Particle Analysis and Display System (PADS):

Back-Scatter Cloud Probe (BCP) Module

Operator Manual

DOC-0234 A-2

PADS 2.8.2

BCP Module 2.8.0

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C O N T E N T S

L i s t   o f   F i g u r e s

1.0 Introduction

The Particle Analysis and Display System (PADS) is a software package that interfaces with instruments produced by Droplet Measurement Technologies (DMT) and other leading instruments used in the atmospheric sciences. This manual describes version 2.8.0 of the PADS module for the Back-Scatter Cloud Probe (BCP).

For an explanation of the basic PADS setup and instructions on how to acquire data using PADS, consult the *PADS Operator Manual, DOC-0116*. Definitions and calculations used in the BCP module are also described in the *PADS Operator Manual*.

2.0 Configuration

Using PADS, you can configure both the software for the instrument and the instrument's data display in PADS. The following two sections explain how to do this.

Configuring the BCP

Your BCP and data system should arrive preconfigured from DMT. In some cases, however, you may want to change the software configuration for the instrument. To do this, follow the steps below. *Note: Droplet Measurement Technologies STRONGLY recommends that customers contact our office prior to changing any of the parameters in the instrument configuration. Improper changes can result in communication failure and/or changes in PADS computation algorithms, which can compromise data validity.*

1. Click on the "BCP" tab.

2. From the **Configure** menu, select **Configure Instrument.** You will see the following window.
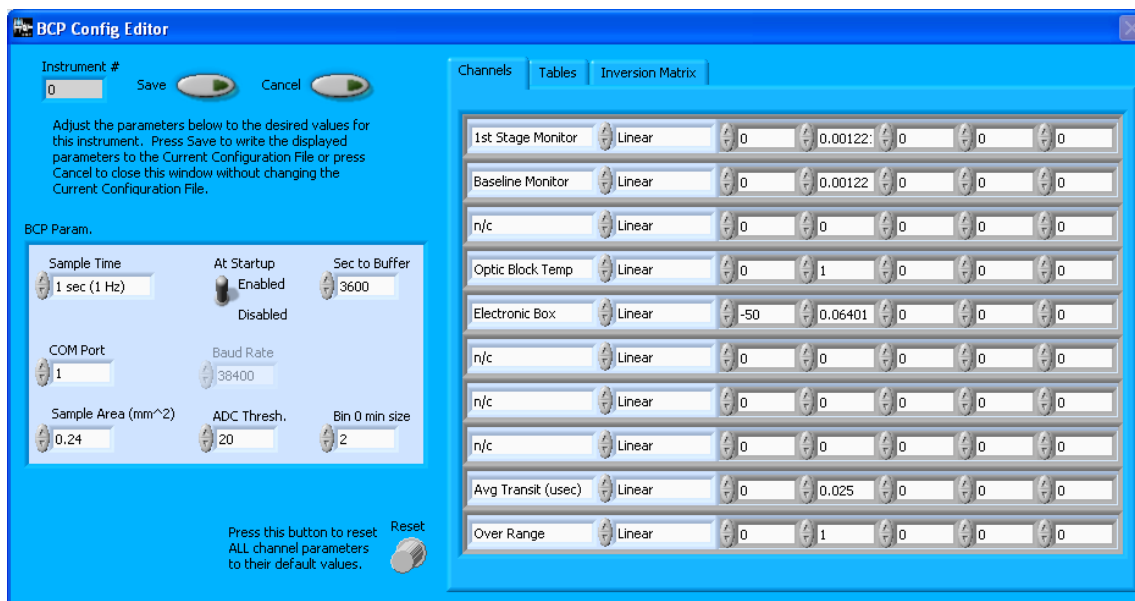
Figure 1: The BCP Configuration Editor Window. The left side of the window contains parameters for the instrument. The table on the right side contains information on BCP channels.

3. Now you can configure the instrument parameters to your desired specifications. You will find a list of the parameters you may want to reconfigure in the two sections below, "Occasionally Reconfigured BCP Parameters" and "Rarely Reconfigured BCP Parameters." If at any time you would like to revert to the previously saved values for the BCP parameters, press **Cancel** to exit the window without saving changes.

4. When you are done configuring the BCP parameters, press **Save** at the top of the Config editor window. (If you would instead like to revert to the previously saved values, click **Cancel**.) Then press the green **Reset Program** button for the new configuration to take effect. Note that pressing the **Reset Program** button will clear any data currently being displayed.

Occasionally Reconfigured BCP Parameters

Sample Time: This parameter shows the time interval you'd like between samples. You can have the probe sample at intervals of .1, .2, .5, 1, 2, 5, or 10 seconds (10, 5, 2, 1, 0.5 or 0.1 Hz). A value of one is recommended, as described in the warning below. Note that if you increase the sample time, you will still collect data for the same number of particles. This is because the probe collects data continuously and relays cumulative data at each sampling interval. For example, say you have the sample time set to .5 seconds. You might see four particles of size 26 μm during the first sample, and five particles of this size during the second sample. If you had set your sample time to one second instead of .5 seconds, you would instead get one sample that showed nine particles of size 26 μm.

WARNING: One hertz sampling is currently recommended, as choosing other values will invalidate time-dependent PADS calculations like number concentration and LWC on optical probes. (ED and MVD are not affected.) This is a known bug in PADS that will be fixed in an upcoming version of the program.

At Startup Enabled / Disabled: If you want the BCP to acquire data when PADS begins sampling, make sure this parameter is in the "Enabled" mode. In some cases, such as if the BCP is inoperative, you may want to use this control to disable the probe. Disabling the BCP allows data to transmit from other instruments without interference.

Sec to Buffer: This is the number of seconds that PADS stores data acquired by the BCP in its memory. One hour has been chosen as the default setting because this is the maximum length of time that data can be stored without taxing computer memory.

COM Port: This is the serial communications port that the BCP uses to connect with the computer. This number should match the computer hardware configuration for the particular computer you are using. If you are not using multiple computers, this number should not be changed.

You will notice that there are other parameters listed on the **BCP** Config Editor window. You should not need to change these, and changing them may compromise your data. If you are curious about these parameters or think you do need to modify them, see the section titled "Rarely Reconfigured BCP Parameters" below or consult with a DMT technical representative.

Rarely Reconfigured BCP Parameters

The BCP configuration editor displays several parameters that you will rarely need to modify. The following is a list of these parameters and an explanation of what they do.

Instrument #: This lists the number corresponding to the instrument you are viewing, in this case the BCP. If your BCP has been assigned instrument number one, you will see "1" in this field. You should not need to modify the instrument number, and in fact you are unable to do so from within PADS.

Baud Rate: The Baud rate is grayed out because it is defined at manufacture, and you should not need to change it. PADS displays this parameter because some probes can run at different baud rates. So if you reconfigure your hardware, the baud rate may change. In general, a higher baud rate means that the probe can transmit data more quickly to the computer. However, higher baud rates may not work with some computers and can result in unreliable data transmission.

Sample Area: This is the physical area in which particles are detected. BCP sample area is a constant regardless of particle size. This value is preconfigured to match your instrument, so it is strongly suggested that you do not change it.

ADC Threshold: The ADC Threshold indicates the smallest peak digital value a particle can have and still be sized by the instrument. Small noise peaks can occasionally occur in the absence of particles, and the ADC Threshold can be used to eliminate such noise.

Bin 0 min size: This is the minimum boundary in μm of bin 0, the bin that sizes the smallest particles the BCP detects. The upper size boundaries of each bin are listed in the **Tables** tab to the right of the BCP Parameter box on the Config Editor screen. The lower boundary of a bin is the upper boundary of the next-smallest bin, so the **Tables** tab can be used to identify lower boundaries for all bins except bin 0.

Channels Tab

The **Channels** tab lists the configurable BCP channels. The first eight of these are A/D housekeeping channels that measure a 0-5 V value from one of the instrument's internal sensors, for example a pressure or temperature sensor, and then convert this voltage to a integer value from 0 to 4095. A conversion equation is used to convert these voltages into other, more meaningful units (e.g., mBar or °C).

The channels table specifies this equation. The second column in the table indicates the type of equation that PADS should use—linear, polynomial, or none. (Do not use the "CAS Temp." option, which is reserved for internal use.) "Linear" indicates a linear equation, while "4th Order Poly" indicates a higher order polynomial equation with up to five terms. "None" means the digital value (between 0 and 4095) will be returned without any scaling.

The right-hand fields in the channels table indicate the coefficients to be used in the conversion equation. Figure 2 shows the setup for a hypothetical channel with the second-order polynomial conversion equation, as follows:

New_Channel = 34.01 + 0.061 x + 0.0092 x^2

where x is the digitized analog value returned by the A/D converter.

Figure 2: Example Channel Specifications in the BCP Config Editor Window

The number of coefficients that PADS uses depends on the equation type. "None" does not use any coefficients. "Linear" uses the first two coefficients, which are listed in the first two table cells after the equation type. "4th Order Poly" uses one to five coefficients.

In cases where there are non-zero numbers in cells that are not used in the function, PADS ignores these numbers. For instance, if you specify "Linear" as your function and have .32 in the farthest right cell, the program will just ignore this value.

Clicking the **Reset** knob at the bottom right of the BCP Parameter window will reset all the channel parameters to their DMT-supplied default values.

Tables Tab

The **Tables** tab lists the threshold table for the BCP. This table tells the instrument the upper boundaries in AD counts for each size bin, as well as the corresponding particle size in μm for each AD count.

These values can be changed by clicking on the arrows to the left of each field. Clicking on the **Reset Tables** button will restore the threshold table to its default values.

A bin's lower size boundary is the same as the upper size boundary of the next-smallest bin. Bin 0's lower size boundary is listed in the **BCP Parameter** window to the left of the Tables tab.

Inversion Matrix Tab

The **Inversion Matrix** tab allows the BCP to retrieve the ambient size spectrum from the measured frequency distribution of counts versus channel. As described in *Appendix B: Calculating Adjusted Particle Counts from the Inversion Matrix*, the raw counts accumulated during the sample period reflect measurements of particles that pass through the laser of the BCP at varying distance from the center of focus and center of

the beam. The intensity of the laser within the particle detection view volume is not constant, so particles with the same size will scatter different amounts of light depending on where they pass through the laser.   The inversion matrix table is used to retrieve the most statistically likely particle-size distribution from the raw frequency. See Appendix B for details on the inversion technique and how PADS uses the inversion matrix to create the ambient size distribution.

The **Unity Matrix** button is used during instrument calibration. Pressing this button undoes any adjustment by the inversion matrix, so that the raw particle-size bin counts (BCP_Raw_Bin_i) equal the counts calculated by the inversion matrix (BCP_Inv_Bin_i). During calibration, which is typically done with precision glass beads, the location of the beads can be kept constant. This reduces the ambiguity of the back-scattered signals that the inversion matrix is designed to correct.

The **Import Matrix** button allows users to import a .csv file to create the inversion matrix table.

The **Default Inversion Matrix** button allows users to restore the inversion matrix to its default values. This default matrix is one chosen as representative of BCPs in general and is not the matrix calculated for optimal use of any one BCP.

After making changes in the instrument configuration window, you will need to press the **Save** button and then click the green **Reset Program** to activate these changes. Clicking **Reset Program** will clear any data PADS is currently displaying.

Configuring the BCP Display

To configure the BCP display, click on the BCP tab if you have not already done so. Then select **Configure** from the menu bar and click on **Configure Display.** This will bring up the following window.
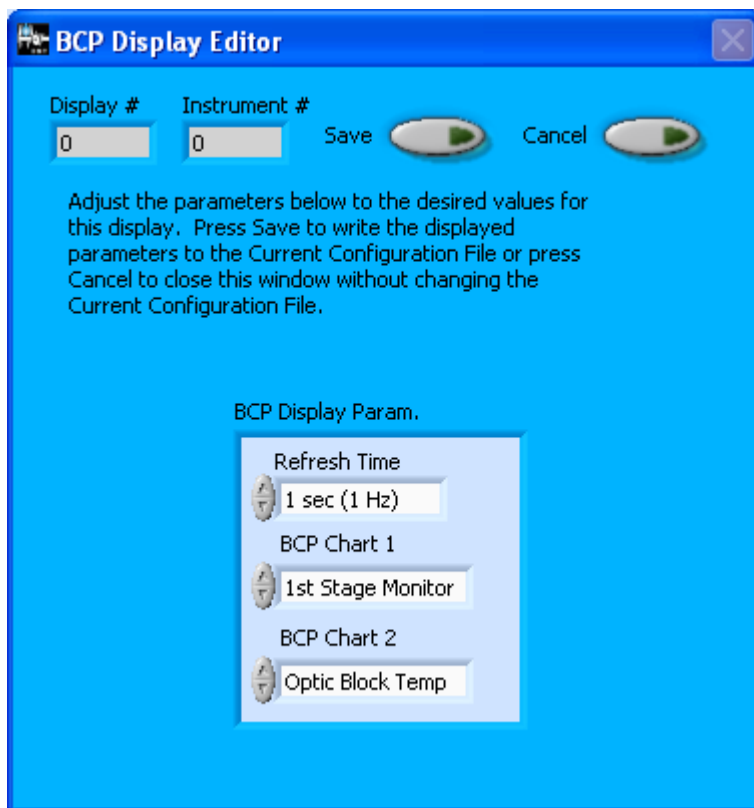
Figure 3: BCP Display Editor

You do not need to modify the **Display #** or **Instrument #**. Changing the **Refresh Time** allows you to set the time intervals for data display during acquisition mode; you can choose any time that is equal to or greater than the sample time. (Choosing a time less than the sample time is not useful, since the same data will be displayed multiple times.)

The BCP Display Parameter box at the bottom of the window also allows you to configure the channels on the BCP's selectable graphs. To change these channels, click on the arrow buttons to scroll between available options for the channels. You can also click on the white fields to bring up a list of all the available options, from which you can then choose the channel you want.

When you are done, click on **Save** to update the configurations or **Cancel** to revert to the previous configuration. After you reset PADS, you will be able to see any changes. Note that clicking **Reset Program** will clear out any data currently being displayed.

Configuring channels in the **Display Editor** will change the display upon start-up. Once PADS has started, you can select any channels to be displayed in the selectable charts. See the "Chart Displays" section for more information.

3.0 The BCP Window

The different parts of the BCP Window are discussed below. For explanations of the **Enable** button, **COM Port** indicator, and **Fault/No Fault** button, see the "Instrument Tabs" section of the *PADS Operator Manual*.

Channel Tabs

The BCP channels are displayed in the data window at the upper left of the BCP tab. These data are specific to the time listed in the upper-right of the PADS window.
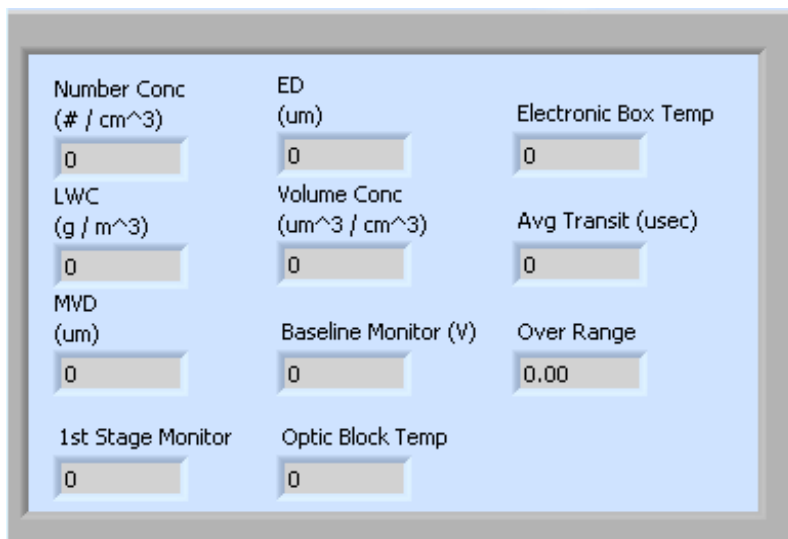

Figure 4: The BCP Data Window

These channels are described in Appendices A and B of the *PADS Operator Manual*.

Histogram Data Window

Below the BCP Data window is the histogram display of BCP-acquired particle data. Like the channel data display, the histogram shows time-specific data. The x-axis labels indicate the upper boundary of each size bin, which PADS reads from the **BCP Config Editor's Table** tab. A bin's lower boundary is the upper boundary of the previous bin, except for the first bin, which has a lower boundary specified in the **Config Editor**.

Note that the bin counts displayed in the histogram are those adjusted using the inversion matrix, rather than raw bin counts.
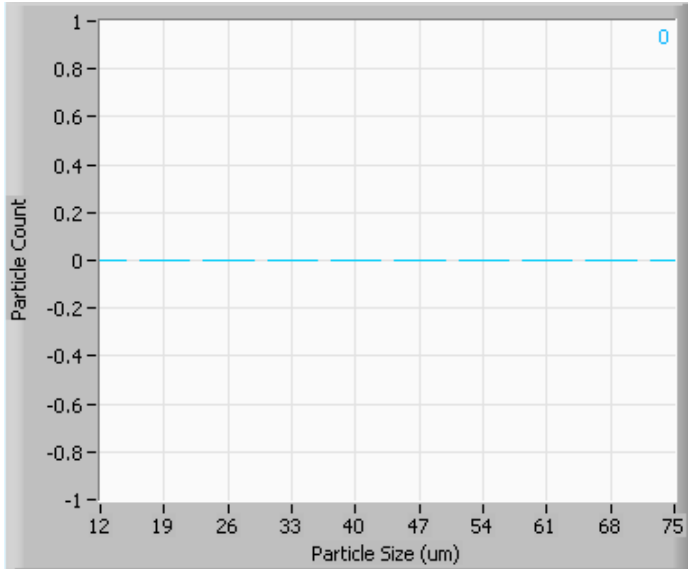
Figure 5: BCP Histogram Display

The y-axis will scale to the values displayed. In the upper right of the histogram is a number in blue (0 in Figure 5) that displays the total particle count for all bins.

Chart Displays

The BCP chart displays consist of a tab with three standard charts, a tab with two selectable charts, and a tab with a real-time large histogram (the "Particle Count Full" tab). You can access any of these charts by selecting the tabs in the upper part of the chart display window. Figure 6 shows these tabs and the standard time-series charts.
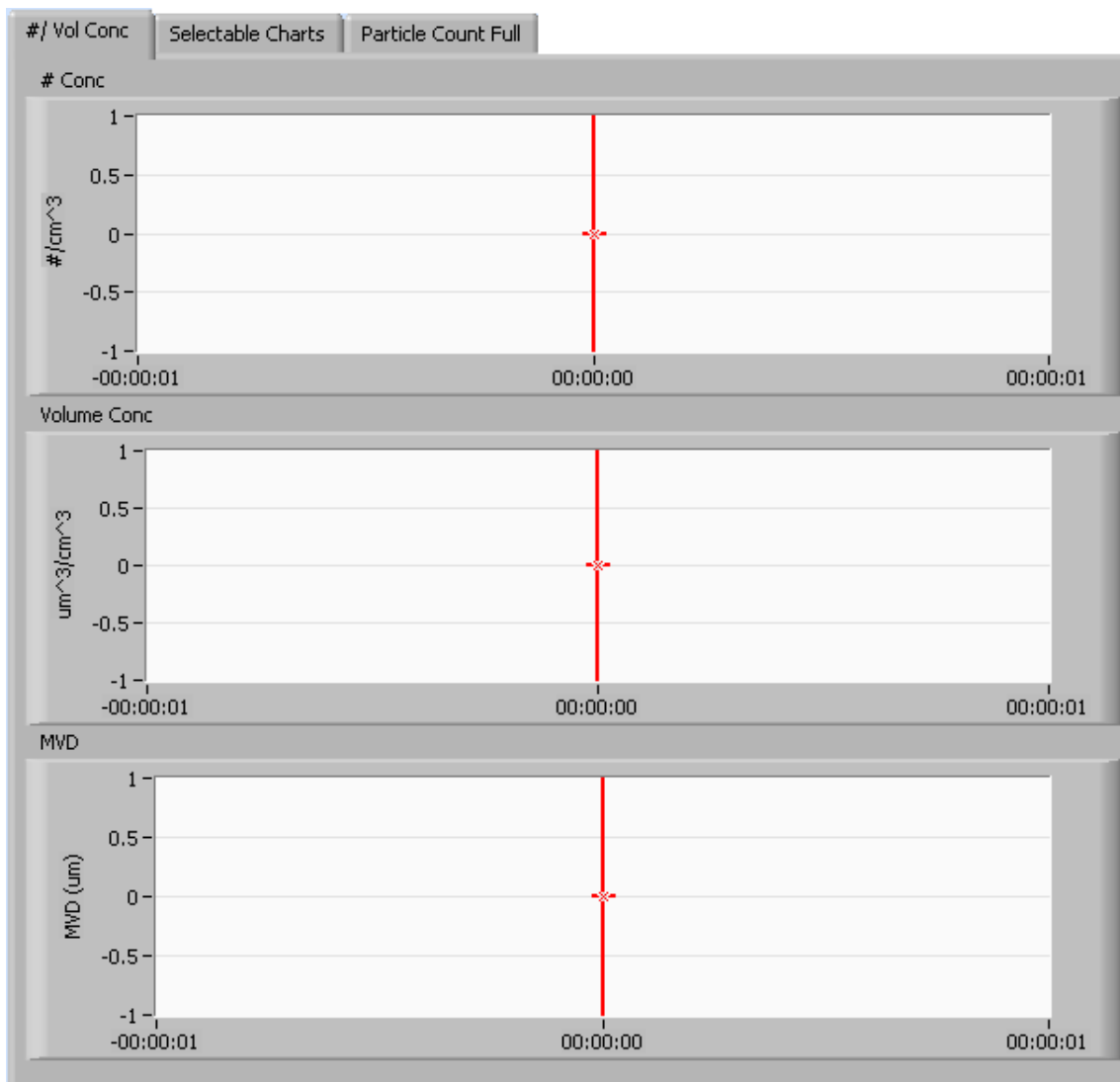
Figure 6: BCP Standard Time-Series Charts

When you access time-series charts in playback mode, the currently selected moment in time is indicated by a red cursor, as shown above. The y-axis value for this time is indicated by cross (+) on this cursor. Note that when you display a large range of time-series data, the chart display does not have sufficient resolution to display each individual time point. To increase resolution, zoom in on the data by changing the time interval to a smaller range.

On all the charts with x and y axes, you can change the scale by typing a different number into the starting and/or ending values on each axis and hitting <Enter>. In acquisition mode, you must disable autoscaling (see below) before you modify fields in this way.

Many charts also show you options for scaling and copying the data when you right-click on them, which brings up a drop-down menu. These options are as follows:

Autoscale   This autoscales the relevant axis. In autoscaling mode, the minimum and maximum values of the axis are set automatically so that all data points can be seen in the display. Note that on charts that have autoscale buttons, like the large histogram chart on some instrument tabs, the buttons override the Autoscale options in the drop-down menu. To see autoscaling options in the drop-down menu, position the cursor over the relevant axis before right-clicking. Note that you may not always be able to autoscale the x-axis.

Copy Data   This copies the chart to the clipboard using a screen capture. This chart can then be pasted into other documents like Word or PowerPoint presentations.

Export Simplified Image   This copies a simplified image of the data to the clipboard or an output file. You can choose the format you desire—bitmap (.bmp), encapsulated postscript (.eps), or enhanced metafile (.emf). Note that when you select the .eps option, you must copy the data to a file. Unless you specify otherwise, output files will be saved in the time-and-date-specific output file directory for the current session.

Clear Graph   This erases the currently displayed data points from the graph.

More information about each of the tabs on the chart displays section is given below.

1. # / Vol Conc

The three graphs on the first tab display particle number concentration (#/cm^3), volume concentration (μm^3/cm^3), and MVD (μm) with respect to time. In playback mode, you can zoom in or out by using the time controls. In acquisition mode, use the "Display Range" control to zoom in or out.

2. Selectable Charts

The **BCP Selectable Charts** tab displays two charts with user-specified channels plotted as a function of time. To change the channels plotted in the selectable charts, you have two options:

1.) To change the charts for the current session only, click on the **BCP Selectable Charts** tab and use the control in the upper left of the chart to select the channel you desire. You can either click on the text control to the right, which brings up a

selectable list of channels, or you can use the button on the left to scroll between channels.

2.) To change the channels shown in the chart's display when PADS starts, go to the **Configure** menu, select **Configure Display**, and choose the desired channel. Then press the **Reset Changes** button to apply this configuration.

3. *Particle Count Full*

The **Particle Count Full** tab shows a larger version of the histogram that appears in the bottom left of the BCP screen. This histogram also allows you to manipulate the display using the controls and features described below.

Autoscale Buttons

The Autoscale controls, Autoscale X and Autoscale Y, let you control how the x and y scales are set. If you enable autoscaling, PADS will automatically select an appropriate scale with which to display the current data. For instance, if the probe is not currently detecting many particles, the y-axis range will decrease. On the other hand, if you disable autoscaling, the scale of the axes will remain constant. In this case, the range will always be the same as it was when autoscaling was disabled. The minimum and maximum Y values can then be changed manually by typing new numbers into these fields. *In playback mode, autoscaling will not take effect until you change the time using the time controls.*

Note that the Autoscale Y button overrides the Autoscale Y option in the drop-down menu that appears when you right-click on the chart.

Log-Scale Button

When you turn on the Log-Scale button, PADS scales the y-axis logarithmically rather than linearly. Autoscaling can be enabled or disabled with this option.

Normalized Button

If you enable normalization, PADS will scale the particle data so that each bin of data is divided by the width of that bin in μm. Normalization is useful when the widths of the size bins are not constant, as may be the case if you have modified the threshold table in the **Config Editor's Tables** tab. Without normalization, the concentrations from one size bin cannot be compared quantitatively from those in another size bin of different width. For example, if 15 particles are counted in a size bin that is 7 μm wide and 15 particles are counted in the next larger channel that is 14 μm wide, the size distribution would

appear flat and we would assume that it was equally probable to measure particles of either size. This is a biased sample, however, since the larger size bin is twice as wide as the smaller. If we normalize by the width, however, we find that the smaller size category has about 2 particles per μm and the larger size bin only has about 1 particle per μm. This is now an unbiased sample.
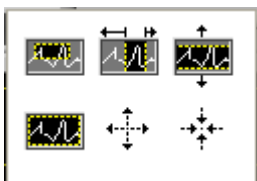
The Graph Tools Buttons

The graph tools buttons look like this:

The left button currently does not have functionality.

The right button allows you to move the histogram display around in the window.

Clicking on the middle button brings up the zoom window, which looks like this:

Before using the zoom controls, turn off autoscaling so your scaling changes stay in effect when new data are displayed.

Selecting the icon on the upper left allows you to select data on the histogram screen and magnify it. This changes both the x and y axes.

Selecting the button on the upper middle allows you to select a horizontal range of data you'd like magnified. This will change the x axis but not the y axis.

Selecting the button on the upper right allows you to select a vertical range of data you'd like to see magnified. This will change the y axis but not the x axis.

Selecting the button on the bottom left sets the axis to the same limit autoscaling would use. Autoscaling is not enabled, however, so when the data change, the axis limit stays constant.

Selecting the button on the bottom middle allows you to zoom in on a target.

Selecting the button on the bottom right allows you to zoom out on a target.

Appendix A: BCP Channels

A list of BCP channels appears below. The BCP output file will contain data values for each channel for each sampling instance. You can also plot each of these channels with respect to time using the BCP Selectable Charts tab. A/D housekeeping channels are listed in italics.

For definitions of the channels, consult *Appendix A: Definitions* in the *PADS Operator Manual*.

Time	BCP_Inv_Bin_9
1st Stage Monitor	BCP_Inv_Bin_10
Baseline Monitor (V)	BCP_Raw_Bin_1
n/c	BCP_Raw_Bin_2
Optic Block Temp (C)	BCP_Raw_Bin_3
Electronic Box Temp (C)	BCP_Raw_Bin_4
n/c	BCP_Raw_Bin_5
n/c	BCP_Raw_Bin_6
n/c	BCP_Raw_Bin_7
Avg Transit (usec)	BCP_Raw_Bin_8
Over Range	BCP_Raw_Bin_9
BCP_Inv_Bin_1	BCP_Raw_Bin_10
BCP_Inv_Bin_2	Number_Conc
BCP_Inv_Bin_3	LWC
BCP_Inv_Bin_4	MVD
BCP_Inv_Bin_5	ED
BCP_Inv_Bin_6	Status
BCP_Inv_Bin_7	GPS Time
BCP_Inv_Bin_8	

BCP channels fall into several broad categories:

Time Channels: The time channels store time data. Time is generated by the PADS computer clock and is the time when the program receives the BCP data. It is given in seconds after midnight on the day the program was started. GPS Time is included in every instrument's list of channels whenever a GPS is included as one of the PADS instruments. GPS Time will be collected from an instrument other than the BCP, even though it appears as a channel in the BCP output file.

Housekeeping Channels: 1st Stage Monitor, Baseline Monitor (V), Optic Block Temp (C), and Electronic Box Temp (C) are A/D housekeeping channels. These channels have a 0-5 V scale measured by a 12-bit A/D converter that gives integer values from 0 to 4095.

Bin Channels: Channels labeled BCP_Inv_Bin_*i* and BCP_Raw_Bin_*i* store data on the number of particles of different sizes that the BCP has detected. The former channels store bin counts that have been adjusted using the Inversion Matrix, and these counts are what the histograms displays. The BCP_Raw_Bin_*i* stores raw counts not adjusted using the matrix.

Channels for Other Statistical Data: Avg_Transit and Over Range store particle statistics collected by the BCP. Status stores statistical data the BCP has gathered on the communication between PADS and the probe.

BCP Calculated Channels: Number_Conc, LWC, MVD, and ED store the results of calculations PADS has performed on BCP particle data.

Unused Channels: Channels marked n/c currently do not store any data.

Appendix B: Calculating Adjusted Particle Counts from the Inversion Matrix

Unlike other DMT optical spectrometers, which define the sample volume with a qualifing detector, the BCP accepts any particle whose scattering signal exceeds a preset electronic threshold. (The use of a qualifying detector restricts the accepted particles to a narrow region of the beam that is very close to the center of focus and center of the beam where the laser intensity is the strongest.) Given that the laser intensity decreases exponentially with increasing distance from the center of focus (the laser has a Gaussian intensity distribution across and along the beam), with no restrictions on sample volume, some fraction of the particles will be undersized with respect to the optimum size. For example, consider a monodispersed distribution of particles, such as glass bead calibration particles. Here the measured size distribution will be distorted towards smaller sizes, since a large fraction of the particles will pass through the less intense portions of the beam—i.e. in the two tails of the Gaussian distribution. Figure B.1 illustrates this effect. The solid curve shows how 30-µm glass beads would be sized with a 10-channel CDP, and the dashed line shows how the BCP measures them. In the BCP, due to the scattering geometry and differences in refractive index between glass (η=1.51) and water (η=1.33), a 45=µm water droplet scatters the same amount of light as a 30-µm glass bead.
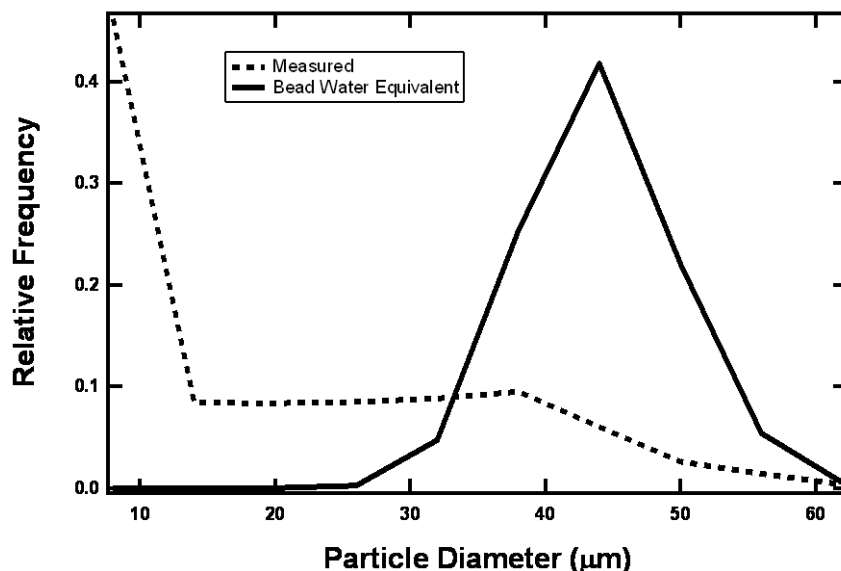

Figure B.1

In order to retrieve the actual size distribution from the distorted measurements, the measurements must be corrected by multiplying them with an adjustment matrix that

accounts for the effect of undersizing in less intense portions of the beam. This type of retrieval is a well-known analysis technique known as "inversion." Given a set of measurements contained in a vector **M,** the actual set of data in the vector **A,** the relationship between **M** and **A** is

$$M = KA \tag{B.1}$$

where **K** is a matrix of values that describe the characteristics of the BCP optical system and the fraction of counts in each size channel that come from undersized particles . For example, for particles that should have been sized in channel 2 of a 10-channel BCP, the actual counts that will be measured in channel 2 are:

M[2]= K[2,2]*A[2]+ K[2,3]*A[3]+ +.... K[2,10]*A[10]

Where **K[2,2]** is the fraction of particles correctly sized in channel 2 of the total **A[2]** particles, **K[2,3]** is the fraction of particles that should have been in channel 3 **(A[3])**, etc.

In order to obtain the true size distribution **A**, equation **B.1** must be solved by moving the matrix **K** to the left side, i.e.

$$K^{-1}M = A \tag{B.2}$$

Where **K^{-1}** is the inverse of **K** and hence the origin of the name "inversion" to describe the retrieval of **A.**

The inverted matrix **K^{-1}** is found for each BCP by measuring glass calibration beads whose size distributions are well characterized and iterating on the individual elements, called "weighting factors," until the product **K^{-1}M** matches the optimum size distribution of the beads. Figure B.2 shows the results from this inversion technique where the two black lines, solid and dashed, are the same as in Fig. B.1, and the red line is the distribution retrieved from the measurements after finding the optimum inversion matrix.
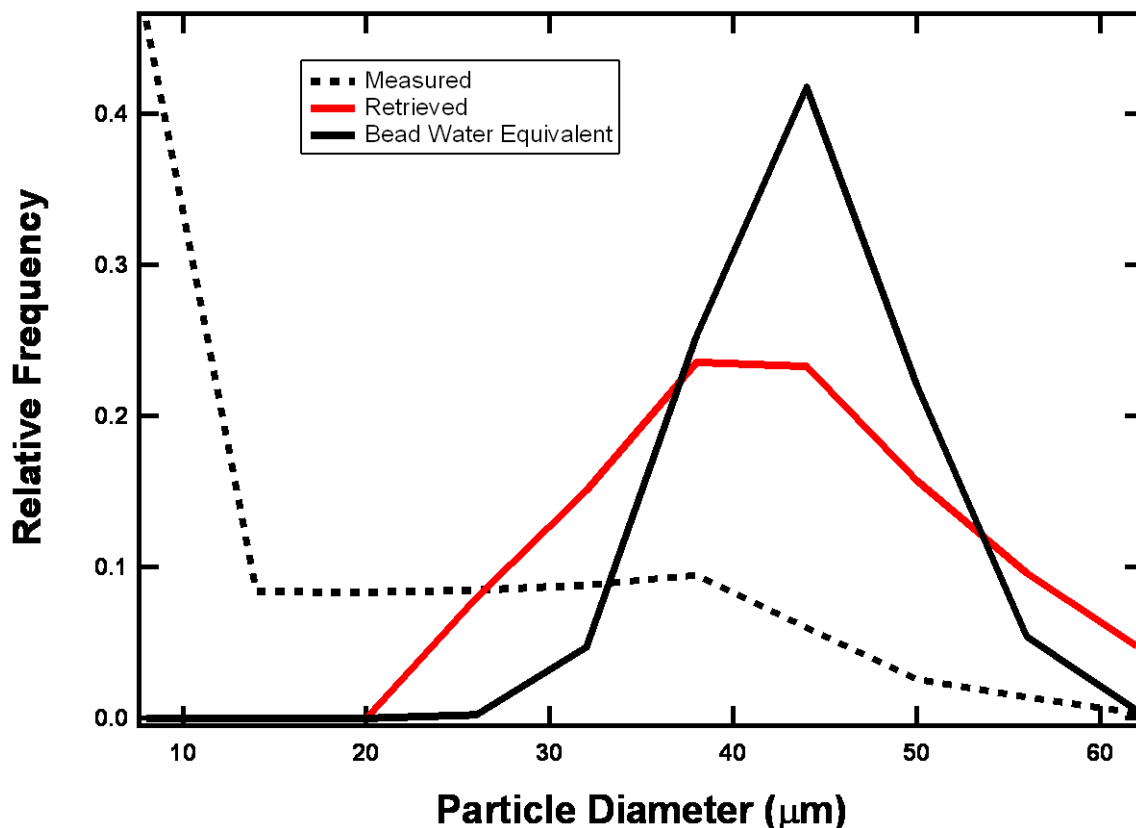
Figure B.2

PADS Methodology

PADS uses the inversion matrix to calculate adjusted particle counts. Specifically, given the following raw bin count and inversion matrix,

Raw Bin Count	Inversion Matrix									
a_0	$b_{0,0}$	$b_{0,1}$	$b_{0,2}$	$b_{0,3}$	$b_{0,4}$	$b_{0,5}$	$b_{0,6}$	$b_{0,7}$	$b_{0,8}$	$b_{0,9}$
a_1	$b_{1,0}$	$b_{1,1}$	$b_{1,2}$	$b_{1,3}$	$b_{1,4}$	$b_{1,5}$	$b_{1,6}$	$b_{1,7}$	$b_{1,8}$	$b_{1,9}$
a_2	$b_{2,0}$	$b_{2,1}$	$b_{2,2}$	$b_{2,3}$	$b_{2,4}$	$b_{2,5}$	$b_{2,6}$	$b_{2,7}$	$b_{2,8}$	$b_{2,9}$
a_3	$b_{3,0}$	$b_{3,1}$	$b_{3,2}$	$b_{3,3}$	$b_{3,4}$	$b_{3,5}$	$b_{3,6}$	$b_{3,7}$	$b_{3,8}$	$b_{3,9}$
a_4	$b_{4,0}$	$b_{4,1}$	$b_{4,2}$	$b_{4,3}$	$b_{4,4}$	$b_{4,5}$	$b_{4,6}$	$b_{4,7}$	$b_{4,8}$	$b_{4,9}$
a_5	$b_{5,0}$	$b_{5,1}$	$b_{5,2}$	$b_{5,3}$	$b_{5,4}$	$b_{5,5}$	$b_{5,6}$	$b_{5,7}$	$b_{5,8}$	$b_{5,9}$
a_6	$b_{6,0}$	$b_{6,1}$	$b_{6,2}$	$b_{6,3}$	$b_{6,4}$	$b_{6,5}$	$b_{6,6}$	$b_{6,7}$	$b_{6,8}$	$b_{6,9}$
a_7	$b_{7,0}$	$b_{7,1}$	$b_{7,2}$	$b_{7,3}$	$b_{7,4}$	$b_{7,5}$	$b_{7,6}$	$b_{7,7}$	$b_{7,8}$	$b_{7,9}$
a_8	$b_{8,0}$	$b_{8,1}$	$b_{8,2}$	$b_{8,3}$	$b_{8,4}$	$b_{8,5}$	$b_{8,6}$	$b_{8,7}$	$b_{8,8}$	$b_{8,9}$
a_9	$b_{9,0}$	$b_{9,1}$	$b_{9,2}$	$b_{9,3}$	$b_{9,4}$	$b_{9,5}$	$b_{9,6}$	$b_{9,7}$	$b_{9,8}$	$b_{9,9}$

then the adjusted bin count c_i for bin i is calculated using the equation

$$c_i = \frac{\sum_{j=0}^{9} a_j b_{i,j}}{\sum_{k=0}^{9}\sum_{j=0}^{9} a_j b_{k,j}} \bullet \sum_{j=0}^{9} a_j$$

(B.3)

In cases where the above equation yields a negative c_i, PADS will report a particle count of zero.

This calculation creates a new, 10-channel size distribution of counts. In order to calculate concentrations, however, the sample volume for the BCP must be determined. This is derived by simultaneously measuring a droplet spray in the wet wind tunnel at DMT with the BCP and a calibrated CDP. Under the assumption that the sample volume of the CDP has been well characterized and that the droplet spray is uniform in concentration over the co-located sample volumes of the CDP and BCP, then the BCP sample area is:

(Sample Area)$_{BCP}$ = **(Sample Area)**$_{CDP}$**(Total Counts)**$_{BCP}$/**(Total Counts)**$_{CDP}$ **(B.4)**

The parameters **(Total Counts)**$_{BCP}$ and **(Total Counts)**$_{CDP}$ are the accumulated counts over all the size bins for the BCP and CDP, respectively. Once the sample area is determined, the retrieved size distribution can be used to determine all the statistics of the spectrum in the same way as all the DMT optical spectrometers. Figure B.3 shows a comparison between the BCP and CDP using water droplets in the wind tunnel.
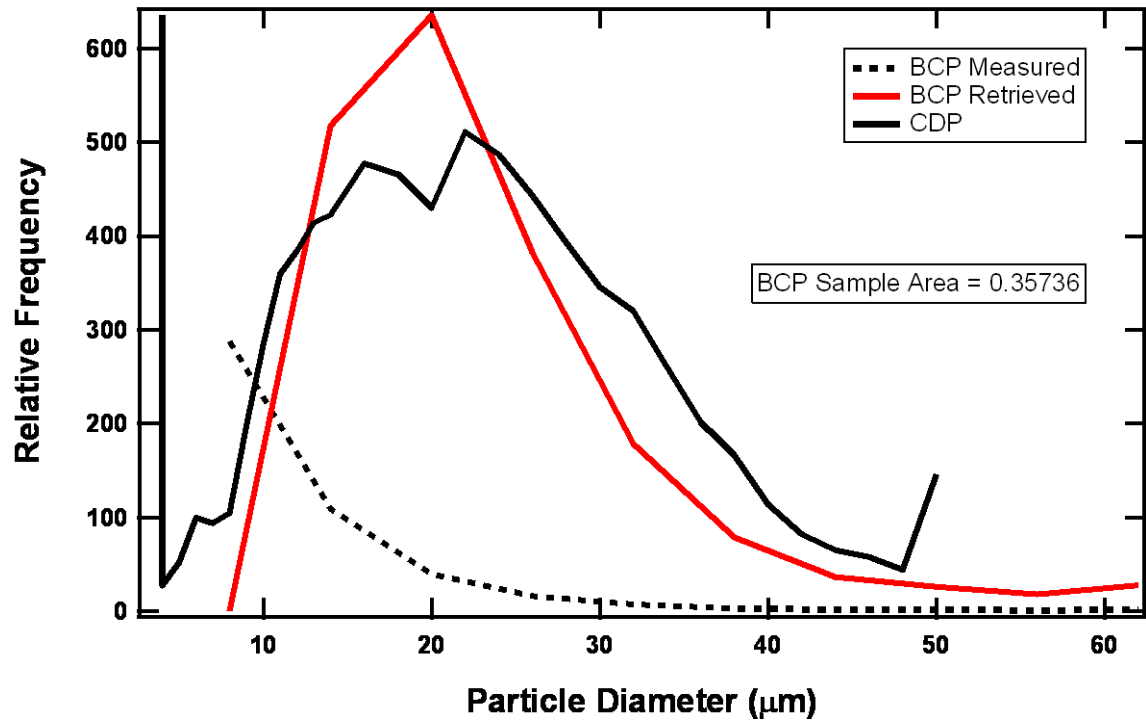
Figure B.3

Appendix C: Revisions to Manual

Rev. Date	Rev No.	Summary	Section
12-18-09	A-2	Expanded explanation of how inversion matrix is used to adjust particle counts	Appendix B