (757)-344-7204.

This document is divided into sections for shift workers and for FTOF system experts. However, only FTOF system experts (as listed in Section 5) are authorized to make changes to the FTOF parameter settings, to work on the hardware or electronics, or to modify the DAQ system software. This division between shift worker 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.

2.1.3 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. [2].

The only element of the FTOF system monitored by the alarm handler is the HV system. Any time a channel trips off an alarm will sound. The alarm handler will identify the specific channel (or channels) that have tripped. These channels can be reset either through the alarm handler or through the nominal FTOF 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.

2.2 High Voltage Controls

The FTOF HV is controlled through the Hall B CS-Studio suite, which is an Eclipse-based collection of tools used as an interface to the EPICS Slow Controls system. To start the user interface on any terminal in the Hall B Counting House, enter the command *clascss*. Fig. 5(left) shows the control panel that is launched.

To bring up the FTOF HV controls, click on the "FTOF" button on the subsystem list. This pops up a sub-menu of all Slow Controls subprograms for the FTOF system (see Fig. 5(right)). Clicking the mouse on the "FTOF HV" option brings up the HV control interface for the FTOF system as shown in Fig. 6. This interface allows for HV operations at a number of functionality levels:

- All channels in the full FTOF system
- All channels in a single FTOF sector (panel-1a, panel-1b, panel-2)
- All channels in a single sector for a given panel
- A single PMT in the FTOF system

The HV Control Interface screen (see Fig. 6) also provides a color key to indicate the channel status:

- HV off - no highlight color (channel color dark green)
- HV on - bright green
- HV ramping up or ramping down - orange
- HV trip - red

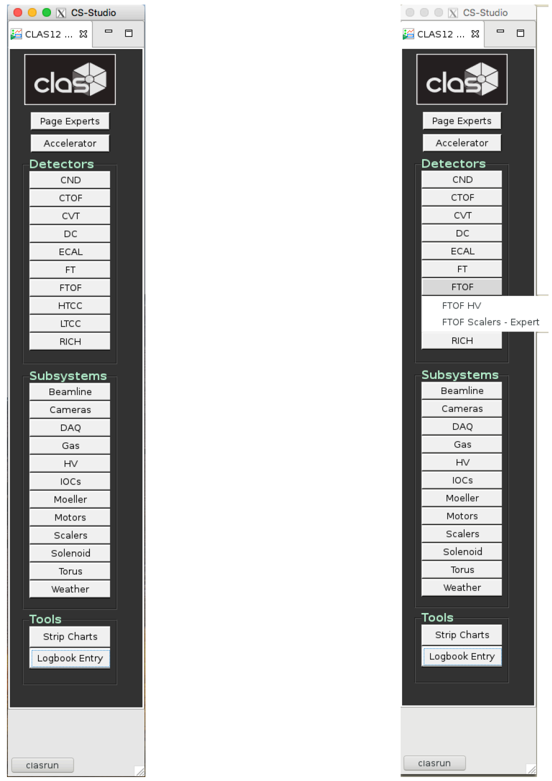

Figure 5: The CS-Studio interface used for the Slow Controls of the CLAS12 detectors and subsystems. (Left) General CLAS12 interface. (Right) Options for the FTOF system.

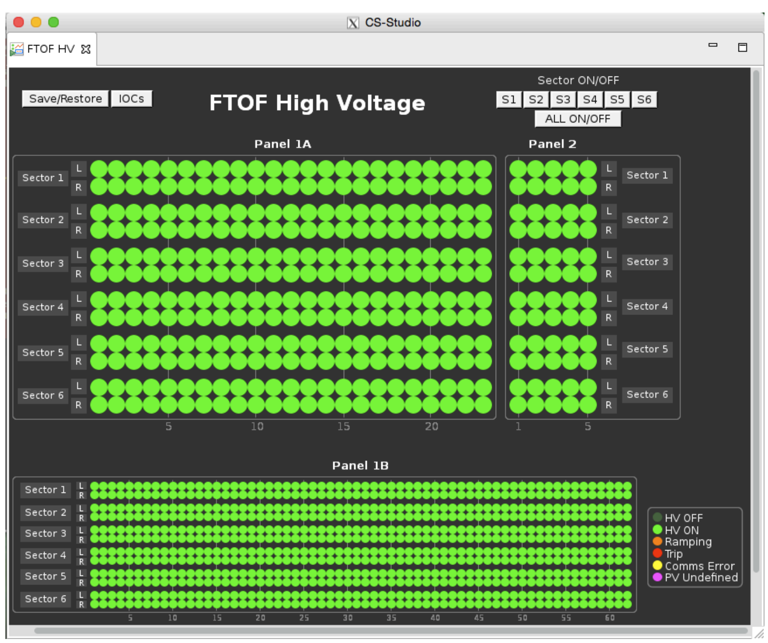

Figure 6: FTOF HV display and control interface.

- Communication problem - yellow
- Undefined channel status - magenta

For the shift worker the most common operations are:

1. To turn the HV for all system PMTs on or off. This is accomplished by clicking the button in the upper right corner "ALL ON/OFF". This pops up a sub-menu with the relevant options "Turn All Off" and "Turn All On".
2. To turn individual PMTs on or off. This is accomplished by clicking on the circle representing the channel of interest. This brings up a control screen for the channel of interest as shown in Fig. 7. Clicking on the button in the "Pw" (Power) column toggles the channel HV on and off.
3. To turn the HV for all PMTs in a single sector on or off. This is accomplished by clicking on the sector button in the upper right corner (S1 $\rightarrow$ S6) (see Fig. 6). This pops up a sub-menu with the relevant options "Turn Sector XX Off" and "Turn Sector XX On".
4. To turn the HV for all PMTs in a given panel and sector on or off. This is accomplished by clicking on the Sector button (Sector 1 $\rightarrow$ Sector 6) next to the panel of interest. This pops up a sub-menu with the relevant options as shown in Fig. 8.

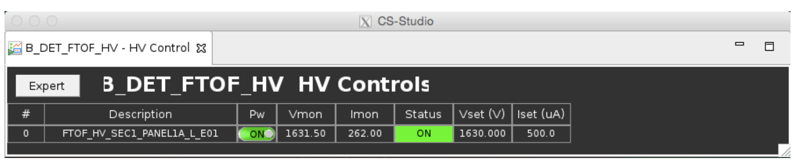

Figure 7: FTOF HV display for single channel parameters.

Note that hovering the mouse pointer on a circle representing a PMT brings up EPICS information on that channel as shown in Fig. 9.

If the "Open Channel Controls" option shown in Fig. 8 is selected, a "novice" window is opened as shown in Fig. 10. This window shows the monitored channel voltage and current (V_{mon} (V) and I_{mon} (μA)), the channel status (OFF, ON), and the set channel voltage and current (V_{set} (V) and I_{set} (μA)). If desired, shift workers can toggle the HV settings for single channels on or off through this interface.

In the upper left corner of this "Channel Controls" window is a button marked "expert" that brings up the window shown in Fig. 11. This allows changes to the system settings for the maximum channel current, maximum channel voltage setting, and the channel HV ramp up and ramp down rates. Clicking on the "novice" button in the upper left corner toggles between the expert and novice screens. The expert screen should only be used by the list of authorized FTOF personnel given in Section 5.

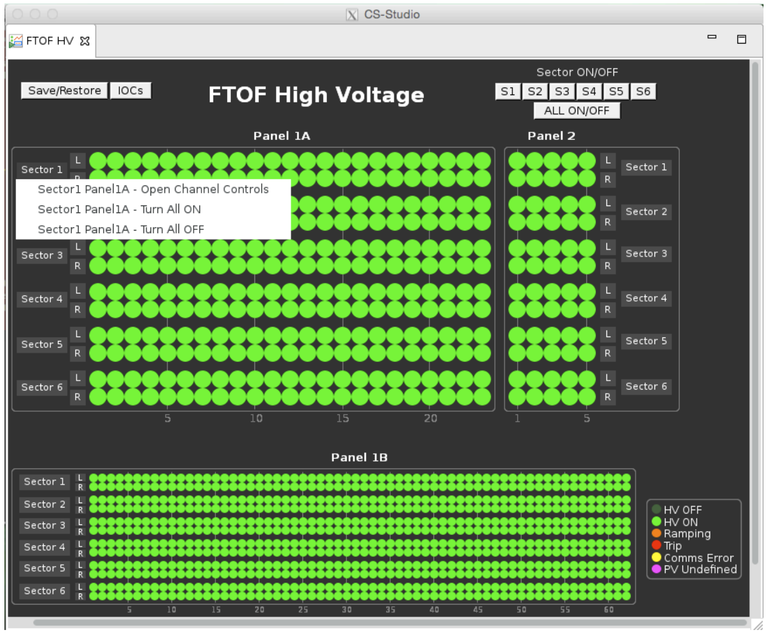

Figure 8: FTOF HV display and control interface to open channel controls for a given panel and sector.

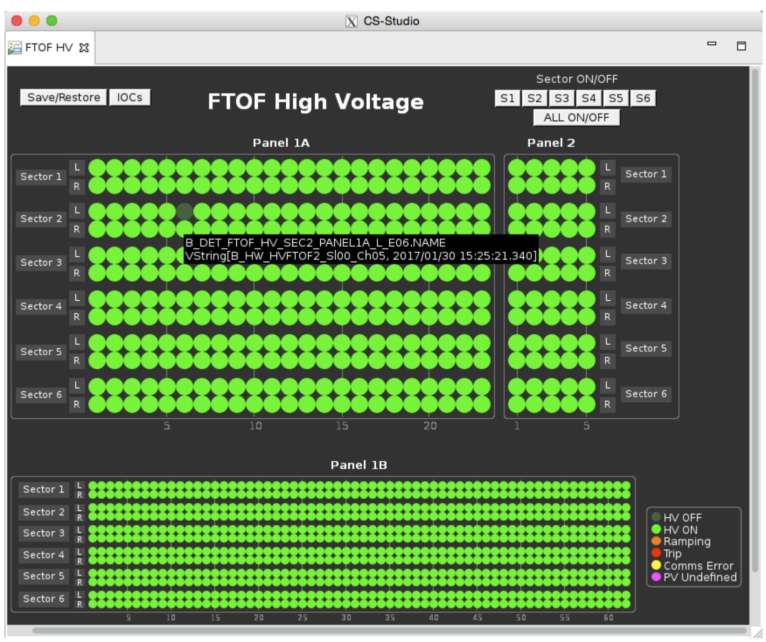

Figure 9: FTOF HV display showing the channel information when the mouse is paused over a PMT circle.

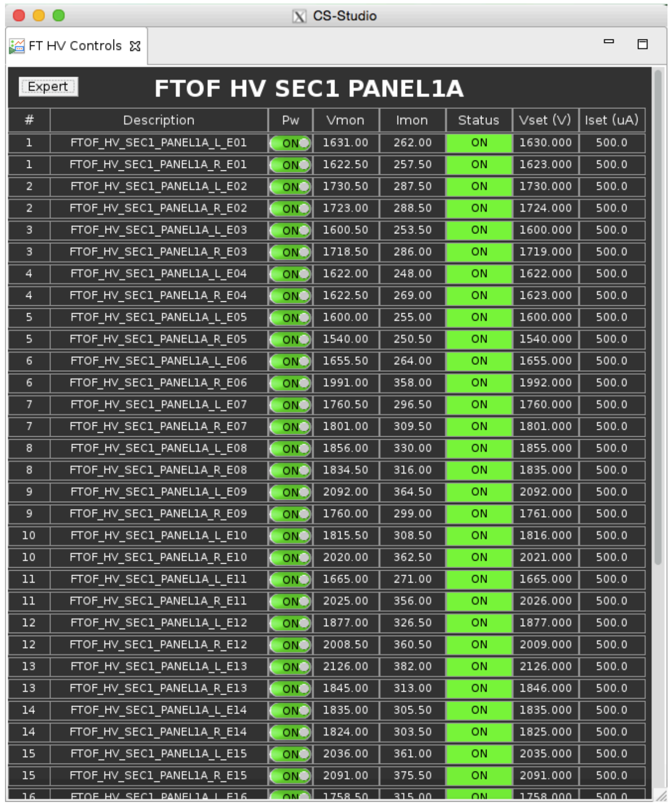

Figure 10: FTOF "novice" channel controls screen.

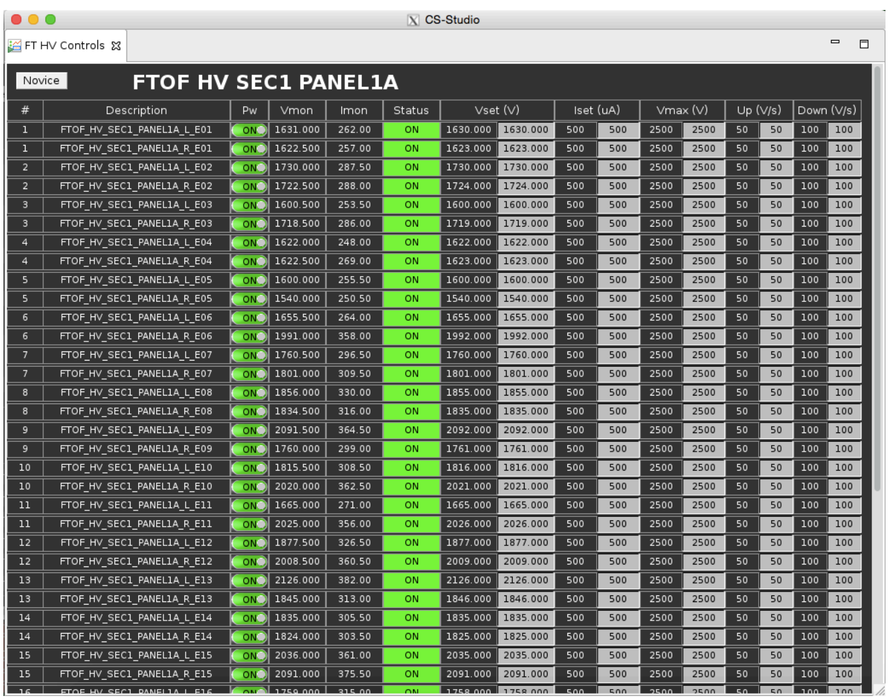

Figure 11: FTOF "expert" channel controls screen.

2.2.1 Resetting the IOCs

If there is a controls problem indicated by the appearance of yellow or magenta channels in Fig. 6, which typically appears for all PMTs in a given sector, the usual cause is an issue of communication between the IOC computer and the HV mainframe. To reboot the IOC for a given sector, click on the "IOCs" button on the Slow Controls panel within the "Subsystems" portion of the interface. Fig. 12 shows the options that appear on the sub-menu that pops up. On this menu, select "IOC Health" to open the control window shown in Fig. 13. Clicking on the "High Voltage" tab along the top of the screen brings up the screen for the IOCs that control the HV mainframes as shown in Fig. 14. Click on the "Reboot" button (under the "Soft Reboot" column) for the HV supply that has the IOC communication problem. The reboot will take less than two minutes to complete and the yellow or magenta communication problem channel indicators should all disappear. Note that the IOCs can be also rebooted through the FTOF channel control screen shown in Fig. 6. Click on the "IOCs" button in the upper left corner and then click on the "Reboot" button for the sector of interest. If rebooting the IOC does not solve the problems, contact the Slow Controls system expert.

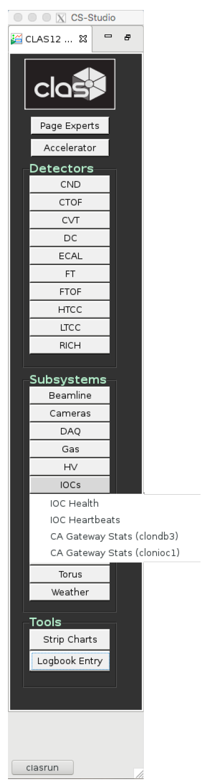

Figure 12: Sub-menu on the primary Slow Controls interface to reboot the IOCs.

2.3 Detector Monitoring

A number of monitoring tools to study the performance of the FTOF detector system have been prepared. One of the most basic and powerful tools, however, is a simple display of the

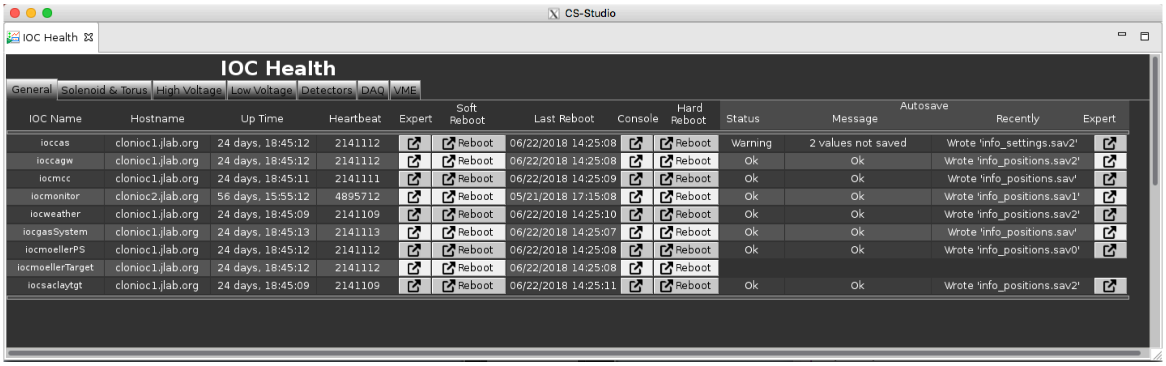

Figure 13: IOC health screen for access to all Hall B IOCs.

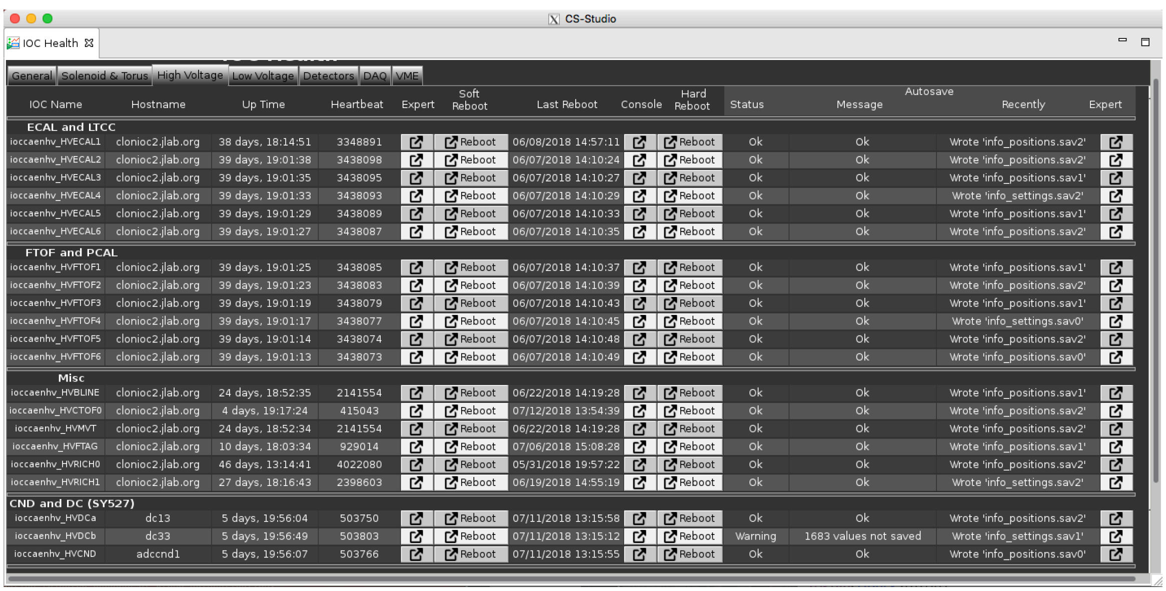

Figure 14: IOC health screen where individual IOCs that control the HV mainframes can be rebooted.

system scalers.

The primary system for viewing the FTOF scalers in the Hall B Counting House is the *mon12* utility. Typing "mon12" on any terminal in the Counting House will bring up the screen shown in Fig. 15(left).

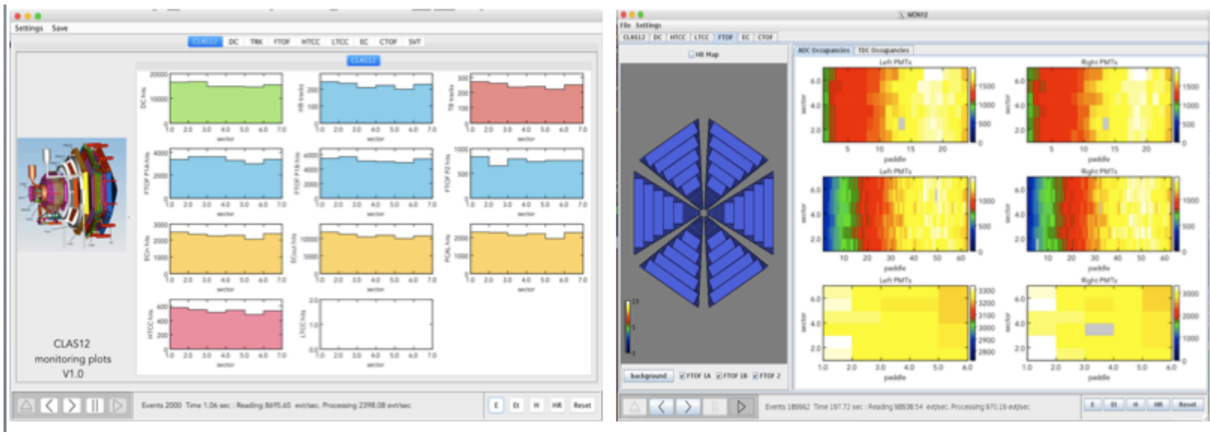

Figure 15: (Left) The main *mon12* display screen showing counts across the different CLAS12 subsystems and sectors. (Right) The FTOF scaler screen within *mon12*.

The *mon12* utility requires the data acquisition system to be operating to display the scaler counts. If a run is in progress, scaler accumulation will begin by selecting the event source (either the ET or HIPO rings or EVIO or HIPO data files in the lower right of the screen) and then clicking on the "play" button (the rightward triangle in the lower left of the screen). The FTOF scalers for panel-1a, panel-1b, and panel-2 for each sector can be viewed for either the FADCs or the discriminators on the FTOF tab by selecting the appropriate source. This brings up the FTOF *mon12* display shown in Fig. 15(right).

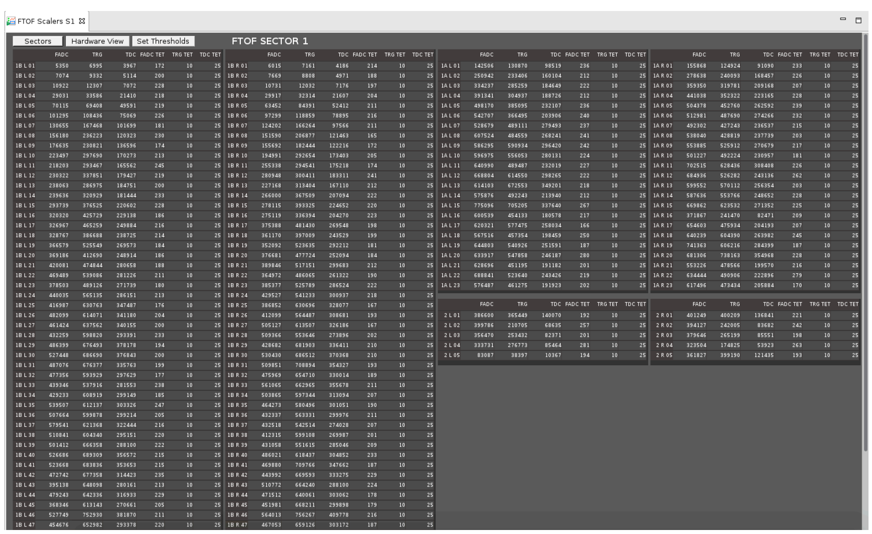

Figure 16: Scaler display for the FTOF counters from the Slow Controls system.

The second manner in which to view the FTOF system scalers is through the CLAS12 Slow Controls system. Shown in the options for the FTOF system in Fig. 5(right) is an option to view the FTOF scalers from the TDCs or FADCs. Selecting the option "FTOF Scalers - Expert" brings up a screen such as that shown in Fig. 16. This screen shows the different scaler sources separately for each sector. The sector to display is selected by clicking on the "Sectors" button in the upper left corner. A different display of the same information can be selected by clicking on the "Hardware View" button. The scalers shown in this display count independently of the data acquisition system.

The final manner in which to monitor the performance of the FTOF hardware is through the expert monitoring suite *ftofmon*. Details on this suite are provided in Section 3.1.4, however this suite is mainly intended for FTOF system experts.

3 Information for Subsystem Experts

3.1 Subsystem Expert Responsibilities

The FTOF subsystem experts have several key responsibilities:

1. Complete hot checkout sign-off before the start of each run period (see Section 3.1.1)

2. Respond to calls on the on-call phone to resolve issues with the FTOF system during data taking (see Section 3.1.2)

3. Take periodic HV gain calibration runs and adjust the system HV settings (see Section 3.1.3)

4. Monitor the system performance with the *ftofmon* expert monitoring suite (see Section 3.1.4)

5. Make repairs to the hardware during maintenance periods (see Section 3.2)

All issues found, work completed, or questions related to the FTOF system should be entered into the e-log (HBLOG and HBTOF) and communicated to the FTOF Group Leader.

3.1.1 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 [3] for each subsystem that includes a sign-off for all hardware elements of the system (e.g. HV, LV, detectors, gas, pulser). For the FTOF system, the hot checkout includes verification that all detectors are operational, that the Slow Controls system for the HV is functioning, and that the DAQ system can fully communicate with the readout electronics.

Fig. 17 shows a screenshot of the hot checkout interface. Under the heading "Hall B CLAS12 Detector", all entries for FTOF (located within the "CLAS12 TOF" subheading) must be verified as ready. Note that often as part of the system checkout before the start of a run period, an initial HV gain calibration is completed (see Section 3.1.3). Reminders to complete the system hot checkout will be sent out shortly before the start of a given run period with the required deadline for completing the work.

3.1.2 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 [4]. Any problems that cannot be quickly solved by the shift workers, where quickly amounts to 10 – 15 minutes, should result in a call to the relevant expert cell phone. The FTOF on-call phone number is (757)-344-7204.

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

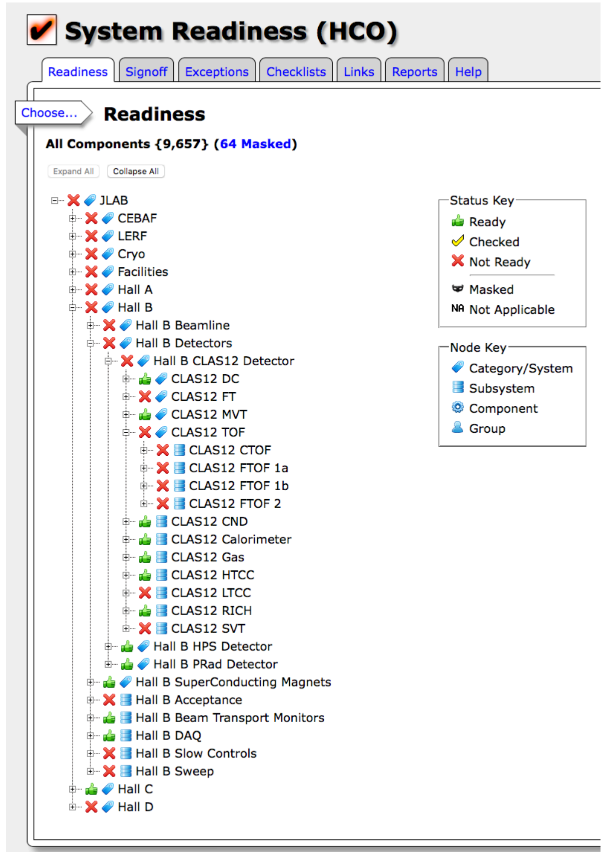

Figure 17: Screenshot of the Hall B hot checkout screen. The FTOF system appears under the "Hall B CLAS12 Detector" and "CLAS TOF" headings. All entries for FTOF have to be verified as functional and all items listed as "Not Ready" must be changed over to "Ready".

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. For the FTOF system, usually problems with a single channel are not important enough to stop the data acquisition. The normal mode of operation after initial investigation of a bad channel is to turn off the HV for that channel until access can be made for a more detailed investigation. This work should be coordinated with the Run Coordinator.

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

3.1.3 HV Gain Calibrations

The HV gain calibrations for the FTOF system are typically completed before the start of each run period, as well as several times during the run period when there is opportunity. The HV gain calibration procedure employs a cosmic ray pixel trigger defined by the Forward Carriage calorimeters. The ADC spectra for each counter are fit to determine the minimum ionizing particle peak position. The end result of the gain calibration amounts to adjusting the system HV settings to position the ADC peaks at their assigned locations corresponding to a specific PMT gain.

The calibration suite for the FTOF system is used to calibrate the PMT gains and the output is a table of PMT HV settings in the appropriate file format to be directly downloaded into the HV power supplies. This calibration suite is also used to determine the parameters to optimize the timing resolution of the system. Full documentation on using the FTOF calibration suite, including a tutorial for using the code, is included on the FTOF web page [5].

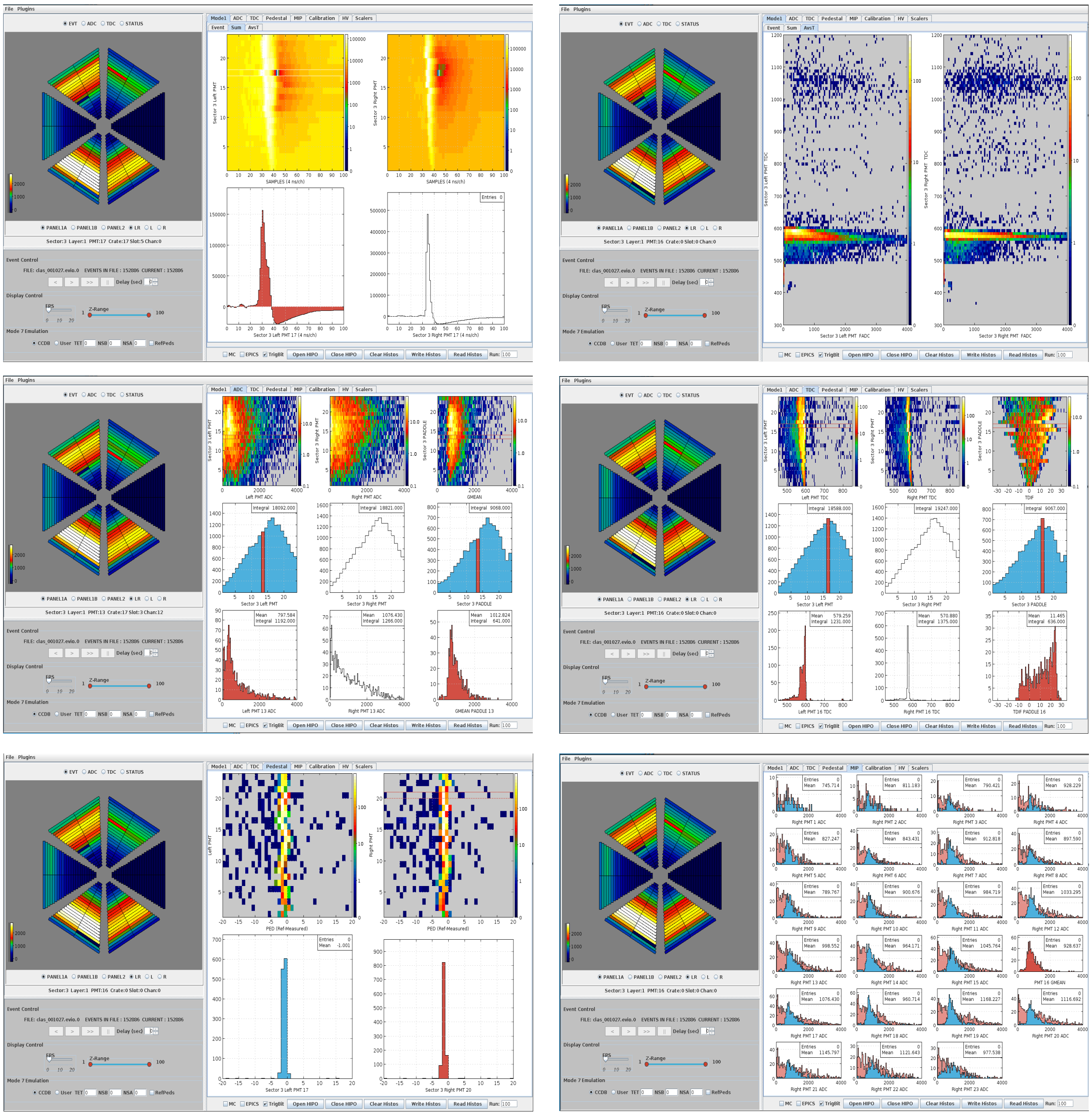

Figure 18: Various screens from the *ftofmon* expert monitoring suite.

3.1.4 Expert Monitoring Suite

The expert monitoring suite for the FTOF system is called *ftofmon*. This code suite is brought up on any Counting House computer by typing “ftofmon”. The suite allows monitoring of the following system quantities:

- FADC Mode 1 time slices
- Channel ADCs and TDCs
- Pedestal centroids and widths
- MIP responses
- HV settings
- Scalers

The suite runs from EVIO or HIPO input files or by attaching directly to the DAQ ET ring. The suite can also read and display input histogram files. Screen captures of the suite are shown in Fig. 18.

3.2 System Failure Modes

For the FTOF detector, there are a number of usual “failure” modes with which the system expert should be familiar. These include the following:

- Bad HV board (see Section 3.2.1)
- Bad HV mainframe (see Section 3.2.2)
- Sudden ADC gain shift (see Section 3.2.3)
- High PMT dark current (see Section 3.2.4)
- Missing anode or dynode signal (see Section 3.2.5)
- Bad PMT (see Section 3.2.6)
- Readout electronics issues (see Section 3.2.7)
- IOC issues (see Section 3.2.8)

3.2.1 Bad HV Board

The evidence for a bad HV board (A1535N) is either that the 24 channels associated with a single board won't ramp up to full voltage before tripping off or bad voltage regulation. For the case of bad voltage regulation, the channels ramp up to full voltage but then fluctuate about the demand voltage setting by up to several hundred volts. Before deciding whether a HV board is bad, some investigation should be completed to ensure that a single HV channel is not causing the problems with the board, which could point to a problem with the PMT or voltage divider. If a board is deemed bad and needs to be replaced, the following steps are necessary:

1. Using the HV control interface, ensure that all HV channels controlled by the mainframe are turned off. Remember that for each sector the HV mainframe for the FTOF also includes the PCAL.

2. Take a spare A1535N board from the storage area in the back room of the Counting House.

3. Turn the front panel key on the HV supply to the "off" position and toggle the main power switch to "off" on the back of the HV supply.

4. On the back of the supply, remove the Radiall connector on the bad board.

5. Pull out the bad board, being careful of the Radiall connectors on the neighboring boards.

6. Install the new board and reconnect the Radiall connector.

7. Be sure to take out the 50 Ω lemo interlock terminator from the old board and plug into the same connector on the new board.

8. Toggle the main power switch to "on" and turn the HV power supply on using the key on the front panel, putting the key in the "local" position.

9. Restore the most recent backup parameter settings for the HV mainframe described in Section 3.3.2. Note that only the parameters associated with the swapped board should need to be restored. It is important to note as well that the "BURT" backup file does not include the parameters for the maximum high voltage settings for the channel. These must be reset for the swapped out board to the nominal values (-2.5 kV for panel-1a and panel-2 channels, -2.0 kV for panel-1b channels). See instructions in Section 3.3.1. These values can also be set channel-by-channel using the FTOF expert channel controls screen discussed in Section 2.2.

10. Enter information on the new board and the old bad board into the Hall B equipment database (see the Appendix).

11. Leave the bad board on the RadCon survey table in Hall B attaching a RadCon tag with a contact listing for the Fast Electronics Group. Send an email to the Fast Electronics Group to pick up the module for testing/repairs.

12. If beam conditions are acceptable, turn on the HV for the FTOF and PCAL channels. Be sure to check with the shift leader before energizing the supply.

3.2.2 Bad Mainframe

From time to time the CAEN mainframes will go bad and need to be serviced in situ or replaced entirely with a spare. If the entire mainframe must be replaced, this can be a fairly significant undertaking and should not be considered without certainty that the problem is actually the mainframe. The final determination regarding the status of the hardware should be made in consultation with the Slow Controls expert after a number of different checks are made.

The basic procedure to swap out a mainframe is as follows:

1. Using the HV control interface, ensure that all HV channels controlled by the mainframe are turned off. Remember that for each sector the HV mainframe for the FTOF also includes the PCAL.

2. Turn the front panel key on the HV supply to the "off" position and toggle the main power switch to "off" on the back of the HV supply.

3. The modules are typically pulled out of the back of the mainframe leaving the Radiall connectors attached. Before pulling the modules from the mainframe, be sure that they are clearly labeled so that they can be put back into their assigned slots.

4. Unplug the power cord from the mainframe.

5. Remove the mainframe from the rack and place it on the RadCon survey table attaching a RadCon tag with contact information listing the Fast Electronics Group. Send email to the Fast Electronics Group to pick up the mainframe for testing/repairs.

6. Install a spare mainframe in the rack, install the boards into their assigned slots, and connect the power cord to the mainframe.

7. Toggle the main power switch to "on" and turn the HV power supply on using the key on the front panel, putting the key in the "local" position.

8. Contact the Slow Controls expert to set up communication to the mainframe.

9. When communication is restored, check the channel settings for all boards to be sure that they are correct before turning on the HV. If there are questions regarding the PCAL settings, contact the ECAL expert. As the channel settings are stored on the individual boards, the parameters should restored without user intervention. However, if necessary, restore the parameter settings as described in Section 3.3.2, making sure that the maximum high voltage limits for each channel are correct (-2.5 kV for panel-1a and panel-2, -2.0 kV for panel-1b).

10. If beam conditions are acceptable, turn on the HV for the FTOF and PCAL channels. Be sure to check with the shift leader before energizing the supply.

3.2.3 Sudden Gain Shift

Sometimes a sudden gain shift can appear in the ADC spectrum for a given counter. There are a number of possible causes for such a condition.

- Problematic PMT/Voltage Divider - sometimes gain shifts can be attributed to a problem with a PMT or voltage divider that requires adjustment of the HV settings. Of course, PMT aging effects also typically lead to a reduced gain that requires an increase of the HV. Such issues are typically seen as slow drifts of the response with time.
- DAQ Problems - the most common cause for an apparent sudden gain shift in the ADC spectra for a counter is due to problems with the FADC settings. Such problems can typically be diagnosed from pedestal shifts or widened pedestals. The pedestals can be checked by taking FADC data in "raw mode" using the *ftofmon* system monitoring suite (see Section 3.1.4). Note that as the panel-1a and panel-2 dynode signal used for the FADC inputs are bipolar pulses (see Section 3.2.5), issues with shifts in the signal summing region can have a dramatic impact on the FADC spectra.
- Bad Inverters - the panel-1b dynode signals, which are used for the input to the FADCs, are nominally positive polarity pulses that are sent through an in-line inverter attached to the Forward Carriage patch panel (see Section 3.4.2). These inverters occasionally go bad and can be diagnosed comparing the signal on either side of the inverter. Bad inverters should be replaced with new spare inverters contained in the FTOF storage cabinets on the upper level of the Pie Tower.
- Light Leak - it is possible that a gain shift can be due to a light leak on the counter. Note that issues with hardware damage are less likely for the panel-1a and panel-1b counters as they are buried between the LTCC/RICH detectors and the calorimeters. Of course, the panel-2 counters are more exposed and hardware issues can either be explored by looking at signals or measuring dark currents at the voltage dividers, the local disconnect patch panels, or the electronics patch panels. The panel-2 detectors themselves can be explored using access with manlifts as necessary, coordinating work through the Run Coordinator and the Hall B Work Coordinator.
- PMT Saturation - In conditions of excessively high rates, the PMT can become current limited and the ADC signals can become distorted and shifted to lower gains. Be sure that bad beam or high rate conditions are not responsible for the issues seen.

3.2.4 High PMT Dark Current

High PMT dark currents can be seen through increased counting rates in the channel scaler displays or in distorted ADC spectra. The dark currents can be measured at either the local disconnect or the electronics patch panels. There are three likely causes for high PMT dark currents:

1. Bad PMT - At times when a PMT goes bad, its dark current can increase. Typical FTOF PMT dark currents are at the level of 50 nA or less. If a bad PMT has been identified, it can only be worked on during designated FTOF servicing periods. However, the usual procedure is to leave the PMT energized and live with the increased dark current unless the higher currents cause the HV supply channel to trip or the HV board to become unstable. If the channel HV needs to be "turned off", change V_{set}=0. The logbook should be updated and the HV setting configuration should be saved as the nominal setting.

2. Light Leak - A light leak in the counter wrapping will also lead to higher dark currents. The issue of light leaks is not expected to be an issue for the panel-1a and panel-1b counters as they are buried within the detectors on the Forward Carriage and ambient light levels are usually very low. However, the panel-2 counters are more exposed. Light leaks can be repaired during opportunities when the Forward Carriage is moved away from the torus magnet into its maintenance position.

3. Reflective Layer Wrapping Problems (panel-1b only) - There is an issue with the wrapping of the reflective layer on some of the panel-1b counters that has been seen to lead to "super-hot" PMTs, with dark currents up to 100 μA. There are several PMTs that have a history of showing such high currents, but occasionally a PMT that had been operating without issue, can suddenly show very large currents. Sometimes the current draw will monotonically reduce over the period of several hours. These PMTs will remain at low currents as long as the HV is not turned off. Sometimes, the currents remain high regardless of how long they are energized. In such cases, judgment should be exercised as to whether to leave the channel on or off. If the channel is turned off (by changing V_{set}=0), the HV setting configuration should be updated and saved.

3.2.5 Missing Anode or Dynode Signal

Each FTOF PMT has two signal outputs, an anode and a dynode. On average, the anode signal is roughly three times larger in amplitude compared to its corresponding dynode signal. For the PMTs of panel-1a and panel-2, the anode is a negative polarity signal and the dynode is a bi-polar signal (negative polarity primary pulse with a positive polarity overshoot and tail). For the panel-1b PMTs, the anode is a negative polarity pulse and the dynode is a positive polarity pulse. Note that in-line signal inverters at the Forward Carriage patch panels invert the panel-1b dynode pulse polarity to be negative. Scope images of representative FTOF PMT anode and dynode pulses are shown in Fig. 19.

Occasionally a signal will disappear from the FTOF monitoring plots. In such a situation, further investigation will be necessary.

- If both anode and dynode signals are missing, this could be due either to a problem with the HV, the VME crate (which would affect and entire board or entire sector), or the PMT itself. If the problem is with the HV board, it should be replaced as detailed in Section 3.2.1. PMT problems are typically apparent as the nominal PMT signal (see Fig. 19) is absent, severely distorted, or replaced by high frequency noise.

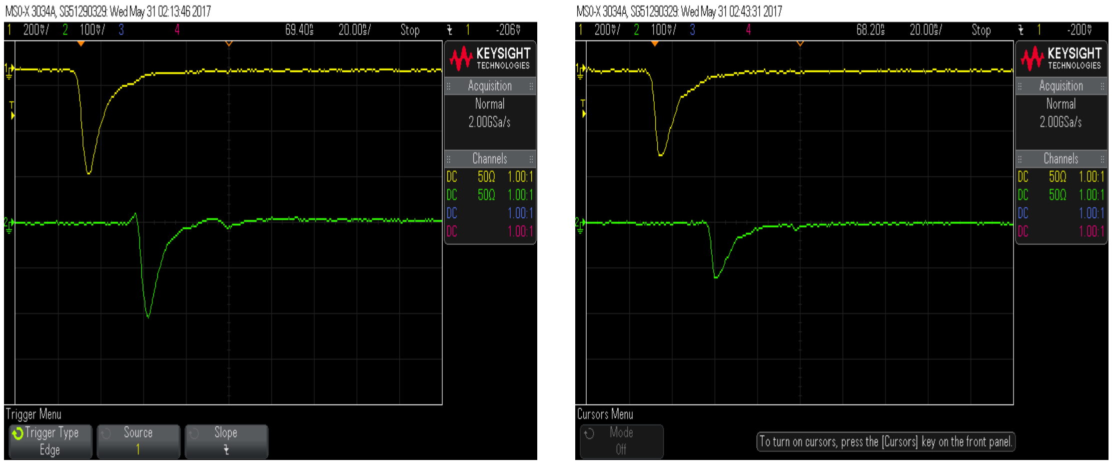

Figure 19: Scope traces for anodes (yellow) and dynodes (green) for typical PMT pulses for panel-1a (left) and panel-1b (right).

- If one signal (anode or dynode) is present for the PMT and the other is missing, this could be a bad cable connection anywhere from the voltage divider to the input to the electronics. The way to diagnose is to use an oscilloscope to look at the signal at each accessible junction point. If the signal is missing from the monitoring data but is seen to be good at the input to the FADC and TDC, contact the DAQ expert for help.

- If the dynode signal is missing from panel-1b, this is likely caused by a bad signal inverter (see Section 3.2.3).

- If either the anode or dynode signal is missing from a panel-1a or panel-2 PMT and the cabling checks out, the problem is likely due to a bad component on the voltage divider. In such a case the channel must be "turned off" by setting $V_{set} = 0$ (with HV channel parameters updated - see Section 3.3.2). Repairs can only be made during a designated FTOF repair cycle.

- If the PMT HV is on but the supply current reads 0, this is likely due to a bad HV cable or connection, or an issue with the HV distribution box.

- Groups of missing signals for consecutive electronics channels are likely due to an unplugged or partially unplugged ribbon cable at the input to TDCs or the output from the discriminators.

3.2.6 Bad PMT

One of the most common failure modes of a PMT is a gradual loss of gain over the period of several years. This can be compensated by adjusting the HV to maintain the gain setting. The PMTs used in the FTOF system have maximum voltage ratings of -2500 V for the PMTs in panel-1a and panel-2, and -2000 V for the PMTs in panel-1b. Once the PMT HV is set to its maximum value and the gain falls below the nominal setting, the PMT should be flagged for replacement during the next servicing opportunity.

3.2.7 Readout Electronics Issues

Readout electronics issues, typically associated with all channels associated with a given discriminator board, TDC board, or FADC board, once diagnosed should be brought to the attention of the DAQ system expert for further diagnosis and attention.

3.2.8 IOC Issues

Loss of communication between the IOC and the HV mainframe is seen by a yellow or magenta color status for all HV channels in a given sector. The IOC should be rebooted following the instructions given in Section 2.2.1. If rebooting the IOC does not solve the problems, contact the Slow Controls system expert.

3.3 HV System Operations

3.3.1 Setting HV Channel Parameters

The CS-Studio program is used to monitor the HV settings of the FTOF system and to toggle the HV off and on for individual or multiple channels in the system. To set the channel values, restore the most recent saved "BURT" backup file (see Section 3.3.2 for details). Note as well that the channel parameters can also be set using control scripts. From the computers in the Hall B Counting House, the scripts are in the sector subdirectories located in the path: */home/clasrun/ftof/hv/sn*, with $n = 1 \to 6$ for FTOF S1 $\to$ S6. There are seven scripts available for each FTOF sector:

- *loadhvmax-sn*: Contains the maximum HV limits for each supply channel (units = V)
- *loadi0-sn*: Contains the maximum current limits for each supply channel (units = μA)
- *loadpw0-sn*: Turns all FTOF channels off
- *loadpw1-sn*: Turns all FTOF channels on
- *loadrup-sn*: Sets the voltage ramp up rates for each supply channel (units = V/s)
- *loadrdn-sn*: Sets the voltage ramp down rates for each supply channel (units = V/s)
- *loadtrip-sn*: Sets the maximum time duration for an overcurrent condition before the channel trips (units = s)

The scripts are run from any of the DAQ machines in the Counting House (using e.g the commands *sh loadhvmax-s1* or *./loadhvmax-s1*).

The nominal settings for the HV channel parameters are as follows:

- HV_{max} values: panel-1a, panel-2: -2500 V, panel-1b: -2000 V
- i_{max} values: 500 μA
- HV ramp up rate: 50 V/s

- HV ramp down rate: 100 V/s
- Overcurrent duration before trip: 1 s

The scripts to set the channel HV values are created by the HV calibration program. Before changing the HV values for any channel in the FTOF system, the existing parameter settings must be saved to a backup file (see Section 3.3.2).

Although not the recommended way to set the HV supply channel parameters, there is the option to adjust settings channel-by-channel using the HV "expert" screen shown in Fig. 11. Here the parameters, V_{set}, I_{set}, V_{max}, and the HV ramp up and ramp down rates, can be entered directly into the parameter field. However, it is imperative that the script settings detailed above be kept fully up to date as they represent the system archive values. This "expert" screen should most properly be used only for viewing the channel parameter set values.

3.3.2 HV Save and Restore

The FTOF HV interface allows all system channel settings (except for the maximum channel HV settings) to be saved into a file or loaded from an archived file by clicking on the "Save/Restore" button in the upper left corner of the main HV screen (see Fig. 6). The files created are referred to as "BURT" backup files, where BURT is an acronym for "Backup and Restore Tool". BURT is a utility for saving the HV system settings into an ASCII file readable by the EPICS Slow Controls system. The save files are stored on the DAQ machines in the Hall B Counting House at: */usr/clas12/DATA/burt/FTOF_HV*.

After clicking on the "Save/Restore" button, a sub-menu appears as shown in Fig. 20 to select "Save Settings" or "Restore Settings". Clicking on "Save Settings" brings up a window "CREATE HV BACKUP" as shown in Fig. 21 showing the save file path and the selected file name that contains the system name along with the date and time. If the "Restore Settings" option is chosen, the window shown in Fig. 22 comes up showing the saved FTOF HV restore files available from which to select. Selecting a file and clicking on "OK" at the bottom of the window loads all channel parameters for the full HV system. Note that a new backup file should be created whenever any HV settings have changed, including HV values, channel parameter settings, and channel on/off settings.

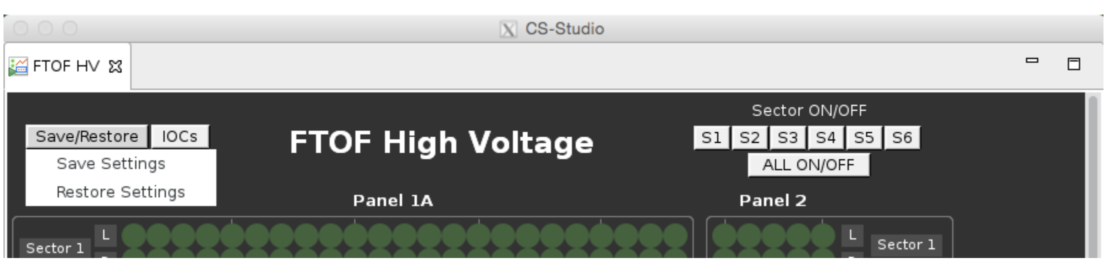

Figure 20: Sub-menu of the FTOF HV control screen for "Save/Restore".

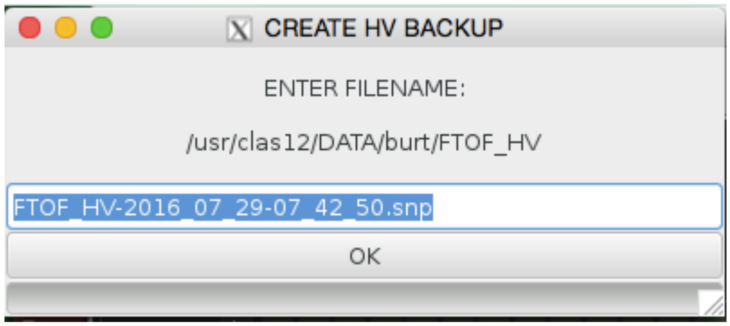

Figure 21: Window that comes up after selecting "Save Settings" during a "Save/Restore" operation (see in Fig. 5(right)).

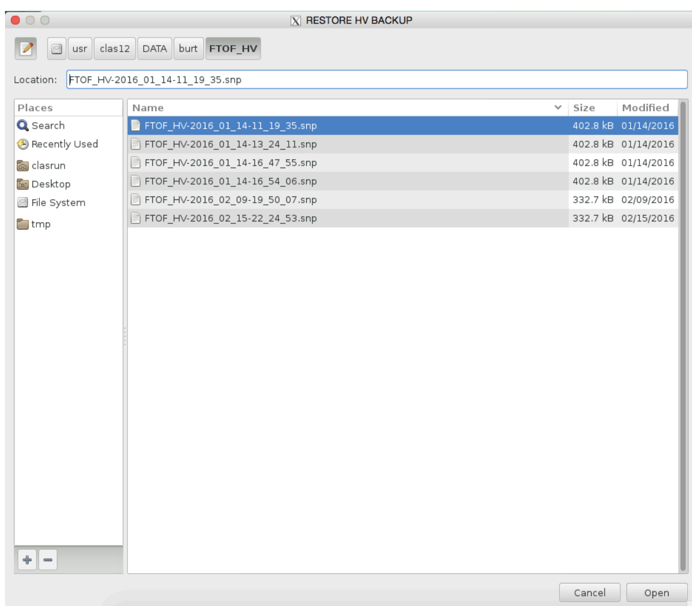

Figure 22: Window that comes up after selecting "Restore Settings" during a "Save/Restore" operation (see in Fig. 5(right)).

3.4 Cabling Details

3.4.1 Signal Cable Maps

The FTOF channel connections to the VME readout electronics are mapped in such a way that neighboring PMTs are not connected to neighboring electronics inputs. This scheme was devised to reduce any electronics noise coupling (i.e. cross-talk). The VME electronics channel mapping is shown in Fig. 23 for the FADCs, in Fig. 24 for the discriminators, and in Fig. 25 for the TDCs.

3.4.2 Signal Cable Layout

The anode and dynode signal cables for each PMT run from the voltage divider to a local disconnect patch panel located behind the panel-2 arrays in each sector. A schematic diagram of this patch panel is shown in Fig. 26. These cables vary in length from 12 ft to 23.25 ft. Note that there are two local disconnect patch panels for each FTOF sector, one for the left anode and dynode cables and one for the right anode and dynode cables. The signal cables for each sector are then strung to the Forward Carriage electronics to a second set of patch panels via 35 ft-long cables. A schematic diagram of these so-called electronics patch panels is shown in Fig. 27. The signals are then run from these patch panels to the discriminators (for the anode signals) and to the FADCs (for the dynode signals) via 5 ft-long cables. Note, as stated in Section 3.2.5, the dynode signals for panel-1b emerge with positive polarity from the voltage dividers. To invert the signal polarity to be compatible with the readout electronics, an in-line inverting transformer (Phillips Scientific Model #460) is connected to the electronics patch panel for each channel. Figs. 30 and 31 in Section 3.4.5 give schematics for the cable and connector types for each segment of the connections from the voltage divider to the readout electronics for the counters in FTOF panel-1a, panel-1b, and panel-2.

3.4.3 HV Cable Layout

The high voltage cables for each PMT run from the voltage divider to a local disconnect HV distribution box located behind the panel-2 arrays in each sector next to the signal cable local disconnect patch panels. Note that there are four HV distribution boxes for each sector, two for the left PMTs and two for the right PMTs of each sector. Fig. 28 shows the layout of the two HV distribution boxes for the left and right PMT HV connections (with left and right defined as in Fig. 2). The output of each HV distribution box is a pair of 35-ft-long multi-conductor cables, each containing 24-channels, with a Radiall connector to mate with the HV A1535N board input connector. See Figs. 30 and 31 in Section 3.4.5 for schematics of the cable and connector types for each segment of the HV connections from the voltage divider to the HV power supplies for the counters in FTOF panel-1a, panel-1b, and panel-2. The HV power supply channel assignments for each sector are nominally given as shown in Fig. 29.

3.4.4 Altering Cable Maps

The nominal procedure if there is a problem with a VME electronics board is to replace the board with a spare unit. However, for testing purposes, it might be necessary to change a

FTOF FADC MAP

#	slot 2	slot 3	slot 4	slot 5	slot 6	slot 7	slot 8	slot 9	slot 10	slot 11	slot 12	slot 13	slot 14	slot 15	slot 16	slot 17	slot18		slot 20
15		15R	16R			15R	16R	31R	32R			47R	48R						
14		13R	14R	5R		13R	14R	29R	30R			45R	46R	61R	62R				
13		15L	16L			15L	16L	31L	32L			47L	48L						
12		13L	14L	5L		13L	14L	29L	30L			45L	46L	61L	62L				
11		11R	12R	3R	4R	11R	12R	27R	28R			43R	44R	59R	60R				
10		9R	10R	1R	2R	9R	10R	25R	26R			41R	42R	57R	58R				
9		11L	12L	3L	4L	11L	12L	27L	28L			43L	44L	59L	60L				
8		9L	10L	1L	2L	9L	10L	25L	26L			41L	42L	57L	58L				
7		7R	8R	23R		7R	8R	23R	24R			39R	40R	55R	56R				
6		5R	6R	21R	22R	5R	6R	21R	22R			37R	38R	53R	54R				
5		7L	8L	23L		7L	8L	23L	24L			39L	40L	55L	56L				
4		5L	6L	21L	22L	5L	6L	21L	22L			37L	38L	53L	54L				
3		3R	4R	19R	20R	3R	4R	19R	20R			35R	36R	51R	52R				
2		1R	2R	17R	18R	1R	2R	17R	18R			33R	34R	49R	50R				
1		3L	4L	19L	20L	3L	4L	19L	20L			35L	36L	51L	52L				
0		1L	2L	17L	18L	1L	2L	17L	18L			33L	34L	49L	50L				

ftof-fadc-map.xlsx

Modified: December 12, 2013

panel-1a

panel-1b

panel-2

Figure 23: Electronics map for each sector for the input connections to the FTOF VME FADCs.

FTOF DISCRIMINATOR MAP

#	slot 2	slot 3	slot 4	slot 5	slot 6	slot 7	slot 8	slot 9	slot 10	slot 11	slot 12	slot 13	slot 14	slot 15	slot 16	slot 17	slot18	slot 19	slot 20
1	1L		2L	17L		18L	1L		2L		17L		18L	33L		34L	49L		50L
2	3L		4L	19L		20L	3L		4L		19L		20L	35L		36L	51L		52L
3	1R		2R	17R		18R	1R		2R		17R		18R	33R		34R	49R		50R
4	3R		4R	19R		20R	3R		4R		19R		20R	35R		36R	51R		52R
5	5L		6L	21L		22L	5L		6L		21L		22L	37L		38L	53L		54L
6	7L		8L	23L			7L		8L		23L		24L	39L		40L	55L		56L
7	5R		6R	21R		22R	5R		6R		21R		22R	37R		38R	53R		54R
8	7R		8R	23R			7R		8R		23R		24R	39R		40R	55R		56R
9	9L		10L	1L		2L	9L		10L		25L		26L	41L		42L	57L		58L
10	11L		12L	3L		4L	11L		12L		27L		28L	43L		44L	59L		60L
11	9R		10R	1R		2R	9R		10R		25R		26R	41R		42R	57R		58R
12	11R		12R	3R		4R	11R		12R		27R		28R	43R		44R	59R		60R
13	13L		14L	5L			13L		14L		29L		30L	45L		46L	61L		62L
14	15L		16L				15L		16L		31L		32L	47L		48L			
15	13R		14R	5R			13R		14R		29R		30R	45R		46R	61R		62R
16	15R		16R				15R		16R		31R		32R	47R		48R			
	DISC	TDC	DISC	DISC	TDC	DISC	DISC	TDC	DISC		DISC	TDC	DISC	DISC	TDC	DISC	DISC		DISC

ftof-disc-map-v2.xlsx

Modified: February 11, 2016

panel-1a

panel-1b

panel-2

Figure 24: Electronics map for each sector for the input connections to the FTOF VME discriminators.

FTOF TDC MAP

slot 2	slot 3		slot 4	slot 5	slot 6		slot 7	slot 8	slot 9		slot 10	slot 11	slot 12	slot 13		slot 14	slot 15	slot 16				slot 17	slot 18	slot 19	slot 20
	15R	16R			15R	16R			31R	32R				47R	48R										
	13R	14R			13R	14R			29R	30R				45R	46R			5R		61R	62R				
	15L	16L			15L	16L			31L	32L				47L	48L										
	13L	14L			13L	14L			29L	30L				45L	46L			5L		61L	62L				
	11R	12R			11R	12R			27R	28R				43R	44R			3R	4R	59R	60R				
	9R	10R			9R	10R			25R	26R				41R	42R			1R	2R	57R	58R				
	11L	12L			11L	12L			27L	28L				43L	44L			3L	4L	59L	60L				
	9L	10L			9L	10L			25L	26L				41L	42L			1L	2L	57L	58L				
	7R	8R			7R	8R			23R	24R				39R	40R			23R		55R	56R				
	5R	6R			5R	6R			21R	22R				37R	38R			21R	22R	53R	54R				
	7L	8L			7L	8L			23L	24L				39L	40L			23L		55L	56L				
	5L	6L			5L	6L			21L	22L				37L	38L			21L	22L	53L	54L				
	3R	4R			3R	4R			19R	20R				35R	36R			19R	20R	51R	52R				
	1R	2R			1R	2R			17R	18R				33R	34R			17R	18R	49R	50R				
	3L	4L			3L	4L			19L	20L				35L	36L			19L	20L	51L	52L				
	1L	2L			1L	2L			17L	18L				33L	34L			17L	18L	49L	50L				
	0:15	16:31			0:15	16:31			0:15	16:31				0:15	16:31			A:0-15	A:16-31	B:0-15	B:16-31				
DISC	TDC		DISC	DISC	TDC		DISC	DISC	TDC		DISC		DISC	TDC		DISC	DISC	LR TDC (128 ch)				DISC	DISC		DISC

ftof-tdc-map.xlsx

Modified: July 25, 2017

LR TDC low resolution TDC

panel-1a

panel-1b

panel-2

Figure 25: Electronics map for each sector for the input connections to the FTOF VME TDCs.

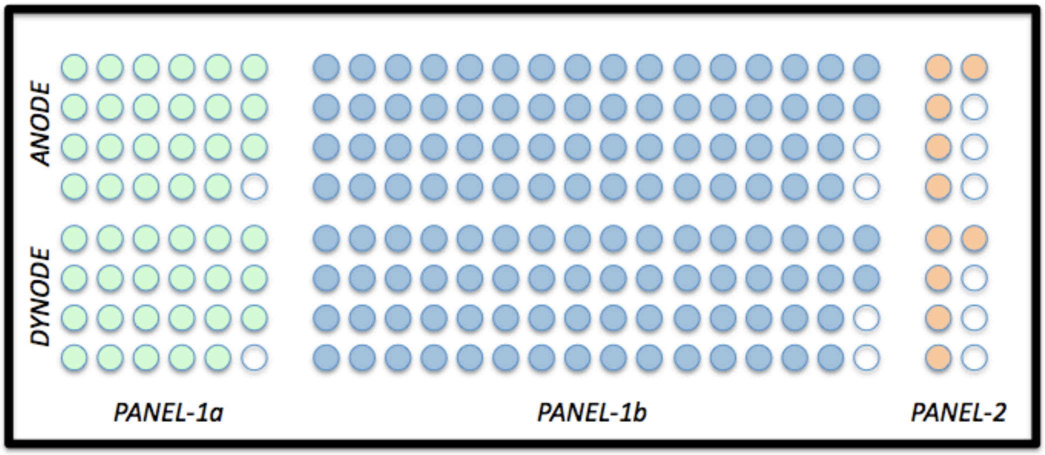

Figure 26: Schematic of the signal cable local disconnect patch panels positioned just behind the panel-2 FTOF counters for each Forward Carriage sector. For each sector there are two such patch panels associated with the left and the right sides of the counter (as defined in Fig. 2). The white filled circles are unused connectors.

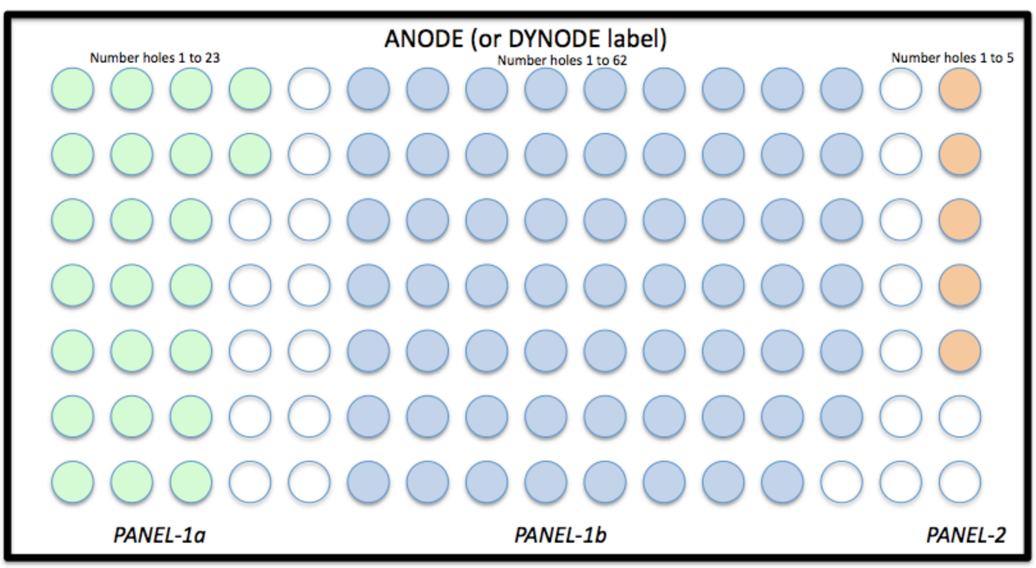

Figure 27: Schematic of the signal cable electronics patch panel located on the Forward Carriage. There are four such panels for each sector for the anode left/right and dynode left/right connections. The white filled circles are unused connections.

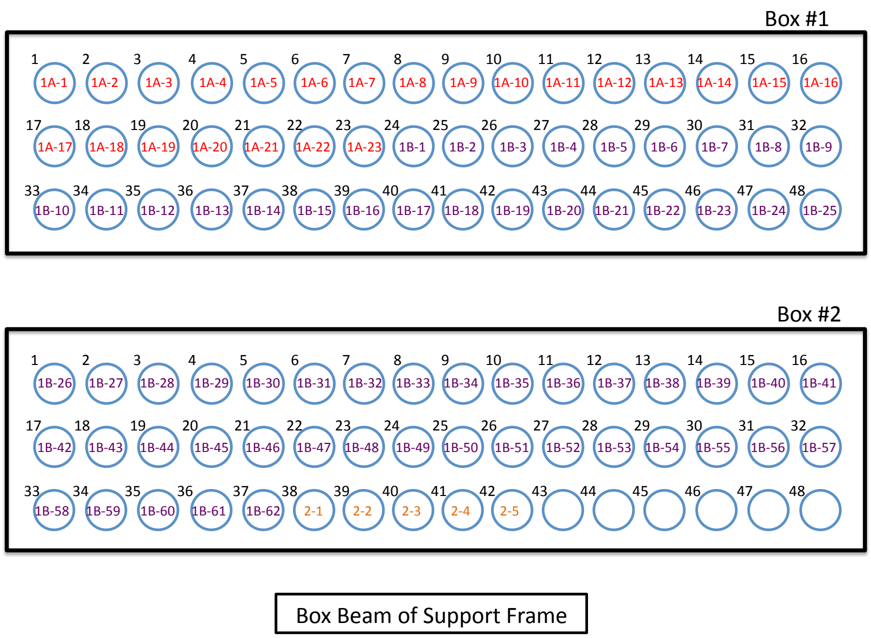

Figure 28: Mapping of the HV channel connections to the HV distribution boxes for each sector. Each sector is connected to four HV distribution boxes, two for the left side PMTs and two for the right side PMTs. Note: The box beam that supports the panel-2 arrays and the patch panels themselves is located under the second box.

FTOF HV Mapping

ftof-hvmap.xlsx

1/6/16

Slot / Ch	Det.	Slot / Ch	Det.	Slot / Ch	Det.	Slot / Ch	Det.	Slot / Ch	Det.	Slot / Ch	Det.	Slot / Ch	Det.	Slot / Ch	Det.
0:00	1a-1L	1:00	1b-2L	2:00	1b-26L	3:00	1b-50L	4:00	1a-1R	5:00	1b-2R	6:00	1b-26R	7:00	1b-50R
0:01	1a-2L	1:01	1b-3L	2:01	1b-27L	3:01	1b-51L	4:01	1a-2R	5:01	1b-3R	6:01	1b-27R	7:01	1b-51R
0:02	1a-3L	1:02	1b-4L	2:02	1b-28L	3:02	1b-52L	4:02	1a-3R	5:02	1b-4R	6:02	1b-28R	7:02	1b-52R
0:03	1a-4L	1:03	1b-5L	2:03	1b-29L	3:03	1b-53L	4:03	1a-4R	5:03	1b-5R	6:03	1b-29R	7:03	1b-53R
0:04	1a-5L	1:04	1b-6L	2:04	1b-30L	3:04	1b-54L	4:04	1a-5R	5:04	1b-6R	6:04	1b-30R	7:04	1b-54R
0:05	1a-6L	1:05	1b-7L	2:05	1b-31L	3:05	1b-55L	4:05	1a-6R	5:05	1b-7R	6:05	1b-31R	7:05	1b-55R
0:06	1a-7L	1:06	1b-8L	2:06	1b-32L	3:06	1b-56L	4:06	1a-7R	5:06	1b-8R	6:06	1b-32R	7:06	1b-56R
0:07	1a-8L	1:07	1b-9L	2:07	1b-33L	3:07	1b-57L	4:07	1a-8R	5:07	1b-9R	6:07	1b-33R	7:07	1b-57R
0:08	1a-9L	1:08	1b-10L	2:08	1b-34L	3:08	1b-58L	4:08	1a-9R	5:08	1b-10R	6:08	1b-34R	7:08	1b-58R
0:09	1a-10L	1:09	1b-11L	2:09	1b-35L	3:09	1b-59L	4:09	1a-10R	5:09	1b-11R	6:09	1b-35R	7:09	1b-59R
0:10	1a-11L	1:10	1b-12L	2:10	1b-36L	3:10	1b-60L	4:10	1a-11R	5:10	1b-12R	6:10	1b-36R	7:10	1b-60R
0:11	1a-12L	1:11	1b-13L	2:11	1b-37L	3:11	1b-61L	4:11	1a-12R	5:11	1b-13R	6:11	1b-37R	7:11	1b-61R
0:12	1a-13L	1:12	1b-14L	2:12	1b-38L	3:12	1b-62L	4:12	1a-13R	5:12	1b-14R	6:12	1b-38R	7:12	1b-62R
0:13	1a-14L	1:13	1b-15L	2:13	1b-39L	3:13	2-1L	4:13	1a-14R	5:13	1b-15R	6:13	1b-39R	7:13	2-1R
0:14	1a-15L	1:14	1b-16L	2:14	1b-40L	3:14	2-2L	4:14	1a-15R	5:14	1b-16R	6:14	1b-40R	7:14	2-2R
0:15	1a-16L	1:15	1b-17L	2:15	1b-41L	3:15	2-3L	4:15	1a-16R	5:15	1b-17R	6:15	1b-41R	7:15	2-3R
0:16	1a-17L	1:16	1b-18L	2:16	1b-42L	3:16	2-4L	4:16	1a-17R	5:16	1b-18R	6:16	1b-42R	7:16	2-4R
0:17	1a-18L	1:17	1b-19L	2:17	1b-43L	3:17	2-5L	4:17	1a-18R	5:17	1b-19R	6:17	1b-43R	7:17	2-5R
0:18	1a-19L	1:18	1b-20L	2:18	1b-44L	3:18		4:18	1a-19R	5:18	1b-20R	6:18	1b-44R	7:18	
0:19	1a-20L	1:19	1b-21L	2:19	1b-45L	3:19		4:19	1a-20R	5:19	1b-21R	6:19	1b-45R	7:19	
0:20	1a-21L	1:20	1b-22L	2:20	1b-46L	3:20		4:20	1a-21R	5:20	1b-22R	6:20	1b-46R	7:20	
0:21	1a-22L	1:21	1b-23L	2:21	1b-47L	3:21		4:21	1a-22R	5:21	1b-23R	6:21	1b-47R	7:21	
0:22	1a-23L	1:22	1b-24L	2:22	1b-48L	3:22		4:22	1a-23R	5:22	1b-24R	6:22	1b-48R	7:22	
0:23	1b-1L	1:23	1b-25L	2:23	1b-49L	3:23		4:23	1b-1R	5:23	1b-25R	6:23	1b-49R	7:23	

1a = panel-1a
1b = panel-1b
2 = panel-2

The layout of the 6 FTOF HV crates (one for each sector) is identical

Figure 29: HV mainframe FTOF channel assignments for each sector.

signal input at the FADC, discriminator, or TDC to an unused channel. This work must always be done in coordination with the DAQ system expert in order to update the channel map used as input to the translation table. This operation is not something that is normally done and should not be attempted by shift workers or FTOF experts as it could lead to problems decoding the data.

Problems with channels within the HV system are more common issues as channels on the HV distribution box or on a A1535N card are reasonably common. The standard procedure when there is a problem with a CAEN HV board is to swap out the problematic board with a spare (see Section 3.2.1). If there is a problem on the HV distribution box on either the left or right side of a sector, there are six spare HV channels that are available. These are detailed in Section 3.4.3. If one of these spare channels is to be used, the first step before disconnecting any system HV cables is to be sure that the channel HV is turned off for the channel to be moved. The SHV cable can then be moved to one of the open connectors on the HV distribution box shown in Fig. 28. In order to update the HV channels map, contact the Slow Controls expert.

3.4.5 Cable Connections

In order to better understand the signal and high voltage cabling scheme for the FTOF system, Figs. 30 and 31 show for panel-1a, panel-1b, and panel-2 the cable and connection types from the counter PMTs to the Forward Carriage electronics and power supplies.

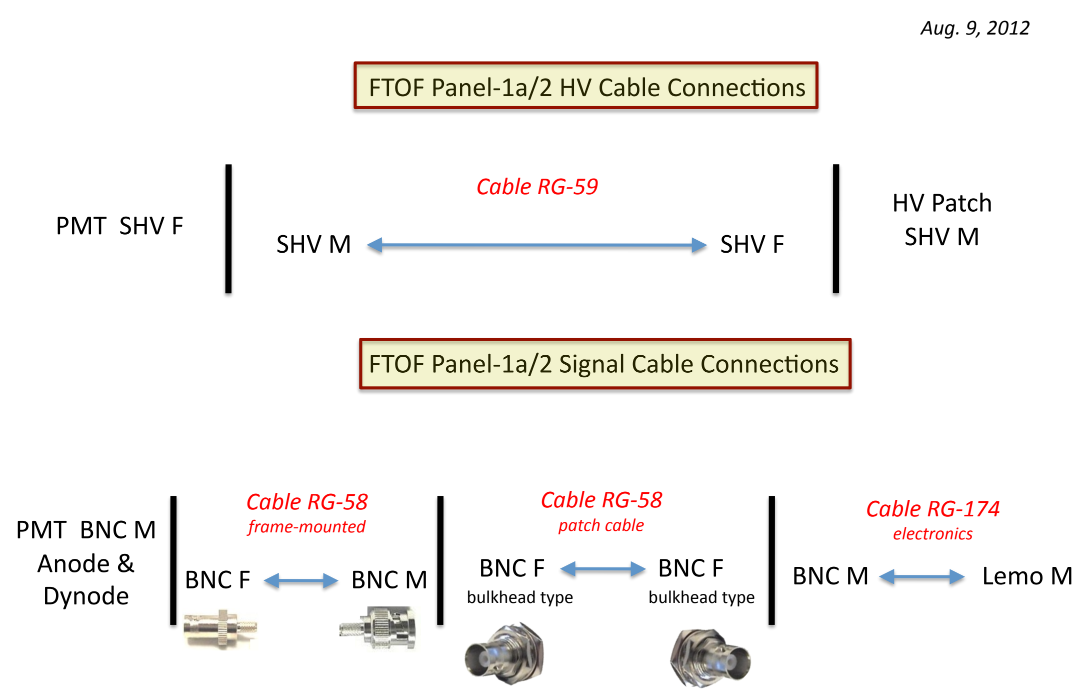

Figure 30: FTOF panel-1a and panel-2 HV and signal cable connections.

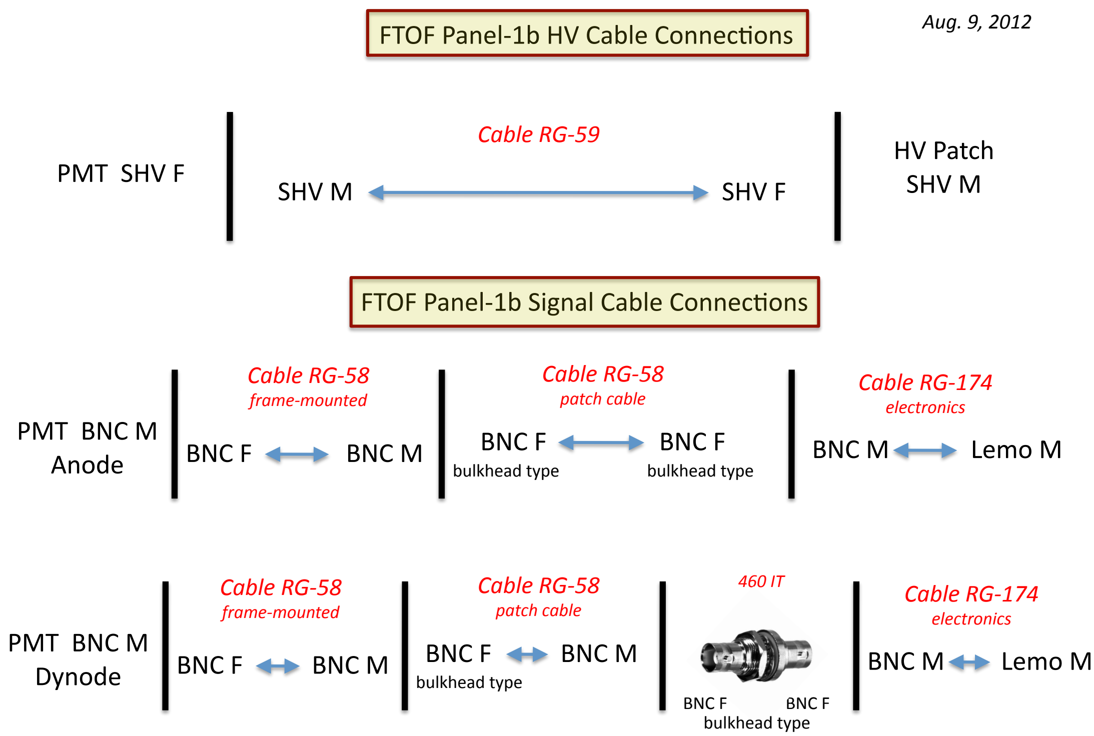

Figure 31: FTOF panel-1b HV and signal cable connections.

3.5 Detector Repairs and Servicing

Repairs and servicing on the FTOF detectors themselves, specifically panel-1a and panel-1b, are highly involved and inherently risky operations. As the counters themselves are structurally robust, no mechanical problems are expected with them during the lifetime of CLAS12. However, PMTs do occasionally go bad due to gain reductions as a function of time and need to be replaced. In addition, voltage dividers can also sometimes go bad due to failed components (particularly with the older custom-made panel-1a and panel-2 voltage dividers). In order to replace a PMT or a voltage divider on either panel-1b or panel-1a, the entire panels have to be removed from the Forward Carriage and placed on the floor of Hall B. This involves removal of the associated LTCC or RICH detector and either one or both FTOF arrays depending on which array needs servicing. Such an operation would never be done to repair a single bad element due to the effort and the risk involved. Of course, PMT and/or divider replacement for the panel-2 counters can be performed in situ using a ladder or a manlift (depending on the PMT location). This work will be carried out either by the FTOF Group Leader or the Hall B technicians during a scheduled hall access. As for panel-1a and panel-1b, mechanical problems with the scintillation counters themselves in panel-2 are not expected to be necessary during the lifetime of CLAS12.

All FTOF detector repairs will be organized through the FTOF Group Leader in conjunction with the Hall B Work Coordinator to be scheduled during a planned down time for Hall B.

4 Documentation

All current documentation for the FTOF system is located on the official FTOF web page [5]. A number of basic subsystem documents can be found there including:

- FTOF System Operations Manual (this document)
  - The source files for the FTOF System Operations Manual are located on the github repository at: *JeffersonLab/clas12-manuals/ftof*
- FTOF Geometry Document
- FTOF Calibration Constants
- FTOF Monte Carlo Simulation Details
- FTOF Reconstruction Document
- FTOF Calibration Algorithms
- FTOF Calibration Tutorial
- Assorted photographs of the detector hardware

If you have any questions related to any of the FTOF system documentation, please contact the FTOF Group Leader.

5 FTOF Authorized Personnel

Beyond turning on/off the FTOF system HV and monitoring the system scalers, all other operations and repairs are only to be carried out by the list of authorized personnel shown in Table 2. The list of authorized personnel for FTOF can only be modified by the FTOF Group Leader.

Name	Telephone	email	Area
Daniel S. Carman	(757)-269-5586	carman@jlab.org	FTOF Group Leader Hardware, Software
Cole Smith	(757)-269-5307	lcsmith@jlab.org	Hardware, *ftofmon*
Sergey Boyarinov	(757)-269-5795	boyarinov@jlab.org	DAQ
Nathan Baltzell	(757)-269-5902	baltzell@jlab.org	Slow Controls

Table 2: FTOF detector authorized personnel.

6 Appendix: Hall B Instrumentation Database

When electronics modules or HV modules are removed from Hall B and replaced during servicing with new boards, the information regarding both the old board and the new board needs to be entered into the Hall B Instrumentation Database. This database is accessed online at *http://clonwiki0.jlab.org* by clicking on the "Hall B Inventory" link. This brings up the access screen shown in Fig. 32. To enter information for the old component, search for it in the database using its property tag information. When the item shows up, click on the "Action" button for "Modify this item". Be sure to change the location of the item to "Hall B Underground/RadCon Table" and change the status of the item to "Action needed/Broken", as well as to leave the item on the RadCon survey table in Hall B. By entering this information, email will be sent to the property custodian to pick up the item for servicing. For the new component, be sure to also change the location as appropriate using the same approach.

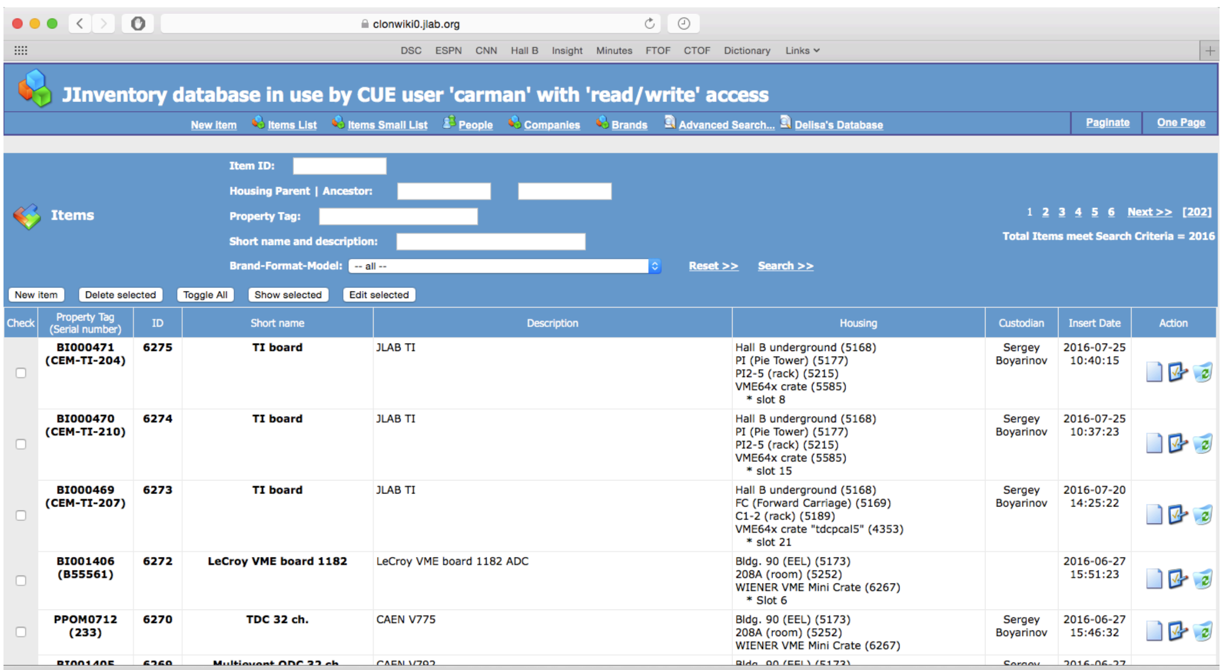

Figure 32: Hall B equipment database web page.

References

[1] Hall B Electronic Logbook: https://logbooks.jlab.org/book/hblog

[2] Hall B BEAST alarm handler:
https://clasweb.jlab.org/wiki/index.php/Slow_Control_Alarms

[3] Hot Checkout page: http://accweb.acc.jlab/hco/readiness (also accessible from the "Shift Documentation" tab on the Run Page wiki [4])

[4] Hall B current run information page:
https://www.jlab.org/Hall-B/run-web/

[5] FTOF web page: http://www.jlab.org/Hall-B/ftof