XIA LLC

UltraLo-1800 Alpha Particle Counter

Quick Start Guide

Version: 1.0

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I. Introduction

The purpose of this document is to give a brief overview of the UltraLo-1800 alpha particle measuring system. It is intended as a quick reference and an introduction to the counter hardware and software. This section covers the theory of operation and provides mechanical information on the counting system and its more important parts. The following sections cover the basics of making a measurement, gives an overview of the counting software, and discuss the types of samples the UltraLo-1800 can measure. For more detailed discussions of these topics, see the User Manual.

A. General System Design

1. Theory of Operation

The UltraLo-1800 is an ionization chamber, as shown in Figure I-1, and has the following differences from the proportional counter. First, the signal electrode is a planar sheet, surrounded by a Guard electrode about 2" wide. Second, the sample is placed inside the chamber and forms the detector's other electrode. In this geometry, the electric field is uniform between the two plates and is everywhere quite low, less than 100 V/cm, and there is no electron gain. Because there is no gain, the counter is extremely sensitive to noise pickup and the great care was required in the UltraLo-1800's design and construction in order to achieve clean, high quality signals.

In an ionization counter the signals are formed from electron *drift*, and their size is proportional to the drift time. This point is critical to the operation of the UltraLo, because it means that α tracks that originate on the far side of the detector from the electrode (i.e. on the sample) generate signals for longer times than do α tracks that originate on the electrode itself. Tracks from the sidewalls can fall anywhere in between, so we need a veto electrode to filter them out. The traces in Figure I-1 illustrate this point, the alpha, ceiling, and sidewall events are all distinct and separable with pulse shape analysis. This is how the UltraLo-1800 can screen out non-sample alphas to be "zero-background".

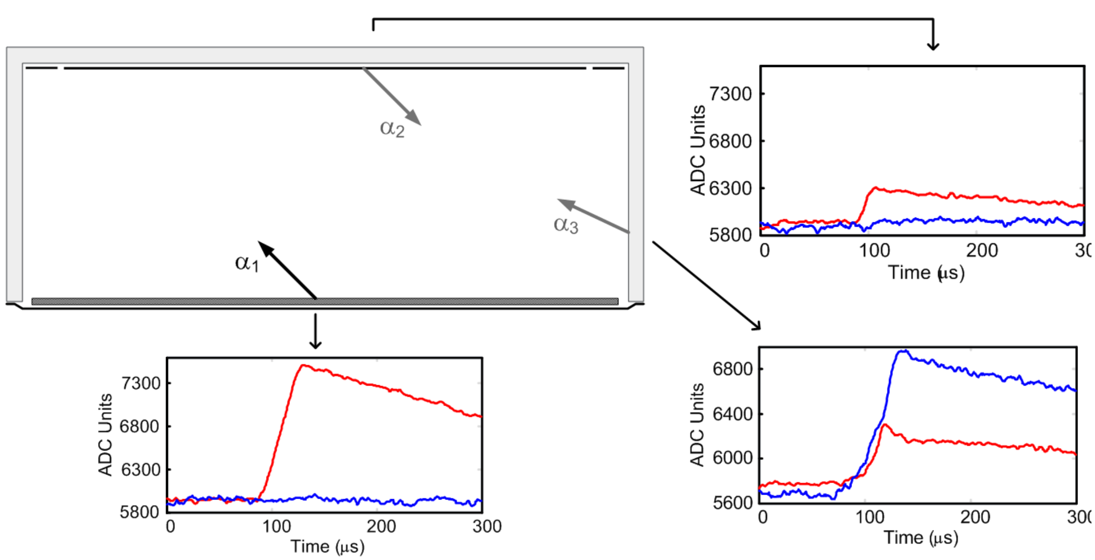


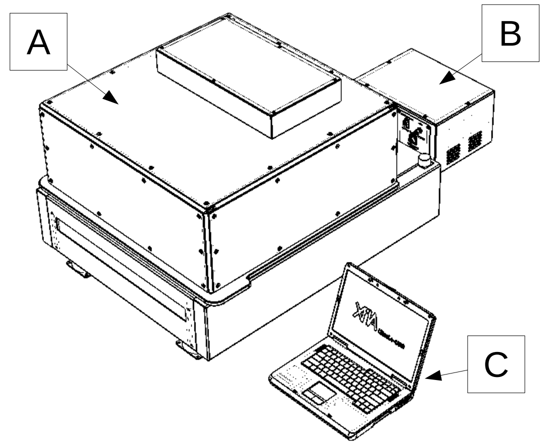
Figure I-1: Schematic depiction of the UltraLo-1800's Active Volume with alpha emissions and resultant traces

2. Mechanical Information

This section introduces the important components of the counter. For information about the dimensions of these components as they pertain to setup requirements, please see the UltraLo Site Preparation Guide.

The entire UltraLo-1800 Alpha Particle Counting system is shown in Figure I-2 top. The system is comprised of three main components, the Counting Module, the Support Box, and the Laptop. These components are connected via various cables (for electrical signals) and tubing (for gas), which are not pictured. The Counting Module is the counter itself: it takes in samples, maintains an environment appropriate for counting, and detects and processes pulses. The Support Box houses the components that the counter requires but that cannot be located inside of it for reasons of noise and/or space, including power supplies and gas control. Finally, the Laptop runs CounterMeasure, the UltraLo counting and control software application.

The Counting Module has two parts: the Upper Half has the Active Volume and Electronics Box, the Lower Half has the Sample Tray and the Sample Changing Mechanism. **Error! Reference source not found.** shows the upper half of the Counting Module as though it were open, allowing you to see the Active Volume. Visible are the fieldshapers (A), which prevent the bowing of the electric field at the volume's edges, and the 3-piece electrode, comprising the central Anode (B), the switchable Interstitial (C), and the Guard (D).



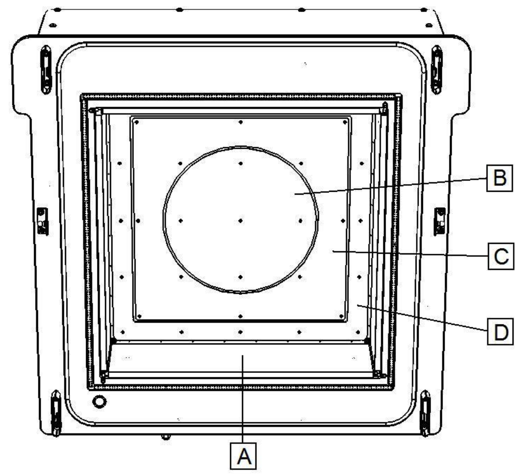


Figure I-2: (Top) Entire UltraLo-1800 setup, including Counting Module (A), Support Box (B), and Laptop (C). (Bottom) Active Volume, showing the 3-piece electrode (Anode: B; Interstitial: C; Guard: D) and fieldshapers (visible one marked A).

II. Making a Standard Measurement

This section details the steps to go through in order to make a typical measurement. For more information on CounterMeasure and the reference buttons/plots, see page 34 of the User Manual.

A. Measurement Procedure

a) Starting the App

Upon starting CounterMeasure you'll see a loading screen while the software attempts to communicate with the hardware. This will take several seconds. You will be able to tell if the connection was successful based on the presence or absence of the "no connection" icon in the bottom-left corner, near the status icons.

b) Main Panel

Begin: If you are not changing samples please skip the next three steps and begin at "Start Run".

Eject tray: If changing samples: hit the Tray Control (eject) button to eject the tray.

Swap Samples: Remove the old sample, put on the new sample, all while being careful not to contaminate the sample. In brief: do not handle the sample directly; use new gloves or cleaned tweezers; and be careful to clean the tray and all sample-handling instruments thoroughly.

Close tray: Push the tray all the way back into the counter. Hit the "Close" button in the Tray Control Dialog.

Start run: Hit the Star Run (play) button. If a purge is required (meaning if the tray was opened), keep the "Purge" box checked, if the tray was not opened uncheck it. Next choose the duration of the run (this does not include the purge time), choose the most appropriate electrode size, and fill in any custom parameters. After that the purge will run automatically, if you're purging, and when it finishes the run will start.

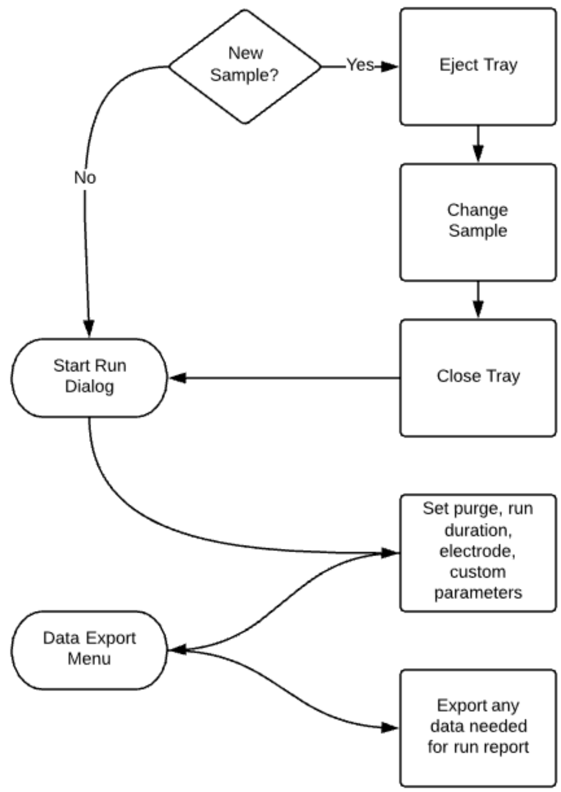


Figure II-1: Measurement flowchart

Watch Data: During and after the run the information on the Main Panel can be extremely useful. For instance, if the Emissivity vs. Time graph shows a large drop through a run, there may be contamination from radon. The spectrum can give information on the specific isotopes in the sample. If there is a significant change over the course of the measurement (say from outgassing or radon) the ROI can be used to select only good data (all graphs will update with only data from the selected time period). All of these graphs should be checked to ensure that the measurement was successful.

c) Analysis

Watch Data: If desired, the Analysis Panel can be opened while a measurement is in progress. For instance, the main graph, Anode Energy vs. Risetime, can show if there are issues with outgassing. Further, the rates of various event types (e.g. ceilings and rounds) should be similar between measurements. Excessive numbers of any event type can indicate a problem. Scrolling through some traces can show any abnormal noise that may have cropped up (such as vibration from unusual environmental activity). If anything looks amiss, contact us at support@xia.com.

d) Run reporting

Exporting Files: After the run is over the user will typically want to generate a report. This can be as simple as inserting the reported emissivity into a spreadsheet, or as complicated as running custom pulse-shape analyses. As suchCounterMeasure has several different exports available. These exports can be performed either immediately after a run ends, or later, after reanalyzing a file.

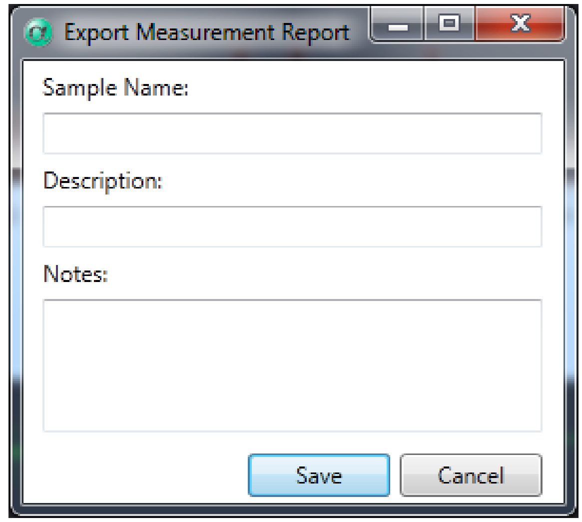


Figure II-2: Export Measurement Report Dialog.

Most users will be interested in the Measurement Reports, which are PDF files that can be generated by navigating to *File* and clicking on "Export Measurement Report…". A dialog (shown in Figure II-2) will pop up, asking for a sample name, a description, and any pertinent notes. These will show up on the report itself, allowing the user to make each report distinct. This report will include: emissivity and error, alpha counts, date, run length, electrode size, as well as the 3 plots on the Main Panel. The exported data responds to a selected ROI, as discussed the User Manual.

There are a few other exports available besides the Measurement Report. To export one of them, go to the Main Panel and navigate to *File* and click on *"*Export". There will be a list of five files available for export, Alpha Spectrum, Alphas, Alpha Time-series, Emissivity, and Analysis Results. These will all be comma-separated (.csv) files, and their contents are detailed in Table II-1.

The final export available is the fit export, available by right-clicking the Event Traces Plot in the Error! Reference source not found.. It will export a .tar.gz file containing 4 files, a .trs containing the raw ADC values of the two traces, another .trs containing the fit values for both traces, and two log files.

Exported File	Contents
Alpha Spectrum	Bin number in MeV vs. number of alphas in that bin.
Alphas	Time since start of run (in seconds) and energy (in MeV) for every alpha.
Alpha Time-series	End time of bin (in seconds) vs. number of alphas in that bin. Same as Counts plot in Main Panel.
Emissivity	End time of bin (in seconds) vs. emissivity at that time (in α/cm^2/h). Final bin is the final emissivity. Same as Emissivity plot on Main Panel.
Analysis Results	Analysis results of every event in the run. Includes event number, trigger time, event class, Anode amplitude, Anode risetime, Anode energy, and Anode timing parameters. (All of these explained more in AAE section of the User Manual.)

Table II-1: Exported files and their contents.

III. Sample Considerations

This section provides a brief introduction to the types of samples the UltraLo-1800 can count, and what the user needs to know in order to count them as accurately as possible. It covers materials, lateral dimensions, and vertical dimensions.

A. Materials

1. Conductors/semiconductors

As previously mentioned in the Theory of Operation section, the UltraLo-1800 is designed such that the sample is inside the counting chamber and forms the ground electrode. Therefore samples require a reasonable conductivity, as in metals or semiconductors. When measuring these samples no special precautions need to be taken outside of good sample handling practices.

2. Insulators

Because UltraLo-1800 samples need to be at least partly conductive, measuring insulators is more difficult than measuring conductors. Insulators tend to accumulate charge, and in the extremely dry environment inside the counter the charge remains on the surface of the insulator. This buildup can be large enough to severely distort the electric field inside the detector, causing inaccurate measurements. For more detail on measuring insulators, including potential ways to overcome this issue, please see this UltraLo-1800 support webpage.

3. Plastics

Plastics are typically insulating, and will often have the problem discussed above. However, in addition to being prone to accumulating charge, plastics can also absorb relatively large amounts of water which will then outgas in the extremely dry environment of the counting chamber, speeding up electron drift. This results in some alpha particles from these materials being misclassified as mid-air events and artificially lowering the material's reported emissivity. The effects of outgassing are described in more detail in the Troubleshooting section of the User's Manual.

4. Powders

Powders are another potentially problematic sample type. Because samples in the UltraLo-1800 are inside the counting chamber there is a chance of contaminating the counter if any powder particles leave the sample tray. Because the counter needs an active purge there is constant gas flow. The chamber is designed to keep turbulence to a minimum, but the possibility of disturbing the powder and contaminating the constituent parts of the detector remains. Now, because the UltraLo-1800 is excellent at screening out alpha particles that don't originate from the tray this contamination may not affect the instrument's functioning, although powder residues may contaminate later samples.

In addition to contamination concerns, getting an accurate measurement of the surface area of a powder is difficult. The UltraLo-1800 can report how many alpha particles the powder generates (provided it's not also insulating or outgassing), but it will not know what area they emanated from, giving a potentially misleading emissivity estimate. It is up to the user to recognize this and correct for it.

B. Lateral Dimensions

The UltraLo-1800 is designed to accommodate two standard sample sizes, any sample that completely covers either size may be counted without background correction. Other sizes may also be counted, but will then require background correction for the activity of the exposed sample tray. For more details, please see "Counting nonstandard samples" in the User's Manual.

The UltraLo measures these two standard sizes using a three-part electrode (see **Error! Reference source not found.**) wherein a relay is used to connect the interstitial electrode to either the outer Guard electrode or the inner Anode electrode. The two resultant sample sizes are described below.

1. Standard #1: 1800 cm^2

The 1800 cm^2 electrode configuration (42.5 cm, 16.7” square) is the standard for measuring large samples and the namesake of the detector. A sample that fills this full area will count very quickly and will benefit from not needing any form of background subtraction.

2. Standard #2: 707 cm^2

The 707 cm^2 electrode configuration is an alternate configuration for measuring 12” (30 cm) wafers without having to perform background subtraction. In this configuration the active area is just a 12” circle in the middle of the counter, meaning pulses from any other part of the tray are rejected. This allows for more accurate and faster counting of wafers or other materials that don’t fill the full 1800 cm^2 configuration.

C. Vertical Dimensions

The UltraLo-1800 is also designed to accommodate sample of differing heights. For thin samples such as wafers or thin sheets of metal the default configuration is the most appropriate. For thicker samples, however, the height will shorten risetimes and can potentially distort the electric field, causing unreliable results. To accommodate these thicker samples there are blocks under the perforated sample tray support that can be rotated to lower it, thus keeping the top of the sample near the intended measuring plane. Three block heights are available (0.440”, 0.315”, and 0.290”) to accommodate nominal sample thicknesses of <1/16” (1.5m), 1/16”-3/16” (1.5mm-4.7mm), and 3/16”-5/16” (4.5mm-8mm), respectively. However, care should be taken to assure that the UltraLo's maximum sample weight limit (20 lbs.) is not exceeded.