LISST-RTSSV

Real-Time Size and Settling Velocity

User's Manual

Version 1.1

October 2026

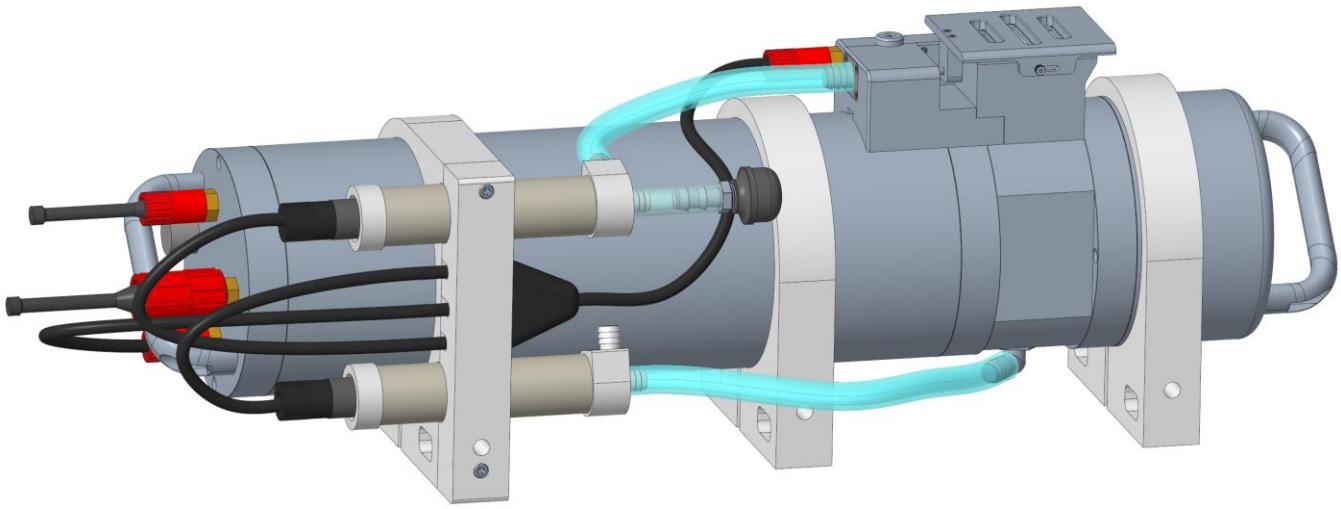
Store Software USB Card Here

SEQUOIA

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LISST-RTSSV Real-Time Size and Settling Velocity Sensor



Technical assistance

For technical assistance please contact your local Distributor or Sequoia. Please be sure to include the instrument serial number with any correspondence.

Warranty

See Sequoia Scientific's standard warranty terms at
www.sequoiasci.com/support/warranty

Sequoia Scientific, Inc. contact information:
Telephone: +1 (855) 753-3313
Email: Support@sequoiasci.com

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I. Introduction

A. General Description

Instrument Description

The LISST-RTSSV is designed for high precision, in-situ measurements of particle size and settling velocity. The instrument uses two cameras with different magnifications to image, count, size, and track particles ranging from several microns to thousands of microns in size. The Large Particle Camera (LPC) has a larger field of view and lower magnification for imaging larger particles. The Small Particle Camera (SPC) has a smaller field of view (within the field of view of the LPC) and a higher magnification for imaging small particles.

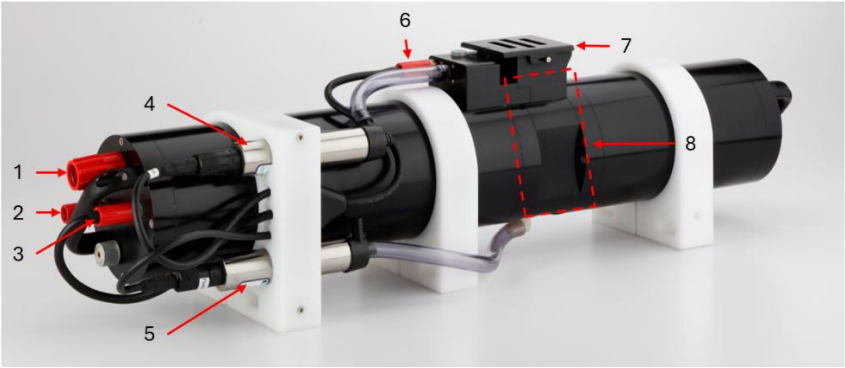
The instrument features a built-in settling column and two pumps, one that that draws sample into the column ("Flush Pump") and one that opens and closes a door at the top of the column to seal the column from the environment ("Door Pump"). The sampling schedule can be programmed by the user for autonomous data collection once deployed.

Included Accessories

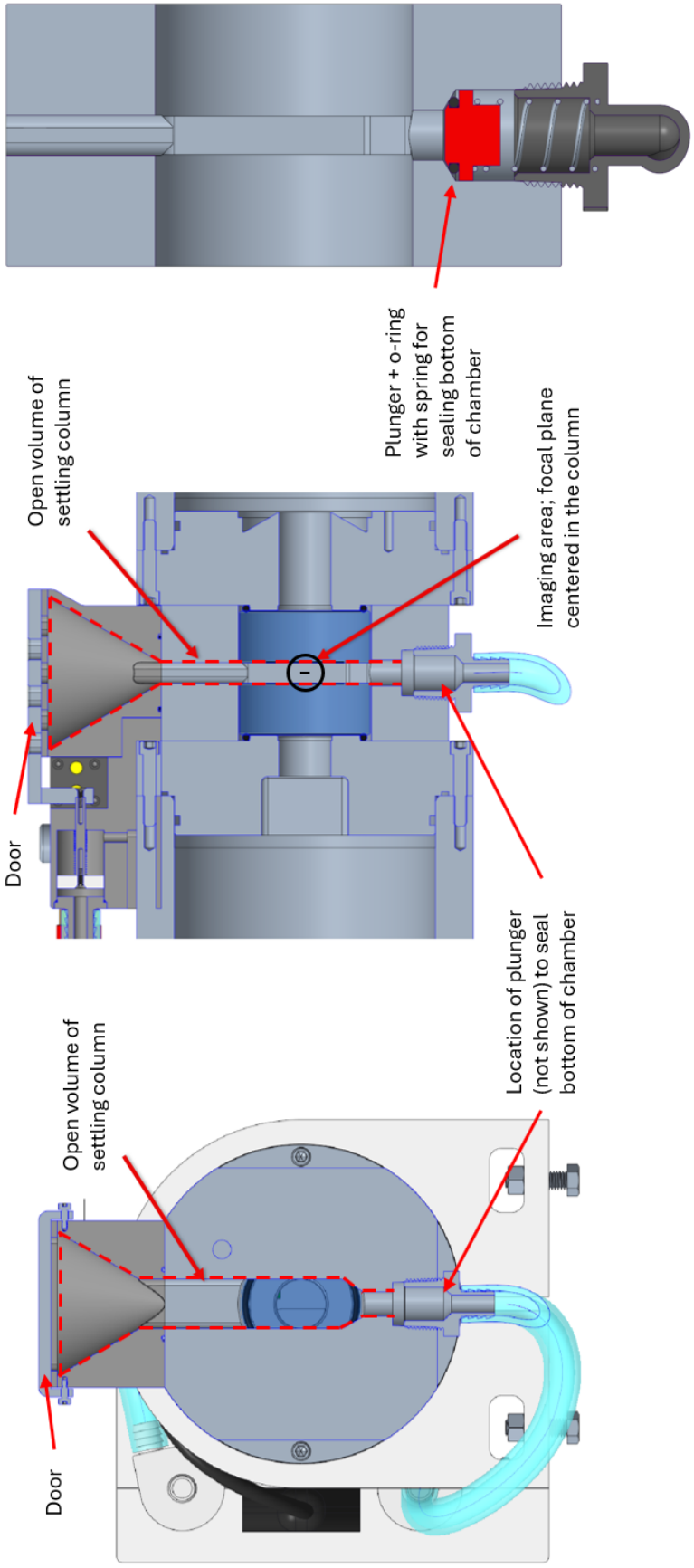
Included with the instrument are two pumps (Seabird 5T), instrument stands, a power cable and power supply (not submersible) for basic operation, an ethernet cable for communication (not submersible), the User's Manual, and a USB card with instrument software.

B. Instrument Diagrams

The diagrams below describe key components/features of the LISST-RTSSV to aid in familiarizing oneself with the instrument capabilities and operation.



1. Ethernet Connector
2. Communication/Power Connector
3. Pump and Door Connector
4. Door Pump (opens/closes door to settling column)
5. Flush Pump (draws sample into settling column)
6. Door Connector
7. Door on Settling Column
8. Settling Column (see diagram below)


Plunger + o-ring with spring for sealing bottom of chamber
Open volume of settling column
Imaging area; focal plane centered in the column
Door
Location of plunger (not shown) to seal bottom of chamber
Open volume of settling column
Door

II. Operation Details

Section Organization

This section contains detailed instructions for performing various procedures with the LISST-RTSSV. These are either in the form of step-by-step instructions or detailed descriptions of the various aspects of instrument operation (e.g. command list, instrument handling and maintenance).

General Precautions

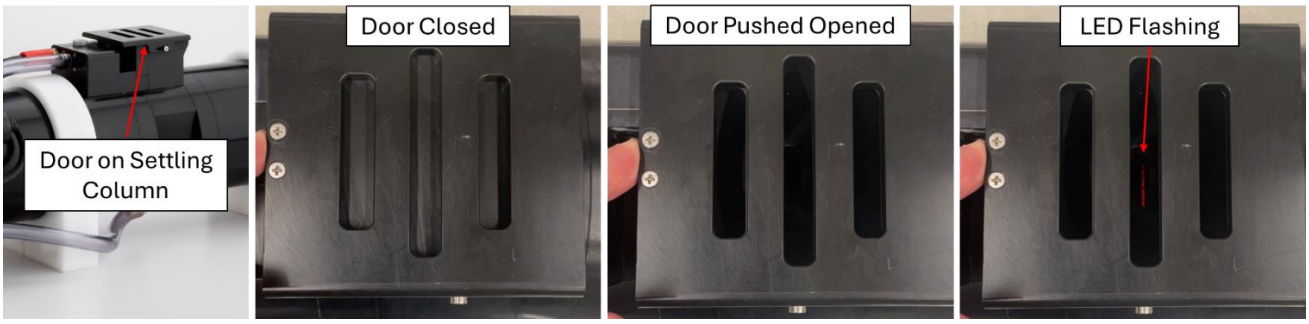
- LISST-RTSSV is a sensitive optical instrument - please handle it gently as you would handle an expensive camera.
- Evidence of shock/rough handling will void the warranty.
- Whenever in transit, store the instrument in the provided padded shipping case.
- Clean and dry the instrument, including the windows, before storage.

C. Connecting to the Instrument

1. Power

Power the instrument using the provided 5-pin power cable and 15V power supply. **When the LISST-RTSSV is first plugged into power it may take several minutes before the internal computer boots up**. A backup power supply is charged before the computer is allowed to boot up. The power supply can take several minutes to charge.

You can slide open the door on the top of the LISST-RTSSV and look into the settling column. The LED will be flashing (red light) if the backup power supply is still charging. If the light is not flashing, the computer should be powered on and the instrument ready.



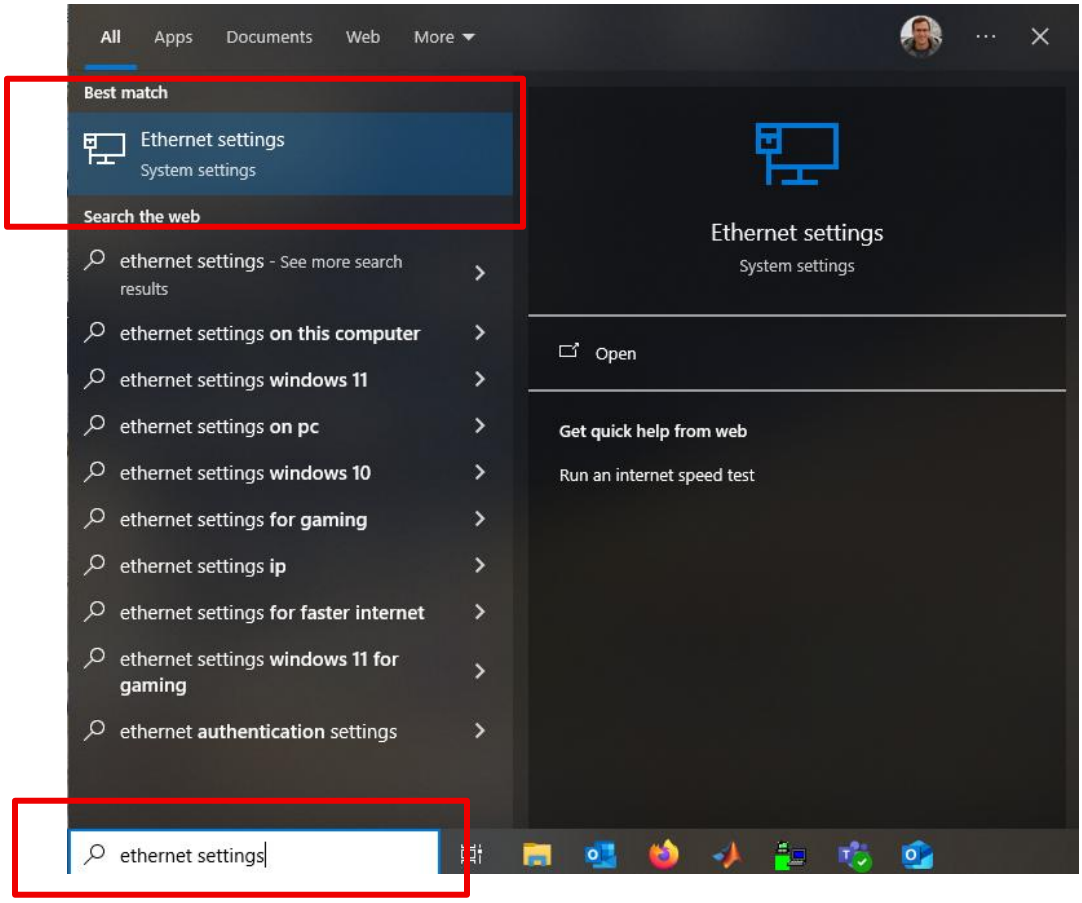
Caution: If the LISST-RTSSV is being powered while in air (i.e., not submerged), it is recommended to disconnect the SubConn cable from the pumps before powering on so that the pumps do not accidentally run if a pre-programmed sampling routine starts. If the LISST-RTSSV is being used for measurements while in air (i.e., not submerged), then the pumps should remain disconnected so that they do not run in air.

2. Ethernet

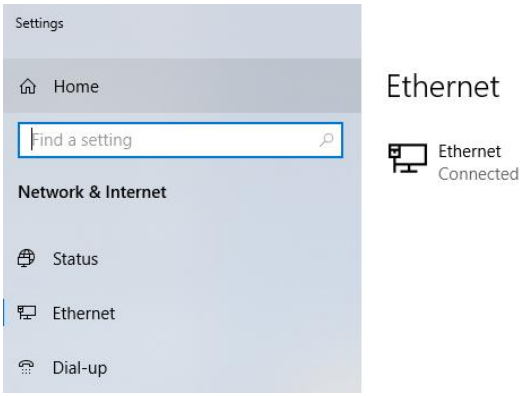
The primary connection to the LISST-RTSSV is through ethernet. The connection allows for configuring the RTSSV Main Control software as well as offloading data from the instrument.

The easiest way to connect to the LISST-RTSSV is by connecting it to your computer using the provided ethernet to USB adaptor. It will require some configuration of the USB adaptor. Follow the steps below.

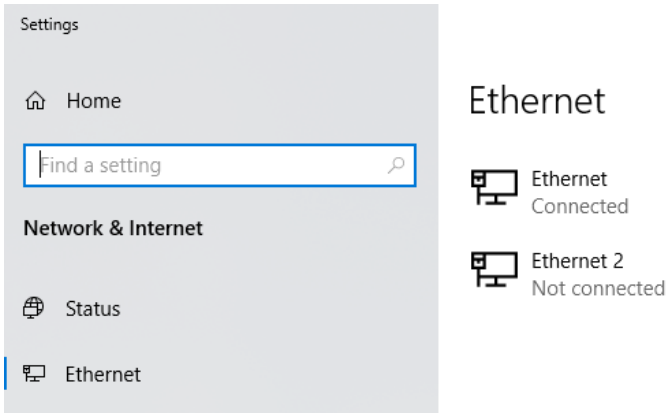
Before plugging the USB to ethernet adaptor into your computer, open the ethernet settings page on your computer. You can type ‘ethernet settings’ into the search bar in the bottom left of your windows desktop.



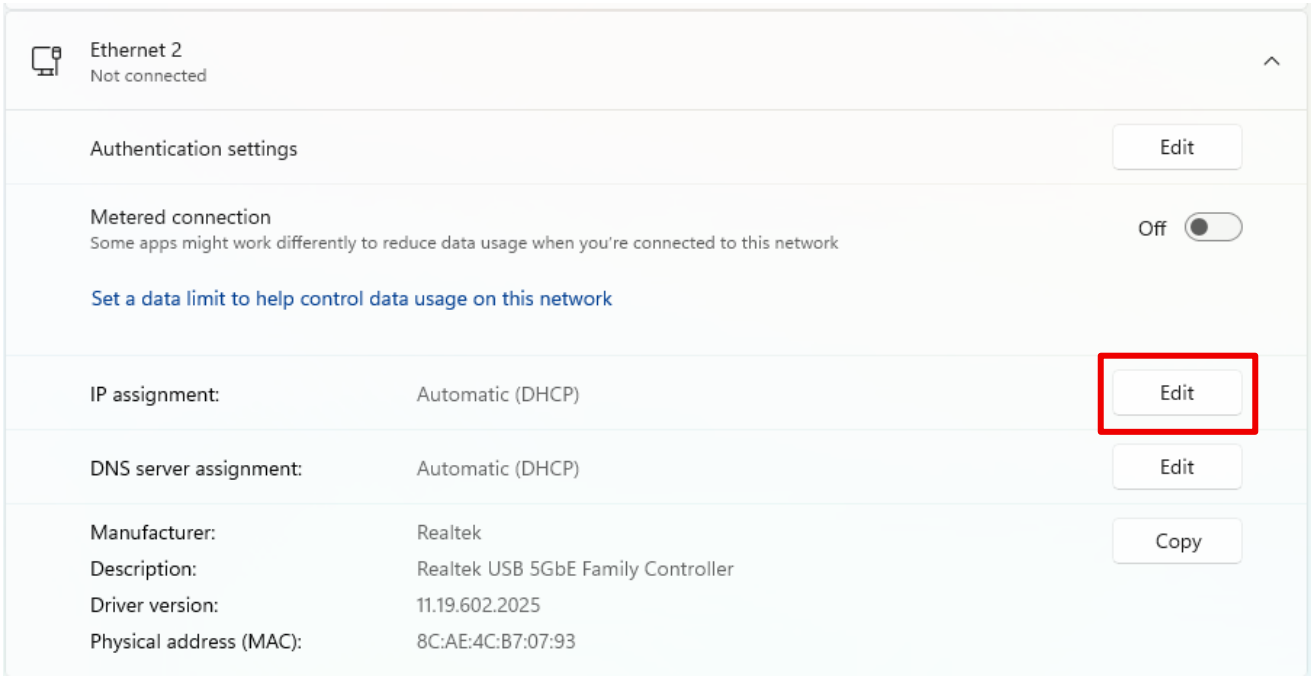
After opening the ethernet settings page, make a note of the ethernet connections listed.



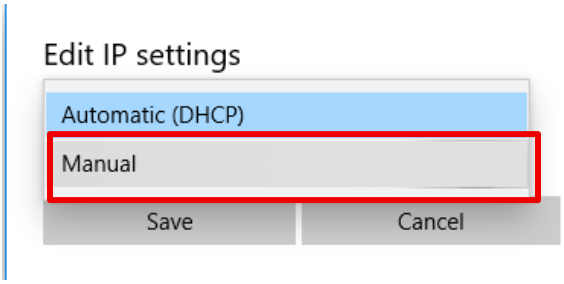
Now plug in the USB to ethernet adaptor. Your computer may need to install drivers for the adaptor, which may take 1-2 minutes. Afterward the adapter will appear in the ethernet settings.



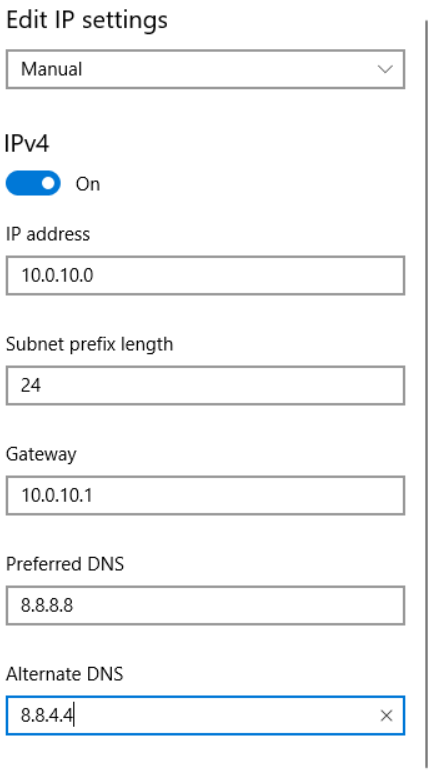
Click on the newly appeared ethernet connection (‘Ethernet 2’ in this example). Click on the edit button up IP settings.



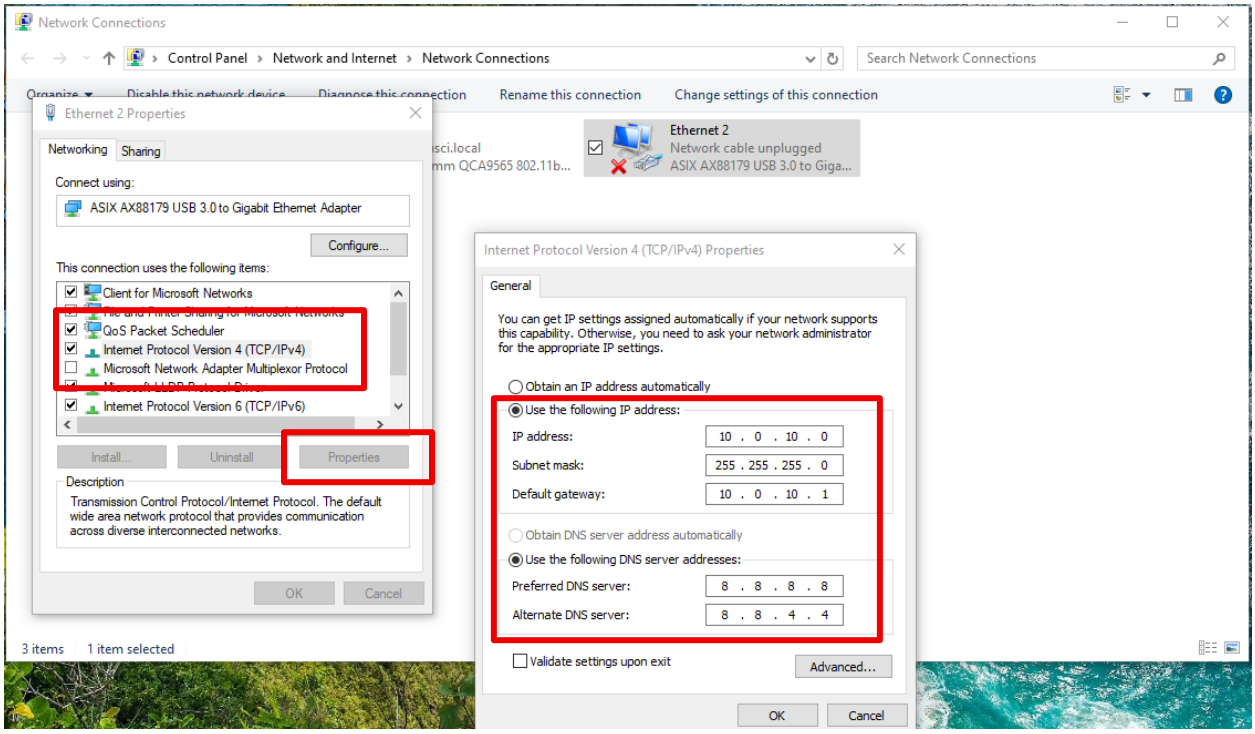
Set the adapter to Manual Mode and turn on IPv4.



Configure the settings according to the screenshot below:



If the ethernet settings appear different on your computer, try opening ‘Network Connections’ instead of ‘Ethernet Settings’. Open the ethernet connection and select ‘Internet Protocol Version 4(TCP/IPv4)’ and select Properties. Select the option to ‘Use the Following IP Address’ and configure the connection according to the following screenshot:



Once configured, you can use the Remote Desktop Connection Windows software to remotely connect to the LISST-RTSSV computer.

IP Address: 10.0.10.165
Username: User
Password: RTSSV

Upon connection, you will see the RTSSV Main Control program running. Keep this program open at all times.

3. Offloading Data

The LISST-RTSSV Data and Log folders are shared over the local network. They can be accessed by typing in the IP address into Windows File Explorer. Credentials for SMB file sharing are:

Username: User
Password: RTSSV

For convenience, the shared folders can be mounted as a network drive. After mounting the drive, the remaining free disk space can be monitored. For maximum offload speed, be sure you are using a 2.5 Gbps ethernet port or USB-to-Ethernet adapter.

4. Serial Port

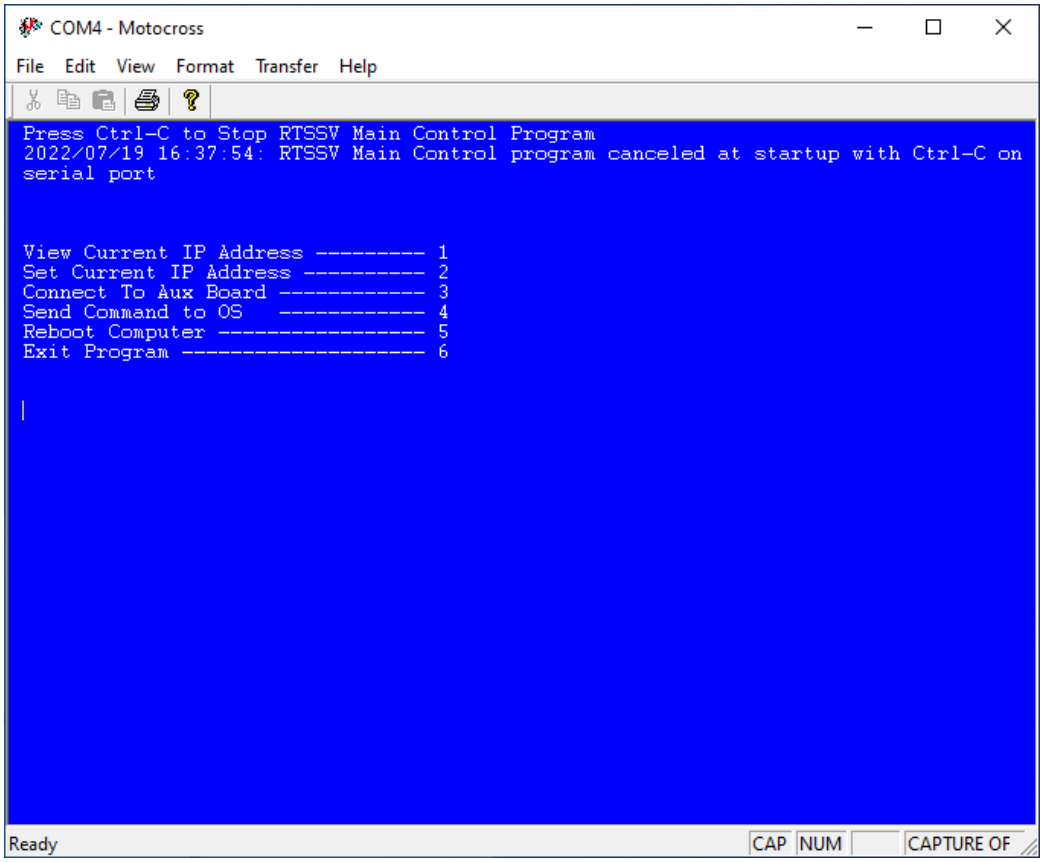
The serial port is available via the USB cable on the LISST-RTSSV power cable. The serial port connects to the internal single board computer. The serial port is managed by the RTSSV Main Control program. The serial port can be used for troubleshooting, reading status updates, or (limited) control of sampling.

Baud: 9600
Parity: None
Data Bits: 8
Stop Bits: 1
Flow Control: None

Troubleshooting Mode

A special troubleshooting mode can be accessed through the serial port, but only when the instrument first boots up. To enter this mode, have the serial port terminal configured and connected. Power on or reboot the instrument. A message will be printed to the serial port: “Press Ctrl-C to stop the main program”. Hit Ctrl-C several times until the troubleshooting menu appears. You will only have a few seconds to send the Ctrl-C characters. (Note that some terminal programs use Ctrl-C for the copy operation, instead of sending characters to the serial port. If you are not able to enter the troubleshooting mode, ensure that your terminal program is indeed sending the Ctrl-C characters)

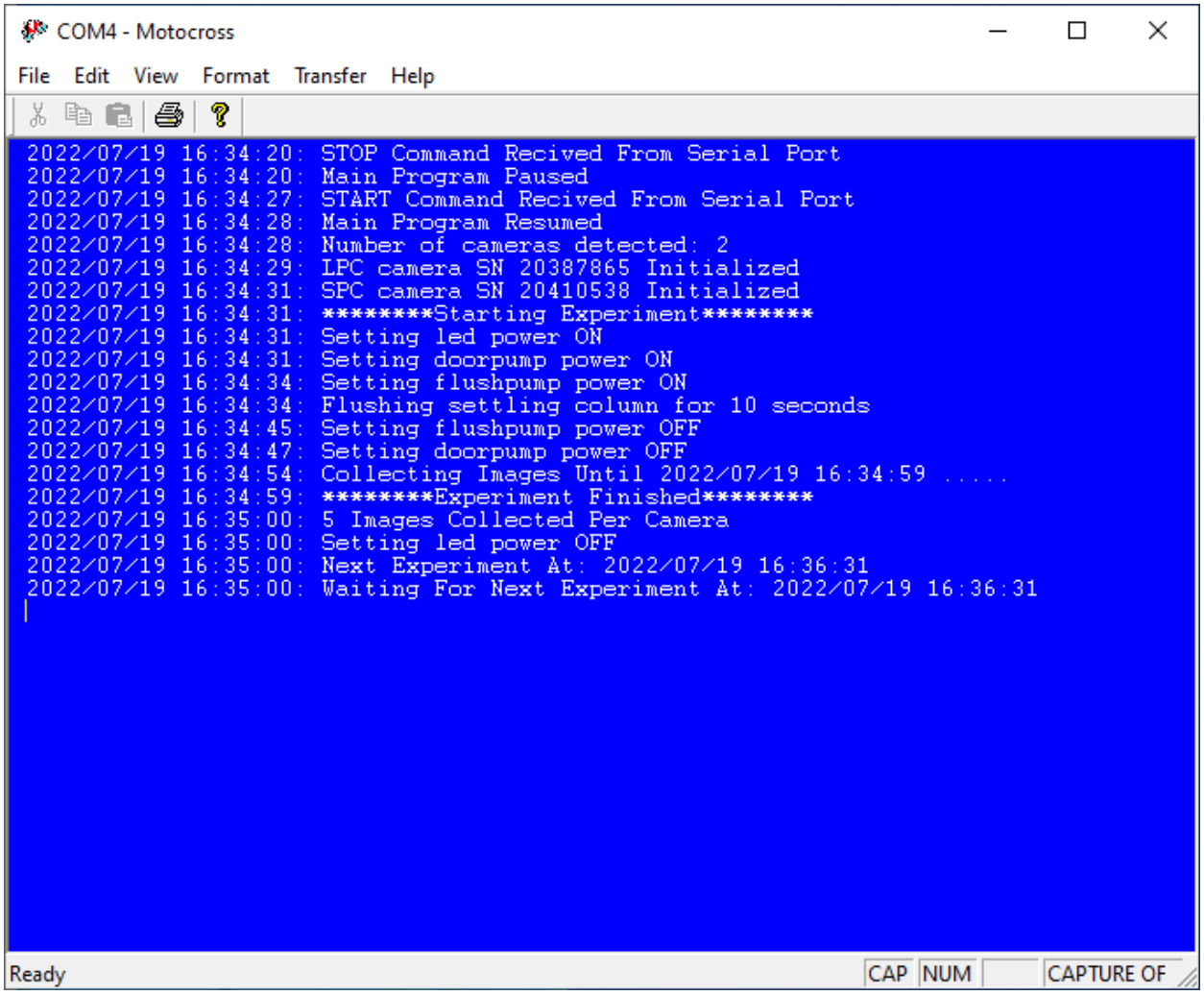
Once in the troubleshooting mode you will have several options:



To exit the troubleshooting mode, send the number 5 to reboot the instrument.

Monitoring Sampling Status

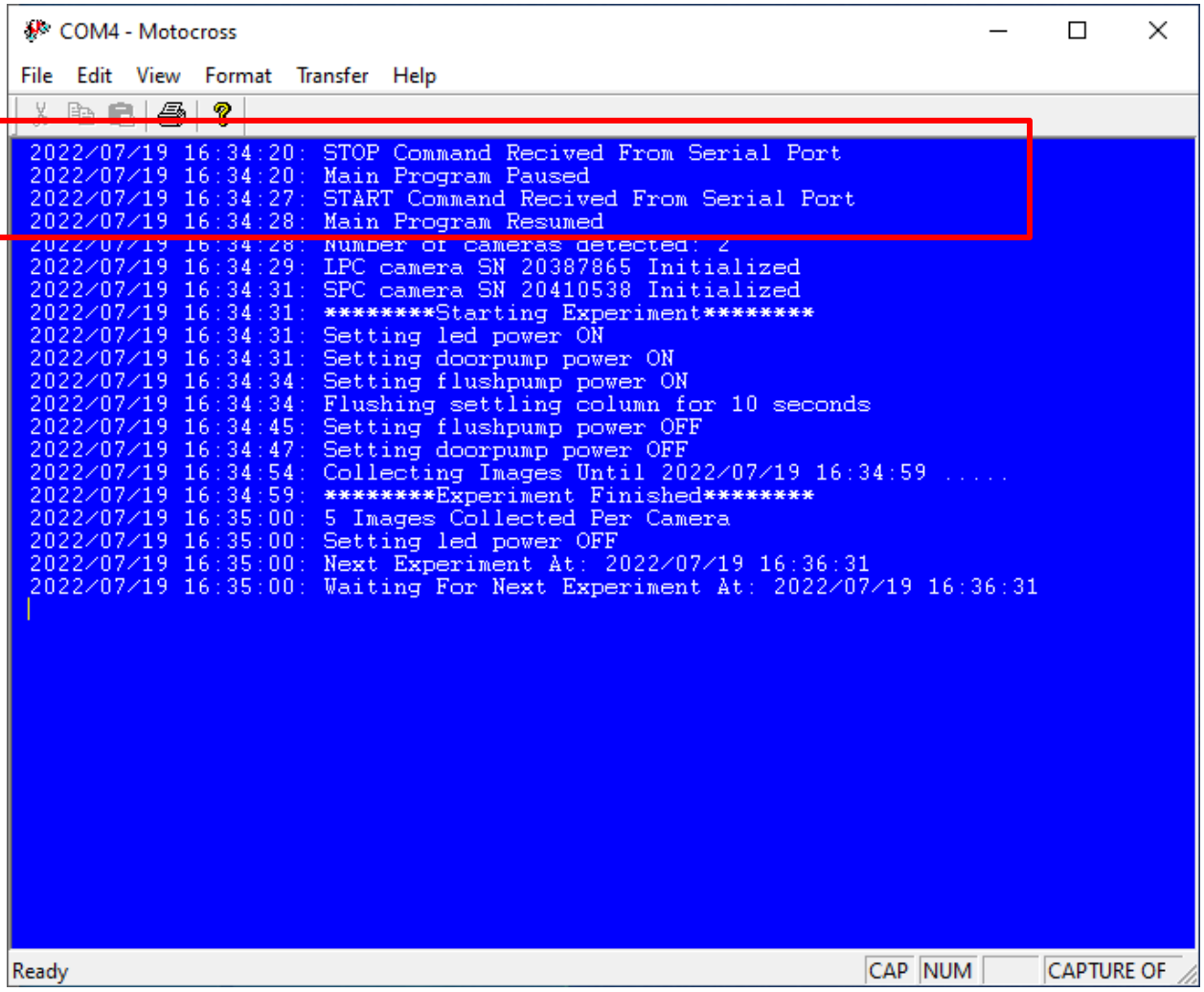
By default, status messages will be printed to the serial port. These messages give information on the current state of the instrument and the progress of the sampling program. These messages can be used to passively monitor the instrument as it samples.



Sample Program Control

If the sampling is being controlled via the serial port, it is recommended that sleep be disabled. This should be done ahead of time (before deployment), by checking the ‘Disable Sleep’ checkbox in the RTSSV Main Control program.

The sample program can be controlled through the serial port via some basic commands. The commands are typed into the serial terminal. There is no echo of the characters you send. A command is always completed by pressing the enter key. A confirmation will be displayed that the command was received, or a message will indicate that the command was not recognized. The commands can be sent at any time the RTSSV Main Program is running. They can be sent at the same time status updates are being transmitted. Commands are not case sensitive.



The available commands are:

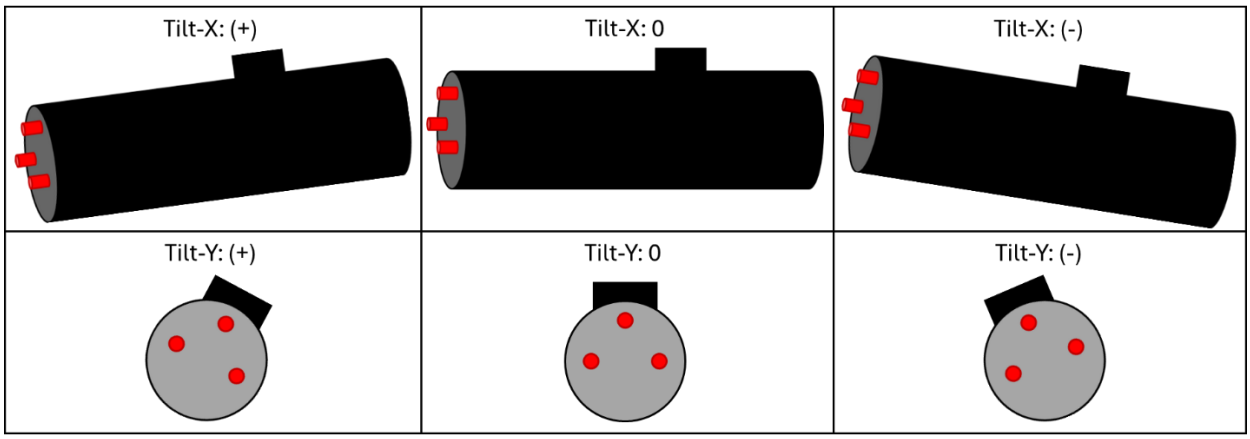
Command	Optional Arguments	Description
Start	Number of Experiments	Starts the current sampling schedule immediately. The start date/time set in the RTSSV Main Control program is ignored and the first experiment begins immediately. Experiments will continue according to the sampling schedule configured in the RTSSV Main Control program. If an optional argument is supplied (e.g. 'start 2'), the program will stop after the specified number of experiments. If no argument is specified, the sampling program will continue to run until it is

		manually stopped via the ‘stop program’ button or a ‘stop’ command is received from the serial port.
Stop	None	Stops the current sampling program. The RTSSV Main Control Program will enter the ‘Paused’ state. It Will remain in this state until the ‘start program’ button is pressed, or a ‘start’ command is received from the serial port.
Reboot	None	Reboots Advantech computer. The RTSSV Main Control program will restart once the computer boots up. Useful for entering the serial port troubleshooting mode.
Reset	None	Hard reset of RTSSV system. Only recommended as a last resort if there is a persistent problem.

D. Deployment Considerations

1. Instrument Tilt

The LISST-RTSSV should be deployed in a leveled orientation, as tilting of the settling column can result in reduced accuracy of a settling measurement due to the Boycott effect. An on-board tilt sensor can be used to assess any tilt in X- and Y-directions, with the sensor readout displayed in the RTSSV Main Control program. The general orientation of the tilt with respect to the instrument position is shown in the figure below. Care should be taken during any deployment (laboratory or field) to ensure the instrument is level (Tilt-X and Tilt-Y of 0) or as close to level as possible to minimize the Boycott effect[1].

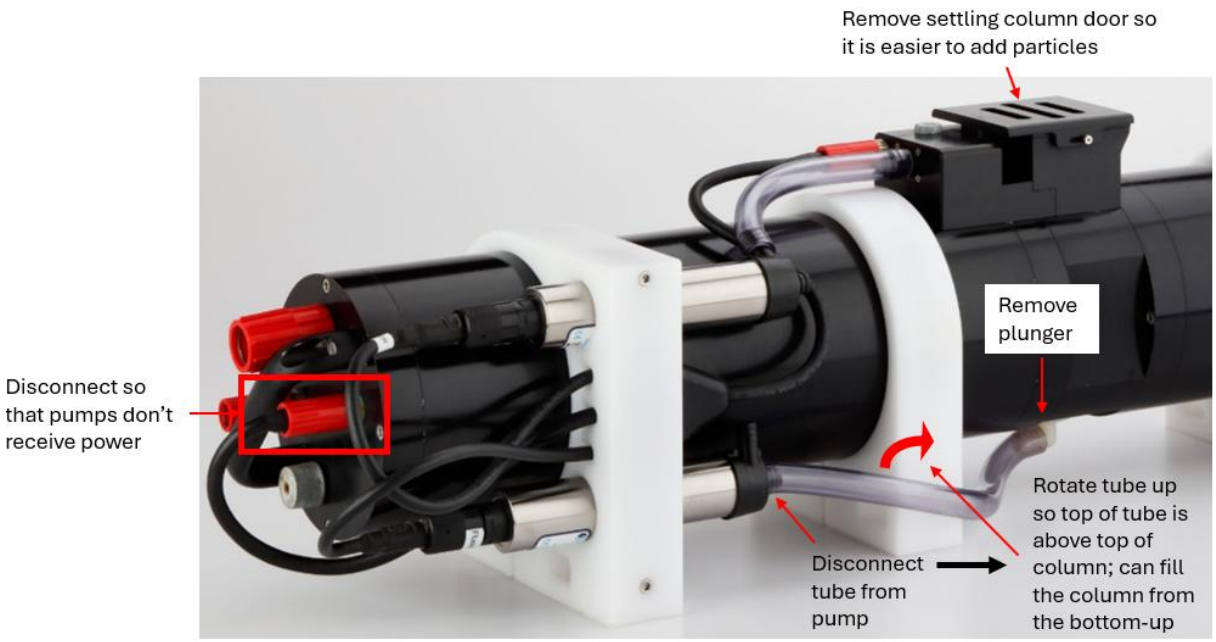


[1] See article from Sequoia: https://www.sequoiasci.com/article/the-boycott-effect/.

2. Using LISST-RTSSV on the Benchtop

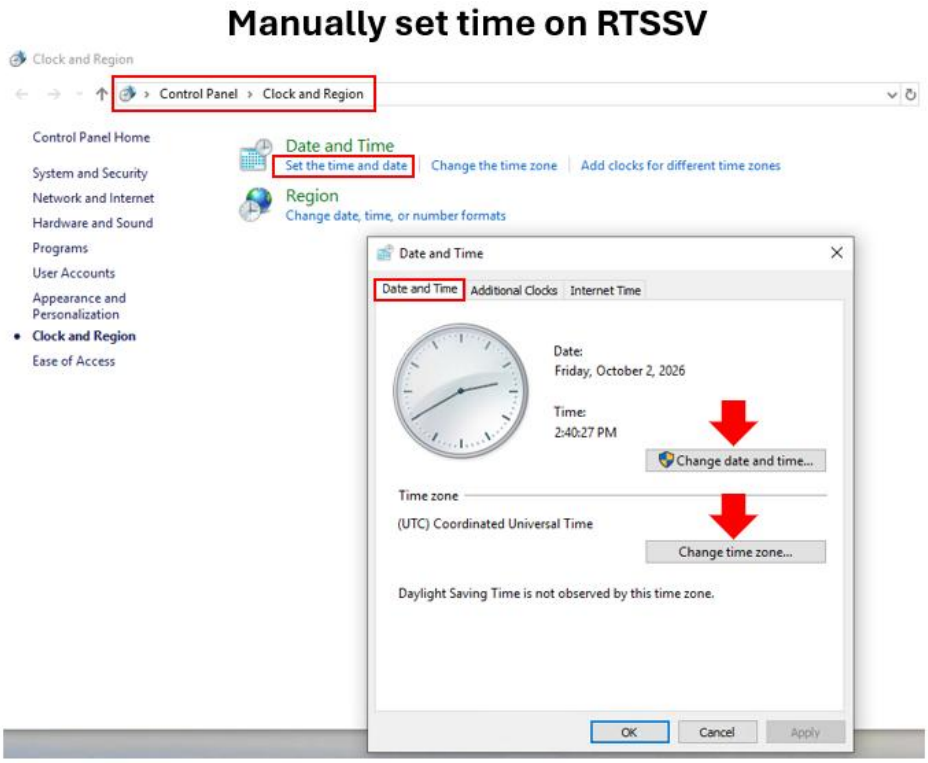
While the LISST-RTSSV is designed for submersible deployments up to 6000m, there are cases where a user may want to make measurements in the laboratory as well. Below are notes/recommendations for doing testing in the lab.

- We recommend submerging the instrument in a tank for testing in the lab. This allows you to maintain the entire functionality of the instrument (e.g., pump operation) and helps maintain a more consistent temperature in the settling column which can reduce the severity/prevalence of convection currents impacting particle settling.
- If the instrument will be used on the benchtop in air, please read the following:
    - The pumps will not function in air and should be disconnected from the instrument to avoid accidentally running them in air, which risks damaging them.
    - Small temperature differences between the air, water in the chamber, and instrument housing will result in convective currents inside the settling chamber that will render settling velocity measurements inaccurate. Particle sizing is still possible, but settling velocity calculations should be ignored unless these currents are corrected for.
    - For ease of use in the lab, we recommend (1) removing the plunger from the bottom of the settling column (inserted into the right-angle fitting), (2) removing the settling column lid, and (3) disconnecting the outflow tubing from the pump and rotating the tube so that it sticks upwards with the top of the tube positioned above the top of the settling column. These steps are not required but may help with the ease-of-use when running samples on the benchtop.



3. Setting Instrument Clock

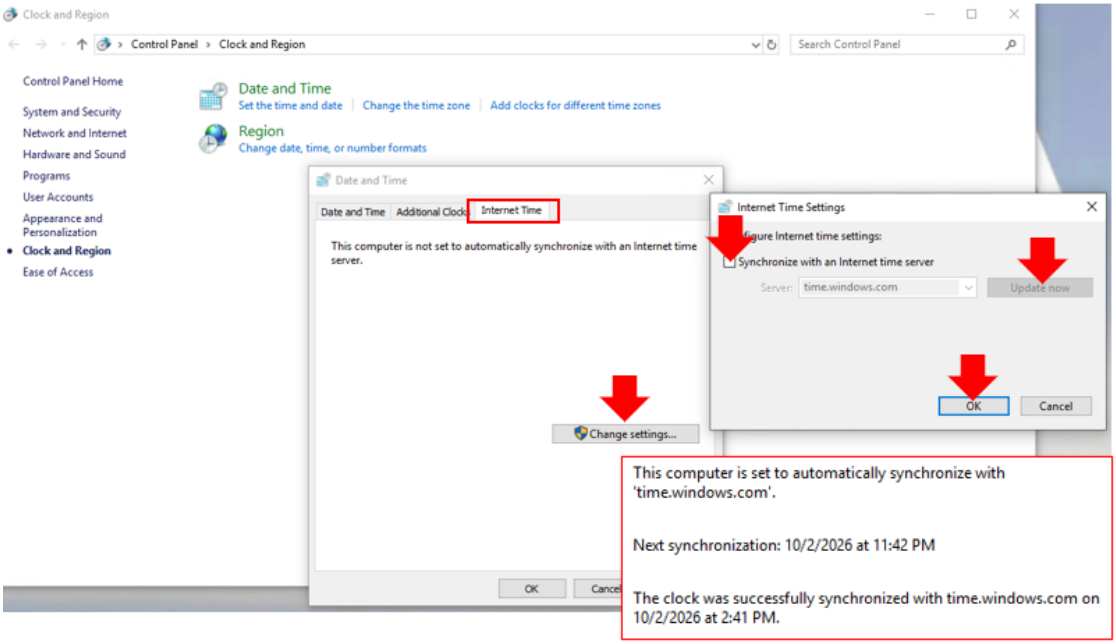
The RTSSV clock can be either set manually or synced to a laptop or network clock if the instrument has internet access. To manually set the RTSSV clock, connect to the RTSSV via Remote Desktop, then navigate to Control Panel → Clock and Region → Set the time and date. You can then manually set the time and time zone for the RTSSV.



If the RTSSV is connected to a local network via ethernet, or if the RTSSV is connected to a laptop with internet access (and that internet access is set to be shared with the RTSSV), then the clock can be synced to a time server. Connect to the RTSSV via Remote Desktop, then navigate to Control Panel → Clock and Region → Set the time and date → Internet Time tab → Change settings. Check the box to "Synchronize with an Internet time server" and select a server to sync with, then press "Update now" to synchronize and press "OK" to close the window. You will see a notification that the clock has synced successfully. You can then uncheck the box after syncing so that the RTSSV doesn't attempt to keep syncing the clock once internet access is lost.

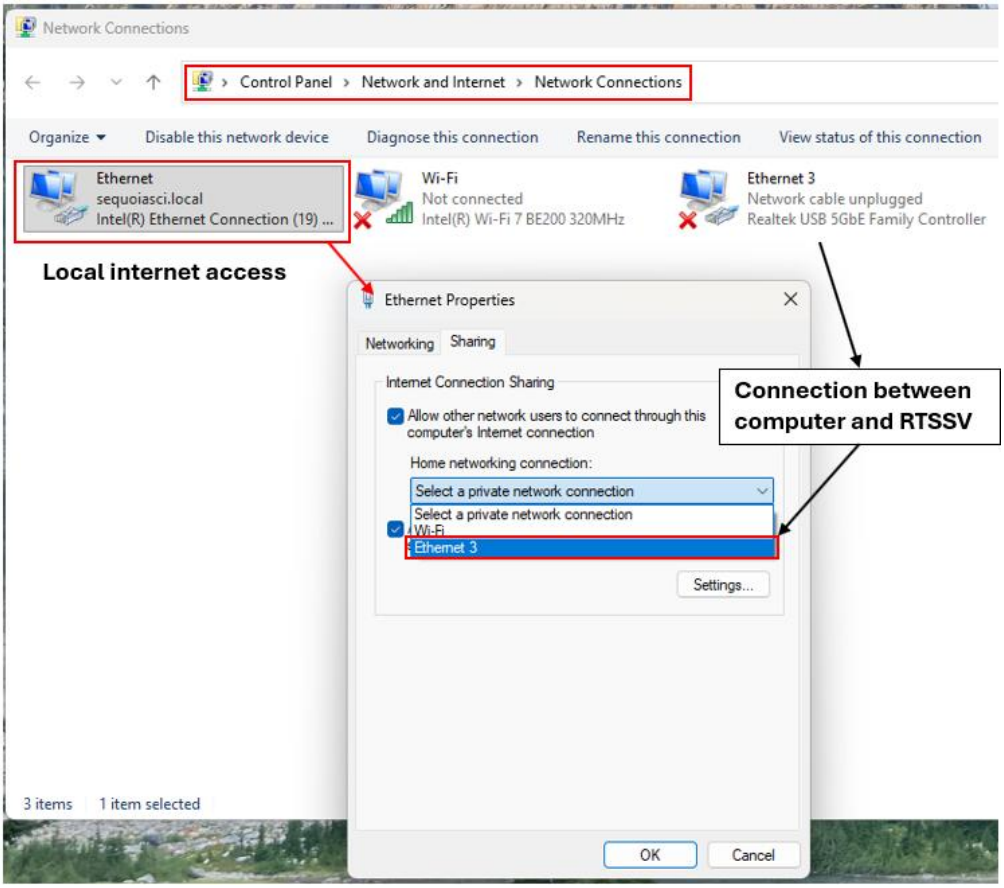
After changing the clock on the RTSSV, it is recommended to turn the instrument off (let the computer shut down), then turn the instrument back on. When the computer boots up, ensure the clock is still set to the correct time.

Sync RTSSV time to laptop; requires access to internet, either via direct ethernet connection or sharing internet from laptop



Once synced, you can then uncheck the box so it doesn't keep attempting to sync once it loses internet again

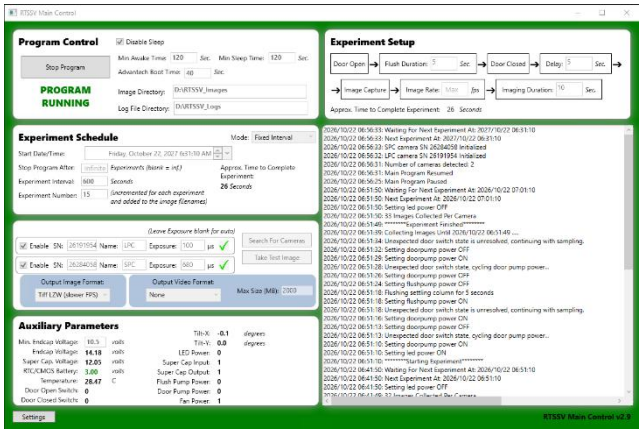
If the RTSSV is connected to a computer (laptop or desktop) but does not have internet access, then the internet connection may not be set to share between the computer and the RTSSV. To check this, on the computer (NOT on the RTSSV), go to Control Panel → Network and Internet → Network Connections. Find the local network being used by the computer, right click and view "Properties", then check the box to "Allow other network users to connect through this computer's Internet connection". In the drop down, choose which network connection you would like to share with; this selection should be the connection between the RTSSV and the computer. Press OK to apply the settings. When the settings are updated, there is a chance that the IPv4 settings will be reset, causing the connection to the RTSSV to be lost. If this occurs, follow the steps discussed previously to reset the IPv4 settings to reconnect to the RTSSV.

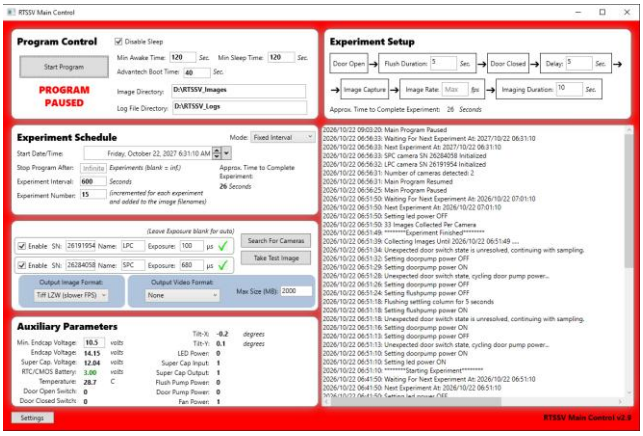


E. Configuration/Sampling – LISST-RTSSV Main Control Program

The RTSSV Main Control program is a windows-based program that runs onboard the internal Advantech single board computer. The program is launched automatically each time the computer boots up. The program provides a user interface for configuring the instrument.

When the instrument boots up, the sampling program will be running (green background). It will execute the sampling procedure and schedule configured in the software. The program can be stopped by pressing the ‘Stop Program’ button. This will put the sampling program into the ‘paused’ state (red background). Once the program is paused, the parameters in the software can be changed and the program restarted.





1. Program Control



This pane allows for:

1. Starting and stopping the sample program
2. Configuring instrument sleep
3. Setting the image and log output directories

2. Sleep

Sleep can be completely disabled by checking the ‘Disable Sleep’ checkbox. It is recommended that sleep be disabled if you need continuous access to the instrument via the ethernet or serial port connection. If the instrument does enter sleep mode, you must wait for the scheduled wake up time, or cycle power to regain access to the instrument ethernet or serial port connection.

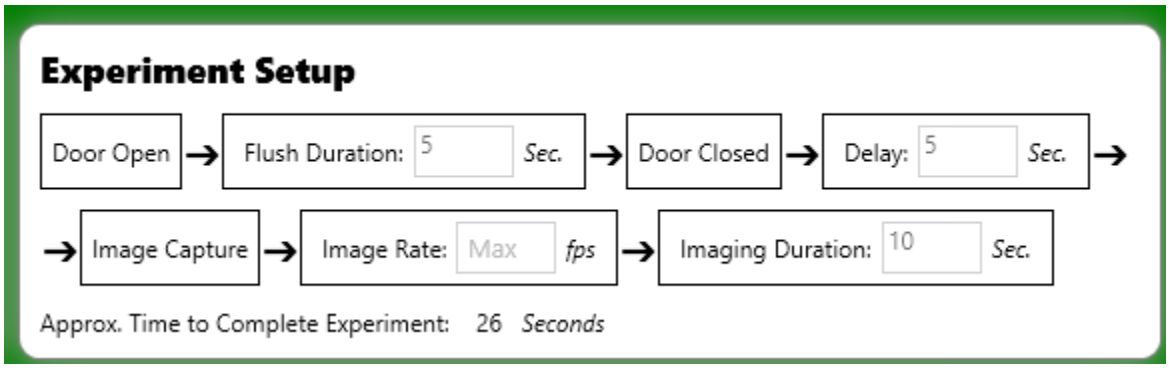
If running off a battery, it is recommended that sleep be enabled. The instrument will only enter sleep if the time (seconds) between experiments is greater than the **Minimum Sleep Time**.

The **Minimum Awake Time** is the minimum time (seconds) the RTSSV will remain awake, even if it is idle. For example, if the minimum awake time is set to 2 minutes, the RTSSV will remain awake for at least 2 minutes before going back to sleep. It will remain awake even if the instrument is idle (no sampling happening). This is used to prevent the scenario where you wake up the instrument (cycling power) and the instrument immediately goes back to sleep because its not time to sample yet. With the minimum awake time set to a few minutes, it will prevent the instrument from going to sleep immediately. This will provide enough time to connect to the instrument and make changes if necessary.

The **Advantech Boot Time** is the amount of time (seconds) needed for the Advantech single board computer to boot up from the off state. This is used to ensure the computer boot up is initiated with enough time to be completed before the start of the next experiment. The **Minimum Sleep Time** must be set larger than the **Advantech Boot Time**. Otherwise, there would not be enough time for the Advantech to boot up between experiments.

If the sample program is stopped and the RTSSV Main Control program is in the 'paused' state, the RTSSV instrument will not enter sleep. It will remain awake until the sample program is started again and current settings allow for sleep.

3. Experiment Setup

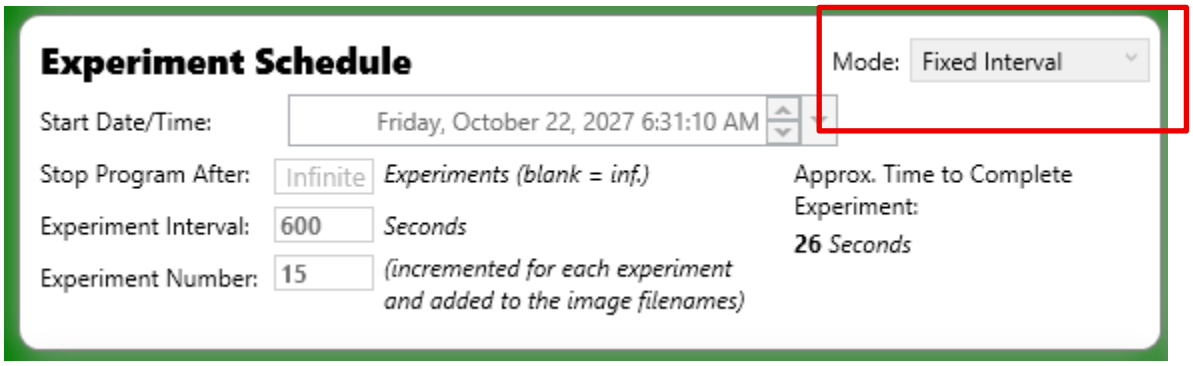


This pane allows for customization of the settling experiment. It allows for setting:

1. Duration of settling column flushing with the 'flushpump'
2. A delay after closing the settling column door to allow for stabilization
3. Image rate in frames per second (fps) (can be left blank for max frame rate).
4. Total settling experiment duration (how long to collect images).

4. Experiment Schedule

Fixed Rate



The experiment schedule pane configures when a settling experiment will occur. The experiments will occur on a repeat schedule that can be customized.

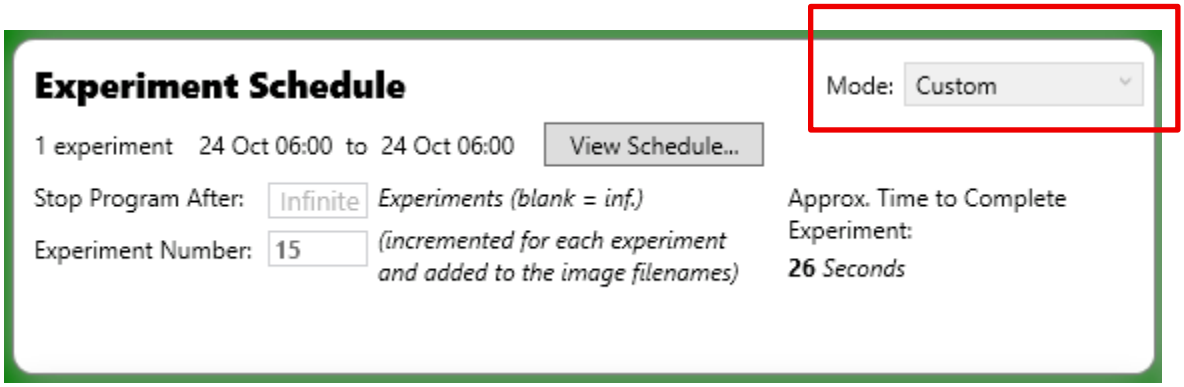
You can specify a date and time for the first experiment to begin. The RTSSV will wait to sample until this date and time has passed. If you want to the sample schedule to start immediately, then set the start date/time to some date in the past.

The **Stop Program After** setting will stop the program after the specified number of experiments. This is an optional parameter. If left blank, the RTSSV will sample indefinitely.

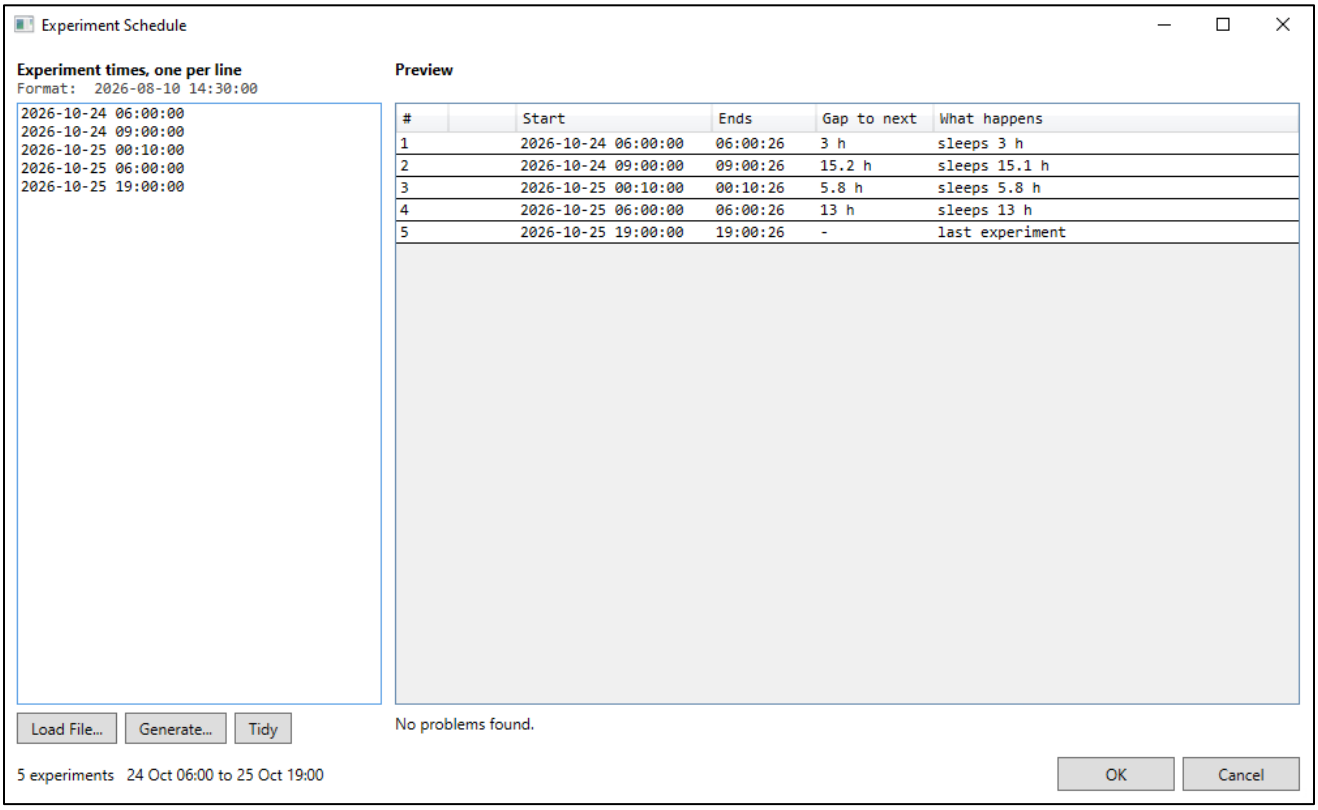
The **Experiment Interval** is how often a settling experiment will be conducted. This interval is defined as the time between the start of one experiment and the start of the next experiment. Therefore, the experiment interval must be greater than the time to complete a settling experiment. If sleep is enabled, the instrument may sleep between experiments if the idle time is greater than the **Minimum Sleep Time**.

Experiment Number is incremented for each settling experiment that is conducted. The experiment number is included in the image filename and is used to organize images into subfolders.

Custom

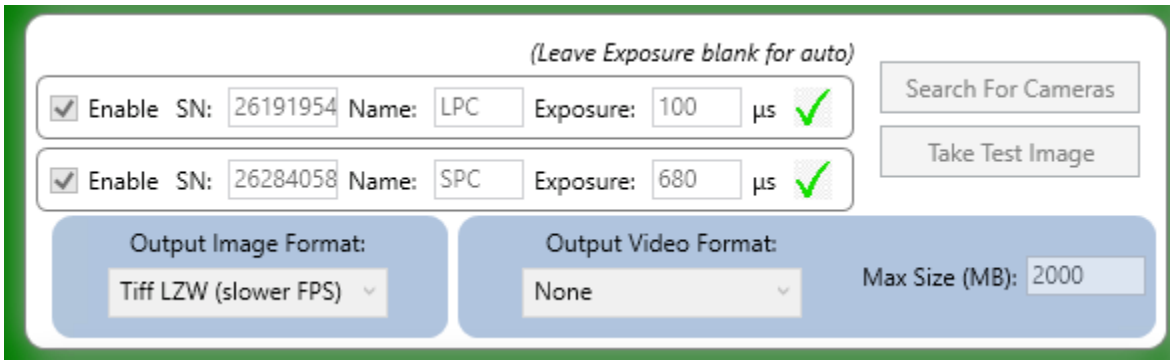


A custom schedule can be defined, where the instrument will collect experiments at predefined times, not at a fixed rate. By clicking ‘edit schedule’, you can enter specific dates or import a list of dates from a text file.



Note the program must be paused to edit the list.

5. Cameras



The Cameras pane allows for setting up and testing the RTSSV cameras. The camera serial number must be entered in the **Camera SN** textbox for the program to properly connect to the camera. If the serial number is unknown, you can use the Search For Cameras button. The serial numbers of the connected cameras will be printed in the status window. This is configured before shipping and doesn't usually need to be adjusted. Optionally, cameras can be disabled by unchecking the checkbox. This is useful if only images from the large or small particle camera need to be saved.

The **Camera Name** is an identifier that is included in the image filename and used to sort images into subfolders.

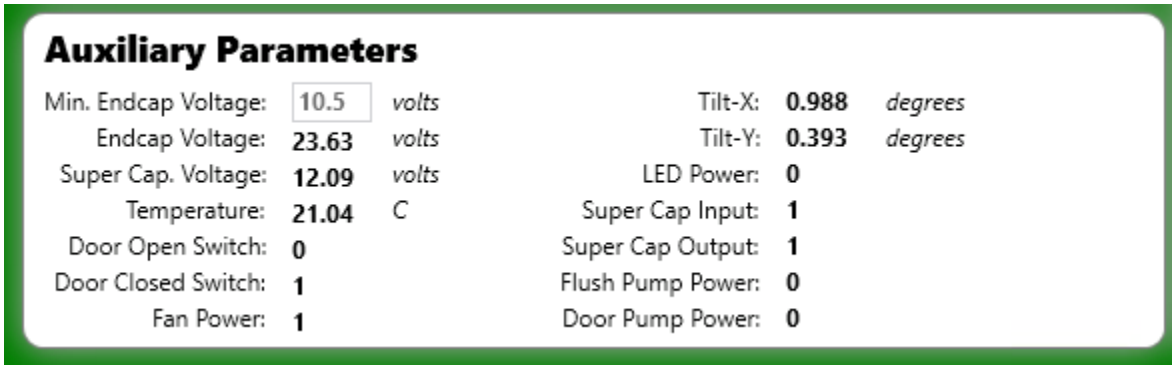
The **Exposure** of each camera can be manually set using the exposure text boxes. If left blank, the cameras will be put into auto exposure mode. This is configured before shipping and doesn't usually need to be adjusted.

Output Image Format allows selection of the image format. Uncompressed formats allow for faster frame rates than compressed formats.

The **Video Output Mode** is a beta feature that saves images as a video. Processing of the video output is currently not supported.

The **Take Test Images** button is used for collecting a single image from each camera. The images will be saved into a 'Test-Images' folder in the Image Directory specified in the Program Control pane.

6. Auxiliary Parameters



The auxiliary parameters pane shows the state of the instrument. The values are updated once per second. These values are also saved in an auxiliary log file.

The only configurable parameter is the **Minimum Endcap Voltage**. This value specifies when the RTSSV will shut down due to low voltage. Sequoia does not recommend changing this value.

7. Log Files

Auxiliary Log File

The state of the instrument is recorded every second in the auxiliary log file. The columns of the log file are:

1	Date
2	Time
3	SuperCapInEnabled
4	SuperCapOutEnabled
5	SBCPowerEnabled

6	LEDPowerEnabled
7	FlushPumpPowerEnabled
8	DoorPumpPowerEnabled,
9	DoorOpenSwitch
10	DoorClosedSwitch
11	FanPowerEnabled
12	IsSCBRunning
13	EndcapVoltage
14	SuperCapVoltage
15	Temperature
16	WakeInSeconds
17	Tilt.X (degrees)
18	Tilt.Y (degrees)
19	Tilt.X (raw counts)
20	Tilt.Y (raw counts)
21	TiltSensorTemp
22	TiltSensorTempCompON

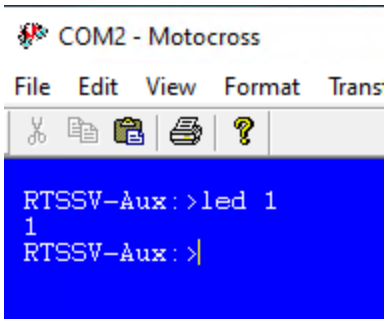
Status Log File

The status log file contains textual updates on the progress of the sampling program. The messages recorded in the log file are identical to the messages printed in the status window of the RTSSV Main Control program and the serial port.

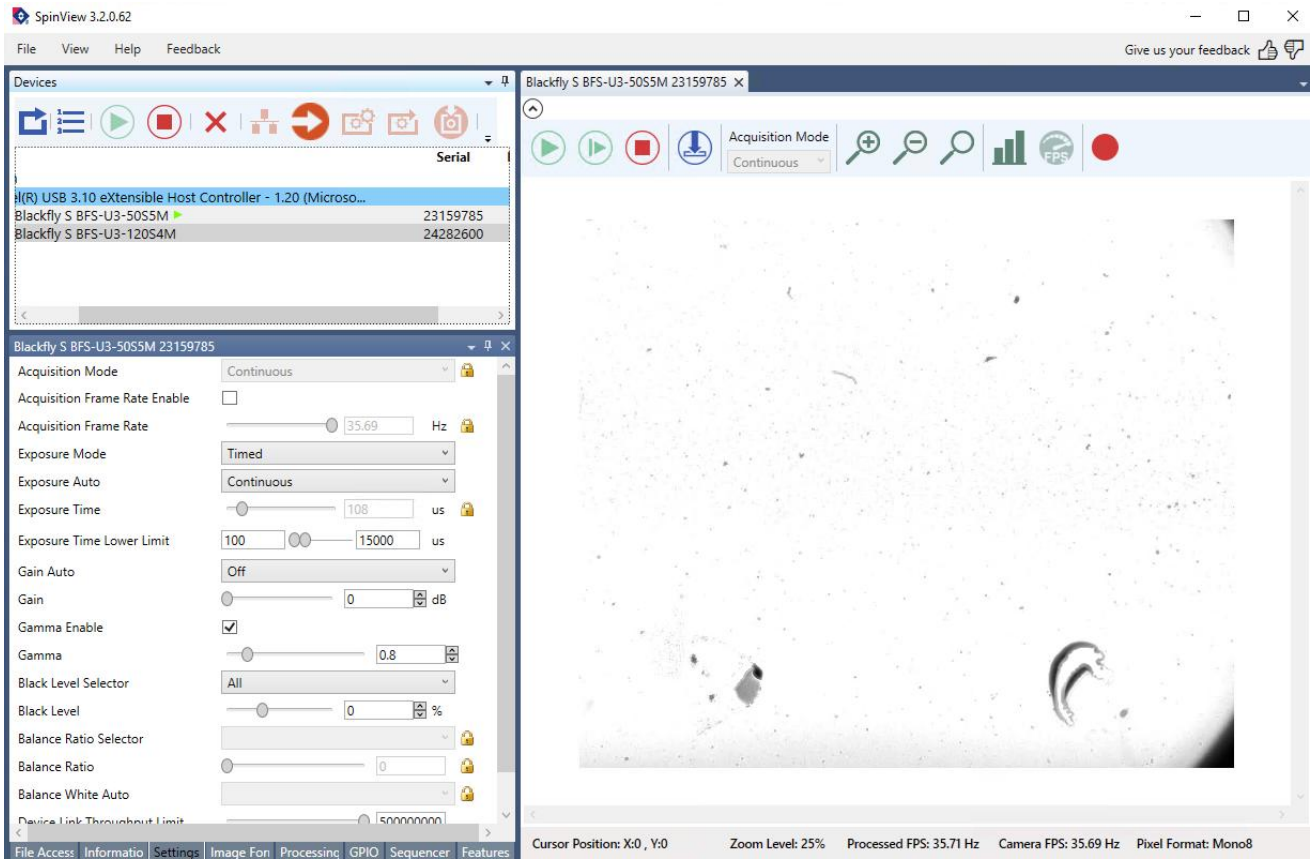
F. View Real Time Images - SpinView

The cameras can be viewed in real time. This can be helpful for troubleshooting or checking the windows for fouling.

First, connect to LISST-RTSSV using remote desktop connection. Close the RTSSV Main Control Program. **Note: The RTSSV Main Control program must be reopened before removing power from the instrument.** Open the 'MotoCross' software using the shortcut on the desktop. Send the 'led 1' command to turn on the LED.



Open the ‘SpinView’ software using the shortcut on the desktop. Double click on of the cameras listed in the top left panel. A real time view of the camera will be displayed. You may need to zoom out to see the whole frame.



When you are finished using SpinView, close both SpinView and Motocross. Relaunch the RTSSV main control program using the shortcut on the desktop. It is now safe to remove power from the instrument.

G. Data Processing – RTSSV Image Processing Software

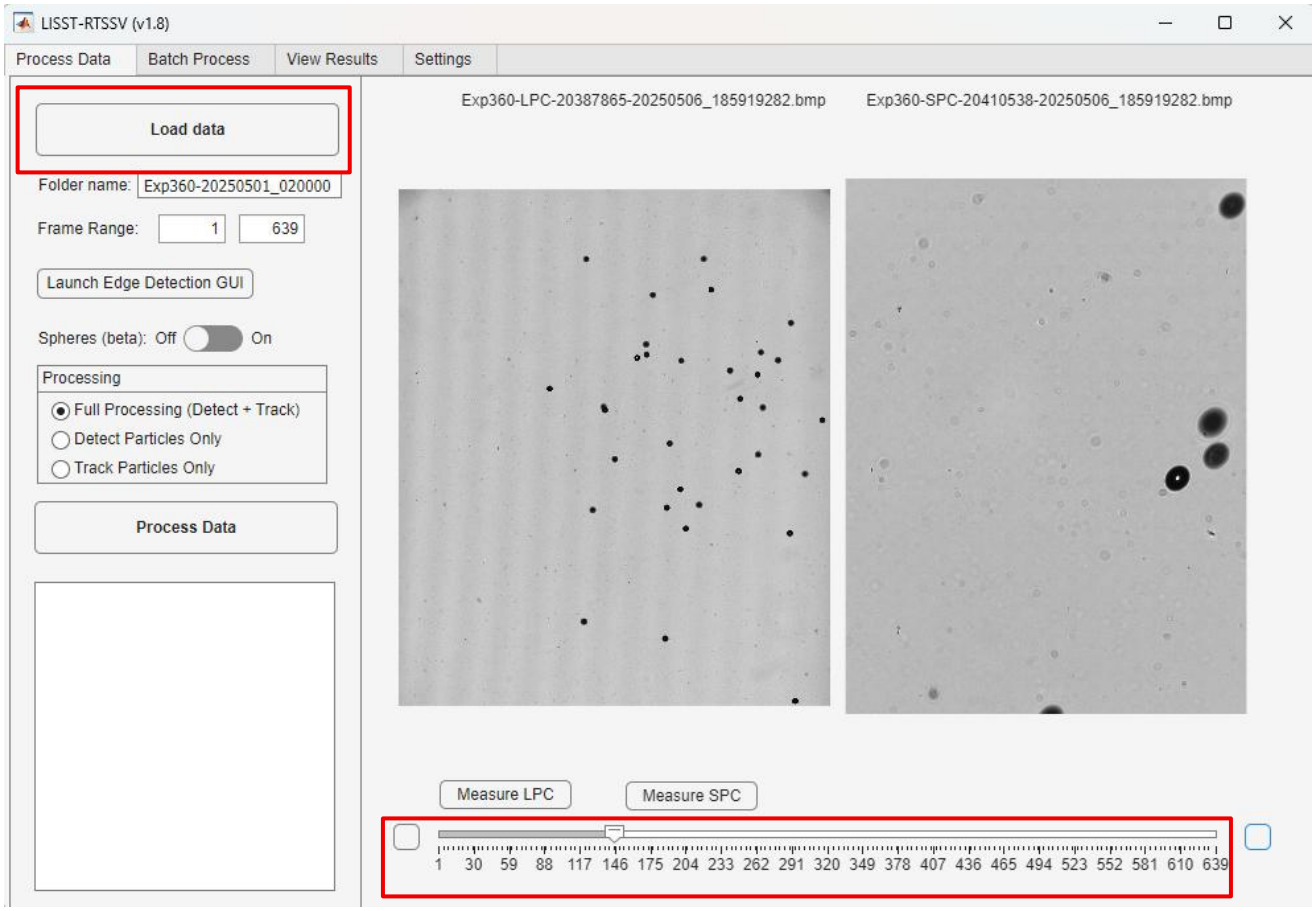
The RTSSV Image processing software is a compiled MatLab program. To run the program the MatLab runtime 2025b must be installed first. The runtime can be downloaded for free from Mathworks website, or find it on the RTSSV ship disk.

The LISST-RTSSV software is distributed as a standalone executable. It does not need to be installed on your computer. Simply copy the entire ‘RTSSV Image Processing Software’ folder from the included USB card to a location on your computer. You can create a shortcut to ‘LISST_RTSSV.exe’ and place it on your desktop for convenience.

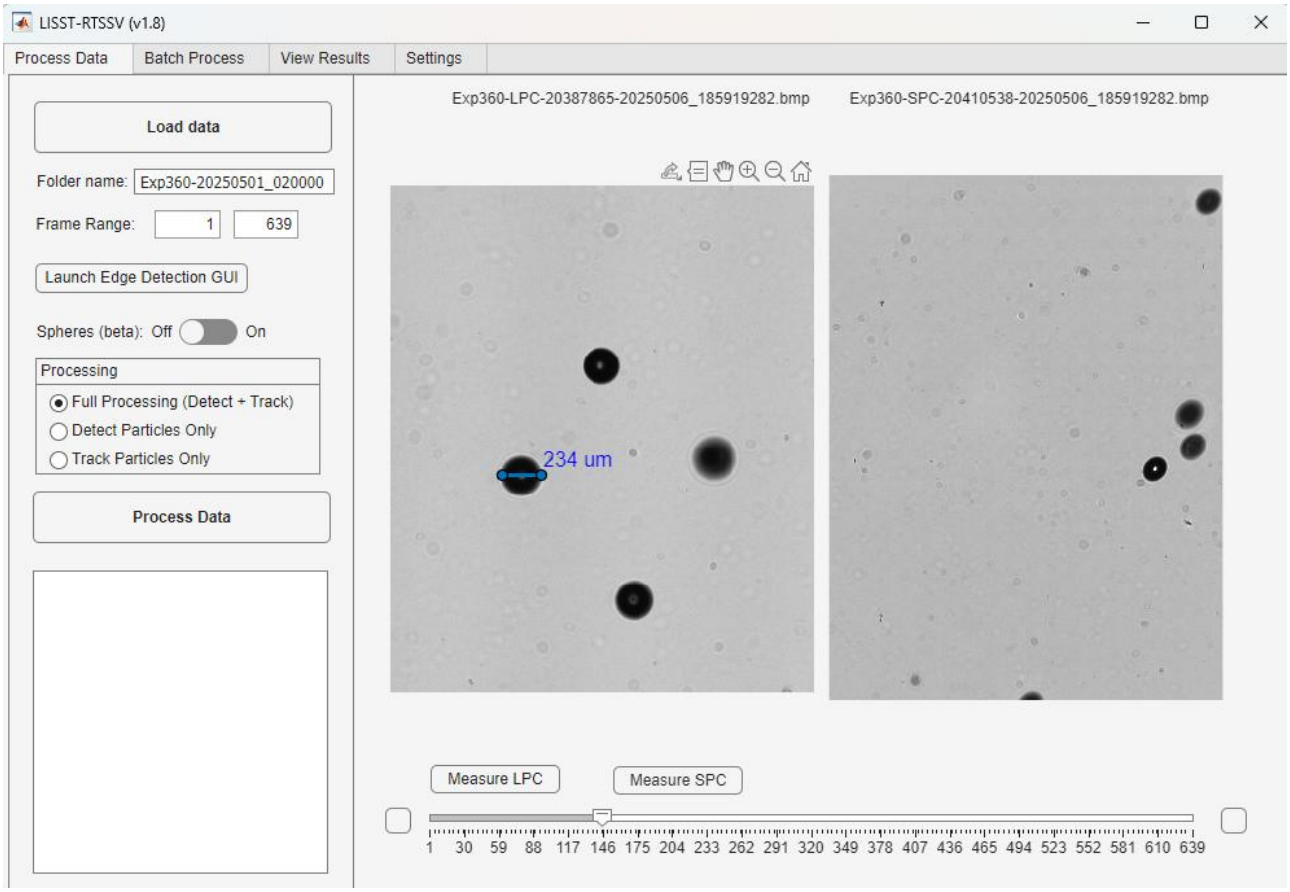
The image processing software GUI will output .mat files containing all the processed image data. The MatLab software is required to work with the .mat data files.

1. Processing a Single Experiment

The ‘Process Data’ tab of the software is used for processing a single experiment. Using the ‘Load Data’ button select experiment directory (e.g. Exp359-20250501_020000). This folder should contain the LPC and SPC folders containing the experiment images. After Loading the data, the LPC and SPC images will appear on the left and right, respectively. You can browse the images using the slider at the bottom. You can restrict the frame range using the two ‘Frame Range’ boxes on the left.



Particles can be manually measured using the ‘Measure’ buttons. You can zoom in before measuring by hovering over one of the images and pressing the zoom button in the top right of the image. After pressing the measure button, hold and drag to measure a distance across the image.



‘Frame Range’ allows you to limit the number of frames that are processed. The processing can be slow for large experiments. If you know that many frames are blank (e.g. at the start or end of the experiment), you can exclude those frames.

The **‘Edge detection GUI’** is an interactive tool that allows you set the edge detection thresholds. The defaults settings are a good starting point. However, if you find that many particles are being missed, you can use this interactive tool to determine the optimal settings. However, be aware that many particles are excluded under the default settings because they are out of focus. Just because a certain setting detects more particles, doesn’t make it better. It should only detect the in-focus particles and exclude the out of focus particles.

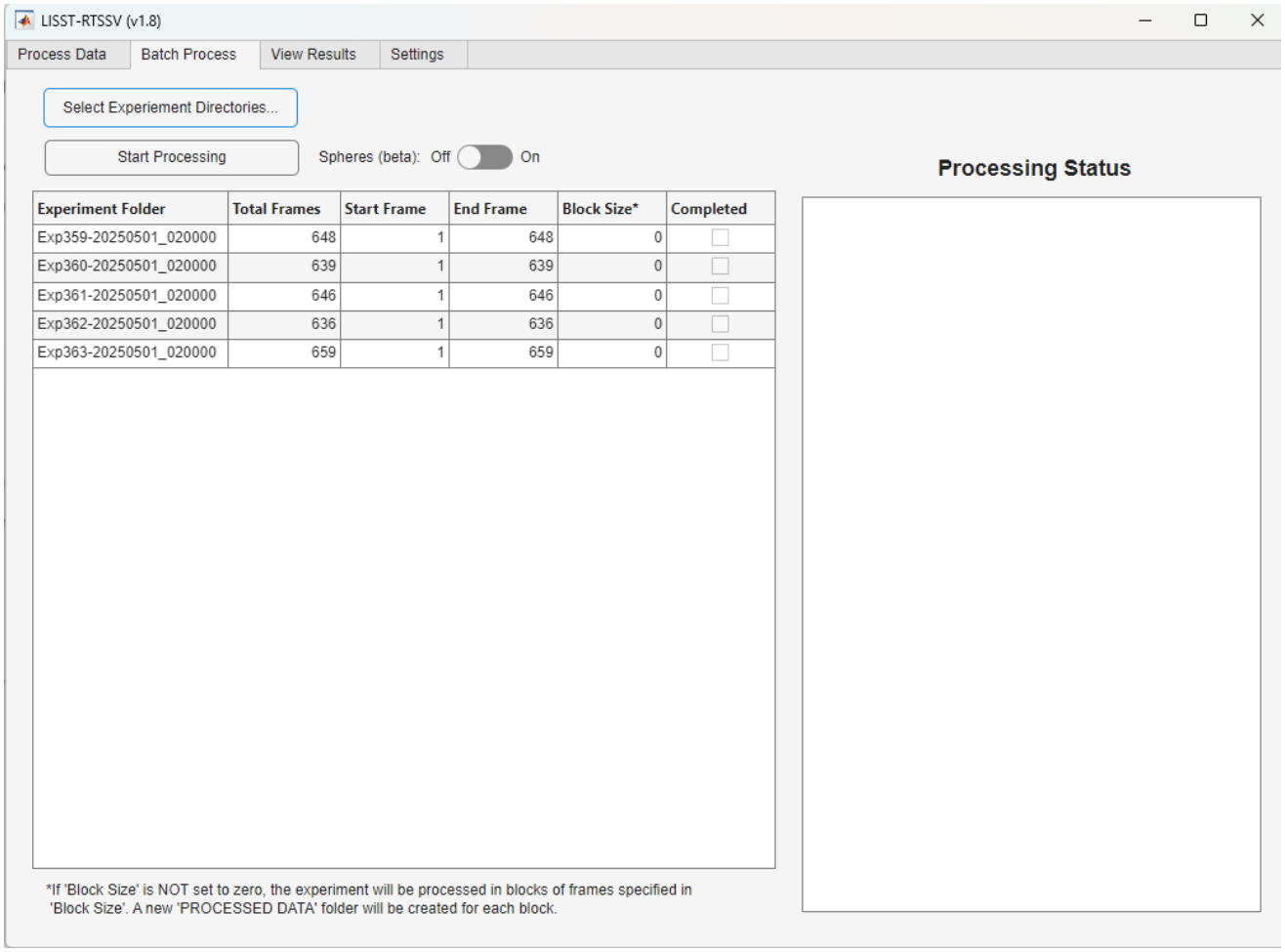
The **‘Spheres’** option is beta version of a tracking algorithm tuned for spherical particles. Spherical particles are harder to track since adjacent particles do not have unique shape characteristics. The algorithm uses the predicted position of the particle to determine the most likely corresponding particle in subsequent frames. This is a new feature without extensive testing, so it’s marked as beta.

The radio buttons in the **‘Processing’** box allow you to select the level of processing. In most cases, the full processing will be used. This will detect the particles in the image, then track the particle’s velocity. These are separate steps that are done sequentially. If only the particle size is needed and not the velocity, you can speed up processing by just selecting ‘detect particles’.

The ‘Process Data’ button will begin the data processing. Updates (including percentage complete) will be displayed in the text box. See ‘Processed Output Format’ for a description of how the processed data is organized.

2. Batch Processing

Multiple experiments can be processed sequentially using the ‘Batch Process’ tab. Use the ‘Select Experiments Directory’ to select multiple experiment directories (use Shift or Ctrl to select multiple folders). After pressing the ‘Start Processing’ button, updates will be displayed in the text box. See ‘Processed Output Format’ for a description of how the processed data is organized.



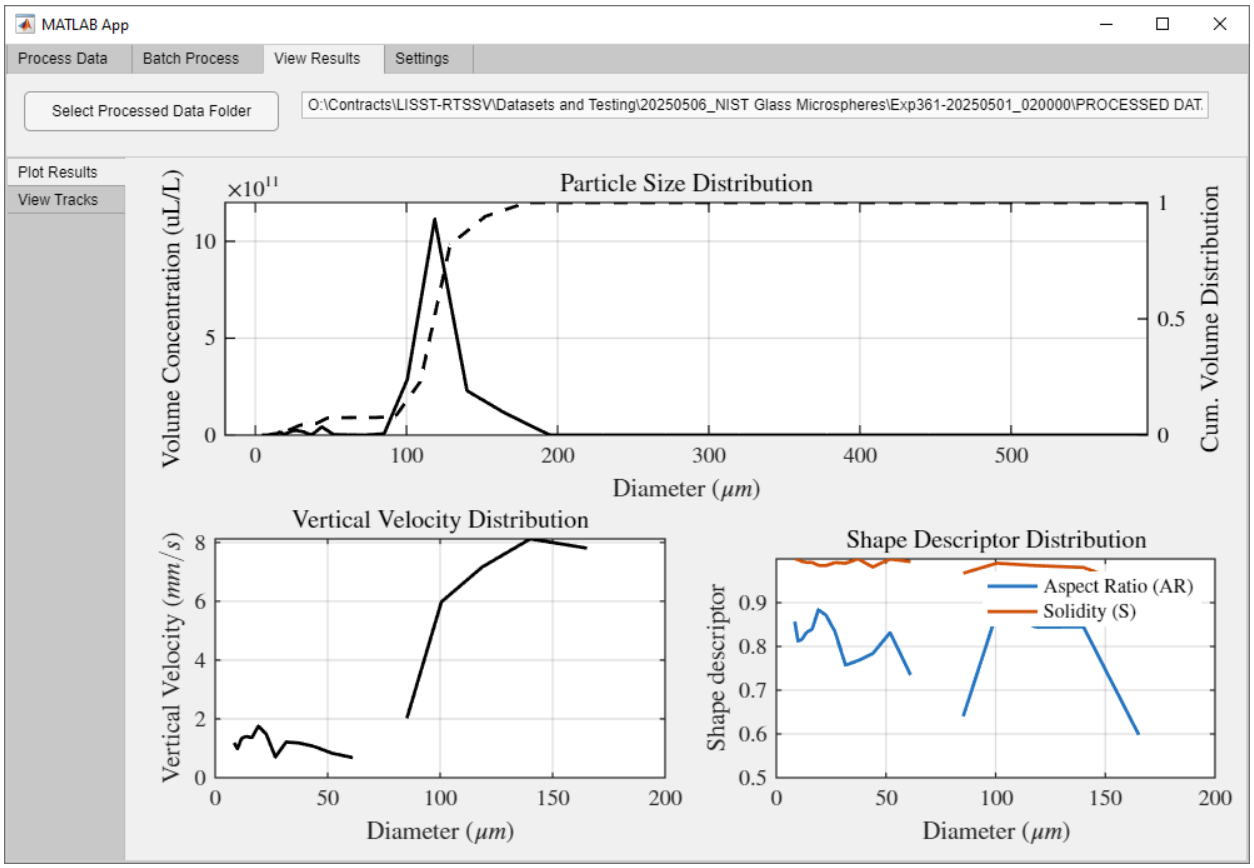
The ‘Spheres’ option is beta version of a tracking algorithm tuned for spherical particles. Spherical particles are harder to track since adjacent particles do not have unique shape characteristics. The algorithm uses the predicted position of the particle to determine the most likely corresponding particle in subsequent frames. This is a new feature without extensive testing, so it’s marked as beta.

In the Batch Processing tab you also have the option of selecting the start and end frame. This can be used to exclude frames at the start or end of an experiment. ‘Block Size’ is an

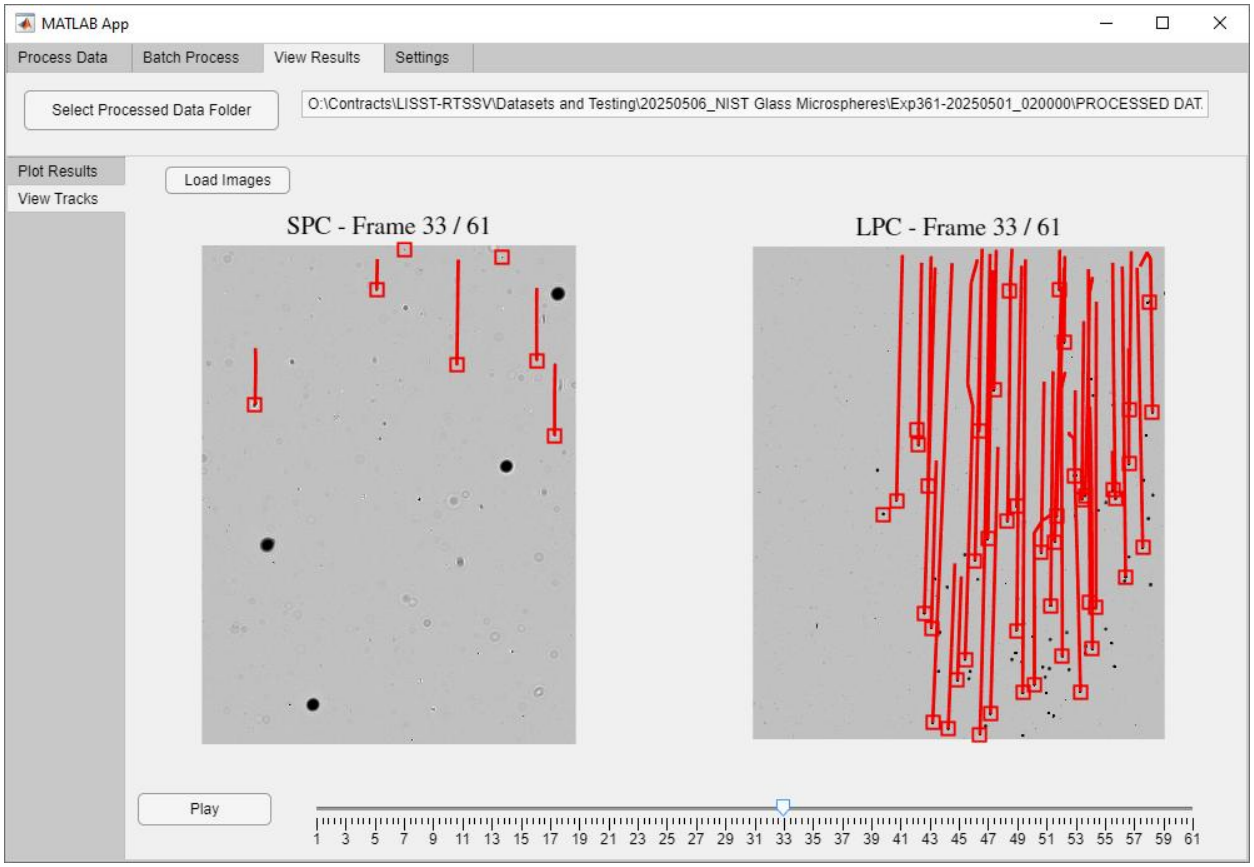
optional parameter that will process the experiment images in chucks. This can be useful if you run out of memory on the computer while processing a large experiment. Setting this to something like 1000 images will use less memory.

3. View Results

The LISST-RTSSV software allows for limited viewing of processed results. On the view results tab, use the 'Select Processed Data Folder' to select a folder containing processed data (named PROCESSED DATA by default). Plots of the size and velocity distribution will be generated.



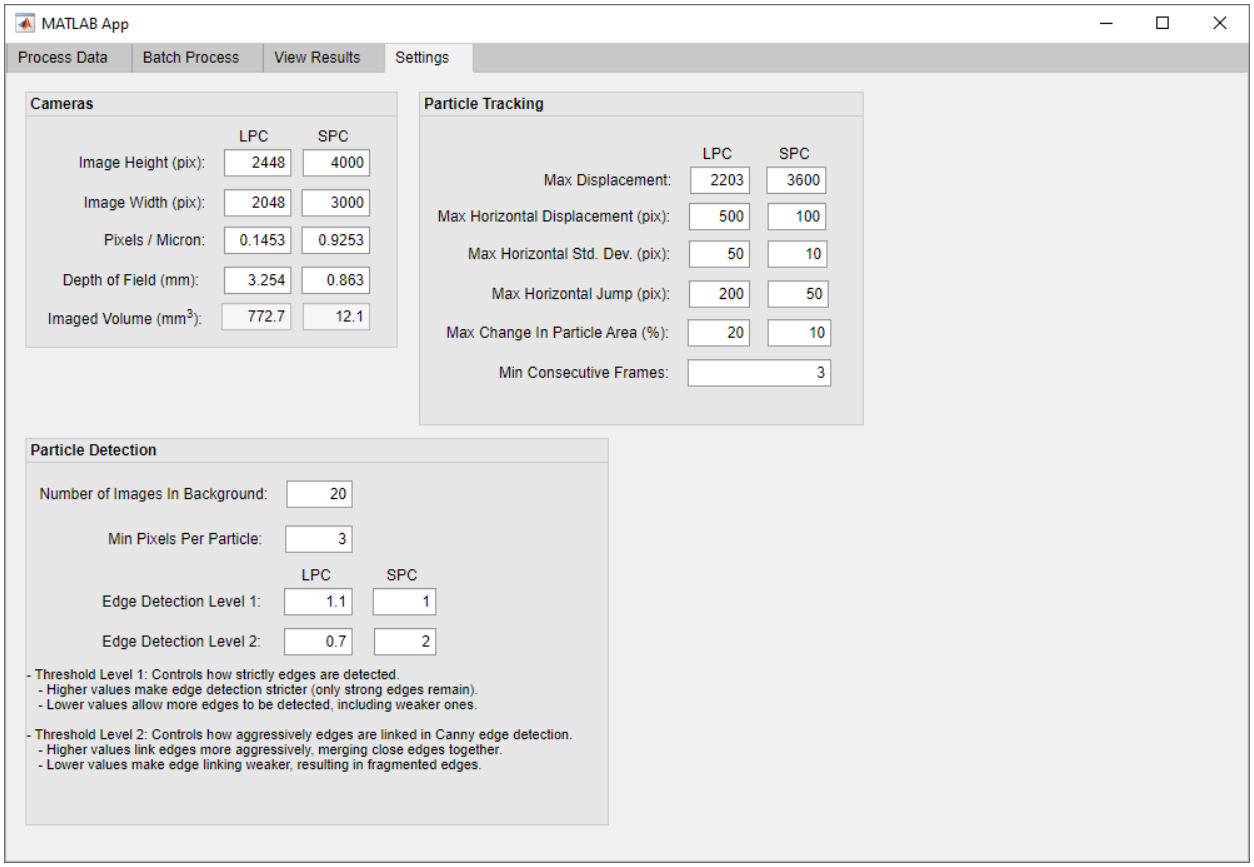
A second tab allows you to view the particle tracks identified by the software. On the View Tracks tab select the 'Load Images' button. Use the slider or the play button to view the particle tracks identified by the software.



See ‘Processed Output Format’ for a description of how the processed data is organized. The processed .mat data files contain much more information than what is displayed by the software.

4. Settings

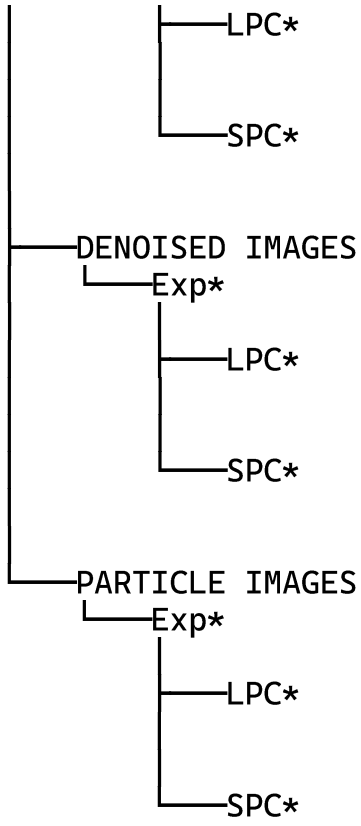
The settings tab contains advanced settings for the cameras, particle detection, and particle tracking. The camera settings should not be changed without contacting Sequoia Scientific, Inc. The particle detection and particle tracking settings may be changed by advanced users.



5. Processed Output Format

The resulting data will placed in a folder called PROCESSED DATA inside the original experiment folder. The processed data folder has the following layout:

```
PROCESSED DATA
├──PARTICLE DATA
│       *particle_data_raw.mat
│
├──RESULTS
│       *distributions.mat
│       *stats.mat
│
├──TRACKING DATA
│        *tracking_data_raw.mat
│
└──PROCESSED IMAGES
   ├──BINARY IMAGES
   │   └──Exp*
   │       │
```



File	Folder	Variable	Contents
<exp>_distributions.mat	RESULTS	results	Calibrated size distributions (SPC+LPC merged) and size-binned velocity/shape.
<exp>_stats.mat	RESULTS	stats	Summary statistics (means, percentiles, etc.) of the distributions.
Below is raw data, typically not needed			
<exp>_particle_data_raw.mat	PARTICLE DATA	particleData	Every particle detected in every frame, per camera, in pixels.
<exp>_tracking_data_raw.mat	TRACKING DATA	tracksData	Verified particle tracks (particles linked across frames), per camera, in pixels.

The ‘size’ of a particle depends on how it is measured. The software measures a detected particle using six different size metrics. We recommend using the area-based measurement (‘aed’), which is the diameter of circle with the same area as the particle (i.e. same number of pixels). This is a widely used size metric and will be the easiest to compare with other size measurements. Below is an explanation of the six different sizing metrics the RTSSV Image Processing software computers:

Area Based Equivalent Diameter (‘aed’)

Diameter of a circle with the same area as the region. Computed as sqrt(4*Area/pi).

Ellipse-Based Equivalent Diameter (‘sed’)

Equivalent diameter of circle with the same are of a fitted ellipse to the particle (Jennings et al. 1988)

Major Axis Length (‘dMa’)

Length of the major axis of a fitted ellipse.

Minor Axis Length (‘dMi’)

Length of the minor axis of a fitted ellipse.

Max Feret Length (‘fMa’)

Maximum distance between any two boundary points.

Min Feret Length (‘fMi’)

Minimum distance between any two boundary points.

distributions.mat

For the sub struct ‘sizeDist’ (size distributions), each of the six different sizing methods has the following data:

Parameter	Description	Unit
binMidPoints	Mid Points of Size Bins	µm
binLowerBound	Upper Limits of Size Bins	µm
binUpperBound	Lower Limits of Size Bins	µm
countPerBin	Number of particles per bin	#
numConcPerBin	Number Concentration of Particles Per Bin	#/L
numCumulativeDist	Cumulative number concentration	0-1

volumeDistPerBin	Volume Concentration of Particles Per Bin	µL/L
volCumulativeDist	Cumulative Volume concentration	0-1

For the sub struct 'sizeDepDist' (Size Dependent Distributions), each of the six different sizing methods has the following data**. Some are three columns wide, the columns correspond to the mean, standard deviation, and particle count, respectively**. The shape parameters are computed using Matlab's 'regionprops' function. See the description of the various parameters here: https://www.mathworks.com/help/images/ref/regionprops.html.

Parameter		Description	Unit
velocity			
	u	Horizontal Velocity	mm/s
	v	Vertical Velocity	mm/s
	w	Resultant Speed Magnitude	mm/s
shape			
	ff	Form Factor (circularity)	-
	c	Convexity	-
	s	Solidity	-
	r	Roundness	-
	co	Compacity	-
	e	Eccentricity	-
	ar	Aspect Ratio	-

particle_data_raw.mat

Parameter	Description	Unit
fn	Frame Number	-
ts	Timestamp	-
x	Centroid (center of mass) – x pixel position	pixels
y	Centroid (center of mass) – y pixel position	pixels
a	Projected Area	$pixels^2$
aed	Area Based Equivalent Diameter	pixels
sed	Ellipse-based Equivalent Diameter	pixels
dMa	Major Axis Length of Fitted Ellipse	pixels
dMi	Minor Axis Length of Fitted Ellipse	pixels
fMa	Maximum Feret Diameter	pixels
fMi	Minimum Feret Diameter	pixels
ff	Form Factor (circularity)	-
c	Convexity	-
s	Solidity	-
r	Roundness	-
co	Compacity	-
e	Eccentricity	-

ar	Aspect Ratio	-

tracking_data_raw.mat

Parameter	Description	Unit
len	Trajectory Length (number of frames)	# of frames
fn	Frame numbers	-
ts	Timestamps	-
x	Horizontal Position Over Time	pixels
y	Vertical Position Over Time	pixels
a	Particle Area Over Time	$pixels^2$
aed	Equivalent Diameters (from area) Over Time	pixels
sed	Ellipse-based Diameters Over Time	pixels
dMa	Major Axis Length of Fitted Ellipse Over Time	pixels
dMi	Minor Axis Length of Fitted Ellipse Over Time	pixels
fMa	Maximum Feret Diameter	pixels
fMi	Minimum Feret Diameter	pixels
ff	Form Factor (circularity)	-
c	Convexity	-
s	Solidity	-
r	Roundness	-
co	Compacity	-
e	Eccentricity	--
ar	Aspect Ratio	
u	Horizontal Velocity (gradient of X)	pixels/frame
v	Vertical Velocity (gradient of y)	pixels/frame
w	Resultant Speed Magnitude	pixels/frame

The '**stats.mat'** file contains statistics for the experiment as whole, not broken out by size bin. Each of these statistics has the suffix '_num' or '_vol' which refers to the particle number-based distribution or the volume-based distribution.

volumeConc	
	aed
	sed
	fMa
	fMi
	dMa
	dMi
size	
	aed
	sed

	fMa
	fMi
	dMa
	dMi
velocity	
	aed
	sed
	fMa
	fMi
	dMa
	dMi
shape	
	aed
	sed
	fMa
	fMi
	dMa
	dMi

III. Instrument Maintainance

H. Cleaning Instrument Before and After Deployment

As the LISST-RTSSV is an optical instrument, care should be taken to clean the optical windows before and after a deployment to prevent damage to the window and/or loss of measurement capabilities due to obstruction of the optical pathway. Before being deployed, the windows should be thoroughly rinsed with filtered water and inspected for damage or buildup on optical surface. To inspect the windows, power up and connect to the instrument. Turn on the LED through the command line, then connect to the cameras through SpinView and view the image output. Fill the chamber with filtered water and ensure the images are largely free of debris/particles. If there appears to be material stuck to the windows, use a soft-bristle brush (e.g., brush for cleaning straws or pipes) to gently brush the windows to free the material. Rinse and repeat until the windows are clean.

After being deployed, the entire instrument should be thoroughly rinsed with filtered fresh water and the windows cleaned and inspected as discussed above. The inside of the settling chamber itself should also be scrubbed with a soft brush and rinsed multiple times to clean out any residual material from the deployment. Tubing should be inspected and cleaned or replaced if necessary. After the instrument is cleaned, the chamber and tubing should be dried (e.g., blown dry with compressed air) to the best of one's ability before storage.

I. Seabird 5T Pump Notes

Two Seabird 5T Pumps are included with the LISST-RTSSV. One pump operates the door to the top of the settling chamber ("Door Pump"), sliding the door open when a sample is being drawn into the chamber and sliding the door closed when a measurement is being performed. The second pump is used to draw sample into the chamber for measurement ("Flush Pump").

The pumps are magnetically coupled and require some back pressure to function correctly. When testing the pumps, they may require a restriction in the inlet and outlet before they will function correctly. An unrestricted pump will make noise but not pump water as the impellor will decouple quickly. Placing a finger over the outlet can provide enough restriction for testing the pump operation.

Warning: The pumps should never be allowed to run dry. They should always be submerged in water when running.

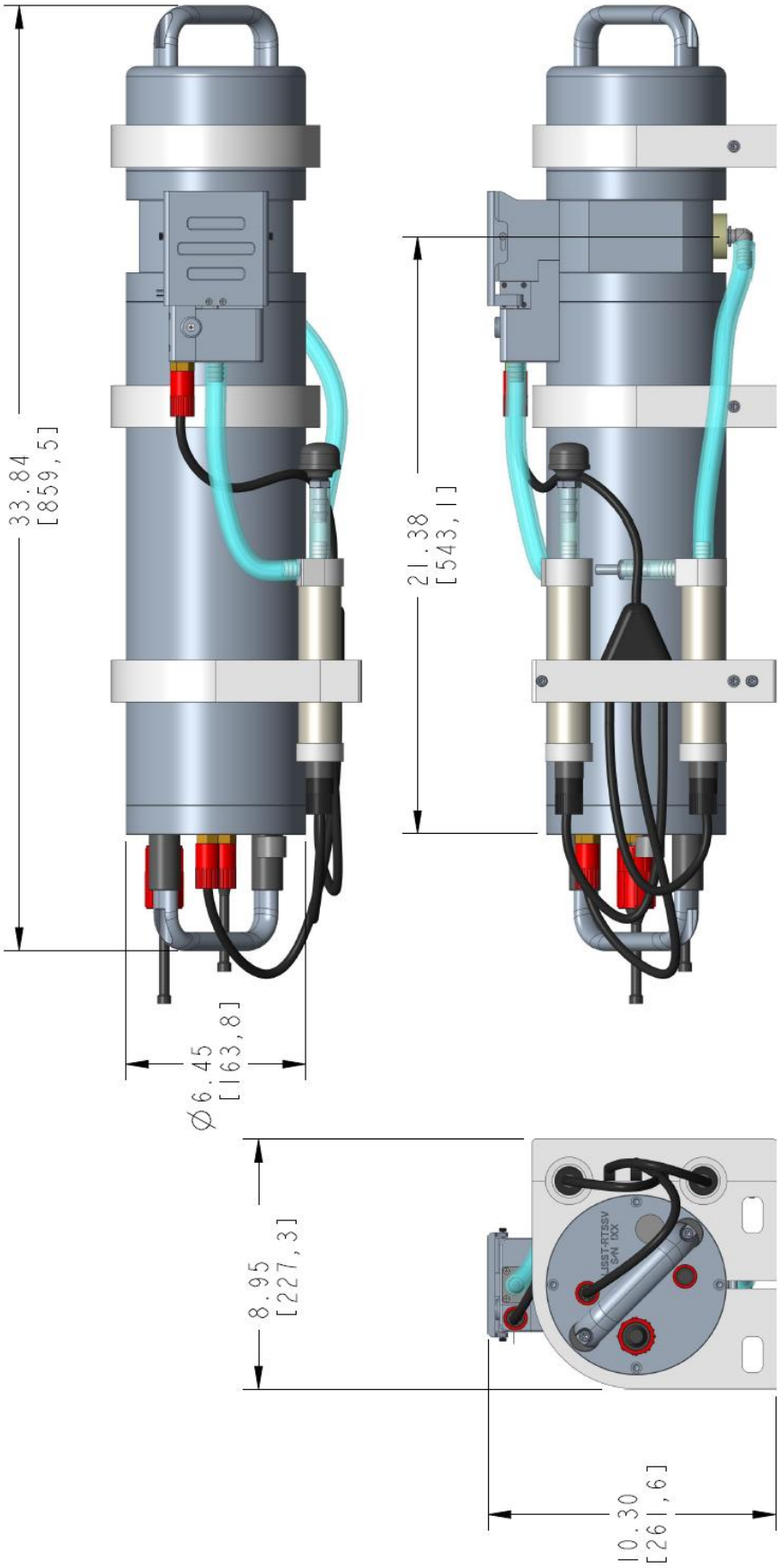
Appendix A: Technical Specifications

General / Electrical

Parameters measured	Particle Size (3.6-4,200 µm), Volume Concentration, Particle Settling Velocity (10-17,000 µm/s)
Data interface	Ethernet
Sample rate	Up to 10 image pairs per second
Input voltage	12 to 30 VDC
Current draw @ 15 V	Max 3A
Storage	1.74 TB internal hard drive (approx. 100,000 image pairs)

Mechanical / Environmental

Operational temperature range	-3 to 40 °C
Storage temperature range	-20 to 60 °C
Dimensions [W x H x L] (See figure on following page)	22.7 cm x 26.1 cm x 85.0 cm (9” x 10” x 34”) including clamps, pump, and door assembly
Weight in air	34.4 kg (75.8 lbs)
Weight in water	15.6 kg (34.4 lbs)
Depth maximum	6,000 meters
Dimensions [D x W x L] of settling column where D is the spacing between the optical windows, W is the width of the column, and L is the length from the top of the column to the center of the optical windows	1.0 cm x 2.5 cm x 12.5 cm (0.4” x 1.0” x 4.9”)
Volume of settling column	125 mL


33.84
[859,5]
21.38
[543,1]
Ø6.45
[163,8]
8.95
[227,3]
10.30
[261,6]

Appendix B: Electrical Connections

Communications and Power Connector (5 pin connector, on connector endcap)

Bulkhead connector: SubConn MCBH5M
Mating cable connector: SubConn MCIL5F



Bulkhead Endview



Cable Endview

Connector Pin #	Use
1	Power/Serial Ground
2	External Power In (+12 to 30 V)
3	Power/Serial Ground
4	Serial Out (to DB-9 Pin 2)
5	Serial In (to DB-9 Pin 3)

Door Connector (3 pin connector, on chamber door)

Bulkhead connector: SubConn MCBH3M
Mating Cable Part Number: SubConn MCIL3F



Bulkhead Endview



Cable Endview

Connector Pin #	Use
1	Common
2	Switch 1 (Door Open)
3	Switch 2 (Door Closed)

Pump and Door Connector (8 pin connector, on connector endcap)

Bulkhead connector: SubConn MCBH8M
Mating Cable Part Number: SubConn MCIL8F

Connector Pin #	Use
1	Ground
2	+12V Power Out (Flush Pump)
3	Ground
4	+12V Power Out (Door Pump)
5	Ground
6	Door Open Switch
7	Door Closed Switch
8	N/C

Ethernet Connector (large 8 pin connector, on connector endcap)

Bulkhead connector: SubConn DBH8M
Mating Cable Part Number: SubConn DIL8F

Revision History

Version 1.0 June 2025	Initial public release.
Version 1.1 October 2026	Added diagrams, added description of laboratory usage, updated screenshots and descriptions of RTSSV Main Control and RTSSV Matlab Software, updated specifications.