User guide

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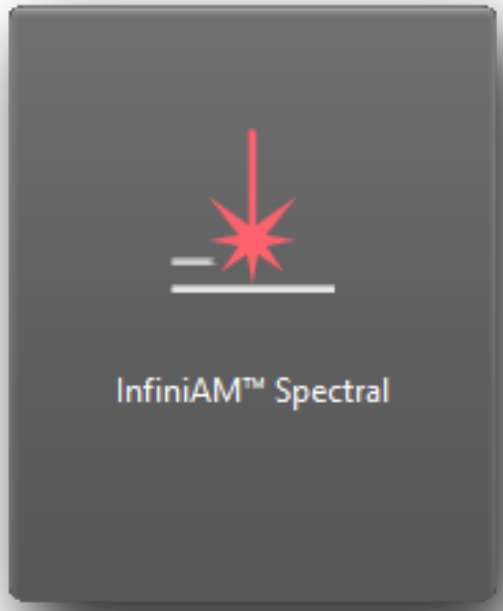
InfiniAM Spectral



Contents

1 Legal notices

1.1 Terms and conditions and warranty

Unless you and Renishaw have agreed and signed a separate written agreement, the equipment and/or software are sold subject to the Renishaw Standard Terms and Conditions supplied with such equipment and/or software, or available on request from your local Renishaw office.

Renishaw warrants its equipment and software for a limited period (as set out in the Standard Terms and Conditions), provided that they are installed and used exactly as defined in associated Renishaw documentation. You should consult these Standard Terms and Conditions to find out the full details of your warranty.

Equipment and/or software purchased by you from a third-party supplier is subject to separate terms and conditions supplied with such equipment and/or software. You should contact your third-party supplier for details.

1.2 Patents

Features of Renishaw's additive manufacturing systems, and other similar systems, are the subject of one or more of the following patents and/or patent applications:

1.2.1 RenAM 500 series

CA 2738618	EP 2331232	IN WO2014/125258	US 10335901
CA 2738619	EP 2875855	IN WO2014/125280	US 10493562
	EP 2956261	IN WO2014/199134	US 10500641
CN 102186554	EP 2956262		US 10639879
CN 105102160	EP 3007879	JP 6482476	US 10933620
CN 105228775	EP 3221073	JP 6571638	US 10974184
CN 105492188	EP 3221075		US 11033968
CN 107107193	EP 3299110		US 11040414
CN 107206494	EP 3323534		US 11104121
CN 107921659	EP 3325240		US 11267052
CN 108189390	EP 3357606		US 11305354
CN 108349005	EP 3377252		US 11478856
CN 108515182	EP 3377253		US 11565346
CN 109177153	EP 3566798		US 8753105
	EP 3689507		US 8794263
	EP 4023387		US 9114478
			US 9669583
			US 9849543
			US 2020-0023463
			US 2021-0354197
			US 2022-0203451
			US 2023-0122273

1.2.2 DataHUB

CN 109937101	EP 3482855	US 11167497	WO 2020/099852
CN 111315512	EP 3538295	US 2020-0276669	
CN 112996615	EP 3880391	US 2021-0394272	

1.2.3 InfiniAM Spectral

CN 105745060	EP 3049235	US 10850326	WO 2020/099852
CN 108349005	EP 3377252	US 11305354	WO 2020/174240
CN 109937101	EP 3482855	US 11040414	
CN 110026554	EP 3482909	US 2020-0276669	
CN 111315512	EP 3538295	US 2021-0039167	
CN 111491777	EP 3880391	US 2021-0394272	
CN 112996615	EP 3930999	US 2022-0168813	
CN 115943048	EP 2020-174240	US 2022-0203451	

1.3 REACH

Information required by Article 33(1) of Regulation (EC) No. 1907/2006 (“REACH”) relating to products containing substances of very high concern (SVHCs) is available at:
Product Environmental Compliance – Additive manufacturing (renishaw.com)

1.4 Control of pollution, applicable in the People’s Republic of China

Renishaw has prepared a table in accordance with the provisions of SJ/T 11364. This is available on request from Renishaw.

1.5 China RoHS

For more information on China RoHS, visit:
Product compliance – Additive manufacturing (renishaw.com)

1.6 Changes to equipment

Renishaw reserves the right to change equipment specifications without notice.

2 Introduction

Renishaw has developed InfiniAM® Spectral software to monitor and provide feedback on the optical emissions from the Additive Manufacturing (AM) process. This feedback helps in understanding component build quality before and after the build is completed, and in monitoring laser input characteristics and beampath spectral emissions.

Data on a build is captured by the LaserVIEW™ and MeltVIEW™ hardware and saved to the AM system Personal Computer (PC). It is then transferred from the AM system PC using a standard 1 Gigabit or 10 Gigabit Ethernet connection to a Data Collection PC. The Data Collection PC uses DataHUB software to process the build data into volumes that can be viewed on a viewing PC installed with InfiniAM Spectral software. Volumes can also be transferred to a back-up/storage server for archiving purposes if required by the user.

The objective of this user guide is to provide detailed information and instructions on how to use the features and functionality of the InfiniAM Spectral software. It includes guidance on navigating the software, interpreting data and results, customising monitoring parameters, and addressing common issues.

2.1 Intended use

InfiniAM provides a robust platform for monitoring and analysing the Renishaw AM processes. It facilitates real-time data collection and visualisation, enabling you to observe and optimise the performance of your 3D printing operations. InfiniAM Spectral displays volume files generated by DataHUB from LaserVIEW or MeltVIEW Additive Manufacturing Process Monitoring (AMPM) data. InfiniAM Spectral can display volumes that are either fully completed or in progress, displaying only the sections of data that have been processed.

2.2 Applicability

InfiniAM supports the RenAM 500 series models: 500, 500 Ultra, and 500 Flex. Earlier Renishaw AM platforms are not supported. For further information regarding the suitability of your system, contact Renishaw.

NOTE: InfiniAM does not support the RenAM 500M AM system.

2.3 Reference documentation

In addition to this installation guide, refer to the following documents for additional information about other aspects of the InfiniAM system, DataHUB and the RenAM 500 series.

- RenAM 500 series additive manufacturing system installation guide (Renishaw part no. H-5800-3692)
- RenAM 500 series additive manufacturing system user guide (Renishaw part no. H-5800-3693)
- InfiniAM and DataHUB software installation guide (Renishaw part no. H-5800-4349)
- InfiniAM Camera user guide (Renishaw part no. H-5800-4675)
- DataHUB user guide (Renishaw part no. H-5800-4761)
- DataHUB developer manual (Renishaw part no. H-5800-4762)

2.4 Critical information in this guide

Within this user guide additional information that is important to read and understand is presented as a warning, caution or note. The definition of each of these and an example of each is given below.

2.4.1 Warning

An example of a warning is as follows:

WARNING: A warning is to tell the end user that there is a possibility of injury to themselves or other people in the vicinity if the described course of action is not followed.

2.4.2 Caution

An example of a caution is as follows:

CAUTION: A caution is to tell the end user that there is a possibility of damage to the equipment if the described course of action is not followed.

2.4.3 Note

An example of a note is as follows:

NOTE: A note is to advise the end user of important information that is related to, or will assist them in the task or activity they are carrying out.

3 Safety

WARNING: All safety information is in accordance with the applicable Renishaw AM system user guide and installation guide – unless otherwise stated within this document.

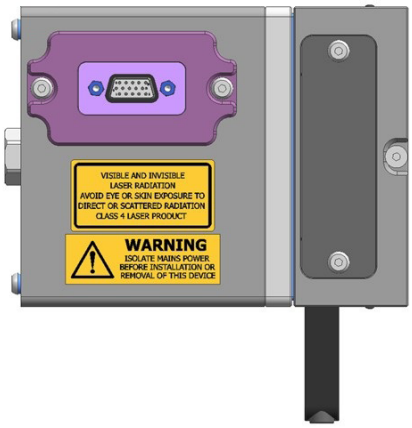
WARNING: Ensure that a blanking plate or the MeltVIEW hardware module is fitted to the laser aperture before turning on the AM system laser.

WARNING: The MeltVIEW hardware module is not interlocked to the laser safety circuit. If the MeltVIEW hardware module is removed and the laser is fired, harmful laser light will be emitted from the laser aperture on the AM system.

3.1 InfiniAM specific laser and warning labels

Additional InfiniAM specific laser and warning labels are fitted to the MeltVIEW module. They are as follows:

1. Class 4 custom laser specific label positioned on the MeltVIEW module below the cable connection.



Part no. P-LA01-0047

2. Electrical warning label positioned on the MeltVIEW module below the cable connection.

Part no. M-6491-0701-01

4 Spare parts

Our equipment is sold subject to the terms and conditions of sale supplied with your purchase of the system, or available on request from your local Renishaw office: **www.renishaw.com/contact.**

All components and sub-assemblies are subject to rigorous quality control. Components purchased from sub-suppliers, such as ball bearings, electric motors or hydraulic cylinders, are supplied in accordance with Renishaw specifications. Renishaw will not honour any warranty claims where faults arise due to non-OEM replacement parts being fitted.

When ordering spare parts, quote the following:

- Description of the spare part and its part number, if known
- Equipment name and model
- Serial number
- Year of manufacture

Details of your Renishaw AM system can be found on the serial number plate on the rear of the AM system. Details of the MeltVIEW module can be found on the serial number plate which is visible when InfiniAM is installed on the Renishaw AM system. Details of the CameraVIEW hardware can be found on the sticker situated on the rear of the camera. The CameraVIEW hardware can be found behind a cover above the chamber.

There are no user-serviceable parts within the InfiniAM system. In the event that the InfiniAM system fails, repair is by exchange of the affected module with a serviceable module from Renishaw. The replacement module will be installed, commissioned and tested by a Renishaw Service engineer.

NOTE: For the contact details of your local Renishaw office or to arrange a service visit, see section 11, “Customer support”.

The InfiniAM and DataHUB software will be periodically updated. All subscription users will be entitled to download the latest software release from their **MyRenishaw** account.

5 Software set-up

Technical specifications may change from time to time. Renishaw reserves the right to change any technical specification at any time. Any specification not listed in the table below is available upon request. See section 11, “Customer support”, for the contact details of your local Renishaw office.

For the Renishaw AM system installation or user guide, contact your local Renishaw office.

5.1 Hardware specification

NOTE: All dimensions are quoted length × width × height.

InfiniAM MeltVIEW module dimensions	140 mm × 105 mm × 189 mm (5.5 in × 4.1 in × 7.5 in)	
Power supply	24 V powered from the Renishaw AM system	
Monitoring range	700 nm to 1700 nm	
AM emissions monitored	Plasma Melt-pool Laser	700 nm to 1040 nm 1090 nm to 1700 nm 1050 nm to 1080 nm
Optical configuration	Co-axial (in-line) to laser beampath	
Sampling rate	≥ 100 kHz	
Sampling resolution	Photodiodes XYZ feedback	12 bit 16 bit
Field-of-view	Plasma Melt-pool	6.3 mm (0.248 in) diameter 2.6 mm (0.102 in) diameter
Measurements taken	Motion control position, focus, laser power and feedback	
Data storage	Up to 7 hours of build data	
Operating temperature range	15 °C to 28 °C ambient (59 °F to 82 °F)	
Operating ambient humidity	15% to 60% RH	
Operating vibration range	58.1 Hz to 500 Hz @ 10 ms^{-2} (1 g)	
Material compatibility	All Renishaw supplied AM metal powders	

5.2 PC hardware specification

5.2.1 Data Collection PC hardware specification (customer-supplied)

Processor	Minimum	Intel i7 quad core (or equivalent)
Graphics card	Minimum	NVIDIA card with at least 10 GB RAM, At least 3500 CUDA cores Compute capability 6.1 or higher (for example, GeForce GTX 1080 Ti, GeForce RTX 3080)
RAM	32 GB DDR4	
Solid state drive	Minimum Recommended	N/A 4 TB
Hard disk drive	10 TB	
Ethernet	1 × 10 Gigabit Ethernet port	

5.2.2 InfiniAM viewing PC specification (customer-supplied)

Processor	Minimum	Intel i7 quad core (or equivalent)
Graphics card	Minimum	NVIDIA card with at least 4 GB RAM (for example, GeForce GTX 1050 Ti, GeForce GTX 1650)
	Recommended	NVIDIA card with at least 8 GB RAM (for example, GeForce GTX 1080, GeForce RTX 3070)
RAM	32 GB DDR4	
Solid state drive	Minimum Recommended	0.5 TB > 1 TB
Hard disk drive	Minimum Recommended	4 TB > 10 TB

5.2.3 Data storage/back-up server (customer-supplied)

Storage memory	> 80 TB

5.3 InfiniAM software pre-installation questionnaire

Customer-supplied equipment			
1.1	Is a 1 Gigabit or 10 Gigabit Ethernet with Cat6 cabling available?		☐ Yes
1.2	Is a Data Collection PC available to the specification listed in section 5.2.1?		☐ Yes
1.3	Is an InfiniAM viewing PC available to the specification listed in section 5.2.2?		☐ Yes
1.4	Is a data storage/back-up server available to the following specification:		☐ Yes
	Storage memory	> 80 TB	

Data Collection PC requirements		
2.1	Is the Data Collection PC configured with an FTP server that can be accessed from the Ethernet location of the AM system PC?	☐ Yes
2.2	Is Ethernet communication possible between the AM system and the Data Collection PC?	☐ Yes
2.3	Is Microsoft IIS available on the Data Collection PC?	☐ Yes
2.4	Is administrator access available for the Data Collection PC?	☐ Yes
2.5	Is a static IP address available for the Data Collection PC or a domain name so that the Data Collection PC can be accessed by the AM system?	☐ Yes

NOTE: Renishaw will not be able to install and run the software effectively if the Data Collection PC does not meet this specification.

NOTE: The Data Collection PC does not need to be a desktop machine with a monitor – it can be accessed through remote desktop connection if needed.

5.4 InfiniAM installation and activation

1. When you order InfiniAM and DataHUB, your sales representative will request an email address. Entitlement IDs for InfiniAM and DataHUB will be sent to this email address.

2. Along with the installation bundles for InfiniAM and DataHUB, you will also receive an installer for the Renishaw Licence Manager.

3. Follow the instructions in the Renishaw Licence Manager user guide for details on how to set up the floating licence server and activate your entitlements.

4. Install InfiniAM and DataHUB in accordance with the *InfiniAM and DataHUB software* installation guide (Renishaw part no. H-5800-4349). If required, contact your nearest Renishaw office. For more information, see section 11, “Customer support”.

6 Commissioning and decommissioning

6.1 Commissioning

The InfiniAM system will be commissioned by a Renishaw Service engineer. See section 11, “Customer support”, for the contact details of your local Renishaw office.

WARNING: The AM system must be electrically isolated before any work is carried out. Isolate it at the mains power supply by moving the main switch to the 0 or OFF position and locking it with a personal padlock. Attach a visible warning sign to indicate that the system is isolated. Carry out safe isolation procedure checks in accordance with IEE standards.

6.2 Decommissioning

The InfiniAM system will be decommissioned by a Renishaw Service engineer. See section 11, “Customer support”, for the contact details of your local Renishaw office.

WARNING: The AM system must be electrically isolated before any work is carried out. Isolate it at the mains power supply by moving the main switch to the 0 or OFF position and locking it with a personal padlock. Attach a visible warning sign to indicate that the system is isolated. Carry out safe isolation procedure checks in accordance with IEE standards.

7 System description

The Renishaw AM process creates homogeneous solid metal components, using high-powered laser energy to melt fine powder, manufacturing parts directly from 3D CAD data.

The aim of this document is to describe to a Renishaw AM system user how to use the Renishaw InfiniAM system, including hardware and software. This will include a description of how to operate the InfiniAM Spectral software and also describe any procedures that are unique to the InfiniAM system.

This user guide has been written based on the assumption that the Renishaw AM system has been fitted with the appropriate hardware (LaserVIEW and/or MeltVIEW), the InfiniAM software and DataHUB software have been installed, the Data Collection PC has been set up and all system hardware and software has been commissioned and tested by a Renishaw Service engineer.

Renishaw has developed the InfiniAM system (see Figure 1 and Figure 2) to monitor and provide feedback on the optical emissions from the AM process. This feedback is essential for understanding component build quality during and after the build process, as well as for monitoring laser input characteristics and beam path spectral emissions.

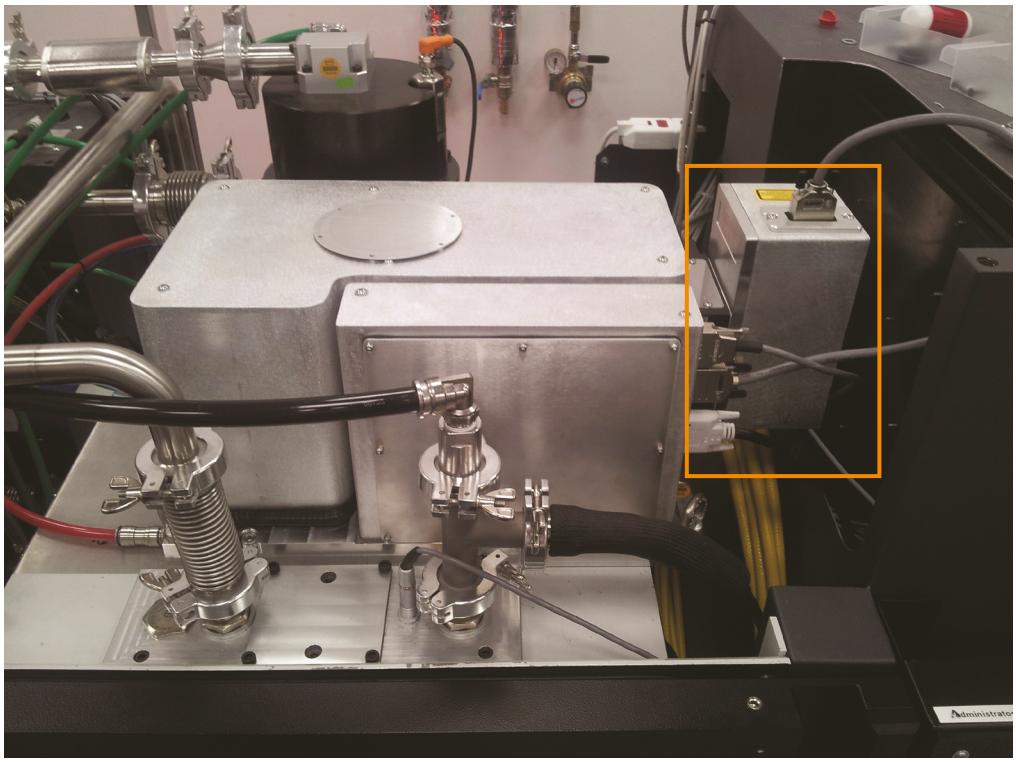


Figure 1 MeltVIEW module installed on a Renishaw AM system

Data on a build is captured by the LaserVIEW and MeltVIEW hardware and written to the AM system PC. It is then transferred from the AM system PC using a standard 1 Gigabit or 10 Gigabit Ethernet connection to a Data Collection PC. The Data Collection PC uses DataHUB software to compile the build data into volumes which can then be viewed on a viewing PC with InfiniAM Spectral software installed (see Figure 3). If required by the user, volumes can then be transferred to a back-up/storage server for archiving purposes.

On the Data Collection PC, photodiode data is processed into a volume file in near real time on a layer-by-layer basis. The volume files contain spatial representations of the data that can be inspected in both 2D and 3D. The processing is carried out by the Renishaw DataHUB software.

DataHUB can be configured to selectively capture all or part of the build and sensor data.

InfiniAM Spectral is data visualisation software. It enables the user to visually inspect data from the LaserVIEW and MeltVIEW hardware via volume files produced by DataHUB. The data can be inspected either as a 3D representation at a resolution of 240 µm (0.009 in), or as individual layers in 2D with a resolution of either 40 µm (0.0015 in) or 150 µm (0.006 in), depending on the volume type.

Tools are available to manipulate how the data is displayed, enabling different features to be drawn out to aid interpretation.

It is also possible to compare different layers – either from the same build or from different builds – in order to assess build consistency.

7.1 The LaserVIEW and MeltVIEW modules

RenAM systems equipped with LaserVIEW and MeltVIEW modules capture the intensity of the laser output and the intensity of light reflected from the fusion substrate back along the optical train. InfiniAM allows you to visualise the captured intensities in 2D and 3D representations of the build, providing an understanding of the laser quality and fusion at various points in the build. It also helps to detect the outliers that may indicate issues such as poor energy absorption or over-melting.

Each laser is equipped with a dedicated LaserVIEW/MeltVIEW module that captures three channels of data:

- LaserVIEW – captures the power of the laser as it enters the build chamber.
- MeltVIEW (Melt-pool) – captures back-reflected light with wavelengths ranging from 1090 nm to 1700 nm, which approximately corresponds to the light emitted by the melt-pool.
- MeltVIEW (Plasma) – captures back-reflected light with wavelengths ranging from 700 nm to 1040 nm, which correlates to the light emitted by the plasma cloud above the melt-pool.

7.1.1 MeltVIEW

Renishaw has developed a module which monitors the optical emissions from the AM process across a wide spectral range.

The MeltVIEW module is an in-line opto-mechanical system which integrates seamlessly into Renishaw AM systems. The device is passive and does not interfere with the laser beam line or interrupt or corrupt the signals to and from the motion control system. The co-axial optical configuration gives a view of the bed which is determined by the laser scanning system, ensuring the melt-pool remains in focus of the sensors throughout the build.

Optical coatings within the system have been tailored to enable the light emitted from plasma and the melt-pool to propagate to the sensors, whilst rejecting the blinding back-reflected laser light. Emissions from both plasma and the melt-pool are in the near-infrared spectrum.

High optical magnification in a compact form factor ensures the field-of-view of the system is sufficiently small. A magnified image of the melt-pool is projected on to the sensors and fills the active region – the surrounding regions have negligible contribution to the signal.

7.1.2 LaserVIEW

The laser monitoring module measures the output of the laser in a Renishaw AM system. At the core of the system is a photodiode which delivers high-speed performance at the laser wavelength. An infrared sensitive photodiode located behind the first turning mirror in the Renishaw optical module is used to capture leakage laser light. In doing so, a measurement is made without disrupting the laser beam characteristics.

The system captures the energy contained in every laser pulse during a build, and short-term deviations or long-term drift in laser output can be easily identified on a layer-by-layer basis.

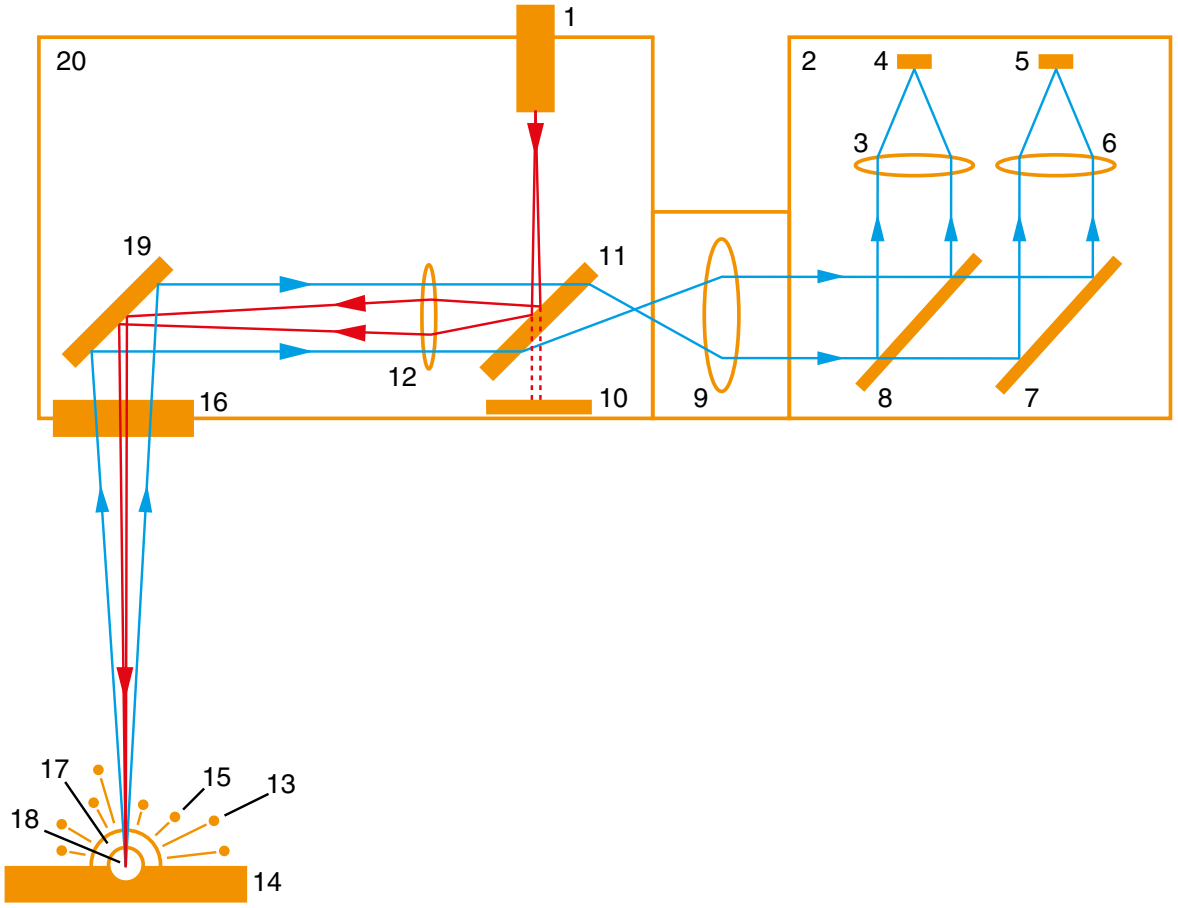
7.2 Operating principle

Figure 2 shows the Renishaw optical module (20), the LaserVIEW hardware module (10) and the MeltVIEW hardware module (2).

A fibre laser (1) emits intense laser light which reflects from a fixed mirror (11) and passes through a dynamic focusing system (12). A small percentage of the laser light leaks through the first turning mirror and impinges on a photodiode (10). The beam is reflected from a two-axis galvanometer mirror system (19), passes through an optical window (16) and comes to a focus on the powder bed (14) of the Renishaw AM system.

The interaction of the intense laser beam with metal powder results in a melt-pool (18) and plasma (17). Plasma and melt-pool both emit in the near-infrared spectrum (700 nm to 1700 nm). Radiation is emitted in all directions, with a small proportion propagating back up the beam line of the Renishaw optical module. The coating on the first turning mirror has been tailored to reflect visible and infrared wavelengths outside the primary laser wavelength. Therefore plasma and melt-pool emissions pass through the mirror and into the MeltVIEW module.

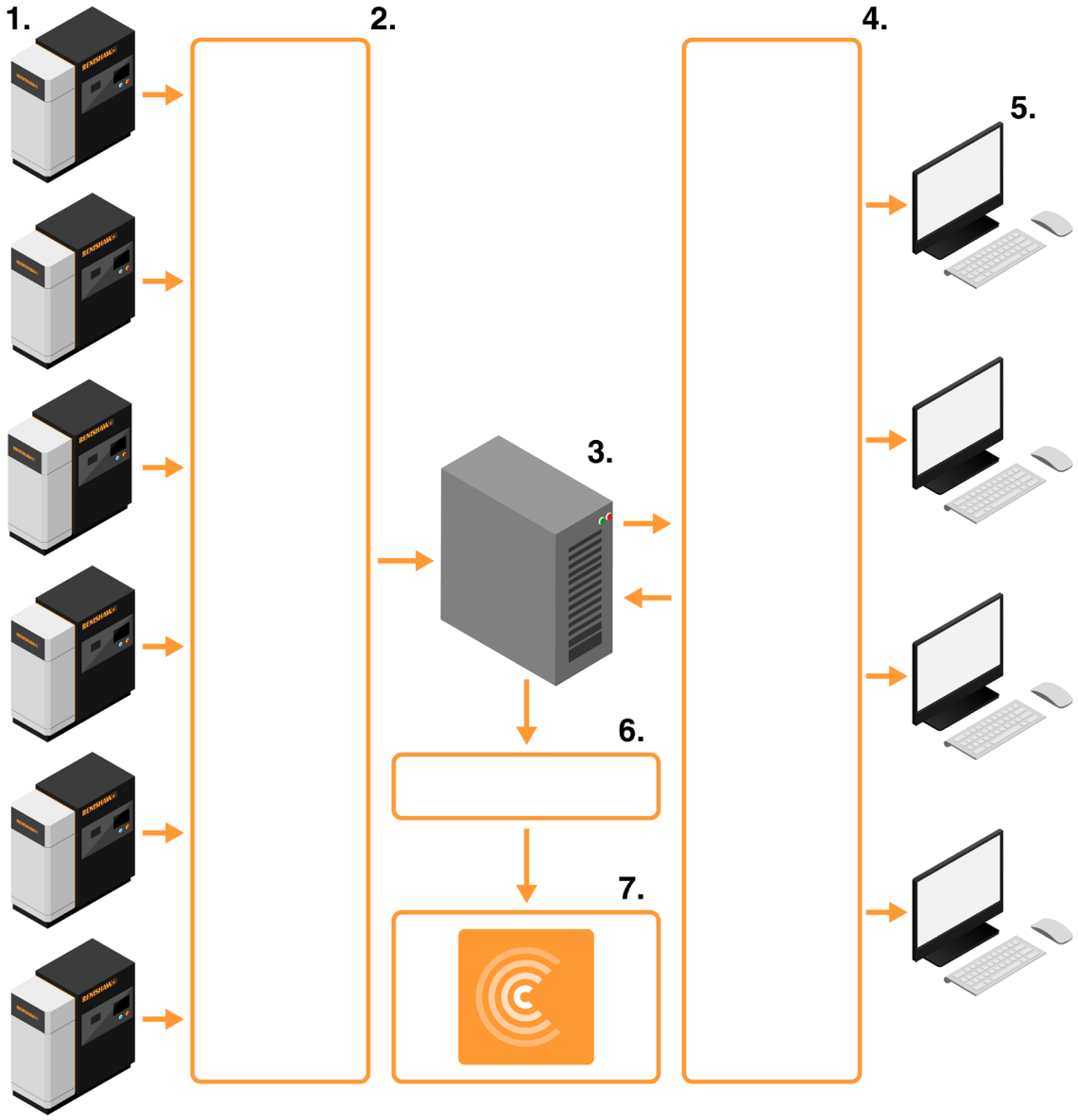
Near-infrared emissions from plasma are separated from the near-infrared emissions from the melt-pool using mirrors (8 and 7). Plasma emissions (700 nm to 1040 nm) are focused onto the surface of an infrared sensitive photodiode (4), whilst melt-pool emissions (1090 nm to 1700 nm) are focused onto the surface of a infrared sensitive photodiode (5).



1	500 W ytterbium fibre laser
2	MeltVIEW hardware module
3	Focusing lens
4	MeltVIEW plasma near-infrared photodiode
5	MeltVIEW melt-pool near-infrared photodiode
6	Focusing lens
7	Mirror
8	Mirror
9	Collimation lens
10	LaserVIEW system photodiode

11	Fixed mirror
12	Dynamic focusing lens
13	Sparks
14	Powder bed
15	Droplets of molten material
16	Optical window
17	Plasma
18	Melt-pool
19	Galvanometer mirror
20	Renishaw optical module

Figure 2 The anatomy of an InfiniAM Spectral-equipped AM system



1	Single or multiple Renishaw AM systems FTP data via a 1 Gigabit or 10 Gigabit Ethernet connection
2	1 Gigabit or 10 Gigabit Ethernet connection supporting single or multiple Renishaw AM systems
3	Data Collection PC with DataHUB software

4	1 Gigabit Ethernet connection
5	Viewing PC with InfiniAM software
6	1 Gigabit Ethernet connection
7	Renishaw Central

Figure 3 How data is transferred from Renishaw AM systems via a Data Collection PC to viewing PCs

7.3 Understanding InfiniAM Spectral datasets

The InfiniAM Spectral hardware records either the power of the laser entering the chamber or the back-reflected light escaping from it, sampling at a frequency of 100 kHz. These samples are aggregated to generate a heat map representing power distribution across each layer for a specific channel. During operation, lasers may fire at the same position on the build plate multiple times per layer due to factors such as laser dwell time, slower scan speed relative to sampling rate, or overlapping paths of two or more lasers. To address this issue, either the maximum intensity among coincident samples is used (Max), or the samples are accumulated together (Sum). These layers are then composed into a 3D volume which InfiniAM can display. This data can be viewed either as high-resolution images of the layers themselves in the Z planar View or lower resolution interpolated slices in the X and Y planar views.

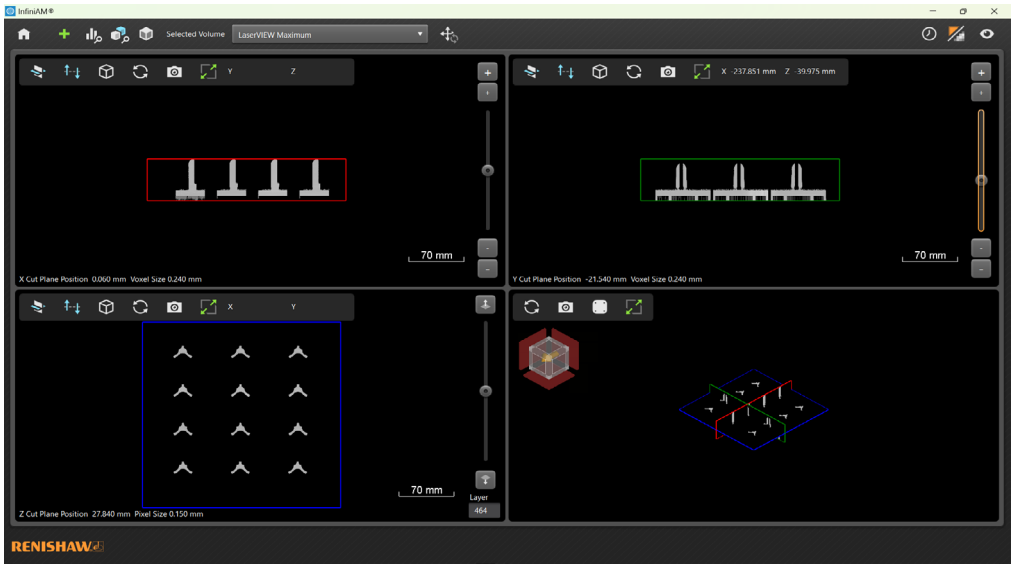


Figure 4 Viewing a dataset in 2D

In addition, the same data can be viewed in 3D within any of the planar views. Data above or below a cut plane along the axis of the view can be excluded as needed.

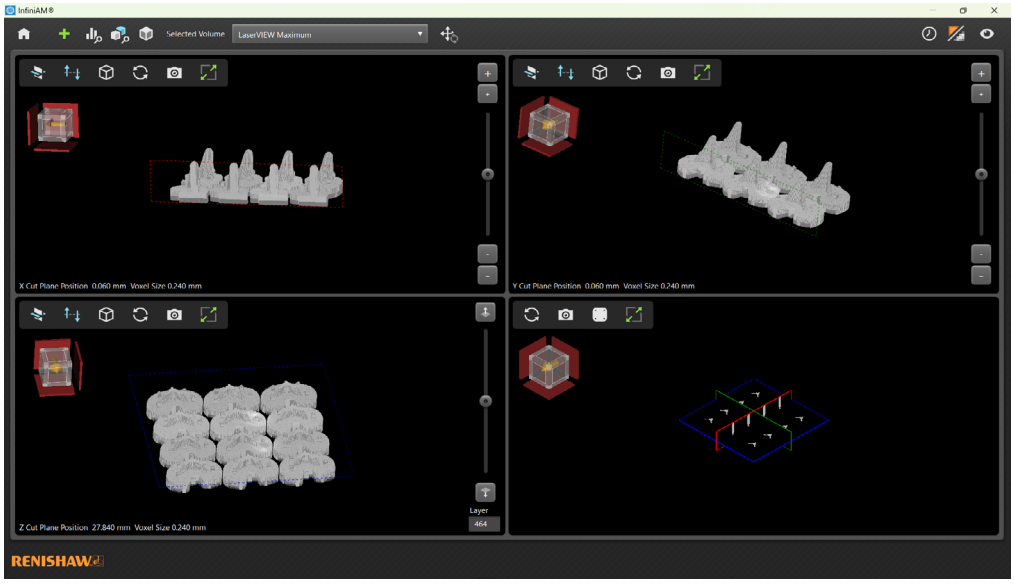


Figure 5 Viewing a dataset in 3D

The LaserVIEW channel can be used to analyse variations in the actual laser power entering the chamber. This data helps to identify the potential issues with the laser and provides a baseline for detecting regions with unusual energy absorption when compared to a MeltVIEW channel.

The MeltVIEW channels can be used to analyse variations in absorbed energy. As it measures the energy escaping the process, with consistent input power and absorption, the back-reflected energy is expected to maintain a consistent ratio relative to the absorbed energy. A lower MeltVIEW value compared to neighbouring values indicates that more input energy has been absorbed, which may correspond to increased melting. Conversely, a higher MeltVIEW value indicates less input energy has been absorbed, potentially corresponding to poor fusion.

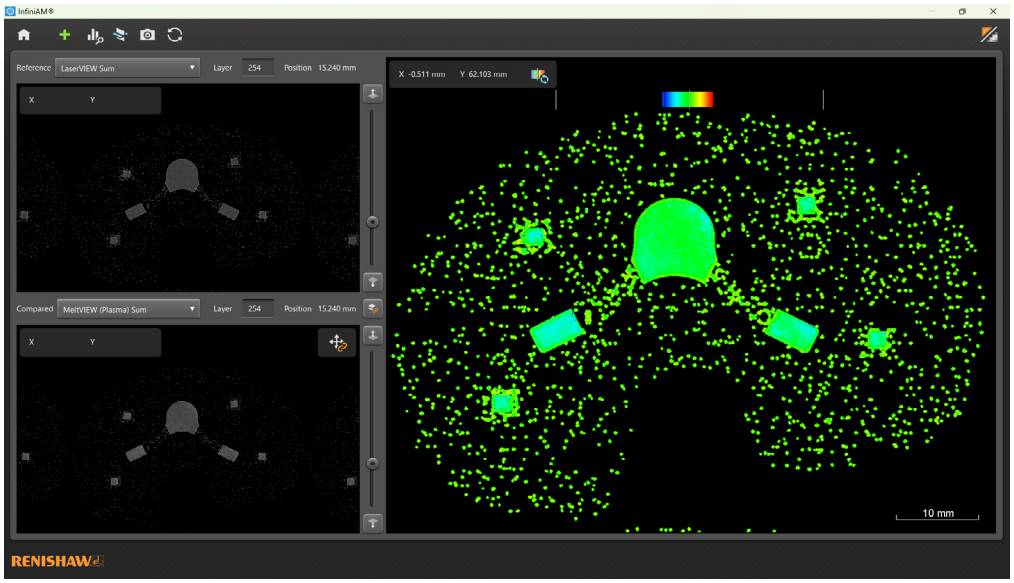


Figure 6 Comparing LaserVIEW (input) with MeltVIEW (output)

Spectral datasets can be compared to one another. Examples of potentially useful comparisons are:

- Parts within the same volume, especially when multiple identical parts are produced in a build
- Neighbouring layers within the same volume
- Equivalent layers across different builds of the same parts
- Equivalent layers from the same build collected by different sensors, such as comparing MeltVIEW (melt pool) and MeltVIEW (plasma)

Each channel displays unique characteristics and thus produces distinct “normal” histograms. The differences between channels should be reconciled accordingly.

8 Operation

InfiniAM Spectral displays volume files generated by DataHUB from LaserVIEW or MeltVIEW AMPM data. InfiniAM Spectral can display volumes that are complete or volumes that are still being processed, in which case only the processed sections of the data will be displayed.

8.1 Loading InfiniAM Spectral dataset

NOTE: A single Data Collection PC can accommodate several AM systems. It can also accommodate several viewing PCs using the InfiniAM software simultaneously.

After opening the InfiniAM Spectral, the 'Load an InfiniAM Spectral Dataset' dialog box allows you to select the datasets for analysis.

8.1.1 Screen layout

1 Volume File

Displays the path of the currently selected dataset. Initially, no dataset will be selected. If the selected file is invalid, 'Volume File' will be outlined in red. Click the 'Browse' button to open a dialog box that allows navigation through the file system to locate an InfiniAM Spectral dataset.

2 Volume Description

Displays the description if the selected dataset is valid.

3 **Alias (optional)**

Enter a name into ‘Alias’ to help identify the dataset on the InfiniAM Spectral screen. If no alias is provided, the dataset location (‘Volume File’) will be used instead.

4 **Load Volume**

Click this button to add the selected dataset to the list of loaded datasets with the current alias. Performing this action will reset the ‘Volume File’ and ‘Alias’, thereby preparing the ‘Volume Description’ for the selection of additional datasets.

5 **Loaded Volume**

Displays all the datasets that have been loaded so far, including any aliases assigned to them.

6 **Remove Volume**

Click the ‘Remove Volume’ button next to any dataset listed in ‘Loaded Volumes’ to unload that dataset, making it unavailable in InfiniAM Spectral.

7 **Cancel**

Returns you to the home screen.

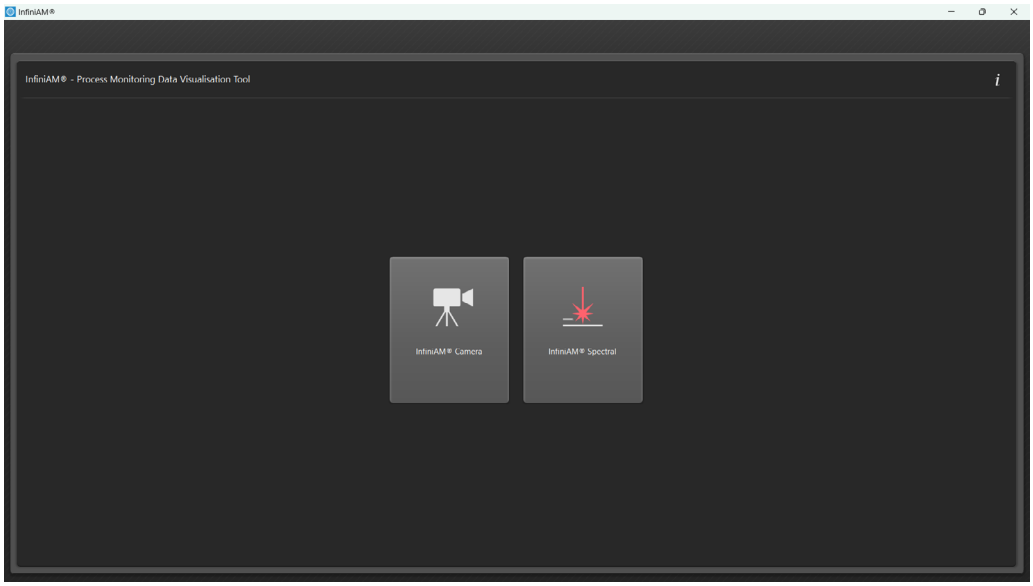
8 **OK**

Click this button to access the ‘InfiniAM Spectral – Display’ screen, which shows all loaded datasets. If no datasets are loaded, the ‘OK’ button will be disabled.

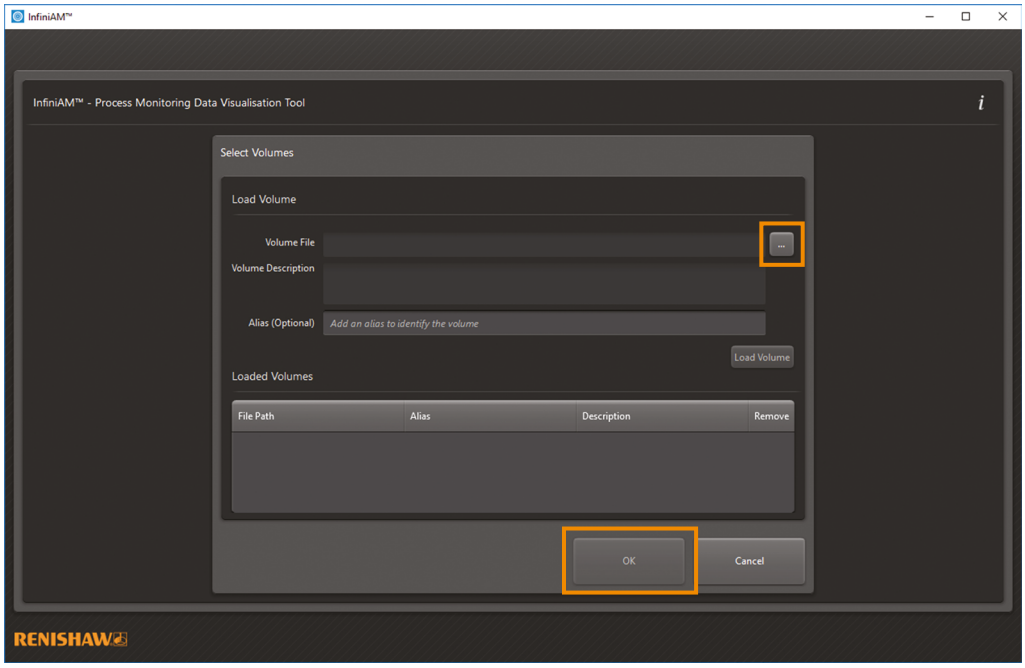
8.1.2 Viewing volume files using InfiniAM software

1. Open the InfiniAM software.

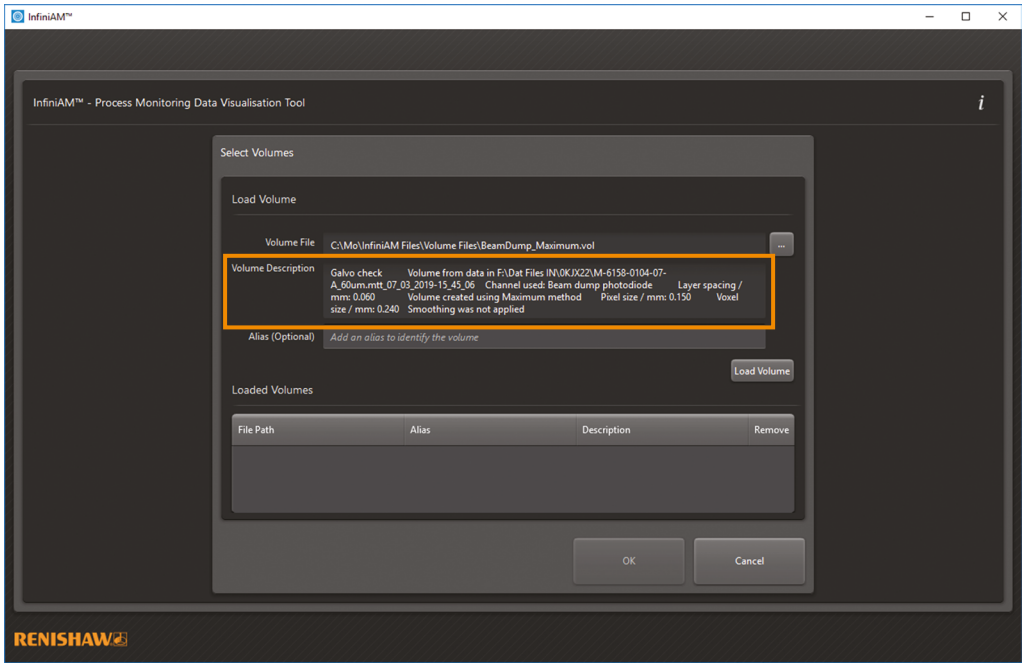
2. From the ‘Home’ page select the ‘InfiniAM Spectral’ button.



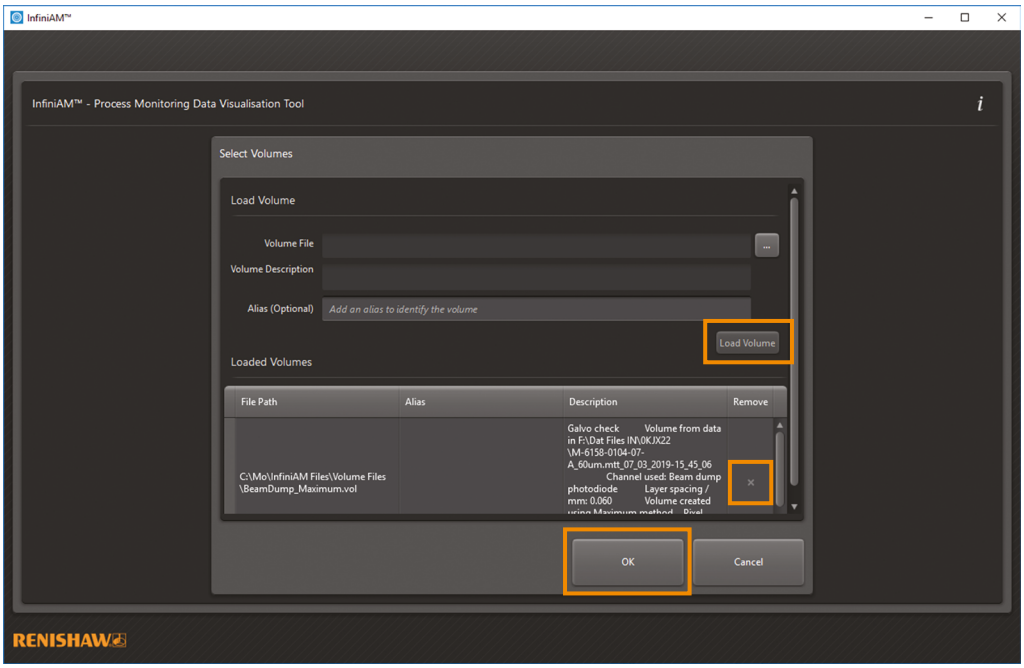
3. The ‘Select Volumes’ page is displayed. To select the volume to be viewed, select the browse ‘…’ button. This opens a dialog box and enables you to browse to the *.vol file generated by DataHUB. Locate the *.vol file to be viewed and select ‘OK’.



4. A description of the volume will now be displayed in the ‘Volume Description’ box. To ease later identification, it is possible to add a short descriptive alias. If this is not added, the file path of the volume will be added automatically to act as an identifier.



5. Select the ‘Load Volume’ button to add the volume to the list that will be available for viewing. A volume can be removed from this list by selecting the ‘x’ button in the ‘Remove’ column of the ‘Loaded Volumes’ list.

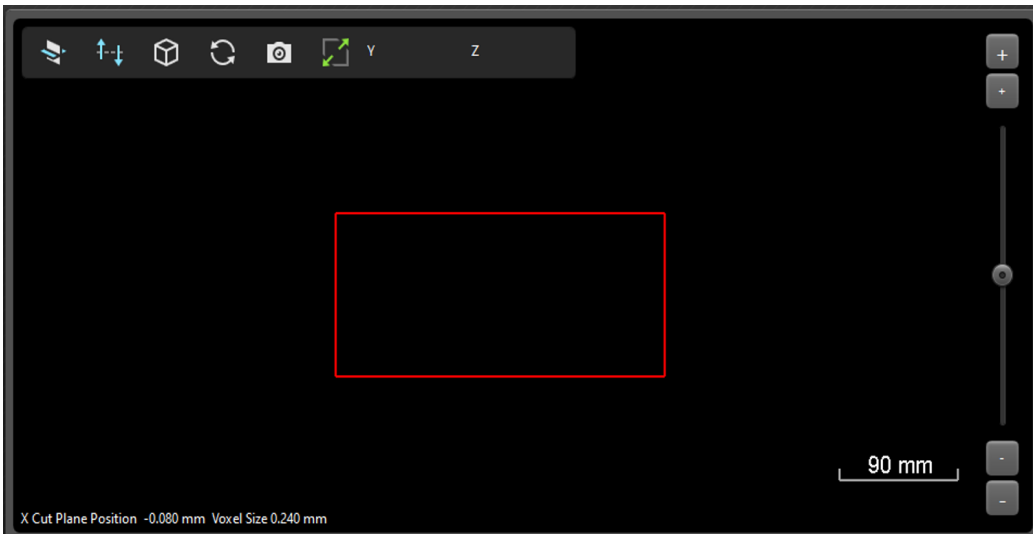


6. Click the ‘OK’ button to proceed to view the volumes in the main viewing mode.

8.1.3 InfiniAM Spectral basic navigation controls

Use the following mouse controls for navigating around a volume file.

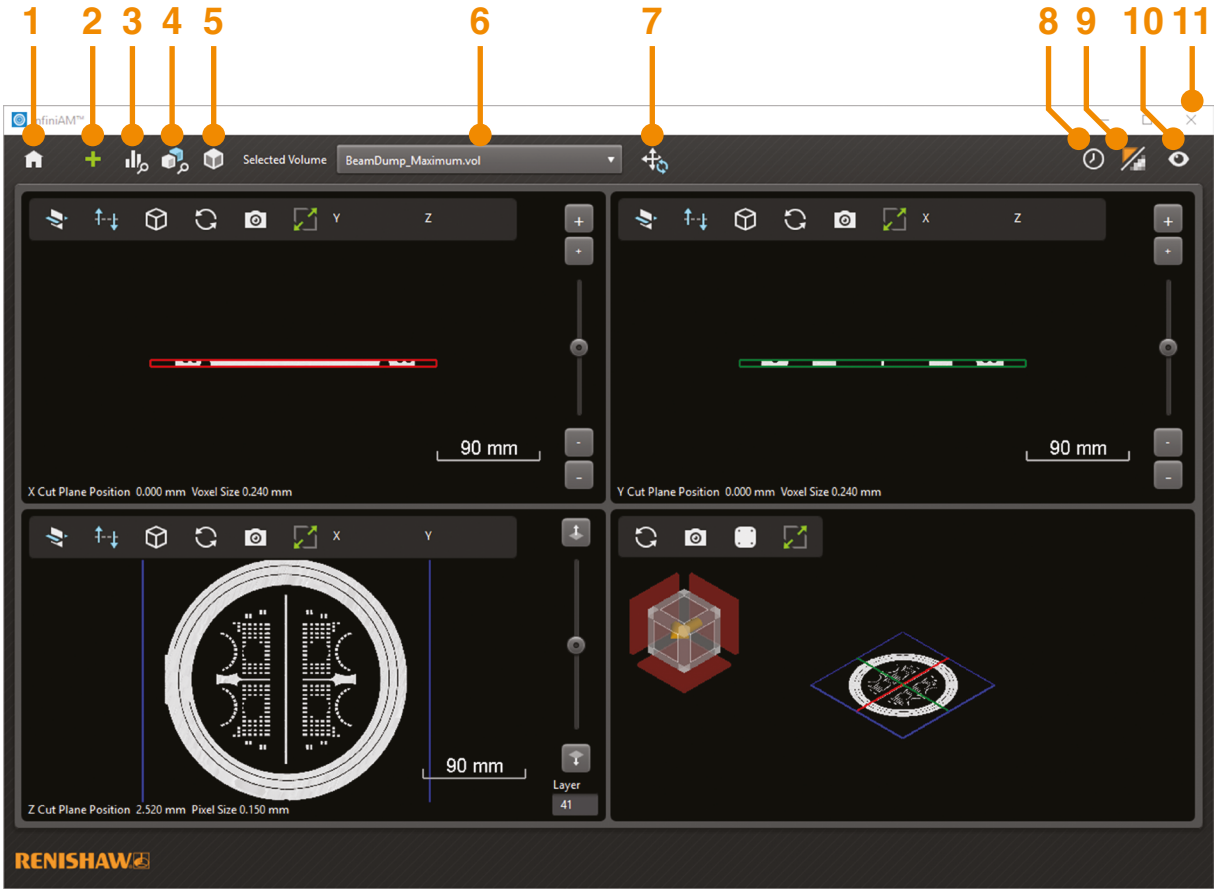
- **Pan**: Select and drag using the right mouse button.
- **Zoom**: hold down the middle mouse button, drag forwards to zoom in and backwards to zoom out; or scroll the middle mouse wheel forwards to zoom in and backwards to zoom out.
- **Rotate (3D mode only)**: Select and drag using the left mouse button. The volume will rotate around the centre of the build plate.
- **Measurement (2D mode only)**: Double-click on the view to begin the measurement from that point, move the mouse to the end measurement point and single-click to stop measuring. The measurement distance (in mm) is then displayed at the bottom of the quadrant. To clear the measurement, simply single-click anywhere within the view.



8.2 Analysing an InfiniAM Spectral Dataset

8.2.1 InfiniAM Spectral toolbar controls

In the Volume view, the InfiniAM Spectral toolbar contains the following controls.



1 

Home

Opens the ‘Home’ page. All the currently open volumes will be unloaded.

2 

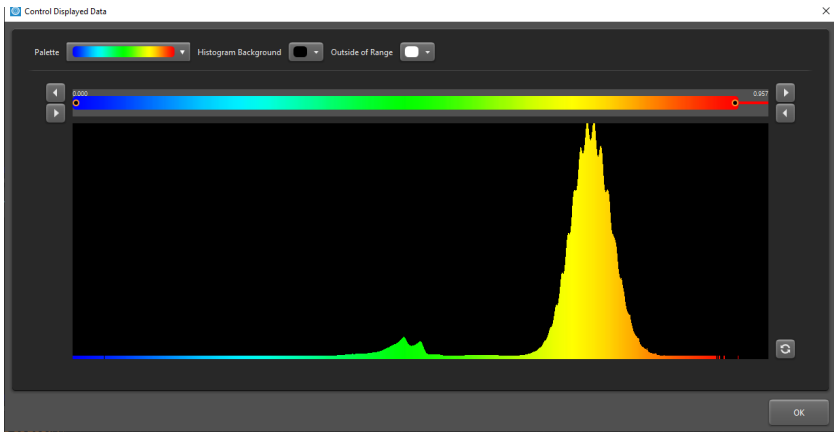
Manage Volumes

Opens the ‘Load Volumes’ dialog box and enables further volumes to be loaded. Existing volumes can also be removed.

3 

Control Displayed Data

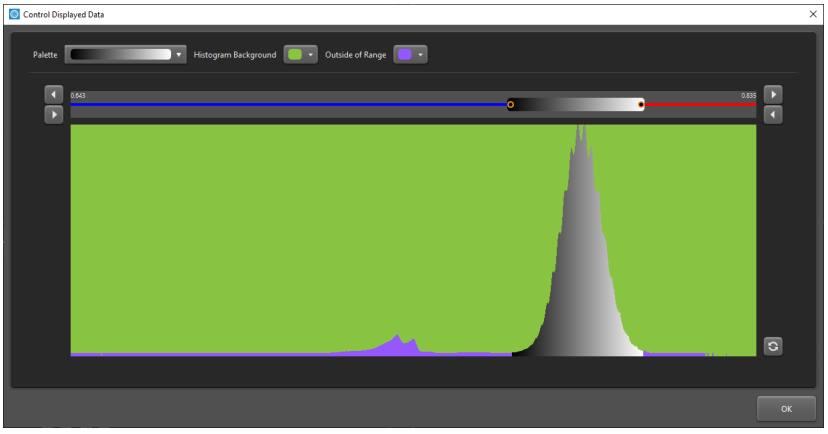
Opens the ‘Control Displayed Data’ tool. This contains a histogram displaying the distribution of pixel values throughout the whole volume. It may contain multiple peaks corresponding to different regions of the build – for example, borders may correspond to one peak and bulk hatching to another. If there are significant anomalies in the build data, these may also give rise to a peak in the histogram.



The ‘Control Displayed Data’ tool allows you to select sub-sets of the data to display. Only the data range currently covered by the palette slider is rendered in the volume view. The length of the slider can be adjusted either by clicking and dragging the ends or by selecting the arrows at either end. The position of the slider can be adjusted by clicking and dragging in its centre. Clicking the reset button will reset the selected range back to the default range.

NOTE: The data being displayed updates dynamically as the slider and the palette are changed. It is often useful to have the ‘Control Displayed Data’ tool open throughout the inspection process, especially if InfiniAM Spectral is being run with a dual-monitor set-up.

The following image displays the ‘Control Displayed Data’ tool with histogram background and outside of range colours selected so they do not clash with the palette colour.



4 

Compare Volumes

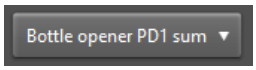
Opens a new screen which displays a comparison between two layers in the same or different volumes.

5 

Orthographic/Perspective View

Orthographic: the build is represented with right angles and parallel lines.

Perspective view: the view is optimised to give a more natural view of the build. Toggle between the two views by selecting the button.

6 

Selected Volume

The histogram background colour may need to be adjusted depending on the colour scheme selected. This only affects the histogram view.

7 

View Reset

Resets the pan, zoom and rotation of the views when volumes are changed.

8 

Sync Current Volume

Selecting this will automatically update the volume data from a live build.

NOTE: This only applies to 3D data. The data displayed in the Z cut plane view will update automatically as more 2D data becomes available.

9 

Interpolated/Pixelated

Selecting this gives the choice of two views of the build, either the Interpolated or the Pixelated view. This controls the way in which pixels and voxels are represented. With the Interpolated view (default), smoothing is applied to give a more realistic representation of the data. With the Pixelated view, no smoothing is applied and hence the pixel and voxel edges are more distinct. Toggle between the two views by selecting the button.

10 

Change Displayed Data Region

This function is useful for initial inspection of a build, as it enables areas of particularly high or low signal to be easily highlighted.

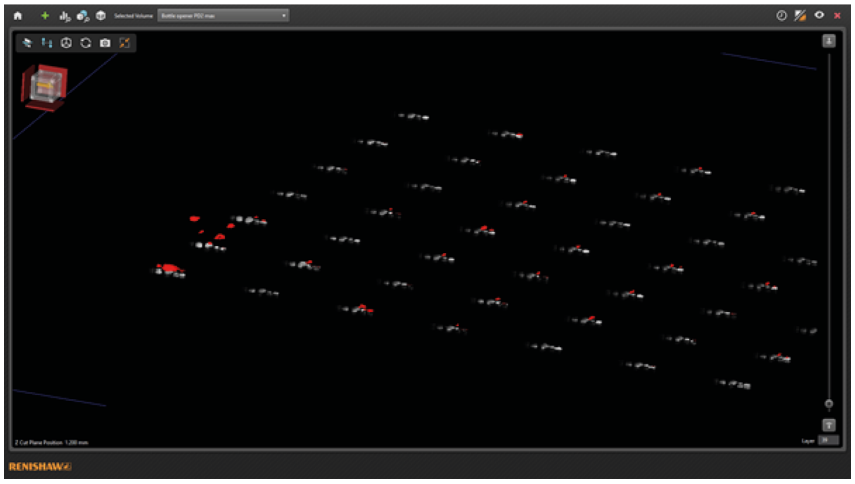


Figure 7 Z cut plane view in 3D mode with the displayed data region set to high. In this example there are areas of unusually high signal in the left corner which are clearly highlighted.

For views which are set to 3D mode, the selected data region is displayed on one side of the cut plane, and the other side is shaded using the 'Within Bounds' setting. For views which are set to 2D mode, only the selected data region is displayed.

The 'Change Displayed Data Region' comes with three options:

10a **Within Bounds**

This displays the data range covered by the palette slider in the 'Control Displayed Data' control. The data is shaded using the currently selected palette.

10b **High**

This displays the data range above what is covered by the palette slider in the 'Control Displayed Data' control. The data is shaded red.

10c **Low**

This displays the data range below what is covered by the palette slider in the 'Control Displayed Data' control. The data is shaded blue.

11 

Close window

Selecting this closes the window and exits the InfiniAM application.

8.2.1.1 Visualising data using control displayed data tool

The ‘Control Displayed Data’ tool window provides a central interface for modifying the presentation of data. By default, InfiniAM Spectral displays all data, but you can select a subset of the data defined between a minimum value and a maximum value, ignoring all data outside of that range. The selected data will be evenly distributed across a colour palette.

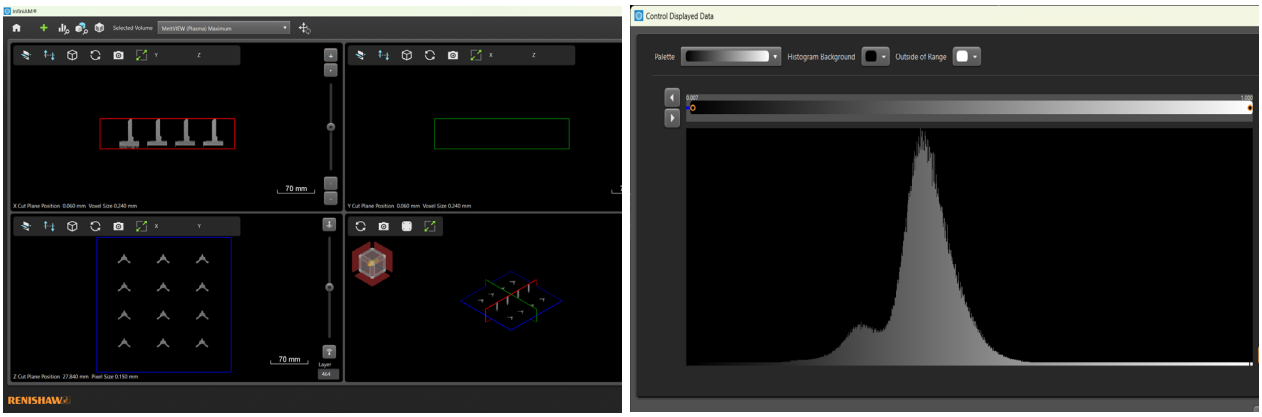


Figure 8 All data displayed

The selected range is aligned with a histogram depicting the prevalence of data values across each layer in the current image source. In such histograms, peaks typically indicate similar data – for example, the contrast between normal and poor energy absorption can represent distinct peaks. This can effectively isolate relevant data from the entire dataset.

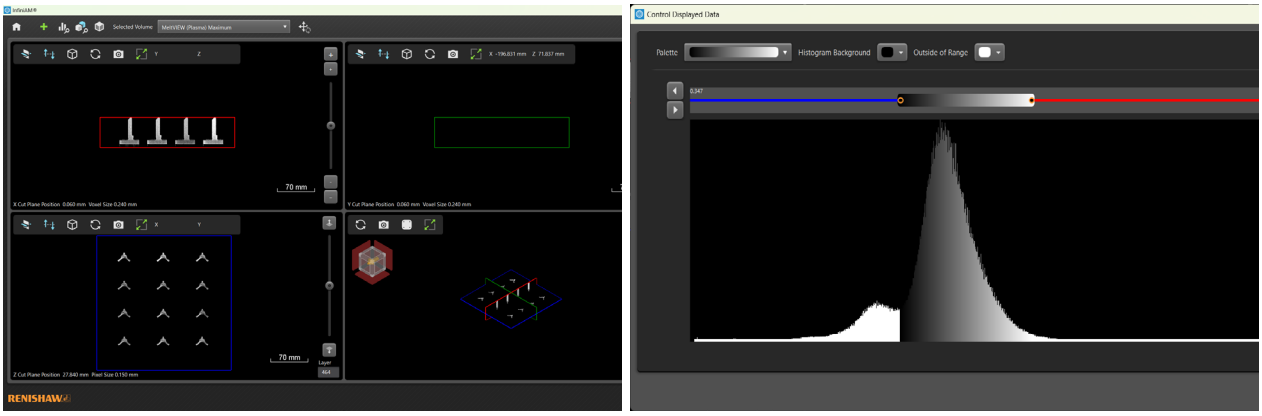
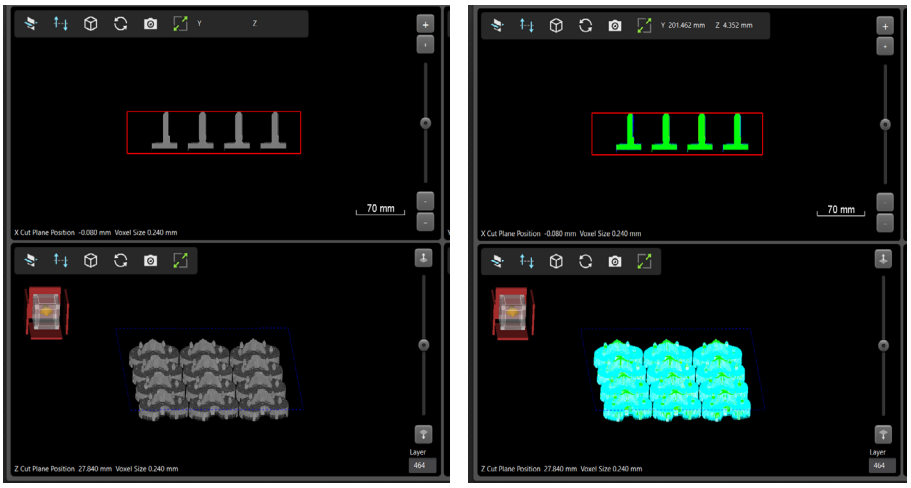


Figure 9 Reducing the displayed data to increase the contrast

Different palettes are useful in different situations. Typically, when the histogram displays a single broad peak, a grey scale or similar palette is more suitable. Alternatively, in cases where there are multiple distinct peaks, a full colour palette tends to be more effective.



When comparing two datasets, the complexity increases as it becomes necessary not only to control the data within each dataset but also to align and correlate the data between them. Although spectral data will be normalised across lasers on a machine, in many instances the data from two datasets are not directly comparable.

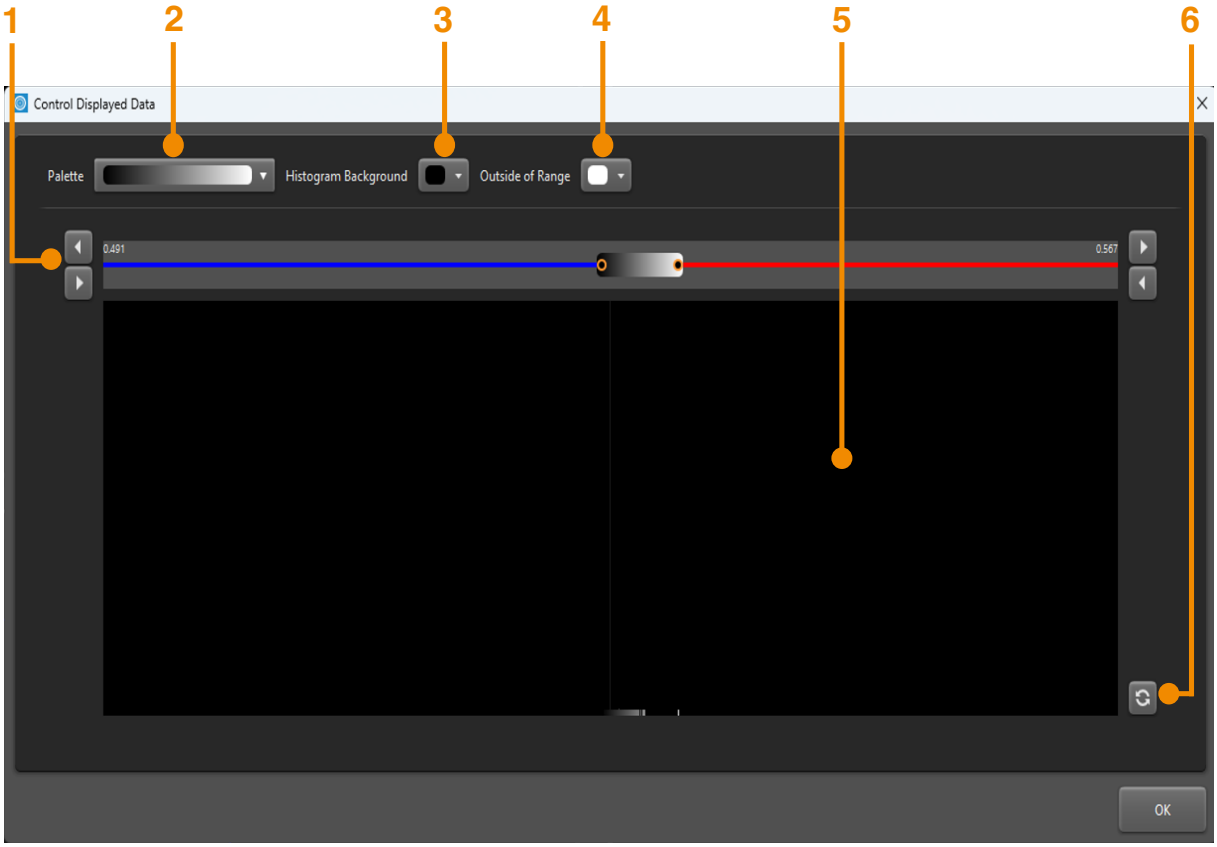
Firstly, each channel has different characteristics, resulting in unique histograms. An obvious use case for comparing LaserVIEW data with MeltVIEW data is to detect deviations in the proportion of energy entering versus exiting the chamber during a build process. To achieve this, it is essential to reconcile the disparities between the channels.

Secondly, although lasers are standardised within a single machine, consistency is not ensured across different machines. When comparing identical parts produced by different machines, the histograms may not match. In such cases, you must determine how to address these discrepancies between the machines.

Data characteristics may vary due to factors like part geometry or material. To compare builds with these differences, you must resolve the variations in the data.

8.2.1.2 Control Displayed Data tool controls

The ‘Control Displayed Data’ tool window offers additional controls to customise the visualisation of data. The toolbar contains the following controls:

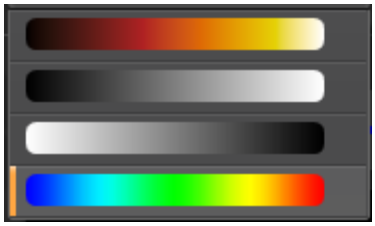


1 Selected Data Range

The specific set of data points that are chosen for analysis during the monitoring process.

2 Palette

By changing the palette, the colour scheme used to represent the intensities of the 2D and 3D data can be changed. This is useful for visualising data according to personal preference. This colour scheme will be used for both the histogram and 2D/3D data display. The rainbow palette is useful for inspecting data in 2D that has several distinct peaks in its histogram. It is less good at highlighting subtle differences in the data. The greyscale palettes are better at highlighting differences in volumes which have a histogram comprised of one broad peak.



3 Histogram Background

The histogram background colour may need to be adjusted depending on the colour scheme selected. This only affects the histogram view.

4 **Outside of Range**

This assigns a colour to the trimmed data. Renishaw recommends using a colour not used to represent data in the histogram. This only affects the histogram view.

5 **Histogram Graph**

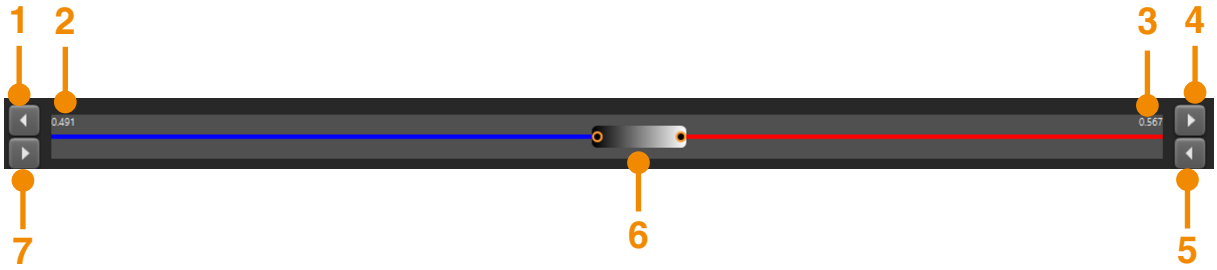
This displays a histogram representing the distribution of values across all layers within the selected volume. The Y axis represents the complete range of potential values within the data, while the X axis indicates the frequency of each value's occurrence. Consequently, the height of each column corresponds to the number of times that particular value appears in the dataset. The histogram is colour-coded in accordance with the selected palette and range settings, reflecting how each value will be displayed.

6 **Reset Range**

This button will reset the selected range back to the default range.

8.2.1.3 Selecting data range in Control Displayed Data tool

The interactive selected data range control in the 'Control Displayed Data' tool window allows you to input specific start and end values to define the range.



1 **Increment Minimum**

Increase the minimum by 0.001, to a maximum of 0.001 below the maximum, or 0.995, whichever is lower.

2 **Minimum**

Displays the current minimum values of the range.

3 **Maximum**

Displays the current maximum values of the range.

4 **Increment Maximum**

Increase the maximum by 0.001, to a maximum of one.

5 **Decrement Maximum**

Reduce the maximum by 0.001, to a minimum of 0.001 above the minimum, or 0.005, whichever is higher.

6 **Range Slider**

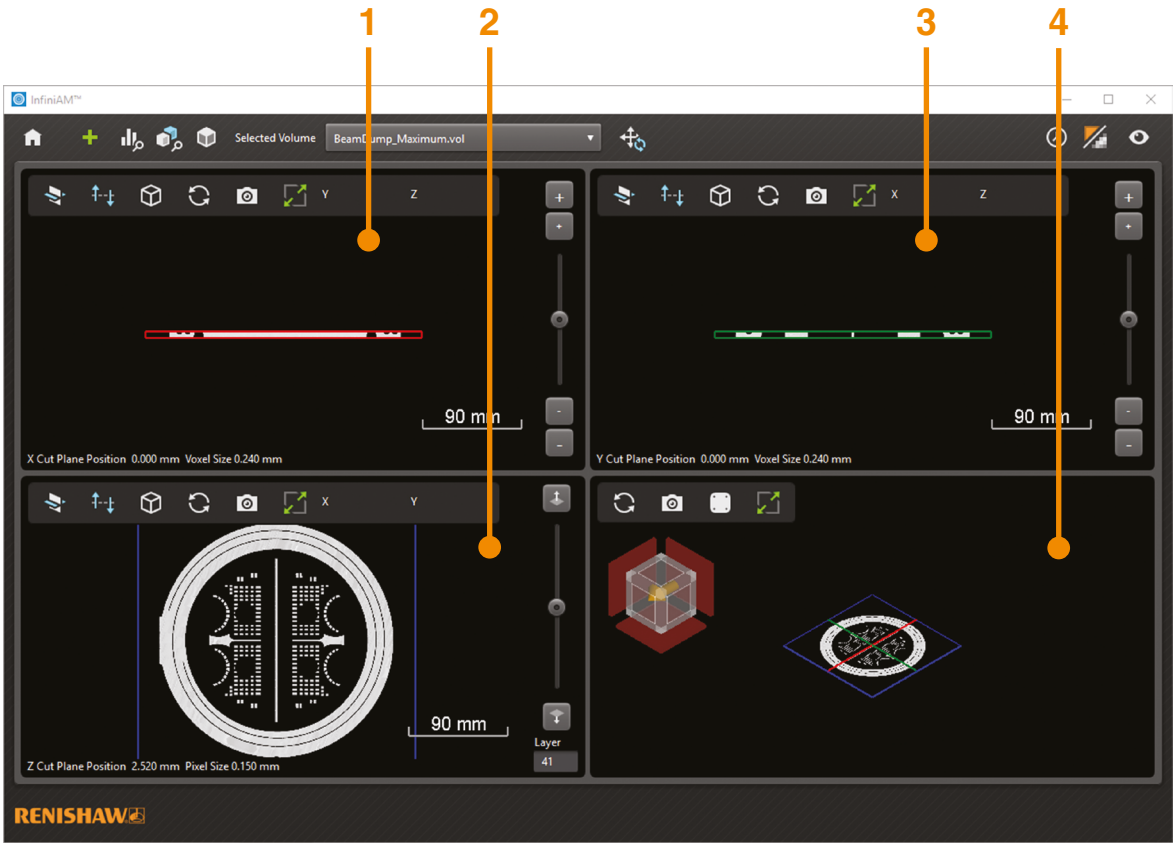
Click and drag the range slider to move the centre point of the range.

7 **Decrement Minimum**

Reduce the minimum by 0.001, to a minimum of zero.

8.2.2 Volume view controls

The volume view of the loaded volume contains four panes. The four panes are as follows:



1	X cut plane
2	Z cut plane

3	Y cut plane
4	Multiplanar view of the volume file

NOTE: The cut plane views enable the volume data to be inspected in all dimensions, in both 2D and 3D. The X and Y cut plane views display data at a resolution of 240 µm (0.009 in) whether in 2D or 3D mode. The Z cut plane view displays data at a resolution of 240 µm (0.009 in) when in 3D mode, but at a resolution of 40 µm (0.0015 in) or 150 µm (0.006 in), depending on the volume type, when in 2D mode.

8.2.2.1 X, Y and Z cut plane controls

InfiniAM Spectral displays multiple views of the dataset. The planar views display the data in three orthogonal directions, in either 2D or 3D. When in 2D, the camera is locked along the normal axis of the data in that view. In 3D the data is cut-planed along that axis instead exposing data “inside” the build.

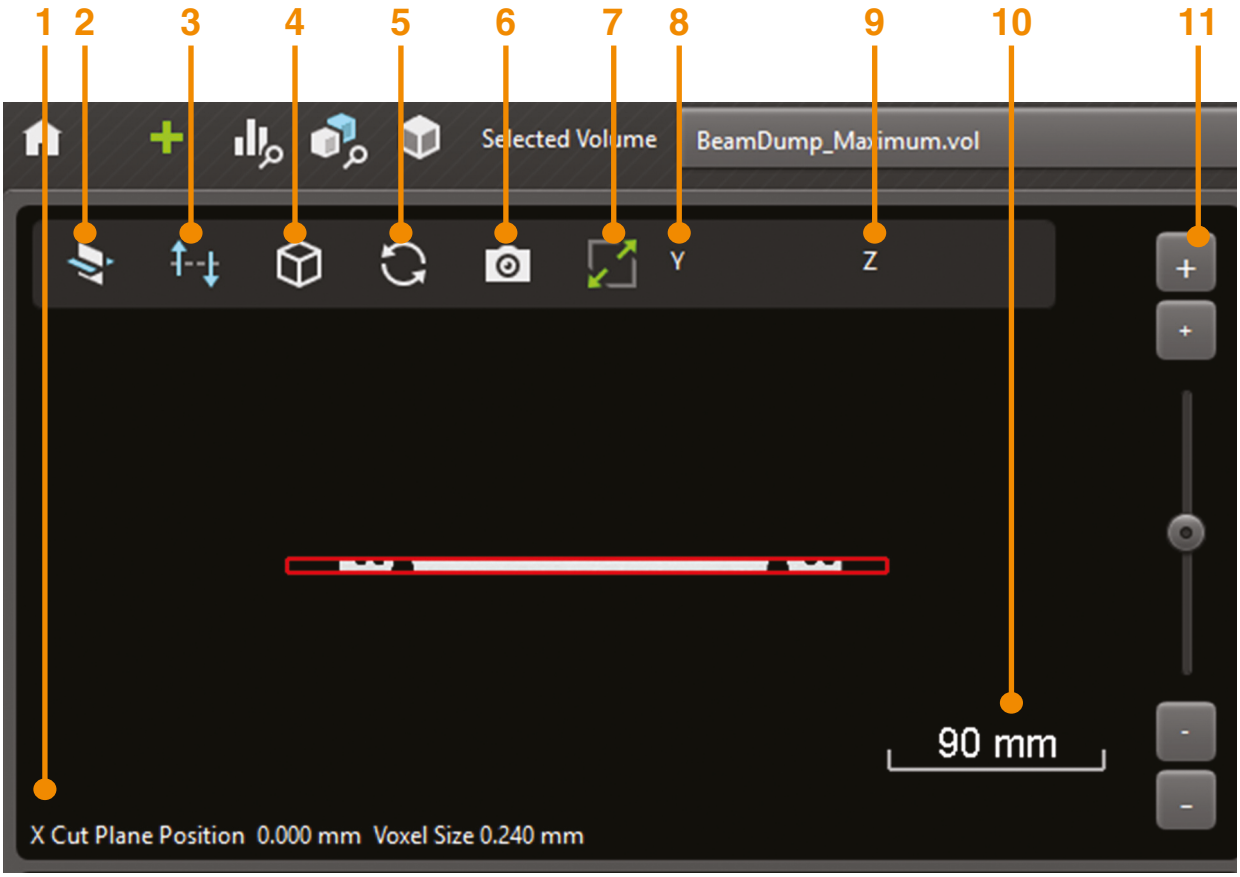
If the data is viewed in 2D:

- Click and drag with the right mouse button to pan the layer.
- Click and drag with the middle mouse button to zoom in and out of the layer.

If the data is viewed in 3D:

- Click and drag with the left mouse button to rotate the build.
- Click and drag with the right mouse button to pan the build.
- Click and drag with the middle mouse button to zoom in and out of the build.

The X, Y and Z cut plane views have the following controls:



1 **Cut Plane Position**

Displays the position of the cut plane in millimetres.

2  **Show/Hide in Multiplanar View**

Selecting this enables a choice of whether to show or hide the cut plane in the multiplanar view.

3  **Flip Cut Plane**

In 3D mode, this toggles the display region of the volume relative to the cut plane, either in front or behind it. It also flips which side of the cut plane data is shown in the multiplanar view.

4

Toggle 2D/3D View

Selecting this enables a 2D or 3D view of the build to be displayed in the selected pane. Toggle between 2D or 3D data as preferred. The navicube is displayed when the 3D view is selected.

5

Reset Camera

This resets the camera to the default viewing position. When viewing 3D data, selecting this resets the position of the camera so that the plane is viewed square on.

6

Screenshot

Selecting this opens the 'Save screenshot' dialog box. This allows you to capture a screenshot of the currently active pane in *.png, *.jpg or *.bmp format. If the active pane is maximised, the view saved will be of the maximised pane.

7

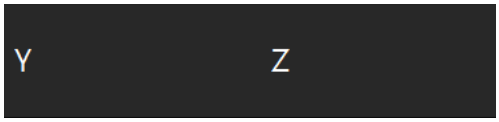
Maximise/Minimise View

This toggles whether the view occupies a quarter of the screen (minimised) or the whole screen (maximised).

8 and 9

Cut Plane Position

This displays the orientation of the cut plane. When 2D data is being viewed, the relative position of the cursor in the plane will be displayed in millimetres next to the orientation characters.



10

Scale

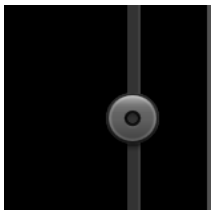
When 2D data is being viewed, this displays an indication of the scale of the build in millimetres. The scale updates dynamically and can be used to estimate the size of features of interest. The maximum scale that can be displayed is 1 000 mm (39.37 in) and the minimum is 0.1 mm (0.004 in).

11 **Increment/Decrement Cut Plane Position**

In all three cut plane views, the position of the cut plane can be changed.

In the X and Y cut plane views, there are two '+' and two '–' buttons to make small and large increments and decrements to the cut plane position.

In the X, Y and Z cut plane views, there is a slider that can be dragged to make large changes to the cut plane position.



In the Z cut plane view, there are two buttons to increment or decrement the cut plane view by one layer. The current layer is displayed in the current layer box. Typing a layer number in the current layer box and selecting return will take you to that layer.

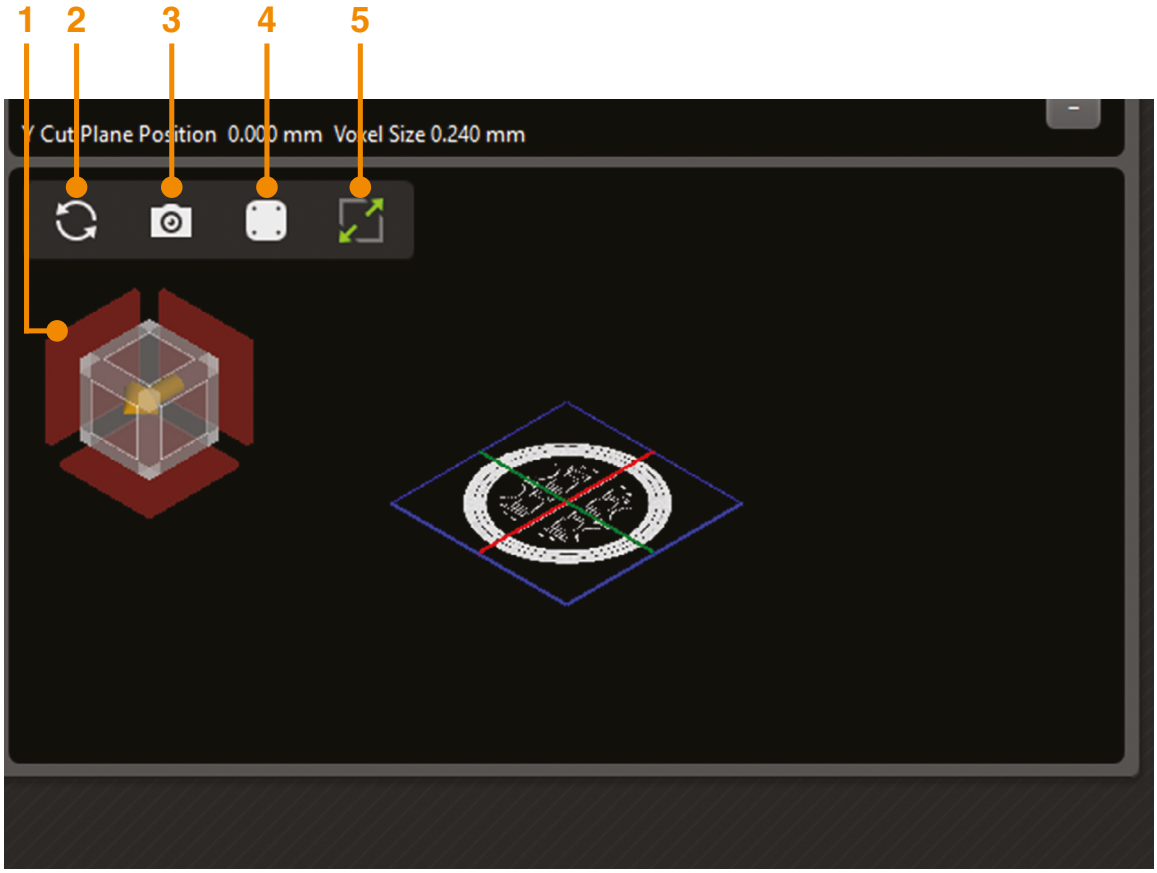
8.2.3 Multi-planar view controls

InfiniAM Spectral displays the cut planes of the planar views (regardless of if they are viewed in 2D or 3D) as they intersect with one another in the multi-planar view.

To interact with the data:

- Click and drag with the left mouse button to rotate the build.
- Click and drag with the right mouse button to pan the build.
- Click and drag with the middle mouse button to zoom in and out of the build.

The multiplanar view has the following controls:



NOTE: The multi-planar view shows the current position of the X, Y and Z cut planes, and is useful for providing overall orientation during the volume inspection process.

1 

Navicube (navigation cube)

Shows the current orientation of the volume in the multi-planar view. The direction of the orange arrow identifies the front of the build plate. Navigate to the predetermined views by selecting the edges, corners and planes of the navicube. Alternatively, the navicube can be selected with the left mouse button and dragged to change the orientation.

2 

Reset Camera

This resets the camera to the default viewing position.

3 

Screenshot

Selecting this opens the ‘Save screenshot’ dialog box. This allows you to capture a screenshot of the currently active pane in *.png, *.jpg or *.bmp format. If the currently active pane is maximised, the view saved will be of the maximised pane.

4 

Toggle Build Plate

Selecting this changes whether or not the build plate is displayed in the multiplanar view.

5 

Maximise/Minimise

This toggles whether the view occupies a quarter of the screen (minimised) or the whole screen (maximised).

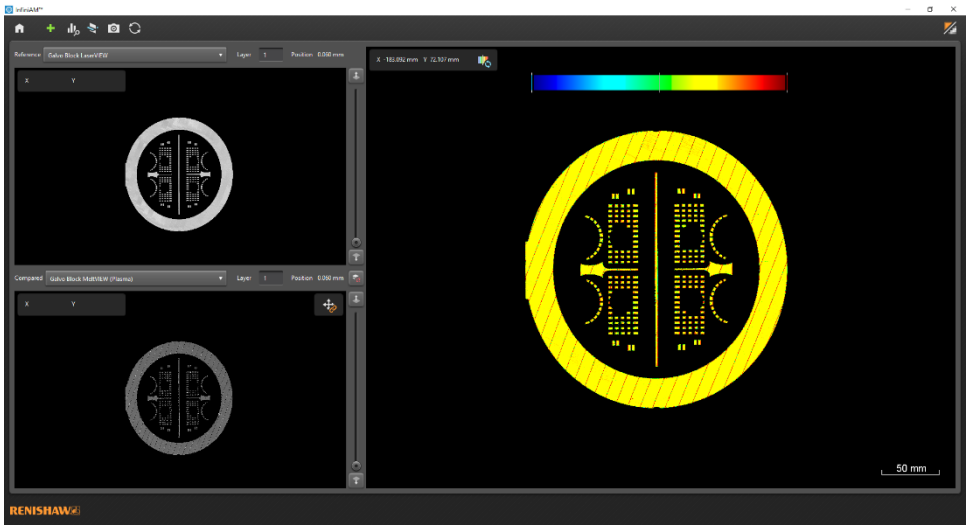
8.3 Comparing volumes

The compare volumes screen displays two layers and a comparison between them. It can compare any two layers in any of the loaded volumes.

Examples of potentially useful comparisons are:

- Between parts within the same volume, where a build contains multiples of the same part
- Neighbouring layers within the same volume
- Equivalent layers for different builds of the same parts
- Equivalent layers for the same build using different sensors, for example, comparing MeltVIEW (Melt-pool) and MeltVIEW (Plasma)

NOTE: It is advised to only compare volumes that have the same pixel size – only compare ‘Sum’ volumes to ‘Sum’ volumes, and ‘Maximum’ volumes to ‘Maximum’ volumes.



8.3.1 Main toolbar

In the Compare Volumes screen, the main toolbar contains the following controls:

1 

Home

This opens the ‘Home’ page. All the currently open volumes will be unloaded.

2 

Manage Volumes

This opens the ‘Load Volumes’ dialog box and enables further volumes to be loaded. Existing volumes can also be removed.

3 

Control Data Ranges Being Compared

This will open the ‘Control Displayed Data’ tool. For more information, see section 8.2.1.2, “Control Displayed Data tool controls”.

4 

Display Volume

This returns the application to the ‘Display Volume’ screen. For more information, see section 8.2.1, “InfiniAM Spectral toolbar controls”.

5 

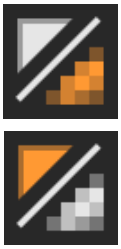
Screenshot

Selecting this opens the ‘Save screenshot’ dialog box. This allows you to capture a screenshot of the comparison view in *.png, *.jpg or *.bmp format. For more information, see section 8.3.4, “Comparison of layers”.

6 

Reset Views

This resets the camera to the default viewing position in all views. This will align the comparison, if it is not currently aligned.

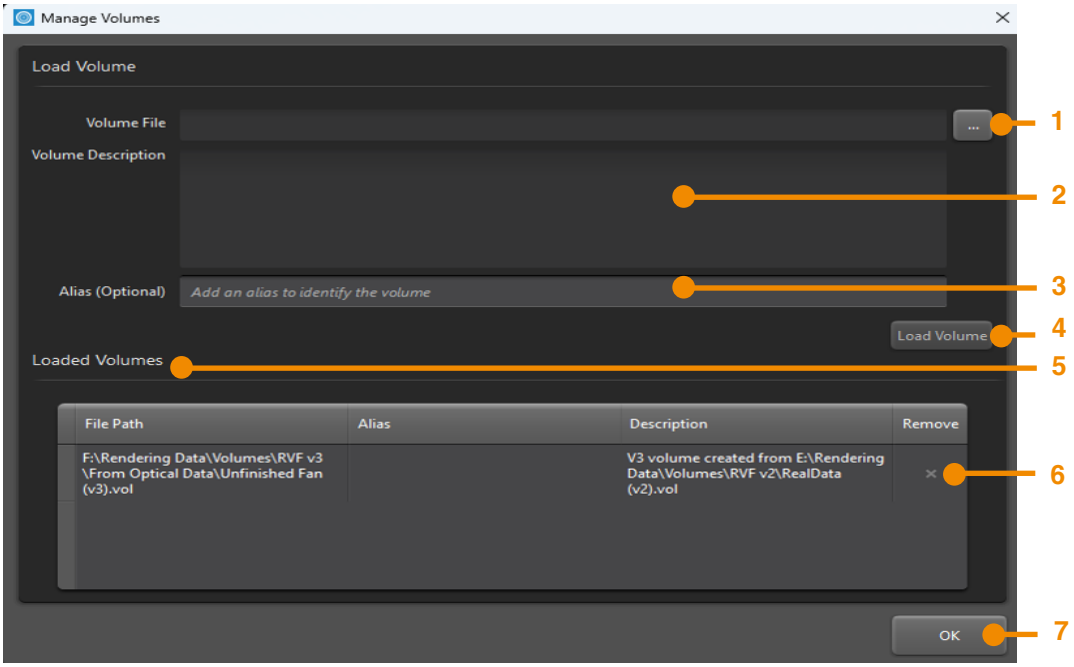
7 

Interpolated/Pixelated

Selecting this gives the choice of two views of the build – either the Interpolated or the Pixelated view. This controls the way in which pixels and voxels are represented. With the Interpolated view (default), smoothing is applied to give a more realistic representation of the data. With the Pixelated view, no smoothing is applied and hence the pixel and voxel edges are more distinct. Toggle between the two options to switch between the two views.

8.3.1.1 Managing Volumes

The ‘Manage Volumes’ dialog box enables you to select the dataset for analysis. This dialog box is consistent across both the ‘InfiniAM Spectral – Display’ and ‘InfiniAM Spectral – Comparison’ screens.



1 Volume File

Displays the path of the currently selected dataset. Initially, no dataset will be selected. If the selected file is invalid, ‘Volume File’ will be outlined in red. Click the ‘Browse’ button to open a dialog box that allows navigation through the file system to locate an InfiniAM Spectral dataset.

2 Volume Description

Displays a description if the selected dataset is valid.

3 Alias (optional)

Enter a name into ‘Alias’ to help identify the dataset on the InfiniAM Spectral screen. If no alias is provided, the dataset location (‘Volume File’) will be used instead.

4 Load Volume

Click this button to add the selected dataset to the list of loaded datasets with the current alias. Performing this action will reset the ‘Volume File’ and ‘Alias’, thereby preparing the ‘Volume Description’ for the selection of additional datasets.

5 Loaded Volume

Displays all the datasets that have been loaded so far, including any ‘Alias’ assigned to them.

6 Remove Volume

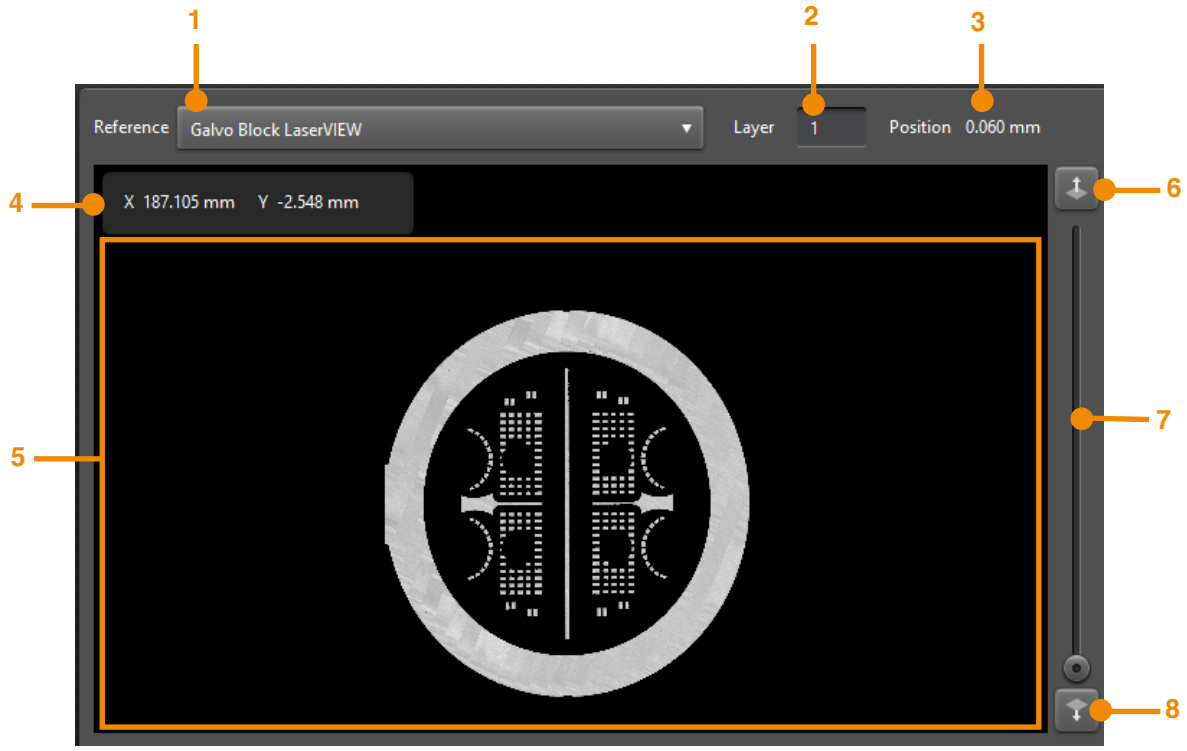
Click the 'Remove Volume' button next to any dataset listed in 'Loaded Volumes' to unload that dataset, making it unavailable in InfiniAM Spectral.

7 OK

Click this button to access the 'InfiniAM Spectral – Display' screen, which shows all loaded datasets. If no datasets are loaded, the 'OK' button will be disabled.

8.3.2 Reference layer

The top left view displays the 2D data for the reference layer.



1 Selecting the Reference Volume

This provides a dropdown list of the set of loaded volumes. Selecting an item from the dropdown list will use that volume as the reference for the comparison. Volumes are identified by the alias provided when they were loaded, or the name and location of the file, if no alias was provided.

2 Selecting the Reference Layer

This displays the currently selected reference layer and can be edited to enter a new layer.

3 Layer Position

The layer position displays the Z position of the selected reference layer relative to the build plate in millimetres.

4 X and Y Positions

Displays the XY co-ordinates of the position indicated by the mouse in millimetres, relative to the centre of the build volume.

5 Navigating the Reference Layer

This displays the 2D data for the selected layer of the selected reference volume. If the mouse is currently over the reference layer display, the X and Y Positions will display the XY co-ordinates of the position indicated by the mouse in millimetres, relative to the centre of the build volume.

By clicking and dragging the right mouse button in the reference layer display, the view of the reference layer, compared layer, and comparison will be synchronously panned in X and Y.

By clicking and dragging the middle mouse button or scrolling the scroll wheel while on the Reference Layer display, the view of the reference layer, compared layer, and comparison will synchronously zoom in and out.

6 Increment Layer

Show the next layer in the cut plane.

7 Layer Slider

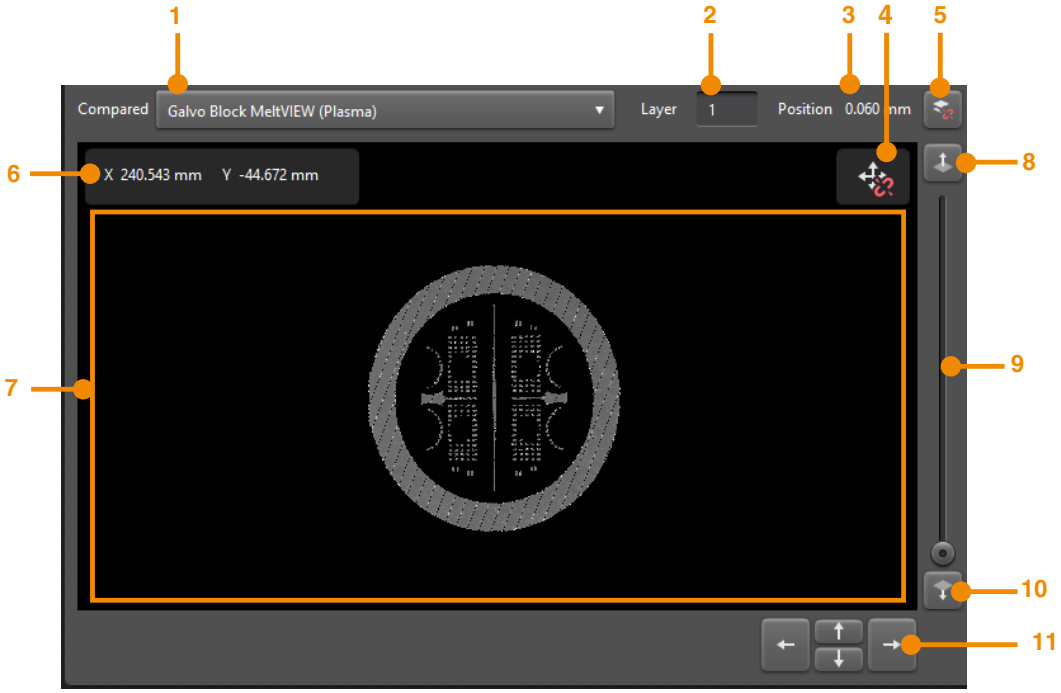
Select and drag the slider to view any layer of the build.

8 Decrement Layer

Show the previous layer in the cut plane.

8.3.3 Compared layer

The bottom left view displays the 2D data of the compared layer.



1 Selecting the Compared Volume

This provides a dropdown list of the set of loaded volumes. Selecting an item from the dropdown list will use that volume as the compared volume for the comparison. Volumes are identified by the alias provided when they were loaded, or the name and location of the file, if no alias was provided.

2 Selecting the Compared Layer

This displays the currently selected compared layer and can be edited to enter a new layer.

3 Layer Position

The layer position displays the Z position of the selected reference layer relative to the build plate in millimetres.

4 Synchronise Panning

By clicking and dragging the right mouse button in the compared layer display, if 'Synchronise Panning' is enabled, the view of the reference layer, compared layer, and comparison will be synchronously panned in X and Y. If it is disabled, only the view of the compared layer will be panned, however the relative locations of the reference and compared layers in the comparison will be shifted by the same amount, allowing features that exist at different points on the build plate to be compared. In addition, the 'Fine Adjustment Controls' (11) will be displayed. These allow for the more precise alignment of features than using the mouse.

Use the middle mouse button or scroll wheel to zoom in and out on the reference, compared, and comparison layers simultaneously.

5 Synchronise Layers

If the 'Synchronise Layers' button is enabled, changing the compared layer will change the reference layer by the same amount and vice versa. If it is disabled, changing one layer acts independently of the other.

6 X and Y Positions

Displays the XY co-ordinates of the position indicated by the mouse in millimetres, relative to the centre of the build volume.

7 Navigating the Compared Layer

This displays the 2D data for the selected layer of the selected compared volume. If the mouse is currently over the compared layer display, the X and Y Positions (6) will display the XY co-ordinates of the position indicated by the mouse in millimetres, relative to the centre of the build volume.

8 Increment Layer

Show the next layer in the cut plane.

9 Layer Slider

Select and drag the slider to view any layer of the build.

10 Decrement Layer

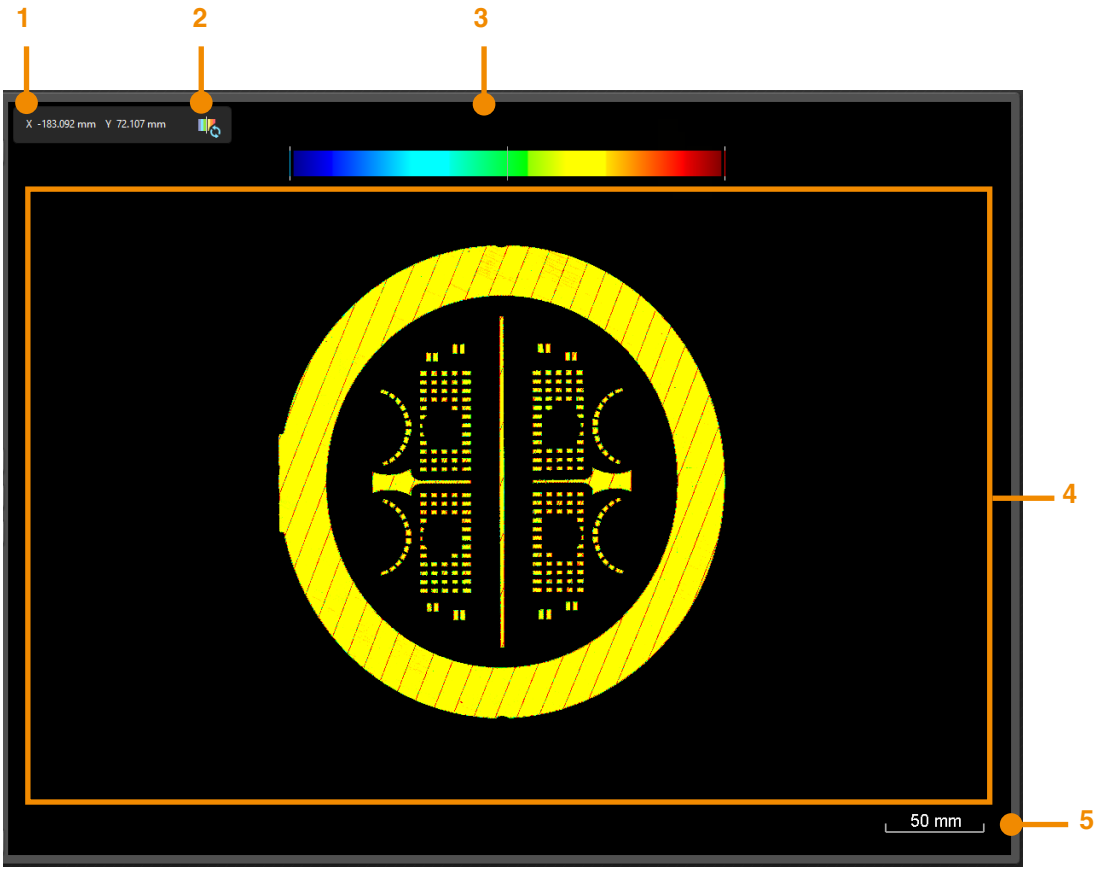
Show the previous layer in the cut plane.

11 Fine Adjustment Controls

Allow for the more precise alignment of features than using the mouse.

8.3.4 Comparison of layers

The right-hand view displays the comparison between the reference and compared layers. The comparison is calculated by subtracting the value of each pixel in the compared layer from the aligned pixel in the reference layer. The difference is then mapped onto a colour scale – a “more red” pixel implies that the compared pixel at this location has a lower intensity than the reference pixel at this location; a “more blue” pixel implies the opposite.



1 X and Y Positions

Displays the XY co-ordinates of the position in the reference layer indicated by the mouse in millimetres, relative to the centre of the build volume.

2 Reset Spectrum Bar

This will reset the Spectrum Bar to cover the full range of data.

3 Spectrum Bar

This controls how the comparison between layers is coloured. The white marks at the extremes of the bar represent the upper and lower bounds of the values. The white mark at the centre of the bar indicates the colour that will be displayed when the reference and compared pixels are identical.

By clicking the left mouse button in the comparison of layers display and dragging up and down, you can increase or decrease the range of values that will be coloured. This allows you to alter the fidelity of the comparison – a smaller range will make differences more apparent, but will only compare a subsection of the full data range.

By clicking the left mouse button in the Comparison of Layers display and dragging left and right, you can move the range of values that will be coloured. This allows you to view a different section of the data range.

4 Comparison of Layers Display

Displays the comparison between the reference and compared layers. If the mouse is currently over the comparison of layers display, the X and Y positions (1) will display the XY co-ordinates of the position in the reference layer indicated by the mouse in millimetres, relative to the centre of the build volume.

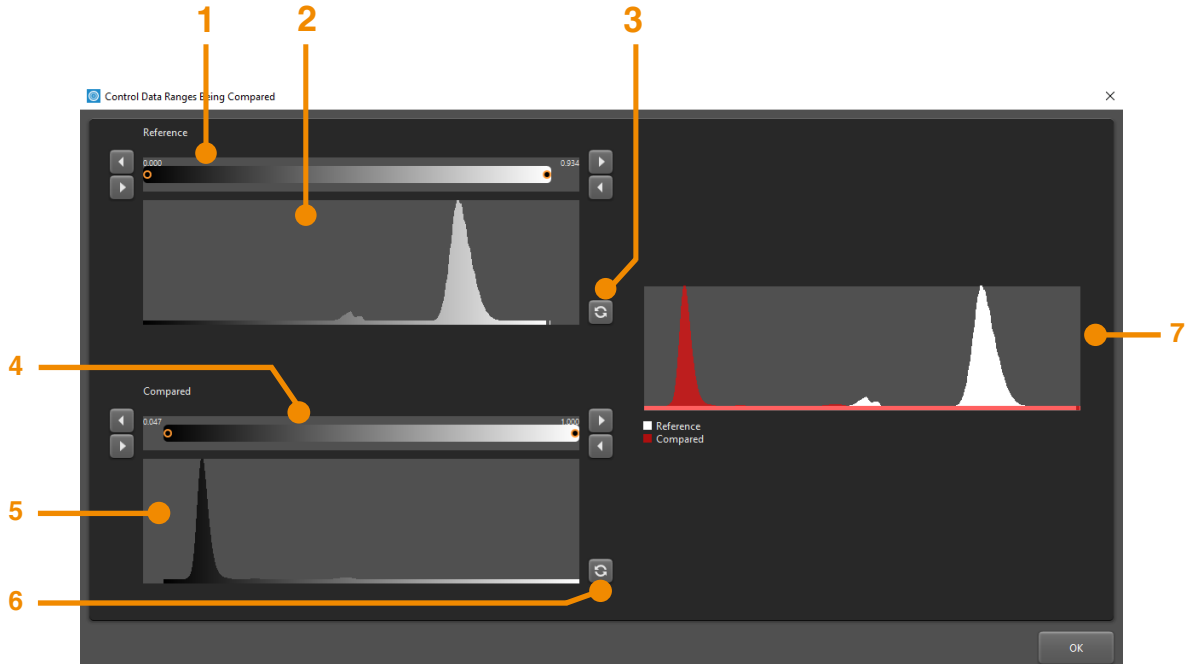
5 Scale Bar

This indicates the scale of the layer in millimetres. The scale updates dynamically and can be used to estimate the size of features of interest. The maximum scale that can be displayed is 1 000 mm (39.37 in) and the minimum is 0.1 mm (0.004 in).

By clicking and dragging the right mouse button in the comparison of layers display, the view of the reference layer, compared layer, and comparison will be synchronously panned in X and Y.

By clicking and dragging the middle mouse button or scrolling the scroll wheel while on the comparison of layers display, the view of the reference layer, compared layer, and comparison will synchronously zoom in and out.

8.3.5 Control Data Ranges Being Compared



1 Reference Selected Data Range

The interactive reference data range control allows you to input the specific start and end values to define the range.

2 Reference Histogram Graph

A histogram displaying the distribution of values in the reference volume. The Y axis represents the range of possible values, and the X axis shows their frequency. Columns with greater heights indicate higher frequencies of those values in the data. The histogram is coloured based on the current palette and range for displaying corresponding reference values.

3 Reference Reset Data Range

This button will reset the selected reference range back to the default range.

4 Compared Selected Data Range

The interactive reference data range control allows you to input the specific start and end values to define the range.

5 Compared Histogram Graph

A histogram displaying the distribution of values in the compared volume. The Y axis represents the range of possible values, and the X axis shows their frequency. Columns with greater heights indicate higher frequencies of those values in the data. The histogram is coloured based on the current palette and range for displaying corresponding compared values.

6 Compared Reset Data Range

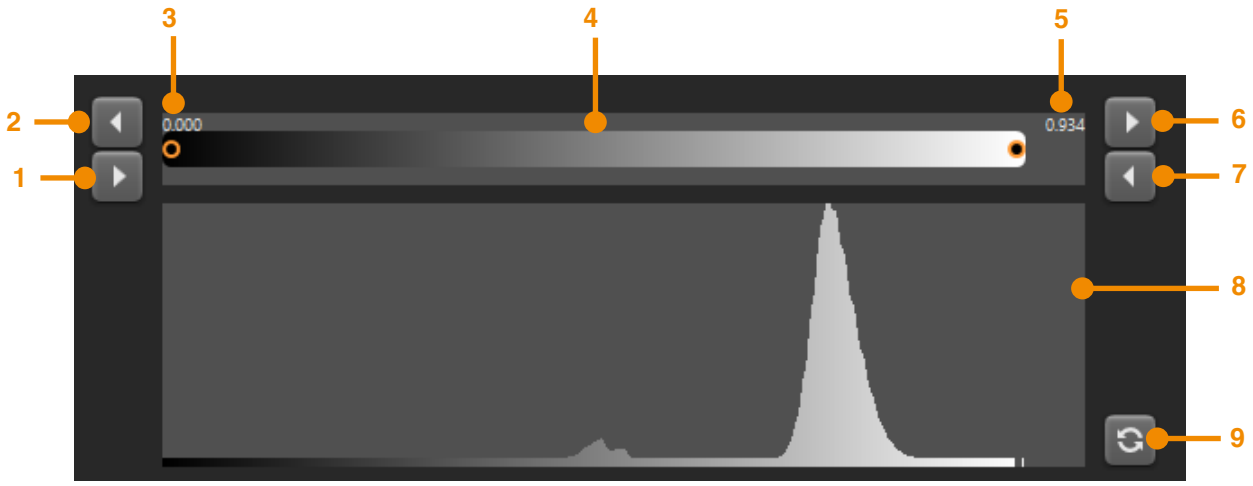
This button will reset the selected compared range back to the default range.

7 Combined Histogram Graph

A histogram displaying the transformed histograms for the reference and compared datasets, overlaying them to visualise their alignment and comparison.

8.3.5.1 Changing the Selected Data Ranges

The Reference Selected Data Range and Compared Selected Data Range control what range of the source data is displayed in their respective view and used in the comparison. Both function as described below, affecting their respective layers.



1 Increment Minimum

Increase the minimum by 0.001, to a maximum of 0.001 below the maximum, or 0.995, whichever is lower.

2 Decrement Minimum

Reduce the minimum by 0.001, to a minimum of zero.

3 Minimum

Displays the current minimum values of the range.

4 Range slider

Click and drag the range slider to move the centre point of the range. It controls what sub-section of the complete range of data values will be used for the comparison.

5 Maximum

Displays the current maximum values of the range.

6 Increment Maximum

Increase the maximum by 0.001, to a maximum of one.

7 Decrement Maximum

Reduce the maximum by 0.001, to a minimum of 0.001 above the minimum, or 0.005, whichever is higher.

8 Histogram

The histogram graph displaying the distribution of values across all layers in the source volume. Peaks tend to correlate with different laser parameters – for example, where different parameters are used when melting the borders of a part compared to the internals of the part, or with defects.

9 Reset Data Range

This button will revert the selected data range to the default – covering the full range of data present in the source volume (as opposed to the absolute range of data that could be present in a volume).

8.3.5.2 Aligning the reference and compared data

The Comparison Histogram superimposes the reference and compared histograms, allowing features within the two histograms to be aligned. For example, while it is expected that different modalities for the same build will, broadly speaking, display the same features, the equivalent peaks may be located at different intensities and have different widths.

9 Maintenance and troubleshooting

9.1 Maintenance schedule

Calibration should be carried out every six months.

WARNING: All user maintenance on the Renishaw AM system is as specified in the relevant user guide. All service engineer maintenance on the Renishaw AM system is as specified in the relevant AM system maintenance manual.

WARNING: The AM system must be electrically isolated before any work is carried out. Isolate it at the mains power supply by moving the main switch to the 0 or OFF position and locking it with a personal padlock. Attach a visible warning sign to indicate that the system is isolated. Carry out safe isolation procedure checks in accordance with IEE standards.

9.2 Maintenance tasks

9.2.1 Calibration

1. The LaserVIEW and MeltVIEW hardware modules must be calibrated by a Renishaw Service engineer.
2. There are no user-serviceable parts within the LaserVIEW and MeltVIEW hardware modules.
3. Contact Renishaw to arrange a service visit. For more information, see section 11, “Customer support”.

9.3 Troubleshooting

Should you encounter any difficulties while operating InfiniAM, contact Renishaw for assistance using the contact information provided in section 11, “Customer support”.

The following are some commonly encountered issues and their respective solutions:

9.3.1 Licensing

InfiniAM may fail to retrieve a licence due to several common issues. Some of these issues are listed below:

–4 There are no licences available for this feature

This message indicates that the licence server configured for InfiniAM has exhausted its available seats for this licence. To access this feature, shut down an existing instance of InfiniAM. If this issue occurs frequently, your organisation may need to consider acquiring additional licences to meet the demand.

–12 Bad return from server

This message indicates that the server installation was unsuccessful. To address this issue, reinstall the licence server.

–15 A connection to the Renishaw Licence Server could not be made

This message indicates that InfiniAM can connect to the host machine specified during installation but cannot connect to a licence server. Possible causes for this issue include:

- The port number specified during installation is incorrect.
- The port is inaccessible due to security settings or being used by another service.
- The licence server is not running.
- The host machine does not have a licence server installed.

–96 Server node is down or not responding

This message indicates that InfiniAM was unable to locate a machine corresponding to the machine name given during installation. Several factors may contribute to this problem, including:

- The machine name provided on installation is incorrect.
- There is a deeper network issue.

-97 The desired vendor daemon is down

This message indicates that an internal component of the licence server has become unresponsive. Typically, restarting the server will resolve this issue. If the problem persists, contact Renishaw for further assistance.

10 InfiniAM limitations

InfiniAM is designed to provide the optimum viewing experience. However, certain limitations in system performance are noted below.

10.1 Using multiple layer thickness

Multiple layer thicknesses can be used during a build, such as 30 µm and 60 µm. This can be done either as separate parts or by using the “Shell” and “Core” functions within QuantAM. 2D layers will be displayed correctly, although their Z positions may be inaccurate. Each single voxel slice of a 3D volume may encompass multiple layers, resulting in intermittent layers not being visualised accurately in 3D views.

10.2 Multi-laser only – crossing lasers

Each MeltVIEW sensor possesses a field-of-view measuring 6.3 mm and 2.6 mm in diameter. There is a possibility that a single sensor may detect the reflected light from multiple laser melt-pools when two lasers operate in close proximity to each other. This scenario can lead to an elevated intensity reading, which may be interpreted as a defect.

10.3 Multi-laser only – intensity

During commissioning, the intensity of each laser’s MeltVIEW sensors will be cross-referenced with other lasers to ensure that feedback from all lasers has the same average intensity. Slight differences in intensity between lasers may persist, especially if the histogram is adjusted to enhance display sensitivity.

11 Customer support

If you experience an issue with your system or software, or if you need advice, contact Renishaw.

11.1 Contact details

Contact details for Renishaw are below:

Phone number:		**+44 (0) 1453 524524** Hours of work: Monday to Friday 08:00 to 17:00 (UTC, subject to DST changes)
Email:	**For quotes and orders related to consumables, parts, and contracts**	**ampd.sales@renishaw.com**
	For scheduled maintenance visits, machine breakdowns or any machine operating queries	**am.support@renishaw.com**
	For any guidance or issues related to build file preparation, general machine operation, machine training, post build testing and analysis	**am_applications@renishaw.com**
	For any QuantAM licence issues or queries	**quantam.support@renishaw.com**
Service address:		Renishaw plc New Mills Wotton-under-Edge Gloucestershire GL12 8JR United Kingdom

1. System type	
2. System serial number	
3. InfiniAM Spectral hardware (MeltVIEW module) serial number	
4. InfiniAM software version	
5. DataHUB software version	

Please quote the details above. The system serial number plate can be found on the rear of the system. Details of the InfiniAM system hardware – the MeltVIEW module – can be found on the serial plate which is visible when InfiniAM Spectral is installed on the Renishaw AM system.

Additional support can be sought by contacting your local Renishaw office. See:
www.renishaw.com/contact

12 Abbreviations

The following abbreviations are used throughout this guide:

Term	Definition
AM	Additive Manufacturing
AMPM	Additive Manufacturing Process Monitoring
DNS	Domain Name System
FTP	File Transfer Protocol
GPU	Graphics Processing Unit
HMI	Human Machine Interface (touch screen)
IIS	Internet Information Services
IP	Internet Protocol
IT	Information technology
OEM	Original equipment manufacturer
PC	Personal Computer
PLC	Programmable Logic Controller
SSL	Secure Sockets Layer

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