# Sens-Tech XDAS readout system

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## I. Introduction:

In December 2010, the old British Phototube manufacture, EMI, called about their new product - after the company changed its name. The system they are marketing is very suitable for our use, digitizing charge from the detector in the beam line. Their system was capable of a large number of channels. Initially, we were offered a system based on integration with CCD readout. It is called the HE system. After many exchanges we bought a 64-channel system. It came pre-assembled. The following pictures show the system.

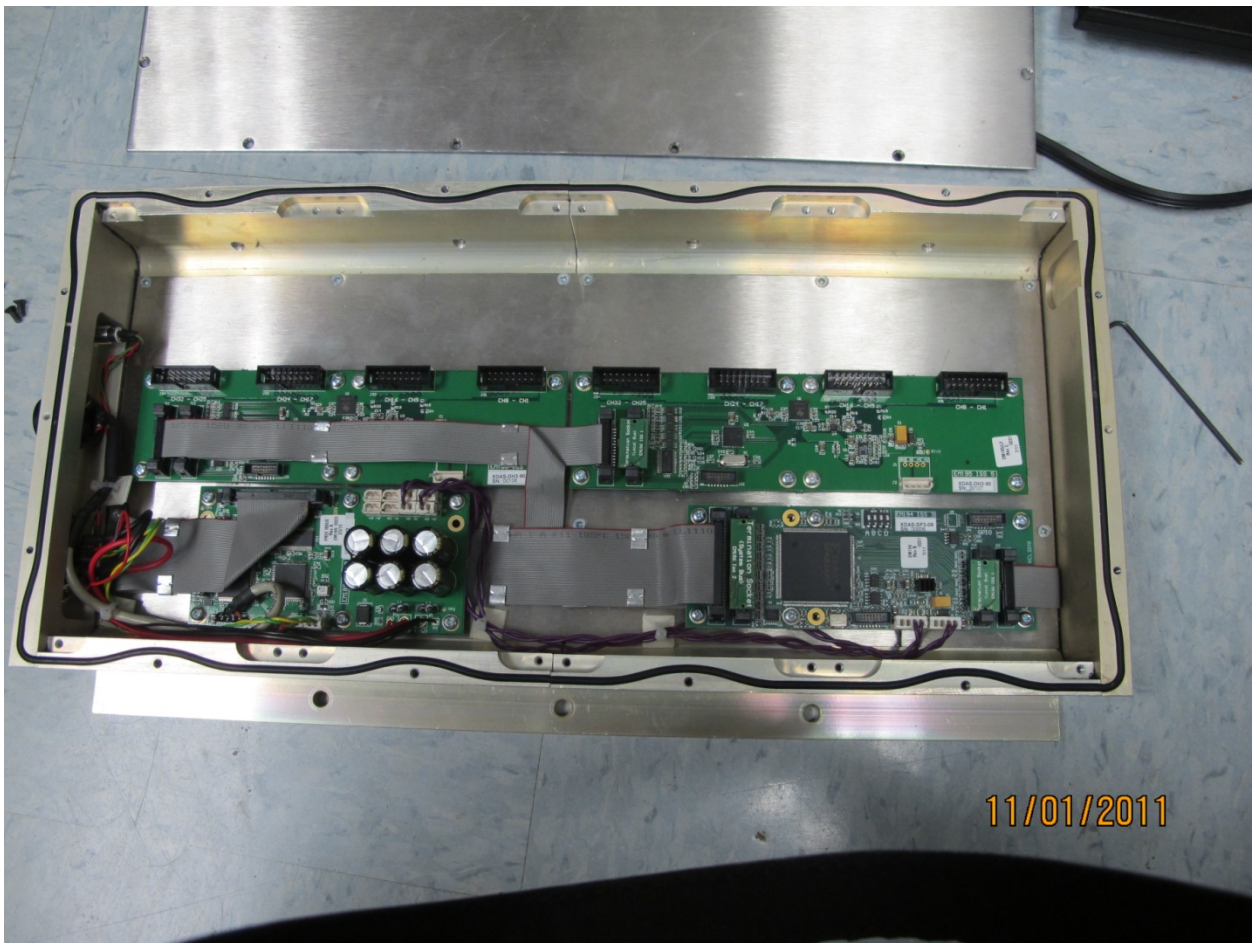


Figure 1: The 64 channel HE system for CCD readout.

It is fairly compact and ready to accept input with cables. We tested the system first with a PC program they supplied and it worked with our SWIC - a beam profile monitor device. This system is for 64 channels and costs about 12K$. After this, they told us that they had a new system based on ASIC design and much cheaper but with some draw backs. We bought 256 channels of it, called the V3 system. It cost less than 7K$. The assembly is pictured below.

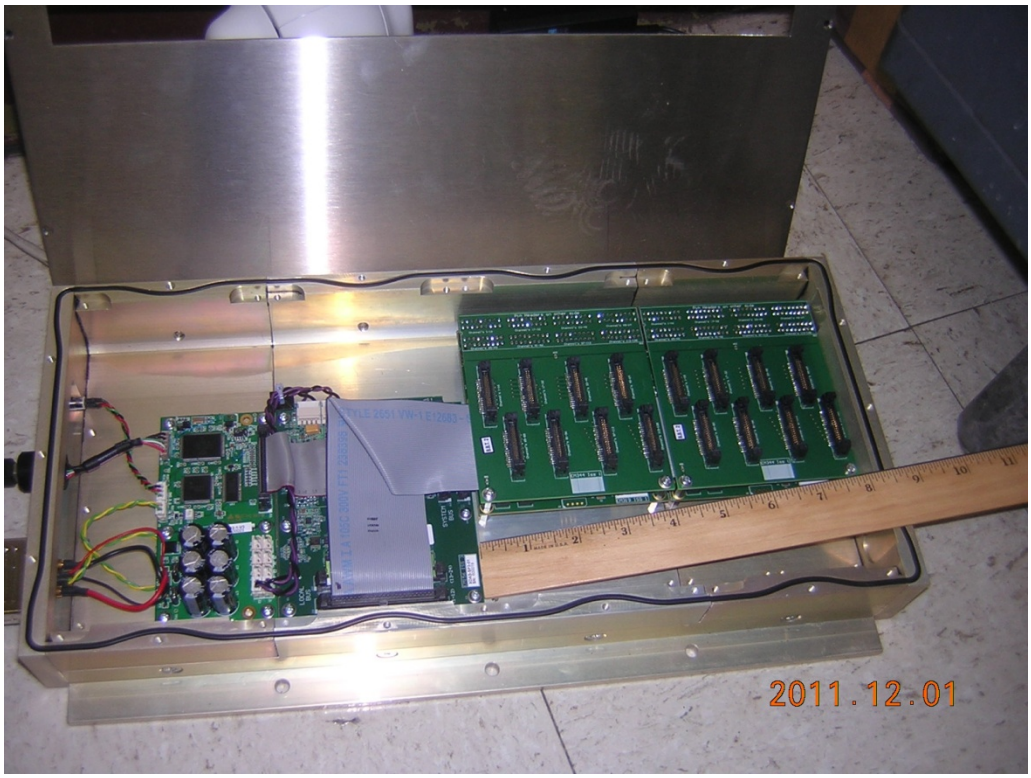


Figure 2: The V3 system is more densely packed and compact than the HE system. Notice that the boxes of the two systems are the same size.

II. Initial system.

We use software installed in the PC to test the system. The system is quite easy to use, but somehow it is very noisy. After quite a while of testing, we realized the system was built for floating ground. It is sensible for them to do that because they tie the detector to this readout and the system is self contained. Our system is more prone to pickup noise with our cable routing through such a noisy environment. We also discovered that we could reduce the noise by adding

an input series resistor of 1 MΩ. We made a breakout board such that we could also reduce the signal to increase the dynamic range.

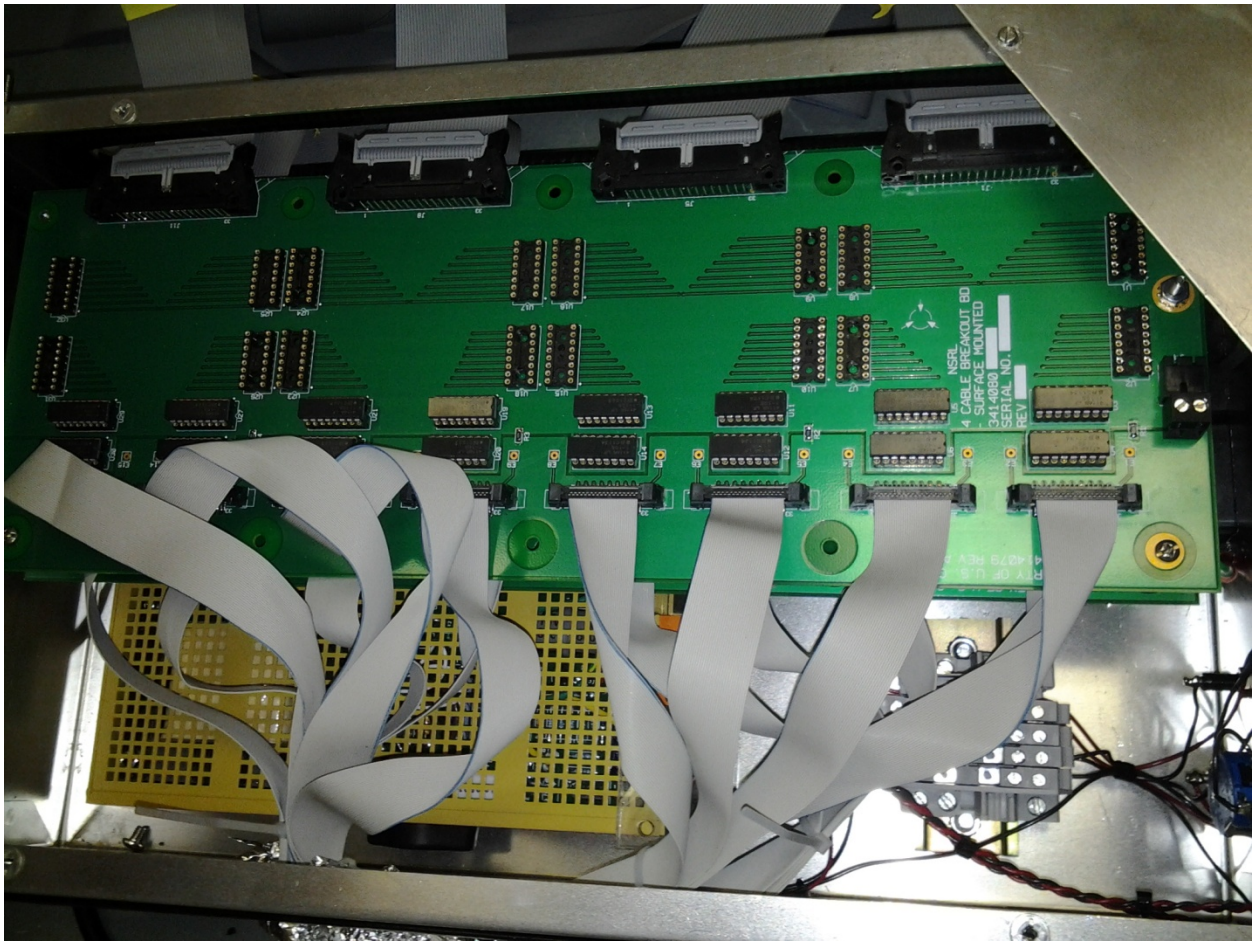


Figure 3: The components in series are the 1 MΩ resistors while the sockets on the side are for resistor to reduce the gain.

We found out that we should ground the system well to reduce the noise pick up. We finally ground the system and avoid using their power supply which is floating electrically.

In doing so, we convince them to make a new cable input board for the V3 system with built-in 1 MΩ series resistors. More detail will be shown later. The normal cable inputs come with alternate ground, $V_{ref}$. The new boards do away with that.

III. Final hardware configuration for V3.

The basic 128-channel system: We decided to build a basic system with 128 channels of V3 electronics. This is the minimum system with only one detector card. We installed the whole system with one signal-processing board and one USB2 card. Each signal board can handle up to 24 detector boards. 7 signal processing boards can be connected in series, to handle up to 21504 channels of detectors.

One very important point is the V3 system input is biased at $V_{ref}$ = 2.0 Volts. All the inputs have to be at this voltage or the system will not function. We provided an external 2.0-volt power supply for reference purposes. The internal $V_{ref}$ is not stiff enough for more current drain.

A. We built the whole system in one box. The following photo shows the layout.

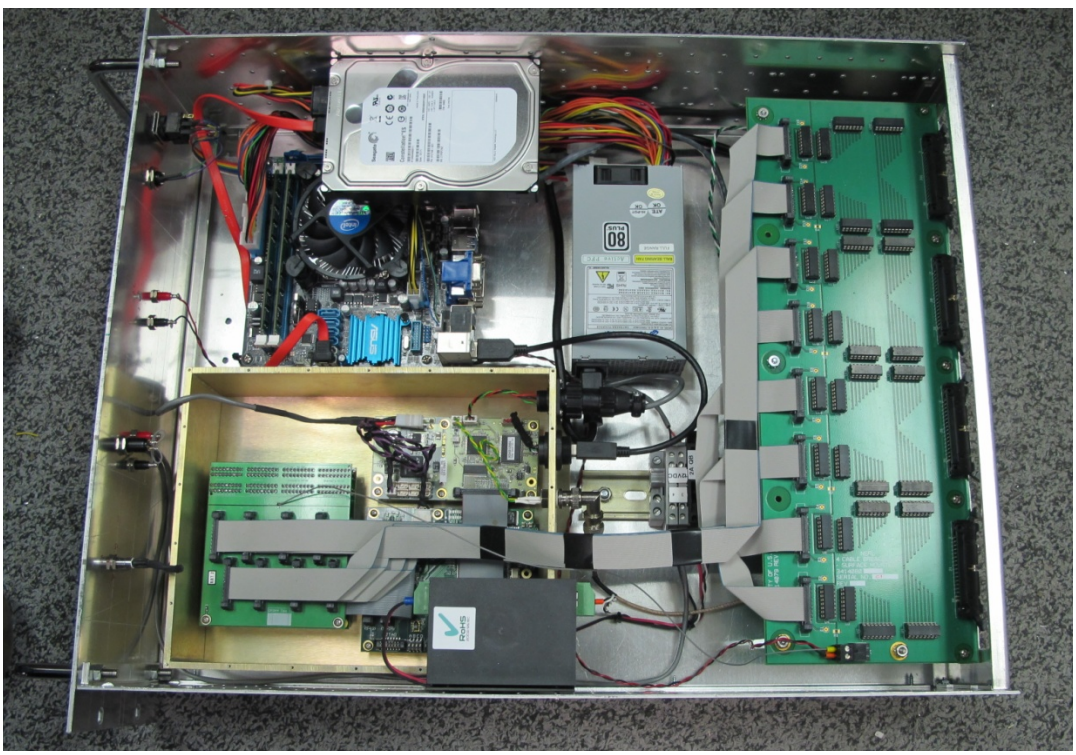

Figure 4: Layout of the V3 system board.

This system includes a frontend computer needed for our DAQ system. The cable from the detector board is connected with surface mount connectors. They have alternating ground with each cable carrying only 16 channels. Our detector

system was built with larger flat cables with no alternating ground; this enables them to carry 32 channels. That is why we had a break-out board on the right where the small cable ends. It redistributes the signals to 4 cables, 32 channels each. Also note that there is a series resistor of 1 MΩ and a 100 KΩ resistor to reduce the gain by a factor of 11. The computer is a very small stand-alone Linux computer without disk. The whole system is grounded together and the system ground is carried by pins 33 and 34 of the cable to the detector ground. Our detector ground is tie to this ground.

We had another variation of this system without computer. We installed this system in the beam cave to reduce the cable length such that the noise pickup would be reduced. The frontend computer is located in a radiation free area. We used ICRON USB 2.0 Ranger 2201 extender. It uses Cat5 cable to extend the USB2 range up to 100 meters.

B. We had a system with 256 elements. It is a 16x16 pixel chamber of 64 x 64 $cm^2$. We built a system with the new detector boards. It had 1 MΩ built in resistance and also there is no alternating ground in the cables. This new board reduces the long cable by factor of 2.
C. This is basically the original configuration. Except we modified the ground. Also, we changed the detector board so we need only 8 cables instead of 16. We had another breakout board near the detector to change to different types of cables. We designed and built the chamber before this system. Also, we do not normally use this type of small cable with surface mount. The next large system may need to use this mini cable. The following two photos show the condensed adaptor board and board for converting the mini cable to normal flat 34 pin cable.

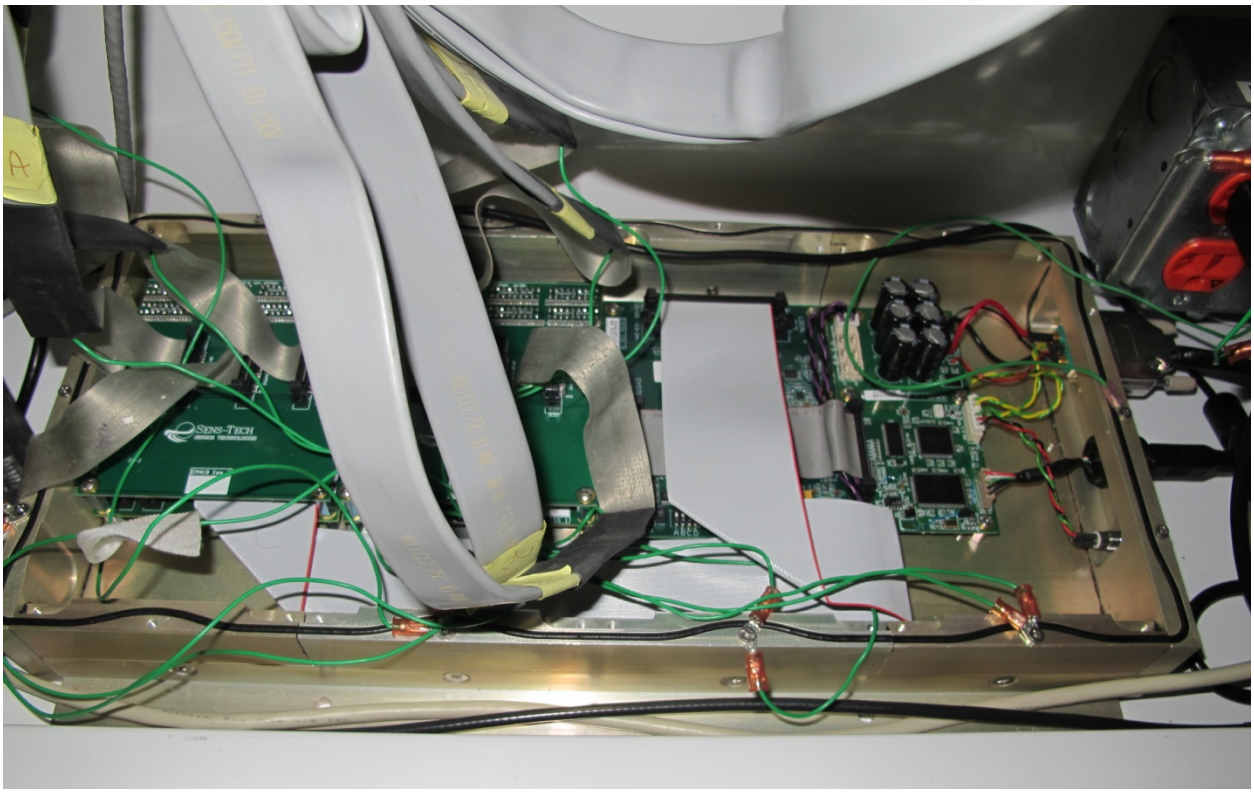

Figure 5: New detector board reduces the long cables by a factor of two.

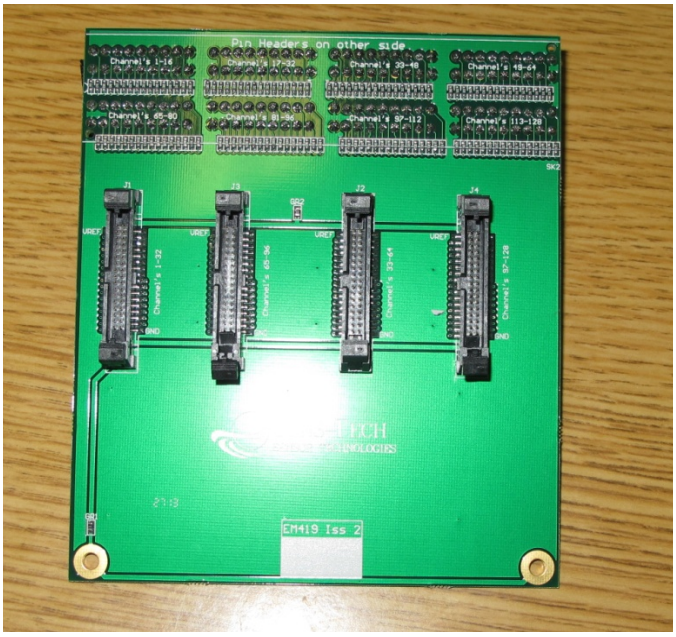


Figure 6: Showing the condensed adaptor board.

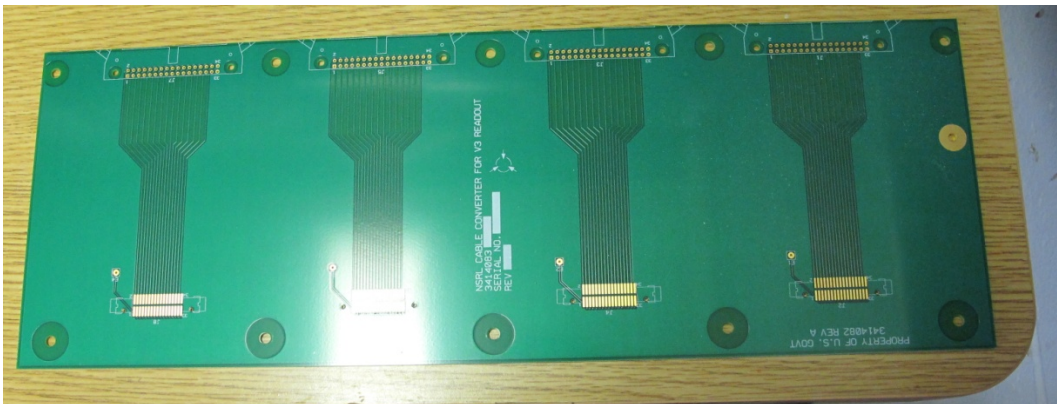


Figure 7: Converter board for converting the mini-cables to normal flat 34-pin cables.

IV. Software for the readout: The system was designed in two parts. The frontend computer is for data collection. The rear computer is for control, data assembly and display.

1. The frontend computer collecting the data via USB port. In our operation, we input a trigger into the Sense-tech system. A normal TTL signal is adequate. When the signal is high, the system starts taking data. It sends data to the rear computer in blocks. The number in each block is controlled by the rear computer. The information is sent to the Sense-tech hardware through USB. The information includes integration time, gain, and block delay. This info is sent when the system starts. The basic system when started will keep on doing the same thing all the time. It just keeps acquiring data until the block time is up. It is then shipped to the rear analysis program.
2. There can be many programs running in the rear computer, all of them can start or stop the data acquisition. Normally this program is started from a pet page but it can be specially setup. The display shows the “XDAS” program.

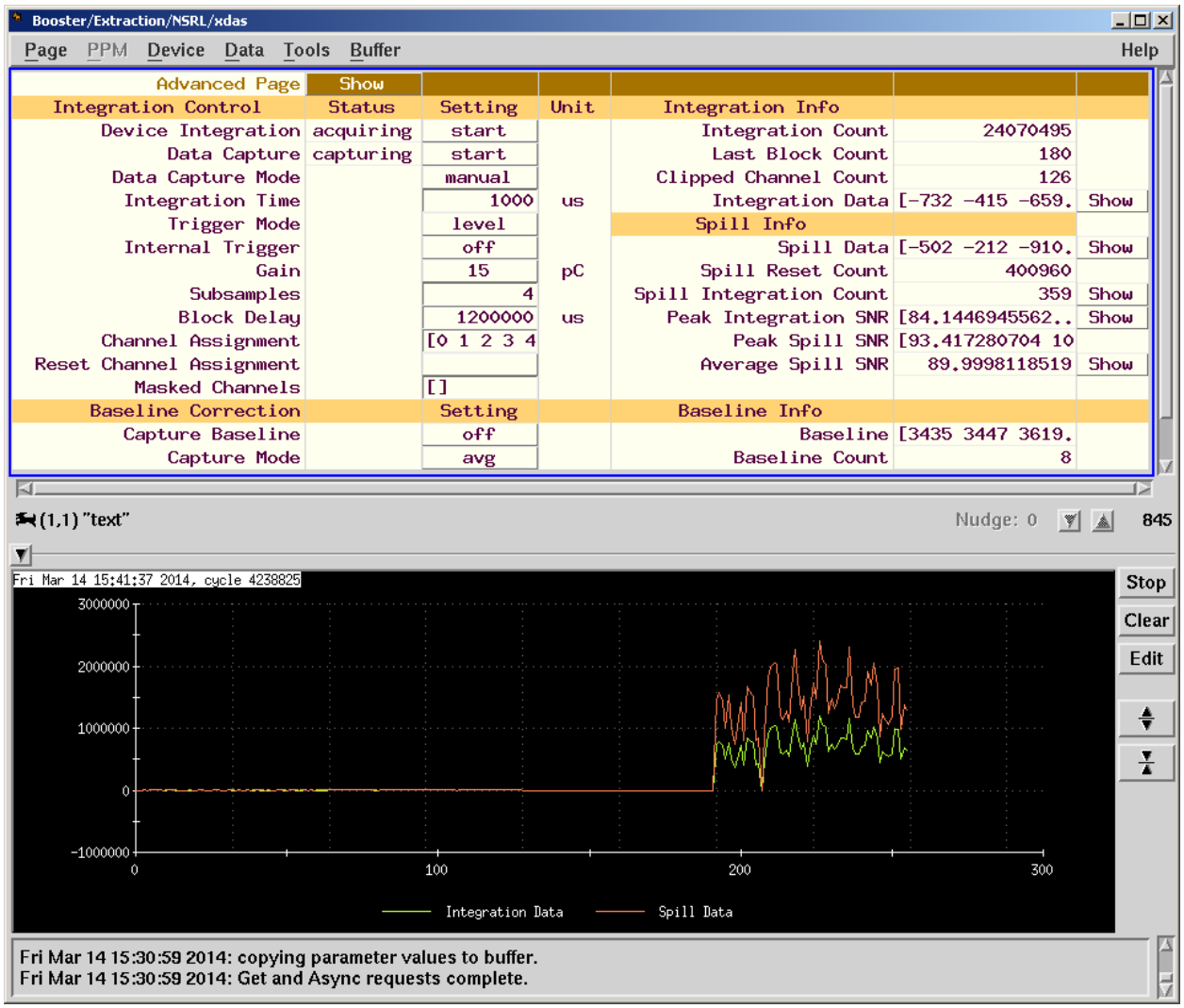


Figure 8: The display of the XDAS program showing the control functions and parameter settings on top, and data dump on the bottom.

In the appendix, there is an instruction manual for using the program. It allows you to change the settings of the device.

a. Integration Time, from 65 to 1,000,000 in units of µs.
b. Gain from 1.875 pC to 15 pC full scale.
c. Subsamples- normally set at 4. Watch that the result is 60 pC for full scale of 64000 counts.
d. Block Delay is the total time of data accumulated before transfer. This is important for low signal data. If we do a long integration time, the noise is less.
e. Channel Assignment allows you to arrange the input to display differently.

f. Masked Channels allows you to mask a bad channel.
g. Capture Baseline - When you select on, the system takes in the background data and averages them to be used for subtraction. Turn off after data is taken. The system is not working while this is underway.
h. Clear – this command will clear the background to 0 – by default.

There are two different types of application program using the data collected for display purposes.

a. Profile Display - We use an old integrator system to collect charge from wire chambers and display in the X-window. It is called Profile Display. The program was modified to accept data from Sense-tech system. We are replacing the 5 beam profile monitors with this new electronic readout system.

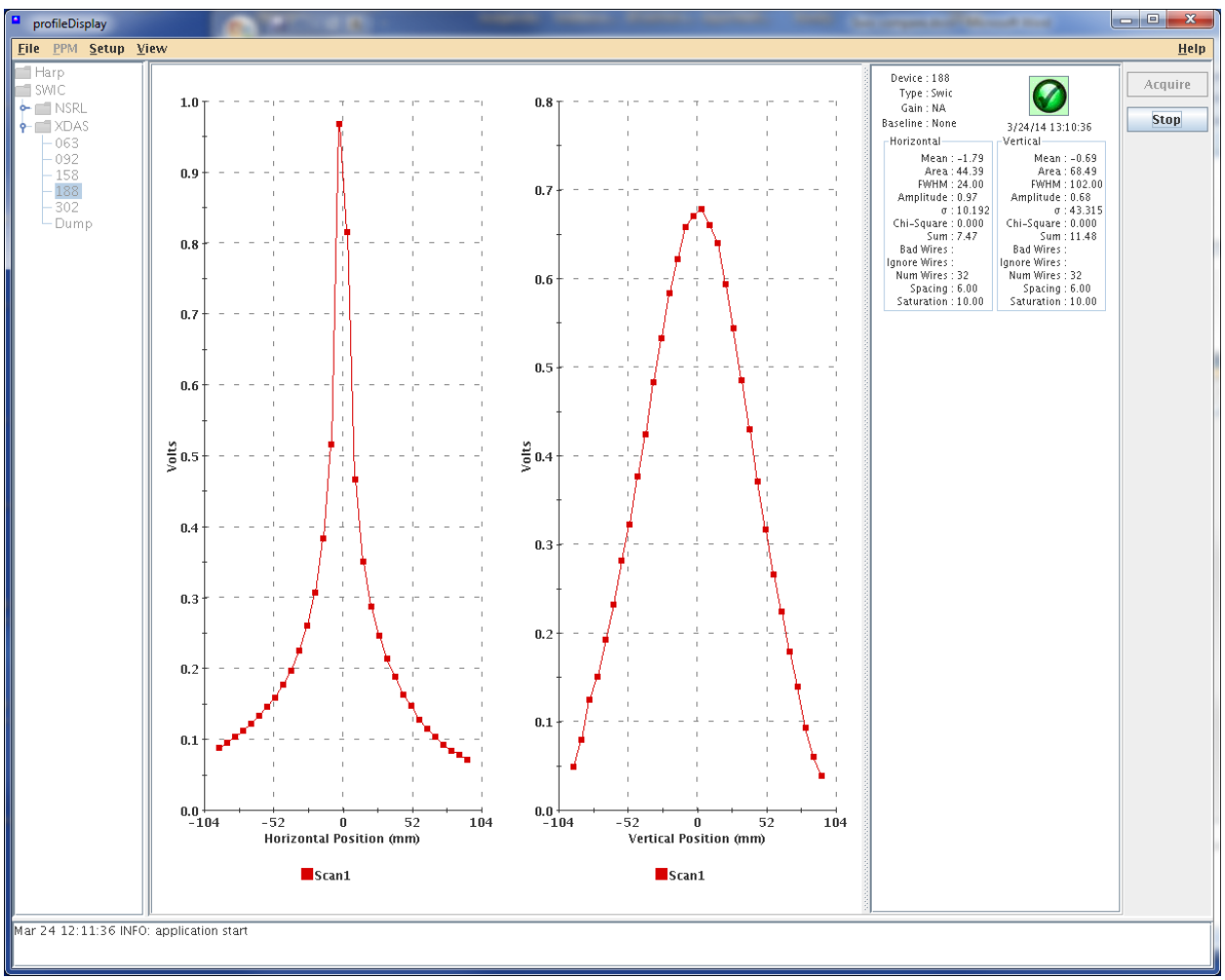


Figure 9: shows an example of the Profile Display as read out by the XDAS system.

b. Pixel display. In the NSRL line, we start a two dimensional detector instead of the old one dimensional device - only using an x/y projection display. We have an 8x8 pixel and 16x16 pixel system.

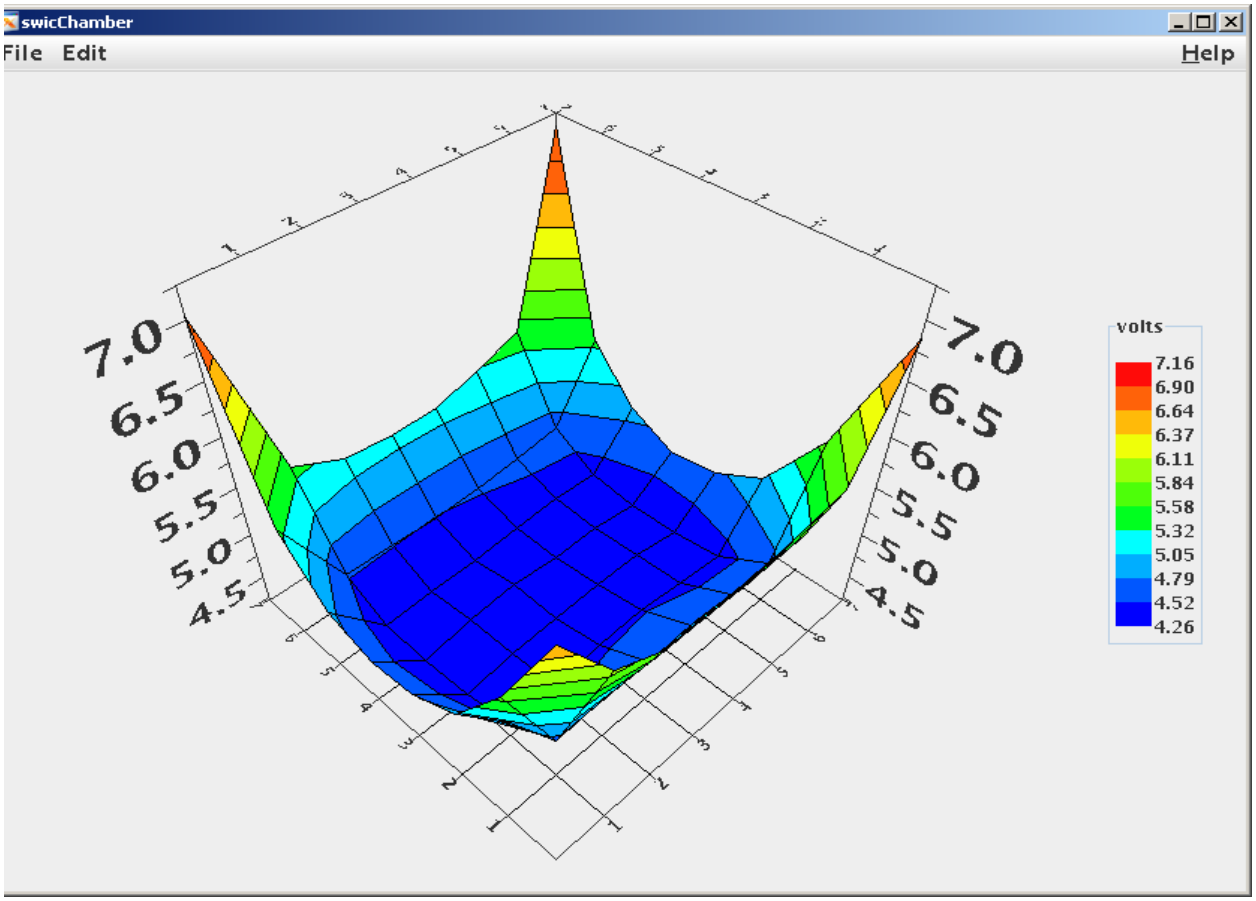


Figure 10: Showing an example of the NSRL beam shape using the 2-D display of the 8x8 pixel ion chamber.

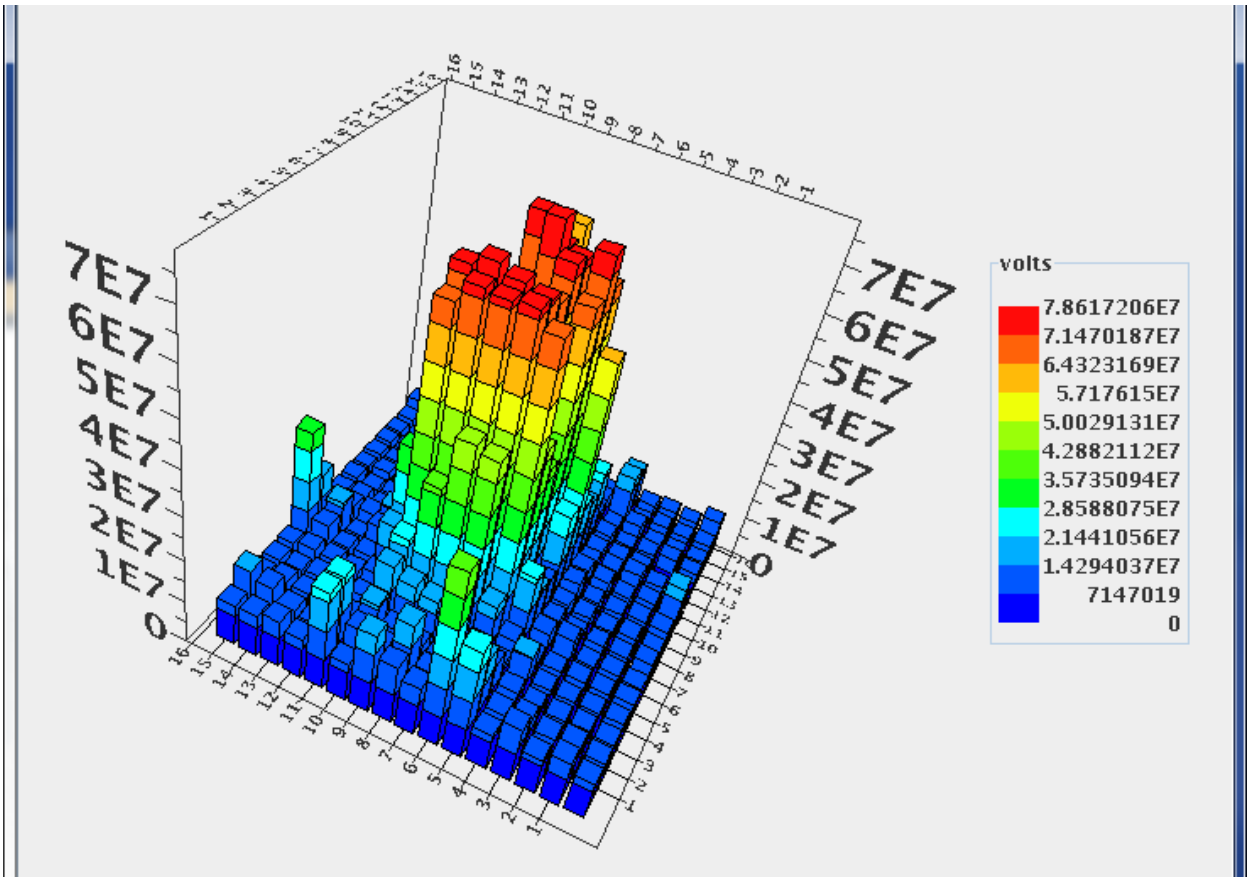


Figure 11: Showing the 2-D display of the NSRL beam shape using a 16x16 pixel ion chamber.

V. Future applications:

We used this readout to accumulate data from diodes exposed to the beam. It has been successfully seen that diodes respond to radiation like ion chambers. Diodes also seem to have additional Z dependence, and we are in the process of confirming that. The following picture is one of the ways we mount the diode on a film. We are trying to use this to study the beam spread in water.

The paint is for repelling water from the diode. We also will try to use these diodes to study the radiation distribution of a solar flare exposure of mouse. It will provide data for simulation.

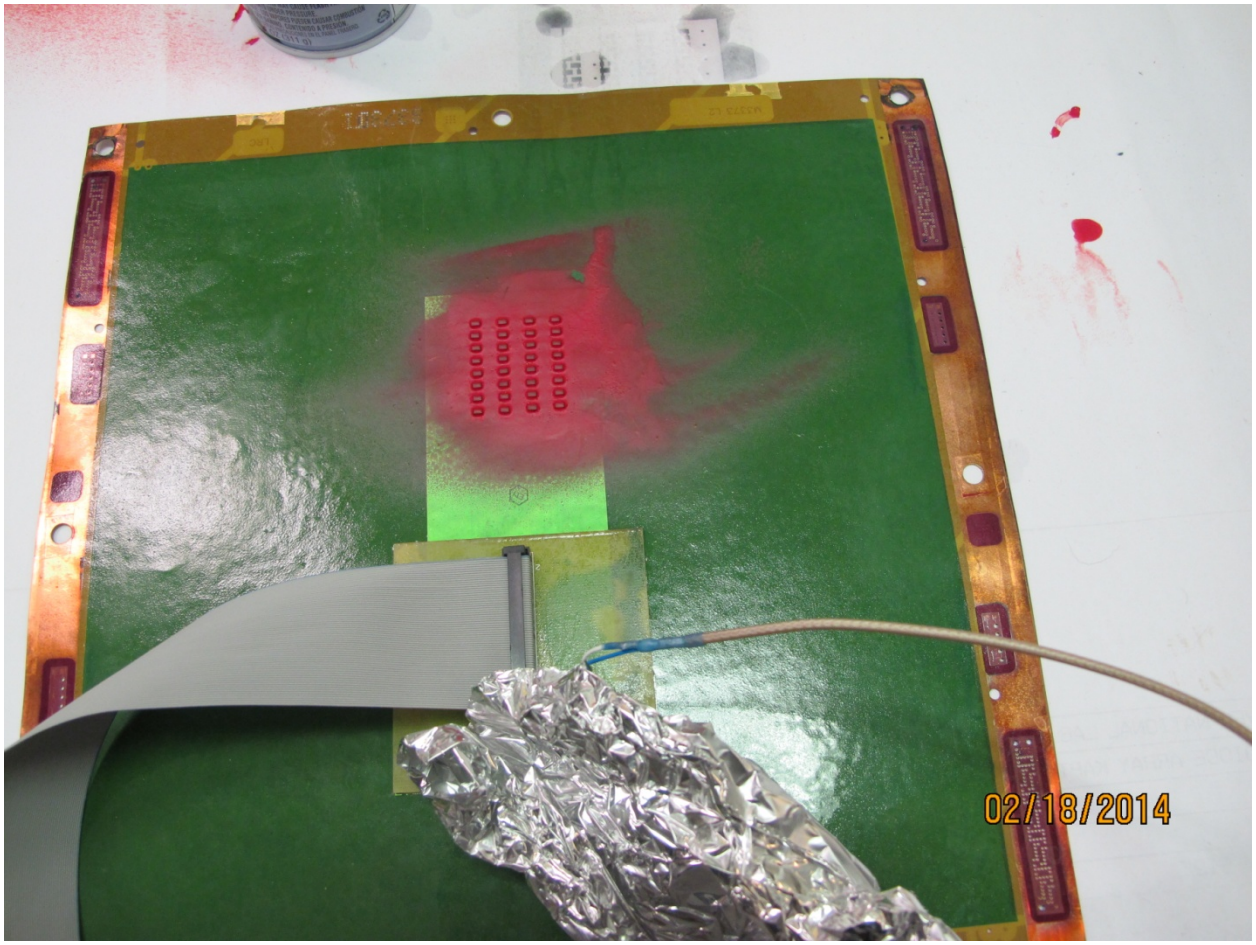


Figure 12: Mounting of 64 diodes to a thin Kapton foil (32 are on the backside of the foil). Readout is by XDAS system.

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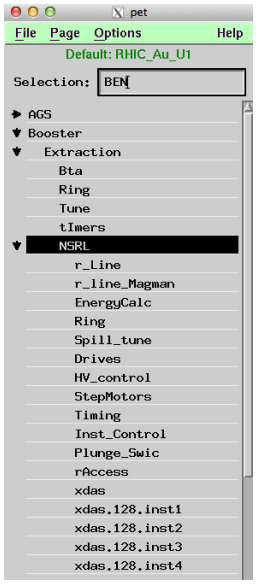
References: The XDAS readout system is documented at the Sens-Tech web site at http://www.sens-tech.com/home/

# Appendix A: Control and Readout of the 128 and 256 pixel system

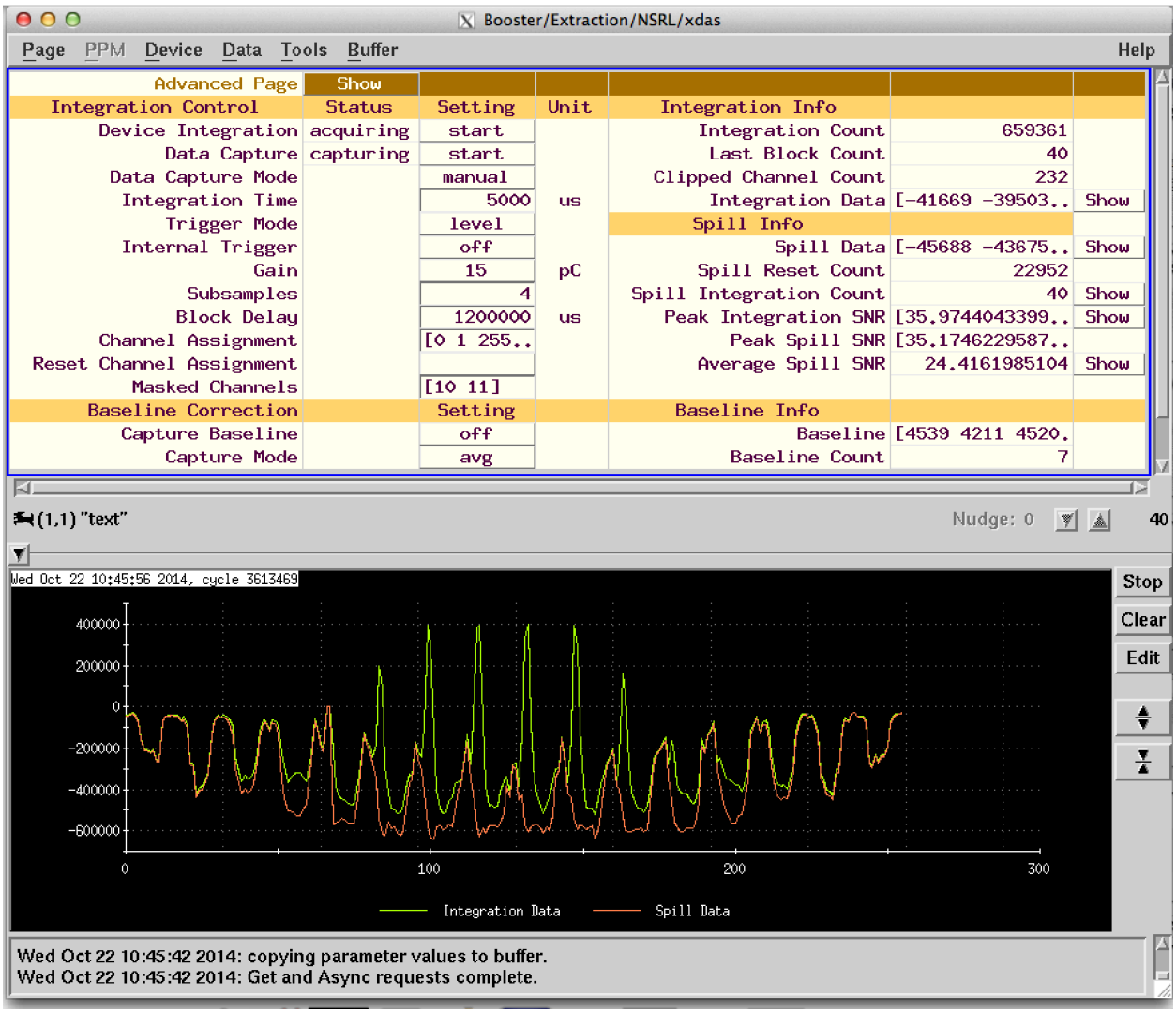
The xdas program is used to read out the 256-pixel chamber and the diode array. It makes use of the linux box, acnlin2a, in the labyrinth to connect via USB cable to the preamplifier array. We use an ado routine driven by pet to read out the channels, and

To Start the program, log on to one of the acnlinXX machines as nsrl:

1) Run pet.
    i) Select Booster → Extraction → NSRL
        (1) There are 4 entry there: xdas, and xdas.128.inst1-3.
        xdas is the 256-pixel display which uses the computer in the labyrinth, acnlin2a, inside the steel box. Inst1-3 are the 3 systems in 957 which are used to control the swic.
        inst1 controls SWIC-302 and one free channel
        inst2 controls SWIC-63 and SWIC-92
        inst3 controls SWIC-158 and SWIC-188.




1. xdas program control
    a. You can start and stop device integration and data capture by clicking the setting and select start or stop. The “device integration” button controls the collection of data by acnlin2a, reading out the pixel array. The “device capture” button tells the computer you are running xdas on to record the data.




b. You can change the specifications by changing the parameters, but you have to stop the device integration first.
c. The integration time should be more than 125 microseconds.
d. Trigger mode should be “level” which is gated by a delayed and stretched Booster-T0 signal, a TTL gate generated in the NIM crate in the dosimetry control room.
e. Internal trigger should be “off”.
f. You can control the gain by selecting 8 different setting. The subsample is 4 (I do not know how to change it yet). That means 64000 is 4 times the setting!!!! So at 15pC setting, 64000 equal to 60 pc.
g. Block Delay- For now, it is good to set at 1.2 seconds!! Bart sets it at 1.2 seconds to avoid the problem of background subtraction. If the signal

level is high then the background subtraction does not affect the data that much.

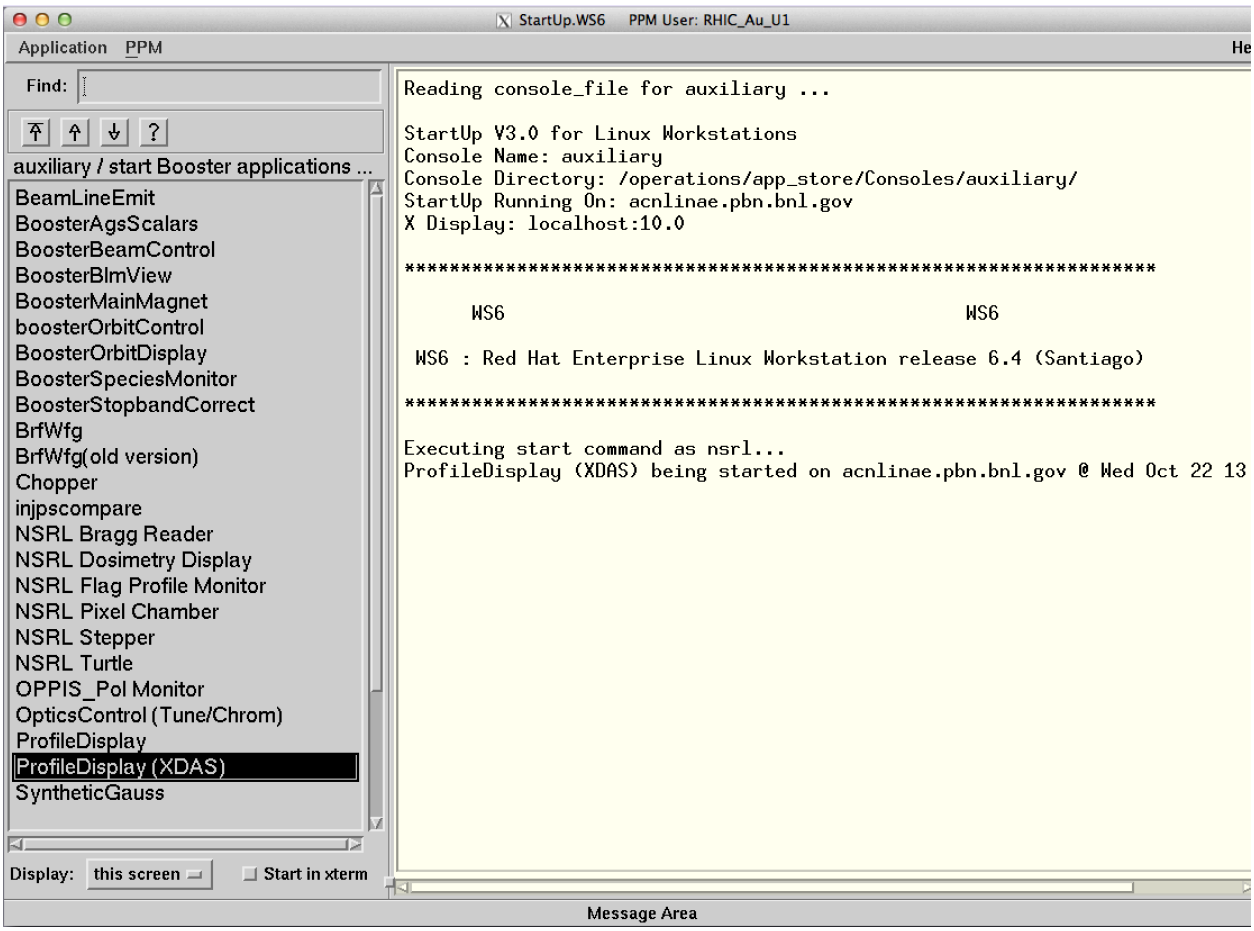
h. Channel assignment- To change this, click the Tools and select Value editor. You can then change the assignment. Do "send" to update the value. We can save the results in the archive. For details, you should ask Bart.
i. We can change the assignment by default reverse and reset. We could save and load the values to and from the archive. It shows up in the "Buffer → Show" - second display to the right. You can select the only save in this branch to minimizes the data. You can then select a parameter and middle click mouse twice to send the value over to the running program.
j. Base line subtraction. It should be done with "Beam Off". Click the Capture Baseline. Select on and take about 7 to 8 pulses. The turn it off. Once done, the baseline info on the right show the value of the baseline, which will be subtracted off the reading when beam is on.
k. If you want to reset the baseline, click the clear below. It will clear the baseline to 0.
l. The display below is for monitoring. You can hide and show the integration and spill data independently.

2. Tools
   a. Changing the channel assignment or the masked channel. Click the parameter setting for "Channel Assignment", and then click the "Tools". Select "Value Editor". You have to enter the number of channels to be modified, 256 for channel assignment. It shows input channel on the left and assignment channel on the right. After putting in the correct value, click on "send". And go to the next set.
   b. For masking, just input the total number on the top and select the channel to be masked.
3. Buffer
   a. Click "Show" for the second display to show. It shows the default of this setting. If you need to load a value, click the load from archive. Select

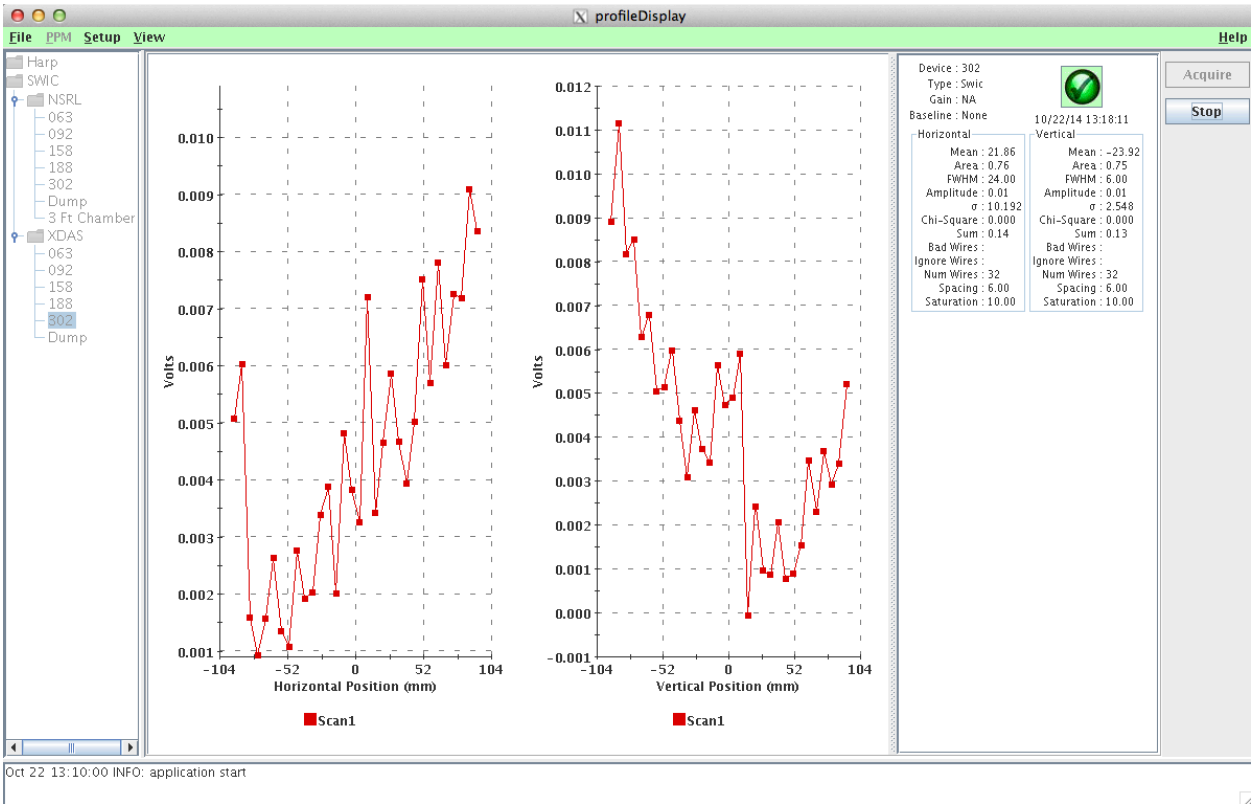
only show archives at the branch, and click “Apply”. In the display on the right, middle click the parameter you want to load and it will sent it to the current program. The other is not changed. Click the buffer show bottom and the right display will disappear.

b. To save the value, go to buffer and click save archive.

4. Reset the program
   a. Sometimes the program may hang. You might have to reset the V3 system. For that, you need to turn power off then on the V3 crate. To reset the program, go to StartUp, type in xd in the find box. There are 4 systems for now. xdasMan for 256 system, running on acnlin2a in the tunnel. The other 3 are for the SWICs 957 system. They control the Profile display.
   b. After you select the right program, you should click “stop & check”. This will stop the front end computer. After it is done, the xdas program will show red in the status and setting.
   c. You then click “start & check & clear” to start the capturing program. The status will clear from red. You should go to page (in XDAS) and select reload.
   d. After all this is done, you can start both programs. Right now it is possible to start at the wrong time and the data is displayed incorrectly. I hope that this will be resolved in the future.

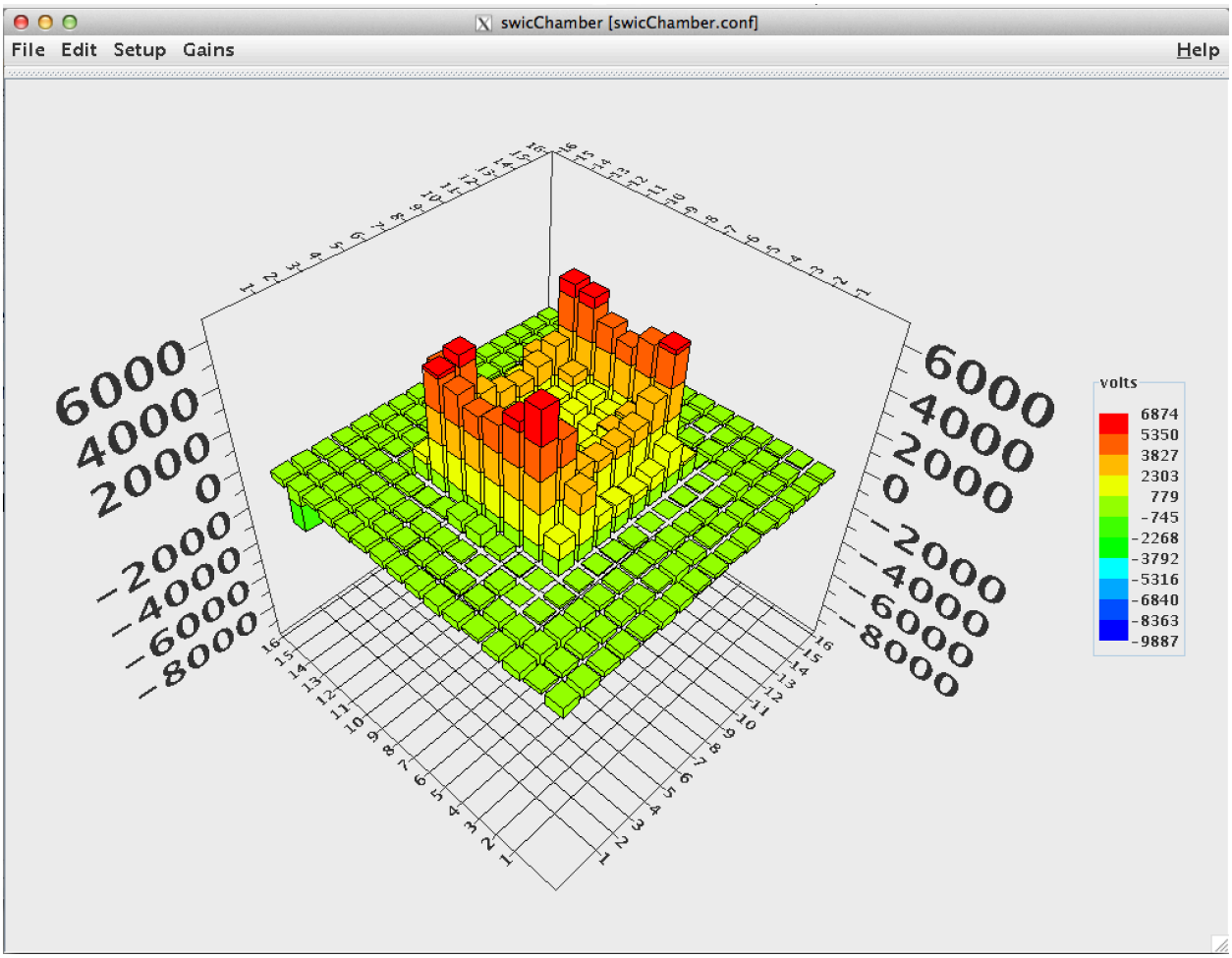



5. Profile Display
   a. For the profile display program, begin with “StartUp”.
   b. Select “start”,
   c. Go to “Booster Application”
   d. Select “ProfileDisplay(XDAS)”.




e. Select “SWIC”
f. Click “XDAS”. It will show you the list of SWICs that can be displayed.
g. Select one of the SWIC channels.
h. Click on “Monitor”. You may be asked whether or not you want to plunge the device. Always select “No”. It will automatically refresh every spill.

For the 16x16 pixel display of the 256 system.




1. Type “xdas16 &” in your xterm as user nsrl. The 16x16 channel display will show up. You can change the display by right clicking the display bar on the right and select “Data View”, change “surface” to “bar”, and click on the radio buttons for “Contoured”, “Zoned”, “Shaded”. “Meshed” should already be checked.
2. The system can accumulate data for many spills. On the “Set Up” pull down menu, click the “Accumulation Mode” button, and input the maximum spills. The system will stop accumulation at the number of spills specified. You should deselect the accumulate mode in the setup to continue spill-by-spill monitoring of the display.

3. Gain- you can set and select the gain of each channel. You can change the gain. Also, you can save the gain to archive. There is a feature to equalize the gain. To do that, you hold ctrl-alt on the keyboard and left click the display channel. When done properly, all channels will be adjusted to the same gain compensating for differences in detector sensitivity.