STJ / MPX-32D Quick Start Guide

Version 2.01

This document describes XIA's instrumentation system for setting up an STJ system with one or more MPX-32D 32-channel modular digital processors.

CONTENTS

OVERVIEW OF THE SYSTEM

The typical STJ system includes a cryostat with STJ detectors and associated control equipment provided by a 3rd party combined with the following equipment provided by XIA:

- Commercial PXI interface and crate, containing:
  - MPX-32D 32-channel digitizer module(s)
- Custom crate + ultra-low noise voltage regulators, containing:
  - STJ Analog 32-channel preamplifier module(s)
  - STJ I/O module, which includes an STJ input override switch
- Linear voltage supply module that provides power to the custom crate
- Associated interconnecting cables

MPX-32D DIGITIZER MODULE

XIA's MPX-32D is a 32-channel digitizer and modular pulse-processor that resides in a computer-controlled PXI crate. Its primary function is to measure pulse-heights, i.e. event energies.

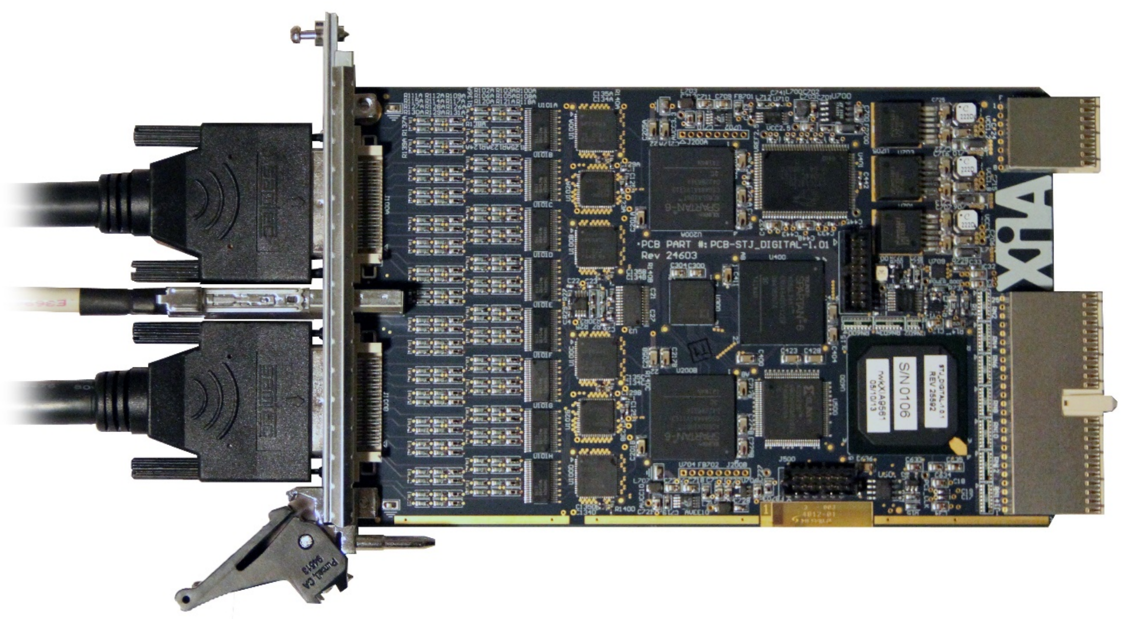

Fig 1: MPX-32D 32-channel digitizer and modular pulse-processor

INPUTS AND OUTPUTS

Name	*Connector Type*	*Description*
Analog Inputs 0-15	SAMTEC VRDPC-50-01-M-RA	16 differential-pair analog inputs

Analog Inputs 16-31	SAMTEC VRDPC-50-01-M-RA	16 differential-pair analog inputs
LVDS I/O	Harting 27 21 121 8006	1 diff-pair analog output is driven by a 14-bit high-speed DAC, i.e. the built-in pulser signal 3 LVDS digital outputs – used for communications and STJ bias voltage DAC control 1 LVDS digital input – used for communications
PXI Backplane	Standard	PXI / CompactPCI 33MHz 32-bit interface

BANKS AND CHANNELS

The 32-channels are divided among 4 'Banks' of 8 channels, each, due to the use of octal ADCs and octal VGAs. Channels 0-7 comprise Bank0, Channels 8-15 comprise Bank1, Channels 16-23 comprise Bank2, Channels 24-31 comprise Bank3. Note that some DSP parameters, e.g. BANK0ADCGAIN, BANK3ADCNYQ, operate at the Bank level, and are thus duplicated 4 times with the Bank identifier (ranging 0-3) included in the name.

VARIABLE GAIN

The analog signal gain passes through a software controlled octal variable-gain amplifier (VGA) stage. The VGA is controlled at the Bank level by the DSP parameters BANK0ADCGAIN, BANK1ADCGAIN, BANK2ADCGAIN and BANK3ADCGAIN.

The digitized signal can be approximately expressed in units of ADC least-signficant-bits (LSB) as:

ADC [LSB] = 10^((BANKnADCGAIN-5)/20) * input signal [mV]

For example, with BANK0ADCGAIN = 20, a 100 mV signal on channels 0-7 yields an ADC amplitude of approximately 576 LSBs. Note that the STJ Analog transimpedance gain is 1 mV/nA, so the gain can also be expressed as:

ADC [LSB] = 10^((BANKnADCGAIN-5)/20) * STJ signal current [nA]

SAMPLE RATE

The on-bard octal ADC's digitize the preamplifier signals at 50 MS/s, i.e. the sampling interval is 20 ns.

ENERGY SCALING

Digital trapezoidal filtering is used to improve the signal-to-noise in order to optimize the energy (amplitude) measurement. The filter includes a fine-grain digital scaling factor

Needs work!!!

Note that analog variable gain and digital scale factor are controlled in ProSpect via the Preamp Gain, Dynamic Range and MCA Bin Width settings…

STJ ANALOG MODULE

XIA's STJ Analog module is a 32-channel preamplifier card, with an associated software-controlled STJ bias voltage DAC and input connection relay for each channel. A backplane diagnostic pulser signal is routed to each channel via a separate relay.

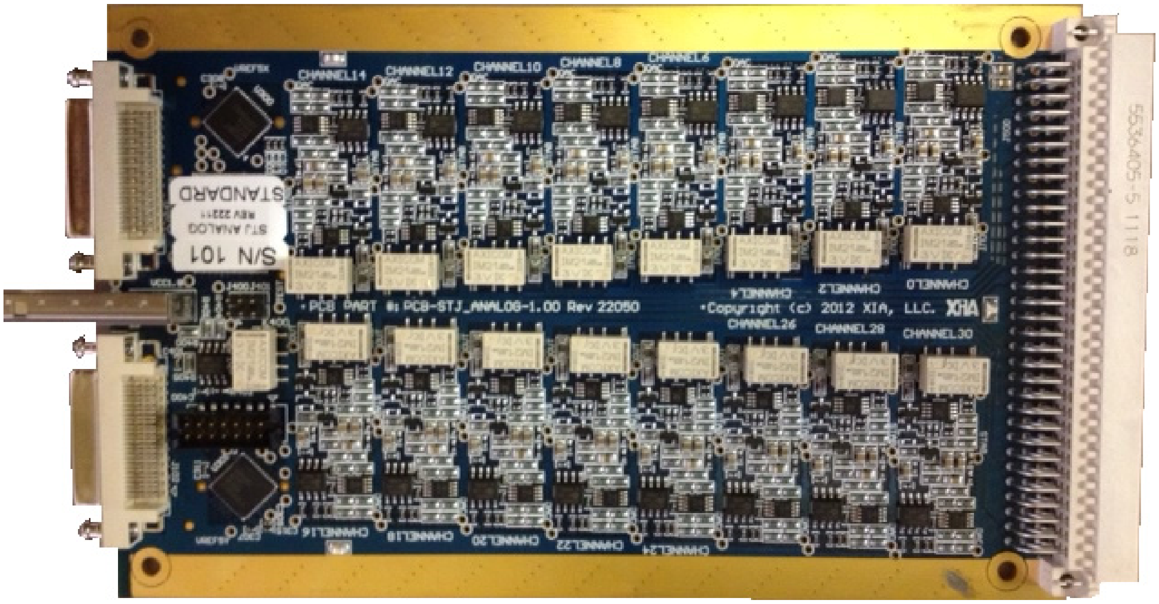

Fig 2: STJ Analog 32-channel preamplifier card

PREAMPLIFIER SCHEMATIC

The basic preamplifier circuit is shown below. The primary feedback elements are a 1 MΩ resistor (which yields the transimpedance gain = 1 mV/nA) in parallel with a 1 pF capacitor. A secondary low-frequency feedback loop maintains the software-selected bias voltage at the STJ input. Each preamplifier circuit includes an STJ Input Relay, which connects its input to either the STJ detector or a local 'dummy detector' resistor-capacitor network (10 kΩ in parallel with 2 nF). All 32 channels share the Pulser Relay, which connects their inputs to the diagnostic pulser signal via per-channel 10 MΩ resistors.

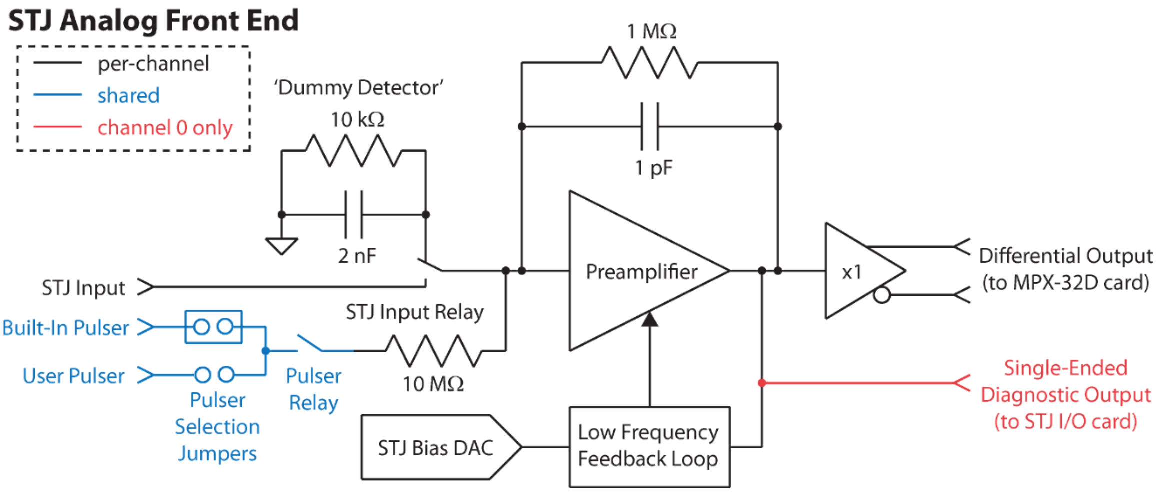

Fig 3: STJ Analog front-end schematic

INPUTS, OUTPUTS AND CONTROLS

Name	***Connector Type***	***Description***
Analog Outputs 0-15	SAMTEC VRDPC-50-01-M-RA	16 differential-pair preamplifier outputs
Analog Outputs 16-31	SAMTEC VRDPC-50-01-M-RA	16 differential-pair preamplifier outputs
LVDS I/O	Harting 27 21 121 8006	1 diff-pair analog input is received as a pulser input 3 LVDS digital inputs – used for communications and STJ bias voltage DAC control 1 LVDS digital output – used for communications
Custom Backplane	Eurocard	The backplane connector carries the STJ input signals, power supply connections and the user pulser signal
Pulser selection jumpers	2x3 2mm header + 2 jumpers	The header and jumpers comprise a DPST switch to select either the software-controlled pulser signal from the MPX-32D or a user pulser input connected via the STJ I/O card. See photos below for jumper configuration

The jumpers at location J400 are set by default, as shown at left below, to connect the preamplifiers to the built-in diagnostic pulser from the MPX-32D module via a software-controlled relay. To select the user pulser input connected to the STJ I/O front-panel SMA connector, move both jumpers towards the backplane connector, as shown at right below.

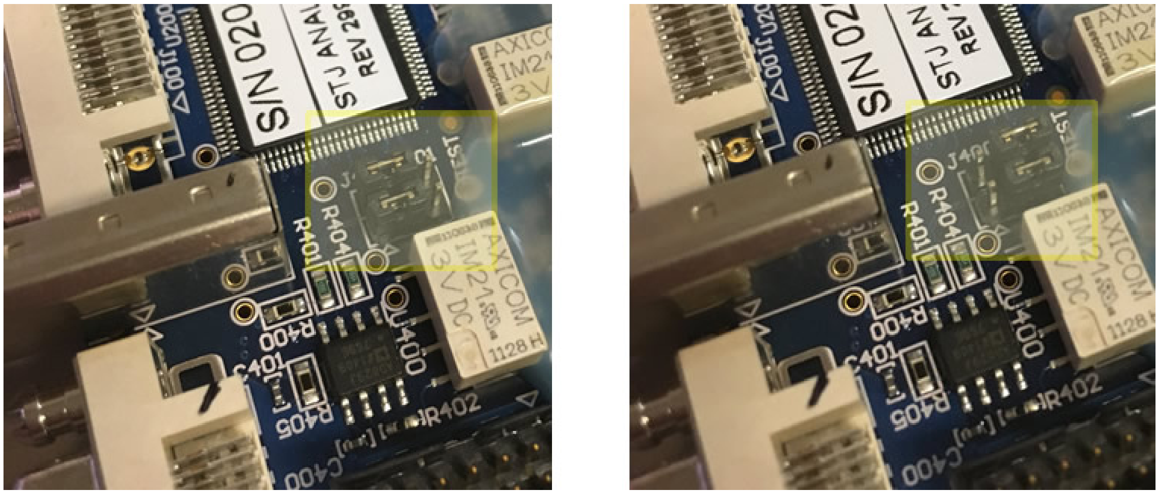

Fig 4: STJ Analog pulser selection jumpers

STJ I/O MODULE

XIA's STJ I/O module must be installed in the left-most slot of the custom crate. It provides a "kill" switch that overrides the software-controlled relay connection between the STJ detectors and the preamplifier inputs, as well as the user pulser analog input and a diagnostic 'channel 0' output for each STJ Analog module installed.

INPUTS, OUTPUTS AND CONTROLS

Name	***Connector Type***	***Description***
"Kill" switch	Toggle switch	Left-hand position: overrides software control of STJ input relays—STJs are disconnected! Right-hand position: software controls STJ input relays
Channel 0 Outputs	SMA (x4)	A single-ended version of the channel 0 preamplifier output signal from each STJ Analog card in the custom crate is routed to an SMA output connector for diagnostic purposes.
User Pulser Input	SMA	The bottom-most SMA connector accepts a user-provided diagnostic pulser input that can be routed to all preamplifiers in the crate via software-controlled relays. **The input is terminated to ground with a 50 Ω resistor.** Note that the STJ Analog pulser selection jumpers must be configured properly, as described above.

CUSTOM CRATE

XIA provides a custom crate designed to house up to four STJ Analog modules (up to 128 STJ detector channels) and the STJ I/O module.

INPUTS AND OUTPUTS

Name	***Connector Type***	***Description***
HDDSUB-78 x4	HDDSUB-78 (x4)	4 rear-panel connectors each provide connections for to up to 32 STJ detectors (see pinout below). Each connector corresponds to one of the four STJ Analog slots, in the same order. Note that XIA does not provide HDDSUB-78 cables to connect the custom crate to the STJ detectors in the cryostat. The cable should be shielded and as short as possible.
Custom Backplane	Eurocard (x5)	4 backplane connectors each carry the STJ input signals from one HDDSUB-78 connector, power supply connections and the pulser input to an STJ Analog module. A fifth slot (left-most) is reserved for the STJ I/O module.
Power input	Circular	The circular connector on the bottom of the chassis connects power from the linear voltage supply module

STJ INPUT CONNECTOR (HDDSUB-78) PINOUT

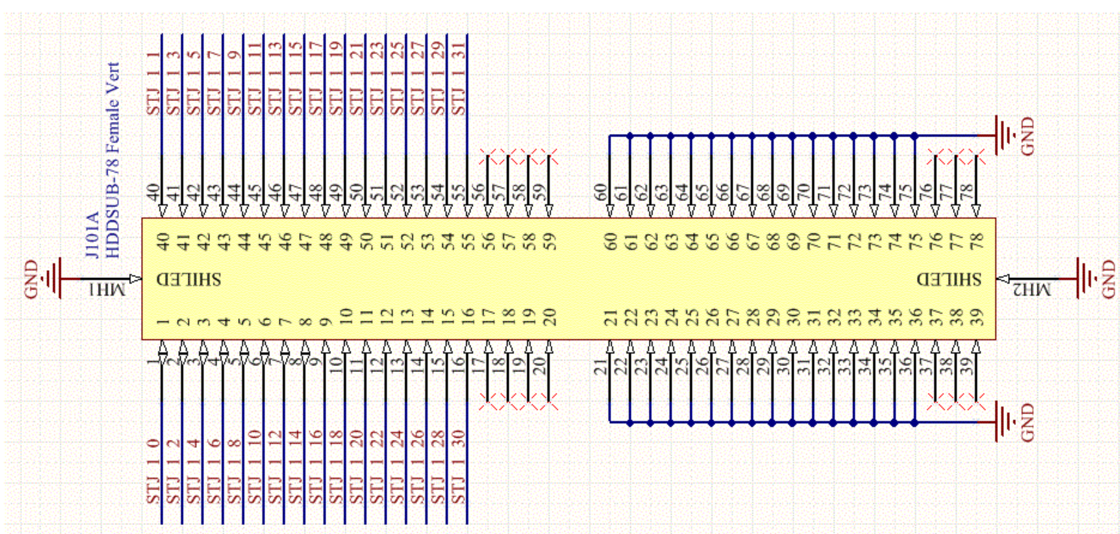

Fig 5: STJ input connector (HDDSUB-78) pinout

QUICK START GUIDE

STJ OR DIAGNOSTIC PULSER INPUT?

The STJ Analog preamplifiers accept inputs both from the STJ detectors and from a diagnostic input, which is connected to either the built-in software-controlled pulser or a user-provided signal. We recommend starting with the built-in pulser to first familiarize the user with the software, settings and data acquisition procedures. This approach bypasses the complex tasks of biasing the STJ detectors and solving system grounding and signal integrity issues. Without proper biasing and grounding, the input signals can do unexpected things.

SYSTEM SETUP

SOFTWARE INSTALLATION

Run the provided ProSpect executable and follow the steps as indicated within the installer.

STJ PREAMPLIFIER INSTALLATION

The custom crate should be connected to detector cryostat via HDDSUB-78 cables (not provided) and a solid ground connection, and to the power supply using the provided power cable with circular connectors. It is critical to make a solid ground connection between the custom crate and the detector cryostat, and to otherwise isolate the two from other ground connections. Ideally the two pieces of hardware are physically co-located and bolted together. If that’s not possible a thick copper braid may be sufficient.

- **Signal integrity issues almost always trace back to poor grounding between the custom crate and the detector cryostat, or improper STJ wiring within the cryostat itself.**
- **The custom crate can safely be powered on/off and connections can safely be made while the PXI crate is powered**

Each STJ Analog card in the system should be installed into one of the four right-hand slots in the custom crate, and connected to its corresponding MPX-32D via 2 Samtec cables and 1 Harting cable.

- **Samtec front-panel connectors are labeled “0-15” or “16-31”. Make sure that every Samtec cable is connected such that the labels on each end are consistent.**

PXI CRATE INSTALLATION

Turn off the PXI crate. Install the required number of MPX-32D modules, power on the PXI crate connected to the host computer and then re-boot the host computer. After Windows starts you should get a notification and prompt to install new drivers for each and every MPX-32D module. This is tedious, but you should only have to do this the first time a slot is occupied.

- **ALWAYS power off the PXI crate before installing or removing MPX-32D cards!**
- **Turn on the PXI crate, then re-boot the computer**

REVIEW PCI BUS CONNECTIONS

Open the Windows Device Manager (right-click on My Computer, select Manage, and then select Device Manager in left panel) and scroll down to and expand the Other Devices section. There should be a "XIA MPX-32D Digitizer and Pulse Processor" entry for each MPX-32D module in the connected PXI crate(s). Double-click on an entry to view the PCI Bus and Slot assignments for that module. It is important to identify the assignments for each module so that its identity in the software can be associated with its physical location in the array.

Note that larger PXI crates will contain multiple PCI bus segments, and that the slot assignments are often not very intuitive: The ordering is typically backwards compared to the labels on the PXI crate.

- **Note the PCI bus and slot numbers for your system**

EDIT THE CONFIGURATION (INI) FILE

You should receive a sample configuration (INI) file. Open the file with a text editor and find the entries for pci_bus and pci_slot towards the end of the file. These values MUST match the device settings for your system. See the "Review PCI Bus Connections" section above.

- **Edit the pci_bus and pci_slot values as necessary and save the INI file.**
- **Save the INI file frequently as settings are adjusted, and note that you can also save and retrieve to/from different INI files**

You can also use the Generate Configuration File dialog, accessible under the Tools menu, to generate a new INI file and view compatible XIA modules detected on the PXI bus.

FIRMWARE (FDD) FILES AND DECIMATION

XIA provides three different firmware (FDD) files, with Decimation values 0, 1 or 2. Decimation sets the base units of the energy filter, and thus the Peaking Time + Gap Time range. We typically recommend using Decimation 0. To use Decimation 1 or 2, i.e. longer peaking times, change the "filename" path(s) in the [firmware definitions] section of the INI file.

FDD File	Decimation	Base Units	Peaking Time + Gap Time Range
stj_decimated0_45T.fdd	0	20 ns	100 ns – 20.48 µs
stj_decimated1_45T.fdd	1	40 ns	200 ns – 40.96 µs
stj_decimated2_45T.fdd	2	80 ns	400 ns – 81.96 µs

Table 1: Decimation and Peaking Time Range

START PROSPECT

When ProSpect is started the first time, you will be prompted to select an initialization file. Please browse to and select the edited INI file. Thereafter, on startup ProSpect will automatically select the most recently used INI file.

Note: It is almost always necessary to re-boot the host computer whenever power is cycled on the PXI crate. Always turn on the PXI crate before starting the host computer.

USING THE PROSPECT SOFTWARE

ProSpect is a Windows application that runs with XIA's Handel drivers. It is primarily intended as a platform for system configuration, but ProSpect can also be used to acquire and save data.

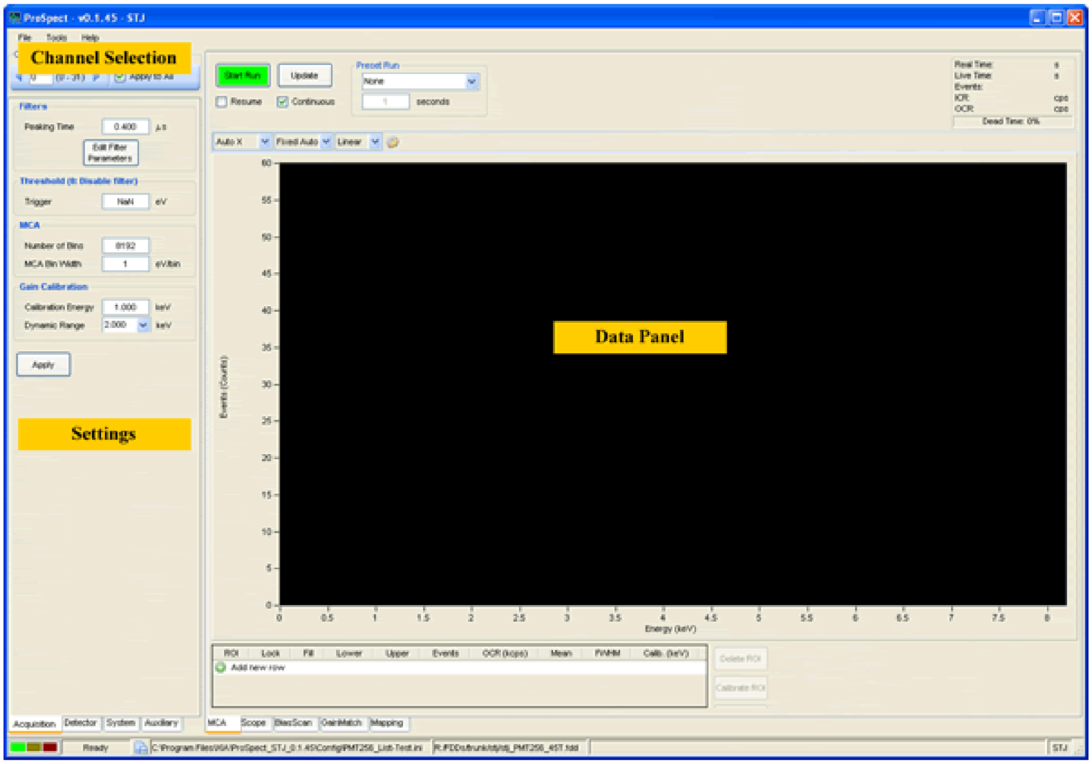

Fig 6: ProSpect is organized into three main areas: Channel Selection, Settings and the Data Panel.

OVERVIEW OF TYPICAL USAGE

Once the STJ bias voltages, gain, thresholds and other settings have been optimized and saved to an INI file as described in this document, the typical usage is:

1. Power on the PXI crate, STJ detectors and preamplifiers, and then wait for preamplifiers to settle, as indicated by the green LED on the custom crate
2. Start ProSpect or initialize the system by selecting your modified INI file
3. Optionally verify the STJ biasing by running a BiasScan operation and inspecting Fiske Mode locations vs bias voltage settings for all channels.
4. Optionally verify the presence of input pulses and the Decay Time setting by acquiring ADC traces with the Scope tool.
5. Optionally calibrate the gain using the GainMatch tool
6. **Adjust the ADC Offset – this must always be done after the system is initialized and/or gain is modified, e.g. during calibration.**
7. Acquire data in MCA mode or Mapping/List mode using ProSpect or XIA's Handel drivers via custom software
8. Analyze data using 3rd party or custom software

CHANNEL SELECTION

The Channel Selection tool applies to all panels and tools. The "Apply to All" check-box ensures that any changes to settings are applied to all modules in the system.

- **Make sure the "Apply to All" check-box is checked!**

SETTINGS

Most settings, or acquisition values, are located in the Acquisition, Detector, and Auxiliary tabs in the left panel. Some settings are only accessible via the DSP Parameters panel, which can be opened via the Tools menu. The following sections contain very brief descriptions of the primary settings. For a more detailed explanation of XIA's approach to digital pulse processing and associated settings, please refer to:

- microDXP Development Kit Manual
- microDXP Technical Reference Manual

SYSTEM TAB

Before changing settings, however, let's take a look at the System tab. The upper section displays the MPX-32D modules in the system and their PCI assignments. The lower selection displays the channels in the selected module.

The primary use for the System tab in this application is the enabling and disabling of channels, performed by clicking in the Disable column adjacent to each channel. When a channel is disabled, data acquisition will be disabled for that channel, which reduces communications and processing overhead. Channels that aren't wired to actual STJ pixels, for example, can and should be disabled. The channel enable/disable settings can be saved to the INI file, such that the state of the system is restored whenever the system is initialized.

AUXILIARY TAB

This panel displays the auxiliary Analog Module status and contains the STJ Relay and Pulser controls.

ANALOG MODULE

The first section displays whether an auxiliary Analog Module has been detected (properly connected to the currently selected MPX-32D module and powered on), the type of auxiliary module and its firmware revision. This information can be used to verify your system setup. The images below show the Auxiliary tab with an STJ Analog card, aka "Analog Module", with revision 0xCD02 detected. If no module is detected, first check your cable connections and power, and then try pushing the Enable/Disable button. When the button transitions from green to red, the system polls the module status.

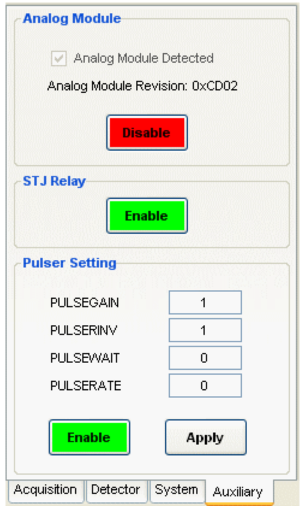

Fig 7: The Auxiliary tab with an STJ Analog auxiliary module connected to the currently selected MPX-32D module.

STJ RELAY

The most important setting on this panel is the STJ Relay Enable/Disable button. By default, STJ Analog on-board relays are open (as shown above): The STJ detectors are terminated with 1MΩ resistors, and the preamplifier inputs are terminated with 10kΩ resistors in parallel with 2nF capacitors, i.e. a 'dummy' detector circuit. When the relays are closed/enabled, the preamplifier inputs are connected only to the HDDSUB-78 pins, i.e. to the STJ detectors, if present. We recommend first familiarizing yourself with the system by using the on-board pulser to generate an input signal before working with actual STJ detectors (see below). Note that if the STJ detectors are not connected the HDDSUB-78 connector(s), the STJ Relay provides a convenient 'low noise' pulser setting: the pulser signal is much cleaner when the dummy detector circuit has been removed via the relay.

- **The "kill" toggle switch on the analog chassis prevents the STJ relays from closing when in the left-hand position. Make sure this switch is in the right-hand position.**
- **Click the STJ Relay Enable/Disable button so that it changes from green to red. Note that the LED on the analog chassis corresponding to the selected STJ Analog module will change from solid green to solid red when the relays are closed.**

PULSER

The Pulser Settings control a rudimentary built-in pulser circuit, which feeds a periodic signal to all preamplifier channels on the Analog Module. The signal is generated by a DAC on the MPX-32D which repeatedly cycles through 4K points of waveform data stored in RAM. It is quite useful for debugging and for exercising the data acquisition system. After system initialization the Pulser Enable/Disable button should be green (as shown above), indicating that the pulser is turned off.

- **Press the button to enable the pulser, keeping the default settings as shown, which generates a periodic pulse with a 1 μs risetime and 5 μs decay time, at 1 kHz frequency.**
- **The PULSEGAIN setting coarsely controls the pulse amplitude, which is proportional to 2^PULSEGAIN. Valid PULSEGAIN values ranges from 0 to 3.**
- **The PULSERINVERT setting controls the polarity of the pulse waveform. It should be set to 0 or 1 such that pulses are positive in the ADC waveform, as viewed in the Scope panel.**

- **The PULSERATE setting controls the rate at which the DAC is updated: update rate = 20 ns * 2^PULSERATE. Note that this setting affects the rise time and decay time! With the default value 0, the waveform spans 80 μs, with a 1 μs risetime and 5 μs decay time. With PULSERATE=1, the waveform spans 160 μs, with a 2 μs risetime and 10 μs decay time, etc.**
- **The PULSEWAIT setting, ranging from 0 to 255, controls the time that the circuit waits before cycling back to the beginning of the waveform data, i.e. it can be used to reduce the count rate. Its units depend on PULSERATE: wait time = 256 * update rate as defined above. For example, with PULSERATE=0, the units are 5.12 μs.**

Now proceed to the Scope Panel section below to explore the Decay Time setting in the Detector tab.

When you are ready to connect to actual STJ detectors, you will typically want to disable the pulser. Note that it is safe to enable the pulser while the STJ Relay is closed, in case you want to combine the periodic signal with the detector signal.

DETECTOR TAB

The Detector Settings need to be edited. Start by first setting the Polarity and Preamp Gain to these recommended settings:

- **Set the Polarity to "-"**
- **Set the Preamp Gain to "150.000 mV/keV"**

POLARITY

For a positive STJ bias voltage, the Preamplifier: Polarity setting should be "-" (negative), and vice versa. When the polarity is set correctly, ADC pulses should be positive as viewed in the Scope panel.

DECAY TIME

When using STJ detectors, the preamplifier Decay Time can only be determined after the STJ bias voltage has been set and x-rays are present. In our experience the Decay Time ranges from a few 10's to 100's of microseconds, depending on the detector. It can be measured directly using the cursors in the Scope panel (with Trace Type = ADC, Trigger Type = Threshold). Note that the Sampling Interval can be adjusted. The minimum value is 20 ns, corresponding to the 50 MHz ADC clock. The trace buffer is 4000 points, yielding an 80 μs waveform with the minimum Sampling Interval. You may need to increase the Sampling Interval for longer decay times.

- **When using the built-in Pulser, the Decay Time should be set to 5.0 μs * 2^(PULSERATE). For example, with PULSERATE=0 (default), it should be set to 5.0 μs.**

PREAMP GAIN

The Preamp Gain setting, along with the Dynamic Range setting on the Acquisition tab, determines the MPX-32 analog and digital gain settings. The exact relationship is a bit convoluted, due to the fact that each bank of 8 channels share the same analog gain setting due to hardware limitations.

- **We recommend starting with a value of 150 mV/keV along with a 2 keV dynamic range, and then using the ROI Calibration tool and/or the GainMatch tool to refine the Preamp Gain setting on a per-channel basis.**

- **Note that with these settings, the built-in pulser (with default settings as shown in Figure 7) should generate events with energy roughly equal to 1 keV and a count rate of 1 kcps.**

ACQUISITION TAB

The Peaking Time and other Filter Parameter settings control the trapezoidal digital filtering algorithms. At minimum, the Peaking Time, Gap Time and Trigger and Energy Thresholds should be optimized for each system. For a thorough explanation of these settings please refer to Chapter 4 of the microDXP Technical Reference Manual.

PEAKING TIME

The Peaking Time control sets the integration time of the slow energy filter. In the past we have gotten the best results with Tantalum STJ's when the Peaking Time is in the range 16 to 18 microseconds, with a Gap Time of 4 to 6 microseconds. These settings are best adjusted after the STJ bias voltage has been set.

- **Make sure the "Apply to All" check-box is checked!**
- **Edit the value in the Peaking Time field and press the Apply button.**

Note that these recommended settings are close to the maximum supported for Decimation 0. If the desired Peaking Time + Gap Time is greater than 20.48 μs, you will need to change the firmware filename path in the INI file to select Decimation 1 or 2, as described in the **Firmware (FDD) Files and Decimation** section above.

THRESHOLD

The STJ processing pipeline includes two separate digital filters: Trigger (fast) and Energy (slow). The trigger filter output is optimized for speed, and is used exclusively to detect input pulses and pileup. The slow energy filter is optimized for noise reduction. It is used primarily for energy measurement, but can also be used to detect very small pulses, i.e. low energy events, but it doesn't do a very good job at pileup detection.

- **When running with actual STJ detectors, the STJ bias voltage should be optimized set properly before attempting to optimize threshold settings!**
- **Thresholds may need to be re-optimized after the gain is modified (either directly or via the Calibration or GainMatch tools)**
- **The Trigger Threshold should always be enabled, i.e. non-zero.** It should be optimized first, with the Energy Threshold disabled, i.e. set to 0. If the gain is set properly, the fast threshold can typically be set below 100 eV. The value can be optimized by acquiring MCA data in short runs and looking for a noise peak near 0 eV. If the threshold is too low, a noise peak will appear and the input count rate will measure higher than expected. The optimal threshold is set just above the value that generates a noise peak.
- **The Energy Threshold can be enabled to extend detection of events to lower energies, and should only be used in combination with a non-zero Trigger Threshold.** After the Trigger Threshold has been optimized, set the Energy Threshold to the lowest value that does not generate a noise peak.

MCA

These settings control the output scaling of the energy measurement, which correspond to the X-axis scaling and granularity in the MCA panel.

- **We recommend always using the maximum Number of Bins: 8192 bins**
- **We recommend using MCA Bin Width = 0.25 eV/Bin with a 2 keV Dynamic Range. If you are interested in energies above 2 keV, increase both of these settings by factors of 2, e.g. 0.50 eV/Bin with 4 keV Dynamic Range, etc.**

BASELINE

The Baseline Average setting determines the number of samples in the running baseline average.

- **We recommend always using the default value: 256 Samples, unless otherwise instructed by XIA**

ADVANCED SETTINGS

Additional acquisition settings are accessible in the Edit Filter Parameters dialog, including the slow filter Gap Time, the Peak Capture method and Fast Trigger Filter settings. Please refer to the microDXP Technical Reference Manual for more details about these settings.

- **Press the Edit Filter Parameters button to edit the advanced acquisition settings**
- **Edit the Gap Time such that the value comfortably exceeds the rise time of incoming pulses as viewed in the Scope panel. Note that the maximum Peaking Time plus Gap Time are constrained by the Decimation, i.e. firmware (FDD) file, as described in the Firmware (FDD) Files and Decimation section.**
- **We recommend always using the Peak Sensing Capture Method! This means that the largest energy value within an appropriate window is recorded, which always yields the optimum energy resolution. With the Peak Sampling method, you will need to adjust the Peak Sampling Time to achieve optimal energy resolution.**
- **We recommend setting the Fast Trigger Filter Peaking Time to 1.000 μs for most STJ systems, which achieves a good balance between speed and noise rejection.**
- **The Max Width setting controls pileup rejection in the Fast Trigger Filter: pulses that remain over threshold for longer than this interval are rejected. This setting should normally be set to a conservative 10 μs. For high count rates (>100 kcps), you may want experiment with reducing this value to reject events that pile up in the Fast Trigger Filter.**

BIASSCAN PANEL

The BiasScan panel is used to plot the STJ I-V curve in order to select a bias voltage for the detector. When the “Start Scan” button is pushed, the bias voltage for each STJ detector is set to the “Starting Offset” value, then the voltage is incremented across the prescribed voltage range. At each increment the output voltage and signal noise level are measured. The output voltage is proportional to the detector current. It is plotted in green, with arbitrary units on the left-hand y-axis (Note that we intend to update the software with y-axis units in Amperes). The noise level is plotted in arbitrary units on the right-hand y-axis.

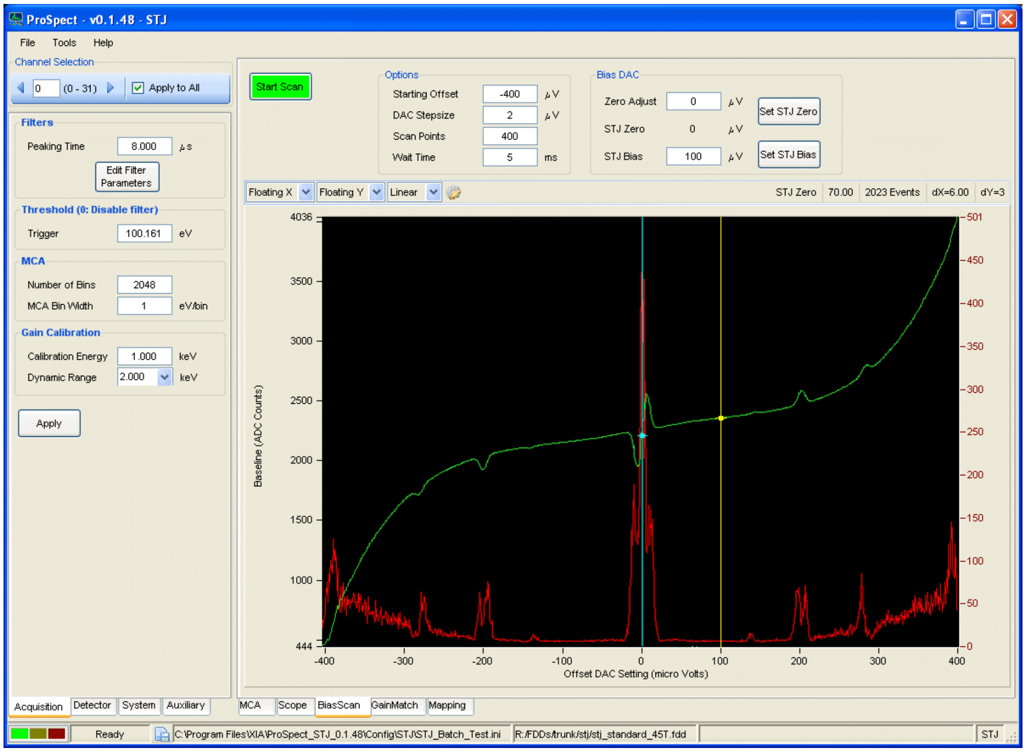

Fig 8: The BiasScan panel acquires and displays the STJ I-V curve. The cursors are used to set the zero-point and bias voltage.

Here are the typical settings used in our prior work with Tantalum STJ detectors:

- **Starting Offset = -500 µV**
- **DAC Stepsize = 1 µV**
- **Scan Points = 500 (a good balance between resolution and time required)**
- **Wait Time = 50 ms**

With the settings above, the scan starts at -500 µV and increments 1000 times by 1 µV, i.e. terminating at +500 µV, and waiting 50 ms between each increment for the voltage to settle. Reducing the Wait Time directly reduces the time required for the scan. In the past we typically reduced the Wait Time when doing a 'sanity check' bias scan, and increased it when doing careful measurements.

- **Press the Start Scan button and wait for the run to complete. The run time depends primarily on the number of Scan Points and the Wait Time.**

By default, the green bias current plot is selected. Click and drag in the plot to quickly zoom. Click and drag on any of the axes to quickly pan. Right-click and select "Full Scale" to zoom all the way out. To zoom in on the red noise plot, first right-click and select "Zoom Reference", then click and drag as before.

There are two vertical cursors in the plot. The blue cursor is used to set the STJ Zero, and the yellow cursor is used to set the STJ Bias voltage, as described below.

SET STJ ZERO

Because of imperfections in ground connections, and the DAC and associated electronics, there is an offset voltage associated with the DAC zero-point, i.e. when the DAC is set to 0V, the STJ detector may in fact be biased with a few 10's of micro-Volts. The inflection point in the characteristic STJ I-V curve is used to find the actual DAC setting that corresponds to 0V at the STJ detector. Drag the blue cursor to the centroid of the inflection point in the green (bias current) plot. Note that the value in the Zero Adjust changes with the cursor selection, and is highlighted yellow if the value is different from the saved STJ Zero.

- **Move the blue cursor to the inflection point in the green plot, then press the "Set STJ Zero" button.**
- **Repeat for all channels!**
- **Press the Start Scan button again to acquire new data with the voltage offsets removed. Note that the inflection point should now be centered along the x-axis, at 0V.**
- **In the past we have had to repeat this entire process a few times to get the offsets set properly. This may have been necessary because of faulty ground connections that led to interactions between the STJ pixels.**

SET STJ BIAS

The STJ bias should be chosen in the appropriate voltage range, and at a voltage that is not associated with a Fiske-mode peak. The noise level plot is useful for identifying the Fiske-mode peaks.

- **Move the yellow cursor to the desired voltage, then press the "Set STJ Bias" button.**
- **Repeat for all channels!**

At this point, all of the STJ detector elements should be properly biased.

SCOPE PANEL

The Scope panel displays raw ADC and filter data for debugging purposes. Data acquisition occurs simultaneously for all channels in the currently selected modules. We strongly recommend reviewing this section before trying to acquire MCA or list-mode Mapping data.

- **Set the Trace Type to "ADC"**
- **Set the Trigger Type to "Threshold"**
- **Turn on the x-ray source, or alternatively, enable the pulser in the Auxiliary tab**
- **Press the Get Trace button to simultaneously acquire a plot of the ADC for all 32 channels**
- **You may need to adjust the Trigger Threshold (in the Acquisition tab) to properly trigger the acquisition. Note that the hardware times out after a second or so if no trigger is generated, and just acquires un-triggered data.**

MEASURE THE RC DECAY TIME

You should see positive RC decay pulses in the ADC data (either from the on-board pulser or from the detector). To get the best energy resolution, the Decay Time setting in the Detector tab must be set properly. Use the cursors in the ADC plot area to measure the decay time τ. Note that energy resolution can be degraded significantly if this setting is way off, but small errors won't really affect the data quality: Don't worry about getting it exactly right. For a more thorough explanation of the measurement, please review section 3.8.3.4 of the microDXP Development Kit Manual, noting that the signal rise time is typically much longer for STJ detectors than for conventional x-ray detectors, e.g. silicon drift.

- **If you're using the pulser, the Decay Time is 5 μs (with PULSERATE=0)**

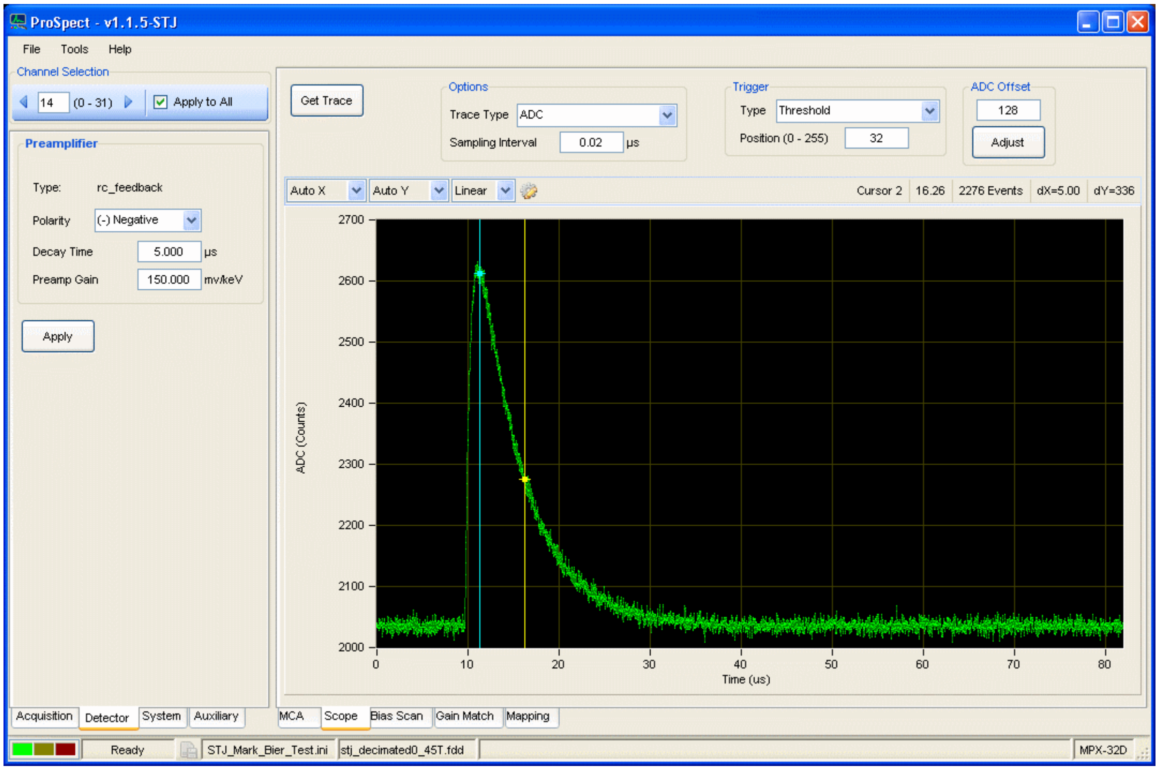

Fig 9: The Scope panel showing a pulse from the built-in pulser (with default settings), with the Polarity set correctly

As a check, change the Trace Type to Scaled Energy and acquire more traces. The output of the energy filter should be a trapezoid with slightly curved edges. If there is significant over-damping or under-shoot after the pulse, the Decay Time is set too low. If there is significant under-damping or over-shoot after the pulse, the Decay Time is set too high.

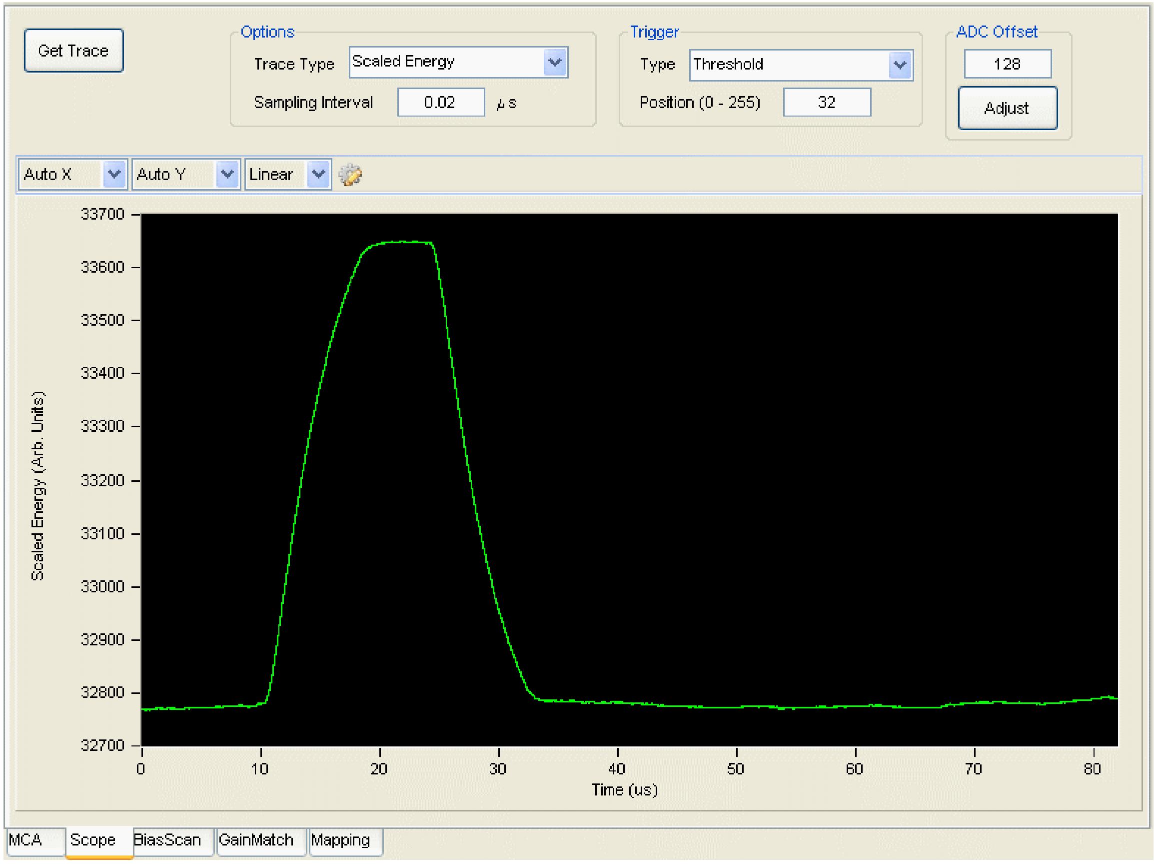

Fig 10: This plot shows the Scaled Energy response to the on-board pulser signal with the Decay Time set properly: The waveform is trapezoidal, and properly damped

ADJUST THE ADC OFFSET

Each ADC channel has a dedicated DAC which operates under computer control to set the ADC offset. By default, the ADC is biased near mid-range. If data is acquired with this default setting, half of the ADC range is wasted, and the effective dynamic range is unnecessarily constrained.

- **It is very important to adjust the ADC Offset before acquiring MCA or list-mode data (but after the STJ bias voltages have been adjusted)!**
- **The offset value, with a range of 1-8191, corresponds directly to the 12-bit ADC, and should be set as low as possible but high enough that the ADC waveform NEVER drops below 0 due to noise. We typically set the offset to 128, which is roughly 3% above the ADC minimum, and which makes 97% of the ADC range available for pulses.**
- **The special value 0 resets the DAC to mid-range**

MCA PANEL

The MCA panel is used to acquire histogrammed energy data and run statistics. It includes Preset Run settings and a Region of Interest (ROI) Calibration tool. During an MCA acquisition run incoming events for each channel are stored according to their measured energy in a separate histogram.

- **Press the Start Run button to begin acquisition, with an optional Preset Run constraint**
- **Press the Stop Run button to end acquisition**

- **Check the Resume box to add data to the pre-existing histogram and statistics, or un-check the box to start first clear the histogram and statistics before acquisition begins**
- **Check the Continuous box to have ProSpect automatically refresh the display at regular intervals. If the box is un-checked, data is only read out when the Update button is pressed or at the end of the run**

PRESET RUN CONSTRAINT

The run duration can be constrained to a fixed Real Time, Live Time, MCA Events or Input Triggers. When the chosen constraint has been reached for a given channel, the run is automatically terminated for that channel. When all channels have met the constraint, the run ends automatically.

- **To apply a Preset Run constraint, select the desired constraint from the drop-down combo-box and enter the desired value in the adjacent field before starting the run.**

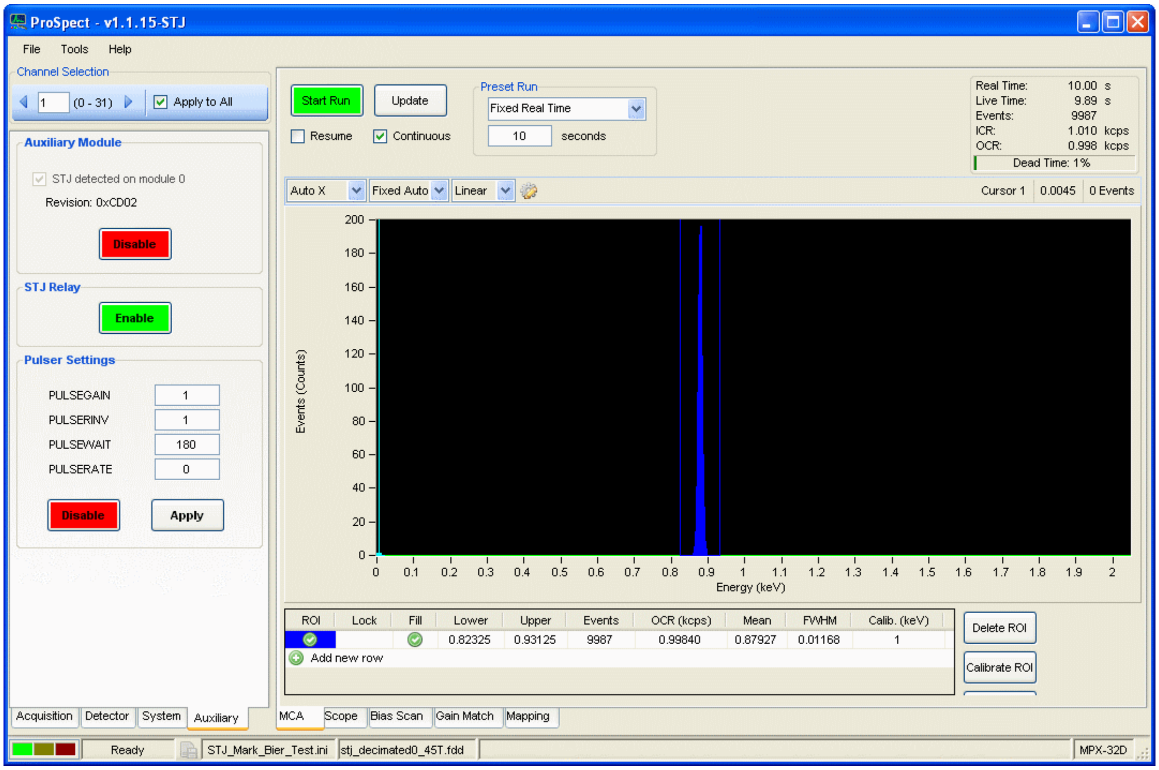

Fig 11: The MCA histogram and statistics are shown for a 10 second Fixed Real Time Preset Run with the built-in pulser (with default settings) used as the input source, with the recommended Preamp Gain = 150 mV/keV and Dynamic Range = 2 keV, and with the STJ Relay disabled, i.e. with additional noise from the 'dummy detector' circuit. Note that the pulser peak has been selected within an ROI, the Mean is 879 eV, and the FWHM is 11.68 eV. Note that the statistics in the upper right hand corner indicate that the Real Time is 10 seconds and the Input Count Rate (ICR) is 1.0 kcps, as expected.

STATISTICS

The run statistics are displayed in the upper right-hand corner, including the Real Time, Live Time, Input Count Rate (ICR) and Output Count Rate (OCR).

REGION OF INTEREST (ROI) AND CALIBRATION

The ROI tool below the histogram is used to select peaks of interest and calibrate the gain on a per-channel basis.

- **Note that for multi-channel systems we recommend using the GainMatch tool instead of the ROI tool to calibrate all active channels at once**
- **Edit the Lower and Upper fields to place an ROI that encloses the peak of interest. Alternatively, use the mouse right-button context menu to place a cursor on the peak and then select Auto Adjust ROI over that cursor.**
- **Enter the desired energy in the Calib. (KeV) field and press Calibrate ROI to automatically adjust the Preamp Gain setting for the selected channel. The peak should jump to the desired energy when new data is acquired.**

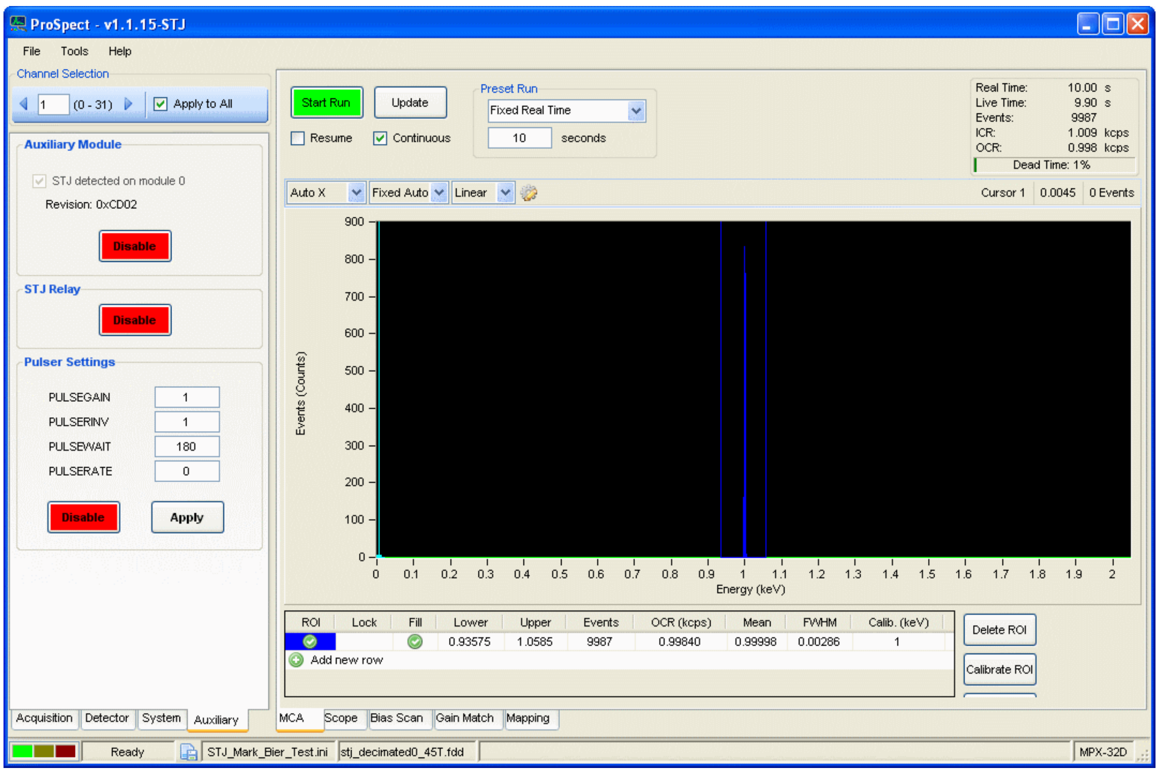

Fig 12: Here is a similar MCA histogram to the one displayed in Fig 11, but this time the peak has been calibrated to 1 keV and the STJ Relay has been enabled, i.e. WITHOUT additional noise from the 'dummy detector' circuit. Note that now the Mean is 999.98 eV, and the FWHM is 2.86 eV.

GAINMATCH PANEL

The GainMatch tool provides an automated sequence runs through several ROI calibration iterations for all active channels. We recommend using this tool to quickly calibrate gain on a per-channel basis in multi-channel systems.

- **We recommend checking the Optimize Gain box. If this box is unchecked, the tool will attempt to calibrate only the Digital Gain while keeping the Analog Gain constant, which can lead to unexpected results if the original peak energy is significantly different than the desired energy.**

- **Enter the desired Calibration Energy and Acquisition Time(s). Note that the Acquisition Time should be sufficient, based on the Input Count Rate, to acquire a peak whose Mean and FWHM can be measured; a few thousand events are typically necessary and sufficient.**

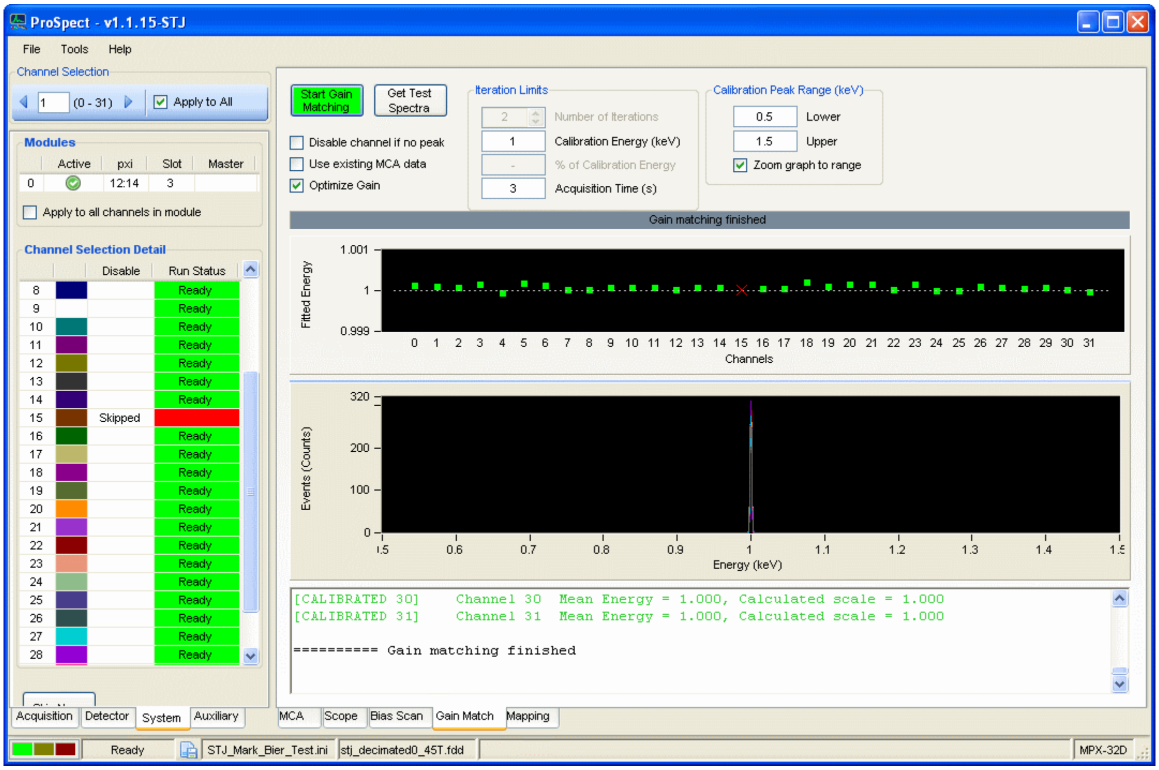

Fig 13: The GainMatch panel for a 32-channel system with Channel 15 disabled, after the Gain Matching sequence has been executed. Note that the Acquisition Time is 3 seconds, which corresponds to 3,000 counts at 1 kcps. Note that the Lower and Upper fields were set conservatively to select the built-in pulser peak at roughly 1 keV on all channels. Note that the data for channel 15 has been omitted, as indicated by the red 'X' in the Channel display area. Finally note that the resulting data in the Energy histogram shows all channels calibrated to 1 keV, per the Calibration Energy (keV) setting.

MAPPING PANEL: LIST-MODE DATA ACQUISITION

The Mapping panel is used for list-mode acquisition, e.g. each event generates an event record with channel ID, time-stamp and energy value. Event records during a run are saved to a binary file.

- **Please refer to the STJ List Mode Specification for further details on the different list-mode options, and the event record, buffer header, and binary file formatting.**

Some of the labels may be confusing on this panel, because it also supports other 'mapping' or scanning modes for other products and applications. The term "pixel" refers an event on any channel, so the Total Number of Pixels setting constrains the total number of events on all channels.

LIST MODE VARIANT

Perhaps the most important setting is the 'List Mode Variant', which defines the type of information stored in the output binary file, as described in the STJ List Mode Specification. At present, this setting is not directly accessible in the Mapping panel.

- **To change the List Mode Variant, open the DSP Parameters… window accessible under the Tools menu, as shown in Figure 14 below. Edit the integer value for LISTMODEVAR and press**

Enter to modify the setting. Press the Refresh button to make sure that the setting was modified properly.

- **To save the List Mode Variant setting, you must manually edit the INI file. Add the following line above "END #0" in the "[default definitions]" section (where X is the List Mode Variant): LISTMODEVAR = X**

Note that some list mode variants require an external logic input to be present on the PXI backplane, typically injected via XIA's PXI-PDM module or other another 3rd party PXI module.

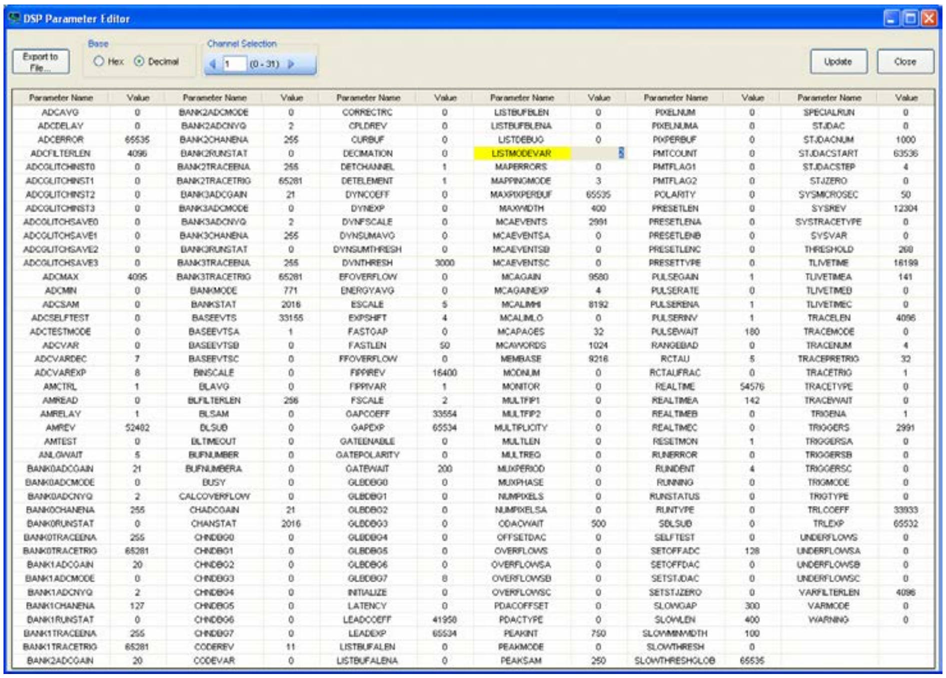

Fig 14: The List Mode Variant setting is accessible in the DSP Parameter Editor. You must press ENTER after modifying the value!

MAPPING OPTIONS

These settings control the duration of the list mode acquisition, buffer size, and the binary Mapping Data File name prefix.

- **The Pixel Advance Mode is always set to "User" for the MPX-32D**
- **The Total Number of Pixels constraint defines the run duration. The run terminates when the total number of events on all channels in the system equals this value. If the Indefinite Run box is checked, the Total Number of Pixels constraint is ignored; instead the run proceeds until the user presses the Stop Mapping button.**
- **The Mapping Pixels Per Buffer constraint limits the number of events stored in the SRAM 'ping-pong' buffers in each MPX-32D module in the system, and thus determines the rate at which the binary file is updated during the acquisition. A smaller number yields a faster refresh rate. At a high enough count rate, and depending on the total number of modules in the system, it is possible to exceed the available bandwidth on the PXI backplane, which can introduce dead time. For this reason, we recommend checking the Maximum Allowed box to store the maximum (65536) events, to avoid creating an unnecessary communications bottleneck.**
- **The Mapping Data File Prefix sets the filename prefix for the binary output file. The Save Data box must be checked, otherwise the output data is simply read from the module and**

discarded. Note that the binary file is stored in the folder selected in the Mapping Data tab of the ProSpect Options dialog, which is accessible under the Tools menu, as shown below.

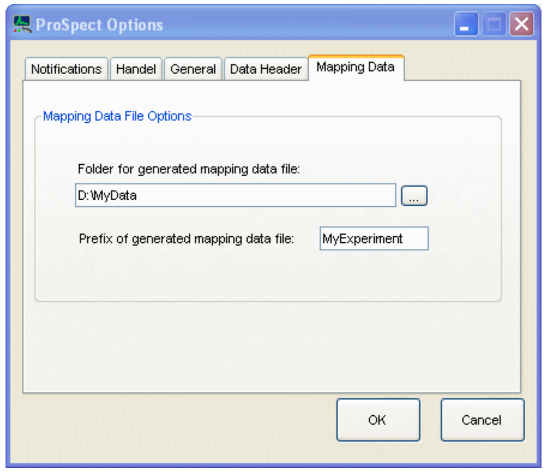

Fig 15: The binary file folder location can be changed in the Mapping Data tab of the ProSpect Options dialog, accessible under the Tools menu

ACQUIRING LIST MODE DATA

We recommend first acquiring data with the Save Data box unchecked, to test that data is actually acquired, as indicated by the "n buffers" pacifier below the Mapping Options section of the panel, which increments every time a ping-pong buffer is read. The refresh rate is: 65536 / (number of channels * count rate) seconds. For example, with 32 channels at 1 kcps, the refresh rate is approximately 2 seconds. If the buffers don't increment as expected, the Scope and MCA tools can be used to diagnose the problem.

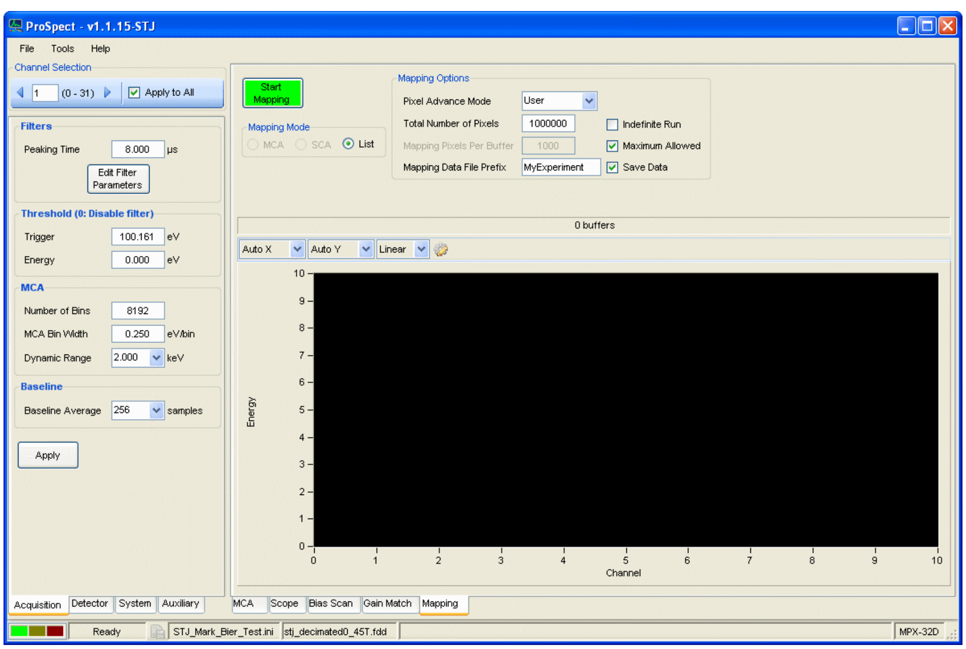

Fig 16: The Mapping panel is used to acquire list-mode data, e.g. channel, energy and timestamp

SAVE THE INI FILE!

At this point you should have all the settings correct. It's time to save the modified settings to your INI file.

- **Select File: Save Configuration (or Ctrl+S) to overwrite the current INI file**
- **Remember that certain settings, e.g. LISTMODEVAR and GATEWAIT, must be edited manually in the INI file. Typically, these are entered just above the "END #0" line in the "[default definitions]" section. These manual edits will be preserved during Save Configuration and Save Configuration As… operations, however, they must be re-entered if the Generate Configuration… tool is used to create a new INI file.**