



Instruments That Advance The Art

microDXP

Development Kit Manual

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Safety

Please take a moment to review these safety precautions. They are provided both for your protection and to prevent damage to the microDXP module and connected equipment. This safety information applies to all operators and service personnel.

Specific Precautions

Please take a moment to review these safety precautions. They are provided to prevent damage to the microDXP and microCOMU printed circuit boards and connected equipment. This safety information applies to all operators and service personnel.

Power Source

The microDXP USB Rapid Development Kit includes a wall-mounted power supply intended to operate from an AC power supply in the 100VAC to 240VAC range at 50Hz or 60Hz. Use of this development kit with AC voltage outside these specifications could damage the unit and nullify the product warranty. Refer to Chapter 2 of this manual for instructions on installing the power supply.

Detector and Preampifier Damage

Because the microDXP does not provide power for the detector or preampifier there is little risk of damage to either resulting from the microDXP itself. Nonetheless, please review all instructions and safety precautions provided with these components before powering a connected system.

Servicing and Cleaning

To avoid personal injury, and/or damage to the microDXP and microCOMU boards or connected equipment, do not attempt to repair or clean these units. These boards are warranted against all defects for one (1) year. Please contact the factory or your distributor before returning items for service.

Warranty Statement

XIA LLC warrants that this product will be free from defects in materials and workmanship for a period of one (1) year from the date of shipment. If any such product proves defective during this warranty period, XIA LLC, at its option, will either repair the defective products without charge for parts and labor, or will provide a replacement in exchange for the defective product.

In order to obtain service under this warranty, Customer must notify XIA LLC of the defect before the expiration of the warranty period and make suitable arrangements for the performance of the service.

This warranty shall not apply to any defect, failure or damage caused by improper uses or inadequate care. XIA LLC shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than XIA LLC representatives to repair or service the product; or b) to repair damage resulting from improper use or connection to incompatible equipment.

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Email Support: support@xia.com

Manual Conventions

The following conventions are used throughout this manual

Convention	Description	Example
»	The » symbol leads you through nested menu items and dialog box options.	The sequence File»Page Setup»Options directs you to pull down the File menu, select the Page Setup item, and choose Options from the sub menu.
Bold	Bold text denotes items that you must select or click on in the software, such as menu items, and dialog box options.	...click on the MCA tab.
[Bold]	Bold text within [] denotes a command button.	[Start Run] indicates the command button labeled Start Run.
monospace	Items in this font denote text or characters that you enter from the keyboard, sections of code, file contents, and syntax examples.	Setup . exe refers to a file called “setup.exe” on the host computer.
<i>Italics</i>	Italic text denotes a new term being introduced , or simply emphasis	<i>peaking time</i> refers to the length of the slow filter. ...it is important first to set the energy filter Gap so that SLOWGAP to <i>at least one unit greater than the preamplifier rise time...</i>
<Key> <Shift-Alt-Delete> or <Ctrl+D>	Angle brackets denote a key on the keyboard (not case sensitive). A hyphen or plus between two or more key names denotes that the keys should be pressed simultaneously (not case sensitive).	<W> indicates the W key <Ctrl+W> represents holding the control key while pressing the W key on the keyboard
<i>Bold italic</i>	Warnings and cautionary text.	<i>CAUTION: Improper connections or settings can result in damage to system components.</i>
CAPITALS	CAPITALS denote DSP parameter names	SLOWLEN is the length of the slow energy filter

1 Introduction

This brief manual is intended to get new users of the microDXP up and running quickly with XIA's ProSpect software application.

1.1 Rapid Development Kit

The microDXP Rapid Development Kit includes the microCOMU or microCOMV-UFF carrier board, power supply, all required cables, and the ProSpect evaluation software and Handel drivers. The kit enables rapid design of systems incorporating the Micro Digital X-ray Processor (microDXP).

1.1.1 Components Included

- microCOMU or microCOMV-UFF hardware interface
- Wall mounted AC power supply, suitable for 100VAC to 240VAC, 50Hz or 60Hz. Compatible with AC power standards and AC plug standards in North America, Japan, UK, Europe, and Australia.
- 6' USB A male to USB Mini-B cable for connecting the microCOMU / microDXP board set to a PC.
- 6' custom DB9 to 3-pin connector for RS232 communication (part number CAB-DB9-3POS).
- 3' SMA to BNC coaxial signal cable

1.1.2 Hardware Features

The microCOMV-UFF carrier board is provided to most customers, paired with a microDXP with on-board USB communications. It provides:

- All the necessary power supplies needed by the microDXP board, derived from an external +5V DC supply, such as the provided AC adapter
- An RS232 interface between the host computer and the microDXP board.
- A GATE input and auxiliary digital I/O lines via board-to-wire connector. Note: use of the auxiliary digital I/O lines may require special firmware.
- I2C signals via board-to-wire connector. This allows additional I2C peripherals (i.e. high voltage supplies, DACs, temperature sensors, EEPROMs, etc.) to be added to the system. Note: use of the I2C connector requires special firmware.
- SMA signal input connector, which supplements the other options available on the microDXP board itself: 2-pin, Lemo, BNC. Note: customers wishing to use the SMA signal input connector are requested to contact XIA LLC to inquire about ordering the compatible variant of the microDXP board.

The microCOMU carrier board is provided to customers who intend to use a microDXP hardware variant that omits on-board USB communications. The microCOMU provides all of the above, plus:

- A standard USB 2.0 high speed connection between the PC and the microCOMU / microDXP board set.

1.1.3 Downloads

The latest software and manuals are available online at:

<https://xia.com/support/microdxdp/>

- microDXP Development Kit Manual (this document)
- microDXP Technical Reference Manual
- microDXP RS-232 Command Specification
- microDXP Gain Specification
- microCOMU Technical Reference Manual
- ProSpect evaluation software

1.2 Software Features

The ProSpect software package supports microDXP configuration, spectrum acquisition, basic analysis, statistics and diagnostics features, as outlined below.

1.2.1 Configuration

- Detector/Preamplifier settings
- Peaking time optimization (via PARSETs)
- MCA format (via the GENSET)

1.2.2 MCA and Multi-SCA Acquisition

- Parameter-set-based acquisition
- Preset fixed-length runs
- Energy calibration
- Variable bin depth for faster readout

1.2.3 Analysis and Statistics

- Dynamic Regions of Interest (ROI)
- Gaussian Fits to multiple ROIs
- Output statistics: ICR, OCR, realtime, deadtime
- Panning and Zooming to examine spectrum features
- Linear and Logarithmic displays
- Export Spectra for additional analysis
- Realtime SCA pulser outputs

1.2.4 Diagnostics

- Scope tool
- Baseline histogram
- DSP Parameter Editor

1.3 System Requirements

1.3.1 Overview

- Windows 10 or above PC with free USB port

- x-ray or gamma-ray detector and preamplifier w/ power supplies – or a spectroscopy-grade pulse generator
- BNC analog signal cable, to match the included adapter
- 100VAC to 240VAC at 50Hz or 60Hz AC voltage mains

1.3.2 Detector/Preamplifier:

The microDXP accommodates nearly all energy-dispersive detector preamplifier signals. The two primary capacitor-discharge topologies, pulsed-reset and resistive-feedback, are supported. The front-end analog circuitry imposes input x-ray pulse-height and voltage range constraints, as indicated in Table 1-1.

<i>Parameter</i>	<i>Minimum</i>	<i>Maximum*</i>
X-ray pulse-height	50 μ V	125 mV
Input voltage range	-	+/- 4.0 V
Decay time τ	100 ns	8.19 ms

Table 1-1: Analog input signal constraints

*The microDXP input circuitry is configured by default for typical x-ray and gamma-ray detector gain values. Larger pulse-heights and input voltage range are accommodated via input signal attenuation (see §2.1.2 for details).

1.3.3 Power Requirements

The carrier board provides all required voltages at the required currents and noise quality from a single external 5.0VDC supply. The provided AC/DC adapter is compatible with 100VAC to 240VAC, at 50Hz or 60Hz, and works with plug standards in North America, Japan, UK, Europe, and Australia.

1.3.4 Operating Environment

Temperature Range: 0° C - 50° C
 Maximum Relative Humidity: 75%, non-condensing.
 Maximum Altitude: 3,000 meters
 Pollution degree 2

Not rated for use in high electromagnetic fields.

Not rated for use in environments with measurable neutron flux. Neutron flux will cause permanent damage to silicon crystals and permanently degrade or impair the performance of this system.

The components on the microDXP and microCOMU boards are not radiation hardened. Although there should not be a problem operating them in environments with modest gamma or X-ray flux, above a certain level this radiation can start to cause bit errors in the digital components. If necessary, please contact XIA LLC to discuss a proposed radiation environment.

1.3.5 Regulatory Compliance

The carrier board included with the USB Rapid Development Kit is RoHS compliant.

1.4 Support

A unique benefit of dealing with a small company like XIA is that the same people who designed them often provide the technical support for our sophisticated instruments. Our customers are thus able to get in-depth technical advice on how to fully utilize our products within the context of their particular applications. Please read through this brief section before contacting us.

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+1 (510) 401-5760

Email Support: support@xia.com

1.4.1 Software and Firmware Updates

For the most recent software and drivers, please visit:

<https://xia.com/support/microdxp/>

Firmware updates will be provided via our secure file download site, on a per-customer basis. Please contact support@xia.com for assistance.

1.4.2 Related Documentation

As a first step in diagnosing a problem, it is helpful to consult the most recent data sheets and user manuals, since these documents may have been updated since the DXP unit was purchased, and they may contain information that could help solving a problem in question. All manuals, datasheets, and application notes can be found on at:

<https://xia.com/support/microdxp/>

1.4.3 Email and Phone Support

The microDXP comes with one year of email and phone support. Support can be renewed for a nominal fee. Please call XIA if your support agreement has expired.

In our experience most problems are not related to hardware failures, but rather to setup procedures and to parameter settings. XIA's ProSpect software and Handel drivers include consistency checks to help select the best parameter values. However, due to large number of possible combinations the user may occasionally request parameter values which conflict among themselves. This can cause the DXP unit to produce unexpected results, such as poor energy resolution or even empty spectra.

Submitting a problem report:

XIA encourages customers to report any problems encountered using any of our software. Unfortunately, due to limited resources XIA is unable to handle bug reports over the phone. In most cases, the XIA engineering team will need to review the bug information and run tests on their hardware before being able to respond.

All software-related bug reports should be emailed to support@xia.com and should contain the following information, which will be used by our technical support personnel to diagnose and solve the problem:

- Your name and organization

- Brief description of the application (type of detector, relevant experimental conditions...etc.)
- XIA hardware name and serial number
- Version of the library (if applicable)
- Operating System
- Description of the problem; steps taken to re-create the bug
- Supporting data:
The most important are digital settings of the spectrometer unit, i.e., the values of the DSP parameters such as the thresholds, filter length, etc. The values of these parameters can be captured into text file in ProSpect as described in §3.8.4.3. Please attach a copy of this file if possible. Capturing an oscilloscope image of the preamp output will be extremely helpful. This can done with the diagnostic tool included in ProSpect.

For general questions and DXP hardware issues please send email to:

support@xia.com

1.4.4 Customer and User Feedback

XIA strives to keep up with the needs of our users. Please send us your feedback regarding the functionality and usability of the microDXP and ProSpect software.

2 Hardware Setup

This manual pertains to the current microDXP hardware offerings: the Xilinx-based RevH first released in 2015, and the Efinix-based RevJ first released in 2022. For older RevG hardware, please refer to the older version 2.5 of this manual (mdo-RDK-MAN-2.5.0).

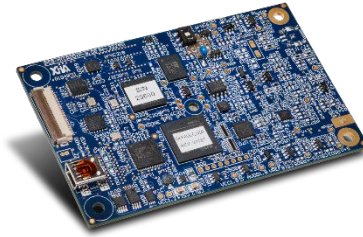


Figure 2-1: The Xilinx-based RevH microDXP

2.1 microDXP and microCOM Hardware Settings

All hardware settings should be made while the power is turned off.

- Preamplifier Type and Input Attenuation settings on the microDXP board do not typically need to be changed.

2.1.1 Preamplifier Type Selection

The preamplifier type selector switch (if present) should already be set properly. Note that the setting must agree with the firmware that is loaded in non-volatile memory. The location of the miniature two-position slide switch S1 is displayed in Figure A-1 of Appendix A. The two positions are silkscreen-labeled RESET and RC. Select RESET for reset-type preamplifiers. Select RC for RC-feedback preamplifiers.

In ProSpect, the preamplifier type corresponding to the loaded firmware is displayed in the Detector tab of the Settings panel. The DSP code variant (DSP parameter CODEVAR) is always even, e.g. “0”, for reset-type preamplifiers, and odd, e.g. “1”, for RC-feedback preamplifiers.

2.1.2 Input Signal Attenuation

The preamplifier signal must not exceed the input voltage range of the microDXP, excluding reset transients that may exceed the range for a few microseconds. The input range and input impedance are specified below in Table 2-1. To accommodate preamplifiers with an output range in excess of +/-4 Volts, an optional attenuation setting is included. Attenuation and the increased input range are achieved by removing the solder from RG1 and shorting the two pads of RG2 together with solder. The microDXP input circuitry can be further customized to accommodate larger input voltage ranges or to change the input impedance. Contact XIA for assistance.

<i>Attenuation Setting</i>	<i>Absolute Maximum Input Voltage</i>	<i>Input Impedance</i>
Default – 0dB Attenuation (RG1 short, RG2 open)	+/- 4.0 V	10 KΩ
Option – 2.7dB Attenuation (RG1 open, RG2 short)	+/- 5.5 V	655 Ω
Custom	Customer-defined	Customer-defined

Table 2-1: The attenuation setting determines the absolute maximum input voltage range and input impedance

2.2 Making Connections

Make sure the microCOMU master power switch is switched (SW3 lever up, toward circuit board) off before making connections. The connections between the microDXP, microCOMU, included accessories, the detector and preamplifier and the host computer or embedded host are depicted in Figure 2-2 for USB communications and in Figure 2-3 for RS-232 communications.

2.2.1 microCOM to microDXP Connection

The microCOM and microDXP boards mate together using board-to-board connectors, and are typically mated before shipping to the customer. If your PC boards are not mated, first remove the short machine screws loosely installed in the steel standoffs on the microCOM. Ensure that the microDXP is in the correct rotation relative to the microCOM board, and then gently press the microDXP down onto the microCOM companion board. It should seat neatly against the steel standoffs. Finally, re-install the 4 machine screws to retain the microDXP board, tightening with a Phillips screwdriver.

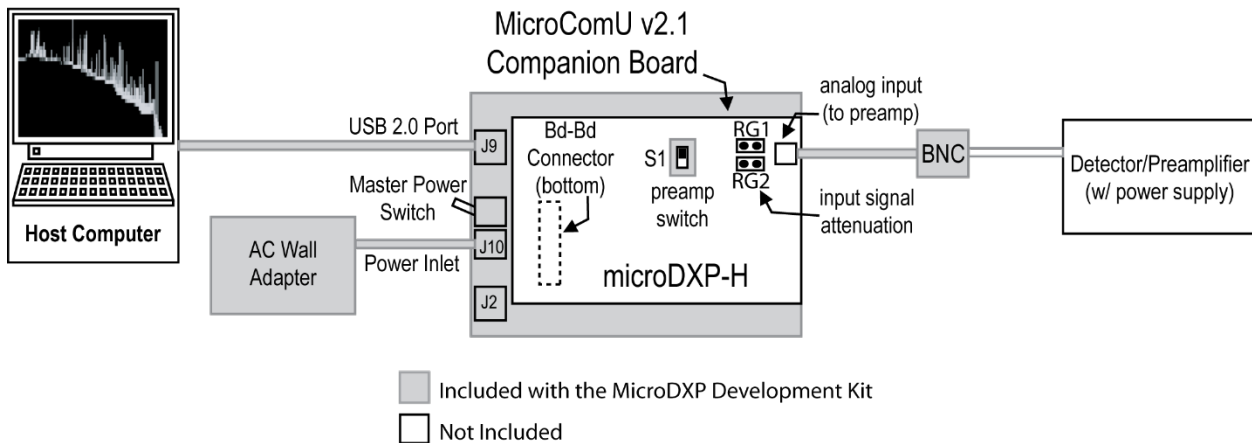


Figure 2-2: Rapid Development Kit in USB Mode: connection diagram shows how to connect the microCOMU and microDXP boards. For a microCOMV-UFF carrier board, connect the USB cable to the connector on the microDXP board.

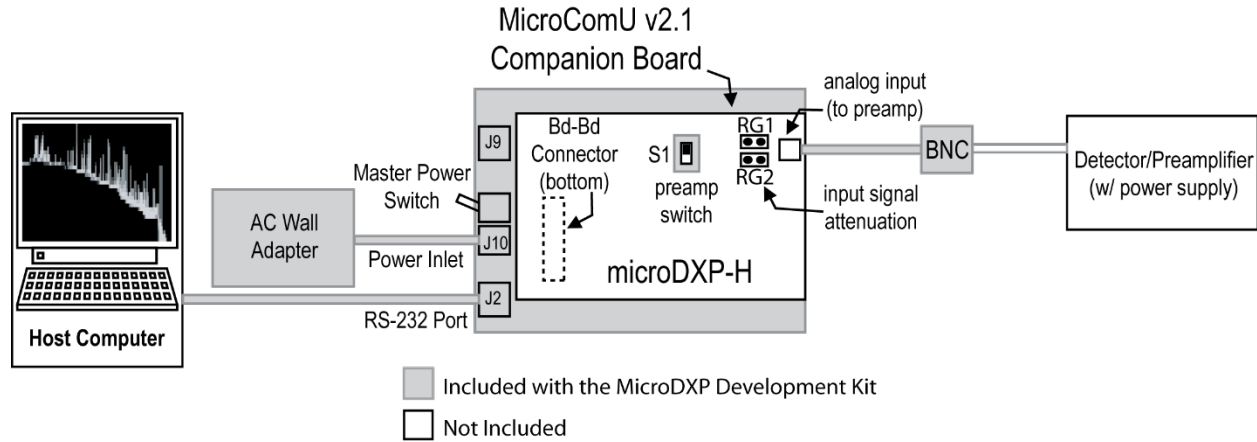


Figure 2-3: Rapid Development Kit in RS232 Mode: connection diagram shows how to connect the microCOMU and microDXP boards. The custom RS232 cable (part number CAB-DB9-3POS) should run between J2 on the microCOMU and a free COM port on the host computer (or a USB to serial port converter). Note that the J2, SW3, and J10 components shown are actually on the underside of the microCOMU companion board. The microDXP preamplifier-type selection switch and input attenuation solder-jumpers are also shown.

2.2.2 Communications

USB and RS-232 communications are supported. For faster readout use the USB interface.

2.2.2.1 USB

If present, use the mini-USB port on the microDXP board. Otherwise use the mini-USB port on the microCOMU. Attach the provided USB cable to a free USB port on the host computer, or via USB hub.

2.2.2.2 RS-232

Attach the custom RS232 cable (part number CAB-DB9-3POS) between J2 on the microCOMU and a free COM port on the host computer. Note that the default setting is 115 kbaud, though higher speeds up to 921 kbaud are supported. Contact XIA if you'd like to change the baud rate from 115 kbaud.

2.2.3 Detector and Preamplifier

Caution: the standard-assembly microDXP accepts a maximum input voltage range +/- 4.0V. If the output voltage of the preamplifier exceeds this range, the microDXP should be modified before connections are made. Please review §2.1.2 to increase the input range to +/- 5.5V, or contact XIA to discuss non-standard input voltage ranges.

Always follow the instructions and precautions provided by the detector/preamplifier manufacturer before making power and bias connections to these components.

2.2.4 Power

Connect the provided AC adapter into a 100VAC to 240VAC at 50Hz or 60Hz AC mains socket. (This AC adapter is compatible with the AC power supply and the AC plug conventions in North America, Japan, UK, Europe, and Australia.) Plug the output into the

microCOM primary power connector at J10 (see Figure 2-1 above). The system can now be powered on using the SW3 master power switch.

3 Using the ProSpect Software

The ProSpect application can be used to configure the microDXP settings, to perform diagnostics and to acquire and export energy spectra.

3.1 Installation

ProSpect operates with Windows 10 and above. The latest windows application and drivers are available online here:

<https://xia.com/support/microdxp/>

3.1.1 First Steps

1. Please close all applications that are currently running.
2. Double-click the installation executable and follow the instructions to install ProSpect and Handel

3.1.2 After Installation

When the ProSpect installation is complete, a shortcut to the application will be located on your desktop.

3.1.3 File Locations

After installation, the ProSpect executable, by default, is located in:

C:\Program Files (x86)\XIA\ProSpect 1.x

3.1.4 Support

XIA values customer feedback. Feedback is an important component of our ongoing efforts to improve the software. All bug fixes and feature suggestions should be directed to the above email address. Please be sure to include as much information as possible when submitting a bug report or feature request. For further instructions please refer to §1.4.

3.2 Starting Up the First Time

ProSpect must first determine to which USB or COM (RS-232 serial) port the instrument is connected, and store that information in a configuration (INI) file. The first time ProSpect is started, an error dialog will appear, indicating that no INI file was specified.

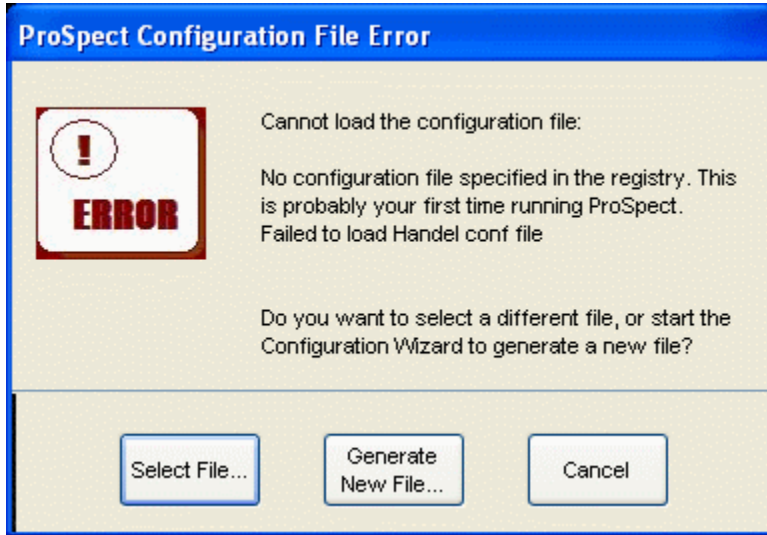


Figure 3-1: The ProSpect Configuration File Error dialog appears the first time ProSpect is started.

Press the **[Generate New File...]** button to open the **Generate Configuration File** dialog, which displays all detected XIA LLC devices. Click in the **Select** column next to the detected microDXP and press the **[Save]** button to generate an appropriate INI file and proceed with initialization.

Note that the microDXP requires approximately 7 seconds to boot up, during which time the device can be recognized but cannot be initialized by the host.

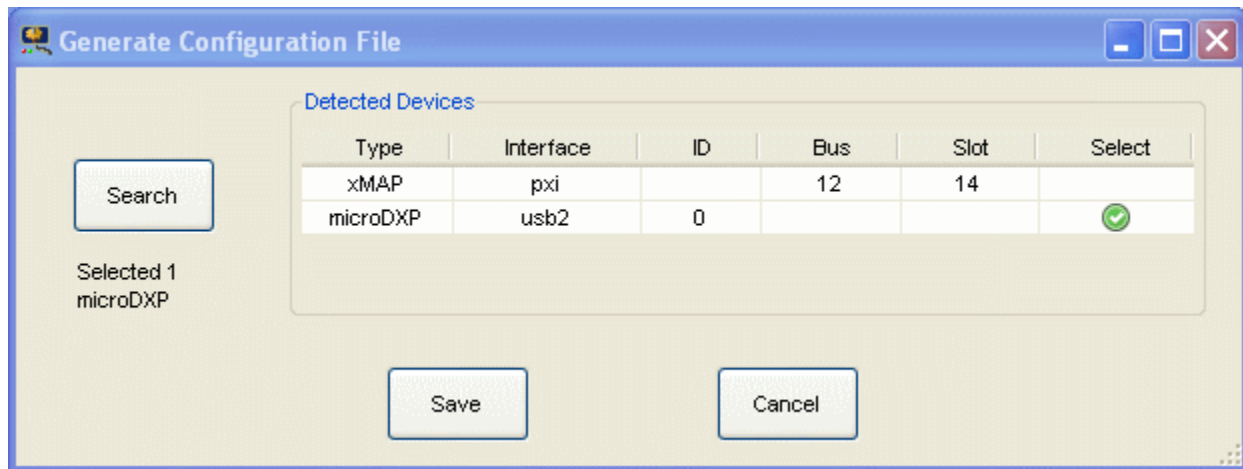


Figure 3-2: The ProSpect Generate Configuration File dialog detects all connected XIA LLC devices. In this screen capture, one xMAP and one microDXP were detected.

3.3 A Quick Tour of ProSpect

3.3.1 Windows, Panels and Tabs

When you start the program, the ProSpect main window should be displayed as in Figure 3-3. Note that both the **Settings** and **Main** panels are tabbed.

The **Settings** panel contains several tabs, but the scope of this document is limited to the **Acquisition** and **Detector** tabs. The **Acquisition** tab provides access to **Peaking Time** selection, and peaking-time-related settings (PARSET) and MCA-related settings (GENSET) parameters. It is intended to be the primary interface for setup and optimization as well as data acquisition, and is referenced throughout §3.5 and §3.6. The **Detector** tab contains global (GLOBSET) settings related to the detector type and preamplifier characteristics, as described in §3.4.

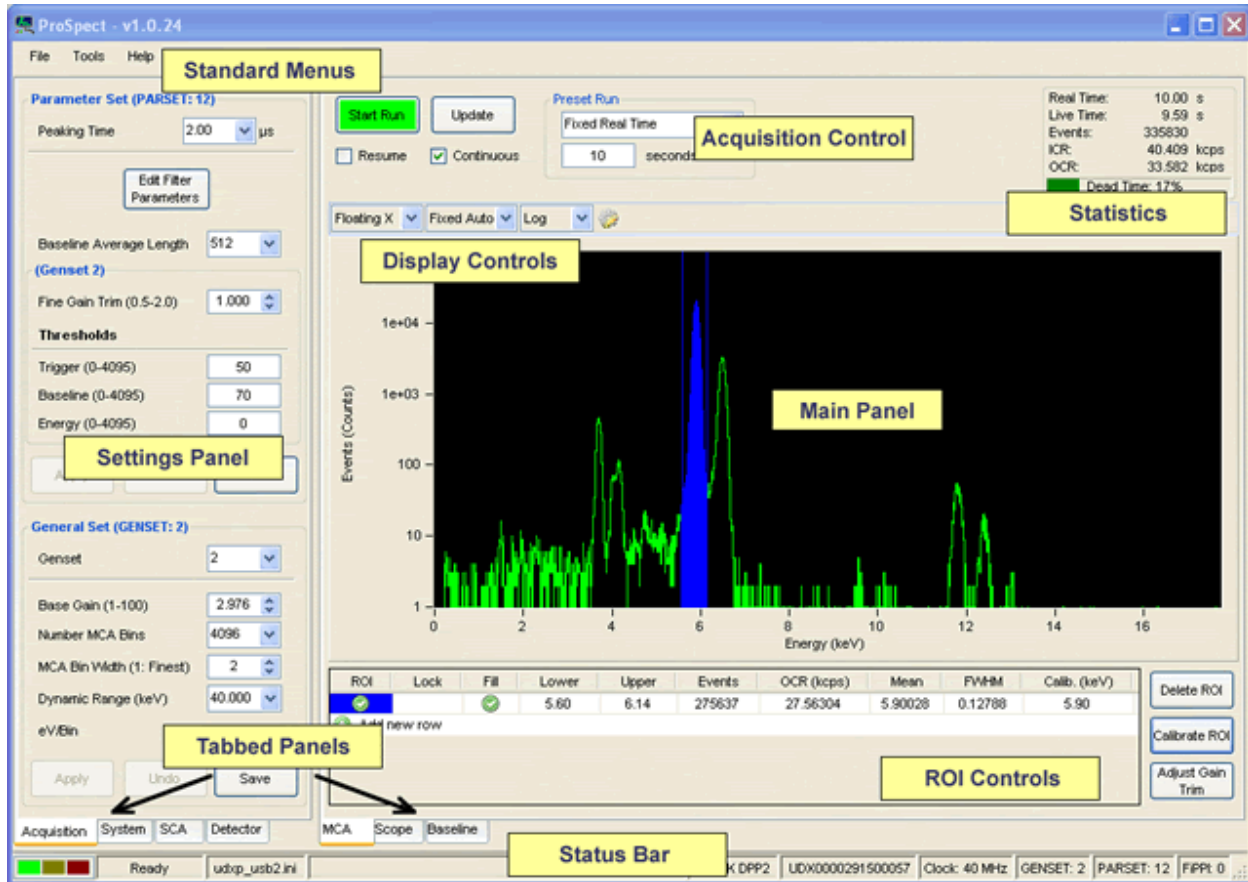


Figure 3-3: The ProSpect application displaying the settings, spectrum acquisition and ROI analysis tools. Note that both the **Settings** panel and **Main** panels are tabbed, with the **Acquisition** and **MCA** tabs selected, respectively.

The **Main** panel contains the default **MCA** spectrum display tab, and the diagnostic **Scope** and **Baseline** tabs. The **MCA** tab displays acquired energy spectrum in the plot area and run statistics, e.g. input count rate, real time, etc., in the **Statistics** area at the top. Statistics for user specified spectral regions of interest (e.g. ROI-selected peak mean and FWHM) are displayed in the **ROI Controls** area at the bottom. The **Scope** tab is an oscilloscope tool for viewing digital signal vectors. The **Baseline** tab displays the diagnostic baseline histogram and baseline history data. Zooming and panning in all **Main** panel tabs (i.e. **MCA**, **Scope**, and **Baseline** tabs) can be customized using the **Display Controls** in conjunction with mouse operations both on the axes and in the plot area.

The **Status Bar** along the bottom contains information about the state of the hardware and software, and the hardware serial number. The status indicator at the lower left corner of

the main window changes to yellow during RS-232 or USB communications, green when idle and red when an error has been detected.

3.3.2 Preview of the Setup Process

The microDXP has been designed for ease-of-use in embedded applications. ProSpect can be used to first optimize detector and preamplifier settings and all the parameters associated with each of the 24 **Peaking Times** in combination with up to 5 MCA spectrum formats and then save them to non-volatile memory. Once setup is complete the client software application need only modify two pointers to select the desired **Peaking Time** and MCA spectrum format to retrieve all the optimized settings from non-volatile memory.

The setup process consists of first configuring the detector preamplifier settings, adjusting the MCA format, and then optimizing the parameters linked to each **Peaking Time**.

3.3.3 GLOBSET, PARSETs and GENSETs

Three different types of parameter tables are stored in non-volatile memory: GLOBSET, GENSET and PARSET.

The singular GLOBSET contains global settings including detector/preamplifier settings, preset run controls, power-down modes, and other advanced settings. There is only one GLOBSET—these global settings are used for all peaking times and MCA formats. In ProSpect only the detector and preamplifier settings are accessible in the **Detector** tab of the **Settings** panel. Changes to these settings are simultaneously applied and saved to nonvolatile memory via the [**Apply / Save**] button.

The GENSET table, accessible in the bottom half of the **Acquisition** tab, defines the number of bins and granularity of the MCA spectrum, as well as the **Base Gain**. Five GENSET tables can be stored, allowing for five different optimized MCA formats. Typically though, only the first GENSET, i.e. GENSET0, is used.

The PARSET table, accessible in the top half of the **Acquisition** tab, include all peaking-time-dependent settings, e.g. thresholds, sampling interval, etc. Selecting a new **Peaking Time** automatically loads a unique set of parameters stored for that peaking time. There is a complete PARSET table stored in non-volatile memory for each **Peaking Time**. To maintain energy calibration and proper triggering across every combination of PARSET and GENSET, each PARSET in fact includes five sets of thresholds and five **Fine Gain Trim** values; one for each GENSET.

3.3.4 Apply, Undo and Save

The microDXP hardware includes non-volatile memory for storing firmware (DSP and FPGA code) and parameter settings. Firmware is altered only through the XUP update utility accessed through the **Firmware** menu. Parameters can be altered through the software in two ways: the user can directly edit, test and save individual parameters, or a complete set of saved parameters can be loaded using the XUP utility.

GENSET and PARSET settings can first be changed in the operating memory of the DSP for testing purposes without altering the non-volatile memory. This is done by first changing an editable field in the **Settings** panel, then pressing the [**Apply**] button. Note that the [**Save**] button subsequently displays in bold, indicating that parameters in DSP memory differ from those stored in non-volatile memory. Once the desired behavior has been verified the new settings can be saved to non-volatile memory such that they are subsequently automatically loaded. Simply press the [**Save**] button. Press the [**Undo**]

button to revert to previous settings in the DSP's operating memory. Note that if a save operation occurred before the [Undo], the [Save] button must be pressed again to push the original settings back into non-volatile memory.

3.4 Detector/Preamplifier (GLOBSET) Settings

The global parameter set, or GLOBSET, includes detector type and preamplifier characteristics, accessible in the **Detector** tab of the **Settings** panel (see Figure 3-4). ProSpect automatically determines the preamplifier type based upon the firmware installed in non-volatile memory. The preamplifier-type must match your preamplifier and the position of switch S1 on the microDXP, as described in §2.1.1 above.

The **Detector** settings always include the signal **Polarity**. For reset-type preamplifiers, the **Reset Interval**, the period of time following the preamplifier reset during which data acquisition is disabled, is also included. For RC-feedback preamplifiers the **RC Decay Time** is included.

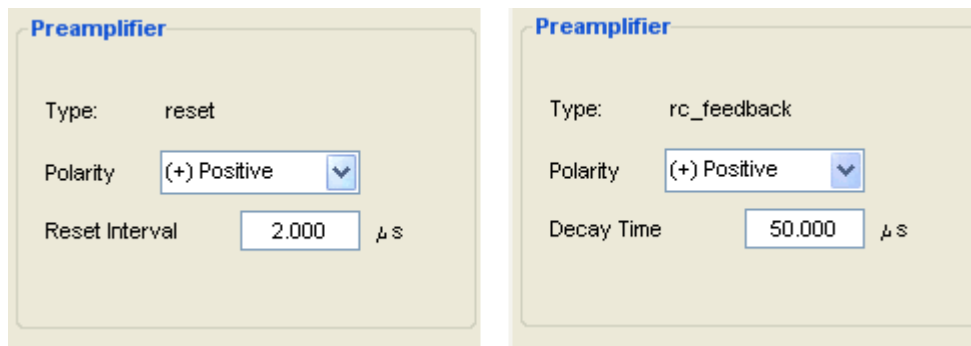


Figure 3-4: The **Settings** panel, with the **Detector** tab displayed, for reset-type preamplifiers (left) or RC-feedback preamplifiers (right).

3.4.1 Viewing the Preamplifier Signal

The **Main** panel contains three tabs. First select the **Scope** tab (see Figure 3-5 below), which acquires and displays the digital signal vectors from the microDXP. Select **ADC** from the **Trace Type** drop-down list and press the [Get Trace] button to refresh the display. The **Sampling Interval** field controls the time interval between individual points, thus larger values will result in a longer displayed period. The minimum value 25 ns (for 40 MSPS ADC) results in a displayed period of approximately 200 μs. A detailed discussion of the **Scope** tool diagnostics can be found in §3.8.3.

3.4.2 Setting the Polarity

We recommend that you review §3.8.3 for an introduction to the **Scope** tool. The microDXP's digital filters expect positive x-ray pulse-steps, i.e. with a rising edge. If the displayed x-ray steps have a falling edge (as in Figure 3-5 below), the detector **Polarity** setting must be modified. If the displayed x-ray steps have a rising edge (as in Figure 3-6 below), the microDXP polarity setting is correct—proceed to the next section.

To change the **Polarity** setting select (+) **Positive** or (-) **Negative** from the drop-down list and press the [Apply/Save] button to apply the new setting and store it to non-volatile memory. Now press the [Get Trace] button again to verify positive pulse-steps.

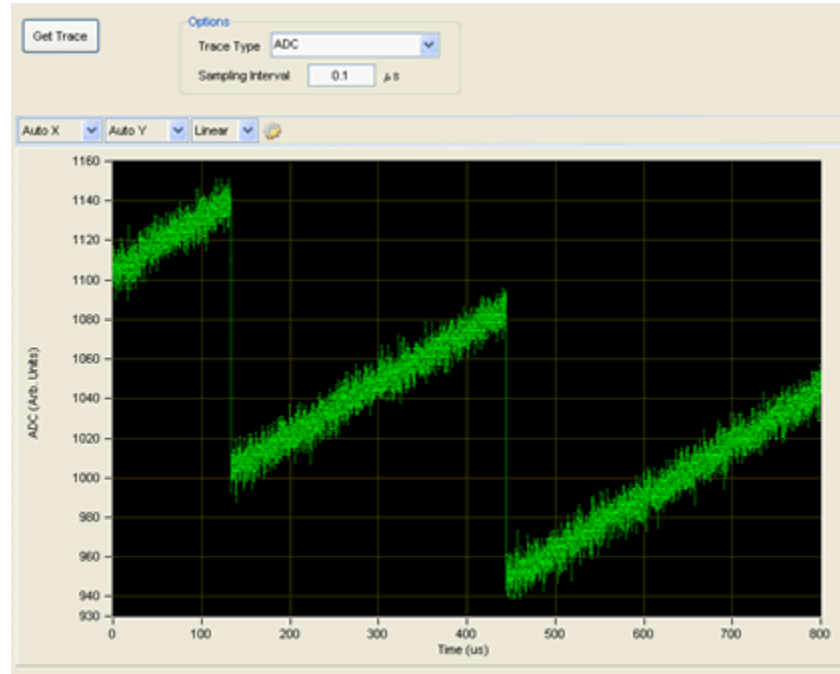


Figure 3-5: The Scope tool, displaying a series of two x-ray pulses from a reset-type preamplifier. Note that pulses have *falling* edges, indicating that the polarity setting is wrong.

3.4.3 Setting the Reset Interval (Reset-Type Preamplifiers)

Reset-preamplifiers produce a large corrective *reset* step when the large-signal ‘staircase’ waveform reaches its limit. This reset transient varies for different preamplifiers, both in the duration and in other signal characteristics, e.g. rise time, charge-injection, overshoot and settling time. Data acquisition should be disabled during the transient. If it is not, artifact events can be introduced into the spectrum and resolution can be degraded due to corruption of the baseline measurement. The **Reset Interval** sets the duration after a preamplifier reset is detected during which baseline and event acquisition is disabled.

The default **Reset Interval** of 2 μs should work reasonably well for most modern SDD detectors. In any case, the setting is best optimized after gain and threshold settings have been chosen, which affect baseline acquisition. Preamplifier reset transients, and how to properly set the **Reset Interval**, are discussed in §3.8.3.3.

3.4.4 Setting the Decay Time (RC-Feedback Preamplifiers)

If you can determine the RC decay constant τ_{RC} of your preamplifier from related documentation, or prefer to measure it using an external scope, do so now. Otherwise, review §3.8.3.4 for an illustrated procedure for measuring the RC decay-constant τ_{RC} of the preamplifier signal using the diagnostic **Scope** tool.

The decay constant must be set properly to get the best energy resolution. Enter the **Decay Time** in microseconds and press the **[Apply / Save]** button to apply the new setting and store it to non-volatile memory.

3.5 MCA (GENSET) Settings

The general parameter set, or GENSET, includes the **Base Gain** and the **Number MCA Bins**, **MCA Bin Width**, and other settings that define the MCA spectrum. Up to five complete GENSETs can be modified and stored such that five optimized MCA formats can automatically be retrieved simply by selecting the GENSET parameter. For now we simply want to prepare GENSET0 with some basic settings.

It is strongly recommended that users first follow the instructions below before tuning the gain via the automated calibration routines described in §3.6.2 and §3.7.2.

3.5.1 Gain Overview

We can express the MCA Bin corresponding to an x-ray with voltage amplitude ΔV_{Preamp} in terms of ProSpect settings and hardware settings, as:

$$\text{MCA Bin} = \frac{0.825 * \text{Input Atten} * \text{Base Gain} * \text{Fine Gain Trim} * \Delta V_{\text{Preamp}} * 16384}{2(\text{MCA Bin Width} - 1) * 2.0 \text{ V}}$$

Equation 3-1

In a significant departure from the previous design, the updated (blue) microDXP design now employs a digitally-controlled switched-gain amplifier architecture with 16 coarse analog gain settings for dynamic ranging in concert with finely adjustable digital gain for energy calibration. This approach adds some complexity to command and control because there are now two separate ‘base gain knobs’, but yields a superior pulse-height measurement. As before, a separate bin width setting defines the granularity, and thus the file size, of the MCA energy spectrum.

Please refer to the microDXP Technical Reference Manual and/or the microDXP Gain Specification for further details, particularly if you plan to directly modify the gain within your embedded application, e.g. to correct for temperature fluctuations.

The change in gain architecture is transparent at the ProSpect application level, i.e. the Handel driver determines the hardware revision and variant, and automatically adjusts the analog and digital gain according to the original acquisition values: **Base Gain** and **Fine Gain Trim**. As before, the bin size (**eV/Bin**) of the MCA spectrum is determined by the **MCA Bin Width** and **Dynamic Range** settings.

3.5.2 Setting the Dynamic Range

The **Dynamic Range** is a software-only setting that assigns an energy in kilo-electron-Volts (keV) to an x-ray voltage pulse that spans roughly 50% of the ADC input range, a practical measurement limit. Along with the **MCA Bin Width**, it determines the energy scale of the MCA spectrum, i.e. the MCA bin size (**eV/bin**).

$$\text{eV/Bin} = \frac{\text{Dynamic Range} * \text{MCA Bin Width}}{8000}$$

Equation 3-2

The **Dynamic Range** setting should correspond to the highest measurable energy, respective of the detector, preamplifier and experimental conditions. A typical x-ray dynamic range is 40 keV or 80 keV, though some thin-window detectors intended for soft x-rays may work best with the minimum 20 keV setting. At very high count rates a larger

Dynamic Range setting can improve throughput. Because this is a software-only setting, it is applied immediately upon selection from the drop-down list.

3.5.3 Setting the Base Gain

The **Base Gain** setting, associated with the GENSET, in fact combines the coarse analog Switched Gain and Digital Base Gain acquisition values into a single ‘gain knob’ with a range of 1-100 that will be familiar to users of the original microDXP. It should be set according to the dynamic range of the input signal: large enough that electronic noise is sufficiently digitized, but small enough that the largest x-rays of interest fit well within the ADC input range. As a rule of thumb, the largest x-rays of interest should span no more than 50% of the ADC input range.

The default **Base Gain** setting of 4.668 serves as an adequate starting point for most detectors. If the Preamplifier Gain is known, use Equation 3-3 to choose the preliminary **Base Gain** setting, e.g. if your preamplifier has 2.5 mV/keV gain, choose 11.84 for a 40 keV spectrum. In any case, the ROI calibration tool can subsequently be used to make adjustments, as described in §3.6.2 below.

$$\text{Base Gain} = \frac{1184}{\text{Dynamic Range [keV]} * \text{Preamplifier Gain } \left[\frac{\text{mV}}{\text{keV}} \right]}$$

Equation 3-3

The **Scope** tool can be used to check the **Base Gain** setting. You should have already verified the signal polarity, such that pulses are displayed with a rising edge as described in §3.4.2. For best results the x-ray pulses with energy equal to the **Dynamic Range** should be digitized at roughly 50% of the ADC range, or 8000 out of 16,384 least-significant-bits (LSBs). X-rays with other energies should of course be scaled accordingly. For example, if the **Dynamic Range** is 40 keV, a 5.9 keV x-ray should be scaled to roughly 7.4% of the ADC range. You can measure the pulse-height directly in the **Scope** window using the cursors. Right-click anywhere in the main window to bring up the context menu, and then select **Place Cursor 1** and **Place Cursor 2** to place a cursors on either side of an x-ray pulse.

Setting the **Base Gain** too low will result in insufficient digitization of the electronic noise, and thus degraded energy resolution, because optimal energy resolution relies on noise averaging. On the other hand, setting the **Base Gain** too high will result in higher deadtime and the attenuation of the high energy x-ray peaks, because pulses with larger heights are more likely to force the ADC signal out-of-range, and such events cannot be processed into the spectrum.

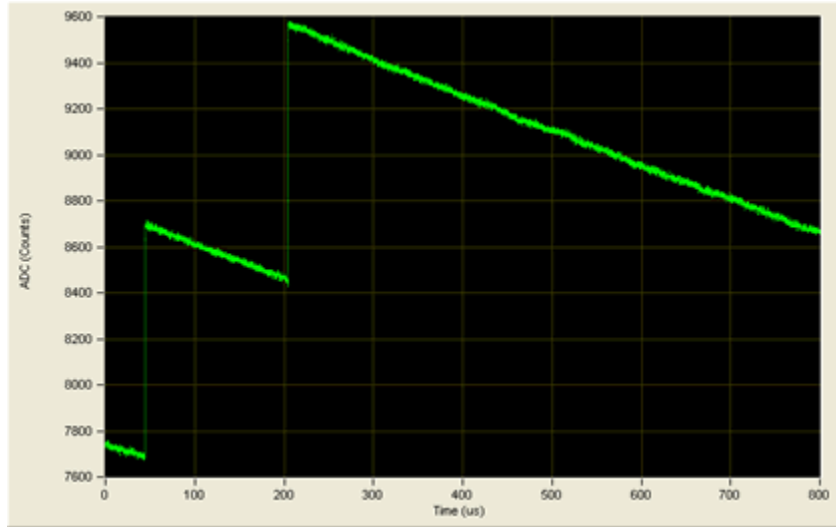


Figure 3-6: An ADC trace from a reset-type preamplifier with the correct polarity and acceptable gain. Note that the 5.9 keV x-ray steps have a *rising* edge and the pulse amplitude of roughly 1000 LSBs, corresponding to roughly 40 keV Dynamic Range.

3.5.4 MCA Format

The microDXP MCA format is quite flexible, with adjustable **Number MCA Bins** ranging up to 8192, and adjustable granularity via the **MCA Bin Width** setting. The DSP doesn't constrain the relationship between these settings, so it's possible to define a spectrum that exceeds the practical limits of the ADC, i.e. such that the MCA energy range significantly exceeds the **Dynamic Range**, which should be avoided. As a rule-of-thumb, the product of **Number MCA Bins** and **MCA Bin Width** should not exceed 8192. When the product equals 8000, the energy range of the MCA spectrum is exactly equal to the **Dynamic Range**, corresponding to voltage pulses that span 50% or less of the ADC input range, a practical measurement limit.

$$\text{Energy Range} = \text{Number MCA Bins} * \text{eV/Bin}$$

Equation 3-4

<i>Number MCA Bins</i>	<i>MCA Bin Width</i>	<i>Bin Size</i>	<i>Energy Range</i>
8192	1	5 eV	40.96 keV
8000	1	5 eV	40.00 keV
4096	1	5 eV	20.48 keV
4000	1	5 eV	20.00 keV
4096	2	10 eV	40.96 keV
4000	2	10 eV	40.00 keV
2048	1	5 eV	10.24 keV
2000	1	5 eV	10.00 keV
2048	2	10 eV	20.24 keV
2000	2	10 eV	20.00 keV
2048	4	20 eV	40.96 keV
2000	4	20 eV	40.00 keV

Table 3-1: Bin Size and Energy Range as a function of Number MCA Bins and MCA Bin Width, with a Dynamic Range of 40 keV. Note that the product of Number MCA Bins and MCA Bin Width is always 8192 or less.

A few examples are shown in Table 3-1 above, all with the **Dynamic Range** equal to 40 keV. The best setting depends on the required bin size, energy range and spectrum file size for a given application. Note that the default setting is 4096 bins with **MCA Bin Width** equal to 2.

First select the desired **Number of MCA Bins**, and then set the **MCA Bin Width** such that the product is less than or equal to 8192. Press **[Apply]** to download the new settings to hardware. Press **[Save]** once you have verified the settings.

3.6 Spectrum Acquisition

At this point the **Polarity**, **Base Gain**, **Dynamic Range**, **Number MCA Bins** and **MCA Bin Width** should have been set as described in §3.4 and §3.5 above. Before saving the GENSET settings, however, the Base Gain should be calibrated from an actual energy spectrum.

Now click on the **MCA** tab, which displays the distribution of measured pulse-heights and thus, after calibration, the energy spectrum of the incident photons. Press the **[Start Run]** button to begin a data acquisition run. If the **Continuous** checkbox is selected the display will refresh automatically, otherwise data will only be displayed after the **[Update]** button is pressed and/or after the run is stopped.

An uncalibrated energy spectrum should now be displayed, as in Figure 3-7 below. Press **[Stop Run]** to end the spectrum acquisition run. A noise peak near channel zero (0) might be displayed if the gain is set too high or a threshold is set too low. If the noise peak overwhelms the energy peak, or if no data is displayed it is likely that the **Polarity** and/or **Base Gain** has not been set properly—please review §3.4 and §3.5 above before continuing.

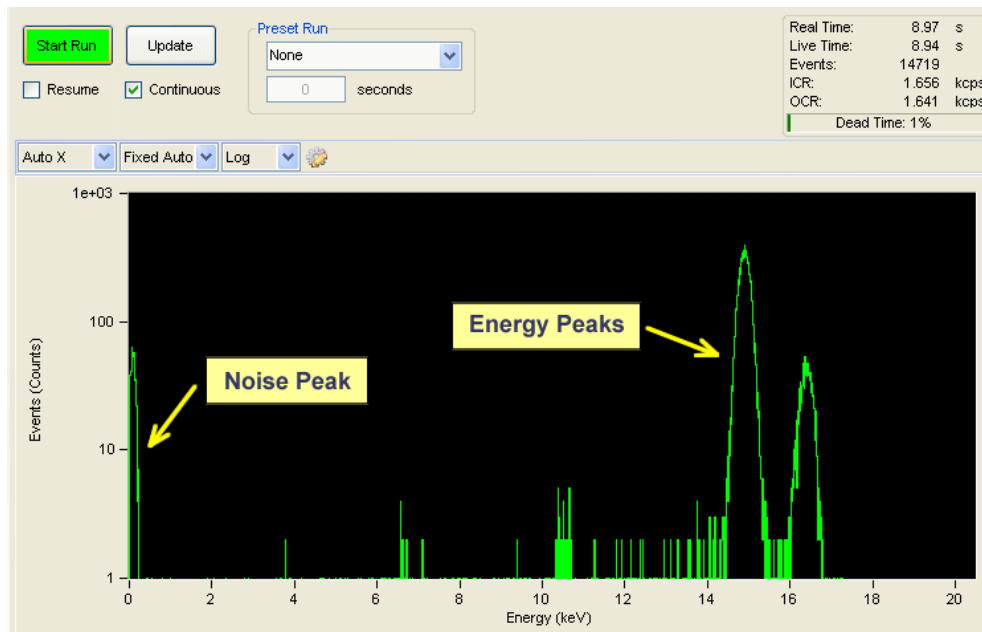


Figure 3-7: An energy spectrum with a significant noise-peak, viewed with a logarithmic vertical scale. Note that the Fe55 $K\alpha$ peak should be at 5.9 keV but is closer to 15 keV, indicating that the **Base Gain** is set too high for a 20 keV **Dynamic Range**.

3.6.1 ROI Selection

In order to calibrate the energy we must first designate the calibration peak with a *Region of Interest* (ROI). By default the ROI table should display as in Figure 3-8A. Click on the **Add New Row** icon to add the first ROI. Up to sixteen (16) ROIs can be added, with the **Mean**, **FWHM**, **OCR** and total number of **Events** displayed for each.

1. Right-click in the spectrum display of the **MCA** tab and select **Place Cursor 1**. Use the left mouse button to drag the cursor within the desired peak, zooming in if necessary using the mouse shift-click + drag operation. Hint: right-click and select **Full Scale** to display all data.
2. Now right-click on cursor 1 and select **Auto ROI**. A shaded region of interest should appear within the peak. If the number of counts in the peak is insufficient, the auto ROI function will not adequately select the peak. Note: if necessary, the ROI limits can be adjusted directly using the left-mouse click-and-drag operation, or by editing the **Lower** and **Upper** fields in the **ROI** table.

The **ROI** table should now display as in Figure 3-8B. Note: the software will scale the active ROI (denoted by the check mark in the far-left column of the table) to the calibration energy. ROIs can be locked by clicking in the **Lock** column.

3.6.2 Base Gain Calibration

Once a known energy peak has been selected with the active ROI, as described in §3.6.1, the **Base Gain** can be calibrated.

Note that the overall gain also includes the **Fine Gain Trim** value that is associated with each **Peaking Time**, i.e. stored in each PARSET, to maintain the gain calibration on a per-peaking-time basis, as described in §3.7.2.

1. At this point the **Fine Gain Trim** should be at its default value of 1.000. If this is not the case, reset the **Fine Gain Trim** in the PARSET area of the **Acquisition** tab to 1.000 and press the **[Apply]** button below.
2. Enter the energy of selected peak in keV units in the **Calib. (keV)** field of the **ROI** table, and press the **[Calibrate ROI]** button to automatically adjust the **Base Gain**. Note that the **Base Gain** was modified as a result.
3. Press the **[Start Run]** button to acquire more data. Note that the spectrum should now be calibrated as in Figure 3-9. If the ROI is properly adjusted, the **Mean** field in the **ROI** table should match the calibration energy entered as in Figure 3-8C.

Note: if the **Base Gain** was modified significantly enough in step 1 above to change the coarse analog Switched Gain setting, the calibration may still be off by up to 1%. In this case, repeat as necessary to achieve the desired accuracy. Another consequence is that the thresholds may need to be re-optimized, so it's important to get the **Base Gain** right before proceeding to §3.7.

Once you are satisfied with the MCA settings and energy calibration, press the **[Save]** button in the GENSET area of the **Acquisition** tab.

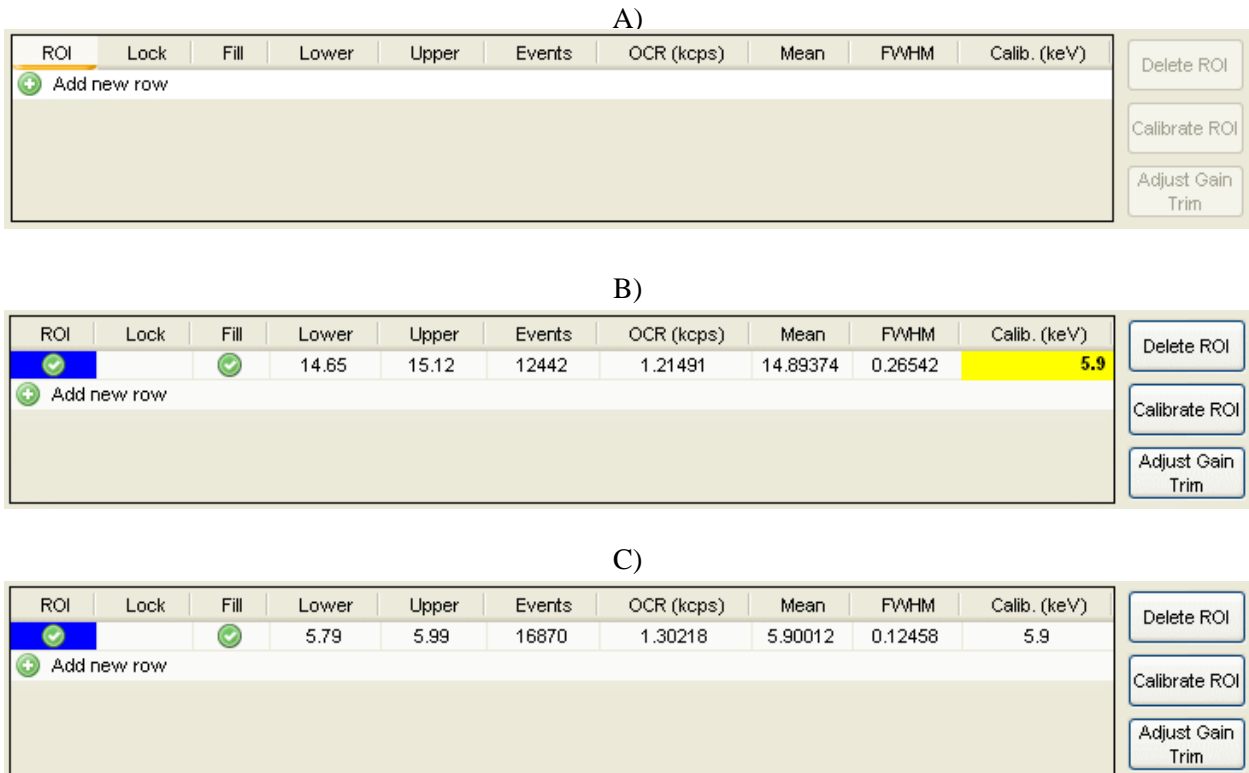


Figure 3-8: A) default ROI table, B) with an uncalibrated peak at 14.89 keV selected and calibration energy of 5.9 keV entered, and C) after base gain calibration of a 5.9 keV Fe⁵⁵ K α peak.

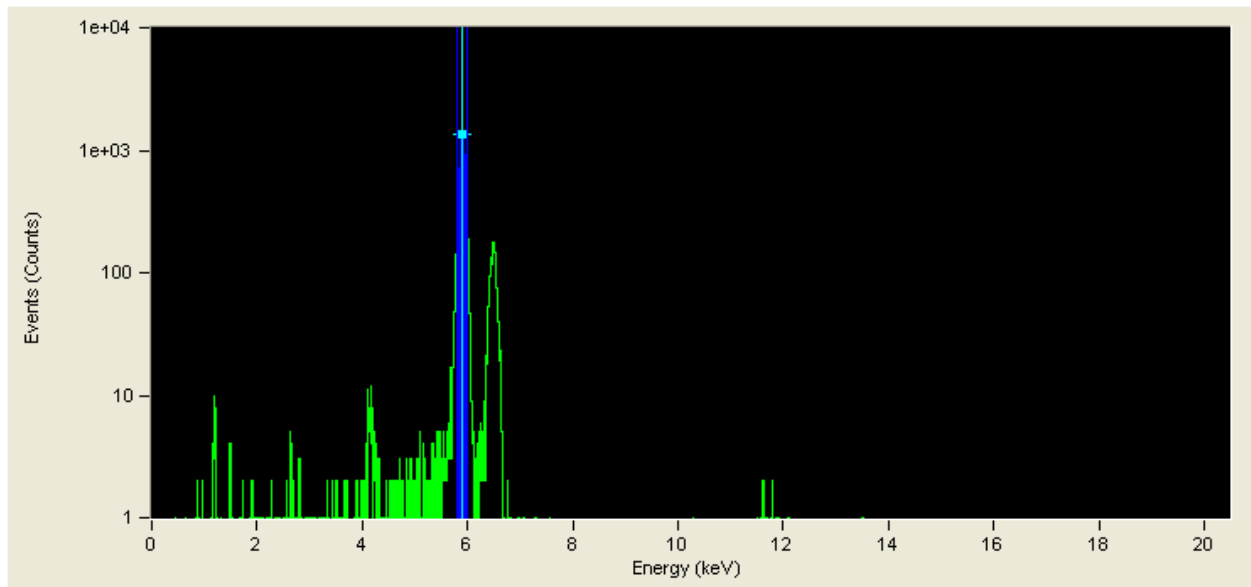


Figure 3-9: The Fe⁵⁵ K α peak is now displayed properly at 5.9keV.

3.7 Peaking Time (PARSET) Optimization

For each of the twenty-four **Peaking Time** values the DSP stores a complete set of all related spectrometer parameters into non-volatile memory, i.e. into the corresponding PARSET. The 24 parameter sets (PARSETs) are first optimized and saved to the on-board non-volatile memory. Subsequent selection of an optimized **Peaking Time** retrieves all relevant digital filtering and peak inspection parameters (e.g. gap time, thresholds, pileup inspection interval, etc.). This functionality is targeted at embedded systems: the configuration and optimization procedures can be performed in the lab using the ProSpect software, such that only a small command set is required within the embedded system itself, e.g. start run, stop run, change PARSET (peaking time), etc. The configuration process need only be performed once, though of course the parameter sets can later be modified. Please refer to the microDXP Technical Reference Manual and the RS-232 Command Specification for further details. All microDXP-related documents are available online at:

<http://www.xia.com/microDXP.html>

Peaking Time (PARSET) selection and the most commonly used parameter settings are accessed directly from the **Acquisition** tab of the **Settings** panel. Less frequently used parameters can be accessed by pressing the **[Edit Filter Parameters]** button. First select the desired **Peaking Time** from the drop-down list. The following sections describe the process of selecting and storing the individual parameters for one peaking time.

The screenshot shows a software interface titled "Parameter Set (PARSET: 12)". It contains several input fields and buttons. At the top, "Peaking Time" is set to "2.00" with a dropdown arrow and a "μs" unit. Below this is a button labeled "Edit Filter Parameters". Further down, "Baseline Average Length" is set to "512" with a dropdown arrow, and "Fine Gain Trim (0.5-2.0)" is set to "1.000" with a double-headed arrow. A section titled "Thresholds (Genset 0)" contains three input fields: "Trigger (0-4095)" set to "110", "Baseline (0-4095)" set to "60", and "Energy (0-4095)" set to "0". At the bottom of the dialog are three buttons: "Apply", "Undo", and "Save".

Figure 3-10: The PARSET area of the **Acquisition** tab includes **Peaking Time** selection and the modification and storage to nonvolatile memory of related settings.

3.7.1 Threshold Settings

Three thresholds, each with its own balance of timing vs. noise performance, can be used simultaneously to distinguish noise, which goes into the baseline distribution, from x-ray

events, which go into the energy spectrum: the fast-filter **Trigger** threshold achieves the best pulse-pileup rejection, whereas the slow-filter **Energy** threshold can be used to detect the lowest energies; the intermediate-filter **Baseline** threshold is somewhere in the middle.

- Thresholds can be individually disabled by setting them to zero (0).

The thresholds are typically the most important PARSET settings to get right. By default they are set conservatively, however, better performance will be achieved when the thresholds are set as described below. We recommend saving the PARSET after each threshold is verified, by pressing the **[Save]** button. Finally, note that if the **Base Gain** is subsequently changed by a significant amount, i.e. by enough to change the coarse analog Switched Gain, the thresholds must be re-optimized and the PARSET saved again. For this reason it's important to first get the **Base Gain** right as described in §3.6.2.

3.7.1.1 Disable the Slow Threshold

By default the **Energy** threshold is disabled, and it should be disabled, i.e. set to 0, in nearly all cases. Although its excellent noise reduction also allows detection of the very lowest energy x-rays, its slow response precludes an accurate determination of deadtime. This results in both degraded pulse pileup inspection and an error in the input count rate calculation. The **Energy** threshold should thus be used only when soft x-rays of interest are present that can't otherwise be detected using the other thresholds, and only then with the understanding that pileup inspection for such events is marginal at best.

3.7.1.2 Trigger Threshold

1. By default the **Energy** threshold and the **Baseline** threshold should be disabled, i.e. set to zero. If this is not the case, set both values to zero now and press **[Apply]**.
2. The default **Trigger** threshold value 192 is a reasonable place to start. Edit the value as necessary and press **[Apply]**.
3. Press **[Start Run]** to acquire data in the **MCA** tab, and then press **[Stop Run]**.
4. If the noise peak is NOT displayed, reduce the **Trigger** threshold by a factor of 2 and repeat step 3 and 4 until the noise peak is visible.
5. When the noise peak is displayed, increase the **Trigger** threshold (now in smaller increments) and repeat until the noise peak is eliminated.
6. Take note of the input and output count rates (ICR and OCR) for the next section. Press the **[Save]** button in the PARSET are of the **Acquisition** tab.

3.7.1.3 Baseline Threshold

1. At this point the **Baseline** and **Energy** thresholds should be disabled (set to zero) and the **Trigger** threshold has been set to a good value.
2. In most cases a starting value of roughly 100 for the **Baseline** threshold is appropriate. Edit the value and press **[Apply]**.
3. Press **[Start Run]** to acquire data in the **MCA** tab, and then press **[Stop Run]**.
4. If the noise peak is NOT displayed, reduce the **Baseline** threshold by a factor of 2 and repeat step 3 and 4 until the noise peak is visible.
5. When the noise peak is displayed, increase the **Baseline** threshold (now in smaller increments) and repeat until the noise peak is eliminated. Note that in most cases

the **Baseline** threshold will have very little effect on the input and output count rates.

6. Press the **[Save]** button to save the new Baseline Threshold to the current PARSET.

3.7.2 Fine Gain Trim

Now we are ready to trim the gain for this peaking time. Remember, the **Base Gain** was stored in the GENSET. The **Fine Gain Trim**, or per-peaking-time calibration, is stored in the PARSET. In fact there is a **Fine Gain Trim** value stored for every PARSET/GENSET combination, allowing for a unique overall gain setting for each combination. This procedure can be skipped if the energy is already calibrated to the required accuracy, e.g. if you are still working with the same **Peaking Time** setting at which the **Base Gain** was last calibrated.

1. Select a known peak in the MCA spectrum and enter its energy in the **Calib. (keV)** field of the **ROI** table, if it hasn't been entered already. Make sure the selected ROI is active, i.e. it has the green check mark in the left-most column of the table.
2. Press the **[Adjust Gain Trim]** button to automatically adjust the **Fine Gain Trim**. Note that the **Fine Gain Trim** has been modified but the **Base Gain** has not.
3. Press the **[Start Run]** button to acquire more data. Compare the **Mean** energy in the **ROI** table to the calibration energy entered.
4. Repeat steps 2 and 3 until the fields match to the required precision.
5. Press the **[Save]** button to save the **Fine Gain Trim** to the current PARSET.

3.7.3 Optimization of Remaining PARSETs

We're now ready to repeat the above process for each of the remaining twenty-three PARSETs, or perhaps only those that will be used, saving each to non-volatile memory after the thresholds have been set and verified. The expedited procedure is outlined below:

1. Write down the **Trigger** and **Baseline** threshold settings for your optimized PARSET.
2. Select the next **Peaking Time** from the drop-down list.
3. Enter the values from step 1 above and press **[Apply]**.
4. Don't re-optimize the **Trigger** threshold unless the **Fast Trigger Filter Peaking Time** (aka FASTLEN) has changed. By default PARSETs 0-7 have a **Fast Trigger Filter Peaking Time** of 50 ns (FASTLEN=2), and the remainder have 100 ns (FASTLEN=4). So, PARSETs 0-7 should all have the same **Trigger** threshold, and PARSETs 8-23 should have the same (but different) **Trigger** threshold. Note that the **Fast Trigger Filter Peaking Time** is displayed in the **Edit Filter Parameters** dialog as described in §3.7.1.3 below.
5. If you are changing from a shorter **Peaking Time** to a longer one, the **Baseline** threshold can likely be reduced a bit. Optimize the **Baseline** threshold as described in §3.7.1.3
6. Calibrate the Fine Gain Trim as described in §3.7.2.
7. Repeat steps 1-6 above for each remaining **Peaking Time**, making sure to **[Save]** often.

Congratulations! You’ve just completed the basic configuration and optimization. We’ve attempted to provide enough software features and documentation to characterize the microDXP performance with a given detector, i.e. map the resolution and throughput vs. peaking time. If you do not achieve satisfactory performance after following the above procedure, continue reading §3.7.4 below, which includes:

- Adjusting the slow gap time for longer preamplifier rise times, as described in §3.7.4.1
- The Peak Capture Method at short peaking times may need adjustment, as described in §3.7.4.2
- Adjustment of the Fast Trigger Filter and pileup inspection parameters is described in §3.7.4.3

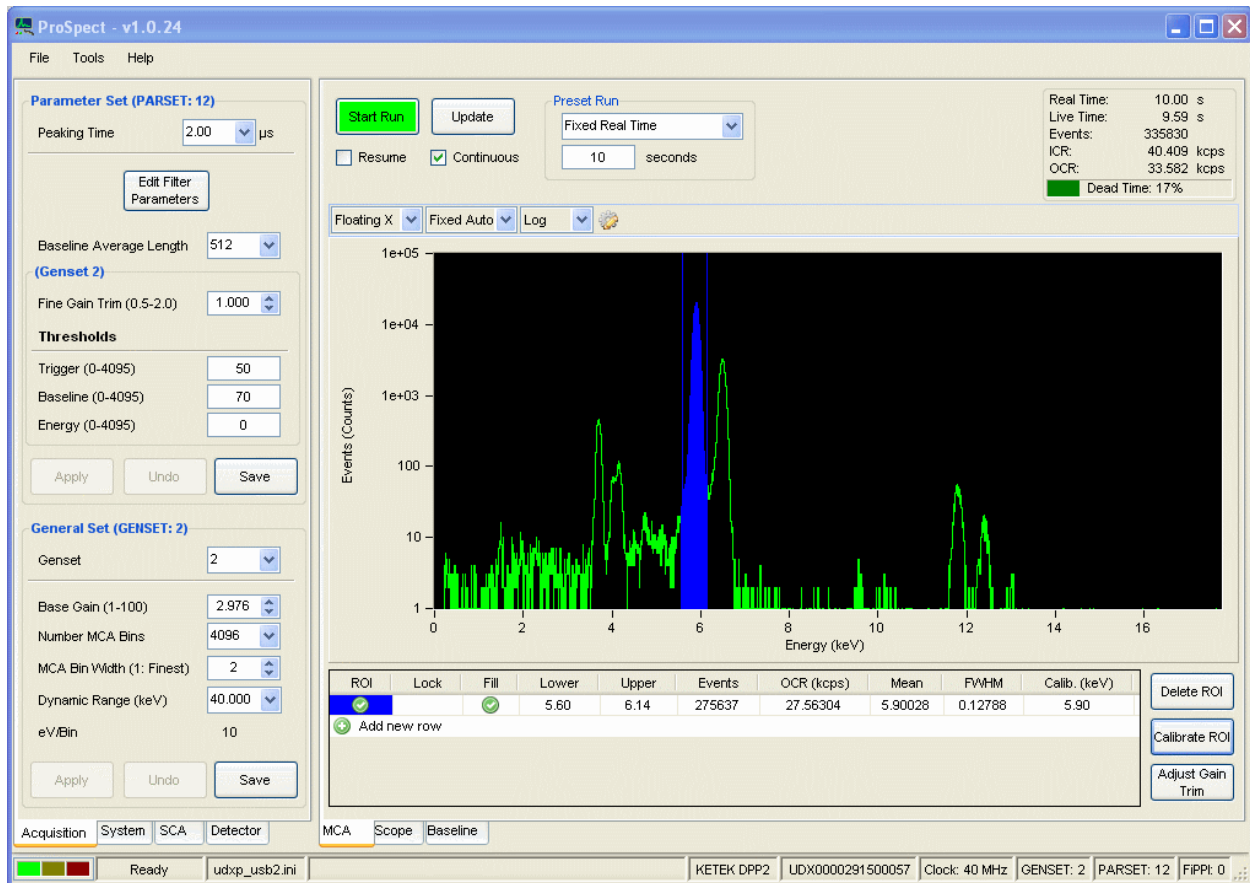


Figure 3-11: A calibrated Fe55 spectrum viewed with a logarithmic vertical scale. An ROI has been created and calibration energy entered, and thus the horizontal axis of the MCA and the measured centroid and FWHM have been scaled.

3.7.4 Advanced Optimizations

Note: explanations of the digital filtering algorithms are described in detail in the microDXP Technical Reference Manual.

Open the **Edit Filter Parameters** dialog by pressing the **[Edit Filter Parameters]** button in the PARSET area of the **Acquisition** tab. This dialog displays the parameters that control the digital filtering algorithm.

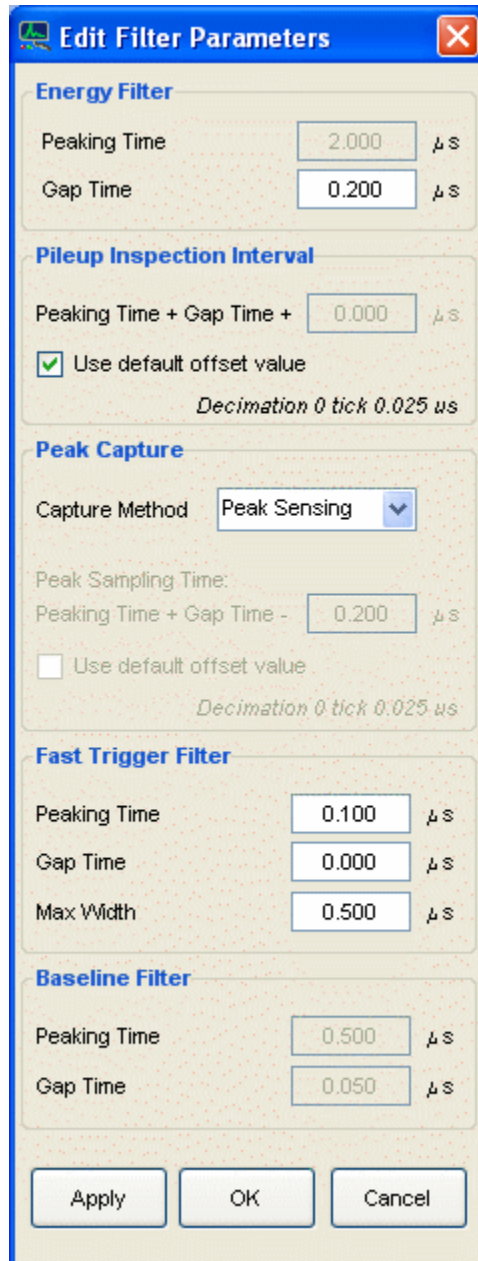


Figure 3-12: The **Edit Filter Parameters** dialog displays the advanced settings for the current Peaking Time.

Changing any of these parameters can significantly alter the performance of microDXP at the selected **Peaking Time**.

1. Make sure the desired **Peaking Time** is selected from the drop-down list.
2. Press [**Edit Filter Parameters**] to open the **Edit Filter Parameters** dialog.
3. Edit the parameters of interest (e.g. energy filter **Gap Time**, **Capture Method**, Fast Trigger Filter **Peaking Time**, etc.).
4. Press [**OK**] to apply the changes and close the dialog, or press [**Apply**] to apply the changes but keep the dialog open for further editing.

5. Press [**Start Run**] to acquire data for comparison in the **MCA** tab, and then press [**Stop Run**].
6. [**Save**] the PARSET to store the modified parameters to non-volatile memory such that they will be retrieved the next time the **Peaking Time** is selected.

3.7.4.1 Preamplifier Rise Time: SLOWGAP

The **Energy Filter Gap Time** is visible as the ‘flat-top’ region of the energy filter output trapezoid. SLOWGAP is typically set such that the flat-top interval is longer than the rise time of the preamplifier output pulses by at least 1 sampling interval:

$$\text{Energy Filter Gap Time} = \text{SLOWGAP} * \text{sampling interval} > \text{rise time}$$

Equation 3-5

In special cases where the very highest output count rates are desired, and perhaps at the expense of energy resolution or peak shape, the user may wish to set the gap time to be significantly less than the preamplifier rise time.

The rise time is easily measured using the **Scope** tool: select **ADC** and set **Sampling Interval** to the minimum value by entering “0”. Press the [**Get Trace**] button and then use the cursors to zoom in on an x-ray pulse, as in below.

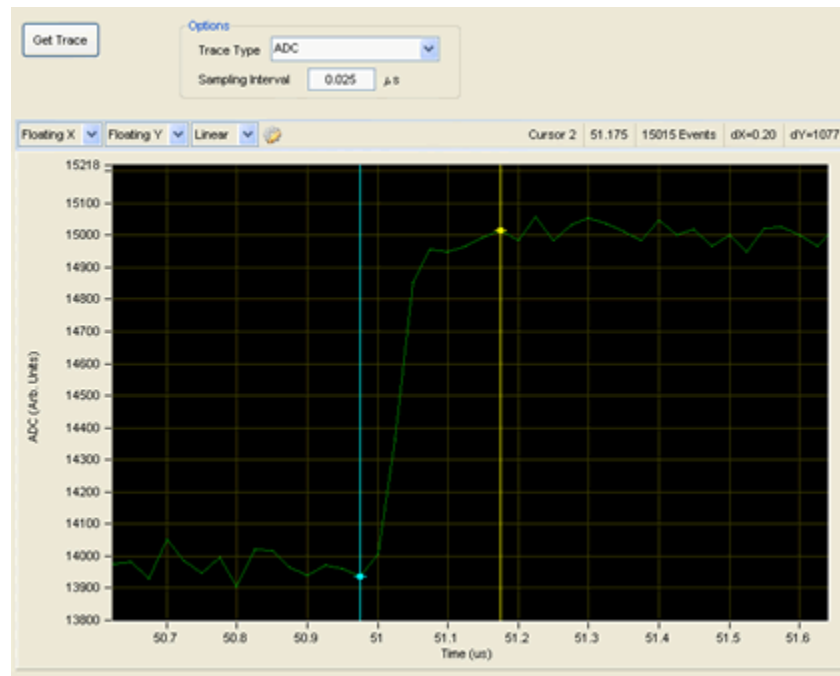


Figure 3-13: Use the cursors to zoom in and measure the preamplifier 0-100% rise time. In this example plot the rise time is ~200 ns as indicated in the dx=0.20 field at the upper right corner.

The **Energy Filter Gap Time** is constrained by the relationship between the slow energy filter and the intermediate baseline filter. The baseline filter length (BASELEN) and gap (BASEGAP) are always constrained to be exactly $\frac{1}{2}$ or $\frac{1}{4}$ the energy filter length (SLOWLEN) and gap (SLOWGAP), respectively, depending on the **Peaking Time**. This

means that the energy filter length and gap increment, or units, must be either 2x or 4x the clock period, as shown in Table 3-2 below.

Note that ProSpect automatically enforces this relationship: it will round the user value up or down as necessary when the [Apply] or [OK] buttons are pressed. The relationship can be determined by the parameter BFACTOR:

$$\text{SLOWLEN} = 2^{(\text{BFACTOR}+1)} * \text{BASELEN}$$

Equation 3-6

Note also that the **Baseline Filter Peaking Time** and **Gap Time** are displayed at the bottom of the **Edit Filter Parameters** dialog, but cannot be edited.

Peaking Time Range	BFACTOR	SLOWGAP increment (with 40MHz clock)
0.1 to 0.6 μs	0	2x (50 ns)
0.8 to 24 μs	1	4x (100 ns)

Table 3-2: The Energy Filter Gap Time (SLOWGAP) increment depends on the Peaking Time and clock speed.

So, for example, if the preamplifier rise time is 120 ns and the **Peaking Time** is 8 μs , BFACTOR=1 and SLOWGAP has an increment of 4x the clock period. With a 40MHz clock the SLOWGAP increment is 100 ns, and the correct setting is 200 ns. With an 80MHz clock the SLOWGAP increment is 50 ns, and the correct setting is 150 ns.

Note: if the input signal displays a range of rise times, as in the case of ballistic deficit, the slow filter gap time should be extended to accommodate the longest rise times.

Open the **Acquisition** tab and press the [Edit Filter Parameters] button. Edit the **Energy Filter Gap Time** as necessary and press [OK]. The new value can be saved to the PARSET by pressing the [Save] button in the PARSET area of the Acquisition tab.

3.7.4.2 Peak Capture Method: Peak Sensing vs Peak Sampling

Two peak capture methods are supported by the microDXP hardware. In general, the default **Peak Sensing** mode is recommended: it is 'automatic' and thus easier to use, and achieves the best pulse-height measurement in most cases. At very short peaking times, and especially when the user sets the **Energy Filter Gap Time** to less than the preamplifier rise time, **Peak Sampling** mode may yield better results. The precise setting has a strong effect on energy resolution and should be determined empirically for each new detector.

In **Peak Sensing** mode, the energy filter output is monitored over a finite interval of time, and the maximum value within that interval is selected. The interval is set automatically, based on the values of the parameters SLOWLEN and PEAKINT. PEAKINT is also a pileup inspection parameter, as will be discussed in further detail in §3.7.4.3.

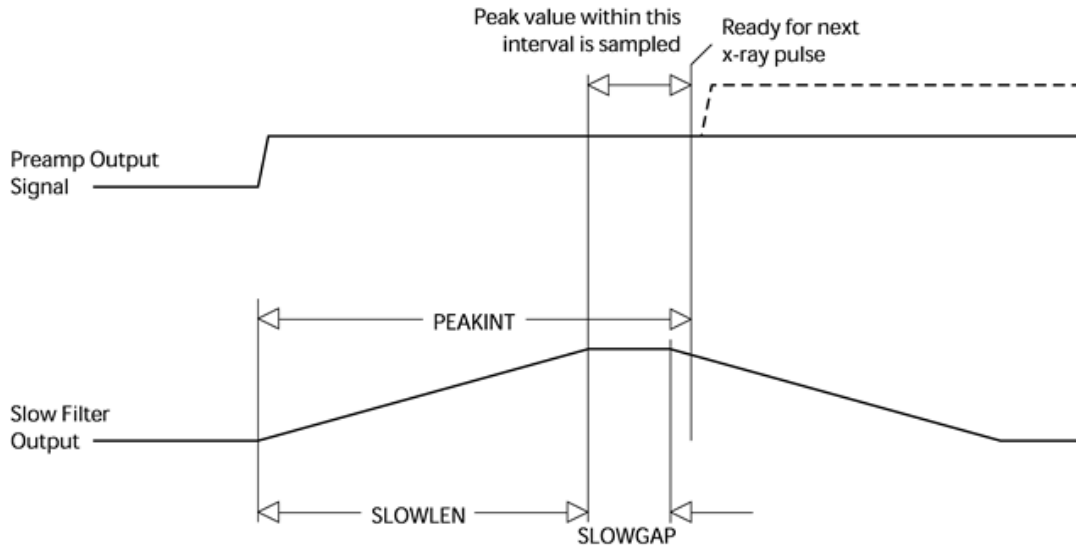


Figure 3-14: In **Peak Sensing** mode, the peak value of the slow energy filter output is selected.

For **Peak Sampling** mode, the slow filter output is instead sampled a *fixed time* after the x-ray is detected, as depicted in Figure 3-15. A timer which expires after PEAKSAM clock cycles is started when an x-ray step is detected. PEAKSAM must be less than PEAKINT, and should typically be set such that the sample point lies in the ‘flat-top’ region of the slow filter output:

$$\text{SLOWLEN} \leq \text{PEAKSAM} \leq \text{SLOWLEN} + \text{SLOWGAP}$$

Equation 3-7

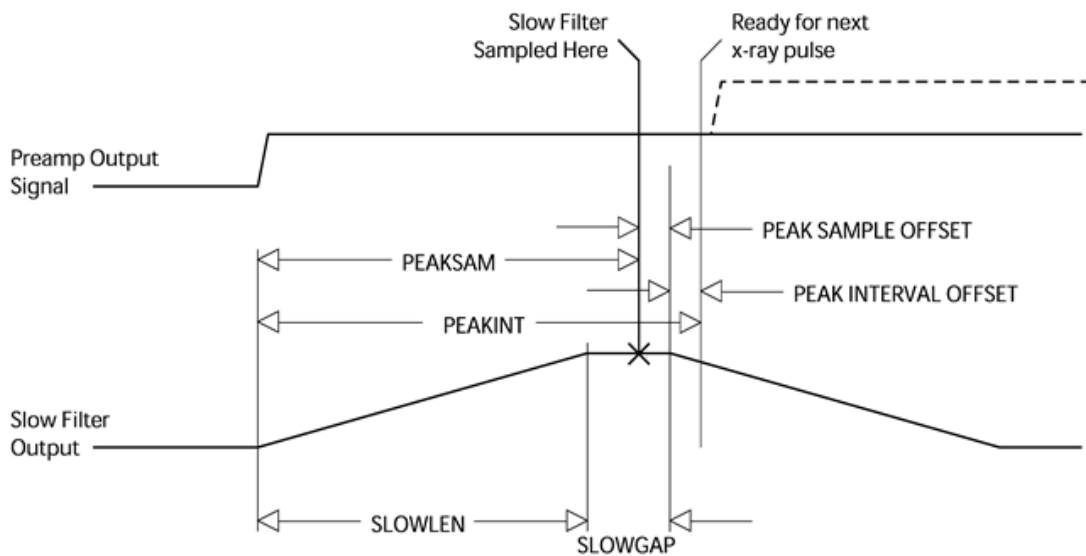


Figure 3-15: In **Peak Sampling** mode, the slow energy filter output is sampled at a fixed time after the x-ray pulse.

Select the desired peak capture method and press **[OK]**. The modification can then be saved to the PARSET by pressing the **[Save]** button in the PARSET area of the **Acquisition** tab.

3.7.4.3 Pileup Inspection: FASTLEN, FASTGAP, MAXWIDTH, PEAKINT

Undetected pulse-pileup results in unwanted pileup peaks in the spectrum. Pileup peaks in the spectrum can often be identified by noting that the apparent energy of the pileup peak is the sum of the energies of the piled-up x-ray pulses.

Two pileup inspection methods are utilized in the microDXP. Fast pileup inspection monitors the pulse width of the fast filter output, or more specifically, the time during which the **Trigger** threshold is exceeded. Slow pileup inspection monitors the time between two successive threshold crossings.

The fast filter is controlled by the parameters FASTLEN and FASTGAP. It is not necessary to set the FASTGAP in relation to the preamplifier rise time, in fact it is set to zero (0) by default, and should left so in nearly all cases.

For the limiting case of a preamplifier rise time equal to zero, the fast filter produces a trapezoid of maximum width:

$$\text{Max Width} = (\text{FASTGAP} + 2 * \text{FASTLEN}) * \text{sampling interval}$$

Equation 3-8

The parameter MAXWIDTH sets the **Max Width** limit for acceptable events, in units of the sampling interval (i.e. 25 ns for 40MHz, 12.5ns for 80MHz). The fast filter trapezoidal waveform convolutes the preamplifier rise time t_r with FASTLEN and FASTGAP, and thus MAXWIDTH should be increased accordingly:

$$\text{MAXWIDTH} \cong \text{FASTGAP} + 2 * \text{FASTLEN} + (t_r / \text{sampling interval})$$

Equation 3-9

The default values (MAXWIDTH = 20; FASTLEN = 4; FASTGAP = 0) are thus appropriate for a preamplifier rise time of roughly 300 ns if the sampling interval is 25 ns (default 40 MSPS ADC), or a preamplifier rise time of roughly 150 ns if the sampling interval is 12.5 ns (high-speed 80 MSPS ADC).

The **Pileup Inspection Interval** is the time between two successive fast filter pulses. PEAKINT sets the minimum separation. By default it is automatically set to:

$$\text{Pileup Inspection Interval} = \text{Peaking Time} + \text{Gap Time}$$

Or

$$\text{PEAKINT} = \text{SLOWLEN} + \text{SLOWGAP}$$

Equation 3-10

...and should be left so in nearly all cases. Smaller settings will increase the magnitude of pileup peaks. Longer settings may in some special cases improve pileup rejection, but typically it will have no effect on pileup and will always increase the dead-time-per-event and thus reduce throughput.

Press the **Edit Filter Parameters** to open the **Edit Filter Parameters** dialog. Edit **Max Width** as necessary and press **[Apply]**. In ProSpect the **Pileup Inspection Interval** is defined as an offset from its default value, per Equation 3-10. The default offset is thus zero. To increase the interval, enter a positive number and press **[Apply]**. Start a new run and re-examine the ratio of the identified pileup peak to its associated energy peak. After the settings have been optimized, press the **[Save]** button, and remember that individual settings are stored and retrieved for each **Peaking Time**.

3.7.5 Viewing the run statistics

The run statistics are displayed in the upper right corner of the **MCA** tab. **Real Time** and **Live Time** are displayed in seconds; **ICR** (input count rate) and **OCR** (output count rate) are displayed in kilo-counts-per-second. The total number of **Events** in the spectrum and the **Dead Time** percentage are also displayed.

3.7.5.1 Livetime and Deadtime

The displayed **Live Time** is NOT the live time of the energy filter, rather it is a measurement of time that the triggering filter remained under threshold. This measurement, along with the number of times the threshold was crossed, or Fast Peaks, is used to calculate the input count rate.

$$\mathbf{ICR = Fast Peaks / Live Time}$$

Equation 3-11

The live time of the energy filter is not displayed in software, but can be calculated according to:

$$\text{Energy filter live time} = \mathbf{Real Time * OCR / ICR}$$

Equation 3-12

The **Dead Time** percentage is displayed in software, calculated as:

$$\mathbf{Dead Time = 1 - OCR/ICR}$$

Equation 3-13

3.7.6 Saving a spectrum

The spectrum export function produces a text file with a descriptive header and a list of values, i.e. the number of counts recorded in each MCA bin. The energy-per-bin and run statistics are included in the header. To save a spectrum select **Save MCA Data...** from the **File** menu. You will be prompted to enter the file name and select a location to save the file.

3.8 Diagnostics

3.8.1 Board Status and Information

The **Board Information** dialog is used to display basic information about the configuration and status of the microDXP hardware. Open the dialog by selecting **Board Information...** under the **Tools** menu.

Click the **Status** tab to display the current status of the PIC microprocessor and DSP. If no error conditions have been detected all values should read zero. Click the **Information** tab to display the current hardware and firmware configuration, as displayed in Figure 3-16 below. Finally, press the **[Export ...]** button to store all info, i.e. status, history and configuration information, to a text file. This text file is useful to XIA support staff when attempting to diagnose hardware and/or firmware problems.

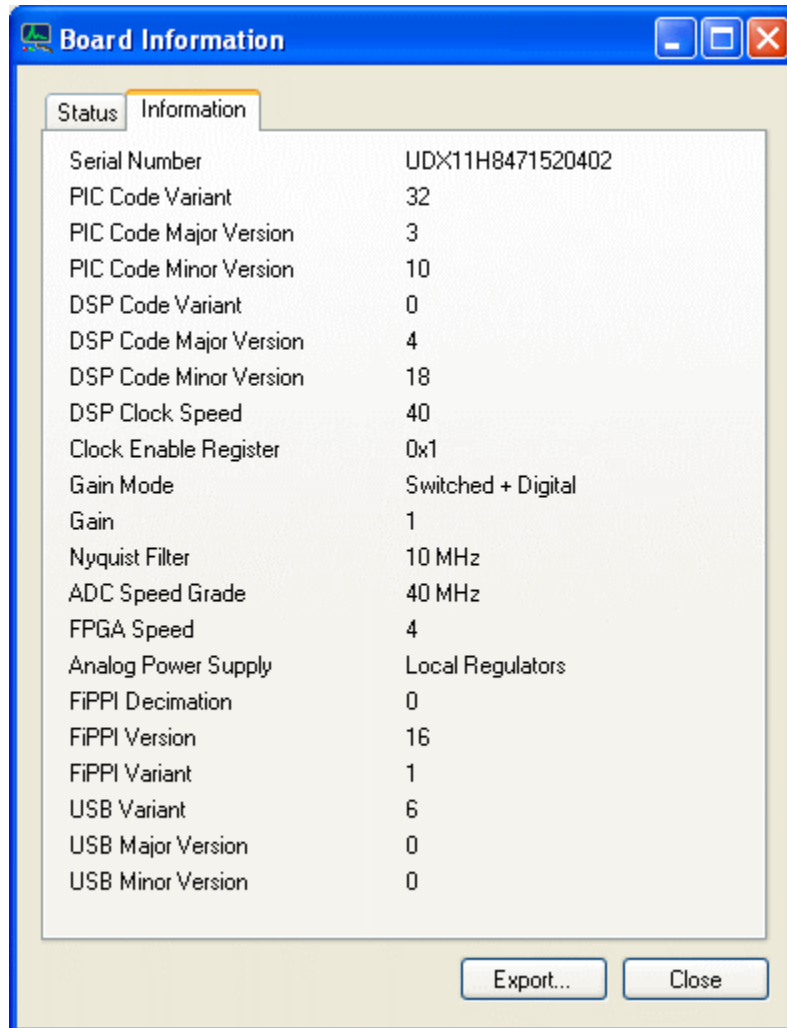


Figure 3-16: The Board Information dialog, displaying the hardware configuration status and information.

3.8.2 Log Files

The software application log files are accessed by selecting **Diagnostics...** from the **Tools** menu. The ProSpect tab displays the contents of `ProSpect.log`, a log of high-level GUI operations, and the Handel tab displays the contents of `ProSpect_handel.log`, which contains low-level information. Both files are saved to the default location:

`C:\Users\\AppData\Roaming\XIALLC\ProSpect\logs`

The log files, and particularly the Handel log file, can be helpful to XIA support staff when attempting to diagnose hardware and/or firmware problems.

3.8.3 The Scope Tool

The **Scope** tab displays 8,000 points of the selected digital signal vector, to be used as a diagnostic tool during setup and debugging.

- The **Trace Type** drop-down list selects the source vector.

- The **Sampling Interval** field controls the time interval between individual points. The minimum value is the ADC sampling interval, e.g. at 40 MSPS the minimum value is 25 ns, and results in a displayed period of 200 μ s.
- The **Trigger Type** drop-down list selects the scope trigger source (which is independent of the event trigger for data acquisition mode), if enabled. We recommend setting **Trigger Type** to **Fast Trigger** in nearly all cases. *Note:* if a trigger source has been selected but no trigger is detected, the **[Get Trace]** operation will time out after a few seconds and return untriggered data. To disable triggering, select **Triggering Disabled** from the **Trigger Type** drop-down list.
- The **Position** field determines the horizontal position of the triggered event. Its value ranges from 0 to 255, with 128 putting the triggered event at the center of the displayed trace.

In order to make sense of the **Scope** data, it's important to distinguish x-ray pulses from noise, and for reset-type preamplifiers we must also identify preamplifier resets and microDXP tracking steps in the display.

3.8.3.1 Identifying Noise

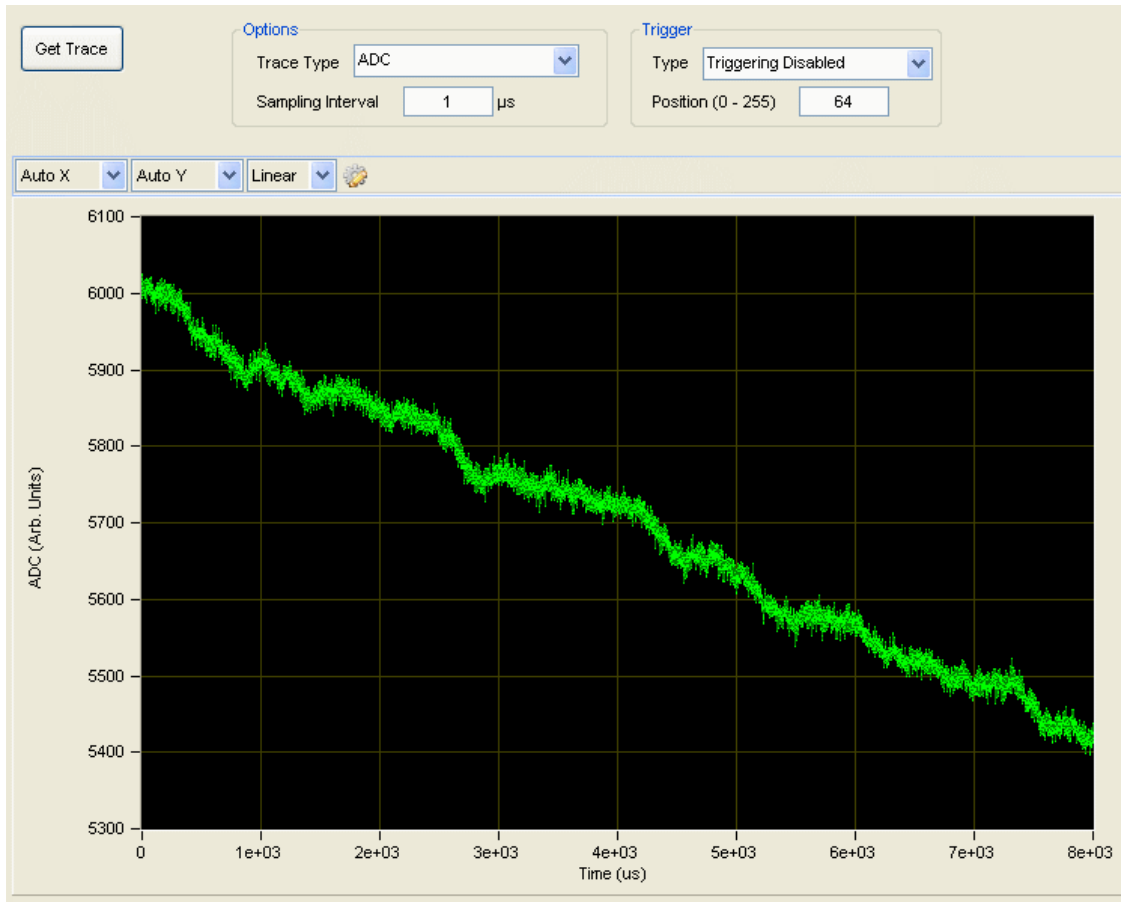


Figure 3-17: An ADC trace displaying noise from a reset-type preamplifier. The **Sampling Interval** is set to 1 μ s, thus the 8000 point display spans 8 ms.

An ADC trace displaying only noise is shown in Figure 3.17. In this case a significant low-frequency noise component (i.e. in the 100Hz -1kHz range) is displayed, in addition to high-frequency noise. High and low-frequency noise are distinguished relative to the spectrometer filter length (i.e. slow filter peaking time): noise components with a period much greater than the peaking time are referred to as *low-frequency*, and are filtered out through baseline averaging; those with a period much shorter are referred to as *high-frequency*, and are filtered out through integration in the energy filter itself. Generally speaking *mid-frequency* noise, that is, components with a period similar to the filter length, is the most difficult to deal with. In any case, it is critical that the preamplifier noise is adequately digitized so that noise reduction can be achieved: the noise should span at least 8 ADC least-significant-bits.

3.8.3.2 Preamplifier Resets and Tracking Steps (Reset Type Preamplifiers ONLY)

Additional signal transients are present for pulsed-reset preamplifiers, and they will often be visible in the ADC and other trace types.

Reset-preamplifiers produce a large corrective *reset* step when the large-signal ‘staircase’ waveform reaches its limit. This reset transient varies for different preamplifiers, both in the duration and in other signal characteristics, e.g. rise time, charge-injection, overshoot and settling time. Reset steps may be difficult to identify because the microDXP front-end circuitry counteracts the transient in an attempt to keep the ADC signal in range.

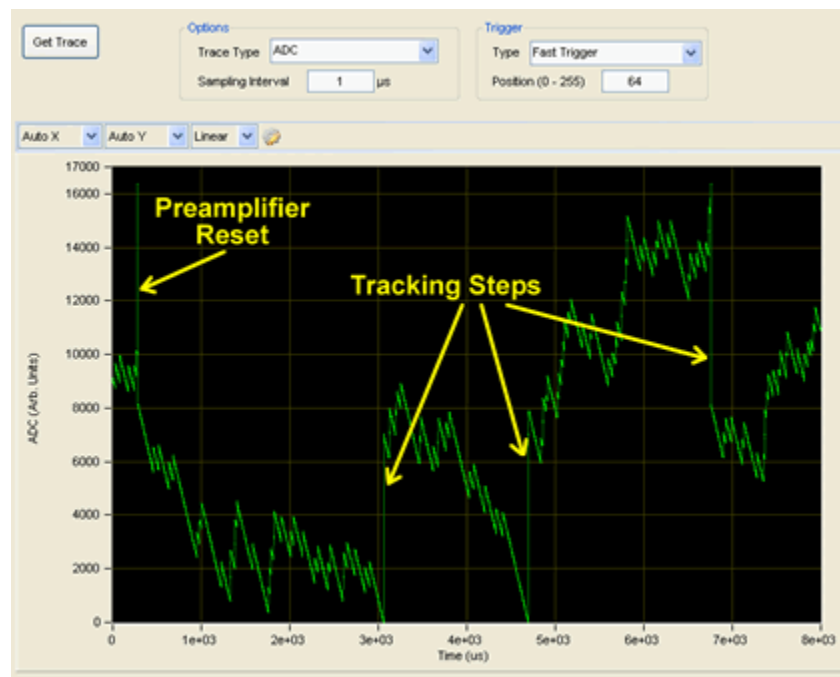


Figure 3-18: There are approximately 120 x-rays displayed for a reset-type detector. The preamplifier reset briefly sends the ADC out-of-range high. The three tracking steps are introduced by the microDXP analog signal conditioner (ASC) in response to the signal first drifting out-of-range low twice, then out-of-range high once.

Other transients, called *tracking steps*, are due to the microDXP itself. The analog signal conditioner (ASC) dynamically maintains the signal within the ADC input range by introducing large voltage steps of approximately one half the ADC range (i.e. pushing the signal from the ADC boundary to near mid-range). The resulting transient tracking steps

are qualitatively similar to the step produced by an x-ray, but occur with both rising and falling edges. Tracking steps can be identified by noting that the transients originate near the ADC minimum (0) or maximum (16384) and terminate near mid-range (6000 to 10000).

One preamplifier reset and three tracking steps are displayed in Figure 3-18. Note that the individual x-ray steps are in the range 1000 vertical units, which is approximately 6% of the ADC input range. We frequently refer to x-ray step heights in terms of ADC percentages.

3.8.3.3 The Preamplifier Reset Interval

The **Reset Interval**, expressed in units of microseconds (μs), determines the wait time after the preamplifier reset transient during which the spectrometer is disabled. A proper setting ensures that the reset transient doesn't pollute the baseline or spectrum, and that excessive dead time is not incurred.

1. In the **Scope** tab, select **ADC** from the **Trace Type** drop-down list and set the **Sampling Interval** to the minimum value, i.e. enter "0".
2. Select **ADC Out-of-Range** for the **Trigger Type** and enter 128 in the **Position** field.
3. Press the **[Get Trace]** button to acquire data.

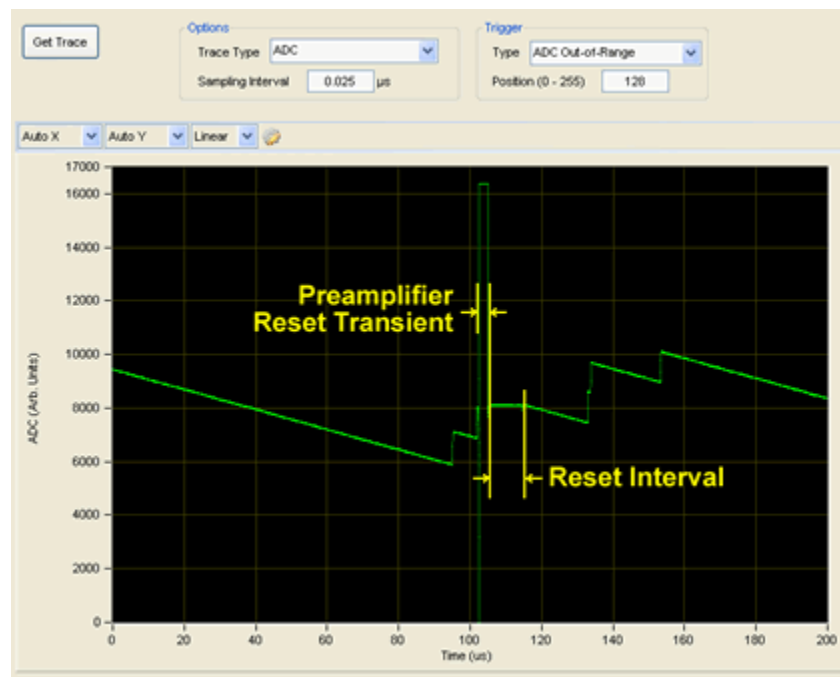


Figure 3-19: A preamplifier transient that lasts roughly 2 μs , with a quite conservative 10 μs Reset Interval that will introduce unnecessary dead time.

We are triggering on the ADC going out of range, thus we should see either a tracking step or a preamplifier reset at the center of the plot. As described in §3.8.3.2 above, the tracking steps can be identified as starting at roughly 0 or 16384, and quickly terminating near the center of the ADC range. Preamplifier reset transients look different: they start anywhere in the ADC range and the often go out of range high and low, and/or stay out of range for

a while. If you're having trouble identifying preamplifier resets, try setting the **Reset Interval** to a value larger than the default 2 μs , so that the resulting flat area after the transient can clearly be observed as in Figure 3-19. The idea is to set the **Reset Interval** such that the ADC signal goes flat for a finite but brief period of time, e.g. 2 μs , after the preamplifier transient.

The **Reset Interval** setting can be modified in the **Detector** tab. Enter the **Reset Interval** in microseconds and press the [**Apply / Save**] button. As a final check, select **Baseline Average** from the **Trace Type** drop-down list and acquire a trace at 100 μs **Sampling Interval**. The ideal trace should look like white noise, as in Figure 3-20. Significant transients and/or periodic signals warrant a more conservative Reset Interval setting.

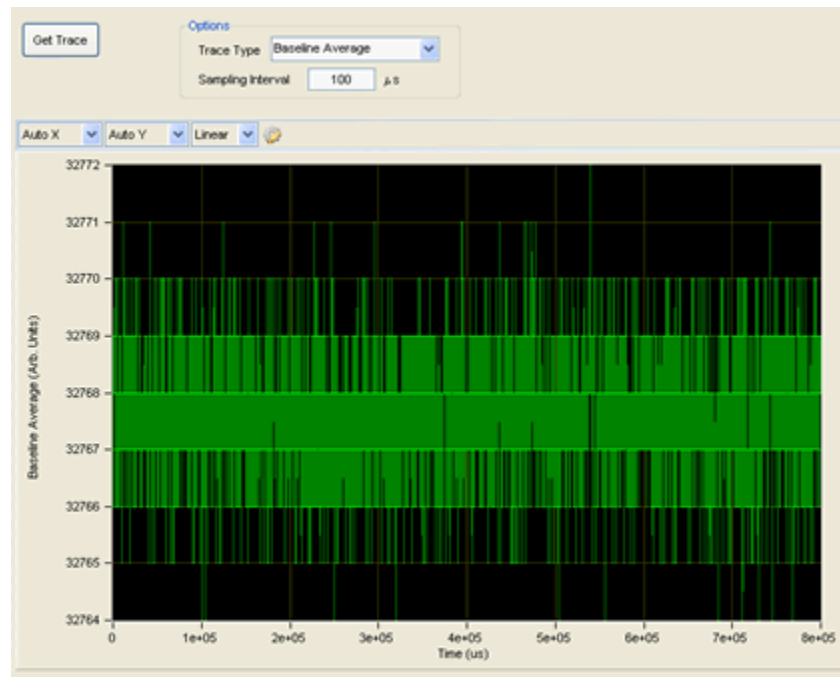


Figure 3-20: A good Baseline Average trace. Note that the zero point has been shifted to 32768 in the plot area because this is a signed vector.

3.8.3.4 Measuring the RC Decay Constant (RC Preamplifiers ONLY)

The **Scope** tool is also useful for measuring the decay time for RC-feedback preamplifiers.

1. First acquire an **ADC** trace that includes at least one well-separated x-ray event as in Figure 3-21 below.
2. Use the zoom tool (accessed via the right click menu or through the display controls at the graph's upper left) if necessary to expand the horizontal axis about the selected event such that the entire decay time is displayed.
3. Right-click in the display area and select **Place Cursor 1**, and then select and drag the cursor before the x-ray pulse such that a baseline value is selected, as in Figure 3.18. Similarly, **Place Cursor 2** and drag it to the peak value of the x-ray pulse.
4. Record the **dY** value from the cursor data display—this is the pulse height.
5. Now move cursor 1 to the point on the decay curve that produces a new **dY** value that is $(1-1/e)$ times the measured pulse height:

$$dY' = \left(1 - \frac{1}{e}\right) * dY \cong 0.63 * dY$$

- The cursors should now be separated by the time constant τ , displayed in μs in the **dX** field, as in Figure 3-22 below.

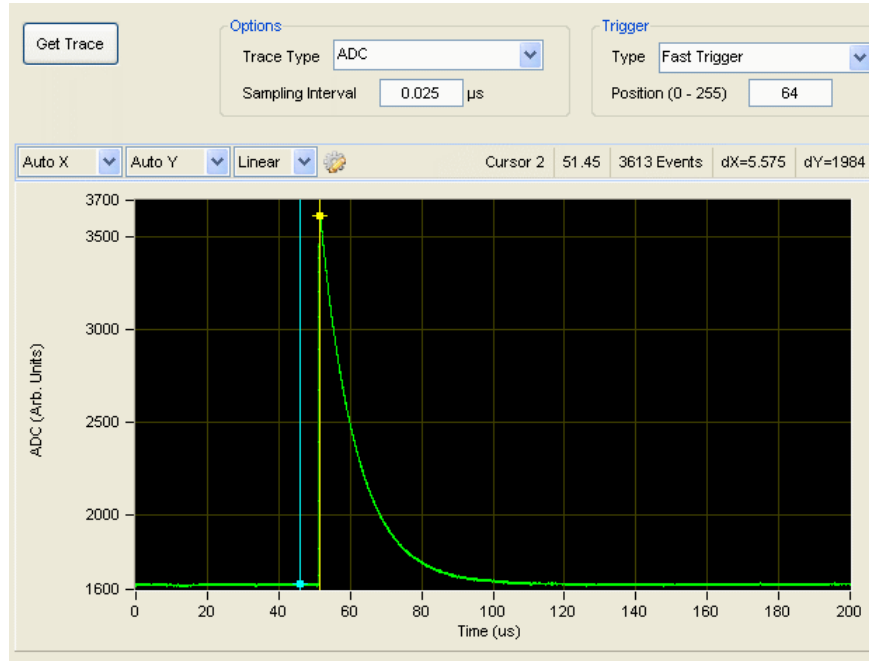


Figure 3-21: A well separated event with an amplitude of ~ 1984 vertical units.

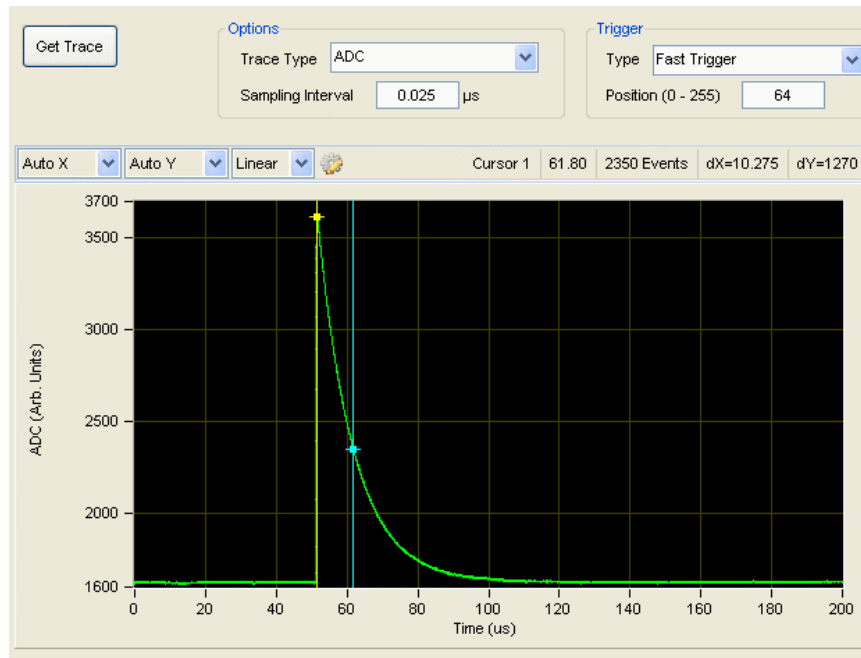


Figure 3-22: The RC decay time of the previous figure is measured to be 10.275 microseconds.

It's also instructive to take a look at the **Scaled Slow Filter** output. If the **RC Decay Time** is set properly, the trapezoid corresponding to an x-ray event should return promptly to baseline with no overshoot or undershoot as shown in Figure 3-23.

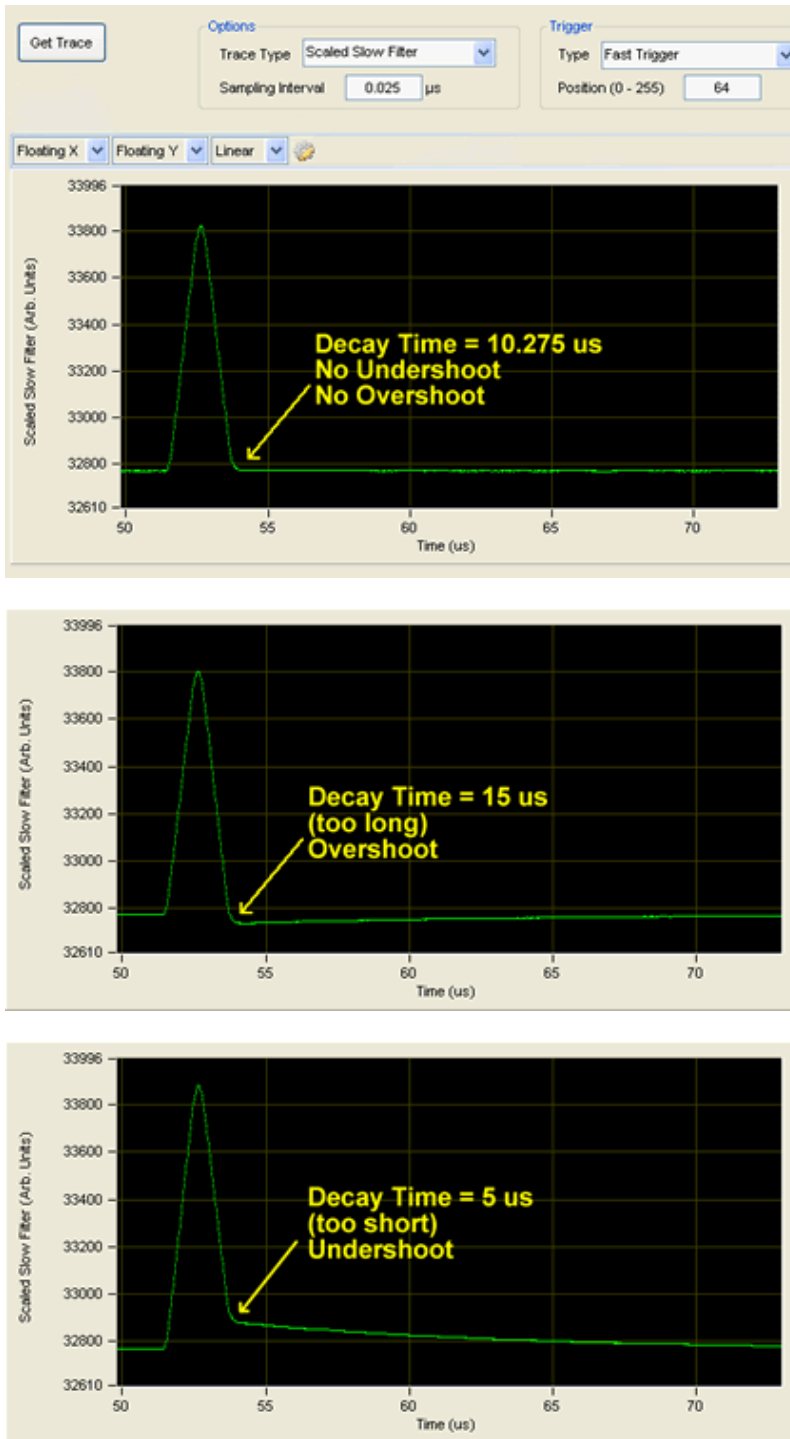


Figure 3-23: Overshoot or undershoot after the Scaled Slow Filter trapezoid indicate an incorrect RC Decay Time setting.

3.8.3.5 Trace Types

Note: all of the Trace Type signals except for **ADC** and **ADC Average** are signed 2's complement vectors. To comport with the unsigned GUI element, we've inverted the sign-bit such that 0 is shifted to 32,768, e.g. as depicted in Figure 3-23.

<i>Trace Type</i>	<i>TRACETYPE</i>	<i>Description</i>
ADC	0	The raw ADC samples (with optional inversion according to the Polarity setting)
ADC Average	1	A running average of the ADC samples, where the average length is equal to the Baseline Average Length
Fast Filter	2	The fast trigger filter output after fast baseline subtraction, scaled to the same units as the Trigger Threshold
Raw Intermediate Filter	3	The output of the intermediate baseline filter, before baseline subtraction
Baseline Samples	4	Samples of the raw intermediate filter when at baseline
Baseline Average	5	A running average of the Baseline Samples , where the average length is equal to the Baseline Average Length , that is subtracted from both the intermediate and energy filters
Scaled Intermediate Filter	6	The intermediate baseline filter after baseline subtraction and scaling by the digital gain coefficient
Raw Energy Filter	7	The output of the slow energy filter, before baseline subtraction
Scaled Energy Filter	8	The slow energy filter after baseline subtraction and scaling by the digital gain coefficient

Table 3-3: Trace Type definitions

3.8.4 Baseline Acquisition

Proper baseline acquisition and averaging is critical to the microDXP's performance. The baseline is the output response of a digital filters when no photons are present. As is standard in pulse-processing applications, baseline measurements are averaged over a time interval value that is sufficiently long to eliminate high-frequency noise, but short enough that the average tracks actual variations in the preamplifier output independent of incident photons. This average is subtracted from the instantaneous measurements of step-pulse heights, yielding improved threshold stability with count rate and the improvement in noise associated with the double-correlated pulse-height measurement.

Baseline acquisition is controlled by the **Baseline Threshold**, the number of samples averaged, or **Baseline Average Length**, and the **Reset Interval**, the time interval after each preamplifier reset during which data acquisition is disabled. The baseline is displayed in two ways: a histogram of baseline samples, i.e. the distribution of instantaneous baseline

measurements, is displayed in the **Baseline** tab. With proper settings, the baseline histogram is an accurate representation of system noise. The **Baseline Average** in the **Scope** tab displays the computed average as a function of time.

Theoretically the distribution of baseline samples is Gaussian with a constant average value. Real world detectors and preamplifiers generate several types of nonlinearities in the baseline distribution, and the mean value may wander with temperature, the rate of incident photons, etc. These effects can be addressed by reducing the number of samples in the average, or the **Baseline Average Length**, as described in §3.8.4.1, or perhaps by increasing the detector **Reset Interval** setting, as described in §3.8.3.3 above.

3.8.4.1 The Baseline Threshold

The **Baseline Threshold**, which has a 12-bit range, is used both to acquire valid baseline samples and to trigger on x-ray events in the intermediate filter. An aggressive setting can result in better sensitivity to low-energy x-rays. An overly-aggressive setting can interfere with baseline sampling and introduce a noise peak in the spectrum.

The **Baseline Threshold** is disabled by default (thresholds can be disabled by setting them to 0). See §3.7.1.3 for instructions on setting the **Baseline Threshold**. Note that the default setting, i.e. conservative **Trigger Threshold** setting with other thresholds disabled, provides little discrimination against low-energy x-ray events, thus the baseline histogram may include the soft x-ray regime of the spectrum as well as the noise peak, as in Figure 3-24. Nonetheless at low to moderate event rates the vast majority of the measurements still fall on the noise peak as intended, and the baseline average is still largely functional. At higher rates the average will be increasingly corrupted by the growing energy component in the average, resulting in a rate-dependent shift in measured event pulse-heights. This degradation disappears when the baseline threshold is set correctly.

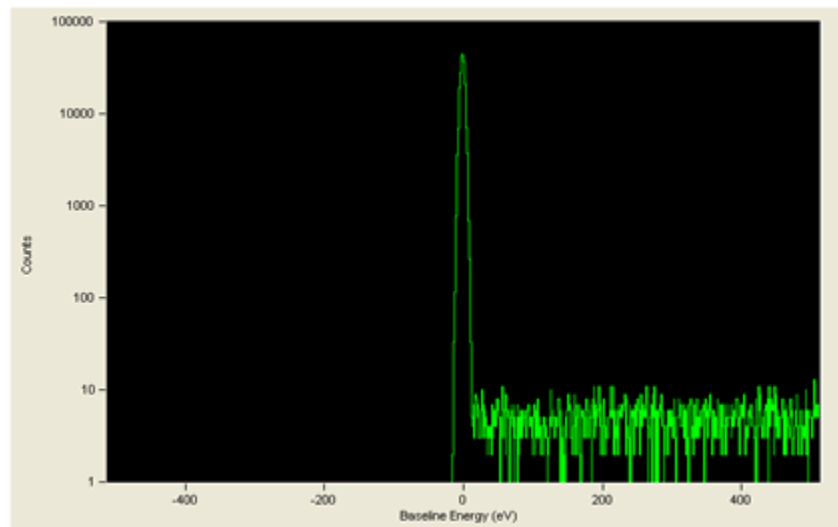


Figure 3-24: Baseline histogram acquired with very conservative threshold settings. The vertical axis is displayed on a logarithmic scale. Note the noise peak at zero, and the significant energy soft x-ray component to the right.

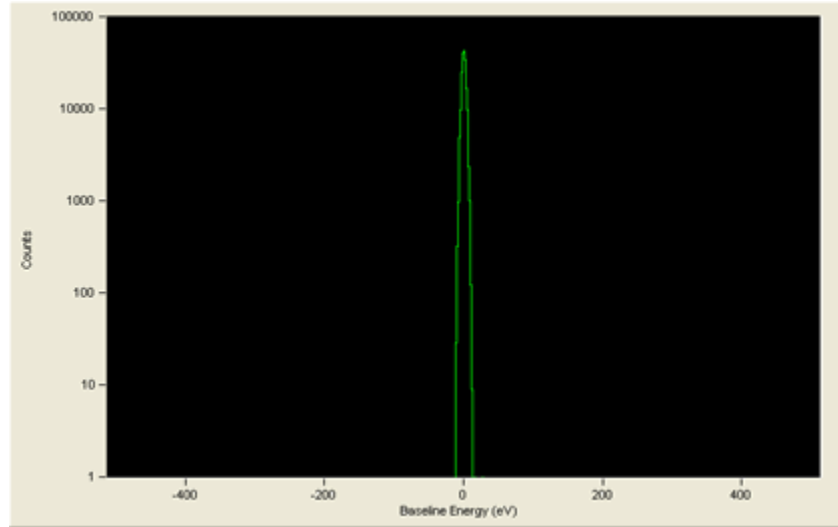


Figure 3-25: A very clean baseline histogram with thresholds set correctly—the noise peak is isolated and Gaussian in appearance.

Open the **Baseline** tab and press **[Get Baseline]** to refresh the histogram display. If the **Baseline Threshold** is set too high, part of the energy spectrum may be displayed in the baseline distribution as in Figure 3-24. If the **Baseline Threshold** is set correctly, only the noise peak should be visible. For a high quality detector and preamplifier, the noise peak should resemble a symmetric Gaussian distribution as shown in Figure 3-25.

3.8.4.2 Number of Samples in the Baseline Average

Real-world detectors and preamplifiers can produce a baseline that varies over time or voltage. A time-variant, or wandering, baseline can be mitigated by reducing the number of samples averaged, or **Baseline Average Length**. It is part of the PARSET, and thus stored on a per-peaking-time basis. Reducing the number of samples allows the average to track with the real variations in the baseline, and thus yields better accuracy. Conversely, fewer samples in the average results in less noise reduction, and thus less precision in the pulse-height measurement.

In the **Scope** tab, select **Baseline Average** from the drop-down list and press the **[Get Trace]** button. A large **Sampling Interval**, e.g. 10-100 μs , is best, because the baseline itself is only sampled periodically. Each point in the display represents the averaged baseline at that instant. The number of baseline points included in the average is determined by the DSP parameter BLFILTER according to the following equation:

$$\text{Baseline Average Length} = \frac{32768}{\text{BLFILTER}}$$

Equation 3-14

BLFILTER defaults to 64, thus the default **Baseline Average Length** is 512. We have found this to be a good balance for most detectors over a range of peaking times. At very high rates, and alternatively for lower quality detectors with significant real variations in the baseline, it is best to reduce the **Baseline Average Length**. At shorter peaking times it is often advantageous to average more points because each individual point contains a larger noise component than for longer peaking times.

1. Open the **Acquisition** tab, select desired **Baseline Average Length** from the drop-down list and press **[Apply]**.
2. Press **[Get Trace]** in the Baseline tab to refresh the display.
3. Repeat steps 1 and 2 as necessary. When the desired performance has been verified press **[Save]**. Remember that individual settings are stored and retrieved for each **Peaking Time**.

3.8.4.3 The DSP Parameters Window

All of the internal hardware settings can be viewed directly in the **DSP Parameters** window. Select **DSP Parameters...** under the **Tools** menu to open the window. Note that the values can be displayed in hexadecimal or decimal format by choosing from the drop-down list.

Values can be modified in DSP memory by directly editing a field and pressing the **[Enter]** key, however, this can have unexpected results and should only be done as directed by XIA support staff.

The screenshot shows the DSP Parameter Editor window with a table of parameters. The window has a title bar 'DSP Parameter Editor' and a menu bar with 'Export to File...' and 'Update' buttons. Below the menu bar are radio buttons for 'Hex' (selected) and 'Decimal'. The table contains 14 columns: Parameter Name, Value, Parameter Name, Value, Parameter Name, Value, Parameter Name, Value, Parameter Name, Value, Parameter Name, Value, Parameter Name, Value. The parameters listed include ADCAVGDIR, COMREADY, FQUOTIENT, CCCC, MCALIMLO, PARSET, SCA0LIMHI, STATSTART, etc.

Parameter Name	Value	Parameter Name	Value	Parameter Name	Value	Parameter Name	Value	Parameter Name	Value	Parameter Name	Value	Parameter Name	Value
ADCAVGDIR	0	COMREADY	1	FQUOTIENT	CCCC	MCALIMLO	0	PARSET	12	SCA0LIMHI	0	STATSTART	3F
ADCAVGLAST	0	COMSTART	200	FSCALE	0	MINVERSION	17	PARVERSION	3	SCA0LIMLO	0	SWGAIN	2
ADCGRADE	1	CTLBLHSTRY	0	GAINBASE	8000	MINWIDTH	4	PEAKINT	148	SCA1LIMHI	0	SWITCHPOS	0
ANLGPPOWER	0	DECIMATION	0	GAINDAC	0	NOMGAIN	4000	PEAKMODE	0	SCA1LIMLO	0	TAUCTRL	FF
AUTOSLEEP	0	DGAIN	8477	GAINMODE	3	NOMGAIN	1	PEAKSAM	140	SCA2LIMHI	0	TAURC	190
BASEBINNING	0	DGAINBASE	8477	GAINWEAK0	8000	NUMASCINTHI	0	POLARITY	1	SCA2LIMLO	0	THRESHOLD	C0
BASEEVTSHI	74	DGAINBASEEXP	0	GAINWEAK1	8000	NUMASCINTLO	2D67	PRESET	0	SCA3LIMHI	0	THRESHOLD0	C0
BASEEVTSLO	8D53	DGAINEXP	FFFF	GAINWEAK2	8000	NUMCAL	8	PRESETLENHI	0	SCA3LIMLO	0	THRESHOLD1	C0
BASELEN	400	DSPSPEED	28	GAINWEAK3	8000	NUMDRDOSHI	0	PRESETLENLO	0	SCATIMEOFF	13	THRESHOLD2	C0
BASESTART	1043	ERRINFO	0	GAINWEAK4	8000	NUMDRDOSLO	A07	RCIGSCOEFF	A3D7	SCATIMEON	13	THRESHOLD3	C0
BASETHRESH	0	EVTBLEN	400	GENCHECKSUM	0	NUMDRUPSHI	0	RCIGSEXP	FFF8	SETOFFADC	666	THRESHOLD4	C0
BASETHRESH0	0	EVTBSTART	C00	GENSET	0	NUMDRUPSL0	A1D	RCILSCOEFF	E1AE	SLEEPDELAY	5	TRACEPRETRIG	80
BASETHRESH1	0	EVTSINRUNHI	4	GENVERSION	3	NUMFIPPI	1	RCILSEXP	FFFA	SLEEPMODE	0	TRACETRIG	8
BASETHRESH2	0	EVTSINRUNLO	31A	GLOBCHECKS...	0	NUMGENSET	16	RCITSCOEFF	B8C5	SLOPEDAC	7D9F	TRACETYPE	4
BASETHRESH3	0	FASTGAP	0	GLOBVERSION	3	NUMGLOBSET	D	RCITSEXP	FFFA	SLOPESET	8000	TRACEWAIT	0
BASETHRESH4	0	FASTLEN	4	HDWRREV	4838	NUMINFO	0	RCSGSCOEFF	A3D7	SLOWGAP	8	UNDRFLOWSHI	0
BFACTOR	1	FASTPEAKSHI	4	HDWRVAR	3131	NUMPARSET	23	RCSGSEXP	FFF8	SLOWLEN	140	UNDRFLOWSL0	0
BINGRANULAR	1	FASTPEAKSLO	A1AD	HISTTYPE	0	NUMRECOVERY	0	RCLSSCOEFF	9494	SLOWTHRESH	0	USER1	A
BINMULTIPLE	2	FIPCONTROL	0	HSTLEN	1F40	NUMRESETSHI	0	RCSLSEXP	FFF9	SLOWTHRESH0	0	USER2	32
BLCUT	1	FIPCTRL	400D	HSTSTART	1443	NUMRESETSLO	CA0	RCSTSCOEFF	8586	SLOWTHRESH1	0	USER3	3FFF
BLFILTER	40	FIPDATE	7DF	INFOCHECKSUM	0	NUMSCA	0	RCSTSEXP	FFF8	SLOWTHRESH2	0	USER4	FE
BUSY	0	FIPDEC	0	INFOTAG	0	NUMSNAPSHO...	0	REALTIMEHI	0	SLOWTHRESH3	0	USER5	0
CALVERSION	0	FIPPIREV	4109	INFOVERSION	0	NUMUPSETSHI	0	REALTIMELO	849E	SLOWTHRESH4	0	USER6	0
CIRCULAR	0	FIPPIVAR	4000	INTGAP	2	NUMUPSETSLO	0	REALTIMEMID	10B	SNAPSHOT	0	USER7	0
CLEARMCA	1	FIPSET	0	INTLEN	50	NUMZIGZAGHI	0	RESETINT	1	SNAPSHOTLEN	1000	USER8	0
CLKCHOICE	0	FIPSTATUS	3FB	LIVETIMEHI	0	NUMZIGZAGLO	0	RUNACTIVE	0	SNAPSHOTST...	3000	WAKEDELAY	0
CLKDEFAULT	0	FIPVARIANT	4000	LIVETIMELO	3A61	NYQUIST	2	RUNENABLE	0	SNAPSTATLEN	E	WHICHTEST	0
CLKENABLE	1	FIPVERSION	4109	LIVETIMEMID	109	OFFSETDAC	8000	RUNERROR	0	SNAPSTATST...	3445	USER5	0
CLKSET	0	FLASHDEV	234F	MAJVERSION	4	OVERFLOWSHI	0	RUNIDENT	5	SPECTLEN	2000	USER6	0
CODEREV	417	FLASHMAKER	BF	MAXWIDTH	14	OVERFLOWSL0	1	RUNMODE	0	SPECTSTART	2000	USER7	0
CODEVAR	0	FPGAGRADE	4	MCALEN	1000	PARCHECKSUM	0	RUNTASKS	413	STATLEN	A	USER8	0
COMLEN	A00	FQUOTEXP	FFF7	MCALIMHI	FFF	PARMODE	0	RUNTYPE	2	STATSMODE	0		

Figure 3-26: The DSP Parameters window, used for diagnostic purposes.

Appendices

Appendix A microDXP Specification

This section describes the microDXP printed circuit board dimensions, hardware settings, mounting-hole and connector locations and pinouts.

A.1 Board Dimensions and Mounting

The microDXP measures 3.375" x 2.125" (as shown in Figure A-1), with four 0.120" diameter mounting holes inset by 0.175" symmetrically with respect to each of the four corners. These mounting holes are intended for use with 4-40 or equivalent screws.

A.2 Preamplicifier Type Selector Switch

The location of the miniature two-position slide switch S1 is displayed in Figure A-1. The two positions are silkscreen-labeled **RESET** and **RC**. Select **RESET** for reset-type preamplifiers. Select **RC** for RC-feedback preamplifiers. Note that the setting must match both your detector preamplifier and the firmware that is installed in non-volatile memory, as indicated in the **Preamplifier Type** field in the **Detector** tab. Please contact XIA if you have the wrong type of firmware installed.

A.3 Input Signal Attenuation

The voltage range of the preamplifier signal must not exceed the input range of the microDXP, excluding reset transients that may exceed the range for a few microseconds. The input range is specified below in Table A.1. To accommodate preamplifiers with an output range in excess of +/-4V Volts, a finite attenuation option is included in the microDXP input circuitry. The input voltage range can be increased to +/-5.5 Volts by removing the solder from RG1 and shorting with solder the two pads of RG2 together. By default the microDXP is shipped with +/-4.0V input range, i.e. with RG1 shorted and RG2 open.

<i>Attenuation Setting</i>	<i>Absolute Maximum Input Voltage</i>	<i>Input Impedance</i>
Default – 0dB Attenuation (RG1 short, RG2 open)	+/- 4.0 V	10 KOhms
Option – 2.7dB Attenuation (RG1 open, RG2 short)	+/- 5.5 V	655 Ohms
Custom	Customer-defined	Customer-defined

Table A-1: The microDXP analog input range depends on the board revision and attenuation setting (Revision C only).

A.4 Connector Locations and Pinouts

As depicted in Figures A-1 and A-2, there are three options for the input signal conductor: twisted-pair (J1), coaxial (J4) or board-to-board (J7). There are also two options for power, communications and auxiliary digital I/O, which is redundantly accessible on two separate connectors: a flat-flex cable (J12) for low and medium speed serial communications and a board-to-board connector (J11) that offers serial protocols as well as high-speed parallel access. Finally, there is a new on-board USB 2.0 option.

The flex-cable interconnect supports RS-232 at 115kbaud, with burst rates up to 10 Kbytes/sec, and Analog Devices DSP serial port (SPORT) communications for faster data transfers, up to 2 Mbytes/sec. The SPORT option is targeted for multi-channel systems and will require some user hardware and DSP code development.

The board-to-board connector supports RS-232 and SPORT serial communications, as well as parallel IDMA access to DSP memory for transfer rates up to 10 Mbytes/sec. This parallel IDMA interface is used as the basis for the microCOMU USB interface.

The latest microDXP hardware includes an on-board mini-USB 2.0 interface (J8), simplifying the implementation design process for embedded systems. The customer need only provide power and auxiliary digital I/O connections via the flat-flex cable or board-to-board connector.

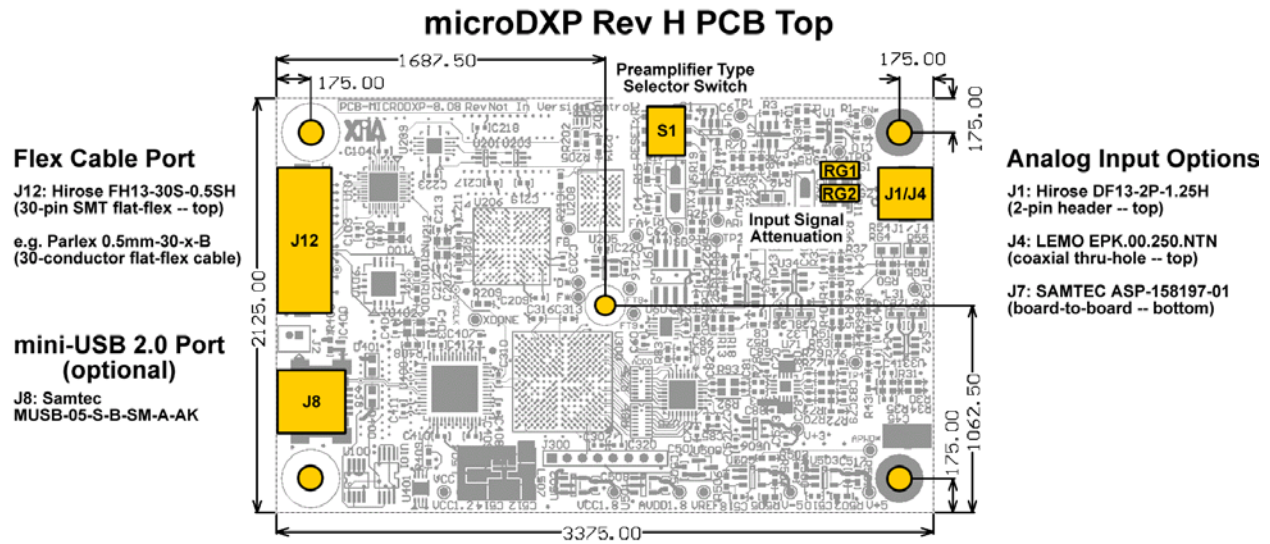


Figure A-1: microDXP connector locations and part numbers, TOP SIDE.

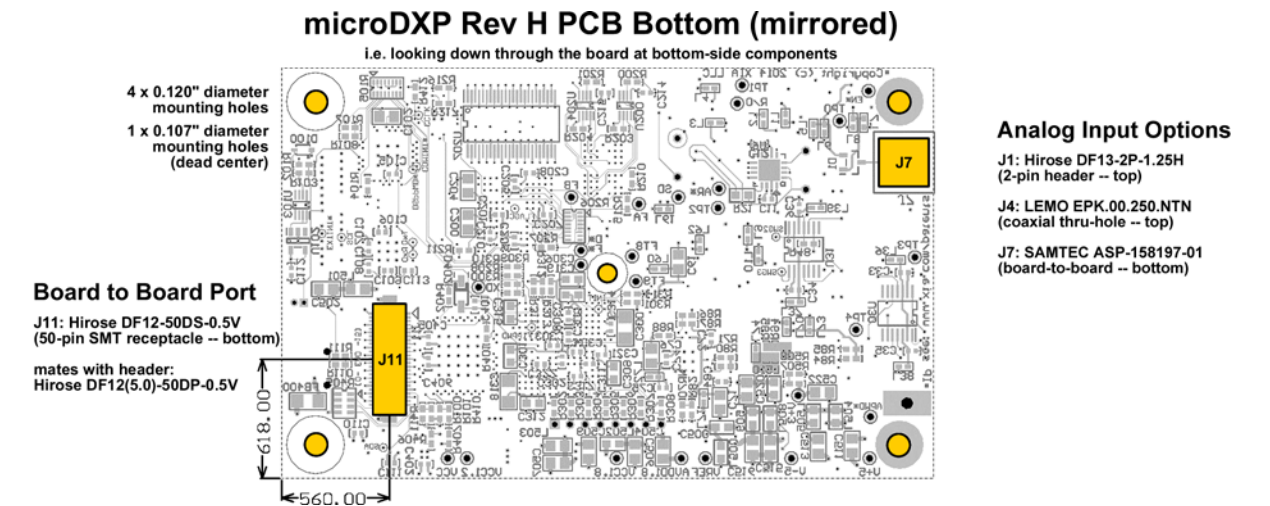


Figure A-2: microDXP connector locations and part numbers, BOTTOM SIDE (mirrored).

J1 - Analog Input: 2-pin SMT right-angle header (TOP SIDE) Hirose P/N: DF13-2P-1.25H (mating P/N: DF13-2S-1.25C; crimp contact P/N: DF13-2630SCFR)		
Pin #	Name	Description
1	SIGNAL	Preamplifier output signal
2	GND	Internal ground connection

Table A-2: Pin assignments for the 2-conductor SMT header analog input connection.

J4 - Analog Input: thru-hole coaxial (TOP SIDE) LEMO P/N: EPK.00.250.NTN		
Pin #	Name	Description
Center	SIGNAL	Preamplifier output signal
Outer	GND	Internal ground connection

Table A-3: Pin assignments for the 2-conductor coaxial analog input connection.

J7 - Analog Input: board-to-board (BOTTOM SIDE) SAMTEC P/N: ASP-158197-01 (mating P/N: HLS-0303-G-12)		
Pin #	Name	Description
Center	SIGNAL	Preamplifier output signal
Outer	GND	Internal ground connection

Table A-4: Pin assignments for the board-to-board analog input connection.

J12 – Flex Cable Port: 30-conductor, 0.5mm locking flex-cable connector; carries power, communications and auxiliary digital I/O Hirose P/N: FH12-30S-0.5SH (e.g. flat-flex cable, Parlex P/N: 0.5MM-30-x-B)		
Pin #	Name	Description
1	+AVDD	Positive DC supply voltage for analog signal conditioner: Regulated +5.0V; or unregulated +5.5V if on-board regulator present.
2	-AVSS	Negative DC supply voltage for analog signal conditioner: Regulated -5.0V; or unregulated -5.5V if on-board regulator present.
3	GND	Internal ground connection
4	+3.3VCC	+3.3V DC supply for on-board digital components.
5	+3.3VCC	+3.3V DC supply for on-board digital components.
6	GND	Internal ground connection
7	SDA	I ² C data line
8	SCL	I ² C clock
9	ExtInt*	External interrupt line, active low.
10	Gate*	Inhibits data acquisition, active low.
11	GND	Internal ground connection
12	RX	RS-232 host receive (microDXP→host)
13	TX	RS-232 host transmit (host→microDXP)
14	GND	Internal ground connection

15	Vprog	PIC programming voltage
16	ProgData	PIC programming data line
17	ProgClk	PIC programming clock
18	Aux0	Auxiliary configurable digital I/O line: connects to FiPPI
19	Aux1	Auxiliary configurable digital I/O line: connects to FiPPI
20	GND	Internal ground connection
21	Aux2	Auxiliary configurable digital I/O line: connects to FiPPI
22	Aux3	Auxiliary configurable digital I/O line: connects to FiPPI
23	+3.3VCC	+3.3V DC supply for on-board digital components.
24	SPORT_CLK	DSP serial port clock line (ADSP218x SPORT)
25	GND	Internal ground connection
26	SPORT_TDATA	DSP serial port transmit data line (ADSP218x SPORT)
27	SPORT_TFS	DSP serial port transmit frame sync line (ADSP218x SPORT)
28	GND	Internal ground connection
29	SPORT_RDATA	DSP serial port receive data line (ADSP218x SPORT)
30	SPORT_RFS	DSP serial port receive frame sync line (ADSP218x SPORT)

Table A-5: Pin assignments for the 30-conductor flat-flex interconnect

J11 – Board-to-Board Port: 50-conductor, 0.5mm mezzanine board-to-board receptacle; carries power, communications and auxiliary digital I/O Hirose P/N: DF12-50DS-0.5V (microCOM mating header P/N: DF12(5.0)-50DP-0.5V)		
Pin #	Name	Description
<i>Odd-numbered pins (top to bottom along the right-side of the connector as shown in Figure A-2)</i>		
1	+3.3VCC	+3.3V DC supply for on-board digital components.
3	+3.3VCC	+3.3V DC supply for on-board digital components.
5	+3.3VCC	+3.3V DC supply for on-board digital components.
7	GND	Internal ground connection
9	EAD15	IDMA data/address I/O line (MSB)
11	EAD14	IDMA data/address I/O line
13	EAD13	IDMA data/address I/O line
15	EAD12	IDMA data/address I/O line
17	EAD11	IDMA data/address I/O line
19	EAD10	IDMA data/address I/O line
21	EAD9	IDMA data/address I/O line
23	EAD8	IDMA data/address I/O line

25	EAD7	IDMA data/address I/O line
27	EAD6	IDMA data/address I/O line
29	EAD5	IDMA data/address I/O line
31	EAD4	IDMA data/address I/O line
33	EAD3	IDMA data/address I/O line
35	EAD2	IDMA data/address I/O line
37	EAD1	IDMA data/address I/O line
39	EAD0	IDMA data/address I/O line (LSB)
41	GND	Internal ground connection
43	EWR*	IDMA write strobe (Active LO)
45	ESel*	IDMA device select INPUT (must be asserted LO to communicate with the microDXP)
47	ERdy*	IDMA data ready (Active LO) OUTPUT
49	ERD*	IDMA read strobe (Active LO)
<i>Even-numbered pins (top to bottom along the left-side of the connector as shown in Figure A-2)</i>		
2	+AVDD	Positive DC supply voltage for analog signal conditioner: Regulated +5.0V; or unregulated +5.5V if on-board regulator present.
4	-AVSS	Negative DC supply voltage for analog signal conditioner: Regulated -5.0V; or unregulated -5.5V if on-board regulator present.
6	+3.3VCC	+3.3V DC supply for on-board digital components.
8	GND	Internal ground connection
10	SPORT_RFS	DSP serial port receive frame sync line (ADSP218x SPORT)
12	SPORT_RDATA	DSP serial port receive data line (ADSP218x SPORT)
14	GND	Internal ground connection
16	SPORT_TFS	DSP serial port transmit frame sync line (ADSP218x SPORT)
18	SPORT_TDATA	DSP serial port transmit data line (ADSP218x SPORT)
20	GND	Internal ground connection
22	SPORT_CLK	DSP serial port clock line (ADSP218x SPORT)
24	GND	Internal ground connection
26	Aux3	Auxiliary configurable digital I/O line: connects to FiPPI
28	Aux2	Auxiliary configurable digital I/O line: connects to FiPPI
30	Aux1	Auxiliary configurable digital I/O line: connects to FiPPI
32	Aux0	Auxiliary configurable digital I/O line: connects to FiPPI
34	Gate*	Inhibits data acquisition, active low.
36	SCL	I ² C clock

38	SDA	I ² C data line
40	GND	Internal ground connection
42	RX (B)	RS-232 host receive (microDXP→host) via serial port B
44	TX (B)	RS-232 host transmit (host→microDXP) via serial port B
46	GND	Internal ground connection
48	EA/D*	IDMA address (HI) / data (LO) selector INPUT
50	ExtInt*	External interrupt line, active low.

Table A-6: Pin assignments for the 50-conductor board-to-board interconnect

A.5 Power Supplies

The microDXP requires three supply voltages to operate. A supply voltage of +3.3V is used to directly power most on-board digital circuitry, with minimal LC filtering at the board entry point. On-board voltage regulators also generate other digital supply voltages. The total current requirement depends on the selected clock speed. The ripple requirements for this supply are not particularly stringent, though excessive radiated noise is to be avoided. If a switching supply is used, it should be well shielded from the microDXP.

By default, supply voltages of +/-5.5V are regulated on-board by default to generate +/-5.0V to power the analog components. This configuration tolerates ~100mV pk-pk from the switching supplies.

<i>Voltage Range</i>	<i>Current (max)</i>	<i>Description</i>
+3.3V +/- 150mV	200mA	Decent switching supply
+5.5V to +6.0V	30mA	Linear or good switching supply
-5.5V to -6.0V	30mA	Linear or good switching supply

Table A-7: Power supply specifications for the default microDXP assembly.

The microDXP can optionally receive +/-5.0V directly with a custom assembly build, i.e. with on-board regulators omitted. In this case either linear or very high quality switching supplies with less than 20mV pk-pk ripple/noise should be used. Contact XIA for details.

<i>Voltage Range</i>	<i>Current (max)</i>	<i>Description</i>
+3.3V +/- 150mV	200mA	Decent switching supply
+5.0V +/- 100mV	30mA	Linear or very good switching supply
-5.0V +/- 100mV	30mA	Linear or very good switching supply

Table A.8: Power supply specifications for the microDXP with on-board regulators omitted.

Appendix B Auxiliary I/O Functions

This Appendix briefly describes the auxiliary hardware functions that can be exercised on the MicroCOM interface board. Note that the connector and pin locations differ for the microCOMU and microCOMV-UFF. For corresponding microDXP pin locations on the flat-flex and board-to-board connectors, refer to the microDXP Technical Reference Manual.

Signal	microCOMU Location J5 TE Connectivity 5-104363-5	microCOMV-UFF Location J4 TE Connectivity 5-104363-4

GATE	Pin 1	Optional LEMO at location J5 (bottom)
AUX[0]	Pin 5	Pin 4
AUX[1]	Pin 4	Pin 3
AUX[2]	Pin 3	Pin 2
AUX[3]	Pin 2	Pin 1
GND	Pin 6	Pin 5

Table B-1: Realtime digital I/O pin assignments

B.1 GATE* Input

The GATE* signal is a logic-level input that disables data acquisition when asserted (LO). This function is the simplest implementation for real time external control of data acquisition. The GATE* signal is routed to a header on the microCOMU, and to a LEMO connector on the MicroCOMV-UFF, as defined in the table above.

B.2 Configurable I/O Lines

Four general-purpose digital I/O lines connected to the FPGA on the microDXP are accessible on the carrier board as shown in the table above. By default, they are defined as SCA pulser outputs, but may be redefined via custom firmware.

B.4 I2C Bus

The peripheral I2C port allows for pass-thru control and/or readout of external devices. For example, an external DAC could be controlled via the microDXP, or an external thermometer could be read. The microDXP reserves address 1001000 for an on-board temperature sensor and 1010010 for a serial EEPROM. Note: currently only 7-bit I2C addresses are supported. The I2C bus can be accessed via a header on the microCOM carrier card as shown below.

Signal	microCOMU Location J3 TE Connectivity 5-104363-3	microCOMV-UFF Location J3 TE Connectivity 5-104363-3
SDA	Pin 3	Pin 3
SCL	Pin 2	Pin 2
GND	Pin 1	Pin 1
Power	+5V @ Pin 4	+3.3V @ Pin 4

Table B-2: Peripheral I2C bus pin assignments

The I2C pass-thru read/write command can be exercised via the Handel DLL or directly via command 0x40. It is not available in ProSpect.

Appendix C System Development Outline

The microCOM board constitutes a simple routing adapter interface providing power and communications access to the microDXP hardware as well as hardware access to some auxiliary I/O for the purposes of development, and serves test platform and design example for those users developing their own interface. This section describes the various options available and issues that must be considered if they are implemented.

The development process can be broken down as follows:

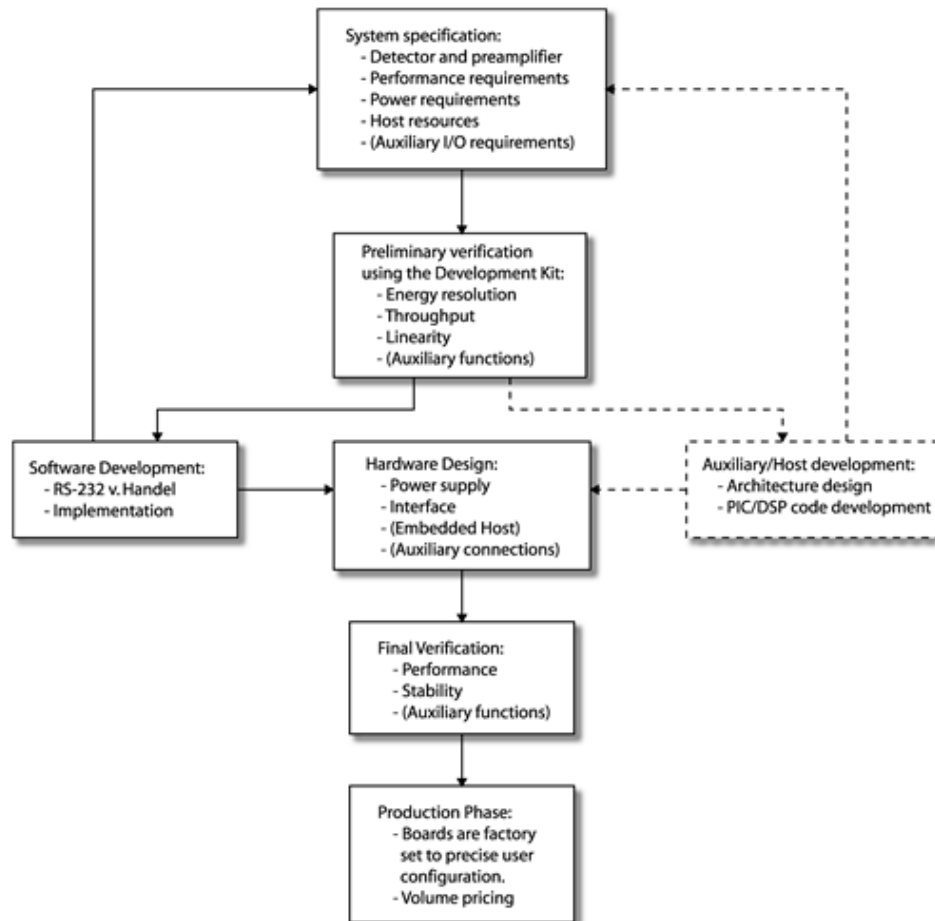


Figure B-1: Overview of development process for systems incorporating the microDXP.

1. **Preliminary Specification:** The detector and preamplifier are chosen. Basic performance goals are specified including energy resolution, throughput and nonlinearities. Power requirements are calculated. Host is specified and resources are calculated. Standard options such as clock speed(s) and variable gain are selected. Special functions, which may use the Auxiliary I/O, are defined. Preliminary consultation with an XIA engineer. Initial quotation is given based upon microDXP configuration, volume and required support level. The microDXP and Development Kit are purchased.

2. **Preliminary Verification:** Preliminary data acquisition using the microCOM hardware interface and ProSpect software. Energy resolution, throughput and linearity verified. Limited auxiliary functions explored.
3. **Software Development:** Implement low-level RS-232 commands for data acquisition. Decide whether to implement configuration command set. Choice is made based upon available host resources and time-to-market considerations. Code is implemented and tested with the microCOM hardware interface. Level of XIA software development support depends on the application.
4. **Auxiliary I/O Development:** Auxiliary circuitry such as I2C components are defined. PIC/DSP code is developed and tested using the MicroCOM, where possible—Note: some auxiliary functions cannot be exercised with the MicroCOM hardware interface. XIA extended support is required for systems that exercise auxiliary functions.
5. **Revised Specification:** Performance and functionality specifications are revised as necessary subsequent to preliminary development and testing. Follow-up consultation with an XIA engineer. Quotation updated to reflect any changes from preliminary specification.
6. **Hardware Design, Manufacture and Test:** Power supply for the microDXP, detector and preamplifier, a routing adapter or embedded host and optional auxiliary circuitry are designed, manufactured and individually tested.
7. **Final Verification:** Complete system test using the customer's hardware and software. Design revisions made as necessary. Level of XIA hardware troubleshooting support depends on the application.
8. **Production:** microDXP hardware options and quality-control test procedures fixed, delivery schedule established. microDXP's are shipped with precise firmware configuration (including all parameter settings) specified by customer.