Beam Test Documentation

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1. Comissioning of Detectors

1.1 Leadbox Irradiation

Once the construction of our self-stretched detectors was completed the first step was to run several quality assurance tests. These tests primarily revolve around gain uniformity studies and signal checks for all panasonics. The first difficulty encountered during testing was the inability to generate signal at low X-ray energies. Due to the thickness of the frame piece that forms the drift (see the gold panel in Figure 1) almost all tests with the 30 by 30 were conducted with the X-ray source irradiating through the "bottom" of the detector. Several attempts were made to irradiate through the readout side of the detector; however, these efforts yielded minimal signal at high X-ray energies. In the case of the third version of the 1-meter GEM, the readout board is even thicker than that of the 30 by 30, and as such signal was best seen when irradiating through the drift side. It should also be noted that we were unable to produce any signal in our self-stretched detectors using radioactive sources such as Cd-109 and Fe-55. While the 1-meter GEM does have thin points (see the circles in Figure 2) that are designed to allow for irradiation with such sources it did not work well in practice.

The next concern and difficulty in arranging our setup was uniform source irradiation. As you can see in Figure 1, placing the detector along one of the long side walls of the leadbox allows for easy cable management but does not allow you to separate the detector and source by more than 30 centimeters. This presented problems as we wanted to conduct tests were the entire active area was uniformly illuminated. Due to the collimation of the source (see the Mini-X operating manual or Amptek website for further information) uniform irradiation was only possible when the detector and source were placed at the two shorter sides of the leadbox. This allows for separation distances as far as 70 centimeters if desired; however, for a completely uncollimated source, distances greater than 50 centimeters proved sufficient. To avoid confusion it should be noted now, that when referring to previous logs, notes, or this documentation that "minimal collimation" refers to the X-ray source with the hollow metal tip attached as you see in Figure 1, "uncollimated" refers to the source without this metal tip attached, and any further collimation such as "5 degree collimation" refers to attaching the metal tip with an added brass plug collimator in place.

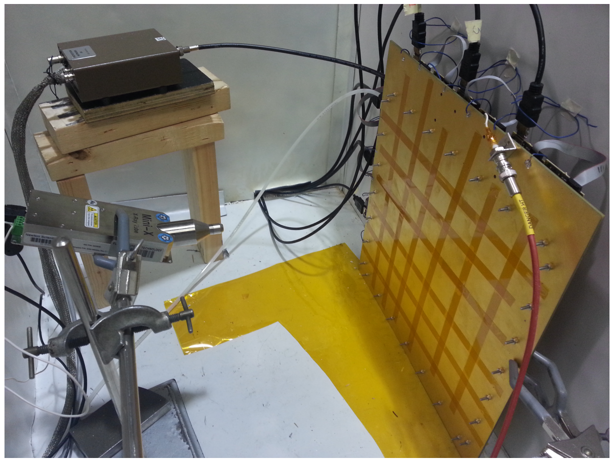

Figure 1: 30 by 30 Detector Vertically Placed

Figure 2: Drift Side of the 1-meter GEM

1.2 Electronics Setup

Once the detector is in place properly the electronics setup becomes the most difficult part of testing. As you can see in Figure 3, for all of our commissioning efforts a single FEC/ADC setup was used to transmit raw data to the SRSPC. In our setup we were unable to use scintillators due to the amount of material being placed inbetween the source and detector, and as such the easiest alternative was self-triggering off the third GEM foil (or the last foil before the readout board). As you can see in Figure 1, a pre-amplifier was connected to the HV connection corresponding to the bottom of the third GEM foil. This pre-amplifier signal (notice the shielded cable in Figure 3 used to reduce noise) was then fed to a linear amplifier, and from that linear amplifier to a discriminator or constant fraction discriminator depending on the circumstances of our particular test (see Figure 3). The signal from the discriminator was then sent to the FEC to provide a trigger signal for data collection (see the LEMO cable in Figure 4).

The inherent difficulty in this self-triggered setup was the sheer amount of noise produced when connecting to the third GEM foil. It was often the case that the amplitude of the noise would exceed or match the amplitude of signal and as such proper discrimination was impossible. In almost all cases of excessive noise the grounding of the leadbox was to blame. In order to solve this problem all panels (inlcuding the floor) of the leadbox were grounded to the NIM crate (see Figure 3) which housed the HV supply. In those few cases where proper grounding did not solve noise issues the soldering between the pre-amplifier and third GEM foil was usually the culprit. Keep in mind this system uses an unshielded BNC cable end soldered directly to the HV connection corresponding to the bottom of third GEM foil. The easiest solution to this problem was to simply re-solder the connection. Once the self-triggering system and APV connections are placed raw data collection can begin.

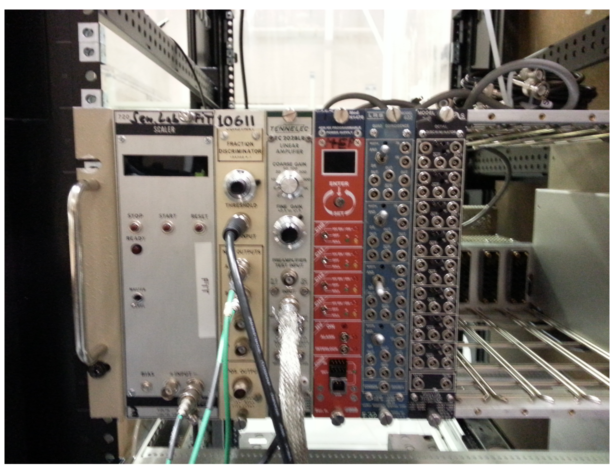

Figure 3: NIM Crate Electronics

1.3 Raw Data Collection

Once data collection begins you will likely find that even under the highest X-ray energies the raw data produced by the APV's do not show signal. This problem is a direct result of using the DATE setup from the MTSPC. Due to the difference in trigger systems (scintillators as opposed to self-triggering) the slow control values need to be adjusted. Whenever DATE begins data collection for a run, several configuration settings for the FEC are loaded automatically. For the SRSPC these

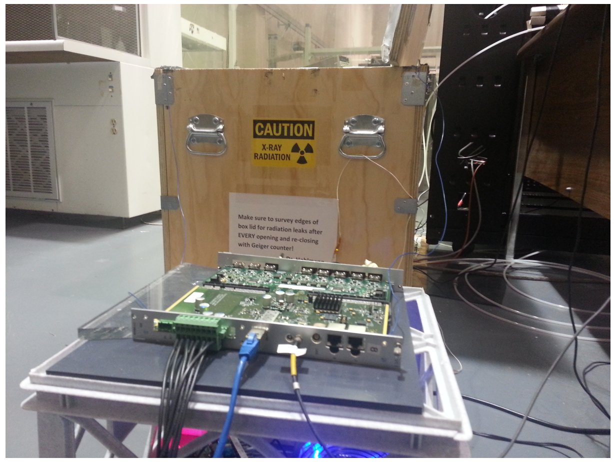

Figure 4: Single FEC/ADC Setup for Detector Analysis

settings are loaded from the file (fec7CosmicRun.txt).

This file controls several crucial aspects such as trigger delay, time window size, and number of time bins present in a single time window. To understand and alter these values correctly a reference document (DATE-GettingStarted.pdf) is stored under the folder "Guides" on the SRSPC. Near the final page of this guide you will find a table with explanations and conversion factors for the hexadecimal values you put into the text file and the decimal values these translate to in DATE. As an added note, keep in mind that the calculator application for all computers running SLC5 can perform decimal to hexadecimal conversions. If you find yourself on another computer that runs DATE you can use the command (editDb) to open the DATE Configuration Database Editor. Under the "Files" section you will see the SOR.commdands (Start of Run commands), click on this group and then click the "Edit file" button. This should open up a list of shell scripts that are executed every time you start a DATE run. If you then examine the shell script you will find the name of your FEC configuration file, along with several other configuration text files. For our purposes the FEC configuration text file is the only one that every need alteration.

Ultimately it is quite difficult to estimate the correct values for your FEC configuration, so the best method is a mixture of educated guesses and trial and error. For the easiest troubleshooting, expand the time window size and number of time bins as far as possible. From this point adjust your trigger delay back and forth until you find a hint of signal. Once this is accomplished you want to adjust the trigger delay so that the start of your signal coincides with the start of your time window. Once this is accomplished you can begin data collection, but it is suggested that you optimize your FEC settings. There is no reason to keep such a large time window and number of time bins if your entire signal only spans 100 nanoseconds. Keeping these values at there maximum will only slow your data taking rate, so it is suggested that you reduce the time window size and number of time bins as far as possible without cutting out important signal information. In our original detector commissioning efforts the FEC configuration was not well optimized and as a result experienced a maximum data taking rate of 75 Hz, as compared to a real trigger rate that measured in the kilohertz range.

With the inclusion of a second pre-amplifier, the Keithly pico-ammeter, and panasonic connector it is possible to collect the charge information for each set of 128 strips. This charge information can then be used in conjunction with the real trigger rate and X-ray energy to give a calculated gain for each sector of strips. Always keep in mind that the High-bay Log Book is a helpful reference to see the settings and results of previous commissioning efforts.

2. Fermilab Test Beam

2.1 Beam Line Setup

Once the detectors were properly tested, commissioned, and packed they were transported to Fermilab, Illinois by Aiwu Zhang and Vallary Bhopatkar. Some initial testing was conducted by Aiwu and Vallary outside the beam line to ensure the proper functioning of all detectors. Problems were discovered with the panasonic connections of the 1-meter GEM's zigzag readout board, as well as the APV's to be used for the 30 by 30. Assistance from a Fermilab technician was able to solve the former; while, replacement with spare APV's solved the latter. After these tests arrangement of the UVA/FIT detectors into the beam line was commenced.

FIT and UVA were allotted the 2-B section of the beamline shown in Figure 5 for setup of detectors, as well as a remotely-controlled mobile table (see Figure 6) for use in positional scans. It should be noted that Fermilab safety procedures required any detector mounted on the mobile table to be mechanically secured for safety. As can be seen in Figure 7, almost every detector on the mobile table was mounted using 80/20 frame pieces and screws provided by Fermilab (although it should be noted that this is material to have on hand for the next beam test). Three UVA detectors (Ref 2, Ref 3, and UVA 3) as well as one FIT detector (Ref 1) were mounted on stationary stands to serve as permanent reference detectors. It should be noted that the arrangement of these reference detectors was changed after excessive noise was observed in the first reference tracker. This noise was thought to be caused by its close proximity to the detectors of the Harvard group stationed at position 2-A (see Figures 8 and 9 for explanation).

For future efforts at Fermilab it should be noted that the most difficult aspect of beamline preparation was the safety inspection. The two most important issues during safety inspections were electronics and cable management. Fermilab procedure required that all cables be properly rated for the amount of HV intended to be carried (this was more a problem for UVA's EIC detector which used thin non-teflon wires to carry HV), and that all cables connected to detectors on the mobile table were fastened to a stationary structure with enough slack to accommodate the range of motion we intended to use. Once we decided on the range of motion we wanted for the mobile table safety switches were mechanically mounted to the floor in order to shut-off the table in case of improper use. The final setup of the detectors, with rough alignment to the beam center, in the Beam Test 1 configuration can be seen in Figure 10.

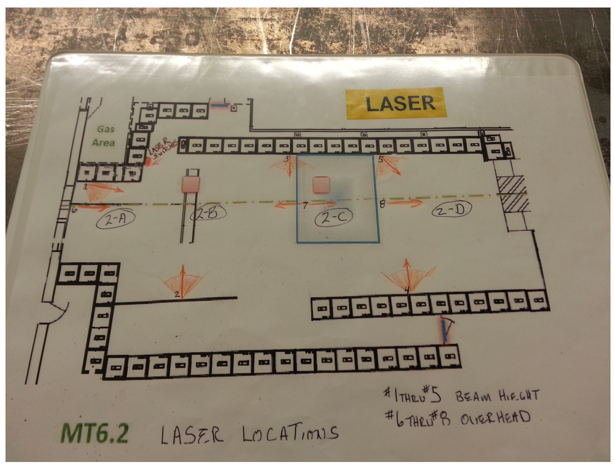

Figure 5: Beam Line Schematic

Figure 6: Mobile Table for Detector Placement

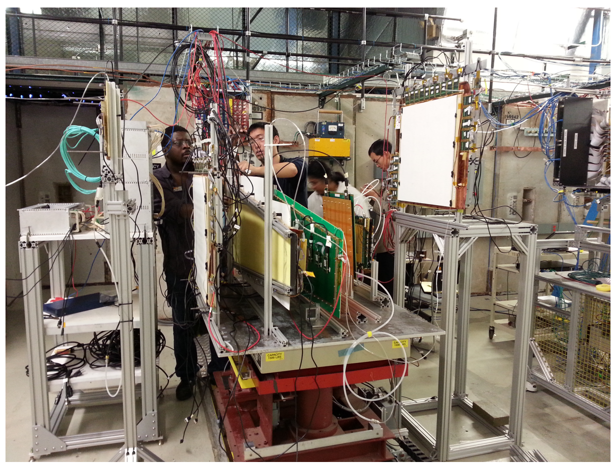

Figure 7: Mobile Table with Detectors Mounted

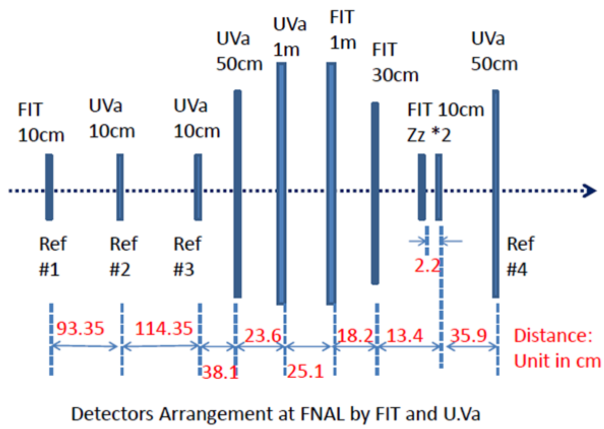

Figure 8: Beam Test Configuration 1

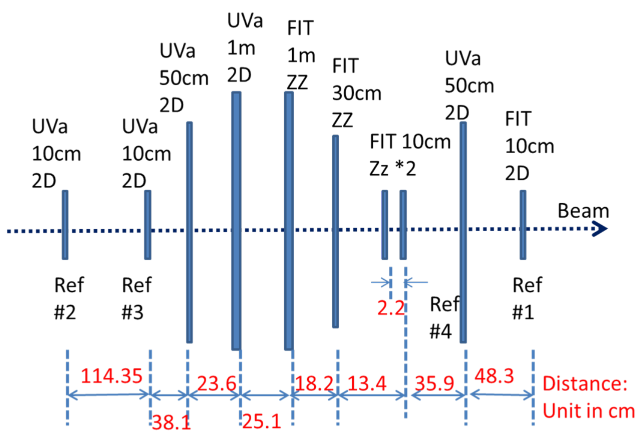

Figure 9: Beam Test Configuration 2

2.2 Initial Results

After correcting for the FEC configuration problems mentioned in section 1.3 of this documentation data acquisition was commenced. Unfortunately AMORE was not ready for anything more than raw data analysis by the time the detectors started recording data. This was sufficient to ensure that signal was being properly reported by the APV's connected to the regions being irradiated; however, it did fail to provide the quality assurance present in cluster statistic measurements. Luckily changes implemented in the corrections to AMORE, specifically those made to the way we declare detector mapping, allow for a more manageable situation in the case of future beam tests scenarios.

The reference detectors and UVA's 50 by 50 detectors provided the easiest

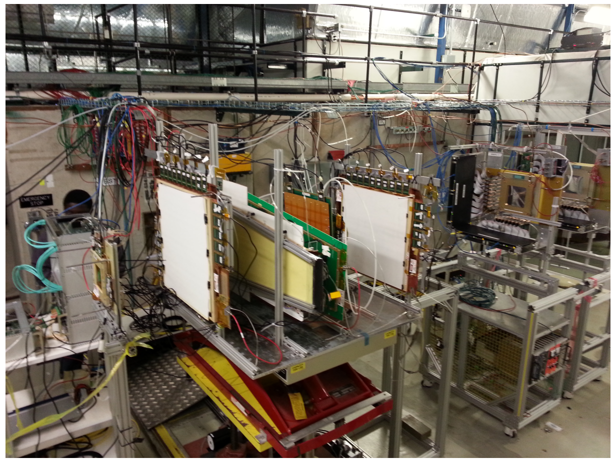

Figure 10: Final Setup of Configuration 1 After Rough Alignment to Beam Center

analysis situation as they all followed the traditional cartesian mapping already implemented for the MTS. See Figure 11 for the first 2-D beam spot images provided by the reference detectors.

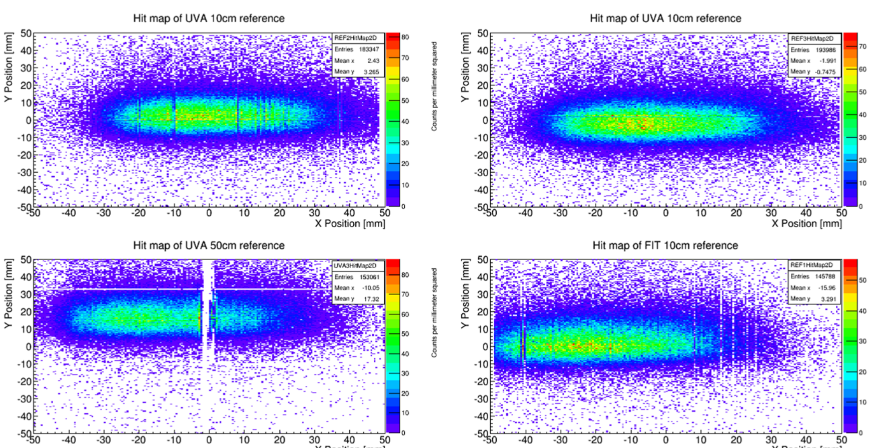

Figure 11: Beam Spot Images for a 20GeV Run