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	msure@jlab.org	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 3.5.

- 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.

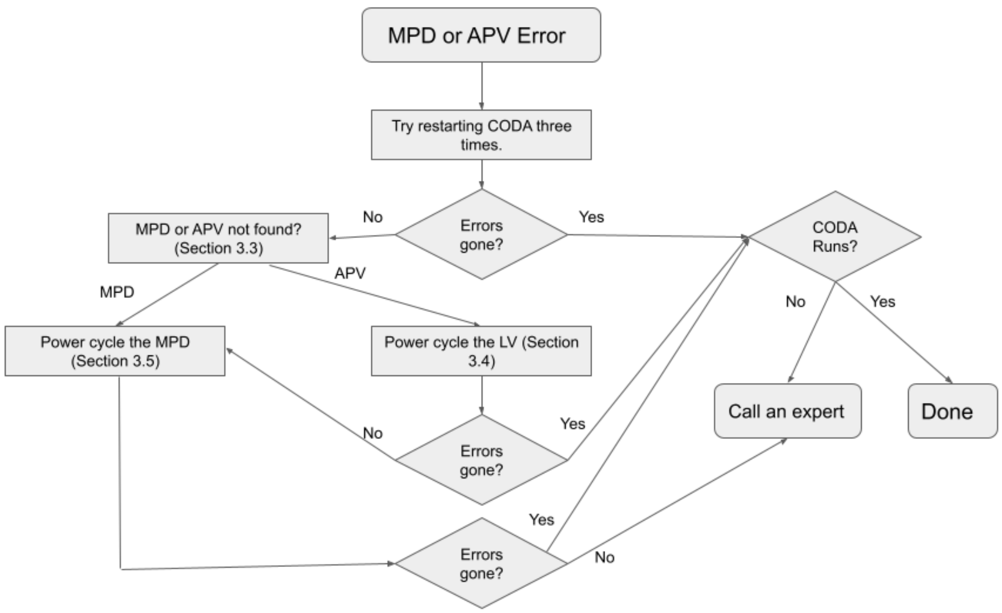


Figure 1: Troubleshoot flowchart for shifters when errors appear in the DAQ.

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.

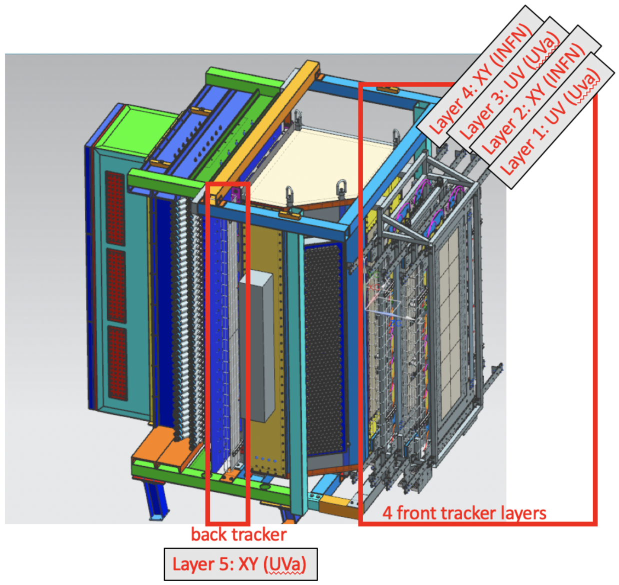


Figure 2: The BigBite detector stack is shown with the front and back tracker GEM layers indicated. The orientation of the strips in each layer is specified as UV or XY.

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:

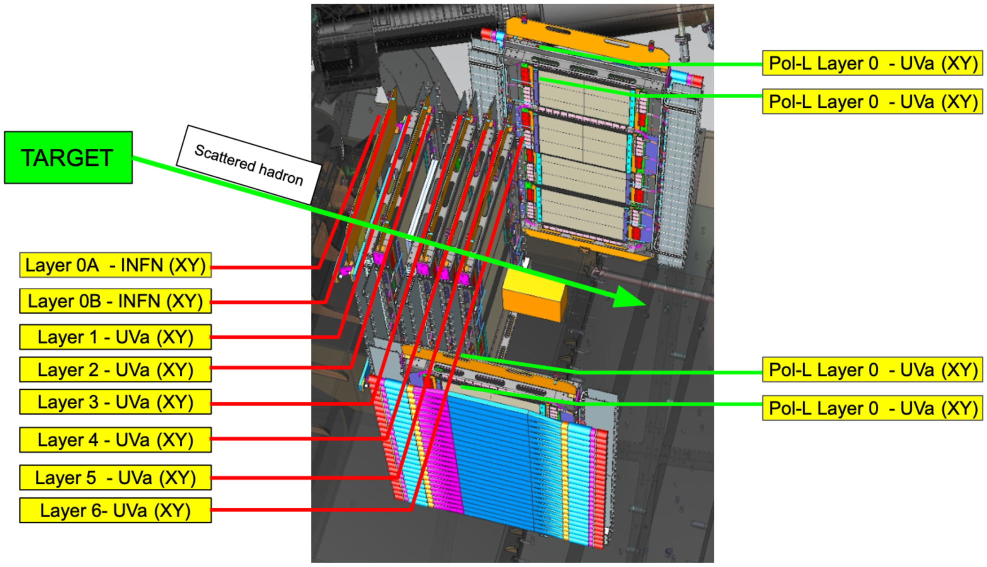


Figure 3: Layout and labels for the layers in the GeN-RP stack configuration

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
			L7: UVa XY	19	36	12
			L7: UVa XY	20	37	12
	sbsvme25		L7: UVa XY	2	38	12
			L7: UVa XY	3	39	15
sbsvtp4 : sbsvtpROC25			L7: UVa XY	4	0	15
			L7: UVa XY	5	1	10
		INFN J1	L0: INFN J1	6	2	15
			L0: INFN J1	7	3	12
			L0: INFN J1	8	4	15
			L0: INFN J1	9	5	12
		INFN J3	L1: INFN J3	10	6	15
			L1: INFN J3	11	7	12
			L1: INFN J3	12	8	15
			L1: INFN J3	13	9	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 Fixing the DAQ

On the a-onl@aonlX (X = 1,2,3,4) machine open up the GEM reset GUI with the following commands:

```
gosbs
GEM_resets.sh
```

The GUI shown in figure 5 will pop onto your screen. Shift workers should only use the first two buttons. Press them to reset the electronics and wait a few minutes and the DAQ issues should be fixed.

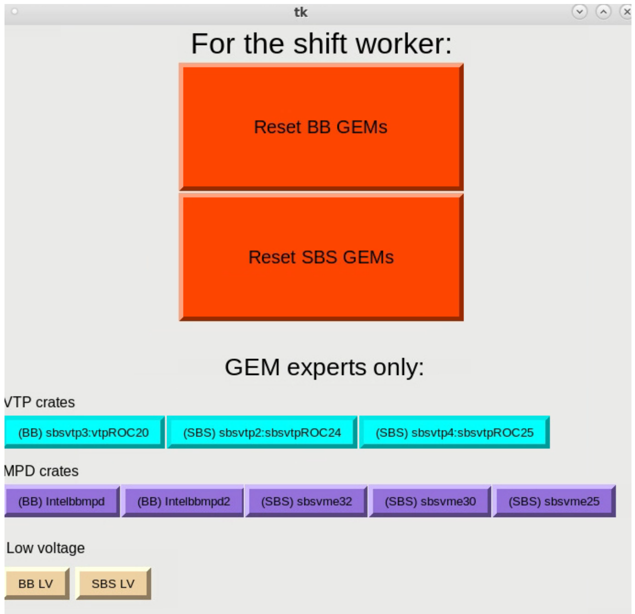


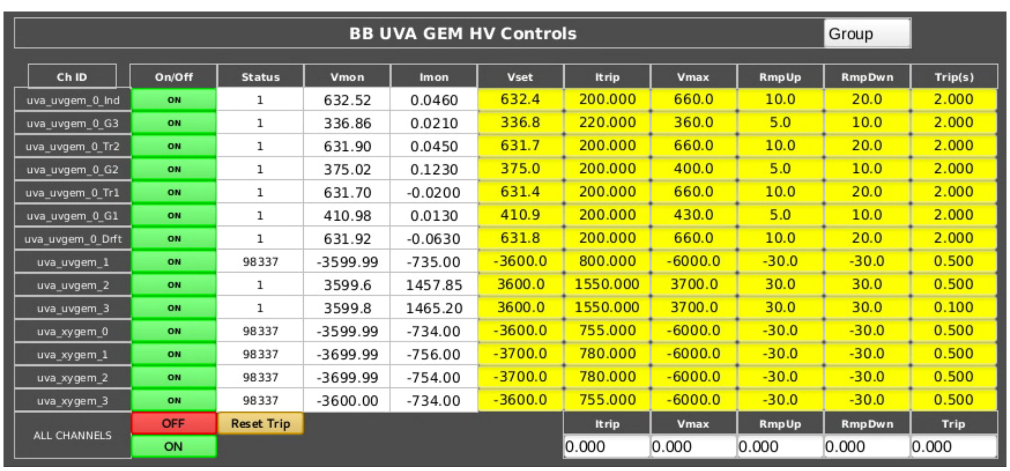
Figure 5: GUI that is used to reboot the GEM electronics. Clicking on the buttons shown will reset the components.

3.5 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 6 and the SBS GEM GUI can be seen in figure 7. 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.

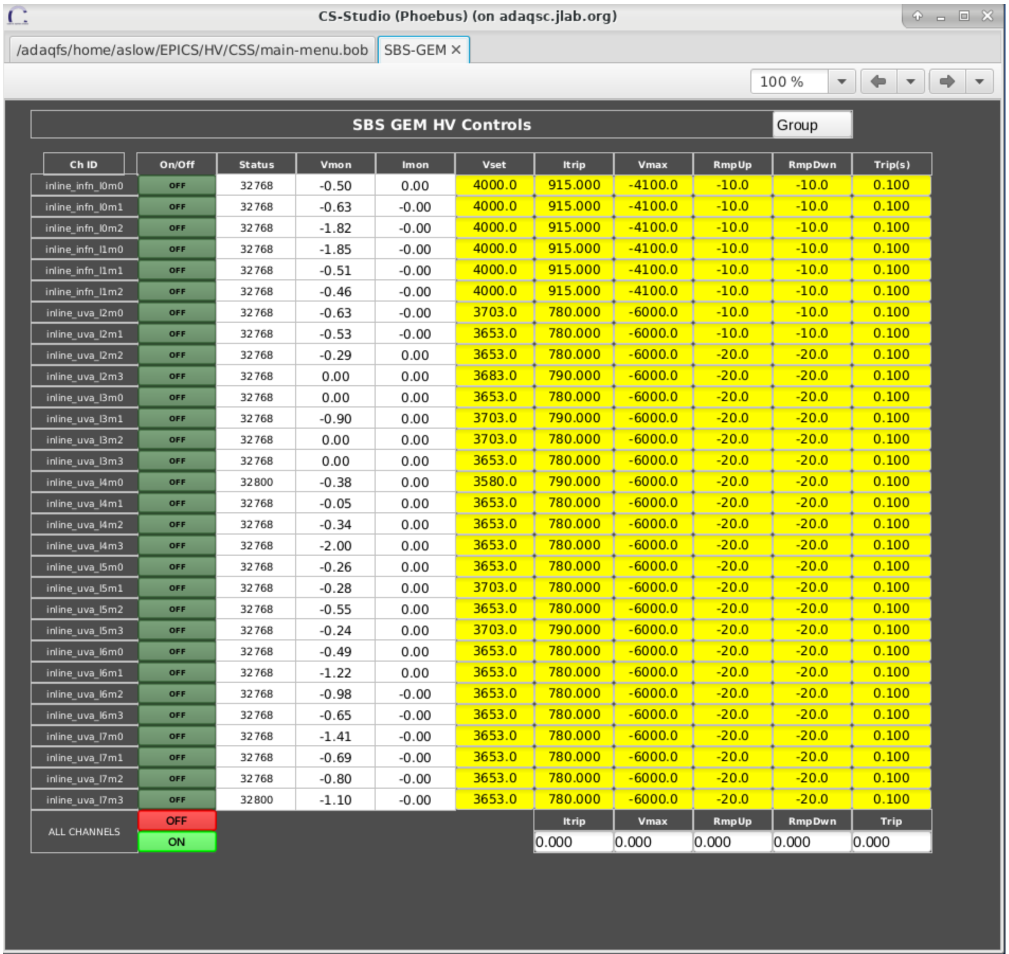
IMPORTANT NOTE: Notice in figure 6 on the bottom left there is an orange "Reset Trip" button. If the first 7 channels trip it will get stuck and this button must be pressed to fix it.



BB UVA GEM HV Controls — Group

Ch ID	On/Off	Status	Vmon	Imon	Vset	Itrip	Vmax	RmpUp	RmpDwn	Trip(s)
uva_uvgem_0_Ind	ON	1	632.52	0.0460	632.4	200.000	660.0	10.0	20.0	2.000
uva_uvgem_0_G3	ON	1	336.86	0.0210	336.8	220.000	360.0	5.0	10.0	2.000
uva_uvgem_0_Tr2	ON	1	631.90	0.0450	631.7	200.000	660.0	10.0	20.0	2.000
uva_uvgem_0_G2	ON	1	375.02	0.1230	375.0	200.000	400.0	5.0	10.0	2.000
uva_uvgem_0_Tr1	ON	1	631.70	-0.0200	631.4	200.000	660.0	10.0	20.0	2.000
uva_uvgem_0_G1	ON	1	410.98	0.0130	410.9	200.000	430.0	5.0	10.0	2.000
uva_uvgem_0_Drft	ON	1	631.92	-0.0630	631.8	200.000	660.0	10.0	20.0	2.000
uva_uvgem_1	ON	98337	-3599.99	-735.00	-3600.0	800.000	-6000.0	-30.0	-30.0	0.500
uva_uvgem_2	ON	1	3599.6	1457.85	3600.0	1550.000	3700.0	30.0	30.0	0.500
uva_uvgem_3	ON	1	3599.8	1465.20	3600.0	1550.000	3700.0	30.0	30.0	0.100
uva_xygem_0	ON	98337	-3599.99	-734.00	-3600.0	755.000	-6000.0	-30.0	-30.0	0.500
uva_xygem_1	ON	98337	-3699.99	-756.00	-3700.0	780.000	-6000.0	-30.0	-30.0	0.500
uva_xygem_2	ON	98337	-3699.99	-754.00	-3700.0	780.000	-6000.0	-30.0	-30.0	0.500
uva_xygem_3	ON	98337	-3600.00	-734.00	-3600.0	755.000	-6000.0	-30.0	-30.0	0.500
ALL CHANNELS	OFF	Reset Trip				Itrip	Vmax	RmpUp	RmpDwn	Trip
	ON					0.000	0.000	0.000	0.000	0.000

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



Ch ID	On/Off	Status	Vmon	Imon	Vset	Itrip	Vmax	RmpUp	RmpDwn	Trip(s)
inline_infn_l0m0	OFF	32768	-0.50	0.00	4000.0	915.000	-4100.0	-10.0	-10.0	0.100
inline_infn_l0m1	OFF	32768	-0.63	-0.00	4000.0	915.000	-4100.0	-10.0	-10.0	0.100
inline_infn_l0m2	OFF	32768	-1.82	-0.00	4000.0	915.000	-4100.0	-10.0	-10.0	0.100
inline_infn_l1m0	OFF	32768	-1.85	-0.00	4000.0	915.000	-4100.0	-10.0	-10.0	0.100
inline_infn_l1m1	OFF	32768	-0.51	-0.00	4000.0	915.000	-4100.0	-10.0	-10.0	0.100
inline_infn_l1m2	OFF	32768	-0.46	-0.00	4000.0	915.000	-4100.0	-10.0	-10.0	0.100
inline_uva_l2m0	OFF	32768	-0.63	-0.00	3703.0	780.000	-6000.0	-10.0	-10.0	0.100
inline_uva_l2m1	OFF	32768	-0.53	-0.00	3653.0	780.000	-6000.0	-10.0	-10.0	0.100
inline_uva_l2m2	OFF	32768	-0.29	0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l2m3	OFF	32768	0.00	0.00	3683.0	790.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l3m0	OFF	32768	0.00	0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l3m1	OFF	32768	-0.90	0.00	3703.0	790.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l3m2	OFF	32768	0.00	0.00	3703.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l3m3	OFF	32768	0.00	0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l4m0	OFF	32800	-0.38	0.00	3580.0	790.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l4m1	OFF	32768	-0.05	0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l4m2	OFF	32768	-0.34	0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l4m3	OFF	32768	-2.00	0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l5m0	OFF	32768	-0.26	0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l5m1	OFF	32768	-0.28	0.00	3703.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l5m2	OFF	32768	-0.55	0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l5m3	OFF	32768	-0.24	0.00	3703.0	790.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l6m0	OFF	32768	-0.49	0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l6m1	OFF	32768	-1.22	0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l6m2	OFF	32768	-0.98	-0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l6m3	OFF	32768	-0.65	-0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l7m0	OFF	32768	-1.41	-0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l7m1	OFF	32768	-0.69	-0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l7m2	OFF	32768	-0.80	-0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100
inline_uva_l7m3	OFF	32800	-1.10	-0.00	3653.0	780.000	-6000.0	-20.0	-20.0	0.100

ALL CHANNELS	Itrip	Vmax	RmpUp	RmpDwn	Trip
OFF / ON	0.000	0.000	0.000	0.000	0.000

Figure 7: Screenshot of the HV GUI for the SBS GEMs in SBS.

3.6 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$\pm$30 cc/min/chamber. BB UVa UV layers 1 and 3 (Ch 07 and Ch08) have a defect and should flow at 375$\pm$30 cc/min/chamber . For the UVa XY module in production conditions should flow at 225$\pm$15 cc/min/chamber. An example screenshot for the BB gas system is shown in figure 8 and SBS gas system in figure 9.

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 $\rightarrow$ GEMs $\rightarrow$ 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.

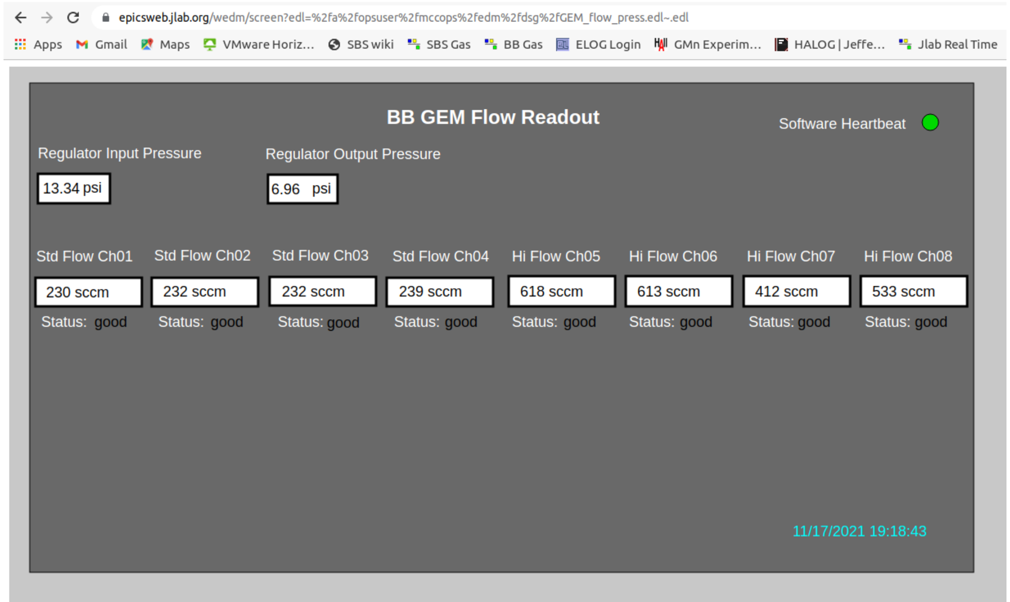


Figure 8: This is a screenshot of nominal flow rates for the BigBite GEMs.

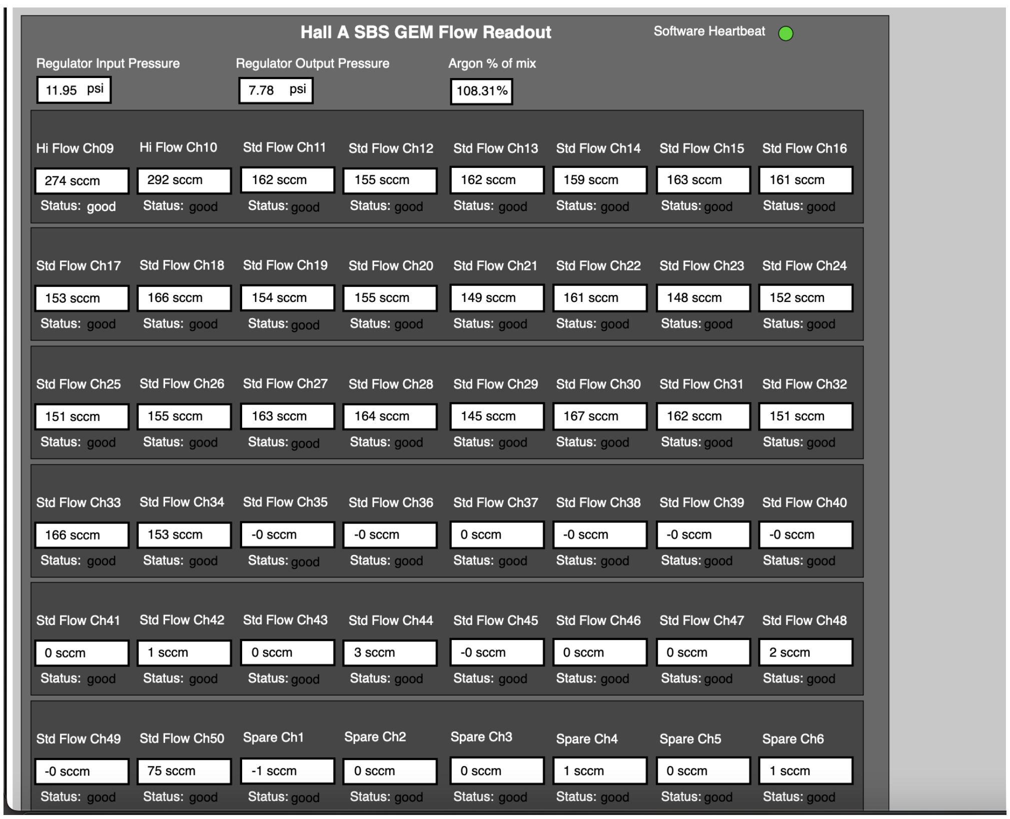


Figure 9: This is a screenshot of flow rates for the SBS GEMs.

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 3.5 and 4.4).
- Gas flow readout and gas can level at least twice a day (see section 3.6).
- Raw APV frames for the beginning of every run (see section 4.12).
- Analyzed low level plots and tracking efficiencies should be checked at least twice a day (see section 4.13).
- Keep track of the gas bottles being used. We should have at least 2 weeks worth of spare gas bottle supply in all the gas sheds combined at all times.

4.2 DAQ for Experts

Experts should use the GUI in section 3.4 but should reset the expert components instead of everything. In case this GUI does not work one can use the website browsers below to reset them.

4.2.1 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. Go to `http://hareboot32.jlab.org`
2. Go to "Device Manager" and then "Control"
3. Check "outlet 5" and under the "Control Action" menu select "Reboot Immediate"

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

1. Go to `http://prexreboot02.jlab.org`
2. Make sure you can see “UVA INLINE GEM LV” in 2 port.
3. Check “outlet 2” and under the “Control Action” menu select “Reboot Immediate,” and then click “Next” and then "Apply".

4.2.2 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 : vtpROC20:
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 : sbsvtpROC24:
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 : sbstpROC25:
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://prexreboot02.jlab.org
3. 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 3" 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"
6. Wait 2 to 5 minutes

4.3 How the reset GUI works

4.4 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 figure.10. The values in figure.10 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.

4.5 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.

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

4.5.1 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**

4.5.2 BigBite UV Layer 0

UV layer 0 is using a special power supply. 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 3.5. If the normal SBS HV GUI is not working, this module can be accessed following these steps:

1. Open a firefox browser (network) and go to: 129.57.192.161
2. It will ask for login credentials. Use "admin" as both the username and password.
3. At the top click on "settings menu", click reboot to restart the power supply
4. It will ask you to confirm the reboot couple more time. Go ahead and do it.

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**

5. After the reboot is complete you may have to enter the login credential back again. Then navigate to Epics from "Settings menu" where you will find a button to restart EPICS service. Click on that. This should restart EPICS on the power supply.

6. If things are still not working then reset the outlet here: `http://129.57.188.120/outlet.html`. Select **Reboot**, **Outlet #8**, and then click **Next**. It should take about 30 seconds to come back online. Then go to step 5 and restart the EPICS service.

4.6 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.

4.7 Configuration File Locations

4.7.1 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 4.8.

4.7.2 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 4.8.

4.8 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 11 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 11: 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 12 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 12: We see this MPD has 12 APVs in the adc slots 0 - 11 on the MPD.

4.9 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.

4.10 Changing the Latency

As mentioned above the GEM "Latency" parameter is set in **ssp_apv_default.cfg**(BigBite) and **vtp_apv_defaults.cfg**(SBS). This is the global latency for all GEMs connected to the given subsystem, namely BigBite and SBS. Some GEM layers/GEM modules/MPDs/APVs may need a slight offset in latency. This can be done by defining a module as shown below in the **ssp_apv_default.cfg/vtp_apv_defaults.cfg** files. Using this method the latency for one layer/module/fiber/APV can be changed by changing the"offset" in one location.

Take note that what actually happens here is that a "group" is defined in the **ssp_apv_default.cfg**(BigBite) and **vtp_apv_defaults.cfg**(SBS) files under "layer_latency" and that group name is assigned to each APV you want the latency offset to be applied, in the MPD configuration files.

4.11 Loading Pedestal Files and Configuring ZS and CM

To first take a pedestal set the CODA configuration properly as described in section 4.9. Check that all APVs look good in the raw data as explained in section 4.12. Then follow the steps:

1. Go to a-onl@aonlX execute `gogem` and then: `./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

```
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 13: (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.

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. It will automatically copy these databases to the correct directories.

3. Edit the VTP config files as described in section 4.9 so that VTP_MPDRO_PEDESTAL_FILENAME and VTP_MPDRO_COMMON_MODE_FILENAME point to these files.

4.12 Raw Event Display

To check raw events we are using Xinzhan's GUI on **a-onl@aonlx**. To run it, execute "gem_view" from any terminal and any directory you are in at any of the aonlx machines.

If the above does not work for any reason, simply navigate to the directory **/adaqfs/home/a-onl/sbs/GEM_data_viewer/MPD_GEM_View_VTP** and 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 14. Anything that does not look like this may be broken. For example, in figure 15 it is clear that APV 11 is problematic. Also the baseline ADC should never be above 1000. An example is shown in figure 16. If common mode (CM) and pedestal subtraction is enabled online then the data should be centered around zero, which is shown in figure 17. Finally, if zero suppression is enabled then there should only be a few strips with data per event. An example is shown in figure 18.

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**.

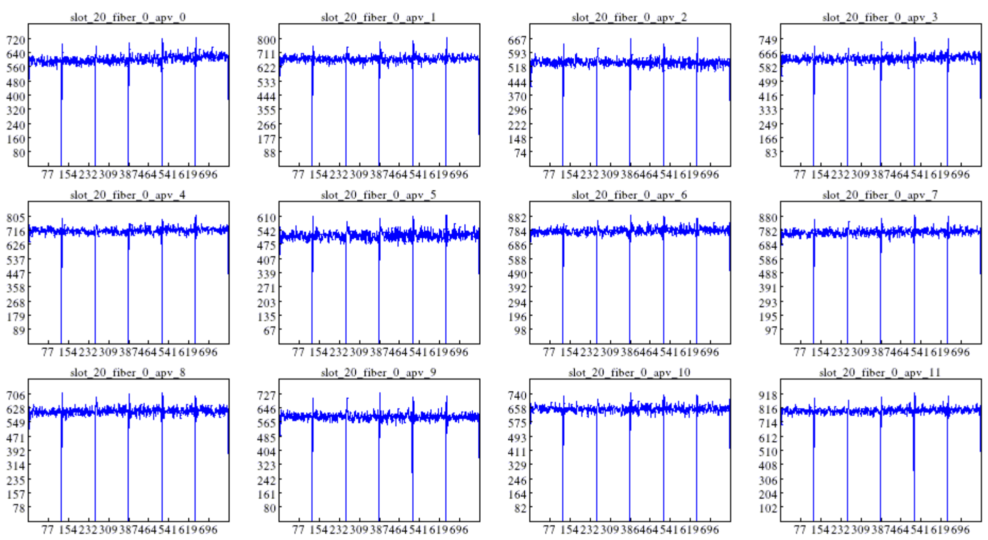


Figure 14: Example of normal pedestal APV raw data.

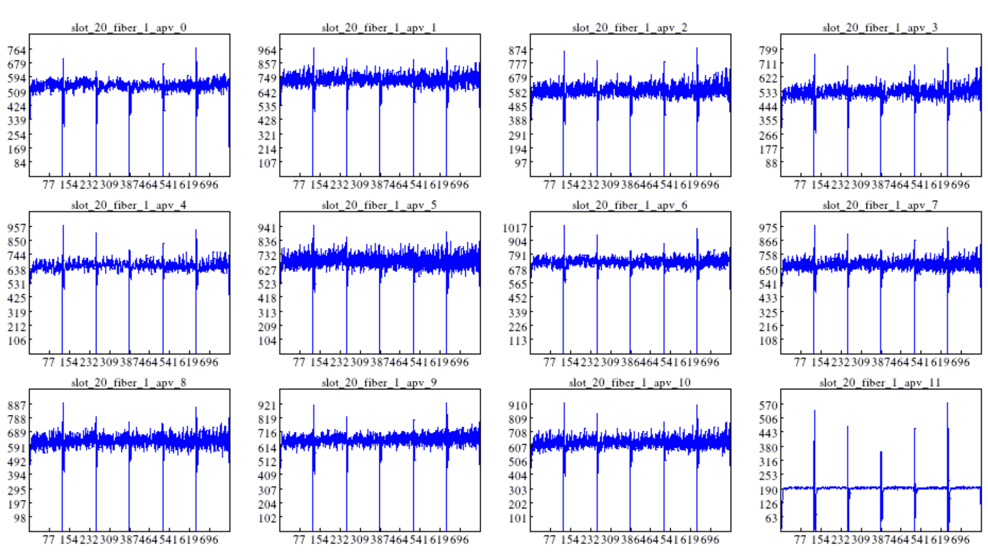


Figure 15: Example of a pedestal run where APV 11 is clearly not working

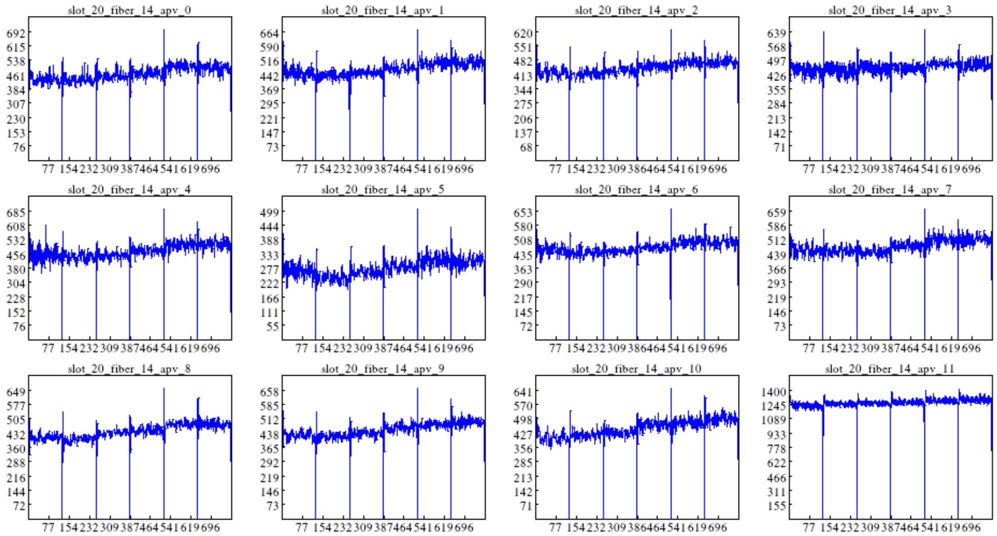


Figure 16: Example of a pedestal run where APV 11 is not working. The baseline ADC values should never be above 1000.

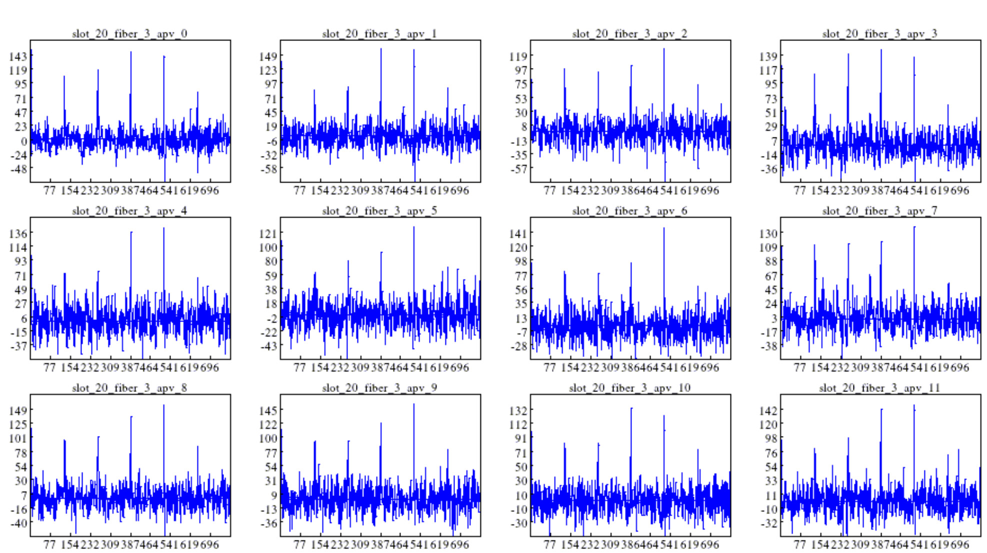


Figure 17: Example of run with pedestal and CM subtracted.

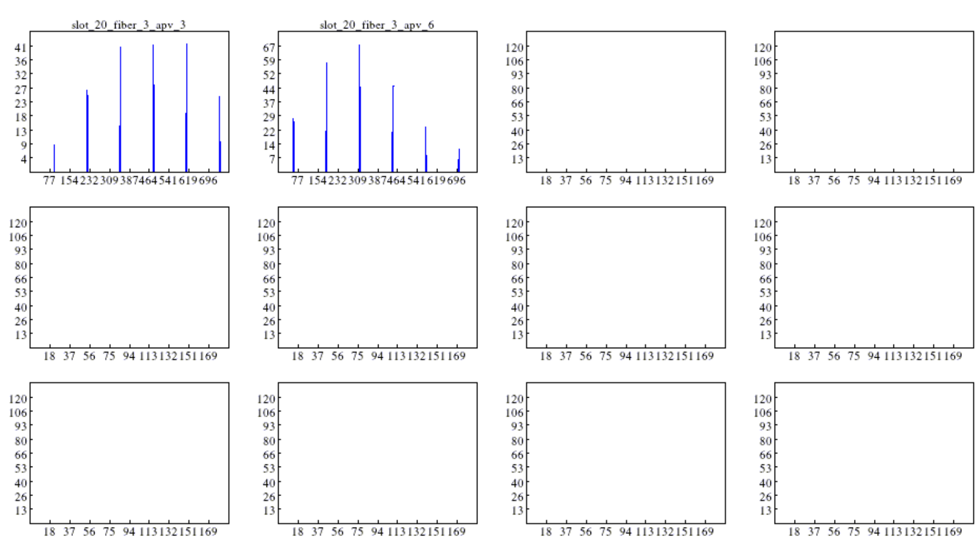


Figure 18: Example of cosmic hit with zero suppression enabled.

4.13 Tracking Analysis

4.13.1 Replaying EVIO Files

To replay EVIO files see instructions on the SBS wiki page

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 definitions 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 through the usual panguin plots found at $SBS_REPLAY/onlineGUIconfig/bb_gem_basic.cfg. An example GUI that opens can been seen in figure 19. Look through all the low level plots for any odd features.

4.13.2 Alignment

Alignment of the GEMs should not be changed often. The process is complicated and you should have experience doing this before changing alignment during production running. 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. Find a recently replayed ROOT file. If none exists then replay a recent run yourself.
   If you do not already have the GEM alignment goemetry saved then set bb.gem.dump_geometry_info = 1 and the 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.chi2ndf<30 && bb.gem.track.ntrack==1 && bb.gem.track.nhits>=5**.
   -Put the list of root files to be included in the alignment at the top of the file before the keyword "endlist".

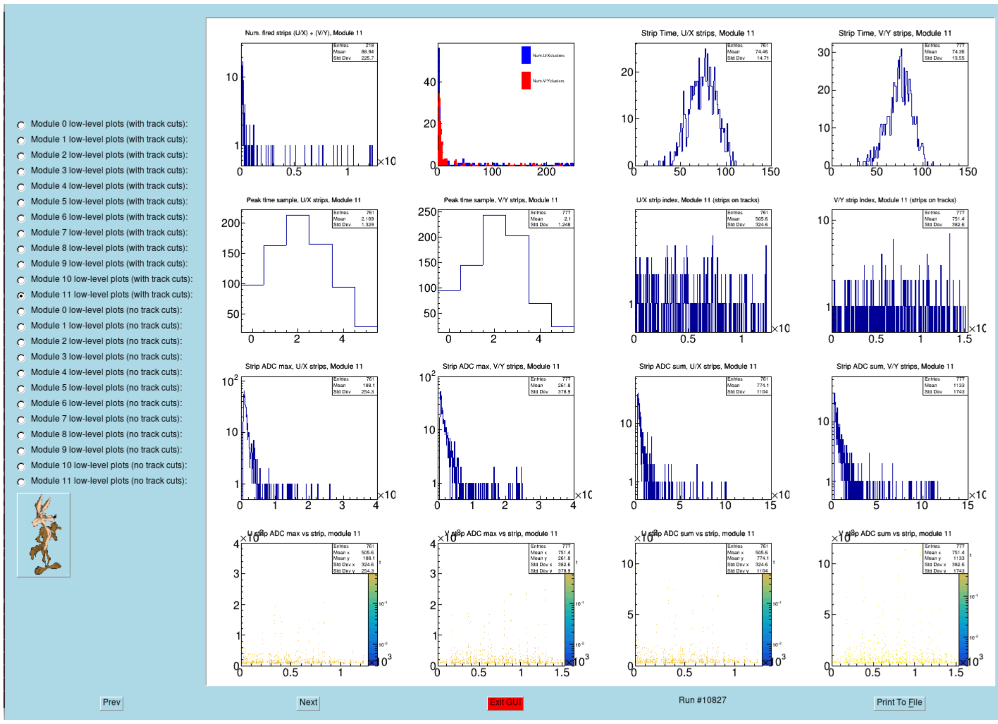


Figure 19: Example of the tracking analysis output.

4. **root 'GEM_align.C("configfilename.txt")'**
   This will start the alignment process. You will get several output files including:
   -GEM_align_results_bb_gem.root where you can see the quality of the results. Here you can check that the alignment is good before uploading it to the DB.
   -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 expected by the analyzer database. This should be copy-pasted into the database. Note that the analyzer expects angles in degrees.

4.14 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.

4.15 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!

4.16 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.

4.16.1 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.

4.17 BigBite GEM and SBS GEM Gas systems in the Hall A Gas Shed

The BigBite and SBS GEM detectors all require a constant flow of Argon/CO2 mixture during most production and commissioning conditions. This gas supply is accomplished via 2 separate mixing systems which take pure Argon and pure CO2, to make a desired gas mixture via Mass Flow Controllers (MFC) and other mixing control electronics. Typically for the SBS program we use a mix ratio of 75/25 Argon/CO2, which is actually interpreted by the Binary Gas Analyzers (BGA) as 78% ± 2% Argon in CO2 for the gas mixture. This value is based on study and data from Jack Segal when the BigBite GEM mixing system was setup and accounts for multiple batches of premix Argon/CO2 from the manufacturer. Ultimately the slight difference in mixture value is a consequence of different techniques used between the manufacturer(probably mass spectroscopy) and the BGA. The goal of of this section is to identify useful components of both the BigBite and SBS GEM mixing systems and their purpose. To locate the regulators and cylinders for the SBS GEM gas, these are in a fenced in area on the left side of the Hall A truck ramp. The fenced in area for the SBS GEMs is also directly next to the storage racks for all Hall A gas. The BigBite GEM regulators and cylinders are located in a fenced in area on the right side of the Hall A truck ramp. Also on the right hand side of the Hall A truck ramp is a room that houses most/all of the mixing system components for both systems, known as the Hall A Gas Shed. To identify the door for the Hall A Gas Shed see figure 20.

Figure 20: Hall A Gas Shed.

4.17.1 BigBite GEM Gas System

As noted above the BigBite GEM gas regulators and cylinders are located on the right side of the Hall A truck ramp. Inside the fenced in area, there is a left regulator which supports 2 cylinders for Argon and there is a right regulator which supports 2 cylinders for CO2. The layout of these regulators and cylinders can be observed from figure 21. The output tubes of each of these regulators will ultimately go to the mixing tank, seen in the middle of figure 22. The system automatically determines, via the MFCs (figure 22) and the mixing control box, the mix percentage. The mixing control box (figure 23) has preset voltages to determine the percentage of each gas. Both the mixing tank and the MFCs are found behind the right most blue metal panels in the Hall A gas shed. After the mixing tank the mixed Ar/CO2 goes to the buffer tank (figure 24), which then directly connects to a tube and the flow meter rack in the Hall. Attached to the buffer tank is a purge valve, which is installed to rapidly change gas from the buffer tank to resolve any issues with the valve of the gas mix ratio. Also connected to the buffer tank is the valve that controls if the gas mixture from the buffer tank goes to the Hall or not, this valve is outlined in red in figure 25. If the valve is rotated clockwise, this closes the valve and stops gas flow to the Hall. If the valve is rotated counter-clockwise, this opens the valve and allows gas flow to the Hall. The location of the valve in figure 25 is open and roughly the amount of rotation necessary to provide approximately 14-15 psi to the Hall flow meter panel. Another useful feature of the BigBite mixing system is the electronic control panels to determine which bottles are currently providing Argon and CO2 to the system, these can be found in figure 26. Many controls are shown, we are only interested in the ones labeled Argon and CO2 respectively. Another important readback system is the BGA, which shows the gas mix ratio of Argon in CO2, the BigBite BGA is shown in figure 27.

4.17.2 SBS GEM Gas System

As noted above the SBS GEM gas regulators and cylinders are located on the left side of the Hall A truck ramp. Inside the fenced in area there are 7 spots for Argon cylinders and 3 spots for CO2 cylinders. The

Figure 21: BigBite GEM regulators and cylinders.

layout of these regulators and cylinders is shown in figure 28. The output of the Argon line and of the CO2 line will ultimately go to a valve control and Mass Flow Controllers (MFCs), which are in the Hall A gas shed and are shown in figure 29. From the tubes/valves for individual gas manual control, the gas goes to a mixing wand which mixes Argon and CO2 according to set values in the MFCs and other SBS GEM gas electronics, the mixing wand is shown in figure 30. Directly after the mixing wand, the mixed gas goes to a buffer tank seen in figure 31. From the buffer tank there is tube that takes the mixed gas directly to the SBS GEM flow meter panel in Hall A, part of this tube is a valve attachment to control the amount of pressure sent to the panel, see figure 32. To close the valve turn it fully perpendicular to the direction of the tube, the pressure gauge attached should approach zero. The SBS GEM gas system also has a BGA, which is where the value for the gas mixture is determined. The SBS GEM BGA is show in figure 33.

4.18 Low Level GEM Plots

A very useful set of plots corresponds to low level histograms and samples. These plots look like goal posts and fish/eyes respectively. The main function of these plots is to send analog and digital signals from the MPD to the APVs very quickly without the use of CODA. By doing this one is able to rapidly evaluate the cable connections for the GEM electronics. For the main setups in Hall A these scripts are available on each vtp crate computer: sbs-onl@sbsvtp3, sbs-onl@sbsvtp2, and sbs-onl@sbsvtp4.

- Connect to the hallgw, **ssh hallgw**.
- Login to the respective crate of interest from adaq@adaq# based on the GEM electronics being evaluated.
- On sbs-onl@sbsvtp# navigate to the directory, **cd /home/sbs-onl/vtp/vtp/test**.
- For the histogram test, which primarily evaluates the APV functionality, call **./vtpMpdHistoMode 0 "path_config.cfg" "the_outfile_name.txt" 5 0**. In this case the program is vtpMpdHistoMode.c which takes 4 parameters. The first parameter is the number of parameters following it. The second parameter is the name of the config file to be tested. The third parameter is the name of the output

Figure 22: MFCs (orange, black, and green) are near the top and the metal cylinder is the mixing tank (below MFCs near middle of picture) for BigBite GEM.

text file. The fourth parameter is the gain value. The fifth parameter is the MPD slot to evaluate, 0 will default to all MPDs in the crate.

- For the sample test, which primarily evaluates the clock phase of the APV, call **./vtpMpdSampleMode 0 "path_config.cfg" "the_outfile_name.txt" 0 60 1**. In this case the program is vtpMpdSampleMode.c. The first parameter is the number of parameters following it. The second parameter is the name of the config file to be tested. The third parameter is the name of the output text file. The fourth parameter is the minimum clock phase value. The fifth parameter is the maximum clock phase value. The sixth parameter is the clock phase step.

- Now we need to analyze the output information. For BBGEMs, output files are linked through directories. Login to aonl@aonl#, **ssh aonl@aonl#**. Navigate to the following directory: **/adaqfs/home/aonl/sbs/GEM_data_viewer/infn_analysis/daq**. In either case now call **root**. For the histogram analysis call **.x readHisto_UVa.cpp("sbsvtp#_mpd/my_histofile.txt","plots/my_histo.pdf")**. This will generate the output file **plots/my_histo.pdf** which can be viewed, **evince plots/my_histo.pdf**, to diagnose electronics. For the sample analysis call **.L readHisto_UVa.cpp**, then **readSample("sbsvtp#_mpd/my_samplefile.txt","plots/my_sample.pdf")**. This will generate the output file **plots/my_sample.pdf** which can be viewed, **evince plots/my_sample.pdf**, to evaluate APV clock phase.

- Now we need to analyze the output information. For SBSGEMs, output files are not linked. So we instead need to copy files: **scp out_file.txt sbsonl@eel124gemdaq:/home/sbsonl/xb/mpd_low_level/files**. Login to sbsonl@eel124gemdaq, **ssh sbsonl@eel124gemdaq**. Navigate to the following directory: **/home/sbsonl/xb/mpd_low_level**. In either case now call **root**. For the histogram analysis call **.x readHisto_INFN.cpp("files/my_histofile.txt","plots/my_histo.pdf")**. This will generate the output file **plots/my_histo.pdf** which can be viewed, **evince plots/my_histo.pdf**, to diagnose electronics. For the sample analysis call **.L readHisto_INFN.cpp**, then

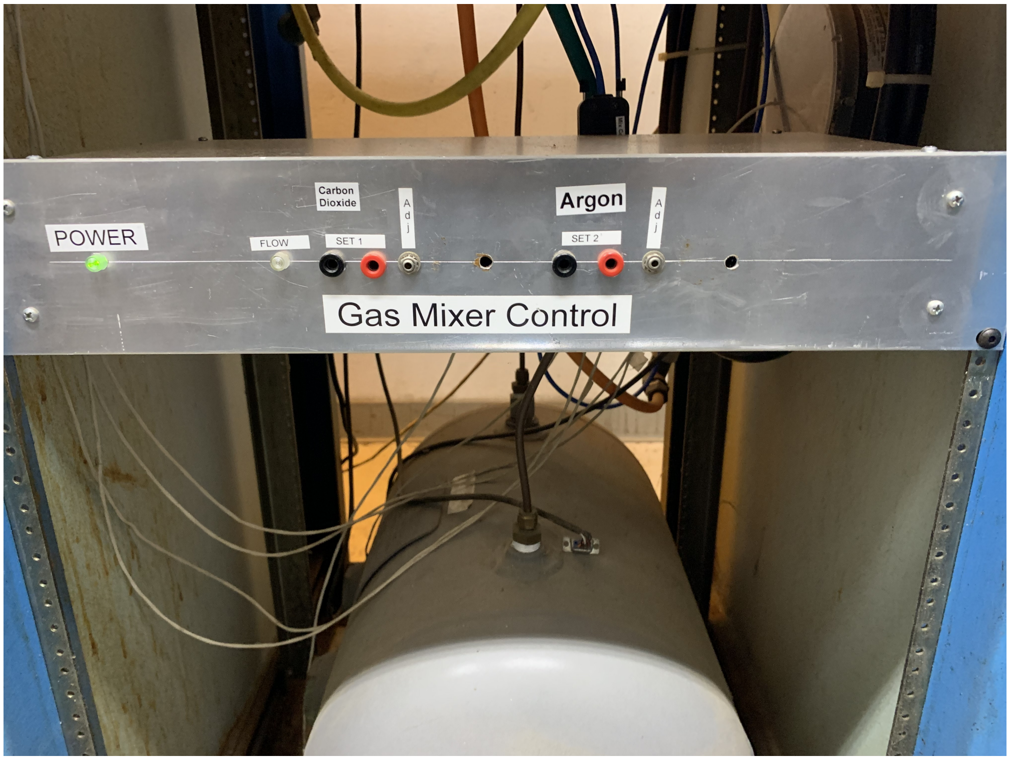


Figure 23: BigBite GEM mixing controller.

readSample("files/my_samplefile.txt","plots/my_sample.pdf"). This will generate the output file **plots/my_sample.pdf** which can be viewed, **evince plots/my_sample.pdf**, to evaluate APV clock phase.

- We should really change the location of the SBS low level analysis to the same location on a-onl. The directory is already linked. We would just need to copy the script and give it a name like **readHisto_SBSGEM.cpp**. But for now I have done this due to time constraints.

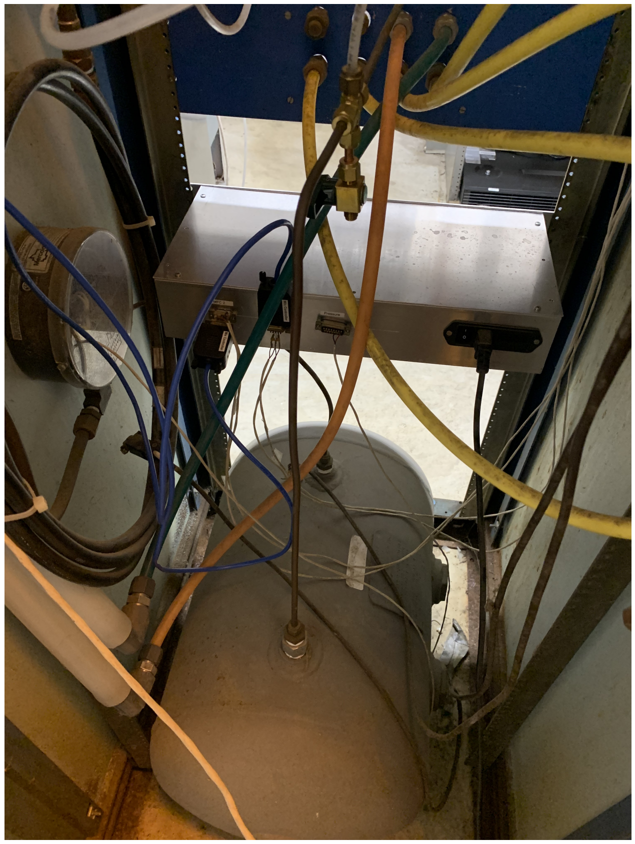


Figure 24: BigBite GEM buffer tank and purge valve.

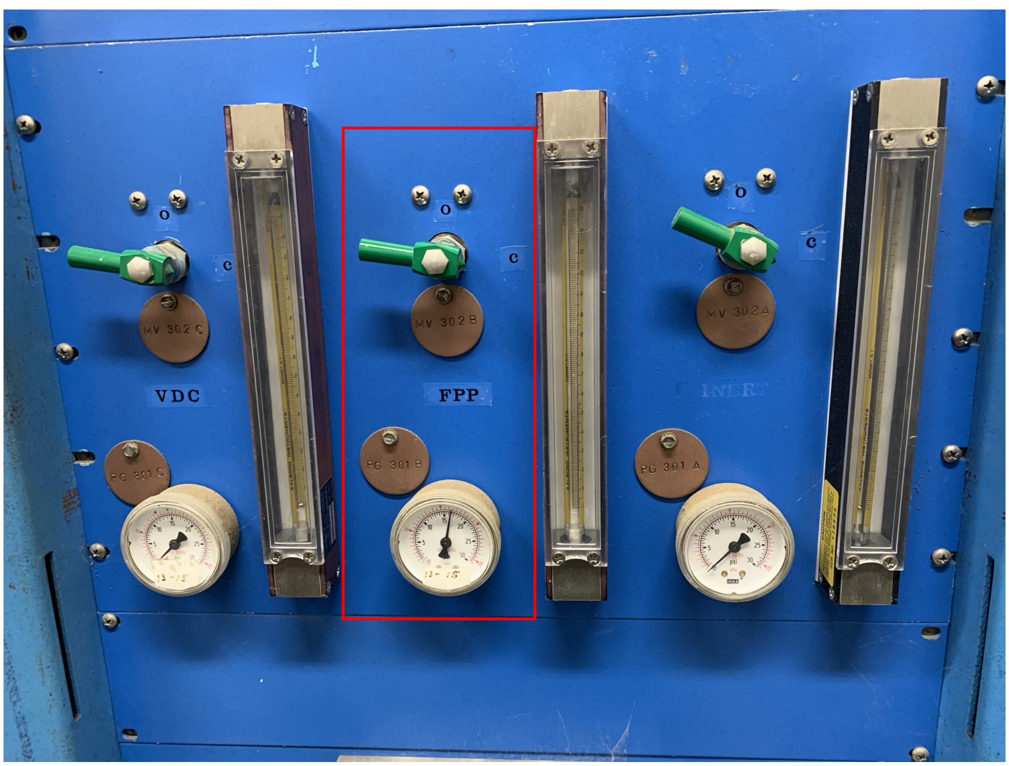


Figure 25: BigBite GEM Hall Shutoff valve

Figure 26: BigBite GEM Electronic Controls

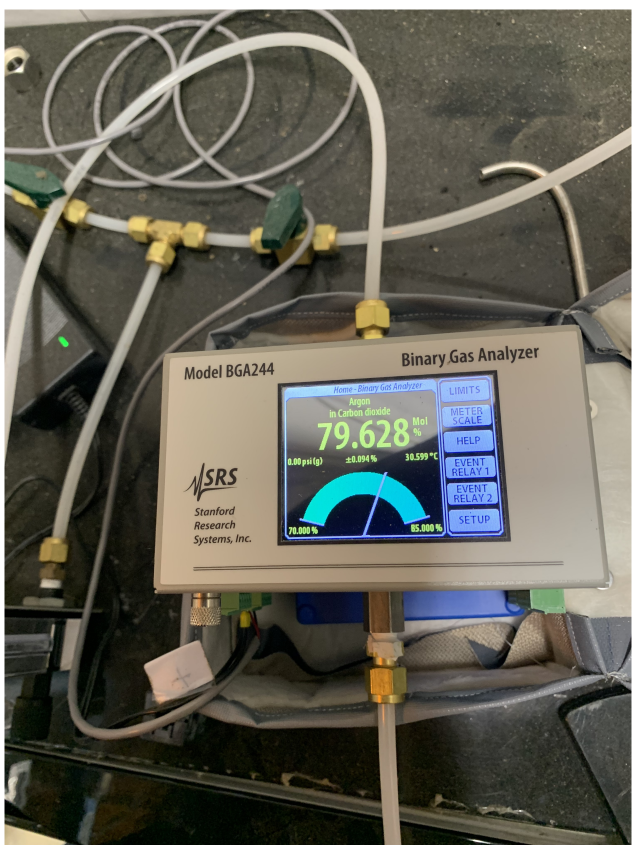


Figure 27: BigBite GEM BGA

Figure 28: SBS GEM regulators and cylinders

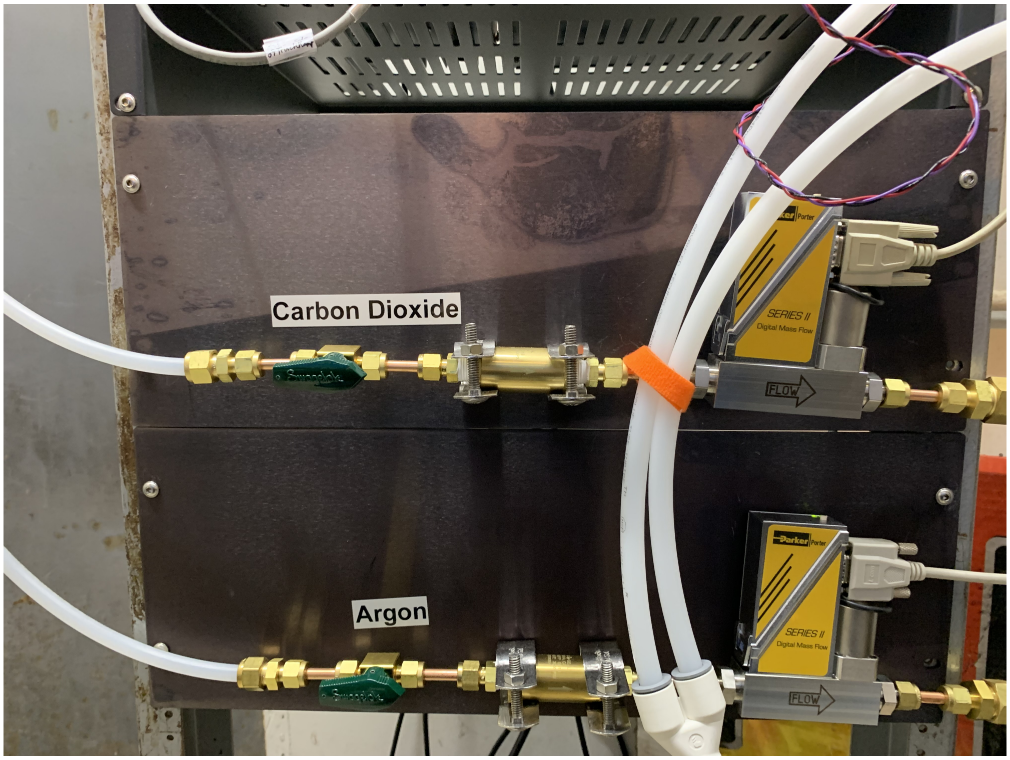


Figure 29: SBS GEM gas input valves and MFCs

Figure 30: SBS GEM Mixing Wand

Figure 31: SBS GEM Buffer Tank

Figure 32: SBS GEM Gas Shut Off Valve, in this picture valve is open

Figure 33: SBS GEM BGA

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
S. Jeffas	Updated replay and alignment section to be more clear	Dec. 8, 2022
E. Wertz	Added sections for Hall A gas shed and both BigBite and SBS GEM gas systems	Feb. 2, 2023
E. Wertz	Added section for Hall A Low Level plots	Oct. 4, 2023