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**Particle Analysis and Display  
System (PADS):  
Cloud and Aerosol  
Spectrometer (CAS)  
Module**

**Operator Manual**

**DOC-0188 A-2, PADS 2.5.6**

**CAS Module 2.5.5**



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Consumable components, such as tubing, filters, pump diaphragms and Nafion humidifier are not covered by this warranty.

# CONTENTS

<b>1.0 Introduction</b> .....	<b>4</b>
<b>2.0 Configuration</b> .....	<b>4</b>
Configuring the CAS .....	4
Configuring the CAS Display .....	10
<b>3.0 The CAS Window</b> .....	<b>12</b>
Channel Tabs .....	12
Histogram Data Window .....	12
Chart Displays .....	13
<b>Appendix A: CAS Channels</b> .....	<b>18</b>

## *List of Figures*

<b>Figure 1: CAS Configuration Editor Window</b> .....	<b>5</b>
<b>Figure 2: CAS Display Editor Window</b> .....	<b>11</b>
<b>Figure 3: CAS Data Window</b> .....	<b>12</b>
<b>Figure 4: CAS Histogram Display</b> .....	<b>13</b>
<b>Figure 5: CAS Time-Series Charts</b> .....	<b>14</b>

## 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 module for the Cloud and Aerosol Spectrometer (CAS).

For an explanation of the basic PADS setup and instructions on how to acquire data using PADS, consult the *PADS Operator Manual*. Definitions and calculations used in the CAS 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 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.

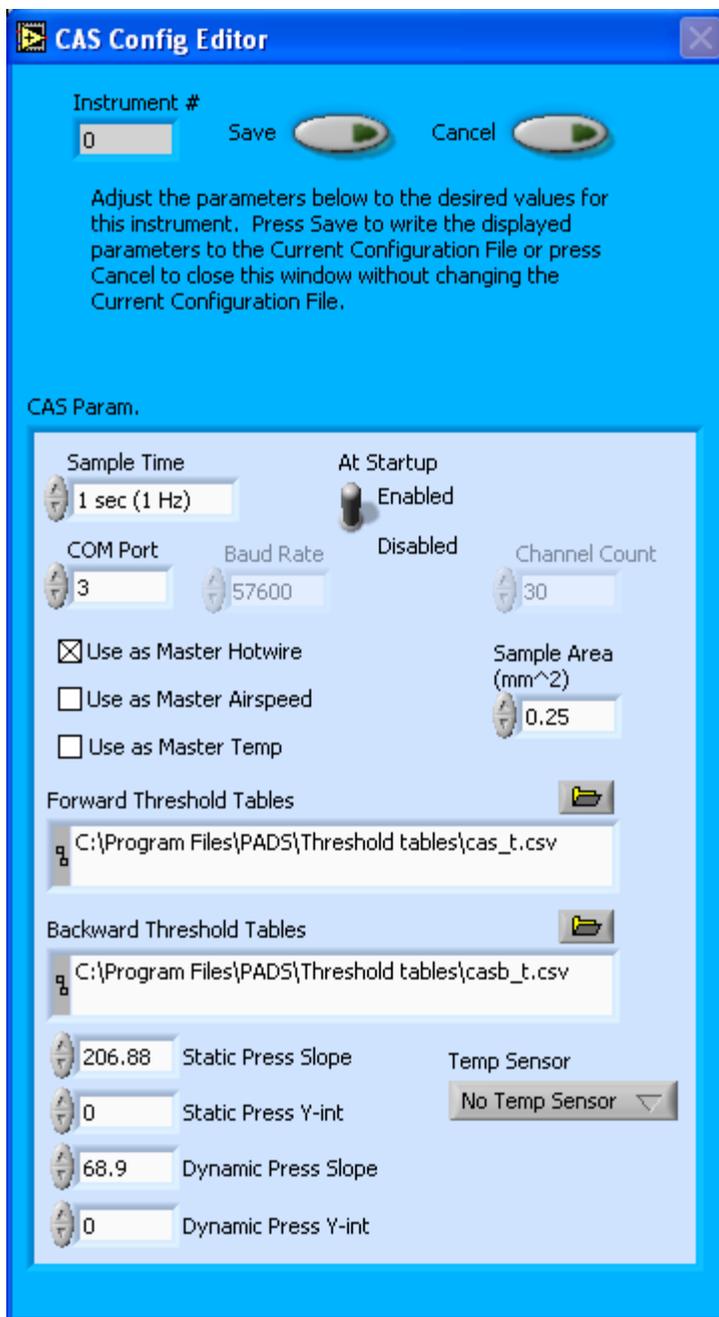


Figure 1: CAS Configuration Editor Window

3. Now you can configure the instrument parameters to your desired specifications. You will find a list of the parameters you may want to reconfigure in the two sections below, “Occasionally Reconfigured CAS Parameters” and “Rarely Reconfigured CAS 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.
4. When you are done configuring the CAS 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 CAS 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 25  $\mu\text{m}$  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  $\mu\text{m}$ .

***WARNING: One hertz sampling is currently recommended, as choosing other values will invalidate time-dependent PADS calculations like number concentration, volume 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 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.

**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.

You will notice that there are other parameters listed on the **CAS Config Editor** window. Most of these you should not need to change, and changing them inadvertently 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 CAS Parameters” below or consult with a DMT technical representative.

### ***Rarely Reconfigured CAS Parameters***

The CAS 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 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.

**Baud Rate:** The Baud rate for the probe is defined at manufacture, and you should not need to change it. PADS lists 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.

**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.

**Use as Master Hotwire:** When checked, this box tells PADS to use the CAS’s hotwire measurement as the default master hotwire source on the Setup window. While multiple instruments can potentially provide this measurement, only one instrument should be selected as the source.

Note that in a CCP system, the Hotwire signal is measured by the CIP. In a CAPS system, the Hotwire signal is usually measured by the CAS, so the CAS and not the CIP should be set to Use as Master Hotwire for these systems.

**Use as Master TAS:** When checked, this box tells PADS to use the CAS’s True Air Speed measurement as the TAS Source on the Setup window.

Several different instruments are capable of providing True Air Speed to PADS. If more than one such instrument is installed in your system, only one of them can be used as the global source for True Air Speed for calculations. When your system comes from DMT, one instrument will be selected as the Master TAS.

**Use as Master Temp:** When checked, this box tells PADS to use the CAS's ambient temperature measurement as the default master temperature source on the Setup window. While multiple instruments can potentially provide this measurement, only one instrument should be selected as the source. (Note that what PADS displays as ambient temperature is really measured temperature that is several degrees warmer than the ambient; see entry under **Ambient Temperature** in the *PADS Operator Manual's Appendix A.*)

**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.

**Forward Threshold Tables:** This field lists the path to the forward-scattering threshold table files. PADS uses these tables to size particles that the instrument's forward-scattering optics have detected. The system uses two forward threshold tables, but PADS only lists one of these tables, `cas_t.csv`, in the Forward Threshold Tables field. The other file, `cas_p.csv`, should be located in the same directory. Note that the Forward Thresholds Tables field should always be set to the `cas_t.csv` file, and PADS finds the `cas_p.csv` file automatically using the same path.

`Cas_t.csv` tells PADS the correct sizing bin for a particle given the peak digital value from the light scattered by the particle. `Cas_p.csv` tells PADS the upper size boundary in microns for each sizing bin.

**Backward Threshold Tables:** This field lists the path to the backward-scattering threshold table files. PADS uses these tables to categorize particles that the instrument's backward-scattering optics have detected. The system uses two backward threshold tables, but PADS only lists one of these tables, `casb_t.csv`, in the Backward Threshold Tables field. The other file, `casb_p.csv`, should be located in the same directory. Note that the Backward Thresholds Tables field should always be set to the `casb_t.csv` file, and PADS finds the `casb_p.csv` file automatically using the same path.

`Casb_t.csv` tells PADS the correct bin for a particle given the peak digital value from the light scattered by the particle. `Casb_p.csv` tells PADS the upper boundary for each bin. Note while the histogram labels these boundaries as “particle size in  $\mu\text{m}$ ,” this label is incorrect. The bins do not actually reflect particle size. Rather, they categorize particles by the intensity of back-scattered light.

**Static Press Slope:** This is the slope used in the linear function to derive static pressure from the voltage output of the static pressure transducer, as follows:

$$\text{Static Pressure} = (\text{Static Press Slope}) * (\text{Voltage}) + \text{Static Press Y-int}$$

Static Press Slope is a calibration coefficient measured by DMT and specific to your transducer. It assumes a 5-volt sensor range that is electronically multiplied by 2 before going to a 0-10 volt analog-to-digital converter. Do not change this parameter without consulting DMT first.

**Static Press Y-int:** This is the intercept term used in the linear function to derive static pressure from the voltage output of the static pressure transducer, as follows:

$$\text{Static Pressure} = (\text{Static Press Slope}) * (\text{Voltage}) + \text{Static Press Y-int}$$

Static Press Y-int is a calibration coefficient measured by DMT and specific to your transducer. It assumes a 5-volt sensor range that is electronically multiplied by 2 before going to a 0-10 volt analog-to-digital converter. Do not change this parameter without consulting DMT first.

**Dynamic Press Slope:** This is the slope used in the linear function to derive dynamic pressure from the voltage output of the dynamic pressure transducer, as follows:

$$\text{Dynamic Pressure} = (\text{Dynamic Press Slope}) * (\text{Voltage}) + \text{Dynamic Press Y-int}$$

Dynamic Press Slope is a calibration coefficient measured by DMT and specific to your transducer. It assumes a 5-volt sensor range that is electronically multiplied by 2 before going to a 0-10 volt analog-to-digital converter. Do not change this parameter without consulting DMT first.

**Dynamic Press Y-int:** This is the intercept term used in the linear function to derive dynamic pressure from the voltage output of the dynamic pressure transducer, as follows:

$$\text{Dynamic Pressure} = (\text{Dynamic Press Slope}) * (\text{Voltage}) + \text{Dynamic Press Y-int}$$

Dynamic Press Y-int is a calibration coefficient measured by DMT and specific to your transducer. It assumes a 5-volt sensor range that is electronically multiplied by 2 before going to a 0-10 volt analog-to-digital converter. Do not change this parameter without consulting DMT first.

**Temp Sensor:** This control tells PADS what kind of temperature sensor is installed in the CAS. It is pre-configured to match the temperature sensor on your particular probe and should not be changed.

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 CAS Display

To configure the CAS display, go to the **Configure** menu from the CAS tab and select **Configure Display**. This will bring up the following window.

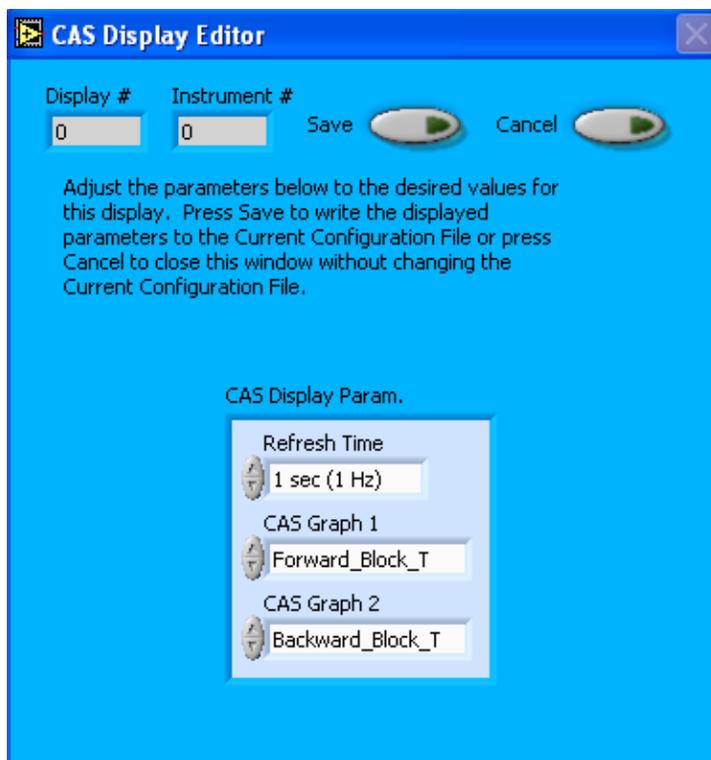


Figure 2: CAS Display Editor Window

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.)

The CAS Display Parameter box at the bottom of the window also allows 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.

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 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 Operator Manual*.

#### Channel Tabs

The CAS Data and Housekeeping tabs are displayed in upper left of the CAS tab, as shown in Figure Three. The information PADS displays in these tabs is specific to the time listed in the upper-right of the PADS window.

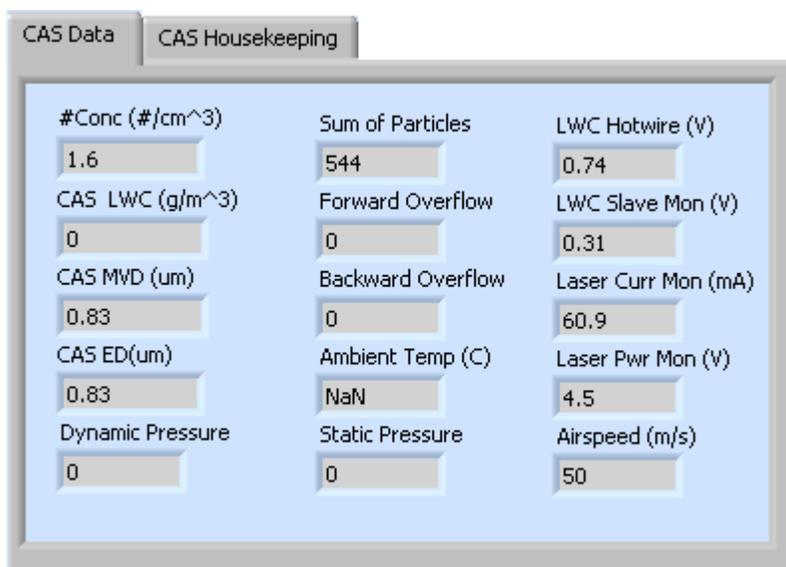


Figure 3: CAS Data Window

#### Histogram Data Window

Below the CAS Data and Housekeeping tabs is the histogram display of CAS-acquired particle data, as shown in Figure 4. The CAS window shows two histograms. One is generated by the forward-scattering optics and one by the backward-scattering optics. The forward-scattering histogram shows the distribution of particles by size. The x-axis labels indicate the upper boundary of each size bin, which PADS reads from the *cas\_p.csv* threshold table. A bin’s lower boundary is the upper boundary of the previous bin, except for the first bin, which has a lower boundary of .5 μm.

The backward-scattering histogram is not useful in determining particle size. (PADS labels the chart’s x-axis units as “particle size in  $\mu\text{m}$ ,” but in fact the chart classifies particles by the intensity of back-scattered light.) The backward-scattering data can be compared to the forward-scattering data to determine particle shape and composition (i.e., liquid or solid).

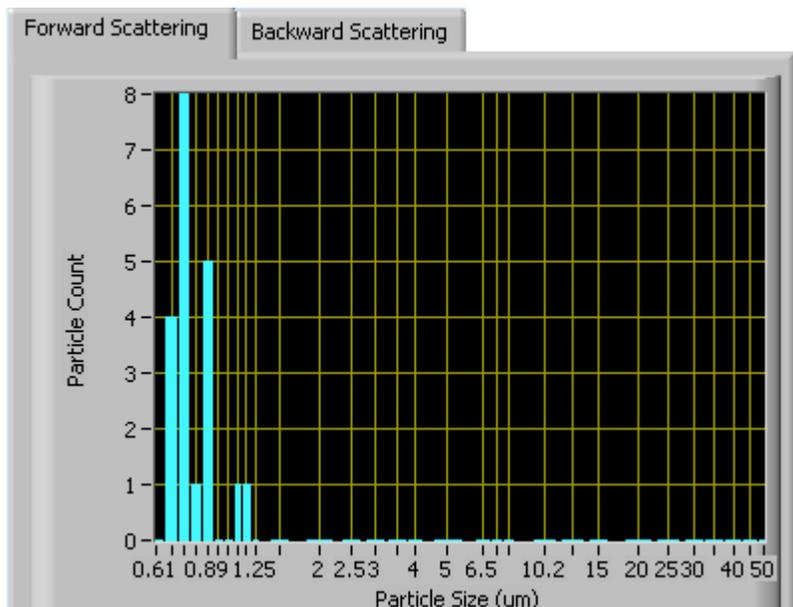


Figure 4: CAS Histogram Display

## Chart Displays

The CAS chart displays consist of tabs with standard charts, selectable charts, and larger versions of the forward-scattering and backward-scattering histograms. You can access any of these charts by selecting the tabs in the upper part of the chart display window. Figure 5 shows these tabs and the standard time-series charts.

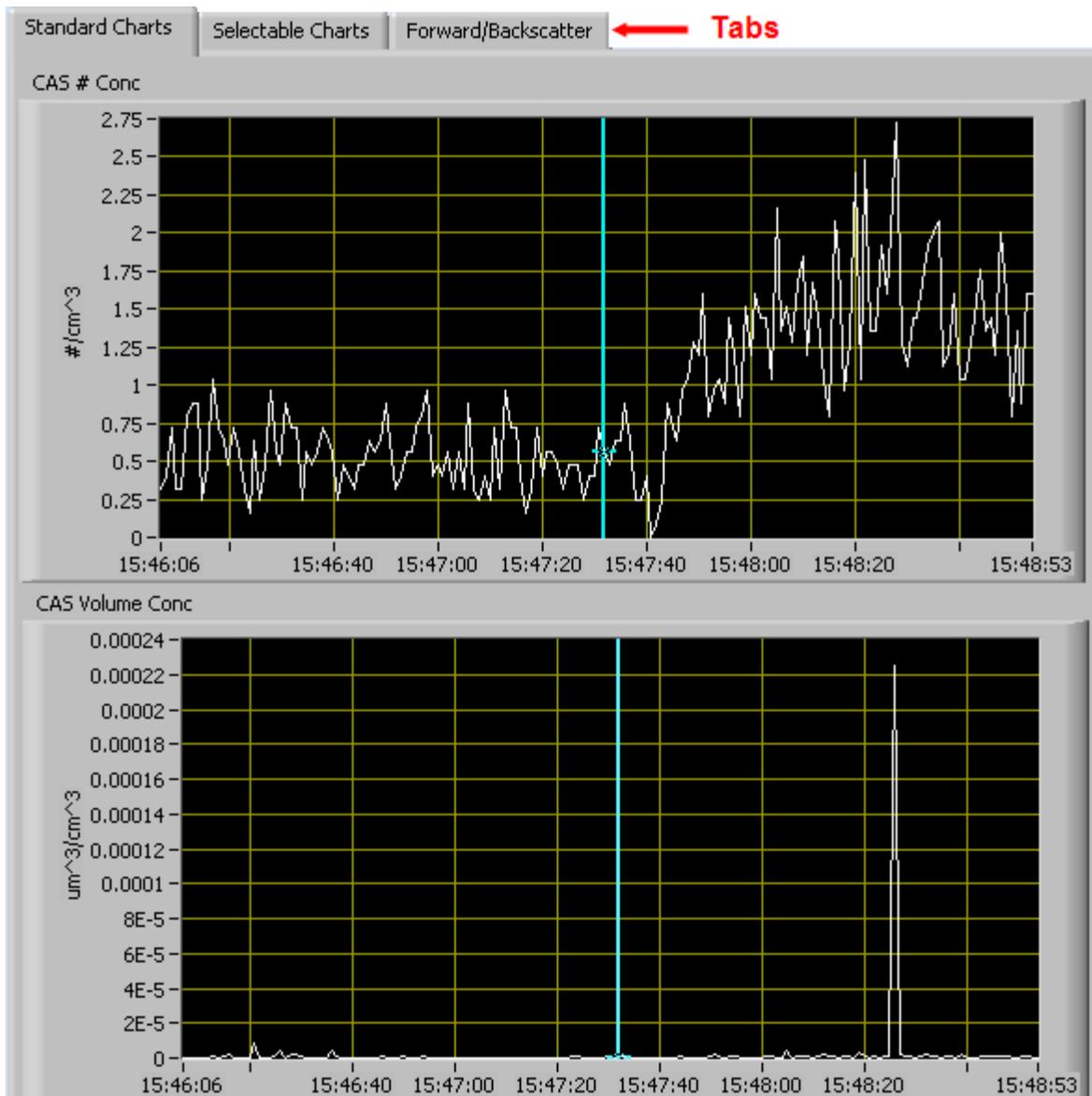


Figure 5: CAS Time-Series Charts

When you access time-series charts in playback mode, the currently selected moment in time is indicated by a blue 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 ending values on each axis. For instance, if you want to change the time period in one of the graphs above to end at 15:47:00, you simply select the field that currently says 15:48:53, type in 15:47:00, and hit the <Enter> key. 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. 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. Standard Charts**

The two graphs on the first tab display particle number concentration ( $\#/cm^3$ ) and volume concentration ( $\mu m^3/cm^3$ ). Note that PADS determines particle counts and volumes based solely on information from CAS's forward-scattering optics. The backward-scattering optics are not useful in sizing particles, as particles with the same volume but different shapes can backward-scatter light in drastically different ways.

In playback mode, you can zoom in or out on the charts by using the time controls. In acquisition mode, use the "Display Range" control to zoom in or out.

## 2. Selectable Charts

The **CAS 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 **CAS 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. Forward/Backscatter

The **Forward/Backscatter** tab shows a larger version of the histogram that appears in the bottom left of the CAS screen. This histogram also allows you to manipulate the display using the controls and features described below.

### Autoscale Button

The Autoscale control lets you control how the y scale is 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 axis 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 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 normalized by the width of that bin in microns. Specifically, PADS divides the particle count by the width of the bin. This yields a curve that more accurately reflects the overall distribution of particle size. On the CAS, many of the bins on the lower end of the size spectrum have a small width. If you do not normalize the data, the number of smaller particles may appear disproportionately low relative to the number of other particles.

## 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 Operator Manual*.

Time	IAC_26	IAC_58
Sum_of_Transit	IAC_27	IAC_59
Sum_of_Particles	IAC_28	IAC_60
Fifo_Full	IAC_29	IAC_61
Reset_Flag	IAC_30	IAC_62
Forward_Overflow	IAC_31	IAC_63
Backward_Overflow	IAC_32	IAC_64
IAC_1	IAC_33	Dynamic_Pressure
IAC_2	IAC_34	Static_Pressure
IAC_3	IAC_35	Ambient_Temp
IAC_4	IAC_36	Forward_Heat_Sink_T
IAC_5	IAC_37	Back_Heat_Sink_T
IAC_6	IAC_38	Forward_Block_T
IAC_7	IAC_39	Backward_Block_T
IAC_8	IAC_40	Photodiode_1
IAC_9	IAC_41	Photodiode_2
IAC_10	IAC_42	Photodiode_3
IAC_11	IAC_43	Photodiode_4
IAC_12	IAC_44	Qualifier_TEC_Temp
IAC_13	IAC_45	Forward_TEC_Temp
IAC_14	IAC_46	Backward_TEC_T
IAC_15	IAC_47	Qual_Heat_Sink_T
IAC_16	IAC_48	Qual_Hi_Gain_Volt
IAC_17	IAC_49	Qual_Mid_Gain_Volt
IAC_18	IAC_50	Qual_Lo_Gain_Volt
IAC_19	IAC_51	Fwd_Hi_Gain_Volt
IAC_20	IAC_52	Fwd_Mid_Gain_Volt
IAC_21	IAC_53	Fwd_Lo_Gain_Volt
IAC_22	IAC_54	Back_Hi_Gain_Volt
IAC_23	IAC_55	Back_Mid_Gain_Volt
IAC_24	IAC_56	Back_Lo_Gain_Volt
IAC_25	IAC_57	Internal_Temp

Spare_Analog_1	CAS_Forw_ch19	CAS_Back_ch13
Spare_Analog_2	CAS_Forw_ch20	CAS_Back_ch14
LWC_Hotwire	CAS_Forw_ch21	CAS_Back_ch15
LWC_Slave_Monitor	CAS_Forw_ch22	CAS_Back_ch16
Laser_Curr_Monitor	CAS_Forw_ch23	CAS_Back_ch17
Laser_Power_Mon	CAS_Forw_ch24	CAS_Back_ch18
CAS_Forw_ch0	CAS_Forw_ch25	CAS_Back_ch19
CAS_Forw_ch1	CAS_Forw_ch26	CAS_Back_ch20
CAS_Forw_ch2	CAS_Forw_ch27	CAS_Back_ch21
CAS_Forw_ch3	CAS_Forw_ch28	CAS_Back_ch22
CAS_Forw_ch4	CAS_Forw_ch29	CAS_Back_ch23
CAS_Forw_ch5	CAS_Back_ch0	CAS_Back_ch24
CAS_Forw_ch6	CAS_Back_ch1	CAS_Back_ch25
CAS_Forw_ch7	CAS_Back_ch2	CAS_Back_ch26
CAS_Forw_ch8	CAS_Back_ch3	CAS_Back_ch27
CAS_Forw_ch9	CAS_Back_ch4	CAS_Back_ch28
CAS_Forw_ch10	CAS_Back_ch5	CAS_Back_ch29
CAS_Forw_ch11	CAS_Back_ch6	Airspeed_(m/s)
CAS_Forw_ch12	CAS_Back_ch7	CAS_#_Conc
CAS_Forw_ch13	CAS_Back_ch8	CAS_LWC
CAS_Forw_ch14	CAS_Back_ch9	CAS_MVD
CAS_Forw_ch15	CAS_Back_ch10	CAS_ED
CAS_Forw_ch16	CAS_Back_ch11	Status
CAS_Forw_ch17	CAS_Back_ch12	GPS Time
CAS_Forw_ch18		

CAS 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 CAS 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 may be collected from an instrument other than the CAS, even though it appears as a channel in the CAS output file.

*Bin Channels:* Channels labeled CAS\_Forw\_ch[i] and CAS\_Back\_ch[i] store data on the number of particles of different sizes that the CAS has detected. These data are used in the histogram displays.

*Channels for Other Statistical Data:* Sum\_of\_Transit, Forward\_Overflow and Backward\_Overflow store particle statistics collected by the CAS. Fifo\_Full stores data about the probe electronics. Status stores statistical data the CAS has gathered on the communication between PADS and the probe.

*Housekeeping Channels:* 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. A complete list of housekeeping channels is given below.

<i>Dynamic_Pressure</i>	<i>Photodiode_2</i>	<i>Qual_Mid_Gain_Volt</i>	<i>Internal_Temp</i>
<i>Static_Pressure</i>	<i>Photodiode_3</i>	<i>Qual_Lo_Gain_Volt</i>	<i>Spare_Analog_1</i>
<i>Ambient_Temp</i>	<i>Photodiode_4</i>	<i>Fwd_Hi_Gain_Volt</i>	<i>Spare_Analog_2</i>
<i>Forward_Heat_Sink_T</i>	<i>Qualifier_TEC_Temp</i>	<i>Fwd_Mid_Gain_Volt</i>	<i>LWC_Hotwire</i>
<i>Back_Heat_Sink_T</i>	<i>Forward_TEC_Temp</i>	<i>Fwd_Lo_Gain_Volt</i>	<i>LWC_Slave_Monitor</i>
<i>Forward_Block_T</i>	<i>Backward_TEC_T</i>	<i>Back_Hi_Gain_Volt</i>	<i>Laser_Curr_Monitor</i>
<i>Backward_Block_T</i>	<i>Qual_Heat_Sink_T</i>	<i>Back_Mid_Gain_Volt</i>	<i>Laser_Power_Mon</i>
<i>Photodiode_1</i>	<i>Qual_Hi_Gain_Volt</i>	<i>Back_Lo_Gain_Volt</i>	

*CAS Calculated Channels:* CAS\_#\_Conc, CAS\_LWC, CAS\_MVD, and CAS\_ED store the results of calculations PADS has performed on CAS particle data. Airspeed\_(m/s) stores air speed, which is either calculated from CAS pressure and temperature channels or supplied by another instrument if an instrument other than the CAS is designated as the TAS Source on the Setup screen.

*Channels that are Currently Nonfunctional or Reserved for Internal Use:* These channels include Sum\_of\_Particles, Reset\_Flag, the IAC\_[i] channels, the Photodiode\_[i] channels, Spare\_Analog\_1, Spare\_Analog\_2, and Laser\_Power\_Mon.