



Instruments That Advance The Art

Pixie-4 Express

Software Manual

- NMISA Customization -

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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 Pixie module and connected equipment. This safety information applies to all operators and service personnel.

Specific Precautions

Observe all of these precautions to ensure your personal safety and to prevent damage to either the Pixie module or equipment connected to it.

Power Source

The Pixie module is powered through a PXI Express (PXIe) chassis. Please refer to the chassis manual for the correct AC voltage connections. The chassis must be powered down to insert and remove the module.

User Adjustments/Disassembly

To avoid personal injury, and/or damage, always turn off power before accessing the Pixie module's on-board switches and jumpers.

Detector and Preamplifier Damage

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

Voltage Ratings

Signals on the analog inputs (gold SMA connectors) must not exceed $\pm 3.5V$. Exceptions apply for certain attenuation and termination settings, see Appendix.

Signals on the digital inputs (gold MMCX connector and 10-pin 2mm har-link connector) must not exceed 3.3V.

Servicing and Cleaning

To avoid personal injury, and/or damage to the Pixie module or connected equipment, do not attempt to repair or clean these units. These modules 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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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.
"window"	Text in quotation refers to window titles, and quotations from other sources	"Options" indicates the window accessed via Tools»Options .
<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</i> the preamplifier risetime...
<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
SMALL CAPS	SMALL CAPS are used for panels/windows/graphs in the GUI.	...go to the MCADISPLAY panel and you see...

1 Introduction

The Pixie-4 Express is designed, among other things, to acquire list mode data from coincident events in multiple radiation detectors. The methods to set up and acquire such coincident data, and basic functions to view results, are described in the Pixie-4 Express User's Manual. A number of special coincidence spectra and counters have been implemented for NMISA. These functions are described in this document.

1.1 Pixie-4 Express NMISA Functions

- Incrementing 16 double coincidence counters, DCn
- Incrementing 16 triple coincidence counters, TCn
- Accumulate separate spectra for singles, double coincidences, and triple coincidences for a channel
- Export as ASCII text (csv)
- Offline reprocessing of data to reproduce coincidence counters and spectra

1.2 System Requirements

The advanced energy plotting functions require the Pixie Viewer software (version 4.32 or higher) and Wavemetrics' Igor Pro (version 6.22 or higher).

1.3 Software Overview

The advanced energy plotting functions are contained in an Igor procedure file (ipf). After starting the Pixie Viewer as described in the User's Manual, the procedure file must be loaded to make use of the functions. See section 2 for details.

The offline functions operate on list mode data files acquired previously. They can (currently) not be used for processing during acquisition.

All controls are consolidated in the USER_CONTROL, panel shown in Figure 3-1

1.4 Support

Please read through this manual before contacting us. Contact information is listed in the first few pages of this manual.

1.5 Principle of Operation

In the standard firmware, the Pixie-4e detects rising edges in the detector signals and issues triggers. In the standard coincidence run type (0x402, group mode), for each trigger it records all channels' pulse data (pulse height, timestamps, coincidence and status flags, etc). As there are 4 channels, a set of 4 pulse heights and 4 timestamps (etc) is recorded for each rising edge from any detector. In the following, this data set is called an event. As the NMISA system has only 3 detectors, they are assumed to be connected to inputs 1, 2, and 3 of the Pixie-4e module, and input 0 will be not connected. The entries for the channel 0 will therefore always be zero (and also the entries for active channels that have no pulse in a given event), but the zero entries are simply ignored.

When setting up the data acquisition, the user can specify:

- A minimum energy $E_{min}(A)$ for each channel ($A=1..3$) and the channel A_n
- 16 pulse height thresholds E_n , each applied to an arbitrary channel B_n ($n=0..15$) and the channel B_n
- 4 pulse height ranges $R_{low}(m)$ to $R_{high}(m)$, ($m=0..3$). R_{high} can be equal to the maximum possible pulse height for an “above threshold” measurement, or it can be a finite number for a “within range” measurement, e.g. a photopeak in the MCA spectrum.
- The channel C_n and the range R_n which are used in the triple coincidence counter.

During data acquisition, for each event, the Pixie-4e:

- Increments double coincidence counters DC_n if pulse height $E(B_n)$ is above threshold E_n AND pulse height $E(A_n)$ is above $E_{min}(A_n)$; ($A_n = 1..3$, $B_n=1..3$, $n=1..15$)
- Increments triple coincidence counters TC_n if pulse height $E(B_n)$ is above threshold E_n AND pulse height $E(A_n)$ is above $E_{min}(A_n)$ AND pulse height $E(C_n)$ is within $R_{low}(R_n)$ to $R_{high}(R_n)$.
- Increments coincidence spectra in addition to the standard singles spectra:

<code>ch1_sgl</code>	= channel 1 singles
<code>ch1_dc12</code>	= channel 1's energies if ch.1 and ch.2 are in coincidence
<code>ch1_dc13</code>	= channel 1's energies if ch.1 and ch.3 are in coincidence
<code>ch1_tc123</code>	= channel 1's energies if ch.1, 2, and 3 are in coincidence
<code>ch2_sgl</code>	... etc ...
<code>ch2_dc12</code>	
<code>ch2_dc23</code>	
<code>ch2_tc123</code>	
<code>ch3_sgl</code>	
<code>ch3_dc13</code>	
<code>ch3_dc23</code>	
<code>ch3_tc123</code>	

After data acquisition, the software

- Reports the counter values and spectra as a .csv text file
- Provides offline routines to parse through list mode data and extract coincidences, incrementing the same spectra and counters as the online DSP.

2 Installation

The custom functions are distributed in a zip file that provides additional files to the standard software distribution. To “install”, go through the following steps

- Install Igor Pro and the Pixie Viewer software as described in the User’s Manual
- Copy the files `User_NMISA.ipf` and `Pixie_NMISA.pxp` from the zip file into the top level folder of the Pixie software distribution, typically `C:/XIA/Pixie4e`
- Copy any `.set` files from the zip file to the Configuration folder of the Pixie software distribution, typically `C:/XIA/Pixie4e/ Configuration`.
- Copy any `.pdf` files from the zip file to the Docs folder of the Pixie software distribution, typically `C:/XIA/Pixie4e/Docs`.
- Open the Pixie Viewer variant by double clicking `Pixie_NMISA.pxp`
- In the PIXIE START UP panel, click [**Start Up System**] or [**Offline Analysis**] to initialize the software.
- Open the USER_CONTROL panel by selecting top menu **XIA » User_Control**

3 Data acquisition settings

3.1 Required Usage of Standard Settings

For the NMISA custom functions, the data must be acquired in run type 0x402. Please see section 4.2.1 of the user manual for details. In particular, please remember that the following parameter restriction must be observed in the settings:

- same trace length and energy filter length for all channels
- MCA binning factor should be 3 or more to ensure the energies are binned into the 8Ki MCA without being cut off
- Allow only one record per CW

This provides a more compact data file where pulses that follow closely no longer create multiple records; instead the data is assembled in a single record. The drawback, relevant usually only in high count rate situations, is that if more than one pulse occurs within the CW in the same channel, only the first pulse is recorded.

The following two options are always enabled in run type 0x402, independent of the checkbox settings:

- enable group trigger for all channels to record data synchronously
- enable option for MCA sum histogram

The options of gating, vetoing, accepting out-of-range or piled up pulses apply to the whole set of 4 channels. So for example, if one out of 4 channels is piled up, nothing is recorded for any channel unless pileup rejection is turned off for that channel. It is best to disable pileup rejection and to allow out of range events initially, in particular for the unused channel 0.

The coincidence settings can be freely selected: If only real coincidences are of interest, check only the boxes in the coincidence tab that match the desired hit pattern and set the **Window Width** appropriately to the experiment (e.g. accommodating cable delays, time of flight delays, etc.). The Pixie module will then only record those events. But if file size and throughput are of no importance, it is equally possible to record all events (**Allowed Hit Patterns** = 0xFFFFE) and have the offline routines filter out coincidences.

All other settings work as in the standard data acquisition, i.e. ensure gain and offsets are set properly, decay time tau is correct, etc.

3.2 NMISA specific settings

The screenshot shows the 'User_Control' window with the following sections:

- NMISA Input Parameters:**
 - E min:** Ch.1 Emin: 100, Ch.2 Emin: 100, Ch.3 Emin: 100.
 - Options:** ModCSRB: 200, ☒ Enable NMISA DSP code.
 - Thresholds:** A grid of 15 rows (E0-E15) and 3 columns (A, B, C) with range for C. Values range from 100 to 10000.
 - Ranges for triple coincidence:** R low 0: 100, R high 0: 60000, R low 1: 100, R high 1: 60000, R low 2: 100, R high 2: 60000, R low 3: 100, R high 3: 60000. Buttons: Show Emin in MCA, Show Thresholds in MCA, Show Ranges in MCA, Hide All. applied to ch. 1.
- NMISA DAQ Options:** Repeat DAQ: 3, Start Repeat Run button.
- Coincidence Counts:**

DC counts	DC rates	TC counts	TC rates
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9
10	10	10	10
11	11	11	11
12	12	12	12
13	13	13	13
14	14	14	14
15	15	15	15

Buttons: Update, Show MCA. Coinc. Count Time: 0.
- Offline Processing:** Process offline, Table, File: nmisa0036.b00, Find button.

Figure 3-1: The USER_CONTROL panel.

The USER_CONTROL panel (top menu **XIA » User_Control**) shows the settings and results for NMISA type runs. Input parameters are on the left, results and additional controls are on the right.

Input parameters include

- Minimum energy Emin for each channel
- DSP options (ModCSRB).
Currently there is only one option, to enable the NMISA specific functions. Use the checkbox to set or clear bit 9.
- Thresholds En for channel B
- Ranges for triple coincidences Rlow(m) to Rhigh (m)
- Choice of channel for A, B and C for each counter DCn and TCn.
Valid range: 1..3
- Choice of energy range for each counter TCn
Valid range: 0..4

The **results block** includes

- Total counts of the double coincidence counter. In each row n , the *DC count* is the number of events for which $E(A_n) > E_{min}(A_n) \text{ AND } E(B_n) > E_n$
- The count rate for each double coincidence counter, i.e. DC count / counting time
- Total counts of the triple coincidence counter. In each row n , the *TC count* is the number of events for which $E(A_n) > E_{min}(A_n) \text{ AND } E(B_n) > E_n \text{ AND } E(C_n)$ within the range R_n
- The count rate for each double coincidence counter, i.e. DC count / counting time
- The control button **[MCA]** opens a plot of the singles and coincidence spectra. Standard Igor functions can be used to zoom in/out, change colors and symbols, etc.
- The control button **[Update]** refreshes the counter values and spectra with the current state of counters and spectra in the module.

Multiple data acquisitions in short sequence can be started with the **[Start Repeat Run]** button. Specify the number of repeated runs in the field **Repeat DAQ**.

The thresholds and limits can be visualized in the MCA spectrum using the **[Show Emin in MCA]**, **[Show Thresholds in MCA]**, and **[Show Ranges in MCA]** buttons. Ranges and thresholds are applied to the channel selected under **applied to ch** (each channel can be set to a different binning factor which will affect the mapping of threshold energy to MCA bin). The thresholds can be removed from the MCA with the **[Hide All]** button.

For offline processing, first specify the file to process in the **File** field. Then click **[Process Offline]**. Igor will go through the file and increment counters and spectra, updating plots and displayed periodically. The list of energies can be displayed as a **[Table]**. The offline routine uses the same input parameters from the USER_CONTROL panel as the online processing, and shows the results in the same counters and spectra.

Important Notes:

- Do not change input parameters during an acquisition.
- Do not start the offline processing routine while a data acquisition is in progress.
- Internal energies are computed in a range of 0..64K. All user defined thresholds are applied on the same scale. However, in energy spectra, energies are divided by 2^N to ensure the entire energy range is mapped in the available MCA bins. For example, as the coincidence spectra have only 8K bins, $N=3$ by default and a peak with internal energy $E=16,000$ will fall into MCA bin 2,000. So to specify a range around the peak for ch.1 shown in Figure 4-1 at bin 2000,
 Rlow must be $\sim 1900 * 8 = 15200$, and
 Rhigh must be $\sim 2100 * 8 = 16800$.
 The binning factor N can be adjusted in the **Advanced** tab of the Pixie-Viewer's standard panels.

4 Results

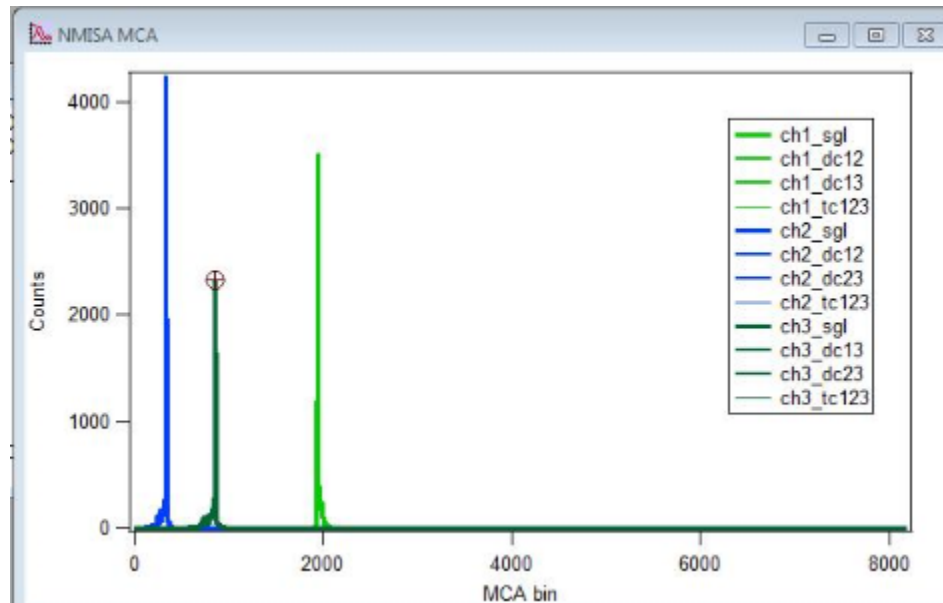


Figure 4-1: Coincidence MCA spectra.

The results of the coincidence processing is shown in the output section of the USER_CONTROL panel and the MCA spectrum display.

The spectra, counters and settings are also saved as CSV text files automatically when the data acquisition has been finished. These are in addition to the standard binary files. The binary files should not be deleted since they contain the raw data used for offline re-processing.

4.1 Spectra Files

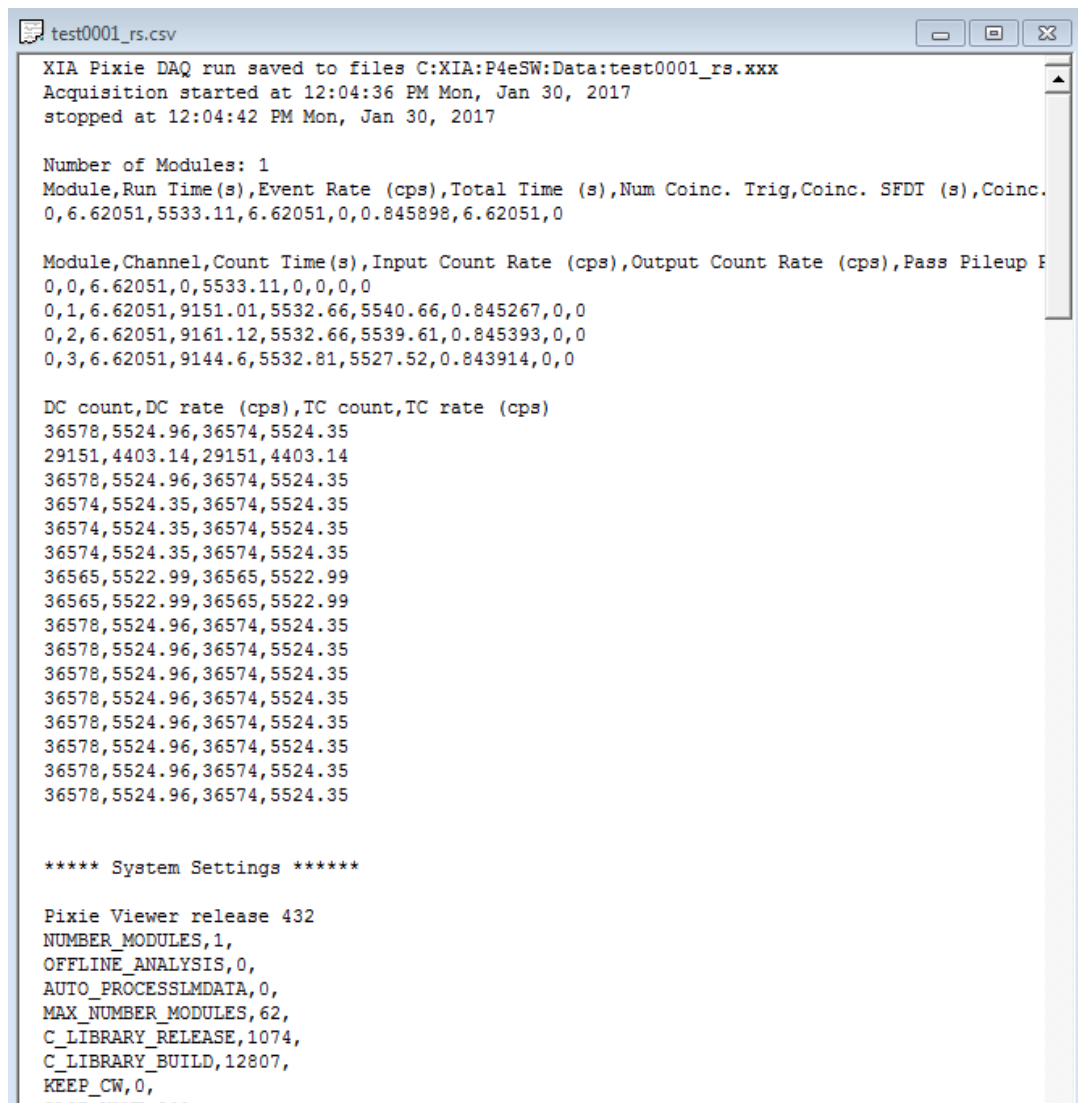
The spectra are saved in a file named `basename|number|.mca.csv`. Basename and number are specified before the data acquisition in the **Run Control** tab of the Pixie-Viewer's standard panels. The file contains a header line with the name of the spectra, followed by 8192 values.

```
test0001_mca.csv
ch1_sgl,ch1_dc12, ch1_dc13,ch1_tc123,ch2_sgl,ch1_dc12, ch2_dc23,ch2_tc123,ch3_sgl,ch3_dc13, ch3_dc23,ch3_tc123
0,0,0,0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0
0,0,0,0,6,0,0,0,0,0,0,0,0
5,0,0,0,7,0,0,0,0,0,0,0,0
4,0,0,0,0,0,0,0,0,0,0,0,0
1,0,0,0,4,0,0,0,0,0,0,0,0
0,0,0,0,3,0,0,0,0,0,0,0,0
0,0,0,0,2,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0
0,0,0,0,2,0,0,0,0,0,0,0,0
4,0,0,0,2,0,0,0,0,0,0,0,0
0,0,0,0,1,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0
0,0,0,0,2,2,0,0,0,0,0,0,0
0,0,0,0,1,1,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0
```

4.2 Counter Files

Counter values and settings are saved in a file named `basename|number|_rs.csv`. Basename and number are specified before the data acquisition in the **Run Control** tab of the Pixie-Viewer's standard panels. The file contains

- 3 lines listing file names and start/stop time of the PC, followed by an empty line
- 3 lines of module-wide counts, rates and times, followed by an empty line
The “counting time” used to compute double and coincidence counter rates is the *Coinc. Count time*.
- 5 lines of standard channel-specific counts, rates and times, followed by an empty line
- 17 lines of coincidence counts and rates, as shown in the output section of the USER_CONTROL panel
- A list of all module input and output parameters



```

test0001_rs.csv
XIA Pixie DAQ run saved to files C:\XIA\P4eSW\Data:test0001_rs.xxx
Acquisition started at 12:04:36 PM Mon, Jan 30, 2017
stopped at 12:04:42 PM Mon, Jan 30, 2017

Number of Modules: 1
Module,Run Time(s),Event Rate (cps),Total Time (s),Num Coinc. Trig,Coinc. SFDI (s),Coinc.
0,6.62051,5533.11,6.62051,0,0.845898,6.62051,0

Module,Channel,Count Time(s),Input Count Rate (cps),Output Count Rate (cps),Pass Pileup F
0,0,6.62051,0,5533.11,0,0,0,0
0,1,6.62051,9151.01,5532.66,5540.66,0.845267,0,0
0,2,6.62051,9161.12,5532.66,5539.61,0.845393,0,0
0,3,6.62051,9144.6,5532.81,5527.52,0.843914,0,0

DC count,DC rate (cps),TC count,TC rate (cps)
36578,5524.96,36574,5524.35
29151,4403.14,29151,4403.14
36578,5524.96,36574,5524.35
36574,5524.35,36574,5524.35
36574,5524.35,36574,5524.35
36574,5524.35,36574,5524.35
36565,5522.99,36565,5522.99
36565,5522.99,36565,5522.99
36578,5524.96,36574,5524.35
36578,5524.96,36574,5524.35
36578,5524.96,36574,5524.35
36578,5524.96,36574,5524.35
36578,5524.96,36574,5524.35
36578,5524.96,36574,5524.35
36578,5524.96,36574,5524.35
36578,5524.96,36574,5524.35
36578,5524.96,36574,5524.35

***** System Settings *****

Pixie Viewer release 432
NUMBER_MODULES,1,
OFFLINE_ANALYSIS,0,
AUTO_PROCESSLMDATA,0,
MAX_NUMBER_MODULES,62,
C_LIBRARY_RELEASE,1074,
C_LIBRARY_BUILD,12807,
KEEP_CW,0,
STOP_TIME,000
  
```

5 Implementation Details

This section provides information about the implementation of the NMISA special functions. This is mainly intended to preserve the approach take for future improvements and upgrades, either by XIA or the end user.

In the Pixie Viewer, the NMSIA functions plug into the standard user functions that are executed before, during, and after the run. Functions customized are

- `User_Control()`
Added new controls and buttons, and updated associated functions to update parameters to/from C library and DSP
- `User_StopRun()`
Added code to save mca and counter values in csv files
- `NMISA_MCA()`
`NMISA_ShowTH`
New function to display singles and coincidence spectra, and to add thresholds to the MCA
- `NMISA_Repeat_StartRun()`,
`NMISA_Repeat_CheckRun()`,
`NMISA_Repeat_StopRun(0)`
New functions to start, poll, stop repeated runs. Derived from equivalent functions in main code
- `NMISA_file_getEdata()`
`NMISA_file_readIFM()`
New functions to read list mode data from file
- `NMISA_process_makethewaves()`
`NMISA_process_file()`
`NMISA_List()`
New functions to parse list mode data, look for coincidences, increment counters and spectra

A number of new variables are defined for I/O with the C library and Pixie-4e module, and others are used in new ways. These variables are

NMISA variable	Igor display variable	C global	DSP parameter
Emin 1-3	FCFDTH	Channel_Parameter_Value “FCFD_THRESHOLD”	DSPTH
E 0-15	User_In	Module_Parameter_Value “User_In”	USERIN
A 0-15 B 0-15 C 0-15 R 0-15	An Bn Cn Rn	Channel_Parameter_Value CH_EXTRA_IN each variable takes 2 bits	CHEXTRAIN0 USHARE
Rlow 0-3 Rhigh 0-3	Extra_In	Module_Parameter_Value “Extra_In”	EXTRAIN
DC/TC	User_Out Extra_Out	Module_Parameter_Value “User_Out” “Extra_Out”	UEXTRAOUT