ProXL-USB

Alpha Particle Counter Control Software Manual

1.0 Introduction

Welcome to the Alpha Sciences Inc. (ASI) **ProXL USB Alpha Particle Counter Control Software Users Guide**. By reading this guide and familiarizing yourself with the basic features of the program, you will be able to easily start the process of counting samples and backgrounds, along with analyzing and saving the data. If you are setting up and installing your counter for the first time, please refer to your ASI **Set Up and Operations Manual** for information regarding how to assemble the counter and it's support equipment.

The ASI Series Alpha Particle Counters, and their predecessor, the analog based 1850 Alpha Particle Counter, have been manufactured since 1979 and are used by customers around the world. These models include:

- Model 1950 (1000 sq cm, 1 window)
- Model 1950-8 (825 sq cm, 1 window)
- Model 2950 Frisch Grid counter
- Model 3950 (1800 sq cm, 2 windows)
- Model 3950-4 (3600 sq cm, 4 windows)
- Model 4950 (3600 sq cm, 4 windows)
- Model 5950 (2116 sq cm, 1 window)

The Alpha Particle Counter was designed to allow users to measure and record the alpha flux emitted from samples placed inside the detector using the principles of the gas flow proportional counter. The counters mentioned here from ASI have a long history of providing reliable service, with some counters actually running for over 10 years or more prior to requiring a simple refurbishment.

The **ProXL USB Alpha Particle Counter Control Software** program is the latest software interface between the counter and the host computer offered by ASI. This software program replaces the previous offerings from ASI known as ***Pro-1950 and Pro XL***. Using the **ProXL USB** program, users can define test parameters such as count time and channel dwell, sample size, region of interest (ROI), detector efficiency, and the like. Additionally, users can use the data analysis portion of the program to determine mean counts, lower limits of detection (LLD), error bar, number of counts, etc. The ProXL USB design allows for a single host PC to control up to 4 (four) individual ASI counters.

Some advantages of the new **ProXL USB** program:

- Single PC can control up to 4 counters through USB ports
- Screen pause allows for data computation while test continues
- New ROI manipulation bar
- All data display during test
- Control of displayed statistics values (CPH, Time, LLD, etc)

ProXL Software Guide

Before using the ProXL USB software, confirm the host PC and counter are connected, that the PC is powered on, and that the green LED indicator on the back of the counting chamber is illuminated. Several of the adjustable software features require the counter(s) be connected for feedback. For information on initially setting up your counter, please see the ASI **Set Up and Operations Manual**. Click on the ProXL icon on your desktop to open the program. Once the program has loaded, choose **Active Counter** from the menu bar (fig, 1). It should show **Viewer**, and **Counter 1** in **dark text**, and Counter 2 through Counter 4 in ghost text. If you have multiple counters attached to this PC, each counter will be indicated by the dark text. When the text is dark, it indicates that the PC has recognized the counter(s) and communications have been established. You can now close this menu.

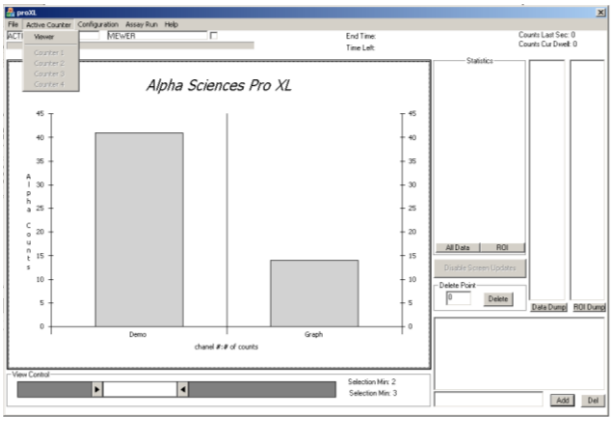


Figure 1

In order to begin using the ProXL USB software program and the alpha particle counter for backgrounds or sample observation, you must first tell the program about the counter and details about the planned assay (counting session). When the ProXL USB program is first opened, a display demo screen (fig. 2) appears.

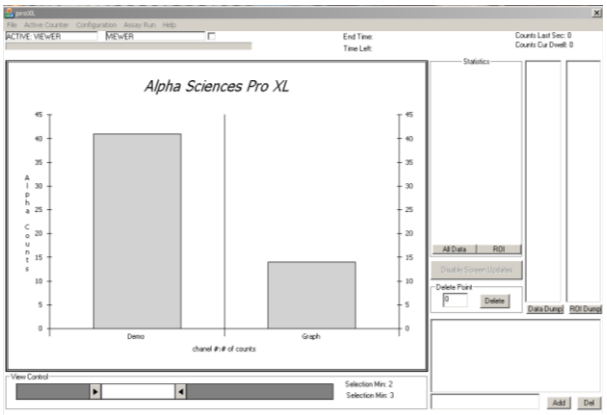


Figure 2

In short, to begin counting you must complete four steps:

1. Configure the counter and save the file (*sec 2.1*)
2. Configure the assay and save the file (*sec 2.2*)
3. Start the assay (*sec 3.0*)
4. Save the data when the assay is complete (*sec 4.0*)

Once the counter has been initially configured (step 1.), there is no need to modify it for future counts, unless the efficiency has been determined to be different. For the next sample assay or background, simply repeat steps 2, 3 and 4. **NOTE:** The area of the counter has been assigned at the factory. **Please do not modify this value**.

2.0 Configuration

Clicking on the **Configuration** tab on the top menu bar will display a choice of either the Counter or Assay configuration screens (fig. 3).

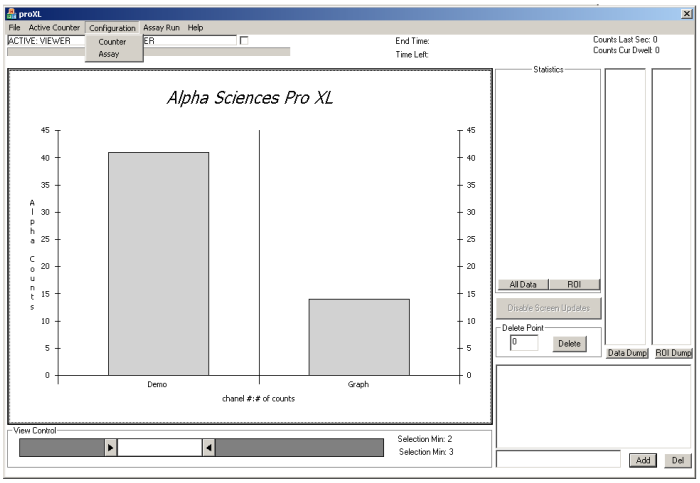


Figure 3

2.1 Counter Configuration

This screen allows you to alter the name, description, area, and efficiency data for your counter(s). You must have the counter you are going to configure open. First, click on the **Active Counter** tab and highlight which counter you are going to configure (1 thru 4). Then click on the **Configuration** tab, draw the pointer over **Counter** and release. This will open the Counter Configuration screen (fig. 4). Again, once this data has been saved as default for this particular counter, there is no need to modify it for future counts, unless the efficiency of the counter changes.

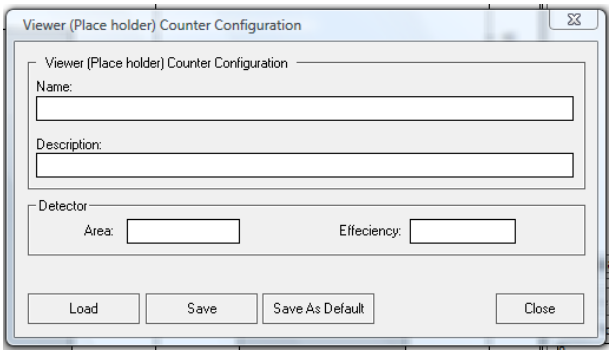


Figure 4

2.1.1 Counter Name

A default name has been given to your counter at the factory based on its serial number. This name can be changed by the user if needed. The information entered into **Counter Name** is not displayed during the assay.

2.1.2 Counter Description

A default counter description has been given to your counter at the factory based on its serial number. If this PC is hosting multiple counters, we generally assign a description (name) followed by a designation of the counters position in series, i.e.; Name, Unit 1. The next counter in series would then receive the next respective description, or Name, Unit 2, and so on, up to four counters. The information entered into **Counter Description** is displayed during the assay and is recorded on the printed report.

2.1.3 Detector Area

NOTE: The area of the counter has been assigned at the factory. **Do not modify this value.** Changing this value will modify the calculations used by the counter. Please see **Sec. 8.0 Factory Default Settings** should this value become accidentally modified.

2.1.4 Detector Efficiency

The efficiency of the counter is calibrated at the factory to 84% using a NIST traceable $_{90}Th^{232}$ Alpha Particle source. The calibrated source is placed approximately 1-2 mm from the detector window, and the efficiency is based on seeing 84% of the known 100% 2 pi emission from the source. The value is entered as 0.84.

2.1.5 Load

Previously defined counter configurations can be opened from:
C:\Program Files\ProXL\counter_config
Choose which counter configuration to load.

2.1.6 Save

Saves your defined counter configurations for ProXL users. ProXL USB users must save files under the “Save as Default” command. Be sure and save the configuration to the correct counter (counter 1, counter 2, etc).

2.1.7 Save as Default

Saves your defined counter configurations for ProXL USB users. Be sure and save the configuration to the correct counter (counter 1, counter 2, etc).

2.1.8 Close

Closes the active screen.

2.2 Assay Configuration

This screen allows you to alter the assay data for your planned counting session. The data here will be modified each time a different size sample is counted, each time the background is recorded, and/or each time the Dwell and Total Time are modified. In short, you will use this screen each time you start a new assay. After clicking on **Configuration**, draw the pointer over **Assay** and release. This will open the **Assay Configuration** screen (fig. 5).

Note: You can find factory pre-defined assay configurations under:
C:\Program Files\ProXL\assay_config

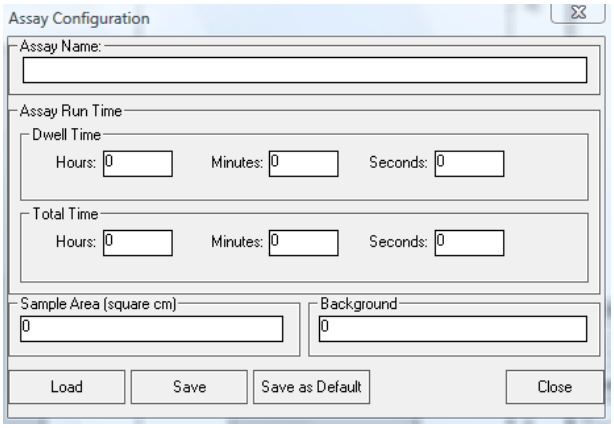


Figure 5

2.2.1 Assay Name

Once you have created an assay file, you can give it a name. The default name is **default assay config**. The information entered into **Assay Name** is not displayed during the assay, but is displayed each time the file is opened.

2.2.2 Assay Run Time

The assay run time, or observation/counting period, is divided into two sections, Dwell Time and Total Time.

2.2.2.1 Dwell Time - Hours, Min, Seconds

The dwell time is defined as the amount of observation time per each channel to be recorded. Typically this is 1 hour for normal assays or backgrounds. In the case of calibration runs with high activity sources, the dwell is shortened to 1 min. The dwell can be assigned any value you wish to use, from 1 second per channel to many hours per channel. If you wish to define the dwell time as 1 hour, enter “1” in the hour box, and

make sure the minute and second box both read “0”. If you wish to define the dwell time as 1 minute, enter “1” in the minute box, and make sure the hour and second box both read “0”, and so on.

2.2.2.2 Total Time - Hours, Min, Seconds

The total time is defined as the overall amount of observation time for the entire assay. Currently in the counting industry, this amount of time can vary from as little as an hour or two, up to several weeks for a single sample assay. If the dwell time indicates the amount of observation time per each channel, then the Total Time will define the total number of channels to record. If you wish to define the total time as 48 hours, enter “48” in the hour box, and make sure the minute and second box both read “0”. If you wish to define the total time as 10 minutes, enter “10” in the minute box, and make sure the hour and second box both read “0”, and so on.

2.2.3 Sample Area (square cm)

Enter the size of your sample to be counted in square centimeters. Use whole numbers only (i.e.; no decimal values).

2.2.4 Background

Enter the current, previously observed background value or the system running background value (a means of determining an average background based on many observations). The alpha particle counters manufactured by ASI. are guaranteed to have an initial background of 5 alpha/cm^2/hour, which would be entered as 5.000. More commonly, backgrounds are in the 2.5 to 2.8 CPH range, which would be entered as 2.500 or 2.800.

If you are running an assay to determine the background of the counter (counts from coming from the counter itself), enter the background value as 0.000. This value will tell the program you are running a background count, and will disable the data compute functions (LLD, net, gross, error bars, etc). All we are interested in is the total number of background counts observed during the defined assay. For more information regarding backgrounds, please see your ASI **Set Up and Operations Manual**

2.2.5 Load

Previously defined assay configurations can be opened from:
C:\Program Files\ProXL\assay_config
Choose which assay configuration to load.

2.2.6 Save

Saves your defined assay configurations under:
C:\Program Files\ProXL\assay_config

2.2.7 Save as Default

Saves your defined assay configurations as the default.

2.2.8 Close

Closes the active screen.

Note: You can find factory pre-defined assay configurations under:
C:\Program Files\ProXL\assay_config

3.0 Starting an Assay

Once you have completed the configuration of the counter and the assay in sections 2.1 and 2.2 above, you can start either a background (***sec. 3.1***) or sample counting (***sec 3.2***) assay.

3.1 Starting a Background Assay

3.1.1 Click on – **Active Counter**, select **Counter 1** (or the counter you are starting)
3.1.2 Click on – **File**, select **New**
3.1.3 Click on – **Assay Run**, select **Start**

A screen will open called Counter Enumeration ID, and will show which counter number (1, 2, 3, or 4) is currently being opened.

3.1.3.1 Counter Configuration – Name/File
The default counter chosen for the assay is displayed.
3.1.3.2 Open *(button)*
Allows you to choose another counter configuration if you wish (***sec 2.1.5***)

3.1.3.3 Assay Configuration – *Name/File*
Once you choose the assay configuration, it is displayed here
3.1.3.4 Open *(button)*
Allows you to choose a pre-defined assay configuration (***sec 2.2.5***)

NOTE: *If you are running an assay to determine the background of the counter (counts from coming from the counter itself), enter the background value as 0.000 (see sec 2.2.4)*

3.1.4 Click on – **Start**

Once the counter configuration and assay configuration are entered into their respective boxes screen, click on the **Start** bar to begin the background assay. The background assay begins and the timers will show remaining assay time. Once the background assay is complete, be sure and save the data (***sec 4.0***). The assay can be stopped by clicking on the **Assay Run** menu tab and then clicking **Stop**. **A stopped assay cannot be re-started**. Once the background assay is complete, save the data (***sec 4.0***)

3.2 Starting a Sample Assay

3.2.1 Click on – **Active Counter**, select **Counter 1** (or the counter you are starting)
3.2.2 Click on – **File**, select **New**
3.2.3 Click on – **Assay Run**, select **Start**

A screen will open called Counter Enumeration ID, and will show which counter number (1, 2, 3, or 4) is currently being opened.

3.2.3.1 Counter Configuration – *Name/File*
The default counter chosen for the assay is displayed.
3.2.3.2 Open (button)
Allows you to choose another counter configuration if you wish (***sec 2.1.5***)

3.2.3.3 Assay Configuration – Name/File
Once you choose the assay configuration, it is displayed here
3.2.3.4 Open (button)
Allows you to choose a pre-defined assay configuration (***sec 2.2.5***)

3.2.4 Click on – **Start**

Once the counter configuration and assay configuration are entered into their respective boxes on the screen, click on the **Start** bar to begin the sample assay. The assay begins and the timers will show remaining assay time. Once the sample assay is complete, be sure and save the data (***sec 4.0***).

The assay can be stopped by clicking on the **Assay Run** menu tab and then clicking **Stop**. **A stopped assay cannot be re-started**.

During the assay, the ROI can be manipulated by clicking on the **Disable Screen** button, and then holding and dragging the Min and Max arrows on the ROI bar. Once the ROI Min / Max has been defined, click the **ROI** data button in the **Statistics** box for the current data. When you are finished observing the ROI, click again on the **Screen Disable** button (now labeled **Screen Enable**) and the program will go back to its normal display and counting status. While in the screen disable mode, the alpha counting portion of the equipment is still acquiring and recording data.

4.0 Saving the Data

Once the assay is complete, or if the assay is stopped, all the data for the current assay **must** be saved. Click on **File** and select **Save**. You may choose to save the file to whichever folder you have created for samples or, if running a background, you may wish to save the background file to the folder we have created called Backgrounds.

Clicking on **Save CSV** saves Complete Screen Value
Clicking on **Save ROI** saves Region of Interest
Clicking on **ROI/CSV** saves both

It is recommended the user not save under these commands, but rather use the general purpose **Save** *command.*

Once the assay data has been saved, the user can open the saved file with the Viewer program to manipulate the ROI and define the data. Click on **Active Counter** and select **Viewer**. Then click on **File** and select **Open**, then find your saved file.

5.0 Computing Data

Once the assay data has been saved, the user can open the file with the Viewer screen described above, and click on the **All Data** or **ROI** button in the **Statistics** box. These buttons run the calculations and give the results in terms of time, counts observed, mean value, net observed, etc. If the entire assay is being displayed (the graph to the left shows the entire assay and the ROI bar is at Min and Max positions), or if the **All Data** button is clicked, the data will reflect the results of all the data. If the ROI is defined by the user (for example, the graph and ROI bar displays from channel 5 to channel 20) and the **ROI** button is clicked, the data will reflect only the results of the ROI (15 hours).

5.1 All Data

During the assay, the **All Data** button can be clicked at anytime to observe current trends. There must be at least two channels of data for the Statistics box to work with. **All Data** displays all the channels and all the counts, regardless of the ROI display.

5.2 ROI

Displays the channels and counts defined by the user, the Region Of Interest

5.3 Manipulating the ROI after the assay

After the assay, the ROI can be manipulated by clicking and dragging the Min and Max arrows on the ROI bar. Once the ROI Min / Max has been defined, click the **ROI** data button in the **Statistics** box for the current data. Placing the mouse pointer anywhere on the ROI bar and right clicking will auto-maximize the ROI Min/Max.

5.4 Manipulating the ROI during the assay

During the assay, the ROI can be manipulated by clicking on the **Disable Screen** button, and then holding and dragging the Min and Max arrows on the ROI bar. Once the ROI Min / Max has been defined, click the **ROI** data button in the **Statistics** box for the current data. Placing the mouse pointer anywhere on the ROI bar and right clicking will auto-maximize the ROI Min/Max. When you are finished observing the ROI, click again on the **Screen Disable** button (now labeled **Screen Enable**) and the program will go back to its normal (all data) display and counting status. While in the screen disable mode, the alpha counting portion of the equipment is still acquiring and recording data.

5.5 Deleting a point

Once the assay is complete, there may be a need to remove a certain channel. This is a permanent modification. Once the point (channel) is deleted, it is gone. Enter the channel number you wish to delete, and press the **Delete** button.

5.6 Data Dump
Pressing the **Data Dump** button saves the entire channel and count data in a format that can be inserted into a spread-sheet program.

5.7 ROI Dump
Pressing the **ROI Dump** button saves the ROI channel and count data in a format that can be inserted into a spread-sheet program

5.8 Add / Delete
The user can enter identifying information, remarks, or other data into the text box. To enter information, type the statement into the box to the left of the Add/Delete key, and the press the **Add** key. To delete information from the text box, highlight the selected statement, and press the **Del** key.

Note: Items in the text box can only be deleted when the assay is complete, or when the Disable Screen button has been clicked on. During the assay, when the screen is live, you will not be able to highlight information in the text box.

5.9 Print
Once the assay is complete, the user can create a hard copy of the screen display by clicking on the **File** menu tab and selecting **Print**. If not already done so, be sure and configure your printer for landscape printing to see the entire display.

6.0 Backup Files
In the case of a power failure or equipment malfunction which causes the host PC to stop, the current existing data (up to within 5 seconds of the last polling) is saved under a backup file. There must be at least 2 channels of data. Each counter (1 through 4) will have its own backup file. Once the malfunction is remedied, the user can retrieve the data collected to that point.

If the user tries to exit the ProXL program while running or when the assay is stopped and the data has not been saved, the program will warn that the file has not been saved. If the program is exited accidentally before saving, the user can access the Backup file to regain the lost data.

6.1 Recovering a backup file
5.1.1 Click on Active Counter and select Viewer.
5.1.2 Click on File and select Open
5.1.3 Find the files C:\Program Files\ProXL\backup_data
5.1.4 You will see the files backup_1, backup_2, etc. (per respective counter)
5.1.5 Open the backup file, and then save under your new file name.

Warning:
The backup data is written as a counter is running. Once the counter is stopped, that backup file is the same as the original file. However, once the counter is re-started (new assay), the backup file is overwritten and a new file is created.

7.0 Screen Description

7.1 Menu Bar

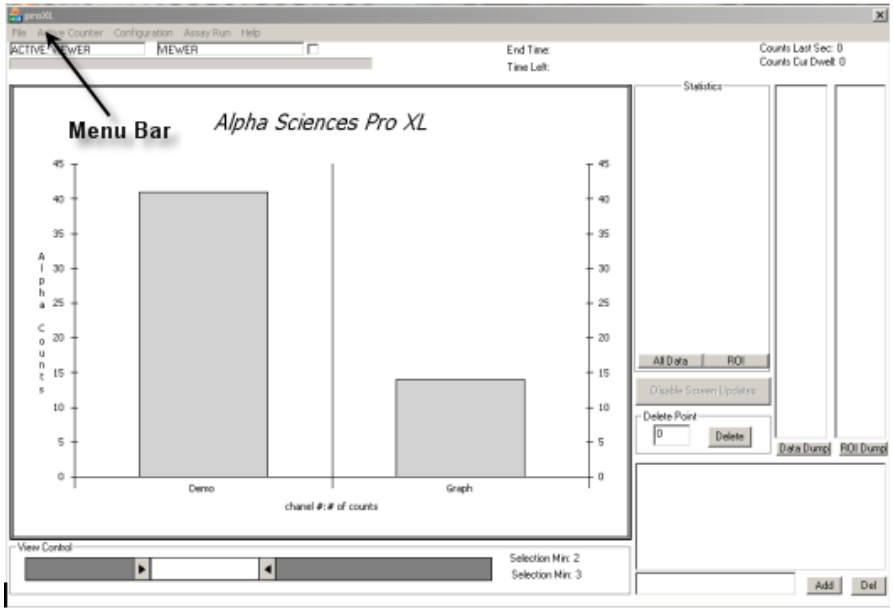


Figure 6

7.1.1 File

7.1.1.1 ***New*** – Starts a new counting assay
7.1.1.2 ***Open*** – Opens an existing file
7.1.1.3 ***Save*** – Saves the current file
7.1.1.4 ***Save CSV*** – Saves the Complete Screen Value
7.1.1.5 ***Save ROI*** – Saves Region Of Interest
7.1.1.6 ***Save ROI/CSV*** – Saves Region Of Interest / Complete Screen Value
7.1.1.7 ***Print*** – Prints the screen display
7.1.1.8 ***Exit*** – Exits the program

7.1.2 Active Counter

7.1.2.1 ***Viewer*** – Used to view previously saved assays.
7.1.2.2 ***Counter 1*** – Shows Counter No.1 display
7.1.2.3 ***Counter 2*** – Shows Counter No.2 display
7.1.2.4 ***Counter 3*** – Shows Counter No.3 display
7.1.2.5 ***Counter 4*** – Shows Counter No.4 display

7.1.3 Configuration

7.1.3.1 ***Counter*** – Opens Counter configuration file
7.1.3.2 ***Assay*** – Opens Assay configuration file

7.1.4 Assay Run

7.1.4.1 ***Start*** – Opens the start screen
7.1.4.2 ***Stop*** – Stops the current assay

7.1.5 Statistics Show

Clicking the "Statistics Show" tab on the main screen allows the user to determine which values are displayed in the Statistics area. Click the box next to the value you wish to have displayed.

7.1.5.1 ***Num Points*** – Number of dwell channels displayed
7.1.5.2 ***Total Counts*** – Number of total counts displayed
7.1.5.3 ***Time*** – Total time displayed (in hours)
7.1.5.4 ***Mean*** – Hourly per-channel average of counts displayed
7.1.5.5 ***Std Dev*** – Standard deviation of the mean value
7.1.5.6 ***CPH*** – Average Counts Per Hour of counts displayed
7.1.5.7 ***Net a/(cm2 hr)*** – Net alpha per sq cm per hour, before efficiency corrected.
7.1.5.8 ***± err*** – Error Bar of the net value, before efficiency corrected
7.1.5.9 ***LLD*** – Lower Limit of Detection
7.1.5.10 ***Det Eff(%)*** – Detector Efficiency in percentage (See 2.1.4)
7.1.5.11 ***Net corr*** – Net alpha per sq cm per hour, after efficiency corrected
7.1.5.12 ***± err*** – Error Bar of the net value, after efficiency corrected
7.1.5.13 ***CDL90*** – Counter Detection Limit at 90%
7.1.5.14 ***LOD 90.0%*** – Limit Of Detection at 90% confidence (1 σ)
7.1.5.15 ***LOD 95.0%*** – Limit Of Detection at 95% confidence (2 σ)
7.1.5.16 ***LOD 99.7%*** – Limit Of Detection at 99.7% confidence (3 σ)

7.1.6 About

The "About" tab displays the current software release information.

7.2 Counter Status

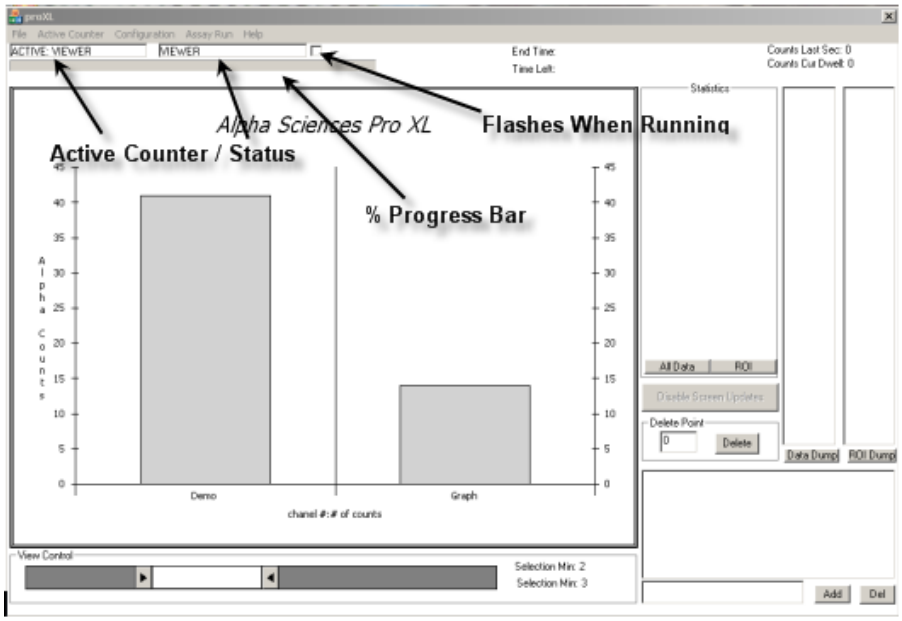


Figure 7

7.2.1 ***Active*** – Box displays the counter number being observed.
7.2.2 ***Status*** – Box displays the status of the assay (running, stopped, viewer).

7.2.3 ***Progress Bar*** – Progress bar advances as assay continues.
7.2.4 ***Check Flashes when Running*** – 1Hz check mark flashes during assay.

7.3 Running Time / Counts

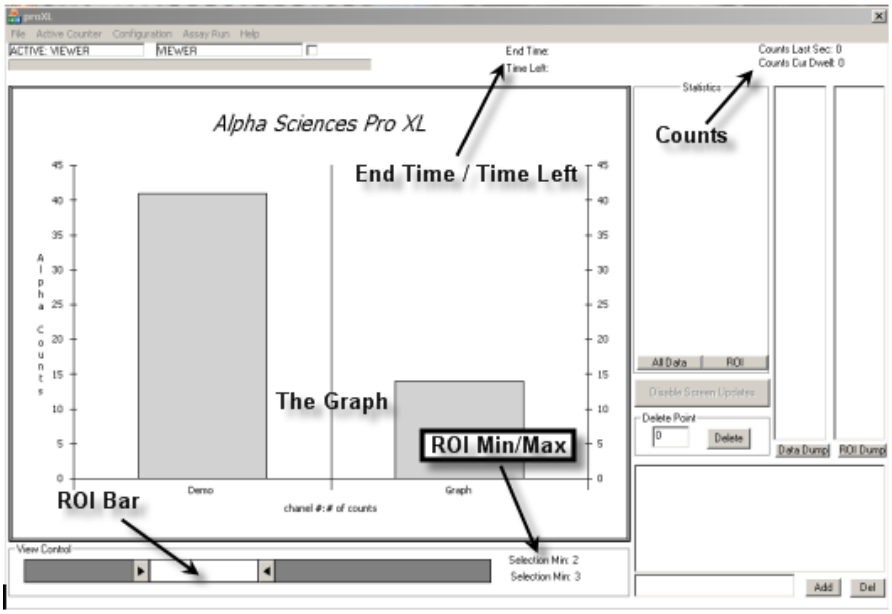


Figure 8

7.3.1 ***End Time*** – Time/date that the current assay will be completed.
7.3.2 ***Time Left*** – Time remaining in the current assay.
7.3.3 ***Counts Last Sec*** – Counts observed in the last second (used for calibrations).
7.3.4 ***Counts Cur. Dwell*** – Counts in the current dwell (channel).
7.3.5 ***The Graph*** – Visual display of time (x axis) and counts (y axis).
7.3.6 ***The ROI Bar*** – Allows user to define the Min and Max ROI positions.
7.3.7 ***ROI Min/Max*** – Displays the current Min / Max ROI positions.

7.4 Data Compute Section

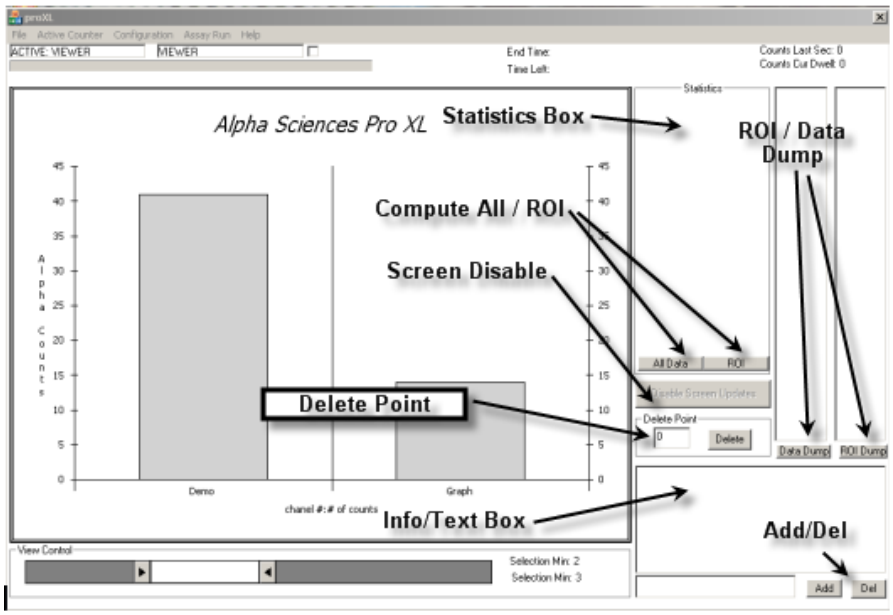


Figure 9

7.4.1 ***Statistics Box*** – Displays assay info after clicking **All** or **ROI** button
7.4.2 ***Compute All / ROI*** – Displays All Data. If ROI assigned, ROI data only.
7.4.3 ***Screen Disable / Enable*** – During an assay, disables screen for ROI manipulation.
7.4.4 ***Delete Point*** – Deletes whichever point (channel #) is entered.
7.4.5 ***Data Dump*** – Saves all the raw data into a text file.
7.4.6 ***ROI Dump*** – Saves only the defined ROI data into a text file.
7.4.7 ***Info / Text Box*** – Auto stamped with start time, text can be added here
7.4.8 ***Add / Del*** – Type text into the box and click **Add**. To remove, highlight and press the **Del** button.

8.0 Default Factory Settings

In the event that a counters host PC should loose the default settings, please use the following guide to reenter the values.

Counter Name – The default setting is your counters serial number. This name can be changed by the user if needed. The information entered into **Counter Name** is not displayed during the assay.

Counter Description – The default setting is your counters serial number. If this PC is hosting multiple counters, we generally assign a description followed by a designation of the counters position in series, i.e.; Name, Unit 1. The next counter in series would then receive the next respective description, or Name, Unit 2, and so on, up to four counters. The information entered into **Counter Description** is displayed during the assay and is recorded on the printed report.

Detector Area – The default setting for your counter is set at the factory based on the size chart below, where ***Model Number = Area.***

It is extremely important to maintain this area value, as changes here will effect the final results of the assay. The information entered into **Detector Area** is displayed during the assay and is recorded on the printed report.

Model 1950 = 1000 (cm^2) 1 window, 11” x 14”
Model 1950-8 = 1600 (cm^2) 1 window, 8” x 16”
Model 2950 = 900 (cm^2) windowless, active grid 12” x 12”
Model 3950 = 1800 (cm^2) 2 windows, 12” x 12” ea.
Model 3950-4 = 3600 (cm^2) 4 windows, 12” x 12” ea.
Model 4950 = 3600 (cm^2) 4 windows, 8” x 16” ea.
Model 5950 = 2116 (cm^2) 1 window, 18.11 x 18.11”

Detector Efficiency – 0.84 (84%, as set at the factory)
Please refer to the ASI **Set Up and Operations Manual** for information regarding adjusting detector efficiency. The information entered into **Detector Efficiency** is displayed during the assay and is recorded on the printed report.

LLD ANNEX-A

Lower Limit of Detection (LLD), How it's applied:

As part of the software display on the ASI Alpha Particle Counters, the LLD is an automatic function of the data compute button. Two major factors effect the LLD: time and background of the tool. The longer the count, and the lower the background, the better the LLD.

The LLD is essentially a reference to both how low a sample can be counted over background, and at what level of confidence that reading is given. If the sample counts well above the background level of the tool, there really is no need to refer to the LLD. However, if the sample is counting at or near the background level of the tool, then the LLD formula becomes very important.

On the pages “LLD, The Formula” and “LLD, The Equation”, we see how we derive our variables for determining the LLD. Here, let's apply the LLD to a typical sample count from our standard 1000 cm^2 Model 1950 counter to see how it works:

Assume that the counting time for measuring the background of the counter and the counting time for measuring the sample are equal. Also assume that the background is 3 alphas per hour for the total 1000 cm^2 area (0.003 $a/cm^2/hr$). The background and sample were each counted for 4 days, which comes out to 96 hours each (24 hours x 4 days = 96 hours). At 3 alphas per hour background over 96 hours, we can say 96 hours x 3 = 288 alpha counts attributable to the background of the tool.

Using the LLD Equation we can state the following:

1) LLD = 4.66 x square root of 288, = 4.66 x 17 = 79 counts above background, over 96 hrs, 1000 cm^2

2) 79 divided by 96 hours = 0.82 alpha counts above background, over 1000 square centimeters.

3) 0.82 divided by 1000 sq. centimeters = 0.0008 alpha counts above background, per hr, per cm^2.

4) Therefore, the LLD is defined as 0.0008 $a/cm^2/hr$.

Now, let's assume the same conditions above, only we count for one day (24 hours). 24 hours x 3 alphas per hour = 72 alpha counts attributable to the background of the tool.

Using the LLD Equation we can state the following:

1) LLD = 4.66 x square root of 72 = 4.66 x 8.5 = 40 counts above background, over 24 hrs, 1000 cm^2

2) 40 divided by 24 hours = 1.7 alpha counts above background, over 1000 cm^2

3) 1.7 divided by 1000 sq. centimeters = 0.002 alpha counts above background, per hr, per cm^2.

4) Therefore, the LLD is defined as 0.002 $a/cm^2/hr$.

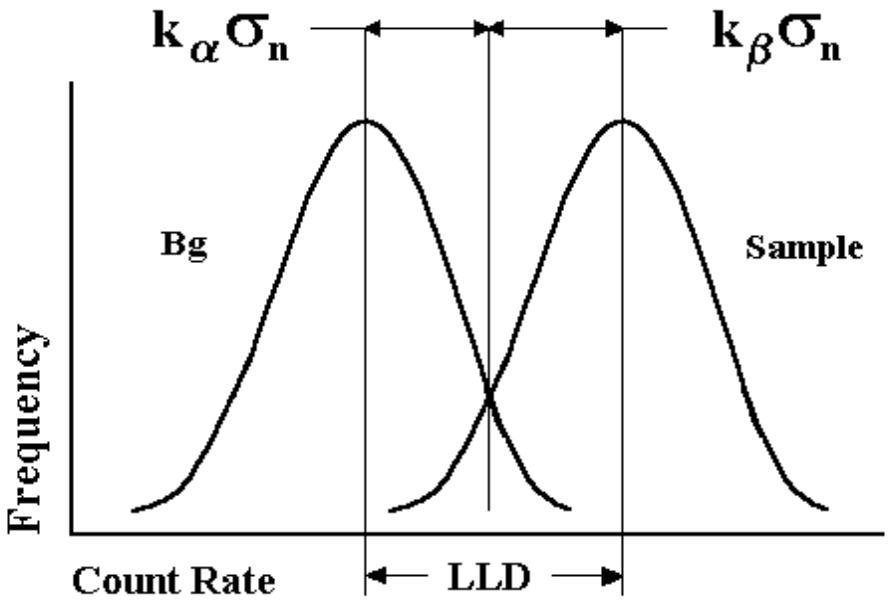
For comparison:

Count Interval	LLD
96 hours	0.0008 $a/cm^2/hr$
24 hours	0.002 $a/cm^2/hr$.

Conclusion: The longer the counting time, the more accurate your data (more sensitive) will be to determine the activity of your sample, most notably when the sample counts and background counts are nearly the same.

LLD ANNEX-B

Lower Limit of Detection, the Formula



$$LLD = (k_\alpha \times \sigma_n) + (k_\beta \times \sigma_n) = (k_\alpha + k_\beta)\sigma_n$$

k_α = Value for the upper % of the standardized normal variate corresponding to the arbitrarily chosen risk for falsely concluding that activity is present (α error).

k_β = Corresponding value for arbitrarily chosen degree of confidence for detecting presence of activity (1-β error)

σ_n = Standard error for net sample activity

LLD ANNEX-C

Lower Limit of Detection, the Equation

If: 1. We set the α & β values at same level
2. Gross and BG count rates ~ =
then

$$\sigma_n = \sqrt{\sigma_G^2 + \sigma_{BG}^2} \approx \sigma_{BG} \times \sqrt{2}$$

$$LLD = 2k \times \sqrt{2} \times \sigma_{BG}$$

Values of k

α	$k = \frac{x}{\sigma}$	$2k \times \sqrt{2}$
0.01	2.327	6.59
0.02	2.054	5.81
0.05	1.645	4.66
0.10	1.282	3.63

$\therefore$ At 95% confidence level

$$LLD = 4.66 \times \sigma_{BG}$$

ERROR BAR FORMULA ANNEX-D

A. Hours of Count, Background and sample time should be same
B. Background Counts, total
C. Sq Rt of B. (Sq Rt of Background Count Total)
D. C/A
E. B/A +/- D, Displayed as a/hr
F. Sample Counts, Total
G. Sq Rt. of F (Sq Rt of Sample Count Total)
H. G/A
J. F/A +/- H, Displayed as a/hr
K. J – E (Sample Counts per hour – Background Counts per hour)
L. Sq Rt. of (D^2 + H2)
M. Sample Size Area, in Sq Cm
N. K/M, displayed as Net a/cm^2/hr
P. L/M, accuracy or error bar.

Example: An alpha counter is first run for 24 hours empty to establish a background level, in this case 2.667 a/hr, or 64 counts in 24 hours. Next, a sample of 182 sq cm is placed inside the counter for the same 24 hour period and counted, showing a final value of 89 counts in 24 hours. This value represents both the sample and background counts combined, and so background is removed in step K. below.

Background = 64 counts, 24 hour period = 2.667 a/hr
Sample (182 sq cm) = 89 counts, 24 hour period = 3.708 Gross a/hr (sample and bkgd)

A. 24 hours	Observation time background and then sample.
B. 64 counts	Background Total (2.667 x 24)
C. 8	Sq Rt of 64 (B)
D. 8/24 = 0.333	Result of C divided by total hours A
E. 2.667 +/- 0.333	Alpha per hour from background
F. 89	Gross counts (**sample and background**)
G. 9.434	Sq Rt of 89 (F)
H. 9.434/24 = 0.393	Result of G divided by total hours A
J. 3.708 +/-0.393	Gross Alpha per hour from **sample and background**
K. 3.708 – 2.667 = 1.041	(Gross sample/bkgd a/hr) – (Background a/h)
L. 0.515	Sq Rt of (Bkgd $Error^2$ + Sample/Bkgd $Error^2$)
M. 182 (cm^2)	Sample size
N. 1.041 / 182 = 0.006	Alpha per cm sq per hour
P. 0.0028	Error

This is reported as the net value, before efficiency corrected, 0.006 a/cm^2/hr, +/- 0.0028

Apply the efficiency factor of 84 % and the values are reported as net corrected;
0.007 a/cm^2/hr, +/- 0.0033

For further information regarding alpha particle counting methods and statistics, please see the **JEDEC Standard JESD-221**, titled **"Alpha Radiation Measurement in Electronic Materials"**, published May 2011 by the ©JEDEC Solid State Technology Association.