Particle Analysis and Display System (PADS):

Cloud and Aerosol Spectrometer (CAS) Module Manual

DOC-0274, Rev A

PADS 3.5, CAS Module 3.5

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Trademark Information

Risks of Installing Additional Software

Instrument computers from DMT are configured to acquire data in a reliable, robust manner. Typically, such instruments are either not connected to a network or are connected to a small, local network that is isolated from the internet, reducing the risk of viruses. Since anti-virus programs can cause erratic behavior when run in the background on data acquisition computers, DMT does not install anti-virus, anti-spam, or anti-malware programs. If you choose to install these programs, you accept the risk associated with them in terms of potential performance degradation of the software installed by DMT.

For similar reasons, DMT recommends that you do not install or run other software on the dedicated instrument computer. Although the installation of some software may be unavoidable, it is particularly important not to run other software while the computer is acquiring data.

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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 the PADS Cloud and Aerosol Spectrometer (CAS) module version 3.5.0.

For an explanation of the basic PADS setup and instructions on how to acquire data using PADS, consult the *PADS Overview Manual, DOC-0300*. Definitions and calculations used in the CAS module are also described in the *PADS Overview Manual*.

2.0 Configuration

Using PADS, you can configure both the software settings for the instrument and the instrument's data display in PADS. The following two sections explain how to do this. Configuring the instrument's software and display affects the default settings PADS uses when starting up. Some parameters can also be changed while PADS is running, but doing so affects the current session only.

2.1 Configuring the CAS

Your CAS 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 "CAS" tab.
2. From the **Configure** menu, select **Configure Instrument.** You will see the following window.

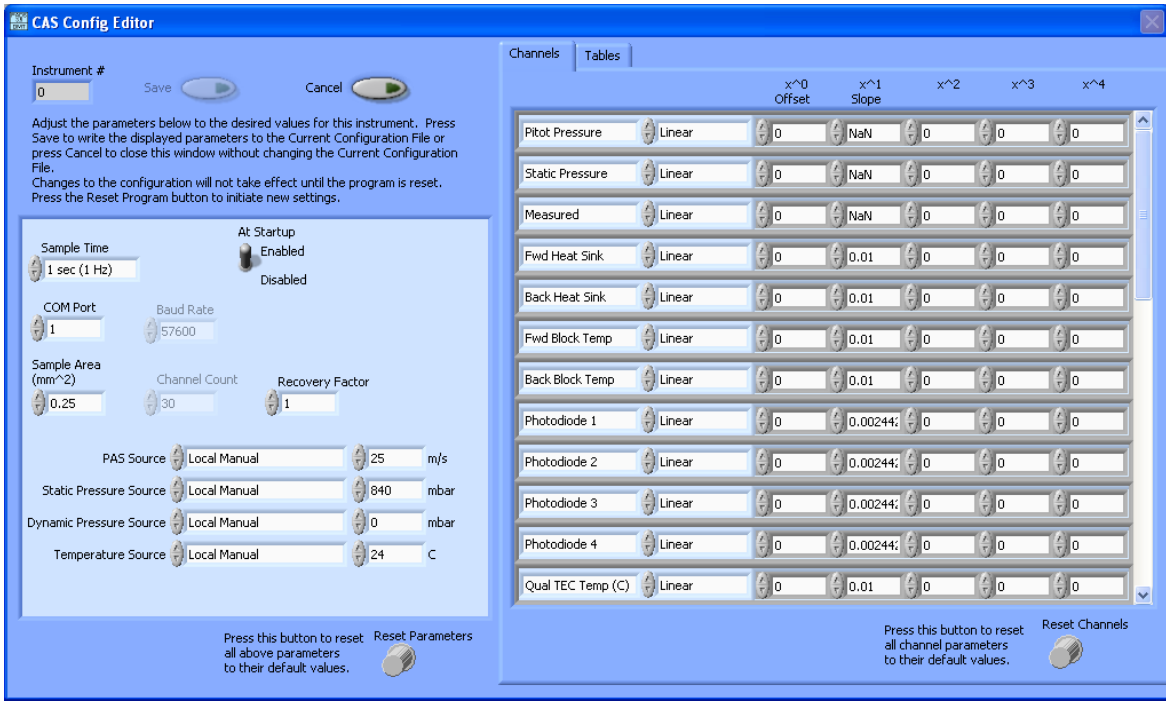

Figure 1: CAS Configuration Editor Window

3. Now you can configure the instrument parameters to your desired specifications. See the definitions below for explanations of individual parameters. If at any time you would like to revert to the previously saved values for the CAS parameters, press **Cancel** to exit the window without saving changes. Pressing **Reset Parameters** reverts parameters to their DMT-supplied default values.

4. When you are done configuring the CAS parameters, press **Save** at the top of the Config editor window. 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.

2.1.1 CAS Parameters

Instrument #: This lists the number corresponding to the instrument you are viewing, in this case the CAS. If your CAS 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.

Sample Time: This parameter shows the time interval you'd like between samples. You can have the probe sample at intervals between 0.04 and 20 sec (25 to 0.05 Hz). 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 25 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 25 µm. *Note:* Sample Time is most often set to 1 Sec. Higher sample rates may or may not work on a given data system, depending on the computer performance and the number and types of instruments PADS is configured to use.

At Startup Enabled / Disabled: If you want the CAS to acquire data when PADS begins sampling, make sure this parameter is in the "Enabled" mode. In some cases, such as if the CAS is inoperative, you may want to use this control to disable the probe. Disabling the CAS allows data to transmit from other instruments without interference. Data will still be written to the disabled instrument's output file, but PADS will write "NaN" to all fields.

COM Port: This is the serial communications port that the CAS 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.

Baud Rate: The baud rate for the probe is defined at manufacture. This parameter has been grayed out and you should not need to change it. If you reconfigure your hardware, however, the baud rate may change. If this occurs, contact DMT for help in changing your baud rate in PADS.

Sample Area: This is the physical area in which particles are detected. CAS 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.

Channel Count: This number indicates how many sizing bins the CAS uses to categorize particles. This number has been grayed out because it is preconfigured for your instrument and should not change.

Recovery Factor: This parameter is used in calculating ambient temperature from measured temperature. PADS uses Bernoulli's equation for this calculation. For more information on this equation and the recovery factor, see the "Ambient Temperature" entry in Appendix B of the *PADS Overview Manual*. By default, Recovery Factor is set to 1.0.

The **PAS Source** control specifies from which of the following sources the system should obtain the applied probe air speed (PAS):

1.) A specific instrument in the system (this can be any instrument capable of measuring air speed)
2.) A manually entered value:
    a. A "Local" value, which at start-up is the value entered in the box to the right of the source control. This number can be changed from the instrument display while the program is running.
    b. A "Global" value entered on the **Setup** tab

Applied PAS is used to calculate sample volume. In flight conditions, you will typically want to select an instrument as the air speed source. However, you will need to enter manual air speed values during probe calibration.

Pressing the **Reset Parameters** button resets all parameters to their DMT-supplied default values. After making changes to the parameters, 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.

2.2 Channels Table

The channels listed in the Channels table are configurable. These are A/D housekeeping channels that measure a 0 - 10 V range from one of the instrument's internal sensors, for example a pressure or temperature sensor. A conversion equation converts the A/D counts into other, more meaningful units (e.g., mBar or °C). You can specify this equation in the Channels table.

Note: *While it is possible to use the Channels table to rename output channels, in most cases your system is preconfigured so that the channels in the table correctly match output from your instrument(s). While minor rescaling of output channels can improve data accuracy, DMT does not recommend altering your basic channel configuration.*

The second column in the table indicates the type of equation that PADS should use—linear, polynomial, or none. ("Thermister D" and "Thermister G" are complicated, pre-set equations used by some instruments, while the "Custom" options are reserved for future 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.

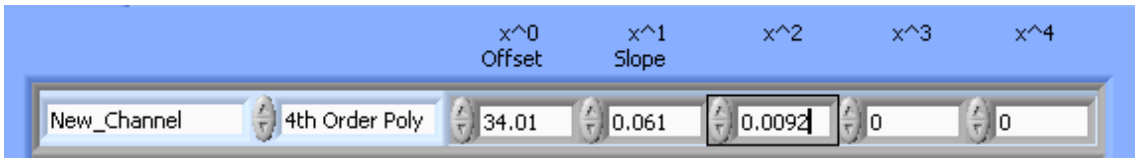

Figure 2: Example Channel Specifications in the Config Editor Window

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 Channels** knob at the bottom of the CAS Parameter window will reset all the channel parameters to their DMT-supplied default values.

After making changes to the Channels tab, 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.

2.3 Tables Tab

The **Tables** tab lists the threshold tables that allow the CAS to bin particles according to size.

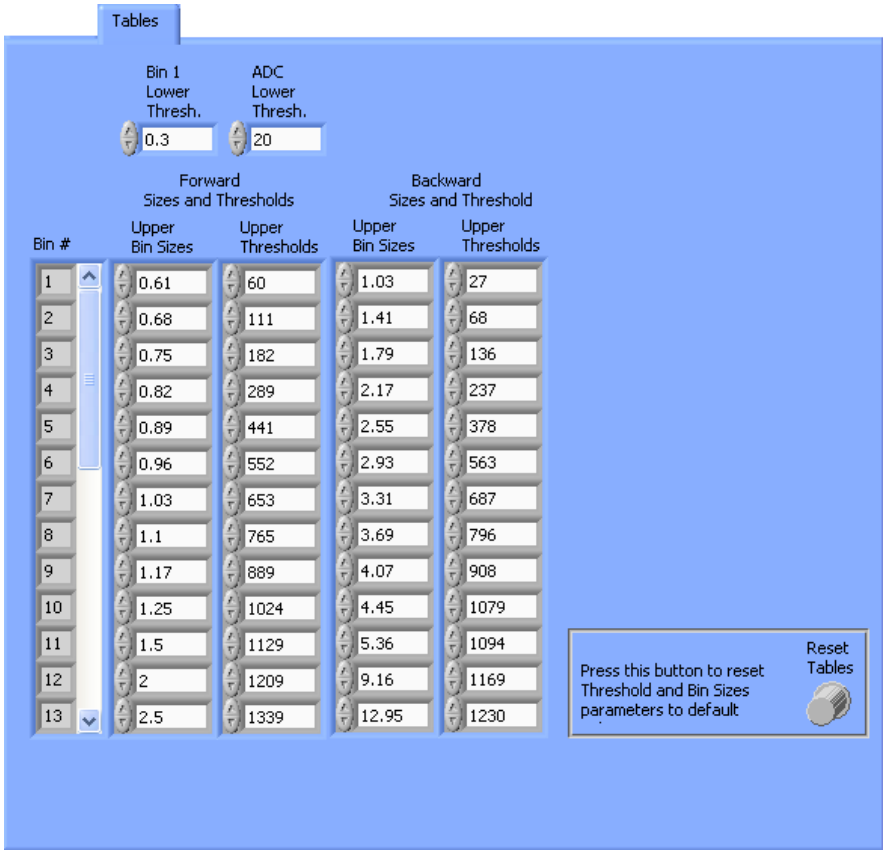

Figure 3: Tables Tab in CAS Config Editor

Bin 1 Lower Thresh. lists the lower size limit in µm of the smallest bin. **ADC Threshold** indicates the smallest peak A/D 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. Both of these parameters can be changed by typing a new value into the text box or by using the control arrows to the left.

The table below consists of five columns. The first column lists the bin number. The second and third columns are for the forward-scattering optics. The second column lists the bin's upper size limit in microns, while the third column lists the A/D count that corresponds to this upper size limit. Lower bin boundaries are the upper limit of the previous bin, except for bin 1, whose lower boundaries are listed above the table.

The fourth and fifth columns are used for binning particles detected by the backward-scattering optics. The fourth column lists the bin's upper size boundary, while the fifth column lists the A/D count that corresponds to this upper size limit. *Note that while the fourth column refers to "size," this is mostly a naming convention; backward-scattering data do not allow for accurate particle sizing, although they are useful for other reasons.* Again, the lower bin boundaries are the upper limit of the previous bin, except for bin 1. The lower A/D count boundary of bin one is the same as that for the forward-scattering optics. Bin 1's lower size boundary is not used on backscatter, so it is not specified.

Bin numbers are fixed, but you can modify both the upper size boundaries and the corresponding A/D count values. To modify a cell, either type in a new value, or use the arrows to the left. The scrollbar to the right allows you to access other rows in the table.

If the threshold tables contain incorrect values, PADS will alert you by displaying a yellow error message. Errors will result if values are not in ascending order or if there is not a value for each bin number listed in column one. If there are extra rows in the table, you can remove them by clicking on the **Remove extra array indices** button. This button only appears if extra indices exist.

The **Reset Tables** knob restores table values to their DMT-supplied defaults.

After making changes to the Tables tab, 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.

2.4 Configuring the CAS Display

To configure the CAS display, click on the CAS 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.

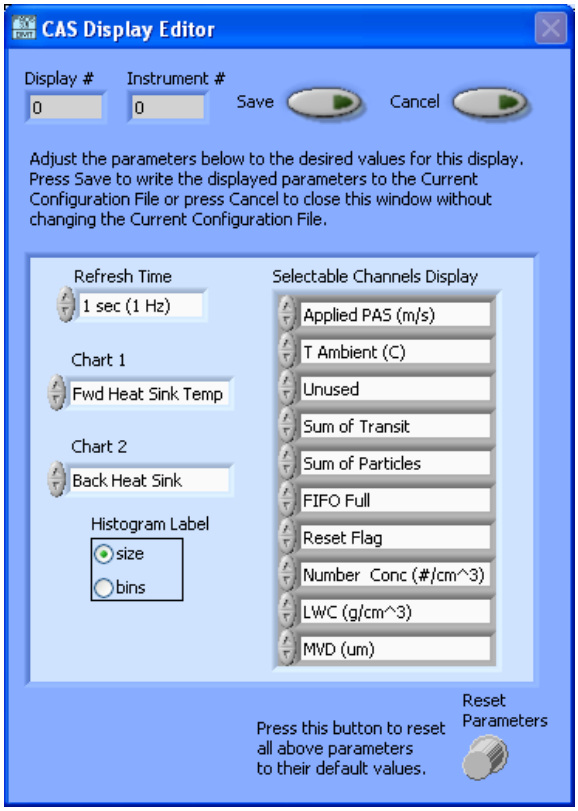

Figure 4: CAS Display Editor Window

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.)

Chart 1 and **Chart 2** allow you to configure the channels on the CAS'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.

Histogram Label: This control allows you to specify the units for the x-axis of the histogram, which can either be size in µm or bin numbers.

The **Selectable Channels Display** controls which channels PADS displays in the upper right of the CAS window.

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 change many of these settings from within the main CAS tab.

3.0 The CAS Window

The different parts of the CAS 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 Overview Manual*.

3.1 Sub-tabs

The CAS window has five sub-tabs, which are discussed below.

3.1.1 Data Tab

The **Data** tab displays the current values for many of the CAS data channels. For more information on these channels, see Appendices A and B of the *PADS Overview Manual*.

3.1.2 LWC / # Conc and LWC / MVD Tabs

The **LWC / # Conc** tab displays a time-trace chart of calculated liquid water content in g/m^3 (shown in green) and # Conc in particles/cm^3 (shown in blue). The **LWC /# MVD** tab displays a time-trace chart of calculated liquid water content in g/m^3 (green) and MVD in µm (blue). A red cursor shows the current moment in time.

3.1.3 Selectable Charts

This tab displays time-trace charts of two user-selectable channels. The charts are overlaid on each other, with the left axis (in green) corresponding to the channel listed in the above left of the chart, and the right axis (in blue) applying to the channel listed in the above right. To change these channels, click on the names of the currently displayed channels, which will bring up a list of options. If you would like to permanently change the **Selectable Charts** channels, as opposed to simply changing them for the current session, you can do so by selecting **Configure > Configure Display** and making the desired changes.

3.1.4 Back Scatter Hist

This tab shows a histogram of the particle counts detected by the back-scattering optics. The x-axis shows bin number, while the bin's upper size boundary[1] is displayed above the data bars. The number in the upper right of the histogram shows the total particle count across the entire histogram.

3.1.5 Tools Tab

The Tools tab lists various **Source** controls**.** If these controls are grayed out, click on **Press to Enable Source Changes** to enable them.

The **Source controls** allow you to set the source for airspeed-related parameters that can be measured by instruments or entered manually. For instance, the PAS Source control specifies from which of **the following** sources the system should obtain the applied probe air speed (Applied PAS):

1.) A specific instrument in the system (this can be any instrument capable of measuring air speed)
2.) A manually entered value:
   a. A "Local" value, which at start-up is the value entered in the box to the right of the source control. This number can be changed from the instrument display while the program is running.
   b. A "Global" value entered on the **Setup** tab

Applied PAS is used to calculate sample volume. In flight conditions, you will typically want to select an instrument as the air speed source. However, you will need to enter manual air speed values during probe calibration. If the PAS source is a manually entered value, PADS will still calculate air speed and store the result in the **PAS (m/s)** channel.

If your CAS is capable of measuring pressures and temperature, you will also see controls that allow you to specify different sources for these variables. (Most CAS cannot measure pressures or temperature.) For pressure and temperature sources, "Local Measured" uses the instrument's measurement, while "Local Manual" uses manually entered values—initially the ones to the right of the source controls, which can be changed from the instrument display when the program is running.

Changing the source settings here changes them for the current session only. (To change the default values used upon start-up, do so from the **Configure > Configure Instrument**

[1] As explained earlier, the term "size" is mostly a naming convention. Backward-scattering data do not allow for accurate particle sizing, although they are useful for other reasons.

menu.) After you have finished specifying new sources, click on the **Press to Lock Source Changes** button to disable further changes.

Note: the PAS source can be changed during acquisition, but if data are reprocessed, those changes to the source that occurred during acquisition will be lost; see the "Configure Menu" section of *DOC-0300,* the *PADS Overview Manual*.

3.2 Selectable Channels Display

The upper right of the CAS window displays current data for ten user-selectable channels. New channels can be selected by clicking on the name of a current channel and selecting a replacement from the drop-down list. To make permanent changes to this list, edit the settings on the CAS Display Editor (select **Configure > Configure Display**).

3.3 Histogram Data Window

Below the CAS tabs is the histogram display of CAS-acquired particle data, as shown in Figure 5. The histogram shows the particle distribution detected by the forward-scattering optics. The number in the upper right of the histogram shows the total particle count across the entire histogram.

The x-axis labels indicate the upper boundary of each bin. A bin's lower boundary is the upper boundary of the previous bin, except for the first bin. You can view and modify the lower boundary of this bin—and other bins—by selecting **Configure > Configure Instrument** and then clicking on the **Tables** tab.

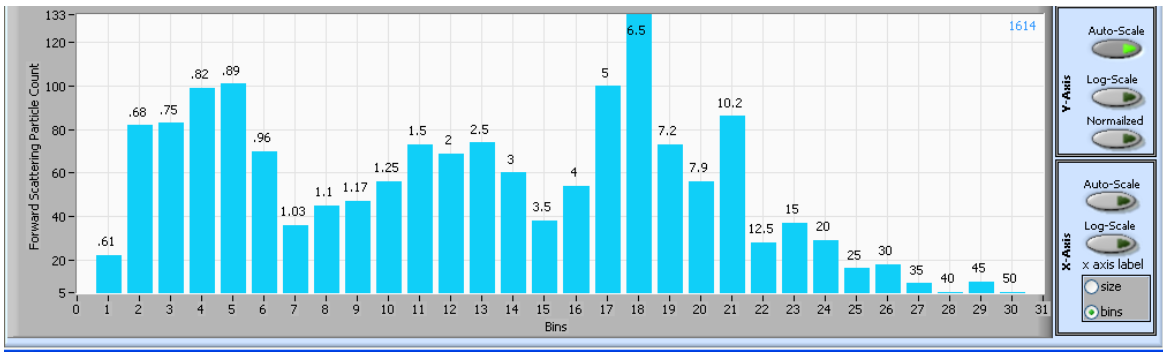

Figure 5: Histogram of Forward-Scattering Particle Counts

To the right of the histogram are buttons that control the scaling and display of the histogram data. **Auto-scale** controls 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 values can then be changed manually by typing new numbers into these fields.

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

If you click on the **Normalized** button, 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 is often the case when an optical spectrometer has to cover a large size range or if some size bins are made larger to decrease uncertainty due to operational limitations. Without normalization, the concentrations from one size bin cannot be compared quantitatively from those in another size bin of different width. For example, if 8 particles are counted in a size bin that is 2 µm wide and 8 particles are counted in the next larger channel that is 4 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 4 particles per µm and the larger size bin only has 2 particles per µm. This is now an unbiased sample.

The **size / bin number** radio buttons allow you to change the x-axis units. When the x-axis displays bin number, each bin's upper size limit in µm is displayed above each data bar.

4.0 Zooming In and Out

There are several ways to zoom in or out on CAS charts and the histogram. As described in the *PADS Overview Manual*, you can use the time-range controls (Figure 6) to zoom. To zoom in on the data, move the green and red controls close to the white control, which will narrow the range of displayed data. To zoom out, move the two colored controls away from the white control.

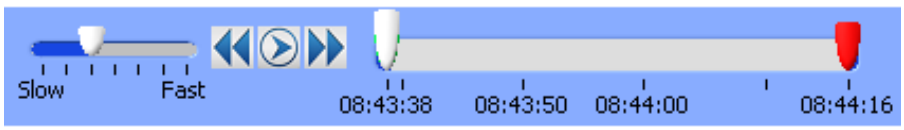

Figure 6: Time-Range Controls

On the chart itself, you can also type numbers directly into the first and last labels on the x and y axis to change the scaling.

Note: Do not right-click on chart and change the auto-scaling using the drop-down menu. This can interfere with the chart display. PADS autoscales most charts automatically. You can turn off autoscaling on the histogram using the buttons in the lower right of the window.

Appendix A: CAS Channels

A list of channels for a 30-bin CAS appears below. The CAS 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 CAS Selectable Charts tab.

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

End Seconds
Day of Year
Year
Status
Unused
Sum of Transit
Sum of Particles
FIFO Full
Reset Flag
Forward Over Range
Backward Over Range
Unused
Dynamic Press (mbar)
Static Press (mbar)
Recovery Temp (C)
Fwd Heat Sink Temp (C)
Back Heat Sink Temp (C)
Fwd Block Temp (C)
Back Block Temp (C)
Spare 1 – 4
Qual TEC Temp (C)
Fwd TEC Temp (C)
Back TEC Temp (C)
Qual Heat Sink Temp (C)
Qual High Gain Baseline (V)
Qual Mid Gain Baseline (V)
Qual Low Gain Baseline (V)
Fwd High Gain Baseline (V)
Fwd Mid Gain Baseline (V)
Fwd Low Gain Baseline (V)
Back High Gain Baseline (V)
Back Mid Gain Baseline (V)
Back Low Gain Baseline (V)
Electronics Temp (C)
RH%
Spare
LWC Hotwire (V)
LWC Slave (V)
Laser Current
Unused
Spare 1 - 8
T Ambient (C)
PAS (m/s)
Number Conc (#/cm^3)
LWC (g/cm^3)
MVD (um)
ED (um)
Applied PAS (m/s)
CAS Bin 1 - 30
CAS back Bin 1 - 30
GPS Time / UTC Seconds
Date
Time

If there is no instrument in the system that reports **GPS Time**, or if such an instrument exists but the user has selected on the CAS Config Editor to show UTC Seconds, the output channel file will contain **UTC Seconds**. Otherwise, it will report **GPS Time**.

Two additional channels, **Date** and **Time**, may be listed after **GPS Time/ UTC Seconds** if **Write Date & Time Stamp** is enabled on the **Setup** tab.

CAS channels fall into several broad categories:

- Time channels
- Bin channels, which store data on the number of particles of different sizes that the CIP has detected
- Particle statistics (e.g., rejected particles, number concentration, etc.)
- Probe statistics
- Channels reserved for internal use (e.g., Host Sync Counter and Reset Flag)

Many of the probe statistics are stored in "housekeeping channels," a term that refers to data gathered with A/D sensors. The CAS has 31 A/D housekeeping channels that have a 0-10 V range measured by a 12-bit A/D converter that gives integer values from 0 to 4095. Several of the housekeeping channels store data that indicate whether the probe is functioning properly. Several others are non-functional. Housekeeping channels are denoted by italics in the list above.

Appendix B: Revisions to Manual

This manual replaces DOC-0188, the *CAS PADS Operator Manual* for PADS version 2.X. All sections have been updated.