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## **Hawkeye**

### **Software Operation Manual**

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# TABLE OF CONTENTS

<b>1.</b>	<b>Hawkeye Startup Procedure</b>	<b>1</b>
1.1	Connecting to the CPI Probe	1
1.2	Connecting to the 2D-S Probe	4
1.3	Connecting to the FCDP	5
<b>2.</b>	<b>3V-CPI Graphical User Interface</b>	<b>7</b>
2.1	View Menu	9
2.1.1	<i>Housekeeping Window</i>	9
2.1.2	<i>Stats Window</i>	13
2.2	Settings Menu	14
2.3	2D-S Control and Monitoring	15
2.3.1	<i>2D-S Laser Power and DC Level</i>	15
2.3.2	<i>3V-CPI Triggering</i>	16
2.4	Image Collection Control and Monitoring	18
2.4.1	<i>Imaging and Background</i>	18
2.4.2	<i>Particle Collection and Associated Controls</i>	21
2.4.3	<i>Image and Background Mean Settings</i>	22
2.4.4	<i>Live Video Mode</i>	23
2.5	Display Options	25
2.5.1	<i>Rates and Image Parameters</i>	25
2.5.2	<i>Displays, Histograms, and ROI X/Y Plots</i>	26
2.6	cpI.INI File Description	30
2.6.1	<i>Enunciator Panel</i>	33
<b>3.</b>	<b>3V-CPI Real-Time Operation and Troubleshooting</b>	<b>36</b>
3.1	Operation and Troubleshooting In Flight	36
3.2	RTIA Log Troubleshooting	38
3.2.1	<i>Sensor Head Powered Off/Camera Connector Disconnected</i>	38
3.2.2	<i>Imaging Laser Power Too Low or Too High</i>	38
3.3	Background Troubleshooting	39
3.3.1	<i>No Background Acquired at Startup</i>	39
3.3.2	<i>Probe Communicating with DAS, but No Background Taken</i>	41
3.4	Threshold Operation and Troubleshooting	43
3.5	Enunciator Warnings	
<b>4.</b>	<b>3V-CPI 2D-S Graphical User Interface and Real-Time Operation</b>	<b>44</b>
4.1	Toolbar	45
4.2	Main Display Window	45
4.3	Set True Air Speed Window	46
4.4	Housekeeping Window	47

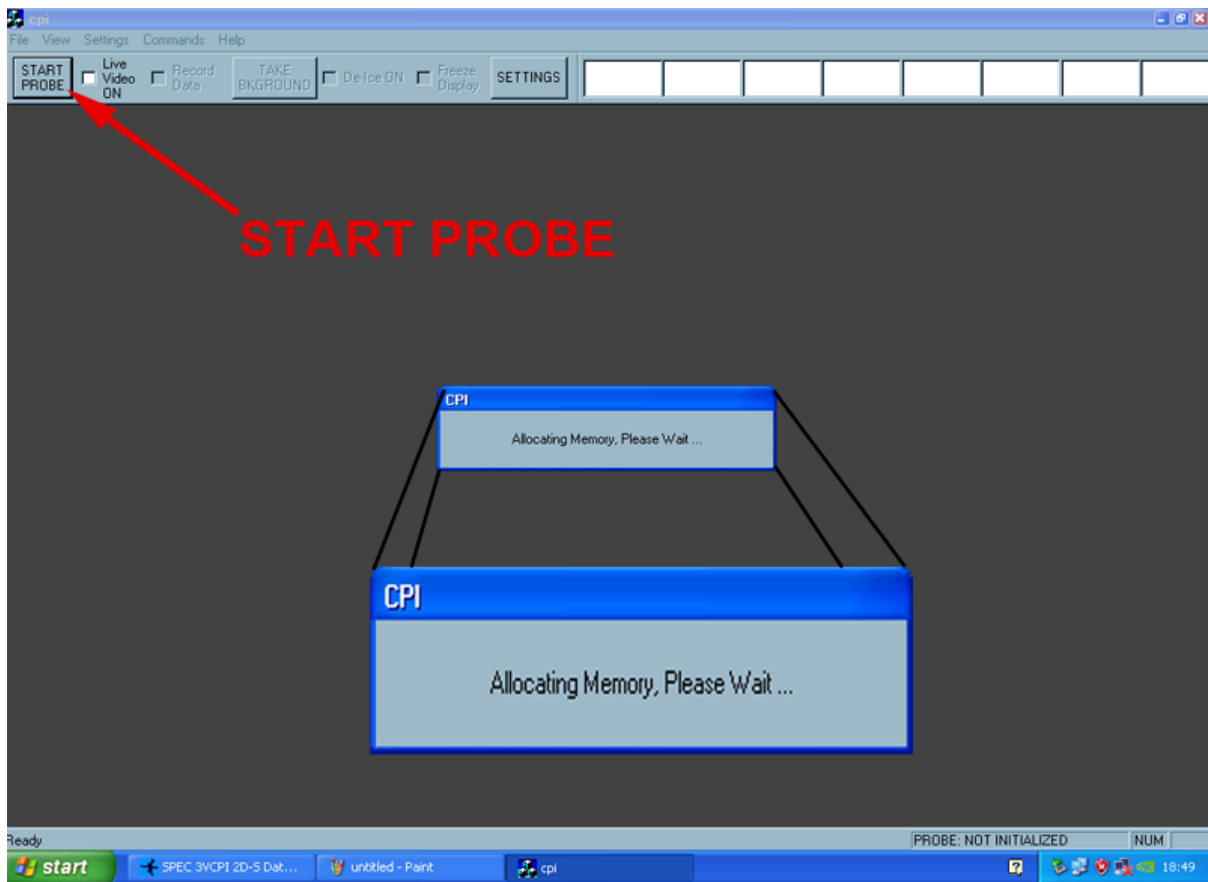
4.5	Send Command Packet Window	49
4.6	Mask Setting	50
4.6.1	<i>Example of Mask Algorithm</i>	52
4.6.2	<i>Suggested Operational Settings for Mask Parameters</i>	53
4.7	Tools Tab Menu	55
4.8	Periodic Mask Generation Window	57
4.9	Automated (AI) Laser Power Adjustments	58
<b>5.</b>	<b>3V-CPI 2D-S Real-Time Operation Troubleshooting</b>	<b>60</b>
5.1	Stuck Bits	60
5.2	No or Loss of Response from the Probe	63
5.3	Distorted Images	63
5.4	Over Masking of Array Elements	63
<b>6.</b>	<b>Hawkeye Shutdown Procedure</b>	<b>64</b>
6.1	Disconnecting from the 3V-CPI Probe	64
6.2	Disconnecting from the 3V-CPI 2D-S Probe	65
6.3	Disconnecting from the FCDP	66
6.4	Shutting Down the System	67
<b>7.</b>	<b>Appendix – CPI INI Example</b>	<b>68</b>

## 1.0 Hawkeye Startup Procedure

1. On the computer desktop, double click the CPI, 2D-S, and FCDP icons to start each respective Graphical User Interface (GUI<sup>1</sup>).
2. After the programs have started, switch on both the FCDP and 3V-CPI sensor power switches on the front panel of the DAS (see Figure 2.3.2 in the Hawkeye Getting Started and Hardware Manual).

### 1.1 Connecting to the CPI probe

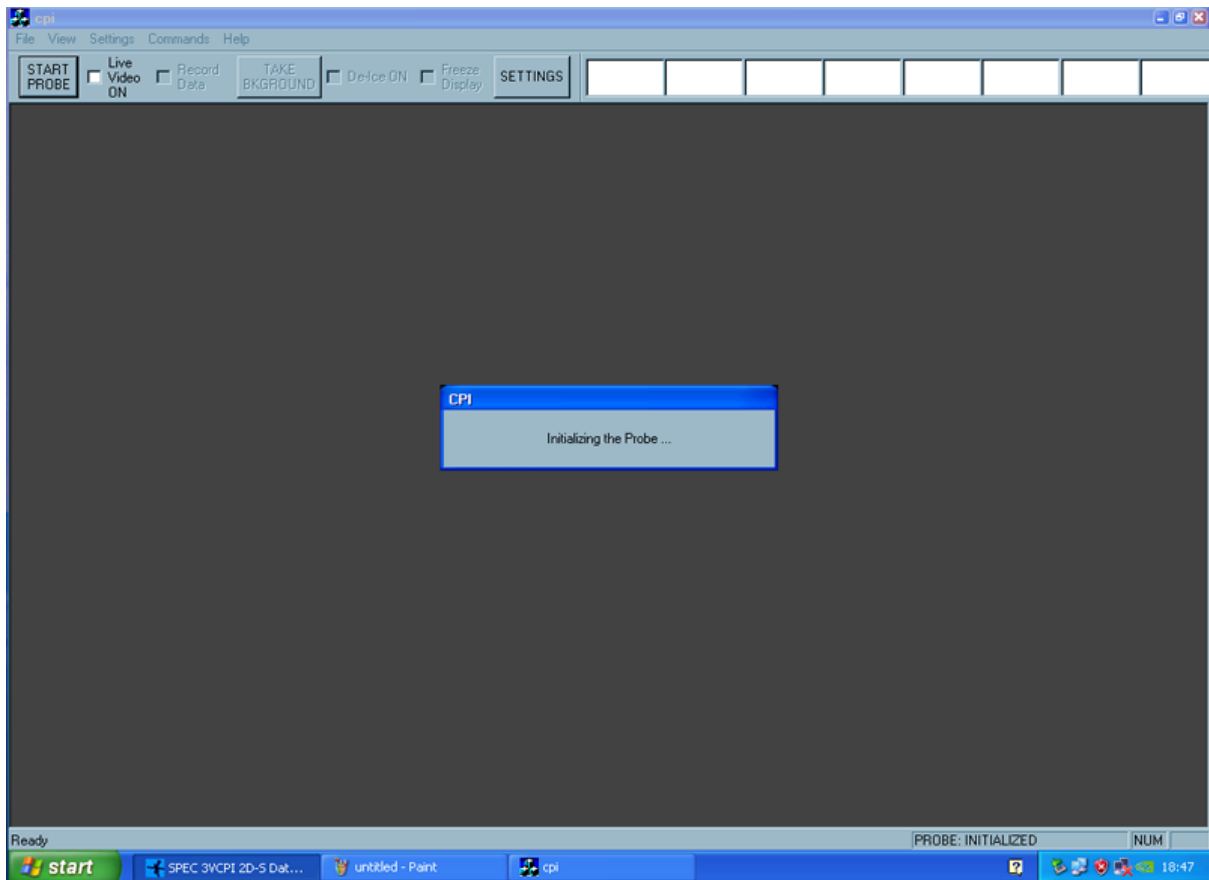
3. Single click the Start Probe button on the left side on the CPI GUI window (see Figure 1.1).



**Figure 1.1.** CPI GUI screen while it is allocating memory.

<sup>1</sup> Each GUI may run simultaneously and independently of each other.

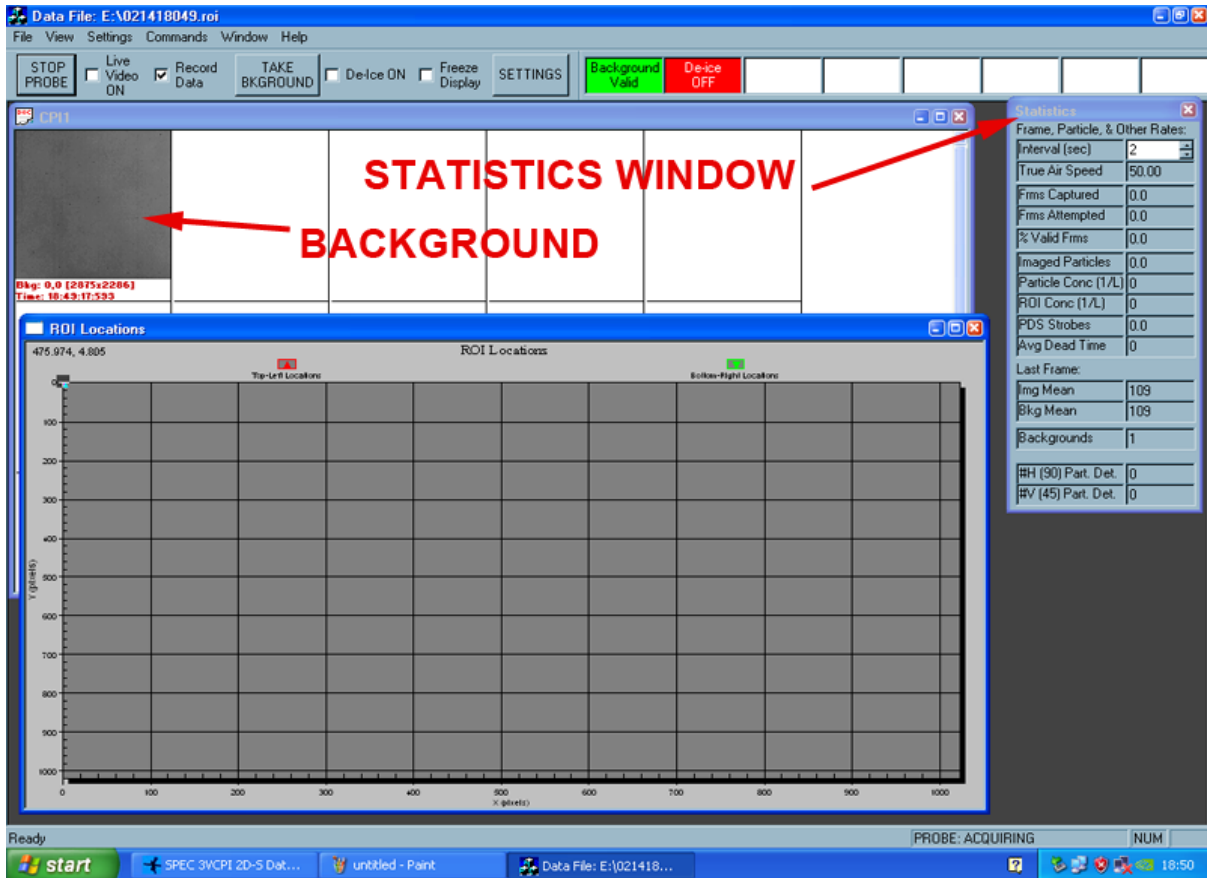
4. In the CPI GUI, you should see an “Allocating Memory” message as shown in **Figure 1.1**. This message indicates that the CPI GUI is allocating memory locally in the DAS computer. It is not yet trying to communicate with the probe (sensor head). Wait about forty seconds.
5. After about forty seconds, the message window should change to “Initializing the Probe...” as shown in **Figure 1.2**. In this step, the CPI GUI tries to communicate with the probe. If it is successful, it sets up probe operating values, receives data packets from the probe, directs the CCD camera to take two background images, and processes those images to establish a background reference for the probe’s imaging system.



**Figure 1.2.** CPI GUI screen while it is initializing the probe.

6. After about ten more seconds, you should see the CPI startup screen, as seen in **Figure 1.3**. This contains a particle image display window with at least one background image. You should see a “Statistics” window on the right-hand side of the screen. If you see a screen like **Figure 1.3**, then your Hawkeye has been started correctly and is running.

If you DO NOT see a screen like **Figure 1.3**, then the software or probe has a problem. Review the Hawkeye cable connection procedure and Hawkeye startup procedure to make sure that they were done correctly. If these procedures were followed correctly, then please see the “Real Time Operation and Troubleshooting, **Section 3.0**.”

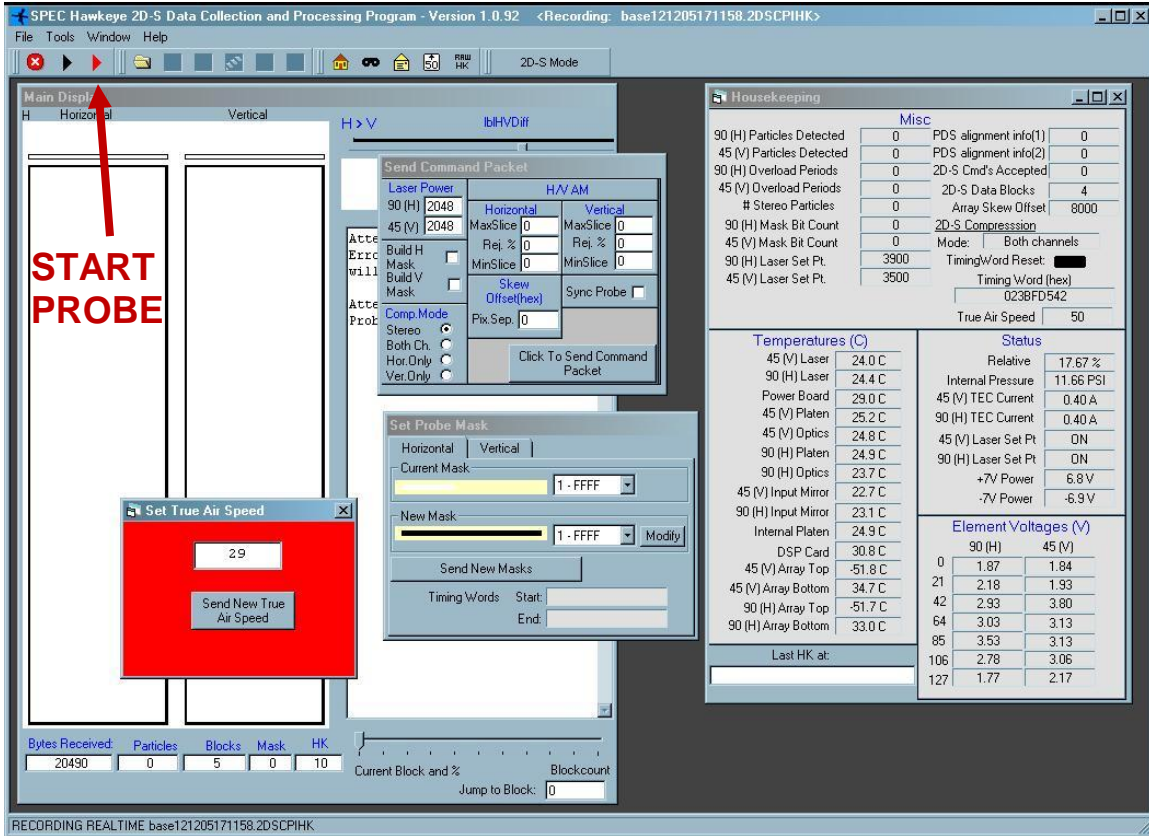


**Figure 1.3.** Startup screen of CPI GUI.

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## 1.2 Connecting to the 2D-S probe

- To initialize the connection between the 2D-S GUI and the probe, click the red arrow in the top left corner of the 2D-S GUI display window (**Figure 1.4**).



**Figure 1.4.** Startup screen for 2D-S GUI.

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### 1.3 Connecting to the FCDP

8. To initialize the connection between the FCDP GUI and the probe, click the green “Connect to Probe” button shown in **Figure 1.5**. This will connect and time sync the probe.
9. Once the network connection has been established, type `df -h /mnt/hda` in the “SSH Command Field”, then click the “Send String” button to check the amount of available flash disk space and ensure there is sufficient memory available for the next period of data collection.
10. Click the green “Start” button (may take around 60 seconds before the display updates).
11. The system is now ready for real-time operation.

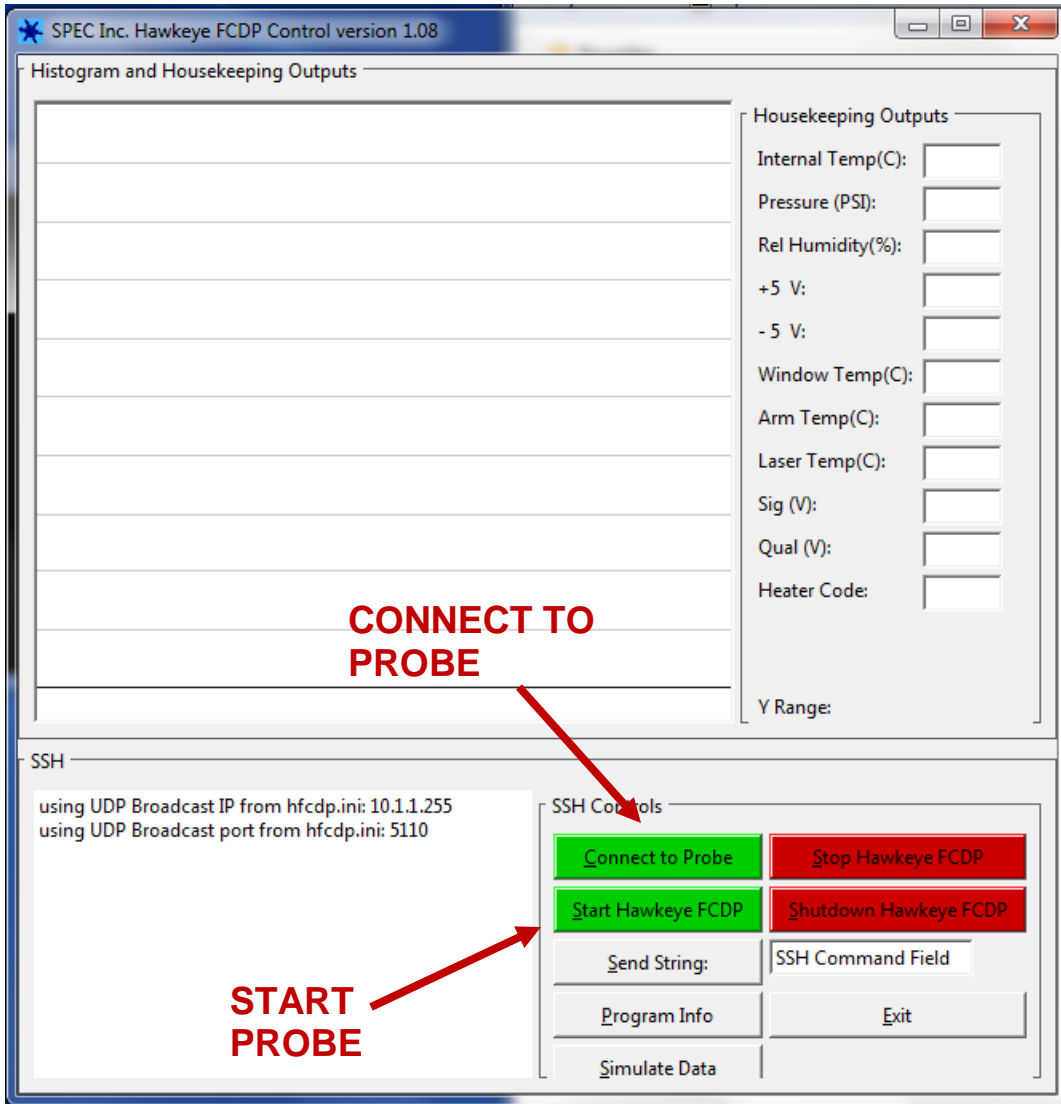


Figure 1.5. Startup screen for Hawkeye FCDP GUI.

## 2.0 3V-CPI, CPI Graphical User Interface

The SPEC 3V-CPI data acquisition system (DAS) and its settings are as important to the collection of high quality data as is the correct operation of the electronics. Were the electronics working perfectly but the GUI settings adjusted incorrectly, the instrument could go an entire flight collecting no useful images. Thus, a thorough understanding of the user adjustable operating parameters is a prerequisite to successful use of the 3V-CPI.

The parameters under user control fall into the following categories:

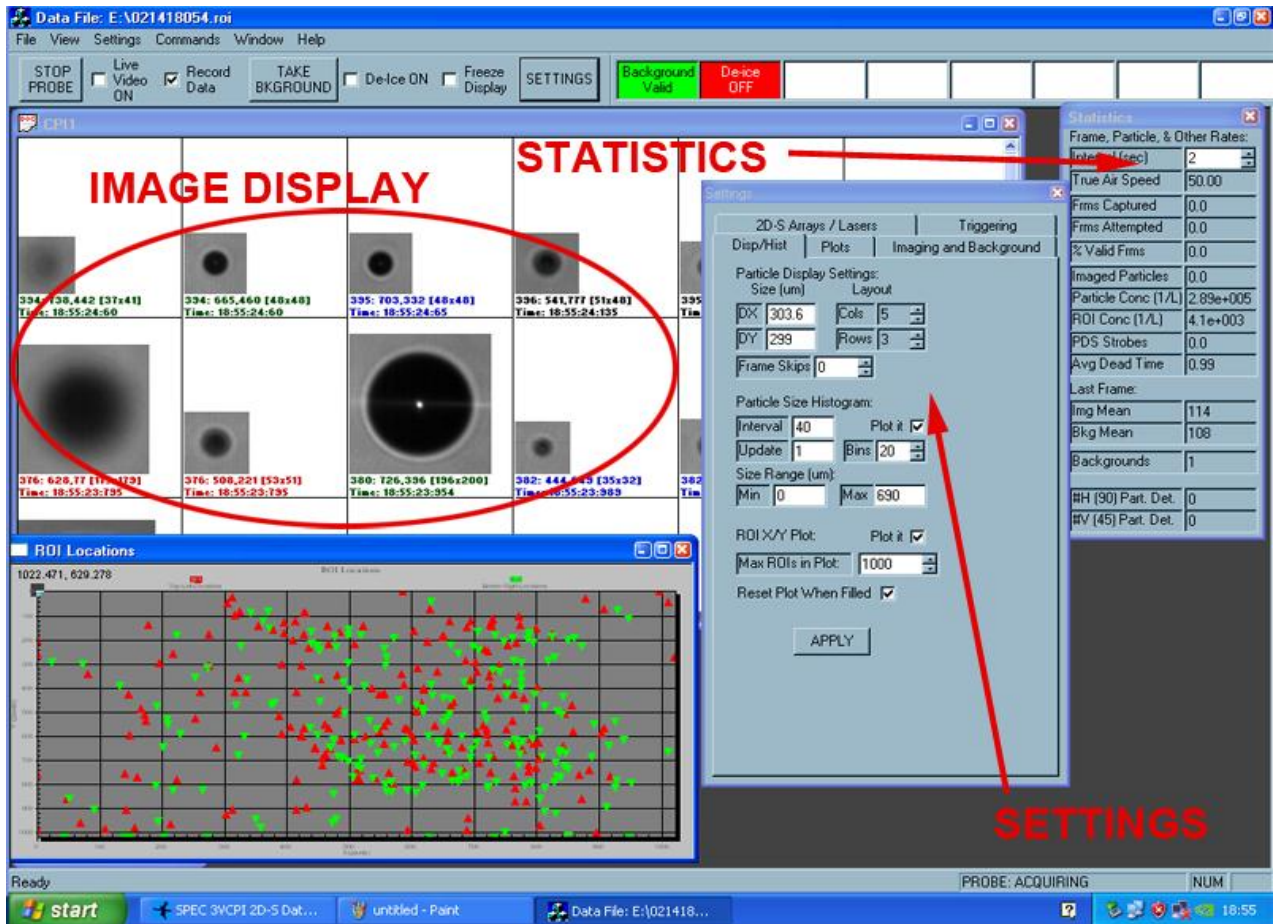
1. Particle detection system through 2D-S Array.
2. Image collection.
3. Probe thermal control.
4. Data acquisition system (DAS) display.

The first two categories affect how particle images are collected. These include items such as horizontal and vertical laser power settings and image mean minimums (to be discussed in the next section). The third category includes the temperature set points of various locations in the probe, as well as whether or not heaters should be automatically turned on if the temperature is below the set points in those regions. The fourth category doesn't affect the operation of the probe; the DAS display parameters only affect how information is presented to the user.

Each time the CPI GUI is started, the program retrieves information from the CPI.ini file. This file contains set points, set point limits, and warning limits for parameters in the first three categories, as well as other information of use to the program. This file is discussed in the next section.

**Figure 2.1** shows the CPI GUI running with an active probe. The very top line tells the user that the program is running with data recording set, so data is being written to file. The name of the file currently being written is also displayed here, along with the DAS time. The data file shown is E:\021418054.roi. On the right side of this line are the standard window controls: Hide, Minimize / Maximize, and Close.

The next line contains the menu items: File, View, Settings, Commands, Window and Help.



**Figure 2.1.** Screen shot of CPI GUI.

Next are the control buttons, check boxes, radio buttons and enunciator window items on a quick access line. From here the user may easily perform operations such as turn on and off the heaters (De-ice ON check box) or take a background. Users will find all of these commands in various sub-menus as well, but their location here provides easy access to these commonly accessed selections. The enunciator window indicates to the user that probe parameters are out of range (such as temperature readings) or other items that the user should be aware of and possibly take action on.

The image display section shown in **Figure 2.1** contains regions of interest (ROIs) cut outs. This is where particles will be displayed as they are processed by the DAS. The statistics and settings windows are another set of quick observation and control windows in which the user can view and control various parameters that are also available in other menus, but are easily accessed here. The settings window can be opened, (if not currently open), by clicking the “Settings” button on the quick access line discussed in the previous paragraph. The “Rates and Image Parameters” window plots various real time parameters to inform the user of

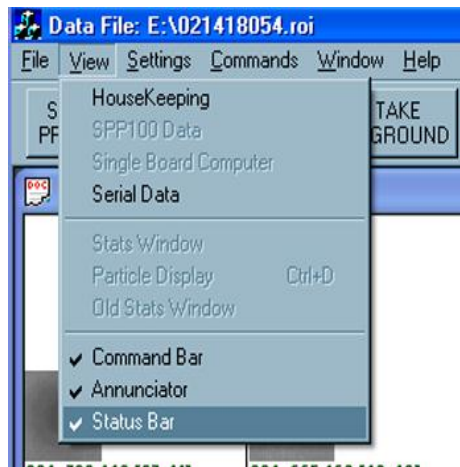
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probe performance, such as the displayed frames per second plotted in red, the percent of valid frames in green.

Detailed descriptions of all the data system menus and displays, including the above items, are given in the following sections. System menu windows will first be generally described; then the operation of the probe and DAS using the categories of parameters under user control will be detailed: PDS system, image collection system, probe thermal control and DAS display.

## 2.1 View Menu

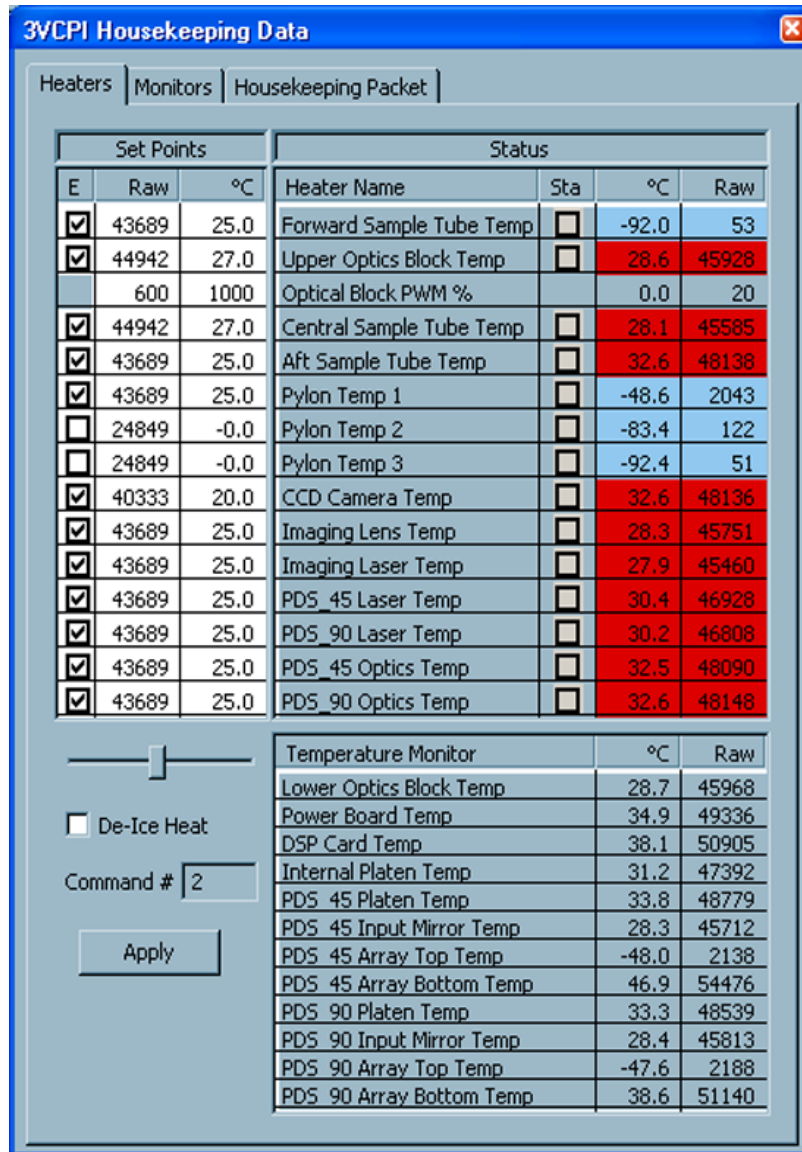
**Figure 2.2** shows a screen shot of the View menu. The “Housekeeping” and “Stats Window” selection items will be discussed in the following sections. The “SPP100 Data”, “Single Board Computer” and “Serial Data” selections are for customized use and not described in this manual. The other 5 items display or remove windows that will not be described but which the user may wish to experiment with by selecting and deselecting from this menu.



**Figure 2.2.** The View drop down menu used for selecting the Housekeeping window.

### 2.1.1 Housekeeping Window

Selecting the first item in the “View” menu opens the housekeeping window shown in **Figure 2.3**. Here, the user may observe all the measured parameters of the operating probe in one window. The housekeeping data is sent by the probe once per second, and is used to evaluate the status or “health” of the probe by monitoring such engineering parameters as internal temperatures, power supply voltages, pylon internal pressure, etc. Real-time values for laser powers and actively controlled temperature zones are also contained in the housekeeping data.



**Figure 2.3.** Housekeeping window, Heaters tab.

The first tab in the Housekeeping window, labeled "Heaters," shows the temperature of the monitors throughout the probe. This is also where the heaters are controlled. To activate the heaters, the user enables the "De-Ice Heat" button in the bottom left. In the top left section, labeled "Set Points," individual heaters can then be enabled (with their respective check box) and controlled (with their respective set point). The 3V-CPI sensor head will turn on heaters if any region is individually enabled and has a measured temperature less than its set point. The actual temperature of a region can be seen to the right in the "Status" section. The temperature and Raw will be highlighted in red if the temperature is above its Set Point for a region and it will be highlighted blue if the region is colder. In **Figure 2.3** the four regions

that are registering in the negatives have unconnected sensors. Pylon Temp 2 and 3 will never be active and are only for future expansion on the 3V-CPI sensor head. If a heater was on during the last second, the sensor head reports that this is the case and the corresponding radio button will be active (black) in the "Sta" column of the "Status" section. The column labeled "RAW" contains analog to digital (ADC) and digital to analog (DAC) converter values currently measured or set by the probe and DAS. The bottom right section shows the sensors that have no corresponding heaters. These should be monitored as well to make sure that there is no region widely out of sync with the rest of the sensor head.

Monitor	Converted	Raw
Probe Time	2/16 21:35:53	
True Air Speed (m/s)	50.00	
Internal Pressure (psi)	11.67	26951
Command #	1	
Relative Humidity (%)	18.41	18464
+7 V Monitor (V)	6.85	44914
-7 V Monitor (V)	6.76	30333
PDS 45 TEC Current (amps)	0.398	7880
PDS 90 TEC Current (amps)	0.399	7904
Number of Horz detected particles	0	0
Number of Vert detected particles	0	0
Number of Stereo detected particles	0	0
Dead Time	37	37
CPI Commands Accepted	1	1

**Figure 2.4.** Housekeeping window, Monitors tab.

The reported values under the Monitors tab, **Figure 2.4**, include the time reported by the probe when it sent its most recent housekeeping information; the True Air Speed, which is controlled through the 2D-S GUI; the internal pressure; the command number, which should increment every time probe operating commands are sent from the DAS to the sensor head; the relative humidity; the +/- 7 V Monitor, which should be about +/- 7 V; the current running to both the horizontal and vertical lasers (PDS 90 and PDS 45); the number of particles detected; the dead time, which is the amount of time during which the probe was processing a particle's image data and therefore could not acquire a subsequent particle image, if present; and the number of CPI Commands Accepted.



Word	Value	Raw	Converted
2	Packet Length	0x53	83
3	Forward Sample Tube Temp	0x33	-92.3856 °C
4	Upper Optics Block Temp	0xb814	30.7157 °C
5	Lower Optics Block Temp	0xb7f0	30.6517 °C
6	Central Sample Tube Temp	0xb505	29.3446 °C
7	Aft Sample Tube Temp	0xbd91	33.299 °C
8	Pylon Temp 1	0x7d7	-48.8668 °C
9	Pylon Temp 2	0x8f	-81.6918 °C
10	Pylon Temp 3	0x34	-92.1929 °C
11	CCD Camera Temp	0xbd88	33.2819 °C
12	Imaging Lens Temp	0xb561	29.5034 °C
13	Imaging Laser Temp	0xb513	29.3687 °C
14	PDS 45 Laser Temp	0xb965	31.3202 °C
15	PDS 90 Laser Temp	0xb8dc	31.0734 °C
16	Power Board Temp	0xc280	35.7787 °C
17	PDS 45 Platen Temp	0xc0d4	34.9198 °C
18	PDS 45 Optics Temp	0xbdcc	33.4113 °C
19	PDS 90 Platen Temp	0xbf90	34.2826 °C
20	PDS 90 Optics Temp	0xbe98	33.8021 °C
21	PDS 45 Input Mirror Temp	0xb738	30.3259 °C
22	PDS 90 Input Mirror Temp	0xb788	30.4672 °C
23	Internal Platen Temp	0xbaf4	32.0479 °C
24	DSP Card Temp	0xc8b0	39.1468 °C
25	PDS 45 Array Top Temp	0x849	-48.0679 °C
26	PDS 45 Array Bottom Temp	0xd4bd	46.8435 °C
27	PDS 90 Array Top Temp	0x877	-47.756 °C
28	PDS 90 Array Bottom Temp	0xc8d0	39.2183 °C
29	Relative Humidity	0x4820	18.415 %
30	Internal Pressure	0x6947	11.6715 psi
31	PDS 45 TEC Current	0x1ec8	0.397924 ...
32	PDS 90 TEC Current	0x1ee0	0.399136 ...
33	PDS 45 Laser On	0x22b8	0.678101 V
34	PDS 90 Laser On	0x229c	0.675965 V
35	+/- 7 V Monitor	0x-f72	6.98224 V

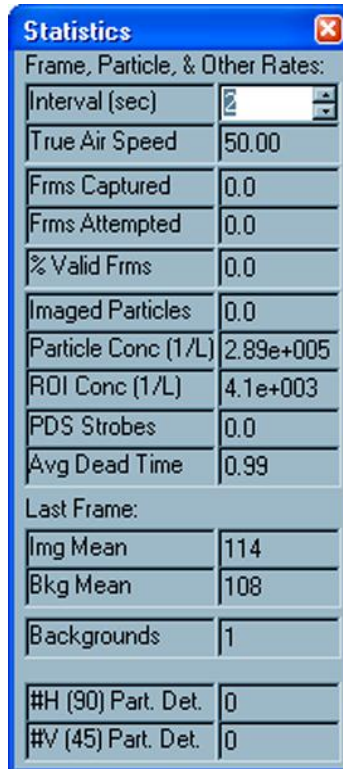
**Figure 2.5.** Housekeeping window, Housekeeping packets tab.



**Figure 2.5** shows the Housekeeping Packet Tab. This is the housekeeping data that is being directly received from the 3V-CPI sensor head.

### 2.1.2 Stats Window

Selecting “Stats Window” in the “View” menu opens the statistics window shown in **Figure 2.6**. This window contains a set of parameters of interest to the user.



Statistics	
Frame, Particle, & Other Rates:	
Interval (sec)	2
True Air Speed	50.00
Frms Captured	0.0
Frms Attempted	0.0
% Valid Frms	0.0
Imaged Particles	0.0
Particle Conc (1/L)	2.89e+005
ROI Conc (1/L)	4.1e+003
PDS Strokes	0.0
Avg Dead Time	0.99
Last Frame:	
Img Mean	114
Bkg Mean	108
Backgrounds	1
#H (90) Part. Det.	0
#V (45) Part. Det.	0

**Figure 2.6.** Statistics window.

Items in the section of the statistics window labeled “Last Frame” are discussed in **Section 2.4**, which covers image collection control and monitoring.

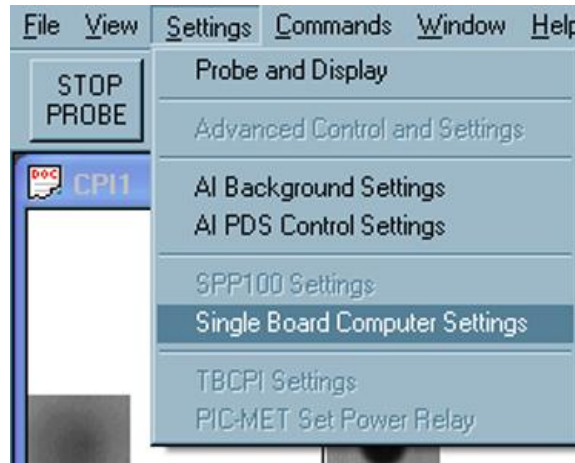
The items in the upper portion of the window are updated at the user selected interval, in seconds which is the first item in the “Frame, Particle, and Other Rates” section. The user also enters air speed here in meters per second, for use in deriving parameters such as particle concentrations. The true air speed has no other function and entering values that do not match the speed of the craft on which the CPI is located will not affect its operation.

The “Frms Captured”, “Frms Attempted” and “% Valid Frms” fields refer to the number of image frames the DAS has received in the last “Interval” period in which a valid ROI was found, the number of frames total received in the same period (with and without ROIs), and

the percentage of valid frames, equal to (frames captured / frames attempted) x 100%, respectively. Imaged particles are the number of ROIs found during the interval. “Particle Conc” is a rough approximation of derived particle concentration and “ROI Conc” is the derived number of ROIs in the last interval period, given in units of number per liter. Note these two values (“Particle Conc” and “ROI Conc”) should not be used; they do not represent actual concentrations! “PDS strobes” is the number of times the PDS system has seen a qualified particle pass through the sample volume during the interval, and “Average Dead Time” is the time, in seconds, summed over the interval that the sensor head was busy processing a current particle and thus unable to image subsequent particles.

## 2.2 Settings Menu

The settings menu is shown in **Figure 2.7** below. The “Probe and Display” selection brings up the window labeled “Settings” in **Figure 2.8**. The “Settings” window provides easy access to many parameters that are also found, but with more searching required, in the “housekeeping” and “advanced control and settings” windows discussed elsewhere.

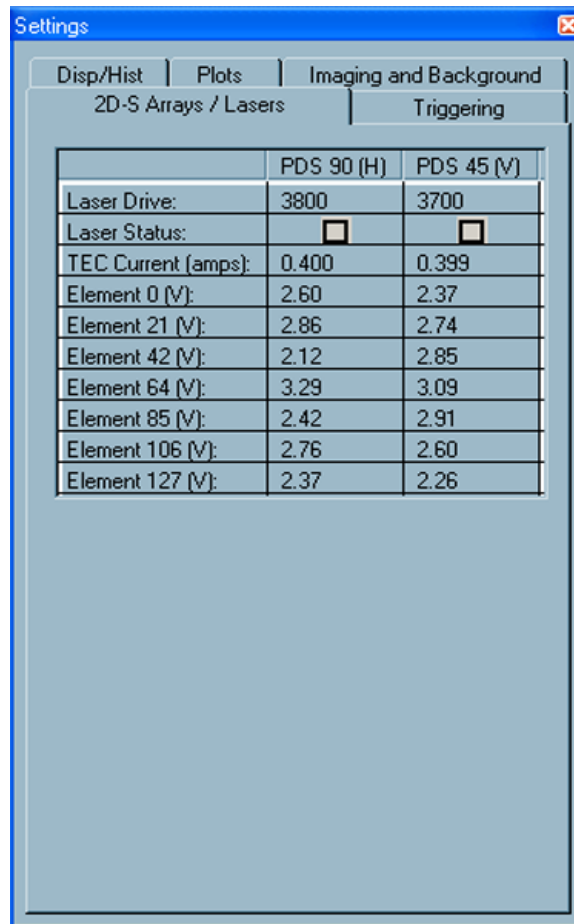


**Figure 2.7.** The Settings Menu

## 2.3 2D-S Control and Monitoring

### 2.3.1 2D-S Laser Power and DC Level

The 2D-S monitors are contained within the 2D-S Arrays/Lasers tab of the Settings menu. Here, the laser drive and elemental voltages for both the horizontal and vertical channels can be seen. Each channel receives voltages from 128 elements located in series on the array board. This menu shows voltages from seven elements representing a uniformly spaced sample of voltages across the array. If the array board is properly illuminated the voltages will peak in the middle elements and be in the range of 1.4V to 3.7V. Low voltage levels may indicate contamination on the windows of the PDS system, requiring cleaning of the windows, or may indicate low laser drive. If the laser drivers need to be adjusted this can be done in the 2D-S GUI, as described in **Section 2.3**.

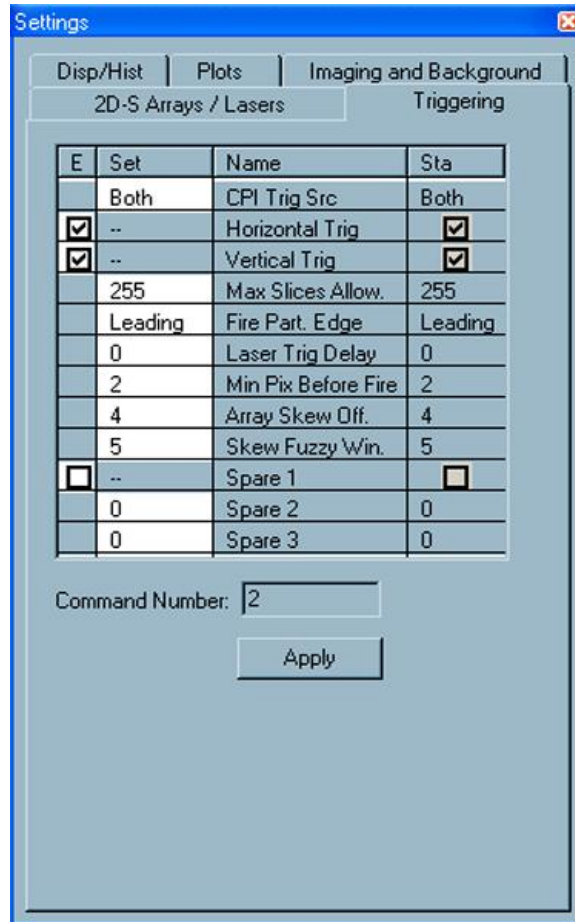


	PDS 90 (H)	PDS 45 (V)
Laser Drive:	3800	3700
Laser Status:	<input type="checkbox"/>	<input type="checkbox"/>
TEC Current (amps):	0.400	0.399
Element 0 (V):	2.60	2.37
Element 21 (V):	2.86	2.74
Element 42 (V):	2.12	2.85
Element 64 (V):	3.29	3.09
Element 85 (V):	2.42	2.91
Element 106 (V):	2.76	2.60
Element 127 (V):	2.37	2.26

**Figure 2.8.** 2D-S Arrays/Lasers tab of the Settings window.

### 2.3.2 3V-CPI Triggering

Combining the 2D-S capabilities with the CPI makes imaging of selective particle sizes possible. This is controlled in the “Triggering” tab of the Settings window, shown in **Figure 2.9**. Options are set in the left hand column and the current status of the Imaging System settings is displayed in the right column.



**Figure 2.9.** Triggering tab of the Settings window.

The first field of the Triggering tab, “*CPI Trig Src*” designates which component of the 3V-CPI controls the triggering. This can be either the DSP, PDS, DAS, or both the PDS and DAS (as pictured in **Figure 2.9**). It is required that “Both” be selected for normal probe operation. The other three settings are used for troubleshooting. The horizontal and vertical channels can be individually selected to trigger the CPI imaging system by using the buttons next to “*Horizontal Trig*” and “*Vertical Trig*”. Normally, both channels are used for triggering (as seen in **Figure 2.9**, with both horizontal and vertical checked). However, the user can select to just have one channel trigger the imaging system. Doing so would result in a lower number of percent valid frames, since it is possible that particles outside of the

imaging systems field of view trigger the system. Each channel that is currently used for triggering will have a checked box on the right.

The next four rows of the menu control what particle size triggers the Imaging System along with when the system is triggered. The first row, "**Max Slices Allow**", sets the maximum particle size that will trigger the imaging system. A slice corresponds to one pixel, 10 microns, in the time dimension of the stereo particle channels. If no maximum limit is desired, then this field is set to 255 as in **Figure 2.9**. A setting of 254 corresponds to 2.54 millimeters, and a setting of 3 corresponds to 30 micrometers. The "**Fire Part. Edge**" field controls whether the imaging system is fired at the leading or trailing edge of the captured particles. If the user wishes to have a maximum limit on particles being imaged, the trailing option must be selected. If not, all particles meeting the minimum pixel requirement will be imaged. The next field, "**Laser Trigger Delay**", is the pixel delay between stereo particle recognition and the firing of the imaging laser (flash bulb). The units are in the time-dimension as well, corresponding to one slice, or 10 microns. The **Laser Trigger Delay** is set during calibration at the time of manufacture, and generally does not need to be adjusted. The typical setting is between 1 and 10. Settings of up to 1000 are allowed for the **Laser Trigger Delay**, but such a large value could cause the probe not to image particles correctly or at all. In the "**Min Pix Before Fire**" field, pix refers to pixels or time-dimensional slices. When set at "2" and the system is in the "Leading" option, as in **Figure 2.9**, the system triggers when the selected stereo particle channels register a 20 micron (2 pixels) particle in the time-dimension. If the "Trailing" option is selected, the system takes into account all particles that are 20 microns or larger and triggers at the trailing edge if they are under the maximum slice limit.

The next two fields in the Triggering Menu account for any error between the horizontal and vertical channels. The "**Array Skew Off**" field controls the offset between the two channels in 10 micron units. This will correct one channel triggering the system before the other because of slight misalignments, electronics, etc. There can also be slight error if the two stereo particle channels are skewed slightly and not perfectly orthogonal to each other. This error could cause particles to be recognized by one channel before the other in one quadrant and the opposite in another. This error is account for with the "**Skew Fuzzy Win**" field. By entering a value for slices in this field, the skew or angle of the channels is accounted for. The values in both of these fields are set during calibration at the time of manufacture, and generally do not need to be adjusted. These values are generally between 0 and 5.

The three Spare fields are currently inactive, and are reserved for future development.

## 2.4 Image Collection Control and Monitoring

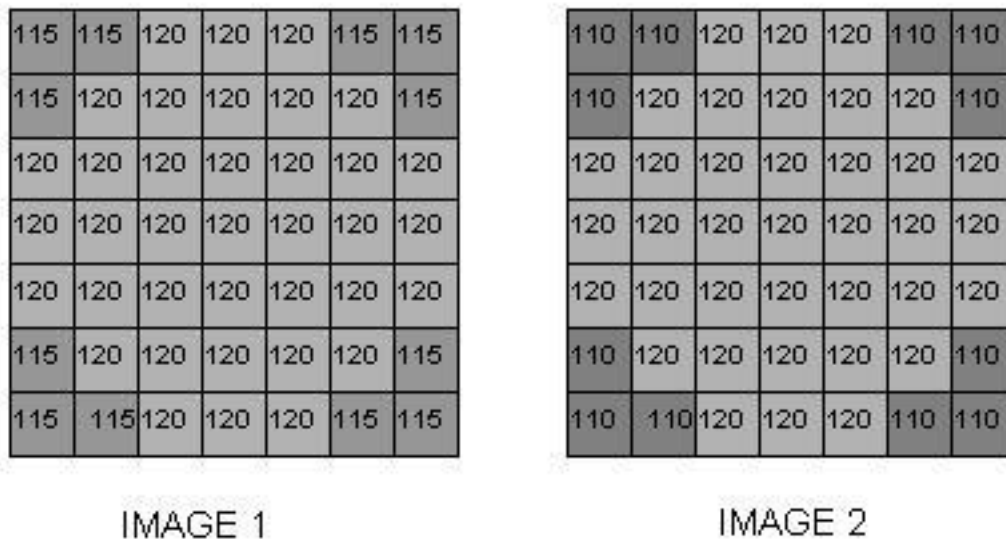
The image processing performed by the DAS is critical in achieving maximum probe performance. Just as poor settings in the 2D-S Array system can cause the probe to receive no images, so can poor settings in the image processing setup parameters cause the probe to process no images, even in the presence of high concentrations of particles.

The DAS takes several steps in order to process images. First it takes a background image: a frame from the CCD camera with no particles present. Then, when received camera frames arrive, which can happen up to 400 times per second—the DAS checks the 2D-S Array Status bit to see if the imaging laser was fired during this frame's exposure period. If it was, the DAS subtracts the frame from the stored background image (pixel by pixel subtraction), and performs a search algorithm to determine if a particle or particles is/are present in the frame and cuts it/them out into ROIs.

The parameters affecting this process are discussed in the next sections.

### 2.4.1 Imaging and Background

Two parameters define the recognition of a particle within a frame: particle threshold and minimum size (pixels). The role of these parameters will first be discussed in explaining how a background image is taken.



**Figure 2.10** Representation of two 7 x 7 CCD camera images.

When the DAS is ready to take a background, it waits until there are fewer than “*Strobes Threshold*” image frames per second that have an associated PDS STATUS (2D-S Array Status) bit high. The PDS STATUS bit indicates the presence of sensed particles. When there are fewer than “*Strobes Threshold*” image frames per second that have an associated PDS STATUS bit high a signal called EXTRIG from the frame grabber, under DAS control, is pulsed once per image frame period, forcing the digital logic system on the sensor head to fire the imaging laser. Two frames are thus generated, a depiction of which is shown in **Figure 2.10**. The two image examples are only 7 x 7 pixels, but the actual CCD camera sends over 1024 x 1024 pixel images—though the camera is capable of 1280 x 1024. To check for a valid background image (the camera will use IMAGE 1 as the background if the process qualifies it), the DAS performs a pixel by pixel subtraction of the two images. The result is shown in **Figure 2.11**.

5	5	0	0	0	5	5
5	0	0	0	0	0	5
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
5	0	0	0	0	0	5
5	5	0	0	0	5	5

SUBTRACTION RESULT

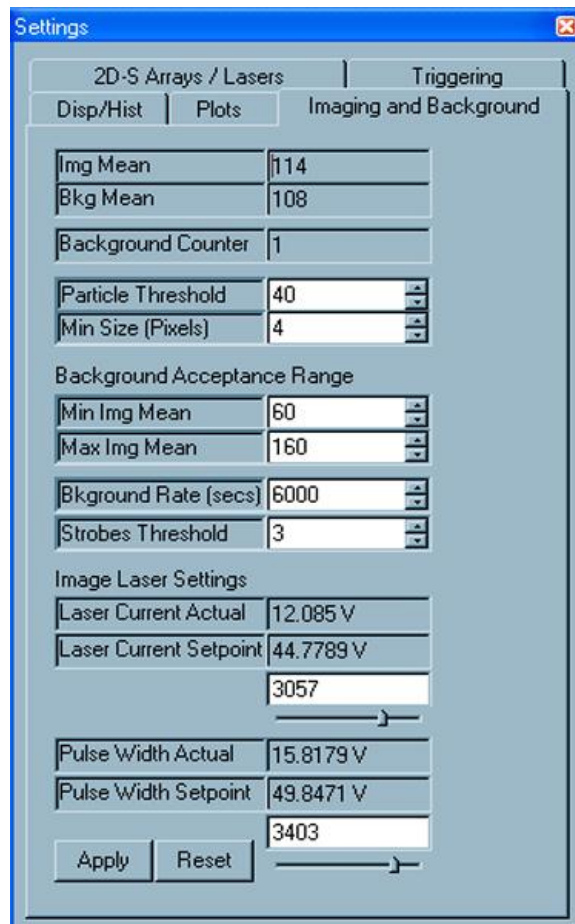
**Figure 2.11** Result of background subtraction applied to images of **Figure 2.10**.

The DAS now checks each pixel value in the subtracted image to see if it is greater than the current “*Particle Threshold*” value divided by three (backgrounds are more strictly tested than when testing for particles, described later). Thus, if the particle threshold were set to 15 by the user, the corner pixels, with value of 5, would meet or exceed the  $15 / 3 = 5$  threshold used for backgrounds. In that case the DAS would check to see if there are equal to or greater than the “*Minimum Pixel Size*” number of pixels collocated that meet or exceed the pixel threshold just described. If the minimum pixel size were set to three, then the above attempt at a background would fail. In that case, the DAS would generate two more EXTRIG signals and perform the background test algorithm just described on two new images. However, if either the particle threshold were raised to 16 or greater, or the minimum pixel size were raised to 4 or greater, the above two images would be considered a valid background. Two realistic values for these parameters are 36 for the particle threshold

and 4 for the minimum pixel size. Using these values, IMAGE 1 would possibly be accepted as a valid background.

Once it is determined there are no particles in the potential background image, the average of the pixel values is taken. For IMAGE 1, the value would be 118.8. This value is then compared with an acceptable range entered by the user: “*Min Img Mean*” and “*Max Img Mean*”. **Figure 2.12** shows these parameters entered in the “Imaging and Background” tab.

The parameters Particle Threshold, Minimum Pixel Size, Strobes Threshold, Minimum and Maximum Image Mean, and Background Rate are readily changed in the “Imaging and Background” tab of the “Settings” window, shown in **Figure 2.12**.



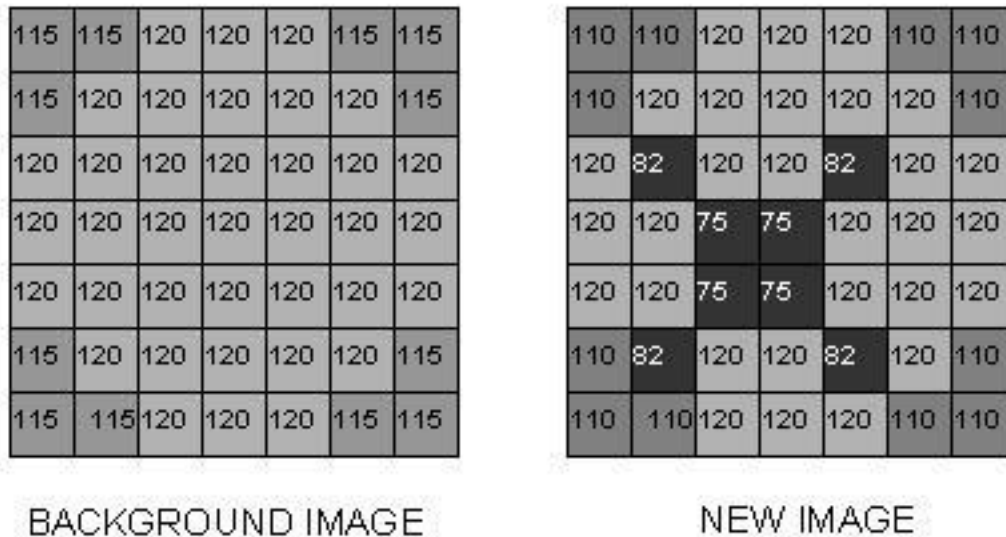
**Figure 2.12** Imaging and Background tab of the Settings window.



Background images are taken almost immediately after the probe is started. No particle images are processed until a valid background is acquired, apparent to the user via a green enunciator declaring “**Background Valid**”. The probe also takes backgrounds at regular intervals, the period of which is set by the user. If the DAS fails to get a valid background in a reasonable amount of time, the enunciator panel displays a red warning of “**Background Failed**”. If the DAS has just started communicating with the sensor head, too many repeated failed attempts to acquire a background will cause the program to stop communications with the sensor head. These failures and others, and their solutions, will be explained in “Real Time Operation and Troubleshooting”, **Section 3.0**.

### 2.4.2 Particle Collection and Associated Controls

The process of searching for particles in an image frame is much like the process for acquiring a background image. The new image (with valid PDS STATUS bit set) is subtracted from the background image and the difference image, referred to as a background subtracted image, is searched for pixels below the particle threshold. An example of the background image (IMAGE 1 taken from **Figure 2.10**), and an image with a potential particle are shown in **Figure 2.13**. **Figure 2.14** shows the background subtracted image.



**Figure 2.13.** Background image and new CCD camera image for particle extraction example.

5	5	0	0	0	5	5
5	0	0	0	0	0	5
0	38	0	0	38	0	0
0	0	45	45	0	0	0
0	0	45	45	0	0	0
5	38	0	0	38	0	5
5	5	0	0	0	5	5

SUBTRACTION RESULT

**Figure 2.14.** Result of background subtraction on images of **Figure 2.13**.

The DAS looks through the background subtracted image and compares the values, such as those shown in **Figure 2.14**, with the particle threshold parameter. With the particle threshold at 40, only four pixels in the image are considered as shadowed due to a particle. If the particle threshold were lowered to 38, the DAS would recognize eight shadowed pixels. The number of collocated pixels is then compared to the minimum pixel size parameter. The value of four for this parameter means that this particle is accepted as an ROI and stored to the current data file (as long as recording is enabled).

Other parameters under user control affect how a recognized ROI is stored. The “ROI X Pad” and “ROI Y Pad” fields, both set to 6 in **Figure 2.12**, tell the DAS to include six pixels to the left and right and six pixels above and below a rectangle that encompasses all recognized shadow pixels (as described in the previous paragraph) when saving the ROI image to file.

### 2.4.3 Image and Background Mean Settings

Because the CCD camera’s active area is unlit, except by the flash of the imaging laser, it is the total incident light energy of this pulse that must be adjusted to change the image brightness and mean. This is important, because if an image is too bright or too dark, it may not respond linearly to the occultation of the laser by passing particles, and sensed particles may not be correctly imaged.

The amount of light reaching the camera (and therefore the brightness of the captured images) is set by changing two imaging laser parameters: “*Laser Current Setpoint*” and

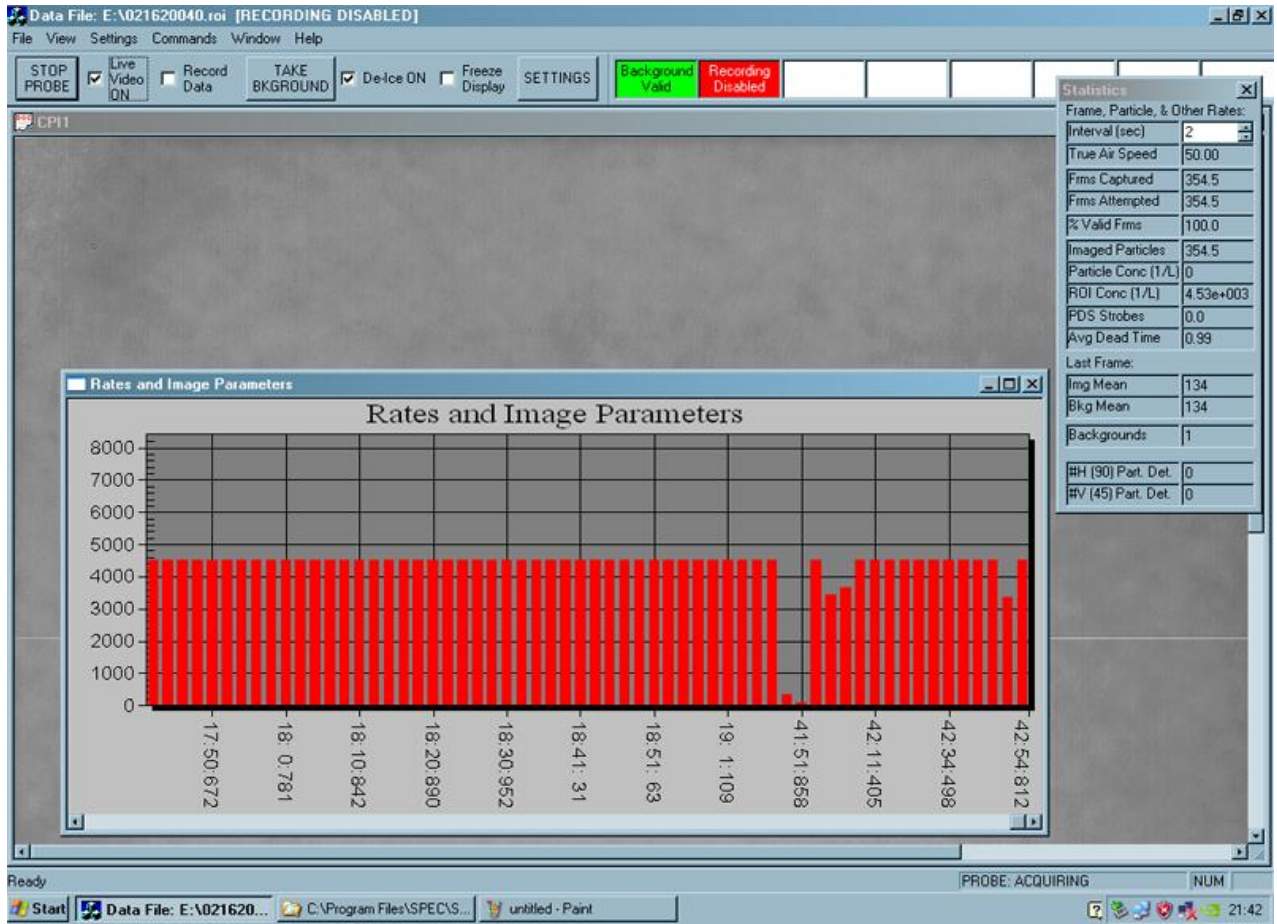
“*Pulse Width Setpoint*”. These parameters are accessed via the “Imaging and Background” tab of the “Settings” window shown in **Figure 2.12**.

**Generally, the DAS is set to run the imaging laser current at a safe maximum when the 3V-CPI is manufactured, and users should need change only the laser pulse width.** The laser power is approximately constant, but for a duration controlled by the “*Pulse Width Setpoint*” parameter. The parameter is given in Voltage units, but the maximum Voltage corresponds to approximately 40 nS (this varies slightly from instrument to instrument). Setting a lower applied Voltage decreases the time the laser is on when it pulses, thus lowering the amount of light to the CCD camera, and lowering the image mean.

#### 2.4.4 Live Video Mode

To adjust the image mean in real time, the user can check the “Live Video On” check box shown in the upper left of **Figure 2.1**, in the main screen. **It is best to run live video with recording disabled, as approximately 400 full images of one Megabyte will be saved to hard disk each second if recording is active.** Live Video Mode is very useful for troubleshooting any image system problems. Once live video is turned on, the image display will look like **Figure 2.15**. A full frame (1024 x 1024) image of the entire CCD camera (though for most CRT and LCD computer monitors, only a fraction of the total image may be seen; move the scroll bars for the image display area to view different portions of the CCD image) will be displayed. A red “*Live Video On*” message will display in the enunciator panel to indicate live video has been selected. The Rates and Image Parameters window (see **Section 2.5**) will show the attempted frames per second at 400 and the % valid images at 100%. The values in the rates and image parameters window will update at the selected update interval.

The image mean will be updated in real time in the “Img Mean” field of the Imaging and Background tab of the Settings window of **Figure 2.12**. While running live video, adjustment of the imaging laser current pulse width (remember to click the “Apply” button) will change the image brightness displayed and reported. Once the image mean is at a desirable value—e.g. somewhere between 100 and 150, though this is different for each probe—turn off live video by unchecking the “Live Video” box. **A new background should be taken immediately after any changes are made to the imaging laser set points.** If not, the background subtraction will now have a large offset due to the changed image mean, causing the particle processing algorithm to work poorly or not at all.



**Figure 2.15.** CPI GUI window and Rates and Image parameters window in Live Video mode

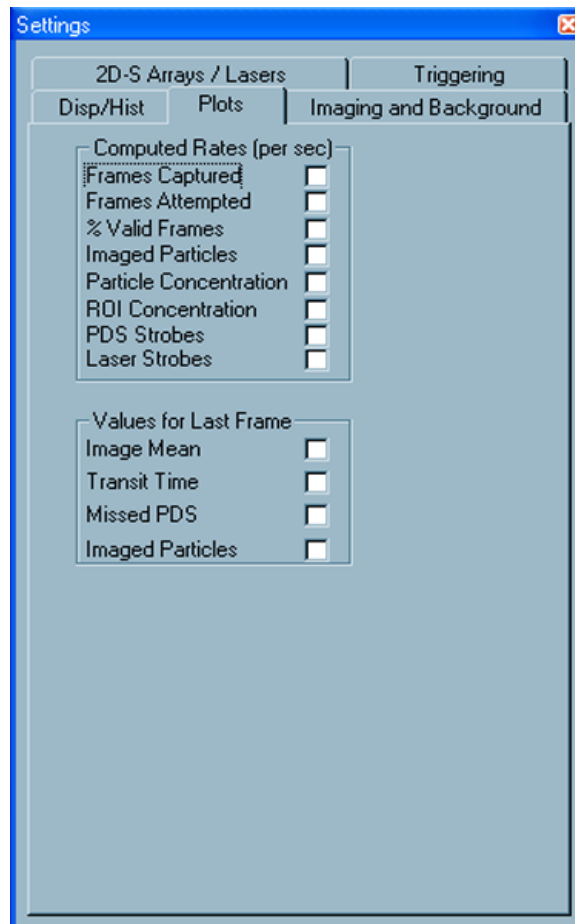
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## 2.5 Display Options

Aside from the displays previously discussed, some derived parameters, size histograms, and ways of examining and storing particle images are available to the user.

### 2.5.1 Rates and Image Parameters

Some of these were seen in **Figure 2.1**. More are available to the user via the “Settings” window in the “Plots” tab, shown in **Figure 2.16**.



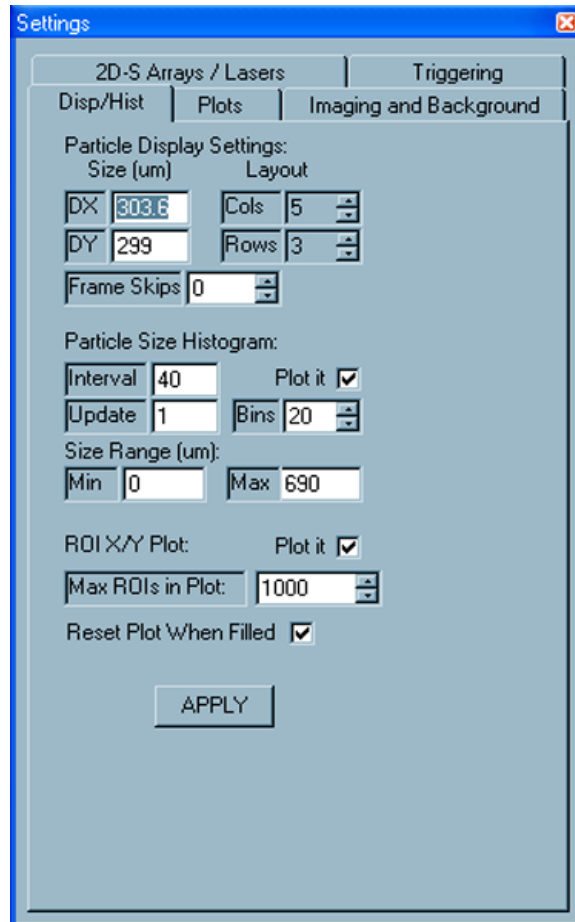
**Figure 2.16.** Plots tab of the Settings window for selecting items to display in the Rates and Image Parameters plot.

A short description of each item available for plotting follows:

1. Frames Captured: The number of frames in which the DAS found particles and cut out ROIs.
2. Frames Attempted: The number of frames the DAS searched for particles due to correlated PDS STATUS bit set.
3. % Valid Frames:  $\text{Frames Captured} / \text{Frames Attempted} \times 100\%$
4. Imaged Particles: The number of ROIs cut out from searched image frames.
5. Particle Concentration: An estimate of the number of particles per liter based on the air speed ROI Concentration: **(This number is only for reference- It should not be used or reported!)**
6. PDS Strokes: Total number of transit time qualified particles sensed.
7. Laser Strokes: The number of times the imaging laser was fired in an attempt to image a sensed particle.
8. Image Mean: The mean of the last processed frame.
9. Transit Time: Interval during which the particle was in both PDS beams.
10. Missed PDS: TBD
11. Imaged Particles: The number of ROIs found in the last processed frame.

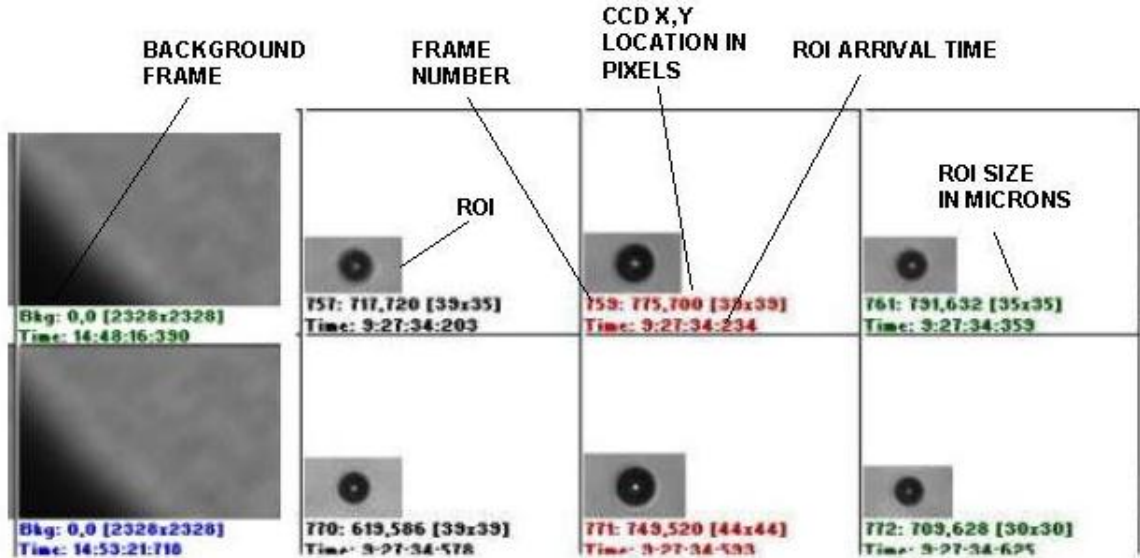
### 2.5.2 Displays, Histograms and ROI X/Y Plots

The last tab available in the “Settings Window” is the “Disp/Hist” tab shown in **Figure 2.17**. Under the label “Layout”, the number of columns and rows for displaying particle images is selected. Shown in **Figure 2.17** is Cols = 5 and Rows = 4. This corresponds to the number of available ROI display boxes in the “Image Display” section of **Figure 2.1**. Each box will display a single ROI when particles are successfully imaged. When changing the number of columns and rows, the size of the ROI display boxes is changed in the “**DX**” and “**DY**” fields, corresponding to the size of an image (in microns) that will fit in the ROI box. Not all DX and DY values will work for a given set of column and row numbers, so experimentation is required.



**Figure 2.17.** Disp/Hist tab of the Settings window.

A close up of eight ROI display boxes is shown in **Figure 2.18**. Beneath each ROI box is the x and y location on the CCD in pixels of the ROI, the total size of the ROI in the box in microns, including the pad (not the total size displayed, which is DX and DY above), and the time the ROI was captured. If more than one ROI is captured in a single frame, ROI display boxes will be plotted one after the other with the x and y location, total size of the ROI, and the time displayed in the same color descriptions to give the user a visual cue that this has occurred. The color of each sequential frame alternates. In the example of **Figure 2.18**, some displayed ROIs are portions of a background, as identified by the reported “Bkg:” information, otherwise the frame number is displayed. Skips in the frame number are a result of no ROI’s found in the frames skipped.



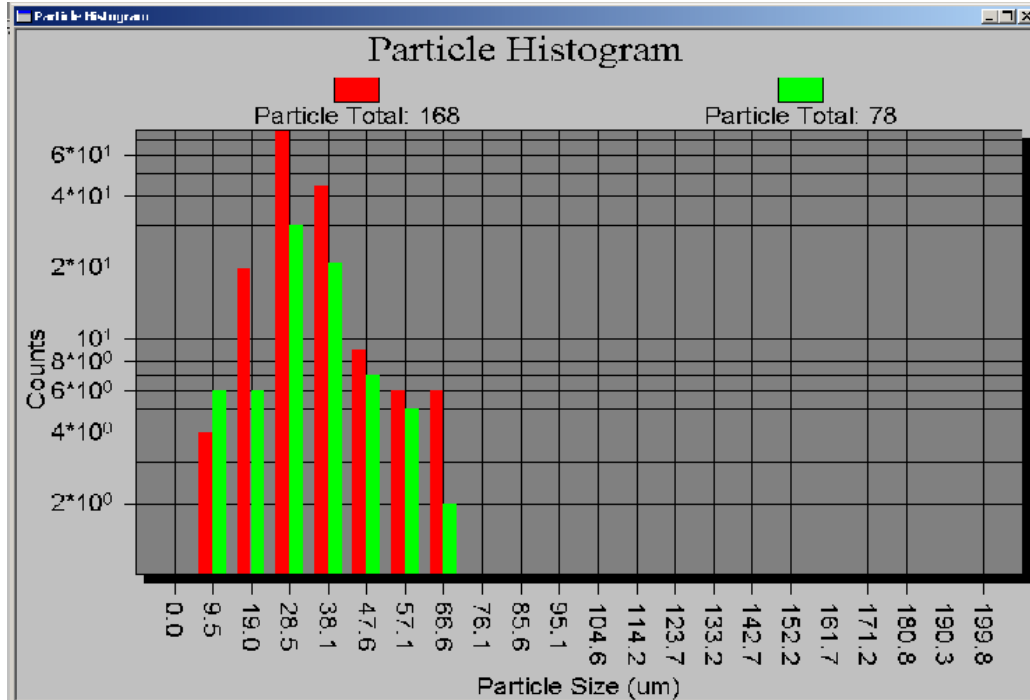
**Figure 2.18.** Close up of ROI display boxes.

The second set of controls in **Figure 2.17** is for the “Particle Size Histogram” display. The histogram plots the number of particles in a given size bin against a number of size bins chosen by the user, as seen in **Figure 2.19**. If the “Plot it” box is checked, the histogram will activate the first time a ROI is found. The particle size range and the number of bins are entered in the “Settings” “Disp/Hist” window in the “*Min*” and “*Max*” size bin text boxes and in the “*Bins*” selection box.

The histogram plot uses two colors, red and green, in plotting. The two are plotted alternately in order to contrast current measurements with past measurements. Two other parameters in **Figure 2.17**, “Interval” and “Update”, affect how often the current color is updated (update) and for how long each color is plotted (interval). For example, if update is 1 sec, and interval is 5 sec, every 1 sec the histogram will update and every 5 sec the counting will alternate between green and red. If update is 5 sec and interval is 20, there will be 4 updates between red and green changing.

To remove the histogram display, either click on the minimize button in the upper right of the histogram window, or uncheck the “Plot it” box in the “Settings” window.

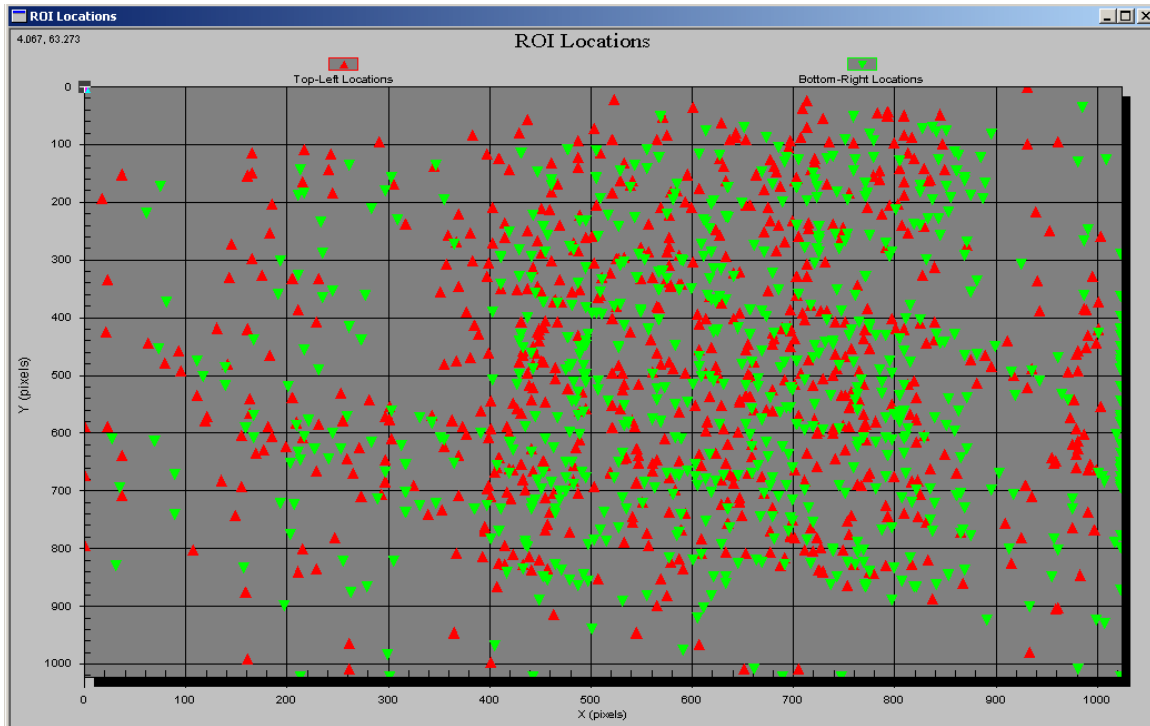




**Figure 2.19.** The particle histogram plot used to size particles in real time.

The last plot of interest shows the location of detected particle ROI locations, shown in **Figure 2.18**. Each ROI's top left corner and lower right corner are plotted, in red and green, respectively, against x and y pixel coordinates of the CCD camera. Thus each axis range is 1 to 1024. This plot provides a visual means of identifying how uniformly the PDS system detects particles in the sample volume. If the ROI locations become biased to one side of this plot, there is likely a problem with the PDS electro-optical system.

To enable the ROI x, y plot, check the "Plot it" box in the "ROI X/Y Plot" section of the "Disp/Hist" tab of the "Settings" window of **Figure 2.17**. The plot will open when the first ROI is found in an image after checking the "Plot it" box. The plot will continue adding red and green markers with each ROI until the "Max ROIs in Plot" number of ROIs is displayed. If "Reset Plot When Filled" box is checked, the plot will be cleared and begin updating again as if just opened. If not checked, the plot will stop updating once the maximum number of ROIs is plotted.



**Figure 2.20.** ROI x, y location plot.

## 2.6 cpi.INI File Description

The cpi.INI file is opened and its information used each time the CPI.exe program is started. Additionally, information is recorded into this file each time the CPI.exe program is stopped by the user, reflecting changes in operation parameters since the program was started.

**WARNING!** The format of the cpi.INI file is critical. Manipulation of the file manually, though some-times necessary, must be performed carefully. Incorrect format of the cpi.INI file can cause the DAS program to fail to communicate correctly with the probe or even to start. Therefore, always back up the cpi.INI file before making changes.

The cpi.INI file is located in the c:\windows\ directory. Editing may be done using the Windows Notepad program. A copy of a sample cpi.INI file is included in appendix **Section 7**, and **has line numbers added for reference that are not in the standard cpi.INI file. These are for reference only and should not be added to the actual file!** The cpi.INI file records the set point value of all parameters accessed from the CPI.exe program. Most changes to the cpi.INI file occur when the user adjusts a parameter (eg, in Advanced control and settings window) during real time operation and then stops data acquisition by hitting the

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“stop probe” button and exits the program. Some parameters in the cpi.INI file, however, must be changed within the file directly, and will be carefully discussed below.

The cpi.INI file is separated into sections, each delimited by brackets. For example, on line 1, [System] indicates to the DAS program that it will find information related to the current system here. **The parameters under [System] come factory configured and should not be changed by the user.**

**Likewise, the parameters under the next heading, [ROI Parameters], should not be changed directly using a text editor such as Notepad.** Some of these parameters are manipulated by the user from within the CPL.exe program, but will be explained in following sections that describe the DAS graphical user interface (GUI).

Next comes the [Probe Settings] heading. This section contains the first parameters a user may need to change directly. For example, the cpi.INI file contains the following:

```

;Setting1 = Forward Sample Tube Temp set point
Setting1=957 0 957

```

The diagram shows the line `Setting1=957 0 957` with three lines pointing from the numbers to labels: a line from the first '957' to 'Current set point', a line from '0' to 'Lower limit', and a line from the second '957' to 'Upper limit'.

Note that the semicolon indicates that the information on the first line is for the user’s information only; the DAS does not do anything with it. The next line tells the user that the next line contains the temperature set point for the Forward Sample Tube. The three numbers, from left to right are:

1. The current set point.
2. The lower limit of the set point.
3. The upper limit of the set point.

The current set point value is written to the file every time the CPL.exe program is shutdown by the user. The lower and upper limits set the acceptable set point range for the particular parameter. These limits serve as the slider limits in the “advanced control and settings” window. If a value is manually typed in that is not within range, an error message will appear “Probe set point out of range”. The only numbers the user may need to change from within a text editor are items 2 and 3. Item 1 is automatically changed from within the CPL.exe program, so should not be manipulated here. **The value of these three items is given in analog to digital conversion (ADC) raw numbers; they are not actual engineering units.** Understanding how to interpret and set these numbers requires looking further into the file.

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The next section of the file, with heading [Gains/Offsets for Readings], contains:

```
;Gain/offset1 is the Forward Sample Tube Temperature (AD590) on J2-1 and J2-19
Gain/Offset1=0.029356 1.877500 10.000000 35.000000
```

The diagram shows the line `Gain/Offset1=0.029356 1.877500 10.000000 35.000000` with four red labels and arrows pointing to the corresponding values: `Gain` points to `0.029356`, `Offset` points to `1.877500`, `Lower Alarm Limit` points to `10.000000`, and `Upper Alarm Limit` points to `35.000000`.

Again note that the semicolon indicates that the information the first line is for the users information only; the DAS does not do anything with it. The next line contains values described from left to right:

1. Gain
2. Offset
3. Lower Alarm Limit
4. Upper Alarm Limit

The gain and offset are applied to measured Analog to Digital Converter (ADC) values. For example, if the ADC is read for the Forward Sample Tube and is determined to be 800, the temperature in degrees Centigrade would be found:

```
Forward Sample Tube Temp = ADC x Gain + Offset
Forward Sample Tube Temp = 800 x 0.029356 + 1.8775
Forward Sample Tube Temp = 25.36 C.
```

The alarm limits are given in engineering units (degrees Centigrade in this case) and tell the DAS that if the derived temperature is less than 10 or greater than 35 degrees Centigrade for the Forward Sample Tube, flash a blue (if less than lower limit) or red (if greater than upper limit) alarm in the housekeeping window. A yellow “invalid temperature” light will also appear in the enunciator panel (see red enunciator windows near the top of **Figure 2.1**).

Returning to the first example lines of the `cpi.INI` file, note that items 2 and 3 are limits given in ADC values. For the given values of 0 and 957, the Forward Sample Tube temperature set point has the range:

```
Upper = 957 x 0.029356 + 1.8775 = 29.97 C.
Lower = 0 x 0.029356 + 1.8775 = 1.8775 C.
```

The effect of these settings is such that, from within the `CPI.exe` program, users may change the Forward Sample Tube set point to be any value from 1.8775 to 29.97 degrees centigrade. If the probe reports back any temperature below 10 degrees C or above 35 degrees C, the DAS should display warning enunciator indicators to the user.

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Other parameters may be changed that have different units, such as Volts or milliWatts, but the procedure is the same. To determine the units, find the parameter in the housekeeping window. For example the PDS45 Laser Power is reported with units of mW (milliWatts). The settings for this, on line 66 of the cpi.INI file, are again given in ADC values:

Setting14=4095 0 4095

And the reported limits —

Gain/Offset19= 0.0246752 -1.6774 15.000000 41.000000

—are 15 and 41 mW, upper and lower, respectively.

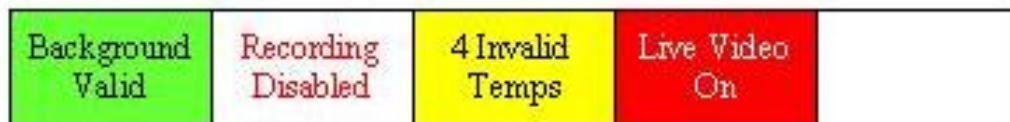
The settings and gains/offsets all have a descriptive line of text above them indicating which physical parameter the values correspond to. Other than the settings limits and alarm limits, the user should not manipulate anything in the cpi.INI file. The limits are set to reasonable values by SPEC before shipping the CPI and data system.

**Finally, a few setting limits and gain/offset limit values are set at the factory and should not be changed:** They are:

1. Imaging laser current set voltage.
2. Imaging laser pulse width set voltage.
3. Imaging Laser Current Set Point.
4. Imaging Laser Pulse Width Set Point.

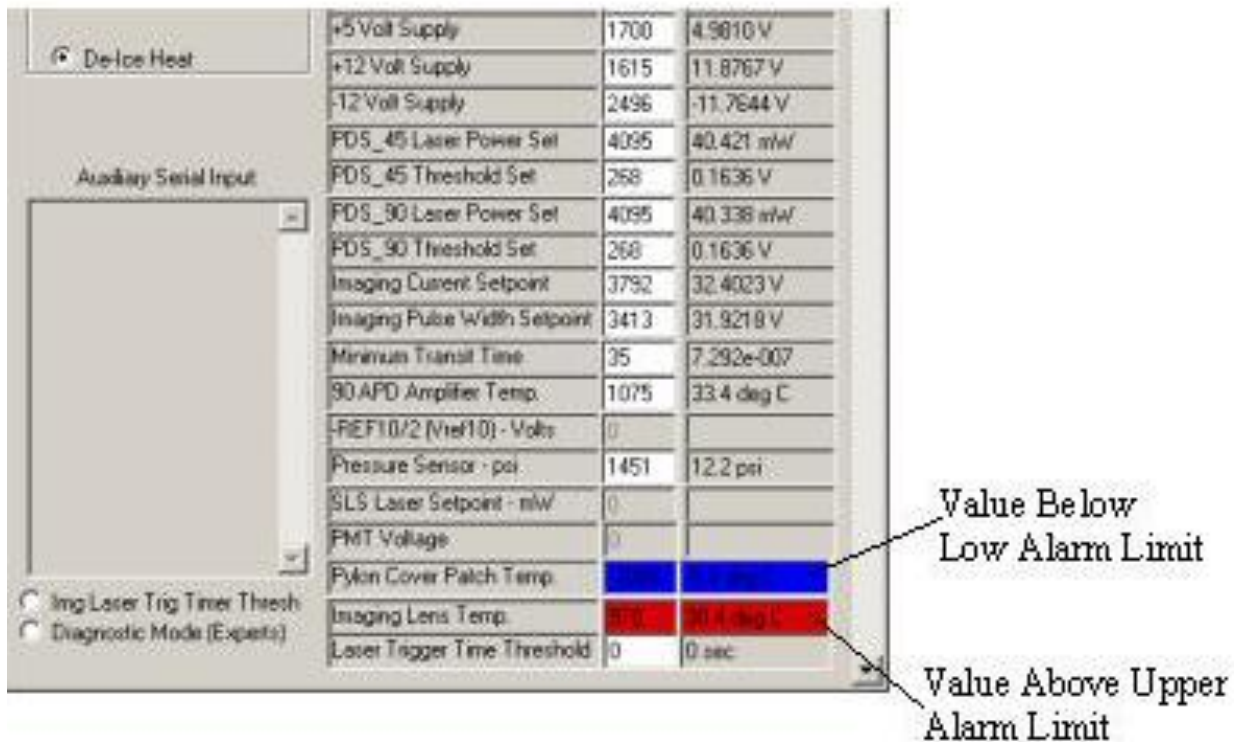
### 2.6.1 Enunciator Panel

The purpose of the enunciator panel is to alert CPI operators to potential instrument problems. **Figure 2.21** shows the enunciator panel that is located at the top of main real time operation window in **Figure 2.1**. Ideally, the user sees a “clean” panel during normal operation. That is, only a green “*background valid*” light is present. The other lights alert the user to some problem conditions for normal operation. “*Recording Disabled*” tells the user that no data is currently being recorded. “*Live Video On*” tells the user that the probe is in Live Video Mode. “*4 Invalid Temperatures*” tells the user that four different temperatures are beyond their alarm limits.



**Figure 2.21.** Enunciator Panel lights

Any light other than “*Background Valid*” should prompt the user to further investigate the problem or take corrective action. “*Live Video On*” can be corrected by clicking off the Live Video checkbox in the main Real Time Operation Window **Figure 2.1**. “*Recording Disabled*” can be corrected by clicking on the Record Data Checkbox in the main operators window. Messages such as “*invalid temperature*”, “*power supply out of range*”, “*PDS detector invalid*” require the user to look at the housekeeping window to further diagnose the problem. **Figure 2.22** shows a portion of the housekeeping window with two parameters out of range. One parameter is turned blue because it is below the lower alarm limit and another parameter is red because it is above the upper alarm limit.



**Figure 2.22.** Section of HouseKeeping window showing out of range parameters.

Provided the alarm limits have been set to reasonable values, these out of range parameters indicate a problem. The “pylon cover patch” heater may not be selected on, for instance, in the advanced control and settings window. If the user enables this heater, the pylon cover patch temperature should increase and the blue alarm should go away. If the heater is already enabled, perhaps the AC2 circuit breaker is off, and there is no AC heater power present (there would be many blue temperatures in this case). For the over range parameter, in **Figure 2.22**, the “*Imaging Lens Temp*,” the heater may be experiencing normal thermal overshoot. In this case the upper alarm limit should be increased, because this is a “false alarm”. The set point may be 25 C, and the actual temperature overshoots to 27 C as the

heater pulses on for one second. A problematic over temperature condition could occur, for example, if a temperature sensor became unattached from its particular heat zone.

Another example of an incorrect alarm range could be the pylon temperature alarm limits of 5 C and 35C, shown on line 135 of the cpi.INI file. This heat zone may have a lower limit that is often exceeded during flights in extremely cold ambient conditions. In this case, the user should decrease the lower limit to below  $-10$  C: a temperature that the pylon may often reach and that does not require a warning to be issued to the user. **For the user to have any confidence that the flashing enunciator lights should be taken seriously, the limits must be customized in the cpi.INI file for a particular CPI in a particular operating environment.**

## 3.0 3V-CPI Real-Time Operation and Troubleshooting

The real time operation and troubleshooting section will outline the process of operating the 3V-CPI in real time. The flowchart in **Figure 3.1** should be used as a step-by-step guide to enable the user to operate the 3V-CPI in the most efficient manner. At certain points in the flow chart, depending on the branch taken, the user will be referred to troubleshooting information for specific operational problems. By using the information in this section, the operator will optimize the data collected by the 3V-CPI.

### 3.1 Operation and Troubleshooting In Flight

This section assumes the user has set up the probe per the instructions in the “Getting Started” Section 2 of the Hawkeye Getting Started Manual and is attempting to run the probe. The flowchart in **Figure 3.1** assumes the user has started the 3V-CPI.exe real time program and is attempting to communicate with the probe by having clicked “Start Probe” in the main window or “Apply and Acquire” in the “Advanced Control and Settings” window.

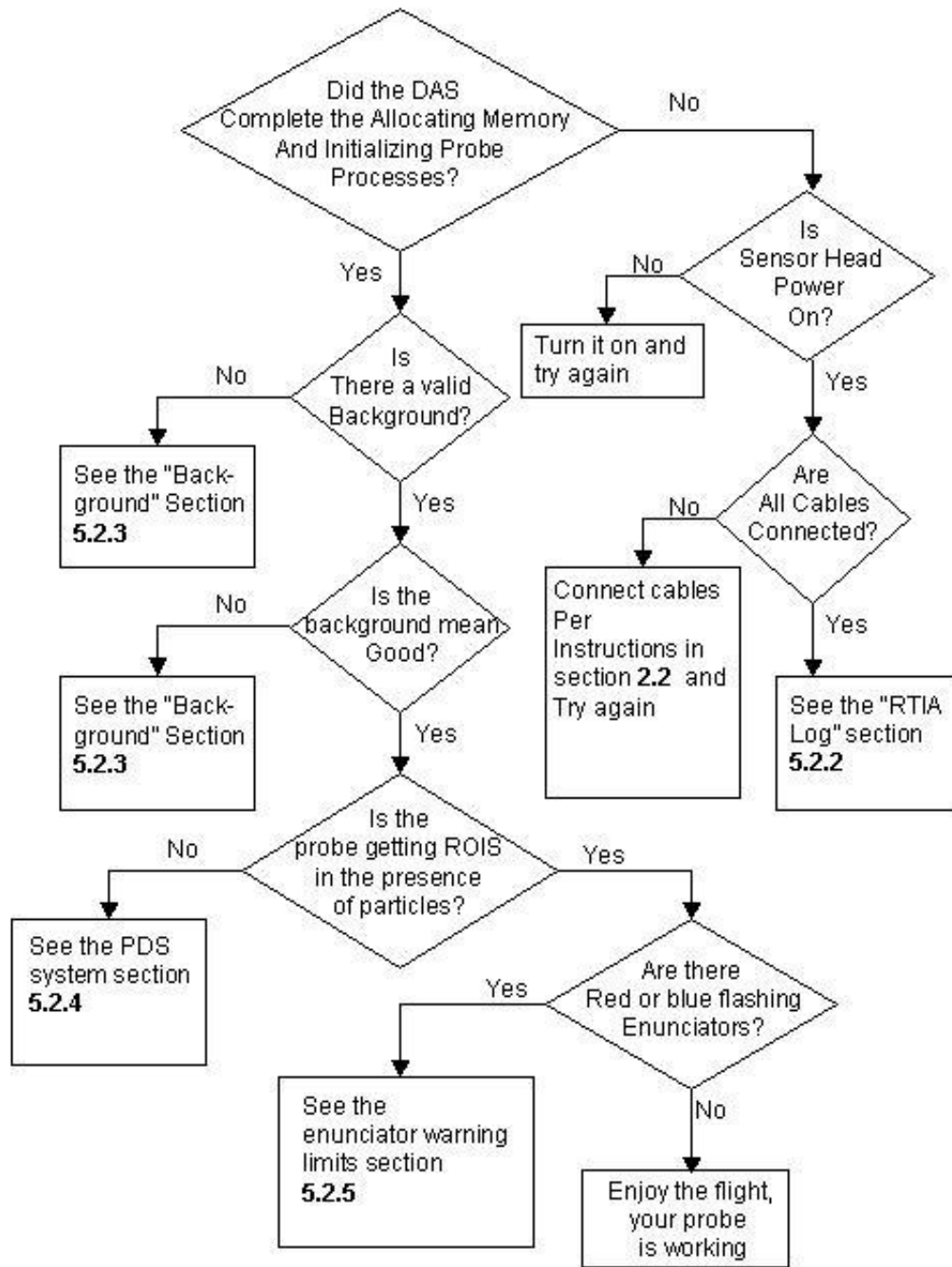
If the probe is not working, the flowchart will lead to one of four sections:

1. RTIA Log Troubleshooting.
2. Background Troubleshooting.
3. Imaging Troubleshooting.
4. Enunciator Troubleshooting.

If the flowchart does not list an observed problem, reading the troubleshooting sections may provide insight and is still suggested. Problems with displaying data such as rates and image parameters are not handled here. The user is referred to **Section 2.5**, “Rates and Image Parameters” for information on this topic.

**AT THIS TIME, THE USER SHOULD BEGIN OPERATING THE PROBE, FOLLOWING THE FIGURE 3.1 FLOW CHART STEP-BY-STEP UNTIL THE “PROBE IS WORKING” BOX IS ARRIVED AT.**





**Figure 3.1.** Troubleshooting flow chart (data system access only).

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## 3.2 RTIA Log Troubleshooting

The rtialog.txt file is found in the following directory:

C:\Program Files\BoulderImagingInc\AcquireNow\3V-CPI\ directory. This file is produced every time the probe is run (overwriting the previous version), and contains information that is useful for troubleshooting many different problems, some of which are described here. The following RTIA subsection headings describe the problem (such as sensor head powered off) and the information in that section includes lines copied from a rtialog.txt file taken when that error occurred.

### 3.2.1 Sensor Head Powered Off / Camera Connector Disconnected

Trying to start communicating with the probe while the sensor head is powered off is a common mistake. Fortunately it is easy to diagnose. See Figure 2.2.1 of the “Connecting the 3V-CPI Sensor Head to the Data Acquisition System,” Section 2.2 of the Hawkeye Getting Started Manual. Locate the sensor power indicator and see that it is lit; if not, turn on the sensor power switch.

If the sensor power is off, the rtialog.txt file will have lines in it that match the following:

```
[0]PCLNKCapture: m_CaptureStartingEvent.Set()
PCLNKCapture::PCD_SWTRIG1_32 SENT - Frame TIMEOUT.
PCLNKCapture::PCD_SWTRIG1_32 SENT - Frame TIMEOUT.
PCLNKCapture::PCD_SWTRIG1_32 SENT - Frame TIMEOUT.
```

If these repeating lines are found in the log file, check the sensor head power is on as described. If the power is on, another cause of these lines in the log file is the data acquisition system (DAS) computer to sensor head camera connector being disconnected. In the Hawkeye Getting Started Manual, see Figures 2.2.3 and 2.2.5 for the J1 sensor camera connector locations on the DAS and sensor head in the “Connecting the 3V-CPI Sensor Head to the Data Acquisition System,” Section 2.2.

### 3.2.2 Imaging Laser Power Too Low or Too High

The probe won't acquire a background if the image mean is too low (or too high). A possibility is that the imaging laser power has been turned down or up in the controls such that the incident light energy is not within operating range on the CCD camera. If this is the case, the rtialog.txt file will have text like the following in it:

```
CSerialComm::ReadDataPacket - a PDS packet received, Cnt=2764.
PCLNKCapture: [0]Frm #2831 (1, 0, 2, 2): 0 0 2 (XFer 0.0086 s, Period 0.0136 s)
CCorecoPCLNKDevice::CompleteAcquire: !m_bFrameCycleComplete
```

---

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CBlobOperator::PerformOperation \*Mean\* = 0.000336sec/frame (Mean= 9.75).  
CBlobOperator::PerformOperation BAD Mean: 9, (Valid: 63, 195).

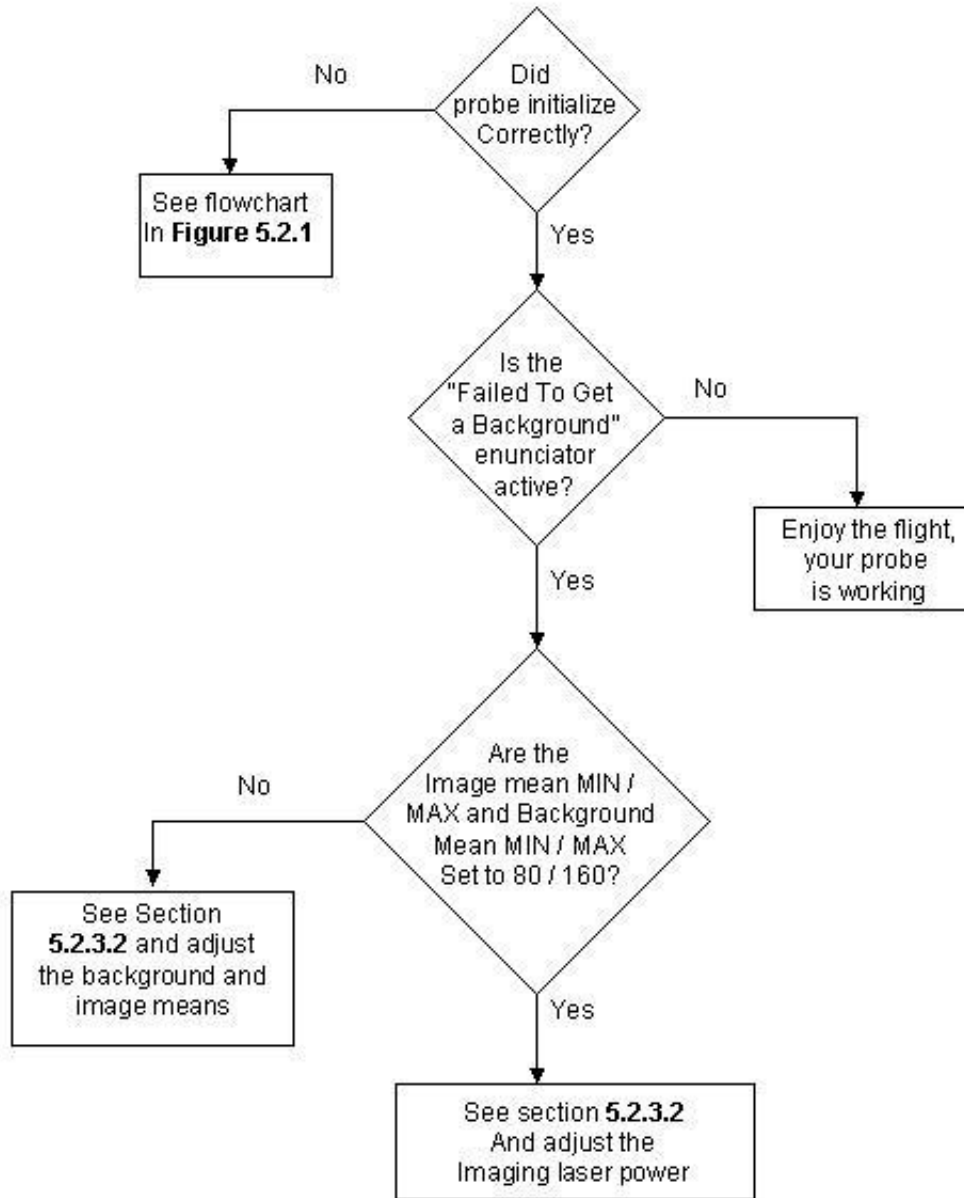
The last line tells the user that the mean of the CCD camera image was 9, but the acceptable range is 63 to 195. In this case, the imaging laser power might have been turned down and needs to be adjusted back up. If the line read "...BAD Mean: 220", the imaging laser would need to be turned down. See **Section 2.2.3.2** "What To Do If Probe Is Communicating With DAS, but No Background Taken" which describes how to adjust the image mean.

### 3.3 Background Troubleshooting

The background collection process and the parameters affecting it are described in detail in **Section 2.4.1**, "Imaging and Background." The first thing the DAS must do on start up is acquire a background from the sensor head CCD camera. The various problems that can occur in taking a background are described in the following sections. The flowchart of **Figure 3.2** provides a guide to steps for correcting background problems.

#### 3.3.1 What To Do If No Background Is Acquired At Startup

See flowcharts of **Figure 3.1** and **Figure 3.2**.



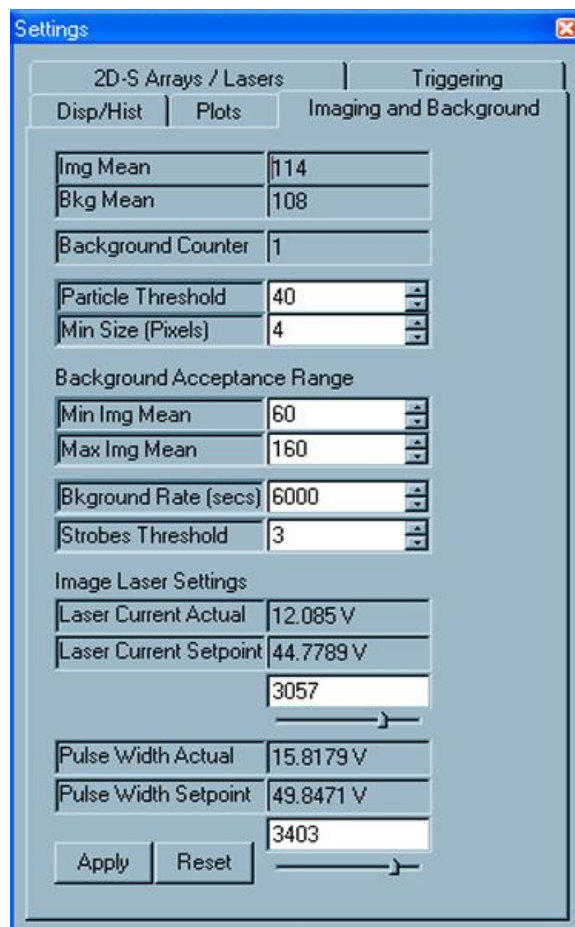
**Figure 3.2.** Background image troubleshooting flowchart.

### 3.3.2 What To Do If Probe Is Communicating With DAS, but No Background Taken

If the “Background Invalid” enunciator is flashing, or if the background image has a very low or high image mean, which varies from probe to probe, steps can be taken to improve the background.

#### High Particle Concentration

The first type of problem that can occur is the DAS attempting to get a background while in the presence of high particle concentrations. The DAS waits until there are less than “Strobes Threshold” particles detected per second before attempting to get a background (see **Figure 3.3**).



**Figure 3.3.** Imaging and Background tab of Settings window

Raising the Strobes Threshold value does not improve the likelihood of getting a valid background while in high particle concentrations because the background validation process will reject images that have a particle present in the image. If the probe is repeatedly trying

to take a background and is in high concentrations, the solution is to exit the cloud for a brief period to allow the probe to take a background image in clear air.

### **Particle Threshold Too Low, Minimum Size (Pixels) Too Low**

The “Particle Threshold” and “Min Size (Pixels)” fields in **Figure 3.3** greatly affect whether or not the DAS detects particles (real or not) in image frames. If the probe is failing to get a background, try changing these values to the more conservative values of 50 for the “Particle Threshold” and “6” for the “Min Size (Pixels)”. **If this is not the problem, the user should go back to the previous settings (somewhere around 40 and 4), as raising these values raises the minimum size particle the probe will measure.** See **Section 2.4.2** “Particle Collection and Associated Controls” for more information on the “Particle Threshold” and “Min Size (Pixels)” settings.

### **Image Mean Too High / Too Low**

Each 3V-CPI has a different range of image means with which it performs well. A reasonable range for most probes, however, is 80 to 160. These limits are entered by the user in the Imaging and Background tab of the Settings window, as shown in **Figure 3.3**.

In **Figure 3.3**, the minimum and maximum image mean are set to 60 and 160, respectively. A wider range is useful for troubleshooting, such as 2 to 255; however, once the retrieved image mean has been adjusted to desired levels, the user should set the limits to 60 and 160 for the “*Min Img Mean*” and “*Max Img Mean*” fields, respectively. **Once changed, as with all fields in the Imaging and Background tab, the user must click the “Apply” button (which may also say “Apply and Acquire”), else the DAS won’t use the new values.**

To adjust the image mean in real time, the user can check the “*Live Video On*” check box in the main screen. **It is best to run live video with recording disabled, as approximately 400 full images of one Megabyte will be saved to hard disk each second if recording is active.** Once live video is turned on, the image display area will show the entire CCD camera image (though for most CRT and LCD computer monitors, only a fraction of the total image may be seen; move the scroll bars for the image display area to view different portions of the CCD image). The image mean will be updated in real time in the “*Img Mean*” field of the Imaging and Background tab in the Settings window (see “*Live Video Mode*” **Section 2.4.4**). While running live video, adjustment of the imaging laser current (remember to click the “Apply” button) will change the image brightness displayed and reported. The Image Laser Current setpoint can be changed by sliding the control bar under the Image Laser Settings portion of the Imaging and Background tab. Once the image mean is at a desirable value—e.g. somewhere between 80 and 160, though this is different for each probe—turn off live video by unchecking the “*Live Video*” box. **A new background should be taken immediately after any changes are made to the imaging laser set points.** If not, the

background subtraction will now have a large offset due to the changed image mean, causing the particle processing algorithm to work poorly or not at all.

**Warning!** If the image mean is outside the limits just described, live video will fail to update the “Display” window and the probe will fail to take a background. To prevent the image mean from falling outside the limits, set “*Min Img Mean*” equal to 1 and the “*Max Img Mean*” equal to 255 when troubleshooting image mean problems. Be sure to return the limits to a proper operating range when you are finished diagnosing and correcting the image mean problem.

### 3.4 Threshold Operation and Troubleshooting

The threshold settings are adjusted in the Imaging and Background tab of the “Settings” window, shown in **Figure 3.3**. 200 is a normal lower limit, though some probes can be operated at even lower values while running in a laboratory (such as the 40 value, shown in **Figure 3.3**). The higher the threshold is set, the fewer small particles are seen. 600 is a nominal upper limit, however, like the lower limit, this is not a hard and fast number.

If the probe is not collecting particles and the 2D-S laser power levels are acceptable, adjust the threshold to a safe value, 350, and click the “Apply” button. At this setting, particles of the smallest size may not be seen, but if in the presence of an ensemble of cloud particles that includes some medium (50 to 100  $\mu\text{m}$ ) to larger particles, this setting should be safely above the noise and allow the PDS system to detect particles. However, if particles are still not collected, lower values should be attempted.

### 3.5 Enunciator Warnings

When operating with no limits exceeded, such as heat zone measured temperatures, laser powers, etc., the DAS enunciator panel (see the upper part of the window shown in **Figure 2.1** in the Software Description **Section 2.6.1**) should have one green background alert stating “*Background Valid*”. Any other alert, given in red, yellow or blue, indicates a parameter is out of the assigned operating range. Users assign these limits in the cpi.INI file, described in **Section 2.6**. The enunciator panel is further described there as well. If any alerts other than “*Background Valid*” or short alerts titled “*Getting Background*” are in the enunciator panel, read **Section 2.6** and address the problem.

## 4.0 3V-CPI 2D-S GUI and Real-Time Operation

The 2D-S portion of the Hawkeye operates using a program called the SPEC\_3V-CPI\_2DS.exe. Since this program works both as a data acquisition program as well as a post-processing program, the Exe is referred to as the Real-Time Acquisition program during data recording and as Playback during post-processing. In this section we discuss the aspects of the Exe related to data recording.

Use the SPEC\_3V-CPI\_2DS Real-Time software to operate the 2D-S portion of the probe. Double-click the SPEC\_3V-CPI\_2DS.exe program icon on the Windows Desktop screen. To learn how to install and update the software see Appendix D. The SPEC\_3V-CPI\_2DS program is also used to playback data files, information on playback and post-processing is discussed in another document.

When the program is started, the GUI (shown below in Figure 4.1) is opened. Typically four windows are displayed in the GUI. Use the Windows tab to recover features that cannot be seen. Drag or shrink windows to see all information at once.

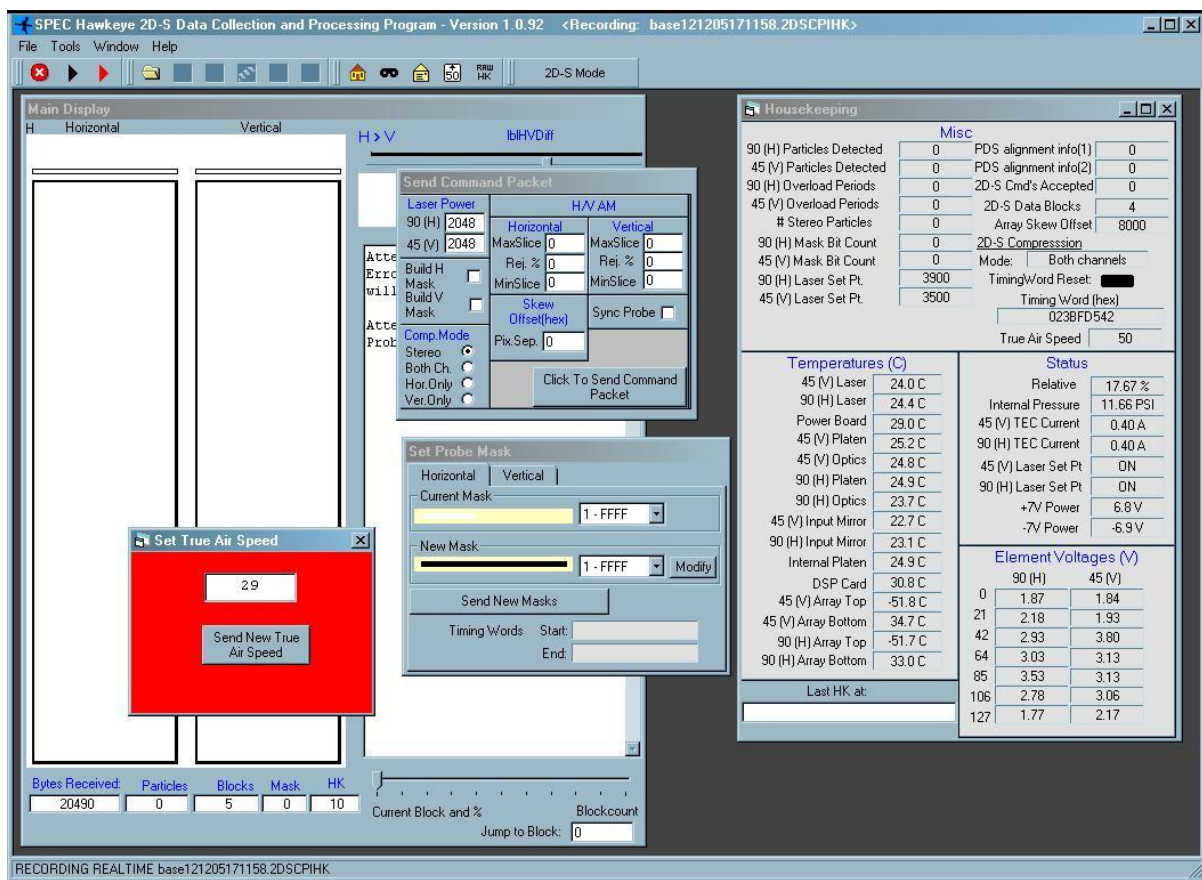


Figure 4.1 3V-CPI 2D-S Main Display Window.

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## 4.1 Tool Bar:

At the top of the GUI is the following toolbar:



Buttons from left to right:

- **Red Circle/White X icon:** Stops recording of Data
- **Black Arrow icon:** Monitors 2D-S but does **NOT record data to file.**
- **Red Arrow icon:** Records Data File.
- **Folder icon:** Opens Recorded Data File for playback
- **House icon:** Opens/Closes Housekeeping window
- **Mask icon:** Opens/Closes Set Mask Window. Displays the current mask on each array. Do not send mask via this window. Use Send Command Packet.
- **Envelope icon:** Opens/Closes Send Command Packet window
- **50 icon:** Opens Set True Airspeed window
- **RAW HK:** Opens/Closes Raw 3V-CPI Housekeeping window
- **2D-128 Mode / 2D-S Mode Button:** Switches between single channel mode and standard dual channel modes. The 2D-128 probe version has only a vertical channel, with the horizontal channel optoelectronics and mechanical arms not installed. Therefore, in this mode, the user interface changes so that only parameters associated with the vertical channel are displayed.

Users of the 3V-CPI probe must run in 2D-S mode. Failure to do so will cause the real-time program to only collect image data from the vertical channel.

## 4.2 Main Display Window

The “Main Display” window shows images captured by horizontal and vertical arrays (currently shown as blank in **Figure 4.1**). Below the horizontal and vertical particle’s window is a set of counters:

**Bytes received:** Records the total amount of bytes received from the 2D-S during data recording.

**H Particles:** Counts the number of particles recorded in the horizontal array in data file

**V Particles:** Counts the number of particles recorded in the vertical array in data file.

**Mask:** This counter records the number of masks that have been taken by the probe. A mask prevents the probe from recording data on array elements that have become hypersensitive and are triggering erratically and not on passing particles.

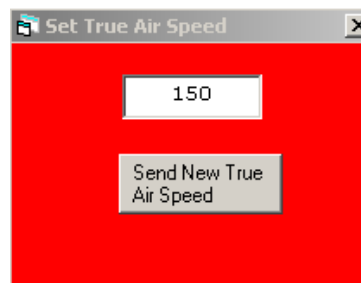
**HK:** The Housekeeping packet counter notes the number of housekeeping packets that have been received from the probe. When the probe is on and communicating with the data computer both the Housekeeping packets and Bytes Received counters will increase. When the counters halt there probably has been a loss of communication with the probe

In the white box to the right of the particle displays is where critical messages on probe performance are reported when the box is checked. To the far right is a window with the headers of H-Time and V-Time. This window displays the timestamp of particles as they are recorded.

The other features of the Main Window are for post-processing and are discussed in the post-processing manual.

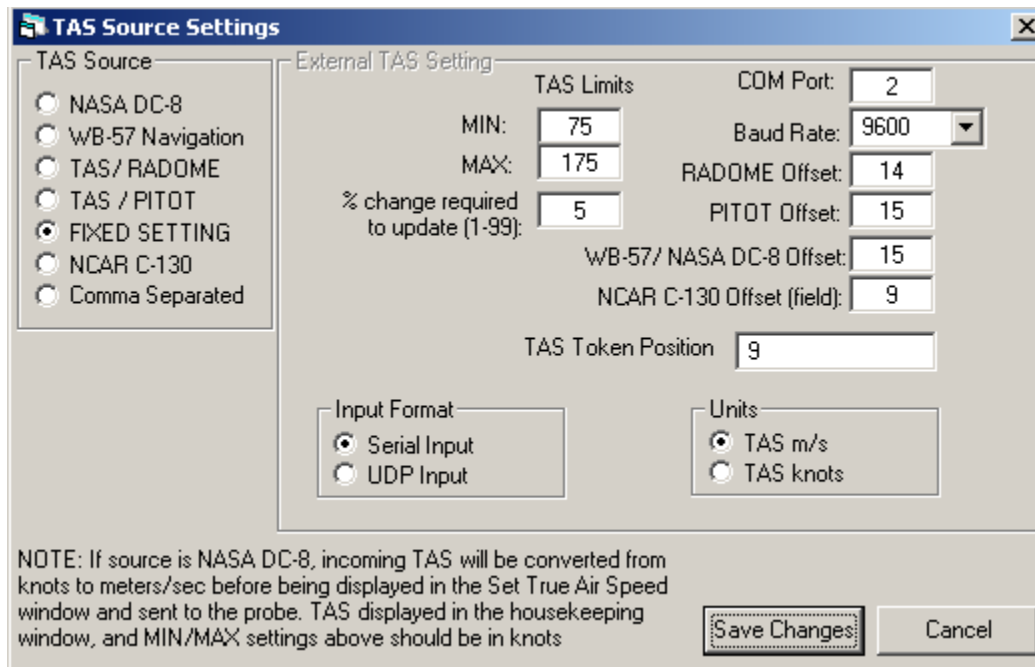
### 4.3 Set True Air Speed Window

**Figure 4.2** displays the “Set True Air Speed” window, which is used to set the true air speed (TAS) manually. The airspeed is typed into this box and sent to the probe by clicking on the “*Send New True Air Speed*” button. The approximate airspeed is necessary to prevent imaging distortions when recording data. The value in this box must be in meters per second. SPEC typically does not manually input the airspeed. On most research aircraft airspeed is available to investigators via a serial string from a COM port or through a second Ethernet card.



**Figure 4.2** Set True Airspeed

Under Tools/TAS Source there is an option to configure the automatic update of TAS to the probe. To set TAS to manual mode, make sure Fixed Settings is chosen. Customers may contact SPEC for a guide on how to configure 2D-S software to properly input TAS from an external source. The window for setting the source of the true air speed is shown in **Figure 4.3**.



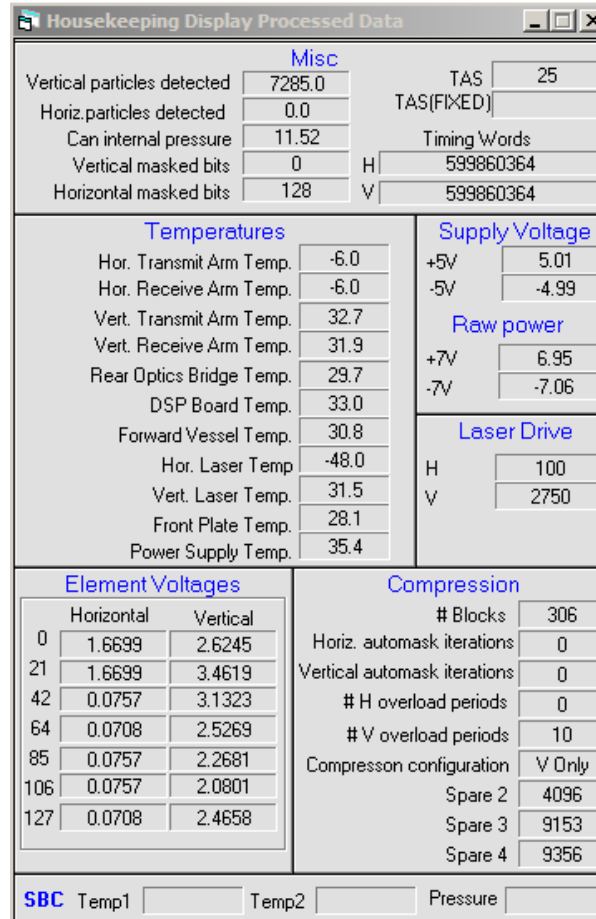
**Figure 4.3** True Air speed Source Settings

**Regardless of the actual airspeed, the probe has an upper limit airspeed of 170 m/s (~340 knots). You should never have an inputted TAS higher than this value sent to the probe. Errors in data recording will occur. It is okay to fly the probe faster, but slight image degradation will occur.**

## 4.4 Housekeeping Window

The housekeeping window, shown in Figure 4.4, is used to determine and observe the overall health of the instrument. If the window is not visible, click the house icon on the menu bar. Temperatures, pressures, and voltages from the probe, lasers, and power supply are displayed in the housekeeping window. While the probe is running, this window must be periodically checked to verify the follow:

- 1) Are the Supply Voltages within 0.25V of their shown value?
- 2) Are the number of horizontal and vertical masked bits 0?
- 3) Are the element voltages between 1.0 and 3.7 volts?
- 4) Are the temperatures between -10 and 50 deg. C?
- 5) Is the TAS as expected?



**Figure 4.4** Housekeeping Display Processed Data

The housekeeping information comes to the GUI from the probe via housekeeping packets. The information is sent in a raw format and gains and offsets correct the data before being displayed. If the information does not appear correct make sure the top of the window says Housekeeping Display Processed Data. If it does not, go to **Tools** and click **Housekeeping Display Processed Data**. Next go to Tools/Analog Settings and click the Set Default Values box, which will reset the gains and offsets to the correct value.

**Misc:** This section tells the operator the number of particles detected in the last second, the pressure measured at the probe and the number of masked array elements in each array. To the right is the current True Airspeed (TAS) displayed in meters per second. It is very important that the displayed airspeed is close to the actual airspeed. The red TAS box simply displays and sends TAS, so check to make sure that this box displays the correct airspeed.

**Temperatures:** Displays temperatures at the probe and power supply, all temperatures above a limit are shaded to alert operator of a potential overheating. As a failsafe if the laser temps exceed 45 degrees Celsius for longer than one minute the laser will be powered down by the DSP.

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**Element Voltages:** This box shows the voltages at Horizontal and Vertical arrays. Element voltages below 1.4 are considered non-optimal. The laser should illuminate the array with a Gaussian distribution with its peak at the center element of the array. The laser edges, which lack intensity, should fall beyond the edges of the array, so that laser intensity should be almost uniform across the array..

**Compression:** This section is important for the # of overload periods. The operator may notice that one array has stopped recording images in high concentrations of particles. If the array is in overload that would tell the operator; the instrument is still operating properly, but must pause before resuming data recording.

The compression configuration field should always read a value of “both”, as set in the command packet window.

**Supply Power, Raw Power, and Laser Drive:** These three sections show the voltages at the power supply and the laser power set points, with a scale of 0-4095 for the latter. This section proves useful when there has been a catastrophic failure in the probe. This will tell the operator if the power supply or laser power board has failed.

## 4.5 Send Command Packet window

The Send Command Packet window, shown in Figure 4.5, is used to send commands to the 2D-S portion of the 3V-CPI probe. This window may not appear at start up, if it doesn't, click on the  icon on the toolbar. Clicking the button at the lower left side of the window sends a packet of information to the probe.

Send Command Packet	
<b>Laser Power</b>	<b>H/V AM</b>
90 (H) 2048	<b>Horizontal</b>
45 (V) 2048	MaxSlice 0
Build H Mask <input type="checkbox"/>	Rej. % 0
Build V Mask <input type="checkbox"/>	MinSlice 0
<b>Comp. Mode</b>	<b>Vertical</b>
Stereo <input checked="" type="radio"/>	MaxSlice 0
Both Ch. <input type="radio"/>	Rej. % 0
Hor.Only <input type="radio"/>	MinSlice 0
Ver.Only <input type="radio"/>	<b>Skew</b>
	Offset(hex)
	Pix.Sep. 0
	Sync Probe <input type="checkbox"/>
	Click To Send Command Packet

**Figure 4.5** Send Command Packet

Important to note in the above image and duplicate in the 2D-S real time software:

1. Comp. Mode should normally be set to Both Ch (in the example it is set to stereo)
2. The MaxSlice, Rej. %, and MinSlice parameters are mask settings describe. The mask processes is described below.
3. The laser drive of the probe can be set to a maximum of 4095, in most cases that much power is not necessary and would saturate the array. The laser drive should be set so that the maximum element voltages are around 3.5 volts. There is a laser power AI algorithm that can be utilized, and if enabled, this number doesn't need to be adjusted.
4. To build masks on either channel because of noisy elements check one or both "Build Mask" boxes. Be sure to have the Build Mask boxes Unchecked when the probe is flying in cloud.

## 4.6 Mask Setting

**Note:** Throughout this portion of the document bits and pixels are used interchangeably, and row and slices are used interchangeably.

Occasionally one or multiple bits (out of the 128 bit array of the 2D-S) may become noisy resulting in the generation of Megabytes of useless data. Common causes for noisy bits include low laser level, contamination on the windows, and condensation on the optics. The probe can be commanded to take a mask to determine if there are any noisy bits. If a bit is determined to be noisy, it is masked and therefore ignored until a new mask is taken. Masked bits will always appear not blocked (no particle can excite the bit).

There are 4 ways to initiate the generation of a new mask:

1. User initiated - the 2D-S program at the data system (2DSGUI), sends a command packet with the "Build H Mask" and/or "Build V Mask" checkboxes checked.
2. Automask initiated – Under the "Tools -> Periodic Mask Generation" menu, there is a checkbox labeled "enable periodic mask generation"; when checked the 2DSGUI will initiate a mask automatically based on the parameters set under this menu.
3. Mask initiate by Stuck bit - Under the "Tools" menu there is a "Stuck Bit Handling" Menu which has four selections, one of which is "Initiate Automask". When this is selected, a new mask is requested by the 2DSGUI. Stuck bits are defined under the "Tools -> Periodic Mask Generation" menu.
4. When the probe is started. The DSP in the probe initiates a mask. This requires no user interaction.

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Additionally a new mask can be manually sent to the probe as opposed to generated by the probe (use “Set Probe Mask window”) – however this option should not be used by the uninitiated user.

Upon receipt of the mask generation command, the DSP will use the MaxSlice, MinSlice and Rej. % parameters, to perform the masking algorithm. These three parameters are defined by the user in the “Send Command Packet” window and are included in the mask generation command packet. On startup the DSP uses the following default values: MaxSlice = 500, MinSlice = 10 and Rej. % = 2% to generate a mask.

The mask algorithm used to determine if any bits are stuck or noisy (rapidly toggling on and off) is an iterative procedure that performs the following steps:

1. Probe enables all pixels - no bits masked.
2. Probe reads the incoming array data until a programmed number of slices (MaxSlice) have been captured, or 1 second of data has been captured and the number of slices is greater than minslice (MinSlice).
3. Only rows with at least one darkened (shaded) pixel are captured.
4. The fraction that each pixel is shaded is determined, by dividing the number of times the pixel is shaded by the total number of captured slices.
5. All pixels whose shaded percentage exceeds the preset threshold (Rej%) are masked.
6. Steps 2-4 will be repeated until less than the minimal number of slices (MinSlice) are captured in a 1 second time period (remember that only slices with a darkened pixel are captured - the rest are ignored).
7. The new mask will be used by the data system. Any pixels that are mask are ignored, and do not trigger the slice to be captured.

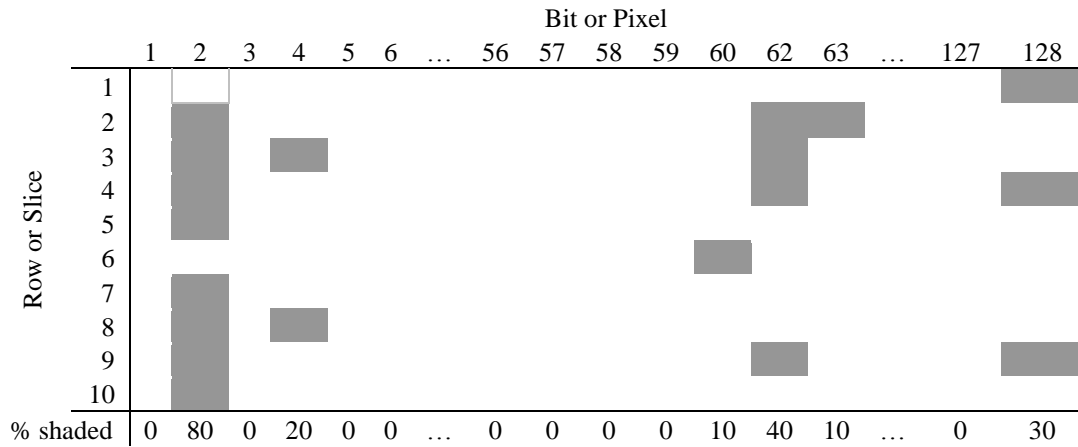
This mask generation process is performed independently for the horizontal and vertical channels. Upon completion of the mask generation, the probe sends the resultant mask for the vertical and horizontal channels to the 2DSGUI. In the 2DSGUI, masked out bits are displayed as a white and enabled pixels are black under the “current mask” in the “set probe mask” menu.

### 4.6.1 An Example of the Mask algorithm

For the flowing example a generate mask packet is sent to the DSP with the following parameters: MaxSlice = 500, MinSlice = 5 and Rej. % = 35%.

First Iteration though mask algorithm:

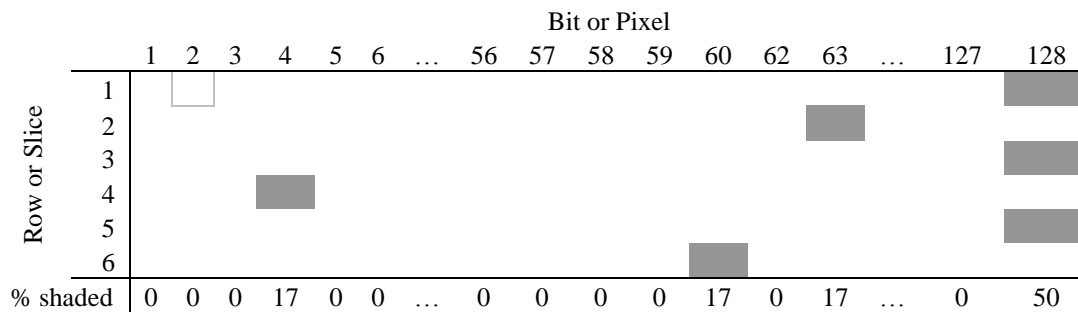
After one second of sampling the following 10 slices of data are collected:



Notice that each row has at least one shaded pixel. We did not collect 500 slices, but we collected more than the minimum required 5 slices, so for each pixel, we determine the shaded percentage. Since the Rej% is set at 35%, bits 2 and 62 will be masked out (ignored). The rest of the pixels are shaded less than the rej% so they are not mask. We perform a second iteration of the mask algorithm to determine if any more bits should be masked.

Second Iteration though mask algorithm:

After one second of sampling the following 6 slices are collect:

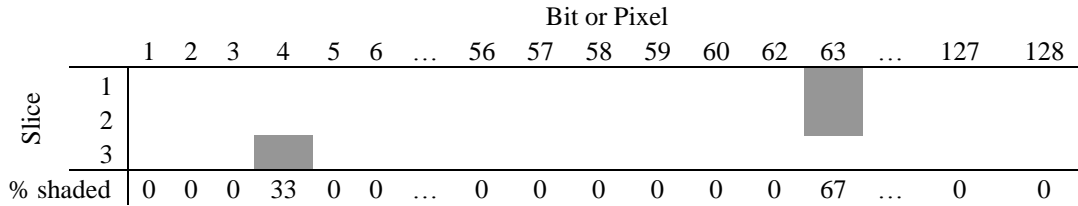


During one second of sampling, we collected 6 slices, which is more than the minimum required 5 slices. So for each pixel, we again determine the shaded percentage. This time bit 128 is shaded 50% so it is also masked out. The rest of the pixels are shaded less than the rej% so they are not mask. We perform third iteration of the mask algorithm to determine if any more bits should be masked.



Third Iteration though mask algorithm:

After one second of sampling the following 3 slices are collect:



Upon the third iteration thru the mask algorithm bits 2, 62 and 128 are masked so they should not be shaded. We only receive 3 slices in a second (below our 5 slice threshold), so our mask is complete and we do not analyze the data to determine the shaded percentage. Note that in the third iteration bit 63 is above the 35% rejection threshold, but not enough samples were collected in a second. For the mask operation, bits 2, 62 and 128 are masked. This mask is relayed back to the 2DSGUI.

It becomes apparent that clear air is highly desirable for performing mask operations, so that valid cloud particles, do not cause pixels to appear noisy, and therefore become mask. Ideally a mask should never be taken in cloud. Occasionally a mask must be taken in cloud to correct a previous poor mask. Below are some suggested operational parameters for mask generation.

**4.6.2 Suggested Operational Settings for Mask Parameters**

**A. High Concentration Cloud:**

In a cloud, the 2D-S should see particles across the entire array. This is especially true in high concentrations of small particles, where many particles are seen in one second. For this condition, all three parameters should be set high:

- MaxSlice: 15000
- Rej. %: 90
- MinSlice: 5000

If the mask comes back with only a few diodes masked off, the mask is likely good. If a lot of diodes are masked off, it is likely that the particle concentration is so high that more than MinSlice slices are occurring in the one second period, and MinSlice can be adjusted up to 10000.

**B. Low Concentration Cloud:**

If only a few particles are showing up per second (as indicated in the housekeeping window), the statistics will be poor for determining noisy bits. MinSlice needs set high enough to ensure enough particles were sampled. If in large ice, a single particle may generate on the order of 200 slices (on the order of twice the array width of 128) or more. So, MinSlice needs tuned to the conditions. A starting point for this condition is as follows:

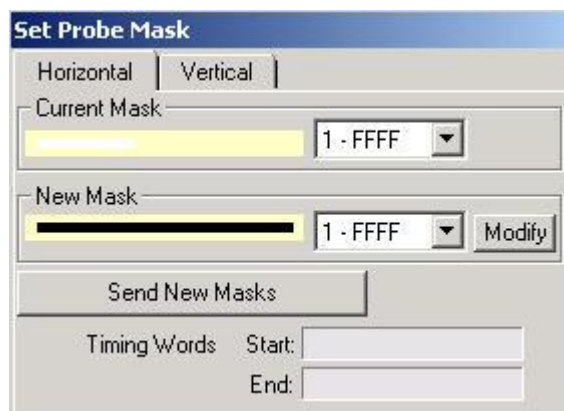
MaxSlice: 5000  
 Rej. %: 90  
 MinSlice: 500

**2. Clear Air**

Clear air is the best time to take a mask, as all of the generated images will be due to noisy diodes, if they exist. Use the following aggressive settings, but be sure to return the values to the more conservative settings, such as in B, above, so that if a mask is taken later, it does not accidentally use these settings in cloud. Doing so will mask out the entire array. The values in parentheses are slightly less aggressive and will allow a noisy diode that is producing a minimum of images to get through:

MaxSlice: 5000  
 Rej. %: 1 (5)  
 MinSlice: 1 (10)

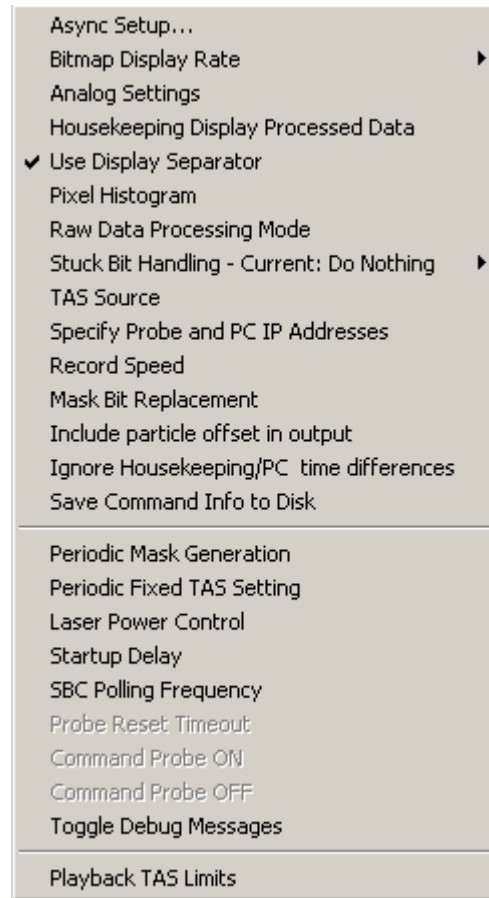
The Set Probe Mask window (shown in **Figure 4.6**) is used to view the current mask setting. Masked out bits are displayed as a white and enabled pixels are black. This window also allows the operator to set a specific predetermine mask; however, **This operation should not be performed by an untrained user.** The Command Window is where the operator should request to build new masks while sending command packets to the probe.



**Figure 4.6** Set Probe Mask

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## 4.7 Tools Tab Menu



**Figure 4.7** Tools Tab

**Async Setup** chooses the COM port for the optional single board computer controller (not a standard item for the 2D-S) for autonomous operation. Contact SPEC if interested in a version of the data and power system that runs autonomously.

**Bitmap Display Rate** sets the maximum number of particles displayed on the Particle Display in each array during a second. Despite being capable of recording thousands of particles per second, the maximum display rate is 10 per second.

**Analog Settings** is where the gain and offsets are entered to adjust housekeeping data from the probe.

**Housekeeping Display Processed Data/ Housekeeping Display Raw Data** is used to toggle between view process and raw housekeeping data. If the data in the housekeeping window looks strange, try selecting this option.

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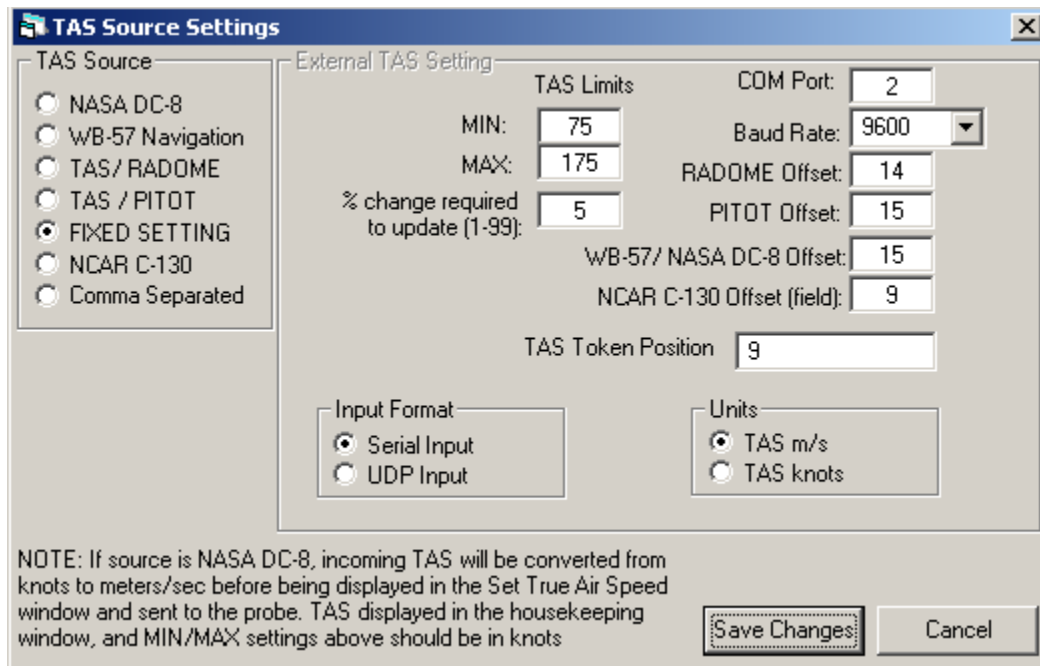
**Use Display Separator** puts a single dotted black line between each displayed particle to better differentiate between particles.

**Pixel Histogram** opens a window in which the number of times each element, for both horizontal and vertical channels, is shadowed. This works only in playback. It is useful for identifying noisy elements, elements that are not working or masked, etc...It is also useful when processing flight data to verify a homogenous sampling distribution across the 128 elements of either channel.

**Raw Data Processing Mode** should be left unchecked (as shown). This mode turns off error testing of the data during playback, and should not normally be used.

**Stuck Bit Handling** is a very important tool. If an array element gets noisy, the operator needs to set what he wants the probe to do. The operator can set it to do nothing and record the noisy bit or he can have the probe initiate an Automask that after a conditional is passed the program will build a mask to remove the noisy bit. (Explained fully in Real-Time Troubleshooting Section)

**TAS Source** is used if the operator wants to set up the 2D-S to receive a True Airspeed connection from an outside source like through a COM Port from another computer.



**Figure 4.8** TAS Source Settings

For normal operation, the 'Fixed Setting' radio button should be selected. In the main menu, choosing the '50 Icon' (see the section on the Toolbar, below) allows the user to enter and send the TAS to the probe.

The 2D-S can also read a serial data stream, in several different formats, that allows the real time program to adjust the TAS from the incoming serial data values.

For more information see Appendix B: **Automatic True Airspeed Update**.

**Specify Probe and PC IP Addresses** allows the IP address of the probe to be entered. The default probe IP address is **192.168.1.133**. The data system computer should use a fixed IP address in the same range (such as 192.168.1.100).

**Record Speed** has two options with the standard option will display particles and housekeeping data and the maximum recording will display no updates. It should only be enabled when the instrument is flying in a completely AI environment where there is no operator on board.

**Mask Bit Replacement** provides a means, during playback post-processing, to fill in horizontal and vertical elements that are masked out.

**Include particle offset in output** should remain unchecked.

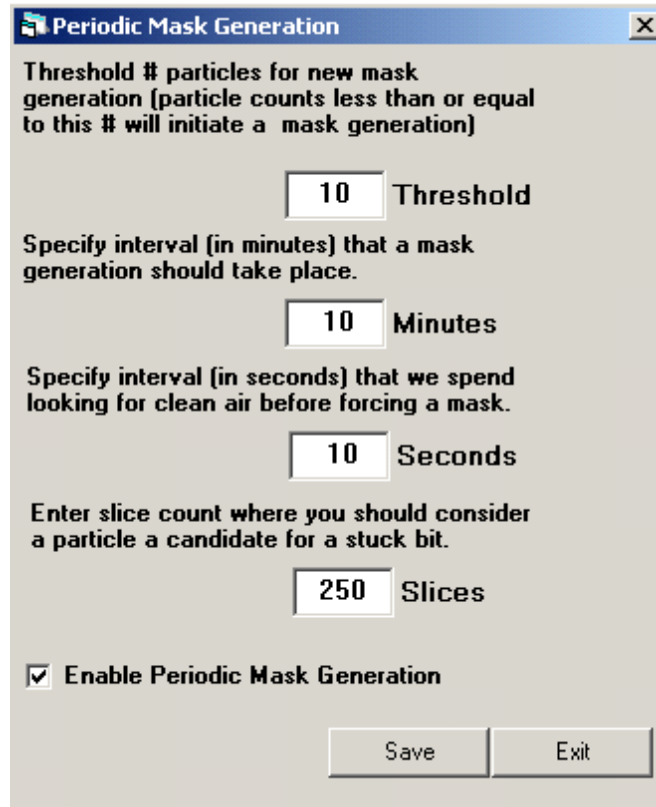
**Ignore Housekeeping/PC time differences** turns off a quality control test that is implemented during playback post-processing. It should be left unchecked, but may be enabled if data processing fails due to such errors.

**Save Command Info to Disk** when enabled, records an ASCII file record of all the values and options sent in command packets to the 2D-S when operating in real time. This troubleshooting tool is normally disabled. The name of the files produced have name format: ``CMDLOGYYMMDDHHMMSS.2DS'`

## 4.8 Periodic Mask Generation Window

The periodic mask generation directs the 2D-S program to take a mask at specified time intervals.

The threshold field is how many particles per second, or less, should transpire before a command should be sent to the probe to take an automask. If clean air is not seen for more than the interval given in the third field, then a mask is taken regardless of the number of particles seen.



**Figure 4.9** Periodic Mask Generation

It also allows choosing of a slice count maximum (equivalent to 10  $\mu\text{m}$  intervals) at which the real time software should consider a particle a stuck bit and take action (re-send a mask, as selected in the previous menu, above). If large particles (snow / ice / rain) are being encountered, this number should be increased to 250. The interval at which masks should be taken is dependent on probe reliability. The values shown here are typical when in cloud infrequently. If flying in cloud a great deal of the time, the mask interval (third box) should be set to around 600 seconds. If an operator is comfortable watching the probe's performance throughout a flight, the period mask generation can be disabled but only as a means preventing a mask from being taken in cloud. The mask algorithm was previously explained in depth in this section.

#### **Periodic Fixed TAS Setting**

When running the probe unattended with a fixed true air speed (TAS), enabling this option will ensure that once per minute, the user-supplied TAS setting is sent to the probe. It is best to leave this disabled.

## 4.9 Automated (AI) Laser Power Adjustments

Automated laser power adjustment saves the operator from having to optimize laser settings continuously. The settings here are typical.

**Figure 4.10** Automated Laser Power Adjustment

### Algorithm for Adjusting Laser Power

The acceptable voltage range for the 2D-S is 1.5 to 3.5 volts. Below that voltage noisy bits are known to occur. Above that value circuit saturation occurs and imaging is compromised. The purpose of the AI algorithm will be to make sure the instrument is working at its peak performance during unsupervised flight.

The AI command box needs 6 user adjustable values to set the AI.

1. The first input needs to be the Desired Maximum Voltage (DMV). This is the array voltage that we'd prefer to see in the housekeeping data.
2. Second input is an acceptable range from the Desired Maximum Voltage (MVR). A plus or minus value from the Desired Maximum voltage we can also tolerate.
3. Third a Maximum Voltage Difference (MVD) from the next highest recorded voltage to the second highest voltage. To insure we aren't adjusting the laser power because 1 array element is very high compared to the others.

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4. A time period to run this AI algorithm in seconds (PER).
5. Power adjustment factor (PAF): The amount of the laser power is bumped in each cycle of the AI to reach the Desired Maximum Voltage or its range.
6. A Time to the AI to wait for laser power adjustments to take effect before retesting to see if a power adjustment had enough of an effect to get to the Desired Maximum Voltage or its range (TSET).

The last two fields are used to mask off the entire array if laser voltages become too low.

The Low Power Mask Voff voltage is used as follows: if the average of the seven horizontal (or vertical) channel element voltages is below this number, the entire horizontal (or vertical) channel is masked off by the data system. This only happens if this feature is enabled. It is useful, because it will mask out channels when their low average voltage is likely to be accompanied by noise.

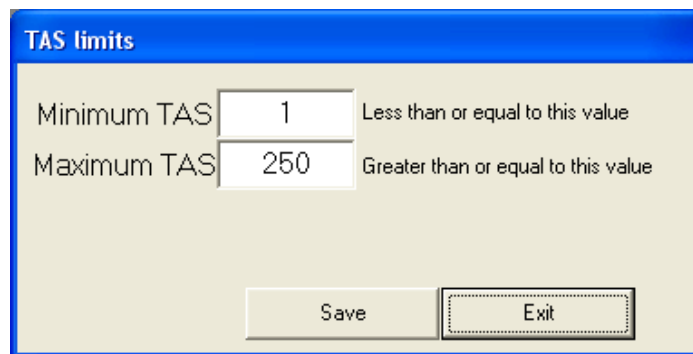
The Low Power Mask Von voltage is the average voltage at which the horizontal (or vertical) channel will come back on after being masked off. When the data system sees this voltage average on the channel, it sends out a mask command so that the entire array is no longer masked.

### Startup Delay

This option should be left unchecked.

### Playback TAS Limits

The limits to the TAS in this menu apply to the playback post-processing. They are for error checking the stored housekeeping values. The values shown, 1 to 250, provide the desired error identification.



**Figure 4.11** True Airspeed Limits



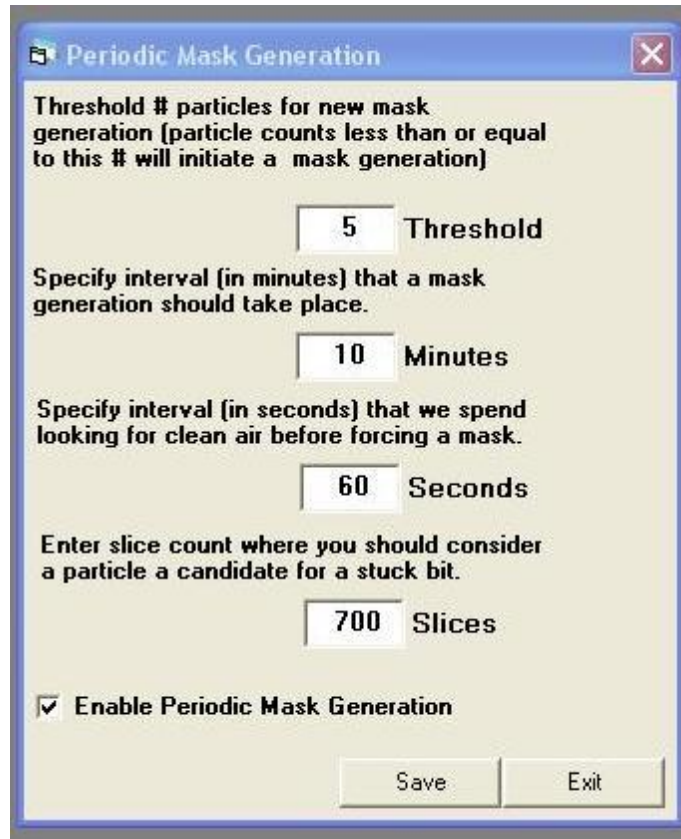
## 5.0 3V-CPI 2D-S Real-Time Operation Troubleshooting

### 5.1 Stuck Bits

The biggest concern the operator should have during operation is watching for errant, noisy pixels, or stuck bit. A stuck bit is defined as a single bit or pixel that stays shaded for a predefined number of contiguous samples resulting in vertical black lines of particle data. These black lines are caused by a number of factors including contamination on the probe windows, condensation, and periods between thermalization. The 2DS GUI allows the user to determine the actions taken when a stuck bit is found. The options, which are listed under Tools / Stuck Bit Handling, are as follows:

1. **Do Nothing** - keeps recording regardless of noise
2. **Notify User** - a window will pop up alerting the operator of a problem, he can then send a command packet to build a new mask.
3. **Resend Mask with Bits Masked Out** - sends the mask to the probe with the identified stuck bits that are to be ignored by the probe.
- 4: **Initiate Automask** - This option starts an automask where the mask algorithm should identify the stuck bits automatically. The mask algorithm uses the user set the limits in the command window in the H/V AM (Automask) boxes. The MaxSlice says if there is more than this many time slices (apparent particles) in one second then run the Automask algorithm. The Rej % is the threshold; when a single pixel makes up more than this percent of total pixel counts then it will be masked out. The MinSlice states that when the algorithm is running, and there is less than this number of time slices in the second then the Automask algorithm will cease.

The number of contiguous samples (with the same bit shaded) which defines a stuck bit is user defined in the “Periodic Mask Generation” Menu under “Tools”. See Figure below.



**Figure 5.1.** Periodic Mask Generation Window

Note: One slice is ~10  $\mu\text{m}$  wide, so the stuck bit count should exceed the maximum expected particle or cloud drop diameter (10mm = 1000 slices). In the figure, a stuck bit is defined at 700 slices which equal 7mm.

Note: To change the number of slices value, the “Periodic Mask Generation” box must first be selected, the number of slices may then be edited, and then “Periodic Mask Generation” may then be de-selected. The 2-DS will always look for stuck bits – independent of whether the “Periodic Mask Generation” box is selected or not.

If one array is too noisy and you want to stop recording on it, go to the Send Command Packet Window. In the Comp. Mode Section chose the array you want to keep recording on and send a new command packet to the probe.

Small amounts of noise are tolerable. If flying through clear air and you see the particle count at 10 per second, it may be okay to leave as is. In post-processing these noisy bits can be removed.

## 5.2 No or Loss of Response from the Probe:

If during data collection the 2D-S program freezes or the 2D-S stops communicating, follow these instructions:

1. Stop recording and exit the real-time program.
2. Cycle power to the probe and see if the LAN connection gets re-established.
3. Start real-time software and hit record.
4. Sometimes it may be necessary to restart Windows with the probe power off to get networking to function properly again. If communications with the probe continues to fail, verify in the Tools→Set Probe IP Address that the probe address is set to 192.168.1.133. In a DOS (cmd) window, type the command: “ping 192.168.1.133”. If the ping fails, there may be a problem with probe power or cabling. Check all connections. The connections may have become loose during taxing or takeoff. Be sure network firewalls are disabled.

## 5.3 Distorted Images

If particles looked squashed or stretched, check the TAS to see if it is close to the actual TAS of the aircraft. If not, send a new TAS to the probe. Using the set TAS box and making sure the TAS Source is set to Fixed (if not using aircraft source).

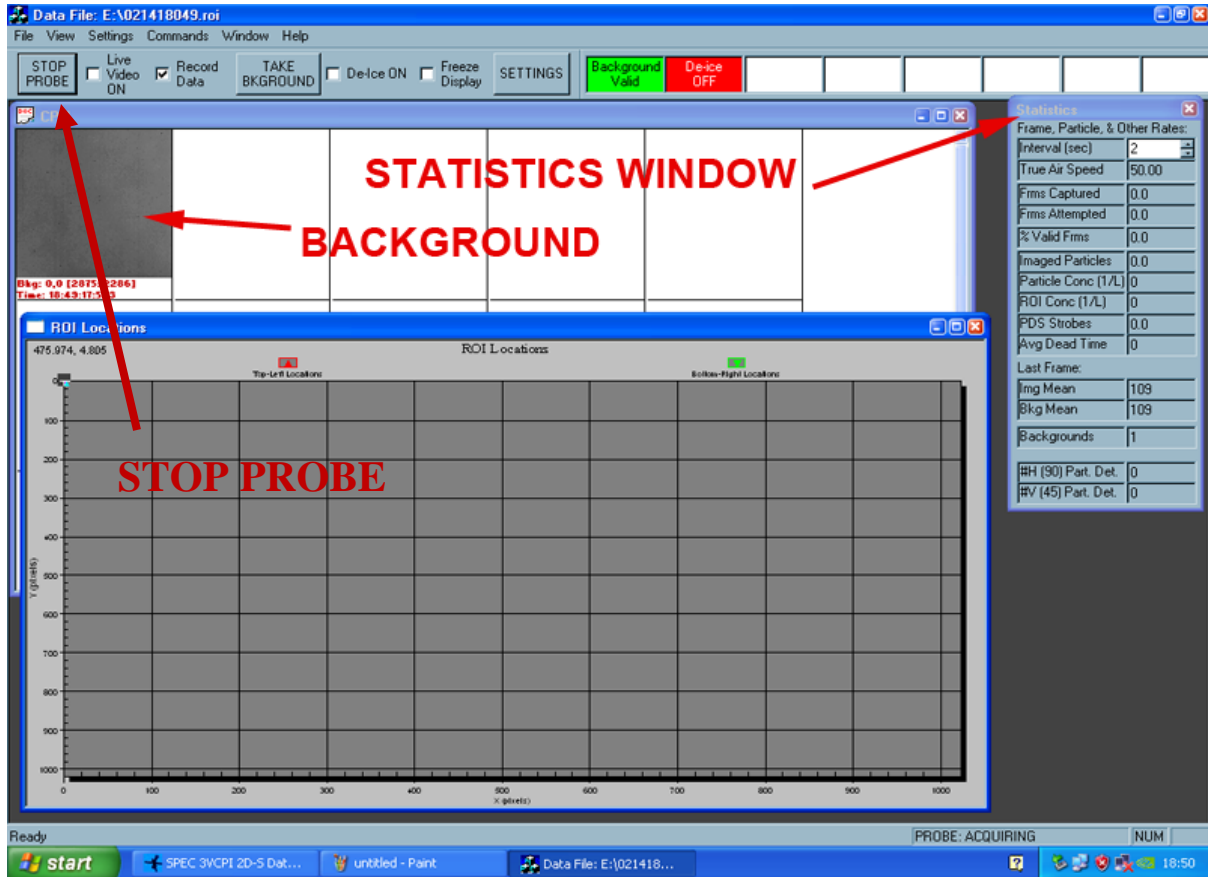
## 5.4 Over Masking of Array Elements

Building masks while in cloud can make substantial amount of the array to be masked out. Similarly if you enter cloud with the improper settings a mask may automatically be generated with the Automask function with the same results. If the array becomes substantially masked while in cloud go to the Send Command Packet window and adjust the Automask's rejection percentage on each array higher and send a command packet to the probe. With a higher rejection percentage the array should become unmasked. You may also want to disable periodic mask generation if flying through persistent cloud cover.

## 6.0 Hawkeye Shutdown Procedure

### 6.1 Disconnecting from the CPI probe

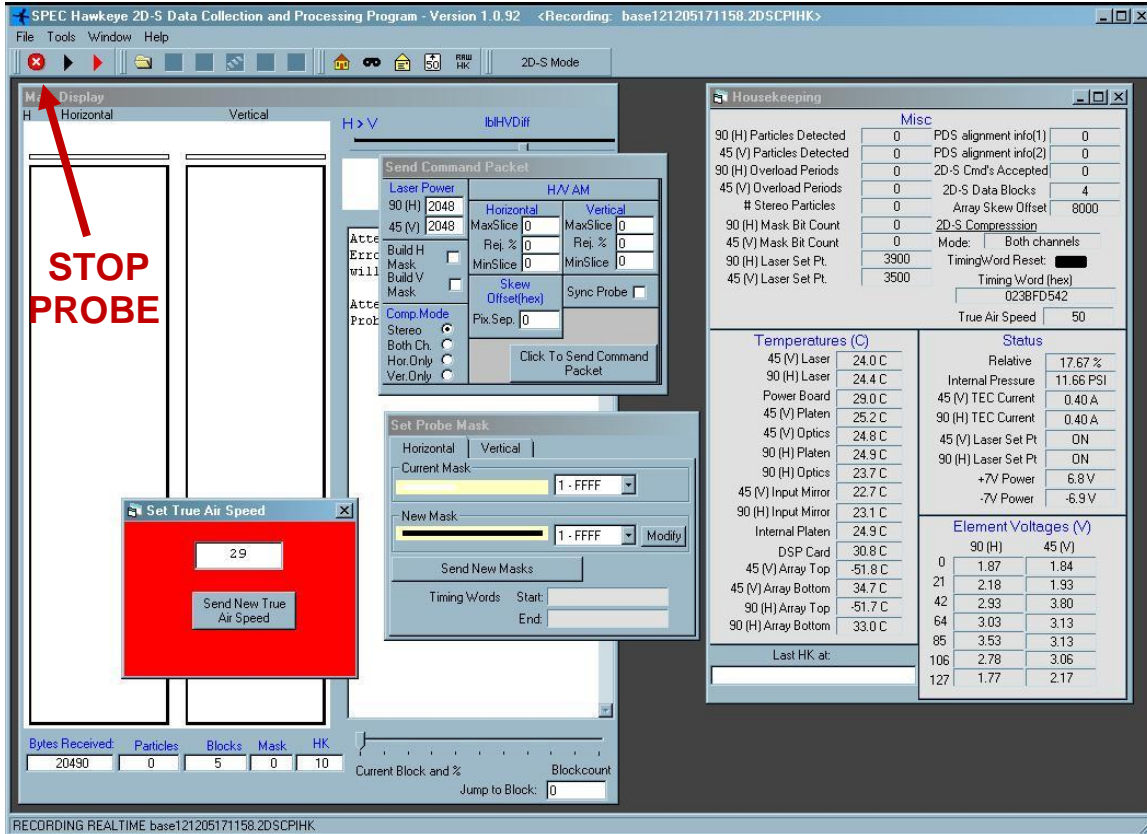
1. To disconnect from the CPI, click the Stop Probe button in the upper left-hand corner (see **Figure 6.1**). Once stopped, the CPI GUI window may be closed.



**Figure 6.1.** 3V-CPI GUI.

## 6.2 Disconnecting from the 2D-S probe

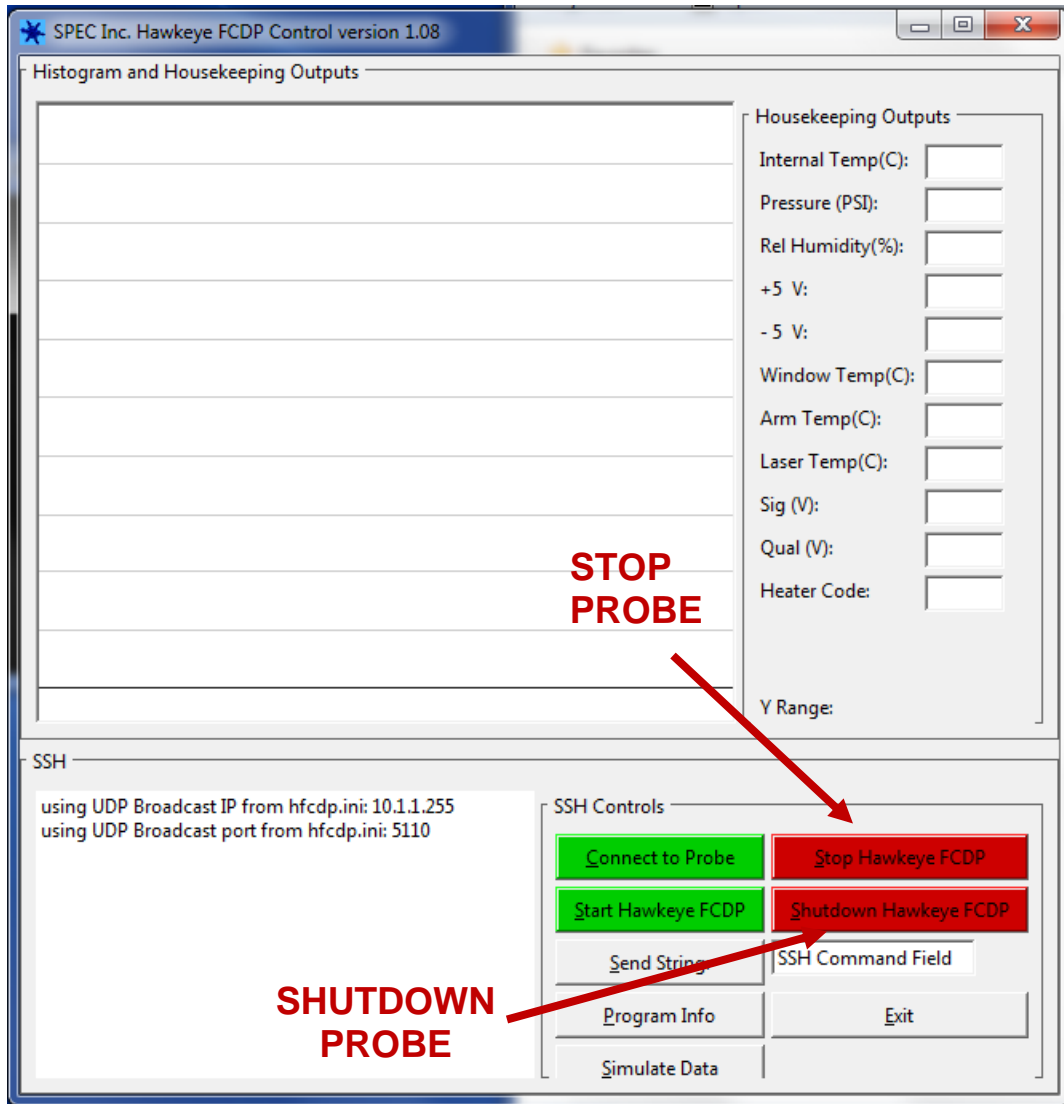
- To disconnect from the 2D-S, click the button with the red circle with an x button (see **Figure 6.2**). Once stopped, the 2D-S GUI window may be closed.



**Figure 6.2.** 3V-CPI 2D-S GUI.

### 6.3 Disconnecting from the FCDP

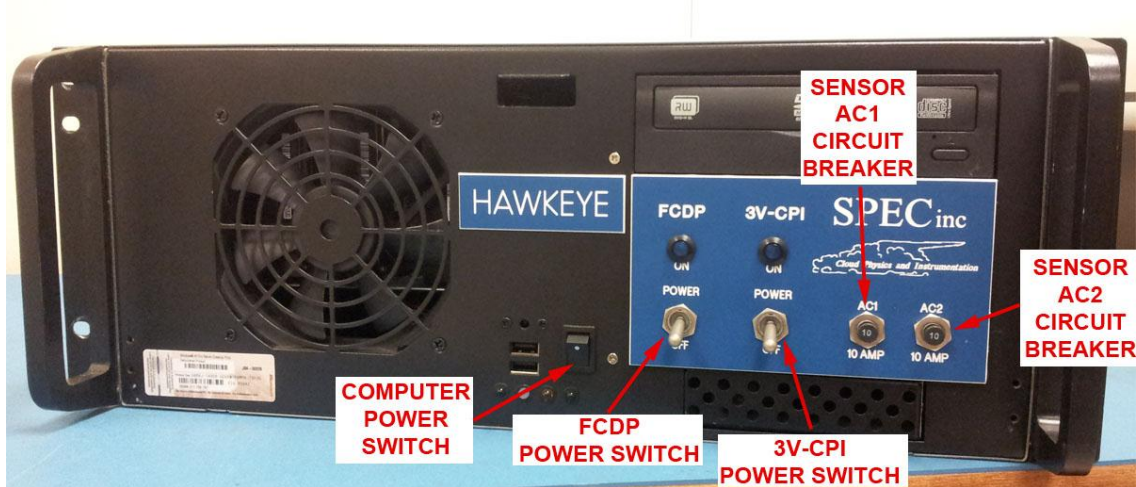
- 3 To disconnect from the FCDP, click the “Stop Hawkeye FCDP” button (see **Figure 2.3.7**).
4. Once the FCDP has stopped collecting data, click the “Shutdown Hawkeye FCDP” button. Once stopped, the FCDP GUI window may be closed.



**Figure 6.3.** Hawkeye FCDP GUI.

## 6.4 Shutting Down the System

5. After the programs have been closed, switch off both of the sensor power switches (FCDP & 3V-CPI) on the front panel of the DAS (see **Figure 6.4**).



**Figure 6.4.** Front panel of the Hawkeye DAS.

6. Shut down the Data Acquisition System (DAS) computer.
7. Once the system has been shut down, it may be disconnected following the procedure in the Hawkeye Getting Started Manual, Sections 2.5.

## 7.0 Appendix – CPI INI Example

```
1 [System]
2 CameraType=1
3 ; ProbeRev#=2 traditional CPIs
4 ; ProbeRev#=3 UAV CPI
5 ; ProbeRev#=4 Tethered CPI
6 ; ProbeRev#=5 3VCPI
7 ProbeRev#=5
8 PixelPolarity=0

9 [ROI Parameters]
10 ImageType=32768
11 DispMode=0
12 StartDrive=5 1 15
13 DriveCount=1 1 6
14 BackgroundRate=60000 10 36000
15 BkgPDSThreshold=3 1 35
16 ROIThreshold=44 20 150
17 ImgMeanMin=65 1 70
18 ImgMeanMax=100 70 255
19 ROIMinSize=3 0 400
20 ROIAspectRatio=640 2 900
21 ROIFillRatio=0.000006 0.000000 0.800000
22 ROIYPad=15 0 50
23 ROIYPad=15 0 50
24 DebugMode=0
25 FullFrame_Skips=0 0 10000
26 [Probe Settings]
27 Mode=3370
28 Heaters=33693
29 Setting1=-1 -64 958
30 Setting2=958 -64 958
31 Setting3=-2 -64 958
32 Setting4=958 -64 958
33 Setting5=0 -64 958
34 Setting6=618 -64 618
35 Setting7=618 -64 618
36 Setting8=-12851 -64 618
37 Setting9=0 -64 958
38 Setting10=788 -64 958
39 Setting11=1964 290 1964
40 Setting12=1964 290 1964
41 Setting13=1964 290 1964
```

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```
42 Setting14=0 0 4095
43 Setting15=0 0 4095
44 Setting16=100 100 1000
45 Setting17=100 100 1000
46 Setting18=4095 0 4095
47 Setting19=4095 0 4095
48 Setting20=50 10 50
49 Heaters2=0
50 Setting22=21 0 4095
51 Setting23=-12851 0 4095
52 Setting24=23 0 4095
53 Setting25=24 0 4095
54 Setting26=25 0 4095
55 Setting27=26 0 4095
56 Setting28=27 0 4095
57 Setting29=28 0 4095
58 Setting30=29 0 4095
59 [Gains/Offsets for Readings]
60 Gain/Offset1=0.029356 1.877500 10.000000 35.000000
61 Gain/Offset2=0.029356 1.877500 20.000000 35.000000
62 Gain/Offset3=0.029356 1.877500 20.000000 35.000000
63 Gain/Offset4=0.029356 1.877500 10.000000 35.000000
64 Gain/Offset5=0.029356 1.877500 10.000000 35.000000
65 Gain/Offset6=0.029356 1.877500 5.000000 35.000000
66 Gain/Offset7=0.029356 1.877500 5.000000 35.000000
67 Gain/Offset8=0.029356 1.877500 -60 60.000000
68 Gain/Offset9=0.029356 1.877500 0.000000 35.000000
69 Gain/Offset10=0.029356 1.877500 0.000000 35.000000
70 Gain/Offset11=0.029356 1.877500 0.000000 60.000000
71 Gain/Offset12=0.029356 1.877500 0.000000 60.000000
72 Gain/Offset13=0.029356 1.877500 0.000000 60.000000
73 Gain/Offset14=0.029356 1.877500 0.000000 60.000000
74 Gain/Offset15= 0.014937 -4.332600 0.000000 35.000000
75 Gain/Offset16= 0.014937 -4.332600 0.000000 35.000000
76 Gain/Offset17= 0.014937 -4.332600 0.000000 35.000000
77 Gain/Offset18= 0.014937 -4.332600 0.000000 35.000000
78 Gain/Offset19= 0.017042976 0.000000 15.000000 35.000000
79 Gain/Offset20= 0.004395 0.000000 5.000000 8.800000
80 Gain/Offset21= 0.0174386 0.000000 15.000000 35.000000
81 Gain/Offset22= 0.004395 0.000000 5.000000 8.800000
82 Gain/Offset23= 0.033308 56.800000 20.000000 35.000000
83 Gain/Offset24= 0.027108 46.200000 20.000000 35.000000
84 Gain/Offset25= 0.014780 0.000000 26.500000 29.500000
85 Gain/Offset26= 0.002930 0.000000 4.500000 5.500000
86 Gain/Offset27= 0.007354 0.000000 11.500000 12.500000
```

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```
87 Gain/Offset28= 0.007354 0.000000 -12.500000 -11.500000
88 Gain/Offset29= 0.007101240.000000 12.000000 35.000000
89 Gain/Offset30= 0.000610352 0.000000 0.000000 60.000000
90 Gain/Offset31= 0.007260083 0.000000 12.000000 35.000000
91 Gain/Offset32= 0.000610352 0.000000 0.000000 40.000000
92 Gain/Offset33= 0.007324219 0.000000 0.000000 30.000000
93 Gain/Offset34= 0.007324219 0.000000 0.000000 30.000000
94 Gain/Offset35= 83.333e-9 0.000000 0.000000 1000.000000
95 ; Dead Time:
96 Gain/Offset36= 1.0 0.000000 0.000000 0

97 [Display Options]
98 ROI DX=132
99 ROI DY=130
100     ROI Columns=5
101     ROI Rows=4
102     Pixel Size(um)=2.3
103     Flags=49174
104     Display Frame Skips=0
105     Histogram Bins=20
106     Histogram Min Size=0
107     Histogram Max Size=300
108     Histogram ITime=40000
109     Histogram Refresh=1000
110     Rates ITime=1000
111     Air Speed(m/s)=150
112     ROI XY Plot Max ROIs=1000
113     ROI XY Plot Reset When Filled=1

114     [Serial Data Parameters]
115     PortSettings=COM2: baud=9600 parity=N data=8 stop=1
116     ;BlockSize=72
117     BlockSize=238
118     BlockMark=\r\n

119     ; Below are parameters for the cycling of settings
120     ; Section below is required, and SettingsSamples must be greater than 1
121     [Settings Sampling]
122     ; Turns cycling ON/OFF
123     DoSettingsSampling=0
124     ; Number of setting cycles
125     SettingsSamples=4

126     ; Section below is required, and SampleDuration must be greater or equal to 10
```

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```
127     [ROI Parameters Period1]
128     ; Duration of cycle period1 in seconds (>= 10)
129     SampleDuration=11
130     ; Below you can specify any or no settings to change
131     BkgPDSThreshold=35
132     ROIThreshold=25
133     ROIMinSize=4
134     ROIAspectRatio=900
135     ROIFillRatio=0.000006
136     ROIXPath=6
137     ROIYPad=6

138     [Probe Settings Period1]
139     ; Probe Settings values for Period 1
140     ; These are optional
141     ; PDS45 Threshold
142     Setting16=800
143     ; PDS90 Threshold
144     Setting17=800

145     [ROI Parameters Period2]
146     SampleDuration=12.5
147     ROIThreshold=45
148     ROIXPath=14
149     ROIYPad=14

150     [Probe Settings Period2]
151     Setting16=600
152     Setting17=601

153     [ROI Parameters Period3]
154     SampleDuration=10.5
155     ROIThreshold=55
156     ROIXPath=10
157     ROIYPad=10

158     [Probe Settings Period3]
159     Setting16=700
160     Setting17=701

161     [ROI Parameters Period4]
162     SampleDuration=10.5
163     ROIThreshold=65
164     ROIXPath=10
```

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```
165      ROIYPad=10

166      [Probe Settings Period4]
167      Setting16=800
168      Setting17=801

169      ; 3v-cpi initial settings
170      ;Setting4 orig 16335 = 13,12,11,10,9,8,7,6,3,2,1,0
171      ; this is all heaters except pylon2 and pylon3 (non-existent)

172      [3VCPI Probe Settings]
173      Mode=13
174      ;Mode is MSB of word 2, 13 = heat on, HZ and Vt
175      ;setting is the heater on bits
176      Setting4=16335 0 65535
177      Setting5=43690 0 65535
178      Setting6=44942 0 65535
179      Setting7=43690 0 65535
180      Setting8=43690 0 65535
181      Setting9=24853 0 65535
182      Setting10=24853 0 65535
183      Setting11=40334 0 65535
184      Setting12=43690 0 65535
185      Setting13=43690 0 65535
186      Setting14=43690 0 65535
187      Setting15=43690 0 65535
188      Setting16=43690 0 65535
189      Setting17=43690 0 65535
190      Setting18=44942 0 65535
191      Setting19=3819 0 65535
192      Setting20=3819 0 4095
193      Setting21=600 0 65535
194      Setting22=1000 0 65535
195      Setting23=255 0 4095
196      Setting24=2055 0 4095
197      Setting25=1281 0 4095
198      [3VCPI Probe Temps]
199      Forward Sample Tube Temp=0 0
200      Upper Optics Block Temp=0 0
201      Lower Optics Block Temp=0 0
202      Central Sample Tube Temp=0 0
203      Aft Sample Tube Temp=0 0
204      Pylon Temp 1=0 0
205      Pylon Temp 2=0 0
206      Pylon Temp 3=0 0
```

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207 CCD Camera Temp=0 0  
208 Imaging Lens Temp=0 0  
209 Imaging Laser Temp=0 0  
210 PDS\_45 Laser Temp=0 0  
211 PDS\_90 Laser Temp=0 0  
212 Power Board Temp=0 0  
213 PDS\_45 Platen Temp=0 0  
214 PDS\_45 Optics Temp=0 0  
215 PDS\_90 Platen Temp=0 0  
216 PDS\_90 Optics Temp=0 0  
217 PDS\_45 Input Mirror Temp=0 0  
218 PDS\_90 Input Mirror Temp=0 0  
219 Internal Platen Temp=0 0  
220 DSP Card Temp=0 0  
221 PDS\_45 Array Top Temp=0 0  
222 PDS\_45 Array Bottom Temp=0 0  
223 PDS\_90 Array Top Temp=0 0  
224 PDS\_90 Array Bottom Temp=0 0  
225 Relative Humidity=0 0  
226 Internal Pressure=0 0  
227 PDS\_45 TEC Current=0 0  
228 PDS\_90 TEC Current=0 0  
229 PDS\_45 Laser On=0 0  
230 PDS\_90 Laser On=0 0  
231 +7 V Monitor=0 0  
232 -7 V Monitor=0 0  
233 PDS\_45 Diode Element 0 Voltage=0 0  
234 PDS\_45 Diode Element 21 Voltage=0 0  
235 PDS\_45 Diode Element 42 Voltage=0 0  
236 PDS\_45 Diode Element 64 Voltage=0 0  
237 PDS\_45 Diode Element 85 Voltage=0 0  
238 PDS\_45 Diode Element 106 Voltage=0 0  
239 PDS\_45 Diode Element 127 Voltage=0 0  
240 Imaging Laser Current Measured Voltage=0 0  
241 PDS\_90 Diode Element 0 Voltage=0 0  
242 PDS\_90 Diode Element 21 Voltage=0 0  
243 PDS\_90 Diode Element 42 Voltage=0 0  
244 PDS\_90 Diode Element 64 Voltage=0 0  
245 PDS\_90 Diode Element 85 Voltage=0 0  
246 PDS\_90 Diode Element 106 Voltage=0 0  
247 PDS\_90 Diode Element 127 Voltage=0 0  
248 Imaging Laser Pulse Width Measured Voltage=0 0  
249 Imaging Laser Current Set Point Voltage=0 0  
250 Imaging Laser Pulse Width control Voltage=0 0

---

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