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Manual

Solution In-Line Alpha Counter (SILAC)

Instruction Manual—Version 4.00

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Instruction Manual—Version 4.00

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1. Abstract

The Solution In-Line Alpha Counter (SILAC) provides near real-time alpha activity measurements of aqueous solutions in gloveboxes located in the Plutonium Facility (TA-55) at Los Alamos National Laboratory (LANL). The SILAC detector and its interface software were first developed by Joel Farnham at LANL [1]. This instruction manual describes the features of the SILAC interface software and contains the schematic and fabrication instructions for the detector.

2. Introduction

2.1 SILAC Detector

The Solution In-Line Alpha Counter (SILAC) detector provides near real-time alpha activity measurements of aqueous solutions. These measurements, which are related to alpha content through a simple model, are useful for the development and process monitoring of waste minimization efforts. The detector is designed to have a dynamic range from 0.1 to 6000 mCi/L and a chemical resistance to 12 M HCl solutions.

The detector's primary components include a scintillation fiber, photodetector, and photodetector housing and end cap. The 3-mm-diameter Bicron BCF-12 scintillator fiber is a polystyrene-based core that contains fluorescent dopants and optical cladding for light transmission. The peak emission of this fiber is 435 nm with a decay time of 3.2 ns.

The photodetector consists of a photomultiplier tube (PMT), high voltage power supply (HVPS), and amplifier/discriminator. The PMT has a 9-mm-diameter cathode and a variable gain up to 3.1×10^6. The peak response of the cathode is 400 nm with a quantum efficiency of 25%. A single low voltage control wire (0 to 1.8 vdc) controls the HVPS and PMT gain. The photodetector housing and end cap are made of polyvinyl chloride (PVC). The housing and end cap are designed to protect the photodetector from the harsh glovebox environment.

In addition to the detector, the detection system also includes the data acquisition (DAQ) board. Outgoing signals from the DAQ board control the detector's data acquisition status and voltage. Incoming signals from the detector to the DAQ board represent the total number of counts per second (cps) measured by the detector. The DAQ board is controlled through the SILAC interface software.

The scintillation fiber contacts an aqueous solution flowing through the detector and produces light through scintillation. The amount of light produced is proportional to the alpha content of the solution. The light produced from the scintillator is measured by the PMT and converted into current pulses. The DAQ board counts these pulses and passes the information to the SILAC program, where the data are processed and plotted for the user.

2.2 SILAC Program

The SILAC interface software was created using LabVIEW 5.1.1 from National Instruments Corporation [2]. No prior knowledge of LabVIEW is necessary to understand this manual. *Section 5, Additional Information* describes resources where additional information about LabVIEW and the SILAC detector may be found.

The purpose of the SILAC program is to serve as an interface between the user and the detector. The program communicates with the user through graphical user interfaces called front panels and with the detector through the DAQ board. Additional information describing the front panel and detector assembly is included in *Appendix A-1: Main Front Panel* and *Appendix B: SILAC Assembly Manual*, respectively. The outgoing signals from the DAQ board control the detector's data acquisition status and voltage. The incoming signals from the detector represent the total number of counts per second measured by the detector.

In addition to transmitting and receiving signals, the program also processes the data received from the detector. First, the software converts the total cps measured into net counts per minute (cpm) and displays this count rate both numerically and graphically. Second, it triggers visual alarms if the count rate is above an upper limit or below a lower limit. Finally, the program triggers a separate visual alarm if the count rate is negative (i.e., the total count rate is less than the background count rate).

The program also contains several useful features. First, the high voltage plateau subroutine allows the user to determine the optimum voltage for operating the detector. This subroutine can automatically measure the total count rate in defined voltage intervals and display these data graphically. Second, the software can save the count rate, detector voltage, and comments to a data file every minute. Third, the background count rate can be manually specified or changed by the user. Finally, the program can exponentially smooth the count rate data points to remove any rapid fluctuations that might be present.

2.3 Conventions Used in this Document

- Most of the text in this document is written in the Times New Roman font. All headings in the document are written in bold in the Arial font.
- References to sections of the document and reference book titles are written in italics in the Times New Roman font. For example, see *Section 5, Additional Information* or the *LabVIEW QuickStart Guide* for more information.

- Control and indicator names in the main body of the text are written in bold in the Times New Roman font. For example, press the **Start** button. Control and indicator names in tables are written in plain text in the Times New Roman font.
- Names of buttons that are not front panel controls are written in bold in the Times New Roman font and enclosed in single quotes. For example, select **'Yes'.**
- Names of files and icons are written in the Courier New font. For example, double-click on the `SILAC 4.00` icon or run `SILAC 4.00.exe`.
- Names of keys on the keyboard are written in the Times New Roman font and enclosed by angled brackets. For example, press <Enter> to accept the new value.
- The term "count rate" is used interchangeably for both the original and exponentially smoothed net count rates measured in cpm. The user may also use the total count rate. To use the total count rate, set the background count rate to zero cpm. See *Section 4.8, Setting the Background Count Rate* for instructions on setting and changing the background count rate.

3. Front Panel

The graphical user interface that allows the user to control the detector is called the main front panel. The main front panel uses controls and indicators to accept input from the user and to display output from the program. Controls are objects that accept various inputs from the user and pass them to the program. The controls are further divided into command controls and program controls, depending on the type of information they send to the program. Indicators, on the other hand, are objects that receive output from the program and display it on the front panel. This section describes the controls and indicators that are located on the main front panel. *Appendix A-1: Main Front Panel* contains a diagram of the main front panel. This diagram uses colored circles to indicate the location and type of the various controls and indicators.

3.1 Command Controls

Command controls are the primary tools used to pass information to the program. These controls may be further divided into buttons and numeric controls. Buttons pass Boolean (True/False) values to the program. These Boolean values initiate or terminate specific processes in the program. The button locations, names, and tasks they perform are listed in Table 1. The location numbers in this table correspond to the green numbered circles located on the main front panel diagram included in *Appendix A-1: Main Front Panel*.

Table 1. Command Control Buttons (Green)

Location	Name	Task
1	Start	Begins/Ends data acquisition.
2	Record	Begins/Ends data recording.
3	Comment	Appends comments to the data file.
4	Limits	Enables/Disables the upper and lower limits.
5	Average	Enables/Disables data smoothing.
6	Set HVPS	Sets the detector voltage.
7	Plateau	Begins the high voltage plateau data acquisition.
8	Calibration	Sets the background count rate.
9	Exit	Exits the program.

Numeric controls pass numeric (floating point or integer) values to the program. Each value represents a different piece of information. The numeric control locations, names, and information they represent are listed in Table 2. The location numbers in this table correspond to the yellow numbered circles located on the main front panel diagram included in *Appendix A-1 Main Front Panel*.

Table 2. Command Control Numeric Controls (Yellow)

Location	Name	Information
1	Upper Limit	Upper limit alarm threshold.
2	Lower Limit	Lower limit alarm threshold.
3	Voltage	Desired detector voltage (0–1250 volts).
4	Interval	Data refresh rate.

3.2 Program Controls

Program controls are additional tools used to pass information to the program. These controls specify important information about the hardware configuration. Once set, these values should not be changed unless the DAQ board is replaced. The program control locations, names, and descriptions are listed in Table 3. The location numbers in this table correspond to the red numbered circles located on the main front panel diagram included in *Appendix A-1: Main Front Panel*.

Table 3. Program Controls (Red)

Location	Name	Description
1	Device	Number of the plug-in DAQ board connected to the detector. This number is the slot number or board ID number assigned to the device during configuration.
2	Channel	Analog output channel that controls the HVPS.
3	Counter	Counter number for the base counter that is used to count events. For the E series devices, 0 and 1 are the only valid values. The E series devices include the DAQPad-6020E and the AT-MIO-16E-10.

3.3 Indicators

Indicators receive output from the program and display it on the front panel. The indicator locations, names, and data they display are listed in Table 4. The location numbers in this table correspond to the blue numbered circles located on the main front panel diagram included in *Appendix A-1: Main Front Panel*.

Table 4. Indicators (Blue)

Location	Name	Data
1	Upper Limit Alarm	Upper limit alarm status.
2	Lower Limit Alarm	Lower limit alarm status.
3	Negative Alarm	Negative count rate alarm status.
4	CPM	Count rate estimated by the program.
5	Timer	Number of seconds elapsed while counting.
6	Background	Background count rate.
7	File CPM	Count rate measured by the detector.
8	Strip Chart	Time evolution of the count rates and limits.
9	Current Voltage	Current detector voltage.

4. Program Specifics

The interface software is designed to perform several different tasks for the user. These tasks include acquiring and saving data, adding comments to the data files, determining the high voltage plateau, changing the detector voltage, and setting the background count rate. Certain parameters must be set, and certain procedures must be followed for the program to perform these tasks. This section details the settings that must be made and the procedures that must be followed to properly perform these tasks.

4.1 Loading the Program

Double-click on the `SILAC 4.00` icon located on the desktop to load the program. If this icon is not present, then find the executable file `SILAC 4.00.exe` on the computer and run this file to load the program.

A dialog box appears when the program is loaded. This dialog box asks if the user wishes to power the detector with the current (default) voltage. Select **'Yes'** to power the detector with this voltage or select **'No'** to leave the detector without power. The **Set HVPS** button turns red to indicate that the voltage is being changed and/or verified. This occurs even if the user selects **'No'.**

Another dialog box appears if any errors occur during this process. This new dialog box describes the errors and identifies where they occurred. The **Set HVPS** button turns blue again once the DAQ board verifies the detector voltage. In addition, the **Current Voltage** indicator changes values to reflect this new voltage. The program's other features become available once the voltage is initially set and verified.

4.2 Acquiring Data

Several parameters must be set before any data may be acquired. These parameters are initialized to their default values when the program is loaded. These default values are normally acceptable for acquiring data in most situations. There may be times, however, when other values are desired. *Section 4.2.1, Settings* describes how to change these parameters. *Section 4.2.2, Data Acquisition* describes how to acquire data once the parameters are set.

4.2.1 Settings

First, the high voltage must be set to an appropriate level. Any voltage on the detector's high voltage plateau qualifies as a suitable voltage. See *Section 4.7, Determining the High Voltage Plateau* for instructions on determining the detector's high voltage plateau and *Section 4.6, Changing the Detector Voltage* for instructions on setting the detector voltage.

Second, the appropriate data smoothing option must be selected. When data smoothing is enabled, the program exponentially smoothes the count rate data and displays the smoothed values on the front panel. This smoothing technique, which uses an exponential smoothing constant of 0.25, removes any rapid fluctuations present in the data. When data smoothing is disabled, the program displays only the current count rate value on the front panel. Data smoothing is enabled by default. Press the **Average** button to disable data smoothing. The word 'Off' appears to indicate that data smoothing is disabled. Press the button again to enable data smoothing. The word 'On' appears to indicate that data smoothing is enabled.

Third, the measurement display interval must be chosen. The measurement display interval specifies the number of seconds the program waits before refreshing the count rate data on the front panel. This is different than the measurement interval, which cannot be modified by the user. There are four possible display intervals to choose from: 1 second, 10 seconds, 30 seconds, or 60 seconds. The default measurement display interval is 30 seconds. Click on the **Interval** numeric control to select a new measurement display interval. A menu ring appears displaying the available intervals. Select the appropriate interval from this list to select the new measurement display interval.

Finally, the upper and lower limits can be set to provide visual alarms if the count rate deviates from a predefined range of values. The upper limit alarm is triggered whenever the count rate exceeds the upper limit. Similarly, the lower limit alarm is triggered whenever the count rate is less than the lower limit. Enter a value in the **Upper Limit** numeric control to set the upper limit. Likewise, enter a value in the **Lower Limit** numeric control to set the lower limit.

The upper and lower limits and their associated visual alarms are enabled by default. To disable the limits and alarms, press the **Limits** button. When disabled, both the upper and lower limits are plotted as 0 in the **Strip Chart** indicator. The button turns yellow to indicate that the limits and alarms have been disabled. Press the button again to enable the limits and alarms. The button turns blue again to indicate that the limits and alarms are enabled.

4.2.2 Data Acquisition

Press the **Start** button to begin acquiring data. The button turns yellow to indicate that data acquisition is occurring. Once data acquisition begins, the **Timer** bar counts the number of seconds that have elapsed. This indicator displays up to 60 seconds before resetting and starting over. A dialog box appears if any errors occur during data acquisition. This dialog box describes the errors and identifies where they occurred.

Press the **Start** button again at any time to terminate the data acquisition. There is a short delay while the program completes the current measurement. This delay lasts up to one second. The **Timer** bar stops counting, and the **Start** button turns blue again to indicate that no data acquisition is occurring.

The front panel contains several indicators that display the count rate data. First, the **CPM** indicator displays the estimated count rate. This value is not the actual number of counts measured by the detector for one minute, but rather an estimate based on shortened measurement intervals. The **File CPM** indicator displays the actual count rate. This value, which is saved in the data file, is the actual number of counts measured by the detector for one minute. Finally, the **Strip Chart** indicator plots the estimated count rate in green, the upper limit in red, and the lower limit in yellow. The current values are added to the previous data, creating a time evolution of the count rate data and limits. All of these indicators are refreshed at the rate defined by the measurement display interval.

The initial horizontal and vertical scales of the **Strip Chart** are set when the program is loaded. These default scales are normally acceptable for displaying data in most situations. There may be times, however, when these scales should be increased or decreased. To change the scale of an axis, enter a new value in the lower limit for that axis. Press <Enter> to accept the new value. Enter a new value in the upper limit for that axis and press <Enter> to accept this new value. The program automatically rescales the axis using the new upper and lower limits. Repeat this process to rescale the other axis.

The front panel also contains three visual features that signal if the count rate is outside an acceptable range. First, the **Upper Limit Alarm** and **Lower Limit Alarm** indicators turn yellow and blink if the count rate is above the upper limit or below the lower limit, respectively. The **CPM** and **Timer** indicator colors also indicate the status of the upper and lower limit alarms. These indicators are green when the count rate is between the upper and lower limits, red when the count rate is above the upper limit, yellow when the count rate is below the lower limit, and magenta when the limits are reversed. Finally, the **Negative Alarm** indicator turns yellow and blinks if the count rate is negative. All of these features are refreshed every second. The first two features, however, are not active when the limits are disabled.

4.3 Recording Data

The detector must be actively acquiring data before any data or comments can be saved to a file. See *Section 4.2, Acquiring Data* for instructions on beginning data acquisition. Once the detector is acquiring data, press the **Record** button to begin the recording process. The button turns yellow to indicate that data recording is occurring.

A dialog box then appears and asks for a new file to store the data. Select an appropriate directory and file name and press **'Save.'** The program creates the new data file with the date, current voltage, and current background count rate included in the header. The header and count data are saved as plain text with the columns separated by tabs. Therefore, the data file should retain the default ".txt" extension to facilitate data retrieval and processing.

A dialog box appears if any errors occur during the file creation process. This dialog box describes the errors and identifies where they occurred. Errors will occur if an existing file is selected, the process is cancelled, or an I/O error occurs when creating the file. The recording process stops, and the **Record** button turns blue again if any of these events occur. Press the **Record** button to restart the recording process.

Once the file is created, the program skips the current measurement and waits until a new measurement is completed before saving the first set of data. Since each measurement takes one minute, there is a delay lasting between one and two minutes before the first set of data is saved to the file. The program saves this initial data and continues to write the current time, count rate, detector voltage, and comments to the file after each subsequent measurement. See *Section 4.5, Adding Comments* for instructions on adding comments.

The actual length of each measurement is slightly longer than one minute. The accuracy of the measurement time is affected by the operating system activities and the detector and acquisition dead times. The count rate values do not need to be adjusted for this additional time, however, because they are the sum of sixty one-second measurements.

After saving the data, the program automatically clears the comments from memory. Another dialog box appears if any errors occur while saving the data. This dialog box also describes the errors and identifies where they occurred.

Data recording may be terminated in two different fashions. First, press the **Record** button to stop recording data but continue data acquisition. Second, press the **Start** button to end both the data recording and acquisition. In both methods, the file path is reset and the **Record** button turns blue again to indicate that no data recording is occurring. In the second method, the **Start** button also turns blue again to indicate that no data acquisition is occurring.

In the first method, the final set of data is saved at the end of the current minute interval or when data acquisition stops, whichever comes first. In the second method, the final set of data is saved immediately, even if the current minute interval has not ended. In both cases, the final set of data may be based on a shortened interval and should therefore be ignored.

4.4 Retrieving Data

A data file may be opened and examined at any time. Since data cannot be saved to the file when it is open, this file should not be opened until the data acquisition associated with it is terminated. See *Section 4.2, Acquiring Data* for instructions on ending data acquisition.

The plain text format of the data files simplifies data retrieval and processing. The count data can be visually examined by using a word processing program or visually examined, processed, and graphed by using a spreadsheet program. By properly importing the data into a spreadsheet, it is possible to plot the count rate as a function of time and/or voltage.

To open a data file with the default word processor, simply double-click on the icon for the file. To open the file with another word processing or spreadsheet program, first load the program and then open the file from within the program. When importing the data file into a spreadsheet, it is possible to strip the header and comments from the file, leaving only the time, count rate, and voltage values. This can be done by modifying the parameters during the file import process.

4.5 Adding Comments

Comments may be entered at any time. However, comments are saved with the data so they are not written to a file unless data recording is occurring. See *Section 4.3, Recording Data* for instructions on recording data.

Press the **Comment** button to enter a comment. A dialog box appears that allows the user to enter a comment. Type a comment in the text box and press **'Done.'** The **Comment** button turns yellow to indicate that a comment has been stored in memory but not saved to a data file. Entering a new comment at this time erases the previous comment and replaces it with the new comment. The **Comment** button remains yellow until the program writes the next set of data to a file. At this time, the program adds the comment to the data file, erases the comment from memory, and turns the **Comment** button blue again to indicate that no more comments are stored in memory.

4.6 Changing the Detector Voltage

In general, the operating voltage for the detector is set at the optimum value determined from high voltage plateau measurements. See *Section 4.7, Determining the High Voltage Plateau* for instructions on performing high voltage plateau measurements. A different operating voltage may be entered at any time, but the voltage will not change unless the **Set HVPS** button is pushed. To change the voltage, first enter the desired voltage in the **Voltage** numeric control. Then press the **Set HVPS** button to power the detector at this new voltage level. The button turns red to indicate that the voltage is being changed.

A dialog box appears if any errors occur while changing the detector voltage. This dialog box describes the errors and identifies where they occurred. The **Set HVPS** button turns blue again once the DAQ board verifies the new voltage. In addition, the **Current Voltage** indicator changes values to reflect this new voltage.

A comment is stored in memory noting that the detector voltage has changed. The **Comment** button turns yellow to indicate that this comment has been entered but not saved to a data file. Entering a new comment at this time erases the previous comment and replaces it with the new comment. The **Comment** button remains yellow until the program writes the next set of data to a file. At this time, the program adds the comment to the data file, erases the comment from memory, and turns the **Comment** button blue again to indicate that no more comments are stored in memory.

4.7 Determining the High Voltage Plateau

All other data acquisition must stop before high voltage plateau data can be acquired. See *Section 4.2, Acquiring Data* for instructions on ending data acquisition. After verifying that no data acquisition is being performed, press the **Plateau** button to begin the high voltage plateau determination subroutine.

4.7.1 Plateau Front Panel

A new front panel appears that allows the user to control the high voltage plateau data acquisition. This plateau front panel contains controls and indicators much like the main front panel. *Appendix A-2: Plateau Front Panel* contains a diagram of the plateau front panel. This diagram uses colored circles to indicate the location and type of the various controls and indicators.

The controls begin data acquisition and specify the beginning, ending, and increment voltages used to determine the high voltage plateau. The control locations, names, and tasks they perform are listed in Table 5. The location numbers in this table correspond to the green numbered circles located on the plateau front panel diagram included in *Appendix A-2: Plateau Front Panel*.

Table 5. Plateau Controls (Green)

Location	Name	Task
1	Start	Begins the high voltage plateau data acquisition.
2	Exit	Exits the high voltage plateau determination subroutine.
3	Start Voltage	Specifies the beginning voltage used to make high voltage plateau measurements.
4	Stop Voltage	Specifies the ending voltage used to make high voltage plateau measurements.
5	Step Voltage	Specifies the voltage increase after each iteration.

The indicators display the current and overall measurement results. The indicator locations, names, and data they display are listed in Table 6. The location numbers in this table correspond to the blue numbered circles located on the plateau front panel diagram included in *Appendix A-2: Plateau Front Panel*.

Table 6. Plateau Indicators (Blue)

Location	Name	Data
1	Strip Chart	Total count rate as a function of the detector voltage.
2	LED	Plateau data acquisition status.
3	Complete	Plateau data acquisition status.
4	Current Counts	Current count rate.
5	Current Voltage	Current voltage level.
6	Time Remaining	Number of minutes (iterations) remaining.

4.7.2 Plateau Measurements

Enter a value in the **Start Voltage** numeric control to specify the beginning voltage. Likewise, enter values in the **Stop Voltage** and **Step Voltage** numeric controls to specify the ending and increment voltages, respectively. After setting these parameters, press the **Start** button to begin acquiring data.

The **LED** indicator blinks to indicate that data acquisition is occurring. The subroutine begins the data acquisition by measuring counts for one minute with the detector powered at the beginning voltage level. After measuring counts for one minute, the subroutine increases the detector voltage by the increment voltage and measures counts for another minute. The **Strip Chart**, **Current Counts**, **Current Voltage,** and **Time Remaining** indicators are also updated at this time to reflect the new data. The subroutine continues this process until the ending voltage is reached or exceeded.

The initial horizontal and vertical scales of the **Strip Chart** are set when the plateau subroutine is loaded. These default scales are normally acceptable for displaying data in most situations. There may be times, however, when these scales should be increased or decreased. To change the scale of an axis, enter a new value in the lower limit for that axis. Press <Enter> to accept the new value. Likewise, enter a new value in the upper limit for that axis and press <Enter> to accept this new value. The subroutine automatically rescales this axis using the new upper and lower limits. Repeat this process to rescale the other axis.

When the data acquisition is complete, the **LED** indicator stops blinking and the **Complete** indicator turns green. Press the **Exit** button to exit this subroutine and return to the main program.

A dialog box appears and asks if the user wishes to save the high voltage plateau data to a file. Select **'Yes'** to save the data or select **'No'** to continue without saving. If the user chooses **'Yes,'** another dialog box appears and asks for a file to store the high voltage plateau data. Select an appropriate directory and file name and press **'Save.'**

Although not present by default, the plateau data file should have a ".txt" extension to facilitate data retrieval and processing.

The subroutine then writes the date, time, voltage levels, and count rates to this file. In addition, the subroutine includes a comment specifying this measurement data is high voltage plateau data. Like the main program, this subroutine saves the header and count data as plain text with the columns separated by tabs. Unlike the main program, however, this subroutine can overwrite existing files when creating new data files. Therefore, selecting an existing file for a new data file erases its previous contents.

The detector voltage is reset to its previous value before returning to the main program. Therefore, it is unnecessary to manually reset the high voltage after returning to the main program. A dialog box also appears upon returning to the main program if any errors occurred during the high voltage plateau determination. This dialog box describes the errors and identifies where they occurred.

4.7.3 Retrieving Plateau Data

The plain text format of the plateau data files simplifies data retrieval and processing. The plateau data can be visually examined by using a word processing program or visually examined, processed, and graphed by using a spreadsheet program. By properly importing the data into a spreadsheet, it is possible to plot the count rate as a function of voltage.

To open a plateau data file with the default word processor, simply double-click on the icon for the file. To open the file with another word processing or spreadsheet program, first load the program and then open the file from within the program. When importing the data file into a spreadsheet, it is possible to strip the header and comments from the file, leaving only the count rate and voltage values. This can be done by modifying the parameters during the file import process.

4.8 Setting the Background Count Rate

The background count rate may be set or changed at any time. Press the **Calibration** button to specify a new background count rate. A dialog box appears and asks for a new background count rate in cpm. Enter a value in the numeric control and press **'Done.'**

Three things occur when the background count rate is set. First, the new background count rate is displayed in the **Background** indicator. Second, the caption of the **CPM** indicator changes to "Counts/Minute–Background" to indicate the displayed value is now the net, not total, count rate. Finally, a comment is stored in memory noting that the background count rate has been changed. The **Comment** button turns yellow to indicate that this comment has been entered but not saved to a data file. Entering a new comment at this time erases the previous comment and replaces it with the new comment. The **Comment** button remains yellow until the program writes the next set of data to a file. At this time, the program adds the comment to the data file, erases the comment from memory, and turns the **Comment** button blue again to indicate that no more comments are stored in memory.

4.9 Exiting the Program

Press the **Exit** button at any time to terminate the program and exit to the operating system. There is a delay lasting at least four seconds while the program turns off the detector. This delay may last up to two minutes if the detector is acquiring data when the **Exit** button is pressed. To reduce the delay time, stop all data acquisition before pressing the **Exit** button. See *Section 4.2, Acquiring Data* for instructions on ending data acquisition.

5. Additional Information

5.1 LabVIEW

This program was created using LabVIEW 5.1.1 from National Instruments Corporation [2]. LabVIEW is an application-building environment based on the graphical programming language G. While LabVIEW may be used to create general-purpose programs, it is designed primarily for instrument control and data acquisition applications.

Several resources exist that provide excellent detailed information on LabVIEW. First, the *LabVIEW QuickStart Guide* [3] and online tutorial provide a brief introduction to the LabVIEW environment. These two resources also provide several simple introductory examples that demonstrate LabVIEW's functionality and capabilities. Second, the *LabVIEW User's Manual* [4] and *LabVIEW G Programming Reference Manual* [5] display more advanced programming techniques and describe how to create, edit, debug, and execute programs (virtual instruments). Third, the *LabVIEW Function and VI Reference Manual* [6] contains detailed descriptions of every built-in function and virtual instrument (VI). Finally, the *LabVIEW Data Acquisition Basics Manual* [7] describes basic data acquisition concepts, routines, and procedures.

5.2 SILAC

Additional information on the SILAC detector is included in *Appendix B: SILAC Assembly Manual*. This appendix contains the *Solution In-Line Alpha Counter Assembly Manual* [8], which provides detailed instructions on assembling and testing the SILAC detector. This manual also contains drawings of the machined parts, schematics, and circuit interconnections plus a parts list including the manufacturers and their addresses.

6. Acknowledgements

The authors wish to acknowledge Professor Gary Mueller (University of Missouri-Rolla, Nuclear Engineering Department) for reviewing this document and providing numerous suggestions for its improvement.

7. References

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[6] *LabVIEW Function and VI Reference Manual*, 321526B-01. National Instruments Corporation. Austin, Texas, 1998.

[7] *LabVIEW Data Acquisition Basics Manual*, 320997C-01. National Instruments Corporation. Austin, Texas, 1998.

[8] Farnham, J. E., *Solution In-Line Alpha Counter Assembly Manual*, unpublished. Los Alamos National Laboratory, 1998.

Appendix A: SILAC Software Diagrams

A-1. Main Front Panel

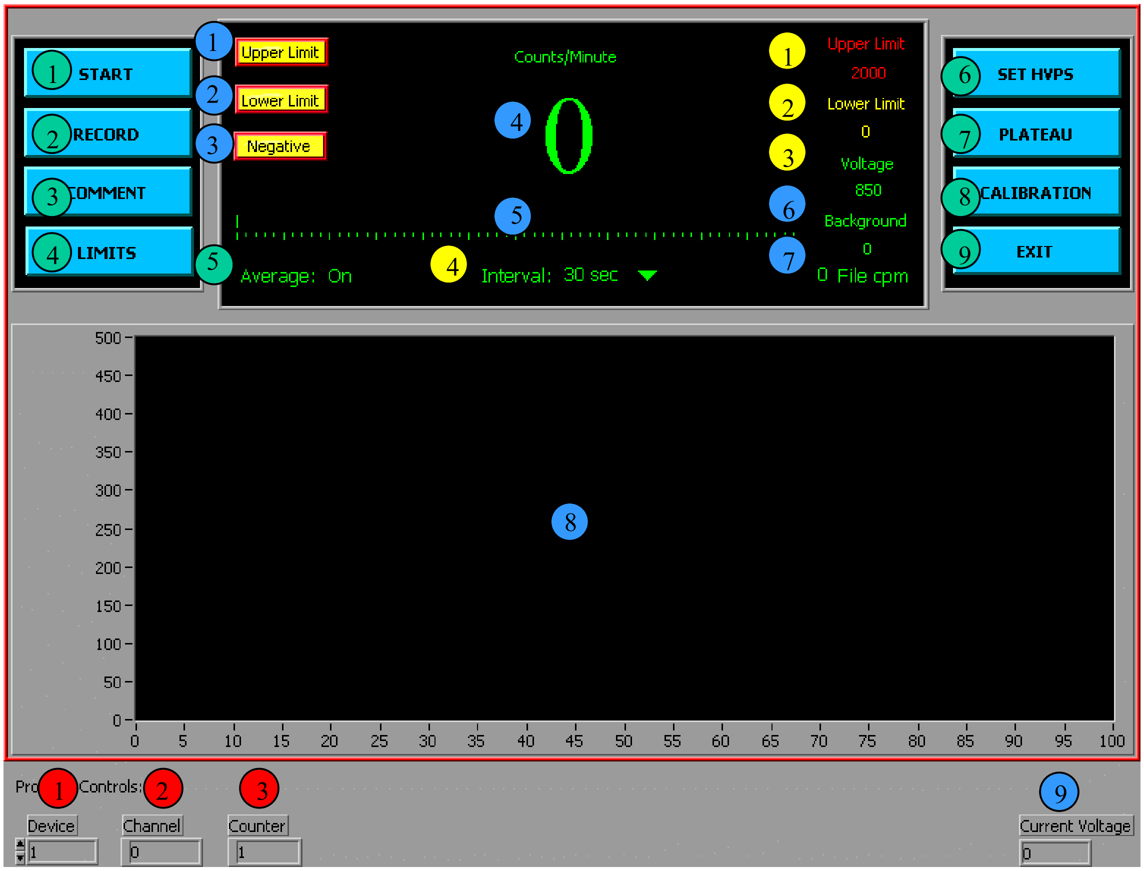

Figure A-1. Main Front Panel Diagram

Table A-I. Command Control Buttons (Green)

Location	Name	Task
1	Start	Begins/Ends data acquisition.
2	Record	Begins/Ends data recording.
3	Comment	Appends comments to the data file.
4	Limits	Enables/Disables the upper and lower limits.
5	Average	Enables/Disables data smoothing.
6	Set HVPS	Sets the detector voltage.
7	Plateau	Begins the high voltage plateau data acquisition.
8	Calibration	Sets the background count rate.
9	Exit	Exits the program.

Table A-II. Command Control Numeric Controls (Yellow)

Location	Name	Information
1	Upper Limit	Upper limit alarm threshold.
2	Lower Limit	Lower limit alarm threshold.
3	Voltage	Desired detector voltage (0–1250 volts).
4	Interval	Data refresh rate.

Table A-III. Program Controls (Red)

Location	Name	Description
1	Device	Number of the plug-in DAQ board connected to the detector. This number is the slot number or board ID number assigned to the device during configuration.
2	Channel	Analog output channel that controls the HVPS.
3	Counter	Counter number for the base counter that is used to count events. For the E series devices, 0 and 1 are the only valid values. The E series devices include the DAQPad-6020E and the AT-MIO-16E-10.

Table A-IV. Indicators (Blue)

Location	Name	Data
1	Upper Limit Alarm	Upper limit alarm status.
2	Lower Limit Alarm	Lower limit alarm status.
3	Negative Alarm	Negative count rate alarm status.
4	CPM	Count rate estimated by the program.
5	Timer	Number of seconds elapsed while counting.
6	Background	Background count rate.
7	File CPM	Count rate measured by the detector.
8	Strip Chart	Time evolution of the count rates and limits.
9	Current Voltage	Current detector voltage.

A-2. Plateau Front Panel

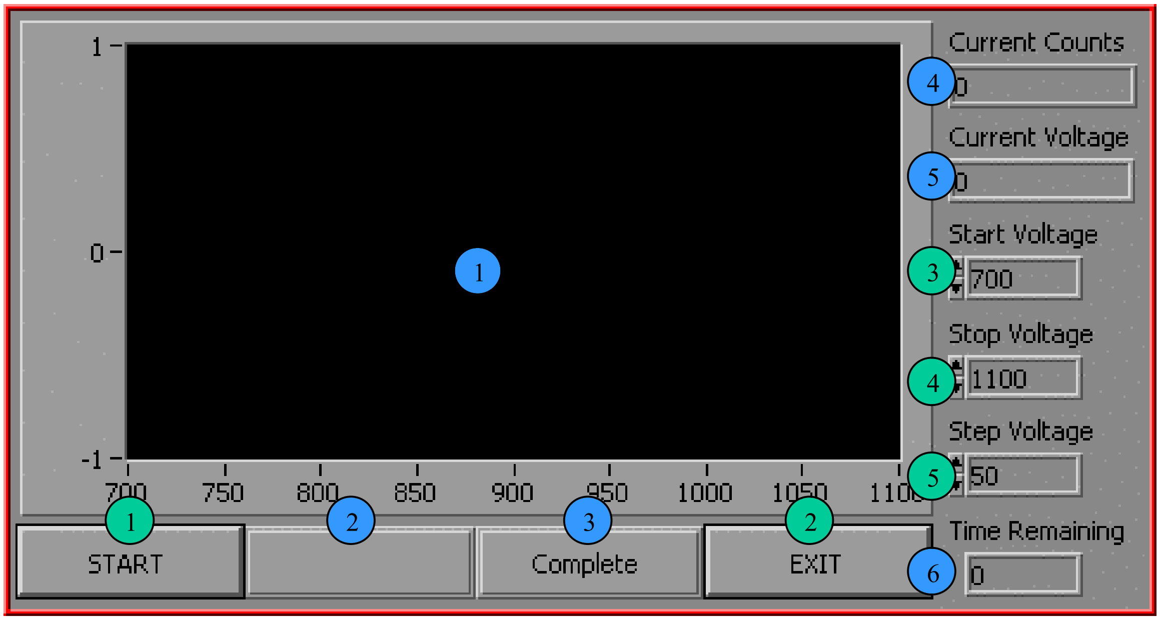

Figure A-2. Plateau Front Panel Diagram

Table A-V. Plateau Controls (Green)

Location	Name	Task
1	Start	Begins the high voltage plateau data acquisition.
2	Exit	Exits the high voltage plateau determination subroutine.
3	Start Voltage	Specifies the beginning voltage used make high voltage plateau measurements.
4	Stop Voltage	Specifies the ending voltage used to make high voltage plateau measurements.
5	Step Voltage	Specifies the voltage increase after each iteration.

Table A-VI. Plateau Indicators (Blue)

Location	Name	Data
1	Strip Chart	Total count rate as a function of the detector voltage.
2	LED	Plateau data acquisition status.
3	Complete	Plateau data acquisition status.
4	Current Counts	Current count rate.
5	Current Voltage	Current voltage level.
6	Time Remaining	Number of minutes (iterations) remaining.

Appendix B: SILAC Assembly Manual

Solution In-Line Alpha Counter Assembly Manual

Joel Farnham

Los Alamos National Laboratory

August 1998

Solution In-Line Alpha Counter
Assembly Instructions

The following instructions describe how to assemble the SILAC components and test the system. Drawings of the machined parts, schematics, circuit interconnections, and a parts list with manufacturer's addresses are also included.

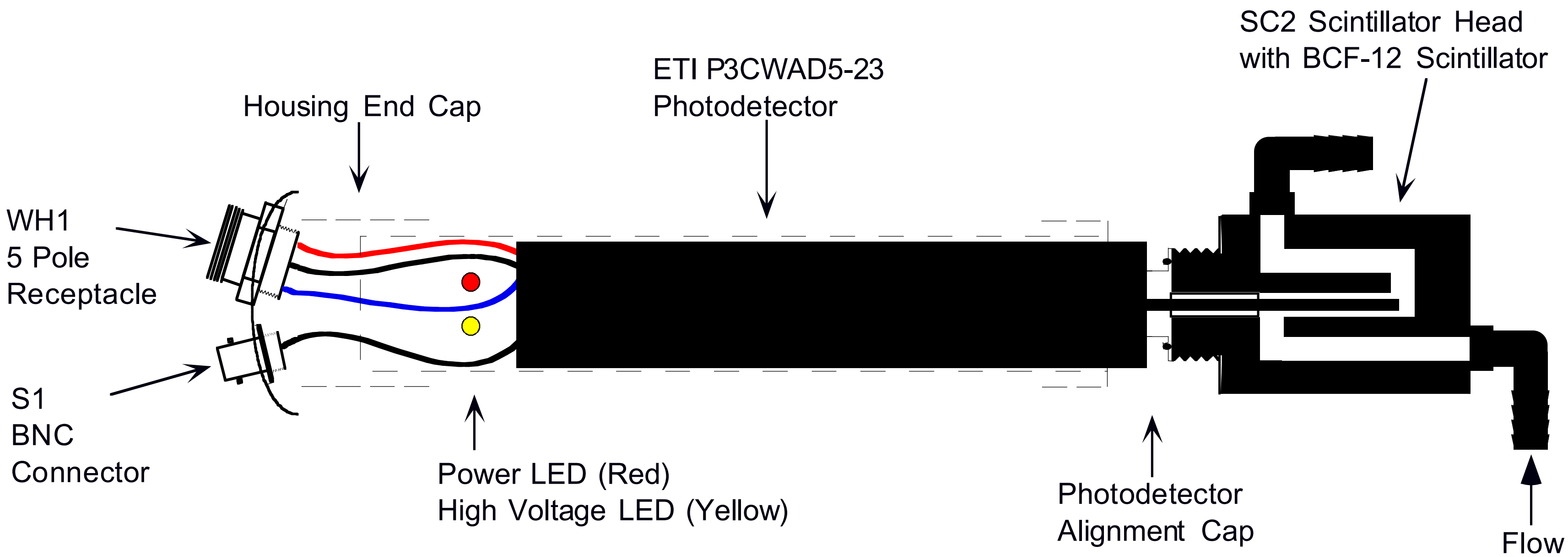

Figure B-1: Components of the SILAC

Bicron BCF-12 Scintillation Fiber:

The BCF-12 scintillation fiber is a polystyrene-based core that contains organic fluorescent dopants and a polymethylmethacrylate optical cladding for light transmission. The peak emission of the fiber is 435 nm with a decay time of 3.2 ns and a 1/e length of 2.2 meters for a 1mm fiber. The dimensions of the fiber used for the 0.1–1000 mCi/L detection range are shown in Figure 2. Shorter lengths can be used for levels of activity above 1 Ci/L. Each end of the fiber is polished to allow for optimum light transmission when coupled to the photomultiplier tube of the photodetector. The optical cladding must be removed to allow the alpha particles to contact the fiber.

Assembly Instructions:

1. Cut the fiber 2-3 mm longer than 7.3 mm to allow for polishing room.
2. Polish each end with 600 grit sandpaper to smooth the rough edges.
3. Follow up with 12, 9, and 3 micron grit paper for the final polished surface finish. The ends should be clear without any clouding.
4. The optical cladding is stripped from the fiber by gently cutting the cladding at 4 cm with a sharp scalpel. Avoid deep cuts into the actual fiber.
5. Gently nick the end of the fiber to start the peeling of the cladding. The easiest method to remove the cladding is by using your thumbnail.
6. Press fit the stripped portion of the fiber into the _" dia. side of the Teflon alignment plug (Fig. 3). Sliding the fiber through a sleeve prevents bowing of the fiber. Leave approximately 1/8" of fiber extended from the _" diameter side of the Teflon.
7. Carefully press fit the scintillator alignment plug and scintillator into the SC2, with a sleeve, until the Teflon seats firmly against the HDPE wall (Fig. 4). Press the remaining 1/8" of extended fiber into the Teflon until the end of the fiber is flush with the end of the _" dia. alignment plug. The head of the alignment plug and scintillator should not extend beyond 0.328", or the distance of the PMT face to the o-ring step of the PMT alignment cap.
8. Install the 1/8 NPT to 3/8" Hose barb fittings to the machined SC2 scintillator head. The pipe thread end of the hose barb should be wrapped with Teflon tape.

Never remove the SC2 from the SILAC with power applied.

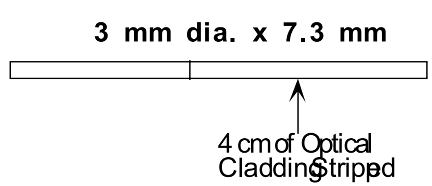

Figure B-2: BCF-12 Fiber

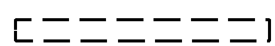

Figure B-3: Scintillator Alignment Plug

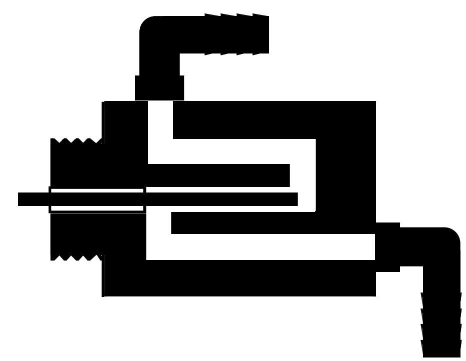

Figure B-4: SC2 Scintillator Head

ETI Photodetector:

The Electron Tubes Inc. photodetector package contains the photomultiplier tube (PMT), high voltage power supply (HVPS), and the amplifier/discriminator circuitry in a cylindrical mu-metal case. The PMT is a 9131B/350 tube with a 9-mm diameter cathode and an approximate gain of 3.1 x 10^6. The smaller 9-mm cathode was selected to minimize the dark count rate. A coaxial cable outputs TTL pulses from the photodetector package for event counting. Control of the HVPS and PMT gain is accomplished with a single low voltage (0 to 1.8 vdc) white control wire. The +5 vdc power is applied to the unit with the red (pos) and black (neg) leads. The total power dissipation of the unit is 175 mW. The SILAC receives power when the computer is energized, and will not operate until the HV control line is energized through programmatic control. **NEVER expose the photodetector to light while the HV control line is energized it will damage the PMT.**

Assembly Instructions:

1. Cut the signal cable and the power leads to a 6-inch length.
2. Strip the insulation _" on the power leads.
3. Strip back the cable jacket _" and comb out the ground braid, then strip _" of insulation on the center conductor of the signal cable.
4. Carefully press fit the photodetector package into the photodetector alignment cap until it bottoms against the opposite wall of the o-ring groove (Fig. 5). Measure the distance from the PMT face to the o-ring step. The distance should be 0.325" to 0.328" (dimension A).
5. Install the Viton .864" x 0.070" wall o-ring.

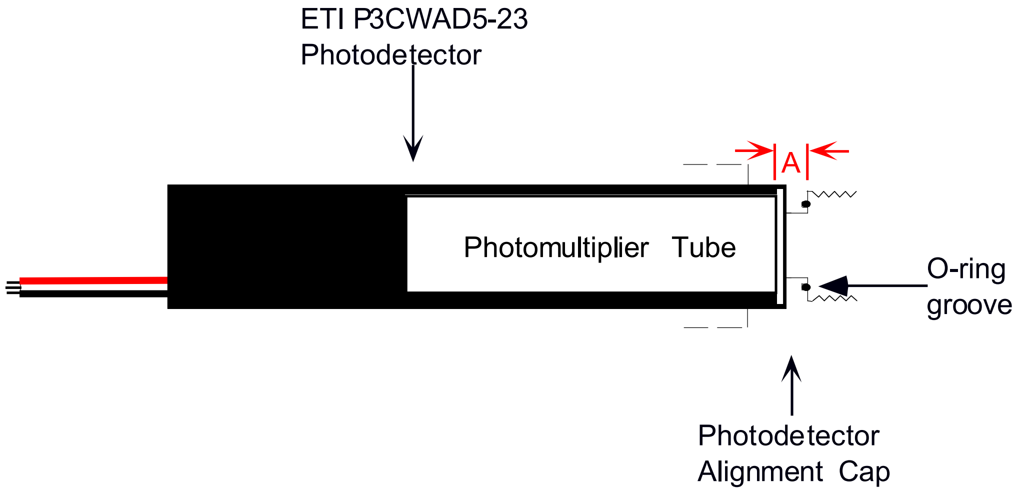

Figure B-5: Photodetector Package installed in Alignment Cap

Photodetector Housing and End Cap:

The housing and end cap are standard SCH 80 PVC components that protect the photodetector package from the hazardous glovebox environment. A red LED indicates power and a yellow LED represents high voltage control power. The circuitry for the two LED's (Fig. 6) is contained in the housing end cap.

Assembly Instructions:

1. Install the WoodHead 5-pole receptacle and the isolated BNC bulkhead jack into the housing end cap.
2. Build the Indicator circuitry as shown in Figure 6 and connect to the WoodHead connector. The leads of the WoodHead should be cut to a manageable length, or ~1 inch. Provide about 4 inches of lead length to the LED's. This allows room for soldering the leads of the photodetector to the end cap.
3. Press fit the LED's into the side wall of the photodetector housing.
4. Fill the end cap with ~ _" deep with gray RTV627 and allow to cure. The filling should cover the connectors and circuit, but not interfere with the attachment to the pipe housing. During the fill process, RTV will leak out between the electrical connector joints. Use hot air from a heat gun to rapidly cure the RTV and stop the leaks. Avoid heat damage to the plastic components.

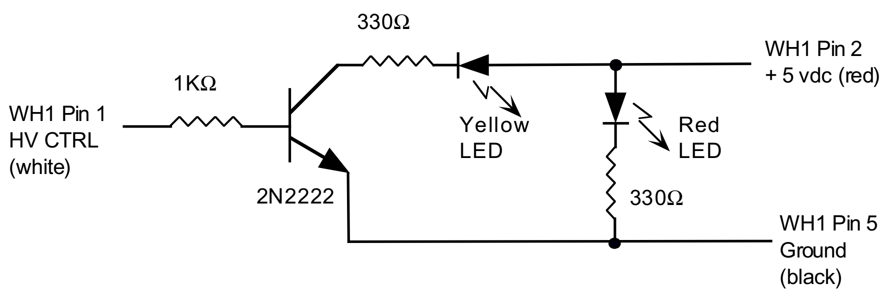

Figure B-6: High Voltage & Power ON Indicator Circuit

Final Assembly Instructions:

1. Insert the photodetector package into the pipe housing and align the socket head mounting holes with the alignment cap. Attach the photodetector alignment cap to the housing pipe.
2. Connect the three power leads to the Woodhead connector. WH1 pin 2 (red) to ETI +5 vdc (red), WH1 pin 5 (black) to ETI ground (black), and WH1 pin 1 (white) to ETI HV CTRL (white).
3. Fill the entire housing with RTV627 to within _" from the end. This will provide corrosion and shock protection for the photodetector package. RTV will leak out between the PMT cap and PVC housing joint. Use the heat gun to stop the leaks.
4. After the RTV has cured, glue the end cap to the pipe housing with standard PVC cement.

SILAC DAQ Board Connection:

Assembly Instructions:

1. Splice a desired length of 22 awg 4-conductor cable to the Woodhead cable assembly. If possible, match wire colors.
2. Cut a BNC cable assembly to a desired length. Strip back the cable jacket _" and comb out the ground braid, then strip _" of insulation on the center conductor of the signal cable. Thin the ground braid enough to fit into the ground pin of the 68-pin connector.
3. Carefully solder the two cables to the 68-pin connector (Fig. 7).
4. Install the pin 2 to pin 41 jumper and the 50-ohm resistor.
5. Finish the assembly of the connector shell.
6. Plug the 68-pin connector into the National Instruments AT-MIO-16E-10 DAQ board, and connect the other ends of the assembly to the SILAC.

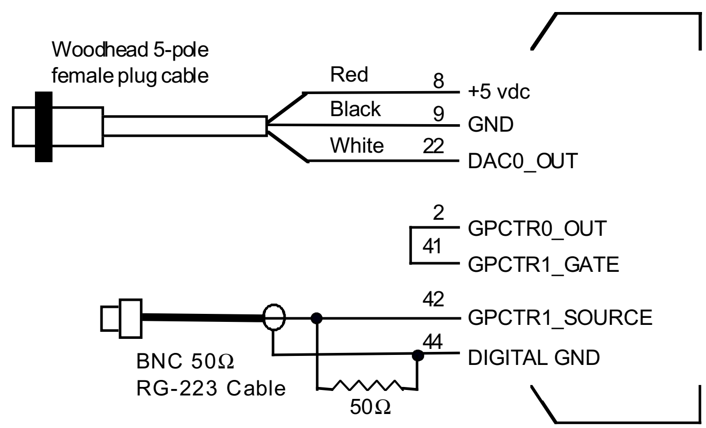

Figure B-7: DAQ 68-pin connector

Testing and Calibration:

Operation of the SILAC requires an operating voltage to be selected. The operating voltage is determined by stepping the counter voltage and recording the count rate at each point for one minute. The collected data is charted, and a voltage is selected where the count rate displays a plateau in the curve. Figure 8 shows a typical background plateau chart (note the log scale for the y-axis). In this example, the desired operating voltage would be 850 volts. The SILAC operating software provides an automatic plateau data collection option. When initiated, the function will display any previous plateau and then allow the user to select the voltage range for the data collection. The user can save the data at the completion of the test.

Volts	Counts
700	0
750	2
800	13
850	18
900	17
950	53
1000	252
1050	514
1100	677

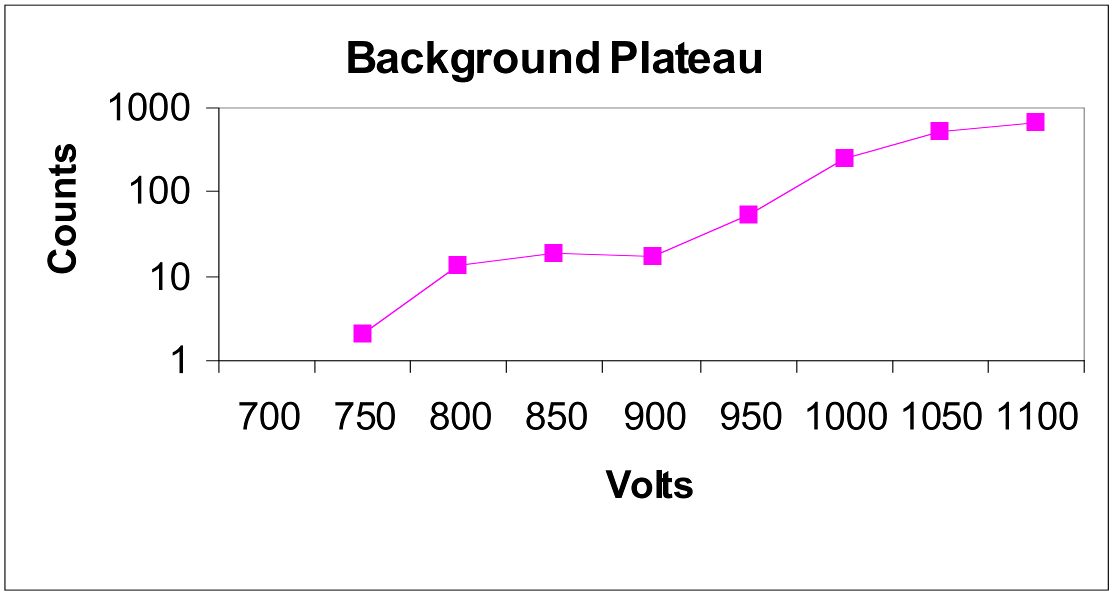

Figure B-8: Typical plateau chart and data

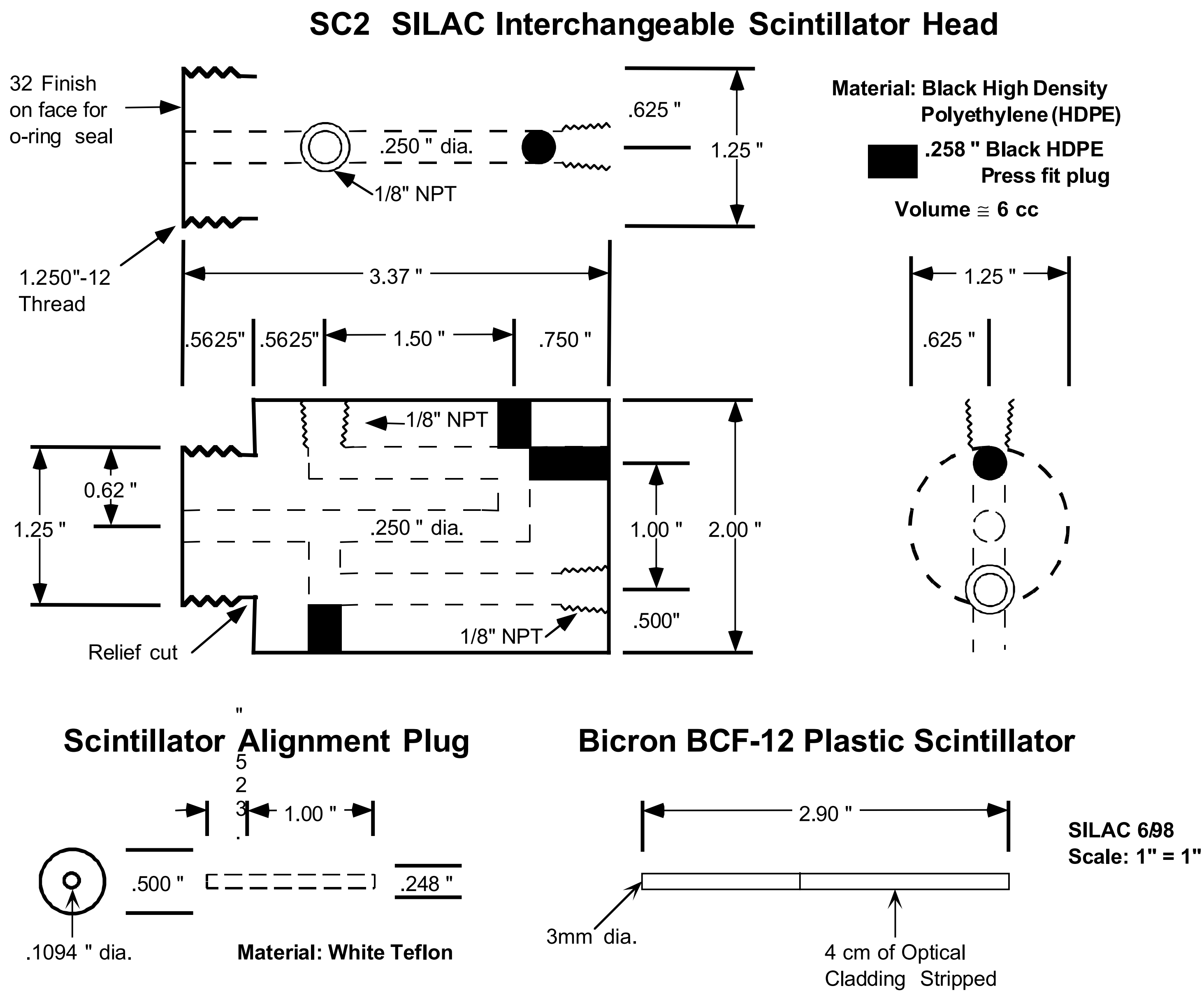

Figure B-9. Interchangeable Scintillator Head, Alignment Plug, and Bicron Plastic Scintillator

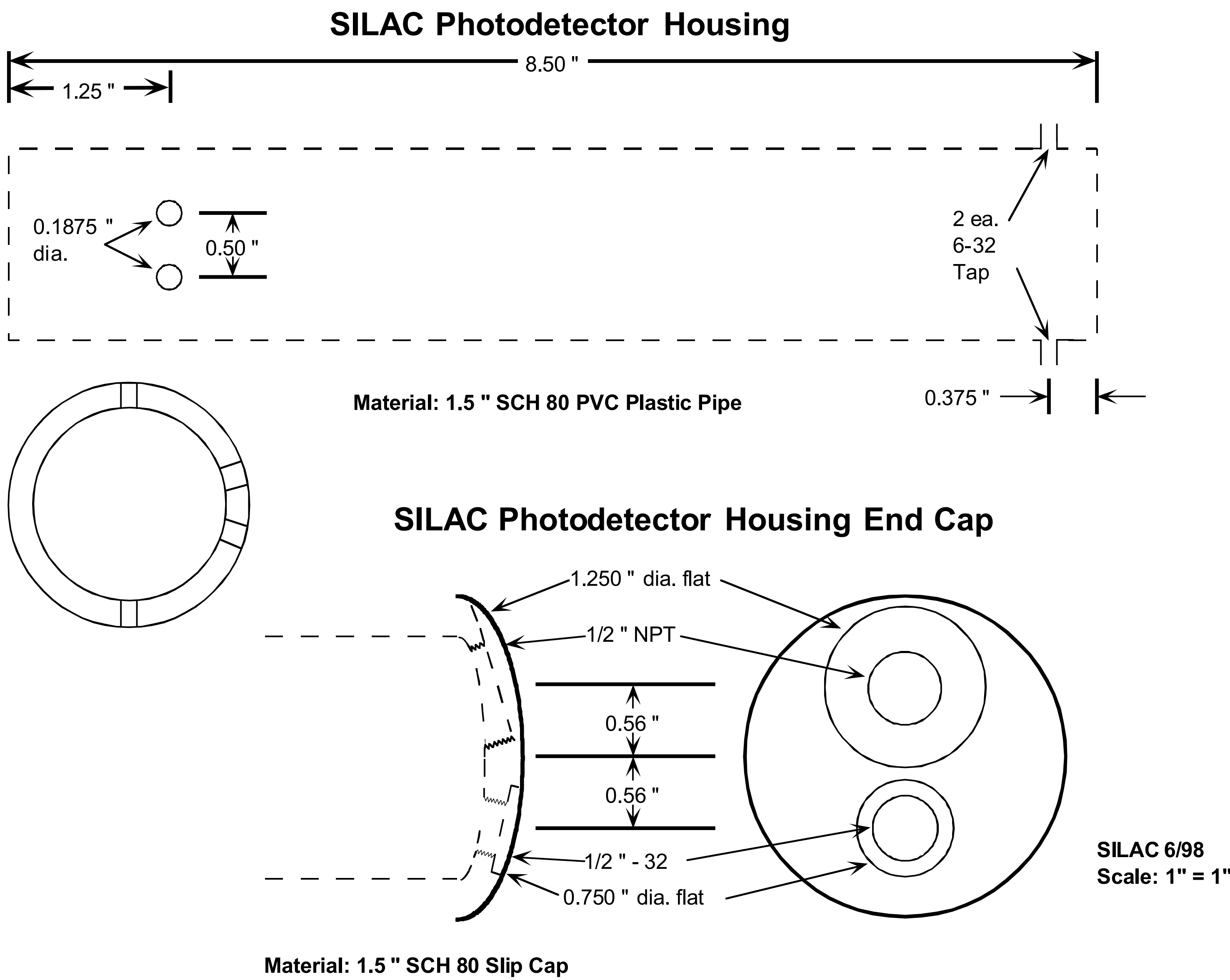

Figure B-10. Photodetector Housing and End Cap

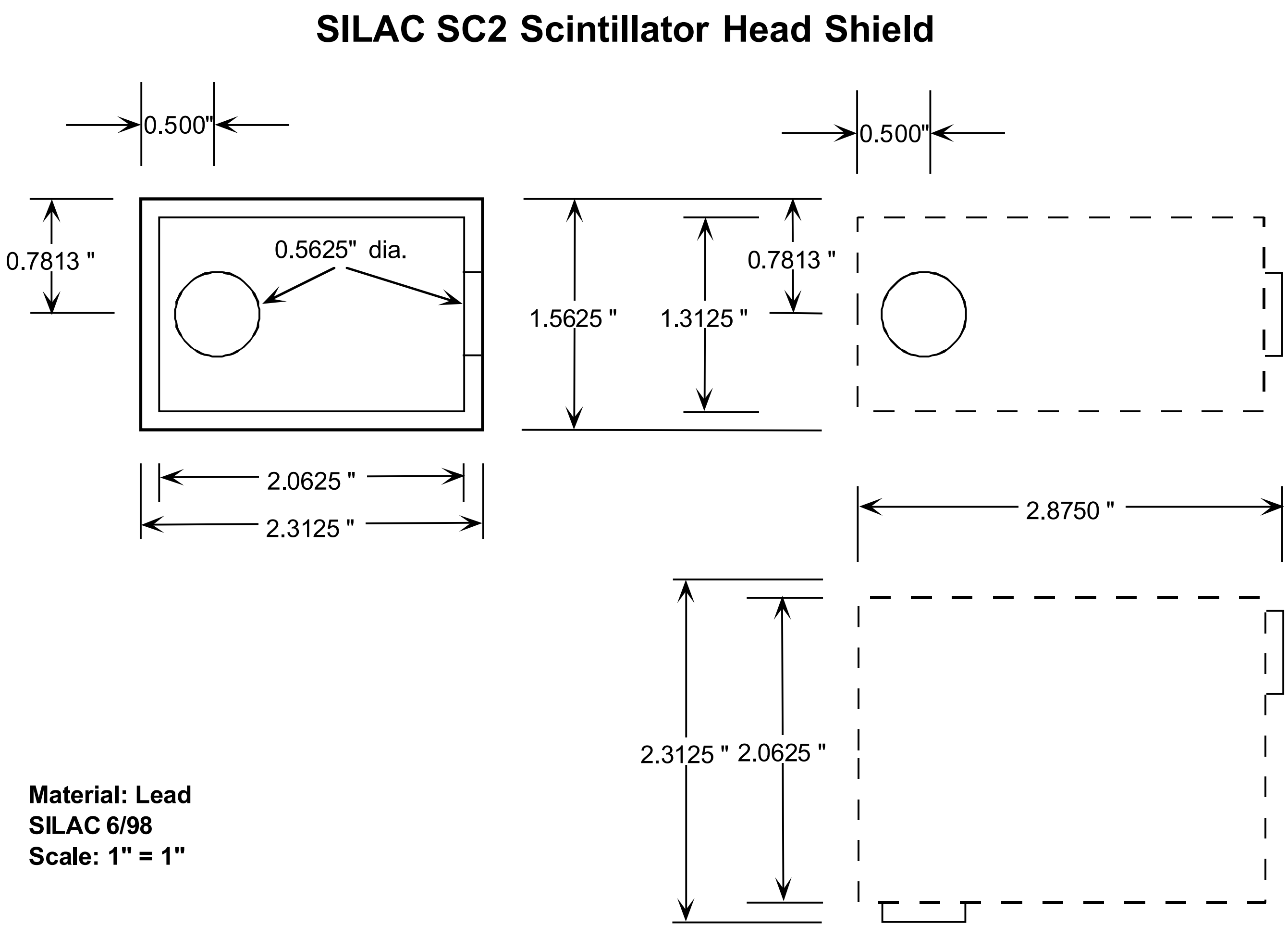

Figure B-11. Scintillator Head Shield

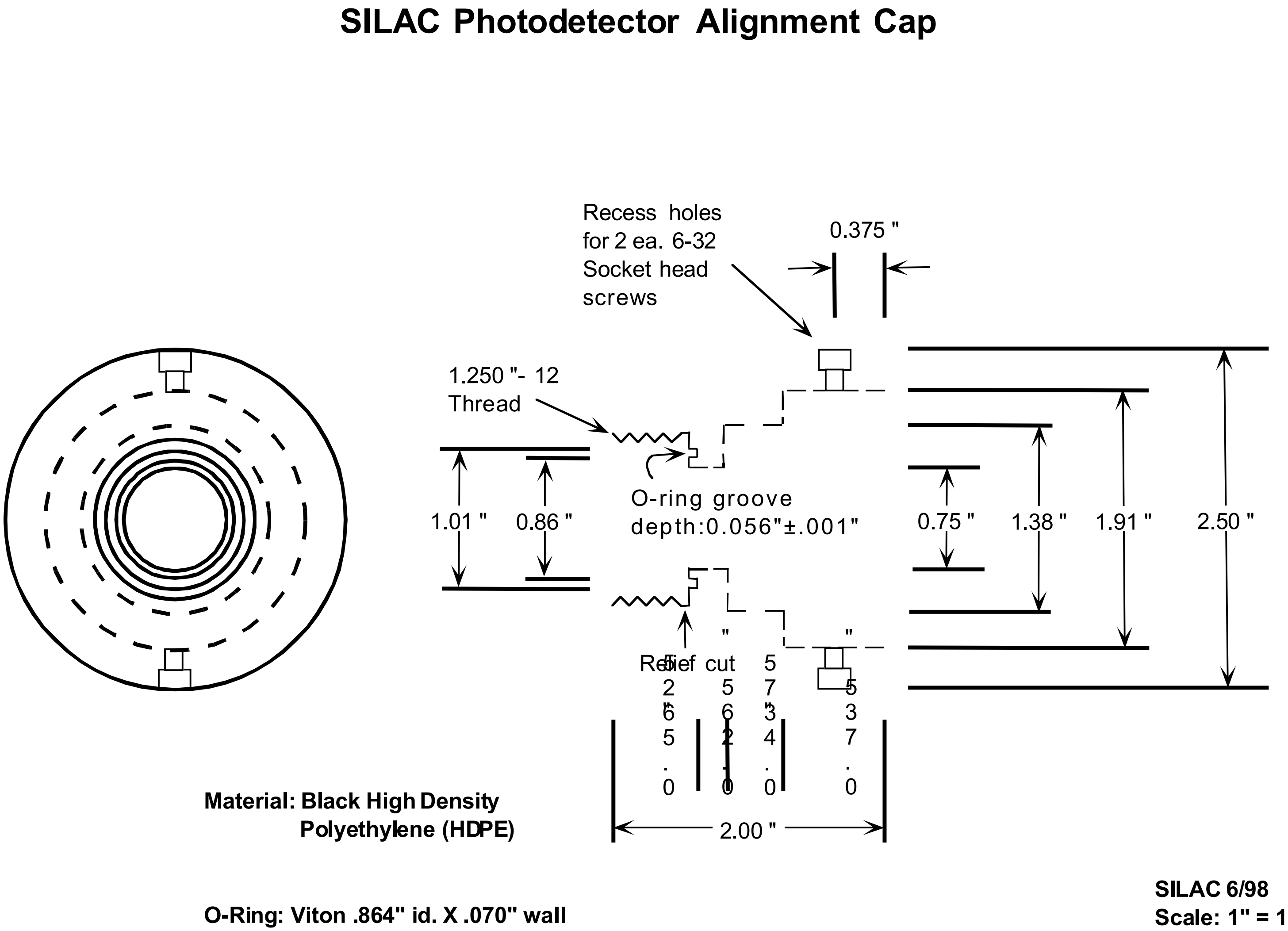

Figure B-12. Photodetector Alignment Cap

Parts List

Table B-II. Parts List

Item	Qty	Description	Manufacturer or Source
1	1 ea.	12”x12”x2” Black High Density PolyEthylene Plastic (HDPE) stock for SC2	Plastic Supply Inc. (JIT)
2	1 ea.	_” dia. x 12” White Teflon rod stock	Plastic Supply Inc. (JIT)
3	1 pk.	Black HDPE 1/8 NPT to 3/8 in. hose barb fitting p/n FK-06451-21	Cole-Parmer Instrument Co.
4	1 ea.	3mm x 1.5 m BCF-12 Scintillation Fiber	Bicron
5	1 ea.	Viton 0.864” id. x 0.070” wall o-ring p/n 2-020	Plastic Supply Inc. (JIT)
6	1 ea.	P30CWAD5-23 Photodetector package	Electron Tubes Inc.
7	2 lbs.	GE GRAY RTV#627	R.S. Hughes
8	1 ea.	1 _” SCH 80 Slip Cap	EHS Supply (JIT)
9	1 ft	1 _” SCH 80 PVC Plastic Pipe	EHS Supply (JIT)
10	1 ea.	Woodhead male 5-pole Receptacle p/n 41310-SS	Summit Electric (JIT)
11	1 ea.	Woodhead female 5-pole plug and 6’ cable assembly p/n41307-SS	Summit Electric (JIT)
12	1 ea.	2N2222A PNP Transistor	Newark Electronics
13	2 ea.	330 ohm 1/8 W Carbon Resistor	Newark Electronics
14	1 ea.	1 K Ohm 1/8 W Carbon Resistor	Newark Electronics
15	1 ea.	T-1 _ Yellow LED (epoxy) p/n HLMP-8305	Newark Electronics
16	1 ea.	T-1 _ Red LED (epoxy) p/n HLMP-4700	Newark Electronics
17	1 ea.	Kings BNC Isolated Bulkhead Jack p/n KC-79-67	Newark Electronics
18	1 ea.	120” 50 ohm BNC plug cable assembly p/n 5697-120	Newark Electronics
19	1 ea.	50 ohm 1/8 W Carbon Resistor	Newark Electronics
20a 20 b	1 ea. 1 ea	AT-MIO-16E-10 E Series Multifunction I/O DAQ Board p/n 777521-01 DAQPad-6020E E Series Multifunction I/O DAQ Board p/n 184376C-01	National Instruments
21	1 ea.	68-pin Cable Connector/Backshell kit p/n 776832-01	National Instruments

Manufacturers

R.S. Hughes
3700 Singer Blvd. N.E.
Albuquerque, NM 87109
505-344-6310

Cole-Parmer Instrument Co.
625 East Bunker Court
Vernon Hills, IL 60061
800-323-4340

National Instruments
6504 Bridge Point Parkway
Austin, TX 78730-5039
800-433-3488

Summit Electric
122B Eastgate
Los Alamos, NM 87545
505-661-5900

Newark Electronics
8205 Spain NE, Suite 214
Albuquerque, NM 87109
800-463-9275

Electron Tubes Inc.
100 Forge Way, Unit F
Rockaway, NJ 07866
800-521-8382

Plastic Supply Inc.
3448 Girard NE
Albuquerque, NM 87107
800-235-1533

Bicron
12345 Kinsman Road
Newbury, OH 44065
800-887-7780

EHS Supply
146 Eastgate
Los Alamos, NM 87545
505-662-7688

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