GEM Operations in the SBS experiments

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November 17, 2021

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	system
Holly Szumila-Vance	214-587-1525	hszumila@jlab.org	DAQ,INFN
Sean Jeffas	201-320-3026	sj9ry@virginia.edu	gas,DAQ,UVa
Ezekiel Wertz	717-269-6488	ewertz@email.wm.edu	gas,DAQ,INFN
John Boyd	405-314-2340	jab7bp@virginia.edu	UVa
Anuruddha Rathnayake	434-466-0327	adr4zs@virginia.edu	UVa, gas
Thir Gautam	347-735-1865	tns.gautam@gmail.com	DAQ, UVa
Xinzhan Bai	434-422-2809	xb4zp@virginia.edu	UVa,analysis
Kondo Gnanvo	321-604-8026	kg6cq@virginia.edu	UVa, gas

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 UVa or INFN GEM.
  2. Contact expert (UVa or INFN) for guidance.
  3. Refer to section 3.4.

- Initialization problems during CODA prestart (see figure 3):
  - Follow chart in figure 1
  - After power cycling anything it may take up to five minutes to work again.

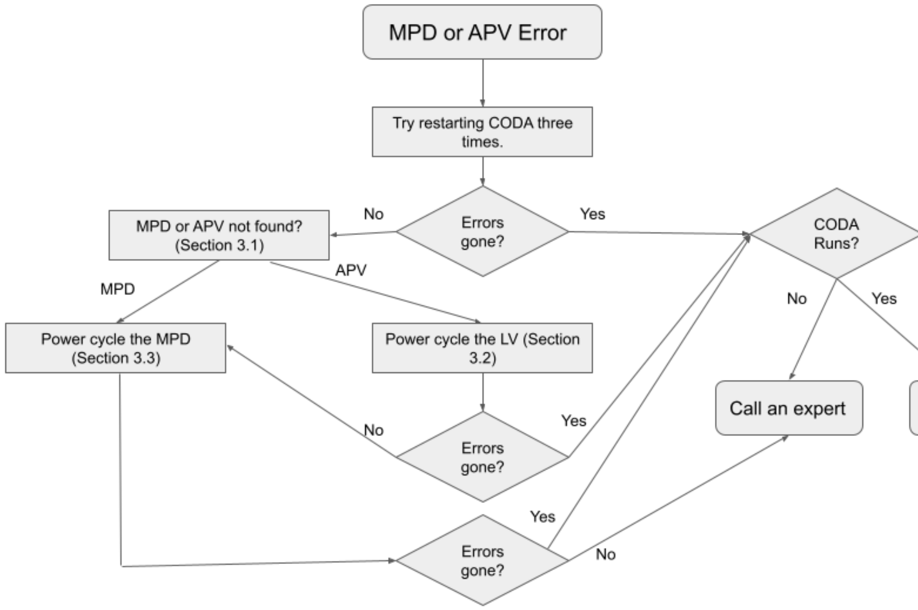

Figure 1: Troubleshoot flowchart for shifters when errors appear in the DAQ.

3 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.

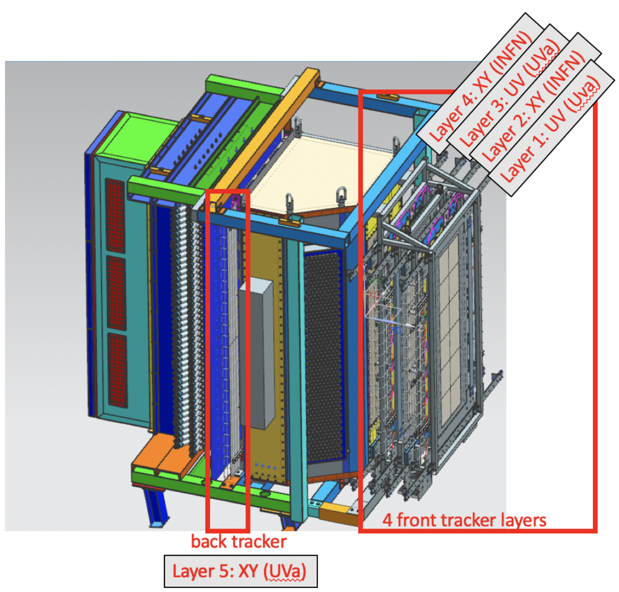

Figure 2: The BigBite detector stack is shown with the front and back tracker GEM layers indicated. The orientation of the strips in each layer is specified as UV or XY. The manufacturer of INFN or UVa is specified for each layer in parentheses.

Layers 1 and 3 are UV layers produced by UVa that consist of a single, large, GEM tracking module (active area of 40 by 150 cm). Layers 2 and 4 are XY layers produced by INFN in three separate modules (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** and Layer 4 is referred to as **J2**. 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.

3.1 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 at the rear of the BigBite detector stack. The crate with the INFN MPDs is **sbs-onl@intelbbmpd** and the crate with the UVa MPDs is **sbs-onl@intelbbmpd2**. The MPD information is carried via fiber to the VTP in the BigBite DAQ weldment. The VTP for the BigBite GEMs is **sbs-onl@sbsvtp3** located in crate **sbs-onl@intelbbgem**. The MPDs are in the DAQ terminals (figure 3) are actually described by their fiber number. The configuration is described in Table 2.

Table 2: GEM MPD fibers in BigBite

GEM	MPD slot	Fiber	nAPVs
UVa back tracker	2	0	12
UVa back tracker	3	1	12
UVa back tracker	4	2	12
UVa back tracker	5	3	12
UVa back tracker	6	4	15
UVa back tracker	7	5	15
UVa back tracker	8	6	10
UVa front tracker	9	7	15
UVa front tracker	10	8	15
UVa front tracker	11	9	15
UVa front tracker	12	10	15
UVa front tracker	13	11	15
UVa front tracker	14	12	15
INFN J0	2	16	15
INFN J0	3	17	12
INFN J0	4	18	15
INFN J0	5	19	12
INFN J2	6	20	15
INFN J2	7	21	12
INFN J2	8	22	15
INFN J2	9	23	12

On **Prestart**, the MPDs initialize all of the APV registers. There is printout in both the terminal for the **vtpROC20** which prints out the results of the initialization, and this output is also written to the end of run log in the logbook. It's important before starting a run to make sure that there are no errors like those seen in Fig. 3.

The errors in Fig. 3 show some issues with certain fibers (where the print out says "MPD", it is actually referring to the fiber number described in Table 2). 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).

```
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 3: 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 #.

3.2 Low voltage

First find the MPD with an error in the DAQ (figure 3). Remember that this MPD # in figure 3 refers the the fiber number. Then use table 2 and determine if this MPD is from UVa or INFN from the fiber number.

IF INFN:
The INFN low voltage is accessible by browser. This low voltage control has two channels: channel 1 controls layer J0, and channel 2 controls layer J2. The operation manual for the low voltage power supply, which includes a remote control command list, can be found: CPX400DP.The following instructions can be used to access the INFN low voltage power supply:

1. Open a firefox browser (from network)
2. In address bar, type: 129.57.188.51 (for BigBite LV supply)
3. Click on Instrument Control
4. Type **OPALL 0** to turn off. Type **OPALL 1** to turn on.

If the INFN low voltage power supply does not seem to recover or respond contact a GEM expert.

IF UVa:
The UVa LV is accesible by browser. The LV has one switch for all UVa GEMs. To power cycle the LV crate:

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"

3.3 Power cycling the crates

First power cycle the VTP crate. To do this open a browser and type:

1. `http://hallavme12.jlab.org`
2. Toggle the "Main Power" button off, then on.

If issues persist then we need to power cycle the MPD crates. First find the MPD with an error in the DAQ (figure 3). Remember that this MPD # in figure 3 refers the the fiber number. Then use table 2 and determine if this MPD is from UVa or INFN from the fiber number.

IF INFN:
WARNING if power cycling the INFN MPDs you must first turn off the INFN HV (see section 3.4). The INFN HV is inside the MPD crate and it is dangerous to power cycle the crate without turning the HV off first. To power cycle:

1. Turn off the INFN HV (see section 3.4)
2. Open a browser and type `http://hareboot6.jlab.org`
3. Select outlet 7
4. Choose "Immediate Reboot" and apply
5. Wait 2 to 5 minutes
6. In a terminal, type:
   ssh sbs-onl@intelbbmpd
   run **linuxvme/mpd/libsrc/test/mpdStatus**
7. Turn HV back on now (see section 3.4).

IF UVa:
To power cycle the crate:

1. In a terminal: **ssh sbs-onl@intelbbmpd**
2. Type **minicom** and enter
3. Type **CAEN** and enter (the words will not appear in the terminal as you type them)
4. Press **C**
5. Type **off** and wait 10 seconds
6. Type **on**
7. Wait 2 to 5 minutes
8. Close terminal and open a new terminal and execute:
   ssh sbs-onl@intelbbmpd2
   run **linuxvme/mpd/libsrc/test/mpdStatus**

3.4 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 high voltage for the GEMs is controlled separately for INFN and UVa. The slow controls for both are at **aslow@adaqsc**. From here, the GEMs are accessed by typing **go_hv**. The INFN and UVa GEMs are under "BB". The UVa GUI can be seen in figure 4 and the INFN GUI can be seen in Fig. 5. 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. The HV for INFN GEM J2 Top should always remain **OFF**, unless directed by GEM Experts or documentation changes. Currently INFN GEM module in J2 Top does not hold reasonable HV in stable conditions.

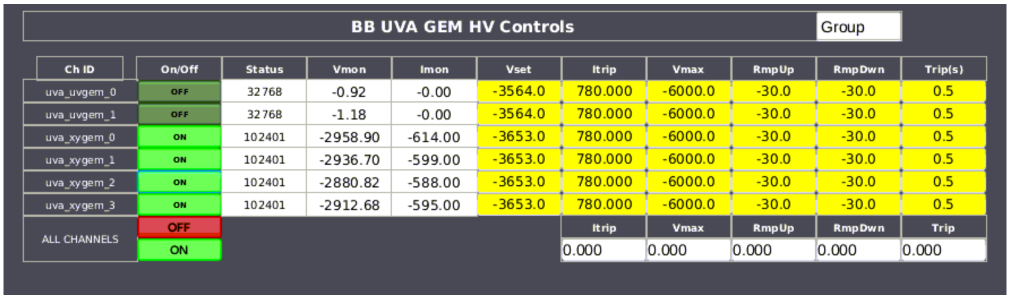

Figure 4: Screenshot of the HV GUI for the UVa GEMs in BB.

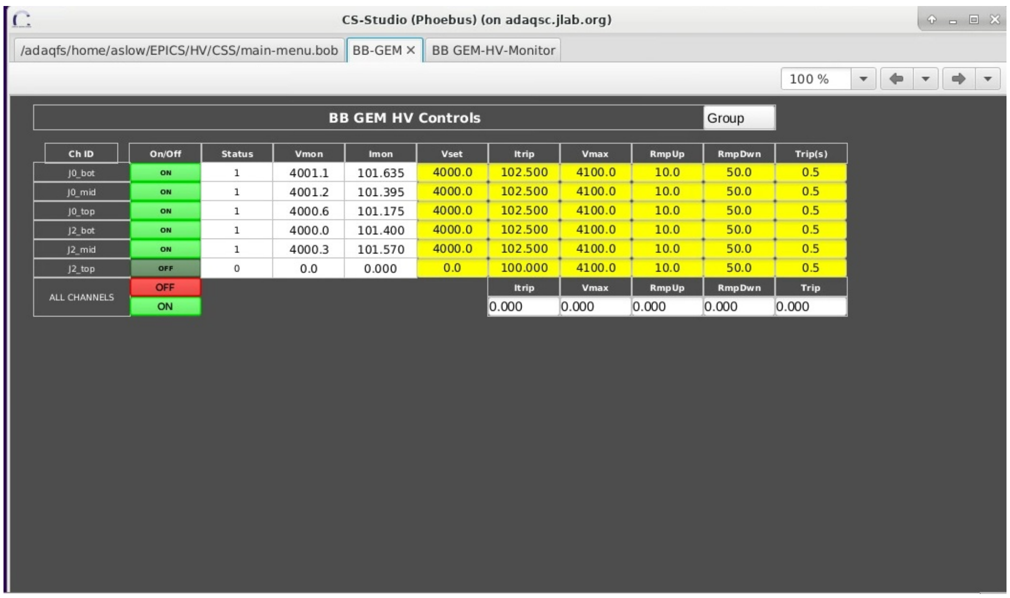

Figure 5: Screenshot of the HV GUI for the INFN GEMs in BB.

3.5 Gas Monitoring

The gas flow monitoring can be accessed by web browser at this link. On this page, the Std Flow Ch01-04 refer to the back tracker four modules. Hi Flow Ch05 and Ch06 refer to the UV layers 1 and 3, respectively. The Hi Flow Ch07 and Ch08 refer to the front tracker XY layers 2 and 4, respectively.

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 the INFN front tracker 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). For UVa UV layers in production conditions, Ar/CO2 (75/25) should flow at 600$\pm$30 cc/min/chamber. For the UVa XY module in production conditions, Ar/CO2 (75/25) should flow at 225$\pm$15 cc/min/chamber. An example screenshot for the BigBite Gas system is shown in Fig. 6.

It is also important to check the amount of gas in the bottles, and change them appropriately. The PSI in the gas bottles can be monitored at this link. It can also be found under "Hall A Tools":

```
ssh aslow@adaqsc
./SBS/start-tools.sh HallATools
```

From here the PSI can be found under "Gas Shied". **Note: For now the system only shows the bottle currently in use. Therefore another bottle may be hooked up to the system, but it has not changed over yet. We are working on getting a readout of all bottles attached to the valve.**

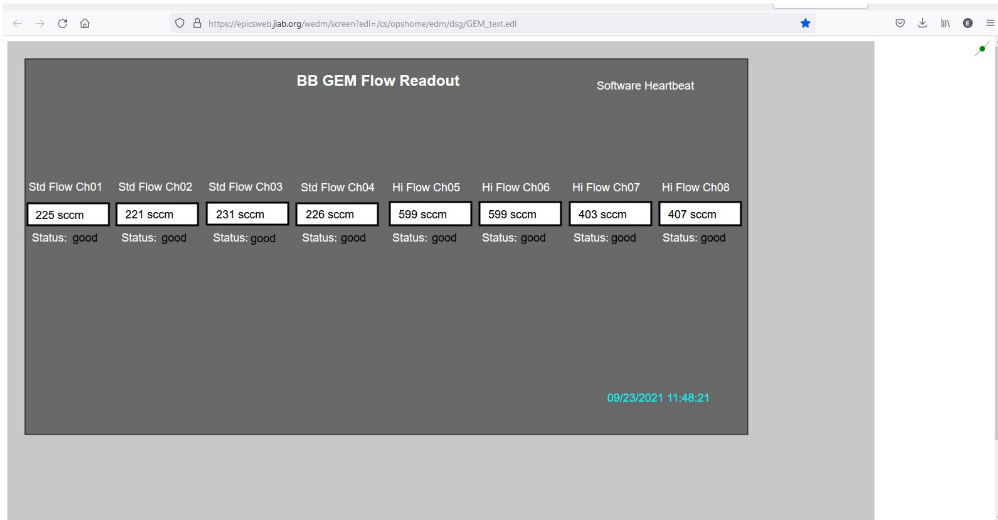

Figure 6: This is a screenshot of nominal flow rates for the BigBite GEMs.

4 Super BigBite GEMs - **IN PROGRESS**

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 3.1. 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.

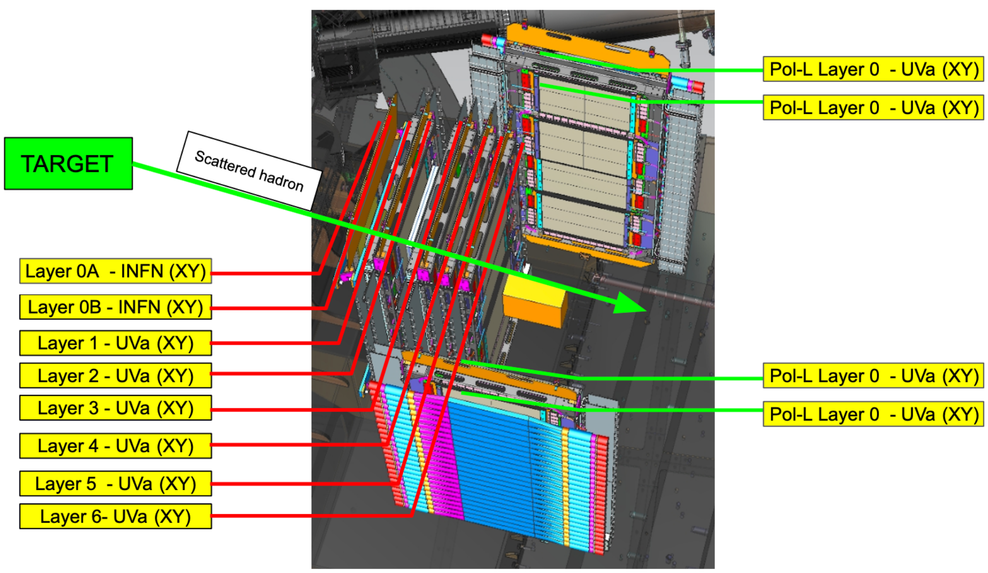

Figure 7: Layout and labels for the layers in the GeN-RP stack configuration

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 second and third UVa layers. 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

Table 3: Layers in the GeN-RP Inline Stack

Layer	Type
Layer 0A	INFN
Layer 0B	INFN
Layer 1	UVa
Layer 2	UVa
Layer X	Steel Analyzer
Layer 3	UVa
Layer 4	UVa
Layer 5	UVa
Layer 6	UVa

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:

Table 4: 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

4.1 DAQ for GeN-RP

The SBS GEMs will run in near similar running conditions to that of the BigBite setup – Common Mode and Pedestal Subtraction, zero suppression, etc. The entirety of the SBS stacks occupies sixty-eight MPDs across four VME crates and two VXS crates (twenty??? VTP cards). The connections between these components follow in similar fashion to the BigBite setup. The placement and nomenclature of these devices is as follows:

Layer	**VME Crate**	**MPD Slot**	**VTP Crate**	**VTP Fiber**	**No. APVs**
Inline 1	sbsvme32				

label01	label02		
some text	item 1	description	description
		descript00ion	descripti1on
	item 2	descriptio2n	description3
		description4	description7
some text	item 1	description	description
		description	description
	item 2	description	description
		description	description

5 FOR EXPERTS ONLY

5.1 Checklist

A GEM expert should be checking these functions every day:

- GEM HV and current several times every day (see section 3.4 and 5.2).
- Gas flow readout and gas can level at least twice a day (see section 3.5).
- Raw APV frames for the beginning of every run (see section 5.7).
- Analyzed low level plots and tracking efficiencies should be checked at least twice a day (see section 5.8).

5.2 Additional information for HV

5.2.1 INFN HV

When HV is being applied on a GEM module from 0 V to the operational HV (4000 V for most of the GEMs except for J2 Top module which should remain off), it should be increased in steps of according to Fig.8. 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 and within the expected range. The current setting is the maximum permitted for each voltage setting. Expected current values will be approximately 1 microAmp less than the maximum, and vary from individual modules. We expect that there will be initially (within about the first 5 minutes) gradual increase of the current setting on the order of 50 to 100 nanoAmps by increments of 5 to 10 nanoAmps. If the current readback is fluctuating by 50-100 nanoAmps quickly, this is a potential problem. That GEM HV should be turned off and an INFN GEM expert should be contacted. The 4050 V setting is provided in Fig. 8, but that should not be regularly used in ramping and should only be used by certain to be determined modules, based on efficiency scans. Sometimes the IOC needs to be restarted when the intelbbmpd crate is power-cycled. Instructions are:

1. ssh sbs-onl@intelbbmpd
2. Call the command: crontab "EPICS/intelbbmpd.crontab"
3. Check the INFN HV GUI to see that there was an improvement.

5.2.2 Alarms for current

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.

HV (V)	Set Max Current (microAmps)
300	7.7
500	13.5
800	21
1000	26
2000	51.5
3000	77
3500	90
3700	95
3800	97.5
3900	100
3950	102
4000	102.5
4050	104

Figure 8: Applied HV and the maximum current for **INFN XY GEMs**.

5.2.3 UVa HV

When HV is being applied on a GEM module 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 Fig.9 for a table of applied HV and the expected current values for UVA XY and UV GEM chambers.

Equivalent/100% divider HV (V)	Applied HV (V)	Expected Current UVA - XY GEMs (μA)	Expected Current UVA - UV GEMs (μA)
100	89	18.18	18.00
500	445	90.91	89.99
1000	891	181.82	179.98
1500	1336	272.73	269.97
2000	1782	363.64	359.96
2500	2227	454.55	449.95
3000	2673	545.45	539.94
3500	3118	636.36	629.94
3700	3296	672.73	665.93
3750	3341	681.82	674.93
3800	3385	690.91	683.93
3850	3430	700.00	692.93
3900	3475	709.09	701.93
3925	3497	713.64	706.43
3950	3519	718.18	710.93
3975	3541	722.73	715.43
4000	3564	727.27	719.93
4025	3586	731.82	724.43
4050	3608	736.36	728.93
4075	3630	740.91	733.43
4100	3653	745.45	737.92
4125	3675	750.00	742.42
4150	3697	754.55	746.92
4175	3720	759.09	751.42
4200	3742	763.64	755.92
4225	3764	768.18	760.42
4250	3786	772.73	764.92

Figure 9: Applied HV and the expected current for **UVa XY and UV GEMs**.

5.3 Configuration File Locations

To access any MPD control 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:

- **vtp_config_TS.cfg** - This file defines all the MPDs and their corresponding fibers on the VTP (see table 2). If an MPD/Fiber needs to be commented out, then this is the place to do it.
- **ssp_avp_default_TS.cfg** - This file is called by vtp_config_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** (INFN MPDs) or **bbgem_crate_2** (UVa MPDs). There is one file for each MPD. If an APV is misbehaving this is the place to comment it out. More detail in section 5.4.

If you need to change to pulser, you need to login to **sbs-onl@intelbbgem**, **cd rol**, and edit the **ti_master_list.c**. Then recompile with **make**.

5.4 How to remove MPDs and APVs from the DAQ

As mentioned above the APVs are located in **MPD_vmeSlot_#.cfg**. 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 3) refer to the fiber numbers in the VTP. In figure 10 there are a few fiber definitions from **vtp_config_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 than the block of code for that fiber in **vtp_config_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 **vtp_config_TS.cfg** for a few fiber defenitions.

The APVs are defined at the bottom of **MPD_vmeSlot_#.cfg** 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.

5.5 How to enable zero suppression or CM subtraction

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

- **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 **sbsvtp3** 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.

CODA configuration "GMN1" reads sbsvtp3.config for normal zero suppressed running, while "GMN1_pedestal" reads sbsvtp3_pedestal.config which is set to pedestal mode.

5.6 Loading a Pedestal File

To first take a pedestal set the ROL variables properly as described in section 5.5. Check that all APVs look good in the raw data as explained in section 5.7. Then follow the steps:

1. Follow section 5.8 on replaying a pedestal run.
2. Copy the output files, daq_ped_bb_gem_runXXXXX.dat and CommonModeRange_bb_gem_runXXXXX.txt, to sbs-onl@sbsvtp3:~/cfg/pedestals. VTP_MPDRO_PEDESTAL_FILENAME and VTP_MPDRO_COMMON_MODE_FILENAME as described in section 5.5 should point to these files. These files should also be copied to $SBS_REPLAY/DB/gemped for future reference and for use in offline analysis.

It is also best to check the pedestal file plots to make sure everything looks normal. Full instructions for pedestals can be found at this link.

For a short explanation:

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

5.7 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 12. Anything that does not look like this may be broken. For example, in figure 13 it is clear that APV 11 is problematic. Also the baseline ADC should never be above 1000. An example is shown in figure 14. If common mode (CM) and pedestal subtraction is enabled online then the data should be centered around zero, which is shown in figure 15. 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**.

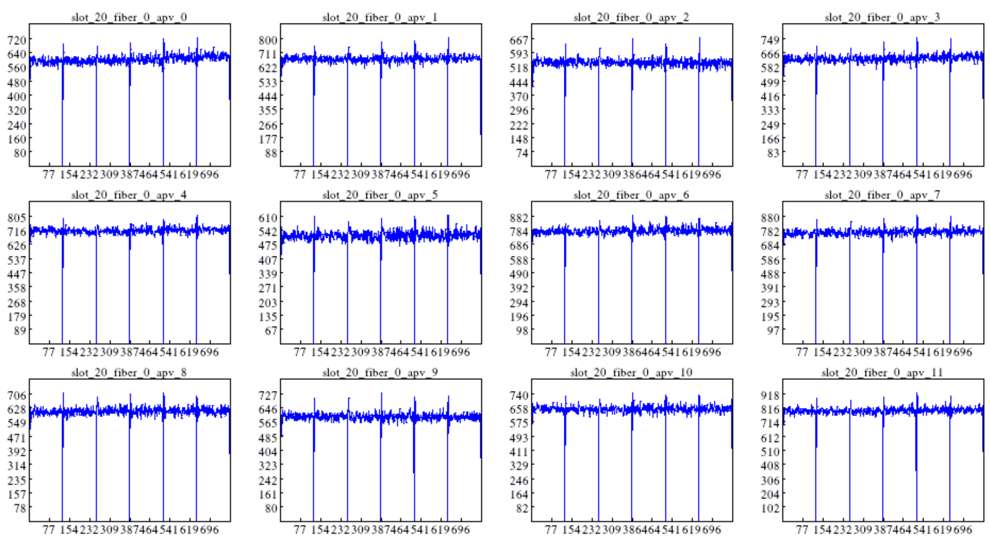

Figure 12: Example of normal pedestal APV raw data.

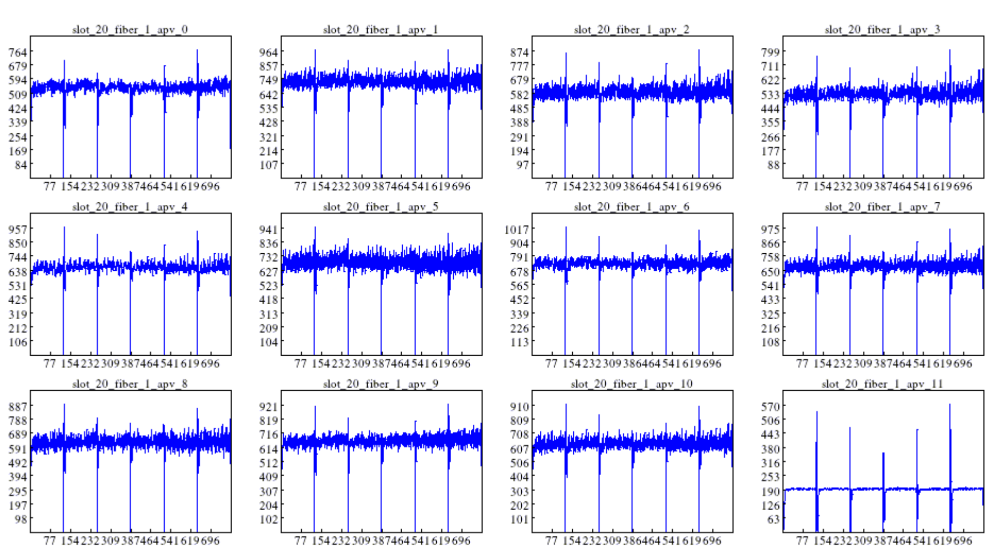

Figure 13: Example of a pedestal run where APV 11 is clearly not working

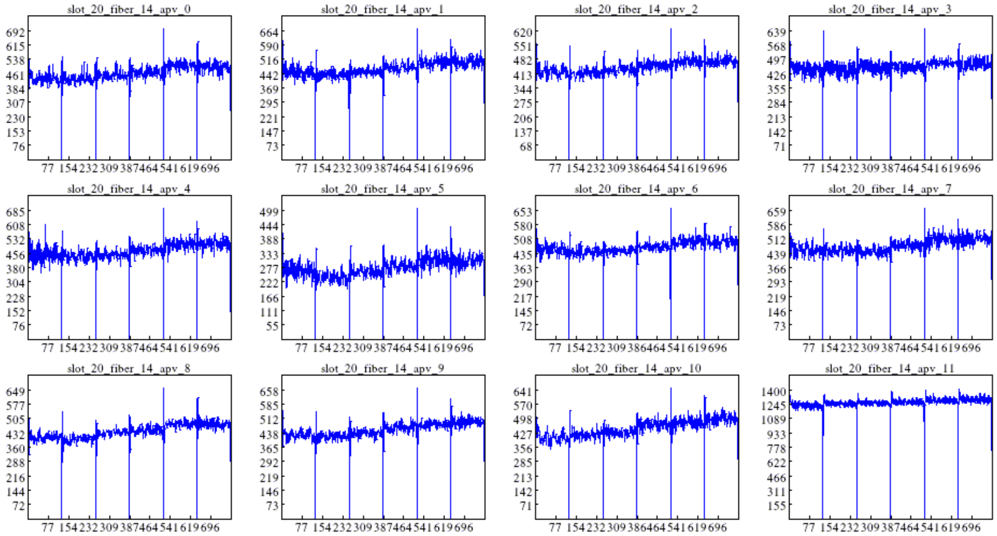

Figure 14: Example of a pedestal run where APV 11 is not working. The baseline ADC values should never be above 1000.

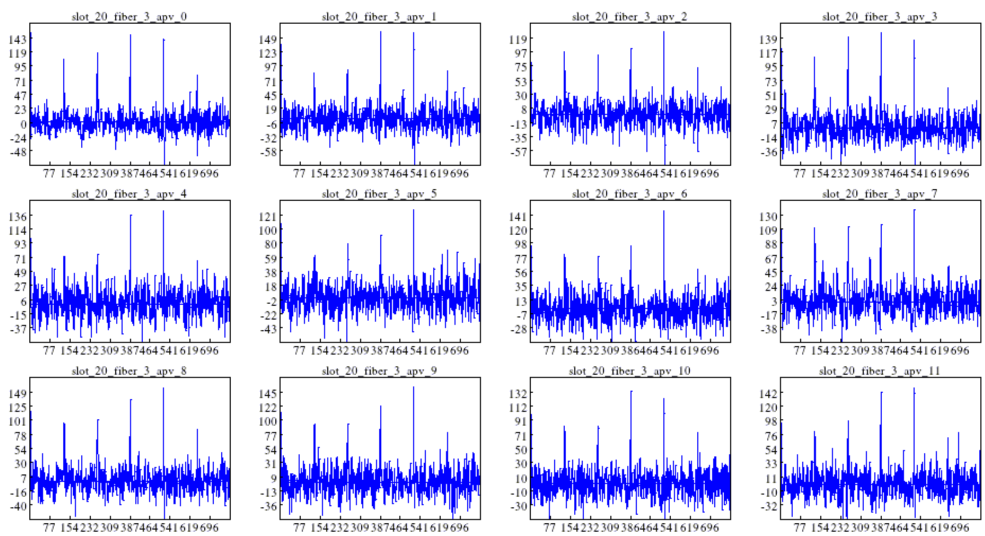

Figure 15: Example of run with pedestal and CM subtracted.

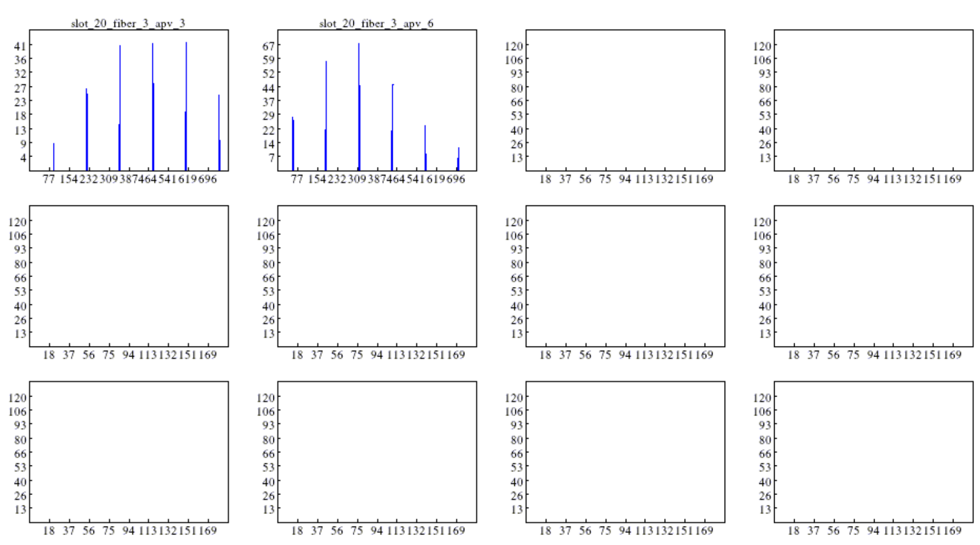

Figure 16: Example of cosmic hit with zero suppression enabled.

5.8 Tracking Analysis

5.8.1 Replaying EVIO Files

To replay EVIO files:

1. log into aonlX under the a-onl account.
2. cd $HOME/sbs/GEM_replay
3. Execute a command with the following format: `./run_BBGEM.sh runnum seg_start seg_num prefix event_begin event_end pedesal_mode`
   - "runnum" is the CODA run number
   - seg_start is the first evio file segment to analyze
   - seg_num is the number of file segments to analyze
   - "prefix" is used to generate the EVIO file name. (Example values of "prefix" under the current CODA setup are "bbgem" or "e1209019_trigtest")
   - event_begin and event_ means analyze starting and ending at these events
   - pedestal_mode is set to 0/1 (off/on) which disables tracking and triggers generation of pedestal diagnostic histograms and output text files for use in DAQ configuration and analyzer database

For example to replay a pedestal run execute:

```
./run_BBGEM.sh runnum 0 1 prefix 0 5000 1
```

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. For replaying many splits in parallel the following command will be useful:

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 17. Look through all the low level plots for any odd features.

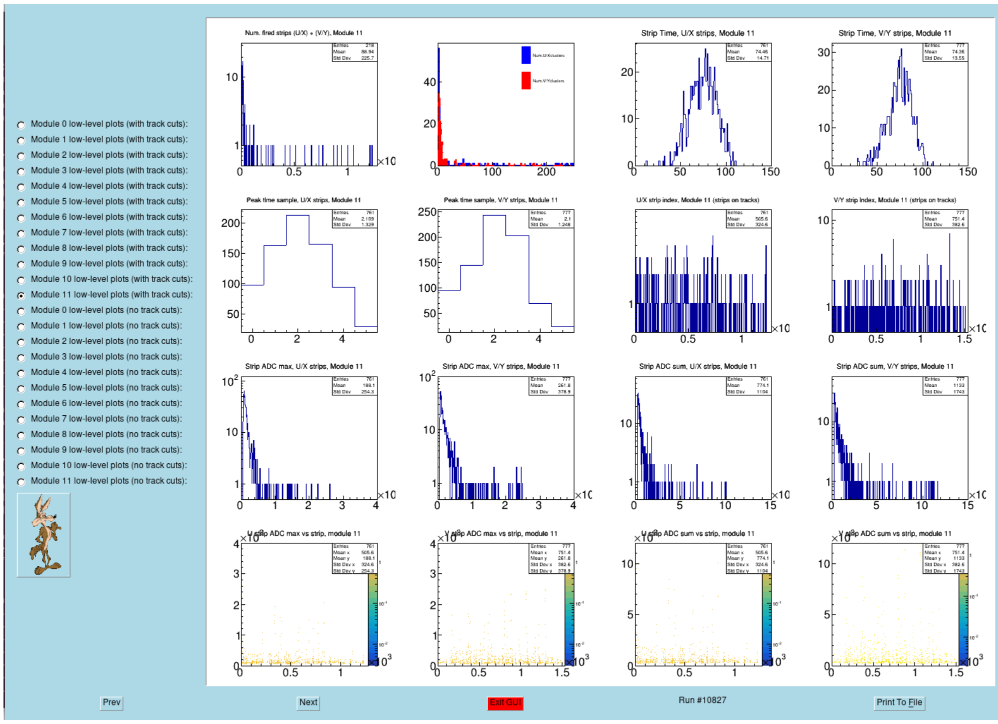

Figure 17: Example of the tracking analysis output.

To plot the tracking and efficiency results run:

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

The GUI that opens can been seen in figure 18. 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.

5.8.2 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".

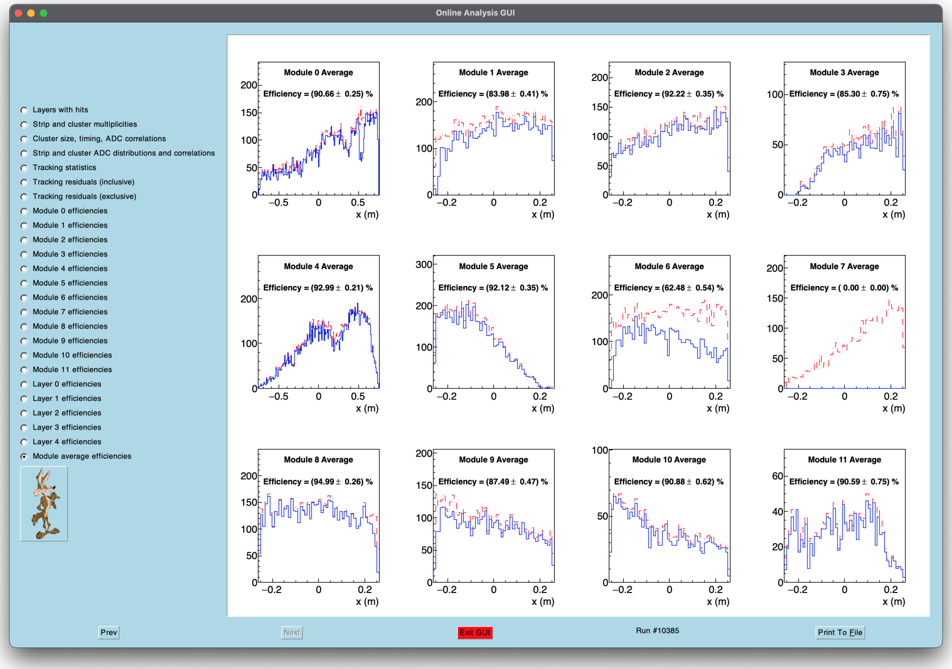

Figure 18: Example of the tracking analysis output.

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

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