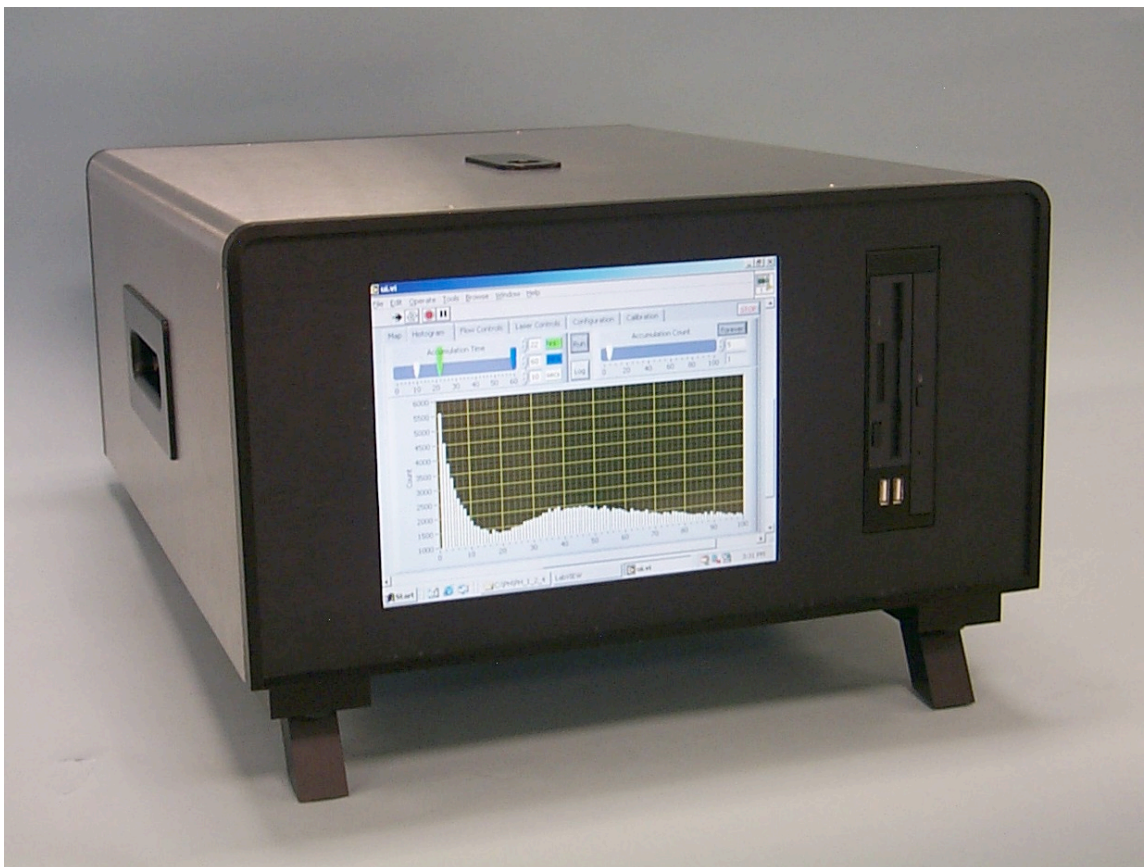


**Ultra High Sensitivity Aerosol
Spectrometer
DMT Model UHSAS-0.055
0.055 – 1.0 microns
Manual**



**Droplet Measurement Technologies
5710 Flatiron Parkway, Suite B
Boulder, CO 80301
USA
Telephone 303-440-5576**

Laser Safety Warnings

STRICT OBSERVANCE OF THE FOLLOWING WARNING LABELS IS ADVISED

This instrument is a Class I laser product. **CAUTION:** Use of control or adjustments or performance of procedures other than specified in this manual may result in hazardous radiation exposure.



This label is displayed on the top cover (front and back) of the instrument.



This label is located on the support structure underneath the instrument cover near the laser interlocks to serve as a warning if the instrument cover is removed.



This label is located on the optical block and the arrow points to the cleaning port.

Chapter One - Unpacking & Cabling

The UHSAS instrument is delivered in a shipping case which also contains the necessary cables etc to make the instrument functional. Remove the instrument from the case by putting your hands in the small cutouts on each of the long sides of the instrument. The handles for the instrument are located in these cutouts. **(The 2 small handle-like protectors on the top lid of the instrument are protectors for the inlet. Do not use these as handles.)** Put your fingers into the handles located about ½ way down each side of the case lifting the instrument from the case and placing it on a stable working area. The front legs of the instrument are hinged so that the front of the instrument case can be elevated. The power cable, keyboard and mouse for the instrument are located in a pouch in the lid of the case.

The instrument will be shipped with a cap on the inlet. Remove this cap before the initial startup. Install sample line (1/8" OD Tygon tubing) and zero filter.

Connect the keyboard/trackpad to a USB port on the front panel. The USB ports are located just below the floppy/CD combo drive.

Before connecting the power cable to the wall power outlet, make sure the instrument on/off switch is in the off position. The on/off switch is a rocker-type, toggle located on the back of the instrument near the power plug. Input power to the instrument can range from 100-240VAC 50/60Hz.

If you are connecting the UHSAS instrument to an Ethernet network, the connector (RJ-45 female) for that cable is located on the back of the instrument.

There is also a serial port connection (9 pin D-connector) located on the back of the instrument that may be used to connect to an external data system.

Chapter Two - Specifications & QC checklist

Laser Type	solid state pumped Nd ³⁺ :YLF
Sample flow	10-100 SCCM (this unit) 1-10 SCCM optional
Sheath airflow setting	700 SCCM
Maximum count rate	3000 per second
Counting efficiency	at least 50% at min. size increasing to 100%
Number of channels	100
Minimum detectable size	0.055 microns
Size range	0.055 – 1.0 micron
Environmental	10 to 30C Sea level to 4 km altitude RH (non-condensing)
Dimensions	56 x 43 x 24 cm
Weight	31kg
Power requirements	100-240VAC 47-63Hz BUSS fuse, GMA-2A

Insert unit specific checklist here

UHSAS 55nm-1000nm QC Checklist

Chapter Three - Getting Started & Shutdown/Power off procedure

The UHSAS instrument contains a computer which runs the Windows2000 operating system. It is assumed that the instrument user is familiar with the normal operation of this operating system on a computer.

Before starting the instrument, ensure that the keyboard/trackpad are connected to the USB port on the front panel of the instrument, that the zero filter is in place on the inlet, that the power switch is in the off position, and the power cable is connected.

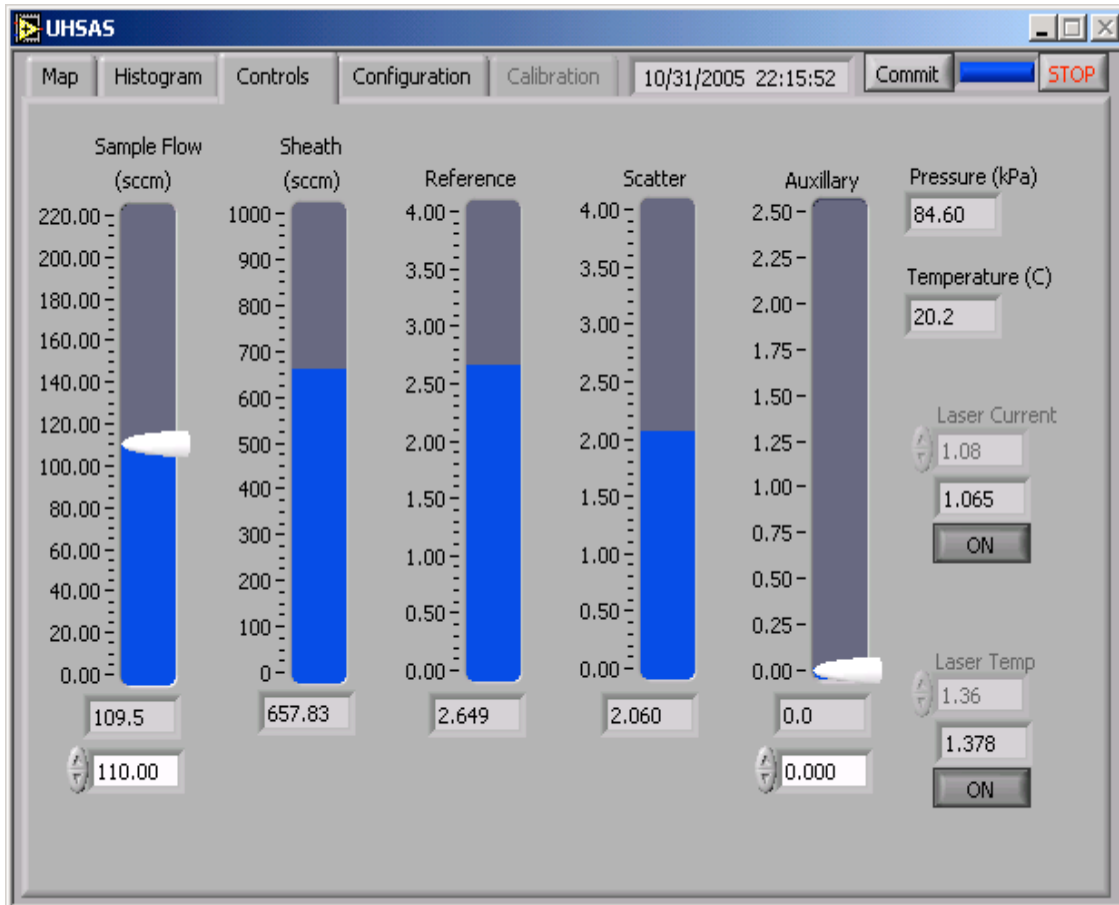
Turn on the instrument with the power switch located on the back panel. When power is applied to the instrument you will see the Windows2000 startup windows on the flat panel display on the front of the instrument. The computer is configured to auto-boot into Windows2000 without the need to supply a login and password at startup. The default user called “droplet” is configured as a user with administrator privileges in Windows2000.

When Windows2000 is booted, the desktop will contain a shortcut labeled UHSAS.vi which will run the LabView executable program which controls the instrument. Select & Run this shortcut. This will bring up the UHSAS window on the desktop.

LabView 7.1 is a software program from National Instruments which provides a user-friendly virtual instrument (commonly called a vi) panel for the control, data display, and data logging of the UHSAS instrument.

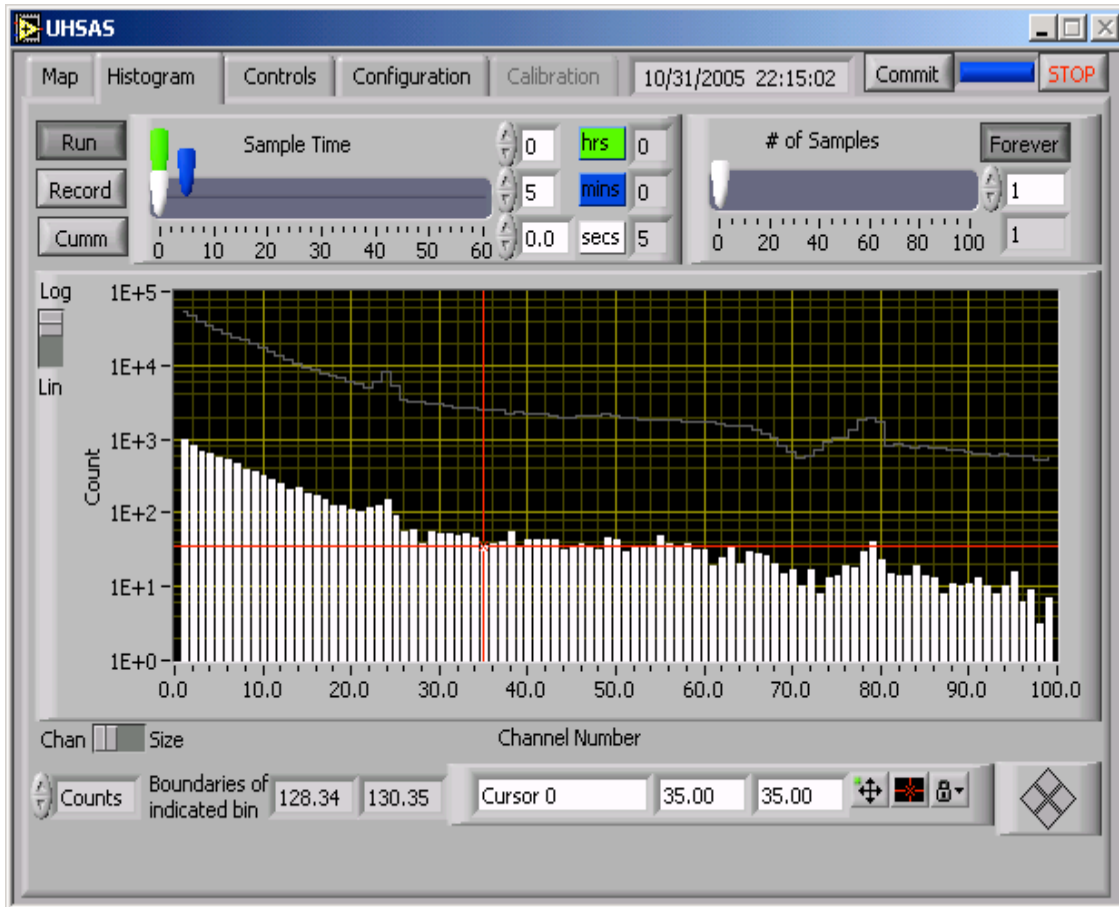
The UHSAS vi controls the instrument through a series of vi displays for various instrument functions. Examples of this display are shown below. Actions on the vi are initiated with the normal “mouse” and “select” buttons on the computer. The UHSAS vi has different views which are selected with the appropriate tab near the top of the display.

The UHSAS.vi starts with the Controls screen as the default screen. The Controls screen allows the user to monitor the various air flows in the instrument, the sample block temperature & pressure, and has monitors for the laser & cavity characteristics. The air flows are measured with electronic flow controllers or meters. The sample flow is controllable by adjusting a flow controller with either the “slider” control or by manually inputting a number in the set voltage box at the bottom of the flow indicator. At startup, check that the Sheath flow is about 700 SCCM and the sample flow should be between 10 and 99 SCCM. Refer to the UHSAS 55nm-1000nm QC Checklist on a previous page for nominal values for Reference, Scatter, Laser Current and Laser Temp.

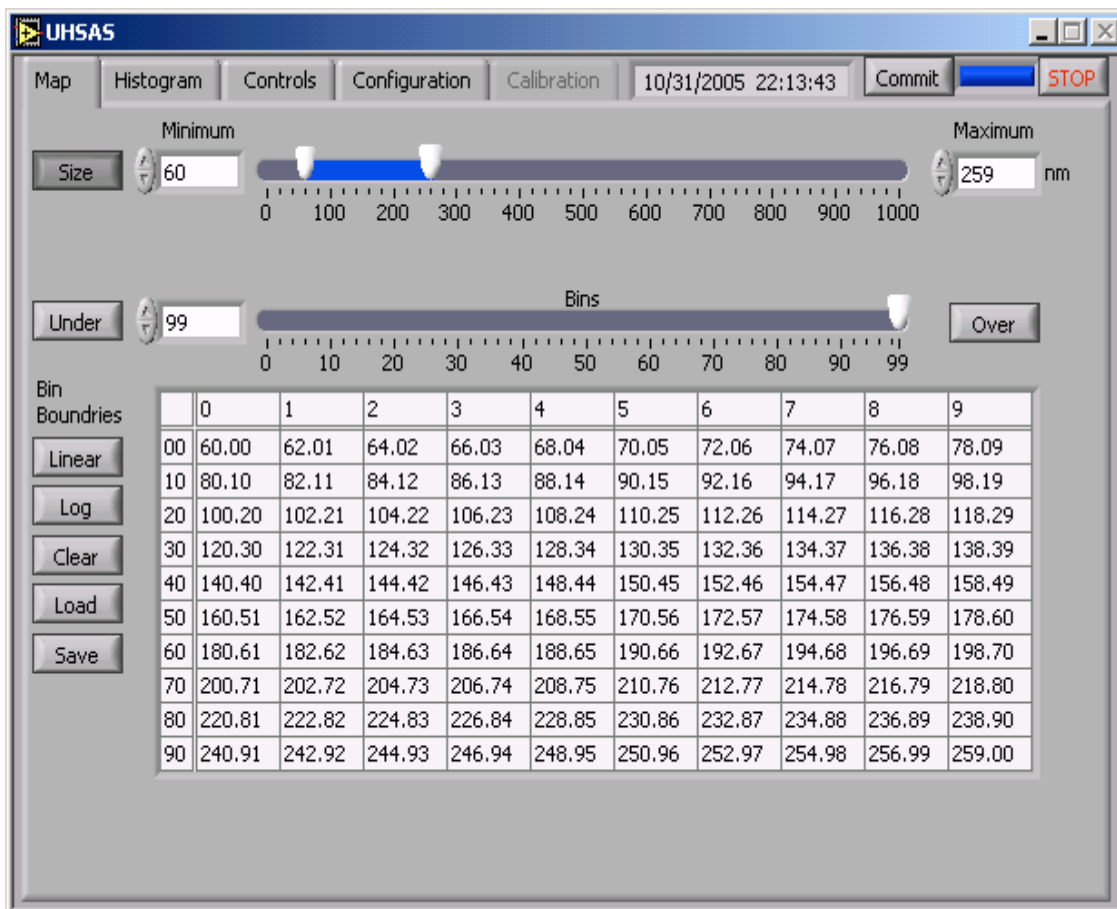


Next, select the Histogram tab to display counts versus channel number. You need to select/push the Run button near the upper left corner of this window to show the particle accumulations. This should have very few counts if the zero filter is in place.

Remove the zero filter for room air sampling and many counts will appear.



The size range displayed on the histogram is controlled through the Map tab. Select the Map tab to change/control the size range displayed. The Map tab shows the boundaries of the bin width map that is used for the display. The map can be modified in multiple ways depending on user preference. See Chapter 6 of the manual for details.



Shutdown / Power off procedure

-Put zero filter on inlet line.

-If file recording is activated, go to Histogram tab and press the Record button. The Record button will change color from a darker grayish appearance to the same color grey as the background.

-Press the rectangular **STOP** button located towards the upper right portion of the UHSAS screen. This stops the execution of the UHSAS.vi.

-Next the computer must be shut down using normal Windows2000 controls and the on/off switch located on the rear panel of the instrument.

Chapter 4 - Theory of operations

Instrument subsystems

The UHSAS is an optical-scattering, laser-based aerosol particle spectrometer system for accurately and precisely sizing particles in the range from 0.055 μm to 1.0 μm diameter. It uses fully user-specified size binning of up to 100 channels anywhere within its size range.

The spectrometer instrument consists of 5 general subsystems, described in this chapter.

- 1) the main optical subsystem responsible for generating the laser light, detecting the scattering from the particles and providing a mechanical enclosure for the optical system and for delivery of the sample aerosol
- 2) the flow system for bringing the sample aerosol through the optical interaction region, including flow control and measurement
- 3) the analog electronics system for amplifying and processing the particle signals
- 4) the digital electronics system for analyzing particle signals, binning signals according to user-specified bin mappings and generating a histogram of number of particles in the specified bins, and for communicating with the PC and system monitor/control functions
- 5) an onboard PC running Windows and a specialized application GUI for instrument control, setup and data reporting and collection

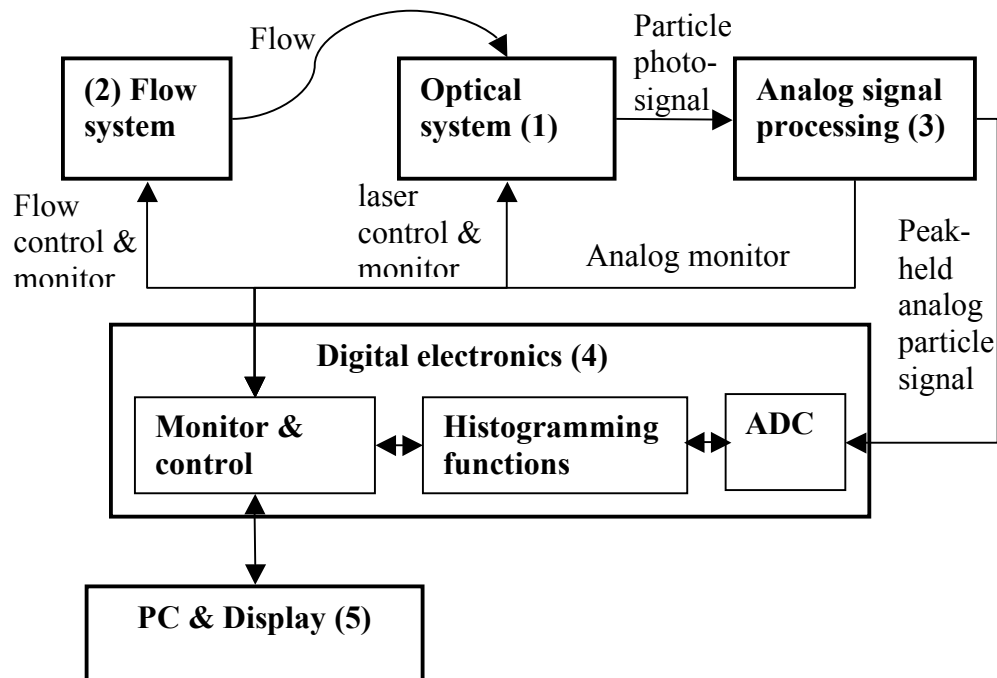


Figure: Block diagram of optical particle spectrometer

1) Optical system

The Optical system consists of

- a) the laser and associated components and optics,
- b) the detection system, including collection optics, photodetectors, and reference monitoring
- c) mechanical housing for above

a) The laser is a semiconductor-diode-pumped Nd^{3+} :YLF solid-state laser. It operates in the fundamental (TEM_{00}) spatial mode on a 1054 nm laser line with an intracavity power of ~ 1 kW. The pump laser is a 1 W single-stripe diode at 800 nm, driven by a stable current source and is temperature-controlled. The laser is a high-quality factor optical resonator built around an Nd^{3+} :YLF active laser crystal, pumped end-on by the diode laser. The laser mirrors have reflectivities near 0.99999 at the lasing wavelength. The laser mode has a $1/e^2$ intensity diameter of 600 μm . The standing wave laser mode is perpendicular to the flow of particles; the light is linearly polarized with the electric field vector parallel to the flow of particles. Particle scatter is collected in a direction perpendicular to both the particle flow and the laser standing-wave. As particles traverse the laser mode, they scatter light into the detection system. The amount of light scattered is a strong function of the particle size.

b) The detection system consists of two pairs of Mangin collection optics capable of collecting light over a large solid angle. The Mangins image the volume of space at which the flow intersects the laser mode onto a photodiode. There are two pairs of collecting optics: one pair images onto an APD for detecting the smallest particles (the primary scattering detection system). The other pair (located on the opposite side of the block) images onto a low-gain PIN photodiode for detection of the upper size range of the instrument (the secondary scattering detection system). Each detector is amplified in a current-to-voltage stage which feeds the analog electronics system. The imaging optics have an acceptance aperture of 23 mm diameter at a distance of 8 mm from the interaction region. The Mangin reflectors are dielectric coated with reflectivity of 0.9. The system can detect particles as small as 55 nm (50% efficiency, 1-10 counts/minute dark count rate). At this particle size, the peak scatter rate corresponds to 100 pW of detected light power at the detector. The system size sensitivity is limited by several noise sources: a fundamental noise process from the photon shot noise on the detected molecular scatter from background gas, a fundamental noise process from the Johnson noise in the photodiode transimpedance feedback resistor, and from technical noise of various sources.

c) The laser and detection optics are built into a sealed mechanical enclosure (the optical block). (See Figures)

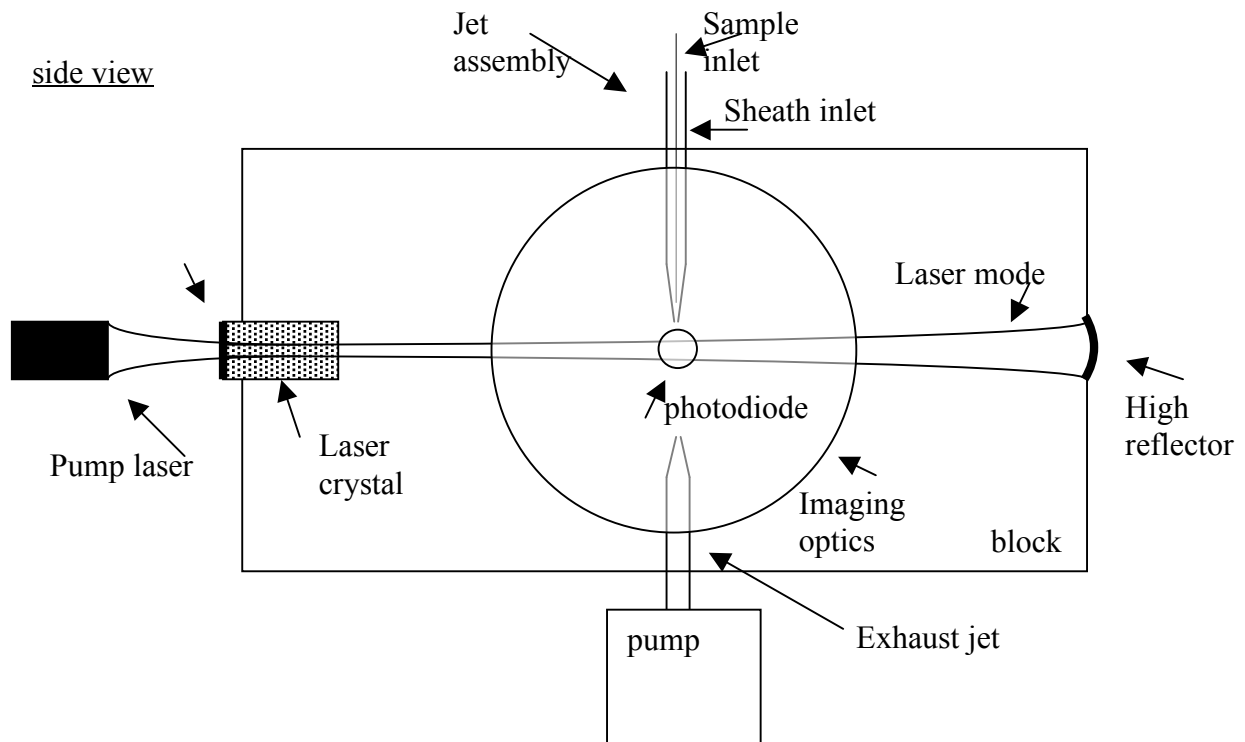


Figure: Side view of optical block

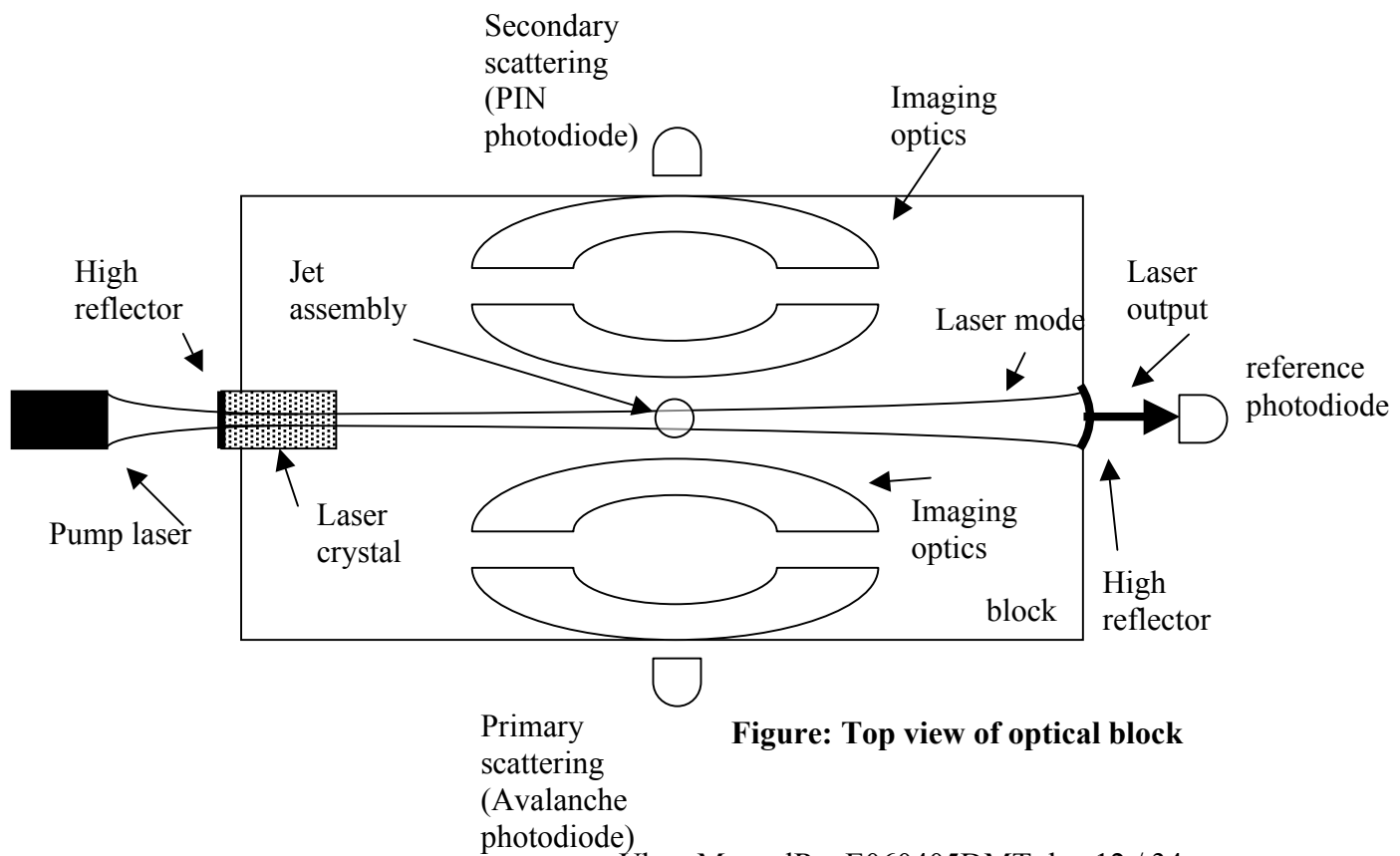


Figure: Top view of optical block

2) flow system

The mechanical laser mount forms a sealed block around the laser and the inlet/exhaust jets. A pump draws on an exhaust jet pulling flow through the inlet jet and across the laser mode. The inlet jet is an aerodynamically focused assembly with a sample nozzle of 500 μm diameter and a sheath nozzle of 760 μm diameter. The tip of the sheath jet sits within 1 mm of the edge of the laser mode. Sample flows are between 1 and 100 sccm and the sheath flow is typically 700 sccm. Particle velocity depends on sheath flow rate, but is on the order of 50 to 100 m/s. The particles are confined to a region of space whose extent is approximately 10 % to 20 % of the laser beam diameter which is 0.5 mm (e^{-2} intensity diameter). This yields a sizing resolution of approximately 2% to 5% of the particle size. (See Figure)

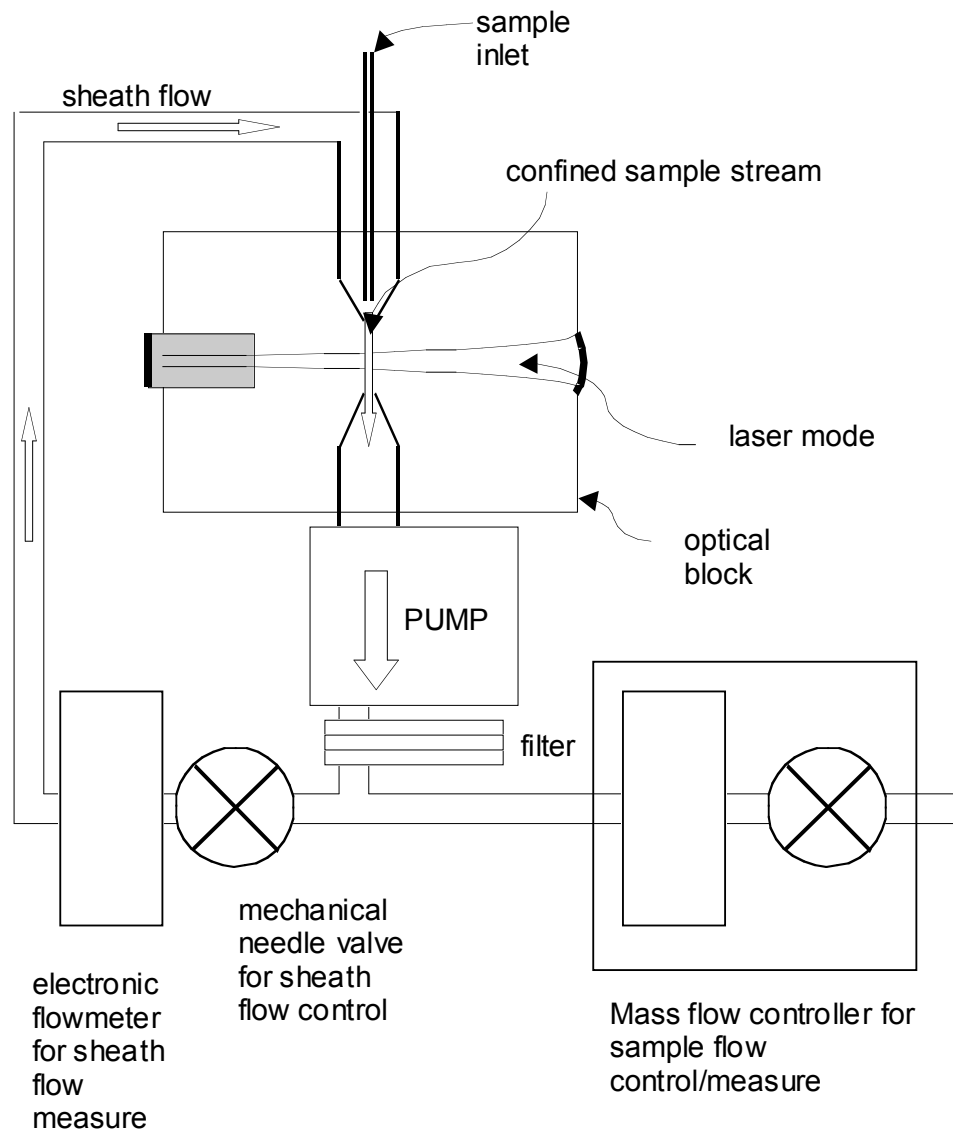


Figure: Schematic diagram of flow system

3) Analog electronics.

The analog chain converts the photocurrent of the detector photodiodes to a voltage and processes that signal (called the particle signal). The chain is repeated for the primary and secondary detection systems.

After the photodiode transimpedance amplifier, the photo signal is mixed with a signal derived from the reference detection system for noise cancellation. This cancels noise fluctuations of the laser, lowering the noise floor and improving sensitivity.

The particle signal is fed into two different AC gain stages, differing in gain as specified below. In total there are four gain stages: high and low for each of the primary and secondary detection systems.

Gain stage labeling convention

	High gain	Low gain
Primary detector	G3	G2
Secondary detector	G1	G0

Gain ratios:

$$G3/G2 = 50$$

$$G2/G1 = 20$$

$$G1/G0 = 20$$

Note that the gain ratios $G3:G2$ and $G1:G0$ are pure electrical amplification gain ratios. The $G2:G1$ ratio is more complicated since it involves two independent photodetectors with independent electronics and on opposite sides of the optical block. See the discussion in the Calibration section.

The gain stages also provide low-pass filtering to the signal. Each gain stage then feeds it's own baseline restoration circuit, which restores the 0 Volt baseline which is disturbed by frequent particle signals after AC coupling. The particle signal is then passed to a peak hold circuit which tracks the rise of the photo-signal as a particle crosses the laser and holds the peak value. The digital system then processes the signal and issues a reset. (See Figure)

The noise-cancellation is not used on the secondary side. The reference detector is used both for noise cancellation and for monitoring of the laser output power (which is directly proportional to the laser cavity power.) At present there is no gain control implemented: if the laser power drifts, the instrument must be calibrated. However, only large drifts in power > 25% really need to be corrected, since the particle sizing sensitivity is a sixth-root of the laser power.

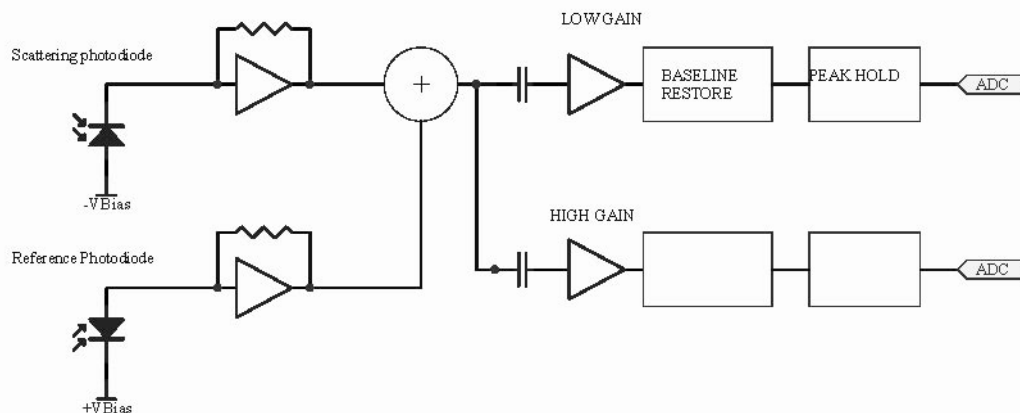


Figure. Block diagram of analog electronics

4) Digital electronics system

a) ADCs and peak height analysis

For each of the four gain stages (2 primary, 2 secondary) there is an associated Analog-to-digital converter. The ADCs run a 16-bit conversion at 100 kHz sample rate. The chain of events is begun as a particle traverses the laser mode and begins scattering light. The particle signal from the highest gain stage on the primary detector (G3) feeds an analog comparator. If the signal exceeds a preset (user-settable) threshold it generates a particle trigger. The threshold value is independent of the particular active bin map: it should be set to register the smallest detectable particle (55 nm diameter) under typical operating parameters. After a trigger is generated and after a small delay to allow the particle signal to reach its maximum, the 4 ADCs sample the 4 peak-held particle signals from the four gain stages. Starting from highest gain (G3) and working down in gain, the first ADC that is not in saturation is the valid particle ADC. The value of this ADC is read and compared to a look-up table of bin boundaries previously loaded into memory. Depending on where in the look-up table the particle signal belongs, a counter for the appropriate channel is incremented (There are certain conditions which will post-invalidate a particle event, for example, if the event falls outside certain timing requirements.) After the particle signal is sampled, a reset is sent to the peak hold circuit and the cycle repeats for the next particle.

The look-up table is the heart of the peak-height analysis in this instrument. It can be reset by the user at any time to generate an arbitrary bin mapping. The user specifies the boundaries of the channels and this is automatically converted, via the calibration curve,

relative gains and calibration points into a mapping of voltages at each of the gain stages. The mapping process is transparent to the user and occurs every time a bin map is committed to the instrument. (See the calibration section below.)

b) monitoring/control

The digital system also provides monitoring and control of onboard systems. It reads and sets the mass flow controller for monitoring and control of the sample flow. It reads the electronic flowmeters for the sheath and purge flows (flows are controlled by mechanically-actuated needle valves). It controls and monitors the pump laser diode by enable/disable lines and current and temperature setpoints. The laser reference from the reference photodiode and the molecular scattering level are sampled on an ADC and read in the digital electronics module. Additional housekeeping parameters such as case temperature and ambient barometric pressure are also monitored. These could be used for correction to flow meters and noise-cancellation circuitry but at present are not. All parameters which are read by the digital system are logged with the sample data. All parameters which are set are stored in configuration files.

5) On-board PC

The onboard PC provides a user interface to the instrument. It is a Pentium-III, 845MHz, single board computer running the Windows2000 Professional OS. The computer has 256Mb of physical memory and a 30Gb hard drive. The monitor is a standard LCD display built into the front panel of the instrument. All normal OS operations are handled by Windows, e.g., networking, file management, printing, etc.. The user interface is a virtual instrument written in LabView 7.1(See VI section). Communication with the digital electronics system is via internal RS232 (115,200 baud, 8N1). The update rate of the PC I/O is controlled from a user settable variable .

Calibration

Calibration is an important process for any particle spectrometer instrument. The UHSAS with it's high resolution and large number of arbitrarily settable bins poses unique challenges in this area. Several features have been added to this instrument to make the calibration process as easy and accurate as possible.

There are 4 separate gain stages which must be "stitched" together for accurate, seamless sizing across the full dynamic range of the instrument. The gain stages are labeled in the table in a preceding section. There are two types of gains that need calibrating: absolute and relative gains. Relative gains are used to calibrate gain stages to one another. Absolute gain is used to fix the overall scale to a known particle size.

The relative gain calibration is somewhat automated, though the results can always be altered if the user needs to make slight adjustments. The relative gain calibration works by sampling an ambient air distribution which contains particles of all sizes measured by the UHSAS. The instrument detects a particle on adjacent gain stages (for example G3 and G2), noting the signal size on both gain stages (in volts). (For example a 100 nm

particle might be 3 V on G3 and 0.060 V on G2.) By noting many such events, a relationship between the signal size of a particle on the two gain stages can be determined---the relative gain. A linear fit to the data for many events produces a relative gain and an offset between adjacent gain stages. By running this procedure on all adjacent gain stage pairs (G3 and G2; G2 and G1; G1 and G0) a complete specification of the relative gains can be developed, linking the optical and electronic signals across the range of the instrument (which spans 6 decades of signal size in volts).

In addition to the relative gains, there is an absolute calibration curve, that is, the shape of the particle signal size (in volts) versus the particle size (in nm) from calibration standards. Once the relative gains are known, the corrected response for the entire instrument can be formed. Since the wavelength of the instrument is 1054 nm, it is expected that all particles below approximately 200-300 nm will lie on a sixth-power curve, that is, the particle signal is a sixth-power of the particle size. This has been hard-coded into the instrument by forcing the signals from G3, G2 and G1 to fall on a sixth-power curve. The final gain stage, G0, used for particles from 300 to 1000 nm has a Mie curve appropriate for the scattering response of the instrument (see Figure). It is a complicated function which is calculated and confirmed by test particle measurement. It's accuracy is questionable. In the event that the user has a preferred curve (empirical or theoretical) with, for example, a different index of refraction), this curve can be entered instead.

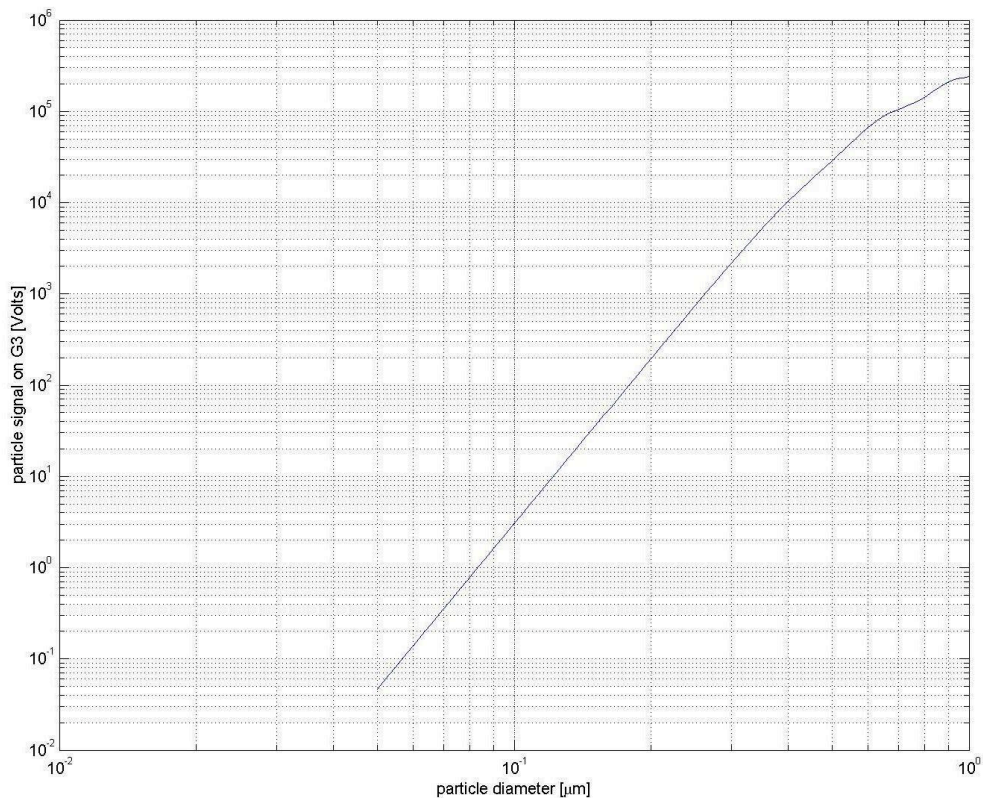


Figure: Example calibration curve

In principle, if all the relative gains are known accurately, and the calibration curve is known, the instrument need only be calibrated in an absolute sense at one point---any point in fact. In practice it is best to use a trusted particle or a few trusted particles. For factory calibration, the NIST SRM 1963 100 nm standard reference material is used to fix the calibration at one point--- and thereby with the relative gains and calibration curve, calibrate the instrument over its range. Other points in the instruments range are checked for accuracy with for example the NIST SRM 1691 269 nm reference particle.

In some cases, the user may have preferred particles to use for calibration. In this case as many particles as needed may be used. If the particles do not all fall on the preset instrument calibration curve, the calibration curve is altered slightly to ensure that the calibration particles will return a result which is the stated size of the particle. The data representing signal size for a given particle size is entered in the VI and is referred to as a calibration point. Note that alteration of the calibration curve from the preset may be required in order to accommodate several possible inconsistencies: for example, particles that have been inconsistently sized with other methods; nonlinearities in the instrument's detection electronics; or improved empirical data on the non-power law portion of the curve.

One comment on the relative gains is needed. In the particle-size regions where detection passes from one gain stage to another, there can be discontinuities in the histograms produced. The histograms are very sensitive to the relative gain parameters, and the relative gain parameters are experimental quantities, subject to statistical and systematic error. The stitching region between G2 and G1 is particularly prominent in this regard, since detection technique changes between these gain stages (they are physically different photo-detectors). The ability to zoom in on these transition regions can overemphasize the stitching errors. The user can optimize the stitching parameters to accommodate unusual requirements in this area, however, the semi-auto-calibration provided should be adequate in most cases.

Whenever changes are made to the relative gain parameters, the calibration curve or the calibration points, the new parameters will be used in the generation of the next bin map as it is committed to the instrument.

Chapter 5 - Acceptance/Performance Checks

Particle size calibration confirmation

In order to confirm calibration of the UHSAS instrument, the following steps should be taken.

- 1) The instrument's primary calibration is to PSL standard reference materials from NIST: the NIST 100 nm SRM and the NIST 269 nm SRM. Other manufacturer's particles may or may not agree with the sizes reported by NIST and therefore in general cannot be used to confirm the factory calibration with high accuracy.
- 2) Confirm that the laser reference level and scattering level are at their original values. If they are not, cleaning may be needed, see the maintenance chapter.
- 3) Run a monodisperse sample of PSL particles to the instrument sample inlet.
- 4) Configure a size bin map around the particle size used. For example a bin map with 99 channels and with a start value of 0.5 times the nominal size and a stop value of 1.5 times the nominal value is a good choice.
- 5) Start a histogram.
- 6) Accumulate a sufficient number of counts and confirm that the peak position is in agreement with the known particle size. If it is not, recalibration may be needed, see below.

Particle size recalibration

It may be necessary to recalibrate the size scale of the UHSAS. Some reasons for this include:

- 1) the laser power has drooped and cannot be fully restored
- 2) internal relative calibration has degraded
- 3) other types of particles (not PSL) with a different index of refraction will be used
- 4) to assure agreement with previously used standard materials.

The "Calibration" tab in the VI is where all calibration procedures are performed. The VI controls for calibration are discussed in the VI chapter and the calibration theory is discussed in the theory section. A complete outline of the calibration process is described here.

First, re-measure the relative gain parameters. To do this choose the relative gain tab labeled "G3:G2 Gain" and press "clear." Open the sample inlet to ambient air in a normal lab (not cleanroom) environment. If this is difficult, arrange the sample inlet to see a broad distribution of particles from 0.1 μm diameter to 1.0 μm diameter from some other way. Press "Run." As particles are sampled, they will begin to appear on the relative gain plot. Those particles which can be measured on both G3 and G2 will be used to measure the relative gain (and offset) between these stages. The gain parameters will begin to appear in the boxes when the required number of data points has been

reached. The process will stop when the preset number of points has been acquired. The graph should show the data points scattered around a best-fit line. Repeat this procedure for the other relative gain tabs (labeled “G2:G1 Gain” and “G1:G0 Gain”). Acquiring a sufficient number of large particles (for G1:G0) may take a significant amount of time (1-10 minutes), especially at flow rates below 60 sccm. This completes the relative gain portion of the calibration.

Next, gather a collection of particles to be used as reference particles and click on the “Calibration curve” tab. The present calibration curve should be shown. The x-axis of the graph shows particle size in nm and the y-axis shows the instrument response in millivolts as it would appear on the highest gain stage (G3). Note that the signal size of large particles is on the order of 10^6 mV on G3. Of course, these particles are measured on other gain stages with significantly less overall gain.

The region covered by each gain stage is indicated by the red dots on the graph. The red dots are the saturation levels of each gain stage, in other words, the largest particles measureable on each gain stage are shown at the red dots. For example, the region below the first red dot is covered by G3, the region between the first and second red dots is covered by G2, etc..

The white dots on the graph show the calibration points, or those points where particles have been run to fix the response of the instrument. These points provide the absolute calibration of the instrument: they move the curve up and down appropriately to convert voltage on various gain stages to particle size. There are two white points fixed by the instrument: one at 10 nm and one at 300 nm. These are used only to define the region of the instrument described by a power-law curve. They are not absolute reference points---they are used only for forward and backward extrapolation of the curve from the real calibration points. For example, if the user supplied one calibration point, say at 100 nm, then the 10 nm point will be used to extrapolate a power-law curve downward from 100 nm and the 300 nm point will be used to extrapolate a power-law curve upward from 100 nm. Above 300 nm, the calibration curve is defined by the “cal curve” shown in the lower right hand corner of the “calibration curve” tab. This is an array of points which specifies the relative signal size of particles above 300 nm. It is used to specify the SHAPE of the calibration curve outside of the power-law response region.

The calibration of the instrument is achieved by entering data into the “calibration points” data array. This is an array of triplets of numbers. The triplets are : The gain stage 0,1,2,or3; the particle size in nm and the particle response in millivolts. If you are recalibrating the instrument, clear all data from the calibration points array by right clicking on a data point and choosing “delete point” EXCEPT for the 100 nm point on gain stage 3. To calibrate follow the following procedure:

- 1) With your collection of particles, make note on which gain stage each particle will be measured by looking at the size of your particle and the calibration curve.
- 2) Choose a particle and introduce it to the sample inlet of the UHSAS.
- 3) Go to the “Map” tab and set up a voltage bin map by :

- a) press “Volts”,
- b) choose a gain stage (G3,G2,G1 or G0)
- c) choose a range from 100 mV to 10000 mV
- d) press “linear”
- e) press “commit”
- 4) Go to the histogram page and note the peak of the voltage histogram, if need be, zoom in on the peak for a better reading
- 5) Return to the “Calibration” tab and the “Calibration curve” tab
- 6) Enter the point into a new data point in the calibration points array
- 7) The calibration curve in the graph should show a new white point where you entered it and the calibration curve should adjust to accommodate the new point.
- 8) If the curve looks completely wrong, check that the correct gain stage and data are entered.
- 9) If needed, remove the 100 nm calibration point
- 10) Repeat for as many particles as needed.
- 11) Changes to the calibration curve will take effect on the next bin map commit.

Flow rate calibration confirmation

In order to confirm calibration of the UHSAS instrument flow meters, the following steps should be taken.

- 1) Sheath and purge flow will not need calibration, as their exact values are not critical. Sheath should be set to 700 sccm with the manual valve, purge valve should be closed.
- 2) Sample flow is calibrated at 5280’.
- 3) To confirm calibration of the sample flow, place a calibrated flow meter in line with the sample inlet.
- 4) The sample flow calibration is performed in software, with parameters entered through the vi.
- 5) On the “configuration” tab, the sample flow and sample set parameters are used to convert mass flow signals into flow rates. The parameters are fit parameters to 3rd order polynomials used to describe the response of the flow controller. The parameters can be changed to accommodate other gases, etc. Consult DMT for instructions or revised calibration parameters.

Chapter 6 - Short Guide to UHSAS User Interface (vi)

In this section:

Red indicates a TAB title

Blue indicates a BUTTON title

Green indicates a SLIDER or INDICATOR or TEXT control title

Orange indicates an area of grouped controls

To Start:

Step 1: run the vi by pressing the arrow in the LabView toolbar.

Step 2: Turn the laser temp on (see **Laser Controls**)

Step 3: Turn the laser current on (see **Laser Controls**)

Step 4: wait a few minutes for warm-up.

Step 5: confirm that the scatter is appropriate (see **Laser Controls**)

Step 6: Confirm that the sample flow is on and set as desired (see **Flow Controls**)

Step 7: Calibrate if necessary (see **Calibration**)

Step 8: Commit the desired bin map (see **Map**)

Step 9: Set histogram parameters as desired (see **Histogram**)

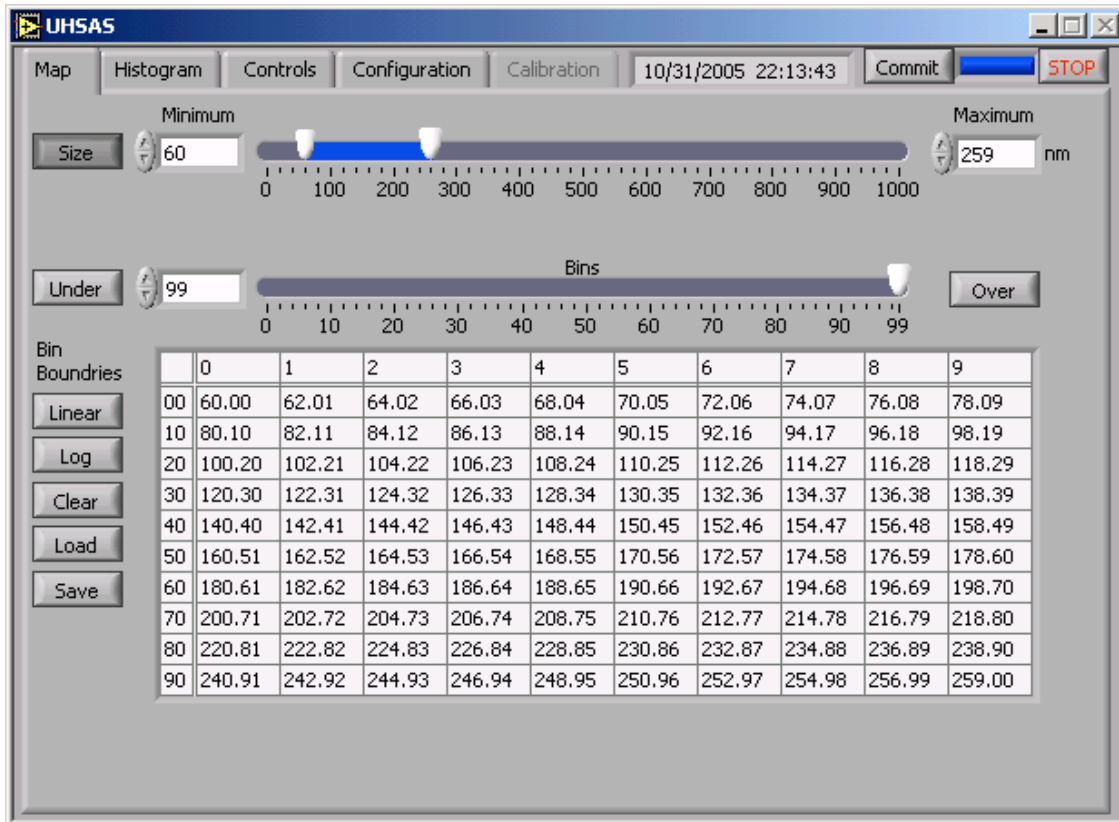
Step 10: **Run** histogram (see **Histogram**)

Step 12: **Record** run if desired (see **Histogram**)

Shut Down: laser current **OFF**, laser temp **OFF**, **stop** vi, exit LabView

Description of vi Tabs:

Map Tab:



This tab sets and commits a bin map (the x-axis of the histogram graph). The sliders at the top of the page are shortcuts for filling the bin map spreadsheet. The bin map spreadsheet values are the values that are committed to the instrument.

Choose [size](#), [volts](#), or [time](#).

[Size](#): histogram of particle diameters, specified in nm.

[Volts](#): histogram in voltage space (mV) of the gain stage chosen (G3, G2 G1 or G0).

[Time](#): histogram of transit times (μ s) of the gain stage chosen.

Specify the range [minimum](#) and [maximum](#) values.

Choose the number of [bins](#).

Choose a [linear](#) or [logarithmic](#) bin spacing to create the bin map.

Bin map appears in the bin table, individual bins can be edited like a spreadsheet.

Press [Commit](#), wait for commit bar to complete. This process downloads the bin map to the histogram microprocessors.

[Null](#): loads nulls into the bin map

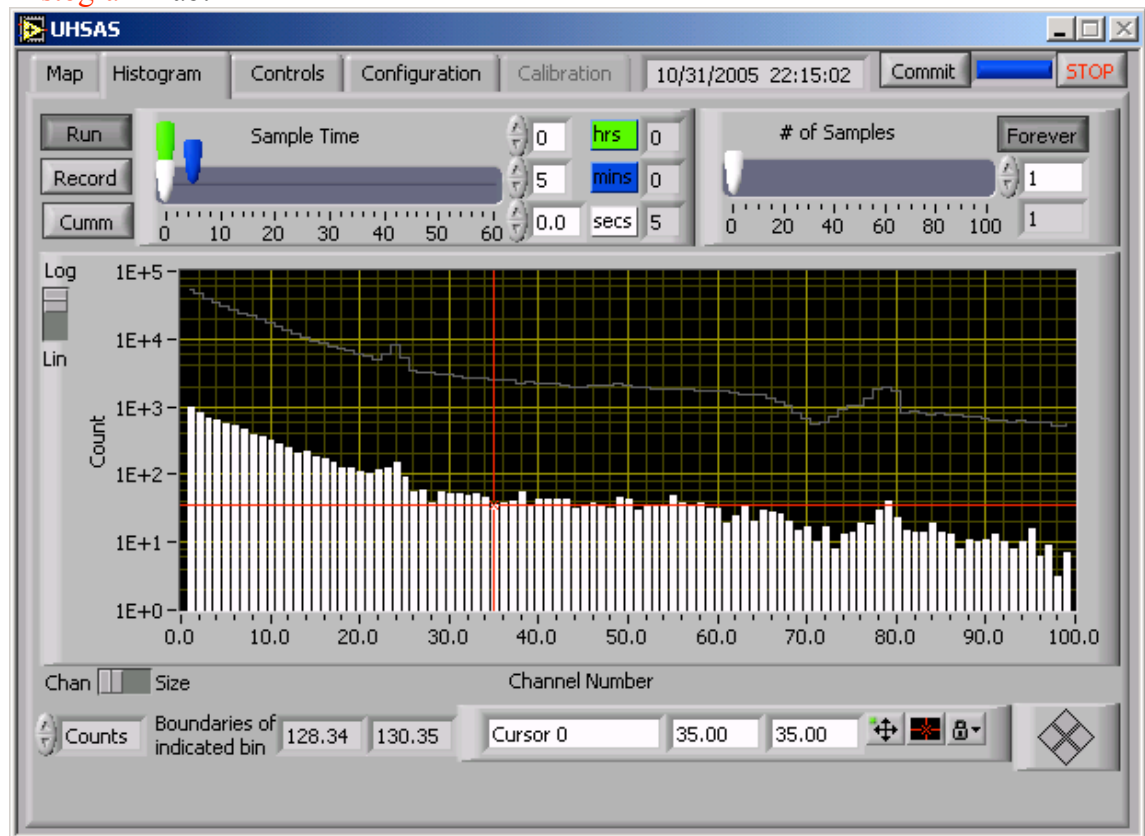
[Read](#): reads a saved bin map file

[Write](#): saves a bin map to file

[Over](#), [Under](#): when active, displays the underflow and overflow bins on the histogram graph. Underflow is minimum detectable particle size (see [trigger threshold](#)) to lower limit of first bin. Overflow is upper limit of last

bin and above. Note that the total number of channels allowed is 100 including the underflow and/or overflow bins.

Histogram Tab:



This tab displays histograms, sets integration times and initiates data logging.

Accumulation count:

Accumulation count sets the number of cycles of **accumulation time** to be performed. The present cycle is displayed. The set point is set using the slider, or by direct entry. When the present cycle exceeds the set point, the histogram stops running, the display holds and the record file completes. If **forever** is selected, the instrument cycles indefinitely, showing the present cycle number.

Accumulation time:

Accumulation time sets the length of time over which counts will be accumulated. At the end of the set time, the histogram data will be written to the record file (if enabled) and the histogram will be reset. Set the accumulation time using the **hrs min sec** sliders.

Run: starts the histogram, resets the accumulation cycle to zero.

Record: initiates histogram logging, prompt will ask for file name.

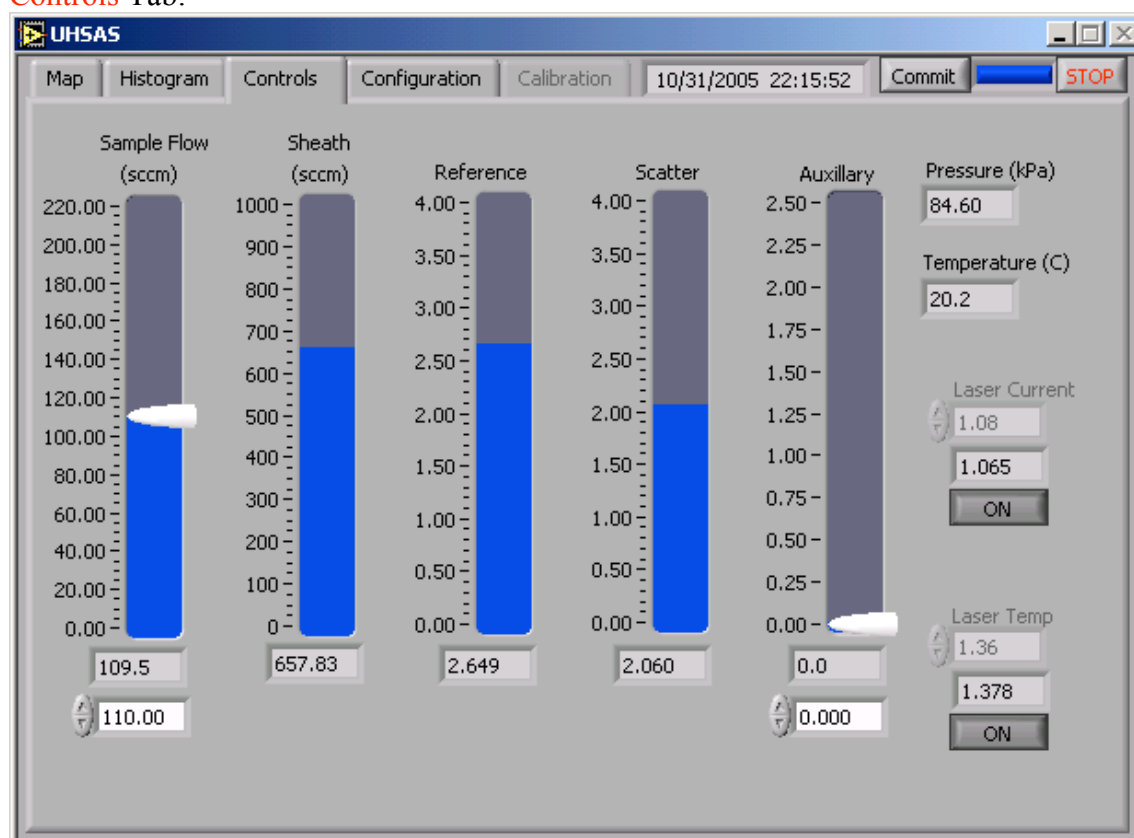
Choosing an existing file will append data with a new header.

Cumm: puts the histogram in cumulative mode. Does not affect record data. Cumulative mode can be entered or left while a histogram is stopped or running.

Histogram graph is set to autoscale the x and y axes. For fixed axes, right click in the graph, uncheck autoscale. Set scale by typing directly into the axis labels.

Histogram y-axis is in counts, x-axis is in bin number. Refer to the **bin map** tab to identify bins, or use the cursor to read the bin boundaries which are reported at the lower left of the page.

Controls Tab:



Sample Set: sets the sample flow [sccm].

Sample Act: reads the actual sample flow [sccm].

Sheath: reads the sheath flow [sccm]. Should be 600-800 sccm.

Purge: reads the purge flow [sccm].

Laser current: sets the pump laser current [A]. The lower display box is the actual current. The set point and actual should be close but not the same. Toggle **ON/OFF** to turn the laser current on or off.

Laser temp: sets the pump laser temperature in arbitrary units. The lower display box is the actual temp. The set point and actual should be close but not the same. A laser at room temperature should read ~1.000. Toggle **ON/OFF** to turn the laser temperature control on or off. The temperature control cannot be turned off with the laser current on. Additionally, if the

laser temperature deviates by more than 20% from its set point, the laser current cannot be enabled. Also, the set points for the laser current and temperature are locked. Changing these parameters could cause significant degradation in the performance of the instrument.

Reference: reads the laser reference voltage from the monitor photodiode.

Scatter: reads the background DC molecular scatter level from the APD.

This should read around 0.200 V to 0.250 V when the pump laser is on.

Auxillary: not used.

Configuration Tab:

The screenshot shows the 'Configuration' tab of the UHSAS software interface. The window title is 'UHSAS'. The top menu bar includes 'Map', 'Histogram', 'Controls', 'Configuration' (selected), 'Calibration', and a timestamp '10/31/2005 22:16:20'. On the right of the menu bar are buttons for 'Commit', 'STOP', 'Save', and 'Load'. The main area is divided into several sections:

- Pulse width:** A spinner set to 3, with 'Min' at 1 and 'Max' at 50.
- Difference:** A spinner set to 1.15.
- Update Rate (Hz):** A spinner set to 10.
- Internal Port:** COM 1.
- External Port:** COM 2.
- Trigger Threshold:** A spinner set to 0.100.
- Optical Block Pot:** A spinner set to 1.
- Vref(mV):** A spinner set to 10000.0.
- Offset(mV):** A spinner set to 0.0.
- Max Count:** A spinner set to 3000.
- Revision #:** A spinner set to 1.
- Software Version:** 3.0.
- User Mode:** A dropdown menu.
- Password:** A text input field.
- Enter Password:** A button.
- Active Config:** A text field showing 'C:\ph\caltest'.
- Normalize Histograms to Bin Width:** A checkbox that is checked.
- Configuration File Date:** A text field showing '19800100'.
- Purge Coefficients:** A spinner set to 0.
- Sheath Coefficients:** A spinner set to 3.
- Sample Coefficients:** A spinner set to 0.
- Sample Set Coefficients:** A spinner set to 0.
- Temperature Coefficients:** A spinner set to 0.
- Pressure Coefficients:** A spinner set to 0.
- Revert to Factory Configuration:** A button.

This tab holds all the instrument configuration parameters and reads some housekeeping values.

Save: saves present instrument configuration to file. Will prompt for file name.

Load: loads saved instrument configuration file. Will prompt for file name. The factory provided config file is called DMTSNxxCAL and should not be overwritten. Choose a new file name for config files with adjusted parameters.

Pulse width: for each of the gain stages (G0,G1,G2,G3) this control sets a window for acceptable particle pulse widths. A particle pulse must be

between these two times for it to be counted. It is specified approximately in microseconds.

Difference: not used.

Pressure: reads the ambient pressure in kPa.

Temperature: reads the case temperature in K.

I/O port: should be set to COM1

Trigger Threshold: this is a very important and somewhat subtle parameter. It specifies the smallest signal voltage (in Volts on G3) that will register as a particle. It is like the lowest threshold on a typical instrument, in that events that are smaller than this signal size will not initiate a count. Everything above this signal size will initiate a count (as long as it satisfies the timing criteria). However, in this instrument, the trigger threshold may not have anything to do with the lowest selected bin. For example, the trigger threshold might be set to 0.100 V with this signal size representing a 55 nm particle. The user can select a lowest bin of 60 nm, so that some triggers (particles between 55 and 60 nm) will not appear as counts (they will appear in the underflow bin if selected). Or, the user could select a lowest bin of 50 to 54.9 nm. No counts will appear in this bin, since the trigger threshold is set to a signal size corresponding to a 55 nm particle.

Optical Block Pot: not used.

Vref: should be 10000 mV

Offset: allows user to specify a voltage offset in the electronics chain of the highest gain channel (G3). It is typically a few mV and should not be important.

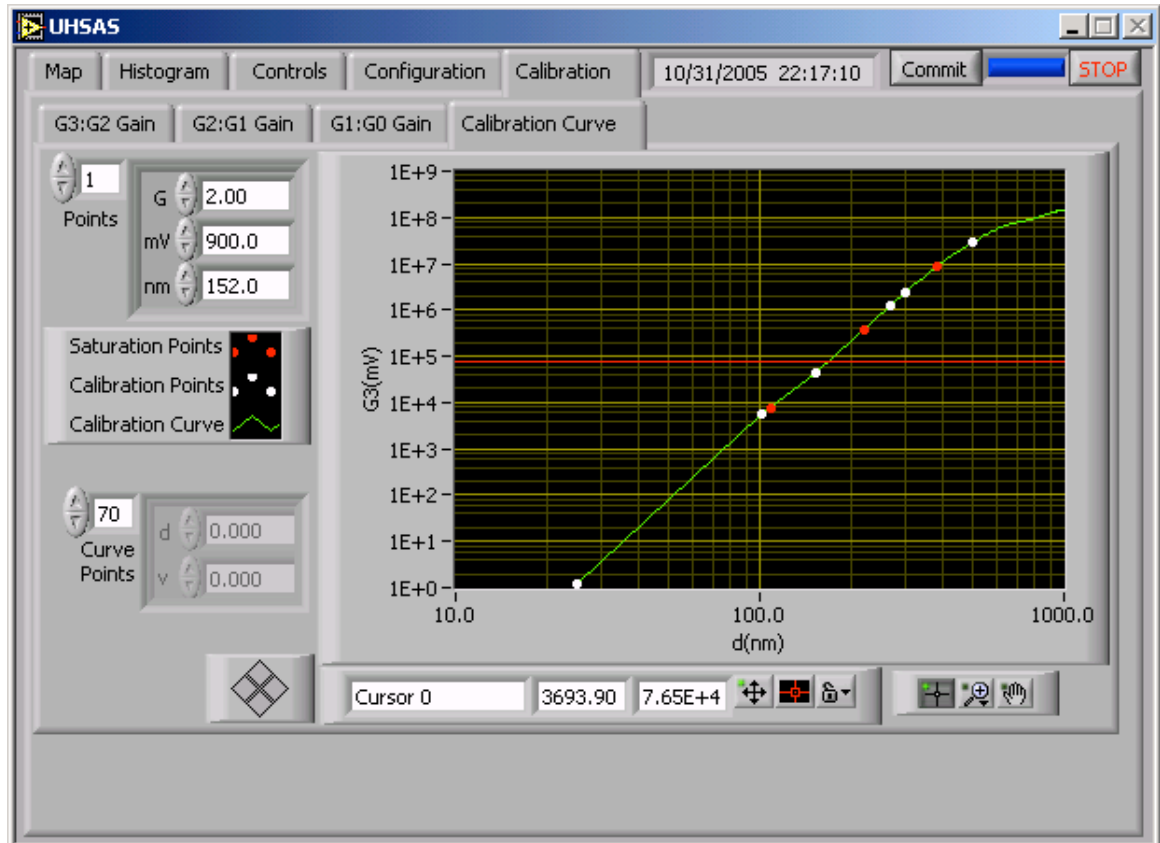
Purge coefficients: conversion coefficients for the purge flow sensor.

Sheath coefficients: conversion coefficients for the sheath flow sensor.

Sample coefficients: conversion coefficients for the sample flow sensor.

Sample set coefficients: conversion coefficients for the sample flow valve

Calibration Tab:



This tab performs the calibration functions of the instrument. (See also the Particle Size Calibration section of this manual.)

There are subtabs on this page:

Calibration Curve subTab:

This tab shows the calibration curve for the instrument. The signal sizes (in mV) are converted into voltage as they would appear on the highest gain stage (G3).

The **points** control specifies the reference particles and their signal sizes. The points control is an (arbitrary length) array of triplets consisting of : **G**: the gain stage on which the particle signal appears; **mV**: the signal size in mV of the particle signal; and **nm**: the size of the particle in nm. At least one point needs to be specified to calibrate the unit. This is normally the NIST 100 nm SRM, which appears as ~4000 mV on G3. Any number of reference particles can be used to calibrate the instrument. The cal-curve will be interpolated between reference points in log-log space. The calibration points are easily measured by running a particle and using the voltage-space histogram on the appropriate gain stage to determine the signal size (see Calibration section of this manual).

G0 points: These points are used to specify the Mie curve of signal size (v) vs particle diameter (d) on the lowest gain channel

(G0). The diameters specified are absolute in nm, and the signal size is specified as a relative number. This is the only gain stage that can be set to something other than a 6th power law. The easiest way to enter many G0 points is to directly edit the configuration file.

G3:G2 Gain, G2:G1 Gain, G1:G0 Gain (the relative gain subTabs)

NOTE: You must commit a size histogram before gain ratio operations!

The relative gain tabs are an automated means to determine the relative gains between gain stages. This is accomplished by running ambient air through the instrument and pressing **CLEAR** and then **RUN** on each of the relative gain tabs. Particles whose signals appear on two adjacent gain stages (this is the overlap region of the gain stages) will be measured and recorded. The relative gain graph will show the gain and offset calculated from these points. This gain and offset (along with the calibration points) will be used as necessary during bin map commit to provide a seamless transition between gain stages. Note that for certain choices of bin map, stitching errors between the gain stages will be noticeable, especially if the bin width is less than 1% of its center near the stitch region.

Service Tab:

The screenshot displays the 'Service' tab of the UHSAS software interface. The window title is 'UHSAS'. The top menu bar includes 'Map', 'Histogram', 'Controls', 'Configuration', 'Calibration', 'Service', and a status bar showing '005 22:20:26' and a 'STOP' button. The 'Service' tab contains several sections: 'User Mode' with a 'Service' button and a 'Password' field; 'Active Config' showing 'C:\ph\caltest'; 'Normalize Histograms to Bin Width' with a checkbox and 'Don't Normalize' option; 'Configuration File Date' showing '19800100'; 'Purge Coefficients' (0, 0.000); 'Sheath Coefficients' (3, 0.000); 'Sample Coefficients' (0, 0.0000); 'Sample Set Coefficients' (0, 0.0000); 'Temperature Coefficients' (0, 0.0000); 'Pressure Coefficients' (0, 10.556); 'Pulse width' (3); 'Min' (1) and 'Max' (50); 'Difference' (1.25); 'Update Rate (Hz)' (10); 'Internal Port COM' (1); 'External Port COM' (2); 'Trigger Threshold' (0.100); 'Optical Block Pot' (1); 'Vref(mV)' (10000.0); 'Offset(mV)' (0.0); 'Max Count' (3000); 'Revision #' (1); 'Software Version 3.0'; and a 'Revert to Factory Configuration' button. A 'Revert Mode' button and 'Save'/'Load' buttons are also present.

This tab allows a “Service” user to input or reset passwords for the “Calibration” and/or “Service” user.

Data logging is controlled through the Histogram screen. To record data to the hard drive, press the Record button on the left side of this screen. You will be prompted for a filename and location. The recorded file is a comma delimited, ascii text file which contains time, housekeeping parameters, and data from each of the 100 channels accumulated over the interval set on the Histogram screen. This data can be read directly into spreadsheets for processing. Each time the Record button is pressed a new file is written but you can append a file to a previously recorded file by using the same filename.

Chapter 7 - Safety Procedures and Troubleshooting

Safety Procedures

CAUTION, do not operate laser with instrument cover off.

This unit is equipped with a Laser safety interlock system. Whenever the cover is removed, 2 mechanical switches are activated. 1 turns off the AC power to the laser control module that supplies power to the laser. The second one disables the laser enable line. Under no circumstances should the user disable these Safety interlocks. The laser should remain off any time the cover is removed. All safety precautions noted on caution labels should be adhered to.

Troubleshooting

Unit has low Laser Reference voltage

- Ensure VI is running and Laser Current is on and Laser temperature is at the correct value
 - If laser current is on and the Scatter and/or Reference value are low, perform the Cleaning the laser optics procedure listed below
 - Contact the service representative for further assistance

Unit will not zero count

- Install supplied zero count filter to the inlet of unit and run 5 minute samples, load a bin map of 55 to 255nm this will help to determine if the unit has a leak or it is counting noise.
 - Noise will typically appear in only the first few channels, if the unit has a leak, typically there will be an ambient looking distribution.
 - If the unit appears to have a leak, check any external connections between the unit and the filter and rerun test
 - If unit appears to have noise counts, Check the reference and Scatter level, clean optics if necessary
 - If acceptable background zero count level cannot be attained, Contact the service representative for further assistance.

Cleaning the Laser Optics

Under normal operating conditions the laser optics should not need to be cleaned very often. If the unit is turned on and off, or moved from place to place frequently, the duration between cleanings may be reduced. There are 2 monitors of the intra-cavity power of the laser, the Reference and the Scatter voltages. The initial values of these can be found on the sheet at the last page of this manual. If either one or both of them drop by 25%, the Laser optics will need to be cleaned. Follow the steps below:

NOTE: Before removing the instrument cover, turn off the laser by depressing the “on” button for the Laser current on the laser control page.

- After ensuring laser current is off, remove the 14 Phillips head screws holding the cover on. Lift the cover straight up until it clears the unit.

- Turn off the pump by using its toggle switch, which is mounted to the top of the pump.
 - *Note:* Whenever pump is turned off, the Sample set flow should be turned down to zero to keep the mass flow controller operating within manufacturer's specifications.
- Loosen the thumbscrews on one of the cleaning ports and remove, ensure o-ring stays with the port.
- Using a Q-tip and spectra-photo grade acetone, clean the optic. A gentle swipe in one direction across the middle portion of the optic seems to work the best. DO NOT use a scrubbing or circular motion, this tends to spread any contamination around and hampers the cleaning effort. Usually 2-3 cleaning swipes using fresh acetone and fresh Q-tips for each swipe is adequate.
- Reinstall cleaning port and tighten thumbscrews, ensure o-ring is installed
- Repeat above 3 steps for other optic.
- Turn pump back on
- Reinstall cover on the unit, do not install screws into cover until power has been rechecked in case unit requires more cleaning
- Turn on the laser current. Let instrument run for 15 minutes to stabilize.
- Check the Scatter and Reference levels of the unit. If they are within 15% of initial values the cleaning was successful. If they are lower than when the cleaning started the cleaning was unsuccessful.
- Repeat above steps until an adequate Scatter and Reference level has been attained.
- Install the 14 Phillips head mounting screw into the cover, unit is now ready for use.

In the unlikely event the laser power cannot be cleaned up to an adequate level, consult the service representative for further assistance.

If the instrument becomes contaminated, it should be returned to the manufacturer for decontamination, cleaning and service.

Chapter 8 - Communications

Most communication for the UHSAS instrument will be through the Ethernet network connection. See your IT support department for assistance with connecting the UHSAS to the network.

A serial port for data collection by an external data system is also available through the back panel. This data stream is ascii text at 115200 baud, 8N1, tab-delimited, and is transmitted at the rate set on the Configuration tab under Update Rate (Hz). The format is given in the first 2 lines of the data file. The serial port connector is a standard 9pin D-connector and can be connected to the serial port of an external computer with a standard female/male straight serial cable.

Appendix A. Interconnect Wiring Drawings

Appendix B - Schematics, Assembly Drawings and CVS's

Appendix C - Cables

Appendix D - Bill of Materials