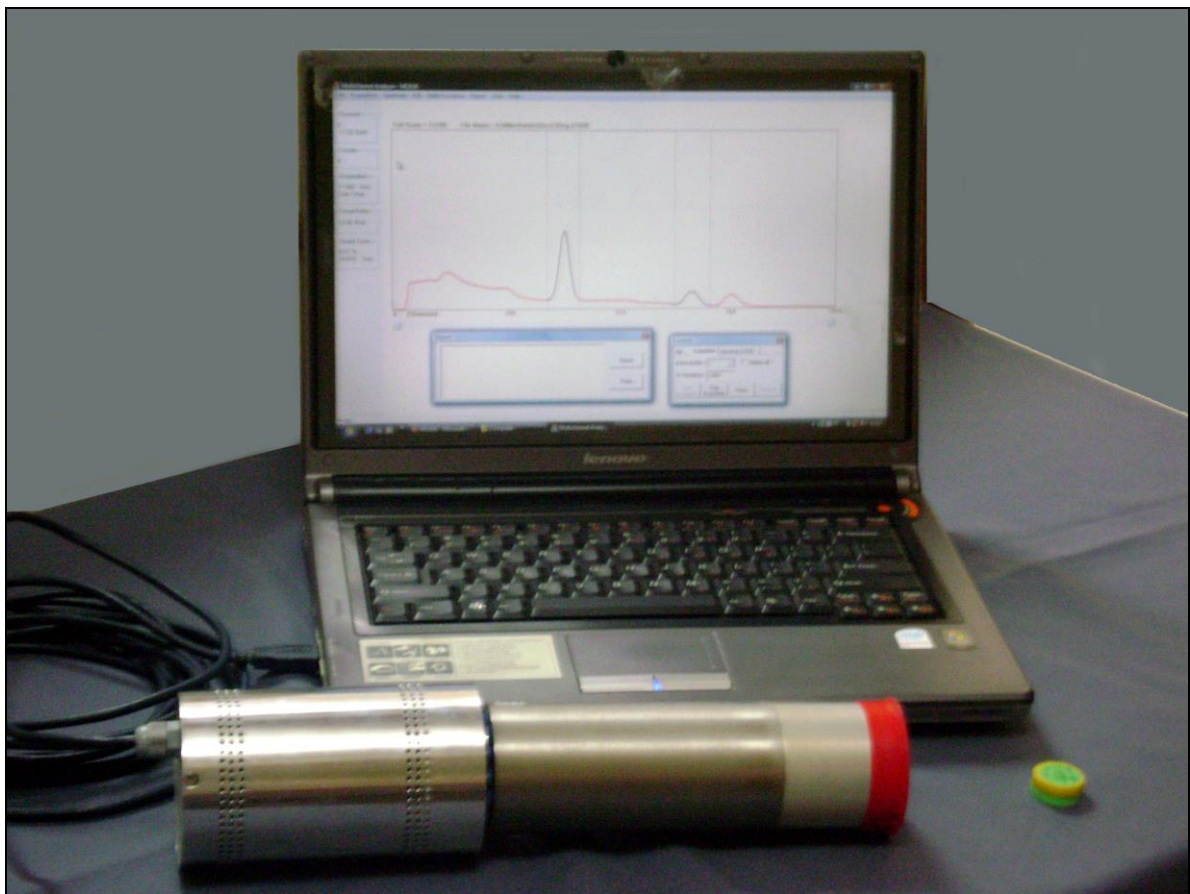


LUDLUM MODEL 730, 732 & 733
PC-based Gamma Ray Spectroscopy System

November 2021

Version 2.35

INSTRUCTION MANUAL:
LUDLUM MODEL 730, 732 & 733
Version – 2.35
PC based Gamma Ray Spectroscopy System



STATEMENT OF WARRANTY

Ludlum Measurements, Inc. warrants the products covered in this manual to be free of defects due to workmanship, material, and design for a period of twelve months from the date of delivery. The calibration of a product is warranted to be within its specified accuracy limits at the time of shipment. In the event of instrument failure, notify Ludlum Measurements to determine if repair, recalibration, or replacement is required.

This warranty excludes the replacement of photomultiplier tubes, G-M and proportional tubes, and scintillation crystals which are broken due to excessive physical abuse or used for purposes other than intended.

There are no warranties, express or implied, including without limitation any implied warranty of merchantability or fitness, which extend beyond the description of the face there of. If the product does not perform as warranted herein, purchaser's sole remedy shall be repair or replacement, at the option of Ludlum Measurements. In no event will Ludlum Measurements be liable for damages, lost revenue, lost wages, or any other incidental or consequential damages, arising from the purchase, use, or inability to use product.

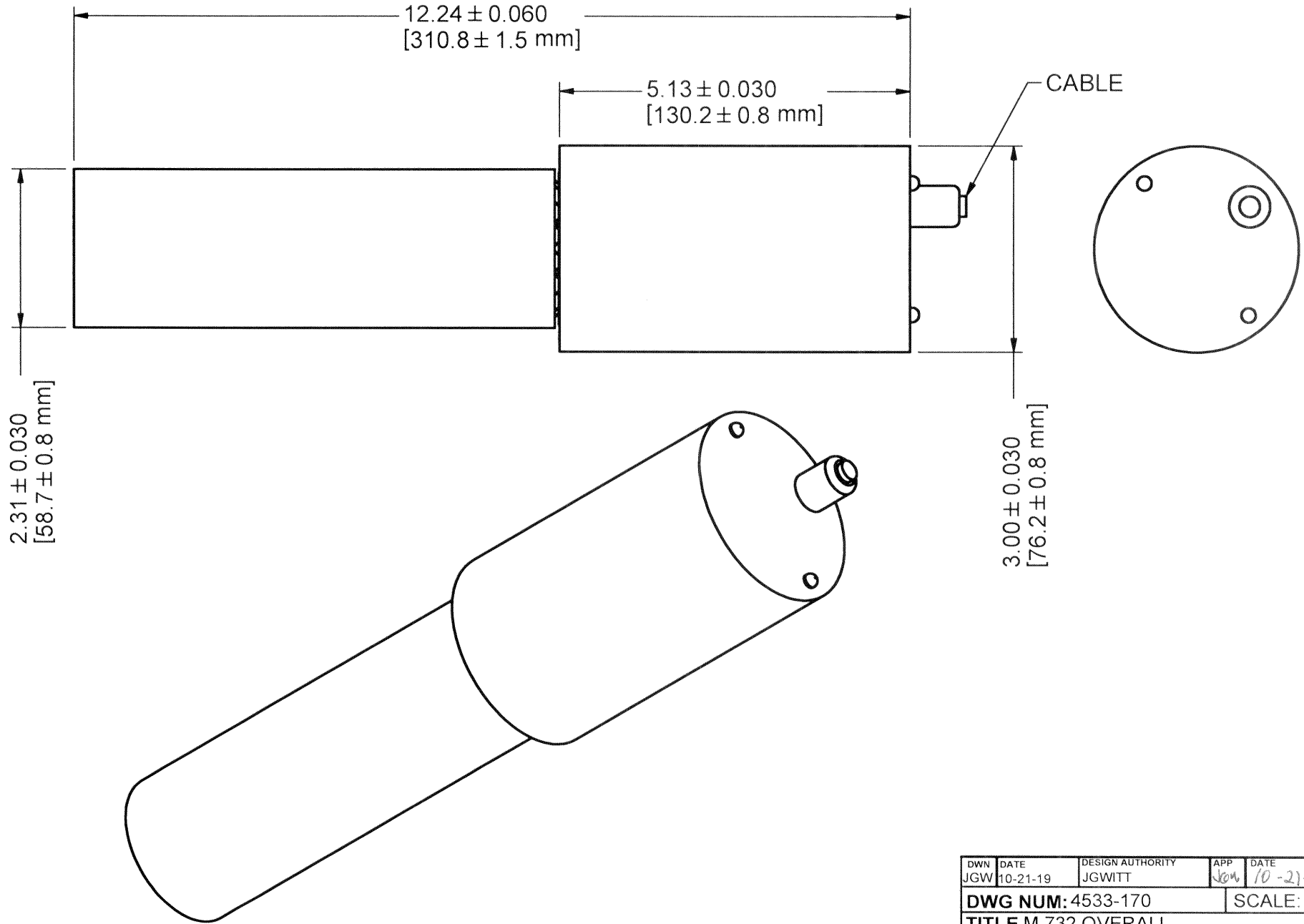
RETURN OF GOODS TO MANUFACTURER

If equipment needs to be returned to Ludlum Measurements, Inc. for repair or calibration, please send to the address below. All shipments should include documentation containing return shipping address, customer name, telephone number, description of service requested, and all other necessary information. Your cooperation will expedite the return of your equipment.

**LUDLUM MEASUREMENTS, INC.
ATTN: REPAIR DEPARTMENT
501 OAK STREET
SWEETWATER, TX 79556**

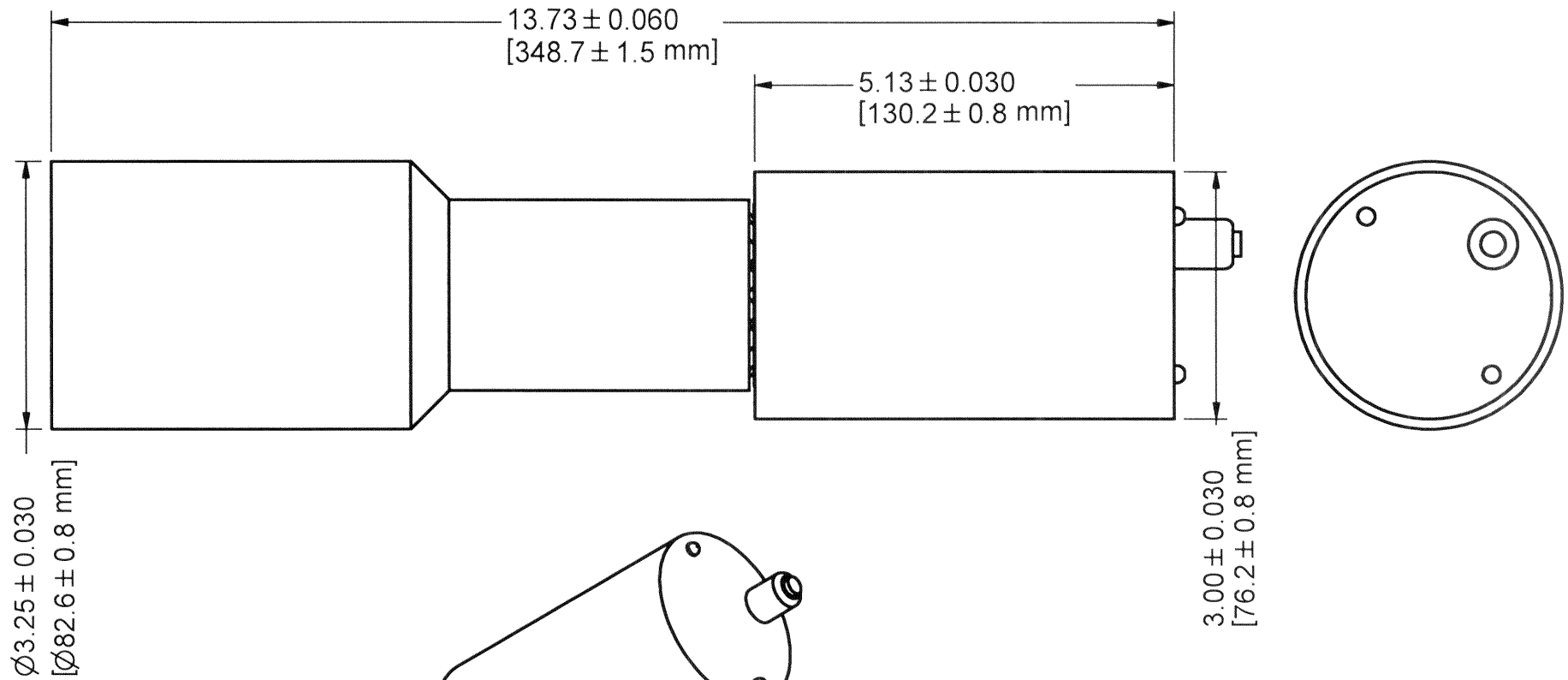
**800-622-0828 325-235-5494
FAX 325-235-4672**


REVISION HISTORY			
REV	DESCRIPTION	DATE	BY
1	VALID	10-21-19	JGW



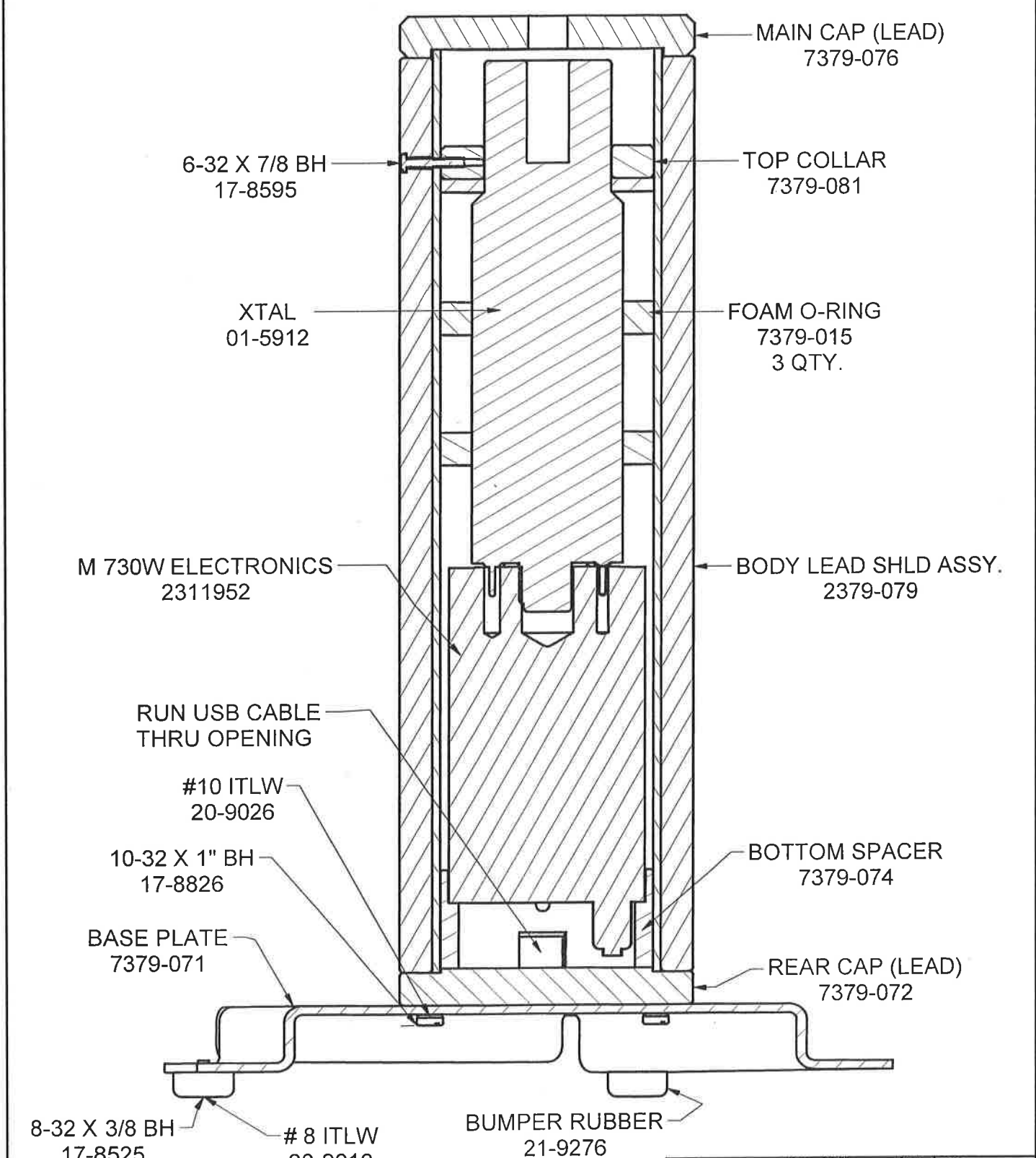
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JGW	10-21-19	JGWITT	JGW	10-21-19
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TITLE M 732 OVERALL				
 LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556		SERIES	SHEET	
		533	170	

REVISION HISTORY			
REV	DESCRIPTION	DATE	BY
1	VALID	10-21-19	JGW



DWN	DATE	DESIGN AUTHORITY	APP	DATE
JGW	10-21-19	JGWITT	NW	10-21-19
DWG NUM: 4533-169			SCALE: 1/2	
TITLE M 733 OVERALL				
 LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556		SERIES	SHEET	
		533	169	

REVISION HISTORY			
REV	DESCRIPTION	DATE	BY
1	VALID	6/20/2012	ADG



DWN	DATE	CHK	DATE	APP	DATE
ADG	06/20/2012			Jaw	6-25-12
DWG NUM: 4379-070				SCALE: 1/1.2	
TITLE M 243-3 WELL COUNTER					
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556			SERIES	SHEET	
			379	70	

INSTRUCTION MANUAL:
LUDLUM MODEL 730, 732 and 733, Version 2.35

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1.0 GENERAL INFORMATION

The LUDLUM MODEL 730 is a gamma-ray spectroscopy system intended to be used with a NaI (TI) detector. It consists of a 1K multi-channel analyzer, software-controlled high-voltage supply, PMT base preamplifier, and spectroscopy amplifier with ADC.

The LUDLUM MODEL 730 is a PC-based gamma ray Spectroscopy system, which communicates with PC through USB port. Data Acquisition and Control is through PC based application software, SAAS (Spectrum Acquisition and Analysis Software).

The LUDLUM MODEL 730 has a built-in 14-Pin PMT base. The voltage divider and pulse processing circuitry is housed as front-end electronics. This PMT base makes it compatible with any NaI (TI) detector with standard 14-Pin PMT.

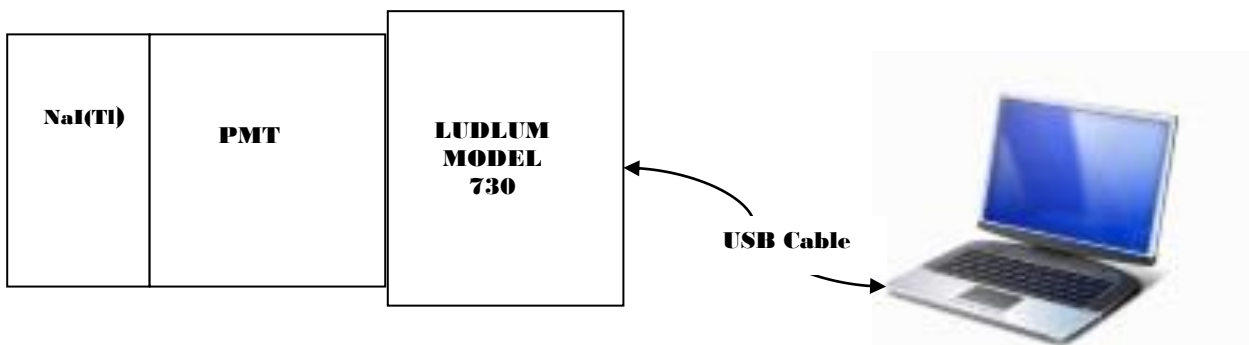
The LUDLUM MODEL 730 is powered through USB port, and hence no external cable (apart from USB cable from PC or laptop) is necessary. The requirement of simple, PC-based gamma ray spectroscopy system is fulfilled by LUDLUM MODEL 730, and hence it positions itself as an important, yet easy-to-operate tool in any nuclear instrument laboratory, including an R & D organization, nuclear power plant, or an educational institution.

The Model 730 electronics may also be sold with attached NaI detectors. The Model 732 and 733 are similar with minor differences. The Model 732 uses a 2 x 2 in. Model 44-11 detector. The Model 733 uses a 3 x 3 in. Model 44-20 detector. Both have integral-line construction.

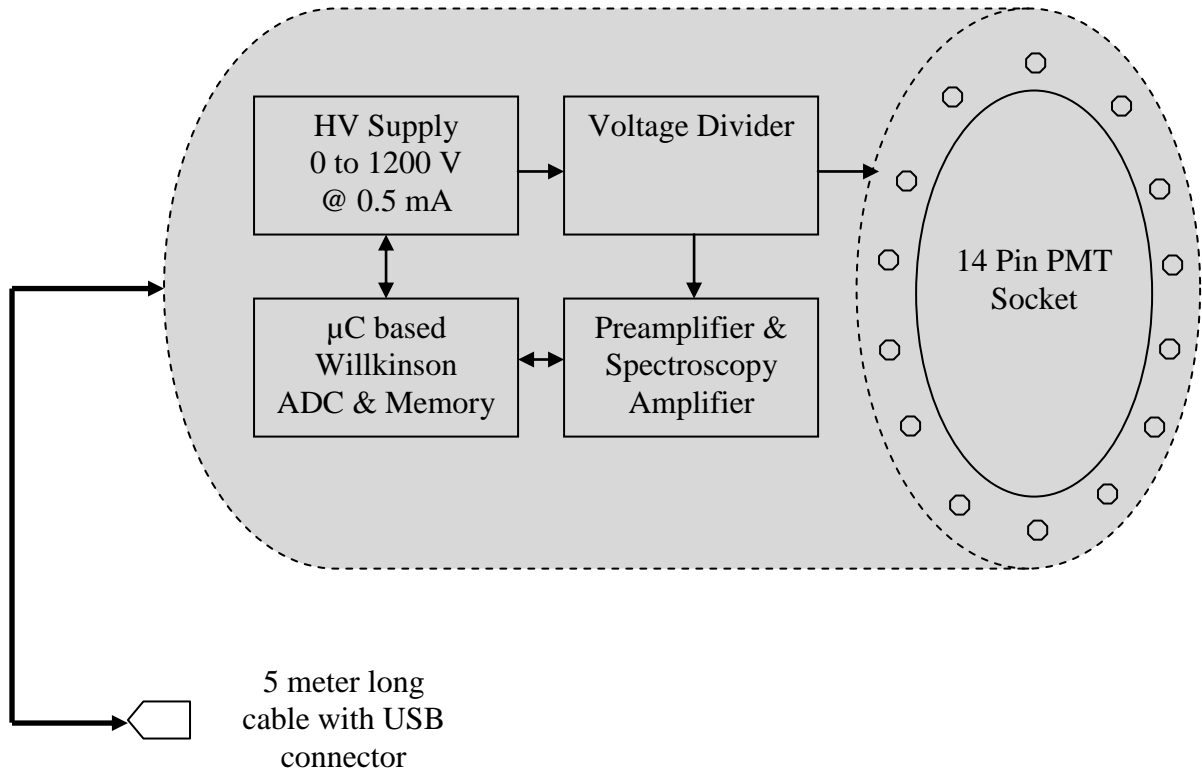
1.1 System Description

A block diagram of the system is shown below. It consists of following constituents.

- a. NaI (TI) Scintillation Detector (not a part of LUDLUM MODEL 730)
- b. LUDLUM MODEL 730
- c. PC or Laptop (not a part of the LUDLUM MODEL 730, supplied as an option at extra cost)



Block Diagram of Gamma Ray Spectroscopy System



Block Diagram of LUDLUM MODEL 730

A preamplifier requires +9 V and -9 V supply. A NaI (TI) detector PMT requires around 1000 Vdc. These voltages are generated by DC-DC convertors operating on 5 Vdc supply from USB port. Power supply for the instrument consists of +5 V for digital circuits and +9 V and -9 V, for analog circuits. High-voltage supply is generated by programmable HV module. It can generate HV up to 1200 Vdc.

High voltage is fed to the PMT through an anode load resistor. This HV is also applied to a dynode chain of 510K resistors. The output is taken from the anode and is coupled through a high-voltage DC decoupling capacitor. This output is fed to the common emitter configuration preamplifier where the signal is buffered and is connected to the input of the spectroscopy amplifier.

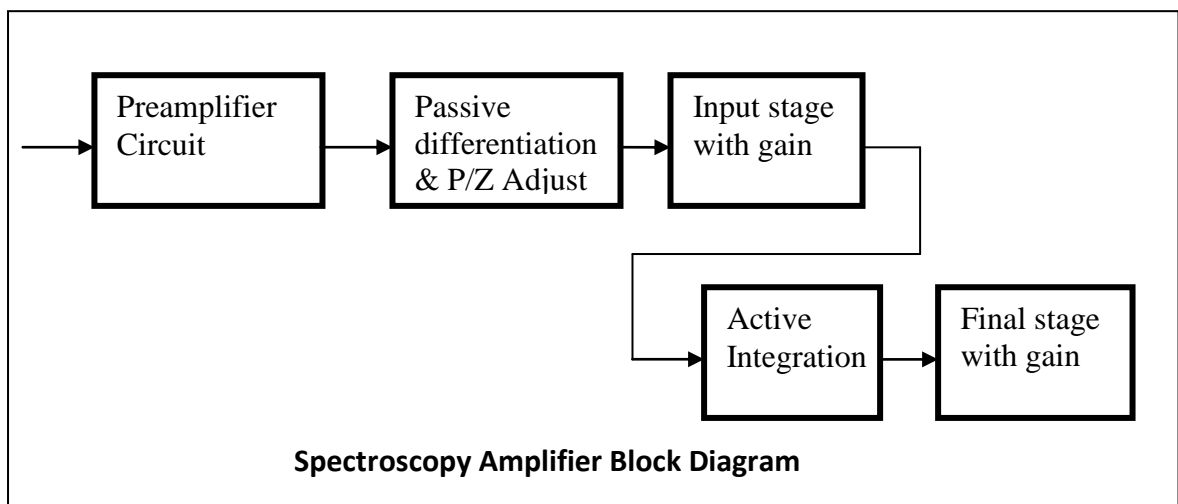
Rise time of the amplifier output is 1 μ S. Amplifier output is then given to 10-bit Wilkinson type ADC. Necessary signals for control of ADC are generated by the micro controller. This controller also handles the USB communication with the PC. Spectrum collected by the 1K channel MCA is first stored in the internal memory of the micro-controller. Then after every second, the spectrum is transferred to the software package, which runs on the PC. The spectrum collected by the LUDLUM MODEL 730 is displayed on the PC screen. Many

other features, like data acquisition and analysis, are available in the package. The full package is described in the next sections of this document.

1.2 Instrument

A preamplifier circuit consists of a three-stage transistor, an emitter-follower type amplifier with buffer. This circuit provides good buffering between the detector output and the front end of the spectroscopy amplifier.

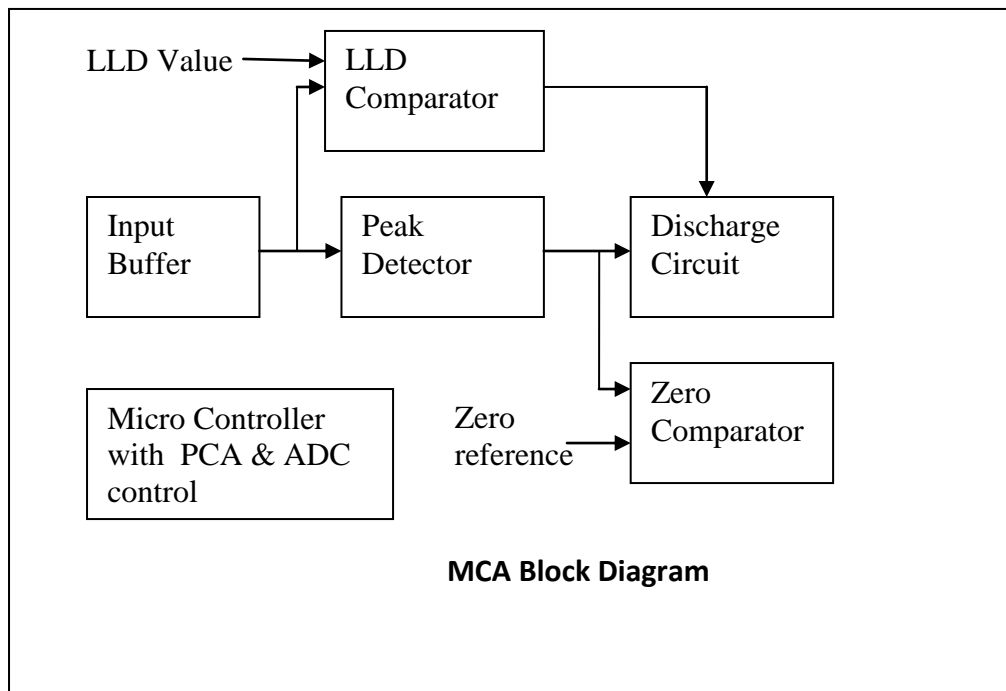
The power supply for the spectroscopy amplifier and 1K multi-channel analyzer is inside the instrument. Preamplifier output goes to the spectroscopy amplifier. The block diagram of the spectroscopy amplifier is shown here.



The spectroscopy amplifier shapes positive input pulses received from the preamplifier. These pulses have fast rise-time and slow fall-time. Pulses undergo passive differentiation and pole zero adjustment. This differentiation is followed by an active integration stage followed by a final stage. The output pulse is near Gaussian, with amplitude settable to +6 V. FINE gain internally sets the pulse amplitude suitable for the ADC input range. Typical output setting would be to get an undistorted output pulse of height around 1.5-2 V for a 660 KeV ¹³⁷Cs source. The rise time of the output pulse is around 1 μsec. This circuitry cuts off the long tail off the output pulse and allows separation of successive pulses effectively.

The HV supply requirement of PMT is 0 to 1200 V maximum. Voltage output can be set to desired value up to 1200 Vdc by software setting.

Output of the spectroscopy amplifier is connected to the input stage of 1K multi-channel analyzer. A block diagram of multi-channel analyzer is shown here.



A 10-bit Wilkinson type ADC is used in the multi-channel analyzer. The spectroscopy amplifier output is given to the input buffer stage. Buffer output is then given to the peak detector circuit. The peak detector circuit charges the silver mica-capacitor to a peak value. At the peak of the input signal, PEAK signal is generated. This signal acts as an interrupt to the micro controller. The micro-controller has a programmable counter array and a 48-MHz, built-in clock. On receiving peak signal, the controller starts the PCA. The 48-MHz system clock is given to the PCA as an input clock. The controller generates a "busy" signal, which blocks further input to the ADC until conversion of the pulse is complete. It also generates a DISCHARGE signal for the discharge circuit. The discharge circuit generates a linear ramp. The capacitor voltage is simultaneously applied to the zero detector circuit. It compares the discharge ramp with the reference level. The comparator generates ZERO signal when the ramp crosses the reference level. The ZERO signal again interrupts the controller. The controller stops the PCA at this point. Pulses measured by PCA during the PEAK and ZERO signals are the channel number.

Peak signal will not be generated if the peak value of the signal is below the LLD value.

Apart from controlling the ADC, the micro controller also handles the USB communication with the PC. It transfers the spectrum to the PC on receiving the request.

2.0 SPECIFICATIONS

Signal Input Configuration

14-Pin base for standard NaI (TI) scintillation detector, built-in voltage divider network, preamp for NaI (TI) detector

High Voltage Power Supply

0-1200 Vdc, 0.5 mA, software programmable in 256 steps, ripple < 30 mV (p-p)

Spectroscopy Amplifier

1 μ sec semi-Gaussian shaping with internal PZ adjust, gain setting x 10 settable by screw driver, output 0-5 V semi-Gaussian, connected internally to ADC input

ADC

1K channel Wilkinson type, 48 MHz clock frequency, conversion time 20 μ sec for FS input

Power Supply

From USB port of PC/laptop, 4.75 V @ 450 mA

Data Acquisition and Analysis Software

Acquisition and display of gamma spectrum, expand, contract, scroll, cursor movement energy calibration, ROI selection, peak analysis, spectrum stabilization, stripping, smoothing, normalization, spectrum storage, and retrieval on PC/laptop

Optional

GPS coordinates can be displayed and stored along with spectrum data if GPS module is connected.

Mechanical


Dimensions : 76 x 125 mm (3.0 x 4.9 in.) (Dia x H) cylindrical aluminum housing with 14-pin PMT socket, weight approximately 1 kg (2.2 lb)

Interconnecting Cable

5 m (16.4 ft) long cable with USB connector

3.0 CONNECTOR DETAILS

4 Pin USB Connector

Sr No	Pin Number	Description	
1	1	+5 V	
2	2	D -	
3	3	D +	
4	4	Ground	

4.0 INSTALLATION

4.1 Unpacking and Handling

Carefully unpack the instrument. Please notify the factory or nearest sales office immediately in case of any physical damage noticed or if the received material is not matching with the packing list.

Check for any physical damage to the instrument. In case of any physical damage during transportation, **DO NOT CONNECT LUDLUM MODEL 730** to PC or laptop, and notify the factory or nearest sales office immediately.

If there is no physical damage to LUDLUM MODEL 730, it is now safe to connect it to a USB port of PC or laptop. However, it is necessary to install the software on your PC/laptop before LUDLUM MODEL 730 can be connected to it. Please refer to “Software Installation” (Section 5) to proceed further.

4.2 Power Requirement

LUDLUM MODEL 730 works on power drawn from a USB port. Typical power requirement is 4.75 V @450 mA. No external power is required.

5.0 OPERATION

5.1 Requirements

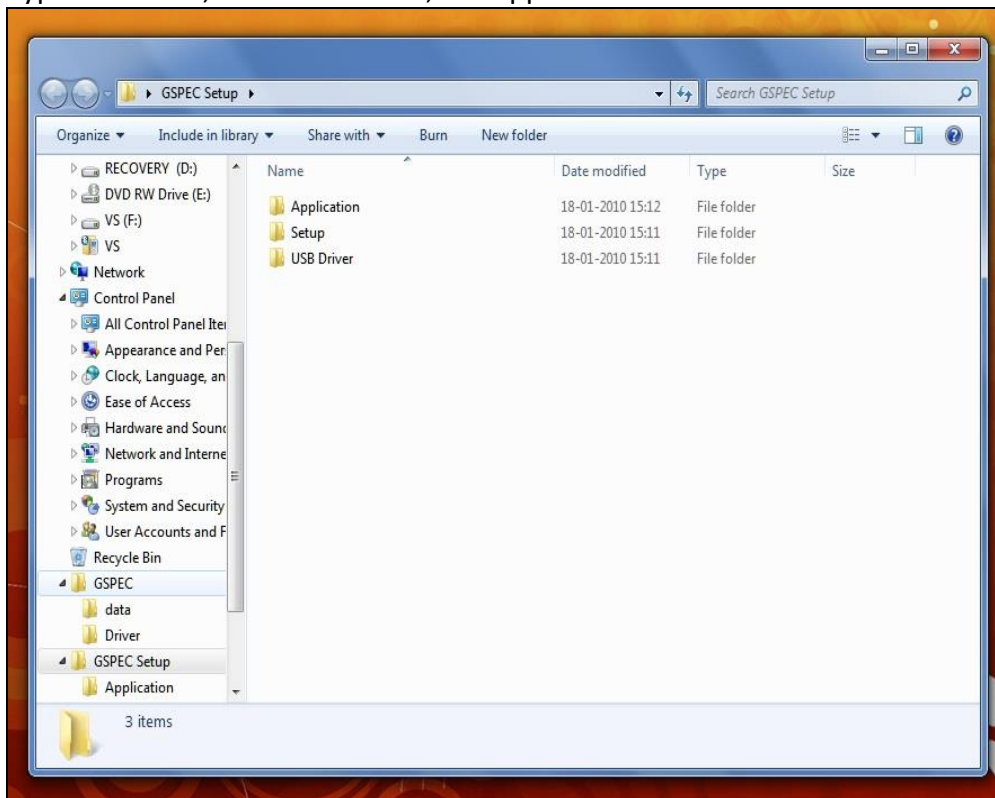
Spectrum Acquisition and Analysis Software (SAAS) works on Windows operating system. Following configuration is necessary for SAAS package.

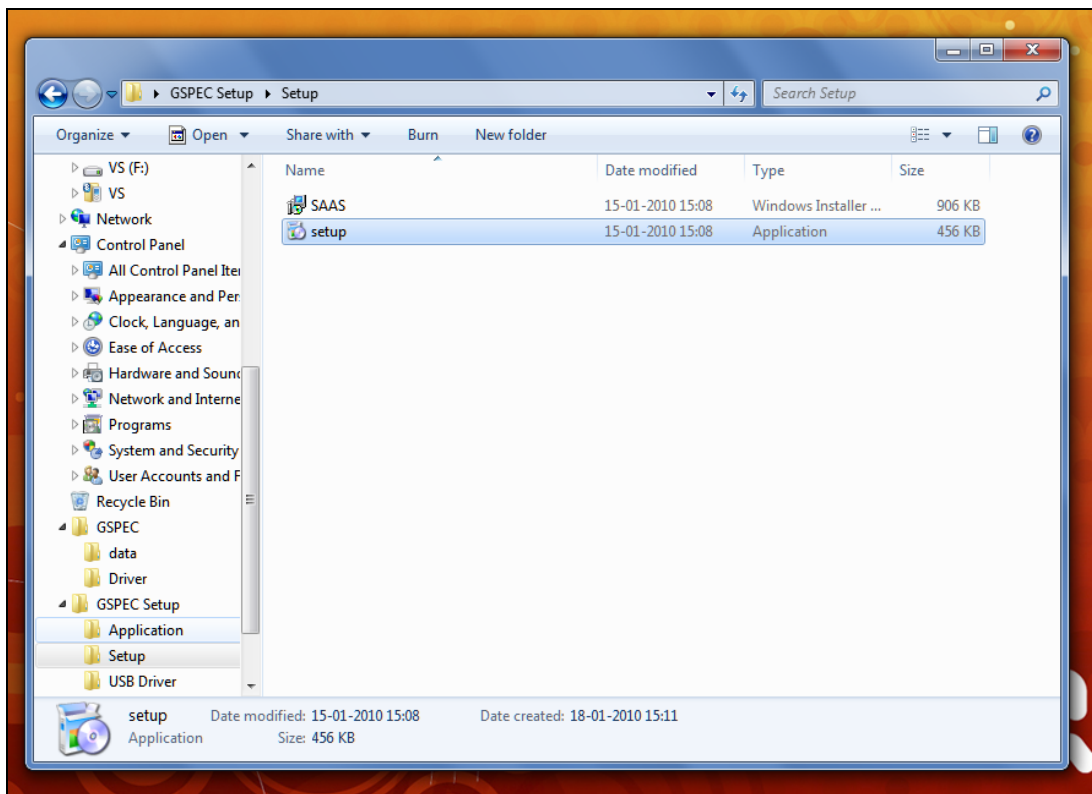
- PC with at least 2 GB RAM and 80 GB hard disk. Memory requirement of the package is maximum 11 MB.
- Windows XP or higher operating system
- **.NET** version 3.5 or 4.0 (Available on installation CD). While installing the software, click on Setup.exe file. This setup file checks the availability of the **.NET** platform on the PC and installs the **.NET** package if not available on the PC.
- Microsoft Office 2007 (Excel application for nuclear library) or higher
- USB port version 2.0
- Display resolution of at least 1024 x 780 pixels for better view

5.2 Software installation

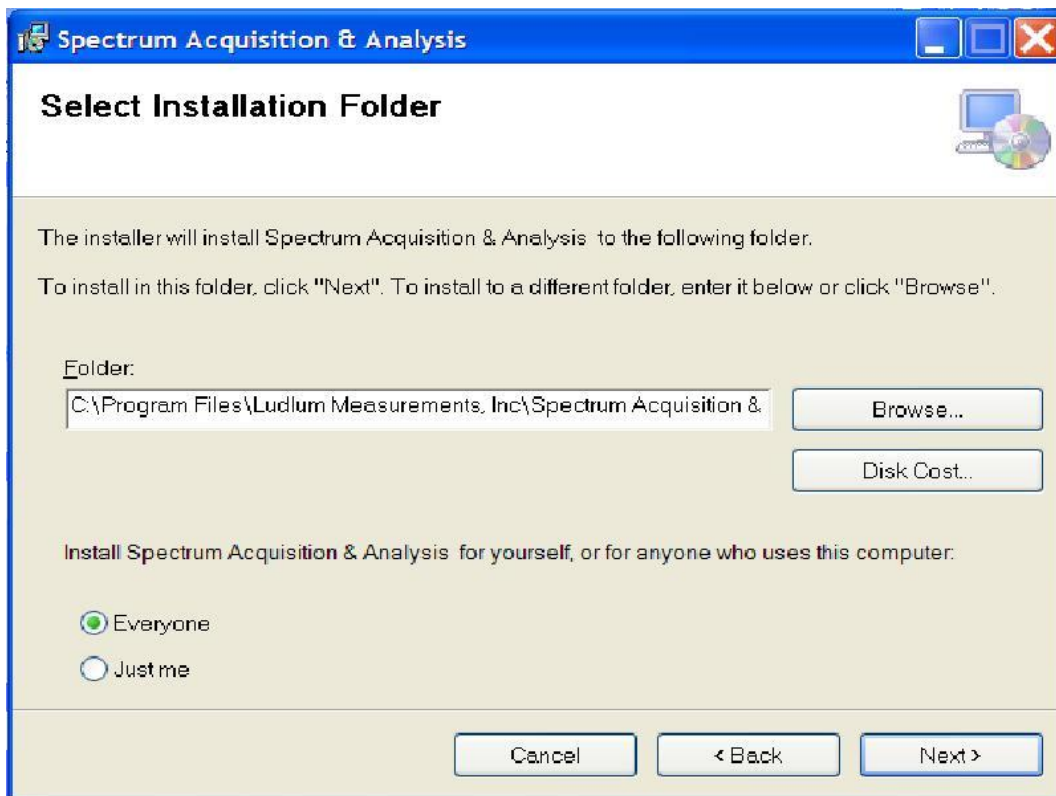
The LUDLUM MODEL 730 is a PC-based MCA. Before we go to the normal operation of the system, it is necessary to load the software package. The software package is provided on a CD supplied along with the LUDLUM MODEL 730. Insert the CD into the CD drive and run the set-up file. There are three directories on the CD. Double-click on SETUP directory and again on SETUP file to start installation as mentioned below.

Typical screens, as shown below, will appear on the monitor.

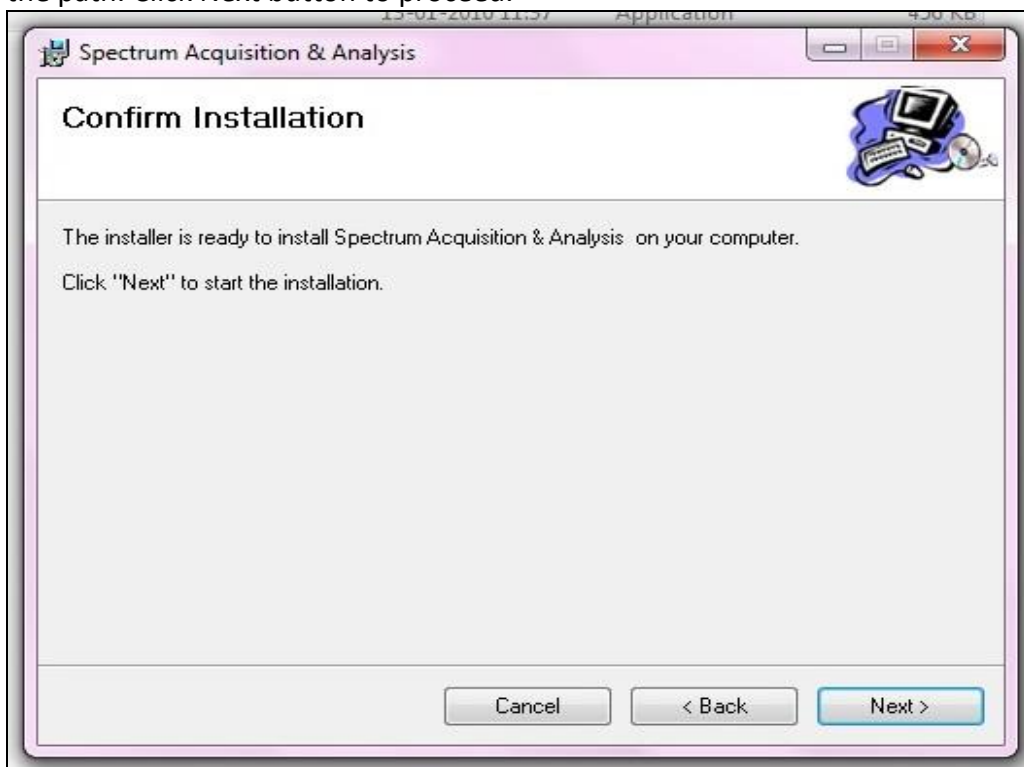




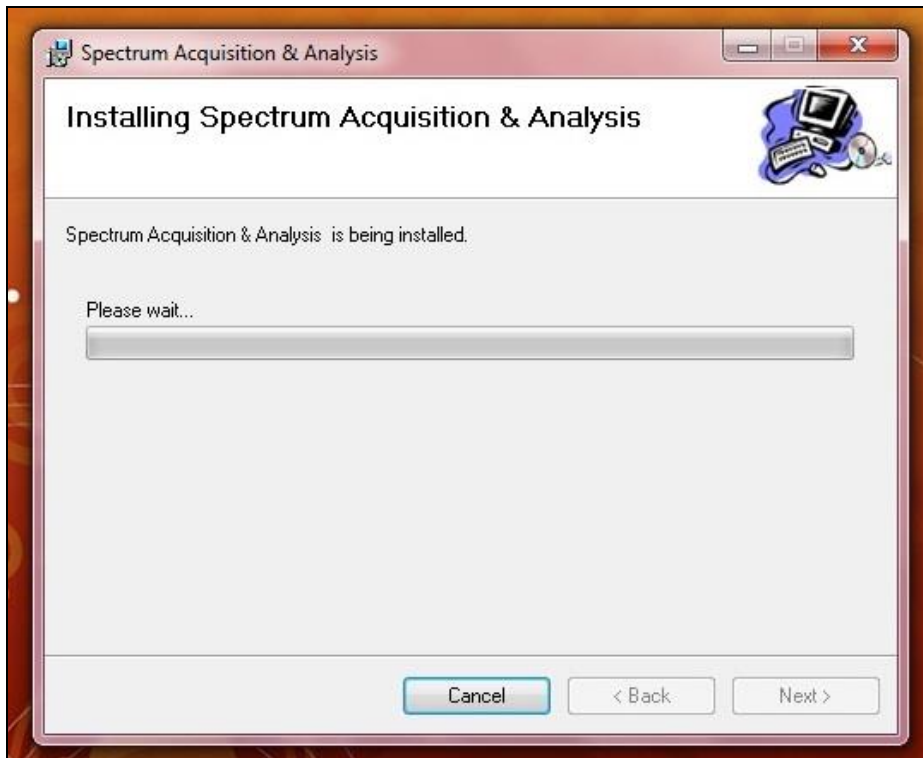
Click on Next button to proceed.



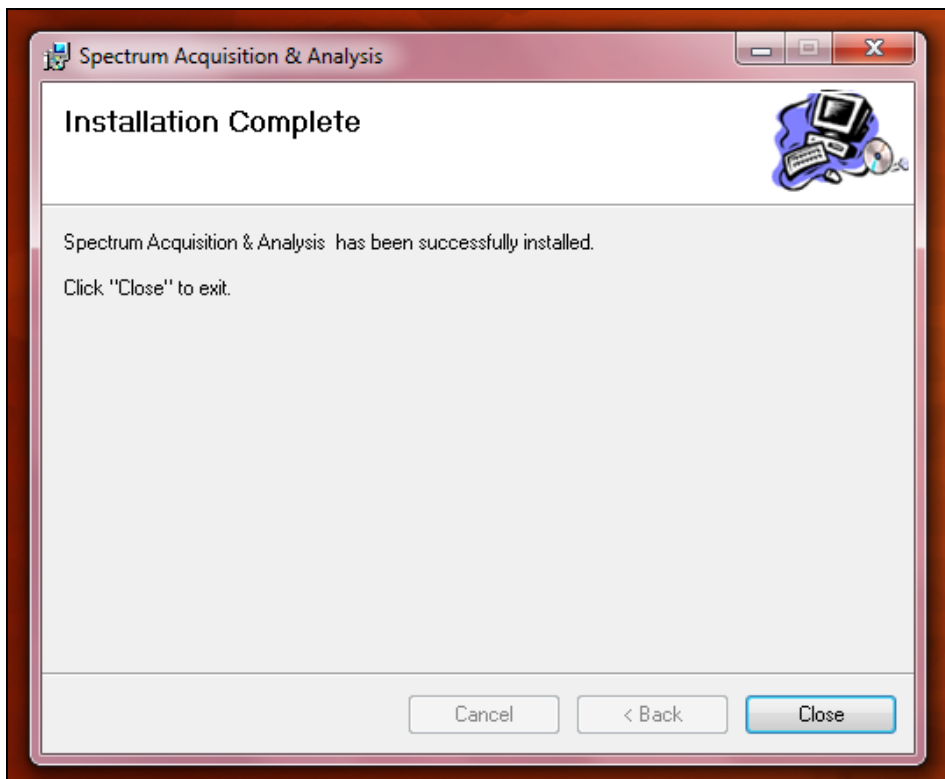
Select the folder path in which the software will be installed. The default path appears in the text box as shown in the picture. To change the path, click on Browse button and select the path. Click Next button to proceed.



Click on Next Button



Set up starts copying the file on PC.



After completion, click on Close button.

This completes the installation of Spectrum Acquisition and Analysis Software. Please note that the SAAS package requires .NET v3.5 for its operation. If the version is not available on the PC, setup program installs .NET package before starting the installation of SAAS package.

The Short Cut Icon can be created as follows :

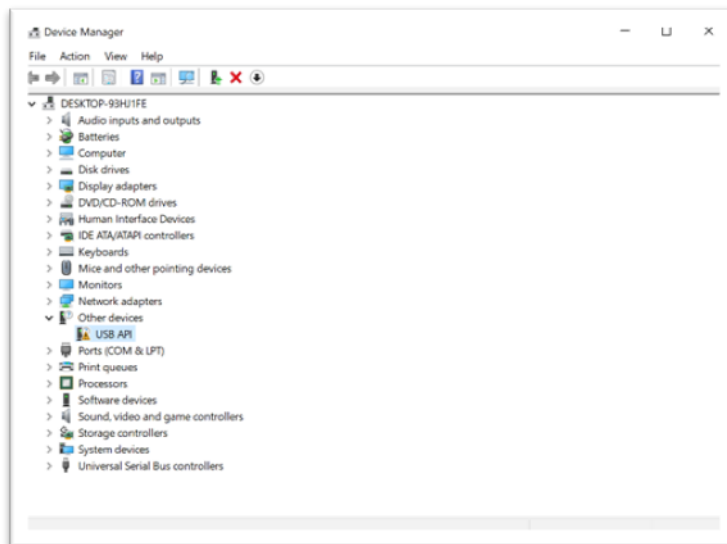
Press Start Button and go to Programs / All Programs. In the list of programs under “Ludlum Measurements, Inc” > “Spectrum Acquisition and Analysis Software” will be seen. Right Click on “Spectrum Acquisition and Analysis Software.” Select Send to create an icon on the desktop.

When LUDLUM MODEL 730 is connected to the USB Port of PC/laptop for the first time, the driver software required for the functioning of LUDLUM MODEL 730 will not be available on PC. Hence, it is necessary to install this driver when LUDLUM MODEL 730 is connected. As soon as the PC/laptop detects the connection of LUDLUM MODEL 730 on the USB port, it will prompt a message that the driver is not found and would install the driver. Use the BROWSE option to select the Driver sub-directory and click OK. This will start installation of the driver software. Follow the instructions to complete it.

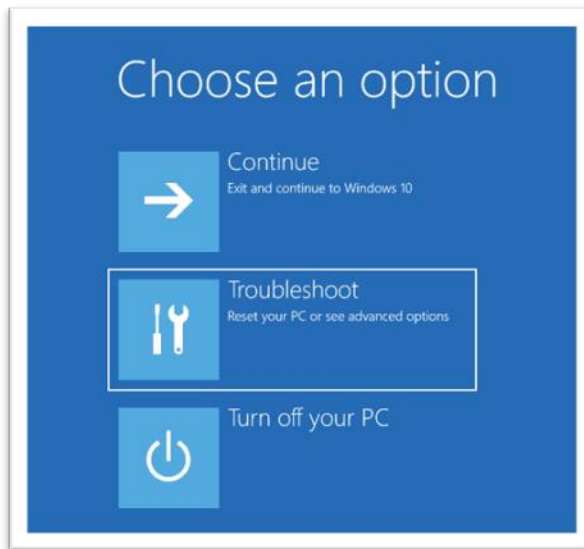
5.2.1 USB Driver Installation

The drivers are located in the USB Driver folder. For Windows 10 or higher, before the drivers can be installed, it is necessary to disable driver signatures. To do this, perform the following steps.

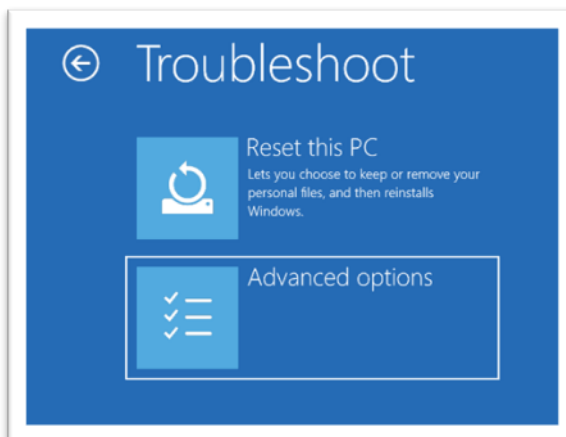
1. Connect the Model 730 to the computer using an available USB port.
2. Open Windows Device Manager and verify that the Model 730 is shown as **USB API**.



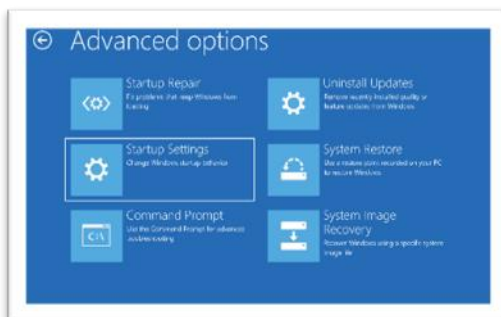
- Restart Windows by holding down the SHIFT key while clicking Restart. This will restart Windows in advanced startup mode.
- The following menu will be displayed. Select **Troubleshoot**.



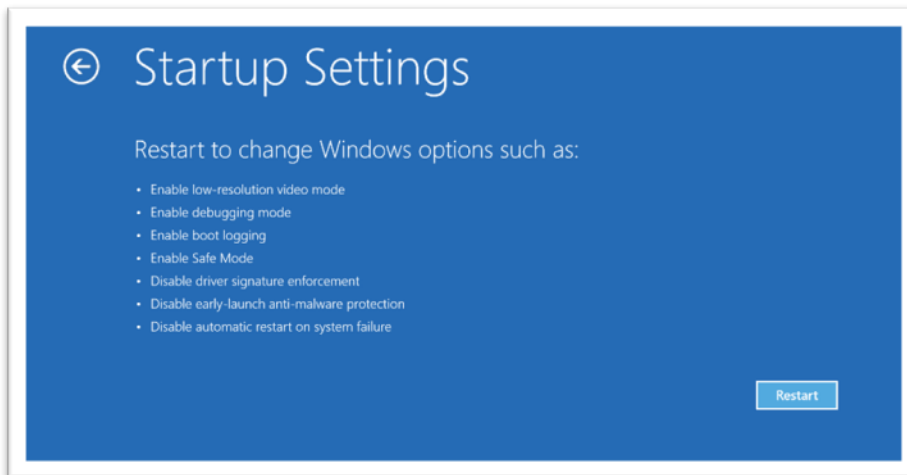
- Select **Advanced options**.



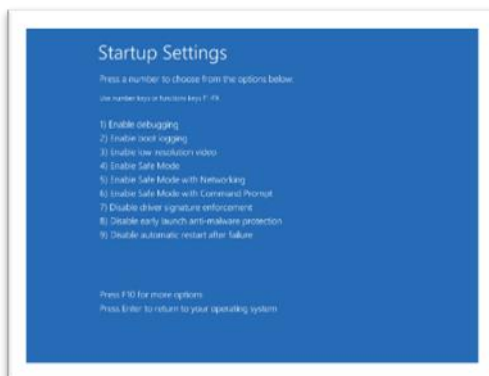
- Select **Startup settings**.



7. Click **Restart**.

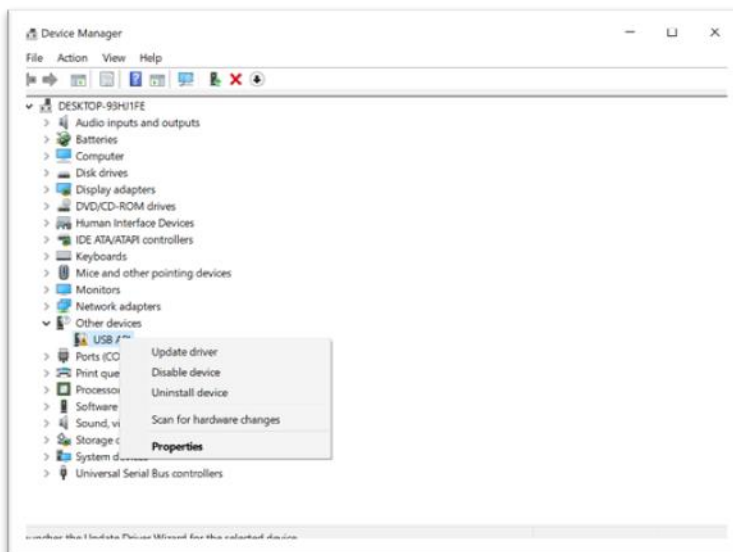


8. When Windows restarts, a new menu option is displayed. Type **7** to select **“Disable driver signature enforcement.”**

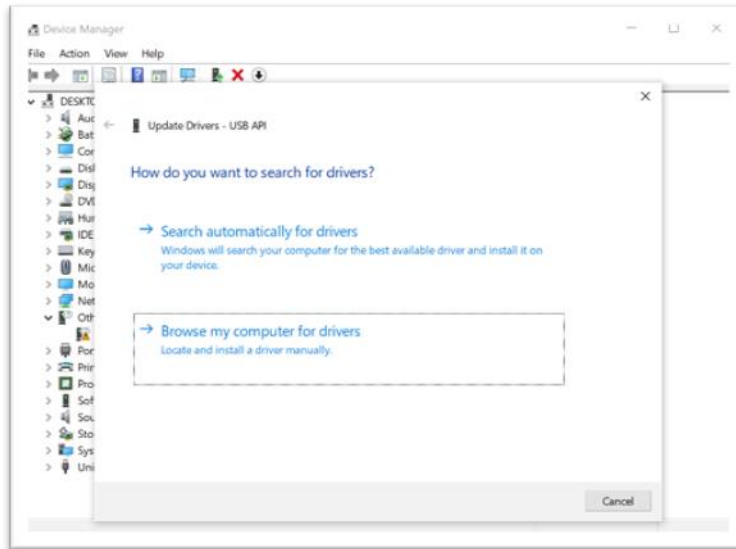


9. Windows will now boot. Log in and proceed back to Device Manager.

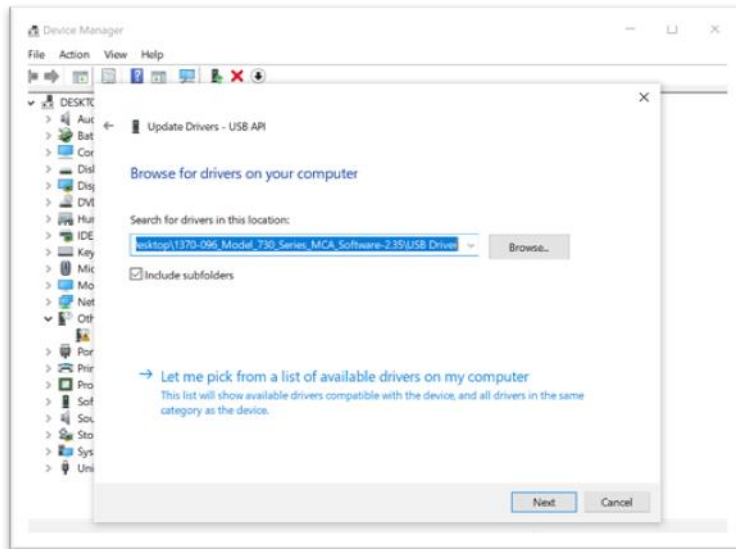
10. Right click on **USB API** and select **Update driver**.



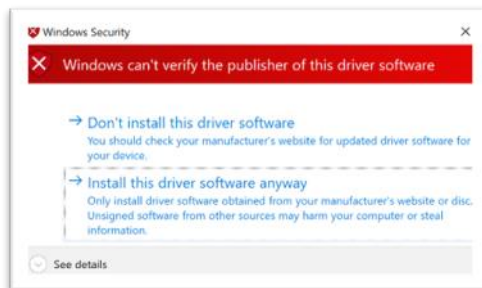
11. Click on “**Browse my computer for drivers.**”



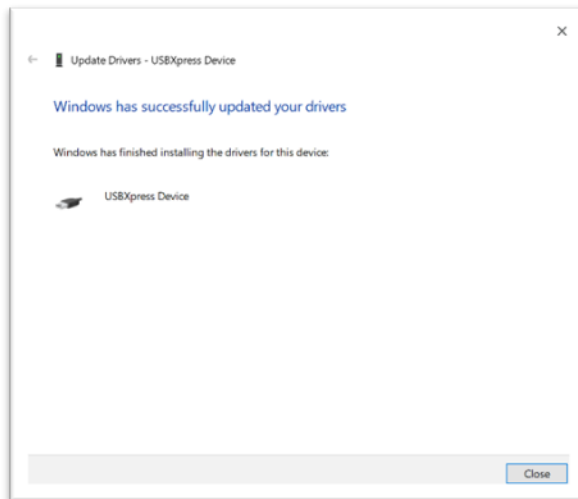
12. Click on **Browse...** and navigate to the USB Driver folder.



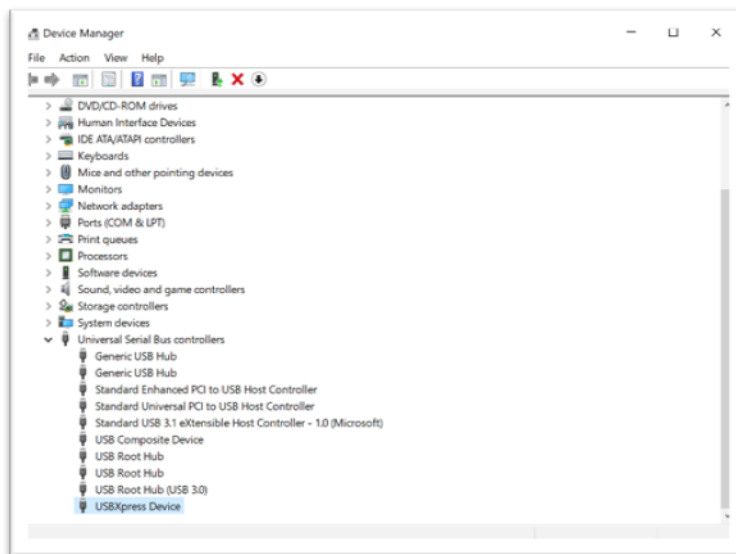
13. Click “**Install this driver software anyway.**”



14. Once completed, you will see the following.



15. In Device Manager, there will be a **USBXpress Device** in the **Universal Serial Bus controllers** group.



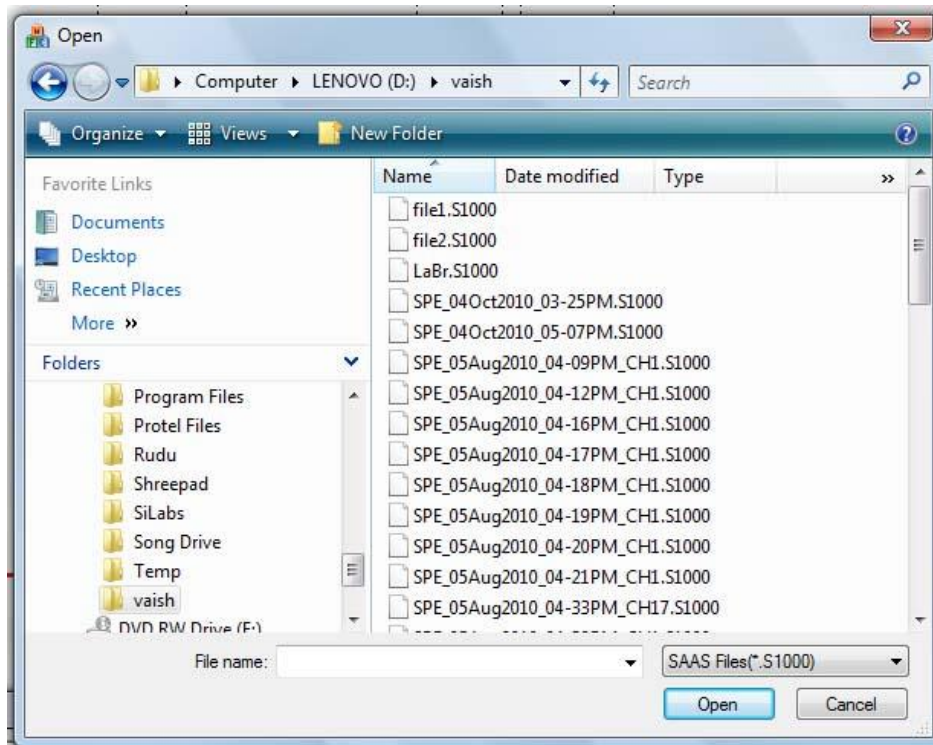
5.2.2 Running Software for the First Time

When LUDLUM MODEL 730 software is run for the first time, the configuration file is not found. Ignore any error message. Click OK to continue. This will start the software properly.

5.3 File functions

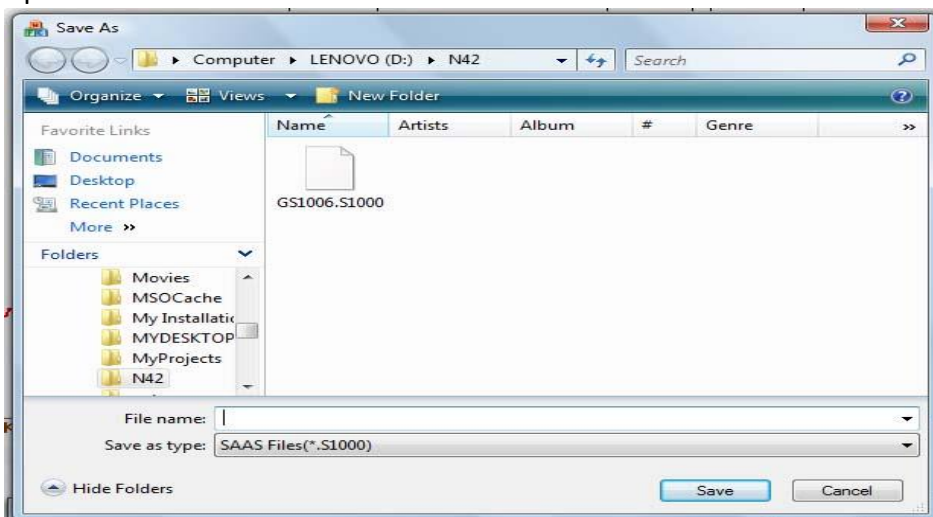
File functions are similar to standard Windows user interface.

Click on File and then open menu. A standard Windows dialogue box opens up, as shown below.

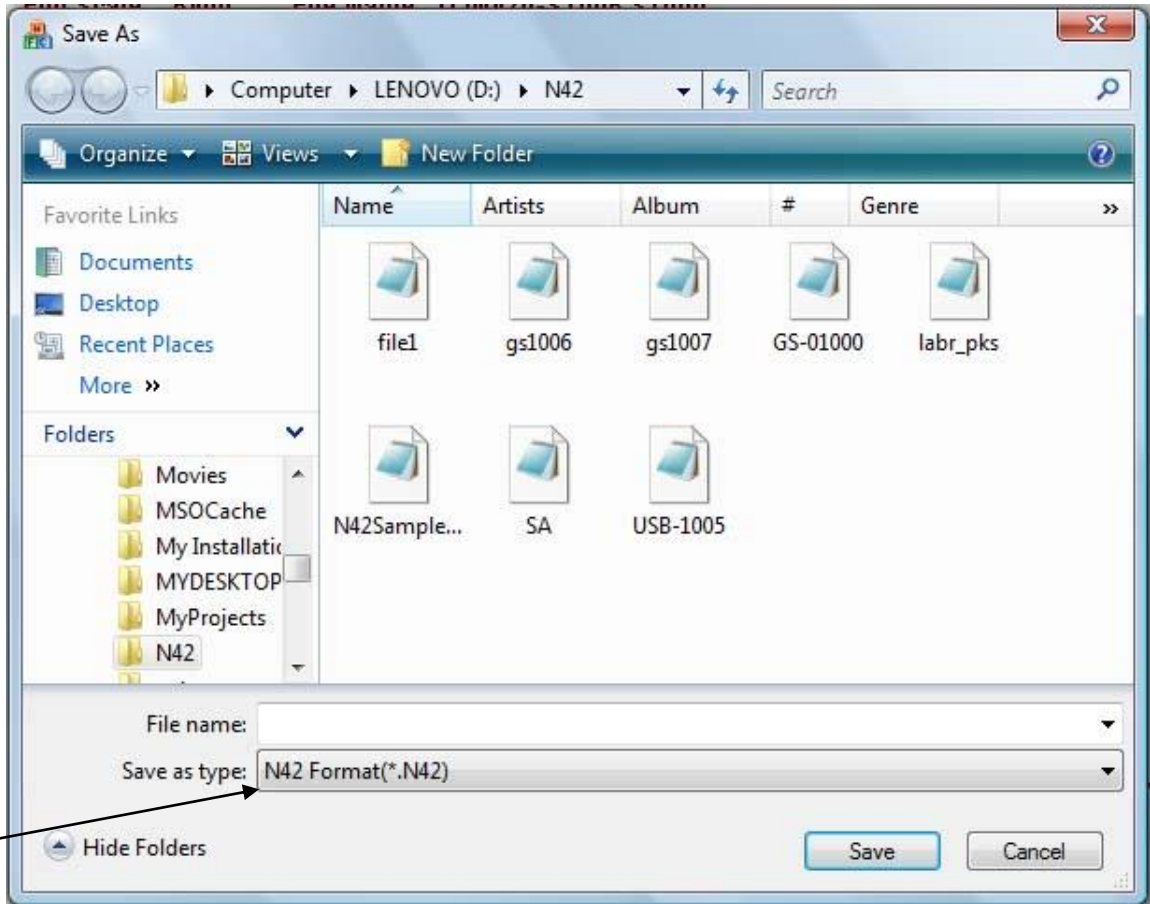


Select the required file and click on Open button. File opens up.

To save the file as Spectrum, click on File and Save menu. The File Save dialogue box opens up.



The package supports the saving of spectrum data in ANSI N42 format. Select N42 file type while saving the spectrum as shown below.



Channel counts, calibration data, system settings and other details will be saved in the file. This file can be opened in other standard packages like Quantum software of PGT, which supports N42 file format.

The Print Spectrum option available in the File menu prints the spectrum on the selected printer.

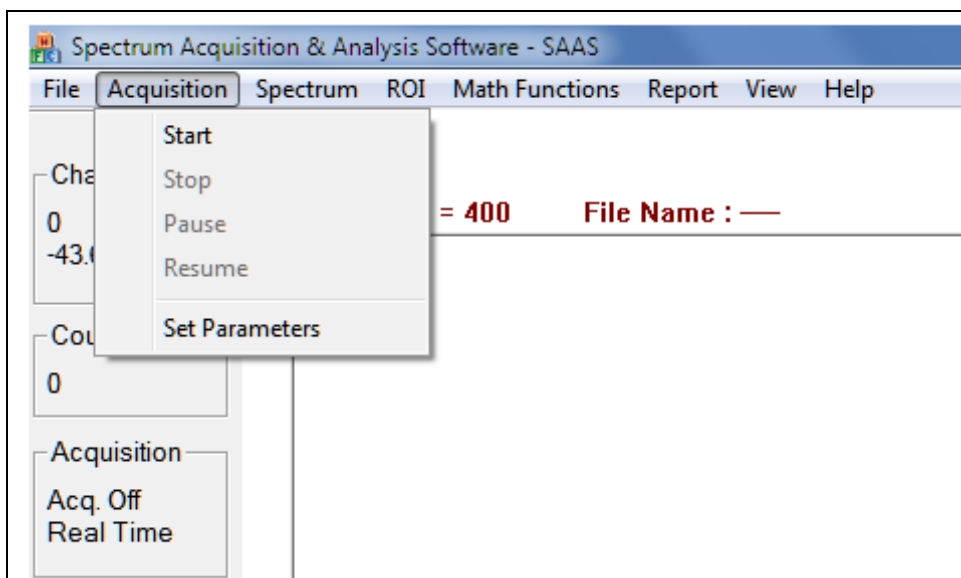
5.4 Setting the parameters

After setup, the first step is to set the different parameters of the system. The basic parameters to be set for acquisition are:

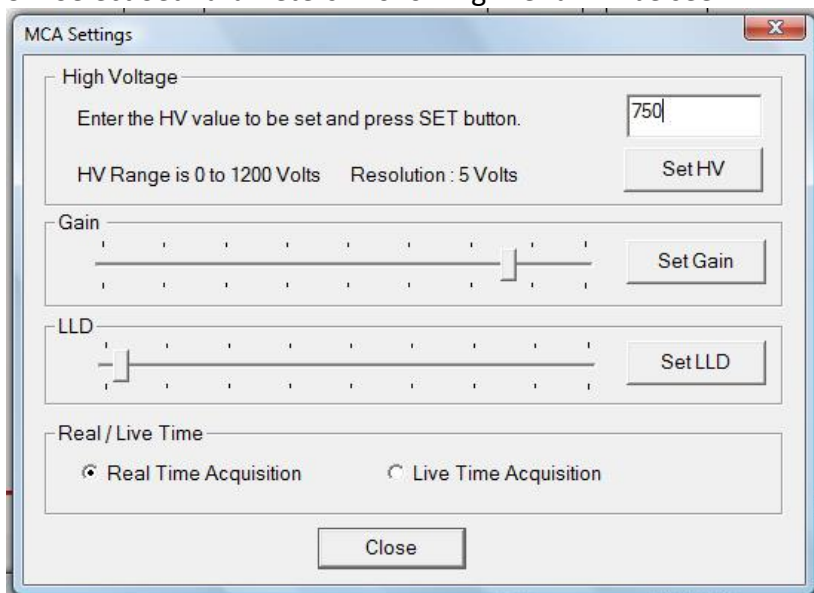
1. HV supply to the detector – up to 1200 V (in 256 Steps)
2. Acquisition time : 1-10,000 seconds
3. Real time or live time

HV supply to the detector is set as follows:

1. Select Acquisition on menu bar
2. Drop-down menu will indicate



3. Select Set Parameters . Following Menu will be seen.

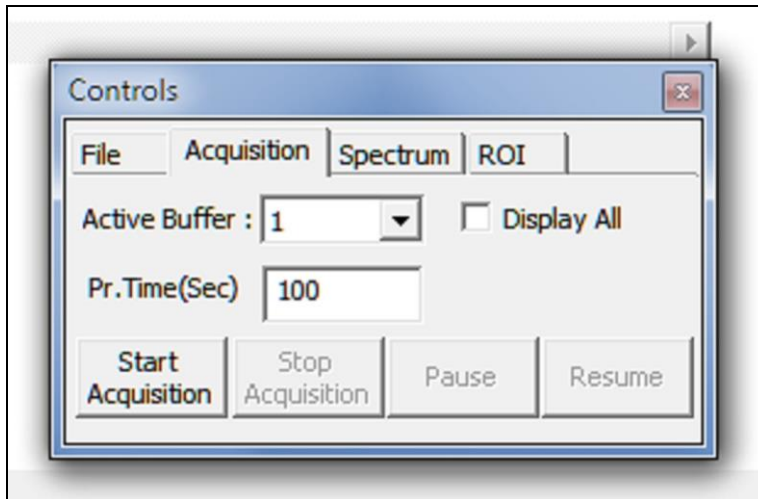


4. Enter HV value, up to 1200 V and press SET Key.

5. Use slide bar to adjust the gain. Then click on Set Gain button.
6. Use slide bar to adjust the LLD. Then click on Set LLD button.
7. Real Time or Live Time Selection is also done in the menu. Click on the option as desired.
8. Press Close to close this Menu.

Setting of acquisition time is done as follows:

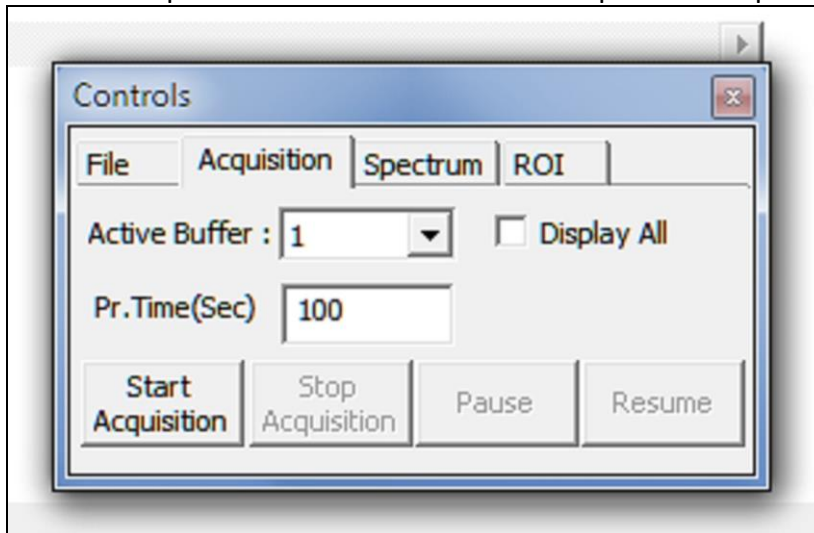
1. On Controls menu select Acquisition panel as below. Enter desired value of Preset Time. In the example below 100 Seconds value is selected.
2. Select Active Buffer as 1.



3. This completes the set-up parameters for the LUDLUM MODEL 730.

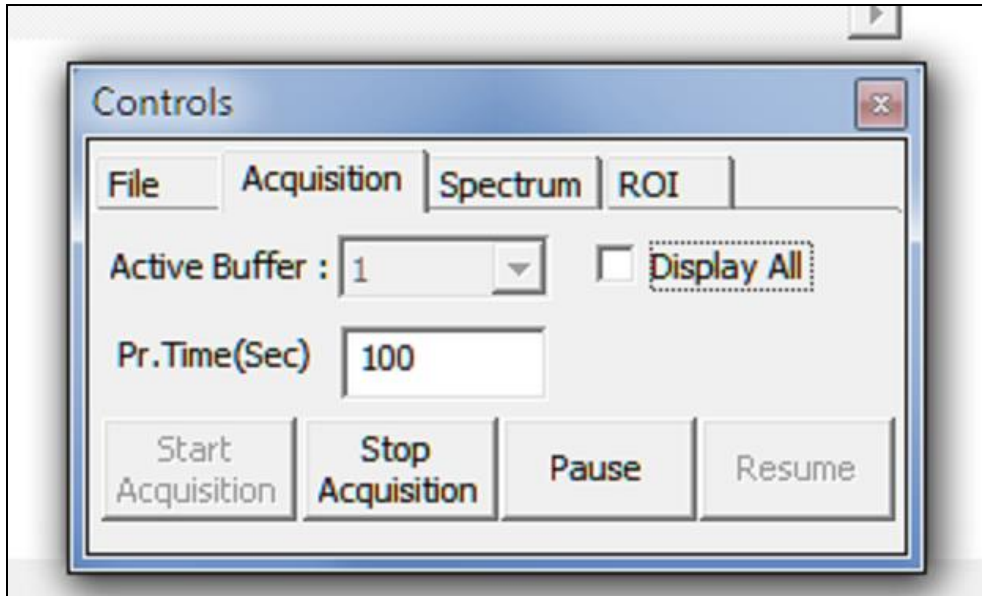
5.5 Acquisition of Spectrum Data

1. In the Controls menu, select Acquisition panel. After setting the Preset Time, press Start Acquisition button. This will start acquisition of spectrum data.

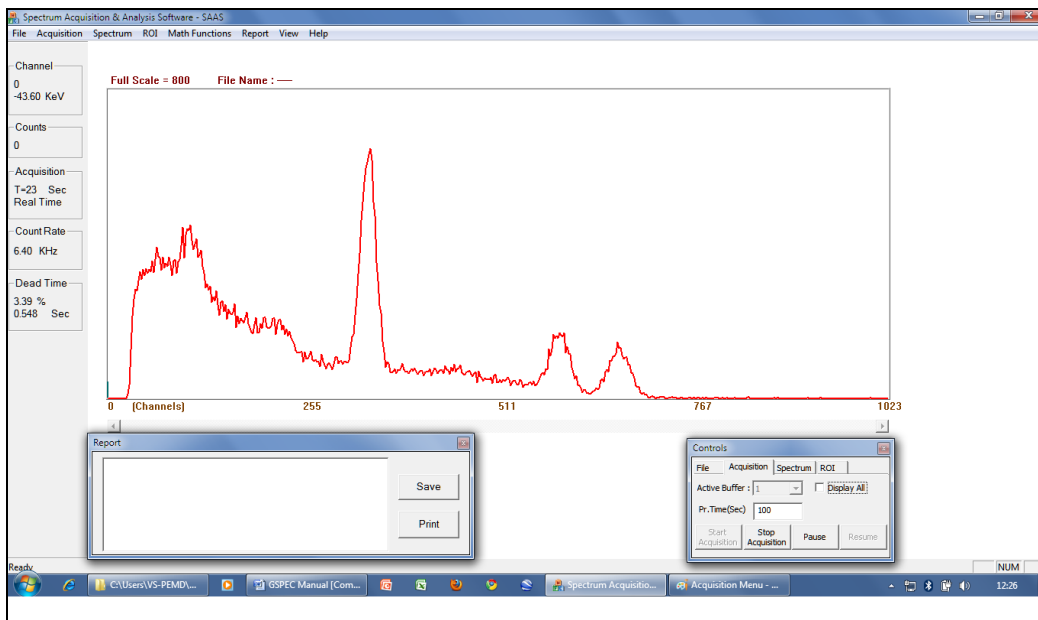


2. As soon as acquisition is started, if there is sufficient input count rate, a build of spectrum will be seen, and the Controls menu will make the Stop Acquisition button

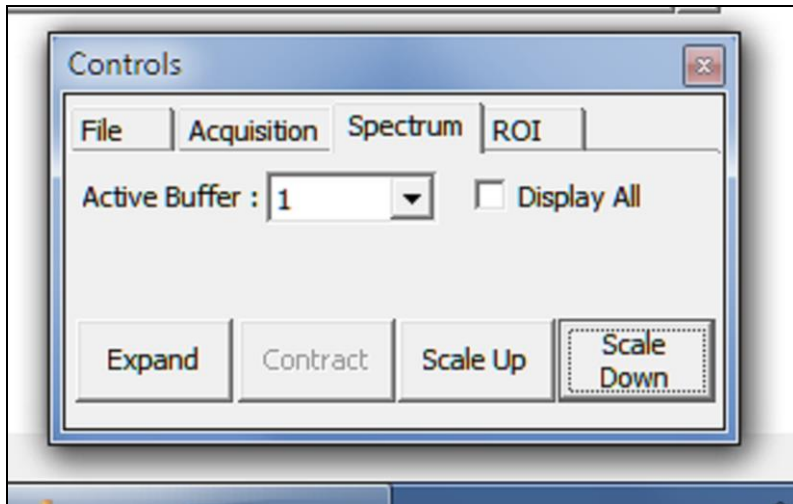
active. Acquisition will continue until the Acquisition Time matches the Preset Time. It can be stopped by pressing Stop Acquisition on Acquisition panel.



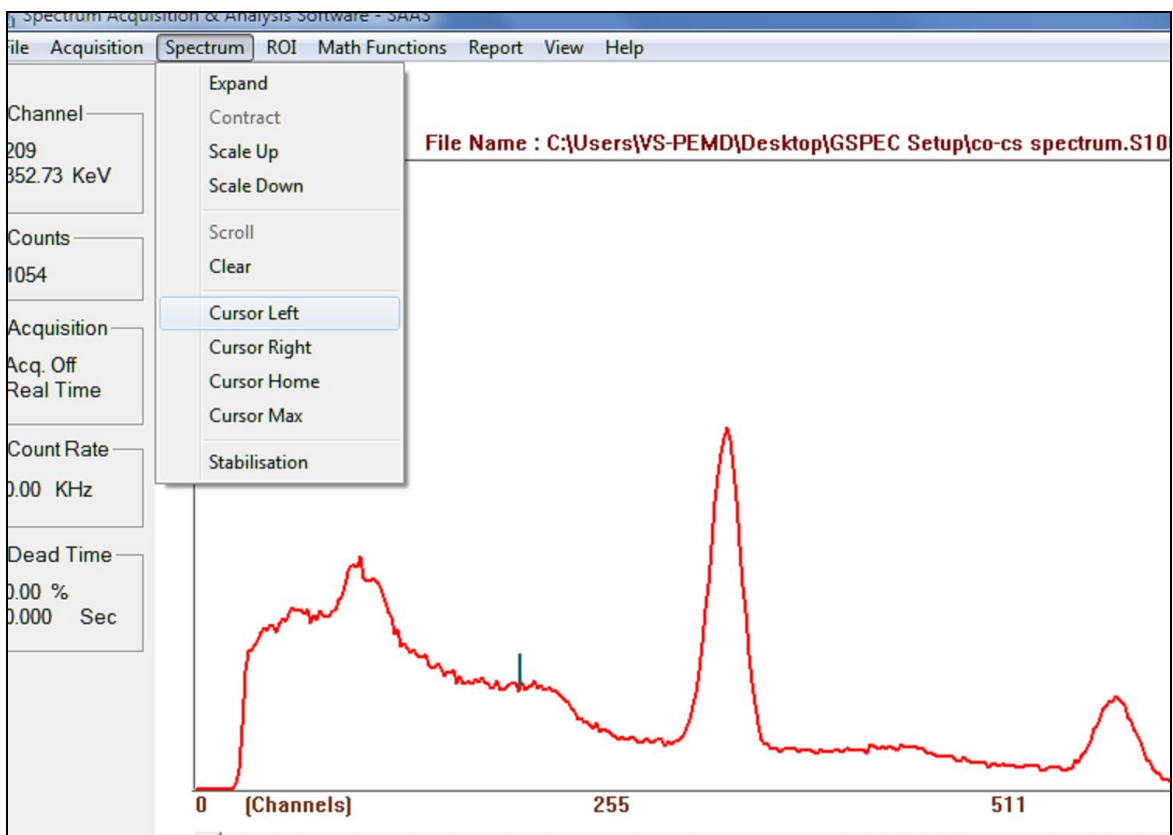
3. As the data is acquired, spectrum will start building up. Typical spectrum for Cesium and Cobalt is shown below.



4. On Controls menu, select Spectrum panel, as shown on the following screen shot, to get access to Spectrum Display Control functions like Expand and Contract (Horizontal) and Scale Up and Scale Down (Vertical). While the spectrum is being built up, Expand and Contract functions can be availed by pressing the “E” (Expand) or “C” (Contract) key on the keyboard. Similarly, Scale Up and Scale Down functions can be used by pressing the up arrow or down arrow keys on the keyboard. These key functions are always available to the user. Use left and right arrow keys to move the cursor.



5. The cursor can be activated by putting the mouse pointer on the desired channel on the spectrum and clicking the left mouse key. This is indicated in the following screen shot.



It can be seen that the cursor is at channel no. 209. It is indicated by a small vertical line on the spectrum display. The cursor can be moved to the left or right by clicking the appropriate selection or by again clicking the mouse pointer at the desired position on the spectrum. The following options are available.

Cursor Left – Moves cursor to the left by 1 channel

Cursor Right – Moves cursor to the right by 1 channel

Cursor Home – Brings cursor to the first channel on the displayed spectrum

Cursor End – Takes cursor to the last channel on the displayed spectrum

Cursor Max – Moves the cursor to the first channel (on right from existing position), which has maximum counts

Similarly, the following options are available to control the display of spectrum or data of the spectrum in the Spectrum drop-down menu.

Expand – Expand the scale by a factor of 2 on the right side of the cursor

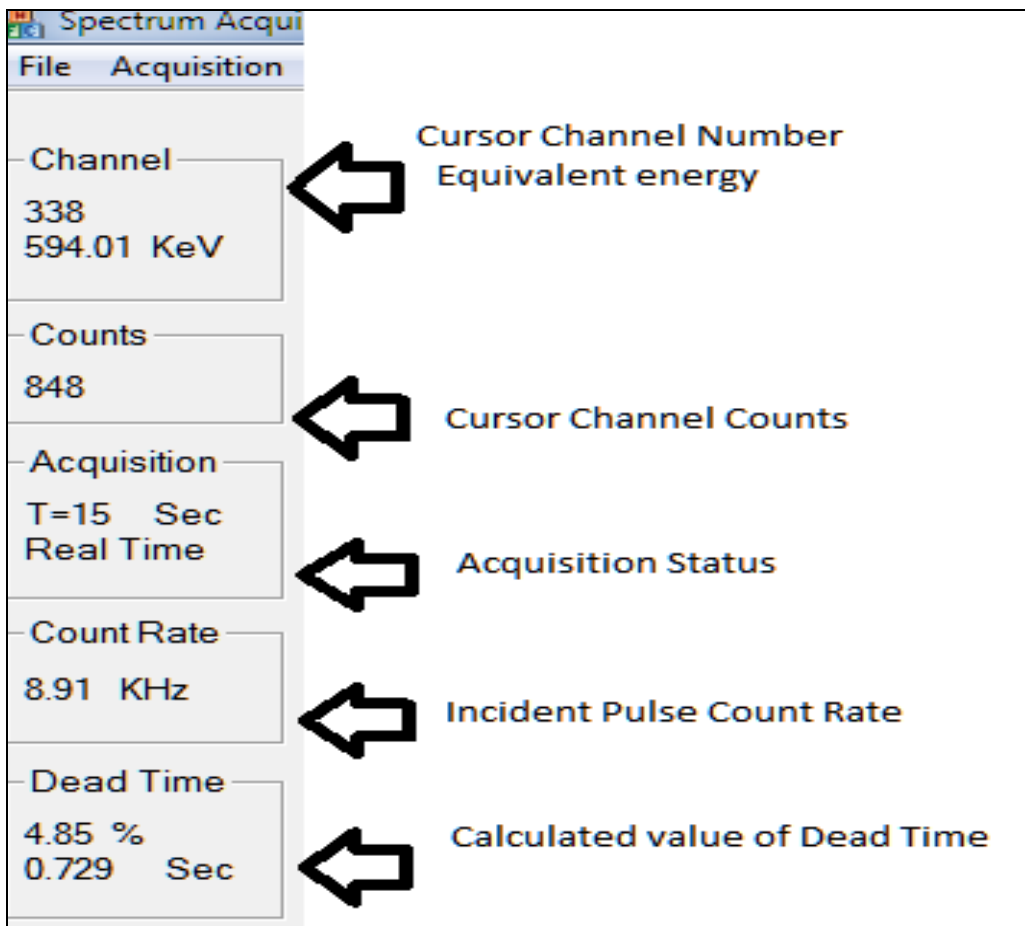
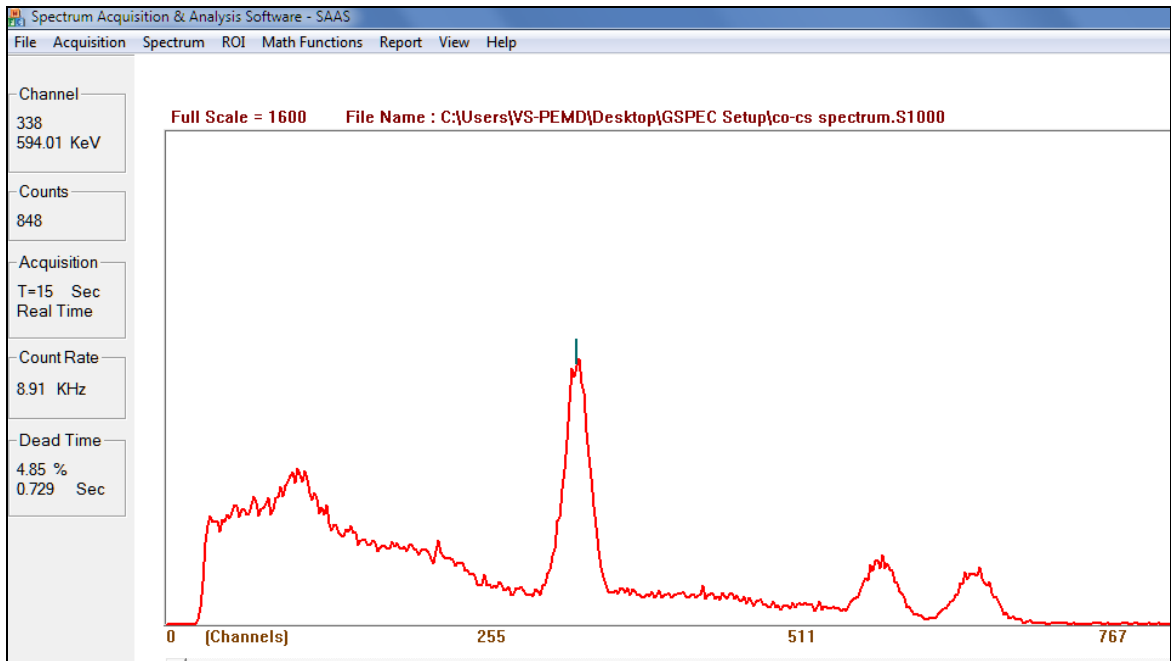
Contract – Contract the spectrum by a factor of 2 on the right of the cursor

Scale Up – Vertical scale up by a factor of 2

Scale Down – Vertical scale down by a factor of 2

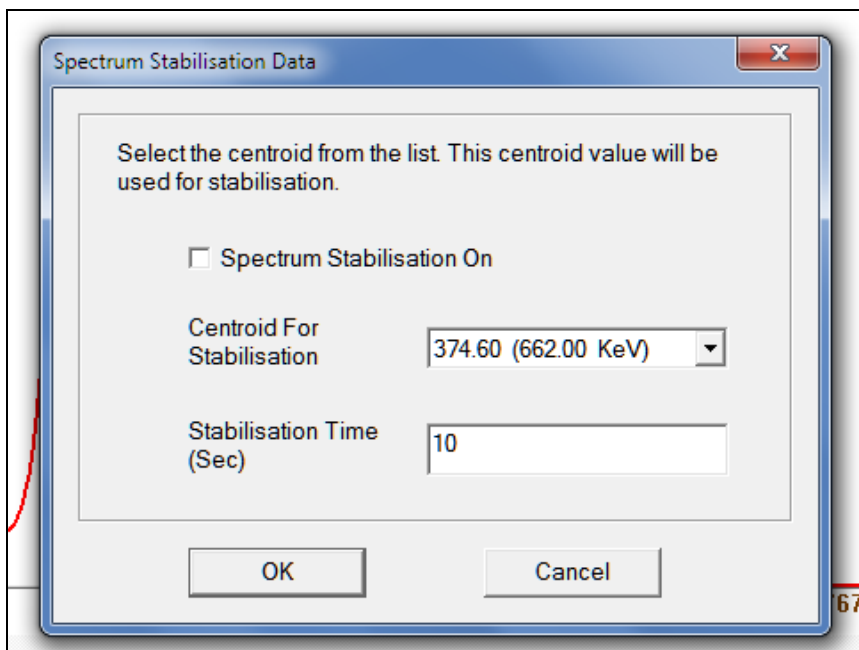
Clear Spectrum – Clicking on this option will clear the spectrum data in the selected buffer.

While the spectrum data is being acquired, the information related to the input count rate, dead time, acquisition time, elapsed time, cursor channel number and counts in cursor channel is provided on the left side of the spectrum as shown below.



Spectrum Stabilization – This is a special function that can be activated by clicking on the Spectrum Stabilization in the Spectrum drop down menu. Before activating this function, it is necessary to understand the meaning of this utility.

Due to internal heating, external temperature variations and due to the internal drifts in the detector, pulse processing electronics and HV supply circuit, there could be a small shift in the output of spectroscopy amplifier. This drift may be continuous initially and random once the system stabilizes. In order to get the stability in the spectrum, i.e. minimum variation in the channel number for given energy of incident gamma rays, it is necessary to get back to the original channel setting for a particular energy pulse input. This is normally done by either adjusting the HV applied to the detector or by adjusting the gain of the spectroscopy amplifier. This stabilization can also be achieved by storing the energy calibration and applying the conversion factors at a fixed time interval. This is done automatically as the spectrum is being acquired. The Spectrum Stabilization menu prompts the user to enter the value of energy and also to enter the value of time interval. However, it is necessary to have the energy calibration done prior to spectrum stabilization.



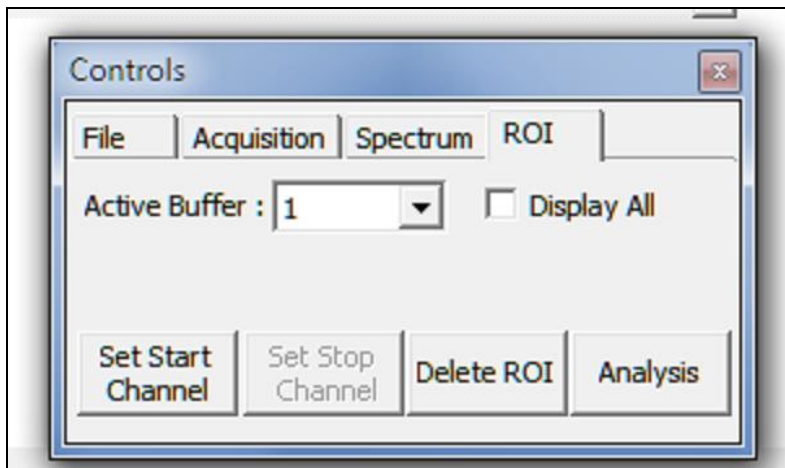
If spectrum stabilization is required to be turned ON, enter the centroid value of the peak and also the time interval at which the stabilization action is to be performed. Check the Spectrum Stabilization ON and this will turn ON the spectrum stabilization. Spectrum Stabilization can be turned OFF by unselecting the Spectrum Stabilization On and closing this menu window.

Peak Search : Use the peak search option to automatically detect the valid peaks. ROIs will be marked after peak search. If the counts inside ROI are less, then peak search will give wrong results. Try spectrum smoothing before applying the peak search option.

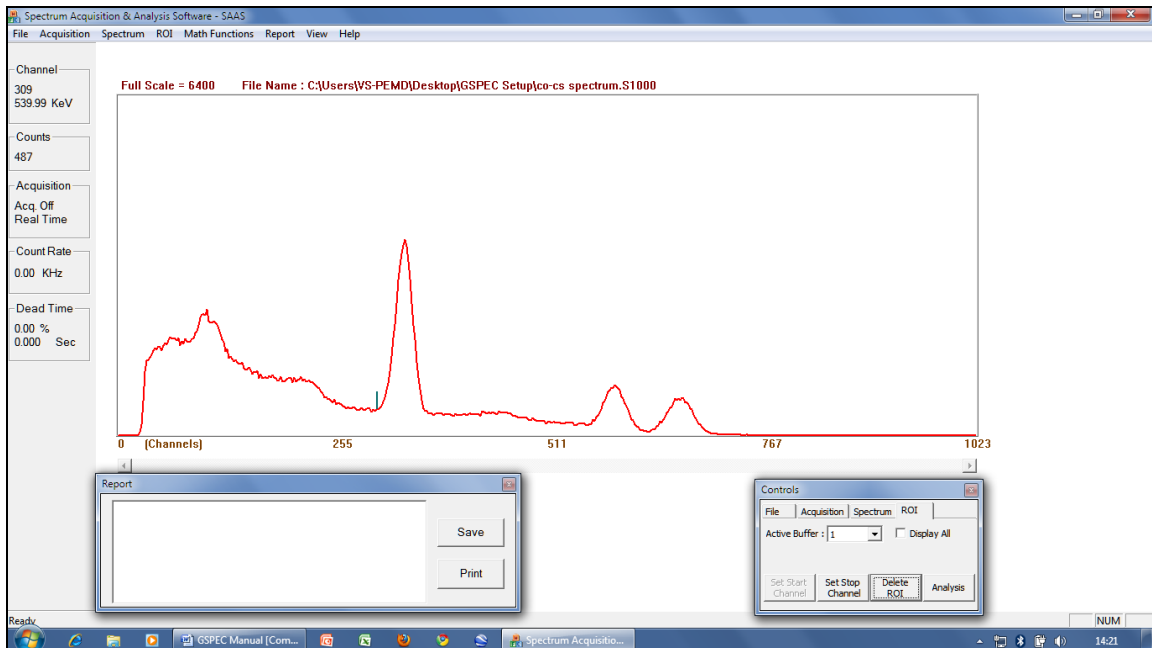
5.6 Spectrum Analysis

5.6.1 ROI Setting

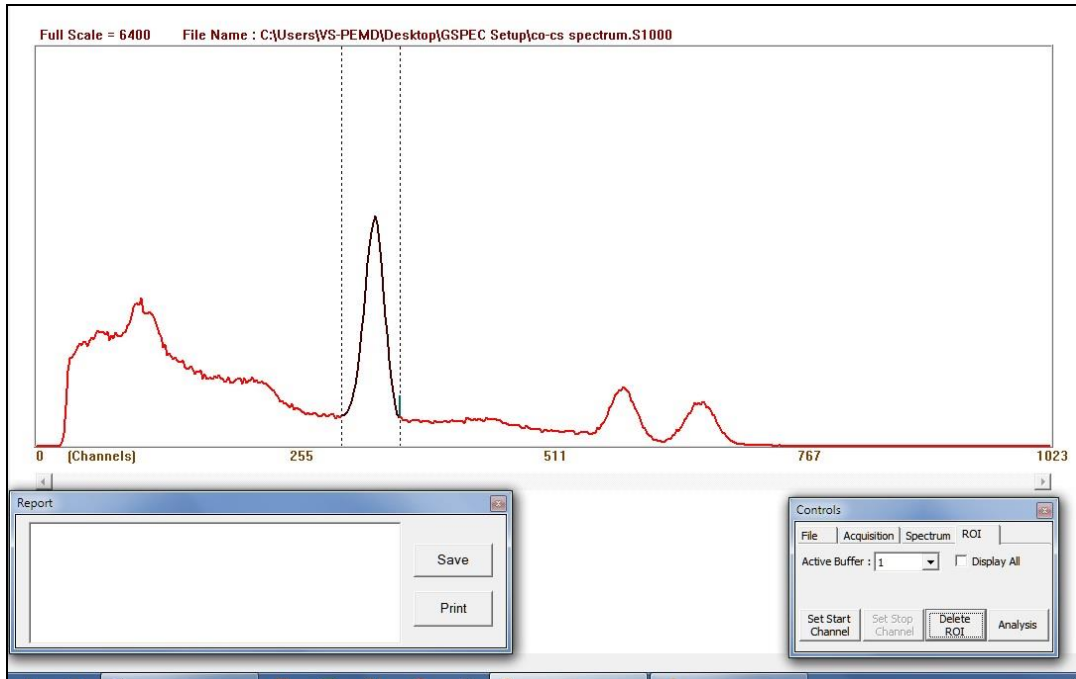
Spectrum analysis is the most important function of the SAAS. However, before the analysis is done, it is necessary to select the peak regions. This is done by selecting the Region of Interest or ROI. For setting up ROIs on the spectrum, select Control Menu and select ROI panel as shown below.



Click the mouse on the desired channel. In the example below, it is the left side of the peak. Now click the Set Start Channel button on the Controls menu.



Click on the next Channel as end of ROI as shown below.



Press Set Stop Channel Button on Controls Menu.

ROI will be selected between the Start and Stop channels as desired. This will be indicated by turning ON the two parallel cursor lines and turning the spectrum display to black. Many ROIs can be set and these will be displayed in similar manner.

The purpose of selecting ROI is to perform energy calibration and to carry out peak analysis.

5.6.2 Energy Calibration

Energy calibration is done by selecting two or three peaks of known radioisotopes. The following example provides details on energy calibration using ^{137}Cs and ^{60}Co radioactive sources.

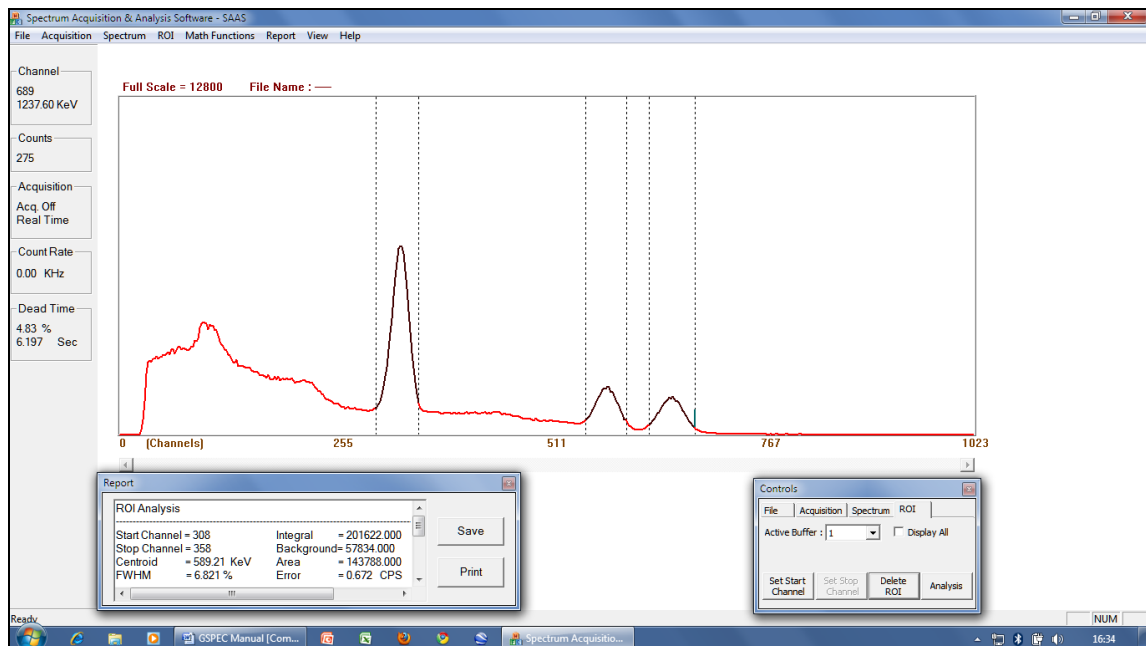
1. Acquire the spectrum for ^{137}Cs and ^{60}Co gamma radiation sources. With ^{137}Cs being a mono-energetic source, it will generate a single peak, whereas ^{60}Co will indicate two peaks. The energies of these radioisotopes are:

^{137}Cs – One peak – 662 keV

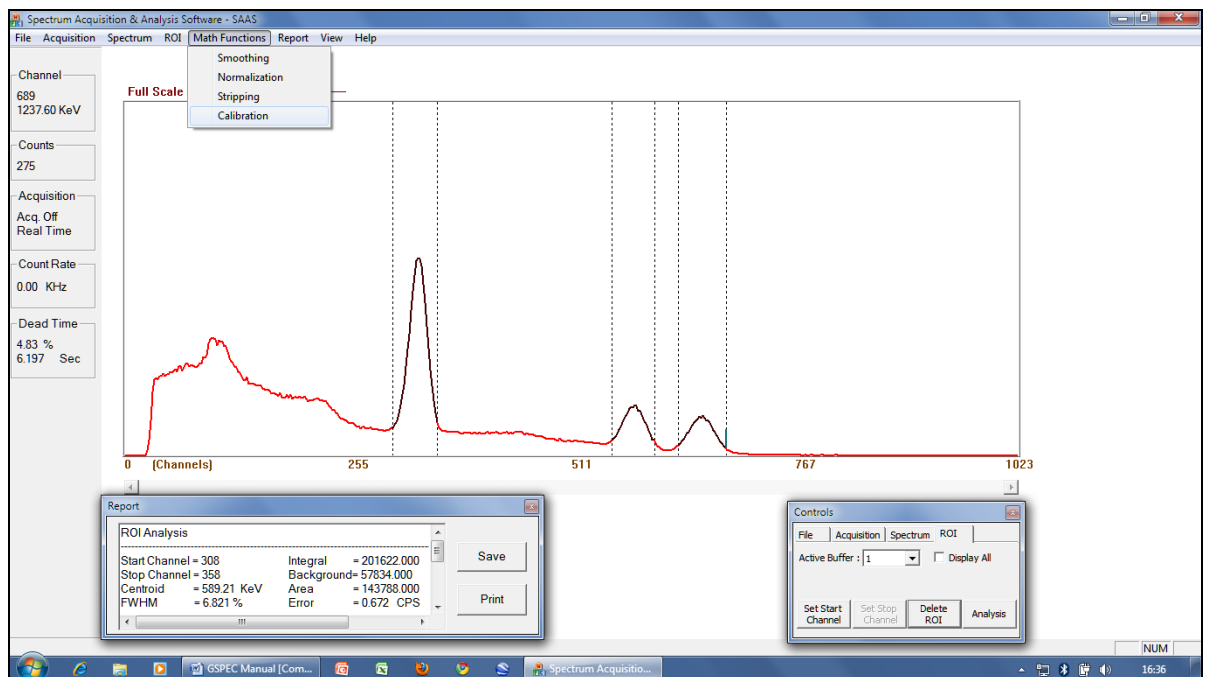
^{60}Co – First peak – 1173 keV

Second peak – 1332 keV

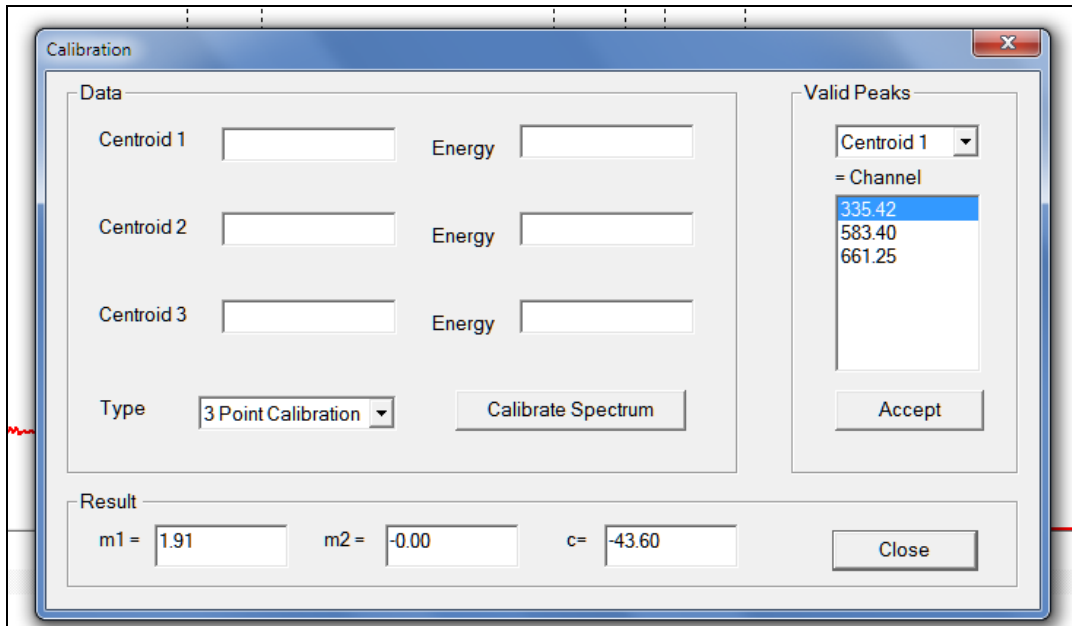
2. Select three ROIs as shown below.



3. Next step is to select the calibration menu. This is done by selecting the Math Functions option from the menu bar, as shown below.



- Energy Calibration menu will be displayed, as shown below.



- The first ROI is indicated by the highlighted number as shown above. Click the Accept button on the Centroid 1 Data Field. Enter energy value in keV (662). Next, select the second channel number and press Accept. Enter the value of the second peak's energy. (In this case 1173.) Similarly, enter 1332 for the third channel number. Press Calibrate Spectrum button to perform energy calibration. Close this window by clicking Close.
- This will revert back to spectrum display. However, all the channels are now calibrated with their energy numbers. Click on the Cs peak, and then the channel number and energy are displayed. This completes the calibration procedure.
- When the spectrum stabilization function is to be used, enter the peak value in the Spectrum Stabilization Options menu. The digital mapping will stabilize the spectrum at the time intervals as selected in the Spectrum Stabilization Options menu.

5.6.3 Peak Analysis

- Energy calibration is followed by peak analysis. This is done by locating the cursor in the desired ROI peak and pressing Analysis button on Controls menu.
- This will generate a detailed report in the Report window. It will contain information of the selected peak.
- Select the next peak, and its analysis will be displayed as shown below.

ROI Analysis

 Start Channel = 308 Integral = 201622.000
 Stop Channel = 358 Background= 57834.000
 Centroid = 662.01 KeV Area = 143788.000
 FWHM = 6.821 % Error = 0.672 CPS

Channel	Counts							
308	1058	1051	1202	1280	1294	1399	1560	1745
316	1876	2011	2259	2431	2615	3008	3269	3570
324	3932	4284	4465	4983	5314	5689	6026	6331
332	6619	6893	7167	7271	7261	7333	7231	7187
340	6953	6690	6295	5986	5631	5119	4759	4327
348	3936	3599	3148	2775	2564	2275	2038	1756
356	1568	1373	1216					

This information can be printed on System Printer if need be.

5.6.4 Spectrum Smoothing

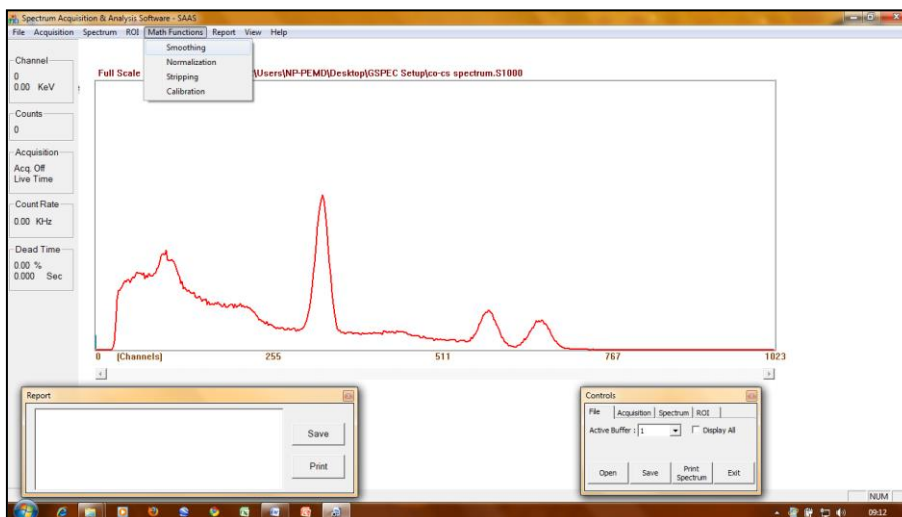
Spectrum Smoothing function offers 3-point or 5-point smoothing of entire spectrum. The formulae for smoothing are as follows:

$$SCX(i) = \frac{CX(i-1) + CX(i) + CX(i+1)}{3} \quad \text{for 3-point smoothing}$$

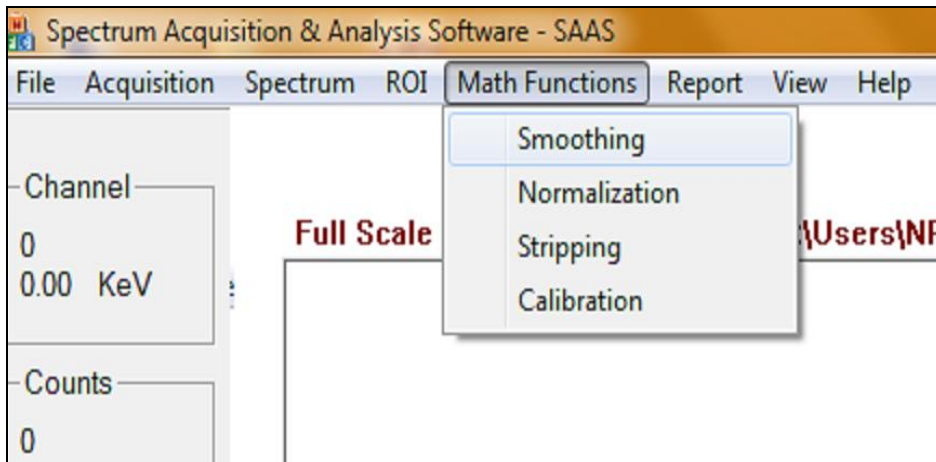
$$SCX(i) = \frac{-3CX(i-2) + 12CX(i-1) + 17CX(i) + 12CX(i+1) - 3CX(i+2)}{35} \quad \text{for 5-point smoothing}$$

Spectrum Smoothing can be done as follows:

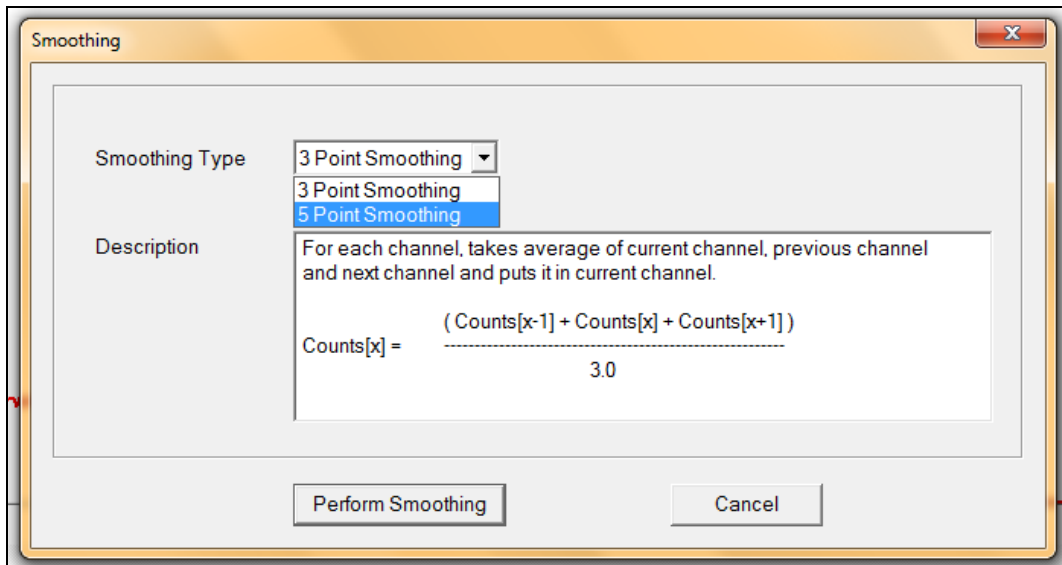
1. From the menu bar select Math Function option.



2. Select Smoothing option in the drop-down menu.



3. The menu for selection of 3 or 5-point smoothing will appear. Select appropriate type of smoothing and press Perform Smoothing. This will smooth the spectrum as desired.



5.6.5 Spectrum Stripping

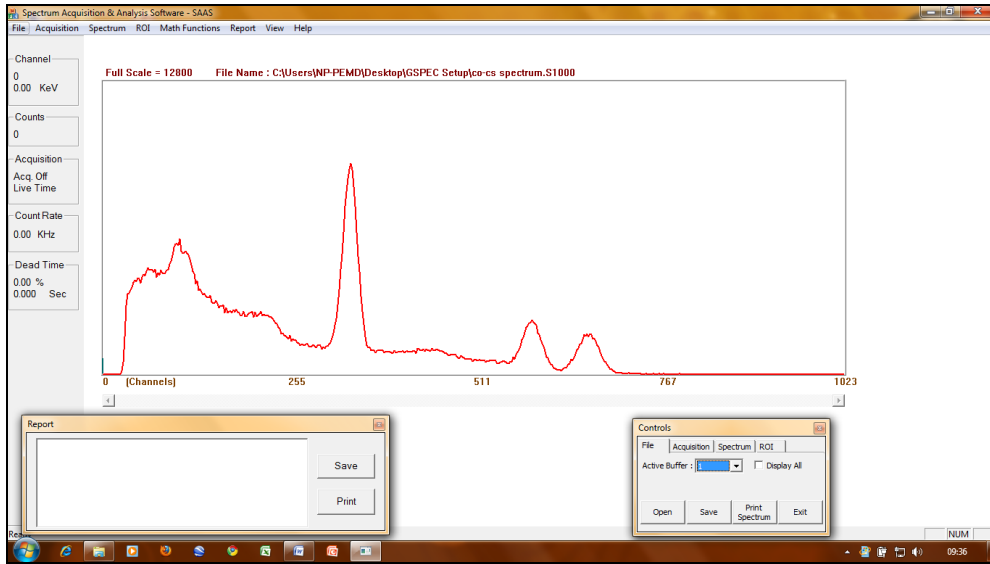
This function provides spectrum stripping by applying the following formula:

$$S_s = S' - F * S$$

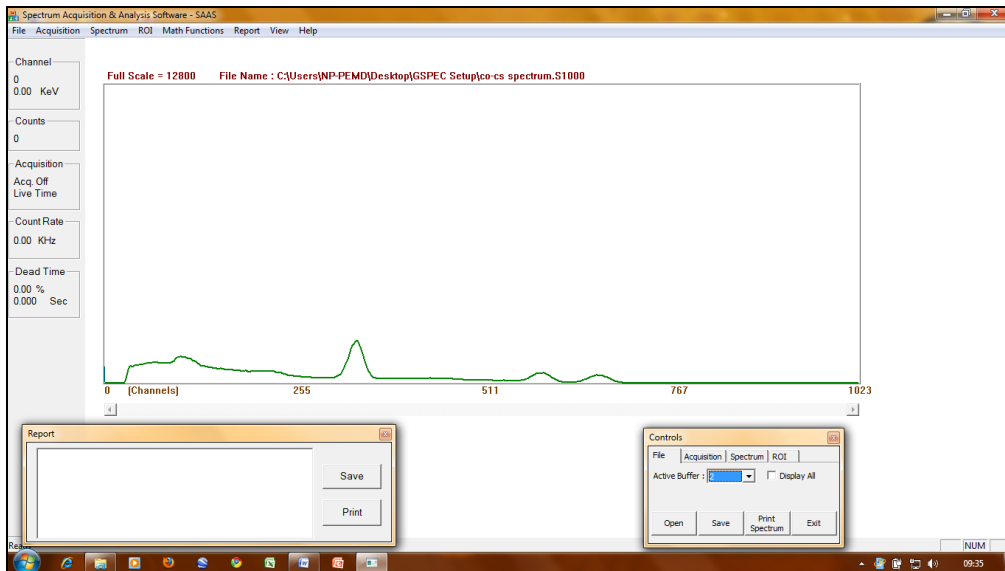
Where S and S' are two spectra are stored in two different storage buffers, the strip factor F can be any user specified value in the range of 0.00 to 999.999.

The processed spectrum S_s is transferred instead of spectrum S'. The memory buffers can be selected from the Control menu. Spectrum stripping can be done as shown on the following screen shot:

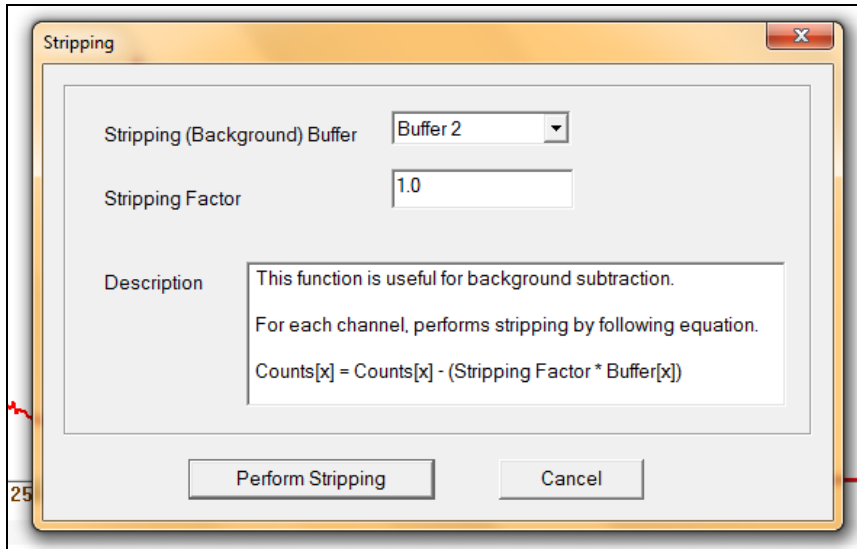
1. Get the spectrum to be stripped in Memory Buffer 1 as shown below.



2. Get the spectrum that is being subtracted in Memory Buffer 2, as shown below:



3. From the menu bar, select Math Function option and then Stripping option from the drop-down menu.



4. Select Background buffer (in the example Memory Buffer 2).
5. Set Stripping factor $F = 1$. The stripping equation will now be:

$$S_1 = S_1 - F * S_2$$

6. Click Perform Stripping. This will subtract spectrum in Memory Buffer 2 from spectrum in Memory Buffer 1 and place the resultant spectrum in Memory Buffer 1.

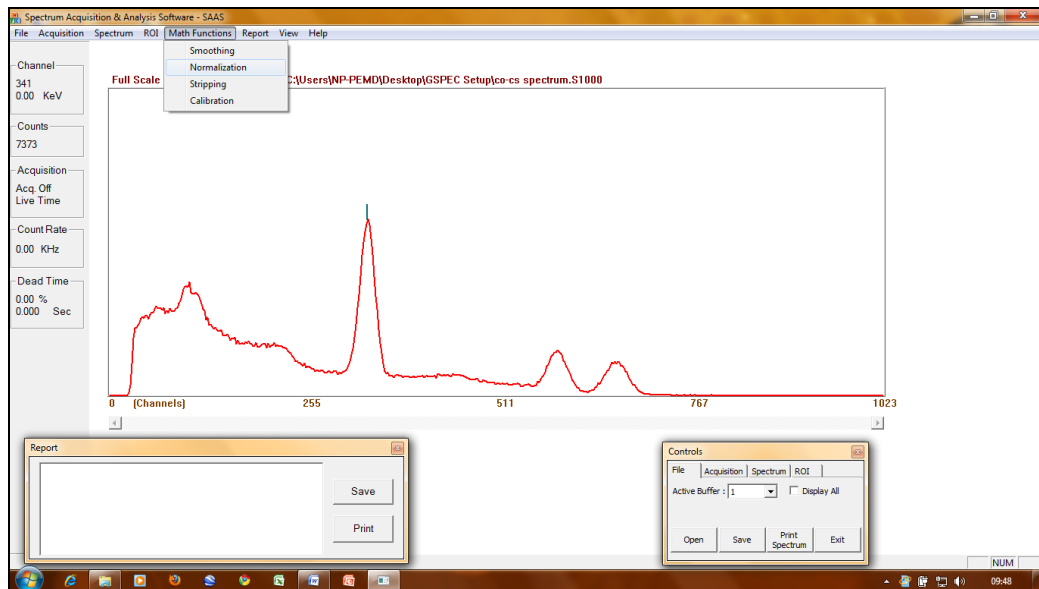
5.6.6 Spectrum Normalization

1. The normalization function allows the user to create a new spectrum by multiplying by a certain factor and adding a certain factor. Normalization will be performed by the following formula :

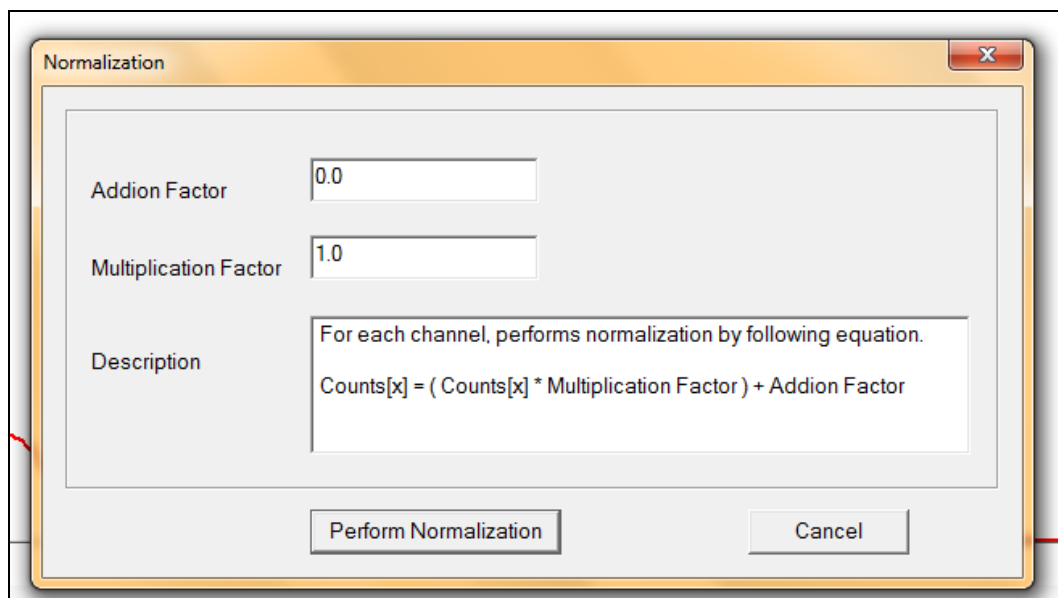
$$S' = S * F + K$$

Where S' is the resultant spectrum, S is the original spectrum, F is the multiplicative constant and K is the additive constant.

2. Normalization can be done as follows. Select Math Function option from the menu bar.
3. Select Normalization option from the drop-down menu.

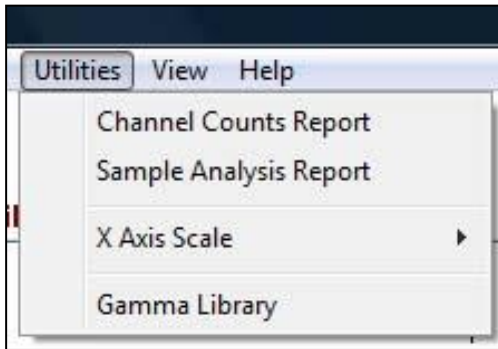


4. The normalization window will appear. Set the multiplication and addition factors and press Perform Normalization button to normalize the spectrum as desired.



5. Normalized spectrum will replace the original spectrum.

6.0 Utilities

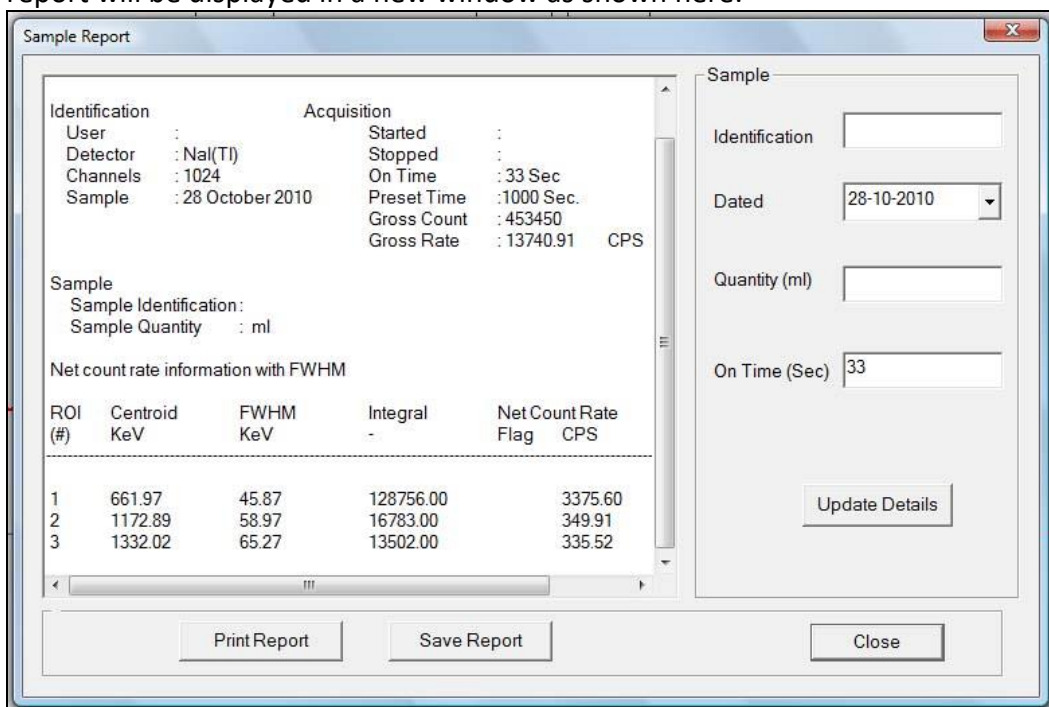


Click on Channel Counts Report menu item in Utilities menu to observe the channel counts in a text mode. Channel counts will be displayed in Report window at the bottom of the screen.



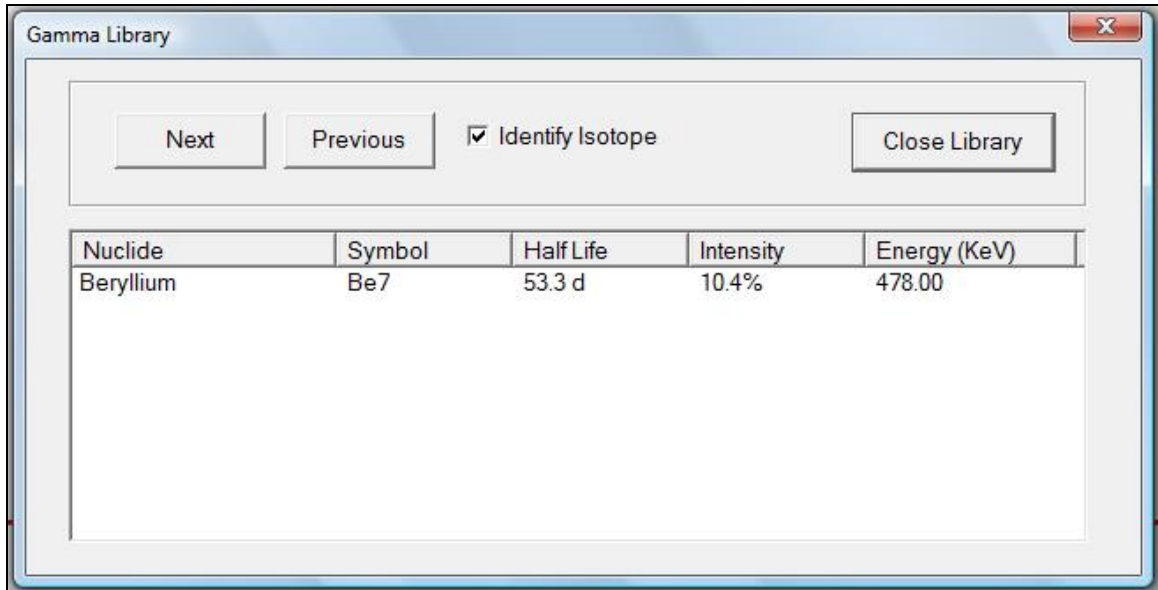
Click on Save button to save the report in a text format. Click on Print button to print the report. Channel number and counts are displayed in a column format so that the text file can be imported easily in Excel application if required.

To get the report of the entire spectrum for selected ROIs, click on Sample Analysis. The report will be displayed in a new window as shown here.



Enter the sample details like Sample ID, quantity, etc. and click on Update Details. Use Save or Print options to save or print the report.

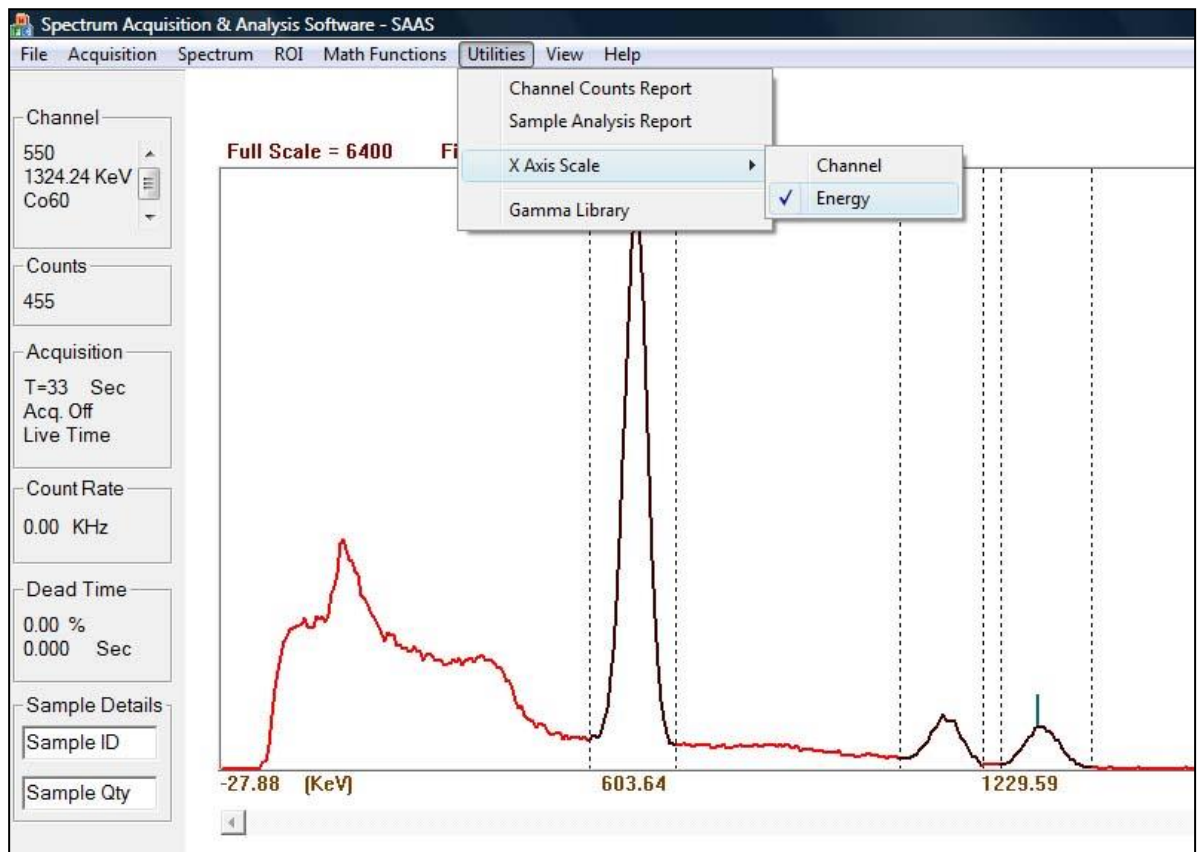
Gamma Library gives the energy details of all gamma radioisotopes with their half life.



Click on Utilities – Gamma Library menu to open the library. The gamma library is stored in an Excel 97-2003 format (.xls) file. The Windows installer stores the library file in Application Data folder of the user.

In the Gamma Library, select “Isotopes of Interest” by clicking on the check box, and then perform an energy calibration (see Section 5.6.2). After the energy calibration is complete, by moving the cursor slowly through the peaks on the screen, the software checks for the possible isotopes near the energy of the cursor channel and displays the isotopes on the screen. It is not necessary to set regions of interest (ROI) to do this. For wide peaks, align the cursor with the top Gaussian portion of the peak. A $\pm 5\%$ variation of energy is considered when the S/W identifies the isotope. For example, for ^{137}Cs (662 KeV), peak energy from 630 to 690 KeV is considered as ^{137}Cs .

In the isotope library, “Next” and “Previous” buttons are used to browse the other isotopes. Since one isotope is displayed at a time, next/previous buttons help to go to the next or previous isotope in the library.



Horizontal scale (Channel/Energy selection) – After calibration of MCA, X axis can be configured to show energy instead of channel number. Click on Utilities → X axis scale → Energy, as shown in the picture above.

7.0 LEAD-SHIELDED WELL COUNTER OPTION (MODEL 243-3)

The Model 243-3 is an option that includes lead shielding. It is a well detector used for gamma ray assay and wipe test analysis. It is shielded with 1.3 cm (0.5 in.) of lead to improve sensitivity by reducing background and other external radiation. The detector is an integrated 4.4 x 5.1 cm (1.75 x 2 in.) (Dia x thickness) NaI (Tl) scintillator.



7.1 Specifications

Well: 1.7 x 3.9 cm (0.7 x 1.6 in.) (Dia x L)

Detector: 4.4 x 5.1 cm (1.75 x 2 in.) NaI (Tl) well scintillator

Sensitivity: will detect 0.005 μCi gamma or 200 dpm removable contamination for $^{99\text{m}}\text{Tc}$, ^{131}I , ^{201}Tl , ^{111}In , ^{125}I , ^{137}Cs , and ^{67}Ga

Efficiency (4 π): 80% for ^{125}I (^{125}I efficiency is based on ^{129}I efficiency of 65%), 90% for $^{99\text{m}}\text{Tc}$, 33% for ^{137}Cs , 43% for ^{60}Co

Background: 1000 cpm

Operating Voltage: 500-1200 volts

Lead Shielding: 1.3 cm (0.5 in.) thick painted lead wall and removable cap

Size:

Base: 20.3 x 20.3 cm (8 x 8 in.) (L x W)

Body: 11.4 x 41.9 cm (4.5 x 16.5 in.) (Dia x H)

Weight: 24.9 kg (55 lb)