Hall A GEM Information and Operations for SBS Experiments

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Contents

1 Introduction

This document supports shift operations and use of the GEM detectors during the SBS experiments. A more expanded document for the INFN BigBite GEM operations is maintained at the INFN GEM manual.

1.1 GEM Experts

The GEM expert on call for a specific date will be listed on the white board in the counting room. If for any reason that person is unavailable or someone else needs to be contacted, the individuals and contact information in Table 1 can be used.

Table 1: GEM experts

Contact	Phone	e-mail	Affiliation
Xinzhan Bai	434-422-2809	xb4zp@virginia.edu	UVa
Holly Szumila-Vance	214-587-1525	hszumila@jlab.org	JLab, INFN
Ezekiel Wertz	717-269-6488	ewertz@wm.edu	W&M, INFN
Anuruddha Rathnayake	434-466-0327	adr4zs@virginia.edu	UVa
Sean Jeffas	201-320-3026	sj9ry@virginia.edu	UVa
John Boyd	405-314-2340	jab7bp@virginia.edu	UVa
Saru Dhital	757-232-0153	saru@jlab.org	Hampton U.
Manjukrishna Suresh	202-569-3559	smanjukrishna92@gmail.com	Hampton U.

1.2 Safety Documentation

The OSP and THA for the GEM operations in Hall A are documented at: ENP-21-113037-OSP. If one needs to access the tops of the GEMs from the platforms in the Hall, the applicable THA and OSP are at: ENP-21-120483-OSP.

2 Common Problems

This section is meant as a quick how-to for the shift worker when questions or issues arise and how to go about resolving them.

- High voltage trips off:
  1. Determine if it is a BigBite or a SuperBigBite GEM.
  2. Determine if UVa or INFN GEM. There are only UVa GEMs in BigBite spectrometer.
  3. Contact the GEM Expert On Call for guidance.
  4. Refer to section 3.6.

- Initialization problems during CODA prestart (see figure 4):
  - Follow chart in figure 1
  - After power cycling anything it may take up to five minutes to work again.

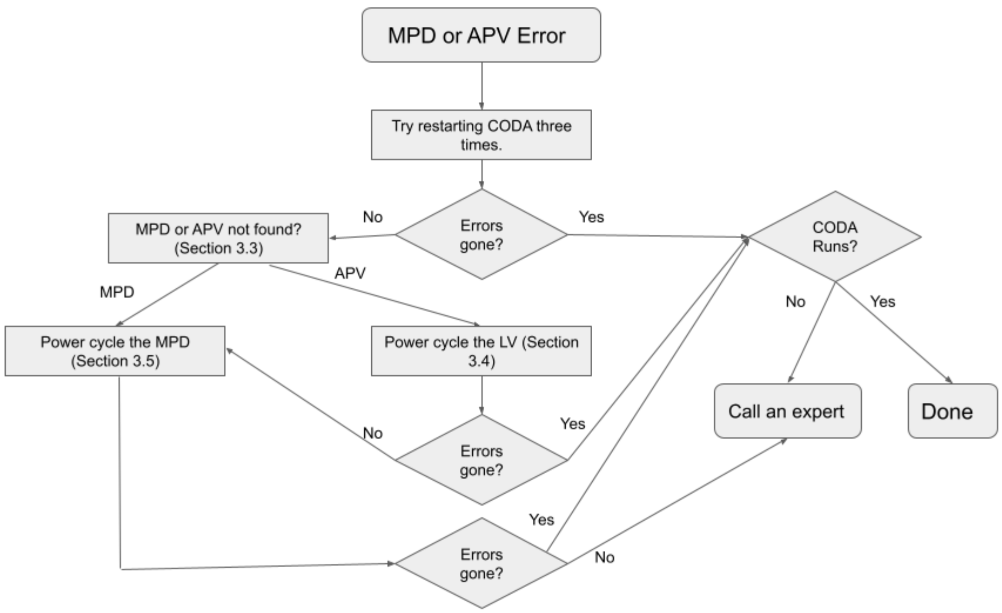

Figure 1: Troubleshoot flowchart for shifters when errors appear in the DAQ.

3 SBS GEMs for Shift Crew

3.1 BigBite GEMs

The BigBite detector stack is composed of a total of 5 GEM trackers. Four GEMs are part of the front tracker detectors that are located between the BigBite magnet and the other BigBite detectors. The fifth GEM layer is located in the middle of the BigBite detector stack and farther downstream than the front trackers. The schematic is shown in Fig. 2.

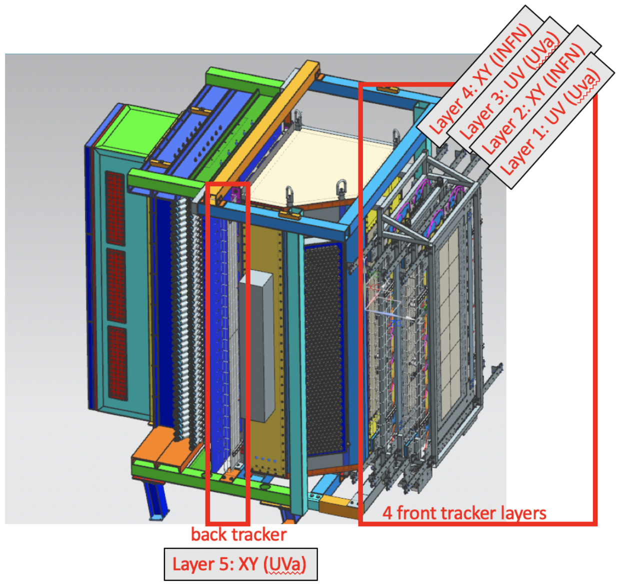

Figure 2: The BigBite detector stack is shown with the front and back tracker GEM layers indicated. The orientation of the strips in each layer is specified as UV or XY.

Layers 1 - 4 are UV layers produced by UVa that consist of a single, large, GEM tracking module (active area of 40 by 150 cm). Layer 2 and 4 used to be an INFN XY layer, historically referred to as J0 and J2. On 11/17/2021 J1 was replaced was **replaced** with a UV layer and on 1/7/2022 J1 was replaced. The above figure is outdated and shows layers 2 and 4 still as INFN. INFN layers are comprised of three separate module, each module with an active area of 40 by 50 cm. These INFN modules are placed top, middle, and bottom. For historical reasons, Layer 2 is sometimes referred to as **J0**. The back tracker is produced by UVa and consists of four modules (each module with an active area of 50 by 60 cm) placed vertically.

3.2 Super BigBite GEMs

The Super BigBite stacks for the GEn-RP configuration consist of three separate stacks and a total of twelve XY readout GEM layers. There is an inline stack (inline with the scattering hadron path) and two side trackers (two layers set perpendicular to the inline stack and hadron path). The inline stack contains eight total GEM layers: two INFN layers at the front of the stack and 6 UVa layers following. The configuration and dimensions of these layers/GEMs are in section 3.3. The following is a drawing of the layout of the stack for the GeN-RP experiment. Note the location of the target with scattering hadron path, as shown.

The inline stack houses the steel analyzer which is used for the charge exchange scattering reaction of the GeN-RP experiment. The steel analyzer sits between the GEM Layer 3 and GEM Layer 4. With the steel analyzer in place, the layers (from target upstream to HCAl downstream) are:

Situated perpendicular to the hadron arm path (and the inline stack) are two side-polarimeter layers. There will be one on each side of the path line. Looking downstream from the target these are Polarimeter Left and Polarimeter Right. Each polarimeter nominally contains two GEM layers (UVa XY layers) and one timing hodoscope layer behind those two layers. The first layer of each side polarimeter is a GEM layer and is oriented "facing" the scattered hadron beam line and in particular, is situated perpendicular to the active CH analyzer.

The layers for each polarimeter (Pol-L and Pol-R) are as follows:

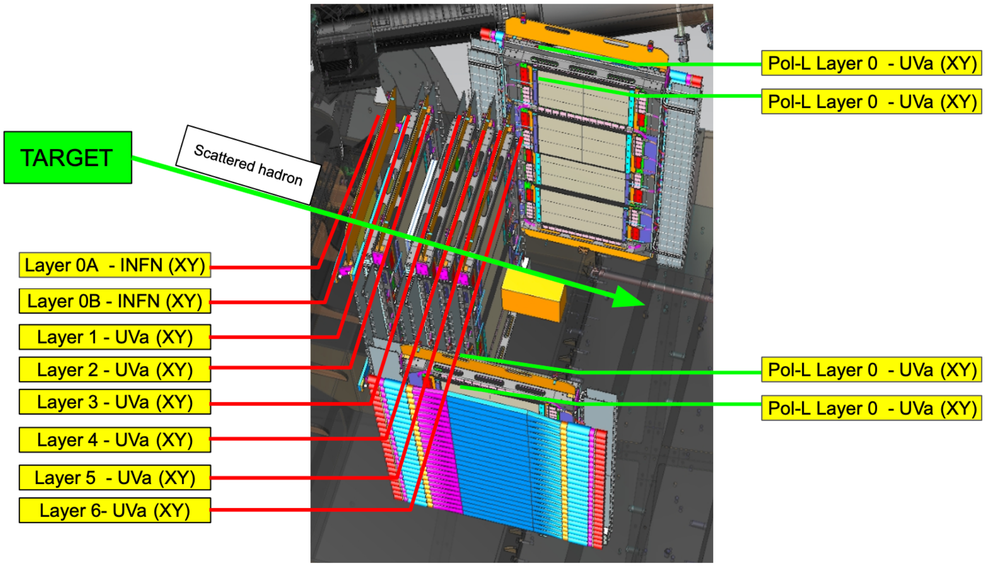

Figure 3: Layout and labels for the layers in the GeN-RP stack configuration

Table 2: Layers in the GeN-RP Inline Stack

Layer	Type
Layer 0 (J1)	INFN
Layer 1 (J3)	INFN
Layer 2	UVa
Layer 3	UVa
Layer x	Steel Analyzer
Layer 4	UVa
Layer 5	UVa
Layer 6	UVa
Layer 7	UVa

Table 3: Layers in the GeN-RP Side Polarimeter Stacks

Layers	Type
Layer 0 of Polarimeter L or R	UVa
Layer 1 of Polarimeter L or R	UVa
Layer 2 of Polarimeter L or R	Timing hodoscope

For the SBS GEn-2 run group, there will be **only the GEn-RP inline frame** installed with all the eight GEM layers in it but without the steel analyzer. Commissioning these GEM detectors and using them as a proton veto detector are the goals of using these GEM detectors during GEn-2 run group.

3.3 DAQ

The optimal running conditions for the GEMs in the DAQ will utilize Common Mode and Pedestal subtraction along with zero suppression. The buffer level should be buffer level 5. The GEMs are readout by MPDs in crates located near the spectrometers. The MPD information is carried via fiber to the VTP in the Hall-A DAQ weldment. All the DAQ information is summarized in table 4 for the BB arm and table 5 for the SBS arm.

Table 4: GEM MPD fibers in BigBite

VTP Crate	MPD Crate	Layer	GEM	MPD Slot	VTP Fiber	No. APVs
sbsvtp3 : vtpROC20	intelbbmpd2	BB Layer 4	L4: UVa XY	2	0	12
			L4: UVa XY	3	1	12
			L4: UVa XY	4	2	12
			L4: UVa XY	5	3	12
			L4: UVa XY	6	4	15
			L4: UVa XY	7	5	15
			L4: UVa XY	8	6	10
		BB L0	L0: UVa UV	9	7	15
			L0: UVa UV	10	8	15
			L0: UVa UV	11	9	15
			L0: UVa UV	12	10	15
		BB L2	L2: UVa UV	13	11	15
			L2: UVa UV	14	12	15
			L2: UVa UV	15	13	15
			L2: UVa UV	16	14	15
	intelbbmpd	BB L1	L1: UVa UV	2	16	15
			L1: UVa UV	3	17	15
			L1: UVa UV	4	18	15
			L2: UVa UV	5	19	15
		BB L3	L3: UVa UV	6	20	15
			L3: UVa UV	7	21	15
			L3: UVa UV	8	22	15
			L2: UVa UV	8	23	15

Table 5: GEM MPD fibers in SuperBigBite

VTP Crate	MPD Crate	Layer	GEM	MPD Slot	VTP Fiber	No. APVs
sbsvtp2 : sbsvtpROC24	sbsvme32	Inline Layer 2	L2: UVa XY	2	0	12
			L2: UVa XY	3	1	12
			L2: UVa XY	4	2	12
			L2: UVa XY	5	3	12
			L2: UVa XY	6	4	15
			L2: UVa XY	7	5	15
			L2: UVa XY	8	6	10
		Inline Layer 3	L3: UVa XY	9	7	12
			L3: UVa XY	10	8	12
			L3: UVa XY	11	9	12
			L3: UVa XY	12	10	12
			L3: UVa XY	13	11	15
			L3: UVa XY	14	12	15
			L3: UVa XY	15	13	10
		Inline Layer 4	L4: UVa XY	16	14	12
			L4: UVa XY	17	15	12
			L4: UVa XY	18	16	12
			L4: UVa XY	19	17	12
			L4: UVa XY	20	18	15
	sbsvme30		L4: UVa XY	2	19	15
			L4: UVa XY	3	20	10
		Inline Layer 5	L5: UVa XY	4	21	12
			L5: UVa XY	5	22	12
			L5: UVa XY	6	23	12
			L5: UVa XY	7	24	12
			L5: UVa XY	8	25	15
			L5: UVa XY	9	26	15
			L5: UVa XY	10	27	10
		Inline Layer 6	L6: UVa XY	11	28	12
			L6: UVa XY	12	29	12
			L6: UVa XY	13	30	12
			L6: UVa XY	14	31	12
			L6: UVa XY	15	32	15
			L6: UVa XY	16	33	15
			L6: UVa XY	17	34	10
		Inline Layer 7	L7: UVa XY	18	35	12
sbsvtp4 : sbsvtpROC25			L7: UVa XY	19	0	12
			L7: UVa XY	20	1	12
	sbsvme25		L7: UVa XY	2	2	12
			L7: UVa XY	3	3	15
			L7: UVa XY	4	4	15
			L7: UVa XY	5	5	10
		INFN J1	L0: INFN J1	6	6	15
			L0: INFN J1	7	7	12
			L0: INFN J1	8	8	15
			L0: INFN J1	9	9	12
		INFN J3	L1: INFN J3	10	10	15
			L1: INFN J3	11	11	12
			L1: INFN J3	12	12	15
			L1: INFN J3	13	13	12

```
Configured APVs (ADC 15 ... 0)            --------------------ERRORS------------------
  MPD  0 :  .... 1111 1111 1111 (#APV 12)
  MPD  1 :  .... .111 1111 1111 (#APV 11)
  MPD  2 :  .... 1111 1111 1111 (#APV 12)
  MPD  3 :  .... 1111 1111 1111 (#APV 12)
  MPD  4 :  .111 1111 1111 1111 (#APV 15)
  MPD  5 :  .111 1111 1111 1111 (#APV 15)
  MPD  6 :  ...1 1111 ...1 1111 (#APV 10)
  MPD  7 :  .111 1111 1111 1111 (#APV 15)
  MPD  8 :  .111 1111 1111 1111 (#APV 15)
  MPD  9 :  .111 1111 1111 1111 (#APV 15)
  MPD 10 :  .111 1111 1111 1111 (#APV 15)
  MPD 11 :  .111 1111 1111 1111 (#APV 15)
  MPD 12 :  .111 1111 1111 .111 (#APV 14)
  MPD 13 :  .111 1111 1111 1111 (#APV 15)
  MPD 14 :  .111 1111 1111 1111 (#APV 15)
  MPD 16 :  .111 1111 1111 111. (#APV 14)
  MPD 17 :  ..EE E1EE EE.E 1EE. (#APV  2)                *APV NotFound*  *APV Config*
  MPD 18 :  .111 1111 1111 1111 (#APV 15)
  MPD 19 :  .111 1.11 11.. 1111 (#APV 12)
  MPD 20 :  .111 EE11 111E 1EEE (#APV  9)                *APV NotFound*  *APV Config*
22Sep2021 12:03:57: vtpROC20 INFO:

  MPD 21 :  ..11 11.E EEE1 111. (#APV  8)                *APV NotFound*  *APV Config*
  MPD 22 :  .111 1111 1111 1111 (#APV 15)
  MPD 23 :  ..EE EE.E EEE. EEEE (#APV  0) *MPD NotFound*
```

Figure 4: This is the printout in the vtpROC20 DAQ terminal where there are some errors for fibers 17, 20, 21 and 23. Remember that the MPD # here refers to the fiber #.

On **Prestart**, the MPDs initialize all of the APV registers. There is printout in both the CODA xterms and in the end of run log in the logbook. Each of the VTPs is one of the CODA xterms with the names listed in the "VTP Crate" column above. Figure 4 shows what a configured GEM printout looks like. The errors in Fig. 4 show some issues with certain fibers. Where the print out says "MPD", it is actually referring to the fiber number described in Table 4. Errors can be with MPDs ("MPD Not Found") or APVs ("APV Not Found"). There should be no errors in this text block in order to proceed with starting the run. For any errors try to reset, download, and prestart CODA again at least three times. **To fix DAQ errors follow the flowchart in figure 1.**

There are many tools available when working with the MPD crates in the Hall. Detailed instructions to run various programs for assessing the detectors are located at Hall_A_GEMs_setup (for experts).

3.4 Low voltage

First determine which GEM we are looking at by checking the "GEM" column in tables 4 and 5.

IF ANY GEM IN BIGBITE (TABLE 4):
To power cycle:

1. Open a firefox browser (from network)
2. Go to `http://hareboot32.jlab.org`
3. Go to "Device Manager" and then "Control"
4. Check "outlet 5" and under the "Control Action" menu select "Reboot Immediate"

IF ANY UVA GEM IN SUPERBIGBITE (TABLE 5):
To power cycle:

1. Open a firefox browser (from network)
2. Go to `http://prexreboot02.jlab.org/NMC/BToq9jYNFQ78ZDj7frUgeA/outlctrl.htm`. Both the user name and the password is "hlauser".
3. Make sure you can see "UVA INLINE GEM LV" in 2 port. If that is not visible, in the upper bar select "Control" then "RPDU" and then "Outlet". This will show the various connect components to the power strip.
4. Check "outlet 2" and under the "Control Action" menu select "Reboot Immediate," and then click "Next."

5. Click “Apply” in the next screen that pops up saying “Outlet Control Confirmation”

IF ANY INFN GEM IN SUPERBIGBITE (TABLE 5):
To power cycle the LV being distributed to the APVs at the GEM layers:

1. Open a firefox browser (from network)
2. Go to http://129.57.188.51/control.cgi
3. If you want to power cycle all of the LV, into the “Input” line type “OPALL 0” and press enter. This will turn off the LV to the INFN GEM electronics. Wait about 5 seconds. Then type “OPALL 1” and press enter. This will turn on the LV to the INFN GEM electronics.
4. If you want to power cycle one of the individual GEM layers this can be achieved by calling a similiar command. Take note that Layer J1 is LV channel 1 and Layer J3 is LV channel 2. So if you want to power cycle Layer J1, into the “Input” Line type “OP1 0” and press enter, wait 5 seconds, and then type “OP1 1” and press enter. For Layer J3, it is the same command, except replace “OP1” with “OP2”.

In the event that the LV supply enters an “error” state or is potentially non-responsive remotely, the INFN LV supply is connected to a remote power outlet. To power cycle the LV supply:

1. Open a firefox browser (from network)
2. Go to http://129.57.188.38, will need username and password from expert.
3. In the options across the top of the “summary” screen click “PDU”. After that along the left side menu select “Outlet Action”, followed by “Control”. Now you should see an action control screen for 8 different outlets.
4. The INFN LV is connected to “Outlet 8”. To reboot the LV, in the drop down box near the top of the options select “Reboot”. Then click the checkbox next to Outlet 8. After that click “Next”, near the bottom of the page. A secondary screen should pop-up and ask you for confirmation. Click “Apply”, and monitor that the status next to Outlet 8 goes to “OFF” temporarily and then back to “ON”. If the status of the outlet does not change, contact a GEM expert.
5. After a power cycle of the LV supply, sometimes the supply does not come back to the proper settings. Follow the instructions directly after these to confirm proper operating settings.

Instructions for evaluating voltage set points for the INFN LV Supply:

1. Open a firefox browser (from network)
2. Go to http://129.57.188.51/control.cgi
3. Verify that there is exclusively remote control of the LV supply by typing in the “Input” line: “IFLOCK?”. If the GUI responds with zero, one will need to type in the “Input” line: “IFLOCK”.
4. In the “Input” line type “V1?”. The GUI should respond with a number value, which corresponds to the set voltage for the supply. If the value does not equal 4.90 V, in the “Input” line type “V1 4.9”. This will alter the set point of the first channel of the supply to be the correct value. Since there are 2 channels on the supply that are being used, one must do the same thing but for channel 2. So in the “Input” line type “V2?”. The GUI should respond with a number value, which corresponds to the set voltage for the supply. If the value does not equal 4.90 V, in the “Input” line type “V2 4.9”. This will alter the set point of the first channel of the supply to be the correct value.
5. If you have to go through this procedure you should make a log entry and contact a GEM expert.

3.5 Power cycling the DAQ crates

First power cycle the VTP crate. Look for the CODA xterm withe the error (see examples in fig 4) and find the crate name at the top of the xterm, **ie** sbsvtp3 :vtpROC20. If you are unsure you can instead just reset every crate listed below.

IF SBSVTP3:
To power cycle:

1. Open a firefox browser (from network)
2. http://hallavme12.jlab.org
3. Toggle the “Main Power” button off, then on. Make sure the “Power Status” changes.

IF SBSVTP2:
To power cycle:

1. Open a firefox browser (from network)
2. Go to http://sbsgemcrate02.jlab.org
3. Toggle the “Main Power” button off, then on. Make sure the “Power Status” changes.

IF SBSVTP4:
To power cycle:

1. Open a firefox browser (from network)
2. Go to http://sbsgemcrate01.jlab.org
3. Toggle the “Main Power” button off, then on. Make sure the “Power Status” changes.

If issues persist then we need to power cycle the MPD crates. First find the MPD with an error in the DAQ (figure 4). Remember that this MPD # in figure 4 refers the the fiber number. Using the VTP crate name and the fiber number use table 4 or 5 to find the ”MPD Crate” where this MPD is located.

IF INTELBBMPD:
To power cycle:

1. Open a browser and type http://hareboot6.jlab.org
2. Select outlet 7
3. Choose ”Immediate Reboot” and apply
4. Wait 2 to 5 minutes

IF INTELBBMPD2:
To power cycle the crate:

1. In a terminal: **ssh adaq@adaq2**
2. In a terminal: **ssh sbs-onl@intelbbmpd**
3. Type **minicom** and enter
4. Type **CAEN** and enter (the words will not appear in the terminal as you type them)
5. Press **C**
6. Type **off** and wait 10 seconds
7. Type **on**

8. Wait 2 to 5 minutes

IF SBSVME32:
To power cycle:

1. Open a firefox browser (from network)
2. Go to http://prexreboot01.jlab.org/NMC/iVMLwY2PmVzAox8PbTOqVw/outlctrl.htm
3. Select outlet 1
4. In "Control Action" choose "Immediate Reboot" and click "Next".
5. Wait 2 to 5 minutes

IF SBSVME30:
To power cycle:

1. Open a firefox browser (from network)
2. Go to http://prexreboot01.jlab.org/NMC/iVMLwY2PmVzAox8PbTOqVw/outlctrl.htm
3. Select outlet 2
4. In "Control Action" choose "Immediate Reboot" and click "Next".
5. Wait 2 to 5 minutes

IF SBSVME25:
To power cycle:

1. Open a firefox browser (from network)
2. Go to http://prexreboot01.jlab.org/NMC/iVMLwY2PmVz
3. Select outlet 3
4. In "Control Action" choose "Immediate Reboot" and click "Next".
5. Wait 2 to 5 minutes

3.6 High voltage

The high voltage for the GEMs shall be **OFF** for all initial beam tuning operations to the Hall. The GEMs may be powered on, once an acceptable beam profile is established.

Only GEM experts should change the GEM HV settings. Shifters can only turn HV on or off. The slow controls for both are at **aslow@adaqsc**. From here, the GEMs are accessed by typing **go_hv**. There are GEMs under "BB" and under "SBS". The BB GEM GUI can be seen in figure 5 and the SBS GEM GUI can be seen in figure 6. The yellow columns are editable, and this is where the voltage settings, trip level, and ramp rate are changed. The HV can be turned on/off using the button on the left of each channel.

3.6.1 Special Instructions for BB GEM layer 0

UV layer 0 is connected to a special power supply which is the first seven channels in figure 5. If UV layer 0 trips the HV box will then need to be rebooted in order to turn the HV back on. To reboot **UV layer 0 HV**:

1. In the address in any browser type: **129.57.188.120**
2. Go to PDU → Outlet Action → Control
3. Select **Reboot**, **Outlet #8**, and then click **Next**. It should take about 30 seconds to come back online

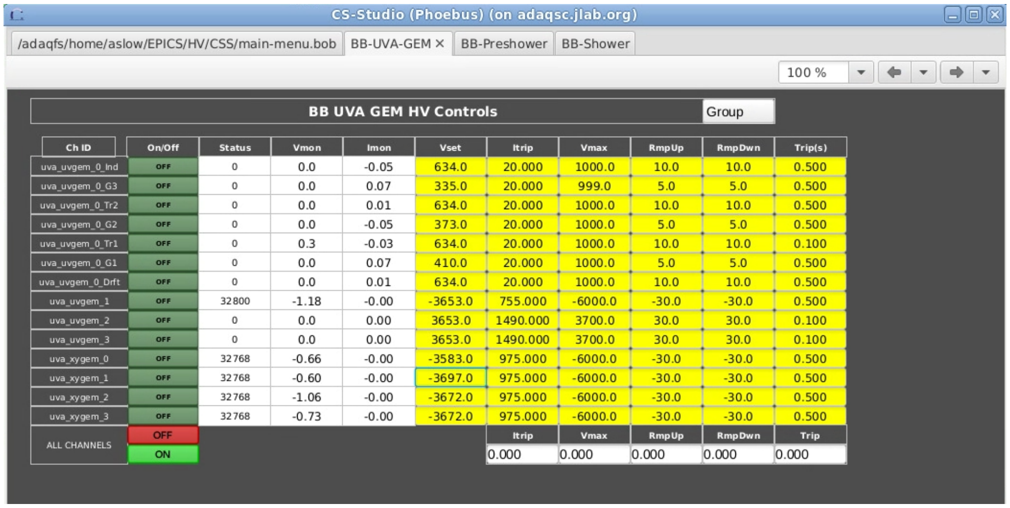

Figure 5: Screenshot of the HV GUI for the GEMs in BB.

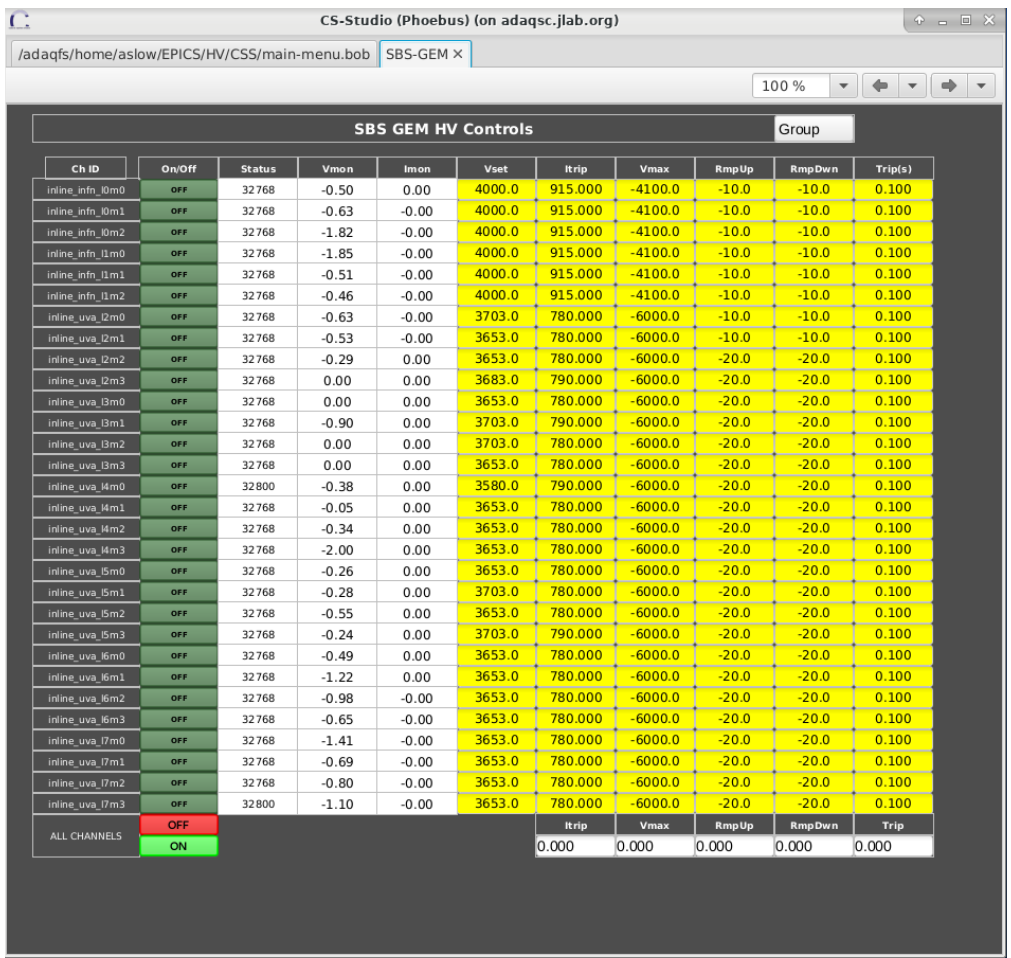

Figure 6: Screenshot of the HV GUI for the SBS GEMs in SBS.

3.7 Gas Monitoring

There is one gas panel for the BB GEMs and one gas panel for the SBS GEMs. The gas flow monitoring can be accessed by web browser:

BB gas webpage: this link
SBS gas webpage: this link

Table 6 shows which gas channel goes to which GEMs. In production conditions, all GEMs will run an Ar/CO2 (75/25) gas mixture. In standby periods when the GEMs will not be in active use or HV work is being tested, the GEMs can be switched over to nitrogen gas.

For INFN GEMs in production conditions Ar/CO2 (75/25) should flow from 300 to 600 cc/min/chamber (larger flux is better for aging mitigation, lower bound should be acceptable to saturate efficiency). In general UVa UV layers should flow at 600±30 cc/min/chamber. BB UVa UV layers 1 and 3 (Ch 07 and Ch08) have a defect and should flow at 375±30 cc/min/chamber . For the UVa XY module in production conditions should flow at 225±15 cc/min/chamber. An example screenshot for the BB gas system is shown in figure 7 and SBS gas system in figure 8.

It is also important to check the amount of gas in the bottles, and change them appropriately. The PSI in the GEM gas can also be monitored with a MyAplot and configurations are available under SBS → GEMs → GEM_BB_Gas/GEM_SBS_Gas. If there is a low pressure alarm or you think the GEM gas is not flushing properly then contact the GEM expert on-call.

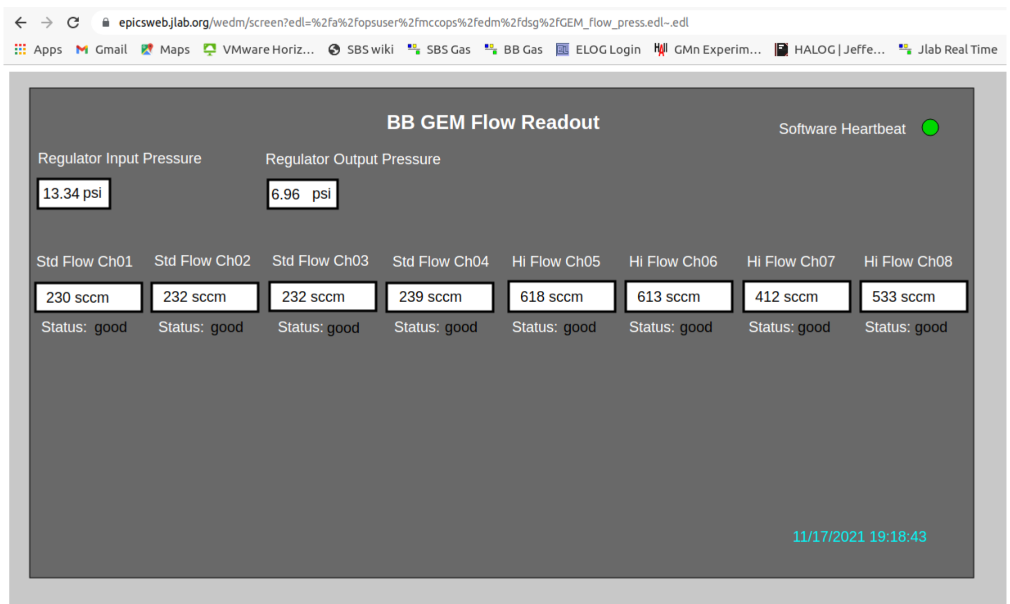

Figure 7: This is a screenshot of nominal flow rates for the BigBite GEMs.

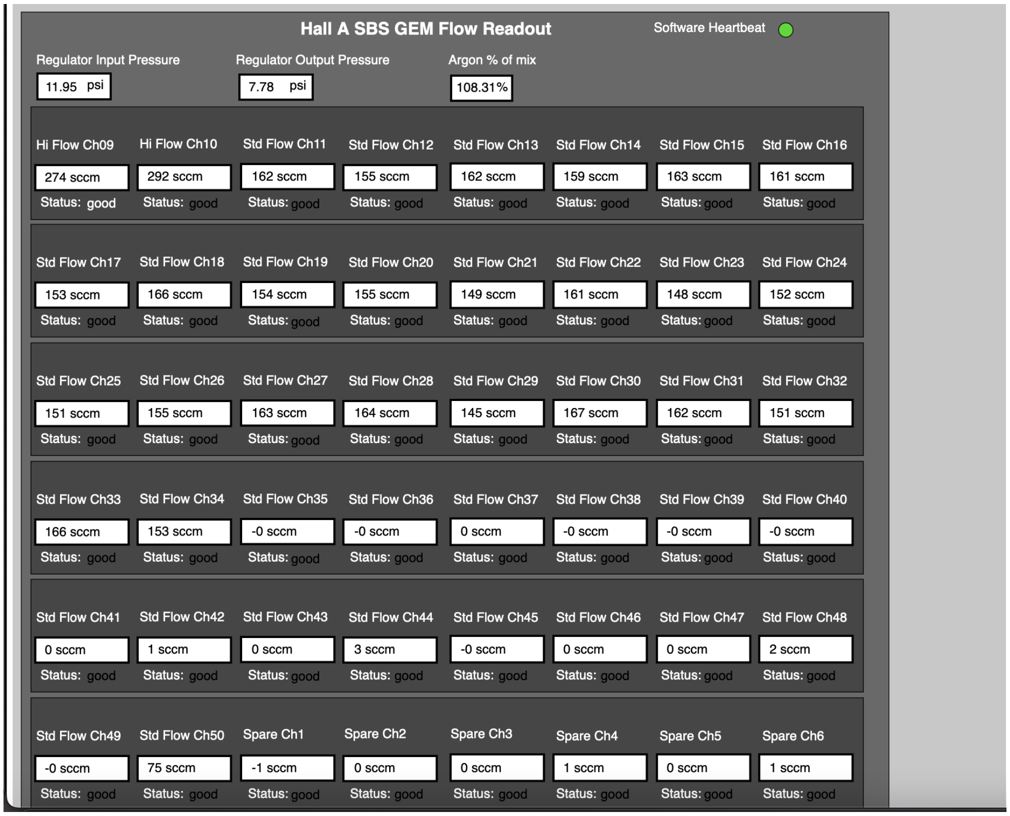

Figure 8: This is a screenshot of flow rates for the SBS GEMs.

Table 6: Relation between gas channel GUI and GEM modules

GUI Channel	GEM
Std Flow Ch01	BB UVa XY G0
Std Flow Ch02	BB UVa XY G1
Std Flow Ch03	BB UVa XY G2
Std Flow Ch04	BB UVa XY G3
Hi Flow Ch05	BB UVa UV L0
Hi Flow Ch06	BB UVa UV L2
Hi Flow Ch07	BB UVa UV L1
Hi Flow Ch08	BB UVa UV L3

GUI Channel	GEM
Hi Flow Ch09	INFN XY L0
Hi Flow Ch10	INFN XY L1
Std Flow Ch11	UVa XY L2 G0
Std Flow Ch12	UVa XY L2 G1
Std Flow Ch13	UVa XY L2 G2
Std Flow Ch14	UVa XY L2 G3
Std Flow Ch15	UVa XY L3 G0
Std Flow Ch16	UVa XY L3 G1

GUI Channel	GEM
Std Flow Ch17	UVa XY L3 G2
Std Flow Ch18	UVa XY L3 G3
Std Flow Ch19	UVa XY L4 G0
Std Flow Ch20	UVa XY L4 G1
Std Flow Ch21	UVa XY L4 G2
Std Flow Ch22	UVa XY L4 G3
Std Flow Ch23	UVa XY L5 G0
Std Flow Ch24	UVa XY L5 G1

GUI Channel	GEM
Std Flow Ch25	UVa XY L5 G2
Std Flow Ch26	UVa XY L5 G3
Std Flow Ch27	UVa XY L6 G0
Std Flow Ch28	UVa XY L6 G1
Std Flow Ch29	UVa XY L6 G2
Std Flow Ch30	UVa XY L6 G3
Std Flow Ch31	UVa XY L7 G0
Std Flow Ch32	UVa XY L7 G1
Std Flow Ch33	UVa XY L7 G2
Std Flow Ch34	UVa XY L7 G3

4 FOR EXPERTS ONLY

4.1 Checklist

A GEM expert should be checking these functions every day:

- GEM HV and current several times every day (see section 3.6 and 4.2).
- Gas flow readout and gas can level at least twice a day (see section 3.7).
- Raw APV frames for the beginning of every run (see section 4.10).
- Analyzed low level plots and tracking efficiencies should be checked at least twice a day (see section 4.11).

4.2 INFN HV

When HV is being applied on a GEM module for the first time after a long shutdown period (2 weeks or more) from 0 V to the operational HV (4100 V), it should be increased in steps of according to Fig.9. The values in Fig.9 are for the INFN parallel dividers. At each increase, one must first change the "ITrip" value and then change the "VSet" value according to the table. If one must decrease, first change the "VSet" value and then change the "ITrip" value. At each step, wait for at least about 1 to 2 minutes and make sure both the HV and the current are stable.

If the GEMs have been operational without problem and you have turned them off for a short period of time and are turning them on to the operational HV, you can simply turn the HV ON. Verify that the readback currents are reasonable.

HV (V)	Set Max Current (microAmps)
300	70
500	115
800	182
1000	227
2000	450
3000	675
3500	790
3700	835
3800	858
3900	880
3950	890
4000	910
4050	920
4100	930
4150	940

Figure 9: Applied HV and the maximum current for **INFN XY GEMs**.

4.3 UVa HV

When HV is being applied on a GEM module for the first time after a long shutdown period (about 2 weeks or more) from 0 V to the operational HV (3653 V for most of the GEMs except for a few of the low gain XY modules where we would run at slightly higher values), it should be increased in steps of about 500 V. At each step, wait for at least about 20-30 seconds and make sure both the HV and the current are stable and within the expected range. See Table 7 for a table of applied HV and the expected current values for UVA XY and UV GEM chambers.

If the GEMs have been operational without a problem and you have turned them off for some reason (about less than 2 weeks) and you are turning them up from 0 V to the operational HV, you can simply turn the HV ON. But make sure the final read back current is correct.

You should not increase HV on any UVA GEM chamber above 3750 V (4200 V equivalent HV for the 100% divider) under any circumstance, except after consulting with senior GEM hardware experts. This HV is the maximum we usually test GEMs under nitrogen and we do not know how stable the GEM detector will be above this point, especially under Ar/CO_2.

Applied HV (V)	100% divider HV(V)	XY GEMs (μA)	UV GEM L1 (μA)	UV GEM L2 & L3 (μA)
100	112	20	20	40
500	561	102	101	202
1000	1122	204	202	404
1250	1403	255	253	505
1750	1964	357	354	707
2000	2245	408	404	808
2250	2526	459	455	909
2500	2806	510	505	1010
2750	3087	561	556	1111
3000	3367	612	606	1212
3100	3480	633	626	1253
3200	3592	653	646	1293
3300	3704	673	667	1333
3350	3760	684	677	1354
3400	3816	694	687	1374
3450	3872	704	697	1394
3475	3901	709	702	1404
3500	3929	714	707	1414
3525	3957	719	712	1424
3550	3985	724	717	1434
3575	4013	730	722	1444
3600	4041	735	727	1455
3625	4069	740	732	1465
3650	4097	745	737	1475
3675	4125	750	742	1485
3700	4153	755	747	1495
3725	4181	760	753	1505
3750	4209	765	758	1515
3775 Do not use	4237	770	763	1525
3800 Do not use	4265	776	768	1535

Table 7: Applied HV and the expected current for **UVA XY and UV GEMs**

4.3.1 BigBite UV Layer 2 and 3 HV

UV layer 2 and 3 both have half the resistance on the HV divider. Therefore the current through these modules will be twice the current that of the UV Layer 1. Last column of Table 7 show the expected current from these two layers. These modules are accessed through the HV GUI like normal, but if that is not working follow these steps to control them remotely:

- Log into **sbs-onl@intelbbgem**
- Enter **minicom**
- Enter **CAEN**

4.3.2 BigBite UV Layer 0

UV layer 0 is using a special power supply, CAEN HiVolta (DT1415ET). This supplies a voltage to each of the parts of the GEM separately instead of using a HV divider. Therefore there are seven channels on it for one GEM. The voltage is set specifically for each GEM foil and transfer region. To find the values use this table, here. First set the total operating voltage at the top of the table. The green column will then tell you what voltages to set every channel to. The currents should always be less than 1 μA when there is no beam. If the current is higher it means a sector is shorted. Under beam conditions the HV channels will start drawing current, which will reduce the gain of the GEM. To offset this, use the spreadsheet again and set orange "current" column with the values you see on the HV GUI. The green voltage column will then tell you what the new HV set points should be to improve the gain.

All of the channels for this module are tied together so if one of them turns off/on, then they all turn off/on. Also if the module trips it cannot be turned back on until it is reset, see section 3.6. If the normal SBS HV GUI is not working, this module can be accessed following these steps:

- Log into **adaq@adaq2**
- Enter **telnet hivoltauva 1470**
- Enter **CAEN**

4.4 Alarms

On intelbbmpd, there is a configuration file for the alarm at: /EPICS/sbs-epics/apps/iocBoot/iocv65xx/alarm.config That file gets loaded whenever the IOC gets restarted. To restart the IOC, do the following on intelbbmpd:

telnet localhost 20004
exit
ctrl-] **q** (To break out of telnet)

The alarms are set using the I/V ratio in [nA/V] for each module at 4 kV. The yellow warning will alarm if the current exceeds 50 nA from this value, and the red alarm will sound if the current exceeds 100 nA from this value.

The BB GEMs will also read in the gas mixture ratio (EPIC variable Shed_gas_Ch_34) and will automaticall shut off the HV if the ratio is outside of the expected range. This will only work if the Hall A alarm handler is running.

4.5 Configuration File Locations

4.5.1 BigBite Configuration Files

To access any MPD config for BigBite GEMs, first log in to **sbs-onl@adaq2**. From there ssh to **sbs-onl@sbsvtp3** to get to the VTP control. The MPD/APV configurations located in **~/cfg**. Here are the files used for configurations:

- **sbsvtp3_TS.cfg -** This file defines all the MPDs and their corresponding fibers on the VTP (see table 4). If an MPD/Fiber needs to be commented out, then this is the place to do it.
- **ssp_avp_default.cfg -** This file is called by sbsvtp3_TS.cfg and defines a bunch of default variables for the APVs. The only one we care about is "Latency" and that shouldn't be changed any more unless the trigger changes.
- **MPD_vmeSlot_#.cfg -** Located in **bbgem_crate_1** or **bbgem_crate_2**. There is one file for each MPD. If an APV is misbehaving this is the place to comment it out. More detail in section 4.6.

4.5.2 Super BigBite Configuration Files

To access any MPD config for SBS GEMs, log in to **sbs-onl@sbsvme24** to get to the VTP control. The MPD/APV configurations located in **~/cfg**. Here are the files used for configurations:

- **sbsvtp2_TS.cfg** and **sbsvtp4_TS.cfg -** These files defines all the MPDs and their corresponding fibers on the VTP (see table 5). If an MPD/Fiber needs to be commented out, then this is the place to do it.

- **vtp_apv_defaults.cfg** - This file is called by both vtp files and defines a bunch of default variables for the APVs. The only one we care about is "Latency" and that shouldn't be changed any more unless the trigger changes.
- **config_MPD_#.txt** - Located in **crate0_MPD**, **crate1_MPD**, or **crate2_MPD**. There is one file for each MPD. If an APV is misbehaving this is the place to comment it out. More detail in section 4.6.

4.6 How to remove MPDs and APVs from the DAQ

As mentioned above the APVs are located in **MPD_vmeSlot_#.cfg**(BigBite) or **config_MPD_#.txt**(SBS). The slot number in the file name refers to the slot number in the MPD crate. The MPD numbers given by the DAQ output (see figure 4) refer to the fiber numbers in the VTP. In figure 10 there are a few fiber definitions from **sbsvtp3_TS.cfg**. Therefore if there are errors in "fiber 1" then this corresponds to the MPD defined in **cfg/bbgem_crate_2/MPD_vmeSlot_3.cfg**. If the whole MPD needs to be removed then the block of code for that fiber in **sbsvtp3_TS.cfg** can be commented out.

```
   {
fiberPort = 0;
mpd:
 @include "cfg/bbgem_crate_2/MPD_vmeSlot_2.cfg"
 },
{
  fiberPort = 1;
  mpd:
  @include "cfg/bbgem_crate_2/MPD_vmeSlot_3.cfg"
  },
```

Figure 10: Example from **sbsvtp3_TS.cfg** for a few fiber defenitions.

The APVs are defined at the bottom of **MPD_vmeSlot_#.cfg**(BigBite) or **config_MPD#.txt**(SBS) for each MPD. Figure 11 shows an example of some APVs defined. If an APV is giving errors this is the place to comment it out of the MPD.

```
apv:
 (
 { adc = 11; i2c = 4; },
 { adc = 10; i2c = 5; },
 { adc = 9; i2c = 6; },
 { adc = 8; i2c = 7; },
 { adc = 7; i2c = 8; },
 { adc = 6; i2c = 9; },
 { adc = 5; i2c = 10; },
 { adc = 4; i2c = 11; },
 { adc = 3; i2c = 12; },
 { adc = 2; i2c = 13; },
 { adc = 1; i2c = 14; },
 { adc = 0; i2c = 15; }
   );
```

Figure 11: We see this MPD has 12 APVs in the adc slots 0 - 11 on the MPD.

4.7 How to enable zero suppression or CM subtraction

The readout list (ROL) defines the VTP run configuration (we are still logged into **sbsvtp3(BigBite) or sbsvtp2/sbsvtp4(SBS)**). This is used for changing run settings like pedestals, common mode subtraction, zero suppression. The only variables that the GEM group should change are located in **~/vtp/cfg/sbsvtp3.config**(BigBite) and **~/vtp/cfg/sbsvtp2.config or sbsvtp4.config**(SBS).

- **VTP_MPDRO_PEDESTAL_FILENAME** - Name of pedestal file used for online subtraction.

- **VTP_MPDRO_COMMON_MODE_FILENAME** - Name of common mode file used for online subtraction.
- **VTP_MPDRO_BUILD_ALL_SAMPLES** - Defines if zero suppression is on (0) or off (1).
- **VTP_MPDRO_ENABLE_CM** - Defines if common mode subtraction is on (1) or off (0).

Pedestal runs should be loaded to **sbsvtpx (x=3,2,4)** at **~/cfg/pedestals**. For example a pedestal run will have VTP_MPDRO_BUILD_ALL_SAMPLES = 1 and VTP_MPDRO_ENABLE_CM = 0. For a run with CM subtraction but not zero suppression use VTP_MPDRO_BUILD_ALL_SAMPLES = 1, VTP_MPDRO_ENABLE_CM = 1, and pedestal and CM file names pointing to a proper pedestal run. For zero suppression use
VTP_MPDRO_BUILD_ALL_SAMPLES = 0, VTP_MPDRO_ENABLE_CM = 1, and again the pedestal and CM file names pointing to a proper pedestal run.

4.8 Changing the Latency

As mentioned above the GEM "Latency" parameter is set in **ssp_avp_default.cfg**(BigBite) and **vtp_apv_defaults.cfg**(SBS). This is the global latency for all GEMs connected to that particular VTP. Some modules may need a slight offset in latency. This can be done by defining a module as shown below. Using this method the latency for one layer can be changed by changing the"offset" in one location.

```
layer_latency:
 ({
   name = "default";
   offset = 0;
 },
 {
   name = "UV0";
   offset = 0;
 },
 {
   name = "UV1";
   offset = 1;
 },
 {
   name = "UV2";
   offset = 0;
 },
 {
   name = "UV3";
   offset = -1;
 },
 {
   name = "XY4";
   offset = -1;
 }
);
```

```
apv:
 (
 {layer = "XY4"; adc = 11; i2c = 4; },
 {layer = "XY4"; adc = 10; i2c = 5; },
 {layer = "XY4"; adc = 9; i2c = 6; },
 {layer = "XY4"; adc = 8; i2c = 7; },
 {layer = "XY4"; adc = 7; i2c = 8; },
 {layer = "XY4"; adc = 6; i2c = 9; },
 {layer = "XY4"; adc = 5; i2c = 10; },
 {layer = "XY4"; adc = 4; i2c = 11; },
 {layer = "XY4"; adc = 3; i2c = 12; },
 {layer = "XY4"; adc = 2; i2c = 13; },
 {layer = "XY4"; adc = 1; i2c = 14; },
 {layer = "XY4"; adc = 0; i2c = 15; }
   );
```

Figure 12: (Left) GEM layer names are defined and latency offsets are set in ssp_avp_default.cfg. (Right) In the corresponding MPD files, MPD_vmeSlot_3.cfg(left), the APVs are given a name to match the correct label.

4.9 Loading Pedestal Files and Configuring ZS and CM

To first take a pedestal set the CODA configuration properly as described in section 4.7. Check that all APVs look good in the raw data as explained in section 4.10. Then follow the steps:

1. Execute`./run_GEM_pedestal.sh runnum`
   This will prompt you to look through the plots and post them to the HALOG. It will also create the following output files:
   daq_ped_bb_gem_runXXXXX.dat
   daq_cmr_bb_gem_runXXXXX.dat
   db_cmr_bb_gem_runXXXXX.dat
   daq_ped_sbs_gem_runXXXXX.dat
   daq_cmr_sbs_gem_runXXXXX.dat
   db_cmr_sbs_gem_runXXXXX.dat
2. Copy the files above to sbs-onl@sbsvtp3:~/cfg/pedestals. All of the GEM VTPs can acces them from here.

3. Copy the files to $SBS_REPLAY/DB/gemped for future reference and for use in offline analysis.
4. Edit the VTP config files as described in section 4.7 so that VTP_MPDRO_PEDESTAL_FILENAME and VTP_MPDRO_COMMON_MODE_FILENAME point to these files.

It is also best to check the pedestal file plots to make sure everything looks normal:

1. `source ~/.bash_profile`
2. `panguin -r runnum -f $SBS_REPLAY/onlineGUIconfig/BBGEM_ped_and_commonmode.cfg`

4.10 Raw Event Display

To check raw events we are using Xinzhan's GUI on **a-onl@aonl1** in the directory **/adaqfs/home/a-onl/sbs/GEM_data_viewer/MPD_GEM_View_VTP**. To run it execute the following in the terminal:

```
source setup_env.sh
./viewer
```

The GUI will open and the file browser can be used to find the EVIO file of interest. The arrows can be used to scroll through events, and the different MPDs are on different tabs at the top. Normal pedestal data will look like figure 13. Anything that does not look like this may be broken. For example, in figure 14 it is clear that APV 11 is problematic. Also the baseline ADC should never be above 1000. An example is shown in figure 15. If common mode (CM) and pedestal subtraction is enabled online then the data should be centered around zero, which is shown in figure 16. Finally, if zero suppression is enabled then there should only be a few strips with data per event. An example is shown in figure 17.

Whenever a setting is changed, always check the data to see that it is working properly before letting the run continue. It is fine to open a run with the GUI while it is still ongoing. **During the experiment every 1/100 events will have no subtractions, so scroll to that event and look through every single fiber to see that things look normal**.

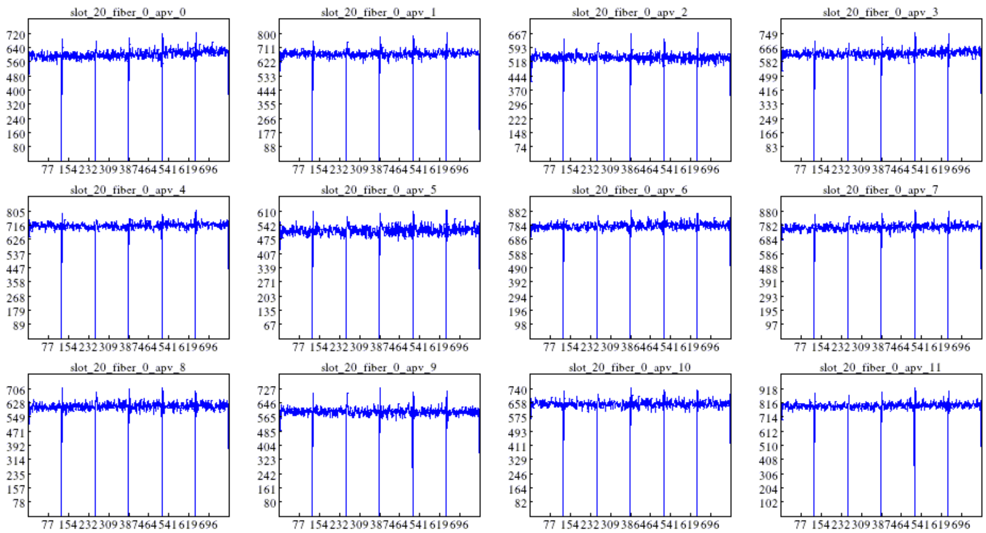

Figure 13: Example of normal pedestal APV raw data.

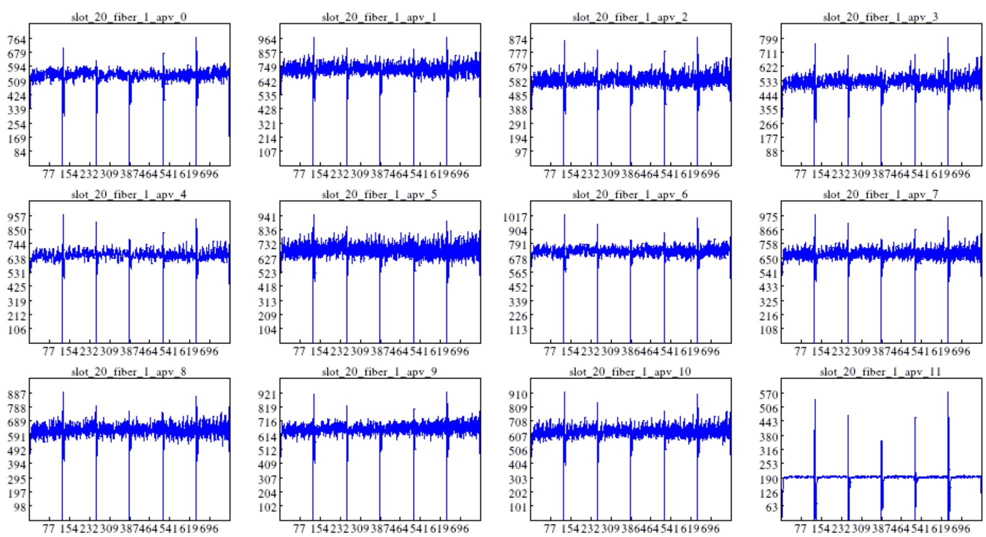

Figure 14: Example of a pedestal run where APV 11 is clearly not working

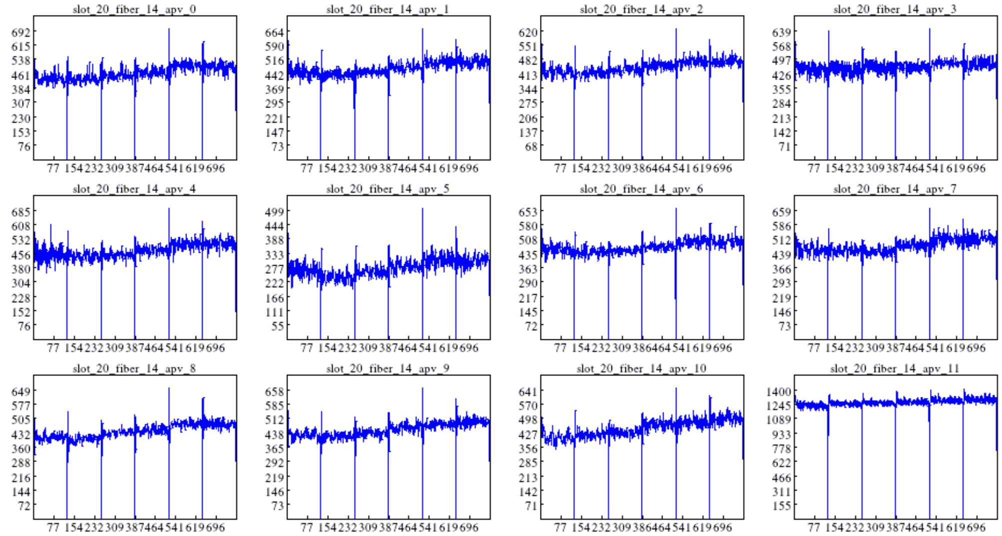

Figure 15: Example of a pedestal run where APV 11 is not working. The baseline ADC values should never be above 1000.

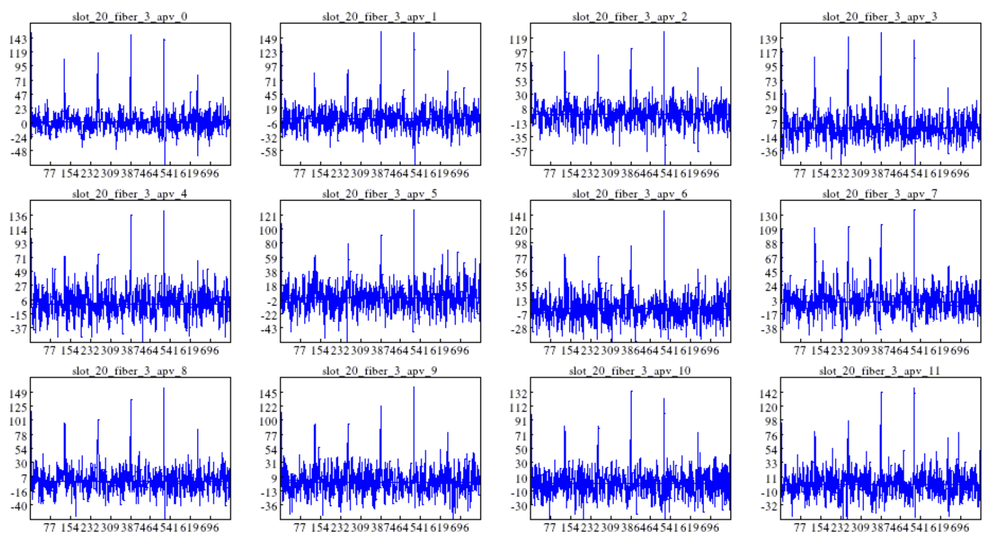

Figure 16: Example of run with pedestal and CM subtracted.

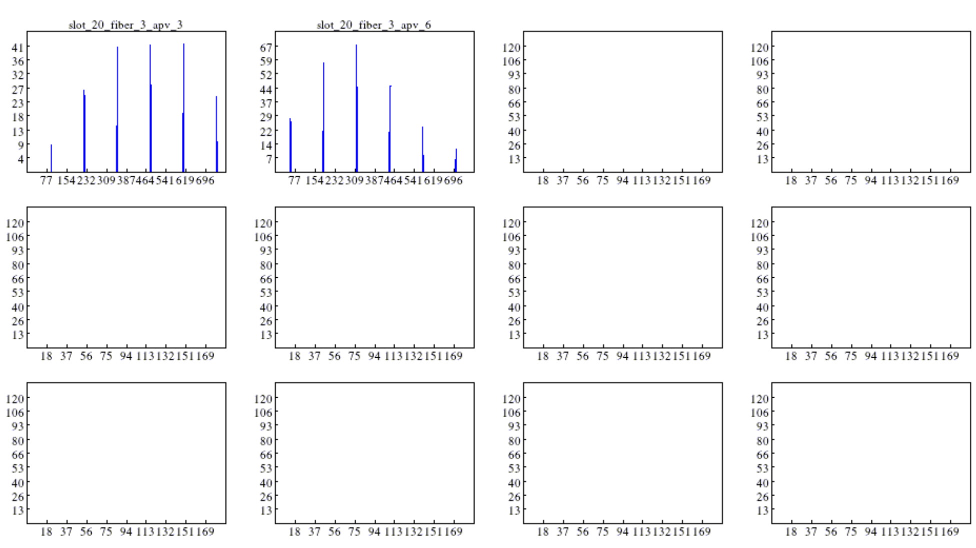

Figure 17: Example of cosmic hit with zero suppression enabled.

4.11 Tracking Analysis

4.11.1 Replaying EVIO Files

To replay EVIO files:

1. Log into aonlX under the a-onl account.
2. Execute `gosbs`
3. Execute a command with the following format: `replay_segments_gmn.sh first_seg last_seg seg_per_job`
    - first_seg is the first segment number to analyze
    - last_seg is the last segment number to analyze
    - seg_per_job is the number of segments to analyze in one job

    For example if we have run 1234 with 30 EVIO splits we can run:
    `replay_segments_gmn.sh 1234 30 10`

This will start 10 jobs with 3 segments eac (0 to 3, 3 to 6, 6 to 9 etc). **NOTE: The aonl machine can only run 30 jobs at once. Please use the "top" command and check that other jobs are not also running and taking up all theCPU space.** The output files are written to ∼/sbs/Rootfiles

The database used for the replay is located at /adaqfs/home/a-onl/sbs/sbs_devel/SBS-replay/DB/db_bb.gem.dat. This contains the defenitions of all the module alignments, pedestal files, and more. If any changes are made it must be recorded here.

After replaying, the raw data should be checked. This can be done by running:

```
panguin -r runnum -f $SBS_REPLAY/onlineGUIconfig/bb_gem_basic.cfg
```

The GUI that opens can been seen in figure 18. Look through all the low level plots for any odd features. Make sure to open bb_gem_basic.cfg and change the "protorootfile" name to match the segment number you are looking at. If you want to look at the whole run you will have to use the "hadd" command to create a combined root file before using panguin.

To plot the tracking and efficiency results run:

```
panguin -r runnum -f $SBS_REPLAY/onlineGUIconfig/bb_gem_efficiency.cfg
```

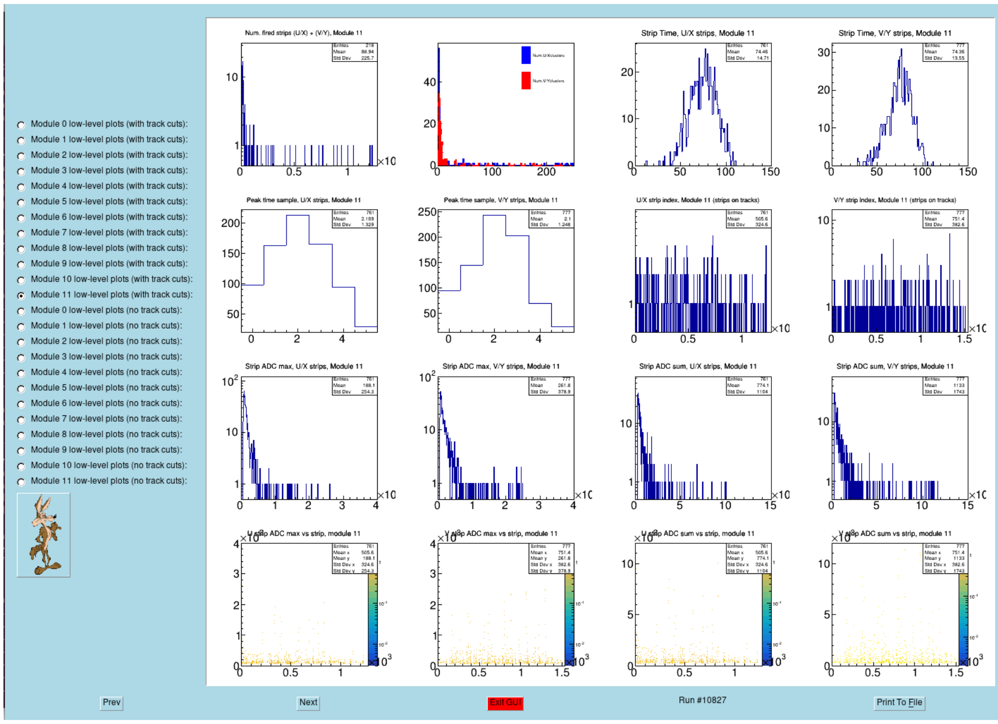

Figure 18: Example of the tracking analysis output.

The GUI that opens can been seen in figure 17. All of these plots should also be checked. The last set of plots, "Module Average Efficiencies", should always be checked. This reads out the tracking efficiency of each module.

4.11.2 Alignment

Alignment of the GEMs should not be changed often. If changes do need to happen, contact Andrew Puckett. For reference here is the process:

1. Log into a-onl@aonlX. The relevant script is at: $SBS_REPLAY/scripts/gems/GEM_align.C

2. Replay the run using the GEMs-only replay.
   Replay should produce a file as **GEM_alignment_info_bb_gem_runXXXXX.txt**. This file contains the GEM position and angle information that the replay used (read from database) in the format the alignment script wants.

3. Setup the config file
   -In **$SBS_REPLAY/scripts/gems there are files called "configalign_bbgem_XXX.txt"** where XXX is a run number. Copy one of these files, and replace XXX with the run number you want to use for the alignment.
   -Copy-paste the information from "GEM_alignment_info_..." produced by the replay into the alignment config file you want to use. This ensures that the starting positions and angles for the alignment match the ones used by the replay.
   -You may also need to tweak the global cut used to select tracks for the alignment. The chi2 cut and number of tracks cut and track number of hits cut might need to be adjusted depending on the quality of the initial alignment. For now, include a cut **bb.gem.track.nhits>=4**.
   -Put the list of root files to be included in the alignment at the top of the file before the keyword "endlist".

4. **.L gems/GEM_align.C+**

5. **GEM_align("configfilename.txt");**
   This will start the alignment process. You will get many output files including:

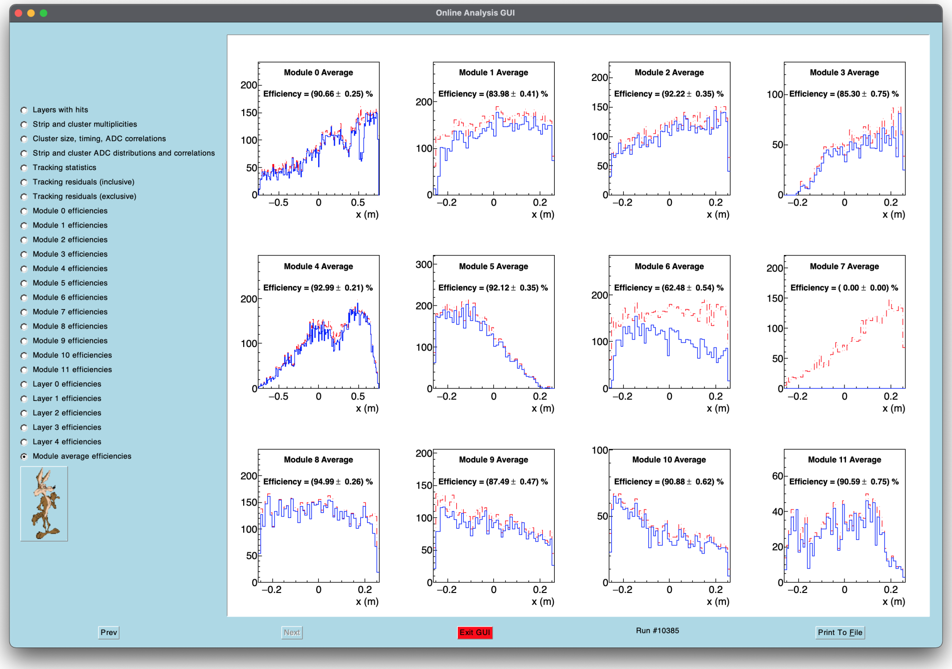

Figure 19: Example of the tracking analysis output.

-GEM_align_results_bb_gem.root where you can see the quality of the results before replaying.
-newGEMalignment.txt contains the alignment results in the format needed for the alignment script itself (units are meters, radians).
-db_align_bb_gem.dat contains the alignment results in the format expeced by the analyzer database. This should be copy-pasted into the database. Note that the analyzer expects angles in degrees.

4.12 GEM HV sector status

The known dead HV sectors on all of the GEMs are well documented. The shorted sector status can be found at GEM HV Sector Status.

4.13 SBS GEM Scintillator Information for Cosmics

There are 6 scintillators on top of the SBS Inline Stack. A layer of 4 scintillators and then 2 more scintillators on top. So that the photomultiplier tubes are pointing downstream. The purpose of these scintillators is to work as the trigger source to take cosmic data with SBS GEMs if we have a significant amount of downtime or to access the functionality of the GEM detectors. The procedure to turn the scintillators on/off is the following:

1. Be able to access adaq@adaq1 or adaq@adaq2 machines.
2. Find the current open Java HV GUI that operates the BBCal HV. Typically this can be found on the adaq1 and by opening the vnc 6 using the command "vncviewer adaq1:6". If no such vnc or Java GUI is available follow the How-To on navigating BBCal HV: BBCal HV
3. Once you find the Java HV GUI, navigate to the section "rpi18:2001".
4. After that find the tab that is "S1".
5. The channels on S1 of interest for the scintillator HV correspond to channels L1.0 through L1.5. Verify that the voltage set points (Target_V) is set to the following:

Table 8: Scintillator Settings

	Channel	**HV Setting**
Scintillator 0	1.0	-1680 V
Scintillator 1	1.1	-1400 V
Scintillator 2	1.2	-1820 V
Scintillator 3	1.3	-1710 V
Scintillator 4	1.4	-1675 V
Scintillator 5	1.5	-1570 V

6. After verifying the voltage set points, you are now ready to enable the HV on these channels. Find the "Ch_En" column and click on each box, until you see a check mark appear. It might take a second as there could be a little bit of delay.

7. Verify that the measured voltage and current are reasonable. If good, proceed to data collection!

4.14 Using the SBS GEM standalone DAQ system

SBS GEMs have its own DAQ/CODA that runs on the **sbs-onl@eel124gemdaq** computer. This was initially setup for the commissioning of the SBS GEMs in the Hall-A, using cosmic data.

4.14.1 Switching back and forth between main experiment CODA and the SBS GEM standalone CODA

If needed at some point, one can switch from the main experiment DAQ to this standalone SBS GEM DAQ by following the procedure,

1. Go to the main DAQ rcgui running in **adaq@adaq2** computer. Make sure it is in a configurations that uses all the SBS GEM components like GEnII-3Stream, and not in a one like GEnII-NoSBSGems.

2. Select "control" in the top left corner and then select "Release components". Then click "Yes" in the pop up window. This will release all the CODA components from the main experiment DAQ making them free.

3. Then log into the **sbs-onl@eel124gemdaq** computer (VNC connection preferred). Take note that this computer is also behind the *hallgw* just like all the other Hall-A computers.

4. Start CODA using the normal procedure.

By following the same procedure from the SBS GEM standalone CODA, one can switch back to start using the main experiment CODA.

5 Revisions

Editor	Description of Changes	Date
J. Boyd	Added sections and revisions. Updated GEM Experts and VME andVTP tables.	Aug. 23, 2022
E. Wertz	Added sections for shifter information for SBS GEMs	Sept. 14, 2022