

LISST-HOLO

User's Guide

Version 1.0
July 2011



Sequoia Scientific, Inc.
2700 Richards Road, Suite 107
Bellevue, WA 98005
USA

Tel: (+1) 425-641-0944
Fax: (+1) 425-643-0595
info@SequoiaSci.com
www.SequoiaSci.com

Technical assistance

To obtain technical assistance related to your LISST-HOLO, please contact your local distributor (a list of our international distributors can be found on www.SequoiaSci.com) or a Sequoia Technical Service Representative listed below.

Please be sure to include the instrument serial number with any correspondence.

Sequoia Technical Service Representatives:

Chuck Pottsmith, VP Technology

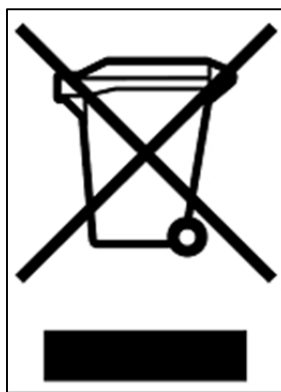
pottsmith@SequoiaSci.com

(+1) 425-641-0944 ext. 107

Ole Mikkelsen, Sales & Marketing Manager

ole.mikkelsen@SequoiaSci.com

(+1) 425-641-0944 ext. 108



Waste Electrical and Electronic Equipment

Smaltimento di apparecchiature elettriche ed elettroniche da rottamare

Table of Contents

1	Introduction	1
2	Contents and Technical Specifications.....	3
2.1	General Features	3
2.2	Parameters Measured and Derived.....	3
2.3	Particle Size and Concentration	3
2.4	Technology	3
2.5	Mechanical and Electrical	3
	<i>Drawings.....</i>	<i>4</i>
	<i>Bulkhead connector Pin-outs.....</i>	<i>5</i>
3	Getting Started	7
3.1	Introduction	7
3.2	Connect cables and power up	7
3.3	Take a hologram	9
4	Hologram Processing with HOLO_Batch and HOLO_Detail	13
4.1	Intro	13
4.2	Install the hologram processing software	13
4.3	Process holograms using HOLO_Batch and HOLO_Detail	15
4.4	HOLO_Batch – automated batch processing of multiple holograms.....	15
	<i>.JPG files output by HOLO_Batch.....</i>	<i>25</i>
	<i>.CSV files output by HOLO_Batch.....</i>	<i>25</i>
	<i>.MAT file output by HOLO_Batch</i>	<i>26</i>
	<i>.JPG files of individual slices</i>	<i>26</i>
	<i>Summary of files created by HOLO_Batch</i>	<i>27</i>
4.5	HOLO_Detail – processing of individual holograms	29
	<i>Select Button</i>	<i>29</i>
	<i>Set ROI, Regen Kernel and Reconstruct Buttons</i>	<i>30</i>
	<i>Improfile Button.....</i>	<i>31</i>
	<i>Zoom and Reset Buttons.....</i>	<i>31</i>
	<i>Grid Button.....</i>	<i>32</i>
	<i>Save Image Button</i>	<i>32</i>
5	LISST-Holo Field Deployment	33
5.1	Introduction	33
5.2	Programming	33
	<i>Selecting the start/stop program using the PC.....</i>	<i>34</i>
5.3	Preparing for Deployment.....	34
	<i>Put the instrument into sleep mode.....</i>	<i>35</i>
	<i>Install External Memory Module (EMM)</i>	<i>35</i>
	<i>Wake up / power up LISST-HOLO</i>	<i>35</i>
5.4	Magnetic Switch Functionality	35
5.5	Start Data Collection Program	36
5.6	Stop Data Collection	37
5.7	Downloading and Viewing Raw Holograms.....	37
	<i>Downloading from EMM</i>	<i>37</i>
	<i>Downloading and deleting from LISST-HOLO internal drive (EMM not installed)</i>	<i>37</i>
	<i>Viewing raw holograms in OpenSeelt</i>	<i>40</i>
5.8	Next Deployment or Powering Down.....	41
6	Reviewing Instrument Info and Other Settings	43
6.1	Intro to other Settings.....	43
6.2	Home	43
	<i>System Status.....</i>	<i>43</i>
	<i>Select program</i>	<i>43</i>
	<i>Programming Information</i>	<i>43</i>

6.3	Images	43
6.4	Log	44
6.5	Configure	45
6.6	Tools	45
6.7	About.....	45
7	Handling, Cleaning, Maintenance and Storage	47
7.1	Handling.....	47
7.2	Cleaning.....	47
7.3	Maintenance	47
7.4	Storage	47
8	Ethernet Communications	49
8.1	Router Use.....	49
	<i>Connecting to the router via your network.....</i>	<i>49</i>
	<i>Connecting to the router wirelessly</i>	<i>49</i>
	<i>Updating LISST-HOLO software via the Internet.....</i>	<i>49</i>
8.2	Changing the IP address of the Linksys E1000 router	49
8.3	Changing the LISST-HOLO IP address.....	50
9	FAQ's	53
10	Endcap LED Status Light Indicators	55
11	LISST-HOLO Size Ranges.....	57
11.1	Size Ranges based on LISST-100X SPHERICAL particles.....	57
11.2	Size Ranges based on LISST-100X RANDOMLY shaped particles.....	59
12	Hologram .PGM File Format Structure	61
13	Warranty	63
14	Index.....	65

1 Introduction

Thank you for purchasing the LISST-HOLO Submersible Digital Holographic Camera!

The intent with this introduction is to get you started using the LISST-HOLO as quickly as possible. Sequoia's goal with the LISST-HOLO is to make the user interface so friendly that no manual would be required for normal operation, except as a first-time introduction to the instrument

The LISST-HOLO was shipped to you in a Pelican case with custom foam padding. Included in the shipping box are the LISST-HOLO, clamps, stands, External Memory Module with USB cable, Ethernet cable, Wireless Router, Serial Cable with Power Supply, and a spare 5-pin cable for connecting the LISST-Holo to alternate power source such as CTD.

Sequoia Scientific, Inc. is pleased that you have chosen one of our products. Thank you! We strive to make our instruments rugged, reliable, and simple to operate. If you should have any difficulties or questions regarding this product, please feel free to contact us at info@sequoiasci.com.



2 Contents and Technical Specifications



- 1) LISST-HOLO w/ small test chamber and External Memory Module (EMM) installed
- 2) Instrument stands
- 3) Clear box with power supplies and communication cables
- 4) Clamps
- 5) Chamber for testing
- 6) Box with Manual, CD with software, wireless router

2.1 General Features

- In-situ digital in-line holographic technology
- Self-contained with internal datalogger
- Ethernet connection to PC for programmable data collection—no software is needed for programming or offloading data
- Power via external battery pack (Optional, not included) or 12V external power source (cable provided)
- Programmable data collection
- Optical path length: 50 mm standard
- Sample volume: 1.86 cm³
- Data processing yields in-focus particle images and volume distribution
- Automated firmware updates possible when instrument is connected to the Internet

2.2 Parameters Measured and Derived

- Particle images for observation and classification
- Particle volume distribution
- Temperature
- Depth

2.3 Particle Size and Concentration

- Size range: 25-2500µm equivalent spherical diameter
- Concentration Range: Beam attenuation coefficient of 0-4 m⁻¹; see also FAQ in section 9.
- Resolution: 50 log spaced size classes, 18% bin widths.

2.4 Technology

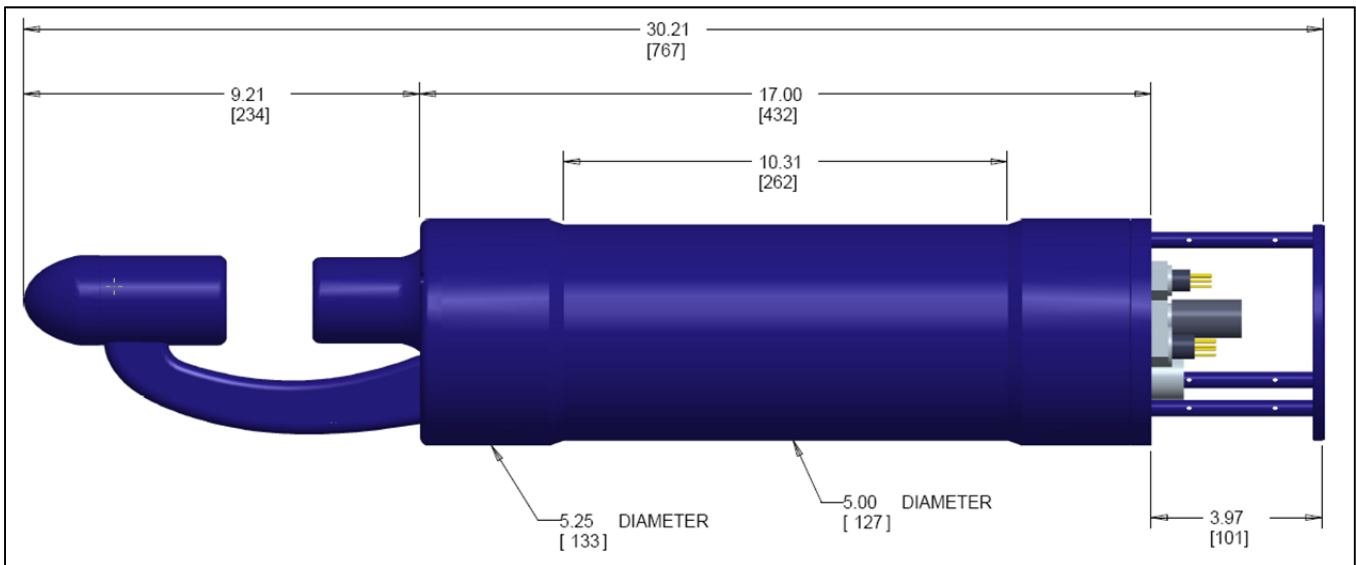
- Solid state diode laser @ 658 nm
- 4.4 µm pixel size digital camera; 1600 × 1200 pixels

2.5 Mechanical and Electrical

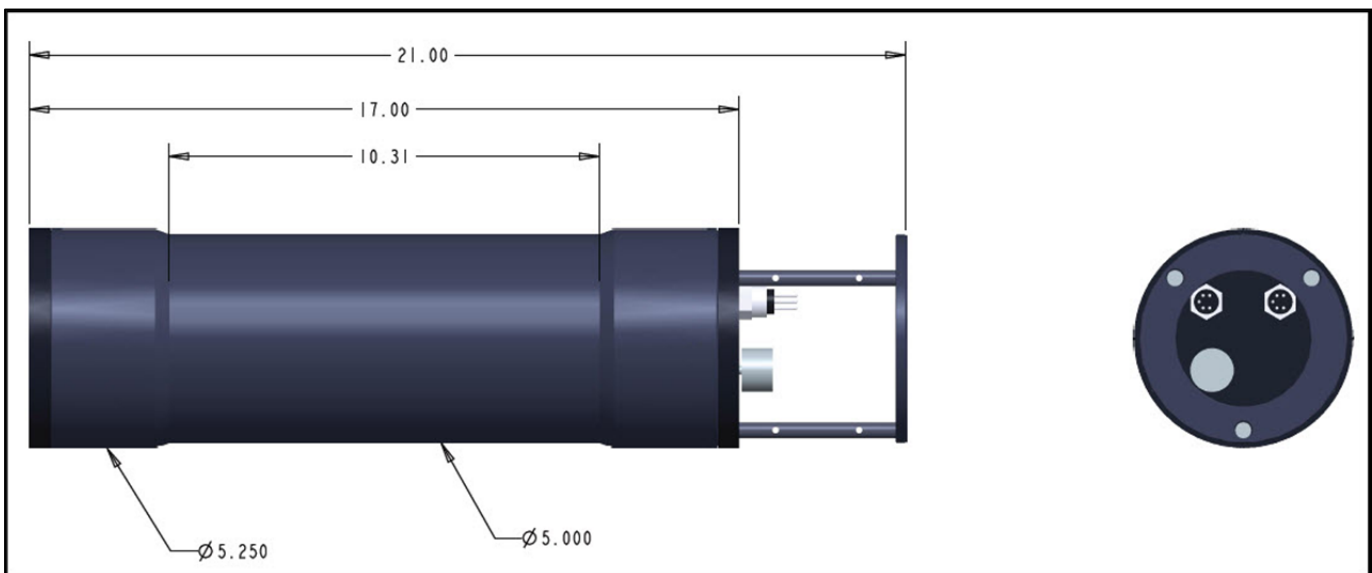
- Dimensions: 13.3 cm (5.25") Ø × 77 cm (30.2") L
- Weight: 9.5/3.6 kg (21/8 lbs) in air/water
- 300 m depth rating
- 32 GB internal solid state drive
- 32 GB External Memory Module (included)
- Battery life (for the Optional External Battery Pack): 10,000 holograms for standard 9V, 42Ah battery

- External power input: 12VDC nominal @ 1 A. 12-24VDC
- Sampling frequency up to 0.2 Hz (one hologram every 5 seconds).
- Power Consumption, sleeping: 0.020 A max.
- Power Consumption, idling (not sampling, laser off, camera off): 0.500 A max.
- Power Consumption, laser on: 0.600 A max.
- Power Consumption, laser and camera on: 0.880 A max.
- NOTE: Upon power up the current draw may briefly reach 1.200 A when all systems are turning on. This maximum draw will be lower than 1.200 A if the operating temperature is larger than 0°C.

Drawings



LISST-HOLO dimensions in inches [mm]

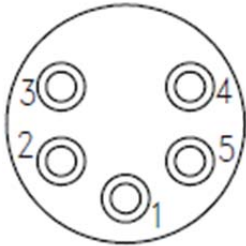


LISST-HOLO External Battery Case (OPTIONAL ACCESSORY). Dimensions in inches.

Bulkhead connector Pin-outs

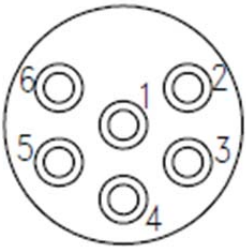
Five-pin connector (Teledyne Impulse part # MCBH(WB)-5-MP SS)

Pin #	Function
1	Power Ground
2	+12 V, 1 A power supply or battery
3	Communications Ground
4	RS232 EIA level out, 19.2K, 8 bit, no parity
5	RS232 EIA level in



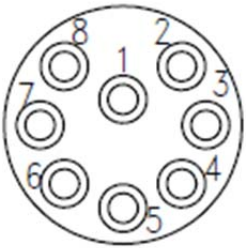
Six-pin Auxiliary Connector (Teledyne Impulse part # MCBH(WB)-6-MP SS)

Pin #	Function
1	Ground
2	Digital Output 1
3	Digital Output 2
4	Digital Output 3
5	Digital Input 1
6	Digital Input 2



Eight-pin Communications Connector (Teledyne Impulse part # MCBH(WB)-8-MP SS)

Pin #	Function
1	Ethernet ATX+
2	Ethernet ATX -
3	Ethernet ARX+
4	Ethernet ARX-
5	USB Vcc
6	USB Data-
7	USB Data+
8	USB Ground



3 Getting Started

3.1 Introduction

This section is designed to enable the first-time user to unpack the LISST-HOLO and capture a hologram within a few minutes after opening the case for the first time. The experienced user may find this section useful for a quick review of the various procedures.

It is not necessary to install any software to go through this section and become familiar with the instrument and its operation.

Section 4 describes how to install and use the software for processing the raw holograms.

Section 5 discusses how to configure and deploy the instrument in the field.

3.2 Connect cables and power up

In order to program and offload data from the LISST-HOLO you need a PC with a web browser and access to a power source.



Take out the instrument stands and place the LISST-HOLO on the stands.

Take out the clear plastic box and open it up.

Inside you will find a number of cables and power supplies, described below.



The yellow cable is an Ethernet cable used for communication with the LISST-HOLO.



The black cable is a 5-pin cable used to power the LISST-HOLO when working in the laboratory.

The 5-pin cable is being used to provide **power** to the LISST-HOLO using the included 110/220VAC power supply; it is **NOT** being used for communication:

The yellow Ethernet cable must be used for communication.

NOTE: If you have an external LISST-HOLO battery pack, you should use the 5-pin cable that shipped with the external battery pack if you wish to power the LISST-HOLO from the external battery pack.



Look at the LISST-HOLO connector endcap. Disconnect the External Memory Module if it is connected.

Undo the dummies and connect the 5-pin cable to the 5-pin bulkhead connector #1 (just below the serial number) and the yellow Ethernet cable to 8-pin bulkhead connector #2 (just above the serial number).

Note that the External Memory Module and the Ethernet cable share the 8-pin bulkhead connector.



The cables are now correctly connected to the LISST-HOLO.

It is necessary to have BOTH cables connected in order to power and communicate with the LISST-HOLO. No power is supplied through the yellow Ethernet cable, only communication.



Connect the yellow Ethernet cable to the wireless router.

DO NOT use the port to the far left.



Connect the router power cable to the router



Plug the router power supply into a 110-220VAC power source.

When the router completes its booting procedure it can be located as **LISST-Holo** on a wireless network. The password for connecting to the router is **manyholograms** (this information is also located on the bottom of the router). Establish a Wi-Fi connection between the router and your PC before you proceed.

If you do not have a Wi-Fi enabled PC, use the black Ethernet cable for connecting the router to the Ethernet port on your PC.



When you are connected to the router, plug in the power to the DB-9 connector.

It is not necessary to have the DB-9 connector attached to the PC.

IMPORTANT: MAKE SURE THAT THE POWER CABLE IS FIRMLY SEATED IN THE CONNECTOR.

EVEN MORE IMPORTANT: NEVER UNPLUG THE POWER TO THE LISST-HOLO WHILE IT IS RUNNING. ALWAYS PUT THE INSTRUMENT TO SLEEP BEFORE UNPLUGGING POWER.



Make sure that the magnetic switch on the connector endcap is in '0' position (off).



Plug in the LISST-HOLO power supply.

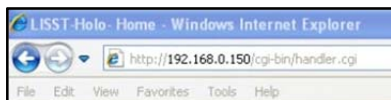
NOTE: The magnetic switch ***MUST*** be in '0' position BEFORE power is switched on. The LISST-HOLO will not communicate or sample properly if the magnetic switch is in '1' (On) position whenever power is applied.



The LISST-HOLO endcap LED will blink for approximately 30 seconds while the instrument is booting up. When it is ready, the green LED will blink every 5 seconds.

Please note: The LISST-HOLO has no internal power. Whenever power is applied to the instrument, the internal processor is powered on and initiates its boot-up procedure. The LISST-HOLO cannot boot up any faster than 30 seconds.

3.3 Take a hologram



If you have followed the instructions in section 3.2 the LISST-HOLO is now powered up and connected to your PC. It is time to take a hologram!

Open up a web-browser on your computer, e.g. Firefox, Google Chrome or Internet Explorer.

To connect to the LISST-HOLO, use URL <http://192.168.0.150/>

Note: The IP address of the instrument can be changed, and in most cases it must be

changed – see your local system administrator for more information on how to get a static IP address. See the FAQ in section 9 for more information on how to change the IP address of the LISST-HOLO.

The LISST-HOLO main screen will then show.

To take a hologram, click the **Tools** option.



On the tools page, click the **Take Images** button to take a hologram.

Note that the laser turns on, then off. It takes a few seconds to capture a hologram in this matter, because the laser has to warm up first. The actual hologram is taken a few milliseconds before the laser turns off.



Then click the Images menu item to go to the Images page, where all holograms on board the memory card are listed.

Click the hologram you wish to view. You will be asked if you want to save it to disk or to view it. Select the Save option, so that you can process the hologram. If you want to process a hologram, you always need to save it to a folder on your PC.



Holograms are stored in .pgm format, which is a lossless compression format.

In order to see the holograms on your PC, you may need to download and install OpenSeelt (<http://openseelt.sourceforge.net/>), which is a FREE viewer for pgm files.

See the FAQ on the About page of the webinterface for more information about OpenSeelt.

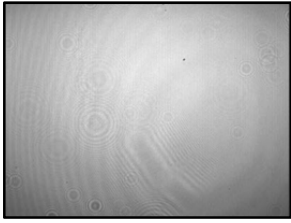
You can of course also use OpenSeelt to view holograms you have already downloaded and stored on your computer.

See section 12 for more information about the hologram .pgm file structure.

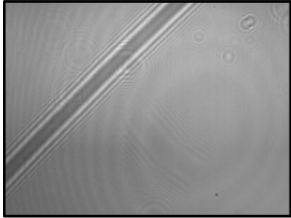
The About page shows the FAQ where you can find more information about how download, install and use OpenSeelt in order to view the unprocessed holograms.



.pgm
format



If you took a hologram without anything in the laser beam, your hologram will typically look something like this.



Try taking another hologram, but hold a hair or thin piece of string into the laser beam.

You should then see something like the image to the left.

Take another 1-2 holograms with other types of material in the laser beam, e.g. a screw, or blow some dust through the laser beam when the hologram is captured.

The LISST-HOLO comes with a test chamber that can be installed between the windows and be filled with water for testing. To install the chamber remove the U-shaped spacer and press the sliding part into the chamber leaving a small gap. Center the openings of the chamber on the windows and insert the U-shaped spacer so that the O-rings seal on the area around the window.

To put the LISST-HOLO to sleep, click the Home button, then click the Sleep button.

You can now safely disconnect the power to the LISST-HOLO.



To continue Getting Started with the LISST-Holo please read Section 4, Hologram Processing in Detail, or skip to Section 5, LISST-Holo Field Deployment.

4 Hologram Processing with HOLO_Batch and HOLO_Detail

4.1 Intro

The holograms are processed using 2 MATLAB-based programs called HOLO_Detail and HOLO_Batch.

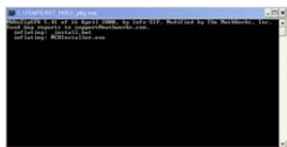
You do not need to be connected to the LISST-HOLO in this chapter; example holograms are supplied on the ship disk.

4.2 Install the hologram processing software



To install the software, insert the CD into your computer, and locate the LISST-HOLO software folder. Inside the folder you will see 2 files: HOLO_Batch_pkg.exe, and HOLO_Detail.exe

Copy both files to a temporary location on your computer, e.g. C:\Temp.

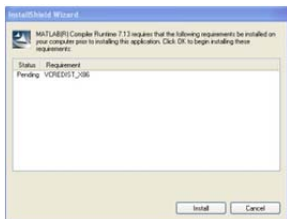


Double-click HOLO_Batch_pkg.exe to begin the installation.

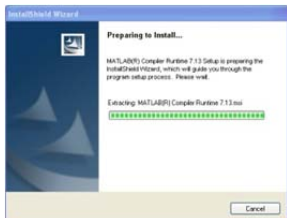
You will see a DOS window open up, detailing the progress of the installation.



Select the language for installation



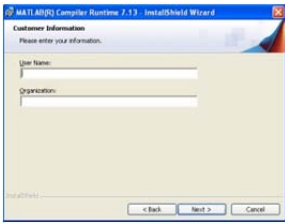
Click Install to install any additional components that the installer requires.



The installer then prepares to install



Click Next



Enter your User Name and Organization



Confirm the destination folder for the installation of the Runtime Compiler



Click Install to begin

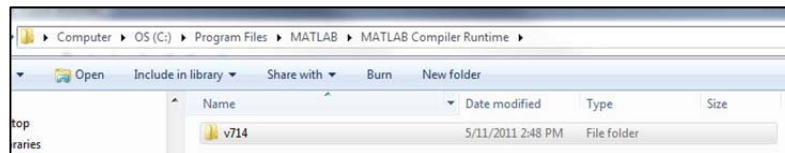


Wait while the installer installs the compiler. This typically takes several minutes



Click finish

Verify that the MATLAB Compiler Runtime was installed. Navigate to C:\Program Files\MATLAB\MATLAB Compiler Runtime and verify that a folder named v714 exists in that location:



NOTE: THE HOLO_BATCH AND HOLO_DETAIL PROCESSING PROGRAMS WILL *ONLY* WORK WITH VERSION 7.14 (V714) OF THE MATLAB COMPILER RUNTIME.



Note that the number of files in C:\Temp has increased.

Now create a folder in your Program Files folder called Sequoia\LISST-HOLO (e.g. the full path should be C:\Program Files\Sequoia\LISST-HOLO)



Move the HOLO_Batch.exe file and the HOLO_Detail.exe file to this folder.

NOTE: Be careful not to move the HOLO_Batch_pkg.exe file!

Delete all files in the C:\Temp folder

If you wish you can now create shortcuts for the HOLO_Batch.exe and HOLO_Detail .exe files and place them on your desktop for easy access.

4.3 Process holograms using HOLO_Batch and HOLO_Detail

Two different programs are supplied for processing holograms; HOLO_Batch and HOLO_Detail.

HOLO_Batch will do batch processing of a selection of holograms, and automatically output the size distribution as well as composite images showing the in-focus particles.

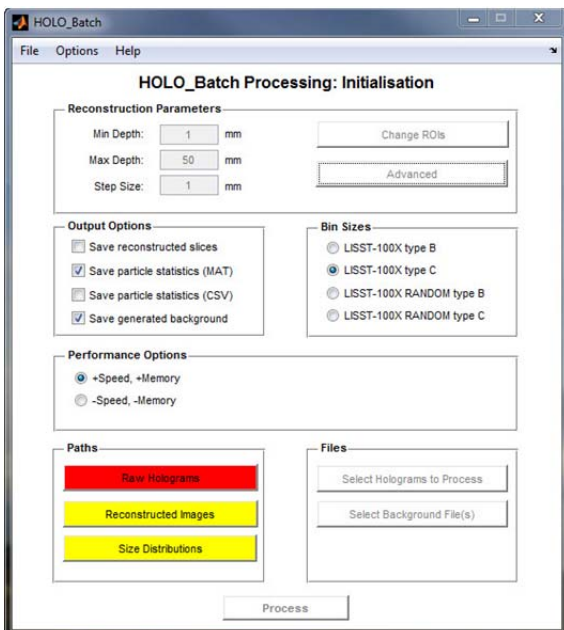
HOLO_Detail only processes one hologram at the time, but allows the user to zoom and analyze a hologram in great detail, in case more detailed image analysis is needed than what is provided with HOLO_Batch.

In the following sections the use of these 2 programs will be explained using example holograms included in the ExampleHolograms folder on your shipdisk.

Before you proceed, you should copy the 4 holograms in ExampleHolograms (Coffee.pgm, 70%transmission.pgm, 80%transmission.pgm, 90%transmission.pgm) to an empty folder on your PC.

4.4 HOLO_Batch – automated batch processing of multiple holograms

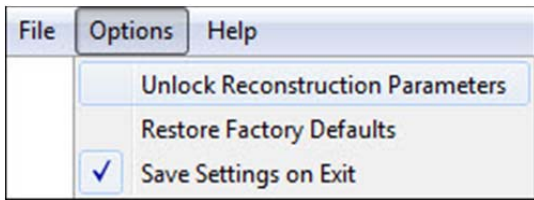
This section describes how to use the automated batch processing program, HOLO_Batch.



Open the program by clicking the HOLO_Batch executable.

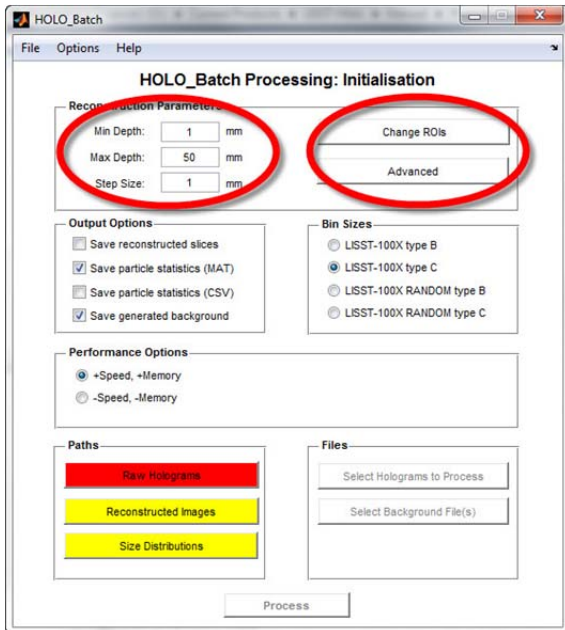
There are 5 main procedures to be performed before processing can begin:

- Select Reconstruction Parameters
- Select Output Options
- Select Particle Bin Size
- Select Paths (Folders)
- Select Files.



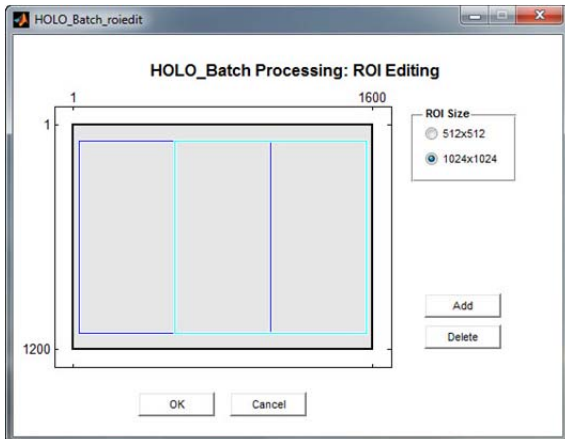
The HOLO_Batch is shipped with factory default settings for the Reconstruction Parameters, and these should normally not be changed.

However, if necessary they can be changed by selecting Unlock Reconstruction Parameters in the Options Menu.



The Change ROIs and Advanced buttons then become active.

Also the three input boxes for selection of the minimum and maximum focal length, as well as the step size become active.



The Change ROIs button opens up a window for selecting the ROI (Region Of Interest) to be processed.

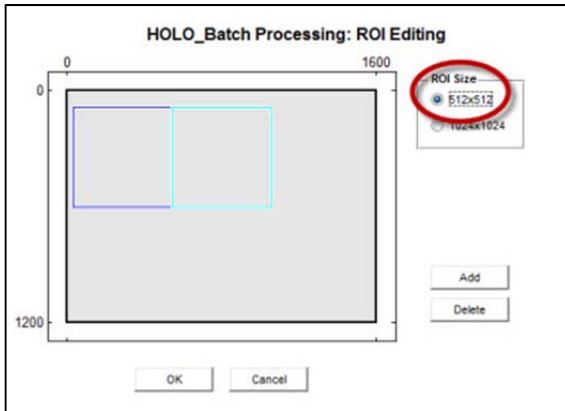
The ROI is the part(s) of the hologram that will be reconstructed. Particle counts will only be computed from the reconstructed part of a hologram.

Once selected, the ROI will be the same for all holograms.

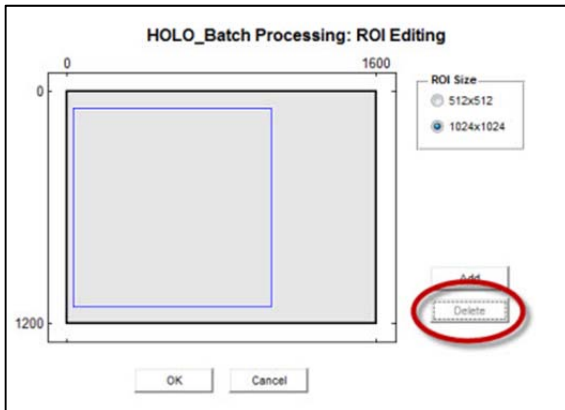
In this example, 2 overlapping ROI's with a size of 1024×1024 pixels are chosen. Particle counts will then be obtained from both ROIs, and adjusted so that particles in the overlapping parts are only counted once.

If you click the Add button, a 3rd ROI will be added, which you can then drag to the desired location.

If you click the Delete button, the last added ROI will be deleted.



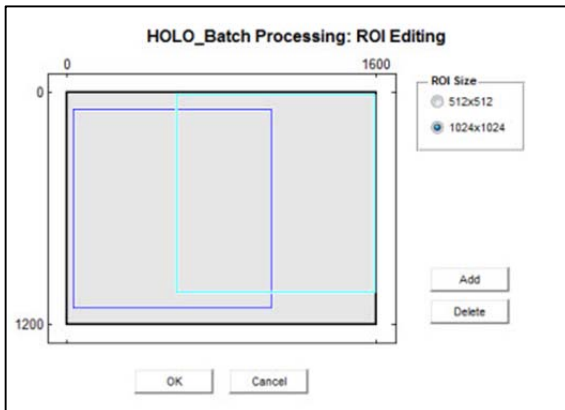
Reconstruction of holograms is memory demanding, so on PC's with smaller memory (<4GB), or slower processors (<2GHz), the 512×512 pixels ROI should be selected.



Note that you can delete and add ROI's using the Delete and Add buttons.

In this example to the left, one of the 1024×1024 pixels ROI's have been deleted.

Subsequently the Delete button has been grayed out.

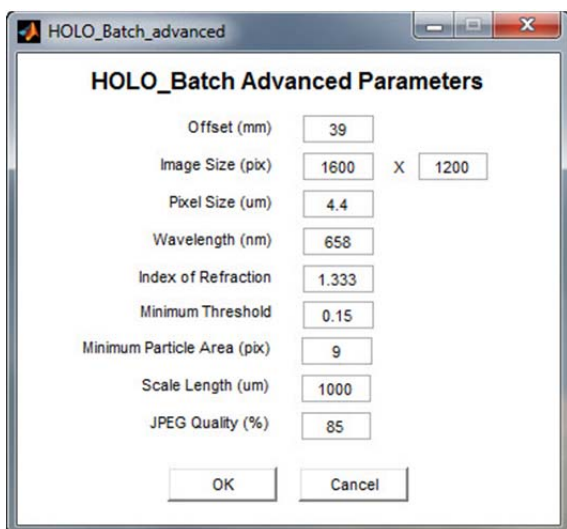


In this example, another 1024×1024 ROI has been added.

Note that the ROIs do not have to be aligned with each other.

Click the OK button when the ROI size and location is satisfying.

Note that the processing time doubles every time you add a new ROI.



The advanced button opens up the settings menu for the advanced parameters.

The values listed in the window to the left are the factory default settings.

With the exception of Minimum Threshold, Scale Length, JPEG Quality, and possibly the Index of Refraction, none of these values should ever be changed unless instructed by Sequoia support personnel to do so.

The **Offset** is the distance in mm from the receive window to the CCD array. The reconstruction software needs this distance in order to properly reconstruct the holograms. For the LISST-HOLO this value is 39 mm. DO NOT CHANGE THIS VALUE.

The **Image Size** is the area of the CCD in pixels. For the LISST-HOLO the image size is 1600 × 1200 pixels. DO NOT CHANGE THIS VALUE.

The **Pixel Size** is the size of each pixel in micro-meters (μm). For the LISST-HOLO the pixel size is 4.4 μm. DO NOT CHANGE THIS VALUE.

The **wavelength** is the wavelength of the laser in nm. For the LISST-HOLO the wavelength is 658 nm. The reconstruction software needs this value in order to properly reconstruct the holograms. DO NOT CHANGE THIS VALUE.

The **Index of Refraction** is for the medium in which the LISST-HOLO is being used. An average value for water is 1.333. If the LISST-HOLO is used in air, e.g. for measuring pollen or snowflakes, the refractive index should be changed to that for air; 1.0003.

The **Minimum Threshold** is used for creating a composite image of all the particles in the hologram. Decreasing this value will cause more pixels to be identified as being a particle; increasing it will cause less pixels to be identified as a particle.

The **Minimum Particle Area** is a measure used to exclude 'particles' that could appear simply due to noise in the image. The default minimum area is 9, meaning that unless a particle has a minimum area of at least 9 coherent pixels (Equivalent Spherical Diameter of ~15μm), it is being excluded from further consideration when computing size distribution etc.

The **Scale Length** is the length of the scale in μm bar being added to the composite images created during processing.

The **JPEG Quality** is the image quality of the composite images being created by HOLO_Batch.

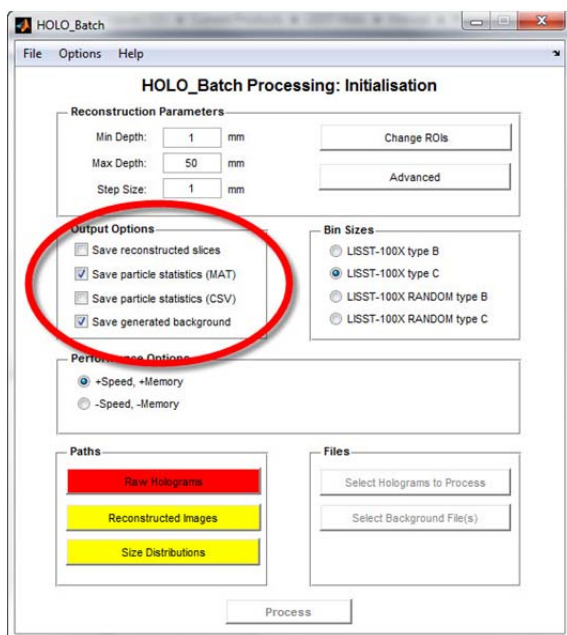
Click OK when you are satisfied with your selections.

If you wish you can change the Reconstruction Parameters.

Reconstruction Parameters		
Min Depth:	1	mm
Max Depth:	50	mm
Step Size:	1	mm

In the example to the left, the hologram will be reconstructed at 50 intervals, each interval 1 mm apart. You cannot select a Min Depth smaller than 1 mm or a Max Depth larger than 50 mm.

Note that the processing time increases linearly with the number of Steps. Upon processing, all particles in all intervals (slices) will be combined into one focused image.



The next step is to select output options.

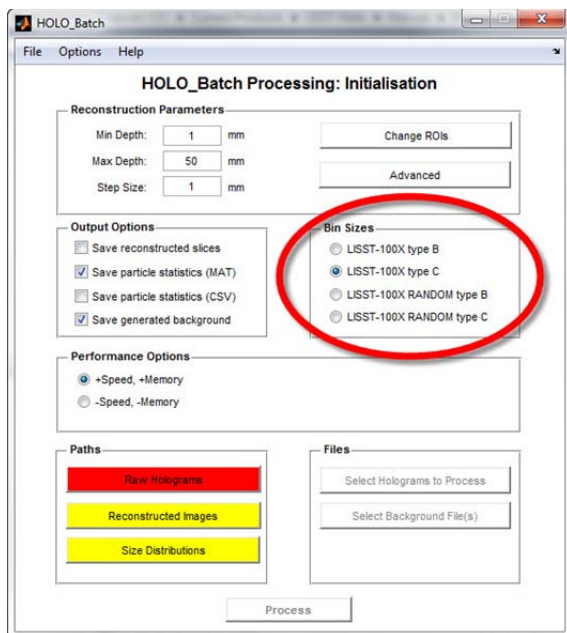
During hologram reconstruction, a number of slices with particles are created. Check 'Save reconstructed slices' if all slices are to be saved.

NOTE: This is extremely memory-consuming so this option should only be selected on 64-bit PC's with more than 6GB memory.

The 'Save particle statistics (MAT)' option creates a particle statistics file in MATLAB .mat format. See section 0 for details.

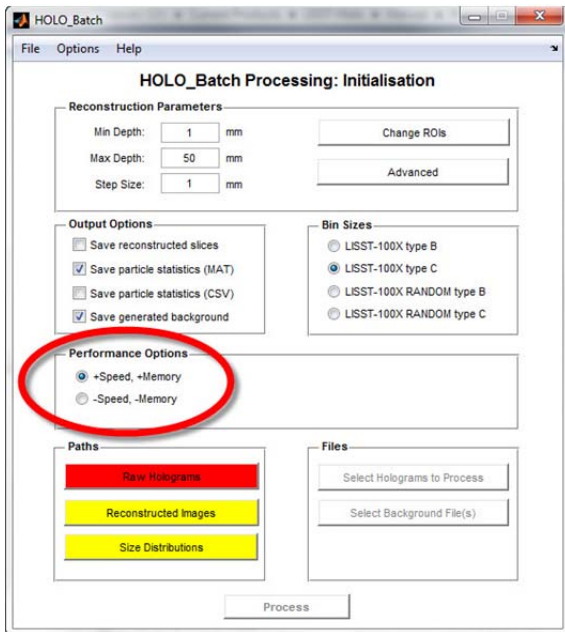
The 'Save particle statistics (CSV)' option creates a particle statistics file in Comma-separated values (ASCII) format. See section 0 for details.

The 'Save generated background' option saves the background image used for processing (if a background image was selected or created; see below).

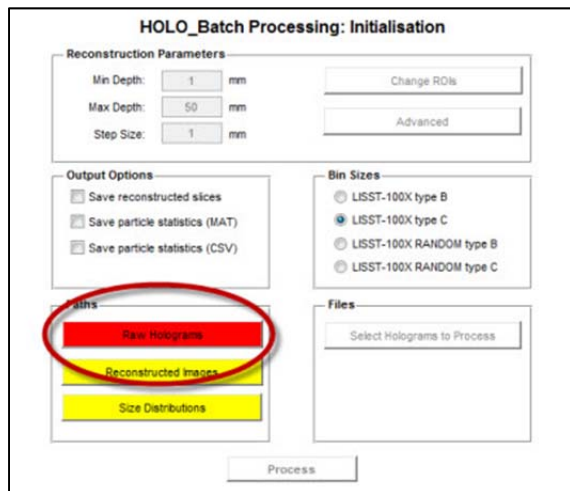


The next step is to select the bin sizes for your particle size distributions. The size bins for the LISST-HOLO are based on the LISST-100X so that data from the 2 instruments can be easily merged. While the LISST-100X has an upper size bin of 250 μ m (type B) or 500 μ m (type C), the LISST-HOLO simply expands the upper limit of size bins up to 8000 μ m (see section 11 for details).

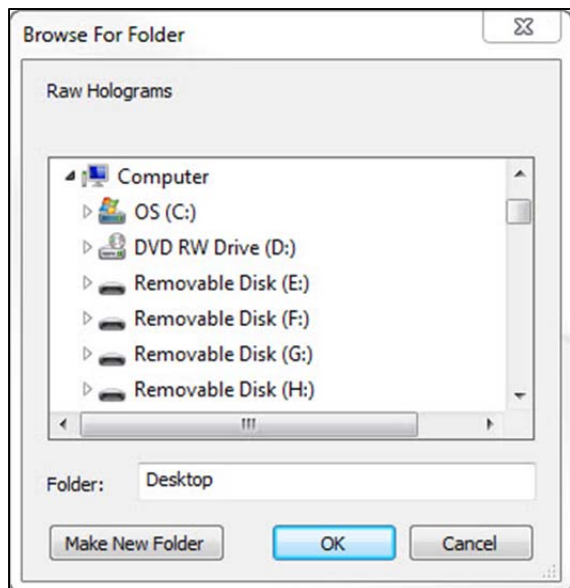
Select the LISST-100X equivalent size bins desired for your output size distributions.



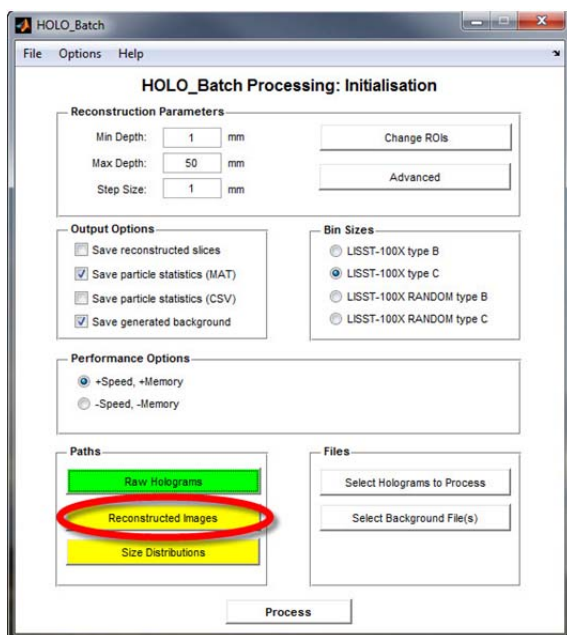
Next, select Performance Options. If you encounter memory issues during hologram processing, select the –Speed, –Memory option in order to reduce memory use and process the holograms slower.



Now click the Raw Holograms button in order to select the path from where HOLO_Batch will read your raw holograms.



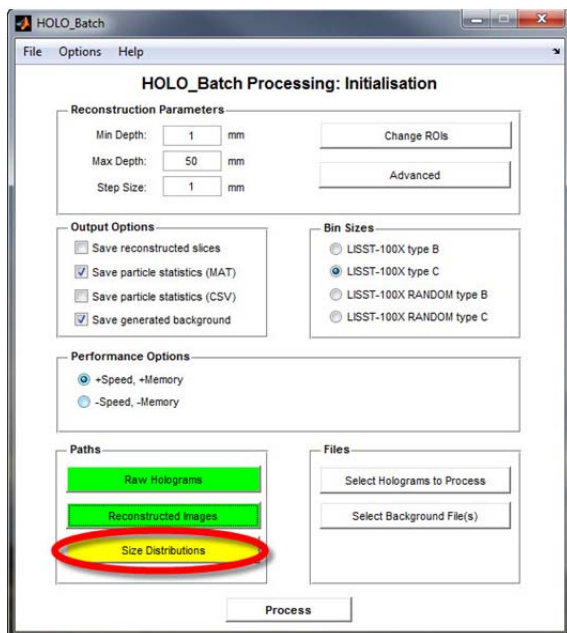
Select the folder where your raw holograms are stored and click OK.



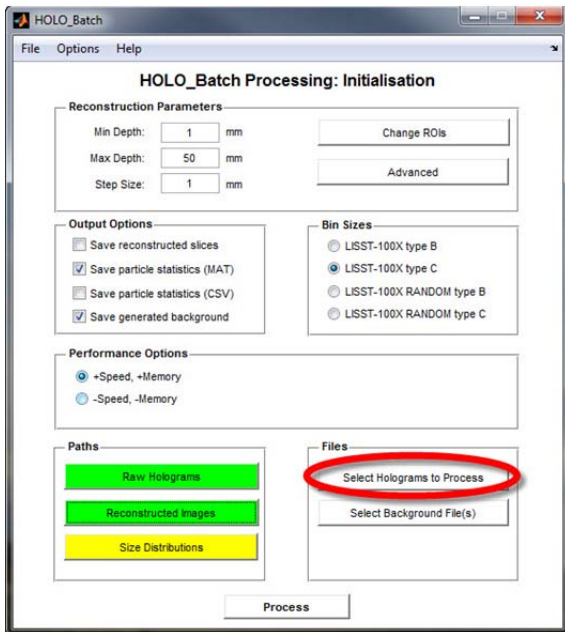
Now click to select the folder where you want the reconstructed images to be stored.

There are two reconstructed images (.jpg format) for each processed hologram.

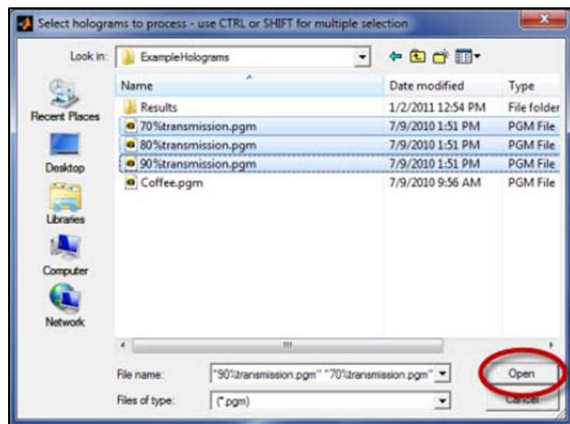
As above, a dialogue box will open up prompting you to select a folder.



Finally, click the Size Distributions button to select the folder where you want the particle size distributions to be stored.

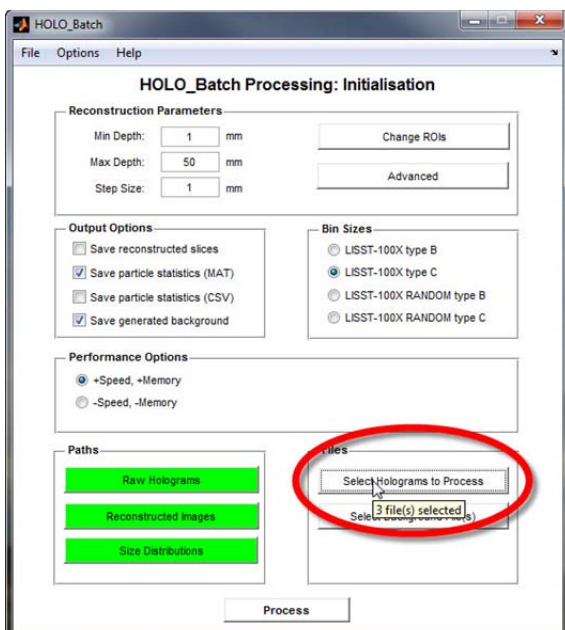


Now click Select Holograms to Process in order to select the holograms to Process.

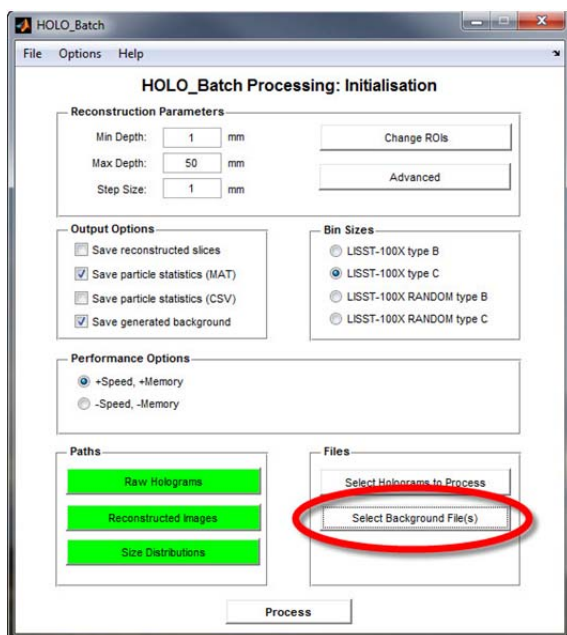


Select the 3 files named 70%transmission.pgm, 80%transmission.pgm and 90%transmission.pgm.

Then click the Open button.



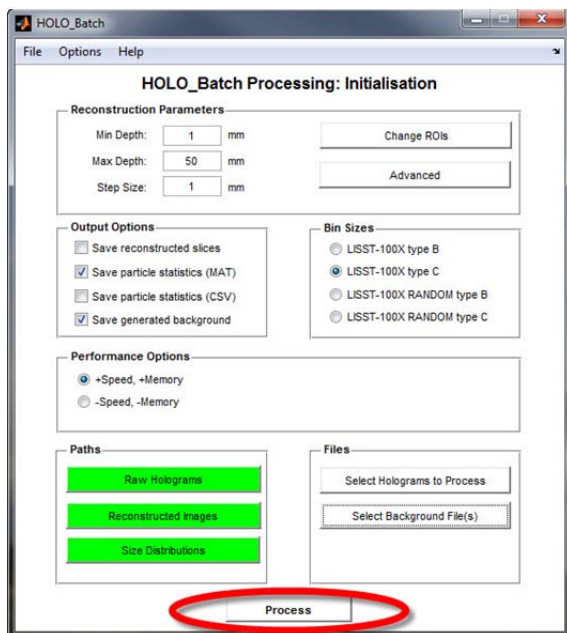
Note that if you hover the mouse above the Select Files to Process button, you will see how many files (if any) are selected.



If you have a hologram obtained in clean water or air, that you would like to subtract from the holograms to process, select it here.

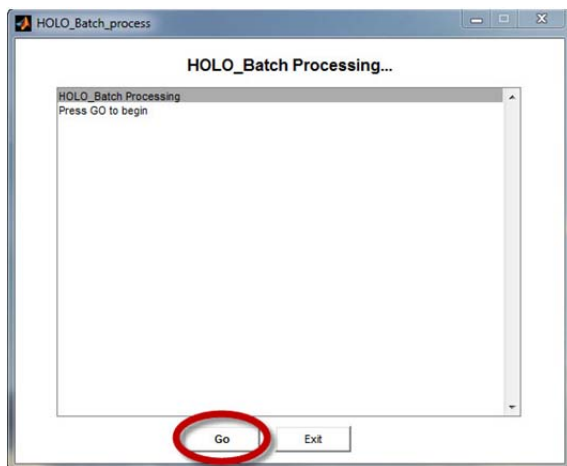
Selecting a background hologram can reduce the noise in the composite output image. You can select multiple background files, which will be averaged into one background file before subtracting.

It is not necessary to supply a background hologram in order to process your holograms; if you do not select a background none will be subtracted.



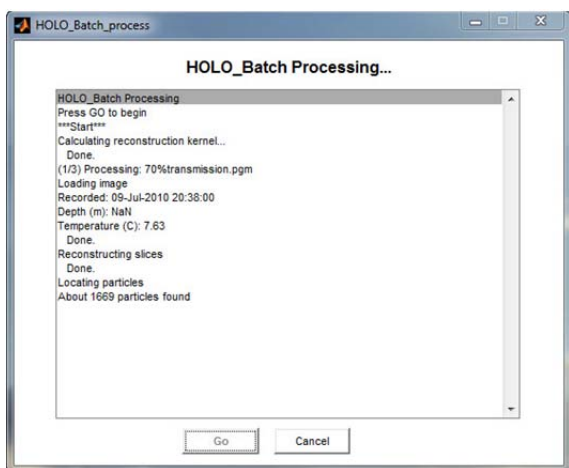
All selections are now complete!

Click the Process button to process the selected holograms.



A status window opens up. During processing, the progress can be followed in this window.

Click the Go button to start processing your holograms.

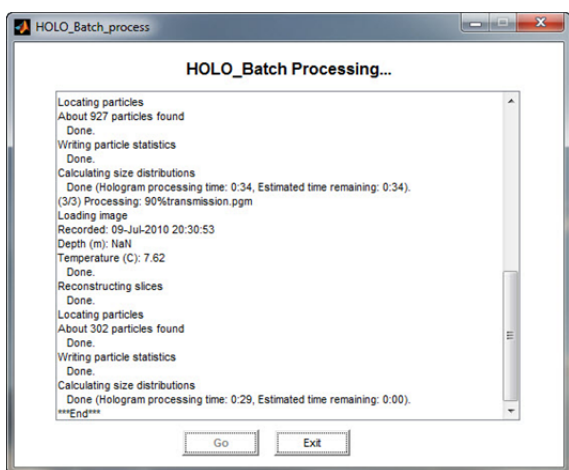


The typical processing speed is about 30 seconds per hologram for a 512×512 ROI.

However, the processing time varies strongly with the number of slices, total ROI area and the number of particles in a reconstructed hologram.

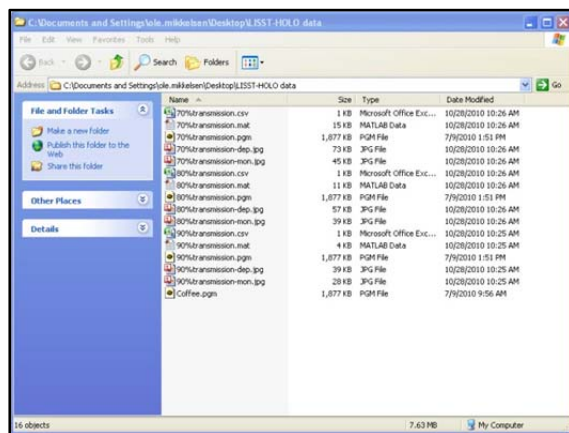
Processing times of up to 2 minutes per hologram is not uncommon for 1024×1024 ROIs with a large number of particles.

If you wish to cancel the processing, click the Cancel button.



When processing is complete, the Cancel button changes to Exit.

Click to Exit the program.

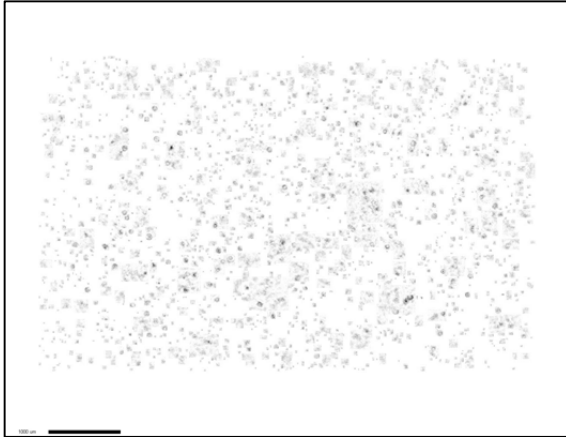


Go to the folder(s) you specified as output paths for your processed data.

You will notice that a number of files have been created for each hologram; Two .JPG files, and depending on your output selections, a .CSV file and/or a .MAT file and/or individual .jpg images for each slice.

In the following these files are briefly described.

.JPG files output by HOLO_Batch

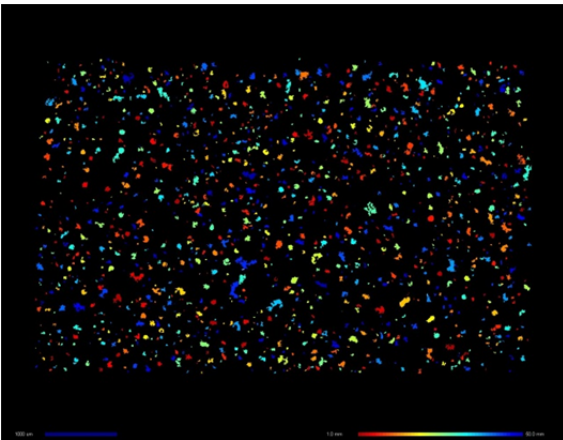


The 2 .JPG files have a –dep and –mon suffix.

The –mon suffix image is a montage of all the particles that were found in all the planes within an ROI.

The scale bar length can be adjusted prior to processing in the Advanced section of HOLO_Batch.

Note that only the part of the hologram covered by the ROI is displayed on the –mon image. The rest of the hologram was not analyzed and therefore cannot be displayed.



The –dep suffix image is a color coded image, where the particles within the ROI have been colored according to their depth of focus.

As with the –mon image, only the part of the hologram covered by the ROI is displayed on the –dep image.

The scale bar is all blue and displayed in the bottom left corner. The colorbar in the bottom right corner shows the location of the particles relative to the transmit window. Red particles are very close to the transmit window, blue particles very close to the receive window.

Using a pair of 3-D glasses will display the particles in a 3-D effect, where the red particles will appear closer to the viewer than the blue particles.

.CSV files output by HOLO_Batch

The .CSV (Comma-Separated-Values) file that is produced for each hologram contains detailed information about the mean and median size of the particle size distribution (computed from the volume distribution). The individual files have a name similar to the filename of the original hologram, e.g. 70%transmission.csv.

A .CSV file with the prefix –pstat will also be created if the checkbox 'Save Particle Stats' was checked. See section 0 for details about the content of the –pstat file.

Additionally, a composite file is created with the name *firsthologram_lasthologram_All.csv*, where firsthologram and lasthologram are the filenames of the first and last holograms that were selected for processing. This composite file has all the information about sample date and time, water depth, temperature etc. as the other .CSV files, but all in one file.

Finally, the composite file has in its first row the lower limit of the size bin for the size distributions in columns 26:75. In the 2nd row is the mid-point of the size bin for the size distributions in columns 26:75 and in the 3rd row is the upper limit of the size bin for the size distributions. The table below shows the parameters in columns 1-75 of the .CSV file.

Column #	Value	Unit
1	Year (YYYY)	N/A
2	Month (MM)	N/A
3	Day (DD)	N/A
4	Hour (HH)	N/A
5	Minute (MM)	N/A

6	Second (SS)	N/A
7	1/100s of a second (hhh)	NOTE: Currently not available. NaN (Not a Number) displayed instead.
8	Depth	m
9	Temperature	°C
10	Input Voltage	V
11	Exposure	N/A
12	Laser Power	N/A
13	Laser Photo Diode	N/A
14	Brightness	N/A
15	Shutter	N/A
16	Gain	N/A
17-24	Reserved for Future Use	N/A
25	Total Volume	ul / l
26-75	Size Distribution	ul / l

.MAT file output by HOLO_Batch

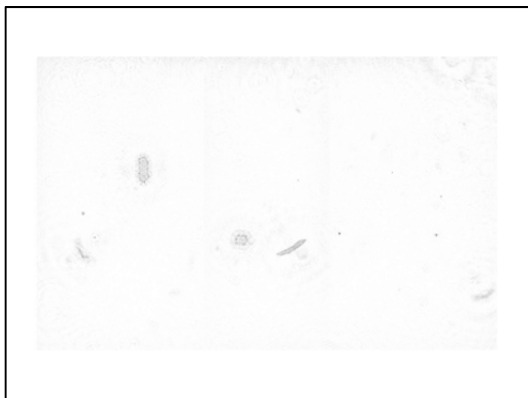
The MATLAB .MAT file can only be opened up in MATLAB. It contains a matrix called partstats. It has dimensions N×10, where N is the number of particles detected in the ROI. A .CSV file with the prefix –pstat will also be created if the checkbox 'Save Particle Stats (CSV)' was checked.

The 10 columns have the following information about each particle:

Column #	Particle Property	Unit
1	Particle Area	μm ²
2	Particle Equivalent Diameter	μm
3	Major Axis Length	μm
4	Minor Axis Length	μm
5	Solidity	Dimensionless
6	Eccentricity	Dimensionless
7	Filled Area	μm ²
8	Convex Area	μm ²
9	Equivalent Convex Area Diameter	μm
10	Particle Volume	μm ³

.JPG files of individual slices

If the check box 'Save Individual Slices' was checked, HOLO_Batch will save a .jpg image for each reconstructed slice, showing the particles that appear on that particular slice.



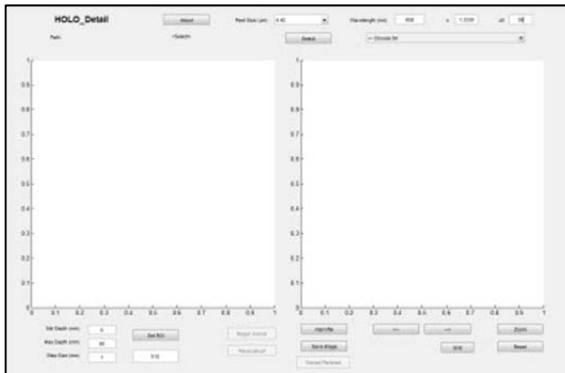
The image on the left is an example of slice number 14 (Coffee-s014.jpg). The actual distance of the slice from the transmit window is computed as slice number $\times$ step size.

If the step size was set to 1 mm, this slice (s014.jpg) would therefore be 14 mm from the transmit window. If the step size was set to 2 mm, slice s014.jpg would be 28 mm from the transmit window.

Summary of files created by HOLO_Batch

Filename and type	Content	Always Created	Check Box Checked?			
			Save Slices	Save Stats (MAT)	Save Stats (CSV)	Save Background
<i>filename-dep.jpg</i>	Color-coded DEPTth image, showing the location of the particles in the depth dimension.	✓				
<i>filename-mon.jpg</i>	Black and White MONTage image, showing the particles in B&W. Useful for more detailed information about the shape and structure of the particles.	✓				
<i>filename.csv</i>	Comma-separated ASCII file with size distribution and other output as described in section 0	✓				
<i>firstfilename_lastfilename_All.csv</i>	Comma-separated ASCII file with size distribution and other output as described in section 0	✓				
<i>filename-snnn.jpg</i>	Reconstructed slices of the hologram. nnn indicates the slice number.		✓			
<i>filename-pstat.mat</i>	MATLAB .MAT file with N x 10 matrix with particle statistics as described in section 0. N is the number of particles in the hologram. Rows 1-3 of the pstat file contain the size bins.			✓		
<i>filename-pstat.csv</i>	Comma-separated ASCII file with N x 10 matrix with particle statistics as described in section 0. N is the number of particles in the hologram. Rows 1-3 of the pstat file contain the size bins.				✓	
<i>background.pgm</i>	Saves the selected background hologram (or the average of multiple selected background holograms).					✓

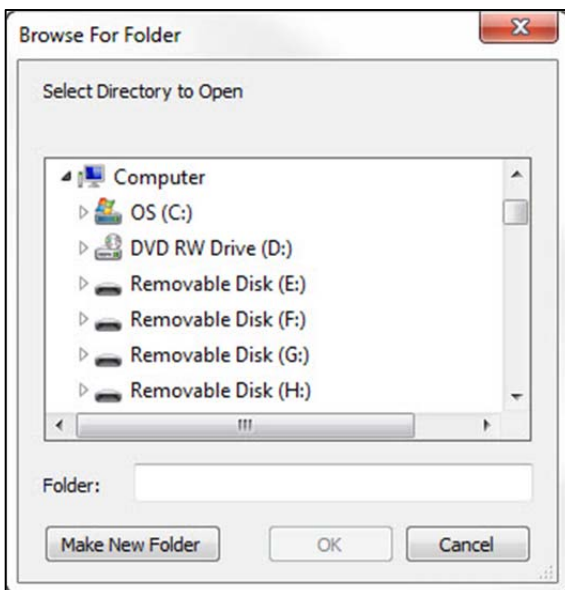
4.5 HOLO_Detail – processing of individual holograms



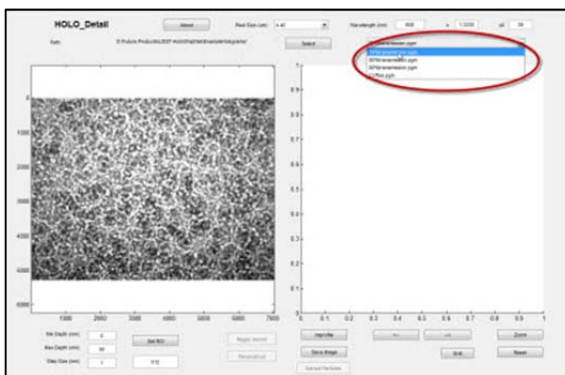
Open the program by clicking the HOLO_Detail executable.

Select Button

Click the Select  button to select a folder for browsing your holograms.



Select the folder where your holograms are stored, then click OK.

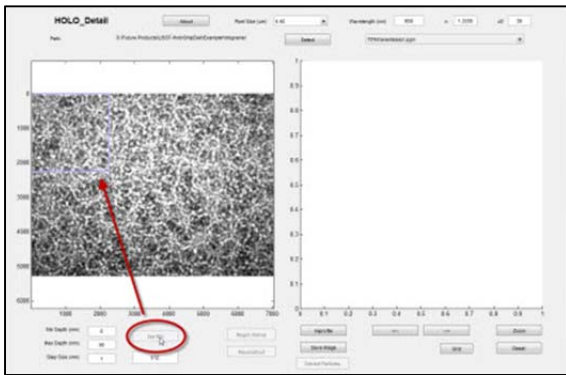


From the drop-down menu, select a hologram to display.

The selected hologram will then show in the left part of the window.

Only one hologram at the time can be selected, shown, and processed in HOLO_Detail.

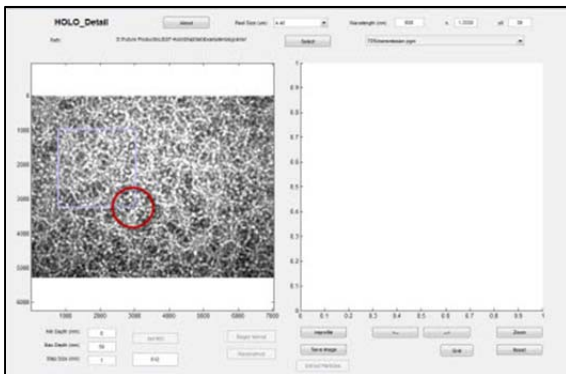
Set ROI, Regen Kernel and Reconstruct Buttons



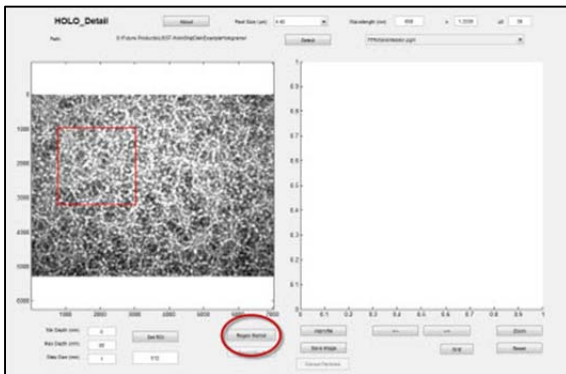
Press the Set ROI button in order to set the Region-Of-Interest of the hologram that will be processed and reconstructed. By default, the ROI shows in the upper left corner as a blue square (arrow).

By default, the size of the ROI is 512x512 pixels, but this can be changed by entering another number in the box below the Set ROI button.

It is recommended that the size of the ROI is either 512x512 or 1024x1024 pixels.



The ROI can be moved to another location by moving the mouse over the ROI, select it, and then move it around to the desired location within the hologram.

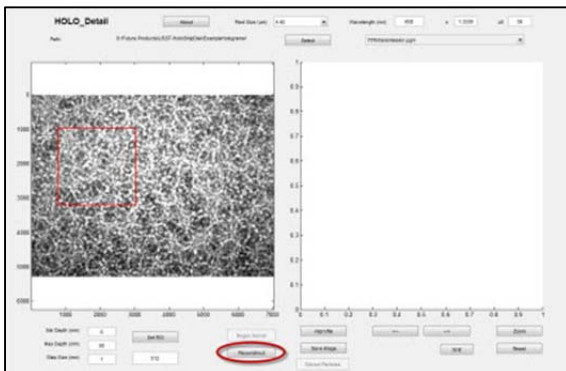


When the ROI is in the desired location, DOUBLE-CLICK it so that the ROI turns red.

Note that the Regen(erate) Kernel button then becomes active.

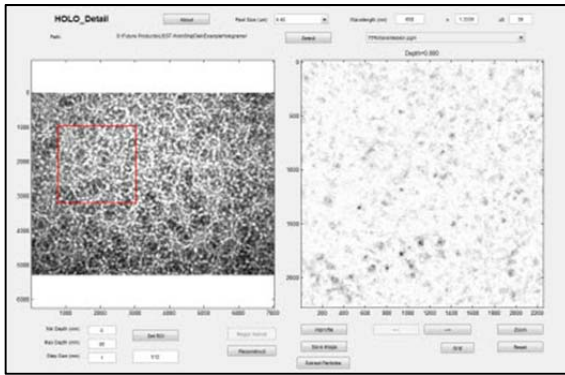
Now set the minimum and maximum depth for the hologram reconstruction, as well as the step size (in mm).

Click the Regen(erate) Kernel to compute the kernel that is to be used for reconstruction of the hologram.



The Reconstruct button subsequently becomes active.

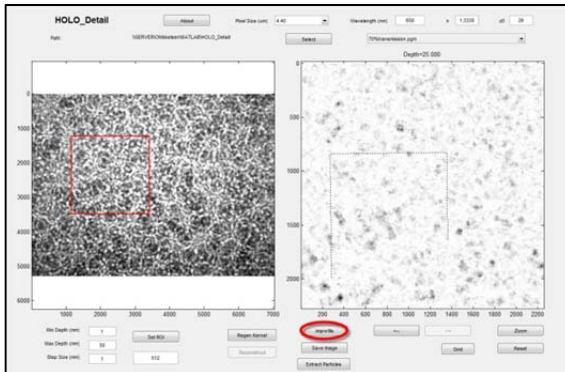
Click the reconstruct button to initiate the reconstruction process.



Upon reconstruction, the individual slices can be viewed on the right by clicking on the left and right arrows.

The scale is in calibrated units (μm), in this case from 1 to 2252 μm (512 pixels @ 4.4 μm per pixel = 2252 μm).

Improfile Button



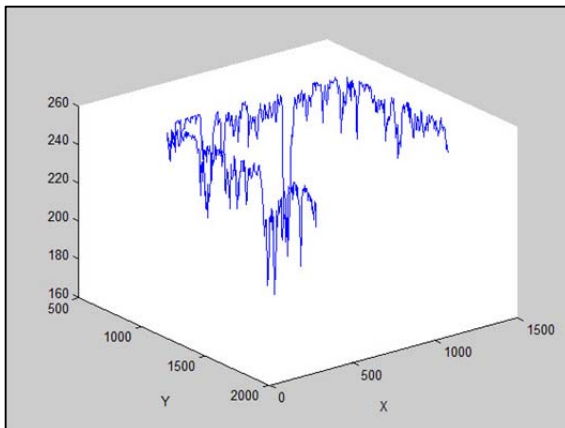
The improfile button can be used to get an idea of the intensity variation along a line transect.

To use, click the improfile button and a + will appear.

Move it to the location on the slice you want to examine in more detail and click once.

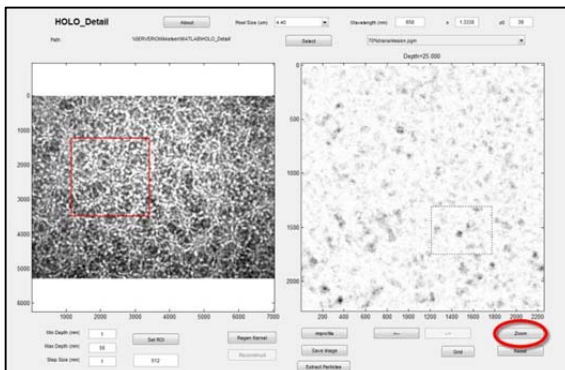
Now drag the cursor to draw a line. Click once to set a point, double-click to mark the end of the transect.

In the image to the left, a transect composed of 3 lines at right angles to each other has been selected.



When you double-click to mark the end of the transect a figure similar to the one on the left will pop up, showing the pixel intensities along the selected transect.

Zoom and Reset Buttons



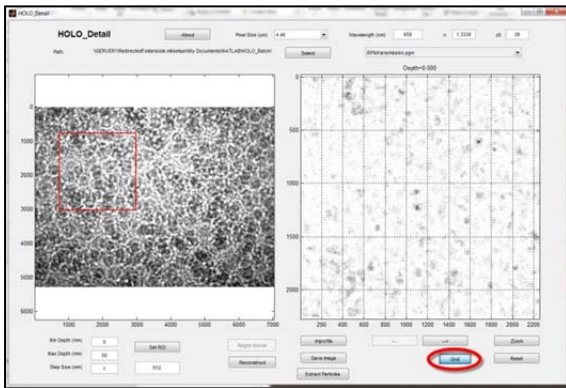
Clicking the zoom button enables you to zoom in on a part of the slice.

Click and drag the cursor to draw a rectangle on the slice and release to zoom to the rectangle.

Note that if you use the arrows to move back and forth between the slices after you have zoomed, the zoom area is retained on the other slices.

Click the Reset button to zoom out again.

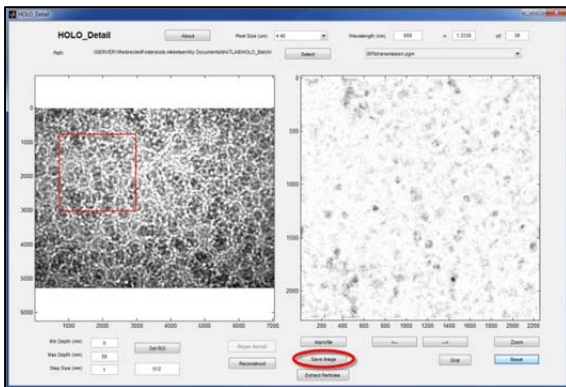
Grid Button



The grid button draws a grid onto the slice. This makes it easier to determine the size of the particles in the slice.

Click the grid button again to turn off the grid.

Save Image Button



The Save Image button enables you to save the current view of your slice as an image on your computer.

The image is saved with a .PNG (Portable Network Graphics) extension.

5 LISST-Holo Field Deployment

5.1 Introduction

The LISST-Holo has many features that make it easy to deploy in the field. Start and Stop conditions can be programmed into the instrument in advance. Once the instrument is started it will wait for the Start Condition to occur before saving holograms. It will continue to save holograms at the programmed rate until the stop condition is reached. The holograms are stored on an external submersible USB Flash memory module.

Up to four different set of Start, Stop, and Sampling conditions can be pre-programmed into the LISST-HOLO. By using the external switch lever the desired Start/Stop condition can be selected without connecting the instrument to a computer.

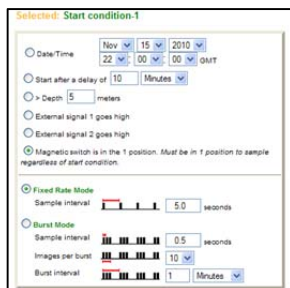
In addition the switch lever is always used to start the selected sampling program. The sections below describe how to configure, start, and stop the data collection.

5.2 Programming

To configure the Start and Stop conditions you must connect to the instrument using the Ethernet connection as described in Sections 3.2 and 3.3.



Clicking on the Home tab will show the current settings for the four sets of sampling conditions. Each of the four sets can be configured differently. The Start Condition, Sampling mode and rate, and the Stop Condition will need to be set.

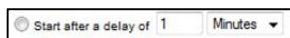


To set the Start condition choose between a Date/Time start, delayed start, depth start, External Signal 1, External Signal 2, or the Magnetic Switch.

To set the sample mode, choose between Fixed rate and burst sampling.



Date/Time start will wait until the selected GMT time is reached before sampling is started and the magnetic switch is in the 1 position. If it is past the specified time the sampling will start immediately if the magnetic switch is in the 1 position.



The Delay Start will start after the specified delay. The delay must be an integer number and can be specified as Minutes or Hours. In this example the LISST-HOLO will start sampling 1 minute after the magnetic switch has been turned to '1' (On) position.



The Depth Start will wait until the depth is greater than the specified value before starting. In this example the LISST-HOLO will start sampling once the depth exceeds 100 m and the magnetic switch is in the 1 position.



The External 1 and External 2 will wait for the voltage on the selected External input located in the Auxiliary 6-pin connector to be greater than 2.4V and the magnetic switch is in the 1 position.

☐ Magnetic switch is in the 1 position. Must be in 1 position to sample regardless of start condition.

The Magnetic switch option will start sampling when the switch is in the 1 position.

NOTE: ALL PROGRAMS MUST BE STARTED BY TURNING THE MAGNETIC SWITCH TO THE 1 POSITION.

The sampling rates and modes also need to be selected. There are two modes:

- Fixed Rate Mode and
- Burst Mode.

The Fixed rate mode will take one hologram at the specified interval. Holograms can be taken at a frequency of up to 0.2 Hz (5 second interval).

The Burst Mode can be used to take a short burst of holograms at fixed interval between the start of each burst. The maximum number of holograms that can be captured in a burst is 20 holograms at a maximum sample rate of 0.2 Hz (5 second interval).

The Stop Conditions also have multiple options: Date/Time, Fixed Duration, Greater than or less than Depth, External Signal 1 or 2, Magnetic switch, or fixed number of Samples.

The Date/Time Stop is used to stop collection at a particular time and date.

The Stop after setting will stop the sampling after the specified amount of time from the start of data collection.

The > Depth value will stop when the depth is larger than the specified depth.

The < Depth value will stop when the depth is smaller than the specified depth.

The External 1 signal and External 2 signal setting will stop collection when the selected signal is less than 0.8 volts.

The Magnetic Switch option will cause sampling to stop when the switch is in the 0 position

The Samples setting will stop data collection when the specified number of samples has been saved.

After making changes to the settings press on the Apply button to save the settings and refresh the page.

All four sets of start and stop conditions can be programmed.

Selecting the start/stop program using the PC

When the four start and stop conditions have been programmed, you can select which program you want to use by selecting the appropriate radio button and clicking apply.

You can also select which program to use by flicking the magnetic switch back and forth, as described in section 5.4. This way you do not have to be connected to the PC in order to select the sampling program, as long as it has already been programmed into the LISST-HOLO using the steps above.

5.3 Preparing for Deployment

Now that the sampling parameters are configured we can prepare the instrument for deployment and start the sampling.

Put the instrument into sleep mode

The first step is to put the instrument into low power sleep mode so that we can disconnect the Ethernet cable and plug in the External Memory Module.



Navigate to the Tools page and click the Sleep button at the Sleep or reboot line.

This will shut down the primary datalogger. The green LED on the endcap should now be blinking every 30 seconds instead of every few seconds.

Install External Memory Module (EMM)

It is NOT necessary to install the EMM in order to sample with the LISST-HOLO. If the EMM is not used, the 8-pin dummy MUST be installed onto the 8-pin connector. Failure to do so may short circuit the instrument and damages the electronics.

!

In order for the EMM to be recognized it must be in place before power is applied OR while the instrument is in sleep mode.



Disconnect the Ethernet cable and plug in the External Memory Module using the special threaded locking part to hold it in place.

Wake up / power up LISST-HOLO

If the system is still powered up but asleep, move the switch to the 1 position and then quickly back to the 0 position.

If the system is disconnected from power, make sure the switch is at the 0 position, then power it back on.

This will wake up the instrument. It will take about 30 seconds to boot. You will see the LED on the endcap flashing in different states during this process.

When the green LED is flashing every few seconds the instrument is awake and ready to start sampling.

5.4 Magnetic Switch Functionality

The switch on the endcap is used to start and stop the sampling PROGRAM, not start and stop the sampling itself (unless switch start has been selected as start/stop condition). The functionality of the switch is summarized below.



0 position.

No sampling, instrument asleep if the power profile is set to sleep between samples.



Move to 1 position.

Instrument wakes up, flashes green N times, pauses and repeats. N represents the sampling program selected (1 to 4), see section 0. Sampling will begin when start conditions are met. If a sampling program is not selected, no flashes will occur and sampling will not occur.

If manually controlled sampling is selected, sampling will start after 6 seconds.



Move to 1 position.
Return to 0 position.
Repeat N times.
Return to 0 position.

System wakes up. Flashes green N times, pause, repeat. N represents the sampling program selected (1 to 4), see section 0. Sampling will not start as switch is in 0 position. If $N > 4$, system defaults to program 4.

If no network access occurs for 10 minutes, it will go to sleep. If sampling occurs and the it is programmed to sleep between samples and there is at least 2 minutes until the next sample, it will go to sleep.



Move to 1 position.
Return to 0 position.
Repeat N times.
Move back to 1 position.

System wakes up. Flashes green N times, pause, repeat. N represents the sampling program selected (1 to 4), see section 0. Sampling will begin when the start conditions are met. If $N > 4$, defaults to program 4.

If manually controlled sampling is selected, sampling will start after about 6 seconds.



Move to 0 position.

Moving the switch to 0 always stops the sampling, regardless of the stop conditions.

If sampling was occurring prior to the switch being in the 0 position, it will not resume until the switch is returned to the 1 position AND the start conditions are met.

If the system was sleeping, it will wake up and will be available for network access. If no network access occurs for 10 minutes, the system will go to sleep.

5.5 Start Data Collection Program

To start the data collection program, move the Switch to the 1 position.

The LED on the endcap will change from green to red indicating that sampling has begun. It will blink slowly until the start condition is reached and it will be on continuously during the acquisition of a hologram.

It will return to green when the stop condition has been reached.

5.6 Stop Data Collection

Data collection will continue until the selected Stop Condition is reached. To Stop the data collection at any time, move the switch to the 0 position. Within a few seconds the LED on the endcap should change from Red to Green.

If the data collection has already stopped the LED will be blinking green regardless of the switch position. However, the switch should be always be placed in the 0 position when sampling is complete.

5.7 Downloading and Viewing Raw Holograms

The raw holograms are saved to the External Memory module if it is installed. Otherwise the holograms are stored on the internal drive of the LISST-HOLO. The offload procedure is different for those two scenarios and will be described in the following.

Downloading from EMM

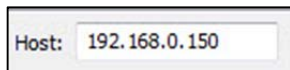
Raw holograms stored on the EMM can be downloaded using the provided USB cable. Remove the External Memory module from the instrument. Leave the locking ring attached to the connector on the instrument. Plug the mating underwater connector of the USB cable onto the Memory Module and then plug the USB end into the PC. The USB flash drive inside the module should now appear on your PC. You can now transfer files as you would from any USB flash drive and subsequently delete the holograms you no longer wish to keep on the EMM.

See section 0 for instructions on how to view the holograms using OpenSeelt.

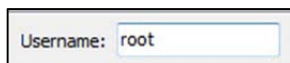
See section 4 for instruction on how to process the holograms.

Downloading and deleting from LISST-HOLO internal drive (EMM not installed)

To download holograms from the internal drive you will need an FTP utility like Filezilla (<http://filezilla-project.org>). When you have started the FTP application, you will need to specify a host, username and password.

A screenshot of the FileZilla interface showing the 'Host' field with the IP address '192.168.0.150' entered.

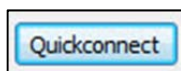
The host is the IP address of the LISST-HOLO, typically **192.168.0.150** unless you have changed it to another IP address (see section 8.3).

A screenshot of the FileZilla interface showing the 'Username' field with the text 'root' entered.

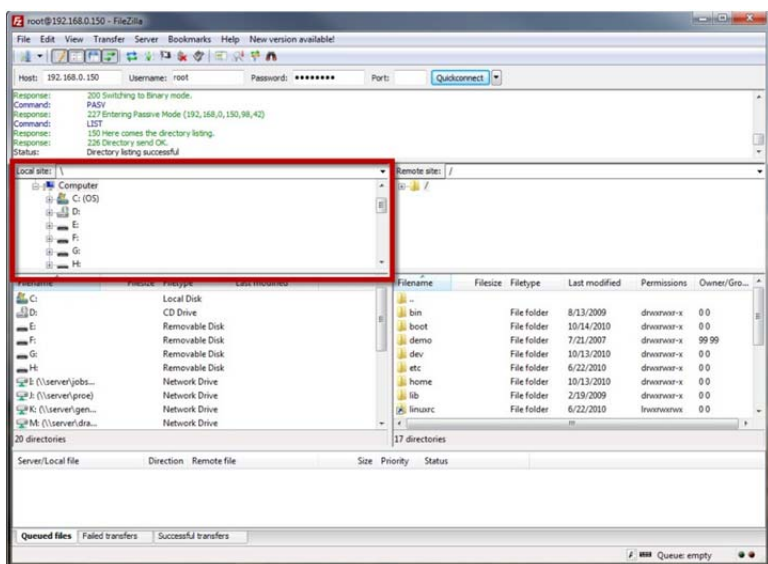
The username is **root**

A screenshot of the FileZilla interface showing the 'Password' field with masked characters (dots) entered.

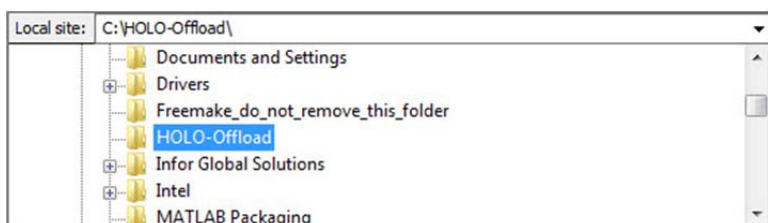
The password is **password**



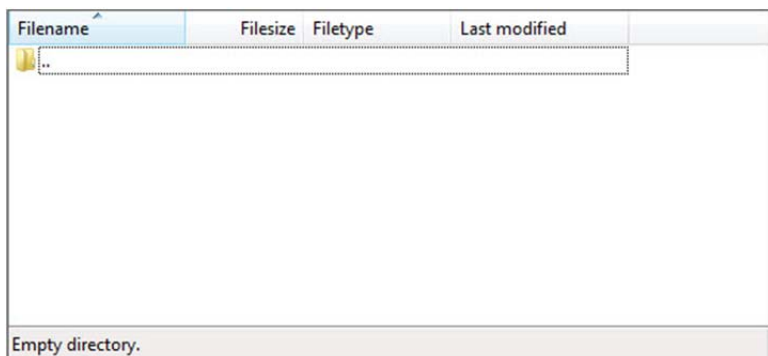
Click the Quickconnect button to start the FTP transfer.



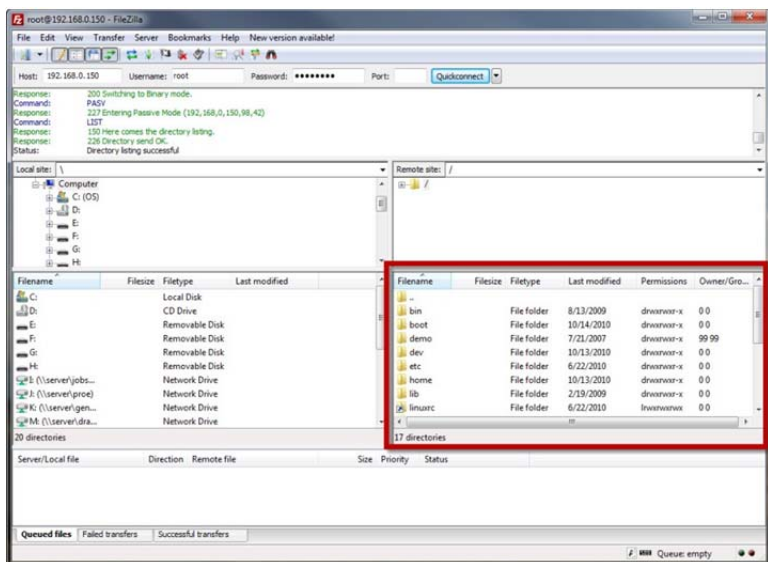
Filezilla will connect to the LISST-HOLO and display the directory listing in the bottom right window. To the left is the destination folder selection. Navigate to the desired destination folder.



In this example, we will offload to a folder on the C drive called HOLO-Offload.



Note that the destination directory window is empty



Focus on the directory listing in the bottom right window.

Filename	Filesize	Filetype	Last modified	Permissions	Owner/Gro...
lib		File folder	2/19/2009	drwxrwxr-x	0 0
linuxrc		File folder	6/22/2010	lrwxrwxrwx	0 0
lost+ fou...		File folder	7/21/2007	drwxrwxr-x	0 0
mnt		File folder	6/21/2011 1:11:...	drwxrwxr-x	0 0
proc		File folder	6/21/2011 11:2...	dr-xr-xr-x	0 0
root		File folder	7/21/2007	drwxrwxr-x	0 0
sbin		File folder	4/30/2009	drwxrwxr-x	0 0
sys		File folder	7/21/2007	drwxrwxr-x	0 0
tmp		File folder	6/22/2011 2:29:...	drwxrwxrwx	0 0

Navigate to the folder called **mnt** and double-click it.

Filename	Filesize	Filetype	Last modified	Permissions	Owner/Gro...
..					
cdrom		File folder	7/21/2007	drwxrwxr-x	0 0
dom		File folder	7/21/2007	drwxrwxr-x	0 0
dos		File folder	7/21/2007	drwxrwxr-x	0 0
flash1		File folder	6/21/2011 7:30:...	drwxrwxrwx	0 0
flash2		File folder	6/22/2010	drwxrwxrwx	0 0
hddboot		File folder	6/22/2010	drwxr-xr-x	0 0
nfs		File folder	7/21/2007	drwxrwxr-x	0 0
ramdrv		File folder	6/21/2011 4:23:...	drwxrwxrwx	0 0

Then navigate to the folder called **flash1** and double-click it.

Filename	Filesize	Filetype	Last modified	Permissions	Owner/Gro...
..					
cgi-bin		File folder	6/20/2011 2:22:...	drwxr-xr-x	0 0
lost+ fou...		File folder	6/20/2011 12:2...	drwx-----	0 0
031-0000...	1,922,065	PGM File	6/20/2011 1:37:...	-rw-rw-rw-	0 0
031-0001...	1,922,065	PGM File	6/20/2011 1:37:...	-rw-rw-rw-	0 0
031-0002...	1,922,065	PGM File	6/20/2011 1:37:...	-rw-rw-rw-	0 0
031-0003...	1,922,065	PGM File	6/20/2011 1:38:...	-rw-rw-rw-	0 0
031-0004...	1,922,065	PGM File	6/20/2011 1:38:...	-rw-rw-rw-	0 0
031-0005...	1,922,065	PGM File	6/20/2011 1:38:...	-rw-rw-rw-	0 0

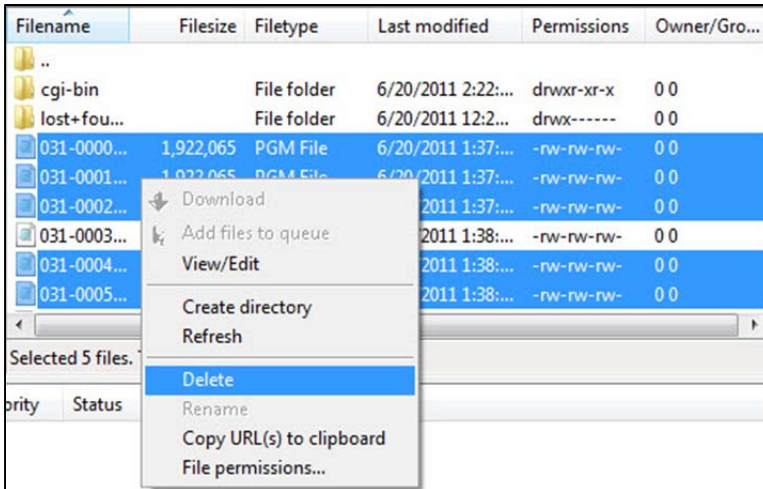
The holograms on the internal drive are now displayed.

Filename	Filesize	Filetype	Last modified	Permissions	Owner/Gro...
..					
cgi-bin		File folder	6/20/2011 2:22:...	drwxr-xr-x	0 0
lost+ fou...		File folder	6/20/2011 12:2...	drwx-----	0 0
031-0000...	1,922,065	PGM File	6/20/2011 1:37:...	-rw-rw-rw-	0 0
031-0001...	1,922,065	PGM File	6/20/2011 1:37:...	-rw-rw-rw-	0 0
031-0002...	1,922,065	PGM File	6/20/2011 1:37:...	-rw-rw-rw-	0 0
031-0003...	1,922,065	PGM File	6/20/2011 1:38:...	-rw-rw-rw-	0 0
031-0004...	1,922,065	PGM File	6/20/2011 1:38:...	-rw-rw-rw-	0 0
031-0005...	1,922,065	PGM File	6/20/2011 1:38:...	-rw-rw-rw-	0 0

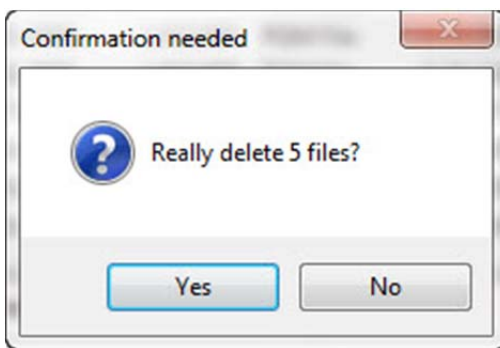
Select the holograms you wish to offload or delete. Use the SHIFT key to select a range of holograms. Use the CTRL key to select several individual holograms. Here 5 holograms have been selected.

Filename	Filesize	Filetype	Last modified	
..				
031-0000.pgm	1,922,065	PGM File	6/22/2011 9:02:06 ...	
031-0001.pgm	1,922,065	PGM File	6/22/2011 9:02:06 ...	
031-0002.pgm	1,922,065	PGM File	6/22/2011 9:02:08 ...	
031-0004.pgm	1,922,065	PGM File	6/22/2011 9:02:08 ...	
031-0005.pgm	1,922,065	PGM File	6/22/2011 9:02:09 ...	
5 files. Total size: 9,610,325 bytes				

Now drag the selected holograms straight across to the destination folder window on the left side of the screen. The holograms will then transfer to the destination folder



To DELETE the holograms, right click on the selected holograms on the **/mnt/flash1/** drive on the LISST-HOLO and select Delete.



You will be asked to confirm the deletion.

The holograms are then deleted from the internal drive on the LISST-HOLO.

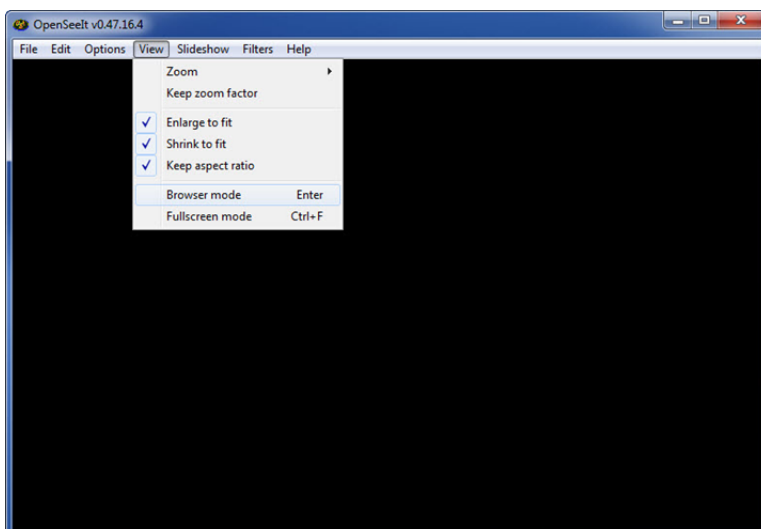
Viewing raw holograms in OpenSeelt

To quickly view the raw holograms, use the Browser mode of the OpenSeelt software.

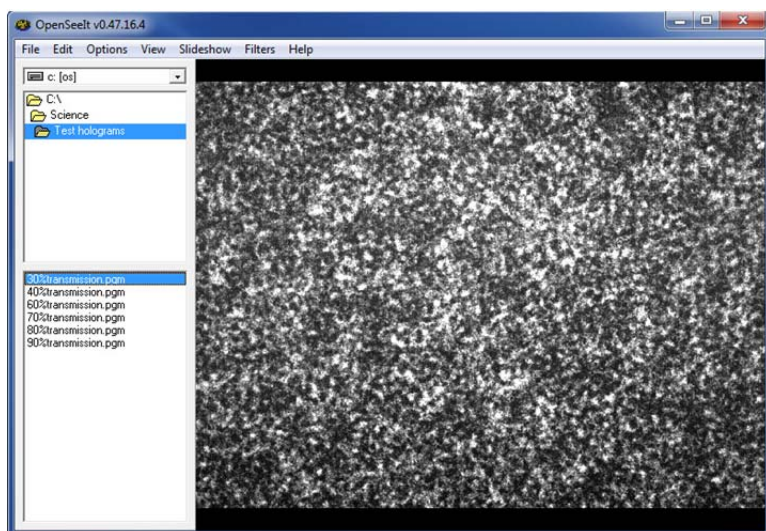
If you have set OpenSeelt to be used for all PGM files you can simply double click on one of the holograms in order to see it in OpenSeelt.

If you press <Enter> within OpenSeelt when a hologram is displaying the View mode changes to Browser mode.

Otherwise follow the instructions below.

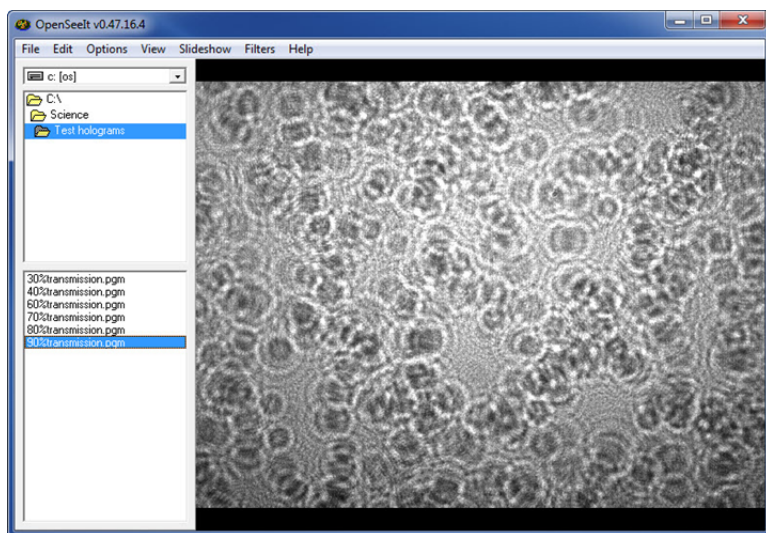


Open up OpenSeelt and select Browser Mode from the View Menu.



Navigate to the folder where your holograms are stored. They will all be displayed in the bottom left of the OpenSeelt window. Use up/down arrow keys to scroll through the holograms. You can use this functionality to quickly determine which holograms will be suitable for processing and which will not.

The hologram on the left will not process well, because there are no visible interference patterns (concentric rings). This is due to the particle concentration being too high.



This hologram will process well, because the interference patterns are clearly visible and distinct.

5.8 Next Deployment or Powering Down

The External Memory Module can now be re-installed on the LISST-Holo and sampling can be started again by moving the switch to the 1 position again. If you do not wish to re-install the External Memory Module you should install the 8-pin dummy on the connector.

There is no need to connect the Ethernet cable and establish communication with the instrument unless the setting for the Start and Stop conditions needs to be changed.

If the instrument is not going to be redeployed it can be powered down. If the instrument is not sampling or writing files the power can simply be disconnected. However, power should only be disconnected when the instrument is in its low power sleep mode. The instrument will automatically go into lower power sleep mode after 10 minutes of no activity. The green LED will blink every 30 seconds when in sleep mode. When the instrument is awake but idle the LED will blink every 5 seconds.

6 Reviewing Instrument Info and Other Settings

6.1 Intro to other Settings

In addition to the Start and Stop Conditions there are other parameters that can be changed using the Ethernet connection. This section will discuss some of the additional parameters that can be accessed from the home page.

6.2 Home

The Home page shows the System Status, Selected Program and Programming Information. In addition it also shows Start and Stop conditions for the four different sampling programs.

System Status



The System Status shows the available memory on the internal flash drive, input voltage, current temperature and depth, endcap switch position, and the state of the two digital inputs.

Select program



The Select Program buttons lets the user select which program should control the LISST-HOLO sampling. Up to 4 programs can be loaded in the LISST-HOLO.

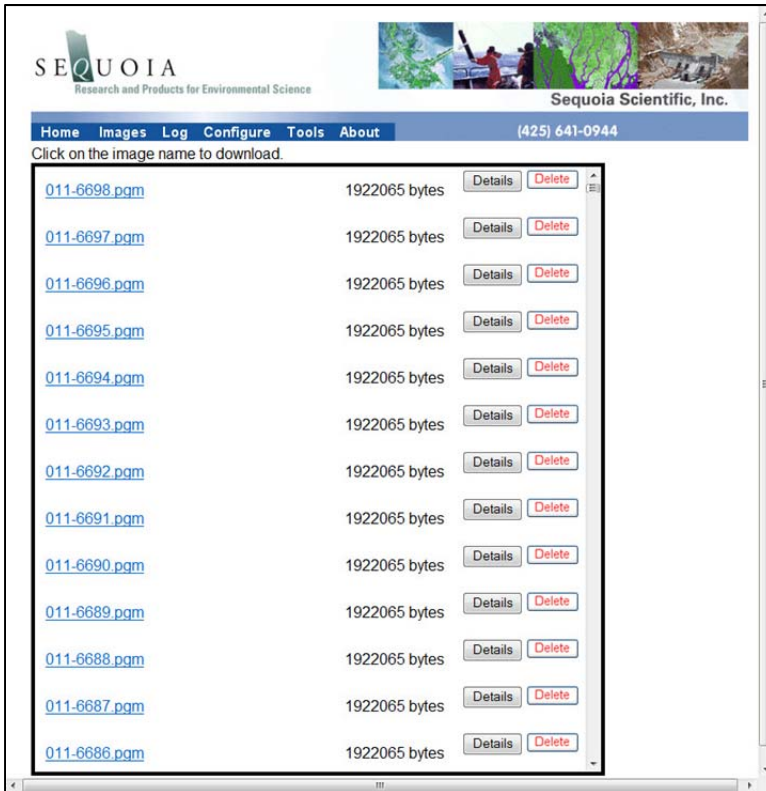
In the example to the left, Program 1 is selected. If another program is to be selected, click the appropriate radio button and then click the Apply button.

Programming Information

The details on the start/stop conditions for the four different programs are reviewed in section 5.2 and will not be repeated here.

6.3 Images

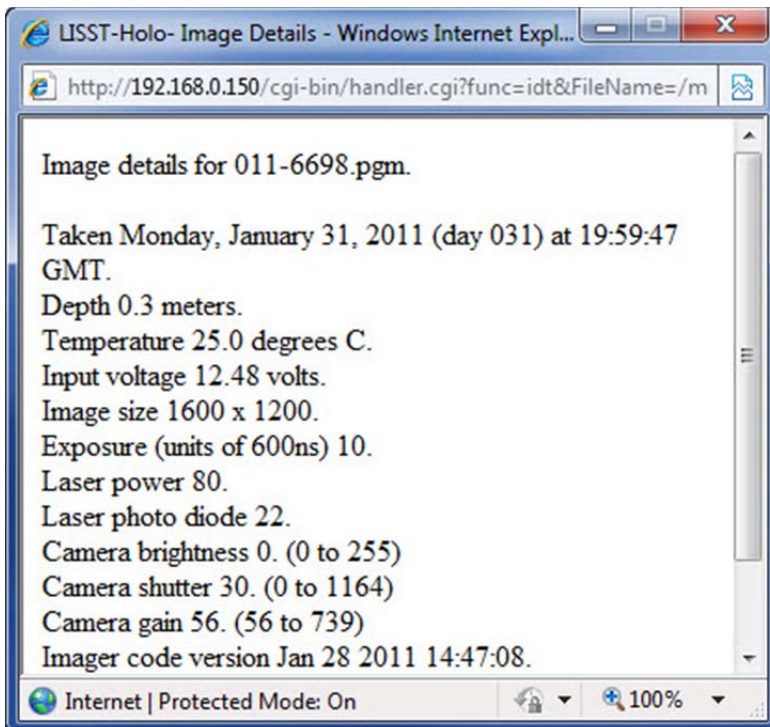
In addition to the External Memory Module the LISST-Holo has an internal flash drive. When the External Memory Module is not attached the holograms will be stored on the internal drive. The Images page shows a listing of the holograms saved on the internal drive.



The hologram file name is a hyperlink to the file on the internal drive of the LISST-HOLO. Click on the file name to download the file to a temporary folder and open the file in OpenSeelt.

To copy the file to a specific folder, right click on the file name and choose "Save Target as" or "Save Link as" and then enter a folder to store the file to.

To see specific information about the hologram such as date and time, depth, and temperature click on the Details button.



The Details Button then opens up a 2nd window showing the details.

Click the Delete button to delete a hologram. You can only delete one hologram at the time using the Delete button.

To download or delete multiple holograms from the internal drive you will need to use an FTP utility like Filezilla (<http://filezilla-project.org>) as described in section 0.

6.4 Log

The LISST-Holo writes information to a file as it is operating. This file contains information that can be helpful in troubleshooting problems. This file can be sent to Sequoia for evaluation. The Log option of the main menu allows the user view the contents of the log file.

6.5 Configure

Selecting Configure on the home page main menu will bring up a window listing many parameters and allows their values to be changed.

Values on this page should not be changed without detailed knowledge of the parameters use or without detailed instructions.

By default this page has restricted access and the user should NOT change any of these values w/o being asked to do so by Sequoia.

6.6 Tools

Selecting Tools on the main menu brings up a window that allows the user to take test image and to change additional parameters such as IP address, send Log file for analysis, check for firmware updates, synchronize time with standard time, and other settings.

Values on this page should not be changed without detailed knowledge of the parameters use or without detailed instructions from Sequoia.

6.7 About

The About page contains information about the hardware and firmware loaded in the instrument. It also contains some FAQs including links to the free OpenSeelt and Filezilla software.

7 Handling, Cleaning, Maintenance and Storage

7.1 Handling

When handling the instrument, at all times please remember that the LISST-HOLO is a high-precision optical instrument.

Avoid mechanical shocks and impact to the housing, as this may cause misalignment of the optical parts.

The instrument pressure housing should not be opened.

7.2 Cleaning

The glass windows of the instrument can be scratched.

Do not use abrasive cleaners on glass or anodized surfaces.

When cleaning windows be careful not to drag and hard particles such as sand across the windows.

Use glass cleaner or liquid dish soap to clean windows.

7.3 Maintenance

Make sure that the windows are as clean as possible.

The connectors and cables should be lubricated with 3M Silicone Spray or equivalent on a frequent basis.

DO NOT use grease on the connectors. Grease may prevent the dummies or cables from mating with the connectors and allow water to penetrate and cause corrosion or short circuit the connector.

7.4 Storage

The LISST-HOLO should be thoroughly cleaned with fresh water and dry out before storage.

Store in a clean dry place or inside the provided ship case.

Make sure the dummy plugs for the connectors are in place before storage.

The instrument should be disconnected from power when not in use.

8 Ethernet Communications

8.1 Router Use

A static IP address is required for access to the LISST-HOLO via a network.

If you are able to simply plug in your LISST-HOLO to your local network, all you have to do is enter the IP address of the LISST-HOLO (<http://192.168.0.150/>).

However, the LISST-HOLO may conflict with the user's or user's administrator security settings, thereby preventing direct connection to the LISST-HOLO via the local network. In that case, a router is required to communicate with the LISST-HOLO.

Connecting to the router via your network

The LISST-HOLO comes with a Linksys E1000 router that has been programmed to communicate with the LISST-HOLO.

Plug your computer's Ethernet port and the LISST-HOLO into any of the numbered ports on the E1000 router. Turn on the router, then power up the LISST-HOLO and open up a web browser. Then initiate communication with the LISST-HOLO as described in section 3.2.

Connecting to the router wirelessly

You may also use a wireless connection to communicate with the router. You must still connect the LISST-HOLO to the router. Then turn the router on and have your computer search for the SSID, which is **LISST-Holo**. When you have connected to the router you need to enter the WAP PSK (password), which is **manyholograms**. Then power up the LISST-HOLO and initiate communication as described in section 3.2.

Updating LISST-HOLO software via the Internet

The Internet port on the E1000 router can be connected to your network to give the LISST-HOLO access to the Internet for software updates.

To log on, leave user name blank and enter **admin** for the password.

8.2 Changing the IP address of the Linksys E1000 router

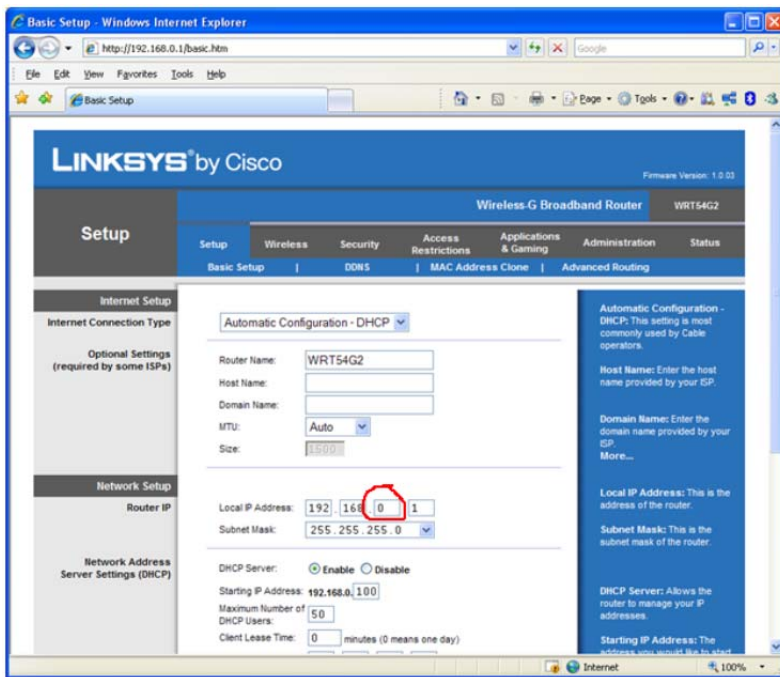


It may be necessary for you to change the IP address of the E1000 router.

You do NOT have to change the IP address of the router if you are only changing the last element of the LISST-HOLO's IP address (150).

If you are changing any of the first 3 elements of the LISST-HOLO's IP address (192.168.0) you ***MUST*** change the IP address of the router to match:

1. Apply power to the Linksys E1000 router.
2. Connect the Ethernet jack in a computer to Ethernet port 1 of the router. Light #1 should come on.
3. Open Internet Explorer and navigate to 192.168.0.1.
4. Leave the user name blank. Enter **admin** as password. This will open up the setup page below.



5. Change the **Local IP Address** from 192.168.0.1 to your new desired IP address.
6. Make a note in this manual of the new local IP address in case you need to change it in the future:

New router IP address:

Date:

New router IP address:

Date:

New router IP address:

Date:

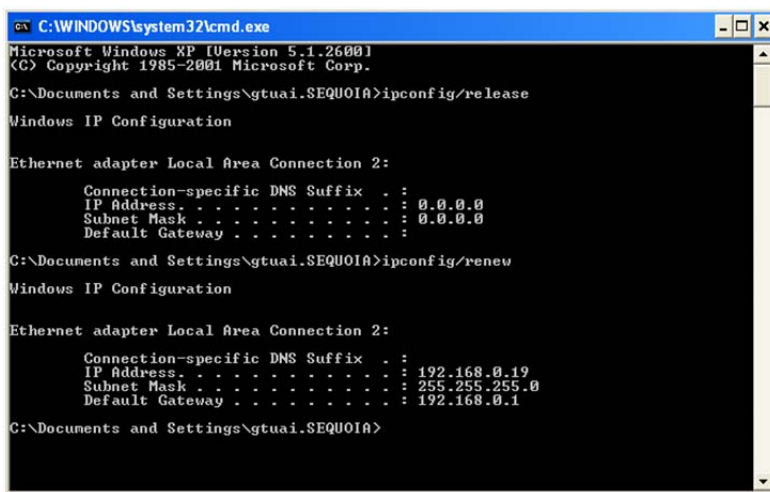
New router IP address:

Date:

7. Now click the Windows Start Button on your PC

8. Type cmd in the search/command line and press <Enter> . You should see the black DOS prompt window.

9. Type ipconfig/release and press <Enter>.
10. Type ipconfig/renew and press <Enter>.
11. The IP address has now been updated from 192.168.0.1 to the IP address you selected.



8.3 Changing the LISST-HOLO IP address

To change the IP address of the LISST-HOLO use the web interface.

Connect as described in section 3.2 and go to the Tools page of the LISST-HOLO web interface.

Scroll down until you get to Network Parameters.

Network parameters	IP Address	192.168.0.150	Changes will occur immediately. Change the IP address in your browser.	Apply
	Netmask	255.255.255.0		
	Gateway	192.168.0.1		
	DNS 1	192.168.0.1		
	DNS 2	192.168.0.1		

Change the IP address to the desired address and click the Apply button. The changes will take effect

immediately, so you will need to enter the new IP address in your browser to continue working with the LISST-HOLO

New LISST-HOLO IP address:

Date:

New LISST-HOLO IP address:

Date:

New LISST-HOLO IP address:

Date:

New LISST-HOLO IP address:

Date:

9 FAQ's

What is a hologram?	Fundamentally, holograms are 3-D images that have first been projected, and then stored on a 2-D surface. In the type of holograms captured by the LISST-HOLO (so-called in-line holograms), a laser beam is emitted and a small part of it is being scattered by the particles in the water. The part of the laser beam that is not being scattered by particles interferes with the scattered light. This creates an interference pattern - a hologram. The interference pattern is captured by a small digital camera. Upon processing of the captured interference pattern (i.e. the hologram), it is possible to recover the original image that created the hologram. Thus, the LISST-HOLO does NOT capture and store an image of the suspended particles. It is the hologram of the particles that is stored. During data processing, the image of the suspended particles is reconstructed from the hologram. Subsequently standard image processing methods can then be applied to get information about particle shape, size, area etc.
Why can't the LISST-HOLO be used when the flow speed is larger than 0.5 m/s?	It takes a few micro-seconds to capture the hologram using the digital camera. The image captured by any digital camera is made up by a large number of pixels. If the particles in the water move more than half a pixel size during the time it takes to capture and store the hologram, it is impossible to process the hologram and get reliable results. For the pixel size used in the LISST-HOLO, a flow speed of more than 0.5 m/s will begin to blur the hologram. Consequently, if the LISST-HOLO is used on a CTD, the CTD speed must be 0.5 m/s or less. Likewise, if the LISST-HOLO is deployed on a mooring or tripod, the current velocity around the instrument must be less than 0.5 m/s.
Why should I connect the LISST-HOLO to the Internet?	Connecting the LISST-HOLO to a local area network that is connected to the Internet has benefits. The first benefit is that the instrument is access from different locations across the network. Connecting the instrument to the Internet has other advantage such as checking for firmware updates, syncing the time with international standards, and transmitting log files to Sequoia. It is not necessary to have the instrument connected to a network or the Internet but it can be useful when needed.
How do I connect the LISST-HOLO to the Internet?	The LISST-HOLO comes configured with a pre-selected IP address, Netmask, Gateway, DNS 1, and DNS 2. These setting will work fine with the provided Wireless router but they will probably not work with your existing local area network. Because the LISST-HOLO requires a static IP address an IP address must be selected so as not to interfere with other computers on the network. It is highly recommended that users work with their network administrators to determine the proper settings for their network. The new value can be entered on the Tools page. Be sure to double check the values before pressing the Apply button. Once the Apply button is changed the IP address will change and you will need to log into the new IP address before communication can be established. If the incorrect values are entered it is possible to change them manually through the serial port connections. Contact Sequoia for details of this procedure.
Why does it take 2 minutes to process one hologram?	Processing (or reconstruction) of a hologram is a mathematical intensive task. Therefore a LISST-HOLO hologram is split up into 4 sub-holograms, which are each processed separately. This is in order to avoid memory problems during processing. Once the 4 sub-holograms have been processed they are merged into one image with particles and processed for size, area, shape etc. The 2 minute processing time per hologram is a maximum expected time on a standard 2.2GHz windows PC with 4GB of memory. However, since the processing is fully automated, it is possible to process holograms overnight or during weekends.
Is it possible to get data in real-time from the LISST-HOLO?	No. It typically takes 2 minutes to reconstruct a hologram into an image that can be analyzed for particle size, shape, area etc.
Does the LISST-HOLO support DHCP?	No. The LISST-HOLO does not support DHCP (Dynamic Host Configuration Protocol).
What is the maximum sample rate for the LISST-HOLO?	The maximum sample rate for the LISST-HOLO is 0.2 Hz (one hologram every 5 seconds).
What is the longest burst the LISST-HOLO can capture	The LISST-HOLO can capture a burst that is 20 holograms long, spaced 5 seconds (0.2 Hz) apart. The LISST-HOLO cannot capture a burst that is longer than 20 holograms. This is because of limitations of writing to the flash drive on the LISST-HOLO.

What is the maximum concentration that the LISST-HOLO can be used with?

The concentration limits for a LISST-HOLO are roughly as tabulated in the table below. See also this article on Sequoia's website: <http://www.sequoiasci.com/Articles/ArticlePage.aspx?pageid=232> for a more thorough explanation.

Mean Particle Diameter		Wentworth Grades	Maximum Concentration
[μm]	[phi]		[mg/l]
1.95	9.00	Clay	8
3.9	8.00	Very Fine Silt	15
7.8	7.00	Fine Silt	31
15.6	6.00	Medium Silt	62
31.25	5.00	Coarse Silt	123
62.5	4.00	Very Fine Sand	247
125	3.00	Fine Sand	494
250	2.00	Medium Sand	987

How do I tell if the suspended sediment concentration is too high?

If you cannot see any interference patterns in the hologram (lots of concentric rings), the concentration is too high and you most likely won't get any sensible data out of the hologram when processing it.

Why can I choose between spherical and random size ranges in HOLO_Batch?

For Sequoia's LISST-100X and LISST-STX instruments, the user has the option to process that data using two different types of particle types: Spherical particles and Randomly shaped particles. The size ranges differs between these two processing options. In order to make it easier for LISST-HOLO users to merge their data with LISST-100X data, this option has been transferred to the HOLO_Batch processing software as well. It has no influence on the processing of the holograms; only on the size bins used for the final size distributions.

Can I connect the LISST-HOLO directly to the Ethernet port on my PC

No. You must always connect via the supplied router or a local network. With the router, you can connect wirelessly to your PC. If your PC does not have wireless capability you can plug the router into your PC. However, in both circumstances the LISST-HOLO must be plugged into the router and NOT the PC.

10 Endcap LED Status Light Indicators

This table describes the LED signals visible from the end cap. The descriptions are roughly in the order in which they would be encountered during normal operation.

LED sequence	What the LISST-Holo is doing.
Troubleshooting notes.	
0.5 second green flash once every 30 seconds	LISST-Holo is sleeping. Flashes are initiated by the motherboard when the power is removed from the Linux system.
Yellow flashing twice a second for 40 to 60 seconds.	Linux system is booting. External trigger caused motherboard to wake up Linux system. If this continues beyond approximately 60 seconds, the internal flash drive has failed. Motherboard initiates this display when it applies power to the Linux system. If it does not occur, the motherboard has not been booted. If this display lasts more than 40 seconds, the Linux system is not responding or the internal flash drive has been corrupted. This display ends when the Linux system sends the first command to the motherboard. Could also be that the Linux system could not initiate the serial communications between the Linux system and motherboard.
2 red flashes, 2 second pause, repeat	Fatal error. Internal flash drive not found. Internal flash drive is a Linux EXT2 device with operational files. It must be replaced by Sequoia.
3 red flashes, 2 second pause, repeat	Fatal error. Inter-program communication socket creation failure.
4 red flashes, 2 second pause, repeat	Fatal error. Setting socket to non-blocking failed.
5 red flashes, 2 second pause, repeat	Fatal error. Could not bind socket to name. Maybe caused by a file system error. If a message indicating a stale NFS handle was detected, it is necessary to rebuild the internal flash drive (more likely) or the root system on the hard disk emulator (less likely). Maybe possible to run fsck after booting from a flash drive; haven't tried this solution. Just as easy to perform a disk copy. Holo must be opened and connected to a VGA-type monitor and PS/2 keyboard. BIOS must be instructed to boot from flash drive. Cannot access BIOS externally because routing BIOS prevents Linux from using externally accessible serial port. Stale NFS handles on the flash drive can sometimes be repaired by inserting the flash drive into a Linux machine and deleting the offending file.
6 red flashes, 2 second pause, repeat	Fatal error. Could not make socket read/write.
7 red flashes, 2 second pause, repeat	Could not mount external drive. Storage will be placed on internal drive.
0.5 second green flash once every five seconds.	Indicates Linux system is operational and idling. It may be sampling or waiting for input. No external flash drive detected. Linux system commands the motherboard to show this display. If it does not occur, the Linux system has not booted.
0.5 second yellow flash every 2 seconds.	Camera is being set up. If this condition persists more than a few seconds, there is a camera or Firewire board problem. The laser will come on during this time for warm up.
0.5 Hz green flashing.	Sampling enabled but the sampling conditions have not been met. Either the magnetic switch is in the 1 position of the sampling was enabled on the Tools page.
1 Hz green flashing.	Start condition met, sampling.
Steady yellow .	Taking sample.

11 LISST-HOLO Size Ranges

11.1 Size Ranges based on LISST-100X SPHERICAL particles.

The LISST-HOLO outputs the size distribution in 50 size ranges logarithmically placed from 1.25 - 4923 microns in diameter (type B), or 2.5 – 9847 microns (type C). In both cases, the upper size in each bin is 1.180 times the lower. These size ranges are chosen so that they are similar to the two different size ranges for the LISST-100X submersible particle size analyzer from Sequoia Scientific, Inc., in order to facilitate merging of data from the two instruments.

The table below shows the lower and upper limit of each size bin in microns, together with the median size (also in microns) for each size bin for type B and C instruments.

Size bin #	Type B			Type C		
	Lower	Upper	Median	Lower	Upper	Median
1	1.25	1.48	1.36	2.50	2.95	2.72
2	1.48	1.74	1.60	2.95	3.48	3.20
3	1.74	2.05	1.89	3.48	4.11	3.78
4	2.05	2.42	2.23	4.11	4.85	4.46
5	2.42	2.86	2.63	4.85	5.72	5.27
6	2.86	3.38	3.11	5.72	6.75	6.21
7	3.38	3.98	3.67	6.75	7.97	7.33
8	3.98	4.70	4.33	7.97	9.40	8.65
9	4.70	5.55	5.11	9.40	11.1	10.2
10	5.55	6.55	6.03	11.1	13.1	12.1
11	6.55	7.72	7.11	13.1	15.4	14.2
12	7.72	9.12	8.39	15.4	18.2	16.8
13	9.12	10.8	9.90	18.2	21.5	19.8
14	10.8	12.7	11.7	21.5	25.4	23.4
15	12.7	15.0	13.8	25.4	30.0	27.6
16	15.0	17.7	16.3	30.0	35.4	32.5
17	17.7	20.9	19.2	35.4	41.7	38.4
18	20.9	24.6	22.7	41.7	49.2	45.3
19	24.6	29.1	26.7	49.2	58.1	53.5
20	29.1	34.3	31.6	58.1	68.6	63.1
21	34.3	40.5	37.2	68.6	80.9	74.5
22	40.5	47.7	43.9	80.9	95.5	87.9
23	47.7	56.3	51.9	95.5	113	104
24	56.3	66.5	61.2	113	133	122
25	66.5	78.4	72.2	133	157	144
26	78.4	92.6	85.2	157	185	170
27	92.6	109	101	185	218	201
28	109	129	119	218	258	237
29	129	152	140	258	304	280
30	152	180	165	304	359	331
31	180	212	195	359	424	390
32	212	250	230	424	500	460
33	250	295	272	500	590	543
34	295	348	320	590	696	641
35	348	411	378	696	822	756
36	411	485	446	822	970	893
37	485	572	527	970	1144	1053

38	572	675	621	1144	1350	1243
39	675	797	733	1350	1593	1467
40	797	940	865	1593	1880	1731
41	940	1109	1021	1880	2219	2043
42	1109	1309	1205	2219	2618	2410
43	1309	1545	1422	2618	3090	2844
44	1545	1823	1678	3090	3646	3357
45	1823	2151	1980	3646	4303	3961
46	2151	2539	2337	4303	5078	4674
47	2539	2996	2757	5078	5992	5516
48	2996	3536	3255	5992	7071	6509
49	3536	4172	3841	7071	8344	7681
50	4172	4923	4533	8344	9847	9065

11.2 Size Ranges based on LISST-100X RANDOMLY shaped particles

The LISST-HOLO outputs the size distribution in 50 size ranges logarithmically placed from 1.00 - 3939 microns in diameter (type B), or 1.90 – 7495 microns (type C). In both cases, the upper size in each bin is 1.180 times the lower. These size ranges are chosen so that they are similar to the two different size ranges for the LISST-100X submersible particle size analyzer from Sequoia Scientific, Inc., in order to facilitate merging of data from the two instruments.

The table below shows the lower and upper limit of each size bin in microns, together with the median size (also in microns) for each size bin for type B and C instruments.

Size bin #	Type B			Type C		
	Lower	Upper	Median	Lower	Upper	Median
1	1.00	1.18	1.09	1.90	2.25	2.07
2	1.18	1.39	1.28	2.25	2.65	2.44
3	1.39	1.64	1.51	2.65	3.13	2.88
4	1.64	1.94	1.79	3.13	3.69	3.40
5	1.94	2.29	2.11	3.69	4.35	4.01
6	2.29	2.70	2.49	4.35	5.14	4.73
7	2.70	3.19	2.93	5.14	6.06	5.58
8	3.19	3.76	3.46	6.06	7.15	6.59
9	3.76	4.44	4.09	7.15	8.44	7.77
10	4.44	5.24	4.82	8.44	9.96	9.17
11	5.24	6.18	5.69	9.96	11.8	10.8
12	6.18	7.29	6.71	11.8	13.9	12.8
13	7.29	8.61	7.92	13.9	16.4	15.1
14	8.61	10.2	9.35	16.4	19.3	17.8
15	10.2	12.0	11.0	19.3	22.8	21.0
16	12.0	14.1	13.0	22.8	26.9	24.8
17	14.1	16.7	15.4	26.9	31.8	29.2
18	16.7	19.7	18.1	31.8	37.5	34.5
19	19.7	23.2	21.4	37.5	44.2	40.7
20	23.2	27.4	25.2	44.2	52.2	48.0
21	27.4	32.4	29.8	52.2	61.6	56.7
22	32.4	38.2	35.2	61.6	72.7	66.9
23	38.2	45.1	41.5	72.7	85.7	78.9
24	45.1	53.2	49.0	85.7	101	93.1
25	53.2	62.8	57.8	101	119	110
26	62.8	74.1	68.2	119	141	130
27	74.1	87.4	80.5	141	166	153
28	87.4	103	94.9	166	196	181
29	103	122	112	196	232	213
30	122	144	132	232	273	252
31	144	169	156	273	322	297
32	169	200	184	322	381	350
33	200	236	217	381	449	413
34	236	279	256	449	530	488
35	279	329	303	530	625	576
36	329	388	357	625	738	679
37	388	458	421	738	871	802
38	458	541	497	871	1028	946

39	541	637	587	1028	1213	1116
40	637	752	692	1213	1431	1317
41	752	888	817	1431	1689	1555
42	888	1047	964	1689	1993	1835
43	1047	1236	1138	1993	2352	2165
44	1236	1458	1343	2352	2775	2555
45	1458	1721	1584	2775	3275	3014
46	1721	2031	1870	3275	3865	3558
47	2031	2397	2206	3865	4561	4198
48	2397	2828	2604	4561	5382	4954
49	2828	3338	3073	5382	6351	5846
50	3338	3939	3626	6351	7495	6899

12 Hologram .PGM File Format Structure

The holograms stored on the flash drive are saved in .PGM format and are composed of two parts.

The first block of bytes in a hologram is the standard PGM format, as follows:

"P5<lf>1600 1200 255<lf> plus 1600 ×1200 bytes containing the hologram data.

The second block of has a size of 1024 bytes and follows immediately after the hologram data. This block holds binary data as follows:

Bytes	Description
0-7	Seconds since epoch. Time stamp indicating when image was obtained. Unsigned long integer.
8-15	Pressure in counts. Unsigned long integer.
16-17	Temperature in counts.
18-19	Battery/power supply voltage in counts
20-21	Exposure time in 600ns increments.
22-23	Laser power in counts.
24-25	Laser photo diode reading, in counts.
26-27	Camera brightness.
28-29	Camera brightness, minimum value.
30-31	Camera brightness, maximum value.
32-33	Camera shutter.
34-35	Camera shutter, minimum value.
36-37	Camera shutter, maximum value.
38-39	Camera gain.
40-41	Camera gain, minimum value.
42-43	Camera gain, maximum value.
44-115	Not used
116-119	Depth coefficient, DepthA. Floating point number.
120-123	Depth coefficient, DepthB. Floating point number.
124-127	Depth coefficient, DepthC. Floating point number.
128-131	Temperature coefficient, TemperatureA. Floating point number.
132-135	Temperature coefficient, TemperatureB. Floating point number.
136-139	Temperature coefficient, TemperatureC. Floating point number.
140-143	Temperature coefficient, TemperatureSlope. Floating point number.
144-147	Temperature coefficient, TemperatureOffset. Floating point number.
148-151	Auxiliary input A/D channel 2. 8 bits, 0 to 255.
152-155	Auxiliary input A/D channel 3. 8 bits, 0 to 255.
156-159	Auxiliary input A/D channel 4. 8 bits, 0 to 255.
160-163	Auxiliary input A/D channel 5. 12 bits, 0 to 4095.
164-167	Auxiliary input A/D channel 6. 12 bits, 0 to 4095.
168-171	Not used
172-173	Inter-frame delay in milliseconds.
174-181	Millisecond time stamp. Use to determine time between previous or following hologram.
182-1023	Unassigned, set to 0

13 Warranty

STATEMENT OF LIMITED WARRANTY AND LIABILITY

This Statement of Limited Warranty applies to all Sequoia Scientific, Inc. ("SEQUOIA") products ("Products"). Any additional or different terms, including any terms in any purchase order, will be of no effect unless agreed to in writing by an authorized representative of SEQUOIA as reflected in a written SEQUOIA quotation.

1. Limited Warranty

SEQUOIA warrants that upon delivery by SEQUOIA (a) the Products will be free from defects in materials and workmanship, (b) the Products will perform substantially in accordance with SEQUOIA's applicable specifications, and (c) any Products (or components or parts thereof) that are manufactured by SEQUOIA do not infringe any U.S. patent or copyright.

2. Correction of Non-Compliance

If, during the twelve months after delivery (the "Warranty Period"), any Product does not comply with the warranties set forth in 1(a) and 1(b) above, SEQUOIA will, at its option, either (a) repair the Product, (b) replace the Product, or (c) refund the purchase price paid by Customer to SEQUOIA for the Product; provided that Customer gives SEQUOIA written notice of the noncompliance within the Warranty Period and ships the Product to SEQUOIA within one month after the end of the Warranty Period. As to any Product repaired or replaced by SEQUOIA, the Warranty Period will end upon the later of the end of the original Warranty Period or 90 days after SEQUOIA's delivery of the repaired or replacement Product to Customer. Any Product, component, part or other item replaced by SEQUOIA becomes the property of SEQUOIA. SEQUOIA may use refurbished components in the repair of Products supplied hereunder.

SEQUOIA's warranties shall be void and not apply if the Product has been subjected to misuse or alteration or repaired by a party not approved by SEQUOIA or the serial number on a product (if applicable) has been altered or defaced. SEQUOIA shall not be liable for normal wear and tear (such as replacement of consumables), nor for defects or failure caused by maintenance, misuse, negligence or failure resulting from non-compliance with SEQUOIA's specifications, operating or maintenance manuals.

3. Infringement Indemnification

If any Product does not comply with the warranty set forth in 1(c) above, SEQUOIA will defend and indemnify Customer against any third-party claim asserted in any proceeding against Customer based on this noncompliance; provided that Customer gives SEQUOIA prompt written notice of the claim, SEQUOIA has exclusive control over the defense and settlement of the claim, Customer provides such assistance as SEQUOIA may request in connection with the defense and settlement of the claim (in which event SEQUOIA will reimburse the reasonable out-of-pocket costs incurred by Customer to provide such assistance), Customer does not settle the claim without the prior written consent of SEQUOIA and, upon SEQUOIA's request, Customer returns the Non-Complying Product to SEQUOIA for modification, replacement or a refund of the purchase price paid by Customer to SEQUOIA for the Non-Complying Product, less a reasonable allowance for Customer's use prior to return.

4. Exclusive Warranties

THE WARRANTIES SET FORTH IN PARAGRAPH 1 ABOVE ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED. SEQUOIA DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED (INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, AND ANY IMPLIED WARRANTY ARISING FROM COURSE OF PERFORMANCE, COURSE OF DEALING, OR USAGE OF TRADE) OTHER THAN THOSE SPECIFICALLY SET FORTH IN PARAGRAPH 1.

5. Exclusive Remedies

CUSTOMER'S RIGHTS AND REMEDIES SET FORTH IN PARAGRAPHS 2 AND 3 ABOVE ARE EXCLUSIVE AND IN LIEU OF ANY AND ALL OTHER RIGHTS AND REMEDIES FOR ANY BREACH OF OR OTHER FAILURE TO COMPLY WITH ANY WARRANTY WITH REGARD TO ANY PRODUCT.

6. No Consequential Damages

SEQUOIA will not be liable for any indirect, incidental, special or consequential damages, any cover, or any loss of revenue, profit, data or use.

7. Limitations of Liability

SEQUOIA's liability (whether in contract, tort, or otherwise; and notwithstanding any fault, negligence, strict liability or product liability) with regard to any Product (including, but not limited to, any breach of or default by SEQUOIA) will in no event exceed the purchase price paid by Customer to SEQUOIA for such Product. Further, SEQUOIA will not be liable for, or be in breach of or default on account of, any delay or failure to perform as a result of any cause, condition or circumstance beyond SEQUOIA's reasonable control.

8. Indemnification by Customer

Customer acknowledges that the Products are designed and manufactured for use in non-critical, monitoring situations. If Customer chooses to purchase a Product or Products for use in applications that could result in damages in excess of the price of the Product if the Product does not operate properly or otherwise fails, Customer acknowledges and agrees that it is Customer's responsibility to provide for redundancy and/or other safety or back-up measures sufficient to assure that failure of a Product(s)

will not cause such damages. Customer agrees that it will defend and hold SEQUOIA harmless from any and all claims and costs (including but not limited to attorney's fees and other costs of defense against such claims) in excess of the price of the Products arising directly or indirectly from such Customer's use of the Products. Such indemnification is a critical part of the consideration being provided by Customer (over and above the price paid for the Product(s)) for the right to use the Products for such purposes and Customer shall not use a Product or Products for such purposes if it is unwilling or unable to provide such indemnification.

9. Statute of Limitations

Customer will not commence any action based on breach of warranty with respect to any Product more than 18 months after SEQUOIA's delivery of such Product.

10. Software

The Products may include or be delivered with certain computer programs, databases or other software that is proprietary to SEQUOIA. SEQUOIA hereby grants Customer a nonexclusive license to use such software solely for the purpose of operating Products. Customer will not: use any such software for any other purpose; modify, adapt, translate, or create derivative works based on any such software; or disassemble, decompile or reverse engineer any such software. No title to or ownership of any software or intellectual property rights are transferred to Customer.

11. U.S. Government Restricted Rights Notice

All software, data, technical information, and written materials provided by SEQUOIA are provided with restricted rights. Use, duplication, or disclosure by the government is subject to restrictions as set forth in subparagraph (c)(1)(ii) of the Rights in Technical Data and Computer Software clause at 48 C.F.R. § 252.227-7013 or in subparagraph (c)(2) of the Commercial Computer Software-Restricted Rights clause at 48 C.F.R. § 52.227-19, as applicable. Portions of these items may be unpublished. SEQUOIA reserves all rights under applicable copyright laws.

12. Controlling Document

In the event of any conflict or inconsistency between any provision of this Statement of Limited Warranty and any other provision of the Order, the provision of this Statement of Limited Warranty will control.

13. Controlling Law

This Statement of Limited Warranty will be governed by the laws of the State of Washington without reference to its rules relating to choice of law for the purpose of applying another jurisdiction's law. The U.N. Convention on Contracts for the International Sale of Goods will not apply.

14 Index

Battery		
case	4	
life	3	
Cables		
connecting.....	8	
ethernet.....	7	
power	7	
Cleaning	47	
Concentration	54	
range	3	
too high	41, 54	
Connectors		
maintenance	47	
pin-outs	5	
Dimensions.....	3	
Downloading.....	37	
External Memory Module	3, 35	
installation	35	
FAQ	53	
Features	3	
Files		
created by HOLO_Batch.....	27	
created by HOLO_Detail.....	32	
download from EMM	37	
download via FTP	37	
format.....	27, 61	
PGM file structure	61	
Filezilla.....	37	
FTP	37	
Getting started.....	7	
Handling	47	
HOLO_Batch	15	
advanced parameters	18	
background hologram	23	
bin sizes	19	
factory default settings.....	16	
output options	19	
performance options	20	
reconstruction parameters	16	
ROI (Region Of Interest).....	16	
HOLO_Detail	29	
Hologram	53	
download from EMM	37	
download from internal drive	37, 44	
PGM file structure.....	61	
processing	15	
processing time	53	
view in OpenSeelt	40	
IP address		
change LISST-HOLO	50	
change router	49	
Maintenance	47	
OpenSeelt.....	40	
Password		
changing router IP	49	
connecting to router.....	8	
connecting via FTP	37	
PNG images.....	32	
Power	3	
consumption	3	
disconnect	11	
supply	3	
Process holograms		
using HOLO_Batch	15	
using HOLO_Detail	29	
Programming		
start conditions	33	
stop conditions.....	34	
Router	49	
connecting	8	
Select program		
using the magnetic switch	35	
using the PC	34	
Size ranges	57, 59	
Software		
installation.....	13	
Specifications.....	3	
Start data collection	36	
Stop data collection.....	37	
Storage.....	47	
Test chamber		
installation.....	11	
URL	9	
Warranty.....	63	
Weight.....	3	