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PNNL OS3300 Alpha/Beta Monitoring System Software and Hardware Operations Manual

January 2024

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JM Barnett

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Pacific Northwest National Laboratory
Richland, Washington 99354

Summary

The Pacific Northwest National Laboratory (PNNL) OS3300 Alpha/Beta Monitoring System Software and Hardware Operations Manual describes how to operate the software and hardware on a personal computer in conjunction with the Berthold Technologies LB150D continuous air monitor. Included are operational details for the software functions and information about how to read and use the dropdown menus and how to understand readings and calculations.

Acronyms and Abbreviations

Bq	Becquerel
CAM	continuous air monitor
cfm	cubic feet per minute
CPM	counts per minute
CPS	counts per second
F_a	alpha factor
F_b	beta factor
F_k	correction factor for filter change
I/O	input/output
kscf	kilo-standard cubic feet
m^3	cubic meters
M_a	correction factor for alpha activity calculations
M_b	correction factor for beta activity calculations
µ	micro
µCi	micro-curie
µCi/mL	micro-curies per milliliter
µs	Microsecond
PC	personal computer
PCI	Peripheral Component Interconnect
PNNL	Pacific Northwest National Laboratory
PNNL OS3300	PNNL OS3300 Alpha/Beta Stack Monitoring System
Ps	pseudo-coincidence count rate
Ps_o	low pseudo-coincidence
222-Rn	radon
220-Rn	thoron
QA	quality assurance
scfm	standard cubic feet per minute
V	volt

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1.0 Introduction

The alpha/beta stack monitoring system is controlled by a personal computer (PC) and measures alpha and beta radioactivity in real time. The sampling system consists of a rake-style sample probe located inside the stack, the sample transport line, and a Berthold Technologies LB150D continuous air monitor (CAM) with alpha/beta pseudo-coincidence counting capability.[1] Air is routed from the stack sample probe through the Berthold Technologies LB150D CAM where alpha, beta, and gamma radioactivity are measured with a triple counter tube stack of thin-window, large-area, proportional counters located directly above the sample filter (Barnett and Snyder 2021). The system also provides readings on man-made alpha and beta radioactive particulate concentrations. The stated minimum detection limits for the LB150D CAM are 1.3E-12 µCi/mL alpha and 8E-12 µCi/mL beta, which meets the ANSI N42.18-2004 minimum detection limits of 2E-12 µCi/mL (Pu-238) and 8E-11 µCi/mL (Co-60), respectively. This manual describes how to install and operate the Pacific Northwest National Laboratory (PNNL) OS3300 Alpha/Beta Stack Monitoring System software on a PC when connected to a LB150D CAM. For details on the LB150D detector, its maintenance, and its calibration procedure, refer to the hardware manual that accompanies the LB150D (EG&G Berthold 1993).

1.1 Formatting Conventions

Software menus are **bolded** in this manual. At times, the words “Menu 1|Menu 2” are used to tell the user to select Menu 1, and then from a dropdown menu, to select the option labeled Menu 2. Clickable buttons are in *italics*. Form labels and text in message boxes, such as “Enter your name,” are enclosed in quotation marks.

1.2 Terms and Definitions

A/B sample flow	The sample alpha/beta air flow through the LB150D CAM where particulates are deposited on an S-class, 8-inch glass fiber filter. S-class filters remove 99.9% of particles 0.3 microns in diameter and larger.
alpha spillover	The ratio of alpha counts in the beta channel to counts in the alpha channel when an alpha source is present. The alpha spillover is expressed as a percent.
artificial activity	Whether from beta emitters or alpha emitters, this term refers to any radioactivity that is not naturally occurring (i.e., the radioactivity of real concern). Examples of “artificial” alpha emitters are Pu-239, U-235, and Am-241; some “artificial” beta emitters are Co-60 and P-32.
beta spillover	The ratio of beta counts in the alpha channel to counts in the beta channel when a beta source is present. Beta spillover is expressed as a percent.
concentration	Concentration is the radionuclide activity per unit volume of air.

[1] Berthold Technologies GmbH & Co. KG, Calmbacher Straße 22, 75323 Bad Wildbad, Germany

continuous air monitor	An instrument, such as the LB150D, that continuously samples and measures the levels of airborne radioactive material in "real time" and has alarm capabilities at pre-set levels. Note: The term continuous air monitor (CAM) is used in this manual to indicate the entire detection system.
database	Microsoft® SQL (Software Query Language) [2] database where the PNNL OS3300 data are stored.
efficiency	The measured count rate from a known activity, usually measured as a fraction (e.g., 0.55) or a percentage (e.g., 55.0%).
integral	Usually referencing the total released or measured radioactivity.
isokinetic sampling	A technique for sampling airborne particulates in which the air stream entering the sampling device has a velocity equal to that of the gas stream just ahead of the sampling port/nozzle of the collector resulting in a collection efficiency of unity.
LB150D	A thin-window, large-area, proportional counter (detector) that collects and analyzes radioactivity deposited on an 8-inch-diameter filter paper.
long count time	A user-supplied period of time (minutes) over which the integrated alpha and beta activities are updated. The long count time must be an integer multiple of short count time. The integral alpha and beta activity alarms are based on the long count time.
natural activity	Whether from beta emitters or alpha emitters, this term refers to any radioactivity that results from natural sources, principally particulate daughters of radon and thoron. This activity interferes with the measurement of artificial activity.
personal computer	The PC on which the PNNL OS3300 software is loaded.
PCI-1780U	A multi-function data acquisition input/output (I/O) Peripheral Component Interconnect (PCI) card, which includes the counter/timers for collecting data from the LB150D and LB110 detectors, manufactured by AdvanTech.[3]
pseudo-coincidence	True coincidence counting occurs when two decays arise from the same nuclear event within a source (i.e., when an atom of radioactive material decays, it emits two radiations at the same time). The two decays are not separated in time. In this application, pseudo-coincidence counting occurs when decays emitted by isotopes in transient equilibrium are separated by a very short period of time. Glenn Knoll refers to this as delayed coincidence in Radiation Detection and Measurement (Knoll 2000).

[2] Microsoft Corporation, 15030 NE 36th St, Redmond, WA 98052 USA
[3] AdvanTech America, 380 Fairview Way, Milpitas, CA 95035 USA

short count time	A user-supplied period of time (minutes) over which the instantaneous alpha and beta activity concentrations are calculated. The short count time is usually an integer number. The high alpha and beta radiation (concentration) alarms are based on the short count time.
stack flow	The air flow in the stack.

2.0 Installation

The PNNL OS3300 software is designed to run on any PC using a 64-bit Microsoft Windows® operating system. The software interacts with the Advantech TM PCI-1780 data acquisition PC card to obtain raw counts from the LB150D CAM. The PCI-1780 data acquisition PC card and drivers must be installed before installing the software. The software also interacts with Microsoft SQL Server® and is configured for communication with two local database instances (“AlphaBetaTritium_XX” and “RPL_OS3300_ConfigParams_XX”) that must be built prior installing the monitoring software. The databases have a numerical designation (XX) that references what system the database exchanges information with (e.g., “AlphaBetaTritium_01” serves the data exchange processes for one system whereas “AlphaBetaTritium_02” serves the data exchange process for an identical but independent system). The LB150D CAM feeds data concurrently to two identical but independent PCs with OS3300 installed on them at the 325 Radiological Processing Laboratory: one is hooked up to the annunciator panel for alarming purposes while the other serves as a backup. For information on installing PNNL OS3300 software, contact PNNL at the following address:

Pacific Northwest National Laboratory
Environmental Protection and Regulatory Programs
Environmental Radiation Task Lead
P.O. Box 999, Mail Stop J2-25
Richland, WA 99352

3.0 Software Operation

The software for PNNL OS3300 provides several functions controlled through the PC environment. Those functions are:

- Set the information flow,
- Collect data at regular intervals,
- Calculate activities and concentrations from data collected,
- Display data and alarm conditions, and
- Run calibration utilities.

These functions are discussed in the following sections.

3.1 General Operations Information

This section describes the process of information flow, including short and long count calculations.

3.1.1 Information Flow

In very general terms, the LB150D CAM collects pulses, and the output of the detected pulses is stored as either an alpha or a beta pulse. The pseudo-coincidence board determines in which bin the counts will be stored. The signals are sent through BNC connector cables[4] from the detectors to the breakout box and then to the PCI-1780U data acquisition card through a 68-pin cable. The PCI-1780U card contains groups of counters and associated timers. When instructed by the software, a group of counters will collect the number of pulses from the LB150D over a period of time equal to the user-selected short count time.

After each short count period has expired, the PNNL OS3300 software requests the time and number of counts from the PCI-1780U card, increases the count time by one short time interval, and restarts the measurement process. The software uses the counts and time values from the PCI-1780U card to calculate the concentration of radioactive material from the alpha and beta pulses during the count period and adds that to the running total. This process is repeated until a long count time is reached. After each long count time, the software stores the values of concentration and activity to a database along with other relevant information (such as the raw counts from the PCI-1780U card).

During each short count time, the software checks the concentration value against the alarm limit. If the alarm limit is exceeded, the software automatically changes the long count time to the short count time for faster data integration. Upon returning to a non-alarm state, the long count time is returned to the user-defined value. Optionally, during the short count time, the raw and calculated data can be stored in a separate database table for reconstructing each long measurement dataset.

[4] Bayonet Neill Concelman electrical cable connector cables are miniature quick connect/disconnect radio frequency connectors used with standard coaxial cables.

3.1.2 Data Collection

The CAM collects count rate data from the detectors for periods of time (set by the user) and then calculates the alpha and beta activity collected on the filter paper for that time period. Two time periods are used; they are referred to as the short count and the long count (Figure 1). A long count time consists of an integral multiple of short count periods. See Section 3.2.6.5 for a detailed discussion of appropriate time periods for the short count and long count.

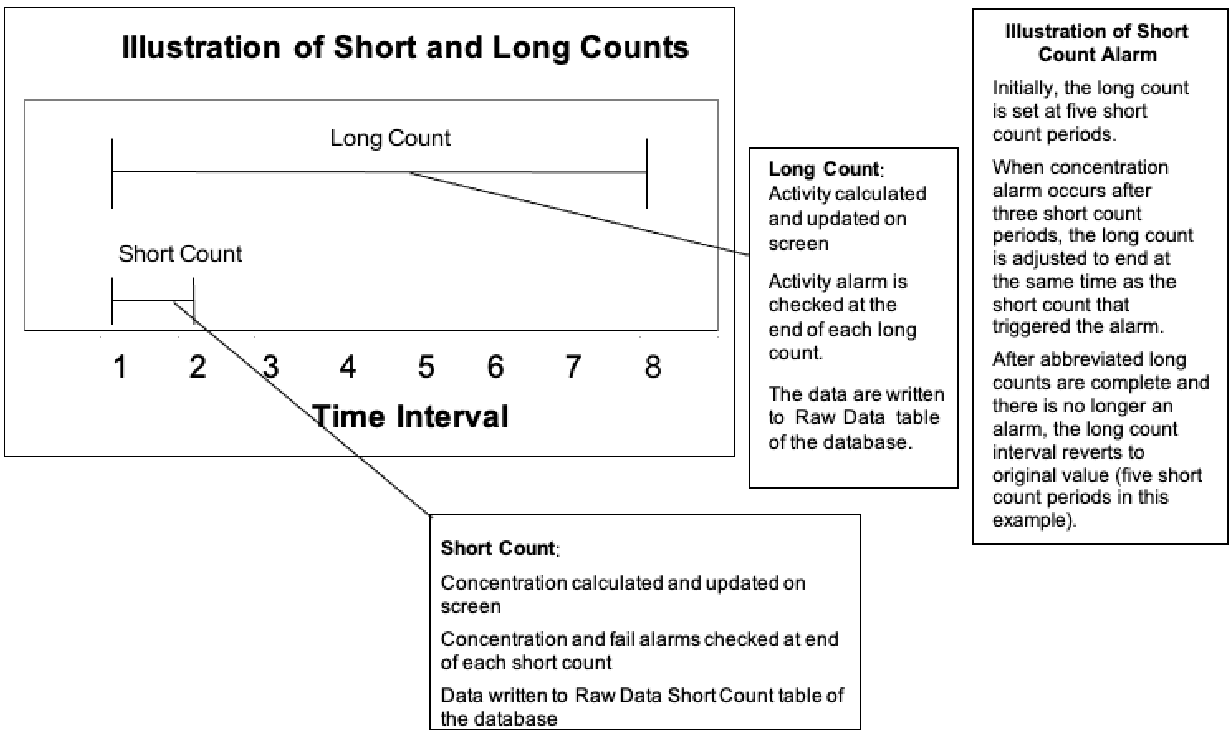


Figure 1. Illustration of Short and Long Counts

3.1.2.1 Short Count Calculations

At the end of each short count, the PNNL OS3300 software obtains the average and gross (uncorrected) alpha and beta count rates from the PCI-1780U card. The PCI-1780U card is a PC-slotted card that interacts with the LB150D CAM. The background is subtracted from each count rate, and then the estimated counts from radon progeny on the filter are subtracted. The resulting net count rates are used to calculate the total alpha and beta concentrations present on the filter. The total alpha and beta concentrations calculated during the previous short count time are then subtracted. The final result is a net alpha and beta concentration that is accumulated on the filter during the lapsed short count period.

The net alpha and beta activity are divided by the sample flow volume, and the resulting concentration is compared to the concentration alarm set point. If the calculated value exceeds the concentration alarm set point, the associated rectangular indicator on the computer screen turns yellow, and selected alarm relays are activated. When the concentration alarm set point is exceeded, the CAM will also initiate a shortened long count equal to the same length as the short count. This allows the CAM to calculate and compare both concentration and activity to the alarm set points each time interval. If the integrated activity and concentration do not exceed alarm set points, the long count time is restored to its previous value, and the CAM begins counting again with the first short count of the long count cycle.

If the user has selected the option to save data to the short count table in the database, data are written to the database at the end of the short count.

3.1.2.2 Long Count Calculations

At the end of each long count, the PNNL OS3300 software sums the net alpha and beta activity calculated during each short count time. The result is the net alpha and beta activity collected on the filter paper during the lapsed long count period. This result is compared to the integral alarm set points. If the calculated activity exceeds the alarm set point, the associated rectangular alarm indicator on the computer screen turns red, and the long count time is set to the short count time.

At the end of each long count, the software writes the measured values and calculated results to the database. The user does not have the option to disable storing long count data to the database.

3.2 PNNL OS3300 Menu Operations

This section explains the menu functions of the PNNL OS3300 software. The software main screen is shown in Figure 2. The menu runs across the top of the screen.

Note: Menu options may not be always available and depends on whether data acquisition is in progress or not.

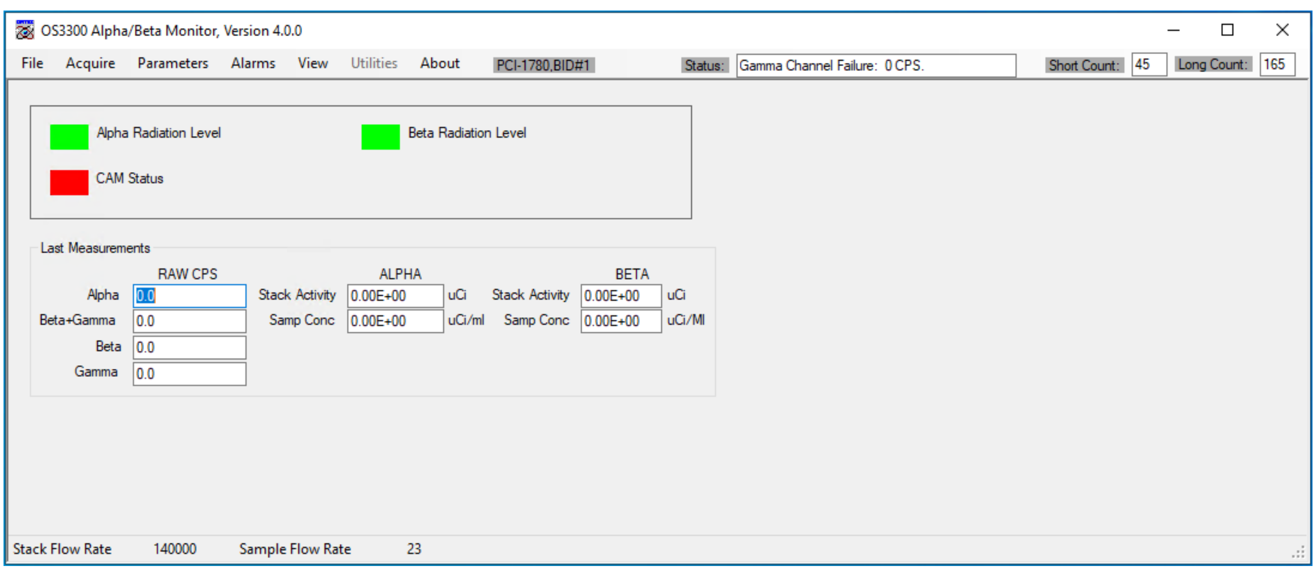


Figure 2. OS3300 Menus and Main Screen

3.2.1 File Menu

The following options are available under the File menu (Figure 3):

- **Print Setup**: Allows for the setting of a printer if one is connected to the computer.
- **Exit**: Closes PNNL OS3300 software.

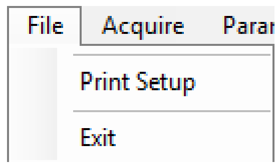


Figure 3. Menu: File

3.2.2 Acquire Dropdown Menu

The following options are under the Acquire menu (Figure 4):

- **Start:** Starts the data acquisition process for the PNNL OS3300 software.
- **Stop:** Stops the data acquisition process for the PNNL OS3300 software.

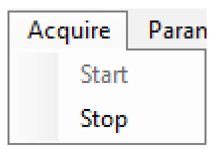


Figure 4. Menu: Acquire

3.2.2.1 Start

The **Acquire|Start** menu option starts the routine data collection from the LB150D CAM; it is only available if data acquisition is currently not in progress.

3.2.2.2 Stop

The **Acquire|Stop** menu option allows the user to stop in-progress data acquisition. If data acquisition is not in progress, this menu option will not be available.

If the Stop menu option is selected, a dialog box will appear (Figure 5).

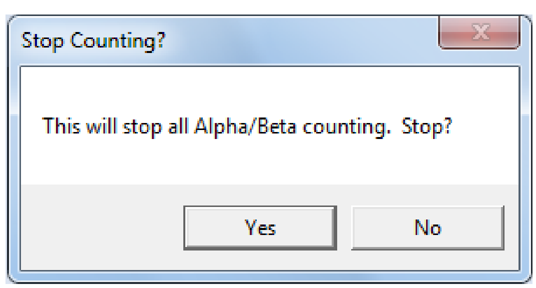


Figure 5. Dialog Box: Confirm Stop Data Acquisition

Note: While the dialog box is displayed, data acquisition will continue in the background. If the user clicks the *No* button, then the dialog box will close and data acquisition will not be stopped. If the user clicks the *Yes* button, the routine data acquisition will stop.

Note: The stack monitoring system computer is equipped with a software monitoring system called "Watchdog." Watchdog has a heart-shaped icon that displays in the system taskbar when the program is running. By clicking on the icon, an interactive window (Figure 6) will appear where the program can be paused and or resumed. Watchdog monitors both PNNL OS3700 and PNNL OS3300 stack monitoring software for system lockups by verifying that timestamps on the database files are being actively updated. If either software program does not successfully provide a new record in a specified amount of time, Watchdog assumes the system has locked up and executes a reboot of the system. All necessary programs are maintained in the startup menu, so the reboot will restart all necessary stack monitoring programs. Because Watchdog triggers on unsuccessful database entries from the software, pause Watchdog before stopping the counting process. Once the interface with PNNL OS3300 is complete, Watchdog will need to be restarted.

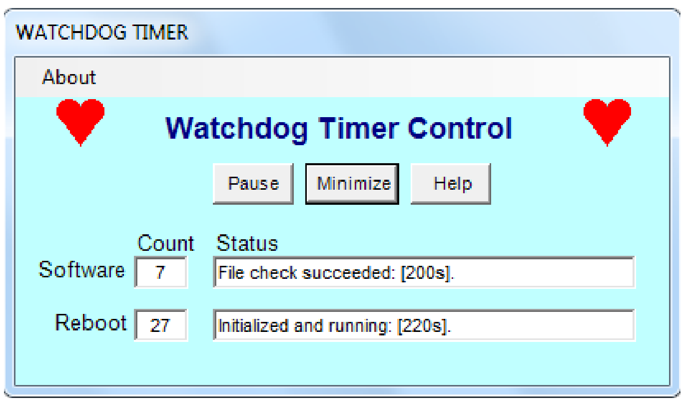


Figure 6. Display: Watchdog Timer

3.2.3 Parameters Menu

The following options are available under the **Parameters** menu (Figure 7):

- **Fail Threshold Settings**: Displays the "Alpha", "Beta+Gamma", and "Gamma" count "Fail Threshold Settings".
- **Preferences**: Displays a preferences window for setting source parameters and related values.
- **Print Configuration Summary**: Displays the current application and alarm setting used by the PNNL OS3300 software.

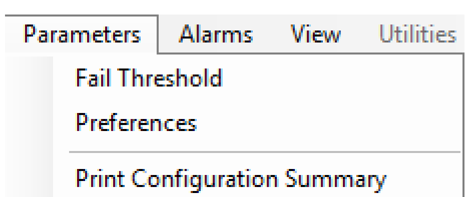


Figure 7. Menu: Parameters

3.2.3.1 Fail Threshold Settings

The **Parameters|Fail Threshold Settings** menu option brings up a dialog box that allows the user to set a minimum count rate for each channel or detector (Figure 8). Count rates below the fail threshold values will cause the CAM to register a fail alarm.

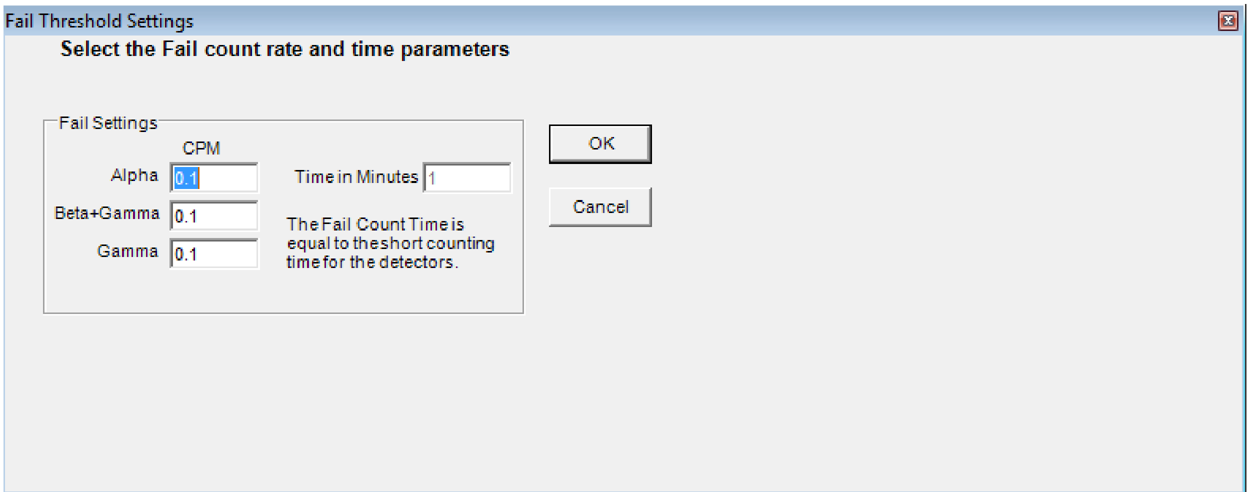


Figure 8. Display: Fail Threshold Settings

The fail threshold setting is an alarm value that determines whether a particular channel or detector of the measuring system is functioning properly. Fail threshold alarm set points are set for the alpha detector ("Alpha"), the beta/gamma detector ("Beta + Gamma"), and the gamma detector ("Gamma"). The values inputted into these boxes (Figure 8) represent the minimum count rates (in counts per minute [CPM]) that must be obtained by the electronics to show that the detectors are functioning. A failure to meet these levels will result in a CAM status alarm on the status screen. This failure is recorded in the event log.

Additional detail on event files is provided in Section 3.2.5.2.

To set new values, click in the text boxes, enter new values, and click *OK*. Setting these values too high may result in an unacceptably high rate of false fail alarms. Setting the alarm set points to negative values can effectively disable the fail alarms. The "Time in Minutes" is the time period the fail alarm is evaluated; it is equal to the short count time and cannot be changed on this form.

To exit the "Fail Threshold Settings" form without changing any values, click the *Cancel* button.

3.2.3.2 Preferences

The **Parameters|Preferences** menu option brings up a display that allows the user to enter the source parameters used in the source check utility, the gamma factor and subtraction option, and the option to save short count data to the database (Figure 9).

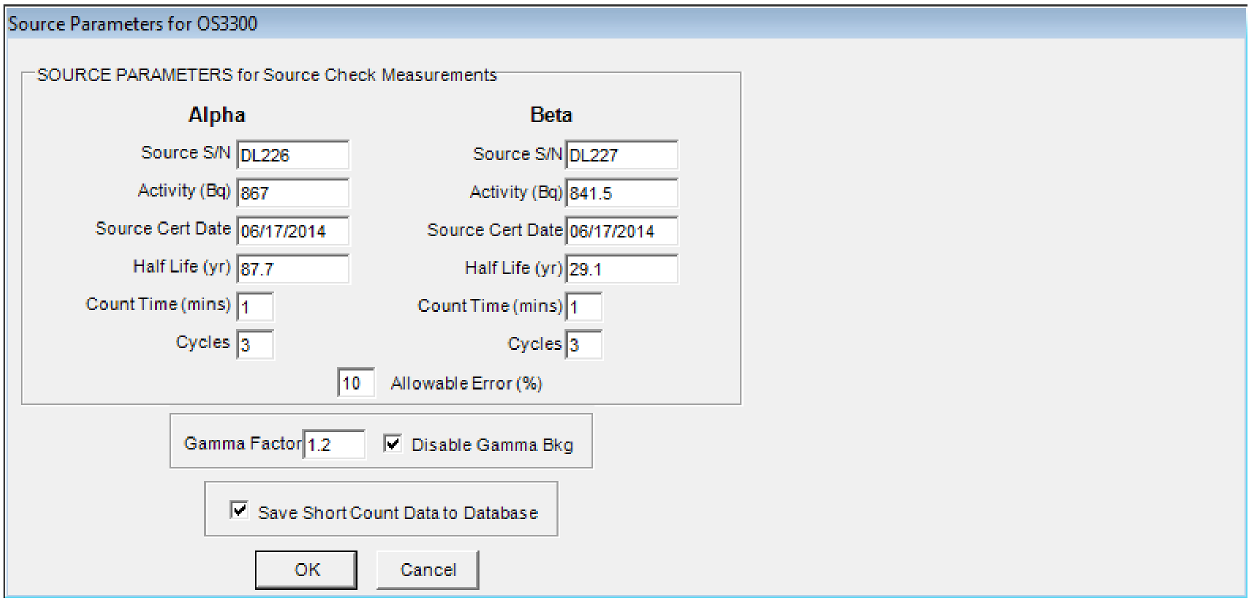


Figure 9. Display: Source Parameters

A number of parameters used by the source check utility are entered on this form, including the source activities, source check count times and number of cycles, and the criteria (allowable error) for passing a source check. The available selections and settings are described below.

- "Source S/N": The serial numbers of the sources used to perform source checks should be entered in this field. The serial number is written to the source check file along with the results of the source check.
- "Activity (Bq)": The activity of each source, in Becquerels (Bq), at the time the source was certified is entered here. The source activity is used by the source check utility to determine the CAM detection efficiency.
- "Source Cert Date": The date the source activity was certified is entered in this field. The data must be entered in the form mm/dd/yyyy. The source activity is decay corrected (by the PNNL OS3300 software) from the source certification date to the date the source check is performed.
- "Half-Life (yr)": The half-life, in decimal years, of the isotope used for each of the check sources is entered in this field. This half-life is used by the CAM software to decay correct the source activity to the date the source check is performed.
- "Count Time (mins)": When the source check utility is run, several counts are completed. The count time for each count is equal to the value entered in this field. The number of counts is set by the parameter "Cycles". The detection efficiency reported when the source check utility is completed is the average detection efficiency for all cycles.
- "Cycles": When the source check utility is run, several count cycles are completed. The number of count cycles is determined by the value entered in this field.

- "Allowable Error %": The allowable error sets the criteria for passing a source check. If the detection efficiency measured during the source check utility is within the "Allowable Error %" of the detection efficiency measured during calibration, the CAM passes the source check. Because of the stability of the CAM and as a measure of conservatism, the allowable error is set at 10%; this value is half the allowed reference response of ± 20% called out in DOE-HDBK-1216-2015 under the IEC 60671 standard (DOE 2016, IEC 2002).
- "Gamma Factor": The gamma factor is a compensation factor used when the gamma background detector and the beta detector are different sizes or have different sensitivities. The measured count rate in the gamma channel is subtracted from the beta/gamma channel count rate to reduce the effects of gamma background from external sources of gamma radiation (Equation 1). The default gamma factor is one, indicating that the two detectors are of equal sensitivity. Experience or testing may produce a slightly different factor. Equation 1 is used to calculate the gross beta count rate.

$$Beta\ Count\ Rate_{gross} = (Beta + GammaCountRate)_{gross} - (Gamma\ Factor)(Gamma\ Count\ Rate_{gross}) \quad (1)$$

- "Disable Gamma Bkg": If testing is required for a more accurate factor, a check box is provided to disable the gamma background subtraction. The default state of the check box is unchecked. If the "Disable Gamma Bkg" box is checked, Equation 1 is reduced to Equation 2 which is then used to calculate the gross beta count rate.

$$Beta\ Count\ Rate_{gross} = (Beta + GammaCountRate)_{gross} \quad (2)$$

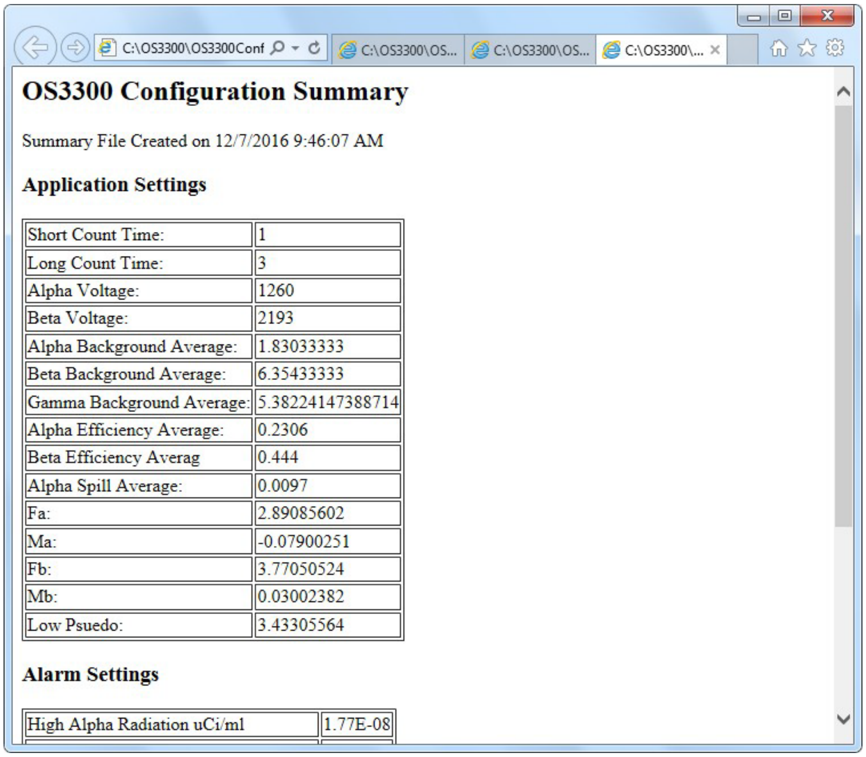
- "Save Short Count Data to Database": When checked, results calculated at the end of each short count are saved to the database. Selecting this option will increase the size of the database at a faster rate.

Clicking the *OK* button will save the parameters to the Microsoft SQL Server OS3300 configuration database and implement the changes on the next counting cycle.

To exit the "Preferences" form without changing any values, click the *Cancel* button.

3.2.3.3 Print Configuration Summary

The Parameter|Print Configuration Summary menu option allows the user to view and print the current application and alarm setting used by the PNNL OS3300 application that are stored in the SQL Server database (Figure 10). Upon selecting "Print Configuration Summary", a browser window will appear displaying the data. To print the "Configuration Summary" to a local printer, right click on the display and select "Print" from the menu that appears.


C:\OS3300\OS3300Conf

OS3300 Configuration Summary

Summary File Created on 12/7/2016 9:46:07 AM

Application Settings

Short Count Time:	1
Long Count Time:	3
Alpha Voltage:	1260
Beta Voltage:	2193
Alpha Background Average:	1.83033333
Beta Background Average:	6.35433333
Gamma Background Average:	5.38224147388714
Alpha Efficiency Average:	0.2306
Beta Efficiency Averag	0.444
Alpha Spill Average:	0.0097
Fa:	2.89085602
Ma:	-0.07900251
Fb:	3.77050524
Mb:	0.03002382
Low Psuedo:	3.43305564

Alarm Settings

High Alpha Radiation uCi/ml	1.77E-08

Figure 10. Display: Print Configuration Summary

3.2.4 Alarms Menu

The following options are available under the **Alarms** menu (Figure 11):

- **Settings**: Displays the configuration parameter screen for the alarm value Settings.
- **Relay Setup**: Displays the configuration parameter screen for the alarm option **Relay Setup** settings.
- **View Alarm History:** Displays a table summary of past alarms.

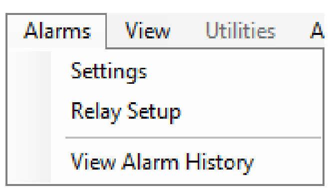


Figure 11. Menu: Alarms

3.2.4.1 Settings

The **Alarms|Settings** menu option brings up a dialog box that is used to set alarm levels (Figure 12). Although eight alarms are listed, the system uses only four to trigger alarms: “High Alpha Radiation”, “High Beta Radiation”, “Integral Alpha Activity”, and “Integral Beta Activity”. The fixed flow rate parameters (i.e., “Fixed Stack Flow Rate” and “Fixed Sample Flow Rate”) are used to enter sample and stack flow rates into the system. The remaining two parameters (i.e., “High Stack Flow Rate” and “High A/B Sampler Flow Rate”) are disabled for the PNNL OS3300 software.

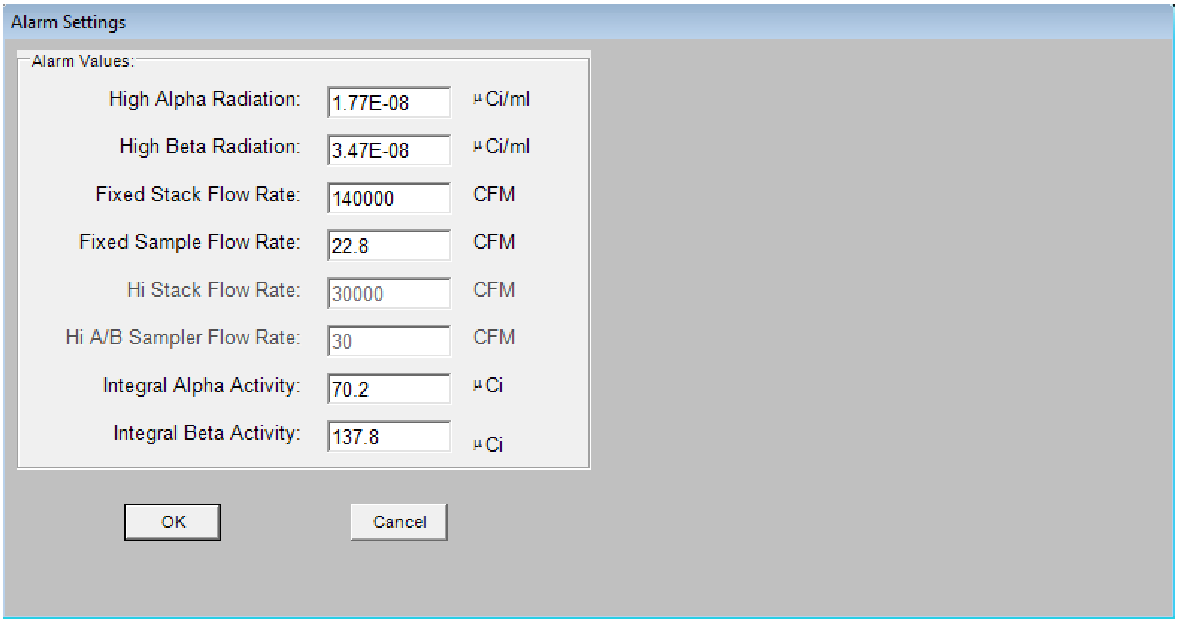


Figure 12. Display: Alarm Settings

To change a setting, click in a text box and enter a new value. When all new values are set, click the *OK* button. To exit without changing any values, click the *Cancel* button.

Once the alarm set points are entered, these values are stored in the software and used to trip the appropriate alarms, for example, a stack monitoring annunciator alarm panel.

The concentration alarms ("High Alpha Radiation" and "High Beta Radiation") are tripped if the concentration measured during a short count time exceeds the alarm set point. This alarm is non-latching. After the concentration alarm is tripped and the concentration released during the following short count time is below the concentration alarm set point, the alarm indicator on the status screen will return to green. If the alarm is tripped during the short count time, the alarm indicator on the main screen will turn yellow, and the long count time will be set equal to the short count time. If, at the end of the long count time, the concentration still exceeds the alarm set point or if the integral alarm is tripped, the alarm indicators on the main screen will turn red. High alpha radiation and high beta radiation alarms typically are tripped before the integral activity alarms because integral activity alarms are only checked at the end of the long count time. The user should determine what is appropriate for the particular installation and enter those values here. Avoid entering values that are too restrictive; this can result in numerous false positives.

The integral activity alarms ("Integral Alpha Activity" and "Integral Beta Activity") are tripped when the net activity released out the stack during the long count time exceeds the alarm set point. If the net activity released during the long count time exceeds the integral activity alarm set point, the radiation level alarm indicator on the status screen will turn red.

The net activity, in µCi, released out the stack is calculated by multiplying the net activity collected on the filter by the ratio of the stack flow rate and the sample flow rate shown in Equation 3.

$$Activity_{net,stack} = (Activity_{net,filter})\left(\frac{Stack\ Flow\ Rate}{Sample\ Flow\ Rate}\right) \quad (3)$$

Like the concentration alarm, the integral activity alarm is non-latching. If the integral activity alarm is tripped (alarm indicator is red), and the net activity released during the following long count time is below the integral activity alarm set point, the alarm indicator on the status screen will return to green.

The “Fixed Stack Flow Rate” and “Fixed Sample Flow Rate” display the fixed flow rates used by the PNNL OS3300 software to calculate flow volumes, concentrations, and net stack activity. These values may be edited by the user. On the PNNL OS3300 system, the stack flow rates will be updated with actual measured flow rate numbers from periodic stack velocity traverses.

Note: The user should take care when adjusting the fixed flow rates because these will affect the concentration and net activity calculations of the CAM.

Note: Changing the fixed flow rates on this screen does not change the actual flow rate of the system.

3.2.4.2 Alarm Relay Setup

The **Alarms|Relay Setup** menu option brings up a dialog box that is used to set up programmable alarm relays for this system (Figure 13).

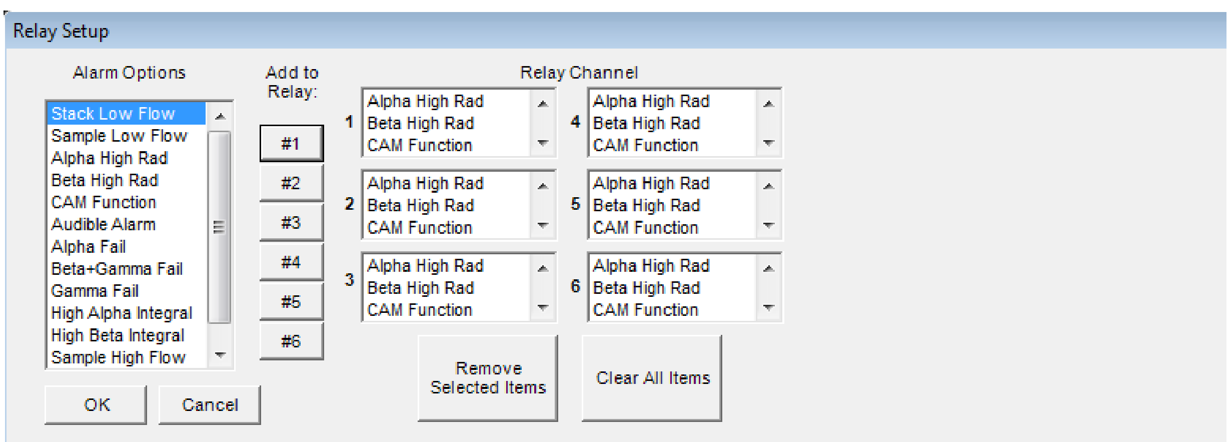


Figure 13. Display: Relay Setup

Up to six relays can be programmed; each one can be programmed to use a combination of alarms. The alarm options are listed in the left-hand pane of the screen. If more than one option is programmed to a single relay (such as “CAM Function” and “Beta High Rad.”), the signal uses an either/or logic. If either alarm is tripped, the relay will be energized. Table 1 provides descriptions of alarm relay outputs.

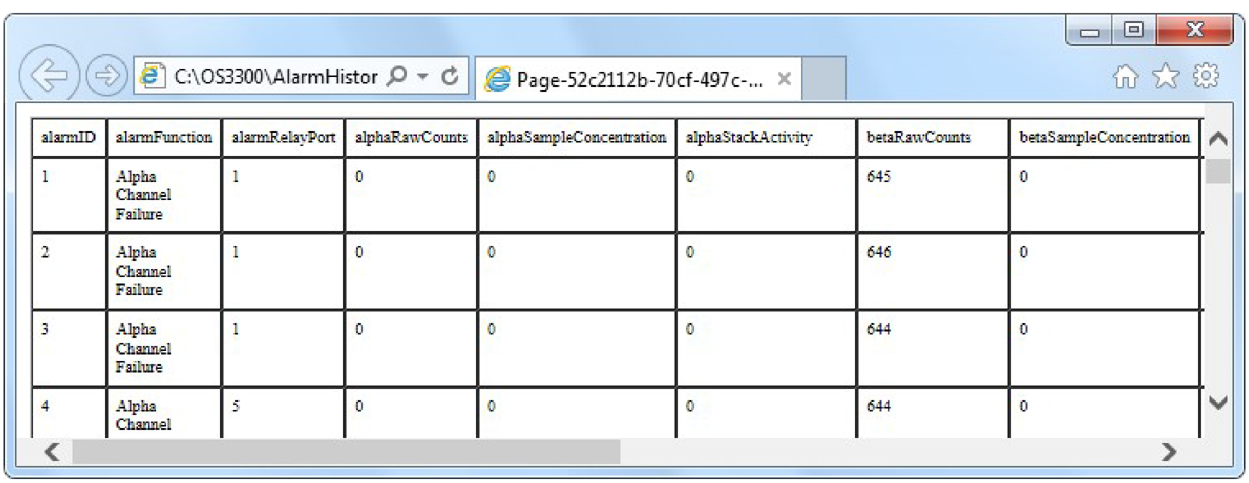
Table 1. Relay Output Descriptions

Function Name	Description
CAM Function	One or more detector count rates were at or below the failure threshold or the software was not able to communicate with the data acquisition hardware.
Alpha Fail	The detector count rate was at or below the failure threshold.
Beta + Gamma Fail	The detector count rate was at or below the failure threshold.
Gamma Fail	The detector count rate was at or below the failure threshold.
Alpha High Rad.	The net alpha activity is above the integral alpha activity threshold or concentration is above concentration threshold.
Beta High Rad.	The net beta activity is above the integral beta activity threshold or concentration is above concentration threshold.
Sample Low Flow	Sample flow rate (standard cubic feet per minute [scfm]) is below the minimum acceptable flow rate.
Stack Low Flow	Stack flow rate (scfm) is below the minimum acceptable flow rate.
High Alpha Integral	The net alpha activity is above the integral alpha activity threshold.
High Beta Integral	The net beta activity is above the integral beta activity threshold.
Sample High Flow	Sample flow rate (scfm) has exceeded the maximum acceptable flow rate.
Stack High Flow	Stack flow rate (scfm) has exceeded the maximum acceptable flow rate.

To add an alarm option to a relay, highlight the alarm (by clicking on it) in the Alarm Options box on the left and then click the appropriate Add to Relay numbered button in the middle of the screen to add it to the relay. Each function can be assigned to any number of relays simultaneously. To remove a specific item from a relay, highlight the alarm option in the box on the right (by clicking on the alarm name) and click *Remove Selected Items*. All other alarm options will remain unchanged. To delete all the alarm options for all the relays, click *Clear All Items*. When the relay channels are set as desired, click *OK*. Once *OK* is clicked, the new relay settings are applied. To exit without changing the relay channels, click the *Cancel* button.

3.2.4.3 Alarm History

The **Alarms|Alarm History** menu option brings up a display window of past PNNL OS3300 alarms that have occurred (Figure 14). The alarms are listed in order, from oldest to newest. A scroll bar will appear when the table size becomes larger than the display window. The alarm information corresponds to the alarm information stored in the “AlphaBetaTritium_XX” SQL database, “AlphaBetaAlarms” table.



alarmID	alarmFunction	alarmRelayPort	alphaRawCounts	alphaSampleConcentration	alphaStackActivity	betaRawCounts	betaSampleConcentration
1	Alpha Channel Failure	1	0	0	0	645	0
2	Alpha Channel Failure	1	0	0	0	646	0
3	Alpha Channel Failure	1	0	0	0	644	0
4	Alpha Channel	5	0	0	0	644	0

Figure 14. Display: Alarm History

3.2.5 View Menu

The following options are available under the **View** menu (Figure 15):

- **Filter Log**: Displays a window for viewing and entering filter information.
- **Event Files**: Displays the current or past daily Event Files contents.

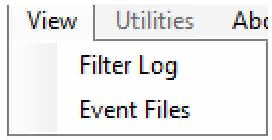


Figure 15. Menu: Alarms

3.2.5.1 Filter Log

The **View|Filter Log** menu option brings up a dialog box for viewing the start and end dates for each filter and for saving detailed emissions data associated with each filter to the disk (Figure 16).

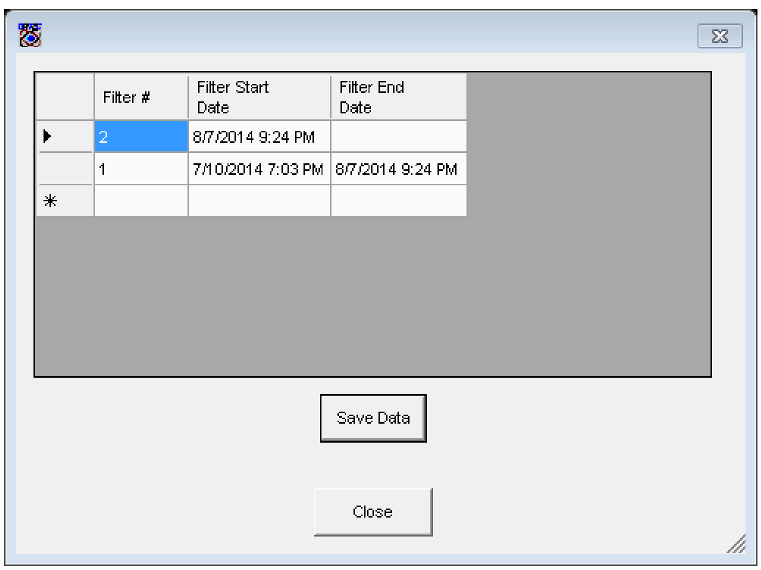


Figure 16. Display: Filter Log

A filter log table in the database keeps track of information produced when a filter is changed. Each filter used by the CAM is assigned a unique number (listed as “Filter #” in the filter log). The date and time the filter is installed are logged as the “Filter Start Date”, and the date and time the filter are removed are logged as the “Filter End Date”. The start and end dates are used to identify specific entries in the CAM database that correspond to the time a specific filter was used.

From the filter data log screen (Figure 16), the operator can save all long count data and calculations associated with a single filter to a file for archival purposes. The *Save Data* button will prompt the user for a filter number (Figure 17). The filter numbers are in the left-hand column labeled “Filter #”. The user is then prompted to provide a name and location for the text file. Data collected after each long count during that filter's run time are copied from the database to the text file.

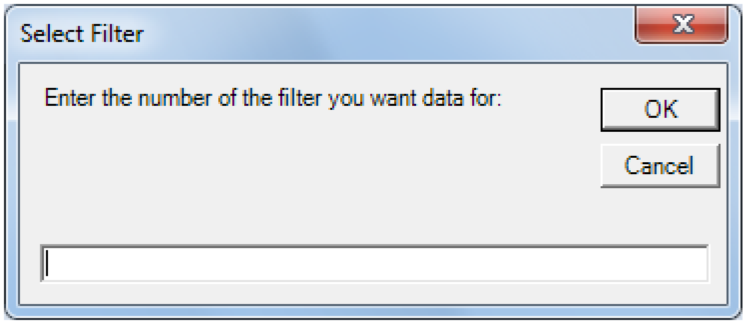


Figure 17. Dialog Box: Select Filter

Table 2 summarizes the data saved to the text file in the order they appear.

Table 2. Filter Log File Parameter Title

Parameter Title in Filter Log File	Explanation
Date	The date the values were logged into the database.
A-stk-Act	The alpha activity released to the stack during the long count time (µCi).
B-stk-Act	The beta activity released to the stack during the long count time (µCi).
Stk-Flo-Rate	The stack flow rate during the long count time (standard cubic feet per minute [scfm]).
Stk-Flo-Tot	The total flow through the stack since the last filter change (kilo-standard cubic feet [kscf]).
AB-Flo-Rate	The flow rate through the alpha/beta sampler (cfm).
Sample-Total	The total volume of air sampled by the alpha/beta sampler since the last filter change (m^3).
Raw-Time	The time the values were logged into the database.

3.2.5.2 Event Files

The **View|Event Files** menu option provides a means for viewing and printing the event log file(s) generated by the PNNL OS3300 software. The event log is a daily file containing information about alarms that occur, user changes to the parameters, and the system status. This log is meant to maintain status reports on the system as a whole. For every software transaction a user makes, a brief description of each event, including the time, date, and action taken, is provided.

The filename format is YYMMDD.log where YY is the year, MM is the month, and DD is the day the file was created.

The selected file can be opened in Windows Notepad®. From here, the user can review the data and save them to other locations if necessary. An example event log file is displayed in (Figure 18).

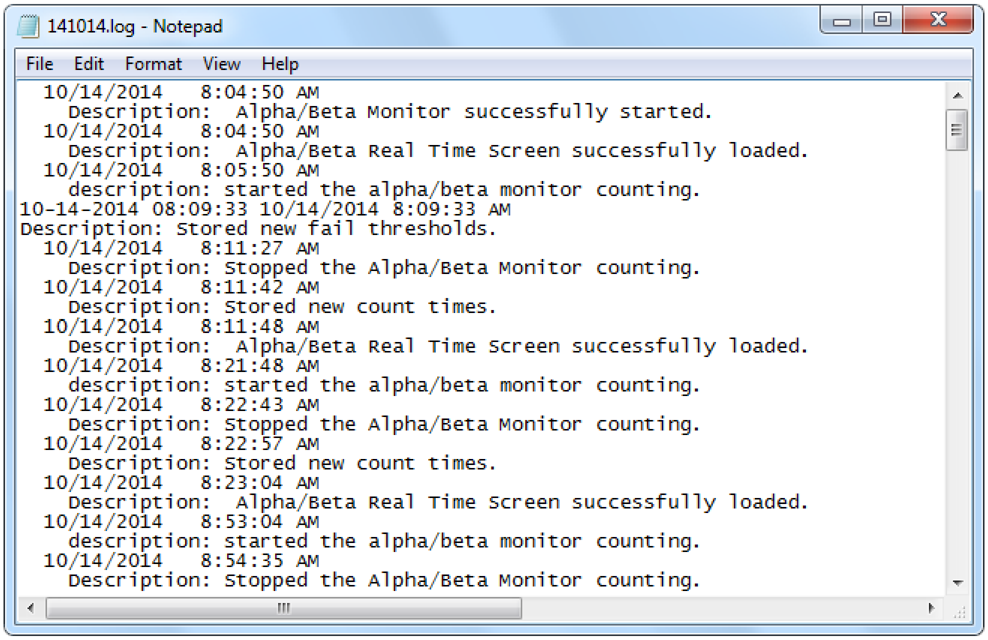


Figure 18. Display: Event File

3.2.6 Utilities Menu

The **Utilities** menu is only available when data acquisition is stopped. The following options are available (Figure 19):

- **Source Check:** Utility allowing the PNNL OS3300 system efficiency to be verified against calibration values.
- **Background:** Utility to determine the background readings for the instrumentation.
- **Efficiency:** Provides a sub-menu of "Efficiency" utility measurement options, including:
  - **Alpha:** Utility to determine the instrumentation efficiency per a known alpha source.
  - **Beta:** Utility to determine the instrumentation efficiency per a known beta source.
- **Pseudo-Coincidence**: Utility to calculate the factors for the linear equation that estimate the activity on the filter from radon progeny.
- **Count Times**: Displays a window for editing the short and long count times and related configuration parameters.
- **Change Filter**: Utility to record the change of the 8-inch-diameter CAM filter.

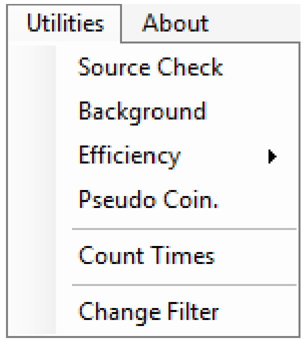


Figure 19. Menu: Utilities

3.2.6.1 Source Check

The **Utilities|Source Check** menu option is used to verify that the CAM detectors are operating within specifications established at calibration. Essentially, the source check function repeats the efficiency measurements performed at calibration and compares the newly measured efficiency values with the efficiency values established at calibration. The calibration efficiency for both alpha and beta are compared to the efficiency obtained during the source check with the same radiological sources. The pass or fail condition is determined by the "Allowable Error (%)" set under the **Preferences|Parameters** menu option (Figure 9). If the new efficiencies are within the percent tolerance of the calibration efficiencies, the system passes the source check.

When the **Source Check** utility is started, the user is prompted to enter their name (Figure 20). Any alphanumeric string may be entered. Entering a blank or clicking *Cancel* cancels the Source Check utility, and the program returns to the main screen.

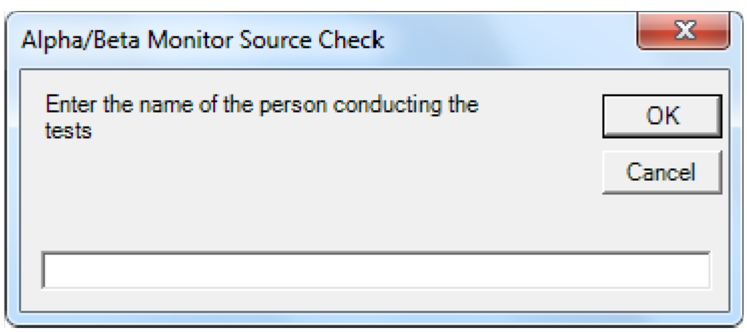


Figure 20. Dialogue Box: Source Check User Name

The user clicks *OK* after entering their name.

A message box will appear asking the user to confirm the source serial number and the source certified activities (the program will decay the source activities to the date the source check was performed). If correct, click *OK*. If incorrect, click *Cancel* and go to **Parameters|Preferences** to change the source activities, certification dates, and serial numbers.

The user is prompted to start the source check function by selecting Start. A dialog box will prompt the user to place an alpha standard source in the chamber. After placing the source in the detector chamber, click *OK*. The system will count the source for the number of cycles indicated in the **Parameters|Preferences** window.

At the end of each cycle, the calculated alpha and beta efficiency are calculated, as well as the alpha and beta spillover (in percent). The alpha efficiency is calculated using Equation 4:

$$Alpha\ Efficiency = \frac{Alpha(cps) - AvgAlphaBkg(cpm)/60}{decay\ corrected\ Alpha\ Source\ Activity(dps)} \quad (4)$$

where $Alpha(cps)$ is the measured alpha counts, $AvgAlphaBkg(cpm)$ background counts measured from the background utility and $decay\ corrected\ Alpha\ Source\ Activity(dps)$ is the decay-corrected source activity using the information entered on the **Parameters|Preferences** form. The beta efficiency is calculated using Equation 5:

$$Beta\ Efficency = \frac{Beta\ (cps) - AvgBetaBkg\ \ (cpm)/60}{decay\ \ corrected\ \ Beta\ \ Source\ \ Activity\ (dps)} \quad (5)$$

where $Beta\ (cps)$ is the measured beta counts with gamma subtraction, $AvgBetaBkg(cpm)$ is the average beta background counts measured from the background utility, and $decay\ corrected\ Beta\ Source\ Activity\ (dps)$ is the decay-corrected source activity calculated by the software using the information on the **Parameters|Preferences** form.

The count time for each cycle and the total remaining time for the source check are displayed on the main screen's status bar as the short count time and the long count time, respectively. At the end of all count cycles, the average detection efficiency is calculated (Figure 21).

If the average measured detection efficiency is not within the established limits (i.e., the "Allowable Limits (%)" in the **Parameters|Preferences** dialog box), the software will indicate that the CAM has failed the source check. If the CAM fails the alpha source check, the dialog box will state that the alpha source check has failed and will present the user with the options to *Retry* or *Cancel*. *Retry* will take the user back to the beginning of the alpha source routine. *Cancel* will cancel the alpha source check, and the dialog box will be displayed asking the user if he wants to run the beta source check. The box includes the option to *OK* or *Cancel*. *Cancel* completely exits the source check routine.

Upon exiting the source check form, the source check results (including failures) are written to the file "C:\Program Files\OS3300\Source Check mm-dd-yyyy.txt" where mm-dd-yyyy is the month, day, and year the source check was performed (Figure 22). If multiple source checks are performed on the same day, the results are appended to the end of the file.

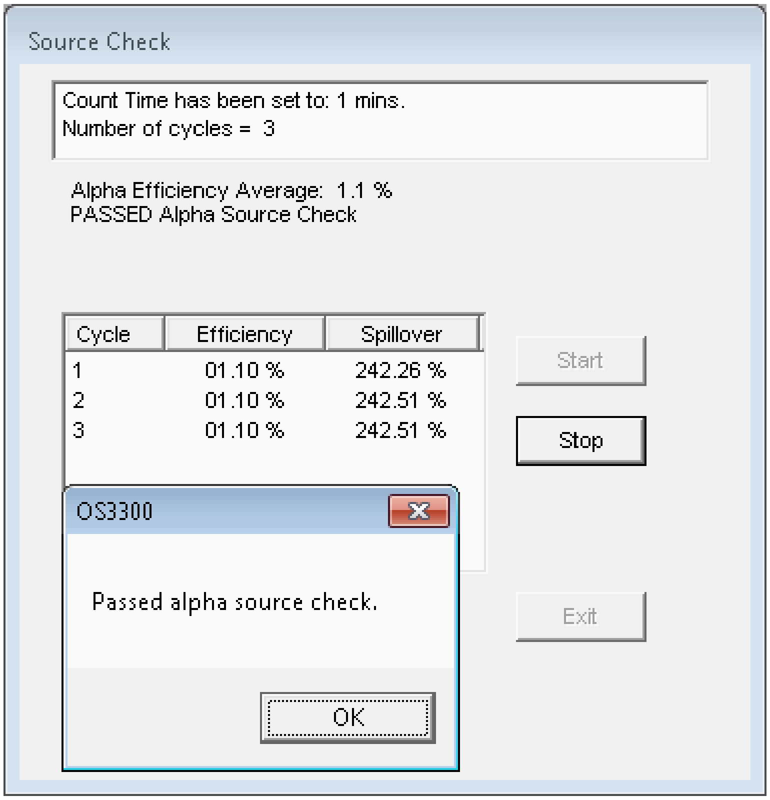


Figure 21. Display: Source Check (example)

```
   Alpha Source Check performed on: 9/26/02 By: kk
          Cycle    Alpha Eff. Spillover
          -----    -------------------
           1       .24       100.00
          -----    -------------------
          Average: 0.2428     1.

PASSED!
      Beta Source Check performed on: 9/26/02 By: kk

          Cycle    Beta Eff.
          -----    ----------
           1       0.2007
          -----    ----------
          Average: 0.2007
Calibration Efficiency ≡ 0.445, FAILED!
```

Figure 22. Source Check File

3.2.6.2 Background

The **Utilities|Background** menu option brings up a dialog box to run a background measurement of the alpha, beta, and gamma channels (Figure 23). The **Background** utility should be run only as part of the instrument calibration.

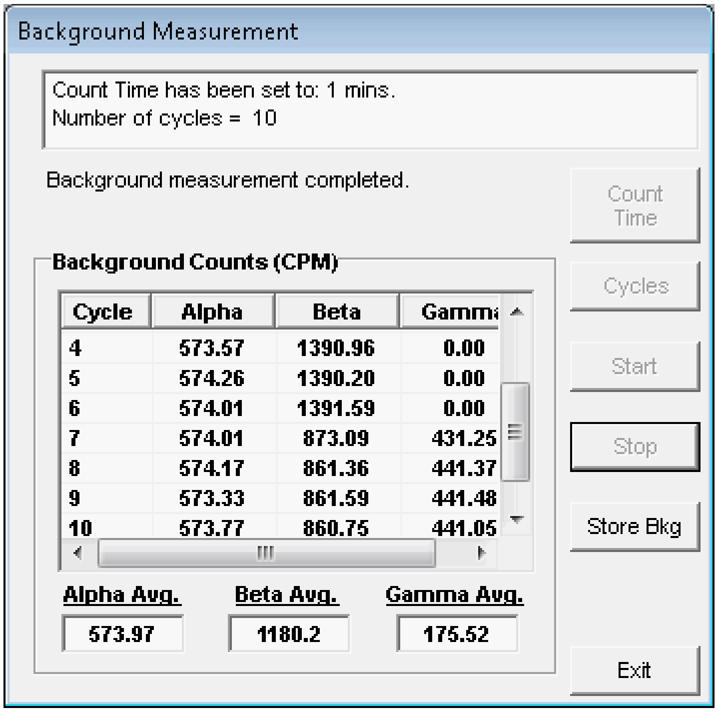


Figure 23. Display: Background (example)

Click the *Count Time* button and enter the desired count time, in minutes, for the background count. The value entered must be between 1 minute and 1,440 minutes. Then click *OK*.

Click the *Cycles* button and enter the desired number of count cycles. Each count cycle will count for the time period entered under count times. Acceptable values for the number of count cycles are 1 to 100.

Click *Start* to begin the background measurement. At the end of each count cycle, the total counts measured by the alpha, beta, and gamma detectors will be indicated. The time remaining in the count cycle is indicated on the status bar.

After all count cycles are complete, the average alpha, beta, and gamma background count rates, in CPM, will be displayed. To store these values in the software to be used for calculations, click the *Store* button.

Caution: Storing the background values may void the previous instrument calibration.

To stop the background count, click the *Stop* button. To exit the background count box, click the *Exit* button.

3.2.6.3 Efficiency

The **Utilities|Efficiency** menu option brings up a dialog box to calculate the efficiency of the alpha and beta detectors (Figure 24). The **Efficiency** utility should be run only as part of the instrument calibration.

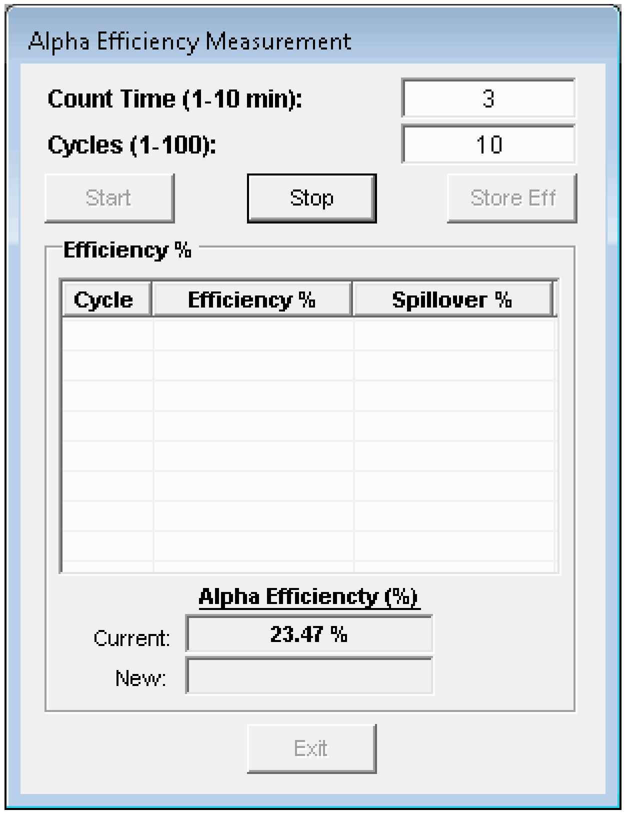


Figure 24. Display: Alpha Efficiency (example)

Efficiencies are calculated using the same efficiency equations used for a source check (see Section 3.2.6.1). Alpha efficiency (Equation 4) is calculated by subtracting the average alpha background stored in the registry after running the background utility from the alpha channel raw counts and dividing that result by the source activity. Beta efficiency (Equation 5) is calculated by subtracting the average beta background stored in the registry from the beta channel raw counts and dividing that result by the source activity. Gamma background (signal from gamma detector) is subtracted from the beta signal when doing the beta efficiency.

To run the efficiency utility, enter the desired “Count Time” in minutes for each cycle of the efficiency count. The value must be an integer between 1 and 10 minutes. Enter the desired number of count “Cycles”. The value must be an integer from 1 to 100.

Click *Start* to begin the detector efficiency measurement. A message box appears confirming the source serial number and activity. If information is correct, click *OK*; if incorrect, click *Cancel* and update the source information by selecting **Parameters|Preferences** (enter correct source parameters in the dialog box and click *OK*). Click *OK* on the second message box once the source is placed in the chamber. The status box will indicate when each efficiency measurement is completed and provide an average efficiency at the end of the counting.

To save the efficiency, click the *Store Eff* button. A dialog box will appear requesting confirmation of storing the values.

Caution: Storing the efficiency values may void the previous instrument calibration.

To stop the efficiency count utility, click the *Stop* button. To exit the efficiency count utility, click the *Exit* button.

3.2.6.4 Pseudo-Coincidence

The **Utility|Pseudo-Coincidence** menu option brings up a dialog box to calculate the factors for the linear equation that estimate the activity on the filter from radon progeny (Figure 25). The utility establishes values for five factors:

- Alpha factor (Fa)
- Beta factor (Fb)
- Correction factor for alpha activity calculations (M_a)
- Correction factor for beta activity calculations (M_b)
- Low pseudo-coincidence rate (Ps_o)

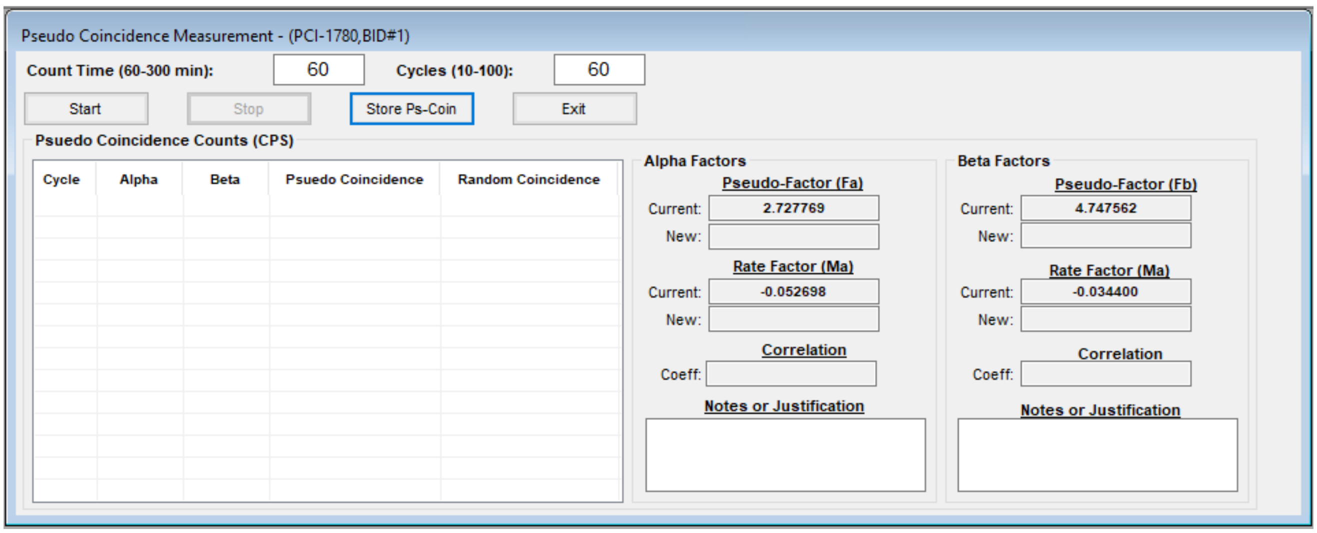


Figure 25. Display: Pseudo-Coincidence (example)

These factors are described in greater detail in Section 4.3. The **Pseudo-Coincidence** utility should be run only as part of the instrument calibration.

The pseudo-coincidence utility collects count rates from the total and random pseudo-coincidence channels that represent typical radon levels in the area where the CAM is installed. Because radon levels fluctuate over the course of a day, total and random pseudo-coincidence count rates must be collected over an extended period of time (at least 10 hours). Before running the **Pseudo-Coincidence** utility, a clean filter should be installed, the system vacuum supply turned on, and clean air sampled for at least 2.5 hours.

To run the **Pseudo-Coincidence** utility, enter the desired “Count Time”, in minutes, for each count; the value must be an integer from 60 to 300 minutes. Enter the desired number of count “Cycles”; the value must be an integer from 10 to 100 cycles. Each count cycle will count for the time period entered under count times.

Click *Start* to begin the pseudo-coincidence measurement. The time remaining in the count cycle is indicated on the status bar. After each count cycle finishes, the cycle number and count rates for the alpha, beta, and pseudo-coincidence are displayed.

After all count cycles are finished, the pseudo-coincidence factors are displayed. To store these values in the SQL Server database, click *Store Ps-Coin*.

Caution: Storing the pseudo-coincidence results may void the previous instrument calibration.

To stop the **Pseudo-Coincidence** utility, click the *Stop* button. To exit the pseudo-coincidence utility, click the *Exit* button.

3.2.6.5 Count Times

The **Utility|Count Times** menu option brings up a dialog box to set the "Short Count Time" and "Long Count Time" for data acquisition (Figure 26). Refer to Sections 3.1.2.1 and 3.1.2.2 for a discussion on how the count times are used in data acquisition.

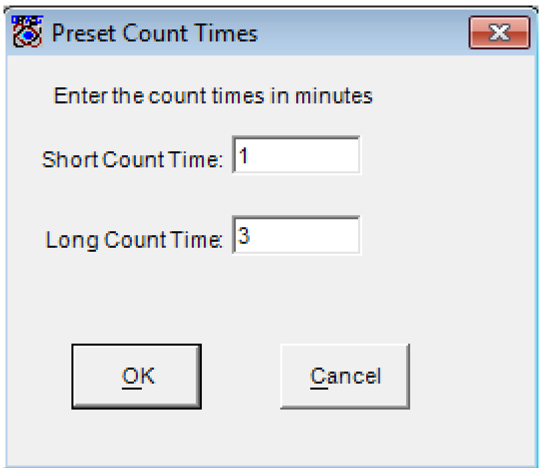


Figure 26. Dialog Box: Count Times

For convenience, if only the short count time is entered and the user then clicks *OK*, the long count time will automatically be set to six times the short count time. Otherwise, the user will need to enter the short count time and then enter an integer multiple of the short count time for the long count time prior to clicking *OK*. The short count and long count times do not have to be integer values, but this is not recommended; only the multiple between the short count time and the long count time must be an integer.

For example, if the short count is set at 3 minutes, the long count needs to be set at 6, 9, 12, or any multiple of 3 minutes. After the desired minutes have been entered correctly, clicking *OK* will result in a message that states the count times you have entered will take effect after acquisition is restarted; otherwise, a message to re-enter appropriate values results. Clicking on *Cancel* will exit the Count Times window without making any changes.

3.2.6.6 Change Filter

The **Utilities|Change Filter** menu option is used when the 8-inch-diameter filter in the CAM is changed. Performing this function accomplishes two goals: it resets the counter for the data acquisition and makes an entry in the filter log.

When it is time to change the CAM filter, select **Acquire|Stop** and then select the **Utilities|Change Filter.** A series of prompts will appear (Figure 27).

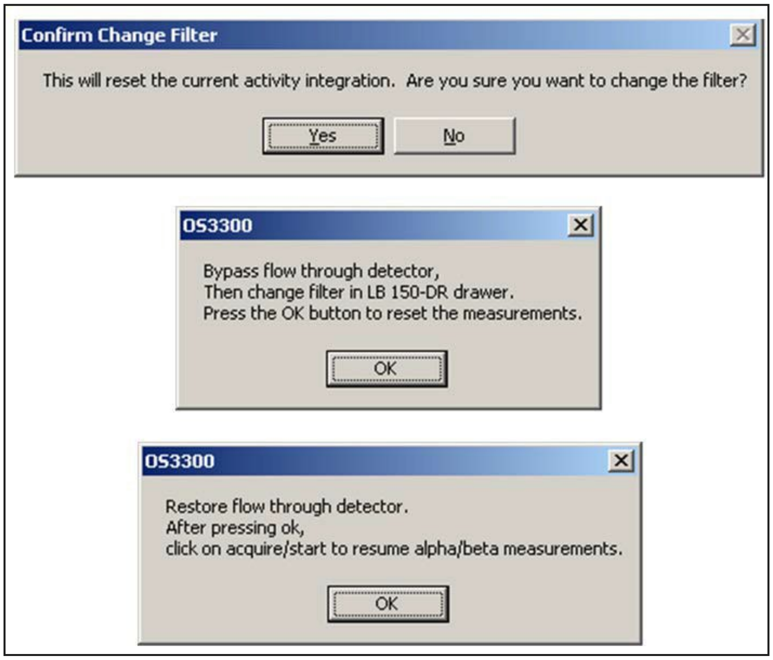


Figure 27. Prompts: Change Filter (example)

The first prompt asks the user to verify this action because it resets the current activity integration. By clicking *Yes*, a second prompt will appear instructing the user to bypass the flow through the detector, change the filter in the LB150D drawer, and then click to reset the software counter. Finally, restore flow to the detector, click *OK* on the final prompt, and select **Acquire|Start** to resume alpha/beta measurements. The filter change information is automatically recorded to the filter log.

3.2.7 About Menu

The **About** menu provides the user information on the PNNL OS3300 software, including the software version number (Figure 28).

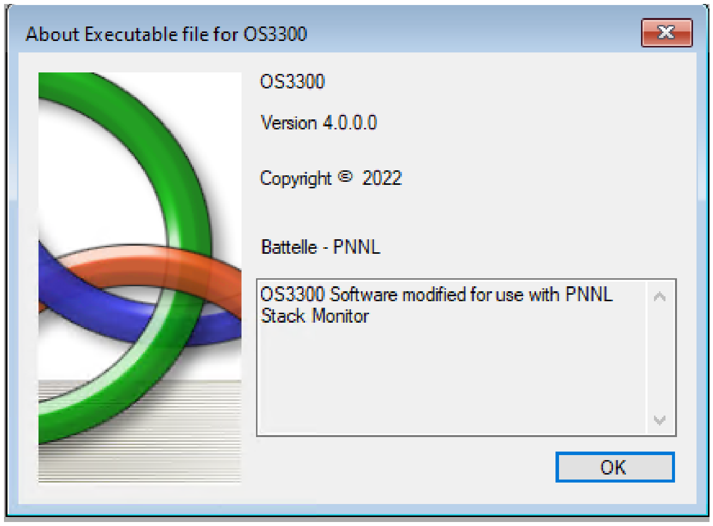


Figure 28. Display: About

3.3 Real-Time Operation

When the PNNL OS3300 software is in real-time data acquisition mode, the system display is as shown in Figure 29. This screen has several features, including alarm indicators, last measurement values, and a software status bar. These features are described in the following subsections.

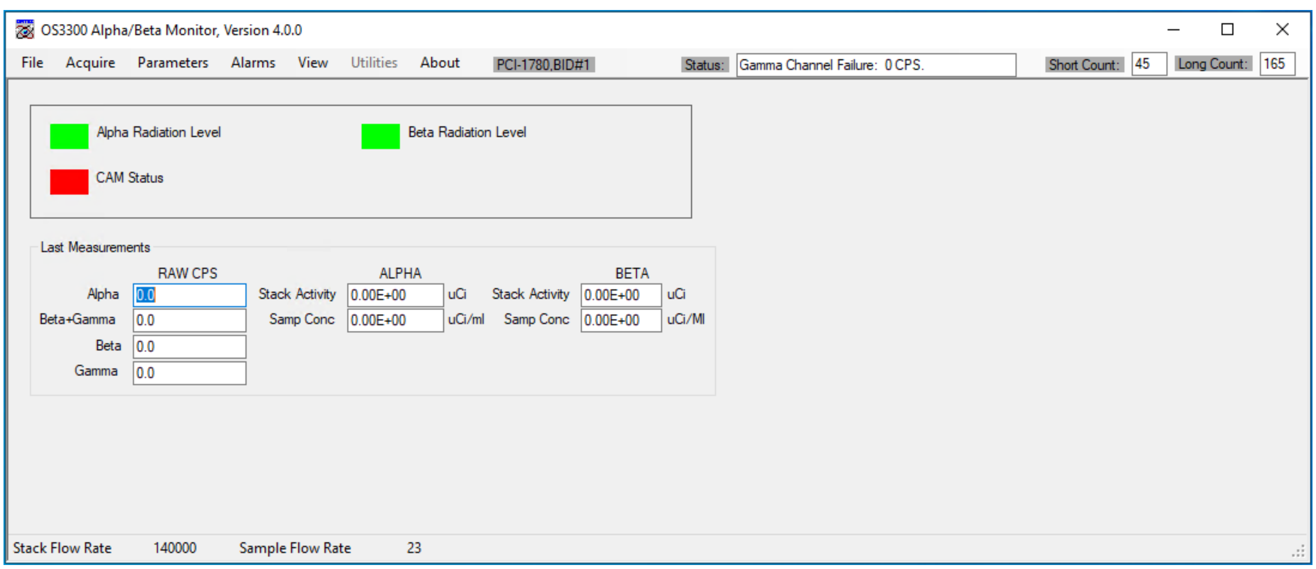


Figure 29. Main Display: Data Acquisition (in progress)

3.3.1 Alarm Indicators

The PNNL OS3300 software display has three alarm indicators that provide the status of the system components (Figure 29). The color green indicates normal status. Red indicates an alarm condition for the specified component. Alarm indicators for alpha and beta activity have a third state, yellow, which indicates that the concentration during a short measuring period was above the alarm limit. Table 3 provides a description for each alarm indicator.

Table 3. Alarm Indicator Definitions

	Alarm Meaning		
Indicator	**Green**	**Yellow**	**Red**
Alpha Radiation Level	Normal operating status	The alpha concentration measured at the end of a short count was above the alpha concentration alarm set point.	Either the alpha integral activity or concentration was above its respective alarm set point at the end of a long count.
Beta Radiation Level	Normal operating status	The beta concentration measured at the end of a short count was above the beta concentration alarm set point.	Either the beta integral activity or concentration was above its respective alarm set point at the end of a long count.
CAM Status	Normal operating status	The CAM status indicator only turns red and does not turn yellow under any conditions.	Any combination of the following: 1. Communications lost to the PCI-1780U I/O card. 2. Alpha, beta/gamma, or gamma count rate less than fail threshold setting.

3.3.2 Last Measurements

The main display (Figure 29) shows the last readings made by the system for several important parameters. These parameters, listed in Table 4, are updated at regular intervals.

Table 4. Last Measurements

Parameter Name	Units	Explanation
Alpha	Raw counts per second (CPS)	Alpha channel count rate for the last short count time.
Beta+Gamma	Raw CPS	Beta/gamma channel gross count rate for the last short-count time.
Beta	Raw CPS	Net beta count rate (beta channel count rate minus gamma channel count rate) for the last short count time.
Gamma	Raw CPS	Gamma channel count rate for the last short count time.
Alpha Stack Activity	µCi	The calculated net alpha activity collected on the filter during the most recent long count time. This value is compared to the “Integral Alpha Activity” alarm set point. This net activity is updated at the end of each long count time.
Alpha Samp Conc	µCi/mL	Alpha concentration measured in the sampled air over the last short count time. This value is compared to the “High- Alpha Radiation” alarm set point. The concentration measured in the sample should equal the concentration in the stack (assuming isokinetic sampling). The measured concentration is updated at the end of each short count time.

Parameter Name	Units	Explanation
Beta Stack Activity	µCi	The calculated net beta activity collected on the filter during the most recent long count time. This value is compared to the “Integral Beta Activity” alarm set point. This net activity is updated at the end of each long count time.
Beta Samp Conc	µCi/mL	Beta concentration measured in the sampled air over the last short count time. This value is compared to the “High-Beta Radiation” alarm set point. The concentration measured in the sample should equal the concentration in the stack (assuming isokinetic sampling). The measured concentration is updated at the end of each short count time.

This section describes “RAW Alpha”, “RAW Beta+Gamma”, “RAW Beta”, and “RAW Gamma” parameters. The alpha and beta stack activity and sample concentration are also described.

3.3.2.1 Raw Alpha

The parameter “Alpha RAW CPS” is the count rate, without background subtraction, as measured from the alpha detector during the last short count time.

3.3.2.2 Raw Beta+Gamma

The parameter “Beta+Gamma RAW CPS” is the count rate, without background subtraction, as measured from the beta detector during the last short count time. The measured count rate includes interference (i.e., counts) from gamma radiation.

3.3.2.3 Raw Beta

The parameter “Beta RAW CPS” is the calculated net count rate, without background subtraction, of the beta detector for the last short count time. The displayed value is the difference between the “Beta+Gamma” value and the “Gamma” value if the ““Disable Gamma Bkg” is not checked on the **Parameters|Preference** form. Otherwise, no gamma subtraction is performed, and the “Beta RAW CPS” and “Beta+Gamma RAW CPS” values are the same.

3.3.2.4 Raw Gamma

The parameter “Gamma RAW CPS” is the count rate, without background subtraction, measured from the gamma detector during the last short count time. The gamma detector is located directly behind the beta detector, so it measures, essentially, the same gamma field as the beta detector. The signal from the gamma detector is subtracted from the signal of the beta detector when “Disable Gamma Bkg” is not checked on the **Parameters|Preferences** window.

3.3.2.5 Alpha and Beta Sample Concentration

The alpha and beta sample concentration are calculated by dividing the net alpha and beta activity measured during the most recent short count time by the sample volume. The net alpha and beta activity is calculated at the end of a short count by subtracting the background counts and estimated radon progeny counts from the gross alpha and beta counts. The resulting net count rates are used to calculate the total alpha and beta concentrations present on the filter. The total alpha and beta concentrations calculated during the previous short count time are then subtracted. The final result is a net alpha and beta concentration that is accumulated on the filter during the lapsed short count period.

Assuming isokinetic sampling, the concentration in the sample should equal the concentration in the stack. The concentration is measured in real time, meaning the measurement is calculated to show the delta change in counts by subtracting the previous counts from the current total to arrive at the most recent short count's concentration.

Both the alpha and beta concentrations are shown on the main display (Figure 29), where:

- "Alpha Samp Conc" (µCi/mL) is the alpha concentration measured over the last short count time; the value is compared to the "High-Alpha Radiation" alarm set point for alarming purposes.
- "Beta Samp Conc" (µCi/mL) is the beta concentration measured over the last short count time; the value is compared to the "High-Beta Radiation" alarm set point for alarming purposes.

3.3.2.6 Alpha and Beta Stack Activity

The parameter "Alpha-Stack Activity" (µCi) is the net activity released through the stack during the last long count time (Figure 29); the value is compared to the "Integral Alpha Activity" alarm set point for alarming purposes.

"Alpha-Stack Activity" is calculated by summing the net alpha activity measured over each short count time within the long count time, and then scaling the result to obtain the activity released from the stack (Equation 6).

$$AlphaActStack_{net} = \frac{\left[\int_{1}^{\substack{\text{num short counts} \\ \text{in long count}}} AlphaActivity_i\right] * StackVolume}{SampleVolume} \tag{6}$$

The parameter "Beta-Stack Activity" (µCi) is the net beta activity released during the last long count time (Figure 29); the value is compared to the "Integral Beta Activity" alarm set point for alarming purposes.

"Beta-Stack Activity" is calculated by summing the net beta activity measured over each short count time within the long count time and then scaling the result to obtain the activity released from the stack (Equation 7).

$$BetaActStack_{net} = \frac{\left[\int_{1}^{\substack{\text{num short counts} \\ \text{in long count}}} BetaActivity_i\right] * StackVolume}{SampleVolume} \tag{7}$$

3.3.3 Status Bar

The status bar is on the bottom of the main screen (Figure 29); it provides stack and sample flow rates (cfm). The CAM status (e.g., channel failure), countdown timers (seconds) for the short count and the long count, and the current time and date are displayed on the top menu bar. Stack flow rates are set in the Alarm Settings menu (Section 3.2.4.1). If the CAM has multiple failure alarms, only the most recent failure alarm is displayed. Table 5 summarizes status bar messages.

Table 5. CAM Status Messages and Definitions

CAM Status Message	Explanation
"Counting"	Normal operating mode.
"Alpha Channel Failure #CPS" "Beta Channel Failure #CPS" "Gamma Channel Failure #CPS"	Count rates are lower than fail threshold setting.
"Detectors Stopped"	Detectors are not counting.
"Counting to acquire operating parameters"	Start-up count running (1 minute).

4.0 Calculations

This section provides the equations that are used to calculate alpha and beta activity.

4.1 Alpha Activity

This section develops the equation used by the PNNL OS3300 software to calculate alpha activity from non-natural sources on the stack CAM filter.

Alpha activity reported by the PNNL OS3300 software is the alpha activity, accumulated on the filter, from non-natural sources of radioactivity. It is calculated with Equation 8.

$$A_{art} = \frac{C_{a-tot} - C_{a-radon}}{Eff * 37000} \tag{8}$$

where
- A_{art} = Non-natural alpha activity, µCi
- C_{a-tot} = Total count rate in the alpha channel, CPS
- $C_{a-radon}$ = Alpha count rate from radon progeny accumulated on the filter, CPS
- Eff = Detection efficiency (set during calibration), unitless
- 37000 = Conversion factor for converting Bq to µCi (37000 Bq / µCi).

The count rate from radon progeny collected on the filter ($C_{a\text{-}radon}$) is measured with a pseudo-coincidence circuit, which counts the number of beta disintegrations that are accompanied, within a brief time period, by an alpha disintegration. Pseudo-coincidence counting is discussed in the subsections that follow.

4.1.1 Pseudo-Coincidence Counting

The radon (222-Rn) and thoron (220-Rn) decay chains decay by alpha emission to very short half-life isotopes that decay by alpha and beta emissions. In the 222-Rn decay chain, the decay of 214-Bi (a beta emitter) is followed by the decay of 214-Po (an alpha emitter with a half-life of 164 µs). Because the half-life of 214-Po is 164 µs and because the definition of half-life states that half the atoms decay within one half-life, there is a 50% probability that any particular 214-Bi decay will be accompanied, within 164 µs, by a 214-Po decay.

Similarly, in the 220-Rn decay chain, the decay of 212-Bi (a beta emitter) is followed the decay of 212-Po (an alpha emitter with a 0.3 µs half-life). Using the same argument as in the previous paragraph, 50% of the 212-Bi decays are accompanied, within 0.3 µs, by a 212-Po decay. Within the 164 µs window while 50% of the 214-Po (from the radon decay chain) decays following a 214-Bi beta emission, essentially all 212-Po atoms from the 220-Rn decay chain will have decayed by alpha emission. Because 212-Bi decays to an alpha emitter only 64% of the time, only 64% of the 212-Bi decays will be accompanied by an alpha emitter within 164 µs (again, the 164-µs window is from the radon decay scheme).

Because it is desirable to have the ratio of beta particles followed by alpha particles within a particular time period equal for both the 222-Rn and 220-Rn decay chains, the timing window used for the radon decay chain was increased from 164 µs to 190 µs. By increasing the window from 164 µs to 190 µs, the number of 214-Bi beta emissions followed by an alpha emission is increased from 50% to 64%. And, during the same time window, 64% of the 212-Bi beta emissions will be followed by an alpha emission.

If a beta decay (by either 214-Bi or 212-Bi) is used to trigger a timing circuit that registers a count only if an alpha decay is detected within 190 μs, then each count registered by this timing circuit would indicate the decay of a radon daughter product. The counts registered by the timing circuit divided by the count time gives the pseudo-coincidence count rate.

Because there are several other isotopes in the 222-Rn and 220-Rn decay schemes that are not counted by the pseudo-coincidence counting circuit, the true number of radon/thoron alpha events counted by the system is only proportional to the pseudo-coincidence count rate. Therefore, a pseudo-coincidence alpha (rate) factor, F_a, is introduced in the equation to account for the radon/thoron alpha emissions that are not counted by the pseudo-coincidence counting circuit (Equation 9).

$$A_{art} = \frac{C_{a-tot} - Ps * F_a}{Eff * 37000} \tag{9}$$

where Ps is the pseudo-coincidence count rate (in CPS) and F_a is the pseudo-coincidence rate factor (ideally 1/0.64 or 1.56).

F_a is set by running the stack CAM with a clean filter, measuring the average pseudo-coincidence count rate over a long period (Ps_{ave}), measuring the gross alpha count rate (C_{ave}), and determining the value for F_a required to make the following equation true (Equation 10).

$$C_{ave} - Ps_{ave} * F_a = 0 \tag{10}$$

Unfortunately, F_a is not constant. As environmental radon levels fluctuate, the ratios of various radon and thoron progeny on the filter paper also fluctuate. As a result, the value of F_a changes as the pseudo- coincidence count rate changes. To account for these fluctuations in F_a, another factor, F(Ps), is added to the equation for calculating artificial alpha activity (Equation 11).

$$A_{art} = \frac{C_{a-tot} - Ps * F_a * F(Ps)}{Eff * 37000} \tag{11}$$

where F(Ps) = F is a linear function of Ps and accounts for the changes in F_a with the pseudo-coincidence count rate. The functional form of *F(Ps)* is given by Equation 12.

$$F(Ps) = \left[1 + M_a * (\frac{Ps - Ps_o}{Ps_o})\right] \tag{12}$$

where Ma is the alpha rate factor (unitless) and Ps_o is the lowest pseudo-coincidence count rate (CPS).

Ps_o is set equal to the lowest measured pseudo-coincidence count rate (Ps):

$$Ps \ = \ Ps_{total} \ - \ Ps_{random} \tag{13}$$

where Ps is the net pseudo-coincidence count rate, Ps_{total} is the count rate of the total pseudo-coincidence count rate channel, and Ps_{random} is the count rate of the random pseudo-coincidence count rate channel.

The PNNL OS3300 software calculates M_a and F_a with linear regression. A detailed description of the calculation is described in Section 4.3.

4.1.2 Time Required for Radon Progeny to Reach Equilibrium

Finally, one more factor must be added to the equation for calculating non-natural alpha activity. When a fresh filter is installed in the CAM, there is essentially no activity present on the filter. As air is drawn through the filter, radon progeny begin to accumulate. However, it takes time for the radon progeny to decay and for the isotopes counted by the pseudo-coincidence counting circuit to reach equilibrium.

The time required for the radon progeny to reach transient equilibrium is accounted for with a filter factor (F_k) that is equal to 1.25 immediately after the filter is changed and decreases linearly to 1.0 over the first 2.5 hours of filter use. After the filter has been installed for 2.5 hours, the filter factor is equal to 1.0 until the filter is changed again.

Equation 14 is used to calculate non-natural alpha activity on the filter paper.

$$A_{art} = \frac{C_{a-tot} - Ps * F_a * F_k * \left(1 + M_a * \frac{Ps - Ps_o}{Ps_o}\right)}{Eff * 37000} \tag{14}$$

where F_k is the correction factor for filter change, unitless.

Equation 14 calculates the total activity collected on the air filter, which is synonymous with the total activity in the volume of air sampled from the stack.

Because there may be an artificial alpha background from materials in the sample chamber, etc., the alpha background measured at the time of calibration is subtracted from the total alpha signal. In this case, the alpha background is not the background from radon or other naturally occurring alpha emitters; it is from alpha emitters that are inherent to the system (e.g., alpha-emitting contaminants in the construction materials). Thus, Equation 15 is the final equation used to calculate non-natural alpha activity on the filter paper.

$$A_{art} = \frac{\left(C_{a-tot} - \frac{C_{a-bkg}}{60}\right) - Ps * F_a * F_k * \left(1 + M_a * \frac{Ps - Ps_o}{Ps_o}\right)}{Eff * 37000} \tag{15}$$

where C_{a-bkg} is the alpha background measured during calibration, CPM.

The PNNL OS3300 software calculates the alpha activity that is released through the stack by multiplying the alpha activity on the filter by the ratio of the total volume of air through the stack to the total volume of air through the sampler (Equation 16).

$$A_{StackActivity} = A_{art} * \left(\frac{StackVolume}{SampleVolume}\right) \quad [\mu Ci] \tag{16}$$

4.2 Beta Activity

This section provides the equation used to calculate beta activity collected on the filter from non-natural sources. The activity from non-natural sources is calculated with Equation17.

$$B_{art} = \frac{C_{b-tot} - C_{b-radon} - C_{gamma}}{Eff * 37000} \tag{17}$$

where
B_{art} = Beta activity from man-made sources, μCi
C_{b-tot} = Total count rate in the beta channel, CPS
$C_{b-radon}$ = Count rate in the beta channel from radon progeny collected on the filter, CPS
C_{gamma} = Count rate in the beta channel from ambient gamma radiation that contributed to the beta count rate, CPS
Eff = Detection efficiency (set during calibration)
37000 = Conversion factor for converting Bq to μCi (37000 Bq / μCi).

The gamma contribution to the count rate of the beta channel is measured in a shielded "guard" detector. Because the sensitivities of the beta detector and shielded gamma detector may be different (i.e., in identical fields, the two detectors may have slightly different responses), a gamma factor is used to make the following equation (Equation 18) balance.

$$C_{gamma} = K * G \tag{18}$$

where G is the count rate in the gamma channel, CPS, and K is the gamma factor. The gamma factor, K, is unitless and is determined by dividing the beta background by the gamma background. The range of K is limited to 0.8 to 1.2; therefore if the calculated value is outside of this range, the closest fit (0.8 or 1.2) is selected.

Following the example of the alpha activity development, the beta activity is then determined from Equation 19.

$$B_{art} = \frac{\left(C_{b-tot} - \frac{C_{b-bkg}}{60}\right) - Ps * F_b * F_k * \left(1 + M_b * \frac{Ps - Ps_o}{Ps_o}\right) - K * G}{Eff * 37000} \tag{19}$$

where C_{b-bkg} is the beta background measured during calibration, CPM.

The PNNL OS3300 software calculates the beta activity that is released through the stack by multiplying the beta activity on the filter by the ratio of the total volume of air through the stack to the total volume of air through the sampler (Equation 20).

$$B_{StackActivity} = B_{art} * \left(\frac{StackVolume}{SampleVolume}\right) \quad [\mu Ci] \tag{20}$$

4.3 Calculation of Rate Factors (M_a and M_b) and Pseudo-Coincidence Factors (F_a and F_b)

This section describes the method used by the PNNL OS3300 software to calculate appropriate values for the alpha and beta rate factors (M_a and M_b), and the alpha and beta pseudo-coincidence factors (F_a and F_b). The use of these variables in the alpha and beta activity calculations is described in Sections 4.1 and 4.2. For clarity, and because the alpha and beta factors are calculated in an identical manner, only the variables M_a and F_a are used in this discussion. However, the calculations are identical for M_b and F_b.

Before the PNNL OS3300 software can calculate M_a and F_a, a clean filter must be installed in the CAM, and the CAM must run for at least 2.5 hours. No artificial activity can be present in the air supply during this utility.

Because no artificial activity is present, the calculated artificial activity should be 0 (Equation 21).

$$0 = \frac{C_{a-tot} - Ps * F_a * F_k * \left(1 + M_a * \frac{Ps - Ps_o}{Ps_o}\right)}{Eff * 37000} \tag{21}$$

Because the filter is installed for at least 2.5 hours before this calculation is performed, F_k equals one, and the equation can be reduced to Equation 22.

$$C_{a-tot} = Ps * F_a * \left(1 + M_a * \frac{Ps - Ps_o}{Ps_o}\right) \tag{22}$$

The PNNL OS3300 software calculates M_a and F_a with linear regression in the following manner. First, assuming no artificial activity (because the CAM ran with a clean filter for at least 2.5 hours before this calculation is performed), Equation 22 becomes Equation 23.

$$0 = C_{a-tot} - Ps * F_a * \left[1 + M_a * \left(\frac{Ps - Ps_o}{Ps_o}\right)\right] \tag{23}$$

Rearranging the terms results in Equation 24.

$$\frac{C_{a-tot}}{Ps} = Ps * \frac{M_a * F_a}{Ps_o} + F_a - M_a * F_a \tag{24}$$

Comparing Equation 24 to the typical linear relation y = m ∗ x + b, results in the following associations (Equation 25):

$$y = \frac{C_{a-tot}}{Ps},\ x = Ps,\ m = \frac{M_a * F_a}{Ps_o},\ b = F_a - M_a * F_a \tag{25}$$

The problem then reduces to measurement of total activity, in the absence of artificial activity, and the associated net pseudo-coincidence count rate with corresponding minimum Ps_o.

With these measured values, the desired parameters can be determined from Equation 26 and Equation 27:

$$F_a = b + m * Ps_o \tag{26}$$

$$M_a = \frac{m * Ps_o}{F_a} \tag{27}$$

4.4 Setting Background Count Times

To have a 1% error with background measurements, the background count time needs to be set so that 10,000 counts will be measured in the set time. For example, if the background count time is 1 minute and 100 counts are measured in that time, then 100 cycles with each cycle being 1 minute are needed to measure a total of 10,000 counts.

4.5 General Statistics Discussion for Calculating Total Counts for Specific Error

Radioactive decay and other nuclear reactions are randomly occurring events and must therefore be described quantitatively in statistical terms. Not only is there constant change in the activity of a specific sample because of the half-life of the nuclide(s), but there is also a fluctuation in the decay rate of a particular sample from one instant to the next because of the random nature of radioactive decay.

However, if the number of atoms that decay during a particular time period (i.e., the counts) is plotted against the number of times each result was obtained (i.e., probability of counts), a bell curve with a normal distribution centered on the average number of events per time period would be obtained (Figure 30).

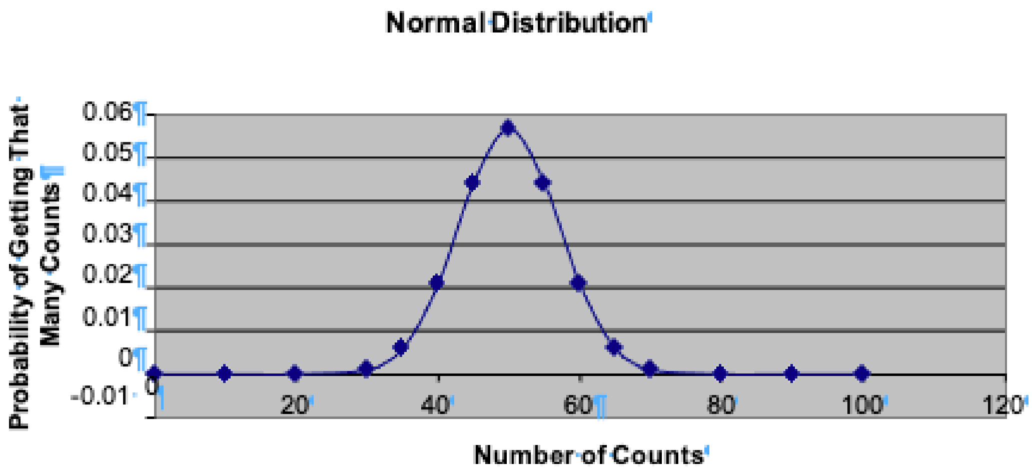


Figure 30. Counts Distribution example

The total area under the curve represents all measurements. Limits may be placed symmetrically above and below the mean value so that the majority of data (area) lie in between. This banded area represents the chance or possibility that a single new observation would have a value lying between the upper and lower limits. These limits are referred to as the “standard deviation about the mean.” One standard deviation, 1σ, is defined as the area between the upper and lower limits representing 68% of the total area. Therefore, the standard deviation is a measure of the dispersion of randomly occurring events about the mean, and 1σ represents the 68% confidence limit (i.e., there is a 68% confidence level that the measured value will be within the defined range). Similarly, 2σ, two standard deviations, represent the 96% confidence limit.

Often, the standard deviation is approximated by the Poisson distribution and is given in Equation 28.

$$\sigma \equiv \sqrt{n} \qquad (28)$$

where σ is the standard deviation, and n is the number of counts observed during the time interval.

When n ≥ ~20, the Poisson and normal distributions nearly coincide. Therefore, the relative error can be calculated with Equation 29.

$$error \equiv \frac{1}{\sqrt{n}} \tag{29}$$

where error is the relative error of the observation, and n is the number of counts observed during the time interval.

The relative error depends on the total number of counts taken and can be made smaller by counting for longer times to obtain more counts (e.g., if n = 10,000, the relative error is 1%).

The interested reader is referred to any number of books with a section on radiation statistics, including *Radiation Detection and Measurement* (Knoll 2000) and *Atoms, Radiation, and Radiation Protection* (Turner 1986).

5.0 Databases

The PNNL OS3300 software uses two SQL databases—“AlphaBetaTritium_XX” and “RPL_OS3300_ConfigParams_XX”. The SQL database “AlphaBetaTritium_XX” is described in Section 5.1. It has several tables that are used to store measured and calculated data. The SQL database “RPL_OS3300_ConfigParams_XX” is described in Section 5.1.5; it contains several tables that are used to store configuration settings for software operation.

5.1 Database AlphaBetaTritium_XX

The “AlphaBetaTritium_XX” database uses the following tables for storing measured and calculated data from the PNNL OS3300 software:

- FilterData: Contains filter information, including filter identifier and filter start/end dates and times.
- QATable: Contains a record of both current and historical quality assurance (QA) stored calibration data.
- RawData: Contains the long count time data, including the date and time stamp, raw count data, flow totals, and the calculated long count activity.
- RawDataShortCount: Contains the short count time data, including the date and time stamp, raw count data, flow rates, flow totals, and calculated concentrations.
- AlphaBetaAlarms: Contains information related to any software alarms, such as raw counts, concentrations, activities, and alarm date/time.

Each of these tables, including the field names, field descriptions, units, and data types, are described in the following subsections.

5.1.1 Table FilterData

The “FilterData” table contains the start and end dates for each CAM filter change, which is the same information presented in the “Filter Log”. The following fields are stored in this table (Table 6):

Table 6. Table “FilterData” Fields

Field Name	Field Description	Unit	Type
FilterNum	Unique identifier. Sequential number assigned to each filter by the database. The value in this field is generated automatically.	NA	Integer
StartDate	Date/time the filter was installed in the CAM.	NA	Date/Time
EndDate	Date/time the filter was removed from the CAM.	NA	Date/Time

5.1.2 Table QATable

The “QATable” contains a record of both current and historical QA stored calibration data. The following fields are stored in this table (Table 7):

Table 7. Table “QATable” Fields

Field Name	Field Description	Unit	Type
QAID	Unique identifier for correlating the QA calibration data with the measured counts and calculated concentrations and activities. The value in this field is automatically generated. Records are added sequentially; the newest record is the last number.	NA	Integer
AlphaEff	Alpha efficiency.	CPS/Bq	Real
BetaEff	Beta efficiency.	CPS/Bq	Real
AlphaBKG	Alpha background count rate.	CPS	Real
BetaBKG	Beta background count rate.	CPS	Real
AlphaVolt	High-voltage setting for alpha detector.	Volts	Real
BetaVolt	High-voltage setting for beta detector.	Volts	Real
F_a	Pseudo-coincidence alpha factor.	NA	Real
F_b	Pseudo-coincidence beta factor.	NA	Real
M_a	Pseudo-coincidence correction factor for alpha activity calculations.	NA	Real
M_b	Pseudo-coincidence correction factor for beta activity calculations.	NA	Real
P0	Lowest pseudo-coincidence count rate.	CPS	Real
EffDate	Date the efficiency measurement was performed.	NA	Date/Time
BetaPlatDate	Date the beta plateau was performed. This field is not currently used by the software.	NA	Date/Time
AlphaPlatDate	Date the alpha plateau was performed. This field is not currently used by the software.	NA	Date/Time
BKGDate	Date the background measurements were performed.	NA	Date/Time
PCDate	Date the pseudo-coincidence factors were measured.	NA	Date/Time
Spillover	Alpha spillover measured by the efficiency utility. Spillover is the ratio of beta channel counts to alpha channel counts with only an alpha source present. Spillover is expressed as a fraction.	NA	Real
GammaBKG	Background measured on the gamma detector.	CPS	Real

5.1.3 Table RawData

The “RawData” table contains the measured and calculated data for the long count time period, including the date and time stamp, raw count data, flow totals, as well as the calculated long count activity. The following fields are stored in this table (Table 8):

Table 8. Table "RawData" Fields

Field Name	Field Description	Unit	Type
RawIndex	Unique identifier assigned by the database. The newest record is the last number.	NA	Integer
AlphaStackAct	The alpha activity measured during the last long count time.	µCi	Real
BetaStackAct	The beta activity measured during the last long count time.	µCi	Real
CAMStatus	Status indicator for the CAM. This field is currently not being used; always a "NULL" value.	NA	Real
StackFlowRate	Flow rate through the stack. This value is set by the user on the **Alarm|Settings** screen. The CAM does not measure the actual flow rate.	cfm	Real
StackFlowTotal	Total volume of air through the stack since the last filter change.	kscf	Real
SampFlowRate	Flow rate of air sampled from the stack and passed through the alpha/beta CAM. This value is set by the user on the **Alarm|Settings** screen. The CAM does not measure the actual flow rate.	cfm	Real
SampleFlowTotal	Total volume of air sampled by the alpha/beta CAM during the last long count time.	m^3	Real
RawDate	Date record was written to the database.	NA	Date/Time
RawTime	Time record was written to the database.	NA	Date/Time
QAID	The QA identification number of the data used in the calculations for data in this record.	NA	Integer
AlphaRAW	Total counts of the alpha channel during the last long count time.	Counts	Real
BetaRAW	Total counts of the beta channel during the last long count time.	Counts	Real
PCTotRAW	Total counts of the pseudo-coincidence channel during the last long count time.	Counts	Real
PCRandomRAW	Total counts of the random pseudo-coincidence channel during the last long count time.	Counts	Real
CountTime	Long count time in seconds.	Seconds	Real
GammaRAW	Total counts of the gamma channel during the last long count time.	Counts	Real

5.1.4 Table RawDataShortCount

The "RawDataShortCount" table contains the measured and calculated data for the short count time period, including the date and time stamp, raw count data, flow rates, flow totals, and calculated concentrations. The following fields are stored in this table (Table 9):

Table 9. Table “RawData” Fields

Field Name	Field Description	Unit	Type
RawIndex	Unique numerical identifier; the value in this field is automatically generated. The newest record is the last number.	NA	Integer
AlphaSampConc	The alpha concentration measured during the last short count time.	µCi/mL	Real
BetaSampConc	The beta concentration measured during the last short count time.	µCi/mL	Real
StackFlowRate	Flow rate through the stack. This value is set by the user on the **Alarm|Settings** screen. The CAM does not measure the actual flow rate.	cfm	Real
StackFlowTotal	Total volume of air through the stack during short count time.	kscf	Real
SampFlowRate	Flow rate of air sampled from the stack and passed through the alpha/beta CAM. This value is set by the user on the **Alarm|Settings** screen. The CAM does not measure the actual flow rate.	cfm	Real
SampleFlowTotal	Total volume of air sampled by the alpha/beta CAM during the last short count.	m^3	Real
RawDate	Date record was written to the database.	NA	Date/Time
RawTime	Time record was written to the database.	NA	Date/Time
QAID	The QA identification number of the data used in the calculations for this record.	NA	Integer
AlphaRAW	Total alpha counts for last short count time.	Counts	Real
BetaRAW	Total beta counts for last short count time.	Counts	Real
PCTotRAW	Total pseudo-coincidence channel counts for last short count time.	Counts	Real
PCRandomRAW	Total random pseudo-coincidence channel counts for last short count time.	Counts	Real
CountTime	Time elapsed since last long count time (short count time multiplied by the number of short count times elapsed since last long count time).	Seconds	Real
GammaRAW	Total gamma counts for last short count time.	Counts	Real

5.1.5 Table AlphaBetaAlarms

The “AlphaBetaAlarms” table contains the information related to any software alarms, such as raw counts, concentrations, activities, and alarm date/time. The following fields are stored in this table (Table 10):

Table 10. Table “AlphaBetaAlarms” Fields

Field Name	Field Description	Unit	Type
alarmID	Unique numerical identifier; the value in this field is automatically generated. The newest record is the last number.	NA	Integer
alarmFunction	Alarm option text.	NA	String
alarmRelayPort	The alarm relay port configured via software and stored in AlarmRelaySettings table.	NA	Integer
alphaRawCounts	Total alpha counts for last short count time.	Counts	Real
alphaSampleConcentration	The alpha concentration measured during the last short count time.	µCi/mL	Real
alphaStackActivity	The alpha activity measured during the last long count time.	µCi	Real
betaRawCounts	Total beta counts for last short count time.	Counts	Real
betaSampleConcentration	The beta concentration measured during the last short count time.	µCi/mL	Real
betaStackActivity	The beta activity measured during the last long count time.	µCi	Real
gammaRawCounts	Total gamma counts for last short count time.	Counts	Real
pseudoCoincTotal	Total pseudo-coincidence channel counts for last short count time.	Counts	Real
pseudoCoincRandom	Total random pseudo-coincidence channel counts for last short count time.	Counts	Real
alarmDateTime	Date and time of the alarm.	NA	Date/Time
QAID	The QA identification number of the data used in the calculations for this record.	NA	Integer
countTime	Long count time.	Seconds	Real
digitalOutCode	The 8-bit digital output that generated was set to activate alarm.	NA	Real
alarmInputCode13	An integer representation of the-alarm function variable bits (13-total). This translates the alarm type to relays that are switched at activation.	NA	Real

5.2 Database RPL_OS3300_ConfigParams_XX

The “RPL_OS3300_ConfigParams_XX” database uses the following tables for storing configuration settings for operation of the PNNL OS3300 software:

- AlarmFunctions: Contains the list of “Alarm Options” used on the **Alarms|Relay** Setup menu form.
- AlarmRelaySettings: Stores the alarm relay settings entered on the **Alarms|Relay** Setup menu form.

- Alarms: Stores the “Alarm Values” entered on the **Alarms|Settings** menu form.
- CountTimes: Stores the “Count Times” information entered on **Utilities|Count Times** menu form.
- HardwareParams: Stores hardware information used by the software.
- OperatorList: Stores the user names of software operators.
- OS3300Variables: Stores the QA identifier and associated calibrations variables being used by the software in its calculations.
- SourceInfo: Stores the source parameters, gamma subtraction value, and the option to store count data as entered on the **Parameters|Preferences** menu form.

Each of these tables, including the field names, field descriptions, units, and datatypes, are described in the following subsections.

Parameters generated during calibration and during CAM operation are stored in the “RPL_OS3300_ConfigParams_XX” database. Upon running the PNNL OS3300 software, the program will retrieve parameter values from the database. A printed copy of the post calibration configuration summary should be maintained to recover from system crashes and/or corrupt files. If the user suspects the calibration data have become corrupt, they should contact the calibration technicians to determine if the calibration is still valid.

5.2.1 Table AlarmFunctions

The “AlarmFunctions” table contains a list of “Alarms Options” that are displayed on the **Alarms|Relay Setup** menu form. The following fields are stored in this table (Table 11):

Table 11. Table “AlarmFunctions” Fields

Field Name	Field Description	Unit	Type
pkID	Unique identifier; the value in this field is automatically generated.	NA	Integer
AlarmFunction	Alarm option text to display on the form.	NA	String

5.2.2 Table AlarmRelaySettings

The “AlarmRelaySettings” table stores the alarm relay settings entered on the **Alarms|Relay Setup** menu form. The following fields are stored in this table (Table 12):

Table 12. Table “AlarmRelaySettings” Fields

Field Name	Field Description	Unit	Type
AlarmFunctionID	Foreign key from AlarmFunctions.	NA	Integer
RelayBit	Relay port on connector used to drive external alarm relays.	NA	Integer

5.2.3 Table Alarms

The "Alarms" table stores the "Alarm Values" entered on the **Alarms|Settings** menu form. The following fields are stored in this table (Table 13):

Table 13. Table "Alarms" Fields

Field Name	Field Description	Unit	Type
pkID	Unique identifier; the value in this field is automatically generated.	NA	Integer
alarmDescription	Description of the alarm (e.g., Alpha Fail Threshold).	NA	String
alarmThreshold	Alarm threshold value.	NA	Real
alarmThresholdUnits	Alarm unit.	NA	String

5.2.4 Table CountTimes

The "CountTimes" table stores the "Count Times" information entered on **Utilities|Count Times** menu form. The following fields are stored in this table (Table 14):

Table 14. Table "CountTimes" Fields

Field Name	Field Description	Unit	Type
pkID	Unique identifier; the value in this field is automatically generated	NA	Integer
ctShort	Short count time.	Minutes	Integer
ctLong	Long count time.	Minutes	Integer
ctFail	Count time associated with CAM threshold failure.	Minutes	Integer

5.2.5 Table HardwareParams

The "HardwareParams" table stores hardware information used by the software. The following fields are stored in this table (Table 15):

Table 15. Table "HardwareParams" Fields

Field Name	Field Description	Unit	Type
pkID	Unique identifier. The value in this field is automatically generated.	NA	Integer
hwPrm_BoardPCI	Hardware board identifier (internal slot number).	NA	Integer
hwPrm_AlphaChannel	Event input channel being used for Alpha counts.	NA	Integer
hwPrm_BetaChannel	Event input channel being used for Beta counts.	NA	Integer
hwPrm_TotalCoincidence	Event input channel being used for Total Coincidence counts.	NA	Integer
hwPrm_RandomCoincidence	Event input channel being used for Random Coincidence counts.	NA	Integer
hwPrm_GammaChannel	Event input channel being used for Gamma Counts.	NA	Integer
hwPrm_DigOut_Port	I/O Port on PCI card for Digital Output.	NA	Integer

Field Name	Field Description	Unit	Type
hwPrm_DigOut_Pulse	I/O Port used for Digital Output Pulse function (not currently implemented for OS3300 functions).	NA	Integer

5.2.6 Table OperatorList

The "OperatorList" table stores the user names of software operators. The following fields are stored in this table (Table 16):

Table 16. Table "OperatorList" Fields

Field Name	Field Description	Unit	Type
olPayroll	Payroll identifier for user.	NA	String
olFirstName	First name of user.	NA	String
olLastName	Last name of user.	NA	String

5.2.7 Table OS3300Variables

The "OS3300Variables" table stores the QA identifier and associated calibrations variables being used by the software in its calculations. The following fields are stored in this table (Table 17):

Table 17. Table "OS3300Variables" Fields

Field Name	Field Description	Unit	Type
pkID	Unique identifier for correlating the QA calibration data with the measured counts and calculated concentrations and activities.	NA	Integer
AlphaVoltage	High-voltage setting for alpha detector.	Volts	Real
BetaVoltage	High-voltage setting for beta detector.	Volts	Real
AlphaBkgAvg	Average alpha background count rate.	CPS	Real
BetaBkgAvg	Average beta background count rate.	CPS	Real
GammaBkgAvg	Average gamma background count rate.	CPS	Real
AlphaEffAvg	Alpha efficiency.	CPS/Bq	Real
BetaEffAvg	Beta efficiency.	CPS/Bq	Real
AlphaSpillAvg	Alpha spillover measured by the efficiency utility. Spillover is the ratio of beta channel counts to alpha channel counts with only an alpha source present. Spillover is expressed as a fraction.	NA	Real
F_a	Pseudo-coincidence alpha factor.	NA	Real
F_b	Pseudo-coincidence beta factor.	NA	Real
M_a	Pseudo-coincidence correction factor for alpha activity calculations.	NA	Real
M_b	Pseudo-coincidence correction factor for beta activity calculations.	NA	Real
LowPsuedo	Lowest pseudo-coincidence count rate.	CPS	Real

5.2.8 Table SourceInfo

The “SourceInfo” table stores the source parameters, gamma subtraction value, and the option to store count data as entered on the **Parameters|Preferences** menu form. The following fields are stored in this table (Table 18):

Table 18. Table “SourceInfo” Fields

Field Name	Field Description	Unit	Type
CheckSourceID	Unique identifier; the value in this field is automatically generated.	NA	Integer
AlphaSourceSerialNumber	Alpha source serial number.	NA	String
AlphaSourceActivity	Alpha source activity.	Bq	Real
AlphaSourceCertDate	Alpha source certification date.	NA	Date
AlphaSourceHalfLife	Alpha source half-life.	Years	Real
AlphaSourceCountTime	Alpha source count time.	Minutes	Integer
AlphaSourceCountCycles	Alpha source count cycles.	NA	Integer
BetaSourceSerialNumber	Beta source serial number.	NA	String
BetaSourceActivity	Beta source activity.	Bq	Real
BetaSourceCertDate	Beta source certification date.	NA	Date
BetaSourceHalfLife	Beta source half-life.	Years	Real
BetaSourceCountTime	Beta source count time.	Minutes	Integer
BetaaSourceCountCycles	Beta source count cycles.	NA	Integer
SourceCheckAllowableError	Allowable source check error (fraction of percent).	NA	Real
GammaFactor	Gamma factor	NA	Real
DisableGammaBackground	Disable gamma background (1 = disable).	NA	Bit
SaveShortCountData	Save short count data to the database (1 = save).	NA	Bit

6.0 Software Maintenance

6.1 Software Development Requirements and Troubleshooting

Troubleshooting, questions, or requests for modifying the source code for the PNNL OS3300 software should be directed to PNNL at the following address:

Pacific Northwest National Laboratory
Environmental Protection and Regulatory Programs
Environmental Radiation Task Lead
P.O. Box 999, Mail Stop J2-25
Richland, WA 99352

6.2 Maintenance Schedules and Procedures

There are six relay outputs controlled by the software. These relays are controlled by digital outputs on the PCI-1780U. These outputs are connected to the breakout box via a 68 SCSI female connector. The outputs (numbers one through six) are programmable from the software. Two additional digital outputs are present on the connector but are not currently used by the software. If any of these relays do not operate correctly (i.e., alarms when there is no alarm or fails to alarm when the level is reached), follow the steps in Table 19.

Table 19. Analog Output Troubleshooting Checklist

Step	Procedure	If there is a problem, take this next step.
1	Check the ribbon cable connections at the PCI-1780U card on the rear of the computer.	• Reconnect if loose. • Repair damaged connector (e.g., bent or broken pins).
2	Check electrical terminations in the breakout box.	• Reconnect loose cables. • Repair damaged connector.

If the checklist fails to remedy the problem, contact the hardware vendor(s) for further assistance.

6.3 Errors and Resolutions

Errors and Resolutions are documented in PNNL's Confluence system (https://confluence.pnnl.gov/). Search for "stackcam errors resolutions".

6.4 Defect Reporting

Contact the PNNL TechDesk (https://techdesk.pnnl.gov/ or [(509) 375-6789]) to report any issues; issues will be routed to the correct team for resolution.

7.0 References

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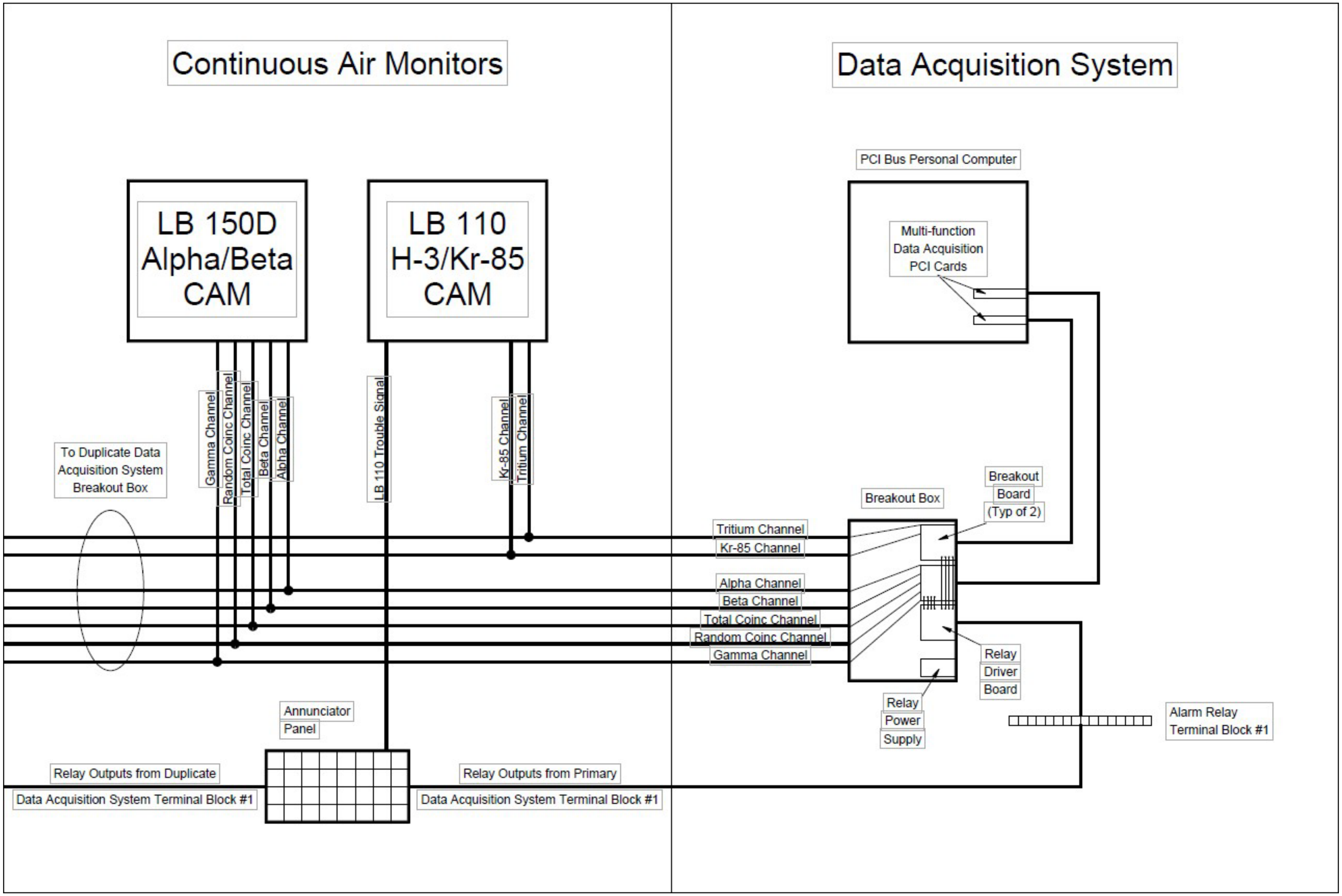
Appendix A – System Diagram



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