Hall B Drift Chamber Operating Procedures

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February 1, 2017

Table of Contents

1. Introduction

This document describes the procedures to be followed in order to operate the CLAS12 drift chambers. There are four systems involved in DC operation: DC gas, low voltage (LV), high voltage (HV) and the drift chamber readout board (DCRB). The CLAS12 drift chamber system is comprised of 18 separate chambers. There are three types: “region 1”, “region 2” and “region 3” depending on location upstream, within or downstream of the CLAS torus magnet. Each chamber has wires arranged in two superlayers of 6 layers by 112wires.

The gas system supplies mixed, clean, pressure-controlled Argon/CO2 gas to each of the 18 drift chambers.

The on-chamber amplifier and readout boards are called “signal translator boards” (STB). There are 7 such boards per superlayer. They distribute low voltage (LV) power to pre-amplifiers located on the board, one for each sense wire. The pre-amps are placed in groups of 16, with six such groups per board. There is an individual fuse for every group of sixteen. Thirty-four conductor signal cables (16 twisted-pair signals) connect each STB group of 16 pre-amps with one connector on the drift chamber readout board (DCRB).

High voltage is supplied to the wires by on-chamber high-voltage translator boards (HVTB), located on the other endplate from the STB. The high voltage is supplied to the HVTB’s by a chain of cables connecting the HV crates (HVCRATE) to the high voltage distribution boards (HVDB) and from there by cables to the HVTB’s.

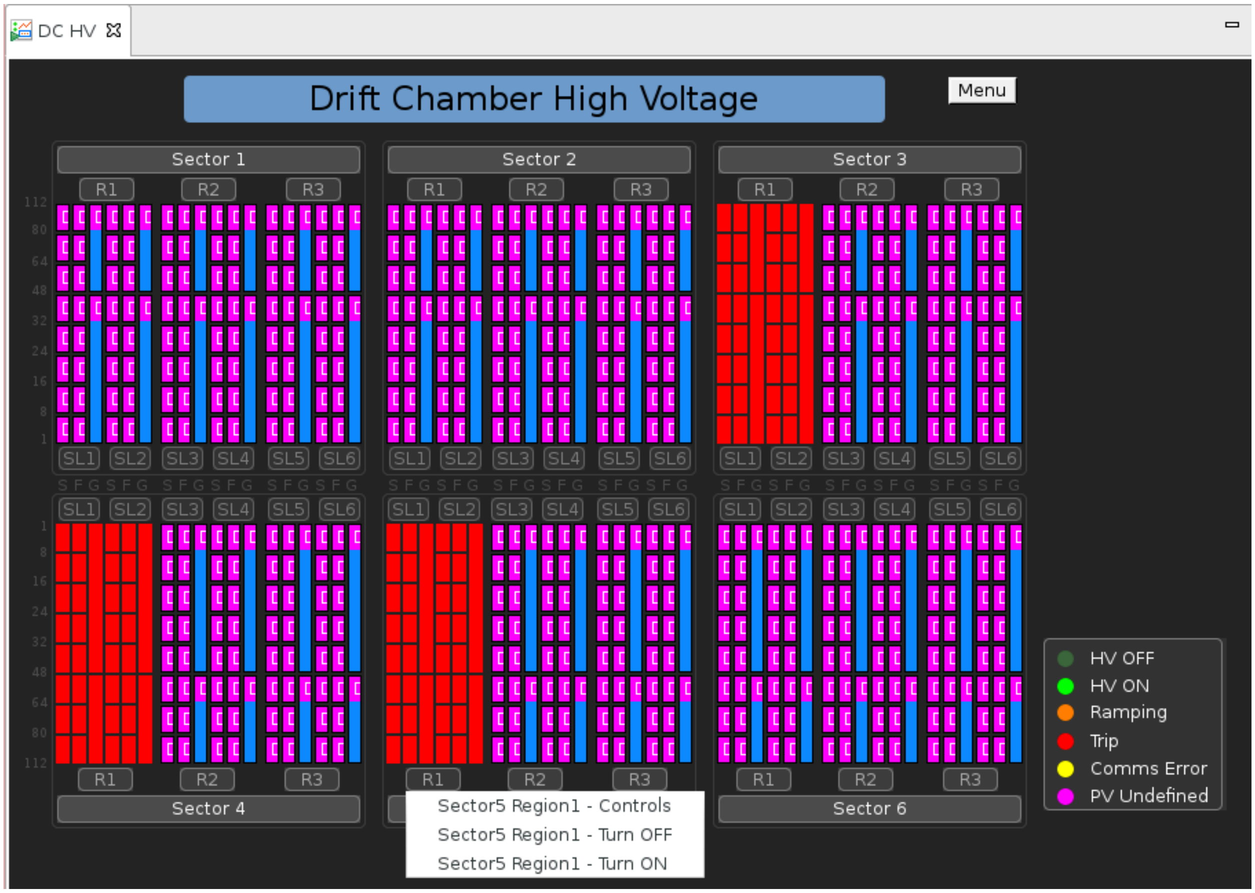
2. High Voltage System

• Introduction and Description of System

The chambers' high voltage is supplied by a CAEN System 527 setup with four crates, a maximum of ten boards each, 24 channels per board. The region 2 and 3 crates are fully-loaded, while the two region 1 crates are half-loaded with only 5 boards installed. (need map of locations in hall)

• EPICS Control Screen

The drift chamber HV control screen has a representation of all of the channels as small rectangles within a larger rectangular shape. The six largest shapes represent the six sectors with the individual channels for Regions 1, 2 and 3 for that sector contained as rectangular areas within the sector.



- ## Turning All Channels On/Off

Click on the grouping you wish, for example, “Sector 2”, then click ***TURN ON*** or ***TURN OFF***. This also works for smaller sub-groupings.

- ## HV Trips

Detecting and Responding to Tripped Channels

If one or more HV channels trip (typically by the current going higher than a software limit), the status message says TRIP and is bright red. There will also be an audible and visual alarm. Respond by resetting the individual channel if only a few were tripped. If many channels tripped, respond by turning all channels on.

Responding to Beam Related Trips

- These are usually caused by excessive beam-induced radiation on the chambers. If it was an intermittent beam problem, simply select ***TURN ON*** to restore operation.
- If the channel cannot be brought back, first determine if it is beam-related by turning the beam OFF and turning the chambers to ***ON***.
- If the chambers’ HV resets, then ask the MCC operators to re-tune the beam.

Resetting an Individual Channel
Cycle power for that channel with its ***on/off*** button.

Paging the Expert On-Call
- If the channel cannot be brought back on, even if the beam has been off for 5 minutes or more, then page the expert.

- ## Expert Operations

Going to Expert Mode
First click on the grouping you wish, whether that is all channels in one sector or a single sector. There will then be an ***EXPERT*** button which puts you into ***EXPERT*** mode.

Changing Operating Voltage, Thresholds and Delays
Enter the appropriate changed value in the whited-out box in the GUI.

Disabling a HV Channel Which Continuously Trips
If one (or two) channels continually trip due to over-current conditions you will need to set their respective voltage(s) to zero. In the expert mode, click on the channel and enter zero (or the desired voltage). Note that you may be able to minimize the resulting dead area (see "minimal disconnect", below).

Detecting Broken Wires (searching for shorts)
Isolate the problem to a specific area and set the voltages to 10V using the ***EXPERT*** button. Because all HV current supplied to the wires passes through a 2 Meg-ohm filter resistor, a short caused by a broken wire will cause the affected channel to draw about 5 microAmps. Unaffected channels will draw the normal dark current of less than 1 microAmp.

Doing a "Minimal Disconnect"
A "minimal disconnect" refers to the operation of disconnecting from HV the smallest group of wires containing the problem area. For example, suppose a sense wire breaks and now touches a field wire inside the chamber. This will cause a short-circuit in the HV system resulting in very high currents which will cause one or more individual HV channels to trip off. Because each HV channel supplies more than one group of wires in parallel, if we can disconnect the individual circuit containing the broken wire then we can in principle, turn on the HV channel again and lose from operation only those wires on the disconnected sub-circuit and not all wires supplied by the HV channel.

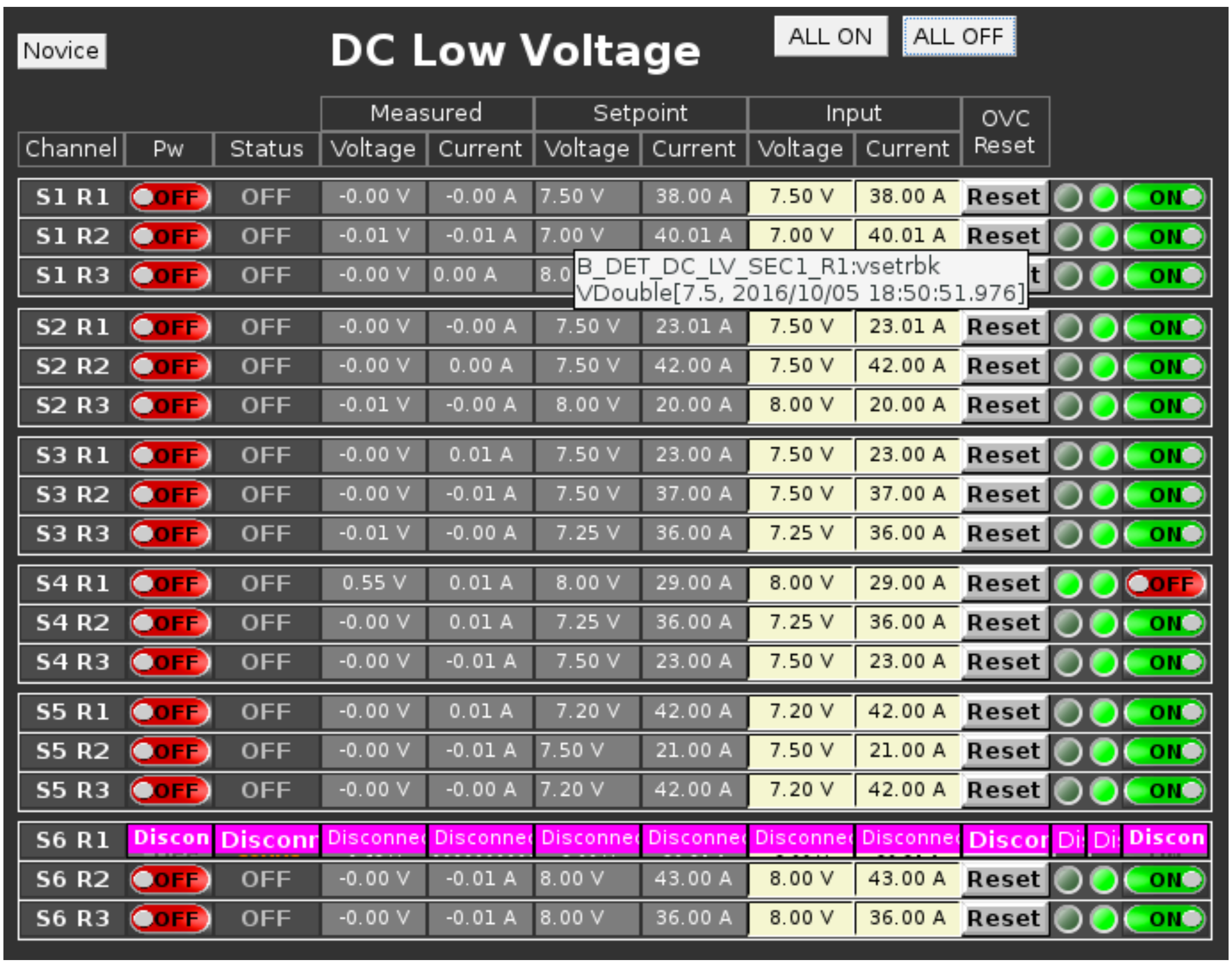
Monitoring Long-Term Operation
Select ***DC HV*** and use the ***stripchart*** button which plots currents vs. time for various groups of channels. When operating normally, the chamber current is proportional beam-induced radiation, so all channels should go up and down as the beam current goes up and down or as beam steering changes. Watch out for channels which behave differently than the average. Current should return to near-zero dark current values when the beam is off. Failure to do this reveals a serious problem.

3. Low Voltage System

• Introduction and Description of System

There are 18 low voltage power supplies; one for each drift chamber. The low voltage power is distributed to the individual Signal Translator Boards (STB) through fused conductors. The individual pre-amplifiers on the STBs are arranged in groups of 16 Single Inline Package (SIP) amplifiers, servicing 16 signal wires from the drift chamber. Each group of 16 SIPs is powered by two fused conductors from the Fuse Box panel, one positive and one neutral/ground return. Each positive conductor (nominally at 7 V potential from the supply) is regulated to 6 V by on-STB regulator.

The fuses are located on a fuse-panel in two grids, each with 6 rows and 7 columns corresponding to the 6 connectors on each of the 7 STB boards per superlayer. Each grid location contains 2 fuses; one positive and one negative. If a positive fuse blows, a group of 16 SIPs (and thus 16 sense wires) will be inoperative. If a negative fuse blows, unregulated (7 V) voltage will still be supplied to the 16 SIPs, so the sense wires' pre-amplifiers (and thus the wire signals) will still be operative. The return current will flow through the STB ground plane and through the other 5 negative fuses assigned to that STB board.



- ## Turning On/Off

Turning All Channels On/Off

The only remote control option is to turn one LV supply on or off through the DCLV EPICS screen by clicking on the ***on/off*** button.

Disabling LV to One Group of 16 SIPs

If for some reason one wants to disable 16 SIPs (and thus 16 sense wires) one can remove the appropriate positive fuse corresponding to that group of SIPs. It is good practice to also remove the corresponding negative fuse.

- ## LV Monitoring Status

Detecting and Resetting an Individual Supply

If a DC LV supply trips, the corresponding button on the EPICS screen will be red. Simply click the ***on/off*** button to reset the supply. If it fails to respond notify the shift leader and/or expert.

Detecting a Possible Blown Fuse

The current drawn by each supply is plotted as an EPICS time-line plot (not shown). A sudden current drop of ~0.3 Amps might indicate that a single positive fuse has blown. Please check the DC Occupancy Plots (see section on Monitoring Drift Chamber performance), paying special attention to the particular chamber (region, sector) as indicated by the name of the LV supply.

- ## Expert Operations

Changing Current Trip Thresholds

Go to Expert Mode and change the ***LOLO, LO, HI*** and HIHI levels to be 2 Amps ***(LOLO, HIHI***) or 1 Amps (***LO, HI***) less than or greater than the nominal value.

Trouble-shooting a Blown Fuse

Turn off the voltage, replace the fuse. If it remains on, good.

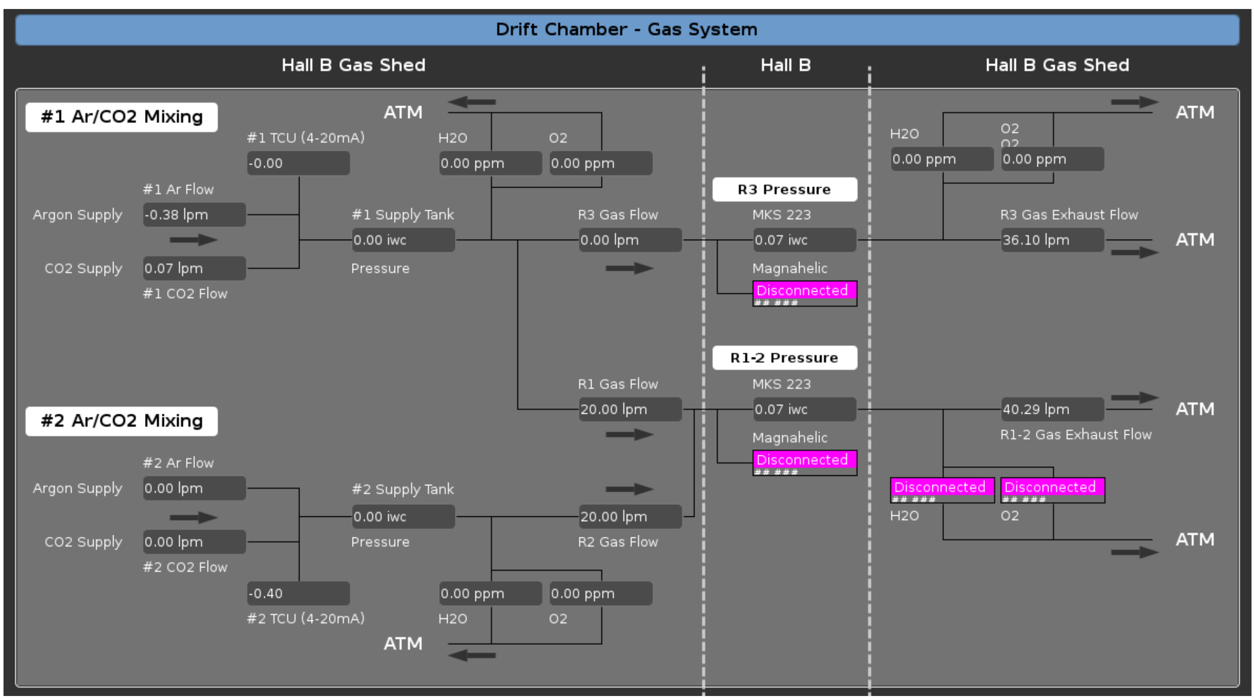
4. Drift Chamber Gas System

All of the drift chambers use an Argon:CO_2 mixture of gas. Currently we are using the gas in a ratio of 90:10 Ar:CO_2. We purchase pure Argon and pure CO_2 and store them in large pressurized tanks located next to the Hall B gas shed. Within the shed we mix the gas and store it in an intermediate pressure vessel, also located adjacent to the gas shed. From there the gas is pumped into the hall and distributed to the individual chambers via manifolds. Note that we pump the gas into the chambers with positive pressure (relative to atmospheric) and pump the gas back up to the gas shed under slightly negative pressure in order to keep the pressure in the chamber very close to the actual (fluctuating) atmospheric pressure.

Note that CLAS shift takers have responsibility to monitor the gas system performance through EPICS. Any changes to operational parameters (pressures, flow rates, alarm levels, etc.) can only be made by experts using control systems located in the gas shed.

- ## Monitoring DC Gas System Status

We monitor the DC gas system using an EPICS screen as shown below. Any deviations from Normal conditions should be reported to the shift leader and possibly, the Gas System on-call personnel. Here is a snapshot of the EPICS screen.



5. Drift Chamber Readout Boards

• Introduction and Description of System

Each of the 18 drift chambers is read out by a single Drift Chamber Readout Board (***DCRB***) crate filled by 14 boards; 7 for one superlayer and 7 for the other. Each board handles 96 channels coming in on six 16-conductor cables. Using FPGA technology, the boards amplify, discriminate and digitize the signal; producing a digital time signal output from an analog drift chamber signal input.

• Monitoring Status of Crates and Boards

Look for green or red lights on the ***DCRB Operations GUI***

• Expert Operations

Changing Discriminator Thresholds

Changing Output Pulse Length

Disabling a Channel from Readout

6. Monitoring Drift Chamber Performance

It is very important to monitor the drift chamber performance in order to detect any problems at an early stage. Some problems will be automatically detected by our EPICS hardware control and monitoring system and will be announced by an audible and/or visual alarm. Other problems may be more subtle and will only be detected by a change in performance; e.g. a change in the average number of hits on a track or a 'hole' developing in the on-line occupancy plot of the DC hits.

In general, we have tried to detect common problems using pattern recognition software, but it is very important for our physicists to remain alert to small changes will may indicate an incipient problem.

• DCRB Scaler Output View of DC Occupancy

The Drift Chamber Readout Board (DCRB) has a scaler output (accumulated hits per wire on a color 2-D plot), as well as the normal data acquisition (DAQ) output. Here one can quickly see large problems: dead areas and hot areas in particular.

• Online Monitoring Plots

Wire Hit Level

1) 1D histogram of number of wires hit per event
2) accumulated hits/event/sector-layer-wire ("2-D occupancy plot")

   (for "all hits", "used in a segment", "used in a cross", "used in a track")

3) hits/event/wire# for each sector-superlayer (36 1-D histograms)

   (for "all hits", "used in a segment", "used in a cross", "used in a track")

Time Hit Level

1) raw time (minus trigger time)

   - summed over all wires for each region

   - summed over all wires for each signal cable

   - summed over all wires for field HV conductor

2) " ti – tj " plot, all I,j combinations for some group of neighboring wires; e.g. the 96 wires on one STB → will show spikes at zero for coherent noise

Cluster, Segment, Cross Level

1) histogram of x location, y location, angles for each s.l.
2) # hits/cross used for sl(i) and for sl(i+1)

Track Level

1) # per event (for each sector, also vs. theta, phi)

Particle Level

1) beta vs. momentum

7. Calling the Expert

8. Glossary:

Layer(1-36) : wires arranged in 6 layers per superlayer, 36 layers per sector

Superlayer(1-6): a grouping of 6 layers, 2 per chamber, 6 per sector

Local superlayer(1-2): one of the 2 superlayers per chamber

Local layer(1-6): layer numbered 1-6 in one superlayer

Wire(1-112): one layer has 112 wires

STB(1-7): "signal translator board", on-chamber boards which provide lv, amplification and readout; each STB board service 96 signal (6 local layers by 16 local wires)

Local wire(1-16): wire number local to an STB board

Local layer(1-6): layer number local to one superlayer and/or one STB board

Connector(STB): there are six 16-pin connectors on each STB, pushing the signals out on 16 twisted-pair conductors

DCRB: "drift chamber readout board", in-crate post-amplification and time digitization boards; one-to-one with the on-chamber STB boards; each STB board is connected via six "signal cables" to one 96-channel DCRB board

DCRB slot: of the 20 slots on the DCRB crates, 14 are devoted to reading out the drift chamber signals. On each crate, boards in slots 4,5,6,7,8,9,10 read out the 7 superlayer-1 stb boards, and boards in slots 13,14,15,16,17,18,19 read out the 7 suplayer-2 stb boards.

Connector(DCRB): there are six 16-pin connectors on each DCRB, receiving the signals from the STB's on six signal (16-twisted-pair-conductor) cables

HVTB(1-7): "high voltage translator board", on-chamber boards which provide high voltage; each HVTB services 96 wires (6 local layers by 16 local wires); one-to-one with the STB's

HVDB(1-2): “high voltage distribution boards”, come in two varieties: “forward” or “back” (2 for each sector, superlayer); these are the intermediate boxes which multiplex high voltage from the CAEN HV supplies to the on-chamber HVTB’s; each box has 3 sets of 4 HV connectors (called “quadruplets”); each quadruplet is composed of 2 “doublets” – the left-hand connector of the doublet has positive voltages for sense and guard and the right-hand connector has negative voltages for the field wires

HVCRATE(1-4): “high voltage crate”, these are 10-slot 24 channel per slot high-voltage supplies from CAEN; crates 1&2 are half-loaded (5 slots) and power the six region 1 chambers; crates 3&4 are fully loaded and power the region 2 and region 3 chambers

HVSLOT(1-10): the slots for the HV boards which are dedicated exclusively to either “sense”, “field” or “guard” wire voltages

HVSUBSLOT-SF(1-3): these are groups of 8 channels (1-8,9-16,17-24) in each of the “sense” and “field” slots;

HVSUBSLOT-G(1-6): for the “guard” slots these are groups of 2 channels (1-2,3-4,5-6,7-8,9-10,11-12)