Update on UVa GEM APV25 readout

SBS Weekly Meeting, Mar 29, 2020

Kondo Gnanvo

Outline

- APV25 common mode fluctuation issues
  - Description of the issues
  - Troubleshooting in EEL124 Clean Room
- Hardware issues: APV25 FE cards & backplanes
  - Description of the issues
  - Solution and timeline
- Summary: Impact on GEM layers installation

I am giving this report base on the tireless work these past several weeks of many people working on trying to fix the issues we are having with the APV readout for the UVa GEMs. But more importantly people like Xinzhan, Anuruddha, Thir and Malinga are doing all the heavy duty work and this is not to be neglected.

Weekly meeting for the commissioning of GEM every Wednesday at 10:00 am

Wiki: https://hallaweb.jlab.org/wiki/index.php/GMn_GEM_Commissioning_Meeting
Outline

- APV25 common mode fluctuation issues
  - Description of the issues
  - Troubleshooting in EEL124 Clean Room

- Hardware issues: APV25 FE cards & backplanes
  - Description of the issues
  - Solution and timeline

- Summary: impact on the GE layers installation
APV25 data structure & processing

- 3 steps to process the APV raw data
  1. Common mode correction for each time sample (128 channels); event / event basis
  2. Pedestal offset subtraction on individual APV25 channel
  3. Zero by applying a $5 \times \sigma$ cut criteria on individual APV25 channel

- A few key points
  1. Common mode correction requires careful implementation for steps 2 & 3 to work
  2. Common mode correction challenging if
     - Fluctuation of time samples becomes too large
     - In high rate environment
  3. External parameters (grounding shielding …) would made the common mode fluctuation worse
     - This is the issue we are struggling against with UVa GEMs in EEL and TEDF setups
     - Might as well not be the only noise related issues
Common mode issues with UVa GEMs: Typical APV25 frames in EEL clean room 124

Distribution of the maximum variation of the baseline between time slices of the same trigger event

- The average variation is the mean value of the distribution
- Large variation here ~ 100 ADCs is a concern
  - Typical pedestal noise of the APV25 is ~15 to 20 ADCs
- This is for the current setup in EEL124 clean room
  - With proper correction algorithm, large variation of this kind is manageable at low rate (Andrew’s script)
  - Can we control this at higher rate and noisier environment?

Baseline fluctuation of individual time slice

- Average fluctuation of 30 ADCs
- Also larger than the typical pedestal noise
- This is in addition to the variation of the baseline from time slice to time slice
Common mode issues with UVa GEMs: Comparison with other setups

- Sigma distribution for each APV
- INFN: 216 APVs
- UVa clean room: 440 APVs
- UVa tdef: 88 APVs
- Siyu PRex: 84 APVs

- INFN setup in testlab shows the best performances with variation ~ 75 ADCs
- UVa setup in EEL124 ~ 100 ADC
- UVa layer in Bigbite in TEDF ~140 ADCs
- UVa modules in PREX > 150 ADCs

The variation is clearly sensitive to the overall noise environment and this is why we are concerned when installed in Hall A.
Common mode issues with UVa GEMs: Impact of 5-slots APV25?

5-slot backplanes disconnected to the GEM layers show some improvement of the baseline variation distribution but overall, the variation remain high.
Common mode issues with UVa GEMs: Troubleshooting

- Lot’s of troubleshooting to try to minimize the common mode fluctuation
  1. We tried different scheme for grounding and shielding with no real improvements
  2. Investigate low voltage power supply and the voltage regulators impacts with no success at all
  3. Trying to pinpoint the main source of the large variation by disconnecting some APV25, cables from the setup not clear

- Some fixes on APV25 and backplane hardware
  1. Problems found on some of the APV25 with missing jumpers that set the IREF biasing current for the VCC
  2. Second problem found on a bunch of backplanes 12-slots and 5-slots with some capacitors missing (broken) ⇒ More details in the next slides
  3. But None of these hardware problems really fixes or improves the common mode fluctuation problems

- Comparison APV25-SRS vs. APV25-MPD
  1. Baseline fluctuation seems less pronounced for APV25 base scalable readout system that we are using at UVa than for the MPD system ⇒ see example on next slide
  2. Some difference in APV25 configurations were reported on the slides presented in at the SBS weekly meeting Nov. 2012
     https://hallaweb.jlab.org/12GeV/SuperBigBite/SBS-minutes/2012/apvGain20121107.pdf
  3. Main difference is the internal are shown in next slides
Common mode issues with UVa GEMs: Troubleshooting APV25-SRS vs APV25-MPD

APV25 and ADC configuration for MPD and SRS systems

- We have almost the same configuration parameters for the two systems.
- Different performances of the two electronics can be related to some differences in hardware that Paolo has identified:
  - protecting diode in the VCC line of the INFN card
  - input capacitance 47 pF vs. 1 pF in SRS
  - 1 MΩ resistor to ground in the SRS input lines
  - external biasing in INFN card vs. internal biasing in SRS (this affect the values of the APV parameters for the optimal working point)

- These differences were identified at the time by Paolo after he studies 2 APV25-SRS cards that we sent to him to compare.
- Maybe that is the reason why in the UVa version of APV25-MPD card which was designed later after the INFN version, there is the possibility to chose between internal and external biasing (see next slides).
- We still could try the internal biasing with a couple of our APV25-MPD cards and check if there is any significant improvement and then decide if we want to switch all the APV25 to internal biasing.
Common mode issues with UVa GEMs: APV25-SRS frames with UV GEMs

- This is the typical APV25 frames we are getting with the UV-strip GEM under test on the cosmic stand at UVa
- 150 cm x 40 cm
- The environment is not much less noisy than the EEL 124 setup
- HDMI cable length shorter (5 m) but that does not explain
- We also did not observe such large variation during the Prad run in Hall B with APV25-SRS
Outline

- APV25 common mode fluctuation issues
  - Description of the issues
  - Troubleshooting in EEL124 Clean Room
- Hardware issues: APV25 FE cards & backplanes
  - Description of the issues
  - Solution and timeline
- Summary: impact on GEM layers installation
Hardware issue #1: APV25 IREFBIAS jumpers

- Two jumpers on UVa version of APV25-MPD cards to select how to provide the IREF current bias to the VCC of the card
  - Jumper J15 shorted ⇒ external bias
  - Jumper J16 shorted and resistors R12 removed ⇒ internal bias

- Problem: We have a whole bunch of APV25 cards with J5 shorted (external bias) but we also have about half with all jumper left open (no bias)
- We sent a batch of the APV25 with no bias to C. Cuevas group to solder J15

- We planned to fix all the APV25 with no bias
  - We will have to disassemble pretty much all the layers to make the fix

- The new twist ⇒ Actually we should try the internal bias (J16 shorted and R12 removed) to see if we improve the common mode problem
  - In that case, it will involve all ~ 900 APV25 cards
  - But since we have to make fix in the cards anyway, we might as well go the the best fix
Hardware issue #2: Missing or broken capacitors on backplanes

- While investigating sources of the large common mode fluctuation, we also found out that a large number of our backplanes (both 5-slots and 12-slots) have each 2 to 3 capacitors missing.

- Not really sure how this happens ⇒ very likely during handling either in the clean room or before during packaging and shipping.

- We need to fix all these backplanes as well, we already have a batch with C. Cuevas to fix for us.

- We would have to identify on the already assembled layers the one with similar problem.
  - More likely many of them but since we need to locate bad APV25 cards anyway, it is not an additional burden.
Summary: Impact on GEM layers installation

- **Common mode issue**

  1. Large fluctuation of the APV25 baseline and large variation form time sample to time sample
  2. Though manageable in cosmic setup environment in EEL124, it might be far more challenging in high rate environment in the hall
  3. Lots of effort to minimize the issue with better grounding, shielding with little success so far ⇨ but ongoing effort
  4. One hope is to try the internal IREF bias of the APV25 cards ⇨ This has been shown to provide better performances with APV25-SRS
    - We have the option available with UVa APV25-MPD cards but will require fixes of all 900+ cards that we have
    - Modification of the APV25 cards is going to happen any way because of the identified APV25 and backplanes hardware issues

- **Timeline for installation in the SBS various detector frames**

  1. It seems to me that we don't have a choice anymore to implement these modifications
  2. Even the layer in Bigbite frame in my view should be involved in the discussion: we don't know the status of the backplanes and APV cards
  3. So we have to readjust the timeline for installation in any case that will involve some delays
    1. Good news is that re-assembly of the layers should be pretty quick (no need for cosmic test anymore. After APV25 cards fixes, we will assemble on the table, HV test in N2 and install directly the layer in the dedicated frame
    2. However taking cards out and getting them fixes by C. Cuevas group will take some time
  4. We need to prioritize activities because resources in term of manpower and time are limited
    1. Do we need to spend time now on high rate test with Sr90 or X-ray in EEL? ⇨ my personal opinion is NON because of manpower
    2. The collaboration should decide the priority tasks and we should stick to it. Only this way we can define a clear timeline.
Backup
Common mode issues with UVa GEMs: Impact of 5-slots APV25

Impact of the 5-slots backplanes on the baseline fluctuation of the 12-slots backplanes:

With 5-slots backplanes **disconnected**

- Entries: 47
- Mean: 14.06
- Std Dev: 3.569

With 5-slots backplanes **connected**

- Entries: 47
- Mean: 26.15
- Std Dev: 4.895
Common mode issues with UVa GEMs: Impact of 5-slots APV25

Impact of the 5-slots backplanes on the baseline fluctuation of the 12-slots backplanes:

- This is not just separating 12-slot backplane from 5-slot backplane in data analysis
- This is hardware change: connected 5-slot backplane to GEM Chamber VS disconnected 5-slot backplane to GEM chamber
- We want to check how the 5-slot backplane affect the APV performance on 12-slot backplane
- 12-slot backplanes are always connected to GEM chambers
Common mode issues with UVa GEMs: Impact of 5-slots APV25

Impact of the 5-slots backplanes on the baseline fluctuation of the 12-slots backplanes:

5-slot backplanes connected to the GEM layers but the HDMI cables and LV cables are removed one by one and we check how it affects the baseline fluctuation.
Common mode issues with UVa GEMs: Impact of 5-slots APV25

Impact of the 5-slots backplanes on the baseline fluctuation of the 12-slots backplanes:
5-slot backplanes connected to the GEM layers but the HDMI cables and LV cables are removed one by one and we check how it affects the baseline fluctuation.